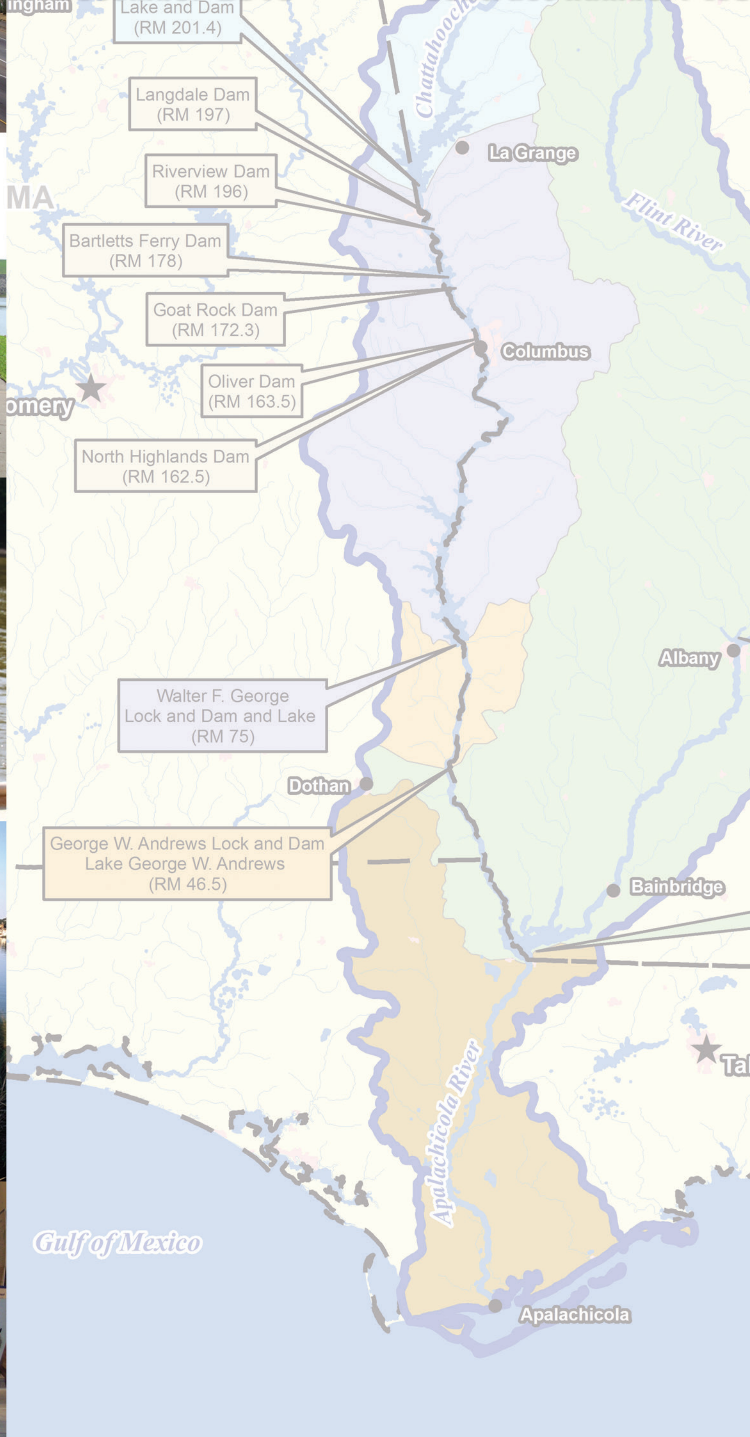
FINAL
Environmental Impact Statement

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

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





US Army Corps of Engineers®
Mobile District

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

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

Appendix J

USFWS Coordination

This page intentionally left blank

Part 1: Fish and Wildlife Coordination Act

This page intentionally left blank

USFWS Planning Aid Letter April 2010

This page intentionally left blank

United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

April 2, 2010

Colonel Byron Jorns
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Jorns:

We are providing your agency with a Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the PAL is to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. We submit the following comments and recommendations under the ESA, the Migratory Bird Treaty Act (MBTA)(49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). These comments are based on previous studies and government documents as well as new datasets and information provided by State and Federal agencies. Although all of the comments from the Florida Fish and Wildlife Conservation Commission (FFWCC) have not been integrated, this final version of the PAL addresses many of the issues that FFWCC raised. We will continue to provide additional expertise and information in the form of another PAL and/or the draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corp's proposal on federally-listed threatened and endangered fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

1. Development of Corps Alternatives and Mitigation

We have identified data needs and assessment methods that can help you in developing alternatives that maximize fish and wildlife benefits, and avoid, minimize and compensate for impacts to fish and wildlife resources, where appropriate.

1.1 Flow Regime

The WCM update should include a thorough evaluation of project-related flow regime alterations and the potential to restore flow regime components that have ecological and geomorphic significance. We recommend the Corps develop alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. To support this effort, we have provided preliminary ecosystem flow guidelines for four river sections; below Buford, West Point, Walter F. George, and Jim Woodruff dams. These flow regime guidelines are guided by the principle that ecosystems evolved as a response to the natural flow regime. Thus, we analyzed river flows and developed flow guidelines based on United States Geological Survey (USGS) flow data that were collected prior to Buford Dam construction in the mid 1950's, a benchmark of the first major river regulation source in the upper Chattahoochee River. Reliance on pre-regulation datasets to derive ecosystem flows is particularly useful for locations where empirically derived ecology-flow relationships are scant (such as the upper Chattahoochee River).

We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation. For example, provision of stable flow windows (*sensu* Freeman et al. 2001) in the spring may increase riverine fish recruitment, even though restoration of other naturally occurring flow regime components may not be attainable. Relatively small discharge changes can have substantial ecological effects. For example, the Tennessee Valley Authority's (TVA's) strategy to increase baseflows below Normandy Dam (Figure 1) during the spring and summer mussel recruitment months resulted in biologically and statistically significant increases in mussel diversity and density (Figure 2, Ahlstedt and Johnson 2004).

Development of environmental flow alternatives would include an evaluation of the operational feasibility, constraints, and tradeoffs to providing the different aspects of environmental flow measures that are captured in our guidelines. Explicit magnitude, frequency, duration, timing, and rate of change guidelines are provided to illustrate the types of flow modifications that are likely to benefit the ecosystem and to help inform the development of Corps flow alternatives. However, should the magnitude of a flow guideline be deemed unattainable, we request that the Corps identify a flow magnitude that is attainable or recommend an attainable frequency for the recommended flow magnitude. An explanation for the change also will be helpful. We recognize these guidelines do not define whether the basin is entering a dry, average, or wet month, which are the lines between the lower and upper limits on the flow prescription graphs. We recommend that you work with us to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

Successful implementation of ecosystem flows in the Chattahoochee River is challenged by water demand increases, reduced operational flexibility imposed by meeting minimum discharge requirements at downstream locations, and the importance of minimizing high discharge-related

damage to infrastructure. To address these challenges, we considered only the range of flows that were likely to be above minimum flow requirements and less than flows that could cause major infrastructure damage as identified by information provided by the National Weather Service (NWS) Advanced Hydrologic Prediction Service (NWS 2010; Table 1). The ecosystem flow guidelines are preliminary because in instances where water is diverted from the channel, or the channel is anthropogenically altered, natural flows may be insufficient to meet ecological needs.

Successful implementation of ecosystem flows in the Apalachicola River is challenged by the same types of limitations described for the Chattahoochee River. The degree of Apalachicola River channel entrenchment and widening, caused largely by Corps reservoir and dredging operations, varies spatially, but the discharge that is now required to reach bankfull elevation and cause floodplain inundation in the upper portion of the river is generally greater than the discharge that was historically required. However, datasets are available that quantify the amount of floodplain habitat inundated with the current level of entrenchment and over a range of discharges. These datasets, in combination with those that describe flow effects on sturgeon spawning and mussel habitats, will help to inform the development of future ecosystem flow guidelines and the evaluation of alternatives.

Thorough explanations of the physical, chemical, and ecological benefits from base flows, pulses, stable flow windows for spawning, and intra- and interannual flow variation are outside the scope of this letter; however, we refer the reader to Junk et al. 1989, Poff et al. 1997, Richter et al. 1998, Freeman et al. 2001, Postel and Richter 2003, and Mathews and Richter 2007 for fuller descriptions. The importance of baseflows, pulses, and flood flows are described within these resources, and they are quantitatively evaluated using the recently developed Environmental Flow Components (EFCs) in Indicators of Hydrologic Alteration (IHA)(Mathews and Richter 2007). General descriptions of the baseflow, pulse, and high pulse flow guidelines are provided below with general descriptions of the ecological significance of those flow guidelines.

Similar to the Instream Flow Guidelines provided to the ACF Compact's Federal Commissioner (USFWS 1999), the guidelines provided in this letter were developed using IHA, use the pre-dam period of record as a benchmark for comparison of flow alternatives, and rely on percentiles to define the frequency of high and low flow extremes. Using EFCs is recommended because the analysis separates ecologically-relevant hydrograph components (e.g., baseflows from pulses) allowing computation of magnitude, frequency, duration, timing, and rate of change statistics on individual hydrograph components rather than on the entire dataset. Consequently, these hydrograph summary statistics are easily developed, interpreted, and communicated, and have been used successfully to inform flow management downstream from hydropower dams.

1.1.1 Baseflow and small pulses

Baseflows determine the amount of habitat that is available for forage, reproduction, and rearing, which has a substantial influence on the abundance, diversity, and distribution of aquatic fauna. We have provided explicit base flow recommendations for every month in dry, average, and wet water years. Small pulses that do not exceed bankfull elevation provide influxes of upstream

trophic subsidies, and reprieves from low dissolved oxygen and high temperature that sometimes occur during summer months. Small pulses are included in the guidelines with explicit magnitude, frequency, duration, timing, and rate of change recommendations (Figures 3-6).

The flow guidelines were based on average daily flows (Figures 3-6). Average daily flows obscure the diel streamflow variation imposed by hydropower generation. Consequently, hydropower generation at Buford, West Point, Walter F. George, and to a lesser extent, Woodruff Dam, may change discharge two orders of magnitude, and change river stage significantly within a few hours. As a result, habitat availability is limited to periods that are too brief for the completion of essential life history requirements. To mitigate this impact, the provision of non-hydropower peaking "windows" should be evaluated during critical reproductive and rearing periods in order to reestablish native plant, fish, and invertebrate abundance and diversity in river reaches downstream from Corps-operated projects. Generally, this period corresponds to March – May when water temperatures increase. The timing, duration, and magnitude of this window should vary interannually in order to optimize the reproductive requirements of each species every few years. However, the duration of the non-peaking window requires additional research, but we expect that a minimum of 4-6 weeks between March and May are required.

The dry, average, and wet year baseflow guidelines are based on a retrospective analysis of the pre-dam hydrograph (Figures 3-6). It will be necessary to use appropriate hydrological and meteorological criteria to classify the coming month into dry, average, or wet categories. However, average daily baseflows should remain near the dry, average, and wet year flow guidelines depending on the category, and should not fall below the lower limit on any day of any year.

1.1.2 High flow pulses

High flow pulses that exceed bankfull elevation provide important ecological services. A large proportion of sport and non-game fishes rely on floodplain habitats to spawn, rear young, and forage. High flow pulses are also major forces that control nutrient and organic matter dynamics in large rivers, create new habitats, and ultimately affect riverine animal biomass (Junk et al. 1989). However, the spring reservoir refill period extends into the principal spawning season for a high proportion of fishes, meaning that spring flows and floodplain inundation are reduced. Thus, ensuring seasonal high flows and river-floodplain connectivity with the timing, frequency, duration, magnitude, and rate of change necessary to sustain ecological functions and wildlife populations are essential flow management objectives for dams on large rivers.

To provide flows that inundate the floodplain, the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain should be evaluated. Similarly, the Savannah District Corps has operated the Savannah River reservoir system in recent years with reduced winter drawdown to provide spring pulses that meet multiple downriver ecosystem objectives. This evaluation should separately consider flow conditions in wet, average, and dry climatic years. Additionally, it should be noted that relatively small changes in river stage can significantly increase the amount of river-floodplain connectivity. Consequently, minor changes

in dam operation could have large and positive effects on the river-floodplain ecosystem.

Recognizing that there are limits on operational flexibility due to the presence of infrastructure in some floodplains, methods should be evaluated to provide the operational flexibility necessary for floodplain inundation, which falls under the Corps' coequal project purpose of "Fish and Wildlife Resources." Such methods could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation; and/or 2) the purchase of structures built in the historic floodplain so that the Corps can intentionally provide flows that inundate the floodplain. These analyses should be simple to conduct, and would include acquisition of floodplain maps and identification of anthropogenic structures within the 2, 10, 50, and 100-year floodplains.

1.2 Floodplain inundation assessments

The relationships among the areal extent of Apalachicola River floodplain inundation, channel entrenchment effects, and water releases from Jim Woodruff Lock and Dam were previously assessed and related to discharge using the datasets and summaries provided by Light et al. 1998 and Light et al. 2006. These datasets have informed biologists and the Corps of the effects of flow releases on river-floodplain resources. Due to the difficulty of surveying all floodplain streams, lakes, and forests, Light et al. 1998 used intensive surveys at a subset of sites, general surveys at approximately 300 sites, and Geographic Information Systems (GIS) to assess the effects of hydrogeomorphic alteration on floodplain inundation areal extent. Light et al. 2006 compared pre-dam stage (prior to 1954) and recent stage (1995–2004) at five streamflow gaging stations in relation to discharge at the Chattahoochee gage (USGS gage number 02358000, Apalachicola River at Chattahoochee, FL). These stage-discharge relationships can also be used to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at different discharges for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

More recently, floodplain elevation maps have been generated using Light Detection and Ranging (LIDAR) remote sensing data with <1 ft accuracy and related to Apalachicola River stage-discharge relationships developed by Light et al. 2006 (Ron Bartel, Northwest Florida Water Management District [NWFWMD], 2010, pers. comm.). Stage-based LIDAR data may provide a more thorough and accurate evaluation of river flow effects on river-floodplain connectivity and habitat availability. We recommend that the Corps contact the NWFWMD to confirm that these datasets exist, request permission to access and use these new datasets, or invite collaboration between the Corps and the NWFWMD to evaluate effects of flow alternatives on floodplain resources. Operations in the environmental flow alternatives should be developed that will use reservoir storage at certain times to augment flow and increase Apalachicola floodplain inundation.

1.3 Water Quality

The effects of reservoir operations on water quality should be closely examined in the WCM update, including ongoing and potential future effects to dissolved oxygen (DO), temperature, nutrient and organic material dynamics, and capacity to assimilate industrial and municipal

discharges. We request that the Mobile District use the WCM update to make necessary modifications that will improve water quality downstream of Corps projects, as is being done by TVA and other Corps districts.

1.3.1 Dissolved Oxygen

The Service is most concerned about low DO in project tailwaters. We recommend that the Corps make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. An appropriate effort would include first monitoring DO upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve DO levels, and conducting post-modification DO monitoring to ensure that DO levels have been improved to State water quality standards. Examples of low DO releases from Buford, West Point, and Walter F. George dams are detailed below.

We urge the Corps to 1) monitor DO upstream and downstream of Lanier Reservoir, West Point Reservoir, Walter F. George Reservoir, and Jim Woodruff Reservoir and 2) experiment with operational and/or structural modifications to improve DO levels, and conduct post-modification DO monitoring to ensure that DO levels increase to state water quality standards. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream dissolved oxygen requirements may be particularly useful. The DO that results from the mixing of two water bodies (DO_{mx}) is a function of the dissolved oxygen (DO_1 and DO_2) and volumes (Q_1 and Q_2) of the two water bodies and is calculated using the following equation:

$$DO_{mx} = \frac{Q_1 * DO_1 + Q_2 * DO_2}{Q_1 + Q_2}$$

1.3.1.1. Buford Dam tailwaters

Low DO levels were recorded by the Georgia Department of Natural Resources-Wildlife Resources Division (GDNR-WRD) just below Buford Dam during 1996-2006. These DO levels affect angler success, GDNR-WRD's stocking rates, and the native aquatic community. Periodic measurements taken during this period resulted in monthly minimum instantaneous $\leq$ 1.0 mg/L in September through December. Monthly average values were < 5.0 mg/L from August through November (Figure 7; Chris Martin, GDNR-WRD, 2010, pers. comm.). Low DO levels persisted downriver, depending on operational and climatic factors. For example, based on GDNR-WRD measurements on November 5, 2005, DO increased to 5.0 mg/L three miles downriver, and increased to 6.0 mg/L 5.2 miles downriver when releases from Buford Dam were < 2.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.).

The Corps upgraded the venting capabilities of the Buford Dam turbines over the past few years. However, the upgrades resulted in < 1.0 mg/L increase over previous conditions (Chris Martin, GDNR-WRD, 2010, pers. comm.). The Corps should thoroughly evaluate the effectiveness of these upgrades.

Useful tools to improve DO levels to State standards in Georgia trout waters (6.0 mg/L daily average, 5.0 mg/L instantaneous) include sluicing instead of running discharge through the

penstocks and units, or to use a combination of the two routing methods. For example, on September 15, 2000, GDNR-WRD recorded a DO level of 1.5 mg/L at Buford Dam during a minimum flow release through the house unit. In contrast, DO levels measured on the same date during sluicing indicate that DO remained above 6.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.). Thus, the Corps has demonstrated that sluicing below Buford Dam is an effective tool to mitigate low DO effects associated with hypolimnetic releases.

1.3.1.2. West Point Dam tailwaters

Dissolved oxygen data collected by the Corps downstream from West Point Dam from 1999 through 2001 indicate that DO levels met or exceeded the Georgia instantaneous standard (4 mg/L) 35% of the monitoring period in 1999, (monitoring from 6/15-9/14), 30% of the monitoring period in 2000 (monitoring from 7/25-9/30), and 4% of the monitoring period in 2001 (monitoring from 6/8-10/5; Georgia Power Company 2002). GDNR-WRD has investigated multiple fish kills below West Point Dam and has concluded that these fish kills are attributable to low dissolved oxygen levels (GDNR-WRD letter to the Corps, November 20, 2008).

1.3.1.3 Walter F. George Dam tailwaters

Low DO levels were associated with minor fish and mussel kills downstream of Walter F. George Dam (Rob Weller, GDNR-WRD, 2008, pers. comm.).

1.3.2 Temperature

The water temperatures of hypolimnetic releases below large dams are lower than would naturally occur during spring and summer months. Low water temperatures negatively affect warmwater fishes that require warmer water temperatures necessary for spawning and growth of young-of-year fishes. Thermal alteration can be ameliorated by structural modification of penstock location in the water column. Another option to moderate thermal alteration is to release (via sluicing) warmer water from a higher elevation in the reservoir's water column. Once this water mixes with the cold hypolimnetic release, water temperatures more closely approximate natural water temperatures. A recent example of sluicing effects in the Mobile District comes from measurements taken during summer 2009 below Allatoona Dam. Sluicing in June caused water temperatures to increase approximately10ºC (Figure 8). Temperature increases were observed many miles downriver (USFWS 2009 unpublished data).

Similar to DO recommendations, we urge the Corps to monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream temperature requirements may be useful. The seasonal timing of such releases exhibiting modified temperatures is of great importance. For example, the current summer thermal regime on the Etowah River, created by operations at Allatoona Dam, provides cool thermal refuge for striped bass in the upper Coosa River system. A thermal modification during the summer months below Allatoona Dam could be detrimental to fishes such as striped bass and lake sturgeon (Matt Thomas, GDNR-WRD, 2010, pers. comm.). Because the Service and GDNR-

WRD have responsibilities to protect native aquatic communities as well as recreational fisheries, we recommend the Corps explore methods for temperature modifications below their facilities, but coordinate closely with State and Federal agencies to determine the appropriate timing of such alterations.

In addition, it should be noted that the current thermal regime of Lanier Reservoir's tailwater is critical to the Chattahoochee River trout fishery and trout production at GDNR-WRD's Buford Hatchery. The tailwater trout fishery in the Chattahoochee, one of Georgia's premier fisheries, is dependent upon cold, well-oxygenated water releases for the survival of trout. The Buford Trout Hatchery produces 400,000 catchable trout annually and is dependent on Lanier Reservoir coldwater storage to maintain this production. Potential impacts to Chattahoochee River trout waters should be considered when making WCM decisions (Matt Thomas, GDNR-WRD, 2010, pers. comm.). The coldwater trout fishery below Buford Dam is of great importance to GDNR-WRD, and is also a responsibility for the Service as an important recreational fishery. Discussions between GDNR-WRD and the Corps should occur to determine if modifications are possible that avoid trout fishery impacts but also provide benefits to native warmwater fisheries below Buford Dam.

1.4 Fish Passage

Corps ACF dams impede the migration of diadromous and potadromous fishes including striped bass, Alabama shad, American eel, and Gulf sturgeon. Jim Woodruff Dam's impact on diadromous fish passage is large compared to dams on other southeastern rivers because it is located in the lower part of a large river basin. Consequently, there is significant interest in improving fish passage at this facility, as well as the two next upstream Corps facilities, George W. Andrews Lock and Dam and Walter F. George Lock and Dam. We appreciate the Corps' willingness and cooperation to modify operations thus far at Jim Woodruff to maximize fish passage for Alabama shad. Support and facilitation of fish passage research at Woodruff Dam, as well as other ACF Federal dams (notably George W. Andrews Lock and Dam and Walter F. George Lock and Dam) should continue with a goal of identifying and implementing operations and/or modifications that would allow riverine species to travel their historic migratory pathways. Provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam, while maintaining the need for operational flexibility.

1.5 Climate Change

The effects of climate change to ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes should be evaluated. It is our understanding that the Corps will be considering sea level rise when developing alternatives (Corps 2009). However, climate change will also affect river flows and the effects of a given set of operating rules will vary depending on whether the basin's climate becomes drier, wetter, more variable, or less variable. In particular, it is vitally important to adapt the level set as the top of conservation (TOC) pool to the long-term hydrology of the basin and the essential purposes the projects serve. In a scenario with greater variability between annual high flows and low flows, for example, it may not be feasible for these projects to simultaneously serve their existing levels of flood control protection and minimum flow support without adapting TOC pool levels to prevailing weather conditions.

The Corps already practices this concept with the multiple action zones and the occasional variances from the rule curves to store water above the TOC pool elevation during dry periods. Several models are developed that will be useful in this analysis and are briefly described in section *2.2 Evaluation of Alternative Models*. In addition to including multiple future climate scenarios into modeled discharge scenarios and Corps alternatives, flow provisions should be created for dry, average, and wet years in order to account for current climate variability.

1.6 Navigation

Navigation is an authorized project purpose for all five ACF Corps dams and the Corps has used reservoir storage in the past to support navigation. In recent years, however, lacking water quality certification to maintain the channel in Florida, we have seen only occasional flow management for the navigation purpose. Current physical channel dimensions dictate the flows that are necessary for navigability. Without providing flows to meet channel depth authorizations, dredging would be necessary to maintain channel navigability. Dredging has significant adverse effects to fish and wildlife. If flows for navigation are included in the WCM update, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support. If flows for navigation are not included in the WCM update, improvement or simplification of the four-zone reservoir operational scheme that governs current operation should be considered.

1.7 Reservoir and Riverine Fisheries Management

The Corps follows a draft Standard Operating Procedure (SOP) for "Lake Regulations and Coordination for Fish Management Purposes." The "fish spawn" SOP goal is to manage for generally stable or rising reservoir levels and for generally stable or gradually declining river levels for about 4 to 6 weeks in the spring months at Corps' reservoirs. These draft SOPs are protective of reservoir fish spawning; however, stable or rising river levels are also beneficial for riverine sport fisheries. We understand it is not feasible to have stable and/or rising water levels in both the reservoirs and river during times of declining basin inflow. To address this issue, recent reservoir and riverine fisheries literature should be reviewed to evaluate whether a 4-6 week stable or rising reservoir window is supported for reservoir fish spawning and/or potentially detrimental to riverine fish spawning. We also recommend development of an alternative that includes modifying the draft SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. Finally, we recommend that the Corps identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

1.8 National Wildlife Refuges

The Service previously recommended to the Corps that a seasonal pattern of reservoir levels at W.F. George Reservoir would best accommodate the needs of Eufaula National Wildlife Refuge. Water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. These recommendations, which we included in the draft FWCA report for the Corps' 1998 Draft EIS on ACF water

allocation, were to manage the reservoir so that it behaves more like a river. Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer were recommended. These recommendations remain valid. How the benefits and impacts of such a scheme compare with the existing operating regime and other alternatives should be considered.

1.9 Apalachicola Bay

The predicted levels of freshwater inflow into Apalachicola Bay resulting from Corps alternatives will be of importance to the Service because they may affect salinity levels. Freshwater inflow reductions cause salinity increases and indirectly increase oyster mortality through increased colonization of marine oyster bed predators (Corps 1998). Additionally, juvenile Gulf sturgeons have optimal growth rates at relatively low salinity (9-10 ppt), and periods of extended higher salinities would likely limit feeding habitat availability.

As part of the Comprehensive Study for the Corps' DEIS (1998), the National Ocean Service (NOS) examined the freshwater inflow effects on the water circulation and salinity changes in Apalachicola Bay. Oysters were selected as a biological response variable because of their commercial fishery importance, habitat requirements, and expected response to salinity fluctuations (Corps 1998). A three-dimensional hydrodynamic model produced output that was used in an integrated biological model to assess the effects of potential freshwater inflow changes to Apalachicola Bay salinities and oysters. Predicted oyster mortality and oyster bed growth rates were compared for the various Corps' alternatives.

More recently, Livingston et al. (2000) developed a spatially-explicit hydrodynamic circulation model of the bay that predicts salinity, among other variables, as a function of freshwater inflow. This model has been used to model oyster mortality and growth in relation to freshwater inputs. The Service has used the results of this model to make inferences on the availability of low-salinity bay habitat for Gulf sturgeon. In addition, an alternative Apalachicola Bay salinity model was recently developed by Peter Sheng at the University of Florida (Sheng and Kim 2009). By using the Corps' daily average discharge output from the ResSim model for the Sumatra gage for the various alternatives, the model can compare the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios. This information can be used to make inferences on the availability of bay habitat for Gulf sturgeon and to model oyster mortality and growth.

We recommend that the Corps or the Corps' consultants (Tetra Tech) contact the NWFWMD and/or the Florida Department of Environmental Protection (FDEP) to request permission to access and use the Livingston et al. models, or invite a collaboration between the Corps and NWFWMD/FDEP to evaluate effects of flow alternatives on Apalachicola Bay resources. The Sheng and Kim (2009) model should also be incorporated in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth. If all models are made available to the Corps and the Service, we recommend that the strengths and limitations of each model be evaluated to determine the model that will best suit the assessment requirements. In addition, coordination should occur with FFWCC's Fish and Wildlife Research

Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

1.10 Decision Support Model to Evaluate Changes to Corps' Operations

It is important to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams. Because of the numerous and sometimes competing demands for water, it is difficult to evaluate the effects of proposed management alternatives and to make the evaluation transparent. However, multiple free decision support tools (e.g., Netica) are available to facilitate the evaluation of alternatives. These tools are versatile in the sense that new information that results from monitoring the effects of management strategies is easily integrated into the analysis and decision process. Consequently, a better and more transparent understanding of how Corps operations affect the ecology and use of the ACF system can lead to improved future management. Therefore, a decision support model should be incorporated into the WCM update process.

1.11 Adaptive Management

An adaptive management program should be developed, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam. The program would formulate hypotheses about how such benefits might be achieved through dam operations, implement those operations, monitor ecosystem responses, and revise the operations based upon lessons learned.

2. Recommendations for Corps Hydrologic Modeling

2.1 Increasing Consumptive Demands

The impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin should be recognized and considered. This is a variable that an analysis of operational alternatives should incorporate along with climate-driven hydrologic variability. The relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes should be quantified. For example, how is sustainable minimum flow release from Woodruff Dam affected if consumptive demands increase by 25, 50 or 100 percent by the years 2020, 2050, and 2080? We recognize the order made by Judge Magnuson limits operational alternatives for the express purposes of water supply. However, we also recognize that surface and groundwater withdrawals will continue to be made at various points in the system. The Corps alternative analysis must include metrics regarding water supply withdrawals including potential increases. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

2.2 Evaluation of Alternative Models

The Corps' unimpaired flows dataset that was used in the 1998 draft EIS was compared to 1) the unimpaired flows dataset that the Corps expects to use for the WCM update and 2) to the pre-Buford Dam USGS streamflow gage data. Aside from the addition of recent flow records, the most recent Corps-modeled unimpaired dataset is essentially unchanged from the 1998 version.

Compared to the USGS gage data, these datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes. We recommend that the use of alternative models be investigated to develop better unimpaired flow and alternative flow datasets.

Similarly, land cover has changed significantly since the early 20th century in the upper and middle portions of the ACF basin. Prior to both mainstem damming and discharge gaging, expansive agriculture, chestnut blight, fire suppression, and other factors affected land cover in the southern Appalachians, Piedmont, Fall-line Sandhills, and upper Coastal Plain regions. The hydrological consequences of land cover changes could have been manifested in the flow extremes observed during droughts and heavy rain. Nevertheless, the pre-dam hydrologic period of record is presently the best available hydrologic dataset to characterize pre-dam streamflows, develop ecosystem flow alternatives, and with which to compare flow alternatives. Models that predict hydrological alteration that occurs in response to land cover changes could be particularly useful in the development and assessment of flow alternatives.

The United States Geological Survey (USGS) is developing a Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) for the ACF. This watershed model will facilitate the inclusion of impacts of precipitation, climate, and land use changes on streamflow, sediment yields, and basin hydrology. If the PRMS is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, it should be used as an additional evaluation tool. The PRMS output potentially could be used to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions. Use of this model is based on the assumption that the PRMS model results reflect average flows and flow extremes better than existing datasets and other models. The latter analysis may be particularly useful to determine if reservoirs can maintain downstream flows through droughts.

National Oceanic and Atmospheric Administration (NOAA) funded the Georgia Water Resources Institute (GWRI) to complete a historical and future assessment of precipitation, evapotranspiration, soil moisture, and run-off trends in the ACF Basin to support ongoing water resources planning in the region. This method used both historical gage data and the Corps unimpaired flows dataset in a Joint Variable Spatial Downscaling model that incorporated climate change effects. Future stream flow, river flow, reservoir level, and power generation forecasts were made at the sub-basin level for the next 100 years. Coordination with USGS and GWRI should occur regarding these new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

Lastly, the Corps' HEC-5Q water quality analyses rely on average daily flow to predict water quality parameters (e.g., temperature and dissolved oxygen) in six hour time steps and at 0.5 mile intervals. Although these model outputs can be used to compare among flow alternatives, they are not expected to accurately predict either the water quality values or the range of values that

are likely to occur in response to hourly discharge changes. Alternative water quality models exist and State resource agencies should be contacted to determine whether water quality models are developed for the ACF Basin. Additionally, regression models that accurately predict water quality parameters (e.g., water temperature and dissolved oxygen) can be developed using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure). Alternative water quality assessment methods should be considered to accurately evaluate effects of flow alternatives on water quality.

3. Evaluation of Corps Alternatives for FWCA Report

3.1 ResSim Model Output Analyses

It is our understanding that ResSim will be used for the Corps' flow analyses. The flow statistics used by the Service in the past to analyze the resulting datasets were derived by using the Indicators of Hydrologic Alteration (IHA) and the Range of Variability Approach (RVA). Because flow is a master variable in fluvial systems, and because the ecology of fish and wildlife is closely linked to the flow regimes in which they evolved, the current evaluation should continue to rely on tools such as IHA, RVA, and Environmental Flow Components (EFCs) (Mathews and Richter 2007). Specific flow statistics and species-specific flow-ecology relationships (as available) that are important to natural resource sustainability, as well as the ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC) study (Freeman et al. 1997), should also be considered.

3.2 HEC-5Q Water Quality Model Output Analyses

It is our understanding that HEC-5Q will be used for the Corps' water quality analyses. We understand that this model predicts water quality parameters in six hour time intervals in river and reservoirs. Similar to the analyses contained in the Corps' 1998 draft EIS (Corps 1998), the analyzed data should be composed of summer values (May through October), separated by drought, dry, average, and wet year types for each alternative. The following information should be developed for each alternative to evaluate the effects on water quality and aquatic resources in the modeled tailrace and riverine locations:

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters;
- Total number of instantaneous "measurements" less than 4 mg/L;
- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L);
- Monthly exceedance figures and box plots with outliers for water temperature; and
- Average stream percent wastewater.

For each alternative, the following information should be developed to evaluate the effects on water quality and aquatic resources for the modeled ACF reservoir locations:

- Average values of summer Chlorophyll a (*u*g/L);
- Average summer retention time (days); and

- Average summer phosphorus loading (pounds/acre/month).

3.3 Floodplain Connectivity Analyses

Assessing the extent of floodplain inundation will be a critical component of the alternatives analysis assessment. The Apalachicola River floodplain analysis should be decided following the Corps' attempt to access the river stage-based LIDAR data collected and housed by the NWFWMD. If the data are made available, the Corps should provide these data to the Service and an analysis of the area of aquatic habitat (separated by aquatic habitat type) connected to the Apalachicola River under the range of discharges for the period of record should be evaluated. If LIDAR data are not provided, the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation should be evaluated using the relationships quantified by Light et al. 1998 and Light et al. 2006.

Although the areal extent of the Chattahoochee River floodplain is one-fifth that of the Apalachicola River floodplain (Davis 1997), it likely served multiple important ecological roles prior to flow alteration by multiple mainstem reservoirs. To our knowledge, the Tri-State Comprehensive Study Riparian Wetland Element (Davis 1997) houses the best available dataset for assessing the effects of flow alternatives on the Chattahoochee River floodplain. These data should be used to evaluate the probable extent of floodplain inundation for each flow alternative. However, data are only available for one riverine site in the Chattahoochee River Basin positioned between Jim Woodruff Lock and Dam and G.W. Andrews Lock and Dam. At unsurveyed locations, known river stages at which floodplain inundations occurs should be used to evaluate the frequency, duration, and timing of floodplain inundation for flow alternatives provided by the Corps (see Table 1 and associated information provided by NWS 2010). At sites without this information, the 2-year recurrence interval discharge to approximate the incipient point of flooding should be used to evaluate the frequency, duration, and timing of floodplain inundation. Because channel alteration (e.g., channel incision) can increase the recurrence interval at which flooding occurs and because we have little information on channel alteration, other data sources should be investigated to aid in the floodplain inundation assessment.

3.4 Reservoir Fisheries Analyses

Sport fisheries are important recreational and economic resources in all of the Federal ACF reservoirs. Important sport fishes in all five reservoirs include largemouth bass and crappie, but each reservoir supports a mix of several additional species, including walleye (Lanier Reservoir only), striped bass, bluegill, redear sunfish, and others. Based on interviews of fisheries managers and researchers in the basin, Ryder et al. (1995) identified the species considered critical in an evaluation of operating alternatives and the relative acceptability of reservoir levels for these species. A Delphi technique was used to obtain expert opinion for select reservoirs on reservoir fish guilds, important seasonal periods for those species, and acceptability ratings for various reservoir levels in the ACF and ACT (Ryder et al. 1995). The Service cooperated with the Corps for the 1998 draft EIS for ACF water allocation to develop a reservoir fisheries performance measure using the findings of Ryder et al. (1996). This information was used to create a reservoir fisheries performance measure by looking at the critical spawning and rearing periods, reservoir elevations during these times, and assigning a greater weight to stable or rising elevations during those time periods. The performance measures were then compared for the various alternatives.

The reservoir fisheries performance measure should be updated with additional information, literature, and/or relevant datasets that have been developed in the past ten years, and used to evaluate the relative impacts of the Corps' alternatives on reservoir sport fisheries. Potential new datasets to be included that have been indentified to date include largemouth bass young-of-year data in West Point Reservoir (Brent Hess, GDNR-WRD, 2010, pers. comm.), as well as black basses and crappie data in relation to reservoir retention times and year-class strength in Walter F. George, West Point, and Bartletts Ferry reservoirs (Mike Maceina, Auburn University, 2010, pers. comm.).

3.5 Riverine Fisheries Analyses

Sport fisheries are also important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. Data identified to date will be provided by the FFWCC and the USGS and used to evaluate the relative impacts of the Corps' alternatives on riverine sport fisheries. Specific measures to be evaluated include year-class strength versus acres of inundated floodplain spawning habitat, changes in catch rates of sportfishes in various water years, and changes in relative weight (condition) of sportfishes in various water years.

3.6 Apalachicola Bay Salinity Analyses

If a salinity model is incorporated in the WCM update process, as described in Section 1.8 above, the model output should be incorporated in the FWCA evaluation. A list of data needs should be developed to be produced as a result of these analyses. These data should include the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios and possibly the percent oyster mortality and oyster growth rates.

3.7 Federally-protected Species Analyses

It is our understanding that the Corps will be conducting certain analyses to evaluate the effects of the various alternatives on federally-protected species. These analyses will be contained in the Corps' Biological Assessment (BA) accompanying the draft EIS. The Service will include these analyses in our FWCA evaluation, assuming they are available for us to do so. The types of analyses that should be evaluated are contained in the "*Analyses for the Effects of the Action*" section of the Service's June 1, 2008, RIOP Biological Opinion (USFWS 2008) and are listed below:

Gulf sturgeon

- Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning;
- Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at

least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning;

- Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae;
- Maximum number of consecutive days per year less than 16,000 cfs; and
- Departures from average water temperatures between March 1st to May 31st.

Freshwater mussels

- Lowest daily flow for each year;
- Inter-annual frequency of flows less than 5,000-10,000 cfs;
- Maximum number of days per year with flows less than 5,000 – 10,000 cfs;
- Maximum number of consecutive days less than 5,000 – 10,000 cfs;
- Median number of days per year less than 5,000 – 10,000 cfs;
- Frequency (percent of days) of daily stage changes (ft/day); and
- Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs.

Floodplain connectivity

- Frequency (% of days) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998);
- Frequency (% of years) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998).

4.0 Recommendations for Additional Coordination

This PAL includes comments from the State wildlife agencies in the basin. As is encouraged under the FWCA, we will continue to coordinate with these agencies, and will coordinate with NOAA Fisheries, as we move forward.

To assist in the development of alternatives and mitigation, we have suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, impacts to Eufaula National Wildlife Refuge, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We have identified analyses to evaluate Corps alternatives with respect to flow, water quality, floodplain connectivity, reservoir and riverine fisheries, Apalachicola Bay resources, and federally-protected species. We anticipate that the next step will be for the Corps and the Service to work together to update the interagency SOW to reflect Corps and Service responsibilities for the evaluations and analyses contained in this PAL. As you know, such a division of labor occurred to produce the prior DEIS and FWCA Report (Corps 1998).

We would like to be involved in the development of alternatives, including the development of environmental flows alternatives. The Service would like to assist in the development of such

alternatives to maximize benefits to ecological resources and to gain a better understanding of the consequences of implementing such alternatives on other authorized project purposes and operational constraints. Once all of the alternatives have been analyzed, we anticipate working with the Corps to identify opportunities for restoration, compensation, and enhancement.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress the Corps water management is not just about avoiding adverse affects, but also to look at opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Everson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL
B. Zettle, Corps, Mobile, AL
M. Eubanks, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
M. Thomas, GDNR-WRD, Social Circle, GA
C. Martin, GDNR-WRD, Social Circle, GA
B. Hess, GDNR-WRD, LaGrange, GA
R. Weller, GDNR-WRD, Albany, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
D. Bernhart, NOAA, St. Petersburg, FL

Literature Cited

Ahlstedt, S.A., J.R. Powell, R.S. Butler, M.T. Fagg, D.W. Hubbs, S.F. Novak, S.R. Palmer, and P.D. Johnson. 2004. Historical and current examination of freshwater mussels (Bivalvia: Margaritiferidae, Unionidae) in the Duck River basin Tennessee. Final report submitted to satisfy the requirements of the Tennessee Wildlife Resource Agency contract FA-02-14725-00.

Couch, C.A., E.H. Hopkins, and P.S. Hardy. 1996. Influences of environmental settings on aquatic ecosystems in the Apalachicola-Chattahoochee-Flint River Basin. U.S. Geological Survey Water-Resources Investigations Report 95-4278.

Davis, M.M. 1997. Tri-State Comprehensive Study Riparian Wetland Element, Report 1: Relationship between Flow and Habitat Value in the Alabama-Coosa-Tallapoosa/Apalachicola-Chattahoochee-Flint (ACT/ACF) River Basins. Miscellaneous Paper EL-97-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Freeman, M.C., J.M. Nestler, and P.N. Johnson. 1997. Riverine Resources: Water Needs and Environmental Effects Analyses in the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. Final Report to the Technical Coordinating Group of the ACT-ACF Comprehensive Study, U.S. Geological Survey, Biological Resources Division, Patuxent Wildlife Research Center, Athens, GA.

Freeman, M.C., Z.H. Bowen, K.D. Bovee, and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11(1): 179-190.

Georgia Power Company. 2002. Final License Application, Applicant-Prepared Environmental Assessment, Middle Chattahoochee Project (FERC No. 2177). December 2002, pg. 34, Appendix E, Figures E-2 through E-4.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood-pulse concept in river-floodplain systems, p. 110-127. *In* D.P. Dodge [ed.] Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106.

Light, H.M, M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida. U.S. Geological Survey Professional Paper 1594.

Light, H.M., Vincent, K.R., Darst, M.R., and Price, F.D. 2006. Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin,W. Huang, J.D. Christensen, M.E. Monaco, T.A. Battista, C.J. Klein, R.L. Howell IV, and G.L. Ray. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Mathews, R., and B.D. Richter. 2007. Application of the indicators of hydrologic alteration software in environmental flow setting. Journal of the American Water Resources Association 43: 1400-1413.

National Weather Service Advanced Hydrologic Prediction Service (NWS) 2010. http://ahps.srh.noaa.gov/

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg, 1997. The Natural Flow Regime. BioScience 47:769-784.

Postel, S. and B. Richter. 2003. Rivers for Life: Managing Water for People and Nature. Island Press. 253 pp.

Richter, B.D., J.V. Baumgartner, D.P. Braun, and J. Powell. 1998. A spatial assessment of hydrologic alteration within a river network. Regulated Rivers 14:329-340.

Ryder, S., J. Taylor, and J. Crance. 1995. Relations between reservoir surface water elevations and reservoir fisheries. Comprehensive Study Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins, U.S. Army Corps of Engineers, Mobile, AL.

Ryder, S., J. Taylor, and J. Crance. 1996. Relations between reservoir surface water elevations and reservoir fisheries in the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. National Biological Service, Ft. Collins, Colorado. 48 p. + apps.

Sheng, Y.P. and T. Kim. 2009. Skill assessment of an integrated modeling system for shallow coastal and estuarine ecosystems. Journal of Marine Systems 79: 212-243.

United States Army Corps of Engineers. 2009. Water Resources Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs, Expires 1 July 2011. July 1, 2009. Circular No. 1165-2-211, Washington, D.C. 31 pp.

United States Army Corps of Engineers. 1998. Draft Environmental Impact Statement Water Allocation for the Apalachicola-Chattahoochee-Flint (ACF) River Basin Main Report, September 1998, Mobile District, Mobile, Alabama.

United States Fish and Wildlife Service. 1999. Instream Flow Guidelines for the ACT and ACF Basins Interstate Water Allocation Formula. October 25, 1999. 40 pp.

United States Fish and Wildlife Service. 2008. Biological Opinion on the U.S. Army Corps of Engineers Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. June 1, 2008, Panama City Field Office, Panama City, Florida. 225 pp.

Table 1. Locations and river stages in the Chattahoochee River where the National Weather Service Advanced Hydrologic Prediction Service predicts damage to occur. Discharges were calculated using stage-discharge relationships at USGS streamflow gages. Only damage to manmade structures was considered as damage. Flooding of riverwalks, riverwalk structures, yards, and moving of equipment or livestock to avoid inundation was not considered to be damage.

Location (upstream to downstream order	Stage at which damage occurs	Discharge at which damage occurs
Chattahoochee at Norcross	16	20631
Chattahoochee at Roswell	14	29846
Chattahoochee at Atlanta	18	22023
Chattahoochee at Whitesburg	26	49379
Chattahoochee at West Point	21	62530
Chattahoochee at Columbus	41	261407

Figure 1. Histogram of mean + standard error daily discharge values reported in cubic feet per second (cfs) obtained from river gauges on the Duck River at Shelbyville (top) and Columbia (bottom), Tennessee by season. Means represent daily discharge values for each month for 10 years pre and 10 years post Reservoir Release Discharge Initiative (RRI) completed at Normandy Dam beginning in late 1991. Letters atop standard error bars indicate significantly different means as determined by Tukey's a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

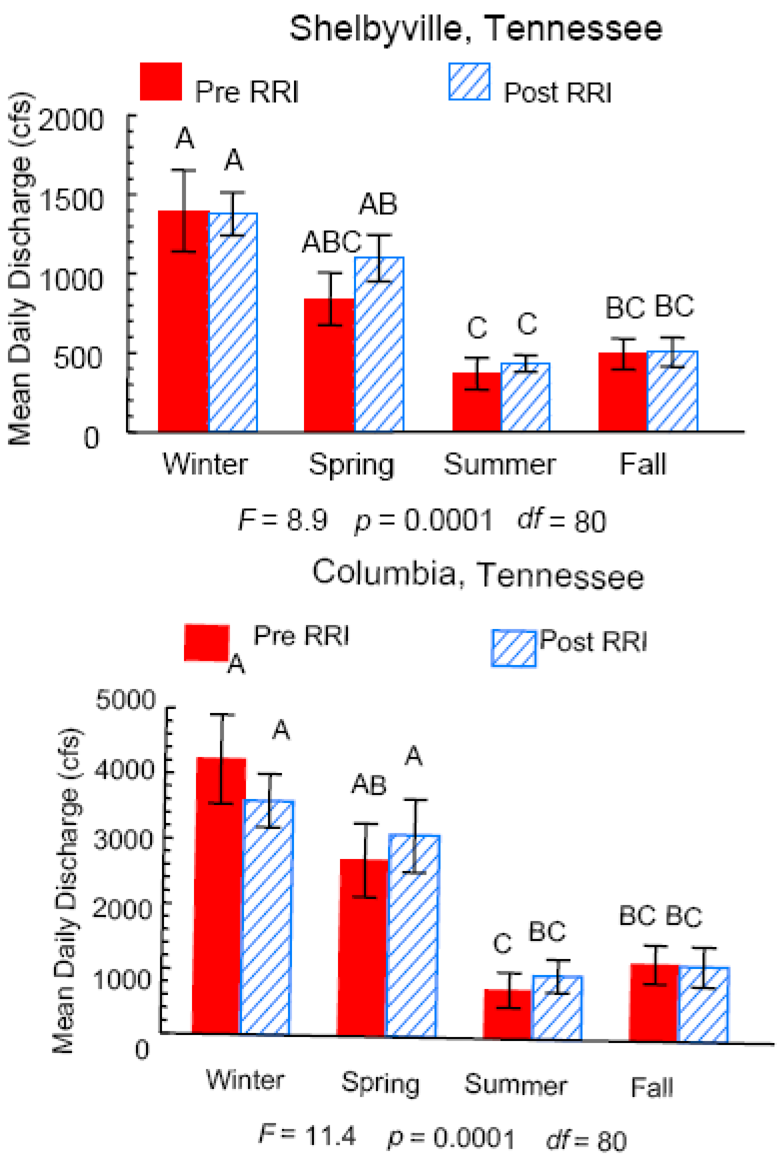


Figure 2. Comparative mean + s.e. of mussel species (top) and mussel number (bottom) sampled from 17 sites in the Duck River in 1977, 1988, and 2002. Letters atop standard error bars indicate statistically different means determined by Tukey's HSD a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

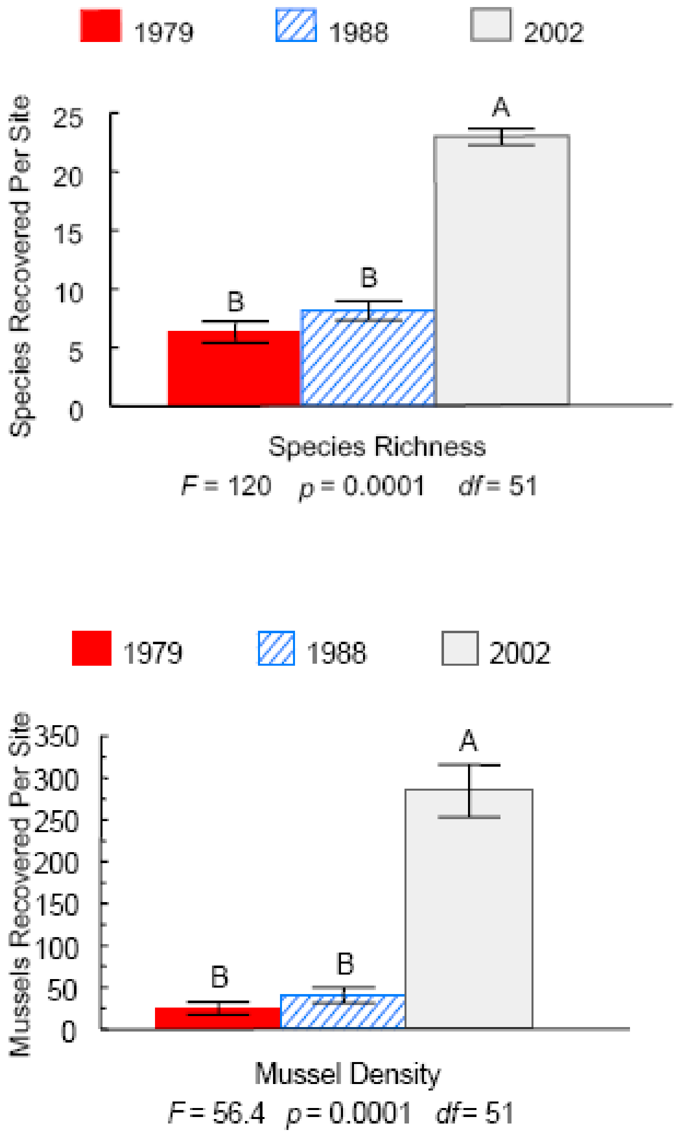
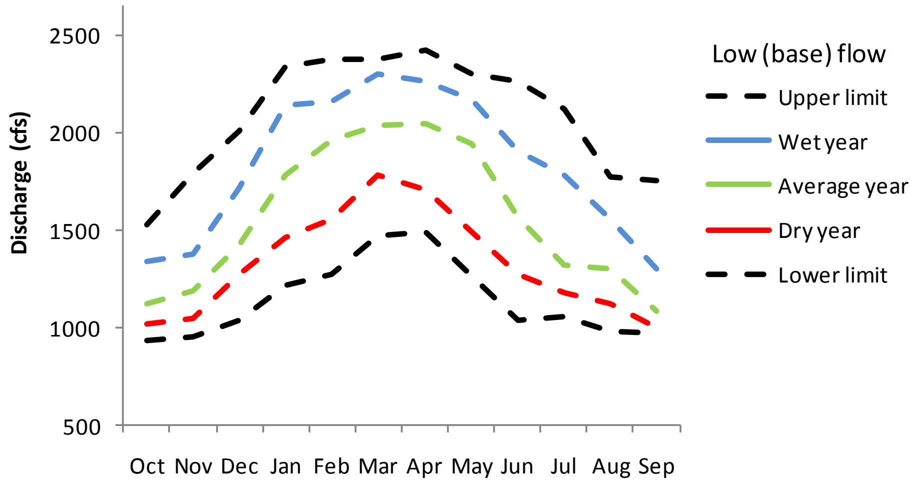


Figure 3. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River USGS Norcross gage.

a)



b)

Data analyzed: The only pre-Buford dam data that were available for this analysis extended between 1903 and 1946 (44 years) at the Chattahoochee River gage (02335000) at Norcross.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS Norcross gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small pulses

At the Chattahoochee River USGS Norcross gage, 9-18 flow pulses per year should be between 3,658 and 4,980 cfs, should last between 2-3 days, and should occur between mid-March and early June. Rise and fall rates can range between 1,260-2,054 cfs and 1,178-733 cfs, respectively.

High pulses

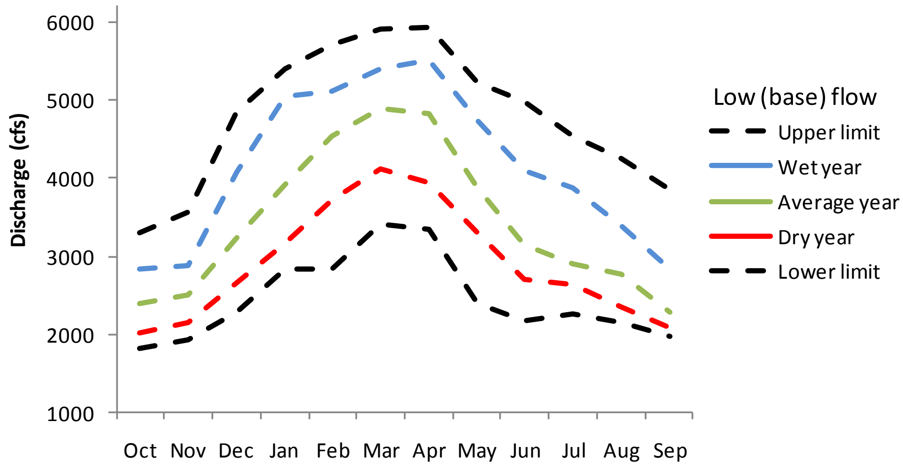
In wet years, a pulse of 17,650-28,080 cfs should last 9-80 days, should occur between early January and early May. Rise rates should range between 697-7518 cfs/day, and fall rates should range between 3376-460 cfs/day.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 4. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the USGS gage below West Point Dam.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1896 and 1955 (60 years) at the Chattahoochee River gage (02339500) below West Point Dam.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Chattahoochee River gage below West Point, 9-16 flow pulses per year should peak between 8,853 and 11,580 cfs, should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates can range between 2,483-3,698 cfs/day and 2,256-1,536 cfs/day, respectively.

High Pulses

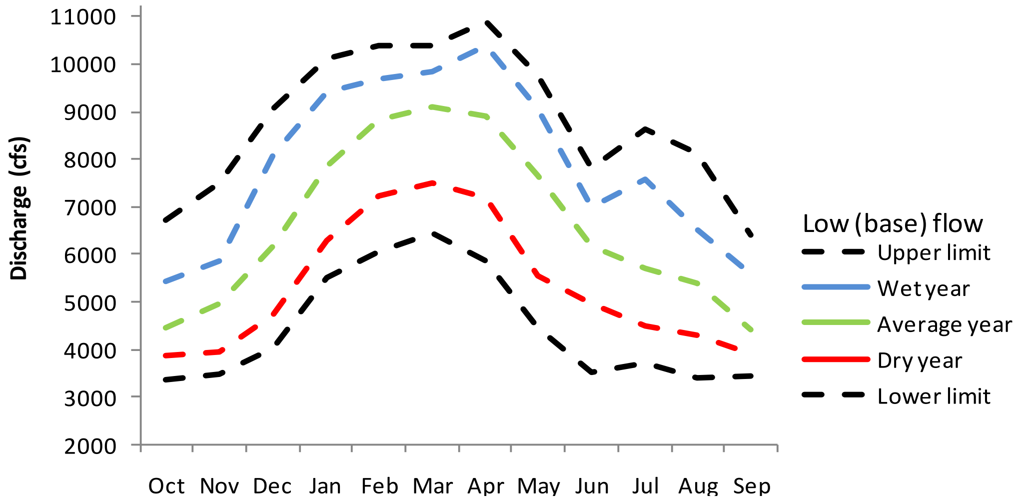
In wet years, a pulse that peaks between 48,830 - 58,950 cfs should last between 19-38 days, and should occur between mid-January and early April. Rise and fall rates can range between 5,563-13,170 cfs/day and 4,230-1787 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 5. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the Walter F. George Corpsnode.

a)



b)

Data analyzed: ACOE unimpaired flows dataset at the Walter F. George node and inferences from West Point analysis results.

Base flow description

No USGS discharge data for the pre-Buford dam period are available at Walter F. George. However, comparisons between pre-Buford USGS gage data and Corps-modeled "unimpaired flows" data show similar median monthly flows. Thus, we used median monthly flows in the Corps-modeled unimpaired dataset (1936-2006) to calculate the predicted low (base) flows that should occur at the W.F. George node. We excluded 103 negative flow values from the Corps dataset in this analysis.

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford Dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

Again, no USGS discharge data for the pre-Buford dam period are available at Walter F. George. Corps-modeled unimpaired flows do not represent the flow extremes (minimum and maximum flow duration, magnitude, timing, frequency, and rate of change) that were observed at USGS gages during the pre-Buford Dam period. Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified.

Small pulses

We infer from the West Point analysis that used real pre-Buford Dam USGS data, that 9-16 flow pulses per year should peak between 1.8-2.4 times higher than the baseflow river stage (approximately 16,369-21,535 cfs) in March for an average flow year. Pulses should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates should not exceed rates from other site recommendations.

High pulses

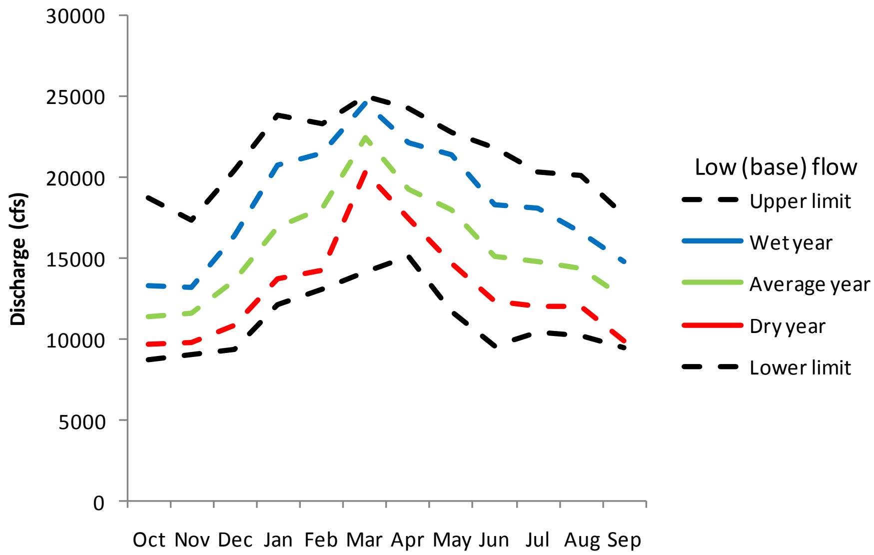
Development of a wet year flow guidelines is complicated by the fact that no stage-discharge relationships are presently known for the river segment between Walter F. George Dam and Woodruff Dam. However, the National Weather Service Advanced Hydrologic Prediction Service indicates that extensive floodplain inundation occurs at a river stage of 150 ft, although no significant damage is predicted to occur up to 160 ft. Consequently, we recommend that the ACOE evaluate wet year releases from Walter F. George that range between 150 and 160 ft. Duration, timing, and rates of change should be similar to the recommendations for West Point Dam.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 6. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Apalachicola River USGS gage at Chattahoochee, FL.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1922 and 1955 (34 years) at the Apalachicola River gage (02358000) at Chattahoochee, FL.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Apalachicola River gage at Chattahoochee, FL, 3-6 flow pulses per year should peak between 30,950 and 41,110 cfs, should last between 4-13 days, and should occur between mid-February and mid-May. Rise and fall rates can range between 2,493-5,356 cfs/day and 2,353-1,473 cfs/day, respectively.

High Pulses

In wet years, a pulse that peaks between 86,630-122,800 cfs should last between 28-68 days, and should occur between late-February and early April. Rise and fall rates can range between 2,544-8,108 cfs/day and 4,236-2,330 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 7. Monthly maximum, average, and minimum dissolved oxygen concentrations in the Chattahoochee River at Buford Dam. Data courtesy of Georgia Department of Natural Resources-Wildlife Resources Division.

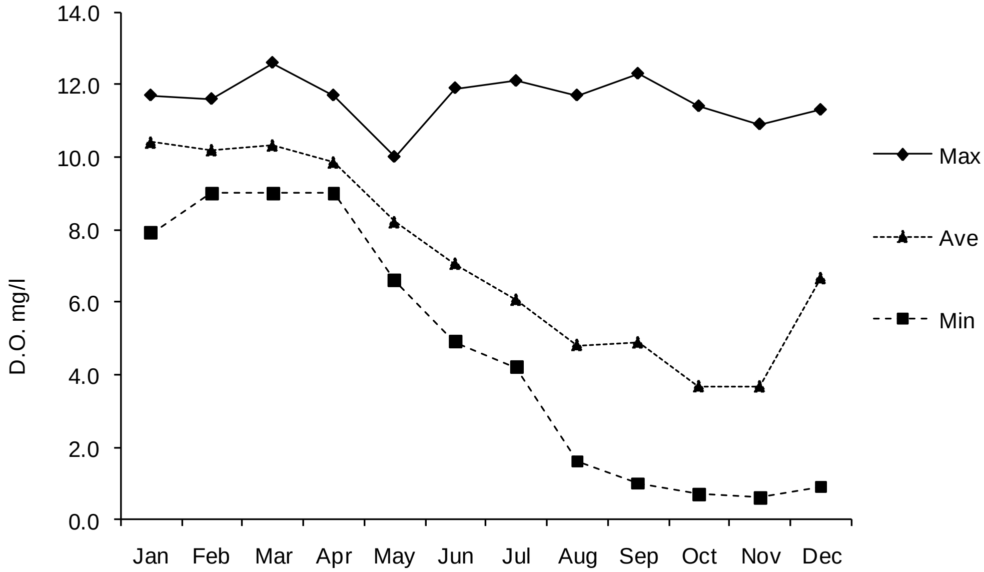
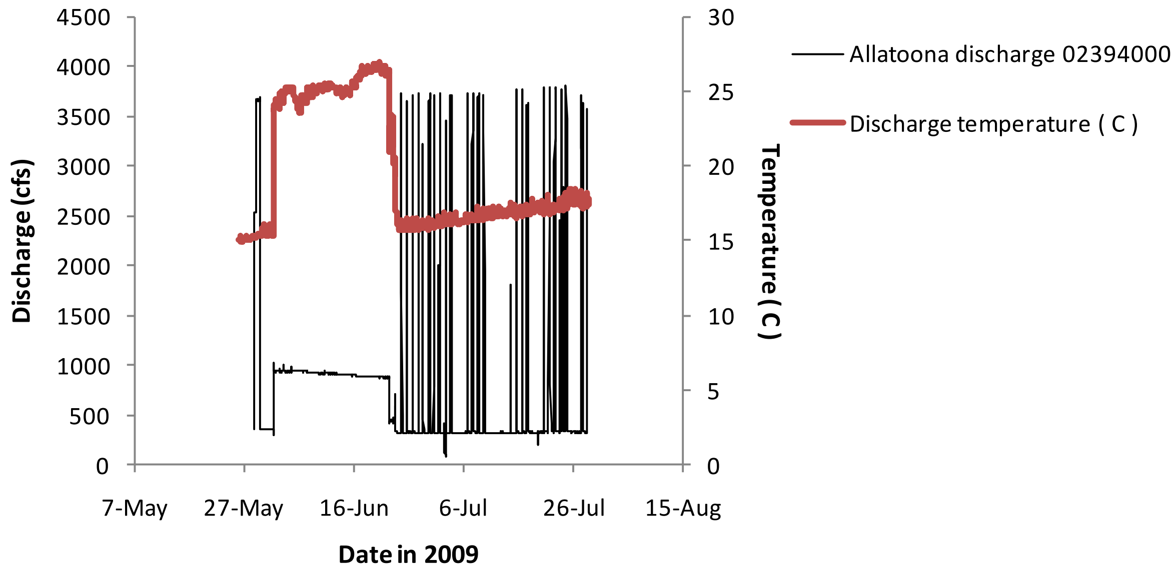


Figure 8. Discharge and water temperature measurements below Allatoona Dam on the Etowah River, Georgia. Sluicing from a location higher in the reservoir's water column occurred in June, causing the observed downriver temperature increases.



USACE Response to Planning Aid Letter January 2011

This page intentionally left blank

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

JAN 18 2011

Inland Environment Team
Planning and Environmental Division

Ms. Sandra Tucker
Field Supervisor
U.S. Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Ms. Tucker:

This is in response to your April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida. In the PAL, you identified the types of analyses the U.S. Fish and Wildlife Service (FWS) would need to evaluate the WCM alternatives pursuant to the Fish and Wildlife Coordination Act (FWCA - 48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). This letter transmits the results of those analyses.

We stand ready to assist with additional information or analysis. Should you have any questions, comments, or recommendations, please contact Mr. Brian Zettle, (251) 690-2115, Email: brian.a.zettle@sam.usace.army.mil.

Sincerely,

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

ACF Water Control Manual Update Response to PAL

U.S. Army Corps of Engineers
1/18/2011

Contents

1 Description of the Proposed Action and Alternatives

1.1 Introduction

The Corps proposes to prepare an updated Master Manual for the ACF Basin. A draft was proposed in 1989 as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. The Corps has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would be five project-level water control manuals, presented as appendices:

- Appendix A: Jim Woodruff Reservoir
- Appendix B: Buford Dam
- Appendix C: Walter F. George Dam
- Appendix D: George W. Andrews Reservoir
- Appendix E: West Point Reservoir

Water control manuals contain drought plans and action zones to assist the Corps in knowing when to reduce or increase reservoir releases and conserve storage in the Corps reservoirs. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines, and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management, and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions.

The updated manual would be prepared in compliance with ER 1110-2-240 and all other Corps regulations and policies. The following sections present the No Action Alternative and the Proposed Action Alternative. The proposed action, presented in Section 2.3, is the USACE's Preferred Alternative.

1.2 No Action Alternative

The CEQ regulations require analysis of the *No Action Alternative* 40 CFR.1502.14. On the basis of the nature of the proposed action, the no action alternative represents no change from the current management direction or level of management intensity. This alternative would represent continuation of the current water control operations at each of the federal projects in the ACF Basin. There is not one comprehensive document that reflects the current operational practices. The No Action Alternative reflects operational practices on the ACF Basin as described in the following documents:

- Draft ACF Water Control Plan dated 1989
- Revised Interim Operations Plan and Environmental Assessment, June 2008
- **South Atlantic Division Regulation (DR) 1130-2-16**, *Project Operations, Lake Regulation and Coordination for Fish Management Purposes* and Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan, (SAM SOP 1130-2-9) February 2005

- Chattahoochee River Management System as described in the Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA, February 1991
- Project Water Control Manuals for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects

The following subsections describe key operational elements that apply to evaluating the No Action Alternative.

1.2.1 General System Operations

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

The Corps operates a series of reservoirs in the ACF Basin to provide for the expressly authorized project purposes of flood damage reduction, hydroelectric power generation, and navigation, as well as for other authorized purposes or incidental benefits including fish and wildlife conservation, recreation, water quality, and water supply. Each of the authorized project purposes is considered when making operational decisions, and these decisions affect how water is stored and released from the projects. In general, to provide the authorized project purposes, flow must be stored during wetter times of each year and released from storage during drier periods of each year. Traditionally, that means that water is stored in the lakes during the spring and released for authorized project purposes in the summer and fall months. In contrast, some benefits such as lakeside recreation, water supply, and lake fish spawn are achieved by retaining water in the lakes, either throughout the year or during specified periods of each year. The flood damage reduction purposes at certain reservoirs require drawing down reservoirs in the fall through winter months to store possible flood waters and refilling of pools in the spring months to be used for multiple project purposes throughout the remainder of the year. The multiple water demands in the basin require that the Corps operate the system in a balanced manner in an attempt to meet all authorized purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods. The balanced water management strategy for the Corps reservoirs in the ACF Basin does not prioritize any project function, but seeks to balance all authorized project purposes. The intent is to maintain a balanced use of conservation storage among all the reservoirs in the system, rather than to maintain the pools at or above certain predetermined elevations.

1.2.2 Action Zones

The *1989 draft ACF Water Control Plan* (USACE, Mobile District 1989a) defines action zones for each of the three major storage projects on the ACF Basin—Lake Lanier (Figure 1.2-1), West Point Lake (Figure 1.2-2), and Walter F. George Lake (Figure 1.2-3). Those zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes should be met. As lake levels decline, Zones 2 through 4 define increasingly critical system water shortages and guide the Corps in reducing flow releases. Flow releases are reduced as pool levels drop as a result of drier-than-normal or drought conditions. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project, and they determine the amount of storage available for purposes such as flood damage reduction, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water quality, and water supply.

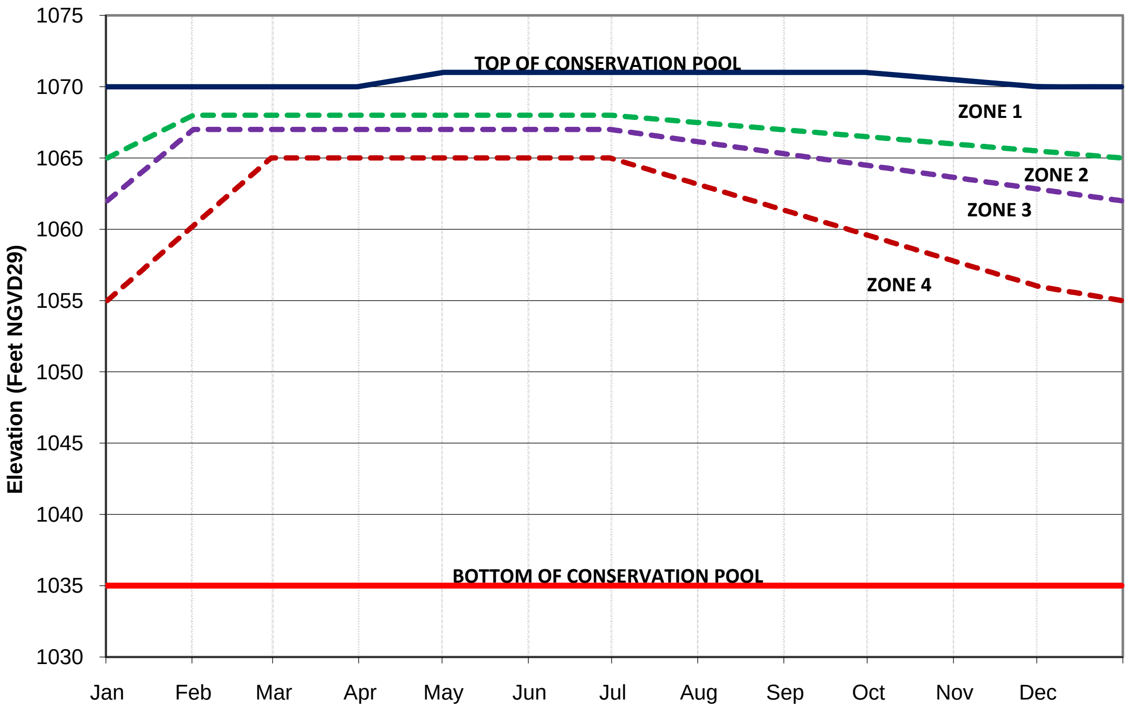


Figure 11.2-1. Lake Lanier water control action zones

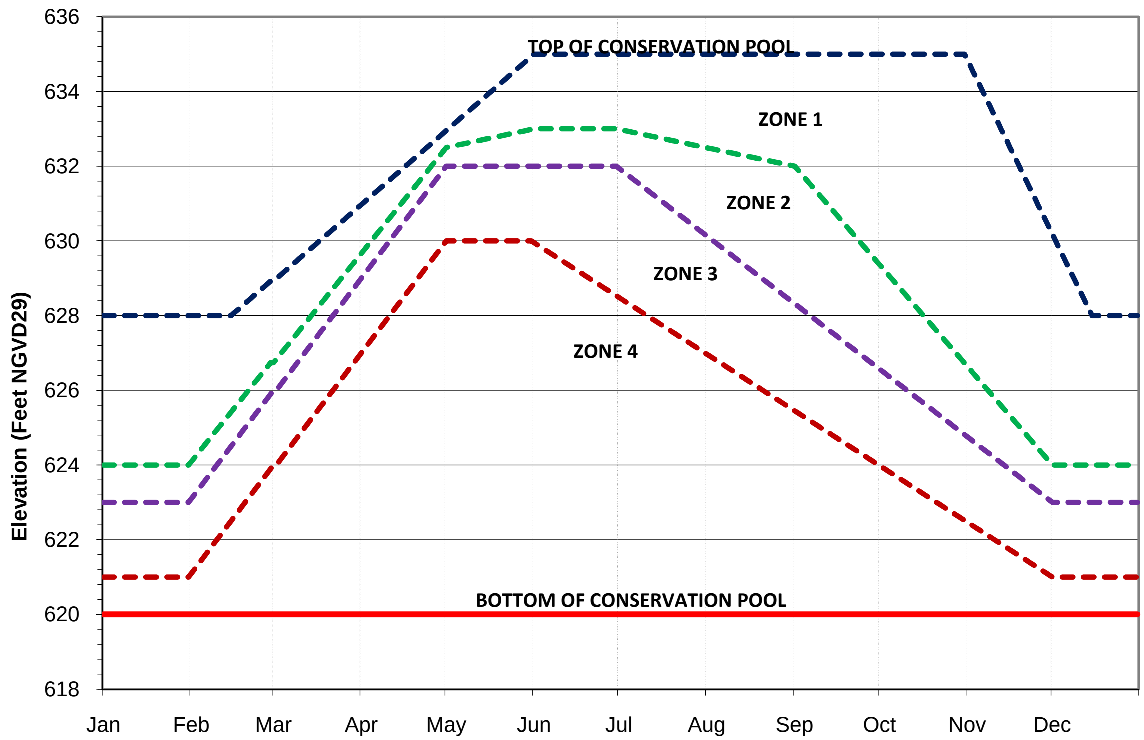


Figure 11.2-2. West Point Lake water control action zones

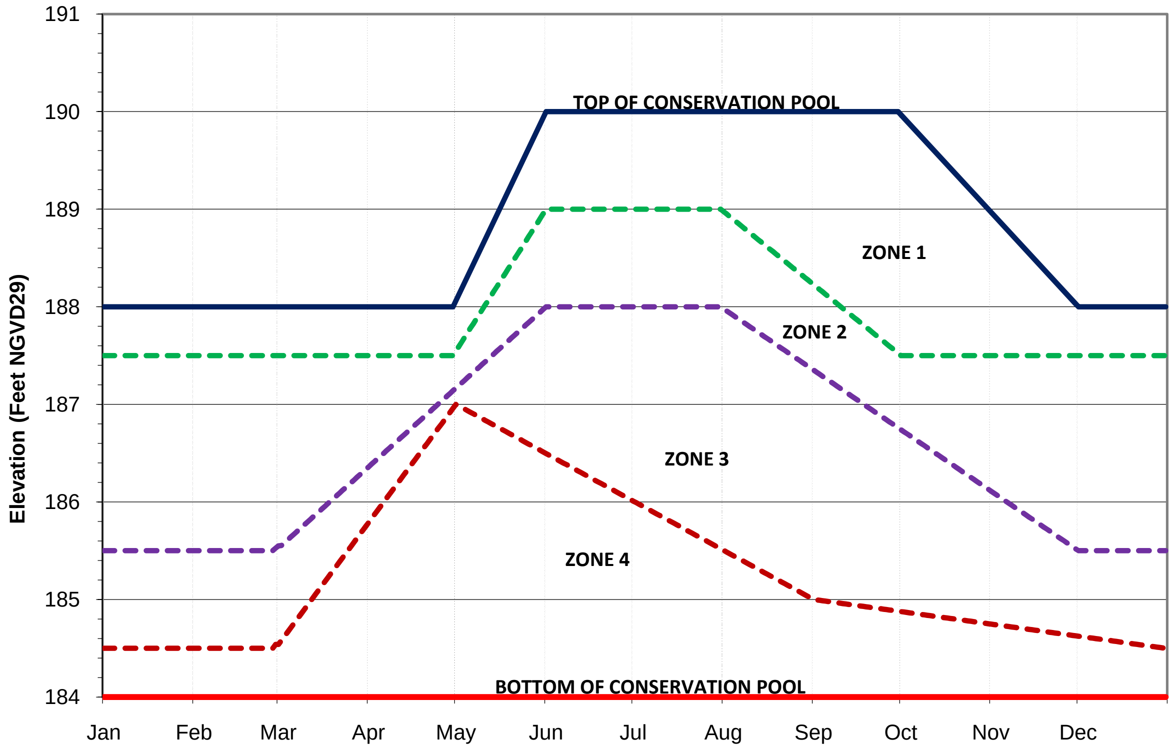


Figure 1.2-3. Walter F. George water control action zones

At the time of development, the zones were derived on the basis of the past operation of the projects, which considered time-of-year, historical pool level/release relationships, operational limits for conservation, and recreational resource impact levels. The action zones are basic guidelines for operating the river system; however, other factors and activities might cause the lakes to operate differently than the zones shown on the charts. Examples of those factors and/or activities may include, but are not limited to: exceptional flood damage reduction measures, fish spawn operations, maintenance and repair of turbines, emergency situations such as a drowning and chemical spills, draw-downs due to shoreline maintenance, releases made to free grounded barges, and other circumstances.

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

- Zone 1: Indicates that releases can be made in support of seasonal navigation (when the channel has been adequately maintained), hydroelectric power releases, water quality and, water supply releases. If all lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
- Zone 2: Indicates that water to support seasonal navigation might be limited. Hydroelectric power generation is supported at a reduced level. Water quality and water supply releases are met. Minimum flow targets are met.

- Zone 3: Indicates that water to support seasonal navigation might be significantly limited. Hydroelectric power generation is supported at a reduced level. Water quality and water supply releases are met. Minimum flow targets are met.
- Zone 4: Indicates that navigation is not supported. Hydroelectric power demands will be met at minimum levels and might occur only for concurrent uses. Water quality and water supply releases are met. Minimum flow targets are met.

The action zones have provided a key management tool for more than 20 years. They play a substantial role in several aspects of operating the lakes and dams. Under the No Action Alternative, it is assumed that the action zones would remain in effect unchanged.

1.2.3 Authorized Project Purposes

The following subsections describe each of the operations in the No Action Alternative for the authorized project purposes in more detail.

1.2.3.1 Flood Damage Reduction

The objective of flood damage reduction operations in the ACF Basin is storage of excess flows thereby reducing downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally. Whenever flood conditions occur, operation to reduce flood damage takes precedence over all other project functions. Flood damage reduction is achieved by storing damaging flood waters, thus reducing downstream river levels below those that would have occurred without the dams in place. Of the five Corps reservoirs, Lake Lanier is drawn down one additional foot; West Point Lake is drawn down at least 7 additional feet beginning in the fall, through winter and into the early spring to provide additional capacity to protect life and property in the basin. Walter F. George operates according to specified schedules for flood damage reduction. George W. Andrews and Jim Woodruff Dams operate to pass inflows.

Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power demands are lower, the *guide curve* operation generally reflects this situation by specifying a lower elevation during such a period. Additional storage for containing flood waters is gained by drawing down the pool in late fall. Those drawdowns can be specifically to reduce flood damage, as at West Point Lake, or coincidentally for other purposes. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower reduced peak stages in the reservoir during major floods.

The timing of flood peaks in the system is of considerable importance in determining the effectiveness of reservoir flood damage reduction operations and the degree to which such operations can be coordinated. During a flood event, excess water above normal pool elevation, or guide curve, should be evacuated through the use of the turbines and spillways in a manner consistent with other project needs as soon as downstream waters have receded sufficiently so that releases from the reservoirs do not cause flows to exceed bankfull flows capacity. Such timely evacuation is necessary so that consecutive flood events will not cause flood waters to exceed allocated flood storage capacities and endanger the integrity of the dam. Under the No Action Alternative, it is assumed that the current flood damage reduction operations would remain in effect unchanged.

1.2.3.2 Hydroelectric Power

The Buford, West Point, Walter F. George, and Jim Woodruff projects include hydroelectric power plants. The total generation capacity of the four ACF hydroelectric power plants is 404 MW. Through the Department of Energy's SEPA, the power plants provide power to more than 300 preference customers throughout the southeastern United States. In 2005 the ACF hydroelectric power plants generated nearly 1.1 million MW-hours, enough electricity to supply approximately 110,000 households in the region. In 2006 the same power plants generated approximately 717,178 MW-hours, which supplied approximately 70,000 households. The decrease in generation was due to a combination of equipment outages and sustained drought conditions. Hydroelectric power generation is achieved by passing flow releases to the maximum extent possible through the turbines at each project, even when making releases to support other project purposes. The Buford, West Point, and Walter F. George projects are operated as *peaking plants*, and provide electricity during the peak demand periods of each day and week. Hydroelectric power peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines. Typically, the Buford, West Point, and Walter F. George projects provide a minimum of 2 hours of generation a day for 5 days a week at plant capacity throughout the year, as long as their respective lake levels are in the conservation pool. For example, demand for peak hydroelectric power at Buford Dam typically occurs on weekdays and occasionally weekends from 5:00 a.m. to 9:00 a.m. and from 3:00 p.m. to 10 p.m. between October 1 and March 31, and on weekdays from 1:00 p.m. to 7:00 p.m. between April 1 and September 30. The 2-hour minimums represent releases that normally meet water supply and water quality demands and provide the capacity specified in marketing arrangements. During dry periods, as the lake levels drop below Zone 1, hydroelectric power generation is reduced proportionally as pool levels decline to as low as 2 hours per day generation at each peaking plant project during extreme low flow conditions. Peak generation could be eliminated or limited to conjunctive releases during severe drought conditions. The typical hours of operation by action zone are presented in Table 5.2-1.

Table 5.2-1. Typical Hours of Peaking Hydroelectric Power Generation by Federal Project

Action zone	Lake Lanier (hours of operation)	West Point (hours of operation)	Walter F. George (hours of operation)
Zone 1	3	4	4
Zone 2	2	2	2
Zone 3	2	2	2
Zone 4	0	0	0

In addition to hydroelectric power generation being governed by action zone, there are also physical limitations that factor into the power generation decisions. The main hydroelectric power units and small house unit intakes at Buford Dam are at elevation 919 ft. However, severe cavitations occur in the main hydroelectric power units when the water surface falls to 1,035 ft or below, at which time the units are taken out of service and generation ceases. The small house unit goes off line when water elevations reach 1,020 ft or below. At this time releases are made through the sluicing gate. Water can be released through the sluicing gate down to 920 ft.

Because it does not have the ability to store appreciable amounts of flow, the Jim Woodruff plant is operated as a run-of-the-river plant where inflows are passed continuously and electricity is generated around the clock. The current Revised Interim Operations Plan (RIOP) includes a limited hydroelectric power peaking operation at Jim Woodruff Dam when daily average releases are less than the combined capacity of the powerhouse turbines (about 16,000 cfs) to deliver extra power during hours of peak demand for electricity. Those peaking releases are included in the daily average discharge computations for the RIOP minimum flow provisions. The peaks are also included in the stage computations for the RIOP maximum fall rate schedule; however, the maximum fall rate schedule addresses the difference between the average river stage on consecutive calendar days, not the shorter-term differences that result from peaking operations within a calendar day. The current RIOP includes a provision that discontinues peaking operations at the Jim Woodruff plant as average daily releases approach 6,000 cfs, to maintain instantaneous releases greater than or equal to the 5,000 cfs minimum flow requirement. Under the No Action Alternative, it is assumed that the current hydroelectric power generation operations would remain in effect unchanged.

1.2.3.3 Navigation

The existing project authorizes a 9 ft-deep by 100 ft-wide waterway from Apalachicola, Florida, to Columbus, Georgia on the Chattahoochee River, and to Bainbridge, Georgia, on the Flint River. Conditions on the Apalachicola River have been such in recent years that a 9 ft-deep channel has not been available for much of the year. Because of deteriorating channel conditions and limited channel availability during the low-flow months, navigation windows were routinely scheduled during the low-flow months in the 1990s. Navigation windows were composed of storing water in the upstream reservoirs for several weeks and then making increased releases for a 10-day to 2-week period to allow commercial barge navigation to make a round trip up river for scheduled delivery of commodities. Concerns were raised regarding the fluctuations of both reservoir and river stages associated with navigation window releases, and the continued use of navigation windows became increasingly controversial, especially during sustained, low-flow periods when observed fluctuations were more extreme. As a result of fluctuating river stages during navigation windows, gradual ramping rates were developed in coordination with the USFWS and Florida Fish and Wildlife Conservation Commission, with the goal to provide for ramping down rates of not more than one-half ft/d during fish spawn activities, and no more than one ft/d during other times of the year, whenever flows were below 20,000 cfs.

The last navigation window was provided in the spring of 2000, and it precipitated complaints that the navigation window was scheduled during the period of fish spawn and had adversely affected both reservoir and riverine fish spawn activities. No navigation windows have been scheduled since, and none are planned in the foreseeable future.

Dredging on the Apalachicola River also was reduced since the 1980s because of a lack of adequate disposal area capacity in certain reaches of the river. No dredging was conducted in 2000 or 2002 because of sustained drought conditions in the basin, and only very limited dredging was conducted in 2001 and then was shut down because of sustained, low flow conditions. No dredging has been conducted since for a variety of reasons related to flow or funding levels and has been indefinitely deferred because of denial of a Section 401 water quality certificate from Florida and recent congressional language that limits funding for dredging operations in the ACF Basin.

The lack of dredging and routine maintenance has led to inadequate depths in the Apalachicola River navigation channel, and commercial navigation is possible only seasonally when flows in the river are naturally high, with flow support for navigation suspended during drier times of the year. Specific navigation operations occur on a case-by-case basis, with limited releases for navigation being made for special shipments when a determination can be made that other project purposes will not be significantly affected and any fluctuations in reservoir levels or river stages will be minimal. Over a period of months, the navigation industry in the ACF Basin works closely with the Corps to coordinate these special shipments. Under the No Action Alternative, it is assumed that the current operations in support of navigation would remain in effect unchanged.

1.2.3.4 Fish and Wildlife Conservation

1.2.3.4.1 Fish Spawning

In addition to providing for minimum flow and water quality releases, the Corps operates the system to provide favorable conditions for annual fish spawning, both in the reservoirs and the Apalachicola River. In most water years (October 1 - September 30) it is not possible to hold both lake levels and river stages at a steady or rising level for the entire spawning period, especially when upstream lakes or the Apalachicola River spawning periods overlap. During the fish spawning period for each waterbody (Table 1.2-2), the Corps' goal is to operate for a generally stable or rising lake level and a generally stable or gradually declining river stage on the Apalachicola River for approximately 4 to 6 weeks during the designated spawning period. When climatic conditions preclude a favorable operation for fish spawn, the

Corps consults with the state fishery agencies and the USFWS on balancing needs in the system and minimizing the effects of fluctuating lake or river levels. Those fish spawn operations were incorporated into a draft *Mobile District Standard Operating Procedure* (CESAM SOP 1130-2-9) in February 2005, following consultation since 2002 with USFWS and state fishery management agencies from Alabama, Florida, and Georgia. Under the No Action Alternative, it is assumed that the fish spawn operations would remain in effect unchanged.

Table 1.2-2. Project-specific Principal Fish Spawning Period

Project	Fish spawn period
Lake Lanier	April 1–June 1
West Point	April 1–June 1
Walter F. George	March 15–May 15
Lake Seminole	March 1–May 1
Apalachicola River	April 1–June 1

1.2.3.4.2 Fish Passage

Each spring (since 2005) from March through May, the Corps has operated the lock at Jim Woodruff Dam to facilitate downstream to upstream passage of Alabama shad and other anadromous fishes (those that return from the sea to the rivers where they were born to breed). There are slight differences in the locking technique each year. However, in general two fish locking cycles are performed each day between 0800 - 1600 hours; one in the morning and one in the afternoon. The operation consists of opening the lower lock gates and getting fish into the lock in one of three ways; either by transporting them into the lock by boat (2005), using attraction flows to entice the fish into the lock (2006–2007), or by leaving the lower gate open for a period before a lockage and allowing the fish to move in without an attraction flow (2008). Once the fish are in the lock (or assumed to be in the lock), the downstream doors are closed. The lock is filled to the lake elevation and the upper gates are opened. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change. Under the No Action Alternative, it is assumed that the current fish passage operation would remain in effect unchanged.

1.2.3.4.3 Endangered Species Conservation - Revised Interim Operations Plan

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

The RIOP specifies two parameters applicable to the daily releases from Jim Woodruff Dam: a minimum discharge (measured in cfs) and a maximum fall rate (measured in feet per day [ft/d]). However, the RIOP also identifies conditions under which maintenance of the maximum fall rate schedule is suspended and more conservative drought contingency operations begin. The RIOP also places limitations on refill but does not require a net drawdown of composite conservation storage unless basin inflow is less than 5,000 cfs.

Minimum Discharge. The RIOP varies minimum discharges from Jim Woodruff Dam by basin inflow and by month, the releases are measured as a daily average flow in cfs at the Chattahoochee, Florida gage.

Table 1.2-3 shows minimum releases from Jim Woodruff Dam prescribed by the RIOP and shows when and how much basin inflow is available for increasing reservoir storage. The RIOP defines basin inflow threshold levels that vary by three seasons: spawning season (March - May); non-spawning season (June–November); and winter (December - February), and incorporates composite conservation storage thresholds that factor into minimum release decisions. Composite conservation storage is calculated by combining the conservation storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake.

Each of the individual storage reservoirs consists of four action zones. The composite conservation storage uses the four zone concepts as well; i.e., Zone 1 of the composite conservation storage represents the combined storage available in Zone 1 for each of the three storage reservoirs. During the spawning season, two sets of four basin inflow thresholds and corresponding releases exist according to composite conservation storage. When composite conservation storage is in Zones 1 and 2, a less conservative operation is in place. When composite conservation storage is in Zone 3, a more conservative operation is in place while still avoiding or minimizing effects on listed species and critical habitat in the river. When composite conservation storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are *triggered* representing the most conservative operational plan. A detailed description of the drought contingency operations is provided below. During the spawning season, a daily monitoring plan that tracks composite conservation storage will be implemented to determine water management operations. Recent climatic and hydrological conditions experienced and meteorological forecasts will be used in addition to the composite conservation storage values when determining the appropriate basin inflow thresholds to use in the upcoming days.

During the non-spawning season, one set of four basin inflow thresholds and corresponding releases exists according to composite conservation storage in Zones 1 - 3. When composite conservation storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are triggered.

During the winter season, only one basin inflow threshold and corresponding minimum release (5,000 cfs) exists while in composite conservation storage Zones 1–3. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions. When composite conservation storage falls below the bottom of Zone 3 into Zone 4, the drought contingency operations are triggered.

The flow rates included in Table 1.2-3 prescribe minimum, and not target, releases for Jim Woodruff Dam. During a given month and basin inflow rate, releases greater than the RIOP minimum release provisions can occur consistent with the maximum fall rate schedule, described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood damage reduction.

Table 1.2-3. RIOP Water Releases from Jim Woodruff Dam

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from JWLD (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June–November	Zones 1, 2, and 3	>= 24,000	>= 16,000	Up to 100% BI > 16,000
		>= 8,000 and < 24,000	>= 8,000 + 50% BI > 8,000	Up to 50% BI > 8,000
		>= 5,000 and < 8,000	>= BI	
		< 5,000	>= 5,000	
December–February	Zones 1, 2, and 3	>= 5,000	>= 5,000 (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Drought zone	NA	>= 4,500[b]	Up to 100% BI > 4,500

Notes: a. Consistent with safety requirements, flood-control purposes, and equipment capabilities.
b. Once composite conservation storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate of 0.25 ft/d drop.

Maximum Fall Rate. Fall rate, also called down-ramping rate, is the vertical drop in river stage (water surface elevation) that occurs over a given period. The fall rates are expressed in units of ft/d and are measured at the Chattahoochee, Florida USGS gage as the difference between the daily average river stage of consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The RIOP maximum fall rate schedule is provided in Table 1.2-4. When composite conservation storage is in Zone 4 and the drought contingency operation described below is implemented, the maximum fall rate schedule is suspended. Unless otherwise noted, fall rates under the drought contingency operation would be managed to match the fall rate of the 1-day basin inflow.

Table 1.2-4. RIOP Maximum Fall Rate Schedule Composite Conservation Storage Zones 1, 2, and 3[a,b]

Release range (cfs)	Maximum fall rate, measured at Chattahoochee gage (ft/d)
> 30,000[c]	No ramping restriction[d]
> 20,000 and <= 30,000[a]	1.0 to 2.0
Exceeds powerhouse capacity (~ 16,000) and <= 20,000[a]	0.5 to 1.0
Within powerhouse capacity and > 8,000[a]	0.25 to 0.5
Within powerhouse capacity and <= 8,000[a]	0.25 or less

Notes: a. Maximum fall rate schedule is suspended in Composite Zone 4.
b. Any changes to the RIOP minimum flows or maximum fall rate provisions resulting from reinitiation of consultation will be incorporated and evaluated.
c. Consistent with safety requirements, flood-control purposes, and equipment capabilities.
d. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down ramping rate, and no ramping rate is required.

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

Drought Contingency Operations. Coupled with the action zones defined for the upstream reservoirs, the RIOP incorporates a drought contingency operation (referred to as drought plan) that specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite conservation storage in the basin is replenished to a level that can support them. The minimum discharge is determined in relation to composite conservation storage and not average basin inflow under the drought plan. When conditions dictate, computations of the volumes of the basin inflows and releases are made on a continuous basis and readjustments are made, as necessary, to assure the required flow releases occur. This is volumetric balancing. The drought plan is triggered when composite conservation storage falls below the bottom of Zone 3 into Zone 4. At that time, all the composite conservation storage Zone 1 - 3 provisions (seasonal storage limitations, maximum fall rate schedule, minimum flow thresholds, and volumetric balancing accounting) are suspended, and management decisions are based on the provisions of the drought plan. The drought plan also includes any combination of (1) a temporary waiver from the existing water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects if the opportunity presents itself or (2) begin spring refill operations at an earlier date to provide additional conservation storage for future needs and provide for a minimum releases less than 5,000 cfs from Jim Woodruff Dam.

The drought plan prescribes two minimum releases on the basis of composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone (Figure 1.2-4). The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point, and Walter F. George plus Zone 4 storage in Lake Lanier. The Drought Zone line has been adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates will be limited to a 0.25 ft/d drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is reinstated. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 3 (i.e., in Zone 2). At that time, the temporary drought plan provisions would be suspended, and all the other provisions would be reinstated. During the drought contingency operations, a monthly monitoring plan that tracks composite conservation storage to determine water management operations (the first day of each month will represent a decision point) would be implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts would be used when determining the set of operations to use in the upcoming month.

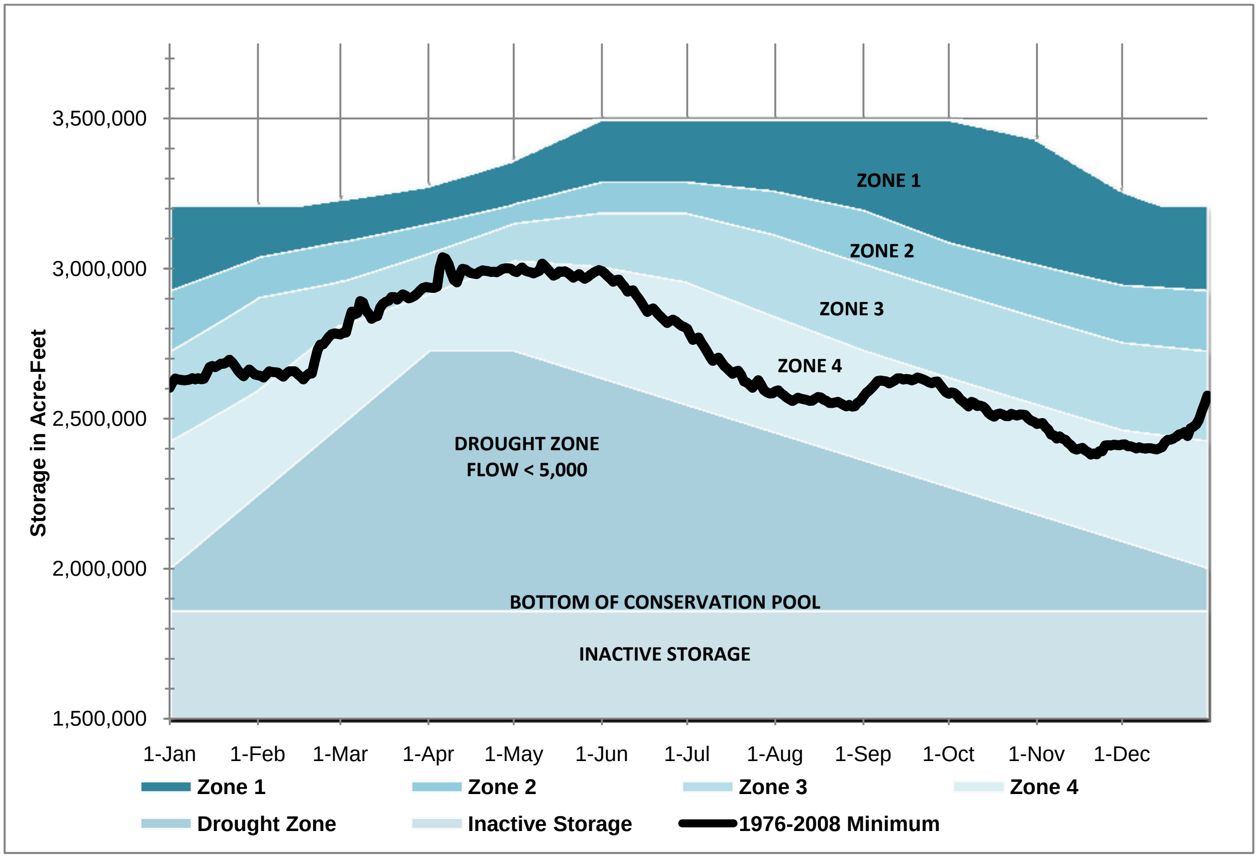


Figure 11.2-4. RIOP Drought Composite Conservation Storage Triggers

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

In the analysis of the No Action Alternative, it is assumed that the current RIOP would remain in effect unchanged. However, based on new information about the distribution and mortality of mussels the Corps requested a reinitiation of consultation for the fat threeridge and RIOP on September 2010. It is not known at this time, whether the results of reinitiation will require additional changes to the RIOP.

1.2.3.5 Recreation

All the Corps lakes have become important recreational resources on the ACF Basin. The five Corps projects in the basin account for 235,291 total acres of land and water. A wide variety of recreational opportunities are provided at the lakes including boating, fishing, picnicking, sightseeing, water skiing, and camping. The reservoirs support popular sport fisheries, some of which have achieved national acclaim for trophy-size catches of largemouth bass. Of the projects, Lake Lanier (Buford Dam) is one of the most visited Corps lakes in the entire United States with more than 7.7 million visitors in 2005. The West Point and Walter F. George Lakes had more than 3.1 and 3.6 million visitors, respectively, in 2005 to also rank among the top 10 most visited Corps lakes in the United States. In addition, Lake Seminole had more than 1.2 million visitors in 2005, and the smaller George W. Andrews project 269,000 visitors. The economic benefits of recreation at the lakes is significant, resulting in visitor spending in 2005 of over $125 million at Lake Lanier, $36 million at West Point Lake, and $111 million at Walter F. George

Lake. Recreation benefits are maximized at the lakes by maintaining full or nearly full pools during the primary recreation season of May 1 through September 8. In response to meeting other authorized project purposes, lake levels can and do decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 5.2-5).

Table 12-5. Water Levels Affecting Federal Project Recreation

Corps project	Initial impact level (IIL) (ft NGVD)	Recreation impact level (RIL) (ft NGVD)	Water Access Limited Level (WAL) (ft NGVD)
Lake Lanier	1,066	1,063	1060
West Pont Lake	632.5	629	627
Walter F. George Lake	187	185	184
Lake Seminole	76	NA	NA

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

When pool levels must be lowered, the rates at which the drawdowns occur are as steady as possible. The action zones are drawn to correlate the line between Zone 2 and Zone 3 to the Initial Impact Level, (IIL), at the beginning of the recreation season (May through early September). If lake levels fall to Zone 3 during the recreation season, releases will normally be limited to 2-hour-a-day generation and minimal navigation support, which tends to stabilize the lake levels until the end of the season. Under the No Action Alternative, it is assumed that recreation operations would remain in effect unchanged.

1.2.3.6 Water Quality

Buford, West Point, and Jim Woodruff Dams all include water quality operations to provide continuous minimum flow releases. There are no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen values are observed below the dam, spillway gates are opened until the dissolved oxygen readings return to an acceptable level. Occasional special releases are also made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam. Additionally, self-aspirating turbines were installed at Buford Dam in 2005 to improve dissolved oxygen levels downstream. At Buford Dam, the small turbine-generator is run continuously to provide a minimum flow from the dam, which ranges up to approximately 600 cfs. At West Point Dam, a similar small generating unit provides a continuous release of approximately 675 cfs. In addition to those flows, Buford Dam is operated in conjunction with the downstream Georgia Power Dam at Morgan Falls to ensure a minimum instream flow of 750 cfs on the Chattahoochee River at Peachtree Creek to meet state water quality commitments. A 5,000 cfs minimum flow is maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which assures an adequate water supply for downstream industrial use and water quality. No water quality problems below Jim Woodruff Dam have been identified in association with project operations.

Although there is no Corps requirement to maintain minimum flows for assimilative capacity at Columbus, Georgia, the Georgia Power projects above Columbus are required in their Federal Energy Regulatory Commission (FERC) licenses to provide 1,850 cfs weekly average, 1,350 cfs daily average, and 800 cfs instantaneous minimum flow at Columbus. Releases from the Georgia Power projects are dependent on upstream releases from West Point Dam and, to a limited extent, those requirements are considered when making release decisions for West Point Dam. Georgia Pacific and Farley Nuclear Plant below George W. Andrews Dam have stated a requirement of 2,000 cfs for assimilative capacity needs. Although that is not a Corps requirement, to the extent practicable, the needs are considered in operations at Walter F. George Dam and Jim Woodruff Dam. Under the No Action Alternative, it is assumed that the current water quality operations would remain in effect unchanged.

1.2.3.7 Water Supply

Various municipal and industry (M&I) entities withdraw water directly from Lake Lanier, and others withdraw directly from the Chattahoochee River downstream of Lake Lanier. Reservoir operations are also influenced by agricultural water withdrawals on the Flint River. Agricultural demands vary depending on the climatic conditions but are generally 1.5 to 2 times the withdrawals for M&I (USFWS 2006). Water withdrawals in Georgia are made pursuant to water withdrawal permits issued by the Georgia Department of Natural Resources. Previous water supply contracts issued by the Corps for withdrawals from Lake Lanier expired in 1990 and have not been reissued. The Water Supply Act of 1958 provides authority for reallocation or addition of storage in Corps reservoirs for water supply, with the cost of storage and associated facilities to be reimbursed by a non-Corps entity via water storage contracts; no storage in projects in the ACF Basin is allocated to water supply.

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

- Gwinnett County—92.91 mgd
- City of Gainesville—18.98 mgd (Includes 8.0 mgd authorized by their relocation contract.)
- City of Cumming—18.79 mgd (Includes water furnished to Forsyth County, GA.)
- City of Buford—1.51 mgd (2.0 mgd authorized by their relocation contract)

In general, Lake Lanier weekly water supply/quality release decisions are based on the Chattahoochee River Management System (as recorded in the *Apalachicola Basin Reservoir Regulation Manual*, Appendix B, February 1991 [USACE, Mobile District 1991]). In coordination with the Atlanta Regional Commission and Georgia Power, the Corps calculates the sum of anticipated downstream water supply river withdrawals by DeKalb County, City of Atlanta, Cobb County/Marietta Water Authority and Fulton County (average annual 291 mgd in 2000), water quality releases to ensure 750 cfs at the Peachtree Creek gaging station (USGS 02336000), minus water returns and inflows between Buford Dam and Peachtree Creek. That approach ensures sufficient water is released from Lake Lanier to allow for Chattahoochee River withdrawals, guarantee sufficient flows to meet 750 cfs at Peachtree Creek, hydroelectric power production and fish and wildlife needs. During the winter and spring, releases from Buford Dam may be reduced because of sufficient downstream tributary flows to meet the Georgia Environmental Protection Division's 750 cfs target water quality flow at Peachtree Creek. To the extent possible, those releases are made in conjunction with peaking power operations to minimize effects on hydroelectric power generation.

Flow releases also support cooling water withdrawals for several industries including critical power plants. Two such facilities are the Farley Nuclear Plant, which requires a minimum elevation of 74.5 ft immediately downstream of George W. Andrews Dam and the Plant Scholtz immediately downstream of Jim Woodruff Dam, which requires a minimum flow of 5,000 cfs but can temporarily operate at water elevation of 37.5 ft (equivalent to flows of 4,200 cfs).

Over 40 percent of Lake Lanier's water is in the *inactive* storage zone (below elevation 1,035 ft). All the water supply users have multiple level intakes in Lake Lanier (in the conservation pool and inactive storage), and several withdraw water from the inactive storage. Gwinnett County has multiple elevation intakes at 1,062, 1,045, and 1,025 ft, and has withdrawn from the 1,025 intake (within the inactive storage zone) for many years. The City of Cumming intakes range from elevation 1,053 down to 1,032 ft. The City of Buford intakes are at elevations 1,062, 1,052, 1,042, and 1,032 ft. The City of Gainesville has three intake structures, each with multiple intake ports ranging from elevation 1,063 down to 1,025 ft. Releases through Buford Dam to the Chattahoochee River draw from the inactive storage zone (releases from the hydroelectric power units and the sluice gates), and the release waters make up the Chattahoochee River that flows downstream to the Atlanta area municipal water intakes downstream. Releases from Lake Lanier also support a number of other downstream M&I water supply needs including the Cities of LaGrange, West Point, Columbus and a number of industries.

Under the No Action Alternative, it is assumed that the current water supply operations between Buford Dam and Peachtree Creek would remain in effect unchanged using 2007 withdrawals of 275 mgd. 2007 was the greatest demand year recorded along this reach.

1.3 Proposed Action Alternative

Under the Proposed Action Alternative, the Corps would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes. The following sections identify key elements of the proposed action that differ from the No Action Alternative.

In light of the July 2009 federal district court ruling, under the proposed action withdrawals directly from Lake Lanier would be limited solely to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 mgd, respectively.

Similarly under the proposed action, the Corps would no longer make releases for water supply and water quality requirements from Buford Dam in accordance with the Chattahoochee River Management System. Instead, off-peak releases for from Buford Dam would be limited to 600 cfs. Water availability for M&I withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to that which is available from the 600 cfs off-peak releases or water incidentally available through peaking hydroelectric power generation, or both.

1.3.1 Action Zones

Under the proposed action, the Corps would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The proposed modifications are shown in Figure 1.3-1, Figure 1.3-2, and Figure 1.3-3. The proposed modifications take into account the ability of the reservoirs to refill (considering hydrology, watershed size, and such), recreation effects and hazard levels, and proportionality of zone drawdown between projects.

The following definitions apply to the revised action zones:

- Zone 1: Indicates that releases can be made in support of a navigation season (January–April or May), hydroelectric power releases, water supply, and water quality releases. If all the lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
- Zone 2: Indicates that releases can be made in support of a navigation season (January - April or May). Hydroelectric power generation is supported at the same or a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 3: Navigation is not supported. Hydroelectric power generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 4: Navigation is not supported. Hydroelectric power demands will be met at a minimum level and might occur only for concurrent uses. Water supply and water quality releases are met. Minimum flow targets are met.

The revised action zones were developed to better:

1. Facilitate refill of each reservoir.
2. Minimize low-water recreational impacts and hazard levels.
3. Balance system storage throughout the basin.
4. Enhance ability to balance refill relative to watershed and hydrology.
5. Achieve proportional drawdown in each reservoir.

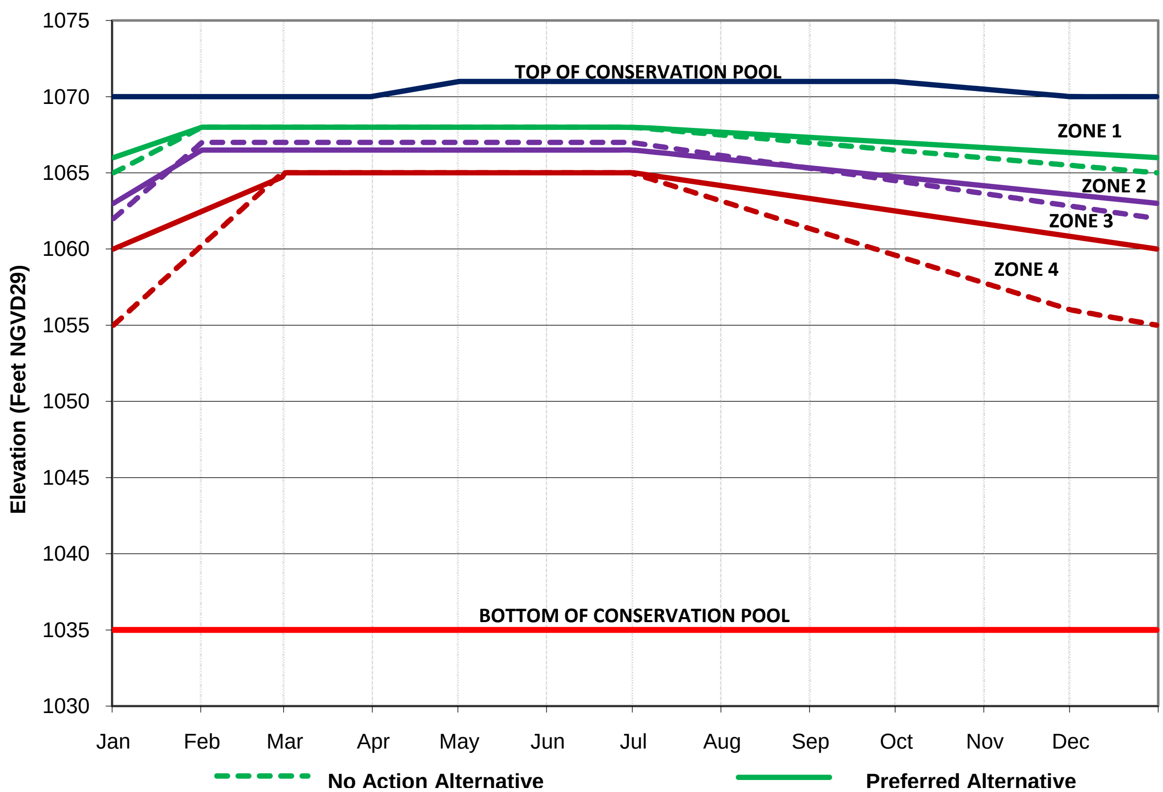


Figure 1.3-1. Lake Lanier Water Control Action Zones

Changes in the Lake Lanier action zones are proposed to facilitate refill and storage of water relative to the watershed size. By increasing Zone 4 to 1,060 ft in January, there will be more water in the reservoir when drought operations go in to effect. This operational change allows for more water storage to balance water management throughout the ACF Basin.

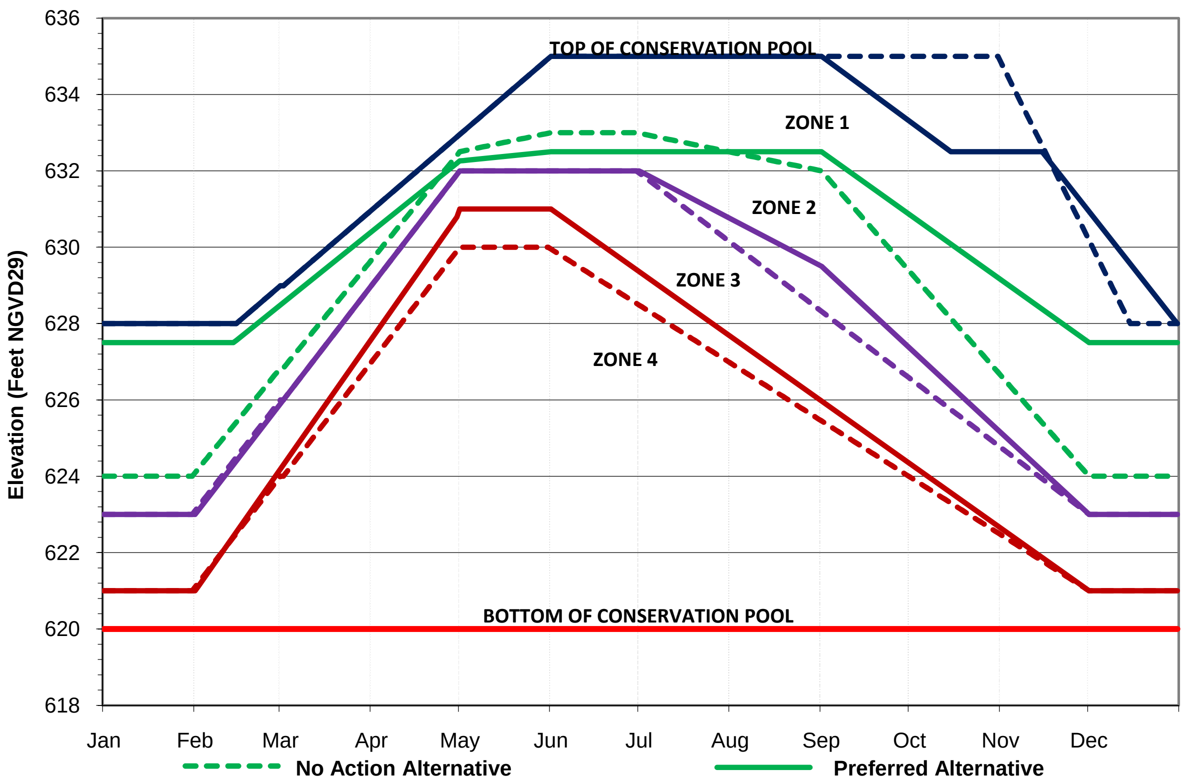


Figure 11.3-2. West Point Water Control Action Zones

The West Point Lake guide curve (top of conservation pool) change is proposed to be maintained at a summer pool level of 635 ft beginning in June and lasting through August. In September, the lake elevation would be gradually drawn down to approximately 632.5 ft by October 1. Lake levels would be held at 632.5 ft until November. In November, another gradual drawdown to winter pool level of 628.0 ft would occur. Winter pool level would be maintained until mid-February. Gradual lake refill would begin in mid-February. Winter pool would be increased through the spring until summer pool elevation is achieved in June.

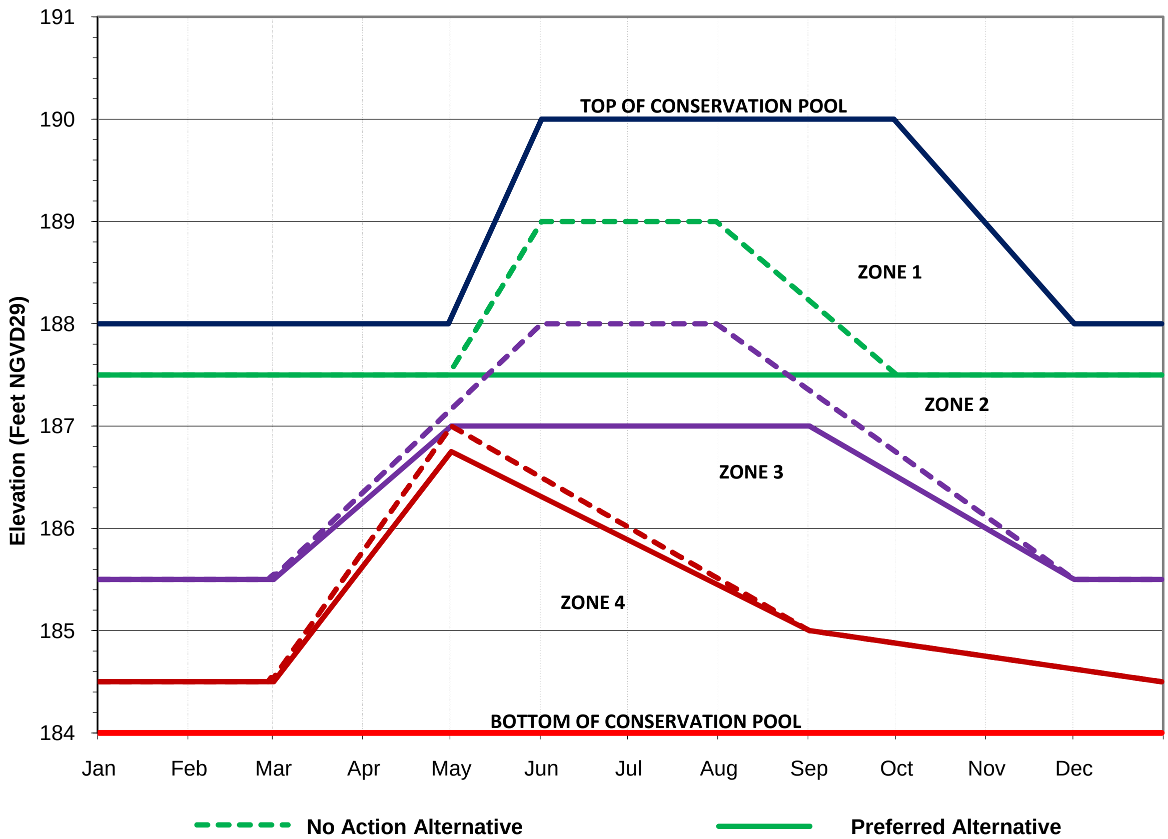


Figure 11.3-3. Walter F. George Water Control Action Zones

Changes to action zones in the Walter F. George project allow use of more available storage in the reservoir to achieve proportional drawdown and balance system storage. Decreasing Zone 2 to 187.5 from May through October and Zone 3 from 188 ft to 187 ft from March through December allows for more storage water to be released downstream during critical low flow periods.

1.3.1.1 Drought Operations

Drought operations are "triggered" when composite conservation storage of the ACF Basin falls below the bottom of Zone 3 into Zone 4, (Figure 1.3-4). At that time all the composite conservation storage Zone 1-3 provisions (seasonal storage limitations, maximum fall rate schedule, minimum flow thresholds, and volumetric balancing accounting) are suspended and management decisions are based on the provisions of the drought plan. The Jim Woodruff Dam minimum discharge is determined in relation to composite conservation storage and not the average basin inflow under the drought plan. The drought plan for the ACF Basin specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite conservation storage within the basin is replenished to a level that can support the minimum releases and maximum fall rates. The drought plan also includes a temporary waiver from the existing water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects if the opportunity presents itself. There is also an opportunity to begin spring refill operations at an earlier date in order to provide additional conservation storage for future needs and to provide for a minimum releases less than 5,000 cfs from Jim Woodruff Dam. Drought operations also include reduced hydropower generation at Lake Lanier as described below.

The drought plan prescribes two minimum releases from Jim Woodruff Dam based on composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone, Figure 1.3-4. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point and Walter F. George plus Zone 4 storage in Lake Lanier. The Drought Zone line has been adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates will be limited to a 0.25 ft/day drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is re-instated. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1). At that time, the temporary drought plan provisions are suspended, and all the other provisions are re-instated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) will be implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts will be used when determining the set of operations to utilize.

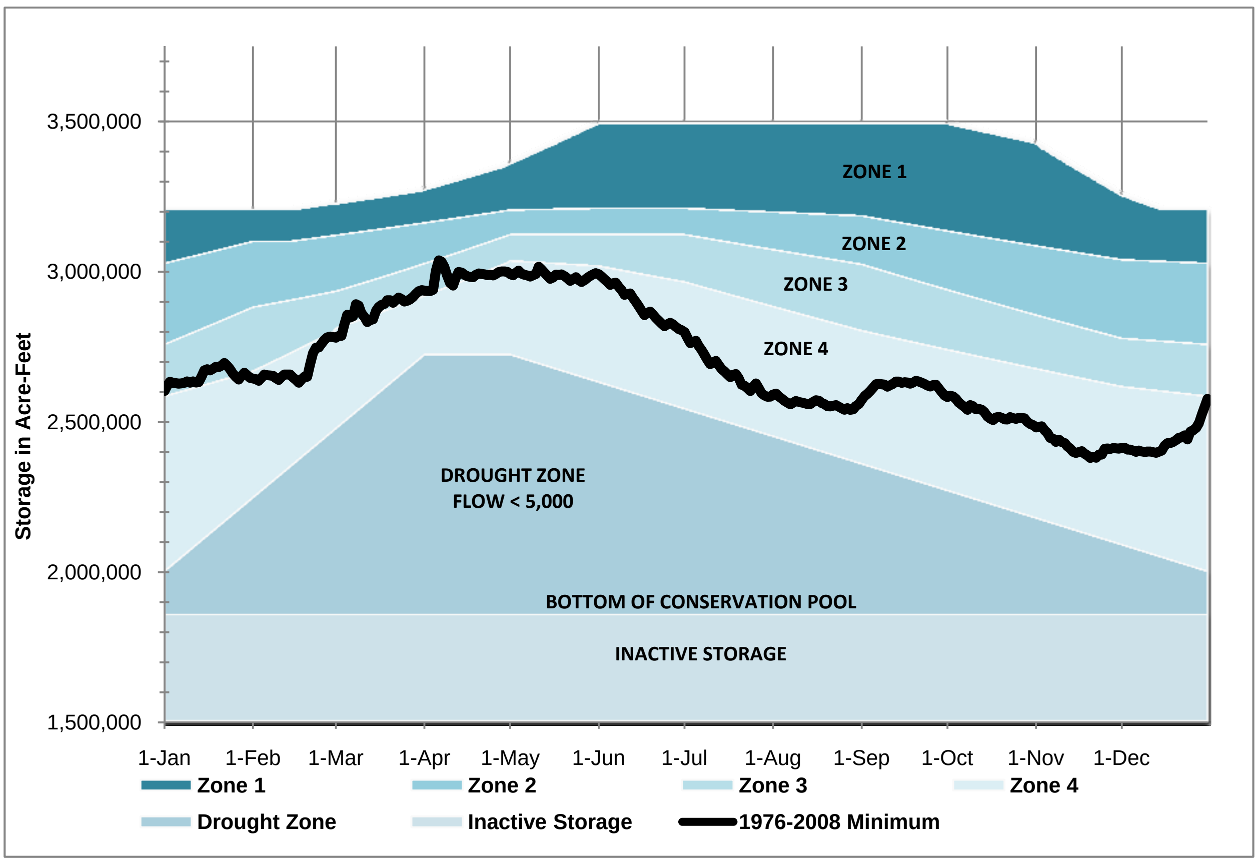


Figure 11.3-4. Drought Composite Conservation Storage Triggers

1.3.1.2 Flood Damage Reduction

The minor guide curve change included in the Proposed Action Alternative for West Point Lake provides an incidental increase in flood storage during the fall drawdown. No changes to the flood damage reduction operations described in the No Action Alternative are proposed. When developing the proposed action, flood damage reduction capabilities and capacities of reservoirs were not reduced.

1.3.1.3 Hydroelectric Power

Under the proposed action, Corps would continue to operate Buford Dam, West Point Dam, Walter F. George Dam, and Jim Woodruff Dam for hydroelectric power generation, as described for the No Action Alternative. The Proposed Action Alternative would not result in changes to hydroelectric power generation operations at West Point Dam, Walter F. George Lock and Dam, or Jim Woodruff Dam, except as might result from changes in the action zones.

Under the Proposed Action Alternative, when Lake Lanier is in Zone 1 or 2 during non-drought conditions, generation would typically be in the hourly ranges shown in the table below. Similarly, during drought operations as described above, generation would typically be reduced to that depicted in Table 1.3-1.

Table 1.3-1. Buford Dam Hydroelectric Power Generation Schedule

Hydroelectric Power Generation hours	No Action	Proposed Action Alternative	
		Non-drought	Drought ops
Zone 1	3	4–2	2
Zone 2	2	4–1	1
Zone 3	2	2–1	1
Zone 4	0	2–1	1

1.3.1.4 Navigation

Under the proposed action, when supported by ACF Basin hydrologic conditions, the Corps will provide a reliable navigation season. In so doing, the goal of the water management is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period of time that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). During the navigation season the flows at the Blountstown, Florida, USGS gage should be adequate to provide at least a 7 ft channel. The most recent channel survey and discharge-stage rating was used to determine the flow required to sustain a minimum navigation depth during the navigation season. The Corps' capacity to support a navigation season will be dependent upon actual and projected system-wide conditions in the ACF Basin prior to and during the months of January, February, March, April and May. These conditions include, but are not limited to:

1. A navigation season can only be supported when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
2. A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Provided drought operations have not been triggered, navigation support

will resume when basin composite conservation storage level recovers to Zone 2 and is forecast to remain above Zone 3 for a practicable, continuous period of time.

3. A navigation season will not be supported when drought operations are in effect. Navigation will not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1.
4. The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. Based on an analysis of these factors, the Corps will determine if the navigation season will continue through part or all of May.
5. Down ramping of flow releases (regardless of period in the navigation season) will adhere to the Jim Woodruff Dam fall rate schedule (Table 1.3-2) for federally listed species.
6. Releases that augment the flows to provide for the 7 ft navigation channel will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, due to diminishing inflows, downstream flows and depths must be reduced, navigation bulletins will be issued to project users. These notices will be issued as expeditiously as possible in order to give barge owners, and other waterway user's, sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Dam to reduce releases.

Though special releases will not be standard practice, they may occur for a short duration to assist navigation during the navigation season (Figure 1.3-5). For instance, releases may be requested to achieve up to a 9-ft channel. These shall be evaluated on a case by case basis, subject to applicable laws and regulations and the conditions above.

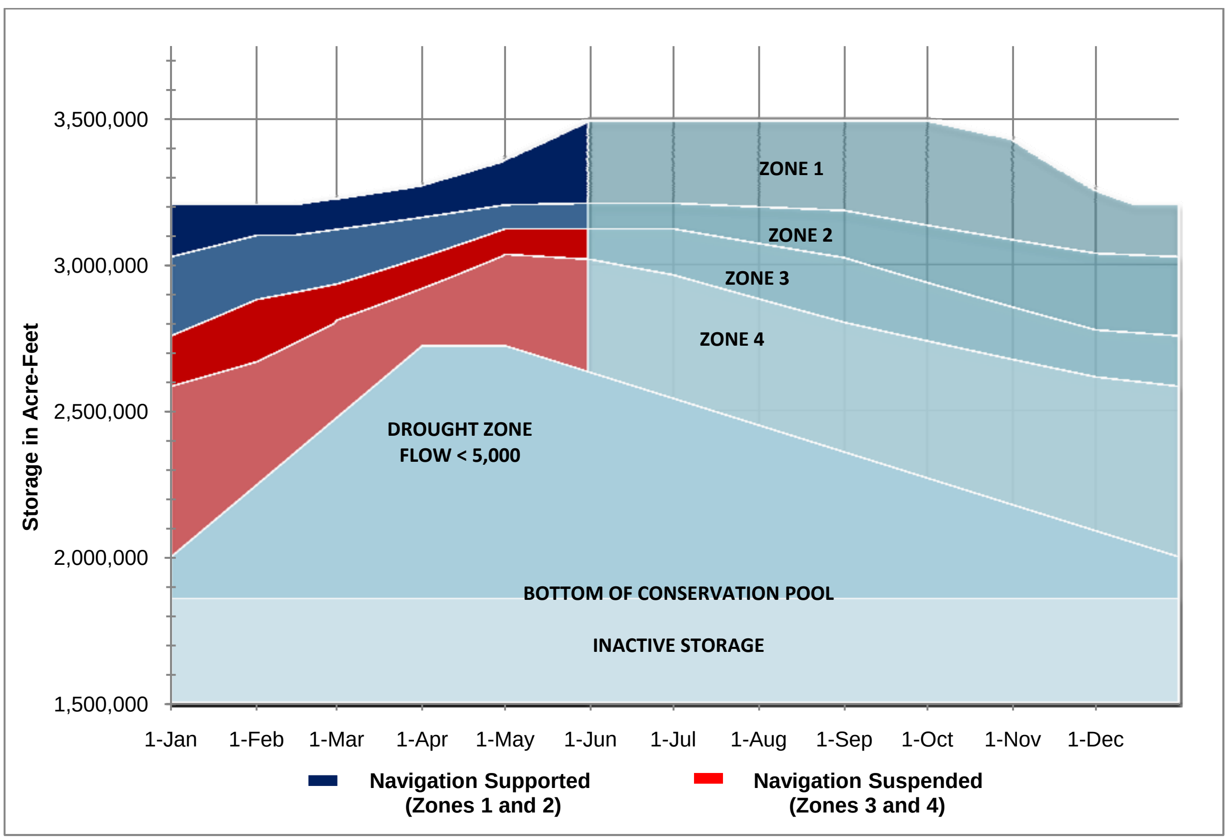


Figure 11.3-5. Composite Conservation Storage for Navigation

1.3.1.5 Fish and Wildlife Conservation

Under the Proposed Action Alternative there are no changes to fish spawn or fish passage operations described in the No Action Alternative.

Federally Listed Species **-** Under the Proposed Action Alternative, the Corps would continue to make releases for threatened and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows as discussed in the No Action Alternative with several modifications.

Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above. The Corps would no longer use volumetric balancing and would revise ramping rate requirements when flows are below 30,000 cfs. Those modifications are proposed on the basis of lessons learned after operating under the RIOP for several years and to reduce the likelihood of triggering releases of less than 5,000 cfs from Jim Woodruff Dam.

Table 1.3-2. Maximum Fall Rate Schedule Composite Conservation Storage Zones 1, 2, and 3[ab]

Release range (cfs)	Maximum fall rate, measured at Chattahoochee gage (ft/d)
> 30,000[c]	No ramping restriction[d]
Exceeds powerhouse capacity (~ 16,000) and <= 30,000[a]	Match 1-day basin inflow fall rate
Within powerhouse capacity and > 8,000[a]	0.25 to 0.5
Within powerhouse capacity and <= 8,000[a]	0.25 or less

Notes: a. Maximum fall rate schedule is suspended in Composite Zone 4.
b. Any changes to the RIOP minimum flows or maximum fall rate provisions resulting from reinitiation of consultation will be incorporated and evaluated.
c. Consistent with safety requirements, flood-control purposes, and equipment capabilities.
d. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down ramping rate, and no ramping rate is required.

Modifications are proposed to ensure full system recovery after drought operations are implemented. No changes to the drought contingency operations described in the RIOP discussion of the No Action Alternative, with the exception of the following:

1. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., in Zone 1).
2. Reshaping the Drought Zone as depicted in Figure 1.3-4.

In the analysis of the Proposed Action Alternative, the only changes to the current RIOP operations in support of listed species are those identified above. However, if the on-going reinitiation of consultation for the fat threeridge and RIOP results in additional changes to the RIOP, those changes will need to be considered at a later date.

1.3.1.6 Recreation

The proposed action has no changes to operations in support of recreation from those described in the No Action Alternative.

1.3.1.7 Water Quality

The Corps would no longer operate in accordance with the Chattahoochee River Management System to provide a specific flow for water quality at Peachtree Creek.

In accordance with the July 2009 federal district court ruling, off-peak releases from Buford Dam would be limited to 600 cfs. Water availability on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to that which is available from the 600 cfs off-peak releases and/or water incidentally available through peaking hydroelectric power generation. Consequently, the water supply providers downstream of Buford Dam will need to limit their withdrawals during off-peak times so that water quality standards in the Chattahoochee River are not violated.

No changes are proposed for releases through the house unit at West Point Dam.

1.3.1.8 Water Supply

Under the Proposed Action Alternative on the basis of the federal district court ruling, water withdrawals directly from Lake Lanier would be limited to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 mgd, respectively.

The Corps would no longer make releases for water supply requirements from Buford Dam in accordance with the Chattahoochee River Management System. Instead, off-peak releases from Buford Dam would be limited to 600 cfs, pursuant to Judge Magnuson’s ruling. Water availability for M&I withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to that which is available from the 600 cfs off-peak releases and/or water incidentally available through peaking hydroelectric power generation. Peaking hydroelectric power generation would occur between 5:00am – 9:00am and 3:00pm – 10:00pm on Monday through Friday between October 1 and March 31 and between 1:00pm – 7:00pm on Monday through Friday between April 1 and September 30.

All other water supply operations in the ACF Basin described in the No Action Alternative would remain the same.

2 RESPONSE TO PLANNING AID LETTER (PAL) SECTION 3

2.1 RESPONSE TO PAL SECTION 3.1 ResSim Model Output Analyses

As requested, Indicators of Hydrologic Alteration (IHA) was used in the development of the analysis of the environmental consequences of the proposed action. This analysis was woven into various sections of water and biological resources analyses. Other tools recommended, Environmental Flow Components (Mathews and Richter 2007) and ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC), were not used in determining the environmental consequences of the Proposed Action Alternative. Existing data and resources were used in this analysis. Some of the recommended tools would have required more extensive study of current conditions. The IHA analysis provided the necessary output to address all of the questions to follow and additional analysis did not appear to add value given the resources needed to develop and use those tools. In the case of RCHARC, the tool developer was also not supportive of its use for this purpose based on deviations from the original intent of the tool realized during the 1998 Draft Water Allocation EIS (Freeman Pers. Comm).

2.2 RESPONSE TO PAL SECTION 3.2 HEC-5Q Water Quality Model Output Analyses

In consideration of the range of potential responses by the state of Georgia and metropolitan Atlanta water users between Buford Dam and Peachtree Creek to the July 2009 Federal district court ruling, the Corps (in the Proposed Action analysis) modeled two scenarios for minimum flow requirements at Peachtree

Creek for water quality purposes. These scenarios were developed assuming that Atlanta's water withdrawers and dischargers into the Chattahoochee River from Buford Dam to Peachtree Creek would manage their operations to meet minimum flow requirements at Peachtree Creek. Scenario 1 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 550 cfs remains in the Chattahoochee River at Peachtree Creek. Scenario 2 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 750 cfs is always available at Peachtree Creek. The 550 cfs flow at Peachtree Creek was analyzed based on a previous request from Georgia EPD for temporary relief from the 750 cfs level during the 2006 – 2008 drought and knowledge that flows lower than this level would not meet the current physical constraints of several water supply intakes between Buford Dam and West Point Lake. In the second scenario, water supply and wastewater providers would manage discharges and withdrawals downstream of Buford Dam to ensure that a minimum flow of 750 cfs would be available at Peachtree Creek as defined in the current Chattahoochee River Management System protocols. In the Proposed Action Alternative evaluation, all Corps operations are the same. The two scenarios reflect two separate potential consumption quantities for the reach between Buford Dam and the confluence with Peachtree Creek. In the plots and figures below, the two scenarios are labeled as scenario 1 and scenario 2 or Alt-550 and Alt_750 respectively.

The HEC-5Q modeled output was processed to illustrate variations between the Proposed Action Alternative and No Action Alternative for the ACF Basin. The modeled results were compared longitudinally down the Chattahoochee River of the ACF Basin and as time series in select locations. Longitudinal plots, or system profiles, were initially examined to understand the most critical locations for water quality related to various parameters. Following an evaluation of the range of longitudinal modeled results, specific locations were selected where the range of modeled output was the greatest. The time series of modeled results were plotted at specific locations to illustrate the seasonal response of pollutants.

Model results were output in six-hour time intervals in the river and reservoirs. The results presented below were analyzed at various seasonal intervals, generally, May through October. All model results were reviewed annually, seasonally, and based on dry, average, and wet year types for each alternative. The following plots can be used to address questions presented in the PAL by parameter. Note that the longitudinal figures present the percent occurrence of modeled output; the opposite of the percent exceedence. It was recommended that percent exceedence may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality.

2.2.1 Dissolved Oxygen

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters.

Figures 2.2-1 and 2.2-2 present the variations of dissolved oxygen modeled along the Chattahoochee River. These results do not explicitly define the number of days when concentrations are less than state standards (6 mg/L for secondary trout waters and 5 mg/L) but they do provide insight to where low dissolved oxygen concentrations occur for the period from May through October. Figures 2.2-3 through 2.2-5 present dissolved oxygen occurrence plots at Norcross, Georgia and Morgan Falls Dam. These locations are within the secondary trout waters.

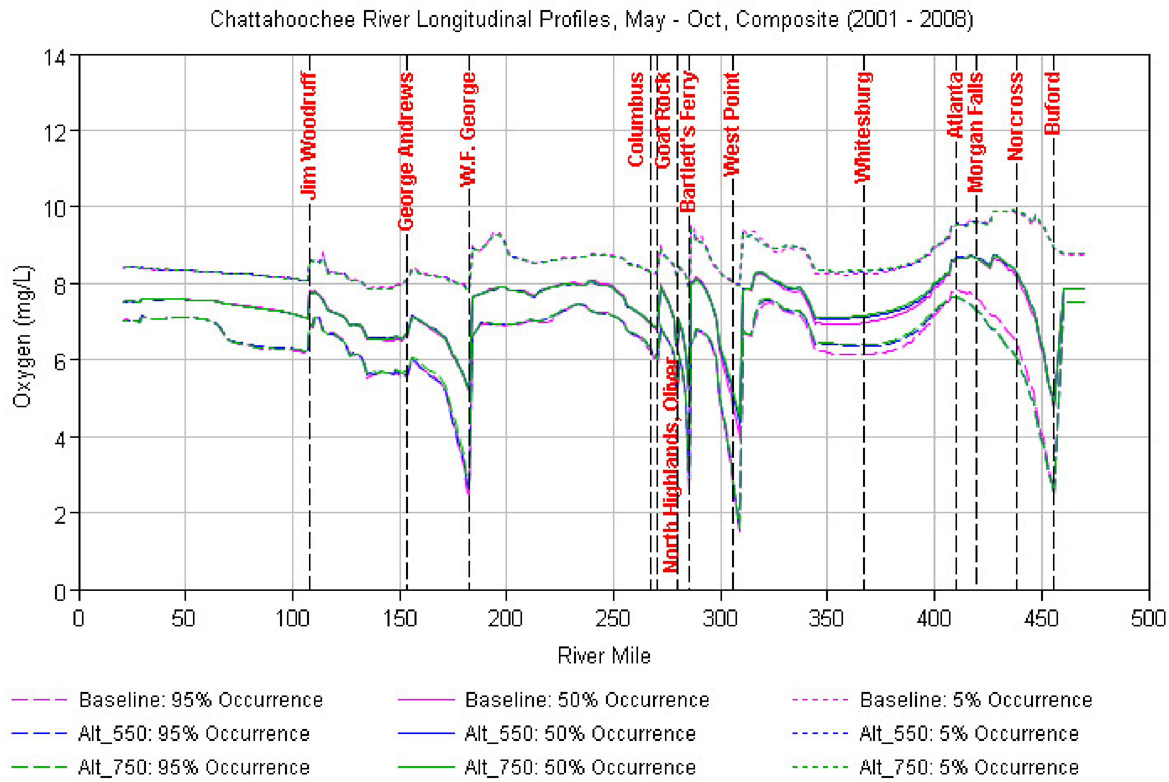


Figure 2.2-1. May – October Dissolved Oxygen for the modeled period from 2001 through 2008.

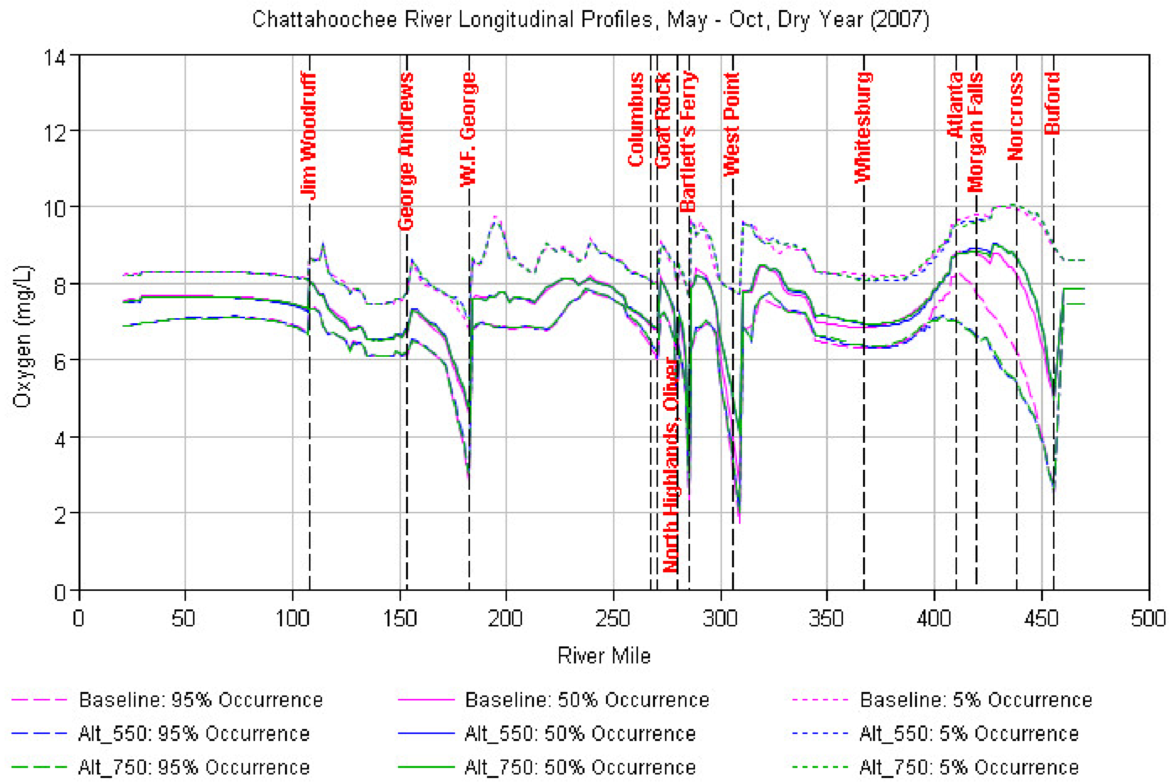


Figure 2.2.-2. May – October Dissolved Oxygen modeled for a representative dry period (2007) when violations would be expected.

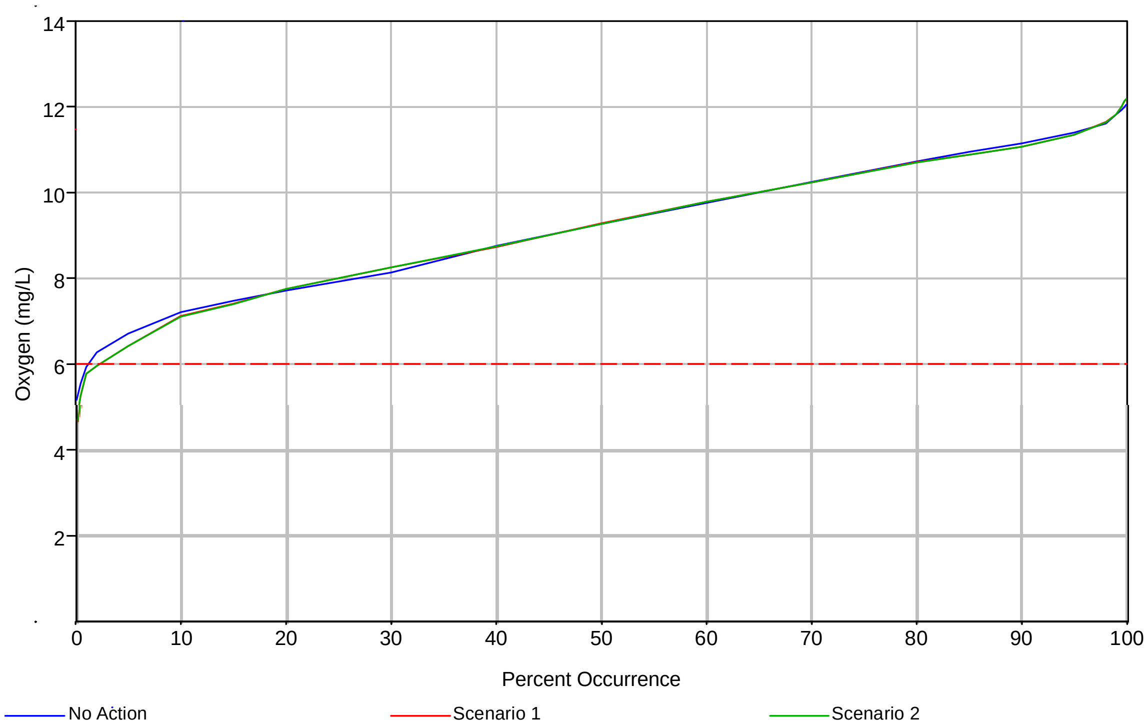


Figure 2.2-3. Occurrence of daily average dissolved oxygen in the Chattahoochee River at Norcross, Georgia, for the period from 2001 through 2008.

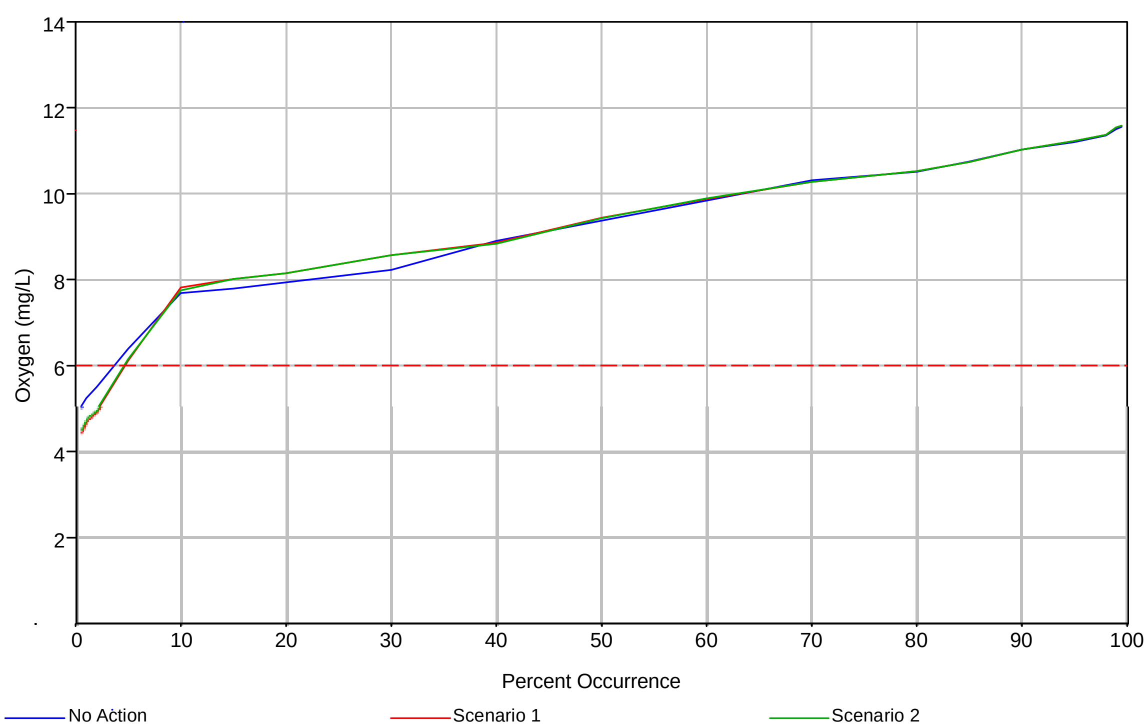


Figure 2.2-4. Occurrence of daily average dissolved oxygen in the Chattahoochee River at Norcross, Georgia, for a representative dry year (2007).

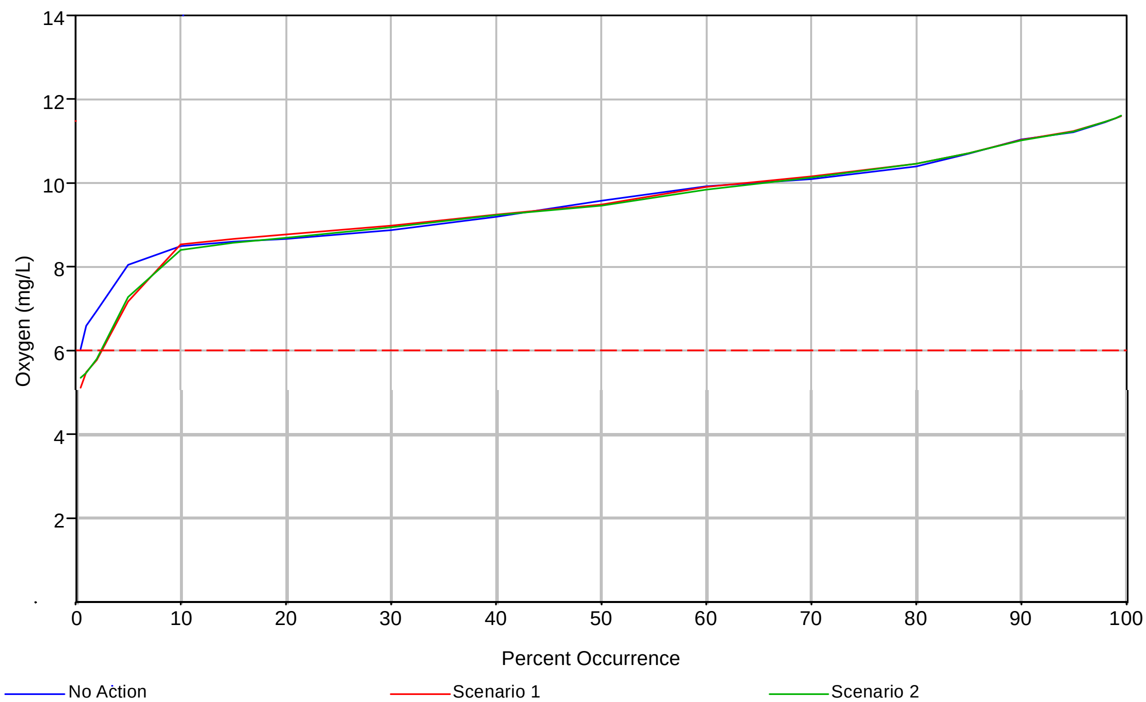


Figure 2.2-5. Occurrence of daily average dissolved oxygen in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for a representative dry year (2007).

The occurrence plots to follow (Figures 2.2-6 through 2.2-21) illustrate occurrences of dissolved oxygen at locations where median concentrations are less than state standards from Figures 2.2-1 and 2.2-2. These locations are downstream of Buford, West Point, Bartlett's Ferry, and Walter F. George Dams.

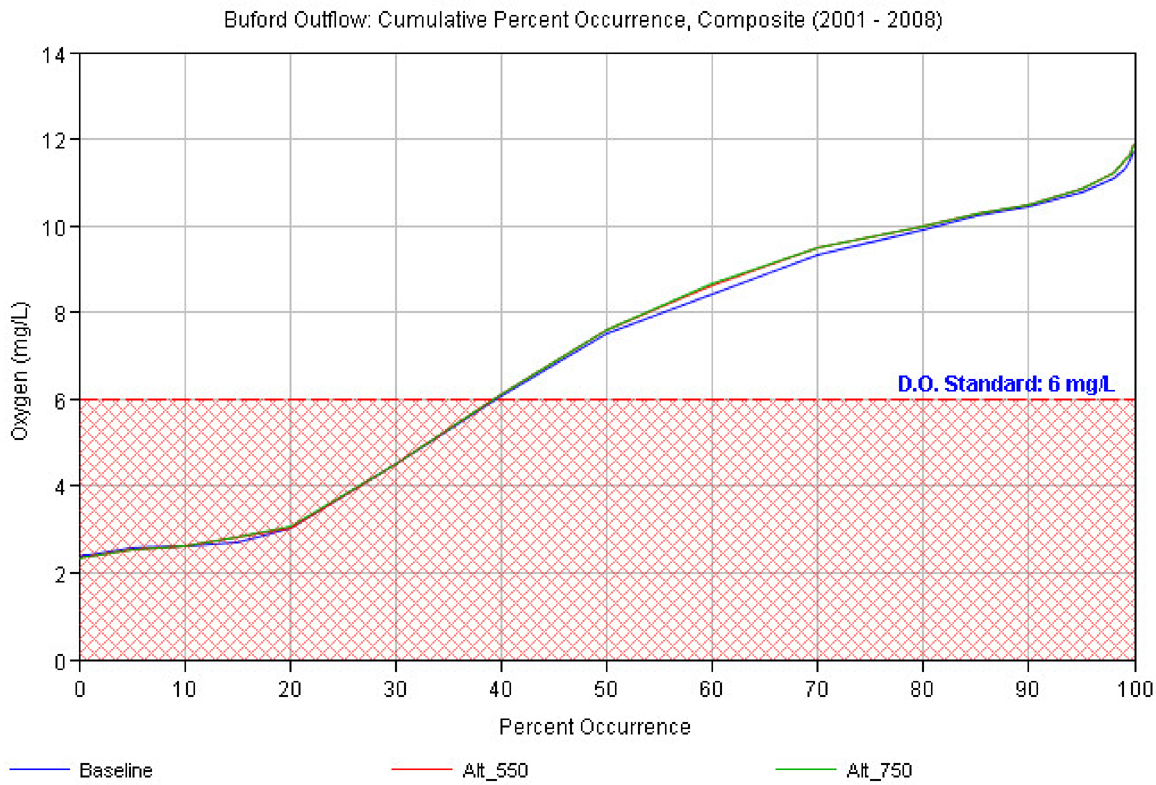


Figure 2.2-6. Dissolved Oxygen occurrence downstream of Buford Dam for the modeled period (2001 – 2008).

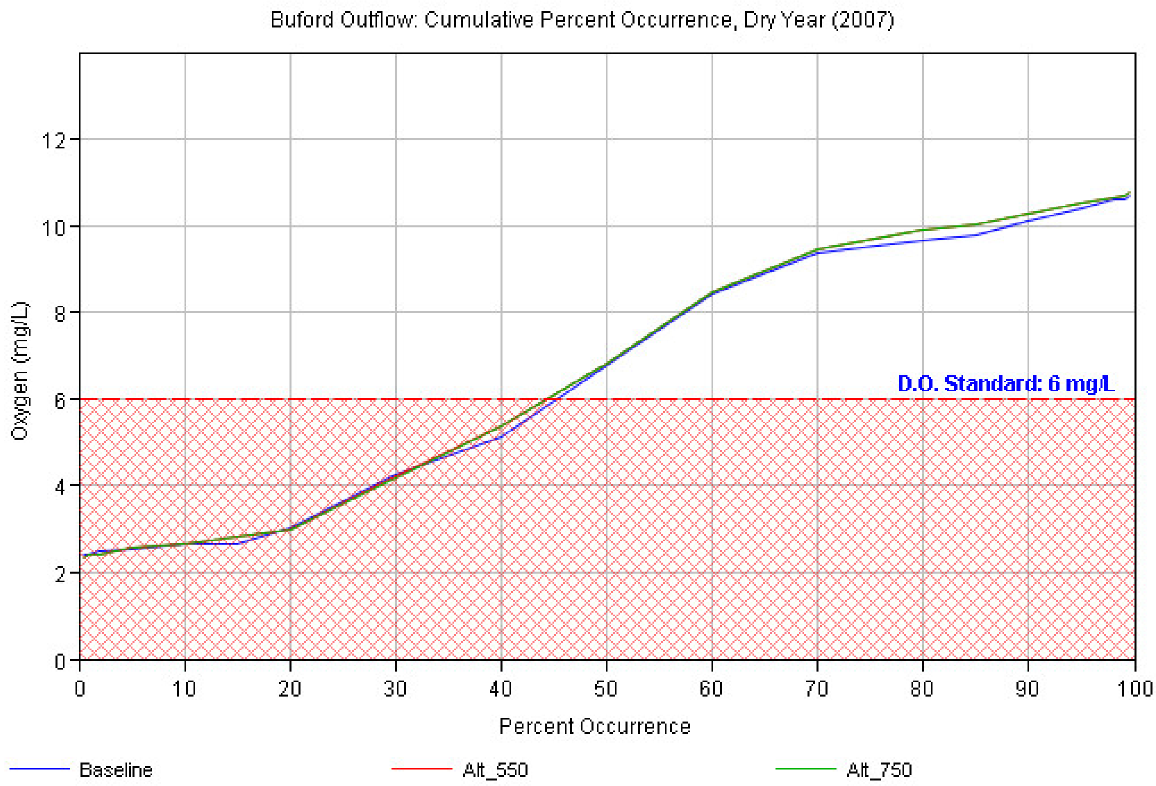


Figure 2.2-7. Dissolved Oxygen occurrence downstream of Buford Dam for a representative dry year (2007).

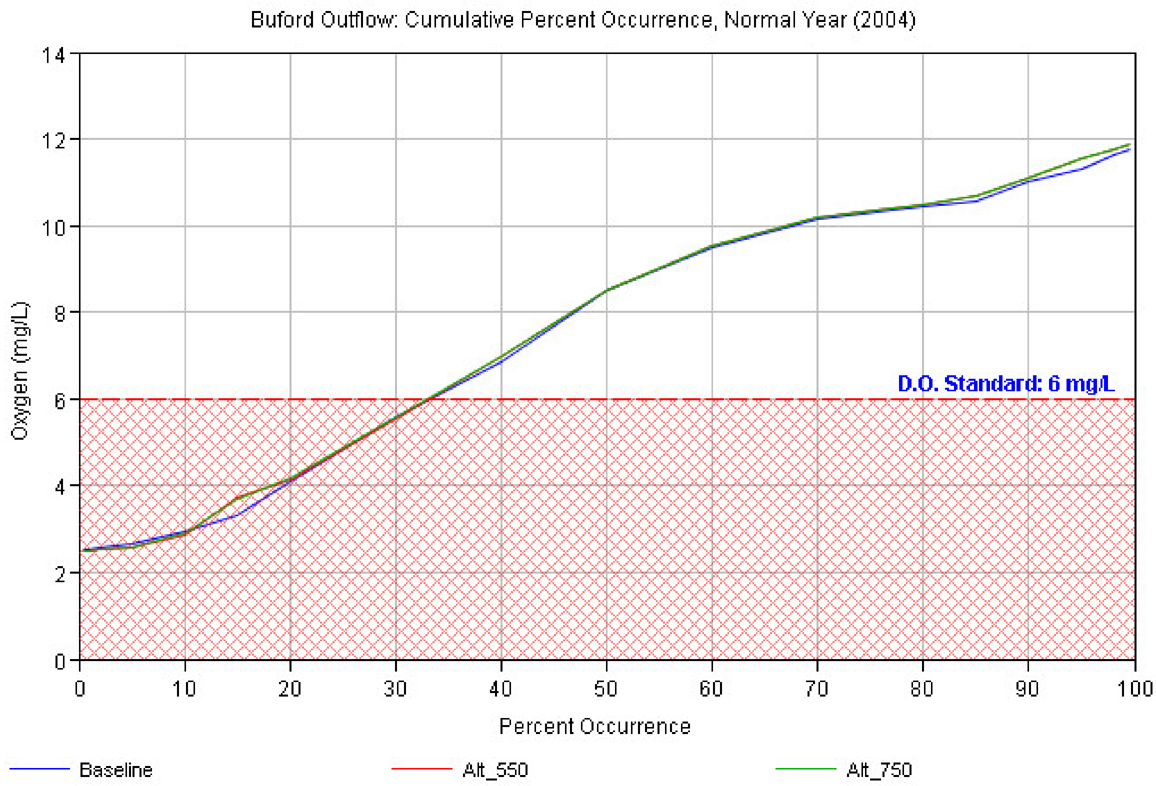


Figure 2.2-8. Dissolved Oxygen occurrence downstream of Buford Dam for a representative normal year (2004).

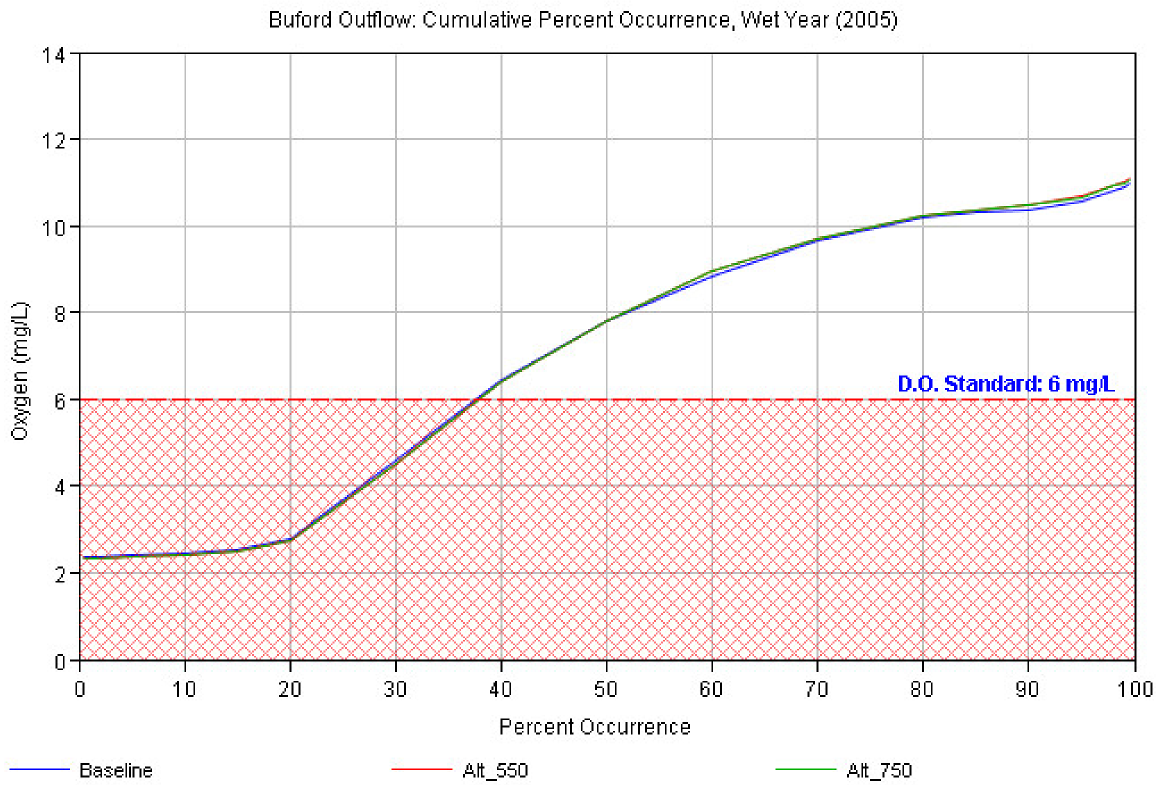


Figure 2.2-9. Dissolved Oxygen occurrence downstream of Buford Dam for a representative wet year (2005).

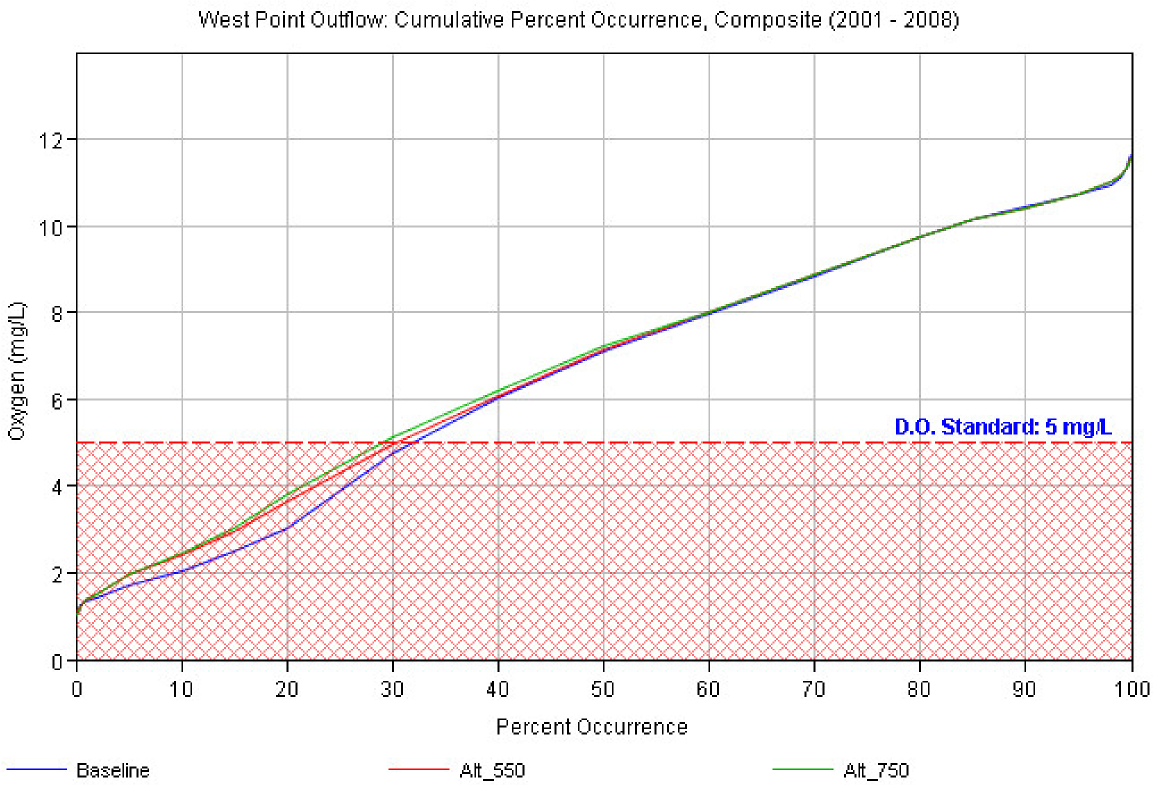


Figure 2.2-10. Dissolved Oxygen occurrence downstream of West Point Dam for the modeled period (2001 - 2008).

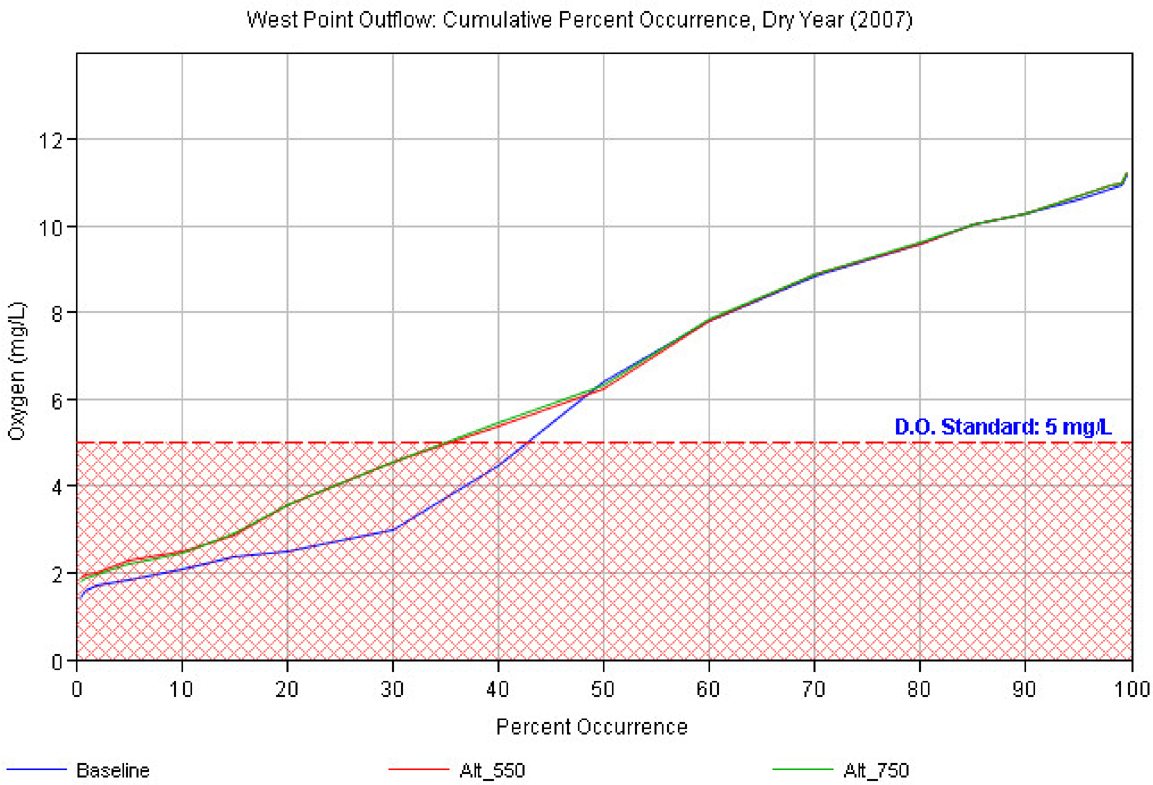


Figure 2.2-11. Dissolved Oxygen occurrence downstream of West Point Dam for a representative dry year (2007).

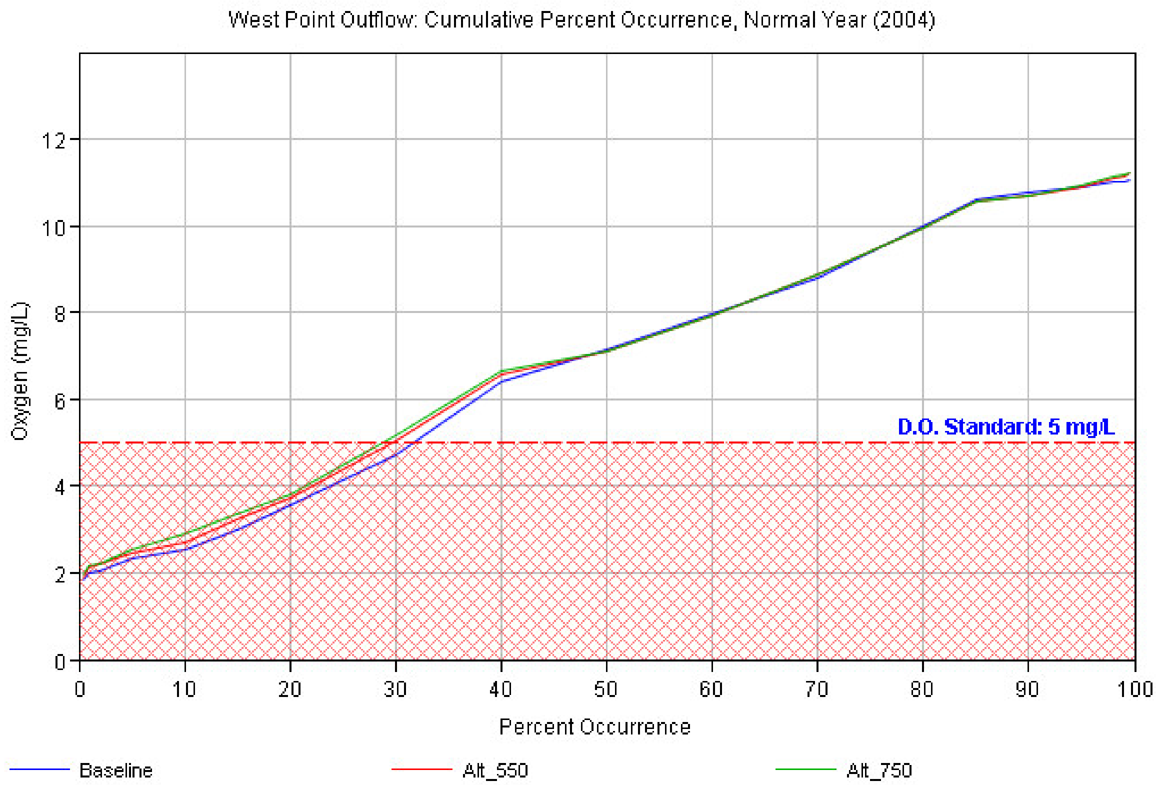


Figure 2.2-12. Dissolved Oxygen occurrence downstream of West Point Dam for a representative normal year (2004).

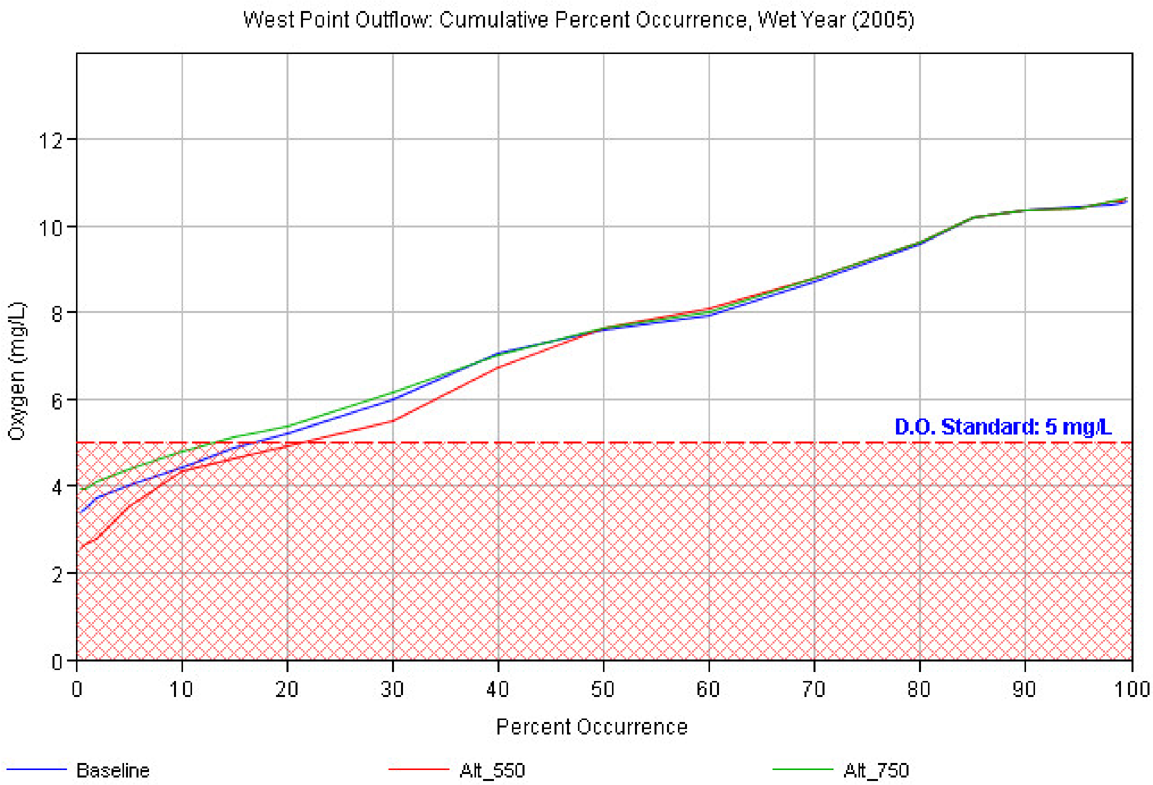


Figure 2.2-13. Dissolved Oxygen occurrence downstream of West Point Dam for a representative wet year (2005).

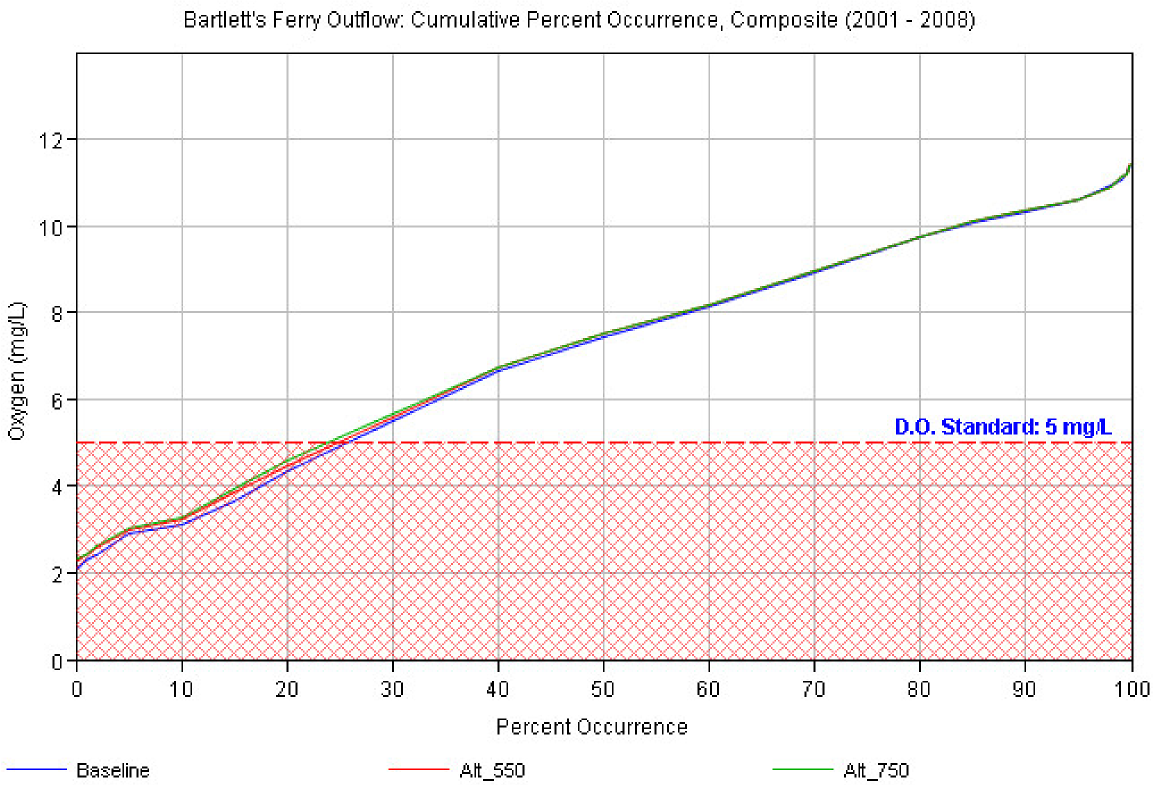


Figure 2.2-15. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for the modeled period (2001 - 2008).

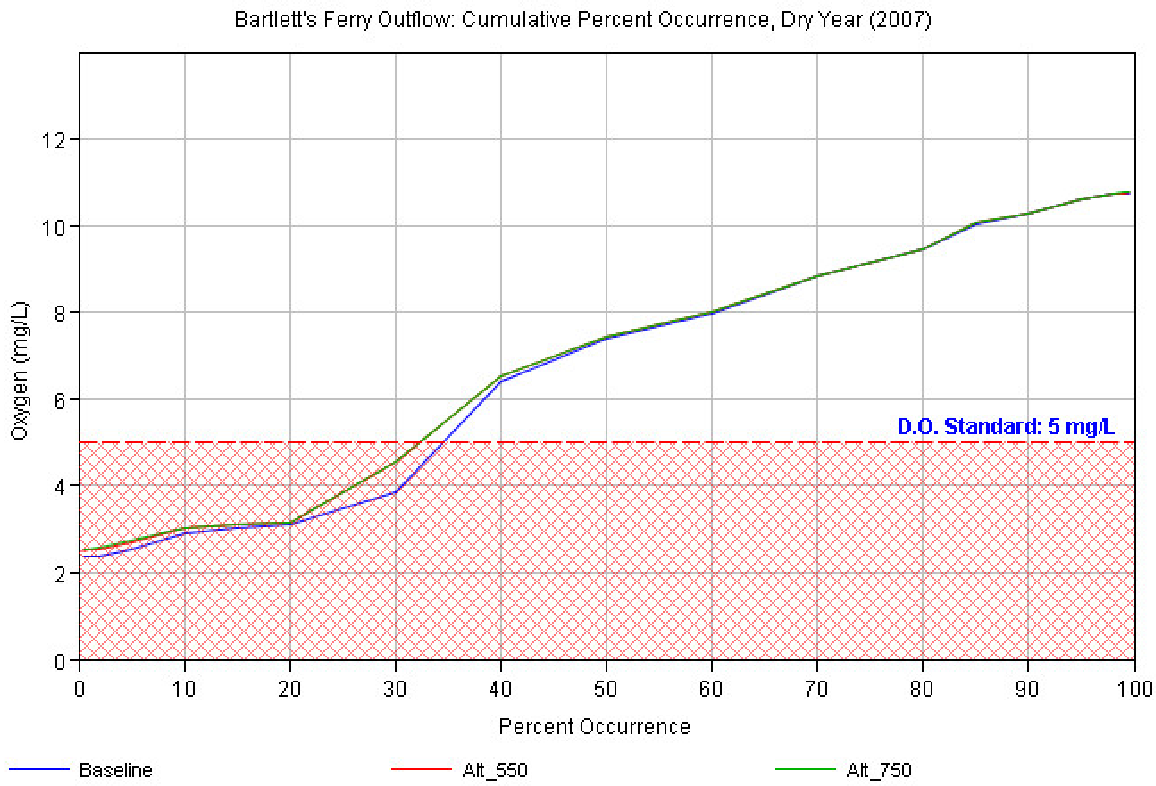


Figure 2.2-16. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for a representative dry year (2007).

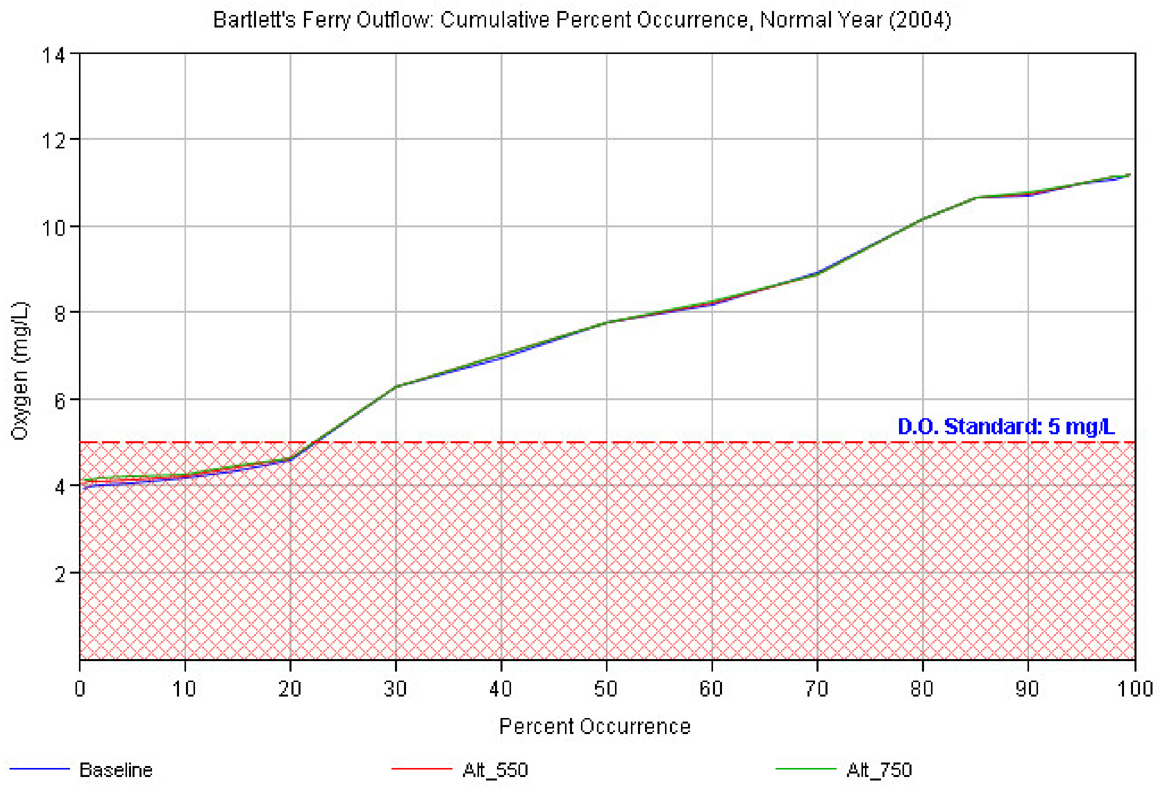


Figure 2.2-17. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for a representative normal year (2004).

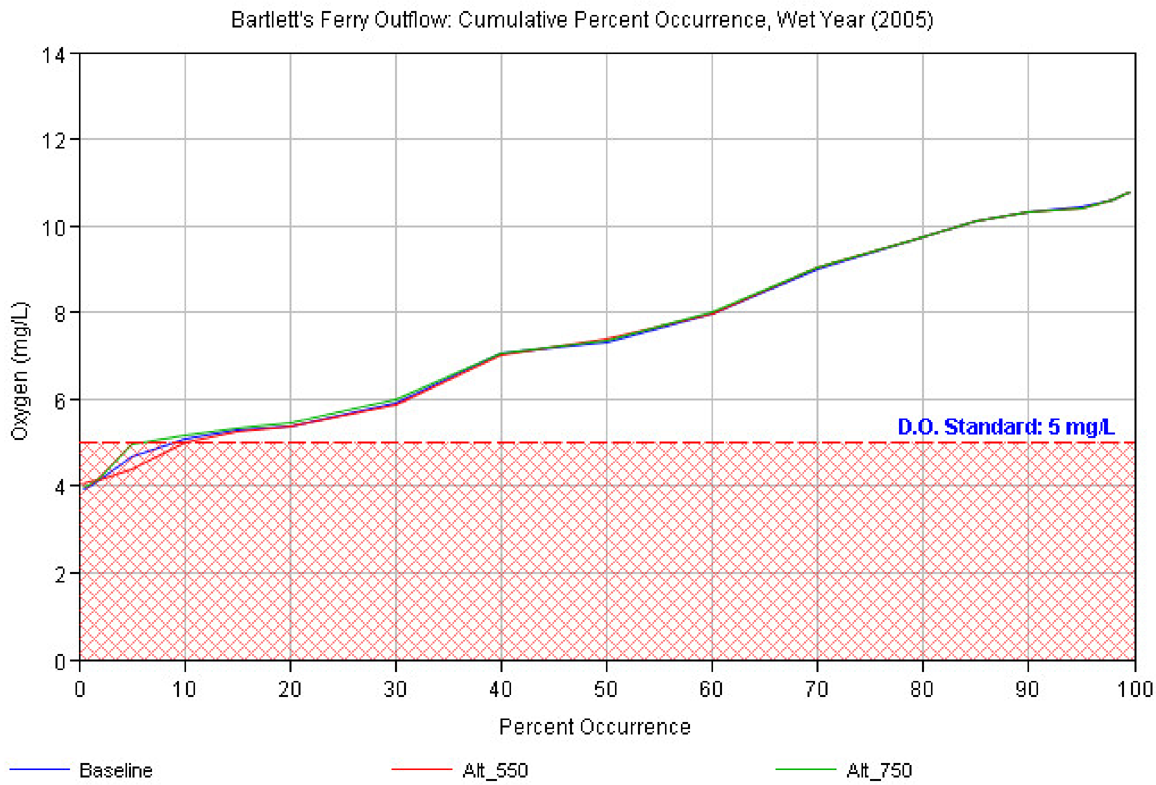


Figure 2.2-18. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for a representative wet year (2005).

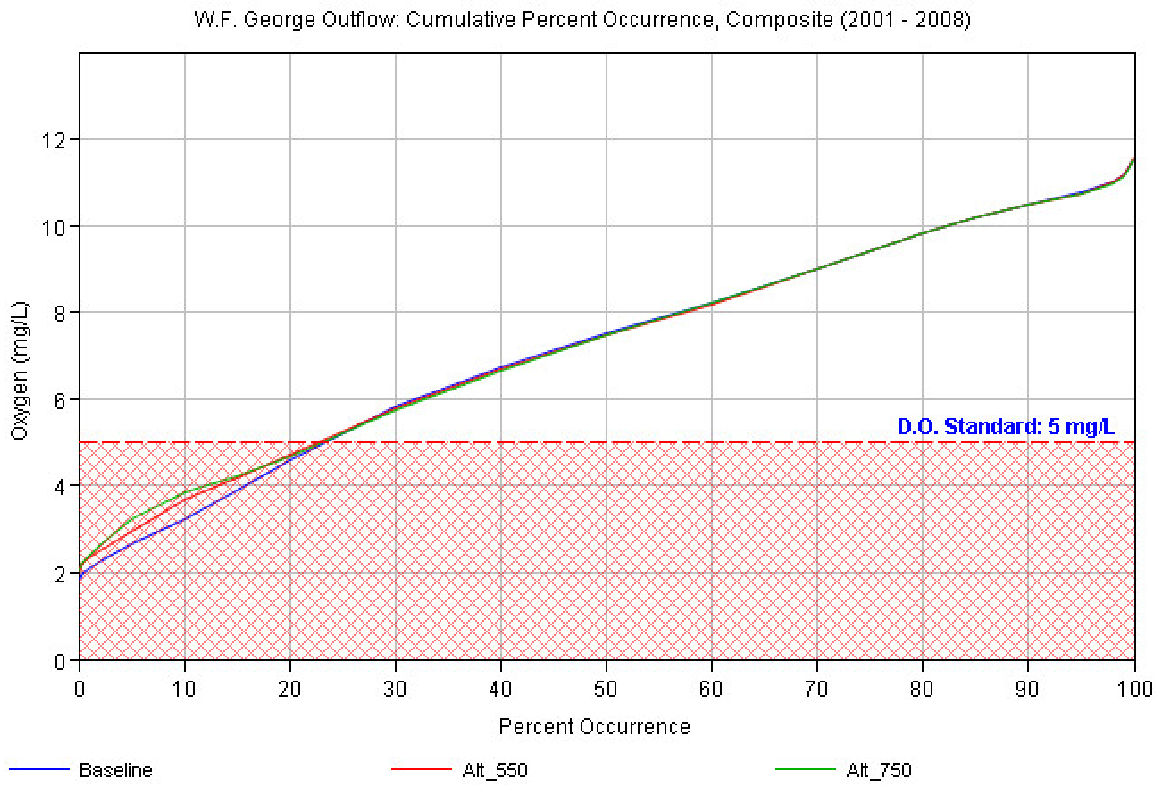


Figure 2.2-19. Dissolved Oxygen occurrence downstream of Walter F. George Dam for the modeled period (2001-2008).

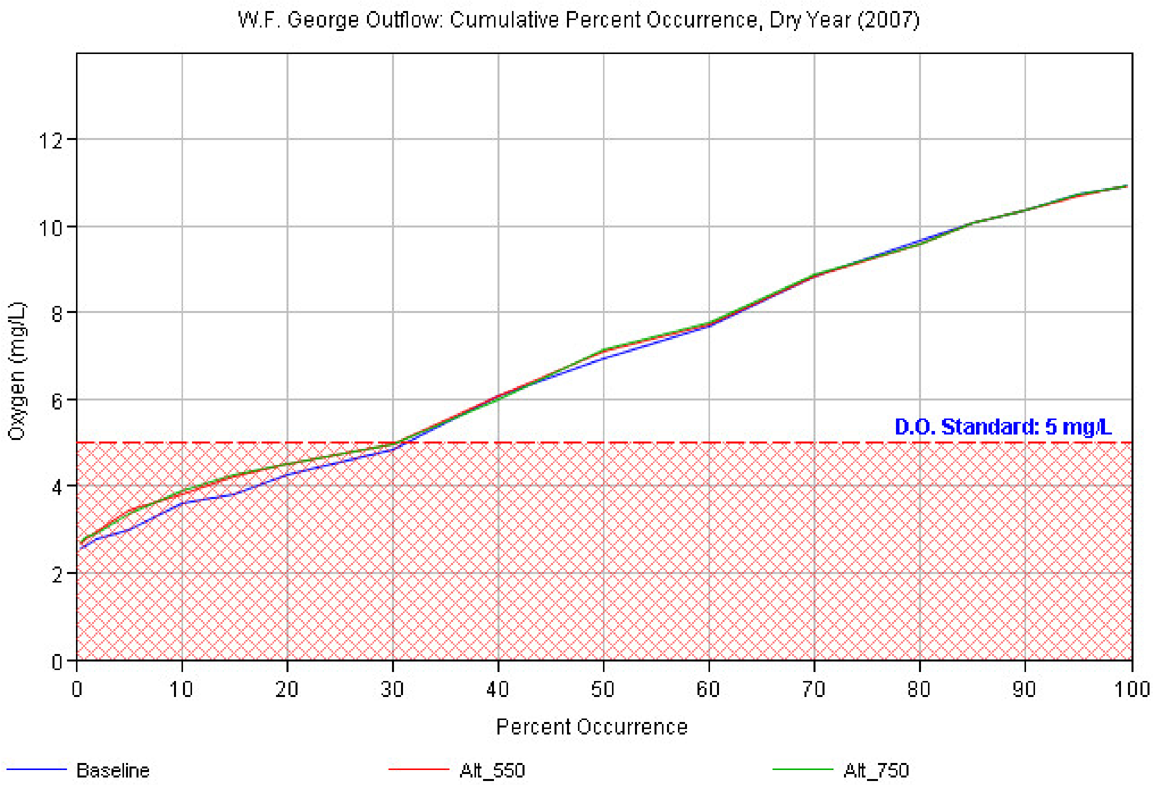


Figure 2.2-20. Dissolved Oxygen occurrence downstream of Walter F. George Dam for a representative dry year (2007).

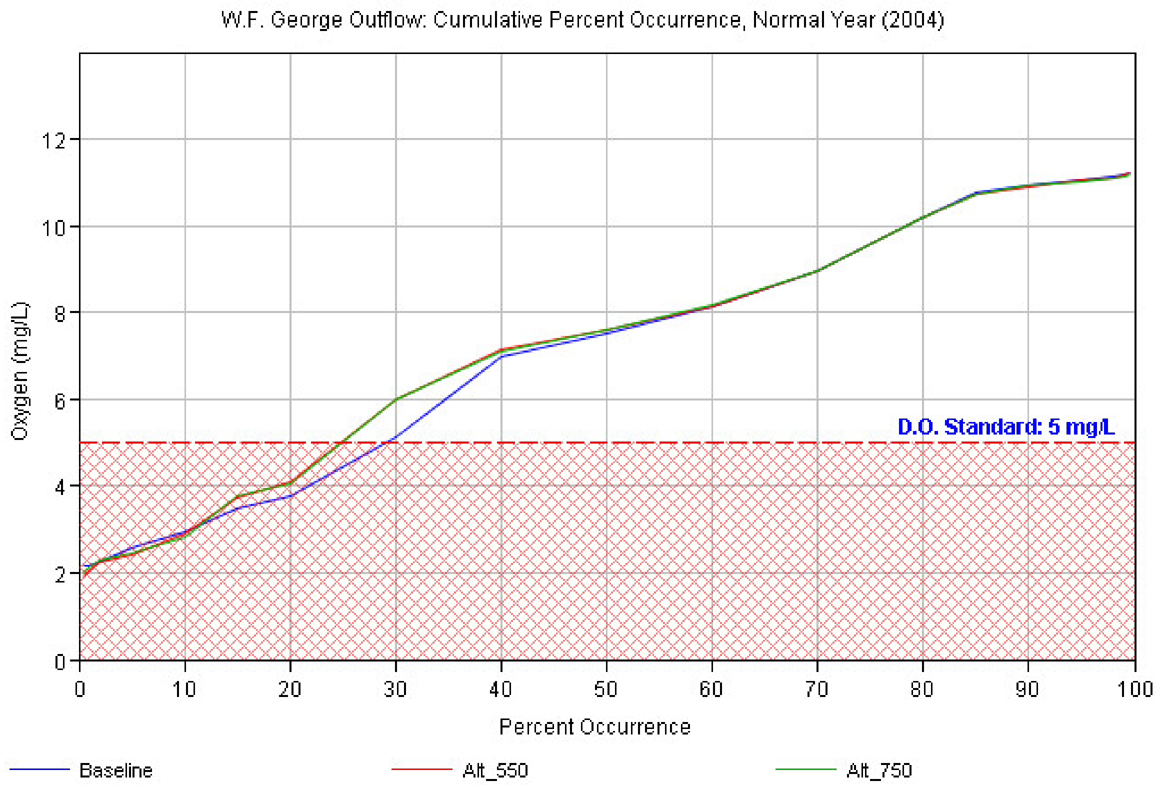


Figure 2.2-21. Dissolved Oxygen occurrence downstream of Walter F. George Dam for a representative normal year (2004).

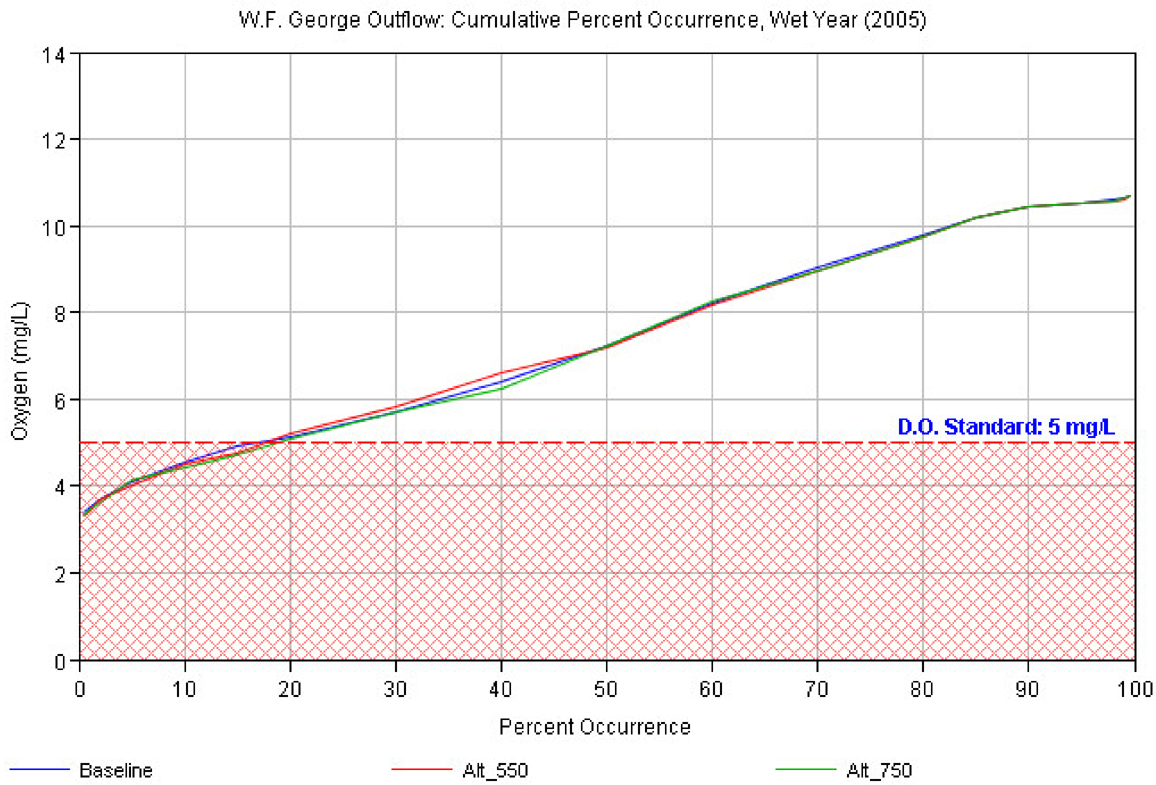


Figure 2.2-21. Dissolved Oxygen occurrence downstream of Walter F. George Dam for a representative wet year (2005).

- Total number of instantaneous "measurements" less than 4 mg/L.

Instantaneous modeled results were not simulated. The river profile simulations suggest that DO values less than 4 mg/L are only expected at several tailrace locations (as illustrated in Figures 2.2-6 through 2.2-21). Time series plots for these locations are also provided below in Figures 2.2-22 through 2.2- 25. Despite low concentrations of dissolved oxygen in dam tailraces, the Proposed Action Alternative generally increases concentrations over the No Action Alternative as illustrated in Figures 2.2-6 through 2.2-21. The exception to this is in periods of wet weather in scenario 1 (Figure 2.2-13), where minimum flows are decreased at Peachtree Creek to 550 cfs but the load transported downstream is not changed. In this scenario concentrations of oxygen consuming pollutants are greater. It may be representative to look at conditions under scenario 2 during wet weather periods. It would be expected that a minimum flow of 750 cfs could be easily achieved at Peachtree Creek during wet weather periods. If instream flows are greater, the concentrations of oxygen consuming pollutants would be more easily assimilated.

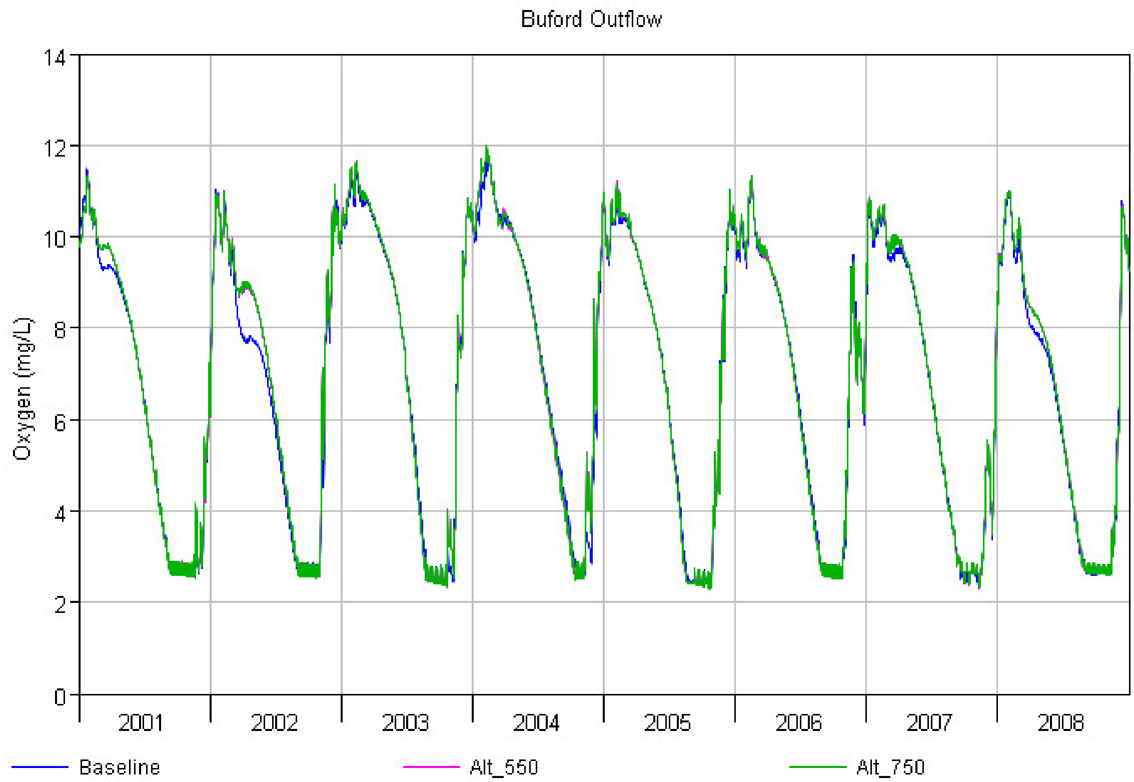


Figure 2.2-22. Time series DO from Buford Dam releases.

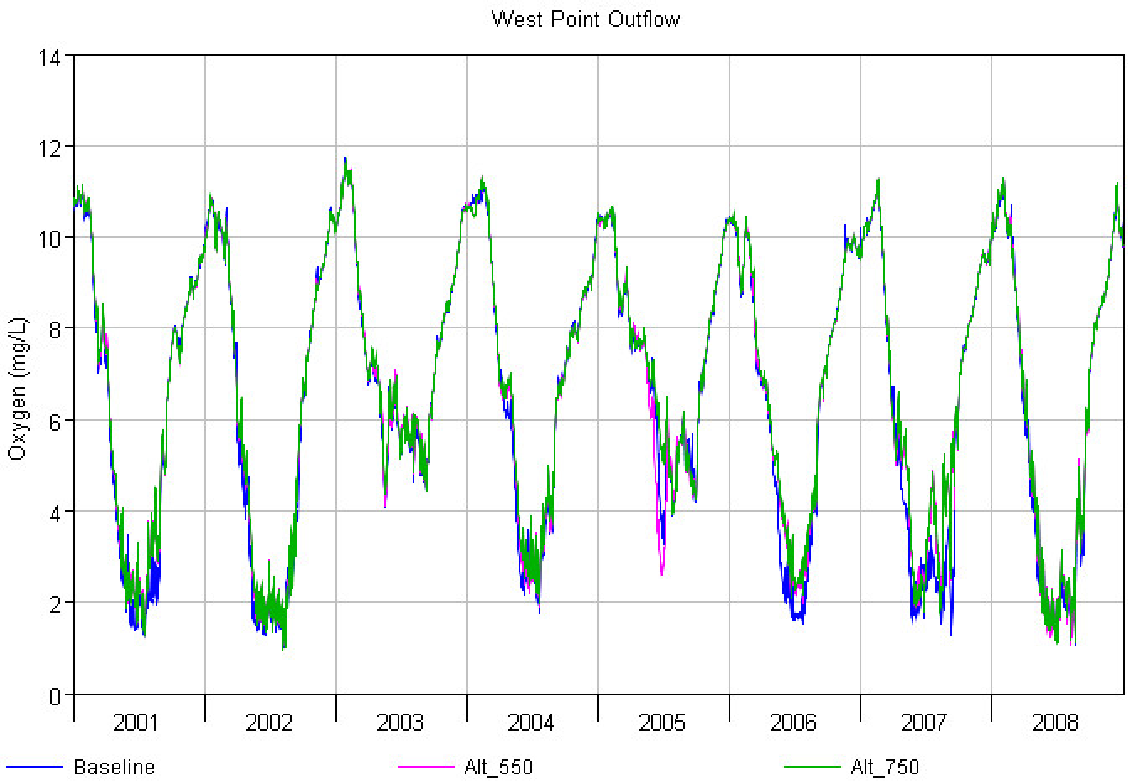


Figure 2.2-23. Time series DO from West Point Dam releases.

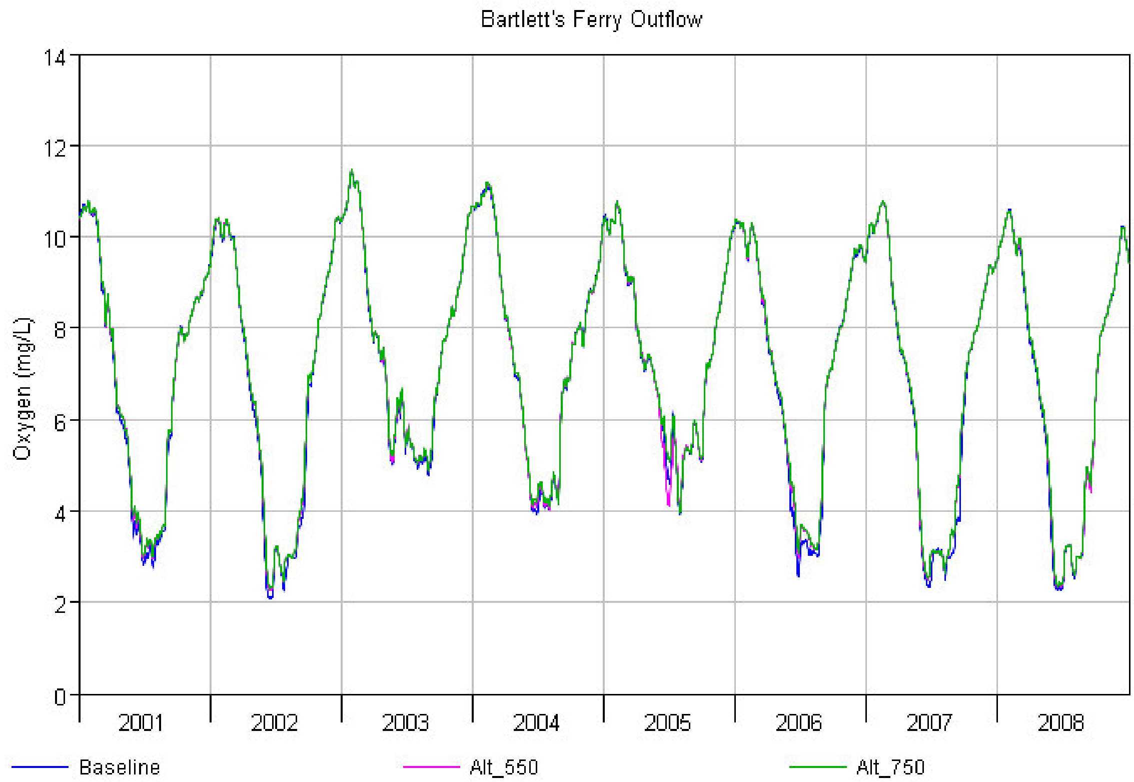


Figure 2.2-24. Time series DO from Bartlett's Ferry Dam releases.

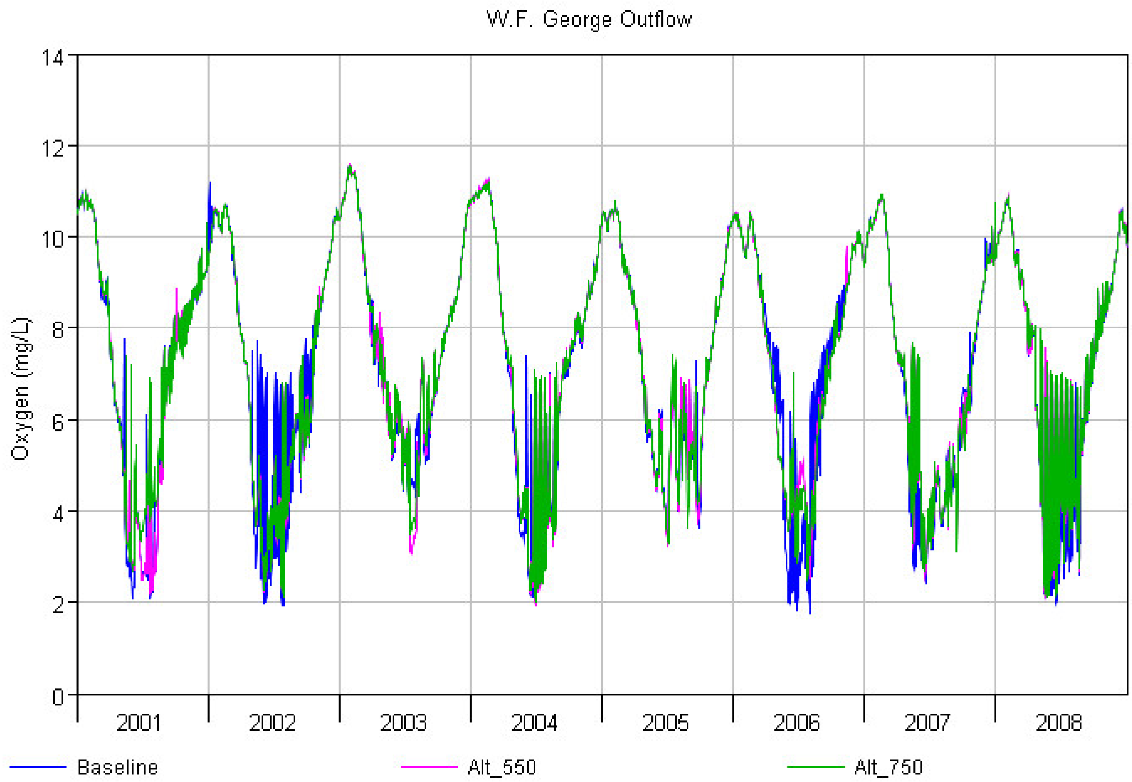


Figure 2.2-25. Time series DO from Walter F. George Dam releases.

- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L).

Monthly exceedance figures for dissolved oxygen were not generated. However, the following figure generally provides the same information in a format we feel is easier to communicate. Figure 2.2-26 illustrates the change in dissolved oxygen values between the No Action Alternative and the Proposed Action (Proposed Action minus No Action is illustrated) at the 5%, 50%, and 95% occurrence intervals. For these DO plots, the 95% occurrence interval means that the values are this number or lower 95% of the simulation at this location (i.e., only 5% of the time the value is higher than this – a rare occurrence). Conversely, the 5% occurrence interval means that the values are this number or lower 5% of the simulation at this location (i.e., 95% of the time the value is higher than this – this too is a rare occurrence). The 50% occurrence represents the average occurrence.

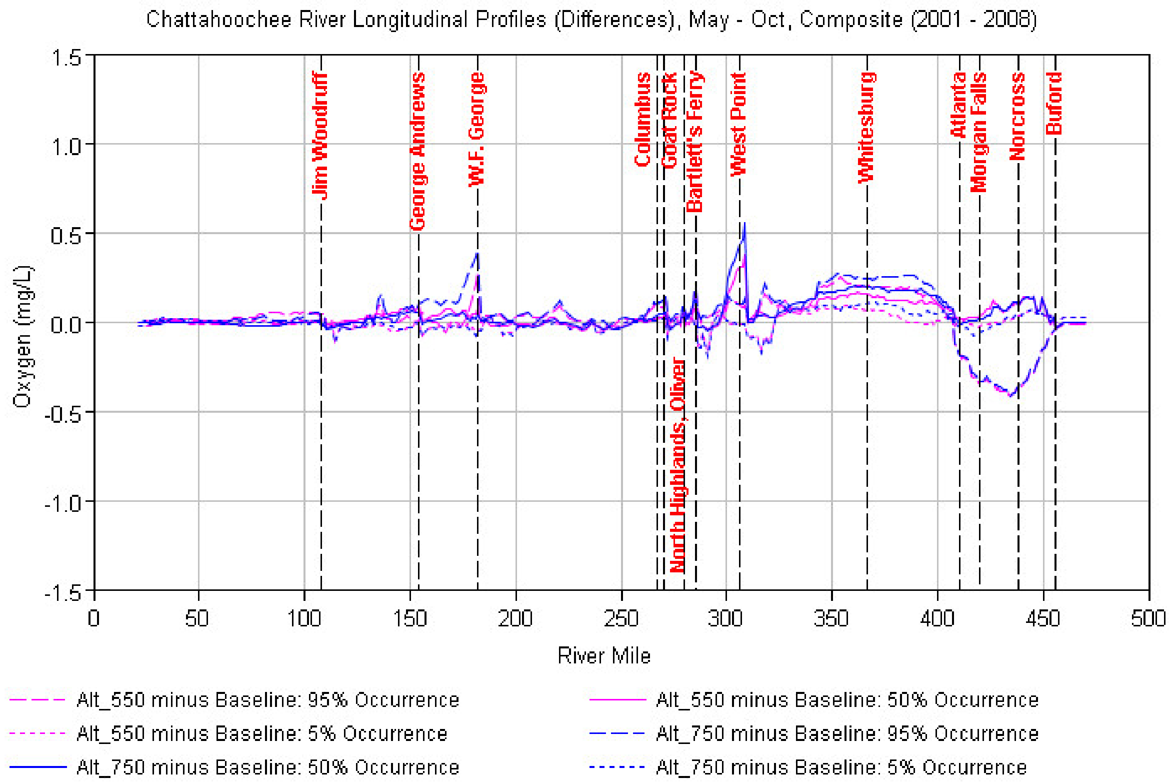


Figure 2.2-26. Changes in longitudinal dissolved oxygen in the Chattahoochee River for a May through October growing season (2001 through 2008).

2.2.2 Water Temperature

- Monthly exceedance figures and box plots with outliers for water temperature; and

Monthly exceedance figures for temperature were not generated. Again, river profiles and occurrence plots illustrated this information more clearly than the box plots. The figures to follow first illustrate temperatures along the riverine profile and then illustrate the change in temperature from the No Action Alternative. (Proposed Action minus No Action is illustrated). The delta profile plots clearly illustrate the magnitude of the change in water temperature of each of the scenarios as compared to the No Action Alternative (baseline condition) illustrated in the plots.

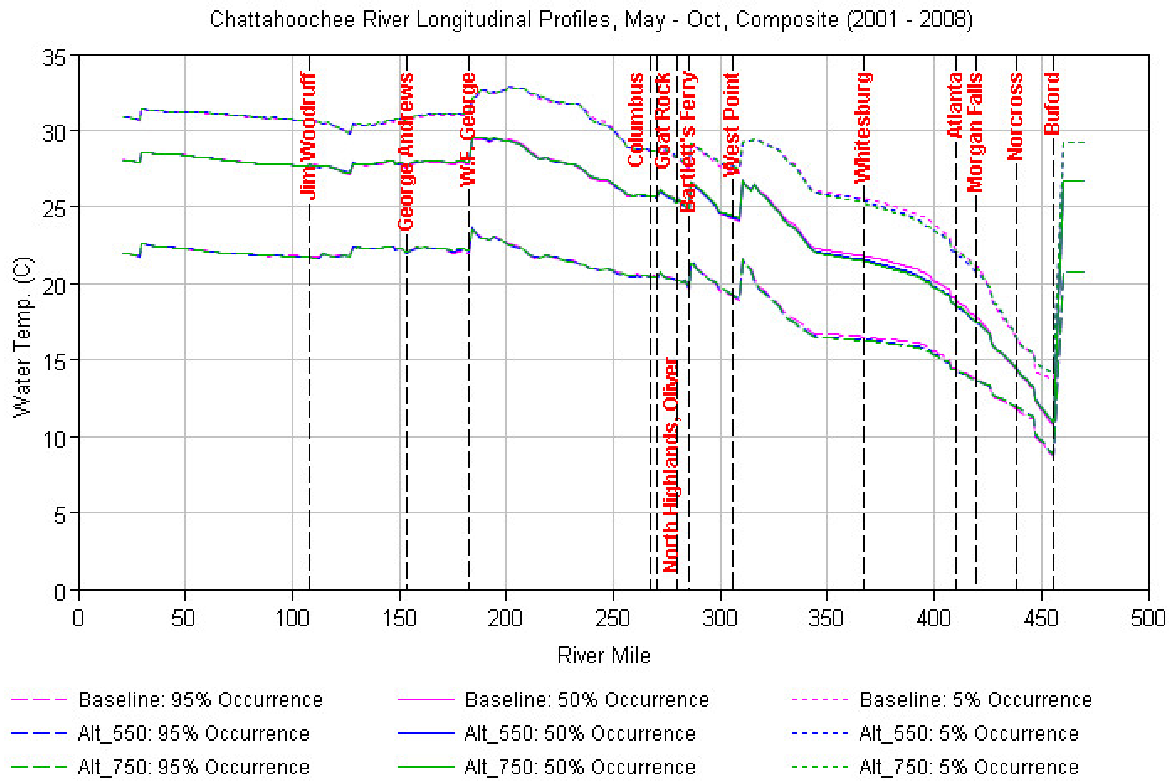


Figure 2.2-26. Temperatures along the Chattahoochee River for the modeled period (2001-2008).

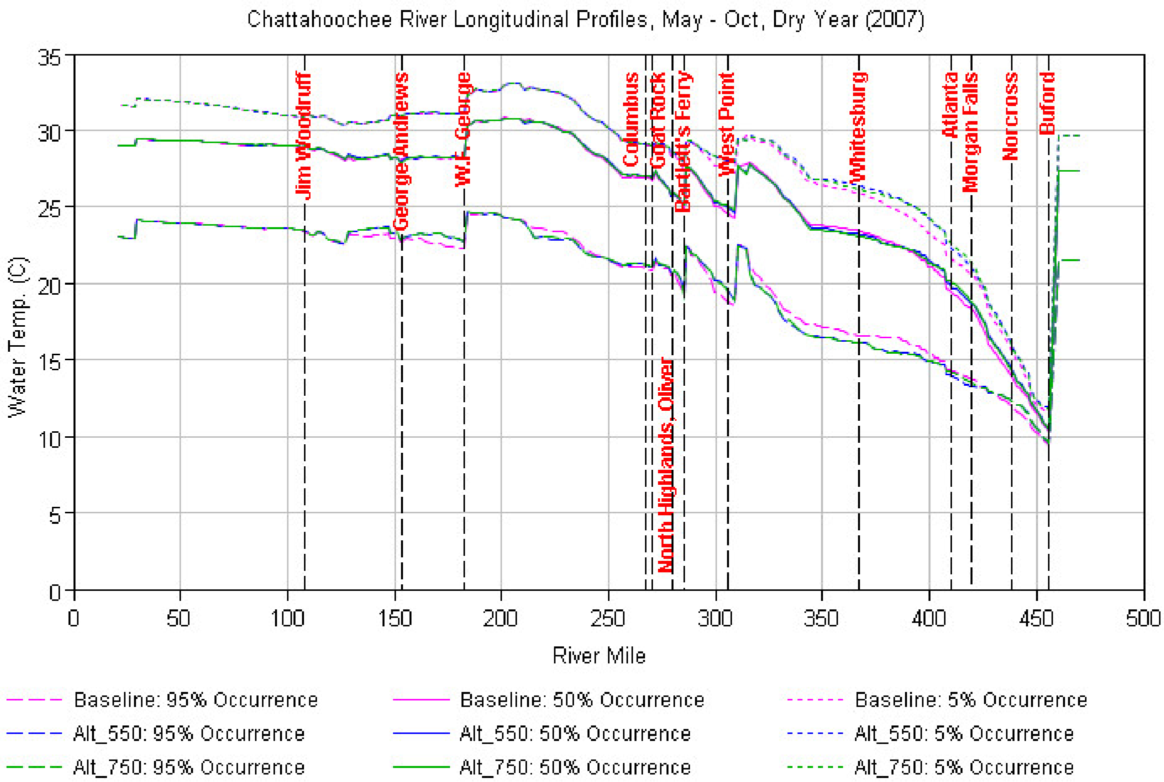


Figure 2.2-27. Temperatures along the Chattahoochee River for a representative dry year (2007).

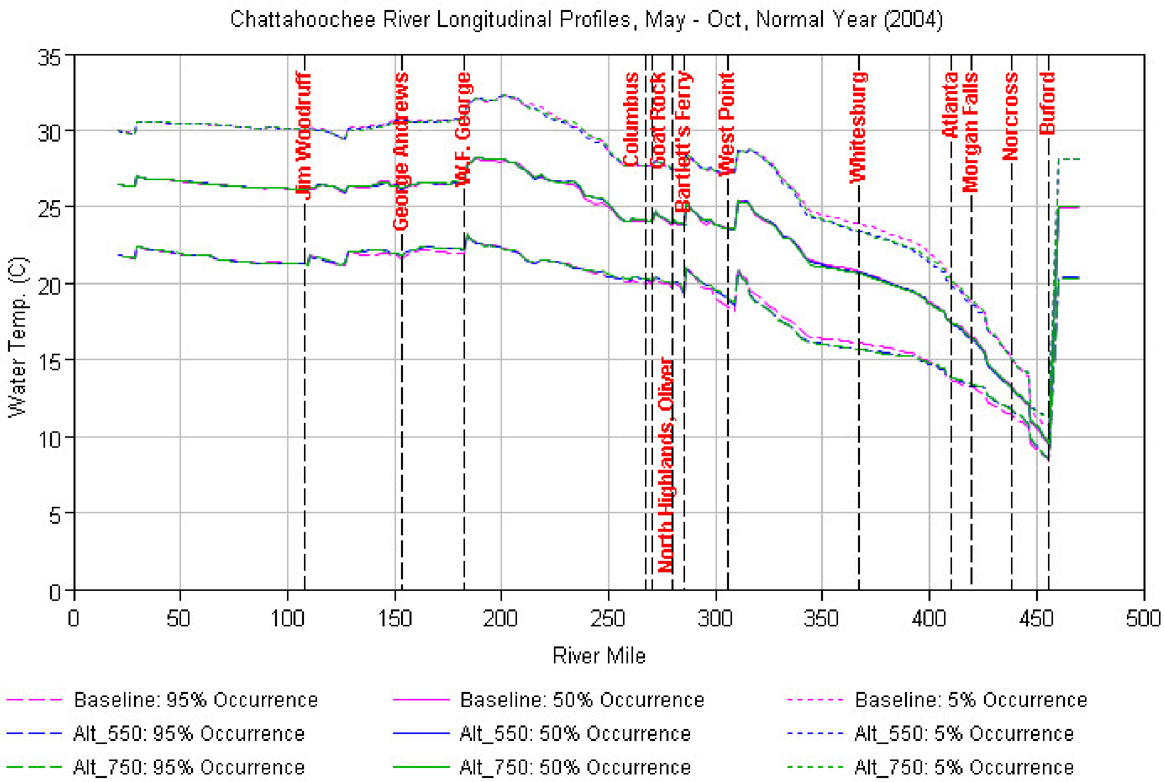


Figure 2.2-28. Temperatures along the Chattahoochee River for a representative normal year (2004).

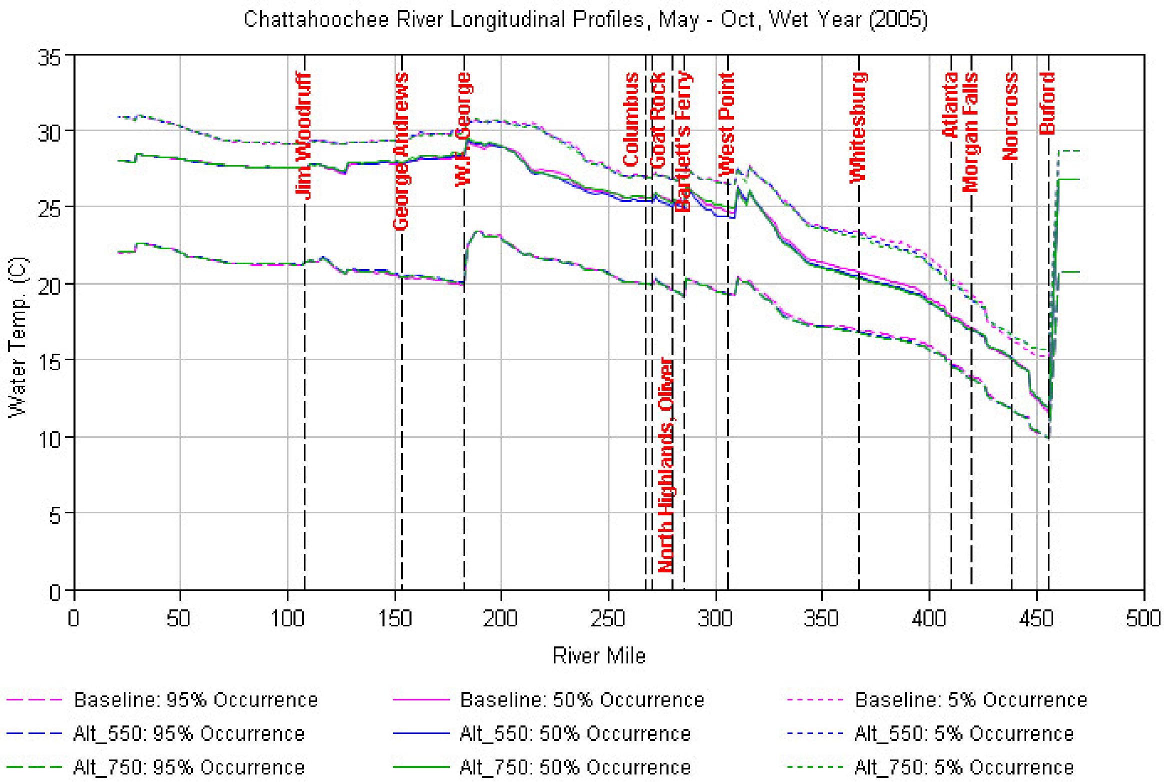


Figure 2.2-29. Temperatures along the Chattahoochee River for a representative wet year (2005).

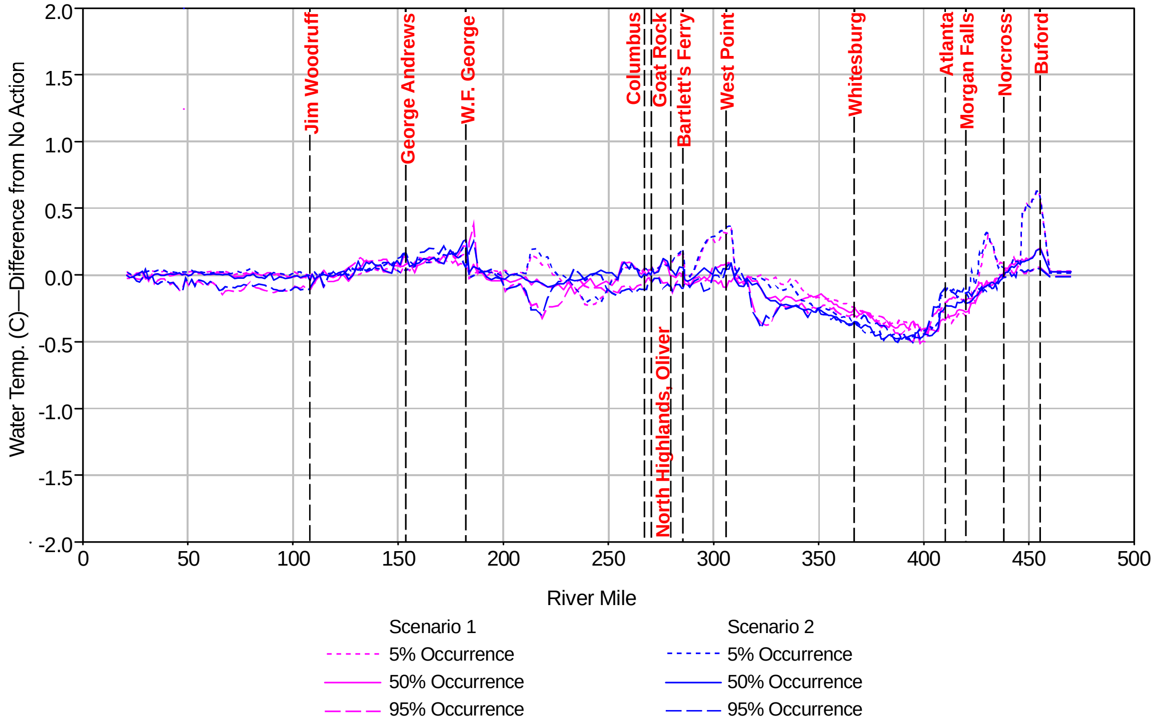


Figure 2.2-30. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions from 2001 through 2008.

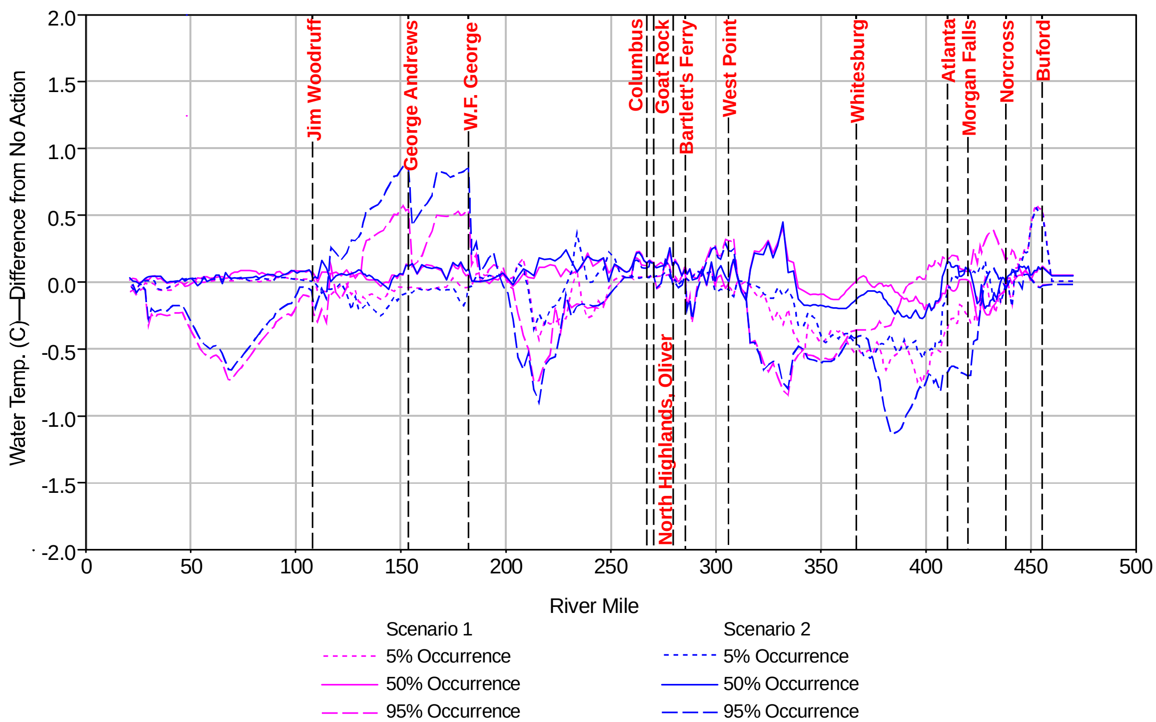


Figure 2.2-31. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions in a normal year (2004).

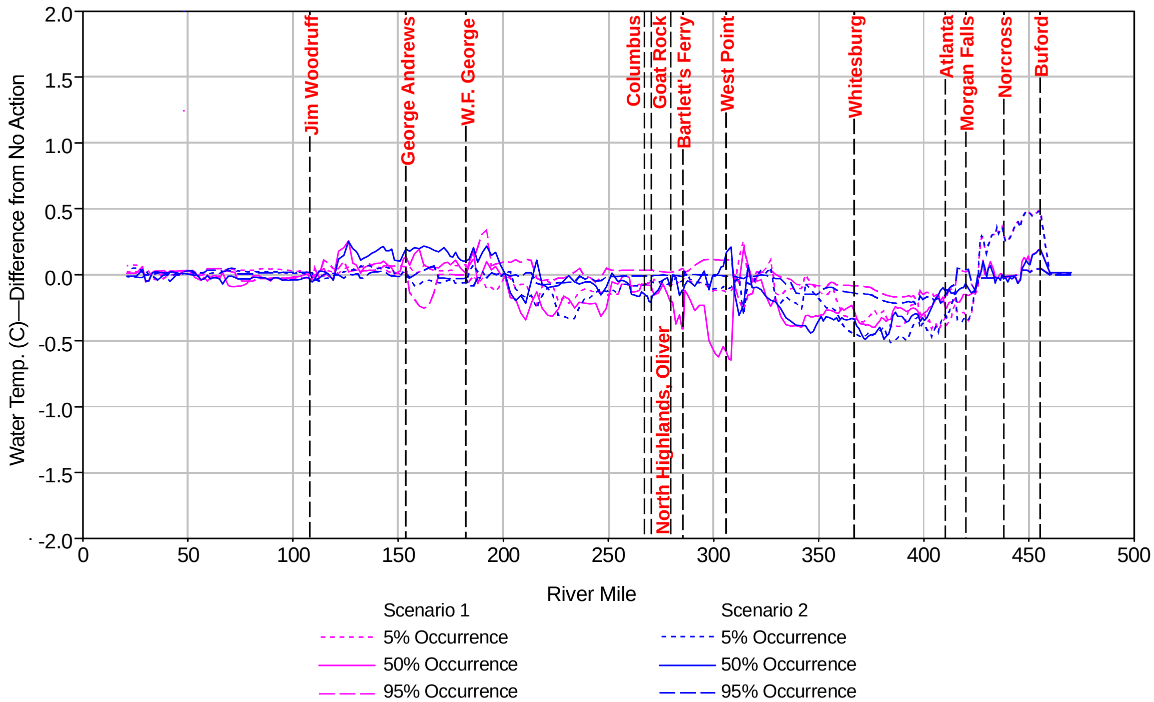


Figure 2.2-32. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions in a wet year (2005).

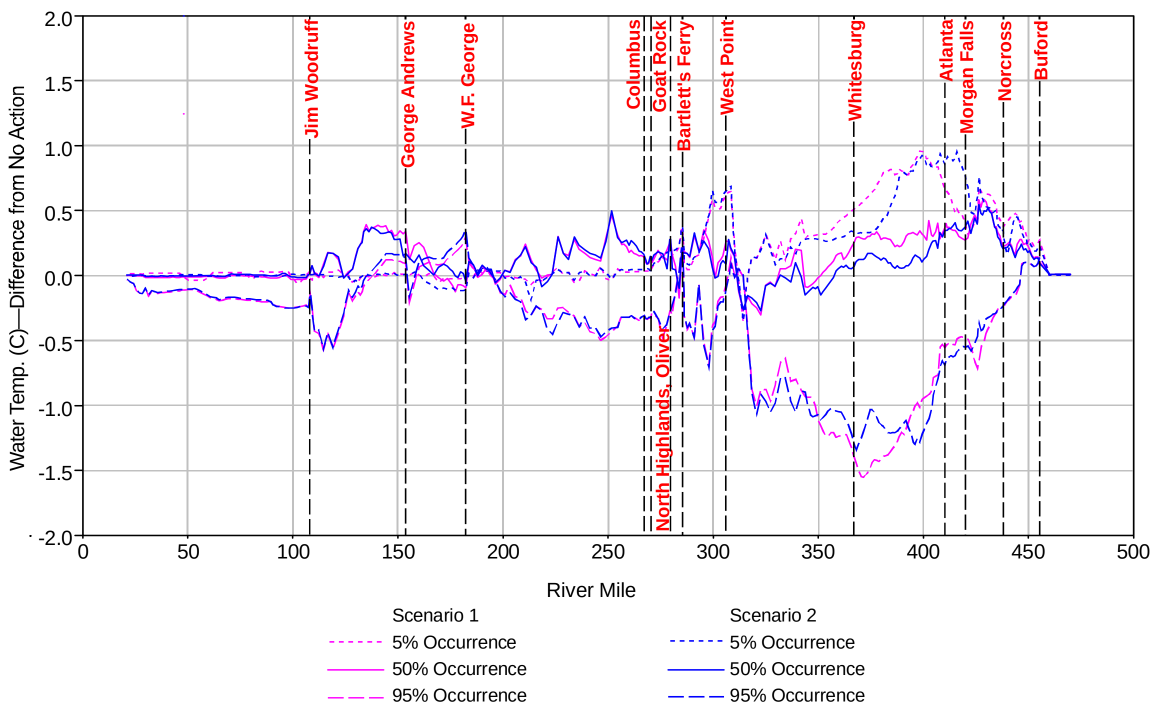


Figure 2.2-33. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions in a dry year (2007).

2.2.3 Wastewater

- Average stream percent wastewater.

Average stream flow percent that is wastewater is presented for May through October in the figures to follow; these figures also present the 5% and 95% occurrences. These results were also output by April through October, as presented in other water quality figures.

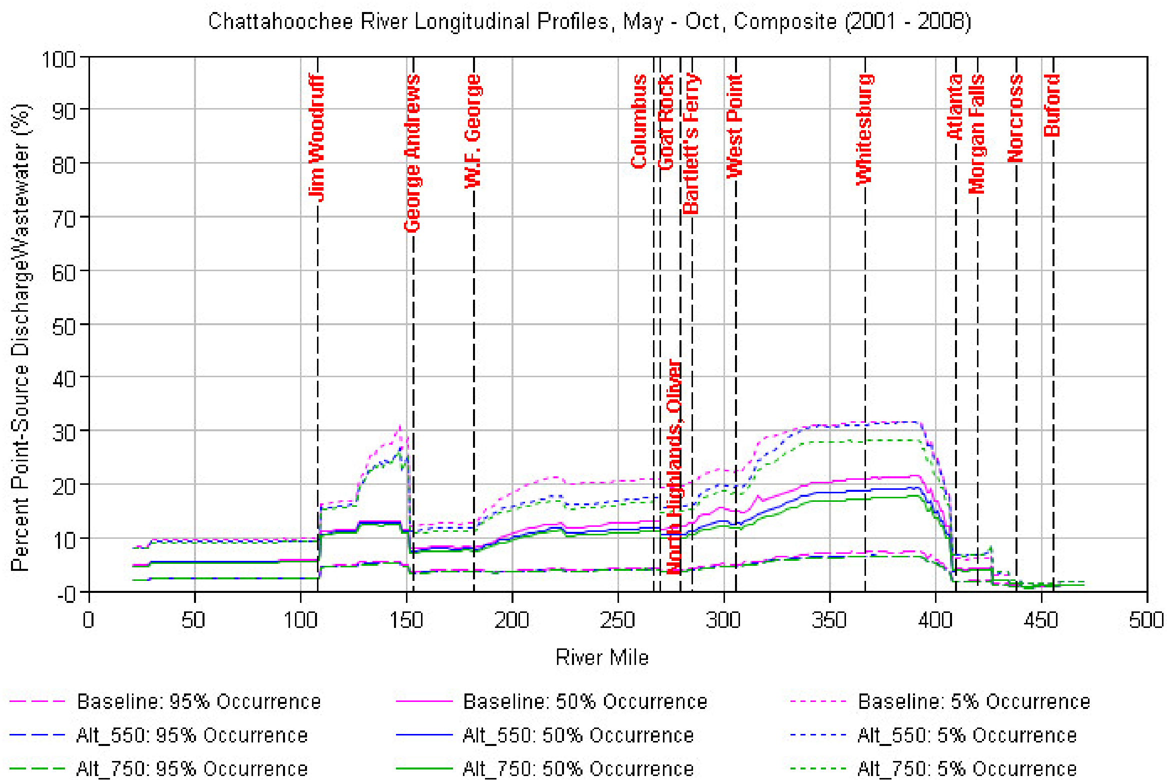


Figure 2.2-34. Percent of total flow that is wastewater along the Chattahoochee River for May through October of the modeled period (2001-2008).

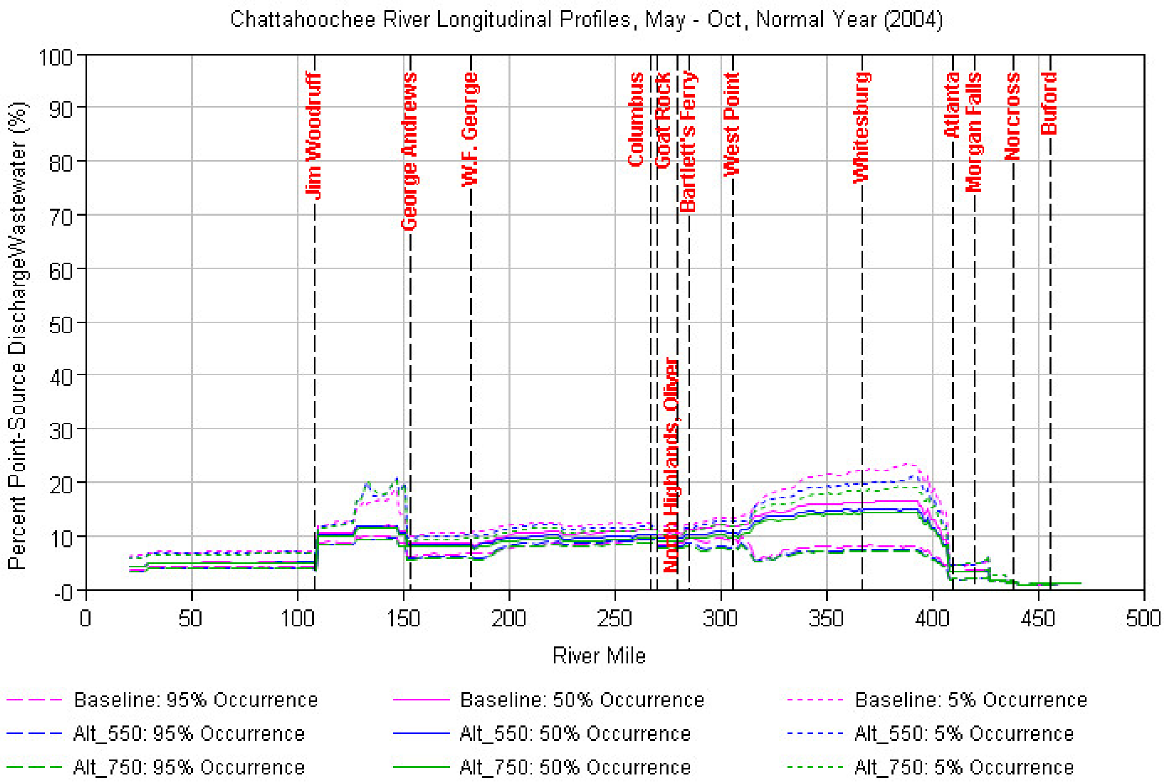


Figure 2.2-35. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative normal year (2004).

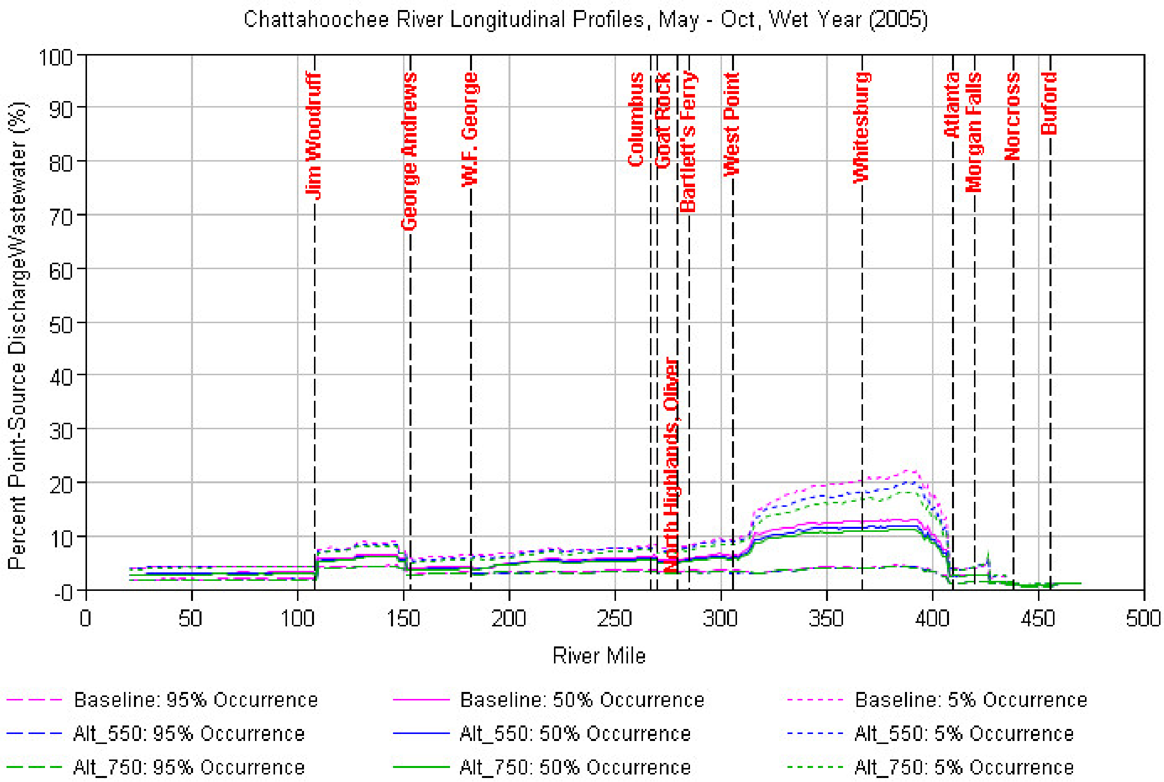


Figure 2.2-36. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative wet year (2005).

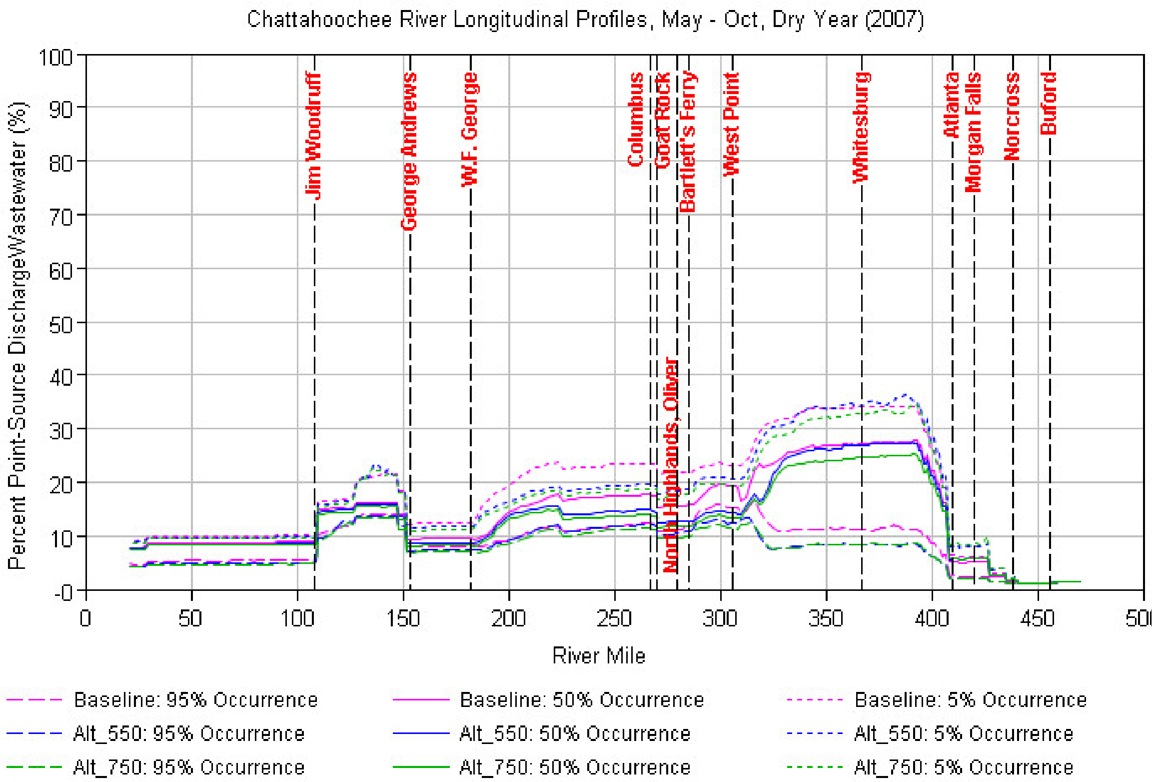


Figure 2.2-37. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative dry year (2007).

2.2.4 Chlorophyll a

- Average values of summer Chlorophyll a (*u*g/L)

Chlorophyll a in various rainfall conditions is presented for the system in the figures to follow. Figures are also provided that present areas in the system where the greatest changes would be expected. The greatest changes would be expected in West Point Lake and Walter F. George in extreme conditions.

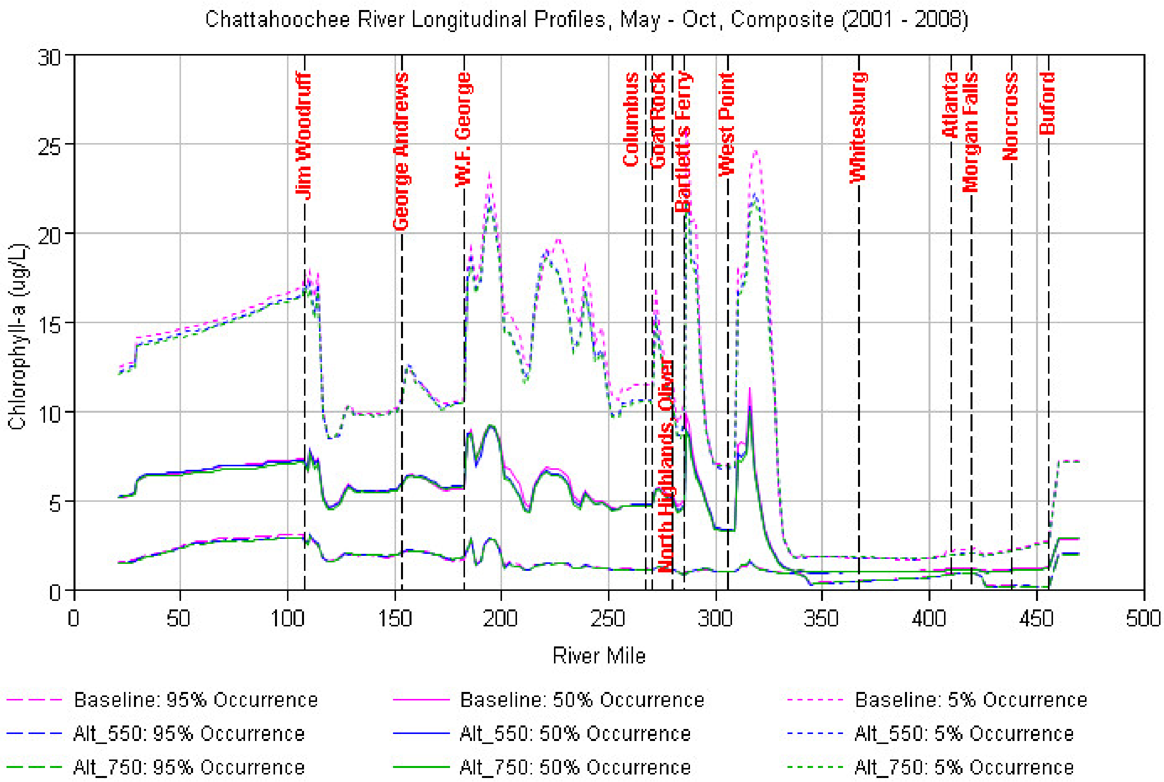


Figure 2.2-38. Chlorophyll *a* along the Chattahoochee River for May through October of the modeled period (2001-2008).

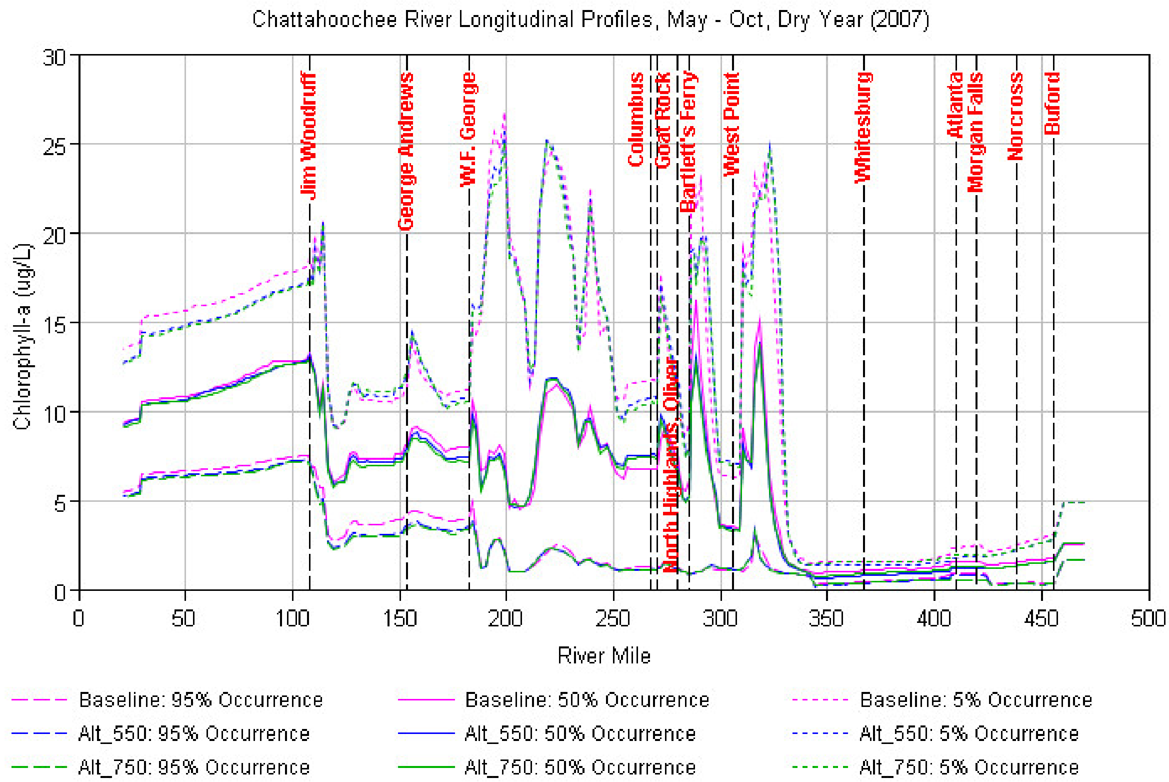


Figure 2.2-39. Chlorophyll *a* along the Chattahoochee River for May through October in a representative dry year (2007).

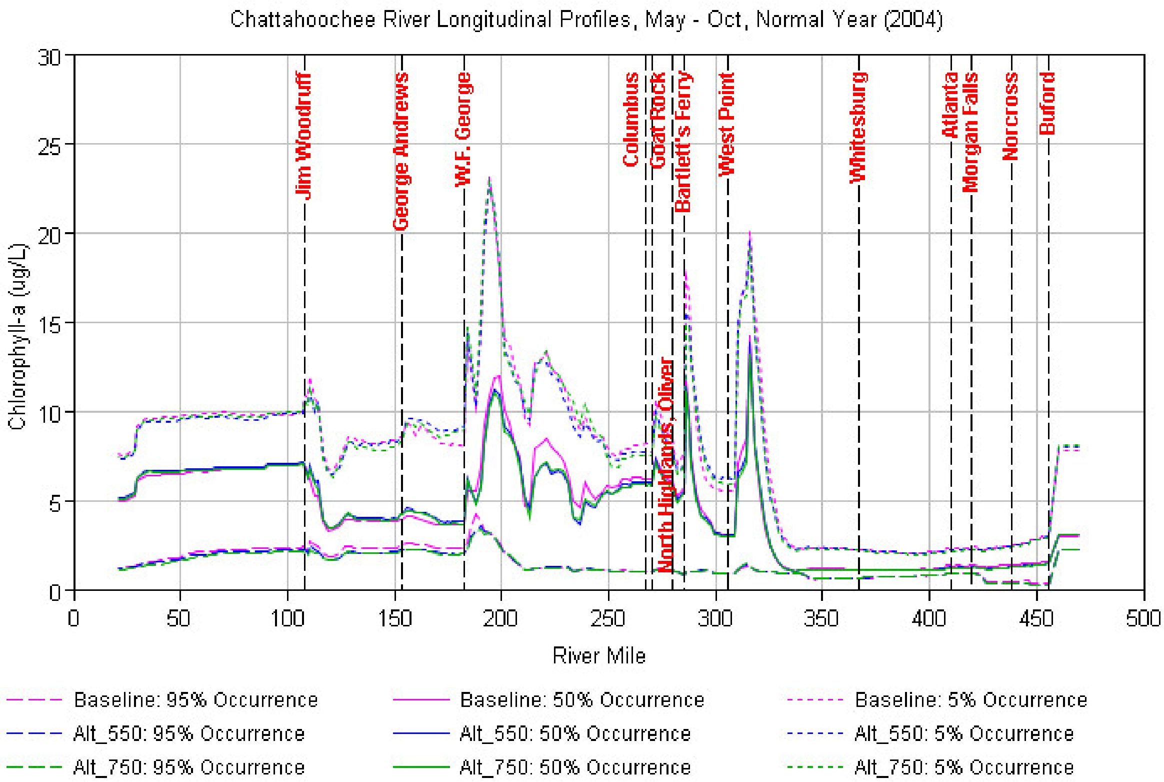


Figure 2.2-40. Chlorophyll *a* along the Chattahoochee River for May through October in a representative normal year (2004).

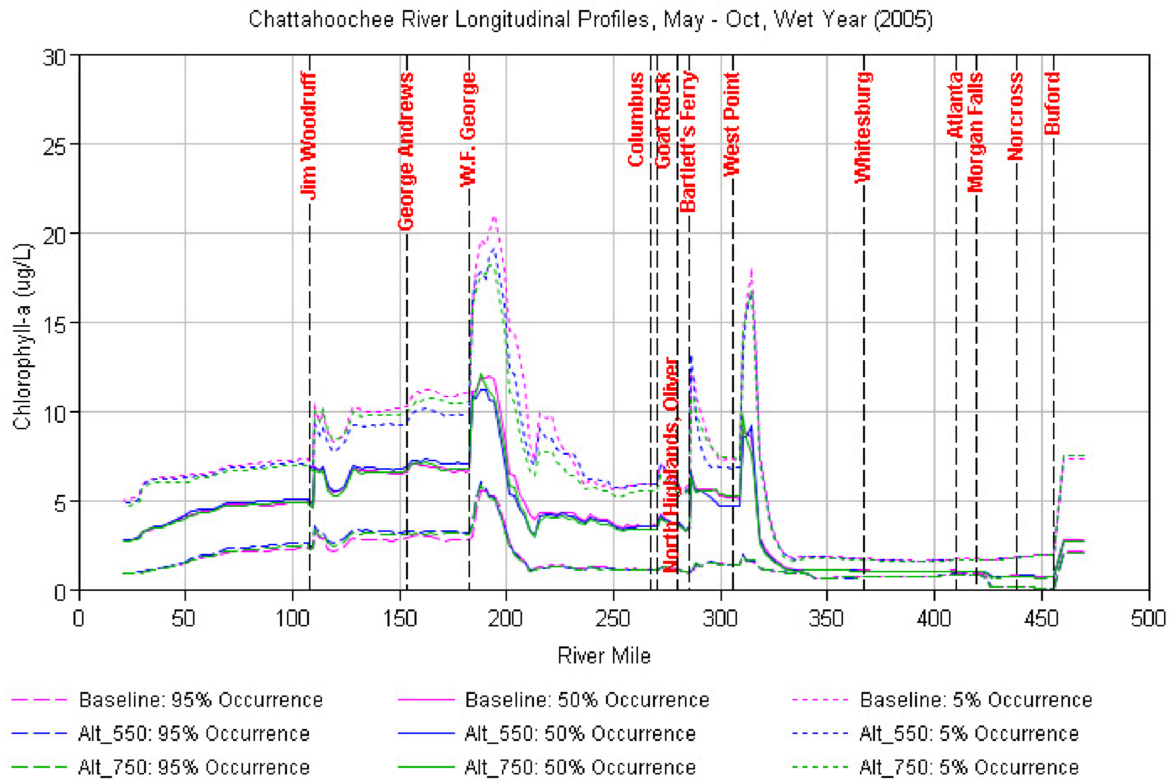


Figure 2.2-41. Chlorophyll *a* along the Chattahoochee River for May through October in a representative wet year (2005).

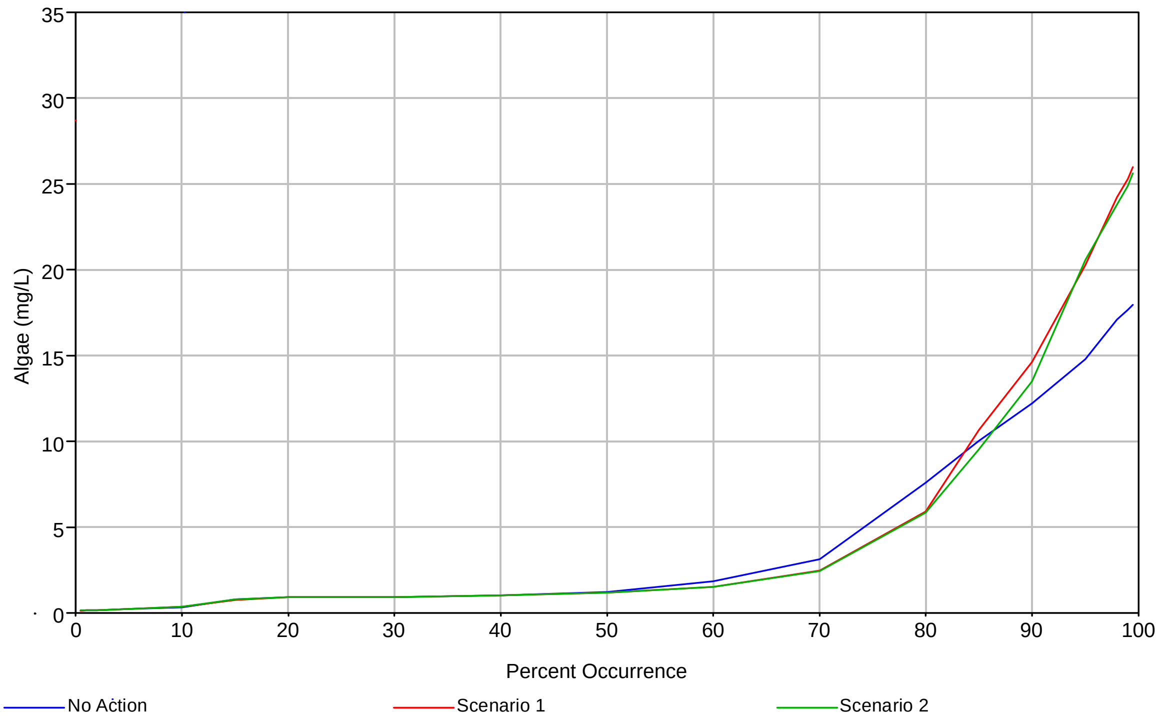


Figure 2.2-42 Occurrence of daily average chlorophyll *a* in a mid-reservoir location of West Point Lake for a representative dry year (2007).

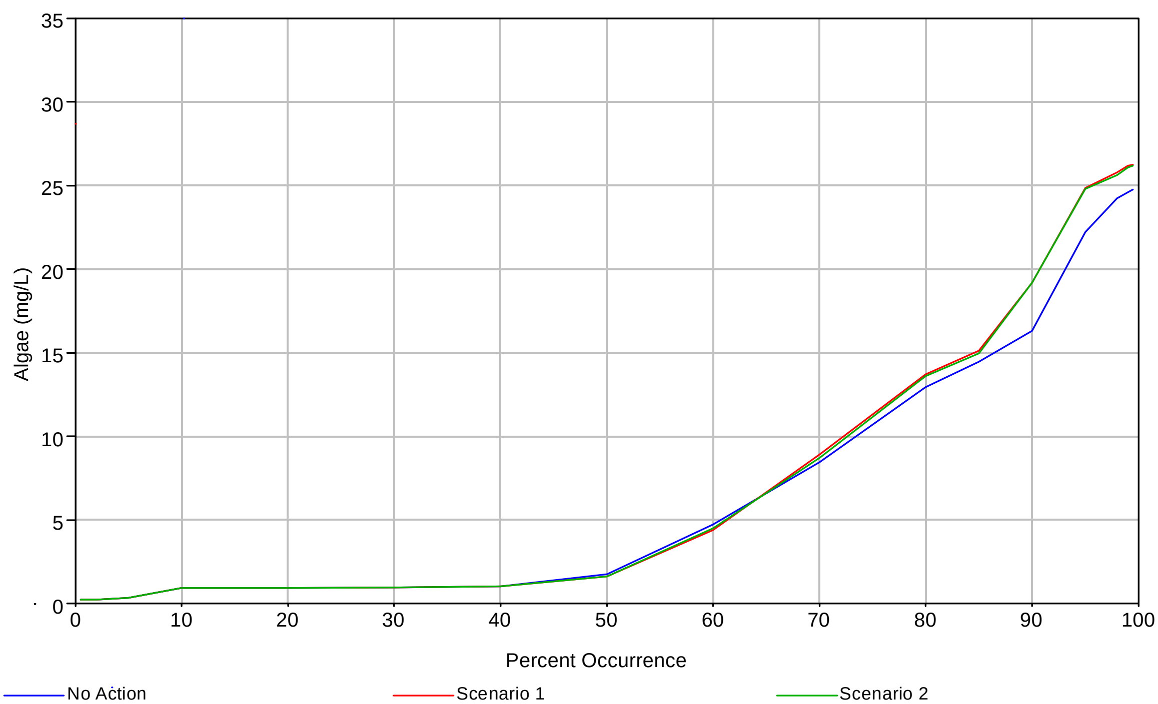


Figure 2.2-43. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Walter F. George Lake for a representative dry year (2007).

2.2.5 Retention

- Average summer retention time (days).

These results are not available at this time but will be requested for future delivery.

2.2.6 Phosphorus

- Average summer phosphorus loading (pounds/acre/month).

The analysis of phosphorus for the environmental consequences was done to compare changes in the Proposed Action Alternative from the No Action Alternative. Modeling was not conducted for total phosphorus; instead results are presented for ortho-phosphorus. Understanding that chlorophyll growth depends on inorganic phosphorus and that measured ortho-phosphorus was available for comparison, ortho-phosphorus is presented to understand how phosphorus responds to changes in water management. The organic fraction of phosphorus also decays before it can be assimilated in the water column. Delta plots were also created to compare the No Action and Proposed Action results.

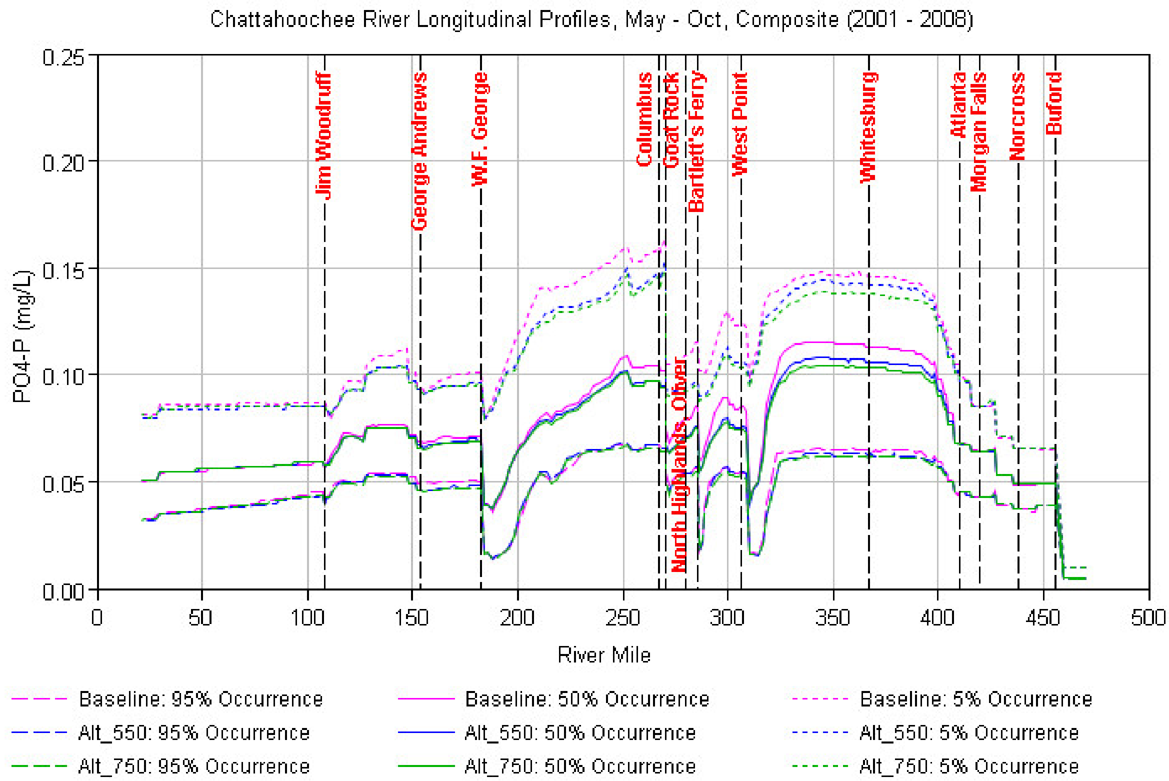


Figure 2.2-44. Ortho-phosphorus along the Chattahoochee River for May through October of the modeled period (2001-2008).

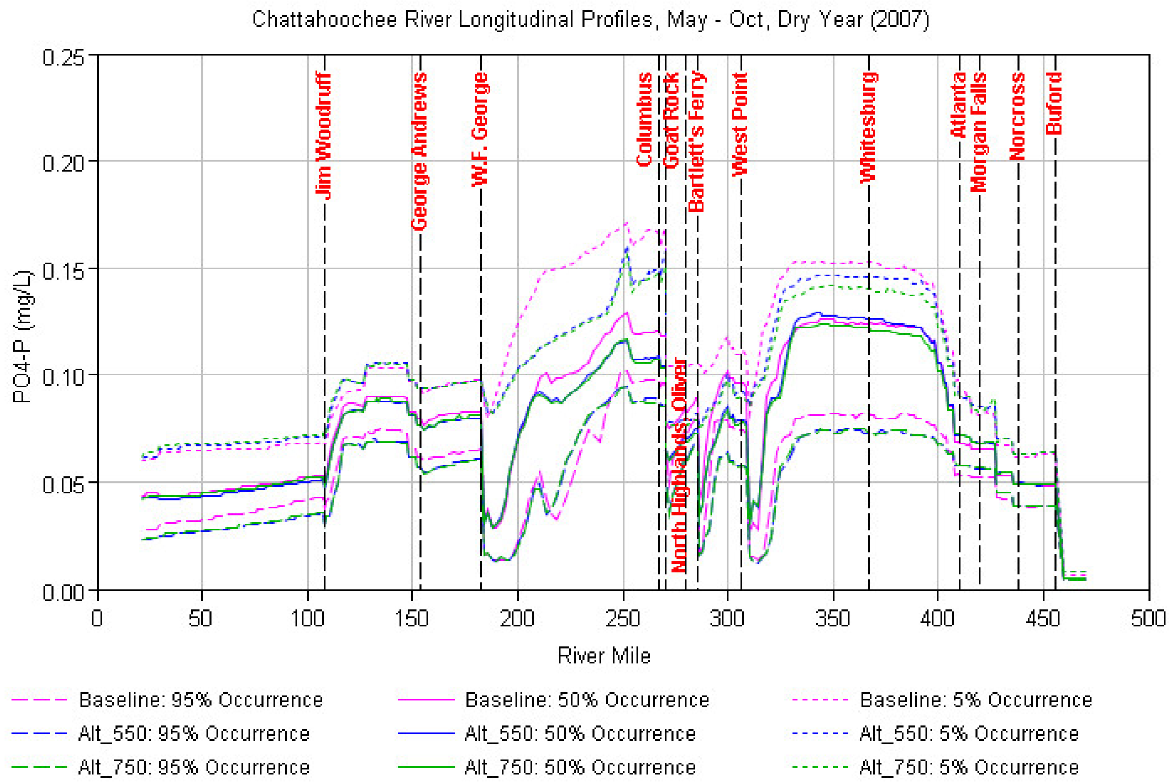


Figure 2.2-45. Ortho-phosphorus along the Chattahoochee River for May through October in a representative dry year (2007).

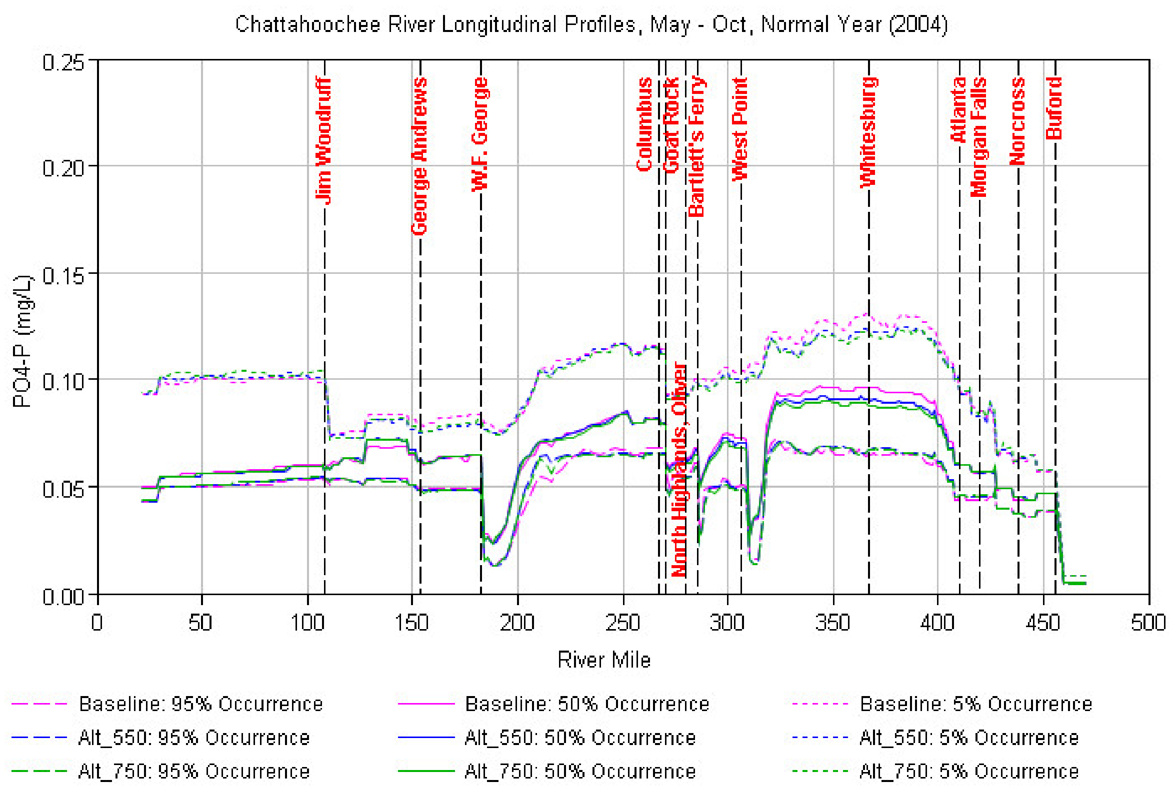


Figure 2.2-46. Ortho-phosphorus along the Chattahoochee River for May through October in a representative normal year (2004).

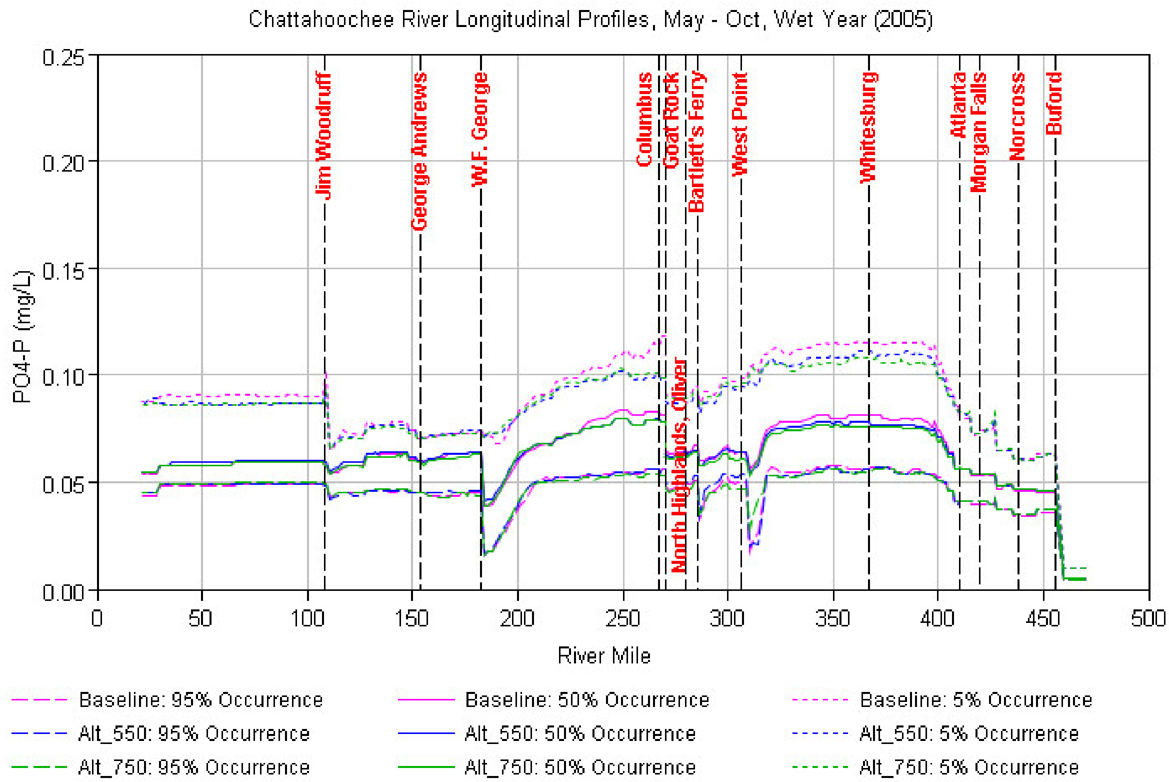


Figure 2.2-47. Ortho-phosphorus along the Chattahoochee River for May through October in a representative wet year (2005).

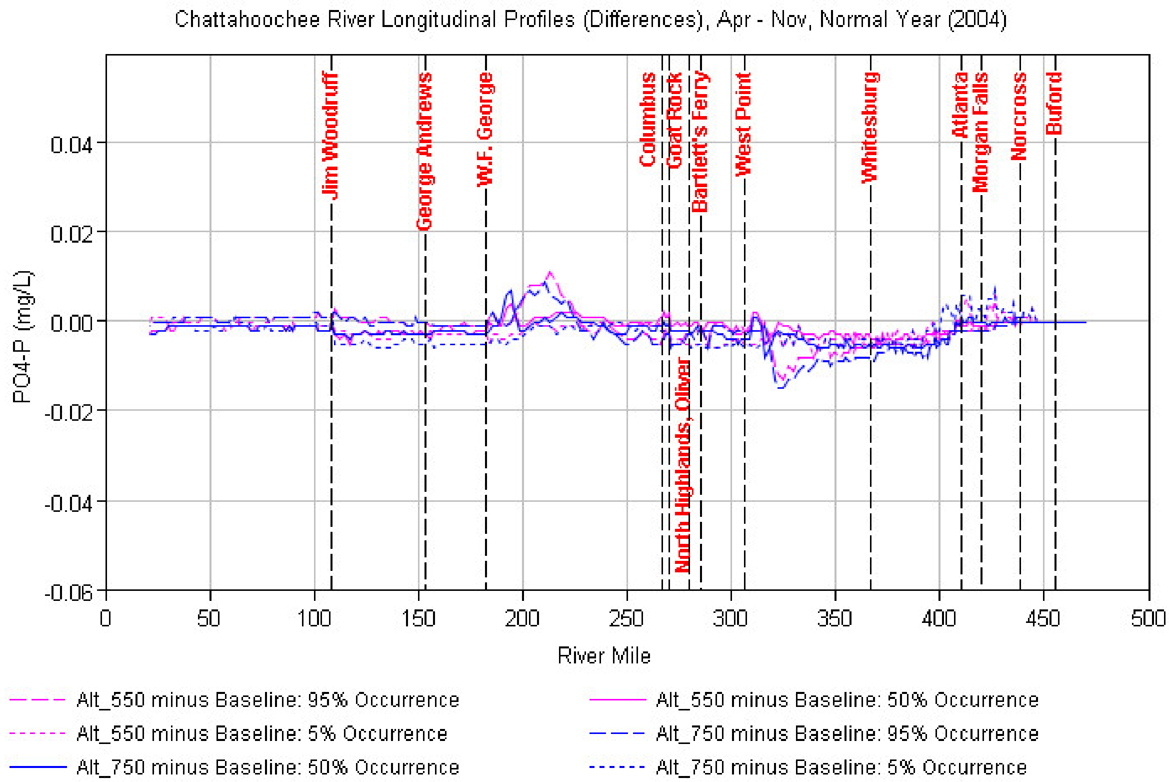


Figure 2.2-48. Changes in longitudinal ortho-phosphorus in the Chattahoochee River for April through October (2001 through 2008).

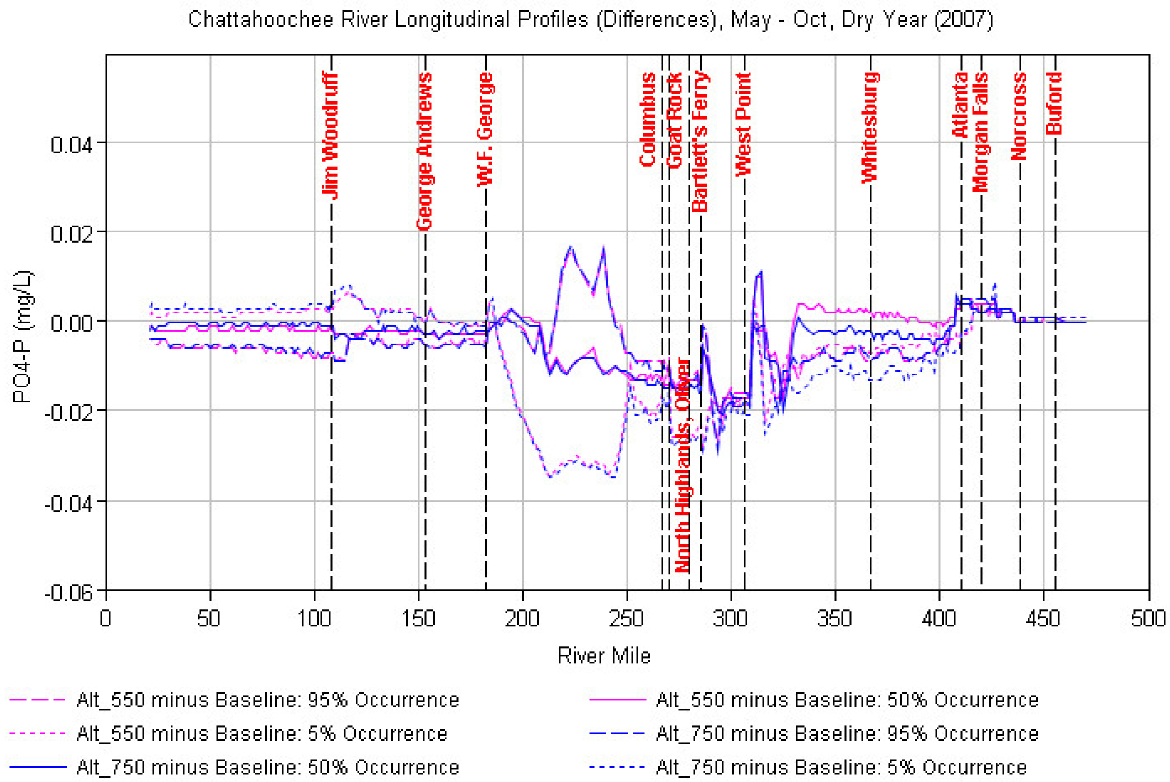


Figure 2.2-49. Changes in longitudinal ortho-phosphorus in the Chattahoochee River for April through October in a representative dry year (2007).

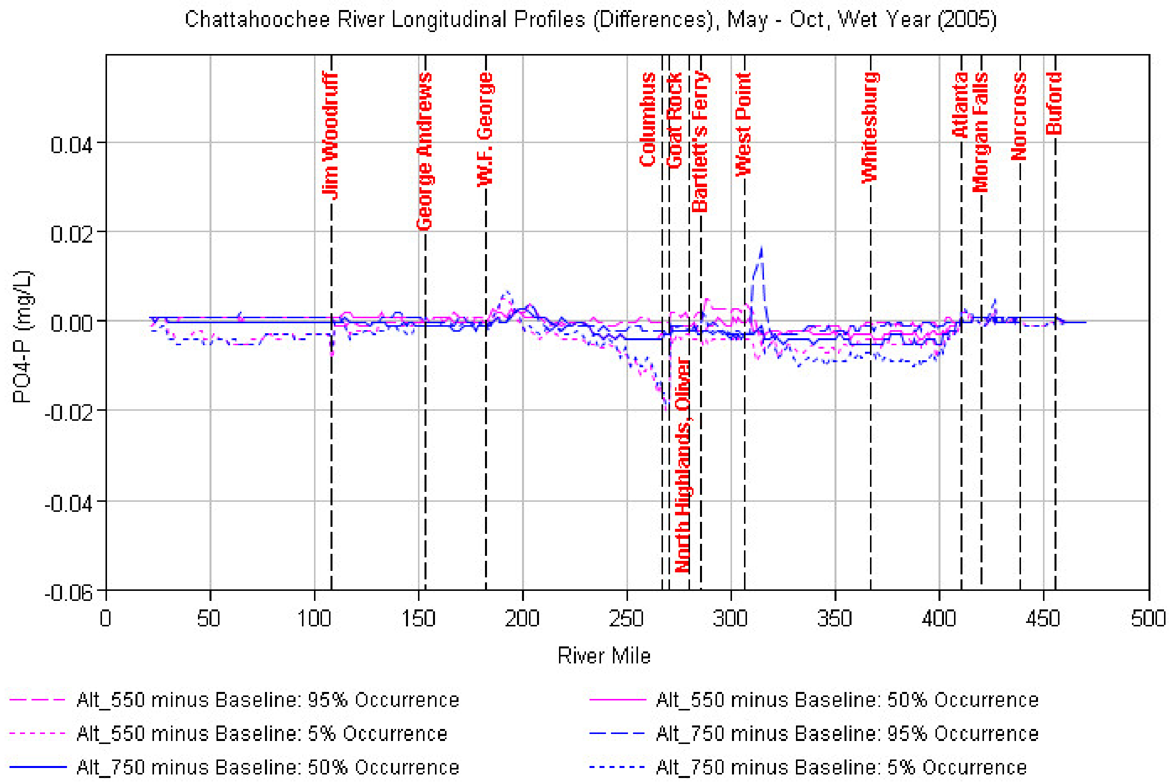


Figure 2.2-50. Changes in longitudinal ortho-phosphorus in the Chattahoochee River for April through October in a representative wet year (2005).

2.3 RESPONSE TO PAL SECTION 3.3 Floodplain Connectivity Analyses

A complete set of the Apalachicola River floodplain LIDAR data is not available and therefore this was not used in this analysis. However, given that conditions in the Proposed Action Alternative are very similar to those for the No Action, little change is expected. Instead, flow ranges from the IHA/RVA models for flooding events were used to evaluate floodplain inundation throughout the system. Using the Range of Variability Approach (RVA; also known as Indicators of Hydrologic Alteration, or IHA) (Richter et al. 1998), the magnitude, frequency, and duration values were calculated for high flows in reaches of the ACF Basin. Comparing those modeling results to the channel capacity allows an estimate of the degree of floodplain (lateral) connectivity, which is a critical component of the ecological function of river systems.

2.3.1 Apalachicola River

Darst and Light (2008) note that water levels have declined in the Apalachicola River basin as a result of local erosion and decreased spring and summer flows from the upstream watersheds. This has led to less frequent floodplain inundation and significantly drier (Darst and Light 2008) forest composition and diminished density of stands than in the past. These affect not only the vegetative makeup of the forest but also the associated wildlife.

The channel capacity of the Apalachicola River at the Chattahoochee, Florida gage is approximately 100,000 cfs. Flow ranges from the IHA/RVA models for flooding events exceed the channel capacity during the same period—early March through early April—in both the No Action and Proposed Action Alternatives (Table 2.3-1). A closer look at the magnitude and duration of maximum flow events indicates that flows would not be expected to exceed the channel capacity for periods of 30 days or more. In the Proposed Action Alternative scenario 1, the channel capacity in maximum flows would likely be exceeded in 20% of events for a 3-day period. In the case of scenario 2, the 3-day maximum flows in 20% of events are slightly lower than the channel capacity. However, the magnitude and duration of floodplain inundations are very similar to those of the No Action Alternative.

Table 2.3-1.
Large flood analysis at Chattahoochee, FL

Chattahoochee, Florida	No Action	Scenario 1	Scenario 2
Peak (cfs)	131400-180300	131400-180400	131400-180800
Duration (days)	41-159	50-158	51-158
Time Frame	Early March–Early April	Early March–Early April	Early March –Early April
Rise Rate (cfs/day)	1490-7350	1310-6945	1327-6962
Fall Rate (cfs/day)	4391-2316	4300-2317	4302-2324

At locations throughout the basin, known river stages at which floodplain inundations occur were used to evaluate the frequency, duration, and timing of floodplain inundation for the Proposed Action and No Action Alternatives.

2.3.2 Chattahoochee River

The approximate high flow capacity of the Chattahoochee River between Lake Lanier and Norcross is 10,000 cfs (USACE, Mobile District 1997). The channel capacity at this location was used as a constraint in the HEC ResSim modeling analysis to ensure that flows did not go higher than 11,000 cfs. Therefore, the modeled IHA/RVA large flood analysis at Norcross indicates peak flows under all conditions are equivalent to 11,000 cfs (Table 2.3-2). The duration of flood events is expected to decrease slightly under the Proposed Action Alternative based on modeling of the 70-year period.

Table 2.3-2.
Large flood analysis at Norcross, GA

Norcross, GA	No Action	Scenario 1	Scenario 2
Peak (cfs)	11000-11000	11000-11000	11000-11000
Duration (days)	34-105	29-79	32-89
Time Frame	Mid-Jan.–Early April	Early Feb.–Early April	Late Jan.–Mid-March
Rise Rate (cfs/day)	259-1124	386-1707	494-1657
Fall Rate (cfs/day)	381-120	530-155	522-117

Overbank flows, and thus floodplain connectivity, have been limited by human structures and flow routing for many years, and the Proposed Action Alternative would not change that. In extreme cases, although rare, there could be brief periods (1–7 days) of riparian inundation over low bank areas into low-lying floodplains and wetlands. At Whitesburg, Georgia, the occurrence of modeled flows exceeding the approximate channel capacity of 18,000 cfs is consistent between the No Action and Proposed Action Alternatives. A magnitude and duration analysis of maximum flows at Whitesburg indicates that the channel is not expected to stay outside its banks for more than 30 days even under the most extreme conditions. In 20% of the maximum modeled flows, the channel capacity could be exceeded for a 7-day period. One- and three-day exceedances of the channel's capacity might occur in 30% of maximum flow events. This is an indication that floodplains and riparian wetlands would likely remain isolated from channel flows in more than 60% of all maximum flow events.

The capacity of the Chattahoochee River channel between West Point and Columbus is around 47,000 cfs. The IHA/RVA indicates that these flows are not expected to occur for more than a 3-day period in 90% of maximum flow events at Columbus, Georgia. The channel capacity is never expected to be exceeded in the Proposed Action Alternative at just downstream of the West Point Dam. Again, the indication is that the floodplains would remain dry with little to no interaction with channel flows.

2.3.3 Flint River

The channel capacity for the Flint River is 30,000–35,000 cfs in the area from Montezuma to Bainbridge. There are two non-Federal impoundments, neither of which substantially alters the flow of the river; nor would they be changed by actions of the USACE. Therefore, there would be no change in lateral (floodplain) connectivity, and no effect on the Flint River would be expected from the Proposed Action Alternative.

2.4 RESPONSE TO PAL SECTION 3.4 Reservoir Fisheries Analyses

The reservoir fisheries performance measure based on the findings of Ryder et al. (1996) that the Service cooperated with the Corps on for the 1998 draft EIS for ACF water allocation was used for this analysis. Unfortunately there is little to no data available to update the reservoir fisheries performance measures. Potential new datasets referenced were reviewed but given the limited resources, the 1998 approach was used.

This assessment focuses on the five reservoirs that are managed by the Corps in the ACF Basin, which are the subject of the water control plan update. The other reservoirs in the basin were excluded from the detailed assessment because most are frequently operated in run of-river modes, which tend to minimize pronounced variations in water levels.

Operational flow changes would affect habitat for reservoir fisheries and other aquatic resources mainly through changes in water levels, changes in reservoir flushing rates (retention times), and associated changes in water quality parameters, such as primary productivity, nutrient loading, dissolved oxygen concentrations, and vertical stratification.

Seasonal water level fluctuations can substantially change the area of shallow-water habitats and inundated shoreline vegetation and, in turn, significantly influence the reproductive success of resident fish populations. High water levels inundating shoreline vegetation during spawning periods frequently have been associated with enhanced reproductive success and strong year class development for largemouth bass, spotted bass, bluegill, crappie, and other littoral species (Ploskey and Reinert 1996; Ryder et al. 1995). Conversely, low or declining water levels can adversely affect reproductive success by reducing the area of available littoral spawning and rearing habitats. In West Point Lake, falling water levels during the rearing season have been correlated with a decline in survival of young-of-year largemouth bass, although surviving fish were larger (Miranda et al. 1984).

In a study of 11 Alabama reservoirs, which included two reservoirs in the ACF Basin, Maceina and Stimpert (1998) found consistent relations between the production of strong crappie year classes and wet winters prior to crappie spawning. Wet winters resulted in shorter retention time (i.e., higher flushing rates) in reservoirs with stable water levels, and higher water levels in fluctuating reservoirs, such as West Point Lake and Walter F. George Lake. High winter inflows may favor crappie production by increasing nutrient loading, which in turn stimulates primary and secondary production later in the growing season (Maceina and Stimpert 1998; Ploskey and Reinert 1996). In reservoirs with stable water levels and low retention, longer post-winter retention also was associated with greater crappie production, possibly related to reduced flushing of young-of-year fish in the discharge from the impoundment and more stable feeding conditions (Maceina and Stimpert 1998).

Substantial daily or weekly fluctuations in reservoir levels associated with hydroelectric power peaking operations may negatively affect reservoir fisheries by dewatering spawning and nursery habitats for littoral species, exposing nests and eggs deposited in shallow-water habitats, and reducing the availability of shoreline cover and its associated invertebrate food supply.

2.4.1 Performance Measures under the Proposed Action Alternative

The performance measures were used to assess relative effects of the No Action Alternative and Proposed Action Alternative on reservoir fisheries habitat, based on the premise that greater departure of reservoir levels from optimum levels for critical guilds of fishes (e.g., littoral spawning, rearing) result in greater impacts to their habitats. All five reservoirs showed higher values for the No Action Alternative, with little or no variation in performance scores between the Proposed Action Alternative scenarios. West Point and Lake Seminole generally operate at closer to optimum water levels for critical fishery guilds with less seasonal fluctuation, as indicated by the median performance scores of 0.67 and 0.70, respectively. Lake Lanier and Walter F. George showed intermediate potential for fisheries impacts related to reservoir levels, as indicated by a performance values of 0.40 and 0.39.

For Lake Lanier and West Point Lake, the Proposed Action Alternative showed the greatest potential for reservoir fisheries impacts (Table 2.4-1). These storage reservoirs exhibit the greatest variation between the No Action Alternative and Proposed Action Alternative. The principal factor contributing to these lower scores under the Proposed Action Alternative is seasonal water level fluctuations, particularly during the spawning period, associated with operations for flood damage reduction (e.g., winter drawdowns), downstream flow targets, hydroelectric power operations, and navigation. The downstream reservoirs of George Andrews and Lake Seminole exhibit a narrower range of scores among the scenarios suggest a lower overall potential for adverse effects due to water level fluctuations.

Table 2.4-1.
Reservoir Fishery Performance Measure Scores

Reservoir	Alternative	Min.	25th Percentile	50th Percentile	75th Percentile	Max.
Lake Lanier	No Action	0.02	0.25	0.40	0.56	0.92
	Scenario 1	0.02	0.23	0.36	0.55	0.89
	Scenario 2	0.02	0.23	0.36	0.56	0.89
West Point Lake	No Action	0.16	0.52	0.67	0.75	0.88
	Scenario 1	0.16	0.53	0.64	0.73	0.82
	Scenario 2	0.16	0.52	0.64	0.72	0.82
W.F. George Lake	No Action	0.20	0.37	0.39	0.41	0.48
	Scenario 1	0.15	0.30	0.36	0.40	0.45
	Scenario 2	0.15	0.31	0.36	0.40	0.45
George F. Andrews Lake	No Action	0.28	0.31	0.33	0.34	0.41
	Scenario 1	0.29	0.31	0.32	0.33	0.39
	Scenario 2	0.29	0.32	0.32	0.33	0.39
Lake Seminole	No Action	0.38	0.64	0.70	0.75	0.95
	Scenario 1	0.36	0.61	0.68	0.73	0.94
	Scenario 2	0.37	0.61	0.68	0.73	0.92

2.4.2 Impacts of Critical Low Flow Periods

The USFWS performance measure provide a means of comparing relative impacts between flow scenarios, but do not distinguish potential impacts resulting from sustained drawdowns covering multiple critical periods, such as spawning seasons. Examination of daily plots of reservoir water elevations for critical low flow periods indicates that, for headwater storage reservoirs, such impacts could be severe (USACE, Mobile District 1998a).

For the purpose of this analysis Lake Lanier was evaluated because it presents the greatest range in water surface elevations. At Lake Lanier, the optimum pool elevation for littoral spawning and rearing guilds of sport fishes is 1,071 ft. Water levels falling 3 ft or more below this elevation (1,068 ft and lower) show acceptability levels of 0.65 and lower, with zero acceptability occurring at water levels of 15 feet or more below optimum (1,056 ft and lower) (Ryder et al. 1995).

Comparison of the modeled flow conditions for the critical low flow years of 1954 through 1960, 1985 through 1989 and 2007 at Lake Lanier shows that reservoir levels during the growing season under the No Action Alternative would decrease below 1,068 ft approximately 68 percent of the time and occur 88 percent of the time during winter drawdown. Departures from the optimum pool elevation average approximately 5 ft during the growing season and 8 ft during winter drawdown. Based on the assumptions of the reservoirs fishery performance measures, these conditions would be expected to impact spawning and rearing seasons for the critical species largemouth bass, spotted bass, white bass, and crappie, resulting in decreased reproductive success and recruitment. However, these conditions have not been documented.

In 2007, conditions were considerably worse than the 1954 and 1989 low flow periods. During this time, pool elevations dropped below 1,071 ft 100 percent of the time, falling nearly 7 ft during the growing season and 11 feet during winter drawdown. Performance measures, which are generally between 0.36 and 0.40, fell to 0.04 to 0.08 during this critical drought period. In 2008, conditions continued to deteriorate with values of 0.21 for No Action Alternative.

In both scenarios of the Proposed Action Alternative, Lake Lanier would decrease below 1,068 ft, 70 percent of the time during the growing season and 90 percent of the time during winter drawdown. Departures from the optimum pool elevation average approximately 5 ft during the growing season and 8 ft during winter drawdown in the No Action Alternative and Proposed Action Alternative. No change from the No Action Alternative would be expected in the impact to spawning and rearing seasons for critical species under the Proposed Action Alternative.

In the worst low flow period, 2007, the Proposed Action Alternative shows slightly improved values over No Action Alternative. In 2008, the Proposed Action Alternative is similar to the No Action Alternative.

2.5 RESPONSE TO PAL SECTION 3.5 Riverine Fisheries Analyses

Sport fisheries are important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. The survival and reproduction of many fishes are intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. There are existing effects of controlled flows in the ACF Basin on lateral connectivity and floodplain inundation. Before the Chattahoochee River became subjected to human controls, there were substantial flows with natural variability in magnitude and seasonal fluctuations (**Error! Reference source not found.** and **Error! Reference source not found.**). The highest baseflows occurred in the spring (January/February to May/June) and ranged from 1,700–2,200 cfs upstream of Atlanta to 7,000–10,000 cfs downstream of Walter F. George Lake. Furthermore, flows in the Apalachicola River ranged from 20,000 to 24,000 cfs. Because of the series of dams now present in the Chattahoochee River system, these baseflows no longer exist and are unlikely to be realized again.

Given the limited availability of data, the IHA baseflow analysis can be used to evaluate the effect to riverine fisheries. Baseflow was compared between pre-dam conditions, the No Action Alternative, and Proposed Action Alternative.

2.5.1 Chattahoochee River downstream of Buford Dam

The No Action Alternative at Norcross, Georgia would have an average year-round baseflow of 1,700–1,800 cfs, with slightly higher values during a short period of mid-summer (in June and July, **Error! Reference source not found.**). During dry years the flow would remain consistent at around 1,500 cfs, whereas in wet years it would be approximately 2,000 cfs, again consistently throughout the year. The lower limit on baseflow would be approximately 1,000 cfs and would continue to support the existing trout and sport fishery in this area.

Under the Proposed Action Alternative at Norcross, there would be somewhat higher flows in average years, ranging from 1,700 to 2,400 cfs, **Error! Reference source not found.**. For wet and dry years there would be consistent year-round flows of 2,400 and 1,500, respectively. Both scenarios of the Proposed Action Alternative would elevate the lower limit of the baseflow to between 1,100 and 1,250 cfs.

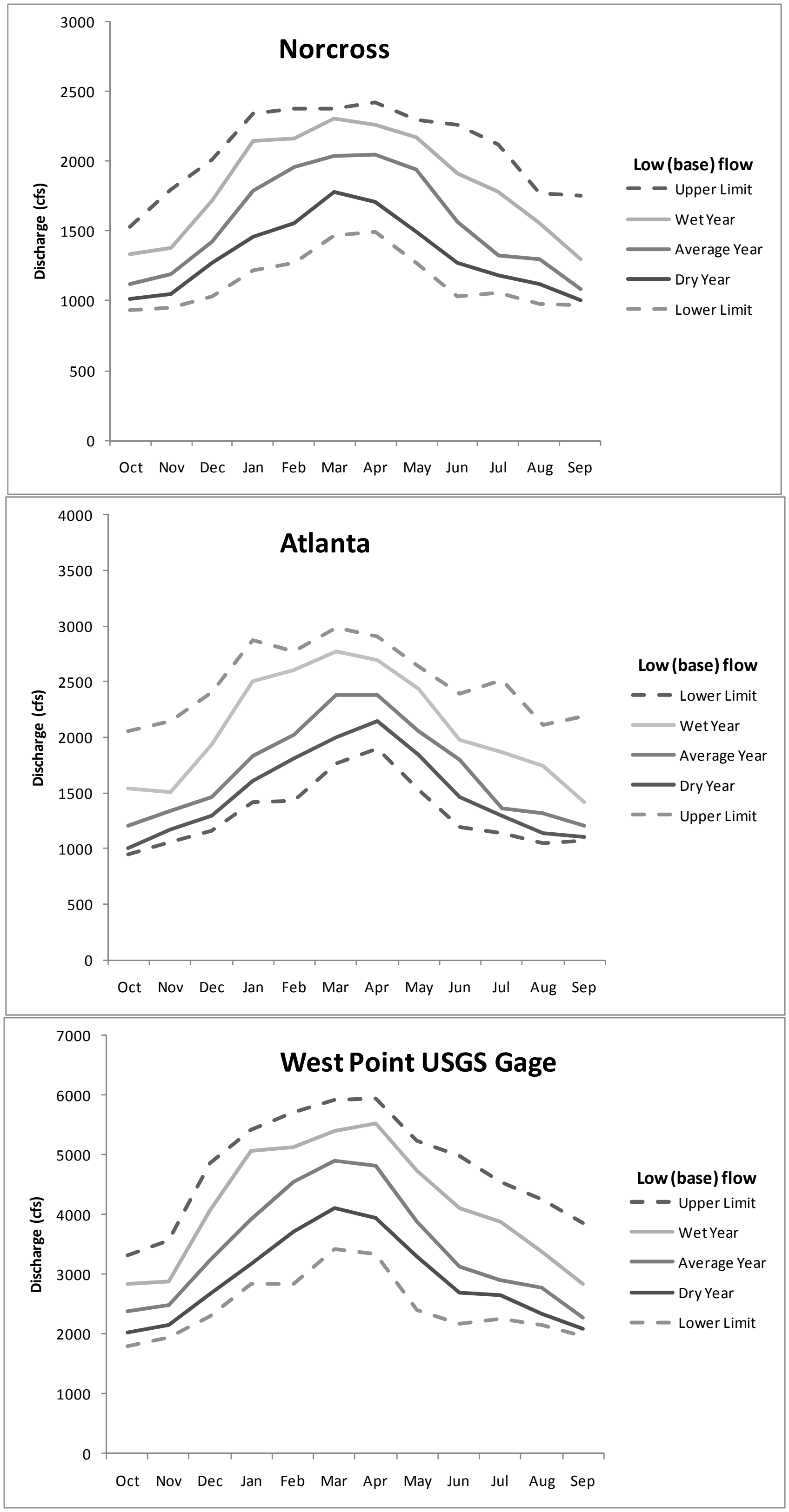


Figure 2.5-1. Pre-dam seasonal baseflow from the Chattahoochee River (top, at Norcross; center, at Atlanta; bottom, downstream of West Point Dam and upstream of Walter F. George Lake).

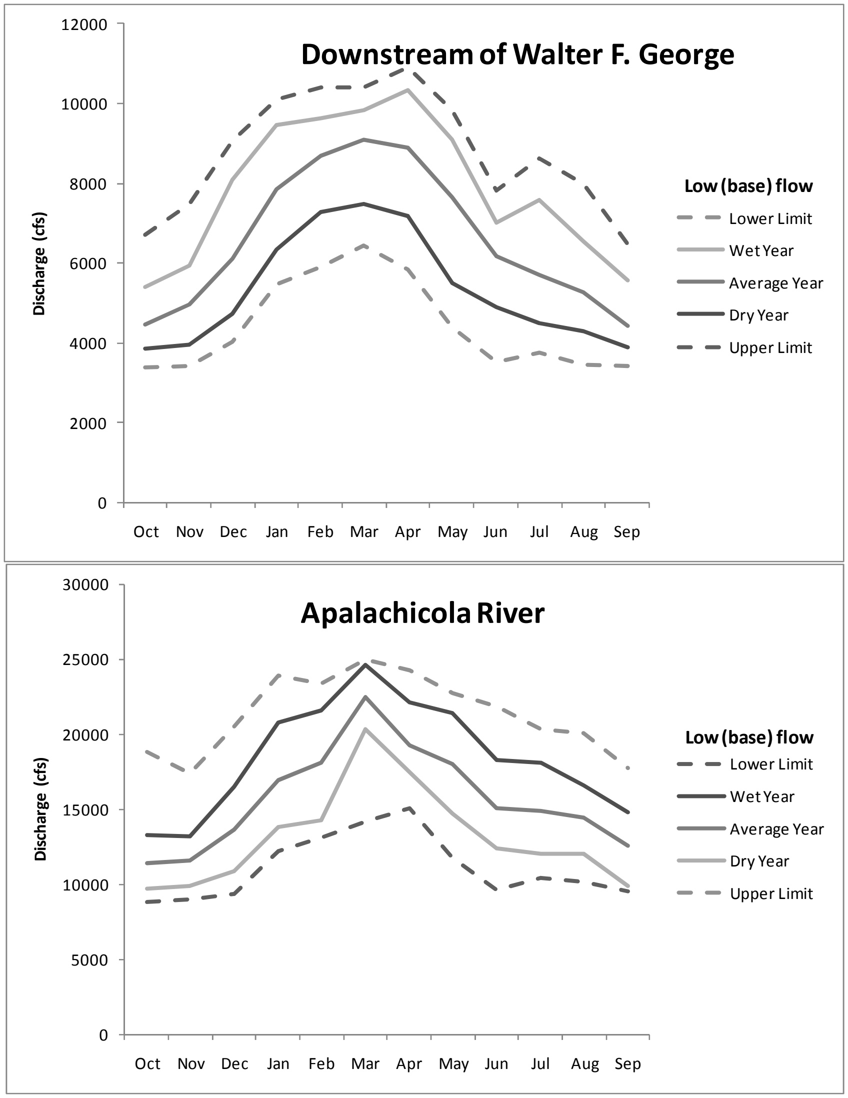


Figure 2.5-2. Pre-dam seasonal baseflow from the Chattahoochee and Apalachicola Rivers (top, downstream of Walter F. George Dam; bottom, Apalachicola River).

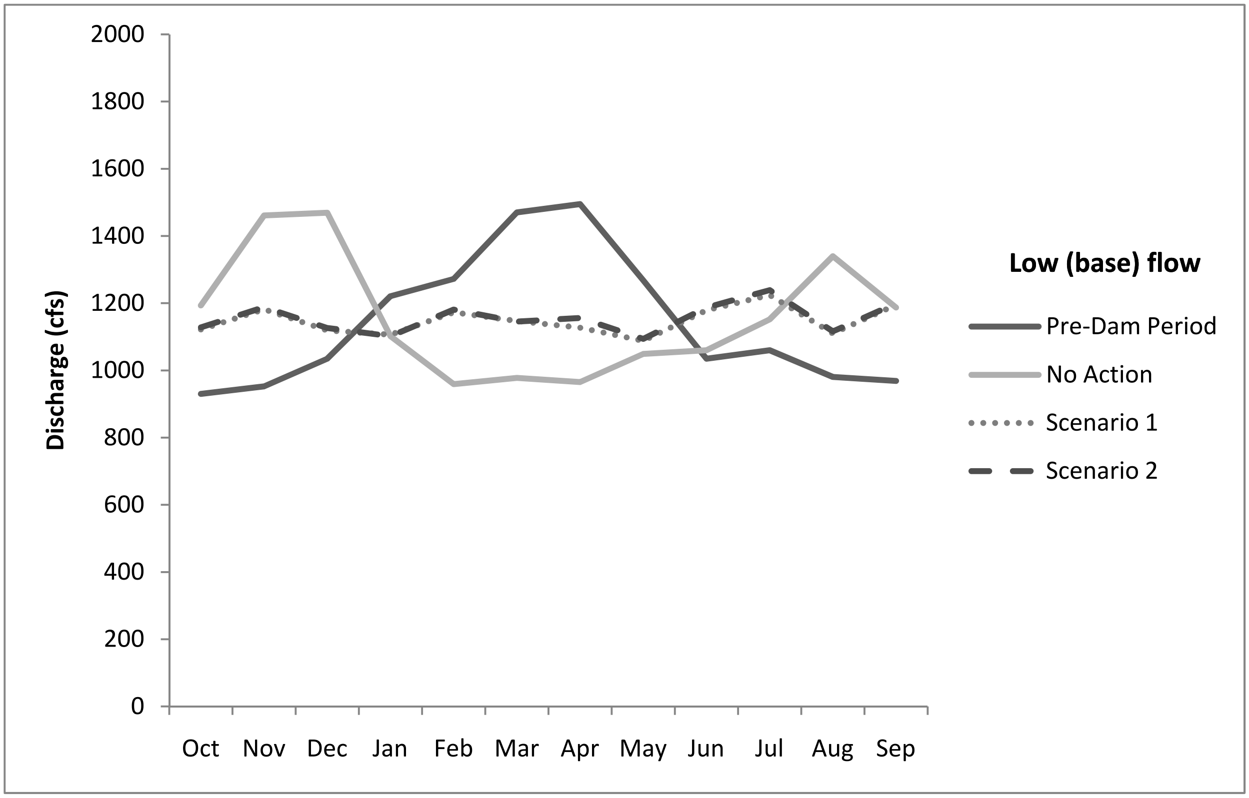


Figure 2.5-3. Norcross, Georgia average baseflow over the modeled period

2.5.2 Chattahoochee River downstream of West Point Dam

Between West Point Dam and Walter F. George Lake, baseline flows during years of average precipitation range from 3,200 to 4,000 cfs, exhibiting little if any seasonal variability in the No Action Alternative (**Error! Reference source not found.**). During dry years, the year-round flows would be only slightly less, on average by approximately 500 cfs. The upper and lower limits of baseflows would range from 3,200–4,800 cfs in the late autumn to 2,000–3,200 cfs in mid- to late summer.

The Proposed Action Alternative between West Point Dam and Walter F. George Lake, although similar in magnitude to the No Action Alternative, exhibits seasonal variability similar to pre-dam conditions (**Error! Reference source not found.**).

2.5.3 Chattahoochee River downstream of Walter F. George Dam

The shapes of the hydrographs downstream of Walter F. George Dam are similar to pre-dam conditions (**Error! Reference source not found.**) for the No Action Alternative, exhibiting similar seasonal patterns with the highest flows in the February–April time frame. The flow magnitude for average years overall, however, is 500–1,000 cfs, reduced from the pre-dam flows.

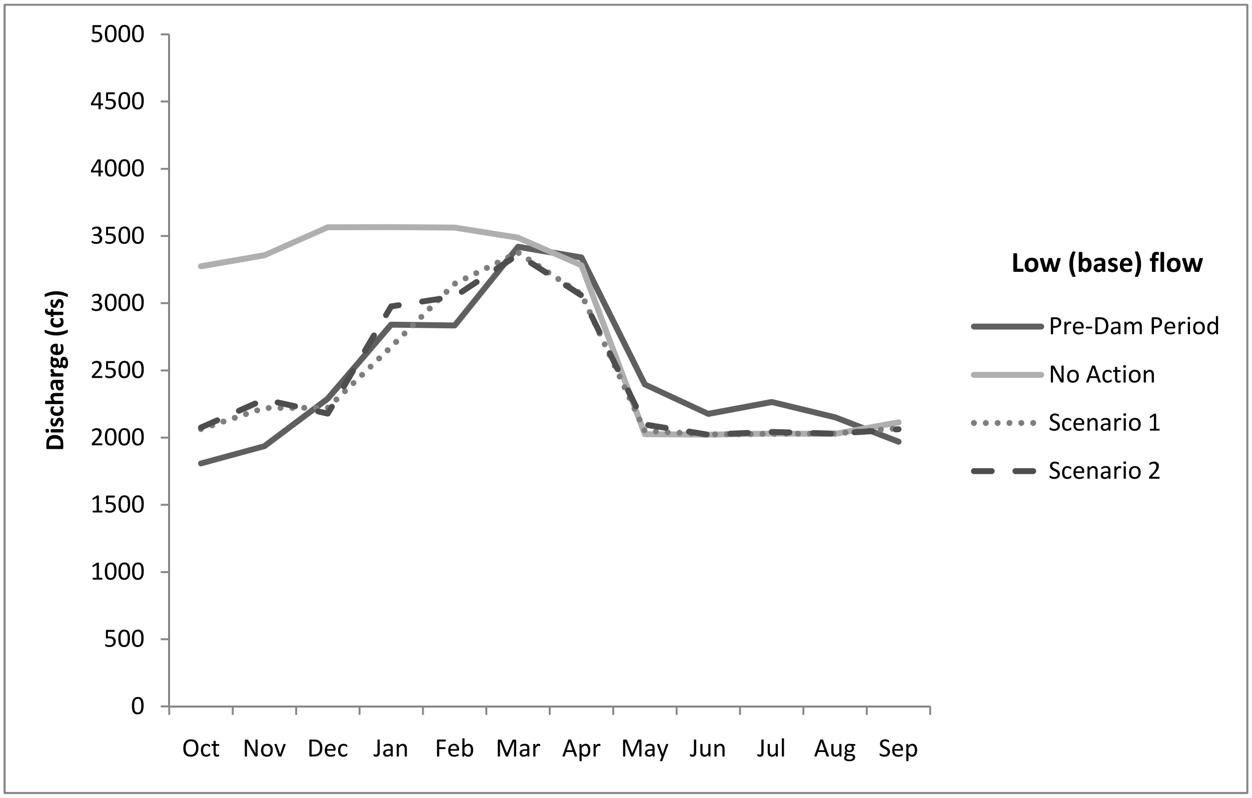


Figure 2.5-4. West Point Dam (UGSG gage location) average baseflow over the modeled period

2.5.4 Apalachicola River

The shapes of the hydrographs downstream of Jim Woodruff Dam are also similar to pre-dam conditions (Figure 2.5-6) for the No Action Alternative, exhibiting similar seasonal patterns with the highest flows in the February–April time frame. The flow magnitude for average years overall, however, is around 500–1,000 cfs, reduced from the pre-dam flows. Nonetheless, the existing fisheries resources would continue to be supported under the No Action Alternative.

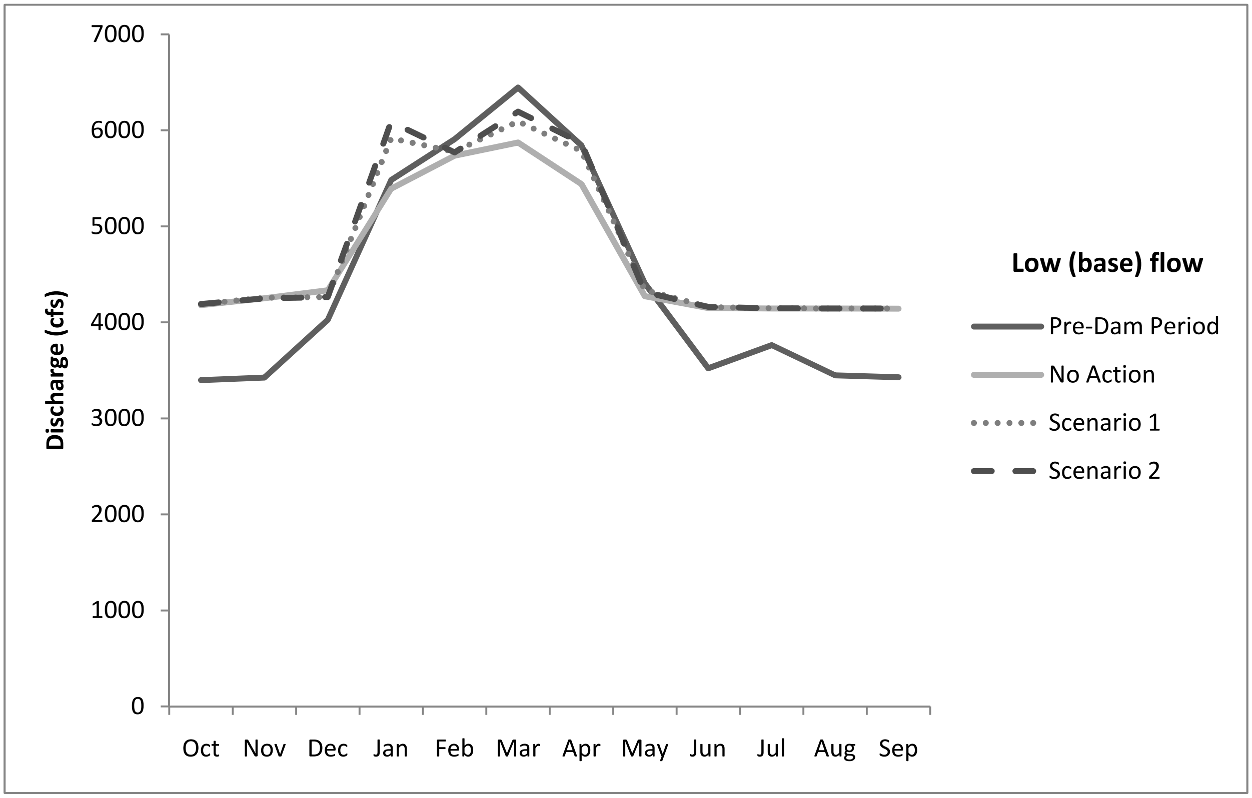


Figure 2.5-5. Average baseflow over the modeled period downstream of Walter F. George Dam

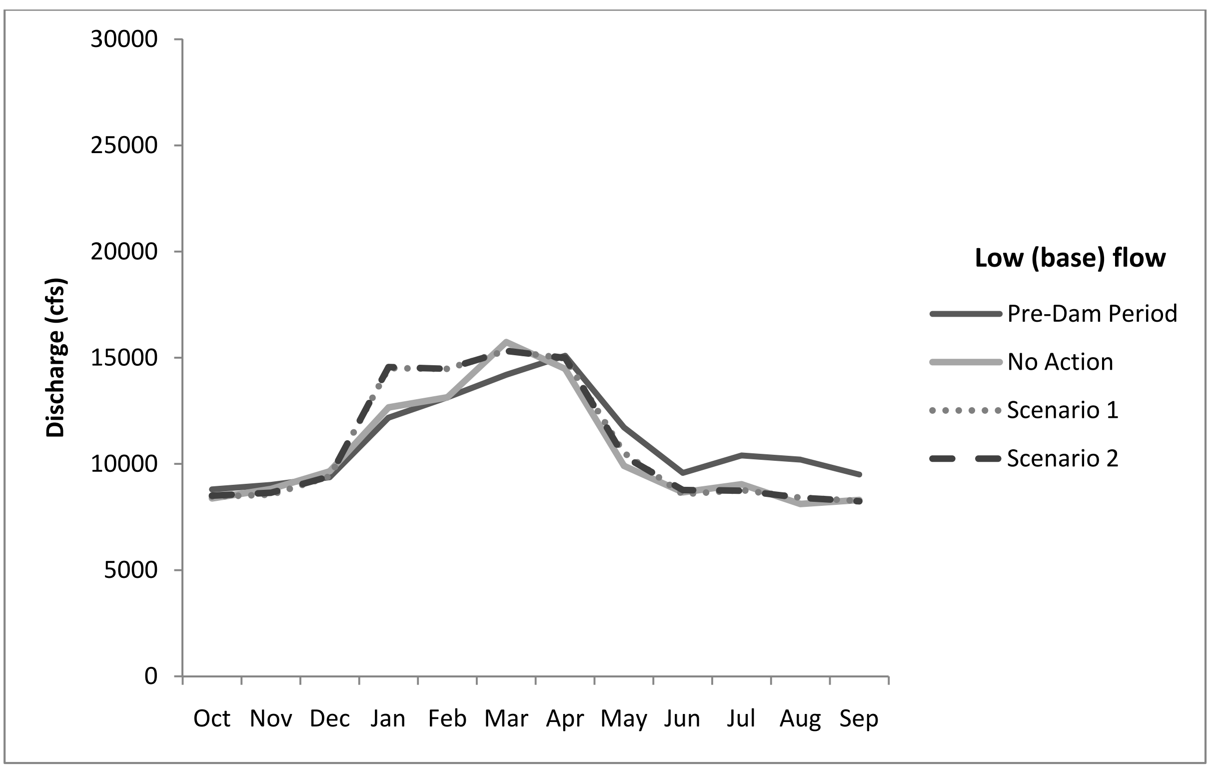


Figure 2.5-6. Average baseflow over the modeled period downstream of Jim Woodruff Dam

2.6 RESPONSE TO PAL SECTION 3.6 Apalachicola Bay Salinity Analyses

The USFWS conducted salinity modeling of the Apalachicola Bay. Based on the preliminary analysis provided by the USFWS, little change in salinity in the Apalachicola Bay would be expected as a result of the Proposed Action Alternative. Freshwater flows are also critical to the protection of the estuarine oyster fishery, which is sensitive to variations in salinity. The oyster fisheries in the estuarine portions of Apalachicola Bay experience impacts from drought and flooding as a result of both natural and unnatural flow variation. The Proposed Action Alternative would present no anticipated change in the flows (wet, dry, or normal) to the estuary from the No Action Alternative, and therefore the Proposed Action Alternative is not expected to change the current state of the oyster fishery.

Similarly, given the absence of appreciable changes in the flow dynamics from the No Action condition, additional impacts on other estuarine species and fisheries are not expected.

2.7 RESPONSE TO PAL SECTION 3.7 Federally-protected Species Analyses

As requested by the USFWS, the Federally-protected species analysis is consistent with the evaluations completed for the RIOP and additional requests by the FFWCC.

2.7.1 Gulf Sturgeon Analysis

2.7.1.1 Spawning Habitat Availability

Gulf sturgeon spawning habitat was quantified at three locations known to support the species using a daily time series analysis of the Proposed Action Alternative. The modeled conditions represent the maximum habitat available during inundation at 8.5- to 17.8-ft depth range from March through May. Similar frequency analyses were completed to depict the amount of continuous habitat available to support the timing of spawning, egg incubation, and early larval development of Gulf sturgeon. Collectively, those stages are estimated to occur over approximately 30 days in the ACF Basin (USFWS 2008b; Pine et al. 2006; Sulak et al. 2004); therefore, the amount of available habitat was estimated to reflect the annual frequency during which conditions range from 8.5 to 17.8 ft for a period of 30 days.

Modeling results indicate that the maximum amount of available habitat ranges from 0 in rare cases to approximately 21 acres and generally shows good agreement among the action alternative flow scenarios (**Error! Reference source not found.**). The median values among the regimes are equivalent, at slightly fewer than 18.0 acres. The annual frequency of flows also shows close correspondence of the action flow alternatives, with a median value of about 18 acres (**Error! Reference source not found.**). All three time series provide nearly 13 acres of habitat in all years.

In both analyses, the Proposed Action Alternative track closely with the No Action Alternative and do not represent an appreciable difference in the availability of Gulf sturgeon spawning habitat. The figures to follow illustrate the No Action Alternative, both scenarios of the Proposed Action Alternative, USGS measured data, and a run-of-river (RoR) regime. The USGS and ROR were included for consistency with completed during the 2008 consultation.

2.7.1.2 Daily Fall Rates With Respect to Gulf Sturgeon

Because Gulf sturgeon spawning most often occurs at depths between 8 and 18 feet, a rapid fall in river stage could result in exposure or stranding of eggs and larvae. A depth of 8 ft over the highest known Gulf sturgeon spawning habitat on the Apalachicola River corresponds to a flow of approximately 40,000 cfs. Under the ACF water control operations, impacts to Gulf sturgeon spawning habitat is not expected. The Jim Woodruff Dam water management operations have mechanisms in place to ensure that when flows are less than 40,000 cfs a decline more than 8 feet in less than 14 days during the months of March, April, and May does not occur. Analysis of the simulated flows verifies that this potential take event does not occur. The Jim Woodruff Dam water management operations also include a fall rate schedule when discharges are within the capacity of the powerhouse that facilitates movement of mussels and host fish as river stages decline.

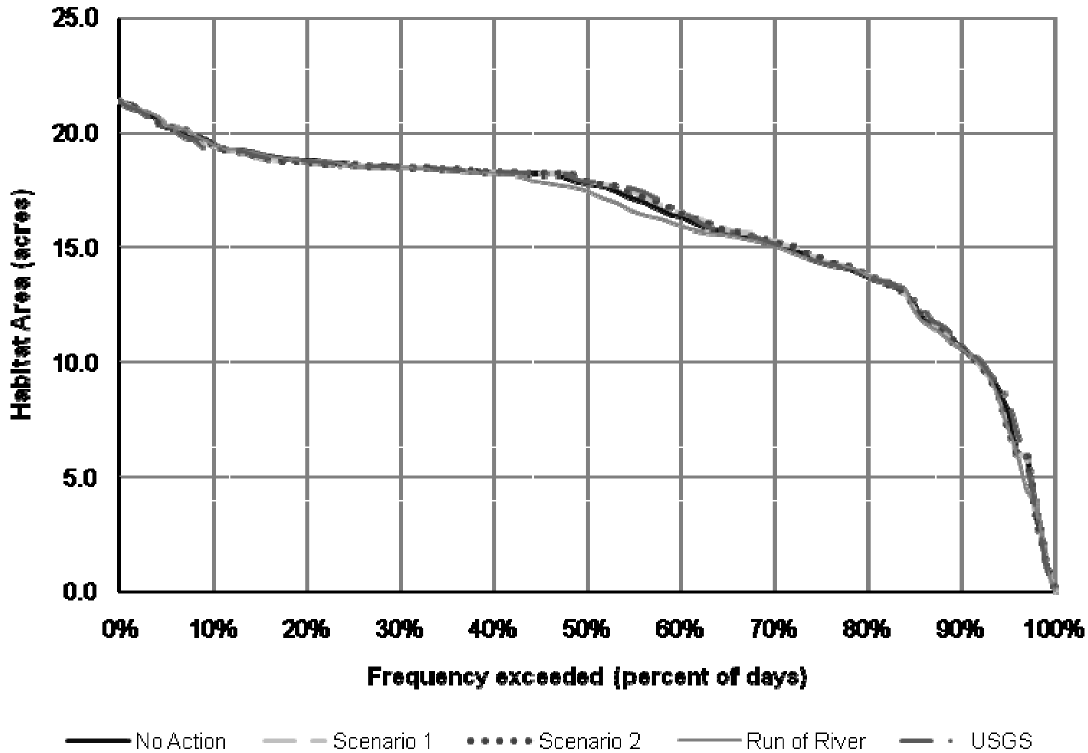


Figure 2.7-1. Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1 through May 31, at each of the three sites that support spawning. (*Figure 4.2.3.A.* from the 2008 BO.*)*

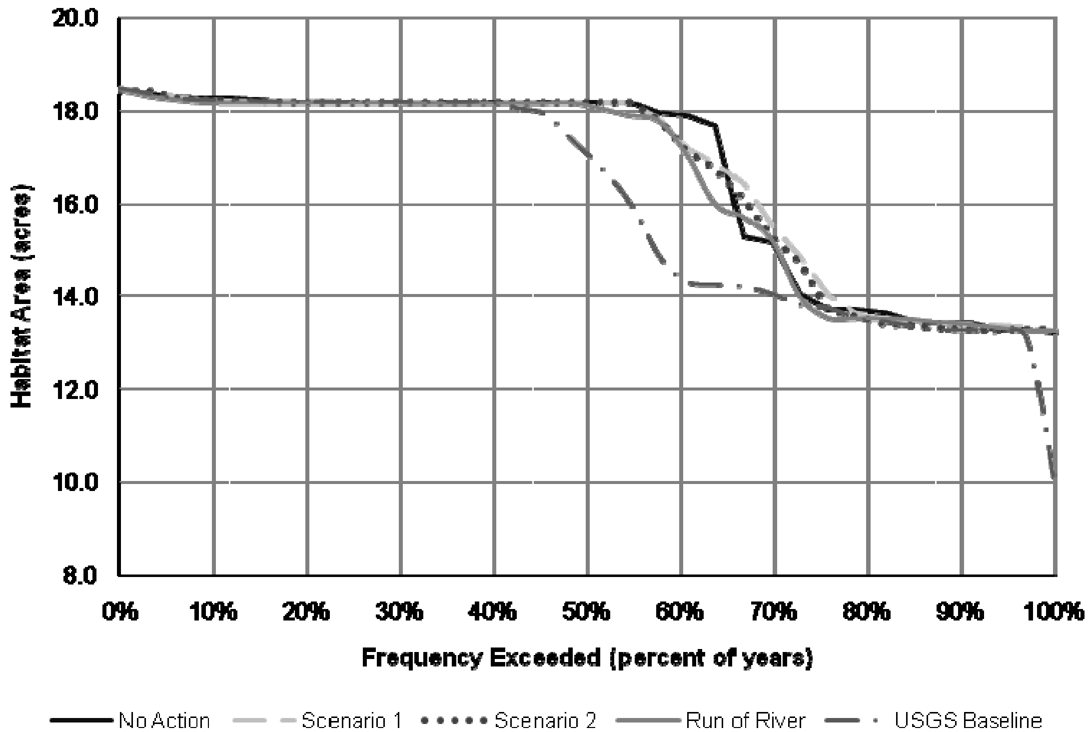


Figure 2.7-2. Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1 through May 31, at each of the three sites that support spawning. (*Figure 4.2.3.B.* from the 2008 BO.*)*

2.7.1.3 Maximum Number of Days per Year Less Than 16,000 cfs

Gulf sturgeon are restricted to the Apalachicola River mainstem below Jim Woodruff Lock and Dam, using select areas for spawning and reproduction from March through May. Adults and sub-adults returning from spawning to the estuarine waters of Apalachicola Bay to feed and juveniles encountering that environment for the first time, require a gradual transition to increasing salinity. Altinok et al. (1998) determined that optimal growth rates of juvenile Gulf sturgeon occur at salinity levels of approximately 9 parts per thousand (ppt). Direct transition to salinities greater than 30 ppt is lethal. Flow data from the Apalachicola River at the Chattahoochee gage show a strong association with salinity levels in Apalachicola Bay and indicate that prolonged flows of less than 16,000 cfs generally result in salinity concentrations over 10 ppt (Livingston et al. 2000). The maximum number of days per year in which flows are less than 16,000 cfs is presented below.

The median of the maximum number of days at less than 16,000 cfs is slightly higher for the No Action Alternative than what has been measured by the USGS (**Error! Reference source not found.**).

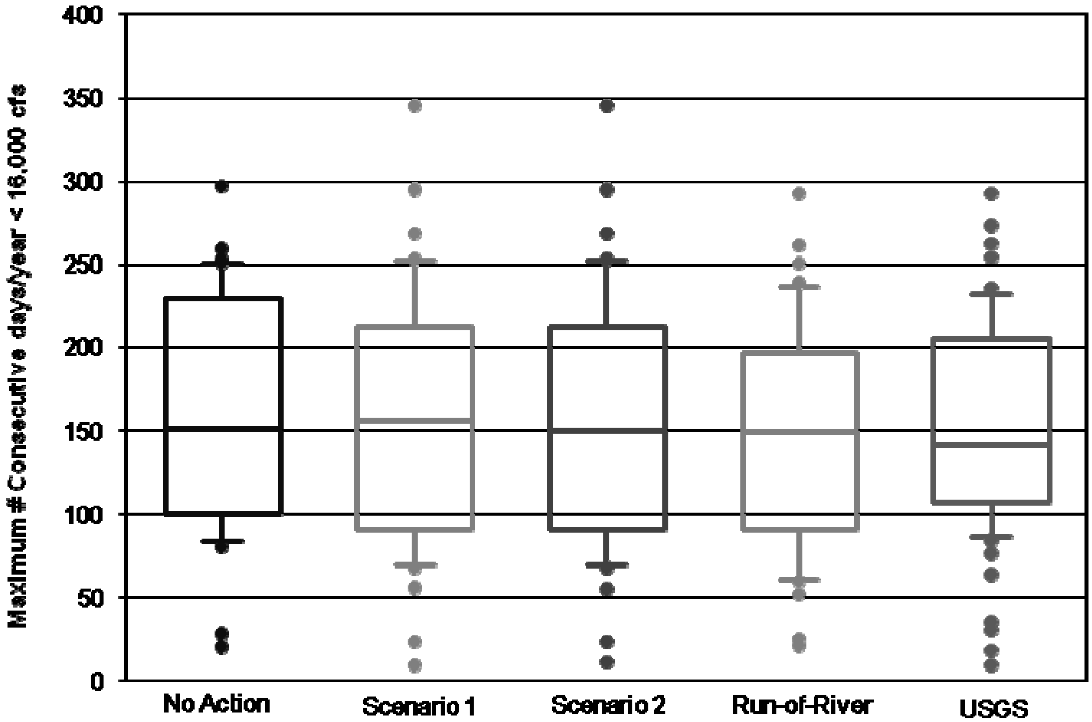


Figure 2.7-3. Range of maximum number of consecutive days per year less than 16,000 cfs with data from 1975 through 2008. (*Figure 4.2.4.A.* from the 2008 BO.*)*

Results of modeling indicate that median values of the maximum number of consecutive days per year where flows are less than 16,000 cfs remains consistent between scenarios for the Proposed Action Alternative and the No Action Alternative at approximately 150 days (**Error! Reference source not found.**). The No Action Alternative 25th and 75th percentile values are approximately 10 and 20 days higher than those represented by the Proposed Action Alternative scenarios. Comparing to the run-of-river (ROR) scenario as presented in USFWS (2008b), the 25th percentile values are similar to the Proposed Action Alternative and 75th percentile values are 16 days higher in the Proposed Action Alternative.

2.7.1.4 Departure from Average Mean Temperature between May 1 and June 31

Water temperatures provide important cues for migration and, particularly for spawning of Gulf sturgeon. Within the Apalachicola River basin, spawning generally occurs during spring as water temperatures approach 17 °C up to 25 °C. Temperature data (2003–2007) from the Blountstown gage were modeled using Hec5Q and are presented below.

The No Action Alternative water temperature conditions are not expected to change. Mean daily water temperature values are nearly identical between the Proposed Action Alternative scenarios and the No Action Alternative, with mean temperatures around 20 °C. The date at which water temperature reaches 17 °C also remained consistent in mid-March and increase to 25 °C in early May.

2.7.2 Freshwater Mussels Analysis

2.7.2.1 Lowest Daily Flow Rate for Each Year

Flow rates, representing the lowest annual levels from 1975 through 2008, were evaluated to determine the potential for exposing and stranding aquatic biota. The results are presented below.

The median low-flow for the No Action Alternative from 1975 through 2008 is 6,043 cfs at Chattahoochee, Florida. Over the period, low-flows are generally low and maintaining the No Action Alternative increases the occurrence of low-flow events over measured data by USGS.

Error! Reference source not found. lists the lowest daily flow rates from 1975 through 2008 for the No Action Alternative and Proposed Action Alternatives. Scenarios 1 and 2 of the Proposed Action Alternative and the No Action Alternative do not include simulated flows less than 5,000 cfs.

Table 2.7-1.
Minimum flow from modeled year.

Year	No Action	Scenario 1	Scenario 2
1975	13986	15005	15061
1976	8115	8971	8999
1977	6022	6051	6073
1978	6651	6651	6651
1979	6433	6472	6478
1980	6114	6115	6115
1981	5049	5049	5049
1982	8401	8388	8386
1983	7946	7928	7928
1984	7652	8070	8070
1985	6174	6321	6381
1986	5049	5049	5049
1987	6064	5786	6021
1988	5050	5050	5050
1989	5735	6415	6346
1990	5435	5491	5433
1991	8763	8749	8747
1992	8086	8205	8208
1993	5877	5873	5803
1994	8472	8624	8596
1995	5500	5433	5477
1996	6680	6648	6664
1997	5775	5757	5758
1998	7530	7699	7677
1999	5018	5021	5001
2000	5050	5029	5029
2001	5050	5050	5050
2002	5050	5025	5009
2003	8751	8533	8543
2004	5993	5781	5787
2005	8921	7435	7435
2006	5050	5050	5050
2007	5034	5050	5050
2008	5050	5050	5050

2.7.2.2 Inter-annual Frequency of Flows less than 5,000–10,000 cfs

Mussels are susceptible to stranding at flows ranging from 5,000 to 10,000 cfs, particularly following high-flow events (> 100,000 cfs) that serve to move individuals into depositional areas (USFWS 2008b). Inter-annual flows, expressed as the frequency of occurrence of the percent of years, were evaluated to address the potential for stranding. The results are presented below.

Evaluation of the inter-annual frequency of flows less than 10,000 cfs indicates a close correspondence of the No Action Alternative and both scenarios of the Proposed Action Alternative (**Error! Reference source not found.**). The lowest flows, including the frequency of those below 5,000 cfs, are most often associated with the run-of-river regime. None of the proposed flow scenarios fall below 5,000 cfs, compared to approximately 56 percent of the run-of-river regime. Both of the Proposed Action scenario simulations provide results consistent with those of the No Action Alternative.

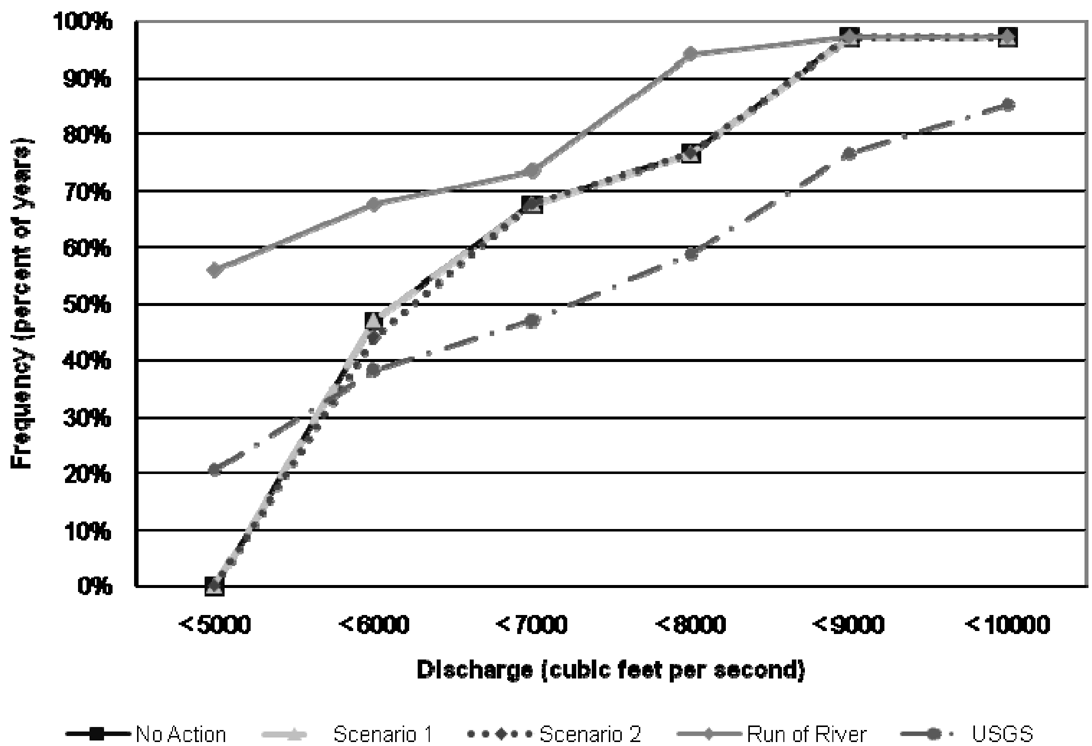


Figure 2.7-4. Inter-annual frequency of flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs based on 1975 – 2008 (*Figure 4.2.5.A.* from the 2008 BO.)

2.7.2.3 Maximum Number of Days per Year Flows less than 5,000–10,000 cfs

The maximum number of days per year with flows less than 5,000–10,000 cfs provides an estimation of the most severe conditions aquatic biota will experience under the proposed flow regimes.

The modeled No Action Alternative tracks closely with the run-of-river in discharges greater than 6,000 cfs (**Error! Reference source not found.**). Though mussels can survive brief periods of stranding by closing their shells or burrowing in substrate, mussels would not be expected to survive long durations of exposure at flows less than 5,000 cfs (as simulated for the RoR condition).

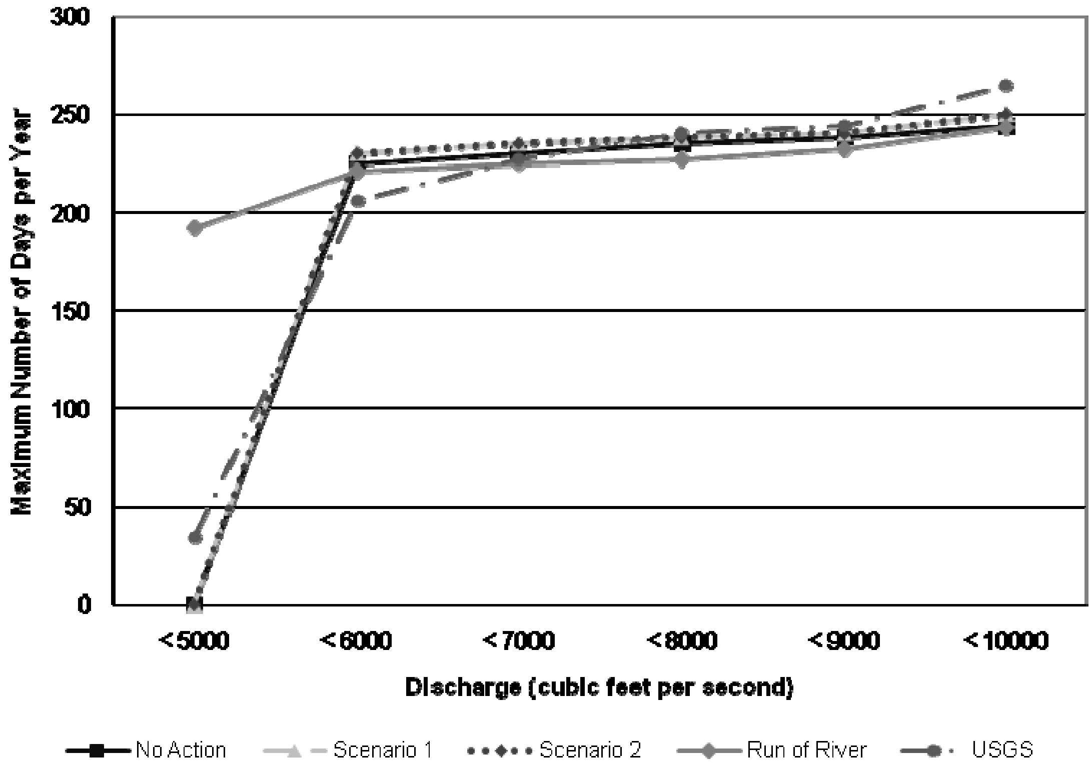


Figure 2.7-5. Maximum number of days per year with flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs from 1975 – 2008 (*Figure 4.2.5.B.* from the 2008 BO.*)*

At flows above 6,000 cfs, all scenarios are more than 200 days, with the run-of-river estimates falling slightly lower than that of the Proposed Action Alternative (**Error! Reference source not found.**). However, the Proposed Action Alternative flows never fall below 5,000 cfs, in contrast to the run-of-river regime, which is estimated to occur approximately 185 days annually. The Proposed Action Alternative is consistent with the No Action Alternative.

2.7.2.4 Maximum Number of Consecutive Days less than 5,000 - 10,000 cfs

Mussels can survive brief periods of stranding by closing their shells or burrowing in substrate. Thus, without extreme water temperatures, mussel survival from stranding is most likely a function of exposure duration (USFWS 2008b). To address that, the maximum number of consecutive days of flows between 5,000 and 10,000 cfs was evaluated.

Error! Reference source not found. shows the maximum number of consecutive days of flows at less than 5,000–10,000 cfs is similar in the Proposed Action Alternative to the No Action Alternative. The No Action Alternative and Proposed Action Alternative are comparable at all flows and offer a beneficial effect from having no occurrence of flows below 5,000 cfs. In contrast, the run-of-river regime provides a slightly lower number of maximum consecutive days with exception to flows below 5,000 cfs, which occur approximately 125 days annually. The No Action and Proposed Action Alternative simulations include no consecutive days with flows less than 5,000 cfs. The Proposed Action Alternative is consistent with the No Action Alternative.

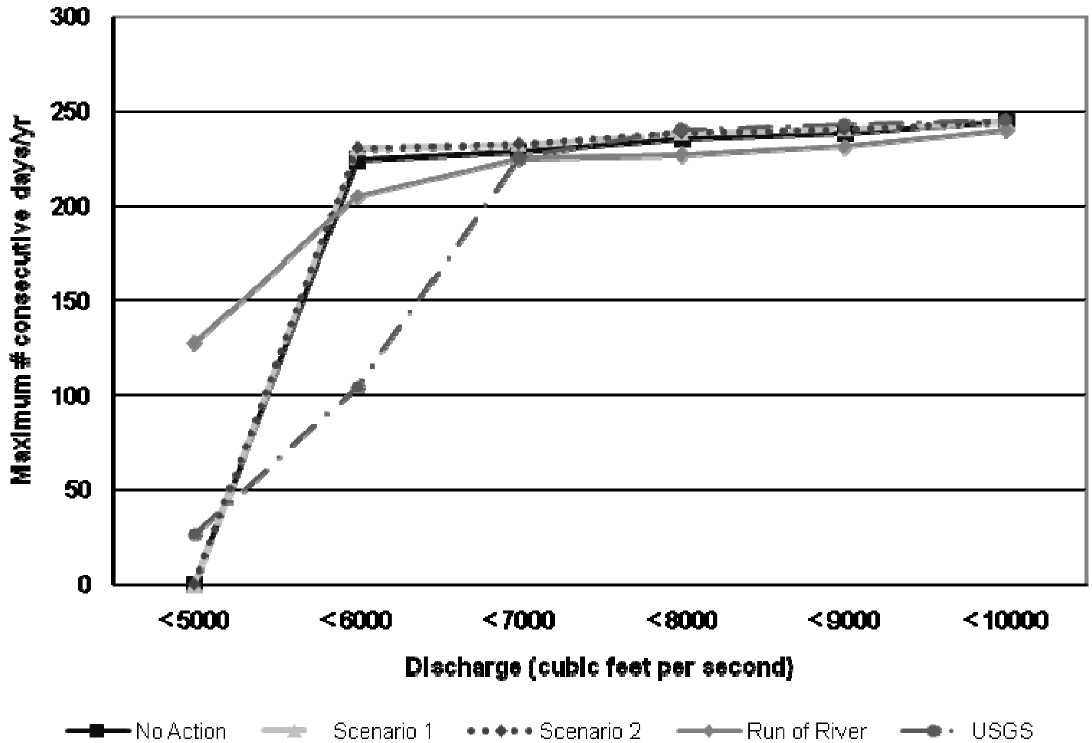


Figure 2.7-6. Maximum number of consecutive days with flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs (*Figure 4.2.5.C.* from the 2008 BO.*)*

2.7.2.5 Median Number of Days per Year Flows less than 5,000–10,000 cfs

The duration of moderate low-flow periods are also an important consideration for the survival of mussels and other aquatic biota. Chronic low-flow events occur with greater frequency than extreme events and, despite the less severe conditions, serve to decrease habitat availability, increase physiological stress, and increase both exposure-related and predatory mortality.

Median flows below 7,000 cfs occur but are limited in the No Action Alternative (**Error! Reference source not found.**). The Proposed Action Alternative offers the lowest median number of days per year at levels less than the 5,000–10,000 cfs thresholds (**Error! Reference source not found.**). The scenarios show no occurrences below 6,000 cfs and, with exception to the < 10,000 cfs value, generally maintain an average of approximately 5 days less than the run-of-river scenario. Only at 9,000 cfs would the Proposed Action Alternative be increased from the No Action Alternative.

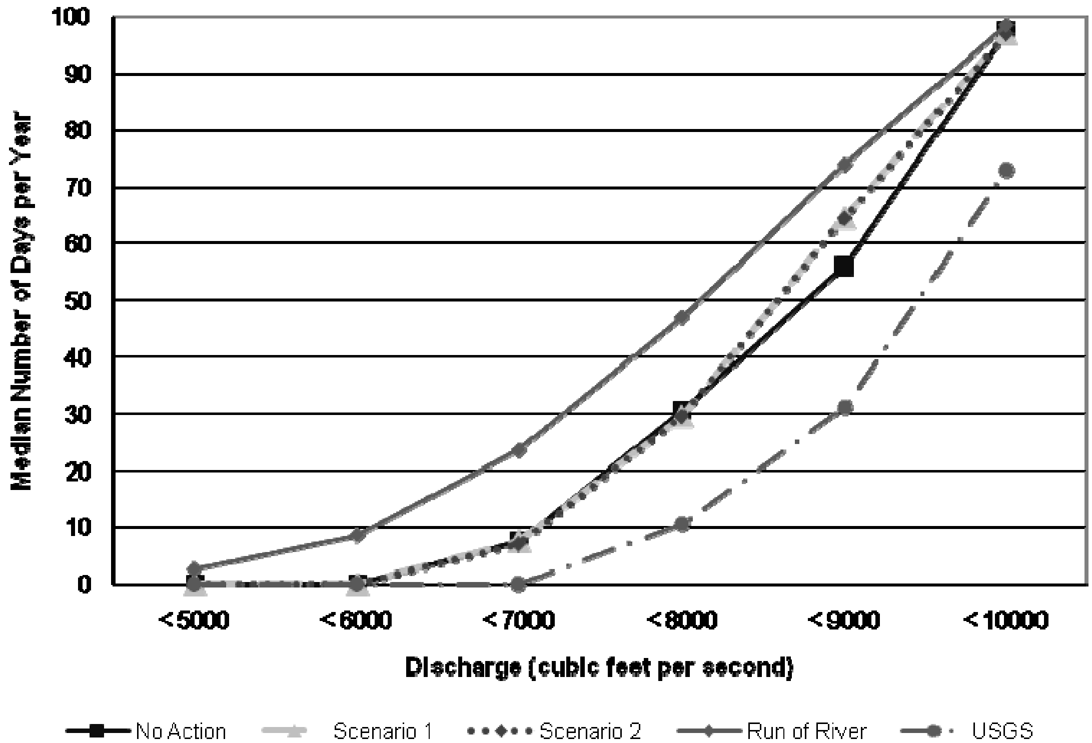


Figure 2.7-7. Median number of days per year with flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs (*Figure 4.2.5.D.* from the 2008 BO.*)*

2.7.2.6 Frequency (Percent of Days) of Daily Stage Change Expressed as ft/Day

The current RIOP maximum fall rate schedule was established to avoid extreme declines in daily river stage levels and decrease the risk of exposure or stranding of aquatic biota. Declining river stages are moderated by operating schedules to provide an attenuation of flows that allow for more gradual fall rates as flows decline. Those rates were evaluated to determine the effect of the Proposed Action Alternative strategies by using frequency histograms of the rate of change in the following categories: <= 0.25 ft/day, > 0.25 to <= 0.50 ft/day, > 0.50 to <= 1.00 ft/day, > 1.00 to <= 2.00 ft/day, and > 2.00 ft/day.

The No Action and Proposed Action fall rates are generally consistent and provide for higher frequencies of fall rates in the lower categories than the observed and RoR (**Error! Reference source not found.**). However, the No Action and Proposed Action simulations generally provide for lower frequencies of fall rates in the higher categories (>1.00 ft/day). Among the falling days the rates of less than 0.25 ft/day are the most common of the action flow scenarios, occurring approximately 25 percent of days. Collectively, the run-of-river fall rates above 0.25 ft/day occur with greater frequency than the Proposed Action Alternative and the No Action Alternative. Those rates increase the risk of exposure or stranding of aquatic organisms; however, because the majority of occurrences are within the 0.25- to 0.50-ft range, the effect of the water level changes is minimized.

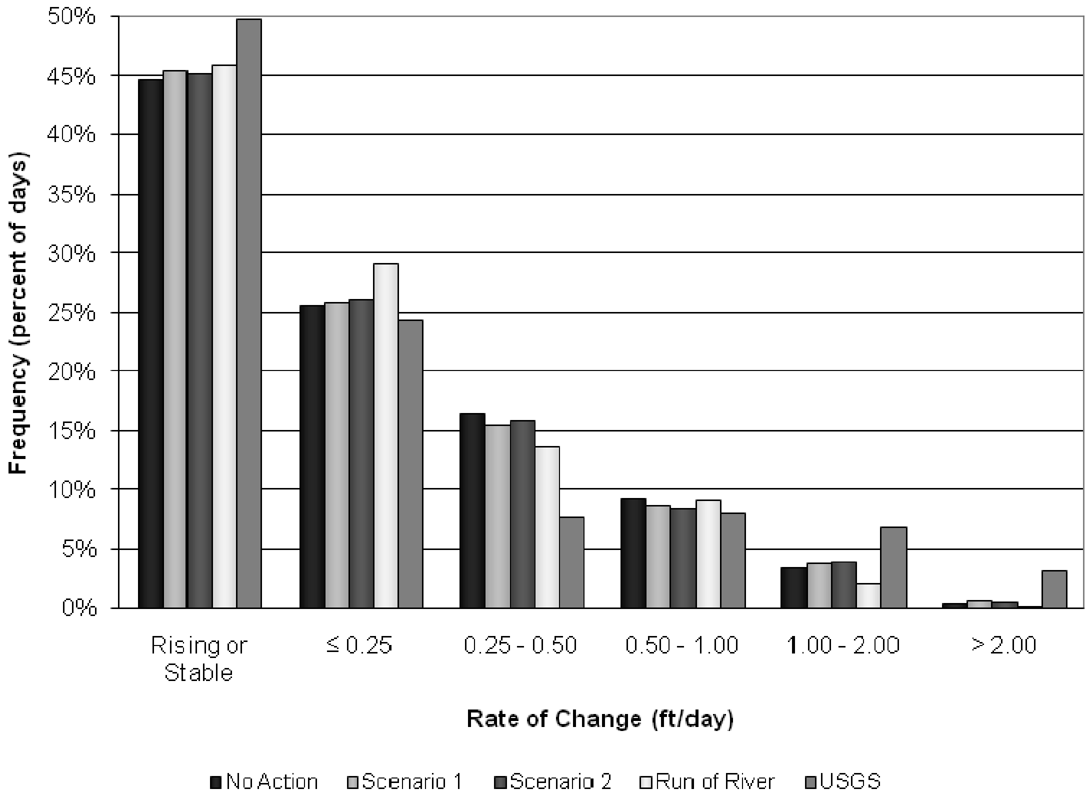


Figure 2.7-8. Frequency (percent of days) of daily stage changes (ft/day) from 1975–2008. (*Figure 4.2.5.E.* from the 2008 BO.*)*

2.7.2.7 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day when Releases at Woodruff Dam are less than 10,000 cfs

A second fall rate analysis was performed to evaluate whether an increase in the percentage of days with rates greater than 0.25 ft/day would affect federally listed mussel species. The evaluation is restricted to periods when releases from Jim Woodruff Dam are less than 10,000 cfs. The results are provided below.

The number of days in the greater than 0.25 ft falling rate categories of the No Action Alternative is nearly double that of measured USGS data (**Error! Reference source not found.**). The Proposed Action Alternatives had a similar number of days in the greater than 0.25 ft falling rate categories as the No Action Alternative. However, as discussed above, the majority of these days occur in the lower fall rate categories. Those results suggest that the Proposed Action Alternative is consistent with the No Action Alternative.

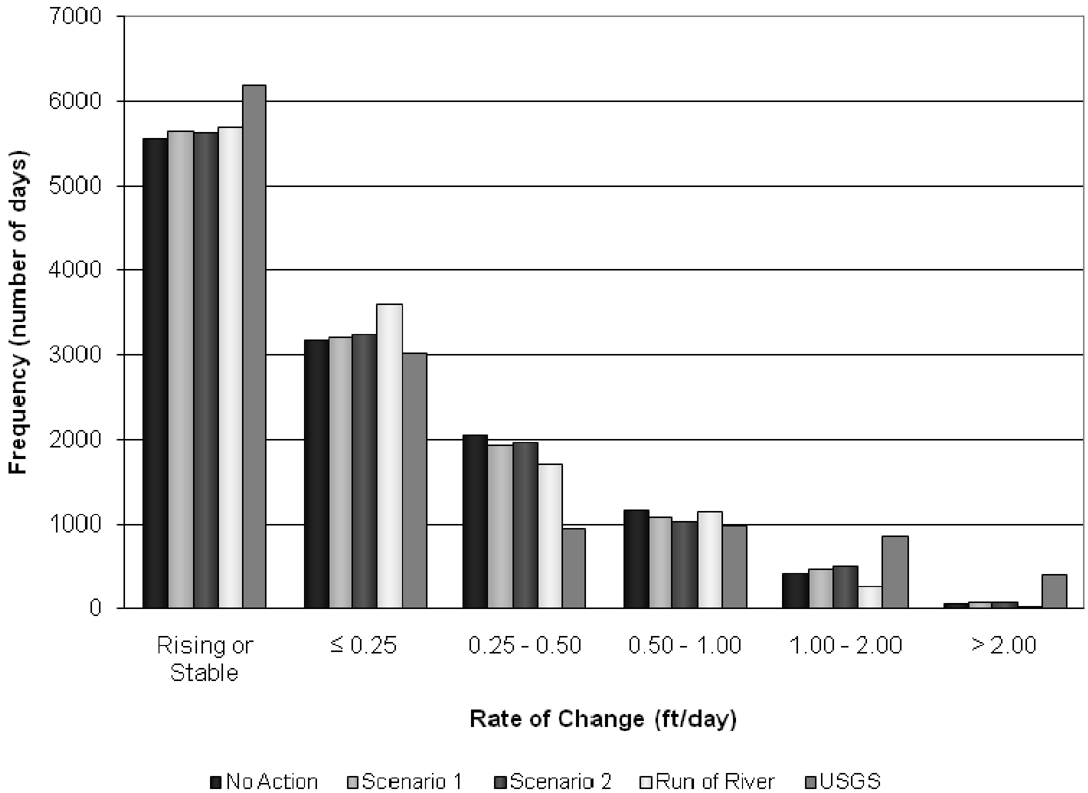


Figure 2.7-9. Frequency (# of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs from 1975-2008. (*Figure 4.2.5.F.* from the 2008 BO.*)*

2.7.3 Floodplain Connectivity Analysis

2.7.3.1 Frequency (% of days) of growing season (April - October) floodplain connectivity (acres) to the main channel using Light et al. 1998

Our analysis uses the relationship documented by Light et al. (1998) between total area of nontidal floodplain area inundated and discharge at the Chattahoochee gage. Figure 2.7-10 displays a frequency analysis (percent of days) during the growing season months (April – October) of connected floodplain area for the No Action Alternative, Proposed Action Alternative scenarios, RoR, and observed. The general area/frequency pattern of the No Action and Proposed Action Alternatives is comparable to the observed and RoR. However, the amount of habitat connected to the main channel at a given frequency for both of these is consistently less than the RoR. Figure 2.7-11 provides a similar analysis as this, but with an extended growing season as requested by the FWCC in their April 2010 supplemental letter to the PAL. The results of that analysis are consistent with those observed in Figure 2.7-10.

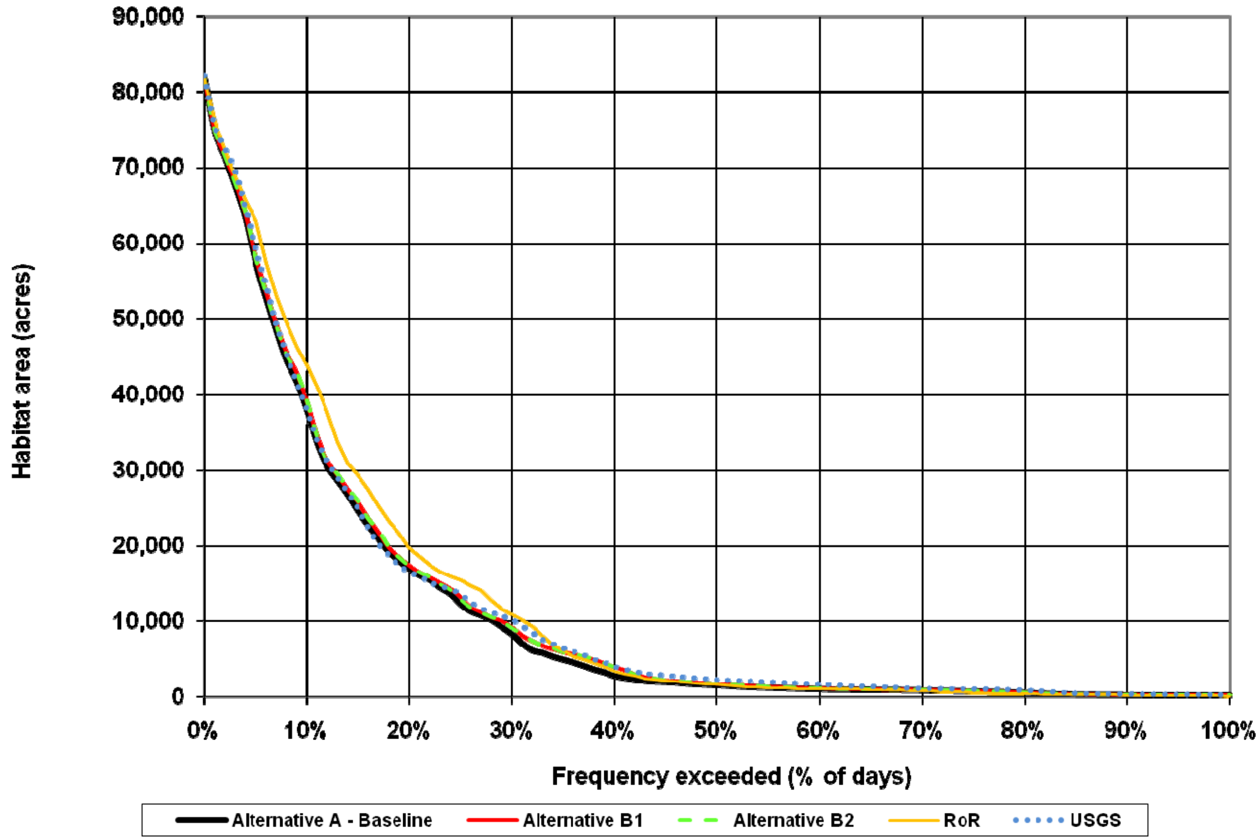


Figure 2.7-10. Frequency (% of days) of growing season (April - October) floodplain connectivity (acres) to the main channel using Light et al. 1998 (*Figure 4.2.6.A.* from the 2008 BO.*)*

2.7.3.2 FWCC Request - Frequency (% of days) of growing season (March-November) floodplain connectivity (acres) to the main channel using Light et al. 1998

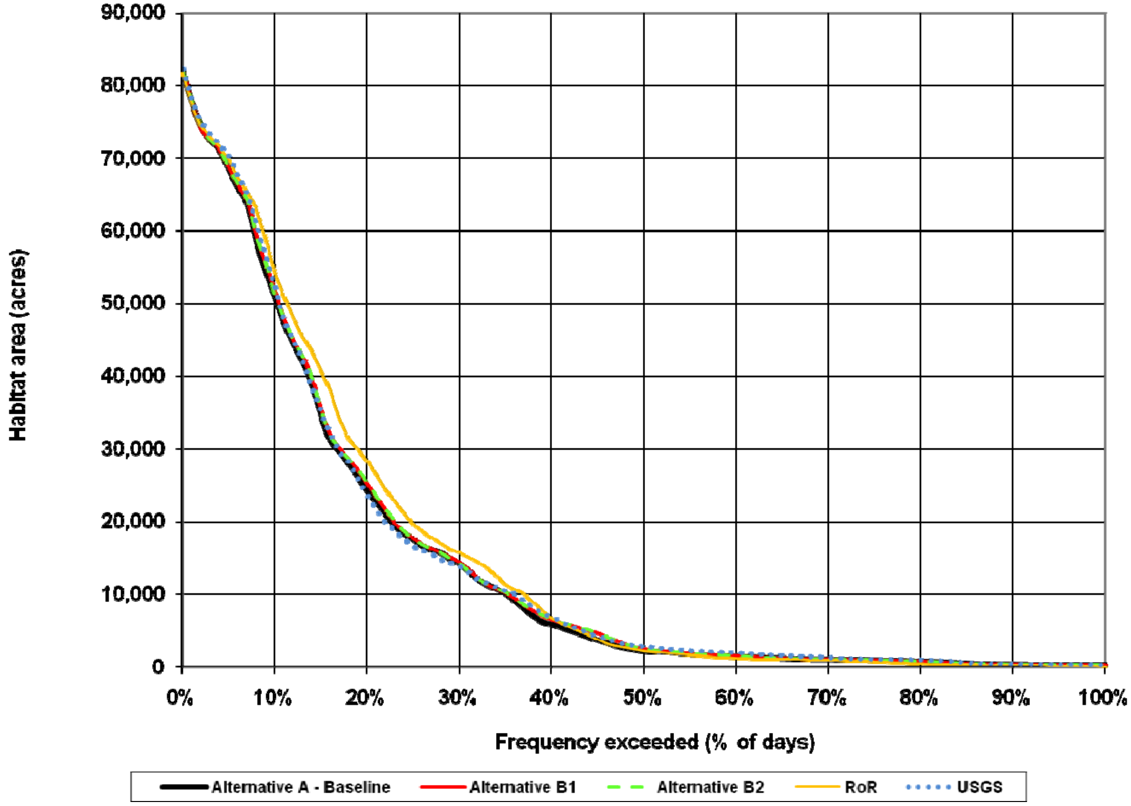


Figure 2.7-11. Frequency (% of days) of growing season (March - November) floodplain connectivity (acres) to the main channel using Light et al. 1998.

2.7.3.3 Frequency (% of years) of growing season (April – October Maximum) 30-day Continuous floodplain connectivity (acres) to the main channel using Light et al. 1998

In order to interpret biological impacts, it is also important to consider the temporal pattern of floodplain inundation. The growing season floodplain inundation was analyzed using a 30-day moving minimum to represent this aspect of habitat availability. The maximum acreage inundated for at least 30 days each year was then identified and illustrated in Figure 2.7-12. Annual 30-day continuous connectivity is roughly comparable between the No Action and the Proposed Action Alternative scenarios, but both are consistently less than the RoR flow regime. The observed flow regime consistently provided less 30-day continuous connectivity than the No Action and the Proposed Action Alternative scenarios.

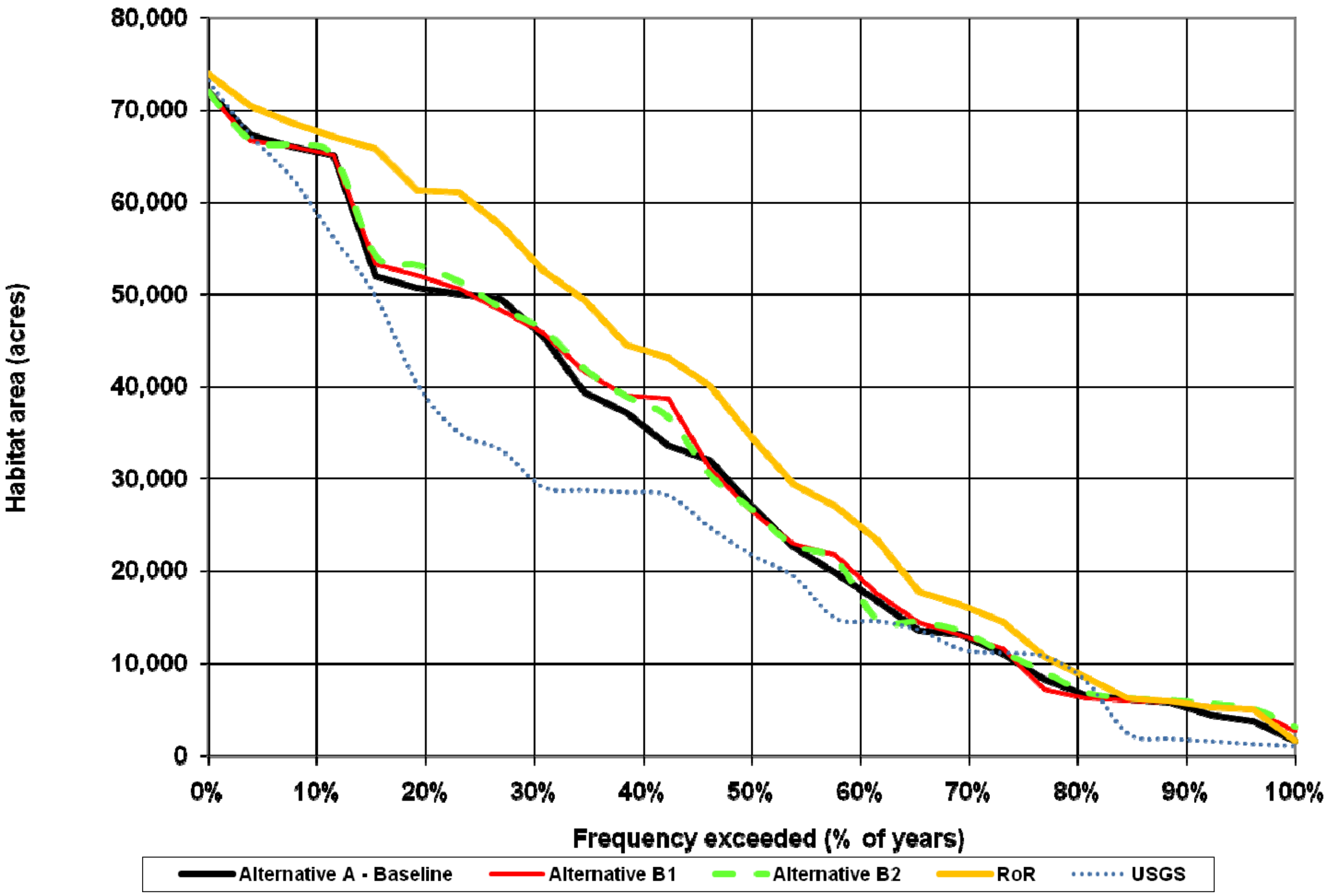


Figure 2.7-12. Frequency (% of years) of growing season (April – October Maximum) 30-day Continuous floodplain connectivity (acres) to the main channel using Light et al. 1998.

2.7.3.4 FWCC Request - Frequency (% of years) of growing season (March-November Maximum) floodplain connectivity (acres) to the main channel using Light et al. 1998.

Figure 2.7-13 provides a similar analysis as the previous section, but with an extended growing season as requested by the FWCC in their April 2010 supplemental letter to the PAL. The results of that analysis are consistent with those observed in Figure 2.7-12.

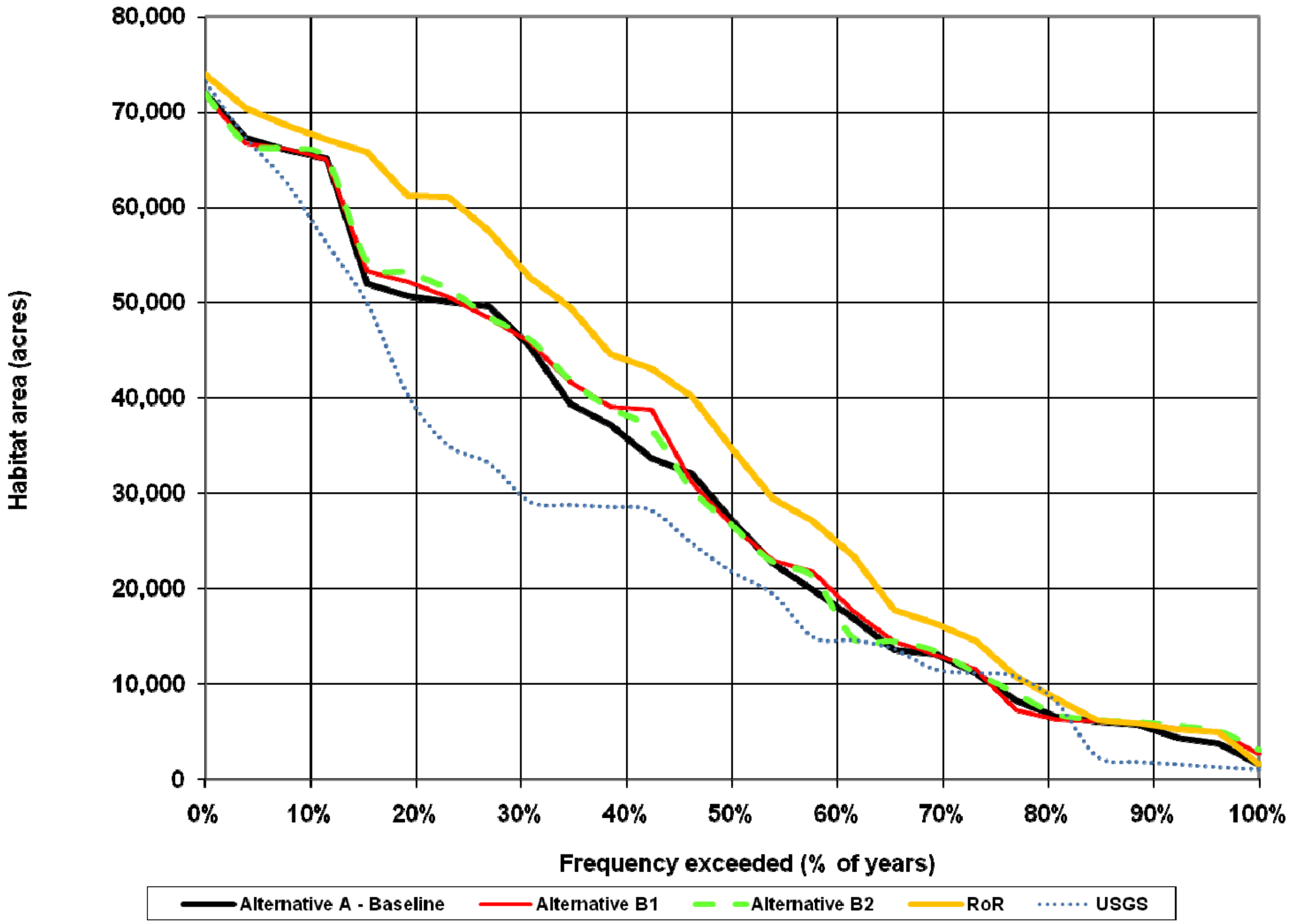


Figure 2.7-13. Frequency (% of years) of growing season (March-November Maximum) floodplain connectivity (acres) to the main channel using Light et al. 1998.

2.7.3.5 FWCC Request - Frequency (% of days) of growing season (March - November) with flows between 12,000 and 30,000 cfs (Tupelo/Cypress Swamps) Darst and Light, 2008

In their April 2010 supplemental letter to the PAL, the FWCC requested that we evaluate the frequency (% of days) of an extended growing season (March-November) with flows between 12,000 and 30,000 cfs. The general area/frequency pattern of the No Action and Proposed Action Alternatives is comparable to the observed and RoR.

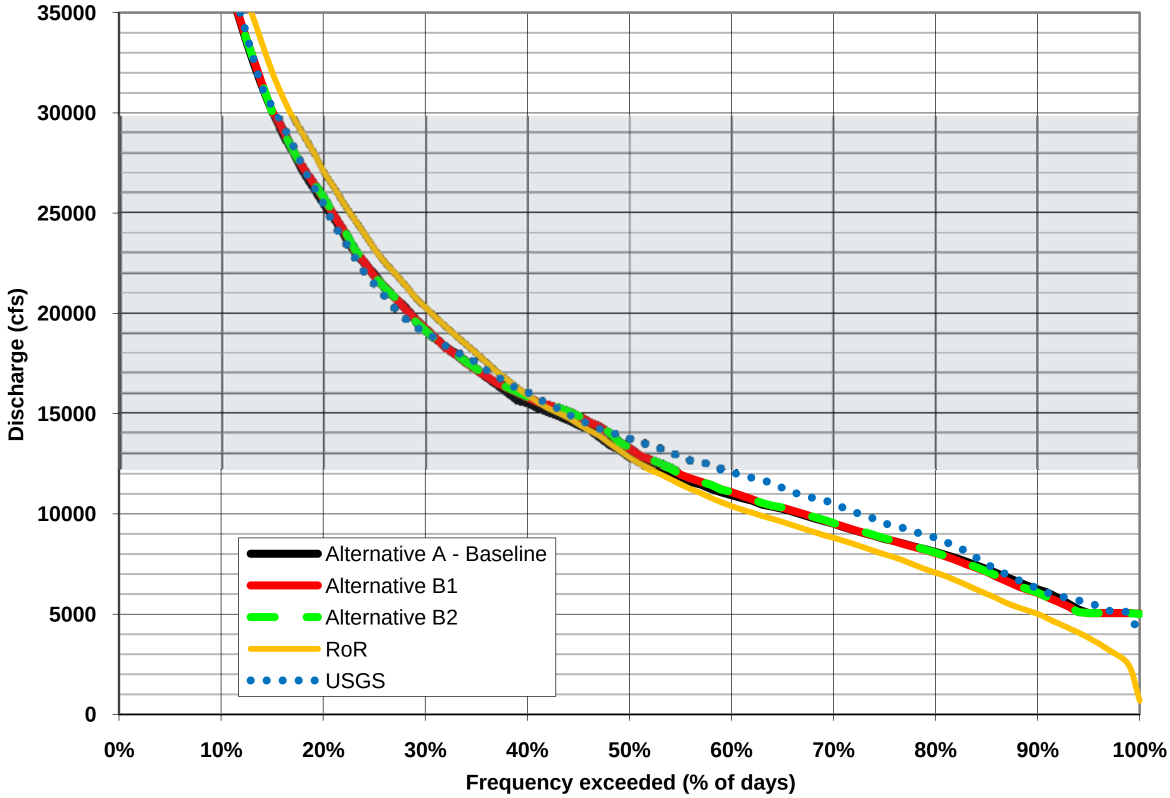


Figure 0-13. Frequency (% of days) of growing season (March - November) with flows between 12,000 and 30,000 cfs (Tupelo/Cypress Swamps) Darst and Light, 2008.

2.8 Additional Analysis - Fish and Wildlife Management Facilities

2.8.1 Eufaula National Wildlife Refuge

The potential impacts on Eufaula National Wildlife Refuge (ENWR) are primarily related to reservoir level fluctuations at W.F. George Lake, influencing the refuge in three critical areas (USFWS 1998): (1) direct effects on habitat availability for wildlife; (2) effects on vegetation communities, particularly with respect to invasive species; and (3) the availability of water during October and November to off-reservoir impoundments that support waterfowl habitat management.

Reservoirs are generally associated with large watersheds and tributaries because of their engineered purpose of providing flood damage reduction, hydroelectric power, and navigation. As a result, they are characterized as receiving large organic and inorganic inputs, high nutrient loads, and contaminants

(Miranda et al. 2010). Depositional filling effectively limits surface area and volume, thereby creating isolation of backwater areas, promoting habitat degradation, and decreasing overall depth (Patton and Lyday 2008).

Water-level fluctuation, common in reservoir settings, also limits the formation of persistent species associations and assemblage structure, especially in vegetation and open littoral zones. Drennen (1995) noted the importance of proper reservoir management strategies in the ACF Basin in support of wood duck (*Aix sponsa*) brooding and rearing habitat, heron rookeries, and foraging habitat for bald eagles, wood storks, and migratory species. Other species, including Florida softshell (*Apalone ferox*), common snapping turtle (*Chelydra serpentine)*, and common slider (*Trachemys scripta*) have been observed nesting in sandbars and mudflats when reservoir levels are below 186 feet (USACE, Mobile District 1998a).

Several factors influence the success of exotic introductions, including habitat connectivity and propagule pressure, disturbance and environmental variability, and species diversity and biotic interactions (Davis et al. 2000; Elton 1958). Davis and colleagues (2000) established the concept of fluctuating resources availability (FRA), which suggests that communities become more susceptible to invasions in response to the amount of unused resources. Disturbances may temporarily reduce the number of native species and thus provide an opportunity for invasive species. The FRA hypothesis specifically predicts that systems with fluctuating resources or elevated productivity will be more susceptible to invasive species. Within the ENWR, alligatorweed (*Alternanthera philoxeroides*) has become the most prolific invader of ephemeral wetlands in response to fluctuating water levels (USFWS 1998). Other undesirable species include black willow (*Salix nigra*), *Sesbania*, and cutgrass (*Leersia* spp.).

Reservoir levels lower than 186 feet provide important wading bird habitat during spring and fall and serve to concentrate waterfowl during the winter months. These habitats, not usually available at higher water levels, provide important forage and nesting areas. For example, Drennen (1995) observed ring-billed gulls feeding on mussels along flats that had become exposed during low-water conditions. However, in contrast, the ability to supply water to off-reservoir impoundments requires reservoir levels above 185 feet (Ziewitz and Luprek 1996). This also allows gravity-flow flooding, which provides a more precise and cost-effective means of adjusting water levels in the impoundments. The sections to follow describe how changes in operations under the No Action and Proposed Action Alternatives influence these factors in the ENWR

Under the No Action Alternative, no changes would be expected. The ability of W.F. George Lake to provide 13.4 mgd to support waterfowl at off-reservoir impoundments would continue.

The two scenarios for the Proposed Action Alternative show only minor differences in water level changes from the No Action Alternative, suggesting a similarly low potential of effect on the shoreline vegetation and wildlife communities at ENWR. Additionally, inspection of water surface elevation plots at Walter F. George Lake for critical low-flow periods indicate that, with the exception of August through November when surface elevation drops to 184.50 ft, if ever, reservoir levels always remain above 185 feet under the Proposed Action Alternative. Thus, W.F. George Lake is expected to continue to provide 13.4 mgd of water to support waterfowl at off-reservoir impoundments.

The USFWS asked that the Corps consider cycling surface elevations at W.F. George to the highest levels (190 ft) in the late winter and lowest levels in early spring (185 ft). This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010). Current reservoir operations use winter draw-downs to accommodate flood releases from upstream projects and higher basin inflow during the wet season (2.8-1). Refilling usually occurs during the spring, typically at the end of the wet season, to provide storage to meet authorized project purposes and augment flows downstream of the project as needed. Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows causing bank erosion and channel modifications below the project. Maintaining low elevations during the summer dry season would remove composite conservation storage from the system at a time when it is most critically needed for flow augmentation and hydroelectric power production. Additionally, this proposed operation contradicts the current fish spawning standard operating procedure for the reservoir, which calls for steady to increasing pool elevations during the spring.

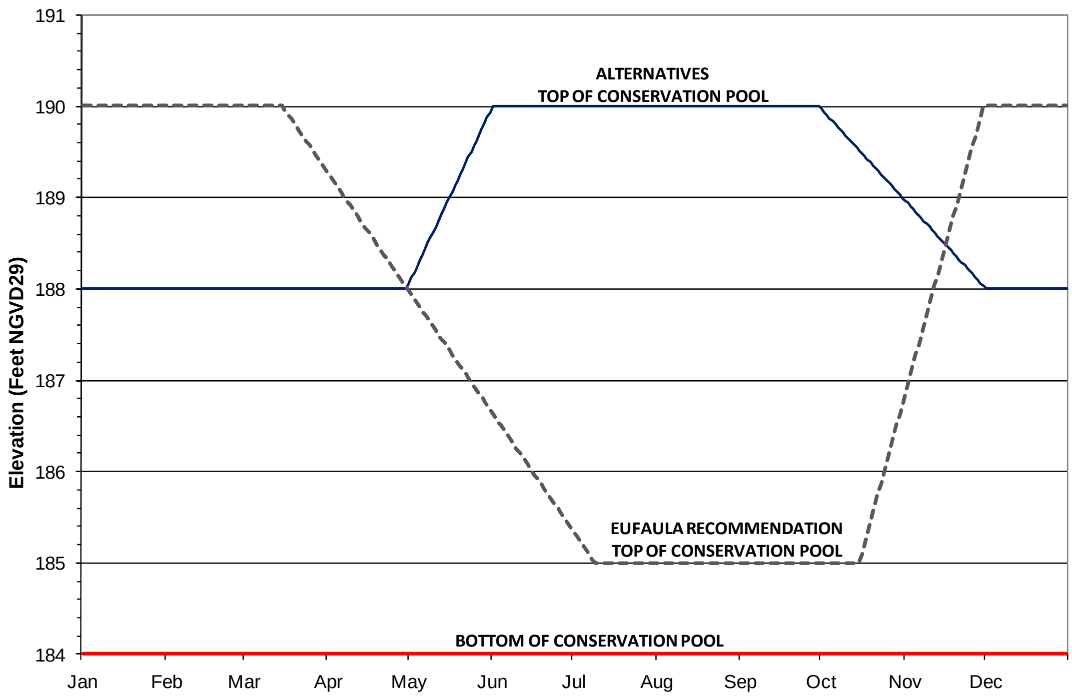


Figure 2.8-1. Eufaula National Wildlife Refuge recommended water surface elevation compared with the No Action and Proposed Action Alternatives top of conservation pool elevation.

2.8.2 Fish hatcheries

There are four fish hatcheries in the ACF Basin. The discussion below describes how changes to operations at Federal reservoirs would affect the hatcheries.

Under the No Action Alternate, no changes would be expected at any of the hatcheries.

Three of the hatcheries in the ACF Basin use groundwater. These hatcheries would not be affected by the Proposed Action Alternative.

Buford Trout Hatchery withdraws about 7 mgd (11 cfs) of flow from the Chattahoochee River below Buford Dam year-round (Ziewitz and Luprek 1996). The results of the HEC-5Q water quality modeling for the period from 1975 through 2008 indicate only minor changes in the Proposed Action Alternative from the No Action Alternative with respect to water temperature and the dissolved oxygen concentrations of coldwater bottom discharges from Lake Lanier through Buford Dam. Therefore, no effects on the Buford trout Hatchery's operation would be expected as a result of the Proposed Action Alternative.

2.9 Response to 27 May 2010 FWS Email

1. Apalachicola River- We would like to examine effects of maintaining 15,400 cfs (Chattahoochee gage) for Navigation through May 15 as a guaranteed continuous minimum flow, and a similar

> analysis through May 31. We would also like to know under which zones you intend to operate for navigation. During our telephone conversation, you indicated that the Corps has modeled a 15,400 cfs navigation season from January 1 through April 30, but that the Corps will not maintain a minimum 15,400 cfs discharge unless requested to do so. Thus, it is unclear whether the baseline and two alternatives represent anticipated operations with or without a request for a 15,400 cfs discharge. If the RES-SIM model does not include a guaranteed continuous minimum flow of 15,400 cfs through April 30, we would like to examine the RES-SIM output for 15,400 cfs extending through April 30, May 15, and May 31 (within the same navigation operating zones) so that we can evaluate the effects of these changes on system operation.

During development of the Navigation Season operation, the Corps simulated various navigation depth scenarios and season length scenarios. At that time, it was assumed that a 7 foot stage at Blountstown provided a 7 foot depth navigation channel, which corresponded to a 15,400 cfs flow. The model simulations considered navigation seasons from December through April; January through April; and December through May. Under these scenarios, navigation support was limited to times when composite conservation storage was in zones 1 or 2. Once composite conservation storage fell below zone 2, the navigation season was no longer supported and additional support could not occur until the composite conservation storage had recovered to above zone 2 (i.e. within zone 1). In evaluating the impacts of implementing the navigation season concept, we analyzed how providing the 15,400 cfs minimum flow impacted the number of times that drought operations were triggered in the basin. The December through May navigation season triggered drought operations approximately twice as often (for the period of record simulation) as the January through April navigation season. The January through April navigation season was more closely in line with the number of times drought operations were triggered under the current operations (Baseline).

We recently completed updated channel surveys of the Apalachicola River. Based on the results of those surveys we have adjusted the navigation flow to 16,200 cfs to provide a 7 foot navigation channel without dredging support during the navigation season. Due to the increased flow necessary to provide the 7 foot channel, we again ran simulations to test the viability of implementing a navigation season. The updated model simulations considered navigation seasons from January through April and January through May. All other rules and triggers remained the same. These simulations demonstrated that extending the navigation season through May does not increase the number of times that drought operations were triggered in the basin as compared to the January through April navigation season and the Baseline. Thus the preferred alternative will include a navigation season that provides for a navigation flow of 16,200 cfs at the Blountstown Gage from January through April/May of each year (as long as the composite conservation storage constraints are not violated).

It should be noted that in all the simulations, as long as the appropriate triggers and conditions were met, the navigation season flows were always supported. This represents the scenario that would demand the most storage to augment flows, and thus was used to test the viability of implementing a navigation season. This is also a good representation of the way we intend to operate in support of navigation. However, in addition to the conditions described above, the determination to extend the navigation season beyond April will depend on ACF basin inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. The Corps will determine if the navigation season will continue through part or all of May based on an analysis of these factors. As with all operations, we reserve the flexibility to shorten, interrupt, or cancel a navigation season due to safety, physical, or mechanical constraints. Since the updated model simulations indicate that a navigation flow of 16,200 cfs is viable from January through May 31, we will not run additional simulations evaluating the viability of a navigation season from January through May 15.

2. Chattahoochee River (Norcross and West Point)- We recommend that the Corps use the RES-SIM model to evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4 weeks from March – May. Reiterating several points from our conference call, a non-peaking hydro window does not mean that power cannot be generated. It simply means that the Corps operate the reservoir in a manner that reduces hydrograph fluctuations that are, in part, due to power generation.

The most important thing to consider in this request is that the Buford and West Point projects were designed to operate as peaking hydropower projects. The District Court specifically addressed this issue in its July 17, 2009 Order (page 93). To meet your requested flow targets the Corps would have to forgo operating the large generators at both dams for 30-60 days. This would cause a tremendous loss of hydropower production at the projects and we believe such a loss of hydropower is not supported by the project authorizations.

However there are also physical, safety, and logistical limitations to operating the projects in a non-hydropower peaking mode for any amount of time, much less 30-60 days. Therefore, to thoroughly address your request (despite the District Court's decision and the required temporary abandonment of an authorized project purpose), we gathered the appropriate PDT members together to discuss the realities of trying to implement the type of operation you requested. First, it is our understanding, based on the PAL, that the target range of flows for the March through May period would be approximately 1,800-2,000 cfs for an average year (as measured at the Norcross Gage below Buford) and approximately 4,500-5,000 cfs for an average year immediately below West Point. Thus we discussed the viability of providing those flows without peaking operations for a minimum 30 day period.

At Buford, releases are made either through one/both of two main units (approximately 4,500-6,200 cfs capacity each), the small unit (approximately 600 cfs capacity), or one of the two jet flow valves installed in the sluice gates (approximately 600 cfs capacity each). Because there is only one emergency gate, only one sluice gate or jet valve is used at a time due to safety constraints. The emergency gate is used whenever releases are made from the jet flow valves or sluice gate to provide a secondary flow shut off should a valve or gate get stuck open. Given the two large units design, they cannot be utilized to meet the target flow. A combination of the small unit and one of the two valves will yield approximately 1,200 cfs. This is less than the target flow for an average or a dry year, but all that is feasible under the current operating procedures for the project. In order to make releases of 1,800 cfs, a combination of the small unit and one partially opened sluice gate would be required. However, the new sluice gates have not been tested for partial openings above the minimum 600 cfs flow. Considerable vibration occurs when the sluice gates are only partially opened which results in increased wear on the gates and the risk of failure. The jet flow valves were installed to eliminate the need for partial gate openings and reduce this risk. Therefore, operations involving extended periods of time with partially opened sluice gates are not advised.

Theoretically, a range of flows between 600 cfs (just the small unit) and 1,200 cfs could be released. However, this range would be lower than the target range for an average or dry year. Managing releases in this fashion, although potentially feasible from a purely mechanical standpoint, also raises serious concerns regarding safety, storage, and hydropower generation. Safety is always the biggest concern when operating equipment differently than the intended purpose and the chance for unforeseen problems is magnified. Finally, as discussed above, the proposed operation inherently impacts hydropower generation both through the cessation of peaking operations and through the use of potentially significant amounts of storage. During dry springs with little to no local inflows, the target flow would require approximately 200 cfs more per day (during the week) and 1,200 cfs more per day (during the weekends) than the peaking operation. This equates to approximately 30,000 acre-feet of water, equivalent to roughly a 1-foot drop in the lake surface elevation. The issue is compounded more by the fact that the operation takes place during the refill period for the project. For all these reasons, we feel it is not prudent to further evaluate non-hydropower peaking ”windows” at the Buford project even if it would not constitute a significant loss to the authorized purpose of hydropower generation.

At West Point, releases are made either through one/both of the two main units (approximately 6,800-7,800 cfs capacity each), the small unit (approximately 675 cfs capacity), or the six spillway gates (capacity of the spillway gates is based on head differential, but generally is about 800 cfs for pool levels during this time of year). Given this design, the main units cannot be utilized to meet the target flow. A combination of the small unit and 5-6 of the spill gates could potentially yield the target flow of approximately 5,000 cfs. Although, the West Point project does not have the mechanical limitations regarding the target flow that exist at Buford Dam, operating as requested in the PAL would raise serious concerns regarding safety, project/downstream recreation, and storage/hydropower generation.

Again, safety is always the biggest concern when operating equipment differently than the intended purpose and the chance for unforeseen problems is magnified. Leaving spillway gates open for extended periods of time increases the possibility of debris getting lodged in the gate and damaging the equipment and produces increased maintenance costs due to additional wear and tear. This is especially problematic since the West Point project is operated remotely from the Walter F. George project site. Finally, this operation inherently impacts hydropower generation both through the cessation of peaking operations and through the use of potentially significant amounts of storage. Generally, the target flow would require higher releases than the peaking operation. The issue is compounded more by the fact that the operation takes place during the refill and active flood control period for the project. For all these reasons, we feel it is not prudent to further evaluate non-hydropower peaking ”windows” at the West Point project, even if it would not constitute a significant loss to the authorized purpose of hydropower generation.

3. Chattahoochee River (Norcross and West Point)- We recommend that the Corps use the RES-SIM model to evaluate the provision of a seasonally varying baseflow hydrograph that more closely approximates natural conditions. Understandably, there are constraints imposed by meeting downstream discharge/water quality requirements and the flexibility of dam operations. Thus, we expect that part of this analysis and modeling effort may include synthesizing information that describes the range of flows that can be delivered from each turbine, and supplementing those flows using alternative methods (e.g., through sluicing).

We discuss the range of flows that can be delivered by each unit at the Buford and West Point projects in the previous response. As suggested in the PAL, we plotted the no action (baseline) and alternative scenario hydrographs for comparison to the pre-dam or “natural” condition base flow hydrographs provided in the PAL (Figures 1 and 2). This comparison illustrates that the presence of the dams and their operation has altered the pre-dam flow regime by generally providing a more stable flow pattern with higher base flow and lower peak flows. Both of these projects were designed to provide flood damage reduction and thus the alteration of seasonal variability and reduction of higher peak flows is not surprising. Evaluating the lower limits against one another provides a quick illustration of the general trends for the various scenarios compared to the more natural flow regime (Figure 3). In the Norcross comparison, the Alternative B scenarios level the hydrograph shape as compared to the Baseline condition. However, they do not mimic the “natural” flow regime. In the West Point comparison, the Alternative B scenarios also generally improve upon the Baseline condition and come closer to mimicking a “natural” hydrograph shape for this location. Additional improvements to either of the hydrographs would require more discussions between our agencies on the most critical aspects and to what extent, if any, the Corps can further modify the proposed operation to meet those needs. Based on our previous discussions, it is agreed that operating to match the “natural” flow regime is not possible at these multipurpose projects since they were designed and built to alter the “natural” flow regime. Defining a real life operation that meets the authorized project purposes and better meets the “natural” hydrograph and then translating that operation into code for the reservoir simulation is a large undertaking. To the extent that FWS feels more needs to be done, we request additional guidance and support.

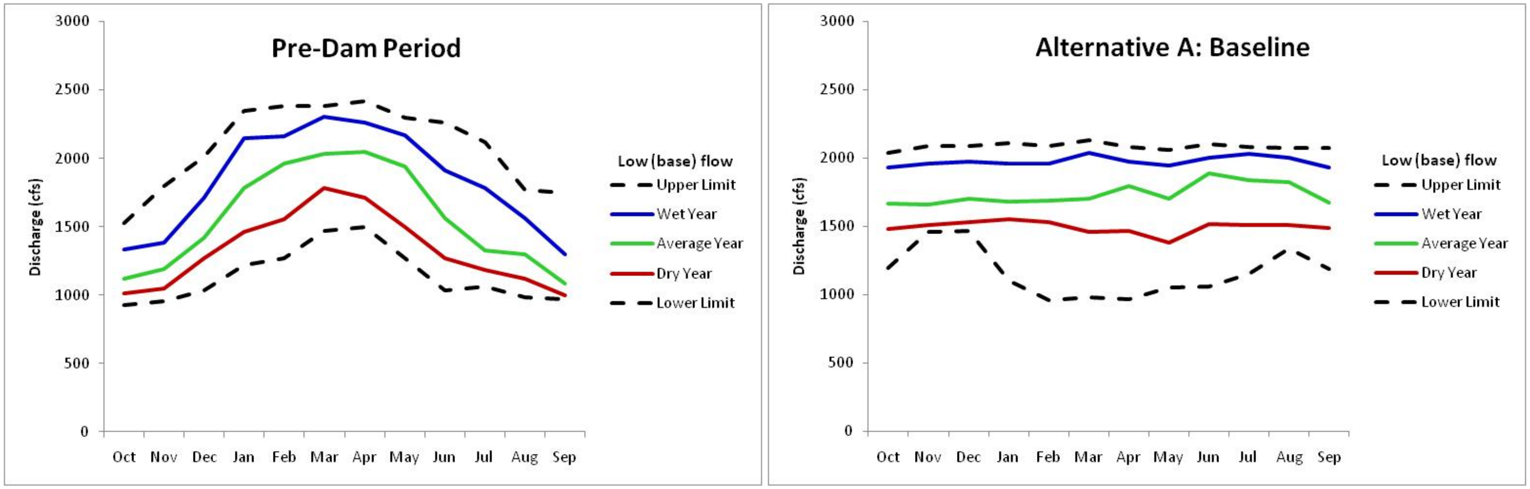
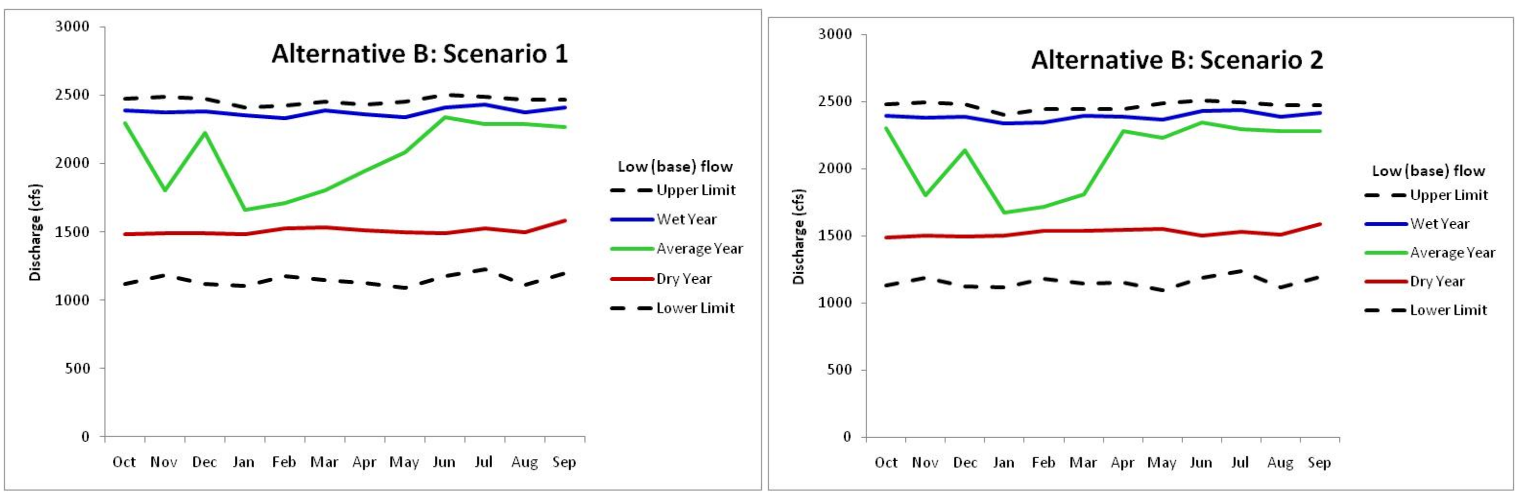

Pre-Dam Period
Alternative A: Baseline
Discharge (cfs)
3000
2500
2000
1500
1000
500
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Upper Limit
Wet Year
Average Year
Dry Year
Lower Limit

Figure 1


Alternative B: Scenario 1
Alternative B: Scenario 2
Discharge (cfs)
3000
2500
2000
1500
1000
500
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Upper Limit
Wet Year
Average Year
Dry Year
Lower Limit

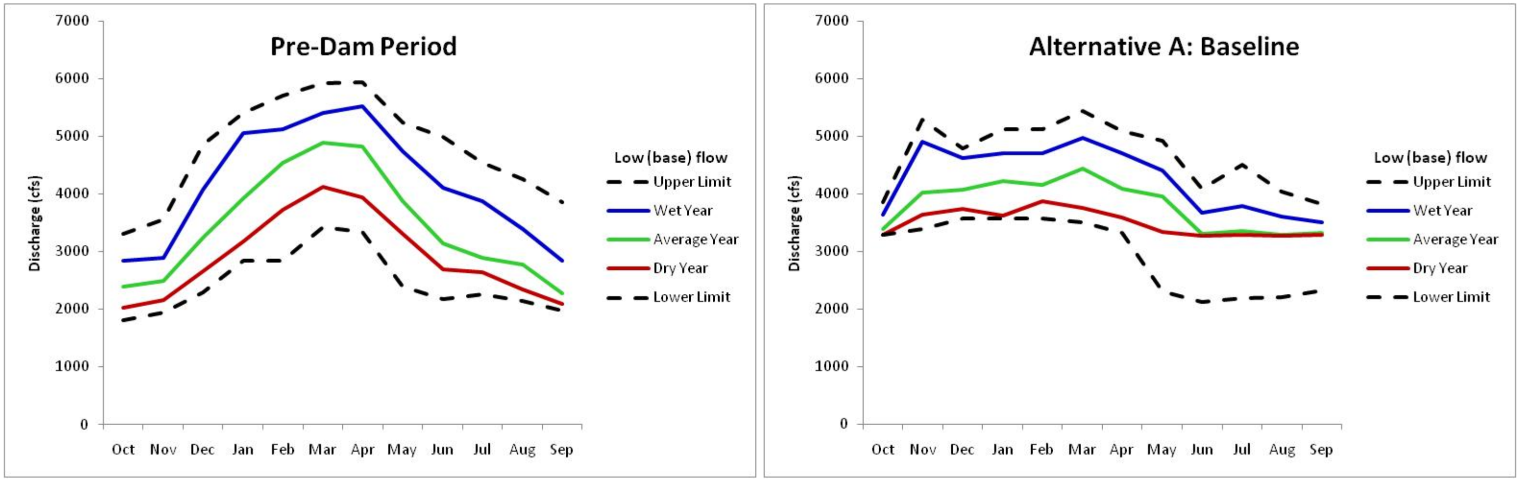
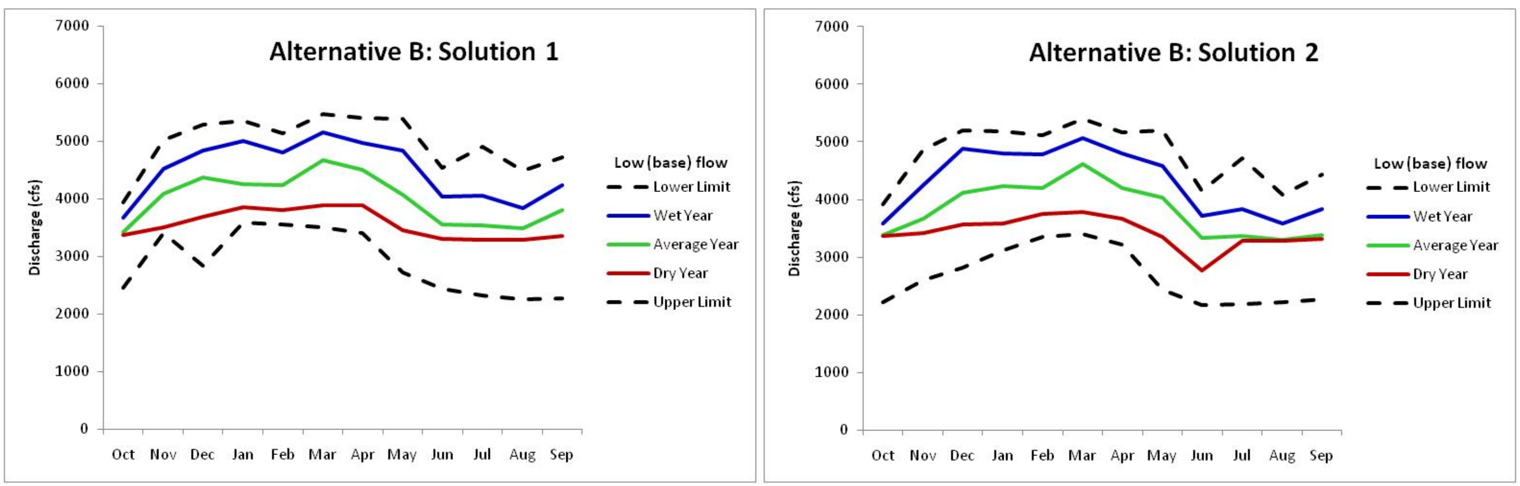
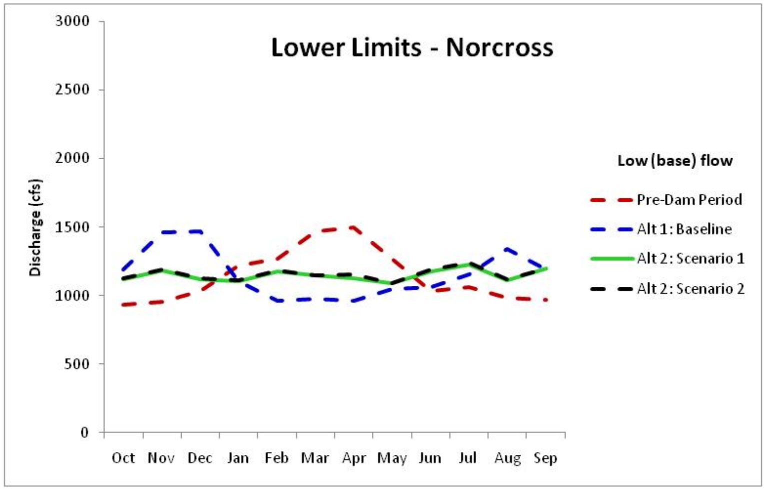

Pre-Dam Period
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Upper Limit
Wet Year
Average Year
Dry Year
Lower Limit
Alternative A: Baseline
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Upper Limit
Wet Year
Average Year
Dry Year
Lower Limit

Figure 2


Alternative B: Solution 1
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Lower Limit
Wet Year
Average Year
Dry Year
Upper Limit
Alternative B: Solution 2
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Lower Limit
Wet Year
Average Year
Dry Year
Upper Limit


Lower Limits - Norcross
Discharge (cfs)
3000
2500
2000
1500
1000
500
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Pre-Dam Period
Alt 1: Baseline
Alt 2: Scenario 1
Alt 2: Scenario 2

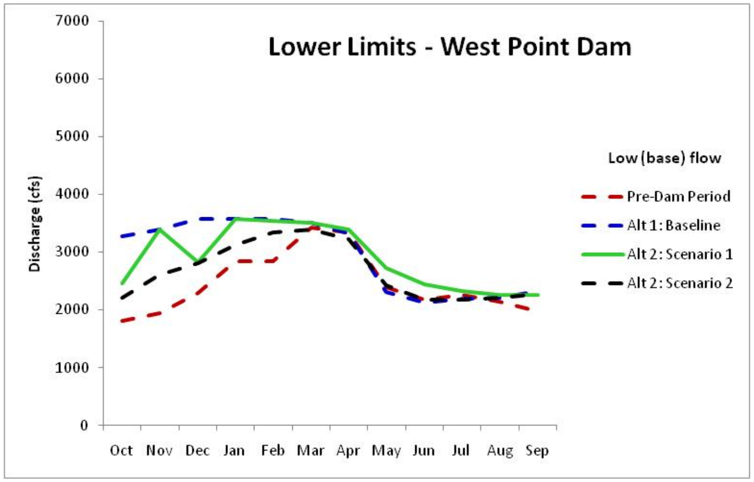

Lower Limits - West Point Dam
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Pre-Dam Period
Alt 1: Baseline
Alt 2: Scenario 1
Alt 2: Scenario 2

Figure 3

4. Chattahoochee River (Norcross and West Point)- Our preliminary analysis of the Baseline, RPLAN550WQ0, and RPLAN750WQ0 alternatives indicates that the timing, duration, and frequency of the small flow pulses is similar to the unimpaired and/or unregulated (pre-Buford Dam USGS data) flow datasets at Norcross for the January 1- March 31 and April 1- June 30 periods. However, the magnitude of the small pulses is smaller than both the unimpaired and unregulated flow datasets. Thus we recommend that the Corps use RES-SIM to model the provision of small pulses with magnitudes that are more similar to the Unimpaired and/or Unregulated flow datasets. Preliminary analysis of flow alternatives at the West Point gage indicates that there is essentially no provision for small pulses, and we recommend that the Corps use RES-SIM to model the provision of small pulses with magnitudes, frequencies, durations, and timings that are more similar to the Unimpaired and/or Unregulated flow datasets at the West Point node.

-And-

5. Chattahoochee River (Norcross and West Point)- Our preliminary analysis indicates that there are no provisions for high pulses in the Unimpaired, Baseline, RPLAN550WQ0, and RPLAN750WQ0 datasets for the January 1- March 31 and April 1- June 30 periods at Norcross and West Point. High pulses wouldn't naturally occur every year, but they would occur in < ½ of the years during this period. Thus, we recommend that the Corps use RES-SIM to model the provision of high pulses, and for the Corps to refer to the Planning Aid Letter to guide the development of RES-SIM model parameters for high pulses.

Again, we request your assistance in defining an operation that meets the authorized project purposes and better meets the small and high flow pulses evident in a natural flow regime.

6. Chattahoochee River (Walter F. George) – We recommend that the Corps use RES-SIM to model the provision of a seasonal pattern of reservoir levels at Walter F. George to best accommodate the needs of Eufaula National Wildlife Refuge (Refuge). As we stated in the PAL, water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. We have recommended reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer. The Corps has stated that this type of operation would impact the Corps' ability to comply with the RIOP. We would like to examine the RES-SIM output for this provision so that we can evaluate the effects of these changes on system operation.

As we discussed before, the Corps has serious misgivings regarding operating the Walter F. George project in this fashion. Our concerns are based on two inherent problems with your proposal from a water management standpoint. To illustrate our concerns and your proposal please reference Figure 2.8-1 above. As you can see, during current operations the reservoir is drawn down in the winter to accommodate flood releases from the upstream projects and higher basin inflow during the wet season. The project is refilled during the spring (typically the end of the wet season) to provide storage to meet authorized project purposes and augment flows downstream of the project as needed. This is a typical reservoir operation and works rather nicely based on the seasonality of the rainfall and the size of the basin. The proposed operation is opposite of how a reservoir is intended to work and essentially removes the reservoir from the system (operationally-not physically). By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased resulting in bank erosion and channel modifications below the project. By holding the reservoir low during the summer dry season, a significant amount of the composite conservation storage is removed from the system during the time when it is most critically needed from both a flow augmentation and hydropower production standpoint. In fact, WFG is typically the first reservoir used to provide flow augmentation under the RIOP. In addition, by moving the refill period to the late summer/fall there is a chance that the project may not refill and extended years of this scenario would stress the remaining storage in the system and the project. The proposed operation also contradicts the current fish spawn SOP for the reservoir which calls for steady to increasing pool elevations during the spring. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant impacts on the authorized project purposes as well as the structural stability and safety of the dam. For these reasons, we do not believe it is prudent to simulate the inherently significant impacts associated with the proposed operation.

USFWS Addendum to Planning Aid Letter March 2011

This page intentionally left blank

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

March 1, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing an Addendum to the U.S. Fish and Wildlife Service (Service)'s April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the WCM Updates is to identify operating criteria and guidelines for managing water storage and release of water from United States Army Corps of Engineers (Corps) reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the Service's 2010 PAL was to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. Based on recent analyses conducted by the Service, we submit the following addendum under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). This addendum solely addresses ecosystem flow guidelines -- all other information and recommendations in the PAL are still applicable. In the future, we will provide additional information in the form of a draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

Rationale for revision of ecosystem flow guidelines

The ecosystem flow guidelines that were delivered in the PAL were developed with the aid of Indicators of Hydrologic Alteration (IHA; TNC 2007). Although the IHA methodology is scientifically defensible, subsequent examination of IHA methodology and output revealed several concerns that could affect possible incorporation of the guidelines in the Corps' operations. Therefore, the Service is providing revised low and high flow guidelines (Figures 1-4 and Tables 1-4).

We had two reasons for revising the flow guidelines. First, the default IHA parameters used for the PAL initially separated the flow data into high and low flows using a percentile of the pre-Buford period of record. This method resulted in representation of low-flow discharges in summer-fall months by many values, and representation of low flows in winter-spring months by fewer values. This means that some months in some years were not represented in subsequent analyses. For example, historic low flows in the Apalachicola River remained above the 75th percentile or above flood stage for prolonged time periods, meaning that those periods were not represented in the low flow analysis. Thus, if the historic flow regime is to be used to help guide low flow alternative development, evaluation, and implementation, the low flow analysis should examine the entire range of low flows that occurred in every month of every year before construction of Buford Dam.

Second, the low and high flow analyses in IHA calculate summary statistics using median values (for non-parametric analyses) to represent each year (TNC 2007). For example, IHA calculates the annual median high pulse magnitude, and uses the median values from every year to calculate summary statistics. While this is a statistically valid approach to summarizing large datasets, summarizing multiple intra-annual pulses by a single value results in a narrower range of magnitude, duration, timing, and rate of change values. Because the intent of the analysis is to quantify a range of discharge values that are likely to be beneficial to riverine habitat and fauna and to facilitate planning for high flows in the Corps' operations, we calculated the following high-flow guidelines by including each high flow event in summary statistic calculation (e.g., percentiles representing upper and lower limits, and dry, average, and wet years). With the exception of not using annual medians to calculate percentiles, the revised method for high flow guideline development is analogous to the "non-advanced" method for high flow analysis in IHA.

Low flow analysis methodology

1. In Microsoft Excel, the seven smallest values from each month in every year were extracted for analysis. We chose multiple values to represent each month so that the overall results are less likely to be influenced by an aberrant value (i.e., less likely to be skewed by one value), especially in future analyses that may examine and compare Corps' modeled flow alternatives which are likely to occasionally contain negative discharge values. A comparison of the effects of one, seven, and ten minimum flow values to represent low flows in each month showed little difference in overall low flow hydrograph shape, similar flow magnitudes throughout the year, and minor differences in winter 90th percentile flow magnitudes. These results also generally correspond to the Web-based Hydrograph Analysis Tool (WHAT Local Minimum Method; Lim et al. 2005) output for baseflow generation. Collectively, these results lend greater support for the decision to use the seven lowest values to characterize low flows.

2. The 10th, 25th, 50th, 75th, and 90th percentiles for each month were calculated on the extracted data to define the lower limit, dry year, average year, wet year, and upper limit, respectively.

3. The Walter F. George low flow guidelines were calculated slightly differently. A long-term period of pre-Buford Dam discharge data was not available below Walter F. George. As a proxy

for actual data, the Corps' unimpaired flows dataset was used. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Thus, these low flow guidelines should be treated as estimates.

4. Note that in this low flow analysis, in cases where an entire month is above flood stage, the lowest values are flood-related values. A strength of the low flow analysis is that the user can characterize the entire range of the lower flows that occur in every month of the user's flow dataset.

High flow analysis methodology

1. In Microsoft Excel, the 75th percentile of all flows in the time series was used as the flow threshold to separate high flows from the remainder of the flow dataset. Because this is consistent with our understanding of the meteorological conditions that should cause pulses to occur, the 75th percentile is a valid threshold to separate low and high flows.

2. The following parameters were then calculated: The duration of each high flow event, the maximum discharge in each sequence of high flows, the date of the initial high flow value, the rise rate (calculated as the difference between the preceding low flow value to the maximum flow divided by the number of time steps (n-1)), and the fall rate (calculated as the difference between the maximum flow and the following low flow value, divided by the number of time steps (n-1)).

3. The 2-year and 10-year recurrence interval discharges were calculated using the following methodology: Maximum discharge was calculated for every year, and the 50th and 90th percentiles in Excel were used to calculate approximations of the 2- and 10-year recurrence intervals, respectively. This is a close approximation to the IHA method, but not as sophisticated as the USGS PeakFQ calculation (Flynn et al. 2006). Nevertheless, these percentiles provide close approximations of these recurrence interval discharges. Although bankfull discharge in the Coastal Plain physiographic province tends to occur more frequently than every two years, we used an approximate 2-year recurrence interval basinwide as a consistent guide.

4. The 2-year and 10-year recurrence interval discharges were used to further separate high flows into small pulses, high pulses, and floods (note: these are the default values used in IHA to separate high flow data). Maximum high flow values between the 75th percentile and the 2-year recurrence interval were classified as small pulses (analogous to High Pulses in IHA). Values between the 2- and 10-year recurrence interval were classified as high pulses (analogous to small floods in IHA), and values greater than the 10-year recurrence interval were classified as floods. With the exception of the Apalachicola River analysis, floods greater than the 10-year recurrence interval were excluded from this letter because they exceed the discharge stages that are predicted to cause damage according to the National Weather Service Advanced Hydrologic Prediction Service (Table 1 in April 2, 2010 PAL).

5. The range of discharge values that were used to define small and high pulses are presented in the tables. Similar to the PAL, we also provide the 25th and 75th percentiles of the magnitudes, frequencies, durations, rise rates, and fall rates which were calculated separately for small pulses,

high pulses, and floods. These values correspond to the high flow guidelines presented in Tables 1-4. Timing values were visually estimated from histograms of pulse or flood occurrence by month.

6. The Walter F. George high flow guidelines were calculated slightly differently.   As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified. Thus, high pulse frequency, duration, timing, and rate of change calculations were used from the West Point analysis. To calculate magnitudes, however, the West Point analysis indicated that pulses should peak 1.6-3.5 times higher than the low flow river discharge in March [7,720-16,500 cubic feet per second (cfs)]. Assuming that pulses at Walter F. George should also peak 1.6-3.5 times higher than March low flow (derived from the Corps' unimpaired flows model output), small pulses below Walter F. George should peak between 14,161-30,978 cfs.

Figure 1. Low flow guidelines for the Chattahoochee River near Norcross, GA (USGS 02335000).

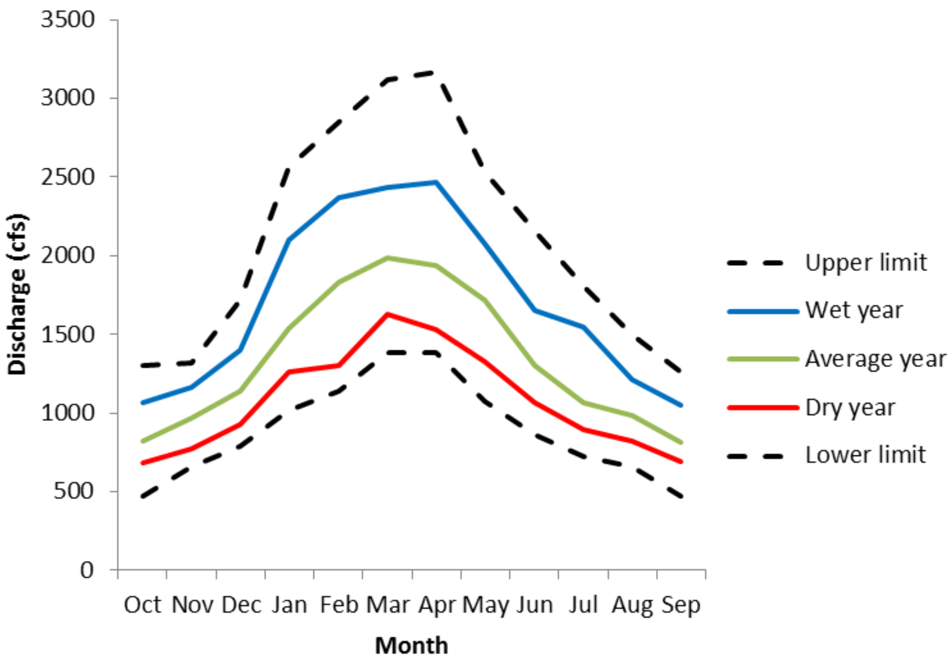


Figure 2. Low flow guidelines for the Chattahoochee River at West Point, GA (USGS 02339500).

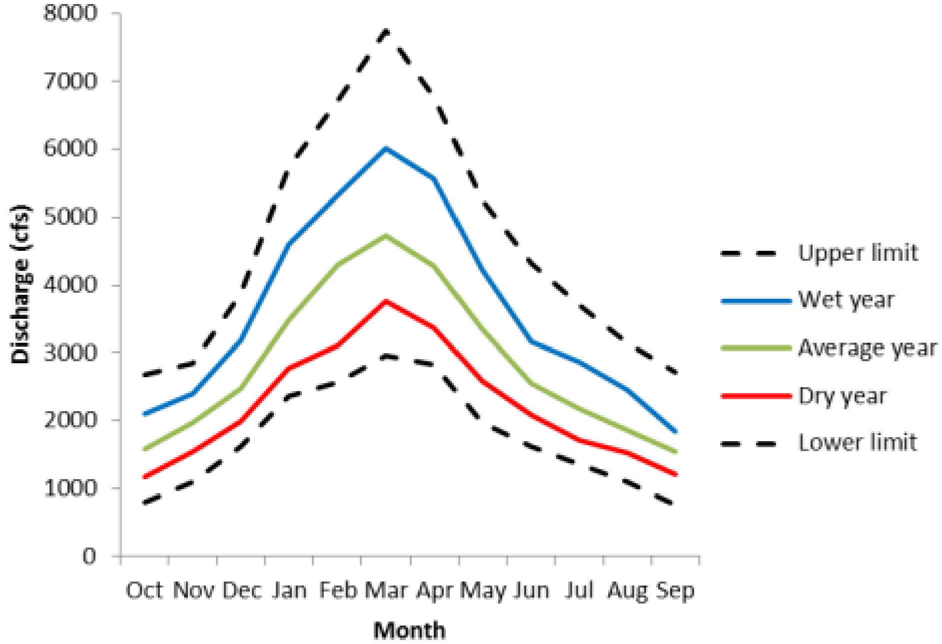


Figure 3. Low flow guidelines for the Chattahoochee River at Walter F. George using the Corps' unimpaired flows dataset.

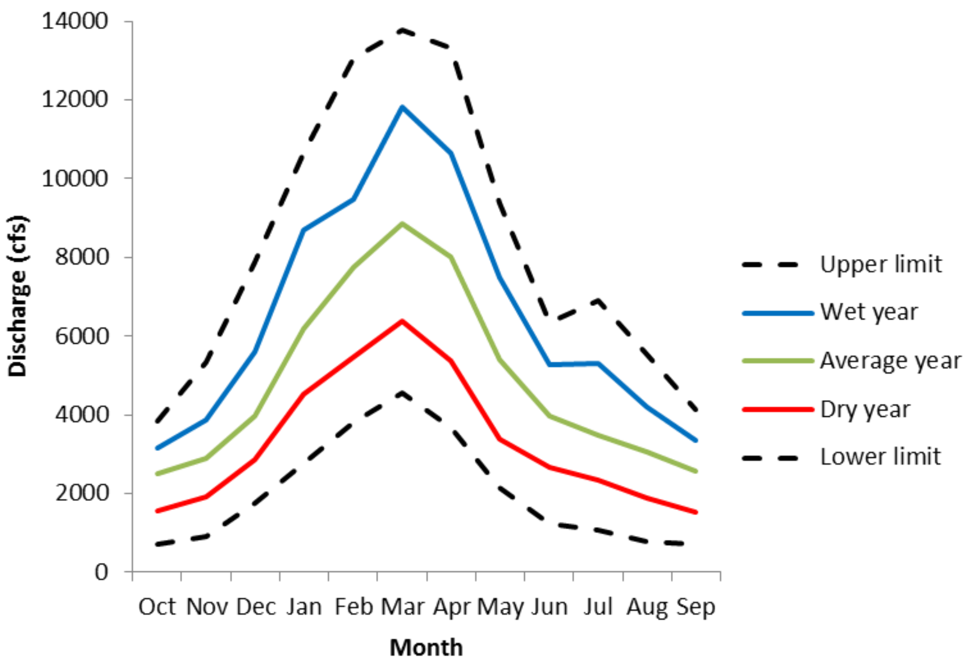


Figure 4. Low flow guidelines for the Apalachicola River at Chattahoochee, FL (USGS 02358000).

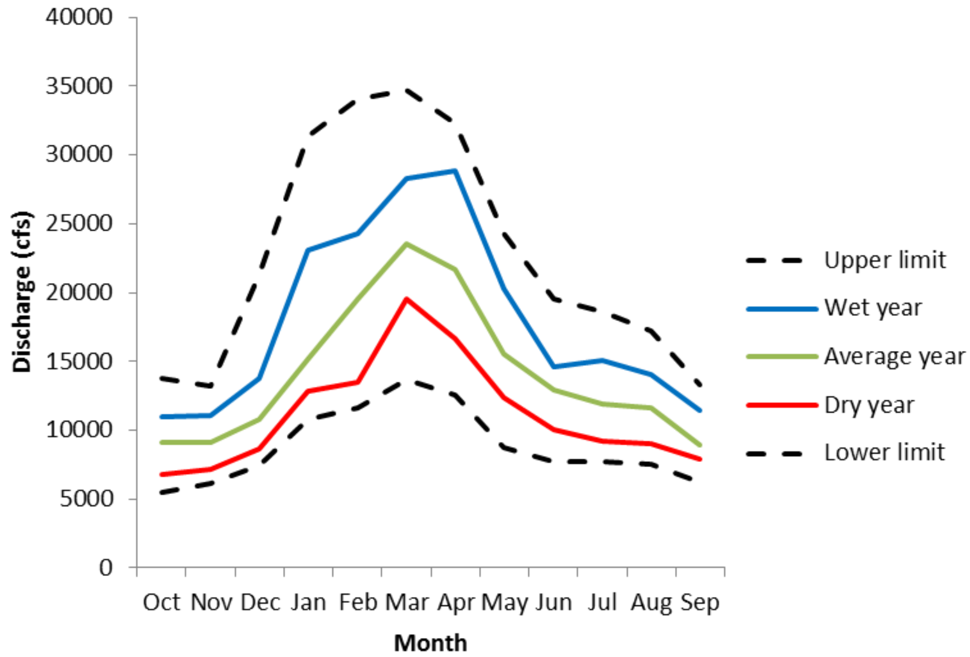


Table 1. High flow guidelines for the Chattahoochee River near Norcross, GA developed from USGS gage 02335000 for the pre-Buford Dam period from January 1, 1903 to September 30, 1946.

	Small pulse	High Pulse
Range used (cfs)	2550-17249	17250-33549
Magnitude (cfs)	3105-6787.5	19000-28900
Frequency (# events/year)	9-18	0-1
Duration (days)	1-5	11-72
Rise Rate (cfs/day)	770-2775	927-7830
Fall Rate (cfs/day)	507-1452	459-2193
Timing	Oct-Sep	Dec- Mar

Table 2. High flow guidelines for the Chattahoochee River near West Point Dam developed from USGS gage 02339500 for the pre-Buford Dam period from August 1, 1896 to December 31, 1955.

	Small pulse	High Pulse
Range used (cfs)	6250-45649	45650-71079
Magnitude (cfs)	7720-16500	51150-60825
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

Table 3. High flow guidelines for the Chattahoochee River at Walter F. George Dam developed from low flow analysis on the Corps' unimpaired flow dataset, and inferences from Chattahoochee River at West Point Dam high flow analysis. See text for additional details.

	Small pulse	High Pulse
Range used (cfs)	N/A	N/A
Magnitude (cfs)	14,161-30,978	95598-114187
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

*Upper range of high pulse values may need to be reevaluated to ensure that damage to structures is avoided. The stage discharge relationship (used to ensure that guidelines do not cause damage) was calculated using available data between 79 ft (6,510 cfs) and 110 ft (90,200 cfs; USGS gage 02343805), meaning that discharge calculations above this range of values are extrapolations and should be used cautiously.

Table 4. High flow guidelines for the Apalachicola River near Chattahoochee, FL developed from USGS gage 02358000 for the pre-Buford Dam period from July 1, 1922 to December 31, 1955.

	Small pulse	High Pulse	Flood
Range used (cfs)	25800-73799	73800-150499	≥ 150500
Magnitude (cfs)	28600-43475	85650-116500	201500-268500
Frequency (# events/year)	3-6	0-1	≥ 10 year RI
Duration (days)	3-15	32.5-68.5	49.5-89.5
Rise Rate (cfs/day)	2166-5606	2763-8056	7650-8761
Fall Rate (cfs/day)	1250-2615	1916-3811	4527-5795
Timing	Dec-Sep	Jan-Mar	Jan-Apr

Thank you for your January 18, 2011, response to the Service's PAL-requested analyses. We are currently reviewing the information that you provided, but recommend using ecosystem flow guidelines as calculated in the manner outlined above. As we continue to review the information you have produced, additional addendums or information requests may be supplied by the Service. We appreciate the opportunity to participate in the planning stages of your project and look forward to exploring opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Everson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL
B. Zettle, Corps, Mobile, AL
Pete Taylor, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
M. Thomas, GDNR-WRD, Social Circle, GA
C. Martin, GDNR-WRD, Social Circle, GA
B. Hess, GDNR-WRD, LaGrange, GA
R. Weller, GDNR-WRD, Albany, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
D. Bernhart, NOAA, St. Petersburg, FL

Literature Cited

Flynn, K.M., Kirby, W.H., and Hummel, P.R. 2006. User's manual for program PeakFQ, Annual Flood Frequency Analysis Using Bulletin 17B Guidelines: U.S. Geological Survey Techniques and Methods Book 4, Chapter B4, 42 pp.

Lim, K.J., B.A. Engel, Z. Tang, J. Choi, K. Kim, S. Muthukrishnan, and D. Tripathy. 2005. Web GIS-based Hydrograph Analysis Tool, WHAT. Journal of the American Water Resources Association 41(6): 1407-1416.

The Nature Conservancy (TNC). 2007. Indicators of Hydrologic Alteration Version 7 User's Manual. 70 pp.

USFWS Questions regarding the ACOE January 18, 2011 Correspondence:

1. In our PAL and the May 27, 2010 email from Will Duncan, we requested that you use the environmental flow guidelines to develop an environmental flow alternative or use the guidelines to analyze your alternatives and to identify the constraining authorization (if present) that impairs the Corps ability to achieve the recommended flow targets. You have provided some of those analyses in this report, but have you completed these analyses and identified the constraints for the remaining flow recommendations for the four river sections (below Buford, West Point, Walter F. George, and Jim Woodruff dams)?
2. How was the RES-SIM model developed and how well does it (ie. the baseline) conditions represent actual operations? Has this type of assessment been completed, specifically for parameters that are biologically relevant? Could the model output be updated through 2010?
3. To gain a better understanding of the constraints that you have, and so we don't continue stating the same thing on every document, can we obtain a copy of your agreement(s) with SEPA in the ACF? For similar reasons, may we also view the original language that describes the "flood damage reduction" authorized purpose?
4. Page 1-7: Why don't the numbers on Table 5.2-1 correspond with the hours of operation in the text above the table? Do the numbers in the text correspond to longer periods (e.g. 11 hours total at Buford on weekends) within which Buford Dam will generate power for e.g. three hours?
5. Page 1-9: When the fish spawn SOP was developed, why did it not include river segments below the major dams? Would a similar SOP for riverine habitats be of interest to the ACOE in the Chattahoochee River?
6. Page 1-14: It is stated that W.F. George currently has no minimum flow requirement, but when low dissolved oxygen values are observed below the dam, spillway gates are opened until the DO readings return to an acceptable level. How often is DO actually measured at this location?
7. Page 1-16: What is your reasoning for assuming that current water supply operations for Buford and Peachtree Creek would remain constant with 2007 demand data for your 10 to 15-year WCM Planning Window?
8. Page 1-16 and 1-21: It appears that the preferred alternative includes increased hydropower generation at Buford. What is the purpose or impetus for this increase (e.g., request from SEPA? Atlanta water supply? etc.)
9. Page 1-17: You mention that increasing Zone 4 would result in more water available, but there is no discussion of how frequently the drought operations were triggered with and without this change. In general, we would like to see your thought process for alternative development (e.g., were you trying to minimize the number of times drought ops were triggered?, etc.) and the results of these analyses (e.g., how did this change affect the occurrence frequency of the drought trigger).
10. Page 1-19: You mention volumetric balancing accounting but state elsewhere in the document that there will be no volumetric balancing in your preferred alternative. Is this a typo?
11. Page 1-20, Figure 11.3-4: Can you please show us a direct comparison of composite storage zones (similar to figs 11.3-1 to 11.3-4) under the no action alternative and preferred alternative? Or possibly a table with values if this figure would be too busy? Specifically, a summary of the composite zone changes (whether each zone is larger or smaller, time of year, reason for change, etc.) would be helpful. It would also be helpful to understand how often your model results indicate that you will operate in the various zones.

12. Page 1-20: You state that the drought plan revisions will remain in place until composite conservation storage reaches Zone 1. As in question #4 above, what is the thought process here and what are the results of the analyses you ran to make this decision?
13. Page 1-21: With what frequency and duration have each of the projects operated in each zone historically, and for each modeling scenario (baseline, alternative 1, and alternative 2)? How often in zone 4 was there peaking (number of peaking events/day) below each project?
14. Page 1-23: It is stated that there will be no changes to fish spawn or fish passage operations under the Proposed Action Alternative. Regardless, new language for fish spawn operations at JWLD will be included in this WCM update though, correct?
15. Page 1-23: You state that RIOP modifications (especially the fall rate and drought zone changes) were based in part on reducing the likelihood of triggering releases less than 5,000 cfs. Again, as in questions 4 & 6, what analyses did you run here to test/justify these decisions and what were the results?
16. Page 2-28: How would results be different if hourly data were used? What are the minimum DO observations observed and how well do the model results stack up against observed DO? Is it appropriate to have all dry years represented by 2007 and normal years by 2004? Same issues apply to temperature analyses on page 2-55.
17. Page 2-49: What is meant by the term "occurrence **interval**?" Where is the interval? Also, page 2-25 mentions that "It was recommended that percent exceedence may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality." Exceedence is a statistical term adopted for use in water policy. Regardless, it is more appropriate in this case to use exceedence. Just be clear that you are not using the term "exceedence" in a policy sense.
18. Page 2-60: The term "rainfall conditions" is used to identify specific years for detailed analyses. Similarly, the terms dry year and average year are used throughout the document without clear explanation regarding what constitutes a dry and average year. This needs to be made very clear. How were they defined, and does the term "rainfall conditions" actually mean a discharge-related variable?
19. Page 2-65: Based on the model input, what are the major drivers of algae change over time? Y-axes should be chlorophyll-a, not algae.
20. Pages 2-72 to 2-76: We had many comments, questions, and concerns about this section. Most concerns centered on the ambiguity of the analysis and the derivation of reported numbers. Because of these problems, we are hard-pressed to provide meaningful review and feedback. However, related to the baseflow analysis, we recommend an alternative analysis for depicting low flows that are likely to occur for each alternative. That analysis and associated rationale is included in the PAL addendum. Such an analysis is more intuitive and should take no more than a day for multiple nodes alternatives. Thus, we strongly encourage the ACOE to complete this analysis in lieu of the results reported in these sections.
21. Page 2-73: "The channel capacity at this location was used as a constraint in the HEC ResSim modeling analysis to ensure that flows did not go higher than 11,000 cfs." Why are the modelers unwilling or unable to model flows greater than 11,000 cfs?
22. Page 2-73: How is channel capacity defined, and where did the number come from?
23. Page 2-76: Can you please fix the figure references throughout the document ie. "Error! Reference source not found?" Does "upstream of Atlanta" refer to Norcross? Please use gage numbers and gage names to identify sites. How were these values determined? Are they percentiles of minimum flows or some annualized metric? How is "Dry year" defined in the

subsequent page? Many of these concerns will be addressed once the revised analysis is implemented.

24. For much of the flow analyses performed, you compare model output from the pre-dam period, no action, scenario 1, and scenario 2. Please provide the range of years and specific datasets used for each scenario.
25. Figures 2.7-1 to 2.7-13 and Table 2.7-1: We understand that direct comparisons cannot be made due to channel bed degradation and removal of hard bottom habitat; however, is it possible to add the pre-dam scenario to these figures?
26. Page 2-80: This statement is inaccurate: "The flow magnitude for average years overall, however, is 500–1,000 cfs, reduced from the pre-dam flows." Baseflows in the summer and fall seasons (including a portion of spawning season) are elevated, not reduced. Graphs depict reported values as averages, but could they be medians based on the non-parametric RVA in IHA?
27. Page 2-83, Figure 2.7.1.1: Spawning Habitat Availability- Overall, there is very weak treatment regarding what data is being conveyed on the graphs. For example, our initial review indicated that the analysis had been cut and paste from the 2008 BO. On the graphs and in legends and text, can you please define ROR, the intent of using USGS data and ROR, and the period of record used. Remember, if we (agencies with previous involvement) are unable to correctly interpret the results, it is unlikely that others will. This needs to be crystal clear. There are also grammatical problems in this section.
28. Page 2-87, Table 2.7-1: Why were there no flows lower than 5,000 cfs? Does that mean the drought plan was never triggered in these scenarios? If not during the exceptionally severe 2007 drought, what hydrologic conditions would it take to trigger the drought zone?
29. Page 2-92: We expect that the fall rates associated with pulses will differ from the RIOP. The RIOP was intended to be protective of organisms at a lower range of flow, and the pulse flow recommendations consider a large range of flows that are relevant to other ecosystem attributes.
30. Page 2-99: Could you please clarify this? "This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010)." Did USFWS request it and then deem it as not a viable option? This is difficult to interpret without having a references section. Please include a references section.
31. Page 2-99: It is stated that "Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows..." Damaging to what? Can you please share the modeling output that demonstrates this?
32. Page 2-101: You discuss analyzing how providing a minimum flow of 15,400 cfs impacted the number of times the drought zone was triggered. As in questions 4, 6, & 7, it would be helpful for us to know what analyses you have completed on triggers and how results influenced your alternative development. For example, it seems unusual that a minimum flow of 15,400 cfs would trigger drought operations more often than a minimum flow of 16,200 cfs.
33. Page 2-101: We appreciate the evaluation of a longer navigation season and feel it would also benefit riverine fishes. Please tell us if this will be a guaranteed minimum flow to provide a 7 ft channel or if it will be only "as requested" by navigation interests. How will this "navigation season" be different from the old navigation windows that were 10 days to a two-week period? Will this be a continuous minimum flow for months? If so, we assume that you are anticipating that you will be able to balance the fish spawn SOP and this new navigation flow, in light of the fact that the prior navigation windows prompted complaints that the windows had adversely affected reservoir fish spawn activities.

34. Page 2-102: W.F. George is also a peaking plant (Page 1-7) but was not included in the discussion of why non-hydropower peaking windows cannot be implemented at ACOE hydropower peaking facilities. It also needs to be addressed.
35. Page 2-109: Where's the references section?

Other Important considerations:

36. The ACOE used HEC-5Q to model daily change in water quality parameters. Are we correct in that the model input used average daily discharge to calculate water quality parameters for each time step? If so, we think it would be wise for the ACOE to acknowledge that daily fluctuations in WQ may be obscured by this simplification, but that this model represents the best available information on water quality responses to instream flow changes.
37. Similarly, it would be wise for the ACOE to propose a coarse plan of action for addressing DO issues caused by ACOE projects (e.g., propose potential collaborations, funding sources, and general steps, and rough timeline needed to do so).
38. Page 1-5: "the river system would operate in a fairly normal manner." Please clarify this.
39. Page 1-6: "…enough electricity to supply approximately 110,000 households." This is important to consider, but is more useful when context is provided. For example, 110,000 households is 3.65% of Georgia households or X% of Florida households.
40. Page 1-15: "Reservoir operations are also influenced by agricultural water withdrawals…" This is an important component of this section, and it needs additional (minor) elaboration so that your point isn't lost. Is the point that water removed from the Flint is offset by reservoirs in the Chattahoochee to meet flow needs in the Apalachicola- especially during low flow periods? If so, that point is lost in this section.
41. Page 2-25: Repeatedly throughout the document, the ACOE uses different terms to describe the alternatives (e.g preferred vs proposed ; scenario 1 vs. alternative 550 vs Alternative B1 or B2); It would be beneficial if consistent terms are used to describe each modeling scenario.
42. Page 2-26: The term "baseline" is used for 24 pages before it is defined on page 2-50. Also, it had been indicated that the methods used to develop all output would be included in this document and they aren't.
43. Page 2-75: It would be appropriate to explain to readers that values closer to "1" are better.
44. Page 2-76: "2.4.2 Impacts of Critical Low Flow Periods" could use improvement. We'd all be better served with a table showing comparisons of the results.

USFWS Coordination Act Report June 2011 with Appendices

This page intentionally left blank

Draft Fish and Wildlife Coordination Act Report

On

Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

Georgia Ecological Services
Athens, Georgia

and

Panama City Ecological Services
Panama City, Florida

and

Southeast Regional Office
Atlanta, Georgia

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia
June 2011

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4980 Wildlife Dr.
Townsend, Georgia 31331

June 17, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing your agency with a Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida in partial fulfillment of Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from US Army Corps of Engineers (Corps) reservoirs. We submit the following comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.), the Migratory Bird Treaty Act (MBTA) (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed threatened and endangered fish and wildlife species protected under the ESA. We anticipate providing comments on the draft Environmental Impact Statement (DEIS) that the Corps is preparing to support its decision regarding the WCM update, and it is our understanding that the Corps intends to include this DFWCAR as an appendix to the DEIS. Delivery of the final version of this report will depend upon the Corps' schedule.

The DFWCAR outlines the fish and wildlife concerns and planning objectives that were provided in our April 2, 2010, Planning Aid Letter (PAL) and March 1, 2011 PAL addendum to you, along with our understanding of the Corps' responses to our concerns and objectives. The DFWCAR describes the alternatives and evaluates the anticipated impacts of the selected plan. The Service does not support the proposed alternative. However, our report provides the Corps with fish and wildlife conservation measures and recommendations. We urge the Corps to consider additional alternatives for analysis that would address our concerns about water quality in project tailraces, alterations of flow regimes that adversely affect fish and wildlife, etc., and could lead to formulation of an environmentally preferable alternative in the Corps' decision-making process for the operations of the ACF reservoirs. We respectfully remind the Corps that

Federal regulations under the National Environmental Policy Act (NEPA) require that, in cases where an EIS has been prepared, the Record of Decision must identify all alternatives that were considered, ". . . specifying the alternative or alternatives which were considered to be environmentally preferable" (40 CFR Section 1505.2(b)). The environmentally preferable alternative is the alternative that will promote the national environmental policy as expressed in NEPA's Section 101. It is our view that by analyzing only one alternative to "no action", in this case an alternative that does not incorporate reasonable options for mitigating all potentially significant impacts to the environmental resources identified through scoping and through the FWCA planning process, the Corps would not fulfill the intent of NEPA or the FWCA.

A draft version of the DFWCAR was distributed to the National Oceanic and Atmospheric Administration (NOAA), Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), and Florida Fish and Wildlife Conservation Commission (FFWCC). The U.S. Fish and Wildlife Service (Service) received notification of no additional comments from ADCNR, comments from GDNR-WRD, FFWCC, and NOAA, and GDNR-Environmental Protection Division (EPD). If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552, or Southeast Regional Office staff biologist Jerry Ziewitz at (850) 553-3646.

Sincerely,

Sandra S. Tucker
Field Supervisor

cc: K. Herrington, USFWS, Panama City, FL
D. Imm, USFWS, Panama City, FL
J. Ziewitz, USFWS, Tallahassee, FL
D. Everson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL
B. Zettle, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
M. Thomas, GDNR-WRD, Social Circle, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
P. Brownell, NOAA, Charleston, SC

EXECUTIVE SUMMARY

In January 2008, the Secretary of the Army directed the Corps to develop updated WCMs for the ACF River Basin. The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. This DFWCAR outlines the Service's fish and wildlife concerns and planning objectives that were previously provided to the Corps, along with our current understanding of the Corps' position on each PAL recommendation. The DFWCAR also describes the alternatives and evaluates the anticipated project impacts of the selected plan.

The Corps' proposed action alternative would limit withdrawals directly from Lake Lanier solely to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 million gallons per day (mgd), respectively. The Corps would no longer make releases for water supply and water quality requirements from Buford Dam. Off-peak releases from Buford Dam would be limited to 600 cubic feet per second (cfs), and water availability for municipal and industrial withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to the 600 cfs off-peak releases or water incidentally available through peaking hydroelectric power generation. There would no longer be specific flows released by the Corps for water quality at Peachtree Creek.

The proposed alternative is comprised of two minimum flow scenarios for the Chattahoochee River at Peachtree Creek. Scenario 1 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 550 cfs remains in the Chattahoochee River at Peachtree Creek. Scenario 2 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 750 cfs is always available at Peachtree Creek.

Under the proposed action alternative, the Corps would modify the action zones for Lake Lanier, West Point Reservoir, and Walter F. George Reservoir. Drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1), versus the no action alternative in which drought plan provisions remain in place until composite conservation storage reaches a level above the top of Zone 3 (i.e., within Zone 2). The Drought Zone would also be reshaped as part of the proposed action alternative.

No changes to flood damage reduction operations would occur, although there is a proposed minor guide curve change for West Point Reservoir that provides an incidental increase in flood storage during the fall drawdown. There would be no change to hydropower production at West Point Reservoir, WFGLD, or JWLD, except as would result from changes in the guide curves for the action zones. The designated amount of hydropower production at Buford Dam would change for all four action zones, and this amount of production would depend on if the Corps is in non-drought or drought operations at a given point in time.

Under the proposed action alternative, the Corps would provide a reliable navigation season. If hydrologic conditions allow, a typical navigation season would extend from January through April or May. Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1.

Releases for federally-listed species below JWLD would be modified in that the maximum fall rates would be different from the no action alternative when releases were between 16,000 cfs and 30,000 cfs. The no action alternative has a maximum fall rate of 0.5 to 2.0 feet per day during that range, depending on the amount of the release, whereas the proposed action alternative would match the 1-day basin inflow fall rate. Additionally, drought provisions could affect changes in releases at JWLD.

The Service does not support the Corps' proposed action alternative for many reasons including a failure to address conservation measures identified in the Planning Aid Letter (PAL; Appendix V), modeling developed from short-term planning horizons and a single consumptive use scenario, increased frequency of low flows, increased storage resulting in lower annual releases to the rivers and bay, and inadequately evaluated impacts to mussels, fisheries, and habitats due to proposed changes from the 1989 draft WCM and the Revised Interim Operating Plan (RIOP).

We do, however, provide the Corps with recommendations intended to benefit fish and wildlife. The Service has suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. The intent of these evaluations and analyses is to inform the development of alternatives and to address the impacts of the proposed action alternative.

TABLE OF CONTENTS

Appendices

I. GDNR's May 23, 2011, review of the Service's draft DFWCAR.

II. FFWCC's May 23, 2011, review of the Service's draft DFWCAR.

III. ADCNR's May 26, 2011, email notification of no additional comments on the Service's draft DFWCAR.

IV. NOAA's June 10, 2011, review of the Service's draft DFWCAR.

V. Service's April 2, 2010, Planning Aid Letter to Corps.

VI. Service's March 1, 2011, Planning Aid Letter addendum to the Corps.

VII. FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011.

VIII. University of Florida's April 27, 2011, Draft interim report to the Service entitled, *Simulating the impact of USACE operating alternatives on salinity and oyster populations in Apalachicola Bay, FL.*

IX. Service's March 9, 2011, USFWS Questions regarding the ACOE January 18, 2011 Correspondence.

X. Service comparison of the Corps baseline model output and observed data for a comparable period.

INTRODUCTION

Purpose, Scope, & Authority

In January 2008, the Secretary of the Army directed the Corps to develop updated WCMs for the ACF River Basin. The following is taken from the Corps' response to the Service's PAL (Corps 2011):

"The Corps proposes to prepare an updated Master Manual for the ACF River Basin. A draft was proposed in 1989 as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. The Corps has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would be five project-level water control manuals, presented as appendices…"

Water control manuals contain drought plans and action zones to assist the Corps in knowing when to reduce or increase reservoir releases and conserve storage in the Corps reservoirs. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions."

The Service's involvement in this project is authorized by the FWCA. The FWCA establishes fish and wildlife conservation as a co-equal purpose or objective of federally-funded or permitted water resource development proposals or projects. This DFWCAR constitutes the report of the Secretary of the Interior as required by Section 2(b) of the FWCA.

FWCA Agency Coordination

The Service distributed a draft of the DFWCAR on May 9, 2011, to GDNR-WRD, ADCNR, FFWCC, and NOAA for their review. We received comments from GDNR-WRD and FFWCC on May 23, 2011, notification of no additional comments from ADCNR on May 26, 2011, and comments from NOAA on June 10, 2011. The Service also received comments from GDNR-EPD on May 23, 2011. However, because the FWCA requires that the Service coordinate with fish and wildlife agencies in order to ensure that fish and wildlife needs receive equal consideration, we will address GDNR-EPD's comments in a correspondence separate from the FWCA process.

Because many of the FFWCC comments should be more appropriately addressed by the Corps, we have separated the FFWCC comments below into those that are to be addressed by the Corps and those addressed by the Service. We encourage the Corps to review these agency correspondences and consider them in their decision-making process. We have addressed recommendations directed to the Service in the body of this DFWCAR. The agency responses to a draft of the DFWCAR are attached as Appendices I- IV and a summary of the correspondences is as follows:

GDNR-WRD

GDNR-WRD emphasizes the importance of the current water temperatures in the Chattahoochee River below Lanier Reservoir as they relate to the trout fishery and the Buford Trout Hatchery, as well as the Chattahoochee River below Morgan Falls Dam as a coolwater refuge during the summer months for striped bass (*Morone saxatilis*). GDNR-WRD agrees with the Service that improvement of dissolved oxygen (DO) downstream of Corps' reservoirs is important and beneficial to aquatic resources, and that this process may present opportunities/options to improve DO conditions. Lastly, they consider the Corps' Fish Spawn SOP to be important and that it should continue, when possible.

FFWCC comments for the Corps

FFWCC considers the Corps' no action alternative and the proposed action alternative to be unacceptable. They state that threatened and endangered species conservation is compromised by the arbitrary storage thresholds in Corps' reservoirs, the full storage capacity of these projects is not being used as Congress intended, and that the balance being struck by the Corps is unreasonable. FFWCC agrees with the Service that the proposed action alternative will be more detrimental for threatened and endangered mussel species in the Apalachicola River and they suggest that all efforts should be made to maintain flows above 6,000 cubic feet per second (cfs) at all times. They state that the proposed action alternatives do not include a true conservation alternative designed to serve the needs of fish and wildlife and related habitats in the Apalachicola River Basin.

FFWCC generally supports the Service's ecosystem flow guidelines and concurs, with modifications, that these guidelines should be used as the yardstick against which to measure any alternative's ability to meet the needs of fish and wildlife in the basin. FFWCC recommends ecosystem flow guidelines based on pre-dam flows be added to all graphs related to fish and wildlife resources, and incorporated into all levels of analysis and decision-making. They recommend that daily pre-dam flow data be used directly to serve as an ecosystem flow guideline in every case, regardless of the type of statistic or graphical display used in the evaluation. FFWCC also recommends that the Run of River (RoR) flow data that is displayed in numerous graphs in the Corps PAL Response should be removed because it is not an appropriate basis for analyses or decisions related to ecosystem protection. They recommend the RoR flow data should be removed and replaced with ecosystem flow guidelines based on pre-dam flows.

FFWCC recommends the analysis of frequency in percent of years of the annual maximum of 30-day minimum acres of inundated floodplain should be replaced with hydrographs. They state that hydrographs provide a more useful tool than frequency curves for assessing critical flows throughout the entire year. In addition, they state that the Corps makes an erroneous assumption in the PAL Response regarding floodplain connectivity. The Corps states that floodplain inundation occurs when flows reach 100,000 cfs in the Apalachicola River; FFWCC identifies much lower flows when floodplain inundation occurs at various reaches of the river.

FFWCC disagrees with the Service's conclusion that the Corps has provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their PAL Response. Per FFWCC's comments above, the analyses should be revised to include comparisons to ecosystem flow guidelines in every graph, hydrographs showing seasonality, duration of flows, and inundated area throughout the year, and expanded views of frequency curve data at the low-flow end. In addition, they state that LIDAR data are now available for the entire Apalachicola River and should be used for more accurate future analysis.

FFWCC remarks that while they appreciate the Service's recommendation to incorporate adaptive management into this process, the Corps has not shown a willingness to modify its behavior in response to monitoring data that show negative impacts on species. For success, clear objectives, sound monitoring, and specific response alternatives should be identified and are necessary components of an adaptive management program.

They also agree that the Corps should explore fish passage operations for anadromous fish species, such as the Alabama shad (*Alosa alabamae*) as part of the WCM update.

<u>FFWCC comments for the Service</u>

As stated above, FFWCC generally supports the Service's ecosystem flow guidelines and concurs, with modifications, that these guidelines should be used as the yardstick against which to measure any alternative's ability to meet the needs of fish and wildlife in the basin. FFWCC proposes a slightly modified ecosystem flow guideline that is calculated from all the data resulting in daily exceedance hydrographs, rather than the Service's current methodology. This recommendation is addressed in the *Conservation Measures Included from the Service's PAL & PAL Addendum* section of the DFWCAR.

FFWCC states that there should be additional analyses of the impact of proposed and existing operations on juvenile Gulf sturgeon (*Acipenser oxyrhinchus desotoi*) in Apalachicola Bay. They generally agree with the conclusions contained in the Apalachicola Bay section of the Service's DFWCAR, but would like to see additional details about potential impacts to estuarine sentinel species, such as Eastern oysters (*Crassostrea virginica*) or white shrimp (*Litopenaeus setiferus*).

FFWCC states that the DFWCAR should address the minimum flows needed to mitigate the impacts of saltwater incursion due to sea level rise.

<u>NOAA</u>

NOAA emphasizes the impacts to fishery and aquatic resources that have been caused by dam construction and operation, including fragmentation of riverine habitats, inundation of habitat, and altered flow conditions. They support the Service's sections of the DFWCAR on "Evaluation of the Selected Plan" and "Fish and Wildlife Conservation Measures and Recommendations" with regard to fishery and aquatic resources under their authority.

Prior Studies and Reports

The following studies and/or reports are the most pertinent documents involved in producing this DFWCAR:

- Corps' April 15, 2008, description of proposed action modification to the Interim Operations Plan at Jim Woodruff Dam;
- Service's June 1, 2008, biological opinion for the Corps' Revised Interim Operations Plan;
- Service's April 2, 2010, PAL to the Corps (Appendix V);
- Corps' June 1, 2010, alternatives development and screening process informal synopsis to the Service;
- Corps' January 18, 2011, response to the Service's PAL;
- Service's March 1, 2011, PAL addendum to the Corps (Appendix VI);
- FFWCC's February 22, 2011, correspondence to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps titled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems (*Appendix VII*);* and
- University of Florida's April 27, 2011, draft interim report to the Service entitled, *Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, Florida* (Sheng et al. 2011; Appendix VIII).

DESCRIPTION OF STUDY AREA

The 19,910 square mile (mi^2) ACF River basin stretches from north central Georgia to the eastern border of Alabama to the Gulf coast through the central Florida panhandle. The drainage principally comprises the Chattahoochee (8,770 mi^2) and Flint (8,460 mi^2) rivers, which meet to form the Apalachicola River (2,680 mi^2) near the border of Florida and Georgia. Water resources in the ACF River basin have been developed to meet various demands for municipal and industrial water supply, flood control, hydropower, navigation, fish and wildlife conservation, recreation, and agricultural water supply (Corps 1998).

There are currently 16 reservoirs impounding the mainstem ACF river system, of which five are federally-owned and 11 are privately-owned projects. Thirteen reservoirs are located on the Chattahoochee River, two on the Flint River, and one, Jim Woodruff Lock & Dam (JWLD), is located near the confluence of the Chattahoochee and Flint rivers which forms the Apalachicola River. The federally-owned projects include JWLD, as well as four projects along the mainstem Chattahoochee River: George W. Andrews Lock & Dam (GWALD), Walter F. George Lock & Dam (WFGLD), West Point Dam, and Buford Dam (Figure 1).

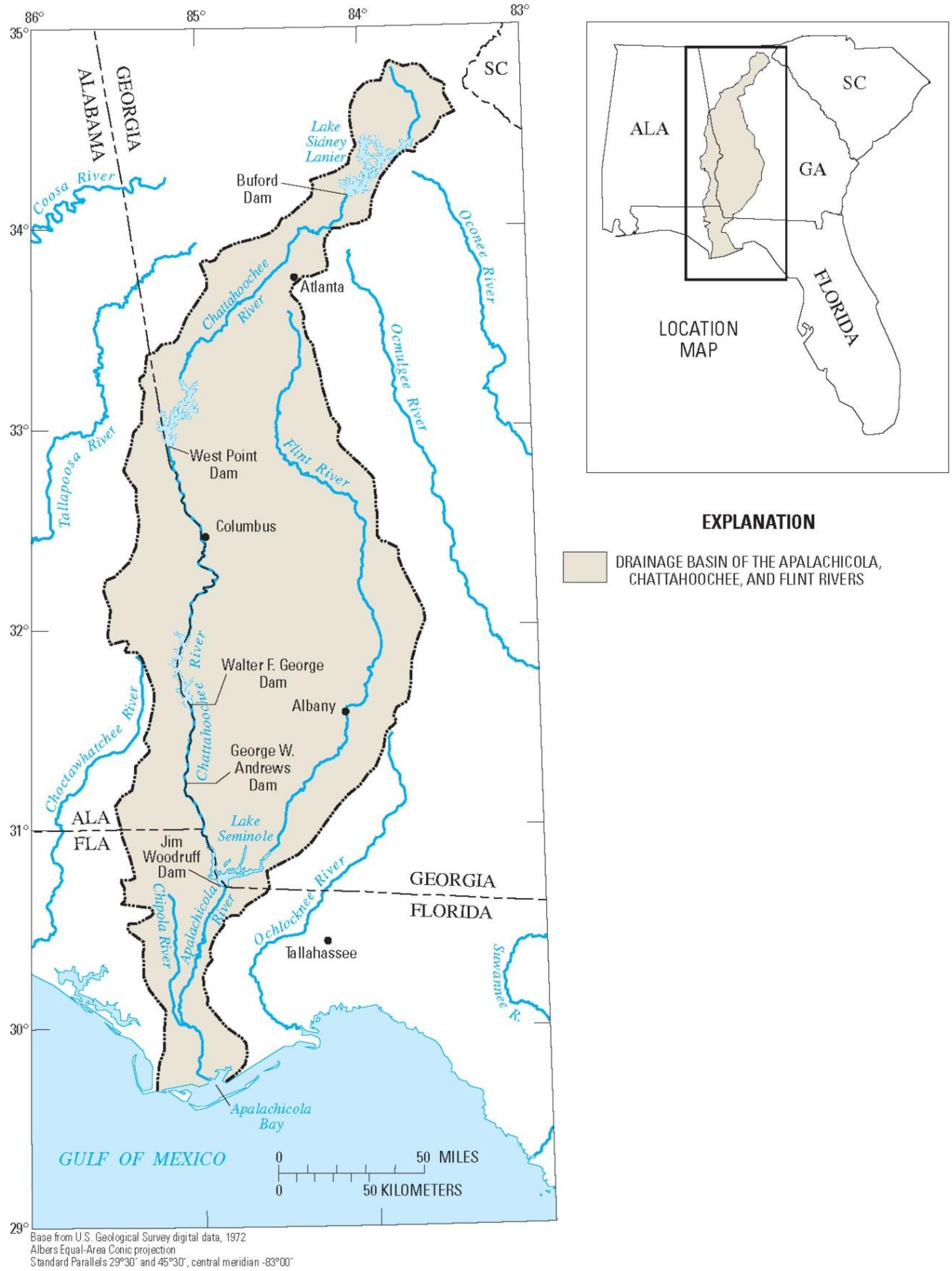


Figure 1. Map of the ACF Basin showing location of the Corps' dams (source: Light et al. 2006).

FISH AND WILDLIFE CONCERNS AND PLANNING OBJECTIVES

The Service's fish and wildlife concerns, planning objectives, recommendations and requested analyses have been previously described in detail to the Corps in our April 2, 2010, PAL and March 1, 2011, PAL addendum. Our recommendations identified in the PAL and PAL addendum collectively reflect the Service's concerns and planning objectives. These were addressed by the Corps and we have included a summary of our current understanding of the Corps' position on each issue in the Fish and Wildlife Conservation Measures Section (Conservation Measures Included from the Service's PAL & PAL Addendum).

DESCRIPTION OF CORPS' SELECTED PLAN

No Action Alternative

The Corps' no action alternative represents continuation of the current water control operations at each of the Federal projects in the ACF Basin. There is not one comprehensive document that reflects the Corps' current operational practices; instead they are described in multiple Corps documents including:

- 1989 Draft ACF Water Control Plan;
- June 2008, Revised Interim Operations Plan (RIOP) and Environmental Assessment;
- February 2005, South Atlantic Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes and Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan, (SAM SOP 1130-2-9);
- February 1991, Chattahoochee River Management System as described in the Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA; and
- Project WCM s for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects.

The no action alternative as it dictates general system operations, action zones, and authorized project purposes is described in detail in the Corps' response to the Service's PAL (Corps 2011).

Proposed Action Alternative

The proposed action alternative as it dictates general system operations, action zones, and authorized project purposes is also described in detail in the Corps' response to the Service's PAL (Corps 2011). The proposed action alternative, in light of the July 2009 Federal district court ruling, would limit withdrawals directly from Lake Lanier solely to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 million gallons per day (mgd), respectively. The Corps would no longer make releases for water supply and water quality requirements from Buford Dam in accordance with the Chattahoochee River Management System. Off-peak releases from Buford Dam would be limited to 600 cubic feet per second (cfs), and water availability for municipal and industrial withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to the 600 cfs off-peak releases or water incidentally available through peaking hydroelectric power generation.

There would no longer be specific flows released by the Corps for water quality at Peachtree Creek.

The proposed alternative is comprised of two minimum flow scenarios for the Chattahoochee River at Peachtree Creek. The Corps provided the following rationale for the two scenarios:

> "Scenario 1 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 550 cfs remains in the Chattahoochee River at Peachtree Creek. Scenario 2 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 750 cfs is always available at Peachtree Creek. The 550 cfs flow at Peachtree Creek was analyzed based on a previous request from Georgia EPD for temporary relief from the 750 cfs level during the 2006 – 2008 drought and knowledge that flows lower than this level would not meet the current physical constraints of several water supply intakes between Buford Dam and West Point Lake."

Under the proposed action alternative, the Corps would modify the action zones for Lake Lanier, West Point Reservoir, and Walter F. George Reservoir. Drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1), versus the no action alternative in which drought plan provisions remain in place until composite conservation storage reaches a level above the top of Zone 3 (i.e., within Zone 2). No changes to flood damage reduction operations would occur, although there is a proposed minor guide curve change for West Point Reservoir that provides an incidental increase in flood storage during the fall drawdown. There would be no change to hydropower production at West Point Reservoir, WFGLD, or JWLD, except as would result from changes in the guide curves for the action zones. The designated amount of hydropower production at Buford Dam would change for all four action zones, and this amount of production would depend on if the Corps is in non-drought or drought operations at a given point in time. Table 1.3-1 in the Corps' response to the Service's PAL (Corps 2011) outlines those changes.

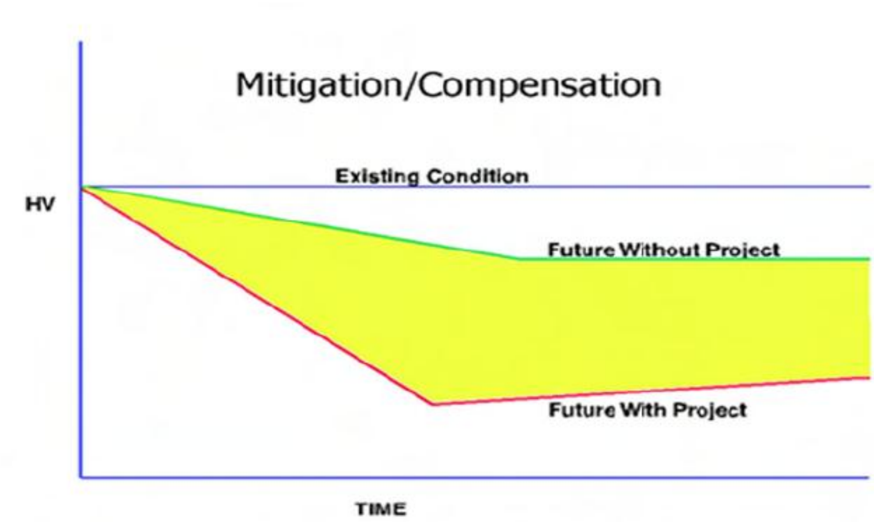
Under the proposed action alternative, the Corps would provide a reliable navigation season. If hydrologic conditions allow, a typical navigation season would extend from January through April or May. During this navigation season the flows at the Blountstown, Florida USGS gage would provide at least a 7-foot channel. Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The determination to extend the navigation season beyond April would depend on inflows, climatic and hydrological conditions, and meteorological and basinwide forecasts. Downramping of flow releases would adhere to the JWLD fall rate schedule. Releases to provide for the 7-foot navigation channel would also be dependent on navigation channel conditions that ensure safe navigation.

Under the proposed action alternative, there would be no changes to fish spawn, fish passage, or recreational operations. Releases for federally-listed species below JWLD would be modified in that the maximum fall rates would be different from the no action alternative when releases were between 16,000 cfs and 30,000 cfs. The no action alternative has a maximum fall rate of 0.5 to 2.0 feet per day during that range, depending on the amount of the release, whereas the proposed action alternative would match the 1-day basin inflow fall rate. Additionally, drought provisions could affect changes in releases at JWLD. As mentioned above, drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1), versus the no action alternative in which drought plan provisions remain in place until composite conservation storage reaches a level above the top of Zone 3 (i.e., within Zone 2). The Drought Zone would also be reshaped as part of the proposed action alternative.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

A fundamental component of the FWCA Report is the evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated. It is standard practice for such analyses to include evaluations and comparisons of long- and short-term future resource conditions with and without the project and for mitigation to be based on projections of future resource conditions (Figure 2).

Figure 2. Mitigation and compensation of habitat values (HV) lost for a hypothetical water resource project. Yellow area projects future habitat values lost and mitigation/compensation needs.



Changes in future resource conditions include changes related to water consumption, water quality, climate change, and associated effects on habitat and biota. For these reasons, we asked the Corps in the PAL to include in their modeling efforts 1) increases in consumptive uses in the ACF basin that are expected to occur and 2) multiple future climate scenarios that could affect lake levels, river discharges, and estuary inflow. The Corps did not incorporate increases in consumptive uses or multiple climate scenarios into their modeling, thereby complicating comparisons between the future conditions with and without the proposed action alternative. In this instance, the future without the project is continued operation of Federal projects in the ACF River Basin in a manner that is consistent with existing operations. Existing operations are modeled by the Corps as the no action alternative, which is problematic because the 2009 ruling by U.S. District Court Judge Magnuson decision renders the no action alternative illegal in the

ACF Basin. However, given no other option, we use the no action alternative to evaluate future fish and wildlife resources without the proposed action alternative, while considering the ecological consequences of unmodeled, long-term changes in consumptive uses and river flows.

A multitude of fish and wildlife resources are dependent upon discharge and have been affected by long-term discharge changes. FFWCC provided a summary and comparison of pre-Buford Dam and post-West Point Dam conditions that exhibit discharge and salinity changes in the Apalachicola River and Bay ecosystems (FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011; Appendix VII). Although the interpretations of the analyses were made by FFWCC and not the Service, impacts identified (hypothesized, realized, or modeled) in FFWCC's correspondence are relevant because operational changes at Corps facilities have the potential to ameliorate, exacerbate, or have no effect on such project-induced impacts and impacts associated with other changes in future resource conditions. Apalachicola River and Bay impacts addressed in the FFWCC letter include:

- Long-term decreases in river flow, especially spring and summer low flows during dry conditions
- Decreases in floodplain inundation and associated changes in forest composition, ichthyofauna, and invertebrates
- Gulf sturgeon spawning and rearing habitat reductions, and population effects as a consequence of barrier construction (JWLD) and flow reductions
- Fish spawning habitat reductions as a consequence of reduced river flows
- Mussel habitat reductions and population effects
- Modeled estuary salinity changes as a response to Apalachicola River discharge changes and upstream flow depletions
- Influence of floodplain organic matter on oyster diet and estuary productivity
- Changes in oyster drill (*Dermocystidium marinum*) prevalence in oysters as a function of estuary inflow and salinity over multiple years.

Negative impacts of current operations on aquatic resources in other portions of the basin include:

- Loss of riverine habitat and fluvial species assemblages, including federally-listed mussel species and Gulf sturgeon that are now thought to be extirpated from the mainstem Chattahoochee River
- Loss of unimpeded passage for migratory fishes
- Fragmentation of aquatic populations in the mainstem and tributaries
- Significantly altered dissolved oxygen and temperature regimes
- Highly altered flow regimes that affect assemblages of riverine aquatic biota in the remaining flowing river segments below dams.

It is reasonable to expect that future conditions with increased population growth, consumptive demands, wastewater input, changes in climate, and continued operation of Federal projects will show increasing impacts to these natural resources. Based on correspondence with the Corps and with the States as part of the FWCA process, we have addressed or are currently addressing the types of impacts that could potentially occur as a consequence of changes in current project operations. However, because the Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for ‘with the project’ and ‘without the project’ scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in your National Environmental Policy Act (NEPA) documents.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Project impacts are identified by comparing future resource conditions under the no action alternative to future conditions with the Corps’ proposed action alternative. Impacts can theoretically be beneficial, adverse, or have no appreciable differences, but are limited to fish and wildlife resources that could be affected by Corps project operation changes. Thus, the intent of this section is to describe effects of project operations on biologically relevant parameters. The overall biological interpretation of the results (e.g. descriptions of whether the proposed action alternative is beneficial, adverse, or no difference compared to the no action alternative) is reserved for the *Evaluation of the Selected Plan* section below.

Analyses Provided by the Corps

In response to the Service’s April 2, 2010, PAL, the Corps completed several requested analyses to support the Service’s and State’s comparison of the no action and proposed action alternatives (Corps 2011). The Corps relied on HEC-ResSim to simulate management alternatives and evaluate the resulting effects to reservoir levels, river stages, and river discharge. Although a thorough explanation of the modeling procedure has not yet been provided, we expect that the modeling procedure was similar to that used in prior consultations. Namely, calculations of basin inflow from January 1939 through December 2008 were determined and anthropogenically-influenced variables (e.g. consumption levels, reservoir evaporation and release schedules) were used to create synthetic flow and discharge datasets that simulate expected conditions under the no action and proposed action alternatives. One strength of this approach lies in the fact that the period between 1939 and 2008 encompassed a broad range of hydrologic conditions (i.e. basin inflows) that may be experienced in the future, thereby providing an opportunity to evaluate effects of management alternatives under a variety of hydrologic conditions.

For many of the analyses, the Corps evaluated a composite period from 2001-2008, but also extracted a subset of the data to represent dry (year 2007), normal (2004), and wet (2005) hydrologic year types. We refer to all of these analyses as ‘year types’. Data were further extracted to examine only the months of April or May (depending on the analysis) through October or November in order to examine effects during critical low flow and fish spawning periods. [Note: Although not all graphs indicated that the April or May through October or November period was used, we assume this to be the case.] While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are lumped for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months. For example, values for modeled chlorophyll-*a* could actually be higher than the values represented on the graphs. We emphasize that this is not a failing of the Corps' analysis, but it does identify an area of investigation for which additional model data are available. We recommend that time series plots also be used (similar to dissolved oxygen plots in Figures 2.2-22 to 2.2-25 of the Corps' Response to PAL) to illustrate variation that is likely to occur.

The Corps' analyses frequently used percent occurrence to characterize distribution of model output. The Corps states "that the longitudinal figures present the percent occurrence of modeled output; the opposite of the percent exceedance. It was recommended that percent exceedance may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality." In recent email correspondence with the Corps (Appendix IX), we recommended using exceedance plots to facilitate interpretations of the data using standard hydrological and statistical approaches because of several important and confusing issues. First, no definition is provided for percent occurrence or for its calculation. Second, we are unable to reconcile seemingly conflicting graphs depicting model output. For example, the 5% occurrence for dissolved oxygen at Norcross for the no action alternative is ~10 mg/L in Figure 2.2-1 in the Corps' Response to the PAL, but the 5% occurrence at Norcross on Figure 2.2-3 is ~6.5 mg/L. Conflicts such as these confound interpretation of approximately 40 graphs of model output throughout the document. We attempted to gain clarification through additional discussion with the Corps (B. Zettle, Corps, April 2011, pers. comm.), but have not received additional clarification to date. However, we have made an attempt to evaluate model output.

As with any model, there are limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. As an example, we have provided the results of a statistical and qualitative analysis that evaluates congruency between actual operations as measured by discharge at USGS gages and model output of existing operations (i.e., the no action alternative) for the comparable post-RIOP period (Appendix X). The analysis shows a high degree of similarity for many components of the hydrograph at most locations, but also several exceptions. Statistical differences between measured discharge and modeled discharge for existing operations include:

> Chattahoochee at Norcross: pulse duration and frequency, and number of reversals;
>
> Chattahoochee at West Point: pulse magnitude, duration, and rise rate, and number of reversals;
>
> Apalachicola at Chattahoochee: number of reversals.

HEC-5Q was used to model water quality. Impacts assessed at multiple locations throughout the basin included effects on dissolved oxygen, water temperature, wastewater, Chlorophyll-*a*, reservoir retention time, phosphorus, floodplain connectivity and reservoir fisheries performance measures. Additional analyses on the Apalachicola River included Gulf sturgeon and freshwater mussel habitat, and the provision of navigation flows below JWLD. Effects on shoreline vegetation and wildlife at Eufaula NWR, as well as water quality at Buford Fish Hatchery were also assessed.

Below, we assess impacts of the proposed action alternative relative to the no action alternative using the Corps analyses. General descriptions of the analyses are presented, but more thorough descriptions of the Corps methodologies and graphical depictions of output may be found in the

Corps' response to the Service's PAL (Corps 2011). Values presented below are approximations based on visual interpretations of graphs provided by the Corps.

Dissolved Oxygen

Suitable dissolved oxygen levels are critical for fish and invertebrates. Simulated daily average dissolved oxygen values varied along the longitudinal river profile, with May-October median and/or 5% occurrence values falling below State standards below Corps projects at Buford, West Point, and WFGLD. The largest differences between the no action and the proposed action alternatives were the following:

> Norcross: The proposed alternative resulted in 0.5 mg/L lower dissolved oxygen levels (lowest: 4.5 mg/L) compared to the no action at the < 5% occurrence level in a dry year (2007).
>
> Morgan Falls: The proposed alternative resulted in 1.0 mg/L lower dissolved oxygen levels (lowest: 5.0 mg/L) compared to the no action at the < 10% occurrence level in a dry year (2007).
>
> Buford Dam downstream: The proposed alternative and no action results were similar. Both were less than the State standard of 6 mg/L at 40% occurrence for the composite 2001-2008 period and 45% for a dry year (2007).
>
> West Point Dam downstream: The proposed alternative and no action results were similar. Both were less than the State standard of 5 mg/L at ~30% occurrence for the composite 2001-2008 period and 35% (proposed alternative)-43% (no action) for a dry year (2007). The proposed alternative consistently had 0.5-1.0 mg/L higher dissolved oxygen between 20-40% occurrence in a dry year (2007).
>
> Bartlett's Ferry: The proposed alternative and no action results were similar. Both were less than the state standard of 5 mg/L at ~25% occurrence for the composite 2001-2008 period, and ~32% in a dry year (2007). The proposed alternative was 0-0.5 mg/L higher than the no action between 20-40% occurrence in a dry year (2007).
>
> Walter F. George downstream: The proposed alternative and no action results were similar. Both were less than the state standard of 5 mg/L at ~23% occurrence for the composite 2001-2008 period, and ~32% in a dry year (2007). The proposed alternative was 0-0.25 mg/L higher than the no action between 0-30% occurrence in a dry year (2007).

Water Temperature

Alteration of water temperature can greatly affect the persistence and abundance of aquatic species in a given location. Most notably, suitable water temperatures are critical for aquatic reproduction. Simulated water temperature for the no action and proposed action alternative varied along the longitudinal river profile, with the largest temperature drops below Buford Dam (16 °C) and West Point Dam (3 °C) for modeled period between 2001-2008 in May through October. Similar trends were observed in representative wet, dry and normal years. The no action and proposed action alternative model results were similar along the longitudinal river profile in wet, dry, and normal years and in the 2001-2008 composite from May through October, with infrequent deviations less than 1°C. The April through October period results were similar, with model output for the no action and proposed action alternatives remaining within 1.5 °C of one another.

Wastewater

In the absence of quantitative models that describe water quality changes in response to flow management alternatives, percent wastewater can serve as a proxy. As percent wastewater increases, wastewater-associated substances are expected to increase. Simulated average stream percent wastewater varied along the longitudinal river profile, with the largest percent wastewater downstream from Atlanta (the maximum reported no action value was 30% wastewater for the 5% occurrence value) and GWALD (the maximum reported no action value was 30% wastewater for the 5% occurrence value) modeled period for the May through October 2001 - 2008 composite period. Similar trends were observed in representative wet, dry and normal years. The no action and proposed action alternative model results were similar along the longitudinal river profile within each year type. Downstream from Atlanta, the percent wastewater in the proposed action alternative model output was 1-3% less than the no action alternative for the 2001-2008 May through October composite and the wet, dry, and normal years.

Chlorophyll *a*

Chlorophyll-*a* is correlated with algal biomass. Because algal mats can cause nuisance conditions in lakes, it is considered to be less desirable in lentic systems. Simulated chlorophyll *a* varied along the longitudinal river profile, with peak concentrations in reservoirs. Similar trends were observed in the 2001-2008 composite and in the wet, dry, and normal years. Results were similar between the no action and proposed action alternative within each year type. However, at occurrences greater than 80-90% in a dry year type, the proposed action alternative had daily average algal concentrations 1-8 mg/L higher than the no action alternative in West Point Reservoir and 1-2 mg/L higher in Walter F. George Reservoir.

Reservoir Retention Time

Higher retention rates may result in decreased reservoir water quality. The Corps did not provide data to assess retention time.

Ortho-phosphorus

Algal growth is stimulated by increases in phosphorus. Simulated ortho-phosphorus varied along the longitudinal river profile, with peak concentrations downstream from Atlanta and Columbus. Similar trends were observed in the 2001-2008 composite and in the wet, dry, and normal years. Results were similar between the no action and proposed action alternative within each year type. However, the no action alternative model output frequently produced concentrations 0-0.02 mg/L greater than the proposed action alternative in the 2001 to 2008 composite. We were unable to interpret the importance of longitudinal plots showing the differences between the no action and proposed action alternative because of the obscure percent occurrence definition and seemingly conflicting modeled results provided to us.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

The Service's PAL used Environmental Flow Components (EFCs) in the Indicators of Hydrologic Alteration (IHA) to develop the magnitude, duration, timing, rise rate, and fall rate guidelines for pulses from the pre-Buford Dam period of record. The Corps used the IHA Range of Variability Approach to describe and compare alternatives in their response to the Service's PAL. The methods are not comparable. However, subsequent analysis of the methodology and results by the Service led to a revised method analogous to the IHA EFC method, but computed in Excel, and better suited to Corps and Service analysis needs. Rationale for the revision and methodology is outlined in detail in the Service's March 1, 2011, PAL addendum. Output from the revised methodology is not yet available for the comparison of the no action alternative, proposed action alternative, and pre-Buford period. However, a floodplain connectivity analysis for the Apalachicola River based on prior consultations for endangered freshwater mussel impacts is provided below (see Freshwater Mussels section).

Reservoir Fisheries

The impacts of the no action and proposed action alternative on reservoir fisheries were based on the premises that reservoir water level fluctuations can impact reproductive success of game fishes. The reservoir fisheries performance measure scores indicate that the no action alternative produced better conditions for fisheries reproduction compared to the proposed alternative.

The Corps completed a second analysis to examine effects on reservoir fisheries during critical low flow periods. The Corps stated that the analysis was completed only on Lanier Reservoir because it experiences the greatest fluctuations in reservoir levels. Based on the low flow period for Lanier Reservoir, the Corps states that "In the worst low flow period, 2007, the Proposed Action Alternative shows slightly improved values over No Action Alternative. In 2008, the Proposed Action Alternative is similar to the No Action Alternative."

Riverine Fisheries

The riverine fisheries analysis relied on IHA output to compare baseflows. Similar to the floodplain connectivity analysis, output from the revised methodology has not yet been provided by the Corps for the comparison of the no action alternative, proposed action alternative, and pre-Buford Dam period. The analysis that was provided did not include the average and wet year low flow values for the pre-dam period in the comparison with the no action and proposed action alternative, a deficit that should be rectified in future correspondence.

Federally-protected Species in the Apalachicola River

Gulf Sturgeon:

The four analyses provided to us that examine impacts of project operations on Gulf sturgeon include spawning habitat availability, daily fall rates, the maximum number of days per year <16,000 cfs, and departure from average mean temperature during the sturgeon spawning season. Spawning habitat availability in the Apalachicola River for Gulf sturgeon was nearly identical between the no action and proposed action alternative. The Corps indicates that discharge fall rates were modeled such that rapid falls in river stage do not result in exposure or stranding of eggs and larvae of Gulf sturgeon. The maximum number of consecutive days <16,000 cfs was calculated because discharges <16,000 cfs cause estuary salinity levels to increase above 10 ppt, thereby creating suboptimal conditions for juvenile Gulf sturgeon growth. The median of the maximum number of consecutive days <16,000 cfs was about 5 days higher for the proposed alternative (Scenario 1 with a 550 cfs target at confluence with Peachtree Creek). However, the 75th percentile of the maximum number of consecutive days <16,000 cfs in the proposed action alternative was about 15 days lower than the no action alternative, meaning that in some years (presumably drier years) there are fewer days per year where estuary inflow creates suboptimal habitat for juvenile Gulf sturgeon. The Corps stated that the average of the mean daily water temperature during the spawning season was nearly identical between the no action and proposed action alternative, meaning that there are no differences in the temperature aspect of spawning cues for Gulf sturgeon.

Freshwater Mussels:

Low flows in the Apalachicola River have the potential to reduce habitat, and expose and strand freshwater mussels. Thus, we requested that the Corps provide several low flow analyses, similar to those provided in the 2008 Biological Opinion (Service 2008). The Corps compared the lowest annual discharges from 1975 through 2008 for the no action and proposed action alternatives. Annual low flows were similar, with the proposed alternative having lower (38% of years), higher (41% of years), or the same (21% of years) annual low flow values compared to the no action alternative. With the exception of 1975, annual low flows from the model output remain below the 50th percentile of September-October (lowest flow months) low flows that occurred pre-Buford Dam (see PAL addendum, Apalachicola low flow graph).

Differences between the no action and proposed action alternative were indistinguishable for the interannual frequency, the maximum number of days per year, or the maximum number of consecutive days per year where flows were less than 5000 cfs, 5000-6000 cfs, 6000-7000 cfs, 7000-8000 cfs, 8000-9000 cfs, and 9000-10,000 cfs. Flows never fell below 5000 cfs for either the no action or proposed action alternative simulations.

River stage fall rates were examined because rapidly declining river stages have the potential to increase the risk of mussel exposure and stranding. Histograms comparing fall rates for the no action and proposed action alternative for all flows combined and flows <10,000 cfs indicate a high degree of similarity, with the ≤ 0.25 category comprising the largest proportion of fall rates. Although the no action had approximately 50 more days in middle fall rate categories (0.25-0.50 ft/day and 0.50-1.00 ft/day) compared to the proposed action, the proposed action alternative had about 50 more days in the 1-2 ft/day category than the no action.

Apalachicola River Floodplain Connectivity

The Apalachicola River and floodplain ecosystems depend on seasonal flooding and connectivity to maintain forest community structure, ensure availability of spawning and rearing habitats, export detritus and nutrients to fuel higher trophic levels in the river and estuary, and support biodiversity in the region. Consequently, effects of project operations on the frequency, magnitude and timing of floods were evaluated. Frequency exceedance plots (percent of days) of floodplain habitat area connected to the Apalachicola River during the growing season (April-October and March-November) and the percent of years during the growing season (April-October and March-November) with 30 days of continuous floodplain connectivity to the main channel were similar between the no action and proposed action alternative. However, in the proposed action alternative, slightly more floodplain acreage is connected to the river for a minimum of 30 days at exceedance frequencies (% of years) less than 45% during the growing season. An additional frequency exceedance plot (percent of days) during the growing season with flows between 12,000 and 30,000 cfs showed indistinguishable differences between the no action and proposed action alternatives.

<u>National Wildlife Refuges and Fish Hatcheries</u>

The Service requested several analyses of impacts to hatcheries and Eufaula NWR, and an evaluation of potential management options that could benefit Eufaula NWR. In response to that request, the Corps provided the following:

> *Eufaula NWR:* "Under the No Action Alternative, no changes would be expected. The ability of W.F. George Lake to provide 13.4 mgd to support waterfowl at off-reservoir impoundments would continue. The two scenarios for the Proposed Action Alternative show only minor differences in water level changes from the No Action Alternative, suggesting a similarly low potential of effect on the shoreline vegetation and wildlife communities at ENWR. Additionally, inspection of water surface elevation plots at Walter F. George Lake for critical low-flow periods indicate that, with the exception of August through November when surface elevation drops to 184.50 ft, if ever, reservoir levels always remain above 185 feet under the Proposed Action Alternative. Thus, W.F. George Lake is expected to continue to provide 13.4 mgd of water to support waterfowl at off-reservoir impoundments.
>
> The USFWS asked that the Corps consider cycling surface elevations at W.F. George to the highest levels (190 ft) in the late winter and lowest levels in early spring (185 ft). This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010). Current reservoir operations use winter draw-downs to accommodate flood releases from upstream projects and higher basin inflow during the wet season. Refilling usually occurs during the spring, typically at the end of the wet season, to provide storage to meet authorized project purposes and augment flows downstream of the project as needed. Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows causing bank erosion and channel modifications below the project. Maintaining low elevations during the summer dry season would remove composite conservation storage from the system at a time when it is most critically needed for flow augmentation and hydroelectric power production. Additionally, this proposed operation contradicts the current fish spawning standard operating procedure for the reservoir, which calls for steady to increasing pool elevations during the spring."
>
> *Fish Hatcheries:* "There are four fish hatcheries in the ACF Basin. The discussion below describes how changes to operations at Federal reservoirs would affect the hatcheries. Under the No Action Alternate, no changes would be expected at any of the hatcheries.

> Three of the hatcheries in the ACF Basin use groundwater. These hatcheries would not be affected by the Proposed Action Alternative.
>
> Buford Trout Hatchery withdraws about 7 mgd (11 cfs) of flow from the Chattahoochee River below Buford Dam year-round (Ziewitz et al. 1996). The results of the HEC-5Q water quality modeling for the period from 1975 through 2008 indicate only minor changes in the Proposed Action Alternative from the No Action Alternative with respect to water temperature and the dissolved oxygen concentrations of coldwater bottom discharges from Lake Lanier through Buford Dam. Therefore, no effects on the Buford trout Hatchery's operation would be expected as a result of the Proposed Action Alternative."

University of Florida Analyses of Apalachicola Bay

A 3D curvilinear-grid hydrodynamic salinity model was developed to simulate the flow and salinity dynamics inside Apalachicola Bay (Sheng et al. 2011; Appendix VIII). The model showed satisfactory performance with observed salinity collected by the Apalachicola National Estuarine Research Reserve in 2004. Specific details on model development and performance are provided in the report. The authors also developed an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it with the hydrodynamic-salinity model to assess the impact of freshwater alteration on oyster populations in Apalachicola Bay. Four discharge scenarios were considered in the 10 year (1999-2008) simulations: 1) observed data from the USGS gaging station 02359170 near Sumatra, Florida, 2) no action alternative (i.e., current operations), 3) proposed alternative minimum flow scenario 1 (550 cfs target at Peachtree Creek), and 4) proposed alternative minimum flow scenario 2 (750 cfs target at Peachtree Creek).

The Service requested that the authors provide various analyses of model output specific to oysters and Gulf sturgeon with the assumption that optimal salinities for oysters are less than 26 ppt (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Sulak et al. 2009). To assess the impacts of the four discharge scenarios on oysters, we requested that comparisons be made at Dry Bar (an oyster bar with strong river influence) and Cat Point (an oyster bar with little river influence). These analyses included salinity exceedance probabilities, summary statistics and exceedance probabilities for oyster growth rates, and salinity contour maps with associated acreages for the total number of days when salinity exceeded 26 ppt in a wet, dry, and average year. For Gulf sturgeon, we requested salinity contour maps describing the total number of days salinity exceeded 10 ppt from 1 October- 31 March for the following years for all 4 scenarios in a dry, wet, and average year.

Analyses indicate that there will be no appreciable difference in the magnitude or timing of estuary freshwater inflow between the no action and proposed action alternatives (Sheng et al. 2011; see Appendix VIII). There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data. However, in general, the Corps' simulated flow scenarios resulted in salinities that had slightly higher highs and lower lows than salinities estimated using Sumatra discharge data. Oyster growth rates were also slightly lower in the Corps' modeled scenarios compared to the observed Sumatra discharge data, especially in August, which is considered the peak growth period for oysters in Apalachicola Bay (Huang 2010). Similarly, the amount of habitat available for Gulf sturgeon was slightly lower in the no action and proposed action alternatives than the observed discharge data at Sumatra.

These effects on the bay relative to historic operations result from changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives, and less so to apparent changes in consumptive water uses. Historic basin inflow rates (the Corps' reported daily project inflow data) from 1976 to 2008 are roughly equivalent with the basin inflow data used in the modeled scenarios (unimpaired flow minus consumptive water uses), and the modeled basin inflow data is actually slightly higher overall (period-of-record average daily basin inflow values are 34 to 103 cfs greater) than the historic data. Therefore, the differences in the bay salinity results do not appear related to any simulated increase in consumptive water demands. However, average annual releases (1976-2008) from Woodruff Dam are about 400 to 500 cfs less than historic under the no-action and proposed alternatives, and average monthly composite reservoir storage is about 35,000 to 111,000 acre feet greater than historic levels in the months of August through October. Although salinities and oyster growth rates are similar between the no action and proposed action alternatives, all model outputs indicate that flows will continue to be lower than what historically and even recently occurred (i.e., pre-IOP in 2006) and thereby continuing suboptimal conditions for oysters, Gulf sturgeon, and other fish and wildlife in Apalachicola Bay.

In their May 23, 2011, correspondence to the Service, FFWCC states that there should be additional analyses of the impact of proposed and existing operations on juvenile Gulf sturgeon in Apalachicola Bay. They generally agree with the conclusions contained in the Apalachicola Bay section of the Service's DFWCAR, but would like to see additional details about potential impacts to estuarine sentinel species, such as eastern oysters or white shrimp. The Service agrees with FFWCC that additional datasets should be sought or generated to quantify impacts to juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species. The Service searched for additional analyses and new datasets prior to drafting the PAL but located few. Thus, the Service welcomes additional information that FFWCC can provide to assess impacts of proposed and existing operations.

FFWCC also states that the DFWCAR should address the minimum flows needed to mitigate the impacts of saltwater incursion due to sea level rise. Thus, we recommend that the Corps capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion. This modeling effort should include both short- and long-term planning horizons.

EVALUATION OF THE SELECTED PLAN

The purpose of this section is to evaluate the relative merits of the no action and proposed action alternative and ultimately determine their acceptability from the standpoint of the Service's responsibilities under the FWCA and our mission to conserve, protect, and enhance fish and wildlife resources. To that end, we succinctly describe the impacts of the proposed action alternative relative to the no action alternative in terms of each biological and/or habitat parameter considered. Each parameter is described as an improvement (+), a negative impact (-), or no change (0) over the no action, regardless of the magnitude of the difference between the no action and proposed action alternative. Scores were determined by assigning values of 1 for + signs, -1 for negative impacts, 0 for no change, and summing values for each reach (Table 1). Larger sums indicate that the proposed alternative is beneficial, without assigning a relative weight to the parameter or reach being considered. We emphasize that this approach is one method to evaluate the proposed action alternative, and it is not meant to be the sole deciding factor in the Service's evaluation. Rationales for the individual assignment of signs are provided in the text below Table 1. The Corps' provided the Service little to no interpretation to accompany their analyses in their Response to the Service's PAL; therefore, the evaluation below is solely based on the Service's interpretation.

Table 1. Scoring of impacts to fish and wildlife resources resulting from the Corps' proposed action alternative relative to the no action alternative. The proposed alternative is better (+), worse (-), or the same (0) as the no action alternative for fish, wildlife or habitat. NAE indicates that the Corps has not adequately evaluated the parameter or the analysis is ongoing, and N/A indicates that the analysis is not applicable. All symbols are applicable to the reach below the dam, except variables shaded in grey are applicable to the reservoir upstream from the dam.

	Buford	West Point	W.F. George	J. Woodruff
Dissolved Oxygen	-	+	+	0
Temperature	-	0	0	0
Waste water	+	+	+	0
Chlorophyll-*a*	NAE	-	-	NAE
Reservoir Retention Time	NAE	NAE	NAE	NAE
Ortho-phosphorus	0	+	+	0
Floodplain connectivity- Chattahoochee and Apalachicola	NAE	NAE	NAE	NAE
Reservoir Fisheries	-	-	-	-
Riverine Fisheries	NAE	NAE	NAE	NAE
Salinity	N/A	N/A	N/A	0
Gulf sturgeon	N/A	N/A	N/A	+
Freshwater mussels	N/A	N/A	N/A	-
Floodplain connectivity- Apalachicola	N/A	N/A	N/A	+
Eufaula NWR	N/A	N/A	0	N/A
Buford Fish Hatchery	-	N/A	N/A	N/A
Score:	-3	1	1	0

Dissolved Oxygen

Higher dissolved oxygen levels are considered to be better for fish and invertebrates, but frequently fell below State standards for both the no action and proposed action alternatives below Buford Dam, West Point Dam, and WFGLD. For the composite period, compared to the no action alternative, the proposed action alternative exhibited lower dissolved oxygen levels immediately below Buford Dam and then transitioned to higher dissolved oxygen levels below Atlanta. Higher proposed action alternative dissolved oxygen levels occurred below West Point Dam and WFGLD, and approximately the same levels between the two alternatives occurred below JWLD. However, the differences between the alternatives were small and occurred at low occurrence levels, meaning that both the no action and proposed action alternatives frequently provide poor conditions for fish and wildlife.

Water Temperature

Temperatures were expected to be similar throughout the ACF Basin, with differences between the no action and proposed action alternative fluctuating between approximately +/- 0.5 degrees C for the composite period. However, when normal, wet, and dry years are separated, the proposed action alternative shows the most drastic deviation from the no action alternative from Buford Dam to West Point Reservoir. In this reach, temperatures under the proposed action alternative were expected to drop up to 1.5 degrees C from the no action alternative with the greatest temperature difference exhibited between Atlanta and West Point Reservoir. The following fisheries information is taken largely from Georgia Power (2006):

Historically a warmwater river, the mainstem Chattahoochee River tailrace became an artificially created coldwater river following the construction of Buford Dam. Bottom releases from Buford Dam create coldwater releases suitable for a non-native brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) fishery in a 48-mile section of river extending downstream to Peachtree Creek.

GDNR has historically stocked this section of river with rainbow and brown trout and manages the trout fishery in two distinct segments: the Buford Dam tailwater extending 30 river miles downstream to Georgia Highway 400; and the Morgan Falls Dam tailwater extending 12 miles downstream to Peachtree Creek. The first segment is colder with greater flow fluctuations and the second segment is warmer with less fluctuations.

Water temperature is of great concern to GDNR in this section of the Chattahoochee River. They are very interested in maintaining the cold temperature regime for the trout fishery, the most popular sport fishery in this section of the Chattahoochee River. They report that high summer water temperatures potentially detrimental to trout have been occurring more frequently in recent years in the Morgan Falls Dam tailwater, and that nonpoint stormwater runoff from impervious surfaces in tributary watersheds appears to contribute to these conditions.

As summer maximum water temperatures have become more marginally suitable for trout, GDNR has diversified its management objectives downstream of Morgan Falls Dam to include restoration of native shoal bass (*Micropterus cataractae*), a warmwater bass species endemic to the ACF River basin. Under the no action alternative, GDNR considers the reach to be a transition zone capable of supporting both coldwater and warmwater fisheries and has initiated a stocking program for shoal bass in the reach of the Chattahoochee River below Morgan Falls Dam. GDNR, along with other State and Federal agencies including ADCNR, the Service, and the National Park Service (NPS) have been involved with restoration and research activities to improve the status of the species.

GDNR has also reintroduced striped bass (*Morone saxatilis*) into what is now West Point Reservoir. Striped bass restoration in the ACF Basin is a collaborative effort between the conservation agencies in Georgia, Alabama, Florida, and the Service, with the goal of restoring a self-sustaining population to the maximum extent possible. The group meets on an annual basis to set goals and discuss ongoing management and research for striped bass in the ACF system. West Point Reservoir is currently designated as a potential broodfish repository and is one of the highest priority reservoirs to receive stocked striped bass.

Because striped bass exhibit upstream migrations to spawn in riverine conditions, a striped bass fishery has developed in the Chattahoochee River downstream of Morgan Falls Dam, the first upstream barrier to striped bass migrating upstream from West Point Reservoir. Persistence of a small population in West Point Reservoir suggests that striped bass in the river are capable of limited natural reproduction. However, coldwater releases from Buford Dam during the spring spawning period of striped bass, and abrupt decreases in water temperature that occur with Buford Dam peaking operations, have been identified as critical factors inhibiting striped bass spawning and adversely affecting survival of eggs and larvae in the upper Chattahoochee River near Morgan Falls Dam (Hess and Jennings 1999). Their movement upstream to Morgan Falls increases as summer progresses, indicating that the water temperatures in the summer serve as a coolwater refuge. GDNR-WRD considers this "coolwater refuge" effect to be of significant importance to the survivability of adult striped bass.

Because the proposed action alternative exhibits colder water temperatures below Buford Dam to West Point Reservoir, most notably the reach below Morgan Falls Dam to West Point Reservoir, the Service views the proposed action alternative as less favorable than the no action alternative. Although the colder temperatures may be more beneficial to the artificial trout fishery, they represent a greater deviation from natural warmwater conditions and a native warmwater fishery in the Chattahoochee River, especially from Morgan Falls Dam to West Point Reservoir. However, the Service proposes that elements of both a coolwater and warmwater fishery potentially could be supported if water quality and flows are improved.

Wastewater

The no action and proposed action alternative model results were similar along the longitudinal river profile within each scenario, with the average stream percent wastewater in the proposed action alternative model output typically 1-3% less than the no action alternative. These modeled results suggest that the proposed action alternative would be slightly more favorable than the no action alternative.

Chlorophyll-*a*

Chlorophyll-*a* is correlated with algal biomass. Because algal mats can cause nuisance conditions in lakes, it is considered to be less desirable in lentic systems. Chlorophyll-*a* was similar between the no action and proposed action alternatives throughout the river system, but slightly larger differences were observed in reservoirs. Under the proposed action alternative, occurrence plots exhibit slightly higher chlorophyll-*a* concentrations within West Point and Walter F. George reservoirs; this indicates that the proposed action alternative is slightly less favorable when compared to the no action alternative. Occurrence plots were not available for Lanier or Jim Woodruff reservoirs. Therefore, occurrence plots should be developed for Lake Lanier and Jim Woodruff reservoirs to assess differences in chlorophyll-*a* between the no action and proposed action alternative.

Reservoir Retention Time

Higher retention rates may result in decreased reservoir water quality. The Corps did not provide data to assess retention time. Therefore, data to assess retention time should be developed to assess differences between the no action and proposed action alternative.

Ortho-phosphorus

Algal growth is stimulated by increases in phosphorus. Thus, phosphorus levels were modeled and compared between the no action and proposed action alternative. Phosphorus levels were slightly lower in the proposed action alternative below West Point Dam and WFGLD and approximately the same below Buford Dam and JWLD. Therefore, the proposed action alternative is slightly more favorable than the no action alternative in certain reaches of the project area.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

Indicated previously, the Corps has not yet provided output from the revised flow guideline development methodology for the comparison of the no action alternative, proposed action alternative, and pre-Buford period. However, a floodplain connectivity analysis for the Apalachicola River based on prior consultations for endangered freshwater mussel impacts is provided below (see *Apalachicola River Floodplain Connectivity* section). The Corps should provide output from the revised flow guideline development methodology for the comparison of the no action alternative, proposed action alternative, and pre-Buford period.

Reservoir Fisheries

Differences between the no action and proposed action alternative reservoir fisheries scores were generally $\leq$ 0.04, suggesting low potential for realized fisheries differences between the two alternatives. However, fishery scores for the proposed action alternative were slightly lower than the no action alternative for all reservoirs. Therefore, the proposed action alternative is slightly less favorable than the no action alternative.

Riverine Fisheries

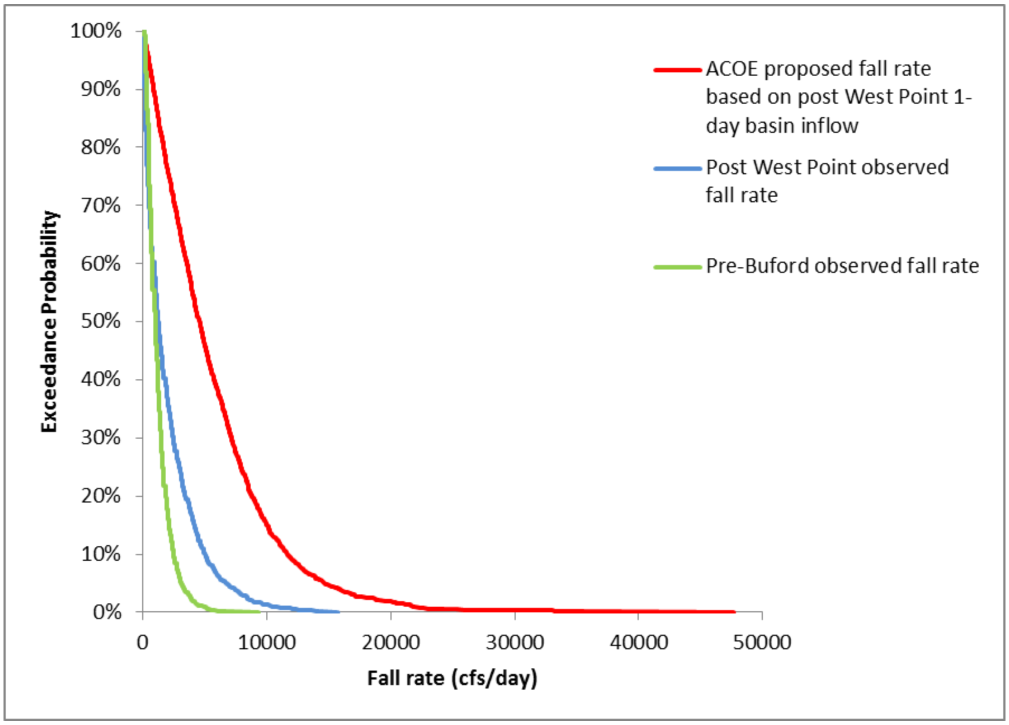
The riverine fisheries analysis provided by the Corps relied on IHA output to compare baseflows. Similar to the floodplain connectivity analysis, output from the revised methodology has not yet been provided by the Corps for the comparison of the no action alternative, proposed action alternative, and pre-Buford Dam period. The analysis that was provided did not include the average and wet year low flow values for the pre-dam period in the comparison with the no action and proposed action alternative, a deficit that should be rectified in future correspondence.

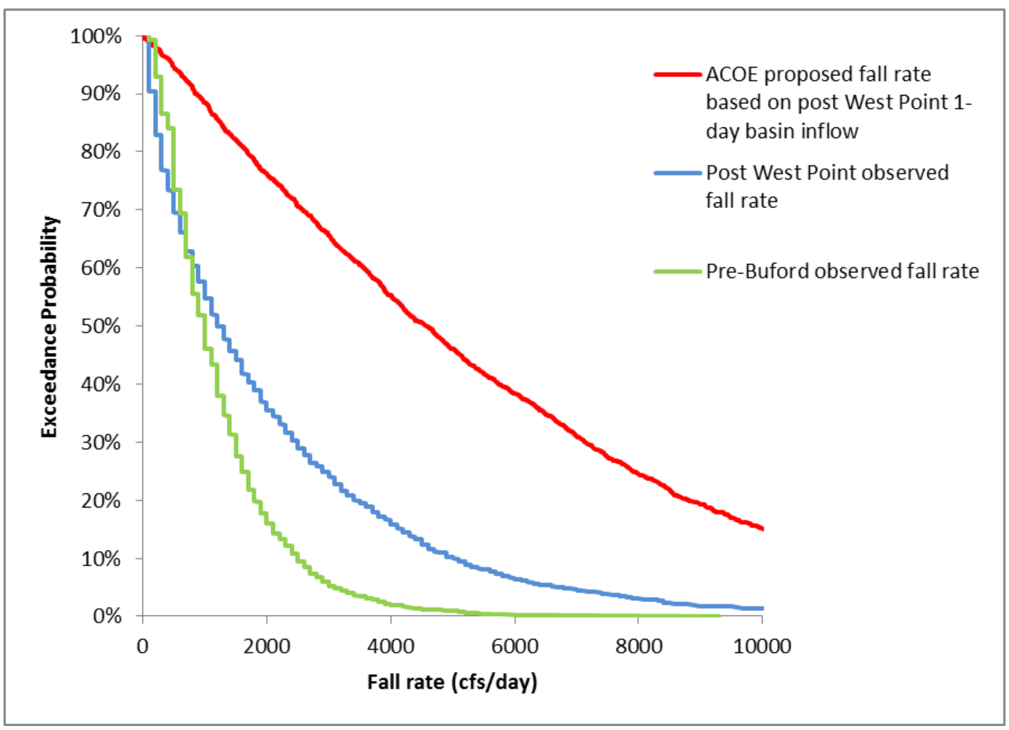
Therefore, the Corps should provide output from the revised ecosystem flow guidelines for the comparison of the no action alternative, proposed action alternative, and pre-Buford Dam period.

In addition, the change to the RIOP in the proposed alternative that requires fall rates to match the 1-day basin inflow below JWLD may result in additional impacts to riverine fishes in the Apalachicola River. Fall rate analyses provided by the Corps indicate that there are slightly more days with fall rates in the 1-2 ft decline per day. We conducted an additional analysis to further evaluate the impacts of such a change. Because we do not have data to analyze the no action and proposed action differences, we compared pre-Buford declines in daily discharge at the Chattahoochee gage to declines in 1-day basin inflow (as computed by the Corps) from 1976 through May 2008 when releases were between 16,000 cfs and 30,000 cfs (Figure 3). Basin inflow was calculated as the sum of daily local inflow at Buford, West Point, WFGLD, and JWLD. This basin inflow calculation method was chosen because it is analogous to the calculation method that the Corps proposes to use to manage fall rates below JWLD. We were unable to compare actual stage declines because basin inflow is not derived from a single gage measurement. The fall rates from the basin inflow data are very different from pre-dam fall rates (e.g., basin inflow fall rates exceeding 1,000 cfs happen more than 87% of the time, compared to 43% of the pre-Buford Dam period). We do not support the use of the 1-day basin inflow fall rate because it may result in less floodplain connectivity in this range of releases, resulting in more floodplain stranded fishes of all ages and smaller year classes.

The Corps has recently provided USFWS with a new Run of River (ROR) scenario. The intent of the ROR scenario is to isolate the impacts of Corps reservoir management on flows, while maintaining the influence of consumptive use activities, including evaporative loss. Thus, the ROR scenario maintains reservoir pool elevations, and quantifies discharge that would otherwise pass Corps reservoirs. We suggest that an additional analysis be conducted to compare fall rates under the ROR scenario to the pre-Buford, post-West Point, and proposed alternative fall rates.

Figure 3. Comparison of declines in daily discharge when releases were between 16,000 and 30,000 cfs in the Pre-Lanier record (Chattahoochee gage 1922-1955) to the 1-Day Woodruff Dam Basin Inflow post-construction of West Point Dam (1976-2008).





Federally-protected Species in the Apalachicola River

Gulf sturgeon

Gulf sturgeon spawning habitat availability was nearly identical between the no action and proposed action alternative. However, the number of consecutive days per year where flows were less than 16,000 cfs was lower for the proposed action alternative, meaning that conditions provided by the proposed action alternative are probably slightly better for spawning Gulf sturgeon.

Freshwater mussels

The only freshwater mussel analysis was for the river segment below JWLD. Although low flows are similar between the no action and proposed action alternative, both model outputs indicate that annual low flows will continue to be lower than what historically occurred and thereby continuing stressful conditions for mussels. Most of the comparisons of project impacts on mussels showed nearly identical results. However, the proposed action alternative had approximately 50 more days in the higher fall rate category, and occasionally had lower annual minimum flows than the no action alternative, meaning that there is a slightly higher potential for mussel stranding under the proposed action alternative. As discussed in the Riverine Fisheries Section, the change to the RIOP in the proposed alternative that requires fall rates to match the 1-day basin inflow below JWLD may result in additional impacts to riverine fishes in the Apalachicola River. Mussel population viability is intricately tied to host fish density (Watters 1997; Haag and Warren 1998). Because many of the fish species dependent on the floodplain serve as host fish to freshwater mussels in the Apalachicola River, freshwater mussels may also be impacted by this change to the RIOP. In addition, the change to the RIOP in the proposed alternative that requires drought plan provisions remain in place until composite conservation storage reaches Zone 1 would result in freshwater mussels being subjected to low flows for longer periods of time than under the no action alternative. Another potential impact to freshwater mussels could result from the effects of the reshaped Drought Zone as part of the proposed action alternative, but the Corps has not provided analysis of this potential impact. Therefore, the proposed action alternative is less favorable than the no action alternative.

Apalachicola River Floodplain Connectivity

The assessment of floodplain connectivity on the Apalachicola River indicated that both alternatives were similar. However, in the proposed action alternative, slightly more floodplain acreage is connected to the river for a minimum of 30 days at exceedance frequencies (% of years) less than 45% during the growing season. This suggests more floodplain would be available as fish habitat, and potentially more inundation of tupelo-cypress swamps, as well as potentially higher fish and invertebrate productivity. Therefore, in the Apalachicola River, the proposed action alternative is slightly more favorable than the no action alternative. However, additional analyses need to be conducted to describe how floodplain connectivity is impacted by the change to the RIOP; specifically those changes that require fall rates to match the 1-day basin inflow below JWLD when releases are between 16,000 and 30,000 cfs.

National Wildlife Refuges and Fish Hatcheries

Eufaula NWR

The Service had requested the examination of alternate Walter F. George Reservoir management strategies to accommodate the request and freshwater needs of Eufaula NWR. The Corps indicated that they are unable to meet that request, meaning that there is no change in reservoir levels and therefore, no change to Eufaula NWR.

Fish Hatcheries

Buford Fish Hatchery relies on a freshwater intake below Buford Dam to support fish rearing. Although there is similar water availability for Buford Fish Hatchery for both alternatives, dissolved oxygen levels were slightly lower below Buford Dam in the proposed action alternative. Therefore, the proposed action alternative is slightly less favorable than the no action alternative.

University of Florida Analyses of Apalachicola Bay

Salinity was modeled in Apalachicola Bay relative to oysters and Gulf sturgeon (Sheng et al. 2011; Appendix VIII). Although analyses indicate that there will be no appreciable difference in salinities in the action and proposed action alternatives (Table 1), simulated salinities between the no action and the proposed action alternatives differed from the observed Sumatra discharge data, resulting in lower oyster growth rates and less available habitat for Gulf sturgeon. This indicates that flows will continue to be lower than what historically and even recently occurred (i.e., pre-IOP in 2006) and thereby continuing suboptimal conditions for oysters, Gulf sturgeon, and other fish and wildlife in Apalachicola Bay.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

The intent of this section is to identify measures that should be taken to prevent the loss of or damage to fish and wildlife resources and to provide for the improvement of such resources. In the PAL and PAL addendum, we identified resources and analyses that would be necessary in order to address planning objectives. Although some planning objectives were addressed by Corps analyses as described in prior sections, many were not adequately addressed. We review our current understanding of the Corps' position on each issue and note whether the planning objectives were adequately addressed. Those planning objectives that were not adequately addressed are conveyed here as conservation measures, or recommendations, that should be taken to benefit fish and wildlife.

Conservation Measures Included from the Service's PAL & PAL Addendum

Flow Regime

- Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes.

  This has not been completed and should be developed. Although the PAL provided sets of low and pulse flow guidelines from which alternatives could be developed and *compared, and requests for modeling non-hydropower peaking windows, the Corps did not develop alternatives based on those guidelines because of management limitations cited in their response to the Service's PAL (Corps 2011). However, within the Service's PAL, we stated:*

"We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation."

We reiterate to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. To date, none of the natural flow regime components have been incorporated into the flow alternative development, and only low flows guidelines were given treatment in a comparison of alternatives for Buford and West Point dams.

- Conduct ecosystem flow analyses using the methodology cited in the Service's PAL addendum should be conducted at four nodes (below Buford, West Point, WFGLD, and JWLD) for the no action and proposed action alternatives and compared with the Service's ecosystem flow guidelines. We also recommend the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March-May.

  In the Service's PAL addendum, we provided updated ecosystem flow guidelines representing natural conditions, as well as updated methodology for the Corps to analyze their low and high flow releases under the no action alternative and proposed action alternative. Such analyses have not been provided to the Service.

  FFWCC generally supports the Service's guidelines, but also recommends a modified approach to the development of low flow guidelines. The Service used the seven lowest values from every month in every year to characterize low flows in dry, average, and wet months for the pre-Buford period. FFWCC proposed that daily exceedance values based on all the pre-Buford hydrology, including baseflows, pulses, and floods, be used to develop guidelines. Subsequent analyses by the Service show that the 90% exceedance roughly corresponds to the lower limit and dry month flow guidelines, and the 50% exceedance values track the wet year flow guidelines, with the exception of the wetter months, lending some support to this alternative approach. We agree with FFWCC that this type of analysis has merit for comparing flow alternatives and characterization of flow data. However, the Service views this method as complementary but not substitutive for flow guideline development.

  1. *Exceedance plots include all flows including pulses and floods. Therefore, low flow guidelines that could come from exceedance plots are potentially influenced by high flows, thereby inflating low flow guideline values. This is particularly evident with exceedance probabilities less than 75%, and in wetter months. One intent of the*

Service's flow guideline development was to separate multiple flow components (low flows, pulses, and floods) and illustrate the inter- and intra-annual variation in flows. Exceedance plots blur the distinction between low flows, and pulses and floods which is one reason why exceedance plots were not used initially.

2. *Daily exceedance plots show a large amount of daily variation. Similar to the Service's flow guidelines, this variation illustrates that a range of low flow values may be beneficial for fish and wildlife resources. However, one intention of the Service's guidelines was to provide managers and modelers real values to evaluate and/or incorporate into a flow alternative. Although selecting the seven lowest values for every month of every year to characterize dry, average, and wet months is a simplification of the pre-Buford hydrology, the Service expects that there is a higher likelihood of successful incorporation of the Service's 60 low flow guideline values (represented by the lower and upper limit, and dry, average, and wet conditions for each of 12 months), than the 365 values required for one year type using the exceedance probability method.*

The Corps addressed the feasibility of providing non-hydropower peaking windows from March to May (4-6 weeks) at Buford Dam and West Point Dam in their response to the Service's PAL (Corps 2011). The Corps states that a loss of hydropower production, as well as physical, safety, and logistical limitations would prohibit the implementation of non-hydropower peaking windows at these facilities. We note that fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production. While the Corps has repeatedly stated that revised water control operations shall reflect existing structural and physical constraints (e.g., no consideration of structural improvements), there is no funding for structural improvements, and such improvements are outside the WCM update process, the Service continues to recommend that the Corps explore options to alter downstream flow releases to minimize impacts to or benefit riverine aquatic resources below their projects in the ACF Basin. Such changes in operation do not necessarily come at the cost of reduced hydropower production.

- Evaluate the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain.

Per the Corps' June 1, 2010, informal synopsis of the Corps' alternatives development and screening process provided to the Service, the Corps considered slight adjustments to the top of conservation pool guide curves at West Point and Walter F. George Reservoirs that included an earlier spring refill. However, no explanation has been provided as to why those adjustments were not included in the preferred alternative. We continue to recommend the Corps address and evaluate all of these options listed above.

- Evaluate methods to provide the operational flexibility necessary for floodplain inundation, which could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation, and/or 2) the purchase of structures built in the historic floodplain so that the Corps could intentionally provide flows that inundate the floodplain.

  This has not been completed. The Corps states that one of their guiding principles for the WCM update process is that the flood control capabilities and capacities of the reservoirs will not be reduced (see Decision Support Model to Evaluate Changes to Corps' Operations below). Corps projects are managed in part for flood damage reduction, the objective of which is "storage of excess flows thereby reducing downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally." The methods suggested by the Service would not reduce the flood control capabilities and capacities of the reservoirs. First identifying and then protecting or purchasing structures that may be impacted by floods at naturally-occurring discharges could actually reduce potential flood damage, increase operational flexibility, as well as benefit aquatic resources. Thus, we encourage the Corps to continue investigating those methods listed above.

- Evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines.

  These analyses have not been conducted by the Corps. The Corps stated in the PAL Response that "Defining a real life operation that meets the authorized project purposes and better meets the "natural" hydrograph and then translating that operation into code for the reservoir simulation is a large undertaking. To the extent that FWS feels more needs to be done, we request additional guidance and support."

  As stated in the PAL, we stress to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. The specific components of the ecosystem flow guidelines were meant to be reviewed and considered for implementation on an individual basis by the Corps rather than collectively considered as a whole.

  Updated ecosystem flow guidelines for four locations in the ACF Basin were provided to the Corps in our March 1, 2011 PAL addendum. We agree that it is a potentially large undertaking to include flow guidelines, but we emphasize that the WCM update is itself a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental flow measures.

- Work with the Service and others to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

The Corps states that they have been engaged in conversations with entities such as the National Weather Service, but indicates that they do not have the reliable science to accurately make these predictions for operation of the ACF Basin system. However, we recommended that the Corps work with the Service so that we could collectively develop reasonable methods for defining hydrological conditions useful for reservoir and ecosystem management. To date, these conversations have not occurred.

<u>Floodplain inundation assessments</u>

- Use LIDAR or stage-discharge relationships to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at all four different flow scenarios including the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation.

  It was the Service's and the Corps understanding that full LIDAR coverage of the Apalachicola River was not available at the time the Corps developed their response to the Service's PAL, but stage-discharge relationships were available. The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. However, in FFWCC's May 23, 2011, review of the Service's DFWCAR, FFWCC states that data are now available for the entire Apalachicola River and should be used for more accurate future analysis. The Corps should use the LIDAR data, if they can be applied, to supplement existing analyses of floodplain inundation in the Apalachicola River.

<u>Dissolved Oxygen</u>

- Ensure that releases from all five ACF dams meet or exceed water quality standards, including monitoring water quality upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve water quality, and conducting post-modification water quality monitoring to ensure that levels have been improved to State water quality standards.

  The Corps states that they currently monitor water temperature, pH, conductivity, and DO below Lanier and West Point, and DO seasonally below Walter. F. George. They state that one of their guiding principles for the WCM update process is that revised water control operations shall reflect existing structural and physical constraints (e.g., no consideration of structural improvements, there is no funding for structural improvements, and such improvements are outside the WCM update process (see Decision Support Model to Evaluate Changes to Corps' Operations below). Subsequently, because the no action and proposed action alternatives significantly affect water quality, do not comply with State standards, and do not meet the designated project purpose of fish and wildlife, we requested that as part of the WCM update the Corps outline the steps that would be necessary on part of the Federal government and other entities to improve water quality below Federal projects in the ACF (Appendix IX). The Corps needs to make it a priority to ensure that releases from all five ACF dams meet or exceed DO, temperature, and other applicable water quality standards. GDNR-

WRD agrees that improvement of DO downstream of Corps reservoirs is important and would be beneficial to aquatic resources. We are available to assist the Corps in exploring alternate funding opportunities.

- Evaluate the effectiveness of the upgraded venting capabilities at Buford turbines.

  The Corps states that research is outside the scope of this WCM update. As stated above, we continue to recommend that the Corps needs to make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. We are available to assist the Corps in exploring alternate funding opportunities.

Temperature

- Monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved.

  As noted above, the Corps states that the revised water control operations shall reflect existing structural and physical constraints, that there is no funding for structural improvements, and such improvements are outside the WCM update process. The Corps needs to make it a priority to manage temperature levels to benefit aquatic life in accordance with resource agency management objectives. We are available to assist the Corps in exploring alternate funding opportunities.

Fish Passage

- Provisions for fish passage should be incorporated in the WCM for JWLD, GWALD, and WFGLD, while maintaining the need for operational flexibility.

  We are unsure whether the Corps will be including formal language in the WCM update for fish locking at JWLD (Appendix IX). The Corps states that they will not be including similar language for GWALD or WFGLD. They state that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the manual does not preclude lockings at GWALD or WFGLD, as well as modifications to lockings at JWLD in the future. However, we continue to recommend formal language be included in the WCM update. There is ample evidence that fish passage operations at the lock at JWLD are passing Alabama shad upstream, and the species may benefit from passage at these other Corps lock and dam facilities. FFWCC also agrees that the Corps should explore fish passage operations for anadromous fish species, such as the Alabama shad as part of the WCM update.

Climate Change

- In addition to considering sea level rise, include multiple future climate scenarios into modeled discharge scenarios and Corps alternatives and create flow provisions for dry, average, and wet years in order to account for current climate variability.

  The Corps states that they have considered climate change to some extent in the form of sea level rise. Their evaluations have determined that sea level rise is not projected to affect JWLD, the lowermost Corps' project in the ACF Basin. No consideration was given to the impact of climate change on hydrology. However, because climate change will potentially affect river flows and Corps operations, the Corps should include future climate scenarios over short and long terms, and flow provisions for dry, average, and wet years.

Navigation

- If navigation is included in the WCM update, evaluate the effects of channel maintenance activities required for navigation support by including an analysis of dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis.

  A navigation window has been included in the Corps' preferred alternative. The Corps has informed us that there are no plans for dredging in the Apalachicola River but that they will dredge portions of the Chattahoochee River. Dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis have not been included by the Corps in an evaluation of the effects of the channel maintenance activities required for navigation flow support. Therefore, we continue to recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support.

- If flows for navigation are not included in the WCM update, consider improvement or simplification of the four-zone reservoir operational scheme that governs current operation.

  Navigational flows are included in the Corps' preferred alternative. However, it is uncertain whether the navigation season will be a guaranteed minimum flow to provide a seven foot channel or if it will be only "as requested" by navigation interests. It is unclear how this flow window was modeled in ResSim.

Reservoir and Riverine Fisheries Management

- Review recent fisheries literature for additional information regarding detrimental impacts to riverine fish spawning due to a 4-6 week stable or rising reservoir window, per the Corps' draft Standard Operating Procedure (SOP) for "Lake Regulations and Coordination For Fish Management Purposes."

  The purpose of this literature search is to critically evaluate the relative merits and costs of operating projects for the benefit of reservoir and riverine fisheries so that the best *available science can be integrated into an informed management approach.*

In ResSim model simulations that were run by the Corps using the entire period of record, the fish spawn SOP governed less than 1% of releases at Corps reservoirs in the ACF Basin. The Corps states this is because fish spawn operations are largely the same as operations that are already conducted for higher priority purposes at their reservoirs.

The Corps states that the fish spawn SOP has been in operation since the 1970's and the operating windows were based on water temperatures. The Corps states that the window is determined by dates because it is labor intensive to base the window on water temperatures. A reservoir fisheries literature search was recently conducted for the Corps by TetraTech but no pertinent research was found. GDNR-WRD believes that the fish spawn SOP is important and should continue. However, additional data should be collected and analyses conducted to support, modify, or reject this management strategy concurrent with SOP implementation.

A literature search has not been conducted regarding downstream flows during the fish spawn SOP period and the resulting impacts to riverine fish spawning. However, FFWCC recently provided the Corps and the Service with riverine spawning information specifically for the Apalachicola River (FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011; Appendix VII). The report details how decreased spring flows have resulted in less aquatic floodplain habitats in the Apalachicola River floodplain system during critical spawning and nursery periods.

We continue to recommend a literature search be conducted for additional supporting information, especially applicable to areas upstream of the Apalachicola River.

- Investigate modifying the Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes.

The Corps states that the existing fish spawn SOP language already indicates they can or will emphasize benefits to river spawning over reservoir spawning if riverine fishes have experienced unfavorable conditions for several years. The existing language in the fish spawn SOP is as follows:

"An imbalance of prey and forage fish could occur following the second or third year of poor or unsuccessful spawning and recruitment, leading to poor sport fishing. Areas where the spawns were recently unsuccessful should be given higher priority for fish management operations under low water conditions." It is unclear in the documentation provided by the Corps how determinations will be made to ensure that river spawning takes precedence over reservoir spawning, and how operations will be modified to facilitate river spawning.

To the Service, the existing language does not seem to pertain to riverine habitats and *instead appears to remain focused on reservoir fisheries. Per our recommendation in the PAL, periodic emphasis of riverine spawning should be included in the fish spawn SOP.*

- Identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

  The Corps states that one of their guiding principles for the WCM update process is that revised operations shall reflect existing structural and physical constraints. They state that there is no funding for structural improvements and such improvements are outside the WCM update process. However, this recommendation could lead to increased operational flexibility for the Corps in the future. We are available to assist the Corps in exploring alternate funding opportunities.

<u>National Wildlife Refuges</u>

- Manage Walter F. George Reservoir so that it behaves more like a river to benefit Eufaula National Wildlife Refuge (NWR). Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer are recommended to provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl.

  In May 2010, after talking with the Corps regarding the recommendations in the Service's PAL, the Service provided the Corps with a set of specific flow tweaks that we would like the Corps to model that could potentially result in more environmentally beneficial flow alternatives. We included the above recommendation as one of the tweaks to be modeled, so that we could examine the ResSim output and evaluate the effects of these changes on system operation. The Corps states that the Walter F. George Reservoir is the first line of defense to provide flow at JWLD for the Revised Interim Operations Plan (RIOP) operations. The Corps also states that holding Walter F. George Reservoir higher in the winter wet season would increase the frequency of damaging downstream flows and maintaining low elevations during the summer dry season would remove storage from the system when it is most critically needed for flow augmentation and hydropower production. This issue has been addressed and is no longer a conservation measure.

<u>Apalachicola Bay</u>

- Incorporate the Sheng and Kim (2009) Apalachicola Bay salinity model in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth.

  The Corps has allowed the Service to use a portion of the Corps transfer funding, previously supplied to the Service for FWCA responsibilities pertaining to the ACF WCM updates, to fund Sheng's work. His modeling results are incorporated into this DFWCAR (above). We recommend that the Corps incorporate modeling results not only to evaluate *effects of their project operations, but also to inform their development of proposed alternatives.*

- Coordinate with FFWCC's Fish and Wildlife Research Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

  FFWCC provided pertinent analyses to the Service and to the Corps comparing the pre-dam and post-West Point periods of record, but did not include analyses for future actions, such as the WCM proposed alternatives or other future Corps' proposed actions. In that correspondence FFWCC provides updated research that raises "significant hydrologic and biological concerns applicable to any alternative [Corps] operation departing from the historic flow regime of the Apalachicola River" (Appendix VII). *We recommend the Corps move forward by coordinating with FFWCC to complete similar analyses on the WCM proposed alternatives and other future Corps' proposed actions.*

<u>Decision Support Model to Evaluate Changes to Corps' Operations</u>

- Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams.

  The Corps stated that they have used a decision support approach on a coarse scale and subsequently shared a synopsis of their decision-making process with the Service. Their June 1, 2010, synopsis indicates that their Modeling Team and Project Delivery Team have developed internal guiding principles for the revised WCM and an iterative process for the development of their alternative(s), which relies heavily on ResSim outputs. The Corps' guiding principles are as follows:

  1. *Flood control capabilities and capacities of the reservoirs will not be reduced (e.g. no measure is acceptable if it raises the likelihood, frequency, or severity of flooding).*
  2. *The ACF will continue to be operated as a system. The balancing of water control operations to achieve each of the project purposes will continue to vary between the individual projects and the time of year. Operation of the projects will continue to usually be performed in a manner which represents a consideration of these oftentimes competing purposes and, whenever possible, reservoir operations are scoped to accommodate these purposes in a complimentary fashion (balancing).*
  3. *The revised water control operations shall be within existing project purposes and authorities.*
  4. *The revised water control operations shall reflect existing structural and physical constraints (e.g. no consideration of structural improvements).*
  5. *The revised water control operations shall meet the existing Endangered Species Act requirements.*
  6. *The fish spawn SOP will continue to be implemented within the reservoirs.*

7. *Reallocation of storage to meet current water supply demands [where current equaled the highest levels of consumption experienced to date] at Lake Sidney Lanier for municipal and industrial (M&I) water supply shall be evaluated in conjunction with revised water control operations. (This guiding principle was subsequently revised to account for a district court ruling in Phase 1 of the consolidated ACF litigation, 17 July 2010 ("Phase I Ruling").*
8. *The revised water control operations will not adversely alter the water quality in Corps reservoirs.*

Ultimately, the Corps feels that the selected alternative reflects the combination of measures necessary for balancing system operations. This decision-making process should be more transparent to stakeholders, both in the WCM update process and in future proposed Corps' actions.

<u>Adaptive Management</u>

- Develop an adaptive management program, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam.

  The Corps states that the periodic updating of the WCM is a form of adaptive management and should be practiced. The Corps states that litigation has prohibited adaptive management from occurring on a periodic basis. While we understand the litigation history surrounding water management in the basin, we continue to recommend that the Corps develop an adaptive management program. We urge the Corps to consider a management approach that fosters implementation of an operational strategy with clearly defined goals or hypotheses, an evaluation to assess outcomes of the operation, and integration of the knowledge gained from that operation into management. Such operational changes do not necessarily occur outside of existing project authorizations and should therefore be of less litigation concern.

  The Corps should also consider that there is at least one consensus-driven stakeholder group working towards a water management solution in the ACF Basin. This group may be able to provide valuable information and insight as a starting point for an adaptive management program.

<u>Increasing Consumptive Demands</u>

- Recognize and consider the impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin and incorporate it into analysis of operational alternatives along with climate-driven hydrologic variability. Quantify the relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes.

  This has not been completed and the Corps is using currently permitted withdrawals and a planning horizon of 10-15 years with the intent of the manuals being updated again within that timeframe. However, there is a precedent that shows that 10-15 year *planning horizon is short-sighted. The last attempted update of the WCM was 23 years ago and it was not completed. We are concerned that the likelihood of updating the WCM in 10-15 years is small due to the issues at hand, large number of stakeholders, and potential for litigation. Therefore, projected future increases in withdrawals should be included in the Corps' analyses.*

- Include metrics regarding water supply withdrawals, including potential increases, in the alternatives analysis. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

  The Corps states that they are using the currently permitted withdrawals to date and that current usage has not yet reached the level of currently permitted withdrawals. As stated above, although the Corps intends to update the manuals again within the next 10-15 years, we are concerned that the likelihood of that being achieved is small due to the issues at hand, large number of stakeholders, and potential for litigation. Long-term goals of sustainable water management could go unrealized using short-term visions. Therefore, projected future increases in withdrawals should be included in the Corps' analyses.

<u>Evaluation of Alternative Models</u>

- Investigate the use of alternative models to develop better unimpaired flow and alternative flow datasets. Compared to the USGS gage data, the unimpaired flow dataset does not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes.

  Fundamental differences in output between the USGS gage data and the no action alternative (ie. current operations) are described in Appendix X. The Corps states that at this point in the process they are locked into using ResSim and HEC-5Q. They state that the 2010 Corps' Federal Storage Reservoir Critical Yield Analyses for the ACT and ACF Basins contains a description of how the datasets were developed and can be found on their website. Although HEC-ResSim has enabled the Corps to model several alternatives, they have indicated that it is difficult and labor intensive to try alternative management scenarios. We encourage the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim. We recommend the use of alternative models be investigated as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.

- If the United States Geological Survey's (USGS) Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, use it as an additional evaluation tool to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions.

  It is our understanding that the PRMS model is not ready for use at this time. However, if and when it is developed specifically for the ACF it should be used by the Corps as an additional evaluation tool for the WCM update process and future Corps' proposed actions.

- Coordinate with USGS and Georgia Water Resources Institute (GWRI) regarding new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

  The Corps states that they coordinate with Georgia Department of Natural Resources-Environmental Protection Division (GEPD), who uses some of GWRI's work, and that time will not allow for ResSim to be changed at this point in the process. We continue to recommend that the Corps coordinate directly with GWRI to address climate-based operational flexibility as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.

- Consider alternative water quality assessment methods to accurately evaluate effects of flow alternatives on water quality. Because the HEC-5Q water quality model outputs are not expected to accurately predict either the water quality values or the range of values that are likely to occur in response to hourly discharge changes, consider using existing alternative water quality models or develop regression models to accurately predict water quality parameters using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure).

  The Corps states that HEC-5Q is advantageous because it considers the system holistically; they also cite similar results between their simulated output to their observed tailrace data. Because HEC-5Q relies on daily average flow it does not accurately reflect water quality values that are likely to occur in response to hourly discharge changes. We continue to recommend alternative water quality assessment methods to accurately evaluate the effects of Corps operations on water quality.

Additional Conservation Measures Developed from the Corp's PAL Response

- There are no minimum flow provisions downstream of WFGLD. When low dissolved oxygen values are observed below the dam, the Corps states that spillway gates are opened until the dissolved oxygen readings return to an acceptable level. The Service has not seen actual data that exhibit an improvement in dissolved oxygen levels using this methodology. However, if this methodology is in fact effective, the Corps should evaluate modifying WFGLD's operations to provide a continuous minimum flow release instead of operating in a "reactive response" mode. Continuous minimum flow releases are already implemented at the other four other Corps' ACF Basin projects.

- Consider other options for operational flexibility that do not include changing the drought provisions or the fall rates when releases are between 16,000 and 30,000 cfs from the RIOP.

- Complete analyses to assess differences between the no action and proposed action alternative relative to chlorophyll-*a* and retention time.

- In your NEPA documentation, the impacts of the proposed action alternative on fish and wildlife resources should not only be described and quantified, but the Corps should also outline your approach to mitigation. Mitigation measures should be based upon more accurate projections of future projected resource conditions with and without the project.

SUMMARY AND FWS POSITION

The Service does not support the Corps' proposed action alternative for many reasons including a failure to address conservation measures identified in the PAL (Appendix V), modeling developed from short-term planning horizons and a single consumptive use scenario, increased frequency of low flows, negative impacts to mussels due to reduced low flows, increased storage resulting in lower annual releases to the rivers and bay, failure to address conservation measures identified in the PAL, and inadequately evaluated impacts to mussels, fisheries, and habitats due to proposed changes from the 1989 draft WCM and the RIOP.

In accordance with the FWCA and Service mitigation policy (FR 46(15):7644-7663; January 23, 1981), we identified steps that should be taken to ensure that fish and wildlife resources are protected or improved. We identified additional conservation measures and steps that should be taken as part of an update to the WCM. Although the Corps stated that consideration and modeling of other flow alternatives using HEC-ResSim is a potentially large undertaking, we emphasize again that the WCM update is itself a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental flow measures. To date, no aspect of the flow guidelines provided in the PAL or PAL addendum have been integrated into the Corps' modeled alternatives.

The Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, and therefore direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for 'with the project' and 'without the project' scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in your National Environmental Policy Act (NEPA) documents.

We also emphasize that the Corps' impact to water quality, primarily dissolved oxygen, below several projects in the ACF Basin is unacceptable. The Corps needs to seek authorization and appropriations to ensure that water quality standards are met below these projects.

Finally, the Service reminds the Corps that when a water body is proposed to be controlled or modified "for any purpose whatever" by a Federal agency, the action agency is required *first* to consult with wildlife agencies (Federal and State) "with a view to the conservation of fish and wildlife resources." Although discussions occurred regarding the WCM update and resource concerns in the ACF Basin, the Corps developed all alternatives well before the Service and State agencies were informed of the proposed action. We understand that the Corps had to move quickly to meet the 2012 deadline laid out by Judge Magnuson's July 2009 ruling; however, proceeding in this manner is not consistent with the purpose of the FWCA, and consequently has hampered consideration and integration of fish and wildlife planning objectives and concerns. To date, all analyses provided by the Corps consist of evaluations of the effects of flow alternatives developed by the Corps with little consideration of project operation enhancement to benefit fish and wildlife. To ensure sustainability for these resources, the Service will continue to work cooperatively with the Corps and all stakeholders. In particular, the Service needs to be an integral member of the Corps' team when formulating and evaluating operational alternatives. We encourage the Corps to follow the recommendations and conservation measures included in this document, and are ready to assist in the development of a WCM that is protective of fish and wildlife resources in the ACF River Basin.

LITERATURE CITED

Altinok, I. and J.M. Grizzle. 2001. Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. Journal of Fish Biology 59:1142–1152.

Georgia Power. 2006. Resource Study Report Fisheries and Aquatic Resources, Morgan Falls Project (FERC No. 2237). Prepared with GeoSyntec Consultants. March 2006.

Haag, W.R., and M.L. Warren, Jr. 1998. Role of ecological factors and reproductive strategies in structuring freshwater mussel communities. Canadian Journal of Fisheries and Aquatic Sciences 55:297-306.

Hess, B.J., and C.A. Jennings. 1999. Reproductive success of stocked striped bass (*Morone saxatilis*) in the Chattahoochee River above West Point Lake: implications for the Morone stocking program. Final Report, prepared for Georgia Department of Natural Resources, Wildlife Resources Division, Fisheries Management Section, Social Circle, Georgia. September 1999.

Huang, W. 2010. Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science 86:526-534.

Light, H.M., K.R. Vincent, M.R. Darst, and F.D. Price. 2006. Water-level decline in the Apalachicola River, Florida, from 1954 to 2004, and effects on floodplain habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston, R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin, W. Huang. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Sheng, Y.P and T. Kim. 2009. Skill assessment of an integrated modeling system for shallow coastal and estuarine ecosystems. Journal of Marine Systems 79: 212-243.

Sheng, Y.P., J.R. Davis, and V.A. Paramygin. 2011. Simulating the impact of USACE operating alternatives on salinity and oyster population in Apalachicola Bay, FL. Draft Interim Report to the U.S. Fish and Wildlife Service. Civil and Coastal Engineering Department, University of Florida. April 27, 2011.

Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Parauka, S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505–515.

United States Army Corps of Engineers. 1998. Draft Environmental Impact Statement Water Allocation for the Apalachicola-Chattahoochee-Flint (ACF) River Basin Main Report, September 1998, Mobile District, Mobile, Alabama.

United States Army Corps of Engineers. 2011. ACF Water Control Manual Update Response to PAL. January 18, 2011.

United States Fish and Wildlife Service. 2008. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. June 1, 2008. 225 p.

Wang, H., W. Huang, M.A. Harwell, L. Edmiston, E. Johnson, P. Hsieh, K. Milla, J. Christensen, J. Stewart, and X. Liu. 2008. Modeling oyster growth rate by coupling oyster population and hydrodynamic models for Apalachicola Bay, Florida, USA. Ecological Modeling 211: 77-89.

Watters, G.T. 1997. Individual-based models of mussel-fish interactions: a cautionary study. Pages 45-62 in: K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, editors, Conservation and management of freshwater mussels II: initiatives for the future. Proceedings of an Upper Mississippi River Conservation Committee symposium, October 1995, St. Louis, MO.

GEORGIA

DEPARTMENT OF NATURAL RESOURCES
MARK WILLIAMS, COMMISSIONER

May 23, 2011

Sandra S. Tucker, Field Supervisor
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Ms. Tucker,

Thank you for the opportunity to review the Fish and Wildlife Service's Draft Fish and Wildlife Coordination Act Report (DFWCAR) to the Corps of Engineers regarding the Water Control Manual update for the Apalachicola-Chattahoochee-Flint (ACF). The DFWCAR discusses several issues related to fisheries management issues important to WRD and we offer the following comments for your consideration in development of the final DFWCAR.

<u>Water Temperature</u>
The current thermal regime in the Chattahoochee River tailwater below Lanier is of considerable importance to the Georgia Wildlife Resources Division (GAWRD). The trout fishery on the Chattahoochee River has existed for nearly 50 years and is considered to be one of the premier fisheries in Georgia (approx. 90,000 trips per year). The fishery is dependent upon cold well-oxygenated water for the survival of both wild brown trout and stocked trout. In addition, the Buford Trout Hatchery, located less than two miles downstream of Buford Dam produces 400,000 catchable trout annually and is dependent upon cold water in the river to maintain this production.

<u>On Page 18:</u> The DFWCAR discusses water temperature in the Chattahoochee River tailrace as it relates to fisheries management efforts, and we offer the following comments to this section for clarification.
The DFWCAR is correct in stating that water temperatures are of significant concern to GAWRD in this Section of the Chattahoochee River and our interest in maintaining the cold temperature regime to support the popular trout fishery in this section of the River. Because summer

maximum temperatures can become marginal for trout survival below Morgan Falls, GAWRD has diversified fishery management strategies in this reach. GAWRD is currently stocking shoal bass below Morgan Falls as we have seen sporadic/inconsistent shoal bass reproduction in this section and have determined that annual supplemental stockings are necessary to maintain a fishery.

The paragraph referencing striped bass stocking on West Point Reservoir should be expanded upon to fully describe the Gulf Striped bass restoration effort. Gulf Striped bass restoration in the ACF is a collaborative effort between the conservation agencies in Georgia, Alabama, Florida, and the FWS with the goal of restoring a self-sustaining population to the maximum extent possible. The group meets on an annual basis to set goals and discuss ongoing management and research for Gulf striped bass in the ACF system. West Point Reservoir is currently designated as a potential broodfish repository and is one of the highest priority reservoirs to receive stocked striped bass.

While the DFWCAR is correct in stating that striped bass exhibit upstream migrations from West Point Reservoir to spawn and that a (summer/early fall) fishery has developed in the Chattahoochee River downstream of Morgan Falls, the DCFWCAR does not mention the significant importance of cool-water refuge upon the survivability of adult striped bass. The movement of striped bass upriver to Morgan Falls is thought to be largely related to water temperature (thermal refuge), as their abundance below Morgan Falls increases as summer progresses.

Dissolved Oxygen

Page 25-26: The DFWCAR identifies the occurrence of low D.O. below reservoirs as an important issue related to this process. WRD agrees with the DFWCAR that improvement to D.O. downstream of the reservoirs is important and beneficial to aquatic resources, and that this process may present opportunities or options to improve D.O. conditions.

Recreational Fishing

Recreational fishing is a very important use of these reservoirs and provides fishing opportunities to Georgia's one million plus anglers. Currently, the USACE implements a fish spawning Standard Operating Procedure (SOP) whereby water levels are managed for stable or rising conditions during a spring period to enhance spawning success and fish recruitment. GAWRD feels that the spawning SOP is important and should continue, when possible.

If you have any questions, please contact Matt Thomas at (770) 918-6406.

Sincerely,

Mark Williams

MW/cb

Florida Fish
and Wildlife
Conservation
Commission

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850) 488-4676

Hearing/speech impaired:
(800) 955-8771 (T)
(800) 955-8770 (V)

MyFWC.com

May 23, 2011

Ms. Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606

RE: Florida Fish and Wildlife Conservation Commission's Comments on Draft Fish and Wildlife Coordination Act Report.

Dear Ms. Lawrence;

The State of Florida, through its Fish and Wildlife Conservation Commission ("Commission") submits the following comments on the *Draft Fish and Wildlife Coordination Act Report on the Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama and Florida* ("Draft Report") shared with us on May 9, 2011. We previously provided comments on your April 2010 Planning Aid Letter ("PAL"), and supplied additional information relevant to the Draft Report in our paper entitled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystem* (February 2011). We have since reviewed (but were not afforded an opportunity to comment on) your March 2011 PAL Addendum. Florida commends the Service for identifying a number of key concerns shared by the Commission and agrees with the Service's general assessment that the Corps of Engineers' proposed alternatives, as reflected in the Corps' January 2011 response to the PAL ("PAL Response"), are unacceptable.

We wish to underscore the importance of consistent, transparent communication among the Corps, the Service and the Commission. As you correctly note, the Fish and Wildlife Coordination Act ("FWCA"), 16 U.S.C. §§ 661 *et seq.*, requires the Corps to consult with the Service <u>and</u> the Commission, Draft Report at 35, but such coordination has not occurred. The Corps has, in fact, refused to coordinate directly with the Commission, instead directing us to funnel our input through the Service. This is not consistent with the Corps' obligations and hinders our ability to conduct our analyses. For instance, the Service apparently has had the PAL Response since January 2011, but was only authorized by the Corps to share it with the Commission in April 2011. We are now forced to comment on the Draft Report in less than three weeks. Better coordination is required.

Nevertheless, we offer the following comments on the Draft Report and, as appropriate, the PAL Response. We trust the Service will continue to convey Florida's concerns in its discussions with the Corps.

The No Action/Baseline alternative is not acceptable.

The No Action/Baseline Alternative is a continuation of existing operations dictated in large measure by the 1989 Draft Water Control Plan ("DWCP") as modified by a series of *ad hoc* operational protocols. As a preliminary matter, it is important to note that this set of operations has never been subjected to FWCA analysis and has similarly eluded consultation requirements imposed by Section 7 of the Endangered Species Act ("ESA"), 16 U.S.C. §§ 1531 *et seq.* It is imperative that the No Action/Baseline Alternative be scrutinized meaningfully and not accepted merely because it constitutes a continuation of the *status quo*.

To that end, threatened and endangered species conservation is compromised by the arbitrary storage thresholds described on pages 1-9 to 1-11 of the PAL Response. These "Actions Zones" reflect interim operational practices implemented through the Revised Interim Operating Plan. Continued adherence to the Action Zones precludes the Corps from using the full conservation storage capacity for all the purposes authorized by Congress when the lakes were constructed, and thereafter. That water should be made available to bring flows more in keeping with the Service's Environmental Flow Guidelines ("Guidelines") as identified in the PAL and PAL Addendum.

For example, year-2000 flow and lake storage hydrographs (Slides 2-7) show that when Apalachicola River flows were 2,000-3,000 cfs lower than the lower limit Guidelines and 5,000-6,000 cfs lower than the dry-year Guidelines, the lakes were still holding 800,000-1,200,000 acre feet of conservation storage plus an additional 1,856,000 acre feet of inactive storage. Existing operations model run (Baseline-0) shows that during the lowest lake levels reached in the entire period (2007), the lakes still held more than 500,000 acre feet of conservation storage plus the inactive storage.

The full storage capacity of these Federal projects is not being used as Congress intended. The balance being struck by the Corps is unreasonable, as threatened and endangered species conservation is being undermined to support, among other things, recreation and sport fishing under present Corps protocols.

For example, Florida has long expressed concerns with the Standard Operating Procedure ("SOP") governing reservoir fish spawning. The SOP deprives the Apalachicola River and its threatened and endangered species of water during the critical spawning period ostensibly for the protection of sport fish spawning in the reservoirs. Yet, there is no credible evidence that a one-foot drop in lake levels has a significant impact on year-class strength in reservoirs. In contrast, we have documented a direct correlation between year-class strength and river flow in the Apalachicola. The water withheld upstream to support sport fish spawning would make a tremendous difference in providing a longer duration of floodplain inundation in April and May to support spawning (including Gulf sturgeon and host fish for threatened and endangered mussel species) in the Apalachicola River.

Finally, analyzing the No Action/Baseline alternative (and all others), the Corps assumes that maximum upstream consumption will occur at all times. This assumption is incorrect, as consumptive use changes seasonally and in response to climatic variation. Some account should be made for this variation in all analyses.

The "Action" Alternatives are not acceptable.

The incremental differences among the No Action/Baseline alternative and the action alternatives is meaningless. These alternatives are so similar in nature, and their effects so indistinguishable, that they would not survive the most basic NEPA challenge. *See, e.g., Muckleshoot Indian Tribe v. U.S. Forest Service*, 177 F.3d 800 (9th Cir. 1999) (holding unlawful NEPA analysis that considered only no action and two virtually identical action alternatives). In fact, the proposed alternatives are little more than a gloss on the No Action/Baseline alternative.

The proposed action alternatives will actually be *worse* for threatened and endangered mussel species due to the increase in storage (and corresponding decrease in flow) caused by raising the Action Zones. While we understand that the final operating criteria chosen will be subject to ESA Section 7 consultation, we agree with the Service that the proposed changes in the reservoir Action Zones, drought protocols, and ramping rates would result in freshwater mussels being subjected to low flows for a greater duration than previously experienced. This is unacceptable, particularly given the repeated culling of mussel populations experienced over the last 5 years. For this reason, we suggest all efforts be made to maintain flows above 6,000 cfs at all times.

Moreover, the proposed action alternatives do not include a true conservation alternative designed to serve the needs of fish and wildlife and related habitats in the Apalachicola River Basin. Rather, all the alternatives are merely variations on a theme of perpetuating existing operations. As you correctly point out, fish and wildlife is a co-equal purpose under the FWCA. Draft Report at 1. The Corps does not acknowledge this, and each of the proposed action alternatives renders fish and wildlife subservient to all other uses.

In its PAL Response, the Corps completely dismisses the notion of developing an operating protocol based on replicating a more natural hydrograph that reflects the importance of the Guidelines. The Commission disagrees that such a protocol is too difficult to justify analysis. That said, the difficulty associated with developing an alternative that actually complies with the FWCA and ESA is irrelevant. The Corps is legally obligated to evaluate at least one alternative that recognizes the co-equal priority of fish and wildlife (and related habitat) maintenance.

The Guidelines (modified as per the Commission's suggestions herein) should be the foundatiou of all analyses of the Corps operations.

We generally support the Service's Guidelines and concur that these guidelines (as modified below) should be used as the yardstick against which to measure the relative "success" or "failure" of any alternative's ability to meet the needs of fish and wildlife in the Basin. Flow guidelines based on pre-dam flows need to be added to all graphs related to fish and wildlife resources, and incorporated into all levels of analysis and decision-making. To accomplish this, we have the following suggestions.

The Guidelines are calculated using only the lowest 7 days in each month, which makes it difficult to directly compare other flow data and constrains the applicable guideline to a single number for each month. To make "apples-to-apples" comparisons, one must convert all other flow data to the lowest 7 days per month before comparing them to the Guidelines, which is unnecessarily complex and prevents the Guidelines from being used in all analyses as intended. For hydrograph-type analyses, the Commission proposes a slightly modified flow guideline that is calculated from <u>all the data</u>, such as the 90% exceedance hydrograph shown on Slide 1. Other daily exceedance hydrographs, such as 75% (blue line, Slide 13), could also be used. An additional benefit of using daily exceedance hydrographs is that they better match conditions in April and May, which typically have much higher flows at the beginning of the month than at the end.

More importantly, however, none of the analyses in Section 2.7 of the PAL Response include pre-dam "guideline" data. Because the Corps did not use hydrographs, neither the Guidelines nor the Commission's exceedance hydrograph alternative can be adapted and added to the Corps' graphs. We recommend that daily pre-dam flow data be used directly to serve as an ecosystem flow guideline in every case regardless of the type of statistic or graphical display used in the evaluation. We provide an example of this in the frequency curves on Slides 9-11 and 17-19, which have a pre-dam "guideline" shown in blue on every graph. Similarly, pre-dam "guideline" flow data should be added to all of the graphs in Section 2.7 of the PAL Response, which display various frequency and "number of days per year" analyses. Calculating various statistics with the pre-dam flow data it is a much more flexible approach that allows an ecosystem guideline to be added to every graph.

Finally, the Corps continues to employ the misguided Run of River ("RoR") rubric in numerous graphs in the PAL Response. All RoR flow data should be removed because it is not an appropriate basis for analyses or decisions related to ecosystem protection. River-floodplain biota has never experienced natural conditions remotely resembling those of the RoR flow regime. Minimum flow in the RoR regime is 34 cfs. Furthermore, RoR flow in late summer and early fall of 2007 averaged 2,700 cfs for a continuous duration of 2.5 months, which represents conditions that riverine biota could not survive. In all graphs related to fish and wildlife resources or ecosystem protection, the RoR rubric should be removed and replaced with an ecosystem guideline based on pre-dam flows (as described in our suggestions above).

Floodplain Inundation Analyses are inappropriate.

Analysis of frequency in percent of years of the annual maximum of 30-day minimum acres of inundated floodplain is not useful and should be replaced with hydrographs similar to Slides 21 and 22. Hydrographs provide a more useful tool than frequency curves for assessing critical flows throughout the entire year, as the Service notes on pages 8-9 of the Draft Report. Because duration and timing of seasonal flow and habitat requirements vary for each species, hydrographs showing the full year are the preferred method for either describing long-term summaries of flow (Slides 13-14) or area data (Slides 21-22), or for focusing on selected individual dry years (Slides 3-5). Hydrographs allow analysis of sturgeon and other fish spawning conditions in the spring, mussel habitat conditions in the summer, and a variety of other biological requirements using the same graph.

In addition, the PAL Response (2-73) contains an erroneous assumption regarding floodplain connectivity. The Corps indicates floodplain inundation in the Apalachicola River does not occur until flows reach 100,000 cfs. However, the approximate flows at which significant floodplain inundation begins in each reach can be estimated from the breaks in the curves in Figure 27B of Light et al., 1998, as follows:

Upper Reach – 28,000-29,000 cfs
Middle Reach – 13,000-14,000 cfs
Nontidal Lower Reach – 13,000-14,000 cfs

It appears the Corps incorrectly assumed that the floodplain is not inundated until river levels exceed top of bank elevations in the upper reach. This assumption is incorrect for two reasons: First, the greatest proportion of floodplain area in the Apalachicola River is in the middle and lower reach where top of bank elevations are much lower (relative to river levels) than in the upper reach. Second, during rising river flow, movement of river water into the floodplain through numerous breaks in the levee at stream and slough mouths allows almost unimpeded connections between the river and floodplain in all reaches. Thus nearly all of the floodplain forest becomes inundated long before the top of bank elevations are overtopped.

Analyses of Bay species should be augmented.

Juvenile Gulf sturgeon analyses are scant. There should be additional analyses of the impact of proposed and existing operations on juvenile sturgeon in the Bay. While we agree generally with the conclusions contained in the Bay section of the Draft Report, we encourage the Service to provide additional details about potential impacts to estuarine sentinel species (e.g., Eastern oysters, *Crassostrea virginica* or White shrimp, *Litopenaeus setiferus*).

Floodplain Inundation Stage Discharge Analyses are inadequate

We disagree with the following statements on Page 25 of Draft Report: *"The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. This has been adequately addressed and is no longer a conservation measure."* The analyses conducted were inadequate and should be revised to include comparisons to ecosystem guidelines in every graph, hydrographs showing seasonality and duration of flows and inundated area throughout the year, and expanded views of frequency curve data at the low-flow end. We have provided some examples of each in the attached slides.

In addition, for your information, LIDAR data are now available for the entire Apalachicola River and should be used for more accurate future analysis.

Adaptive Management only works if operations are modified as necessary.

The Draft Report contains a recommendation to implement Adaptive Management. Fundamentally, this concept is about taking action to improve progress toward desired outcomes. The key to successful adaptive management, therefore, is to modify operations that are shown, through monitoring, to be detrimental to species. While the Commission appreciates the Service's recommendation to incorporate adaptive management principles into the Water Control Planning process, the Corps has not shown a willingness to modify its behavior in response to monitoring data that show negative impacts on species.

For adaptive management to succeed, clear objectives (e.g., restoration of a viable reproductive mussel population in Swift Slough) must be identified. Sound monitoring techniques must be employed, and the data reviewed regularly to ascertain whether the goals are being met. Finally, specific response alternatives should be identified in the event the stated goals are not being met. Each of these three elements is a necessary component of any adaptive management program.

Climate Change Analysis

One of the impacts of climate change is an anticipated rise in sea levels. The Draft Report should address the minimum flows needed to mitigate the impacts of salt water incursion due to sea level rise.

Fish Passage

We agree that the Corps should look at fish passage operations for anadromous fish species, such as the Alabama shad, as part of the Water Control Manual update.

We thank you for the opportunity to comment and your attention to this matter. Again we hope for improved coordination in the future.

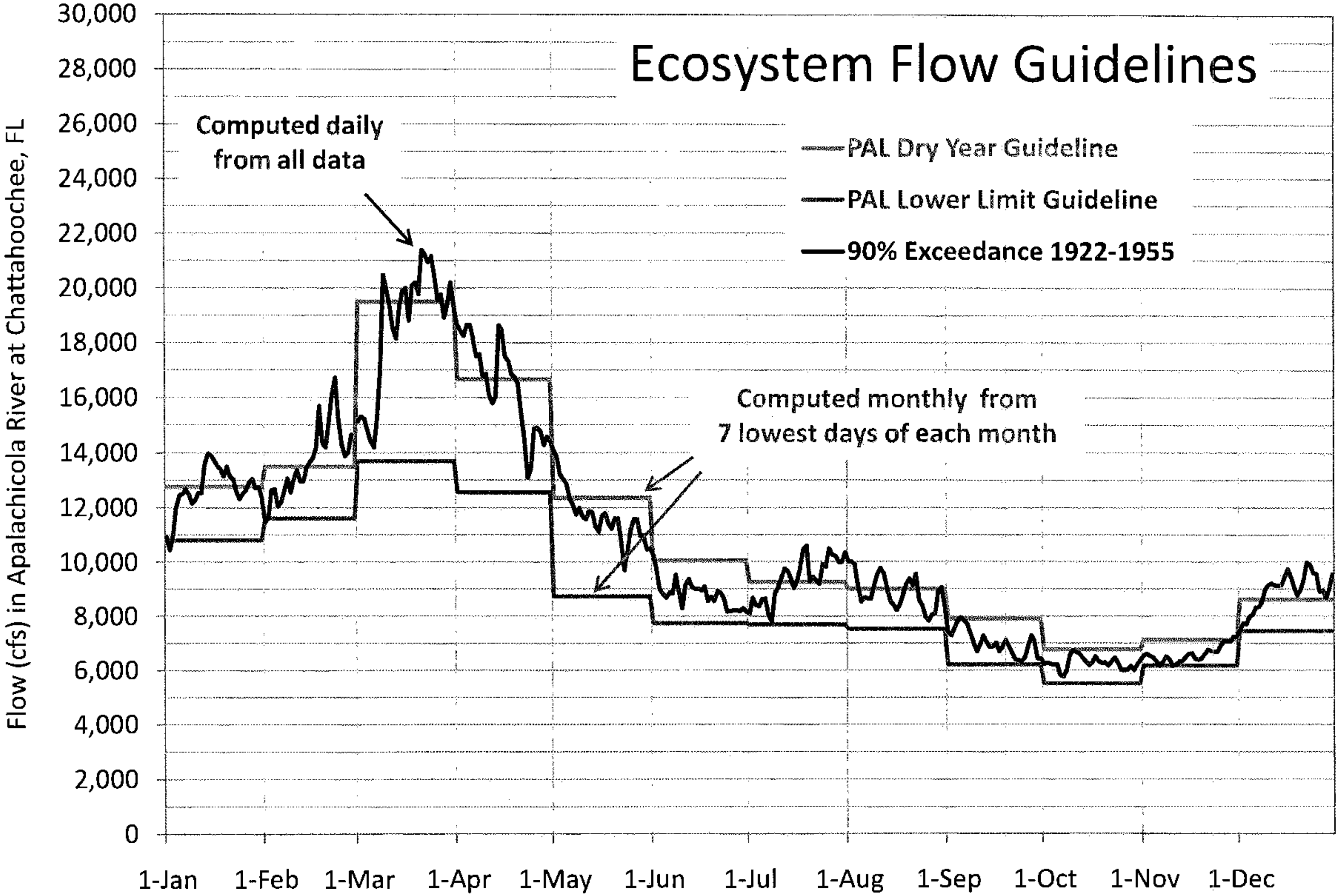
Respectfully,

Harold G. Vielhauer
General Counsel

cc: Mr. Don Imm
USFWS-Panama City Field Office

Ms. Sandy Tucker
US Fish and Wildlife Service

Encl.

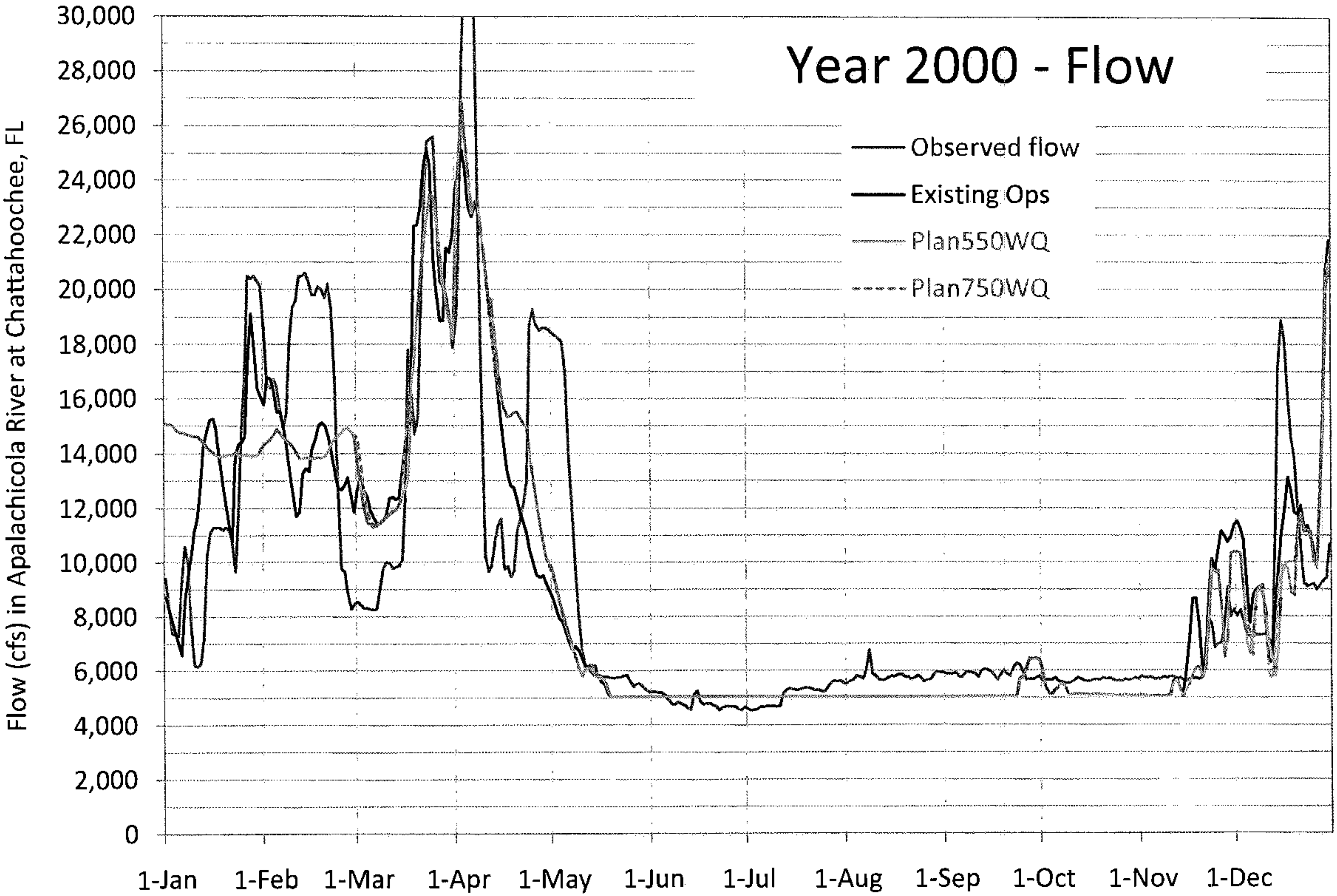

Ecosystem Flow Guidelines
Computed daily from all data
PAL Dry Year Guideline
PAL Lower Limit Guideline
90% Exceedance 1922-1955
Computed monthly from 7 lowest days of each month
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

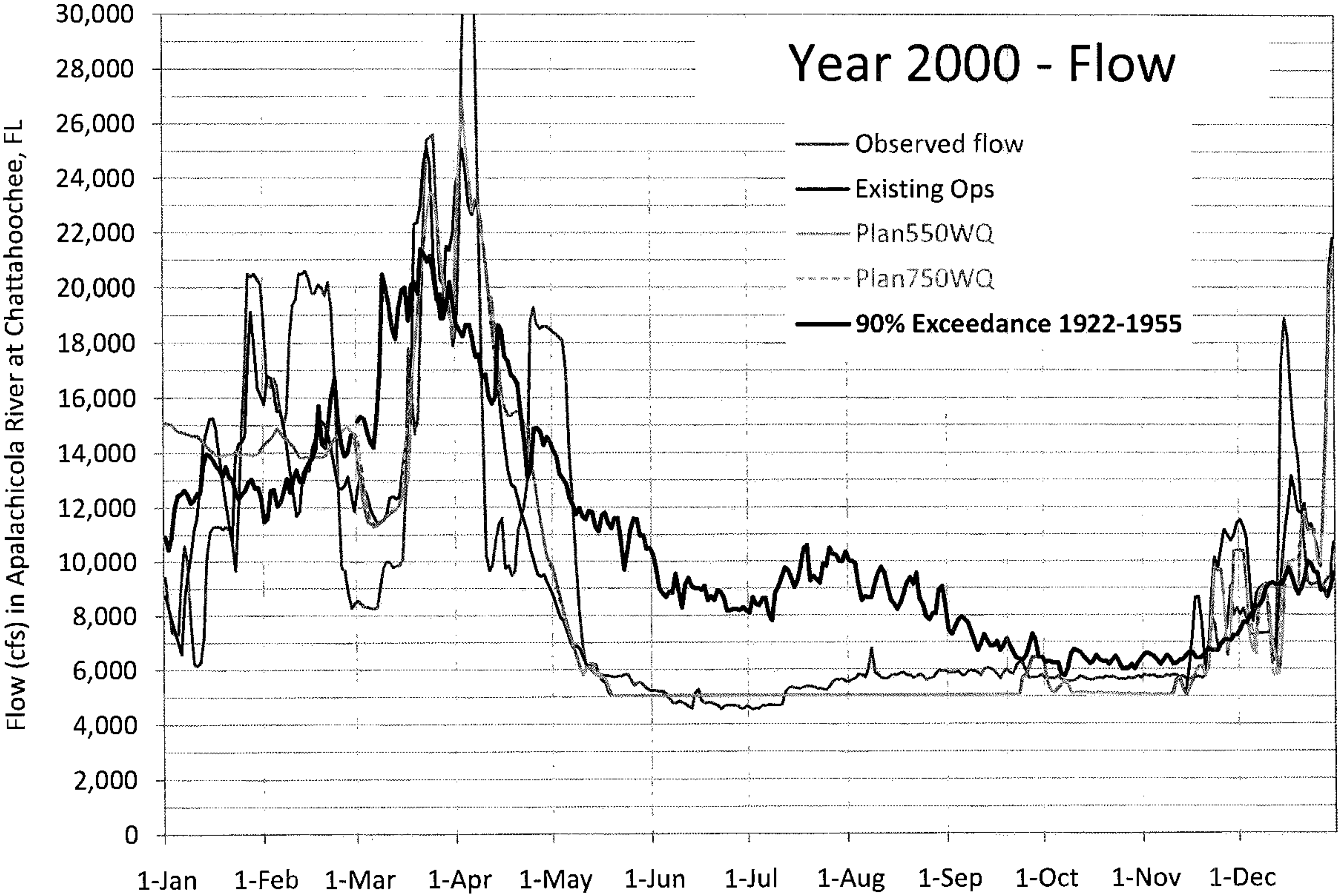
Flows Vs Lake Storage

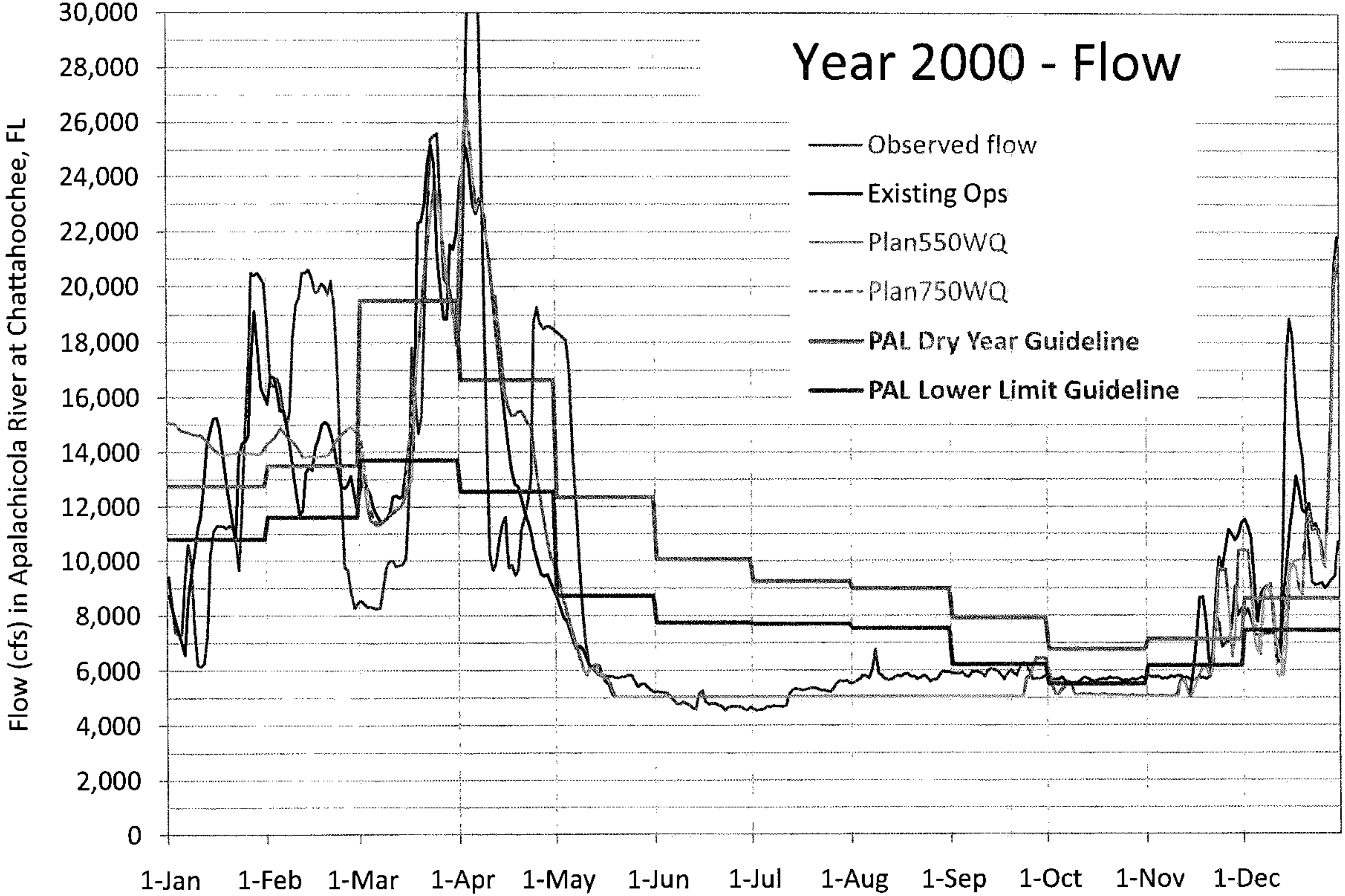
*At times when Ecosystem Flow Guidelines are **not** met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

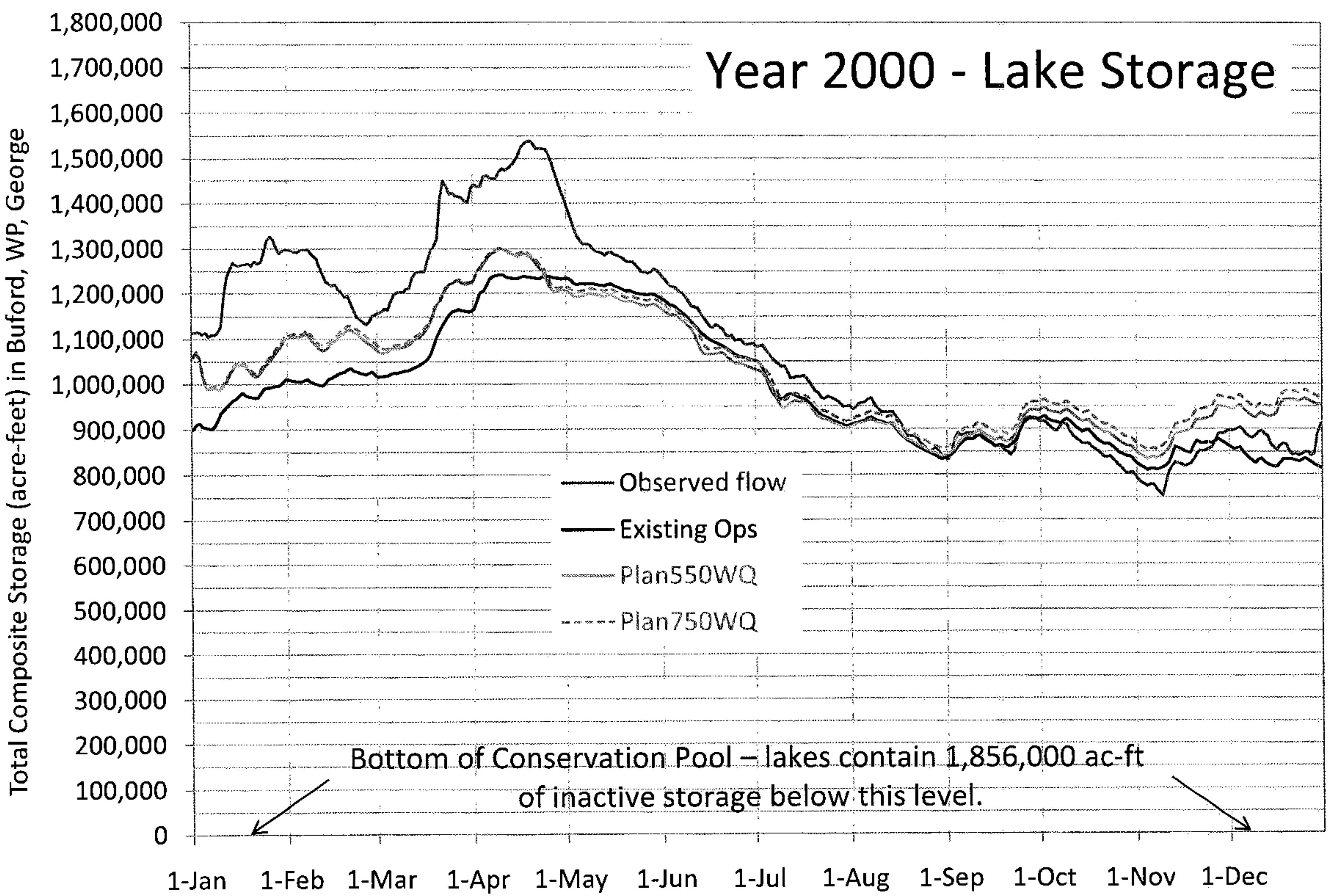
Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output

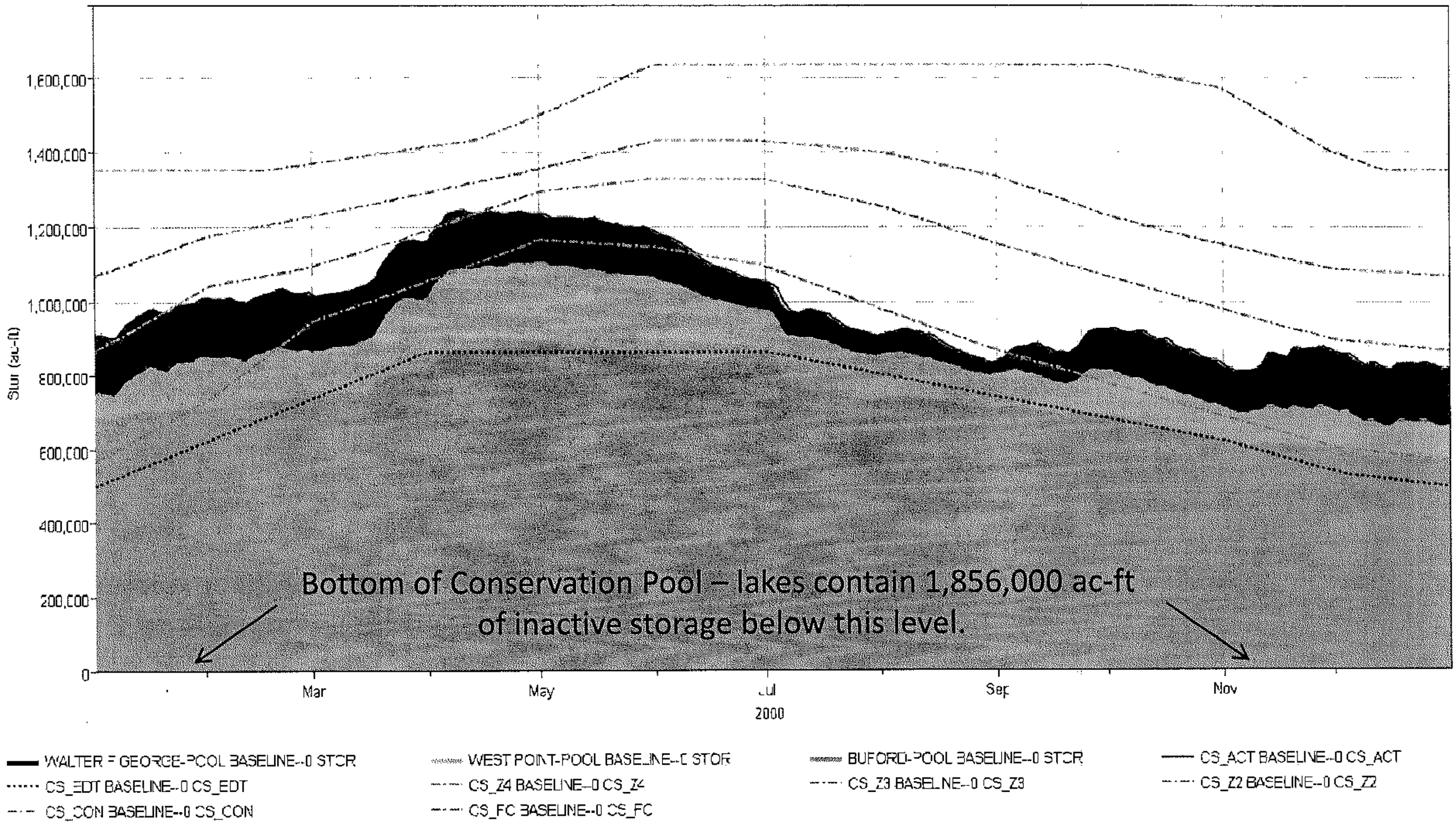

Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Lake Storage
Total Composite Storage (acre-feet) in Buford, WP, George
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft
of inactive storage below this level.

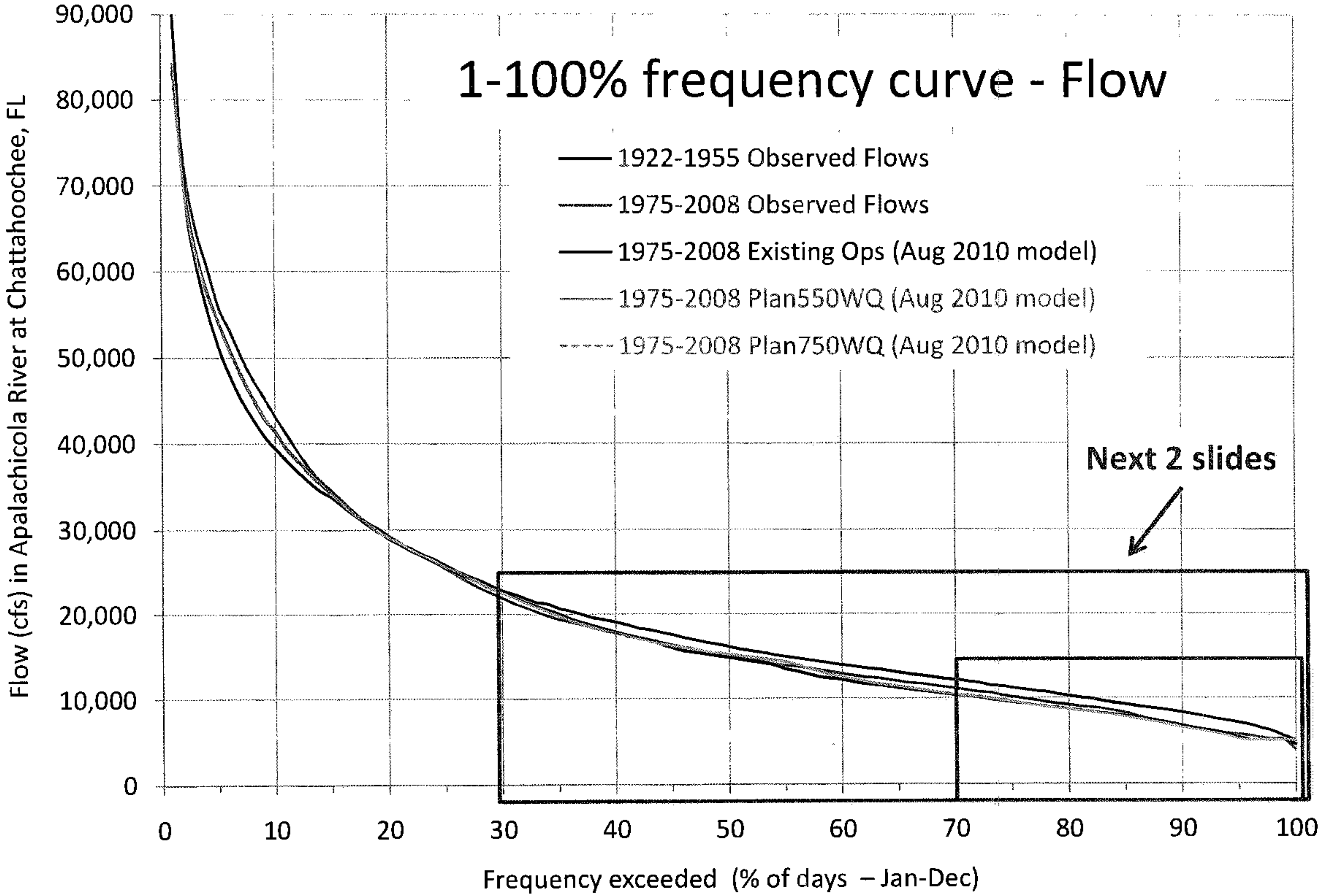
Year 2000 - Lake Storage (Existing Ops only)

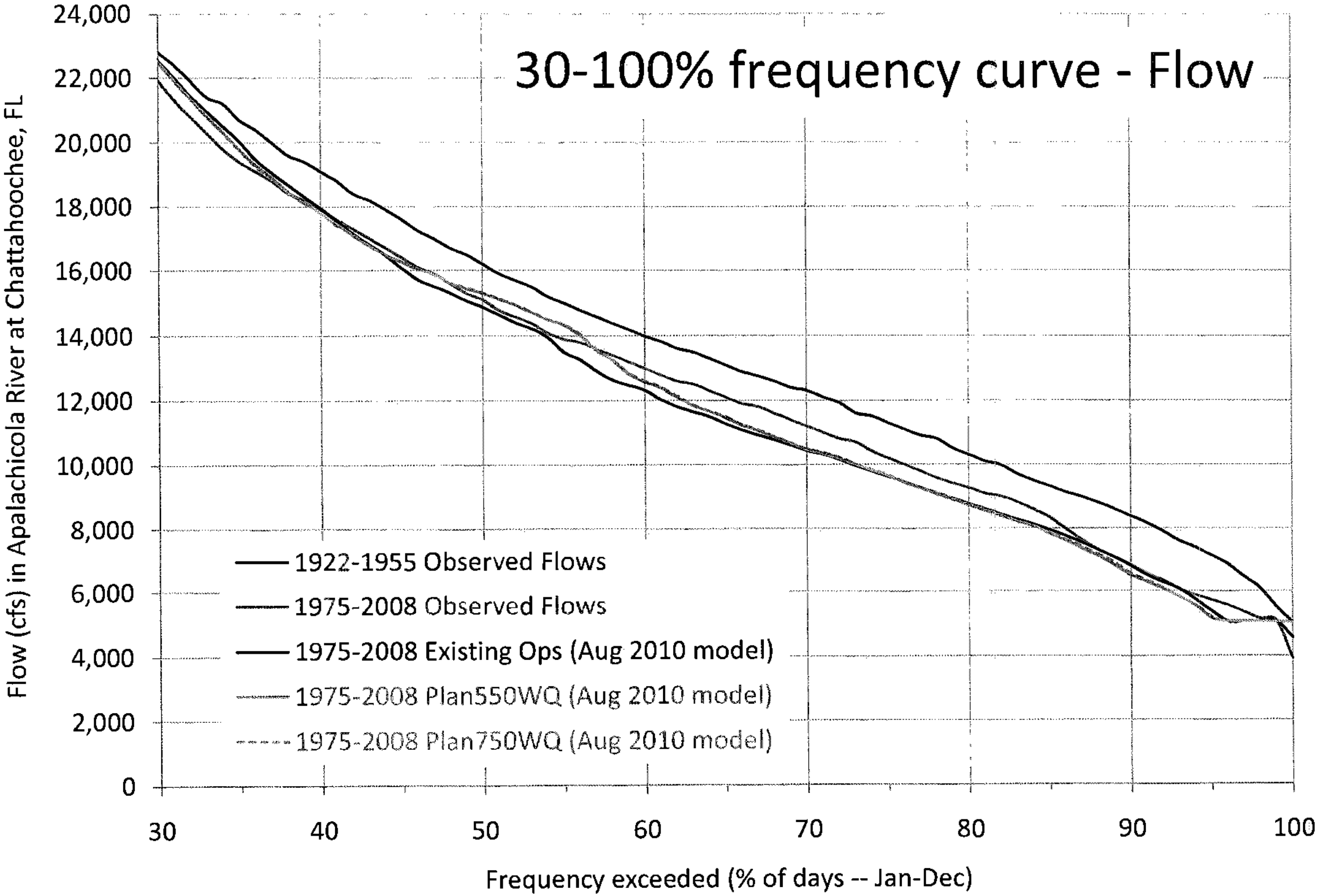


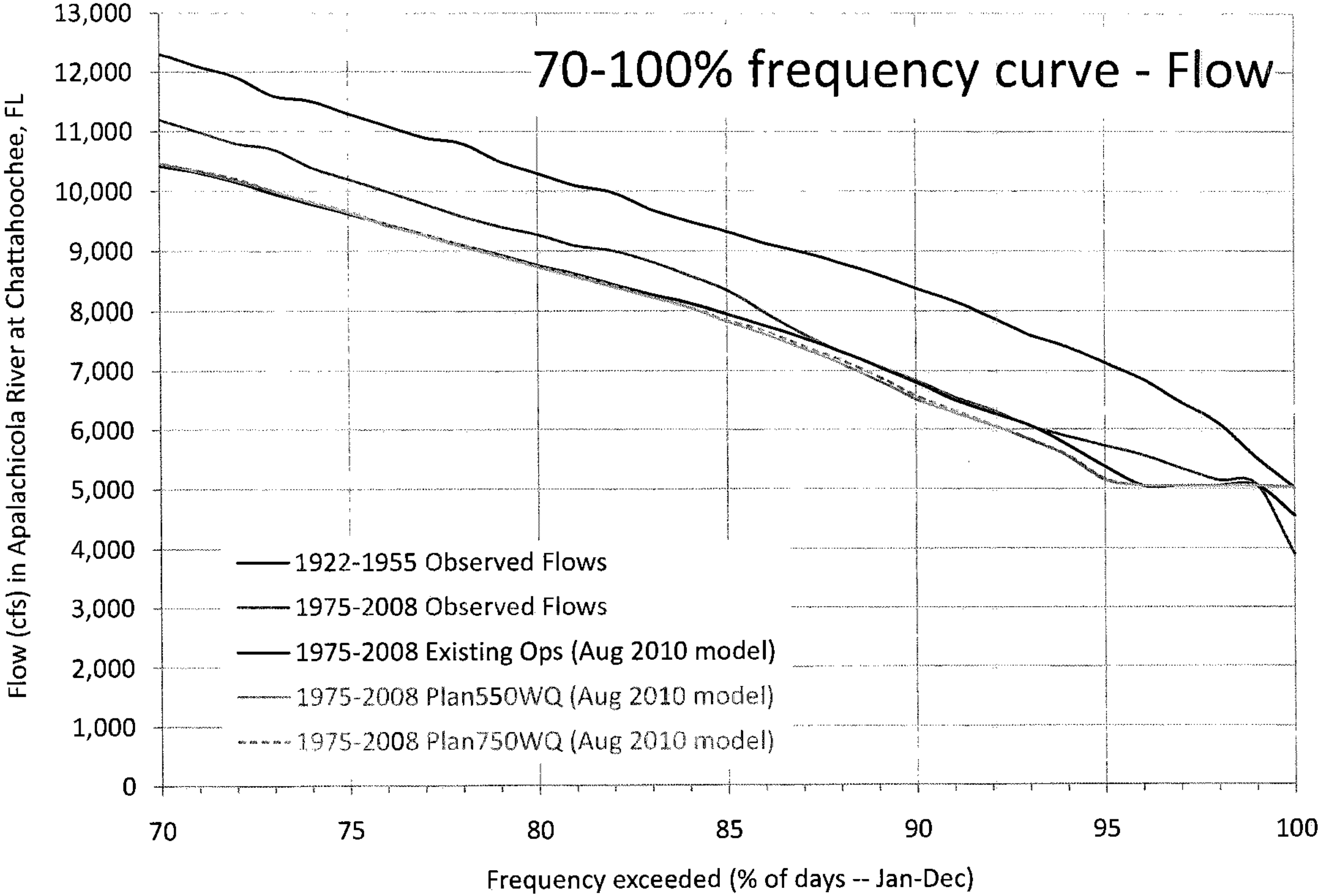
Flow Frequency Curves

Frequency that flows are exceeded
(% of days -- Jan-Dec)*

To distinguish from growing season only (Mar-Nov)


1-100% frequency curve - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)
Next 2 slides
Flow (cfs) in Apalachicola River at Chattahoochee, FL
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
10
20
30
40
50
60
70
80
90
100
Frequency exceeded (% of days – Jan-Dec)

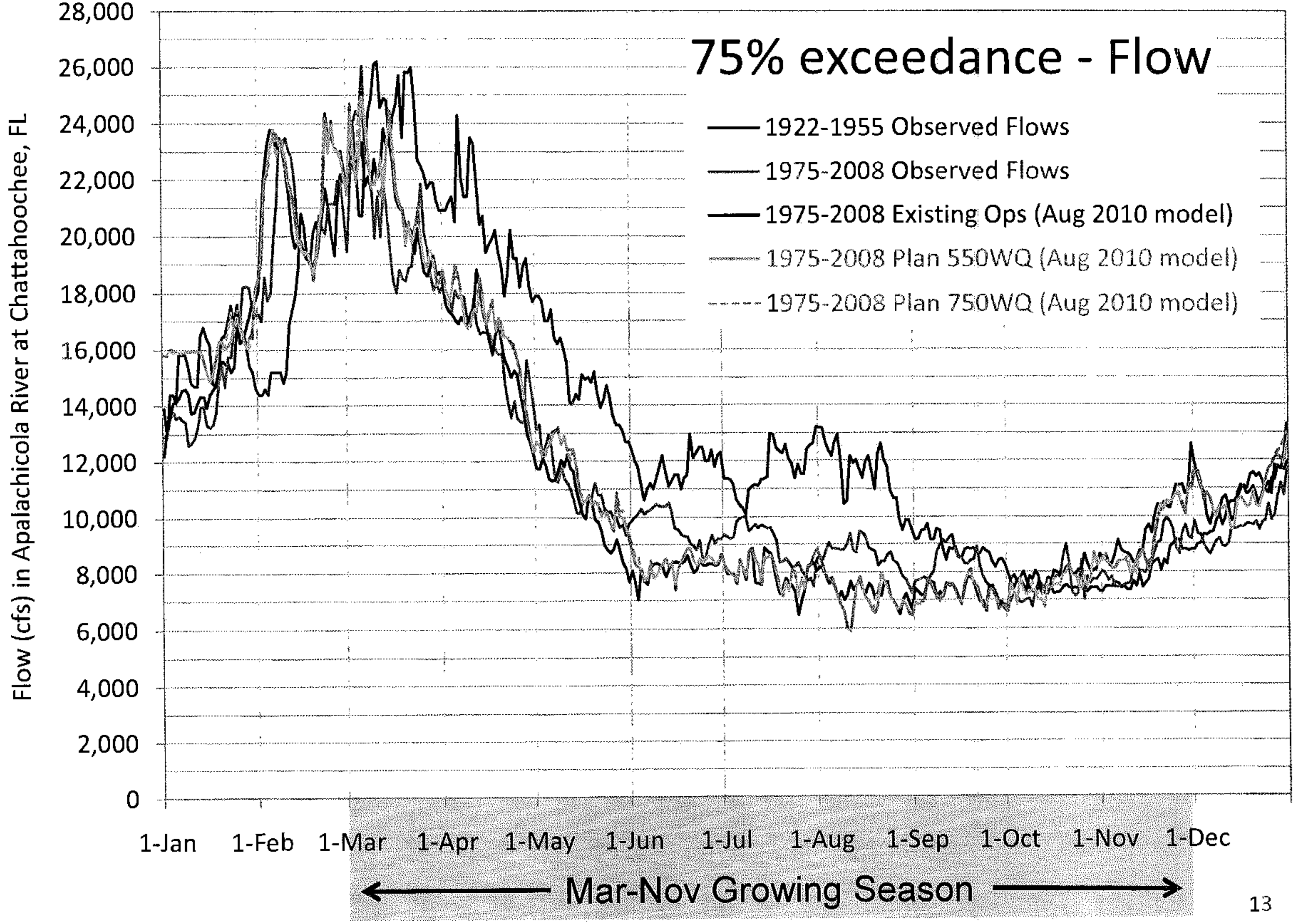

30-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)
30
40
50
60
70
80
90
100
Frequency exceeded (% of days -- Jan-Dec)

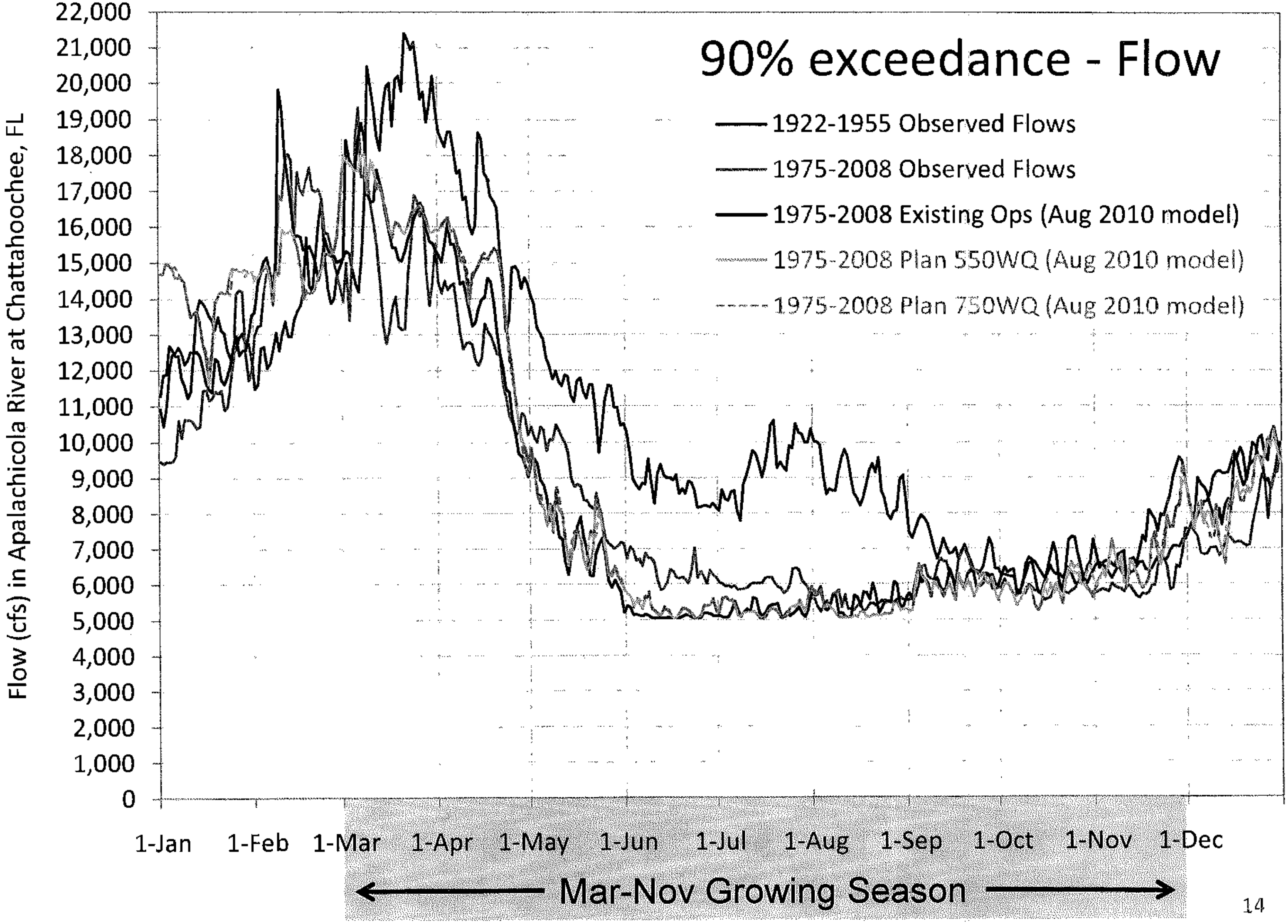

70-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
70
75
80
85
90
95
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

Flow Exceedance Hydrographs

Daily exceedance flows for selected frequencies: 75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

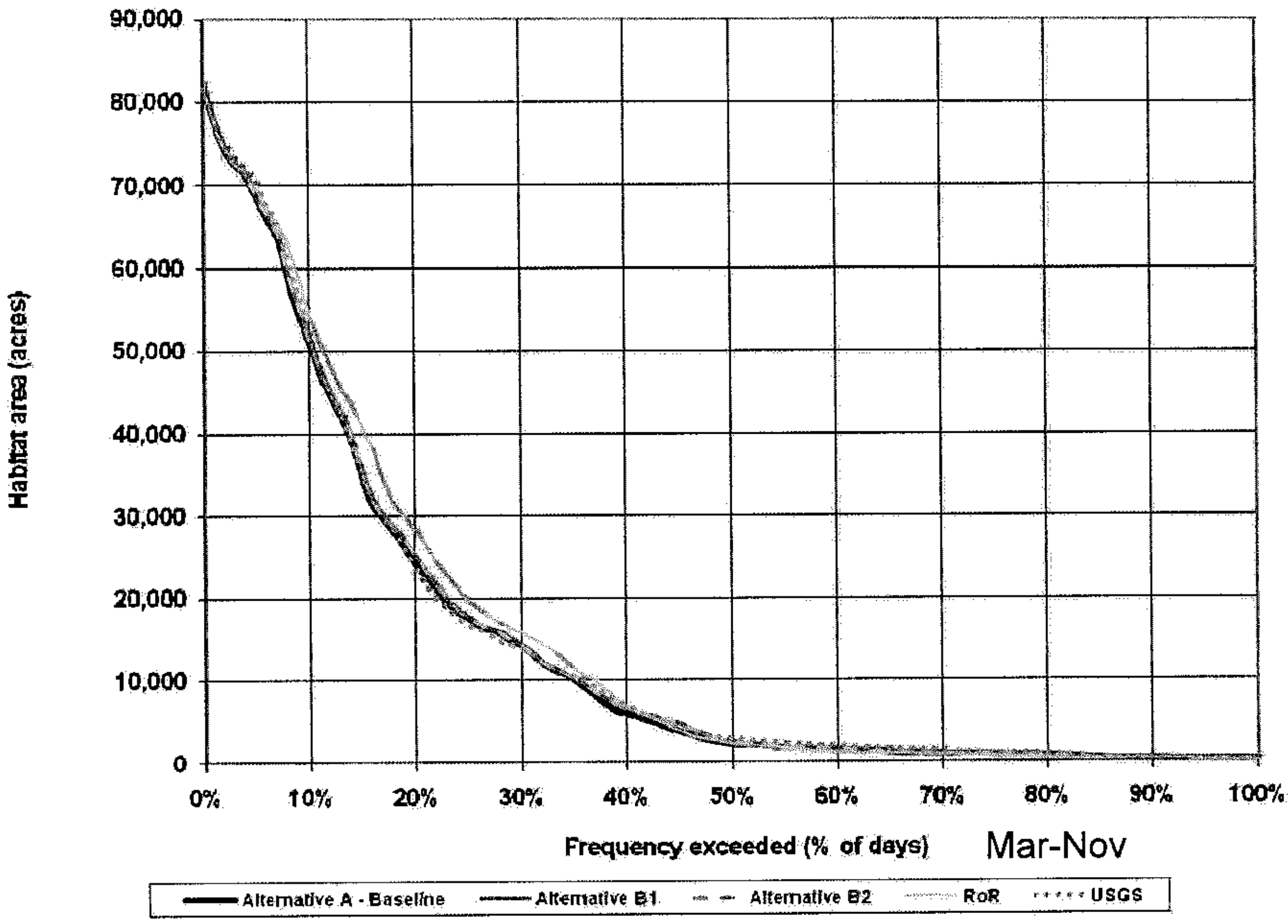

90% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

Area Frequency Curves

Frequency that acres of inundated floodplain are exceeded in the growing season (% of days – Mar-Nov)

Analysis provided by Corps

Graph from Corps 1/18/2011 Response to PAL, page 2-95:

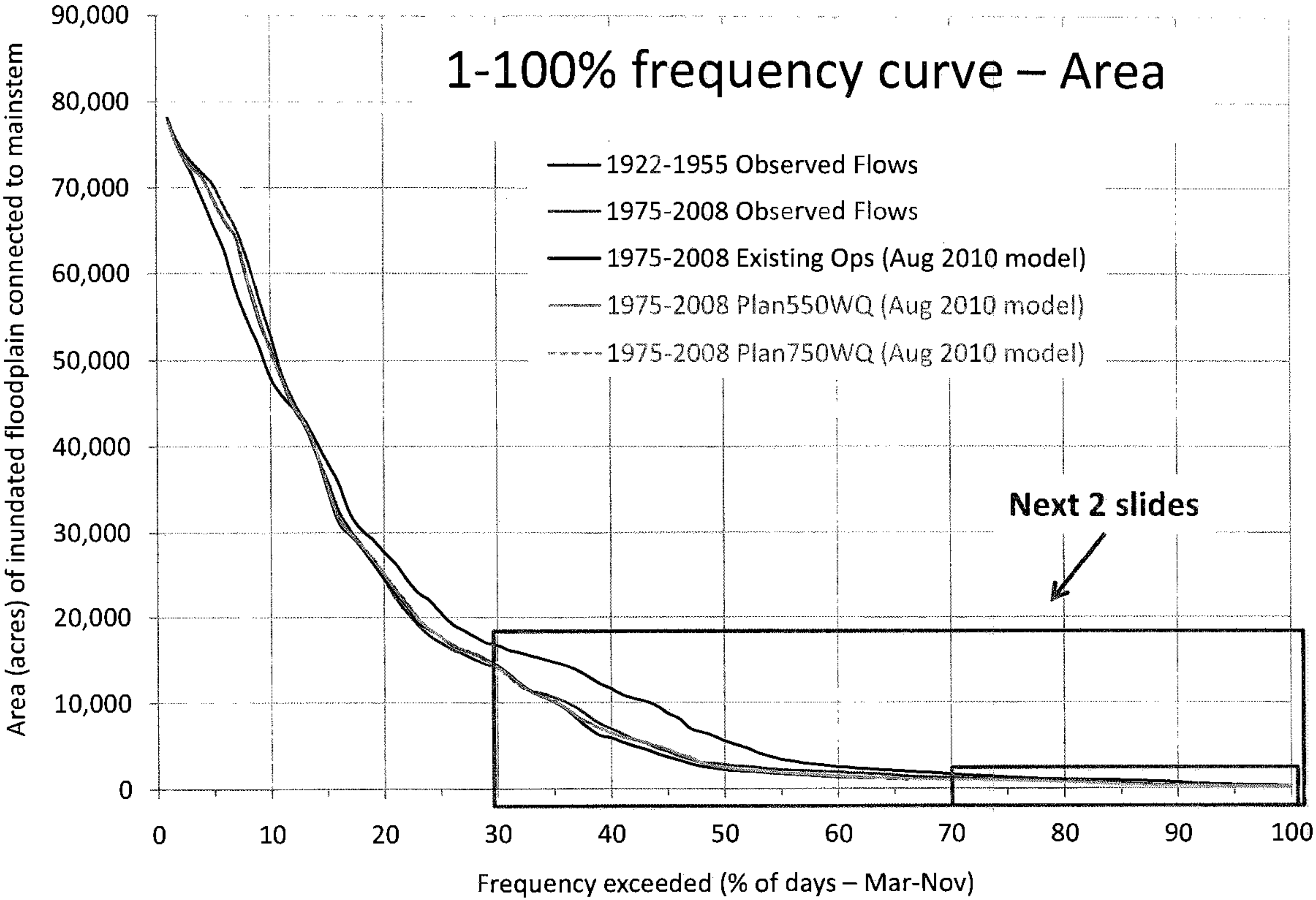


This graph was created by the Corps in response to FFWCC request.

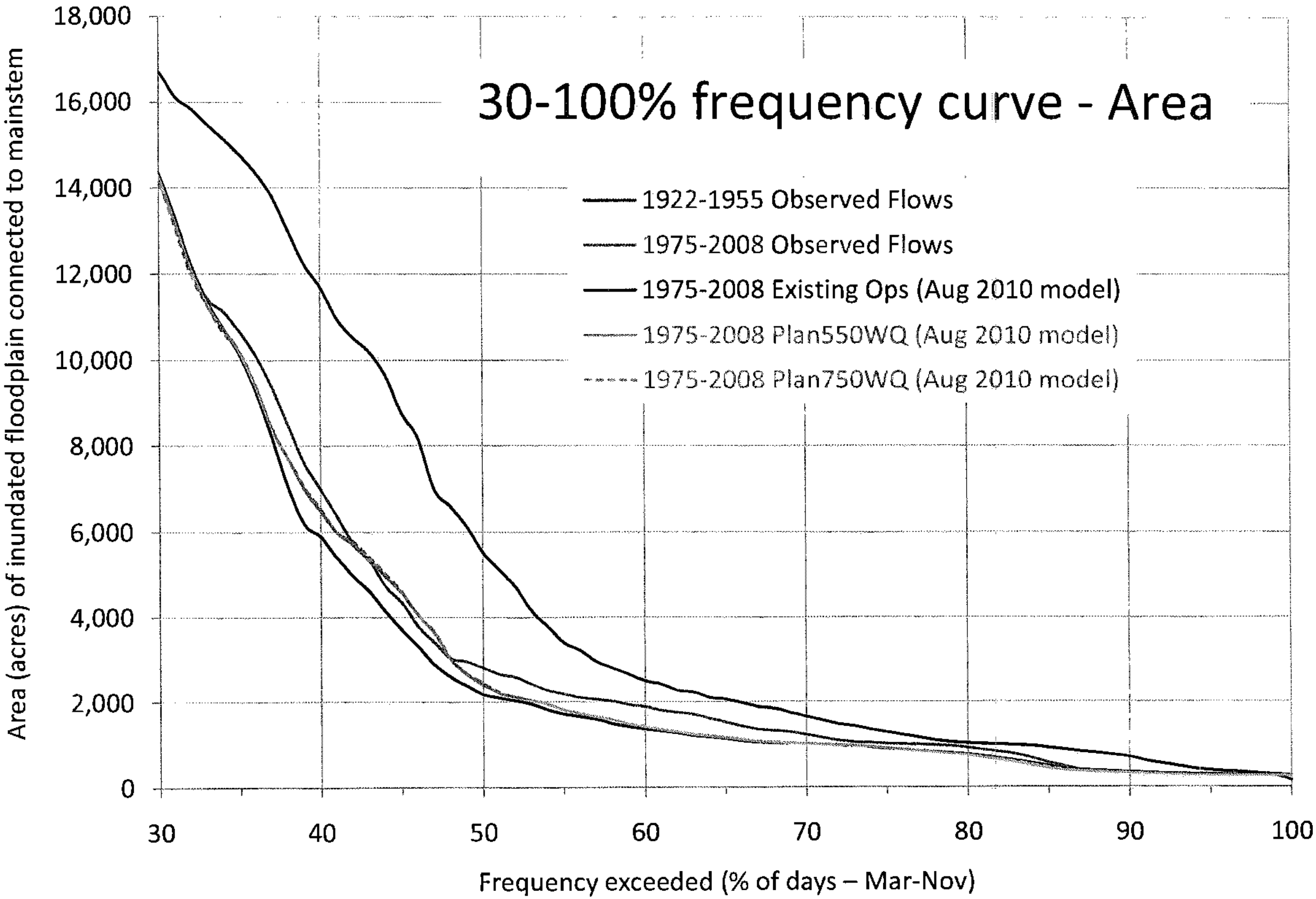
Suggested revisions:

-- Remove RoR and replace with appropriate ecosystem flow guideline (1922-1955 observed flow)

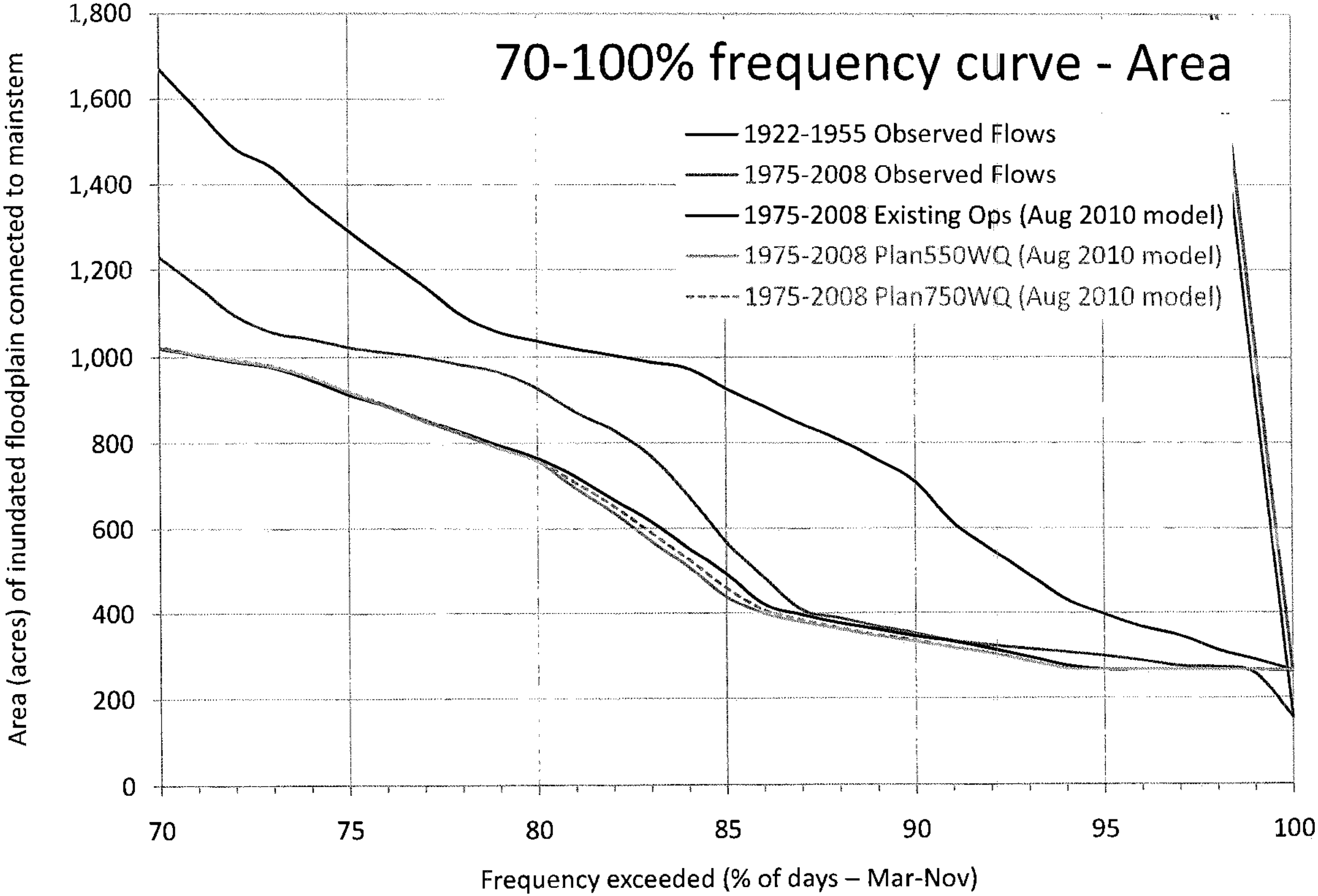
-- Expand data at low end



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

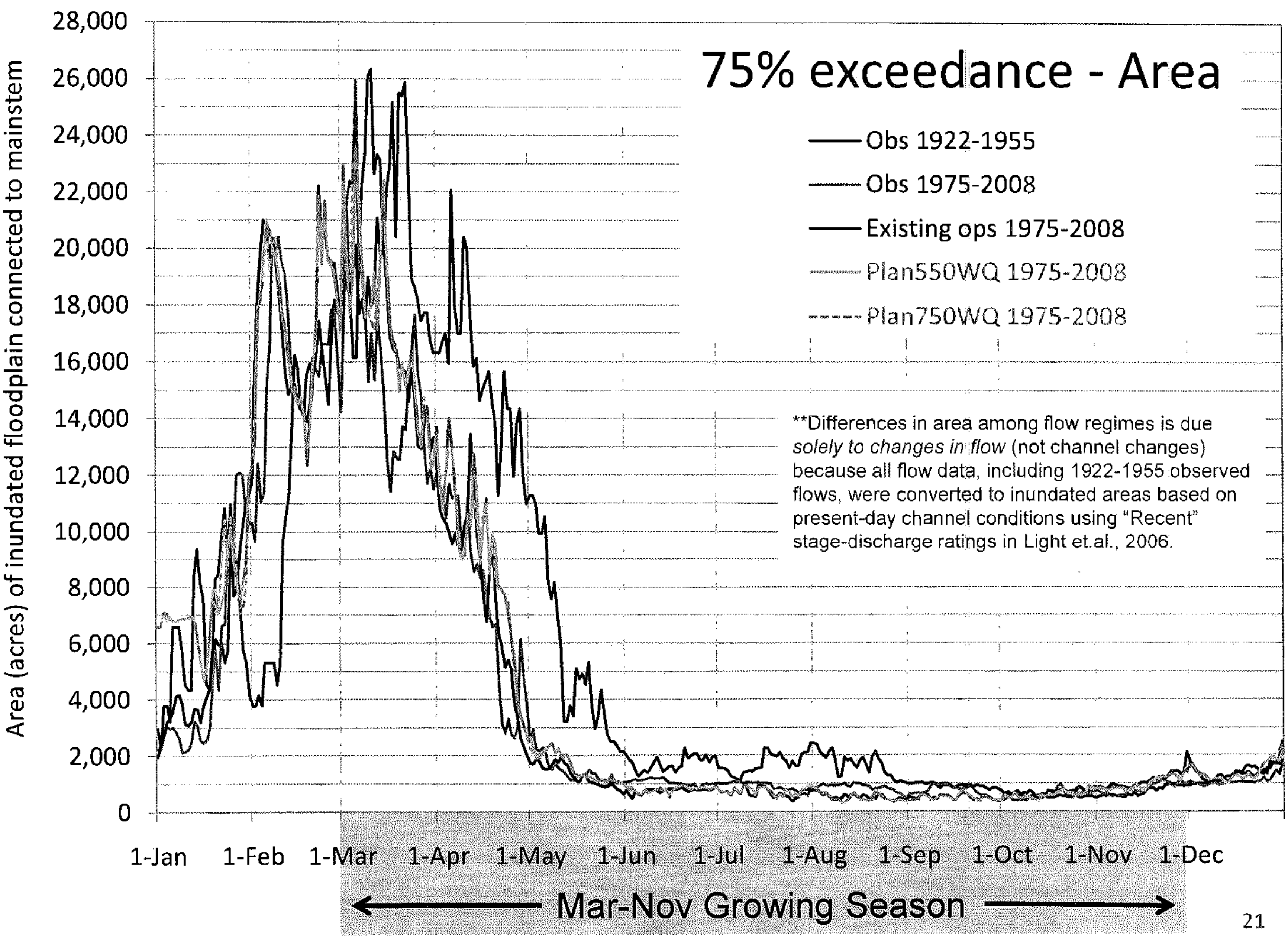


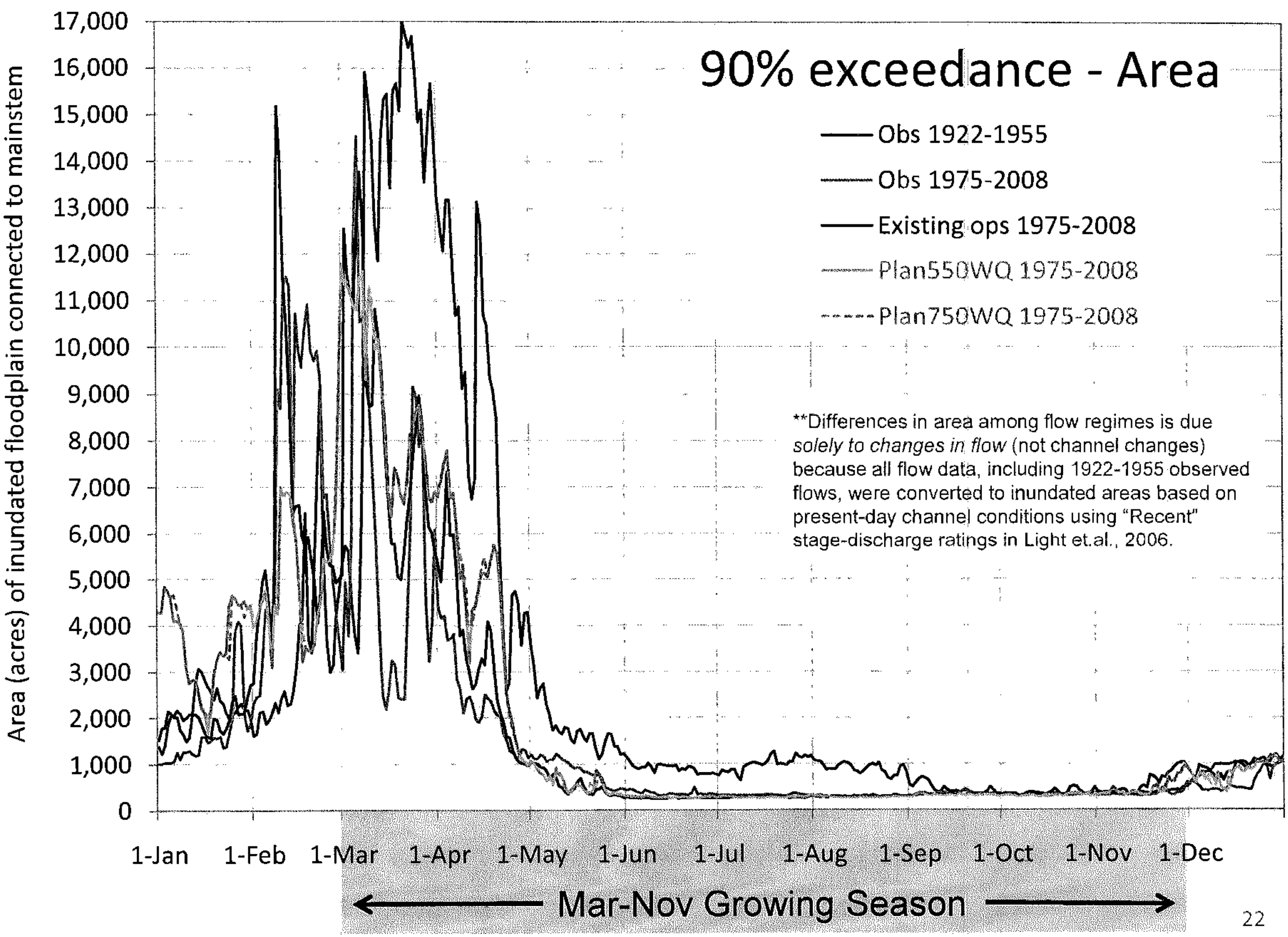
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

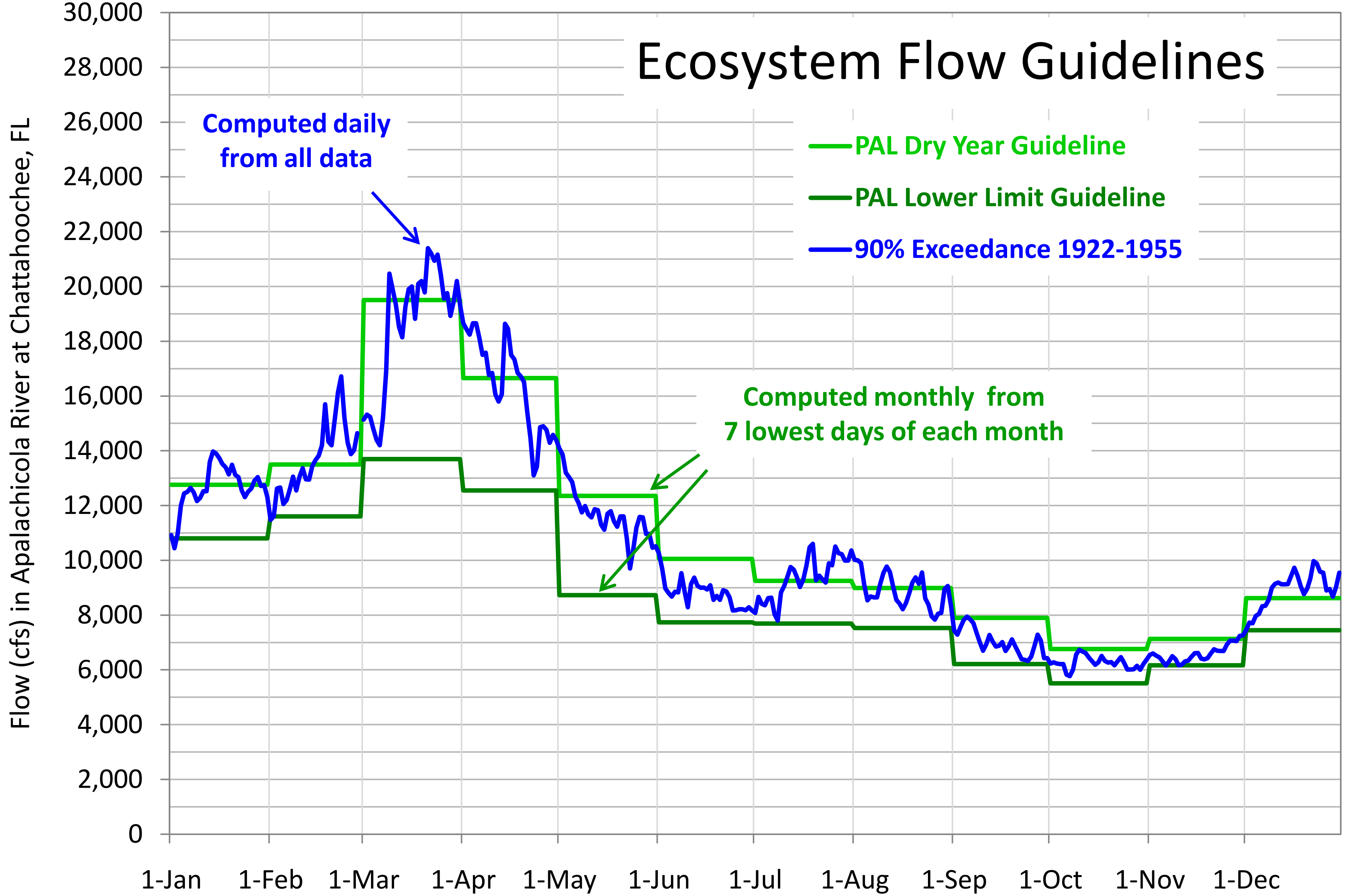
Area Exceedance Hydrographs

Daily exceedance for acres of inundated floodplain at selected frequencies:
75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season


90% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due solely to changes in flow (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

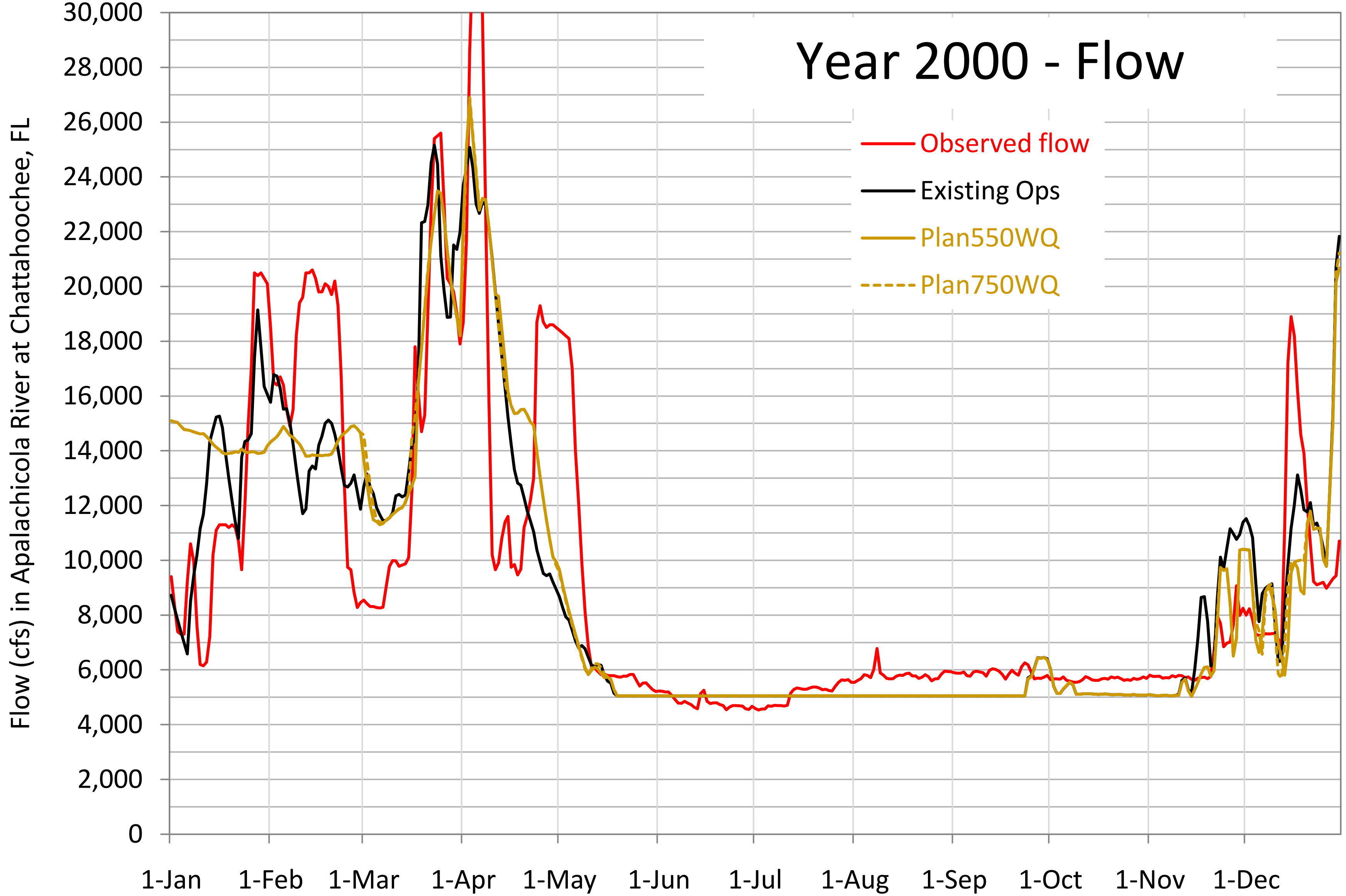

Ecosystem Flow Guidelines
Computed daily from all data
PAL Dry Year Guideline
PAL Lower Limit Guideline
90% Exceedance 1922-1955
Computed monthly from 7 lowest days of each month
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

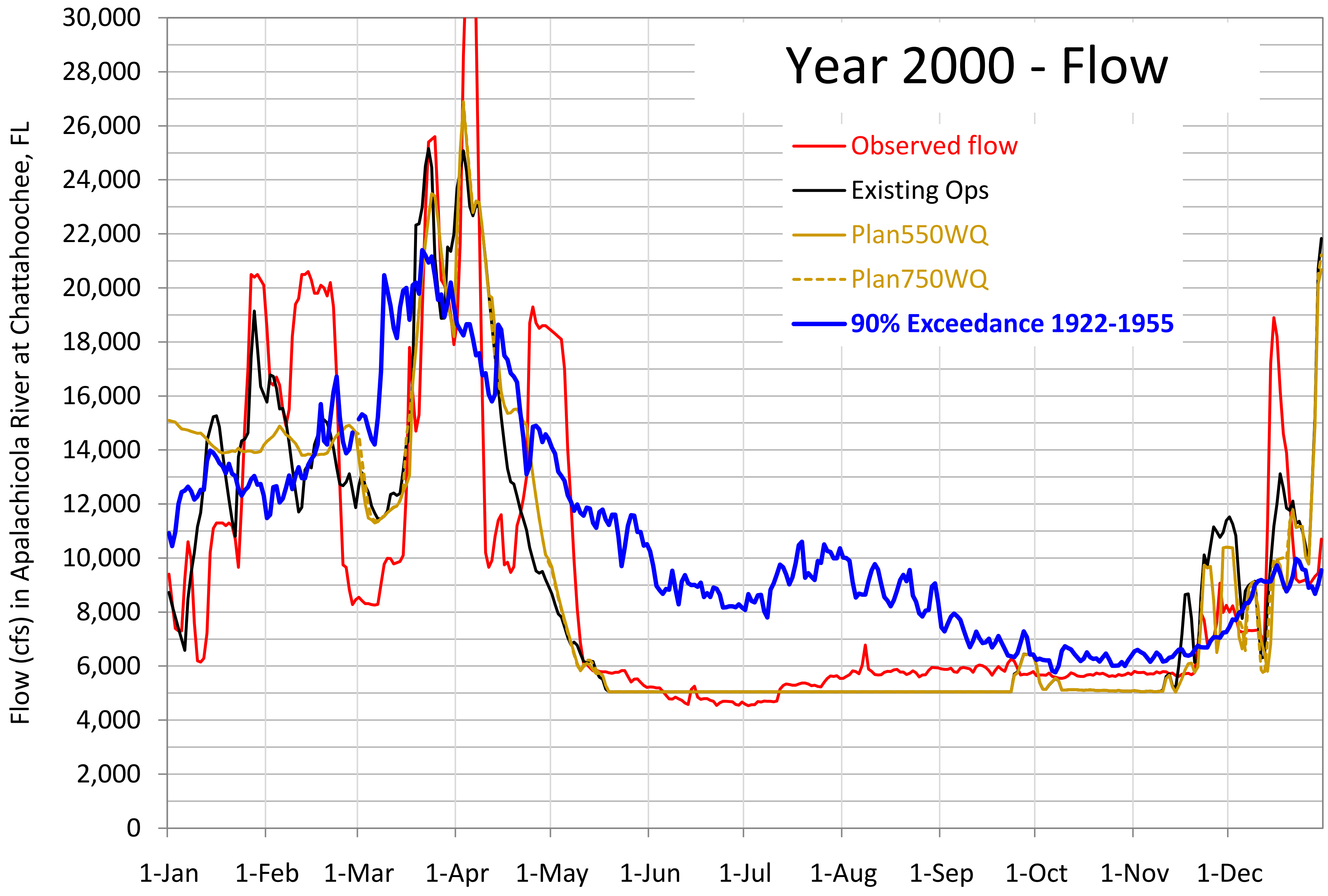
Flows Vs Lake Storage

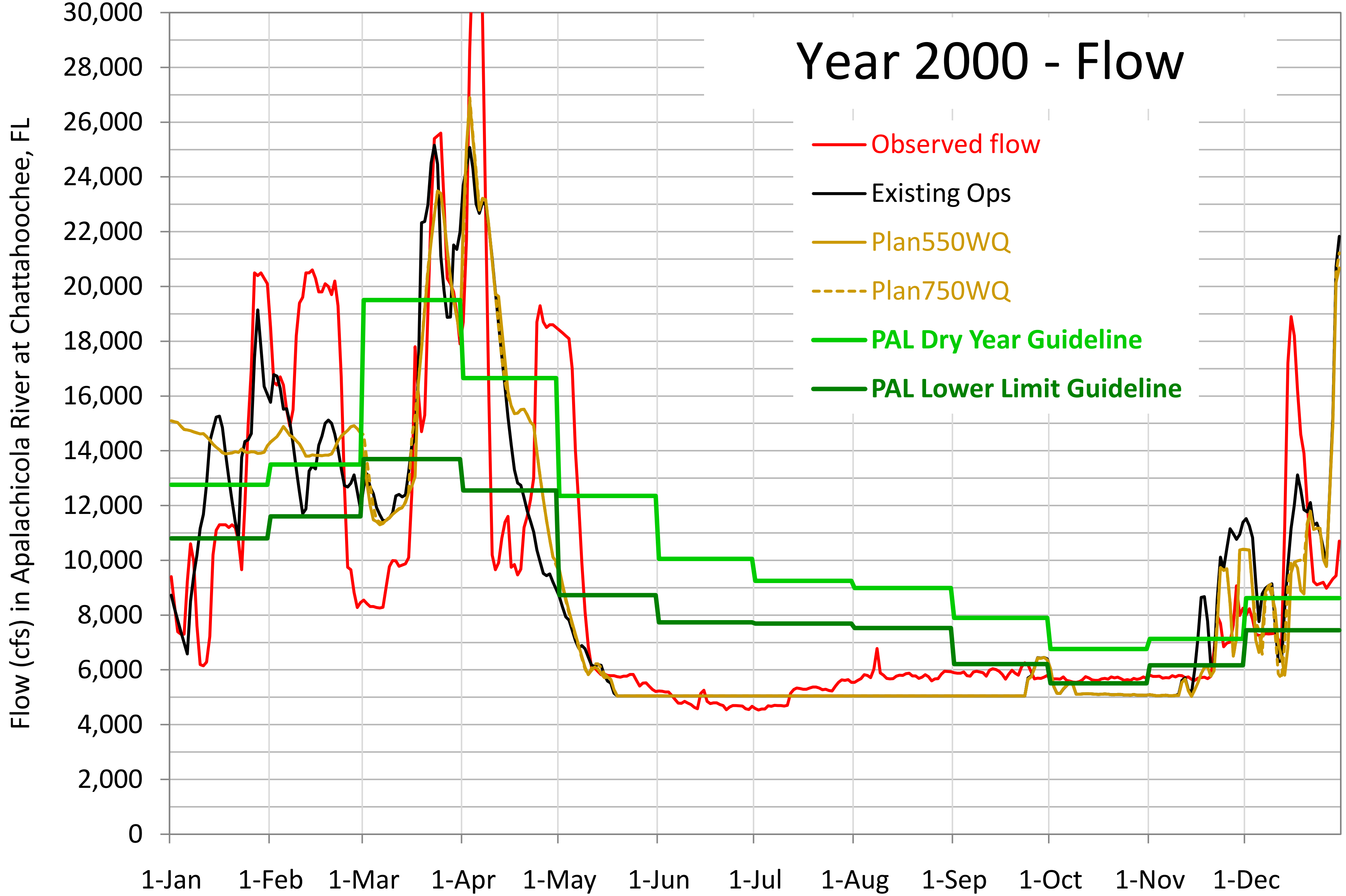
At times when Ecosystem Flow Guidelines are ***not*** *met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

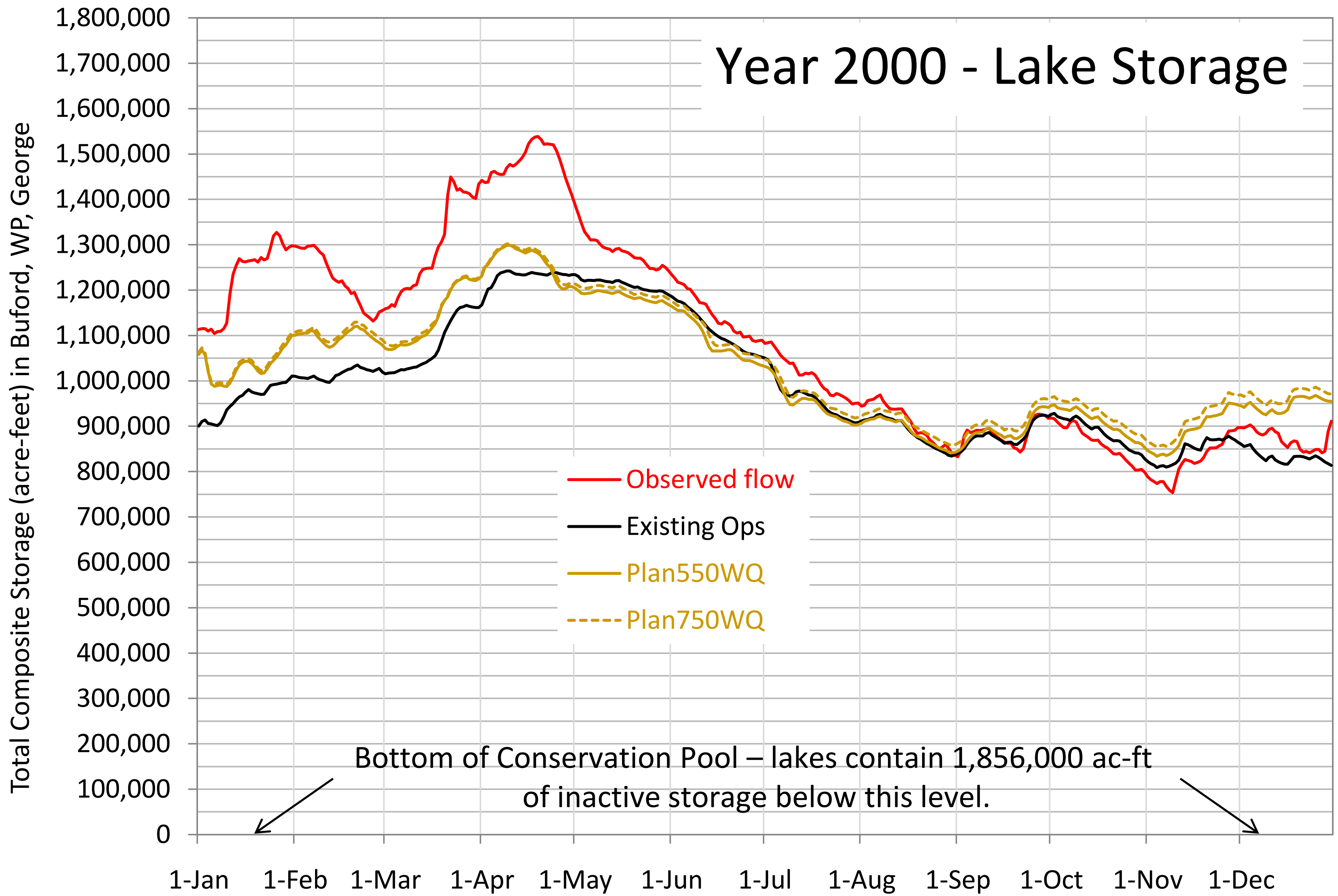
Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output

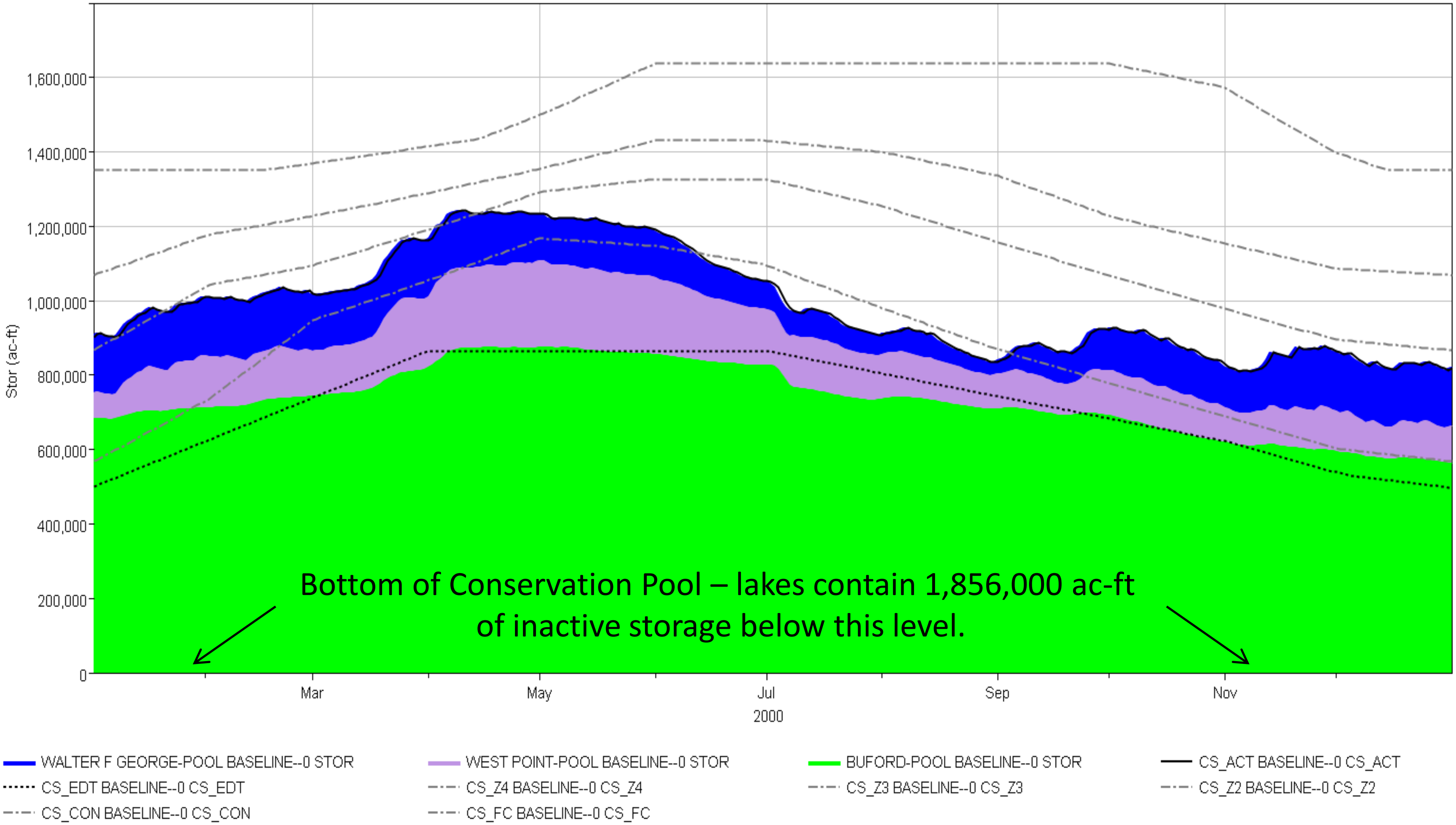

Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Lake Storage
Total Composite Storage (acre-feet) in Buford, WP, George
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft
of inactive storage below this level.

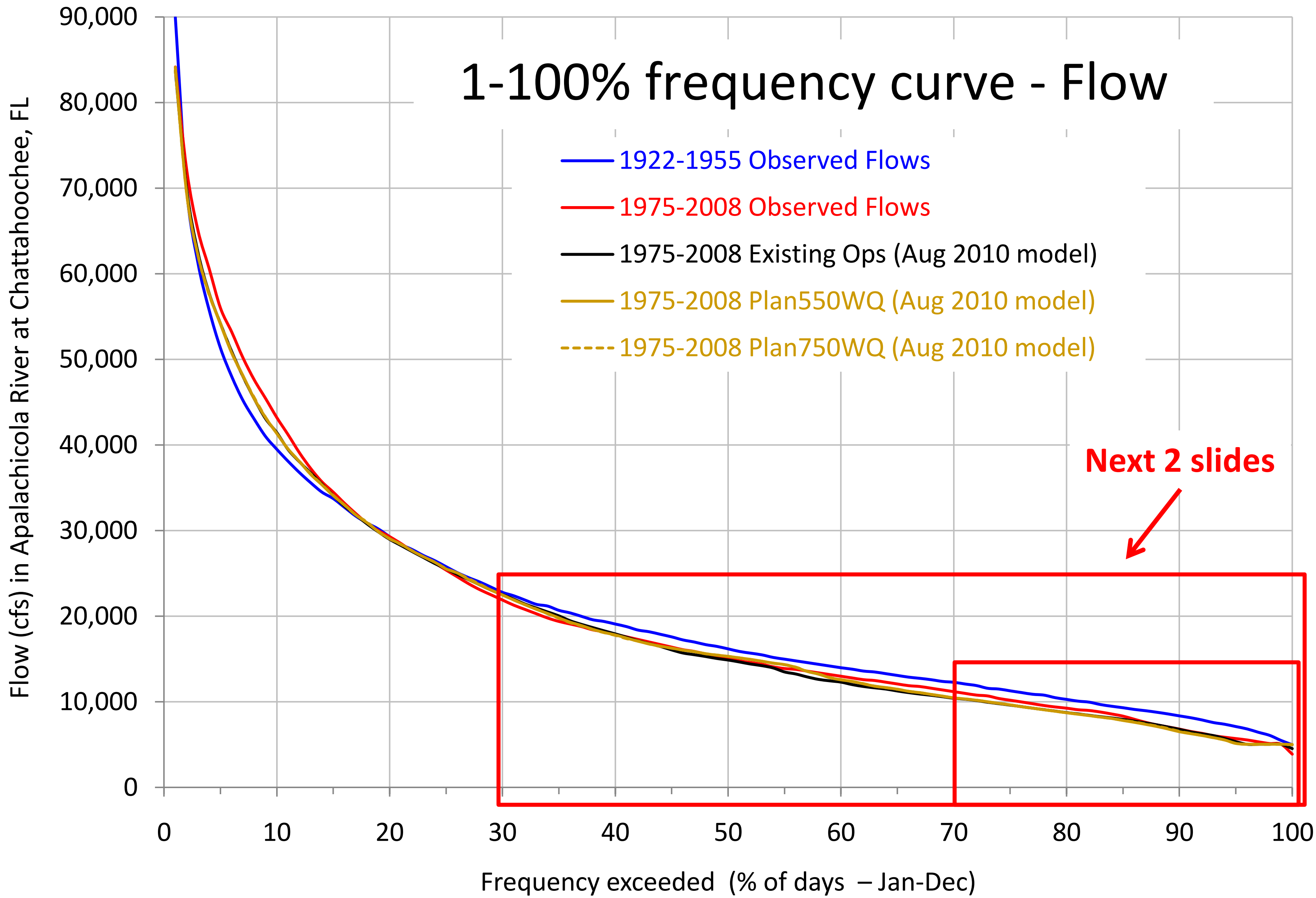
Year 2000 - Lake Storage (Existing Ops only)

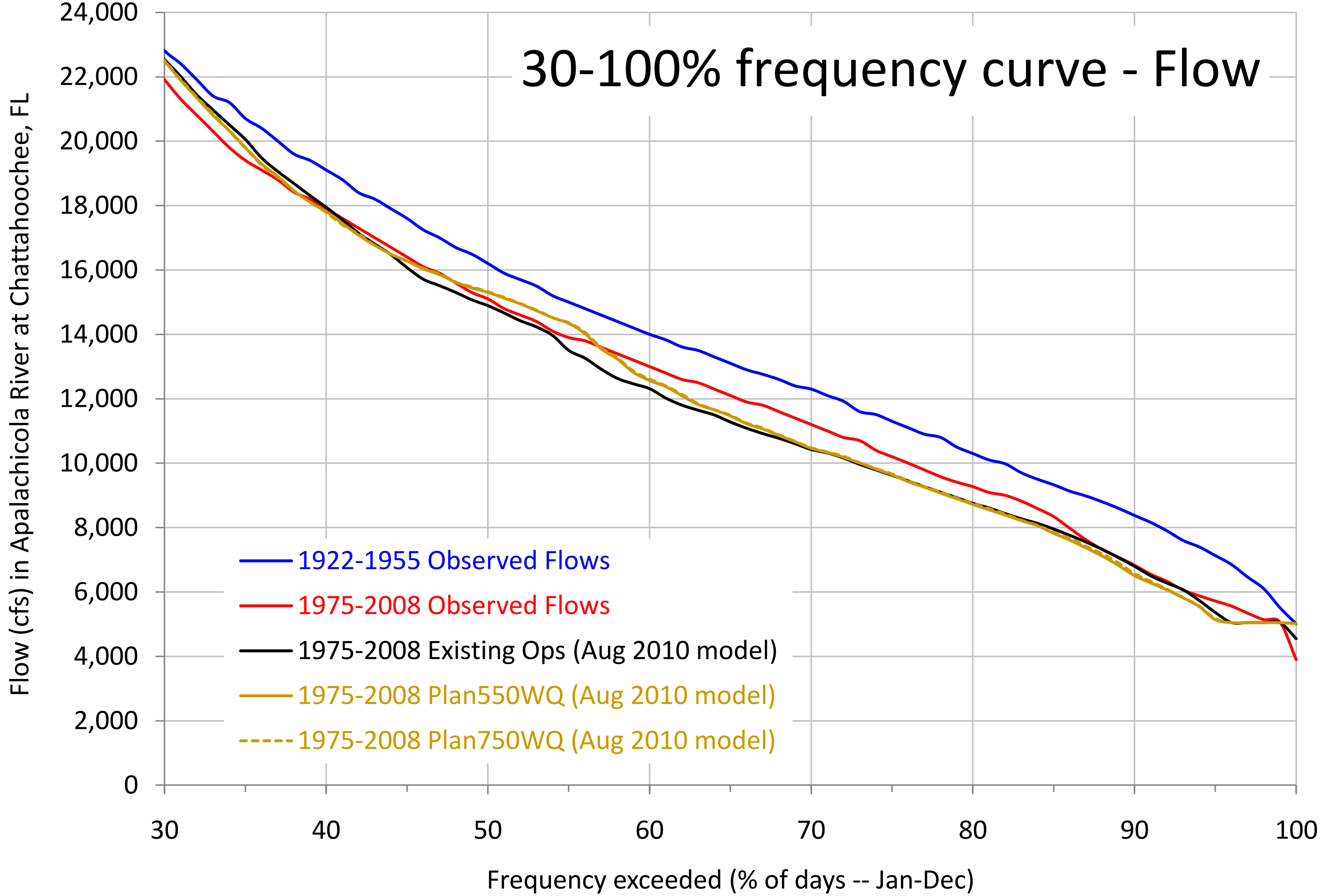


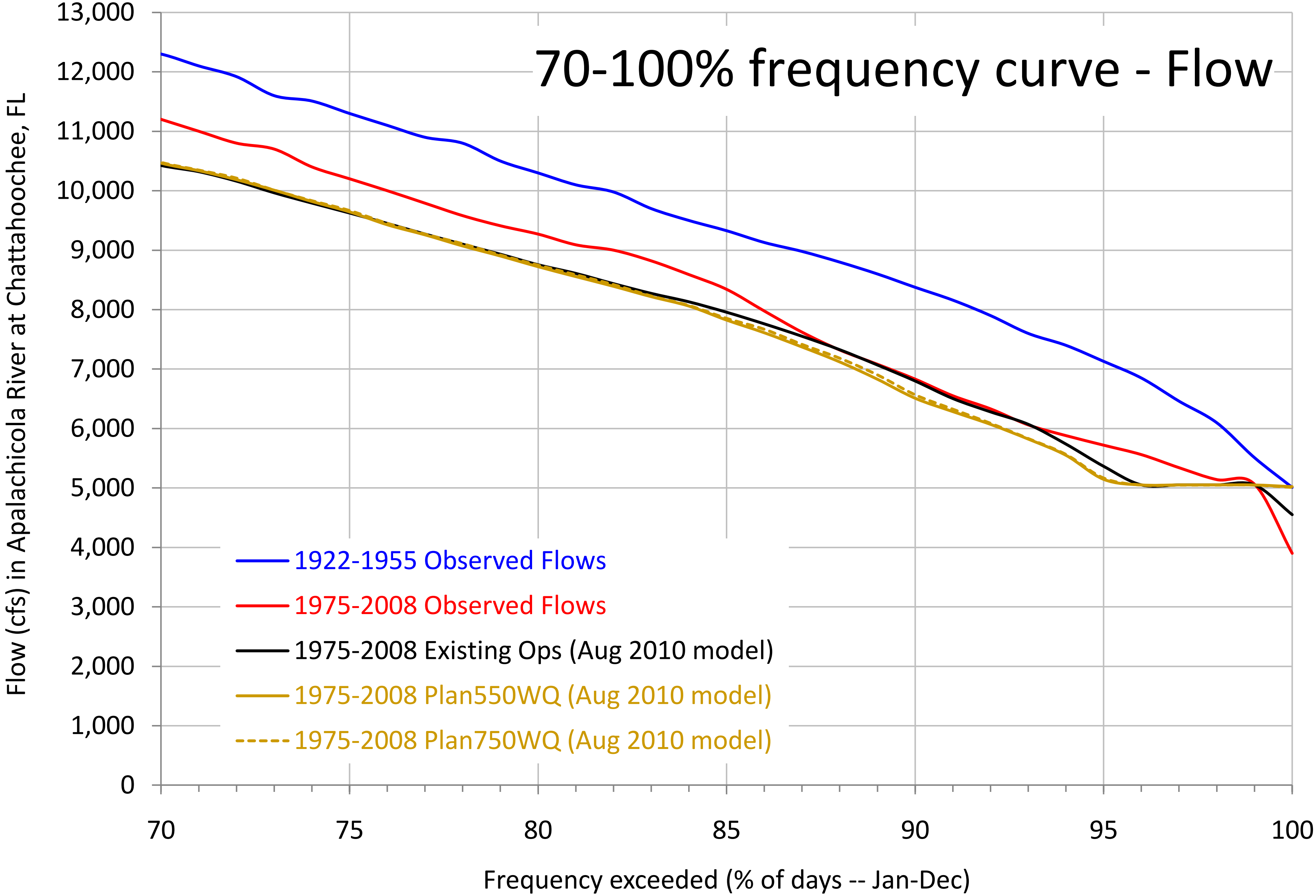
Flow Frequency Curves

Frequency that flows are exceeded (% of days -- Jan-Dec)*

**To distinguish from growing season only (Mar-Nov)*


1-100% frequency curve - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)
Next 2 slides
Flow (cfs) in Apalachicola River at Chattahoochee, FL
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
10
20
30
40
50
60
70
80
90
100
Frequency exceeded (% of days – Jan-Dec)

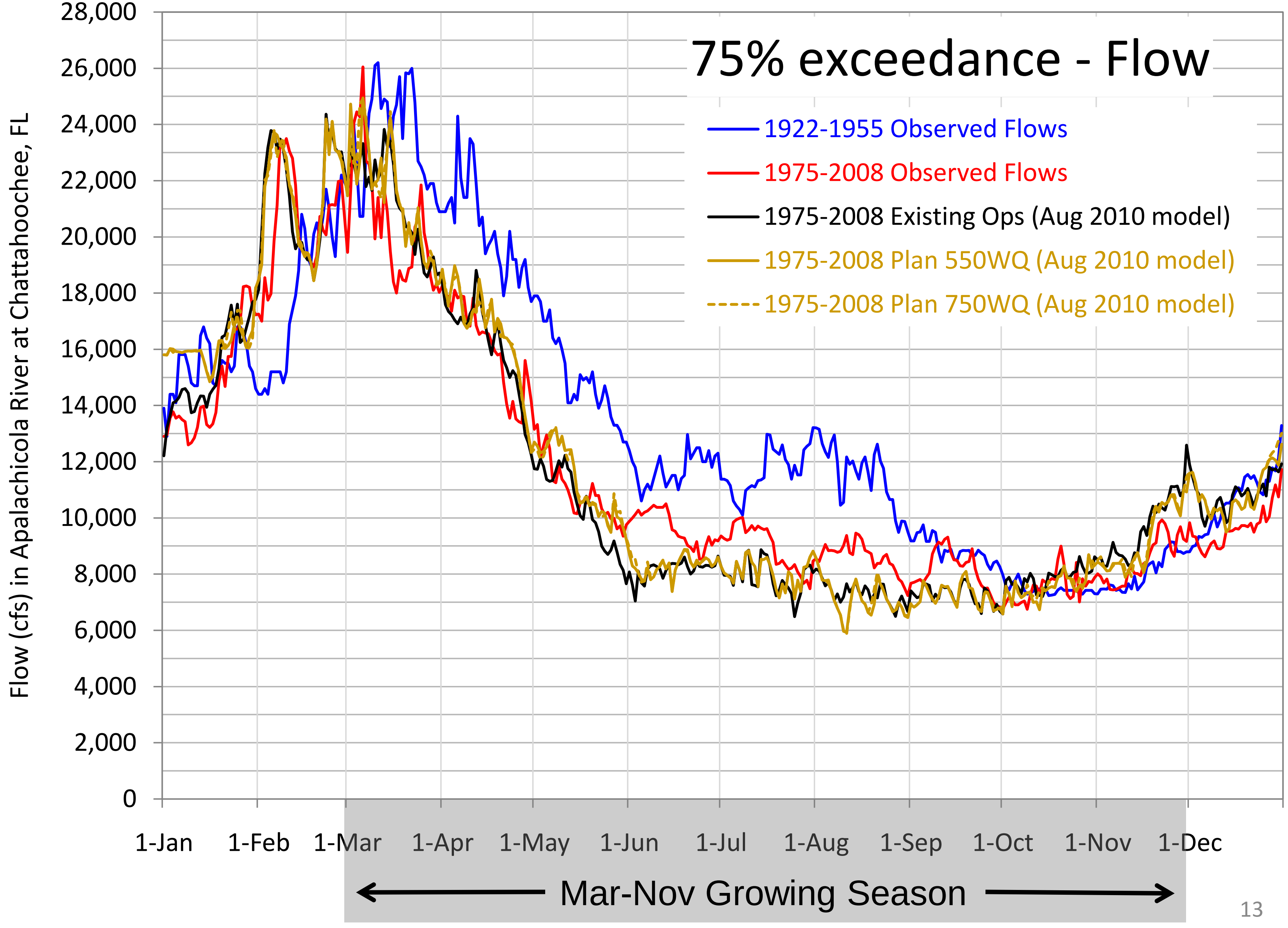

30-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
30
40
50
60
70
80
90
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)


70-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
70
75
80
85
90
95
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

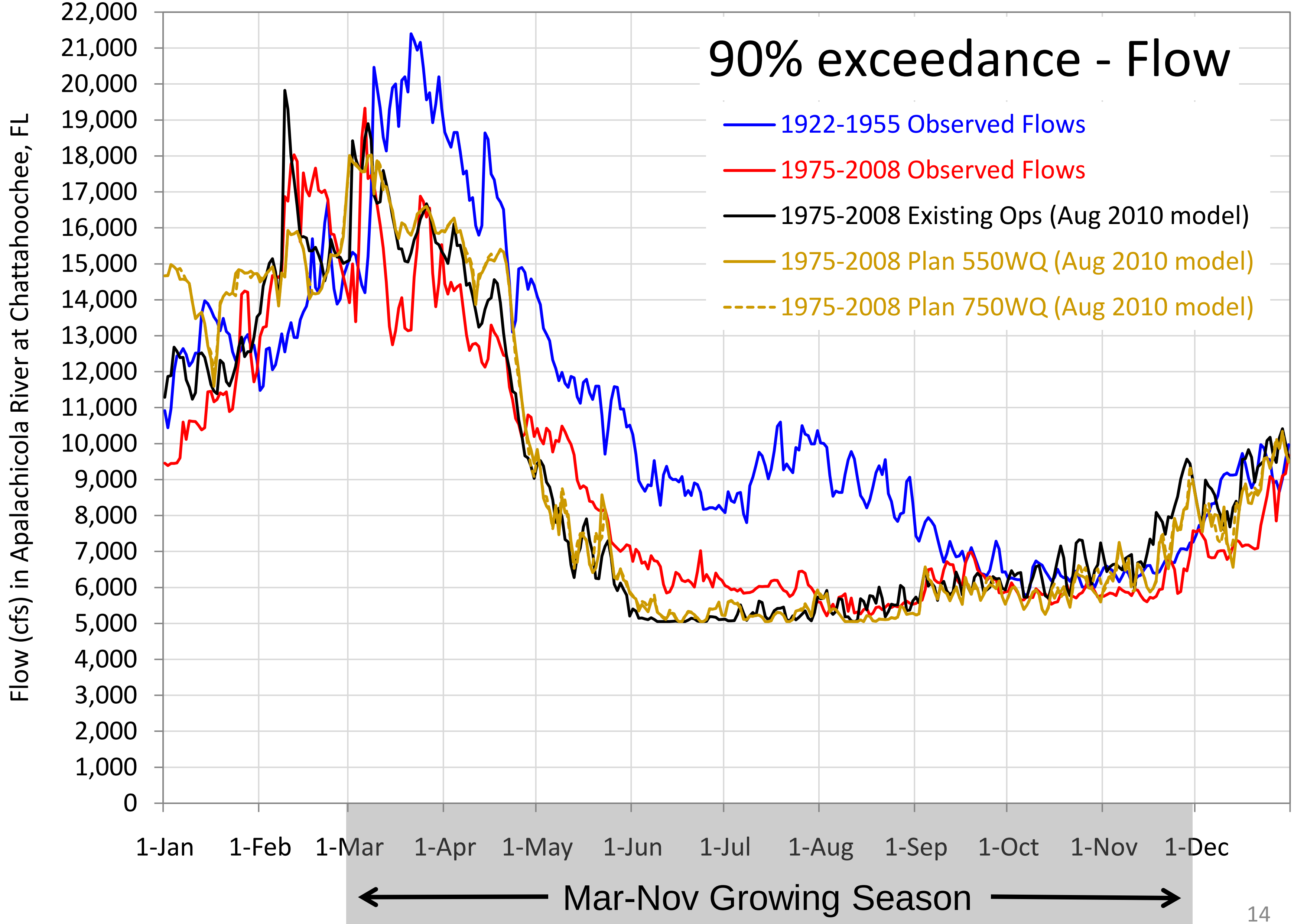
Flow Exceedance Hydrographs

Daily exceedance flows for selected frequencies: 75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.



75% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

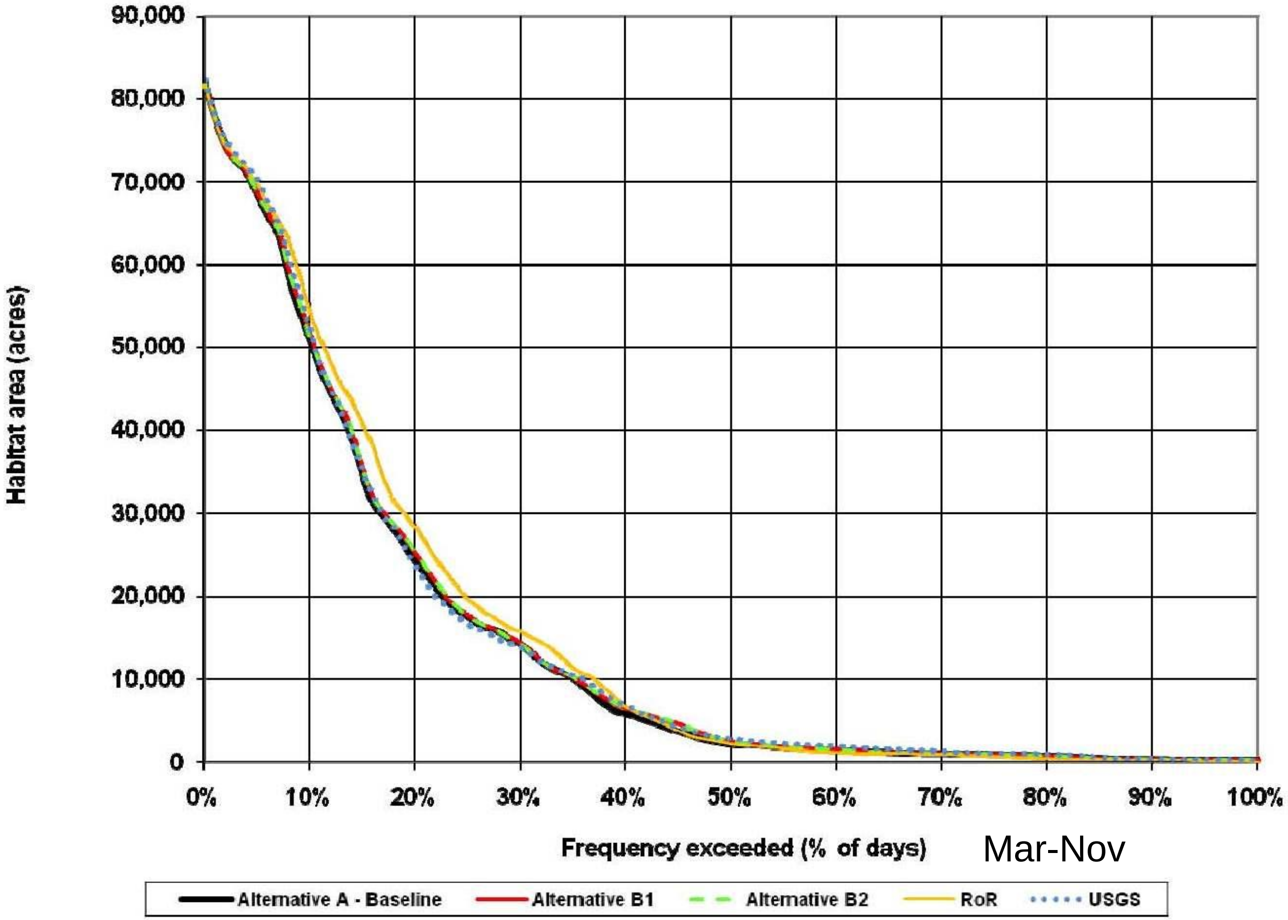

90% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

Area Frequency Curves

Frequency that acres of inundated floodplain are exceeded in the growing season (% of days – Mar-Nov)

Analysis provided by Corps

Graph from Corps 1/18/2011 Response to PAL, page 2-95:

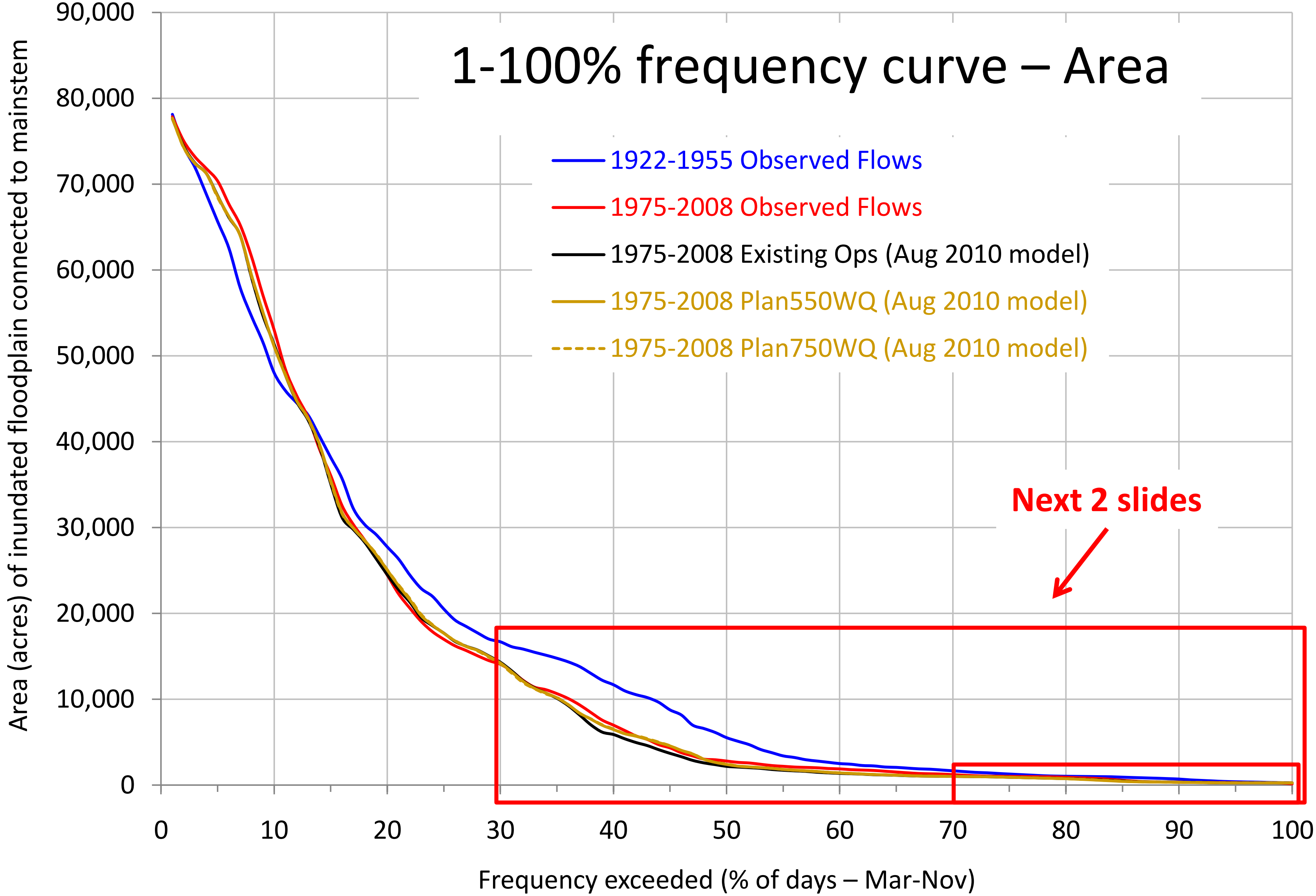


This graph was created by the Corps in response to FFWCC request.

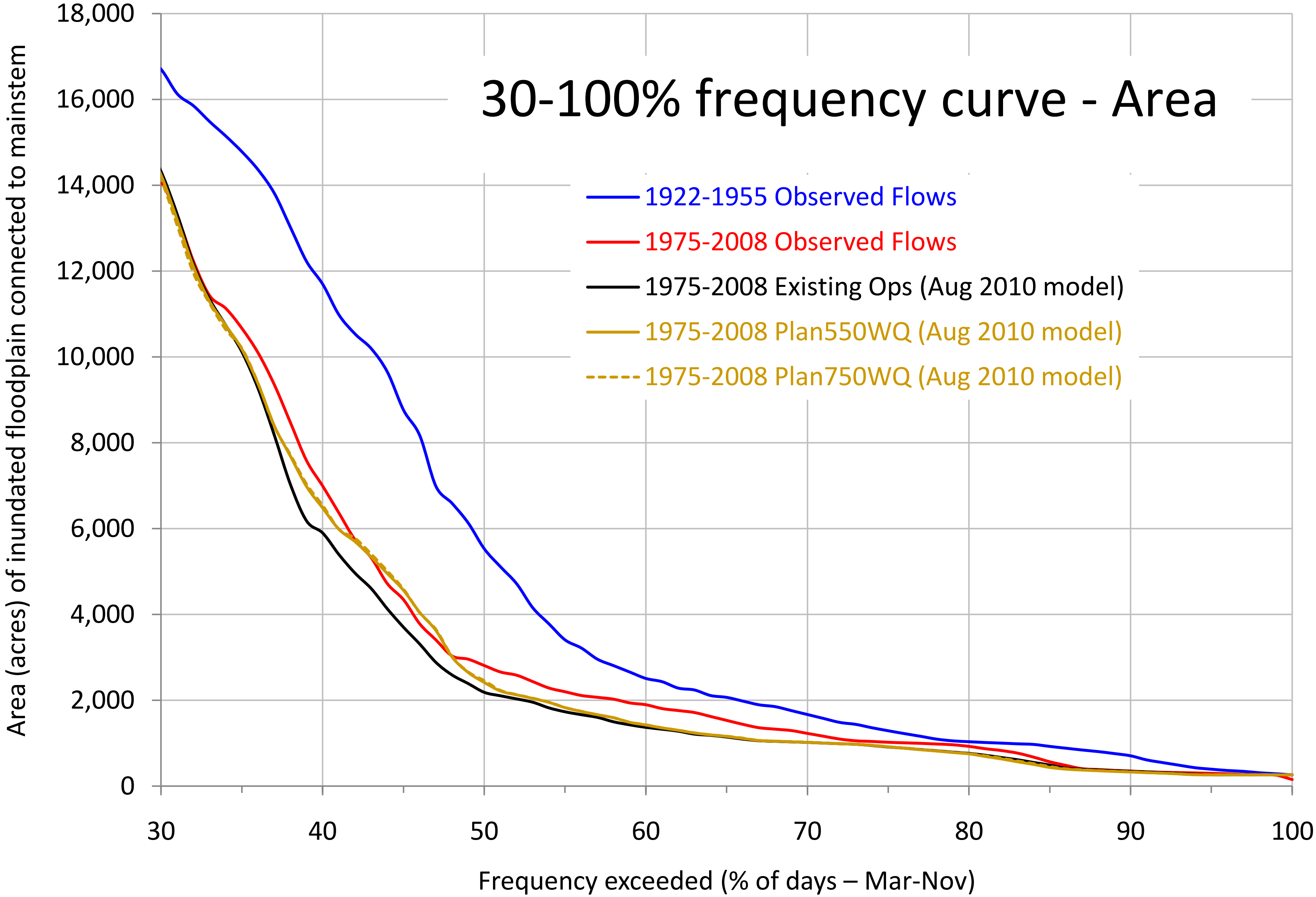
Suggested revisions:

-- Remove RoR and replace with appropriate ecosystem flow guideline (1922-1955 observed flow)

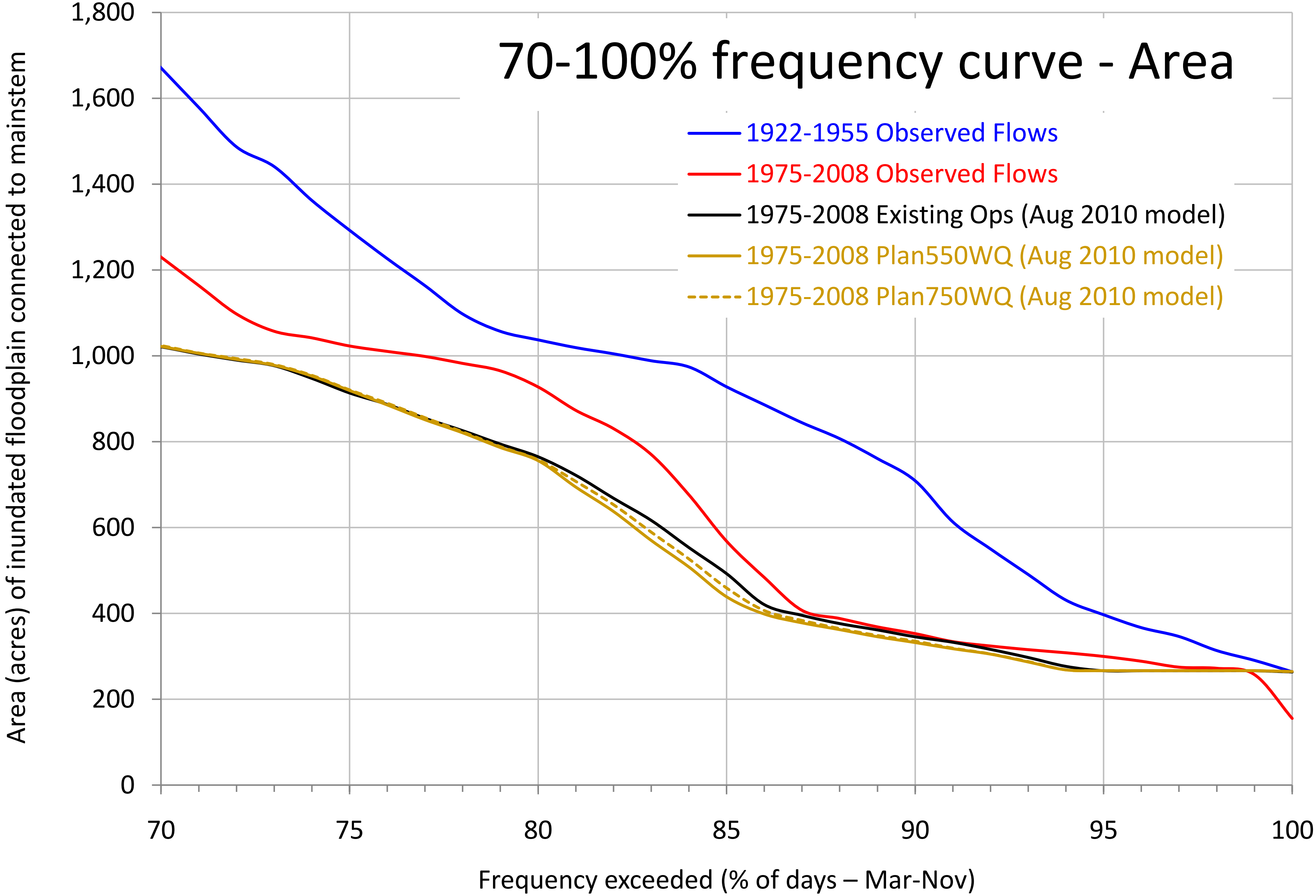
-- Expand data at low end



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using “Recent” stage-discharge ratings in Light et.al., 2006.

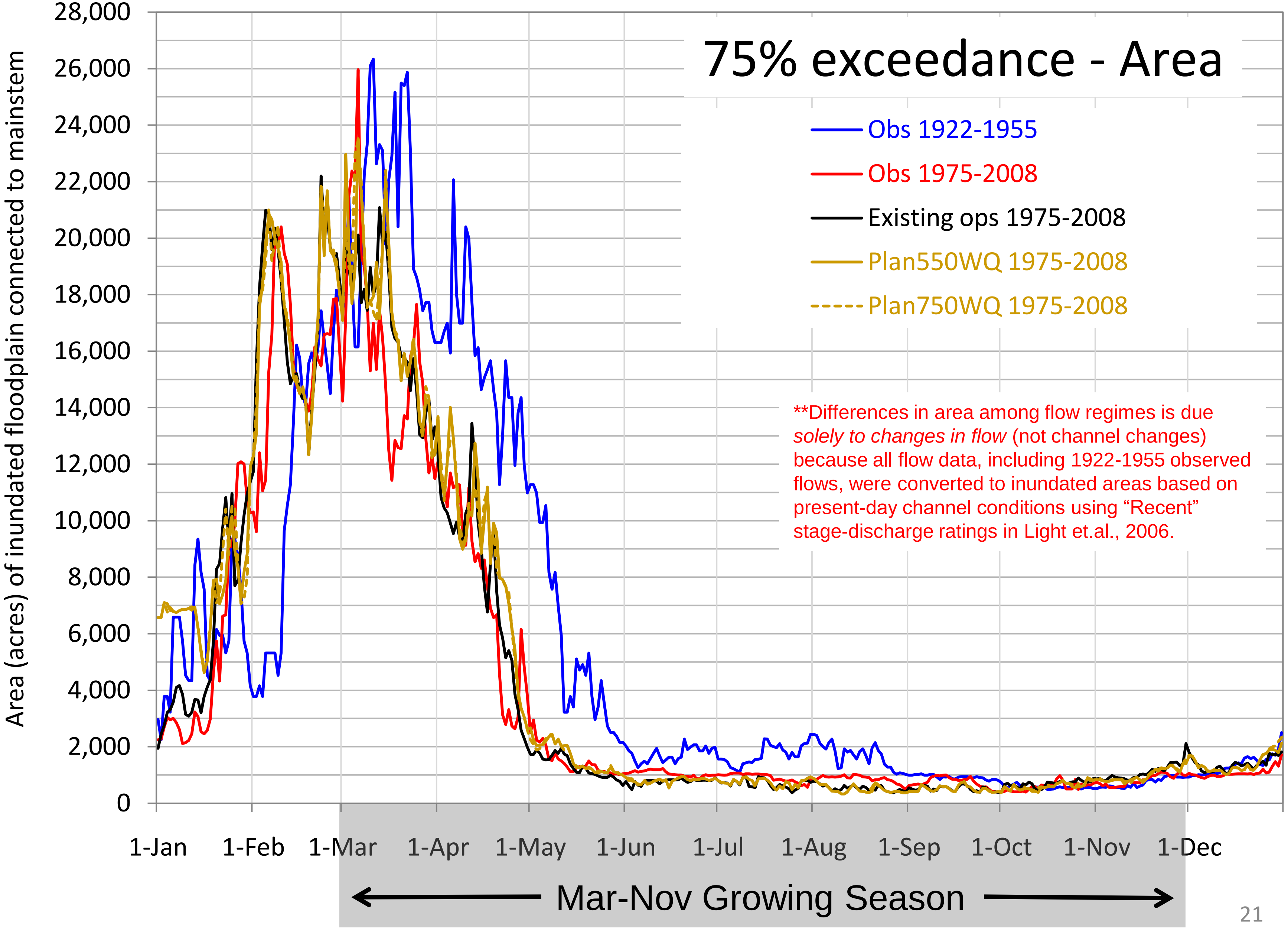


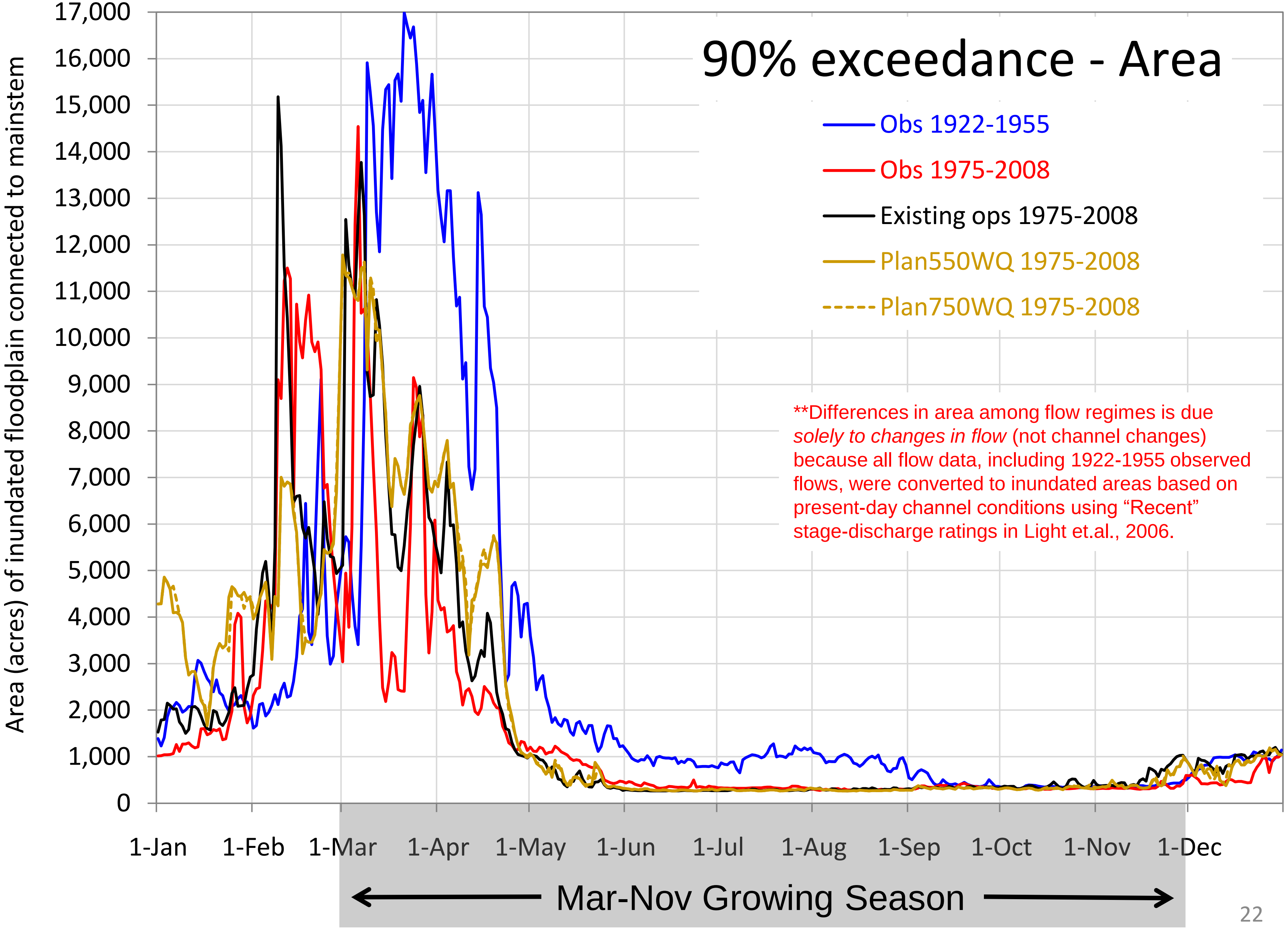
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

Area Exceedance Hydrographs

Daily exceedance for acres of inundated floodplain at selected frequencies:
75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due solely to changes in flow (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season


90% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due solely to changes in flow (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

"Greene, Chris" <Chris.Greene@dcnr.alabama.gov>

05/26/2011 10:51 AM

To "'Alice_Lawrence@fws.gov'" <Alice_Lawrence@fws.gov>

cc

bcc

Subject RE: Draft Fish and Widlife Coordination Act Report for the Corps' ACF Water Control Manual Update

History: This message has been forwarded.

Alice,

We have reviewed the Draft FWCA Report for the Corps' ACF Water Control Manual update and have no additional comments.

Thanks,

J. Chris Greene
Environmental Affairs Supervisor
Alabama Wildlife & Freshwater Fisheries Division
Fisheries Section
64 North Union Street, Suite 658
Montgomery, Alabama 36104
334-353-0210

From: Alice_Lawrence@fws.gov [mailto:Alice_Lawrence@fws.gov]
Sent: Monday, May 09, 2011 9:37 AM
To: matt_thomas@dnr.state.ga.us; Cook, Stan; ted.hoehn@myfwc.com; david.bernhart@noaa.gov; prescott.brownell@noaa.gov; miles.croom@noaa.gov
Cc: Sandy_Tucker@fws.gov; Donald_Imm@fws.gov; Jerry_Ziewitz@fws.gov; Will_Duncan@fws.gov; karen_herrington@fws.gov
Subject: Draft Fish and Widlife Coordination Act Report for the Corps' ACF Water Control Manual Update

Hello everyone- here is the Service's Draft FWCA Report for the Corps' ACF WCM update. Please review the report and provide us with official comments that represent your agency. This will enable us to reflect your comments in our Final Draft FWCA Report and include your letters as appendices.

You already have many of the appendices that are currently referenced in the report. However, if you would like one of the appendices that you don't already have, please let me know and I can get it to you. Also, it is our understanding that the Corps is updating some of the figures and text that was provided in their January 18, 2011, Response to the Service's PAL. However, we do not have that information and wanted to go ahead and get this draft report to you.

We would like to have your comments by COB May 23rd so that we may deliver a Final Draft FWCA Report to the Corps by June 1, 2011. We know it is a quick turnaround but really appreciate your review.
Thanks so much- Alice, Will, and Karen

Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606
Phone: 706.613.9493 X 222
Fax: 706.613.6059

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
(727) 824-5317; FAX (727) 824-5300
http://sero.nmfs.noaa.gov/

June 10, 2011 F/SER47:PB/pw

(Sent via Electronic Mail)

Ms. Sandra F. Tucker
Field Supervisor
U.S. Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Ms. Tucker:

NOAA's National Marine Fisheries Service (NMFS) reviewed your Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the Mobile District Corps of Engineers' (COE) proposed Water Control Manual (WCM) update for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The update to the WCM proposed by the COE is described in their response dated January 18, 2011, to the Planning Aid Letter provided to the COE by the U.S. Fish and Wildlife Service on April 2, 2010. In consideration of potential impacts on estuarine, coastal, marine, and riverine fishery and aquatic resources, NMFS may provide additional comments directly to the COE under the authority of the Magnuson-Stevens Fishery Conservation and Management Act and the Endangered Species Act when the COE releases the updated WCM for public review.

The purpose of the update is to identify new operating criteria and guidelines the COE will use for operating five COE reservoirs within the ACF River Basin, which encompasses portions of the states of Georgia, Alabama, and Florida and historically has been a source of freshwater and ecological support for fish and wildlife, diadromous fish, Apalachicola Bay, and coastal marine ecosystems.

Major impacts to historic fishery and aquatic resources have taken place since the beginning of dam construction in the early 19th century. Federal dams and water resource operations by the COE have had substantial effects on the living resources of the ACF River Basin. The water storage capacity of Buford Dam and Lake Lanier is the largest of all the dams on the Chattahoochee River. The WCM update has the potential to positively influence water resource management in the ACF, but other dams and water withdrawals are significant and should also be considered in the WCM. For example, construction of non-federal dams and hydropower dams licensed by the Federal Energy Regulatory Commission are additional factors in alteration of aquatic resources and fish and wildlife habitats and are not managed by the COE but nonetheless influence COE operations. Significant impacts have resulted from fragmentation of riverine habitats by dams that block fish migrations, inundate habitat, and alter natural seasonal flow conditions.

Your DFWCAR reviews many important and complex environmental land and water resource management factors that should be considered by the COE in final development of the WCM update. NMFS supports the U.S. Fish and Wildlife Service's sections on "Evaluation of the Selected Plan," and "Fish and Wildlife Conservation Measures and Recommendations" with regard to fishery and aquatic resources under our authority.

We appreciate the opportunity to provide comments on the DFWCAR. Please direct related correspondence to the attention of Prescott Brownell at our Charleston Area Office. He may be reached at (843) 762-8609 or by e-mail at Prescott.Brownell@noaa.gov.

Sincerely,

/ for

Miles M. Croom
Assistant Regional Administrator
Habitat Conservation Division

cc:

FWS, Alice_Lawrence@fws.gov
F/SER47, Prescott.Brownell@noaa.gov

United States Department of the Interior

Fish and Wildlife Service

105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

April 2, 2010

Colonel Byron Jorns
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Jorns:

We are providing your agency with a Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the PAL is to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. We submit the following comments and recommendations under the ESA, the Migratory Bird Treaty Act (MBTA)(49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). These comments are based on previous studies and government documents as well as new datasets and information provided by State and Federal agencies. Although all of the comments from the Florida Fish and Wildlife Conservation Commission (FFWCC) have not been integrated, this final version of the PAL addresses many of the issues that FFWCC raised. We will continue to provide additional expertise and information in the form of another PAL and/or the draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corp's proposal on federally-listed threatened and endangered fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

1. Development of Corps Alternatives and Mitigation

We have identified data needs and assessment methods that can help you in developing alternatives that maximize fish and wildlife benefits, and avoid, minimize and compensate for impacts to fish and wildlife resources, where appropriate.

1.1 Flow Regime

The WCM update should include a thorough evaluation of project-related flow regime alterations and the potential to restore flow regime components that have ecological and geomorphic significance. We recommend the Corps develop alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. To support this effort, we have provided preliminary ecosystem flow guidelines for four river sections; below Buford, West Point, Walter F. George, and Jim Woodruff dams. These flow regime guidelines are guided by the principle that ecosystems evolved as a response to the natural flow regime. Thus, we analyzed river flows and developed flow guidelines based on United States Geological Survey (USGS) flow data that were collected prior to Buford Dam construction in the mid 1950's, a benchmark of the first major river regulation source in the upper Chattahoochee River. Reliance on pre-regulation datasets to derive ecosystem flows is particularly useful for locations where empirically derived ecology-flow relationships are scant (such as the upper Chattahoochee River).

We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation. For example, provision of stable flow windows (*sensu* Freeman et al. 2001) in the spring may increase riverine fish recruitment, even though restoration of other naturally occurring flow regime components may not be attainable. Relatively small discharge changes can have substantial ecological effects. For example, the Tennessee Valley Authority's (TVA's) strategy to increase baseflows below Normandy Dam (Figure 1) during the spring and summer mussel recruitment months resulted in biologically and statistically significant increases in mussel diversity and density (Figure 2, Ahlstedt and Johnson 2004).

Development of environmental flow alternatives would include an evaluation of the operational feasibility, constraints, and tradeoffs to providing the different aspects of environmental flow measures that are captured in our guidelines. Explicit magnitude, frequency, duration, timing, and rate of change guidelines are provided to illustrate the types of flow modifications that are likely to benefit the ecosystem and to help inform the development of Corps flow alternatives. However, should the magnitude of a flow guideline be deemed unattainable, we request that the Corps identify a flow magnitude that is attainable or recommend an attainable frequency for the recommended flow magnitude. An explanation for the change also will be helpful. We recognize these guidelines do not define whether the basin is entering a dry, average, or wet month, which are the lines between the lower and upper limits on the flow prescription graphs. We recommend that you work with us to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

Successful implementation of ecosystem flows in the Chattahoochee River is challenged by water demand increases, reduced operational flexibility imposed by meeting minimum discharge requirements at downstream locations, and the importance of minimizing high discharge-related

damage to infrastructure. To address these challenges, we considered only the range of flows that were likely to be above minimum flow requirements and less than flows that could cause major infrastructure damage as identified by information provided by the National Weather Service (NWS) Advanced Hydrologic Prediction Service (NWS 2010; Table 1). The ecosystem flow guidelines are preliminary because in instances where water is diverted from the channel, or the channel is anthropogenically altered, natural flows may be insufficient to meet ecological needs.

Successful implementation of ecosystem flows in the Apalachicola River is challenged by the same types of limitations described for the Chattahoochee River. The degree of Apalachicola River channel entrenchment and widening, caused largely by Corps reservoir and dredging operations, varies spatially, but the discharge that is now required to reach bankfull elevation and cause floodplain inundation in the upper portion of the river is generally greater than the discharge that was historically required. However, datasets are available that quantify the amount of floodplain habitat inundated with the current level of entrenchment and over a range of discharges. These datasets, in combination with those that describe flow effects on sturgeon spawning and mussel habitats, will help to inform the development of future ecosystem flow guidelines and the evaluation of alternatives.

Thorough explanations of the physical, chemical, and ecological benefits from base flows, pulses, stable flow windows for spawning, and intra- and interannual flow variation are outside the scope of this letter; however, we refer the reader to Junk et al. 1989, Poff et al. 1997, Richter et al. 1998, Freeman et al. 2001, Postel and Richter 2003, and Mathews and Richter 2007 for fuller descriptions. The importance of baseflows, pulses, and flood flows are described within these resources, and they are quantitatively evaluated using the recently developed Environmental Flow Components (EFCs) in Indicators of Hydrologic Alteration (IHA)(Mathews and Richter 2007). General descriptions of the baseflow, pulse, and high pulse flow guidelines are provided below with general descriptions of the ecological significance of those flow guidelines.

Similar to the Instream Flow Guidelines provided to the ACF Compact's Federal Commissioner (USFWS 1999), the guidelines provided in this letter were developed using IHA, use the pre-dam period of record as a benchmark for comparison of flow alternatives, and rely on percentiles to define the frequency of high and low flow extremes. Using EFCs is recommended because the analysis separates ecologically-relevant hydrograph components (e.g., baseflows from pulses) allowing computation of magnitude, frequency, duration, timing, and rate of change statistics on individual hydrograph components rather than on the entire dataset. Consequently, these hydrograph summary statistics are easily developed, interpreted, and communicated, and have been used successfully to inform flow management downstream from hydropower dams.

<u>1.1.1 Baseflow and small pulses</u>
Baseflows determine the amount of habitat that is available for forage, reproduction, and rearing, which has a substantial influence on the abundance, diversity, and distribution of aquatic fauna. We have provided explicit base flow recommendations for every month in dry, average, and wet water years. Small pulses that do not exceed bankfull elevation provide influxes of upstream

trophic subsidies, and reprieves from low dissolved oxygen and high temperature that sometimes occur during summer months. Small pulses are included in the guidelines with explicit magnitude, frequency, duration, timing, and rate of change recommendations (Figures 3-6).

The flow guidelines were based on average daily flows (Figures 3-6). Average daily flows obscure the diel streamflow variation imposed by hydropower generation. Consequently, hydropower generation at Buford, West Point, Walter F. George, and to a lesser extent, Woodruff Dam, may change discharge two orders of magnitude, and change river stage significantly within a few hours. As a result, habitat availability is limited to periods that are too brief for the completion of essential life history requirements. To mitigate this impact, the provision of non-hydropower peaking "windows" should be evaluated during critical reproductive and rearing periods in order to reestablish native plant, fish, and invertebrate abundance and diversity in river reaches downstream from Corps-operated projects. Generally, this period corresponds to March – May when water temperatures increase. The timing, duration, and magnitude of this window should vary interannually in order to optimize the reproductive requirements of each species every few years. However, the duration of the non-peaking window requires additional research, but we expect that a minimum of 4-6 weeks between March and May are required.

The dry, average, and wet year baseflow guidelines are based on a retrospective analysis of the pre-dam hydrograph (Figures 3-6). It will be necessary to use appropriate hydrological and meteorological criteria to classify the coming month into dry, average, or wet categories. However, average daily baseflows should remain near the dry, average, and wet year flow guidelines depending on the category, and should not fall below the lower limit on any day of any year.

1.1.2 High flow pulses

High flow pulses that exceed bankfull elevation provide important ecological services. A large proportion of sport and non-game fishes rely on floodplain habitats to spawn, rear young, and forage. High flow pulses are also major forces that control nutrient and organic matter dynamics in large rivers, create new habitats, and ultimately affect riverine animal biomass (Junk et al. 1989). However, the spring reservoir refill period extends into the principal spawning season for a high proportion of fishes, meaning that spring flows and floodplain inundation are reduced. Thus, ensuring seasonal high flows and river-floodplain connectivity with the timing, frequency, duration, magnitude, and rate of change necessary to sustain ecological functions and wildlife populations are essential flow management objectives for dams on large rivers.

To provide flows that inundate the floodplain, the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain should be evaluated. Similarly, the Savannah District Corps has operated the Savannah River reservoir system in recent years with reduced winter drawdown to provide spring pulses that meet multiple downriver ecosystem objectives. This evaluation should separately consider flow conditions in wet, average, and dry climatic years. Additionally, it should be noted that relatively small changes in river stage can significantly increase the amount of river-floodplain connectivity. Consequently, minor changes

in dam operation could have large and positive effects on the river-floodplain ecosystem.

Recognizing that there are limits on operational flexibility due to the presence of infrastructure in some floodplains, methods should be evaluated to provide the operational flexibility necessary for floodplain inundation, which falls under the Corps' coequal project purpose of "Fish and Wildlife Resources." Such methods could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation; and/or 2) the purchase of structures built in the historic floodplain so that the Corps can intentionally provide flows that inundate the floodplain. These analyses should be simple to conduct, and would include acquisition of floodplain maps and identification of anthropogenic structures within the 2, 10, 50, and 100-year floodplains.

<u>1.2 Floodplain inundation assessments</u>

The relationships among the areal extent of Apalachicola River floodplain inundation, channel entrenchment effects, and water releases from Jim Woodruff Lock and Dam were previously assessed and related to discharge using the datasets and summaries provided by Light et al. 1998 and Light et al. 2006. These datasets have informed biologists and the Corps of the effects of flow releases on river-floodplain resources. Due to the difficulty of surveying all floodplain streams, lakes, and forests, Light et al. 1998 used intensive surveys at a subset of sites, general surveys at approximately 300 sites, and Geographic Information Systems (GIS) to assess the effects of hydrogeomorphic alteration on floodplain inundation areal extent. Light et al. 2006 compared pre-dam stage (prior to 1954) and recent stage (1995–2004) at five streamflow gaging stations in relation to discharge at the Chattahoochee gage (USGS gage number 02358000, Apalachicola River at Chattahoochee, FL). These stage-discharge relationships can also be used to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at different discharges for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

More recently, floodplain elevation maps have been generated using Light Detection and Ranging (LIDAR) remote sensing data with <1 ft accuracy and related to Apalachicola River stage-discharge relationships developed by Light et al. 2006 (Ron Bartel, Northwest Florida Water Management District [NWFWMD], 2010, pers. comm.). Stage-based LIDAR data may provide a more thorough and accurate evaluation of river flow effects on river-floodplain connectivity and habitat availability. We recommend that the Corps contact the NWFWMD to confirm that these datasets exist, request permission to access and use these new datasets, or invite collaboration between the Corps and the NWFWMD to evaluate effects of flow alternatives on floodplain resources. Operations in the environmental flow alternatives should be developed that will use reservoir storage at certain times to augment flow and increase Apalachicola floodplain inundation.

<u>1.3 Water Quality</u>

The effects of reservoir operations on water quality should be closely examined in the WCM update, including ongoing and potential future effects to dissolved oxygen (DO), temperature, nutrient and organic material dynamics, and capacity to assimilate industrial and municipal

discharges. We request that the Mobile District use the WCM update to make necessary modifications that will improve water quality downstream of Corps projects, as is being done by TVA and other Corps districts.

1.3.1 Dissolved Oxygen

The Service is most concerned about low DO in project tailwaters. We recommend that the Corps make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. An appropriate effort would include first monitoring DO upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve DO levels, and conducting post-modification DO monitoring to ensure that DO levels have been improved to State water quality standards. Examples of low DO releases from Buford, West Point, and Walter F. George dams are detailed below.

We urge the Corps to 1) monitor DO upstream and downstream of Lanier Reservoir, West Point Reservoir, Walter F. George Reservoir, and Jim Woodruff Reservoir and 2) experiment with operational and/or structural modifications to improve DO levels, and conduct post-modification DO monitoring to ensure that DO levels increase to state water quality standards. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream dissolved oxygen requirements may be particularly useful. The DO that results from the mixing of two water bodies (DO_{mx}) is a function of the dissolved oxygen (DO_1 and DO_2) and volumes (Q_1 and Q_2) of the two water bodies and is calculated using the following equation:

$$DO_{mx} = \frac{Q_1 * DO_1 + Q_2 * DO_2}{Q_1 + Q_2}$$

1.3.1.1. Buford Dam tailwaters

Low DO levels were recorded by the Georgia Department of Natural Resources-Wildlife Resources Division (GDNR-WRD) just below Buford Dam during 1996-2006. These DO levels affect angler success, GDNR-WRD's stocking rates, and the native aquatic community. Periodic measurements taken during this period resulted in monthly minimum instantaneous $\leq$ 1.0 mg/L in September through December. Monthly average values were < 5.0 mg/L from August through November (Figure 7; Chris Martin, GDNR-WRD, 2010, pers. comm.). Low DO levels persisted downriver, depending on operational and climatic factors. For example, based on GDNR-WRD measurements on November 5, 2005, DO increased to 5.0 mg/L three miles downriver, and increased to 6.0 mg/L 5.2 miles downriver when releases from Buford Dam were < 2.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.).

The Corps upgraded the venting capabilities of the Buford Dam turbines over the past few years. However, the upgrades resulted in < 1.0 mg/L increase over previous conditions (Chris Martin, GDNR-WRD, 2010, pers. comm.). The Corps should thoroughly evaluate the effectiveness of these upgrades.

Useful tools to improve DO levels to State standards in Georgia trout waters (6.0 mg/L daily average, 5.0 mg/L instantaneous) include sluicing instead of running discharge through the

penstocks and units, or to use a combination of the two routing methods. For example, on September 15, 2000, GDNR-WRD recorded a DO level of 1.5 mg/L at Buford Dam during a minimum flow release through the house unit. In contrast, DO levels measured on the same date during sluicing indicate that DO remained above 6.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.). Thus, the Corps has demonstrated that sluicing below Buford Dam is an effective tool to mitigate low DO effects associated with hypolimnetic releases.

1.3.1.2. West Point Dam tailwaters

Dissolved oxygen data collected by the Corps downstream from West Point Dam from 1999 through 2001 indicate that DO levels met or exceeded the Georgia instantaneous standard (4 mg/L) 35% of the monitoring period in 1999, (monitoring from 6/15-9/14), 30% of the monitoring period in 2000 (monitoring from 7/25-9/30), and 4% of the monitoring period in 2001 (monitoring from 6/8-10/5; Georgia Power Company 2002). GDNR-WRD has investigated multiple fish kills below West Point Dam and has concluded that these fish kills are attributable to low dissolved oxygen levels (GDNR-WRD letter to the Corps, November 20, 2008).

1.3.1.3 Walter F. George Dam tailwaters

Low DO levels were associated with minor fish and mussel kills downstream of Walter F. George Dam (Rob Weller, GDNR-WRD, 2008, pers. comm.).

1.3.2 Temperature

The water temperatures of hypolimnetic releases below large dams are lower than would naturally occur during spring and summer months. Low water temperatures negatively affect warmwater fishes that require warmer water temperatures necessary for spawning and growth of young-of-year fishes. Thermal alteration can be ameliorated by structural modification of penstock location in the water column. Another option to moderate thermal alteration is to release (via sluicing) warmer water from a higher elevation in the reservoir's water column. Once this water mixes with the cold hypolimnetic release, water temperatures more closely approximate natural water temperatures. A recent example of sluicing effects in the Mobile District comes from measurements taken during summer 2009 below Allatoona Dam. Sluicing in June caused water temperatures to increase approximately10ºC (Figure 8). Temperature increases were observed many miles downriver (USFWS 2009 unpublished data).

Similar to DO recommendations, we urge the Corps to monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream temperature requirements may be useful. The seasonal timing of such releases exhibiting modified temperatures is of great importance. For example, the current summer thermal regime on the Etowah River, created by operations at Allatoona Dam, provides cool thermal refuge for striped bass in the upper Coosa River system. A thermal modification during the summer months below Allatoona Dam could be detrimental to fishes such as striped bass and lake sturgeon (Matt Thomas, GDNR-WRD, 2010, pers. comm.). Because the Service and GDNR-

WRD have responsibilities to protect native aquatic communities as well as recreational fisheries, we recommend the Corps explore methods for temperature modifications below their facilities, but coordinate closely with State and Federal agencies to determine the appropriate timing of such alterations.

In addition, it should be noted that the current thermal regime of Lanier Reservoir's tailwater is critical to the Chattahoochee River trout fishery and trout production at GDNR-WRD's Buford Hatchery. The tailwater trout fishery in the Chattahoochee, one of Georgia's premier fisheries, is dependent upon cold, well-oxygenated water releases for the survival of trout. The Buford Trout Hatchery produces 400,000 catchable trout annually and is dependent on Lanier Reservoir coldwater storage to maintain this production. Potential impacts to Chattahoochee River trout waters should be considered when making WCM decisions (Matt Thomas, GDNR-WRD, 2010, pers. comm.). The coldwater trout fishery below Buford Dam is of great importance to GDNR-WRD, and is also a responsibility for the Service as an important recreational fishery. Discussions between GDNR-WRD and the Corps should occur to determine if modifications are possible that avoid trout fishery impacts but also provide benefits to native warmwater fisheries below Buford Dam.

<u>1.4 Fish Passage</u>
Corps ACF dams impede the migration of diadromous and potadromous fishes including striped bass, Alabama shad, American eel, and Gulf sturgeon. Jim Woodruff Dam's impact on diadromous fish passage is large compared to dams on other southeastern rivers because it is located in the lower part of a large river basin. Consequently, there is significant interest in improving fish passage at this facility, as well as the two next upstream Corps facilities, George W. Andrews Lock and Dam and Walter F. George Lock and Dam. We appreciate the Corps' willingness and cooperation to modify operations thus far at Jim Woodruff to maximize fish passage for Alabama shad. Support and facilitation of fish passage research at Woodruff Dam, as well as other ACF Federal dams (notably George W. Andrews Lock and Dam and Walter F. George Lock and Dam) should continue with a goal of identifying and implementing operations and/or modifications that would allow riverine species to travel their historic migratory pathways. Provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam, while maintaining the need for operational flexibility.

<u>1.5 Climate Change</u>
The effects of climate change to ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes should be evaluated. It is our understanding that the Corps will be considering sea level rise when developing alternatives (Corps 2009). However, climate change will also affect river flows and the effects of a given set of operating rules will vary depending on whether the basin's climate becomes drier, wetter, more variable, or less variable. In particular, it is vitally important to adapt the level set as the top of conservation (TOC) pool to the long-term hydrology of the basin and the essential purposes the projects serve. In a scenario with greater variability between annual high flows and low flows, for example, it may not be feasible for these projects to simultaneously serve their existing levels of flood control protection and minimum flow support without adapting TOC pool levels to prevailing weather conditions.

The Corps already practices this concept with the multiple action zones and the occasional variances from the rule curves to store water above the TOC pool elevation during dry periods. Several models are developed that will be useful in this analysis and are briefly described in section *2.2 Evaluation of Alternative Models*. In addition to including multiple future climate scenarios into modeled discharge scenarios and Corps alternatives, flow provisions should be created for dry, average, and wet years in order to account for current climate variability.

1.6 Navigation

Navigation is an authorized project purpose for all five ACF Corps dams and the Corps has used reservoir storage in the past to support navigation. In recent years, however, lacking water quality certification to maintain the channel in Florida, we have seen only occasional flow management for the navigation purpose. Current physical channel dimensions dictate the flows that are necessary for navigability. Without providing flows to meet channel depth authorizations, dredging would be necessary to maintain channel navigability. Dredging has significant adverse effects to fish and wildlife. If flows for navigation are included in the WCM update, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support. If flows for navigation are not included in the WCM update, improvement or simplification of the four-zone reservoir operational scheme that governs current operation should be considered.

1.7 Reservoir and Riverine Fisheries Management

The Corps follows a draft Standard Operating Procedure (SOP) for "Lake Regulations and Coordination for Fish Management Purposes." The "fish spawn" SOP goal is to manage for generally stable or rising reservoir levels and for generally stable or gradually declining river levels for about 4 to 6 weeks in the spring months at Corps' reservoirs. These draft SOPs are protective of reservoir fish spawning; however, stable or rising river levels are also beneficial for riverine sport fisheries. We understand it is not feasible to have stable and/or rising water levels in both the reservoirs and river during times of declining basin inflow. To address this issue, recent reservoir and riverine fisheries literature should be reviewed to evaluate whether a 4-6 week stable or rising reservoir window is supported for reservoir fish spawning and/or potentially detrimental to riverine fish spawning. We also recommend development of an alternative that includes modifying the draft SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. Finally, we recommend that the Corps identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

1.8 National Wildlife Refuges

The Service previously recommended to the Corps that a seasonal pattern of reservoir levels at W.F. George Reservoir would best accommodate the needs of Eufaula National Wildlife Refuge. Water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. These recommendations, which we included in the draft FWCA report for the Corps' 1998 Draft EIS on ACF water

allocation, were to manage the reservoir so that it behaves more like a river. Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer were recommended. These recommendations remain valid. How the benefits and impacts of such a scheme compare with the existing operating regime and other alternatives should be considered.

1.9 Apalachicola Bay

The predicted levels of freshwater inflow into Apalachicola Bay resulting from Corps alternatives will be of importance to the Service because they may affect salinity levels. Freshwater inflow reductions cause salinity increases and indirectly increase oyster mortality through increased colonization of marine oyster bed predators (Corps 1998). Additionally, juvenile Gulf sturgeons have optimal growth rates at relatively low salinity (9-10 ppt), and periods of extended higher salinities would likely limit feeding habitat availability.

As part of the Comprehensive Study for the Corps' DEIS (1998), the National Ocean Service (NOS) examined the freshwater inflow effects on the water circulation and salinity changes in Apalachicola Bay. Oysters were selected as a biological response variable because of their commercial fishery importance, habitat requirements, and expected response to salinity fluctuations (Corps 1998). A three-dimensional hydrodynamic model produced output that was used in an integrated biological model to assess the effects of potential freshwater inflow changes to Apalachicola Bay salinities and oysters. Predicted oyster mortality and oyster bed growth rates were compared for the various Corps' alternatives.

More recently, Livingston et al. (2000) developed a spatially-explicit hydrodynamic circulation model of the bay that predicts salinity, among other variables, as a function of freshwater inflow. This model has been used to model oyster mortality and growth in relation to freshwater inputs. The Service has used the results of this model to make inferences on the availability of low-salinity bay habitat for Gulf sturgeon. In addition, an alternative Apalachicola Bay salinity model was recently developed by Peter Sheng at the University of Florida (Sheng and Kim 2009). By using the Corps' daily average discharge output from the ResSim model for the Sumatra gage for the various alternatives, the model can compare the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios. This information can be used to make inferences on the availability of bay habitat for Gulf sturgeon and to model oyster mortality and growth.

We recommend that the Corps or the Corps' consultants (Tetra Tech) contact the NWFWMD and/or the Florida Department of Environmental Protection (FDEP) to request permission to access and use the Livingston et al. models, or invite a collaboration between the Corps and NWFWMD/FDEP to evaluate effects of flow alternatives on Apalachicola Bay resources. The Sheng and Kim (2009) model should also be incorporated in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth. If all models are made available to the Corps and the Service, we recommend that the strengths and limitations of each model be evaluated to determine the model that will best suit the assessment requirements. In addition, coordination should occur with FFWCC's Fish and Wildlife Research

Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

1.10 Decision Support Model to Evaluate Changes to Corps' Operations

It is important to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams. Because of the numerous and sometimes competing demands for water, it is difficult to evaluate the effects of proposed management alternatives and to make the evaluation transparent. However, multiple free decision support tools (e.g., Netica) are available to facilitate the evaluation of alternatives. These tools are versatile in the sense that new information that results from monitoring the effects of management strategies is easily integrated into the analysis and decision process. Consequently, a better and more transparent understanding of how Corps operations affect the ecology and use of the ACF system can lead to improved future management. Therefore, a decision support model should be incorporated into the WCM update process.

1.11 Adaptive Management

An adaptive management program should be developed, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam. The program would formulate hypotheses about how such benefits might be achieved through dam operations, implement those operations, monitor ecosystem responses, and revise the operations based upon lessons learned.

2. Recommendations for Corps Hydrologic Modeling

2.1 Increasing Consumptive Demands

The impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin should be recognized and considered. This is a variable that an analysis of operational alternatives should incorporate along with climate-driven hydrologic variability. The relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes should be quantified. For example, how is sustainable minimum flow release from Woodruff Dam affected if consumptive demands increase by 25, 50 or 100 percent by the years 2020, 2050, and 2080? We recognize the order made by Judge Magnuson limits operational alternatives for the express purposes of water supply. However, we also recognize that surface and groundwater withdrawals will continue to be made at various points in the system. The Corps alternative analysis must include metrics regarding water supply withdrawals including potential increases. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

2.2 Evaluation of Alternative Models

The Corps' unimpaired flows dataset that was used in the 1998 draft EIS was compared to 1) the unimpaired flows dataset that the Corps expects to use for the WCM update and 2) to the pre-Buford Dam USGS streamflow gage data. Aside from the addition of recent flow records, the most recent Corps-modeled unimpaired dataset is essentially unchanged from the 1998 version.

Compared to the USGS gage data, these datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes. We recommend that the use of alternative models be investigated to develop better unimpaired flow and alternative flow datasets.

Similarly, land cover has changed significantly since the early 20th century in the upper and middle portions of the ACF basin. Prior to both mainstem damming and discharge gaging, expansive agriculture, chestnut blight, fire suppression, and other factors affected land cover in the southern Appalachians, Piedmont, Fall-line Sandhills, and upper Coastal Plain regions. The hydrological consequences of land cover changes could have been manifested in the flow extremes observed during droughts and heavy rain. Nevertheless, the pre-dam hydrologic period of record is presently the best available hydrologic dataset to characterize pre-dam streamflows, develop ecosystem flow alternatives, and with which to compare flow alternatives. Models that predict hydrological alteration that occurs in response to land cover changes could be particularly useful in the development and assessment of flow alternatives.

The United States Geological Survey (USGS) is developing a Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) for the ACF. This watershed model will facilitate the inclusion of impacts of precipitation, climate, and land use changes on streamflow, sediment yields, and basin hydrology. If the PRMS is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, it should be used as an additional evaluation tool. The PRMS output potentially could be used to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions. Use of this model is based on the assumption that the PRMS model results reflect average flows and flow extremes better than existing datasets and other models. The latter analysis may be particularly useful to determine if reservoirs can maintain downstream flows through droughts.

National Oceanic and Atmospheric Administration (NOAA) funded the Georgia Water Resources Institute (GWRI) to complete a historical and future assessment of precipitation, evapotranspiration, soil moisture, and run-off trends in the ACF Basin to support ongoing water resources planning in the region. This method used both historical gage data and the Corps unimpaired flows dataset in a Joint Variable Spatial Downscaling model that incorporated climate change effects. Future stream flow, river flow, reservoir level, and power generation forecasts were made at the sub-basin level for the next 100 years. Coordination with USGS and GWRI should occur regarding these new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

Lastly, the Corps' HEC-5Q water quality analyses rely on average daily flow to predict water quality parameters (e.g., temperature and dissolved oxygen) in six hour time steps and at 0.5 mile intervals. Although these model outputs can be used to compare among flow alternatives, they are not expected to accurately predict either the water quality values or the range of values that

are likely to occur in response to hourly discharge changes. Alternative water quality models exist and State resource agencies should be contacted to determine whether water quality models are developed for the ACF Basin. Additionally, regression models that accurately predict water quality parameters (e.g., water temperature and dissolved oxygen) can be developed using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure). Alternative water quality assessment methods should be considered to accurately evaluate effects of flow alternatives on water quality.

3. Evaluation of Corps Alternatives for FWCA Report

3.1 ResSim Model Output Analyses

It is our understanding that ResSim will be used for the Corps' flow analyses. The flow statistics used by the Service in the past to analyze the resulting datasets were derived by using the Indicators of Hydrologic Alteration (IHA) and the Range of Variability Approach (RVA). Because flow is a master variable in fluvial systems, and because the ecology of fish and wildlife is closely linked to the flow regimes in which they evolved, the current evaluation should continue to rely on tools such as IHA, RVA, and Environmental Flow Components (EFCs) (Mathews and Richter 2007). Specific flow statistics and species-specific flow-ecology relationships (as available) that are important to natural resource sustainability, as well as the ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC) study (Freeman et al. 1997), should also be considered.

3.2 HEC-5Q Water Quality Model Output Analyses

It is our understanding that HEC-5Q will be used for the Corps' water quality analyses. We understand that this model predicts water quality parameters in six hour time intervals in river and reservoirs. Similar to the analyses contained in the Corps' 1998 draft EIS (Corps 1998), the analyzed data should be composed of summer values (May through October), separated by drought, dry, average, and wet year types for each alternative. The following information should be developed for each alternative to evaluate the effects on water quality and aquatic resources in the modeled tailrace and riverine locations:

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters;
- Total number of instantaneous "measurements" less than 4 mg/L;
- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L);
- Monthly exceedance figures and box plots with outliers for water temperature; and
- Average stream percent wastewater.

For each alternative, the following information should be developed to evaluate the effects on water quality and aquatic resources for the modeled ACF reservoir locations:

- Average values of summer Chlorophyll a (*u*g/L);
- Average summer retention time (days); and

- Average summer phosphorus loading (pounds/acre/month).

3.3 Floodplain Connectivity Analyses

Assessing the extent of floodplain inundation will be a critical component of the alternatives analysis assessment. The Apalachicola River floodplain analysis should be decided following the Corps' attempt to access the river stage-based LIDAR data collected and housed by the NWFWMD. If the data are made available, the Corps should provide these data to the Service and an analysis of the area of aquatic habitat (separated by aquatic habitat type) connected to the Apalachicola River under the range of discharges for the period of record should be evaluated. If LIDAR data are not provided, the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation should be evaluated using the relationships quantified by Light et al. 1998 and Light et al. 2006.

Although the areal extent of the Chattahoochee River floodplain is one-fifth that of the Apalachicola River floodplain (Davis 1997), it likely served multiple important ecological roles prior to flow alteration by multiple mainstem reservoirs. To our knowledge, the Tri-State Comprehensive Study Riparian Wetland Element (Davis 1997) houses the best available dataset for assessing the effects of flow alternatives on the Chattahoochee River floodplain. These data should be used to evaluate the probable extent of floodplain inundation for each flow alternative. However, data are only available for one riverine site in the Chattahoochee River Basin positioned between Jim Woodruff Lock and Dam and G.W. Andrews Lock and Dam. At unsurveyed locations, known river stages at which floodplain inundations occurs should be used to evaluate the frequency, duration, and timing of floodplain inundation for flow alternatives provided by the Corps (see Table 1 and associated information provided by NWS 2010). At sites without this information, the 2-year recurrence interval discharge to approximate the incipient point of flooding should be used to evaluate the frequency, duration, and timing of floodplain inundation. Because channel alteration (e.g., channel incision) can increase the recurrence interval at which flooding occurs and because we have little information on channel alteration, other data sources should be investigated to aid in the floodplain inundation assessment.

3.4 Reservoir Fisheries Analyses

Sport fisheries are important recreational and economic resources in all of the Federal ACF reservoirs. Important sport fishes in all five reservoirs include largemouth bass and crappie, but each reservoir supports a mix of several additional species, including walleye (Lanier Reservoir only), striped bass, bluegill, redear sunfish, and others. Based on interviews of fisheries managers and researchers in the basin, Ryder et al. (1995) identified the species considered critical in an evaluation of operating alternatives and the relative acceptability of reservoir levels for these species. A Delphi technique was used to obtain expert opinion for select reservoirs on reservoir fish guilds, important seasonal periods for those species, and acceptability ratings for various reservoir levels in the ACF and ACT (Ryder et al. 1995). The Service cooperated with the Corps for the 1998 draft EIS for ACF water allocation to develop a reservoir fisheries performance measure using the findings of Ryder et al. (1996). This information was used to create a reservoir fisheries performance measure by looking at the critical spawning and rearing periods, reservoir elevations during these times, and assigning a greater weight to stable or rising elevations during those time periods. The performance measures were then compared for the various alternatives.

The reservoir fisheries performance measure should be updated with additional information, literature, and/or relevant datasets that have been developed in the past ten years, and used to evaluate the relative impacts of the Corps' alternatives on reservoir sport fisheries. Potential new datasets to be included that have been indentified to date include largemouth bass young-of-year data in West Point Reservoir (Brent Hess, GDNR-WRD, 2010, pers. comm.), as well as black basses and crappie data in relation to reservoir retention times and year-class strength in Walter F. George, West Point, and Bartletts Ferry reservoirs (Mike Maceina, Auburn University, 2010, pers. comm.).

3.5 Riverine Fisheries Analyses

Sport fisheries are also important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. Data identified to date will be provided by the FFWCC and the USGS and used to evaluate the relative impacts of the Corps' alternatives on riverine sport fisheries. Specific measures to be evaluated include year-class strength versus acres of inundated floodplain spawning habitat, changes in catch rates of sportfishes in various water years, and changes in relative weight (condition) of sportfishes in various water years.

3.6 Apalachicola Bay Salinity Analyses

If a salinity model is incorporated in the WCM update process, as described in Section 1.8 above, the model output should be incorporated in the FWCA evaluation. A list of data needs should be developed to be produced as a result of these analyses. These data should include the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios and possibly the percent oyster mortality and oyster growth rates.

3.7 Federally-protected Species Analyses

It is our understanding that the Corps will be conducting certain analyses to evaluate the effects of the various alternatives on federally-protected species. These analyses will be contained in the Corps' Biological Assessment (BA) accompanying the draft EIS. The Service will include these analyses in our FWCA evaluation, assuming they are available for us to do so. The types of analyses that should be evaluated are contained in the "*Analyses for the Effects of the Action*" section of the Service's June 1, 2008, RIOP Biological Opinion (USFWS 2008) and are listed below:

Gulf sturgeon

- Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning;
- Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at

least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning;

- Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae;
- Maximum number of consecutive days per year less than 16,000 cfs; and
- Departures from average water temperatures between March 1st to May 31st.

Freshwater mussels

- Lowest daily flow for each year;
- Inter-annual frequency of flows less than 5,000-10,000 cfs;
- Maximum number of days per year with flows less than 5,000 – 10,000 cfs;
- Maximum number of consecutive days less than 5,000 – 10,000 cfs;
- Median number of days per year less than 5,000 – 10,000 cfs;
- Frequency (percent of days) of daily stage changes (ft/day); and
- Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs.

Floodplain connectivity

- Frequency (% of days) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998);
- Frequency (% of years) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998).

4.0 Recommendations for Additional Coordination

This PAL includes comments from the State wildlife agencies in the basin. As is encouraged under the FWCA, we will continue to coordinate with these agencies, and will coordinate with NOAA Fisheries, as we move forward.

To assist in the development of alternatives and mitigation, we have suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, impacts to Eufaula National Wildlife Refuge, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We have identified analyses to evaluate Corps alternatives with respect to flow, water quality, floodplain connectivity, reservoir and riverine fisheries, Apalachicola Bay resources, and federally-protected species. We anticipate that the next step will be for the Corps and the Service to work together to update the interagency SOW to reflect Corps and Service responsibilities for the evaluations and analyses contained in this PAL. As you know, such a division of labor occurred to produce the prior DEIS and FWCA Report (Corps 1998).

We would like to be involved in the development of alternatives, including the development of environmental flows alternatives. The Service would like to assist in the development of such

alternatives to maximize benefits to ecological resources and to gain a better understanding of the consequences of implementing such alternatives on other authorized project purposes and operational constraints. Once all of the alternatives have been analyzed, we anticipate working with the Corps to identify opportunities for restoration, compensation, and enhancement.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress the Corps water management is not just about avoiding adverse affects, but also to look at opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Everson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL
B. Zettle, Corps, Mobile, AL
M. Eubanks, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
M. Thomas, GDNR-WRD, Social Circle, GA
C. Martin, GDNR-WRD, Social Circle, GA
B. Hess, GDNR-WRD, LaGrange, GA
R. Weller, GDNR-WRD, Albany, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
D. Bernhart, NOAA, St. Petersburg, FL

Literature Cited

Ahlstedt, S.A., J.R. Powell, R.S. Butler, M.T. Fagg, D.W. Hubbs, S.F. Novak, S.R. Palmer, and P.D. Johnson. 2004. Historical and current examination of freshwater mussels (Bivalvia: Margaritiferidae, Unionidae) in the Duck River basin Tennessee. Final report submitted to satisfy the requirements of the Tennessee Wildlife Resource Agency contract FA-02-14725-00.

Couch, C.A., E.H. Hopkins, and P.S. Hardy. 1996. Influences of environmental settings on aquatic ecosystems in the Apalachicola-Chattahoochee-Flint River Basin. U.S. Geological Survey Water-Resources Investigations Report 95-4278.

Davis, M.M. 1997. Tri-State Comprehensive Study Riparian Wetland Element, Report 1: Relationship between Flow and Habitat Value in the Alabama-Coosa-Tallapoosa/Apalachicola-Chattahoochee-Flint (ACT/ACF) River Basins. Miscellaneous Paper EL-97-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Freeman, M.C., J.M. Nestler, and P.N. Johnson. 1997. Riverine Resources: Water Needs and Environmental Effects Analyses in the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. Final Report to the Technical Coordinating Group of the ACT-ACF Comprehensive Study, U.S. Geological Survey, Biological Resources Division, Patuxent Wildlife Research Center, Athens, GA.

Freeman, M.C., Z.H. Bowen, K.D. Bovee, and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11(1): 179-190.

Georgia Power Company. 2002. Final License Application, Applicant-Prepared Environmental Assessment, Middle Chattahoochee Project (FERC No. 2177). December 2002, pg. 34, Appendix E, Figures E-2 through E-4.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood-pulse concept in river-floodplain systems, p. 110-127. *In* D.P. Dodge [ed.] Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106.

Light, H.M, M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida. U.S. Geological Survey Professional Paper 1594.

Light, H.M., Vincent, K.R., Darst, M.R., and Price, F.D. 2006. Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin,W. Huang, J.D. Christensen, M.E. Monaco, T.A. Battista, C.J. Klein, R.L. Howell IV, and G.L. Ray. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Mathews, R., and B.D. Richter. 2007. Application of the indicators of hydrologic alteration software in environmental flow setting. Journal of the American Water Resources Association 43: 1400-1413.

National Weather Service Advanced Hydrologic Prediction Service (NWS) 2010. http://ahps.srh.noaa.gov/

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg, 1997. The Natural Flow Regime. BioScience 47:769-784.

Postel, S. and B. Richter. 2003. Rivers for Life: Managing Water for People and Nature. Island Press. 253 pp.

Richter, B.D., J.V. Baumgartner, D.P. Braun, and J. Powell. 1998. A spatial assessment of hydrologic alteration within a river network. Regulated Rivers 14:329-340.

Ryder, S., J. Taylor, and J. Crance. 1995. Relations between reservoir surface water elevations and reservoir fisheries. Comprehensive Study Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins, U.S. Army Corps of Engineers, Mobile, AL.

Ryder, S., J. Taylor, and J. Crance. 1996. Relations between reservoir surface water elevations and reservoir fisheries in the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. National Biological Service, Ft. Collins, Colorado. 48 p. + apps.

Sheng, Y.P. and T. Kim. 2009. Skill assessment of an integrated modeling system for shallow coastal and estuarine ecosystems. Journal of Marine Systems 79: 212-243.

United States Army Corps of Engineers. 2009. Water Resources Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs, Expires 1 July 2011. July 1, 2009. Circular No. 1165-2-211, Washington, D.C. 31 pp.

United States Army Corps of Engineers. 1998. Draft Environmental Impact Statement Water Allocation for the Apalachicola-Chattahoochee-Flint (ACF) River Basin Main Report, September 1998, Mobile District, Mobile, Alabama.

United States Fish and Wildlife Service. 1999. Instream Flow Guidelines for the ACT and ACF Basins Interstate Water Allocation Formula. October 25, 1999. 40 pp.

United States Fish and Wildlife Service. 2008. Biological Opinion on the U.S. Army Corps of Engineers Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. June 1, 2008, Panama City Field Office, Panama City, Florida. 225 pp.

Table 1. Locations and river stages in the Chattahoochee River where the National Weather Service Advanced Hydrologic Prediction Service predicts damage to occur. Discharges were calculated using stage-discharge relationships at USGS streamflow gages. Only damage to manmade structures was considered as damage. Flooding of riverwalks, riverwalk structures, yards, and moving of equipment or livestock to avoid inundation was not considered to be damage.

Location (upstream to downstream order	Stage at which damage occurs	Discharge at which damage occurs
Chattahoochee at Norcross	16	20631
Chattahoochee at Roswell	14	29846
Chattahoochee at Atlanta	18	22023
Chattahoochee at Whitesburg	26	49379
Chattahoochee at West Point	21	62530
Chattahoochee at Columbus	41	261407

Figure 1. Histogram of mean + standard error daily discharge values reported in cubic feet per second (cfs) obtained from river gauges on the Duck River at Shelbyville (top) and Columbia (bottom), Tennessee by season. Means represent daily discharge values for each month for 10 years pre and 10 years post Reservoir Release Discharge Initiative (RRI) completed at Normandy Dam beginning in late 1991. Letters atop standard error bars indicate significantly different means as determined by Tukey's a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

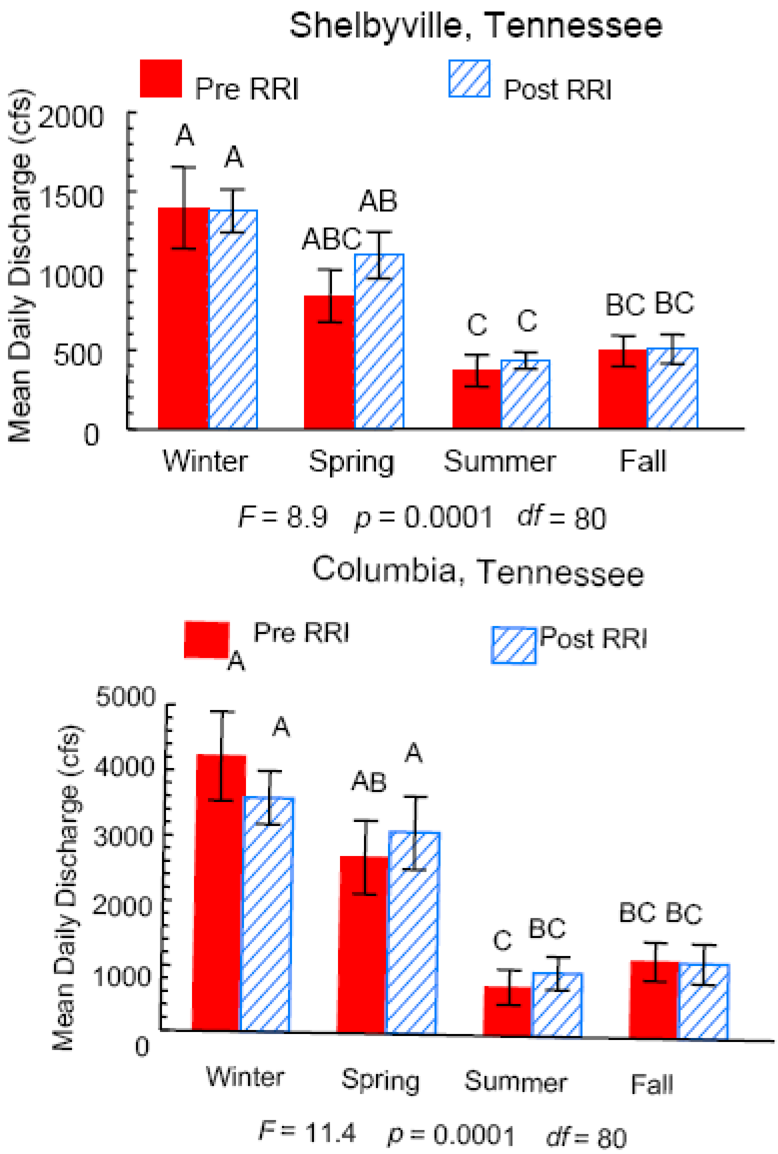
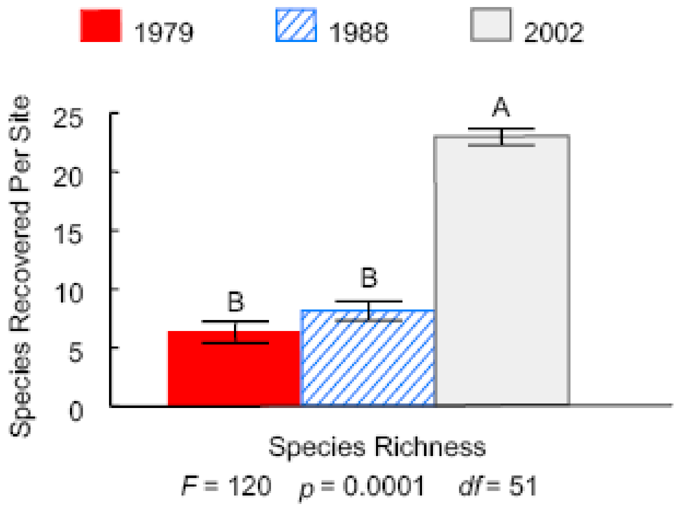


Figure 2. Comparative mean + s.e. of mussel species (top) and mussel number (bottom) sampled from 17 sites in the Duck River in 1977, 1988, and 2002. Letters atop standard error bars indicate statistically different means determined by Tukey's HSD a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.



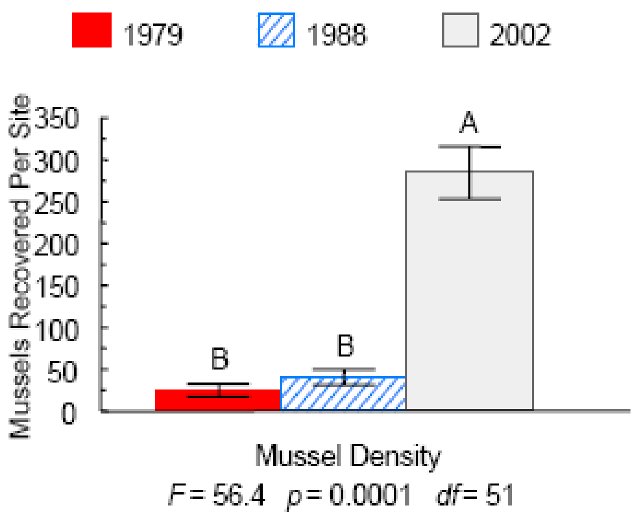
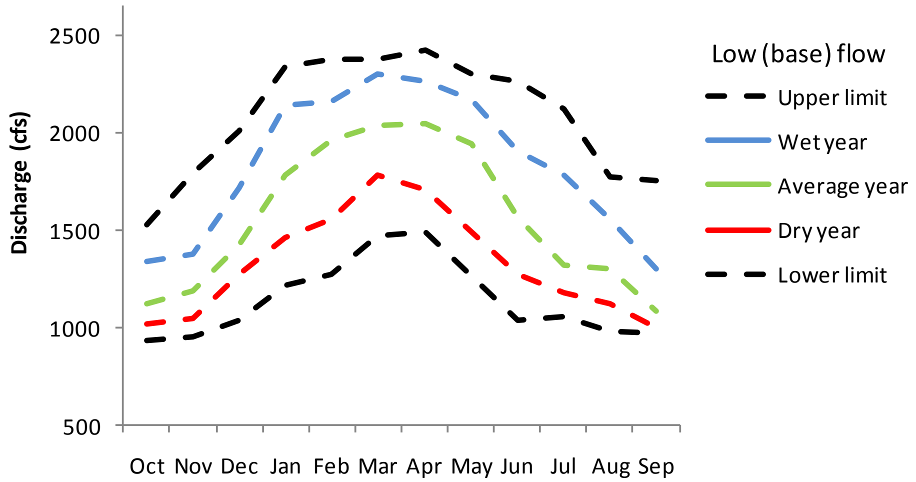


Figure 3. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River USGS Norcross gage.

a)



b)

Data analyzed: The only pre-Buford dam data that were available for this analysis extended between 1903 and 1946 (44 years) at the Chattahoochee River gage (02335000) at Norcross.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS Norcross gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small pulses

At the Chattahoochee River USGS Norcross gage, 9-18 flow pulses per year should be between 3,658 and 4,980 cfs, should last between 2-3 days, and should occur between mid-March and early June. Rise and fall rates can range between 1,260-2,054 cfs and 1,178-733 cfs, respectively.

High pulses

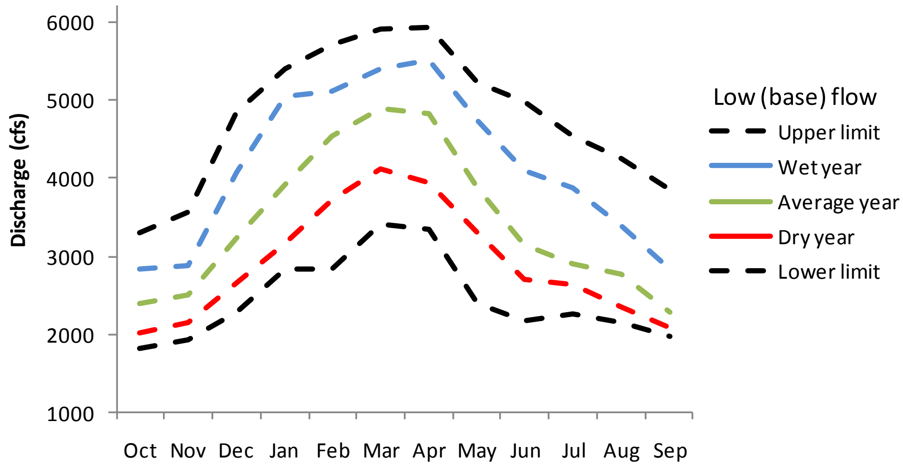
In wet years, a pulse of 17,650-28,080 cfs should last 9-80 days, should occur between early January and early May. Rise rates should range between 697-7518 cfs/day, and fall rates should range between 3376-460 cfs/day.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 4. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the USGS gage below West Point Dam.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1896 and 1955 (60 years) at the Chattahoochee River gage (02339500) below West Point Dam.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Chattahoochee River gage below West Point, 9-16 flow pulses per year should peak between 8,853 and 11,580 cfs, should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates can range between 2,483-3,698 cfs/day and 2,256-1,536 cfs/day, respectively.

High Pulses

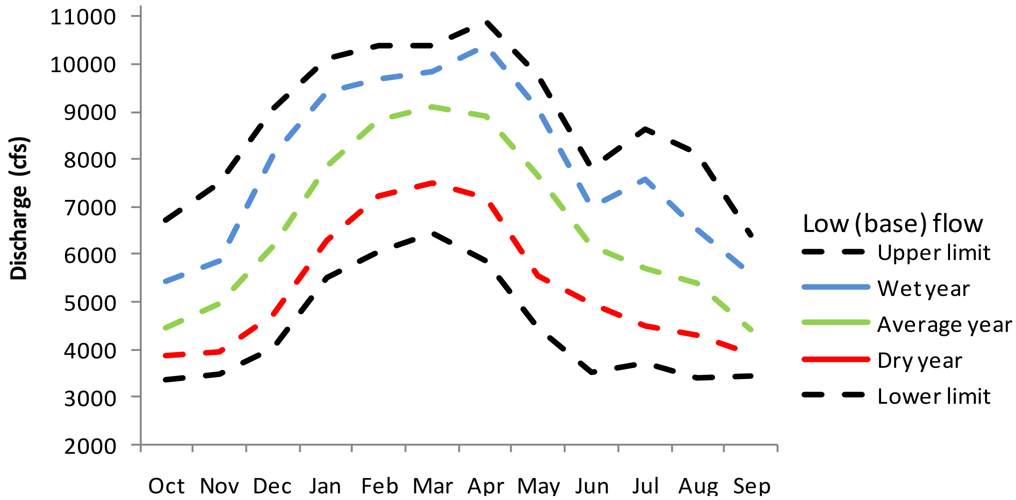
In wet years, a pulse that peaks between 48,830 - 58,950 cfs should last between 19-38 days, and should occur between mid-January and early April. Rise and fall rates can range between 5,563-13,170 cfs/day and 4,230-1787 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 5. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the Walter F. George Corpsnode.

a)



b)

Data analyzed: ACOE unimpaired flows dataset at the Walter F. George node and inferences from West Point analysis results.

Base flow description

No USGS discharge data for the pre-Buford dam period are available at Walter F. George. However, comparisons between pre-Buford USGS gage data and Corps-modeled "unimpaired flows" data show similar median monthly flows. Thus, we used median monthly flows in the Corps-modeled unimpaired dataset (1936-2006) to calculate the predicted low (base) flows that should occur at the W.F. George node. We excluded 103 negative flow values from the Corps dataset in this analysis.

Low (base) flows are defined as all flows that fall below the lower 25^{th} percentile of flows for the pre-Buford Dam period at the USGS West Point gage. The 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

Again, no USGS discharge data for the pre-Buford dam period are available at Walter F. George. Corps-modeled unimpaired flows do not represent the flow extremes (minimum and maximum flow duration, magnitude, timing, frequency, and rate of change) that were observed at USGS gages during the pre-Buford Dam period. Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified.

Small pulses

We infer from the West Point analysis that used real pre-Buford Dam USGS data, that 9-16 flow pulses per year should peak between 1.8-2.4 times higher than the baseflow river stage (approximately 16,369-21,535 cfs) in March for an average flow year. Pulses should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates should not exceed rates from other site recommendations.

High pulses

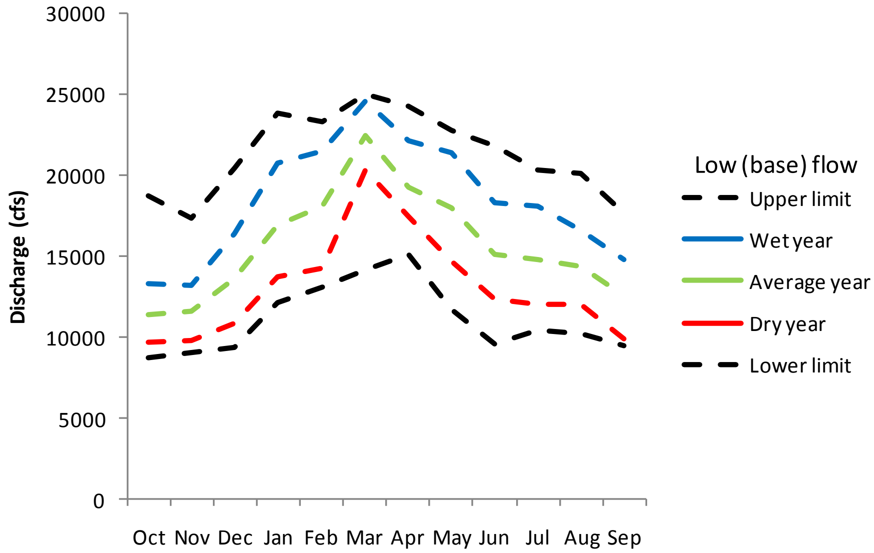
Development of a wet year flow guidelines is complicated by the fact that no stage-discharge relationships are presently known for the river segment between Walter F. George Dam and Woodruff Dam. However, the National Weather Service Advanced Hydrologic Prediction Service indicates that extensive floodplain inundation occurs at a river stage of 150 ft, although no significant damage is predicted to occur up to 160 ft. Consequently, we recommend that the ACOE evaluate wet year releases from Walter F. George that range between 150 and 160 ft. Duration, timing, and rates of change should be similar to the recommendations for West Point Dam.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 6. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Apalachicola River USGS gage at Chattahoochee, FL.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1922 and 1955 (34 years) at the Apalachicola River gage (02358000) at Chattahoochee, FL.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Apalachicola River gage at Chattahoochee, FL, 3-6 flow pulses per year should peak between 30,950 and 41,110 cfs, should last between 4-13 days, and should occur between mid-February and mid-May. Rise and fall rates can range between 2,493-5,356 cfs/day and 2,353-1,473 cfs/day, respectively.

High Pulses

In wet years, a pulse that peaks between 86,630-122,800 cfs should last between 28-68 days, and should occur between late-February and early April. Rise and fall rates can range between 2,544-8,108 cfs/day and 4,236-2,330 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 7. Monthly maximum, average, and minimum dissolved oxygen concentrations in the Chattahoochee River at Buford Dam. Data courtesy of Georgia Department of Natural Resources-Wildlife Resources Division.

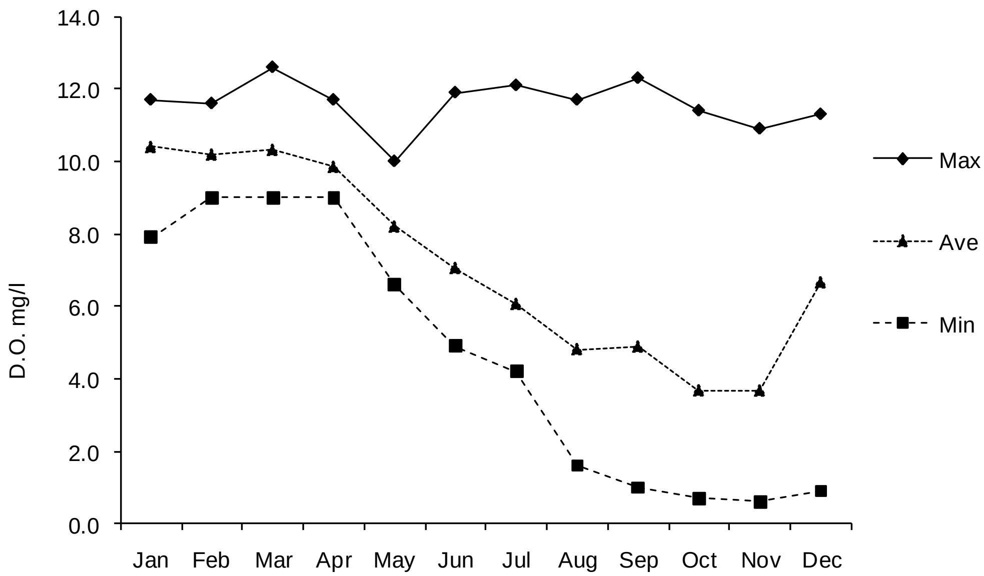
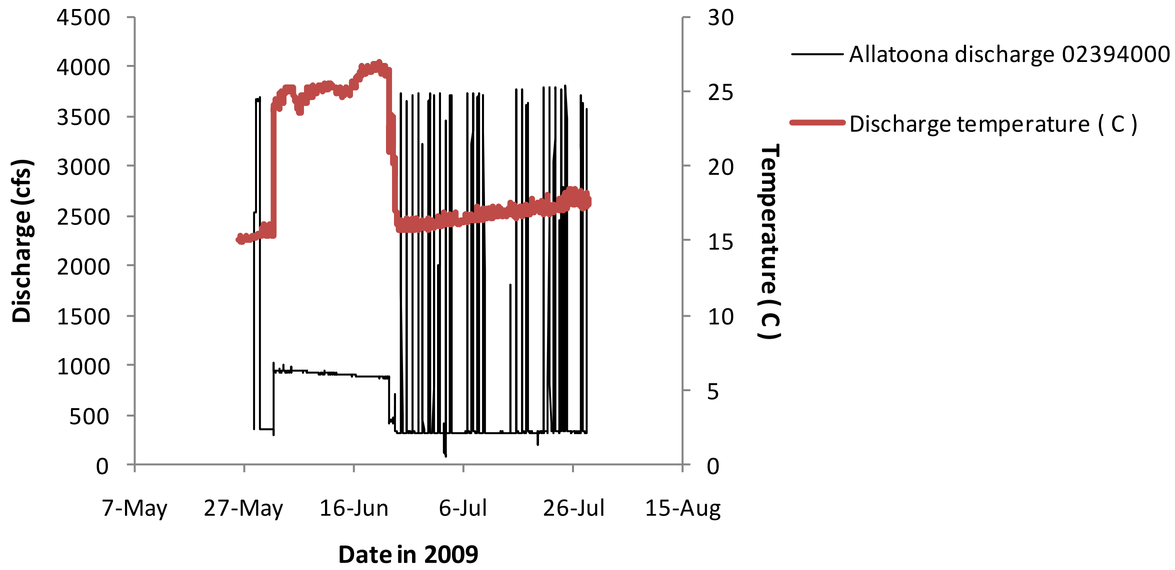


Figure 8. Discharge and water temperature measurements below Allatoona Dam on the Etowah River, Georgia. Sluicing from a location higher in the reservoir's water column occurred in June, causing the observed downriver temperature increases.



United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

March 1, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing an Addendum to the U.S. Fish and Wildlife Service (Service)'s April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the WCM Updates is to identify operating criteria and guidelines for managing water storage and release of water from United States Army Corps of Engineers (Corps) reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the Service's 2010 PAL was to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. Based on recent analyses conducted by the Service, we submit the following addendum under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). This addendum solely addresses ecosystem flow guidelines -- all other information and recommendations in the PAL are still applicable. In the future, we will provide additional information in the form of a draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

Rationale for revision of ecosystem flow guidelines

The ecosystem flow guidelines that were delivered in the PAL were developed with the aid of Indicators of Hydrologic Alteration (IHA; TNC 2007). Although the IHA methodology is scientifically defensible, subsequent examination of IHA methodology and output revealed several concerns that could affect possible incorporation of the guidelines in the Corps' operations. Therefore, the Service is providing revised low and high flow guidelines (Figures 1-4 and Tables 1-4).

We had two reasons for revising the flow guidelines. First, the default IHA parameters used for the PAL initially separated the flow data into high and low flows using a percentile of the pre-Buford period of record. This method resulted in representation of low-flow discharges in summer-fall months by many values, and representation of low flows in winter-spring months by fewer values. This means that some months in some years were not represented in subsequent analyses. For example, historic low flows in the Apalachicola River remained above the 75th percentile or above flood stage for prolonged time periods, meaning that those periods were not represented in the low flow analysis. Thus, if the historic flow regime is to be used to help guide low flow alternative development, evaluation, and implementation, the low flow analysis should examine the entire range of low flows that occurred in every month of every year before construction of Buford Dam.

Second, the low and high flow analyses in IHA calculate summary statistics using median values (for non-parametric analyses) to represent each year (TNC 2007). For example, IHA calculates the annual median high pulse magnitude, and uses the median values from every year to calculate summary statistics. While this is a statistically valid approach to summarizing large datasets, summarizing multiple intra-annual pulses by a single value results in a narrower range of magnitude, duration, timing, and rate of change values. Because the intent of the analysis is to quantify a range of discharge values that are likely to be beneficial to riverine habitat and fauna and to facilitate planning for high flows in the Corps' operations, we calculated the following high-flow guidelines by including each high flow event in summary statistic calculation (e.g., percentiles representing upper and lower limits, and dry, average, and wet years). With the exception of not using annual medians to calculate percentiles, the revised method for high flow guideline development is analogous to the "non-advanced" method for high flow analysis in IHA.

Low flow analysis methodology

1. In Microsoft Excel, the seven smallest values from each month in every year were extracted for analysis. We chose multiple values to represent each month so that the overall results are less likely to be influenced by an aberrant value (i.e., less likely to be skewed by one value), especially in future analyses that may examine and compare Corps' modeled flow alternatives which are likely to occasionally contain negative discharge values. A comparison of the effects of one, seven, and ten minimum flow values to represent low flows in each month showed little difference in overall low flow hydrograph shape, similar flow magnitudes throughout the year, and minor differences in winter 90th percentile flow magnitudes. These results also generally correspond to the Web-based Hydrograph Analysis Tool (WHAT Local Minimum Method; Lim et al. 2005) output for baseflow generation. Collectively, these results lend greater support for the decision to use the seven lowest values to characterize low flows.

2. The 10th, 25th, 50th, 75th, and 90th percentiles for each month were calculated on the extracted data to define the lower limit, dry year, average year, wet year, and upper limit, respectively.

3. The Walter F. George low flow guidelines were calculated slightly differently. A long-term period of pre-Buford Dam discharge data was not available below Walter F. George. As a proxy

for actual data, the Corps' unimpaired flows dataset was used. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Thus, these low flow guidelines should be treated as estimates.

4. Note that in this low flow analysis, in cases where an entire month is above flood stage, the lowest values are flood-related values. A strength of the low flow analysis is that the user can characterize the entire range of the lower flows that occur in every month of the user's flow dataset.

High flow analysis methodology

1. In Microsoft Excel, the 75th percentile of all flows in the time series was used as the flow threshold to separate high flows from the remainder of the flow dataset. Because this is consistent with our understanding of the meteorological conditions that should cause pulses to occur, the 75th percentile is a valid threshold to separate low and high flows.

2. The following parameters were then calculated: The duration of each high flow event, the maximum discharge in each sequence of high flows, the date of the initial high flow value, the rise rate (calculated as the difference between the preceding low flow value to the maximum flow divided by the number of time steps (n-1)), and the fall rate (calculated as the difference between the maximum flow and the following low flow value, divided by the number of time steps (n-1)).

3. The 2-year and 10-year recurrence interval discharges were calculated using the following methodology: Maximum discharge was calculated for every year, and the 50th and 90th percentiles in Excel were used to calculate approximations of the 2- and 10-year recurrence intervals, respectively. This is a close approximation to the IHA method, but not as sophisticated as the USGS PeakFQ calculation (Flynn et al. 2006). Nevertheless, these percentiles provide close approximations of these recurrence interval discharges. Although bankfull discharge in the Coastal Plain physiographic province tends to occur more frequently than every two years, we used an approximate 2-year recurrence interval basinwide as a consistent guide.

4. The 2-year and 10-year recurrence interval discharges were used to further separate high flows into small pulses, high pulses, and floods (note: these are the default values used in IHA to separate high flow data). Maximum high flow values between the 75th percentile and the 2-year recurrence interval were classified as small pulses (analogous to High Pulses in IHA). Values between the 2- and 10-year recurrence interval were classified as high pulses (analogous to small floods in IHA), and values greater than the 10-year recurrence interval were classified as floods. With the exception of the Apalachicola River analysis, floods greater than the 10-year recurrence interval were excluded from this letter because they exceed the discharge stages that are predicted to cause damage according to the National Weather Service Advanced Hydrologic Prediction Service (Table 1 in April 2, 2010 PAL).

5. The range of discharge values that were used to define small and high pulses are presented in the tables. Similar to the PAL, we also provide the 25th and 75th percentiles of the magnitudes, frequencies, durations, rise rates, and fall rates which were calculated separately for small pulses,

high pulses, and floods. These values correspond to the high flow guidelines presented in Tables 1-4. Timing values were visually estimated from histograms of pulse or flood occurrence by month.

6. The Walter F. George high flow guidelines were calculated slightly differently. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified. Thus, high pulse frequency, duration, timing, and rate of change calculations were used from the West Point analysis. To calculate magnitudes, however, the West Point analysis indicated that pulses should peak 1.6-3.5 times higher than the low flow river discharge in March [7,720-16,500 cubic feet per second (cfs)]. Assuming that pulses at Walter F. George should also peak 1.6-3.5 times higher than March low flow (derived from the Corps' unimpaired flows model output), small pulses below Walter F. George should peak between 14,161-30,978 cfs.

Figure 1. Low flow guidelines for the Chattahoochee River near Norcross, GA (USGS 02335000).

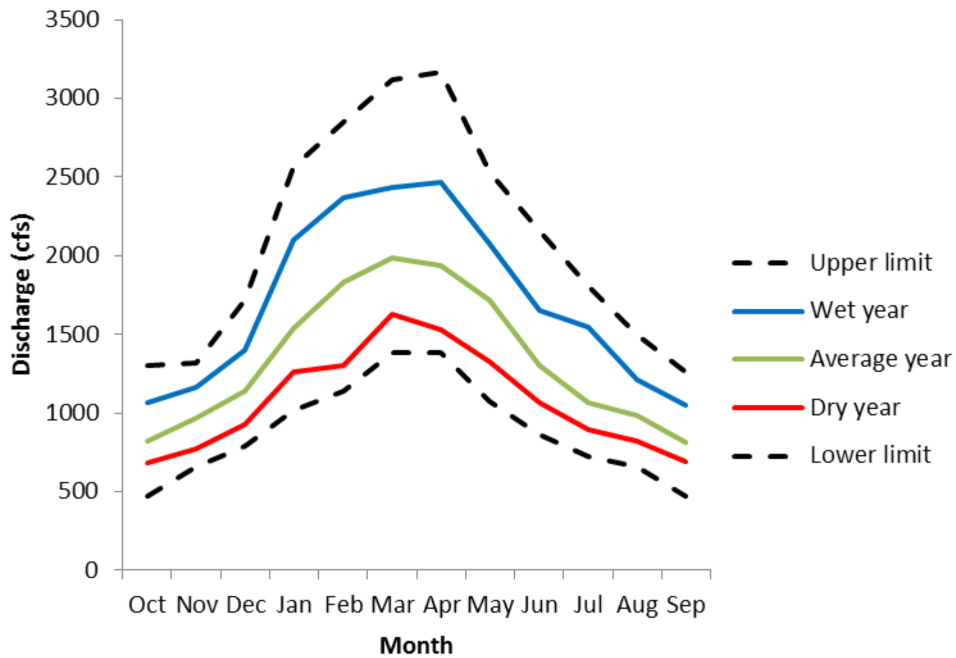


Figure 2. Low flow guidelines for the Chattahoochee River at West Point, GA (USGS 02339500).

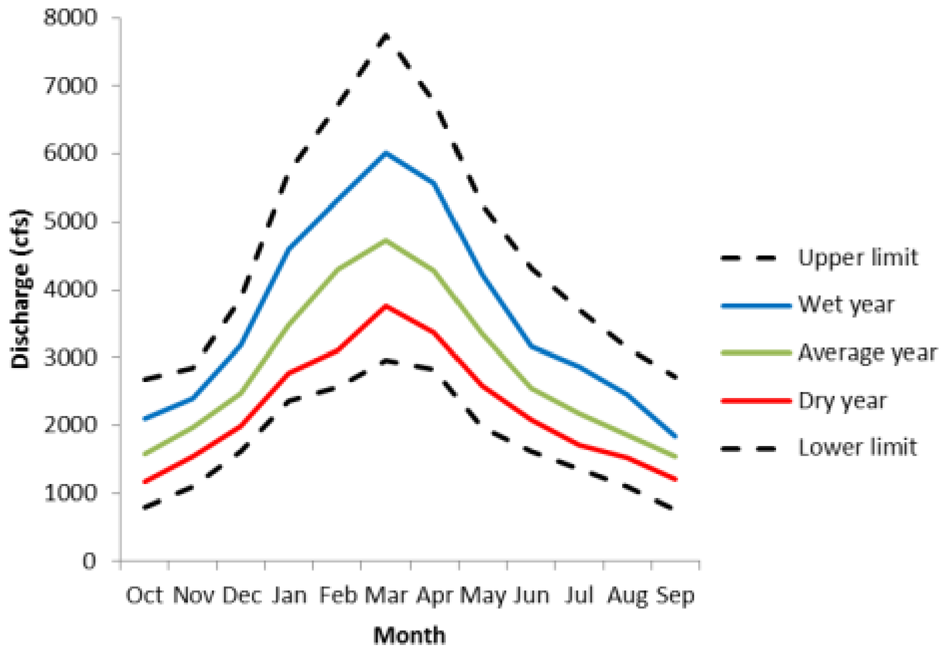


Figure 3. Low flow guidelines for the Chattahoochee River at Walter F. George using the Corps' unimpaired flows dataset.

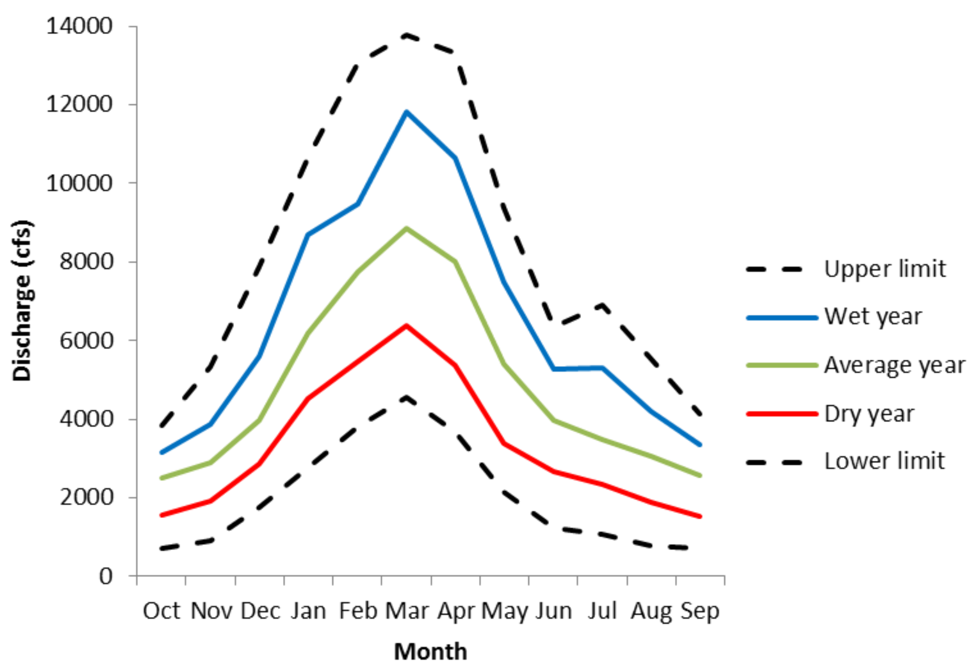


Figure 4. Low flow guidelines for the Apalachicola River at Chattahoochee, FL (USGS 02358000).

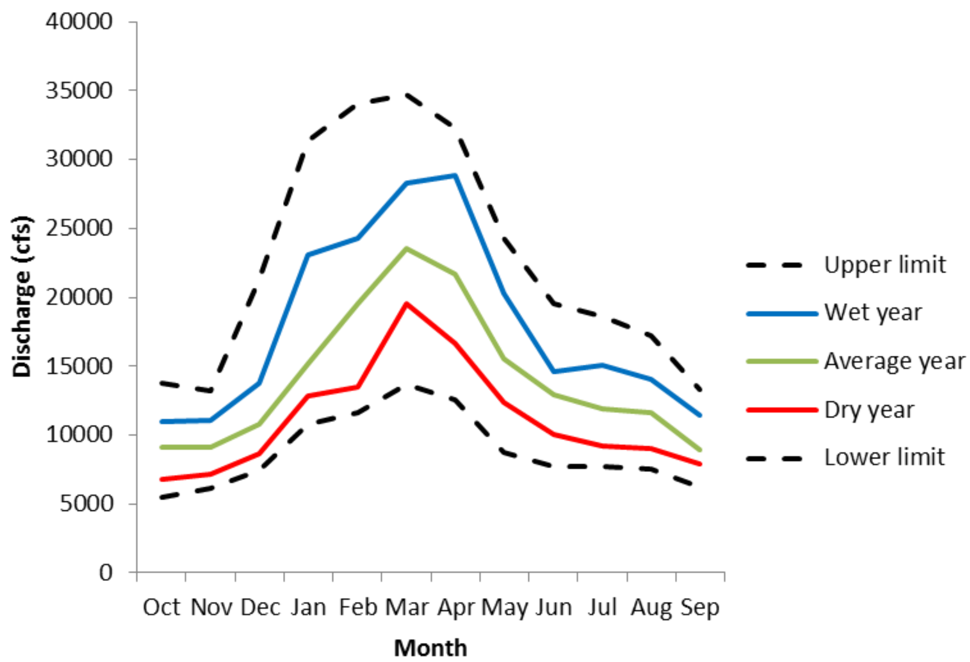


Table 1. High flow guidelines for the Chattahoochee River near Norcross, GA developed from USGS gage 02335000 for the pre-Buford Dam period from January 1, 1903 to September 30, 1946.

	Small pulse	High Pulse
Range used (cfs)	2550-17249	17250-33549
Magnitude (cfs)	3105-6787.5	19000-28900
Frequency (# events/year)	9-18	0-1
Duration (days)	1-5	11-72
Rise Rate (cfs/day)	770-2775	927-7830
Fall Rate (cfs/day)	507-1452	459-2193
Timing	Oct-Sep	Dec- Mar

Table 2. High flow guidelines for the Chattahoochee River near West Point Dam developed from USGS gage 02339500 for the pre-Buford Dam period from August 1, 1896 to December 31, 1955.

	Small pulse	High Pulse
Range used (cfs)	6250-45649	45650-71079
Magnitude (cfs)	7720-16500	51150-60825
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

Table 3. High flow guidelines for the Chattahoochee River at Walter F. George Dam developed from low flow analysis on the Corps' unimpaired flow dataset, and inferences from Chattahoochee River at West Point Dam high flow analysis. See text for additional details.

	Small pulse	High Pulse
Range used (cfs)	N/A	N/A
Magnitude (cfs)	14,161-30,978	95598-114187
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

*Upper range of high pulse values may need to be reevaluated to ensure that damage to structures is avoided. The stage discharge relationship (used to ensure that guidelines do not cause damage) was calculated using available data between 79 ft (6,510 cfs) and 110 ft (90,200 cfs; USGS gage 02343805), meaning that discharge calculations above this range of values are extrapolations and should be used cautiously.

Table 4. High flow guidelines for the Apalachicola River near Chattahoochee, FL developed from USGS gage 02358000 for the pre-Buford Dam period from July 1, 1922 to December 31, 1955.

	Small pulse	High Pulse	Flood
Range used (cfs)	25800-73799	73800-150499	≥ 150500
Magnitude (cfs)	28600-43475	85650-116500	201500-268500
Frequency (# events/year)	3-6	0-1	≥ 10 year RI
Duration (days)	3-15	32.5-68.5	49.5-89.5
Rise Rate (cfs/day)	2166-5606	2763-8056	7650-8761
Fall Rate (cfs/day)	1250-2615	1916-3811	4527-5795
Timing	Dec-Sep	Jan-Mar	Jan-Apr

Thank you for your January 18, 2011, response to the Service's PAL-requested analyses. We are currently reviewing the information that you provided, but recommend using ecosystem flow guidelines as calculated in the manner outlined above. As we continue to review the information you have produced, additional addendums or information requests may be supplied by the Service. We appreciate the opportunity to participate in the planning stages of your project and look forward to exploring opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Everson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL
B. Zettle, Corps, Mobile, AL
Pete Taylor, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
M. Thomas, GDNR-WRD, Social Circle, GA
C. Martin, GDNR-WRD, Social Circle, GA
B. Hess, GDNR-WRD, LaGrange, GA
R. Weller, GDNR-WRD, Albany, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
D. Bernhart, NOAA, St. Petersburg, FL

Literature Cited

Flynn, K.M., Kirby, W.H., and Hummel, P.R. 2006. User's manual for program PeakFQ, Annual Flood Frequency Analysis Using Bulletin 17B Guidelines: U.S. Geological Survey Techniques and Methods Book 4, Chapter B4, 42 pp.

Lim, K.J., B.A. Engel, Z. Tang, J. Choi, K. Kim, S. Muthukrishnan, and D. Tripathy. 2005. Web GIS-based Hydrograph Analysis Tool, WHAT. Journal of the American Water Resources Association 41(6): 1407-1416.

The Nature Conservancy (TNC). 2007. Indicators of Hydrologic Alteration Version 7 User's Manual. 70 pp.

Florida Fish and Wildlife Conservation Commission

Commissioners
Rodney Barreto
Chair
Miami
Richard Corbett
Vice Chairman
Tampa
Kathy Barco
Jacksonville
Ronald M. Bergeron
Fort Lauderdale
Dwight Stephenson
Delray Beach
Kenneth W. Wright
Winter Park
Brian S. Yablonski
Tallahassee

Executive Staff
Nick Wiley
Executive Director
Greg Holder
Assistant Executive Director
Karen Ventimiglia
Deputy Chief of Staff

Legal Office
Bud Vielhauer
General Counsel

(850) 487-1764
(850) 487-1790 FAX

Managing fish and wildlife resources for their long-term well-being and the benefit of people.

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850) 488-4676

Hearing/speech impaired:
(800) 955-8771 (T)
(800) 955-8770 (V)

MyFWC.com

May 23, 2011

Ms. Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606

RE: Florida Fish and Wildlife Conservation Commission's Comments on Draft Fish and Wildlife Coordination Act Report.

Dear Ms. Lawrence;

The State of Florida, through its Fish and Wildlife Conservation Commission ("Commission") submits the following comments on the *Draft Fish and Wildlife Coordination Act Report on the Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama and Florida* ("Draft Report") shared with us on May 9, 2011. We previously provided comments on your April 2010 Planning Aid Letter ("PAL"), and supplied additional information relevant to the Draft Report in our paper entitled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystem* (February 2011). We have since reviewed (but were not afforded an opportunity to comment on) your March 2011 PAL Addendum. Florida commends the Service for identifying a number of key concerns shared by the Commission and agrees with the Service's general assessment that the Corps of Engineers' proposed alternatives, as reflected in the Corps' January 2011 response to the PAL ("PAL Response"), are unacceptable.

We wish to underscore the importance of consistent, transparent communication among the Corps, the Service and the Commission. As you correctly note, the Fish and Wildlife Coordination Act ("FWCA"), 16 U.S.C. §§ 661 *et seq.*, requires the Corps to consult with the Service and the Commission, Draft Report at 35, but such coordination has not occurred. The Corps has, in fact, refused to coordinate directly with the Commission, instead directing us to funnel our input through the Service. This is not consistent with the Corps' obligations and hinders our ability to conduct our analyses. For instance, the Service apparently has had the PAL Response since January 2011, but was only authorized by the Corps to share it with the Commission in April 2011. We are now forced to comment on the Draft Report in less than three weeks. Better coordination is required.

Nevertheless, we offer the following comments on the Draft Report and, as appropriate, the PAL Response. We trust the Service will continue to convey Florida's concerns in its discussions with the Corps.

The No Action/Baseline alternative is not acceptable.

The No Action/Baseline Alternative is a continuation of existing operations dictated in large measure by the 1989 Draft Water Control Plan ("DWCP") as modified by a series of *ad hoc* operational protocols. As a preliminary matter, it is important to note that this set of operations has never been subjected to FWCA analysis and has similarly eluded consultation requirements imposed by Section 7 of the Endangered Species Act ("ESA"), 16 U.S.C. §§ 1531 *et seq.* It is imperative that the No Action/Baseline Alternative be scrutinized meaningfully and not accepted merely because it constitutes a continuation of the *status quo*.

To that end, threatened and endangered species conservation is compromised by the arbitrary storage thresholds described on pages 1-9 to 1-11 of the PAL Response. These "Actions Zones" reflect interim operational practices implemented through the Revised Interim Operating Plan. Continued adherence to the Action Zones precludes the Corps from using the full conservation storage capacity for all the purposes authorized by Congress when the lakes were constructed, and thereafter. That water should be made available to bring flows more in keeping with the Service's Environmental Flow Guidelines ("Guidelines") as identified in the PAL and PAL Addendum.

For example, year-2000 flow and lake storage hydrographs (Slides 2-7) show that when Apalachicola River flows were 2,000-3,000 cfs lower than the lower limit Guidelines and 5,000-6,000 cfs lower than the dry-year Guidelines, the lakes were still holding 800,000-1,200,000 acre feet of conservation storage plus an additional 1,856,000 acre feet of inactive storage. Existing operations model run (Baseline-0) shows that during the lowest lake levels reached in the entire period (2007), the lakes still held more than 500,000 acre feet of conservation storage plus the inactive storage.

The full storage capacity of these Federal projects is not being used as Congress intended. The balance being struck by the Corps is unreasonable, as threatened and endangered species conservation is being undermined to support, among other things, recreation and sport fishing under present Corps protocols.

For example, Florida has long expressed concerns with the Standard Operating Procedure ("SOP") governing reservoir fish spawning. The SOP deprives the Apalachicola River and its threatened and endangered species of water during the critical spawning period ostensibly for the protection of sport fish spawning in the reservoirs. Yet, there is no credible evidence that a one-foot drop in lake levels has a significant impact on year-class strength in reservoirs. In contrast, we have documented a direct correlation between year-class strength and river flow in the Apalachicola. The water withheld upstream to support sport fish spawning would make a tremendous difference in providing a longer duration of floodplain inundation in April and May to support spawning (including Gulf sturgeon and host fish for threatened and endangered mussel species) in the Apalachicola River.

Finally, analyzing the No Action/Baseline alternative (and all others), the Corps assumes that maximum upstream consumption will occur at all times. This assumption is incorrect, as consumptive use changes seasonally and in response to climatic variation. Some account should be made for this variation in all analyses.

The "Action" Alternatives are not acceptable.

The incremental differences among the No Action/Baseline alternative and the action alternatives is meaningless. These alternatives are so similar in nature, and their effects so indistinguishable, that they would not survive the most basic NEPA challenge. *See, e.g., Muckleshoot Indian Tribe v. U.S. Forest Service*, 177 F.3d 800 (9th Cir. 1999) (holding unlawful NEPA analysis that considered only no action and two virtually identical action alternatives). In fact, the proposed alternatives are little more than a gloss on the No Action/Baseline alternative.

The proposed action alternatives will actually be *worse* for threatened and endangered mussel species due to the increase in storage (and corresponding decrease in flow) caused by raising the Action Zones. While we understand that the final operating criteria chosen will be subject to ESA Section 7 consultation, we agree with the Service that the proposed changes in the reservoir Action Zones, drought protocols, and ramping rates would result in freshwater mussels being subjected to low flows for a greater duration than previously experienced. This is unacceptable, particularly given the repeated culling of mussel populations experienced over the last 5 years. For this reason, we suggest all efforts be made to maintain flows above 6,000 cfs at all times.

Moreover, the proposed action alternatives do not include a true conservation alternative designed to serve the needs of fish and wildlife and related habitats in the Apalachicola River Basin. Rather, all the alternatives are merely variations on a theme of perpetuating existing operations. As you correctly point out, fish and wildlife is a co-equal purpose under the FWCA. Draft Report at 1. The Corps does not acknowledge this, and each of the proposed action alternatives renders fish and wildlife subservient to all other uses.

In its PAL Response, the Corps completely dismisses the notion of developing an operating protocol based on replicating a more natural hydrograph that reflects the importance of the Guidelines. The Commission disagrees that such a protocol is too difficult to justify analysis. That said, the difficulty associated with developing an alternative that actually complies with the FWCA and ESA is irrelevant. The Corps is legally obligated to evaluate at least one alternative that recognizes the co-equal priority of fish and wildlife (and related habitat) maintenance.

The Guidelines (modified as per the Commission's suggestions herein) should be the foundatiou of all analyses of the Corps operations.

We generally support the Service's Guidelines and concur that these guidelines (as modified below) should be used as the yardstick against which to measure the relative "success" or "failure" of any alternative's ability to meet the needs of fish and wildlife in the Basin. Flow guidelines based on pre-dam flows need to be added to all graphs related to fish and wildlife resources, and incorporated into all levels of analysis and decision-making. To accomplish this, we have the following suggestions.

The Guidelines are calculated using only the lowest 7 days in each month, which makes it difficult to directly compare other flow data and constrains the applicable guideline to a single number for each month. To make "apples-to-apples" comparisons, one must convert all other flow data to the lowest 7 days per month before comparing them to the Guidelines, which is unnecessarily complex and prevents the Guidelines from being used in all analyses as intended. For hydrograph-type analyses, the Commission proposes a slightly modified flow guideline that is calculated from <u>all the data</u>, such as the 90% exceedance hydrograph shown on Slide 1. Other daily exceedance hydrographs, such as 75% (blue line, Slide 13), could also be used. An additional benefit of using daily exceedance hydrographs is that they better match conditions in April and May, which typically have much higher flows at the beginning of the month than at the end.

More importantly, however, none of the analyses in Section 2.7 of the PAL Response include pre-dam "guideline" data. Because the Corps did not use hydrographs, neither the Guidelines nor the Commission's exceedance hydrograph alternative can be adapted and added to the Corps' graphs. We recommend that daily pre-dam flow data be used directly to serve as an ecosystem flow guideline in every case regardless of the type of statistic or graphical display used in the evaluation. We provide an example of this in the frequency curves on Slides 9-11 and 17-19, which have a pre-dam "guideline" shown in blue on every graph. Similarly, pre-dam "guideline" flow data should be added to all of the graphs in Section 2.7 of the PAL Response, which display various frequency and "number of days per year" analyses. Calculating various statistics with the pre-dam flow data it is a much more flexible approach that allows an ecosystem guideline to be added to every graph.

Finally, the Corps continues to employ the misguided Run of River ("RoR") rubric in numerous graphs in the PAL Response. All RoR flow data should be removed because it is not an appropriate basis for analyses or decisions related to ecosystem protection. River-floodplain biota has never experienced natural conditions remotely resembling those of the RoR flow regime. Minimum flow in the RoR regime is 34 cfs. Furthermore, RoR flow in late summer and early fall of 2007 averaged 2,700 cfs for a continuous duration of 2.5 months, which represents conditions that riverine biota could not survive. In all graphs related to fish and wildlife resources or ecosystem protection, the RoR rubric should be removed and replaced with an ecosystem guideline based on pre-dam flows (as described in our suggestions above).

Floodplain Inundation Analyses are inappropriate.

Analysis of frequency in percent of years of the annual maximum of 30-day minimum acres of inundated floodplain is not useful and should be replaced with hydrographs similar to Slides 21 and 22. Hydrographs provide a more useful tool than frequency curves for assessing critical flows throughout the entire year, as the Service notes on pages 8-9 of the Draft Report. Because duration and timing of seasonal flow and habitat requirements vary for each species, hydrographs showing the full year are the preferred method for either describing long-term summaries of flow (Slides 13-14) or area data (Slides 21-22), or for focusing on selected individual dry years (Slides 3-5). Hydrographs allow analysis of sturgeon and other fish spawning conditions in the spring, mussel habitat conditions in the summer, and a variety of other biological requirements using the same graph.

In addition, the PAL Response (2-73) contains an erroneous assumption regarding floodplain connectivity. The Corps indicates floodplain inundation in the Apalachicola River does not occur until flows reach 100,000 cfs. However, the approximate flows at which significant floodplain inundation begins in each reach can be estimated from the breaks in the curves in Figure 27B of Light et al., 1998, as follows:

Upper Reach – 28,000-29,000 cfs
Middle Reach – 13,000-14,000 cfs
Nontidal Lower Reach – 13,000-14,000 cfs

It appears the Corps incorrectly assumed that the floodplain is not inundated until river levels exceed top of bank elevations in the upper reach. This assumption is incorrect for two reasons: First, the greatest proportion of floodplain area in the Apalachicola River is in the middle and lower reach where top of bank elevations are much lower (relative to river levels) than in the upper reach. Second, during rising river flow, movement of river water into the floodplain through numerous breaks in the levee at stream and slough mouths allows almost unimpeded connections between the river and floodplain in all reaches. Thus nearly all of the floodplain forest becomes inundated long before the top of bank elevations are overtopped.

Analyses of Bay species should be augmented.

Juvenile Gulf sturgeon analyses are scant. There should be additional analyses of the impact of proposed and existing operations on juvenile sturgeon in the Bay. While we agree generally with the conclusions contained in the Bay section of the Draft Report, we encourage the Service to provide additional details about potential impacts to estuarine sentinel species (e.g., Eastern oysters, *Crassostrea virginica* or White shrimp, *Litopenaeus setiferus*).

Floodplain Inundation Stage Discharge Analyses are inadequate

We disagree with the following statements on Page 25 of Draft Report: *"The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. This has been adequately addressed and is no longer a conservation measure."* The analyses conducted were inadequate and should be revised to include comparisons to ecosystem guidelines in every graph, hydrographs showing seasonality and duration of flows and inundated area throughout the year, and expanded views of frequency curve data at the low-flow end. We have provided some examples of each in the attached slides.

In addition, for your information, LIDAR data are now available for the entire Apalachicola River and should be used for more accurate future analysis.

Adaptive Management only works if operations are modified as necessary.

The Draft Report contains a recommendation to implement Adaptive Management. Fundamentally, this concept is about taking action to improve progress toward desired outcomes. The key to successful adaptive management, therefore, is to modify operations that are shown, through monitoring, to be detrimental to species. While the Commission appreciates the Service's recommendation to incorporate adaptive management principles into the Water Control Planning process, the Corps has not shown a willingness to modify its behavior in response to monitoring data that show negative impacts on species.

For adaptive management to succeed, clear objectives (e.g., restoration of a viable reproductive mussel population in Swift Slough) must be identified. Sound monitoring techniques must be employed, and the data reviewed regularly to ascertain whether the goals are being met. Finally, specific response alternatives should be identified in the event the stated goals are not being met. Each of these three elements is a necessary component of any adaptive management program.

Climate Change Analysis

One of the impacts of climate change is an anticipated rise in sea levels. The Draft Report should address the minimum flows needed to mitigate the impacts of salt water incursion due to sea level rise.

Fish Passage

We agree that the Corps should look at fish passage operations for anadromous fish species, such as the Alabama shad, as part of the Water Control Manual update.

We thank you for the opportunity to comment and your attention to this matter. Again we hope for improved coordination in the future.

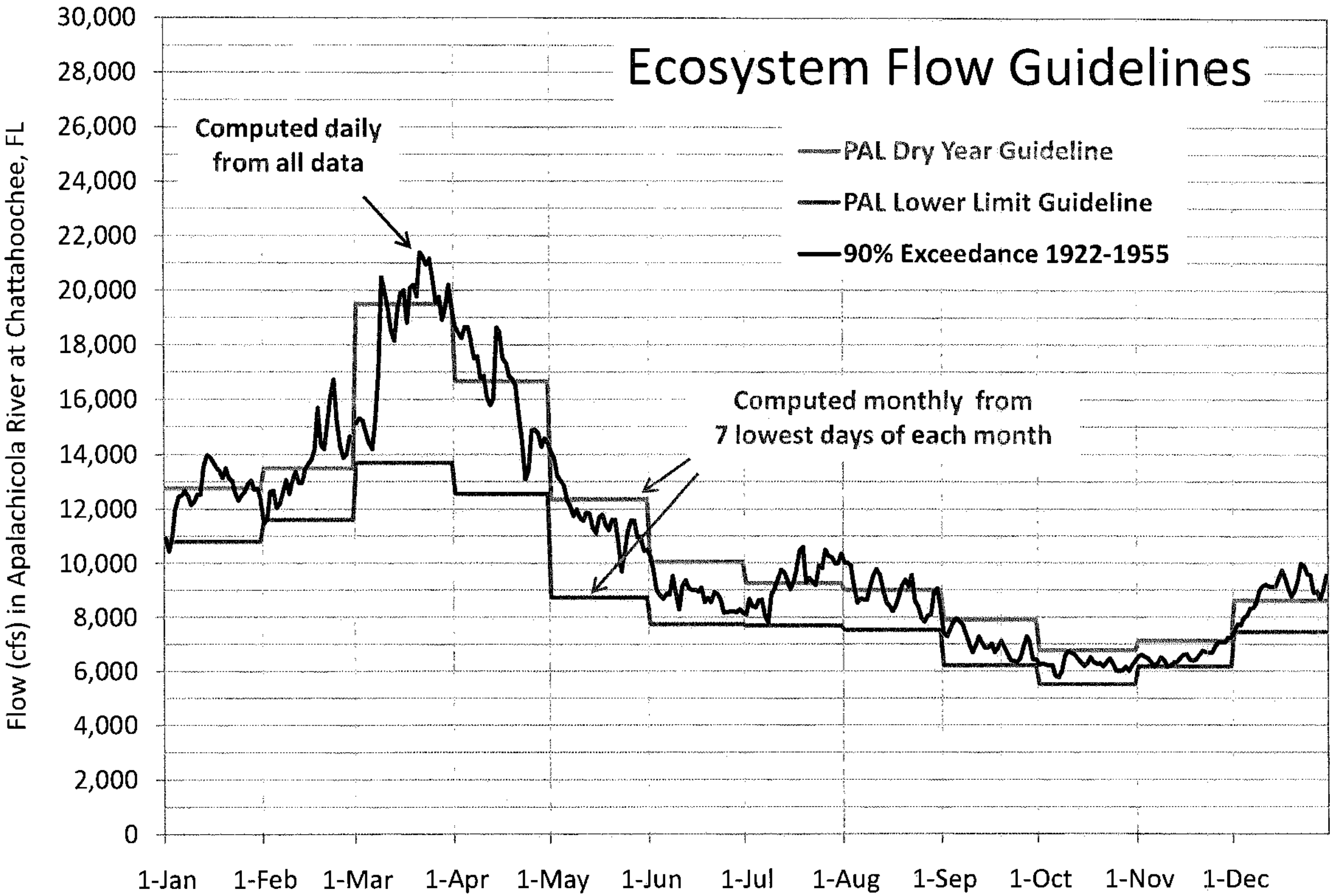
Respectfully,

Harold G. Vielhauer
General Counsel

cc: Mr. Don Imm
USFWS-Panama City Field Office

Ms. Sandy Tucker
US Fish and Wildlife Service

Encl.

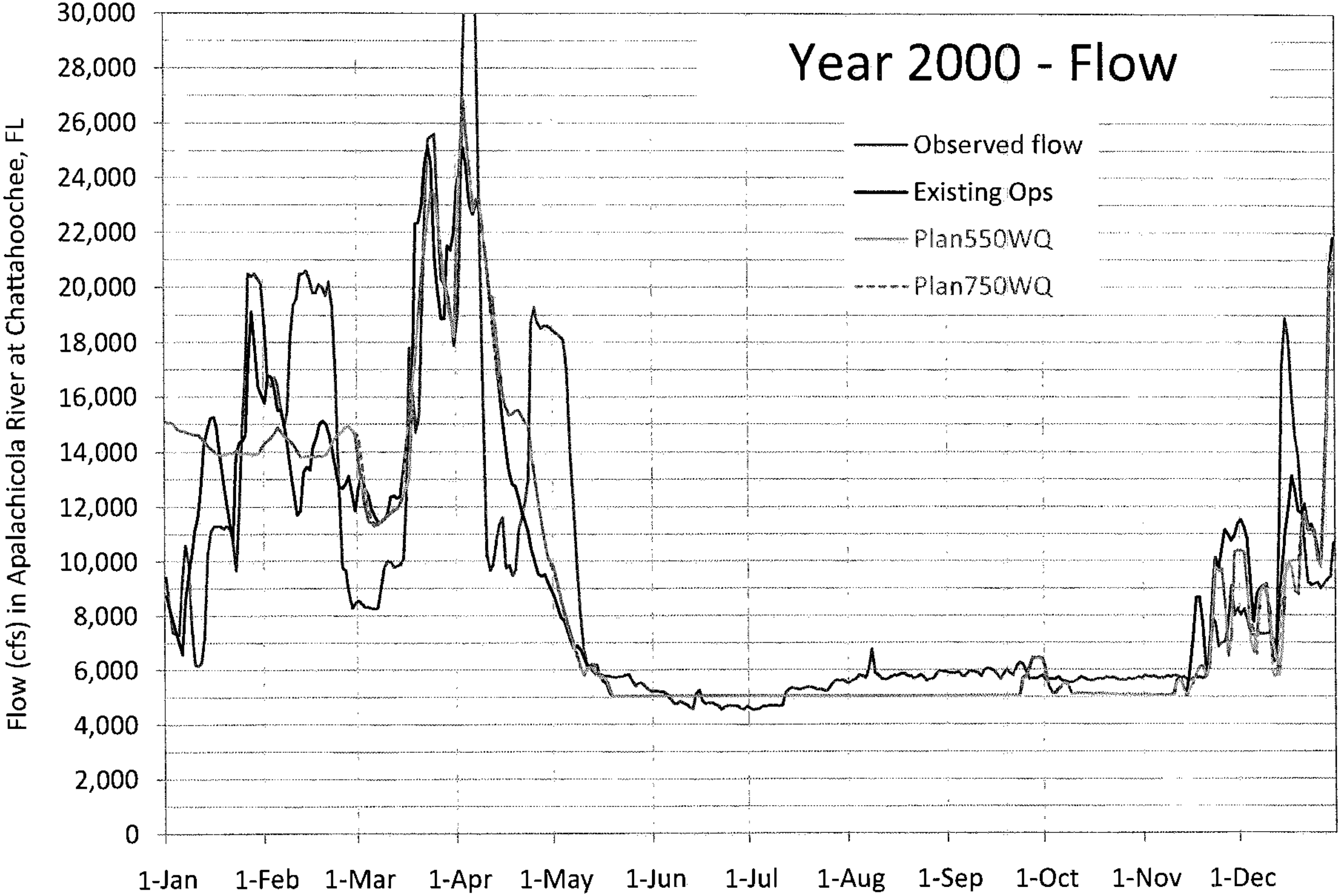

Ecosystem Flow Guidelines
Computed daily from all data
PAL Dry Year Guideline
PAL Lower Limit Guideline
90% Exceedance 1922-1955
Computed monthly from 7 lowest days of each month
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

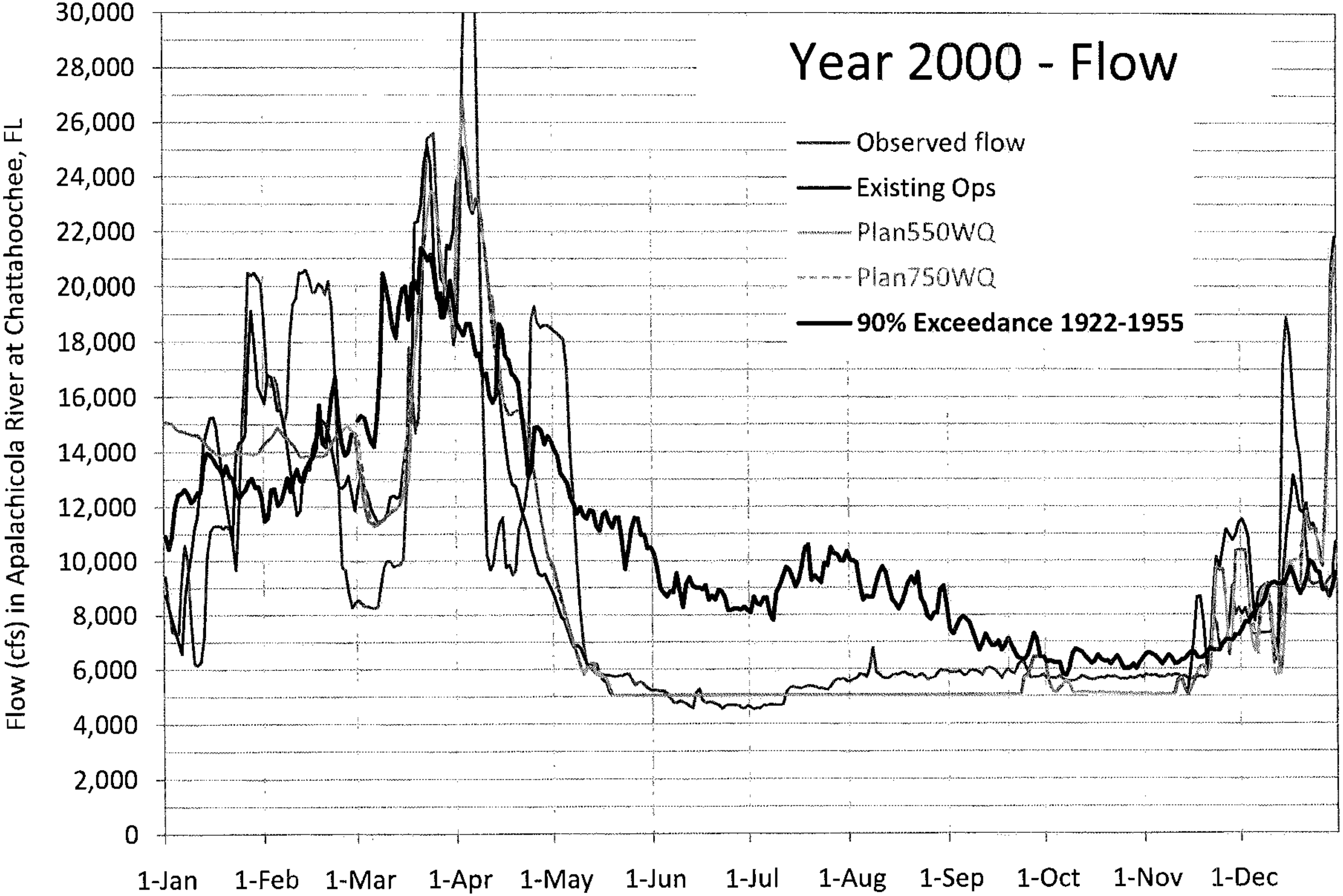
Flows Vs Lake Storage

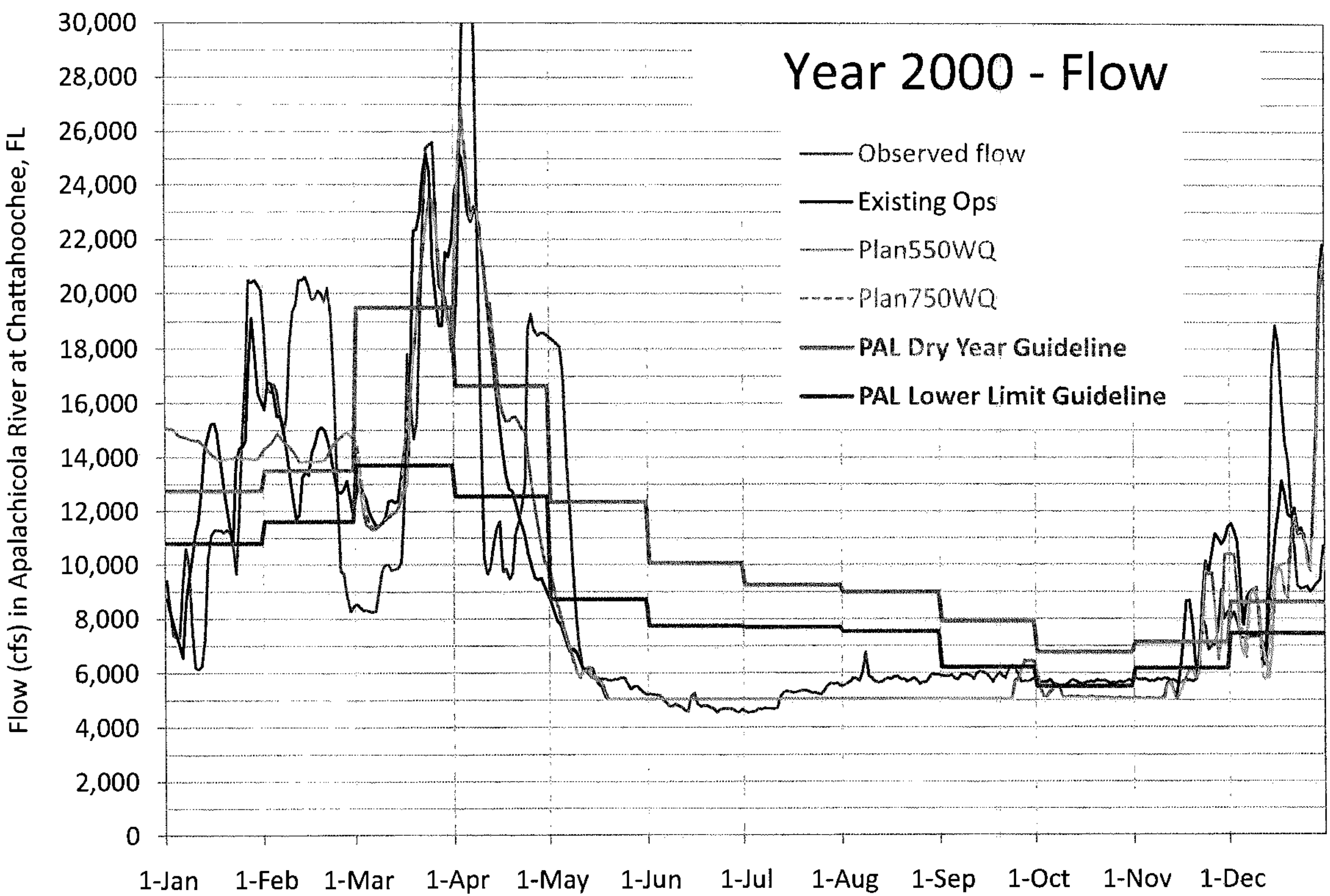
*At times when Ecosystem Flow Guidelines are **not** met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

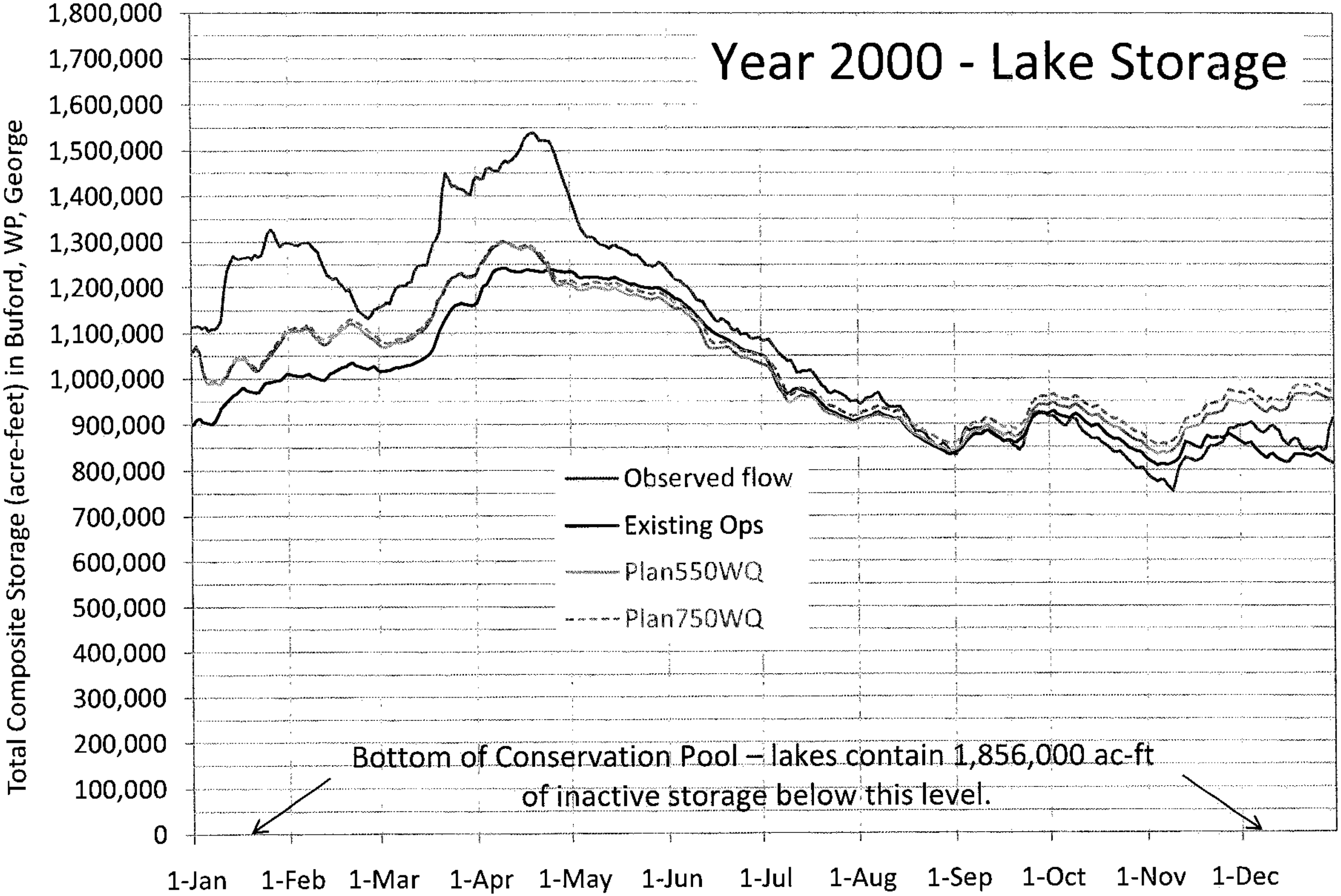
Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output

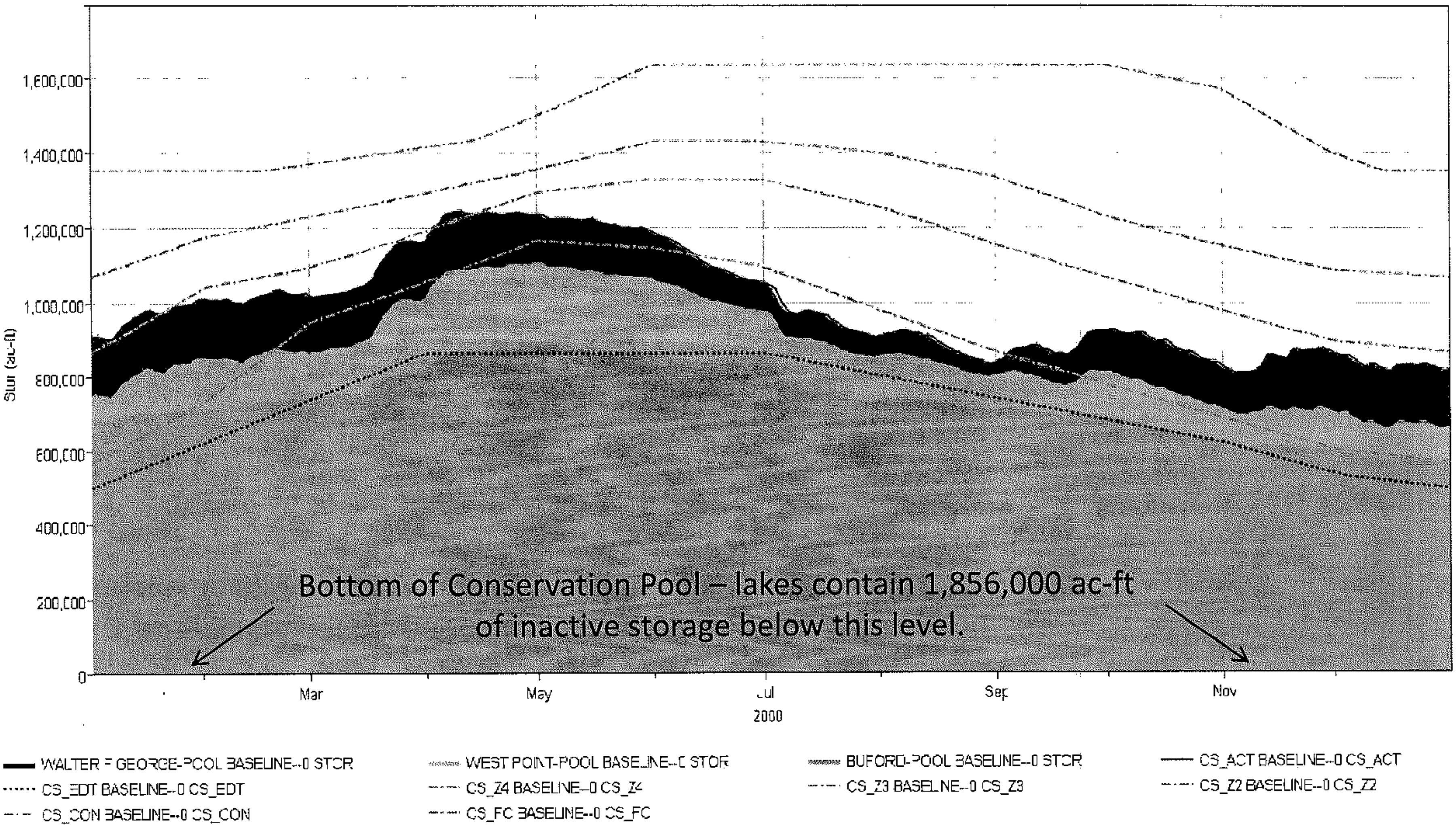

Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Lake Storage
Total Composite Storage (acre-feet) in Buford, WP, George
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft
of inactive storage below this level.
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

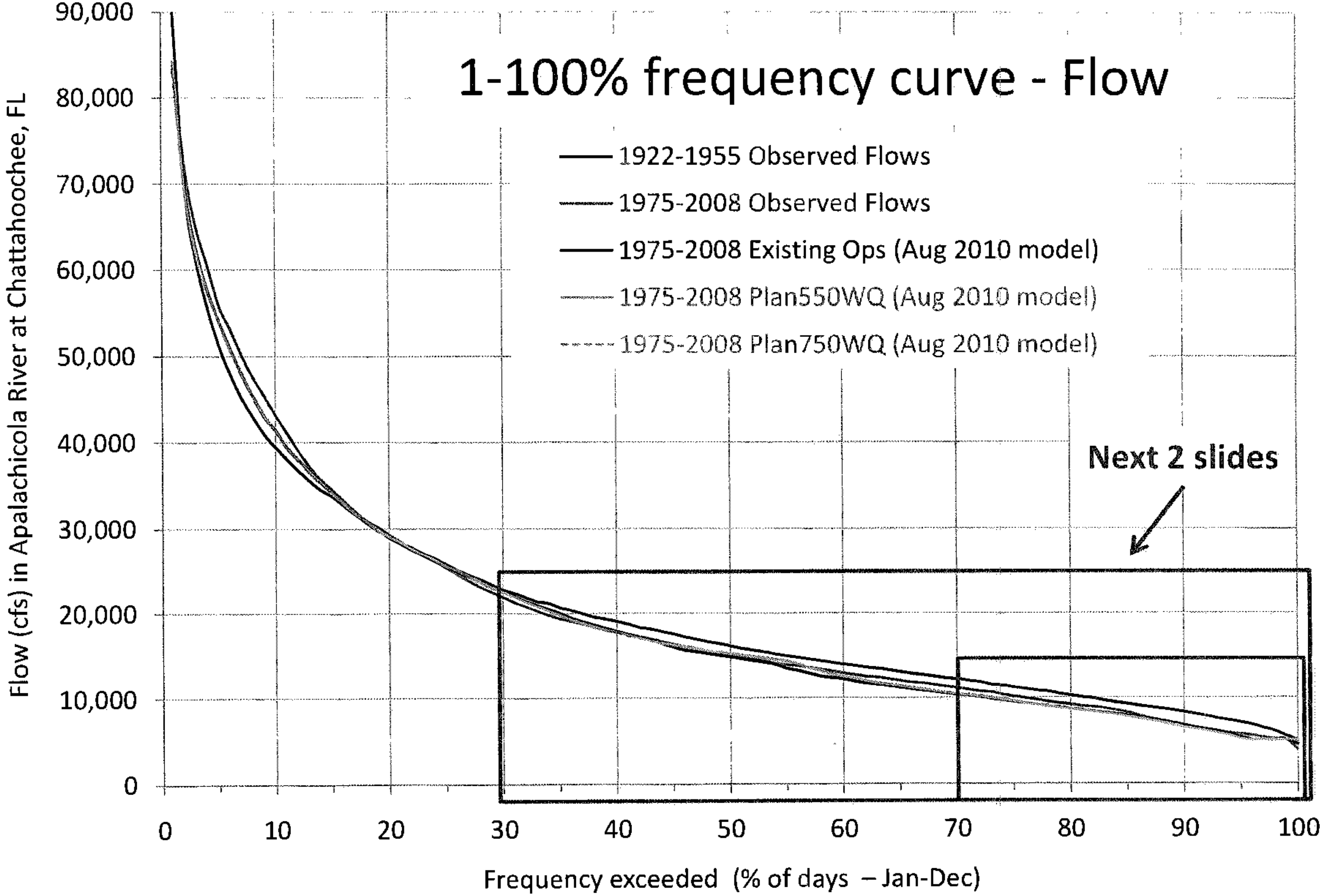
Year 2000 - Lake Storage (Existing Ops only)

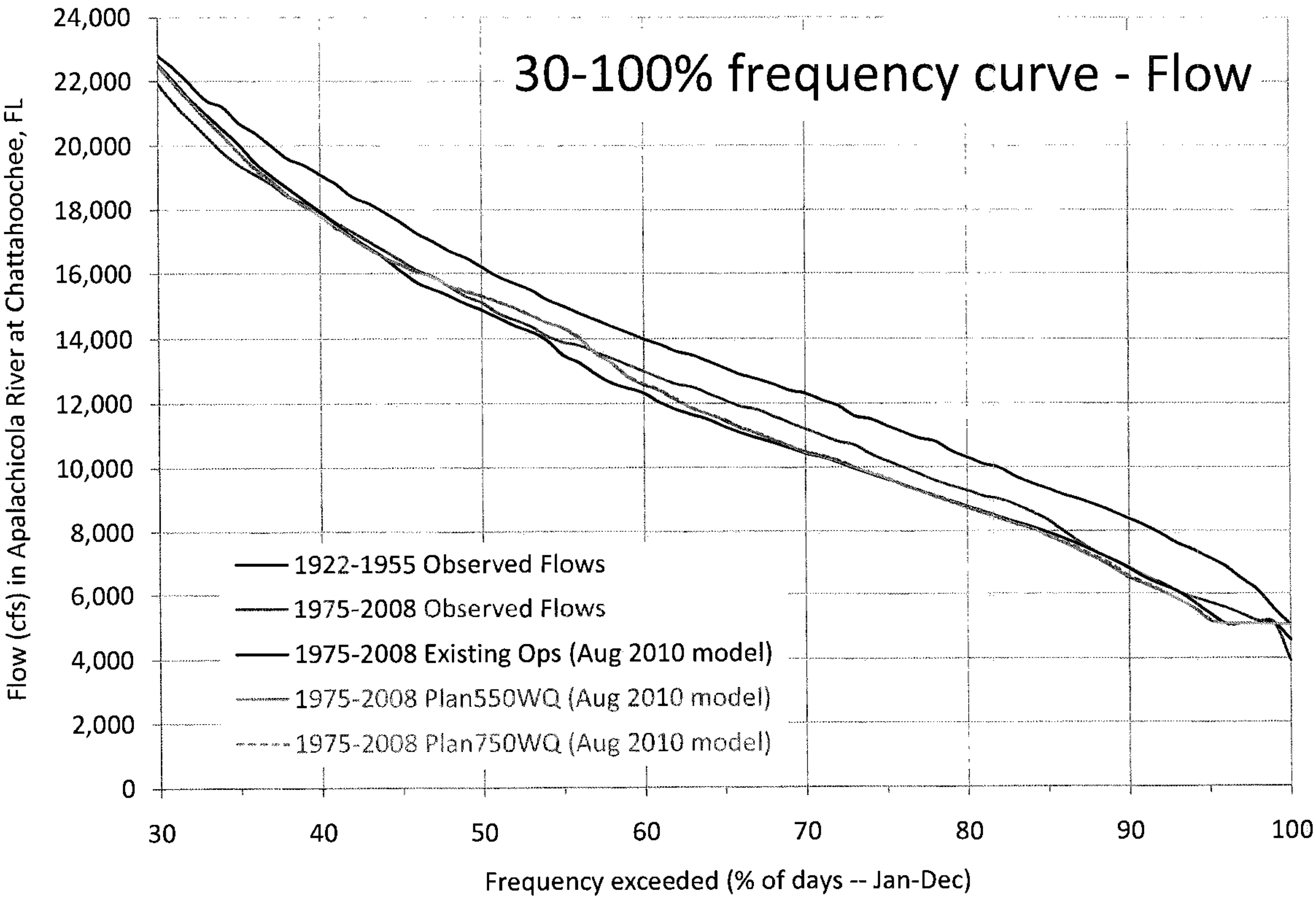


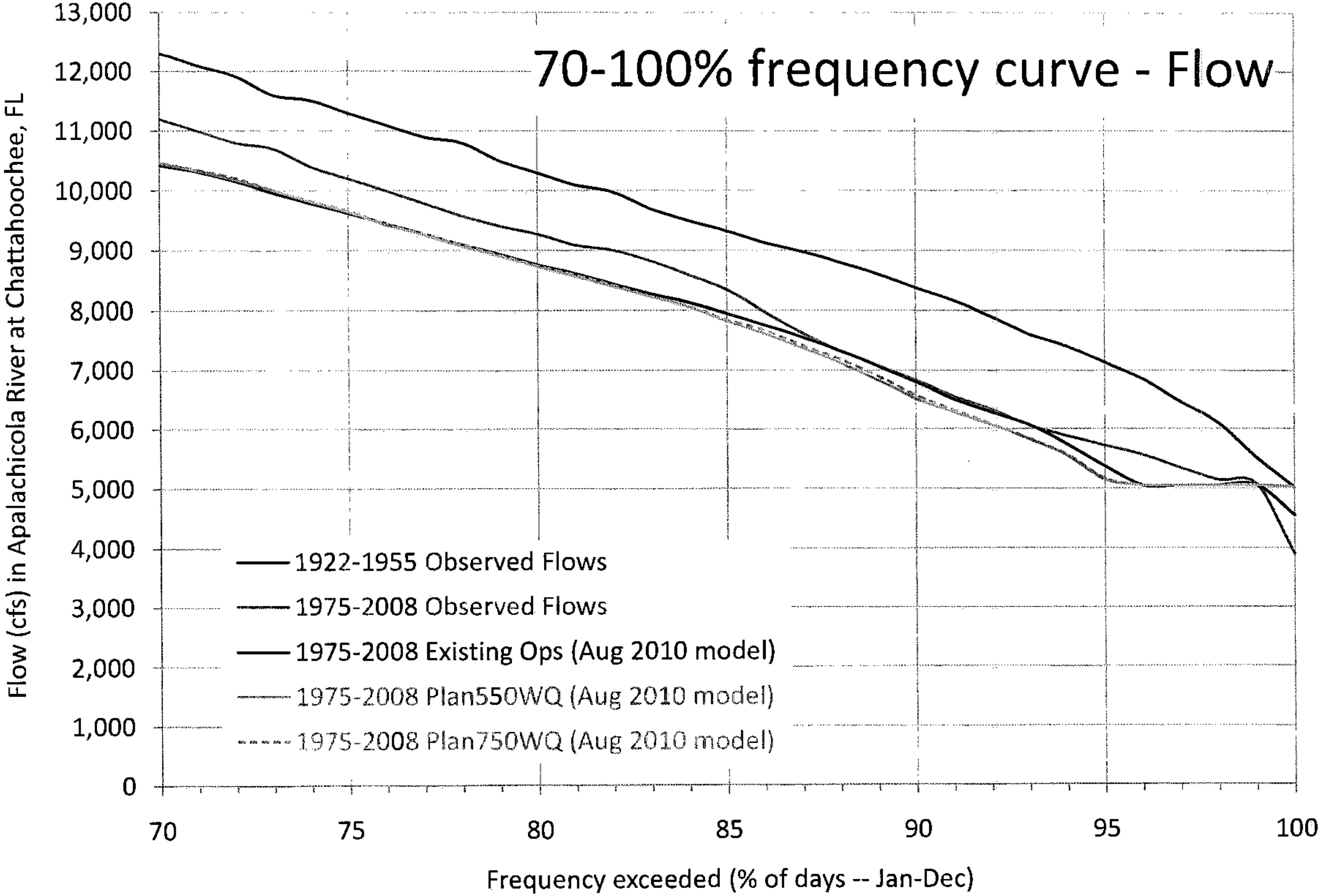
Flow Frequency Curves

Frequency that flows are exceeded
(% of days -- Jan-Dec)*

**To distinguish from growing season only (Mar-Nov)*


1-100% frequency curve - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)
Next 2 slides
Flow (cfs) in Apalachicola River at Chattahoochee, FL
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
10
20
30
40
50
60
70
80
90
100
Frequency exceeded (% of days – Jan-Dec)

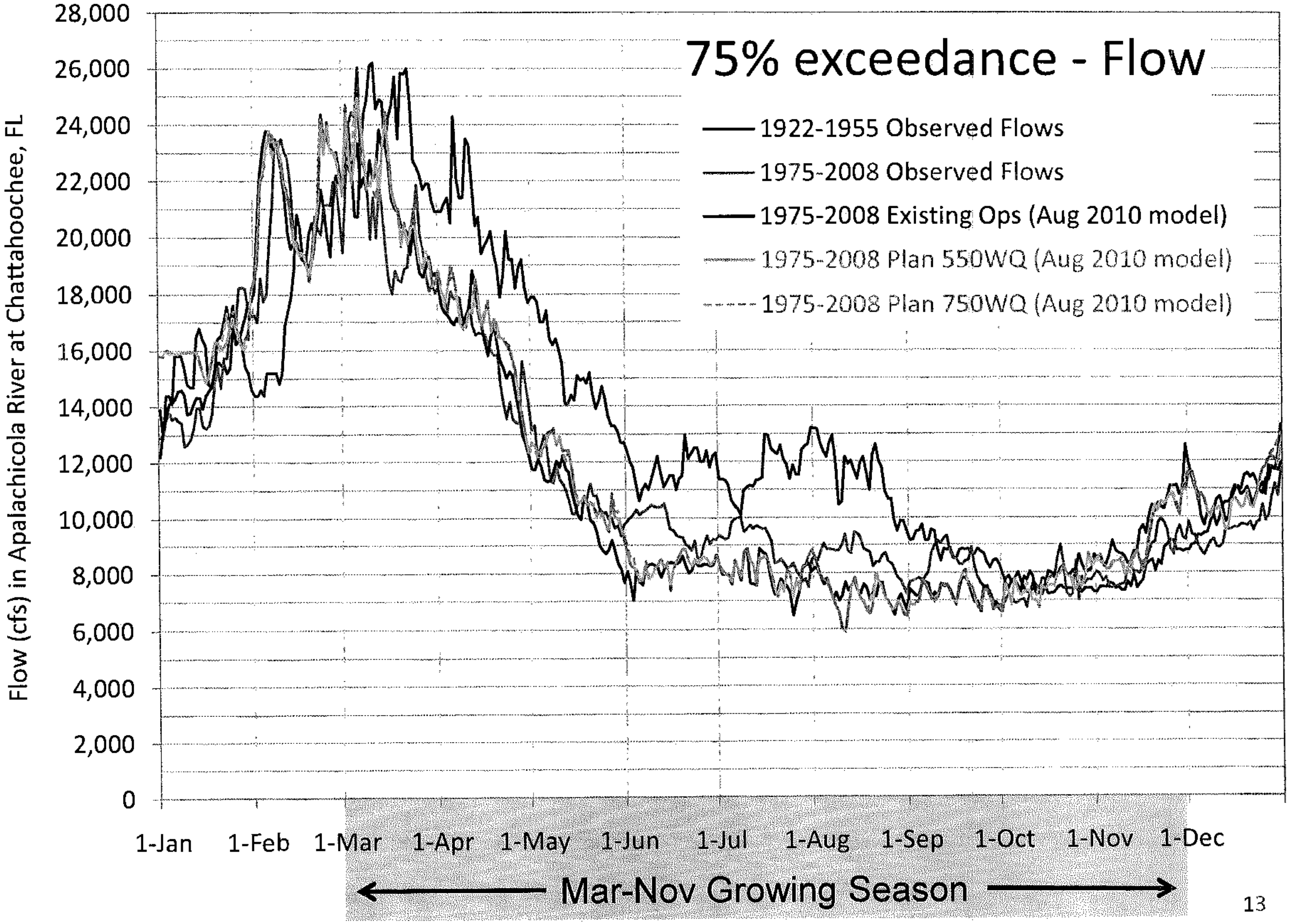

30-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
30
40
50
60
70
80
90
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

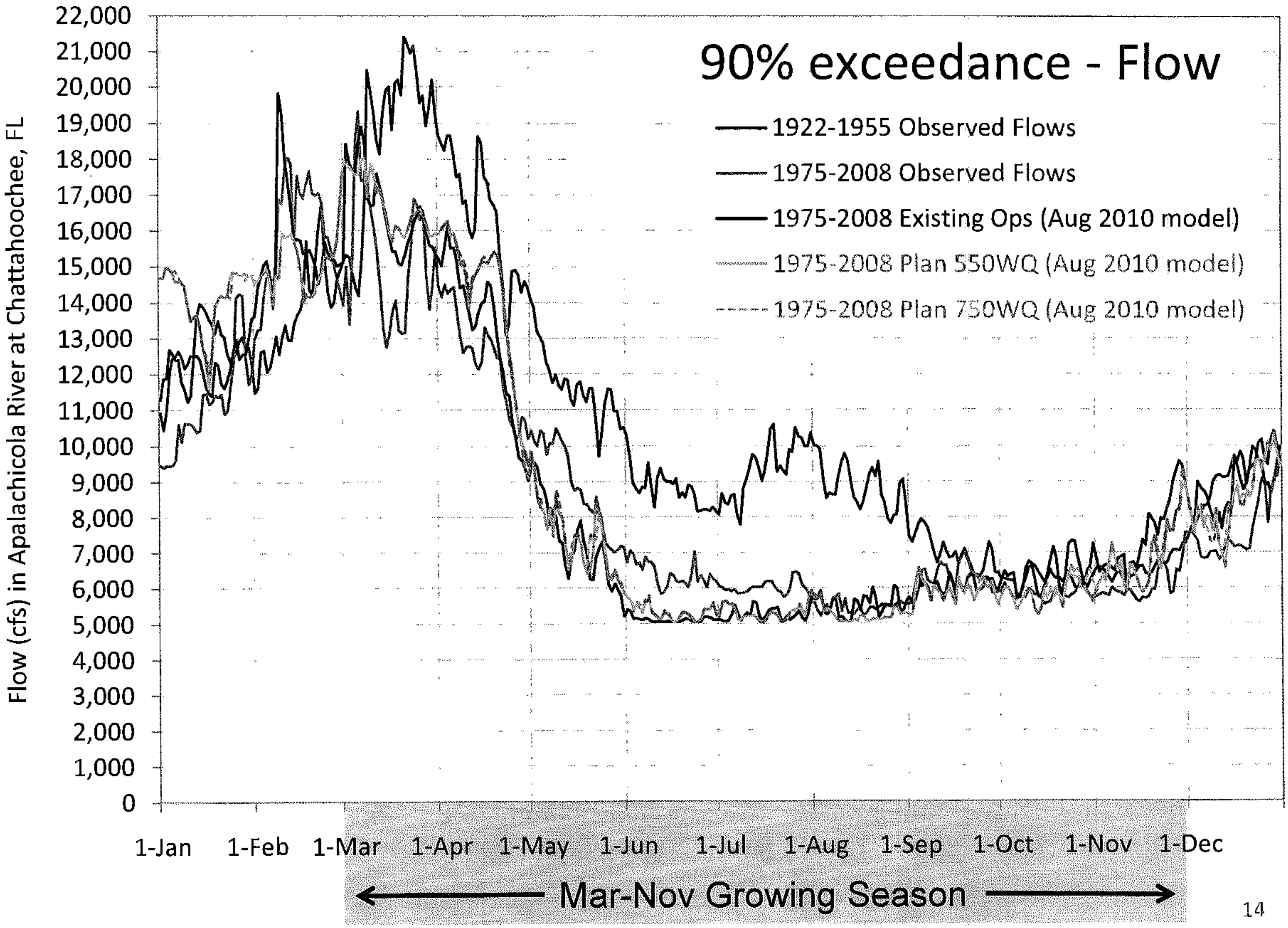

70-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
70
75
80
85
90
95
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

Flow Exceedance Hydrographs

Daily exceedance flows for selected frequencies: 75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

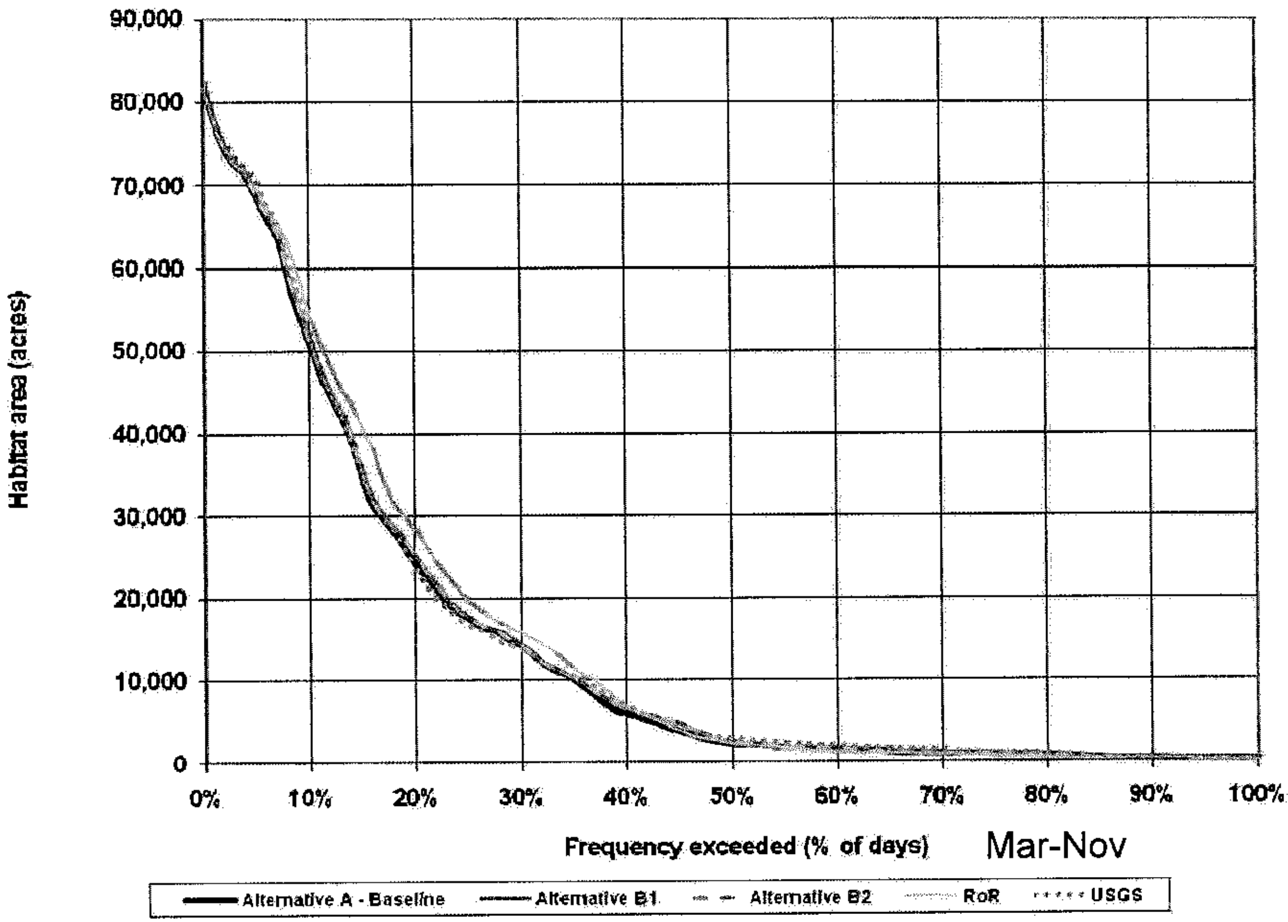

90% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

Area Frequency Curves

Frequency that acres of inundated floodplain are exceeded in the growing season (% of days – Mar-Nov)

Analysis provided by Corps

Graph from Corps 1/18/2011 Response to PAL, page 2-95:

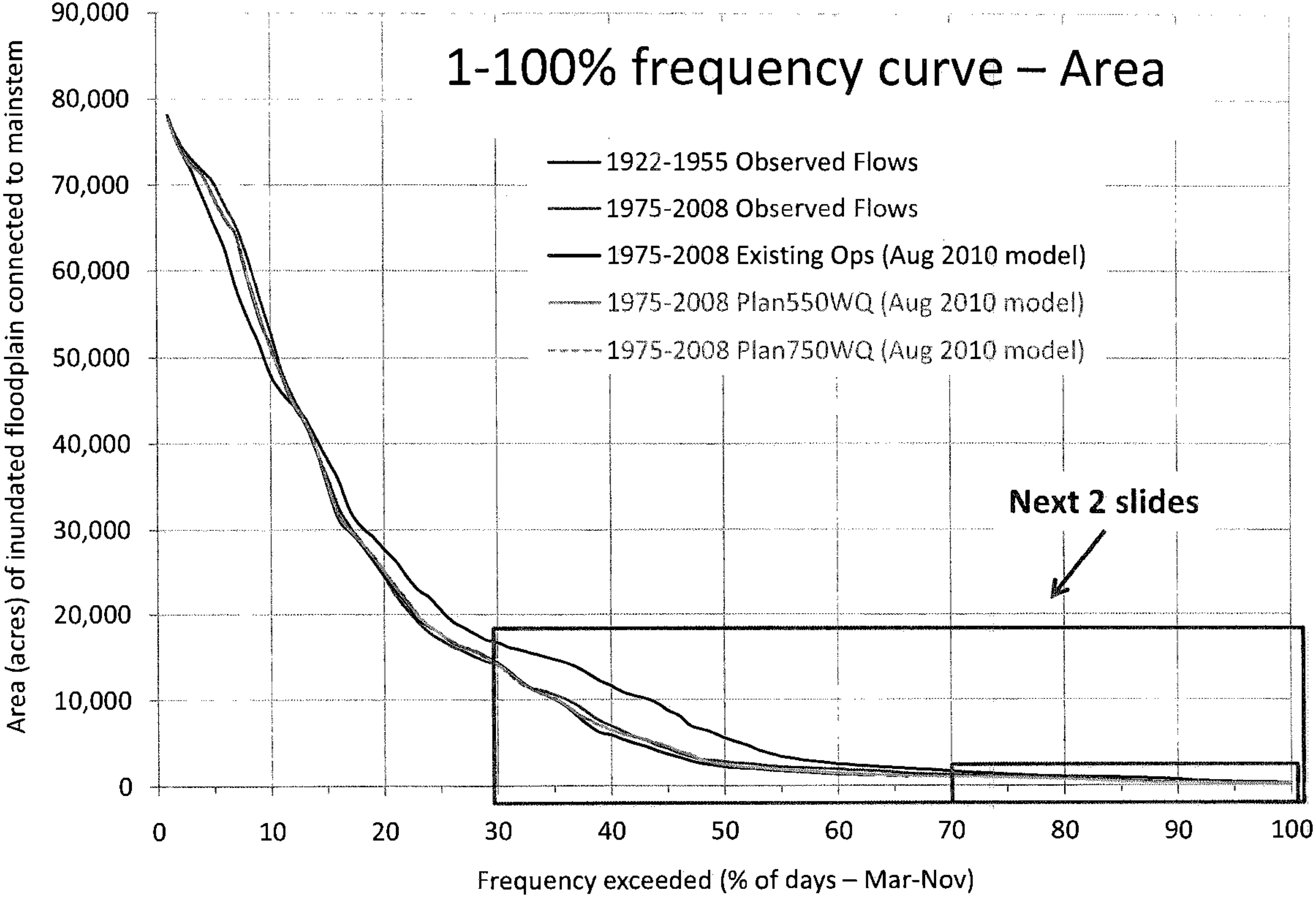


This graph was created by the Corps in response to FFWCC request.

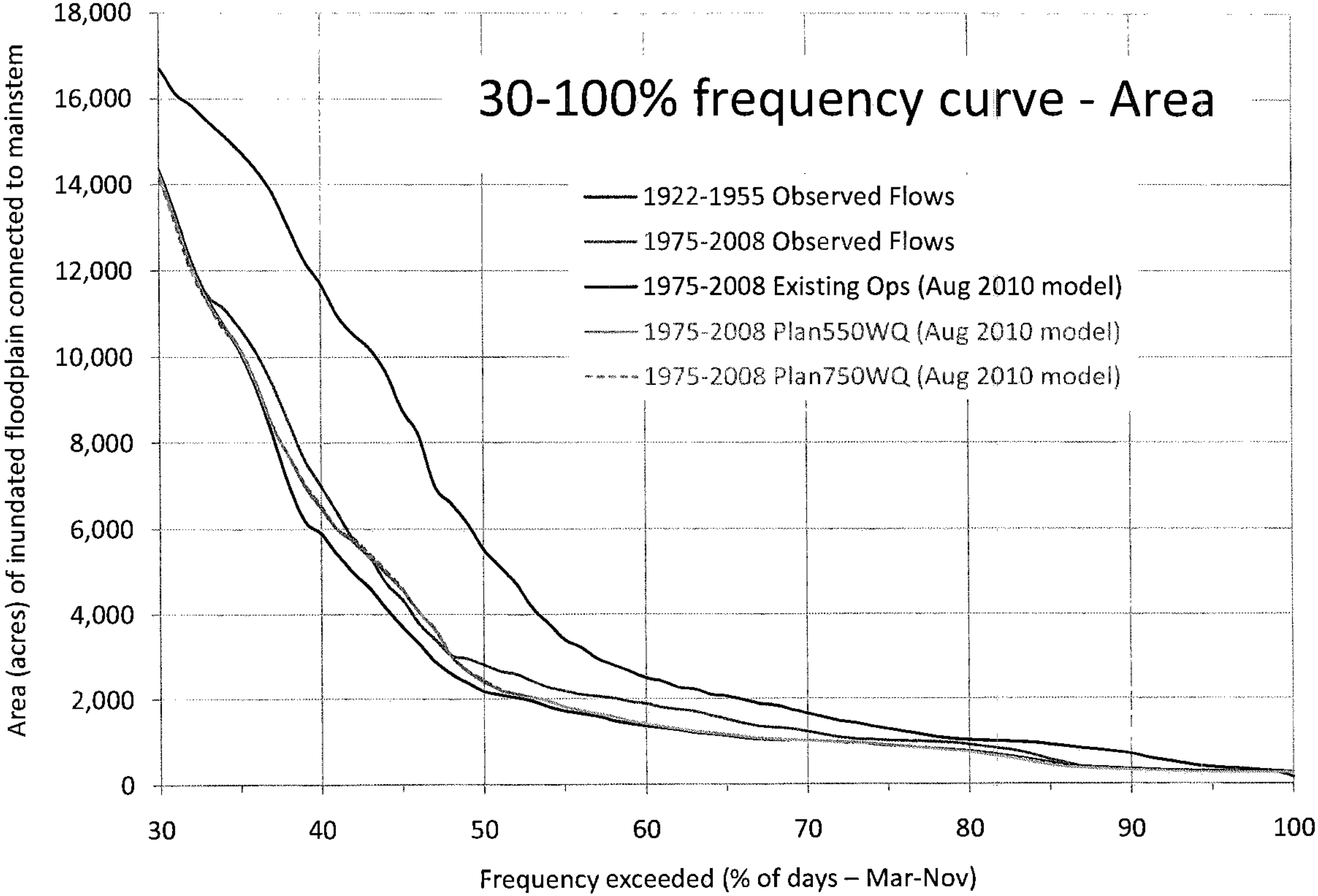
Suggested revisions:

-- Remove RoR and replace with appropriate ecosystem flow guideline (1922-1955 observed flow)

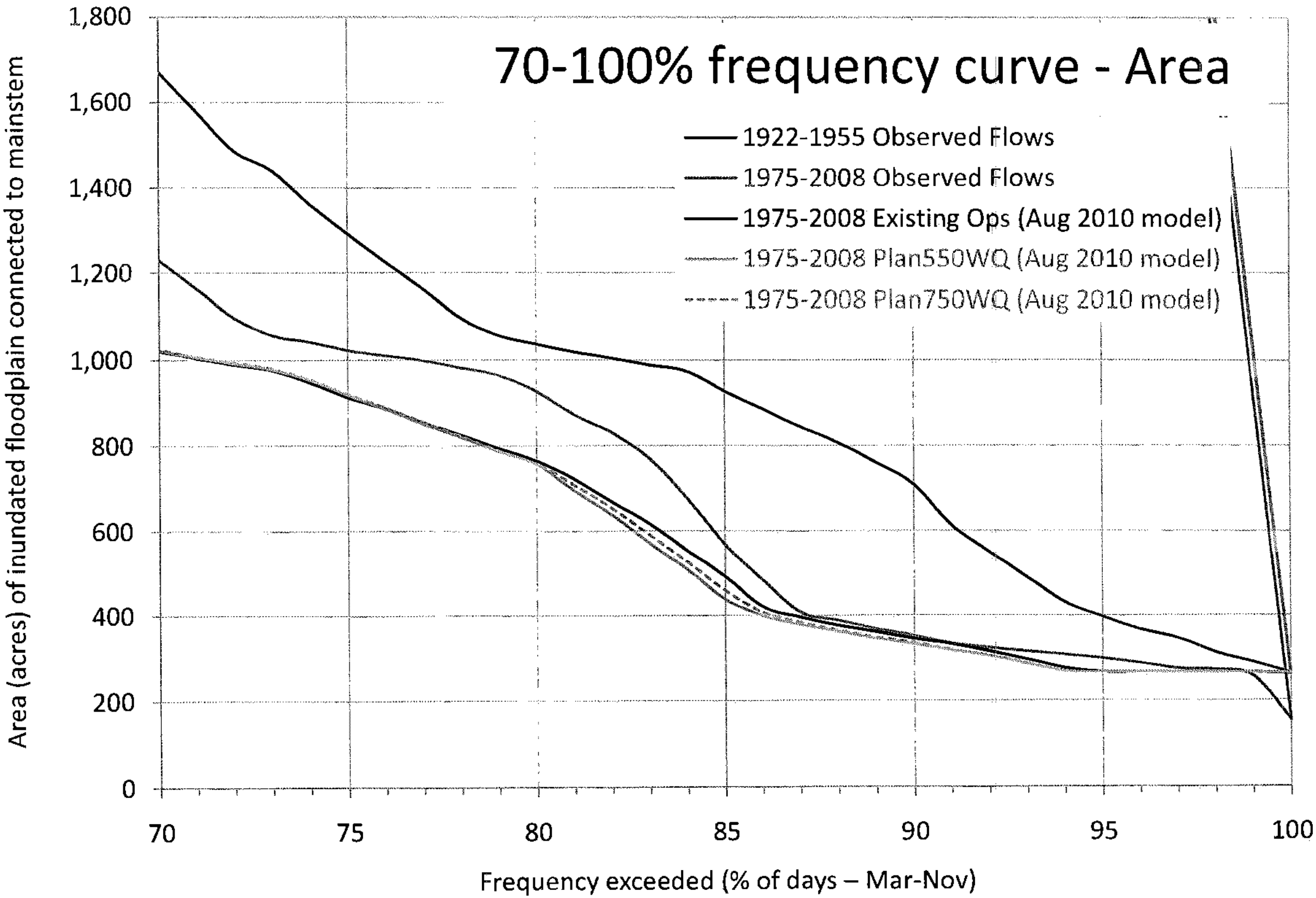
-- Expand data at low end



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

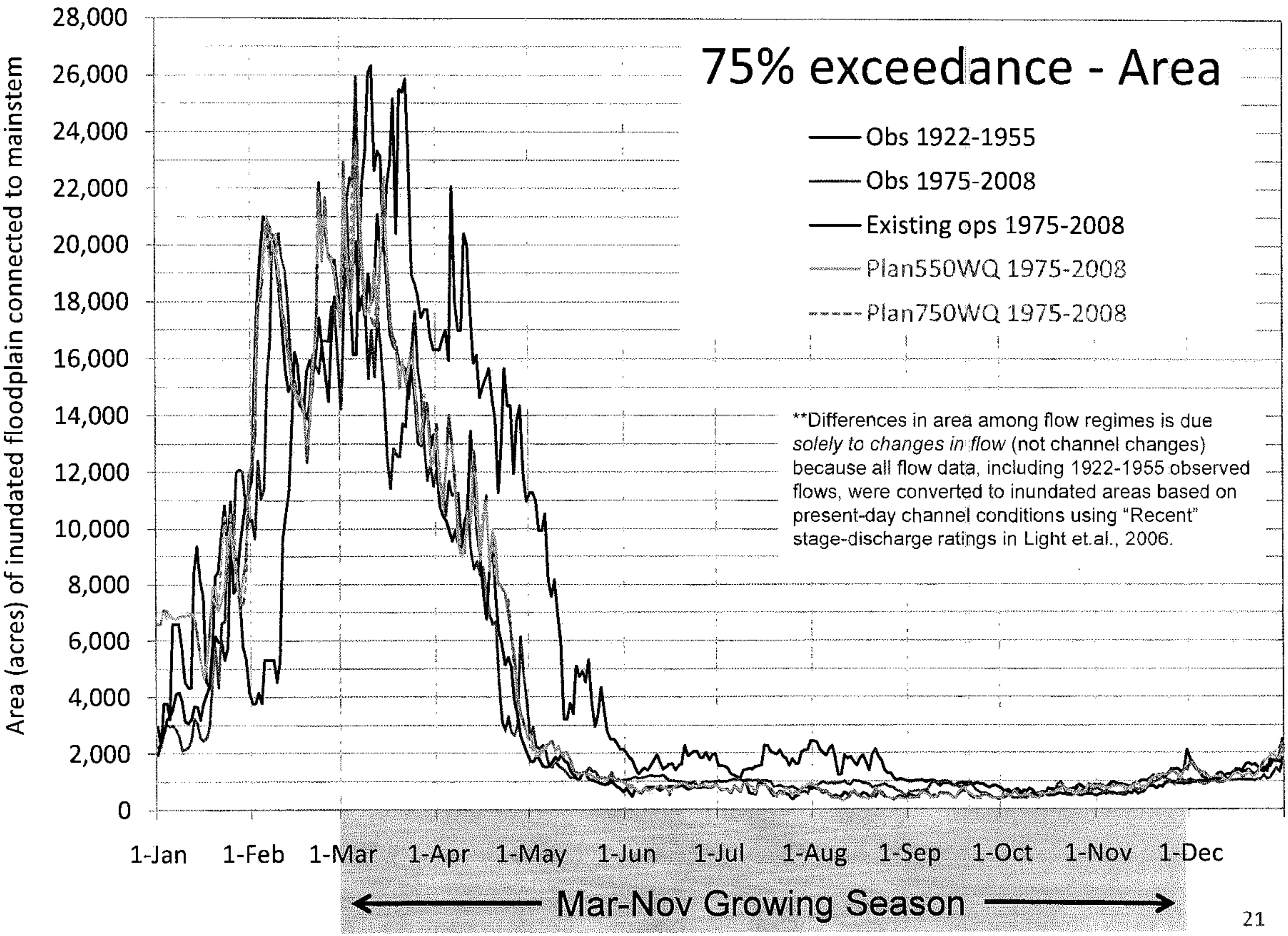


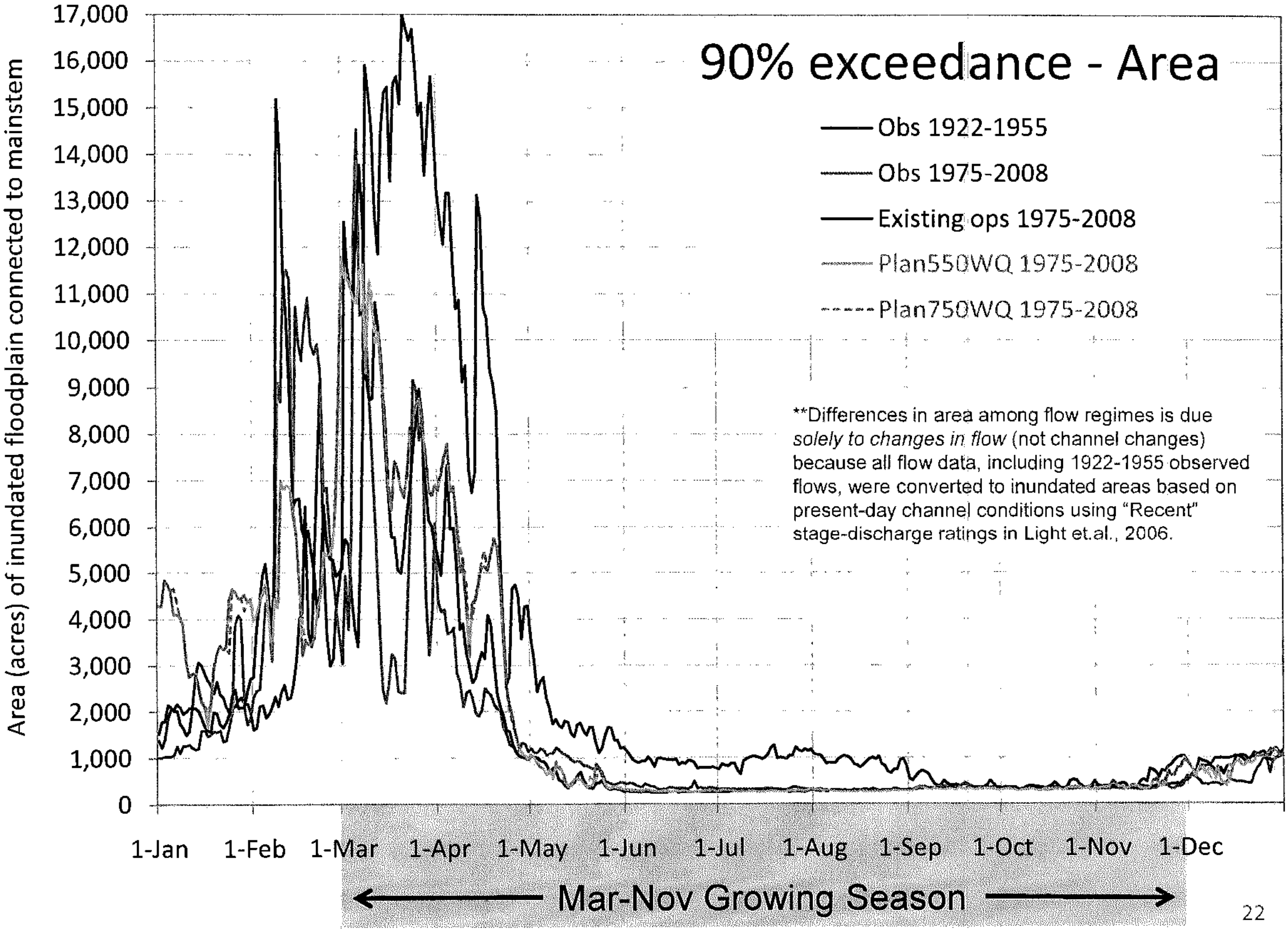
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

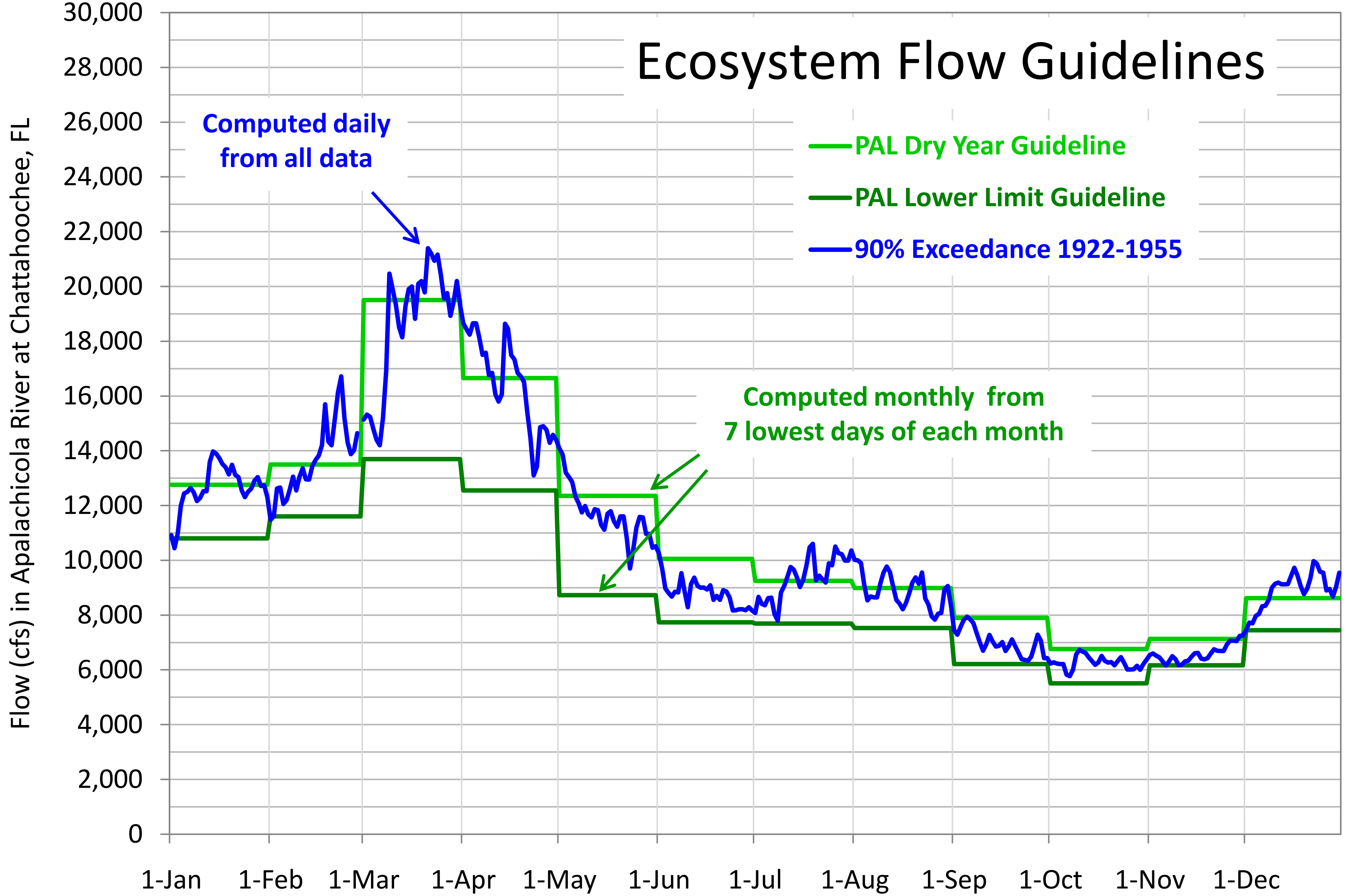
Area Exceedance Hydrographs

Daily exceedance for acres of inundated floodplain at selected frequencies: 75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season


90% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

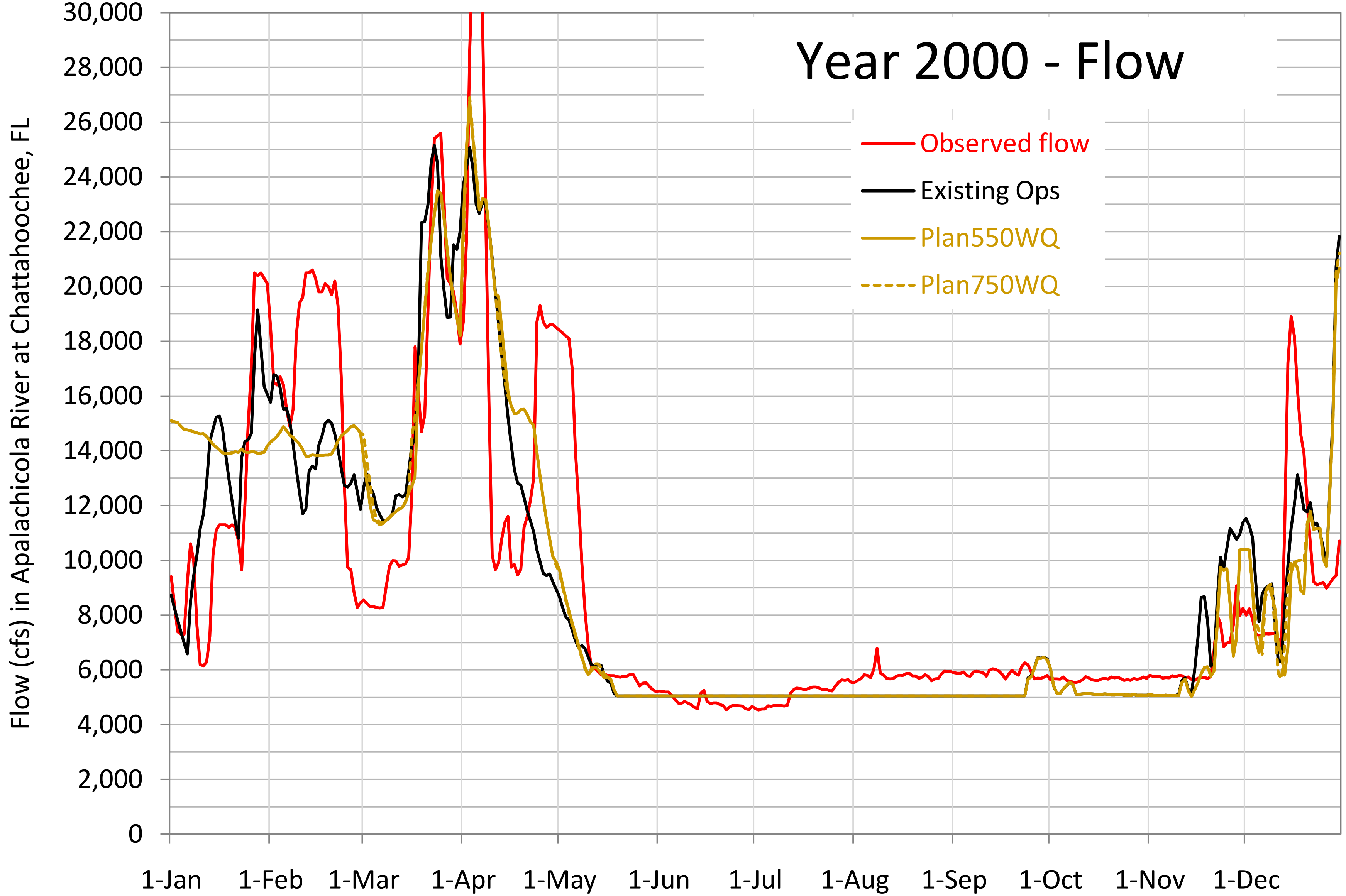

Ecosystem Flow Guidelines
Computed daily from all data
PAL Dry Year Guideline
PAL Lower Limit Guideline
90% Exceedance 1922-1955
Computed monthly from 7 lowest days of each month
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

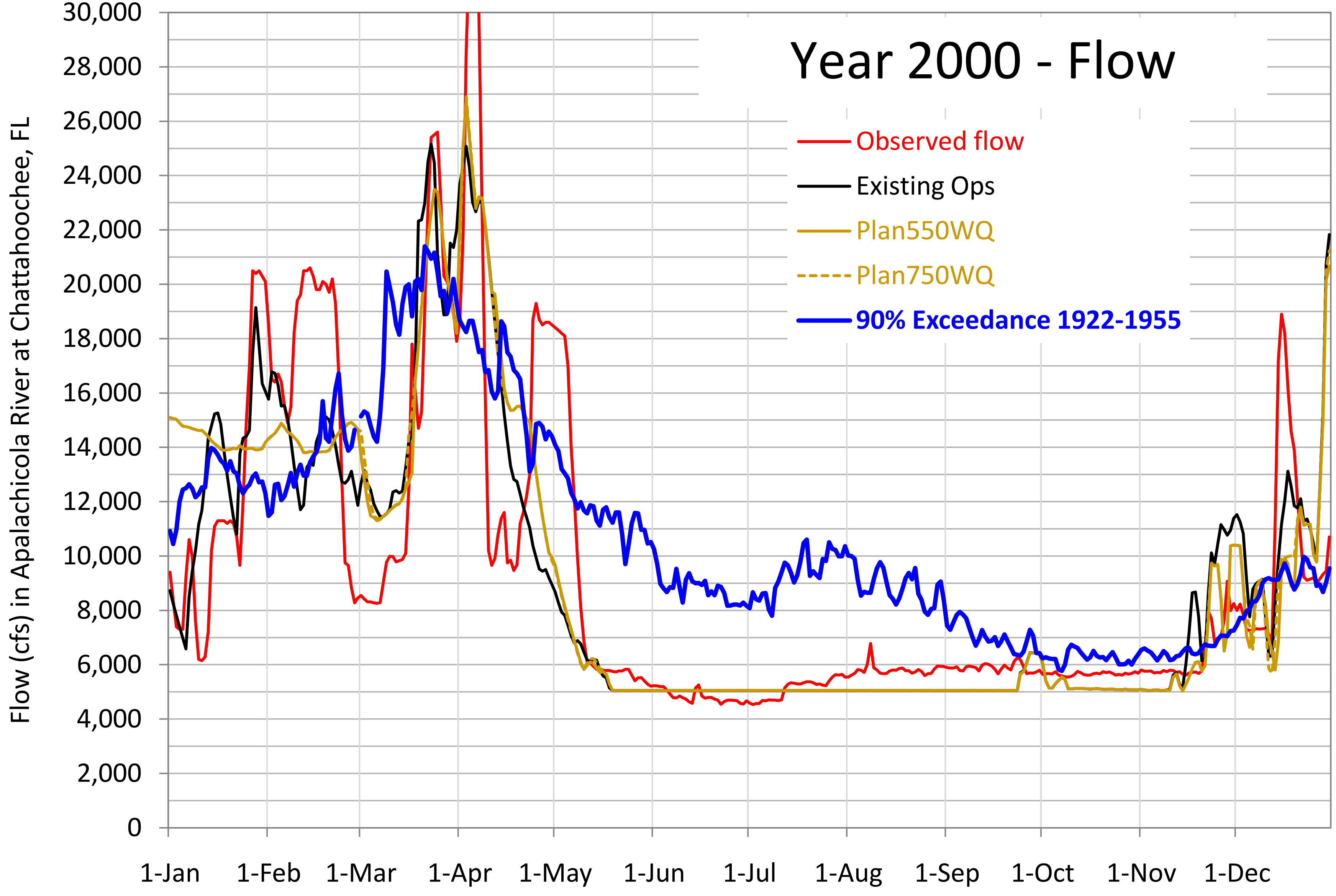
Flows Vs Lake Storage

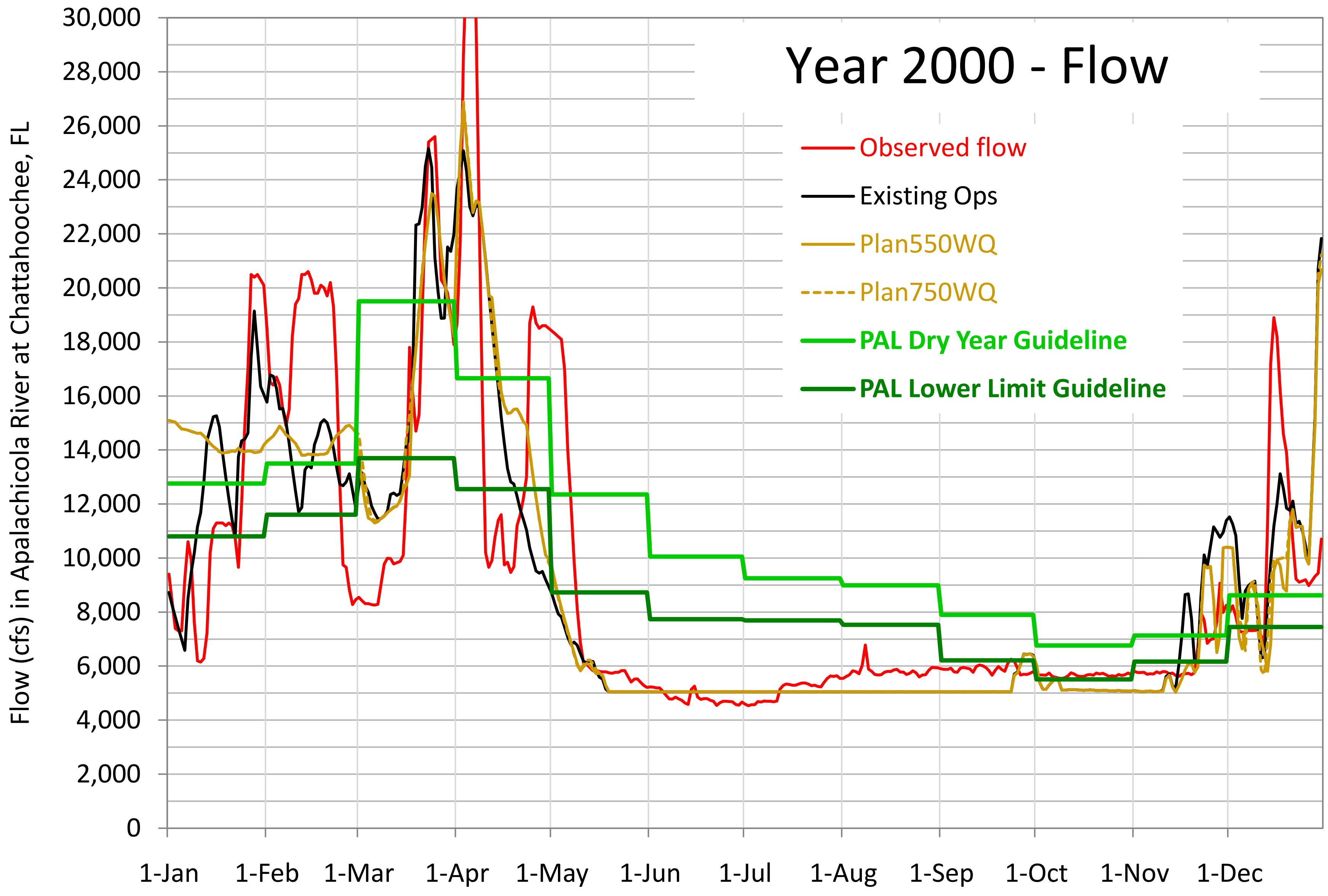
At times when Ecosystem Flow Guidelines are ***not*** *met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

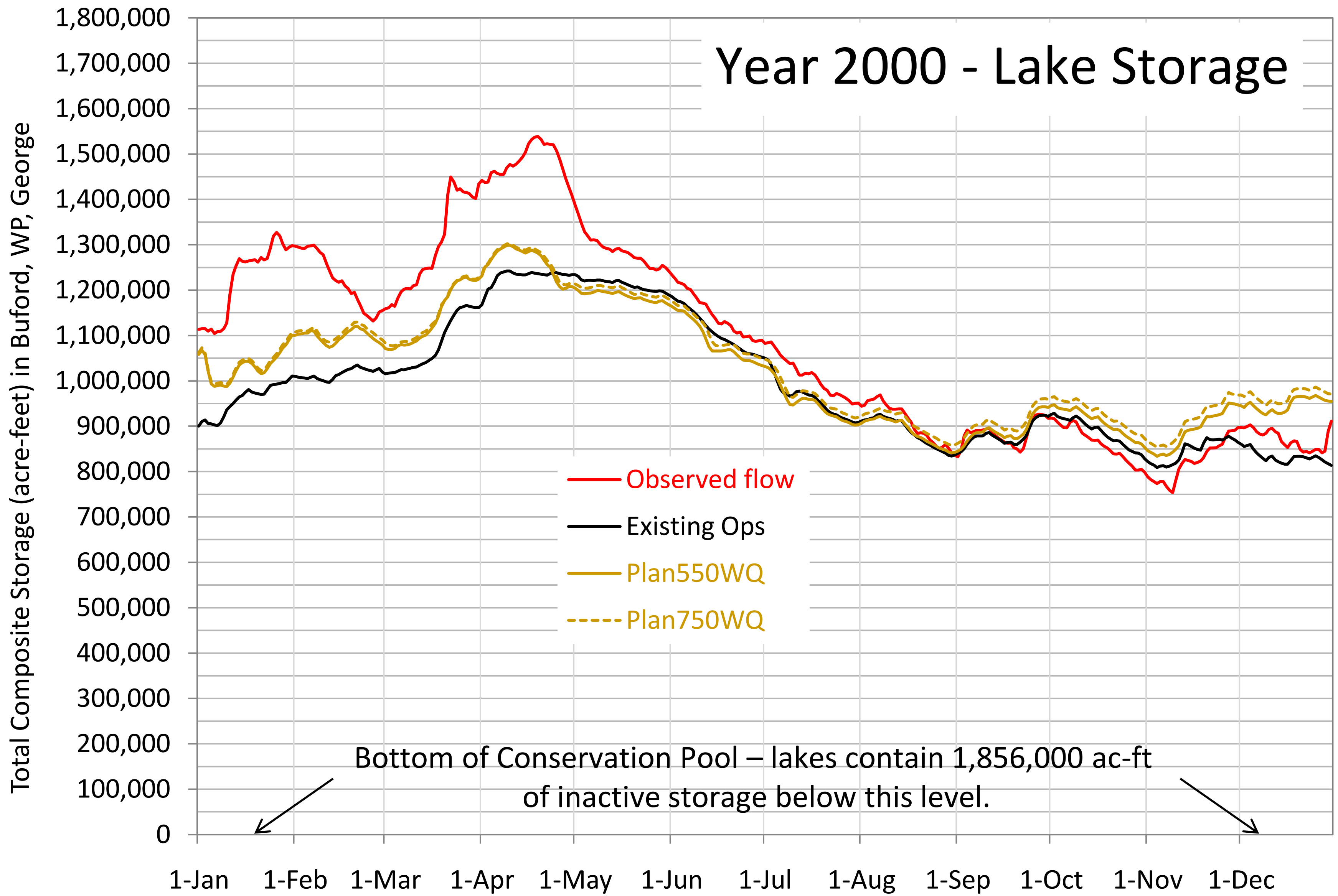
Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output

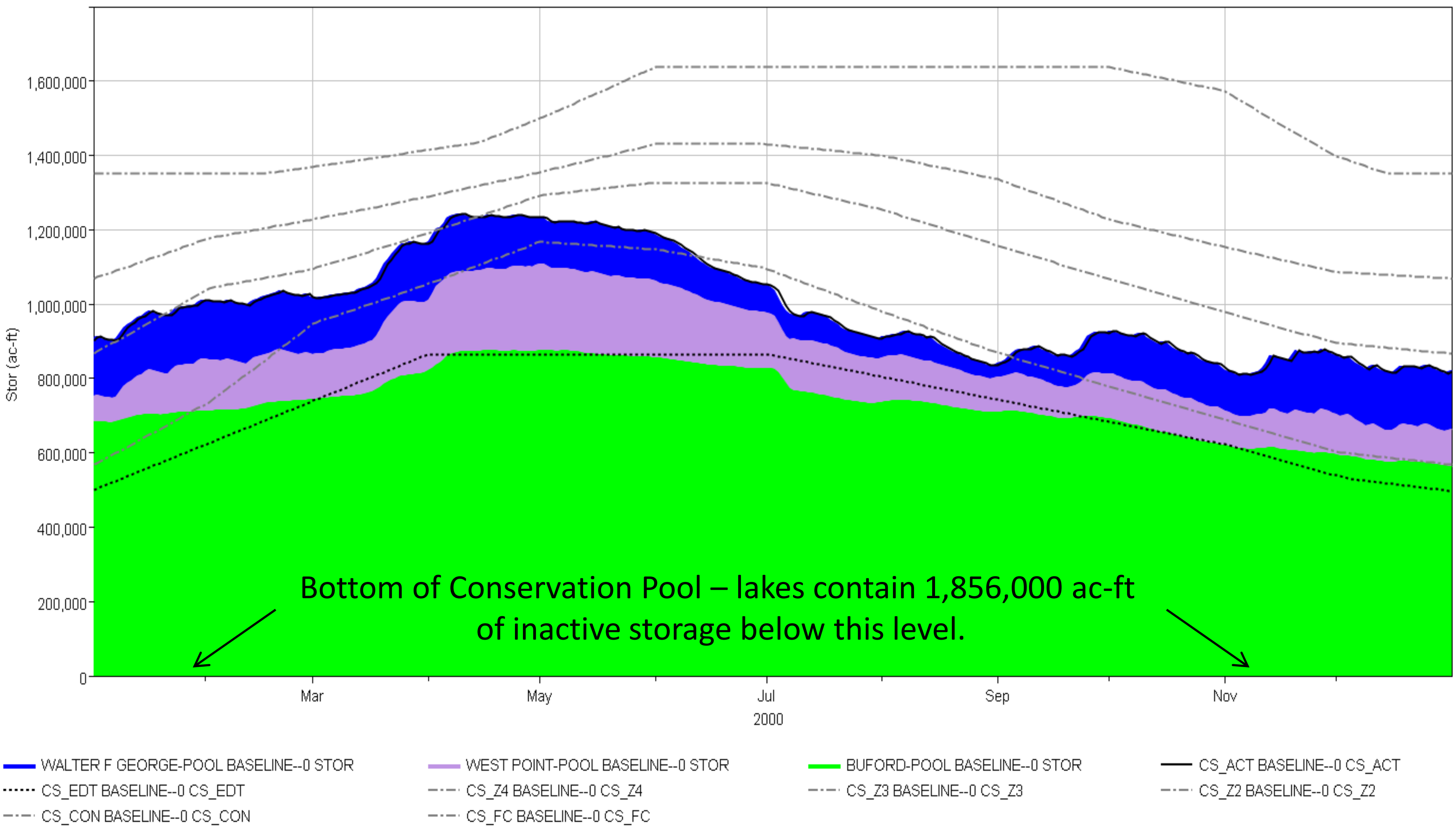

Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Lake Storage
Total Composite Storage (acre-feet) in Buford, WP, George
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft
of inactive storage below this level.

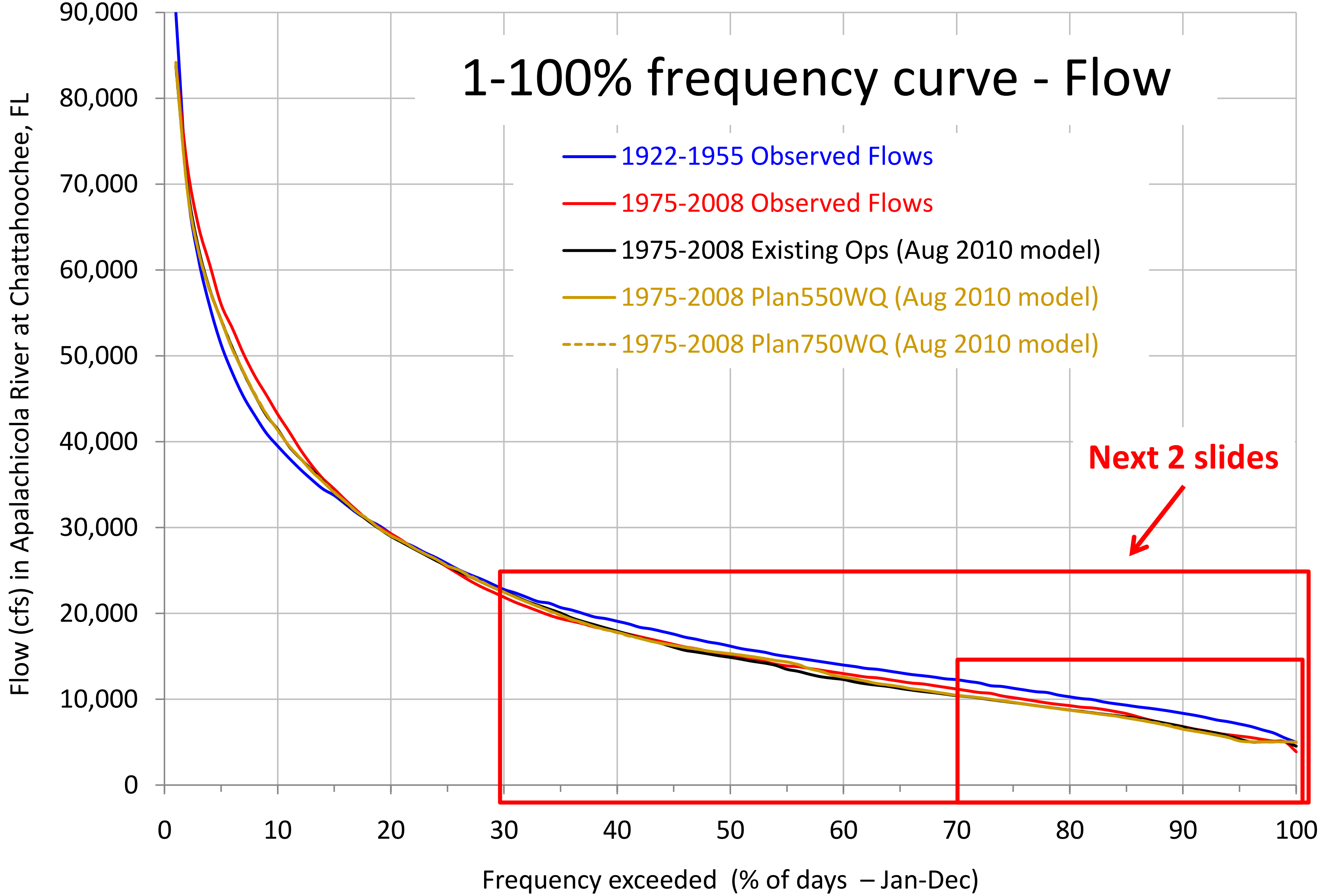
Year 2000 - Lake Storage (Existing Ops only)

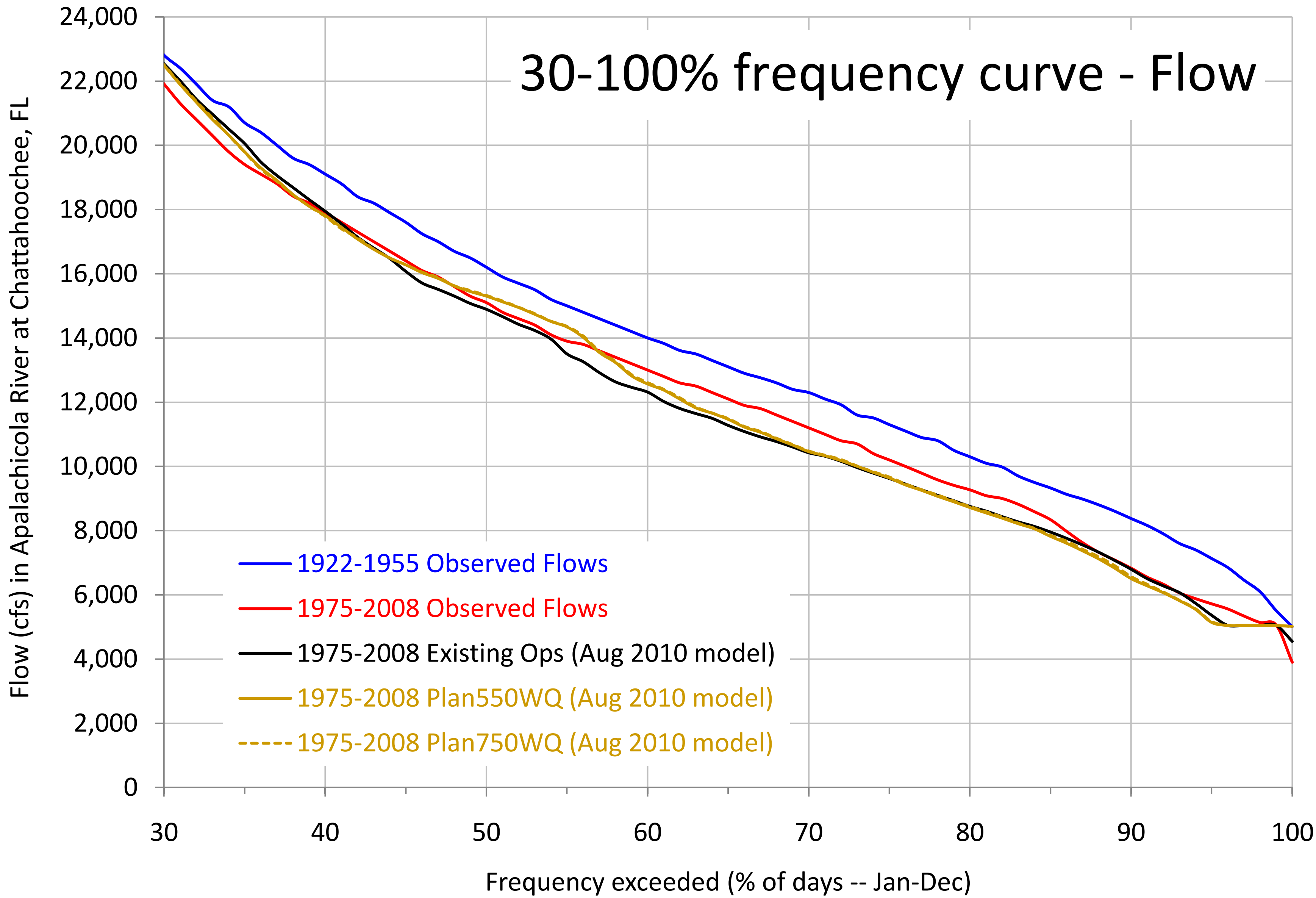


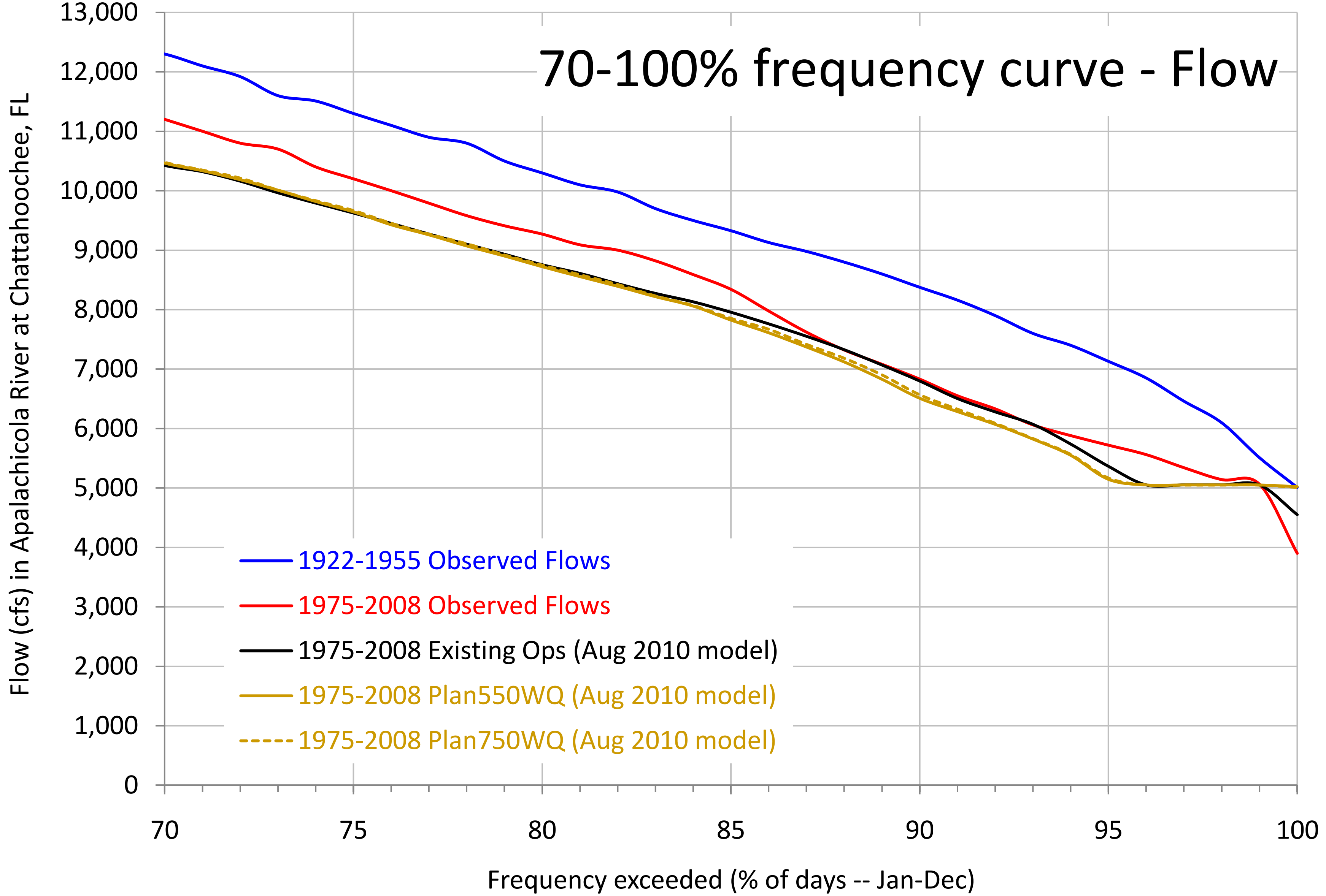
Flow Frequency Curves

Frequency that flows are exceeded
(% of days -- Jan-Dec)*

**To distinguish from growing season only (Mar-Nov)*


1-100% frequency curve - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)
Next 2 slides
Flow (cfs) in Apalachicola River at Chattahoochee, FL
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
10
20
30
40
50
60
70
80
90
100
Frequency exceeded (% of days – Jan-Dec)

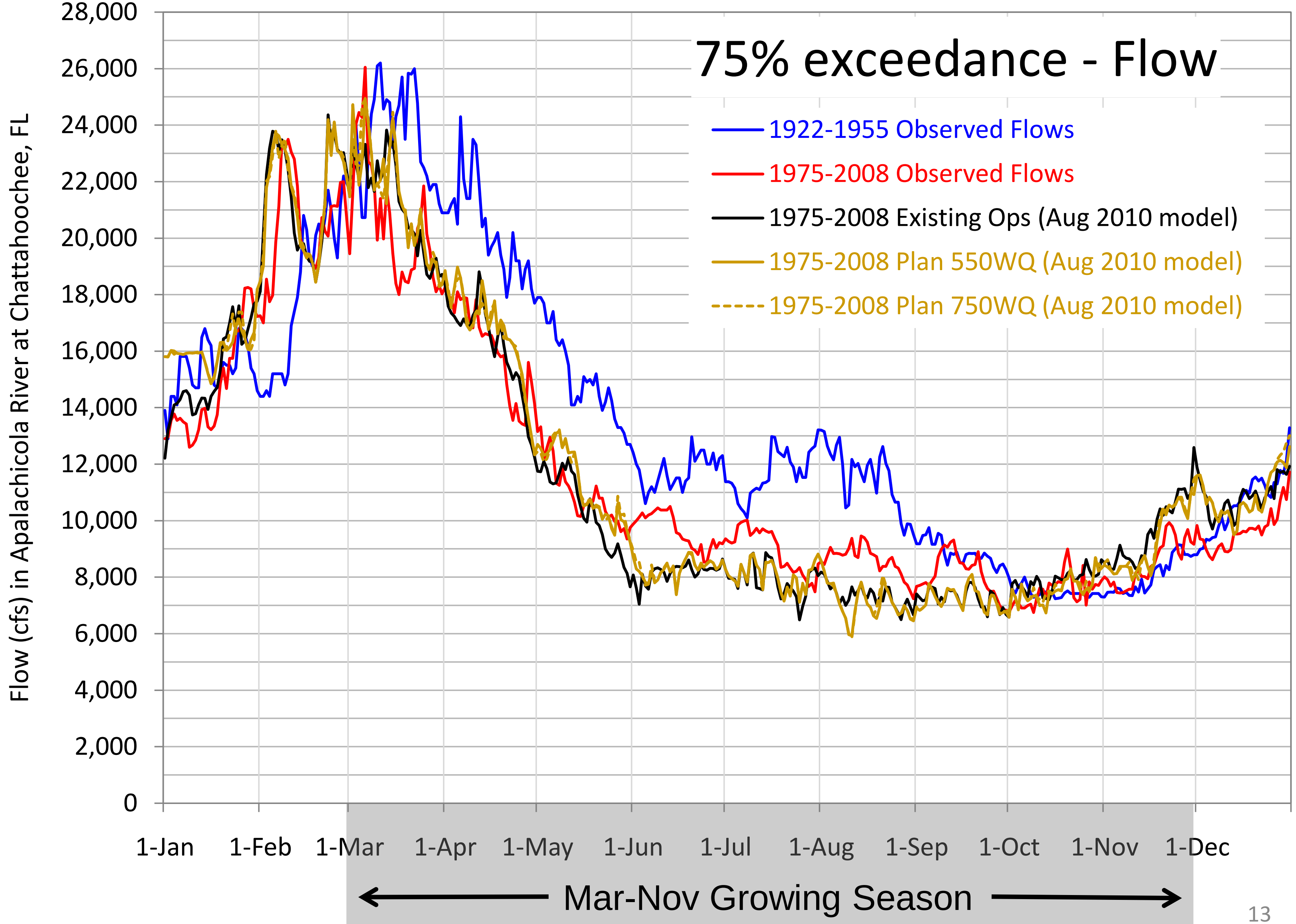

30-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
30
40
50
60
70
80
90
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

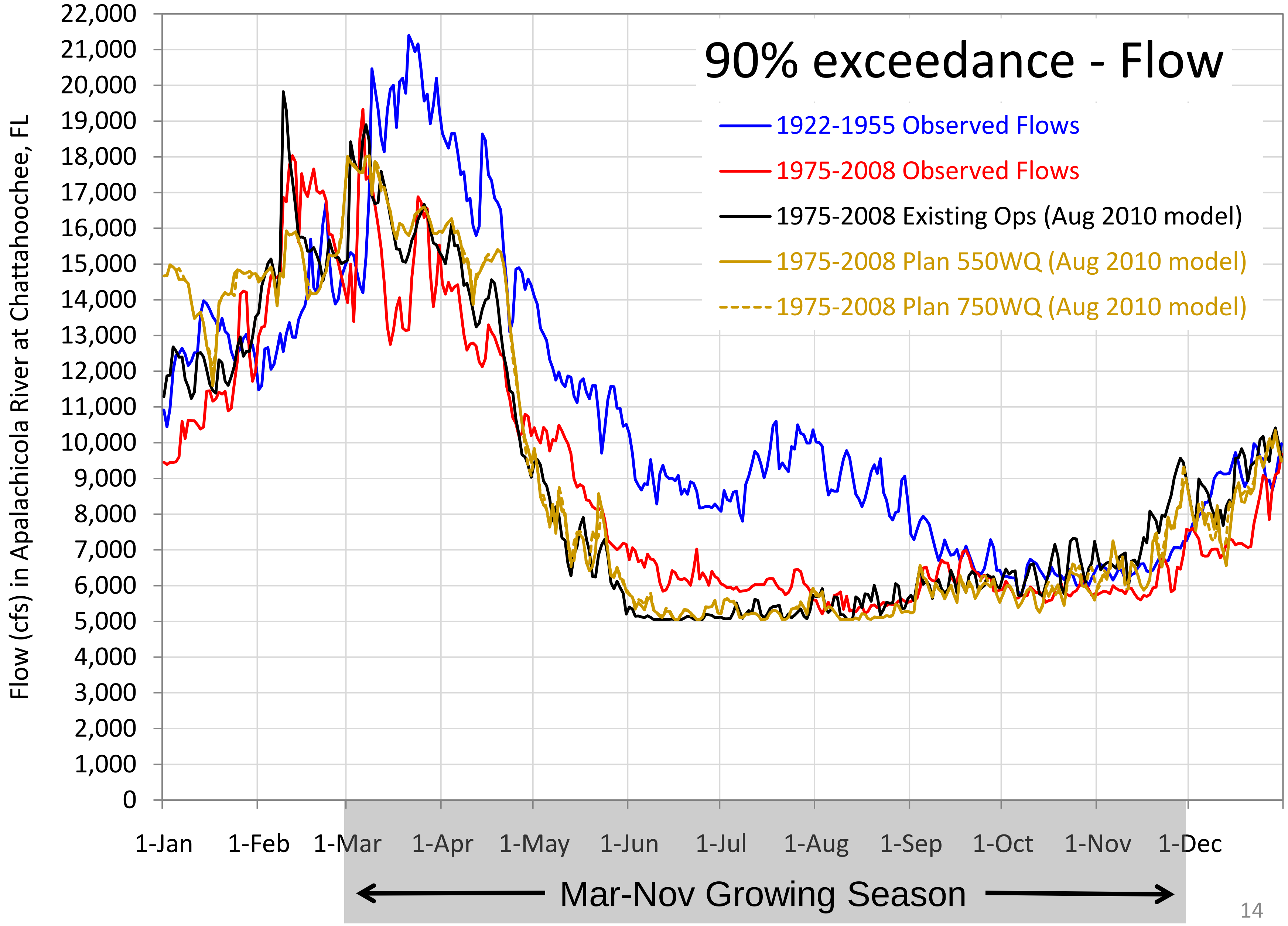

70-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
70
75
80
85
90
95
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

Flow Exceedance Hydrographs

Daily exceedance flows for selected frequencies: 75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

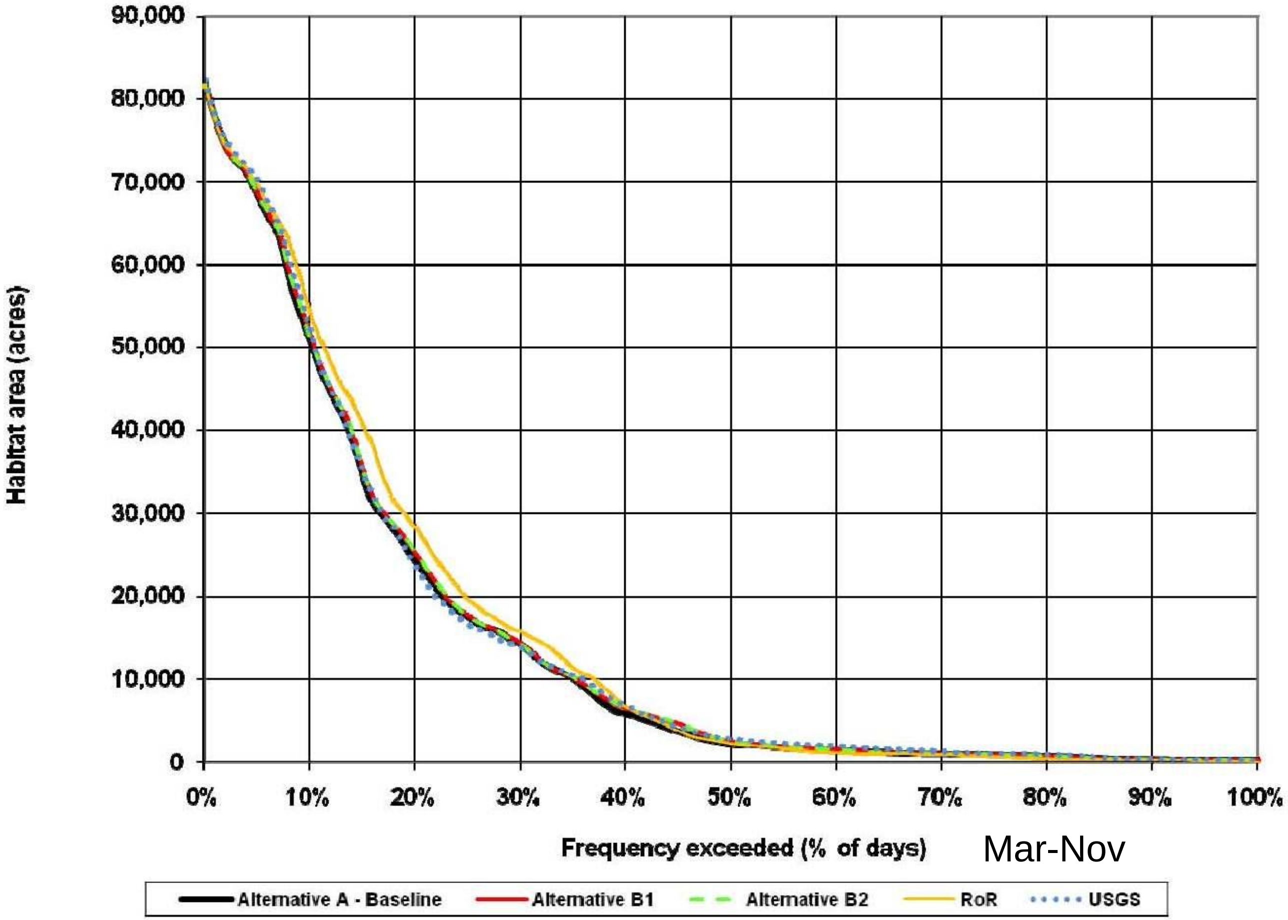

90% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

Area Frequency Curves

Frequency that acres of inundated floodplain are exceeded in the growing season (% of days – Mar-Nov)

Analysis provided by Corps

Graph from Corps 1/18/2011 Response to PAL, page 2-95:

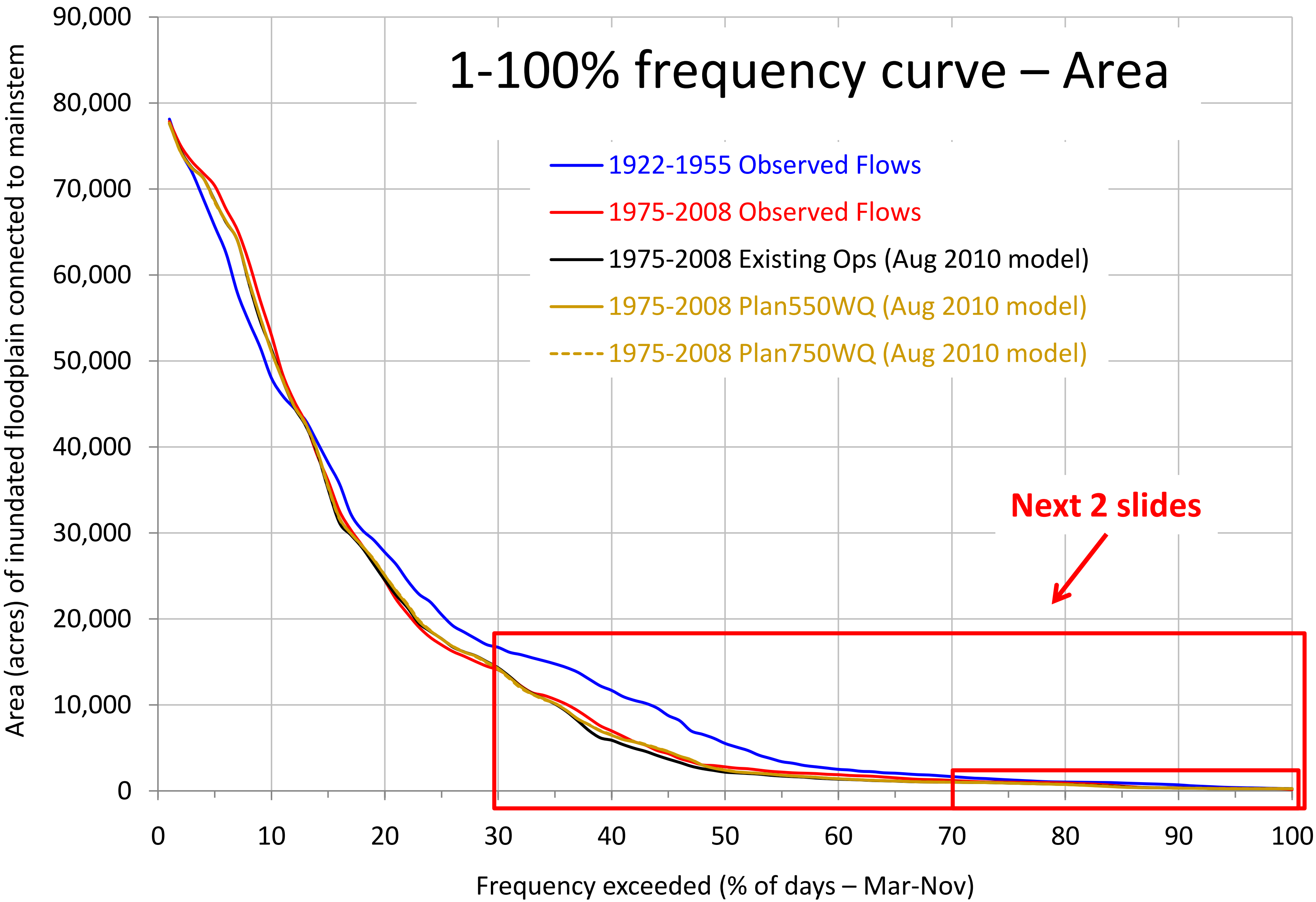


This graph was created by the Corps in response to FFWCC request.

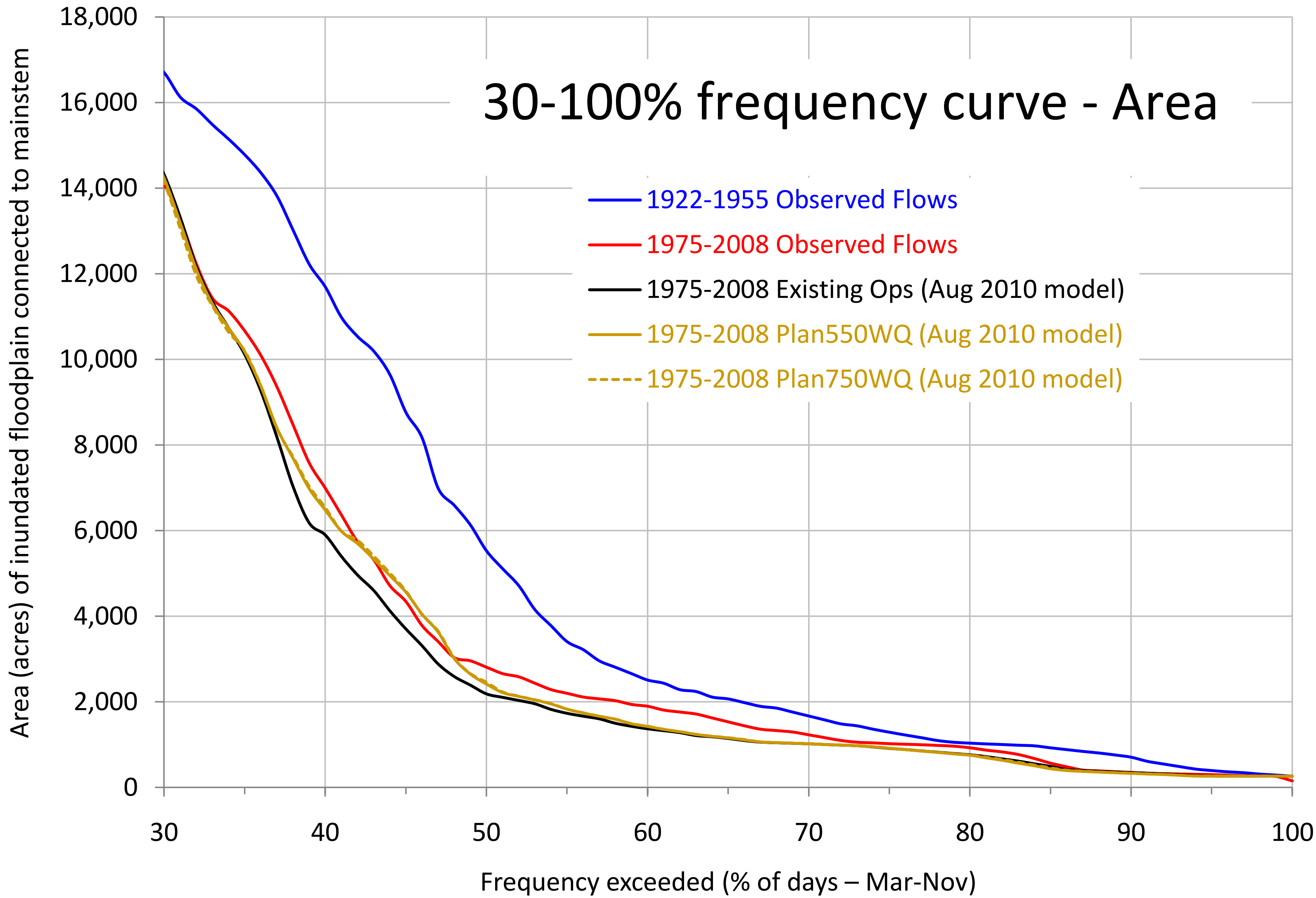
Suggested revisions:

-- Remove RoR and replace with appropriate ecosystem flow guideline (1922-1955 observed flow)

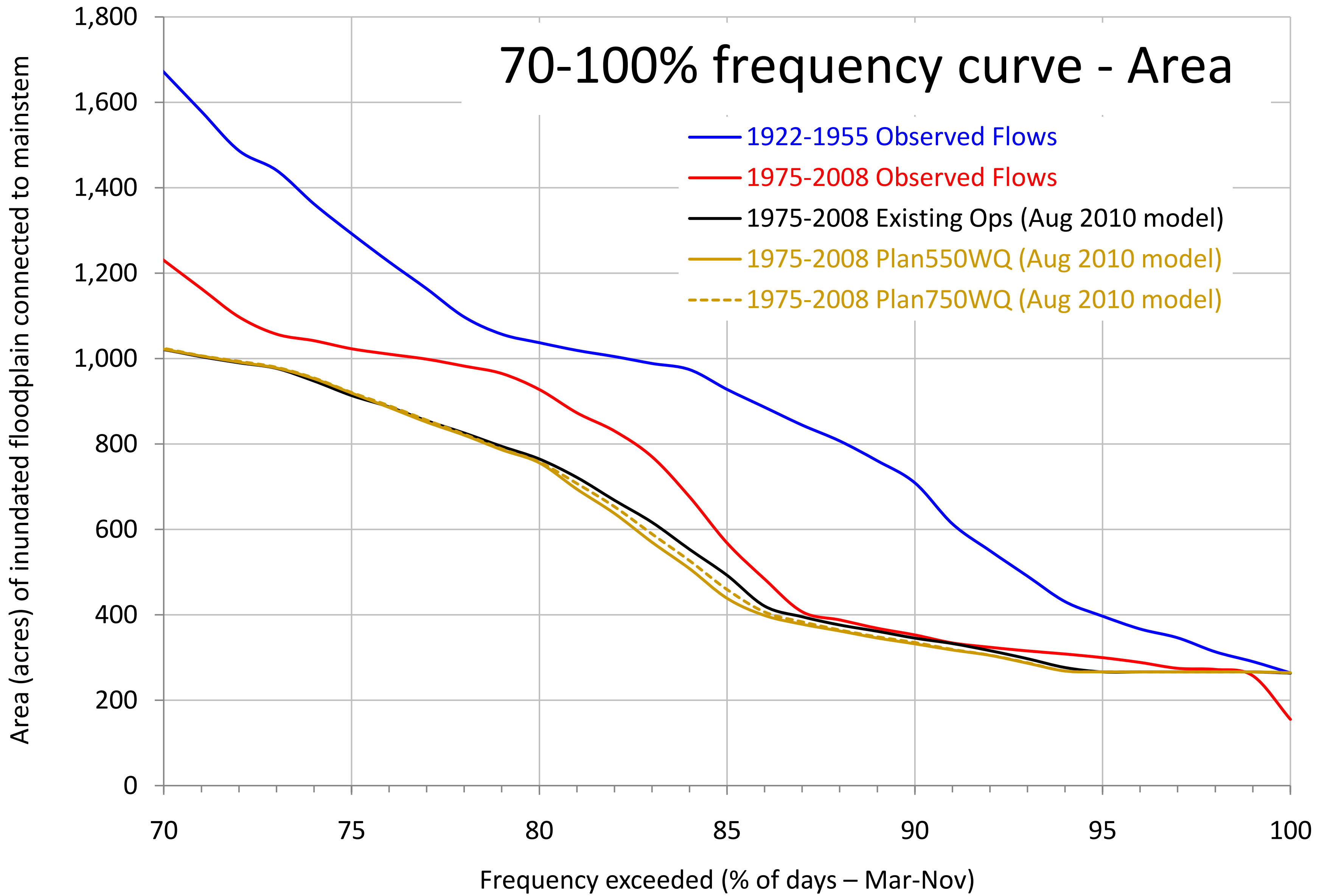
-- Expand data at low end



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

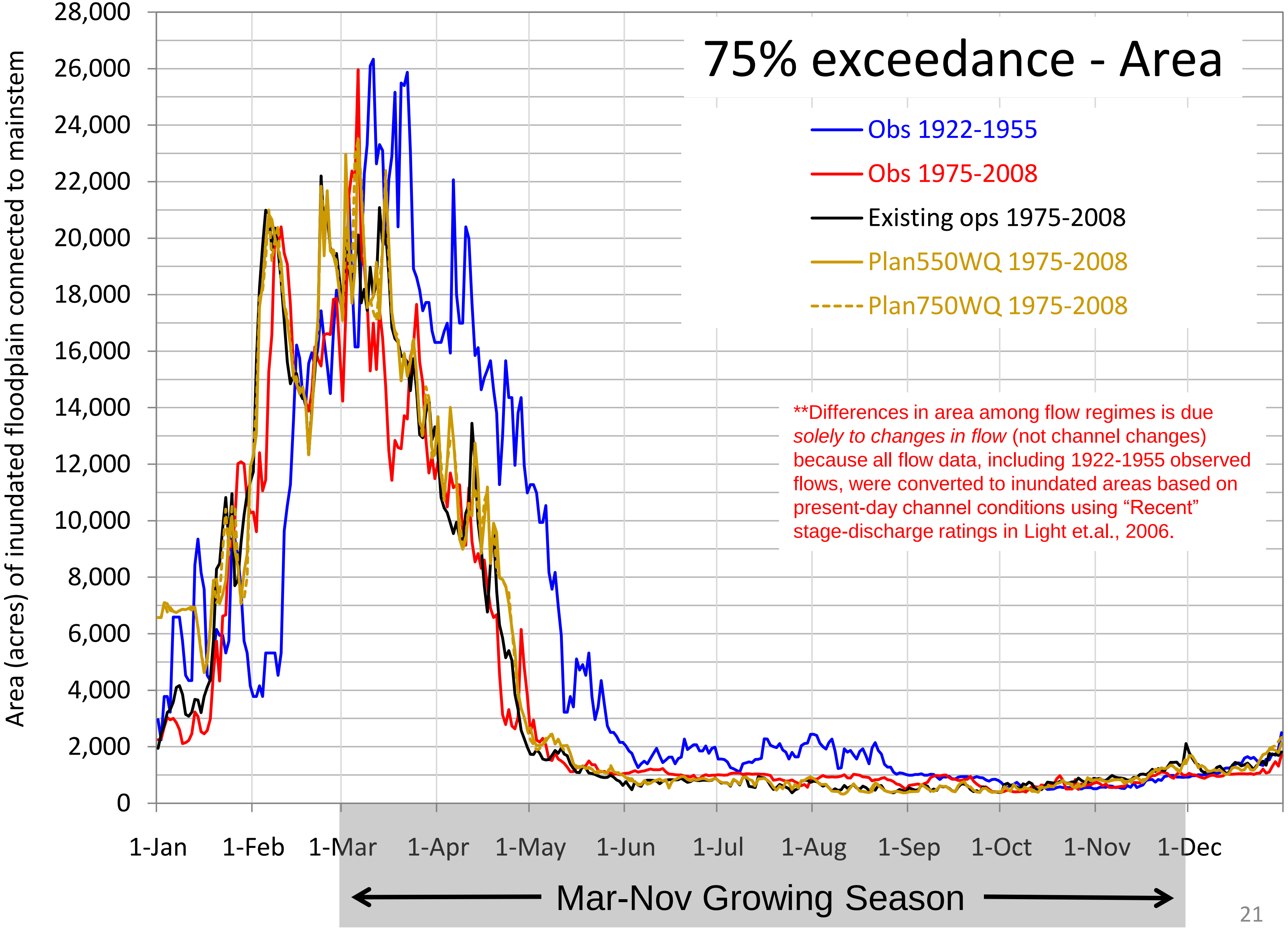


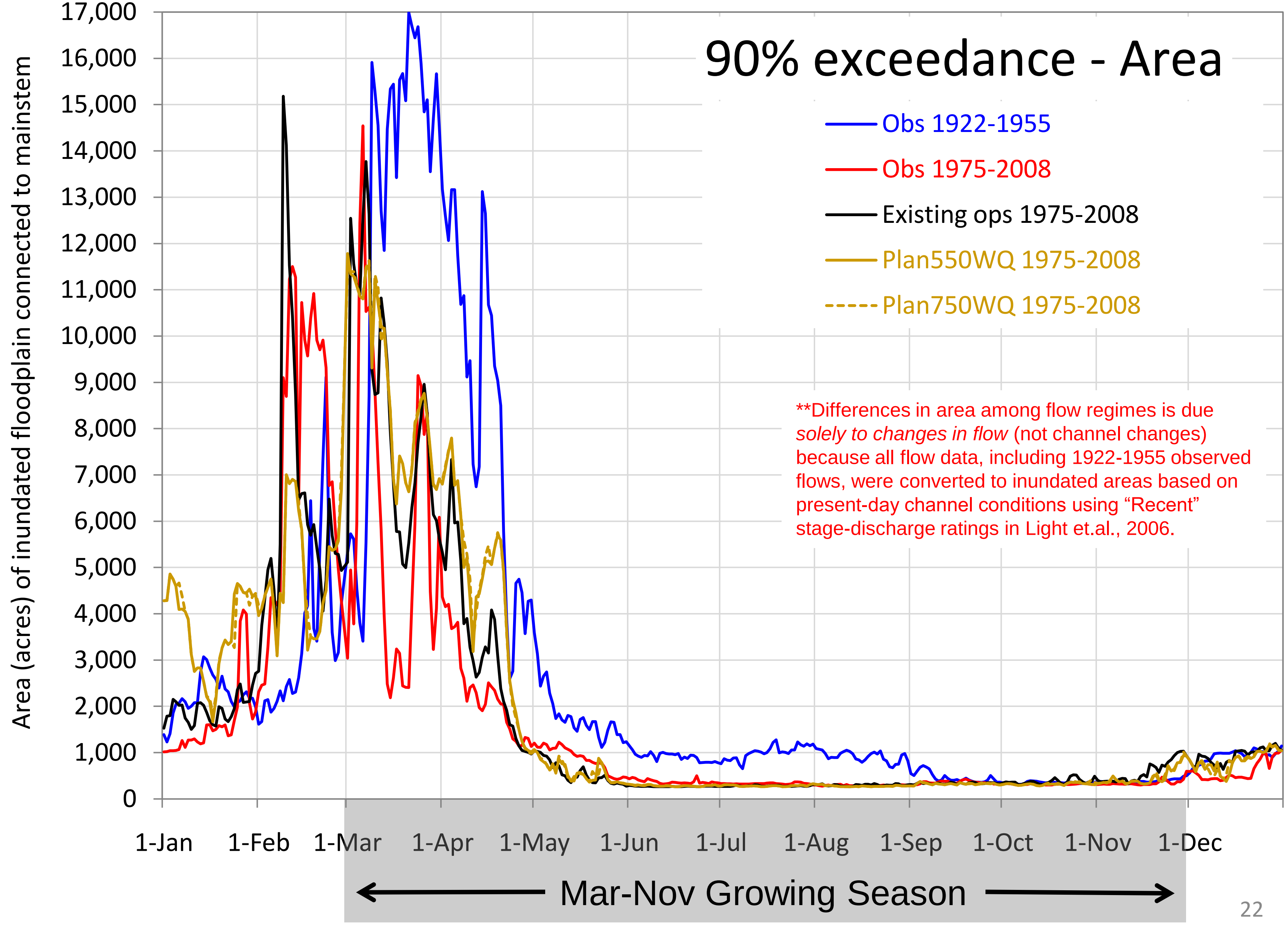
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

Area Exceedance Hydrographs

Daily exceedance for acres of inundated floodplain at selected frequencies:
75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due solely to changes in flow (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season


90% exceedance - Area
Obs 1922-1955
Obs 1975-2008
Existing ops 1975-2008
Plan550WQ 1975-2008
Plan750WQ 1975-2008
**Differences in area among flow regimes is due solely to changes in flow (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.
Area (acres) of inundated floodplain connected to mainstem
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, FL

Draft Interim Report

By

Y. Peter Sheng, Ph.D.,
Justin R. Davis, Ph.D., and
Vladimir A. Paramygin, Ph.D.

Civil and Coastal Engineering Department
University of Florida

Presented to the

Fish and Wildlife Service
U.S. Department of Interior

April 27, 2011

Table of Contents

Introduction

The Apalachicola-Chatahoochee-Flint (ACF) system is an important watershed-riverine-estuarine ecosystem which encompasses the tri-state area of Georgia, Alabama, and Florida. Freshwater originates in northeast Georgia and flows through Chattahoochee River, Flint River, and Apalachicola River before reaching the Apalachicola Bay in Florida. While the freshwater is used for drinking and agriculture, it is also vital to the shellfish in the Apalachicola Bay. Reduced freshwater flow in the ACF system will result in higher salinity in the Apalachicola Bay which could adversely impact the oysters. Low salinity, on the other hand, may endanger the federally threatened Gulf sturgeon in the Bay. Therefore, it is important to develop quantitative understanding on how freshwater flow in the ACF system impacts the salinity in the Apalachicola Bay, so that the amount of freshwater flow necessary to maintain fish and wildlife in Bay can be better understood.

As a first step towards the development of an integrated modeling system of the ACF system to enable assessment of the impact of freshwater withdrawal and climate change on the salinity and biological species inside the Apalachicola Bay, Sheng and Paramygin (2010a) developed a hydrodynamic model to simulate the flow and salinity distribution inside Apalachicola Bay. Their model is based on the 3D curvilinear-grid hydrodynamic model CH3D (Sheng 1987, Sheng et al. 2008, Sheng and Paramygin 2010a) and was successfully applied to simulate the salinity dynamics in the Bay during the summer of 2004 when 5 hurricanes passed the region. The simulation captured the significant variation in salinity that occurred during the 2004 hurricane season. The CH3D model used by Sheng and Paramygin (2010a) has several advantages over the model used by Huang (2010) for Apalachicola Bay:

- It uses a boundary-fitted grid to accurately resolve the complex shorelines of the Apalachicola Bay system;
- It uses very high spatial grid resolution (~20 m) in the horizontal directions;
- It can simulate circulation driven by wind, tide, and density gradients, while allowing flooding and drying of the shorelines during hurricanes and storms;
- It can be coupled to a large scale circulation model of the Gulf of Mexico;
- It allows incorporation of various wind and precipitation fields; and
- It has been integrated with ecosystem models, CH3D-IMS (Sheng and Kim 2009), and inundation models, CH3D-SSMS (Sheng et al. 2010; Sheng and Paramygin 2010b).

Therefore in this study we used the CH3D model for Apalachicola Bay to study the impact of freshwater alteration on the salinity, Gulf sturgeon, and oyster population in the Apalachicola Bay.

Results of the hydrodynamic and salinity simulations can be used to simulate the oyster population inside the Apalachicola Bay. Hofmann et al. (1992), Klinck et al. (1992), Powell et al. (2003) developed an oyster population dynamic model for oysters in Galveston Bay, Texas. Since Apalachicola Bay and Galveston Bay have similar-sized adult oyster populations, Wang et al. (2008) applied the post-settlement population dynamic model of Powell, Hofmann, and Klinck to Apalachicola Bay with necessary modifications to account for the specific conditions in Apalachicola Bay. Post-settlement adult oysters are divided into four size groups, while oyster filtration rate is assumed to be dependent on salinity, temperature, and turbidity, spawning patterns are dependent on the relationship between temperature and food supply during critical feeding periods, the same temperature-dependent reproduction efficiency equations from Galveston Bay holds true, and no specific relationship exists between salinity and oyster growth rate. Thus, low salinity results in low oyster reproduction due to lower filtration rate and higher respiration. Livingston et al. (2000) also studied the oyster population in Apalachicola Bay.

Wang et al. (2008) simulated the oyster population between March 2004 and June 2005 at two sites: Dry Bar, a site with strong river influence located to the southwest of the Apalachicola River, and Cat Point, a site with little river influence located to the southeast of the River. Model results agreed well with data except during July and September 2004 when hurricanes were affecting the Apalachicola Bay. Nevertheless, Wang et al. (2008) suggested that, anticipating increased freshwater use upstream of the Apalachicola River, Apalachicola Bay will become increasingly saltier, causing a substantial decrease in oyster growth rates, particularly in summer when oyster growth rates are normally high in the Bay.

During this study, we constructed and validated an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it to the hydrodynamic-salinity model described above to assess the impact of freshwater alteration on oyster population in Apalachicola Bay.

Initial Model Setup and Verification

A CH3D model computational grid was developed for Apalachicola Bay and surrounding areas to simulate the salinity distribution in the bay, the grid, selected data sites, and bathymetry/topography values used in the model are shown in Figures 1 and 2. From hereon, this grid is referred to as the “fine” grid. A coarse grid has also been developed which has 4 times fewer grid cells. The “coarse” grid is obtained by merging 2 by 2 cell blocks of the fine grid into a single grid cell of the coarse grid and reapplying the bathymetry/topography interpolation.

CH3D is applied in a 3D mode with 8 vertical sigma-grid layers. The time step used for simulations is set to 1 minute which allows to 1 year to be simulated in approximately 1.2 days of wall clock time on a single CPU core (Intel Core i7 870 @ 2.93 Ghz).

The model has two open boundaries – at the west and south ends, tidal forcing (in a form of tidal constituents) is used at these boundaries to drive the tides inside the model domain. The tidal constituents are based on the data at the NOAA tidal gage (872-8690) located at the mouth of the Apalachicola River (Figure 1). Significant constituents (amplitudes > 1 cm) are K1, M2, O1, P1, S2, SA, and SSA.

A river flow boundary condition is introduced at the Apalachicola River (Sumatra gage) and the flows are based on the daily flow rates provided by the USACE. It is assumed that flow at the Sumatra gage is freshwater only, hence the river boundary value of salinity is set to 0 ppt.

Wind forcing over the domain is based on 6-hourly wind data from the NOGAPS model (https://www.fnmoc.navy.mil/public) and is linearly interpolated in time at the time step of the CH3D model.

The initial salinity field is based on interpolation of a HYCOM model snapshot of surface salinity; hence, the initial salinity profile is vertically uniform. Subsequently, all model simulations use a spin-up period of 3 months prior to starting the main simulation to ensure that there is time to establish a realistic (spatial and vertical) salinity distribution in the domain.

Apalachicola National Estuarine Research Reserve (ANERR) provides salinity data at several sites. Comparisons with observed data were done to verify the model, which showed satisfactory performance (Figure 3 and Figure 4) with the test year being simulated (2004).

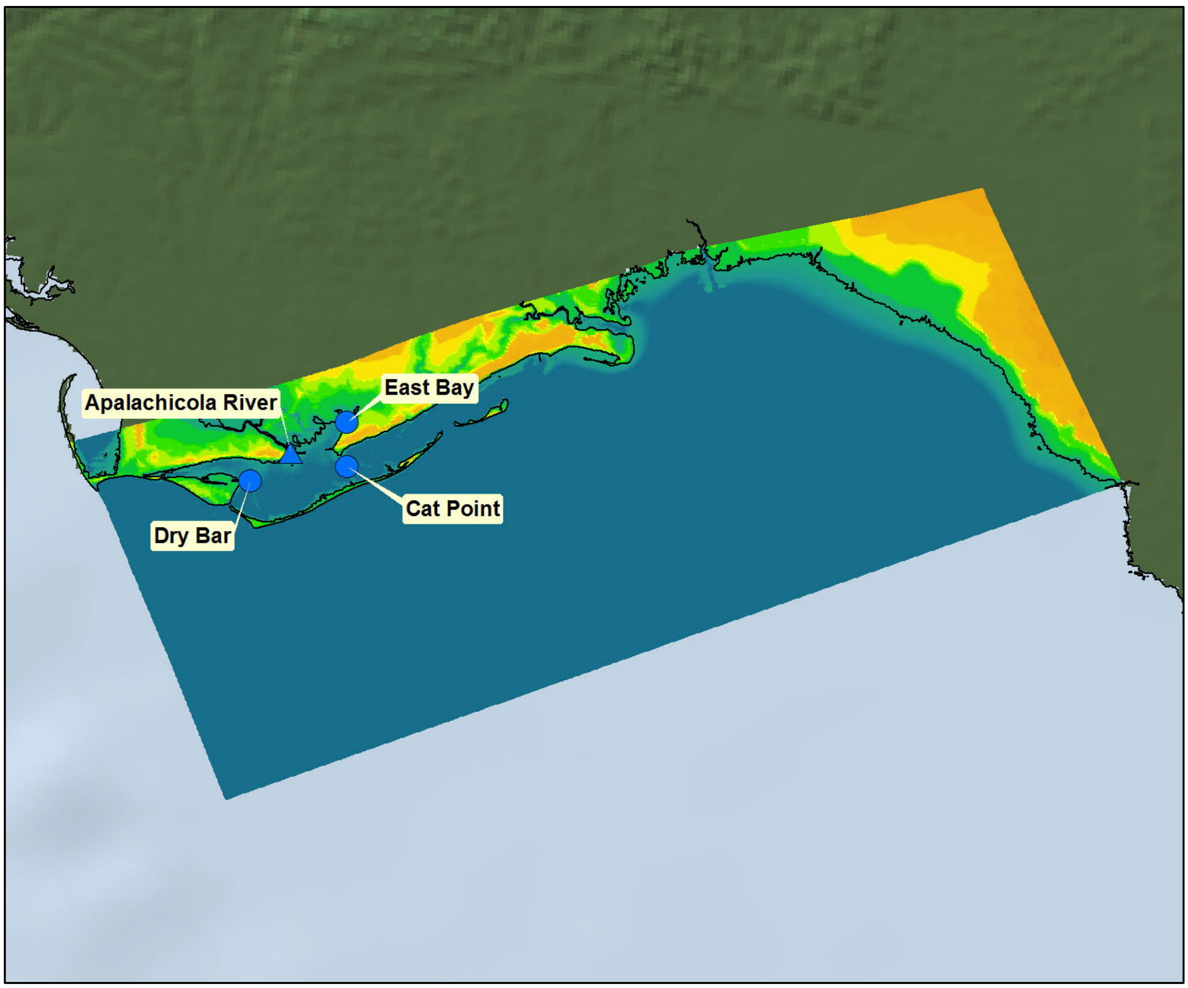


Figure 1. CH3D model grid and selected data sites

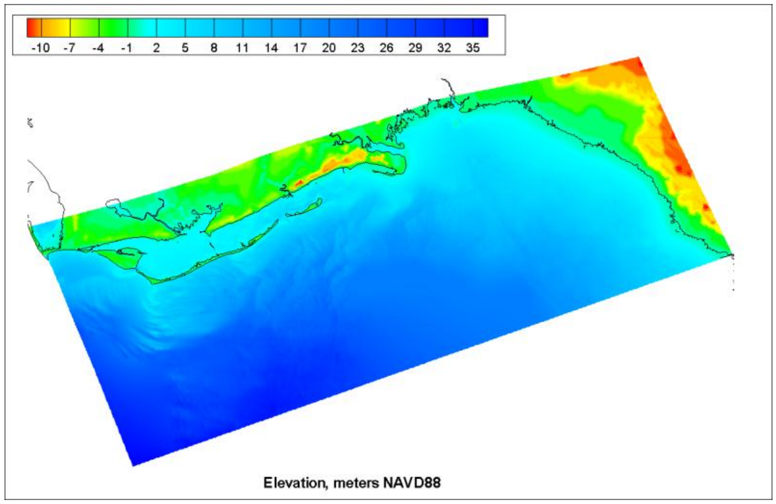


Figure 2. CH3D model grid bathymetry / topography

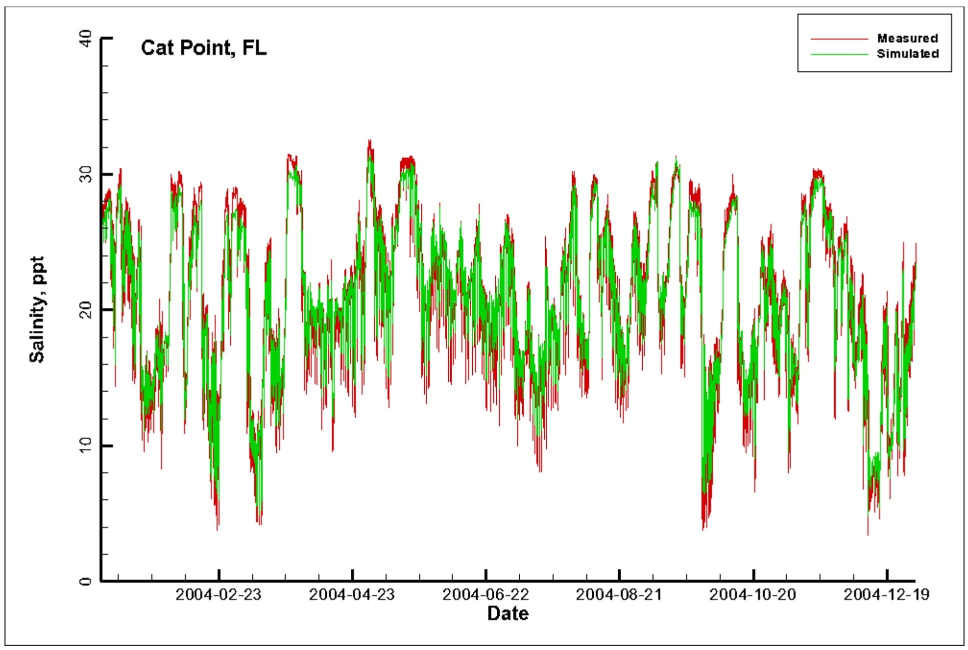


Figure 3. Simulated salinity at the Cat Point site during 2004

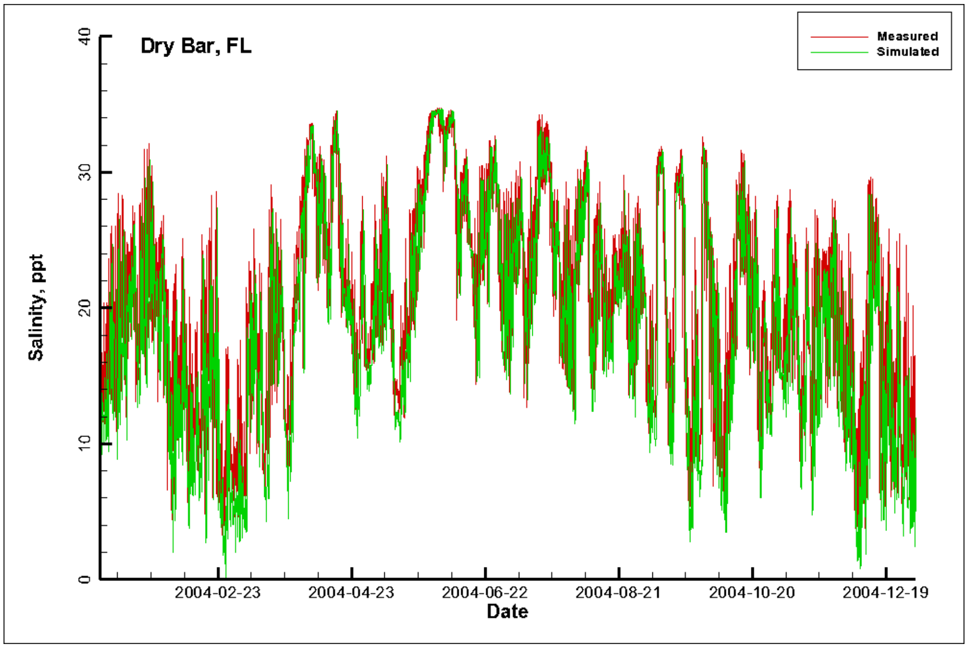


Figure 4. Simulated salinity at the Dry Bar site during 2004

10 Year Simulations

1999-2008. Fine grid

Four flow discharge scenarios were considered for the 10 year (1999-2008) simulations:

a) Observed

b) Current operations

c) Alternative #1

d) Alternative #2

Base scenario a) uses observed flow rates at the Sumatra gage provided by the USACE. Scenarios b), c) and d) use altered flows, statistics for the time series of flow rates are provided in Table 1.

With the exception of these flow rates all other model parameters and forcing remain the same for all scenarios.

Table 1. Statistics for the flow rates (m^3/s) at the Sumatra gage

	mean	mean %	std dev	std dev %	min	max
Observed	519.2		411.4		124.6	4700.6
Current	514.4	0.92	391.3	4.89	136.4	3965.7
Alt #1	515.9	0.64	391.4	4.86	136.4	3965.7
Alt #2	516.4	0.54	391.0	4.96	136.4	3965.7

Salinity for the observed scenario during 2004 is consistent with the results produced by the verification simulation displayed in Figure 3 and Figure 4. These results show that there is little difference in salinity inside Apalachicola Bay between the observed scenario and the current and alternate scenarios. However, due to reduced flow rates, simulated salinity in current and alternate scenarios results in slightly higher highs and lower lows as compared to the observed scenario.

1980-1989. Fine grid

Another 10 year time period was also considered (1980-1989). This period was chosen to correspond to the period used by Huang (2010). The same grid was used as in the previous simulations.

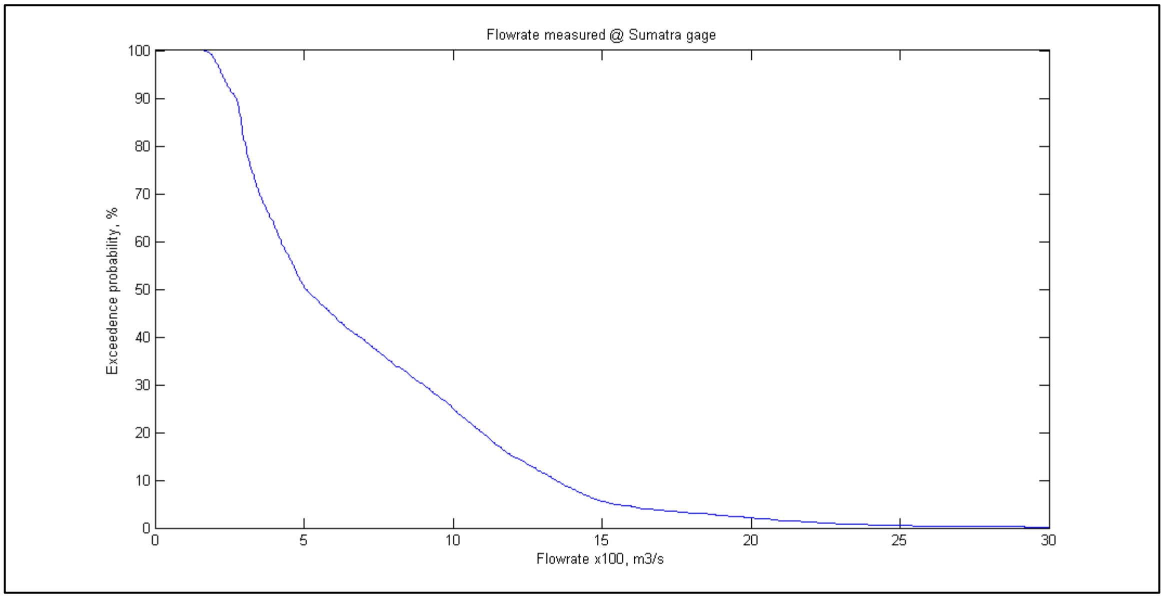


Figure 5. Obsereved flowrate probability of exceedence at the Sumatra gage

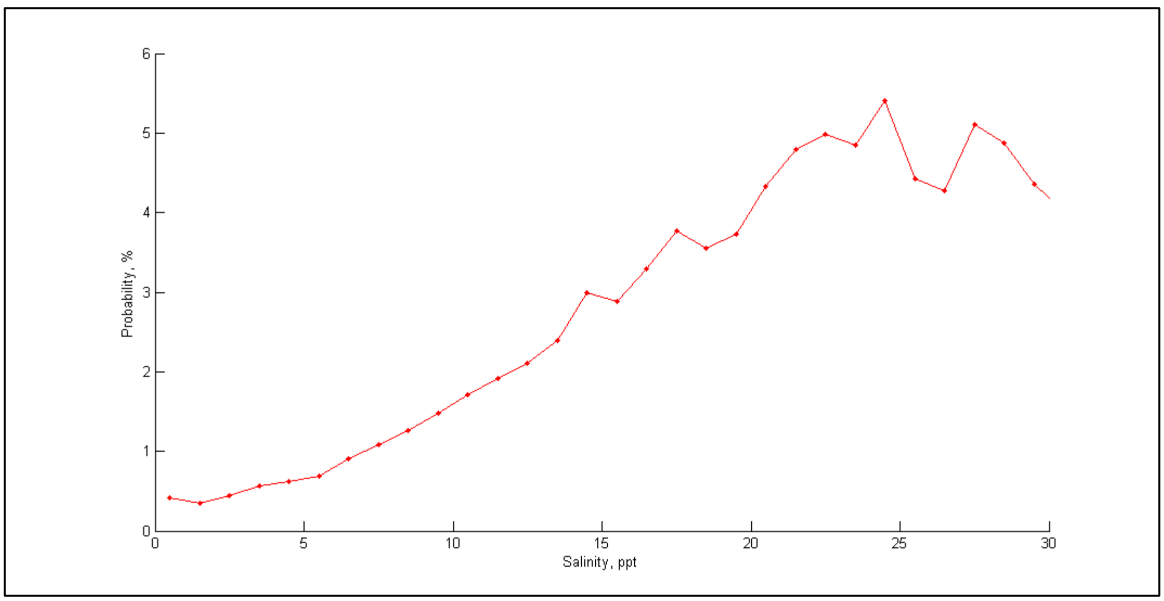


Figure 6. Probability density of simulated salinity at Cat Point

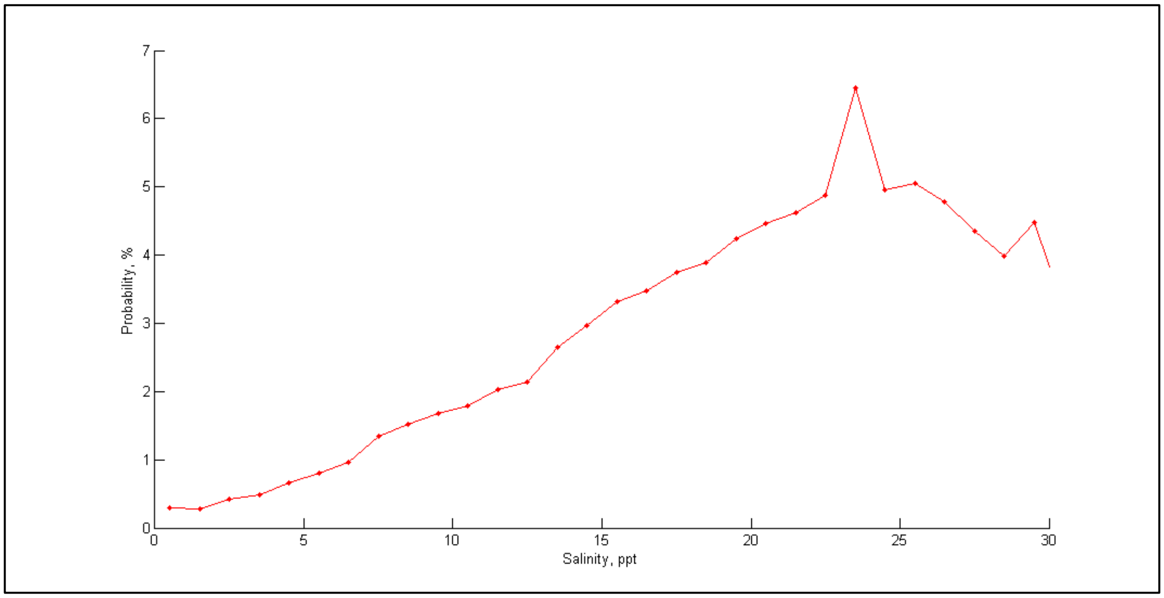


Figure 7. Probability density of simulated salinity at Dry Bar

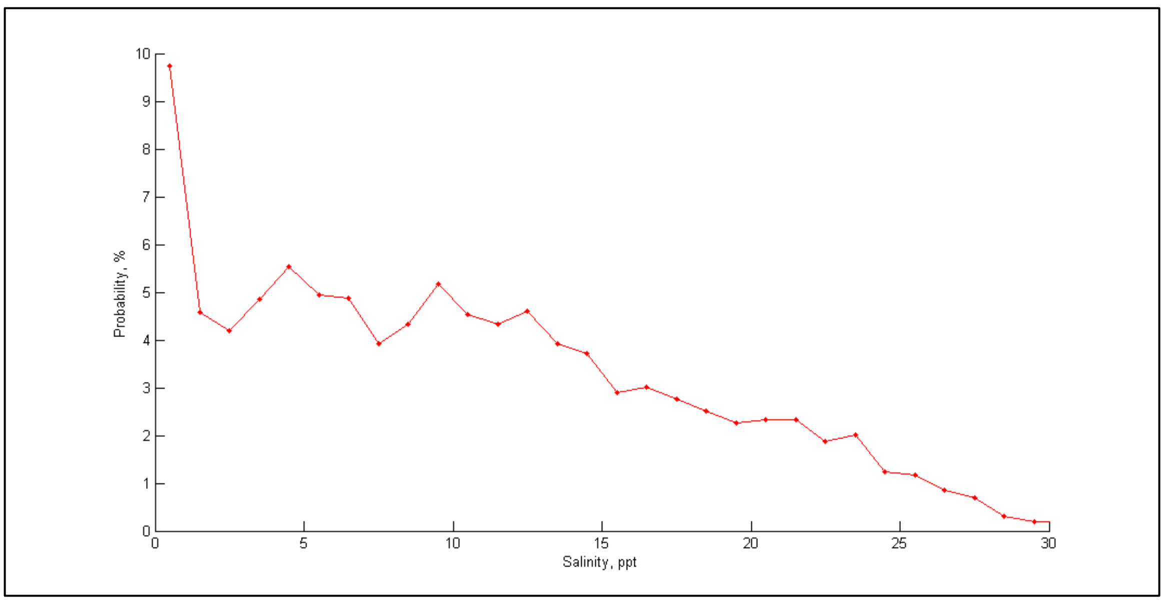


Figure 8. Probability density of simulated salinity at East Bay

1980-1989. Coarse grid

Due to the simulated salinity differing slightly from the results of Huang (2010) – a coarser grid was developed in an attempt to better reproduce Huang's two distinctive peaks in the probability of exceedance figures for salinity; however, results were similar to those produced by the finer grid model and aggregate functions (e.g. probability of exceedence, probability density, etc.) showed little difference compared to the fine grid model results.

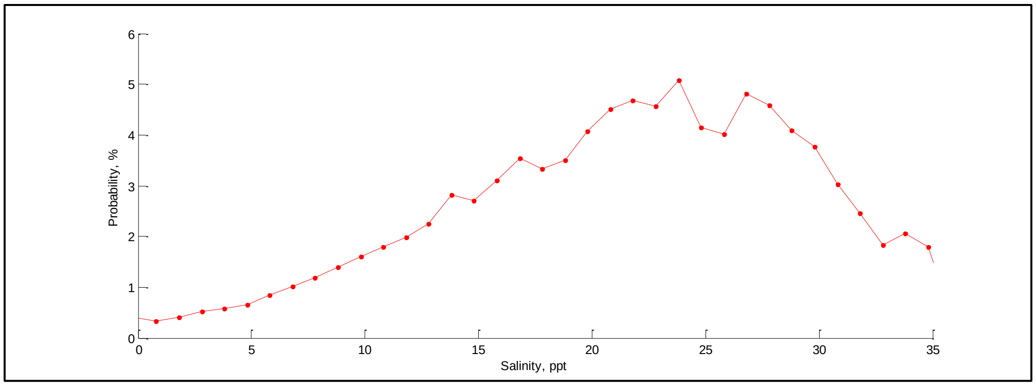


Figure 9. Probability density of simulated salinity at Cat Point

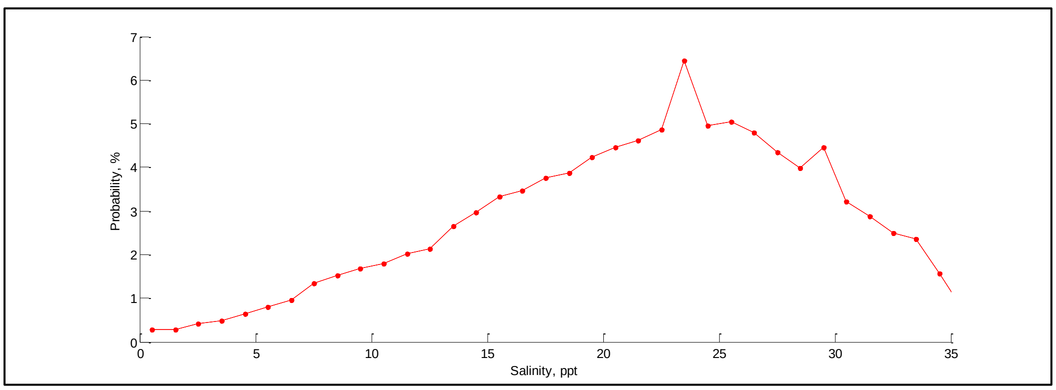


Figure 10. Probability density of simulated salinity at Dry Bar

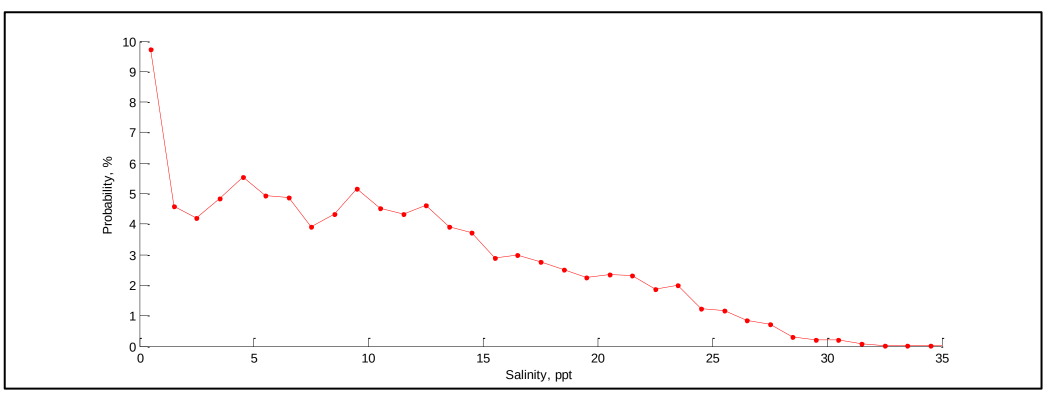


Figure 11. Probability density of simulated salinity at East Bay

Analysis Products

A number of model outputs were requested by the FWS – the complete list is available in Appendix B. This section comprises of the figures and tables that are dedicated to fulfilling the request and provide various information based on the results of simulations. All model results presented in this section are based on the 10 year simulation (1999-2008) fine grid using the four different flow scenarios. Given that the flow rate is the only parameter which changes – it is the only parameter that affects the differences in salinity and therefore results, generally, correlate well with the flow at Sumatra gage.

Figure 12 and Figure 13 show the exceedence probability at the Cat Point and Dry Bar sites, respectively, for the four scenarios. As it was mentioned previously – the observed scenario produces slightly higher highs and lower lows in salinity values and there is very little difference, however, between the Current, Alternative #1 and Alternative #2 scenarios.

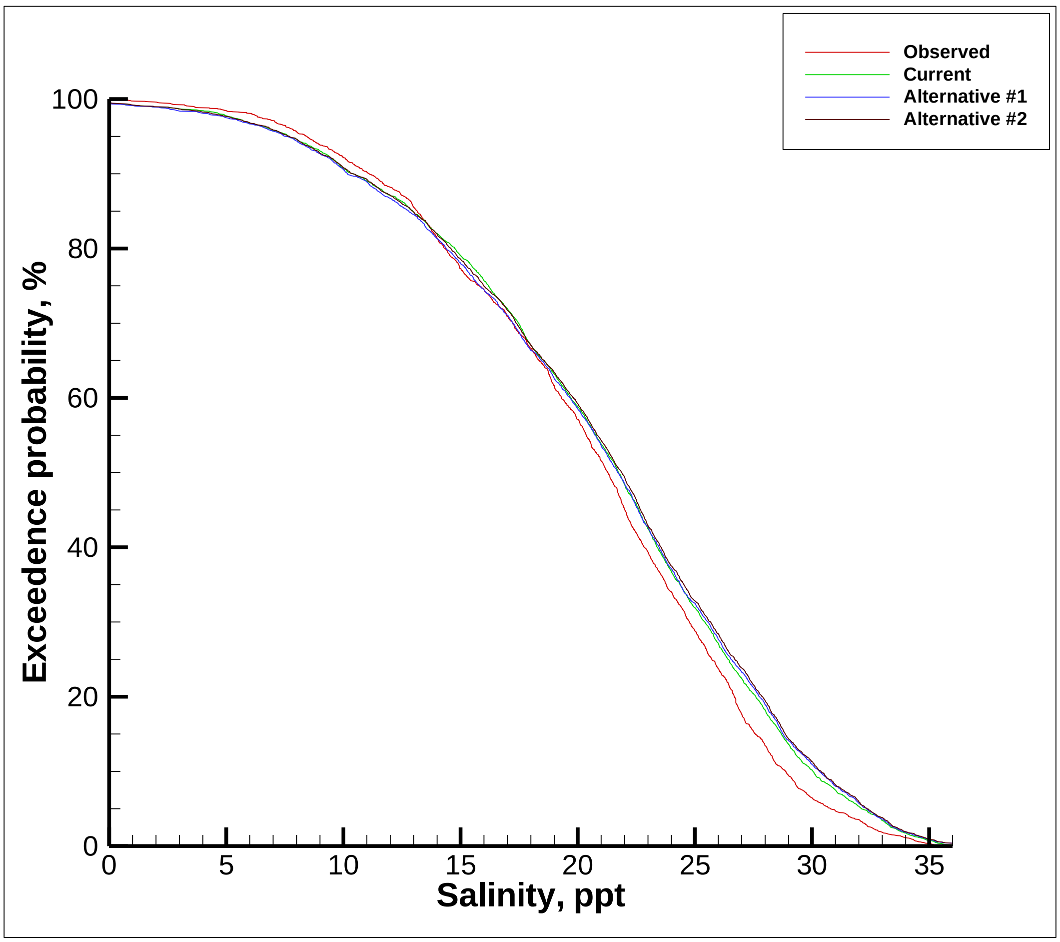


Figure 12. Probability of exceedence at the Cat Point site

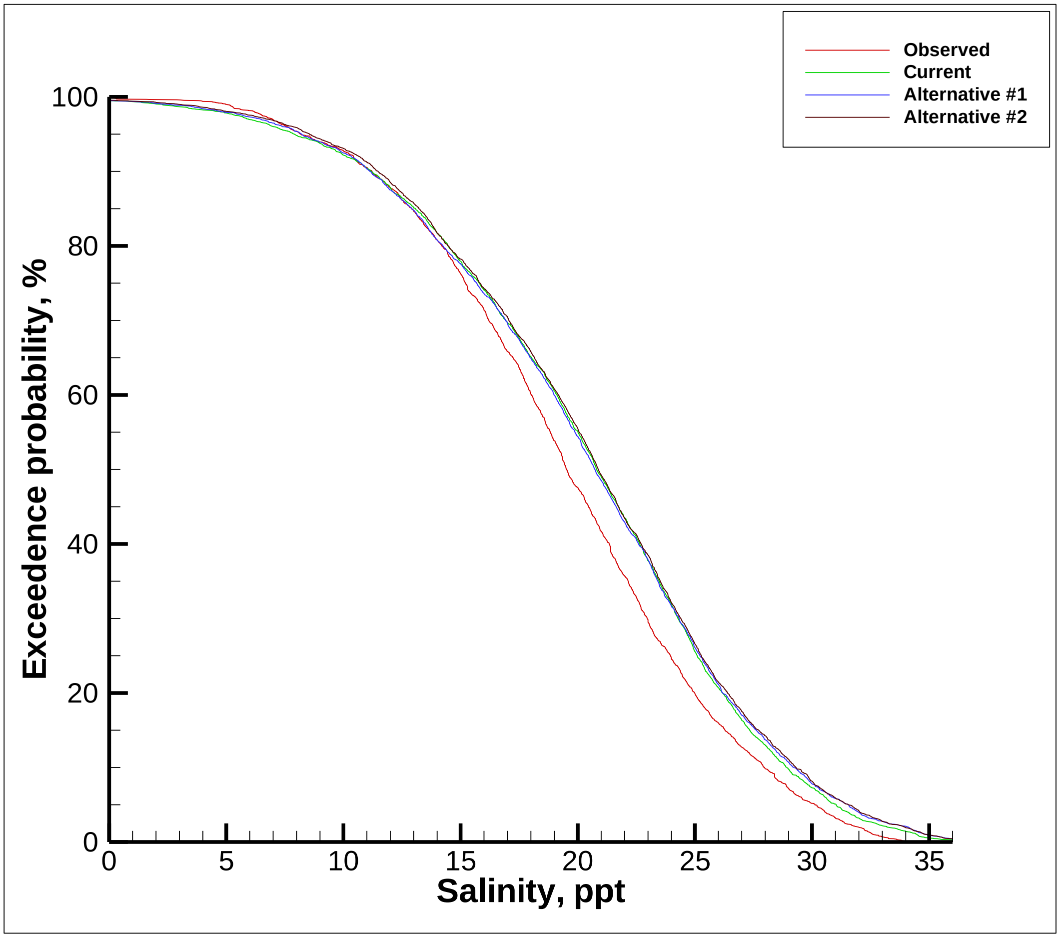


Figure 13. Probability of exceedence at the Dry Bar site

Summary statistics for growth rates of Class 4 (Marketable) oysters at the Cat Point and Dry Bar sites are presented in the tables and figures below. It can be clearly seen that the mean growth rate in August is significantly larger (3 to 4 times) as compared to the growth rate for the entire year at the Cat Point site and smaller for the Dry Bar site. Oyster population model results are based on the simulated bottom salinity at Cat Point and Dry Bar for the four flow scenarios.

Table 2. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Cat Point for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	1.78	5.79
	Current	1.41	4.66
	Alternate #1	1.30	4.31
	Alternate #2	1.31	4.35
Median	Observed	2.65	7.08
	Current	2.65	7.00
	Alternate #1	2.63	6.99
	Alternate #2	2.63	6.99
Standard Deviation	Observed	5.73	5.00
	Current	6.46	7.10
	Alternate #1	6.63	8.01
	Alternate #2	6.62	7.90
Interquartile Range	Observed	1.43	2.10
	Current	1.39	2.16
	Alternate #1	1.42	2.17
	Alternate #2	1.42	2.17

Table 3. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Dry Bar for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	2.92	2.19
	Current	2.42	0.81
	Alternate #1	2.39	0.69
	Alternate #2	2.44	0.78
Median	Observed	4.42	5.26
	Current	4.41	5.14
	Alternate #1	4.39	5.14
	Alternate #2	4.39	5.15
Standard Deviation	Observed	5.04	7.63
	Current	6.36	10.45
	Alternate #1	6.26	10.39
	Alternate #2	6.20	10.32
Interquartile Range	Observed	1.87	1.23
	Current	1.97	1.23
	Alternate #1	2.05	1.95
	Alternate #2	2.03	1.63

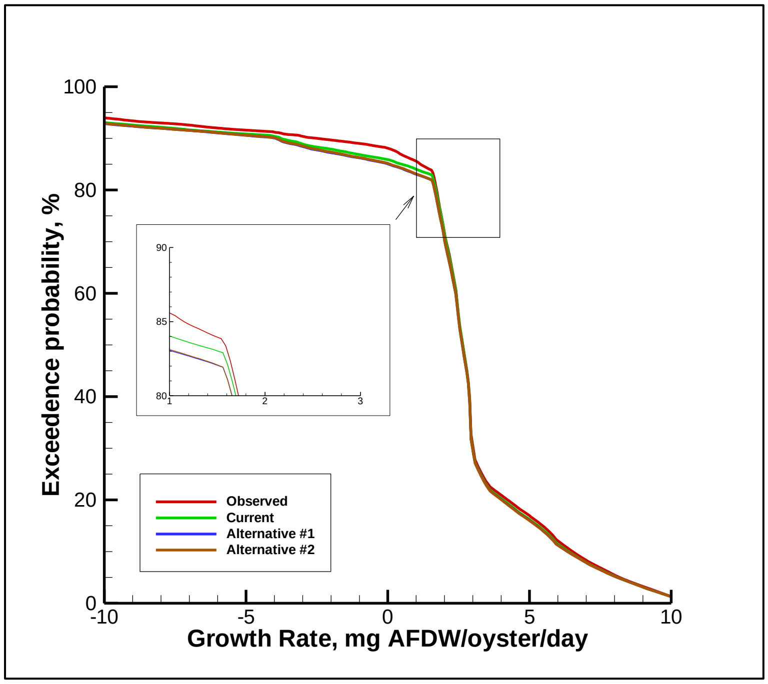


Figure 14. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

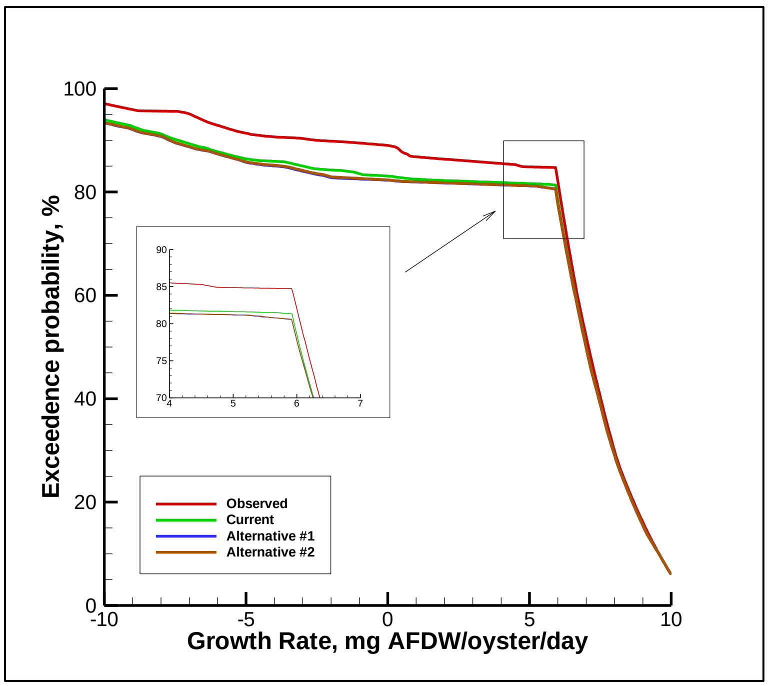


Figure 15. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

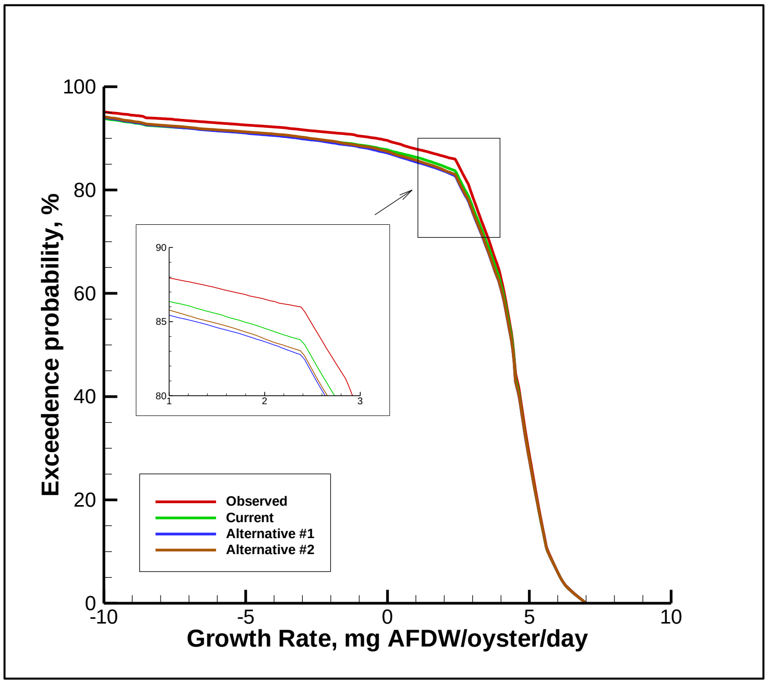


Figure 16. Exceedance probabilty at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

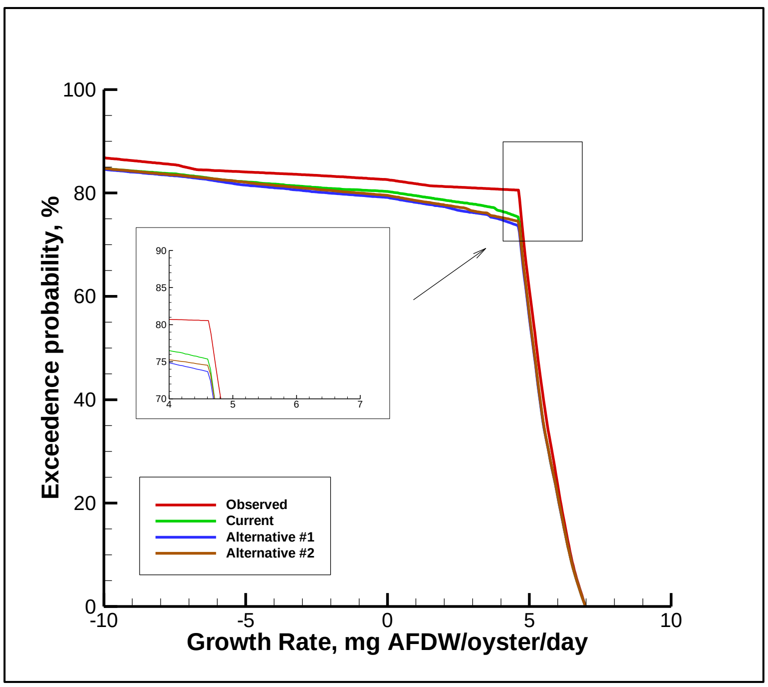
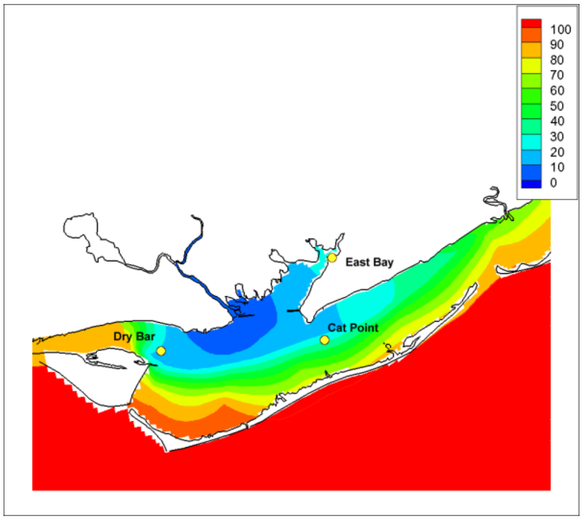
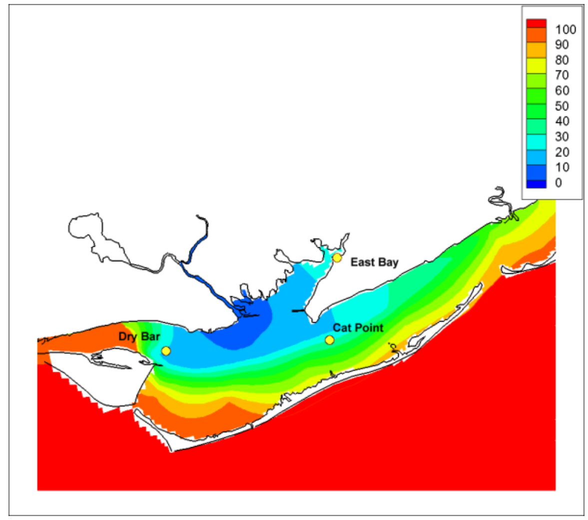


Figure 17. Exceedence probability at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

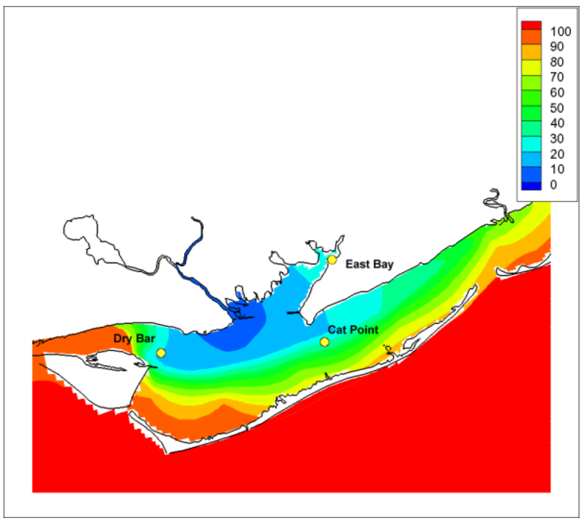
The following figures and tables present the number of days when salinity exceeds 26 ppt (important for oysters) and when the salinity exceeds 10 ppt (important for sturgeon).



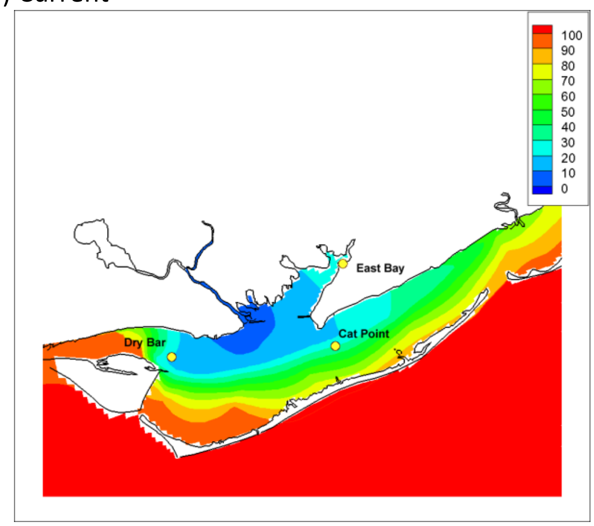
a) Observed



b) Current



c) Alternative #1

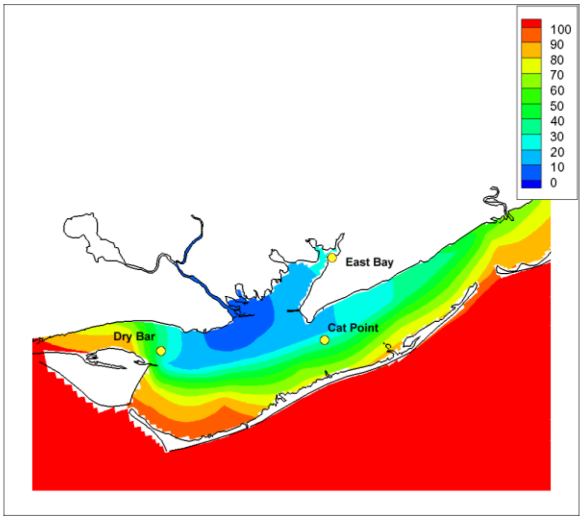


d) Alternative #2

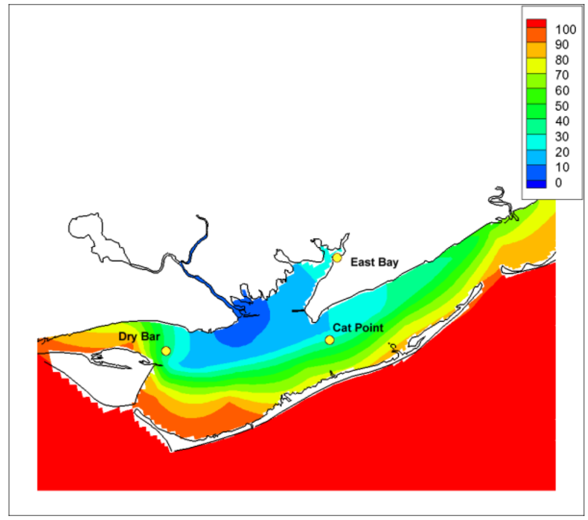
Figure 18. Percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

Table 4 Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

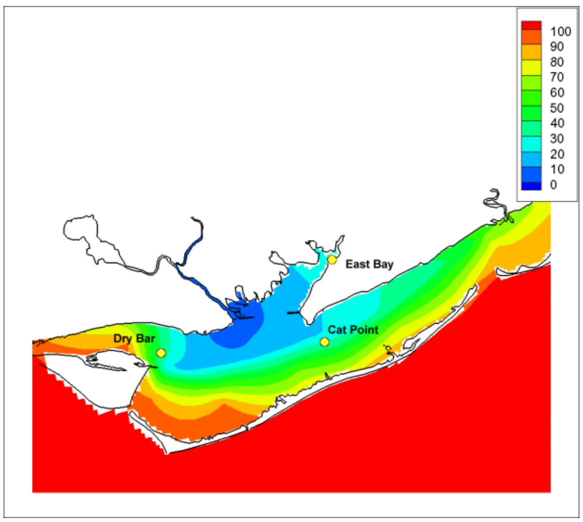
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	8682.77	5804.57	5499.89	5079.00
10-20	17059.82	17788.53	17818.89	17741.41
20-30	10170.56	10540.15	10608.20	10777.82
30-40	9461.74	9566.44	9603.08	9618.79
40-50	9057.60	9050.27	9019.90	9077.49
50-60	9839.71	9555.97	9539.22	9509.90
60-70	12861.35	12208.02	12175.56	12048.88
70-80	12351.46	12982.80	12978.61	13360.77
80-90	18268.06	10956.86	10889.85	10521.30



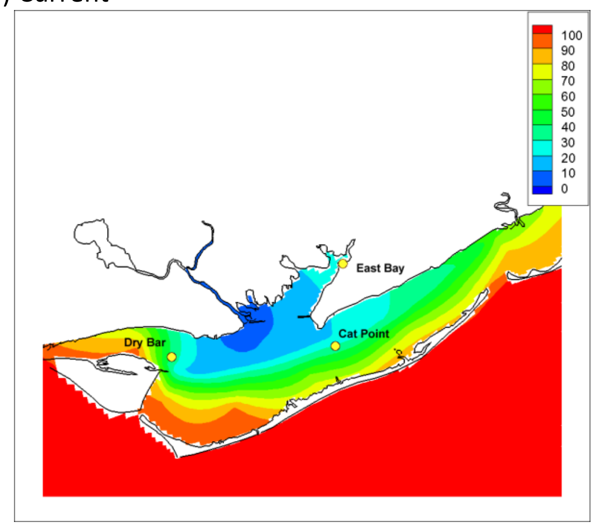
a) Observed



b) Current



c) Alternative #1

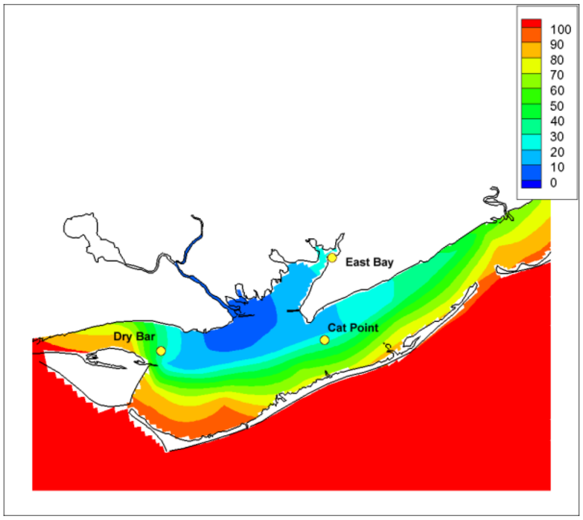


d) Alternative #2

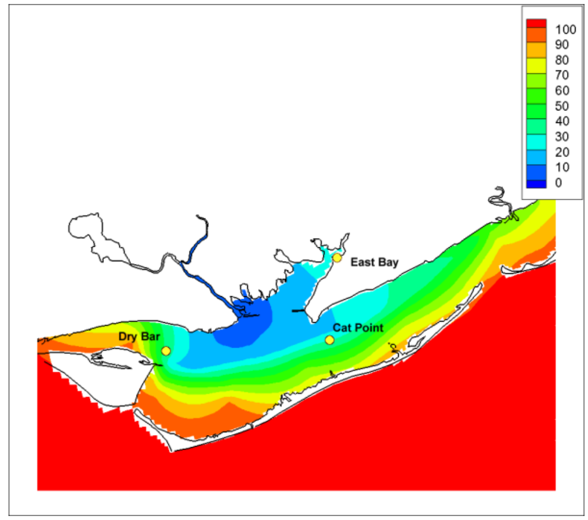
Figure 19. Percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual discharge) year (2005)

Table 5. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual flow) year (2005)

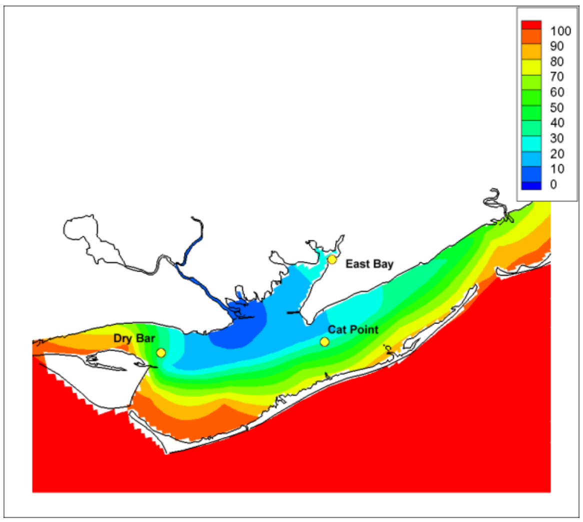
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7032.70	4895.77	4640.30	4420.43
10-20	15968.84	15783.53	15684.06	15553.18
20-30	10609.25	11019.67	11166.25	11263.63
30-40	9845.99	10061.67	10050.15	10084.70
40-50	9505.71	9453.36	9484.77	9463.83
50-60	10223.96	10063.76	9995.71	9976.86
60-70	13348.20	12568.19	12504.32	12366.12
70-80	13862.28	14223.49	14231.87	14372.17
80-90	15062.14	14692.55	14662.19	14608.79



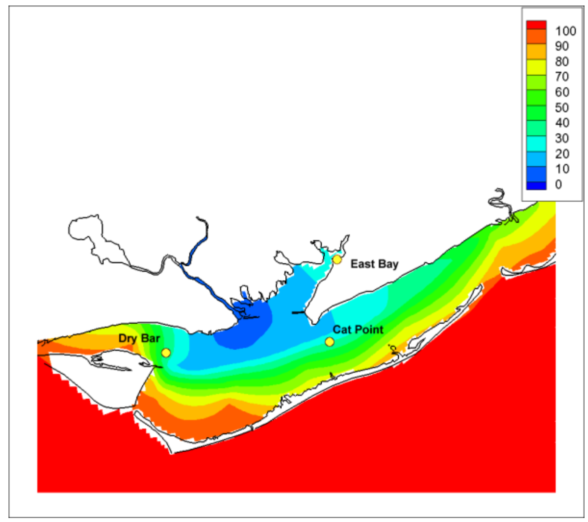
a) Observed



b) Current



c) Alternative #1

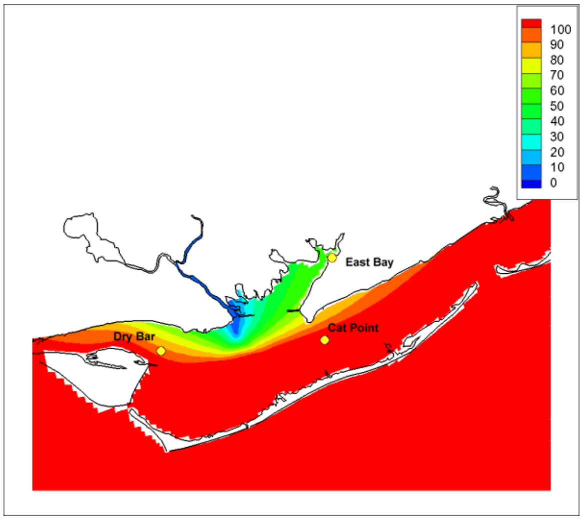


d) Alternative #2

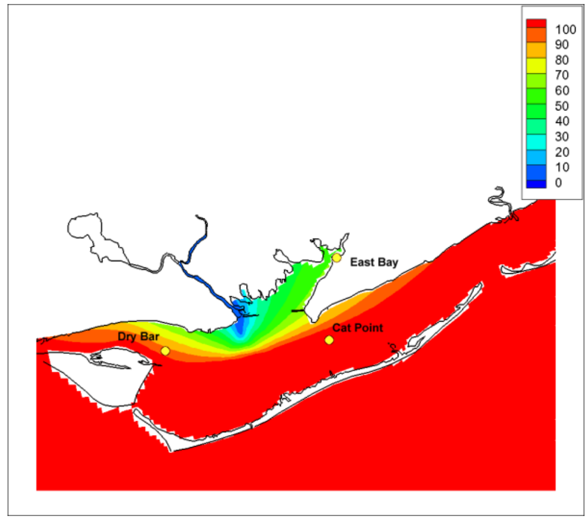
Figure 20. Percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

Table 6. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

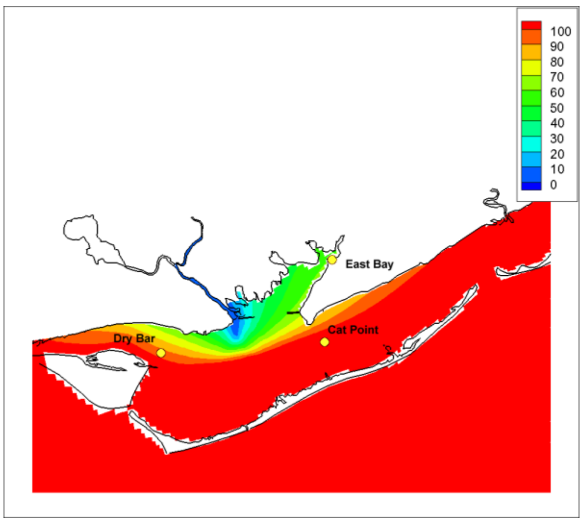
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7649.38	5406.71	5247.56	5290.49
10-20	16005.49	16189.76	16167.77	16163.59
20-30	10287.82	10636.47	10689.87	10681.49
30-40	9789.45	9850.18	9873.21	9867.97
40-50	9432.42	9459.64	9452.32	9468.02
50-60	10277.35	10073.19	10009.32	10011.41
60-70	13204.76	12466.63	12489.66	12479.19
70-80	13785.85	14188.94	14174.29	14171.14
80-90	14313.54	13396.37	13339.83	13367.05



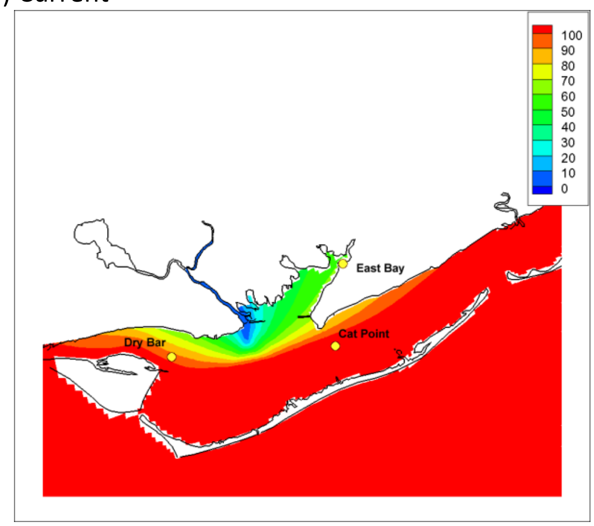
a) Observed



b) Current



c) Alternative #1

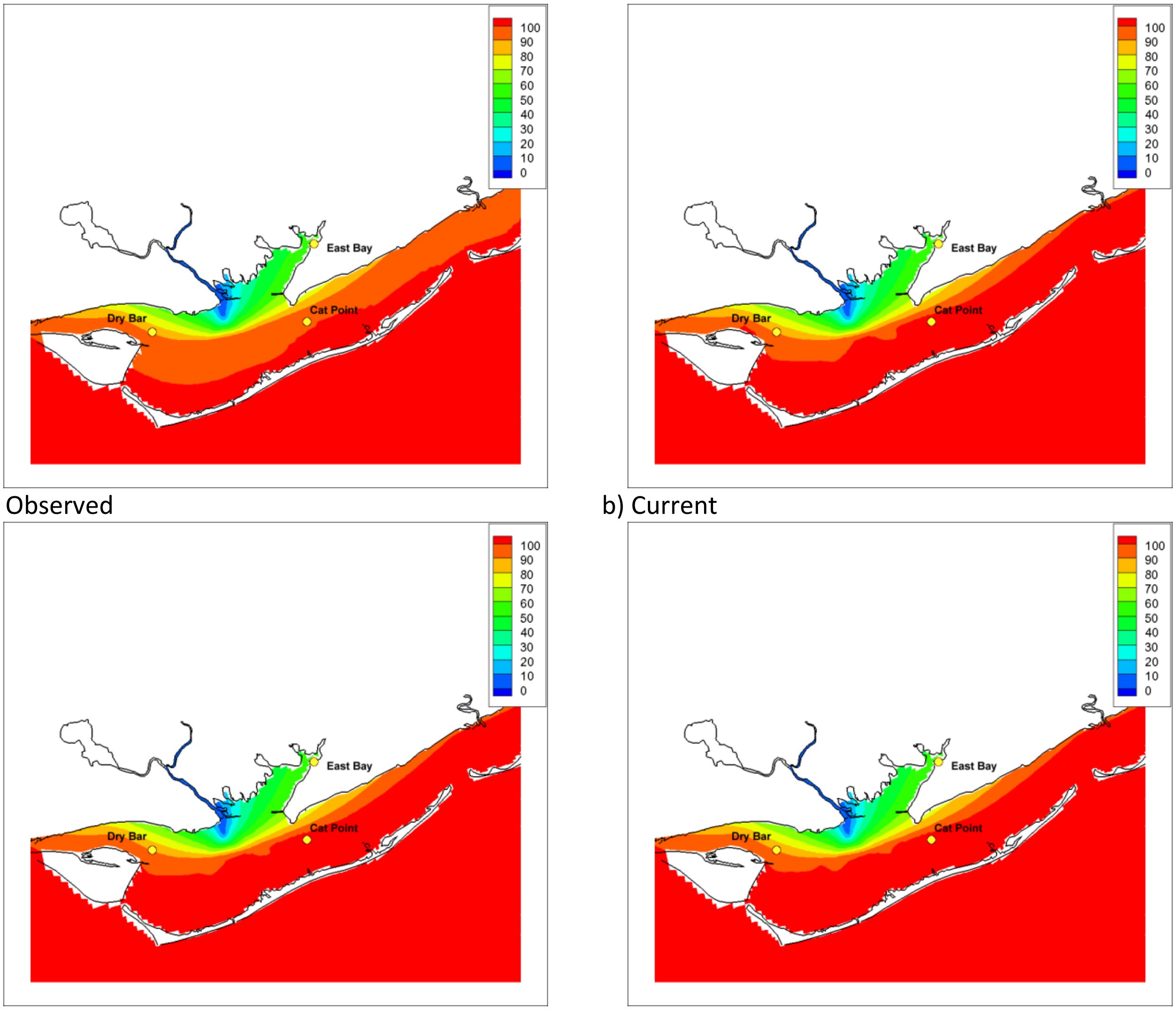


d) Alternative #2

Figure 21. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

Table 7. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	526.64	493.14	463.82	468.01
10-20	794.67	785.25	770.59	775.83
20-30	1045.95	1031.29	1022.92	1019.78
30-40	1460.56	1420.78	1383.09	1387.27
40-50	3085.51	2980.81	2884.48	2911.71
50-60	4935.56	4982.67	4887.40	4918.81
60-70	3075.04	3082.37	3226.85	3204.87
70-80	3390.19	3340.98	3351.45	3348.31
80-90	5305.15	5225.58	5049.68	5062.24



a) Observed

b) Current

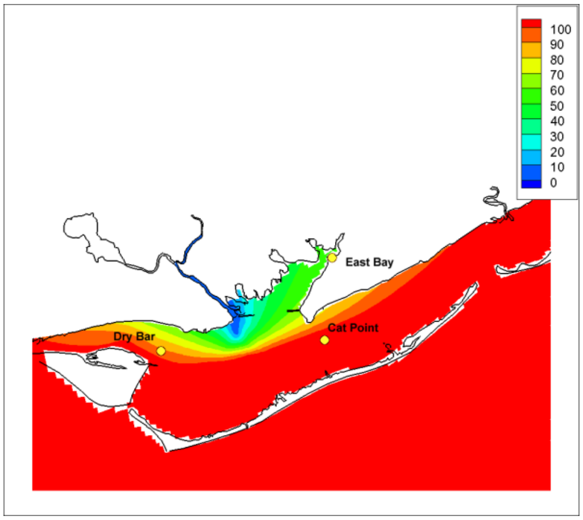
c) Alternative #1

d) Alternative #2

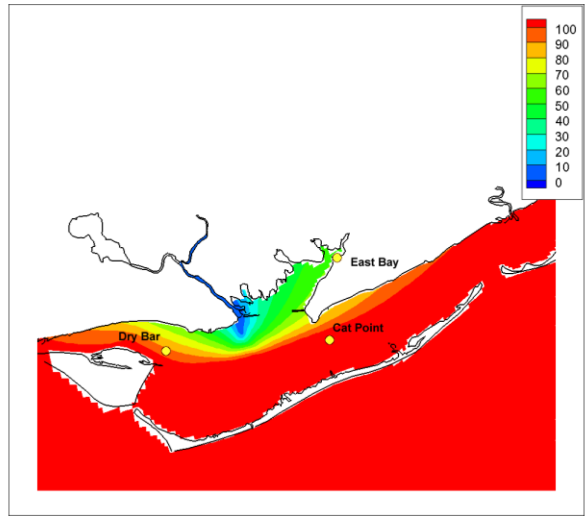
Figure 22. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

Table 8. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

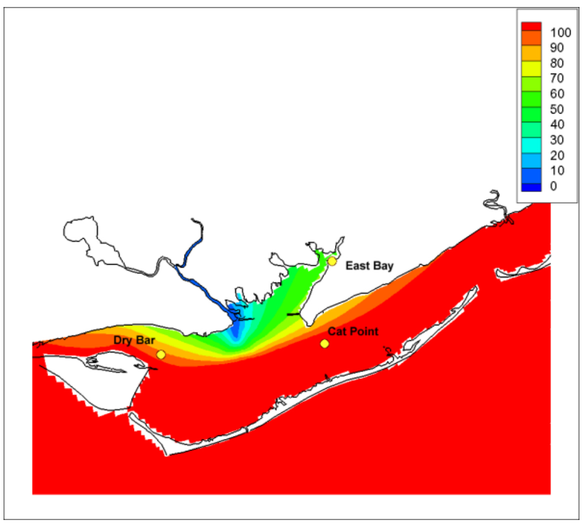
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	571.66	506.75	505.70	488.95
10-20	899.37	885.76	854.35	855.40
20-30	1137.04	1105.63	1119.24	1109.82
30-40	1675.20	1614.47	1606.10	1570.50
40-50	3975.46	3800.61	3743.02	3727.32
50-60	4733.49	4844.47	4885.30	4913.57
60-70	3294.91	3284.44	3265.59	3269.78
70-80	4268.62	4090.63	4029.90	4010.01
80-90	7307.01	6996.05	6997.10	6869.37



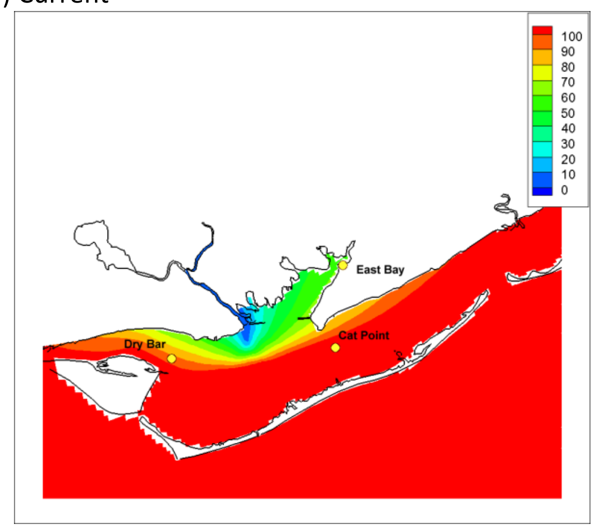
a) Observed



b) Current



c) Alternative #1



d) Alternative #2

Figure 23. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

Table 9. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	531.88	505.70	481.62	468.01
10-20	818.75	793.63	793.63	776.87
20-30	1052.23	1040.72	1040.72	1051.19
30-40	1464.75	1477.32	1454.28	1405.07
40-50	3229.99	3090.74	3046.77	3009.08
50-60	4983.72	4995.24	4995.24	5028.74
60-70	3073.99	3062.47	3107.50	3110.64
70-80	3455.10	3453.01	3418.45	3401.70
80-90	5599.36	5463.25	5407.75	5325.04

References

Chanley, P. E. (1958) "Survival of some juvenile bivalves in water of low salinity," Proc. Natl. Shellfish Assoc., 48, pp. 52-65.

Dame, R. F. (1972) "The ecological energies of growth, respiration and assimilation in the intertidal American Oyster *Crassotrea virginica*," Mar. Biol. (Berl.), 17, pp. 243-250.

Davis, H. C. and Calabrese, A. (1964) "Combined effects of temperature and salinity on development of eggs and growth of larve of *M. Mercenaria* and *C. Virginica*," Fishery Bulletin, 63(3), pp. 643-655.

Doering, P. H. and Oviatt, C. A. (1986) "Application of filtration rate models to field populations of bivalves: an assessment using experimental mesocosms," Marine Ecology - Progress Series, 21, pp. 265-275.

Hayes, P. F. and Menzel, R. W. (1981) "The reproductive cycle of early setting *Crassostrea virginica* (Gmelin) in the northern Gulf of Mexico, and its implications for population recruitment," Biological Bulletin, 160 (1), pp. 80-88.

Hofmann, E. E., Klinck, J. M., Kraeuter, J. N., Powell, E. N., Grizzle, R. E., Buckner, S. C. and Bricelj, V. M. (2006) "A population dynamics model of the hard clam, *Mercenaria Mercenaria*: Development of the age- and length-frequency structure of the population," Shellfish Research, 25(2), pp. 417-444.

Hofmann, E. E., Powell, E. N., Klinck, J. M. and Wilson, E. A. (1992) "Modeling oyster populations. III. Critical feeding periods, growth and reproduction," Journal of Shellfish Research, 11(2), pp. 399-416.

Hofmann, E. E., Klinck, J. M., Powell, E. N., Boyles, S. and Ellis, M. (1994) "Modeling oyster populations. II. Adult size and reproductive effort," Journal of Shellfish Research, 13(1), pp. pp. 165-182.

Huang, W. (2010) "Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science, 86 (2010), pp. 526-534.

Ingle, R. M and Dawson Jr., C. E. (1952) "Growth of the American Oyster *Crassostrea virginica* (Gmelin) in Florida waters," Bulletin of Marine Science, 2(2), pp. 393-404.

Klinck, J. M., Powell, E. N., Hofmann, E. E., Wilson, E. A. and Ray, S. M. (1992) "Modeling oyster populations: the effect of density and food supply on production," Proceedings of the Adv. Mar. Tech. Conf. 5, pp. 85-105.

Klinck, J. M., Hofmann, E. E., Powell, E. N. and Dekshenieks, M. M. (2002) "Impact of channelization on oyster production: a hydrodynamic-oyster population model for Galveston Bay, Texas," Environmental Modeling and Assessment, 7, pp. pp. 273-289.

Powell, E. N., Hofmann, E. E., Klinck, J. M. and Ray, S. M. (1992) "Modeling oyster populations. I. A commentary on filtration rate. Is faster always better?" Shellfish Research, 11(2), pp. 387-398.

Powell, E. N., Klinck, J. M. and Hofmann, E. E. (1996) “Modeling diseased oyster populations. II. Triggering mechanisms for *Perkinsus Marinus* epizootics,” Journal of Shellfish Research, 15(1), pp. 141-165.

Powell, E. N., Klinck, J. M., Hofmann, E. E., Wilson-Ormond, E. A. and Ellis, M. S. (1995) “Modeling oyster populations. V. Declining phytoplankton stocks and the population dynamics of American Oyster (*Crassostrea virginica*) populations,” Fisheries Research, 24, pp. 199-222.

Sheng, Y. P. (1990) “Evolution of a Three-Dimensional Curvilinear-Grid Hydrodynamic Model for Estuaries, Lakes and Coastal Waters: CH3D,” Estuarine and Coastal Modeling, Proc. of Estuarine and Coastal Circulation and Pollution Transport Model Data Comparison Specialty Conference, ASCE, pp. 40-49.

Shumway, S. E. and Koehn, R. E. (1982) “Oxygen consumption in the American oyster *Crassostrea virginica*,” Marine Ecology – Progress Series, 9, pp. 59-68.

Soniat, T. M., Powell, E. N., Hofmann, E. E. and Klinck, J. M. (1998) “Understanding the success and failure of oyster populations: the importance of sampled variables and sample timing,” Journal of Shellfish Research, 17, pp. 1149-1166.

Soniat, T. M. and Ray, S. M. (1985) “Relationships between possible available food and the composition, condition and reproductive state of oysters from Galveston Bay, Texas,” Contrib. Mar. Sci., 28, pp. 109-121.

Soniat, T. M., Ray, S. M. and Jeffrey, L. M. (1984) “Components of the seston and possible available food for oysters in Galveston Bay, Texas,” Contrib. Mar. Sci., 27, pp. 127-141.

Thompson, R. J. and Bayne, B. L. (1974) “Some relationships between growth, metabolism and food in the mussel *Mytilus edulis*,” Mar. Biol., 27, pp. 317-326.

Wang, H., Huang, W., Harwell, M. A., Edmiston, L., Johnson, E., Hsieh, P., Milla, K., Christensen, J., Stewart, J. and Liu, X. (2008) “Modeling oyster growth rate by coupling oyster population and hydrodynamic models for Apalachicola Bay, Florida, USA,” Ecological Modelling, 211, pp. 77-89.

Winter, J. E., Acevedo, M. A. and Navarro, J. M. (1984) “Quempillén estuary, an experimental oyster cultivation station in southern Chile. Energy balance in *Ostrea chilensis*,” Marine Ecology – Progress Series, 20, pp. 151-164.

Appendix A. Description of the Oyster Population Model

The time-dependent, post-settlement, oyster population model (e.g. Powell et al. 1992; Hofmann et al. 1992, 1994; Klinck et al. 1992, 2002) is based on the energy flow equation in which net production is calculated from the difference between assimilation and respiration and where the net production is the sum of somatic and reproductive tissue production.

Governing Equations

The governing equation is

$$NP_j = P_{gj} + P_{rj} = A_j - R_j$$

Where *j* is the size class, NP_j is the net production, P_{gj} is the somatic production, P_{rj} is the reproductive tissue production, A_j is the assimilation, and R_j is the respiration. The equation for each oyster class can be written as (Klinck et al. 2002)

$$\frac{dO_j}{dt} = -\alpha_j O_j + \beta_j O_{j+1} - \gamma_j O_j + \delta_j O_{j-1} - loss_j$$

where O_j is the somatic energy present in each class, j, of oysters in units of [cal/m^2]. Total energy is calculated by adding the reproductive portions to the amount calculated by the preceding equation.

Term	Representation
$\frac{dO_j}{dt}$	The time rate of change of O_j
$-\alpha_j O_j$	Loss from O_j to O_{j-1}
$\beta_j O_{j+1}$	Gain to O_j from O_{j+1}
$-\gamma_j O_j$	Loss from O_j to O_{j+1}
$\delta_j O_{j-1}$	Gain to O_j from O_{j-1}
$-loss_j$	Loss from O_j due to mortality, predation, etc.

This equation is then solved using a Crank-Nicholson approach. Assuming $\frac{dO_j}{dt} = F$, then

$$\frac{O_j^{n+1} - O_j^n}{\Delta t} = \frac{1}{2}[F^{n+1} + F^n]$$

where the equations for *F* are defined as

$$F^{n+1} = -\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1} - loss_j^n$$

$$F^n = -\alpha_j O_j^n + \beta_j O_{j+1}^n - \gamma_j O_j^n + \delta_j O_{j-1}^n - loss_j^n$$

Substituting these two equations into the equation for $\frac{O_j^{n+1} - O_j^n}{\Delta t}$ and rearranging terms such that the *n+1* terms are on the left and the *n* terms are on the right and multiplying by Δt yields

$$O_j^{n+1} - \frac{\Delta t}{2}\left[-\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1}\right]$$
$$= O_j^{n} + \frac{\Delta t}{2}\left[-\alpha_j O_j^{n} + \beta_j O_{j+1}^{n} - \gamma_j O_j^{n} + \delta_j O_{j-1}^{n}\right] - \Delta t * loss_j^n$$

which then can be rewritten as

$$O_j^{n+1}\left[1 + \frac{\Delta t}{2}\alpha_j + \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^{n+1}\left[-\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^{n+1}\left[-\frac{\Delta t}{2}\beta_j\right]$$
$$= O_j^{n}\left[1 - \frac{\Delta t}{2}\alpha_j - \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^{n}\left[\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^{n}\left[\frac{\Delta t}{2}\beta_j\right] - \Delta t * loss_j^n$$

where the transfer and loss rates are defined as

$$\alpha_j = \frac{w_j}{w_{j-1}}\frac{w_j}{w_j - w_{j-1}}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} < 0$$
$$\alpha_j = 0 \quad \text{for } NP_j^{n+1} \geq 0$$

$$\gamma_j = \frac{w_j}{w_{j+1}}\frac{w_j}{w_{j+1} - w_j}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} > 0$$
$$\gamma_j = 0 \quad \text{for } NP_j^{n+1} \leq 0$$

$$\beta_j = \frac{w_{j+1}}{w_j}\frac{w_j}{w_{j+1} - w_j}\left|NP_{j+1}^{n+1}\right| \quad \text{for } NP_{j+1}^{n+1} < 0$$
$$\beta_j = 0 \quad \text{for } NP_{j+1}^{n+1} \geq 0$$

$$\delta_j = \frac{w_{j-1}}{w_j}\frac{w_j}{w_j - w_{j-1}}\left|NP_{j-1}^{n+1}\right| \quad \text{for } NP_{j-1}^{n+1} > 0$$
$$\delta_j = 0 \quad \text{for } NP_{j-1}^{n+1} \leq 0$$

$$-\Delta t * loss_j^n = -\Delta t * MortalityRate * O_j^n$$

Assimilation Term

Size and Temperature

$$FR_j = \frac{L_j^{0.96} T^{0.95}}{2.95}$$

$$L_j = W_j^{0.317} 10^{0.669}$$

Where FR_j is the filtration rate (ml filtered per individual per min); L_j is the length in cm (Doering and Oviatt 1986), obtained from W_j, the ash-free dry weight (g); and T is the temperature in Celsius.

Salinity

$$FR_{sj} = \begin{cases} FR_j & S \geq 7.5 \text{ ppt} \\ \dfrac{FR_j(S-3.5)}{4} \quad \text{when} & 3.5 \text{ ppt} < S < 7.5 \text{ ppt} \\ 0 & S \leq 3.5 \text{ ppt} \end{cases}$$

where S is the ambient salinity in ppt.

Turbidity

$$FR_{\tau j} = FR_{sj}(1 - 0.01x)$$

where x is the percent reduction in filtration rate. The equation for total particulate content, τ, (inorganic + organic) (g/L) can be written as

$$\tau = (4.17 * 10^{-4}) * 10^{0.0418x}$$

This equation was printed incorrectly in several papers, e.g. Hofmann et al. (1992) and Powell et al. (1992), but later corrected in Powell et al. (1995). This equation can then be rewritten in terms of filtration rate as

$$x = \frac{\log_{10}\tau + 3.38}{0.0418}$$

Finally, the equation for filtration rate can then be rewritten as

$$FR_{\tau j} = FR_{sj}\left[1 - 0.01\left(\frac{\log_{10}\tau + 3.38}{0.0418}\right)\right]$$

This equation was written incorrectly in several papers, e.g. Powell et al. (1992) and Powell et al. (1996), but correct in Powell et al. (1995).

Ingestion

$$I_j = f * FR_{\tau j}$$

where f is the measured food value (mg/L) and I_j is the ingestion.

Assimilation

$$A_j = I_j * A_{eff}$$

where the assimilation efficiency, A_{eff}, is defined as 0.75 (Powell et al. 1992).

Respiration Term

Temperature and Weight

Respiration as a function of temperature and weight was obtained from Powell et al. (1992) via Dame (1972) as

$$R_{TW} = (69.7 + 12.6 * T)W_j^{b-1} \quad \text{where } b = 0.75$$

where R is defined in units of µL O_2 consumed per hr per g dry weight (Powell et al. 1992). These units are converted to calories using the relation 1 mL O_2=4.75 cal used by Winter et al. (1984) via Thompson and Bayne (1974).

Salinity

Salinity's effect on oyster respiration were parameterized using the Powell et al. (1992) formulation which used data provided in Shumway and Koehn (1982) as

$$R_r = \begin{cases} 0.007 * T + 2.099 & \text{when } T < 20\ ^{\circ}C \\ 0.0915 * T + 1.324 & T \geq 20\ ^{\circ}C \end{cases}$$

where R_r is the ratio of respiration at 10 ppt to respiration at 20 ppt.

$$R_r = \frac{R_{10\text{ ppt}}}{R_{20\text{ ppt}}}$$

Respiration

$$R_j = \begin{cases} R_{TW} & & S \geq 15\text{ ppt} \\ R_{TW}\left(1 + \left[\frac{(15 - S) * (R_r - 1)}{5}\right]\right) & \text{when} & 10\text{ ppt} < S < 15\text{ ppt} \\ R_{TW}R_r & & S \leq 10\text{ ppt} \end{cases}$$

Per Powell et al. (1992), Shumway and Koehn (1982) identified salinity's effect on respiration at 20 ppt; however, a 15 ppt cutoff is used to conform to Chanley's (1958) growth observations.

Reproduction

For adult oysters (e.g. those considered adult or marketable but not those considered spat or juvenile), net production is apportioned into growth and reproduction by using the following formulation

$$P_{rj} = R_{eff} * NP_j$$

where P_{rj} is the portion of new production in reproduction, R_{eff} is the temperature dependent reproductive efficiency defined as (Hofmann et al. 2006)

$$R_{eff} = R_1 * T - R_0$$

where R_1 and R_0 are constants. This equation is written incorrectly (temperature dependence is missing) in Powell et al. (1992). In general, the maximum value of R_{eff} is limited to some value R_{max} such that this equation can be rewritten as

$$R_{eff} = \min(R_1 * T - R_0,\ R_{max})$$

and min() represents the minimum value function.

Based on observations by Soniat and Ray (1985), the R_1 and R_0 constants have a seasonal component such that (Hofmann et al. 1992)

$$\begin{aligned} R_1 &= 0.054 \text{ and } R_0 = 0.729 \quad \text{for} \quad \text{January} - \text{June} \\ R_1 &= 0.047 \text{ and } R_0 = 0.809 \quad \quad \quad \text{July} - \text{December} \end{aligned}$$

These constants are defined correctly in Hofmann et al. (1992), Powell et al. (1992) and Powell et al. (1996) but incorrectly in Powell et al. (1995) and Wang et al. (2008) (R_1 was defined as 0.0047 instead of 0.047 for the July-December period).

Spawning

Following Wang et al. (2008), spawning occurs when the cumulative reproductive biomass (R_{total}) exceeds 20% of the total biomass and the temperature is greater than or equal to 25 degrees C (Ingle and Dawson 1952; Hayes and Menzel 1981). Once spawning occurs, reproductive biomass was divided into male (R_m) and female (R_f) biomass. The ratio of females to males (f_{ratio}) is calculated using

$$f_{ratio} = 0.021 L_b - 0.62$$

where L_b is the shell length in mm. Then, the female portion of reproductive biomass can be calculated by combining the following two equations

$$f_{ratio} = \frac{R_f}{R_m}$$

$$R_{total} = R_f + R_m$$

to yield

$$R_f = \left(\frac{R_{total}}{1 + \frac{1}{f_{ratio}}} \right)$$

Then, the female portion of biomass can be converted into eggs spawned by

$$\text{Number of Eggs Spawned} = \left[R_f \left(\frac{6100 \text{ calories}}{\text{g dry weight}} \right)_{\text{oysters}} \right] \left(\frac{\text{g dry weight}}{6133 \text{ calories}} \right)_{\text{oyster eggs}} \left(\frac{1}{W_{\text{egg}}} \right)$$

where the term within the square brackets on the right hand side represents the female biomass converted to calories and the weight on an egg, W_{egg}, is 13 ng per egg (Powell et al. 1992 p. 393). Wang et al. (2008) and others (e.g. Powell et al. 1995, 1996) define the weight of an egg as

$$W_{\text{egg}} = 2.14 * 10^{-14} * V_{\text{egg}}$$

where V_{egg} is the oyster egg volume in (μm^3).

Larval Recruitment

Following Wang et al. (2008), larval life span was set to 15 days (Ingle and Dawson 1952), and larval to spat survival was set at $1/10^8$ (Powell et al. 1996)

$$\text{Number of New Spat per Spawn} = \frac{1}{10^8} * \text{Number of Larvae Recruited per Spawn}$$

It is not clear how larval life span is to be applied.

Mortality

Lavae

$$\text{Number of Larvae Recruited per Spawn} = s * \text{Number of Eggs Spawned}$$

where *s*, the survival rate per spawn is defined as (Davis and Calabrese 1964)

$$s = \begin{cases} 0.7 & for \quad 27.5\ ^{\circ}C \leq T \leq 32.5\ ^{\circ}C \text{ and } 10\ ppt \leq S \leq 27.5\ ppt \\ 0 & \text{otherwise} \end{cases}$$

The variable, *s*, is defined incorrectly in Wang et al. (2008) as mortality rate.

Post-settlement Population

Mortality of the post-settlement population follows the formulation of Wang et al. (2008)

$$\text{Number dying per time} = k_d(\text{number of living})$$

$$k_d = \begin{cases} 0 & \text{if} \quad \text{Winter or Spring (Sep} - \text{Apr)} \\ \text{Constant} & \text{otherwise} \end{cases}$$

where k_d is the daily mortality rate. However, because low salinity is a major cause of catastrophic mortality, the equation of daily mortality rate is modified as follows

$$k_d = (\alpha_1 S + \beta_1)T + (\alpha_2 S + \beta_2) \quad \text{if} \quad S < 6 \text{ ppt}$$

where α_1=-0.000348, β_1=0.01764, α_2=0.00232, and β_2=-0.3089 (Powell et al. 1996). α_1 is defined incorrectly in Wang et al. (2008) as -0.00034.

Growth Rate Formulation

$$(\text{Oyster Growth Rate})_j = (NP_{somatic})_j * W_j * \frac{1000\text{ mg}}{\text{g}} * \frac{86400\text{ s}}{\text{day}} \qquad \left[\frac{\text{mg AFDW}}{\text{oyster} * \text{day}}\right]$$

where Net Production is provided in units of [1/s] and W is the average oyster weight in units of [g AFDW/oyster]

Specific Relations for Apalachicola Bay Model

Size Classes

Characteristics of the size classes were based on Wang et al. (2008). Average length was from field measurement, while average biomass was determined from the following length-weight relationships:

$$\ln(Biomass) = C_1 * \ln(Length) + C_2$$

which can be solved for biomass as

$$Biomass = (Length)^{C_1} * e^{C_2}$$

where

Site	C_1	C_2	R^2
Cat Point	2.505	-10.980	0.83
Dry Bar	2.202	-9.125	0.90

Site	1 (Spat)	2 (Juvenile)	3 (Adult)	4 (Marketable)
Cat Point				
Initial Count	0	26	22	21
Average Length (mm)	12	36	66	85
Average Biomass (g AFDW)	0.0086	0.1349	0.6157	1.1605
Dry Bar				
Initial Count	0	26	22	21
Average Length (mm)	12	39	66	96
Average Biomass (g AFDW)	0.0259	0.3472	1.1059	2.5236

Total Particulate Content<>Turbidity

Based on a water quality analysis of storm-water inputs into Apalachicola Bay, Wang et al. (2008) defined the relation between total particulate content and turbidity as

$$\tau = 1.4593 * \text{Turbidity} + 0.904$$

where total particulate content, τ, is in units of mg/L and Turbidity is in NTU.

Food<>Chlorophyll-a

Following Wang et al. (2008), Chlorophyll-a was used as an index of available food following the formulas presented in (Soniat et al. 1984, 1998)

$$\text{Food} = 1.4593 * \text{Chlorophyll} - \text{a} + 0.520$$

where Food*,* is in units of mg dry weight/L (Soniat et al. 1998) and Chlorophyll-a is in units of µg/L (Soniat et al. 1998). The units of food are converted into calories using the caloric conversion of 5168 cal per g dry weight (Wang et al. 2008).

Reproduction

The maximum reproductive efficiency, R_{max}, was set to 0.8 (Wang et al. 2008). Furthermore, following the assumptions of Wang et al. (2008), when *NP* < 0, reproduction was assumed to be zero or there was no resorption of gonadal tissue.

Post-Settlement Mortality

For periods when salinity is greater than 6 ppt, the daily mortality rate, k_d, was defined as (Wang et al. 2008)

Site	Reference Year	High-Salinity Year	Low-Salinity Year
Cat Point	0.00020	0.00061	0.00014
Dry Bar	0.00079	0.00122	0.00038

Average/Reference Year Simulations

Using the average year data shown in Figure 3 of Wang et al. (2008), the average year was simulated and then compared to the reference year lines for marketable oysters of Figure 6 of Wang et al. (2008).

Cat Point

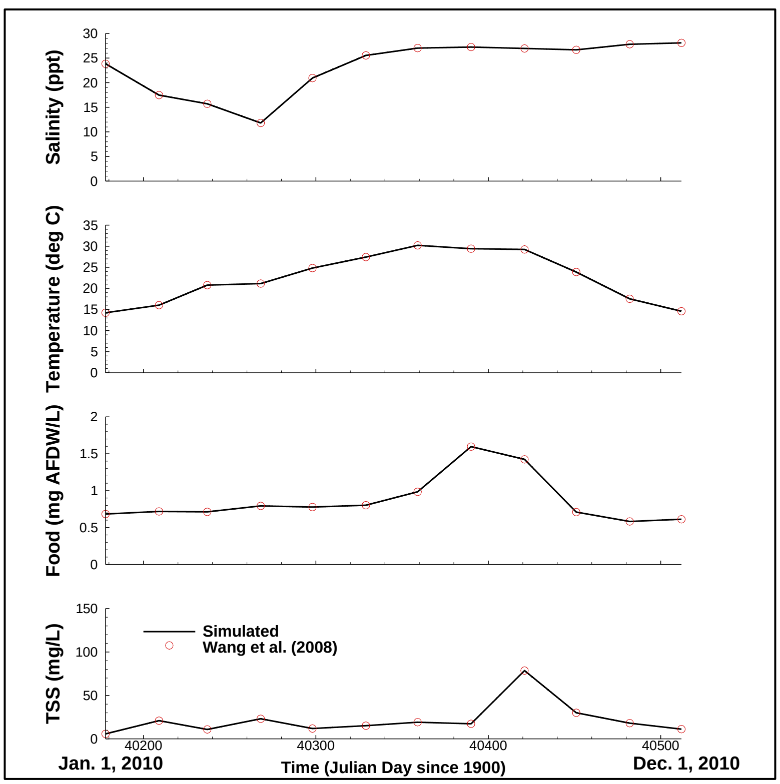


Figure 24. Forcing functions for the Cat Point reference year simulation

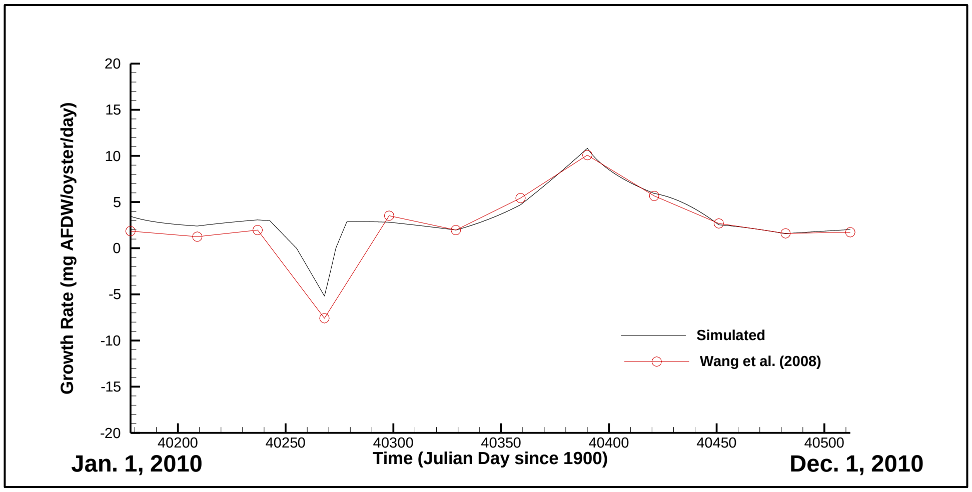


Figure 25. A comparison between the marketable oyster growth rate at Cat Point during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Dry Bar

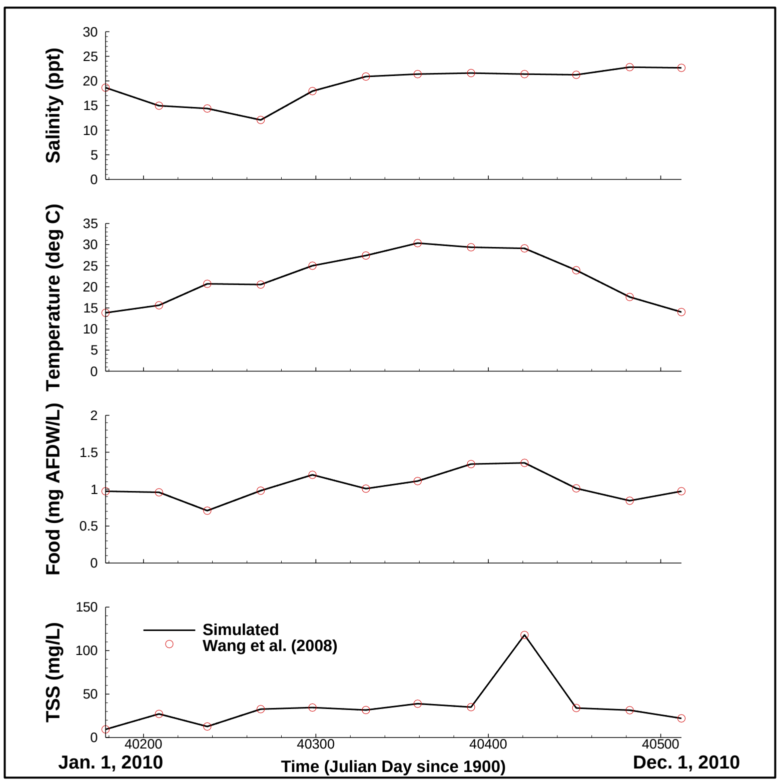


Figure 26. Forcing functions for the Dry Bar reference year simulation

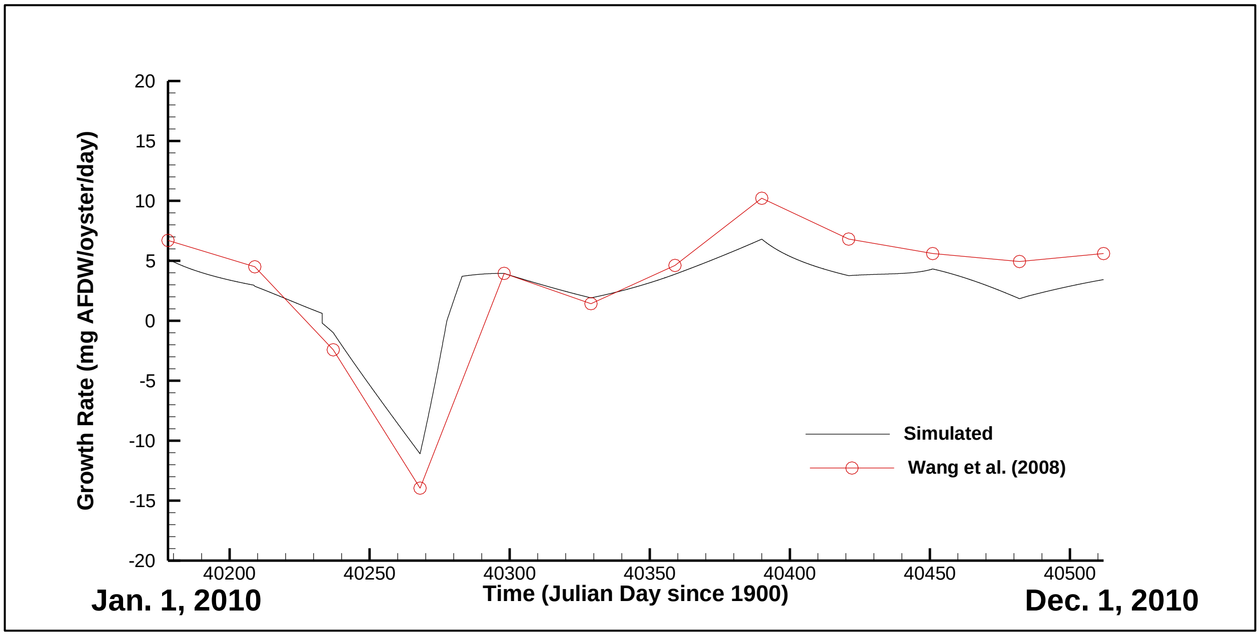


Figure 27. A comparison between the marketable oyster growth rate at Dry Bar during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Mar 2004 – June 2005 Cat Point Simulation

Using data obtained for the period of Mar. 2004 to June 2005, growth rate at Cat Point was simulated and compared to the total growth rate values shown in Figure 5a of Wang et al. (2008). Two sets of simulations were performed, one with the original observed salinity/temperature data and the second with daily averaged data.

Observed Salinity/Temperature

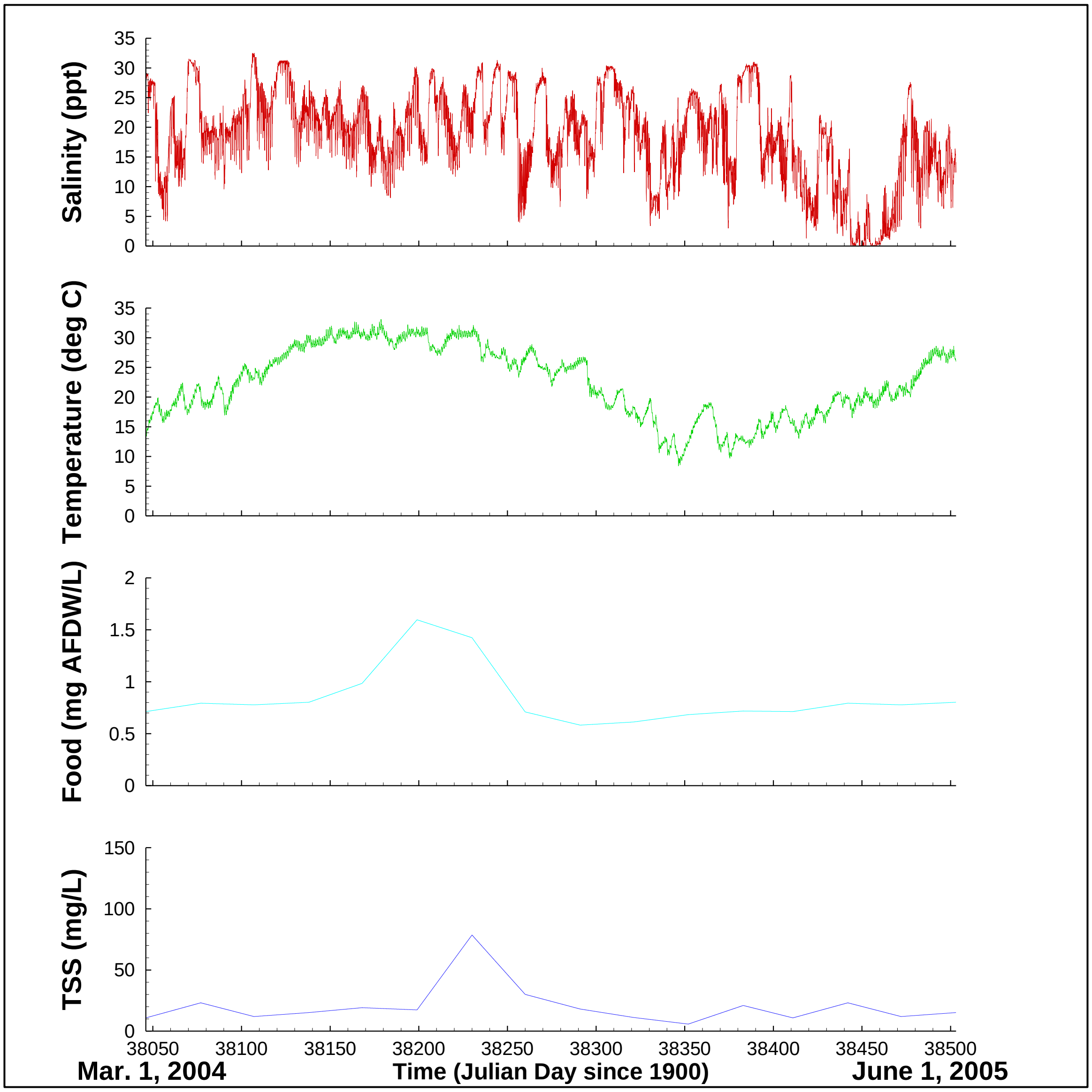


Figure 28. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the observed salinity/temperature data

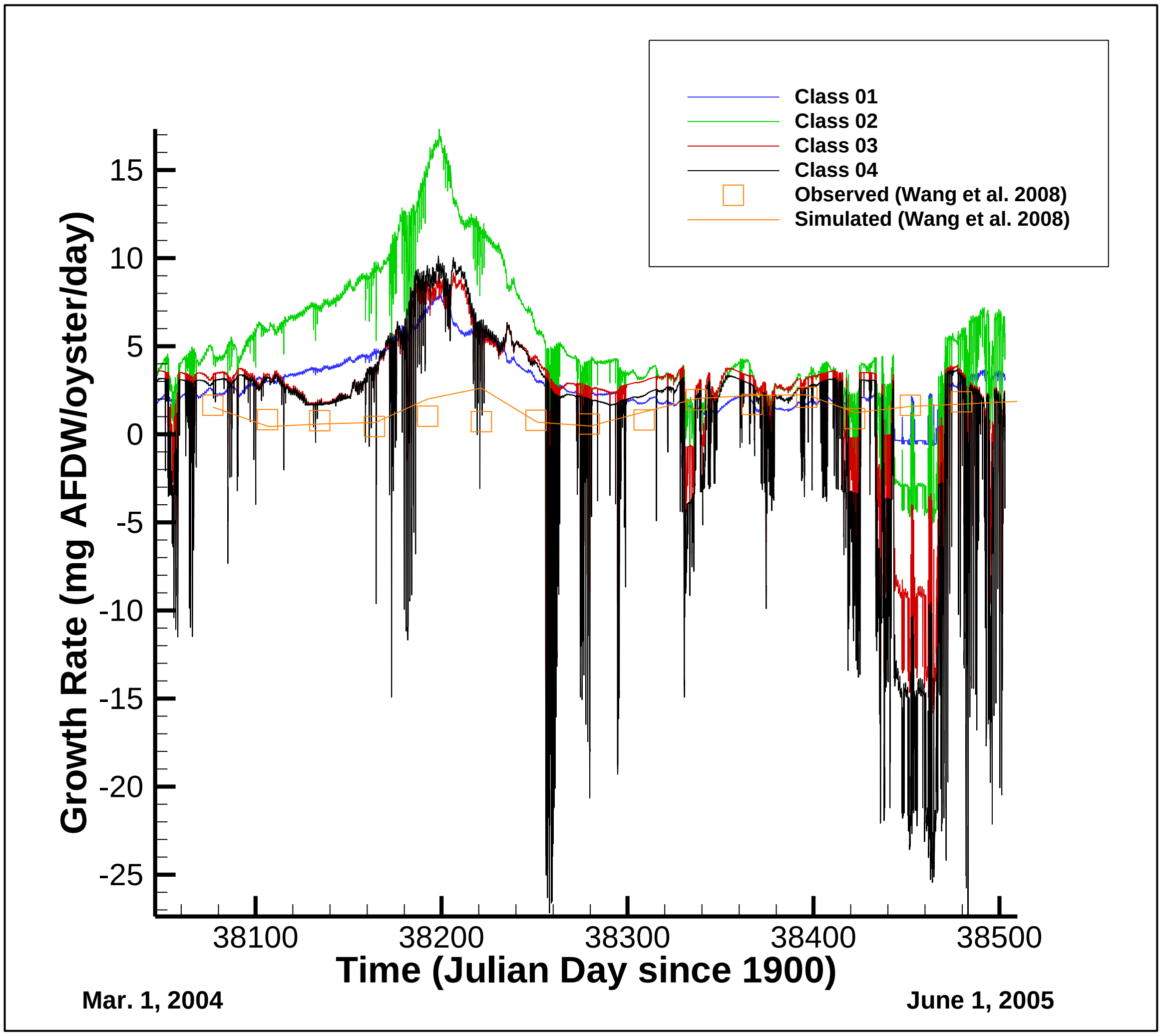


Figure 29. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the observed salinity/temperature data

Daily Averaged Salinity/Temperature Data

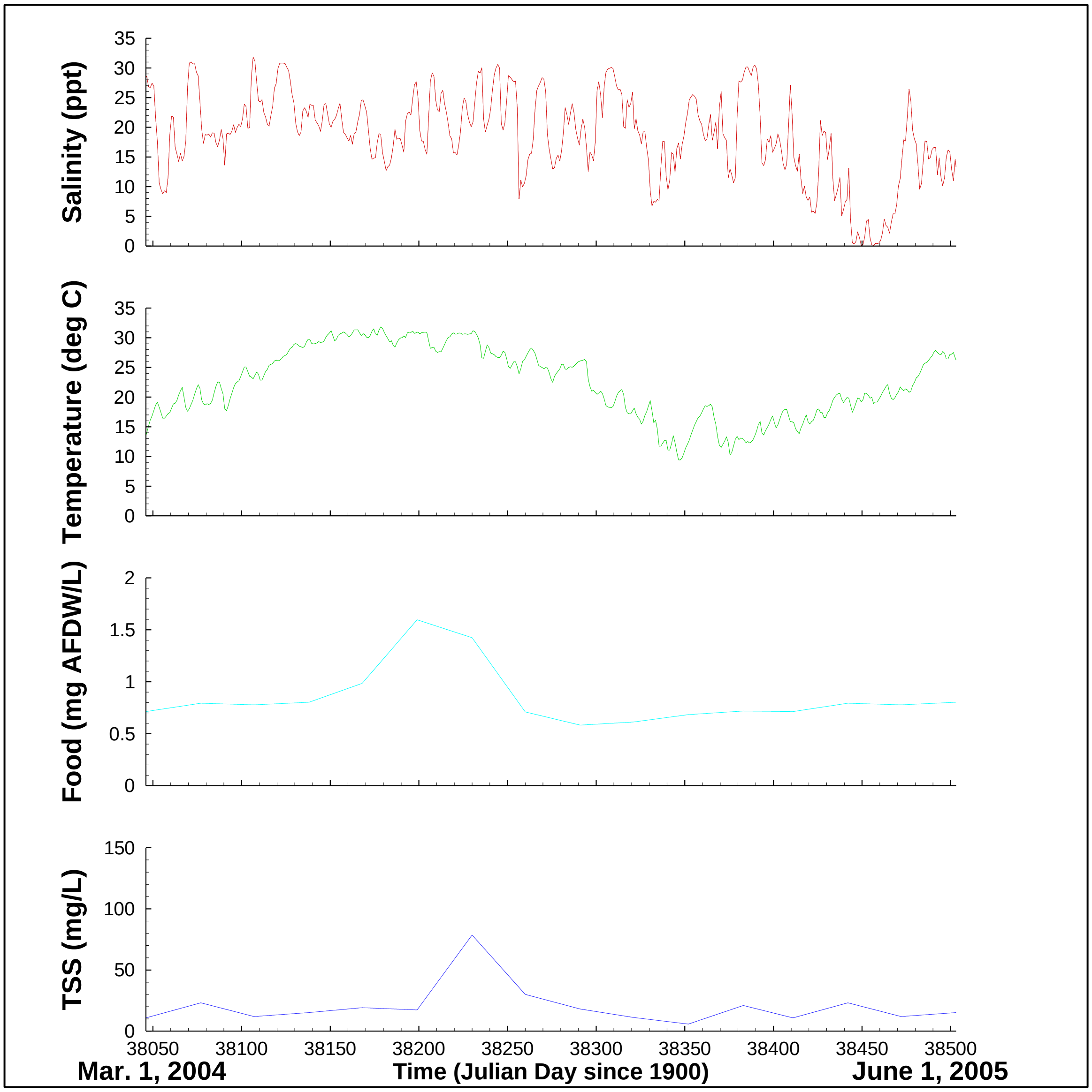


Figure 30. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the daily averaged salinity/temperature data

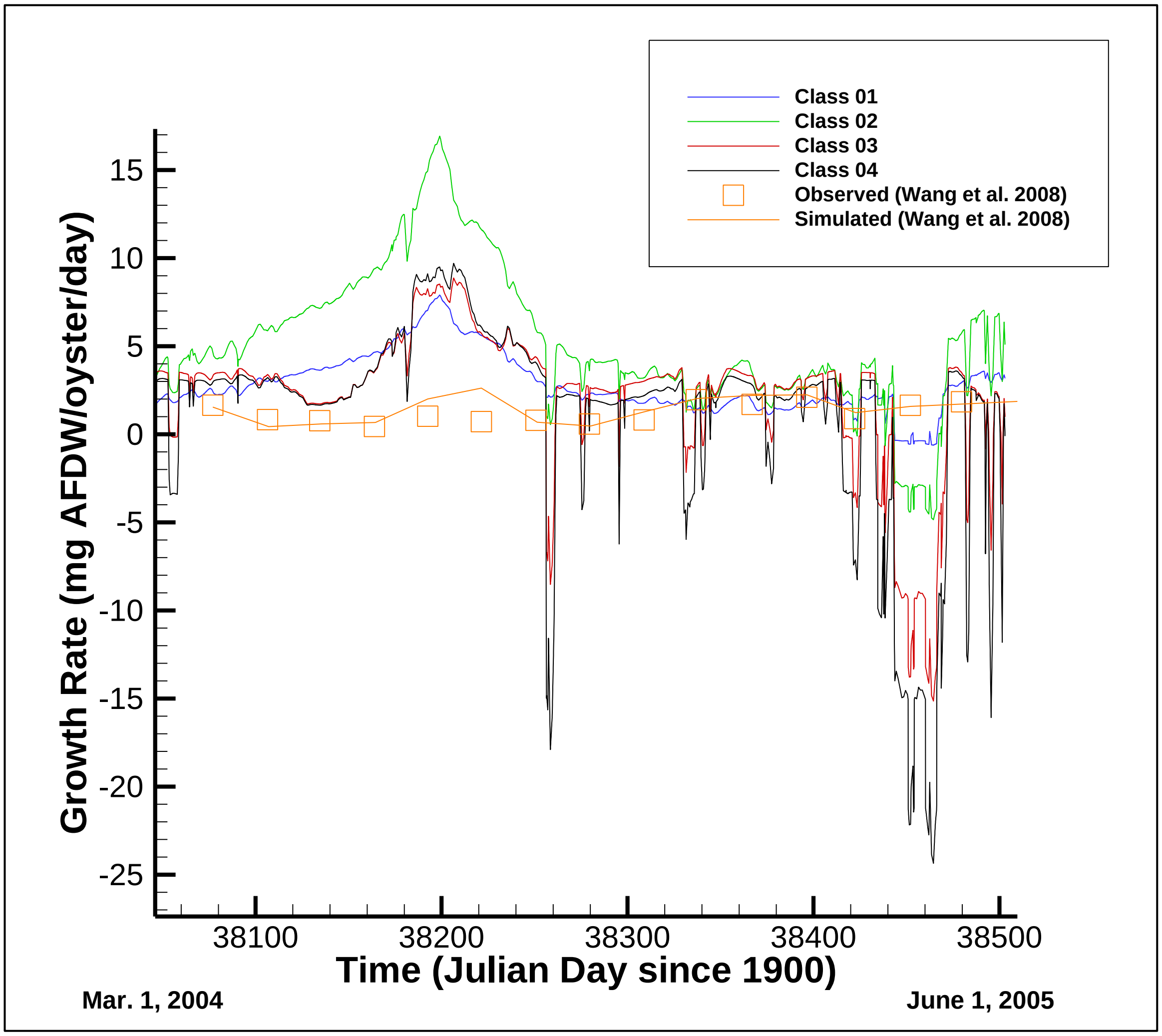


Figure 31. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the daily averaged salinity/temperature data

Appendix B. FWS Requested Results

The following revised list of requested results was email by Karen Herrington to Y. Peter Sheng on April 5, 2011. Items A1, B1, B2 and B4 were eliminated from an earlier larger list of requested results.

A. Oysters:

1.
2. Probability of exceedence at Cat Point and Dry Bar station for all 4 scenarios
3. Summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
4. Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
5. August (generally peak growth rates) summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
6. August Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
7. Salinity contour map for the total number of days salinity exceeds 26 ppt in the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2002 (based on ranked mean annual discharge)
    - Wet year = 2005
    - Average year = 2001

B. Sturgeon:

1.
2.
3. Salinity contour map for the total number of days salinity exceeds 10 ppt from 1 October- 31 March for the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2001 (based on ranked mean Oct-March discharge)
    - Wet year = 2009
    - Average year = 2004
4.

USFWS Questions regarding the ACOE January 18, 2011 Correspondence:

1. In our PAL and the May 27, 2010 email from Will Duncan, we requested that you use the environmental flow guidelines to develop an environmental flow alternative or use the guidelines to analyze your alternatives and to identify the constraining authorization (if present) that impairs the Corps ability to achieve the recommended flow targets. You have provided some of those analyses in this report, but have you completed these analyses and identified the constraints for the remaining flow recommendations for the four river sections (below Buford, West Point, Walter F. George, and Jim Woodruff dams)?
2. How was the RES-SIM model developed and how well does it (ie. the baseline) conditions represent actual operations? Has this type of assessment been completed, specifically for parameters that are biologically relevant? Could the model output be updated through 2010?
3. To gain a better understanding of the constraints that you have, and so we don't continue stating the same thing on every document, can we obtain a copy of your agreement(s) with SEPA in the ACF? For similar reasons, may we also view the original language that describes the "flood damage reduction" authorized purpose?
4. Page 1-7: Why don't the numbers on Table 5.2-1 correspond with the hours of operation in the text above the table? Do the numbers in the text correspond to longer periods (e.g. 11 hours total at Buford on weekends) within which Buford Dam will generate power for e.g. three hours?
5. Page 1-9: When the fish spawn SOP was developed, why did it not include river segments below the major dams? Would a similar SOP for riverine habitats be of interest to the ACOE in the Chattahoochee River?
6. Page 1-14: It is stated that W.F. George currently has no minimum flow requirement, but when low dissolved oxygen values are observed below the dam, spillway gates are opened until the DO readings return to an acceptable level. How often is DO actually measured at this location?
7. Page 1-16: What is your reasoning for assuming that current water supply operations for Buford and Peachtree Creek would remain constant with 2007 demand data for your 10 to 15-year WCM Planning Window?
8. Page 1-16 and 1-21: It appears that the preferred alternative includes increased hydropower generation at Buford. What is the purpose or impetus for this increase (e.g., request from SEPA? Atlanta water supply? etc.)
9. Page 1-17: You mention that increasing Zone 4 would result in more water available, but there is no discussion of how frequently the drought operations were triggered with and without this change. In general, we would like to see your thought process for alternative development (e.g., were you trying to minimize the number of times drought ops were triggered?, etc.) and the results of these analyses (e.g., how did this change affect the occurrence frequency of the drought trigger).
10. Page 1-19: You mention volumetric balancing accounting but state elsewhere in the document that there will be no volumetric balancing in your preferred alternative. Is this a typo?
11. Page 1-20, Figure 11.3-4: Can you please show us a direct comparison of composite storage zones (similar to figs 11.3-1 to 11.3-4) under the no action alternative and preferred alternative? Or possibly a table with values if this figure would be too busy? Specifically, a summary of the composite zone changes (whether each zone is larger or smaller, time of year, reason for change, etc.) would be helpful. It would also be helpful to understand how often your model results indicate that you will operate in the various zones.

12. Page 1-20: You state that the drought plan revisions will remain in place until composite conservation storage reaches Zone 1. As in question #4 above, what is the thought process here and what are the results of the analyses you ran to make this decision?
13. Page 1-21: With what frequency and duration have each of the projects operated in each zone historically, and for each modeling scenario (baseline, alternative 1, and alternative 2)? How often in zone 4 was there peaking (number of peaking events/day) below each project?
14. Page 1-23: It is stated that there will be no changes to fish spawn or fish passage operations under the Proposed Action Alternative. Regardless, new language for fish spawn operations at JWLD will be included in this WCM update though, correct?
15. Page 1-23: You state that RIOP modifications (especially the fall rate and drought zone changes) were based in part on reducing the likelihood of triggering releases less than 5,000 cfs. Again, as in questions 4 & 6, what analyses did you run here to test/justify these decisions and what were the results?
16. Page 2-28: How would results be different if hourly data were used? What are the minimum DO observations observed and how well do the model results stack up against observed DO? Is it appropriate to have all dry years represented by 2007 and normal years by 2004? Same issues apply to temperature analyses on page 2-55.
17. Page 2-49: What is meant by the term "occurrence **interval**?" Where is the interval? Also, page 2-25 mentions that "It was recommended that percent exceedence may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality." Exceedence is a statistical term adopted for use in water policy. Regardless, it is more appropriate in this case to use exceedence. Just be clear that you are not using the term "exceedence" in a policy sense.
18. Page 2-60: The term "rainfall conditions" is used to identify specific years for detailed analyses. Similarly, the terms dry year and average year are used throughout the document without clear explanation regarding what constitutes a dry and average year. This needs to be made very clear. How were they defined, and does the term "rainfall conditions" actually mean a discharge-related variable?
19. Page 2-65: Based on the model input, what are the major drivers of algae change over time? Y-axes should be chlorophyll-a, not algae.
20. Pages 2-72 to 2-76: We had many comments, questions, and concerns about this section. Most concerns centered on the ambiguity of the analysis and the derivation of reported numbers. Because of these problems, we are hard-pressed to provide meaningful review and feedback. However, related to the baseflow analysis, we recommend an alternative analysis for depicting low flows that are likely to occur for each alternative. That analysis and associated rationale is included in the PAL addendum. Such an analysis is more intuitive and should take no more than a day for multiple nodes alternatives. Thus, we strongly encourage the ACOE to complete this analysis in lieu of the results reported in these sections.
21. Page 2-73: "The channel capacity at this location was used as a constraint in the HEC ResSim modeling analysis to ensure that flows did not go higher than 11,000 cfs." Why are the modelers unwilling or unable to model flows greater than 11,000 cfs?
22. Page 2-73: How is channel capacity defined, and where did the number come from?
23. Page 2-76: Can you please fix the figure references throughout the document ie. "Error! Reference source not found?" Does "upstream of Atlanta" refer to Norcross? Please use gage numbers and gage names to identify sites. How were these values determined? Are they percentiles of minimum flows or some annualized metric? How is "Dry year" defined in the

subsequent page? Many of these concerns will be addressed once the revised analysis is implemented.

24. For much of the flow analyses performed, you compare model output from the pre-dam period, no action, scenario 1, and scenario 2. Please provide the range of years and specific datasets used for each scenario.
25. Figures 2.7-1 to 2.7-13 and Table 2.7-1: We understand that direct comparisons cannot be made due to channel bed degradation and removal of hard bottom habitat; however, is it possible to add the pre-dam scenario to these figures?
26. Page 2-80: This statement is inaccurate: "The flow magnitude for average years overall, however, is 500–1,000 cfs, reduced from the pre-dam flows." Baseflows in the summer and fall seasons (including a portion of spawning season) are elevated, not reduced. Graphs depict reported values as averages, but could they be medians based on the non-parametric RVA in IHA?
27. Page 2-83, Figure 2.7.1.1: Spawning Habitat Availability- Overall, there is very weak treatment regarding what data is being conveyed on the graphs. For example, our initial review indicated that the analysis had been cut and paste from the 2008 BO. On the graphs and in legends and text, can you please define ROR, the intent of using USGS data and ROR, and the period of record used. Remember, if we (agencies with previous involvement) are unable to correctly interpret the results, it is unlikely that others will. This needs to be crystal clear. There are also grammatical problems in this section.
28. Page 2-87, Table 2.7-1: Why were there no flows lower than 5,000 cfs? Does that mean the drought plan was never triggered in these scenarios? If not during the exceptionally severe 2007 drought, what hydrologic conditions would it take to trigger the drought zone?
29. Page 2-92: We expect that the fall rates associated with pulses will differ from the RIOP. The RIOP was intended to be protective of organisms at a lower range of flow, and the pulse flow recommendations consider a large range of flows that are relevant to other ecosystem attributes.
30. Page 2-99: Could you please clarify this? "This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010)." Did USFWS request it and then deem it as not a viable option? This is difficult to interpret without having a references section. Please include a references section.
31. Page 2-99: It is stated that "Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows..." Damaging to what? Can you please share the modeling output that demonstrates this?
32. Page 2-101: You discuss analyzing how providing a minimum flow of 15,400 cfs impacted the number of times the drought zone was triggered. As in questions 4, 6, & 7, it would be helpful for us to know what analyses you have completed on triggers and how results influenced your alternative development. For example, it seems unusual that a minimum flow of 15,400 cfs would trigger drought operations more often than a minimum flow of 16,200 cfs.
33. Page 2-101: We appreciate the evaluation of a longer navigation season and feel it would also benefit riverine fishes. Please tell us if this will be a guaranteed minimum flow to provide a 7 ft channel or if it will be only "as requested" by navigation interests. How will this "navigation season" be different from the old navigation windows that were 10 days to a two-week period? Will this be a continuous minimum flow for months? If so, we assume that you are anticipating that you will be able to balance the fish spawn SOP and this new navigation flow, in light of the fact that the prior navigation windows prompted complaints that the windows had adversely affected reservoir fish spawn activities.

34. Page 2-102: W.F. George is also a peaking plant (Page 1-7) but was not included in the discussion of why non-hydropower peaking windows cannot be implemented at ACOE hydropower peaking facilities. It also needs to be addressed.
35. Page 2-109: Where's the references section?

Other Important considerations:

36. The ACOE used HEC-5Q to model daily change in water quality parameters. Are we correct in that the model input used average daily discharge to calculate water quality parameters for each time step? If so, we think it would be wise for the ACOE to acknowledge that daily fluctuations in WQ may be obscured by this simplification, but that this model represents the best available information on water quality responses to instream flow changes.
37. Similarly, it would be wise for the ACOE to propose a coarse plan of action for addressing DO issues caused by ACOE projects (e.g., propose potential collaborations, funding sources, and general steps, and rough timeline needed to do so).
38. Page 1-5: "the river system would operate in a fairly normal manner." Please clarify this.
39. Page 1-6: "…enough electricity to supply approximately 110,000 households." This is important to consider, but is more useful when context is provided. For example, 110,000 households is 3.65% of Georgia households or X% of Florida households.
40. Page 1-15: "Reservoir operations are also influenced by agricultural water withdrawals…" This is an important component of this section, and it needs additional (minor) elaboration so that your point isn't lost. Is the point that water removed from the Flint is offset by reservoirs in the Chattahoochee to meet flow needs in the Apalachicola- especially during low flow periods? If so, that point is lost in this section.
41. Page 2-25: Repeatedly throughout the document, the ACOE uses different terms to describe the alternatives (e.g preferred vs proposed ; scenario 1 vs. alternative 550 vs Alternative B1 or B2); It would be beneficial if consistent terms are used to describe each modeling scenario.
42. Page 2-26: The term "baseline" is used for 24 pages before it is defined on page 2-50. Also, it had been indicated that the methods used to develop all output would be included in this document and they aren't.
43. Page 2-75: It would be appropriate to explain to readers that values closer to "1" are better.
44. Page 2-76: "2.4.2 Impacts of Critical Low Flow Periods" could use improvement. We'd all be better served with a table showing comparisons of the results.

Comparison of ACOE Baseline HEC Res-Sim output and observed data for a comparable period

Based on the Corps' response to the Planning Aid Letter, the baseline model output from HEC Res-Sim represents current operations following implementation of the RIOP (post September 2006). Therefore, there should be good general agreement between baseline conditions and observed conditions since September 2006. In instances where the modeled data are statistically different from observed data (ie. black boxes in table below), users of the Res-Sim output should be cautious regarding comparisons and recommendations based on that aspect of the data. In instances where statistical significance was not detected (white boxes in table), there is support for using that aspect of the data for comparison of flow alternatives to the baseline model output.

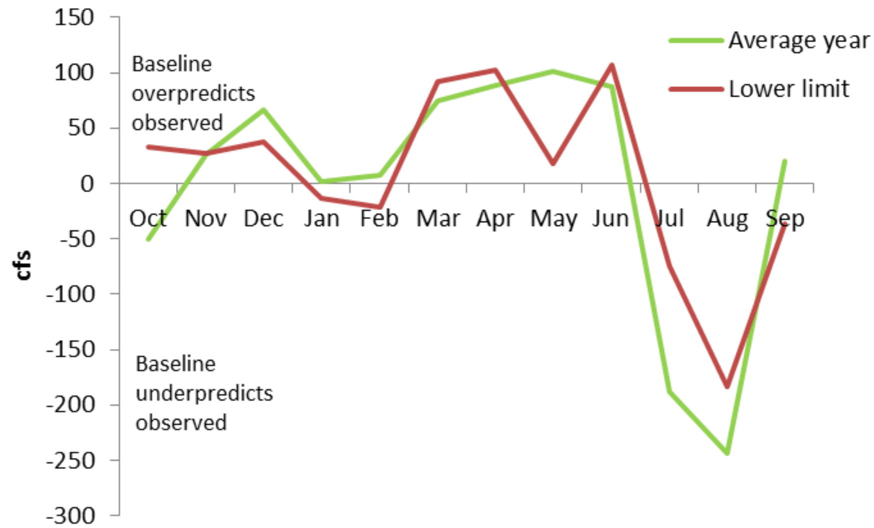
	Pulse Magnitude (cfs)	Pulse Duration (days)	Pulse Rise Rate (cfs/day)	Pulse Fall Rate (cfs/day)	Pulse Frequency (#/month)	Reversals (#/month)
Chattahoochee at Norcross	9*	2	-97	-108	-1.35	-2.6
Chattahoochee at West Point	-984*	2*	-483	-93	-0.18	-2.1
Apalachicola at Chattahoochee	-2791	7.7*	-1454*	-924*	-0.33	-4.7

Statistics and nuances of the table: Tests of statistical differences between the ACOE modeled baseline scenario and observed discharge in the Chattahoochee and Apalachicola rivers are provided in the table. Black boxes depict statistical differences. For the purposes of this analysis, we assumed that pulses were independent of one another. Two-tailed t-tests were used to test for statistical significance, except paired t-tests were used for monthly pulse frequency and reversals. P-values < 0.05 were used as thresholds for statistical significance. Pooled variances were used except in instances when the Satterthwaite method was used for unequal variances (*). Numbers in the table are the mean baseline value minus the mean observed value.

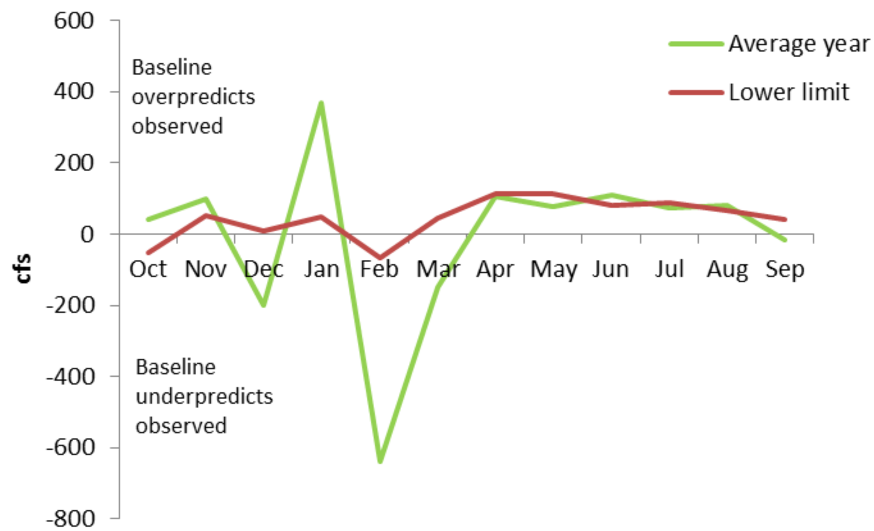
In this analysis (Table above), pulses were defined as any pulse or flood greater than the 75th percentile of the modeled baseline scenario. Analysis period included Sep 01, 2006 to Dec 31, 2008, the period for which the baseline scenario (presumably reflective of current operations) was implemented and for which observed data can be compared.

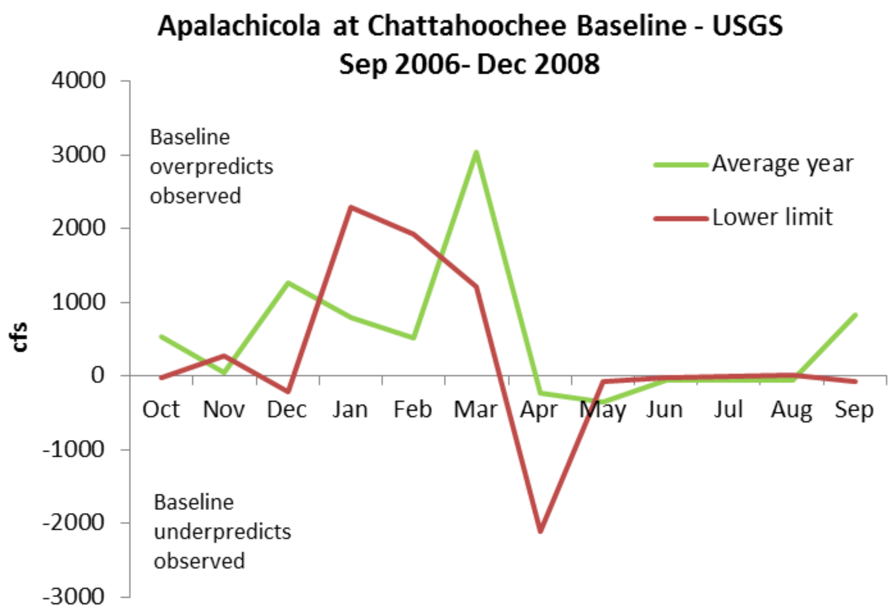
Figures: Using the same period of record for modeled baseline and observed discharge, the low flow analysis was conducted using the 7 lowest flows observed for every month of every year. The lines on the graph are the differences between the baseline and the observed USGS data for the 50^{th} percentile (average year) and 10^{th} percentile (lower limit). Values less than 0 indicate that the baseline modeled discharge underpredicted observed discharge, and values greater than 0 indicate the converse. Beyond the graphical comparison, no statistics were calculated for low flows.

Chattahoochee at Norcross
Sep 2006 to Dec 2008



Chattahoochee below West Point Dam
Sep 2006 to Dec 2008




Apalachicola at Chattahoochee Baseline - USGS
Sep 2006- Dec 2008
4000
3000
2000
1000
0
-1000
-2000
-3000
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Average year
Lower limit
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

USFWS Planning Aid Letter August 2013

This page intentionally left blank

United States Department of the Interior

Fish and Wildlife Service

105 West Park Drive, Suite D
Athens, Georgia 30606
706-613-9493 Fax: 706-613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
706-544-6428 Fax: 706-544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
912-832-8739 Fax: 912-832-8744

August 29, 2013

Mr. Curtis Flakes
Chief, Planning and Environmental Division
United States Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001

Subject: Planning Aid Letter, Apalachicola-Chattahoochee-Flint Water Control Manual Updates

Dear Mr. Flakes:

The U.S. Army Corps of Engineers, Mobile District (Corps), currently is updating the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM update identifies operating criteria and guidelines for managing water storage and release of water from Corps reservoirs and, therefore, will guide future water management operations in the basin. We previously provided Planning Aid Letters (PALs) for the proposed WCM update to the Corps April 2, 2010, and March 1, 2011; these PALS identify resource values and issues in the basin, including rare species, and propose preliminary changes, mitigation, or enhancement opportunities to minimize impacts and facilitate your National Environmental Policy Act analysis of the project. The comments in these PALs are still applicable.

The Service, in previous correspondence (July 19, 2013, Revised Alternative to the Corps), identified performance measures that the Corps should use, in simulated operations, to compare the relative effects of the no-action and action alternatives considered for the WCM update on various target species. We used these performance measures in the development of the Service's Revised Alternative. In this PAL, we fully describe these performance measures. We submit these comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Migratory Bird Treaty Act, (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq.*), and the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). Our comments are based on previous studies and government documents, as well as new datasets and information provided by State and Federal agencies. We will provide additional expertise and information in our FWCA Report and during a separate section 7 consultation under the ESA.

Description of Performance Measures

Apalachicola River Floodplain Fish Spawning and Rearing

The Floodplain Spawning Habitat Performance Measure (FSHPM) calculates the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April through October. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

Multiple studies establish the importance of floodplain habitats to the life history of many riverine fishes, including several specific to the Apalachicola River (Walsh et al. 2006, 2009; Pine et al. 2006; Dutterer et al. 2011). These studies provide evidence of spawning and rearing activity for at least 44 species representing 16 families (predominantly Centrarchidae and Cyprinidae) in floodplain habitats, when available, during the growing season. Fish use in floodplain habitats requires time for adult movement from the main channel into the floodplain, courtship and spawning behaviors, egg incubation, and juvenile growth to a size capable of moving to and surviving in the main channel when water levels recede. We consider 30 days of continuous inundation minimally sufficient to ensure successful completion of the reproductive process in the floodplain. A greater spatial extent of habitat availability provides greater benefits for fish reproduction. The spatial extent of non-tidal floodplain inundation as a function of discharge from Woodruff Dam was quantified (Figure 1; Light et al. 1998, 2006).

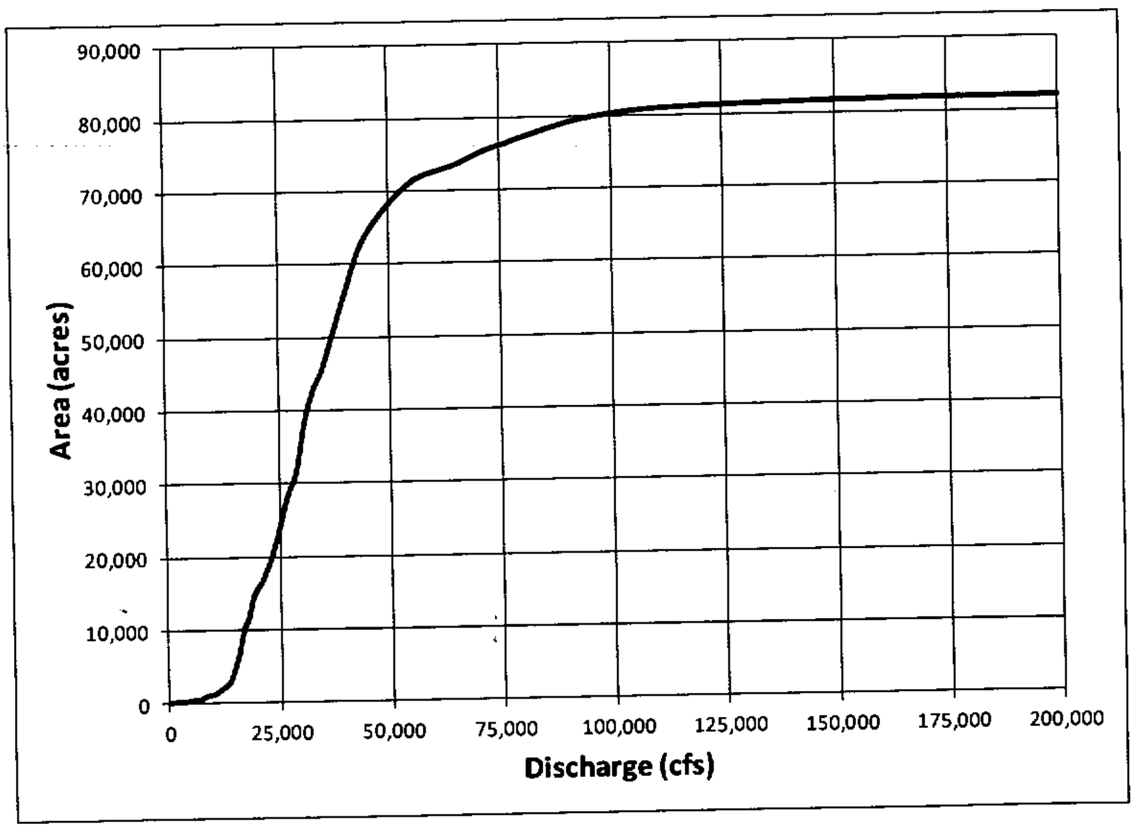


Figure 1. Area (acres) of aquatic non-tidal floodplain habitat connected to the main channel of the Apalachicola River as a function of discharge (cubic feet per second) from Woodruff Dam (data from Light et al. 1998).

The FSHPM computes a 30-day running minimum inundated floodplain acreage from observed or simulated daily releases from Woodruff Dam during April through October. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of eggs and larvae. The FSHPM is an Excel workbook that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous floodplain habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to floodplain-spawning fishes in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated floodplain habitat while balancing other project purposes. While this metric is developed to analyze the April-October period, the April to May period is most important because it encompasses spawning and peak abundance of early life stages of floodplain fishes (Walsh et al. 2006). Peak inundation during the growing season generally occurs in April. However, given the protracted spawning period of many fishes, we included April through October in the Excel workbook.

Gulf Sturgeon Spawning

The Sturgeon Spawning Habitat Performance Measure (SSHPM) calculates the maximum amount of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) spawning habitat available for at least 30 consecutive days from March through May. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

There are at least 10 potential Gulf sturgeon spawning sites on the Apalachicola River, based on the presence of a limestone, marl, or other hard substrate where sturgeon deposit their adhesive eggs. Egg collections have confirmed that three of these sites (river miles 105, 100, and 99) support spawning at a range of depths from 8.5 to 17.8 feet, a range that excludes the deepest 10 percent and shallowest 10 percent of collections. The SSHPM uses the discharge-habitat relationships for these three sites to predict spawning habitat availability based on these depths (Figure 2).

The SSHPM computes a 30-day running minimum habitat acreage from observed or simulated daily releases from Woodruff Dam during March through May. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of sturgeon eggs and larvae. The SSHPM is an Excel workbook application that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to sturgeon spawning in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated Gulf sturgeon spawning habitat while balancing other project purposes.

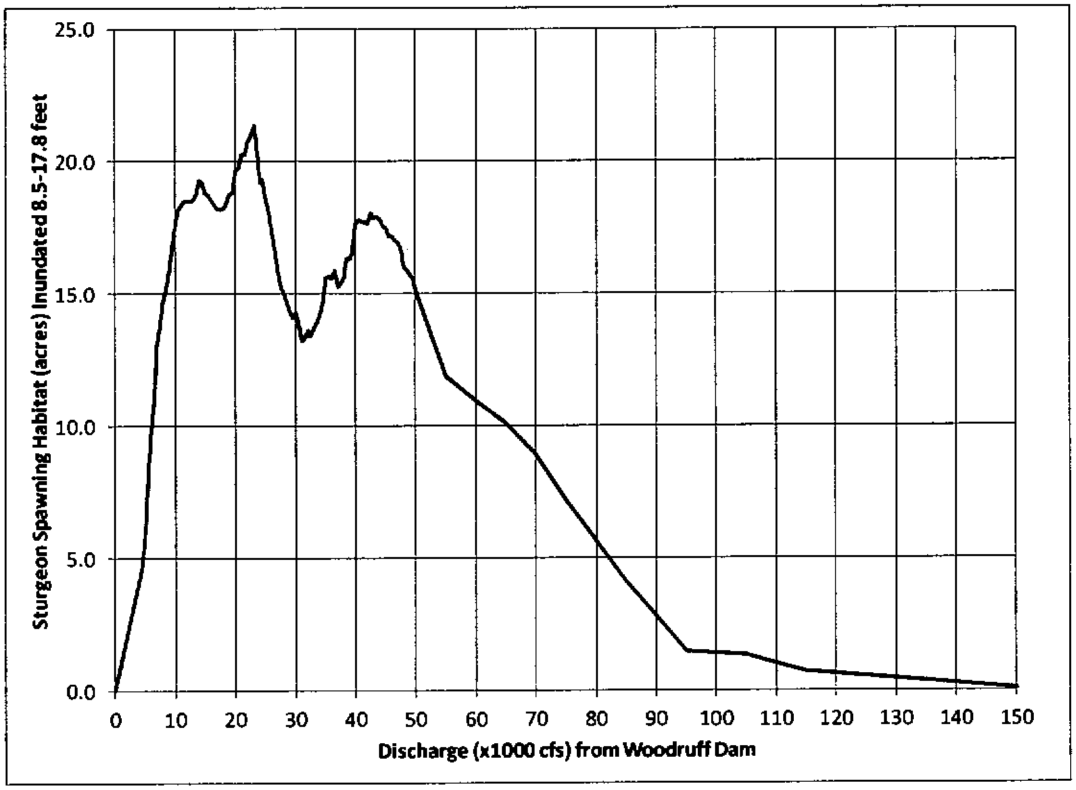


Figure 2. Area (acres) of hard substrate inundated to depths of 8.5 to 17.8 feet at the three known Gulf sturgeon spawning sites on the Apalachicola River at flows of 0 to 150,000 cfs (USFWS 2008).

Apalachicola River Mussels

The Service currently is working on a habitat-based performance measure for the federally-endangered fat threeridge (*Amblema neislerii*) in the Apalachicola River, but this metric will not be ready in time for use in the draft Environmental Impact Statement (EIS) and is not applicable to other mussel species. At this time, the best data available to evaluate the effects of operating alternatives on all three federally-listed mussels are the frequency, magnitude, and duration of low flows in the Apalachicola River.

The Apalachicola River Mussel Performance Measures (ARMPMs) are a suite of hydrologic measures related to mussel survival. Over the past eight years, we have described direct effects to mussels by exposure during low flow conditions. The ARMPMs are based on several of the low-flow and fall-rate metrics described in the biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012). The ARMPMs include the following metrics: (1) the inter-annual frequency of flow rates less than 5,000 to 10,000 cfs; (2) the median number of days per year less than the thresholds of 5,000 to 10,000 cfs; (3) the median number of consecutive days per year of discharge less than 5,000 to 10,000 cfs; (4) the median fall rates when flows are less than 10,000 cfs; (5) and the maximum fall rates when flows are less than 10,000 cfs.

The ARMPMs are an Excel workbook that requires multiple years of daily discharges as input. The primary outputs are graphical frequency distributions (line charts) for ARMPMs 1-3 above and calculations of ARMPMs 4 and 5. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The metrics should serve as the basis for comparing the relative effects to mussels in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that reduce the occurrence and fall rates of low flows, while balancing other project purposes.

Reservoir Fisheries

Multiple game and non-game fishes use the littoral zone for spawning and rearing (e.g., Centrarchidae). The Reservoir Fisheries Performance Measure (RFPM) is an index of habitat conditions for these littoral-zone spawning fishes, computed from time-series of daily surface elevations for Lanier, West Point, and W.F. George reservoirs using the Corps' elevation vs. surface area relationships for each reservoir. We have not developed a RFPM for Andrews and Seminole reservoirs because operating alternatives for these relatively shallow and essentially run-of-river impoundments are unlikely to change their patterns of surface elevation variability.

Like the FSHPM, the RFPM computes a 30-day running minimum habitat acreage during the spawning season from observed or simulated daily reservoir elevations. The annual maximum of these values during the spawning season represents the amount of habitat continuously available for at least 30 days to support spawning behaviors and the growth and development of early life-history stages.

The depth of productive littoral-zone habitat varies with surface elevation, water quality, the extent and duration of reservoir draw-downs in previous years, and other factors. The Corps' fish management plans from the 1970's suggest that 20 feet below full summer pool elevation is the "approximate bottom of the productive zone" for each of the three large storage reservoirs (Corps 1974a, 1974b, 1975). However, fisheries managers and experts for these reservoirs described depths greater than 15, 7, and 10 feet below full summer pool as "totally unacceptable" for littoral spawning or rearing habitat in Lanier, West Point, and W.F. George, respectively (Ryder et al. 1995). The RFPM uses the elevations from Ryder et al. (1995) corresponding to the "unacceptable" depths below full pool as the "floor" of the littoral productive zone.

Ploskey and Reinert (1995) cited numerous studies of successful reproduction and development of strong year classes associated with years of high water inundating terrestrial vegetation in reservoirs. They found positive correlations in West Point and W.F. George reservoirs between spring-time perimeter area (depth less than 6 meters) and standing crop data for Centrarchids. Flooded terrestrial vegetation is especially important to fisheries in Lanier and West Point, where aquatic vegetation is relatively sparse in constantly inundated areas. Miranda et al. (1984) found positive correlations between young-of-year largemouth bass abundance and the extent and duration of flood-pool inundation (i.e., elevations exceeding the top of the conservation pool) at West Point reservoir.

Based on this information, the RFPM computes two subsets of the area of the productive zone inundated during the spawning season for 30 days or more: 1) the area, if any, exposed during the previous growing season for at least 45 consecutive days, where terrestrial vegetation could have colonized exposed shorelines during the previous year; and 2) the area, if any, above the normal full pool elevation that could support perennial terrestrial vegetation (Figure 3). The second subset is a subset of the first, and by adding these two areas to the full inundated area of the productive zone, the RFPM triple-counts inundated acres above normal full pool and double-counts inundated acres that were exposed during the previous year.

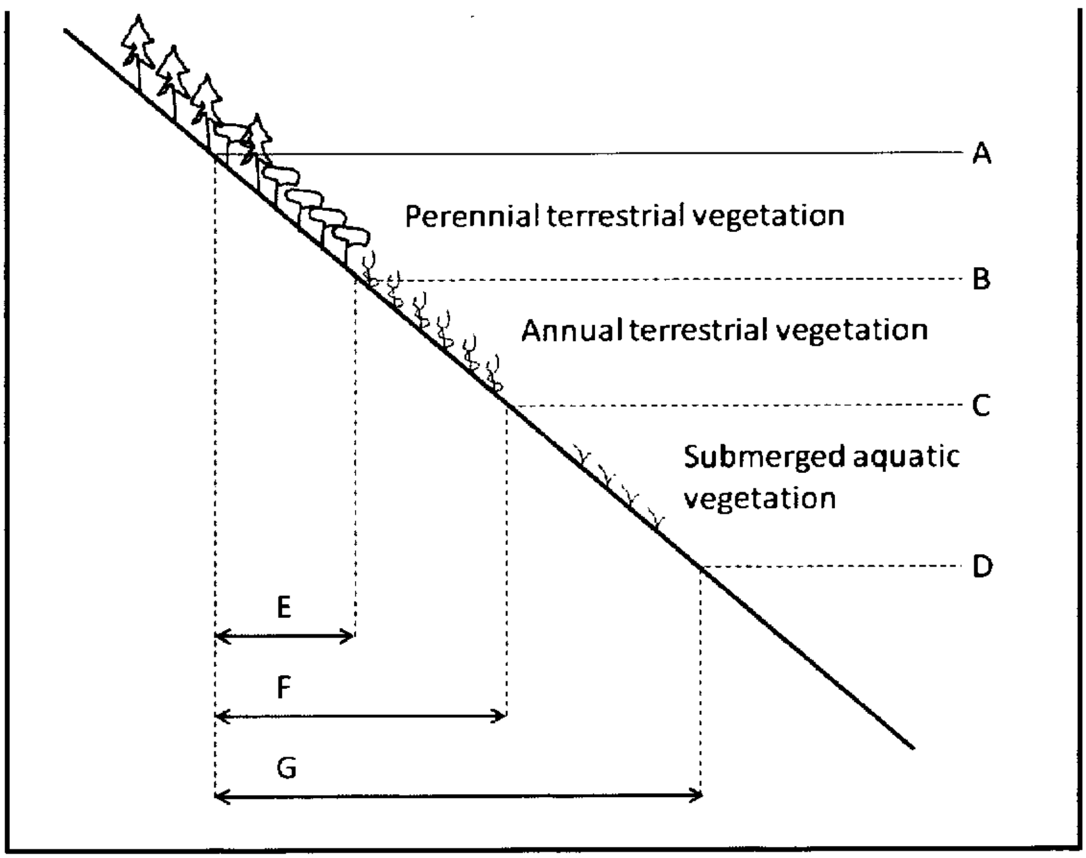


Figure 3. Conceptual drawing of a reservoir shoreline showing RFPM physical features, where
A = maximum surface water elevation sustained for at least 30 days during the spawning season;
B = full conservation pool elevation and lower extent of perennial terrestrial vegetation;
C = the minimum elevation exposed for at least 45 days during the growing season in the previous year;
D = the elevation of the lower extent of reservoir productive zone;
E = the inundated area between A and B;
F = the inundated area between A and C; and
G = the inundated area between A and D.

In this depiction, A exceeds both B and C, and the RFPM would report for the year the sum of E + F + G as the annual habitat acreage (E is triple counted, and F is double counted). In years when A does not exceed B, E is 0; when A does not exceed C, F is zero; and when A does not exceed D, G is zero.

The fish spawning seasons specific to each reservoir for the RFPM are identified in the Corps' Standard Operating Procedure (SOP) for fish spawning in the ACF system (Table 1). The intent of the SOP is to maintain stable or rising reservoir levels for 4 weeks during the 8-week window to promote successful fish spawning and rearing. The 30-day running minimum area calculated in the RFPM begins on the first day of the fish spawn window and concludes on the day that captures the last day of the spawn window in the 30-day minimum calculation. The other temporal and spatial parameters used in the RFPM (e.g., growing season length, elevation of the lower extent of the productive zone) for each reservoir are given in Table 1 along with the values we recommend for its use; however all are user-definable parameters.

Table 1. User-definable parameters for the RFPM with recommended values for its use.

Parameter	Lanier	West Point	W.F. George
Growing season[1] start	Mar. 30	Mar. 20	Mar. 10
Growing season[2] end	Oct. 30	Nov. 5	Nov. 15
Spawning season start	Apr. 1	Apr. 1	Mar. 15
Spawning season end	Jun. 1	Jun. 1	May 15
Elevation (ft) for lower extent of reservoir productive zone	1056	628	180
Exposure duration (days) for establishing terrestrial vegetation during the growing season	45	45	45
Inundation duration (days) for spawning/early rearing	30	30	30
Full conservation pool elevation (ft) and lower extent of perennial terrestrial vegetation	1071	635	190

1=Average dates of last spring freeze (National Weather Service 2013a).
2=Average dates of first fall freeze (National Weather Service 2013b).

Although many other factors besides reservoir elevations, such as flow-through volume, nutrient loading, etc., may influence the population dynamics of reservoir fishes, we believe the RFPM is a relatively simple and useful index for ranking the effects of operating alternatives on reservoir fisheries habitat. We considered using the performance measure that the Service developed for the Corps' 1998 ACF Water Allocation DEIS, which was based in part on the expert-opinion survey results described in Ryder et al. (1995). We prefer and now recommend the RFPM, because it relies solely on direct measures of reservoir area that are likely to contain the habitat features supporting successful fish reproduction. Further, the RFPM results are more easily computed and interpreted than those of the 1998 DEIS performance measure, and are consistent with the Corps' fish spawn SOP, which was adopted after the 1998 DEIS.

The RFPM is an Excel workbook that requires multiple years of daily reservoir elevations as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) for each reservoir of annual maximum 30-day continuous habitat availability. The spreadsheet is organized for comparing the distributions of observed reservoir levels, existing operations (the RIOP) as simulated by ResSim, and up to 6 additional simulated operations alternatives. Displaying additional alternatives is possible by replicating the functions within the spreadsheet.

Chattahoochee River Shoal Bass Recruitment

The Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM) predicts shoal bass (*Micropterus cataractae*) recruitment using a combination of discharge and river water temperatures. Shoal bass are a recently-described black bass endemic to the ACF River Basin, are listed as a species of concern by American Fisheries Society, and are regionally vulnerable (Warren et al. 2000). They frequently occur in shoals over rocky sediments in water exceeding 0.66 feet per second (Sammons and Goclowski 2012). Shoal bass frequently co-occur with other shoal-dwelling native species and their population response to discharge and water quality may be an indicator of shoal fish community response. Because of their recreational fishery significance and the availability of potentially suitable shoal habitat, Georgia Department of Natural Resources and the National Park Service initiated a 5-year shoal bass stocking program in 2003 below Morgan Falls Dam on the Chattahoochee River.

A study was initiated to evaluate the success of the stocking program and to characterize variables affecting recruitment (Long and Porta 2011). The relative abundance (electrofishing catch-per-unit effort) of age-3 shoal bass was of specific interest because these individuals were the minimum age (size) susceptible to capture, had the potential to be stocked, and were present in the river for a duration of time acceptable for inferences regarding cohort recruitment. Mean spring water temperature was highly correlated with discharge, and spring water temperature and bass length at stocking were strong predictors of age-3 catch per unit effort ($F_{2,3}$= 20.78, R^2 = 0.93, $p < 0.10$). Because stocked and wild shoal bass had similar lengths, growth rates, and longevity, we expect that wild and stocked fish respond similarly to river water temperatures and that the multiple regression formula of Long and Porta (2011) can be used to make inferences regarding both wild and stocked shoal bass:

$$\log_{10}\text{age-3 abundance} = -6.262 + 0.055_{LStock} + 0.306_{SpTemp}$$

where LStock is length in millimeters at time of stocking, and SpTemp is Spring water temperature (from stock date to June 21) in degrees Celsius.

In order to use Long and Porta's (2011) multiple regression model to evaluate multiple alternatives for the WCM updates, we estimated the relationship between discharge and water temperature in the Chattahoochee River at two locations. We used United States Geological Survey (USGS) average daily discharge and temperature data from the Chattahoochee River below Morgan Falls Dam, Georgia gage (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the Chattahoochee River at Atlanta, Georgia gage (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012). Both locations were within the study area of Long and Porta (2011). Average temperature and discharge were used for May and June (combined), because averages were used to develop the multiple regression model, and May and June constitute a majority of the spring stocking events (Long and Porta 2011). Exponential relationships produced the best-fit lines (Atlanta R^2 = 0.94; Morgan Falls R^2 = 0.88; Figure 4).

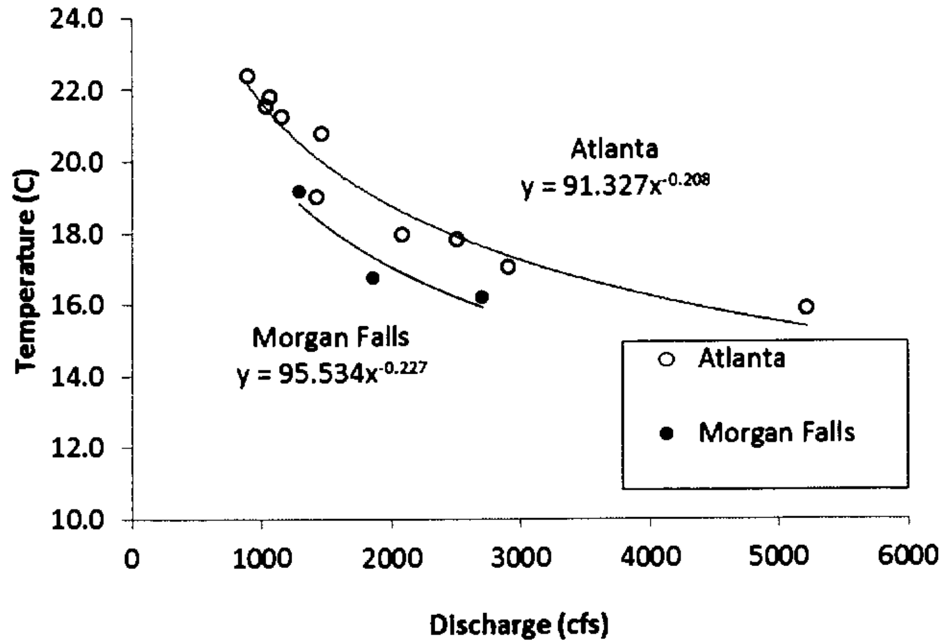


Figure 4. The relationship between spring temperature and average daily discharge for the USGS gage near the Chattahoochee River below Morgan Falls Dam, Georgia (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the USGS gage near the Chattahoochee River at Atlanta, Georgia (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012).

Based on these regressions, the CRSBPM is an Excel workbook that computes the average water temperature for May-June based on modeled discharge from the reservoir, then uses the Long and Porta (2011) regression formula to calculate recruitment as catch-per-unit effort of stocked age-3 shoal bass. The user can specify a bass length at stocking to examine recruitment effects. However, it is important that the user specify a length within the range measured in the study (23.7-68.0 mm), and that a consistent length is used to compare alternatives. We used 30 mm because smaller fish are likely to be more vulnerable to temperature changes, although trends are the same for any size selected. The primary output is a graphical frequency distribution ("box and whiskers" plot) that compares predicted age-3 catch-per-unit effort (not log-transformed) among multiple alternatives. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The metric should serve as the basis for comparing the relative effects to age-3 shoal bass in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve shoal bass recruitment, while balancing other project purposes.

Apalachicola Bay Salinity

Because salinity in Apalachicola Bay is influenced by river flows, low salinities are prevalent during wet, high flow years and high salinities are prevalent during droughts. Optimal salinities for oysters are less than 26 parts per thousand (ppt) (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Randall and Sulak 2007;

Sulak et al. 2009). In our 2010 draft FWCA Report, the Service evaluated the effects of reservoir operation alternatives on salinity in Apalachicola Bay using output from a hydrodynamic salinity model developed by Sheng et al. (2011). This model provides detailed information about salinity throughout the bay over various freshwater inflows; however, it is time consuming and requires intensive data post-processing. While revising the alternative we submitted in July 2013, we sought a simpler, nimbler way to evaluate the effects of reservoir operations on salinity in Apalachicola Bay. Because we examined over 80 alternatives, hydrodynamic salinity modeling was not feasible.

The Apalachicola National Estuarine Research Reserve provided us their average daily salinity data for monitoring stations in the bay from 1992 to 2013. We focused on East Bay, which is important juvenile Gulf sturgeon habitat from October through March. We also focused on Cat Point and Dry Bar, which are commercially important oyster bars and where low salinities are most important from May through October. We developed regression relationships between the mean monthly salinity at each of these locations within Apalachicola Bay and the mean monthly discharge at the USGS gage in the Apalachicola River near Chattahoochee, FL (USGS gage 02358000; Figure 5). The Apalachicola Bay Salinity Performance Measure (ABSPM) uses these regressions to compute the mean monthly salinity for these three locations for each month of every year in the simulated discharge period of record. These values represent the average monthly salinities that are experienced at these locations to support Gulf sturgeon and oyster growth and survival.

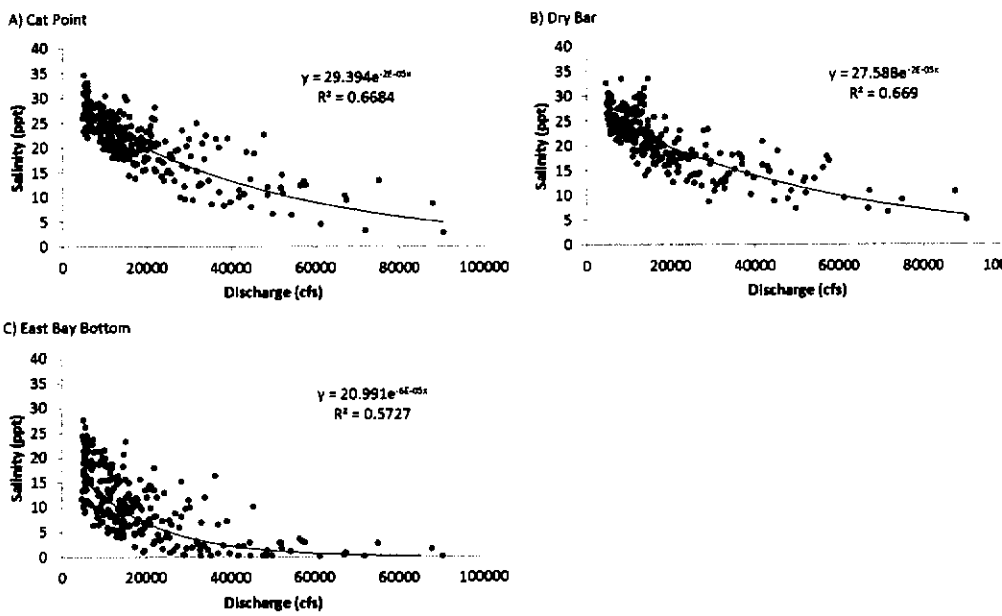


Figure 5. The relationship between Apalachicola River at Chattahoochee discharge (USGS #02358000) and Apalachicola Bay salinity at A) Cat Point, B) Dry Bar, and C) the bottom of East Bay.

The ABSPM is an Excel workbook that produces a graphical frequency distribution ("box and whiskers" plot) of mean monthly salinity for October through March for juvenile sturgeon in East Bay, and May through October for oysters at Cat Point and Dry Bar. The spreadsheet is organized for comparing the salinity distributions resulting from existing operations (the RIOP) as simulated in ResSim, and up to six additional simulated operations alternatives. The ABSPM should serve as the basis for comparing the relative effects of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve oyster and sturgeon growth and survival as measured by these performance metrics, while balancing other project purposes.

The Corps should note that the ABSPM is a coarse metric, because it is based on mean monthly salinities. Differences among the alternatives that we have analyzed to date are relatively minor. This may be due to the coarse temporal scale of the metric or the possibility that substantial changes in the bay salinity metric require large amounts of water. Finer spatiotemporal-scale evaluation is necessary to discern whether changes in reservoir operations may improve salinity regimes for sturgeon, oysters, and other bay resources. The Service recommends that the Corps also consider hydrodynamic salinity modeling for comparing the relative effects on Apalachicola Bay salinity in simulated operations of the no-action and action alternatives considered for the WCM update.

Summary

This PAL describes six performance measures that we recommend the Corps use to evaluate impacts of the no-action and action alternatives considered for the WCM update on various target species. We request the opportunity to analyze the Corps' future alternatives using the Service's performance measures. Alternatively, we can provide technical assistance or Excel workbooks for the Corps' analyses, as needed.

Our revised alternative, provided to you July 19, 2013, exhibited improvements to all these performance measures, except the ABSPM, when compared to conditions under the Revised Interim Operating Plan. As discussed above, a lack of notable improvement to the ABSPM may be due to the coarseness of the metric or the requirement for substantial changes in reservoir operations to result in changes to the bay salinity metric. Because most performance measures improved in our revised alternative, we did not prioritize them during our alternative development process. We can develop tailored recommendations in the future if it appears a priority ranking for the six performance measures is needed during the Corps' alternative development process.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress that the Corps' water management is not just about avoiding adverse effects, but also about restoring and improving habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Robin B. Goodloe
Acting Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
K. Herrington, USFWS, St. Charles, MO
S. Abbott, USFWS, Ft. Benning, GA
C. Sumner, Corps, Mobile, AL
D. Imm, USFWS, Panama City, FL
D. Everson, USFWS, Daphne, AL
B. Zettle, Corps, Mobile, AL

Literature Cited

Altinok, I., and J.M. Grizzle. 2001. Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. Journal of Fish Biology 59:1142–1152.

Dutterer, A.C., C. Mesing, R. Cailteux, M.S. Allen, W.E. Pine, III, and P.A. Strickland. 2011. Fish recruitment is influenced by river flows and floodplain inundation at the Apalachicola River, Florida. Unpublished final report submitted to the Florida Fish and Wildlife Conservation Commission. 24 pp.

Huang, W. 2010. Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science 86:526-534.

Light, H.M., M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida. U.S. Geological Survey Professional Paper 1594.

Light, H.M., K.R. Vincent, M.R. Darst, and F.D. Price. 2006. Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston, R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin, and W. Huang. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Long, J.M., and M.J. Porta. 2011. Determine status of shoal bass restoration and effects of environmental variation on timing of spawning and early life-history characteristics of two populations of shoal bass in the upper Chattahoochee River basin. Final Report.

Miranda, L.E., W.L. Shelton, and T.D. Bryce. 1984. Effects of water level manipulation on abundance, mortality, and growth of young-of-year largemouth bass in West Point Reservoir, Alabama-Georgia. North American Journal of Fisheries Management 4:314-320.

National Weather Service. 2013a. Last Spring Freeze Dates in Georgia. National Weather Service Weather Forecast Office, Peachtree City, GA. Online map at http://www.srh.noaa.gov/ffc/?n=lastfrz, accessed on 5/20/2013.

National Weather Service. 2013b. Autumn's First Freeze Dates in Georgia. National Weather Service Weather Forecast Office, Peachtree City, GA. Online map at http://www.srh.noaa.gov/ffc/?n=firstfrz, accessed on 5/20/2013.

Pine III, W.E., O.T.Burgess, S.J.Walsh, and A.C.Dutterer. 2006. Examination of fish spawning, movement, and habitat utilization patterns in the Battle Bend region of the Apalachicola River, Florida.

Unpublished final report to the Florida Fish and Wildlife Conservation Commission, Tallahassee, FL p. 39.

Ploskey, G.R., and T.R. Reinert. 1995. Assessing Impacts of Water Management on Reservoir Fish Reproductive Success in the Alabama-Coosa-Tallapoosa/Apalachicola-Chattahoochee-Flint River Basins. Technical Report EL-95-30, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. 48 pp.

Randall, M.T., and K.J. Sulak. 2007. Relationship between recruitment of Gulf sturgeon, *Acipenser oxyrinchus desotoi*, and water flow in the Suwannee River, Florida. American Fisheries Society Special Publication, Proceedings of Anadromous Sturgeon Symposium, Quebec City, Quebec, August 2003.

Ryder, S., J. Taylor, and J.H. Crance. 1995. Relations between Reservoir Surface Water Elevations and Reservoir Fisheries. Comprehensive Study ACT/ACF River Basins. U.S. Army Corps of Engineers, Mobile District. 178 pp.

Sammons, S.M., and M.R. Goclowski. 2012. Relations Between Shoal Bass and Sympatric Congeneric Black Bass Species in Georgia Rivers with Emphasis on Movement Patterns, Habitat Use, and Recruitment. Final Report Submitted to Georgia Department of Natural Resources Wildlife Resources Division.

Sheng, Y.P., J.R. Davis, and V.A. Paramygin. 2011. Simulating the impact of USACE operating alternatives on salinity and oyster population in Apalachicola Bay, FL. Draft Interim Report to the U.S. Fish and Wildlife Service. Civil and Coastal Engineering Department, University of Florida. April 27, 2011.

Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Parauka, S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505–515.

U.S. Army Corps of Engineers (Corps). 1974a. Lake Sidney Lanier, Chattahoochee River, Georgia; Design Memorandum; The Master Plan, Appendix D - Fish Management Plan. U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama. Unpublished report dated July 1974. 132 pp.

U.S. Army Corps of Engineers (Corps). 1974b. Walter F. George Lake, Chattahoochee River, Georgia and Alabama; Design Memorandum; The Master Plan, Appendix D - Fish Management Plan. U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama. Unpublished report dated July 1974. 162 pp.

U.S. Army Corps of Engineers (Corps). 1975. West Point Lake, Chattahoochee River, Alabama and Georgia; Design Memorandum; The Master Plan, Appendix D - Fish Management Plan. U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama. Unpublished report dated July 1975. 129 pp.

U.S. Fish and Wildlife Service (USWFS). 2006. Biological Opinion and Conference Report on the U.S. Army Corps of Engineers, Mobile District, Interim Operation Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. USFWS Panama City Field Office, Florida. Unpublished report dated September 22, 2006. 166 p.

U.S. Fish and Wildlife Service (USFWS). 2008. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. USFWS, Panama City Field Office, Florida. Unpublished report dated June 1, 2008. 211 pp.

U.S. Fish and Wildlife Service (USFWS). 2012. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. U.S. Fish and Wildlife Service, Panama City Field Office, Florida. Unpublished report dated May 22, 2012. 166 pp.

Walsh, S.J., W.B.Tate, and M.A.Burgess. 2006. Fishes of the Apalachicola River floodplain: role of habitat and hydrology to recruitment. U. S. Geological Survey. Unpublished final report submitted to the Florida Fish and Wildlife Conservation Commission. 124 pp.

Walsh, S.J., E.N. Buttermore, O.T. Burgess, and W.E. Pine, III. 2009. Composition of Age-0 Fish Assemblages in the Apalachicola River, River Styx, and Battle Bend, Florida. U.S. Geological Survey Open-File Report 2009-1145. 28 pp.

Warren, M.L., B.M. Burr, S.J. Walsh, H.L. Bart, R.C. Cashner, D.A. Etnier, B.J. Freeman, B.R. Kuhajda, R.L. Mayden, H.W. Robison, S.T. Ross, and W.C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25, pp. 7-29.

USACE Response to Planning Aid Letter January 2015

This page intentionally left blank

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

January 21, 2015

REPLYTO
ATTENTION OF:

Inland Environmental Team
Planning and Environmental Division

Mr. Donald Imm
Field Supervisor
U.S. Fish and Wildlife Service
Westpark Center, Suite D
105 Westpark Drive
Athens, Georgia 30606

Dear Mr. Imm:

The enclosed document is in response to your April1, 2010, March 1, 2011, and August 29, 2013 Planning Aid Letters (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint River Basin in Florida, Georgia and Alabama. In the PALs, you identified the types of data and analyses the U.S. Fish and Wildlife Service (FWS) would need to evaluate the WCM alternatives pursuant to the Fish and Wildlife Coordination Act (FWCA - 48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). This letter transmits the results of those analyses and/or our response. In addition, we are describing the proposed action and current action alternatives that are currently proposed to be carried forward for final evaluation in our Environmental Impact Statement (EIS).

Thank you for your assistance thus far in our effort to update these manuals. Based on our review of your letter and this response, we request that you provide us with your Draft FWCA Report at your earliest convenience. We are ready to assist with additional information or analyses. Should you have any questions, comments, or recommendations, please contact Mr. Chuck Sumner at (251) 694-3857 or e-mail: lewis.c.sumner@sam.usace.army.mil.

Sincerely,

Brian C. Peck for

Curtis M. Flakes
Chief, Planning and Environmental
Division

Enclosure

ACF Water Control Manual Update Response to Planning Aid Letter

U.S. Army Corps of Engineers
October 2014

Contents

1 Description of the Proposed Action and Alternatives

1.1 Introduction

The U.S. Army Corps of Engineers (USACE) proposes to prepare an updated Master Manual for the Apalachicola, Chattahoochee, and Flint River (ACF) Basin. A draft Master Manual was proposed in 1989 along with certain changes to the project manuals, as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. USACE has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would include five project-level water control manuals, presented as appendices that would specify how the various reservoir projects will be operated as a balanced system:

- Appendix A: Jim Woodruff Reservoir
- Appendix B: Buford Dam
- Appendix C: Walter F. George Dam
- Appendix D: George W. Andrews Reservoir
- Appendix E: West Point Reservoir

Water control manuals (WCM) also contain drought operations plans and divide the amount of water in storage into action zones to assist federal water managers in knowing when to reduce or increase reservoir releases and conserve storage in the USACE reservoirs, and how to ensure the safety of dams during extreme conditions such as floods. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines, and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management, and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions.

The updated manual would be prepared in compliance with Engineer Regulation (ER) 1110-2-240 and all other pertinent USACE regulations and policies. Accordingly, the updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, will reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues.

On June 28, 2011, the U.S. Court of Appeals for the Eleventh Circuit issued an opinion that the authorizing documents for the Buford Dam project include water supply as an authorized purpose. Additionally, the 2011 decision ordered the USACE to reconsider whether it has the legal authority to operate the Buford Project to accommodate Georgia's request made in 2000 to adjust the operation of Lake Lanier, and to enter into agreements with the State, or water supply providers, to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta. The USACE provided a legal opinion in 2012, concluding that it has sufficient authority under applicable law to accommodate that request, but noting that any decision to take action on Georgia's request would require a separate analysis. On January 11, 2013, the Governor of the State of Georgia provided updated demographic and water demand data to confirm the continued need for 705 million gallons per day (mgd) to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040 rather than 2030 as specified in the 2000 request.

Because updating the water control plans and manuals requires making a decision on Georgia's water supply request, USACE will consider, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013 requested from Lake Lanier and downstream at Atlanta. The following sections present the No Action Alternative (NAA) and the Proposed Action Alternative (PAA). The PAA, presented in Section 1.4, is USACE's Preferred Alternative.

1.2 Alternative Formulation Process

1.2.1 Models Used

The alternatives formulation process relied extensively on modeling using the latest software application, HEC-ResSim Version 3.2, Build 3.2.1.19. The software incorporates characteristics of the basin and individual reservoirs including physical constraints (spillway capacities, area-discharge curves, flows associated with hydroelectric power generation, and such) and operational procedures (action zones, balancing, and the like). After ensuring that the corresponding HEC-ResSim models could effectively reproduce the HEC-5 (the predecessor model used for simulating ACF operations) results, Mobile District and HEC created another HEC-ResSim model that captured the most significant operations as of 2008, and the Revised Interim Operating Plan (RIOP)(See Section 1.3.4.4.3 for further RIOP discussion) rules and head limits constraints. That model was presented to stakeholders in October 2008 and generally accepted as a promising improvement to ACF reservoir system modeling. Mobile District and HEC have continued to refine the HEC-ResSim model, using it to evaluate alternatives in support of the 2012 Legal Opinion.

USACE HEC also developed HEC-5Q to provide an analytic tool for evaluating the water quality response. The model is linked with the HEC-ResSim model through an input of flows by reach. The enhanced HEC-5Q developed for the Columbia River Basin was generalized and improved to meet the requirements of the ACT Basin. Longitudinally segmented reservoirs were layered so that the vertical distribution of phytoplankton, dissolved oxygen (DO), and other parameters could be represented. A branching of longitudinally segmented reservoirs was added as an option; it included variable water surface elevations based on backwater computations. A graphical user interface was also added to facilitate displaying and interpreting model results.

1.2.2 Development of Alternatives

On the basis of the operational challenges and problems associated with existing basin operations, extensive stakeholder input during three rounds of scoping, and accounting for the Eleventh Circuit Court of Appeals' ruling, the USACE developed objectives for the WCM updated and identified numerous management measures for possible consideration in the updated WCM. A measure can be defined as a feature or activity that can be implemented at a specific geographic site to address one or more of the objectives. The measures considered in updating the WCM included variations for revising reservoir drawdown and refill periods, reshaping action zones, and balancing zone drawdown proportionally among projects; revising hydroelectric power generation; revising drought operations and environmental flows; and developing navigation-specific operations. The USACE used an iterative process to identify the various measures that would be further developed, analyzed, and refined toward the goal of developing an updated WCM. Each water management measure was considered individually and determined whether it passed the screening criteria established for the WCM update.

The approach to formulating plans employs two phases. In the first phase, water management measures were identified and screened to identify the set of measures that will be combined to form water management alternatives. The evaluation of water management alternatives in this phase assumed that the water supply withdrawals from Lake Lanier would be limited to the 20 mgd withdrawn under the relocation contracts; releases from Buford Dam would be made in accordance with the Chattahoochee River Management System (CRMS), the existing operation; and water supply withdrawals from the Chattahoochee River in the Atlanta metro area would be limited to the amounts withdrawn in 2007. These assumptions facilitate the comparison of the performance of the water management alternatives using a consistent baseline condition that is relatively independent of the influence of the water supply withdrawals from Lake Lanier under the expired contracts. In this phase the No Action Water Management Alternative and six other Water Management Alternatives were considered. The alternative suggested by U.S. Fish and Wildlife Service (USFWS) in a July 19, 2013, letter was among the alternatives considered. The results of ResSim modeling pertaining to the project purposes were used to rank the ability of the alternatives to meet the objectives established for the WCM update. The water management alternative finally chosen represented the best balance of all authorized project purposes. The result of this formulation phase was the identification of a Water Management Proposed Action Alternative.

In the second phase of alternatives formulation, measures for analyzing different levels of water supply use that might be accommodated, including the Georgia 2013 request for water supply from Lake Lanier and for downstream withdrawers were identified and screened to identify the set of measures that were then combined to form water supply alternatives. For this phase, the Water Management No Action Alternative and the Water Management Proposed Action Alternative were used to evaluate and compare the water supply options. The result of this formulation phase was the identification of a tentative PAA. Refinements to the Water Management Proposed Action Alternative and the PAA will be considered in the interest of improving efficiency or reducing adverse effects. The PAA resulting from this two-phased formulation process will consist of a Water Management Proposed Action Alternative together with a proposal for providing some amount of water supply for the Atlanta region.

As a result of the alternatives formulation process, USACE has to date developed a total of eight alternatives. These alternatives are comprised of either the existing water management plan (Water Management No Action Alternative) or the Water Management Proposed Action Alternative together with some quantity of water withdrawn from Lake Lanier and a release from Buford Dam to satisfy either existing or future (2040) water needs for metro Atlanta. For the purposes of the FWCAR, this discussion will focus on comparing the PAA to the NAA; however some graphical data of the other six alternatives will be presented for completeness. Full details of the iterative process used in the alternative selection methodology as well as all project impacts of each alternative will be provided in the Draft Environmental Impact Statement.

1.3 No Action Alternative

The CEQ regulations require analysis of the NAA 40 CFR.1502.14. In the ACF WCM EIS, no action represents no change from the current management direction or level of management intensity. This alternative would represent continuation of the current water control operations at each of the federal projects in the ACF Basin. The USACE's operations have changed incrementally since completion of the 1958 ACF Master Manual. The changes were documented in a draft water control plan in 1989. However, additional incremental changes in water control operations have occurred since 1989 and are reflected in the No Action Alternative operation and the RIOP. Except in very general terms, it is not possible to describe a single set of reservoir operations that apply to the entire period since completion of the 1958 ACF Master Manual. The NAA reflects operational practices on the ACF Basin as described in the following documents:

- Draft ACF Water Control Plan dated 1989
- Project Water Control Manuals for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) (USACE, Mobile District, 2010b)
- RIOP and Environmental Assessment (EA) (June 2008), as modified by the updated RIOP/EA (May 2012)
- South Atlantic Division Regulation (DR) PDS-O-1, *Project Operations, Lake Regulation and Coordination for Fish Management Purposes* (May 31, 2010) and Draft *Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Procedure* (SOP), (USACE, Mobile District SOP 1130-2-9) February 2005
- Chattahoochee River Management System (CRMS) as described in the ACF Basin Master Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA, February 1991

Additionally, the NAA includes current water supply operations including withdrawals directly from Lake Lanier as well as releases from Buford Dam for downstream withdrawal. The following subsections describe key operational elements that apply to evaluating the NAA.

1.3.1 General System Operations

The USACE operates five dams in the ACF Basin (in upstream to downstream order)—Buford, West Point, Walter F. George, George W. Andrews (Andrews) on the mainstem of the Chattahoochee River, and Jim Woodruff (Woodruff), immediately below the confluence of the Chattahoochee and Flint rivers at the upstream extent of the Apalachicola River. Buford Dam, West Point Dam, and Walter F. George Lock and Dam are reservoirs (Lake Lanier, West Point Lake, and Walter F. George Lake, respectively) with a combined conservation storage capacity (relative to the top of each reservoir's full summer pool) of about 1.64 million acre-feet (ac-ft). Jim Woodruff Lock and Dam (Lake Seminole) is operated as a run-of-river project and only very limited pondage is available to support project purposes (USACE, Mobile District 1998a). Andrews is a lock and dam without any appreciable water storage behind it.

The last environmental impact statements evaluating the environmental consequences of the individual operating reservoirs in the ACF Basin were completed in the 1970's. Since then incremental changes in project operations have occurred due to changes in hydropower contracts and operating schedules, changes in navigation flow requirements, and other changes related to water quality, environment, or other uses of the system.

The reservoirs in the ACF Basin are managed and operated in accordance with authorized project purposes of flood risk management (formerly referred to as flood control or flood damage reduction), hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water quality, and water supply and as an integrated system of water resource projects in which each reservoir has a role to play. ACF Basin water control operations consider all project functions and account for the full range of hydrologic conditions from flood to drought. Because actions taken at the upstream portion of the basin affect conditions downstream, the federal projects in the ACF Basin are operated as a system rather than as a series of individual, independent projects. The balancing of water control operations to meet each of these purposes varies between the individual projects and time of year. Operation of the projects is usually performed in a manner which represents a consideration of these at times competing purposes and, whenever possible, reservoir operations are managed to accommodate these purposes in a complementary fashion. For example, flood waters are evacuated to the greatest extent practicable through the powerhouse turbines to produce electricity. In addition to specific purposes for which these projects are operated, a variety of activities also benefit the operational patterns of these projects.

Many factors must be evaluated in determining project or system operation, including project requirements, time of year, weather conditions and trends, downstream needs, and the amount of water remaining in storage. The guidelines are not limited to a specific hydrologic condition, and therefore the Master Manual differs from a flood risk management or drought management plan; however, the plan is broad enough that it can fulfill requirements for a drought management plan.

Traditionally, the federal projects in the ACF Basin have been operated in such a manner that hydroelectric power generation requirements controlled during the summer months when energy demands are high, while navigation needs dominated during the fall, low-flow months. Whenever rainfall has caused water levels to rise excessively, flood risk management operations override other project functions. During extreme drought conditions, water supply and water quality requirements have been the major operating concerns. During the extreme drought period beginning in 2006, federally listed threatened and endangered species conservation also became a priority consideration in managing the system. This water management approach recognizes that extreme droughts may produce situations where trade-offs are required. For example, in extreme droughts project operations directed primarily at water supply, water quality, and/or endangered species conservation, may receive higher consideration than other purposes, such as hydroelectric power generation, navigation, or recreation.

1.3.2 Guide Curves

A guide curve is the seasonally variable desired pool elevation in a reservoir to fully meet project purposes. Existing guide curves are shown in the Water Control Manuals for Buford Dam (1991), West Point Dam (1984), Walter F. George Lock and Dam (1993), George W. Andrews Lock and Dam (1996), and Jim Woodruff Lock and Dam (1985) projects. The guide curves for Lanier, West Point, and Walter F. George lakes are shown in Figure 1.3-1, Figure 1.3-2, and Figure 1.3-3.

1.3.3 Action Zones

The *1989 draft ACF Water Control Plan* (USACE, Mobile District 1989a) defines action zones for each of the three major storage projects on the ACF Basin—Lake Lanier (Figure 1.3-1), West Point Lake (Figure 1.3-2), and Walter F. George Lake (Figure 1.3-3). Those zones are used to manage the reservoirs at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each reservoir, defines a reservoir condition where all authorized project purposes should be met. As lake levels decline, Zones 2 through 4 define increasingly critical system water shortages and guide the USACE in reducing flow releases resulting from drier-than-normal or drought conditions. The action zones also provide guidance on meeting minimum hydroelectric power generation needs at each project, and they determine the amount of storage available for downstream purposes such as flood risk management, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water quality, and water supply.

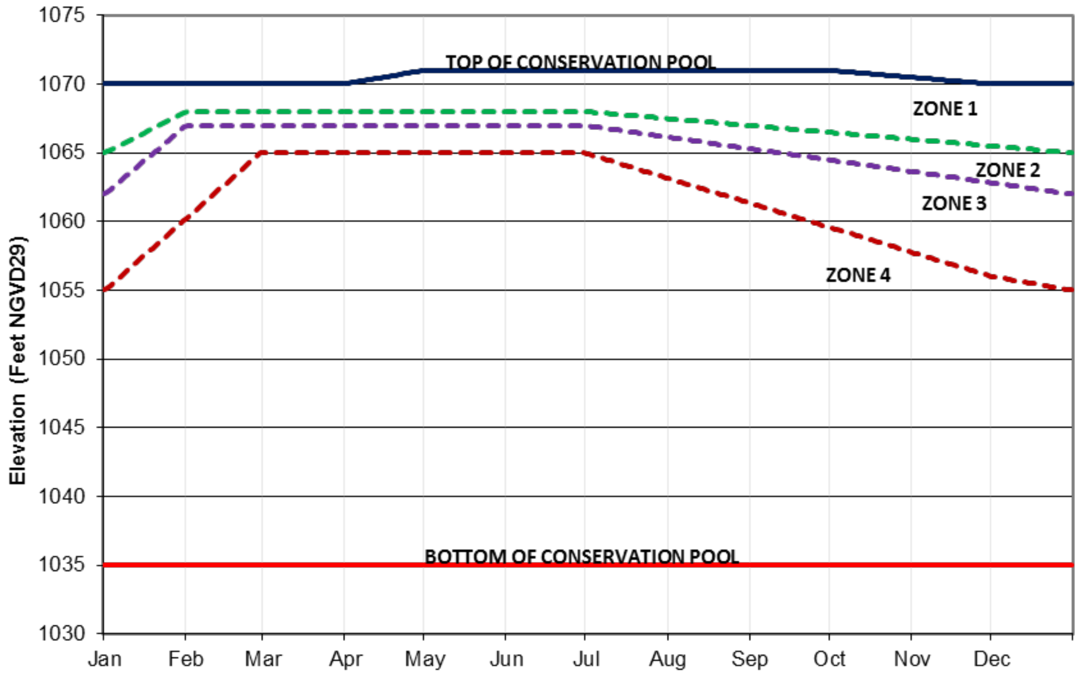


Figure 1.3-1. Lake Lanier water control action zones

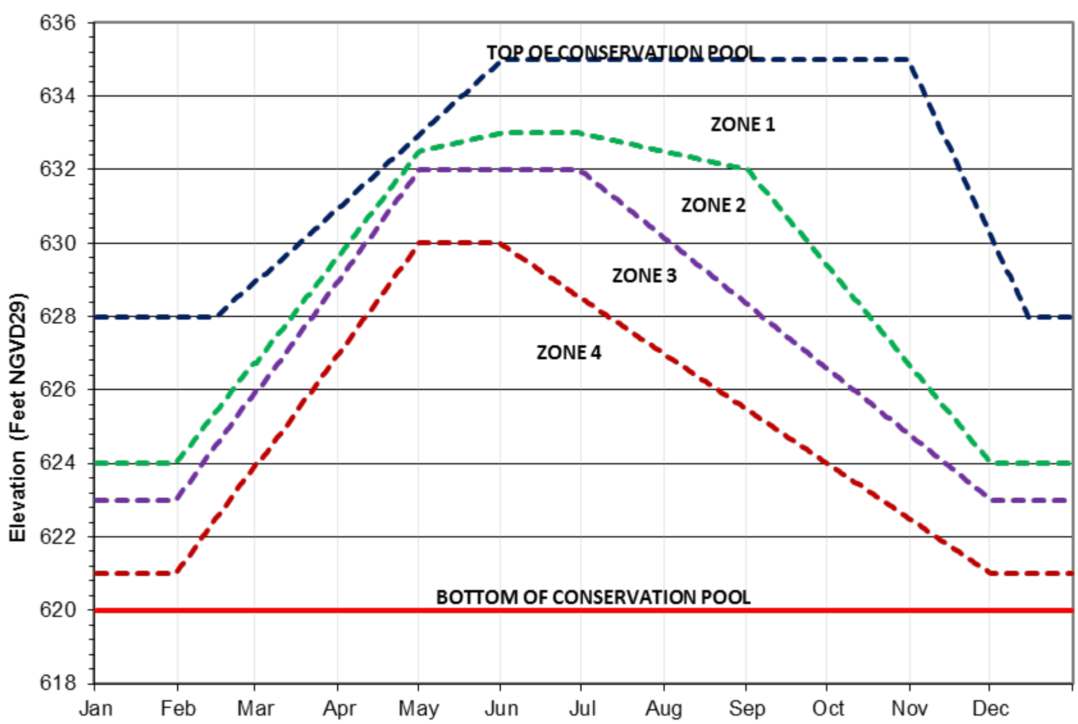


Figure 1.3-2. West Point Lake water control action zones

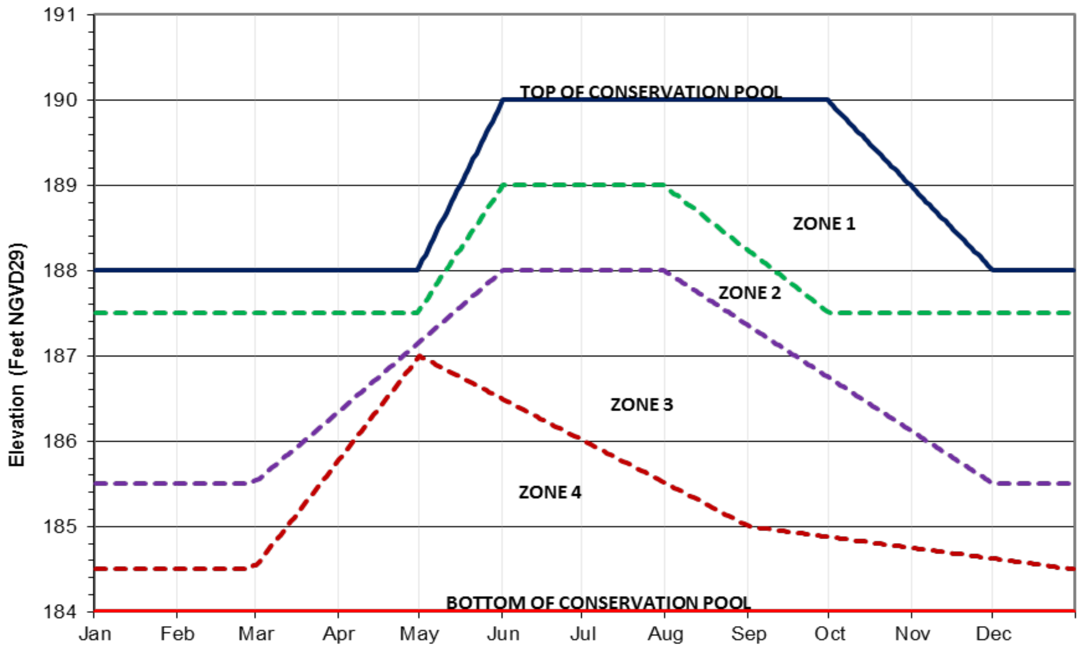


Figure 1.3-3. Walter F. George Lake water control action zones

At the time of their development in 1989, action zones were derived on the basis of past project operations, which considered time of year, historical pool level/release relationships, operational limits for conservation, and recreational resource impact levels. The action zones have provided a key management tool for more than 20 years providing the basic guidelines for operating the river system; however, other factors and activities might cause the USACE to operate the reservoirs differently than the zones shown on the charts. Examples of those factors or activities could include exceptional flood risk management measures, fish spawn operations, maintenance and repair of turbines, emergency situations such as a drowning and chemical spills, draw-downs because of shoreline maintenance, releases made to free grounded barges, and other circumstances.

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

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

The action zones have provided a key management tool for more than 20 years. They play a substantial role in several aspects of operating the lakes and dams. Under the NAA, it is assumed that the action zones would remain in effect unchanged.

1.3.4 Authorized Project Purposes

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

1.3.4.1 Flood Risk Management

The objective of flood risk management operations (formerly referred to as flood control) is to impound excess flows, thereby reducing downstream river levels below flood stage. Whenever flood conditions occur, operation for flood risk management takes precedence over all other project functions. Only Buford and West Point Dams have storage allocated for flood risk management operations. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower peak stages throughout the reservoir during major floods. George W. Andrews and Jim Woodruff dams operate to pass inflows.

The timing of flood peaks in the ACF Basin is of considerable importance in determining the effectiveness of reservoir operations for flood risk management and the degree to which such operations can be coordinated. During a flood event, excess water above the normal pool elevation or *guide curve* is evacuated (released) consistent with other project needs as soon as downstream waters have receded enough that releases from the reservoirs will not increase the natural maximum flood heights downstream. This timely evacuation is necessary so that consecutive flood events will not cause floodwaters to exceed allocated storage capacities and endanger the integrity of the dam. Both turbines and spillways are used, as necessary, to evacuate floodwaters.

Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power generation demands are lower, the guide curve operation generally reflects this situation by specifying a lower elevation during this time period. Transitions between the seasonal levels are gradual to moderate increases or decreases in outflow. By drawing down the pool in late fall, either specifically for flood risk management (flood control) as at West Point or coincidentally for other purposes, additional storage is gained for containing floodwaters.

For flood risk management purposes, releases are reduced or terminated at Buford Dam, except for the small hydropower unit, as soon as it appears that downstream river stages will exceed flood stage. Key gaging stations in the vicinity are intensively monitored to determine when floodwaters have begun to recede so that flood storage in the reservoir can be expeditiously evacuated in a manner consistent with other project functions without exacerbating downstream flooding. Projects on the middle and lower river pass flood waters once the pool has reached the top of the conservation pool. West Point and Walter F. George operate according to specified flood risk management plans, as outlined in their Water Control Manuals. Spillway gates are opened if necessary to assist the turbines in passing these flows.

Even though the traditional flood season spans several months, discrete incidences of flooding should have insignificant long-duration effects if pool elevations are maintained close to guide curve elevations. No pool is allowed to remain above its guide curve for any appreciable length of time without prior approval of a temporary deviation or variance by the USACE South Atlantic Division.

1.3.4.2 Hydroelectric Power Generation

Hydroelectric power generation is a small but key feature in meeting the power demands of the region. Hydroelectric power generation plants provide a portion of the region's electric power peak demands. Peaking capability on short notice is greatly valued for power grid reliability. Hydroelectric power generation is instantaneously available to meet extreme increases in power demand or to replace unexpected interruptions in thermal generation. The power generated by the USACE projects in the ACF Basin is marketed by the Southeastern Power Administration (SEPA), an agency of the Department of Energy. SEPA markets power on the basis of a system that comprises a large geographical area to a number of cooperatives and municipal retail suppliers of power, referred to as *preference customers.* Projects within SEPA's Georgia-Alabama-South Carolina system include Buford, West Point, and Walter F. George on the Chattahoochee; four projects in the Alabama, Coosa, and Tallapoosa River Basin; and three projects on the Savannah River Basin. The 10 powerhouses in this system have been operated most of the time as *peaking plants* in an integrated fashion to produce an aggregate hydroelectric power generation supply for the system. As a result, power generation demands have been balanced among these projects weekly to enhance the long-term generating capability of the entire system. By integrating the operation of these projects, the total utility and marketability of power produced for the entire system is greatly increased and the adverse effects on the reservoirs are more balanced. When the system obligation cannot be met, the SEPA arranges for supplemental power or purchases from other sources, or both.

The storage projects (Lake Lanier, West Point Lake, and Walter F. George Lake) are operated as *peaking plants* and generally provide at least two hours of generation a day, five days a week at powerhouse capacity through the year, as long as sufficient conservation storage is available. The amount of generation per day is governed by a preset guide curve and action zones for each reservoir, with diminishing energy generation with declining storage. Minimum generation provides the release that would normally meet downstream water supply and water quality demands, as well as provides the capacity specified in SEPA's marketing arrangement. During the summer and early fall (July through October) typical operation provides minimum generation of four hours a day at a project if the pool level is above Zone 3, as identified on Figure 1.3-1 (Lake Lanier), Figure 1.3-2 (West Point Lake), and Figure 1.3-3 (Walter F. George Lake). This increase assists in meeting the high energy demands during that period. Minimum releases may also be increased if local inflows below the project are insufficient to meet water quality/water supply requirements. Additional generation solely to meet system hydroelectric power generation demands does not occur.

Because it does not have the ability to store appreciable amounts of flow, the Jim Woodruff (Lake Seminole) project is operated as a run-of-river plant and is dependent on releases from the upstream impoundments on the Chattahoochee River and from the Flint River. Unlike projects with appreciable conservation storage, run-of-river hydroelectric power generation facilities do not follow a guide curve, nor do they fluctuate or redistribute flows. The output of the plant varies with changes in the inflow entering Lake Seminole. The Jim Woodruff is a one-project system and power generated is marketed by SEPA to seven preference customers in the northern part of Florida to provide a specific minimum capacity and weekly energy. When that obligation cannot be met, the SEPA arranges for supplemental power or purchases from other sources, or both.

The current RIOP includes a limited hydroelectric power peaking operation at Jim Woodruff Dam when daily average releases are less than the combined capacity of the powerhouse turbines (about 16,000 cubic feet per second (cfs)) to deliver extra power during hours of peak demand for electricity. Those peaking releases are included in the daily average discharge computations for the RIOP minimum flow provisions. The peaks are also included in the stage computations for the RIOP maximum fall rate schedule; however, the maximum fall rate schedule addresses the difference between the average river stage on consecutive calendar days, not the shorter-term differences that result from peaking operations within a calendar day. The current RIOP includes a provision that discontinues peaking operations at the Jim Woodruff plant as average daily releases approach 6,700 cfs, to maintain instantaneous releases greater than or equal to the 5,000 cfs minimum flow requirement.

Droughts experienced over the basin in the past 35 years have revealed that, during extended low-flow seasons, operation of the federal projects in the ACF Basin for hydroelectric power generation production to meet the SEPA contract requests do not provide enough flexibility to adequately meet other authorized purposes. During these times, water taken from storage during the high-energy-demand months (June through September) would draw the pools down to such an extent that recreation would be affected in the lakes and less storage would be available late in the year to meet other release requirements, such as navigation or water quality. In such instances, hydroelectric power generation has been curtailed, as necessary, to balance the entire system operation. The typical hours of operation by action zone are presented in Table 1.3-1.

Table 1.3-1. Typical hours of peaking hydroelectric power generation by USACE project

Action zone	Buford Dam (hours of operation)	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	3	4	4
Zone 2	2	2	2
Zone 3	2	2	2
Zone 4	0	0	0

In addition to hydroelectric power generation being governed by action zone, physical limitations also factor into the power generation decisions. The main hydroelectric power generation units and small house unit intakes at Buford Dam are at elevation 919 ft. However, severe cavitation occurs in the main hydroelectric power generation units when the water surface falls to 1,035 ft or below, at which time the units are taken out of service and generation ceases. The small house unit goes off-line when water elevations reach 1,020 ft or below. With this measure the current hydroelectric power generation schedule would be maintained.

Under the NAA, it is assumed that the current hydroelectric power generation operations would remain in effect unchanged.

1.3.4.3 Navigation

The existing authorized navigation project includes a 9-ft by 100-ft navigation channel from Apalachicola, Florida, to Columbus, Georgia, on the Chattahoochee River, and to Bainbridge, Georgia, on the Flint River. Hydraulic and sedimentation characteristics of the Apalachicola River have been such that, despite maintenance dredging, the controlling channel depth has typically been less than 9 ft during a large portion of the normal low-flow period of the summer and fall each year. Groundings have been frequent, and barge loadings have been reduced considerably at times in the past to avoid grounding delays. Because of deteriorating channel conditions and limited channel availability during the low-flow months, navigation windows were routinely scheduled during the low-flow months in the 1990s. Navigation windows were composed of storing water in the upstream reservoirs for several weeks and then making increased releases for a 10-day to 2-week period to allow commercial barge navigation to make a round trip up river for scheduled delivery of commodities. Concerns were raised regarding the fluctuations of both reservoir and river stages associated with navigation window releases, and the continued use of navigation windows became increasingly controversial, especially during sustained, low-flow periods when observed fluctuations were more extreme. As a result of fluctuating river stages during navigation windows, gradual ramping rates were developed in coordination with the USFWS and Florida Fish and Wildlife Conservation Commission, with the goal to provide for ramping down rates of not more than one-half ft/d during fish spawn activities, and no more than one ft/d during other times of the year, whenever flows were below 20,000 cfs.

Through most of the 1990s, the navigation channel on the ACF Basin was used consistently and frequently by commercial traffic. The authorized navigation channel downstream of Jim Woodruff Dam was maintained in reasonably reliable condition by way of maintenance dredging, snagging, and training works, combined with flows from upstream that were generally sufficient to meet navigation needs. During that period, annual tonnage ranged from 550,000 to 640,000, and annual traffic ranged from 900 to 1,200 trips. Navigational use of the ACF waterway declined precipitously during 1999 and has not recovered since. The last navigation window was provided in the spring of 2000, and it precipitated complaints that the navigation window was scheduled during the period of fish spawn and had adversely affected both reservoir and riverine fish spawn activities. No navigation windows have been scheduled since, and none are planned in the foreseeable future.

No dredging was conducted in 2000 or 2002 because of sustained drought conditions in the basin, and only very limited dredging was conducted in 2001 and then was shut down because of sustained, low flow conditions. The navigation project was not maintained in 2002–2005, principally due to the lack of navigation traffic, environmental conditions and constraints on dredging activities, and consequently, funding constraints. In March 2004 the USACE, Mobile District applied for a 5-year renewal of the Section 401 water quality certification for maintenance dredging of the authorized navigation channel in the Apalachicola River. After an extended period of coordination and negotiation regarding renewal of water quality certification, the Florida DEP formally denied the Mobile District's request on October 11, 2005 (USACE, Mobile District 2006). No maintenance dredging on the Apalachicola River, or appreciable navigation use of the ACF navigation system, has occurred since. In June 2012, the Mobile District applied to the Florida DEP for a permit to continue to conduct routine maintenance snagging to remove tree snags from the navigation channel in the Apalachicola River portion of the project. The request did not include any proposed dredging activity. The snagging permit was issued to USACE, Mobile District, on November 27, 2013 and is in effect for ten years from the issue date (FLDEP 2013a). Minimal navigation dredging occurred in 2010 on the Chattahoochee River upstream of Jim Woodruff Lock and Dam to facilitate navigation on that portion of the ACF waterway, but no dredging has been conducted since. No water management activities are routinely being undertaken in the ACF Basin specifically to support navigation.

Although navigation is an authorized purpose of the USACE projects in the ACF Basin, the basin is not set up to actively support navigation flow requirements which are currently estimated to require 20,600 cfs for a 9-ft channel This is principally due to a lack of commercial navigation use and the inability to secure the necessary water quality certification from the Florida DEP to perform the required maintenance dredging and other operational activities for the navigation channel downstream of Jim Woodruff Dam, as discussed above. Limited use of special releases to assist with critical navigation requirements (in the form of a brief navigation window) have been addressed on a case-by-case basis. Such special releases, when requested, are coordinated with Alabama, Florida, and Georgia; federal resource agencies; and key stakeholders.

1.3.4.4 Fish and Wildlife Conservation

West Point Dam is the only federal project in the ACF Basin with *fish and wildlife conservation* specifically included in its original authorization by Congress. Nonetheless, the ACF Basin USACE reservoirs (Lanier, West Point, Walter F. George, Andrews, and Seminole lakes) operate to support fish and wildlife conservation pursuant to the authority in either the Fish and Wildlife Coordination Act or the Endangered Species Act (ESA). Generally, reservoir operations for fish and wildlife conservation consist of either maintaining pool elevations during fish spawns or making special releases to minimize the possibility of fish kills. Special drawdowns for specific environmental purposes may be specified from time to time, but only after coordination with state and federal resource agencies and others, as appropriate. Although the possibility of requiring water control actions may extend throughout a season, the actual actions are usually of short duration. In addition to fishery management, these operations include aquatic plant control, waterfowl, and other terrestrial habitat management. The various projects in the basin have specific operations for fish and wildlife, which are described in the individual reservoir regulation manuals for these projects. Specific fish and wildlife conservation activities on the USACE ACF Basin projects are addressed in more detail in the following paragraphs.

1.3.4.4.1 Fish Spawning

In addition to providing for minimum flow and water quality releases, the USACE operates the system to provide favorable conditions for annual fish spawning, both in the reservoirs and the Apalachicola River. In most water years (October 1 - September 30) it is not possible to hold both lake levels and river stages at a steady or rising level for the entire spawning period, especially when upstream lakes or the Apalachicola River spawning periods overlap. During the fish spawning period for each waterbody (Table 1.3-2), the USACE's goal is to operate for a generally stable or rising lake level and a generally stable or gradually declining river stage on the Apalachicola River for approximately 4 to 6 weeks during the designated spawning period. When climatic conditions preclude a favorable operation for fish spawn, the USACE consults with the state fishery agencies and the USFWS on balancing needs in the system and minimizing the effects of fluctuating lake or river levels. USACE South Atlantic Division Regulation (DR) 1130-2-16 (March 30, 2001) and Mobile District Draft Standard Operating Procedure (SOP) 1130-2-9 (February 2005) were developed to address reservoir regulation and coordination for fish management purposes. South Atlantic DR 1130-2-16 has been updated and renumbered as South Atlantic DR PDS-O-1 (May 31, 2010), *Project Operations, Lake Regulation and Coordination for Fish Management Purposes.* It specifically applies to operations at Lake Lanier, West Point Lake, Walter F. George Lake, and Lake Seminole in the ACF Basin as well as other reservoirs in the USACE South Atlantic Division. Under the NAA, it is assumed that the fish spawn operations would remain in effect unchanged.

Table 1.3-2. Specific principal fish spawning period

	Fish spawn period
Lake Lanier	April 1–June 1
West Point Lake	April 1–June 1
Walter F. George Lake	March 15–May 15
Lake Seminole	March 1–May 1
Apalachicola River	April 1–June 1

1.3.4.4.2 Fish Passage

Most springs (since 2005) from March through May, the USACE has operated the lock at Jim Woodruff Dam to facilitate downstream to upstream passage of Alabama shad and other anadromous fishes (those that return from the sea to the rivers where they were born to breed). There are slight differences in the locking technique each year. However, in general two fish locking cycles are performed each day between 8 a.m. and 4 p.m.; one in the morning and one in the afternoon. The operation consists of opening the lower lock gates and getting fish into the lock in one of three ways—by transporting them into the lock by boat (2005), using attraction flows to entice the fish into the lock (2006–2007), by leaving the lower gate open for a period before a lockage and allowing the fish to move in without an attraction flow (2008), in 2009 no lockages were done, and attraction flows were used again in 2010 - 2012. Once the fish are in the lock (or assumed to be in the lock), the downstream doors are closed. The lock is filled to the reservoir elevation and the upper gates are opened. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change. Under the NAA, it is assumed that the current fish passage operation would remain in effect unchanged.

1.3.4.4.3 Endangered Species Conservation - Revised Interim Operations Plan

In addition to fish spawn management and fish passage operations, the USACE manages releases from Jim Woodruff Dam to support the federally protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. That operation is governed by a set of minimum flow and maximum fall rate provisions called the Revised Interim Operations Plan (RIOP) resulting from formal consultation concluded in May 2012 with USFWS issuance of a new Biological Opinion for Jim Woodruff Lock and Dam.

The May 2012 RIOP is governed by two basic parameters applicable to daily releases from Jim Woodruff Dam: a minimum discharge in relation to average basin inflows (measured as daily average in cfs) and a maximum fall rate (vertical drop in river stage [ft/day]). The 2012 RIOP places limitations on refill, but it does not require a net drawdown of composite conservation storage (discussed in more detail below) unless basin inflow is less than 5,000 cfs.

Minimum Discharge. The RIOP varies minimum discharges from Jim Woodruff Dam by basin inflow and by month, and the releases are measured as a daily average flow in cfs at the Chattahoochee gage. Table 1.3-3 shows minimum releases from Jim Woodruff Dam prescribed by the RIOP and shows when and how much basin inflow is available for increasing reservoir storage. Except when basin inflow is less than 5,000 cfs, the minimum releases are not required to exceed basin inflow. The RIOP defines additional basin inflow threshold levels that vary by three seasons: spawning season (March–May); non-spawning season (June–November); and winter (December–February). The RIOP incorporates composite conservation storage thresholds that factor into minimum release decisions. Composite conservation storage is calculated by combining the conservation storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Conservation storage in each of the individual reservoirs consists of four zones, which are determined by the operational guide curve for each project. The composite conservation storage uses the four-zone concept as well (i.e., Zone 1 of the composite conservation storage represents the combined storage available in Zone 1 for each of the three storage reservoirs). Figure 1.3-4 illustrates the ac-ft of storage available for Composite Zones 1 through 4 throughout the year.

Table 1.3-3. May 2012 RIOP for Jim Woodruff Dam, Apalachicola River minimum discharge from Woodruff Dam by month and by basin inflow (BI) rates

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from Jim Woodruff Lock and Dam (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000	≥ 25,000	Up to 100% BI>25,000
		≥ 16,000 and < 34,000	≥ 16,000+50% BI > 16,000	Up to 50% BI>16,000
		≥ 5,000 and < 16,000	≥ BI	
		< 5,000	≥ 5,000	
	Zone 3	≥ 39,000	≥ 25,000	Up to 100% BI>25,000
		≥ 11,000 and < 39,000	≥ 11,000+50% BI > 11,000	Up to 50% BI>11,000
		≥ 5,000 and < 11,000	≥ BI	
		< 5,000	≥ 5,000	
June–November	Zones 1,2, and 3	≥ 22,000	≥ 16,000	Up to 100% BI>16,000
		≥ 10,000 and < 22,000	≥ 10,000+50% BI > 8,000	Up to 50% BI>10,000
		≥ 5,000 and < 10,000	≥ BI	
		< 5,000	≥ 5,000	
December–February	Zones 1,2, and 3	≥ 5,000	≥ 5,000 (Store all BI> 5,000)	Up to 100% BI > 5,000
		< 5,000	≥ 5,000	
At all times	Zone 4	NA	≥ 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	≥ 4,500[b]	Up to 100% BI > 4,500

Source: USACE, Mobile District 2012; USFWS 2012.

a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

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

The 2012 RIOP operations and thresholds from March through May are intended to support Gulf sturgeon spawning activities. The 16,000 cfs minimum release is also based on evaluation of spawning and rearing needs for the host fish necessary for mussel reproduction. The RIOP operations from June through February are intended to support the federally protected mussels, host fish for mussels, and young sturgeon.

During spawning season, two sets of four basin-inflow thresholds and corresponding releases exist according to the composite conservation storage (Figure 1.3-4). When the composite conservation storage is in Zones 1 and 2, a less conservative operation is in place. When the composite conservation storage is in Zone 3, a more conservative operation is in place while still avoiding or minimizing impacts on federally listed species and designated critical habitat in the river. When the composite conservation storage falls below the bottom of Zone 3 into Zone 4, the drought contingency operations are *triggered*. Drought contingency operations are summarized below.

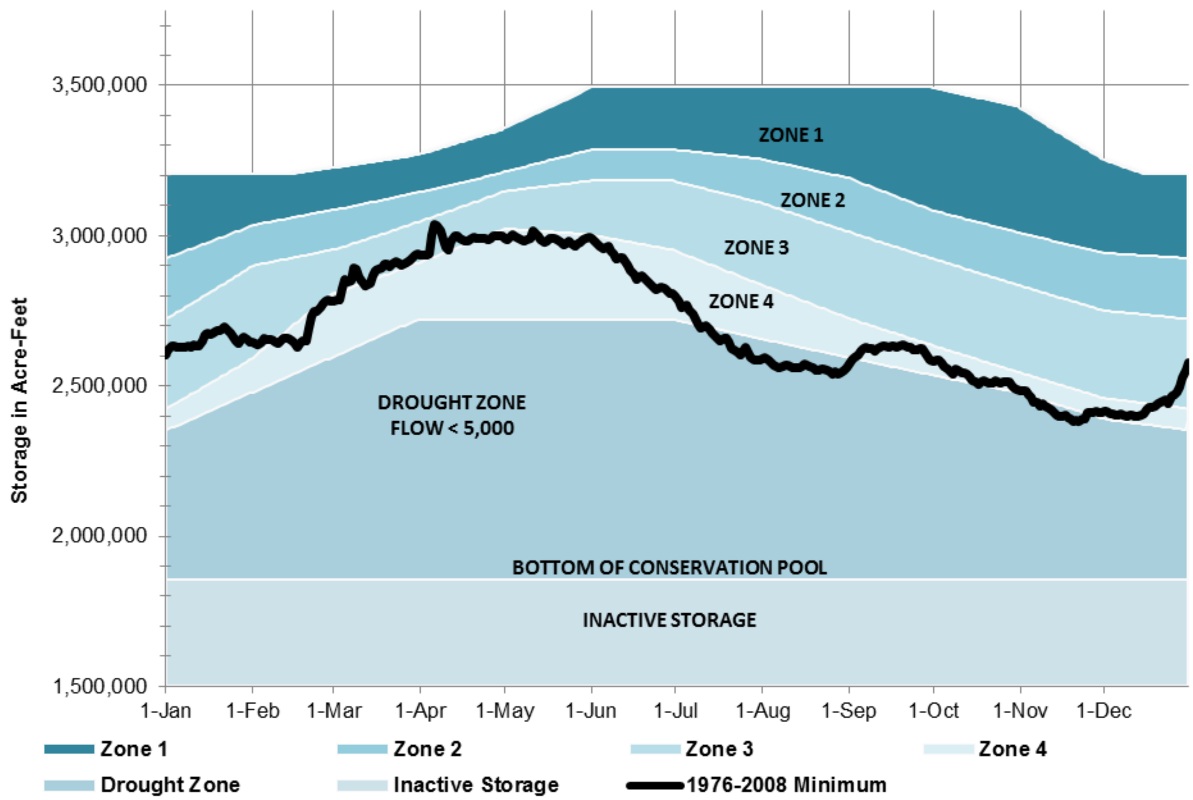


Figure 1.3-4. Basin composite conservation storage and associated action zones (in ac-ft).

During spawning season (March through May), the composite conservation storage is monitored daily to determine water management operations. Recently experienced climatic and hydrologic conditions and meteorological forecasts are used in addition to composite conservation storage values when determining the appropriate basin inflow thresholds in support of water management operations.

During non-spawning season (June through November), one set of four basin inflow thresholds and corresponding releases exists according to composite conservation storage in Zones 1 through 3. When composite conservation storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are triggered.

During the winter season (December through February), there is only one basin inflow threshold and corresponding minimum release (5,000 cfs) while in composite conservation storage Zones 1 through 3. There are no basin inflow storage restrictions as long as this minimum flow is met under these conditions. When composite conservation storage falls below the bottom of Zone 3 into Zone 4, drought contingency operations are triggered.

The flow rates included in Table 1.3-3 prescribe minimum, not target, releases for Jim Woodruff Dam. During a given month and basin inflow rate, releases greater than the minimum releases in Table 1.3-3 may occur consistent with the maximum fall rate schedule, described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

Maximum Fall Rate. The fall rate, also called the down-ramping rate, is the vertical drop in river stage (water surface elevation) that occurs over a given period. Fall rates are expressed in units of feet per day (ft/day), and they are measured at the Chattahoochee, Florida U.S. Geological Survey (USGS) gage as the difference between the daily average river stage for consecutive calendar days. Rise rates are not addressed. Table 1.3-4 lists the maximum fall rates. The maximum fall rate schedule is suspended when composite conservation storage is in Zone 4 and the drought contingency operation is implemented. Unless otherwise noted, fall rates under the drought contingency operation would be managed to match the fall rate of the basin inflow.

Table 1.3-4. May 2012 RIOP for Jim Woodruff Dam: Apalachicola River maximum fall rate for discharge from Woodruff Dam by release range for composite conservation storage Zones 1, 2, and 3 [a,b]

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 [a]	Fall rate is not limited [c,d]
> 20,000 and ≤ 30,000 [b]	1.0 to 2.0 [d]
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [b]	0.5 to 1.0 [d]
Within Powerhouse Capacity and > 10,000 [b]	0.25 to 0.5
Within Powerhouse Capacity and ≤ 10,000 [b]	0.25 or less

Source: USACE, Mobile District 2012; USFWS 2012

a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

b. The maximum fall rate schedule is suspended in Composite Zone 4.

c. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down-ramping rate, and no ramping rate is required.

d. Maximum fall rates must be less than 8 ft in a consecutive 14-day period when flows are less than 40,000 cfs in March, April, and May in order to avoid take of Gulf sturgeon eggs and larvae.

During the Gulf sturgeon spawning period (March - May), the USACE will make releases from Jim Woodruff Dam to ensure that river stage declines of 8 feet or more will not occur in less than 14 days when river flows are less than 40,000 cfs (under both normal and drought operations).

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

The drought plan prescribes two minimum releases on the basis of composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone (Figure 1.3-4). The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point, and Walter F. George, plus Zone 4 storage in Lake Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored.

Once the composite conservation storage falls into the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates are limited to a

0.25 ft/day drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is reinstated. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1). At that time, the temporary drought plan provisions are suspended, and all the other provisions are reinstated. During drought contingency operations, a monthly monitoring plan that tracks composite conservation storage to determine water management operations (the first day of each month represents a decision point) is implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts are used when determining the set of operations in the upcoming month.

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

1.3.4.5 Recreation

All the USACE lakes have become important recreational resources on the ACF Basin. A wide variety of recreational opportunities are provided at the lakes including boating, fishing, picnicking, sightseeing, water skiing, and camping. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 1.3-5).

Table 1.3-5. Water levels affecting USACE project recreation

USACE project	Initial impact level (IIL) (ft NGVD)	Recreation impact level (RIL) (ft NGVD)	Water Access Limited Level (WAL) (ft NGVD)
Lake Lanier	1,066	1,063	1060
West Pont Lake	632.5	629	627
Walter F. George Lake	187	185	184
Lake Seminole	76	NA	NA

To maximize the potential recreational use of all the projects, the USACE operates the reservoirs in the ACF Basin as a system, keeping the drawdown levels and rates balanced among the reservoirs. The USACE gives those considerations greater attention during the primary recreation season of May through early September. Reservoirs are managed to maintain a steady pool at as high a level as possible, consistent with other authorized purposes, particularly during the primary recreation season. To sustain reasonable access to the reservoir during periods of declining inflows to the reservoirs, drawdowns are performed at as steady a rate as possible. There may be times during drought conditions when water releases are reduced to levels that satisfy only downstream water supply/water quality requirements. This conservation of storage generally allows the pools to be maintained at a higher level throughout the prime recreation season.

As other ACF water management objectives are addressed, lake levels might decline during prime recreation periods. Large reservoir drawdowns impact recreational use: access to the water for boaters and swimmers is inhibited; submerged hazards (e.g., trees, shoals, boulders) become exposed or nearly exposed, posing safety issues; and exposed banks and reservoir bottoms become unsightly and diminish the recreation experience. Consequently, for Lake Lanier, West Point Lake, and Walter F. George Lake, certain levels were identified in each impoundment at which recreation activities would be affected (Table 1.3-5). The *Initial Impact level* (IIL) represents the level at which recreation impacts are first observed (i.e., some boat launching ramps are unusable, most beaches are unusable or minimally usable, and navigation hazards begin to surface). The *Recreation Impact level* (RIL) defines the level at which major impacts on concessionaires and recreation are observed (more ramps are not usable, all beaches are unusable, boats begin having problems maneuvering in and out of marina basin areas, loss of retail business occurs). The level at which severe impacts are observed in all aspects of recreational activities is called the *Water Access Limited level* (WAL). At this point, all or almost all boat ramps are out of service, all swimming beaches are unusable, major navigation hazards occur, channels to marinas are impassable and/or wet slips must be relocated, and a majority of private boat docks are unusable. The NAA assumed that recreation operations would remain in effect unchanged.

1.3.4.6 Water Quality

Buford Dam, West Point Dam, and Jim Woodruff Lock and Dam all provide continuous minimum releases which, in addition to meeting other project purposes and providing associated benefits, also benefits downstream water quality. Walter F. George Lock and Dam and George W. Andrews Lock and Dam have no specific minimum flow provisions.

At Buford Dam, the small turbine is operated continuously to provide a minimum flow from the dam of approximately 600 cfs. When it is necessary to have the unit out of service, the releases are made through the sluice. Under agreements with Georgia, discharges from Buford Dam, when considered in combination with the contribution of local drainage between the dam and the city of Atlanta and reregulation by GPC's Morgan Falls Dam, are to be sufficient to provide a minimum flow rate of 750 cfs at Peachtree Creek. Reregulation of streamflows at Morgan Falls Dam to provide that required flow is often not possible without weekend releases at Buford Dam.

During periods of reservoir stratification and reservoir turnover (destratification) in the fall, releases from Buford Dam hydroelectric units or sluice gates can contain high concentrations of metals, such as iron and manganese, which can cause toxicity problems at the Buford Trout Hatchery, 2 mi downstream of the dam. The release water during summer and fall is also low in dissolved oxygen (DO) except during periods of peaking generation. Self-aspirating turbines were installed at Buford Dam in 2005 to improve DO levels downstream. However, minimal benefits to downstream DO have been recorded since installation. The hatchery has also installed a water treatment system, but there still may be an occasional need for emergency releases of water from Lake Lanier for water quality purposes.

At West Point Dam, a small generating unit provides a continuous release of about 675 cfs. This flow provides low flow augmentation to benefit water quality and public health. As with Buford Dam, the release waters during reservoir stratification are low in DO concentration during minimum release periods.

Even though there are no specific continuous minimum flow requirements below Walter F. George Lock and Dam, the USACE has an established SOP to address conditions when low DO values are observed below the dam (USACE, Mobile District 1993a).

Because of the shallowness of the reservoir and the relative amount of storage when compared to inflow, Lake Seminole and George W. Andrews Lake do not stratify and water quality downstream of the dam does not fluctuate to the same degree as at other reservoirs in the basin. However, minimum releases of at least 5,000 cfs are maintained from Jim Woodruff Dam (except under extreme drought conditions). Those minimum flows are needed to meet environmental flow requirements for endangered species conservation, but as a by-product they also meet the water supply and waste assimilation needs of downstream industrial users.

While operating to serve other federally authorized purposes, USACE reservoirs in the ACF Basin provide downstream flow conditions that collaterally support waste assimilation needs of numerous municipal and industrial (M&I) wastewater dischargers in the basin. That collateral benefit of project operations is particularly valuable during annual low flow (summer/fall) periods and extended drought periods. The NAA assumed that the current water quality operations would remain in effect unchanged.

1.3.4.7 Water Supply

Various M&I entities withdraw water directly from Lake Lanier, and others withdraw directly from the Chattahoochee River downstream of Lake Lanier. Reservoir operations are also influenced by agricultural water withdrawals on the Flint River. Agricultural demands vary depending on the climatic conditions but are generally 1.5 to 2 times the withdrawals for M&I (USFWS 2006). Water withdrawals in Georgia are made pursuant to water withdrawal permits issued by the Georgia Department of Natural Resources. Previous water supply contracts issued by the USACE for withdrawals from Lake Lanier expired in 1990 and have not been reissued. The Water Supply Act of 1958 provides authority for reallocation or addition of storage in USACE reservoirs for water supply, with the cost of storage and associated facilities to be reimbursed by a non-USACE entity via water storage agreements; no storage in projects in the ACF Basin is allocated to water supply.

Water management for the water supply/water quality function involves taking water from storage, either directly from the reservoir or through dam releases for downstream interests. Such operations ensure that sufficient drinking water is available for M&I needs and agreements to provide in-stream flow for water quality are not violated. Releases from projects in the system will be the minimum (capacity) release for hydroelectric power or releases needed for basin-wide water supply/water quality, whichever is greater. The water supply users withdrawing water directly from Lake Lanier and their 2007 withdrawal amounts total approximately 128 mgd, as follows:

- Gwinnett County—88.19 mgd
- City of Gainesville—18.75 mgd (Includes net withdrawal of 8.0 mgd authorized by their relocation contract[1].)
- City of Cumming—20.07 mgd (Includes water furnished to Forsyth County, GA.)
- City of Buford—1.47 mgd (2.0 mgd authorized by their relocation contract)

In general, Lake Lanier weekly water supply/quality release decisions are based on the Chattahoochee River Management System (as recorded in the *Apalachicola Basin Reservoir Regulation Manual*, Appendix B, February 1991 [USACE, Mobile District 1991]). Under the management system, in coordination with the Atlanta Regional Commission and Georgia Power Company, the USACE determines weekly the daily amounts of water to release from Buford Dam to accommodate the anticipated downstream river withdrawals for M&I water supply by DeKalb County, City of Atlanta, Cobb County/Marietta Water Authority, and Fulton County, and to assure water quality at the confluence of the Chattahoochee River and Peachtree Creek. Such a weekly schedule of Buford Dam water releases is to ensure that sufficient water is available for Chattahoochee River water supply withdrawals, water quality flows at Peachtree Creek, hydroelectric power generation and fish and wildlife conservation needs. During the winter and spring, releases from Lanier can be reduced because of sufficient downstream tributary flows to meet the GAEPD's target water quality flow at Peachtree Creek. To the extent possible, the releases are in conjunction with peaking power operations and minimize effects on hydroelectric power generation. In 2007, downstream withdrawals averaged 277 mgd.

The NAA assumed that releases from Buford Dam would continue to be made to provide for the current need of 277 mgd for downstream withdrawals by metro Atlanta water providers and current withdrawals

[1] As part of the compensation for the municipal property acquired for the Buford Dam project and under the resulting relocation contracts terms, each city was granted the right to withdraw, free of charge, specified amounts of water from the reservoir. It was agreed that Buford could withdraw 2.0 mgd and Gainesville 8.0 mgd. Presently Gainesville withdraws approximately 18 mgd and returns approximately 10 mgd resulting in a net withdrawal of 8 mgd. The total gross withdrawal under relocation contracts is 20 mgd.

from Lake Lanier amounting to 128 mgd, including 20 mgd for the relocation contracts, would continue. Additionally, it is assumed that the withdrawals from West Point Lake for the relocation contract would continue.

1.4 Proposed Action Alternative

Under the PAA, the USACE would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes. In light of the July 2011 Eleventh Circuit Court of Appeals ruling, USACE is considering, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013 requested from Lake Lanier and downstream at Atlanta. The following sections identify key elements of the PAA that differ from the NAA.

1.4.1 Action Zones

Under the PAA, the USACE would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The proposed modifications are shown in Figure 1.4-1, Figure 1.4-2, and Figure 1.4-3. At Lake Lanier, Zones 1, 2 and 3 were expanded to reflect proportionality of contributing watershed size and historic operations to meet system demands. The action zones reflected by Figure 1.4-1 achieve a more equitable balance between action zone sizing based on the project's watershed size and because they provide a proportionately balanced drawdown among the projects when operating in Zone 1. In refining the action zones, generally they were revised upward in the winter months at Lake Lanier and at West Point Lake and downward in the summer months at Walter F. George Lake, as reflected in Figure 1.4-1, Figure 1.4-2, and Figure 1.4-3, respectively.

The following definitions apply to the revised action zones:

- Zone 1: Indicates that releases can be made in support of a navigation season (January–April or May), hydroelectric power releases, water supply, and water quality releases. If all the lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
- Zone 2: Indicates that releases can be made in support of a navigation season (January - April or May). Hydroelectric power generation is supported at the same or a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 3: Navigation is not supported. Hydroelectric power generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 4: Navigation is not supported. Hydroelectric power demands will be met at a minimum level and might occur only for concurrent uses. Water supply and water quality releases are met. Minimum flow targets are met.

The revised action zones were developed to better:

1. Facilitate refill of each reservoir.
2. Minimize low-water recreational impacts and hazard levels.
3. Balance system storage throughout the basin.
4. Enhance ability to balance refill relative to watershed and hydrology.
5. Achieve proportional drawdown in each reservoir.

Changes in the Lake Lanier action zones are proposed to facilitate refill and storage of water relative to the watershed size. By increasing Zone 4 to 1,060 ft in January, there will be more water in the reservoir when drought operations go in to effect. This operational change allows for more water storage to balance water management throughout the ACF Basin.

The zones were derived on the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects.

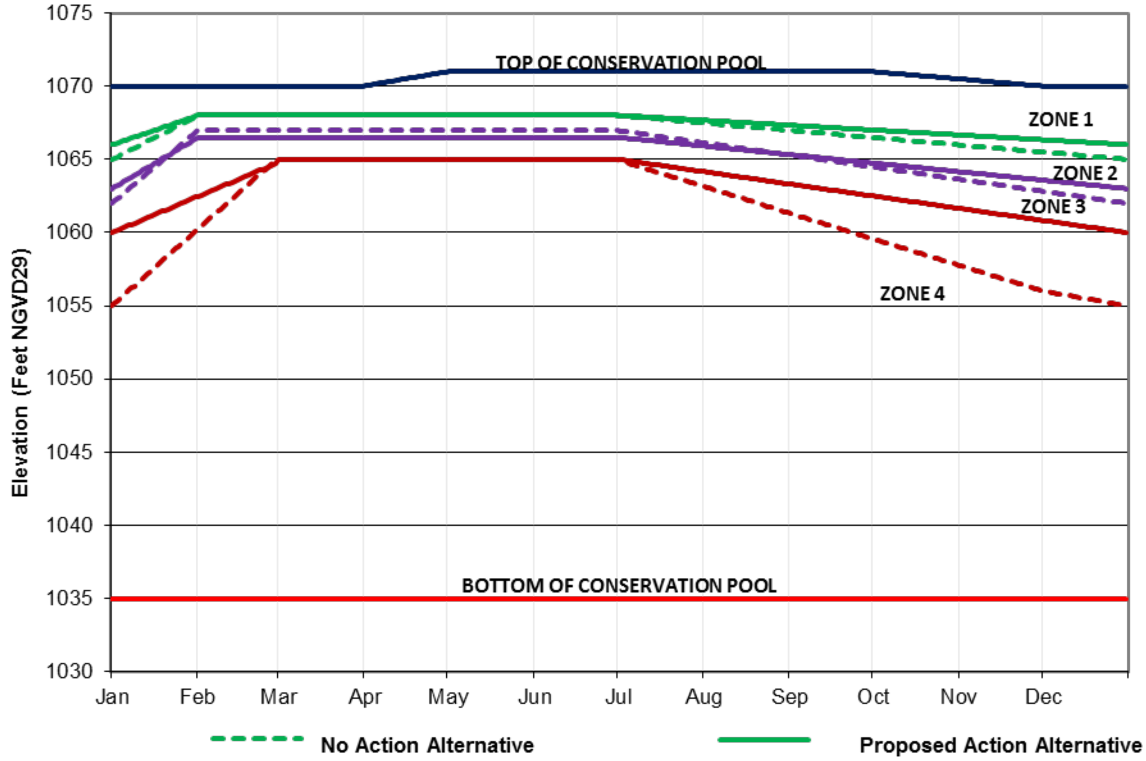


Figure 1.4-1. Lake Lanier water control action zones

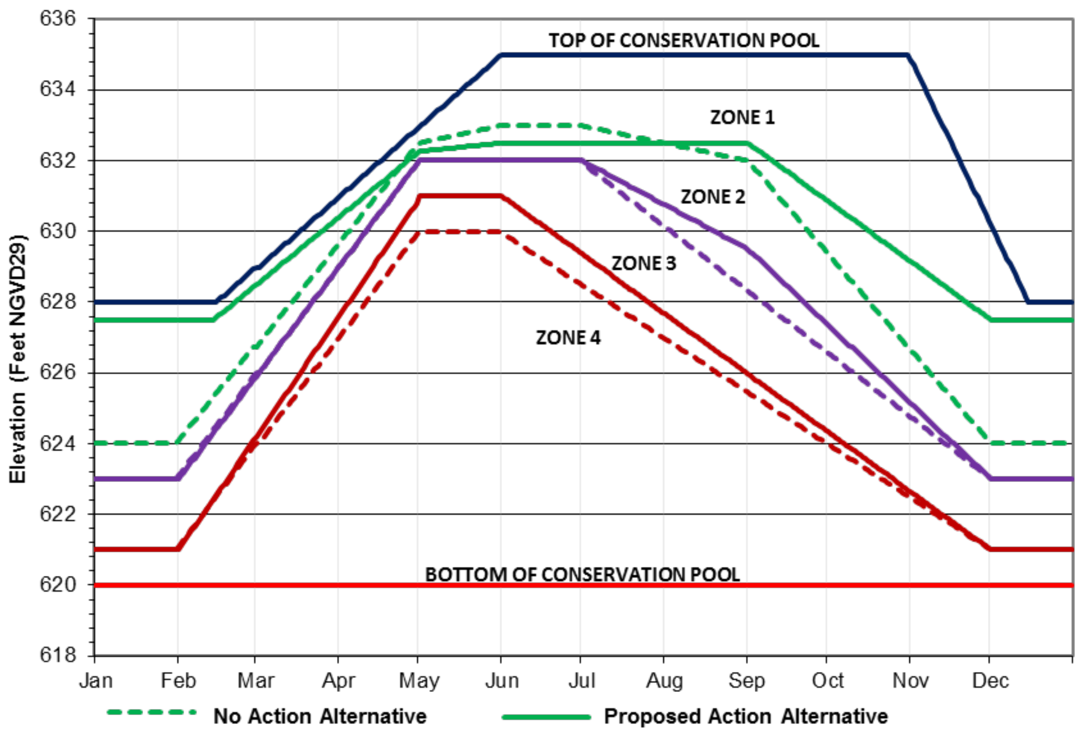


Figure 1.4-2. West Point Lake water control action zones

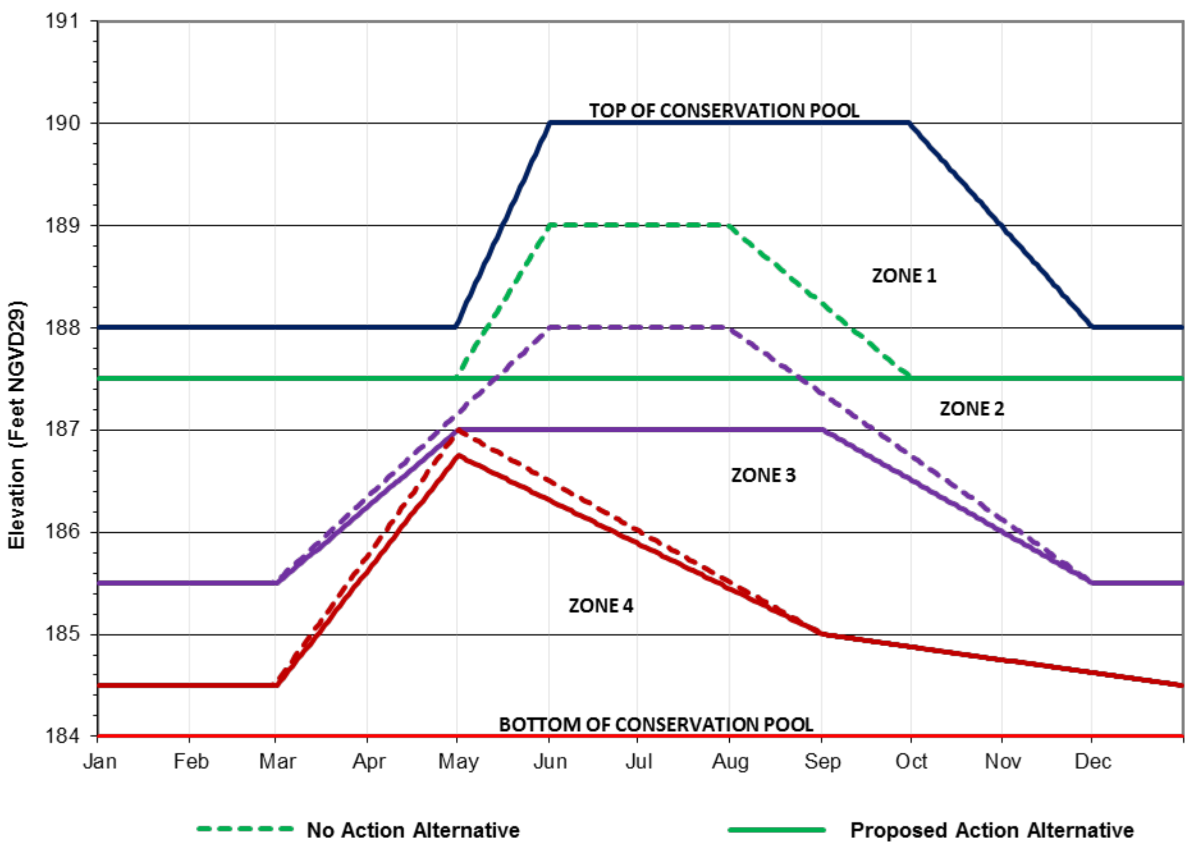


Figure 1.4-3. Walter F. George Lake water control action zones

Changes to action zones in the Walter F. George Lake allow use of more available storage in the reservoir to achieve proportional drawdown and balance system storage. Decreasing Zone 2 to 187.5 from May through October and Zone 3 from 188 ft to 187 ft from March through December allows for more storage water to be released downstream during critical low flow periods.

1.4.1.1 Drought Operations

The proposed drought plan is similar to the NAA drought plan and incorporates the drought provisions of the May 2012 RIOP which specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite conservation storage (Table 1.4.1 and Figure 1.4-4) within the basin is replenished to a level that can support them. Under the drought plan the minimum discharge is determined in relation to composite conservation storage and not average basin inflow. Drought operations are “triggered” on the first day of the month when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3 in the PAA (Figure 1.4-4). At that time all the composite conservation storage Zone 1-2 provisions (seasonal storage limitations, maximum fall rate schedule, and minimum flow thresholds) are suspended and management decisions are based on the provisions of the drought plan. Under the drought plan, the Jim Woodruff Dam minimum discharge is determined in relation to composite conservation storage only. The drought plan includes a temporary waiver from the existing water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects if the opportunity presents itself and/or begin spring refill operations at an earlier date in order to provide additional conservation storage for future needs as well as provide for a minimum releases less than 5,000 cfs from Jim Woodruff Dam.

Table 1.4.1 Proposed Drought Operation for Jim Woodruff Dam, Apalachicola River minimum discharge from Woodruff Dam by month and by basin inflow (BI) rate. (No change from No Action)

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from Jim Woodruff Lock and Dam (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000	≥ 25,000	Up to 100% BI>25,000
		≥ 16,000 and < 34,000	≥ 16,000+50% BI > 16,000	Up to 50% BI>16,000
		≥ 5,000 and < 16,000	≥ BI	
		< 5,000	≥ 5,000	
	Zone 3	≥ 39,000	≥ 25,000	Up to 100% BI>25,000
		≥ 11,000 and < 39,000	≥ 11,000+50% BI > 11,000	Up to 50% BI>11,000
		≥ 5,000 and < 11,000	≥ BI	
		< 5,000	≥ 5,000	
June–November	Zones 1,2, and 3	≥ 22,000	≥ 16,000	Up to 100% BI>16,000
		≥ 10,000 and < 22,000	≥ 10,000+50% BI > 8,000	Up to 50% BI>10,000
		≥ 5,000 and < 10,000	≥ BI	
		< 5,000	≥ 5,000	
December–February	Zones 1,2, and 3	≥ 5,000	≥ 5,000 (Store all BI> 5,000)	Up to 100% BI > 5,000
		< 5,000	≥ 5,000	
At all times	Zone 4	NA	≥ 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	≥ 4,500[b]	Up to 100% BI > 4,500

The drought plan prescribes two minimum releases from Jim Woodruff Dam based on composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone, Figure 1.4-4. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point and Walter F. George plus Zone 4 storage in Lake Lanier; however, the Drought Zone line has been adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates will be limited to a 0.25 ft/day drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is re-instated. The drought plan provisions of the PAA remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1). If recovery conditions are achieved in February, drought plan provisions will not be suspended until March, provided composite conservation storage remains above Zone 4. At that time, the temporary drought plan provisions are suspended, and all the other provisions are re-instated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) will be implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts will be used when determining the set of operations to utilize in the upcoming month.

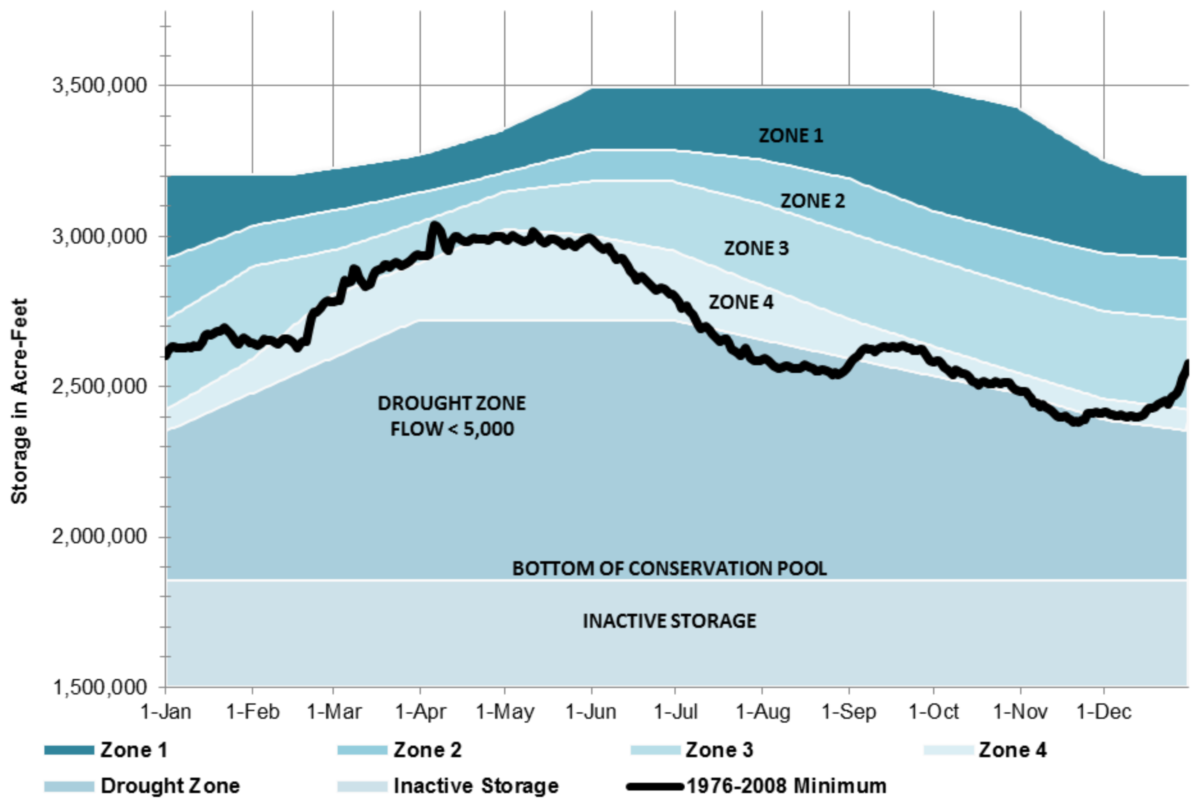


Figure 1.4-4. Basin composite conservation storage and associated action zones (in ac-ft).

1.4.1.2 Flood Risk Management

No changes to the flood risk management operations described in the NAA are proposed. When developing the PAA, flood risk management capabilities and capacities of reservoirs were not reduced.

1.4.1.3 Hydroelectric Power

Under the PAA, USACE would operate Buford Dam, West Point Dam, Walter F. George Dam, and Jim Woodruff Dam for hydroelectric power generation, but the amount of generation would vary by action zone. Conservation storage at Lake Lanier is much more sensitive to hydroelectric power generation operations because of the small drainage area above Buford Dam from which to refill the reservoir, particularly under drought conditions. The proposed generation schedule at Lake Lanier would provide greater operational flexibility to meet power demands in the system while conserving storage as variable climate conditions might dictate.

Under the PAA, when Lake Lanier is in Zone 1 or 2 during non-drought conditions, generation would typically be in the hourly ranges shown in the table below. Similarly, during drought operations as described above, generation would typically be reduced to that depicted in Table 1.4.2.

Table 1.4-2. Typical hours of peaking hydroelectric power generation by USACE project

Action zone	Buford Dam (hours of operation)	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	0–4	0-4	0-4
Zone 2	0–4	0-2	0-2
Zone 3	0–2	0-2	0-2
Zone 4	0–2	0	0

1.4.1.4 Navigation

Under the PAA, when supported by ACF Basin hydrologic conditions, USACE will provide a reliable navigation season. The water management objective is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period of time that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). During the navigation season the flows at the Blountstown, Florida, USGS gage (USGS 02358700) should be adequate to provide at least a 7 ft channel. The most recent channel survey and discharge-stage rating was used to determine the flow required to sustain a minimum navigation depth during the navigation season. The USACE's capacity to support a navigation season will be dependent upon actual and projected system-wide conditions in the ACF Basin prior to and during the months of January, February, March, April and May (Figure 1.4-5). These conditions include, but are not limited to:

1. A navigation season can only be supported when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
2. A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Provided drought operations have not been triggered, navigation support will resume when basin composite conservation storage level recovers to Zone 2 and is forecast to remain above Zone 3 for a practicable, continuous period of time.
3. A navigation season will not be supported when drought operations are in effect. Navigation will not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1.
4. The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. Based on an analysis of these factors, the Corps will determine if the navigation season will continue through part or all of May.
5. Down ramping of flow releases (regardless of period in the navigation season) will adhere to the Jim Woodruff Dam fall rate schedule (Table 1.3-4) for federally listed species.
6. Releases that augment the flows to provide for the 7-ft navigation channel will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, due to diminishing inflows, downstream flows and depths must be reduced, navigation bulletins will be issued to project users. These notices will be issued as expeditiously as possible in order to give barge owners, and other waterway user's, sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Dam to reduce releases.

Though special releases will not be standard practice, they may occur for a short duration to assist navigation during the navigation season (Figure 1.4-5). For instance, releases may be requested to achieve up to a 9-ft channel. These shall be evaluated on a case by case basis, subject to applicable laws and regulations and the conditions above.

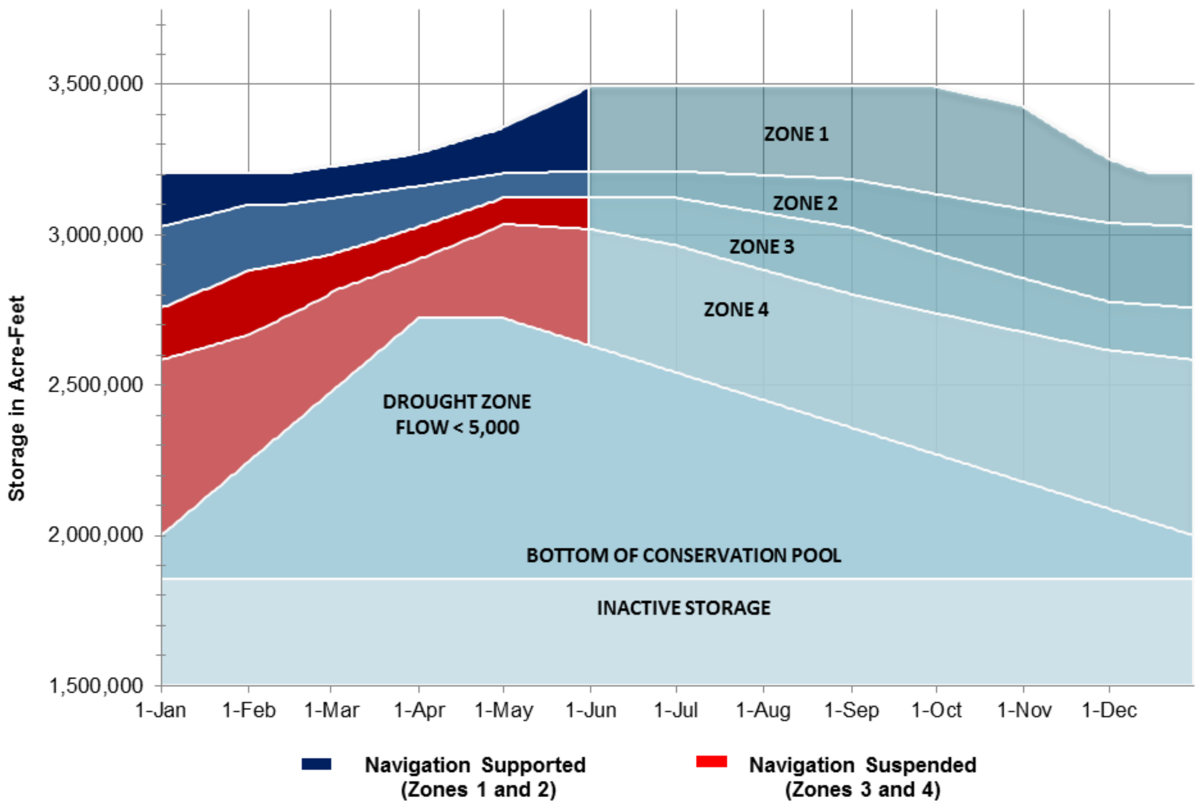


Figure 1.4-5. Composite conservation storage for navigation

1.4.1.5 Fish and Wildlife Conservation

Under the PAA, there are no changes to fish spawn or fish passage operations described in the NAA.

Federally Listed Species - Under the PAA, the USACE would continue to make releases for threatened and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows in accordance with the May 2012 RIOP described previously under the NAA and the PAA for Drought Operations (Table 1.4.1), but with one modification, suspending the ramping rate during prolonged low flow. When Basin Inflow (BI) has been less than 7,000 cfs for 30 days the use of the ramping rate will be suspended and will be resumed when BI has been greater than 10,000 for 30 days. The PAA ramping rate is shown in Table 1.4.3. Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above.

Table 1.4.3 Proposed Apalachicola River maximum fall rate for discharge from Woodruff Dam by release range for composite conservation storage Zones 1, 2, and 3 [a,b]

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 [a]	Fall rate is not limited [c,d]
> 20,000 and ≤ 30,000 [b]	1.0 to 2.0 [d]
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [b]	0.5 to 1.0 [d]
Within Powerhouse Capacity and > 10,000 [b]	0.25 to 0.5
Within Powerhouse Capacity and ≤ 10,000 [b]	0.25 or less[e]

Source: USACE, Mobile District 2012; USFWS 2012

a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

b. The maximum fall rate schedule is suspended in Composite Zone 4.

c. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down-ramping rate, and no ramping rate is required.

d. Maximum fall rates must be less than 8 ft in a consecutive 14-day period when flows are less than 40,000 cfs in March, April, and May in order to avoid take of Gulf sturgeon eggs and larvae.

e. Fall rate suspended when basin inflow <7,000 cfs for 30 days and resumed when >10,000 cfs for 30 days.

1.4.1.6 Recreation

The PAA has no changes to operations in support of recreation from those described in the NAA.

1.4.1.7 Water Quality

Under the PAA, releases from Buford Dam would be made sufficient to provide a minimum flow rate of 750 cfs at Peachtree Creek from May through October and 650 cfs from November through April. Under agreements with Georgia, discharges from Buford Dam, when considered in combination with the contribution of local drainage between the dam and the city of Atlanta and reregulation by GPC's Morgan Falls Dam, are to be sufficient to provide a minimum flow rate at Peachtree Creek of 750 cfs (May through October) and 650 (November through April).

No changes are proposed for releases through the house unit at West Point Dam.

1.4.1.8 Water Supply

Under the PAA, the Corps would continue to accommodate net withdrawals of 8 mgd by the City of Gainesville, and withdrawals of 2 mgd by the City of Buford, from Lake Lanier under relocation agreements. In addition, under the authority of the Water Supply Act of 1958, the Corps would reallocate 189,500 acre-feet of storage in Lake Lanier to accommodate a portion (165) mgd of Georgia's 2040 water supply need. The PAA assumes that an additional 40 mgd would be withdrawn from the yet-to-be constructed Glades Reservoir to meet that future need. Finally, under the authority of the 1946 River and Harbor Act, the Corps would make releases from Buford Dam to provide for water supply withdrawals of up to 408 mgd from the Chattahoochee River downstream at Atlanta by 2040.All other water supply operations in the ACF Basin described in the NAA would remain the same.

2 RESPONSE TO PLANNING AID LETTERS

The USFWS provided Planning Aid Letters (PAL) dated April 1, 2010; March 1, 2011; and August 29, 2013. The 2010 PAL recommended analyses using Indicators of Hydrologic Alteration. This approach was superseded by recommendations in the 2011 PAL Addendum which provided revised high and low flow guidelines to be used instead of the IHA. The 2013 PAL provided additional performance metrics to be used to compare the relative effects of the NAA and PAA.

In response to the 2011 Eleventh Circuit Court ruling, USACE developed eight alternatives comprised of either the existing water management plan (Water Management No Action Alternative) or the Water Management Proposed Action Alternative together with some quantity of water withdrawn from Lake Lanier and a release from Buford Dam to satisfy either existing or future (2040) water needs for metro Atlanta. In figures shown in subsequent sections, the results of several alternatives are shown on the same figure. The NAA is identified as No Action or Alt1A and the PAA is identified as Proposed Action or Alt7H.

The responses below are keyed to specific performance metrics or issues raised in the 2010 PAL and later added, amended, or augmented by the 2011 and 2013 PALs.

2.1 ResSim Model Output Analyses

As requested, the revised ecosystem guidelines provided by the 2011 PAL Addendum were used in the development of the analysis of the environmental consequences of the PAA. This analysis was woven into various sections of water and biological resources analyses.

2.2 HEC-5Q Water Quality Model Output Analyses

The HEC-5Q modeled output was processed to illustrate variations between the PAA and NAA for the ACF Basin. The modeled results were compared longitudinally down the Chattahoochee River of the ACF Basin and as time series in select locations. Longitudinal plots, or system profiles, were initially examined to understand the most critical locations for water quality related to various parameters. Following an evaluation of the range of longitudinal modeled results, specific locations were selected where the range of modeled output was the greatest. The time series of modeled results were plotted at specific locations to illustrate the seasonal response of pollutants.

Model results were output in six-hour time intervals in the river and reservoirs. The results presented below were analyzed at various seasonal intervals; generally, May through October for dissolved oxygen (DO) and April through October for nutrients (total phosphorus, total nitrogen, and chlorophyll *a*). All model results were reviewed annually, seasonally, and based on dry, normal, and wet years for each alternative. Dry and wet years were defined by the driest 25th percentile (1 in 4 yr) and the wettest 25th percentile (1 in 4 yr). The following plots can be used to address questions presented in the 2010 PAL by parameter. Note that the longitudinal figures present the percent occurrence of modeled output; the opposite of the percent exceedance. It was recommended that percent exceedance may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality. In the following figures the PAA is labeled as Alt7H.

2.2.1 Dissolved Oxygen

a. Total number of days with DO below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters.

Figure 2.2-1and Figure 2.2-2 present the variations of DO modeled along the Chattahoochee River. These results do not explicitly define the number of days when concentrations are less than state standards (6 mg/L for secondary trout waters and 5 mg/L) but they do provide insight to where low DO concentrations occur for the period from May through October. Figure 2.2-3 through Figure 2.2-6 present DO occurrence plots at Norcross, Georgia and Morgan Falls Dam. These locations are within the secondary trout waters.

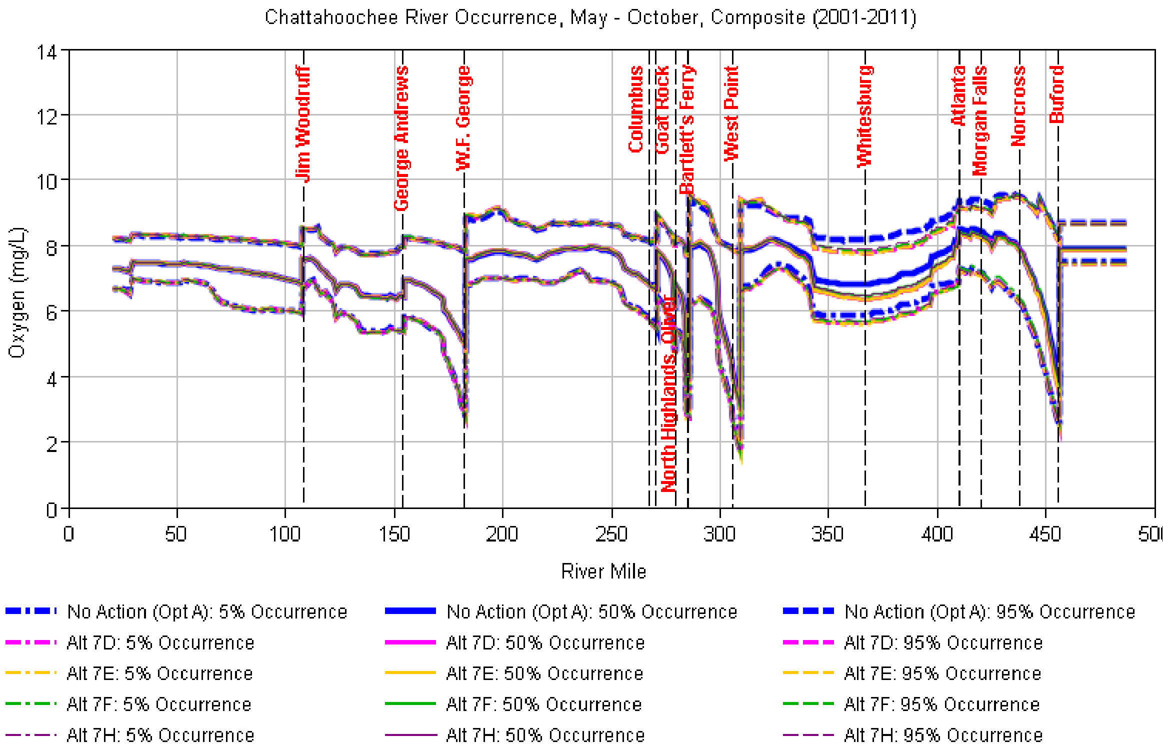


Figure 2.2-1. May through October DO for the modeled period from 2001 through 2011.

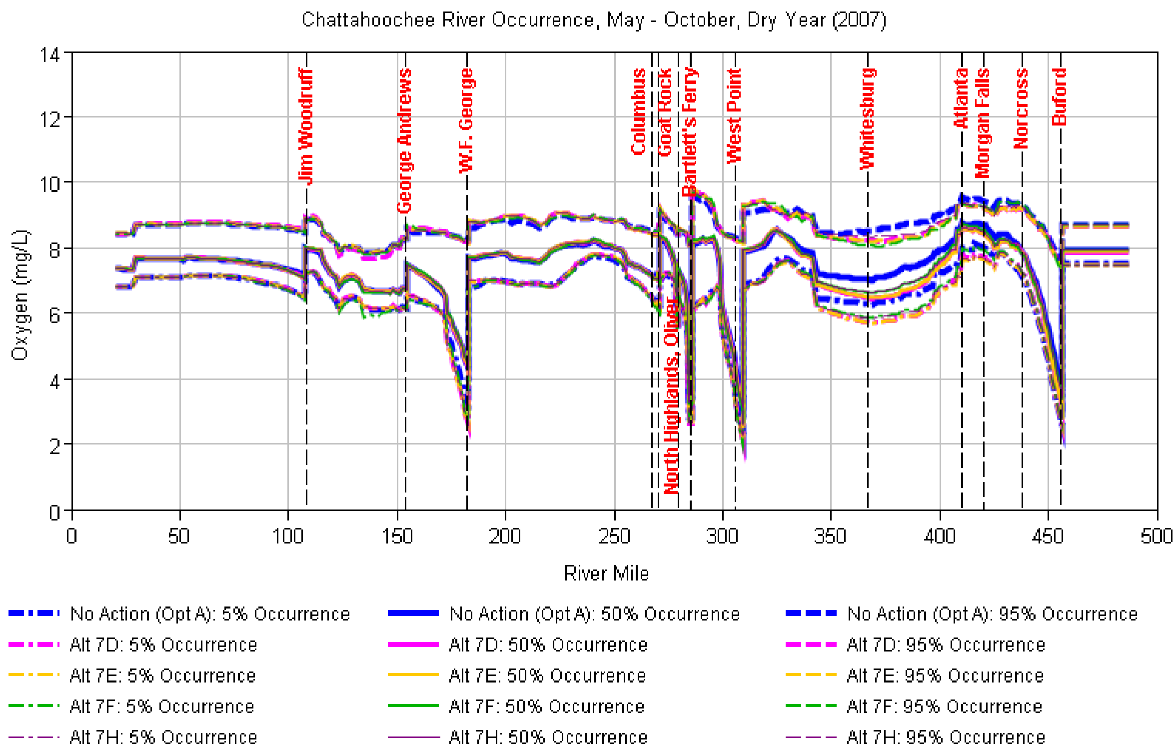


Figure 2.2-2. May through October DO modeled for a representative dry period (2007) when low concentrations would be expected.

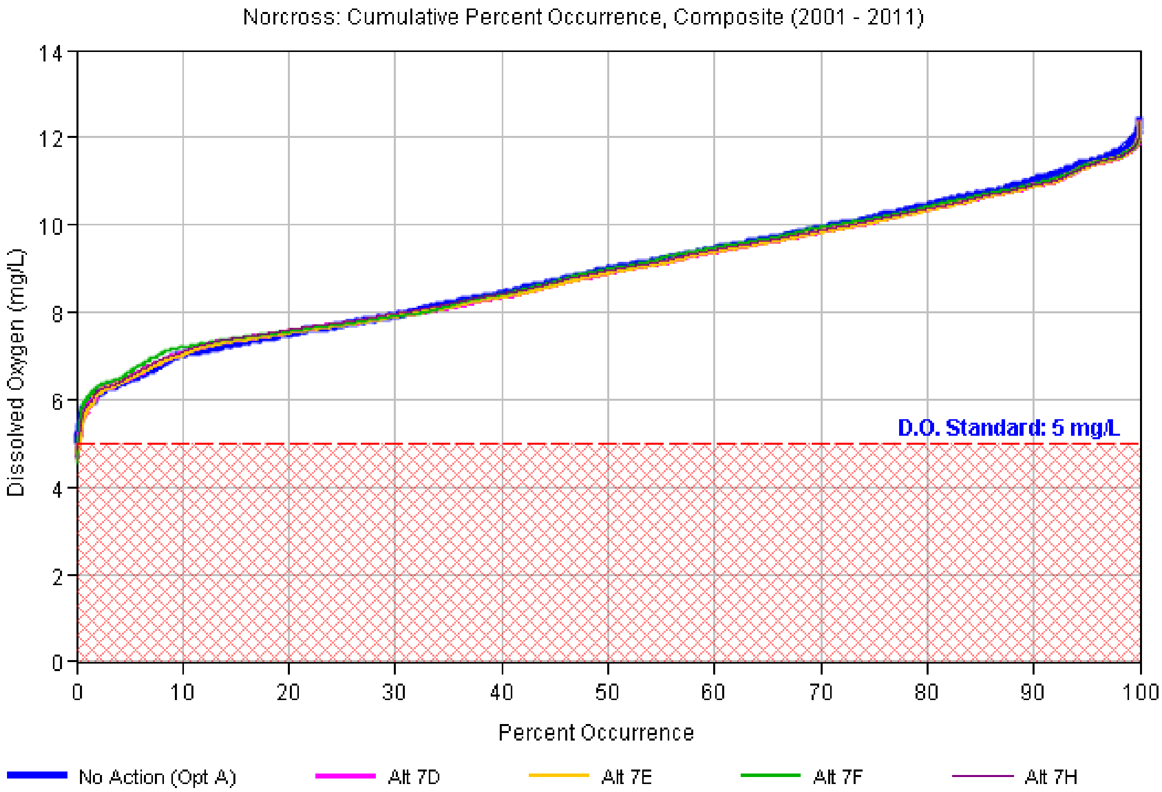


Figure 2.2-3. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for the period from 2001 through 2011.

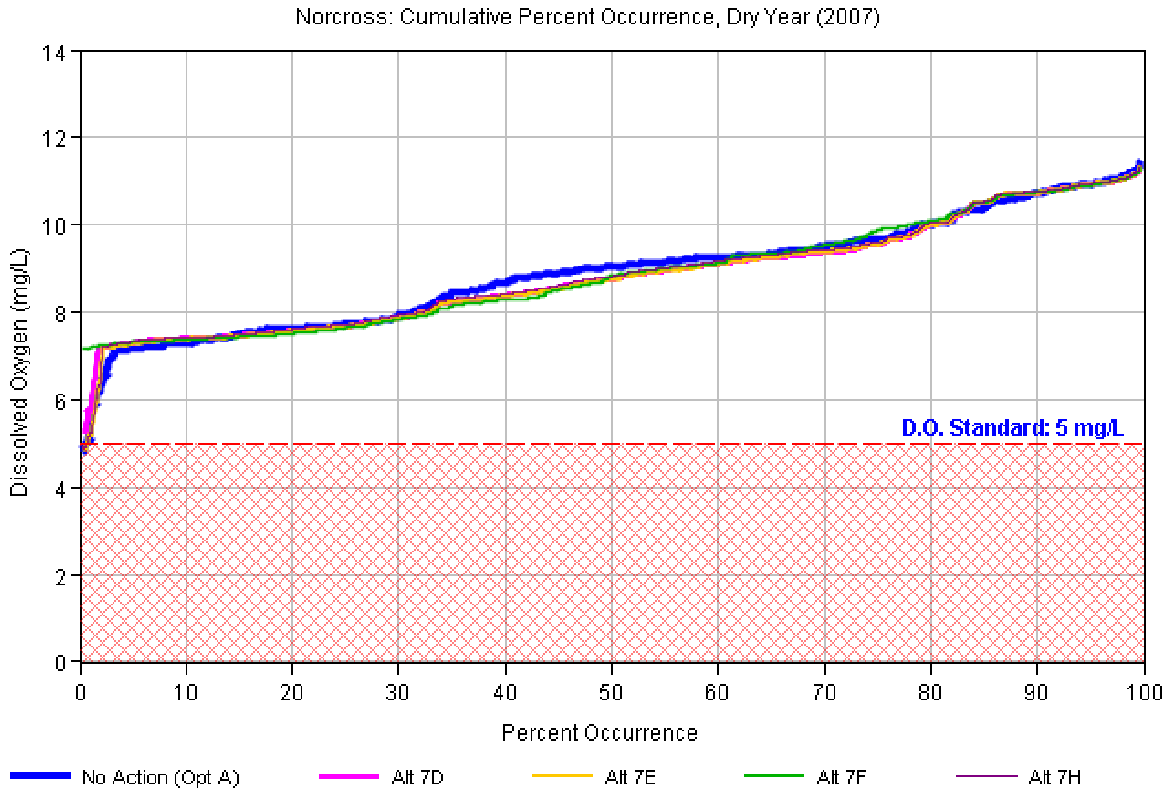


Figure 2.2-4. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for a representative dry year (2007).

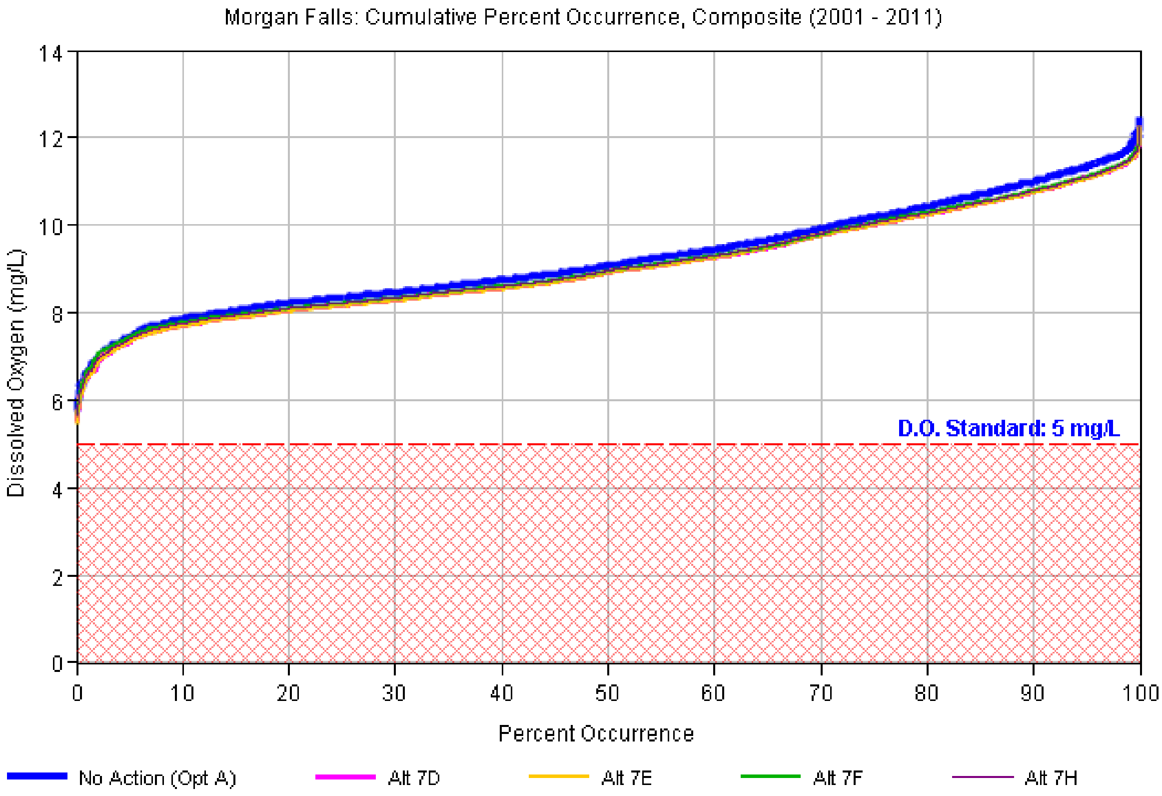


Figure 2.2-5. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for the period from 2001 through 2011.

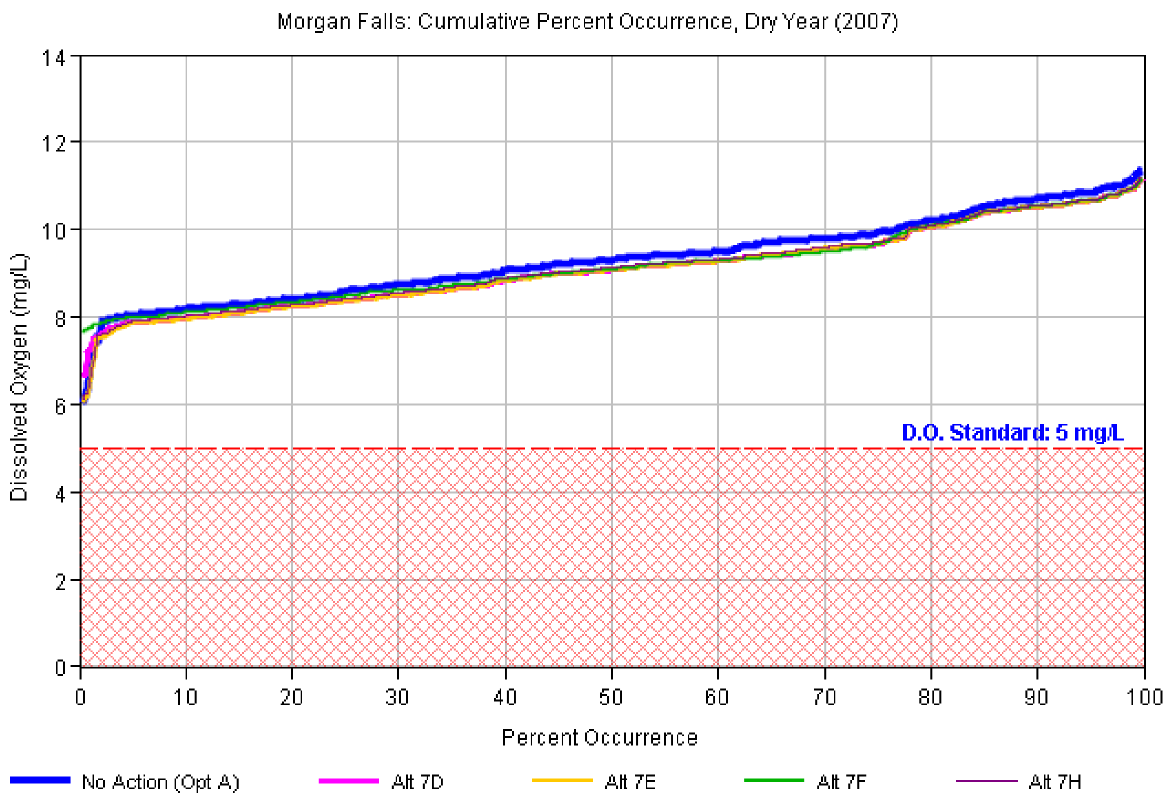


Figure 2.2-6. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for a representative dry year (2007).

The following occurrence plots (Figure 2.2-7 through Figure 2.2-14) illustrate occurrences of DO at locations where, based on Figure 2.2-1and Figure 2.2-2, median concentrations are less than state standards. These locations are downstream of Buford, West Point, Bartletts Ferry, and Walter F. George dams.

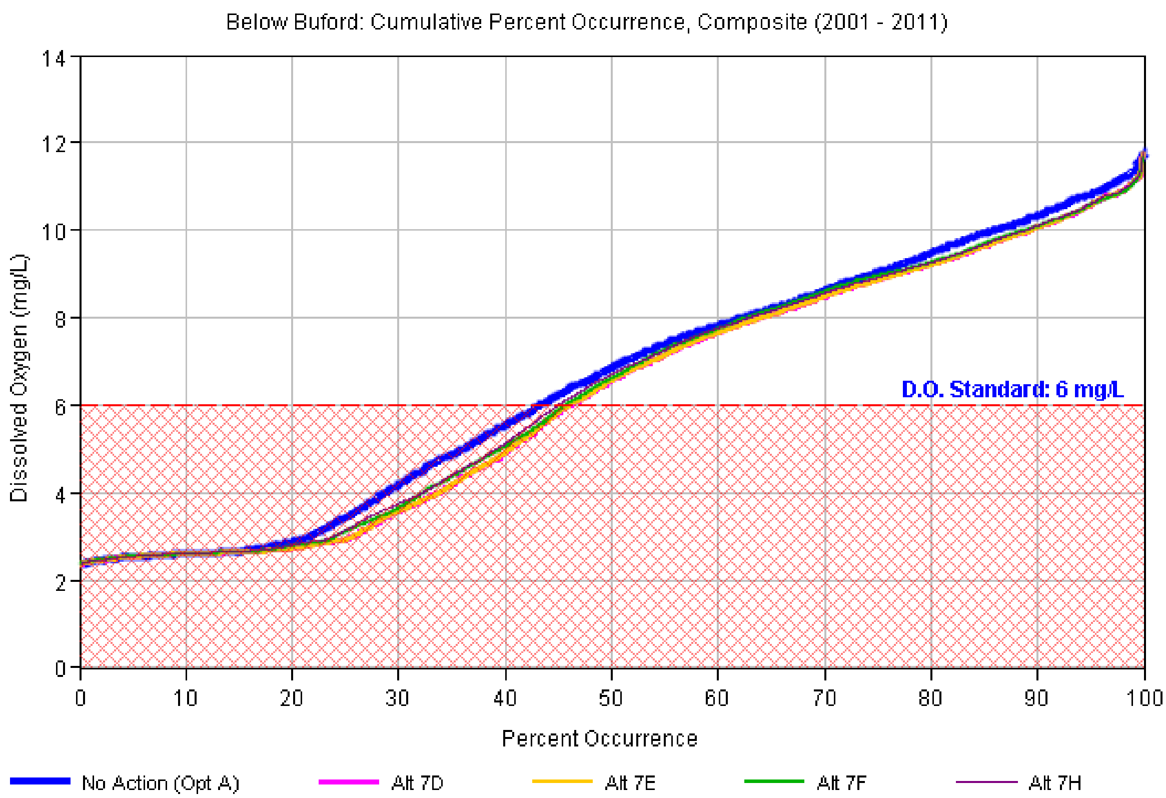


Figure 2.2-7. DO occurrence downstream of Buford Dam for the modeled period (2001 – 2011).

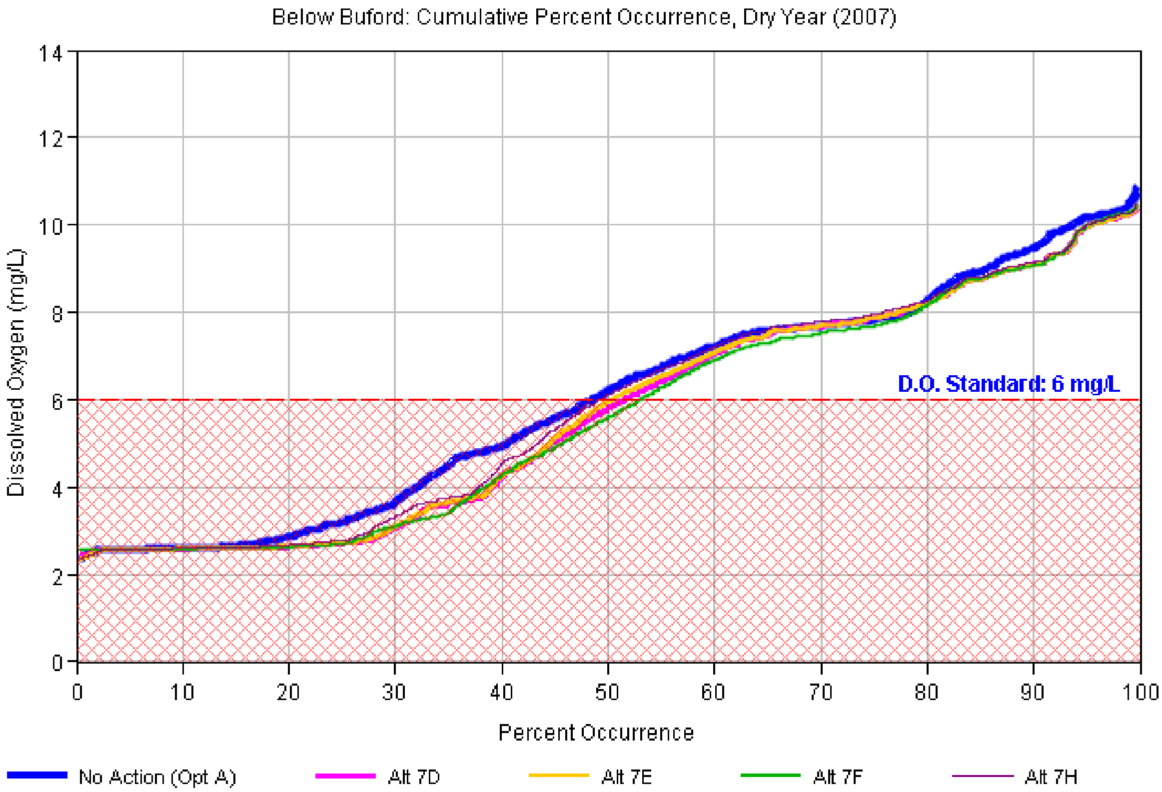


Figure 2.2-8. DO occurrence downstream of Buford Dam for a representative dry year (2007).

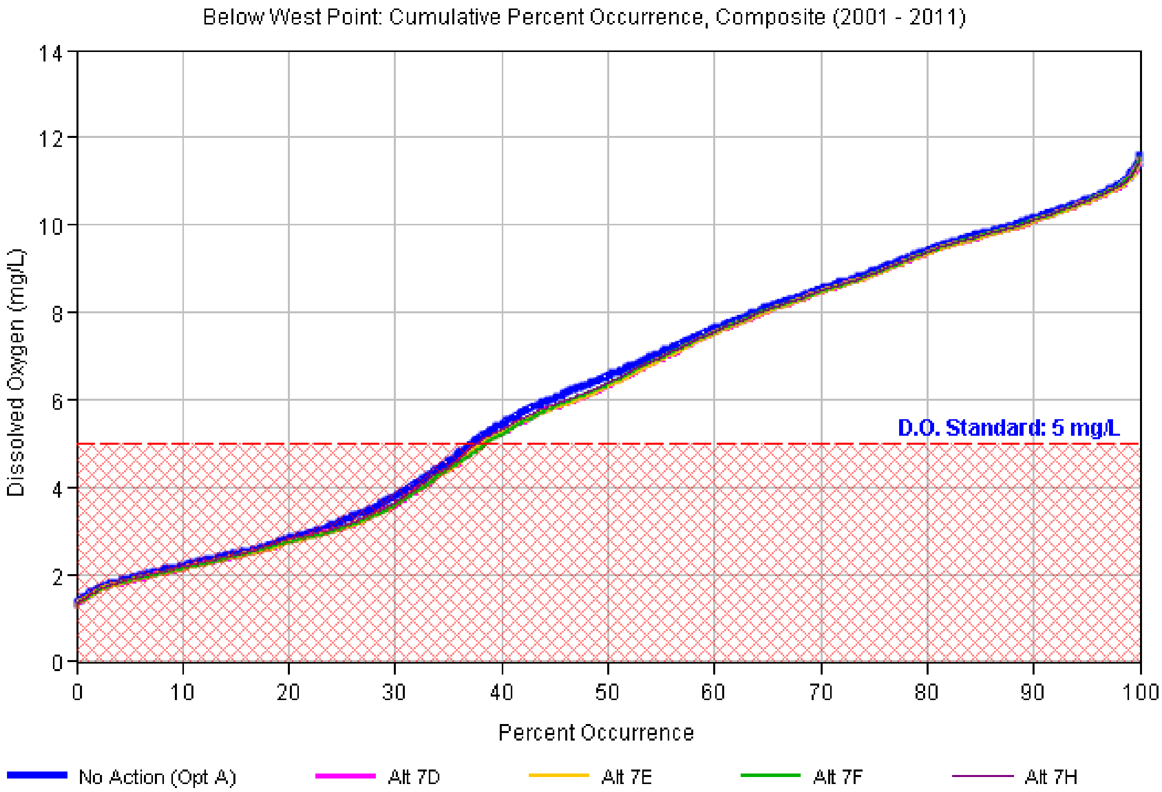


Figure 2.2-9. DO occurrence downstream of West Point Dam for the modeled period (2001 - 2011).

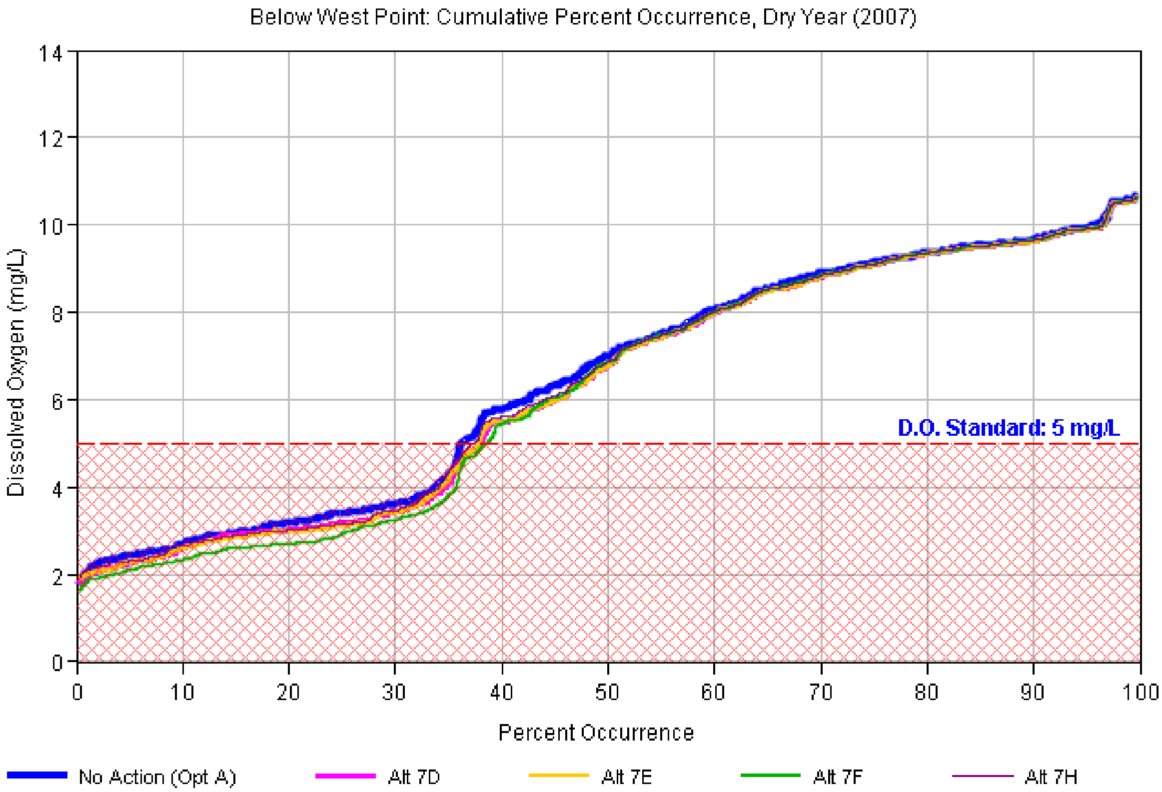


Figure 2.2-10. DO occurrence downstream of West Point Dam for a representative dry year (2007).

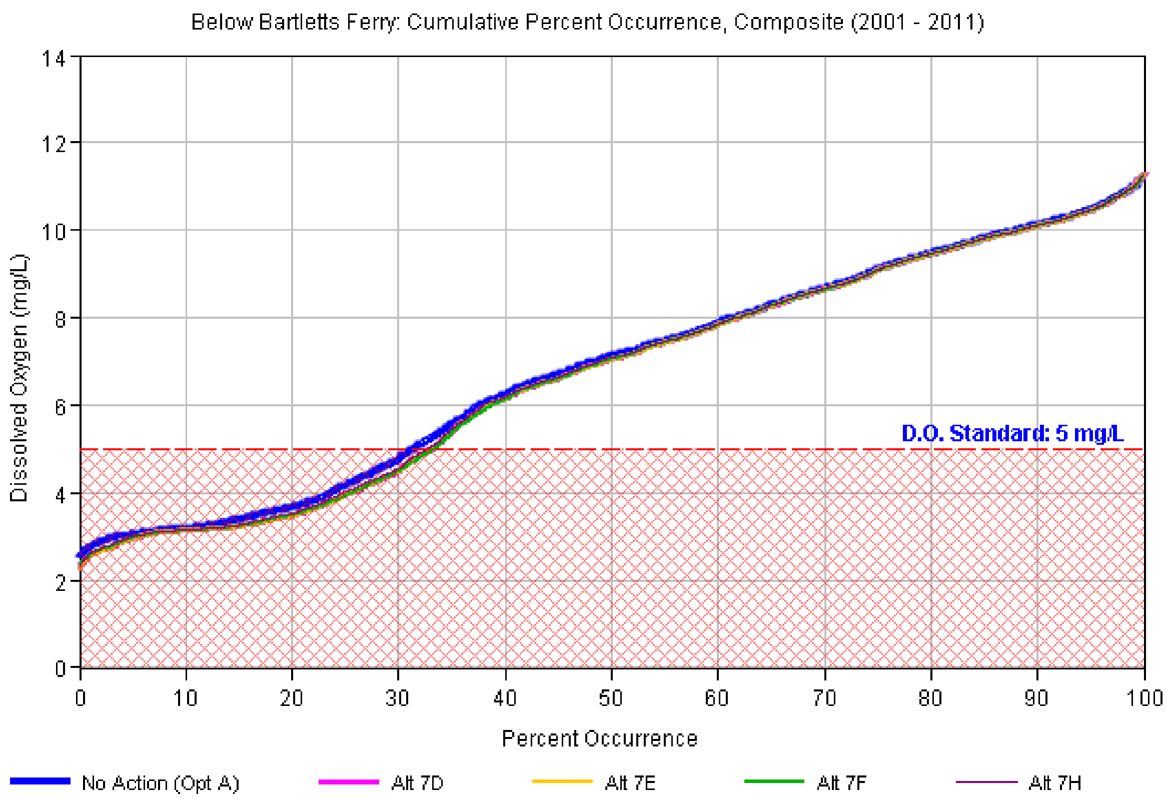


Figure 2.2-11. DO occurrence downstream of Bartletts Ferry Dam for the modeled period (2001 - 2011).

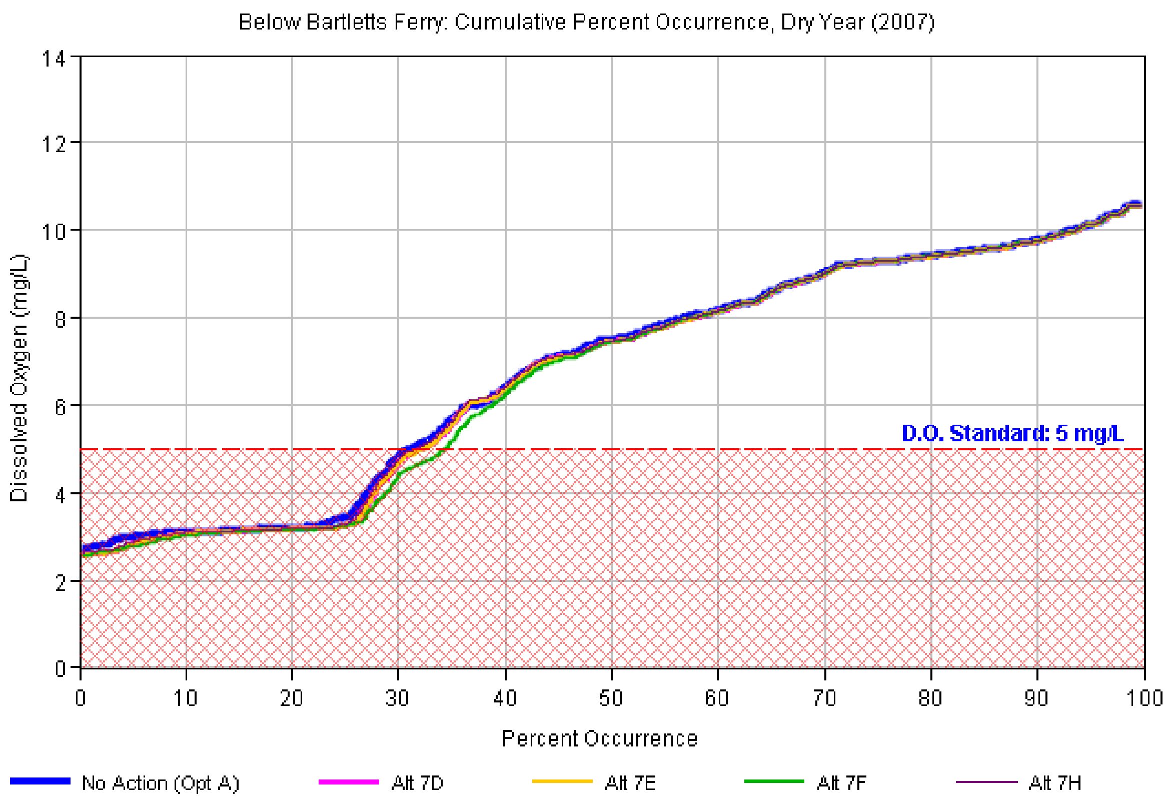


Figure 2.2-12. DO occurrence downstream of Bartletts Ferry Dam for a representative dry year (2007).

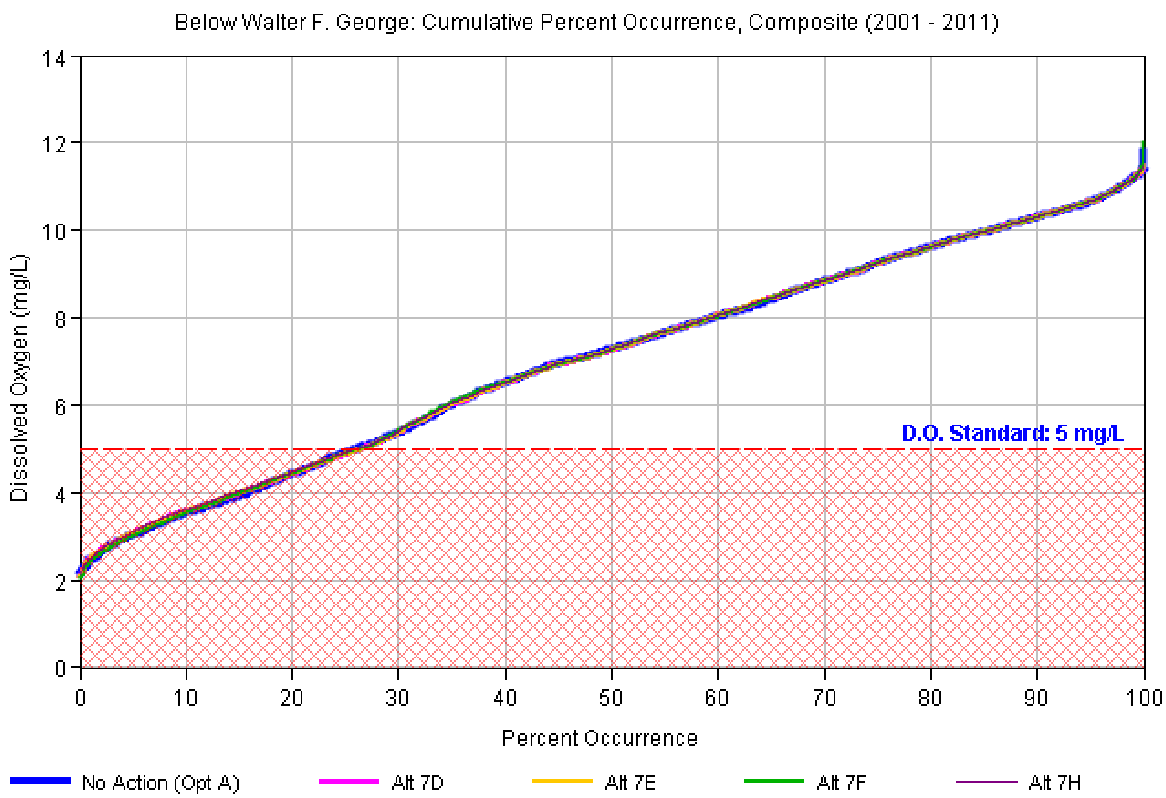


Figure 2.2-13. DO occurrence downstream of Walter F. George Dam for the modeled period (2001-2011).

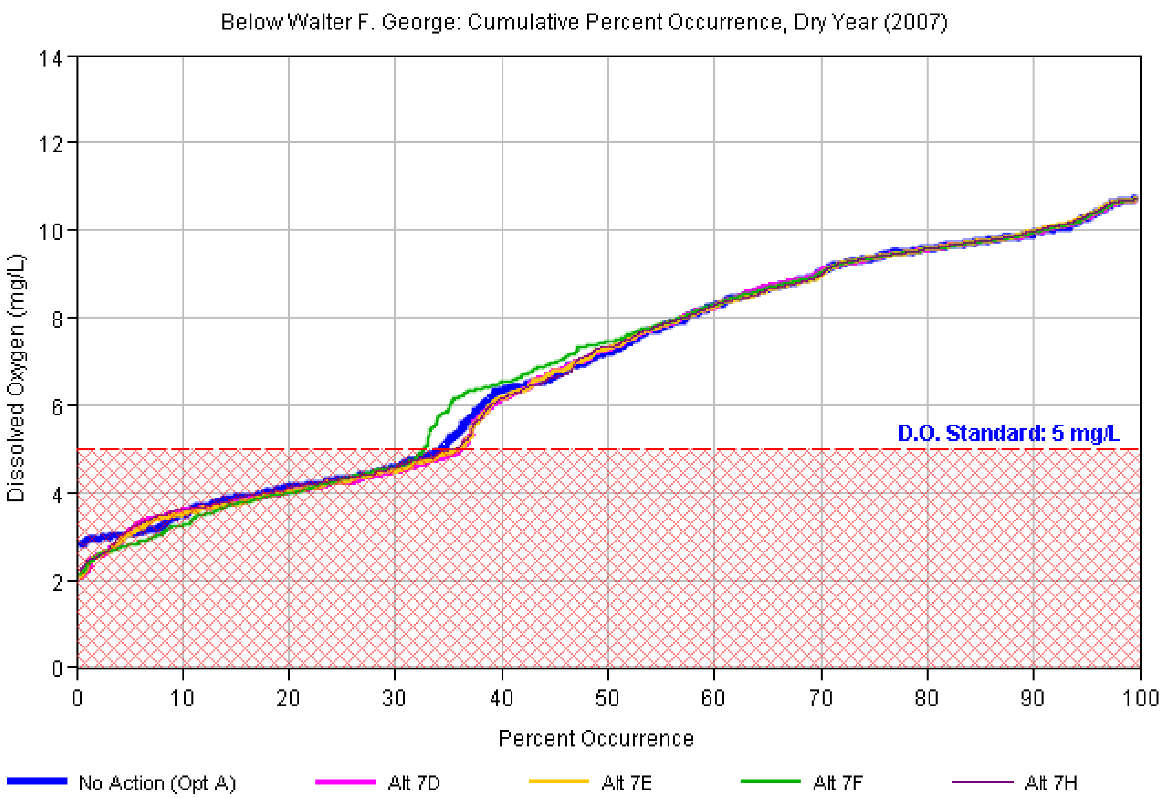


Figure 2.2-14. DO occurrence downstream of Walter F. George Dam for a representative dry year (2007).

b. Total number of instantaneous "measurements" less than 4 mg/L.

Instantaneous modeled results were not simulated. The river profile simulations suggest that DO values less than 4 mg/L are only expected at several tailrace locations (as illustrated in Figure 2.2-7 through Figure 2.2-14). Time series plots for these locations are also provided below in Figure 2.2-15 through Figure 2.2-18.

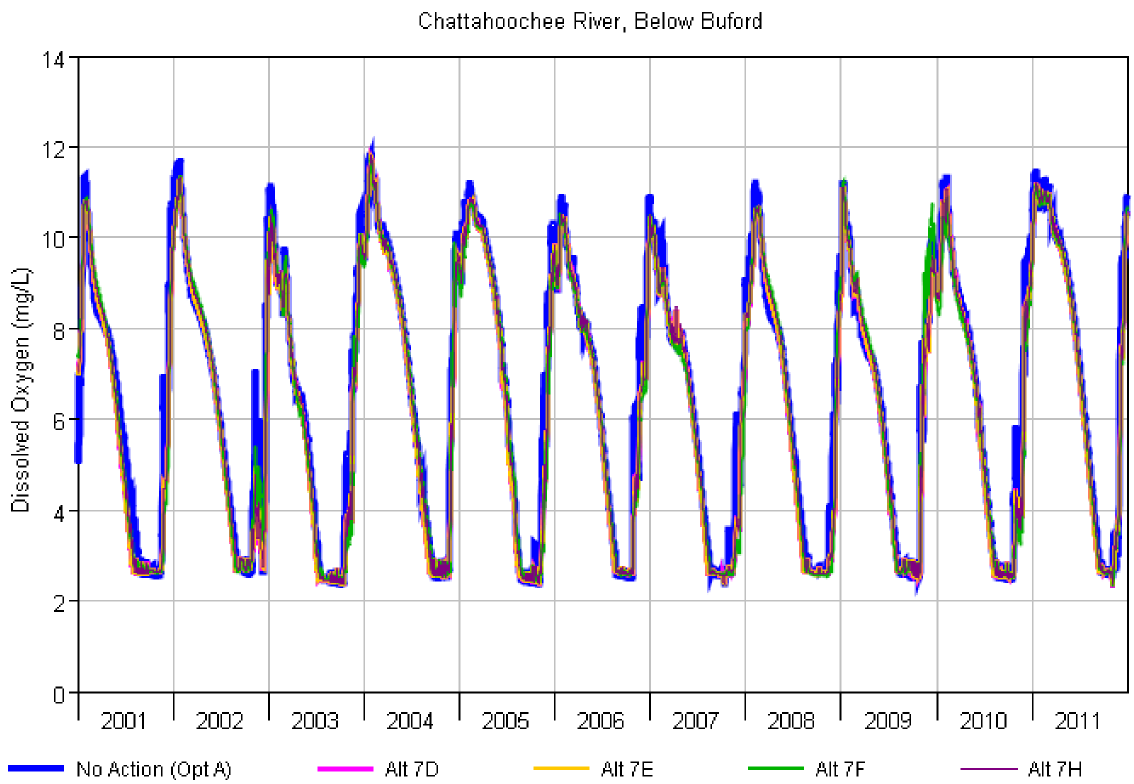


Figure 2.2-15. Time series DO from Buford Dam releases.

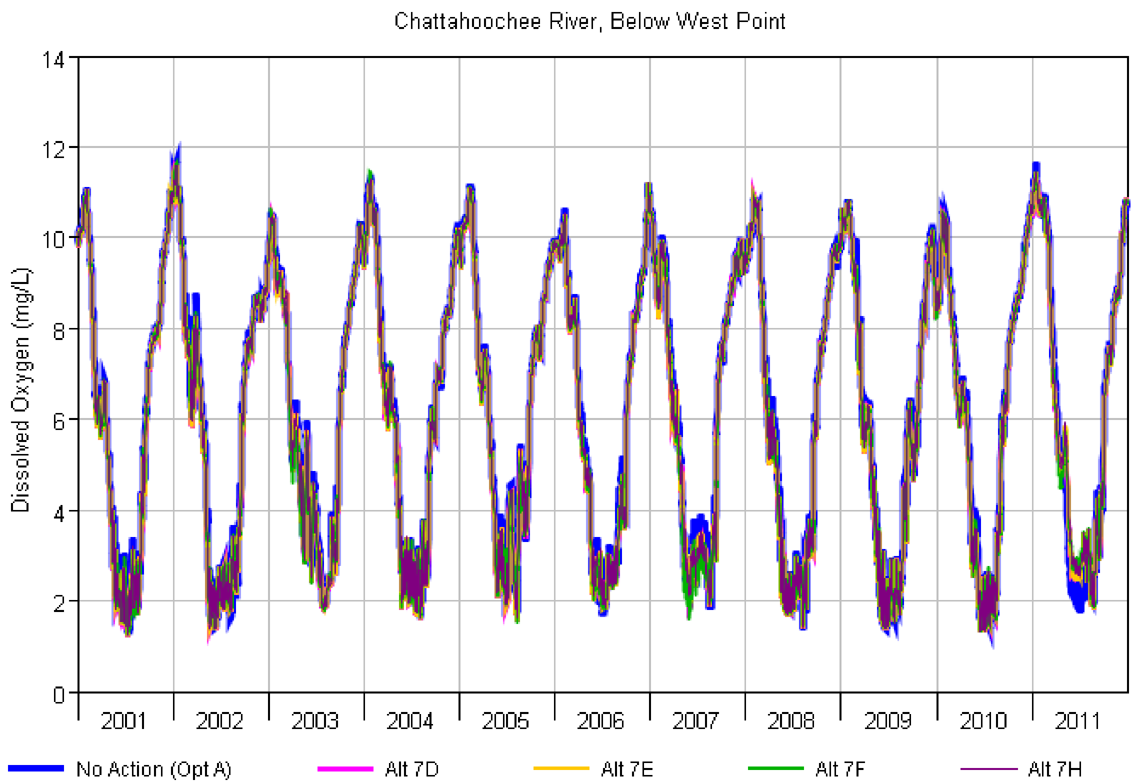


Figure 2.2-16. Time series DO from West Point Dam releases.

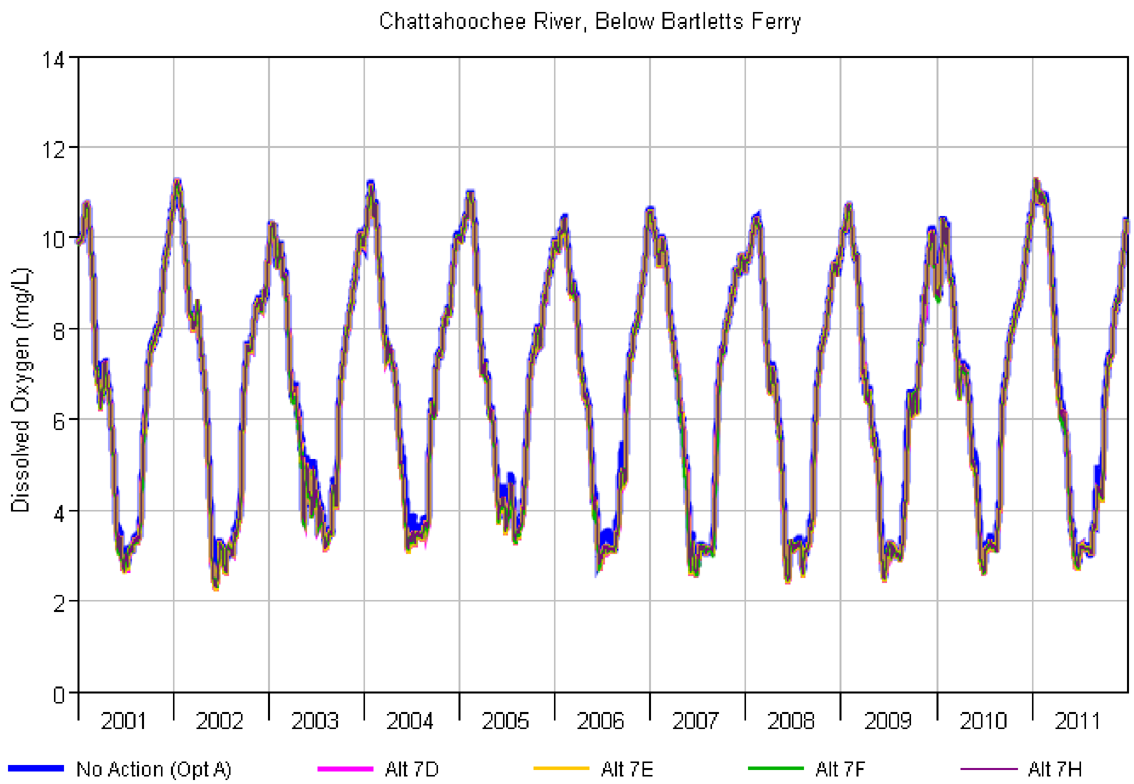


Figure 2.2-17. Time series DO from Bartletts Ferry Dam releases.

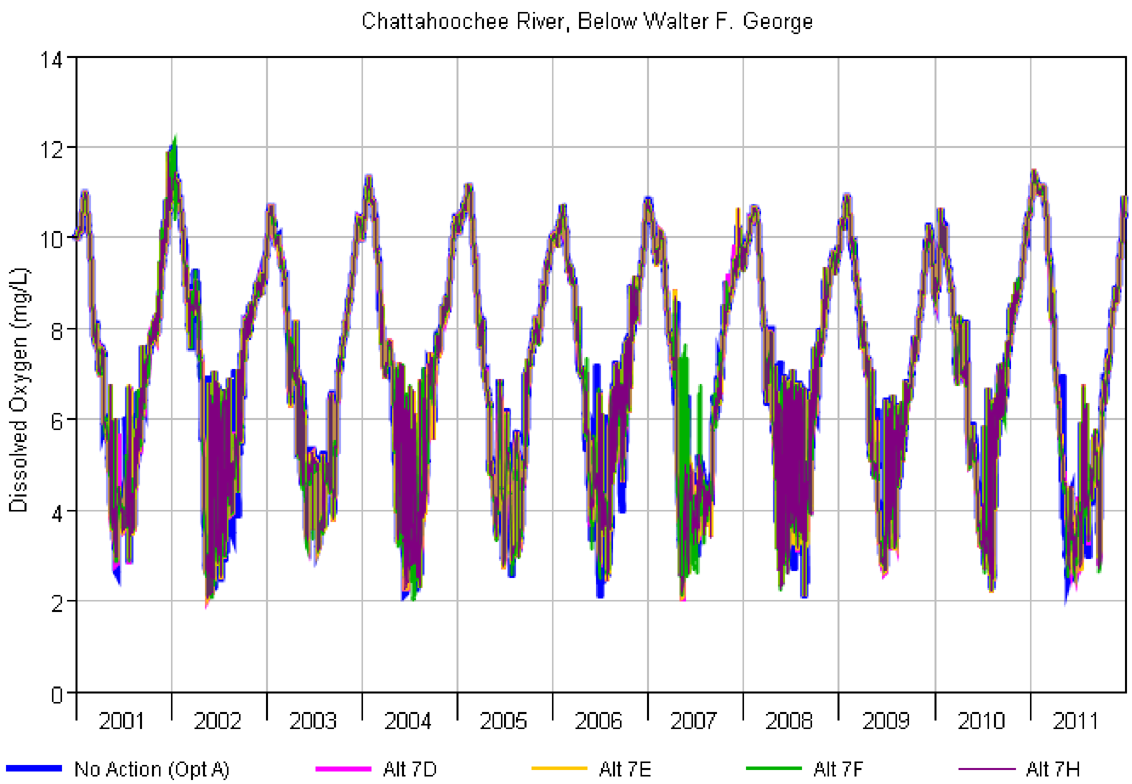


Figure 2.2-18. Time series DO from Walter F. George Dam releases.

c. Monthly exceedance figures and box plots with outliers for DO (mg/L).

Monthly exceedance figures for DO were not generated. However, the following figure generally provides the same information in a format we believe is easier to communicate. Figure 2.2-19 illustrates the change in DO values between the NAA and the PAA (PAA minus NAA is illustrated) at the 5, 50, and 95 percent occurrence intervals. For these DO plots, the 95 percent occurrence interval means that the values are this number or lower 95 percent of the simulation at this location (i.e., only 5 percent of the time the value is higher than this – a rare occurrence). Conversely, the 5 percent occurrence interval means that the values are this number or lower 5 percent of the simulation at this location (i.e., 95 percent of the time the value is higher than this – this too is a rare occurrence). The 50 percent occurrence represents the median occurrence.

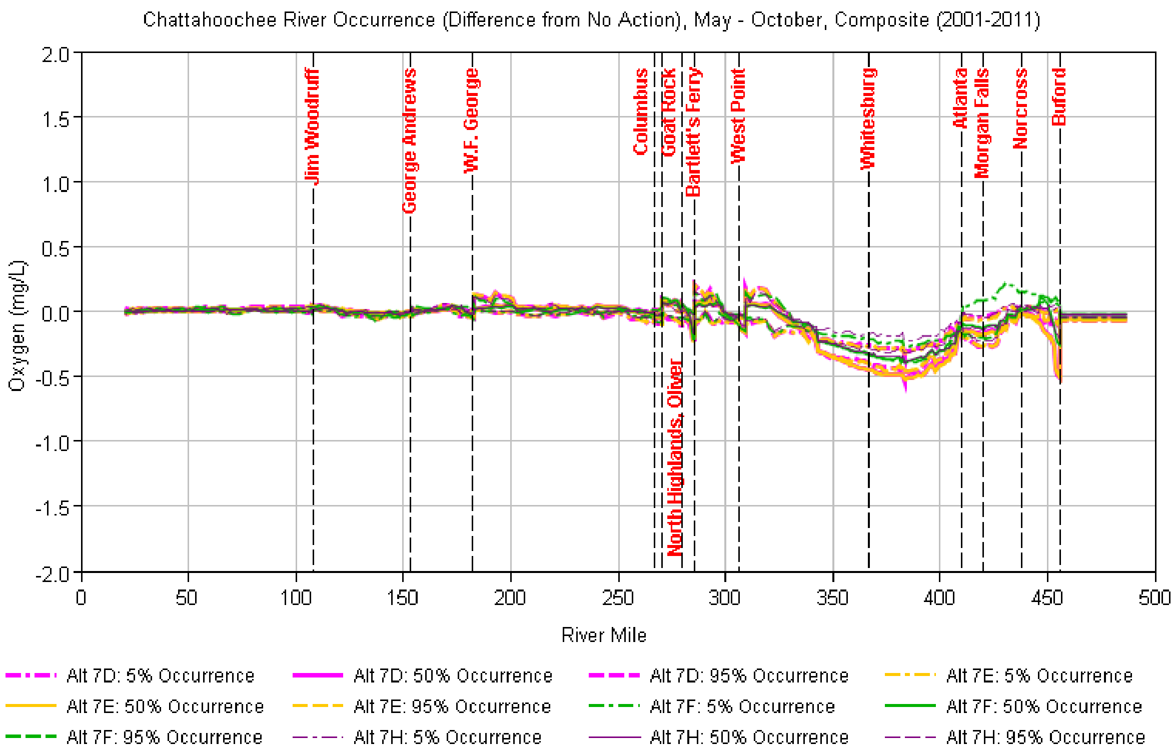


Figure 2.2-19. Changes in longitudinal DO in the Chattahoochee River for the May through October for the model period (2001 through 2011).

2.2.2 Water Temperature

a. Monthly exceedance figures and box plots with outliers for water temperature.

Monthly exceedance figures for temperature were not generated. Again, we believe that river profiles and occurrence plots illustrate this information more clearly than the box plots. The following figures first illustrate temperatures along the riverine profile and then illustrate the change in temperature from the NAA (PAA minus the NAA is illustrated). The delta profile plots clearly illustrate the magnitude of the change in water temperature of each of the alternatives as compared to the NAA.

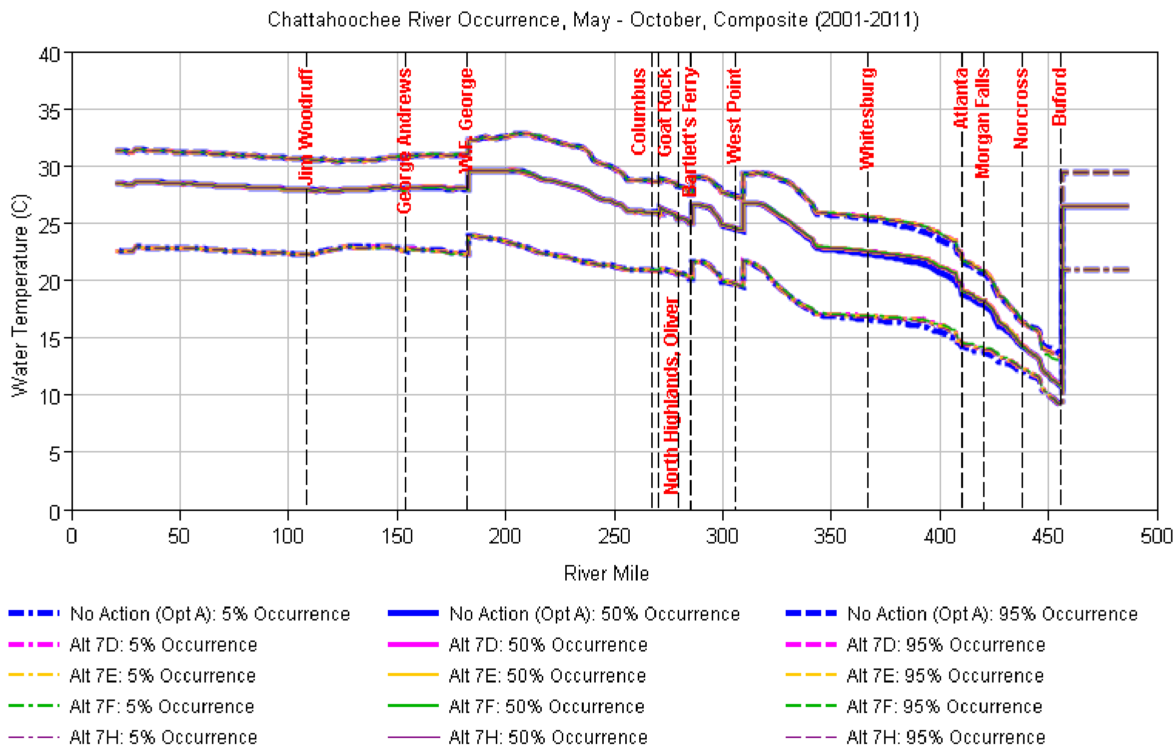


Figure 2.2-20. May through October water temperatures along the Chattahoochee River for the modeled period (2001-2011).

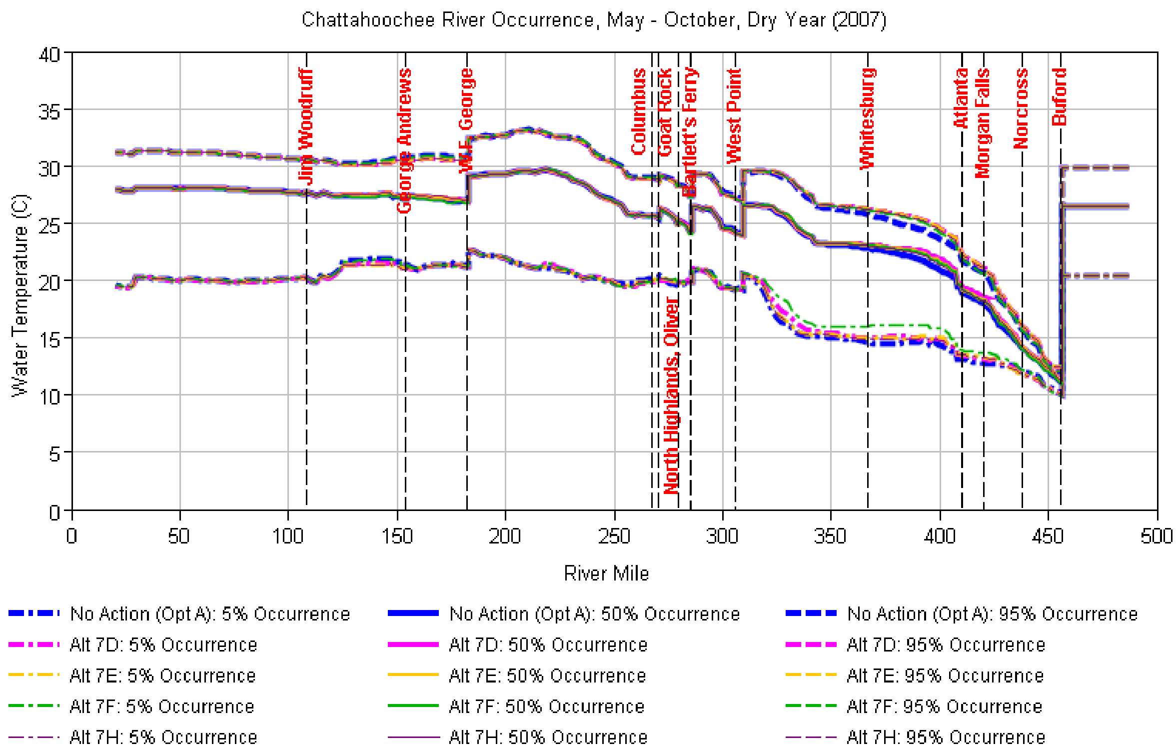


Figure 2.2-21. May through October water temperatures along the Chattahoochee River for a representative dry year (2007).

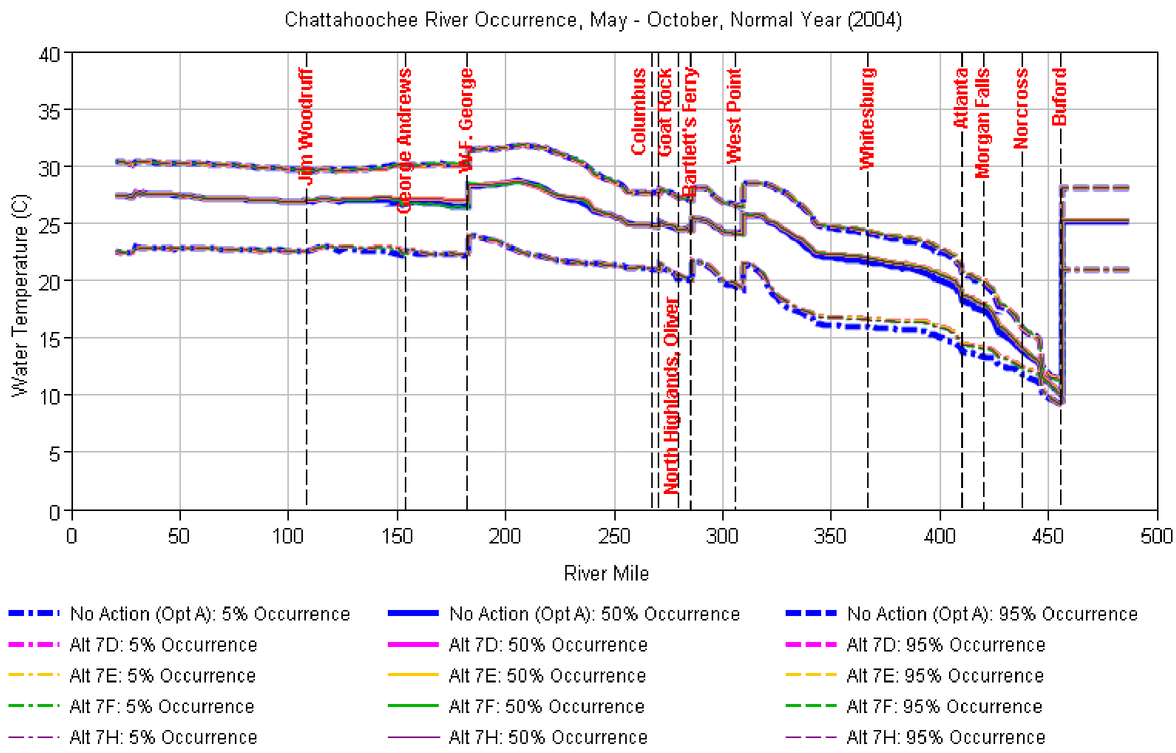


Figure 2.2-22. May through October water temperatures along the Chattahoochee River for a representative normal year (2004).

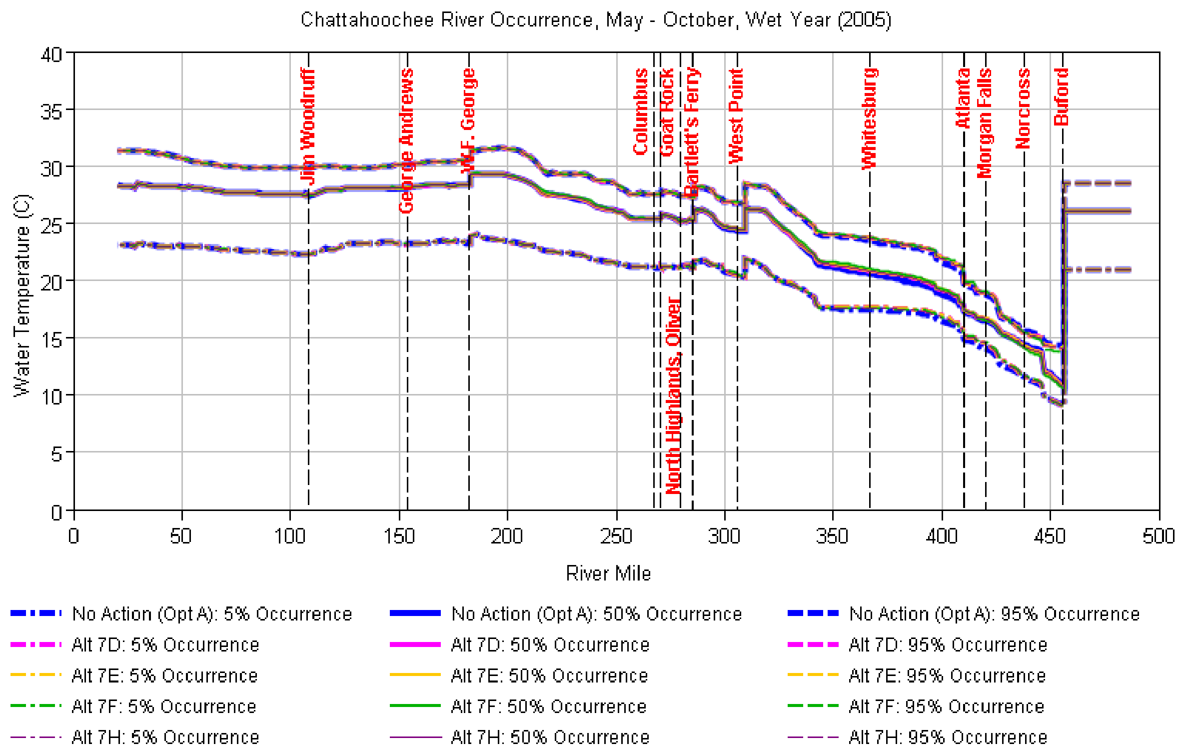


Figure 2.2-23. May through October water temperatures along the Chattahoochee River for a representative wet year (2005).

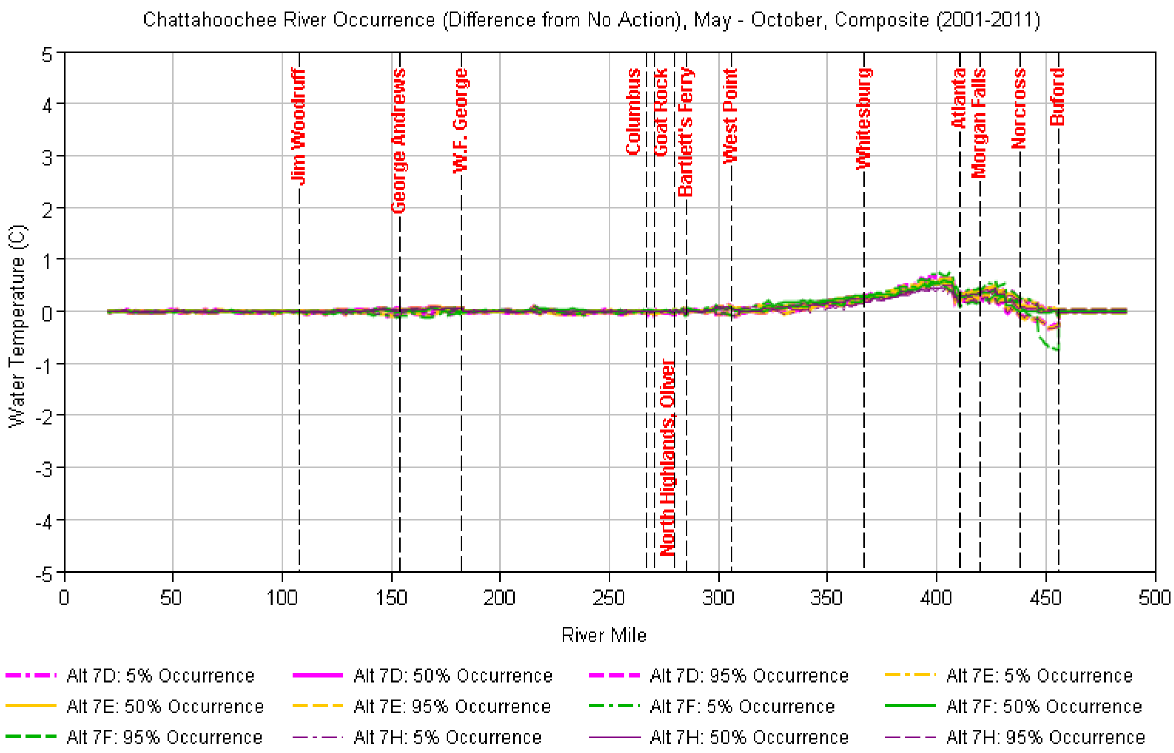


Figure 2.2-24. Changes in longitudinal water temperature in the Chattahoochee River for May through October for the modeled period from 2001 through 2011.

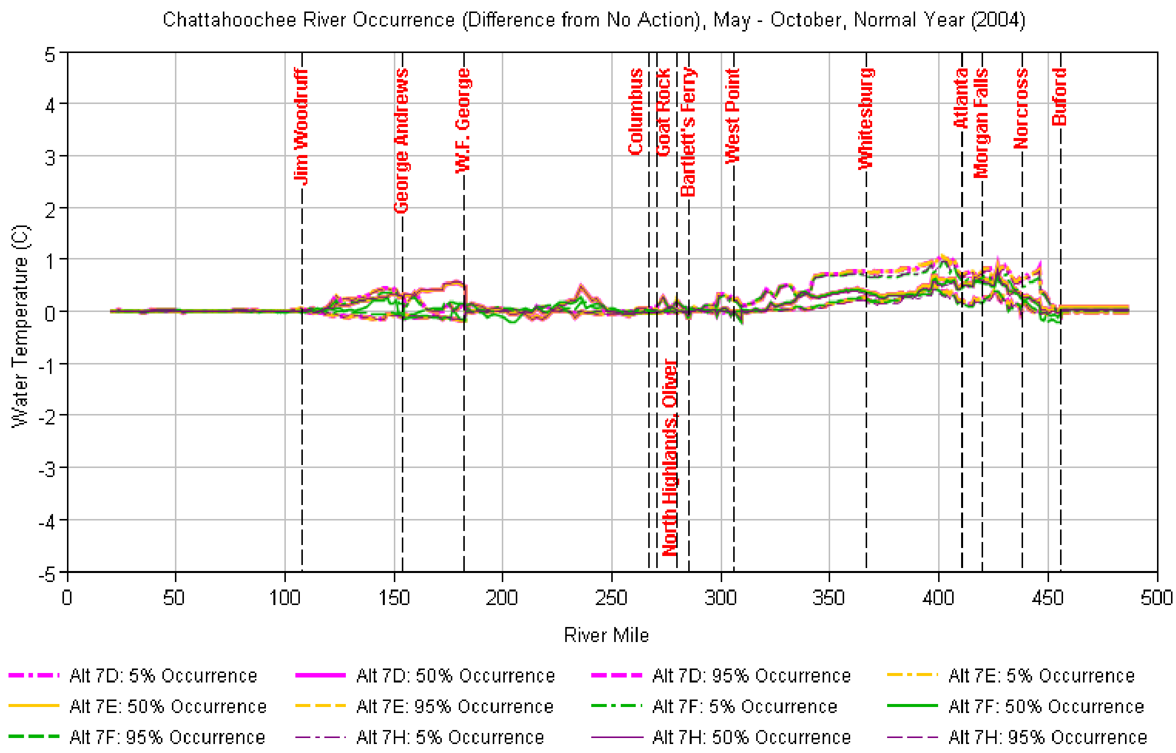


Figure 2.2-25. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a normal year (2004).

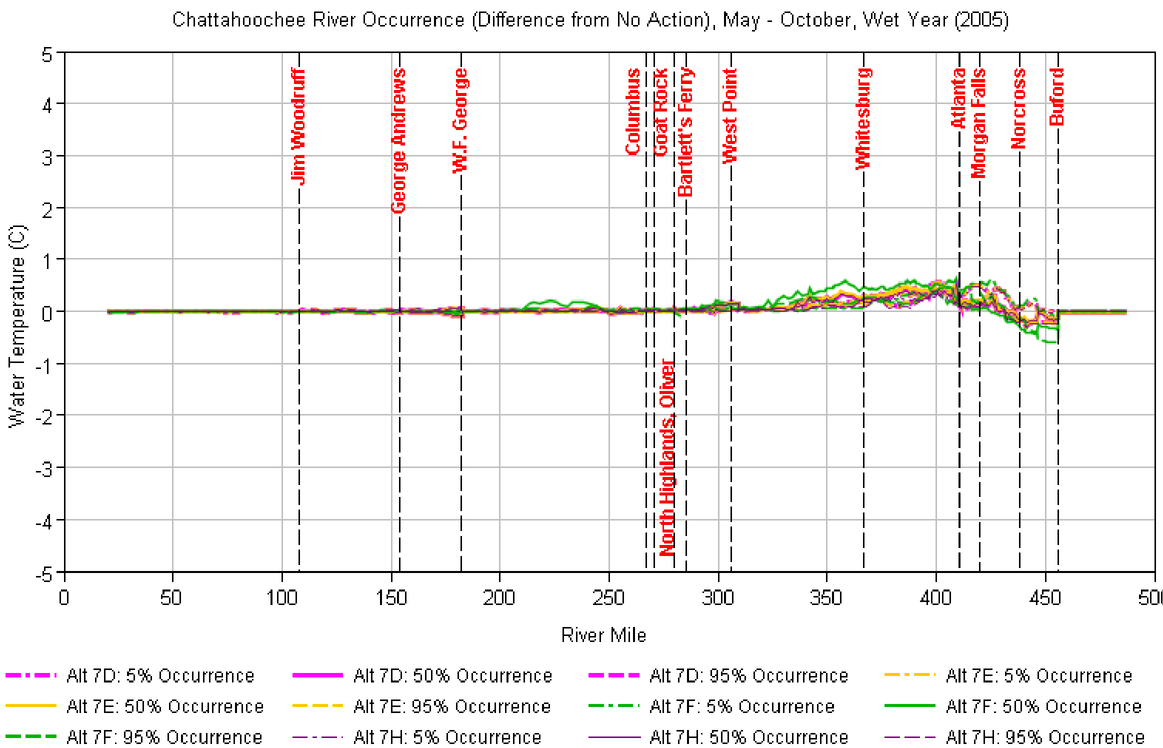


Figure 2.2-26. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a wet year (2005).

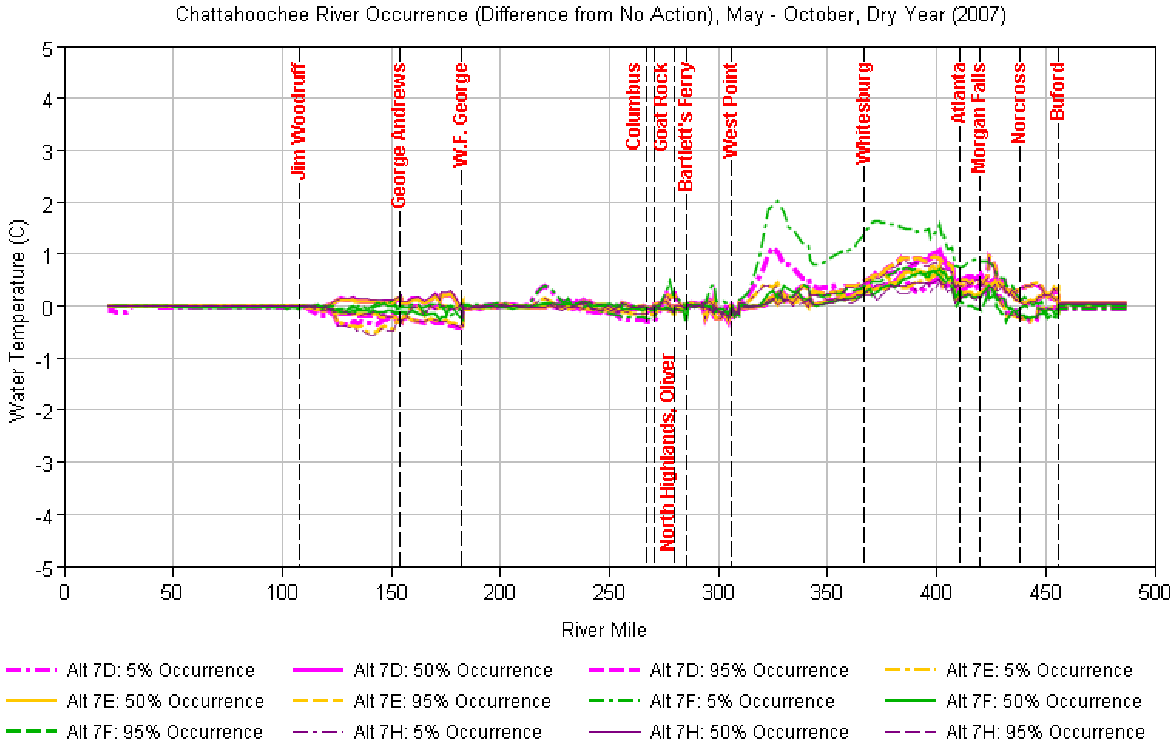


Figure 2.2-27. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a dry year (2007).

2.2.3 Wastewater

a. Average stream percent wastewater.

Average stream flow percent that is wastewater is presented for May through October in the figures to follow; these figures also present the 5 percent and 95 percent occurrences.

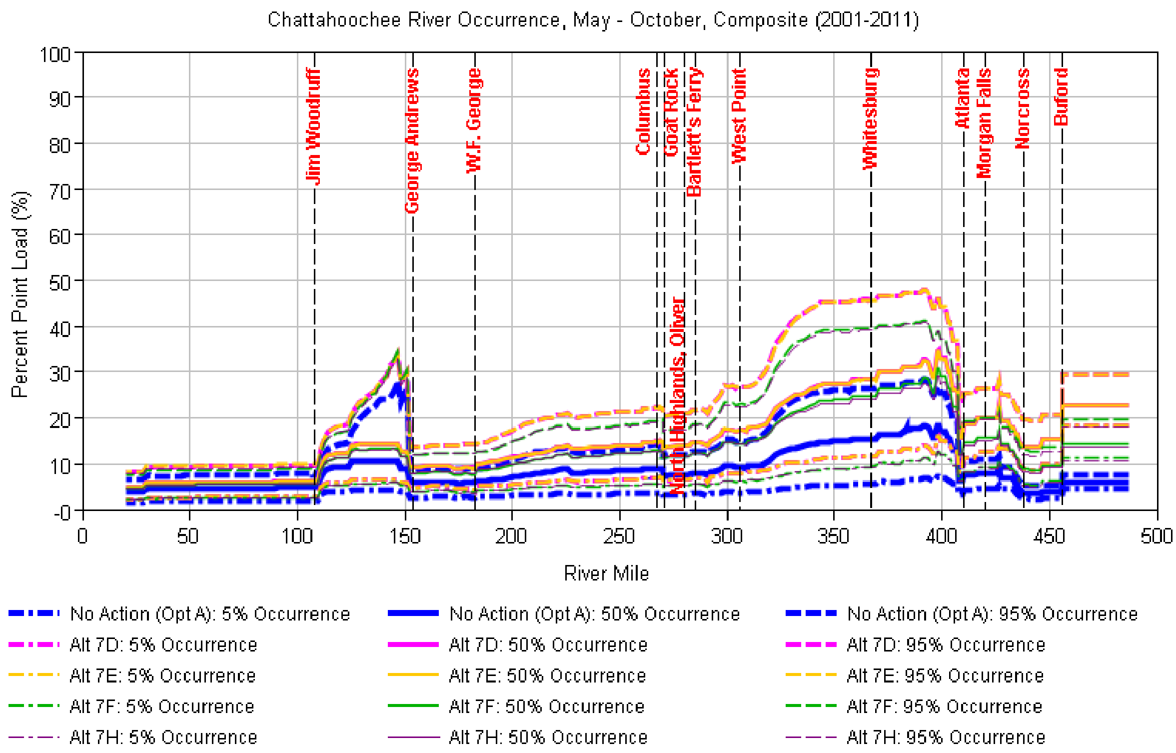


Figure 2.2-28. Percent of total flow that is wastewater along the Chattahoochee River for May through October of the modeled period (2001-2011).

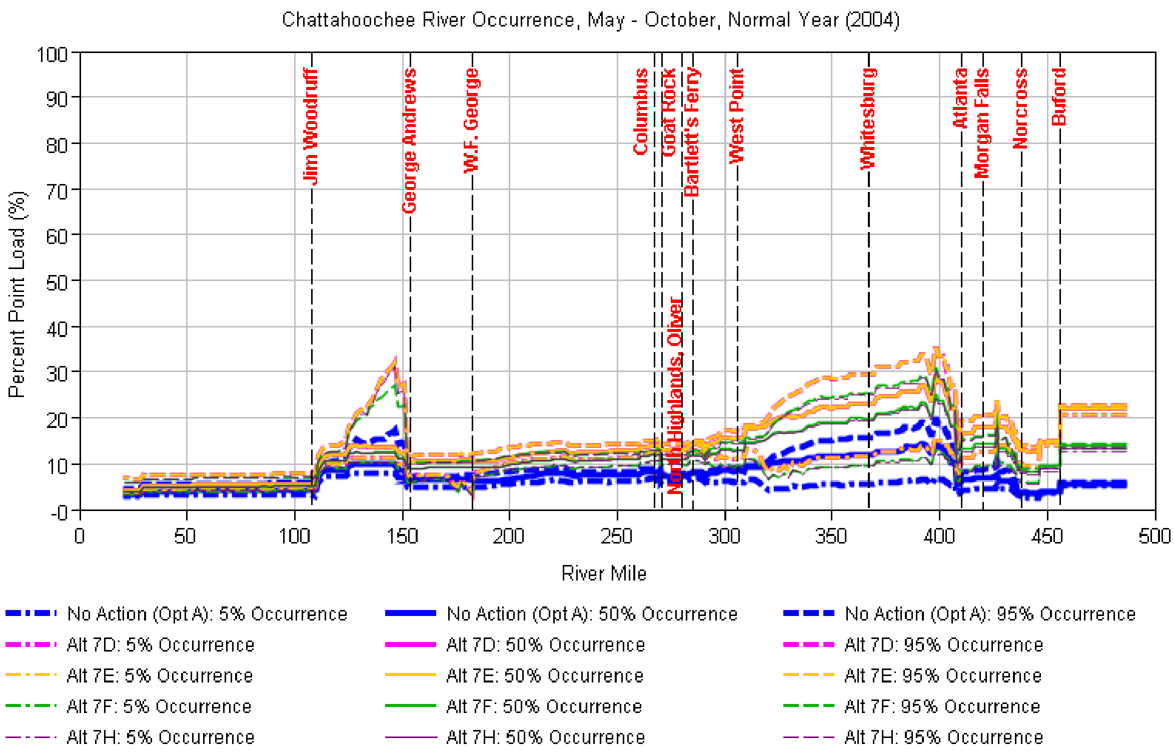


Figure 2.2-29. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative normal year (2004).

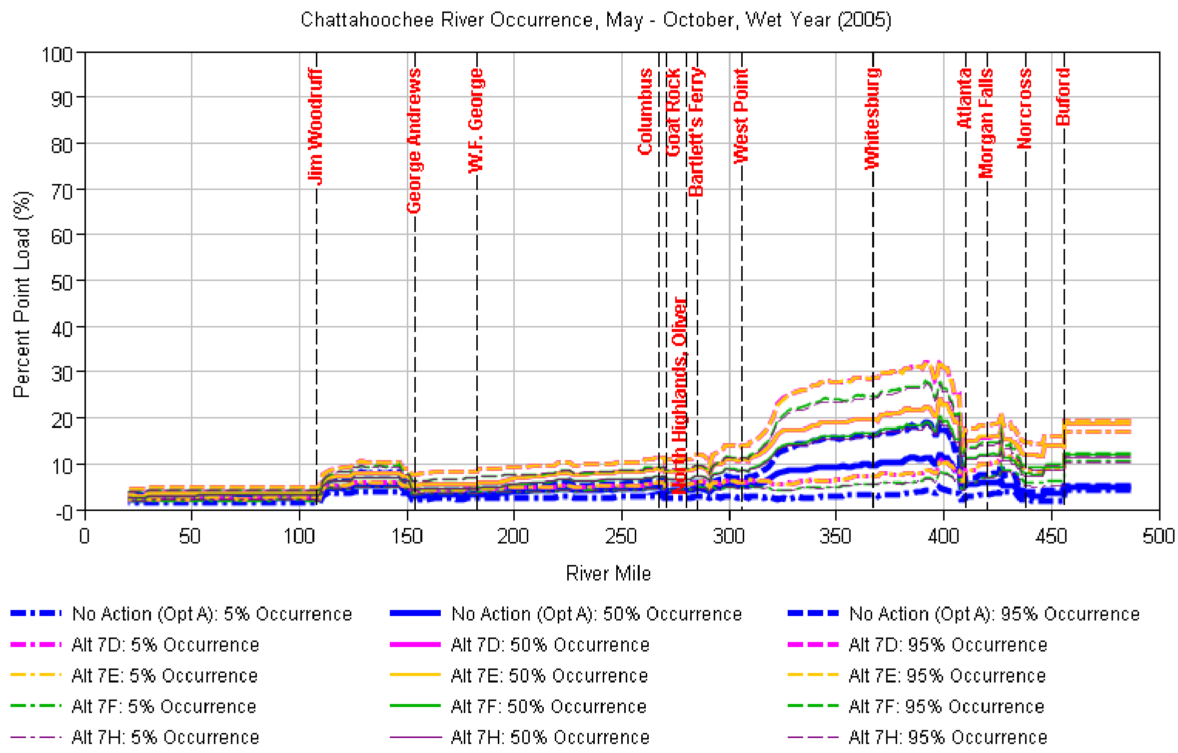


Figure 2.2-30. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative wet year (2005).

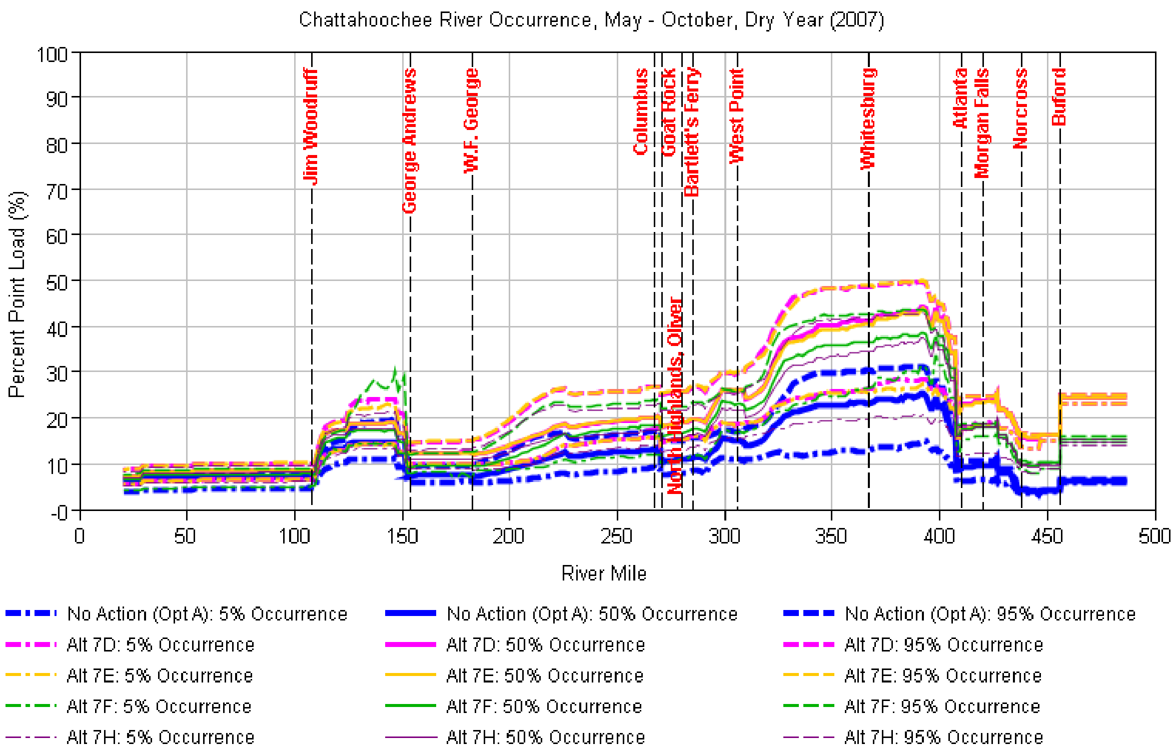


Figure 2.2-31. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative dry year (2007).

2.2.4 Chlorophyll *a*

a. Average values of summer Chlorophyll *a* (*u*g/L)

Chlorophyll *a* in various rainfall conditions is presented for the system in the following figures. Figures are also provided that present areas in the system where the greatest changes would be expected. The greatest changes would be expected in West Point Lake, Bartletts Ferry Lake, and Walter F. George in extreme conditions. Table 2.2-1 presents the growing season (April through October) average and annual geometric mean of chlorophyll *a* in USACE reservoirs.

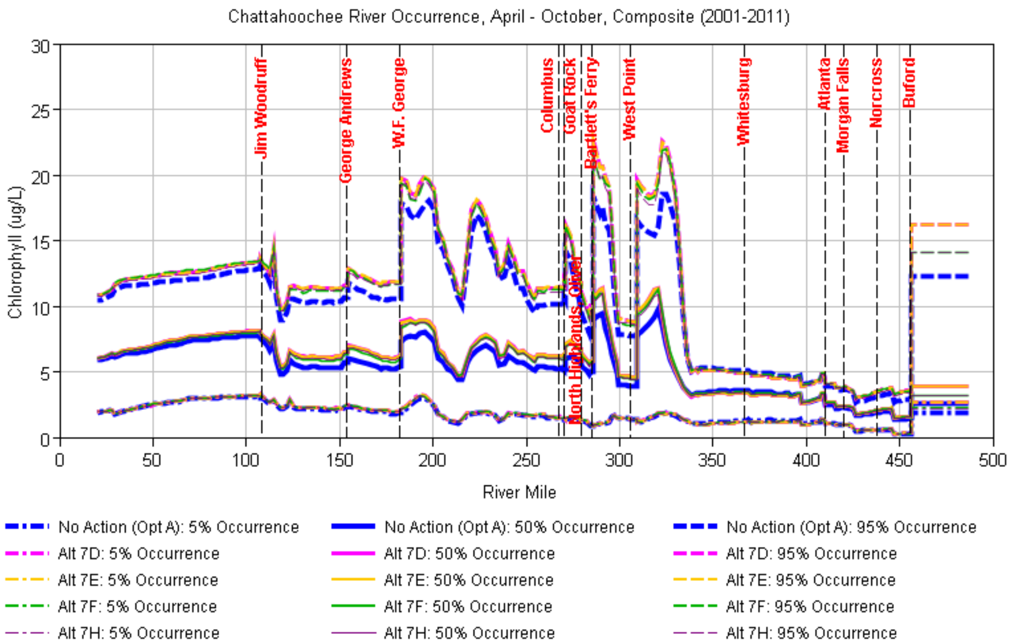


Figure 2.2-32. Chlorophyll *a* along the Chattahoochee River for April through October of the modeled period (2001-2011).

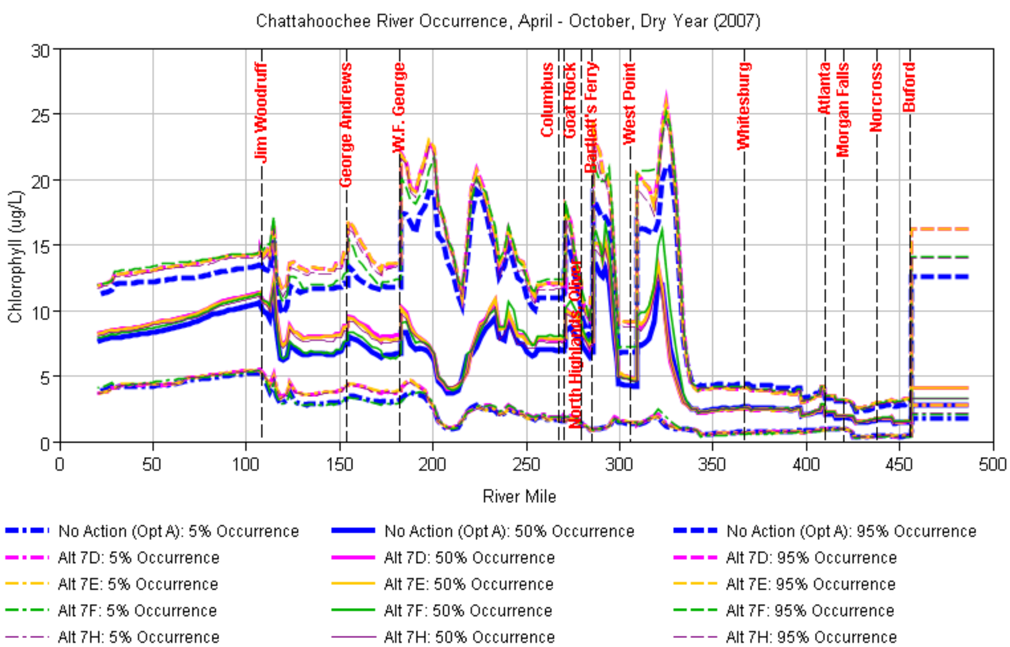


Figure 2.2-33. Chlorophyll *a* along the Chattahoochee River for April through October in a representative dry year (2007).

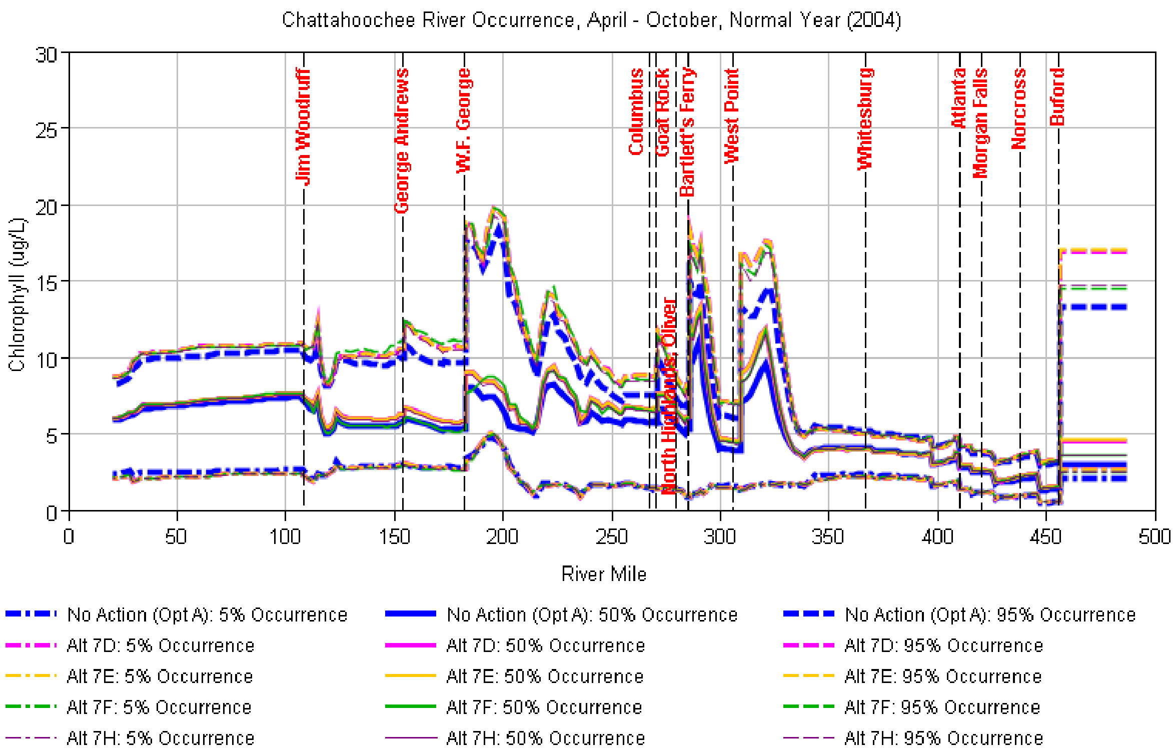


Figure 2.2-34. Chlorophyll *a* along the Chattahoochee River for April through October in a representative normal year (2004).

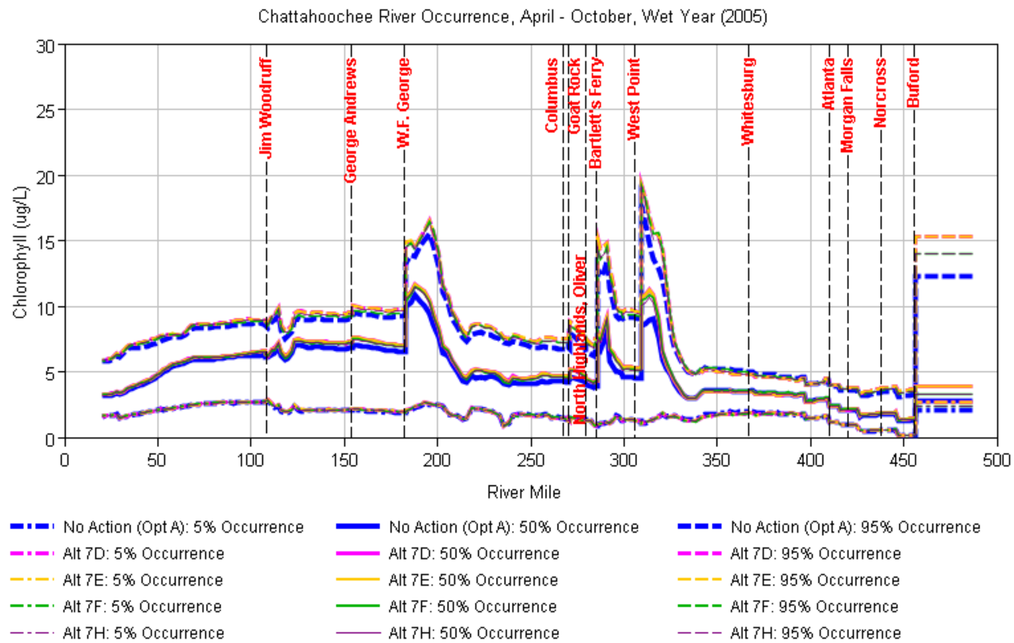


Figure 2.2-35. Chlorophyll *a* along the Chattahoochee River for April through October in a representative wet year (2005).

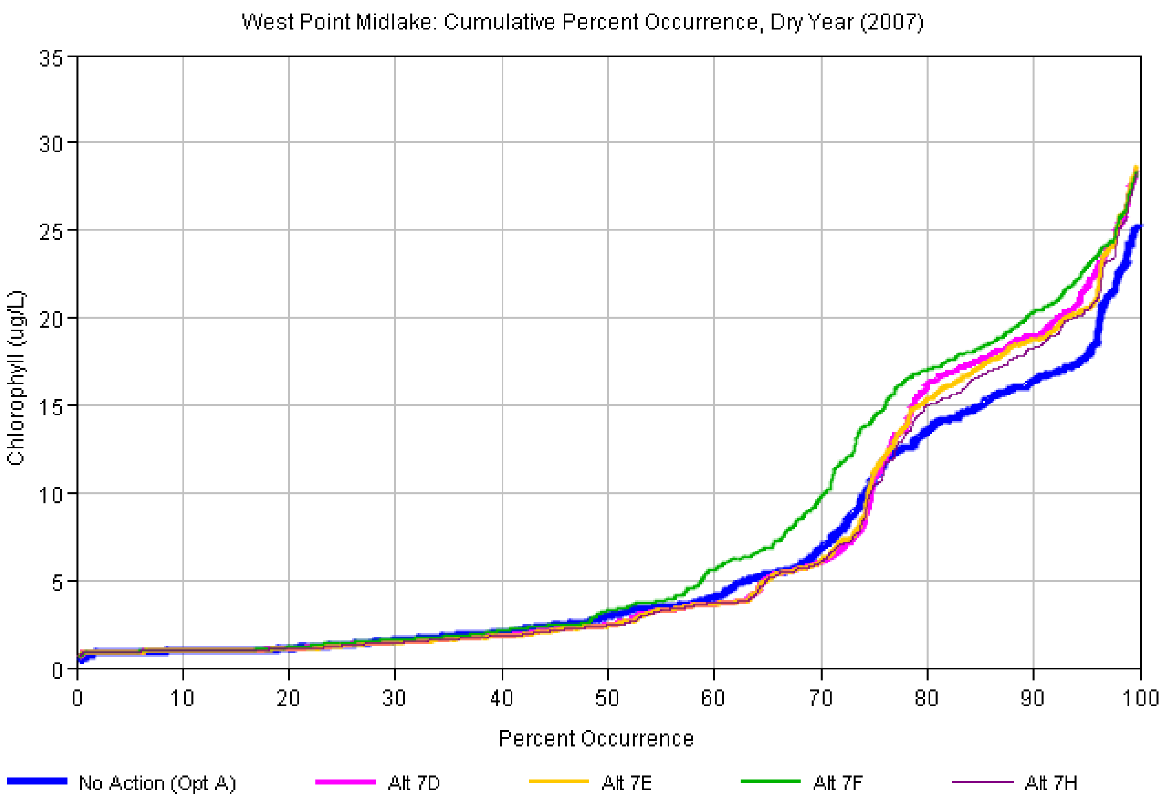


Figure 2.2-36. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of West Point Lake for a representative dry year (2007).

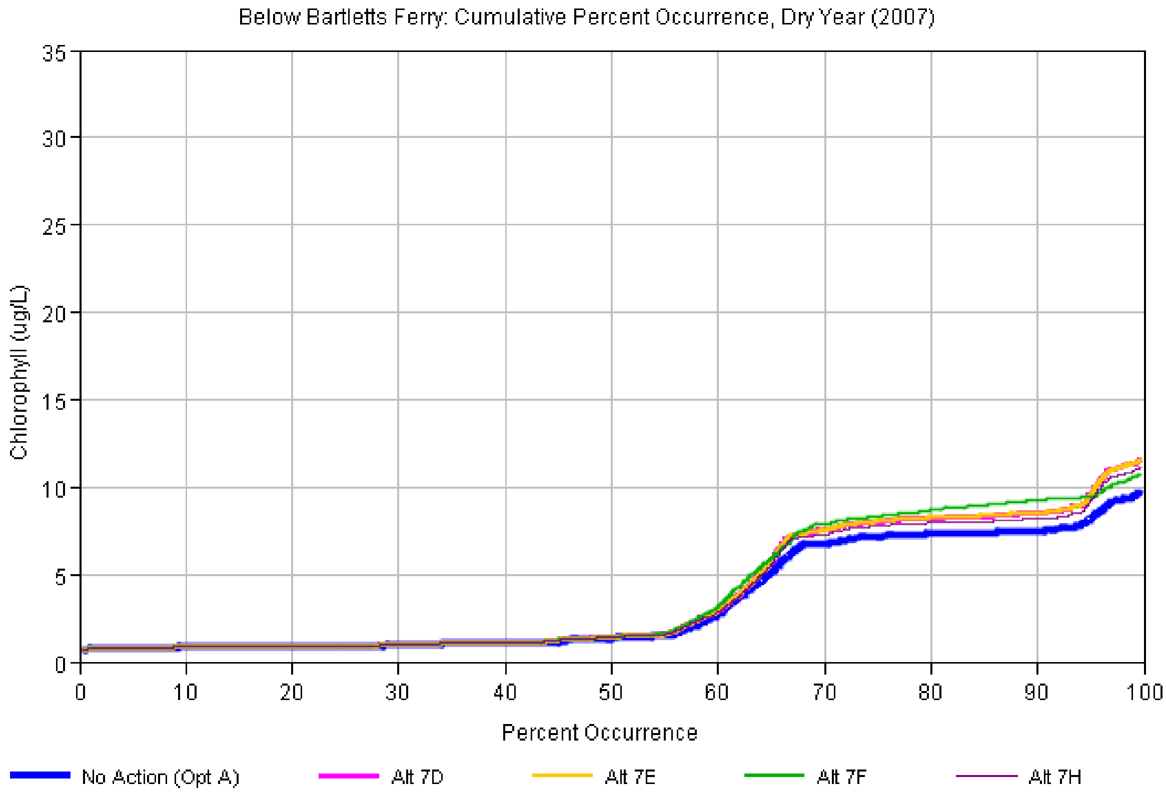


Figure 2.2-37. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Bartletts Ferry Lake for a representative dry year (2007).

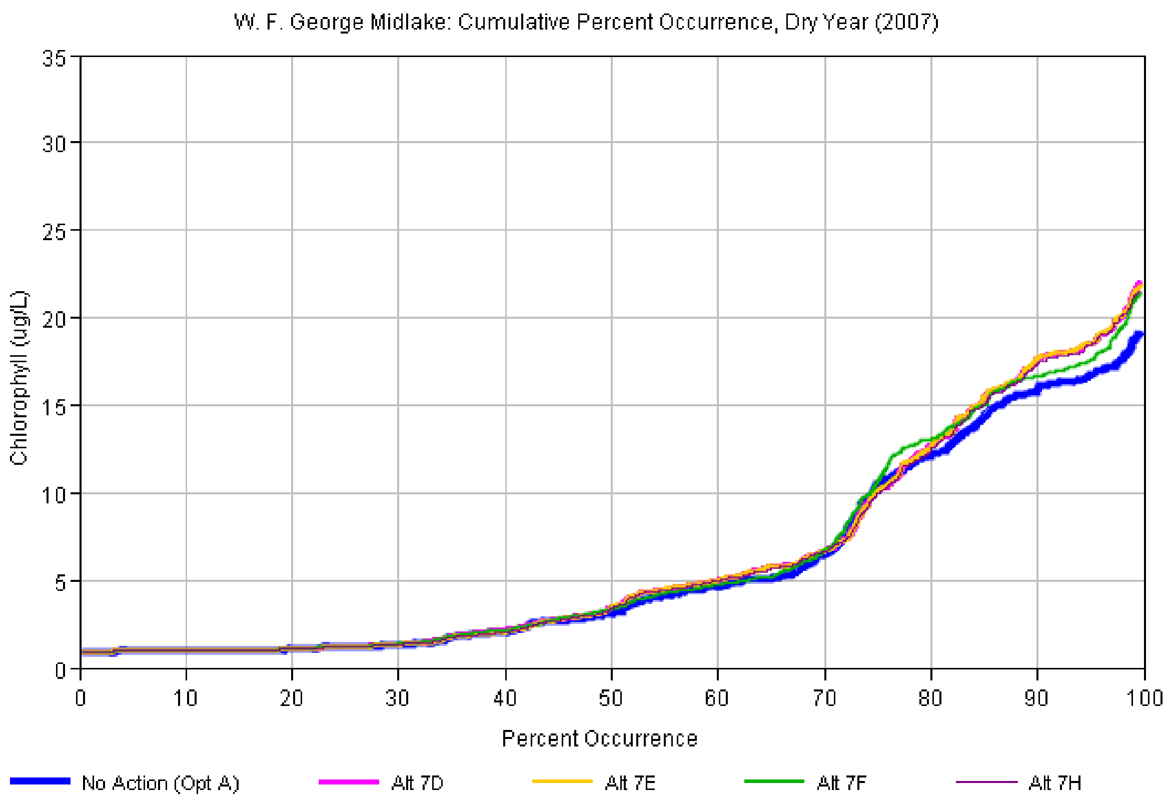


Figure 2.2-38. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Walter F. George Lake for a representative dry year (2007).

Table 2.2-1. Growing season (April-October) average and annual geometric mean of chlorophyll *a* at USACE reservoirs in the ACF Basin

Year	Modeled (µg/L)		Change from No Action Alternative (µg/L)
	No Action	Proposed Action	PAA
	Lake Sidney Lanier[a]		
2000	2.6	5.7	3.1
2001	3.2	4.2	0.9
2002	3.8	4.8	1
2003	3.7	4.3	0.6
2004	4.6	5.2	0.6
2005	4.2	4.8	0.5
2006	4.1	4.7	0.6

Year	Modeled (µg/L)		Change from No Action Alternative (µg/L)
	No Action	Proposed Action	PAA
2007	4.2	4.9	0.7
2008	4	4.7	0.7
2009	4.2	4.7	0.5
2010	4.1	4.6	0.5
2011	4.2	4.9	0.6
West Point Mid-Lake[a]			
2000	7.9	12.1	4.1
2001	8.1	8.4	0.4
2002	11.1	11.9	0.7
2003	4.4	4.5	0.1
2004	5.8	6.4	0.7
2005	4.1	4.3	0.1
2006	7.2	7.5	0.3
2007	9.4	9.8	0.4
2008	10.7	11.2	0.4
2009	7.8	9.2	1.3
2010	6.2	6.7	0.5
2011	8.1	9.8	1.7
Walter F. George Mid-Lake[a]			
2000	9.3	9.9	0.6
2001	7.7	8.1	0.5
2002	8.1	8.8	0.7
2003	4.9	5.1	0.3
2004	7	7.7	0.6
2005	4.9	5.2	0.3
2006	8.3	9.2	0.9
2007	9	9.5	0.5
2008	9.3	10.1	0.7
2009	6.9	7.4	0.5
2010	5.9	6.3	0.4
2011	8.1	8.5	0.4
Lake Seminole Mid-Lake[b]			
2000	3.3	3.4	0.1
2001	2.4	2.5	0.1

Year	Modeled (µg/L)		Change from No Action Alternative (µg/L)
	No Action	Proposed Action	PAA
2002	3	3.2	0.2
2003	3.2	3.3	0.1
2004	3.1	3.2	0.1
2005	3.1	3.2	0.1
2006	3	3.3	0.3
2007	3.3	3.6	0.4
2008	3.3	3.6	0.3
2009	2.7	2.8	0.1
2010	2.7	2.7	0.1
2011	2.9	3.1	0.3

[a]: Based on growing season average
[b]: Based on geometric mean for the modeled period

2.2.5 Retention

a. Average summer retention time (days).

Table 2.2-2 presents monthly retention times for the water quality model period (2001 through 2011).

Table 2.2-2. Monthly retention times (in days) for reservoirs on the Chattahoochee River for the period from 2001 through 2011

Retention time (days)

Year-Month	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
01-Jan	1003	1241	1	1	74	74	24	24	1	1	4	4	0.2	0.2	72	72	1.4	1.4	14	14
01-Feb	1185	1292	1	1	68	67	20	20	1	1	3	3	0.2	0.2	70	70	1.4	1.4	15	15
01-Mar	1369	1319	1	1	29	28	7	7	0	0	1	1	0.1	0.0	15	15	0.3	0.3	3	3
01-Apr	1222	958	1	1	65	60	14	14	1	1	2	2	0.1	0.1	35	34	0.7	0.7	5	5
01-May	1109	905	1	1	147	133	37	34	2	2	6	6	0.3	0.3	162	134	2.8	2.4	20	19
01-Jun	1273	944	1	1	84	81	24	23	1	1	4	4	0.2	0.2	69	70	1.2	1.2	11	11
01-Jul	902	704	1	1	110	103	30	27	1	1	5	5	0.2	0.2	130	119	2.3	2.1	17	16
01-Aug	666	665	1	1	104	107	32	32	1	1	5	5	0.2	0.2	129	115	2.3	2.1	21	20
01-Sep	671	663	1	1	102	107	38	39	2	2	6	7	0.3	0.3	146	155	2.7	2.8	23	24
01-Oct	610	825	1	1	76	112	35	48	2	2	6	8	0.3	0.4	116	133	2.3	2.6	25	26
01-Nov	588	862	1	1	81	126	30	37	1	2	5	6	0.2	0.3	110	132	2.2	2.7	26	29
01-Dec	616	850	1	1	86	119	35	40	2	2	6	7	0.3	0.3	130	148	2.6	3.0	23	23
02-Jan	893	1210	1	1	78	52	28	21	1	1	5	3	0.2	0.2	92	68	1.8	1.4	20	16
02-Feb	1236	1311	1	1	64	91	23	29	1	1	4	5	0.2	0.2	64	77	1.2	1.5	14	16
02-Mar	1375	1439	1	1	112	97	25	22	1	1	4	4	0.2	0.2	65	63	1.3	1.2	13	13
02-Apr	1126	1020	1	1	106	104	31	30	1	1	5	5	0.2	0.2	75	73	1.5	1.5	13	12
02-May	1111	893	1	1	108	91	36	31	2	1	6	5	0.3	0.2	163	106	3.0	2.1	24	22
02-Jun	945	838	1	1	167	170	54	54	2	2	9	9	0.4	0.4	291	230	4.9	4.3	34	32
02-Jul	875	784	1	1	148	154	45	45	2	2	7	7	0.3	0.3	195	182	3.6	3.6	32	32
02-Aug	713	650	1	1	135	144	52	53	2	2	9	9	0.4	0.4	223	242	4.2	4.7	32	32
02-Sep	847	889	1	1	139	153	44	45	2	2	7	7	0.3	0.3	166	235	3.3	4.6	24	28
02-Oct	634	1005	1	1	91	103	23	25	1	1	4	4	0.2	0.2	145	150	2.9	3.0	21	21
02-Nov	693	959	1	1	57	57	14	14	1	1	2	2	0.1	0.1	63	65	1.2	1.3	11	11
02-Dec	695	926	1	1	34	35	10	11	0	0	2	2	0.1	0.1	42	43	0.8	0.8	10	10
03-Jan	669	628	1	1	68	60	19	18	1	1	3	3	0.1	0.1	77	67	1.5	1.4	12	10
03-Feb	746	659	1	1	47	47	12	12	1	1	2	2	0.1	0.1	38	39	0.7	0.8	8	9
03-Mar	330	281	0	0	32	30	8	7	0	0	1	1	0.1	0.1	25	24	0.5	0.5	4	4
03-Apr	459	478	0	0	53	53	10	10	0	0	2	2	0.1	0.1	34	33	0.7	0.7	6	6

	Retention time (days)																			
	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
Year-Month	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
03-May	294	297	0	0	20	21	5	5	0	0	1	1	0.0	0.0	25	25	0.4	0.4	5	5
03-Jun	293	303	0	0	24	24	6	6	0	0	1	1	0.0	0.0	25	25	0.4	0.4	5	5
03-Jul	303	311	0	0	35	35	9	9	0	0	1	1	0.1	0.1	30	30	0.5	0.5	6	6
03-Aug	482	495	0	0	68	69	16	16	1	1	3	3	0.1	0.1	53	53	0.9	0.9	8	8
03-Sep	622	611	1	1	106	104	26	26	1	1	4	4	0.2	0.2	111	110	1.9	1.9	14	14
03-Oct	609	599	1	1	106	104	31	30	1	1	5	5	0.2	0.2	89	88	1.7	1.6	16	16
03-Nov	503	581	0	1	37	38	12	12	1	1	2	2	0.1	0.1	51	52	1.0	1.0	13	14
03-Dec	539	544	1	1	36	36	15	15	1	1	2	2	0.1	0.1	57	57	1.1	1.1	12	12
04-Jan	635	293	1	0	50	36	17	13	1	1	3	2	0.1	0.1	48	40	0.9	0.8	12	11
04-Feb	391	678	0	1	33	39	10	11	0	0	2	2	0.1	0.1	28	30	0.6	0.6	6	7
04-Mar	464	424	0	0	69	64	19	18	1	1	3	3	0.1	0.1	65	56	1.3	1.2	11	9
04-Apr	521	353	1	0	89	62	22	17	1	1	4	3	0.2	0.1	83	65	1.6	1.4	16	13
04-May	560	953	1	1	83	136	23	33	1	2	4	6	0.2	0.3	96	140	1.9	2.8	15	20
04-Jun	756	971	1	1	127	126	28	28	1	1	5	5	0.2	0.2	149	149	2.7	2.8	18	20
04-Jul	756	723	1	1	100	115	22	23	1	1	4	4	0.2	0.2	120	140	2.1	2.4	17	17
04-Aug	755	718	1	1	114	113	23	22	1	1	4	4	0.2	0.2	122	119	2.1	2.1	20	20
04-Sep	587	695	0	0	54	54	12	12	1	1	2	2	0.1	0.1	45	45	0.8	0.8	8	8
04-Oct	560	634	1	1	91	100	22	24	1	1	4	4	0.2	0.2	75	79	1.4	1.5	11	12
04-Nov	440	637	0	0	29	31	9	9	0	0	1	2	0.1	0.1	33	34	0.7	0.7	9	10
04-Dec	291	292	0	0	27	27	9	9	0	0	2	2	0.1	0.1	35	35	0.7	0.7	8	8
05-Jan	575	586	1	1	52	51	16	16	1	1	3	3	0.1	0.1	51	51	1.0	1.0	10	10
05-Feb	343	361	0	0	31	31	9	9	0	0	2	2	0.1	0.1	31	32	0.6	0.6	8	8
05-Mar	304	310	0	0	26	26	6	6	0	0	1	1	0.0	0.0	23	23	0.8	0.8	5	5
05-Apr	396	401	0	0	34	34	8	8	0	0	1	1	0.1	0.1	18	18	0.3	0.3	3	3
05-May	392	443	0	0	65	69	16	17	1	1	3	3	0.1	0.1	70	69	1.3	1.3	9	9
05-Jun	422	409	0	0	69	67	15	14	1	1	2	2	0.1	0.1	50	51	0.9	0.9	8	8
05-Jul	298	305	0	0	22	22	6	6	0	0	1	1	0.0	0.0	22	22	0.4	0.4	4	4
05-Aug	296	303	0	0	43	44	11	11	0	0	2	2	0.1	0.1	37	37	0.6	0.6	7	7
05-Sep	508	521	1	1	96	98	26	27	1	1	4	4	0.2	0.2	117	119	2.0	2.0	14	14
05-Oct	637	625	1	1	121	119	32	32	1	1	5	5	0.2	0.2	89	88	1.7	1.7	16	16

	Retention time (days)																			
	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
Year-Month	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
05-Nov	610	606	1	1	57	56	19	19	1	1	3	3	0.1	0.1	68	67	1.3	1.3	16	16
05-Dec	601	602	1	1	43	43	16	16	1	1	3	3	0.1	0.1	53	53	1.0	1.0	11	11
06-Jan	393	440	0	0	31	32	13	13	1	1	2	2	0.1	0.1	40	41	0.8	0.8	8	8
06-Feb	462	474	0	0	34	34	11	11	1	1	2	2	0.1	0.1	35	35	0.7	0.7	8	8
06-Mar	499	502	0	0	52	52	13	13	1	1	2	2	0.1	0.1	39	39	0.8	0.7	8	8
06-Apr	438	382	0	0	75	63	22	19	1	1	4	3	0.2	0.1	61	56	1.2	1.1	12	11
06-May	466	322	1	0	74	56	24	19	1	1	4	3	0.2	0.1	89	56	1.6	1.2	14	11
06-Jun	698	881	1	1	119	117	36	37	2	2	6	6	0.3	0.3	177	155	3.3	3.2	27	26
06-Jul	668	719	1	1	96	138	37	53	2	2	6	9	0.3	0.4	137	254	2.7	4.9	26	35
06-Aug	649	789	1	1	150	148	50	50	2	2	8	8	0.4	0.4	193	195	3.8	4.0	32	31
06-Sep	656	809	1	1	104	151	36	49	2	2	6	8	0.3	0.4	150	202	2.9	4.0	25	28
06-Oct	660	838	1	1	88	128	32	41	1	2	5	7	0.2	0.3	142	189	2.8	3.7	25	31
06-Nov	681	900	1	1	88	80	24	22	1	1	4	4	0.2	0.2	81	80	1.6	1.6	17	17
06-Dec	701	920	1	1	76	80	24	26	1	1	4	4	0.2	0.2	87	91	1.7	1.8	19	19
07-Jan	722	980	1	1	47	49	14	14	1	1	2	2	0.1	0.1	46	47	0.9	0.9	9	9
07-Feb	744	1013	1	1	71	80	19	20	1	1	3	3	0.1	0.2	59	62	1.2	1.2	10	11
07-Mar	708	576	1	1	81	84	20	20	1	1	3	3	0.2	0.2	52	54	1.0	1.1	9	10
07-Apr	528	302	1	0	141	75	34	22	2	1	6	4	0.3	0.2	78	56	1.6	1.2	13	10
07-May	526	456	1	1	99	91	33	31	2	1	6	5	0.3	0.2	157	125	3.2	2.7	24	22
07-Jun	819	665	1	1	141	144	49	49	2	2	8	8	0.4	0.4	191	182	3.9	3.9	33	33
07-Jul	770	819	1	1	136	137	54	53	2	2	9	9	0.4	0.4	195	200	4.0	4.3	32	33
07-Aug	600	639	1	1	111	107	53	51	2	2	9	8	0.4	0.4	157	154	3.4	3.4	33	33
07-Sep	612	591	1	1	104	100	51	50	2	2	8	8	0.4	0.4	175	171	3.9	3.9	33	33
07-Oct	444	390	1	1	84	85	45	45	2	2	7	7	0.3	0.3	186	184	4.2	4.2	33	33
07-Nov	567	675	1	1	90	99	48	53	2	2	8	8	0.4	0.4	167	200	3.7	4.4	34	38
07-Dec	814	812	1	1	120	118	47	47	2	2	8	8	0.4	0.4	249	256	5.0	5.1	32	33
08-Jan	1012	964	1	1	87	107	26	28	1	1	4	5	0.2	0.2	70	73	1.4	1.5	12	12
08-Feb	1198	1134	1	1	98	95	22	21	1	1	4	3	0.2	0.2	46	46	0.9	0.9	7	7
08-Mar	1311	1240	1	1	87	83	21	21	1	1	4	3	0.2	0.2	55	54	1.1	1.1	8	8
08-Apr	1098	1015	1	1	119	121	27	27	1	1	4	4	0.2	0.2	64	64	1.3	1.3	10	10

Retention time (days)

Year-Month	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
08-May	975	798	1	1	166	131	39	33	2	2	6	6	0.3	0.3	249	146	4.4	2.9	23	21
08-Jun	747	622	1	1	162	161	49	49	2	2	8	8	0.4	0.4	273	207	5.1	4.2	32	30
08-Jul	811	665	1	1	149	151	46	46	2	2	8	8	0.4	0.4	217	202	4.1	4.1	30	30
08-Aug	818	681	1	1	162	167	35	35	2	2	6	6	0.3	0.3	109	143	1.9	2.4	16	17
08-Sep	665	547	1	1	141	149	45	45	2	2	8	8	0.4	0.4	146	146	2.8	2.8	18	18
08-Oct	770	627	1	1	97	128	37	42	2	2	6	7	0.3	0.3	135	141	2.6	2.7	23	24
08-Nov	745	666	1	1	108	134	47	50	2	2	8	8	0.3	0.4	93	99	1.8	1.9	19	20
08-Dec	696	912	1	1	76	67	26	22	1	1	4	4	0.2	0.2	45	43	0.9	0.8	7	7
09-Jan	677	957	1	1	61	69	21	22	1	1	3	4	0.2	0.2	58	61	1.1	1.2	11	11
09-Feb	984	916	1	1	95	99	28	28	1	1	5	5	0.2	0.2	79	82	1.6	1.7	15	16
09-Mar	1338	1237	1	1	43	41	9	9	0	0	2	1	0.1	0.1	25	24	0.6	0.6	6	6
09-Apr	1019	1254	1	1	63	63	13	13	1	1	2	2	0.1	0.1	23	23	0.4	0.4	3	3
09-May	743	1035	1	1	102	119	22	25	1	1	4	4	0.2	0.2	61	63	1.1	1.1	9	9
09-Jun	681	786	1	1	108	105	30	30	1	1	5	5	0.2	0.2	96	99	1.7	1.8	12	12
09-Jul	658	779	1	1	138	162	44	52	2	2	7	9	0.3	0.4	145	146	2.7	2.8	20	20
09-Aug	667	811	1	1	142	169	42	50	2	2	7	8	0.3	0.4	157	162	2.8	3.0	21	22
09-Sep	698	1003	0	0	30	31	9	10	0	0	2	2	0.1	0.1	38	41	0.7	0.7	10	11
09-Oct	651	670	0	0	40	41	10	10	0	0	2	2	0.1	0.1	33	33	0.6	0.6	9	9
09-Nov	272	381	0	0	20	22	6	6	0	0	1	1	0.0	0.0	19	20	0.4	0.4	5	6
09-Dec	202	204	0	0	15	15	5	5	0	0	1	1	0.0	0.0	11	11	0.2	0.2	3	3
10-Jan	247	250	0	0	24	24	7	7	0	0	1	1	0.1	0.1	20	20	0.4	0.4	4	4
10-Feb	216	219	0	0	22	22	7	7	0	0	1	1	0.1	0.1	19	19	0.4	0.4	3	3
10-Mar	300	305	0	0	27	27	7	7	0	0	1	1	0.1	0.1	22	22	0.4	0.4	5	5
10-Apr	480	494	0	0	65	66	17	17	1	1	3	3	0.1	0.1	54	54	1.1	1.1	10	10
10-May	339	369	0	0	46	47	12	12	1	1	2	2	0.1	0.1	41	40	0.7	0.7	7	7
10-Jun	620	610	1	1	98	98	27	27	1	1	4	4	0.2	0.2	96	101	1.7	1.8	13	13
10-Jul	617	601	1	1	113	117	34	34	2	2	6	6	0.3	0.3	137	137	2.5	2.5	18	18
10-Aug	598	583	1	1	112	115	36	37	2	2	6	6	0.3	0.3	145	147	2.6	2.7	22	22
10-Sep	571	646	1	1	97	98	35	36	2	2	6	6	0.3	0.3	152	152	2.8	2.8	28	28
10-Oct	602	687	1	1	93	113	35	41	2	2	6	7	0.3	0.3	125	133	2.3	2.5	25	24

	Retention time (days)																			
	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
Year-Month	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
10-Nov	679	703	1	1	80	85	29	30	1	1	5	5	0.2	0.2	101	106	2.0	2.1	21	22
10-Dec	561	703	1	1	65	67	24	24	1	1	4	4	0.2	0.2	92	89	1.8	1.8	19	19
11-Jan	708	506	1	1	79	39	26	17	1	1	4	3	0.2	0.1	88	47	1.7	1.1	17	12
11-Feb	743	986	1	1	54	101	16	24	1	1	3	4	0.1	0.2	46	75	0.9	1.4	10	12
11-Mar	464	530	0	0	42	43	12	13	1	1	2	2	0.1	0.1	38	38	0.7	0.7	10	10
11-Apr	281	223	0	0	45	40	13	12	1	1	2	2	0.1	0.1	47	43	0.9	0.8	10	9
11-May	357	256	0	0	75	49	24	17	1	1	4	3	0.2	0.1	126	63	2.4	1.4	22	16
11-Jun	648	813	1	1	127	115	46	46	2	2	8	7	0.3	0.3	178	157	3.4	3.3	34	32
11-Jul	682	768	1	1	139	132	48	51	2	2	8	8	0.4	0.4	176	221	3.3	4.3	29	35
11-Aug	618	643	1	1	121	119	48	53	2	2	8	9	0.4	0.4	165	174	3.2	3.5	34	34
11-Sep	619	695	1	1	99	112	35	41	2	2	6	7	0.3	0.3	132	134	2.7	2.9	33	33
11-Oct	607	662	1	1	106	98	48	50	2	2	8	8	0.4	0.4	163	158	3.5	3.6	34	33
11-Nov	632	471	1	1	79	69	36	34	2	2	6	6	0.3	0.3	136	149	3.0	3.3	32	33
11-Dec	663	1126	1	1	91	109	28	33	1	1	5	5	0.2	0.3	142	198	2.9	3.9	32	35
Overall Median	643	665	1	1	82	85	24	24	1	1	4	4	0	0	79	72	2	1	14	14
Apr-Oct Median	637	665	1	1	102	105	32	31	1	1	5	5	0	0	125	125	2	2	18	18
Apr-Oct Average	654	660	1	1	98	101	30	31	1	1	5	5	0	0	118	117	2	2	19	19

2.2.6 Phosphorus

a. Average summer phosphorus loading (pounds/acre/month).

Alabama, Florida, and Georgia have established criteria for reservoirs and lakes in the ACF Basin for total phosphorus (TP) loads. The nutrient criteria for TP in major headwaters contributing to the lakes in Georgia and Alabama are based on annual loads in pounds. In accordance with the water quality standards set by Alabama and Georgia, the TP annual loading for West Point Lake headwaters at Chattahoochee River at U.S. Highway 27 should not exceed 1,400,000 lbs and for Walter F. George Lake headwaters, the annual TP loading at Chattahoochee River at U.S. Highway 39 should not exceed 2,000,000 lbs. The calculated TP loads for the NAA and the PAA are shown in Table 2.2-3. The loads were calculated using the HEC-5Q model outputs of TP concentrations (mg/L) and modeled flows (cfs) with proper conversion factors applied to derive annual loads in lbs. The numbers in the table are annual TP loads in lbs. Florida has nutrient criteria established for freshwater streams. As per Florida's standards, the final numeric nutrient criteria for freshwater streams in Florida Panhandle West for TP is 0.06 mg/L and 0.01 mg/L for clear lakes with a range of 0.01-0.03 mg/L.

Table 2.2-3. Total phosphorus loads at West Point Lake headwaters and Walter F. George Lake headwaters for the modeled period (2001–2011)

		Annual total phosphorus loads in lbs	
Year	**Location**	**No Action**	**Proposed Action**
2001	West Point Lake headwaters	712,042	819,239
	Walter F. George Lake headwaters	1,373,380	1,496,488
2002	West Point Lake headwaters	670,891	796,697
	Walter F. George Lake headwaters	1,079,952	1,202,749
2003	West Point Lake headwaters	1,270,703	1,408,768
	Walter F. George Lake headwaters	1,954,469	2,098,159

2004	West Point Lake headwaters	883,364	987,643
	Walter F. George Lake headwaters	1,451,393	1,562,383
2005	West Point Lake headwaters	1,116,965	1,232,542
	Walter F. George Lake headwaters	2,010,591	2,144,219
2006	West Point Lake headwaters	705,698	794,918
	Walter F. George Lake headwaters	1,198,458	1,286,756
2007	West Point Lake headwaters	469,004	564,871
	Walter F. George Lake headwaters	922,982	1,025,569
2008	West Point Lake headwaters	441,386	518,935
	Walter F. George Lake headwaters	1,159,097	1,258,390
2009	West Point Lake headwaters	1,245,841	1,352,346
	Walter F. George Lake headwaters	2,399,330	2,560,087

2010	West Point Lake headwaters	851,467	936,327
	Walter F. George Lake headwaters	1,555,310	1,643,827
2011	West Point Lake headwaters	628,419	735,635
	Walter F. George Lake headwaters	1,048,589	1,153,484

Longitudinal profiles were used as an initial indication of changes that would be expected between the NAA and the PAA. Figure 2.2-39 through Figure 2.2-41 illustrates the response of TP to changes between the NAA and the PAA. Figure 2.2-42 and Figure 2.2-43 illustrate the change in TP between the NAA and the PAA for the modeled period and a representative dry year when the greatest variation would be expected.

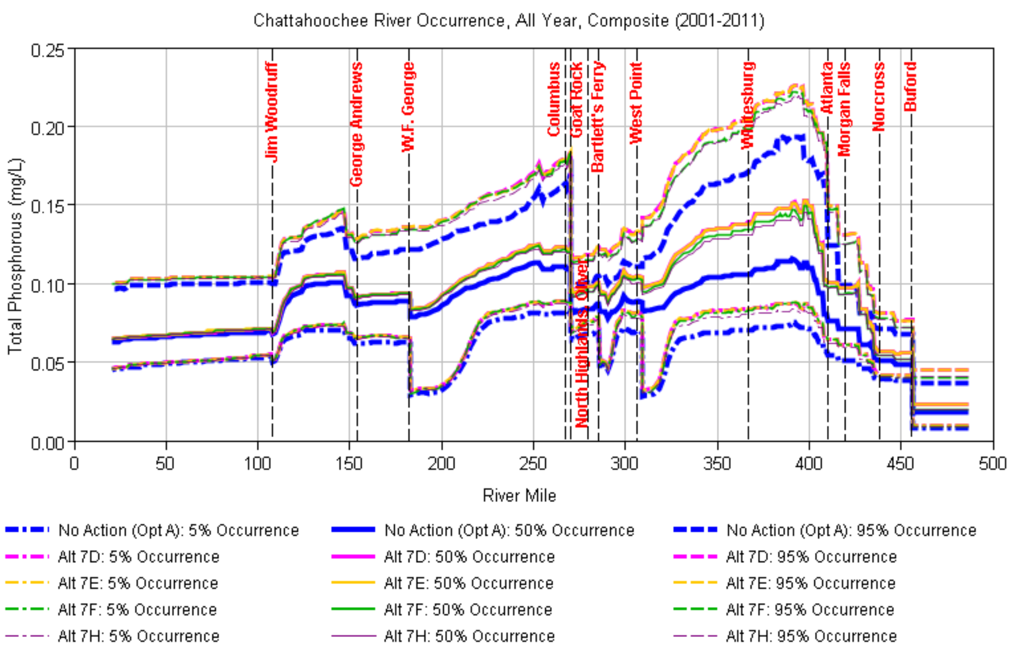


Figure 2.2-39. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for the period 2001-2011 for the NAA and the PAA

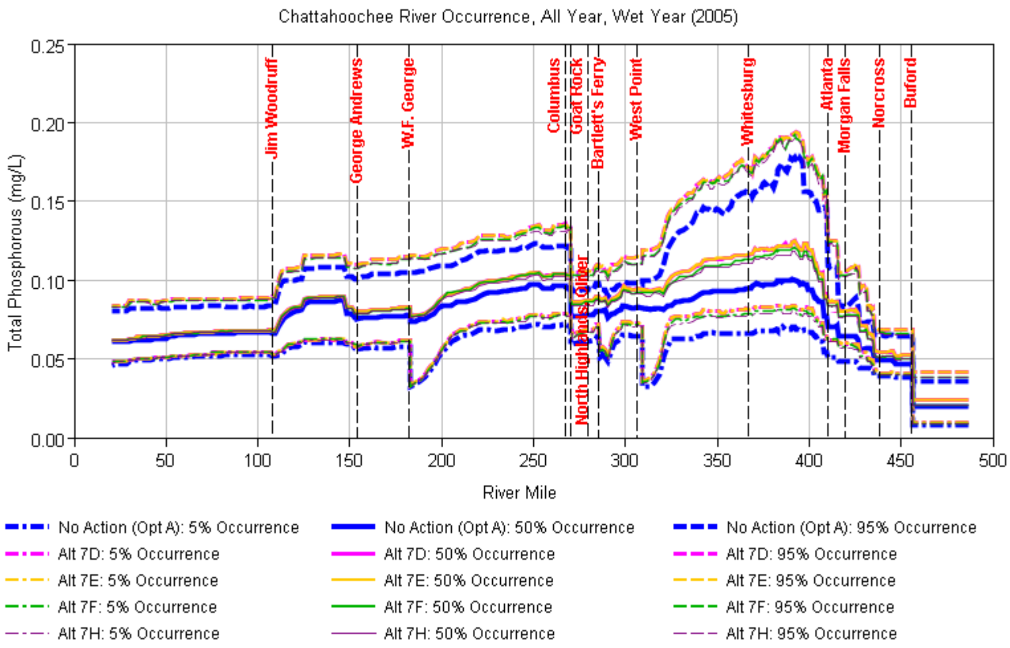


Figure 2.2-40. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a wet year (2005) for the NAA and the PAA

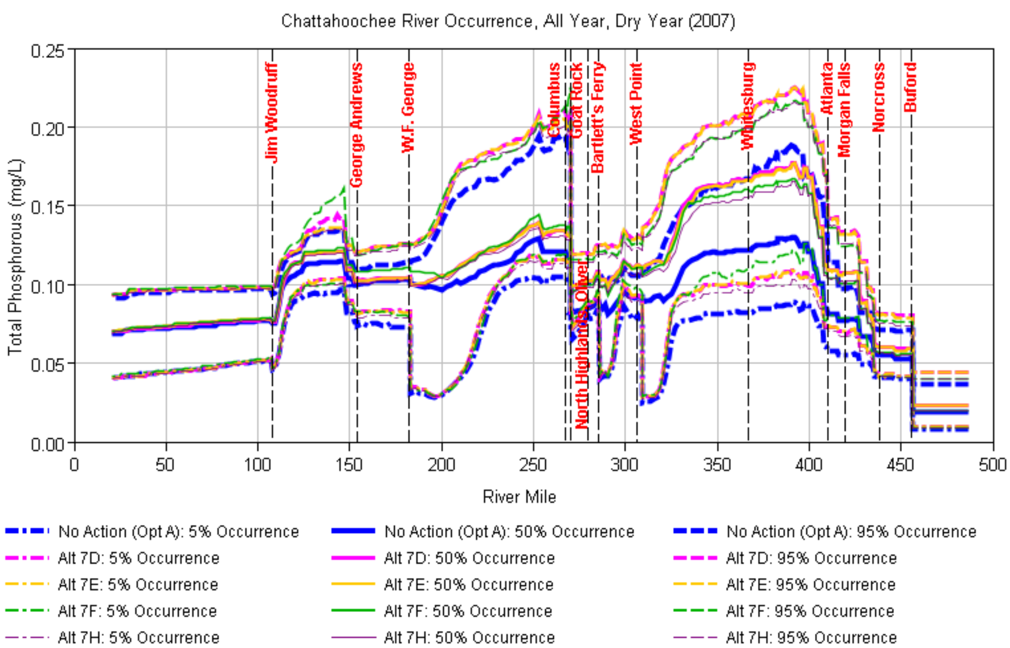


Figure 2.2-41. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a dry year (2007) for the NAA and the PAA

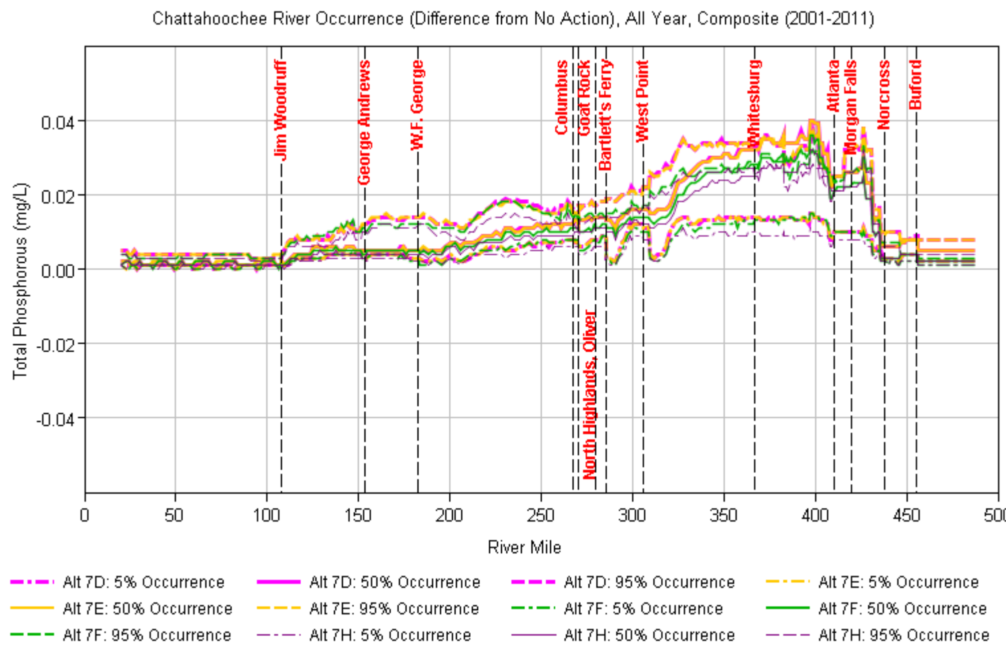


Figure 2.2-42. Longitudinal profile of change in daily total phosphorus in the ACF Basin from the NAA for the PAA for the model period (2001-2011)

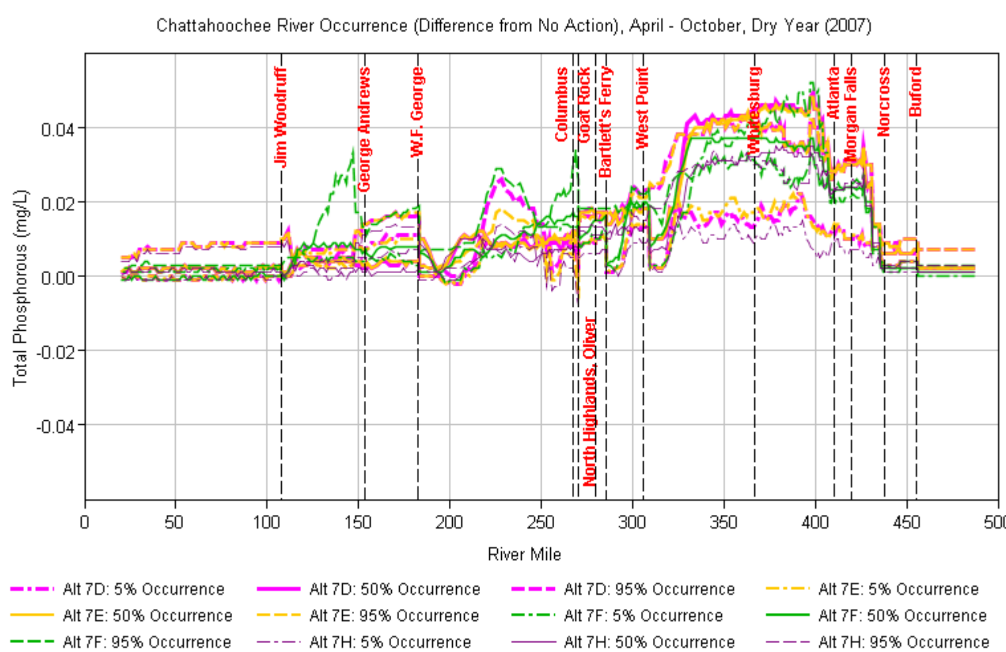


Figure 2.2-43. Longitudinal profile of change in daily total phosphorus from the NAA in the ACF Basin during growing season (April through October) of a dry year (2007) for the PAA

2.3 Floodplain Connectivity Analyses

A complete set of the Apalachicola River floodplain LIDAR data is not available and therefore this was not used in this analysis. However, available data was used to determine the annual maximum 30-day growing season floodplain connectivity as described in the 2013 PAL. These results are illustrated in Figure 2.3-1 and Figure 2.3-2. Given that conditions in the PAA are very similar to those for the 2012 RIOP, little change would be expected.

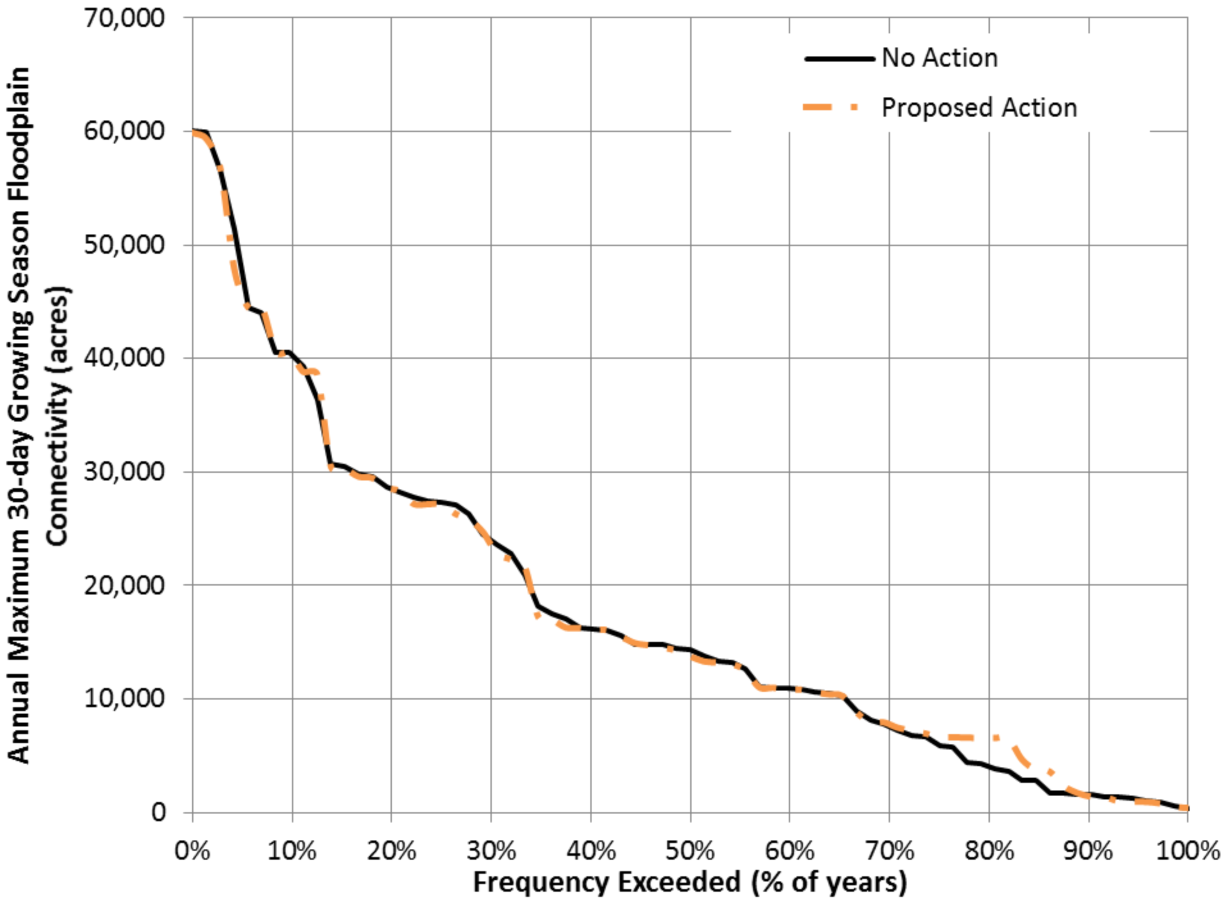


Figure 2.3-1. Frequency of annual maximum 30-day growing season (April through September) floodplain connectivity in acres for the NAA and PAA over the modeled period

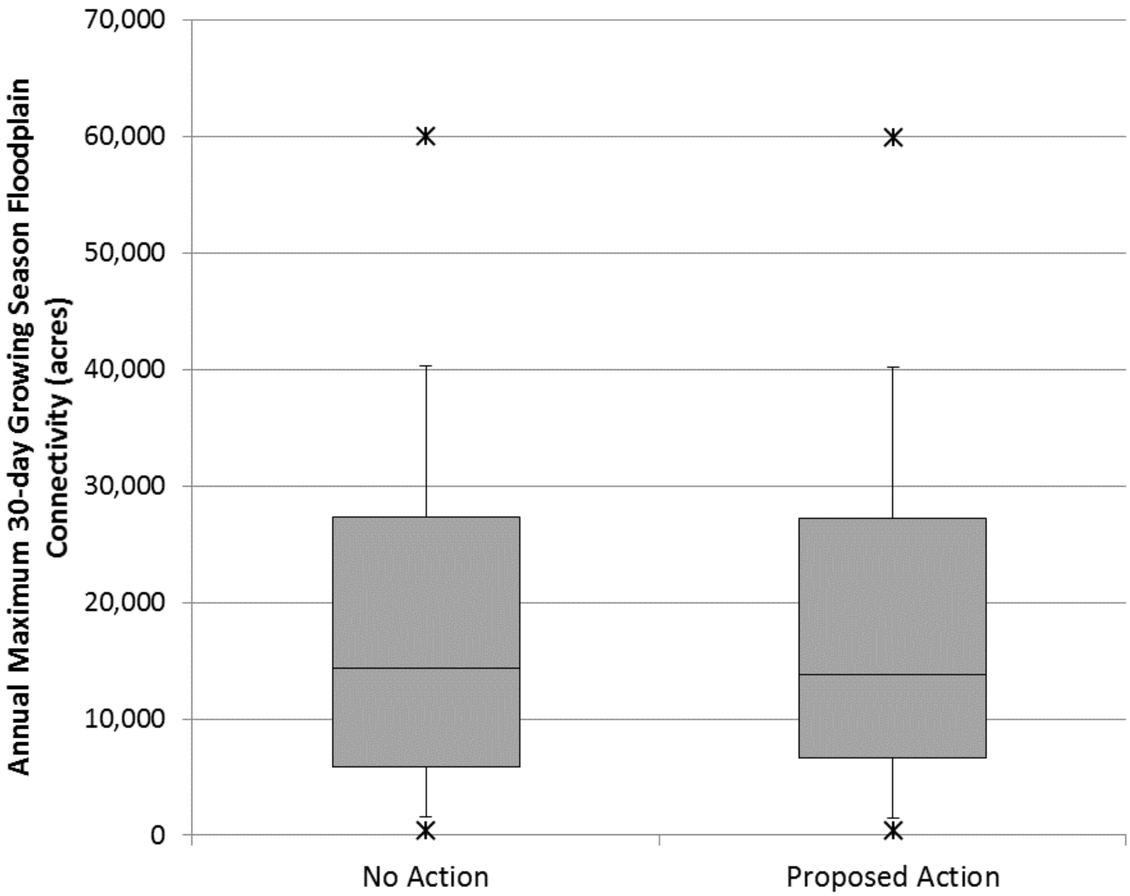


Figure 2.3-2. Statistics (minimum; 10th, 25th, 50th, 75th, and 90th percentiles; and maximum) for the annual maximum 30-day growing season (April through September) floodplain connectivity in acres for the NAA and PAA over the modeled period

Similar results would be expected along the Chattahoochee River; given that conditions in the PAA are very similar to the NAA, little change would be expected. The Chattahoochee River is essentially disconnected from its floodplain, so floodplain connectivity would not be influenced by the different alternatives. Changes in streamflow on the Chattahoochee River from Norcross to Columbus are minor and would not be expected to reach flows defined in Table 1 of the 2010 PAL. USACE manages operations to reduce flooding. Flood risk management operations would remain unchanged from those currently employed.

2.4 Reservoir Fisheries Analyses

Reservoir fisheries were evaluated using methods described in the 2013 PAL. Previous work based on Ryder et al. (1996) was not used for this analysis.

Operational flow changes would affect habitat for reservoir fisheries and other aquatic resources mainly through changes in water levels, reservoir flushing rates (retention times), and associated changes in water quality parameters, such as nutrient loading and DO concentrations. Seasonal water level fluctuations can substantially change the area of shallow-water habitats and inundated shoreline vegetation in reservoirs and, in turn, influence the reproductive success of resident fish populations.

Substantial daily or weekly fluctuations in reservoir levels associated with hydroelectric power generation peaking operations could adversely affect reservoir fisheries by dewatering spawning and nursery habitats for littoral species, exposing nests and eggs deposited in shallow-water habitats, and reducing the availability of shoreline cover and its associated invertebrate food supply. Performance measures developed by the USFWS were used in this evaluation, specifically to assess reservoir fisheries habitat, based on the assumption that a greater departure of reservoir levels from optimum (e.g., littoral spawning, rearing) results in a greater effect on habitats, including loss. The Reservoir Fisheries Performance Measure (RFPM) was recommended by the USFWS because it specifically characterizes the spatial extent of the reservoir most likely to support successful fish survival and reproduction as a direct function of containing suitable habitat features.

The effect of the alternatives on reservoir fisheries was determined using the area (in acres) of productive zone inundated for more than 30 days during the spawning season, as calculated using the RFPM. The inundated productive zone was defined for each reservoir and is presented in Figure 2.4-1, Figure 2.4-2, and Figure 2.4-3. These figures illustrate little difference between median values of the productive zone between the NAA and PAA.

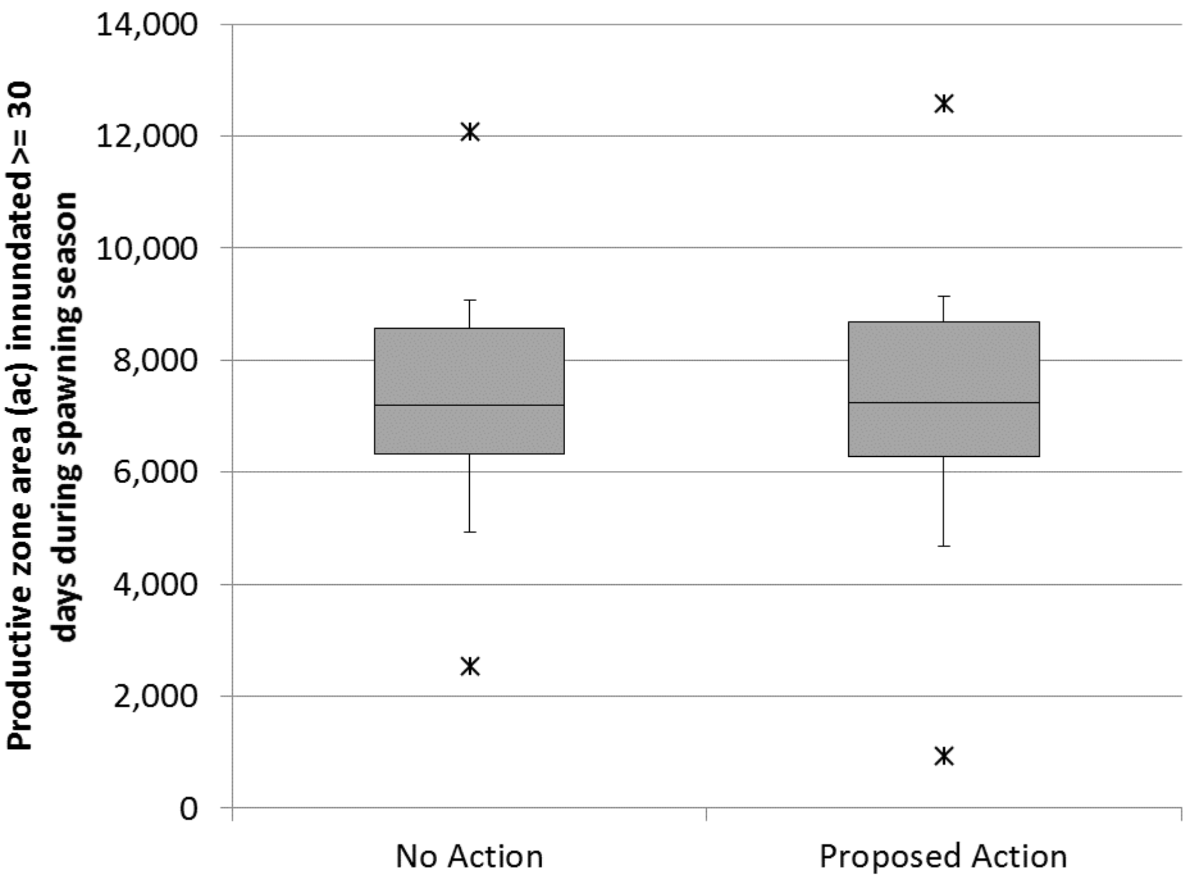


Figure 2.4-1. Reservoir fisheries performance measure results for the NAA and PAA at Lake Sidney Lanier

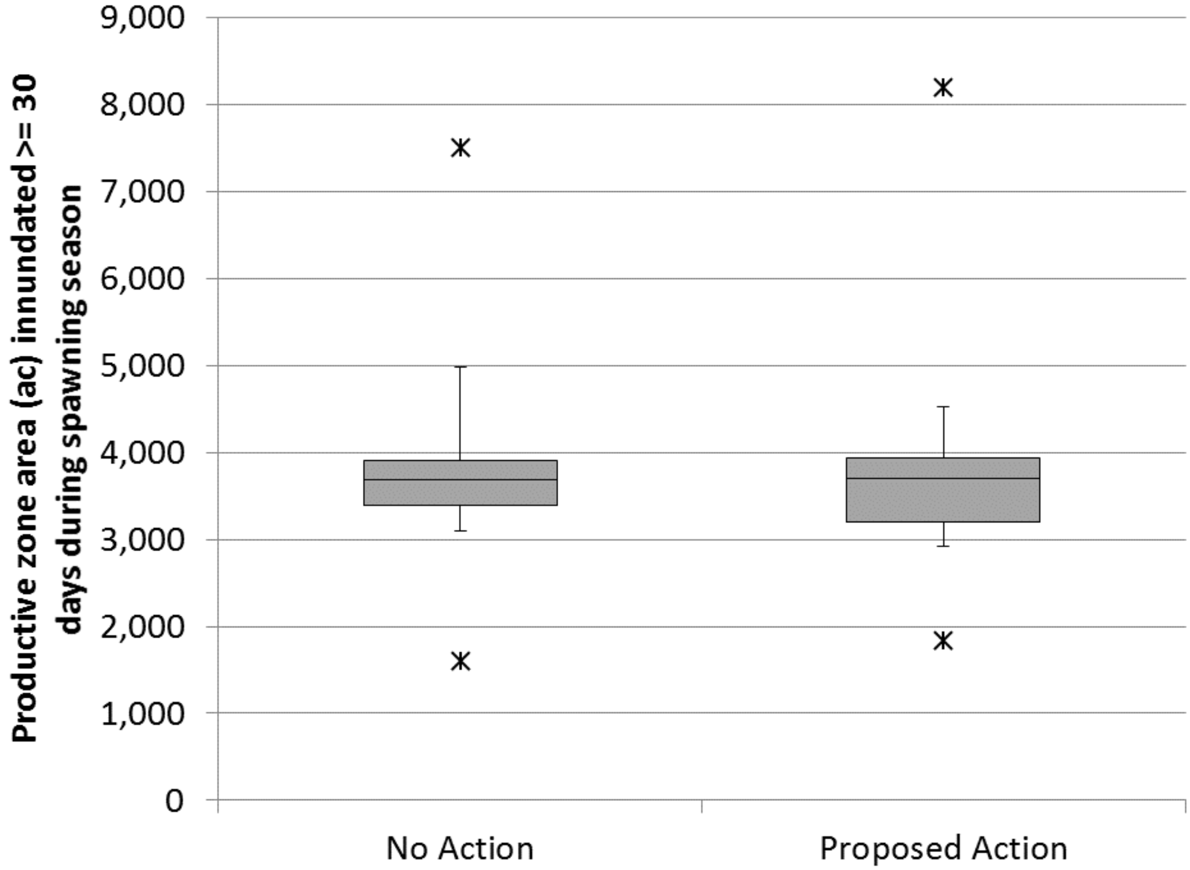


Figure 2.4-2. Reservoir fisheries performance measure results for the NAA and PAA at West Point Lake

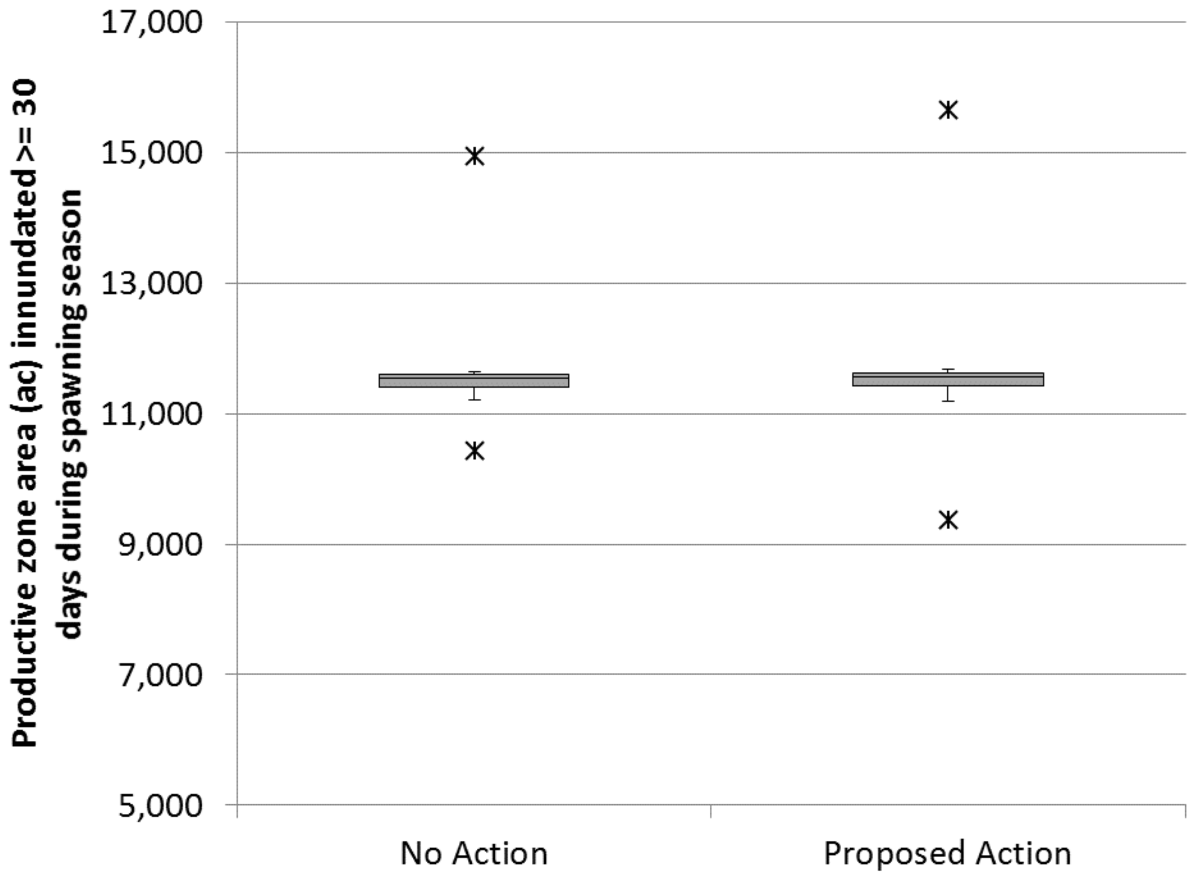


Figure 2.4-3. Reservoir fisheries performance measure results for the NAA and PAA at Walter F. George Lake

2.5 Riverine Fisheries Analyses

Sport fisheries are important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. The survival and reproduction of many fishes are intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. There are existing effects of controlled flows in the ACF Basin on lateral connectivity and floodplain inundation. Before the Chattahoochee River became subjected to human controls, there were substantial flows with natural variability in magnitude and seasonal fluctuations. Because of the series of dams now present in the Chattahoochee River system, the Chattahoochee River is essentially disconnected from its floodplain. Fish and aquatic resources in the ACF Basin between Buford Dam and Apalachicola Bay will be affected differently due to differences in streamflow and water quality. Since water quality was described in response to specific requests by USFWS in Section 2.2, this section describe how streamflow may affect riverine fisheries.

The monthly flow range at the 10th, 25th, 50th, 75th and 90th percentile exceedance for the NAA and PAA were compared. These flows were calculated from HEC-ResSim results at various points in the Chattahoochee River to represent the monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded).

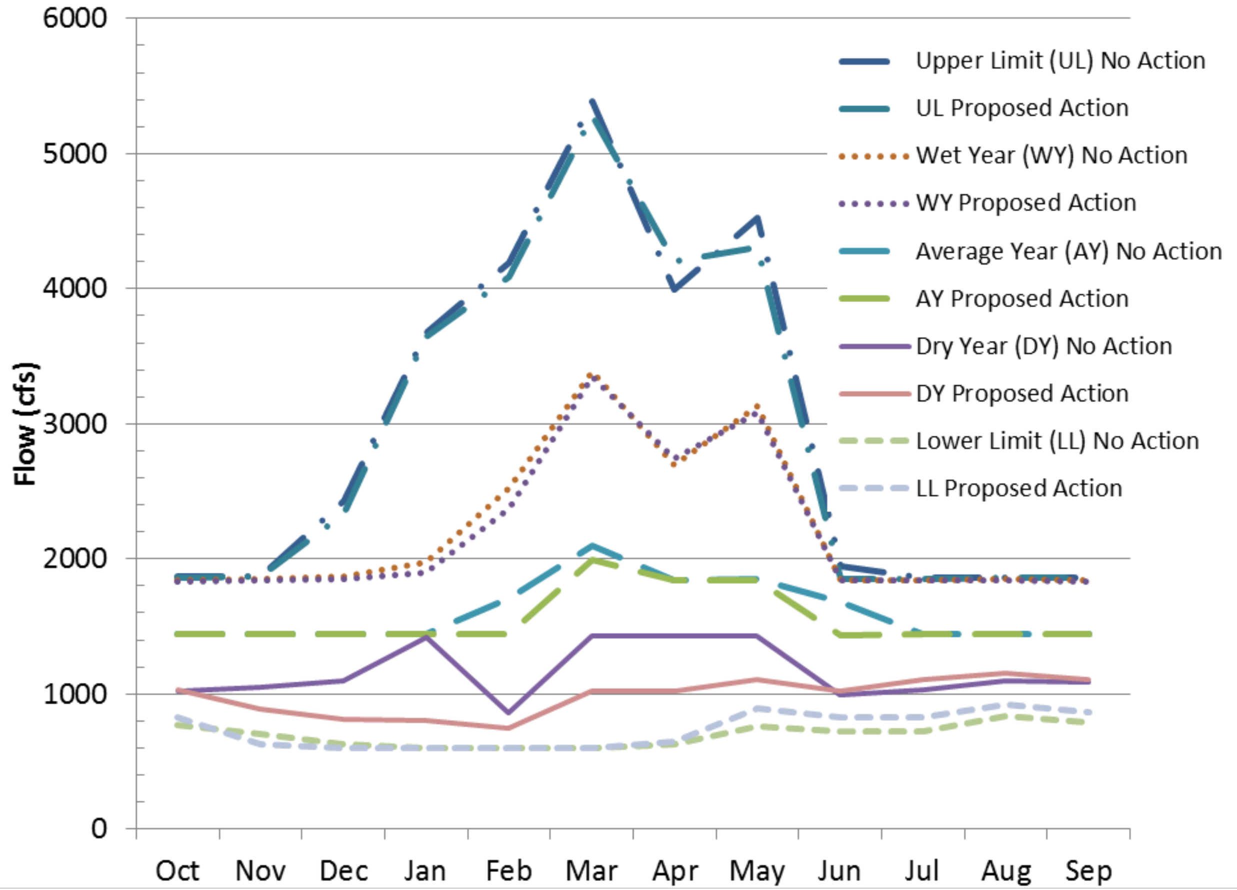


Figure 2.5-1. Buford Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

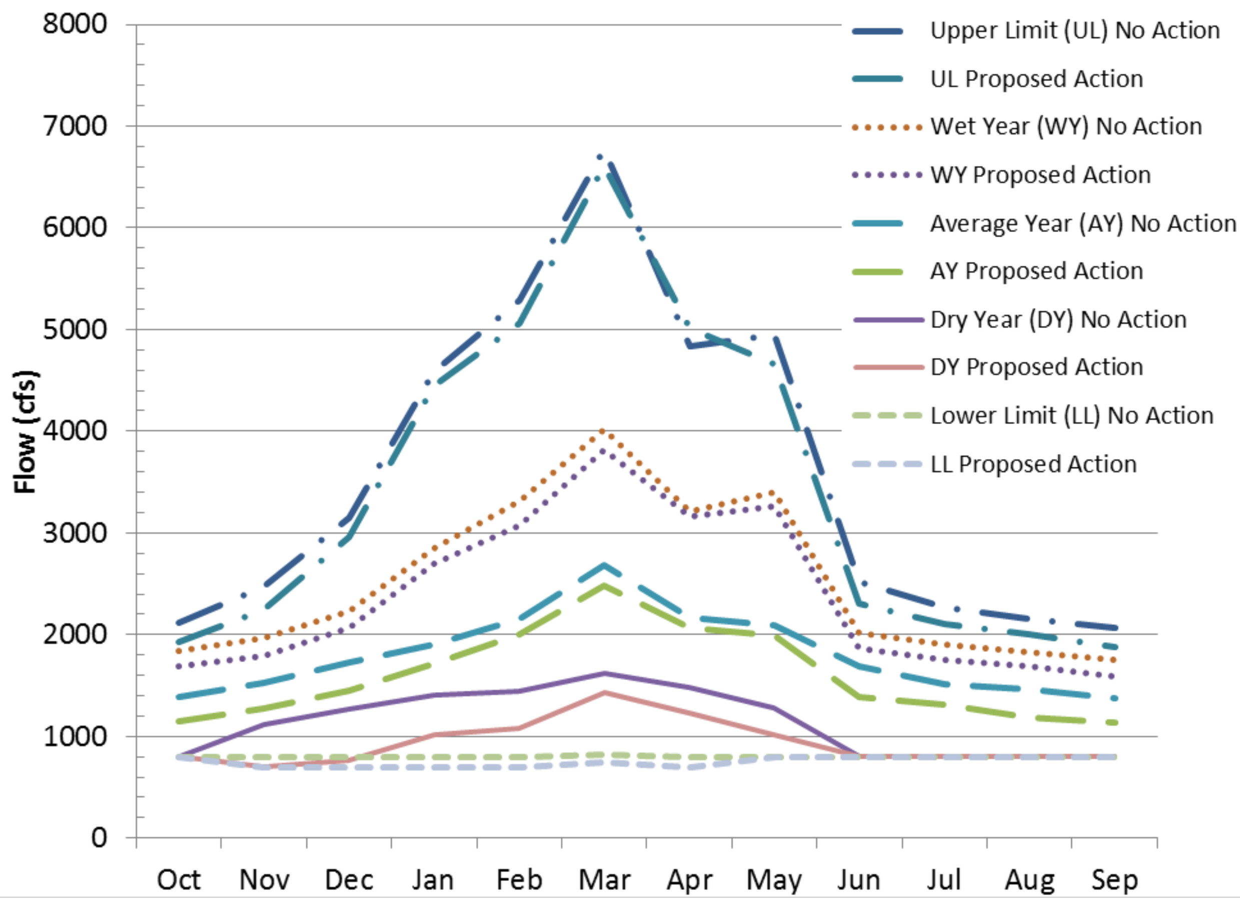


Figure 2.5-2. Atlanta, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10^{th} percent exceeded), a wet year (25^{th} percent exceeded), an average year (50^{th} percent exceeded), a dry year (75^{th} percent exceeded), and the lower limit (90^{th} percent exceeded)].

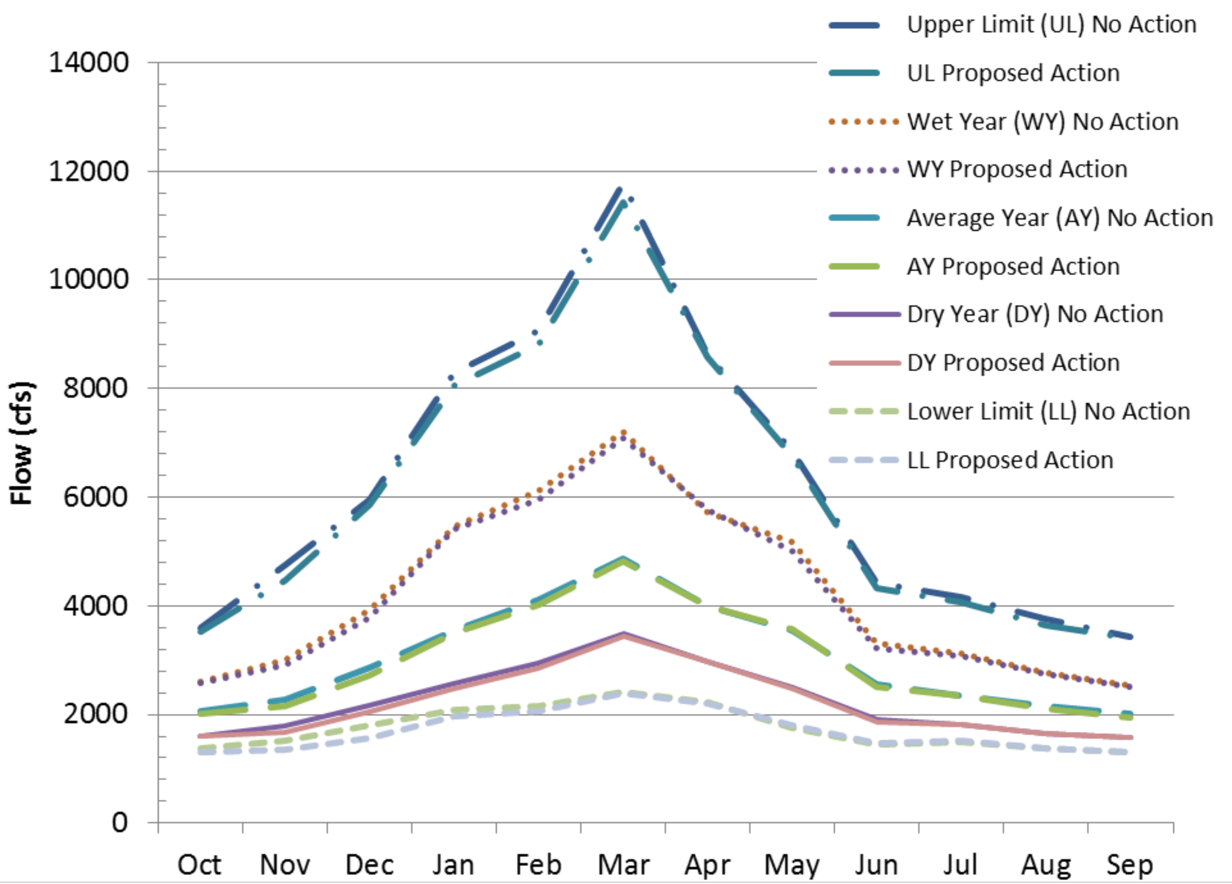


Figure 2.5-3. Whitesburg, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

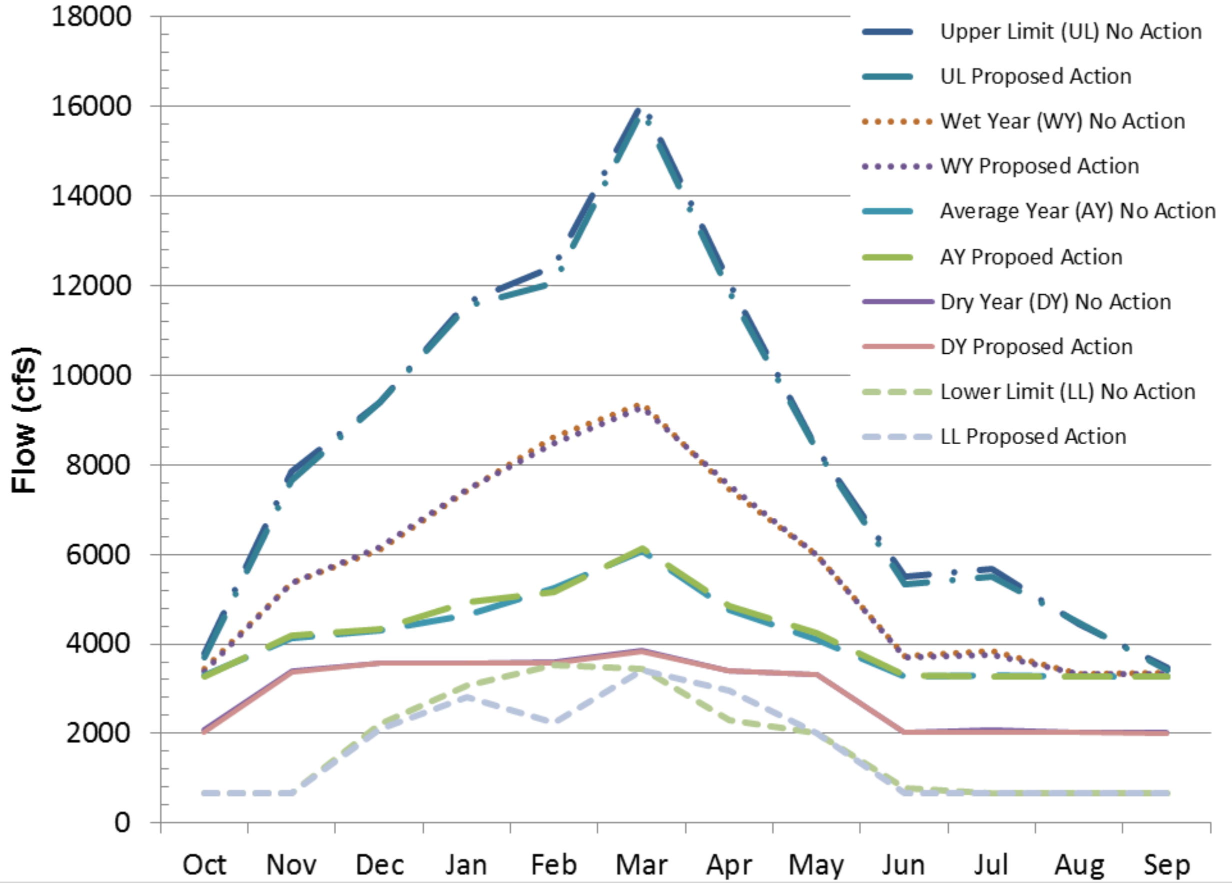


Figure 2.5-4. West Point Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

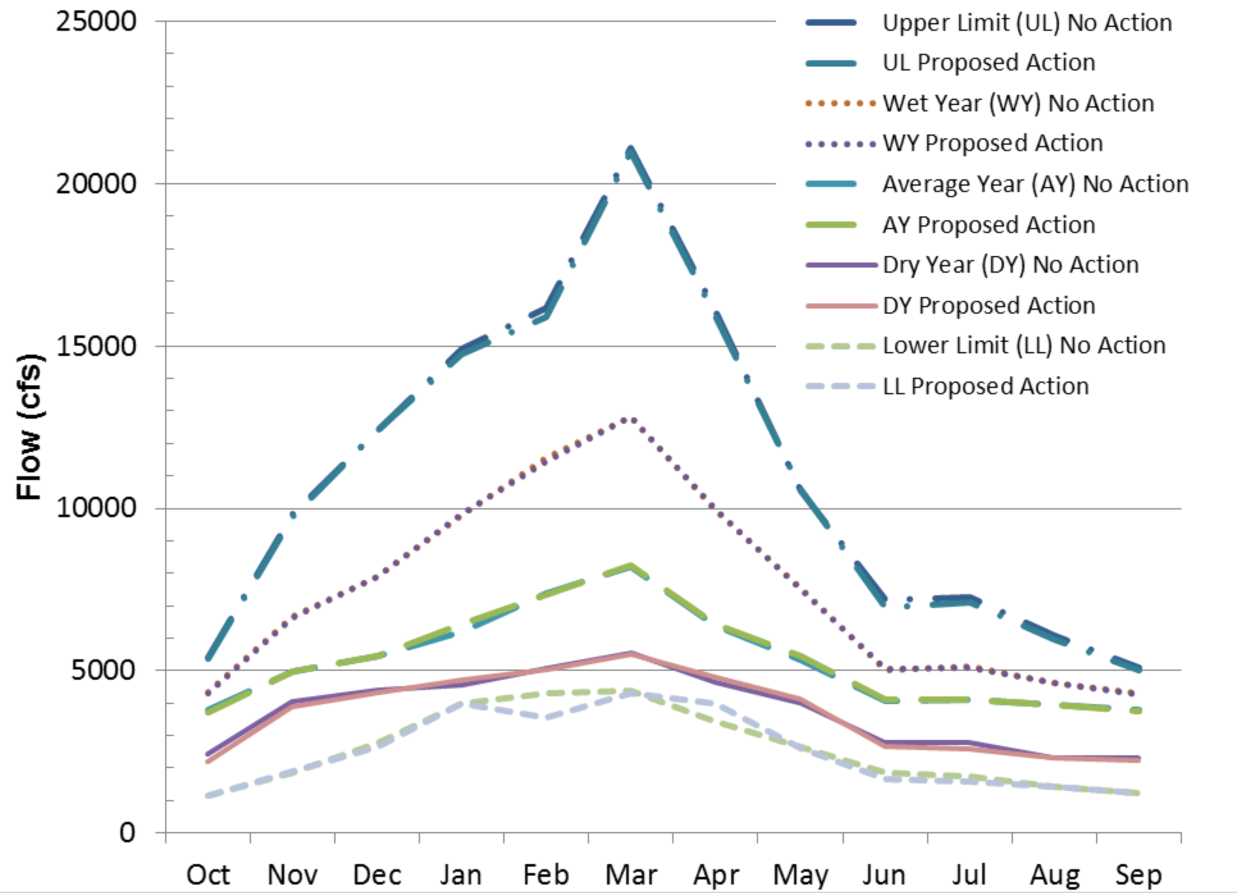


Figure 2.5-5. Columbus, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

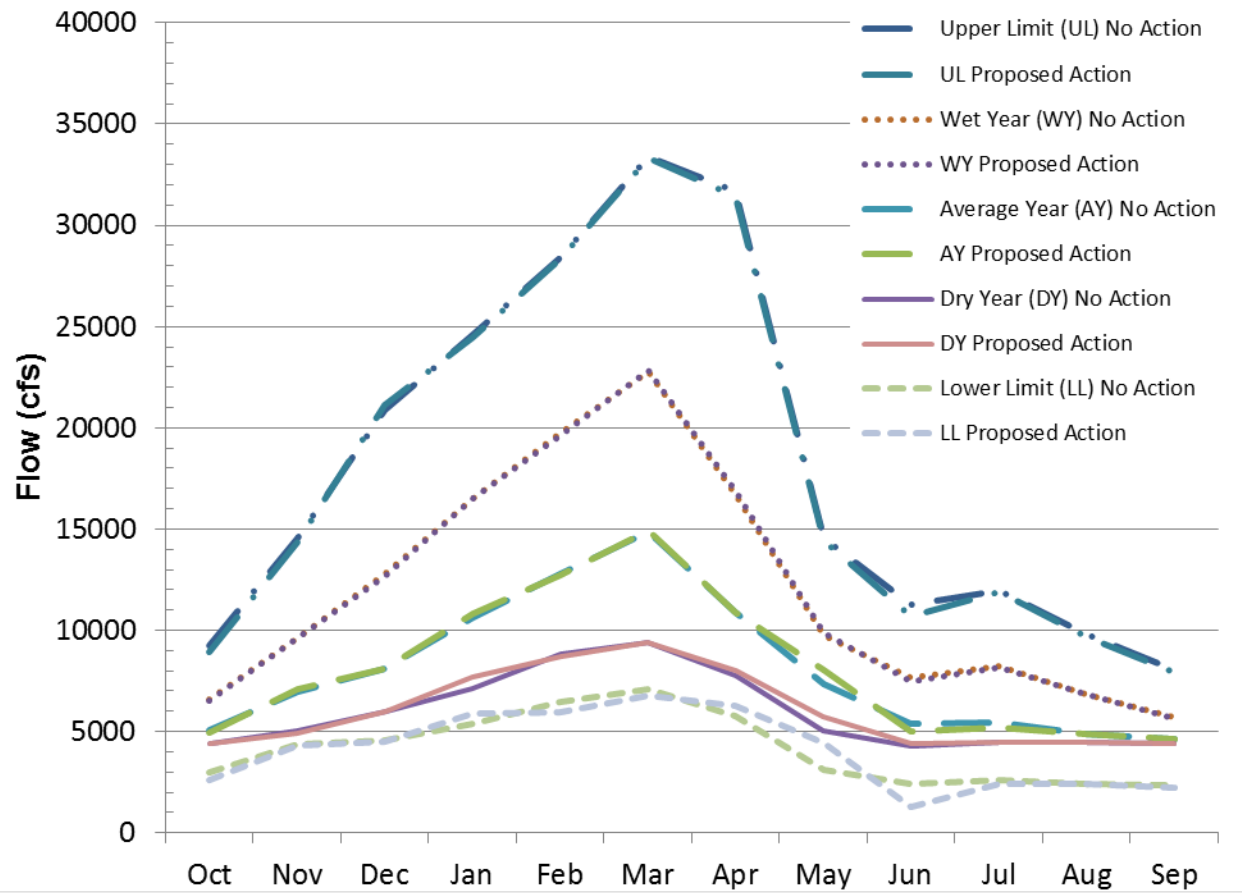


Figure 2.5-6. George Andrews Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

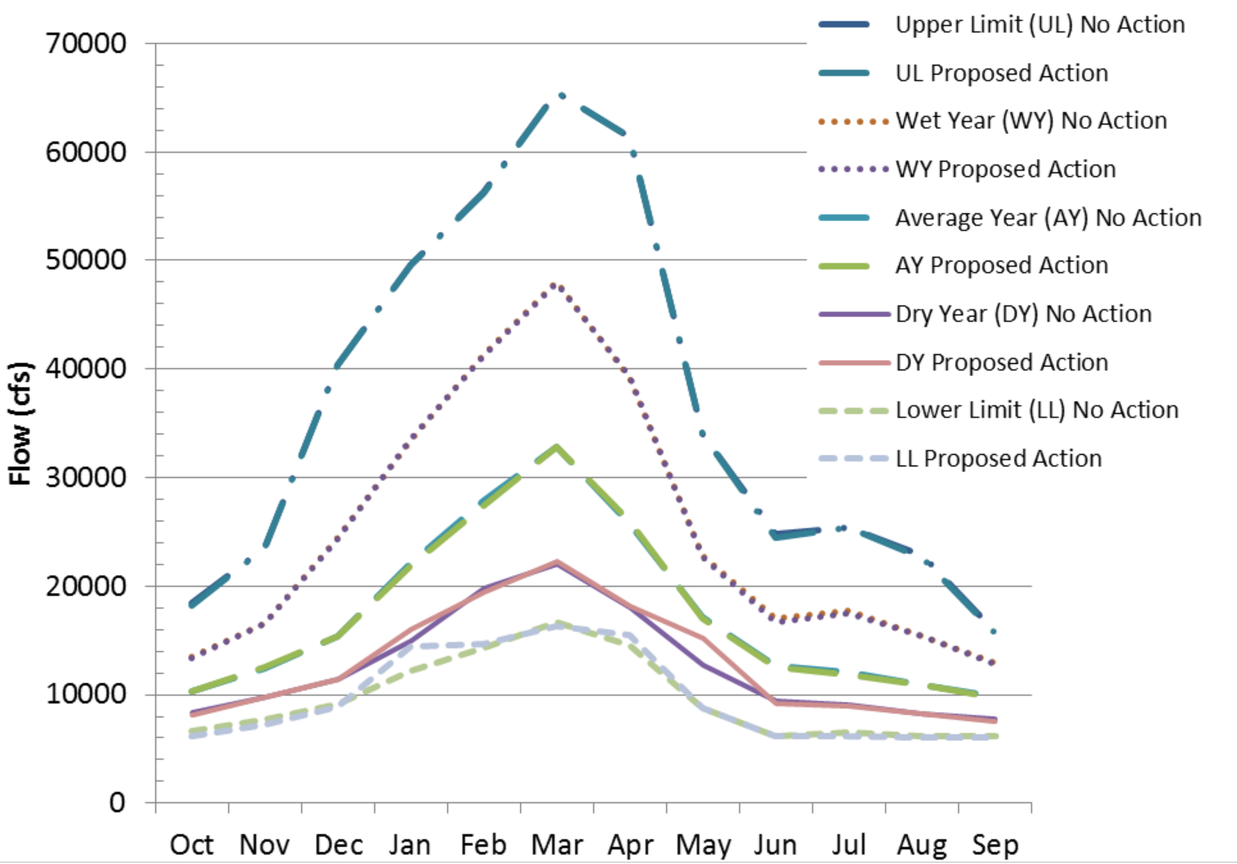


Figure 2.5-7. Chattahoochee, Florida monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

2.5.1 Chattahoochee River Shoal Bass Recruitment

As requested in the 2013 PAL, results from both the HEC-5Q and HEC-ResSim modeling efforts were used to evaluate the Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM). Shoal bass (*Micropterus cataratae*) are a fairly recently described species (Williams and Burgess 1999) in the centrarchid (sunfish) family and is endemic to the ACF Basin. Shoal bass frequently occur in shoals (commonly co-occurring with other species) over rocky sediments in flows exceeding 0.66 ft per second. Recruitment of age-3 bass is of particular interest since this cohort has survived prevalent river conditions and has the potential to be stocked to support the recreational fishery. Recruitment success is largely dependent on surface water and spring temperature and is highly correlated with discharge.

The CRSBPM was evaluated in Atlanta, Georgia near river mile 410. The slightly higher median age-3 abundance from the PAA would be expected to be beneficial to shoal bass (Figure 2.5-8).

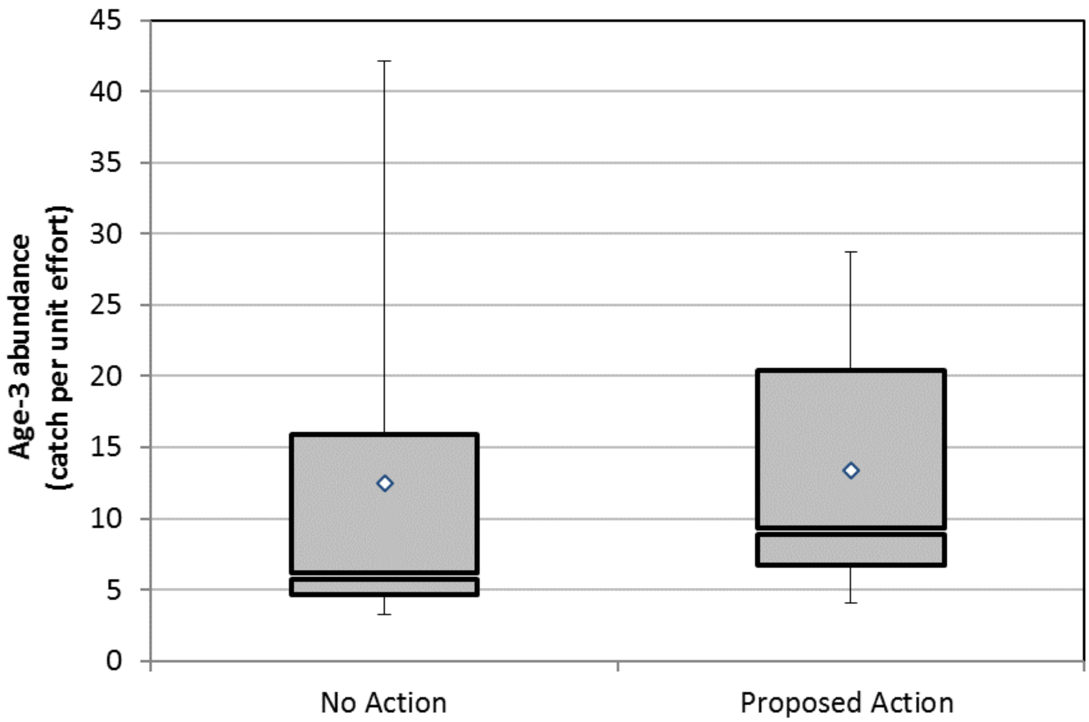


Figure 2.5-8. Shoal bass age-3 abundance at Atlanta, Georgia for the NAA and PAA (minimum; 25th, 50th, and 75th percentiles; maximum; and mean, where mean is represented by the diamond)

2.6 Apalachicola Bay Salinity Analyses

The USFWS conducted salinity modeling of the Apalachicola Bay. USACE reviewed USFWS model and concluded that, since there would be little change in the releases from Jim Woodruff Dam, little change in salinity in the Apalachicola Bay would be expected as a result of the PAA. Freshwater flows are also critical to the protection of the estuarine oyster fishery, which is sensitive to variations in salinity. The oyster fisheries in the estuarine portions of Apalachicola Bay experience impacts from drought and flooding as a result of both natural and unnatural flow variation. The PAA would present no anticipated change in the flows (wet, dry, or normal) to the estuary from the NAA, and therefore the PAA is not expected to change the current state of the oyster fishery.

Similarly, given the absence of appreciable changes in the flow dynamics from the NAA, additional impacts on other estuarine species and fisheries are not expected.

2.7 Federally-protected Species Analyses

As requested by the USFWS, the Federally-protected species analysis is consistent with the evaluations completed for the 2012 RIOP.

2.7.1 Gulf Sturgeon Analysis

Applying the Sturgeon Spawning Habitat Performance Measure described in the 2013 PAL, USACE found that no effects on Gulf sturgeon would be expected as a result of implementing the PAA compared to the NAA. Gulf sturgeon spawning habitat was quantified at three locations known to support the species. The maximum amount of habitat available during inundation at 8.5 to 17.8 ft depths from March through May, as well as the amount of habitat available during which conditions range from 8.5 to 17.8 ft over a 30-day period to support the timing of three life stages (spawning, egg incubation, and early larval development) of Gulf sturgeon were evaluated. Collectively, these three stages have been estimated to occur over approximately 30 days in the ACF Basin (USFWS 2008b; Pine et al. 2006; Sulak et al. 2004). The effects of the alternatives were based on the change in median annual Gulf sturgeon spawning habitat from that available under the NAA, which is 18.17 acres. The median spawning habitat under all the alternatives, including the PAA, would be expected to be equal to the NAA at 18.17 acres.

This approach to evaluating Gulf sturgeon habitat was used instead of those presented in the 2010 PAL. However, review of other information presented in this response would be expected to address points identified in the 2010 PAL. Daily fall rates were evaluated for protection of mussels (Section 2.7.2). The maximum number of days per year with flows less than 10,000 cfs is discussed in Section 2.7.2.3. Figure 2.2-24through Figure 2.2-27 illustrate the departure from average water temperature between May and October. Though this is not the USFWS requested period, those figures along with Figure 2.7-1 illustrate that little to no change in water temperature would be expected in the Apalachicola River.

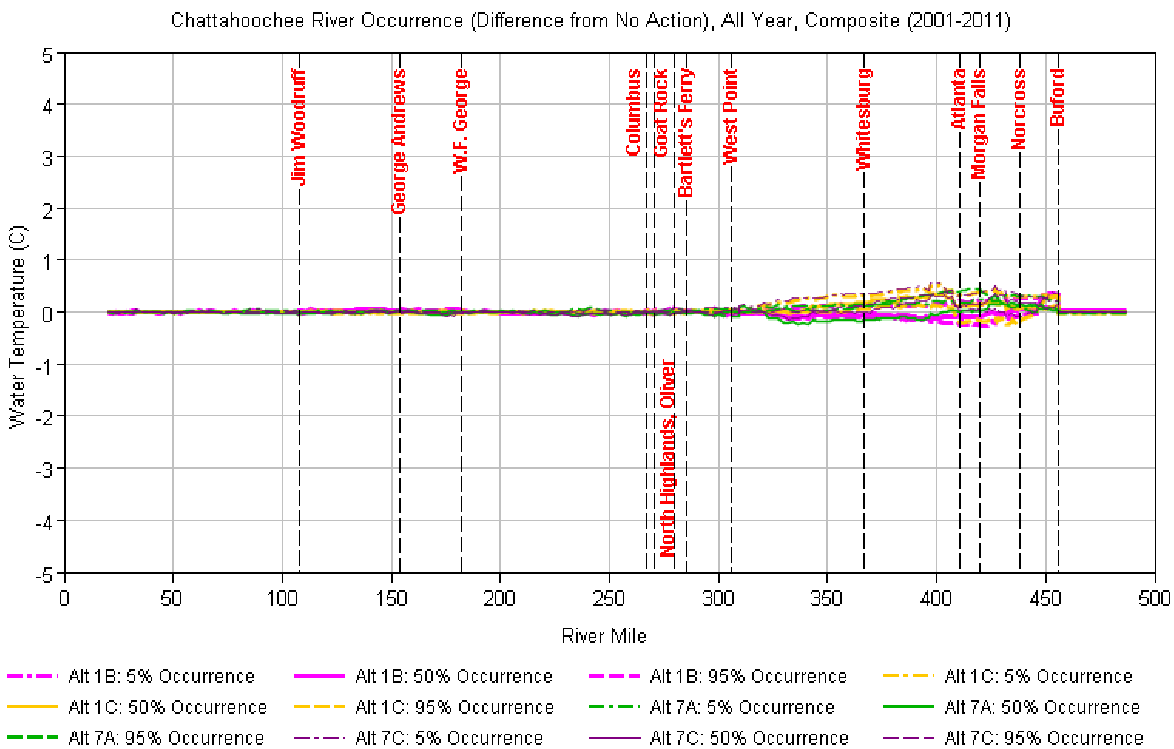


Figure 2.7-1. Change in water temperature for the modeled period 2001 through 2011

2.7.2 Freshwater Mussels Analysis

2.7.2.1 Lowest Daily Flow Rate for Each Year

The lowest annual flows at Chattahoochee, Florida for the modeled period from 1939 through 2011 are presented in Table 2.7-1. Both the PAA and the NAA do not include simulated flows less than 5,000 cfs.

Table 2.7-1.
Minimum modeled flow at Chattahoochee, Florida for the modeled period.

	Flow (cfs)	
Year	**No Action**	**Proposed Action**
1939	9443	9442
1940	7284	6196
1941	5040	5188
1942	9619	9619
1943	7833	7827
1944	9161	9163
1945	9119	9406
1946	10409	10317
1947	9881	9884
1948	11905	11905
1949	13462	13471
1950	7757	7701
1951	5576	5050
1952	7189	7115
1953	8852	8852
1954	5458	5050
1955	5019	5050
1956	5400	5050
1957	5537	5600
1958	8257	8254
1959	8451	8489
1960	8825	8775
1961	7872	7869
1962	7382	7374
1963	5716	5693
1964	12680	12673
1965	9392	9399
1966	8453	8453
1967	7555	7550
1968	5780	5278
1969	5976	5951
1970	6996	6996
1971	9831	9862
1972	6794	6787
1973	8634	8636
1974	8534	8490
1975	14286	14355
1976	8157	8262
1977	6345	6200

	Flow (cfs)	
Year	**No Action**	**Proposed Action**
1978	6918	6203
1979	6723	6675
1980	6447	6441
1981	5045	5049
1982	8363	8576
1983	8507	8504
1984	8292	8292
1985	5889	6183
1986	5049	5049
1987	6289	6087
1988	5050	5050
1989	8271	6311
1990	6106	5964
1991	9002	9005
1992	8435	7281
1993	5709	5543
1994	8880	10618
1995	7167	7006
1996	7644	7645
1997	5841	5781
1998	8296	7748
1999	5050	5050
2000	5050	5050
2001	5101	5296
2002	5050	5050
2003	8938	8977
2004	7035	5844
2005	9128	9123
2006	5050	5050
2007	5050	4550
2008	5050	5050
2009	7470	5859
2010	5721	5709
2011	5010	5050

2.7.2.2 Inter-annual Frequency of Flows less than 5,000–10,000 cfs

Mussels are susceptible to stranding at flows ranging from 5,000 to 10,000 cfs, particularly following high-flow events (> 100,000 cfs) that serve to move individuals into depositional areas (USFWS 2008b). Inter-annual flows, expressed as the frequency of occurrence of the percent of years, were evaluated to address the potential for stranding. The results are presented below.

Evaluation of the inter-annual frequency of flows less than 10,000 cfs indicates a close correspondence of the NAA and PAA (Figure 2.7-2).

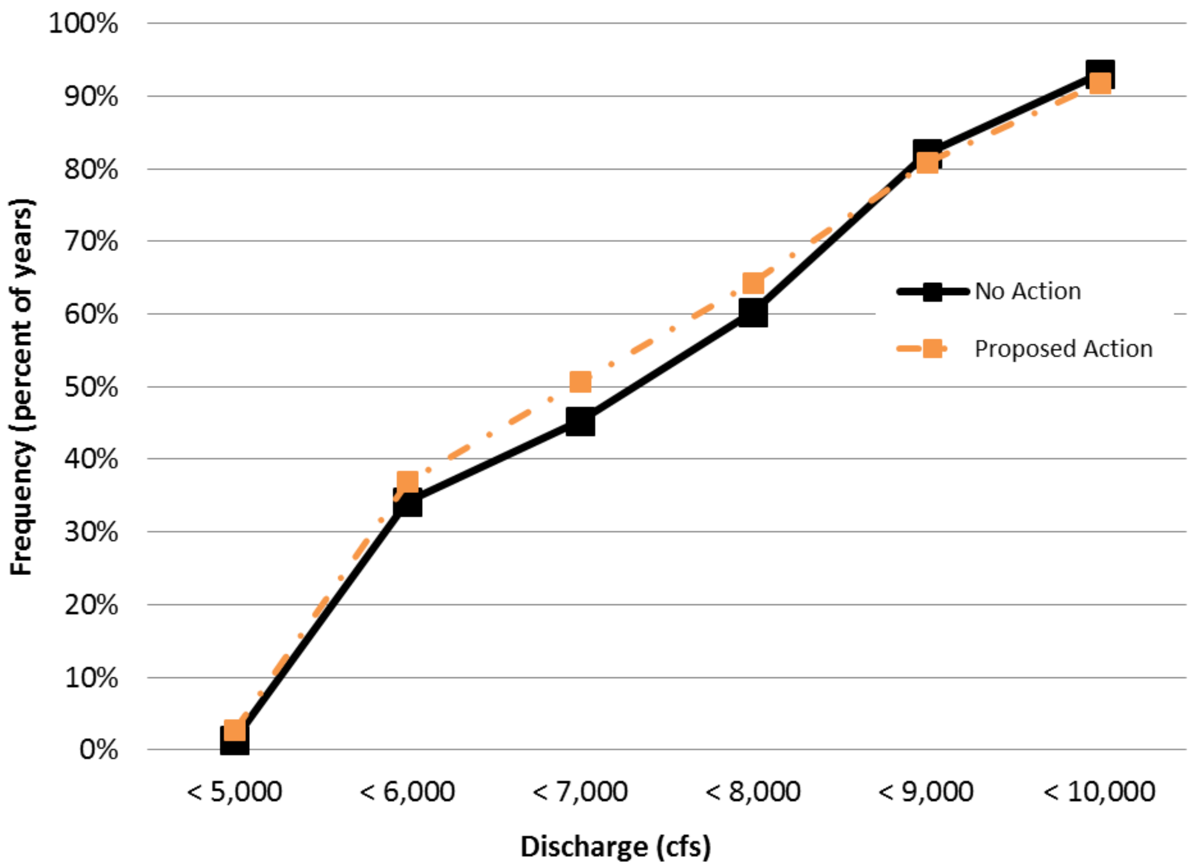


Figure 2.7-2. Inter-annual frequency of flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs based on 1939 – 2011 (*Figure 4.2.5.A.* from the 2008 Biological Opinion [BO] and *Figure 4.2.3.A.* from the 2012 BO)

2.7.2.3 Maximum Number of Days per Year Flows less than 5,000–10,000 cfs

The maximum number of days per year with flows less than 5,000–10,000 cfs provides an estimation of the most severe conditions aquatic biota will experience under the proposed flow regimes. The modeled NAA tracks closely with the PAA in discharges greater than 6,000 cfs (Figure 2.7-3).

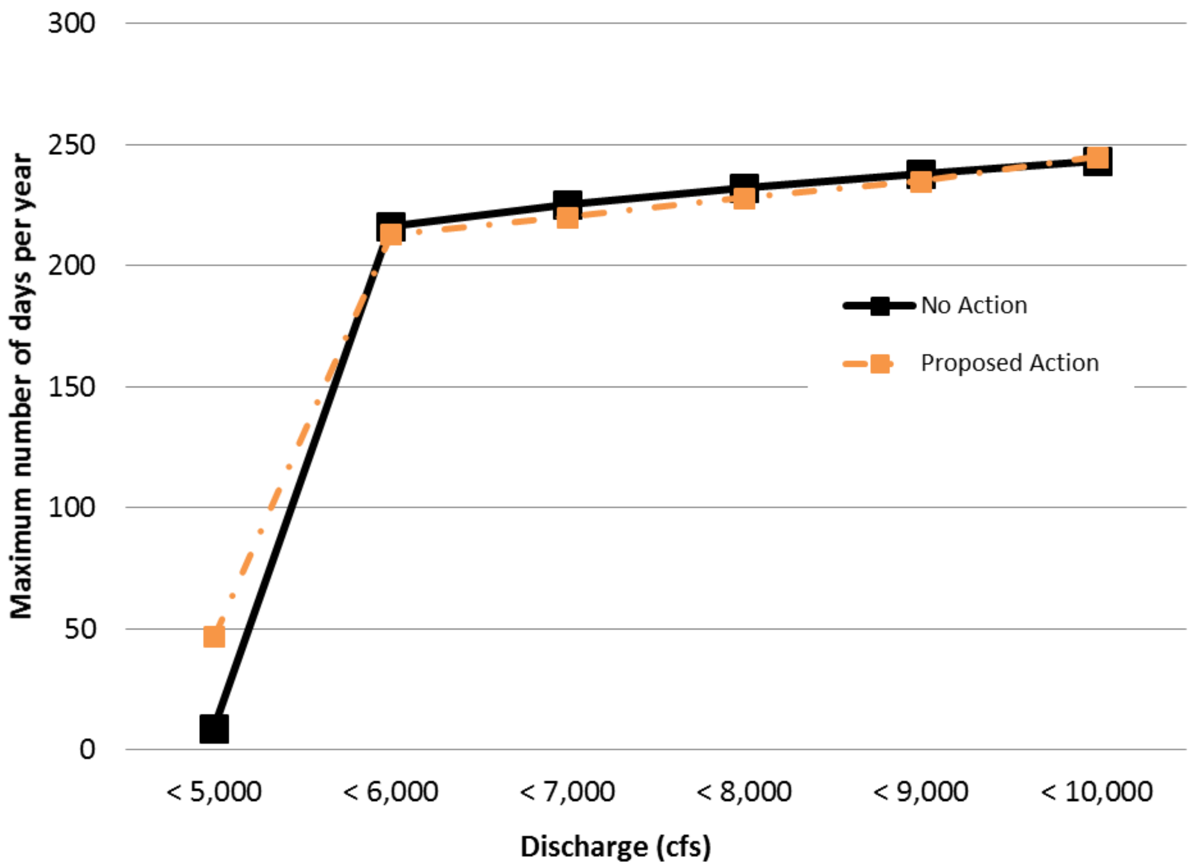


Figure 2.7-3. Maximum number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.B.* from the 2008 BO and *Figure 4.2.3.B.* from the 2012 BO*)*

2.7.2.4 Maximum Number of Consecutive Days less than 5,000 - 10,000 cfs

Mussels can survive brief periods of stranding by closing their shells or burrowing in substrate. Thus, without extreme water temperatures, mussel survival from stranding is most likely a function of exposure duration (USFWS 2008b). To address that, the maximum number of consecutive days of flows between 5,000 and 10,000 cfs was evaluated. Figure 2.7-4 shows the maximum number of consecutive days of flows at less than 5,000–10,000 cfs is similar in the PAA to the NAA.

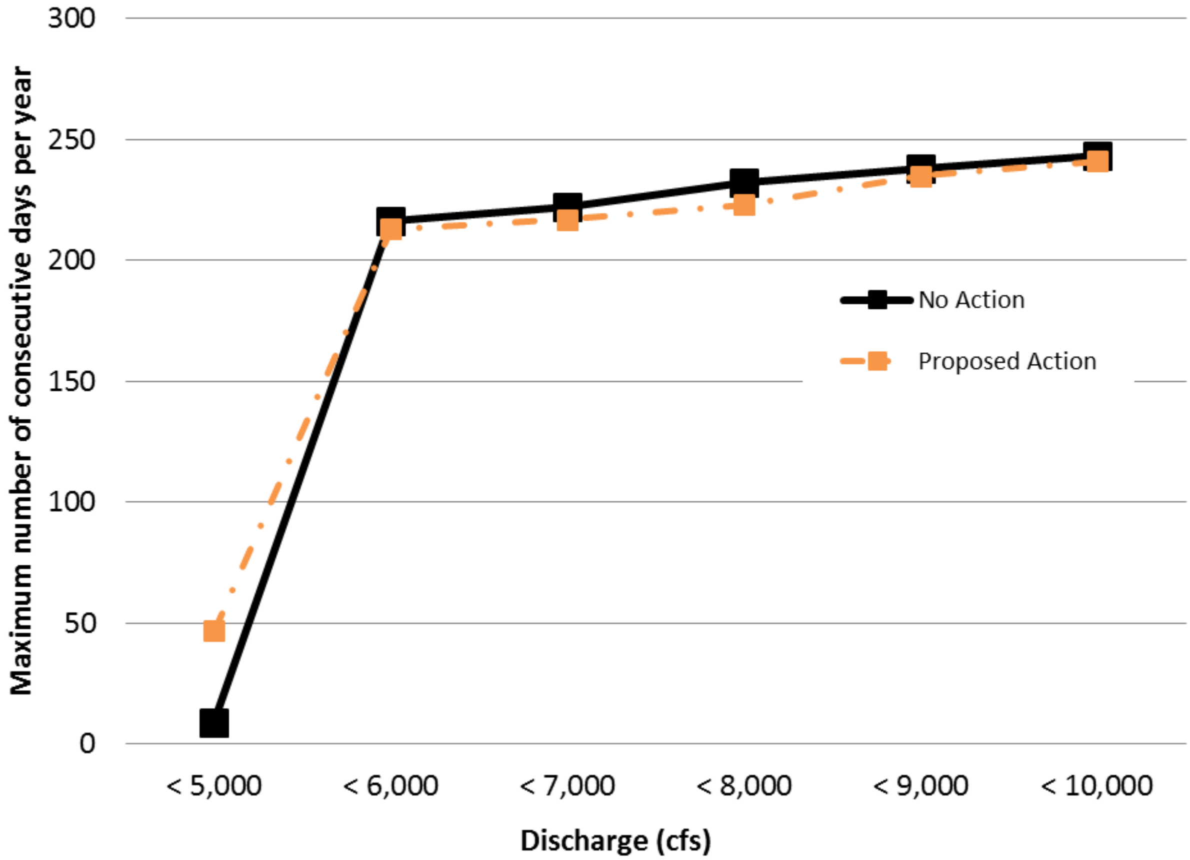


Figure 2.7-4. Maximum number of consecutive days with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.C.* from the 2008 BO and *Figure 4.2.3.C.* from the 2012 BO*)*

2.7.2.5 Median Number of Days per Year Flows less than 5,000–10,000 cfs

The duration of moderate low-flow periods are also an important consideration for the survival of mussels and other aquatic biota. Chronic low-flow events occur with greater frequency than extreme events and, despite the less severe conditions, serve to decrease habitat availability, increase physiological stress, and increase both exposure-related and predatory mortality. Median flows below 7,000 cfs would not be expected in the NAA and would only occur once in the PAA (Figure 2.7-5). The median number of consecutive days per year was also evaluated (Figure 2.7-6).

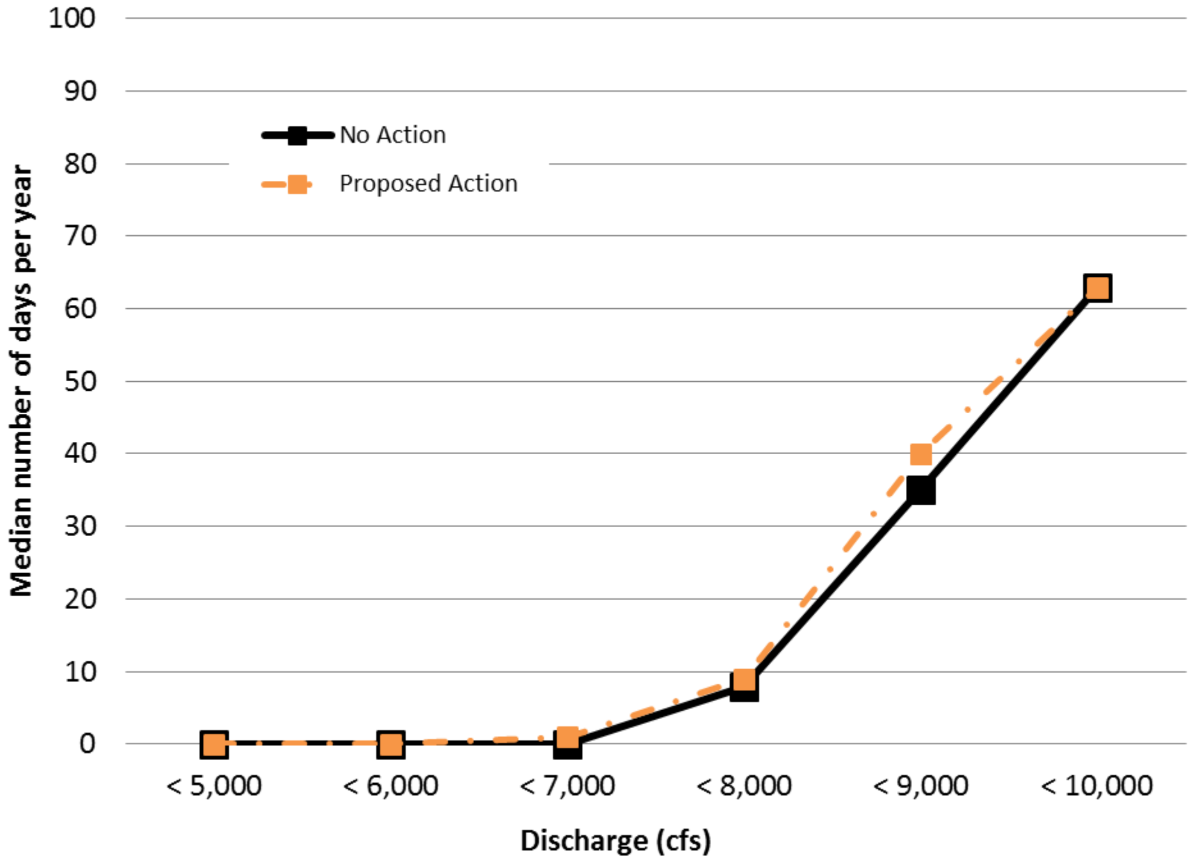


Figure 2.7-5. Median number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.D.* from the 2008 BO and *Figure 4.2.3.D.* from the 2012 BO*)*

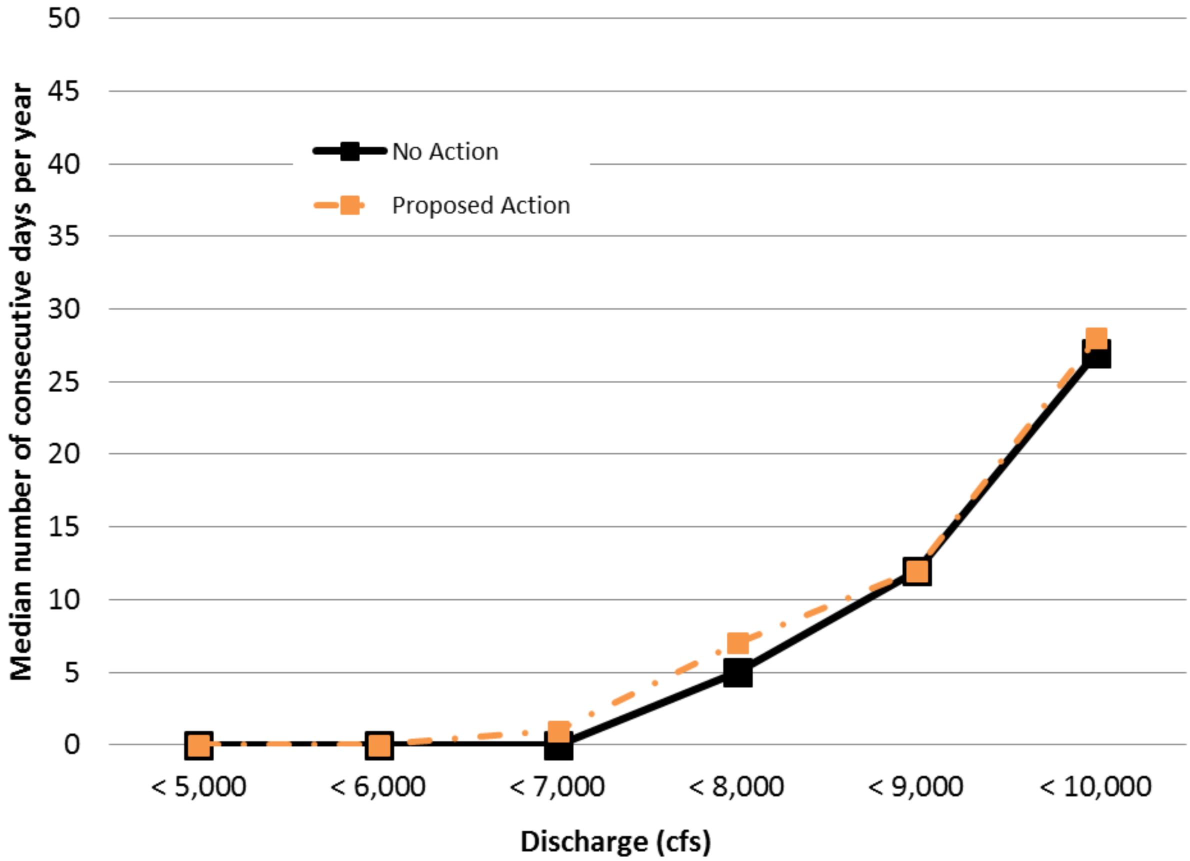


Figure 2.7-6. Median number of consecutive days per year with flows between 5,000-6,000; 6,000-7000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.3.E.* from the 2012 BO [Figure was not included in the 2008 BO]*)*

2.7.2.6 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day

The 2012 RIOP maximum fall rate schedule was established to avoid extreme declines in daily river stage levels and decrease the risk of exposure or stranding of aquatic biota. Declining river stages are moderated by operating schedules to provide an attenuation of flows that allow for more gradual fall rates as flows decline. Those rates are not presented but results presented in Section 0, for releases from Woodruff Dam less than 10,000 cfs would be expected to sufficiently illustrate differences between the NAA and PAA since the listed mussels generally do not occur at stages higher than those equivalent to 10,000 cfs.

2.7.2.7 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day when Releases at Woodruff Dam are less than 10,000 cfs

A fall rate analysis was performed to evaluate whether an increase in the percentage of days with rates greater than 0.25 ft/day would affect federally listed mussel species. The evaluation is restricted to periods when releases from Jim Woodruff Dam are less than 10,000 cfs. The results are illustrated in Figure 2.7-7.

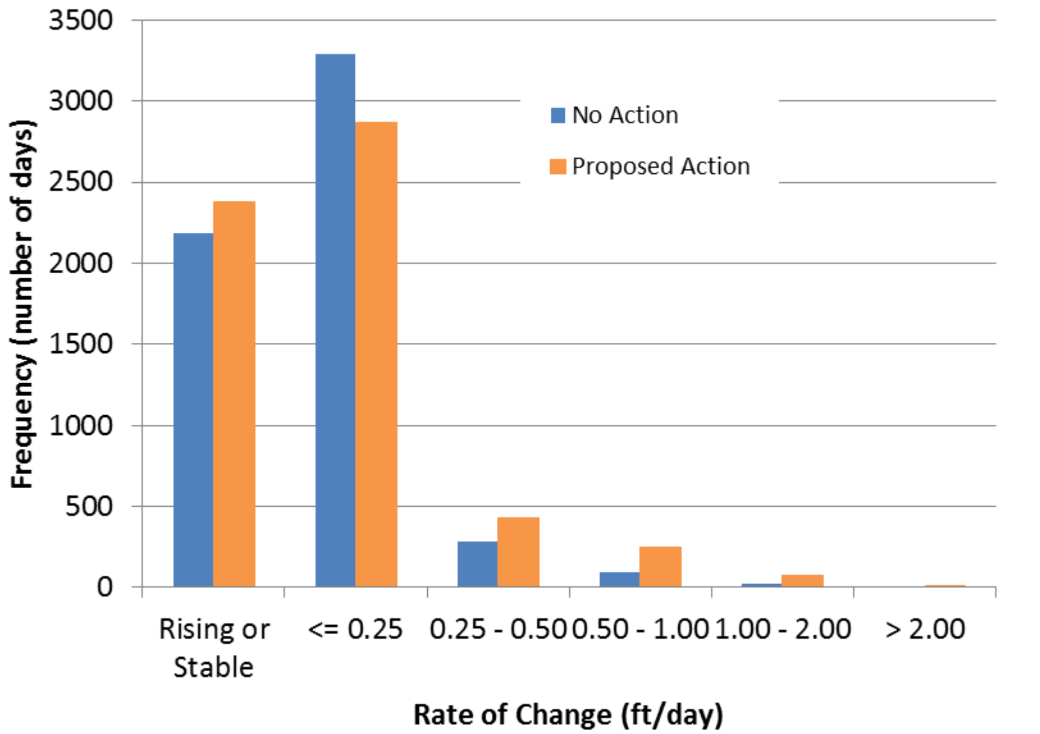


Figure 2.7-7. Frequency (number of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs from 1939-2011. (*Figure 4.2.5.F.* from the 2008 BO and *Figure 4.2.3.G.* from the 2012 BO*)*

2.8 Additional Analysis - Fish and Wildlife Management Facilities

2.8.1 Eufaula National Wildlife Refuge

The potential impacts on Eufaula National Wildlife Refuge (ENWR) are primarily related to reservoir level fluctuations at W.F. George Lake, influencing the refuge in three critical areas (USFWS 1998): (1) direct effects on habitat availability for wildlife; (2) effects on vegetation communities, particularly with respect to invasive species; and (3) the availability of water during October and November to off-reservoir impoundments that support waterfowl habitat management.

Reservoirs are generally associated with large watersheds and tributaries because of their engineered purpose of providing flood damage reduction, hydroelectric power, and navigation. As a result, they are characterized as receiving large organic and inorganic inputs, high nutrient loads, and contaminants (Miranda et al. 2010). Depositional filling effectively limits surface area and volume, thereby creating isolation of backwater areas, promoting habitat degradation, and decreasing overall depth (Patton and Lyday 2008).

Water-level fluctuation, common in reservoir settings, also limits the formation of persistent species associations and assemblage structure, especially in vegetation and open littoral zones. Drennen (1995) noted the importance of proper reservoir management strategies in the ACF Basin in support of wood duck (*Aix sponsa*) brooding and rearing habitat, heron rookeries, and foraging habitat for bald eagles, wood storks, and migratory species. Other species, including Florida softshell (*Apalone ferox*), common snapping turtle (*Chelydra serpentine)*, and common slider (*Trachemys scripta*) have been observed nesting in sandbars and mudflats when reservoir levels are below 186 feet (USACE, Mobile District 1998a).

Several factors influence the success of exotic introductions, including habitat connectivity and propagule pressure, disturbance and environmental variability, and species diversity and biotic interactions (Davis et al. 2000; Elton 1958). Davis and colleagues (2000) established the concept of fluctuating resources availability (FRA), which suggests that communities become more susceptible to invasions in response to the amount of unused resources. Disturbances may temporarily reduce the number of native species and thus provide an opportunity for invasive species. The FRA hypothesis specifically predicts that systems with fluctuating resources or elevated productivity will be more susceptible to invasive species. Within the ENWR, alligatorweed (*Alternanthera philoxeroides*) has become the most prolific invader of ephemeral wetlands in response to fluctuating water levels (USFWS 1998). Other undesirable species include black willow (*Salix nigra*), *Sesbania*, and cutgrass (*Leersia* spp.).

Reservoir levels lower than 186 feet provide important wading bird habitat during spring and fall and serve to concentrate waterfowl during the winter months. These habitats, not usually available at higher water levels, provide important forage and nesting areas. For example, Drennen (1995) observed ring-billed gulls feeding on mussels along flats that had become exposed during low-water conditions. However, in contrast, the ability to supply water to off-reservoir impoundments requires reservoir levels above 185 feet (Ziewitz and Luprek 1996). This also allows gravity-flow flooding, which provides a more precise and cost-effective means of adjusting water levels in the impoundments.

The USACE considered the USFWS request to cycle Walter F. George Lake between the highest levels (190 ft) in late winter/early spring to the lowest levels (185 ft) in late summer to accommodate Eufaula National Wildlife Refuge operations (Figure 2.8-1). As proposed, the option would require operation of the reservoir at its highest pool levels during winter-spring, when flood releases are typically the greatest. That would reduce the ability of the project to attenuate approximately 87,000 ac-ft of potential downstream flooding. By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased, resulting in bank erosion and channel modifications below the project. Similarly, to operate the project at its lowest levels during the summer is contrary to what is required to meet the highest demands for recreation, hydroelectric power, and flow augmentation. Essentially, such an option would remove Walter F. George Lock and Dam from the system approach to operations across the basin and eliminate approximately 100,000 ac-ft of conservation storage that could be used to meet authorized project purposes in the summer. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant adverse effects on the authorized project purposes and the structural stability and safety of the dam. For these reasons, operations to manage Walter F. George Lake to benefit the Eufaula Wildlife Refuge operations were not considered further.

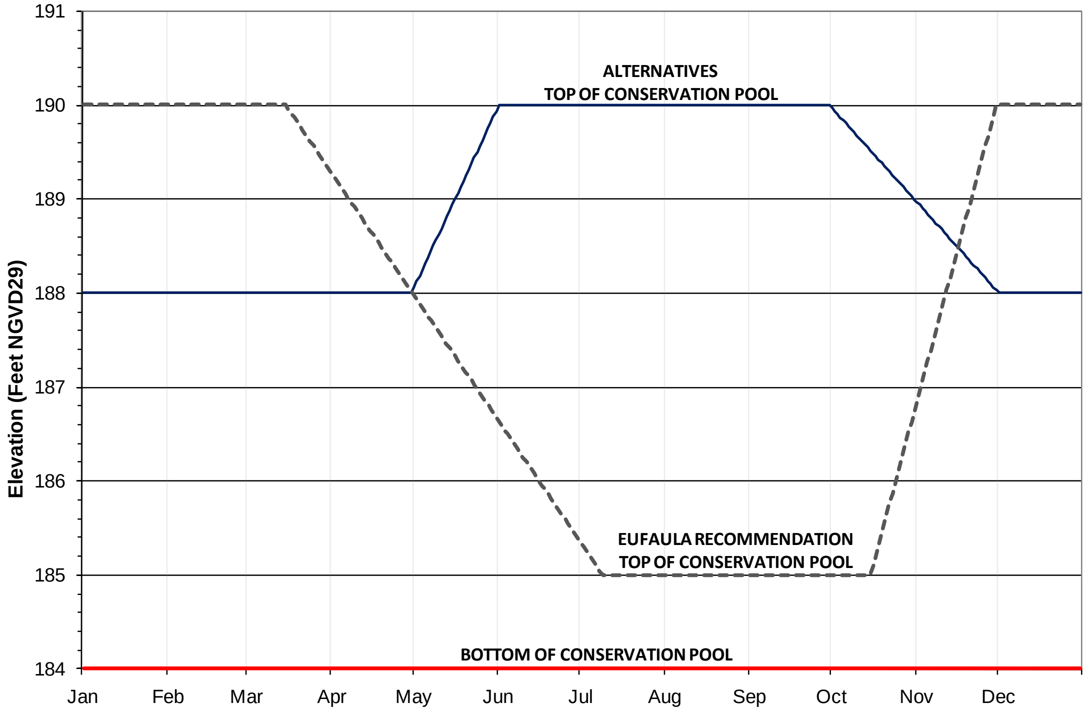


Figure 2.8-1. Eufaula National Wildlife Refuge recommended water surface elevation compared with the NAA and PAA top of conservation pool elevation.

The differences between the median daily water surface elevations at Walter F. George Lake are negligible between the NAA and PAA (Figure 2.8-2).

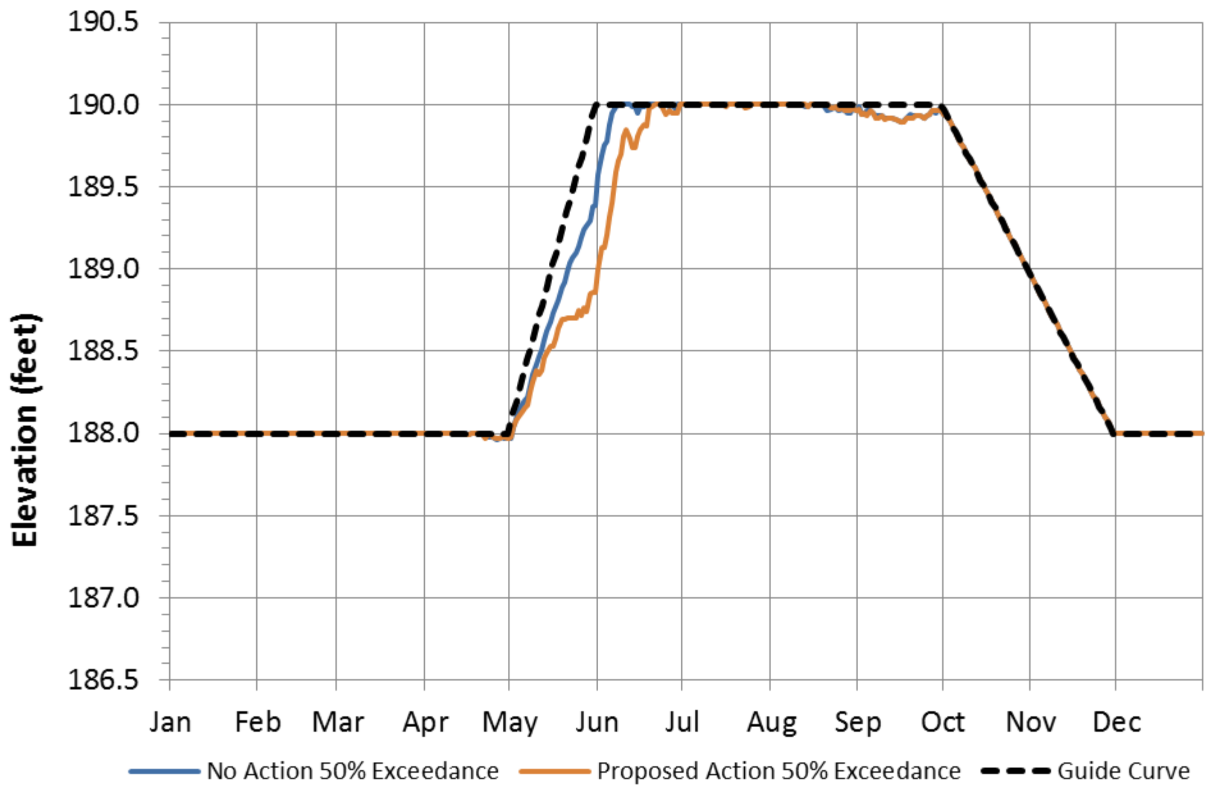


Figure 2.8-2. Walter F. George Lake, median daily water surface elevation over the modeled period of record (1939-2011) for the NAA and PAA

2.8.2 Fish hatcheries

Four major fish hatcheries are in the ACF Basin. Buford Trout Hatchery is the only fish hatchery in the ACF Basin that relies on surface flows for its operations, and it is the largest user of water. Changes in flow on the Chattahoochee River are negligible between alternatives, and would not be expected to affect operations at the Buford Trout Hatchery (Figure 2.8-3).

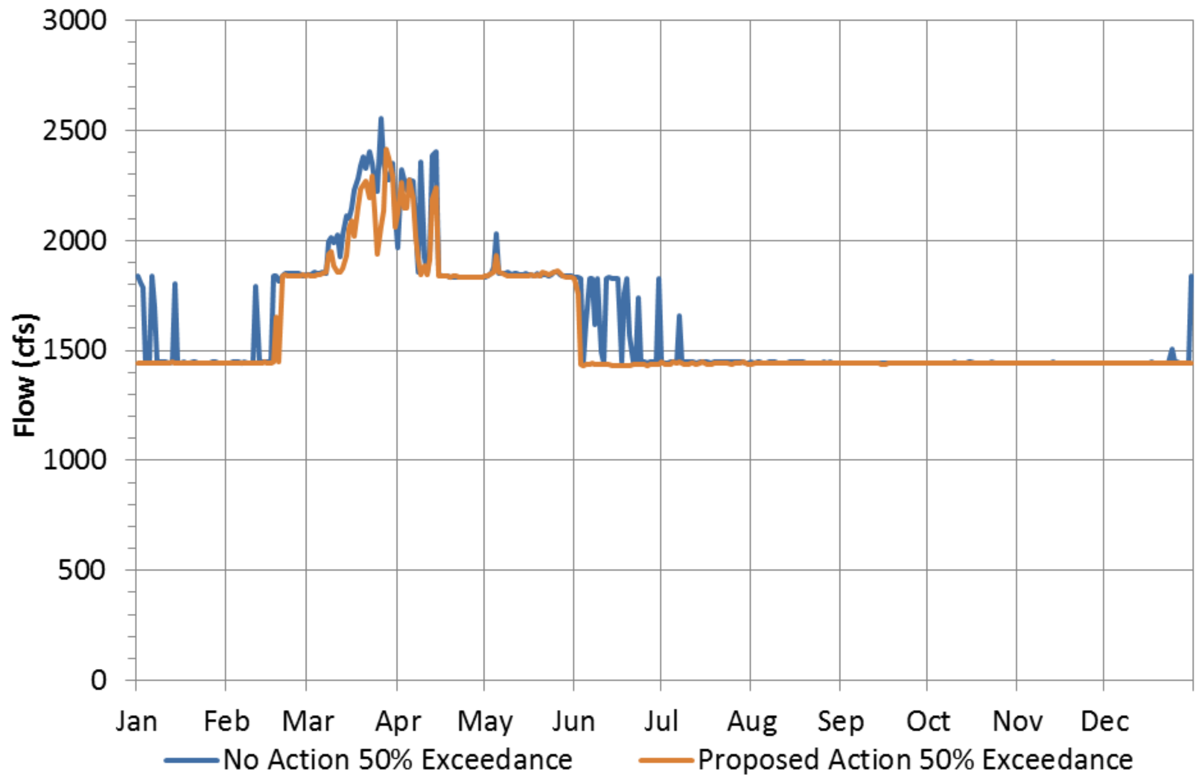


Figure 2.8-3. Chattahoochee River—median daily flows below Buford Dam, Georgia (RM 348.1) for the NAA and PAA

USFWS Request March 2015

This page intentionally left blank

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4980 Wildlife Dr.
Townsend, Georgia 31331

March 12, 2015

Dear Mr. Sumner,

Thank you for your response to our Planning Aid Letter (PAL). We have reviewed the information provided to us in the Apalachicola-Chattahoochee-Flint Water Control Manual (WCM) Update Response to Planning Aid Letter received on January 30, 2015. The review and exchange of information between the United States Army Corps of Engineers (Corps) and the United States Fish and Wildlife Service (USFWS) is a continuation of coordination under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). This coordination will facilitate your National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 *et seq*.) analysis of the project.

Subsection 2(a) of the FWCA provides that the Federal agency constructing, permitting, or licensing a water resource development project "shall first consult" with the USFWS, with the principal procedural element to include the opportunity for continuing participation in planning that begins at the early stages such as at the reconnaissance stage. So that the Corps might give equal consideration to fish and wildlife, we recommended an alternative that would avoid and minimize adverse effects to fish and wildlife, and in some cases, enhance conditions for fish and wildlife affected by project operations. Your response indicated that you considered the alternative, but dismissed it in favor of the Proposed Action Alternative (PAA) that you will carry forward in your analysis to support a decision for a revised WCM.

The reasons for your dismissal of the PAL alternative and other alternatives are not clear; therefore, it is not evident whether the fish and wildlife benefits associated with our recommendations received the equal consideration mandated under Section 2 of the FWCA. Further, action agencies are required under NEPA regulations at 40 CFR 1502.14 to "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated." We are not aware of the process that the Corps has applied in dismissing or selecting alternatives, or will apply in making the final decision.

We request the following information to assist in our evaluation and report development, facilitate coordination with the States, and help ensure that the intent of the FWCA and NEPA is achieved:

1. Quantitative and operational measures (feature or activity) that defined each of the eight alternatives considered by the Corps, including reservoir drawdown and refill periods, action zone elevations, reservoir balancing methods, hydropower generation, drought operations, navigation, and environmental flow releases. The criteria used to compare and rank the alternatives will also assist our review.

2. Modeling parameters used to reproduce the USFWS alternative in Hydrologic Engineering Center-ResSim (ResSim), including a list of any changes made to the alternative since it was delivered to you and the rationale for such changes. Please also provide the water quality and hydrological model output for the USFWS alternative for all nodes in the Apalachicola, Chattahoochee, and Flint rivers.

3. DSS file(s) that includes the ResSim output for each node for each of the eight alternatives considered, including reservoir elevations, flows, and water quality.

4. Quantitative relationships among hydrology, temperature, and dissolved oxygen that were used to produce the dissolved oxygen and temperature graphs.

5. Modeled dissolved oxygen and temperature data for all Chattahoochee River nodes for all alternatives.

6. High flow guidelines for the PAA and No Action Alternative (NAA), or the data necessary for USFWS to produce them.

7. Clarification of the demands data that were used for Phase 1 and Phase 2 of your analysis. Please provide your analysis of demands scenarios that were considered.

8. Composite zones for the NAA and the other alternatives considered. Please confirm the method used to compute composite zones.

9. Estimates showing percent of days in Zones 1-4 and the drought zone for each alternative. Please include a table or graph showing the number of days required to transition from drought operations to Zone 1 for each alternative. Alternatively, you may provide USFWS with the requisite data and we will compute the statistics.

10. A description of how navigation was incorporated into ResSim. For example, was it a continuous navigation period for a period of 4-5 months, or several three-week periods

nested within the 4-5 month period? Please provide the discharge and duration values that were used, and clarify whether May was included in the modeling.

11. The analysis used to define action zone elevations.

We expect that many of the information needs that we identified are already available as DSS files, a format that should be efficient to transfer to us and that we are prepared to use. Additional information and data requests may be made in the future as part of the ongoing coordination with the States and the Corps. Please contact Will Duncan or Alice Lawrence at 706-613-9493, or Grant Webber at 850-769-0552 should you have questions regarding the requested information.

Sincerely,

Donald Imm

Draft Fish and Wildlife Coordination Act Report July 2015

This page intentionally left blank

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4980 Wildlife Dr.
Townsend, Georgia 31331

July 31, 2015

Colonel Jon J. Chytka
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Chytka:

We are providing your agency with a Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida in fulfillment of Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from U.S. Army Corps of Engineers (Corps) reservoirs. We submit the following comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Migratory Bird Treaty Act (MBTA) (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq.*), and the FWCA. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed threatened and endangered fish and wildlife species protected under the ESA. We anticipate providing comments on the draft Environmental Impact Statement (DEIS) that the Corps is preparing to support its decision regarding the WCM update, and it is our understanding that the Corps intends to include this DFWCAR as an appendix to the DEIS. Delivery of the final version of this report will depend upon the Corps' schedule.

A draft version of the DFWCAR was distributed to the National Oceanic and Atmospheric Administration (NOAA), Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), and Florida Fish and Wildlife Conservation Commission (FFWCC). The Service subsequently received comments from FFWCC, ADCNR, NOAA, and GDNR-WRD. Since the Service received comments on the DFWCAR, and based on new information received from the Corps, the Service has recently developed an additional Appendix to the DFWCAR (Appendix XV) that has not yet been reviewed by the State wildlife agencies and NOAA. *If these agencies have comments on Appendix XV, which pertains to the Corps' alternatives selection process, we* *respectfully ask that they supply their comment letters regarding Appendix XV directly to the Corps and copy the Service on their correspondence.*

The problems with the methodology that the Corps used to select alternatives, detailed in Appendix XV, are considered to be significant by the Service. When several corrections were made by the Service, the ranking of alternatives changed. Regardless, the Service provides this DFWCAR in the event the Corps proceeds with the alternative that they have selected.

The DFWCAR outlines the fish and wildlife concerns and planning objectives that were provided in our April 2, 2010, Planning Aid Letter (PAL), March 1, 2011, PAL addendum, July 19, 2013, submission of the United States Fish and Wildlife Service's (Service) revised alternative, and August 29, 2013, PAL to you, along with our understanding of the Corps' responses to our concerns and objectives. The DFWCAR describes the alternatives and evaluates the anticipated impacts of the selected plan. Currently, the Service does not fully support the Corps' proposed alternative. However, our report provides the Corps with fish and wildlife conservation measures, recommendations, and methodologies that would address our concerns.

We urge the Corps, in cooperation with the Service and the State wildlife agencies, consider additional alternatives for analysis and analyses of potential impacts that would address our concerns about water quality in project tailraces, alterations of flow regimes that adversely affect fish and wildlife, etc., and that could lead to formulation of an environmentally preferable alternative in the Corps' decision-making process for the operations of the ACF Corps' reservoirs.

The Service recognizes the Corps' desire to complete this study in a timely manner but believes that a more informed alternative selection methodology and impact analysis should be utilized. The Service is willing to work with the Corps to expeditiously identify and implement such recommendations. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, Panama City Ecological Services staff biologist Grant Webber at (850) 769-0552, or Southeast Regional Office staff biologist David Walther at (337) 291-3122.

Sincerely,

Donald Imm
Field Supervisor

cc: G. Webber, USFWS, Panama City, FL
C. Phillips, USFWS, Panama City, FL
D. Walther, USFWS, Lafayette, LA
B. Pearson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL

B. Zettle, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
T. Litts, GDNR-WRD, Social Circle, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
N. Kajumba, EPA, Atlanta, GA
B. Cox, NPS, Atlanta, GA
P. Wilber, NOAA, Charleston, SC

Draft Fish and Wildlife Coordination Act Report

On

Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

Georgia Ecological Services
Athens, Georgia

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia
July 2015

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4980 Wildlife Dr.
Townsend, Georgia 31331

July 31, 2015

Colonel Jon J. Chytka
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Chytka:

We are providing your agency with a Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida in fulfillment of Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from U.S. Army Corps of Engineers (Corps) reservoirs. We submit the following comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.), the Migratory Bird Treaty Act (MBTA) (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed threatened and endangered fish and wildlife species protected under the ESA. We anticipate providing comments on the draft Environmental Impact Statement (DEIS) that the Corps is preparing to support its decision regarding the WCM update, and it is our understanding that the Corps intends to include this DFWCAR as an appendix to the DEIS. Delivery of the final version of this report will depend upon the Corps' schedule.

A draft version of the DFWCAR was distributed to the National Oceanic and Atmospheric Administration (NOAA), Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), and Florida Fish and Wildlife Conservation Commission (FFWCC). The Service subsequently received comments from FFWCC, ADCNR, NOAA, and GDNR-WRD. Since the Service received comments on the DFWCAR, and based on new information received from the Corps, the Service has recently developed an additional Appendix to the DFWCAR (Appendix XV) that has not yet been reviewed by the State wildlife agencies and NOAA. *If these agencies have comments on Appendix XV, which pertains to the Corps' alternatives selection process, we* *respectfully ask that they supply their comment letters regarding Appendix XV directly to the Corps and copy the Service on their correspondence.*

The problems with the methodology that the Corps used to select alternatives, detailed in Appendix XV, are considered to be significant by the Service. When several corrections were made by the Service, the ranking of alternatives changed. Regardless, the Service provides this DFWCAR in the event the Corps proceeds with the alternative that they have selected.

The DFWCAR outlines the fish and wildlife concerns and planning objectives that were provided in our April 2, 2010, Planning Aid Letter (PAL), March 1, 2011, PAL addendum, July 19, 2013, submission of the United States Fish and Wildlife Service's (Service) revised alternative, and August 29, 2013, PAL to you, along with our understanding of the Corps' responses to our concerns and objectives. The DFWCAR describes the alternatives and evaluates the anticipated impacts of the selected plan. Currently, the Service does not fully support the Corps' proposed alternative. However, our report provides the Corps with fish and wildlife conservation measures, recommendations, and methodologies that would address our concerns.

We urge the Corps, in cooperation with the Service and the State wildlife agencies, consider additional alternatives for analysis and analyses of potential impacts that would address our concerns about water quality in project tailraces, alterations of flow regimes that adversely affect fish and wildlife, etc., and that could lead to formulation of an environmentally preferable alternative in the Corps' decision-making process for the operations of the ACF Corps' reservoirs.

The Service recognizes the Corps' desire to complete this study in a timely manner but believes that a more informed alternative selection methodology and impact analysis should be utilized. The Service is willing to work with the Corps to expeditiously identify and implement such recommendations. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, Panama City Ecological Services staff biologist Grant Webber at (850) 769-0552, or Southeast Regional Office staff biologist David Walther at (337) 291-3122.

Sincerely,

Donald Imm
Field Supervisor

cc: G. Webber, USFWS, Panama City, FL
C. Phillips, USFWS, Panama City, FL
D. Walther, USFWS, Lafayette, LA
B. Pearson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL

B. Zettle, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
T. Litts, GDNR-WRD, Social Circle, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
N. Kajumba, EPA, Atlanta, GA
B. Cox, NPS, Atlanta, GA
P. Wilber, NOAA, Charleston, SC

EXECUTIVE SUMMARY

The United States Army Corps of Engineers (Corps) proposes to prepare an updated Master Manual for the Apalachicola-Chattahoochee-Flint (ACF) Basin. The purpose of the Water Control Manual (WCM) updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. This Draft Fish and Wildlife Coordination Act Report (DFWCAR) outlines the United States Fish and Wildlife Service (Service)'s fish and wildlife concerns and planning objectives, describes the alternatives, and evaluates the anticipated project impacts of the selected plan.

The Corps' proposed action alternative (PAA) would modify the action zones for Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir. The Corps states in general, the action zones would be revised upward in the winter months at Lanier Reservoir and at West Point Reservoir and downward in the summer months at Walter F. George Reservoir.

The proposed drought plan would be similar to the No Action Alternative (NAA), except drought operations would be "triggered" when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3 in the PAA. Under the NAA, drought operations are currently "triggered" when composite conservation storage falls below the bottom of Zone 3 into Zone 4.

The PAA proposes no changes to the NAA flood risk management operations. Under the PAA, the hours of hydropower generation would continue to vary by action zone, but a greater range of hourly production would be incorporated for operational flexibility in all action zones except for Zone 4 at West Point Reservoir and Walter F. George Reservoir.

Under the PAA, the Corps would provide a reliable navigation season if hydrologic conditions allow, typically extending from January through April or May. Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The Corps' determination to extend the navigation season beyond April would depend on inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. Down ramping of flow releases would adhere to the Jim Woodruff fall rate schedule for federally-listed species, regardless of period in the navigation season. Augmenting flow releases to provide a 7-foot navigation channel would be dependent on channel conditions that ensure safe navigation. In addition, special releases may occur for a short duration to assist navigation during the navigation season.

Under the PAA, there would be no changes to the NAA for fish spawn, fish passage, or recreation operations. Releases for federally-listed species below Jim Woodruff would be modified in that the ramping rate would be suspended during prolonged low flow. The ramping rate would be suspended when basin inflow is less than 7,000 cubic feet per second (cfs) for 30 days and would be resumed when basin inflow is greater than 10,000 cfs for 30 days.

The PAA would include releases from Buford Dam, when considered in combination with contribution of local drainage between the dam and the city of Atlanta and reregulation of Georgia Power Company's Morgan Falls Dam, to be sufficient to provide a minimum flow at

Peachtree Creek of 750 cfs during May through October and 650 cfs during November through April. In contrast, the NAA includes releases from Buford Dam that provide a minimum flow at Peachtree Creek of 750 cfs year-round.

The PAA would continue to accommodate net withdrawals of 8 million gallons per day (mgd) by the City of Gainesville and withdrawals of 2 mgd by the City of Buford from Lanier Reservoir under relocation agreements. Additionally, 189,500 acre-feet of storage in Lanier Reservoir would be reallocated by the Corps to accommodate a portion (165 mgd) of Georgia's 2040 water supply need; this assumes that an additional 40 mgd would be withdrawn from the yet-to-be constructed Glades Reservoir to meet that future need. The Corps would also make releases from Buford Dam to provide for water supply withdrawals up to 408 mgd from the Chattahoochee River downstream at Atlanta by 2040. All other water supply operations would remain the same as the NAA.

The Service does not fully support the Corps' adoption of the PAA for the following reasons:

- the Corps' current alternatives selection process (Service 2015; Appendix XV),
- a failure to adequately address conservation measures identified in the Service's PAL (Service 2010; Appendix V), PAL addendum (Service 2011; Appendix VI), and the Service's 2011 DFWCAR (Service 2011) and subsequently included in this report,
- modeling developed from limited consumptive use scenarios without sufficiently considering climate change and future increase in consumptive demands,
- inadequately assessed effects to riverine ecosystems and federally-listed Gulf Sturgeon,
- increased frequency of low flows causing negative impacts to federally-listed mussels, and
- increased storage resulting in lower magnitude releases and possibly slightly higher salinities to the Apalachicola River and East Bay. Based on model results provided by the Corps, the negative effects of the PAA on fish and wildlife resources are a consequence of reservoir system operation changes and increases in consumptive demands that are part of the PAA.

We do, however, provide the Corps with recommendations intended to benefit fish and wildlife at the end of this document. The Service has suggested evaluations and analyses that address flow, water quality, fish passage, climate change, reservoir and riverine fisheries management, Apalachicola Bay resources, the inclusion of a decision support model and adaptive management, federally-petitioned species under the Endangered Species Act (ESA), impacts to the National Park Service (NPS)'s Chattahoochee River National Recreation Area, and ecosystem services. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We also recommend that the Corps outline an approach to mitigation, which is one of the intents of coordination under the Fish and Wildlife Coordination Act (FWCA). The intent of these evaluations and analyses is to inform the development of alternatives and to address the impacts of the PAA.

TABLE OF CONTENTS

Appendices

I. FFWCC's June 15, 2015, review of the Service's draft DFWCAR.

II. ADCNR's June 16, 2015, review of the Service's draft DFWCAR.

III. GDNR's June 25, 2015, review of the Service's draft DFWCAR.

IV. NOAA's June 18, 2015, review of the Service's draft DFWCAR.

V. Service's April 2, 2010, Planning Aid Letter to Corps.

VI. Service's March 1, 2011, Planning Aid Letter addendum to Corps.

VII. Service's January 11, 2013, Scoping comments to Corps.

VIII. Service's July 19, 2013, Revised Alternative to Corps.

IX. Service's August 29, 2013, Performance Measures PAL to Corps.

X. Service's November 13, 2013, Request for information from State wildlife agencies.

XI. FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011.

XII. University of Florida's April 27, 2011, Draft interim report to the Service entitled, *Simulating the impact of USACE operating alternatives on salinity and oyster populations in Apalachicola Bay, FL.*

XIII. Service's March 12, 2015, Questions regarding the Corps' January 21, 2015, Response to Service's PAL.

XIV. Service's 2011 comparison of the Corps baseline model output and observed data for a comparable period.

XV. Service's 2015 comments regarding the Corps' alternatives selection process.

INTRODUCTION

Purpose, Scope, & Authority

The following is taken from the United States Army Corps of Engineers (Corps)' response to the United States Fish and Wildlife Service (Service)'s Planning Aid Letter (PAL) (Corps 2015a):

> "The Corps proposes to prepare an updated Master Manual for the ACF River Basin. A draft Master Manual was proposed in 1989 along with certain changes to the project manuals, as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. The Corps has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would be five project-level water control manuals, presented as appendices that would specify how the various reservoir projects will be operated as a balanced system.
>
> …Water control manuals also contain drought operations plans and divide the amount of water in storage into action zones to assist federal water managers in knowing when to reduce or increase reservoir releases and conserve storage in the Corps reservoirs, and how to ensure the safety of dams during extreme conditions such as floods. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines, and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions.
>
> …the updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, will reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues."

The Service's involvement in this project is authorized by the Fish and Wildlife Coordination Act (FWCA). The FWCA establishes fish and wildlife conservation as a co-equal purpose or objective of federally-funded or permitted water resource development proposals or projects.

This Draft Fish and Wildlife Coordination Act Report (DFWCAR) is presented in fulfillment of FWCA and constitutes the final report of the Secretary of the Interior as required by Section 2(b) of the FWCA.

FWCA Agency Coordination

The Service distributed a draft of the DFWCAR on May 19, 2015, to Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), Florida Fish and Wildlife Conservation Commission (FFWCC), and National Oceanographic and Atmospheric Administration (NOAA) for their review. We received comments from FFWCC on June 15, 2015, ADCNR on June 16, 2015, NOAA on June 18, 2015, and from GDNR on June 25, 2015. The Service also received comments from GDNR-Environmental Protection Division (GDNR-EPD) on June 5, 2015. However, because the FWCA requires that the Service coordinate with fish and wildlife agencies to ensure that fish and wildlife needs receive equal consideration, we have addressed GDNR-EPD's comments in a June 18, 2015, correspondence separate from the FWCA process.

We encourage the Corps to review these agency correspondences and consider them in their decision-making process. The agency responses to a draft of the DFWCAR are attached as Appendices I-IV; a summary of the correspondences is as follows:

<u>FFWCC</u>

FFWCC shares a number of key concerns with the Service's DFWCAR and agrees with the Service's general assessment that the PAA is unacceptable. FFWCC emphasizes the importance of consistent, transparent communication among the Corps, Service, and FFWCC. FFWCC notes that the Corps is required to consult with the Service *and* FFWCC, but this has not occurred; FFWCC requests the relevant datasets supporting the Corps' analyses. Until the relevant datasets are provided to FFWCC, they state that they cannot fully and effectively provide detailed comments as requested. After reviewing the Corps' datasets they will provide additional comments on these materials, as well as the DFWCAR, in accordance with FWCA. FFWCC notes that they, as well as the Service, earlier asked the Corps to address the impacts of current and projected consumptive water uses as part of the WCM Update process. The FFWCC states that the Corps has not offered any such analysis, and based on information being developed supporting litigation captioned *Florida vs. Georgia*, No 142 Orig., they "reject the Service's apparent interim conclusion that upstream consumptive uses are not having a significant effect on Florida's fish and wildlife resources."

Service Response: Per FFWCC's request, we have provided FFWCC with all relevant information that we have been provided by the Corps. The Service contacted FFWCC representatives/counsel to gain clarification regarding FFWCC's last sentence (cited above). FFWCC stated that this refers to the Service's statement in the DFWCAR that, "based on model results provided by the Corps, the negative effects of the PAA on fish and wildlife resources are, in part, a consequence of reservoir system operation changes. They are not solely the result of increases in consumptive demands that are part of the PAA." The Service does not consider this particular comment as necessarily addressing the issue of significance; rather that effects are jointly caused by both reservoir operations and increased consumptive demands. In this Final Draft version of the DFWCAR we have tried to clarify the meaning of our statement.

ADCNR

ADCNR encourages the Corps to fully develop and analyze alternatives or suites of alternatives that will maximize and benefit fish and wildlife resources of the State of Alabama. They also encourage decision support models, in an adaptive management framework, to evaluate these alternatives.

Specific concerns highlighted in ADCNR's correspondence include water quality, instream flow, increasing consumptive demand, State-protected aquatic species, and drought conditions and impacts. In terms of water quality, ADCNR agrees that releases from the Corps' ACF dams should meet or exceed State water quality standards and that water quality issues should be a priority for the protection of aquatic resources. Assessments for improvement should be fully considered in the suites of evaluated alternatives and the PAA. ADCNR agrees with the Service that alternative water quality assessment methods should be used to evaluate the effects of Corps' operations on water quality. ADCNR believes improvements to current Corps' facilities are within the scope of the WCM update process and recommend they be addressed while analyzing alternatives.

In terms of instream flow, ADCNR states that the responsibility of the Corps' water control operations must include a flow regime that maintains ecological integrity to protect the physical, chemical, and biological functions of waters flowing into the State of Alabama. Per their Instream Flow Policy implemented in 2012, ADCNR states that it is their policy to advocate for the protection of instream flow requirements in all water allocation decisions.

ADCNR requests the Corps a conduct comprehensive analysis of increasing consumptive demands in the ACF Basin and include those with the suite of considered alternatives. ADCNR states that increased demands including increased water supply withdrawals, increased volume storage, and changes in industrial, municipal, and agricultural practices could impact hydrologic conditions.

ADCNR states that potential impacts to State-protected species by Corps operations should be avoided and minimized. Impacts should be fully assessed and potential impacts from operating under the PAA should not be greater than operating under the NAA.

In terms of drought conditions and impacts, ADCNR is concerned that minimum flows during drought conditions under the PAA would have significant negative impacts on aquatic species. They recommend an analysis of alternative instream flow regimes be conducted such that minimum flows during drought conditions under the PAA are not lower than under the NAA.

ADCNR also recommends an anadromous fish passage plan be developed for George W. Andrews Lock & Dam (GWLD) and Walter F. George Lock & Dam (WFGLD).

GDNR

GDNR's comments pertain primarily to water temperature, fishery performance measures, fish passage, and water quality. In terms of water temperature, GDNR states that the thermal regime below Buford Dam is of importance to GDNR and to recreational anglers. An introduced trout fishery is supported from Buford Dam to Bull Sluice Reservoir and this section of the Chattahoochee River receives approximately 90,000 angler trips per year. GDNR suggests that downstream recreation should be considered as a coequal consideration in the WCM update process. They note that increased hydropeaking operations at Buford Dam would reduce available recreational opportunities in NPS' Chattahoochee River National Recreation Area, which are typically limited to times of minimum flows.

GDNR states that increased water temperatures would have different impacts on trout populations depending on the distance from Buford Dam. Water temperature is not expected by GDNR to be a concern at the Buford Trout Hatchery intake, with one possible exception being an increased frequency of 2-unit generations during the fall, when water drawn from the thermocline, pre-turnover, can lead to drastic temperature increases in a short time, leading to shock. South of the Norcross gage, GDNR states that small temperature increases may lead to localized stress and mortality if water temperatures exceed 22ºC for any considerable length of time; it is only currently a concern during summer months, which experience the most impact on water temperatures due to warmwater tributary inputs and solar radiation. Because research by GDNR indicates limited trout movement in the Chattahoochee River, a localized mortality event could lead to extended, severely reduced angler opportunities in a given section.

GDNR clarifies that summer habitat for striped bass in West Point Reservoir can be very marginal and the cool flows in the Morgan Falls tailrace mitigate for the lack of summer coolwater, high oxygen habitat. The Service had stated in the DFWCAR that spring coldwater releases may have a critical inhibiting impact on the West Point Reservoir striped bass reproduction, based on Hess and Jennings (1999). Hess and Jennings (1999) suggest temperature as possibly an inhibiting factor for reproduction, but also mention low flows as another potential inhibiting factor; therefore, GDNR states that it may not be appropriate to view higher flows/low temperatures as negative in an evaluation of riverine fish habitat.

In terms of fishery performance measures, GDNR reiterates the importance of individualizing the response of vegetation to water level management at Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir as part of the Reservoir Fishery Performance Measure (RFPM). They are concerned about using a single metric for three very different reservoirs. GDNR hopes to continue to work with the Service to refine the RFPM to more accurately model the fishery-related effects of water levels in each reservoir.

GDNR considers the continuation of the Corps' fish spawn management procedures as critically important for reservoir fisheries. As a Conservation Measure in the DFWCAR, the Service suggests investigate modifying the Fish Spawn Standard Operation Procedures (SOPs) to occassionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. GDNR would like to understand this Conservation Measure in more detail and state that conditions to meet this goal may be difficult in most years; in addition, the per-unit impacts in water management choices may not be uniform between rivers and reservoirs.

GDNR states that it is appropriate to use water temperature as the driving factor related to shoal bass abundance in the Chattahoochee River Shoal Bass Performance Measure (CRBPM) for the Morgan Falls tailwater. However, GDNR states that thermal impacts farther downstream, between Peachtree Creek and West Point Reservoir, are likely minimal relative to shoal bass reproduction and recruitment in normal years. Apparent limited shoal bass abundance in this reach could be due to other limiting factors that should be addressed and considered when using the CRBPM to inform flow regimes.

In terms of fish passage, GDNR agrees that improved fish passage would provide benefits to multiple species (e.g., increased habitat availability for Gulf Sturgeon and Striped Bass).

In terms of water quality, GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from increased residence time or nutrient loading. GDNR states that Lanier Reservoir and Walter F. George Reservoir have not historically had problems of algal mats and/or fish kills due to chlorophyll-*a* or phosphorous loading, and West Point Reservoir nutrient levels have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. When classifying water quality changes as positive or negative, potential benefits from increases in residence time or nutrient loading that can lead to increases biomass and improved fishing should be considered.

GDNR agrees that increased dissolved oxygen levels below Corps' dams would have positive benefits to tailwater fisheries. The State water quality standard at Norcross and Morgan Falls both fall within State-listed trout waters, and as such, were incorrectly cited in the Corps' response to the Service's PAL (Corps 2015a) and subsequently the Service's DFWCAR as a daily average of 5.0 mg/L instead of 6.0 mg/L. An increase in dissolved oxygen at Buford Trout Hatchery in the late summer and fall pre-turnover period would alleviate stress on trout held in hatchery raceways. Increases in dissolved oxygen levels below West Point Dam should provide a benefit to shoal bass populations. Electrofishing surveys below WFGLD have indicated that low dissolved oxygen may severely impact recreational fishing opportunities for several miles downstream.

GDNR also clarifies that Buford Trout Hatchery's withdrawal, listed as 7 mgd, is a pass-through system and the net withdrawal is negligible on downstream flows (limited to evaporation).

<u>NOAA</u>

NOAA is supportive of the Service's comments addressing the current inadequacy of the evaluation of the PAA on Gulf Sturgeon and recommends the Corps provide a more thorough evaluation of the effects of implementing the PAA on Gulf Sturgeon. NOAA is supportive of the Service's comments that fish passage provisions, with operational flexibility, should be incorporated at not only Jim Woodruff Lock and Dam (JWLD), but also at the two Corps facilities upstream of JWLD, GWLD and WFGLD.

In addition, NOAA states that additional examinations are needed to determine how variations in freshwater inflow to Apalachicola Bay affect seagrass, fish, and shellfish abundances. NOAA recommends the Corps coordinate with FFWCC to complete analyses and include an updated Apalachicola Bay salinity model for predicting oyster mortality and growth in the WCM.

Prior Studies and Reports

The following studies and/or reports are the most pertinent documents involved in producing this DFWCAR:

- Corps' April 15, 2008, description of proposed action modification to the Interim Operations Plan at Jim Woodruff Dam;
- Service's 2008 and 2012 biological opinions for the Corps' Revised Interim Operations Plan;
- Service's April 2, 2010, PAL to the Corps (Appendix V);
- Corps' January 18, 2011, response to the Service's PAL;
- FFWCC's February 22, 2011, correspondence to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps titled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems (*Appendix XI*);*
- Service's March 1, 2011, PAL addendum to the Corps (Appendix VI);
- University of Florida's April 27, 2011, draft interim report to the Service entitled, *Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, Florida* (Sheng et al. 2011; Appendix XII);
- Service's June 2011 DFWCAR to the Corps;
- Service's July 19, 2013, Revised alternative for consideration in the ACF River Basin WCM to the Corps (Appendix VIII);
- Service's August 29, 2013, PAL to the Corps (Appendix IX);
- Corps' February 6, 2014, HEC5Q and Service water temperature model comparisons; and
- Corps' January 21, 2015, response to the Service's PAL.

DESCRIPTION OF STUDY AREA

The 19,910 square mile (mi^2) ACF River basin stretches from north central Georgia to the eastern border of Alabama to the Gulf coast through the central Florida panhandle. The drainage principally comprises the Chattahoochee (8,770 mi^2) and Flint (8,460 mi^2) rivers, which meet to form the Apalachicola River (2,680 mi^2) near the border of Florida and Georgia. Water resources in the ACF River basin have been developed to meet various demands for municipal and industrial water supply, flood control, hydropower, navigation, fish and wildlife conservation, recreation, and agricultural water supply (Corps 1998).

There are currently 14 reservoirs impounding the mainstem ACF river system, of which five are federally-owned and 9 are privately-owned projects. Eleven reservoirs are located on the Chattahoochee River, two on the Flint River, and one, JWLD, is located near the confluence of the Chattahoochee and Flint rivers which forms the Apalachicola River. The federally-owned projects include JWLD, as well as four projects along the mainstem Chattahoochee River: GWALD, WFGLD, West Point Dam, and Buford Dam (Figure 1).

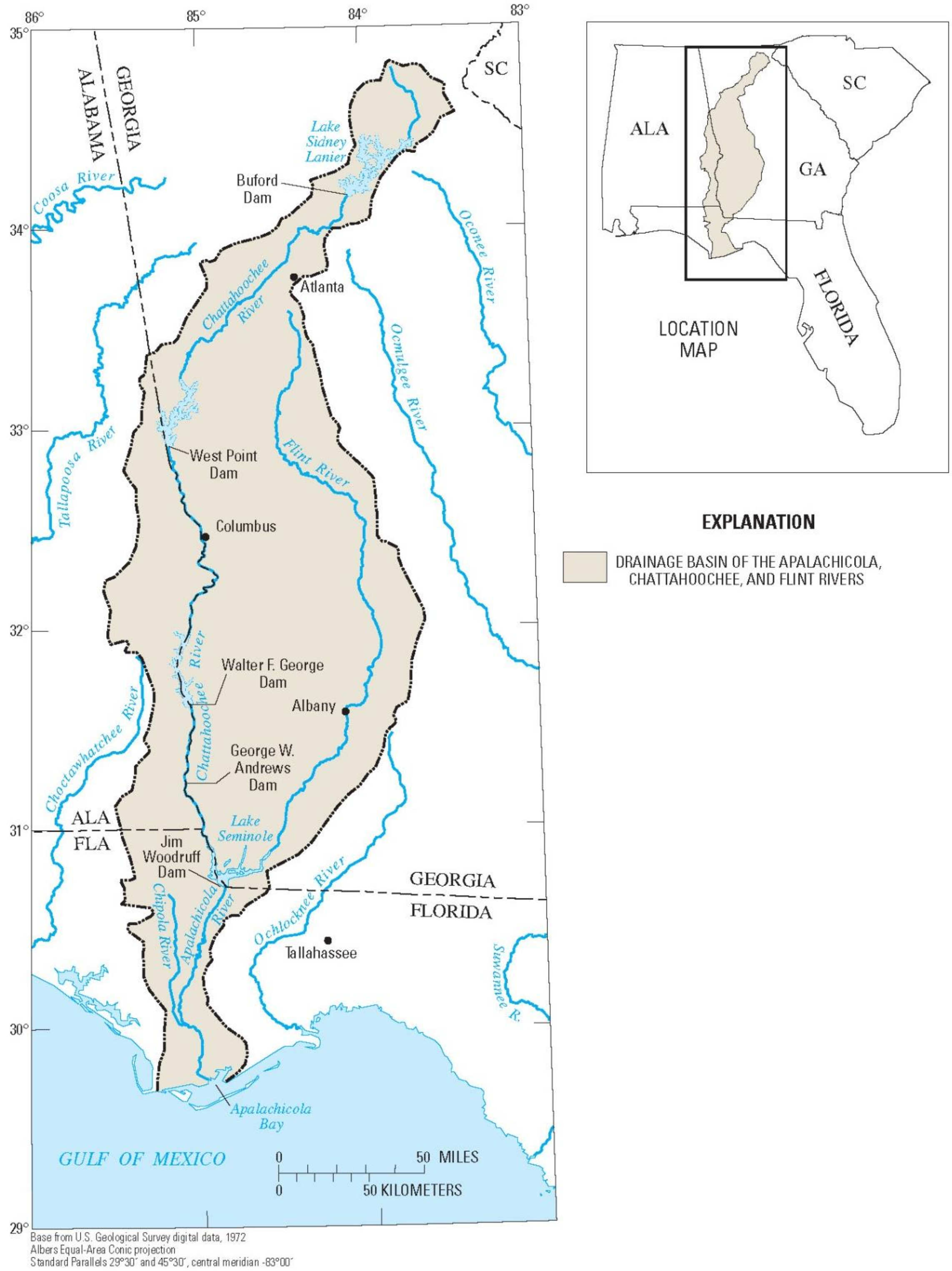


Figure 1. Map of the ACF Basin showing location of the Corps' dams (source: Light et al. 2006).

FISH AND WILDLIFE CONCERNS AND PLANNING OBJECTIVES

The Service's fish and wildlife concerns, planning objectives, recommendations and requested analyses have been previously described in detail to the Corps in our 2010 PAL (Service 2010; Appendix V) and 2011 PAL addendum (Service 2011; Appendix VI). Some of our concerns and planning objectives were represented in our scoping comments (Service 2013; Appendix VII), revised alternative (Service 2013; Appendix VIII), and 2013 PAL (Service 2013; Appendix IX). Our overarching planning objective is to identify negative impacts to aquatic ecosystems, and provide considerations for improving, protecting, and mitigating for losses to aquatic resources associated with the revision of the Corps' Water Control Manual.

In the Fish and Wildlife Conservation Measures and Recommendations Section we have included a summary of our current understanding of the Corps' position on each issue, as well as additional conservation measures and recommendations developed from the Corps' 2011 response to the Service's PAL and more recent conservation and mitigation measures. These more recent measures include recommendations for the Corps' to consider the effects of the PAA on species in the ACF Basin that have been petitioned for Federal listing under the ESA, impacts to NPS' Chattahoochee River National Recreation Area, and ecosystem services, as well as the development of appropriate mitigation.

DESCRIPTION OF CORPS' NO ACTION ALTERNATIVE AND SELECTED PLAN

No Action Alternative

The Corps' NAA represents continuation of the current water control operations at each of the Federal projects in the ACF Basin. There is not one comprehensive document that reflects the Corps' current operational practices; instead they are described in multiple Corps documents including:

- 1989 Draft ACF Water Control Plan;
- June 2008, Revised Interim Operations Plan (RIOP) and Environmental Assessment, as modified by the updated RIOP/EA (May 2012);
- May 2010, South Atlantic Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes and February 2005, Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan (SAM SOP 1130-2-9);
- February 1991, Chattahoochee River Management System as described in the Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA; and
- Project WCM s for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects.

The NAA as it dictates general system operations, action zones, and authorized project purposes is described in detail in the Corps' response to the Service's PAL (Corps 2015a). The NAA also includes current water supply operations including withdrawals directly from Lanier Reservoir and Buford Dam releases for downstream withdrawal.

Proposed Action Alternative

The PAA as it dictates general system operations, action zones, and authorized project purposes is also described in detail in the Corps' response to the Service's PAL (Corps 2015a). In light of the July 2011 Eleventh Circuit Court of Appeals ruling, the Corps is considering current levels of water supply withdrawals and a portion (165 mgd) of Georgia's 2040 water supply need within Lanier Reservoir, assuming an additional 40 mgd would be withdrawn from projected construction and use of Glades Reservoir. Releases from Buford Dam would provide for water supply withdrawals of up to 408 mgd from the Chattahoochee River at Atlanta. The PAA provides a minimum flow rate of 750 cfs at Peachtree Creek from May through October and 650 cfs from November through April.

Under the PAA, the Corps would modify the action zones for Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir. Specifically, the action zones in Lanier Reservoir and West Point Reservoir are shifted upward in the fall and winter months and the action zones are shifted downward in Walter F. George Reservoir, primarily during summer months.

The hours of hydropower generation under the PAA would continue to vary by action zone, but a greater range of hourly production would be incorporated in all action zones at Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir except for Zone 4 at West Point Reservoir and Walter F. George Reservoir. This operational flexibility appears that it would result in potentially more variability in hydropower production at Buford Dam and less hydropower production at West Point Dam and Walter F. George Dam.

Under the PAA, the Corps would provide a reliable navigation season. If hydrologic conditions allow, a typical navigation season would extend from January through April or May. During this navigation season the flows at the Blountstown, Florida USGS gage would provide at least a 7-foot channel, which corresponds to 16,200 cfs at Blountstown (Corps 2015b). Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The determination to extend the navigation season beyond April would depend on inflows, climatic and hydrological conditions, and meteorological and basinwide forecasts. Downramping of flow releases would adhere to the JWLD fall rate schedule. Releases to provide for the 7-foot navigation channel would also be dependent on navigation channel conditions that ensure safe navigation.

Under the PAA, there would be no changes to flood damage reduction, fish spawn, fish passage, or recreational operations. Releases for federally-listed species below JWLD would be modified in that the ramping rate would be suspended during prolonged low flows. Use of ramping rate rules would be suspended when basin inflow has been less than 7,000 cfs for 30 days, and would be resumed when basin inflow is greater than 10,000 cfs for 30 days.

The PAA would include a drought plan that would be similar to the NAA, but drought operations would be "triggered" when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3. Under the NAA, drought operations are currently "triggered" when composite conservation storage falls below the bottom of Zone 3 into Zone 4. Under both the NAA and PAA, drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2. Additionally, reshaping of the action zones, including the Drought Zone, will affect both the duration and magnitude of flow releases throughout the system of reservoirs.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

A fundamental component of the FWCA Report is the evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated. It is standard practice for such analyses to include evaluations and comparisons of long- and short-term future resource conditions with and without the project and for mitigation to be based on projections of future resource conditions (Figure 2).

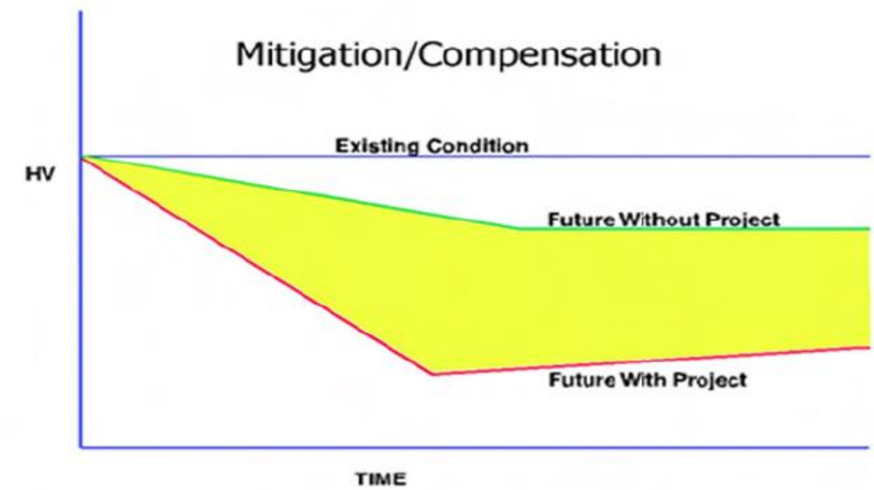


Figure 2. Mitigation and compensation of habitat values (HV) lost for a hypothetical water resource project. Yellow area projects future habitat values lost and mitigation/compensation needs.

The Corps combined multiple changes to operations at Corps projects with increased allocation of water for the Atlanta area in order to formulate the PAA. Although the PAA consists of multiple changes to the existing WCM, the PAA represents a single action (formulation of a new WCM) that describes "the project." In order to discuss and evaluate mitigation measures, we defined the following terms based on our understanding of the Corps' actions:

> *Existing condition* is defined as the condition of the system without the modification to existing operations or additional consumptive uses.
>
> *Future without the project* is defined as the condition of the system without changes to Corps projects or an increased allocation for the Atlanta area. The future without the project should include forecasts for climate change and increased municipal, industrial, and agricultural consumptive demands from elsewhere in the ACF Basin.

> *Future with the project* is defined as the condition of the system with changes to Corps projects and an increased allocation for the Atlanta area. The future with the project should include forecasts for climate change and increased municipal, industrial, and agricultural consumptive demands from elsewhere in the ACF Basin.

The *existing condition (blue line)* has been modeled by the Corps as the NAA, not including future consumptive demands and climate change. No *future without the Project* (green line) scenario was provided in the Corps' analyses. The *future without the Project* should include existing operations of Corps projects, with projected consumptive demands and climate change. Similarly, the *future with the project (red line)* is not fully represented. The PAA included proposed changes to operations and future consumptive demands through 2040 for the Atlanta area, but did not incorporate basinwide consumptive demand projections or climate change.

Changes in future resource conditions include changes related to water consumption, water quality, climate change, and associated effects on habitat and biota. For these reasons, we asked the Corps in the 2010 PAL (Service 2010; Appendix V) to include in their modeling efforts multiple future climate scenarios that could affect reservoir levels, river discharges, and estuary inflow. The Corps did not incorporate multiple climate scenarios into their modeling, thereby complicating comparisons between the future conditions with and without the PAA; they state that detailed climate change modeling and an impacts discussion have been incorporated in the DEIS when it becomes available. However, the Corps did incorporate increased consumptive water use in the Atlanta area in response to the ruling of the Eleventh Circuit Court, thereby incorporating, in part, a component that is necessary to evaluate the *Future with the Project*. Consequently, we have no option but to use the NAA to evaluate future fish and wildlife resources without the PAA, and to use the PAA as a proxy for future with the project.

A multitude of fish and wildlife resources are dependent upon discharge and have been affected by long-term discharge changes. FFWCC provided a summary and comparison of pre-Buford Dam and post-West Point Dam conditions that exhibit discharge and salinity changes in the Apalachicola River and Bay ecosystems (FFWCC 2011; Appendix XI). Although the interpretations of the analyses were made by FFWCC and not the Service, impacts identified (hypothesized, realized, or modeled) in FFWCC's correspondence are relevant because operational changes at Corps facilities have the potential to ameliorate, exacerbate, or have no effect on such project-induced impacts and impacts associated with other changes in future resource conditions. Apalachicola River and Bay impacts addressed in the FFWCC letter include:

- Long-term decreases in river flow, especially spring and summer low flows during dry conditions
- Decreases in floodplain inundation and associated changes in forest composition, ichthyofauna, and invertebrates
- Gulf sturgeon spawning and rearing habitat reductions, and population effects as a consequence of barrier construction (JWLD) and flow reductions
- Fish spawning habitat reductions as a consequence of reduced river flows
- Mussel habitat reductions and population effects
- Modeled estuary salinity changes as a response to Apalachicola River discharge changes and upstream flow depletions

- Influence of floodplain organic matter on oyster diet and estuary productivity
- Changes in oyster drill (*Dermocystidium marinum*) prevalence in oysters as a function of estuary inflow and salinity over multiple years.

Negative impacts of current operations on aquatic resources in other portions of the basin include:

- Loss of riverine habitat and fluvial species assemblages, including federally-listed mussel species and Gulf sturgeon that are now thought to be extirpated from the mainstem Chattahoochee River
- Loss of unimpeded passage for migratory fishes
- Fragmentation of aquatic populations in the mainstem and tributaries
- Significantly altered dissolved oxygen and temperature regimes
- Highly altered flow regimes that affect assemblages of riverine aquatic biota in the remaining flowing river segments below dams.

It is reasonable to expect that future conditions exhibiting the cumulative combination of increased population growth, consumptive demands, wastewater input, changes in climate, and continued operation of Federal projects will show increasing impacts to these natural resources. Based on correspondence with the Corps and with the States as part of the FWCA process, we have addressed or are currently addressing the types of impacts that could potentially occur as a consequence of changes in current project operations. The Corps has included projected increases in consumptive uses. However, because the Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, including climate change and sea level rise, direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for 'with the project' and 'without the project' scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in the Corps' National Environmental Policy Act (NEPA) documents.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Project impacts should be identified by comparing future resource conditions under the NAA to future conditions with the Corps' PAA. Impacts can theoretically be beneficial, adverse, or have no appreciable differences, but are limited to fish and wildlife resources that could be affected by Corps project operation changes. Thus, the intent of this section is to describe effects of project operations on biologically relevant parameters. The overall biological interpretation of the results (e.g. descriptions of whether the PAA is beneficial, adverse, or no difference compared to the NAA) is reserved for the *Evaluation of the Selected Plan* section below.

Analyses Provided by the Corps

In response to the Service's April 2, 2010, PAL, March 1, 2011, PAL addendum, and August 29, 2013, PAL, the Corps completed several requested analyses to support the comparison of the NAA and PAA (Corps 2015a). The Corps relied on HEC-ResSim to simulate management alternatives and evaluate the resulting effects to reservoir levels, river stages, and river discharge. Our understanding is that calculations of basin inflow from January 1939 through December

2008 were determined and anthropogenically-influenced variables (e.g. consumption levels, reservoir evaporation and release schedules) were used to create synthetic flow and discharge datasets that simulate expected conditions under the NAA and PAA. Datasets through 2008 were used for phase one of the Corps' alternatives formulation; datasets thorough 2011 were subsequently available and were used for phase two of the Corps' alternatives formulation. The phased approach to the Corps' formulation of alternatives is described in greater detail in the Corps' response to the Service's PAL (page 1-4, Corps 2015a).

As with any model, there are limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. As an example, we have provided the results of a statistical and qualitative analysis that evaluates congruency between actual operations as measured by discharge at USGS gages and model output of existing operations (i.e., the NAA) for the comparable post-RIOP period (Service 2011; Appendix XIV). The analysis shows a high degree of similarity for many components of the hydrograph at most locations, but also several exceptions. Statistical differences between measured discharge and modeled discharge for existing operations include:

Chattahoochee at Norcross: pulse duration and frequency, and number of reversals;

Chattahoochee at West Point: pulse magnitude, duration, and rise rate, and number of reversals;

Apalachicola at Chattahoochee: number of reversals.

The intent of HEC-ResSim is not to perfectly replicate existing operations. HEC-ResSim results are particularly useful for comparing trends, not necessarily absolute magnitudes. Therefore, it is recommended to the reader and analyst that interpretation of the aforementioned parameters is focused on data trends, not absolute magnitudes, during comparisons of alternatives.

HEC-5Q was used to model water quality. Impacts assessed at multiple locations throughout the basin using HEC-5Q included effects on dissolved oxygen, water temperature, wastewater, chlorophyll-*a*, reservoir retention time, and phosphorus. For many of the analyses, the Corps evaluated a composite period from 2001-2011, but also extracted a subset of the data to represent dry (2007), normal (2004), and wet (2005) hydrologic year types. Data were further extracted to examine only the months of April or May (depending on the analysis) through October in order to examine effects during critical low flow and fish spawning periods. While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are combined for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months. For example, daily values within a month for modeled chlorophyll-*a* could actually be higher than the values represented on graphs that combine multiple months. We emphasize that this is not a failing of the Corps' analysis, but it does identify an area of investigation for which additional model data are available. We recommend that time series plots also be used (similar to dissolved oxygen plots in Figures 2.2-15 to 2.2-18 of the Corps' 2015 response to PAL) to illustrate variation that is likely to occur.

Using the recommended performance measures included in the Service's PAL (Service 2013; Appendix IX), floodplain connectivity, reservoir fisheries, and Chattahoochee River shoal bass recruitment analyses were performed by the Corps. Federally-protected species analyses on the Apalachicola River included Gulf Sturgeon and freshwater mussels. Effects on shoreline vegetation and wildlife at Eufaula National Wildlife Refuge (NWR), as well as flows at Buford Fish Hatchery were also assessed.

Below, we assess impacts of the PAA relative to the NAA using the Corps analyses. General descriptions of the analyses are presented, but more thorough descriptions of the Corps methodologies and graphical depictions of output may be found in the Corps' response to the Service's PAL (Corps 2015a). Values presented below are approximations based on visual interpretations of graphs provided by the Corps.

Dissolved Oxygen

Suitable dissolved oxygen levels are critical for fish and invertebrates. The Corps' simulation of dissolved oxygen includes 4 measurements per day. The Corps then summarized these data as daily average occurrence plots. Daily average dissolved oxygen values varied along the longitudinal river profile, with May-October median dissolved oxygen values in both the NAA and PAA analyses falling below State standards below Corps projects at Buford Dam, West Point Dam, and Walter F. George Dam. Generally, dissolved oxygen levels were similar in the NAA and PAA. The largest differences between the NAA and PAA occurred in the dry year (2007) simulation, with the greatest differences below Buford Dam stretching from Atlanta to below Whitesburg on the Chattahoochee River. We emphasize that the results provided by the Corps represent modeled data. Results may differ from observed dissolved oxygen values that occur during similar weather and hydrological conditions.

Buford Dam downstream: The PAA and NAA results were similar. Both were less than the State standard of 6 mg/L at 45% occurrence for the composite 2001-2011 period and 50% occurrence for a dry year (2007). The NAA produced 1.0 mg/L higher dissolved oxygen at the 35% occurrence for both the composite period and a dry year simulation. This represents the largest deviation between the NAA and PAA. Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L.

Norcross: The PAA and NAA results were similar and generally remained above the 6.0 mg/L State standard, except for approximately 2% of both the composite (2001-2011) and dry (2007) modeled period.

Morgan Falls: The PAA and NAA results were similar and remained above the 6.0 mg/L State standard, except for <1% of the composite (2001-2011) modeled period.

West Point Dam downstream: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~38% occurrence for the composite (2001-2011) period and dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 1.7 mg/L.

Bartletts Ferry: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~32% occurrence for the composite (2001-2011) period and dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L. However, it should be noted that this modeled data will not likely accurately reflect dissolved oxygen values in Bartletts Ferry tailrace. As a result of Georgia Power Company (GPC)'s recent Federal Energy Regulatory Commission (FERC) relicensing process, GPC has recently initiated installing stoplogs to improve dissolved oxygen levels in their tailrace during summer months each year (FERC 2014). GPC's monitoring results to date indicate dissolved oxygen levels in Bartletts Ferry tailrace meet State water quality standards as a result of this methodology.

Walter F. George downstream: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~25% occurrence for the composite (2001-2011) period and 35% occurrence for the dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L.

Water Temperature

Alteration of water temperature can greatly affect the persistence and abundance of aquatic species in a given location. Most notably, suitable water temperatures are critical for reproduction. Simulated water temperature for the NAA and PAA varied along the longitudinal river profile, with the largest temperature drops below Buford Dam (17 °C) and West Point Dam (3 °C) for modeled period between 2001-2011 in May through October. The NAA and PAA model results were similar along the longitudinal river profile in wet, dry, and normal years and in the 2001-2011 composite from May through October, with modeled warmer water temperatures (less than 1°C) most spatially prevalent in normal and dry years.

Wastewater

In the absence of quantitative models that describe water quality changes in response to flow management alternatives, percent wastewater can serve as a proxy. As percent wastewater increases, wastewater-associated substances are expected to increase along with negative impacts to the aquatic environment. Simulated average stream percent wastewater from May through October varied along the longitudinal river profile, with the largest percent wastewater between Atlanta and West Point Dam (the maximum reported NAA value was 28% wastewater for the 95% occurrence value) and below George W. Andrews Dam (the maximum reported NAA value was 28% wastewater for the 95% occurrence value) for the 2001 - 2011 composite period. Similar trends were observed in representative wet, dry and normal years. Percent wastewater in the PAA was approximately 15% greater than the NAA in the river segment between Atlanta and West Point Dam, making average conditions under the PAA more similar to drought conditions under the NAA. These trends persist along the longitudinal river profile, but the magnitude of the differences between the NAA and PAA decline in a downriver direction.

Chlorophyll *a*

Chlorophyll-*a* is correlated with algal biomass. Because algal mats can cause nuisance conditions in lakes and river shoals, it is often considered to be undesirable. Chlorophyll-*a* is also an indicator of eutrophication, stemming from increases in organic matter or nutrients and potentially causing water quality problems. Simulated chlorophyll-*a* varied along the longitudinal river profile during the April through October modeled period, with peak concentrations in reservoirs. Similar trends were observed in the 2001-2011 composite and in the wet, dry, and normal years. Results were similar between the NAA and PAA, with any differences between the two resulting in higher chlorophyll-*a* values as a result of the PAA. However, in dry and normal years, as well as for the composite period, the PAA 95% occurrence had daily average algal concentrations 1-5 µg/L higher than the NAA in Walter F. George Reservoir, West Point Reservoir and Bartletts Ferry Reservoir. The 50% and 5% occurrences for the NAA and PAA in the composite period and all year types were similar.

In their comments on the Service's DFWCAR (GDNR 2015; Appendix III), GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from nutrient loading. They state that algal mats and fish kills related to chlorophyll-*a* have not historically been a problem at Lanier Reservoir or Walter F. George Reservoir, and that the nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. If not at critical levels, GDNR states that an increase could lead to increased biomass and improved fishing within these three reservoirs. GDNR states that when classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

Reservoir Retention Time

We requested average summer retention times at each Corps reservoir. Data were provided in hard copy, tabular format for each month. Reviewing a subset of the data, June through August retention times at West Point Reservoir were generally similar between the NAA and PAA between 2001 and 2011. However, qualitative evaluation of the PAA showed higher retention times in 2002 (max= 9 days higher in August), 2006 (max= 42 days higher in July), 2008 (max= 5 days higher in August), and 2009 (max= 27 days higher in August). We request the average summer retention time data be summarized by the Corps for each of the Corps reservoirs to facilitate quantitative comparisons.

Phosphorus

Algal growth is stimulated by increases in phosphorus. Total phosphorus loads over the modeled period (2001-2011) at both of the selected locations, the headwaters of West Point Reservoir and Walter F. George Reservoir, both increased in the PAA when compared to the NAA. Simulated total phosphorus varied along the longitudinal river profile, with peak concentrations downstream from Atlanta and Columbus. Similar trends were observed in the 2001-2011 composite and in the wet and dry year longitudinal profiles; a normal year longitudinal profile was not included. Results were similar between the NAA and PAA during the composite period and within each year type; however, any differences observed between the PAA and NAA resulted in higher total phosphorus levels in the PAA analysis. Model output frequently produced concentrations 0.01-0.03 mg/L greater in the PAA analysis than the NAA analysis in the composite period and up to 0.05 mg/L greater during a dry year.

In their comments on the Service's DFWCAR (GDNR 2015; Appendix III), GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from nutrient loading. They state that algal mats and fish kills related to phosphorus have not historically been a problem at Lanier Reservoir or Walter F. George Reservoir, and that the nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. If not at critical levels, GDNR states that an increase could lead to increased biomass and improved fishing within these three reservoirs. GDNR states that when classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

Floodplain Connectivity

The Apalachicola River and floodplain ecosystems depend on seasonal flooding and connectivity to maintain forest community structure, ensure availability of spawning and rearing habitats, export detritus and nutrients to fuel higher trophic levels in the river and estuary, and support biodiversity in the region. Floodplain connectivity can result in functions such as regulation of soil and water chemistry, flood storage and displacement of energy, and carbon sequestration. Consequently, effects of project operations on the frequency, magnitude and timing of floods were evaluated. The Service developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation. The measure calculates the maximum amount of spawning habitat available for at least 30 consecutive days during the months of April through October. It is unclear whether the Corps used the FSHPM to develop the graphical comparison. As described by the Corps, it is unknown whether they calculated *consecutive* days. The Corps used the period from April through September, not April through October as specified by the FSHPM. We suspect that the results would be similar, but clarification and corrections should be made. The annual maximum 30-day growing season floodplain connectivity is the same for the NAA and PAA for the April through September period, with the exception of slightly higher connected acreage at the 80th percentile of years.

The State of Florida previously suggested that LIDAR (Light Detection and Ranging) data were available and should be used in this analysis. We agree that LIDAR data likely would be informative, especially regarding quantification of acreage connected at a range of discharges in the Apalachicola River. However, given that the NAA and PAA exceedance curves are nearly the same, we do not expect that using LIDAR data would lend additional insights.

Chattahoochee River floodplain connectivity would be expected to be nearly the same between the NAA and PAA. Conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain. Therefore, we do not expect differences in floodplain inundation in the Chattahoochee River.

Reservoir Fisheries

The Reservoir Fisheries Performance Measure (RFPM) was used to quantify the effects of the NAA and PAA on reservoir fisheries for the entire period of record. The RFPM uses the acreage of productive zone inundated for more than 30 days during the spawning season, and gives weight to inundated habitats that have potentially been colonized by terrestrial vegetation. The RFPM is fully described in the Service's PAL (Service 2013; Appendix IX). Differences between the NAA and PAA are small at each Corps reservoir (Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir). Results from the reservoir retention time analysis (2001-2011) indicate that there may be an improvement in reservoir fisheries in some years, given that retention times may increase and reservoir fisheries may respond positively.

GDNR expressed concern to the Service regarding use of the RFPM. Concerns included a) additional analyses that rely on more current fisheries data could lend additional insights, b) the length of time necessary for terrestrial vegetation to colonize previously exposed shoreline may be longer than allowed for in the performance measure, representing a potential future refinement, and c) giving extra weight to re-inundated habitat could be construed as a recommendation to intentionally reduce reservoir levels.

We generally agreed with the first concern, if more current fisheries data were to be provided. However, in GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III) they state that the currency of the data may not be the issue as the datasets span a 20+ year timeframe. Instead, the ability of currently-used sampling gears may be limited for this particular data need.

Based on GDNR's observations, we also agree that the length of time necessary for terrestrial vegetation to colonize previously exposed shoreline may be longer, especially for Lanier Reservoir. With regards to weighting re-inundated habitat, the process that was originally used to define optimal reservoir levels for fisheries (the Delphi process) included the following expert opinion from biologists in Georgia, Alabama, and Florida representing State wildlife agencies, power companies, universities, the Service, and the Corps:

> "The fisheries experts noted throughout the survey process that reservoir levels are only part of what affect reservoir fisheries. Spawning will take place at a number of reservoir levels and what matters most are fluctuations from that level, with avoidance of drawdowns during spawning (and rearing) being paramount. However, ideal reservoir levels for spawning (usually full-pool) ensure that the greatest spawning area is available for fish."

The 2013 RFPM takes drawdowns into account by calculating the "minimum" elevation and acreage continuously available for at least 30 days per year. Fluctuations above the minimum do not provide benefits, and 'dips' below the minimum count against the measure for that year. Thus, years with more continuously inundated acreage are considered better and are quantified as such in the performance measure. Finally, the Delphi approach emphasized maximizing "spawning area," but relied on expert opinion to derive water levels and effects of lower levels. The 2013 RFPM improved upon the Delphi approach by using a direct measure of acreage in the calculation.

Following a meeting requested by GDNR (January 15, 2015), we further investigated GDNR's concern regarding the inclusion of re-inundated acreage. We compared RFPM results from existing operations to the alternative submitted by the Service using both including and excluding re-inundated acreage. We found that both alternatives produce similar RFPM results. However, differences between averages and medians for including versus excluding re-inundated acreage techniques, although relatively small, can potentially lead to divergent conclusions regarding the effects to reservoir fisheries.

We requested that GDNR compile information and draft correspondence that can be used to refine the RFPM on January 15, 2015. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they state that most of their concerns surround the use of a single metric for three very different reservoirs (Lanier, West Point, and Walter F. George Reservoirs). Most of the fish habitat at Walter F. George Reservoir is in the form of submerged and emergent aquatic vegetation, versus Lanier Reservoir, and similarly West Point Reservoir, in which the majority of the flooded vegetation is terrestrial. Therefore, reservoir operations may have differing responses to vegetative growth in each of the three reservoirs. We would like to work with GDNR to incorporate refinement to the RFPM. We continue to recommend use of the RFPM until new information is developed and incorporated as appropriate.

Riverine Fisheries

The riverine fisheries analysis includes comparisons to the Service's ecosystem flow guidelines (Service 2011; Appendix VI) and the Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM) (Service 2013; Appendix IX).

Instream Flow Guidelines:

The exceedance graphs supplied by the Corps are not calculated in a manner that is comparable to the Service's ecosystem flow guidelines. The Corps has indicated that they will not be providing additional analyses of the NAA and PAA in the manner requested by the Service. If we have the time to produce comparisons between the NAA and PAA using the ecosystem flow guidelines, they will be integrated in subsequent Service reports.

Chattahoochee River Shoal Bass Recruitment:

The status of Shoal Bass in the Chattahoochee River between West Point Reservoir and Atlanta is less studied than in Chattahoochee River tributaries and the river near Morgan Falls Dam, although habitat appears suitable. Shoal Bass are a warmwater species of black bass native to the ACF Basin; because water temperatures increase to a level that could support a warmwater fishery in river shoals of the mainstem Chattahoochee River from Morgan Falls Dam to West Point Reservoir, Shoal Bass are of interest to natural resource managers. Their co-occurrence with other warmwater species may make them a useful sentinel species for warmwater fish communities. The CRSBPM (Chattahoochee River Shoal Bass Performance Measure) relies on the relationship between Shoal Bass recruitment and water temperature in the spring (Service 2013; Appendix IX). Water temperature decreases as flow increases. The CRSBPM shows that the PAA results in higher abundance (catch per unit effort) of shoal bass than the NAA.

The CRSBPM is used to quantify effects of the NAA and PAA on shoal bass recruitment from Morgan Falls Dam to West Point Reservoir. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they state that using water temperature as the driving factor related to shoal bass abundance is appropriate for the upper stretch of the Morgan Falls tailwater. They state that thermal impacts below Peachtree Creek are likely minimal to shoal bass reproduction and recruitment in normal years. Despite this, shoal bass abundance appears to be limited between Peachtree Creek and West Point Reservoir and it is possible that there are additional limiting factors that should be addressed and considered when using the CRSBPM to inform flow regimes. GDNR states that this measure should be updated as new information becomes available.

It should be noted that the CRSBPM results generated by the Corps use simulated water temperatures from the HEC-5Q model. HEC-5Q provides consistently lower values for seasonal mean temperatures (~2° Celsius at flows less than 1000 cfs) than observed data at Atlanta (Corps 2014); the CRSBPM developed by the Service used observed data. Although HEC-5Q produces lower temperatures as a function of discharge than the Service's methodology used to develop the CRSBPM, the Shoal Bass abundance trend should remain the same.

Federally-protected Species in the Apalachicola River

Gulf Sturgeon:

The following analyses were requested in the Service's 2010 PAL (Appendix V) and recommended in the Service's 2013 PAL (Appendix IX). In addition, the Service's 2013 PAL also recommended use of the Sturgeon Spawning Habitat Performance Measure (SSHPM). Following the analysis descriptions below (in italics), we provide a summary of available information and identify remaining information gaps.

Frequency (% of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning. The Service's 2013 PAL provided the SSHPM as an addition to the analyses recommended in the Service's 2010 PAL. The Corps indicated that they used the SSHPM and concluded that there were no differences between the NAA and PAA based on the median annual spawning habitat availability. The SSHPM results were not provided to us, so we are unable to evaluate effects beyond the median at this time.

Frequency (% of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning. The SSHPM computes the annual spawning habitat available for 30 days, and plots the distribution of annual spawning habitat as boxplots. The distribution of data displayed by the SSHPM informs interpretation of annual spawning acreage frequency. Therefore, the SSHPM results should be prepared, shared, and incorporated to help inform an interannual analysis of sturgeon spawning habitat effects.

Daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. Regarding daily fall rates, the Corps referenced the daily fall rate results provided for mussels. Mussel fall rate results are specific to flows less than 10,000 cfs all year for every year. Furthermore, as referenced in the Service's 2013 PAL, the maximum amount of sturgeon spawning habitat available occurs between 10,000 and 50,000 cfs, a range not encompassed by the fall rates computed for mussels. We recommend that the analysis be specific to the sturgeon spawning and early life stages that include the larger range of flows that encompass sturgeon spawning.

Maximum number of consecutive days per year less than 16,000 cfs. The Corps referenced the mussel analysis that evaluates the maximum number of days per year with flows less than 10,000 cfs. The maximum number of consecutive days <16,000 cfs was calculated because discharges <16,000 cfs cause estuary salinity levels to increase above 10 ppt at some locations, thereby creating suboptimal conditions for juvenile Gulf Sturgeon growth at those locations. This analysis was not provided and therefore, we cannot evaluate differences between the PAA and NAA for this metric.

Departures from average water temperatures between March 1st to May 31st. The Corps referenced the HEC-5Q water temperature differences from the NAA, for a year-round composite period (2001-2011). Other data referenced by the Corps include analyses during May-October for a composite period (2001-2011) and all year types. These analyses show no difference between the NAA and PAA below JWLD. Although the March 1st to May 31st period wasn't specifically evaluated, these results suggest that there are no temperature differences in average water temperature between March 1st and May 31st.

Freshwater Mussels:

Low flows in the Apalachicola River have the potential to reduce habitat, and expose and strand freshwater mussels. Lower flows may result in changes in flow energy, dissolved oxygen, water temperatures, and differences in availability of suitable substrate and food. Thus, we requested that the Corps provide several low flow analyses, similar to those provided in the 2008 and 2012 biological opinions (Service 2008, Service 2012). The following analyses were requested in the Service's 2010 PAL (Appendix V) and were recommended again in the Service's 2013 PAL (Appendix IX). The Service's 2013 PAL also recommended use of the Apalachicola River Mussel Performance Measure (ARMPM), which is included in the analyses below. Following the analysis descriptions below (in italics), we provide a summary of available information.

Lowest daily flow for each year. The effects to mussels are more extreme at the lower range of flows. In the Apalachicola River, federally-listed mussel species are generally known to occur from JWLD [located at approximately River Mile (RM) 106] down to lower reaches, with the highest densities currently located from approximately RM 50 to RM 34. When considering flows less than 6,000 cfs, PAA annual minimum flows were lower than the NAA by more than 50 cfs in 10 years, greater in 5 years, and similar in 11 years. When considering the entire period of record (1939-2011), the PAA resulted in lower annual minimum flows than the NAA in 38 years, identical annual minimum flows in 13 years, and greater annual minimum flows in 22 years. During the 2007 drought, PAA flows were projected to be lower (4,550 cfs) than the NAA (5,050 cfs). These results demonstrate that overall annual minimum flows under the PAA are lower, and in droughts they are likely to be more extreme.

Inter-annual frequency of flows less than 5,000-10,000 cfs;
Maximum number of days per year with flows less than 5,000 – 10,000 cfs; and
Maximum number of consecutive days less than 5,000 – 10,000 cfs. These three metrics showed similar trends. The percent of years when flows were below 5,000-6,000 cfs, 6,000-7,000 cfs, and 7,000-8,000 cfs is greater under the PAA. The maximum number of days/year and the maximum number of consecutive days per year that flows are less than 5,000 cfs is approximately 35 days greater under the PAA. These results demonstrate that the PAA results in more frequent lower flows that remain low for longer periods compared to the NAA, thereby creating conditions that could increase mortality of both common and federally-listed mussels.

Median number of days per year less than 5,000 – 10,000 cfs; and
Median number of consecutive days per year less than 5,000 – 10,000 cfs (added to the ARMPM). The PAA and NAA were similar, although at flows between 7,000-10,000 cfs the PAA had a slightly greater median number of days per year. Because the median is a measure of central tendency, these results demonstrate that the PAA and NAA perform similarly when considering a large range of hydrologic year types. However, the PAA's trend of slightly lower medians in relation to the NAA mirrors that of the previous set of metrics, thereby creating conditions that could increase mortality of both common and federally-listed mussels.

Frequency (percent of days) of daily stage changes (ft/day); and

Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs. River stage fall rates were examined because rapidly declining river stages have the potential to increase the risk of mussel exposure and stranding. The Corps did not evaluate the former, which includes the entire range of flows, because federally-listed mussels generally do not occur at stages higher than those equivalent to 10,000 cfs. The Corps' histogram comparing fall rates for the NAA and PAA for the modeled period of record (1939-2011) below JWLD when releases are less than 10,000 cfs indicate a high degree of similarity, with the ≤ 0.25 ft/day category comprising the largest proportion of fall rates. The NAA had approximately 450 more days when fall rates were ≤ 0.25 ft/day. The PAA had approximately 400 more days in the higher fall rate categories compared to the NAA. Collectively, the fall rate results indicate that the PAA results in flows that have a higher potential to strand mussels. These results may reflect the Corps' fall rate modification as part of the PAA. When basin inflow has been less than 7,000 cfs for 30 days, the use of the 0.25 ft/day fall rate will be suspended and will be resumed when basin inflow has been greater than 10,000 cfs for 30 days. The slow rate of federally-listed mussel recolonization into re-inundated habitat means that few mussels occupy habitats that were exposed over the previous 30 days. Slow ramping rates for declining flows that would expose these recently re-inundated habitats may provide limited benefits to mussels, and may come at a cost to reservoir storage.

National Wildlife Refuges and Fish Hatcheries

The Service requested several analyses of impacts to Eufaula National Wildlife Refuge (NWR) and hatcheries (Service 2010; Appendix V), and an evaluation of potential management options that could benefit Eufaula NWR. In response to that request, the Corps provided the following (Corps 2015a):

> *Eufaula NWR:* "The USACE considered the USFWS request to cycle Walter F. George Lake between the highest levels (190 ft) in late winter/early spring to the lowest levels (185 ft) in late summer to accommodate Eufaula National Wildlife Refuge operations (Figure 2.8-1). As proposed, the option would require operation of the reservoir at its highest pool levels during winter-spring, when flood releases are typically the greatest. That would reduce the ability of the project to attenuate approximately 87,000 ac-ft of potential downstream flooding. By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased, resulting in bank erosion and channel modifications below the project. Similarly, to operate the project at its lowest levels during the summer is contrary to what is required to meet the highest demands for recreation, hydroelectric power, and flow augmentation. Essentially, such an option would remove Walter F. George Lock and Dam from the system approach to operations across the basin and eliminate approximately 100,000 ac-ft of conservation storage that could be used to meet authorized project purposes in the summer. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant adverse effects on the authorized project purposes and the structural stability and safety of the dam. For these reasons, operations to manage Walter F. George Lake to benefit the Eufaula Wildlife Refuge operations were not considered further."

> *Fish Hatcheries:* "Four major fish hatcheries are in the ACF Basin. Buford Trout Hatchery is the only fish hatchery in the ACF Basin that relies on surface flows for its operations, and it is the largest user of water. Changes in flow on the Chattahoochee River are negligible between alternatives, and would not be expected to affect operations at the Buford Trout Hatchery (Figure 2.8-3)."

Buford Trout Hatchery withdraws about 7 mgd (11 cfs) of flow from the Chattahoochee River below Buford Dam year-round (Corps 2011). In their comments on the DFWCAR, GDNR has clarified that this is a pass-through system and the net withdrawal of water is limited to evaporation, thus is negligible on downstream flows (GDNR 2015; Appendix III). It appears from the Corps' analysis of median daily flows below Buford Dam that changes in flow are negligible between alternatives; however, the period of record is not specified but should be provided. We also suggest that flows below the median be analyzed, as they are more likely to impact the hatchery than median flows. The results of the HEC-5Q water quality modeling indicate only minor changes in water temperature and dissolved oxygen at this location as a result of the PAA in comparison to the NAA.

<u>Analyses of Apalachicola Bay</u>

We used a combination of sources to evaluate effects to Apalachicola Bay. The Corps provided the Apalachicola Bay salinity model results from HydroLogics (2012) that included a comparison between the RIOP and proposed changes to the RIOP described in the February 2012 Biological Assessment by the Corps of Engineers. HydroLogics found very limited differences between the two operational scenarios. The Service previously relied upon the University of Florida's 3D hydrodynamic salinity modeling for Apalachicola Bay to interpret effects to salinities, oysters, and juvenile sturgeon. Because of the length of time necessary to conclude the University of Florida 3D hydrodynamic salinity modeling in Apalachicola Bay, it was not possible to include those results in this report. However, if results become available, we will provide them in the future. In place of those results, however, we identify three lines of evidence that suggest differences between the NAA and PAA:

> 1) The Apalachicola Bay Salinity Performance Measure (ABSPM) shows no difference in salinities between the NAA and PAA at Cat Point and Dry Bar, but a 1.0 ppt increase in the median salinity at East Bay;
>
> 2) Low flows in the Apalachicola River at the Chattahoochee gage are lower in the PAA than in the NAA. Differences in low flows most likely manifest themselves in relatively minor salinity shifts, but may exceed salinity thresholds for juvenile Gulf Sturgeon and oysters; and
>
> 3) The range of flows used previously in the hydrodynamic salinity model [2011 Alternative 2 (Alt2)] are similar to the PAA, and the 2011 Alt2 resulted in slightly slower, but nearly identical, oyster growth rates at Cat Point compared to the 2011 NAA. It also resulted in lower acreage suitable for juvenile sturgeon compared to the 2011 NAA. Each of these lines of evidence is treated in the subsections below.

ABSPM. The ABSPM is described fully in the Service's 2013 PAL (Appendix IX). In that document we state, "Differences among the alternatives that we have analyzed to date are relatively minor. This may be due to the coarse temporal scale of the metric or the possibility that substantial changes in the bay salinity metric require large amounts of water..." We continue to view the ABSPM as a coarse metric and expect that additional statistical approaches currently unavailable to us may help the Corps and Service decipher whether different results are *statistically* different or meaningful. We also suggest that fine resolution models of bay salinities also show little salinity difference between alternatives previously considered (Sheng et al. 2011; Appendix XII). The Service calculated the ABSPM using the Corps' 2015 data. Results show that there is no predicted salinity difference between the PAA and NAA at Cat Point or Dry Bar, and a 1.0 ppt increase in the median at East Bay (Figure 3). Although the East Bay salinity increase seems relatively minor, it resulted in a larger portion of modeled salinities exceeding the 10 ppt optimal salinity for juvenile sturgeon (see the greater 50^{th}-75^{th} percentiles for East Bay in Figure 3).

Estuary inflow analysis. Salinities in the estuary increase as Apalachicola River discharge decreases (Service 2013; Appendix IX). We evaluated changes in estuary inflows using results from the ARMPM which specifically evaluates differences between the NAA and PAA at a range of low flows. A description of the results is provided in the freshwater mussel section. In summary, the PAA results in higher percent of years when flows are < 5,000 cfs, < 6,000 cfs, < 7,000 cfs, and < 8,000 cfs, and a ~35 day increase in the maximum number of consecutive days per year when salinities are < 5,000 cfs. Discharge decreases are of concern for mussels and the bay. The salinity difference between inflows of 5000 cfs and 8000 cfs is 1.6 ppt at Cat Point, 1.5 ppt at Dry Bar, and 2.6 ppt at East Bay (Table 1). We stress that the trendlines upon which the salinity estimates are based account for a large proportion of the variance in the discharge salinity relationship. However, the University of Florida 3D modeling should provide a better spatial depiction and quantification of impacts to salinity throughout the estuary. That said, although it appears that changes in discharge at low flows manifest themselves in relatively minor salinity shifts in magnitude at these monitoring points, these shifts may exceed the salinity thresholds we identified in our 2013 PAL (Service 2013; Appendix IX).

Table 1. Apalachicola Bay salinities (ppt) predicted by the salinity-discharge relationships in the ABSPM.

Chattahoochee Gage Discharge (cfs)	Cat Point	Dry Bar	East Bay
5000	26.6	25.0	15.6
6000	26.1	24.5	14.6
7000	25.6	24.0	13.8
8000	25.0	23.5	13.0
9000	24.6	23.0	12.2
10,000	24.1	22.6	11.5

Hydrodynamic salinity model. During the evaluation of alternatives in 2011, we used a 3D curvilinear-grid hydrodynamic salinity model to simulate the flow and salinity dynamics inside Apalachicola Bay (Sheng et al. 2011; Appendix XII). The modeling effort (described below) that we anticipate including in this report is the same as the one developed in 2011, but with a revised inflow dataset. The 2011 salinity modeling considered years 1999-2008. The range of flows used previously in the hydrodynamic salinity model (2011 Alt2) are similar to the 2015 PAA. Using the inflow data from the 2011 modeling, we compared estuary salinities (from the ABSPM) to the 2015 PAA for the 1999-2008 period of record. We found that the 2015 PAA produced similar salinities to those generated from the 2011 Alternative 2 based on salinity responses at Cat Point, Dry Bar, and East Bay (Figure 4). Consequently, we expect that the 3D salinity model for the 2015 PAA may produce similar salinity and oyster growth rate results as the 2011 Alt2. The 2011 Alt2 3D salinity model resulted in slightly higher, but nearly identical, salinities at Cat Point and Dry Bar. Salinity changes resulted in a 0.10 mg ash free dry weight (AFDW)/oyster/day decreased growth rate (a 7.1% decrease) at Cat Point compared to the NAA, and a 0.02 mg AFDW/oyster/day increased growth rate (a 0.8% increase) at Dry Bar (based on a comparison of means for all months). It also resulted in less acreage considered suitable for juvenile sturgeon at Cat Point and Dry bar during dry, average, and wet years. Effects to juvenile Gulf Sturgeon in East Bay were not evaluated using the 3D hydrodynamic salinity model because the model overpredicts salinities in East Bay (Sheng et al. 2011; Appendix XII).

The following information was included in the Service's 2011 DFWCAR and is relevant to the interpretation of Apalachicola Bay salinity modeling and oyster and sturgeon responses:

> "The model showed satisfactory performance with observed salinity collected by the Apalachicola National Estuarine Research Reserve in 2004. Specific details on model development and performance are provided in the report. The authors also developed an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it with the hydrodynamic-salinity model to assess the impact of freshwater alteration on oyster populations in Apalachicola Bay. Four discharge scenarios were considered in the 10 year (1999-2008) simulations: 1) observed data from the USGS gaging station 02359170 near Sumatra, Florida, 2) no action alternative (i.e., current operations), 3) proposed alternative minimum flow scenario 1 (550 cfs target at Peachtree Creek), and 4) proposed alternative minimum flow scenario 2 (750 cfs target at Peachtree Creek).
>
> The Service requested that the authors provide various analyses of model output specific to oysters and Gulf sturgeon with the assumption that optimal salinities for oysters are less than 26 ppt (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Sulak et al. 2009). To assess the impacts of the four discharge scenarios on oysters, we requested that comparisons be made at Dry Bar (an oyster bar with strong river influence) and Cat Point (an oyster bar with little river influence). These analyses included salinity exceedance probabilities, summary statistics and exceedance probabilities for oyster growth rates, and salinity contour maps with associated acreages for the total number of days when salinity exceeded 26 ppt in a wet, dry, and average year. For Gulf sturgeon, we requested salinity contour maps describing the total number of days salinity exceeded 10 ppt from 1 October- 31 March for the following years for all 4 scenarios in a dry, wet, and average year.
>
> Analyses indicate that there will be no appreciable difference in the magnitude or timing of estuary freshwater inflow between the no action and proposed action alternatives

(Sheng et al. 2011). There is little difference in salinity or oyster growth rates in any of the various analyses.

These effects on the bay relative to historic operations result from changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives, and less so to apparent changes in consumptive water uses. Historic basin inflow rates (the Corps' reported daily project inflow data) from 1976 to 2008 are roughly equivalent with the basin inflow data used in the modeled scenarios (unimpaired flow minus consumptive water uses), and the modeled basin inflow data is actually slightly higher overall (period-of-record average daily basin inflow values are 34 to 103 cfs greater) than the historic data. Therefore, the differences in the bay salinity results do not appear related to any simulated increase in consumptive water demands. However, average annual releases (1976-2008) from Woodruff Dam are about 400 to 500 cfs less than historic under the no-action and proposed alternatives, and average monthly composite reservoir storage is about 35,000 to 111,000 acre feet greater than historic levels in the months of August through October. Although salinities and oyster growth rates are similar between the no action and proposed action alternatives, all model outputs indicate that flows will continue to be lower than what historically and even recently occurred (i.e., pre-IOP in 2006) and thereby continuing suboptimal conditions for oysters, Gulf sturgeon, and other fish and wildlife in Apalachicola Bay.

In their May 23, 2011, correspondence to the Service, FFWCC states that there should be additional analyses of the impact of proposed and existing operations on juvenile Gulf sturgeon in Apalachicola Bay. They generally agree with the conclusions contained in the Apalachicola Bay section of the Service's DFWCAR, but would like to see additional details about potential impacts to estuarine sentinel species, such as eastern oysters or white shrimp. The Service agrees with FFWCC that additional datasets should be sought or generated to quantify impacts to juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species. The Service searched for additional analyses and new datasets prior to drafting the PAL but located few. Thus, the Service welcomes additional information that FFWCC can provide to assess impacts of proposed and existing operations.

FFWCC also states that the DFWCAR should address the minimum flows needed to mitigate the impacts of saltwater incursion due to sea level rise. Thus, we recommend that the Corps capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion. This modeling effort should include both short- and long-term planning horizons."

The Service agrees with FFWCC's 2011 comment that additional biological information should be sought to inform an assessment of impacts associated with proposed and existing operations. We requested additional information from FFWCC on November 13, 2013, and continue to welcome additional quantitative relationships between salinity and the biology of the Apalachicola Bay.

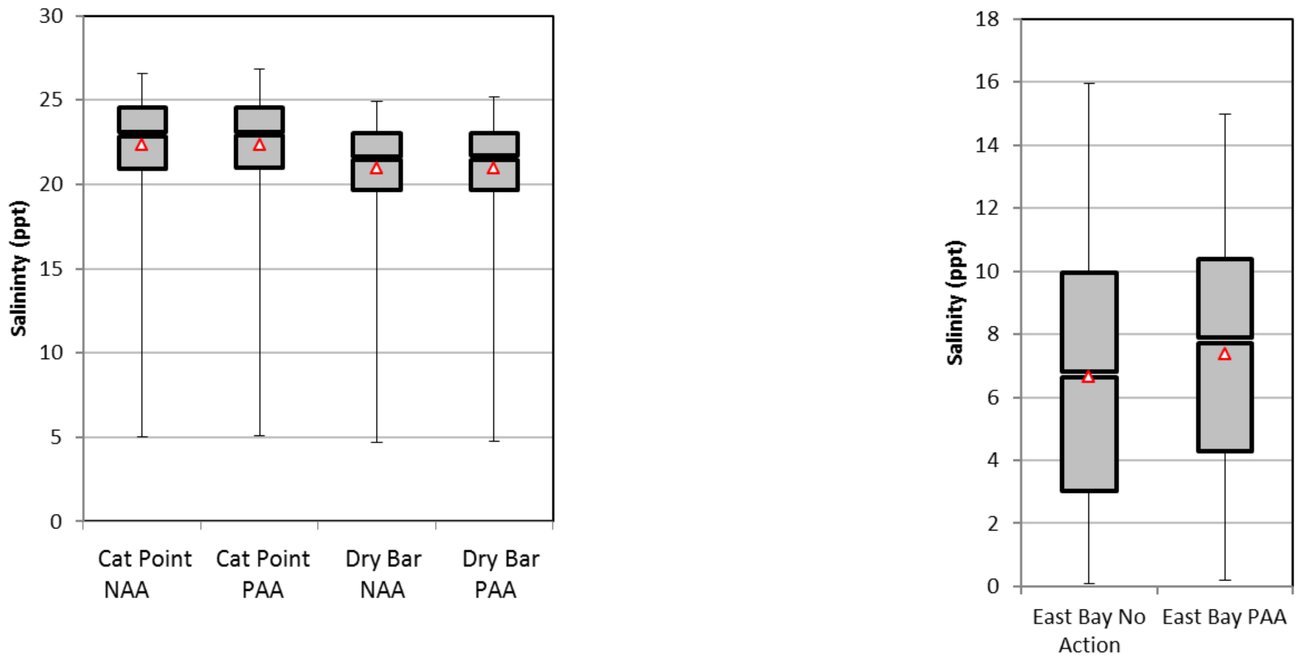


Figure 3. Salinity results for the Apalachicola Bay Salinity Performance Measure (ABSPM) for the NAA and PAA. These data include 1939-2008.

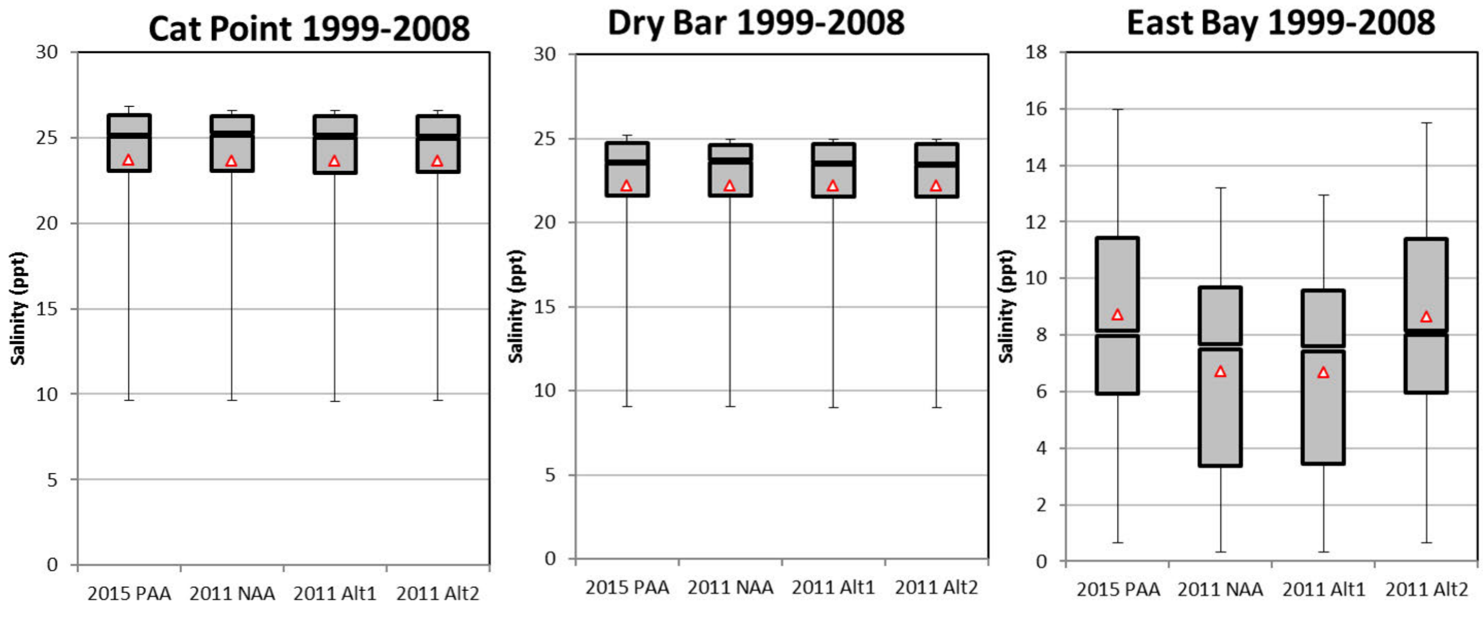


Figure 4. Salinities as predicted from the ABSPM for the PAA in 2015 and for comparison, the alternatives proposed in 2011. The period 1999-2008 represents the period used in the 2011 estuary modeling, which showed no difference between the NAA, 2011 Alt1, and 2011 Alt2.

EVALUATION OF THE SELECTED PLAN

The purpose of this section is to evaluate the relative merits of the NAA and PAA and ultimately determine their acceptability from the standpoint of the Service's responsibilities under the FWCA and our mission to conserve, protect, and enhance fish and wildlife resources. To that end, we succinctly describe the impacts of the PAA relative to the NAA in terms of each biological and/or habitat parameter considered. Each parameter is described as an improvement (+), a negative impact (-), or no change (0) over the NAA, regardless of the magnitude of the difference between the NAA and PAA. We emphasize that this approach is one method to evaluate the PAA, and it is not meant to be the sole deciding factor in the Service's evaluation. Rationales for the individual assignment of signs are provided in the text below Table 2. The Corps provided the Service limited interpretation of their analyses in their 2015 response to the Service's PAL (Corps 2015a); the evaluation below is solely based on the Service's interpretation.

Table 2. Scoring of impacts to fish and wildlife resources resulting from the Corps' PAA relative to the NAA. The PAA is better (+), worse (-), or the same (0) as the NAA for fish, wildlife or habitat. NAE indicates that the Corps has not adequately evaluated the parameter or the analysis is ongoing, and N/A indicates that the analysis is not applicable. All symbols are applicable to the reach below the dam, except variables shaded in grey are applicable to the reservoir upstream from the dam.

	Buford	West Point	W.F. George	J. Woodruff
Dissolved Oxygen	-	0	0	0
Temperature		0	0	0
Coldwater fishery	-	N/A	N/A	N/A
Warmwater fish community	+	0	0	0
Wastewater	-	-	-	-
Chlorophyll-*a*	-	-	-	-
Reservoir Retention Time	NAE	NAE	NAE	NAE
Phosphorus	-	-	-	-
Floodplain connectivity:				
Chattahoochee	0	0	0	N/A
Apalachicola	N/A	N/A	N/A	0
Reservoir Fisheries	0	0	0	N/A
Riverine Fisheries				
Shoal bass	+	N/A	N/A	N/A
Flow guidelines	NAE	NAE	NAE	NAE
Salinity	N/A	N/A	N/A	-
Gulf sturgeon	N/A	N/A	N/A	NAE
Freshwater mussels	N/A	N/A	N/A	-
Eufaula NWR	N/A	N/A	0	N/A
Buford Fish Hatchery	0	N/A	N/A	N/A

Dissolved Oxygen

Higher dissolved oxygen levels are considered to be better for fish and invertebrates, but frequently fell below State standards for both the NAA and PAA below Buford Dam, West Point Dam, and WFGLD. For the composite period, compared to the NAA, the PAA exhibited lower dissolved oxygen levels immediately below Buford Dam and then transitioned to similar dissolved oxygen levels below Atlanta. However, the differences between the alternatives were small and occurred at low occurrence levels, meaning that both the NAA and PAA frequently provide poor conditions for fish and wildlife.

Water Temperature

Temperatures were expected to be similar throughout the ACF Basin, with differences between the NAA and PAA fluctuating between -0.25 and 0.5°C for the composite period. However, when normal, wet, and dry years are separated, the PAA shows the most drastic deviation from the NAA from Norcross to West Point Reservoir. In this reach, temperatures under the PAA were expected to warm up to ~0.5°C from the NAA with the greatest temperature difference exhibited between Atlanta and West Point Reservoir. The following fisheries information is taken largely from Georgia Power Company (2006):

Historically a warmwater river, the mainstem Chattahoochee River tailrace became an artificially created coldwater river following the construction of Buford Dam. Bottom releases from Buford Dam create coldwater releases suitable for a non-native brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) fishery in a 48-mile section of river extending downstream to Peachtree Creek.

GDNR has historically stocked this section of river with rainbow and brown trout and manages the trout fishery in two distinct segments: the Buford Dam tailwater extending 30 river miles downstream to Georgia Highway 400; and the Morgan Falls Dam tailwater extending 12 miles downstream to Peachtree Creek. The first segment is colder with greater flow fluctuations and the second segment is warmer with less fluctuations.

Water temperature is of great concern to GDNR in this section of the Chattahoochee River. They are very interested in maintaining the cold temperature regime for the trout fishery, the most popular sport fishery in this section of the Chattahoochee River. They report that high summer water temperatures potentially detrimental to trout have been occurring more frequently in recent years in the Morgan Falls Dam tailwater, and that nonpoint stormwater runoff from impervious surfaces in tributary watersheds appears to contribute to these conditions. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they note that increased water temperatures will have different impacts on the trout population depending on the distance from Buford Dam. As an example, GDNR states that temperature is not expected to be of concern at Buford Trout Hatchery, located approximately two miles downstream of Buford Dam, except for possibly an increased frequency of 2-unit generations during the fall pre-turnover period, when water drawn from the thermocline of Lanier Reservoir can lead to drastic temperature increases in a short time, leading to shock. Currently a concern during summer months, south of the Norcross gage small temperature increases may lead to localized stress and mortality if water temperature exceeds 22ºC for any considerable length of time.

As summer maximum water temperatures have become more marginally suitable for trout, GDNR has diversified its management objectives downstream of Morgan Falls Dam to include restoration of native shoal bass (*Micropterus cataractae*), a warmwater bass species endemic to the ACF River basin. Under the NAA, GDNR considers the reach to be a transition zone capable of supporting both coldwater and warmwater fisheries and initiated a stocking program for shoal bass in the reach of the Chattahoochee River below Morgan Falls Dam. GDNR, along with other State and Federal agencies including ADCNR, the Service, and the National Park Service (NPS) have been involved with restoration and research activities to improve the status of the species.

GDNR has also reintroduced striped bass (*Morone saxatilis*) into what is now West Point Reservoir. Striped bass restoration in the ACF Basin is a collaborative effort between the conservation agencies in Georgia, Alabama, Florida, and the Service, with the goal of restoring a self-sustaining population to the maximum extent possible. The group meets on an annual basis to set goals and discuss ongoing management and research for striped bass in the ACF system. West Point Reservoir is currently designated as a potential broodfish repository and is one of the highest priority reservoirs to receive stocked striped bass.

Because striped bass exhibit upstream migrations to spawn in riverine conditions, a striped bass fishery has developed in the Chattahoochee River downstream of Morgan Falls Dam, the first upstream barrier to striped bass migrating upstream from West Point Reservoir. Persistence of a small population in West Point Reservoir suggests that striped bass in the river are capable of limited natural reproduction. However, coldwater releases from Buford Dam during the spring spawning period of striped bass, and abrupt decreases in water temperature that occur with Buford Dam peaking operations, have been identified as critical factors inhibiting striped bass spawning and adversely affecting survival of eggs and larvae in the upper Chattahoochee River near Morgan Falls Dam (Hess and Jennings 1999). GDNR clarified in their comments on the Service's DFWCAR that Hess and Jennings (1999) also mentioned low flows as another potential inhibiting factor to reproduction (GDNR 2015; Appendix III). Striped bass movement upstream to Morgan Falls increases as summer progresses, indicating that the water temperatures in the summer serve as a coolwater refuge. GDNR-WRD considers this "coolwater refuge" effect to be of significant importance to the survivability of adult striped bass.

Because the PAA exhibits slightly warmer water temperatures below Buford Dam to Norcross, the PAA is less favorable than the NAA for the coldwater fishery. Water temperatures are warmer between Whitesburg and West Point, which is an improvement for the warmwater fish community including shoal bass. The Service proposes that elements of both a cold-cool water and warmwater fishery potentially could be supported if water quality and flows are improved. The PAA has the potential to benefit the warmwater fishery without compromising the coldwater fishery strictly from a temperature aspect.

Wastewater

The NAA and PAA model results were similar along the longitudinal river profile within each scenario, with the average stream percent wastewater in the PAA model output typically greater than the NAA. These modeled results suggest that the PAA would be slightly less favorable than the NAA.

Chlorophyll-*a*

Chlorophyll-*a* is correlated with algal biomass, which may cause nuisance conditions in aquatic ecosystems. Chlorophyll-*a* was higher in the PAA than the NAA throughout the river system, but differences were relatively small. This indicates that the PAA is slightly less favorable when compared to the NAA.

Reservoir Retention Time

Higher retention rates may result in decreased reservoir water quality. We requested average summer retention times at each Corps reservoir. Data were provided in hard copy, tabular format for each month. At West Point Reservoir, June through August retention times were generally similar between the NAA and PAA between 2001 and 2011. However, qualitative evaluation of the PAA showed higher retention times in 2002 (max= 9 days higher in August), 2006 (max= 42 days higher in July), 2008 (max= 5 days higher in August), and 2009 (max= 27 days higher in August). We request the average summer retention time data be summarized by the Corps for each of the Corps reservoirs to facilitate quantitative comparisons; therefore, we are not currently able to evaluate the PAA in comparison to the NAA.

Phosphorus

Algal growth is stimulated by increases in phosphorus. Thus, phosphorus levels were modeled and compared between the NAA and PAA. Total phosphorus loads at both of the selected locations, the headwaters of West Point Reservoir and Walter F. George Reservoir, both increased in the PAA when compared to the NAA. Any differences observed between the PAA and NAA in the longitudinal profiles resulted in higher total phosphorus levels in the PAA.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

The Service developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation. The measure calculates the maximum amount of spawning habitat available for at least 30 consecutive days during the months of April through October. It is unclear whether the Corps used the FSHPM to develop the graphical comparison. As described by the Corps, it is unknown whether they calculated *consecutive* days. The Corps used the period from April through September, not April through October as specified by the FSHPM.

Apalachicola River floodplain connectivity, evaluated using the annual maximum 30-day acreage during the April through September growing season, is nearly identical between the NAA and PAA. Chattahoochee River floodplain connectivity would be expected to be nearly identical between the NAA and PAA; conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain.

Indicated previously, the Corps has not yet provided output from the ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford period. The Corps should provide output from the ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford period.

Reservoir Fisheries

RFPM differences between the NAA and PAA were generally small, suggesting low potential for realized fisheries differences between the two alternatives.

Riverine Fisheries

It appears the riverine fisheries analysis provided by the Corps relied on percentiles that do not separate low and high flows. Output from the revised ecosystem flow guideline methodology recommended in the Service's PAL addendum (Service 2011; Appendix VI) has not yet been provided by the Corps for the comparison of the NAA, PAA, and pre-Buford Dam period. Therefore, the Corps should provide output from the revised ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford Dam period.

The CRSBPM shows that the PAA results in higher abundance of Shoal Bass than the NAA. This may indicate that for the river section upstream from West Point Reservoir, conditions are more favorable for the native warmwater fish community. Based on modeled water temperatures, there are small anticipated effects to the coldwater fish community below Buford Dam.

In addition, we requested daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. Although daily fall rates are applicable to Gulf Sturgeon, they are also relevant to riverine and floodplain fishes in the Apalachicola River. We did not receive an analysis of daily fall rates for Gulf Sturgeon. This analysis should be completed in order to provide a more thorough evaluation of effects to the Apalachicola River and floodplain fishes. Should fall rates be higher under the PAA, the PAA would be less preferable because they may result in less floodplain connectivity, resulting in more floodplain stranded fishes of all ages and smaller year classes. Effects to fishes are also implicated in the FSHPM above.

Federally-protected Species in the Apalachicola River

Gulf Sturgeon

Effects to Gulf Sturgeon were not adequately assessed, as described in the *Project Impacts & Evaluation Methodology* section above. For the Service to adequately assess the Corps' future determination of the proposed action under the ESA, we will need to review suitable analyses of the effects of the proposed action.

Freshwater mussels

The only freshwater mussel analysis was for the river segment below JWLD. The PAA results in lower flows that remain low for longer periods compared to the NAA, thereby creating conditions that are less hospitable for mussel communities, including federally-listed mussels.

Mussel population viability is intricately tied to host fish density (Watters 1997; Haag and Warren 1998). Because many of the fish species dependent on the floodplain serve as host fish to freshwater mussels in the Apalachicola River, freshwater mussels may also be impacted by fall rates that occur at higher flow magnitudes. Although high flow fall rates were not evaluated, other mussel indicators show negative impacts to freshwater mussels, making the PAA less preferable for mussels.

National Wildlife Refuges and Fish Hatcheries

Eufaula NWR

The Service had requested the examination of alternate Walter F. George Reservoir management strategies to accommodate the request and freshwater needs of Eufaula NWR. The Corps indicated that they are unable to meet that request, meaning that there is no change in reservoir levels and therefore, no change to Eufaula NWR.

Fish Hatcheries

Buford Fish Hatchery relies on a freshwater intake below Buford Dam to support fish rearing. There is similar water availability for Buford Fish Hatchery for both alternatives. Dissolved oxygen levels and temperatures were nearly identical. Therefore, effects of the PAA on Buford Fish Hatchery are the same as the NAA.

Analyses of Apalachicola Bay

Several lines of evidence suggest that the PAA may result in greater Apalachicola Bay salinities when compared to the NAA. The ABSPM shows no difference in salinities between the NAA and PAA at Cat Point and Dry Bar, but a 1.0 ppt increase in the median salinity at East Bay. Additionally, low flows in the Apalachicola River at Chattahoochee are lower in the PAA than in the NAA. Differences in low flows most likely manifest themselves in relatively minor salinity shifts, but may exceed salinity thresholds for juvenile Gulf Sturgeon and oysters. In addition, the range of flows used previously in the University of Florida's hydrodynamic salinity model [2011 Alternative 2 (Alt2)] are similar to the PAA, and the 2011 Alt2 resulted in slower oyster growth rates at Cat Point compared to the 2011 NAA, and lower juvenile sturgeon acreage compared to the 2011 NAA.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

The intent of this section is to identify measures that should be taken to prevent the loss of or damage to fish and wildlife resources and to provide for the improvement of such resources. In the Service's 2010 PAL and 2011 PAL addendum, we identified resources and analyses that would be necessary in order to address planning objectives. Although some planning objectives were addressed by Corps analyses as described in prior sections, several were not adequately addressed. We review our current understanding of the Corps' position on each issue (italicized text) and note whether the planning objectives were adequately addressed. Those planning objectives that were not adequately addressed are conveyed here as conservation measures, or recommendations, that should be taken to reduce impacts and benefit fish and wildlife (Table 3).

The conservation measures provided in the Service's 2011 DFWCAR included the development of an alternative or a suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. The Corps indicated that it is difficult and labor intensive to try alternative management scenarios, and as such, we encouraged the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim (Service 2011).

We investigated a suite of operational alternatives that could provide benefits to fish and wildlife resources; a Service-developed alternative was provided to the Corps as part of our scoping comments (Service 2013; Appendix VII). We provide a discussion of our alternative in this section because its formulation stems from our previously recommended conservation measures, including, "Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes" and "Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams."

Table 4. Fish and wildlife conservation measures and recommendations.

Fish and Wildlife Service Alternative Evaluation:		
	ALT1	Clarify the criteria required for an alternative to warrant full consideration
Conservation Measures Included from the Service's 2010 PAL & 2011 PAL Addendum:		
Flow Regime		
	FR1	Develop a suite of flow alternatives
	FR2	Conduct ecosystem flow analyses using guidelines
	FR3	Provide fish access to and inundation of the floodplain
	FR4	Evaluate methods to provide the operational flexibility necessary for floodplain inundation
	FR5	Evaluate the operational feasibly of implementing environmental flow measures
	FR6	Develop appropriate predictive hydrological and meteorological criteria
Floodplain Inundation Assessment		
	FP 1	Utilize LIDAR to evaluate floodplain inundation
Water Quality		
	WQ1	Improve and monitor dissolved oxygen
	WQ2	Evaluate/upgrade venting capabilities at Buford turbines
	WQ3	Improve and monitor water temperatures
Fish Passage		
	FM1	Improve fish passage
Climate Change		
	CC1	Include multiple future climate scenarios into modeling

Navigation		
	NV1	Evaluate the effects of channel maintenance activities
Reservoir and Riverine Fishes/Fisheries Management		
	FM2	Review recent fisheries literature
	FM3	Modify Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning
	FM4	Implement fish and wildlife recreation facility improvements
Apalachicola Bay		
	AB1	Incorporate an updated Apalachicola Bay salinity model
	AB2	Determine freshwater inflow effects on benthic communities of Apalachicola Bay
Decision Support Model to Evaluate Changes to Corps' Operations		
	DS1	Incorporate a decision support model into the WCM update process
Adaptive Management		
	AMP1	Develop an adaptive management program
Increasing Consumptive Demands		
	CD1	Consider the impacts of increasing consumptive water demands
Evaluation of Alternative Models		
	AM1	Use alternative models to better represent flow
	AM2	Precipitation-Runoff Modeling System as an evaluation system
	AM3	New models to explicitly address climate-based operational flexibility
	AM4	Alternative water quality assessment methods
Conservation Measures Developed from the Corps' 2011 PAL Response:		
	FR7	Minimum flow provisions downstream of WFGLD
	FR8	Drought zone trigger changes
Additional Conservation Measures:		
	FM5	Evaluate effects to Gulf Sturgeon
	FM6	Evaluate effects to petitioned species
	NPS1	Evaluate effects to NPS' Chattahoochee River National Recreation Area
	ES1	Ecosystem services impacts should be described and quantified
Mitigation Measures:		
	MIT1	Identify a mitigation approach
	MIT2	Habitat-based evaluation techniques
	MIT3	Mitigate estuary impacts

Fish and Wildlife Service Alternative Evaluation

Subsequent discussions with the Corps (as cited in Service 2013; Appendix VIII) indicated that to warrant full consideration, an alternative would need to: 1) accommodate a navigation season, and 2) retain the storage action zones to ensure a balanced system operation. Consequently, we addressed both criteria in subsequent modeling and submitted a revised alternative to the Corps.

Although the Corps stated that action zone changes would eliminate the Service's alternative from consideration at the time, the Corps subsequently adopted changes to the storage action zones in the PAA. Action zone changes affect the reservoir system's ability to meet multiple project objectives in a variety of hydrological conditions. Had changes to action zones not been removed from consideration, the alternative that the Service submitted would have more comprehensively considered the range of options that could result in better system performance while providing benefits to fish and wildlife. We ask that the Corps clarify the criteria required for an alternative to warrant full consideration.

We reviewed the rationale for eliminating the Service's alternative from consideration. We provide the list of criteria that the Corps used to rank alternatives, and a comparison of the Service's alternative relative to the PAA based on their summary. We stress that our review is ongoing, and that additional information pertaining to our evaluation will be included in subsequent Service reports.

Table 4. Summary of conclusions drawn by the Corps' evaluation criteria and rankings used to select the PAA and a qualitative comparison of the Service's alternative to the PAA.

Evaluation Criteria by project purpose	Difference relative to PAA
Water Quality/Peachtree Creek Q >750	Better
Hydropower (System)	Worse
Navigation (System)	Better
Recreation (Buford, WP, WFG)	Worse
Fish and Wildlife (Apalachicola)	Worse

Additionally, the Service has recently reviewed new information from the Corps regarding their current alternatives selection process and we are greatly concerned with the methodology used by the Corps. Our concerns are described in detail in Appendix XV; due to the fact that Appendix XV has been recently developed, these concerns have not yet been reviewed as part of the DFWCAR by the State wildlife agencies and NOAA in relation to their responsibilities under FWCA.

Conservation Measures Included from the Service's 2010 PAL & 2011 PAL Addendum

<u>Flow Regime</u>

FR1) Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes.

> *This has not been completed and should be developed. Iterative development should consider a range of operational changes, including changes to action zones, flow triggers, target and minimum flows, and flows identified for navigation, conservation, hydropower, and recreation purposes. Additionally, the Service provided the Corps sets of low and pulse flow guidelines to aid in flow alternative development and evaluation (Service 2011; Appendix VI). Flow guidelines were not used to develop or evaluate*

alternatives. Since providing the flow guidelines, we developed the CRSBPM to assist with the evaluation of flow alternatives in the Chattahoochee River. We continue to recommend use of both the flow guidelines and the CRSBPM. As additional performance metrics become available for the Chattahoochee River, we can reconsider the use of flow guidelines in the Chattahoochee River.

Although the Service's 2011 PAL addendum provided sets of low and pulse flow guidelines from which alternatives could be developed and compared, and the Service's 2010 PAL included requests for modeling non-hydropower peaking windows, the Corps did not develop alternatives based on those guidelines because of management limitations cited in their response to the Service's PAL (Corps 2011). However, within the Service's 2010 PAL, we stated:

"We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation."

We reiterate to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. To date, none of the natural flow regime components have been incorporated into the flow alternative development…"

FR2) Conduct ecosystem flow analyses using the methodology cited in the Service's 2011 PAL addendum, composed of analyses at four nodes (below Buford, West Point, WFGLD, and JWLD) for the NAA and PAA. Subsequently, compare the results with the Service's ecosystem flow guidelines. We also recommend the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March-May.

In the Service's 2011 PAL addendum, we provided updated ecosystem flow guidelines representing natural conditions, as well as updated methodology for the Corps to analyze their low and high flow releases under the NAA and PAA. Such analyses have not been provided to the Service.

FFWCC generally supports the Service's guidelines, but also recommends a modified approach to the development of low flow guidelines (FFWCC 2011). The Service used the seven lowest values from every month in every year to characterize low flows in dry, average, and wet months for the pre-Buford period. FFWCC proposed that daily exceedance values based on all the pre-Buford hydrology, including baseflows, pulses, and floods, be used to develop guidelines. Subsequent analyses by the Service show that the 90% exceedance roughly corresponds to the lower limit and dry month flow guidelines, and the 50% exceedance values track the wet year flow guidelines, with the exception of the wetter months, lending some support to this alternative approach. We *agree with FFWCC that this type of analysis has merit for comparing flow alternatives and characterization of flow data. However, the Service views this method as complementary but not substitutive for flow guideline development, because:*

1. *Exceedance plots include all flows including pulses and floods. Therefore, low flow guidelines that could come from exceedance plots are potentially influenced by high flows, thereby inflating low flow guideline values. This is particularly evident with exceedance probabilities less than 75%, and in wetter months. One intent of the Service's flow guideline development was to separate multiple flow components (low flows, pulses, and floods) and illustrate the inter- and intra-annual variation in flows. Exceedance plots blur the distinction between low flows, and pulses and floods which is one reason why exceedance plots were not used initially.*

2. *Daily exceedance plots show a large amount of daily variation. Similar to the Service's flow guidelines, this variation illustrates that a range of low flow values may be beneficial for fish and wildlife resources. However, one intention of the Service's guidelines was to provide managers and modelers real values to evaluate and/or incorporate into a flow alternative. Although selecting the seven lowest values for every month of every year to characterize dry, average, and wet months is a simplification of the pre-Buford hydrology, the Service expects that there is a higher likelihood of successful incorporation of the Service's 60 low flow guideline values (represented by the lower and upper limit, and dry, average, and wet conditions for each of 12 months), than the 365 values required for one year type using the exceedance probability method.*

The Corps addressed the feasibility of providing non-hydropower peaking windows from March to May (4-6 weeks) at Buford Dam and West Point Dam in their response to the Service's PAL (Corps 2011). The Corps states that a loss of hydropower production, as well as physical, safety, and logistical limitations would prohibit the implementation of non-hydropower peaking windows at these facilities. We note that fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production. While the Corps has repeatedly stated that revised water control operations shall reflect existing structural and physical constraints (e.g., no consideration of structural improvements), there is no funding for structural improvements, and such improvements are outside the WCM update process, the Service continues to recommend that the Corps explore options to alter downstream flow releases to minimize impacts to or benefit riverine aquatic resources below their projects in the ACF Basin. Such changes in operation do not necessarily come at the cost of reduced hydropower production.

FR3) Evaluate the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain.

The PAA proposes zone changes in Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir, but incorporates no changes to the top of the conservation pool guide curves. We continue to recommend the Corps address and evaluate all of these options listed above.

FR4) Evaluate methods to provide the operational flexibility necessary for floodplain inundation, which could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation, and/or 2) the purchase of structures built in the historic floodplain so that the Corps could intentionally provide flows that inundate the floodplain.

This has not been completed. In the past the Corps has stated that one of their guiding principles for the WCM update process is that the flood control capabilities and capacities of the reservoirs will not be reduced (see Decision Support Model to Evaluate Changes to Corps' Operations below). Corps projects are managed in part for flood damage reduction, the objective of which is "storage of excess flows thereby reducing downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally." The methods suggested by the Service would not reduce the flood control capabilities and capacities of the reservoirs. First identifying and then protecting or purchasing structures that may be impacted by floods at naturally-occurring discharges could actually reduce potential flood damage, increase operational flexibility, as well as benefit aquatic resources. Thus, we encourage the Corps to continue investigating those methods listed above.

FR5) Evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines.

These analyses have not been conducted by the Corps. The Corps stated in their 2011 PAL Response that "Defining a real life operation that meets the authorized project purposes and better meets the "natural" hydrograph and then translating that operation into code for the reservoir simulation is a large undertaking. To the extent that FWS feels more needs to be done, we request additional guidance and support."

As stated in the 2010 PAL, we stress to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. The specific components of the ecosystem flow guidelines were meant to be reviewed and considered for implementation on an individual basis by the Corps rather than collectively considered as a whole.

Updated ecosystem flow guidelines for four locations in the ACF Basin were provided to the Corps in our 2011 PAL addendum. We agree that it is a potentially large undertaking to include flow guidelines, but we emphasize that the WCM update is itself a large *undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental flow measures.*

FR6) Work with the Service and others to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

In the past, the Corps has stated that they have been engaged in conversations with entities such as the National Weather Service, but indicated that they do not have the reliable science to accurately make these predictions for operation of the ACF Basin system. We have recommended that the Corps work with the Service so that we may collectively develop reasonable methods for defining hydrological conditions useful for reservoir and ecosystem management. To date, these conversations have not occurred.

Floodplain inundation assessments

FP1) Use LIDAR and stage-discharge relationships to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River to compare the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation in the NAA, PAA, and pre- Buford period.

The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. When the data are available, the Corps should use LIDAR, if applicable, to supplement existing analyses of floodplain inundation in the Apalachicola River.

Dissolved Oxygen

WQ1) Ensure that releases from all five ACF dams meet or exceed water quality standards, including monitoring water quality upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve water quality, and conducting post-modification water quality monitoring to ensure that levels have been improved to State water quality standards.

The Corps has stated that they currently monitor water temperature, pH, conductivity, and DO below Buford Dam and West Point Dam, and DO seasonally below WFGLD. They have stated that one of their guiding principles for the WCM update process is that revised water control operations shall reflect existing structural and physical constraints [e.g., no consideration of structural improvements, there is no funding for structural improvements, and such improvements are outside the WCM update process (see Decision Support Model to Evaluate Changes to Corps' Operations below)]. Subsequently, because the NAA and PAA significantly affect water quality, do not comply with State standards, and do not meet the designated project purpose of fish and wildlife, we continue to request that as part of the WCM update the Corps outline the steps that would be necessary on part of the Federal government and other entities to improve *water quality below Federal projects in the ACF Basin.*

The Corps should make it a priority to ensure that releases from all five ACF dams meet or exceed DO, temperature, and other applicable water quality standards. In GDNR's 2011 comments on the Service's DFWCAR (Service 2011), GDNR-WRD agrees that improvement of DO downstream of Corps reservoirs is important and would be beneficial to aquatic resources. We are available to assist the Corps in exploring alternate funding opportunities, including Corps restoration authorities (e.g., Section 1135 or 216) to address these impacts.

WQ2) Evaluate the effectiveness of the upgraded venting capabilities at Buford turbines.

The Corps has stated that research is outside the scope of the WCM update process. As stated above, we continue to recommend that the Corps needs to make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. We are available to assist the Corps in exploring alternate funding opportunities, including Corps restoration authorities (e.g., Section 1135 or 216) to address these impacts.

Temperature

WQ3) Monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved.

As noted above, the Corps has stated that the revised water control operations shall reflect existing structural and physical constraints, that there is no funding for structural improvements, and such improvements are outside the WCM update process. The Corps needs to make it a priority to manage temperature levels to benefit aquatic life in accordance with resource agency management objectives. We are available to assist the Corps in exploring alternate funding opportunities.

Fish Passage

FM1) Provisions for fish passage should be incorporated in the WCM for JWLD, GWALD, and WFGLD, while maintaining the need for operational flexibility.

Although the Corps has included formal language in the WCM update for fish locking at JWLD, they have not included similar language for GWALD or WFGLD. They have stated that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the manual does not preclude lockings at GWALD or WFGLD. However, we continue to recommend formal language be included in the WCM update. There is ample evidence that fish passage operations at the lock at JWLD are passing Alabama shad upstream, and the species may benefit from passage at these other Corps lock and dam facilities. In

FFWCC's 2011 comments on the Service's 2011 DFWCAR (Service 2011), FFWCC also agrees that the Corps should explore fish passage operations for anadromous fish species, such as the Alabama shad as part of the WCM update.

Climate Change

CC1) In addition to considering sea level rise, include multiple future climate scenarios into modeled discharge scenarios and Corps alternatives and create flow provisions for dry, average, and wet years in order to account for current climate variability.

The Corps states that they have considered climate change to some extent in the form of sea level rise. Their evaluations have determined that sea level rise is not projected to affect JWLD, the lowermost Corps' project in the ACF Basin. No consideration has been given to the impact of climate change on hydrology. However, because climate change will potentially affect river flows and Corps operations, the Corps should include future climate scenarios over short and long terms, and flow provisions for dry, average, and wet years. Available sources that have been brought to our attention and may be of use are the National Climate Change Viewer (http://www.usgs.gov/climate_landuse/clu_rd/nex-dcp30.asp) and the National Climate Assessment (http://nca2014.globalchange.gov/downloads).

Navigation

NV1) If navigation is included in the WCM update, evaluate the effects of channel maintenance activities required for navigation support by including an analysis of dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis.

A navigation season has been included in the Corps' PAA to achieve a 7-foot channel at Blountstown, Florida from January through April or May. The Corps states that though special releases will not be standard practice, they may occur as a result of case-by-case requests to the Corps for a short duration to assist navigation during the navigation season (e.g., to achieve a 9-foot channel). Dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis have not been included by the Corps in an evaluation of the effects of the PAA. Therefore, we assume there are no plans for dredging in the Apalachicola or Chattahoochee Rivers related to the PAA. If the Corps anticipates that maintenance dredging will need to occur in the future, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support as indirect or cumulative impacts within the NEPA documentation.

Reservoir and Riverine Fisheries Management

FM2) Review recent fisheries literature for additional information regarding detrimental impacts to riverine fish spawning due to a 4-6 week stable or rising reservoir window, per the Corps' draft Standard Operating Procedure (SOP) for "Lake Regulations and Coordination For Fish Management Purposes."

The purpose of this literature search is to critically evaluate the relative merits and costs of operating projects for the benefit of reservoir and riverine fisheries so that the best available science can be integrated into an informed management approach.

In past ResSim model simulations that were run by the Corps using the entire period of record at the time, the fish spawn SOP governed less than 1% of releases at Corps reservoirs in the ACF Basin. The Corps states this is because fish spawn operations are largely the same as operations that are already conducted for higher priority purposes at their reservoirs.

The Corps states that the fish spawn SOP has been in operation since the 1970's and the operating windows were based on water temperatures. The Corps states that the window is determined by dates because it is labor intensive to base the window on water temperatures. A reservoir fisheries literature search was recently conducted for the Corps by TetraTech but no pertinent research was found. In the past, GDNR-WRD has stated that the fish spawn SOP is important and should continue. However, given potential changes to the system and news insights since the 1970's, we recommend that additional data should be collected and analyses conducted to ensure that no modifications or improvements to this management strategy are needed concurrent with SOP implementation.

A literature search has not been conducted regarding downstream flows during the fish spawn SOP period and the resulting impacts to riverine fish spawning. However, FFWCC recently provided the Corps and the Service with riverine spawning information specifically for the Apalachicola River (FFWCC 2011; Appendix XI). The report details how decreased spring flows have resulted in less aquatic floodplain habitats in the Apalachicola River floodplain system during critical spawning and nursery periods.

We continue to recommend a literature search be conducted for additional supporting information, especially applicable to areas upstream of the Apalachicola River.

FM3) Investigate modifying the Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes.

The Corps states that the existing fish spawn SOP language already indicates they can or will emphasize benefits to river spawning over reservoir spawning if riverine fishes have experienced unfavorable conditions for several years. The existing language in the fish spawn SOP is as follows:

"An imbalance of prey and forage fish could occur following the second or third year of poor or unsuccessful spawning and recruitment, leading to poor sport fishing. Areas where the spawns were recently unsuccessful should be given higher priority for fish management operations under low water conditions." It is unclear in the documentation provided by the Corps how determinations will be made to ensure that river spawning

takes precedence over reservoir spawning, and how operations will be modified to facilitate river spawning. To the Service, the existing language does not seem to pertain to riverine habitats and instead appears to remain focused on reservoir fisheries. Per our recommendation in the PAL, periodic emphasis of riverine spawning should be included in the fish spawn SOP. We are available to work with the Corps to develop specific SOP revisions that recognize both reservoir and riverine habitat management.

FM4) Identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

The Corps has stated that one of their guiding principles for the WCM update process is that revised operations shall reflect existing structural and physical constraints. They have also stated that there is no funding for structural improvements and such improvements are outside the WCM update process. However, this recommendation could lead to increased operational flexibility for the Corps in the future. We are available to assist the Corps in exploring alternate funding opportunities.

Apalachicola Bay

AB1) Incorporate an updated Apalachicola Bay salinity model (Sheng et al. 2011; Appendix XII) in the WCM update process to predict effects to oyster mortality and growth.

Previous modeling results (Sheng et al. 2011; Appendix XII) are incorporated into this DFWCAR (above). If updated results are produced in an allowable timeframe, we recommend that the Corps incorporate Sheng's modeling results not only to evaluate effects of their project operations, but also to inform their development of a PAA.

AB2) Coordinate with FFWCC's Fish and Wildlife Research Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

FFWCC provided pertinent analyses to the Service and to the Corps comparing the pre-dam and post-West Point periods of record, but did not include analyses for future actions, such as the WCM proposed alternatives or other future Corps' proposed actions. In that correspondence FFWCC provides updated research that raises "significant hydrologic and biological concerns applicable to any alternative [Corps] operation departing from the historic flow regime of the Apalachicola River" (FFWCC 2011; Appendix XI). We recommend the Corps move forward by coordinating with FFWCC and the Service's Panama City Field Office to complete similar analyses on the WCM proposed alternatives and other future Corps' proposed actions.

Decision Support Model to Evaluate Changes to Corps' Operations

DS1) Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams.

> *The Corps has stated that they have used a decision support approach on a coarse scale; they subsequently shared a synopsis of their decision-making process with the Service in 2010. This synopsis from the Corps indicated that at the time, their Modeling Team and Project Delivery Team had developed internal guiding principles for the revised WCM and an iterative process for the development of their alternative(s), which relied heavily on ResSim outputs. The Corps' guiding principles at that time were as follows:*
>
> 1. *Flood control capabilities and capacities of the reservoirs will not be reduced (e.g. no measure is acceptable if it raises the likelihood, frequency, or severity of flooding).*
> 2. *The ACF will continue to be operated as a system. The balancing of water control operations to achieve each of the project purposes will continue to vary between the individual projects and the time of year. Operation of the projects will continue to usually be performed in a manner which represents a consideration of these oftentimes competing purposes and, whenever possible, reservoir operations are scoped to accommodate these purposes in a complimentary fashion (balancing).*
> 3. *The revised water control operations shall be within existing project purposes and authorities.*
> 4. *The revised water control operations shall reflect existing structural and physical constraints (e.g. no consideration of structural improvements).*
> 5. *The revised water control operations shall meet the existing Endangered Species Act requirements.*
> 6. *The fish spawn SOP will continue to be implemented within the reservoirs.*
> 7. *Reallocation of storage to meet current water supply demands [where current equaled the highest levels of consumption experienced to date] at Lake Sidney Lanier for municipal and industrial (M&I) water supply shall be evaluated in conjunction with revised water control operations. (This guiding principle was subsequently revised to account for a district court ruling in Phase 1 of the consolidated ACF litigation, 17 July 2010 ("Phase I Ruling").*
> 8. *The revised water control operations will not adversely alter the water quality in Corps reservoirs.*
>
> *We request that the Corps provide updated guiding principles if they have changed.*

<u>Adaptive Management</u>

AMP1) Develop an adaptive management program, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam.

The Corps states that the periodic updating of the WCM is a form of adaptive management and should be practiced. We urge the Corps to consider a management approach that fosters implementation of an operational strategy with clearly defined goals or hypotheses, an evaluation to assess outcomes of the operation, and integration of the knowledge gained from that operation into management. The adaptive management program should be interdisciplinary and include multiple agencies and organizations representing stakeholders within the ACF Basin.

Increasing Consumptive Demands

CD1) Recognize and consider the impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin and incorporate it into analysis of operational alternatives along with climate-driven hydrologic variability. Quantify the relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes. Include metrics regarding water supply withdrawals, including potential increases, in the alternatives analysis. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

In the PAA the Corps included future M&I water withdrawals to accommodate a projected 2040 water supply need in the Atlanta area. However, this does not include future consumptive use projections for the same time period at other locations in the basin (e.g., municipal, industrial, and agricultural increases in the Chattahoochee below the Atlanta area, increases in the Flint Basin). Therefore, projected future increases including all categories of withdrawals across the ACF, as well as predictions for climate-driven hydrologic variability, should be included in the Corps' analyses. In addition, a "Future without project" that incorporated such future consumptive water demands was not evaluated in the Corps response to the Service's PAL (Corps 2015a; Appendix X), making comparisons between a more accurate representation of an "Existing condition", "Future without project", and the "Future with Project" not possible.

Evaluation of Alternative Models

AM1) Investigate the use of alternative models to develop better unimpaired flow and alternative flow datasets. Compared to the USGS gage data, the unimpaired flow dataset does not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes.

Fundamental differences in output between the USGS gage data and the NAA (e.g., current operations) are described in Appendix XIV. In the past, the Corps has stated that *at this point in the process they are locked into using ResSim and HEC-5Q. The Corps has indicated that it is difficult and labor intensive to try alternative management scenarios. We encourage the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim. We recommend the use of alternative models be investigated as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.*

AM2) If the United States Geological Survey's (USGS) Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, use it as an additional evaluation tool to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions.

It is our understanding that the PRMS model is not ready for use at this time. However, if and when it is developed specifically for the ACF it should be used by the Corps as an additional evaluation tool for the WCM update process and future Corps' proposed actions.

AM3) Coordinate with USGS and Georgia Water Resources Institute (GWRI) regarding new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

We continue to recommend that the Corps coordinate directly with GWRI to address climate-based operational flexibility as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.

AM4) Consider alternative water quality assessment methods to accurately evaluate effects of flow alternatives on water quality. Because the HEC-5Q water quality model outputs are not expected to accurately predict either the water quality values or the range of values that are likely to occur in response to hourly discharge changes, consider using existing alternative water quality models or develop regression models to accurately predict water quality parameters using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure).

The Corps states that HEC-5Q is advantageous because it considers the system holistically and also cite similar results between their simulated output to their observed tailrace data. Because HEC-5Q relies on daily average flow it does not accurately reflect water quality values that are likely to occur in response to hourly discharge changes. We continue to recommend alternative water quality assessment methods to accurately evaluate the effects of Corps operations on water quality.

Conservation Measures Developed from the Corps' 2011 PAL Response

FR7) There are no minimum flow provisions downstream of WFGLD. When low dissolved oxygen values are observed below the dam, the Corps states that spillway gates are opened until the dissolved oxygen readings return to an acceptable level. The Service has not seen actual data that exhibit an improvement in dissolved oxygen levels using this methodology. However, if this methodology is in fact effective, the Corps should evaluate modifying WFGLD's operations to provide a continuous minimum flow release instead of operating in a "reactive response" mode. Continuous minimum flow releases are already implemented at the other four other Corps' ACF Basin projects.

FR8) Consider other options for operational flexibility that do not include changing the drought zone trigger from Zone 3 to Zone 2, and postponing the reinstatement of normal operations until Zone 1 is reached. While these changes enable the Corps to operate the reservoir system in a more conservative manner, they likely result in an increased frequency and duration of low flows in the Apalachicola River.

Additional Conservation Measures

FM5) Evaluation of effects to Gulf Sturgeon was specified in our PAL's. The Service developed the SSHPM to facilitate the Corps' analysis, but this information was not included in the information provided to the Service. Effects to Gulf Sturgeon should be included in the development and evaluation of alternatives.

FM6) The impacts of the PAA to species in the ACF Basin currently petitioned for Federal listing under the ESA should also be described and quantified. Updated surveys and quantitative relationships between Corps operations and population or habitat effects for many of these species are lacking; effort should be expended to update surveys and quantify effects of proposed future actions to these species. This information will improve our understanding and future evaluation of project impacts on a larger variety of species that inhabit a broader set of ecosystems and river segments.

NPS1) The impacts of the PAA to NPS' Chattahoochee River National Recreation Area should be described and quantified. NPS' January 14, 2013 scoping comments to the Corps include information and recommendations associated with the Corps' flow releases from Lanier reservoir that should be considered.

ES1) The impacts of the PAA to ecosystem services should be described and quantified. Ecosystem services are the benefits that humans derive from ecosystems. These services provided by riverine ecosystems are diverse, such as water filtration provided by aquatic invertebrates and carbon sequestration provided by floodplain connectivity. In addition, riverine habitats can provide excellent recreational opportunities. These are among the ecosystem services that are, to some extent, affected by flow management.

Mitigation Measures

MIT1) In the Corps' NEPA documentation, the impacts of the PAA on fish and wildlife resources should not only be described and quantified, but the Corps should also outline an approach to mitigation. Mitigation measures should be based upon more accurate projections of future projected resource conditions with and without the project.

MIT2) Development of mitigation measures should be scientifically formulated, and based on the future with and future without the project scenarios, and a determination of the net change between the two. The Service's Mitigation Policy (FR 46(15):7644-7663; January 23, 1981) calls for evaluation using habitat-based evaluation techniques wherever possible. The Habitat Evaluation Procedures (HEP) developed by the Service are specified for use as a basic tool for evaluating project impacts and as a basis for formulating subsequent recommendations for mitigation. It can yield data that can be used effectively in comparing alternatives and conditions. Other available "standard" techniques that may be applicable include the Habitat Evaluation System (HES) and Wetland Evaluation Technique (WET) developed by the Corps of Engineers, and the Hydromorphologic Methodology (HGM). Where instream flows are involved, the Service's Instream Flow Incremental Methodology (IFIM) may be able to provide information in making mitigation recommendations. Other updated evaluation systems may be used, provided they conform to the policies contained in the Mitigation Policy.

MIT3) Impacts to the estuary that result from lower inflow and higher salinities have been quantified using empirical relationships and models. Mitigation for these impacts should be determined and implemented, and we recommend that the Corps consult with the State of Florida and the Service's Panama City Field Office.

The Service is available to work with the Corps to identify suitable mitigation measures.

SUMMARY AND FWS POSITION

The Service does not fully support the Corps' adoption of the PAA for the following reasons:

- the Corps' alternatives selection process (Service 2015; Appendix XV),
- a failure to adequately address conservation measures identified in the Service's PAL (Service 2010; Appendix V), PAL addendum (Service 2011; Appendix VI), and the Service's 2011 DFWCAR (Service 2011) and subsequently included in this report,
- modeling developed from limited consumptive use scenarios without sufficiently considering climate change and future increase in consumptive demands,
- inadequately assessed effects to riverine ecosystems and federally-listed Gulf Sturgeon,
- increased frequency of low flows causing negative impacts to federally-listed mussels, and

- increased storage resulting in lower magnitude releases and most likely higher salinities to the Apalachicola River and Bay. Based on model results provided by the Corps, the negative effects of the PAA on fish and wildlife resources are a consequence of reservoir system operation changes and increases in consumptive demands that are part of the PAA.

In accordance with the FWCA and Service mitigation policy (FR 46(15):7644-7663; January 23, 1981), we identified steps that should be taken to ensure that fish and wildlife resources are protected or improved. We identified additional conservation measures and steps that should be taken as part of an update to the WCM. We emphasize again that the WCM update is a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental measures.

The Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, and therefore direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for ‘with the project’ and ‘without the project’ scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in the Corps’ NEPA documents and our report.

We also emphasize that the Corps’ impact to water quality, primarily dissolved oxygen, below several projects in the ACF Basin is unacceptable. The Corps needs to seek authorization and appropriations to ensure that water quality standards are met below these projects.

To date, all analyses provided by the Corps consist of evaluations of the effects of a PAA developed by the Corps, which excluding actions already taken by the Corps at JWLD, includes no project operation improvement to benefit fish and wildlife. To ensure sustainability for these resources, and especially those that are imperiled, the Service will continue to work cooperatively with the Corps and all stakeholders. In particular, the Service needs to be an integral member of the Corps’ team when formulating and evaluating operational alternatives. We encourage the Corps to follow the recommendations and conservation measures included in this document and are ready to assist in the development of a WCM that balances protection of fish and wildlife resources in the ACF River Basin with other project purposes.

LITERATURE CITED

Altinok, I. and J.M. Grizzle. 2001. Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. Journal of Fish Biology 59:1142–1152.

Federal Energy Regulatory Commission. 2014. Order issuing new license. Project No. 485-065. December 22, 2014. 58 pp.

Florida Fish and Wildlife Conservation Commission (FFWCC). 2011. Florida Fish and Wildlife Conservation Commission Comments on Draft Fish and Wildlife Coordination Act Report. 27 pp.

Georgia Power Company. 2006. Resource Study Report Fisheries and Aquatic Resources, Morgan Falls Project (FERC No. 2237). Prepared with GeoSyntec Consultants. March 2006.

Haag, W.R., and M.L. Warren, Jr. 1998. Role of ecological factors and reproductive strategies in structuring freshwater mussel communities. Canadian Journal of Fisheries and Aquatic Sciences 55:297-306.

Hess, B.J., and C.A. Jennings. 1999. Reproductive success of stocked striped bass (*Morone saxatilis*) in the Chattahoochee River above West Point Lake: implications for the Morone stocking program. Final Report, prepared for Georgia Department of Natural Resources, Wildlife Resources Division, Fisheries Management Section, Social Circle, Georgia. September 1999.

Huang, W. 2010. Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science 86:526-534.

HydroLogics. 2012. Memorandum from Dean Randall and Megan Wiley Rivera, HydroLogics, Inc., May 21, 2012, Re: Apalachicola Bay salinity model and OASIS.Light, H.M., K.R. Vincent, M.R. Darst, and F.D. Price. 2006. Water-level decline in the Apalachicola River, Florida, from 1954 to 2004, and effects on floodplain habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston, R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin, W. Huang. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Parauka, S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505–515.

United States Army Corps of Engineers. 1998. Draft Environmental Impact Statement Water Allocation for the Apalachicola-Chattahoochee-Flint (ACF) River Basin Main Report, September 1998, Mobile District, Mobile, Alabama.

United States Army Corps of Engineers. 2011. ACF Water Control Manual Update Response to PAL. January 18, 2011.

United States Army Corps of Engineers. 2014. HEC5Q and FWS water temperature model comparisons. Prepared by Evan Heisman, NWW Hydrology Section. 7 pp.

United States Army Corps of Engineers. 2015a. ACF Water Control Manual Update Response to PAL. January 21, 2015.

United States Army Corps of Engineers. 2015b. Apalachicola-Chattahoochee-Flint (ACF) Watershed HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment. Appendix K – Development of Alternatives. June 2014

United States Fish and Wildlife Service. 2008. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. June 1, 2008. 225 p.

United States Fish and Wildlife Service. 2011. Draft Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida. Southeast Region, Atlanta, Georgia, June 2011. 41 pp.

United States Fish and Wildlife Service. 2012. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. May 22, 2012. 117 p.

Wang, H., W. Huang, M.A. Harwell, L. Edmiston, E. Johnson, P. Hsieh, K. Milla, J. Christensen, J. Stewart, and X. Liu. 2008. Modeling oyster growth rate by coupling oyster population and hydrodynamic models for Apalachicola Bay, Florida, USA. Ecological Modeling 211: 77-89.

Watters, G.T. 1997. Individual-based models of mussel-fish interactions: a cautionary study. Pages 45-62 in: K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, editors, Conservation and management of freshwater mussels II: initiatives for the future. Proceedings of an Upper Mississippi River Conservation Committee symposium, October 1995, St. Louis, MO.

Florida Fish and Wildlife Conservation Commission

Commissioners
Richard A. Corbett
Chairman
Tampa

Brian Yablonski
Vice Chairman
Tallahassee

Ronald M. Bergeron
Fort Lauderdale

Richard Hanas
Oviedo

Aliese P. "Liesa" Priddy
Immokalee

Bo Rivard
Panama City

Charles W. Roberts III
Tallahassee

Executive Staff
Nick Wiley
Executive Director

Eric Sutton
Assistant Executive Director

Jennifer Fitzwater
Chief of Staff

Legal Office
Harold "Bud" Vielhauer
General Counsel
(850) 487-1764
(850) 487-1790-FAX

Managing fish and wildlife resources for their long-term well-being and the benefit of people.

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850) 488-4676

Hearing/speech-impaired:
(800) 955-8771 (T)
(800) 955-8770 (V)

MyFWC.com

June 15, 2015

Ms. Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606

RE: Florida Fish and Wildlife Conservation Commission's Comments on June 2015 Draft Fish and Wildlife Coordination Act Report.

Dear Ms. Lawrence:

The State of Florida, through its Fish and Wildlife Conservation Commission ("Commission"), submits the following comments on the *Draft Fish and Wildlife Coordination Act Report on the Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama and Florida* ("Draft Report").[1] Florida commends the Service for identifying a number of key concerns shared by the Commission and agrees with the Service's general assessment that the Corps' Proposed Action Alternative ("PAA"), as reflected in the Corps' October 2014 response to the Service's planning aid letters ("PAL Response"), is unacceptable.

As indicated in our May 2011 letter, we wish to underscore the importance of consistent, transparent communication among the Corps, the Service and the Commission. As you correctly note, the Fish and Wildlife Coordination Act ("FWCA"), 16 U.S.C. §§ 661 *et seq.*, requires the Corps to consult with the Service and the Commission, Draft Report at 45, but such coordination has not occurred. Florida first received the Draft Report and corresponding Corps materials on May 19, 2015. We have been asked to respond to the Draft Report, the PAL Response, and the PAA, all by June 16, 2015. However, the Corps has not provided to the Service or the Commission any of the relevant datasets supporting the Corps' analyses. At this point, the absence of substantive data precludes us from fully assessing the validity of the agencies' conclusions. Until all relevant datasets have been provided to the Commission, we cannot fully and effectively provide detailed comments as requested. Based on the limited information that has been provided, we concur with the Service that "all analyses provided by the Corps consist of evaluations of the effects of a PAA developed by the Corps that includes no consideration of project operation enhancement to benefit fish and wildlife."

We hereby request copies of the complete datasets the Corps is using to develop the PAA (and any other alternatives for the Water Control Manual Update), as well as in preparing the PAL Response. Upon receipt of the datasets and any additional analysis completed in

[1] Florida previously provided comments on your April 2010 Planning Aid Letter, and supplied additional information relevant to the Draft Report in our paper entitled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystem* (February 2011) and an addendum in May 2011. Florida also provided additional comments to the U.S Army Corps of Engineers ("Corps") during its re-initiation of scoping pursuant to the National Environmental Policy Act (January 2013). Those comments are incorporated fully herein by this reference.

response to the Service, we will provide additional comments on these materials, as well as the Draft Report, in accordance to the FWCA.

In the meantime, we note the Commission and the Service earlier asked the Corps to address the impacts of current and projected consumptive water uses as part of the Water Control Manual Update process. The Corps has not offered any such analysis. Based on information being developed in support of the litigation captioned *Florida v. Georgia*, No 142 Orig., we reject the Service's apparent interim conclusion that upstream consumptive uses are not having a significant effect on Florida's fish and wildlife resources.

We thank you for the opportunity to comment and your continued attention to this matter. We hope for improved coordination in the future.

Sincerely,

Bud Vielhauer,
General Counsel

Cc: Mr. Donald Imm, U.S. Fish and Wildlife Service
Donald_Imm@fws.gov
Ms. Catherine Phillips, U.S. Fish and Wildlife Service- Panama City
Catherine_Phillips@fws.gov
Mr. Curtis Flakes, U.S. Army Corp of Engineers-Mobile District
Curtis.M.Flakes@sam.usace.army.mil

STATE OF ALABAMA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
WILDLIFE AND FRESHWATER FISHERIES DIVISION

64 North Union Street, Ste. 567
P. O. Box 301456
Montgomery, AL 36130-1456
Phone: (334) 242-3465 Fax: (334) 242-3032
www.outdooralabama.com

ROBERT BENTLEY
GOVERNOR

N. GUNTER GUY, JR.
COMMISSIONER

CURTIS JONES
DEPUTY COMMISSIONER

The mission of the Wildlife and Freshwater Fisheries Division is to manage, protect, conserve, and enhance the wildlife and aquatic resources of Alabama for the sustainable benefit of the people of Alabama.

CHARLES F. "CHUCK" SYKES
DIRECTOR

FRED R. HARDERS
ASSISTANT DIRECTOR

June 16, 2015

Mr. Donald Imm
U. S. Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

RE: Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida

Dear Mr. Imm:

The Alabama Department of Conservation and Natural Resources (ADCNR), Division of Wildlife and Freshwater Fisheries has reviewed the Draft Fish and Wildlife Coordination Act Report (DFWCAR) prepared by the U. S. Fish and Wildlife Service (USFWS) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida and provides the following comments. We encourage the U. S. Army Corps of Engineers (the Corps) to fully develop and analyze alternatives or suites of alternatives that will maximize and benefit fish and wildlife resources of the State of Alabama. We also encourage continued incorporation of decision support models, in an adaptive management framework, to evaluate these alternatives. Consideration of additional alternatives for analysis will address specific concerns highlighted in this letter and include: water quality, instream flow, increasing consumptive demand, state-protected aquatic species, and drought conditions and impacts. These specific areas are priorities for ADCNR for the protection and management of state-trust resources.

- *Water Quality* Water releases from the five ACF dams should meet or exceed State water quality standards. We agree with USFWS recommendations that water quality issues should be a priority for the protection of aquatic resources. State standards for dissolved oxygen should consistently be met, and assessments for improvement should be fully considered in the suites of evaluated alternatives and the Proposed Action Alternative (PAA). Water temperature should also be a priority in the manual update process, with a suite of alternatives analyzed for appropriate management. We also agree with the recommendation that alternative water quality assessment methods be used to evaluate the effects of Corps operations on water quality. Additionally, ADCNR believes that structural and physical improvements to current facilities are within the scope of the WCM update process and recommend they be addressed when analyzing alternatives for water quality management.

- *Instream Flow* The Corps' operations do not require approval of or the licensing process of the Federal Energy Regulatory Commission. However, the responsibility of the Corps' water control operations must include a flow regime that maintains ecological integrity to protect the physical, chemical, and biological functions of waters flowing into the State of Alabama through the

Apalachicola River. Natural flow regimes in a stream or river channel adequately support the full suite of ecological functions (biodiversity, channel maintenance, floodplain operation) through factors such as timing (seasonal), frequency (how often), magnitude (size of water events), rate of change (how quickly water is delivered), and duration (how long do the events last) to ensure complete ecosystem functions. Deviations from the natural flow regime of rivers and streams affect their physical, chemical, and biological functions. Whether there is a significant impact on ecological integrity depends on the magnitude of deviation. ADCNR implemented an Instream Flow Policy in 2012 which explains our position on flow standards. The following are excerpts from that policy:

Instream flows are incorrectly thought of as minimum flows by many. Minimum flows are just that, minimal, and do not fully protect stream functions. The whole concept of a minimum flow had led to many rivers and streams becoming depleted and damaged with respect to their hydrological and ecosystem function. Minimum flows actually become maximum flows in highly used and altered systems since managed flows are rarely allowed to exceed this "minimum" limit. "Conservation Flow" is defined as the minimum continuous water flow requirement as determined by ADCNR that is necessary to maintain the biological, physical, and chemical integrity of a waterway using generally accepted scientific methodologies. Conservation flow for regulated waterways shall be as follows: 1) for waterways regulated for hydropower production the requirement shall be determined through the Federal Energy Regulatory Commission licensing process; 2) for waterways regulated for other purposes (such as drinking water impoundments) the recommended seasonal requirement is 30% of Mean Annual Flow (MAF) for July through November, 60% MAF for January through April, and 40% MAF for May, June, and December or will be based on accepted instream flow methodology such as the Instream Flow Incremental Methodology (IFIM).

"Subsistence Flow" is the minimum water flow requirement as determined by ADCNR that must remain in a waterway in order to avoid serious or long-term adverse effects on the biological integrity of the waterway. Subsistence flow shall be determined as follows: 1) for waterways regulated for hydropower production the requirement shall be determined through the Federal Energy Regulatory Commission licensing process; 2) for waterways regulated for other purposes (such as drinking water impoundments) and for unregulated waterways the requirement is 10% of Mean Annual Flow (MAF) or will be based on an accepted instream flow methodology such as the Instream Flow Incremental Methodology (IFIM).

It is the policy of ADCNR to advocate for the protection of instream flow requirements in all water allocation decisions.

- <u>Increasing Consumptive Demands</u> ADCNR requests the Corps conduct comprehensive analysis of increasing consumptive demands in the ACF Basin, and include those with the suite of considered alternatives. Increased consumptive demands in the basin could have negative impacts on the aquatic resources of the State of Alabama. Increased demands including: increased water supply withdrawals, increased volume storage, and changes in industrial, municipal, and agricultures practices could change and impact hydrologic conditions throughout the basin. Hydrologic conditions below Corps' dams are the responsibility of the Corps, and as such instream flow regimes should be designed to restore and/or maintain the ecological integrity of the system.

- <u>State-protected species</u> Potential impacts to state-protected species by Corps operations should be avoided and minimized. Impacts should be fully assessed in the suite of alternatives presented in the manual updates. Potential impacts resulting from operating under the PAA should not be greater than operating under the no action alternative (NAA).

- *Drought conditions and impacts* We are concerned that minimum flows during drought conditions, under the PAA, would have significant negative impacts on aquatic species. State-protected mussels in particular would suffer extreme negative impacts. An analysis of alternative instream flow regimes should be conducted such that minimum flows during drought conditions under the PAA are not lower than minimum flows under the NAA. Sufficient instream flows should provide water quality that meets state standards, and allows for the management and protection of and state-trust resources.

- *Fish Passage* A fish passage plan for anadromous fish species should be developed and included for George W. Andrews Lock & Dam and Walter F. George Lock & Dam in the final WCM updates.

In conclusion, we appreciate the opportunity to comment on the Draft Fish and Wildlife Coordination Act Report. ADCNR stands ready to work with the Corps to develop Water Control Manuals that protect and conserve the fish and wildlife resources of the State of Alabama. We encourage the Corps to work alongside State and Federal agencies, and with stakeholders to provide comprehensive analysis of all alternatives for the ACF Basin.

References

Annear, T., I. Chisholm, H. Beecher, A. Locke, P. Aarrestad, C. Coomer, C. Estes, J. Hunt, R. Jacobson, G. Jobsis, J. Kauffman, J. Marshall, K. Mayes, G. Smith, R. Wentworth, and C. Stalnaker. 2004. Instream Flows for Riverine Resource Stewardship – Revised Edition. Instream Flow Council, Cheyenne, WY.

Sincerely,

Taconya D. Goar

Taconya D. Goar
Environmental Affairs Coordinator

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
MARK WILLIAMS, COMMISSIONER

June 25, 2015

Donald Imm, Project Leader
U.S. Fish and Wildlife Service
Georgia Ecological Services
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Mr. Imm:

Thank you for the opportunity to once again review the Fish and Wildlife Service's (FWS) Draft Fish and Wildlife Coordination Act Report (DFWCAR) to the Corps of Engineers regarding the Water Control Manual update for the Apalachicola-Chattahoochee-Flint (ACF) basin. We are following up on our comments dated May 23, 2011 to address additional issues related to fisheries management that the Georgia Wildlife Resources Division (GAWRD) deems important.

Water Temperature

The thermal regime below Lake Lanier remains of importance to GAWRD and to Georgia anglers. The Lanier Tailwater (Buford Dam to Bull Sluice Reservoir) hosts a year-round fishery for wild brown trout and stocked rainbow trout. This fishery has existed for more than 50 years and produced a new state record brown trout in 2014. This section of the Chattahoochee River alone accounts for approximately 90,000 angler trips per year. On page 33, the DFWCAR suggests that hydropower and fish and wildlife should be coequal considerations in the water control manual. In addition, GAWRD suggests that downstream recreation should be a consideration as well. Increased hydropeaking operations would reduce the available recreational opportunities in the Chattahoochee River National Recreation Area as these are typically limited to times of minimum flows.

In any evaluation of water temperatures in this section of river, it is important to note that increased water temperatures will have different impacts on the trout population depending on the distance from Buford Dam. For instance, temperature is not expected to be a concern under any feasible operation regime at the Buford Trout Hatchery intake, which is located approximately two miles downstream of Buford Dam. Water temperatures in this part of the river never exceed critical species tolerance. One possible exception for this could be an increased frequency of 2-unit generations during the fall pre-turnover period, when water drawn from the thermocline of Lake Lanier can lead to drastic temperature increases in a short time, leading to shock. However, south of

2 MARTIN LUTHER KING, JR. DRIVE, S.E., SUITE 1252 EAST | ATLANTA, GEORGIA 30334-9000
404.656.3500 | FAX 404.656.0770 | WWW.GADNR.ORG

the Norcross gauge referenced in the DFWCAR, small temperature increases may lead to localized stress and mortality if water temperature exceeds 22°C for any considerable length of time. It is also important to note that this is only currently a concern during summer months when warmwater tributary inputs and solar radiation have the most impact on water temperatures in this section. Research by GAWRD indicates very little movement by trout in the Chattahoochee River, therefore a localized mortality event could lead to extended, severely limited recreational fishing opportunities in the affected section.

The DFWCAR addresses the West Point Reservoir gulf-strain striped bass population as requested in GAWRD's 2011 letter; however the impacts of temperature on striped bass above West Point reservoir need to be clarified. Summer habitat in West Point can be very marginal, and the cool flows from Morgan Falls dam (resulting from Buford Dam releases) mitigate for that lack of summer coolwater, high oxygen habitat. Page 25 of the DFWCAR states that spring coldwater releases may have a critical inhibiting impact on striped bass reproduction in the West Point population, citing Hess and Jennings (1999). The authors of this report suggested temperature was possibly an inhibiting factor to reproduction, but mentioned low flows as another potential inhibiting factor. Therefore, it may not be appropriate to view higher flows/low temperatures as negative in an evaluation of riverine fish habitat in the Corps' proposal. The striped bass management strategy for GAWRD at West Point Reservoir is similar to many other reservoirs in the state; while the potential for natural reproduction exists under ideal conditions; stocking is likely to be necessary to maintain a fishable population size and genetic repository of gulf-strain striped bass given the possibility of year-class failures due to multiple environmental factors.

Fishery Performance Measures

As mentioned in the DFWCAR, GAWRD requested a meeting with FWS to discuss details of the Reservoir Fishery Performance Measure (RFPM). Much of GAWRD's concerns center around the use of a single metric for three very different reservoirs. Most fish habitat at Walter F. George Reservoir is realized in the form of submerged and emergent aquatic vegetation. Fluctuations in water levels help promote the growth of this aquatic vegetation, and we believe the RFPM should better reflect this potential at Walter F. George. Conversely, Lanier Reservoir has very limited potential for aquatic vegetation due to its steeper banks and hard clay substrate. The majority of flooded vegetation is terrestrial and establishes during extended drawdowns (droughts). While these extended drawdowns can lead to future habitat benefits, we believe it is important that any evaluation tool does not encourage drought-like drawdowns at Corps reservoirs during normal years. West Point Reservoir is relatively similar to Lanier in that its potential for aquatic vegetation is limited; however it still deserves an individualized approach in the RFPM. More current data is requested by FWS in the DFWCAR, however GADNR does not believe that currency of the data is an issue given the 20+ year standardized sampling data sets at these reservoirs; however, the abilities of currently-used sampling gears may be limited for certain data needs, e.g. assessment of young-of-year sportfish. The GADNR hopes to continue to work with FWS to refine the RFPM to more accurately model the fishery-related effects of water levels in each reservoir.

Aside from the RFPM, the continuation of the Corps' fish spawn management procedures is critically important for reservoir fisheries. A rapid reservoir elevation decrease immediately following spawning activity could lead to a year-class failure for multiple species in a reservoir. On page 38 of the DFWCAR, FWS suggests "modifying the Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning". We (GAWRD) would like to understand the mechanism for this decision process in more detail. Conditions to meet this goal without "unreasonably compromising other project purposes" may be difficult in most years, and the per-unit impacts in water management choices may not be uniform between rivers and reservoirs. Given our experience managing reservoirs and rivers in this system, GAWRD should be able to offer suggestions relative to this effort.

The Chattahoochee River Shoal Bass Performance Measure (CRSBPM) is used in the DFWCAR to attempt to quantify effects of the No Action Alternative (NAA) and Preferred Action Alternative (PAA) on shoal bass recruitment from Morgan Falls Dam to West Point Reservoir. This model is based on research conducted within listed trout waters in an approximately eight-mile stretch below Morgan Falls Dam. This is the area which is most thermally impacted during high-flow years, and GAWRD annually stocks shoal bass in this section to mitigate for poor recruitment during these high-flow years. This poor recruitment appears to be a result of depressed spring/summer water temperatures that inhibit gonad development in adult shoal bass. The model uses water temperature as the driving factor related to shoal bass abundance, which is appropriate in this upper stretch of the Morgan Falls Tailwater. However, thermal impacts to the Chattahoochee River below Peachtree Creek are likely minimal relative to shoal bass reproduction and recruitment in normal years, yet recent samples conducted by GADNR and Auburn University indicate that shoal bass abundance appears to be limited between Peachtree Creek and West Point Reservoir. It is possible that there are other limiting factors beyond water temperature (e.g. habitat or water quality) that should be addressed and considered when using the CRSBPM to inform flow regimes. The shoal bass is a recently-described (1999) species and research into its life history characteristics is ongoing. If appropriate, the CRSBPM should be updated as new information on this species becomes available.

Fish Passage

On page 7 and 8 of the DFWCAR, comments from the Florida Fish and Wildlife Conservation Commission suggest negative consequences to fish populations from fish passage impediments. The GAWRD agrees that improved fish passage would provide benefits to multiple species. As outlined in a March 24, 2014 MOU between GAWRD, GAEPD, and USFWS, allowing passage through Jim Woodruff Lock and Dam may greatly increase the amount of available gulf sturgeon habitat. Given the incised nature of the channel in the lower Chattahoochee River due to dredging operations, the ability to accommodate river-floodplain interactions (FWS recommendation FR3) may be limited, and added fish passage may have a greater impact on habitat availability. Striped bass have been found to reproduce below West Point Dam based on samples in Walter F. George Reservoir. Passage through Walter F. George Lock and Dam may provide positive benefits to the gulf striped bass population in the ACF.

Water Quality

In the evaluation of the selected plan, it is important to consider that there may be positive benefits to a reservoir fishery from increased residence time or nutrient loading. Algal mats and fish kills due to chlorophyll-*a* or phosphorous loading have not historically been a problem at Lanier or Walter F. George, and the nutrient levels at West Point have drastically decreased following upstream waste water infrastructure improvements in the past two decades. If chlorophyll-*a* and phosphorous are not at critical levels, an increase can actually lead to increased biomass and improved fishing in all three reservoirs. When classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

The GAWRD agrees with FWS that increased dissolved oxygen levels below Corps dams would have positive benefits to tailwater fisheries. On page 10 of the DFWCAR (and in the October 2014 Corps Response to the previous Planning Aid Letters), the standards for the Norcross and Morgan Falls stations are incorrect. As these stations both fall within state-listed trout waters, the state standard for dissolved oxygen is actually 6.0 mg/L, the same as the Buford Dam station. While differences in temperature between the NAA and the PAA are not generally a concern at Buford Trout Hatchery, depressed dissolved oxygen concentrations below the state standard and suspended metals such as iron and manganese in the late summer and fall can be problematic. An increase in dissolved oxygen during the critical pre-turnover period would alleviate much of this stress on fish being held in hatchery raceways. Below West Point Dam, increases in dissolved oxygen concentrations should provide a benefit to middle Chattahoochee shoal bass populations, particularly when combined with efforts by Georgia Power to increase dissolved oxygen levels below their hydropower projects in the area. Below Walter F. George Lock and Dam, electrofishing surveys have indicated that low dissolved oxygen may severely impact recreational fishing opportunities for several miles.

On page 18, the withdrawal for Buford Trout Hatchery is listed as 7 mgd. However, it is important to note that this is a pass-through system and the net withdrawal of river water is negligible on downstream flows (limited to evaporation while passing through the hatchery). As written, it appears that GAWRD is a net user of 7 mgd of ACF flows.

If you have any questions, please contact Thom Litts at (770) 918-6406.

Sincerely,

Mark Williams

cc: Gail Cowie, EPD
Thom Litts, WRD

Re: ACF Water Control Manual Update ACOE Draft Fish and Wildlife Coordination Act Report for review

1 message

Pace Wilber - NOAA Federal <pace.wilber@noaa.gov>
To: "Lawrence, Alice" <alice_lawrence@fws.gov>
Cc: Fritz Rohde <Fritz.Rohde@noaa.gov>, Will Duncan <Will_Duncan@fws.gov>

Thu, Jun 18, 2015 at 9:07 AM

Hello Alice.

Thank you for providing the NMFS an opportunity to review the Draft Fish and Wildlife Coordination Act Report for the proposed U.S. Army Corps of Engineers Water Control Manual updates for the Apalachicola-Chattahoochee-Flint River Basin Georgia, Alabama, and Florida. The NMFS greatly appreciates the care the U.S. Fish and Wildlife Service (FWS) has taken in preparing the report.

1). The NMFS agrees with comments by FWS pointing out multiple times the inadequacy of the effects evaluation on Gulf Sturgeon, which does not support the Proposed Action Alternative because the Corps “inadequately assessed effects to riverine ecosystems and the federally-listed Gulf Sturgeon (page 44 of FWS report).” Discussion of dissolved oxygen (DO) concentrations (page 10 of the FWS report) indicate releases actually decrease DO concentrations, which makes sense if releases are from the bottom of a reservoir. The NMFS recommends the Corps provide a more thorough evaluation of the effects of implementing the water control plan on Gulf Sturgeon.

2). The NMFS agrees with FWS (page 36) that provisions for fish passage, with operational flexibility, should be incorporated into all the dams, not just Jim Woodruff Dam. Conservation locking at Jim Woodruff Lock and Dam is passing Alabama Shad upstream. Fish passage at George W. Andrews Dam and Walter F. George Dam would aid Alabama Shad in the ACF Basin.

3). Additional examinations are needed of how variations in freshwater inflow to Apalachicola Bay affect seagrass, fish, and shellfish abundances. The NMFS recommends the Corps coordinate with Florida Fish and Wildlife Conservation Commission to complete the analyses and include in the water control manual an updated Apalachicola Bay salinity model for predicting oyster mortality and growth (page 39).

On Mon, Apr 27, 2015 at 10:11 AM, Lawrence, Alice <alice_lawrence@fws.gov> wrote:

> Hello- I hope everyone is doing well. If you remember, you reviewed our agency's last round of the Draft Fish and Wildlife Coordination Act Report (DFWCAR) back in 2011 regarding ACOE's ACF Water Control Manual Update before it was submitted to the Mobile District ACOE. At that time, we incorporated and attached the comments we received from the State wildlife agencies and NOAA Fisheries to the DFWCAR before it was submitted to ACOE. Under the Fish and Wildlife Coordination Act, ACOE is required to consult with the Service and the State wildlife agencies, "to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation..."
>
> We are currently preparing an updated DFWCAR for the Mobile District to include in their upcoming DEIS and I am 1) notifying you as the State wildlife agencies and NOAA Fisheries of our projected timeline, and 2) forwarding you background material from ACOE to assist in your review of the DFWCAR. We are planning on having a DFWCAR for you to review no later than early May, with the hopes that we may receive any comments you may have within 20 days after receiving the DFWCAR. I know this is a short turnaround time and we apologize- we have a short turnaround time as well. ACOE would like our completed DFWCAR in early June.
>
> I am attaching the Corps' Response to the Service's PAL as background material for you to better understand

the DFWCAR when we send it along to you for your review. Our office received this document at the end of January, but I was out of the office until mid-March so I did not receive it until then.

Thanks everyone! Please let Will or I know if you have questions (I will be in and out the rest of the day but should be in the office the rest of the week). Alice

Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606
706.613.9493 X 222

United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

April 2, 2010

Colonel Byron Jorns
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Jorns:

We are providing your agency with a Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the PAL is to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. We submit the following comments and recommendations under the ESA, the Migratory Bird Treaty Act (MBTA)(49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). These comments are based on previous studies and government documents as well as new datasets and information provided by State and Federal agencies. Although all of the comments from the Florida Fish and Wildlife Conservation Commission (FFWCC) have not been integrated, this final version of the PAL addresses many of the issues that FFWCC raised. We will continue to provide additional expertise and information in the form of another PAL and/or the draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corp's proposal on federally-listed threatened and endangered fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

1. Development of Corps Alternatives and Mitigation

We have identified data needs and assessment methods that can help you in developing alternatives that maximize fish and wildlife benefits, and avoid, minimize and compensate for impacts to fish and wildlife resources, where appropriate.

1.1 Flow Regime

The WCM update should include a thorough evaluation of project-related flow regime alterations and the potential to restore flow regime components that have ecological and geomorphic significance. We recommend the Corps develop alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. To support this effort, we have provided preliminary ecosystem flow guidelines for four river sections; below Buford, West Point, Walter F. George, and Jim Woodruff dams. These flow regime guidelines are guided by the principle that ecosystems evolved as a response to the natural flow regime. Thus, we analyzed river flows and developed flow guidelines based on United States Geological Survey (USGS) flow data that were collected prior to Buford Dam construction in the mid 1950's, a benchmark of the first major river regulation source in the upper Chattahoochee River. Reliance on pre-regulation datasets to derive ecosystem flows is particularly useful for locations where empirically derived ecology-flow relationships are scant (such as the upper Chattahoochee River).

We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation. For example, provision of stable flow windows (*sensu* Freeman et al. 2001) in the spring may increase riverine fish recruitment, even though restoration of other naturally occurring flow regime components may not be attainable. Relatively small discharge changes can have substantial ecological effects. For example, the Tennessee Valley Authority's (TVA's) strategy to increase baseflows below Normandy Dam (Figure 1) during the spring and summer mussel recruitment months resulted in biologically and statistically significant increases in mussel diversity and density (Figure 2, Ahlstedt and Johnson 2004).

Development of environmental flow alternatives would include an evaluation of the operational feasibility, constraints, and tradeoffs to providing the different aspects of environmental flow measures that are captured in our guidelines. Explicit magnitude, frequency, duration, timing, and rate of change guidelines are provided to illustrate the types of flow modifications that are likely to benefit the ecosystem and to help inform the development of Corps flow alternatives. However, should the magnitude of a flow guideline be deemed unattainable, we request that the Corps identify a flow magnitude that is attainable or recommend an attainable frequency for the recommended flow magnitude. An explanation for the change also will be helpful. We recognize these guidelines do not define whether the basin is entering a dry, average, or wet month, which are the lines between the lower and upper limits on the flow prescription graphs. We recommend that you work with us to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

Successful implementation of ecosystem flows in the Chattahoochee River is challenged by water demand increases, reduced operational flexibility imposed by meeting minimum discharge requirements at downstream locations, and the importance of minimizing high discharge-related

damage to infrastructure. To address these challenges, we considered only the range of flows that were likely to be above minimum flow requirements and less than flows that could cause major infrastructure damage as identified by information provided by the National Weather Service (NWS) Advanced Hydrologic Prediction Service (NWS 2010; Table 1). The ecosystem flow guidelines are preliminary because in instances where water is diverted from the channel, or the channel is anthropogenically altered, natural flows may be insufficient to meet ecological needs.

Successful implementation of ecosystem flows in the Apalachicola River is challenged by the same types of limitations described for the Chattahoochee River. The degree of Apalachicola River channel entrenchment and widening, caused largely by Corps reservoir and dredging operations, varies spatially, but the discharge that is now required to reach bankfull elevation and cause floodplain inundation in the upper portion of the river is generally greater than the discharge that was historically required. However, datasets are available that quantify the amount of floodplain habitat inundated with the current level of entrenchment and over a range of discharges. These datasets, in combination with those that describe flow effects on sturgeon spawning and mussel habitats, will help to inform the development of future ecosystem flow guidelines and the evaluation of alternatives.

Thorough explanations of the physical, chemical, and ecological benefits from base flows, pulses, stable flow windows for spawning, and intra- and interannual flow variation are outside the scope of this letter; however, we refer the reader to Junk et al. 1989, Poff et al. 1997, Richter et al. 1998, Freeman et al. 2001, Postel and Richter 2003, and Mathews and Richter 2007 for fuller descriptions. The importance of baseflows, pulses, and flood flows are described within these resources, and they are quantitatively evaluated using the recently developed Environmental Flow Components (EFCs) in Indicators of Hydrologic Alteration (IHA)(Mathews and Richter 2007). General descriptions of the baseflow, pulse, and high pulse flow guidelines are provided below with general descriptions of the ecological significance of those flow guidelines.

Similar to the Instream Flow Guidelines provided to the ACF Compact's Federal Commissioner (USFWS 1999), the guidelines provided in this letter were developed using IHA, use the pre-dam period of record as a benchmark for comparison of flow alternatives, and rely on percentiles to define the frequency of high and low flow extremes. Using EFCs is recommended because the analysis separates ecologically-relevant hydrograph components (e.g., baseflows from pulses) allowing computation of magnitude, frequency, duration, timing, and rate of change statistics on individual hydrograph components rather than on the entire dataset. Consequently, these hydrograph summary statistics are easily developed, interpreted, and communicated, and have been used successfully to inform flow management downstream from hydropower dams.

<u>1.1.1 Baseflow and small pulses</u>

Baseflows determine the amount of habitat that is available for forage, reproduction, and rearing, which has a substantial influence on the abundance, diversity, and distribution of aquatic fauna. We have provided explicit base flow recommendations for every month in dry, average, and wet water years. Small pulses that do not exceed bankfull elevation provide influxes of upstream

trophic subsidies, and reprieves from low dissolved oxygen and high temperature that sometimes occur during summer months. Small pulses are included in the guidelines with explicit magnitude, frequency, duration, timing, and rate of change recommendations (Figures 3-6).

The flow guidelines were based on average daily flows (Figures 3-6). Average daily flows obscure the diel streamflow variation imposed by hydropower generation. Consequently, hydropower generation at Buford, West Point, Walter F. George, and to a lesser extent, Woodruff Dam, may change discharge two orders of magnitude, and change river stage significantly within a few hours. As a result, habitat availability is limited to periods that are too brief for the completion of essential life history requirements. To mitigate this impact, the provision of non-hydropower peaking "windows" should be evaluated during critical reproductive and rearing periods in order to reestablish native plant, fish, and invertebrate abundance and diversity in river reaches downstream from Corps-operated projects. Generally, this period corresponds to March – May when water temperatures increase. The timing, duration, and magnitude of this window should vary interannually in order to optimize the reproductive requirements of each species every few years. However, the duration of the non-peaking window requires additional research, but we expect that a minimum of 4-6 weeks between March and May are required.

The dry, average, and wet year baseflow guidelines are based on a retrospective analysis of the pre-dam hydrograph (Figures 3-6). It will be necessary to use appropriate hydrological and meteorological criteria to classify the coming month into dry, average, or wet categories. However, average daily baseflows should remain near the dry, average, and wet year flow guidelines depending on the category, and should not fall below the lower limit on any day of any year.

1.1.2 High flow pulses

High flow pulses that exceed bankfull elevation provide important ecological services. A large proportion of sport and non-game fishes rely on floodplain habitats to spawn, rear young, and forage. High flow pulses are also major forces that control nutrient and organic matter dynamics in large rivers, create new habitats, and ultimately affect riverine animal biomass (Junk et al. 1989). However, the spring reservoir refill period extends into the principal spawning season for a high proportion of fishes, meaning that spring flows and floodplain inundation are reduced. Thus, ensuring seasonal high flows and river-floodplain connectivity with the timing, frequency, duration, magnitude, and rate of change necessary to sustain ecological functions and wildlife populations are essential flow management objectives for dams on large rivers.

To provide flows that inundate the floodplain, the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain should be evaluated. Similarly, the Savannah District Corps has operated the Savannah River reservoir system in recent years with reduced winter drawdown to provide spring pulses that meet multiple downriver ecosystem objectives. This evaluation should separately consider flow conditions in wet, average, and dry climatic years. Additionally, it should be noted that relatively small changes in river stage can significantly increase the amount of river-floodplain connectivity. Consequently, minor changes

in dam operation could have large and positive effects on the river-floodplain ecosystem.

Recognizing that there are limits on operational flexibility due to the presence of infrastructure in some floodplains, methods should be evaluated to provide the operational flexibility necessary for floodplain inundation, which falls under the Corps' coequal project purpose of "Fish and Wildlife Resources." Such methods could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation; and/or 2) the purchase of structures built in the historic floodplain so that the Corps can intentionally provide flows that inundate the floodplain. These analyses should be simple to conduct, and would include acquisition of floodplain maps and identification of anthropogenic structures within the 2, 10, 50, and 100-year floodplains.

1.2 Floodplain inundation assessments

The relationships among the areal extent of Apalachicola River floodplain inundation, channel entrenchment effects, and water releases from Jim Woodruff Lock and Dam were previously assessed and related to discharge using the datasets and summaries provided by Light et al. 1998 and Light et al. 2006. These datasets have informed biologists and the Corps of the effects of flow releases on river-floodplain resources. Due to the difficulty of surveying all floodplain streams, lakes, and forests, Light et al. 1998 used intensive surveys at a subset of sites, general surveys at approximately 300 sites, and Geographic Information Systems (GIS) to assess the effects of hydrogeomorphic alteration on floodplain inundation areal extent. Light et al. 2006 compared pre-dam stage (prior to 1954) and recent stage (1995–2004) at five streamflow gaging stations in relation to discharge at the Chattahoochee gage (USGS gage number 02358000, Apalachicola River at Chattahoochee, FL). These stage-discharge relationships can also be used to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at different discharges for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

More recently, floodplain elevation maps have been generated using Light Detection and Ranging (LIDAR) remote sensing data with <1 ft accuracy and related to Apalachicola River stage-discharge relationships developed by Light et al. 2006 (Ron Bartel, Northwest Florida Water Management District [NWFWMD], 2010, pers. comm.). Stage-based LIDAR data may provide a more thorough and accurate evaluation of river flow effects on river-floodplain connectivity and habitat availability. We recommend that the Corps contact the NWFWMD to confirm that these datasets exist, request permission to access and use these new datasets, or invite collaboration between the Corps and the NWFWMD to evaluate effects of flow alternatives on floodplain resources. Operations in the environmental flow alternatives should be developed that will use reservoir storage at certain times to augment flow and increase Apalachicola floodplain inundation.

1.3 Water Quality

The effects of reservoir operations on water quality should be closely examined in the WCM update, including ongoing and potential future effects to dissolved oxygen (DO), temperature, nutrient and organic material dynamics, and capacity to assimilate industrial and municipal

discharges. We request that the Mobile District use the WCM update to make necessary modifications that will improve water quality downstream of Corps projects, as is being done by TVA and other Corps districts.

1.3.1 Dissolved Oxygen

The Service is most concerned about low DO in project tailwaters. We recommend that the Corps make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. An appropriate effort would include first monitoring DO upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve DO levels, and conducting post-modification DO monitoring to ensure that DO levels have been improved to State water quality standards. Examples of low DO releases from Buford, West Point, and Walter F. George dams are detailed below.

We urge the Corps to 1) monitor DO upstream and downstream of Lanier Reservoir, West Point Reservoir, Walter F. George Reservoir, and Jim Woodruff Reservoir and 2) experiment with operational and/or structural modifications to improve DO levels, and conduct post-modification DO monitoring to ensure that DO levels increase to state water quality standards. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream dissolved oxygen requirements may be particularly useful. The DO that results from the mixing of two water bodies (DO_{mx}) is a function of the dissolved oxygen (DO_1 and DO_2) and volumes (Q_1 and Q_2) of the two water bodies and is calculated using the following equation:

$$DO_{mx} = \frac{Q_1 * DO_1 + Q_2 * DO_2}{Q_1 + Q_2}$$

1.3.1.1. Buford Dam tailwaters

Low DO levels were recorded by the Georgia Department of Natural Resources-Wildlife Resources Division (GDNR-WRD) just below Buford Dam during 1996-2006. These DO levels affect angler success, GDNR-WRD’s stocking rates, and the native aquatic community. Periodic measurements taken during this period resulted in monthly minimum instantaneous $\leq$ 1.0 mg/L in September through December. Monthly average values were < 5.0 mg/L from August through November (Figure 7; Chris Martin, GDNR-WRD, 2010, pers. comm.). Low DO levels persisted downriver, depending on operational and climatic factors. For example, based on GDNR-WRD measurements on November 5, 2005, DO increased to 5.0 mg/L three miles downriver, and increased to 6.0 mg/L 5.2 miles downriver when releases from Buford Dam were < 2.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.).

The Corps upgraded the venting capabilities of the Buford Dam turbines over the past few years. However, the upgrades resulted in < 1.0 mg/L increase over previous conditions (Chris Martin, GDNR-WRD, 2010, pers. comm.). The Corps should thoroughly evaluate the effectiveness of these upgrades.

Useful tools to improve DO levels to State standards in Georgia trout waters (6.0 mg/L daily average, 5.0 mg/L instantaneous) include sluicing instead of running discharge through the

penstocks and units, or to use a combination of the two routing methods. For example, on September 15, 2000, GDNR-WRD recorded a DO level of 1.5 mg/L at Buford Dam during a minimum flow release through the house unit. In contrast, DO levels measured on the same date during sluicing indicate that DO remained above 6.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.). Thus, the Corps has demonstrated that sluicing below Buford Dam is an effective tool to mitigate low DO effects associated with hypolimnetic releases.

1.3.1.2. West Point Dam tailwaters

Dissolved oxygen data collected by the Corps downstream from West Point Dam from 1999 through 2001 indicate that DO levels met or exceeded the Georgia instantaneous standard (4 mg/L) 35% of the monitoring period in 1999, (monitoring from 6/15-9/14), 30% of the monitoring period in 2000 (monitoring from 7/25-9/30), and 4% of the monitoring period in 2001 (monitoring from 6/8-10/5; Georgia Power Company 2002). GDNR-WRD has investigated multiple fish kills below West Point Dam and has concluded that these fish kills are attributable to low dissolved oxygen levels (GDNR-WRD letter to the Corps, November 20, 2008).

1.3.1.3 Walter F. George Dam tailwaters

Low DO levels were associated with minor fish and mussel kills downstream of Walter F. George Dam (Rob Weller, GDNR-WRD, 2008, pers. comm.).

1.3.2 Temperature

The water temperatures of hypolimnetic releases below large dams are lower than would naturally occur during spring and summer months. Low water temperatures negatively affect warmwater fishes that require warmer water temperatures necessary for spawning and growth of young-of-year fishes. Thermal alteration can be ameliorated by structural modification of penstock location in the water column. Another option to moderate thermal alteration is to release (via sluicing) warmer water from a higher elevation in the reservoir's water column. Once this water mixes with the cold hypolimnetic release, water temperatures more closely approximate natural water temperatures. A recent example of sluicing effects in the Mobile District comes from measurements taken during summer 2009 below Allatoona Dam. Sluicing in June caused water temperatures to increase approximately10ºC (Figure 8). Temperature increases were observed many miles downriver (USFWS 2009 unpublished data).

Similar to DO recommendations, we urge the Corps to monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream temperature requirements may be useful. The seasonal timing of such releases exhibiting modified temperatures is of great importance. For example, the current summer thermal regime on the Etowah River, created by operations at Allatoona Dam, provides cool thermal refuge for striped bass in the upper Coosa River system. A thermal modification during the summer months below Allatoona Dam could be detrimental to fishes such as striped bass and lake sturgeon (Matt Thomas, GDNR-WRD, 2010, pers. comm.). Because the Service and GDNR-

WRD have responsibilities to protect native aquatic communities as well as recreational fisheries, we recommend the Corps explore methods for temperature modifications below their facilities, but coordinate closely with State and Federal agencies to determine the appropriate timing of such alterations.

In addition, it should be noted that the current thermal regime of Lanier Reservoir's tailwater is critical to the Chattahoochee River trout fishery and trout production at GDNR-WRD's Buford Hatchery. The tailwater trout fishery in the Chattahoochee, one of Georgia's premier fisheries, is dependent upon cold, well-oxygenated water releases for the survival of trout. The Buford Trout Hatchery produces 400,000 catchable trout annually and is dependent on Lanier Reservoir coldwater storage to maintain this production. Potential impacts to Chattahoochee River trout waters should be considered when making WCM decisions (Matt Thomas, GDNR-WRD, 2010, pers. comm.). The coldwater trout fishery below Buford Dam is of great importance to GDNR-WRD, and is also a responsibility for the Service as an important recreational fishery. Discussions between GDNR-WRD and the Corps should occur to determine if modifications are possible that avoid trout fishery impacts but also provide benefits to native warmwater fisheries below Buford Dam.

1.4 Fish Passage

Corps ACF dams impede the migration of diadromous and potadromous fishes including striped bass, Alabama shad, American eel, and Gulf sturgeon. Jim Woodruff Dam's impact on diadromous fish passage is large compared to dams on other southeastern rivers because it is located in the lower part of a large river basin. Consequently, there is significant interest in improving fish passage at this facility, as well as the two next upstream Corps facilities, George W. Andrews Lock and Dam and Walter F. George Lock and Dam. We appreciate the Corps' willingness and cooperation to modify operations thus far at Jim Woodruff to maximize fish passage for Alabama shad. Support and facilitation of fish passage research at Woodruff Dam, as well as other ACF Federal dams (notably George W. Andrews Lock and Dam and Walter F. George Lock and Dam) should continue with a goal of identifying and implementing operations and/or modifications that would allow riverine species to travel their historic migratory pathways. Provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam, while maintaining the need for operational flexibility.

1.5 Climate Change

The effects of climate change to ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes should be evaluated. It is our understanding that the Corps will be considering sea level rise when developing alternatives (Corps 2009). However, climate change will also affect river flows and the effects of a given set of operating rules will vary depending on whether the basin's climate becomes drier, wetter, more variable, or less variable. In particular, it is vitally important to adapt the level set as the top of conservation (TOC) pool to the long-term hydrology of the basin and the essential purposes the projects serve. In a scenario with greater variability between annual high flows and low flows, for example, it may not be feasible for these projects to simultaneously serve their existing levels of flood control protection and minimum flow support without adapting TOC pool levels to prevailing weather conditions.

The Corps already practices this concept with the multiple action zones and the occasional variances from the rule curves to store water above the TOC pool elevation during dry periods. Several models are developed that will be useful in this analysis and are briefly described in section *2.2 Evaluation of Alternative Models*. In addition to including multiple future climate scenarios into modeled discharge scenarios and Corps alternatives, flow provisions should be created for dry, average, and wet years in order to account for current climate variability.

1.6 Navigation

Navigation is an authorized project purpose for all five ACF Corps dams and the Corps has used reservoir storage in the past to support navigation. In recent years, however, lacking water quality certification to maintain the channel in Florida, we have seen only occasional flow management for the navigation purpose. Current physical channel dimensions dictate the flows that are necessary for navigability. Without providing flows to meet channel depth authorizations, dredging would be necessary to maintain channel navigability. Dredging has significant adverse effects to fish and wildlife. If flows for navigation are included in the WCM update, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support. If flows for navigation are not included in the WCM update, improvement or simplification of the four-zone reservoir operational scheme that governs current operation should be considered.

1.7 Reservoir and Riverine Fisheries Management

The Corps follows a draft Standard Operating Procedure (SOP) for “Lake Regulations and Coordination for Fish Management Purposes.” The “fish spawn” SOP goal is to manage for generally stable or rising reservoir levels and for generally stable or gradually declining river levels for about 4 to 6 weeks in the spring months at Corps’ reservoirs. These draft SOPs are protective of reservoir fish spawning; however, stable or rising river levels are also beneficial for riverine sport fisheries. We understand it is not feasible to have stable and/or rising water levels in both the reservoirs and river during times of declining basin inflow. To address this issue, recent reservoir and riverine fisheries literature should be reviewed to evaluate whether a 4-6 week stable or rising reservoir window is supported for reservoir fish spawning and/or potentially detrimental to riverine fish spawning. We also recommend development of an alternative that includes modifying the draft SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. Finally, we recommend that the Corps identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

1.8 National Wildlife Refuges

The Service previously recommended to the Corps that a seasonal pattern of reservoir levels at W.F. George Reservoir would best accommodate the needs of Eufaula National Wildlife Refuge. Water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. These recommendations, which we included in the draft FWCA report for the Corps' 1998 Draft EIS on ACF water

allocation, were to manage the reservoir so that it behaves more like a river. Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer were recommended. These recommendations remain valid. How the benefits and impacts of such a scheme compare with the existing operating regime and other alternatives should be considered.

1.9 Apalachicola Bay

The predicted levels of freshwater inflow into Apalachicola Bay resulting from Corps alternatives will be of importance to the Service because they may affect salinity levels. Freshwater inflow reductions cause salinity increases and indirectly increase oyster mortality through increased colonization of marine oyster bed predators (Corps 1998). Additionally, juvenile Gulf sturgeons have optimal growth rates at relatively low salinity (9-10 ppt), and periods of extended higher salinities would likely limit feeding habitat availability.

As part of the Comprehensive Study for the Corps' DEIS (1998), the National Ocean Service (NOS) examined the freshwater inflow effects on the water circulation and salinity changes in Apalachicola Bay. Oysters were selected as a biological response variable because of their commercial fishery importance, habitat requirements, and expected response to salinity fluctuations (Corps 1998). A three-dimensional hydrodynamic model produced output that was used in an integrated biological model to assess the effects of potential freshwater inflow changes to Apalachicola Bay salinities and oysters. Predicted oyster mortality and oyster bed growth rates were compared for the various Corps' alternatives.

More recently, Livingston et al. (2000) developed a spatially-explicit hydrodynamic circulation model of the bay that predicts salinity, among other variables, as a function of freshwater inflow. This model has been used to model oyster mortality and growth in relation to freshwater inputs. The Service has used the results of this model to make inferences on the availability of low-salinity bay habitat for Gulf sturgeon. In addition, an alternative Apalachicola Bay salinity model was recently developed by Peter Sheng at the University of Florida (Sheng and Kim 2009). By using the Corps' daily average discharge output from the ResSim model for the Sumatra gage for the various alternatives, the model can compare the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios. This information can be used to make inferences on the availability of bay habitat for Gulf sturgeon and to model oyster mortality and growth.

We recommend that the Corps or the Corps' consultants (Tetra Tech) contact the NWFWMD and/or the Florida Department of Environmental Protection (FDEP) to request permission to access and use the Livingston et al. models, or invite a collaboration between the Corps and NWFWMD/FDEP to evaluate effects of flow alternatives on Apalachicola Bay resources. The Sheng and Kim (2009) model should also be incorporated in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth. If all models are made available to the Corps and the Service, we recommend that the strengths and limitations of each model be evaluated to determine the model that will best suit the assessment requirements. In addition, coordination should occur with FFWCC's Fish and Wildlife Research

Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

1.10 Decision Support Model to Evaluate Changes to Corps' Operations

It is important to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams. Because of the numerous and sometimes competing demands for water, it is difficult to evaluate the effects of proposed management alternatives and to make the evaluation transparent. However, multiple free decision support tools (e.g., Netica) are available to facilitate the evaluation of alternatives. These tools are versatile in the sense that new information that results from monitoring the effects of management strategies is easily integrated into the analysis and decision process. Consequently, a better and more transparent understanding of how Corps operations affect the ecology and use of the ACF system can lead to improved future management. Therefore, a decision support model should be incorporated into the WCM update process.

1.11 Adaptive Management

An adaptive management program should be developed, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam. The program would formulate hypotheses about how such benefits might be achieved through dam operations, implement those operations, monitor ecosystem responses, and revise the operations based upon lessons learned.

2. Recommendations for Corps Hydrologic Modeling

2.1 Increasing Consumptive Demands

The impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin should be recognized and considered. This is a variable that an analysis of operational alternatives should incorporate along with climate-driven hydrologic variability. The relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes should be quantified. For example, how is sustainable minimum flow release from Woodruff Dam affected if consumptive demands increase by 25, 50 or 100 percent by the years 2020, 2050, and 2080? We recognize the order made by Judge Magnuson limits operational alternatives for the express purposes of water supply. However, we also recognize that surface and groundwater withdrawals will continue to be made at various points in the system. The Corps alternative analysis must include metrics regarding water supply withdrawals including potential increases. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

2.2 Evaluation of Alternative Models

The Corps' unimpaired flows dataset that was used in the 1998 draft EIS was compared to 1) the unimpaired flows dataset that the Corps expects to use for the WCM update and 2) to the pre-Buford Dam USGS streamflow gage data. Aside from the addition of recent flow records, the most recent Corps-modeled unimpaired dataset is essentially unchanged from the 1998 version.

Compared to the USGS gage data, these datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes. We recommend that the use of alternative models be investigated to develop better unimpaired flow and alternative flow datasets.

Similarly, land cover has changed significantly since the early 20th century in the upper and middle portions of the ACF basin. Prior to both mainstem damming and discharge gaging, expansive agriculture, chestnut blight, fire suppression, and other factors affected land cover in the southern Appalachians, Piedmont, Fall-line Sandhills, and upper Coastal Plain regions. The hydrological consequences of land cover changes could have been manifested in the flow extremes observed during droughts and heavy rain. Nevertheless, the pre-dam hydrologic period of record is presently the best available hydrologic dataset to characterize pre-dam streamflows, develop ecosystem flow alternatives, and with which to compare flow alternatives. Models that predict hydrological alteration that occurs in response to land cover changes could be particularly useful in the development and assessment of flow alternatives.

The United States Geological Survey (USGS) is developing a Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) for the ACF. This watershed model will facilitate the inclusion of impacts of precipitation, climate, and land use changes on streamflow, sediment yields, and basin hydrology. If the PRMS is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, it should be used as an additional evaluation tool. The PRMS output potentially could be used to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions. Use of this model is based on the assumption that the PRMS model results reflect average flows and flow extremes better than existing datasets and other models. The latter analysis may be particularly useful to determine if reservoirs can maintain downstream flows through droughts.

National Oceanic and Atmospheric Administration (NOAA) funded the Georgia Water Resources Institute (GWRI) to complete a historical and future assessment of precipitation, evapotranspiration, soil moisture, and run-off trends in the ACF Basin to support ongoing water resources planning in the region. This method used both historical gage data and the Corps unimpaired flows dataset in a Joint Variable Spatial Downscaling model that incorporated climate change effects. Future stream flow, river flow, reservoir level, and power generation forecasts were made at the sub-basin level for the next 100 years. Coordination with USGS and GWRI should occur regarding these new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

Lastly, the Corps' HEC-5Q water quality analyses rely on average daily flow to predict water quality parameters (e.g., temperature and dissolved oxygen) in six hour time steps and at 0.5 mile intervals. Although these model outputs can be used to compare among flow alternatives, they are not expected to accurately predict either the water quality values or the range of values that

are likely to occur in response to hourly discharge changes. Alternative water quality models exist and State resource agencies should be contacted to determine whether water quality models are developed for the ACF Basin. Additionally, regression models that accurately predict water quality parameters (e.g., water temperature and dissolved oxygen) can be developed using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure). Alternative water quality assessment methods should be considered to accurately evaluate effects of flow alternatives on water quality.

3. Evaluation of Corps Alternatives for FWCA Report

3.1 ResSim Model Output Analyses

It is our understanding that ResSim will be used for the Corps' flow analyses. The flow statistics used by the Service in the past to analyze the resulting datasets were derived by using the Indicators of Hydrologic Alteration (IHA) and the Range of Variability Approach (RVA). Because flow is a master variable in fluvial systems, and because the ecology of fish and wildlife is closely linked to the flow regimes in which they evolved, the current evaluation should continue to rely on tools such as IHA, RVA, and Environmental Flow Components (EFCs) (Mathews and Richter 2007). Specific flow statistics and species-specific flow-ecology relationships (as available) that are important to natural resource sustainability, as well as the ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC) study (Freeman et al. 1997), should also be considered.

3.2 HEC-5Q Water Quality Model Output Analyses

It is our understanding that HEC-5Q will be used for the Corps' water quality analyses. We understand that this model predicts water quality parameters in six hour time intervals in river and reservoirs. Similar to the analyses contained in the Corps' 1998 draft EIS (Corps 1998), the analyzed data should be composed of summer values (May through October), separated by drought, dry, average, and wet year types for each alternative. The following information should be developed for each alternative to evaluate the effects on water quality and aquatic resources in the modeled tailrace and riverine locations:

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters;
- Total number of instantaneous "measurements" less than 4 mg/L;
- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L);
- Monthly exceedance figures and box plots with outliers for water temperature; and
- Average stream percent wastewater.

For each alternative, the following information should be developed to evaluate the effects on water quality and aquatic resources for the modeled ACF reservoir locations:

- Average values of summer Chlorophyll a (*u*g/L);
- Average summer retention time (days); and

- Average summer phosphorus loading (pounds/acre/month).

3.3 Floodplain Connectivity Analyses

Assessing the extent of floodplain inundation will be a critical component of the alternatives analysis assessment. The Apalachicola River floodplain analysis should be decided following the Corps' attempt to access the river stage-based LIDAR data collected and housed by the NWFWMD. If the data are made available, the Corps should provide these data to the Service and an analysis of the area of aquatic habitat (separated by aquatic habitat type) connected to the Apalachicola River under the range of discharges for the period of record should be evaluated. If LIDAR data are not provided, the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation should be evaluated using the relationships quantified by Light et al. 1998 and Light et al. 2006.

Although the areal extent of the Chattahoochee River floodplain is one-fifth that of the Apalachicola River floodplain (Davis 1997), it likely served multiple important ecological roles prior to flow alteration by multiple mainstem reservoirs. To our knowledge, the Tri-State Comprehensive Study Riparian Wetland Element (Davis 1997) houses the best available dataset for assessing the effects of flow alternatives on the Chattahoochee River floodplain. These data should be used to evaluate the probable extent of floodplain inundation for each flow alternative. However, data are only available for one riverine site in the Chattahoochee River Basin positioned between Jim Woodruff Lock and Dam and G.W. Andrews Lock and Dam. At unsurveyed locations, known river stages at which floodplain inundations occurs should be used to evaluate the frequency, duration, and timing of floodplain inundation for flow alternatives provided by the Corps (see Table 1 and associated information provided by NWS 2010). At sites without this information, the 2-year recurrence interval discharge to approximate the incipient point of flooding should be used to evaluate the frequency, duration, and timing of floodplain inundation. Because channel alteration (e.g., channel incision) can increase the recurrence interval at which flooding occurs and because we have little information on channel alteration, other data sources should be investigated to aid in the floodplain inundation assessment.

3.4 Reservoir Fisheries Analyses

Sport fisheries are important recreational and economic resources in all of the Federal ACF reservoirs. Important sport fishes in all five reservoirs include largemouth bass and crappie, but each reservoir supports a mix of several additional species, including walleye (Lanier Reservoir only), striped bass, bluegill, redear sunfish, and others. Based on interviews of fisheries managers and researchers in the basin, Ryder et al. (1995) identified the species considered critical in an evaluation of operating alternatives and the relative acceptability of reservoir levels for these species. A Delphi technique was used to obtain expert opinion for select reservoirs on reservoir fish guilds, important seasonal periods for those species, and acceptability ratings for various reservoir levels in the ACF and ACT (Ryder et al. 1995). The Service cooperated with the Corps for the 1998 draft EIS for ACF water allocation to develop a reservoir fisheries performance measure using the findings of Ryder et al. (1996). This information was used to create a reservoir fisheries performance measure by looking at the critical spawning and rearing periods, reservoir elevations during these times, and assigning a greater weight to stable or rising elevations during those time periods. The performance measures were then compared for the various alternatives.

The reservoir fisheries performance measure should be updated with additional information, literature, and/or relevant datasets that have been developed in the past ten years, and used to evaluate the relative impacts of the Corps' alternatives on reservoir sport fisheries. Potential new datasets to be included that have been indentified to date include largemouth bass young-of-year data in West Point Reservoir (Brent Hess, GDNR-WRD, 2010, pers. comm.), as well as black basses and crappie data in relation to reservoir retention times and year-class strength in Walter F. George, West Point, and Bartletts Ferry reservoirs (Mike Maceina, Auburn University, 2010, pers. comm.).

<u>3.5 Riverine Fisheries Analyses</u>
Sport fisheries are also important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. Data identified to date will be provided by the FFWCC and the USGS and used to evaluate the relative impacts of the Corps' alternatives on riverine sport fisheries. Specific measures to be evaluated include year-class strength versus acres of inundated floodplain spawning habitat, changes in catch rates of sportfishes in various water years, and changes in relative weight (condition) of sportfishes in various water years.

<u>3.6 Apalachicola Bay Salinity Analyses</u>
If a salinity model is incorporated in the WCM update process, as described in Section 1.8 above, the model output should be incorporated in the FWCA evaluation. A list of data needs should be developed to be produced as a result of these analyses. These data should include the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios and possibly the percent oyster mortality and oyster growth rates.

<u>3.7 Federally-protected Species Analyses</u>
It is our understanding that the Corps will be conducting certain analyses to evaluate the effects of the various alternatives on federally-protected species. These analyses will be contained in the Corps' Biological Assessment (BA) accompanying the draft EIS. The Service will include these analyses in our FWCA evaluation, assuming they are available for us to do so. The types of analyses that should be evaluated are contained in the "*Analyses for the Effects of the Action*" section of the Service's June 1, 2008, RIOP Biological Opinion (USFWS 2008) and are listed below:

Gulf sturgeon

- Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning;
- Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at

least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning;
- Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae;
- Maximum number of consecutive days per year less than 16,000 cfs; and
- Departures from average water temperatures between March 1st to May 31st.

Freshwater mussels
- Lowest daily flow for each year;
- Inter-annual frequency of flows less than 5,000-10,000 cfs;
- Maximum number of days per year with flows less than 5,000 – 10,000 cfs;
- Maximum number of consecutive days less than 5,000 – 10,000 cfs;
- Median number of days per year less than 5,000 – 10,000 cfs;
- Frequency (percent of days) of daily stage changes (ft/day); and
- Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs.

Floodplain connectivity
- Frequency (% of days) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998);
- Frequency (% of years) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998).

4.0 Recommendations for Additional Coordination

This PAL includes comments from the State wildlife agencies in the basin. As is encouraged under the FWCA, we will continue to coordinate with these agencies, and will coordinate with NOAA Fisheries, as we move forward.

To assist in the development of alternatives and mitigation, we have suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, impacts to Eufaula National Wildlife Refuge, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We have identified analyses to evaluate Corps alternatives with respect to flow, water quality, floodplain connectivity, reservoir and riverine fisheries, Apalachicola Bay resources, and federally-protected species. We anticipate that the next step will be for the Corps and the Service to work together to update the interagency SOW to reflect Corps and Service responsibilities for the evaluations and analyses contained in this PAL. As you know, such a division of labor occurred to produce the prior DEIS and FWCA Report (Corps 1998).

We would like to be involved in the development of alternatives, including the development of environmental flows alternatives. The Service would like to assist in the development of such

alternatives to maximize benefits to ecological resources and to gain a better understanding of the consequences of implementing such alternatives on other authorized project purposes and operational constraints. Once all of the alternatives have been analyzed, we anticipate working with the Corps to identify opportunities for restoration, compensation, and enhancement.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress the Corps water management is not just about avoiding adverse affects, but also to look at opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Everson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL
B. Zettle, Corps, Mobile, AL
M. Eubanks, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
M. Thomas, GDNR-WRD, Social Circle, GA
C. Martin, GDNR-WRD, Social Circle, GA
B. Hess, GDNR-WRD, LaGrange, GA
R. Weller, GDNR-WRD, Albany, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
D. Bernhart, NOAA, St. Petersburg, FL

Literature Cited

Ahlstedt, S.A., J.R. Powell, R.S. Butler, M.T. Fagg, D.W. Hubbs, S.F. Novak, S.R. Palmer, and P.D. Johnson. 2004. Historical and current examination of freshwater mussels (Bivalvia: Margaritiferidae, Unionidae) in the Duck River basin Tennessee. Final report submitted to satisfy the requirements of the Tennessee Wildlife Resource Agency contract FA-02-14725-00.

Couch, C.A., E.H. Hopkins, and P.S. Hardy. 1996. Influences of environmental settings on aquatic ecosystems in the Apalachicola-Chattahoochee-Flint River Basin. U.S. Geological Survey Water-Resources Investigations Report 95-4278.

Davis, M.M. 1997. Tri-State Comprehensive Study Riparian Wetland Element, Report 1: Relationship between Flow and Habitat Value in the Alabama-Coosa-Tallapoosa/Apalachicola-Chattahoochee-Flint (ACT/ACF) River Basins. Miscellaneous Paper EL-97-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Freeman, M.C., J.M. Nestler, and P.N. Johnson. 1997. Riverine Resources: Water Needs and Environmental Effects Analyses in the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. Final Report to the Technical Coordinating Group of the ACT-ACF Comprehensive Study, U.S. Geological Survey, Biological Resources Division, Patuxent Wildlife Research Center, Athens, GA.

Freeman, M.C., Z.H. Bowen, K.D. Bovee, and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11(1): 179-190.

Georgia Power Company. 2002. Final License Application, Applicant-Prepared Environmental Assessment, Middle Chattahoochee Project (FERC No. 2177). December 2002, pg. 34, Appendix E, Figures E-2 through E-4.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood-pulse concept in river-floodplain systems, p. 110-127. *In* D.P. Dodge [ed.] Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106.

Light, H.M, M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida. U.S. Geological Survey Professional Paper 1594.

Light, H.M., Vincent, K.R., Darst, M.R., and Price, F.D. 2006. Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin,W. Huang, J.D. Christensen, M.E. Monaco, T.A. Battista, C.J. Klein, R.L. Howell IV, and G.L. Ray. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Mathews, R., and B.D. Richter. 2007. Application of the indicators of hydrologic alteration software in environmental flow setting. Journal of the American Water Resources Association 43: 1400-1413.

National Weather Service Advanced Hydrologic Prediction Service (NWS) 2010. http://ahps.srh.noaa.gov/

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg, 1997. The Natural Flow Regime. BioScience 47:769-784.

Postel, S. and B. Richter. 2003. Rivers for Life: Managing Water for People and Nature. Island Press. 253 pp.

Richter, B.D., J.V. Baumgartner, D.P. Braun, and J. Powell. 1998. A spatial assessment of hydrologic alteration within a river network. Regulated Rivers 14:329-340.

Ryder, S., J. Taylor, and J. Crance. 1995. Relations between reservoir surface water elevations and reservoir fisheries. Comprehensive Study Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins, U.S. Army Corps of Engineers, Mobile, AL.

Ryder, S., J. Taylor, and J. Crance. 1996. Relations between reservoir surface water elevations and reservoir fisheries in the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins. National Biological Service, Ft. Collins, Colorado. 48 p. + apps.

Sheng, Y.P. and T. Kim. 2009. Skill assessment of an integrated modeling system for shallow coastal and estuarine ecosystems. Journal of Marine Systems 79: 212-243.

United States Army Corps of Engineers. 2009. Water Resources Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs, Expires 1 July 2011. July 1, 2009. Circular No. 1165-2-211, Washington, D.C. 31 pp.

United States Army Corps of Engineers. 1998. Draft Environmental Impact Statement Water Allocation for the Apalachicola-Chattahoochee-Flint (ACF) River Basin Main Report, September 1998, Mobile District, Mobile, Alabama.

United States Fish and Wildlife Service. 1999. Instream Flow Guidelines for the ACT and ACF Basins Interstate Water Allocation Formula. October 25, 1999. 40 pp.

United States Fish and Wildlife Service. 2008. Biological Opinion on the U.S. Army Corps of Engineers Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. June 1, 2008, Panama City Field Office, Panama City, Florida. 225 pp.

Table 1. Locations and river stages in the Chattahoochee River where the National Weather Service Advanced Hydrologic Prediction Service predicts damage to occur. Discharges were calculated using stage-discharge relationships at USGS streamflow gages. Only damage to manmade structures was considered as damage. Flooding of riverwalks, riverwalk structures, yards, and moving of equipment or livestock to avoid inundation was not considered to be damage.

Location (upstream to downstream order	Stage at which damage occurs	Discharge at which damage occurs
Chattahoochee at Norcross	16	20631
Chattahoochee at Roswell	14	29846
Chattahoochee at Atlanta	18	22023
Chattahoochee at Whitesburg	26	49379
Chattahoochee at West Point	21	62530
Chattahoochee at Columbus	41	261407

Figure 1. Histogram of mean + standard error daily discharge values reported in cubic feet per second (cfs) obtained from river gauges on the Duck River at Shelbyville (top) and Columbia (bottom), Tennessee by season. Means represent daily discharge values for each month for 10 years pre and 10 years post Reservoir Release Discharge Initiative (RRI) completed at Normandy Dam beginning in late 1991. Letters atop standard error bars indicate significantly different means as determined by Tukey's a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

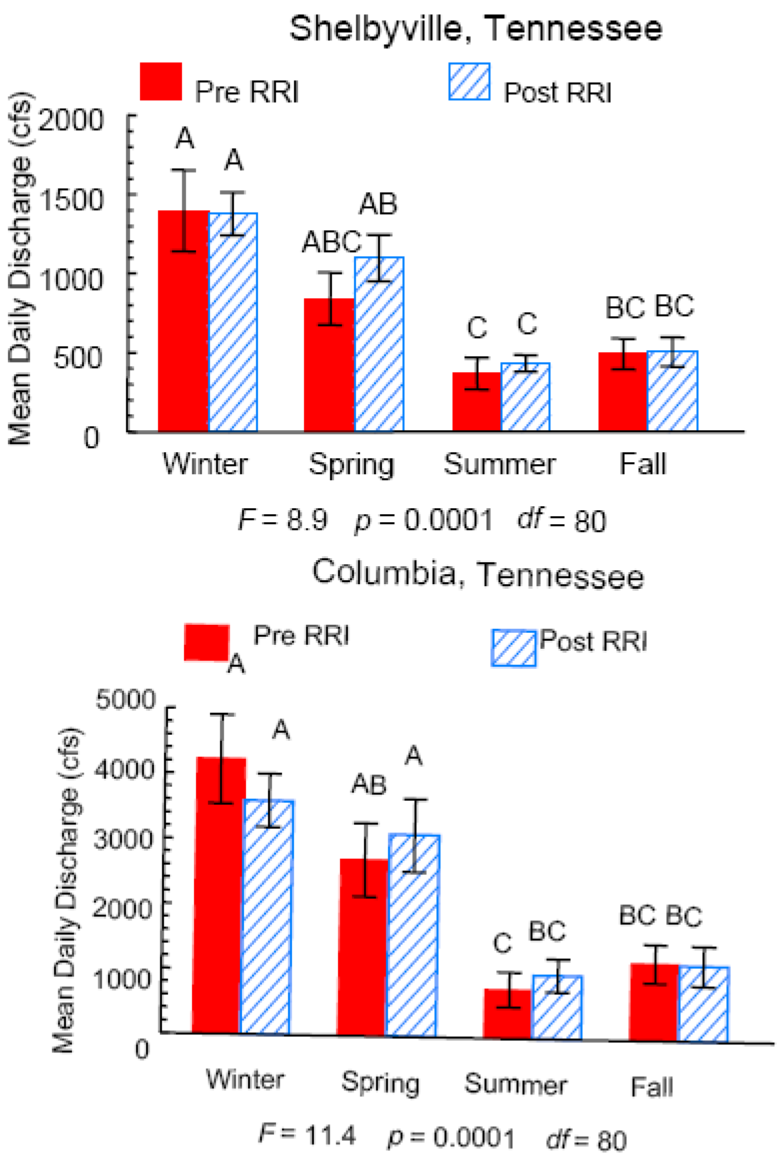


Figure 2. Comparative mean + s.e. of mussel species (top) and mussel number (bottom) sampled from 17 sites in the Duck River in 1977, 1988, and 2002. Letters atop standard error bars indicate statistically different means determined by Tukey's HSD a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

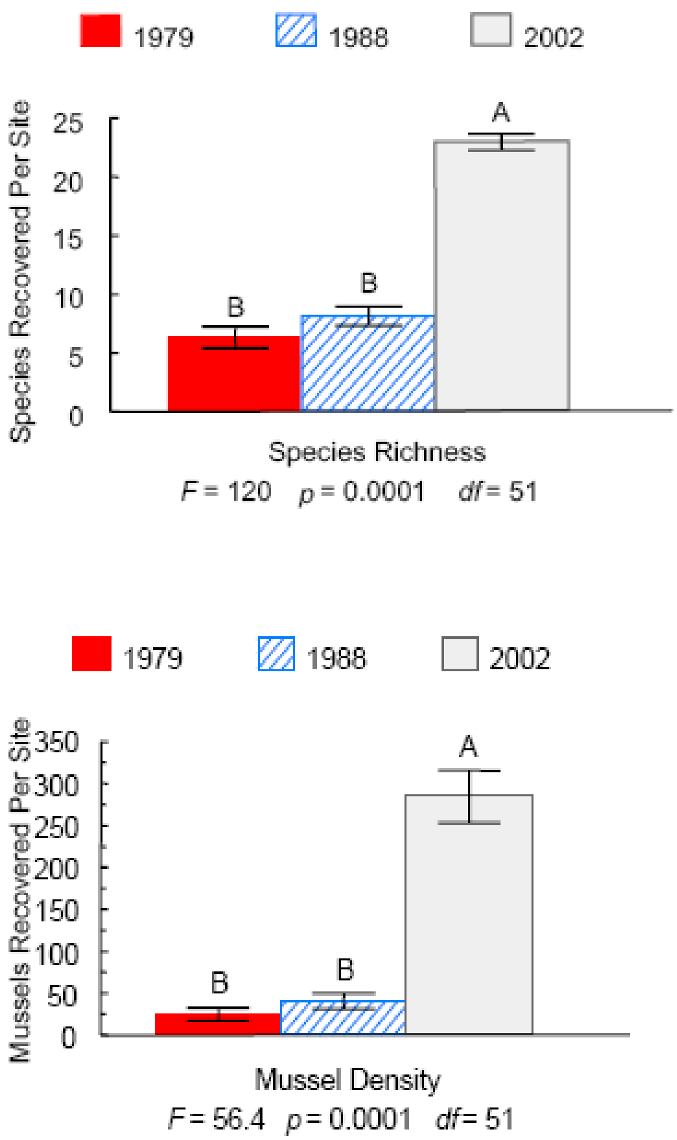
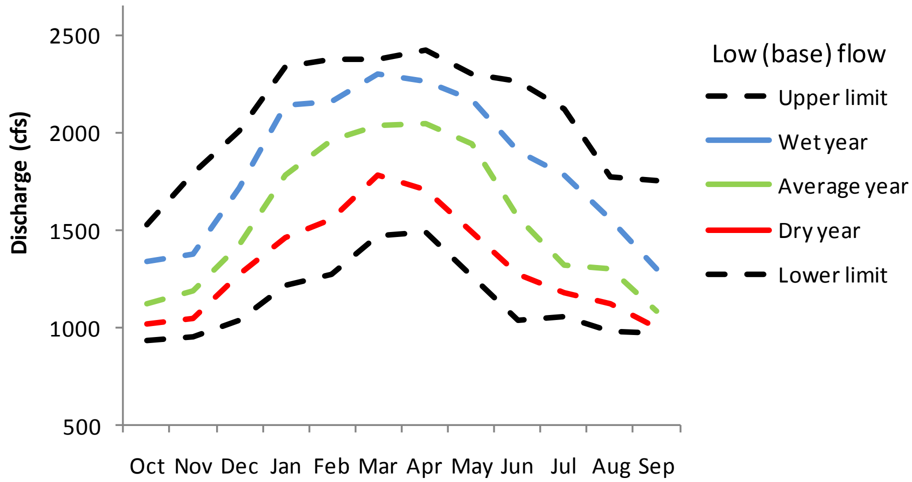


Figure 3. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River USGS Norcross gage.

a)



b)

Data analyzed: The only pre-Buford dam data that were available for this analysis extended between 1903 and 1946 (44 years) at the Chattahoochee River gage (02335000) at Norcross.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS Norcross gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small pulses

At the Chattahoochee River USGS Norcross gage, 9-18 flow pulses per year should be between 3,658 and 4,980 cfs, should last between 2-3 days, and should occur between mid-March and early June. Rise and fall rates can range between 1,260-2,054 cfs and 1,178-733 cfs, respectively.

High pulses

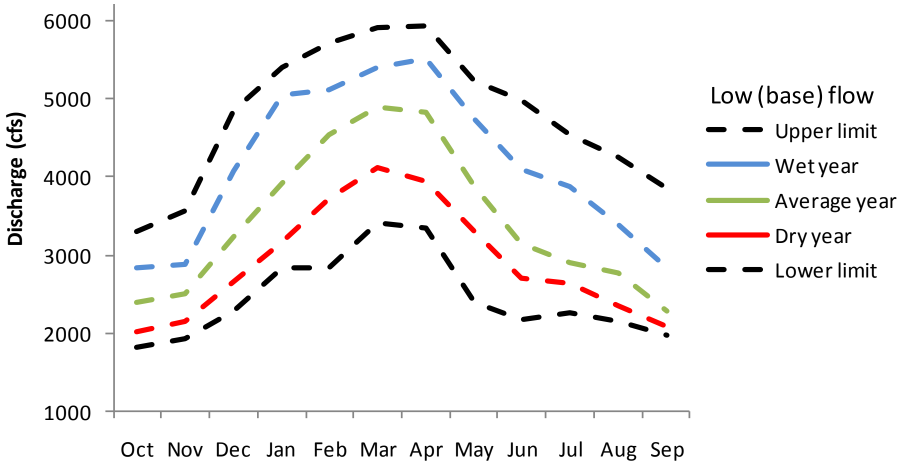
In wet years, a pulse of 17,650-28,080 cfs should last 9-80 days, should occur between early January and early May. Rise rates should range between 697-7518 cfs/day, and fall rates should range between 3376-460 cfs/day.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 4. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the USGS gage below West Point Dam.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1896 and 1955 (60 years) at the Chattahoochee River gage (02339500) below West Point Dam.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Chattahoochee River gage below West Point, 9-16 flow pulses per year should peak between 8,853 and 11,580 cfs, should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates can range between 2,483-3,698 cfs/day and 2,256-1,536 cfs/day, respectively.

High Pulses

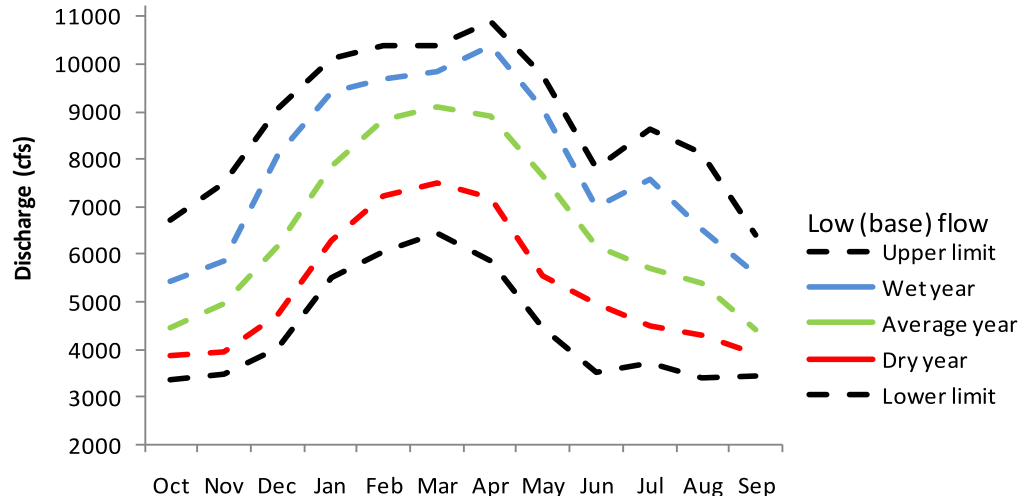
In wet years, a pulse that peaks between 48,830 - 58,950 cfs should last between 19-38 days, and should occur between mid-January and early April. Rise and fall rates can range between 5,563-13,170 cfs/day and 4,230-1787 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 5. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the Walter F. George Corpsnode.

a)



b)

Data analyzed: ACOE unimpaired flows dataset at the Walter F. George node and inferences from West Point analysis results.

Base flow description

No USGS discharge data for the pre-Buford dam period are available at Walter F. George. However, comparisons between pre-Buford USGS gage data and Corps-modeled "unimpaired flows" data show similar median monthly flows. Thus, we used median monthly flows in the Corps-modeled unimpaired dataset (1936-2006) to calculate the predicted low (base) flows that should occur at the W.F. George node. We excluded 103 negative flow values from the Corps dataset in this analysis.

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford Dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

Again, no USGS discharge data for the pre-Buford dam period are available at Walter F. George. Corps-modeled unimpaired flows do not represent the flow extremes (minimum and maximum flow duration, magnitude, timing, frequency, and rate of change) that were observed at USGS gages during the pre-Buford Dam period. Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified.

Small pulses

We infer from the West Point analysis that used real pre-Buford Dam USGS data, that 9-16 flow pulses per year should peak between 1.8-2.4 times higher than the baseflow river stage (approximately 16,369-21,535 cfs) in March for an average flow year. Pulses should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates should not exceed rates from other site recommendations.

High pulses

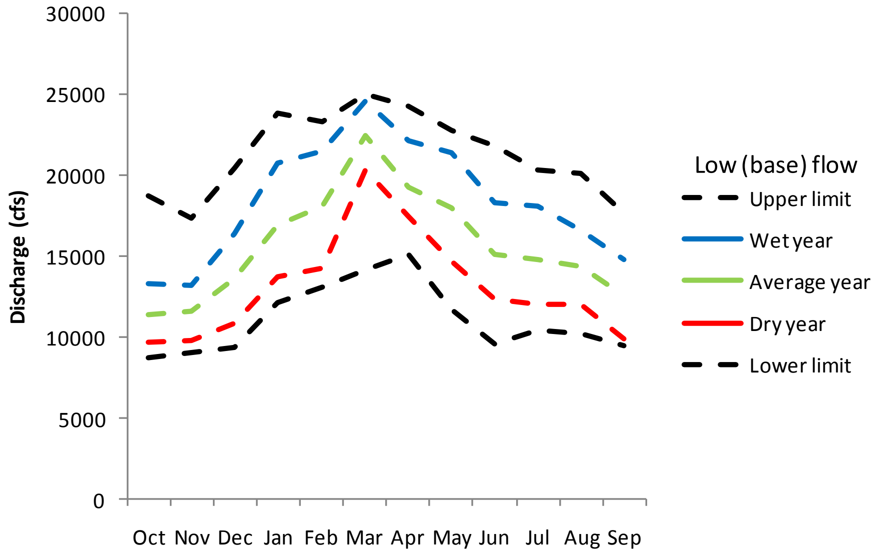
Development of a wet year flow guidelines is complicated by the fact that no stage-discharge relationships are presently known for the river segment between Walter F. George Dam and Woodruff Dam. However, the National Weather Service Advanced Hydrologic Prediction Service indicates that extensive floodplain inundation occurs at a river stage of 150 ft, although no significant damage is predicted to occur up to 160 ft. Consequently, we recommend that the ACOE evaluate wet year releases from Walter F. George that range between 150 and 160 ft. Duration, timing, and rates of change should be similar to the recommendations for West Point Dam.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 6. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Apalachicola River USGS gage at Chattahoochee, FL.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1922 and 1955 (34 years) at the Apalachicola River gage (02358000) at Chattahoochee, FL.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Apalachicola River gage at Chattahoochee, FL, 3-6 flow pulses per year should peak between 30,950 and 41,110 cfs, should last between 4-13 days, and should occur between mid-February and mid-May. Rise and fall rates can range between 2,493-5,356 cfs/day and 2,353-1,473 cfs/day, respectively.

High Pulses

In wet years, a pulse that peaks between 86,630-122,800 cfs should last between 28-68 days, and should occur between late-February and early April. Rise and fall rates can range between 2,544-8,108 cfs/day and 4,236-2,330 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 7. Monthly maximum, average, and minimum dissolved oxygen concentrations in the Chattahoochee River at Buford Dam. Data courtesy of Georgia Department of Natural Resources-Wildlife Resources Division.

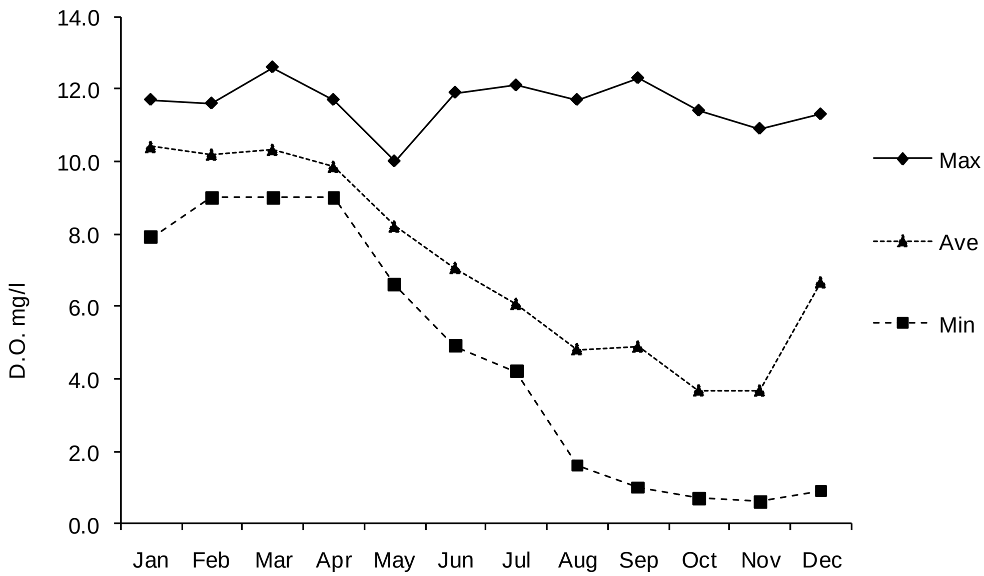
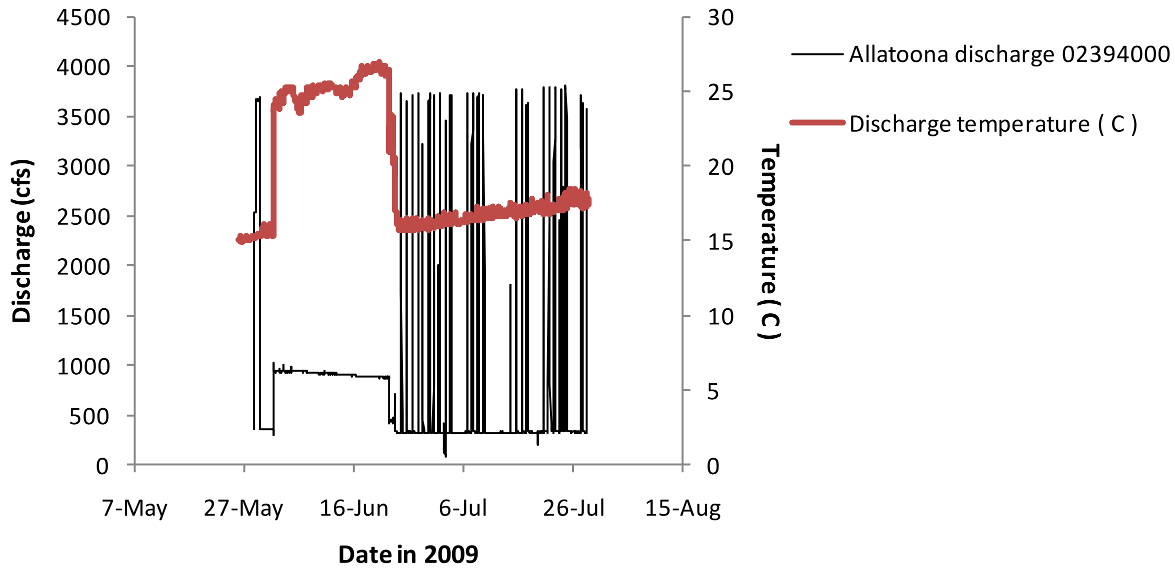


Figure 8. Discharge and water temperature measurements below Allatoona Dam on the Etowah River, Georgia. Sluicing from a location higher in the reservoir's water column occurred in June, causing the observed downriver temperature increases.



United States Department of the Interior

Fish and Wildlife Service

105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

March 1, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing an Addendum to the U.S. Fish and Wildlife Service (Service)'s April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the WCM Updates is to identify operating criteria and guidelines for managing water storage and release of water from United States Army Corps of Engineers (Corps) reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the Service's 2010 PAL was to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. Based on recent analyses conducted by the Service, we submit the following addendum under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). This addendum solely addresses ecosystem flow guidelines -- all other information and recommendations in the PAL are still applicable. In the future, we will provide additional information in the form of a draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

Rationale for revision of ecosystem flow guidelines

The ecosystem flow guidelines that were delivered in the PAL were developed with the aid of Indicators of Hydrologic Alteration (IHA; TNC 2007). Although the IHA methodology is scientifically defensible, subsequent examination of IHA methodology and output revealed several concerns that could affect possible incorporation of the guidelines in the Corps' operations. Therefore, the Service is providing revised low and high flow guidelines (Figures 1-4 and Tables 1-4).

We had two reasons for revising the flow guidelines. First, the default IHA parameters used for the PAL initially separated the flow data into high and low flows using a percentile of the pre-Buford period of record. This method resulted in representation of low-flow discharges in summer-fall months by many values, and representation of low flows in winter-spring months by fewer values. This means that some months in some years were not represented in subsequent analyses. For example, historic low flows in the Apalachicola River remained above the 75th percentile or above flood stage for prolonged time periods, meaning that those periods were not represented in the low flow analysis. Thus, if the historic flow regime is to be used to help guide low flow alternative development, evaluation, and implementation, the low flow analysis should examine the entire range of low flows that occurred in every month of every year before construction of Buford Dam.

Second, the low and high flow analyses in IHA calculate summary statistics using median values (for non-parametric analyses) to represent each year (TNC 2007). For example, IHA calculates the annual median high pulse magnitude, and uses the median values from every year to calculate summary statistics. While this is a statistically valid approach to summarizing large datasets, summarizing multiple intra-annual pulses by a single value results in a narrower range of magnitude, duration, timing, and rate of change values. Because the intent of the analysis is to quantify a range of discharge values that are likely to be beneficial to riverine habitat and fauna and to facilitate planning for high flows in the Corps' operations, we calculated the following high-flow guidelines by including each high flow event in summary statistic calculation (e.g., percentiles representing upper and lower limits, and dry, average, and wet years). With the exception of not using annual medians to calculate percentiles, the revised method for high flow guideline development is analogous to the "non-advanced" method for high flow analysis in IHA.

Low flow analysis methodology

1. In Microsoft Excel, the seven smallest values from each month in every year were extracted for analysis. We chose multiple values to represent each month so that the overall results are less likely to be influenced by an aberrant value (i.e., less likely to be skewed by one value), especially in future analyses that may examine and compare Corps' modeled flow alternatives which are likely to occasionally contain negative discharge values. A comparison of the effects of one, seven, and ten minimum flow values to represent low flows in each month showed little difference in overall low flow hydrograph shape, similar flow magnitudes throughout the year, and minor differences in winter 90th percentile flow magnitudes. These results also generally correspond to the Web-based Hydrograph Analysis Tool (WHAT Local Minimum Method; Lim et al. 2005) output for baseflow generation. Collectively, these results lend greater support for the decision to use the seven lowest values to characterize low flows.

2. The 10th, 25th, 50th, 75th, and 90th percentiles for each month were calculated on the extracted data to define the lower limit, dry year, average year, wet year, and upper limit, respectively.

3. The Walter F. George low flow guidelines were calculated slightly differently. A long-term period of pre-Buford Dam discharge data was not available below Walter F. George. As a proxy

for actual data, the Corps' unimpaired flows dataset was used. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Thus, these low flow guidelines should be treated as estimates.

4. Note that in this low flow analysis, in cases where an entire month is above flood stage, the lowest values are flood-related values. A strength of the low flow analysis is that the user can characterize the entire range of the lower flows that occur in every month of the user's flow dataset.

High flow analysis methodology

1. In Microsoft Excel, the 75th percentile of all flows in the time series was used as the flow threshold to separate high flows from the remainder of the flow dataset. Because this is consistent with our understanding of the meteorological conditions that should cause pulses to occur, the 75th percentile is a valid threshold to separate low and high flows.

2. The following parameters were then calculated: The duration of each high flow event, the maximum discharge in each sequence of high flows, the date of the initial high flow value, the rise rate (calculated as the difference between the preceding low flow value to the maximum flow divided by the number of time steps (n-1)), and the fall rate (calculated as the difference between the maximum flow and the following low flow value, divided by the number of time steps (n-1)).

3. The 2-year and 10-year recurrence interval discharges were calculated using the following methodology: Maximum discharge was calculated for every year, and the 50th and 90th percentiles in Excel were used to calculate approximations of the 2- and 10-year recurrence intervals, respectively. This is a close approximation to the IHA method, but not as sophisticated as the USGS PeakFQ calculation (Flynn et al. 2006). Nevertheless, these percentiles provide close approximations of these recurrence interval discharges. Although bankfull discharge in the Coastal Plain physiographic province tends to occur more frequently than every two years, we used an approximate 2-year recurrence interval basinwide as a consistent guide.

4. The 2-year and 10-year recurrence interval discharges were used to further separate high flows into small pulses, high pulses, and floods (note: these are the default values used in IHA to separate high flow data). Maximum high flow values between the 75th percentile and the 2-year recurrence interval were classified as small pulses (analogous to High Pulses in IHA). Values between the 2- and 10-year recurrence interval were classified as high pulses (analogous to small floods in IHA), and values greater than the 10-year recurrence interval were classified as floods. With the exception of the Apalachicola River analysis, floods greater than the 10-year recurrence interval were excluded from this letter because they exceed the discharge stages that are predicted to cause damage according to the National Weather Service Advanced Hydrologic Prediction Service (Table 1 in April 2, 2010 PAL).

5. The range of discharge values that were used to define small and high pulses are presented in the tables. Similar to the PAL, we also provide the 25th and 75th percentiles of the magnitudes, frequencies, durations, rise rates, and fall rates which were calculated separately for small pulses,

high pulses, and floods. These values correspond to the high flow guidelines presented in Tables 1-4. Timing values were visually estimated from histograms of pulse or flood occurrence by month.

6. The Walter F. George high flow guidelines were calculated slightly differently.   As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified. Thus, high pulse frequency, duration, timing, and rate of change calculations were used from the West Point analysis. To calculate magnitudes, however, the West Point analysis indicated that pulses should peak 1.6-3.5 times higher than the low flow river discharge in March [7,720-16,500 cubic feet per second (cfs)]. Assuming that pulses at Walter F. George should also peak 1.6-3.5 times higher than March low flow (derived from the Corps' unimpaired flows model output), small pulses below Walter F. George should peak between 14,161-30,978 cfs.

Figure 1. Low flow guidelines for the Chattahoochee River near Norcross, GA (USGS 02335000).

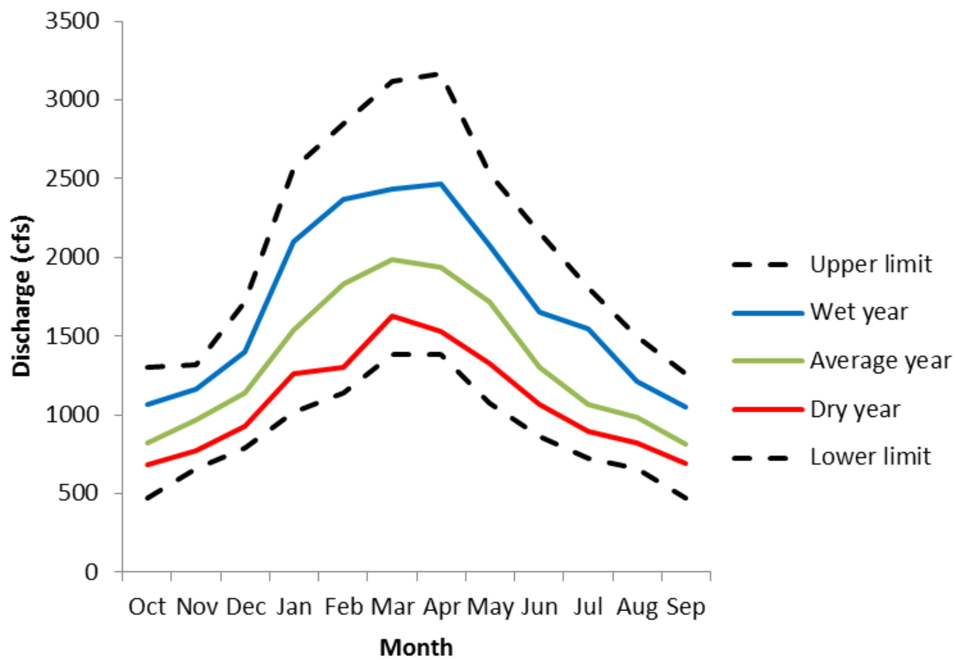


Figure 2. Low flow guidelines for the Chattahoochee River at West Point, GA (USGS 02339500).

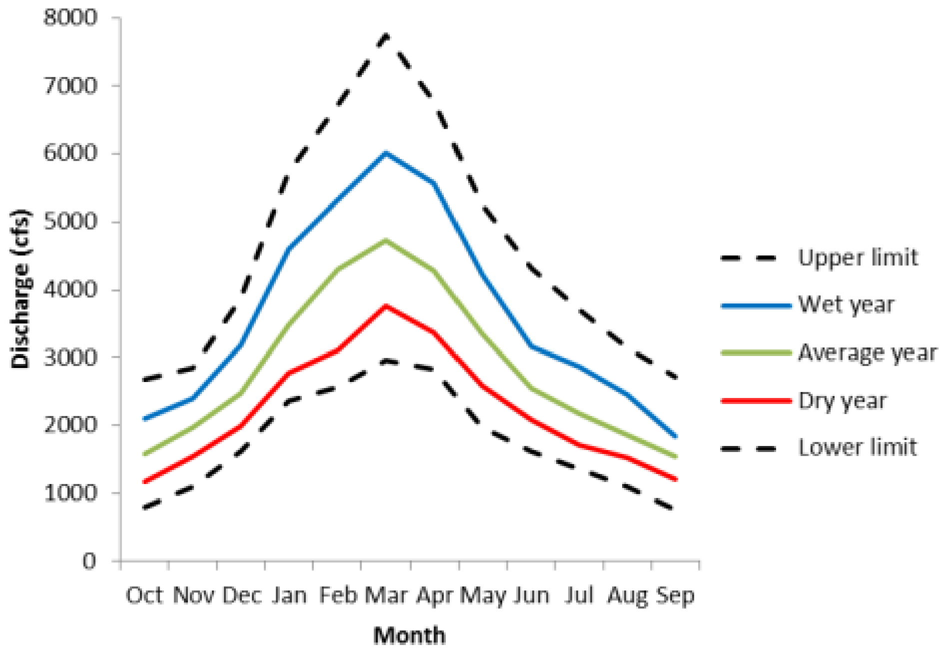


Figure 3. Low flow guidelines for the Chattahoochee River at Walter F. George using the Corps' unimpaired flows dataset.

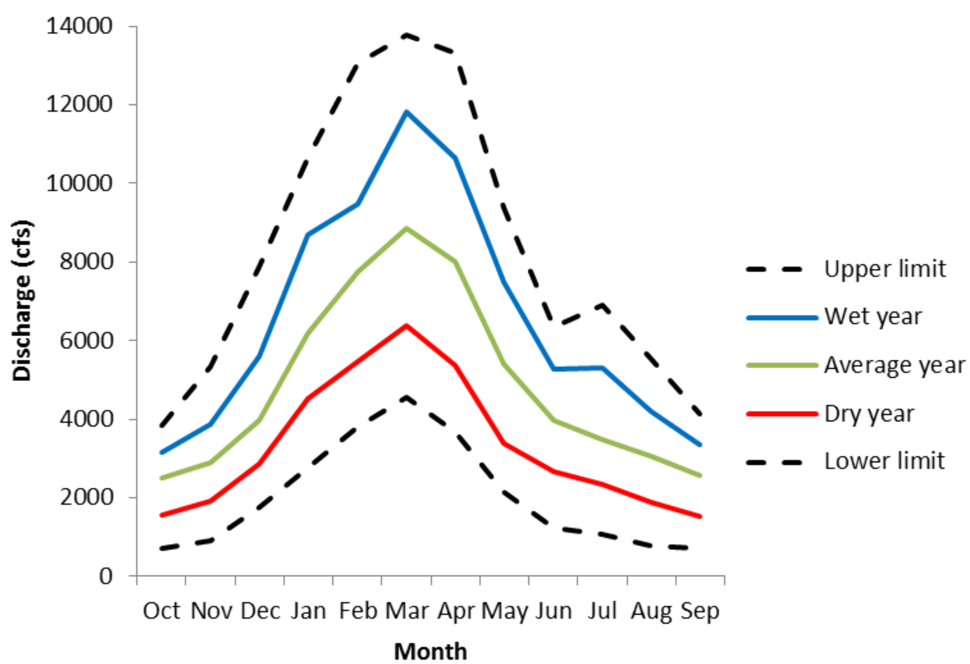


Figure 4. Low flow guidelines for the Apalachicola River at Chattahoochee, FL (USGS 02358000).

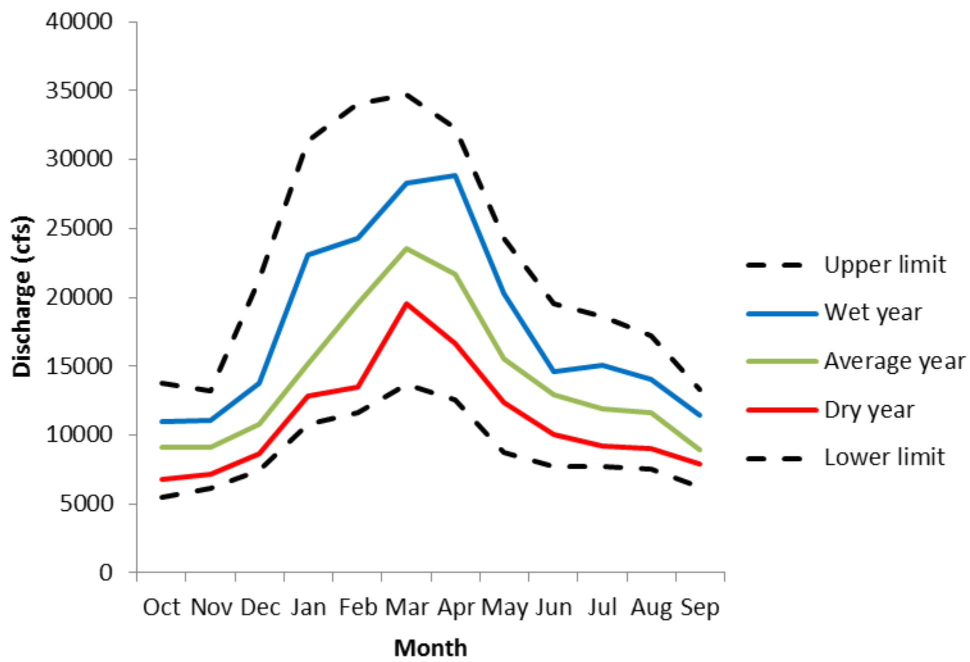


Table 1. High flow guidelines for the Chattahoochee River near Norcross, GA developed from USGS gage 02335000 for the pre-Buford Dam period from January 1, 1903 to September 30, 1946.

	Small pulse	High Pulse
Range used (cfs)	2550-17249	17250-33549
Magnitude (cfs)	3105-6787.5	19000-28900
Frequency (# events/year)	9-18	0-1
Duration (days)	1-5	11-72
Rise Rate (cfs/day)	770-2775	927-7830
Fall Rate (cfs/day)	507-1452	459-2193
Timing	Oct-Sep	Dec- Mar

Table 2. High flow guidelines for the Chattahoochee River near West Point Dam developed from USGS gage 02339500 for the pre-Buford Dam period from August 1, 1896 to December 31, 1955.

	Small pulse	High Pulse
Range used (cfs)	6250-45649	45650-71079
Magnitude (cfs)	7720-16500	51150-60825
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

Table 3. High flow guidelines for the Chattahoochee River at Walter F. George Dam developed from low flow analysis on the Corps' unimpaired flow dataset, and inferences from Chattahoochee River at West Point Dam high flow analysis. See text for additional details.

	Small pulse	High Pulse
Range used (cfs)	N/A	N/A
Magnitude (cfs)	14,161-30,978	95598-114187
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

*Upper range of high pulse values may need to be reevaluated to ensure that damage to structures is avoided. The stage discharge relationship (used to ensure that guidelines do not cause damage) was calculated using available data between 79 ft (6,510 cfs) and 110 ft (90,200 cfs; USGS gage 02343805), meaning that discharge calculations above this range of values are extrapolations and should be used cautiously.

Table 4. High flow guidelines for the Apalachicola River near Chattahoochee, FL developed from USGS gage 02358000 for the pre-Buford Dam period from July 1, 1922 to December 31, 1955.

	Small pulse	High Pulse	Flood
Range used (cfs)	25800-73799	73800-150499	≥ 150500
Magnitude (cfs)	28600-43475	85650-116500	201500-268500
Frequency (# events/year)	3-6	0-1	≥ 10 year RI
Duration (days)	3-15	32.5-68.5	49.5-89.5
Rise Rate (cfs/day)	2166-5606	2763-8056	7650-8761
Fall Rate (cfs/day)	1250-2615	1916-3811	4527-5795
Timing	Dec-Sep	Jan-Mar	Jan-Apr

Thank you for your January 18, 2011, response to the Service's PAL-requested analyses. We are currently reviewing the information that you provided, but recommend using ecosystem flow guidelines as calculated in the manner outlined above. As we continue to review the information you have produced, additional addendums or information requests may be supplied by the Service. We appreciate the opportunity to participate in the planning stages of your project and look forward to exploring opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Everson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL
B. Zettle, Corps, Mobile, AL
Pete Taylor, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
M. Thomas, GDNR-WRD, Social Circle, GA
C. Martin, GDNR-WRD, Social Circle, GA
B. Hess, GDNR-WRD, LaGrange, GA
R. Weller, GDNR-WRD, Albany, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
D. Bernhart, NOAA, St. Petersburg, FL

Literature Cited

Flynn, K.M., Kirby, W.H., and Hummel, P.R. 2006. User's manual for program PeakFQ, Annual Flood Frequency Analysis Using Bulletin 17B Guidelines: U.S. Geological Survey Techniques and Methods Book 4, Chapter B4, 42 pp.

Lim, K.J., B.A. Engel, Z. Tang, J. Choi, K. Kim, S. Muthukrishnan, and D. Tripathy. 2005. Web GIS-based Hydrograph Analysis Tool, WHAT. Journal of the American Water Resources Association 41(6): 1407-1416.

The Nature Conservancy (TNC). 2007. Indicators of Hydrologic Alteration Version 7 User's Manual. 70 pp.

United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

January 11, 2013

Col. Steven J. Roemhildt, District Engineer
United States Army Corps of Engineers, Mobile
c/o Tetra Tech, Incorporated
61 St. Joseph Street, Suite 550
Mobile, Alabama 36602-3521

Dear Col. Roemhildt:

The U.S. Fish and Wildlife Service (Service) has reviewed the United States Army Corps of Engineers' (Corps) October 12, 2012, Notice of Intent (NOI). The NOI announces the Corps' plans to revise the scope of the Draft Environmental Impact Statement (DEIS) for updating the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The new scoping is necessary to accommodate a June 2011 decision of the U.S. Court of Appeals for the Eleventh Circuit, and a June 2012 legal opinion of the Corps' Chief Counsel regarding authority to accommodate municipal and industrial water supply from the Buford Dam/Lake Lanier Project. Our comments at this time represent input from our Alabama, Florida, and Georgia Ecological Services Field Offices, as well as our Southeast Regional Office pursuant to the Service's authorities under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.) and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq*.).

The recommendations we provided in our June 2011 Draft Fish and Wildlife Coordination Act Report are still relevant and should continue to inform the scope of the DEIS. In addition to our previous input to the process, we wish to submit a concept for an alternative, described in the paragraphs below, to receive full consideration in the DEIS. This alternative would support flows in the Apalachicola and Chattahoochee rivers for the fish and wildlife purpose of the ACF projects. Apalachicola River flows are supported at levels greater than 5,000 cubic feet per second (cfs) as an environmentally-preferable substitute for the loss of flow support via the navigation purpose that occurred prior to the year 2000. Limited use of the ACF reservoirs when storage is available to support flows greater than the current minimum release of 5,000 cfs could reduce the occurrence of short-term declines in flows that either directly harm fish and wildlife or otherwise limit their populations. In addition, flow support in the Chattahoochee River would restore some natural flow regime components resulting in improvements in ecosystem elements that were lost or reduced as a consequence of flow regulation.

The focus of this alternative includes the regulated portion of the basin: Apalachicola River, Apalachicola Bay and the Chattahoochee River. The alternative we recommend supports monthly target and minimum releases from the system in a manner that is balanced with other project purposes and that avoids or minimizes some adverse effects of the current Revised Interim Operating Plan (RIOP), which uses system storage primarily to support the 5,000 cfs minimum release. We provide the following outline of such an alternative, but we believe that with more time and effort, this alternative can be improved upon to avoid or minimize adverse effects to fish and wildlife in the Apalachicola and Chattahoochee rivers. We fully expect the Corps to modify it as necessary to improve upon its potential to “avoid or minimize adverse effects” and to “restore and enhance the quality of the human environment,” consistent with 40 CFR §1500.2(e) and §1500.2(f), respectively. We would like to work with you to further improve this alternative.

Reservoir Operations Alternative for Monthly Target and Minimum Flow Support

The governing features of the alternative we recommend are as follows:

1. Operate the system for target and minimum releases from Buford and Woodruff dams, consistent with current project-specific rules for flood-control, hydropower generation by storage zone, head limits, and maximum fall rates.
2. The targets and minimum releases are month- and zone-specific (Table 1 and 2).
3. Target releases are subject to zone-specific augmentation limits (Table 3).
4. Storage zones (1-4) are redefined for Lanier, West Point, and George, relative to the authorized top and bottom of the conservation pool.
5. Each storage zone contains a consistent year-round percentage of the total conservation storage at a project, but these percentages vary among the projects (Table 4).
6. Release decisions for Buford and Woodruff dams are based on the current composite storage zone (sum of storage in Lanier, West Point, and George), month, and the previous 7-day basin inflow.
7. If basin inflow exceeds the month/zone target, release the target flow from Buford and Woodruff dams. Basin inflow exceeding the target is available for storage.
8. If basin inflow does not exceed the month/zone target minus the zone augmentation limit, the release from Buford and Woodruff dams are the greater of: a) the month/zone minimum, or b) basin inflow plus the zone augmentation limit.
9. Each project makes daily releases to support its local operating requirements or to replenish storage in the project downstream, whichever is greater, so that all projects remain in the same operating zone.
10. Maximum fall rates and flow support for Woodruff Dam releases greater than 5,000 cfs are suspended when storage declines to Zone 4, and resumed when storage returns to a specified zone (“drought relief end zone”).
11. When flows at Woodruff Dam have been less than 7,000 cfs for more than 30 days, maximum fall rates are suspended and resumed when flows have been greater than 10,000 cfs for 30 days.

We have tested this alternative with a hydrologic model of the basin that is comparable to the Corps' ACF ResSim model (the daily time step ACF Stella model developed during the ACF Comprehensive Study) using the Corps' 1939-2008 unimpaired flows and existing consumptive water demands. We believe our preliminary results demonstrate for this type of alternative both: a) its feasibility, because simulated reservoir elevations are comparable to historic patterns; and b) its potential for reducing environmental impacts, because simulated flows represent modest to significant improvements relative to the RIOP for several biologically relevant, flow-based, performance measures in the Chattahoochee and Apalachicola rivers. Although we programmed the model to suspend support of Woodruff Dam releases greater than 5,000 cfs when storage enters Zone 4 and resume such support upon refill to a user-specified zone (feature 10 listed above), reservoir levels in simulations of the settings in Tables 1-4 resuming support in Zone 1 versus Zone 3 were not appreciably different. Therefore, it appears unnecessary under this alternative to delay the resumption of normal operations until a complete refill of reservoir storage, probably due to its zone-graduated flows and augmentation limits. However, we recommend testing the utility of this feature in any evaluation of alternative flows, augmentation limits, and zone definitions.

On November 29-30, 2012, the Service hosted a Technical Workshop for Alternatives to Reservoir Operations in the ACF. Over 50 people attended including stakeholders representing all three States, multiple interest groups, and two members of your staff. We presented an earlier version of this alternative and preliminary model results. We have since further refined our alternative by adding specific flow targets for Buford Dam to improve flows in the Chattahoochee River. We are willing and able to share the model with the Corps and others, and would welcome further discussions with your staff about modeling this concept in ResSim as an alternative for the DEIS. We view the values given in Tables 1-4 as flexible parameters, and we encourage the Corps to test different sets of values as necessary to achieve the best balance of results for project purposes that are dependent on river flows and reservoir levels. Our primary interest is in improving flows and levels for fish and wildlife resources, for which this alternative appears promising, but we acknowledge the need to examine significant effects on all environmental resources affected by the operations of the ACF reservoirs, including the National Park Service's Chattahoochee River National Recreation Area. We would like to work with you on potential improvements to this alternative, and we can quickly evaluate changes in model parameters in the ACF Stella model in conjunction with your work in ResSim. In addition, the States of Florida and Georgia also presented alternatives at the workshop in Eufaula, and some of their concepts could be incorporated to improve this alternative.

We have not yet examined how this alternative performs under scenarios of potential climate change, increasing consumptive demands, or its response to HEC-5Q water quality analyses, but we recognize the importance and necessity of doing so. Significant changes to the long-term patterns of basin inflow to the Corps' projects will affect flow regimes and reservoir levels. The minimum releases built into the alternative concept we propose, and to a lesser extent the targets and augmentation limits, would insulate to some degree flow-dependent resources from the adverse effects of continuing increases in consumptive demands and from some changes in precipitation/runoff patterns in the basin. However, this insulation is limited by the storage and refill capacity of the reservoirs, and we recommend that the Corps evaluate how its proposed action and all reasonable alternatives would distribute the impacts of potential declines in basin inflow between reservoir- and river-dependent resources.

During our workshop, the alternative presented by State of Georgia and the Atlanta Regional Commission included flow targets for mussels that were based on bathymetric modeling in ArcGIS. Essentially, the Georgia Environmental Protection Division (GEPD) used the Corps' bathymetric data from 2009-2010 to delineate all the areas in the channel with a slope of 0.1 to 0.4, assuming that this is the preferred channel slope for the fat threeridge. They then linked the flow to stage and delineated the habitat that was less than 3-ft of inundation, assuming that fat threeridge prefer these shallow areas. These areas of slope and depth were then combined and modeled under various flow values to determine how much habitat (acres) was available at various flows from 10,000 cfs to 2,000 cfs. They concluded that more mussel habitat was available when flows were lower, so they recommended flows of 5,000 cfs with some pulses depending on basin inflows. There are several issues with this approach:

1) This method identifies a large amount of low slope-habitat in the actively migrating center of the channel. These habitats are comprised of coarse, shifting, sandy substrate. Mussel sampling last summer confirms that listed mussels do not occupy these habitats.
2) Our 2012 biological opinion on the RIOP discusses how the moderately depositional fat threeridge habitat is generally characterized by slopes of 10-40%, and that mussels in this habitat are generally found at a depth of about1-m regardless of flow. However, we also reported that fat threeridge are present in deeper, stable habitats in addition to the moderately depositional habitat. Additional sampling this summer indicates that fat threeridge can be abundant in these deep-water habitats associated with large woody material, along outside bends of the river, and in areas upstream of point bars. Slope may not play an important role in distribution, and it is likely that fat threeridge occur in areas with stable substrate that provide refuge from high flows, regardless of slope and depth.

We are currently undertaking a large-scale mussel distribution study using side-scan sonar and bathymetric data coupled with mussel sampling to determine mussel distribution in the river. We are willing to cooperate with GEPD to use our information to refine their approach in the future, but we do not support the performance measure for mussel habitat that GEPD described at the workshop.

We appreciate the opportunity to comment and look forward to continued participation as the WCM update moves forward. If you have any questions about these comments, please contact me at 706-613-9493 ext. 230, or Don Imm at 850-769-0552 ext. 247. I have assigned staff biologists Alice Lawrence (706-613-9493 ext. 222) and Will Duncan (ext. 227) to this project, and Dr. Imm has assigned staff biologist Karen Herrington (850-769-0552 ext. 250).

Sincerely,

Sandra S. Tucker
Field Supervisor

cc: Jerry Ziewitz, FWS, Tallahassee, FL
Don Imm, FWS, Panama City, FL
Karen Herrington, St. Charles, MO
Bill Pearson, FWS, Daphne, AL
Dan Everson, FWS, Daphne, AL
Jennifer Pritchett, FWS, Daphne, AL
Stephanie Nash, FWS, Washington, D.C.
Joyce Stanley, OEPC, Atlanta, GA
Loretta Sutton, OEPC, Washington, D.C.

Table 1. Target and minimum releases (cfs) from Woodruff Dam.

	Zone1		Zone2		Zone3		Zone4
Month	Target*	Minimum	Target**	Minimum	Target***	Minimum	Minimum
JAN	21,000	10,000	15,000	10,000	10,000	5,000	5,000
FEB	28,000	10,000	20,000	10,000	10,000	5,000	5,000
MAR	33,000	16,000	22,000	16,000	16,000	5,000	5,000
APR	26,000	16,000	18,000	16,000	16,000	5,000	5,000
MAY	18,000	16,000	13,000	10,000	10,000	5,000	5,000
JUN	15,000	12,000	11,000	8,000	8,000	5,000	5,000
JUL	14,000	10,000	10,000	7,000	7,000	5,000	5,000
AUG	13,000	10,000	10,000	7,000	7,000	5,000	5,000
SEP	11,000	10,000	9,000	6,000	6,000	5,000	5,000
OCT	11,000	10,000	8,000	5,000	5,000	5,000	5,000
NOV	11,000	10,000	9,000	6,000	6,000	5,000	5,000
DEC	15,000	10,000	11,000	8,000	8,000	5,000	5,000

* Median observed flows, 1939-2008 (rounded to nearest 1,000).
** Observed flows exceeded 75% of the time, 1939-2008 (rounded to nearest 1,000).
*** The minimum releases of Zone2 are the target releases of Zone3.

Table 2. Target flows (cfs) for the Chattahoochee River at Peachtree Creek

Month	Zone 1*	Zones 2 and 3*	Zone 4
JAN	1,908	1,561	750
FEB	2,267	1,611	750
MAR	2,466	2,020	750
APR	2,404	1,896	750
MAY	2,131	1,648	750
JUN	1,611	1,326	750
JUL	1,326	1,109	750
AUG	1,220	1,022	750
SEP	1,009	857	750
OCT	1,016	843	750
NOV	1,202	954	750
DEC	1,412	1,152	750

*Discharge values derived from the low flow guidelines estimated for median and dry hydrological conditions at the Peachtree Creek node.

Table 3. Target augmentation limits (cfs) by zone.

Zone1	3,000
Zone2	2,000
Zone3	1,000
Zone4	n/a

Table 4. Allocation (percent) of conservation storage by zone.

	Lanier	West Point	WF George	Composite
Zone1	10%	20%	25%	13%
Zone2	20%	20%	25%	21%
Zone3	20%	20%	25%	21%
Zone4	50%	40%	25%	46%

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Field Office
1601 Balboa Avenue
Panama City, FL 32405-3721

Tel: (850) 769-0552
Fax: (850) 763-2177

July 19, 2013

Mr. Curtis Flakes
Chief, Planning and Environmental Division
U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

RE: Revised alternative for consideration in the Apalachicola-Chattahoochee-Flint (ACF) River Basin Water Control Manual (WCM)

Dear Mr. Flakes :

The U.S. Fish and Wildlife Service (Service) is pleased to provide you with the first deliverable in our current scope of work for a Fish and Wildlife Coordination Act (FWCA) Report on the Corps' update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The reservoir operations alternative that we describe in this letter is a refinement of the alternative that we outlined in our response dated January 11, 2013, to the Corps' October 12, 2012, Notice of Intent to reopen public scoping for the WCM update. Results suggest that our revised alternative would address the Corps' purpose and need for action in a manner consistent with the ACF projects' authorized purposes while protecting and enhancing habitat conditions for a broad suite of fish and wildlife resources.

The Service recommend that the Corps give this alternative full consideration in preparation of the Draft Environmental Impact Statement (DEIS) for the WCM to satisfy both the "equal consideration" provision of the FWCA and regulations to evaluate all reasonable alternatives under the National Environmental Policy Act (40 CFR 1502.14). We summarize in this letter the components of the alternative that your staff will require for hydrologic simulations of the proposed action and alternatives in the DEIS. We also provide summaries of how our alternative performs on several measures of habitat conditions relative to current operations (Enclosure 1). However, in advance of including the alternative in the DEIS, we strongly recommend that the Corps work with us to represent and evaluate the alternative in HEC-ResSim. Our hydrologic model is programmed in the STELLA dynamic modeling and simulation software. It is a nimble tool that enables rapid testing of multiple operating scenarios, but coordinating with you to model our alternative in ResSim will help ensure that: 1) the fish and wildlife benefits we see in our STELLA model results are replicated in ResSim; and 2) our STELLA model is properly representing the Corps' operations, especially how you balance system-wide storage. Our next scheduled FWCA deliverable is a Planning Aid Letter that will fully explain the development and application of performance measures that we used to evaluate a range of choices for operating the reservoirs, which we recommend to the Corps for evaluating all alternatives you may consider for the WCM update.

During April and May this year, we discussed with your staff the Corps' criteria for alternatives to evaluate in the DEIS. Our January, 2013, alternative already satisfied most of these criteria (e.g., no change to flood storage, releases from Lanier to support Atlanta water supply needs, etc.). Our discussions identified two primary modifications necessary for the Service's alternative to warrant full consideration in the Corps' analysis:

1) accommodate a navigation season; and
2) retain the storage action zones to ensure a balanced system operation.

Our revised alternative for enhancing the fish and wildlife benefits of project operations addresses both of these criteria. It specifies target and minimum flows that would provide a 9 to 7-feet deep navigation channel during January to May of most years. It relies on the Corps' "Option A" definition of the storage action zones in Lanier, West Point, and George. As before, our recommended alternative manages system releases according to a set of storage-zone-specific monthly minimum and target releases, where the use of storage to achieve the targets is subject to flow augmentation limits.

Upon request, we provided the Georgia Environmental Protection Division (GAEPD) a copy of our hydrologic STELLA-based model of the alternative that we proposed in our January scoping comments. GAEPD's review of this model discovered an error in the evaporative loss calculations and in the unimpaired flows data that we were using, which we subsequently corrected. GAEPD's letter to the Corps dated June 28, 2013, addressed these same errors, but did not acknowledge our corrections. The Service appreciates the GAEPD review, which has increased our confidence in the STELLA model as a means of representing alternative reservoir operations in the ACF system. In response to the GAEPD letter, we requested that your staff provide the latest set of demand data used by the Corps, but we have not received those data to date.

One issue we encountered while modeling various alternatives was head-limit restrictions at Woodruff Dam. Because release decisions are based on 7-day basin inflow and the adjustment of Lake Seminole's rule curve to account for head limit restrictions, variations in daily inflow in combination with head-limit restrictions would sometimes lead to insufficient storage in Lake Seminole to achieve the intended release. We saw two options for dealing with this issue: 1) allow the system to draw upon storage in Lake Seminole below 76.0 feet elevation, or 2) make supplemental releases from W.F. George to avoid a Seminole drawdown. Since the Corps seldom draws Seminole below 76.0 feet in actual practice, we chose option 2. In our STELLA model, supplemental releases from W.F. George are triggered when the elevation at Lake Seminole drops below 76.5 feet and are increased when the elevation drops below 76.25 feet. We requested information from James Hathorn of your staff to determine how the Corps represents Woodruff Dam head limits and any associated supplemental releases from W. F. George in ResSim in order to configure the STELLA model similarly. Because we are currently working with James to ensure consistency between ResSim and STELLA, we would like the opportunity to modify our approach to represent system operations and river flows in a manner acceptable to the Corps, which may result in minor modifications to our recommended alternative. Our present configuration of the STELLA model to represent our recommended alternative achieves 99.5% compliance with the daily minimum releases, and 96.2% compliance with the daily target releases as conditioned by the augmentation limits in the full 70-year simulation. The small fraction of days we do not achieve complete compliance is due to the head-limits and storage balancing issues described above.

We used the following approach for developing our alternative using the STELLA model.

1) We adopted existing, or developed new, performance measures for fish and wildlife resources dependent on ACF river flows or reservoir levels, including:
   - Apalachicola River floodplain fish spawning and rearing
   - Gulf sturgeon spawning
   - Apalachicola River mussels (several hydrologic metrics related to mussel survival)
   - Reservoir fisheries (Lanier, West Point, and W.F. George)
   - Chattahoochee River shoal bass recruitment
   - Apalachicola Bay salinity
2) We used the performance measures to compare period-of-record simulated flows and levels under current operations (the Revised Interim Operations Plan [RIOP]), the alternative recommended in our January, 2013, scoping comments (FWS1), and one or more test alternatives.
3) We tested the sensitivity of the model to changes in target flows, minimum flows, augmentation limits, and action zones independently to determine the effect of these operating parameters on simulated flows and levels and the performance measures.

4) Based on what we learned about single-parameter changes on model performance, we then explored the effects of multiple-parameter changes on model output, steering the tests to improve overall performance on the suite of performance measures.
5) We eliminated alternatives from further consideration that resulted in excessive impacts to flows and levels (e.g., alternatives that simulated a complete depletion of composite conservation storage).

We tested over 80 combinations of storage-zone-specific monthly minimum releases, target releases, and augmentation limits. The best-performing alternative relative to the fish and wildlife performance measures listed above, which we label FWS2 is described below. FWS2 represents a significant improvement on these measures compared to the RIOP and to the alternative concept that we provided in our January, 2013, scoping comments (labeled as "Scoping" in the charts of the Enclosure).

FWS2 Alternative Description

The governing features of the alternative we recommend are as follows:

1. Operate the system for minimum releases from Buford Dam, and target and minimum releases from Woodruff Dam, consistent with current project-specific rules for flood-control, hydropower generation by storage zone, head limits, and maximum fall rates.
2. The targets and minimum releases are month- and zone-specific (Tables 1, 2, and 3).
3. Target releases are subject to monthly composite zone-specific augmentation limits (Table 4).
4. Storage action zones (1-4) are as defined under the Corps' "Option A" zones, which the Corps provided to us.
5. If 7-day basin inflow exceeds the month/zone target, release the target flow from Woodruff Dams. All basin inflow exceeding the target is available for storage, subject to flood control rules.
6. If basin inflow does not exceed the month/zone target minus the zone augmentation limit, the release from Woodruff Dam is the greater of: a) the month/zone minimum, or b) basin inflow plus the zone augmentation limit.
7. Each project makes daily releases to support its local operating requirements or to replenish storage in the project downstream, whichever is greater, so that all projects remain in the same operating zone. The system is operated in such a manner that releases for the Apalachicola River are supplied from Lake Seminole, Lake Seminole is then supported by releases from W.F. George, releases are then made from West Point to balance West Point with George and finally releases are made from Lanier to balance Lanier and West Point.

8. Maximum fall rates and flow support for Woodruff Dam releases greater than 5,000 cfs are suspended when storage declines to Zone 4, and resumed when storage returns to Zone 3.
9. When releases from Woodruff Dam are less than 7,000 cfs for more than 30 days, maximum fall rates are suspended and resumed when releases exceed 10,000 cfs for 30 days.

We have not yet examined how this alternative performs under scenarios of potential climate change or increasing consumptive demands, or analyzed its effects on water quality, but we recognize the importance and necessity of doing so. Significant changes to the long-term patterns of basin inflow to the Corps' projects will affect flow regimes and reservoir levels.

Although we now submit this alternative for the Corps' full consideration in the DEIS for the WCM update, we are prepared to work with you to answer any questions that you may have and to revise it as necessary to ensure that it remains a viable option for the Corps. As you can see in the Enclosure, the improvements to fish and wildlife performance measures are in many instances substantial.

We appreciate the opportunity to coordinate with the Corps as the WCM update moves forward. If you have any questions about this alternative, please contact me at ext. 247, or Sandy Tucker at 706-613-9493 ext. 230.

Sincerely,

Donald W. [signature]

Dr. Donald W. Imm
Project Leader

Enclosure:
Performance Measures Comparing RIOP simulations in STELLA to the FWS Scoping alternative (Scoping) and the current FWS recommended alternative (FWS 2)

cc: Jerry Ziewitz, FWS, Tallahassee, FL
Sandra Tucker, FWS, Athens, GA
Karen Herrington, St. Charles, MO
Bill Pearson, FWS, Daphne, AL
Dan Everson, FWS, Daphne, AL
Jennifer Pritchett, FWS, Daphne, AL

Table 1. FWS2 Target flows (cfs) for the Apalachicola River at Woodruff Dam.

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

Table 2. FWS2 Minimum flows (cfs) for the Apalachicola River at Woodruff Dam.

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

Table 3. FWS2 Minimum flows (cfs) for the Chattahoochee River at the Peachtree Creek USGS gage.

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	1,910	750	650	650
Feb	2,270	1,170	650	650
Mar	2,470	1,390	750	650
Apr	2,400	1,470	750	650
May	2,130	750	750	650
Jun	1,610	750	750	650
Jul	1,330	750	750	650
Aug	1,220	750	750	650
Sep	1,010	750	650	650
Oct	1,020	750	650	650
Nov	1,200	750	650	650
Dec	1,410	750	650	650

Table 4. Augmentation Limits (cfs) for FWS2.

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

Enclosure: Performance Measures Comparing RIOP simulations in STELLA to the FWS Scoping alternative (Scoping) and the current FWS recommended alternative (FWS 2)

Figure 1. Inter-annual frequency (percent of years) of discharge events less than 5,000 to 10,000 cfs under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

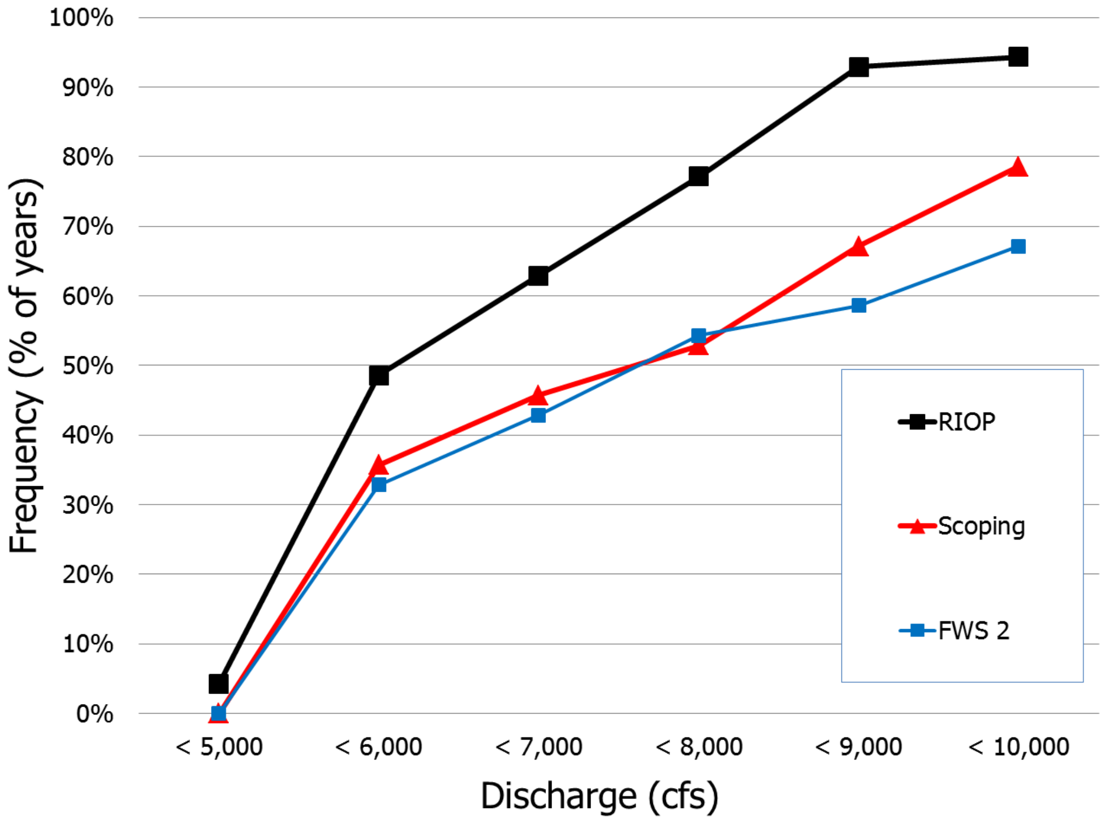


Figure 2. Median number of days per year of discharge less than 5,000 to 10,000 cfs under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

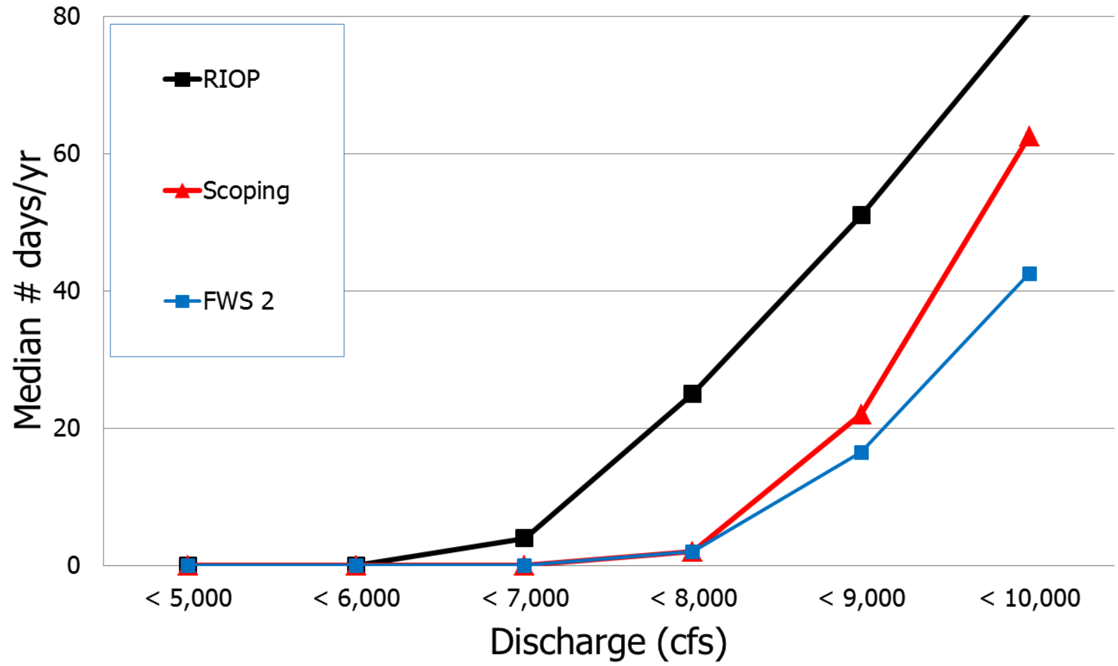


Figure 3. Median number of consecutive days per year of discharge less than 5,000 to 10,000 cfs under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

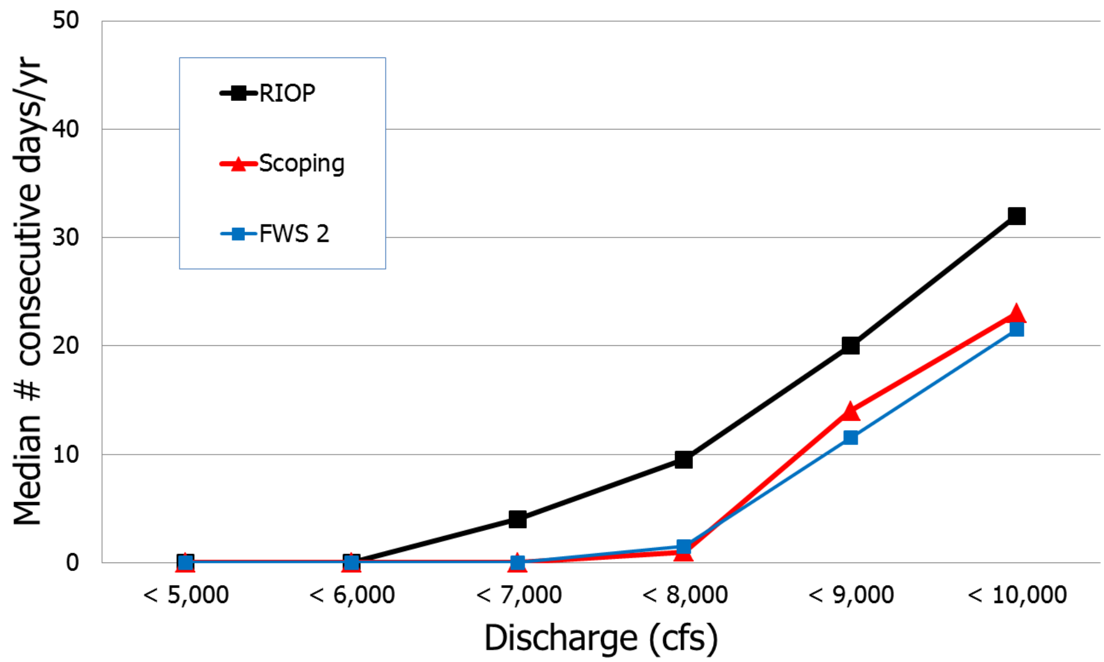


Figure 4. Annual maximum of growing-season (April-October) floodplain connectivity (acres) to the main channel for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2). Note: Performance of this measure is likely actually better than appears here as a result of the modeling issue with head limits described in the attached letter.

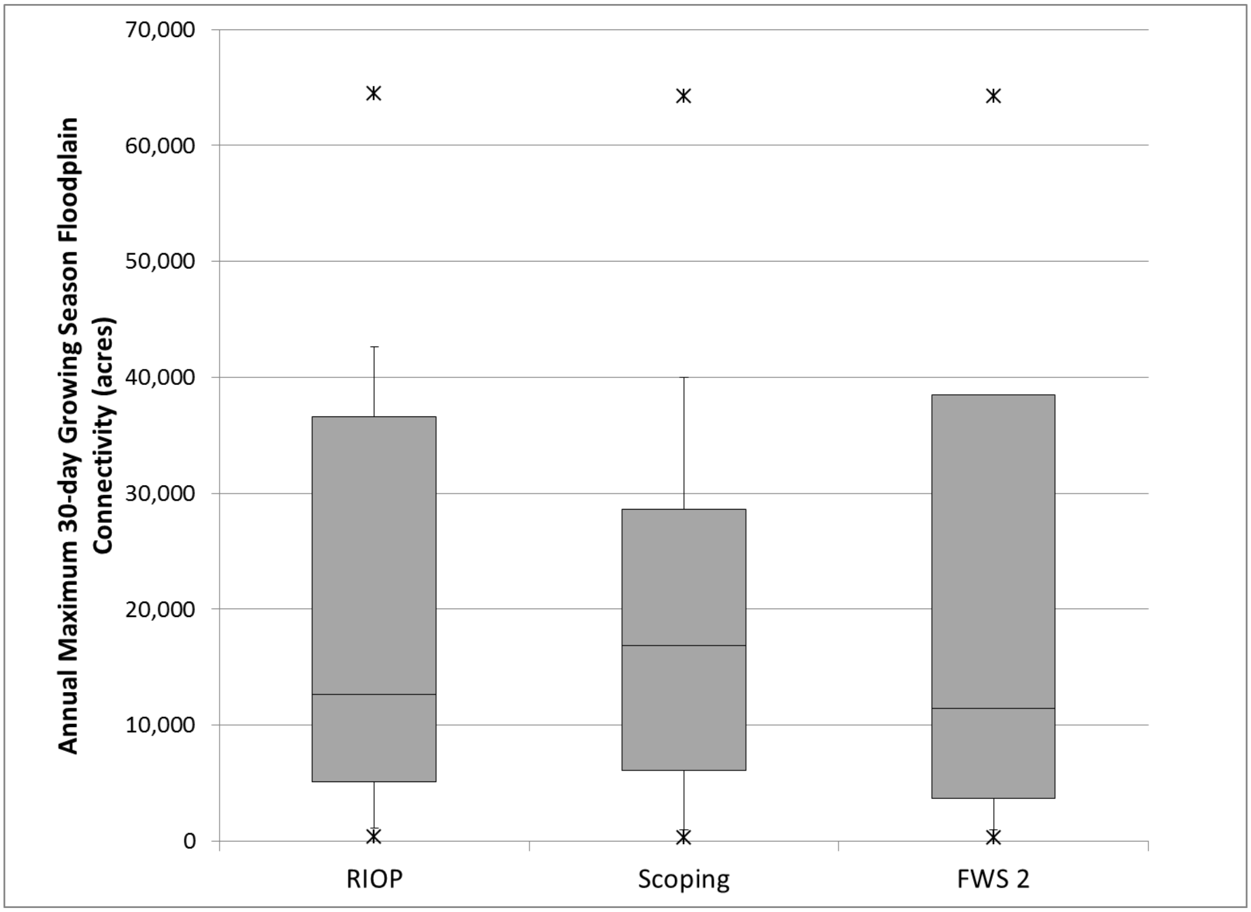


Figure 5. Annual Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1 through May 31, at the two known spawning sites, under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

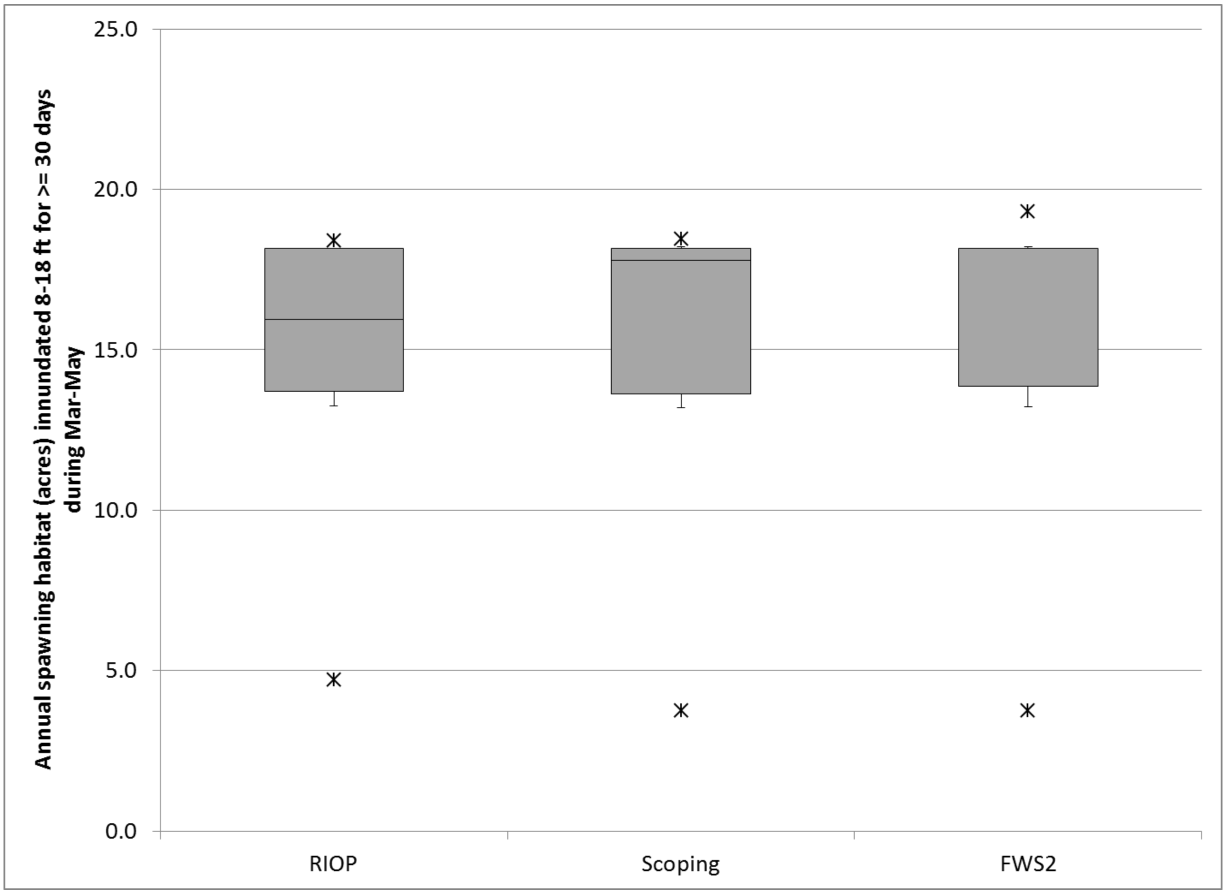


Figure 6. The amount of productive zone (acres) inundated during the reservoir fishery spawning season in Lake Lanier for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

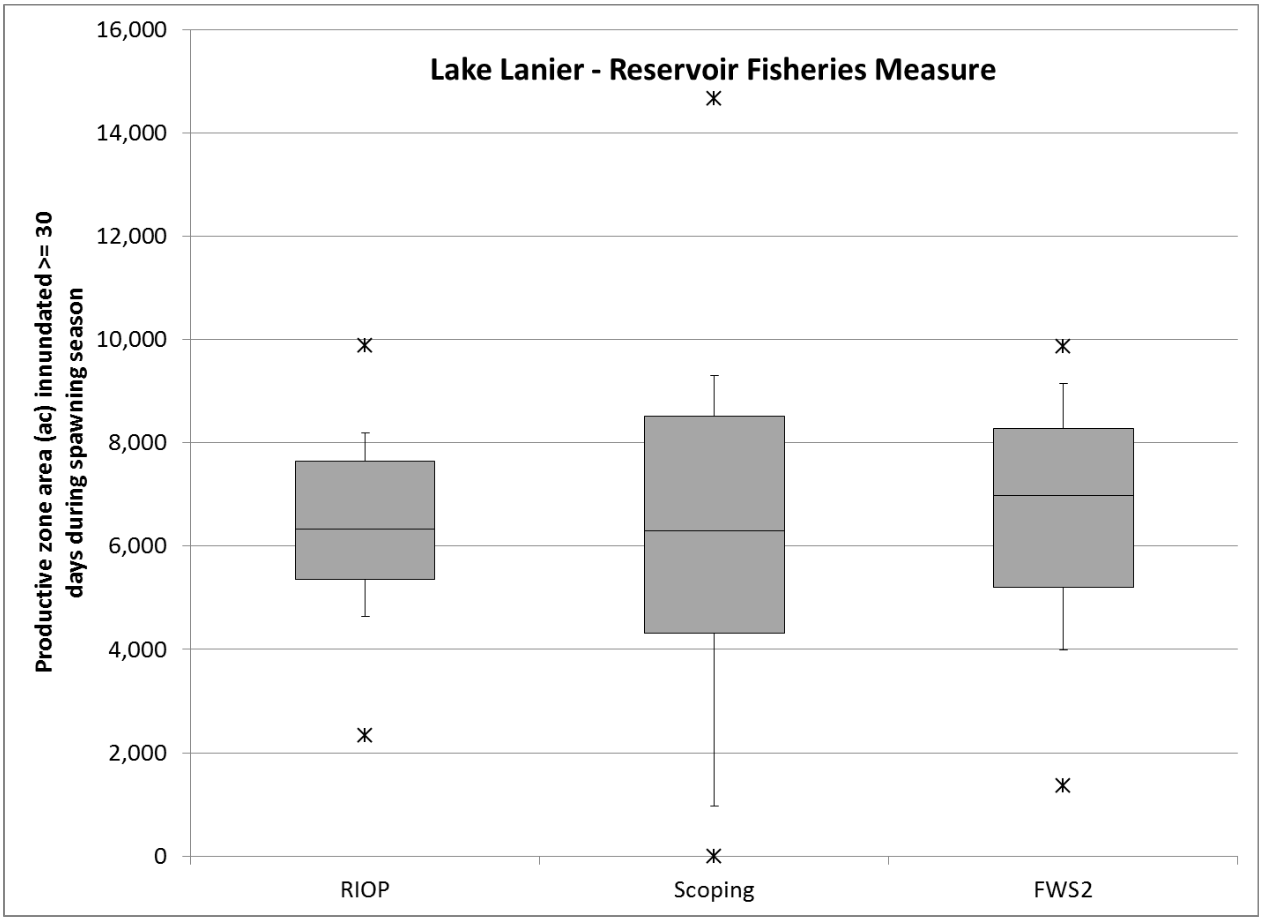


Figure 7. The amount of productive zone (acres) inundated during the reservoir fishery spawning season in West Point Lake for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

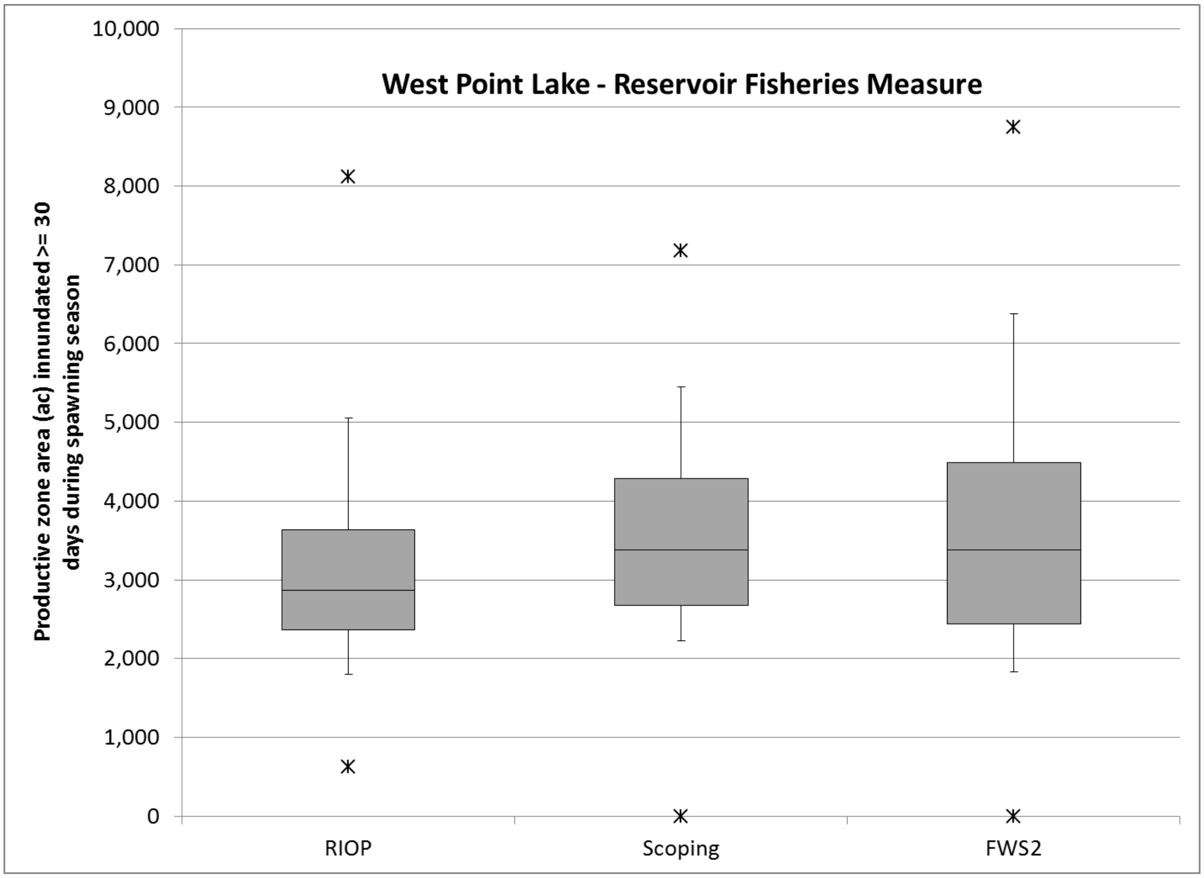


Figure 8. The amount of productive zone (acres) inundated during the reservoir fishery spawning season in W.F. George Reservoir for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

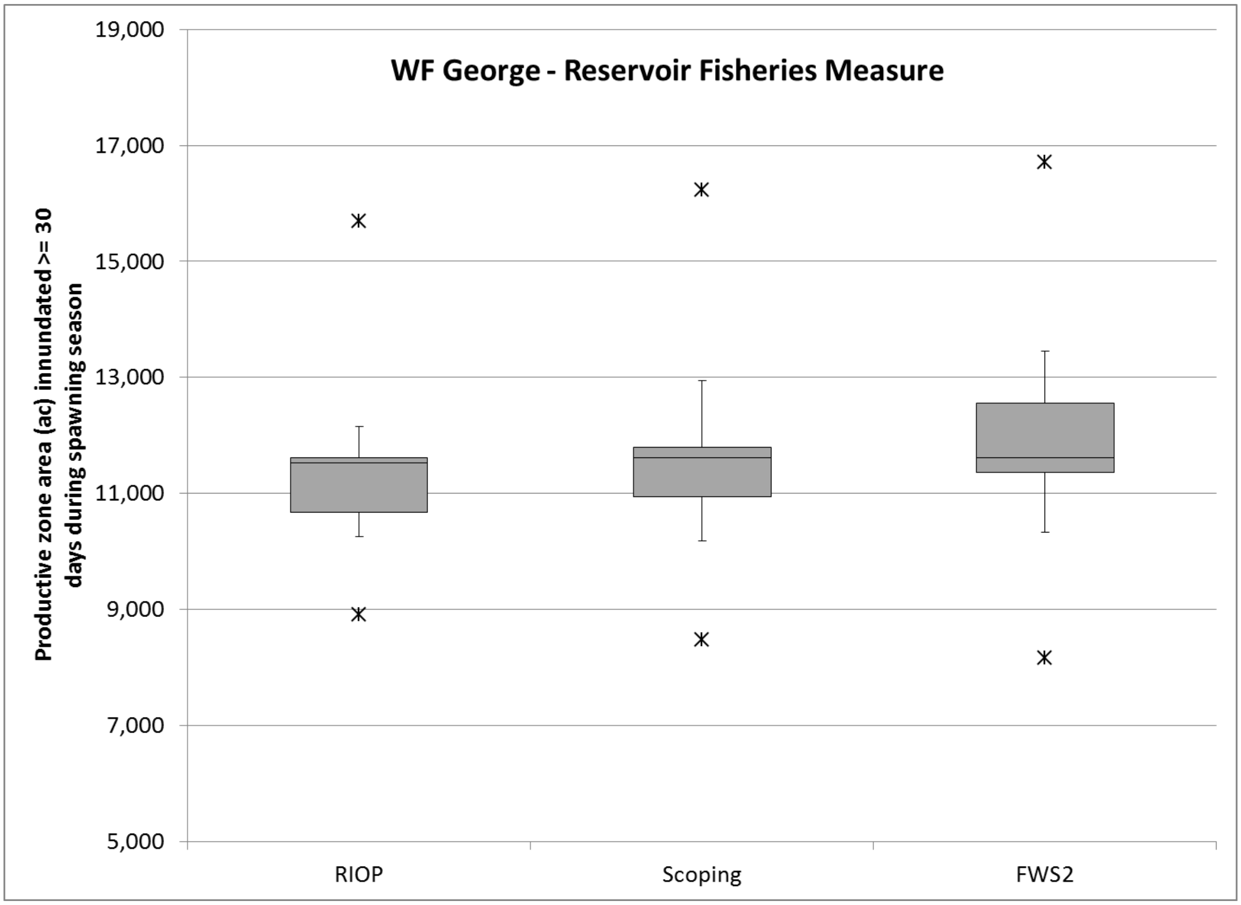
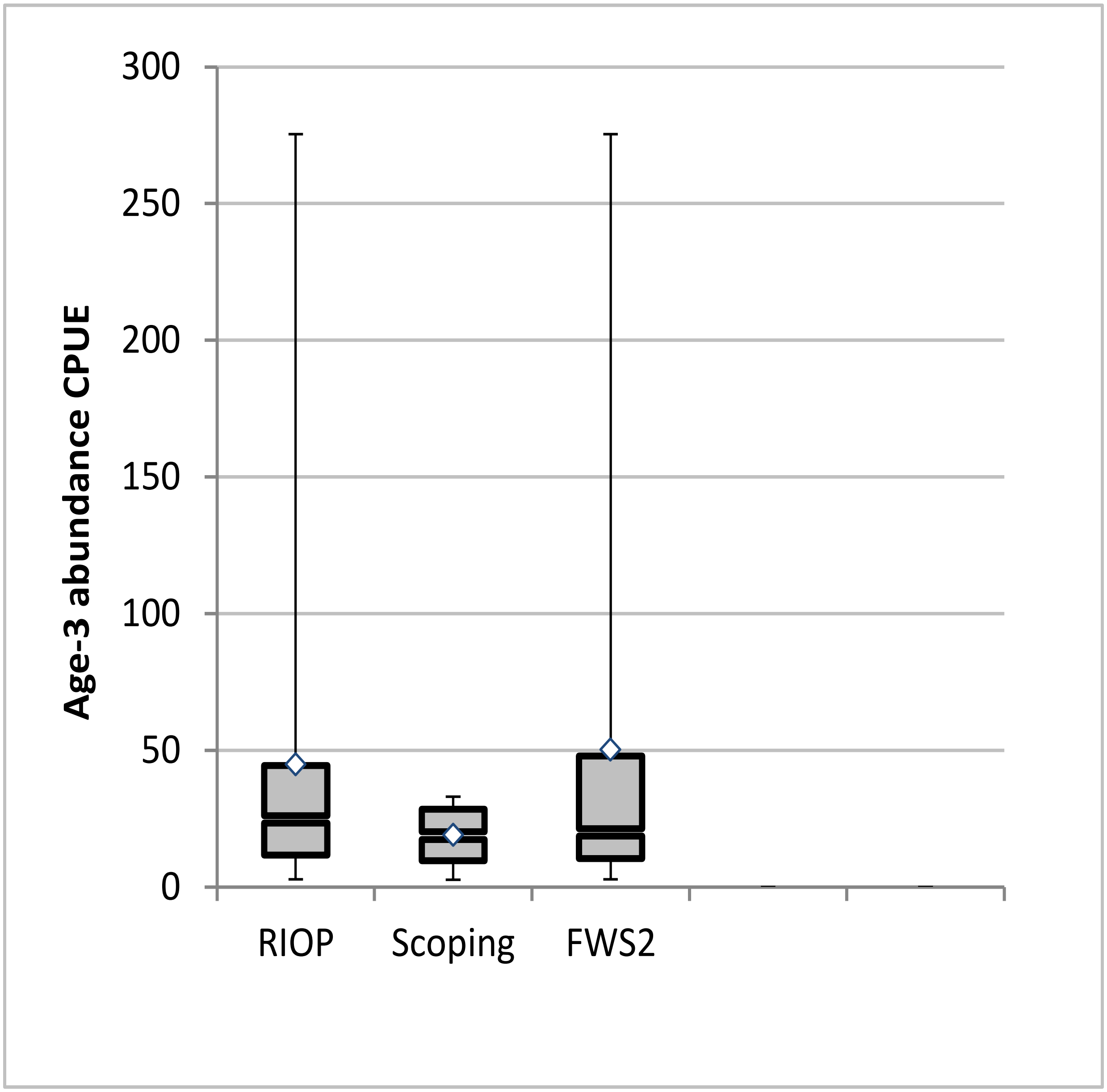


Figure 9. Catch per unit effort (CPUE) of age-3 shoal bass, an indicator of recruitment, under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2). Annual CPUE estimates are for the Chattahoochee River at the Atlanta gage for 30 mm shoal bass as predicted from empirical results from Porta 2011[1].



[1] Porta, M.J. 2011. Effects of environmental variation on stocking success of an endemic black bass species in the Chattahoochee River, Georgia. Masters thesis, Oklahoma State University, Stillwater.

Figure 10. Median daily reservoir elevations for Lake Lanier for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

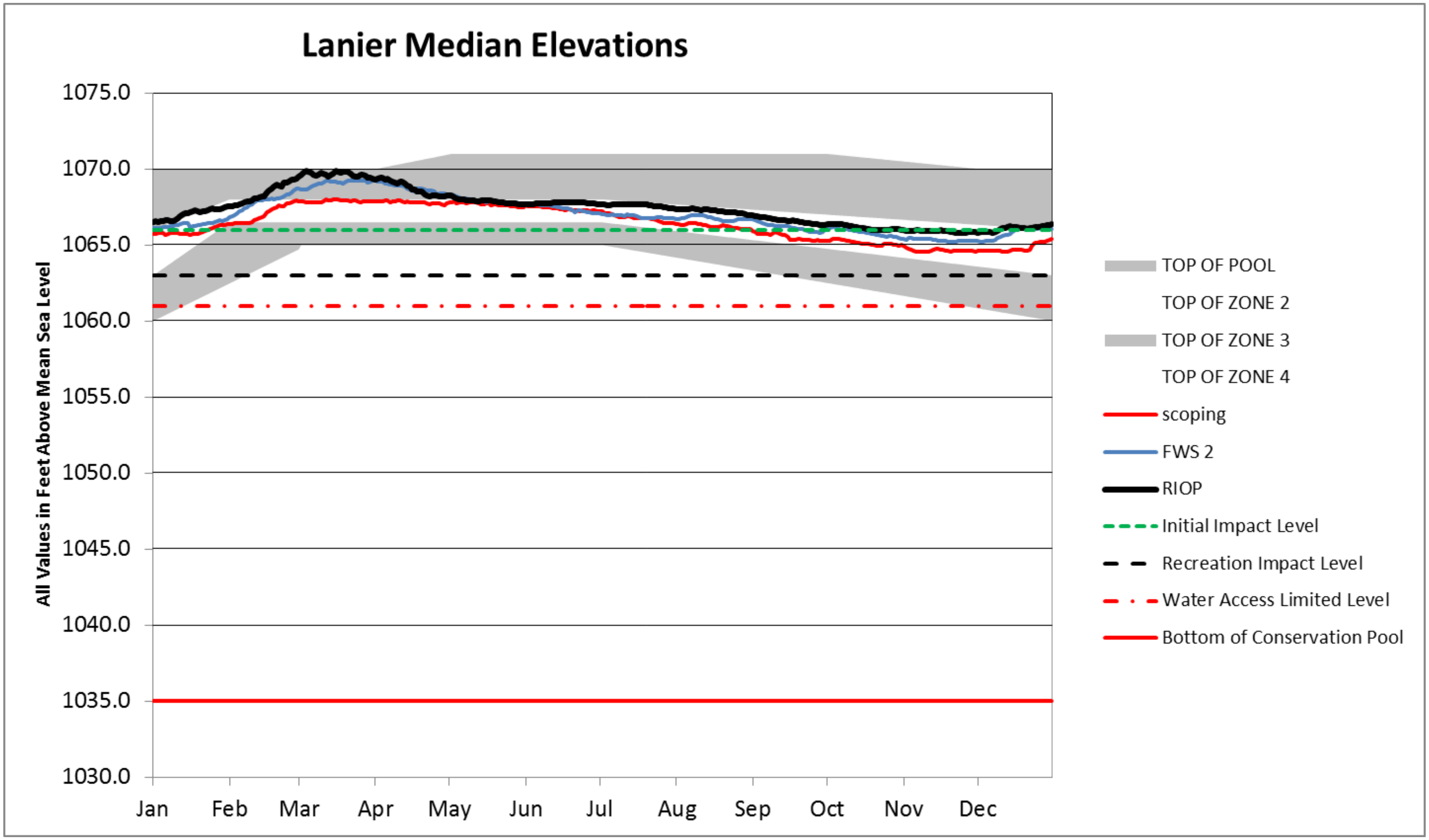


Figure 11. Lake Lanier reservoir elevations that are exceeded 75 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

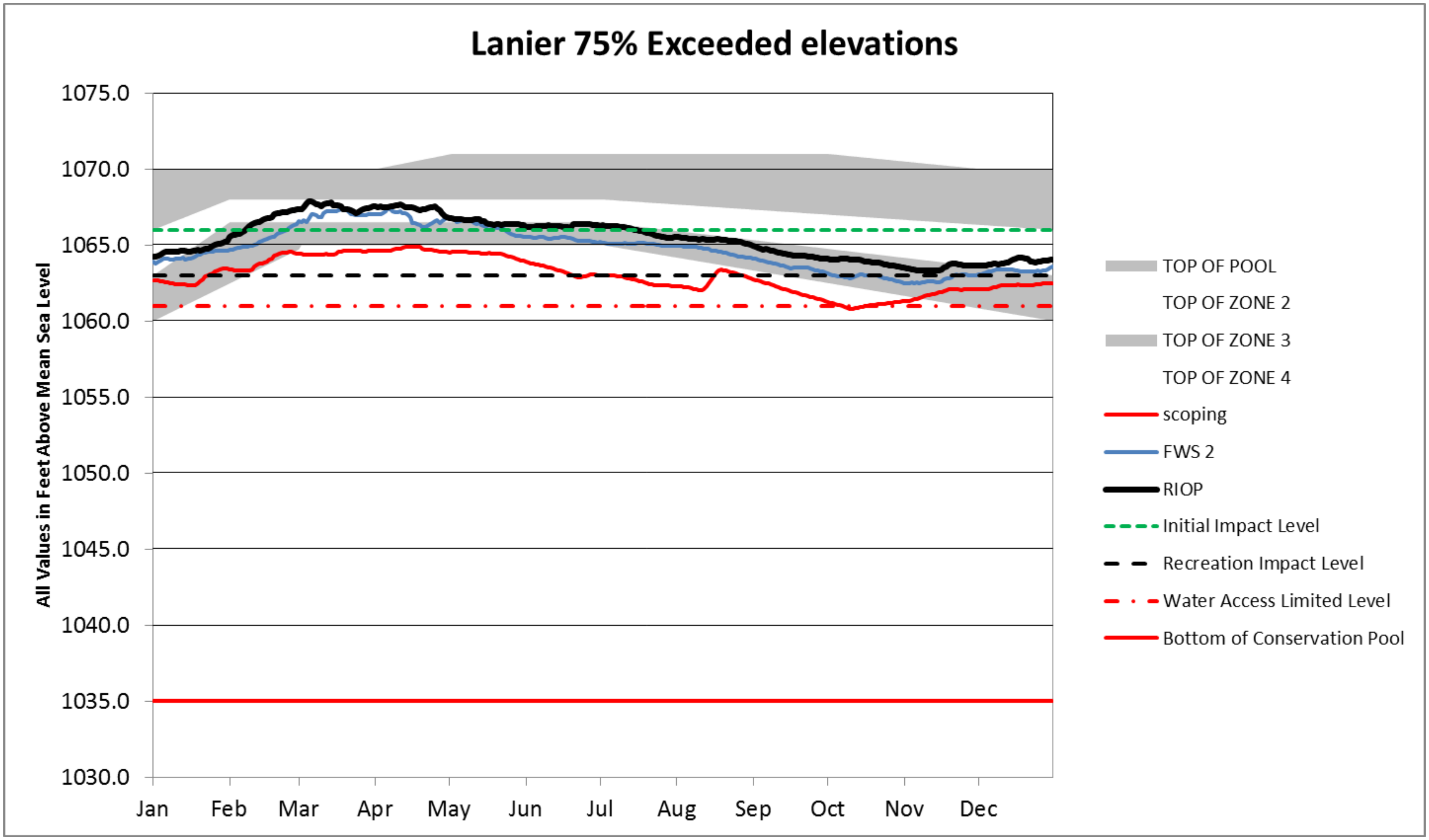


Figure 12. Lake Lanier reservoir elevations that are exceeded 90 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

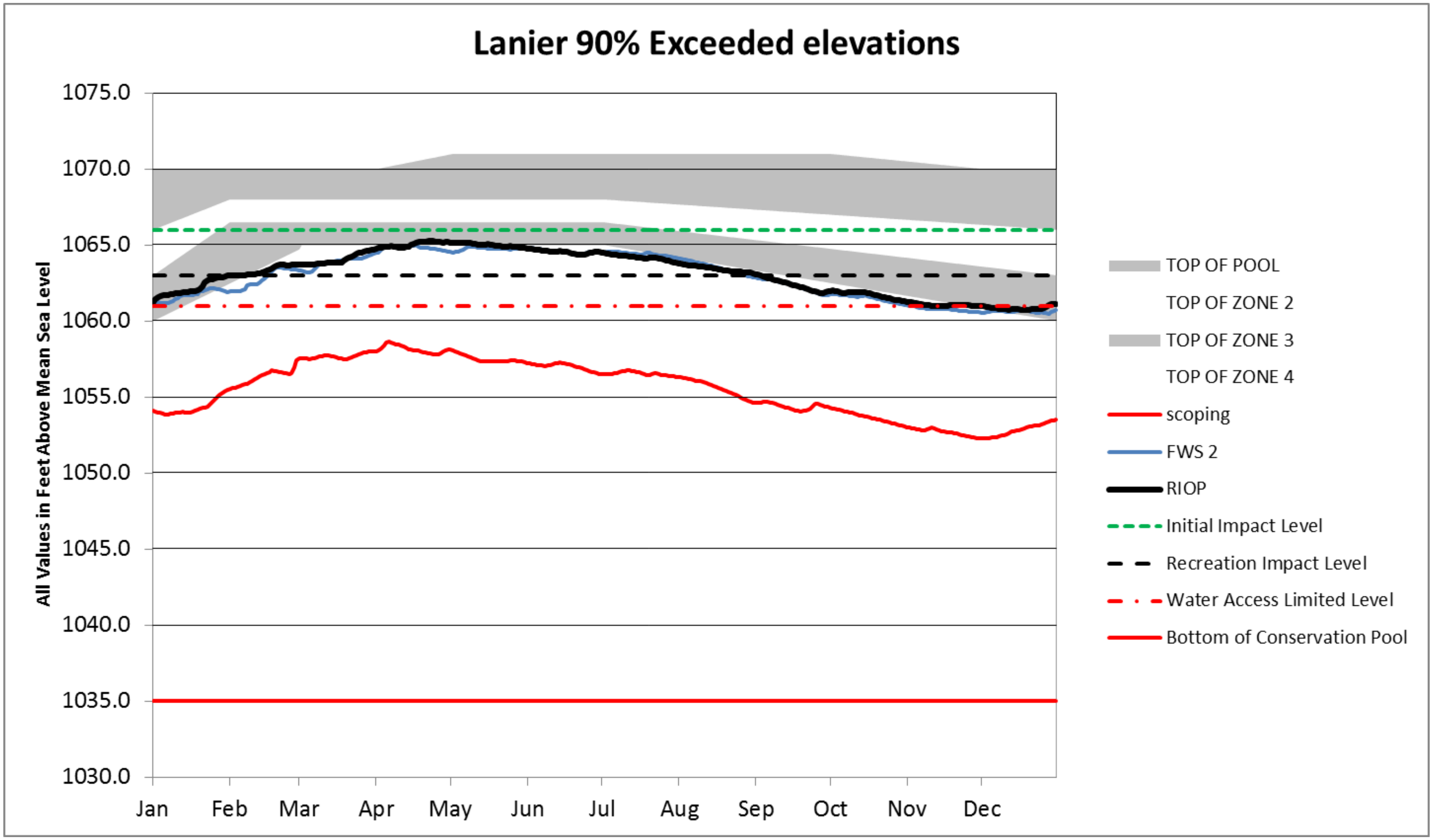


Figure 13. The minimum daily Lake Lanier reservoir elevations for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

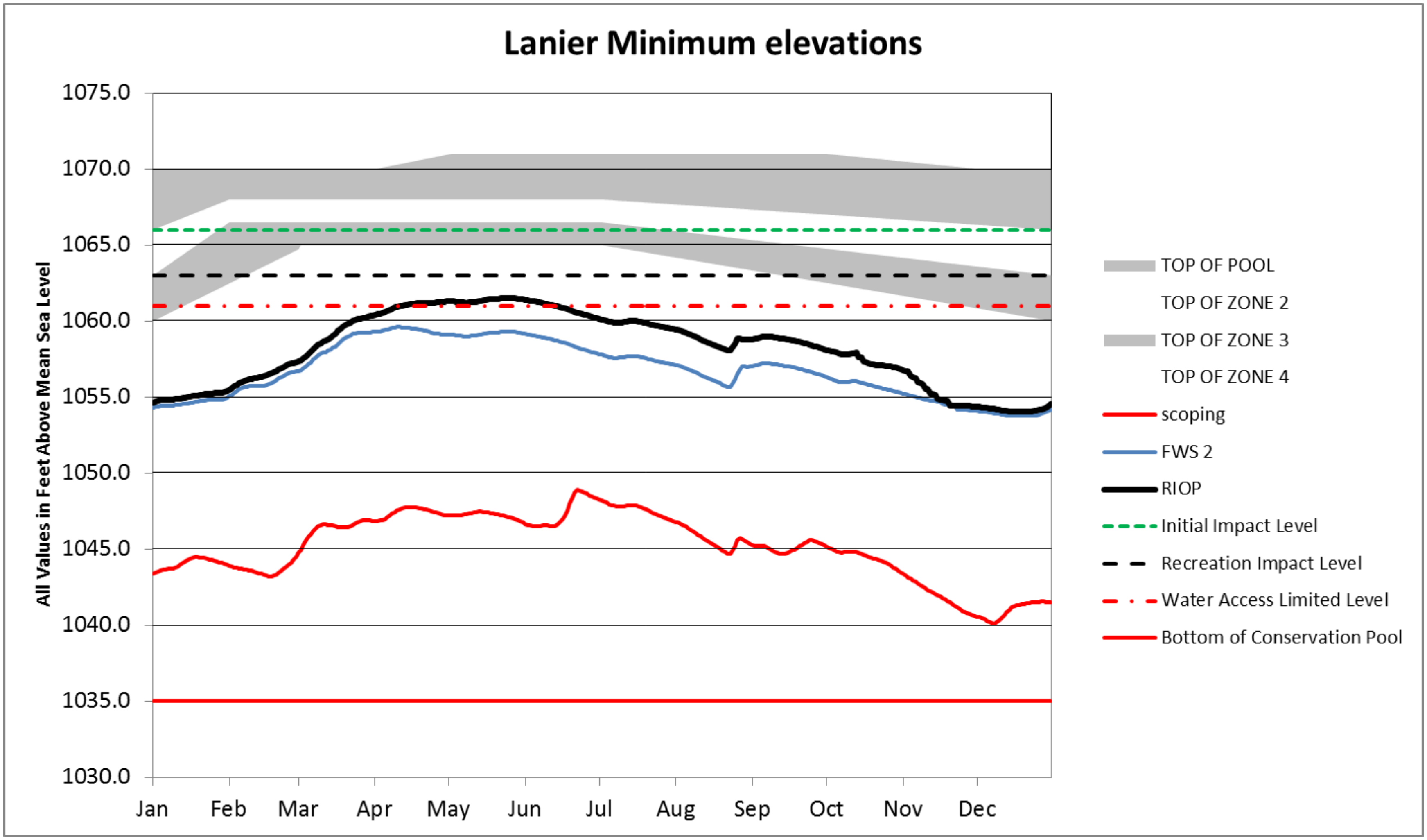


Figure 14. Median daily reservoir elevations for West Point Lake for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

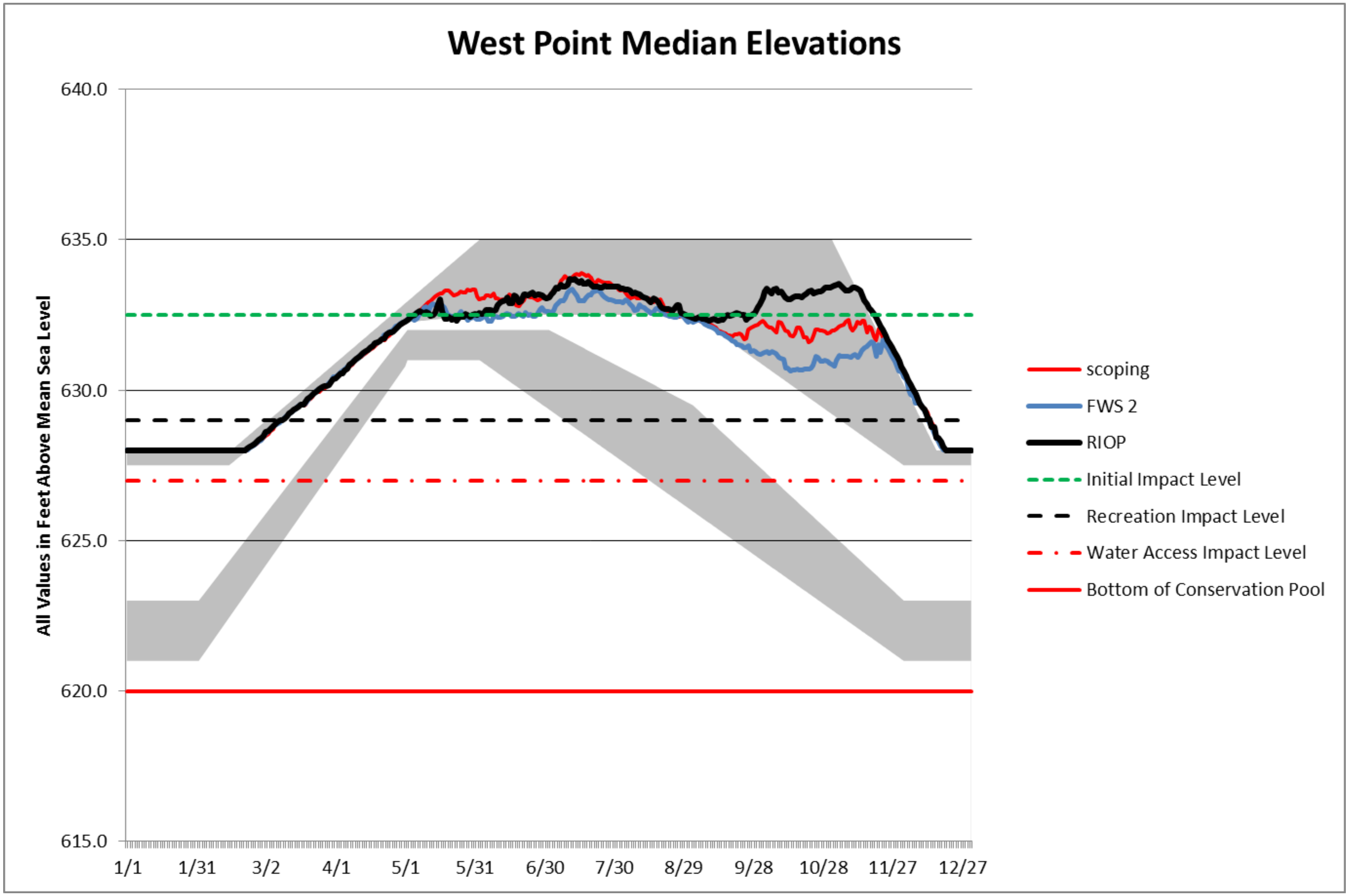


Figure 15. West Point Lake reservoir elevations that are exceeded 75 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

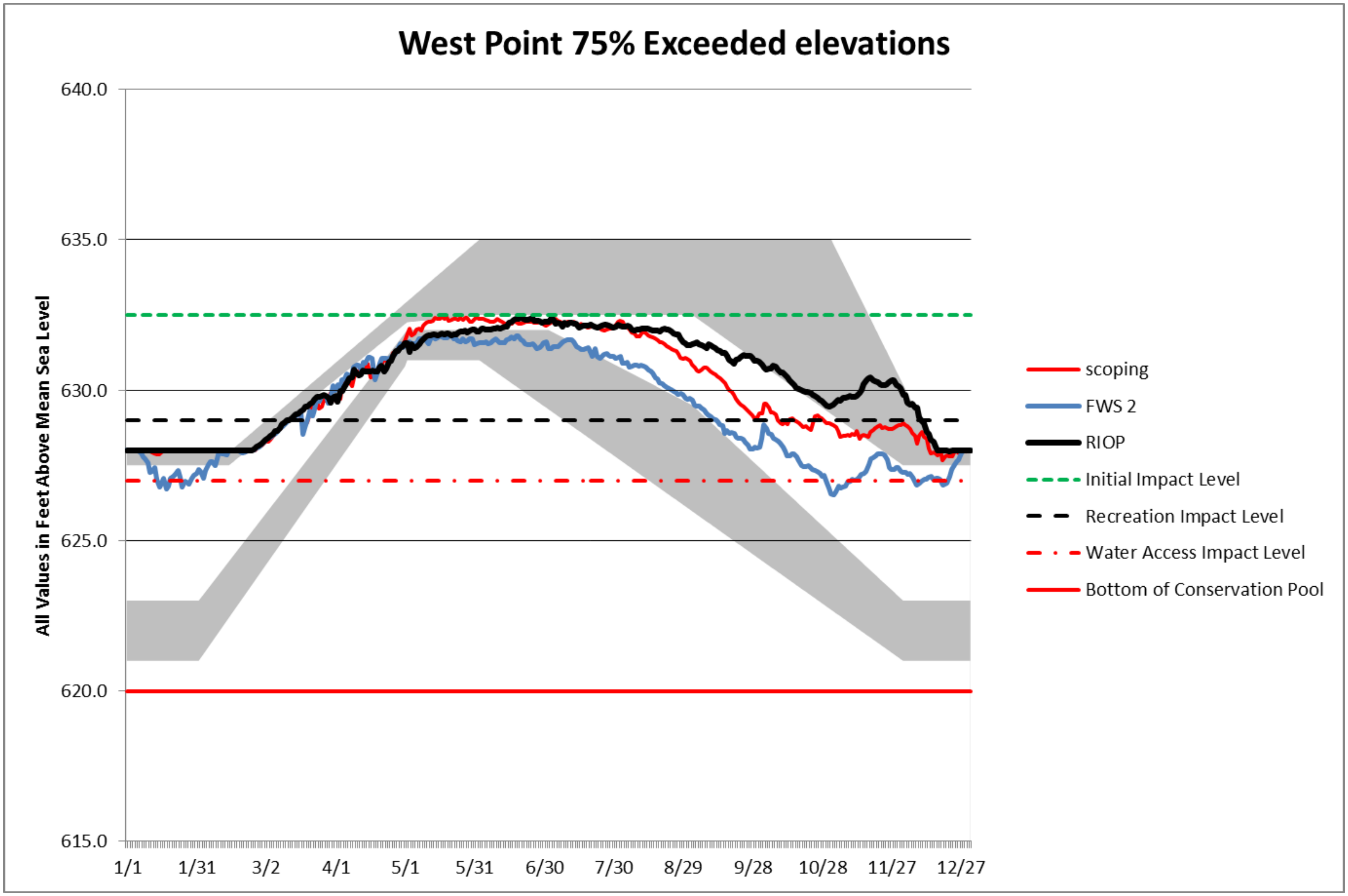


Figure 16. West Point Lake reservoir elevations that are exceeded 90 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

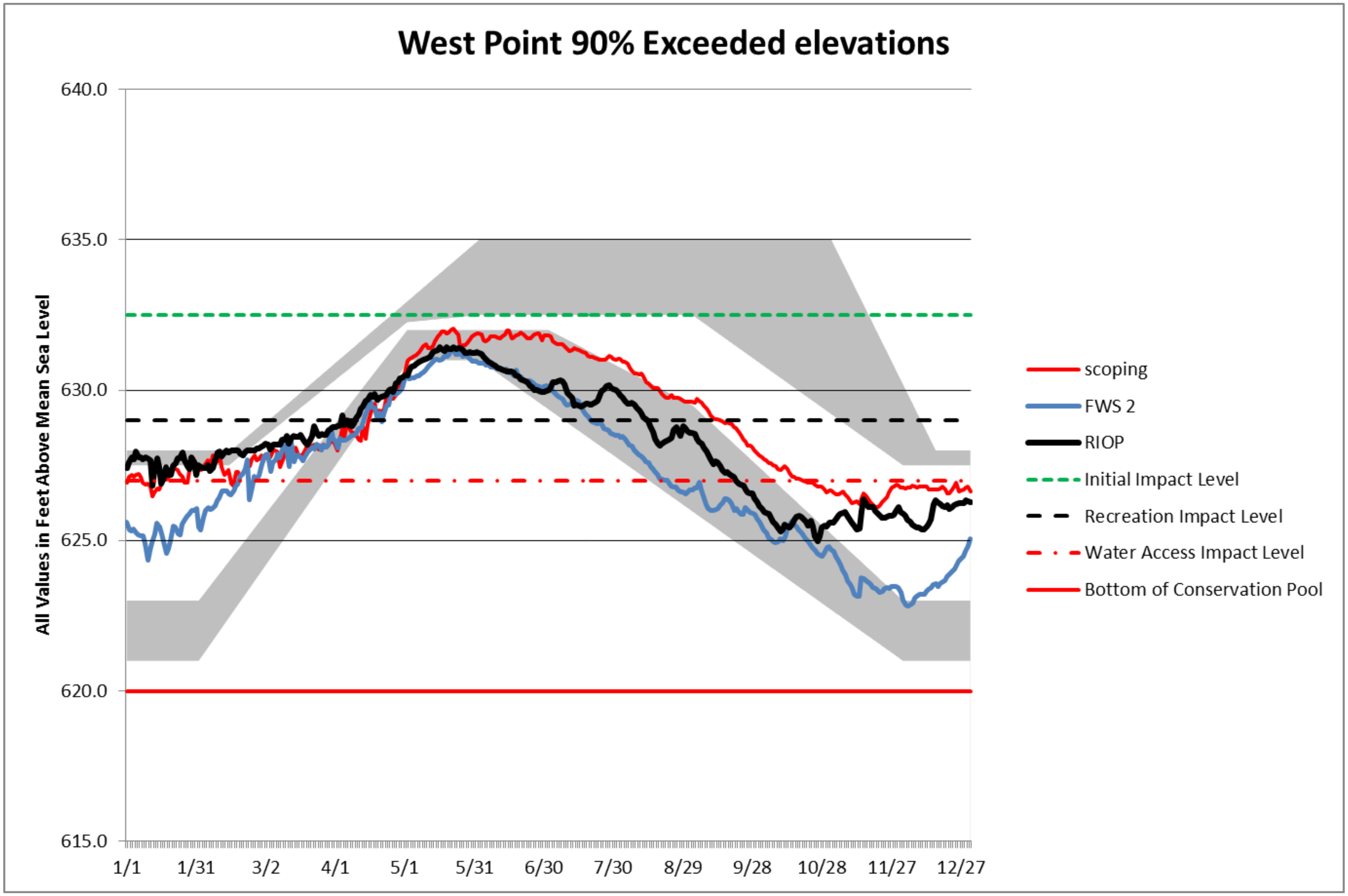


Figure 17. The minimum daily West Point Lake reservoir elevations for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

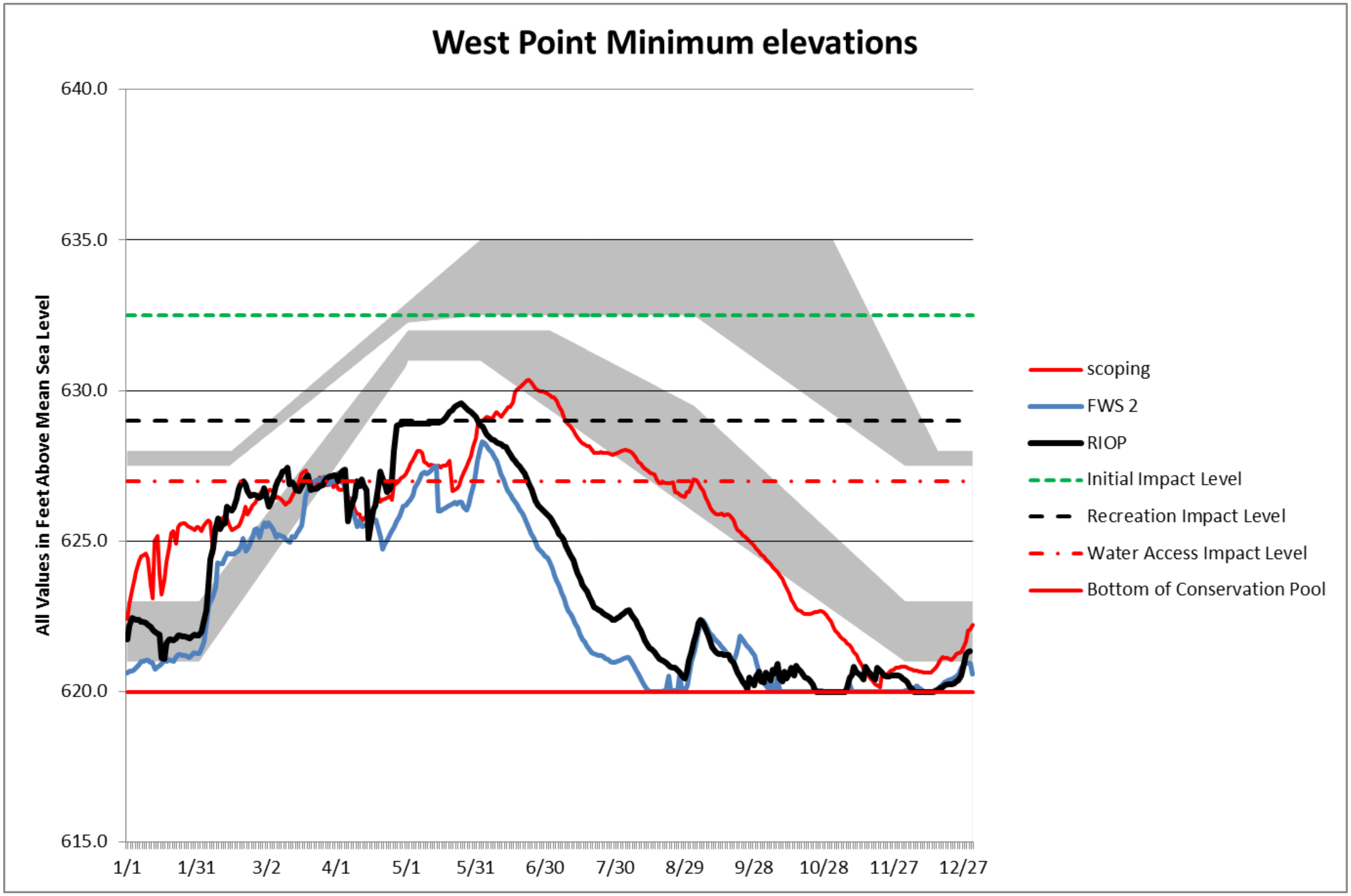


Figure 18. Median daily reservoir elevations for W.F. George for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

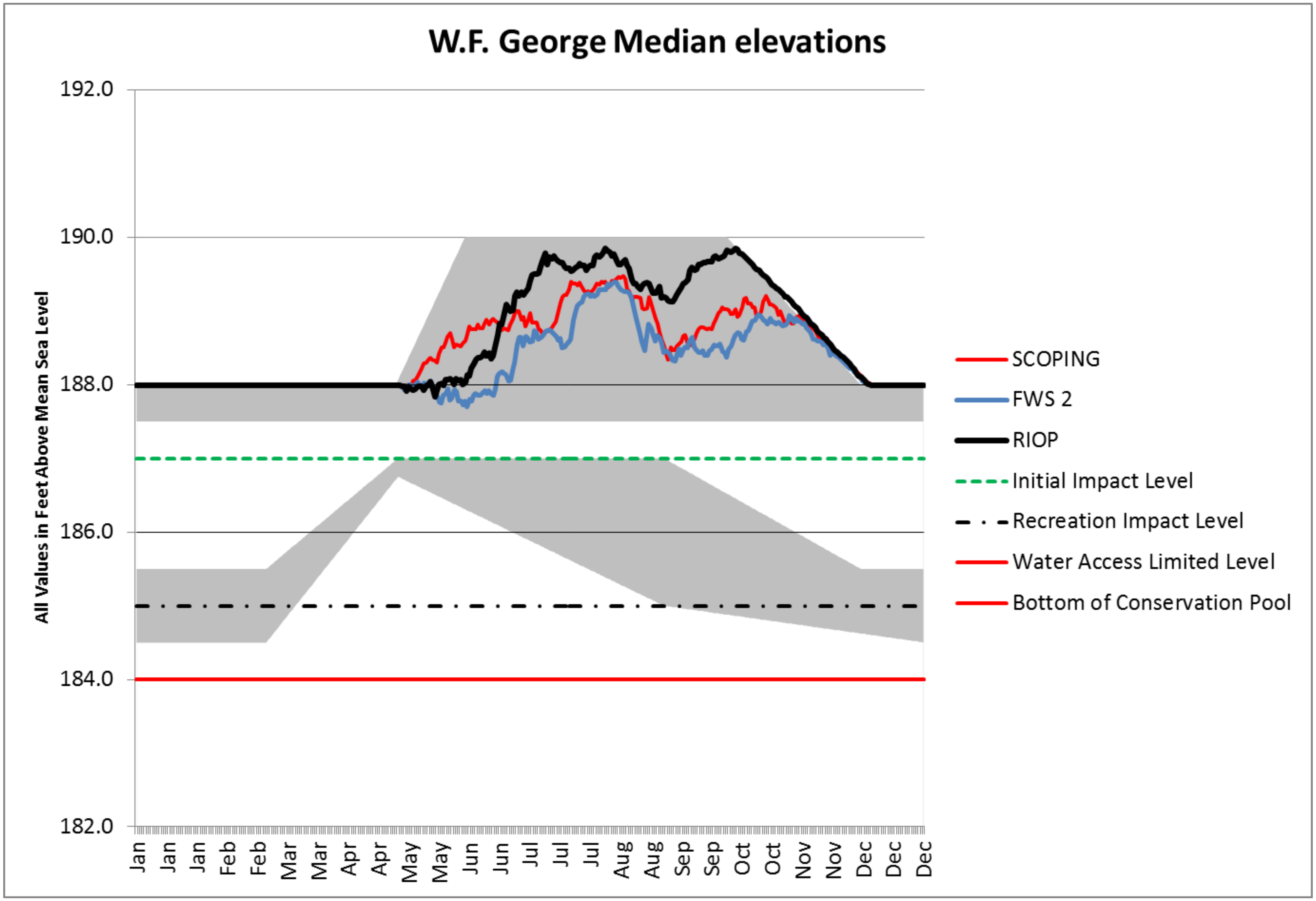


Figure 19. W.F. George reservoir elevations that are exceeded 75 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

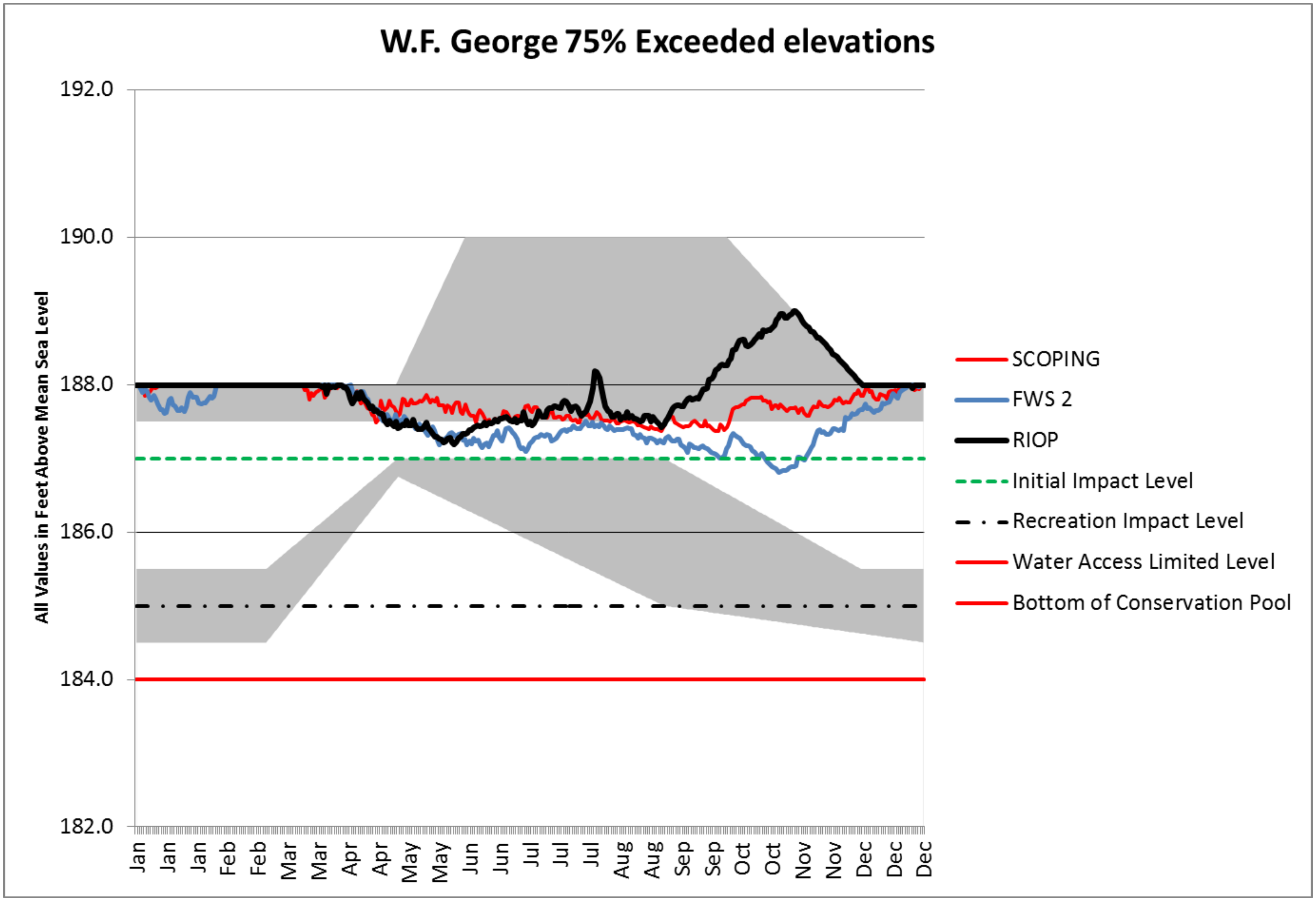


Figure 20. W.F. George reservoir elevations that are exceeded 90 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

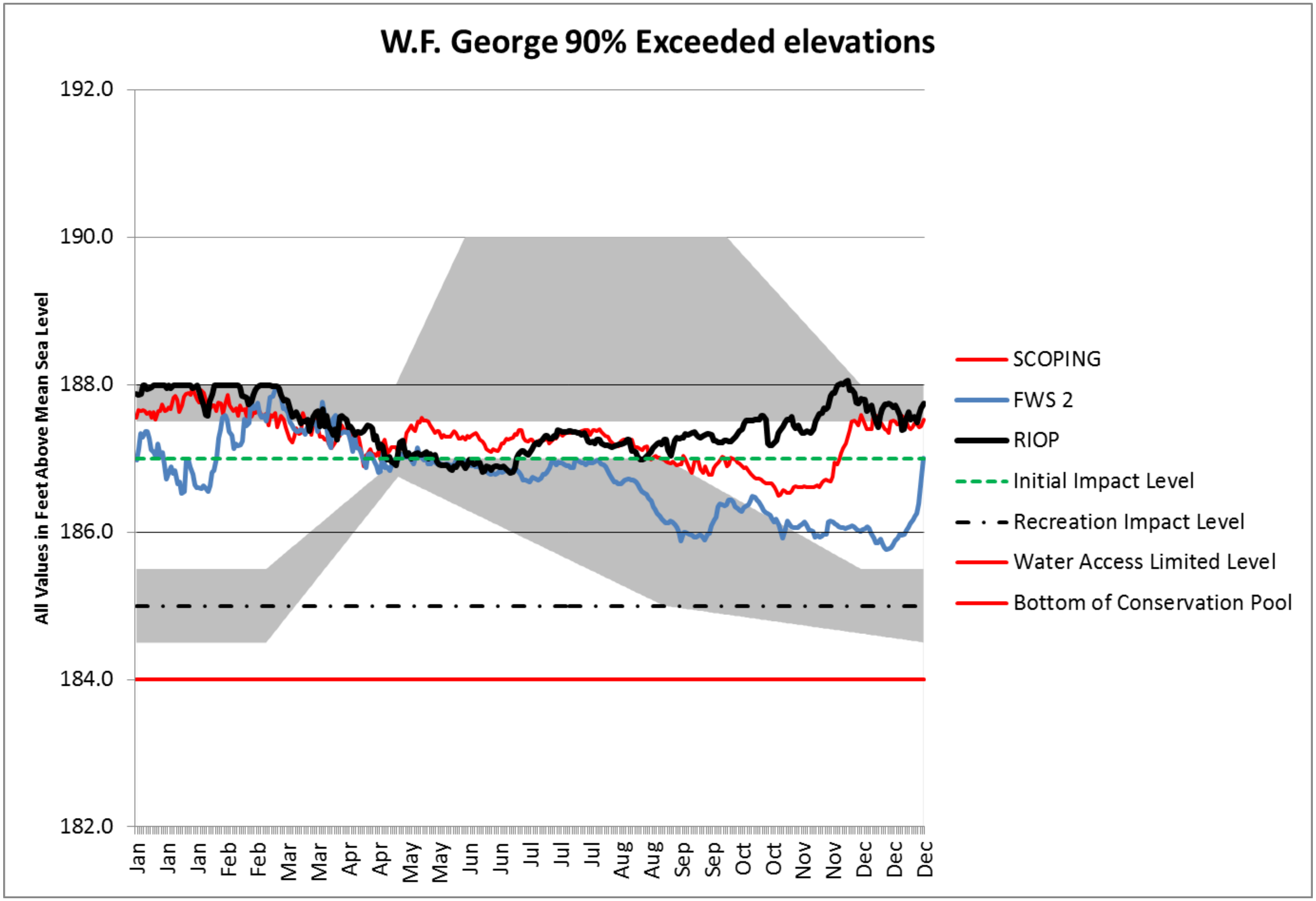
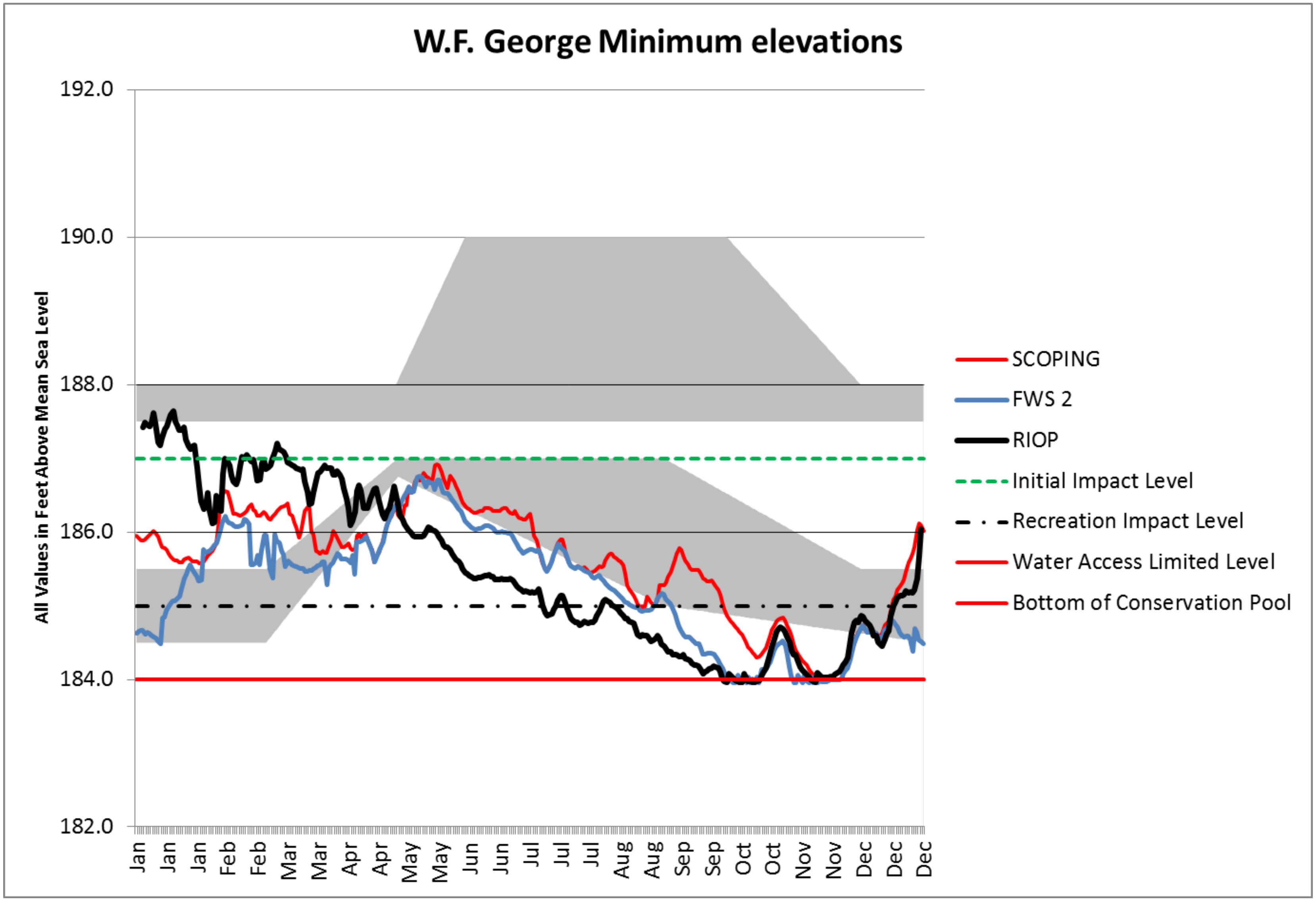


Figure 21. The minimum daily W.F. George reservoir elevations for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..



United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
706-613-9493 Fax: 706-613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
706-544-6428 Fax: 706-544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
912-832-8739 Fax: 912-832-8744

August 29, 2013

Mr. Curtis Flakes
Chief, Planning and Environmental Division
United States Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001

Subject: Planning Aid Letter, Apalachicola-Chattahoochee-Flint Water Control Manual Updates

Dear Mr. Flakes:

The U.S. Army Corps of Engineers, Mobile District (Corps), currently is updating the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM update identifies operating criteria and guidelines for managing water storage and release of water from Corps reservoirs and, therefore, will guide future water management operations in the basin. We previously provided Planning Aid Letters (PALs) for the proposed WCM update to the Corps April 2, 2010, and March 1, 2011; these PALS identify resource values and issues in the basin, including rare species, and propose preliminary changes, mitigation, or enhancement opportunities to minimize impacts and facilitate your National Environmental Policy Act analysis of the project. The comments in these PALs are still applicable.

The Service, in previous correspondence (July 19, 2013, Revised Alternative to the Corps), identified performance measures that the Corps should use, in simulated operations, to compare the relative effects of the no-action and action alternatives considered for the WCM update on various target species. We used these performance measures in the development of the Service's Revised Alternative. In this PAL, we fully describe these performance measures. We submit these comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Migratory Bird Treaty Act, (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq.*), and the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). Our comments are based on previous studies and government documents, as well as new datasets and information provided by State and Federal agencies. We will provide additional expertise and information in our FWCA Report and during a separate section 7 consultation under the ESA.

Description of Performance Measures

Apalachicola River Floodplain Fish Spawning and Rearing

The Floodplain Spawning Habitat Performance Measure (FSHPM) calculates the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April through October. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

Multiple studies establish the importance of floodplain habitats to the life history of many riverine fishes, including several specific to the Apalachicola River (Walsh et al. 2006, 2009; Pine et al. 2006; Dutterer et al. 2011). These studies provide evidence of spawning and rearing activity for at least 44 species representing 16 families (predominantly Centrarchidae and Cyprinidae) in floodplain habitats, when available, during the growing season. Fish use in floodplain habitats requires time for adult movement from the main channel into the floodplain, courtship and spawning behaviors, egg incubation, and juvenile growth to a size capable of moving to and surviving in the main channel when water levels recede. We consider 30 days of continuous inundation minimally sufficient to ensure successful completion of the reproductive process in the floodplain. A greater spatial extent of habitat availability provides greater benefits for fish reproduction. The spatial extent of non-tidal floodplain inundation as a function of discharge from Woodruff Dam was quantified (Figure 1; Light et al. 1998, 2006).

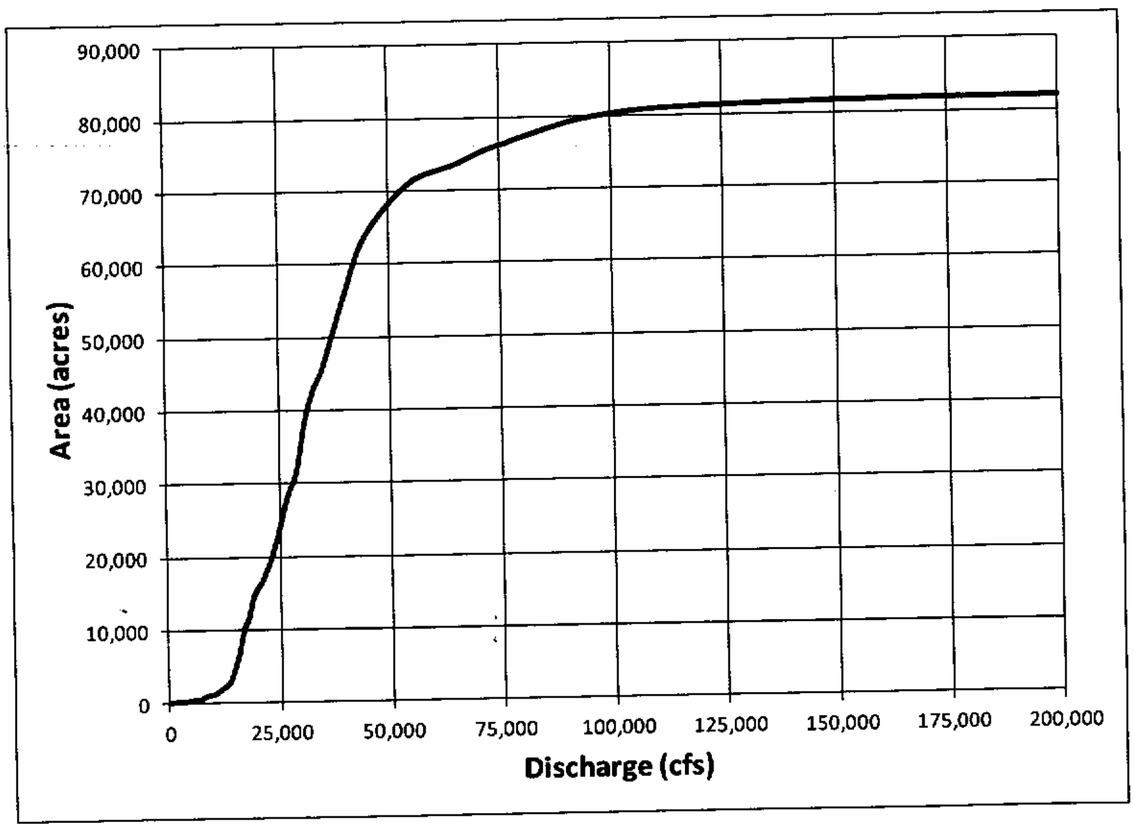


Figure 1. Area (acres) of aquatic non-tidal floodplain habitat connected to the main channel of the Apalachicola River as a function of discharge (cubic feet per second) from Woodruff Dam (data from Light et al. 1998).

The FSHPM computes a 30-day running minimum inundated floodplain acreage from observed or simulated daily releases from Woodruff Dam during April through October. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of eggs and larvae. The FSHPM is an Excel workbook that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous floodplain habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to floodplain-spawning fishes in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated floodplain habitat while balancing other project purposes. While this metric is developed to analyze the April-October period, the April to May period is most important because it encompasses spawning and peak abundance of early life stages of floodplain fishes (Walsh et al. 2006). Peak inundation during the growing season generally occurs in April. However, given the protracted spawning period of many fishes, we included April through October in the Excel workbook.

Gulf Sturgeon Spawning

The Sturgeon Spawning Habitat Performance Measure (SSHPM) calculates the maximum amount of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) spawning habitat available for at least 30 consecutive days from March through May. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

There are at least 10 potential Gulf sturgeon spawning sites on the Apalachicola River, based on the presence of a limestone, marl, or other hard substrate where sturgeon deposit their adhesive eggs. Egg collections have confirmed that three of these sites (river miles 105, 100, and 99) support spawning at a range of depths from 8.5 to 17.8 feet, a range that excludes the deepest 10 percent and shallowest 10 percent of collections. The SSHPM uses the discharge-habitat relationships for these three sites to predict spawning habitat availability based on these depths (Figure 2).

The SSHPM computes a 30-day running minimum habitat acreage from observed or simulated daily releases from Woodruff Dam during March through May. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of sturgeon eggs and larvae. The SSHPM is an Excel workbook application that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to sturgeon spawning in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated Gulf sturgeon spawning habitat while balancing other project purposes.

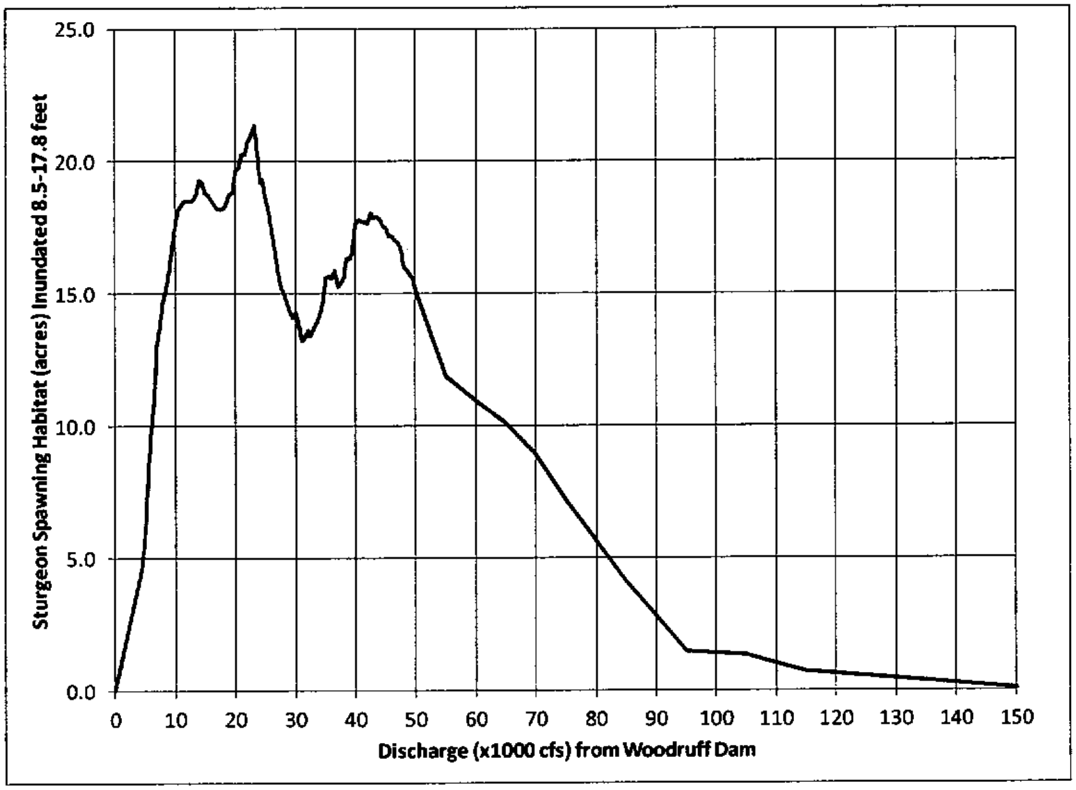


Figure 2. Area (acres) of hard substrate inundated to depths of 8.5 to 17.8 feet at the three known Gulf sturgeon spawning sites on the Apalachicola River at flows of 0 to 150,000 cfs (USFWS 2008).

Apalachicola River Mussels

The Service currently is working on a habitat-based performance measure for the federally-endangered fat threeridge (*Amblema neislerii*) in the Apalachicola River, but this metric will not be ready in time for use in the draft Environmental Impact Statement (EIS) and is not applicable to other mussel species. At this time, the best data available to evaluate the effects of operating alternatives on all three federally-listed mussels are the frequency, magnitude, and duration of low flows in the Apalachicola River.

The Apalachicola River Mussel Performance Measures (ARMPMs) are a suite of hydrologic measures related to mussel survival. Over the past eight years, we have described direct effects to mussels by exposure during low flow conditions. The ARMPMs are based on several of the low-flow and fall-rate metrics described in the biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012). The ARMPMs include the following metrics: (1) the inter-annual frequency of flow rates less than 5,000 to 10,000 cfs; (2) the median number of days per year less than the thresholds of 5,000 to 10,000 cfs; (3) the median number of consecutive days per year of discharge less than 5,000 to 10,000 cfs; (4) the median fall rates when flows are less than 10,000 cfs; (5) and the maximum fall rates when flows are less than 10,000 cfs.

The ARMPMs are an Excel workbook that requires multiple years of daily discharges as input. The primary outputs are graphical frequency distributions (line charts) for ARMPMs 1-3 above and calculations of ARMPMs 4 and 5. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The metrics should serve as the basis for comparing the relative effects to mussels in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that reduce the occurrence and fall rates of low flows, while balancing other project purposes.

Reservoir Fisheries

Multiple game and non-game fishes use the littoral zone for spawning and rearing (e.g., Centrarchidae). The Reservoir Fisheries Performance Measure (RFPM) is an index of habitat conditions for these littoral-zone spawning fishes, computed from time-series of daily surface elevations for Lanier, West Point, and W.F. George reservoirs using the Corps' elevation vs. surface area relationships for each reservoir. We have not developed a RFPM for Andrews and Seminole reservoirs because operating alternatives for these relatively shallow and essentially run-of-river impoundments are unlikely to change their patterns of surface elevation variability.

Like the FSHPM, the RFPM computes a 30-day running minimum habitat acreage during the spawning season from observed or simulated daily reservoir elevations. The annual maximum of these values during the spawning season represents the amount of habitat continuously available for at least 30 days to support spawning behaviors and the growth and development of early life-history stages.

The depth of productive littoral-zone habitat varies with surface elevation, water quality, the extent and duration of reservoir draw-downs in previous years, and other factors. The Corps' fish management plans from the 1970's suggest that 20 feet below full summer pool elevation is the "approximate bottom of the productive zone" for each of the three large storage reservoirs (Corps 1974a, 1974b, 1975). However, fisheries managers and experts for these reservoirs described depths greater than 15, 7, and 10 feet below full summer pool as "totally unacceptable" for littoral spawning or rearing habitat in Lanier, West Point, and W.F. George, respectively (Ryder et al. 1995). The RFPM uses the elevations from Ryder et al. (1995) corresponding to the "unacceptable" depths below full pool as the "floor" of the littoral productive zone.

Ploskey and Reinert (1995) cited numerous studies of successful reproduction and development of strong year classes associated with years of high water inundating terrestrial vegetation in reservoirs. They found positive correlations in West Point and W.F. George reservoirs between spring-time perimeter area (depth less than 6 meters) and standing crop data for Centrarchids. Flooded terrestrial vegetation is especially important to fisheries in Lanier and West Point, where aquatic vegetation is relatively sparse in constantly inundated areas. Miranda et al. (1984) found positive correlations between young-of-year largemouth bass abundance and the extent and duration of flood-pool inundation (i.e., elevations exceeding the top of the conservation pool) at West Point reservoir.

Based on this information, the RFPM computes two subsets of the area of the productive zone inundated during the spawning season for 30 days or more: 1) the area, if any, exposed during the previous growing season for at least 45 consecutive days, where terrestrial vegetation could have colonized exposed shorelines during the previous year; and 2) the area, if any, above the normal full pool elevation that could support perennial terrestrial vegetation (Figure 3). The second subset is a subset of the first, and by adding these two areas to the full inundated area of the productive zone, the RFPM triple-counts inundated acres above normal full pool and double-counts inundated acres that were exposed during the previous year.

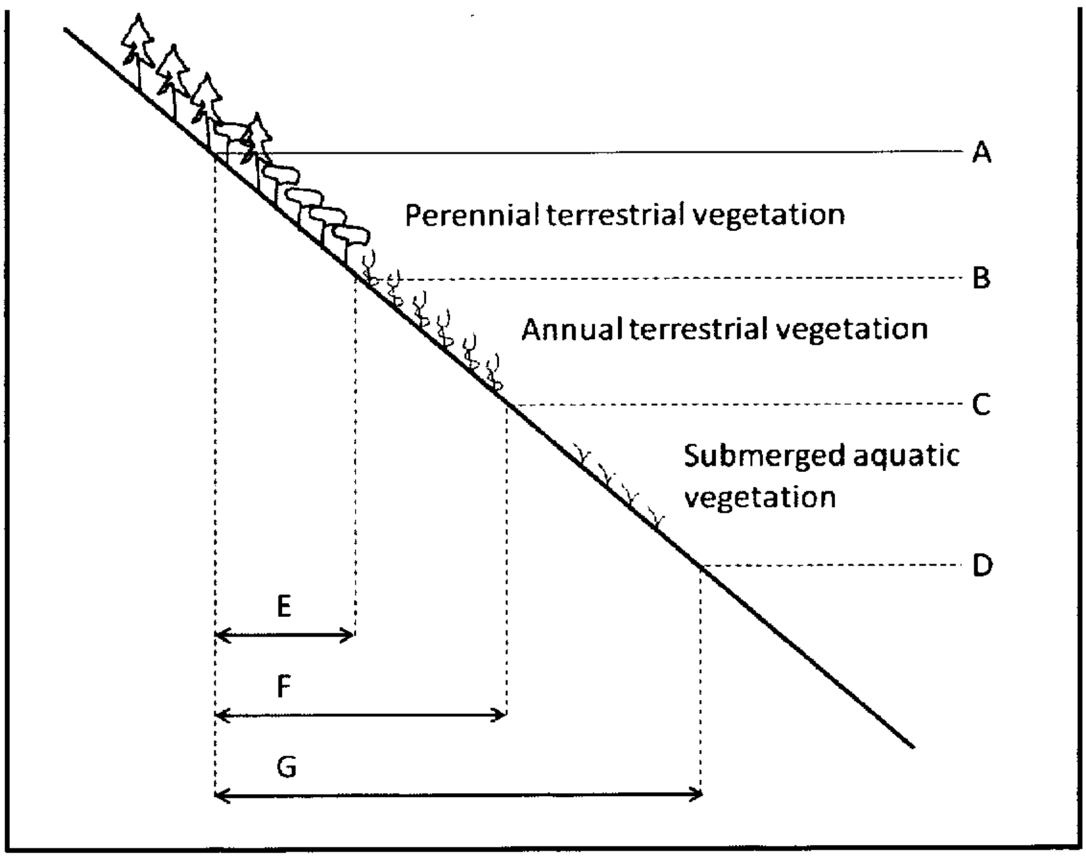


Figure 3. Conceptual drawing of a reservoir shoreline showing RFPM physical features, where
A = maximum surface water elevation sustained for at least 30 days during the spawning season;
B = full conservation pool elevation and lower extent of perennial terrestrial vegetation;
C = the minimum elevation exposed for at least 45 days during the growing season in the previous year;
D = the elevation of the lower extent of reservoir productive zone;
E = the inundated area between A and B;
F = the inundated area between A and C; and
G = the inundated area between A and D.

In this depiction, A exceeds both B and C, and the RFPM would report for the year the sum of E + F + G as the annual habitat acreage (E is triple counted, and F is double counted). In years when A does not exceed B, E is 0; when A does not exceed C, F is zero; and when A does not exceed D, G is zero.

The fish spawning seasons specific to each reservoir for the RFPM are identified in the Corps' Standard Operating Procedure (SOP) for fish spawning in the ACF system (Table 1). The intent of the SOP is to maintain stable or rising reservoir levels for 4 weeks during the 8-week window to promote successful fish spawning and rearing. The 30-day running minimum area calculated in the RFPM begins on the first day of the fish spawn window and concludes on the day that captures the last day of the spawn window in the 30-day minimum calculation. The other temporal and spatial parameters used in the RFPM (e.g., growing season length, elevation of the lower extent of the productive zone) for each reservoir are given in Table 1 along with the values we recommend for its use; however all are user-definable parameters.

Table 1. User-definable parameters for the RFPM with recommended values for its use.

Parameter	Lanier	West Point	W.F. George
Growing season[1] start	Mar. 30	Mar. 20	Mar. 10
Growing season[2] end	Oct. 30	Nov. 5	Nov. 15
Spawning season start	Apr. 1	Apr. 1	Mar. 15
Spawning season end	Jun. 1	Jun. 1	May 15
Elevation (ft) for lower extent of reservoir productive zone	1056	628	180
Exposure duration (days) for establishing terrestrial vegetation during the growing season	45	45	45
Inundation duration (days) for spawning/early rearing	30	30	30
Full conservation pool elevation (ft) and lower extent of perennial terrestrial vegetation	1071	635	190

1=Average dates of last spring freeze (National Weather Service 2013a).
2=Average dates of first fall freeze (National Weather Service 2013b).

Although many other factors besides reservoir elevations, such as flow-through volume, nutrient loading, etc., may influence the population dynamics of reservoir fishes, we believe the RFPM is a relatively simple and useful index for ranking the effects of operating alternatives on reservoir fisheries habitat. We considered using the performance measure that the Service developed for the Corps' 1998 ACF Water Allocation DEIS, which was based in part on the expert-opinion survey results described in Ryder et al. (1995). We prefer and now recommend the RFPM, because it relies solely on direct measures of reservoir area that are likely to contain the habitat features supporting successful fish reproduction. Further, the RFPM results are more easily computed and interpreted than those of the 1998 DEIS performance measure, and are consistent with the Corps' fish spawn SOP, which was adopted after the 1998 DEIS.

The RFPM is an Excel workbook that requires multiple years of daily reservoir elevations as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) for each reservoir of annual maximum 30-day continuous habitat availability. The spreadsheet is organized for comparing the distributions of observed reservoir levels, existing operations (the RIOP) as simulated by ResSim, and up to 6 additional simulated operations alternatives. Displaying additional alternatives is possible by replicating the functions within the spreadsheet.

Chattahoochee River Shoal Bass Recruitment

The Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM) predicts shoal bass (*Micropterus cataractae*) recruitment using a combination of discharge and river water temperatures. Shoal bass are a recently-described black bass endemic to the ACF River Basin, are listed as a species of concern by American Fisheries Society, and are regionally vulnerable (Warren et al. 2000). They frequently occur in shoals over rocky sediments in water exceeding 0.66 feet per second (Sammons and Goclowski 2012). Shoal bass frequently co-occur with other shoal-dwelling native species and their population response to discharge and water quality may be an indicator of shoal fish community response. Because of their recreational fishery significance and the availability of potentially suitable shoal habitat, Georgia Department of Natural Resources and the National Park Service initiated a 5-year shoal bass stocking program in 2003 below Morgan Falls Dam on the Chattahoochee River.

A study was initiated to evaluate the success of the stocking program and to characterize variables affecting recruitment (Long and Porta 2011). The relative abundance (electrofishing catch-per-unit effort) of age-3 shoal bass was of specific interest because these individuals were the minimum age (size) susceptible to capture, had the potential to be stocked, and were present in the river for a duration of time acceptable for inferences regarding cohort recruitment. Mean spring water temperature was highly correlated with discharge, and spring water temperature and bass length at stocking were strong predictors of age-3 catch per unit effort ($F_{2,3}$= 20.78, $R^2 = 0.93$, $p < 0.10$). Because stocked and wild shoal bass had similar lengths, growth rates, and longevity, we expect that wild and stocked fish respond similarly to river water temperatures and that the multiple regression formula of Long and Porta (2011) can be used to make inferences regarding both wild and stocked shoal bass:

$$\log_{10}\text{age-3 abundance} = -6.262 + 0.055_{\text{LStock}} + 0.306_{\text{SpTemp}}$$

where LStock is length in millimeters at time of stocking, and SpTemp is Spring water temperature (from stock date to June 21) in degrees Celsius.

In order to use Long and Porta's (2011) multiple regression model to evaluate multiple alternatives for the WCM updates, we estimated the relationship between discharge and water temperature in the Chattahoochee River at two locations. We used United States Geological Survey (USGS) average daily discharge and temperature data from the Chattahoochee River below Morgan Falls Dam, Georgia gage (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the Chattahoochee River at Atlanta, Georgia gage (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012). Both locations were within the study area of Long and Porta (2011). Average temperature and discharge were used for May and June (combined), because averages were used to develop the multiple regression model, and May and June constitute a majority of the spring stocking events (Long and Porta 2011). Exponential relationships produced the best-fit lines (Atlanta $R^2 = 0.94$; Morgan Falls $R^2 = 0.88$; Figure 4).

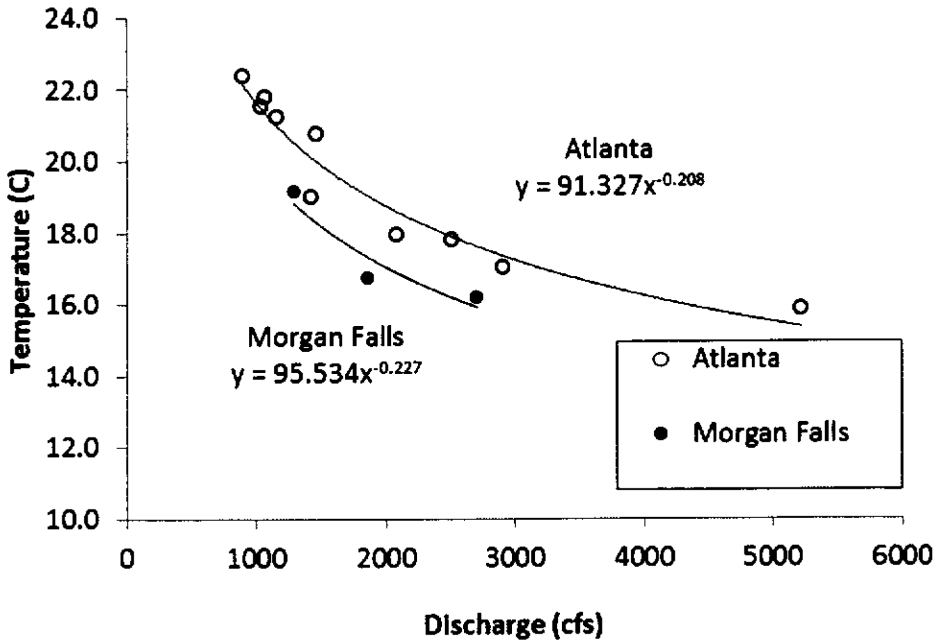


Figure 4. The relationship between spring temperature and average daily discharge for the USGS gage near the Chattahoochee River below Morgan Falls Dam, Georgia (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the USGS gage near the Chattahoochee River at Atlanta, Georgia (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012).

Based on these regressions, the CRSBPM is an Excel workbook that computes the average water temperature for May-June based on modeled discharge from the reservoir, then uses the Long and Porta (2011) regression formula to calculate recruitment as catch-per-unit effort of stocked age-3 shoal bass. The user can specify a bass length at stocking to examine recruitment effects. However, it is important that the user specify a length within the range measured in the study (23.7-68.0 mm), and that a consistent length is used to compare alternatives. We used 30 mm because smaller fish are likely to be more vulnerable to temperature changes, although trends are the same for any size selected. The primary output is a graphical frequency distribution ("box and whiskers" plot) that compares predicted age-3 catch-per-unit effort (not log-transformed) among multiple alternatives. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The metric should serve as the basis for comparing the relative effects to age-3 shoal bass in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve shoal bass recruitment, while balancing other project purposes.

Apalachicola Bay Salinity

Because salinity in Apalachicola Bay is influenced by river flows, low salinities are prevalent during wet, high flow years and high salinities are prevalent during droughts. Optimal salinities for oysters are less than 26 parts per thousand (ppt) (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Randall and Sulak 2007;

Sulak et al. 2009). In our 2010 draft FWCA Report, the Service evaluated the effects of reservoir operation alternatives on salinity in Apalachicola Bay using output from a hydrodynamic salinity model developed by Sheng et al. (2011). This model provides detailed information about salinity throughout the bay over various freshwater inflows; however, it is time consuming and requires intensive data post-processing. While revising the alternative we submitted in July 2013, we sought a simpler, nimbler way to evaluate the effects of reservoir operations on salinity in Apalachicola Bay. Because we examined over 80 alternatives, hydrodynamic salinity modeling was not feasible.

The Apalachicola National Estuarine Research Reserve provided us their average daily salinity data for monitoring stations in the bay from 1992 to 2013. We focused on East Bay, which is important juvenile Gulf sturgeon habitat from October through March. We also focused on Cat Point and Dry Bar, which are commercially important oyster bars and where low salinities are most important from May through October. We developed regression relationships between the mean monthly salinity at each of these locations within Apalachicola Bay and the mean monthly discharge at the USGS gage in the Apalachicola River near Chattahoochee, FL (USGS gage 02358000; Figure 5). The Apalachicola Bay Salinity Performance Measure (ABSPM) uses these regressions to compute the mean monthly salinity for these three locations for each month of every year in the simulated discharge period of record. These values represent the average monthly salinities that are experienced at these locations to support Gulf sturgeon and oyster growth and survival.

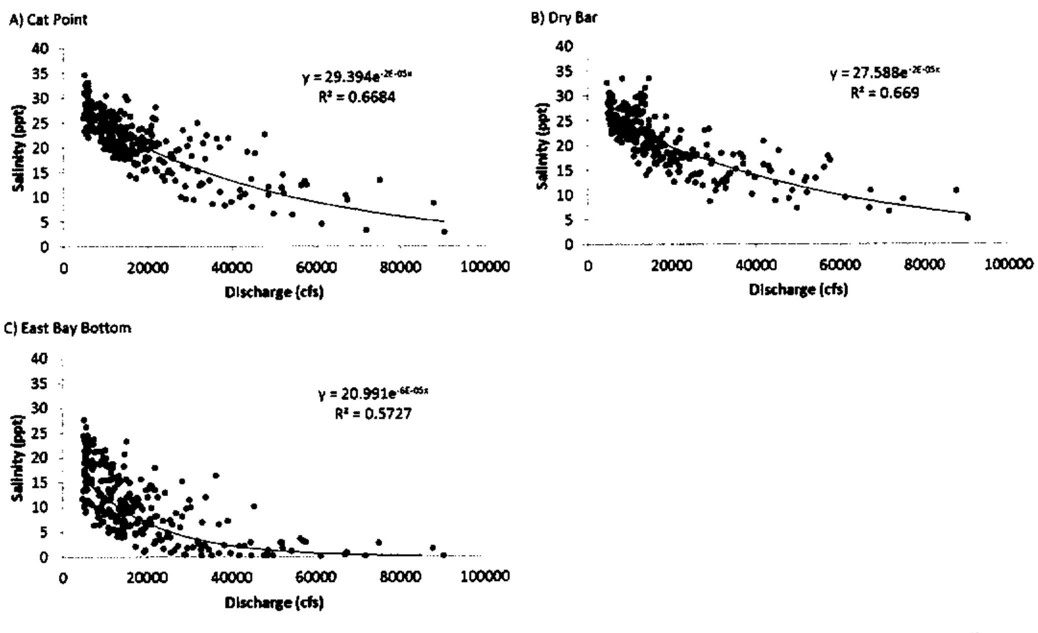


Figure 5. The relationship between Apalachicola River at Chattahoochee discharge (USGS #02358000) and Apalachicola Bay salinity at A) Cat Point, B) Dry Bar, and C) the bottom of East Bay.

The ABSPM is an Excel workbook that produces a graphical frequency distribution ("box and whiskers" plot) of mean monthly salinity for October through March for juvenile sturgeon in East Bay, and May through October for oysters at Cat Point and Dry Bar. The spreadsheet is organized for comparing the salinity distributions resulting from existing operations (the RIOP) as simulated in ResSim, and up to six additional simulated operations alternatives. The ABSPM should serve as the basis for comparing the relative effects of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve oyster and sturgeon growth and survival as measured by these performance metrics, while balancing other project purposes.

The Corps should note that the ABSPM is a coarse metric, because it is based on mean monthly salinities. Differences among the alternatives that we have analyzed to date are relatively minor. This may be due to the coarse temporal scale of the metric or the possibility that substantial changes in the bay salinity metric require large amounts of water. Finer spatiotemporal-scale evaluation is necessary to discern whether changes in reservoir operations may improve salinity regimes for sturgeon, oysters, and other bay resources. The Service recommends that the Corps also consider hydrodynamic salinity modeling for comparing the relative effects on Apalachicola Bay salinity in simulated operations of the no-action and action alternatives considered for the WCM update.

Summary

This PAL describes six performance measures that we recommend the Corps use to evaluate impacts of the no-action and action alternatives considered for the WCM update on various target species. We request the opportunity to analyze the Corps' future alternatives using the Service's performance measures. Alternatively, we can provide technical assistance or Excel workbooks for the Corps' analyses, as needed.

Our revised alternative, provided to you July 19, 2013, exhibited improvements to all these performance measures, except the ABSPM, when compared to conditions under the Revised Interim Operating Plan. As discussed above, a lack of notable improvement to the ABSPM may be due to the coarseness of the metric or the requirement for substantial changes in reservoir operations to result in changes to the bay salinity metric. Because most performance measures improved in our revised alternative, we did not prioritize them during our alternative development process. We can develop tailored recommendations in the future if it appears a priority ranking for the six performance measures is needed during the Corps' alternative development process.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress that the Corps' water management is not just about avoiding adverse effects, but also about restoring and improving habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Robin B. Goodloe
Acting Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
K. Herrington, USFWS, St. Charles, MO
S. Abbott, USFWS, Ft. Benning, GA
C. Sumner, Corps, Mobile, AL
D. Imm, USFWS, Panama City, FL
D. Everson, USFWS, Daphne, AL
B. Zettle, Corps, Mobile, AL

Literature Cited

Altinok, I., and J.M. Grizzle. 2001. Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. Journal of Fish Biology 59:1142–1152.

Dutterer, A.C., C. Mesing, R. Cailteux, M.S. Allen, W.E. Pine, III, and P.A. Strickland. 2011. Fish recruitment is influenced by river flows and floodplain inundation at the Apalachicola River, Florida. Unpublished final report submitted to the Florida Fish and Wildlife Conservation Commission. 24 pp.

Huang, W. 2010. Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science 86:526-534.

Light, H.M., M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida. U.S. Geological Survey Professional Paper 1594.

Light, H.M., K.R. Vincent, M.R. Darst, and F.D. Price. 2006. Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston, R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin, and W. Huang. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Long, J.M., and M.J. Porta. 2011. Determine status of shoal bass restoration and effects of environmental variation on timing of spawning and early life-history characteristics of two populations of shoal bass in the upper Chattahoochee River basin. Final Report.

Miranda, L.E., W.L. Shelton, and T.D. Bryce. 1984. Effects of water level manipulation on abundance, mortality, and growth of young-of-year largemouth bass in West Point Reservoir, Alabama-Georgia. North American Journal of Fisheries Management 4:314-320.

National Weather Service. 2013a. Last Spring Freeze Dates in Georgia. National Weather Service Weather Forecast Office, Peachtree City, GA. Online map at http://www.srh.noaa.gov/ffc/?n=lastfrz, accessed on 5/20/2013.

National Weather Service. 2013b. Autumn's First Freeze Dates in Georgia. National Weather Service Weather Forecast Office, Peachtree City, GA. Online map at http://www.srh.noaa.gov/ffc/?n=firstfrz, accessed on 5/20/2013.

Pine III, W.E., O.T.Burgess, S.J.Walsh, and A.C.Dutterer. 2006. Examination of fish spawning, movement, and habitat utilization patterns in the Battle Bend region of the Apalachicola River, Florida.

Unpublished final report to the Florida Fish and Wildlife Conservation Commission, Tallahassee, FL p. 39.

Ploskey, G.R., and T.R. Reinert. 1995. Assessing Impacts of Water Management on Reservoir Fish Reproductive Success in the Alabama-Coosa-Tallapoosa/Apalachicola-Chattahoochee-Flint River Basins. Technical Report EL-95-30, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. 48 pp.

Randall, M.T., and K.J. Sulak. 2007. Relationship between recruitment of Gulf sturgeon, *Acipenser oxyrinchus desotoi*, and water flow in the Suwannee River, Florida. American Fisheries Society Special Publication, Proceedings of Anadromous Sturgeon Symposium, Quebec City, Quebec, August 2003.

Ryder, S., J. Taylor, and J.H. Crance. 1995. Relations between Reservoir Surface Water Elevations and Reservoir Fisheries. Comprehensive Study ACT/ACF River Basins. U.S. Army Corps of Engineers, Mobile District. 178 pp.

Sammons, S.M., and M.R. Goclowski. 2012. Relations Between Shoal Bass and Sympatric Congeneric Black Bass Species in Georgia Rivers with Emphasis on Movement Patterns, Habitat Use, and Recruitment. Final Report Submitted to Georgia Department of Natural Resources Wildlife Resources Division.

Sheng, Y.P., J.R. Davis, and V.A. Paramygin. 2011. Simulating the impact of USACE operating alternatives on salinity and oyster population in Apalachicola Bay, FL. Draft Interim Report to the U.S. Fish and Wildlife Service. Civil and Coastal Engineering Department, University of Florida. April 27, 2011.

Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Parauka, S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505–515.

U.S. Army Corps of Engineers (Corps). 1974a. Lake Sidney Lanier, Chattahoochee River, Georgia; Design Memorandum; The Master Plan, Appendix D - Fish Management Plan. U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama. Unpublished report dated July 1974. 132 pp.

U.S. Army Corps of Engineers (Corps). 1974b. Walter F. George Lake, Chattahoochee River, Georgia and Alabama; Design Memorandum; The Master Plan, Appendix D - Fish Management Plan. U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama. Unpublished report dated July 1974. 162 pp.

U.S. Army Corps of Engineers (Corps). 1975. West Point Lake, Chattahoochee River, Alabama and Georgia; Design Memorandum; The Master Plan, Appendix D - Fish Management Plan. U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama. Unpublished report dated July 1975. 129 pp.

U.S. Fish and Wildlife Service (USWFS). 2006. Biological Opinion and Conference Report on the U.S. Army Corps of Engineers, Mobile District, Interim Operation Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. USFWS Panama City Field Office, Florida. Unpublished report dated September 22, 2006. 166 p.

U.S. Fish and Wildlife Service (USFWS). 2008. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. USFWS, Panama City Field Office, Florida. Unpublished report dated June 1, 2008. 211 pp.

U.S. Fish and Wildlife Service (USFWS). 2012. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. U.S. Fish and Wildlife Service, Panama City Field Office, Florida. Unpublished report dated May 22, 2012. 166 pp.

Walsh, S.J., W.B.Tate, and M.A.Burgess. 2006. Fishes of the Apalachicola River floodplain: role of habitat and hydrology to recruitment. U. S. Geological Survey. Unpublished final report submitted to the Florida Fish and Wildlife Conservation Commission. 124 pp.

Walsh, S.J., E.N. Buttermore, O.T. Burgess, and W.E. Pine, III. 2009. Composition of Age-0 Fish Assemblages in the Apalachicola River, River Styx, and Battle Bend, Florida. U.S. Geological Survey Open-File Report 2009-1145. 28 pp.

Warren, M.L., B.M. Burr, S.J. Walsh, H.L. Bart, R.C. Cashner, D.A. Etnier, B.J. Freeman, B.R. Kuhajda, R.L. Mayden, H.W. Robison, S.T. Ross, and W.C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25, pp. 7-29.

United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
706-613-9493 Fax: 706-613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
706-544-6428 Fax: 706-544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
912-832-8739 Fax: 912-832-8744

November 13, 2013

Mr. Stan Cook
Chief Fisheries Section
Alabama Department of Conservation and Natural Resources
PO Box 301456
Montgomery, AL 36130

Subject: ACF Water Control Manual Updates – Request for Information

Dear Mr. Cook:

The U.S. Army Corps of Engineers, Mobile District (Corps), has resumed the Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM identifies operating criteria and guidelines for managing water storage and release of water from Corps' reservoirs. The proposed update will guide future water management operations at Corps projects in the basin. The Corps has resumed consultation with the U.S. Fish and Wildlife Service (Service) for this action under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*).

The FWCA provides the basic authority for the Service's involvement in evaluating impacts of proposed water resource development projects, including construction and operation of dams, on fish and wildlife resources. The statute requires the Federal action agency for a water resource development project to (1) provide equal consideration to fish and wildlife resource issues as is given to other project purposes in project planning, (2) consult with the Service and State fish and wildlife agency (and the National Marine Fisheries Service in some instances) about these impacts, and (3) work with the Service and State to develop measures to protect, develop, and improve wildlife and their habitat. Where possible, the Federal action agency must incorporate these recommendations in project plans.

The previous Planning Aid Letters (PALs; dated April 2, 2010, and March 1, 2011) and the draft FWCAR (dated June 17, 2011) identified resource values and issues in the basin, including rare species, and proposed changes, mitigation, or enhancement opportunities to minimize impacts and facilitate the Corps' National Environmental Policy Act (NEPA) analysis of the project. The comments in these documents still are applicable. We now are advising the Corps on the current WCM update. In our July 19, 2013, letter (enclosed), we (1) identified a revised reservoir operation alternative that would not result in excessive impacts to river flows or reservoir levels and (2) recommended that the Corps give it full consideration in their NEPA analyses. We

followed up with a PAL that identified performance measures the Corps should use in NEPA evaluations of project effects on fish and wildlife resources and their habitats (August 29, 2013, enclosed). We used performance measures for fish and wildlife resources to develop the Service's Revised Alternative. We have continued to refine the Stella model used to develop the revised alternative, and although the revised alternative has not changed, the performance measure results included in the enclosure of the July 2013 letter have changed accordingly.

We will provide the Corps additional expertise and information in a future FWCAR and during section 7 consultation under the Endangered Species Act. We anticipate coordination with your agency during this process. At this stage in the process, we would appreciate if your agency would share with us any new information or datasets, relevant to the Corps' WCM update since our 2011 draft FWCA report, so that we may be best informed in developing comments and recommendations to the Corps. Over the course of the next year, we plan to share information from the Corps and the draft FWCA report with you, and will attach your comments to the final report to the Corps (unless you choose to provide the Corps with a separate FWCA report).

We appreciate your input in the planning stages of this project. If you have questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Robin B. Goodloe
Acting Field Supervisor

Attachments:
July 19, 2013, USFWS letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

August 29, 2013, USFWS Planning Aid Letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Imm, USFWS, Panama City, FL
K. Herrington, USFWS, St. Charles, MO
B. Pearson, USFWS, Daphne, AL
J. Earle, USFWS, Eufaula, AL
M. Thomas, GADNR, Social Circle, GA
H. Vielhauer, FFWCC, Tallahassee, FL
T. Hoehn, FFWCC, Tallahassee, FL
D. Bernhart, NOAA, St. Petersburg, FL
P. Gagliano, EPA, Atlanta, GA
C. Jackson, Chattahoochee River NRA, GA
B. Turner, ACF Stakeholders, Albany, GA

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
706-613-9493 Fax: 706-613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
706-544-6428 Fax: 706-544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
912-832-8739 Fax: 912-832-8744

November 13, 2013

Mr. Harold G. Vielhauer
General Council
Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, Florida 32399-1600

Subject: ACF Water Control Manual Updates – Request for Information

Dear Mr. Vielhauer:

The U.S. Army Corps of Engineers, Mobile District (Corps), has resumed the Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM identifies operating criteria and guidelines for managing water storage and release of water from Corps' reservoirs. The proposed update will guide future water management operations at Corps projects in the basin. The Corps has resumed consultation with the U.S. Fish and Wildlife Service (Service) for this action under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*).

The FWCA provides the basic authority for the Service's involvement in evaluating impacts of proposed water resource development projects, including construction and operation of dams, on fish and wildlife resources. The statute requires the Federal action agency for a water resource development project to (1) provide equal consideration to fish and wildlife resource issues as is given to other project purposes in project planning, (2) consult with the Service and State fish and wildlife agency (and the National Marine Fisheries Service in some instances) about these impacts, and (3) work with the Service and State to develop measures to protect, develop, and improve wildlife and their habitat. Where possible, the Federal action agency must incorporate these recommendations in project plans.

The previous Planning Aid Letters (PALs; dated April 2, 2010, and March 1, 2011) and the draft FWCAR (dated June 17, 2011) identified resource values and issues in the basin, including rare species, and proposed changes, mitigation, or enhancement opportunities to minimize impacts and facilitate the Corps' National Environmental Policy Act (NEPA) analysis of the project. The comments in these documents still are applicable. We now are advising the Corps on the current WCM update. In our July 19, 2013, letter (enclosed), we (1) identified a revised reservoir operation alternative that would not result in excessive impacts to river flows or reservoir levels and (2) recommended that the Corps give it full consideration in their NEPA analyses. We

followed up with a PAL that identified performance measures the Corps should use in NEPA evaluations of project effects on fish and wildlife resources and their habitats (August 29, 2013, enclosed). We used performance measures for fish and wildlife resources to develop the Service's Revised Alternative. We have continued to refine the Stella model used to develop the revised alternative, and although the revised alternative has not changed, the performance measure results included in the enclosure of the July 2013 letter have changed accordingly.

We will provide the Corps additional expertise and information in a future FWCAR and during section 7 consultation under the Endangered Species Act. We anticipate coordination with your agency during this process. At this stage in the process, we would appreciate if your agency would share with us any new information or datasets, relevant to the Corps' WCM update since our 2011 draft FWCA report, so that we may be best informed in developing comments and recommendations to the Corps. Over the course of the next year, we plan to share information from the Corps and the draft FWCA report with you, and will attach your comments to the final report to the Corps (unless you choose to provide the Corps with a separate FWCA report).

We appreciate your input in the planning stages of this project. If you have questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Robin B. Goodloe
Acting Field Supervisor

Attachments:
July 19, 2013, USFWS letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

August 29, 2013, USFWS Planning Aid Letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Imm, USFWS, Panama City, FL
K. Herrington, USFWS, St. Charles, MO
B. Pearson, USFWS, Daphne, AL
J. Earle, USFWS, Eufaula, AL
M. Thomas, GADNR, Social Circle, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
D. Bernhart, NOAA, St. Petersburg, FL
P. Gagliano, EPA, Atlanta, GA
C. Jackson, Chattahoochee River NRA, GA
B. Turner, ACF Stakeholders, Albany, GA

United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
706-613-9493 Fax: 706-613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
706-544-6428 Fax: 706-544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
912-832-8739 Fax: 912-832-8744

November 13, 2013

Mr. Matt Thomas
Assistant Chief of Fisheries
Georgia Department of Natural Resources-Wildlife Resources Division
2070 U.S. Highway 278, SE
Social Circle, Georgia 30025-4711

Subject: ACF Water Control Manual Updates – Request for Information

Dear Mr. Thomas:

The U.S. Army Corps of Engineers, Mobile District (Corps), has resumed the Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM identifies operating criteria and guidelines for managing water storage and release of water from Corps' reservoirs. The proposed update will guide future water management operations at Corps projects in the basin. The Corps has resumed consultation with the U.S. Fish and Wildlife Service (Service) for this action under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*).

The FWCA provides the basic authority for the Service's involvement in evaluating impacts of proposed water resource development projects, including construction and operation of dams, on fish and wildlife resources. The statute requires the Federal action agency for a water resource development project to (1) provide equal consideration to fish and wildlife resource issues as is given to other project purposes in project planning, (2) consult with the Service and State fish and wildlife agency (and the National Marine Fisheries Service in some instances) about these impacts, and (3) work with the Service and State to develop measures to protect, develop, and improve wildlife and their habitat. Where possible, the Federal action agency must incorporate these recommendations in project plans.

The previous Planning Aid Letters (PALs; dated April 2, 2010, and March 1, 2011) and the draft FWCAR (dated June 17, 2011) identified resource values and issues in the basin, including rare species, and proposed changes, mitigation, or enhancement opportunities to minimize impacts and facilitate the Corps' National Environmental Policy Act (NEPA) analysis of the project. The comments in these documents still are applicable. We now are advising the Corps on the current WCM update. In our July 19, 2013, letter (enclosed), we (1) identified a revised reservoir operation alternative that would not result in excessive impacts to river flows or reservoir levels and (2) recommended that the Corps give it full consideration in their NEPA analyses. We

followed up with a PAL that identified performance measures the Corps should use in NEPA evaluations of project effects on fish and wildlife resources and their habitats (August 29, 2013, enclosed). We used performance measures for fish and wildlife resources to develop the Service's Revised Alternative. We have continued to refine the Stella model used to develop the revised alternative, and although the revised alternative has not changed, the performance measure results included in the enclosure of the July 2013 letter have changed accordingly.

We will provide the Corps additional expertise and information in a future FWCAR and during section 7 consultation under the Endangered Species Act. We anticipate coordination with your agency during this process. At this stage in the process, we would appreciate if your agency would share with us any new information or datasets, relevant to the Corps' WCM update since our 2011 draft FWCA report, so that we may be best informed in developing comments and recommendations to the Corps. Over the course of the next year, we plan to share information from the Corps and the draft FWCA report with you, and will attach your comments to the final report to the Corps (unless you choose to provide the Corps with a separate FWCA report).

We appreciate your input in the planning stages of this project. If you have questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Robin B. Goodloe
Acting Field Supervisor

Attachments:
July 19, 2013, USFWS letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

August 29, 2013, USFWS Planning Aid Letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

cc: J. Ziewitz, USFWS, Tallahassee, FL
D. Imm, USFWS, Panama City, FL
K. Herrington, USFWS, St. Charles, MO
B. Pearson, USFWS, Daphne, AL
J. Earle, USFWS, Eufaula, AL
S. Cook, ADCNR, Montgomery, AL
H. Vielhauer, FFWCC, Tallahassee, FL
T. Hoehn, FFWCC, Tallahassee, FL
D. Bernhart, NOAA, St. Petersburg, FL
P. Gagliano, EPA, Atlanta, GA
C. Jackson, Chattahoochee River NRA, GA
B. Turner, ACF Stakeholders, Albany, GA

Florida Fish and Wildlife Conservation Commission

Commissioners
Rodney Barreto
Chair
Miami

Richard Corbett
Vice Chairman
Tampa

Kathy Barco
Jacksonville

Ronald M. Bergeron
Fort Lauderdale

Dwight Stephenson
Delray Beach

Kenneth W. Wright
Winter Park

Brian S. Yablonski
Tallahassee

Executive Staff
Nick Wiley
Executive Director

Greg Holder
Assistant Executive Director

Karen Ventimiglia
Deputy Chief of Staff

Legal Office
Bud Vielhauer
General Counsel

(850) 487-1764
(850) 487-1790 FAX

Managing fish and wildlife resources for their long-term well-being and the benefit of people.

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850) 488-4676

Hearing/speech impaired:
(800) 955-8771 (T)
(800) 955-8770 (V)

MyFWC.com

February 22, 2011

Mr. Donald Imm
Field Supervisor
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405-3721

Major General Todd T. Semonite
South Atlantic Division
U.S. Army Corps of Engineers
Room 10M15
60 Forsyth Street, S.W.
Atlanta, GA 30303-8801

RE: ACF Master Water Control Manual Update; Fish and Wildlife Coordination Act Comments

Dear Mr. Imm and Major General Semonite:

Pursuant to its consultative role under the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661 *et seq.*, the Florida Fish and Wildlife Conservation Commission hereby provides initial comments on the ACF Master Water Control Manual update. These comments identify relevant fish and wildlife concerns that should be considered in development and analysis of alternative operating regimes (including baseline operations) as the Manual update proceeds. While the Corps has declined to consult directly with Florida, asking instead that we direct our concerns to the Fish and Wildlife Service, we trust these issues will be given appropriate consideration throughout the Manual update process.

We cannot yet comment on the specific alternatives under review because we still have not received any modeling information from the Corps. Rather, we have relied only on limited information made available by the Service. This represents a breakdown in the intergovernmental consultation process, which compromises our ability to provide effective comments. Nevertheless, the enclosed document includes updated research, raising significant hydrologic and biological concerns applicable to any alternative operation that departs from the historic flow regime of the Apalachicola River.

In closing, we reiterate our request that the federal agencies share with Florida all available modeling information relating to the alternatives presently under consideration. Only a fully transparent process can effectively incorporate all relevant scientific and commercial information bearing on the selection of alternatives to be pursued in the Corps' forthcoming draft environmental impact statement.

Sincerely,

Harold G. Vielhauer

Harold G. Vielhauer
General Counsel

Encl.
cc: Thomas M. Beason, Florida DEP

The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems
(February 2011)

1. Introduction to River and Floodplain Impacts

The Apalachicola River-floodplain system harbors an extensive array of natural habitats of great value to the State of Florida. This system includes wetland forests and aquatic habitats that undergo seasonal inundation from the mainstem of the Apalachicola River. Major components of the floodplain ecosystem include 124 miles of major channels, over 400 miles of floodplain channels, 118,000 acres of wetland forests, and 9,000 acres of tidal marshes (Appendix A). More than 60% of the floodplain wetlands in this system are state-owned conservation lands that were acquired primarily to preserve and protect the Apalachicola River and Bay.

The floodplain and its biological resources are degrading as a result of reduced flows from upstream. Most pointedly, there has been a 20-30% decline in spring and summer flows during dry conditions, resulting in less aquatic habitat, based on a comparison of the baseline period (pre-Lanier 1923-1955) to the recent period (post-West Point 1975-2008). The associated harm to biological resources has been most severe during years with low flows, and is expected to worsen if upstream demands increase and Apalachicola River flows continue to decline.

a. Long-Term Decrease in River Flow

Long-term changes in flow in the Apalachicola River have been measured at the Chattahoochee gage (station 02358000; USGS, 2010)[1]. Since 1981, low flows have been lower in magnitude and have occurred more frequently and for longer durations than at any time in the previous 60 years. The problem has been most acute in the last 10 years, with annual average flows in 2000, 2002, and 2007 being lower than any previous year in the entire 86-year period of record. Daily mean flows less than 6,000 cfs occurred almost 4 times more frequently in the recent period (820 days) than in the baseline period (223 days). Daily mean flows less than 5,000 cfs occurred 106 days in the recent period, but never occurred at any time during the baseline period.

Under low-flow conditions, April-August flows have declined an average of 3,200 cfs from baseline to recent periods; this represents a proportional decrease in flows of 23% and 29% for the 75% and 90% exceedance flows, respectively (Figure 1).[2] Flow declines are evident at

[1] All river flow values presented in this report refer to discharge measured at the Chattahoochee gage.
[2] The 90% exceedance flows are ideal for assessing biological impacts because they represent very stressful conditions that occur frequently enough to prevent full biological recovery before the next event occurs. Moreover, in the late spring, summer, and fall of recent drought years, there were several consecutive months during which 90% exceedance flows represented actual flows relatively well (gray bars, Figure 3). This is partly because the summer pulses that were common in the lowest-flow years of the earliest period (Figure 2) have all but disappeared in the latest period (Figure 3). In the hot summer months of June-August, pulses of 11,000 cfs or higher occurred in every year of the baseline period, even during the worst drought years, providing riverine organisms temporary relief from the extreme

higher flows as well; proportional decreases in April-August flows were 12% and 16% for the 25% and 50% exceedance flows, respectively. A shift in the timing of the flood season was apparent to some extent in all five graphs in Figure 1. For example, in the 75% and 90% exceedance hydrographs, the highest flow values in the baseline period occurred during a 2-3 week period from early to late March, whereas the highest values in the recent period occurred several weeks earlier between early February and early March.

An alternative analysis averaging the daily flows for groups of relatively homogeneous years further shows the long-term flow change. Individual years in the baseline and recent periods can be sorted by mean annual flow and then grouped into three nearly equal groups: 1) high-flow years, 2) normal-flow years, and 3) low-flow years (Figure 4; Appendix B). The results show a significant decline in spring and summer flows from the 11 lowest-flow years in the baseline period to the 11 lowest-flow years in the recent period. In April through August of low-flow years, recent discharge averaged about 4,600 cfs less than baseline discharge, which represents a 31% decline in flows. Again, a shift in timing of the flood season was evident in low-flow years in Figure 4; the recent flood season began about 2 weeks earlier in February and ended about 2 weeks earlier in April than the baseline flood season.

Low-flow years were relatively well distributed throughout the baseline period, but 7 of the 11 lowest-flow years in the recent period occurred in the last decade (1999, 2000, 2001, 2002, 2006, 2007, and 2008). Although the timing of droughts is dictated by climatic conditions, there has been an increase in the frequency and duration of very low flows that cannot be explained by changes in climate. Low-flow years in the recent period (1975-2008) had less annual flow but no decline in annual rainfall compared to the baseline period (1923-1955) (Figure 5). This observation was confirmed in a related analysis in Appendix C, which found a significant decrease in the proportion of annual rainfall reaching the Apalachicola River as annual streamflow in low-flow years, from 26% in the baseline period to 22% in the recent period. These results indicate that human activities are increasing the severity of hydrologic droughts on the ACF.

b. General Biological Impacts

Primary functions of the floodplain system include seasonal flood pulsing to which biota are dependent and adapted, connectivity between the channel and floodplain so they behave as an integrated, interdependent unit, and the export of fresh water, detritus, and nutrient/sediment inputs to the Apalachicola Bay. Ecosystem services generated by this system include: (a) habitat for several threatened and endangered species, (b) vast floodplain forests that support high biological diversity and productivity, (c) wetland services such as water quality improvement, flood mitigation, and detritus production for downstream food webs, (d) recreational use and hunting that generate tourism dollars and license fees, (e) a key refuge area for the Atlantic flyway, and (f) support of the Bay as the second most productive fishery on the East and Gulf Coasts of the United States.

---

conditions. However, in the recent period there were 6 years during which June-August flows never exceeded 11,000 cfs; in 2 of those years, 2000 and 2007, flows were less than 7,000 cfs continuously throughout the entire summer and most of the fall.

Flow declines during spring and summer have a greater impact on Apalachicola riverine biota than declines at other times of the year. Reproductive activity, early life stages, and growth of most floodplain organisms are concentrated in the spring and summer months. Flow declines during the spring of low-flow years occurred in the 10,000-30,000 cfs flow range (Figure 4), reducing inundation throughout very large areas of cypress-tupelo swamps (48,000 acres; Table 1). Spring is the primary season for fish spawning. When water levels and flows are too low to inundate floodplain swamps, riverine fishes lose access to food supplies as well as spawning and nursery habitat critical for reproductive activities.

Lack of water in floodplain swamps during spring months inhibits growth and survival of tupelo trees and other plant species that depend on wet conditions. Documented harm to riverine swamps has been extensive, including an estimated loss of over 3 million swamp trees from 1976-2004 (Darst and Light 2008). In addition, four plant species listed by the State of Florida as endangered, threatened, or commercially exploited (Coile and Garland 2003) grow in swamps and low bottomland hardwood forests of the Apalachicola River floodplain at elevations affected by flows of 10,000 to 30,000 cfs (endangered Thorne's buckthorn, *Sideroxylon thornei*; threatened cardinal flower, *Lobelia cardinalis*; threatened corkwood, *Leitneria floridana*; and commercially exploited royal fern, *Osmunda regalis*)[3]. Preservation of these state-listed species is dependent on sufficient flows in the Apalachicola River, particularly during the first 2-3 months of the growing season in the spring.

Flow declines during the summer occurred in the 5,000-15,000 cfs flow range (Figure 4), reducing connectivity of aquatic habitats in the floodplain of the riverine reach (Figure 6) and increasing salinity in the river and distributaries of the lower tidal reach (Figures 7 and 8). In the riverine reach, decreased flows cause loss of aquatic habitats as floodplain sloughs, streams, and lakes become disconnected from the main channel, exposing stream beds and creating isolated pools that become anoxic in hot weather. Decreased flows also expose woody debris along stream banks in the riverine reach, and expose other habitats that were historically covered with water during the summer. Fish access to these important habitats is critical for food and shelter for juveniles during the summer-fall nursery season, and mussels need flowing-water habitat for survival year-round. Many estuarine organisms, including juvenile Gulf sturgeon, require adequate flows in summer and fall to maintain tolerable salinities in feeding grounds in the river and distributaries of the lower tidal reach.

Decreased inundation of floodplain forests in the spring has greatly reduced available aquatic habitats for fishes during their peak spawning season. Of the approximately 230 miles of floodplain sloughs, streams, and lakes in the riverine reach (upper 86 miles of the river), less than one-quarter remain connected at the very low flows which have become much more prevalent in summer. As very low flow periods become more frequent and last longer, aquatic

[3] These four species have been found at low elevations in Apalachicola River floodplain forests by Angus Gholson (Gholson 1985), Melanie Darst (unpublished field notes in files of USGS, Tallahassee), and Loran Anderson and others (FSU herbarium labels). Corkwood and royal fern are classified as obligate wetland species in the National wetland plant list (Reed 1997). Cardinal flower is an obligate wetland species according to the Florida wetland plant manual (Tobe et al. 1998). Thorne's buckthorn is so rare that it is not listed in either source, but appears to be an obligate wetland species based on the consistently low and wet habitat conditions described on FSU herbarium labels for this species. (An "obligate wetland species" almost always occurs in wetlands under natural conditions.)

habitats will be progressively reduced in extent and degraded in quality due to lack of water flow from the Apalachicola River mainstem. Effects extend to the Lower Chipola River, which receives about 75% of its flow directly from the Apalachicola River, and in the river and distributaries of the lower tidal reach, which become more saline when flows are very low.

Table 1. Selected species and habitats of the Apalachicola River and floodplain that have been adversely affected by decreased flow in spring and summer of low-flow years. [up, upper; mid, middle; lo, lower; mi, mile; ac, acre]

Season	**Effects of decreased flow on selected species and habitats** (fish/mussel impacts described in more detail later in report)	**Amount and type of affected habitat**	**Location of affected habitat**					
			Riverine			**Tidal**		
			Up	**Mid**	**Lo**	**Up**	**Mid**	**Lo**
April May	Spawning activities of the threatened Gulf sturgeon[1] are reduced when limestone shoals are exposed during spawing season.	3 confirmed and several potential sites (upper 6 mi)	●					
	Fish feeding and spawning activities are severely restricted when floodplain forests are not inundated during spawning season.	48,000 ac of swamp forests[4]	●	●	●	●	●	
	Reduced inundation of tupelo-cypress swamps in the spring inhibits tree regeneration, causing long-term declines in the number of trees and a shift in forest composition toward a drier mix of species.							
	State-listed plants in swamp forests[2] are affected by reduced flood inundation in the spring.							
June July August	Striped bass mortality occurs when cool-water floodplain streams are not accessible for thermal refuge. Adults of this species need an escape from high temperatures in main channel during summer.	11 cool-water refuge streams[5]	●	●				
	Fish spawning and juvenile survival is reduced when floodplain sloughs are disconnected from main channel during summer. Fishes and invertebrates die when trapped in disconnected pools.	200 mi of floodplain sloughs, streams, lakes[6]	●	●	●			
	Fish and invertebrate productivity declines when woody debris along sloping banks of main channel and floodplain sloughs are exposed.	750 mi of bank habitat[7]	●	●	●	●		
	Dessication and mortality of endangered fat three-ridge[1] and threatened purple bank climber[1] occurs where limestone shoals, bars along channel margins, or other critical habitats are exposed.	Sites along 90 mi of main channel and 2 mi of Swift Slough[8]	●	●	●	●		
	Salinity in lower tidal reach increases during extended periods of low flow, affecting fishes, aquatic invertebrates, submerged aquatic plants, and wetland plants[3] that are intolerant of high salinity .	6 mi of main channel, 90 mi of sloughs, 7,400 ac of swamp forests, 9,000 ac of tidal marshes[9]						●

Footnotes on next page

Table1. [Continued – Footnotes]

[1]Federally listed.

[2]Endangered Thorne's buckthorn (*Sideroxylon thornei*), threatened cardinal flower (*Lobelia cardinalis*) and commercially exploited royal fern (*Osmunda regalis*).

[3]Including State-listed species: threatened corkwood (*Leitneria floridana*), threatened cardinal flower (*Lobelia cardinalis*) and commercially exploited royal fern (*Osmunda regalis*).

[4]Appendix A Part 3. Riverine swamps (22,270 acres) plus upper and middle tidal swamps (26,100) equals 48,370 acres; rounded to 48,000 acres.

[5]Ten streams located throughout the upper riverine reach and one stream in the upper part of the middle riverine reach.

[6]Slough disconnection occurs in riverine reach but not tidal reach. Of the 230.5 miles of sloughs in the riverine reach, 18.7 miles are permanently connected (Light et al. 1998). [230.5 – 18.7 = 211.8; rounded to 200 miles]

[7]Appendix A Part 2. Includes banks along both sides of 85.8 miles of Apalachicola River, 16.5 miles of Lower Chipola River, and 230.5 miles of floodplain channels in riverine reach. Also includes 6.6 miles of major channels and 38.9 miles of floodplain channels in upper tidal reach. [85.8 + 16.5 + 230.5 + 6.6 + 38.9 = 378.3; doubled for banks on both sides is 756.6; rounded to 750 miles]

[8]Both species have been found throughout the upper 90 mile of the river. Primary site for purple bankclimber is at Race Shoal less than a mile downstream of Woodruff Dam, and primary sites for fat three-ridge are at multiple locations between river miles 30 and 55.

[9]Appendix A Part 2 and 3. Rounded numbers for all tidal floodplain channel lengths and wetland areas that are affected by salinity according to Figure 7. Nearly all are located in the lower tidal reach. [Figure 7 shows that not all lower tidal sloughs are affected by salinity, but several miles in the extreme lowest part of the middle tidal reach are affected by salinity. When the affected middle tidal reach sloughs were added, and the unaffected lower tidal reach sloughs subtracted, the total length was 90.5 miles, which was rounded to 90 miles.]

Of the myriad biological consequences of reduced flow in the Apalachicola River and floodplain we focus primarily on the following three impacts:

- loss of spawning and rearing habitats for an array of fish species leading to bottlenecks in fish reproduction, survival, and growth, especially when flows needed for strong year classes do not occur
- exposure of known spawning habitat of the federally protected Gulf sturgeon leading to failed reproductive success, and increases in salinity of delta distributaries leading to degraded conditions not suited for Gulf sturgeon juveniles
- high mortality of federally protected mussel species due to stranding, habitat loss, and isolation along banks of the mainstem and in floodplain sloughs.

2. Fishery resources

The Apalachicola River-floodplain system has one of the largest assemblages of freshwater fishes in Florida (Bailey et al.1954; Bass 1983). A total of 142 fresh water and estuarine fish species have been found in the riverine and tidal reaches of this river system. Approximately 99 species of fish are known to occur in the riverine reach and 79 of these species (80%) have utilized or are known to occur in floodplain habitats during their life history (Appendix E). At least 45 species are known to utilize the Apalachicola River floodplain for spawning and nursery habitats based on larval fish light trap collections from 2002-2007 (Walsh et al. 2006, 2008; Stephen J. Walsh, USGS, personal communication, 2010).

There are eight diadromous species, four endemic species, and twelve introduced species found in the system. Among these species are the anadromous Gulf sturgeon, catadromous American eel, endemic blue-striped shiner, and endemic shoal bass (Yerger 1977). The system also supports some of the largest extant populations remaining in the U.S. of two anadromous species, Alabama shad (Mettee et al. 1996) and Gulf striped bass (Wooley and Crateau 1983).

The sport fishery consists primarily of Centrachids (sunfishes, basses, and black crappie), Ictalurids (mainly channel catfish, flathead catfish, and blue catfish), and to a much lesser extent striped mullet near the rock shoals in the upper riverine reach and southern flounder in the lower riverine reach. Centrarchids were one of the dominant families in larval fish collections in the Apalachicola River and floodplain (Walsh et al. 2006, 2008). Sunfishes, largemouth bass, striped bass, white bass, black crappie, and catfish provide favorite recreational fisheries below Jim Woodruff Lock and Dam (JWLD).

During a 12-year period (1990-2002) the recreational fresh water fishery within the first 6 miles below JWLD and the lower 10 miles above the mouth has been estimated to generate a combined $1,353,000 to $2,032,000 annually from fishing effort during a 14-week peak creel survey period conducted from mid-February through May (DEP 2004). There are no estimates for the recreational fresh water fishing in the remaining 90 miles of main river channel or the more than 400 miles of floodplain sloughs, streams, and lakes in the riverine and tidal reaches of the system. However, field observations indicate there are significant bream, bass, black crappie, and freshwater catfish recreational fisheries in the remaining sections of the main river and backwaters that have not been surveyed for angler catches.

Decreased spring and summer flows have resulted in less aquatic floodplain habitats in the Apalachicola River-floodplain system during critical spawning and nursery periods. Walsh et al. (2008) identified early March to mid-June as the prime spawning and nursery periods for most of the fresh water species (including Centrachids) within the system. Some species continue to spawn in the summer months, and adequate flows throughout the summer are important for juvenile growth as well. During typical dry and drought conditions, availability of inundated floodplain aquatic habitat in April-May has declined 50-80% since 1975 compared to the baseline period of 1923-1955 (Figure 9a). About one-third of the sloughs in the middle riverine reach, which were connected to the main channel nearly all summer in the baseline period, have been completely disconnected during drought conditions in the summer since 1975 (Figure 9b).

That said, flows can be highly variable (<5,000 to >200,000 cfs). In the following paragraphs, fish life cycle processes in the Apalachicola River and floodplain are described in terms of the three major flow categories (high, medium, and low; measured at Chattahoochee, Florida).

High flows (>30,000 cfs) occur in most years from January through April inundating large areas of the 82,000-acre forested floodplain in the riverine reach (Figure 10). During flows of 32,000 cfs approximately one-half of the nontidal floodplain (40,700 acres) is connected to the main channel, while at 50,000 cfs, approximately 82% of the floodplain (67,400 acres) is inundated (Light et al. 1998). When these backwater areas are flooded, they serve as a refuge from the high velocities within the main channel and an opportunity for fish to migrate into the inundated floodplain to feed on aquatic and terrestrial organisms.

From March to June, adult largemouth bass and other species migrate into floodplain habitats during high flows for feeding and spawning. Pine et al. (2008) reported a strong seasonal movement of adult sonic tagged fish (largemouth bass, redear sunfish and spotted suckers) from the mainstem channel of the Apalachicola River to floodplain habitats during the spawning season from March to June. Over a 45-60 day period following these movements to the floodplain, larval fish catches in light traps increased substantially. Light traps collected 45 species of larval fish in the floodplain from 2002-2007 (Walsh et al. 2006, 2008; Stephen J. Walsh, personal communication, 2010), demonstrating the importance of floodplain aquatic habitats for reproduction. Maintaining high flows and inundation of the floodplain from March through June provides much needed aquatic habitats for newly hatched larval fish during this prime spawning and nursery period.

Medium flows (10,000-30,000 cfs) maintain main channel connections with tupelo-cypress swamps and floodplain sloughs and backwaters. All of the 230 miles of nontidal sloughs are connected at flows of about 19,000 cfs, and about half of them are connected at 10,000 cfs (Light et al. 1998). Thermal cool-water refuges for Gulf striped bass in the upper riverine reach are connected to the main channel during medium flows and provide critical summer habitats. Area of inundated floodplain forest, which is used for spawning and nursery habitats, is greatly reduced as flows decline below 14,000 cfs (Figure 11). As flows dropped below this level during a recent study, many adult fish returned to the main channel or major sloughs and larval fish collections in light traps declined (Pine et al. 2008).

Ongoing FWC fishery studies show that strong year-classes of largemouth bass were produced during years with extended periods of flows exceeding 13,000 cfs during spring and summer months (2003 and 2005) (Figure 12). Year-classes of largemouth bass were weak during years when flows were much lower than normal through most of the spring and summer (2004, 2006, 2007, and 2008). These data show a strong positive correlation ($r^2=0.88$; $p<0.05$) between March-September flows and fish abundance (Allen et al. 2009). March-September flows exceeded typical historic drought conditions 100% of the time in 2003 and 2005, but less than 50% of the time in 2004, 2006, 2007, and 2008. Three years of size distribution data for four sportfish species (Figure 13) also show markedly higher numbers of age-0 fish in a wet year (2005), as compared with dry years (2006 and 2007).

Strong age-0 largemouth bass year-class estimates from electrofishing catch rates were confirmed at age-1 and age-2 as these cohorts recruited to the adult populations and contributed significantly to the fishery (Figure 14). Maintaining floodplain forest inundation for extended periods during prime spawning and nursery periods in the spring is critical for producing stronger year-classes of many fish species within the Apalachicola River-floodplain system. Slough connectivity in the summer is also needed for subsequent juvenile growth and survival.

Low flows (<10,000 cfs) typically occurred during September, October, and November prior to 1955; however, it has become more common in recent years for low flows to occur throughout both summer and fall (Figures 1 and 4). When flows drop below 10,000 cfs during spring, floodplain forests are almost completely drained of standing water (Light et al. 1998). Adult fish that were using inundated forest areas for spawning must abandon their nests as they return to sloughs and the main channel where nursery habitats, cover, and food are much more limited. Adult and larval fish can become stranded in isolated pools if rates of decline are >1-2 feet/day.

There are only an estimated 740 acres of aquatic floodplain habitat (mostly in large backwater sloughs) at 8,000 cfs (Light et al. 1998). Many smaller sloughs are disconnected from the main channel, and water becomes stagnant as dissolved oxygen values decline through summer into fall. Adult fish become concentrated in deep areas of major sloughs and the main channel, while young age-0 fish are concentrated in connected sloughs and backwaters presumably for shelter and food. Comparisons of size distributions from electrofishing samples of 4 different species in 2005 revealed age-0 sportfish collected in September were substantially more abundant in sloughs compared to main channel habitats (Figure 15).

During **very low flows** (<6,000 cfs) much of the woody structure and natural bank root systems in main channel and side channel habitats is exposed. Valuable habitat complexity becomes unavailable for spawning, nursery, and predator avoidance functions (Light et al. 1998), and also limits the amount of aquatic habitat with macro-invertebrate populations that can be utilized as food by fish (Ager et al. 1986). As flows drop below 6,000 cfs, extensive side pools and low flow aquatic habitats that would otherwise be used as spawning and nursery areas become disconnected and often completely dry. Only a limited number of backwater sloughs in the middle and lower riverine reaches remain connected to the main channel at very low flows. Spawning and nursery habitats are extremely limited and shallow if very low flows exist during the March-June prime spawning season, which occurred in late spring of 2000 and 2007.

In addition, many cool-water spring runs in the upper riverine reach are too shallow to provide thermal refuge for adult Gulf striped bass survival during summer (Long et al. 2009). Rock shoals in the upper riverine reach are exposed and much of the river bottom has limited submersed woody debris useful for fish habitat. Dissolved oxygen levels in disconnected sloughs and backwater lakes are lower than the main channel during very low flows in summer and fall. Very low dissolved oxygen levels (<2.0 ppm) have been observed in the upper reaches of several connected major sloughs (Florida River, River Styx, and Kennedy Creek) during very low flows.

Persistent low flows negatively impact the year-classes of many freshwater species that rely on floodplain aquatic habitats for spawning and nursery functions. Crayfish (*Procambarus* spp.) are an important food item found in stomachs of sportfish such as largemouth bass that inhabit the Apalachicola River main channel and floodplains (Ager et al. 1986). In floodplain habitats of the Escambia River, Florida, crayfish constituted the bulk of the animal biomass (Bass 2002). Most riverine crayfish populations are directly controlled by annual water level fluctuations, and reduced crayfish populations during drought conditions have been observed in other rivers (Huner 1978 and 1997). Pollard et al. (1983) suggested that reductions in the extent and duration of flooding in Louisiana swamp habitats would likely diminish biological production in the Atchafalaya basin, thus resulting in less food for freshwater fishes with potential impacts on survival, growth, and condition. Similarly, lower flows and decreased inundation of crayfish habitats in the Apalachicola River-floodplain system have likely caused large reductions in this important food supply for fishes, resulting in slower growth, poor body condition, and potentially poor survival of fish.

Studies of fish length and weight in the Apalachicola River over multiple years support this assumption. Age-0 largemouth bass collected in electrofishing samples in September (2003 - 2007) revealed significantly higher ($p < 0.05$) mean total lengths and relative weight (Wr) values[4] during years with high spring-summer flows (2003 and 2005) compared to years with low spring-summer flows (2004, 2006, and 2007) (Figures 16 and 17). These results suggest that better feeding conditions existed in years with greater floodplain inundation of nursery habitats (Cailteux et al. 2007).

In summary if very low flows persist during critical spawning and nursery periods in spring and summer, weak year-classes and a decline in fish populations can be expected for many species. Consecutive and multiple years of very low flows can reduce survival and growth of young-of-the-year fish species that typically utilize floodplain habitats during critical production and development periods. Extended periods of low and very low flows are a bottleneck to the vitality of fish populations in the system and these low flows are a key factor limiting fish productivity and survival. Further reductions in flow will continue to reduce the capacity of both the channel and floodplain aquatic habitats for fish production and survival.

[4] Relative weight (Wr) is the ratio of the actual weight of a fish to what a rapidly growing healthy fish of the same length should weigh, which is called "standard weight" (Anderson and Neumann 1996). These Wr values can be calculated and compared statistically.

a. Gulf sturgeon

Estimates of the population of Gulf Sturgeon in the Apalachicola River system range widely depending on the collection type and analytical treatment of the data. One thing is clear; the population is quite low. Because the species exhibits a high degree of fidelity for specific rivers within panhandle Florida, it is unlikely that further declines can be repopulated from other sources such as the Suwannee River (USFWS and GSMFC 1995). Consequently, the future status of the Gulf sturgeon population in the Apalachicola River-floodplain system is dependent upon the maintenance of spawning and rearing habitats within the river.

Because the original habitats have been severely diminished through truncation by the JWLD, spawning and rearing of the population are now dependent only on the Apalachicola River-floodplain system itself. Within this constraint, two regions are known to be particularly vulnerable to low flows: hard bottom sites as exemplified by the Race Shoal outcrop and the distributaries of the Apalachicola River delta. While other sturgeon habitats undoubtedly are vulnerable to effects from low flows, the critical role of these two habitats has been documented.

Gulf sturgeons are long-lived, with some individuals reaching at least 42 years in age. The age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years. Research on spawning periodicity of Gulf sturgeon indicate that males may be capable of annual spawning, but females require more than one year between spawning events (Huff 1975; Fox et al. 2000).

Increasing water temperature and flow during spring usually initiate spawning movements of adult Gulf sturgeon (Huff 1975). Spawning normally occurs between mid-March and early June, corresponding to typical historic high flow conditions. The peak spawning period occurs in the April-May timeframe pending appropriate water temperatures (16-20°C / 64-71°F), flows, and possibly lunar phases. River flow may also serve as an environmental cue that initiates both sturgeon migration and spawning.

Habitat at spawning sites where egg collection has occurred is well documented (Sulak and Clugston 1999; Fox et al. 2000; USFWS 2008). Fertilized eggs hatch in approximately 2 - 4 days and the larval fish inhabit cracks and crevices at the spawning site and in nearby areas to further develop. After 14 days, the larval fish are free-swimming. Flow and velocity requirements for Young-of-Year (YOY) sturgeon may vary depending on suitable substrate type. Chan et al. (1997) reported that YOY Gulf sturgeon under laboratory conditions exposed to water velocities over 12 cm/s (0.4 ft/s) preferred a cobble substrate, but at water velocities under 12 cm/s (0.4 ft/s) they used a variety of substrates (sand, gravel, and cobble). If spring flows and water velocities are too high or too low, several life-history stages of Gulf sturgeon may be adversely affected.

Within the system, seven locations have been identified as potential spawning areas, with documentation of sturgeon eggs at three sites below JWLD. These documented spawning sites ranged in length from 390 ft to 10,000 ft, and consisted of limestone outcropping habitats, shelves, walls, and high sand bluffs with hard substrates. Where limestone outcropping occurs, it is a shelf along one or both banks, generally in the vertical range of stages inundated by flows of 6,000 to 11,000 cfs.

The primary known spawning area, Race Shoal, is located at RM 105 near the town of Chattahoochee, Florida.[5] Detailed Army Corp of Engineers (COE) bathymetric surveys of Race Shoal in 2005 were used to develop a flow/stage to depth of rock relationship (USFWS 2008). This relationship has been used to predict and estimate the area of submersed rock habitat that may be available for spawning given a specific flow range and water level. From this an accurate estimate of flow necessary to cover Race Shoal can be derived. A depth of 4 feet is considered to be the minimum depth for Gulf sturgeon spawning. Approximately 21,600 cfs flow is needed to cover the entire shoal to a depth of 4 ft. Spawning depths can be maintained with a flow of 15,000 cfs in the more steeply sloping habitat closer to the channel thalweg. However, this habitat is considered to be suboptimal because of less texture in the rock surface, steeper slopes, and higher velocities. Since the construction of JWLD in 1954 and prior to the recent droughts beginning in 1999, flows exceeded 15,000 cfs for at least two consecutive weeks[6] at some time during peak spawning season (April-May) in 41 out of 44 years (93% of the years from 1955-1998). This has not been the case since 1999. Flows exceeded 15,000 cfs for two consecutive weeks in April-May in only 6 out of 12 years from 1999-2010 (50% of the years). In one of those years, 2006, the minimum flow during the highest 2-week period of the peak spawning season was only 15,200 cfs. As a consequence, sturgeon eggs were collected in 2006 only at the lower, less favorable portions of the shoal because most of the shoal was exposed.

Gulf Sturgeon were observed in the spring of 2008 to spawn over at least a 41-day period (Scollan and Parauka 2008). The upper egg sample site at Race Shoal accounted for the most spawning activity with 72% of the total eggs recorded during the 2008 study. Water temperatures ranged from 19.12 to 24.41°C during the period when eggs were collected (April 4 to May 14, 2008), which was consistent with previous studies conducted on the Apalachicola River. When egg collections from 2005, 2006, and selected 2008 collections are combined, the middle 80% of the data ranges from water depths of 7.2 to 17.1 ft, with a median elevation of 37 ft above mean sea level. Multiple females likely contributed to the spawning based on multiple spikes in egg collections and evidence of three groups of radio tagged adult sturgeon moving upriver during the study.

The relationship between egg collection and river stage is illustrated by differences between spring 2005 and 2006 (Figures 18 and 19). Lower flows and stages in 2006 appear to restrict collections to a narrower width of the limestone outcrop. Under normal flows the preferred spawning substrate appears to be located on the “flatter slope” portion of the hard-bottom shoal near the left descending shore based on the cross-section. These limestone areas are extremely rough and irregular. This irregularity and roughness provides a refuge for newly

---

[5] However, the collection of three very small 1- 4” (25-100 mm TL) YOY sturgeon in June 2009 at the mouth of the Brothers River suggests another possible spawning area in the lower Apalachicola River or Brothers River (FWC unpublished data).

[6] Two weeks is the approximate time required for eggs to hatch and larvae to become free-swimming.

hatched fry from high velocities due to the many cracks and crevices in the rock. USFWS (2008) provides further support of this by stating that “at one location where sturgeon eggs were collected from a depth of 14.1 ft on May 2, 2005, the water velocity 1 ft below the water surface was 3.8 ft/sec and was 0.4 ft/sec 1 ft above the river bed.” The shallow depths and exposed rock during low flows associated with flow regulation during drought condition severely restrict spawning activities and egg survival to levels approaching zero (Flowers et al. 2009)

The Gulf sturgeon spawning season is of course a critical period for the life cycle of the species. Figure 20 compares the number of days with flows during dry (75% exceedance) and drought (90% exceedance) conditions in the baseline (1923-1955) and recent years (1975-2008) above 15,000 cfs (considered to be the threshold of suboptimal conditions for spawning at Race Shoal). For the 90% exceedance flow (bottom graph), the estimated number of days during drought conditions was 49 days during the baseline but only 15 days during the recent period. A similar but less severe trend is shown for 75% exceedance flows (top graph). These estimates indicate that lower flow conditions now severely reduce the availability of suitable Gulf sturgeon spawning habitat at Race Shoal.

As noted above, there has been a temporal shift in the timing of high flows, along with the typical falling stage to summer levels, to earlier in the year. The shift is occurring when water temperatures are too low for sturgeon to spawn and at a time when spawning runs typically would not occur. This shift in flow regime is an additional factor in the inhibition or failure of successful spawning of this T&E species within this river system.

After spring spawning, adults appear to stay in the main river system until October or November (6 to 8 months). During the spring and summer, adult Gulf sturgeon in general do not appear to actively feed while inhabiting freshwater rivers and as a result lose weight (Mason and Clugston 1993; USFWS 2008; Wooley et al. 1985). However, adult sturgeon are believed to actively forage as soon as they enter the estuarine and marine environments after the fall migration from the rivers. During this time, they regain not only all of the mass they lost, but also grow significantly more. Furthermore, when females are becoming spawn-ready, even greater volumes of food must be consumed to generate the mass of eggs and sustain the upstream migration to the spawning site. With a limited timeframe for winter-feeding opportunities (~October through ~April), active foraging must be initiated as rapidly as possible as a survival strategy.

Protecting YOY and sub-adult Gulf sturgeon is also critical. These usually stay within the distributaries and estuary during their first six years. Kynard and Parker’s (2004) experimental observations indicate that movement and migration of the larvae and juveniles are primarily conducted at night resulting in a stop-and-start downstream movement. The downstream migration of the YOY juveniles is stopped upstream of the freshwater/saltwater zone. YOY have been reported to be limited to freshwater environment due to an inability to osmoregulate. Sulak and Clugston (1999) estimated that, in the Suwannee River, larval/juvenile fish needed to spend approximately 5 months in fresh water between the spawning grounds and the mouth of the river where salinities increase. Limited collections of larval/juveniles have been acquired from plankton tows (Race Shoal) or trawls in the lower Apalachicola River near the mouth of Brothers River (Wooley et al. 1982; Foster et al. 1988; FWC unpublished data).

Recent statements to USFWS from USGS staff speculate that "Successful year-classes may be infrequent, may depend on mid-summer water conditions for YOY, rather than on spawning success" (Sulak pers. comm. 2009). Flowers et al. (2009) further states that "it is important to keep in mind that a strong year-class appearing in the length-frequency distribution is the product of, first, good spawning conditions, and then several ‘‘good’’ years for sturgeon survival over a variety of life stages." It remains undetermined which factors (spawning success, mid-summer water conditions, and prey abundance, or others) play the dominant role in YOY survival and sturgeon population growth.

Juveniles to sub-adult sturgeon generally undergo increased salinity tolerance with age. As they mature the salinity tolerance is up to 5 parts per thousand (ppt), but salinities greater than 10 ppt may limit access to feeding habitat (Parauka et al. 2001) or result in death (Kynard and Parker 2004). As the sturgeon matures, the salinity tolerance increases due to physiological changes. Usually once they exceed 170 grams, they are capable of more rapid osmoregulation (Altinok et al. 1998).

Once fish reach age-1, they most likely feed near the mouth of the river and in low salinity regions of Apalachicola Bay. This behavior would be consistent with information from the Suwannee River estuary (Sulak et al. 2004; Parkyn et al. 2006). The Bay is shallow, averaging 1.8 to 2.7 m in depth. Soft muddy substrates comprise an estimated 78% of the open water zone with the remainder divided between oyster reefs and sandy sediments with submerged aquatic vegetation (Livingston 1984). Livingston (1983) reported that polychaete worms were the most abundant infaunal species found in the sediments of the Apalachicola Bay during the winter months. Further efforts in 1999 by The Florida Department of Environmental Protection (DEP) demonstrated that polychaetes, bivalves, gastropods, and amphipods dominated the benthos of Apalachicola Bay (Iocco et al. 2002). All of these organisms have been reported as food items for Gulf sturgeon (Huff 1975; Mason and Clugston 1993). The highest infaunal abundance in the Apalachicola Bay region occurred in the sediments of the lower river and distributaries (dominated by amphipods), and the second highest abundance occurred in East Bay (dominated by polychaetes). The DEP study also noted that salinity was negatively correlated with average abundance and biomass of infaunal organisms, but positively correlated with average species richness of infaunal organisms.

Juvenile sturgeon remain in low salinity and fresh water regions of the system to reduce early mortality (Flowers et al. 2009; Kynard and Parker 2004; Altinok et al. 1998). Higher salinity levels during low flows in the nearshore and estuarine areas may affect osmoregulation and thus reduce foraging areas. Figure 21 shows that during the months of June through November at low flow conditions an estimated 7,000 cfs is needed to provide low salinity (<10 ppt) conditions in the distributaries of the Apalachicola delta. This condition is reduced from an estimated 140 days during the baseline to an estimated 29 days during the recent period. In the brackish-water zone of the lower tidal reach, elevated salinities in lower river and distributary streams occur during low flows (Figure 8). Salinities gradually increase with decreasing flow, but are highest when flows drop below 7,000 cfs. Total number of days when daily mean flows were less than or equal to 7,000 cfs was much higher in the recent period (1,336 days) than in the baseline period (555 days). Flows were less than 7,000 cfs for more than 200 days per year in two of the last ten years. In the preceding 75 years (1923-1998), the duration of time with flows less than 7,000 cfs never exceeded 100 days per year.

Some direct observations now corroborate the restriction of juvenile sturgeon to delta and nearshore areas of Apalachicola Bay. The US Geological Survey conducted a limited winter study during 2006-2007 to monitor the movements of juvenile sturgeon within the East Bay-Apalachicola Bay area (Sulak et al. 2009). An array of 14 passive receivers was deployed that tracked the movements of four juvenile sturgeon (age 1-2 fish) ranging from 350-750 mm total length (TL). Of the radio tagged sturgeon, three (429-680 mm TL) were located several times although no locations were obtained for a fourth fish. These preliminary observations indicate that juvenile sturgeon remained close to shore (within 1-3 km), and mostly in the East Bay area (Figure 22). After October 2006, no encounters were detected by receivers within the main Apalachicola River proper or East River proper until late March 2007 when the fish began moving into that area. During the monitoring period, no data were obtained from the three receivers deployed further offshore in the bay. These preliminary observations suggest that early juvenile sturgeon may be using very shallow, nearshore areas and distributaries as winter feeding grounds.

b. Endangered mussels

The Apalachicola River basin historically contained a diverse mussel fauna of 34 species including 7 endemics. At least 3 of these endemics are believed to be extinct and 5 species are protected under the Endangered Species Act. The Apalachicola River-floodplain system in Florida including the Lower Chipola River downstream of Dead Lakes is presently known to contain extant populations of at least 3 federally protected mussels; the federally endangered *Amblema neislerii* (fat threeridge), federally threatened *Elliptoideus sloatianus* (purple bankclimber), and federally threatened *Elliptio chipolaensis* (Chipola slabshell). The status of threatened and endangered (T&E) mussel species in the Apalachicola River-floodplain can be generally characterized as declining. The USFWS (2008) concluded that both the fat threeridge and purple bankclimber were in various states of decline and that purple bankclimber populations may be experiencing “widespread reproductive failure” in both the Apalachicola and Flint Rivers.

Mussels are often considered a “keystone” species within rivers and perform critical ecological functions that positively influence diversity of other macroinvertebrate and fish communities (Vaughn and Hakenkamp 2001; Vaughn et al. 2001; Zimmerman 2004). Shell producing mollusks such as unionids have been postulated as ecosystem engineers; like oyster beds, the production of abundant, persistent shells (both live and dead) creates habitat resources that are otherwise unavailable to aquatic organisms such as invertebrates, periphyton, and small fishes (Gutierrez et aI. 2003). Similarly, communities of mussels may be able to stabilize substrates (Zimmerman 2007), thus creating important permanent habitats. The combination of mussel shell shapes and sizes within a mussel “bed” has been shown to contribute to substrate stability within the laboratory (Zimmerman and de Szaly 2007). In the Apalachicola River system and other Gulf drainage streams where relatively large stable substrates such as gravel and cobble are rare, live mussel communities themselves may represent key habitats for other biota (Johnson and Brown 2000; Zimmerman 2004).

Comparisons between historical and recent records indicate that dramatic declines in mussel abundance, distribution, and diversity of the Apalachicola and Chipola Rivers have occurred in the past 100 years. Brim-Box and Williams (2000) found historical records for 27 species in the mainstem Apalachicola River but found only 8 species during recent surveys. Unionid species richness in the Chipola River declined from 27 species historically to 19 species (Brim-Box and Williams 2000). Additionally, dramatic changes in the distribution of many ACF unionids have also occurred suggesting that habitat degradation is not limited to mainstem reaches.

Apalachicola mussels, including T&E species, generally live in rivers with flowing water all or most of the year and are relatively sedentary for their adult lives. Most adult mussel species are relatively sessile but can move underwater both vertically (Watters et al. 2001) and horizontally for short distances in response to water-level fluctuations or temperature changes. However, stranding also is common and movement can be limited. If the mussel becomes exposed, horizontal movement becomes an even greater effort and the animal may bury itself as a last resort if submergence is not achieved. Substrates such as sand and firm mud are easier for mussels to navigate than heavier substrates such as gravel and cobble. Mussels living on some types of bedrock, such as that at Race Shoal, are probably unable to move at all.

The three T&E mussel species in the Apalachicola River system require one or more specific fish hosts in order to reproduce (Table 2). These species must be in proximity to their host fish when water temperatures are at the correct temperature. Other conditions, such as water turbidity (fish hosts visually identify conglutinates as food items), water velocity, and connectivity between river and floodplain can have far-reaching implications to mussel reproductive success.

Table 2. Summary of reproductive variables of the fat threeridge, purple bankclimber, and Chipola slabshell. Table summarized from O'Brien and Williams (2002), Johnson (2007) pers. comm., Keller and Ruessler (1997), Priester (2007, unpublished data), and G. Zimmerman (pers. obs., June 2006).

Species	Brooding	Gravid temperature	Glochidia mechanism	Potential fish hosts
Fat threeridge	Short-term summer	75.2^{o}F	Sticky, web-like mass; conglutinate	Weed shiner; bluegill; redear sunfish; largemouth bass; blackbanded darter
Purple bankclimber	Long-term / short term winter / spring	46.4 to 59.0^{o}F	Thin conglutinates	eastern mosquitofish; blackbanded darter; guppy; greater jumprock
Chipola slabshell	Possibly short-term in the summer	Not known	Conglutinate is likely	bluegill; possibly other sunfish species

It is believed that the upper age is approximately 27 years for the fat threeridge and 15 years for the purple bankclimber. No growth data are known from the Chipola slabshell. Between 2006 and 2007 the USFWS thin-sectioned 31 dead shells of the fat threeridge. Thin-sectioning is a process by which a shell is cut into thin slices cross-grain and the number of observed annuli is counted as years under a microscope, similar to reading the annual rings of a tree (Neves and Moyer 1988; McCuaig and Green 1983). The USFWS found fat threeridge ages ranged from 2 years old (36 mm total length) to 27 years old (85 mm total length). They also found that there was a statistically significant relationship between the length of fat threeridge and age (USFWS 2008).

EnviroScience similarly conducted age and growth analyses on 11 purple bankclimber shells collected in 2005 (EnviroScience, unpub. data). Estimated assigned ages ranged from 3 years old (80 mm total length) to 15 years old (184 mm total length). Subsequent USFWS analysis of the length-age data (USFWS 2008) identified a pattern of fast initial growth, followed by slower and slower growth as age increased.

The fat threeridge generally inhabits Chipola and Apalachicola River main channel margins and floodplain sloughs in slow to moderate current and along moderate to steep banks (EnviroScience 2006a). This species is highly vulnerable to decreased flows because it prefers habitats of relatively shallow depth (<3 ft) that become exposed at very low flows. The fat threeridge has a thick heavy shell but it is still moderately mobile underwater because of the folds in its shell that allow it to move in mud (Watters 1994). The bank slopes along where the fat threeridge is normally found allow it to adjust its preferred depth by traveling relatively short distances unless impeded as water levels fluctuate. Under very low flow conditions, however, the fat threeridge can easily become stranded due to its heavy shell once the base of the slope becomes dewatered because the mussel must travel greater and greater distances to reach water. In addition, habitat on moderately steep banks under tree canopy is cooler than open flats, because of the shade from overhanging vegetation and the cool groundwater discharge from bank drainage. During very low flows, soil temperatures are much higher on the open flats than along the steeper, vegetated slopes at the edge of the channel.

The purple bankclimber inhabits river channels in moderate to fast current over sand or sand mixed with mud, cobble, gravel, trees, or bedrock (Williams and Butler 1994; EnviroScience 2006a). Most purple bankclimbers that have been recently collected have been found associated with the bedrock outcrop at Race Shoal near the dam and deeper habitats with larger, stable substrates such as bedrock, tree stumps, and gravel / cobble mixes in relatively fast currents (EnviroScience 2006a and unpublished data; FFWCC unpublished data; USFWS 2008). The purple bankclimber is intolerant of being stranded above the water based on field observations and observed mortality among tagged individuals from Swift Slough and Race Shoal during very low flow years (EnviroScience 2006b and unpublished data from Race Shoal monitoring efforts, Table 3).

The purple bankclimber develops a large, thick, heavy and sculptured shell that allows it to withstand high shear stress areas where many other mussel shell types would be dislodged (Watters 1994). In the ACF it is commonly found lying on its side rather than buried in the substrate. However, these characteristics make the species relatively immobile once stranded above water and it appears very intolerant of high temperatures and slow or stagnant water compared to other Apalachicola River unionids.

Almost all recent records of the purple bankclimber within the Apalachicola River system have been from deep habitats, as previously suitable habitat at higher elevations has been regularly exposed in the very low flows prevalent in recent droughts. For example, relatively fresh dead and live purple bankclimber were collected from Swift Slough in 2005 and 2006; however, all live individuals were later found dead and the species has since probably been extirpated from Swift Slough and other vulnerable shallow suitable habitats due to the effects of long periods of very low flows since 2006. The Chipola Cutoff and the Lower Chipola

River support some purple bankclimbers among stump and tree root habitats in moderate to high flow in some parts of the main channel and channel margins at greater depths (>8 ft), as does the Apalachicola River main channel in the lower riverine reach near RM 26 (see Figures 6 and 12 in EnviroScience 2006a). Because these areas have been under-sampled and many habitats require diving during normal flows, the size and extent of purple bankclimber populations within the Lower Chipola River and Chipola Cutoff remain relatively unknown.

Table 3. Recent timeline of mussel surveys and observations of mortality in the Apalachicola River-floodplain system. Chatt = Chattahoochee gage; Wewa = Wewahitchka gage; Mi35 = Mile 35 gage; AR = Apalachicola River; RM = River Mile; FTR = fat threeridge, PBC = purple bankclimber.

Date	River stage (ft)[7]	River flow (cfs)[8]	Site	Observation
2005 (10/23 to 11/10)	Wewa 14.2-15.1	8,800-10,200	AR (RM 40-48) Lower Chipola River Chipola Cutoff Swift Slough	Large and previously unknown populations of FTR observed in shallow habitats, with some minor mortality along AR channel margins. Swift Slough represented one of the largest known populations of FTR of any site.
	Chatt 41.3-43.0	8,700-12,100	AR (RM 105)	Most (90%) of PBC were observed at Race Shoals (EnviroScience 2006a).
2006 (6/14)	Wewa12.5	6,400	AR (RM 43.5)	Mussels observed stranded in AR channel margins. Translocated 800 FTR from marginal to deeper habitats as flows dropped below 6,500. These later died as the relocation site was exposed.
			AR (RM 44.3)	Established monitoring sites of tagged FTR at 3 different elevations
2006 (7/14)	Mi35 5.0	5,700	AR (RM 44.3)	>80% of tagged FTR were dead or not found due to exposure after 4 weeks, including the control site at the lowest elevation.

[7] Feet above NGVD at gage closest to the indicated site. Mile 35 gage data was used if Wewa gage data was missing.
[8] Estimated flows at Chattahoochee gage associated with stage at the closest gage, calculated using stage-discharge relations in Light et al (2006). (Travel time is accounted for.)

Date	River stage (ft)[7]	River flow (cfs)[8]	Site	Observation
2006 (8/3)	Wewa 11.6	5,400	Swift Slough	Swift Slough was temporarily disconnected; FTR population estimated for Swift Slough was 18,000 individuals that had already experienced approximately 25% mortality.
2006 (8/7)	Wewa 12.1	6,000	AR (RM 46.8)	A long term monitoring site using ~500 tagged FTR was established.
2007 (5/29 to 12/20)	Wewa 10.8-11.7	4,700-5,500	Swift Slough	Beginning late May 2007, Swift Slough was disconnected continuously for almost 7 months and >90% of mussels died including almost all those at established tagging sites.
	Chatt 38.9-39.6[9]	4,800-5,800[23]	AR (RM 105)	Over 80 PBC at Race Shoals were nearly exposed (<1 ft) for almost 7 months. (Few PBC were found in 2009 searches).
2007 (6/14)	Mi35 4.7	5,400	AR (RM 46.8 and other nearby sites)	Approx. 47% of FTR were recaptured alive after 10 months; observed mortality was low. It is uncertain if loss of 53% was due to death, non-detection, or exodus from site. Persistence of mainstem FTR sites following high flows is uncertain.
2007 (11/14)	Wewa 11.2	5,000	AR (RM 40-48)	Six small sites with tagged FTR individuals (n = 50) were established to monitor acute effects of continued low flow.
2009 (Aug.)	--	--	AR (RM 105)	Few PBC found by FFWCC staff in qualitative searches.

In June 2008 there were an estimated 233,500 fat threeridge individuals within Florida's Apalachicola and Lower Chipola River basin that were affected by low flows (USFWS 2008). This estimate only included data from animals inundated at or above 5,000 cfs (Chattahoochee

[9] Stages and flows were within this range at the Chattahoochee gage for this entire period except for a 4-day pulse from 9/4 to 9/7 when stages were 39.7-40.2 and flows were 6,000-6,900.

gage). It is the remnant of an earlier population that included many tens of thousands of mussels that had died when extended periods of very low flow occurred in 2006-2007 following three years of higher sustained flows (Figure 23). In Swift Slough alone, an estimated 10,600 to 33,879 individuals died since 2006 (EnviroScience 2006b).

T&E mussel populations in the Apalachicola River-floodplain system are directly affected by low flows. Mussels were stranded during very low flow in 2006-2007 on channel margin habitats in the mainstem and in the loop stream they occupied (Swift Slough) when it was cut off at its connection with the mainstem. During a tag and recapture study performed on the Apalachicola River at river mile 44.3 by EnviroScience in 2006, approximately 25% of mussels tagged during the first two weeks of exposure died, and 70% after four weeks of exposure (Figure 24). Ultimately, over 90% of the mussels at the site died at three bank elevations from exposure including the lowest elevation that was originally intended as a control (an elevation that was not expected to be exposed). This type of mortality was likely widespread in 2007 because antecedent flows had not been below 9,000 cfs for an extended period since late 2002 (Figure 23). During that time, fat threeridge and other mussels moved higher in elevation along the river banks to their preferred depths. Based on this information it is likely that mussels are most at risk during an initial and relatively rapid drawdown to very low flow conditions following multiple years of normal and high flows.

Mussel habitat is also directly reduced as slough connections to the mainstem river are severed or greatly reduced during very low flow periods. Such disconnections from the main channel can limit mussels' access to fish hosts, a condition that ultimately has a large affect on mussel reproduction and distribution (Watters 1996). For example, rare and endangered mussel species (e.g. fat threeridge, northern riffleshell) typically experience many years of poor or no reproduction and population decline with an occasional successful year of reproduction and surviving cohort. If a successful reproduction year happens to occur during a very low flow year, then new mussel distribution will be limited by the availability of suitable habitat. While potential habitat exists in many of the sloughs and tributaries of the upper and middle riverine reaches, very few of these localities are able to support mussels (EnviroScience 2006a) because they have become increasingly disconnected. In the upper riverine reach, much of the water-level decline was due to channel incision. In contrast, reduced connections with the mainstem in the lower riverine reach of the Apalachicola, and in the Chipola Cutoff and Lower Chipola River, are mainly and increasingly due to decreased flows from upstream.

Mussel habitats also can become unavailable when extended periods of very low flows result in rapid colonization of depositional bars along channel margins by willow trees, grasses, and other vegetation (e.g. Apalachicola River NM 44.3). Mussels may not be able to return to these areas for some time, or, their ability to move with changes in water levels may be compromised due to the physical presence of the thick vegetation biomass. Movement may be particularly difficult in areas with minimal slopes where mussels must travel farther to track water level changes (e.g. NM 44.3). In steeper-sloped habitats such as Swift Slough and the Lower Chipola River, most mussel species, including the fat threeridge, can utilize the root complexes of established bank vegetation for refuge from high flows. However, for mussels to become established in complex root masses these areas must remain inundated continuously.

Conversely, if beneficial vegetation on steeper banks is harmed by extended periods of very low flows, this may decrease the amount of habitat available to mussels.

The highest mussel concentrations were commonly associated with areas of minor groundwater upwelling (G. Zimmerman, pers. obs. 6-26-06, 6-13-07). These areas act as refugia and are able to sustain mussels longer during periods of extended low flow. The amount of groundwater discharge is likely related to the extent and duration of moderate and high inundating flows that recharge surficial groundwater in the floodplain. It is reasonable to assume that groundwater-fed refugia for mussels are steadily reduced during extended droughts unless the floodplain is recharged by occasional inundation.

At Race Shoal (RM 105) near the dam, purple bankclimbers can be damaged by the synergistic effects of low flows. Race Shoal is a limestone outcrop with a very irregular surface consisting of gravel-filled depressions and well-defined pools. Mussels that exist there have very limited, if any, ability to migrate with receding flows. Very low flows have been observed to strand purple bankclimbers in shallow pools that also contain large populations of the invasive Asian clam (*Corbicula fluminea*) and algae. Most of the pools are spring fed which keeps them cool. But the spring water likely contains little oxygen or food, and when it is not mixed with Apalachicola River water the mussels will die. A compounding problem at Race Shoal, Swift Slough, and other channel margin habitats is that the Asian clam is the first to die under very low flow conditions. Once the Asian clams die, sometimes thousands in a single pool, the fouled water and poor water quality kills the remaining endangered native mussels, even those in deeper pools that would have otherwise survived (G. Zimmerman, pers. obs. 7-12-06).

Mussel populations within the shallow channel margins of the mainstem (e.g. RM 44.3) and in floodplain sloughs have been the most affected by low flows. Table 3 shows the results of recent survey efforts in these areas.

It is extremely difficult to estimate mussel mortality that results from extreme temperatures and exposure due to flow fluctuations. Mussels can die in a matter of hours once exposed without water in the sun at high temperatures in the open, or may persist for months in damp shaded sandy substrates, buried and kept cool by groundwater inputs (e.g. Swift Slough and RM 46.8 in areas along the channel margin). It also is difficult to determine whether the primary mechanism for mortality exposure for the fat threeridge is desiccation or high temperatures. Fat threeridge are apparently relatively tolerant of short term impacts compared to other mussel species in the Apalachicola River system, and have been tagged and persisted for days living in pools with surface temperatures in excess of 105^{o}F, although the bulk of the mussels themselves were buried in the much cooler groundwater-infused substrate along the bank margin. However, approximately 70 percent of tagged fat threeridge from the Apalachicola River main channel at RM 44.3 died after four weeks of exposure (Figure 24).

An analysis of Apalachicola River flows from the baseline period (1923 – 1955) compared to the recent period (1975 – 2008) shows a marked decrease in the availability of flowing water during the recent period (Figure 25). During the baseline period, an analysis of flows during drought conditions (90% exceedance flows) found only 81 days where the flow dropped below 6,200 cfs – the flow needed to maintain flowing water to a depth of 0.5 ft in Swift

Slough. By contrast, the recent period shows a nearly 250% increase in the frequency of flows below 6,200 cfs (201 days). Again, because mussel populations are long-lived and relatively sessile, under many conditions exposed mussels can only survive for a few days once exposed to high surface temperatures and without water. As low and very low flows have increased in the recent period, the ability of mussel populations to survive and persist in many Apalachicola River and floodplain habitats has decreased.

The effect of extremely high flows on mussel populations in the Apalachicola River system is relatively unknown. In other river systems, high river flows have been linked to patterns of mussel distribution (Layzer and Madison 1995). While the fat threeridge is known to exist in large numbers in moderately depositional areas along the borders of specific reaches of the main channel of the Apalachicola, it is unclear if these populations could persist in one area or if they would be regularly "blown out" downstream by high flows. Florida and the USFWS have established a number of tag-recapture sites on the main channel of the Apalachicola River near RM 40-50 and within Swift Slough to determine mussel movement and mortality and if mussels commonly dislodge under high flows. To date, these populations have persisted in the same locations for at least two years including conditions of relatively high flows in 2008 and 2009 (Figure 23).

The potential for populations to remain in place under high flows leads one to question the assumption made by the USFWS that the origin of high numbers (~18,000) of fat threeridge estimated to exist in the upper reaches of Swift Slough in 2006 were a result of mussels being blown in from a larger population upstream (USFWS 2008). Based on this assumption, USFWS concluded that the Swift Slough fat threeridge population was not self-sustaining (i.e., it was likely a "sink" population), and Swift Slough was discounted from the overall population estimate regarding the effects of low flows on the species. The USFWS based its opinion on the presumed ages of the fat threeridge collected there as well as that high numbers of fat threeridge had not been observed in Swift Slough during the 2000 drought. However, a relatively normal distribution of sizes and presumably ages of fat threeridge was known to exist in Swift Slough in 2006 at the time of the die-off (EnviroScience 2006a).

It is unlikely that a full range of sizes were "blown in" together by flooding because fast-moving water sorts sediment and other objects by size, and thus would have carried small and large mussels to different locations. In addition, there was no obvious source for the suspected blown-in mussels. The dredge spoil disposal site extending for approximately a mile immediately upstream of the head of Swift Slough had been used for spoil disposal as recently as 2000, and no mussels were found there prior to the 2006-2007 drought. Furthermore, if large numbers of mussels had been moved by high floods in this reach, a few mussels should also have been found in downstream sloughs such as Hog or Moccasin Slough, but none were found there.

A more likely explanation for the large numbers of mussels in Swift Slough in 2006 is that either the population was overlooked or buried in 2000 or growth rates are much faster than estimated from length-age curves. The length histogram generated for the fat threeridge collected from Swift Slough in 2005 (EnviroScience 2006a) showed that the population consisted of juveniles and adults of various size ranges (i.e., a normally reproducing population). Recent surveys of Swift Slough in 2010 have again shown that now that it is reconnected to the main stem of the Apalachicola River, recruitment is again occurring (T. Hoehn, personal communication, 2010).

There is recent evidence indicating that fat threeridge populations on the main river channel are vulnerable to rapid water level fluctuations down to very low flows, particularly after extended periods of relatively normal flows. Related to this point, a long term monitoring site of over 500 fat threeridge mussels was established on the main stem of the Apalachicola River in 2006, upstream of Wewahitchka at NM 46.8 (EnviroScience, unpub. data). In September, 2010 the FFWCC visited the site and marked the locations of recaptured mussels that had been tagged, and noted their condition (live, fresh dead, or dead). A total of 78 tagged fat threeridge were recaptured in the upper 1.5 ft of water depth. Of those recaptured, 35% were found dead (8 fresh dead, 20 dead). All mussels found were found by wading, and all were categorized as either high risk (49%) or moderate risk (51%) from exposure / stranding (FFWCC unpub. 9-13-2010 data). All mussels found had been marked with an "O", indicating that they had originally been found and replaced below 1.5 ft of depth in prior years (2006 and 2008). Mussels with an "X" were those that had been placed in less than 1.5 ft of water in prior years. None of those mussels were found, despite extensive surveys of the surrounding areas. This suggests that most mussels tagged in the shallowest areas had died.

Monitoring of the 46.8 site was conducted again in November 2010 to detect mussels in deeper water. Additional mortality of fat threeridge was detected from mussel stranding, and the data are currently being processed. Initial results indicated that fat threeridge populations did not tend to migrate laterally (i.e., upstream or downstream) but generally only perpendicular to flow (up and down the river bank), as most mussels were recaptured within a few feet laterally of where they had been last placed. It is not yet certain if recruitment of mussels at the site (influx of mussels into the site and reproduction) offsets mortality rates.

These new data indicate that the PVA used to model fat threeridge populations in the Biological Opinion model (USFWS 2008) may be flawed. The model did not take into account large mortality events that have been observed as a result of a series of normal years followed by a sudden drop in river elevation as a result of very low flows (2006). Recent conversations with the USFWS (K. Herrington, 12-15-2010) indicated that the USFWS has observed significant mortality associated with two years of normal flows followed by a very low flow event in 2010, and confirms observations by EnviroScience and FFWCC staff. As fat threeridge move up the bank slope during normal flows to their preferred habitat, morality occurs when the mussels become stranded as water levels drop rapidly. Because the PVA did not take into account these mortality events, it is likely that the BiOp model underestimates extinction probabilities.

3. Introduction to Bay Impacts

Apalachicola Bay (Figure 26) is located in the panhandle of Florida at the terminus of the Apalachicola-Chattahoochee-Flint (ACF) River system and is one of the least contaminated, most productive estuarine areas in the US (Livingston 1984). Primary freshwater inflow to the bay is derived from the Apalachicola River, Florida's largest river in terms of volume. A complex and unique interaction of river flow, bay bathymetry, winds, and tides combine to make this such a productive estuary (Livingston et al. 1997) and home to a variety of ecologically and commercially important species. The large input of fresh water from the Apalachicola River to the bay has long been documented to be one of the primary reasons behind the high productivity in the system. Among the variety of functions provided by the river to the bay, two of the most important are the provision of a continuous supply of nutrients that fuel the bay's primary and secondary production and the setup of a favorable salinity regime for growth and reproduction of numerous organisms, including the eastern oyster.

The importance of maintaining the natural flow regime of fresh water inputs to estuaries and thus supporting the ecosystem services that estuaries provide has become a well-established principle of coastal ecology and management. Freshwater inflows to the bay are primarily derived from the Apalachicola River with discharge divided between the main opening adjacent to the City of Apalachicola and the delta distributary system entering the western side of East Bay. Discharge through the distributary systems varies seasonally but estimates suggest that up to 20% of the total river flow may be diverted through this system into East Bay directly. In addition to the river, freshwater enters East Bay from the Tates Hell Swamp via Whiskey George and Cash Creeks.

4. Salinity/Flow Relationships

Estuaries function as transition zones between the salt environment of the sea and the freshwater of a river. Salinity fluctuation in these dynamic environments has been shown to be a dominant feature of estuaries and to a great extent helps to determine the type and distribution of organisms found in these systems. Horizontal gradients in salinity can form physiological barriers affecting the distribution of organisms, both fresh- and salt- water species, as well as screening out potential predators that might impact their population. Alterations of these patterns, especially increases in salinity, could eliminate these barriers and cause significant changes in resident species' assemblages in estuaries. Discharge from the Apalachicola River (the principal source of freshwater to the system) is the primary factor influencing salinity in the bay.

Salinity generally increases in the bay from north to south as distance from the mouth of the river increases and from west to east as one approaches the major openings to the Gulf to the east (Figure 27). Because of the geometric configuration (i.e., a relatively short distance between the river and the sea side) and dynamic nature of the bay, salinity values may range from 0 to near 35 psu (practical salinity units) over relatively short distances thus making considerable contributions to spatial and temporal variability. Lowest salinity is usually found around the mouth of the river and in East Bay with highest salinity observed in St. George Sound.

Vertical salinity stratification is often observed throughout the bay with higher salinity noted in bottom waters (Figure 28). This is particularly noticeable in deeper portions of the bay (e.g., navigation channel) but can be observed in shallow areas like East Bay as well where differences between surface and bottom salinity can exceed 10 psu (Edmiston 2008). Temporal changes in salinity are great and can be observed on a variety of scales. Short-term (tidal) variability can exceed 15 psu particularly in areas relatively close to the river mouth (Figure 29); weekly to monthly variability is primarily wind induced (Figure 30); seasonal variability is related to river flow and horizontal density gradients (Figure 31).

Low bay salinities generally coincide with high river discharge during winter and spring while highest salinities occur during fall low-flows. Secondary salinity reductions may be observed during late summer-early fall and are most pronounced in association with tropical storms. Long-term salinity trends typically follow river flow fluctuations (Livingston 1984) with low salinities predominant during wet, high-flow years and high salinities prevalent during droughts (Figure 32). River flows were high during 2003 and 2005 while 2007 was a drought year; salinities during 2003 and 2005 were correspondingly low while highest values were seen in 2007.

As part of a long-term monitoring program, the Apalachicola National Estuarine Research Reserve (ANERR) has been continuously recording salinity and other variables at three locations (four data loggers) within the bay since 1993 (Figure 33). These sites are located in areas with both ecological and commercial importance. Long-term daily average salinity data collected at these sites from 1993 to 2001 show the effects of low river flow, related to drought conditions during 1999 through 2001, on salinity in the bay. Two mid-bay stations (Cat Point to the east and Dry Bar to the west) as well as an East Bay site in the upper reaches of the bay, illustrate salinity differences between wet (1993-1998) and dry (1999-2001) conditions (Figures 34-37). Over all sites, salinity averaged about 4.5 psu greater during the drought relative to pre-drought years. Similar figures could be developed for other drought time periods (e.g., 2007) yet the overall salinity relationships remain unchanged; bay salinities decrease with higher river flow and increase under lower flow conditions.

Nui et al. (1998) showed that salinity at the Cat Point and Dry Bar sites reacts to changes in river flow (based on readings from the Sumatra gage) with a one-day lag, but the response differs by site. Fluctuations in river flow during a normal year explain as much as 10 psu of the salinity variability at either site with a slightly greater effect noted at Dry Bar. Water level fluctuation, caused by tides and meteorological conditions, is the dominant factor influencing bottom salinity at Cat Point in the eastern part of Apalachicola Bay. However, while water level is positively correlated with salinity at Cat Point it is negatively correlated with salinity at Dry Bar, suggesting the importance of river flow on the western side of the bay.

Morey and Dukhovskoy (2007) analyzed the long-term ANERR data logger records (Jan 1993-Dec 2005) to examine salinity variability within the bay, physical mechanisms affecting this variability, and the linkage between this variability and fluctuations in Apalachicola River discharge. Their analysis confirmed the importance of river discharge on salinity variability at the three ANERR sites.

A variety of models, like those developed by Niu et al. (1998) and Morey and Dubhovskoy (2007), can be used to estimate or predict salinity at specific locations in the bay but are dependent on having sufficient data on all environmental variables included in the models. Development of simple regression models relating salinity at certain bay sites with river flow is desirable provided these new models do not suffer from significant loss in explained variability. In an attempt to examine alternative models, we regressed mean monthly river flows measured at both the USGS Chattahoochee and Sumatra gages against mean monthly salinity values at the three ANERR data logger sites (Cat Point, Dry Bar and East Bay) for the period from January 2000 to December 2009. Best fit models were exponential regressions; these models are shown in Figures 38 (Chattahoochee flow) and 39 (Sumatra flow). As expected because of its location in the basin, discharge at Sumatra explained more of the variation in salinity than Chattahoochee flows and was used for all further comparisons. Also as expected, salinity at Dry Bar and Cat Point were more closely related to discharge than in upper East Bay regardless of location of discharge.

To further examine the relationship between discharge and salinity at these bay locations, we made two sets of estimates using the regressions developed with Sumatra discharge: (1) salinity at each site relative to specific incremental flows and (2) salinity at each site resulting from specific flow depletions at various discharge levels. Predicted salinities for various incremental flows are shown in Table 4.

Table 4. Salinity (psu) at three ANERR data logger sites in Apalachicola Bay estimated for specific incremental flows based on discharge (cfs) at the USGS Sumatra gage. Regression equations used to estimate these salinities are shown in Figure 39.

	Estimated Salinity		
Flow	Cat Point	Dry Bar	East Bay
5000	27.8	26.2	20.0
7500	26.5	24.9	17.2
10000	25.2	23.7	14.8
15000	22.8	21.5	11.0
20000	20.6	19.4	8.1
25000	18.7	17.6	6.0
30000	16.9	15.9	4.5
40000	13.8	13.0	2.5
50000	11.3	10.7	1.3
60000	9.3	8.7	0.7
75000	6.9	6.5	0.3

Generally, predicted salinities underestimated values observed during the relatively severe 2007 drought when bay salinities reached high levels. Observed mean salinity at Cat Point, for example, never fell below 31 psu between September and December 2007, reaching a maximum monthly mean of 34.6 psu in October. Mean river flow during this period (Sept-Dec) was about 6,400 cfs yielding an estimated mean salinity of 27.1 psu using the regression. Thus, while these regressions may describe the general salinity-flow relationship, predictions should be used with caution. Regressions that factor in winds and tides (Niu et al. 1998) may provide more accurate predictions, especially at the low-flow end of the discharge hydrograph; however, these models are more difficult to set up and require significantly more data to run.

In an attempt to refine predictions at the low-flow end of the hydrograph, regression models were developed after separating drought years from “normal”; the years 2000 and 2007 were considered drought years while all others were classified as normal. Regressions were recalculated with only slight improvement in predictions during low-flow conditions; revised regressions still underestimated salinity at Cat Point and Dry Bar under drought (Figure 40). As can be seen in the plots, this underestimation is caused by considerable variability in monthly salinity at low flows; least squared, best-fit regression models tend to average these conditions, thus underestimating the extremes observed.

While absolute salinity may be underestimated (particularly at low flows), these regressions may be useful in comparisons of flow scenarios where salinity differences among alternatives are sought and the data required to support the more complex multivariate models are not readily available. To this end we generated a series of salinity estimates from the original regressions (Figure 40) for increasing flow depletions; depletions were made from the lowest, middle, and highest mean monthly flows observed in 2007 and 2008. This time period contained a severe drought extending throughout most of 2007; proposals had been made to drop flows to even lower levels than were observed through upstream reservoir operations. Incremental depletions were taken from a base monthly flow and salinities were estimated for the three ANERR data logger sites (Table 5).

Table 5. Salinity at three ANERR data logger sites in Apalachicola Bay estimated for various flow depletions. Estimates are given for three levels of river discharge: low, mid, and high-flow conditions based on observed flows during 2007-2008. Regressions used to estimate these salinities are based on discharge at the USGS Sumatra gage (equations in Figure 39); all flow rates are given in cfs.

		Estimated Salinity		
	Flow	Cat Point	Dry Bar	East Bay
Low flow	5789	27.4	25.8	19.1
depletions				
500	5289	27.7	26.1	19.7
750	5039	27.8	26.2	20.0
1000	4789	28.0	26.3	20.3
1500	4289	28.2	26.6	20.9
Mid flow	10544	24.9	23.5	14.4
depletions				
1000	9544	25.4	23.9	15.3
2500	8044	26.2	24.7	16.7
5000	5544	27.5	25.9	19.4
High flow	30552	16.7	15.7	4.3
depletions				
1000	29552	17.0	16.0	4.6
2500	28052	17.6	16.5	5.0
5000	25552	18.5	17.4	5.8

Results indicate that, as expected, salinity increases with increasing amounts of depletion; salinity increases were greater under low-flow rates than at mid- to high-flow conditions for the same amount of depletion. For example, salinity increased by 0.5-1.2 psu at the three sites for a depletion of 1,000 cfs for the low-flow condition, but only by 0.3 psu for the same depletion at high flow. As with the previous use, caution is suggested in interpreting these salinity differences; further refinements of the models are warranted.

5. Nutrient Input and Primary Production.

The river delivers nutrients to the bay in two forms – as particulate and dissolved organic matter and as dissolved inorganic nitrogen (DIN) and phosphorus (DIP). The organic matter comes primarily as detrital material that the river collects from the 450 km^2 bottomland hardwood flood plain and lower wetlands that produce some 360,000 tons of litter per year (Livingston 1984). This addition of flood plain and wetland organic matter provides an organic subsidy of about 100 g carbon (C) m^{-2} y^{-1} to Apalachicola Bay, with most delivered during the high flow period (Mattraw and Elder 1982). Analyses of stable isotopes in the particulate detritus and oysters have suggested that this subsidy might provide up to 40% of oyster diets in the bay (Chanton and Lewis 2002).

But most of the growth of oysters and other animals in the bay occurs during the warmer lower flow months when the primary productivity of the phytoplankton in the bay is greatest and the supply of inorganic DIN and DIP is most critical. About 75% of the annual phytoplankton production of some 255 g C m^{-2} y^{-1} occurs during May through September (Mortazavi et al. 2000a, Putland and Iverson 2007). During this period the Apalachicola River provides about 8 times more DIN (the nutrient most limiting to primary production during this period) than the near shore Gulf of Mexico tidal inputs (Mortazavi et al. 2000b). The delivery of DIN by the river is directly proportional to the discharge of water from the river (Figure 41; Mortazavi et al. 2000b, Putland 2006), so the primary production and growth of the phytoplankton and all of the animals (including oysters) that graze on them are clearly coupled with and dependent upon the flow of river water into the bay during these warm lower flow months. This linkage is well illustrated by a recent comparison of phytoplankton growth and productivity throughout the bay during a wet (2003) and dry (2004) summer (Figure 42; Putland 2005) where greatest growth and production occur at a mid-range of salinities. As salinity increases above this range, productivity/growth decline. The base of the food web throughout the bay was markedly richer with higher river flows and greater fertilization. And, as discussed below, the availability of food for oysters is a critical factor in their ability to survive disease.

6. Apalachicola Bay Oysters.

One of the most characteristic organisms in the estuary for which Apalachicola Bay is well known is the eastern oyster (*Crassostrea virginica*); Apalachicola Bay supplies nearly 90% of Florida’s commercial landings and 10% of the national total. As such, oysters have become a major focus in the ongoing allocation of fresh water in the ACF drainage.

Freshwater inflow provides a continuing supply of nutrients that fuel the phytoplankton base for rapid oyster growth. In addition the low and variable salinity regime resulting from river input repels predators and disease that thrive in higher salinity conditions. River flow has been linked directly with commercial landings in the bay (Wilber 1992) with decreased mortality coincident with lowered salinities (Livingston et al. 2000).

Oyster mortality results from a combination of predation and disease. Stone crabs, blue crabs, and gastropod mollusks are primary predators. Disease mortality is produced by the protozoan parasite *Perkinsus marinus*, which is the causative agent of Dermo disease (derived from the earlier name *Dermocystidium marinum*). *P. marinsus* is common and widespread in oysters from the Gulf of Mexico (Craig et al. 1989) with prevalence greater than 50% at 48 of 49 sites examined around the Gulf; no site was parasite free. The parasite tends to be most prevalent during warm months in high salinity areas (Soniat 1996). Oyster mortality from Dermo decreases as salinity decreases with a threshold of pathogenicity reported between 9 and 12 ppt (Ragone and Burreson 1993). While Dermo survived in salinity less than 9 ppt, oyster mortality was minimal.

A monitoring program was initiated in 2007 to measure and document the incidence and prevalence of Dermo disease in oysters in Apalachicola Bay. The monitoring program provided monthly measurements of Dermo disease prevalence and intensity which were used for calibration and evaluation of a coupled oyster-parasite model (Hofmann et al. 1995; Powell et al. 1996) that was implemented for Apalachicola Bay.

a. Dermo prevalence.

Prevalence of Dermo infection, expressed as total, advanced, or weighted prevalence, varied seasonally with maximum values during summer months and minimum values in winter. High prevalence was generally coincident with high temperature and high salinity as has been observed in other areas of the Gulf (Soniat 1996) although overlap with cooler months was observed. Dermo was always prevalent in Apalachicola Bay oyster collections with infection rates similar at the two sites (Cat Pt. and Dry Bar). While individual oysters were often found to be disease free, total prevalence (proportion of infected oysters per site) at a site never dropped below 37% (Dry Bar Feb 2008) and was commonly observed to exceed 80%. Highest prevalence during the study was noted at Dry Bar in October 2008 with near 100% infection.

Despite similar total prevalence at the two sites, highest infection intensities (i.e., advanced prevalence) were measured in oysters from Cat Point. Advanced prevalence (proportion of infected oysters in Mackin scale classes 3-5) was higher at Cat Point during both 2007 and 2008 with values often exceeding 40%. The prevalence of advanced infection was somewhat lower (< 40%) at both sites during 2009 with highest infection shifting to Dry Bar.

Weighted prevalence (average infection intensity of all oysters per site) generally followed the pattern noted for advanced prevalence at the two sites. Highest values were observed at Cat Point during 2007 and 2008 while relatively similar intensities occurred during 2009. Average weighted prevalence over the sampling period was slightly higher at Cat Point (1.48) than Dry Bar (1.23) reflecting the greater proportion of advanced cases at Cat Point.

Weighted prevalence remained above 1.0 at both sites for the majority of the months measured in 2007 and 2008. Weighted prevalence is expressed on a scale that goes from 0 to 5, the Mackin scale. The Mackin scale is based on the doubling time of the disease organism, so a one unit increase on this scale represents a substantial increase in disease burden for the oyster host. Values above 2.5 indicate high disease burden, which is a precursor of a disease epizootic.

Both advanced (Figure 43) and weighted (Figure 44) prevalence showed coincident patterns with mean salinity although considerable variation was observed. For example, highest advanced and weighted prevalence was noted in July 2008 at a time when only moderately high salinity was recorded; highest salinities were noted in June and October 2008 and in July 2009 when prevalence was highly variable (low, high and moderate, respectively).

Linear regressions were used to determine relationships between salinity and disease prevalence at individual sites and at all sites combined. Based on these regressions, a significant portion of the variation in disease prevalence at all sites combined could be attributed to salinity alone and the higher the salinity, the greater the disease (Figure 45). Advanced prevalence was significantly related to salinity either by individual sites or sites combined (Figure 46). Variation was slightly greater at Cat Point than at Dry Bar when sites were assessed separately; salinity explained 32% of the variation in advanced prevalence when the sites were combined. Similarly, weighted prevalence was also significantly related to salinity either by individual sites or sites combined (Figure 47). As before, salinity explained a greater proportion of the variation in weighted prevalence at Dry Bar than at Cat Point. When sites were combined, the relationship explained about 37% of the variation in average disease intensity.

Multiple regressions were also run with salinity and temperature as the independent variables against each of the three dependent Dermo variables (i.e., total, advanced, and weighted prevalence). Adding temperature to salinity in a multiple regression analysis increased the amount of variation explained but only moderately. For all cases except Cat Point total prevalence, the addition of temperature significantly increased the variance explained in Dermo prevalence. This increase was noted for both sites tested separately or combined. Adjusted correlation coefficients (R^2) increased from 10-15%. The significant incorporation of salinity and temperature into the multiple regression models of disease prevalence indicates that both variables play a role in the incidence and prevalence of Dermo and that increased disease will occur at increased salinities and temperatures.

7. Dermo and oyster density

The relationship between Dermo disease and oyster abundance was examined by plotting estimated oyster density (quadrat collections taken by the Florida Department of Agriculture and Consumer Services, Division of Aquaculture) relative to Dermo advanced prevalence (Figure 48). Total and weighted prevalence could be examined as well but are not plotted here.

At Cat Point, initial densities of 500-600/m^2 declined to <250/m^2 coincident with increasing advanced Dermo prevalence during the first 2 years of the survey (Figure 49A). During the third year densities were not observed to increase significantly despite a decrease in disease. As a caveat it should be pointed out that density data were limited during 2009 precluding definitive conclusions concerning oyster abundance. Pearson correlation between density and advanced Dermo was marginally significant ($r=-0.443$; $n=21$, $p<0.05$; cutoff $r=-0.433$) suggesting a declining trend of density with increasing advanced disease levels. At Dry Bar, densities declined steadily throughout the survey period from initial levels >800/m^2 to about 500/m^2 during the second year to lows of about 300/m^2 during 2009 (Figure 49B). Advanced Dermo prevalence increased during 2007 and 2008 with peaks in 2009 slightly lower than 2008. As noted for Cat Point, limited data from 2009 preclude definitive conclusions concerning oyster abundance. No significant correlation was noted at Dry Bar between density and advanced Dermo ($r=-0.086$; $n=20$, $p>0.05$). Oyster densities in 2010 increased somewhat at Dry Bar yet remained low at Cat Point; no Dermo information was available coincident with recent density estimates.

In 2007 Dermo weighted prevalence at Cat Point remained high throughout the fall and into the early part of 2008. The typical reduction in Dermo that occurs in the fall did not occur until January of 2008 and was confined to two months rather than the typical 4-5 months. Dermo weighted prevalence in January 2008 at Cat Point was above 2.0; whereas, it was just above 1.0 in January 2007 and just below 1.0 in January 2009. The high salinity in 2007 resulted in increased Dermo prevalence which carried over into 2008. As a result, the oysters started the growing season in 2008 with a higher than normal disease burden. This allowed the weighted prevalence of Dermo to be higher in April, May, June and July than was observed in the equivalent months in 2007 and 2009. The pattern of disease prevalence at Dry Bay is similar, but with lower measured weighted disease prevalence values.

The rapid decline in disease prevalence at Cat Point in September 2008 was likely the result of a disease epizootic – the sick animals die which results in a decline in disease prevalence. Similarly, the reduction in weighted disease prevalence in late fall of 2007 at Cat Point is likely associated with an epizootic. The disease levels still remained high following this event which indicates that Dermo disease was well established at this time. Supporting evidence for epizootics is provided by the oyster density measurements which show significant reductions in oyster density at Cat Point and Dry Bay, relative to early in 2007, beginning in fall 2007 and continuing through 2008. The reduced oyster density has continued through 2009 and 2010 at both sites, indicating no recovery from the disease epizootic in 2007/08.

The measurements of Dermo disease show (1) increased disease prevalence associated with the sustained high salinity in 2007 that persisted throughout the fall, (2) carryover of the disease into the next year, (3) a disease epizootic in fall of 2008, and (4) a possible disease epizootic in late fall-early winter of 2007.

a. Apalachicola Bay oyster population simulations using 2007-2008 conditions.

The time evolution of oysters at Cat Point was simulated using the observed salinity and temperature conditions from 2007 and 2008. The simulated market-sized oysters declined over time, decreasing to about 150 oysters m^{-2} (Figure 49), which is similar to the oyster density values actually measured in 2007 and 2008 at Cat Point (Figure 48A). The total oyster population also declined over time but the decrease is less than obtained for the market-sized portion of the population (Figure 49A). The long-term decline in the simulated population indicates that the conditions that existed in 2007-2008 were not conducive to maintenance and/or expansion of the Apalachicola Bay oyster population.

Simulated Dermo disease intensity at Cat Point ranged between 0.5 and 2.5 (Figure 49B), which is similar to the range measured at Cat Point (Figure 44). This agreement indicates that the Dermo disease processes were correctly simulated by the oyster-disease model.

An increase in salinity in Apalachicola Bay by itself has consequences for the oyster population by increasing Dermo disease prevalence and intensity. However, associated with salinity changes are coincident changes in food supply and larval recruitment. Should either of these decline, coincident with an increase in salinity, then oyster populations in Apalachicola Bay will be seriously impacted.

River and Floodplain Literature Cited

Ager, L.A., C.L. Mesing, and M.J. Hill. 1985. Fishery study, Apalachicola River maintenance dredging disposal site evaluation program: Final report prepared for U.S. Army Engineer District, Mobile, Ala., under Contract no. DACW01-82-C-0056: Florida Game and Fresh Water Fish Commission, 73 p., plus appendixes.

Ager, L.A., C.L. Mesing, M.J. Hill, R.S. Land, M. Spelman, and R.W. Rousseau. 1986. Fisheries ecology and dredging impacts on the Apalachicola River System. Five-Year Completion Report, Florida Game and Freshwater Fish Commission, Tallahassee, Florida. 97 pp.

Allen, M.S., W.E. Pine, III, J. Tetzlaff, and D. Dutterer. 2009. Evaluation of Monitoring Programs for Relating Fish Recruitment and Growth to River Flow. Final Report to the Florida Fish and Wildlife Conservation Commission. School of Forestry and Resource Conservation, The University of Florida, Gainesville. 57 pp.

Altinok, I., S.M. Galli, and F.A. Chapman. 1998. Ionic and osmotic regulation capabilities of juvenile Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*. Comparative Biochemistry and Physiology 120:609-616.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447–482 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Bailey, R.M., H.E. Winn, and C.L. Smith. 1954. Fishes from the Escambia River, Alabama, and Florida, with ecological and taxonomic notes. Proceedings from Acad. Nat. Sci. Phila. 106:109-164.

Bass, D.G., Jr. 1983. Rivers of Florida and their fishes: Florida Game and Fresh Water Fish Commission, 97 p.

Bass, D.G., Jr. 2002. Fish and Wildlife Conservation Commission Annual Report. Blackwater Fisheries Research and Development Center Studies I-IV. Holt, Florida.

Bass, D.G., Jr., and T. Hoehn. 2010 (in prep.) Florida's Freshwater Fishes. 351pp.

Bass, D. G., Jr. 1995. Checklist of fishes recorded from rivers of Florida. Florida Game and Fresh Water Fish Commission. Wallop-Breaux Project F-36. Tallahassee.

Brim Box, J., and J.D. Williams. 2000. Unionid mollusks of the Apalachicola Basin in Alabama, Florida, and Georgia. Bulletin of the Alabama Museum of Natural History No. 22. 143 pp.

Cailteux, R., D. A. Dobbins, and P. A. Strickland. 2007. Impact of water level on sportfish and catfish year classes in the Apalachicola River. Florida Fish and Wildlife Conservation Commission Annual Report. Quincy, Florida.

Chan, M.D., E.D. Dibble, and K.J. Killgore. 1997. A laboratory examination of water velocity and substrate preference by age-0 Gulf sturgeons. Transactions of the American Fisheries Society 126:330-333.

Coile, N.C., and M.A. Garland. 2003. Notes on Florida's Endangered and Threatened Plants. Florida Department of Agriculture and Consumer Services, Bureau of Entomology, Nematology, and Plant Pathology—Botany Section, Contribution No. 38, 4th edition. Gainesville, Florida. (http://www.virtualherbarium.org/EPAC/refs.html)

Darst, M.R., and H.M. Light. 2008. Drier forest composition associated with hydrologic change in the Apalachicola River floodplain, Florida: U.S. Geological Survey Scientific Investigations Report 2008-5062, 81 p. *http://pubs.usgs.gov/sir/2008/5062/*

DEP (Department of Environmental Protection). 2004. Uniqueness of the Apalachicola River & Bay Drainage Basin. Apalachicola, Florida.

EnviroScience. 2006a. Freshwater mussel and habitat surveys of the Apalachicola River, Chipola River and selected sloughs/tributaries. Final report submitted to the Florida Department of Environmental Protection. 40pp + figures and appendices.

EnviroScience. 2006b. Swift Slough Population (Abundance) Estimate for the federally endangered *Amblema neislerii* (Fat Threeridge) and federally threatened *Elliptoideus sloatianus* (Purple Bankclimber). Draft Report submitted to the Florida Department of Environmental Protection. 4pp + figures and appendices.

Flowers, H.D., W.E, Pine, III, A.C. Dutterer, K.G. Johnson, J.W. Ziewitz, M.S. Allen, and F.M. Parauka. 2009. Spawning site selection and potential implications of modified flow regimes on viability of Gulf sturgeon populations. Transactions of the American Fisheries Society 138:1266-1284.

Foster, A.M., L.A. Patrick, and J.M. Barkuloo. 1988. Striped bass and sturgeon egg and larva studies on the Apalachicola River. 1987 Progress Report, U.S. Fish and Wildlife Service. Panama City, Florida. 12 pp.

Fox, D.A., J.E. Hightower, and F.M. Parauka. 2000. Gulf sturgeon spawning migration and habitat in the Choctawhatchee river system, Alabama-Florida. Transactions of the American Fisheries Society129:811-826.

Fuller, S.L.H. 1974. Clams and mussels (Mollusca: Bivalvia). Pages 215-273 in: C.W. Hart and S.L.H. Fuller, editors, Pollution Ecology of Freshwater Invertebrates. Academic Press, New York.

Gholson, A.K., Jr. 1985. Vegetation analysis for the Apalachicola River Maintenance Dredging Disposal Site Evaluation Study. U.S. Army Corps of Engineers, Mobile, AL. 203 p.

Gutierrez, J.L., C.G. Jones, D.L. Strayer, and 0.0. Iribarne. 2003. Mollusks as ecosystem engineers: the role of shell production in aquatic habitats. Oikos 101:79-90.

Hill, M.J., E.A. Long, and R.W. Rousseau. 1990. 1985-1990 Completion report: Apalachicola River Watershed investigations: Study I. General fisheries and aquatic habitat survey, Study II. Fisheries survey: Florida Game and Fresh Water Fish Commission, 74 pp.

Huff, J.A. 1975. Life History of the Gulf of Mexico Sturgeon, *Acipenser oxyrinchus desotoi* in Suwannee River, Florida. Florida Department of Natural Resources, Marine Research Publication No. 16. 32 pp.

Huner, J.V. 1978. Exploitation of freshwater crayfishes in North America. Fisheries 3:2-5.

Huner, J.V. 1997. The crayfish industry in North America. Fisheries 22:28-31.

Iocco, L.E., W. Stevenson, and R.J. Diaz. 2002. Apalachicola Bay benthic mapping project: Preliminary Data Report. NOAA Coastal Services Center. 60 pp.

Johnson, P.D., and K.M. Brown. 2000. The importance of microhabitat factors and habitat stability to the threatened Louisiana pearl shell, *Margaritifera hembeli 69*(Conrad). Canadian Journal of Zoology 78:271-277.

Keefer, L.C. 1986. Life history of striped bass in the Flint River. Georgia Department of Natural Resources, Atlanta, Georgia.

Keller, A.E., and D.S. Ruessler. 1997. Determination or verification of host fish for nine species of unionid mussels. American Midland Naturalist 138(2):402-407.

Kynard, B., and E. Parker. 2004. Ontogenetic behavior and migration of Gulf of Mexico Sturgeon, *Acipenser oxyrinchus desotoi*, with notes on body color and development. Environmental Biology of Fishes 70:43-55.

Layzer, J.B., and L.M. Madison. 1995. Microhabitat use by freshwater mussels and recommendations for determining their instream flow needs. Regulated Rivers: Research & Management 10:329–345.

Leitman, H.M., 1984, Forest map and hydrologic conditions, Apalachicola River floodplain, Florida: U.S. Geological Survey Hydrologic Investigations Atlas HA-672.

Light, H.M., M.R. Darst, and J.W. Grubbs. 1995. Hydrologic conditions, habitat characteristics, and occurrence of fishes in the Apalachicola River floodplain, Florida: Second annual report of progress, October 1993-September 1994, U.S. Geological Survey Open- File Report 95-167, 33 pp.

Light, H.M., M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida: U.S. Geological Survey Professional Paper 1594, 77 p., *http://fl.water.usgs.gov/Abstracts/pp1594_light.html*

Light, H.M., Vincent, K.R., Darst, M.R., and Price, F.D. 2006. Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 pp., plus CD.

Livingston, R.J. 1983. Resource atlas for the Apalachicola estuary. Report number 55. Florida Sea Grant Program, Tallahassee, Florida.

Livingston, R.J. 1984. The ecology of the Apalachicola Bay system: an estuarine profile. U.S. Fish and Wildlife Service, USFWS/OBS-82/05, Washington, DC.

Livingston, R.J., P.S. Sheridan, B.G. McLane, F.G. Lewis, III, and G.G. Kobylinski. 1977. The biota of the Apalachicola Bay system: Functional relationships, *in* R.J. Livingston and E.A. Joyce, eds., Proceedings of the conference on the Apalachicola drainage system: Florida Marine Research Publication no. 26, p. 75-100. Tallahassee, Florida.

Long, E. A., C. Mesing, K.J. Herrington, R. Weller, and I. Wirgin. 2009 and in press. Restoration of Gulf Striped Bass: Lessons and Management Implications. American Fisheries Biology and Management of Inland Striped Bass and Hybrid Striped Bass Symposium, Nashville, Tennessee.

Mason, W.T., and J.P. Clugston. 1993. Foods of the Gulf sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 122:378-385.

McCuaig, J. M. and R. H. Green. 1983. Unionid growth curves derived from annual growth rings: a baseline model for Long Point Bay, Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences 40:436-442.

Mettee, M.F., P.E. O'Neil, and J.M. Pierson 1996. Fishes of Alabama and the Mobile Basin. Oxmoor House, Birmingham, Alabama. 115 pp.

Neves, R.J., and S.N. Moyer. 1988. Evaluation of techniques for age determination of freshwater mussels (Unionidae). American Malacological Bulletin 6(2):179-188.

O'Brien, C.A., and J.D. Williams. 2002. Reproductive biology of four freshwater mussels (Bivalvia: Unionidae) endemic to the eastern Gulf Coastal Plain drainages of Alabama, Florida, and Georgia. American Malacological Bulletin 17(1/2):147-158.

Parauka, F.M., S.K. Alam, and D.A. Fox. 2001. Movement and habitat use of subadult Gulf sturgeon in Choctawhatchee Bay, Florida. Proceedings Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 55:280-297.

Parkyn, D.C., D. J. Murie, D.E. Colle, and J.D. Holloway. 2006. Post-release survival and riverine movements of Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi*; Acipenseriformes) following induced spawning. Journal of Applied Ichthyology 22: 1–7.

Pera, T.P., J. W. Armbruster, and S.A. Schaefer. 2006. A new species of *Notropis* (Cypriniformes: Cyprinidae) from the southeastern United States. Copeia 2006 (3):423-430.

Pine, W., D. Duetterer, O.T., Burgess and S.J., Walsh. 2008. Examination of fish spawning, movement, and habitat utilization patterns in the Battle Bend region of the Apalachicola River. Completion report submitted to Florida Fish and Wildlife Conservation Commission, FWC contract 06132. Gainesville, Florida.

Pollard, J.E., S.M. Melancon, and L.S. Blakely. 1983. Importance of bottomland hardwoods to crayfish and fish in the Henderson Lake area, Atchafalaya Basin. Louisiana. Wetlands 3:1-25.

Reed, P. B., Jr. 1997. Revision of the national list of plant species that occur in wetlands. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, USA.

Scollan, D., and F. M. Parauka. 2008. Documentation of Gulf Sturgeon Spawning in the Apalachicola River Florida, Spring 2008. U.S. Fish and Wildlife Service. Panama City, Florida. 27 pp.

Snelson, F.F. Jr., T.J. Krabbenhoft, and J.M. Quattro. 2009. *Elassoma gilberti*, a new species of Pygmy Sunfish (Elassomatidae) from Florida and Georgia. Bull. Florida Museum Nat. Hist. 48(4):119-144.

Sulak, K.J., and J.P. Clugston. 1999. Recent advances in life history of Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*, in the Suwannee River, Florida, USA: a synopsis. Journal of Applied Ichthyology 15:116-128.

Sulak, K.J., M. Randall, J. Clugston, and W.H. Clark. 2004. Critical spawning habitat, early life history requirements, and other life history and population aspects of the Gulf sturgeon in the Suwannee River. Final Report to the Florida Fish and Wildlife Conservation Commission, Nongame Wildlife Program. U.S. Geological Survey, Gainesville, FL.

Sulak, K.J., M. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.H. Harden, R.H. Lukens, F. Paruka, S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf Sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505-515.

Tobe, J.D., K.C. Burks, R.W. Cantrell, M.A. Garland, M.E. Sweeley, D.W. Hall, P. Wallace, G. Anglin, G. Nelson, J.R. Cooper, D. Bickner, K. Gilbert, N. Aymond, K. Greenwood, and N. Raymond. 1998. Florida Wetland Plants: An Identification Manual. Florida Department of Environmental Protection, Tallahassee. 598 p.

U.S. Department of Commerce. 2009. National Climatic Data Center (NCDC): Climate division precipitation data, accessed December 22, 2009: *http://www1.ncdc.noaa.gov/pub/data/cirs/drd964x.pcp.txt*

USFWS (U.S. Fish and Wildlife Service). 2008. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. U.S. Fish and Wildlife Service, Panama City

Field Office, Florida, June 1, 2008. (http://www.fws.gov/southeast/drought/BO%20for%20RIOP%206-1-2008.pdf)

USFWS and GSMFC (U.S. Fish and Wildlife Service and Gulf States Marine Fisheries Commission). 1995. Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) Recovery / Management Plan. Atlanta, Georgia. 170 pp.

USGS (U.S. Geological Survey). 2010. USGS 02358000 Apalachicola River at Chattahoochee Fla, Surface-water, Daily streamflow: NWISWeb Data for Florida, *http://waterdata.usgs.gov/fl/nwis/uv?02358000*

Vaughn, C.C., and C.C. Hakenkamp. 2001. The functional role of burrowing bivalves in freshwater ecosystems. Freshwater Biology 46:1431-1446.

Vaughn, C.C., D.E. Spooner, M. Moore, and K.B. Gido. 2001. The functional role of unionids in streams: comparative and experimental evidence from Ouachita Mountain rivers. Journal o/the North American Benthological Society. Presented at NABS Annual meeting, LaCrosse, WI, 2001.

Walsh, S.J., E. N. Buttermore, O.T. Burgess, and W. Pine, III. 2008. Composition of Age-0 Fish Assemblages in the Apalachicola River, River Styx, and Battle Bend, Florida. U.S. Geological Survey Open-File Report 2009-1145. 28 pp. Prepared in cooperation with the Florida Fish and Wildlife Conservation Commission, Gainesville, Florida.

Walsh, S.J., W.B. Tate, and M.A. Burgess. 2006. Fishes of the Apalachicola River Foodplain: Role of habitat and hydrology to recruitment. Final report submitted March 31, 2006 to Florida Fish and Wildlife Conservation Commission. U.S. Geological Survey, Gainesville, Florida. 124 pp.

Watters, G.T. 1994. Form and function of unionoidean shell sculpture and shape (Bivalvia). American Malacological Bulletin 11(1):1-20.

Watters, G.T. 1996. Small dams as barriers to freshwater mussels (Bivalvia, Unionoida) and their hosts. Biological Conservation 75(1):79-85.

Watters, G.T., S.H. O'Dee, and S. Chordas, III. 2001. Patterns of vertical migration in freshwater mussels (Bivalvia: Unionoida). Journal of Freshwater Ecology 16(4):541-550.

Williams, J.D., and R.S. Butler. 1994. Class Bivalvia, freshwater bivalves. Pages 53-128, 740-742 in: R. Ashton, ed. Rare and Endangered Biota of Florida. Volume 6. Invertebrates. University of Florida Press, Gainesville.

Wooley, C.M., and E.J. Crateau. 1983. Biology, population estimates, and movement of native and introduced striped bass, Apalachicola River, Florida. North American Journal of Fisheries Management 3:383-394.

Wooley, C.M., and E.J. Crateau. 1985. Movement, microhabitat, exploitation, and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. North American Journal of Fisheries Management 5:590-605.

Wooley, C.M., P.A. Moon, and E.J. Crateau. 1982. A larval Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi*) from the Apalachicola River, Florida. Northeast Gulf Science 5(2):57-58.

Yerger, R.W. 1977. Fishes of the Apalachicola River, *in* R.J. Livingston and E.A. Joyce, eds., Proceedings of the conference on the Apalachicola drainage system: Florida Marine Research Publication No. 26, pp. 22-33. Tallahassee, Florida.

Zimmerman, G.F. 2004. Unionid mussels and substrate stability: experiments in an artificial stream. Unpublished masters essay. Kent State University, Kent, Ohio. 91pp.

Zimmerman, G.F., and F.A. de Szalay. 2007. Influence of unionid mussels (Mollusca: Unionidae) on sediment stability: an artificial stream study. Fundamental and Applied Limnology (Archiv für Hydrobiologie) 168(4):299–306.

Bay Literature Cited

Chanton, J. and F. G. Lewis. 2002. Examination of coupling between primary and secondary production in a river-dominated estuary: Apalachicola Bay, Florida, U.S.A. Limnology and Oceanography 47:683-697.

Craig, A., E.N. Powell, R.R. Fay, and J.M. Brooks. 1989. Distribution of *Perkinsus marinus* in Gulf coast oyster populations. Estuaries 12: 82-91.

Edmiston, H. L. 2008. A River Meets the Bay – a characterization of the Apalachicola River and Bay system. Apalachicola National Estuarine Research Reserve. 188 pp.

Hofmann, E.E., E.N. Powell, J.M. Klinck and G. Saunders. 1995. Modeling diseased oyster populations I. Modeling *Perkinsus marinus* infections in oysters. Journal of Shellfish Research 14: 121-151.

Huang, W. and W. K. Jones. 1997. Three-dimensional modeling of circulation and salinity for the low river flow season in Apalachicola Bay, Florida. Water Resources Special Report 97-10, Northwest Florida Water Management District, Havana, FL.

Livingston, R.J. 1984. The ecology of the Apalachicola Bay system: an estuarine profile. U.S. Fish and Wildlife Service FWS/OBS 82/05. 148 pp.

Livingston, R.J., X. Niu, F.G. Lewis III, and G.C. Woodsum. 1997. Freshwater input to a Gulf estuary: long-term control of trophic organization. Ecological Applications 7: 277-299.

Livingston, R.J., F.G. Lewis, G.C. Woodsum, X.-F. Niu, B. Galperin, W. Huang, J.D. Christensen, M.E. Monaco, T.A. Battista, C.J. Klein, R.L. Howell IV, and G.L. Ray. 2000. Modelling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50: 655-672.

Mattraw, H. C. and J. F. Elder. 1982. Nutrient and detritus transport in the Apalachicola River, Florida. U.S. Geological Survey Water Supply Paper 2196-C. U.S. Govt. Printing Office, Washington, D.C.

Morey, S.L. and D.S. Dukhovskoy. 2007. Analysis of the variability of Apalachicola Bay water properties in response to variations in the Apalachicola River discharge rate. Final Report, Florida Department of Environmental Protection, Tallahassee, FL. 33 pp.

Mortazavi, B., R. L. Iverson, W. M. Landing, F. G. Lewis, and W. Huang. 2000a. Control of phytoplankton production and biomass in a river-dominated estuary: Apalachicola Bay, Florida USA. Marine Ecology Progress Series 198:19-31.

Mortazavi, B., R. L. Iverson, W. Huang, F. G. Lewis, and J. M. Caffrey. 2000b. Nitrogen budget of Apalachicola Bay, a bar-built estuary in the northeastern Gulf of Mexico. Marine Ecology Progress Series 195:1-14.

Niu, X., H.L. Edmiston, and G.O. Bailey. 1998. Time series models for salinity and other environmental factors in the Apalachicola estuarine system. Estuarine, Coastal and Shelf Science 46: 549-563.

Powell, E.N., E.E. Hofmann, and J.M. Klinck. 1996. Modeling diseased oyster populations II. Triggering mechanisms for *Perkinsus marinus* epizootics. Journal of Shellfish Research 15: 141-165.

Putland, J. N. 2005. Ecology of Phytoplankton, *Acartia tonsa*, and Microzooplankton in Apalachicola Bay, Florida. Ph.D. Dissertation, Department of Oceanography, Florida State University, Tallahassee, FL.

Putland, J. N. 2006. Apalachicola River and Apalachicola Bay: Trends in Discharge, Nutrient Concentration, and Phytoplankton Biomass and Productivity. Report to the Florida Department of Environmental Protection, Office of General Counsel.

Putland, J. N. and R. L. Iverson 2007a. Phytoplankton biomass in a subtropical estuary: distribution, size composition, and carbon:chlorophyll ratios. Estuaries and Coasts 30:878-885.

Ragone, L.M. and E.M. Burreson. 1993. Effect of salinity on infection progression and pathogenicity of *Perkinsus marinus* in the eastern oyster, *Crassostrea virginica* (Gmelin). Journal of Shellfish Research 12: 1-7.

Ray, S.M. 1966. A review of the culture method for detecting *Dermocystidium marinum*, with suggested modifications and precautions. Proceedings of the National Shellfisheries Association 54: 55-69.

Soniat, T.M. 1985. Changes in levels of infection of oysters by *Perkinsus marinus*, with special reference to the interaction of temperature and salinity upon parasitism. Northeast Gulf Science 7: 171-174.

Soniat, T.M. 1996. Epizootiology of *Perkinsus marinus* disease of eastern oysters in the Gulf of Mexico. Journal of Shellfish Research 15: 35-43.

Wilber, D.H. 1992. Associations between freshwater inflows and oyster productivity in Apalachicola Bay, Florida. Estuarine, Coastal and Shelf Science 35: 179-190.

Figures

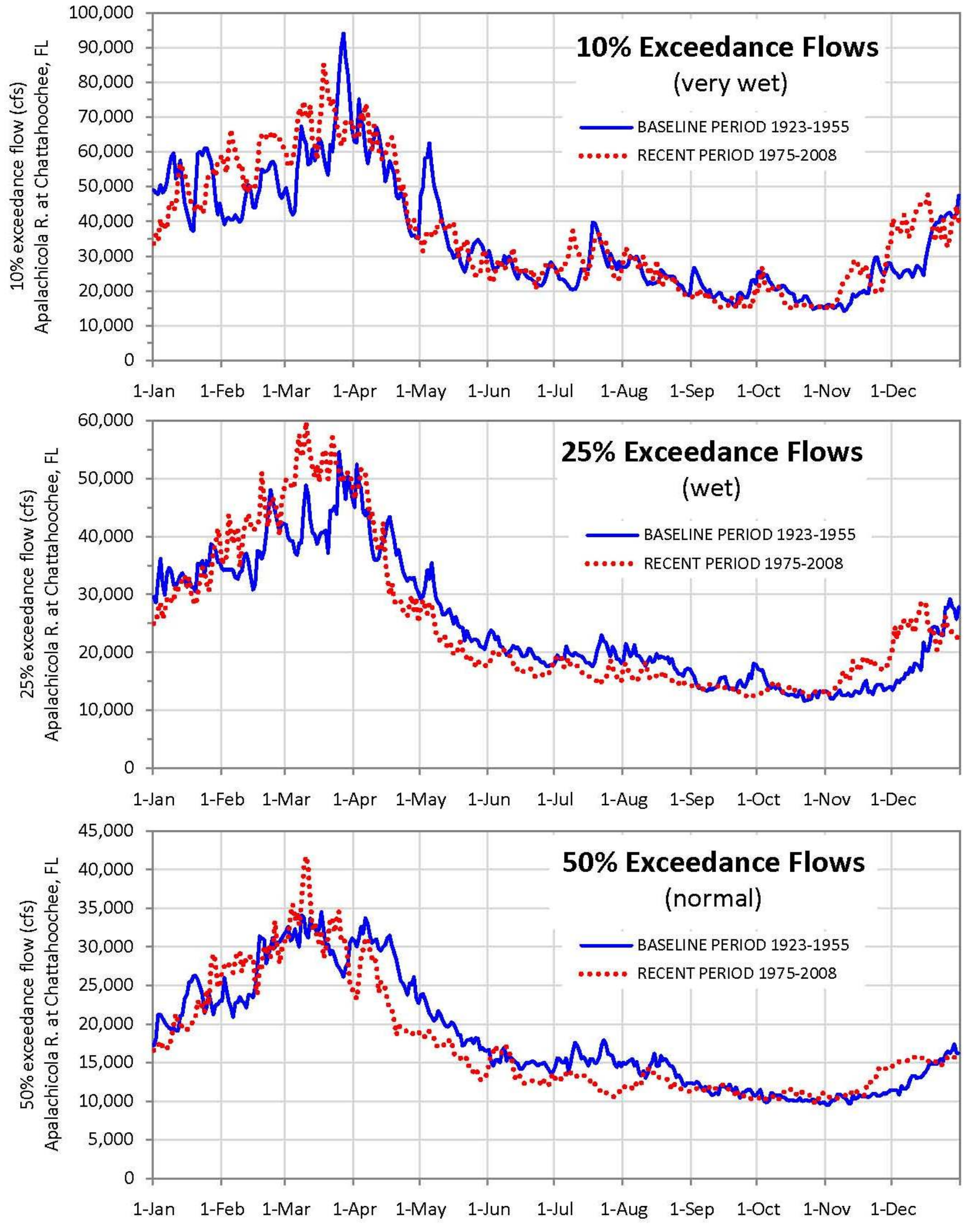
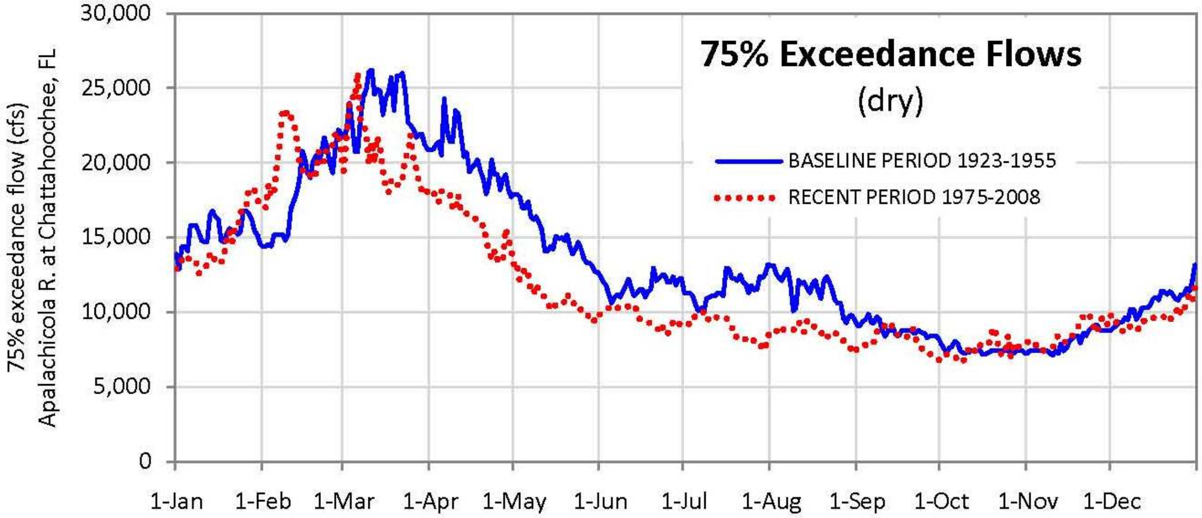


Figure 1. Flow in the Apalachicola River during two time periods (baseline and recent) under conditions ranging from very wet (10% exceedance) to drought (90% exceedance) (USGS 2010).



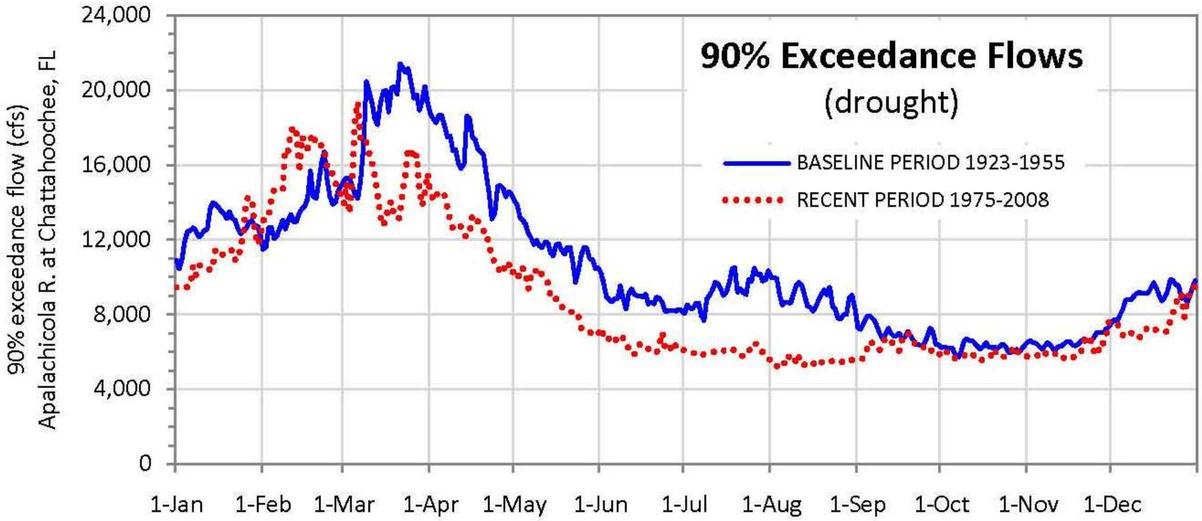


Figure 1. Continued.

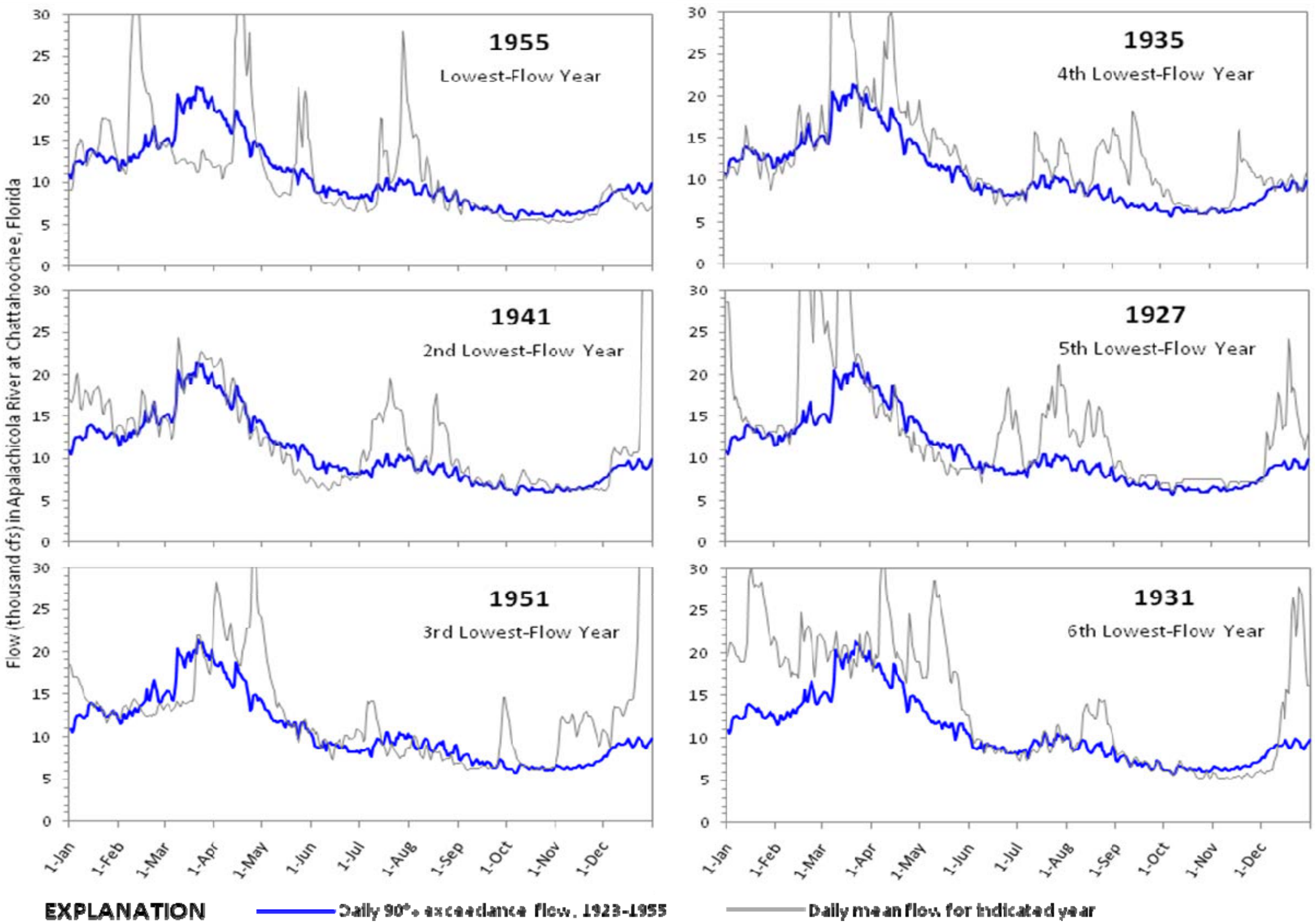


Figure 2. Daily 90% exceedance flow compared to daily mean flow in the lowest-flow years for the period 1923-1955. Six lowest-flow years were selected on the basis of mean annual flow. Flows >30,000 cfs are not shown (USGS 2010).

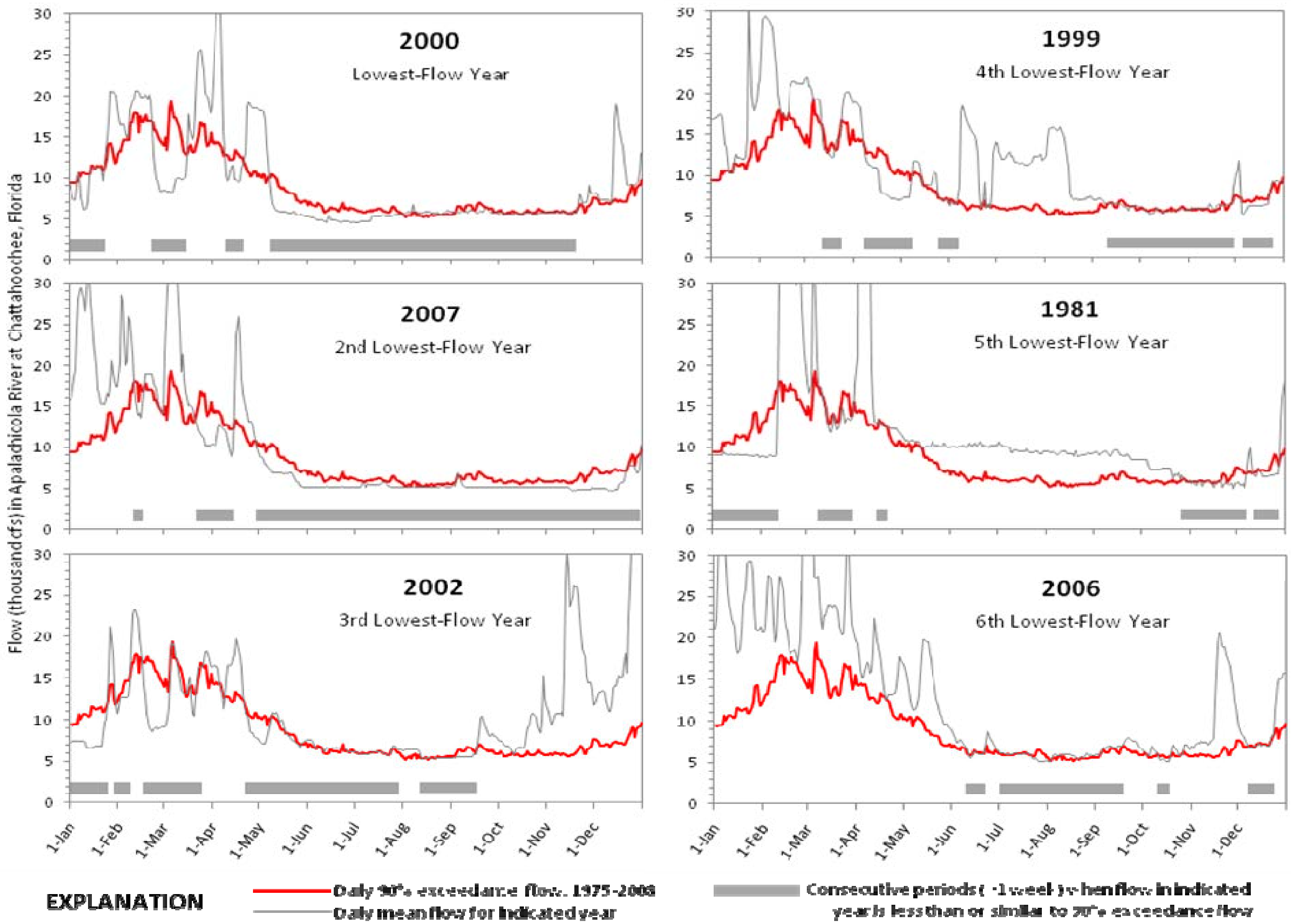


Figure 3. Daily 90% exceedance flow compared to daily mean flow in the lowest-flow years for the period 1975-2008. Six lowest-flow years were selected on the basis of mean annual flow. Flows >30,000 cfs are not shown (USGS 2010).

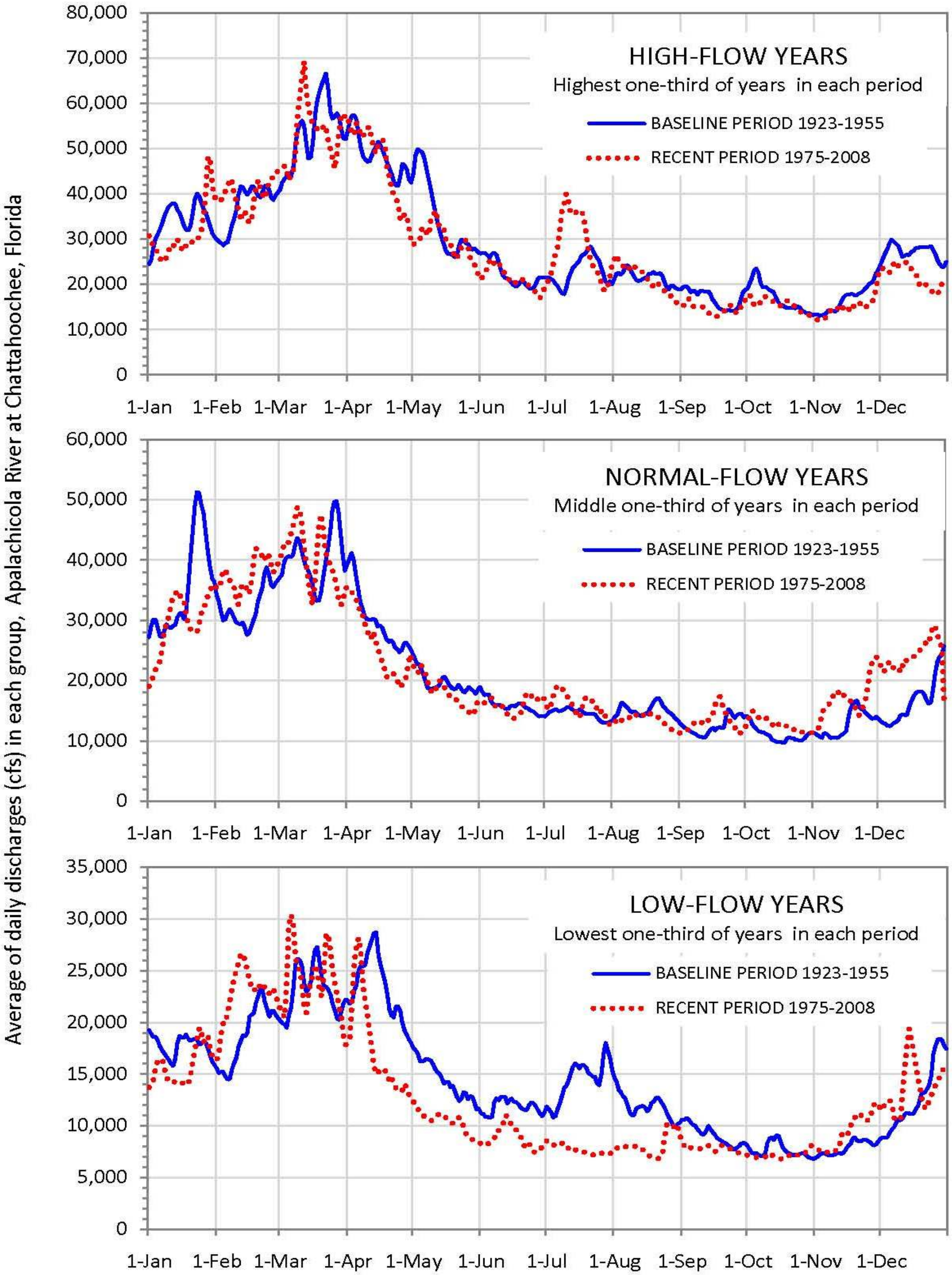


Figure 4. Average of the daily discharges in the Apalachicola River in three groups (high-flow, normal-flow, and low-flow years) within two time periods (baseline and recent). Years were sorted into three nearly equal groups on the basis of mean annual discharge (see list in Appendix B).

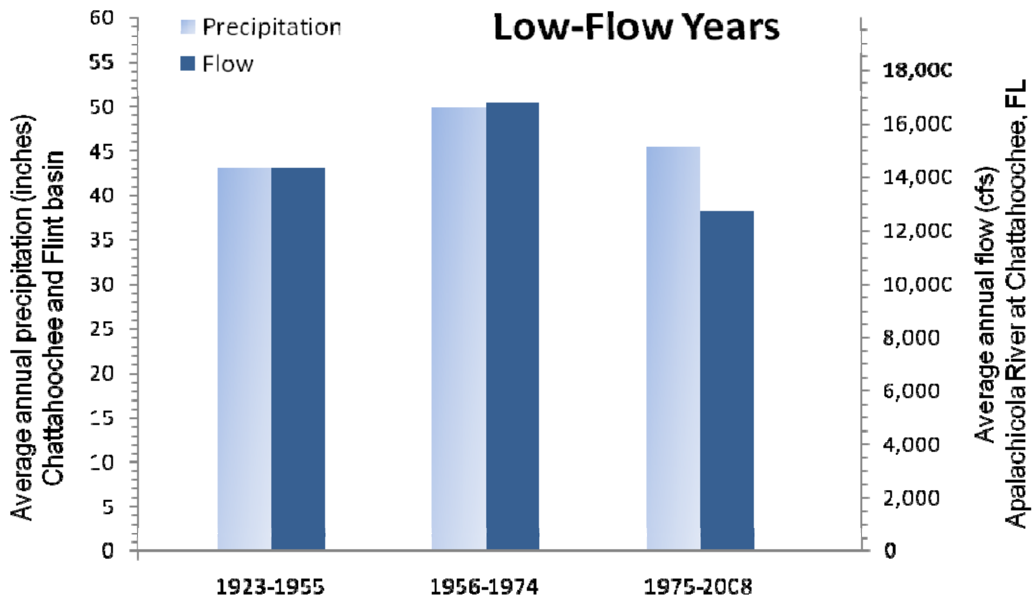


Figure 5. Annual precipitation in the Chattahoochee and Flint River basins compared to annual streamflow in the Apalachicola River in low-flow years during three time periods. Low-flow years are the lowest one-third of years in each time period, ranked in terms of mean annual flow. Data for each year are listed in Appendix C. The right axis was adjusted to make precipitation and flow bars the same height in the baseline period (1923-1955), so that rainfall-flow relations in later periods could be visually compared to the baseline condition (US Dept of Commerce 2009; USGS 2010).

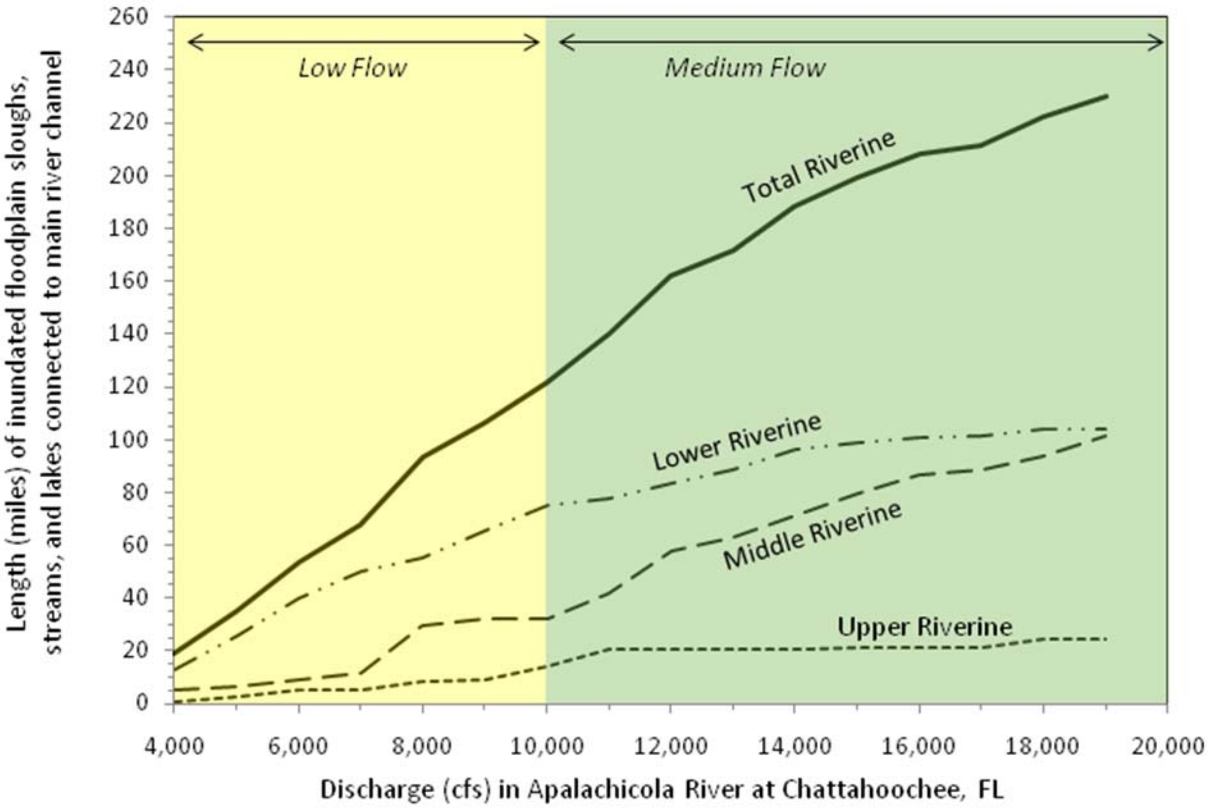


Figure 6. Length of floodplain sloughs, streams, and lakes in relation to flow in the riverine (nontidal) reach of the Apalachicola River. Length represents the linear distance along inundated reaches of floodplain sloughs, streams, and lakes that are connected to the main river channel under present channel conditions. Data from Table 7 in Light et al. (1998).

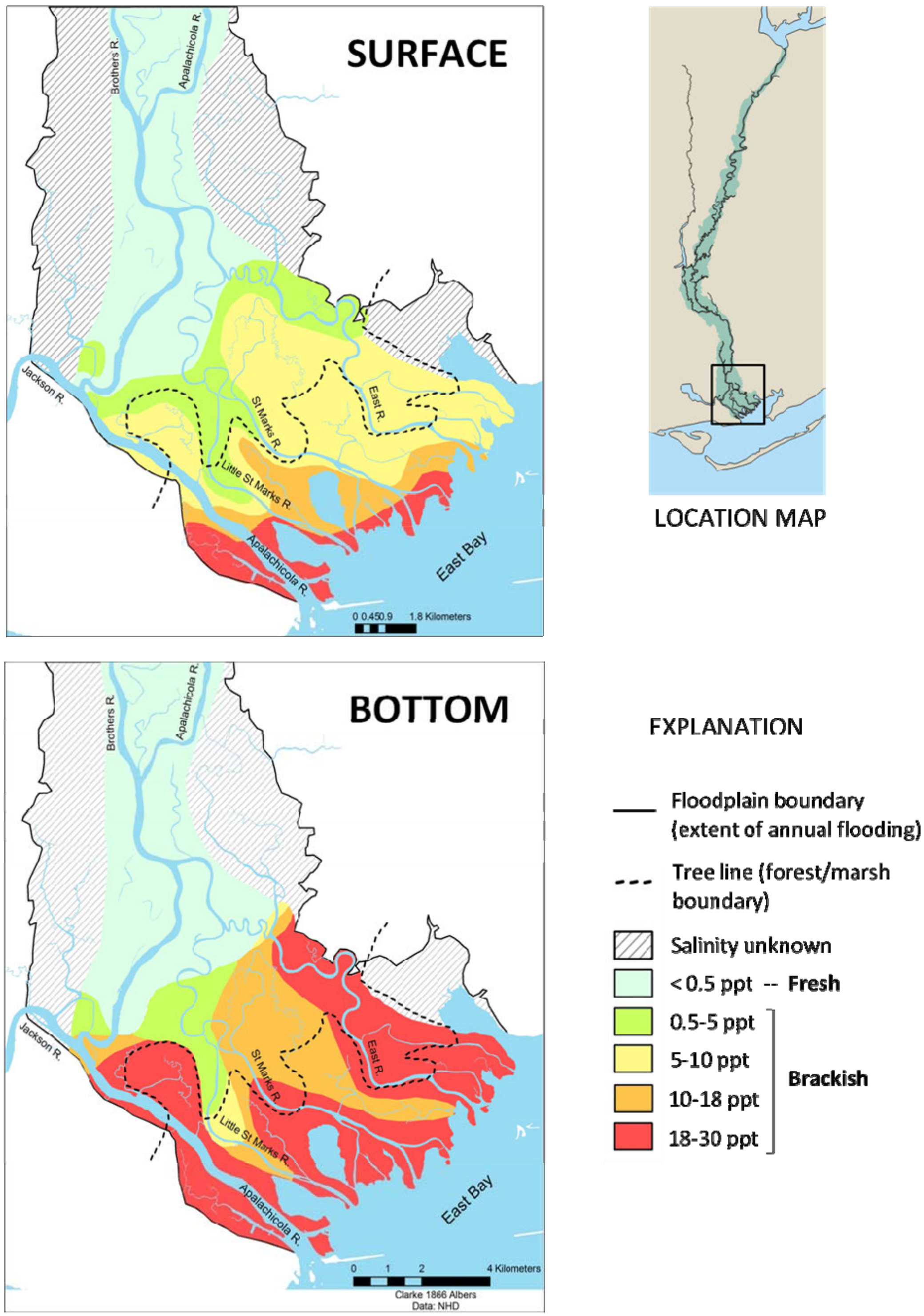
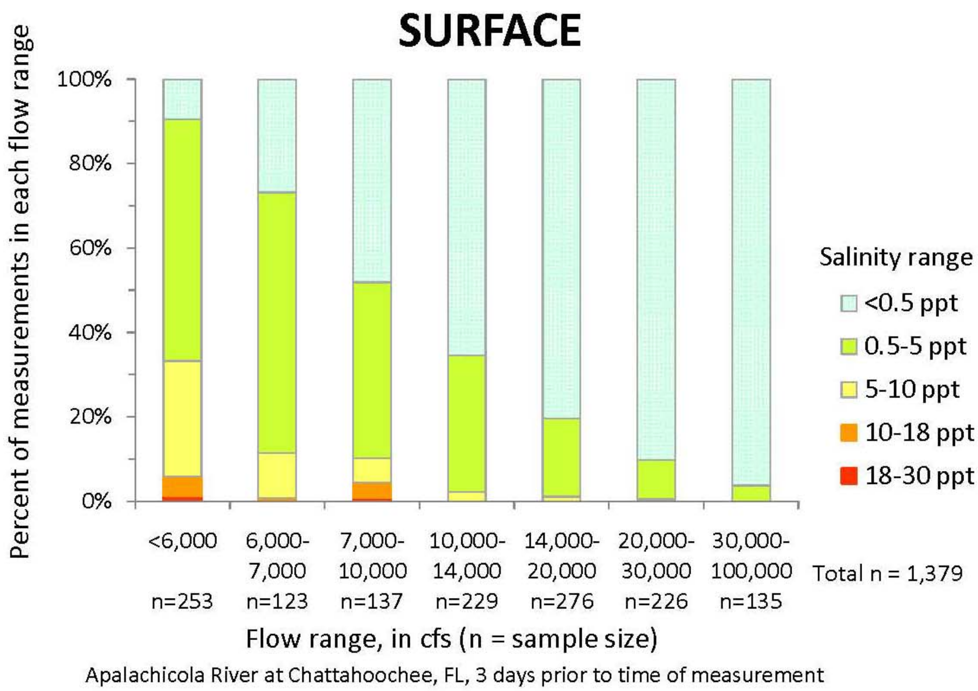


Figure 7. Zones indicating maximum upstream extent of brackish salinities (surface and bottom) in the lower Apalachicola River and distributaries. Zones were determined from data described in Appendix D.



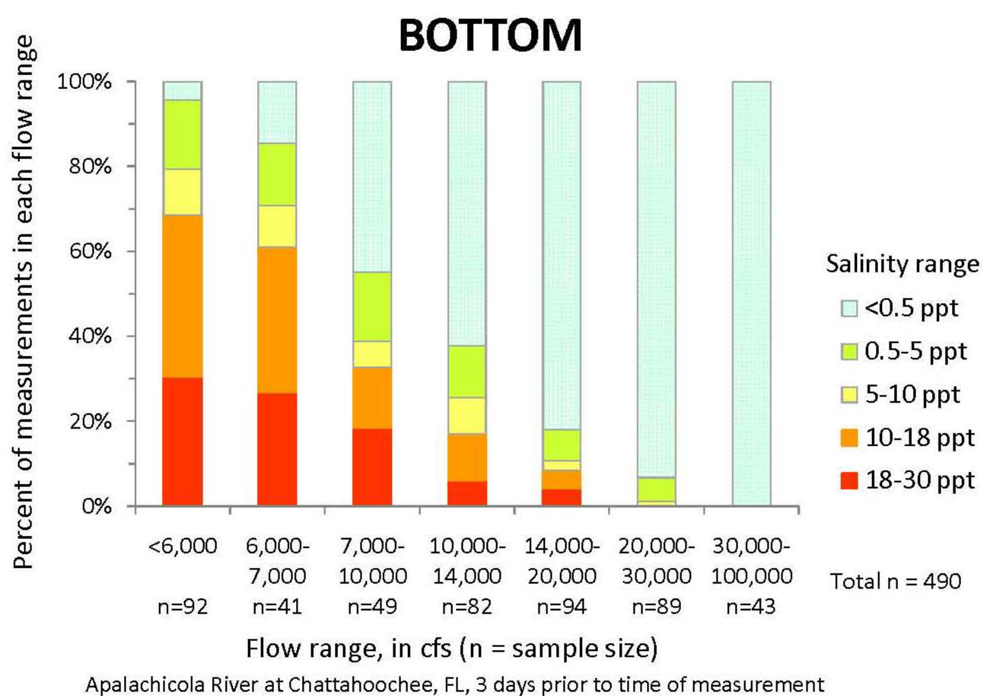


Figure 8. Surface and bottom salinity in brackish-water reaches of the lower Apalachicola River and distributaries in relation to river flow. This analysis is based on measurements from brackish-water zones only (see Figure 7). Source data are described in Appendix D. A time lag of 3 days (to account for travel time from the streamgage at Chattahoochee, Florida) was used to determine river flow associated with each salinity measurement.

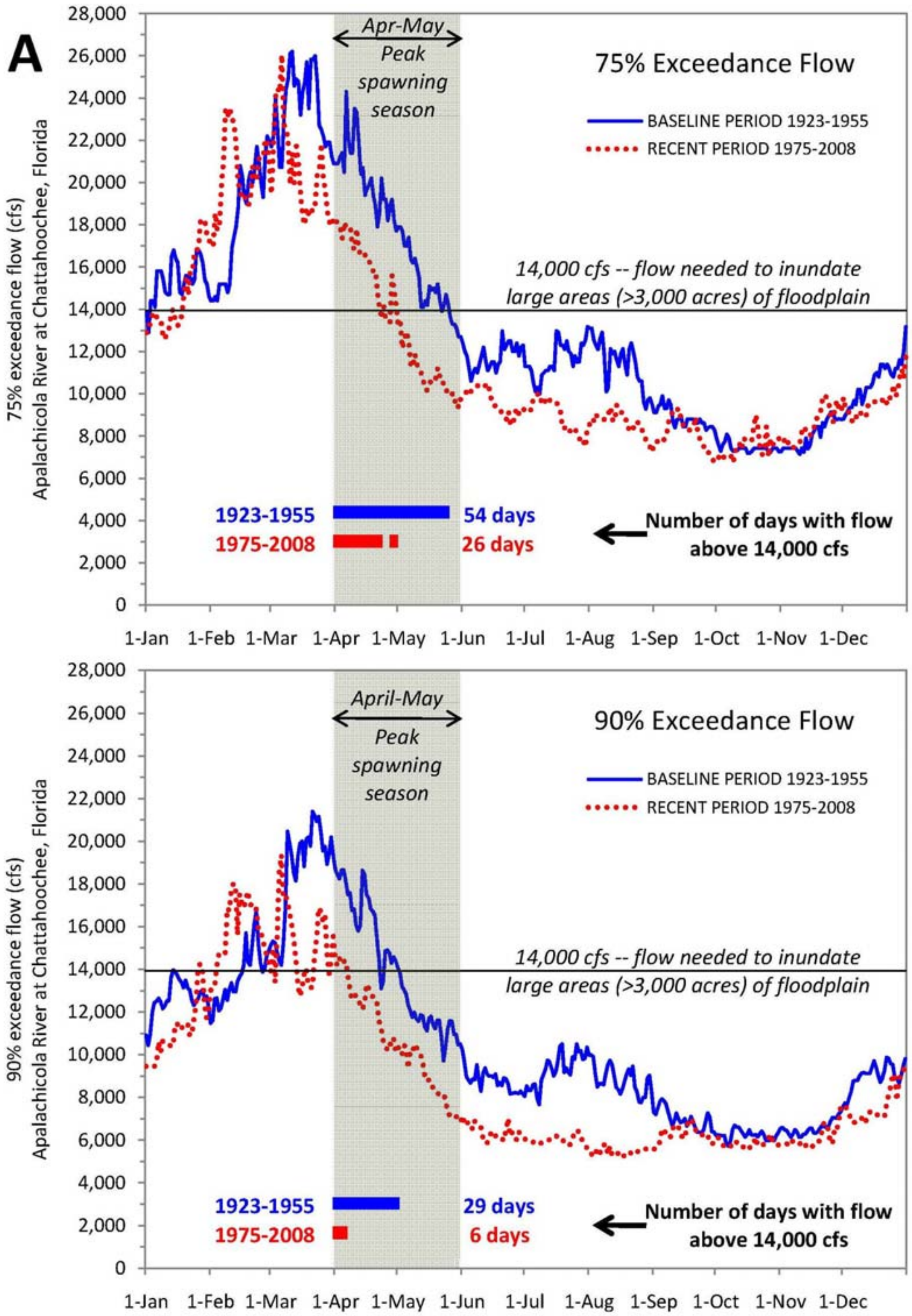


Figure 9. Decrease in availability of fish spawning and nursery habitat as a result of lower flows since 1975. (A) Floodplain forest inundation in spring. (B) Slough connectivity in summer. Baseline and recent flows are compared during dry (75% exceedance) and drought (90% exceedance) conditions.

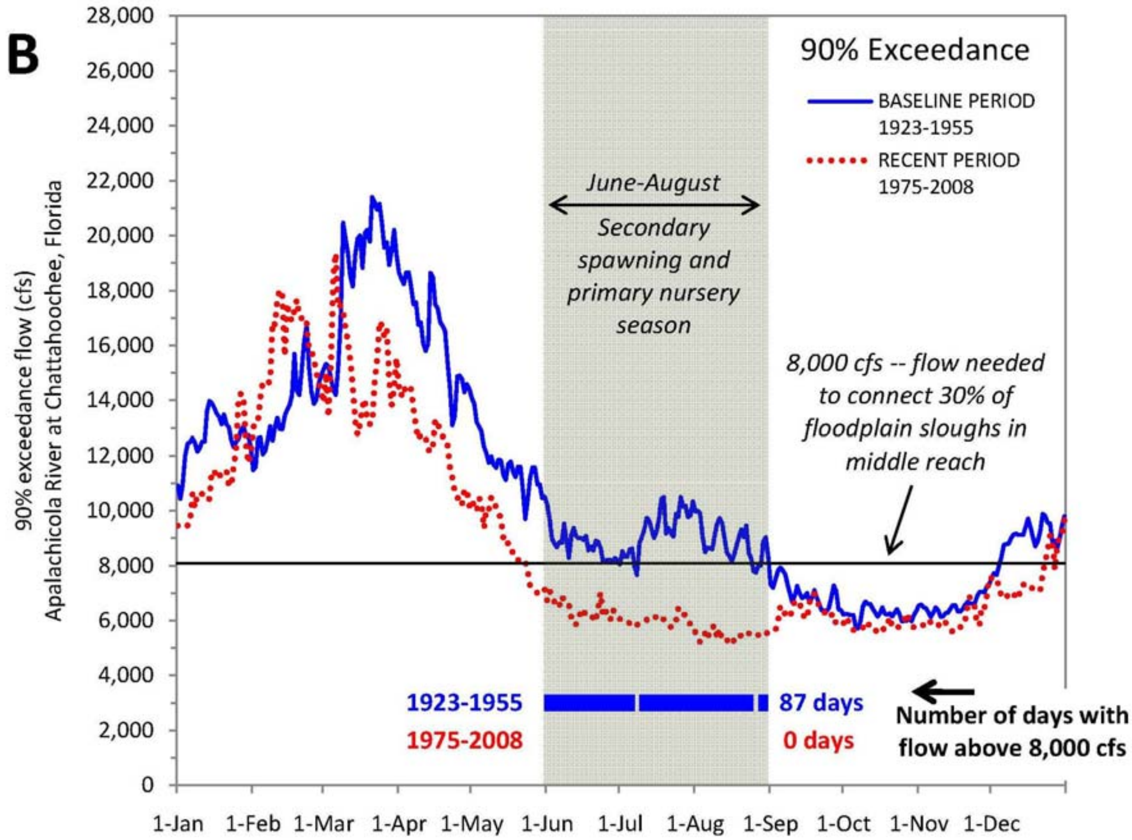


Figure 9. Continued -- (B) Slough connectivity in summer.

High Flows (> 30,000 cfs)

Figure 10. Forested floodplains inundated during high flows provide refuge from the main channel as well as feeding, spawning and nursery habitats for fish. Of the 99 species of fish known to occur in the Apalachicola River-floodplain system, 80% utilize aquatic floodplain habitats at some time during their life cycle. Photograph from Light et al. (1998).

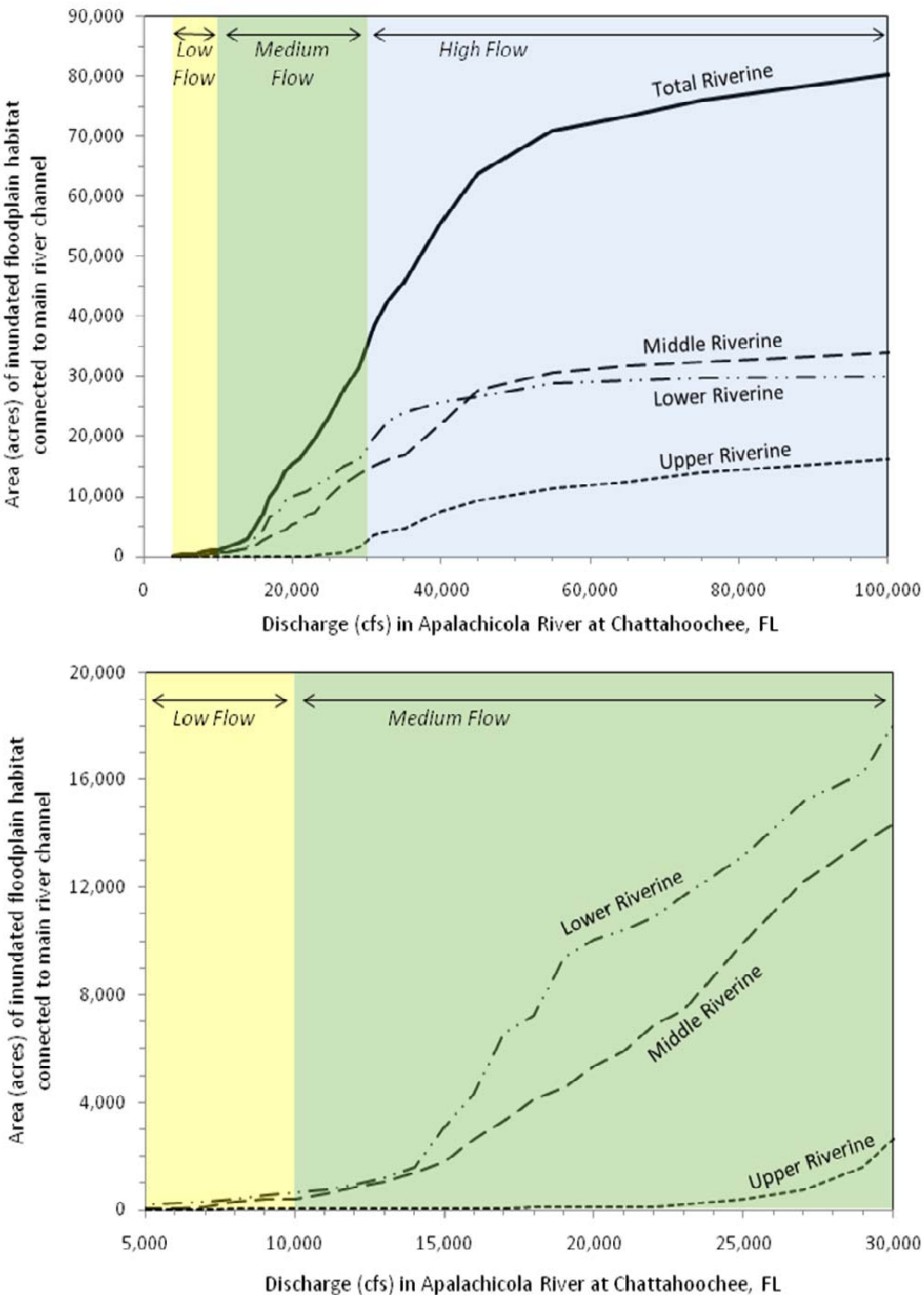


Figure 11. Area of inundated floodplain habitat in relation to flow in the riverine (nontidal) reach of the Apalachicola River. Area represents inundated floodplain habitat that is connected to the main river channel under present channel conditions. Modified from Figure 27 in Light et al. (1998).

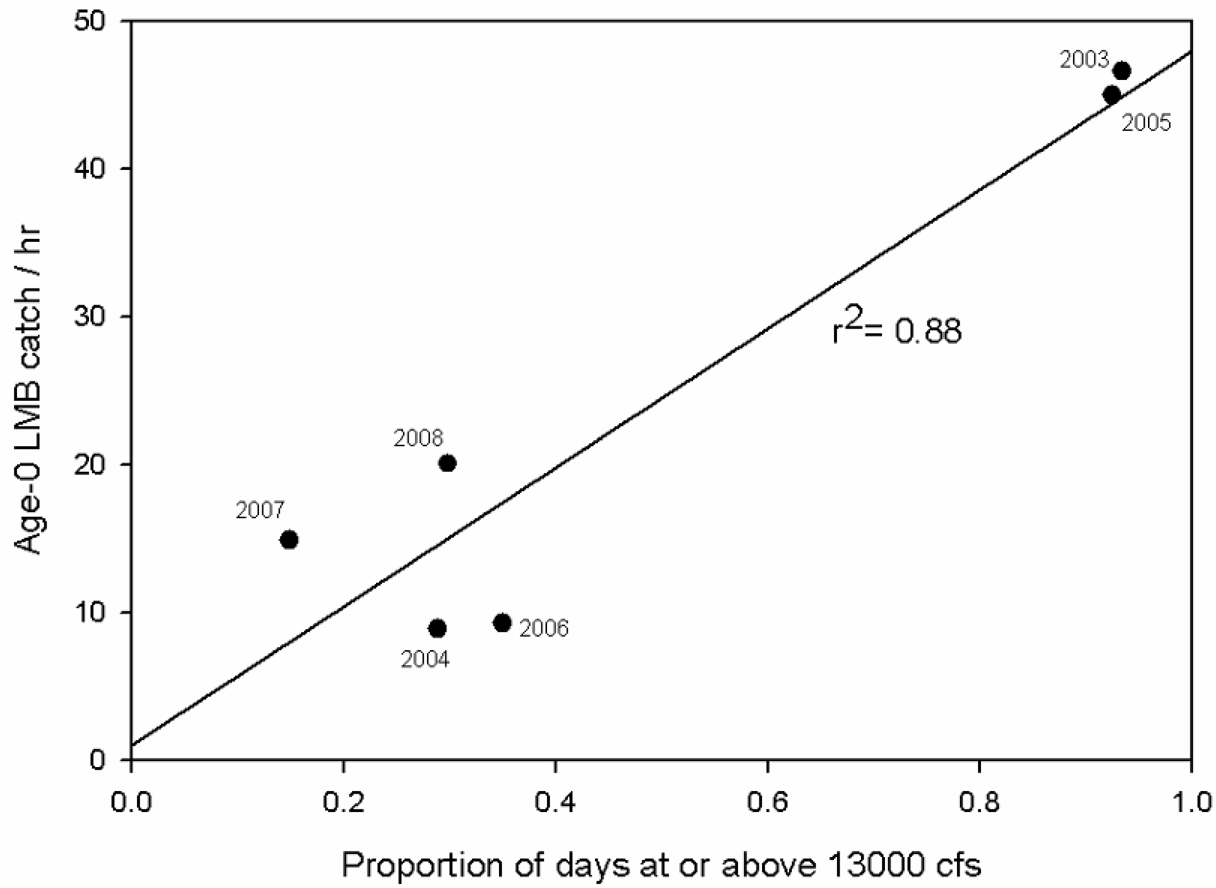


Figure 12. Relationship of mean catch per hour of age-0 largemouth bass (LMB) to the proportion of days during March 1 – September 30 that met or exceeded the 13,000 cfs threshold at USGS gage 02358000 near Chattahoochee, FL. From Allen et al. (2009).

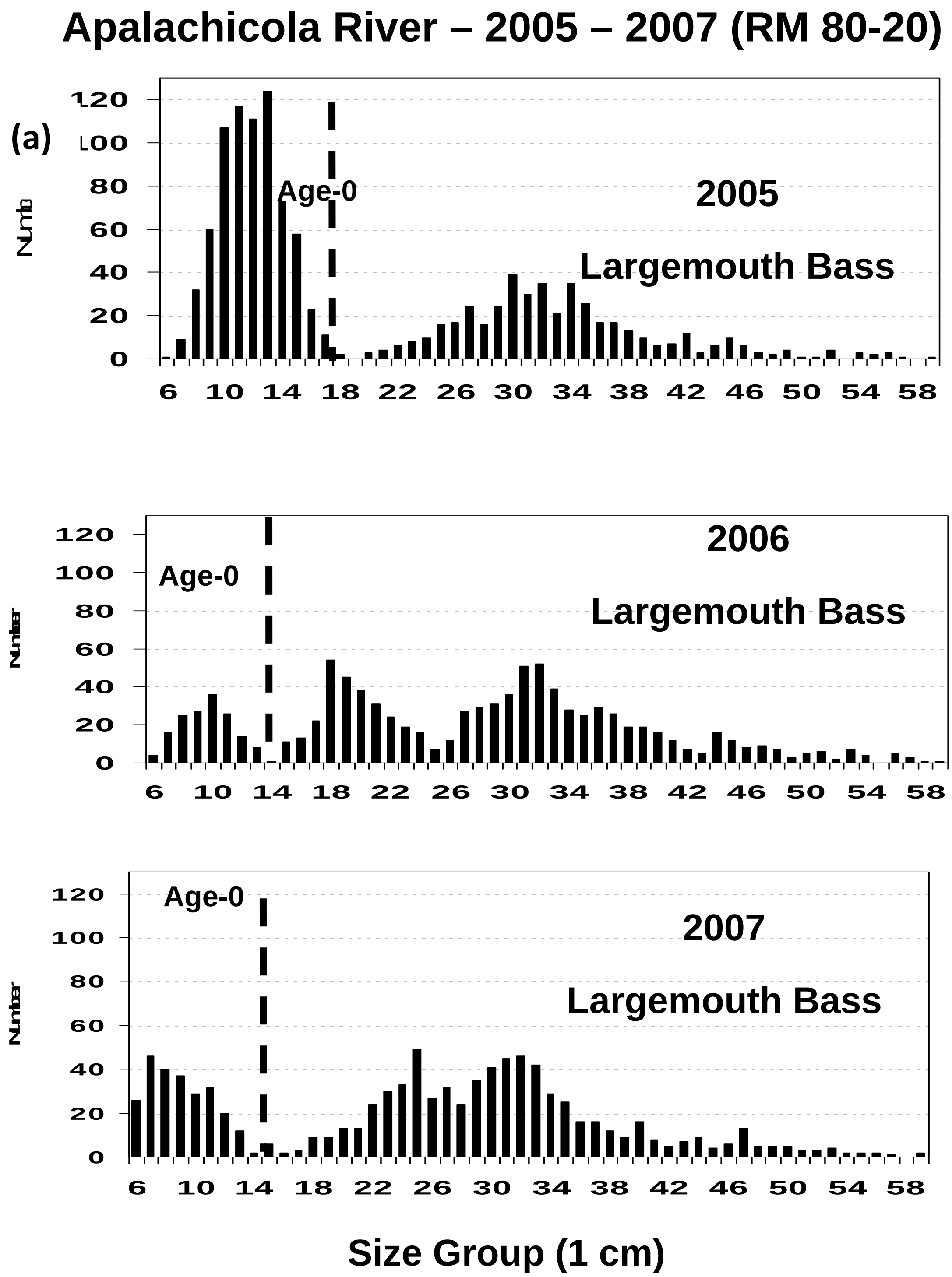
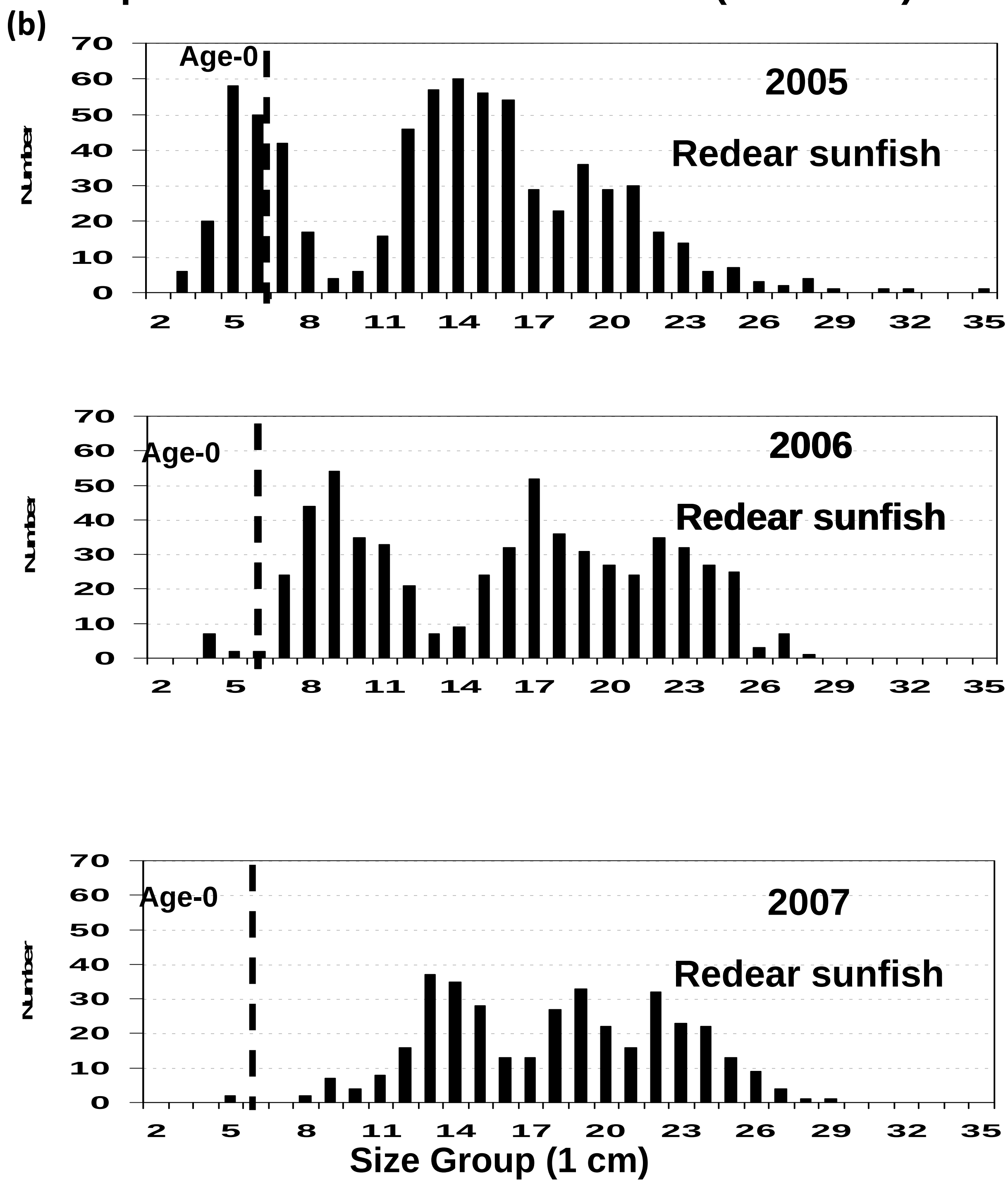


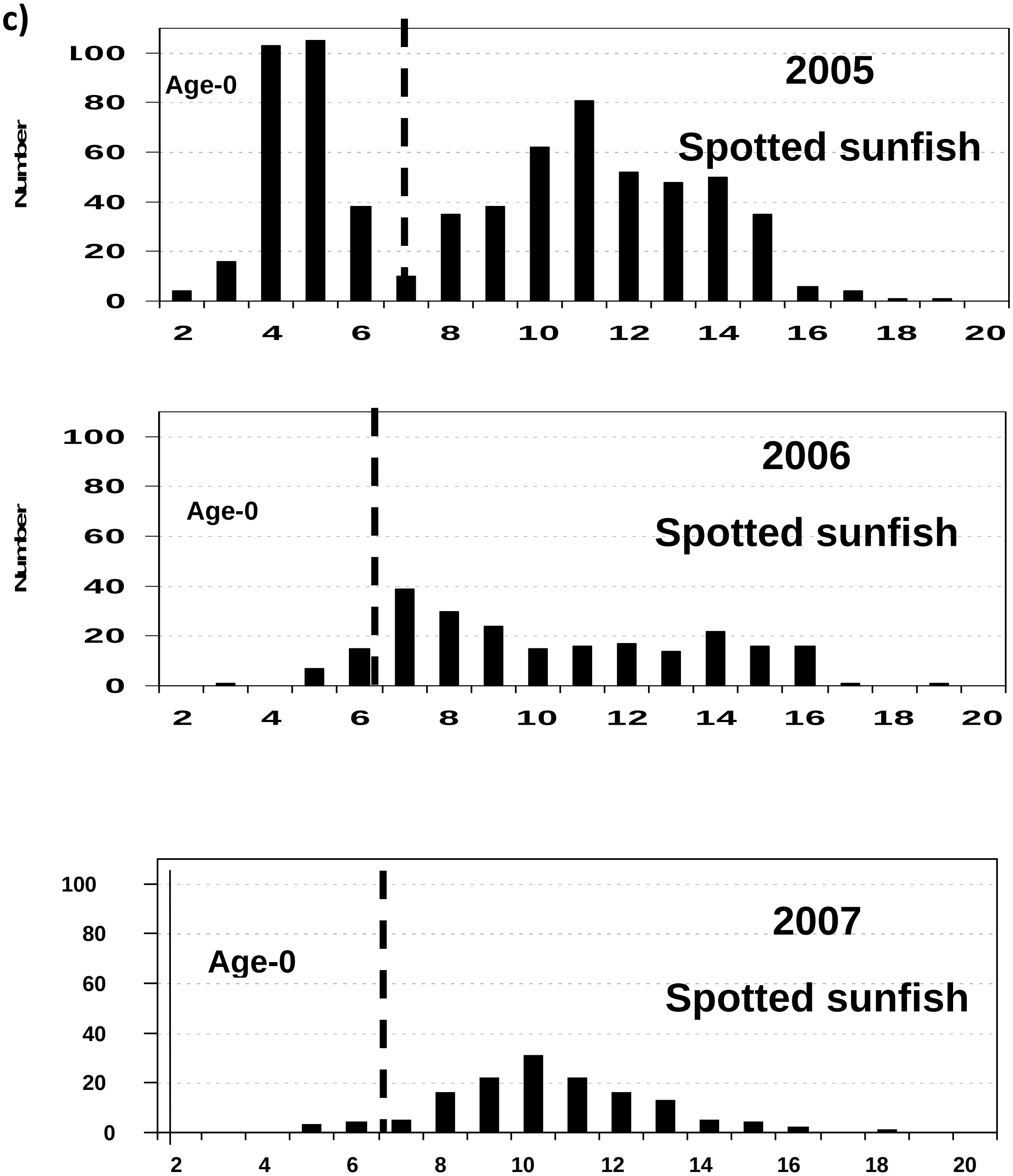
Figure 13. Size distribution of fish collected by electrofishing in the Apalachicola River main channel and sloughs in September 2005-2007 (a) largemouth bass (b) redear sunfish, (c) spotted sunfish, and (d) warmouth sunfish. Electrofishing effort among years was equal, with a total of 100 samples (10 minutes/sample) collected in each year (50 samples in the main channel plus 50 samples in the sloughs).

Apalachicola River – 2005 - 2007 (RM 80-20)



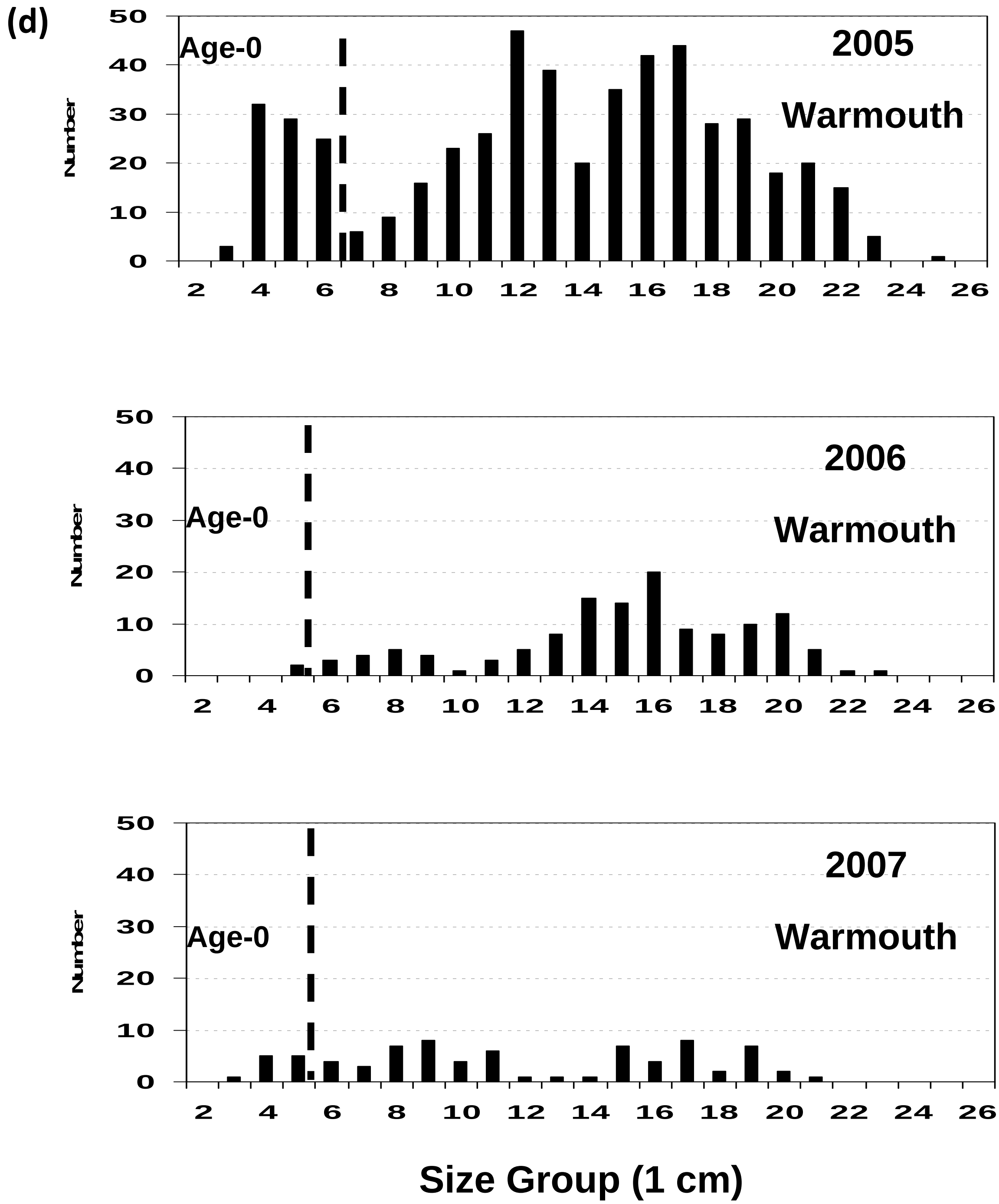
Apalachicola River – 2005-2007 (RM 80-20)

(c)



Size Group (1 cm)

Apalachicola River – 2005 - 2007(RM 80-20)



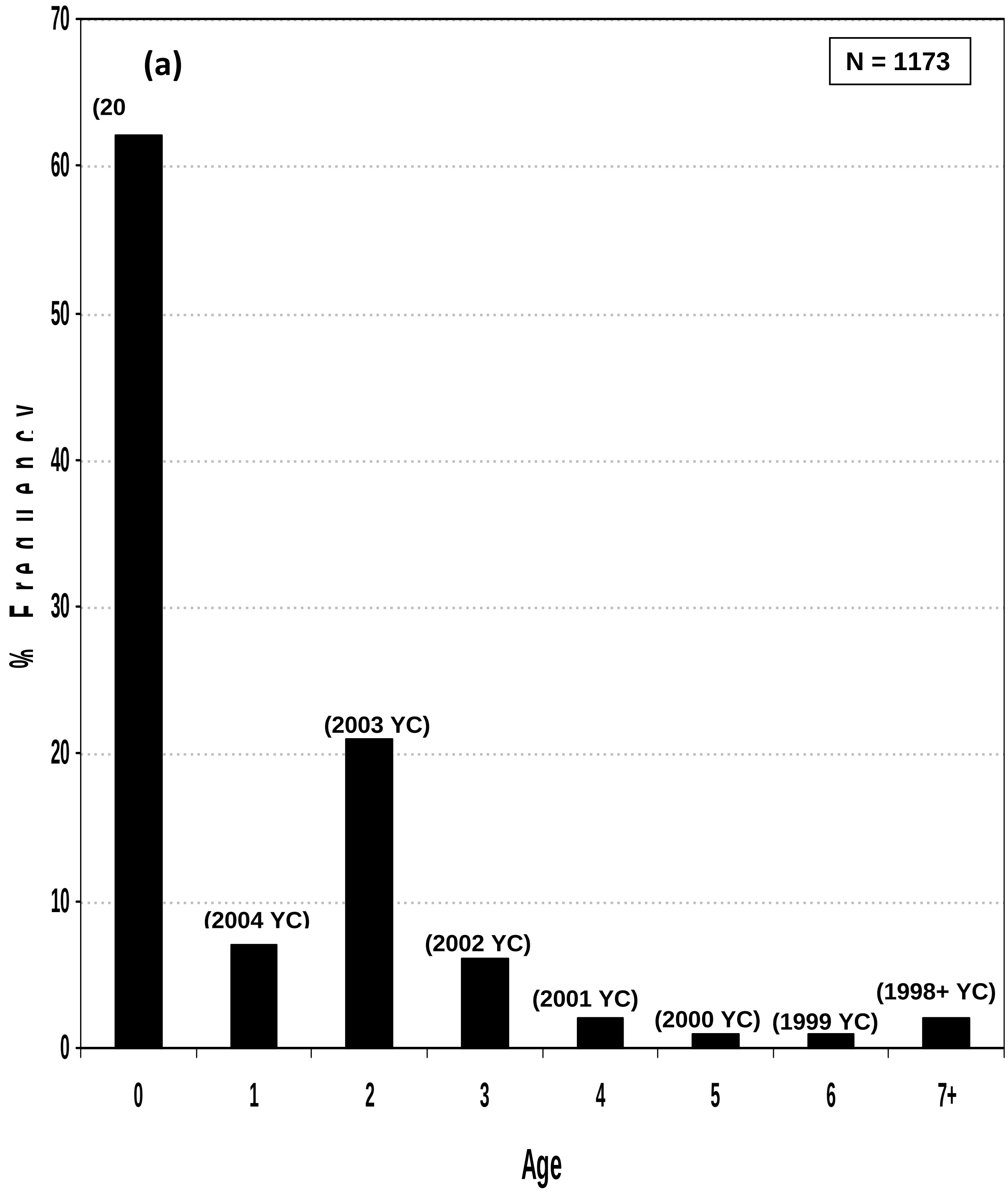
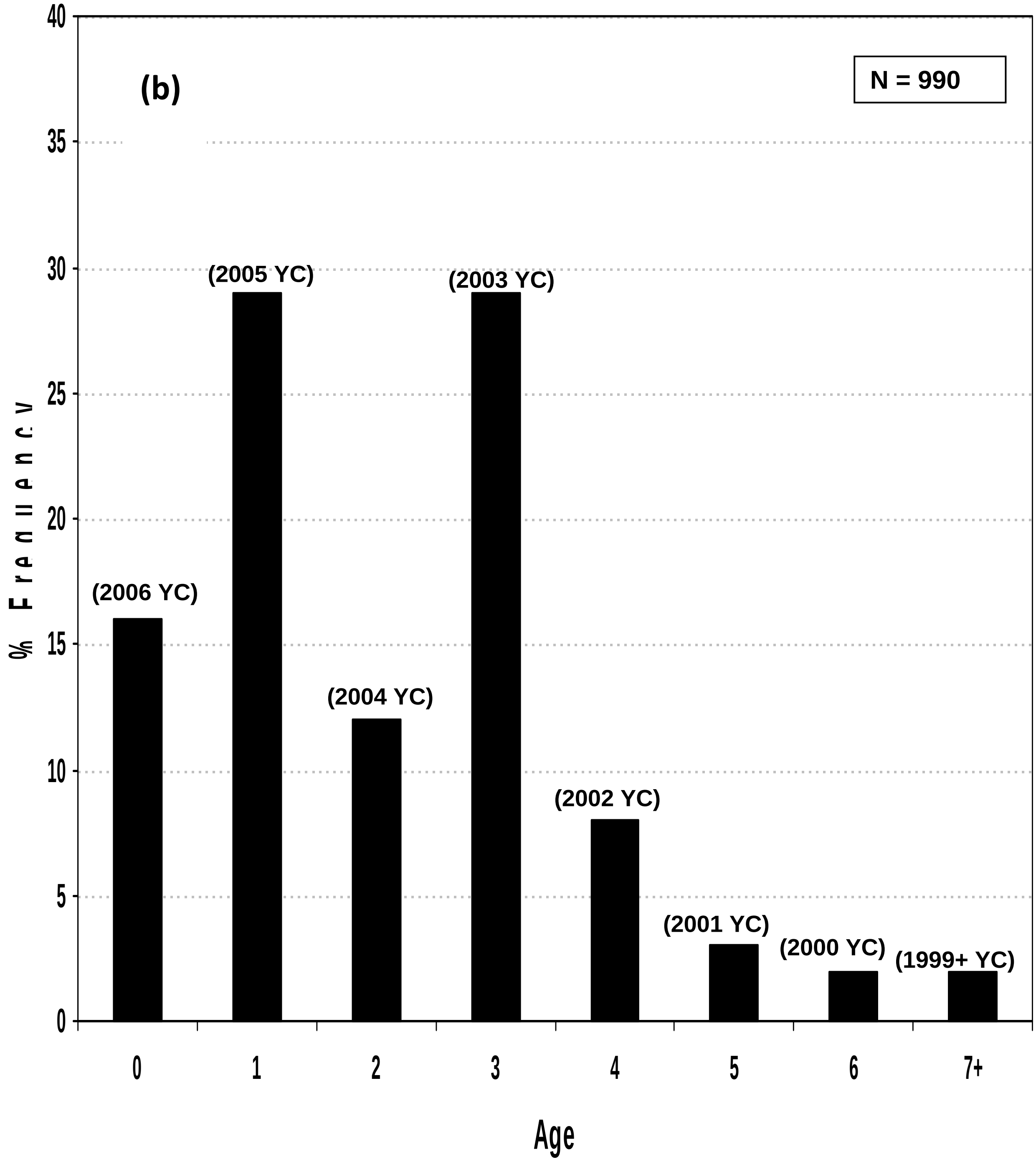
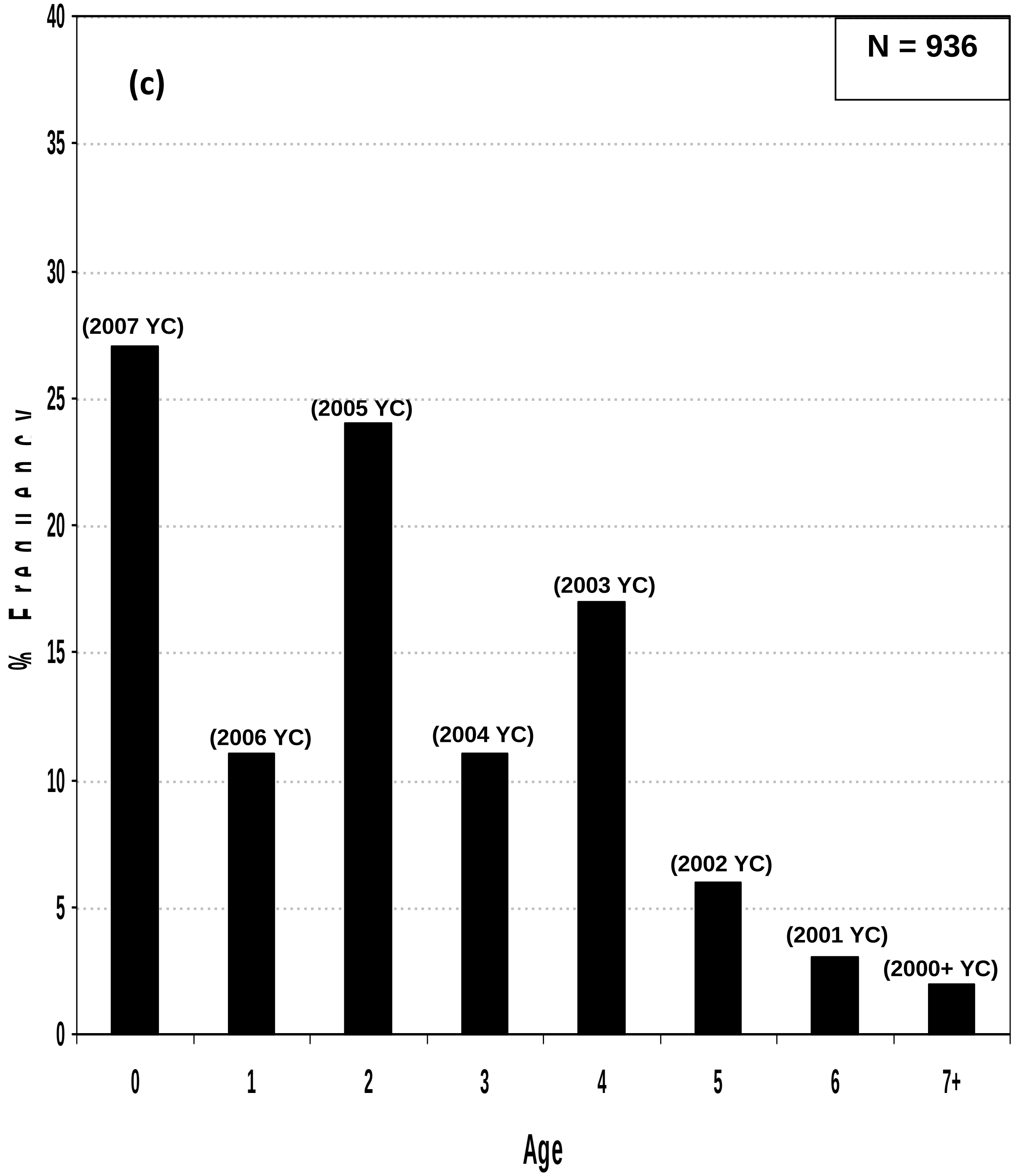


Figure 14. Age distribution of largemouth bass collected by electrofishing in the Apalachicola River-floodplain system (a) in September 2005, (b) in September 2006, and (c) in September 2007. YC=year class.


(b)
N = 990
% Frequency
Age
(2006 YC)
(2005 YC)
(2004 YC)
(2003 YC)
(2002 YC)
(2001 YC)
(2000 YC)
(1999+ YC)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7+


N = 936
(c)
(2007 YC)
(2006 YC)
(2005 YC)
(2004 YC)
(2003 YC)
(2002 YC)
(2001 YC)
(2000+ YC)
% Frequency
Age
0
1
2
3
4
5
6
7+
0
5
10
15
20
25
30
35
40

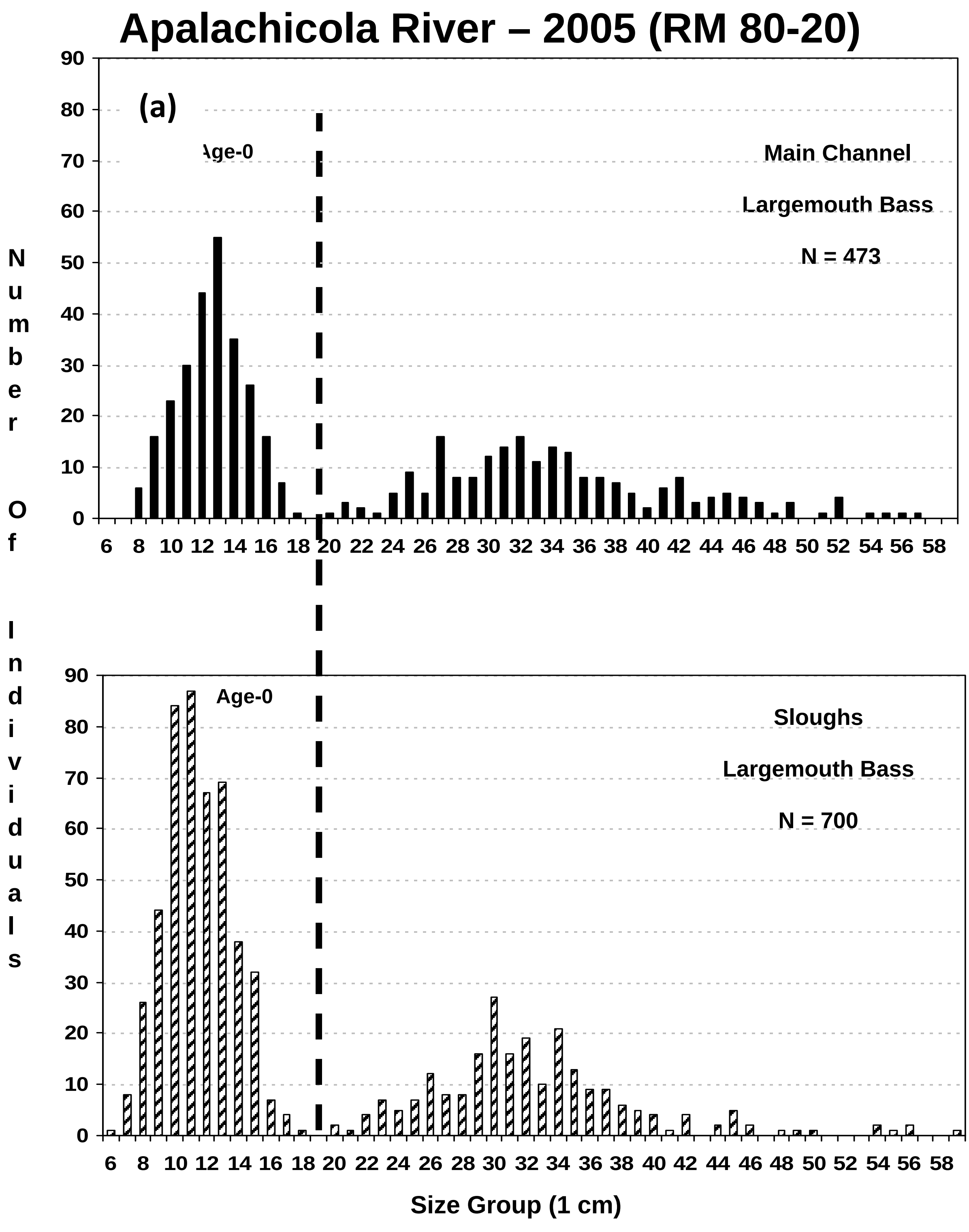
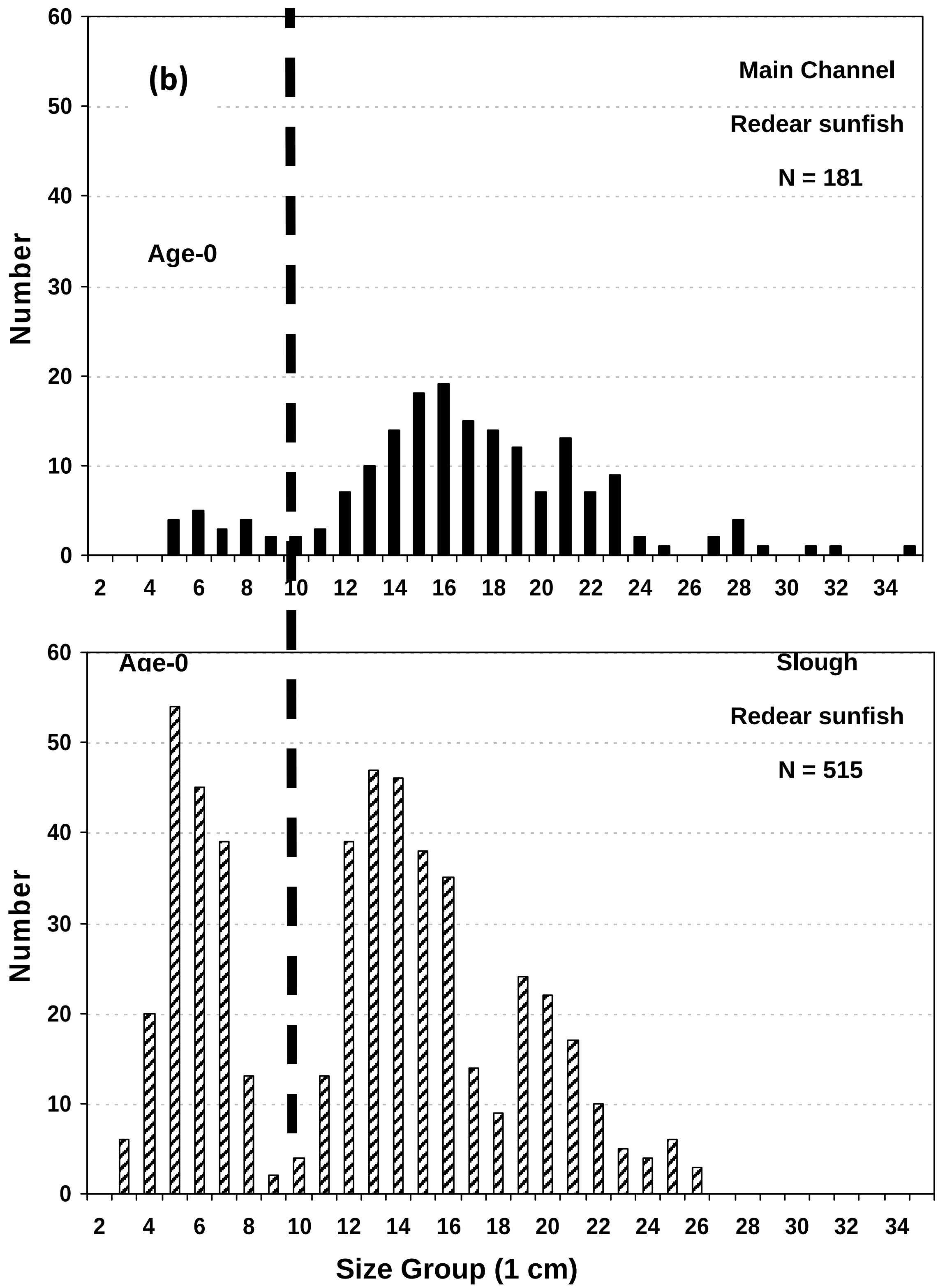
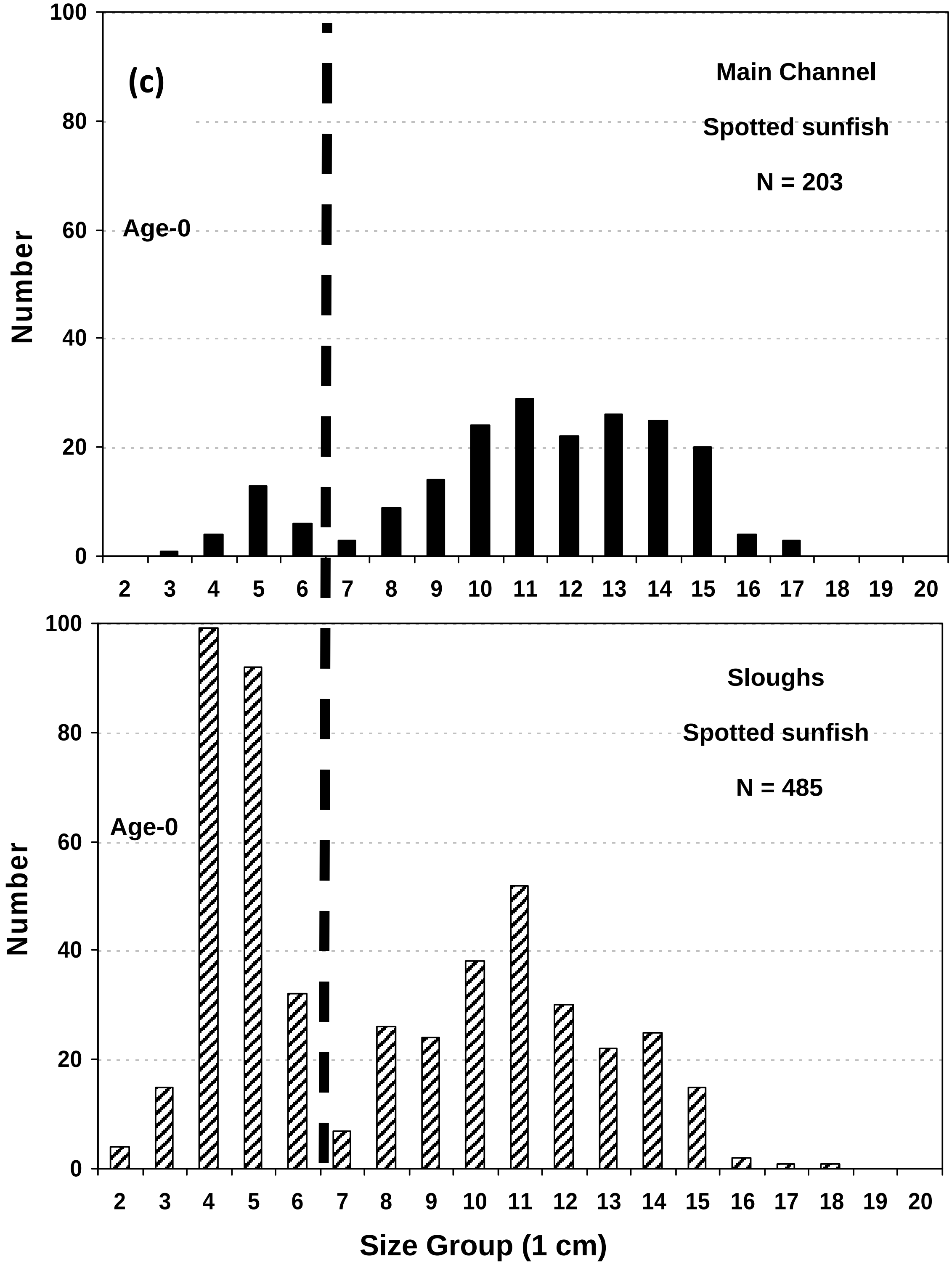
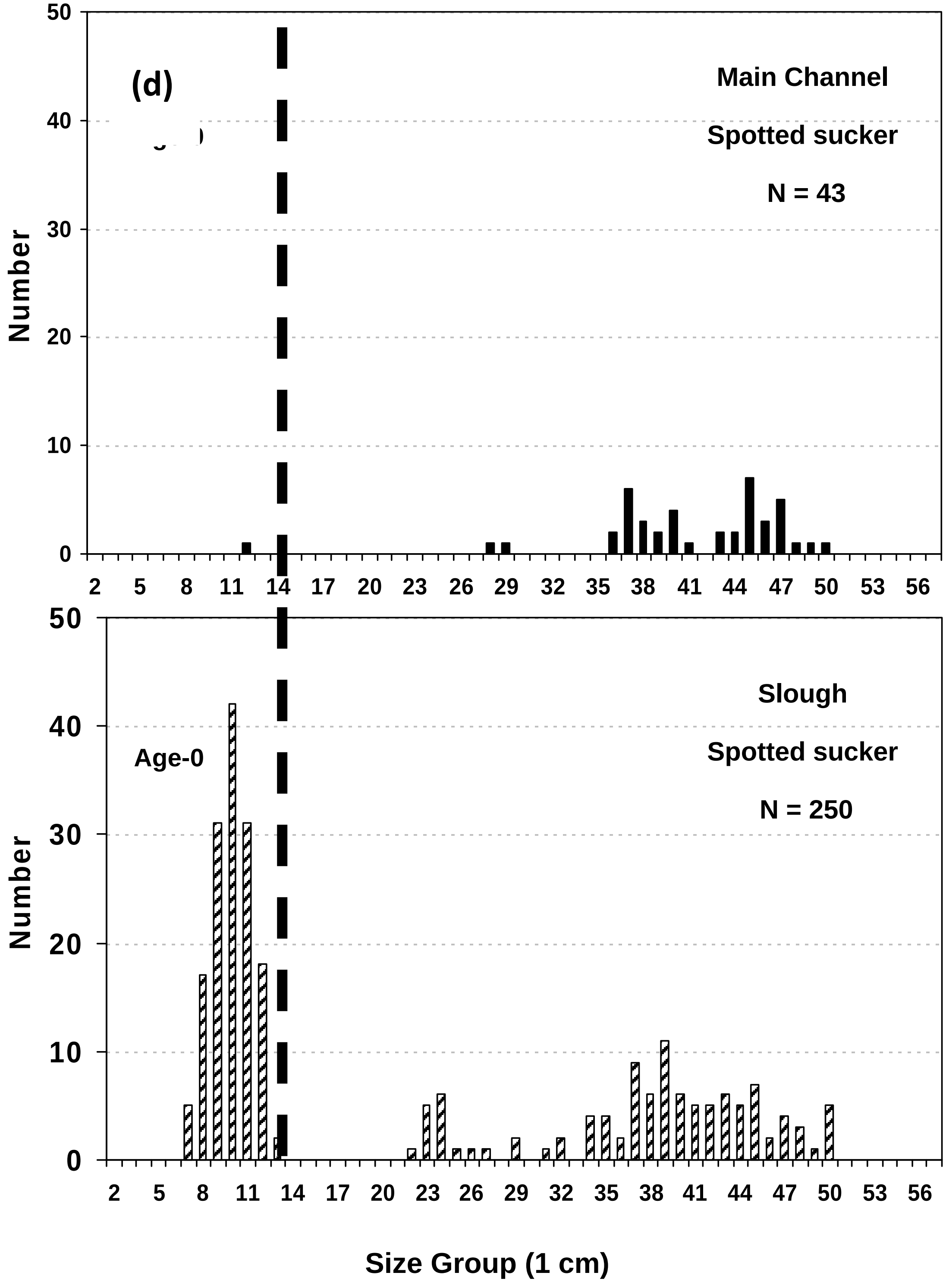


Figure 15. Size distribution of fish collected by electrofishing in the Apalachicola River main channel and sloughs in September 2005 (a) largemouth bass, (b) redear sunfish, (c) spotted sunfish, and (d) spotted suckers. Electrofishing effort was equal in main channel and sloughs. A total of 100 samples (10 minutes/sample) were collected, with 50 samples in the main channel and 50 samples in the sloughs.



(b)
Main Channel
Redear sunfish
N = 181
Age-0
Number
Age-0
Slough
Redear sunfish
N = 515
Number
Size Group (1 cm)


(c)
Main Channel
Spotted sunfish
N = 203
Age-0
Number
100
80
60
40
20
0
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Sloughs
Spotted sunfish
N = 485
Age-0
Number
100
80
60
40
20
0
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Size Group (1 cm)



(d)
Main Channel
Spotted sucker
N = 43
Number
Slough
Spotted sucker
N = 250
Age-0
Number
Size Group (1 cm)

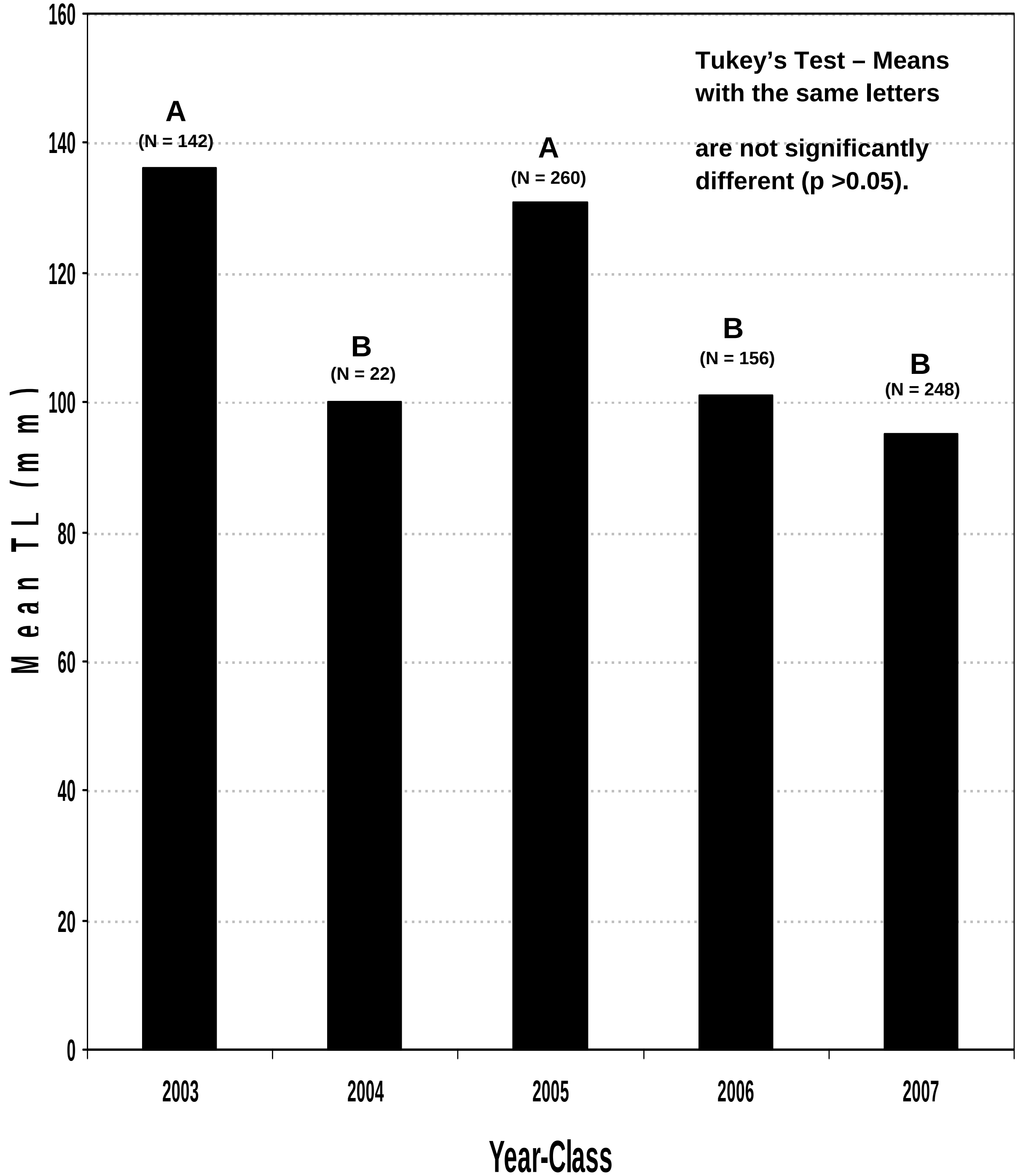


Figure 16. Mean total length (mm) of age-0 largemouth bass collected by electrofishing in the Apalachicola River sloughs and main channel in September. (High spring-summer flows in 2003 and 2005; low spring-summer flows in 2004, 2006, and 2007). Means with the same letters are not significantly different (p>0.05, Tukey's Test). Unpublished data, Charles Mesing, FWC, 2008.

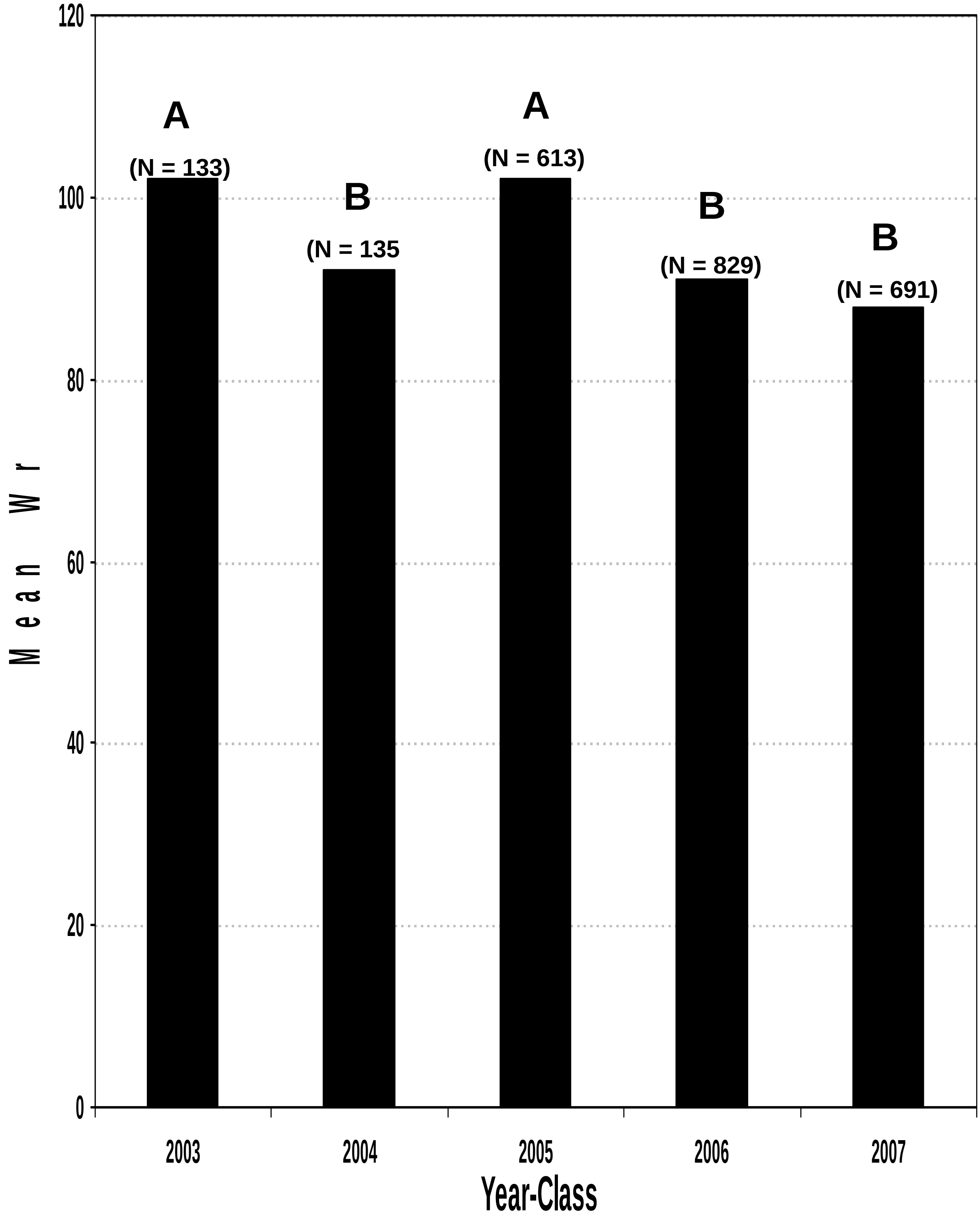


Figure 17. Mean Relative Weights (Wr) of age-0 largemouth bass collected by electrofishing in the Apalachicola River sloughs and main channel in September. (High spring-summer flows in 2003 and 2005; low spring-summer flows in 2004, 2006, and 2007). Means with the same letters are not significantly different (p>0.05, Tukey's Test).

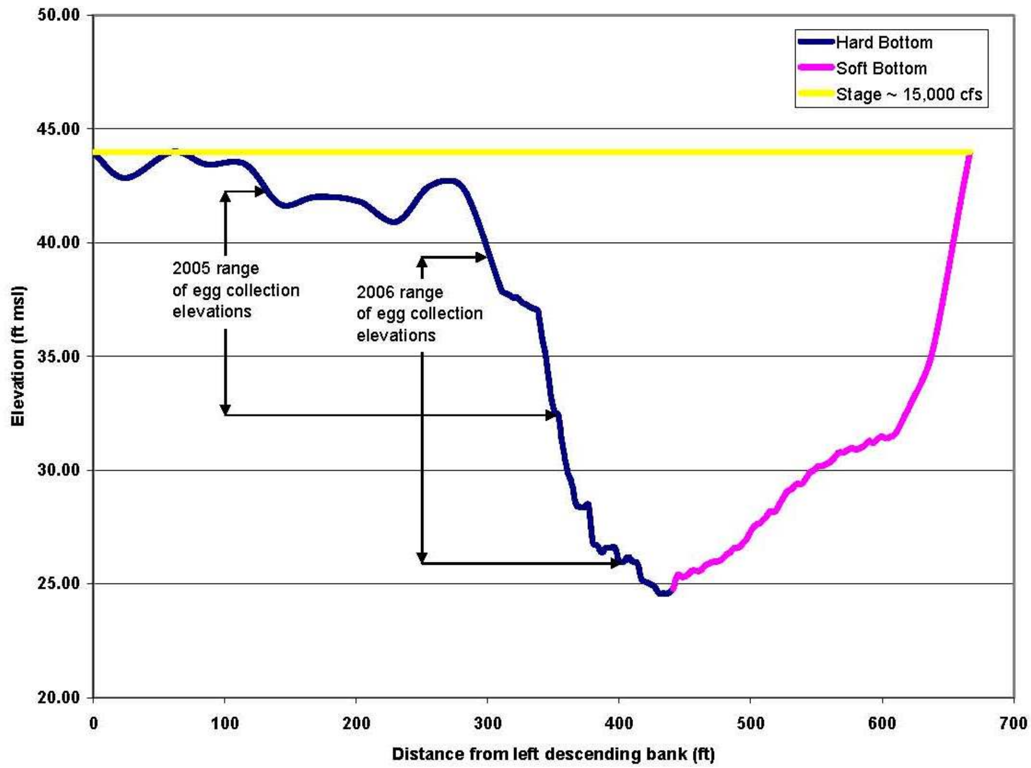


Figure 3.6.1.4.B. Cross section of the river at RM 105, which spans the limestone shoal where sturgeon eggs were collected in both 2005 and 2006.

Figure 18. Cross section of the river at RM 105, which spans the limestone shoal where sturgeon eggs were collected in both 2005 and 2006. From Biological Opinion (USFWS, 2008).

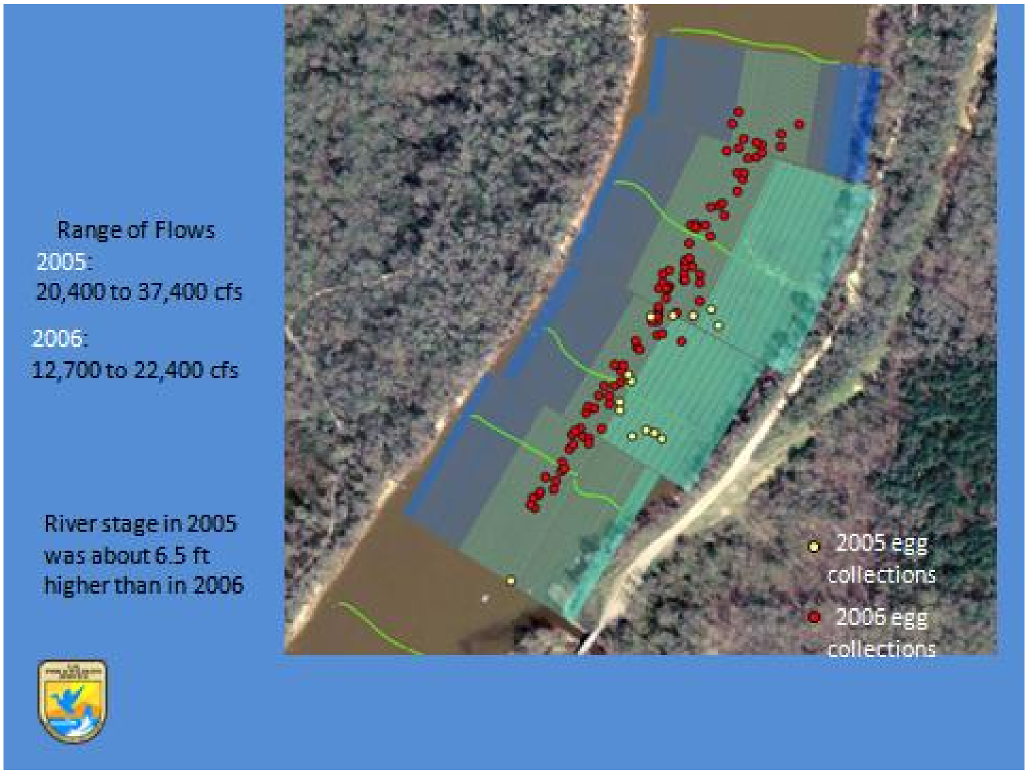


Figure 19. Gulf sturgeon egg collections during the 2005 and 2006 spawning season superimposed on the Race Shoal site depth grid. Lower flows and stages in 2006 appear to restrict collections to a narrower range of depth of the limestone outcrop. From Scollan and Parauka (2008).

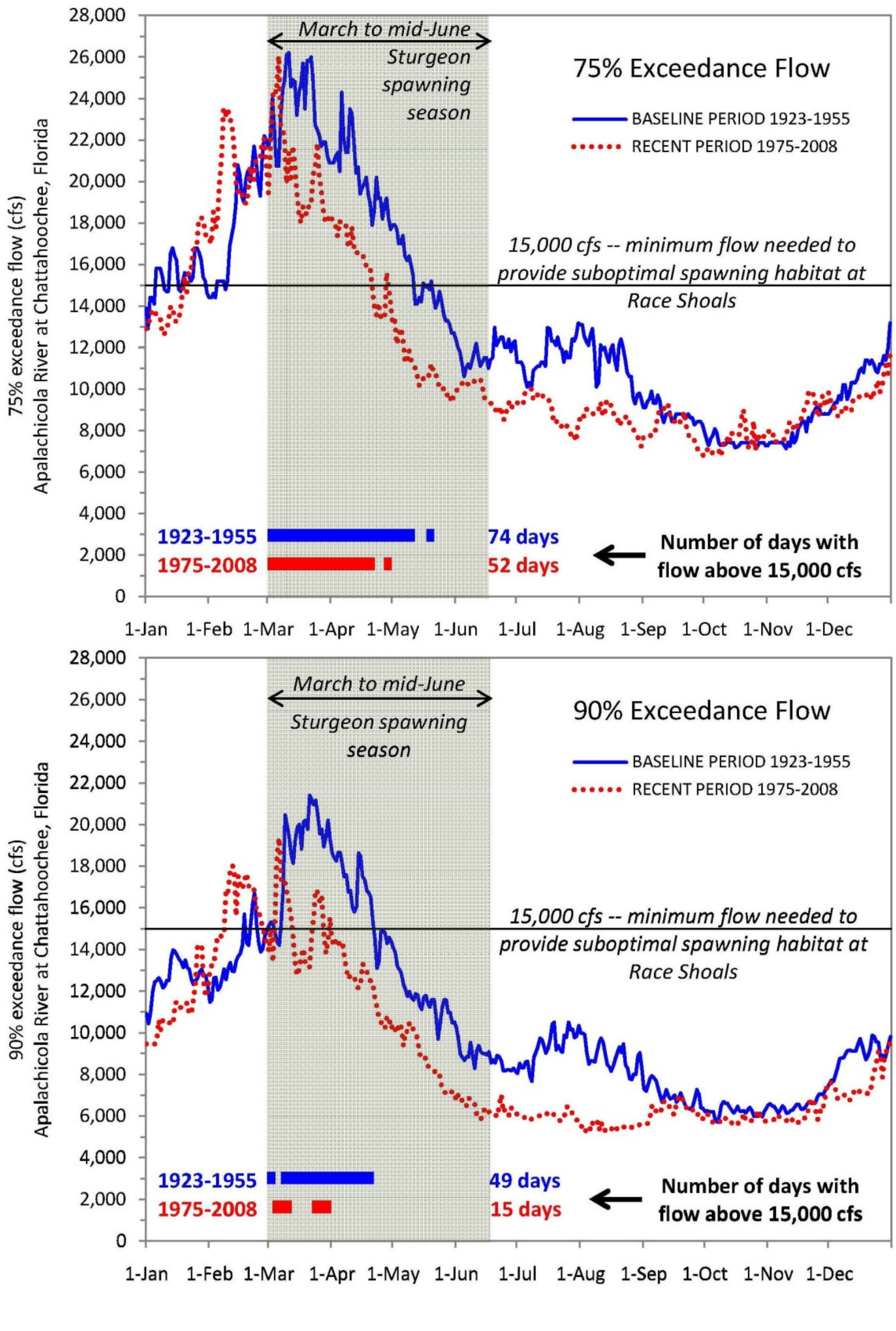


Figure 20. Decrease in availability of sturgeon spawning habitat at Race Shoal in March through May during dry (75% exceedance) and drought (90% exceedance) conditions. Hydrographs show 90% exceedance flows in the earliest 33 years (1923-1955) and the latest 34 years (1975-2008) of the period of record for Apalachicola River at Chattahoochee, Florida. [Flow data from USGS, 2010; see text for discussion of sturgeon spawning habitat and hydrology section for explanation of flow hydrographs.]

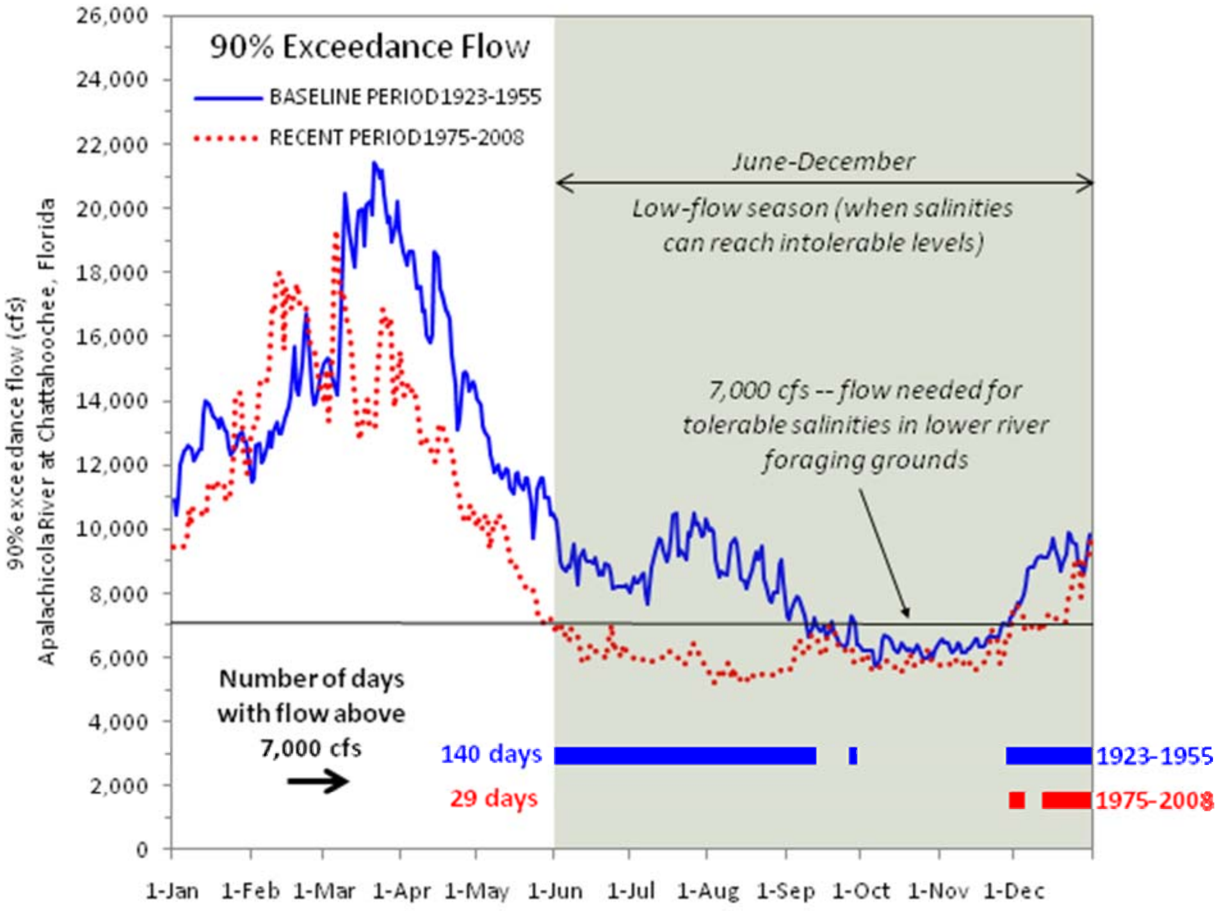


Figure 21. Decrease in availability of lower river foraging grounds with tolerable salinities for juvenile sturgeon in June through December during drought conditions. Hydrographs show 90% exceedance flows in the earliest 33 years (1923-1955) and the latest 34 years (1975-2008) of the period of record for Apalachicola River at Chattahoochee, Florida. [Flow data from USGS, 2010; see text for discussion of juvenile sturgeon foraging habitat requirements.]

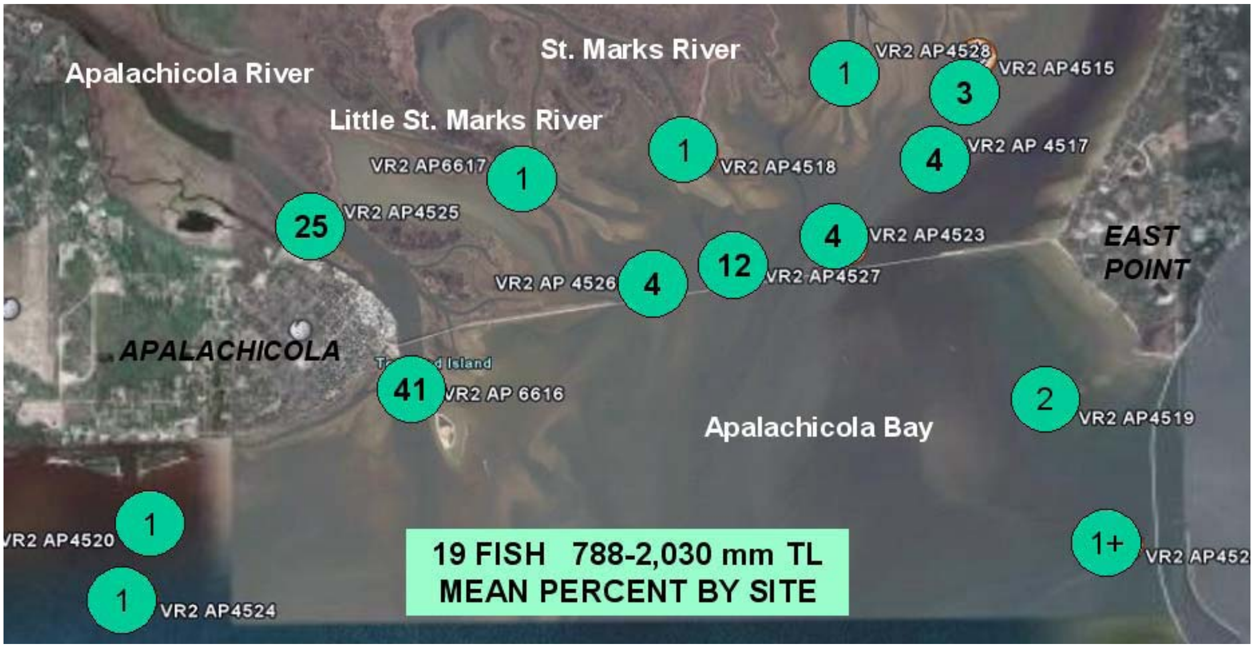
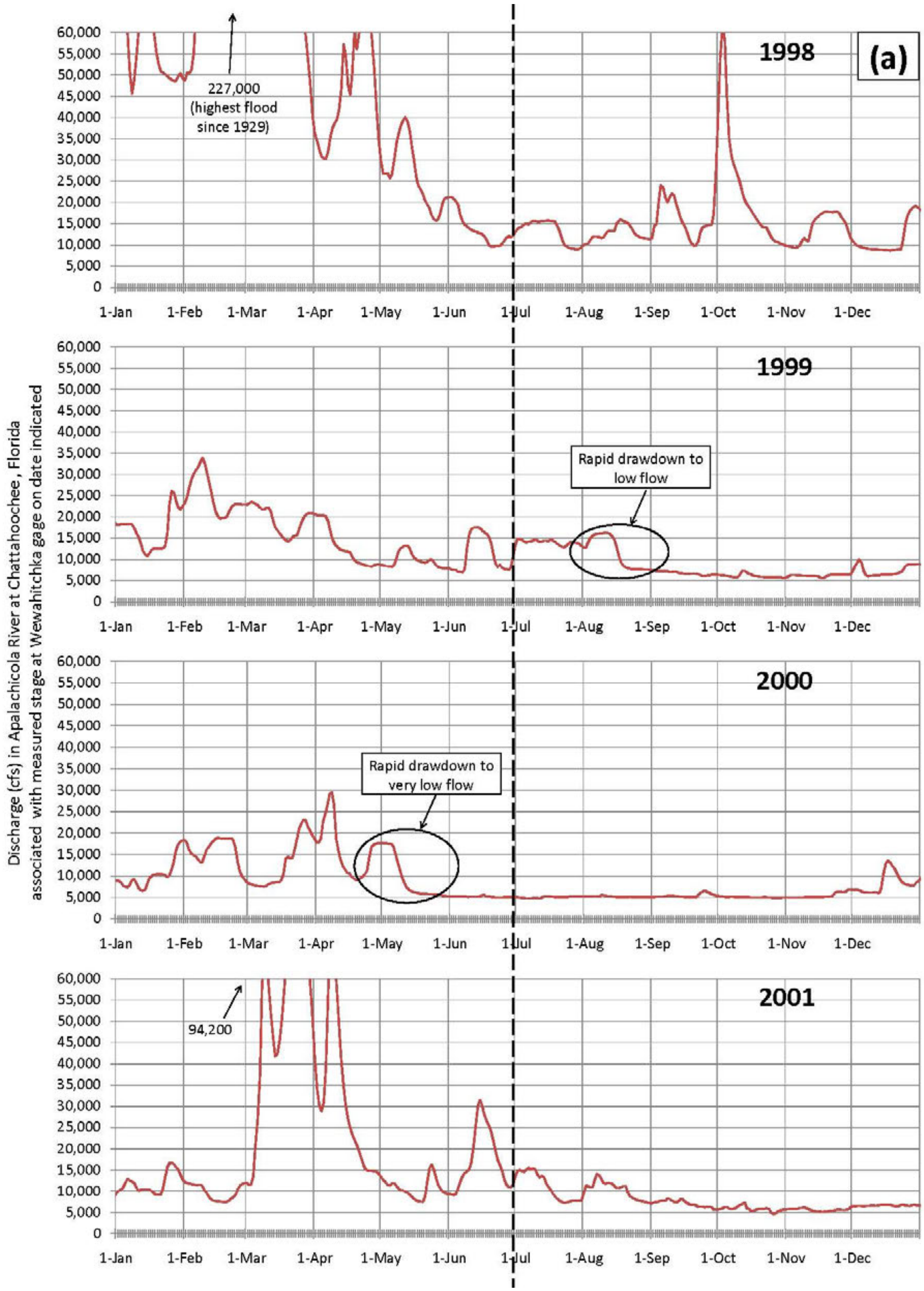
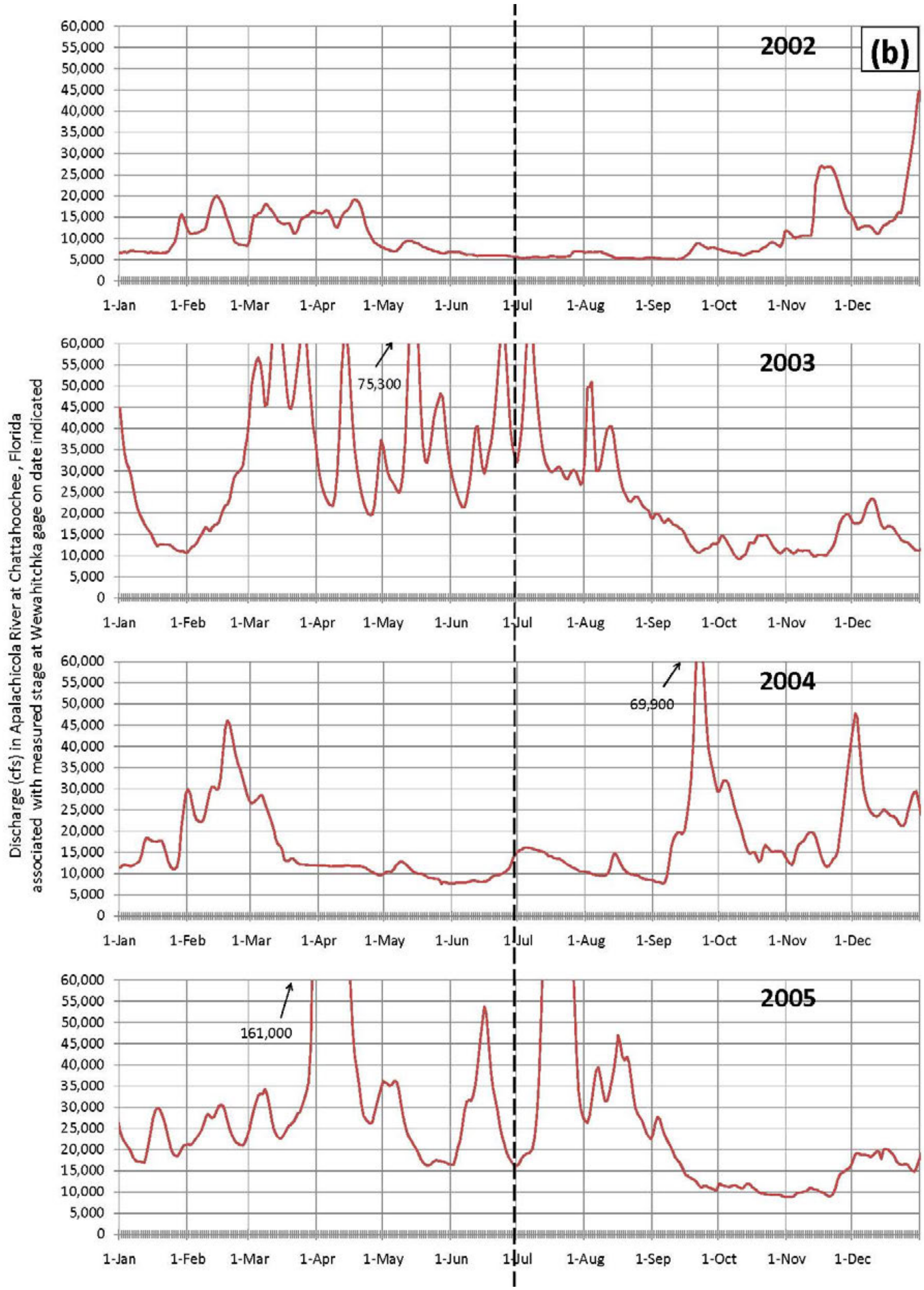


Figure 22. Distribution of Gulf sturgeon encounters during October 2006 through March 2007 while salinities were low in the distributaries of the delta and Bay margin. Of the 19 fish tagged, only 3 were detected after release. Numbers in the green dots represent frequency of encounters. From Sulak et al. (2009).

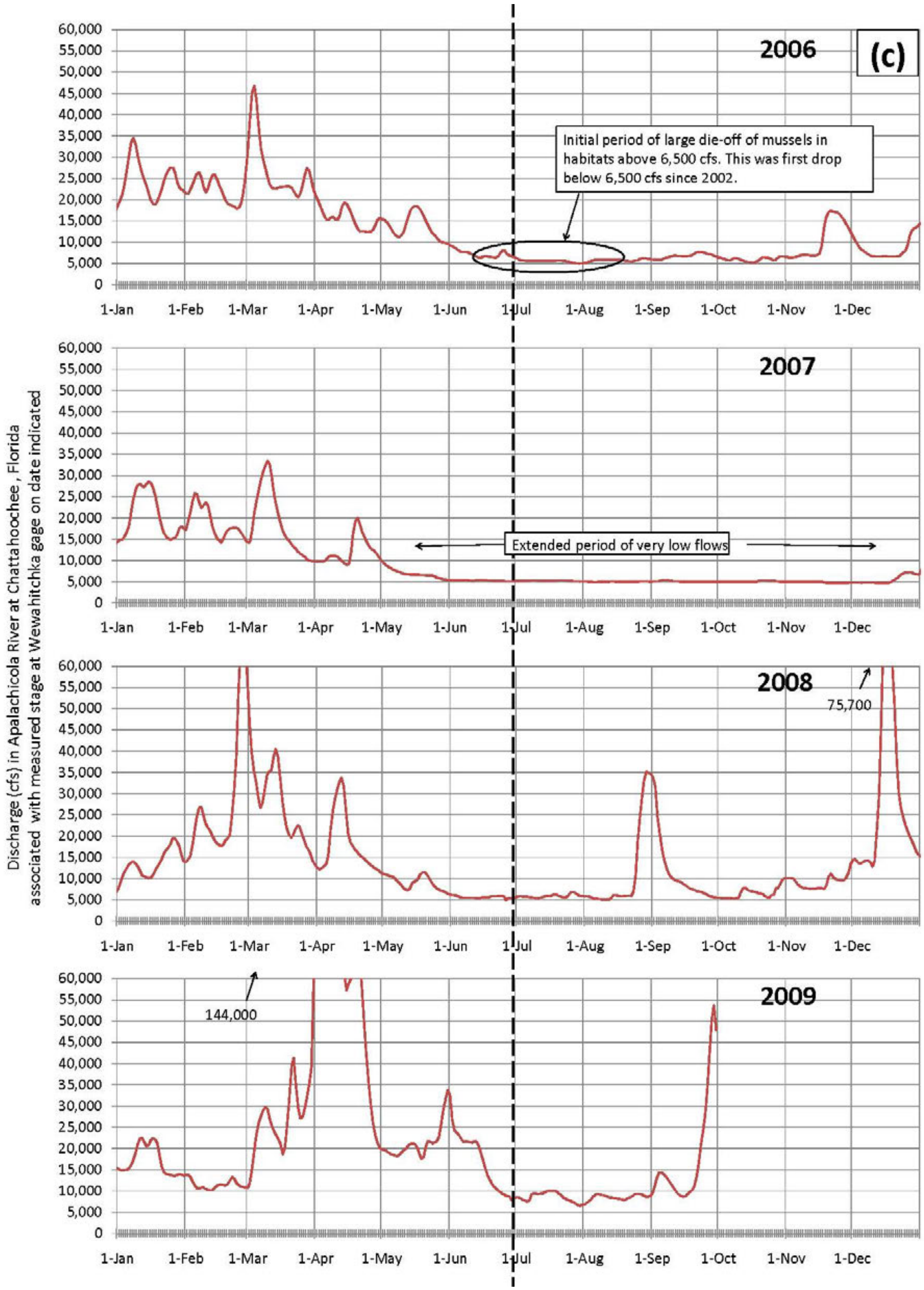
Figure 23. (on the following 3 pages). Annual flow hydrographs for the Apalachicola River (a) 1998 – 2001, (b) 2002 – 2005, (c) 2006 – 2009. The dashed line extending vertically through all the graphs at July 1 was added as a guide to facilitate year-to-year comparisons of summer flows. Flows above 60,000 cfs are not shown except for annotations on annual peaks. These hydrographs are based on river stage at the Wewahitchka gage (Wewa) because the largest populations of listed mussels are located in that reach of the river. Average discharge at the Chattahoochee gage associated with Wewa stage observed on the indicated dates was estimated using Wewa-Chattahoochee gage ratings modified from Light et al. (2006). Travel time from the Chattahoochee to Wewa gages has been accounted for in these graphs.

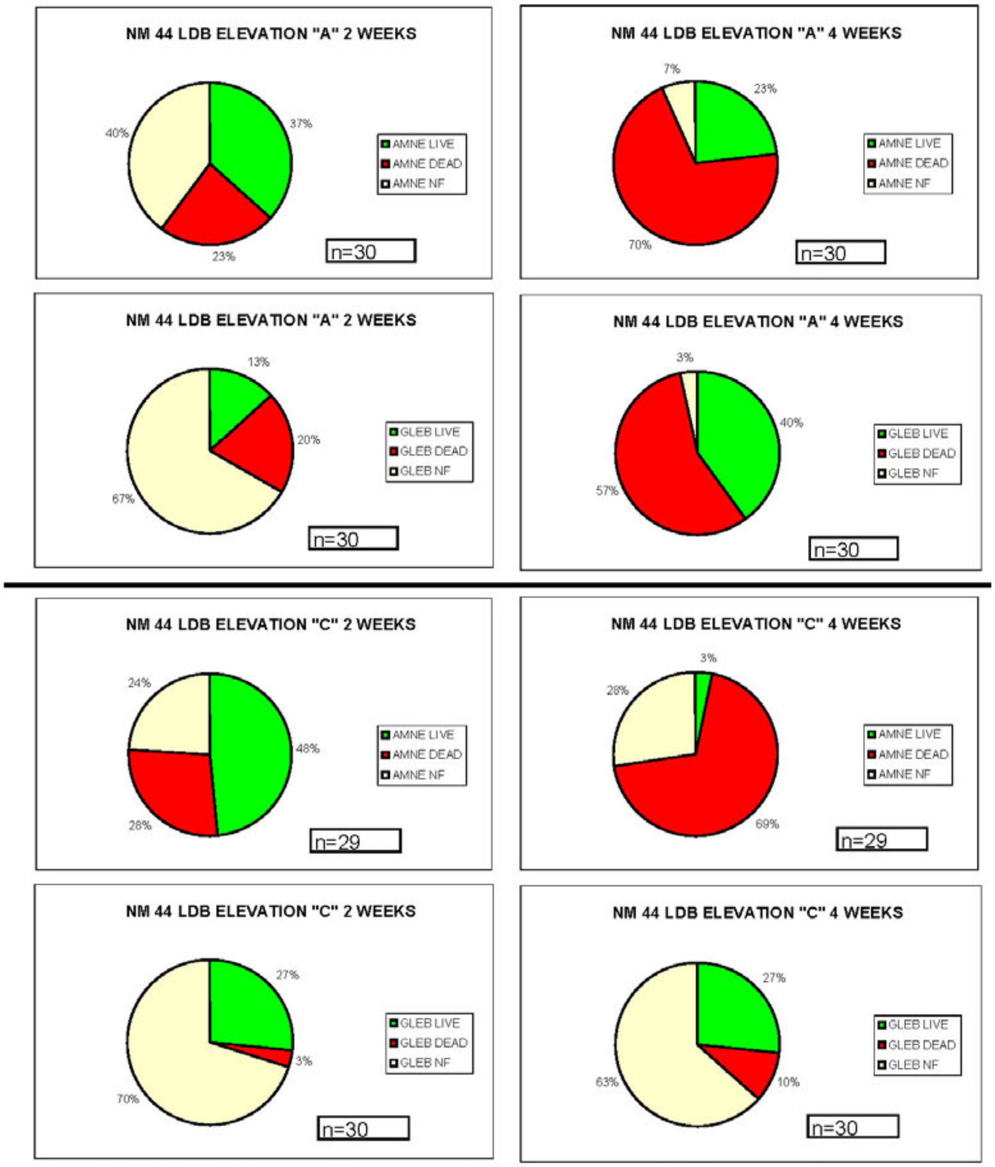


(a)
1998
227,000
(highest flood
since 1929)
1999
Rapid drawdown to
low flow
2000
Rapid drawdown to
very low flow
2001
94,200
Discharge (cfs) in Apalachicola River at Chattahoochee, Florida
associated with measured stage at Wewahitchka gage on date indicated
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec



(b)
2002
2003
2004
2005
75,300
69,900
161,000
Discharge (cfs) in Apalachicola River at Chattahoochee , Florida
associated with measured stage at Wewahitchka gage on date indicated
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


(c)
2006
2007
2008
2009
Initial period of large die-off of mussels in habitats above 6,500 cfs. This was first drop below 6,500 cfs since 2002.
Extended period of very low flows
75,700
144,000
Discharge (cfs) in Apalachicola River at Chattahoochee, Florida associated with measured stage at Wewahitchka gage on date indicated
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec



High Elevation "A" = (1.6ft above pool) Low Elevation "C" = (0.08ft below pool)
Pool elevation calc. = 94.01at 11:39 AM Central 6-14-06 Chatta. Gage ~5840 at dam

AMNE = *Amblema neslerii* (endangered fat threeridge)
GLEB = *Glebula rotundata* (non-listed round pearshell)
NF = not found

Figure 24. Results of mark and recapture at two elevations, Apalachicola River NM (RM) ~44.3 on 6/13/2006, 6/28/2006, and 7/12/2006. Mark and recapture studies of the fat threeridge on a channel margin area of the main stem at two elevations on the Apalachicola River found approximately 25% mortality after two weeks of exposure, and approximately 70% mortality after four weeks of exposure. The non-listed round pearlshell was found to have a greater tolerance to exposure. Almost all mussels (>90%) at this site perished including those at elevation “C” (which was initially established as a control site, but all its mussels died when flows were reduced more than anticipated).

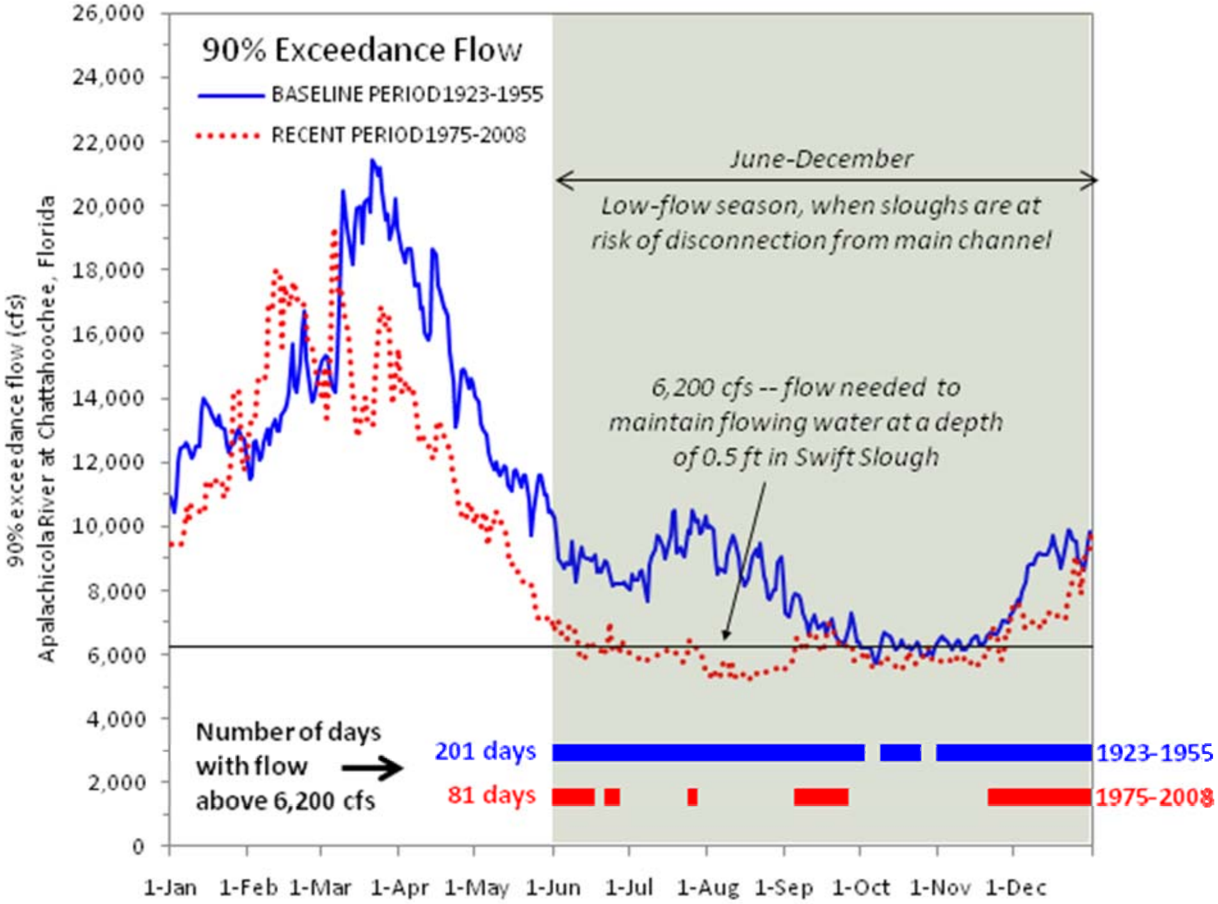


Figure 25. Decrease in availability of flowing-water for mussels in Swift Slough in June through December during drought (90% exceedance) conditions.

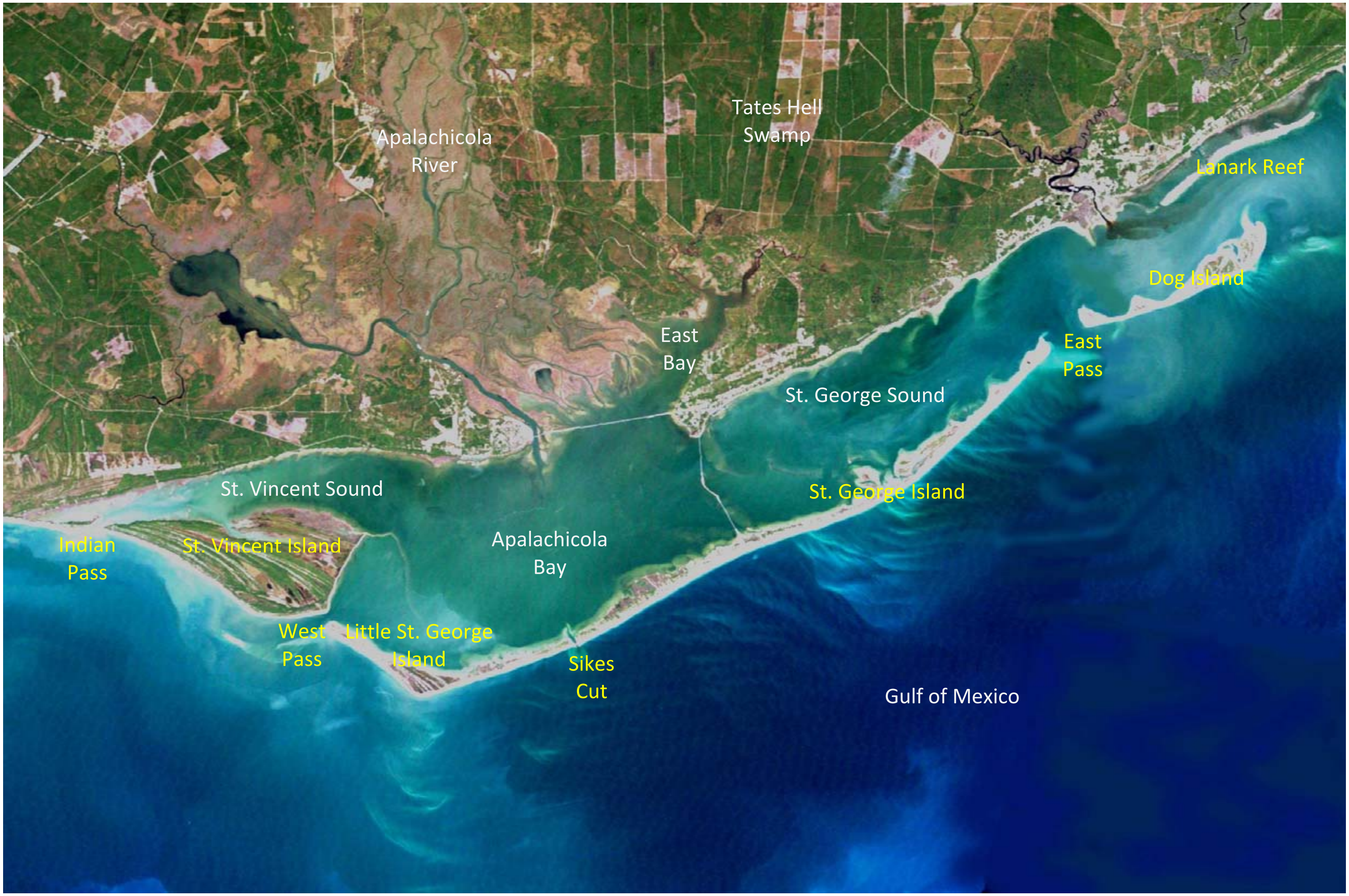


Figure 26. General location map of Apalachicola Bay showing prominent bay features including the four main sections of the bay, surrounding barrier islands and inlets/openings to the Gulf of Mexico.

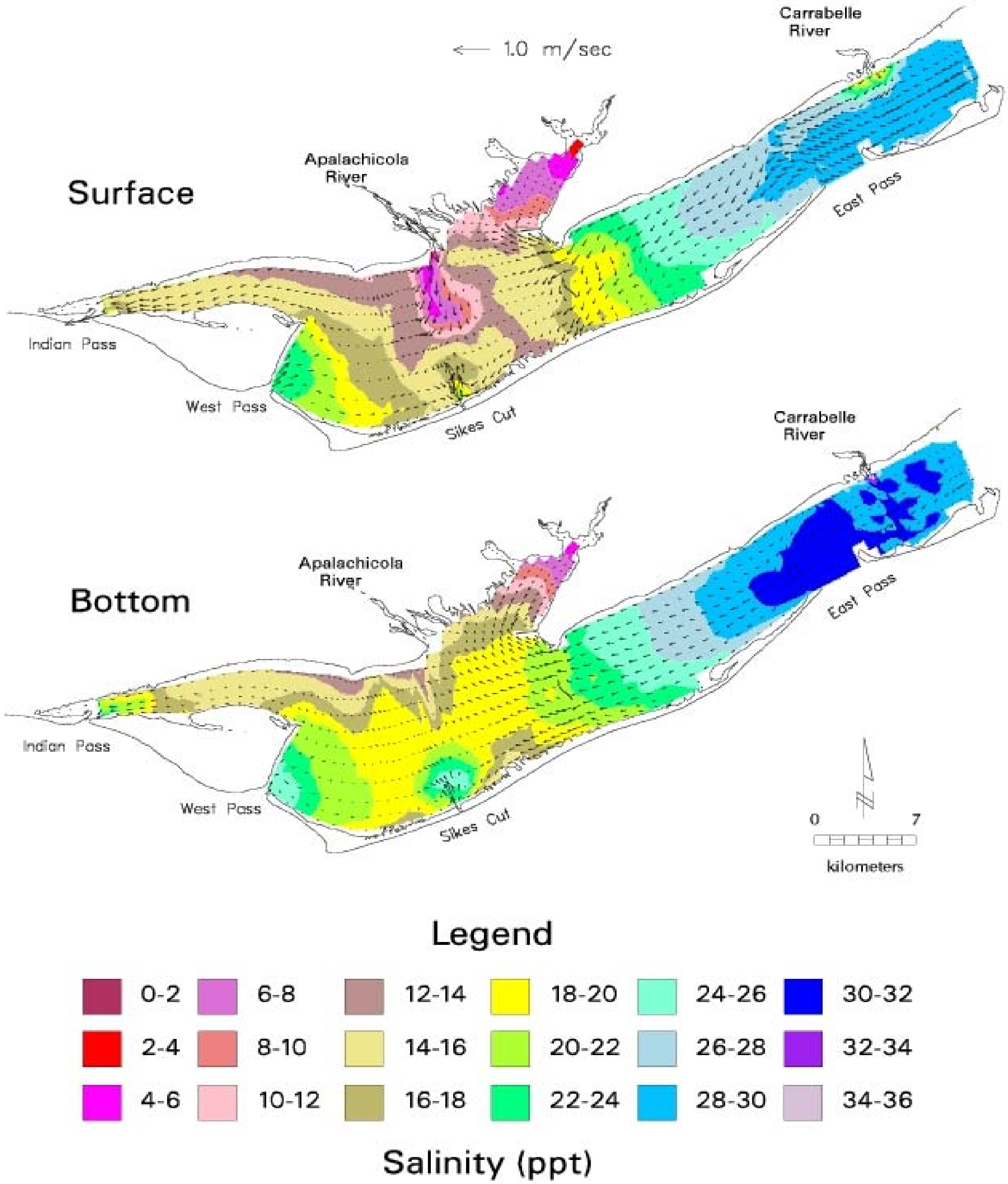


Figure 27. Horizontal salinity distribution in Apalachicola Bay showing hourly-averaged salinity. Surface (upper image) and bottom (lower image) salinity contours were generated using a 3-dimensional hydrodynamic model (Huang and Jones 1997). Ppt and psu are used interchangeable in this report to describe salinity units.

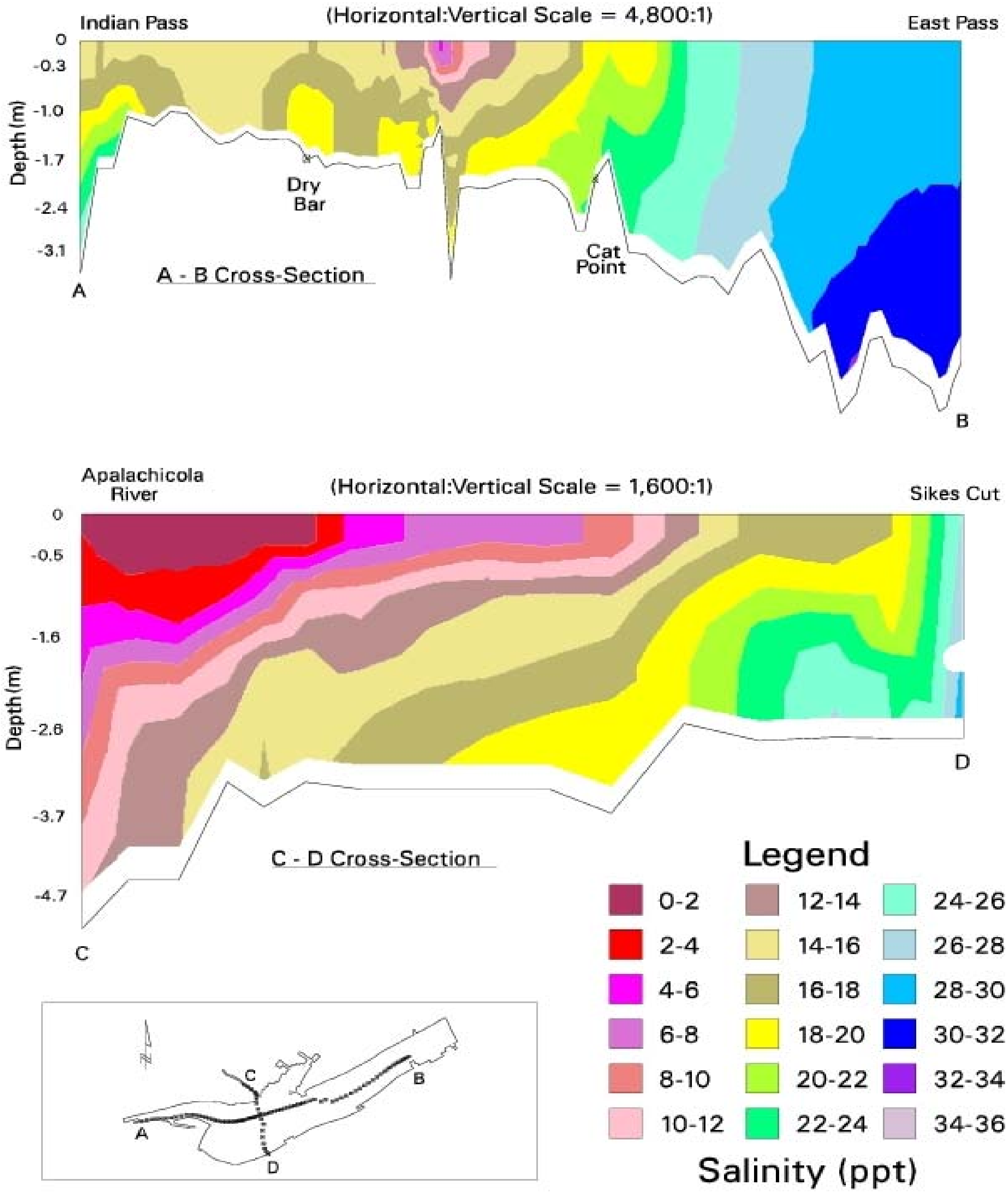


Figure 28. Vertical cross sections of Apalachicola Bay showing hourly-averaged salinity. Cross sections run east to west (A-B: upper image) and north to south (C-D: lower image). Salinity contours were generated using a 3-dimensional hydrodynamic model (Huang and Jones 1997).

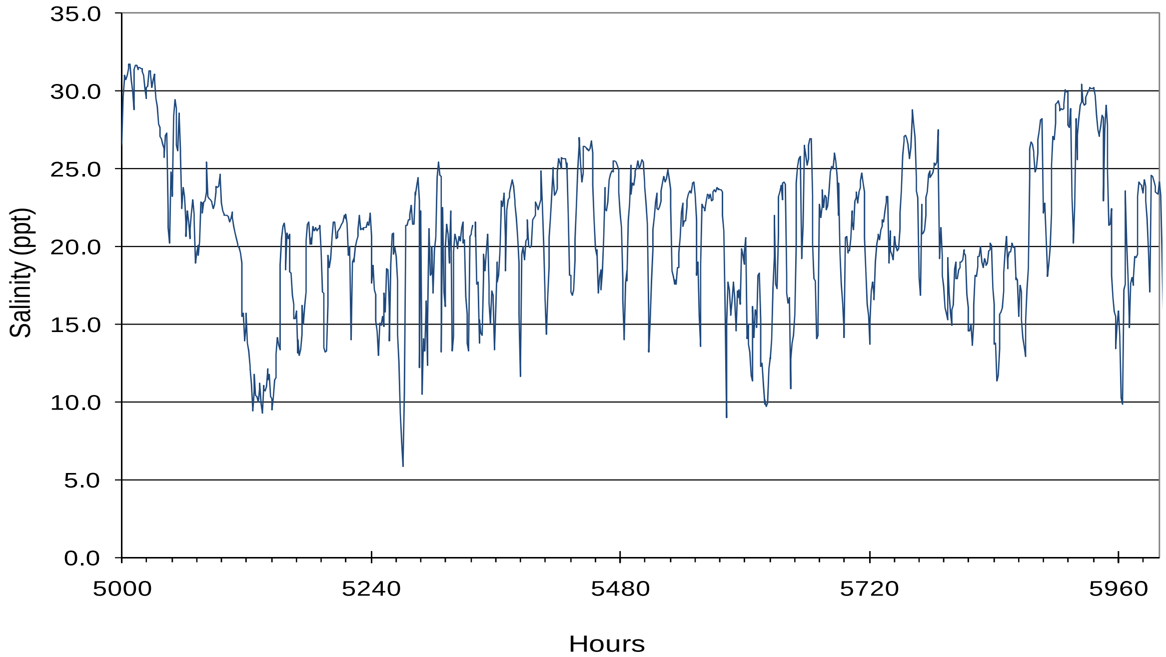


Figure 29. Short-term tidal salinity variation observed near Gorrie Bridge in lower East Bay. Hourly measurements are shown with figure intervals every 24 hours. Data were collected between 9/26-11/6/93. Data source: NWFWMD.

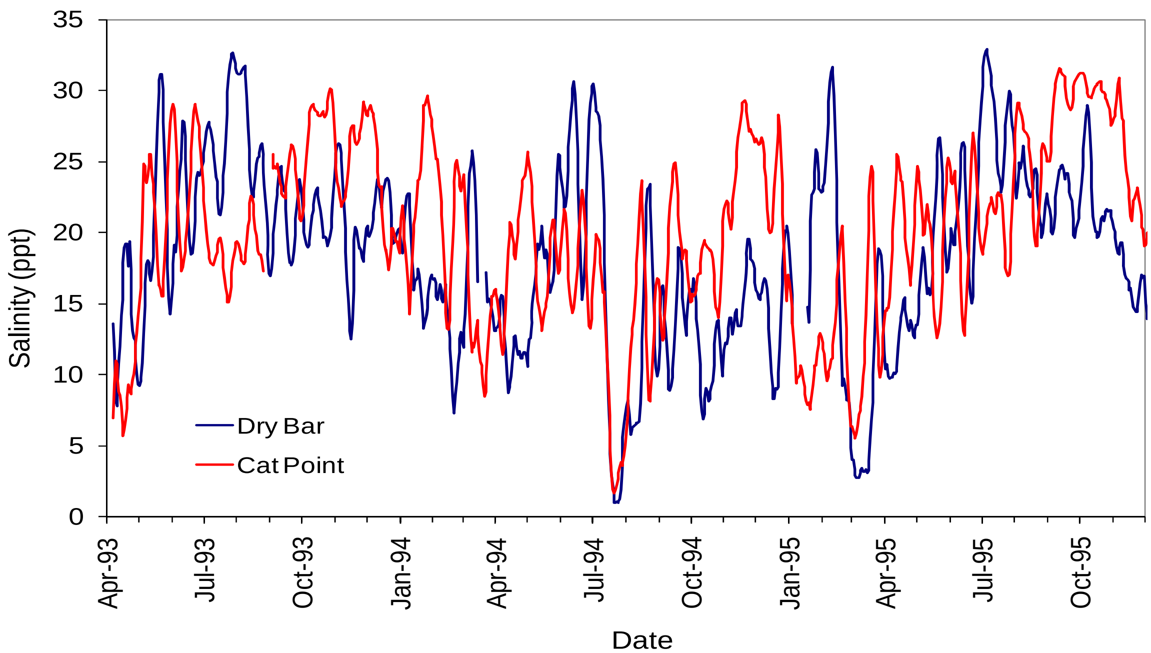


Figure 30. Weekly to monthly salinity variability observed at two sites in Apalachicola Bay. Data are shown as 7-day moving averages collected between 4/1/93-12/21/95. Data source: ANERR.

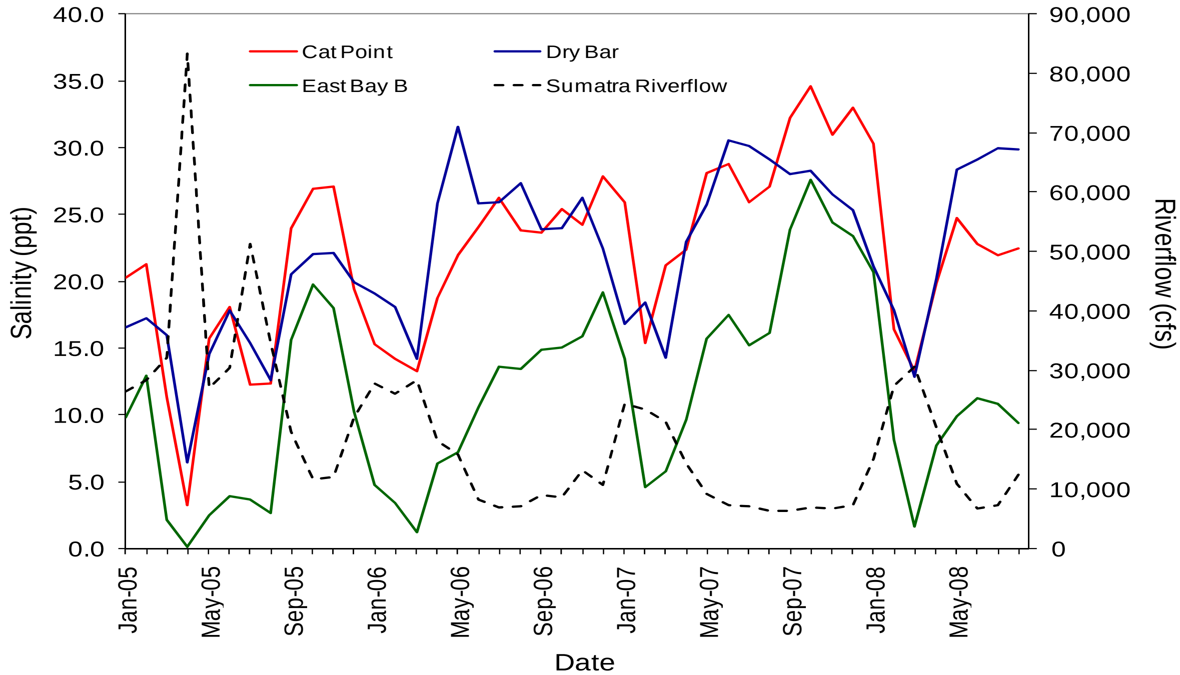


Figure 31. Seasonal salinity variation observed at three sites in Apalachicola Bay. Salinity values shown are monthly averages collected between 1/05-8/08. Mean monthly river flow is taken from the Sumatra gage. Data source: ANERR (salinity) and USGS (river flow).

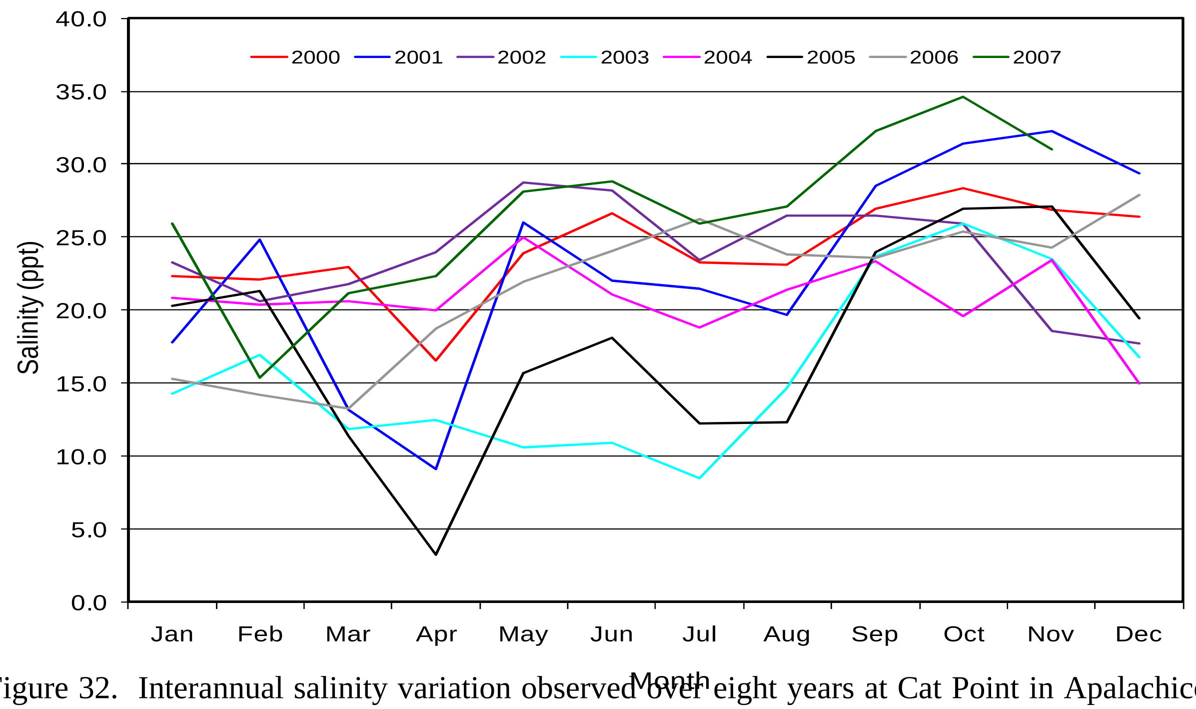


Figure 32. Interannual salinity variation observed over eight years at Cat Point in Apalachicola Bay. Salinity values are monthly averages shown by year collected between 2000 and 2007. Data source: ANERR.

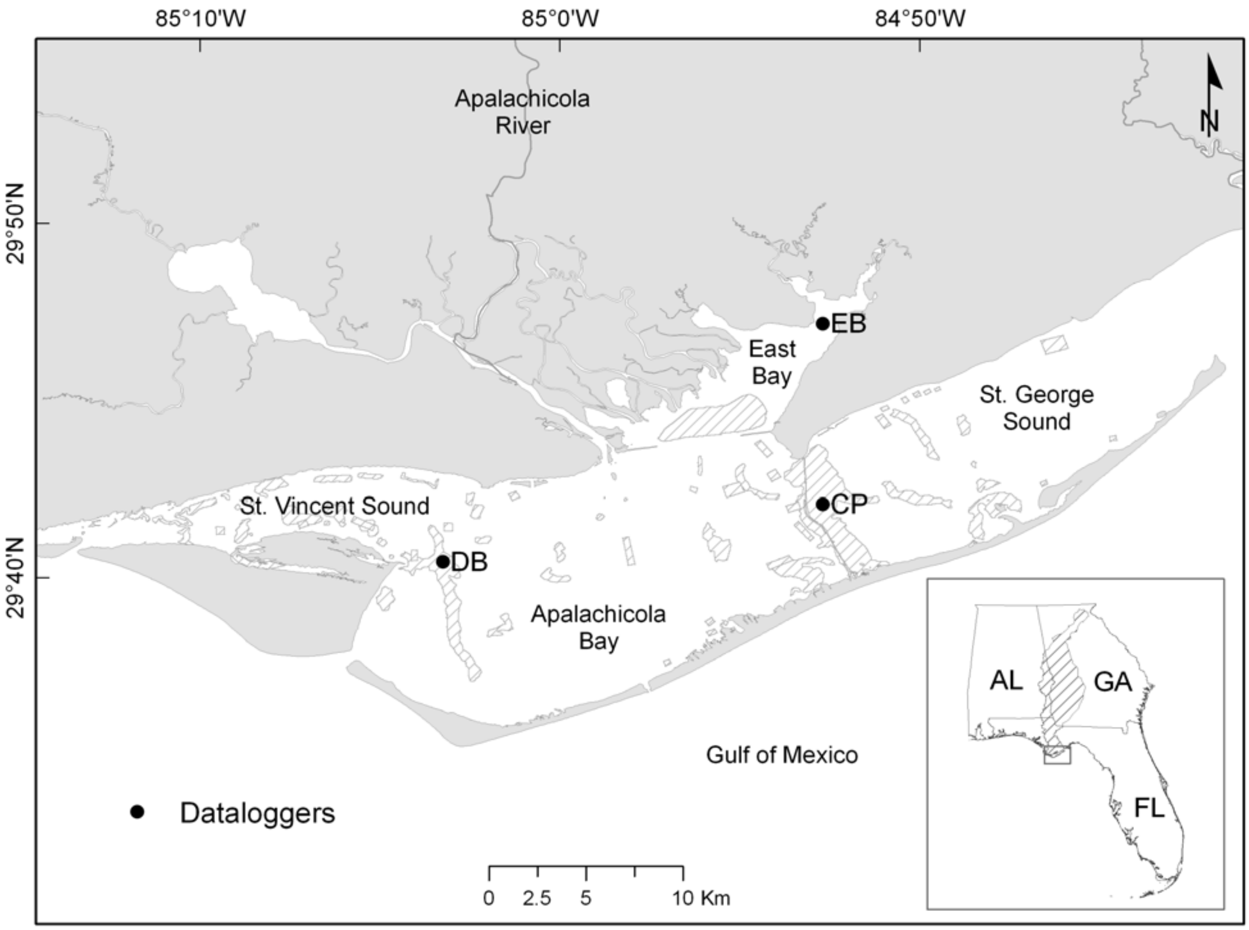
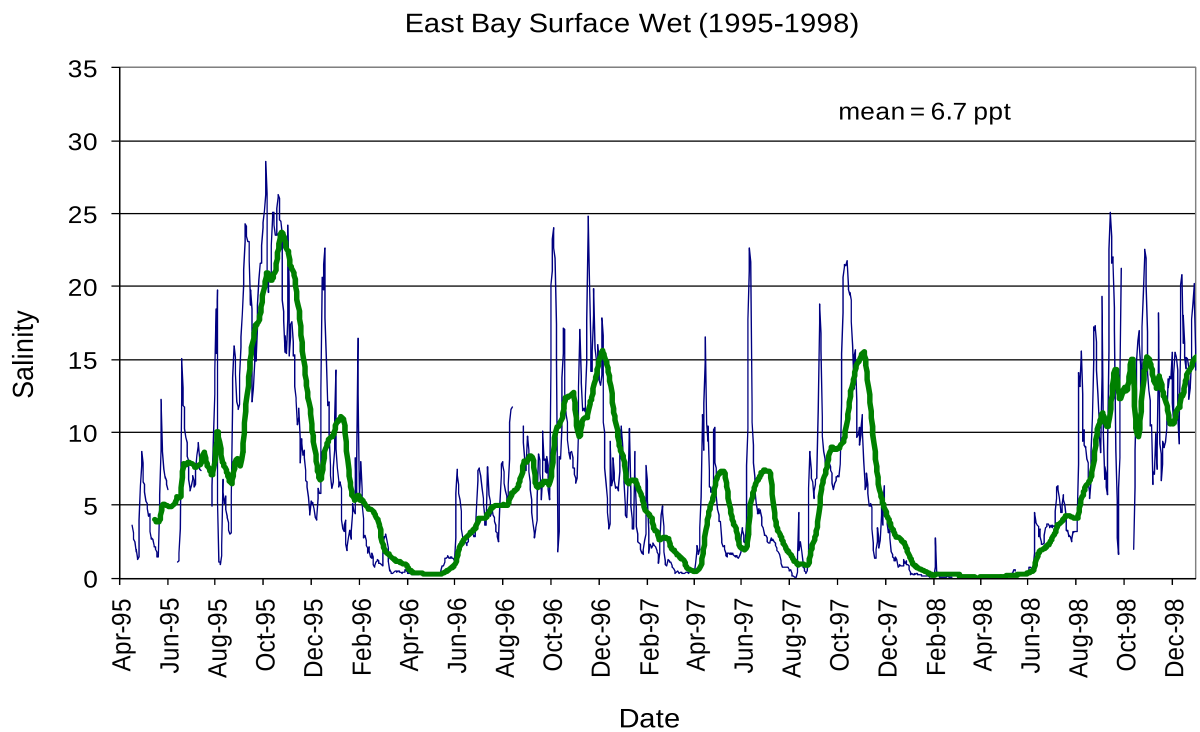


Figure 33. Location of ANERR dataloggers for collection of continuously recorded salinity measurements (15-30 min intervals; 1993 to present). Stations are: EB (upper East Bay), DB (Dry Bar) and CP (Cat Point). Cross-hatched areas in the bay indicate sites of major oyster reefs.



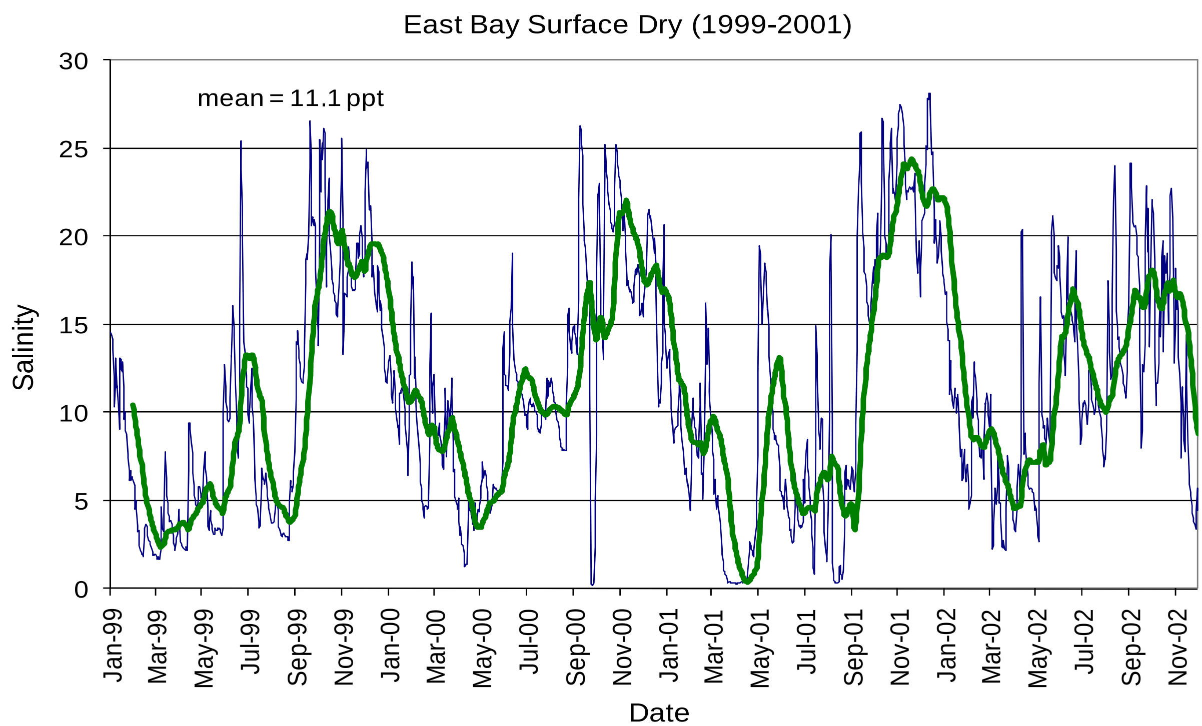


Figure 34. Mean daily surface salinity and a 30-day moving average at the East Bay site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.

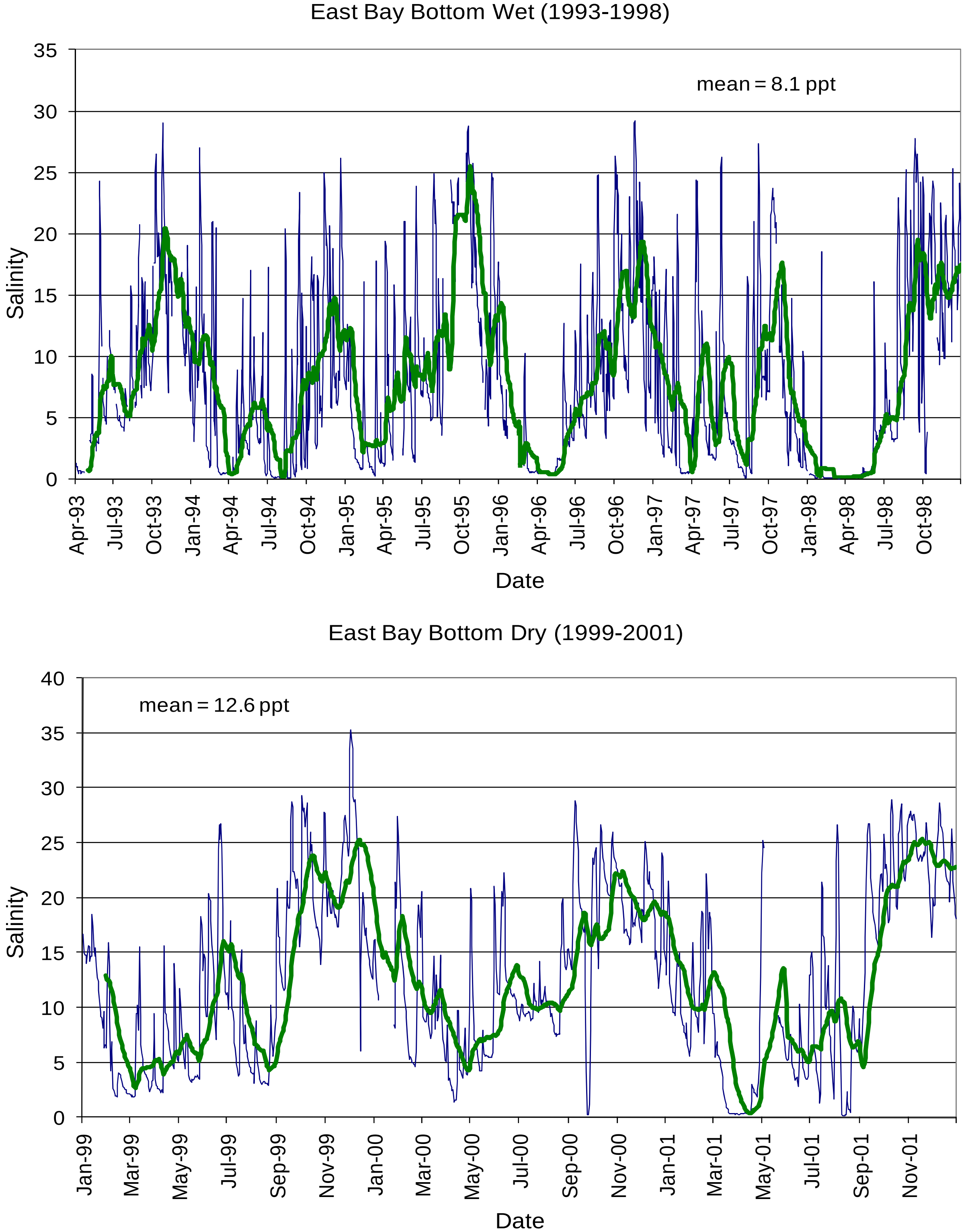


Figure 35. Mean daily bottom salinity and a 30-day moving average at the East Bay site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.

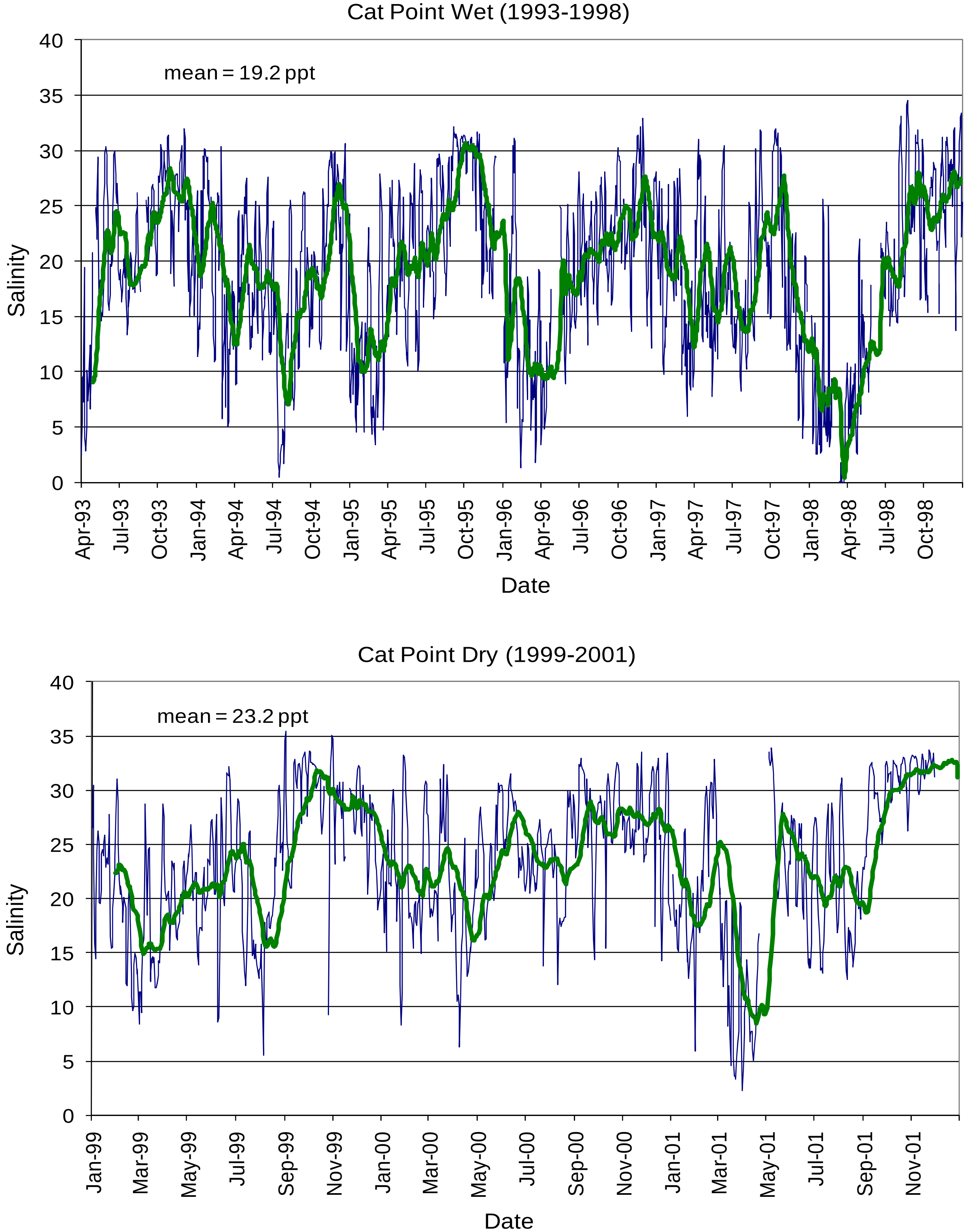
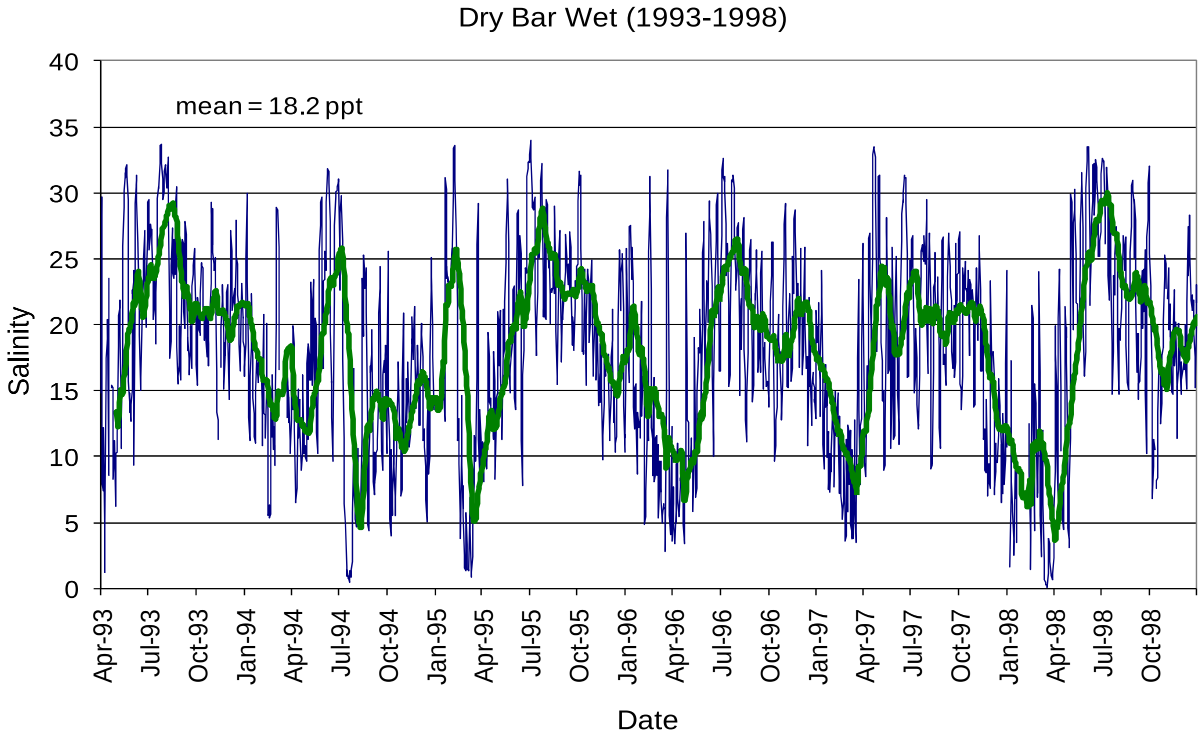


Figure 36. Mean daily mid-depth salinity and a 30-day moving average at the Cat Point site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.



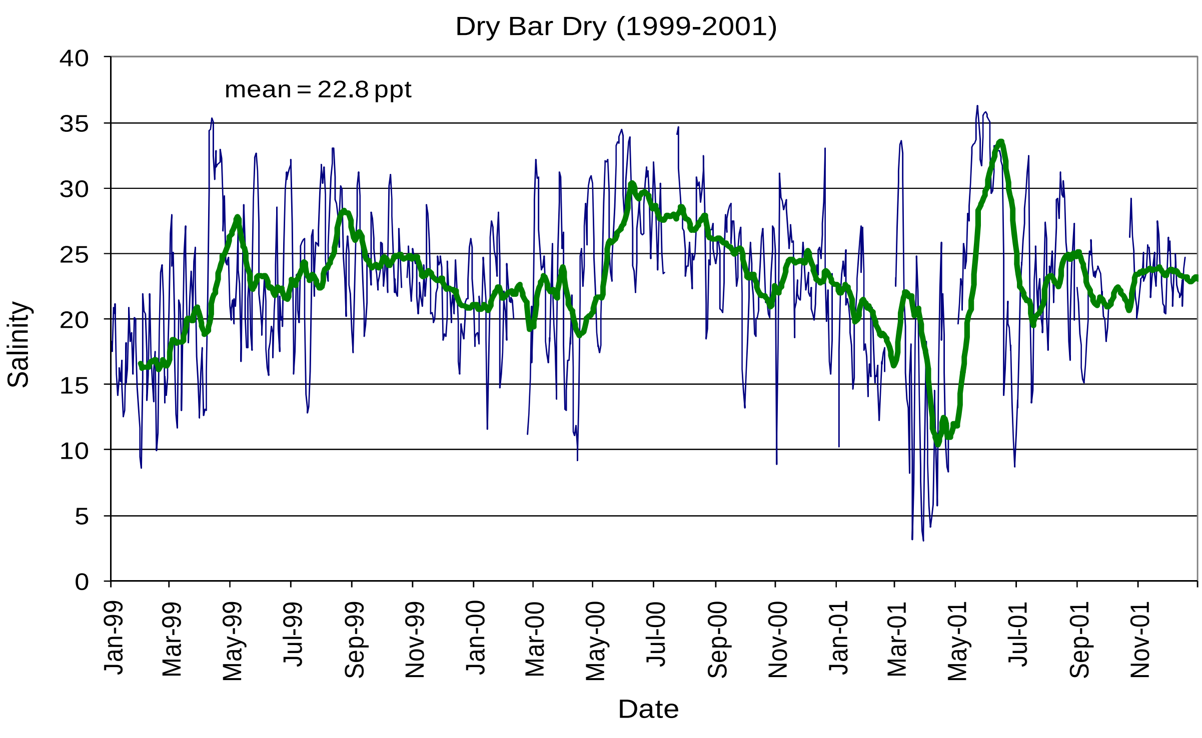


Figure 37. Mean daily mid-depth salinity and a 30-day moving average at the Dry Bar site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.

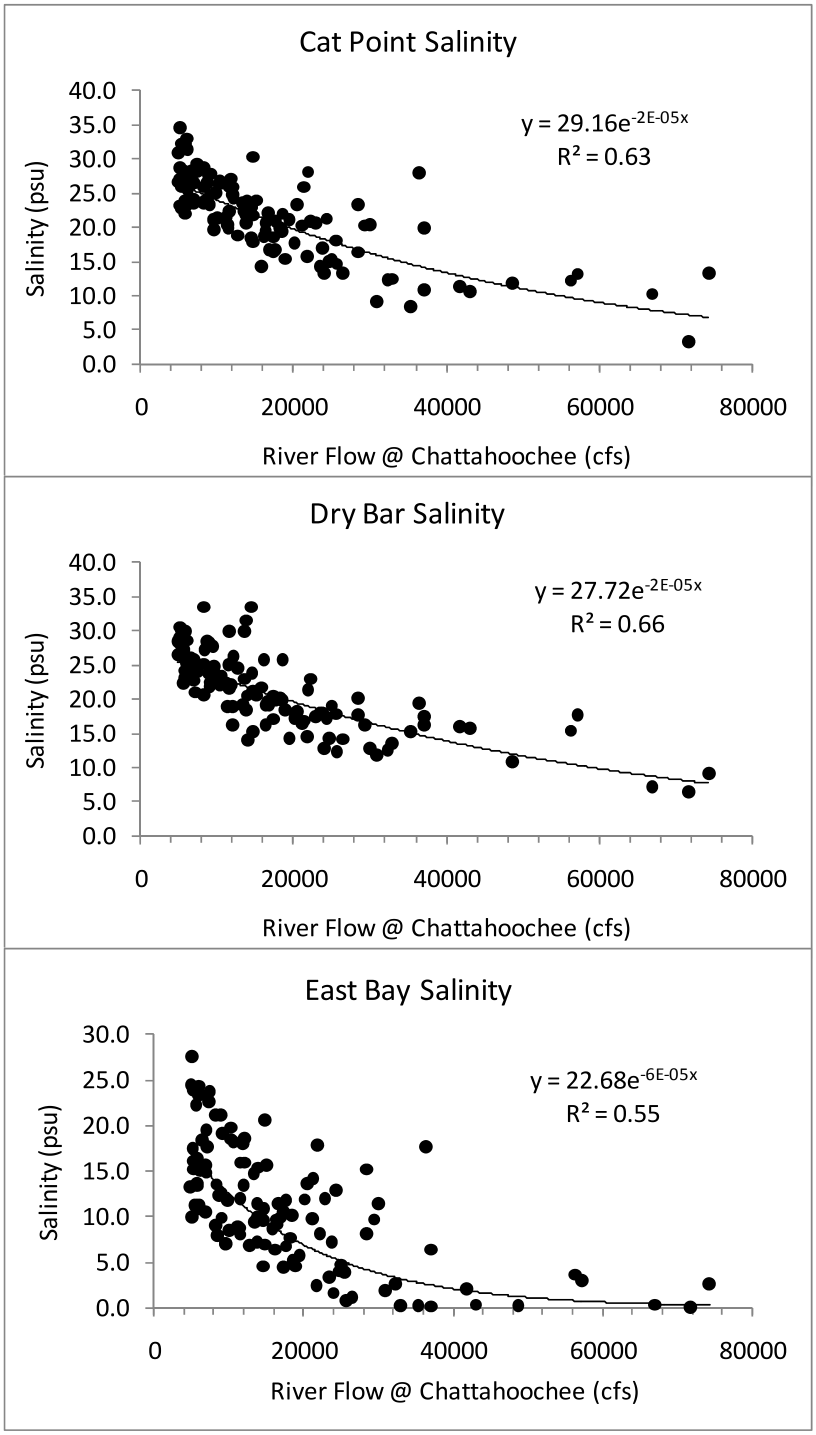


Figure 38. Simple exponential regressions between river flow at the Chattahoochee gage and salinity at three ANERR data logger sites: Cat Point (upper panel), Dry Bar (middle panel) and East Bay (lower panel). Regressions are based on monthly averaged flow and salinity measurements.

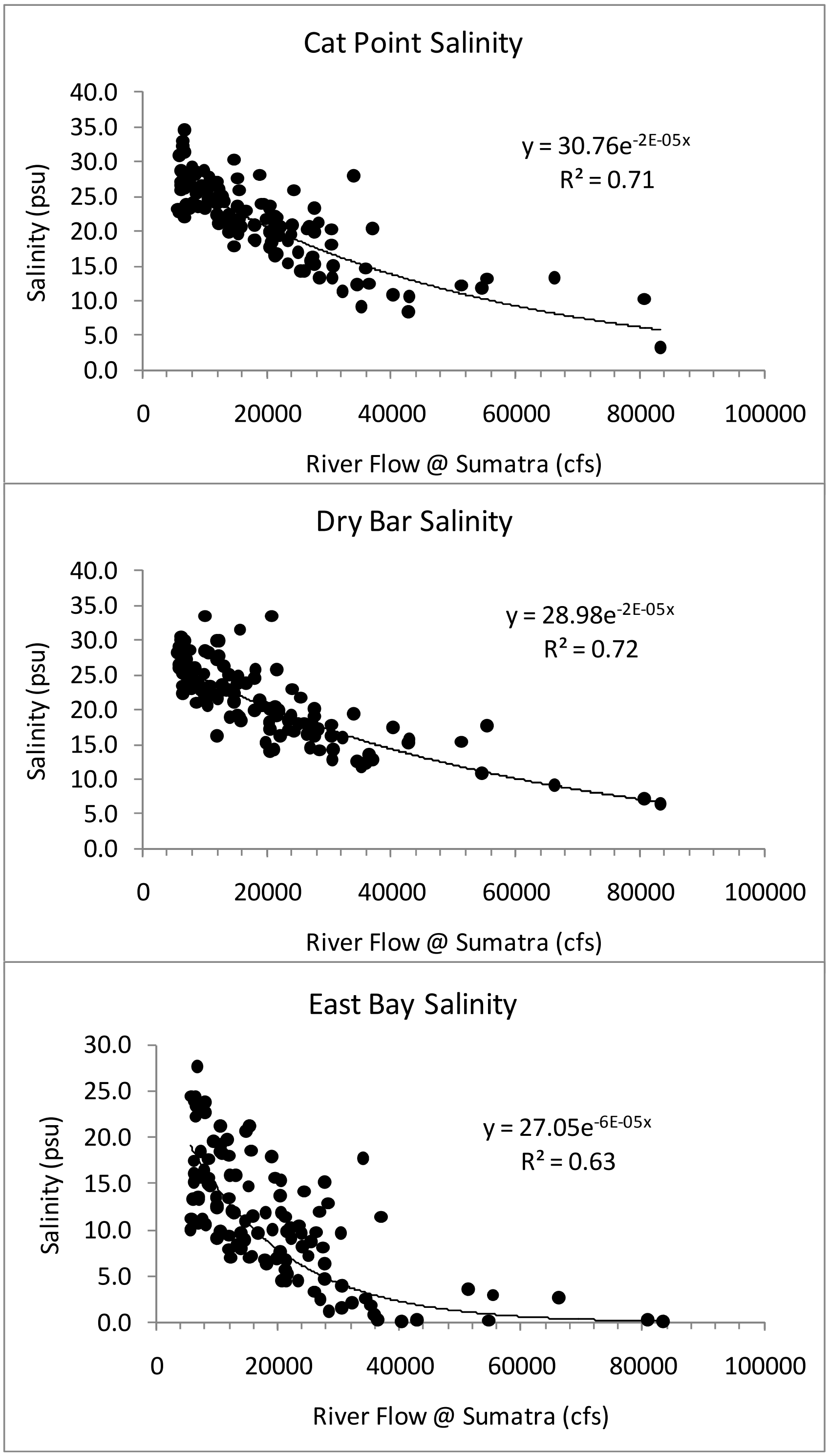


Figure 39. Simple exponential regressions between river flow at the Sumatra gage and salinity at three ANERR data logger sites: Cat Point (upper panel), Dry Bar (middle panel) and East Bay (lower panel). Regressions are based on monthly averaged flow and salinity measurements.

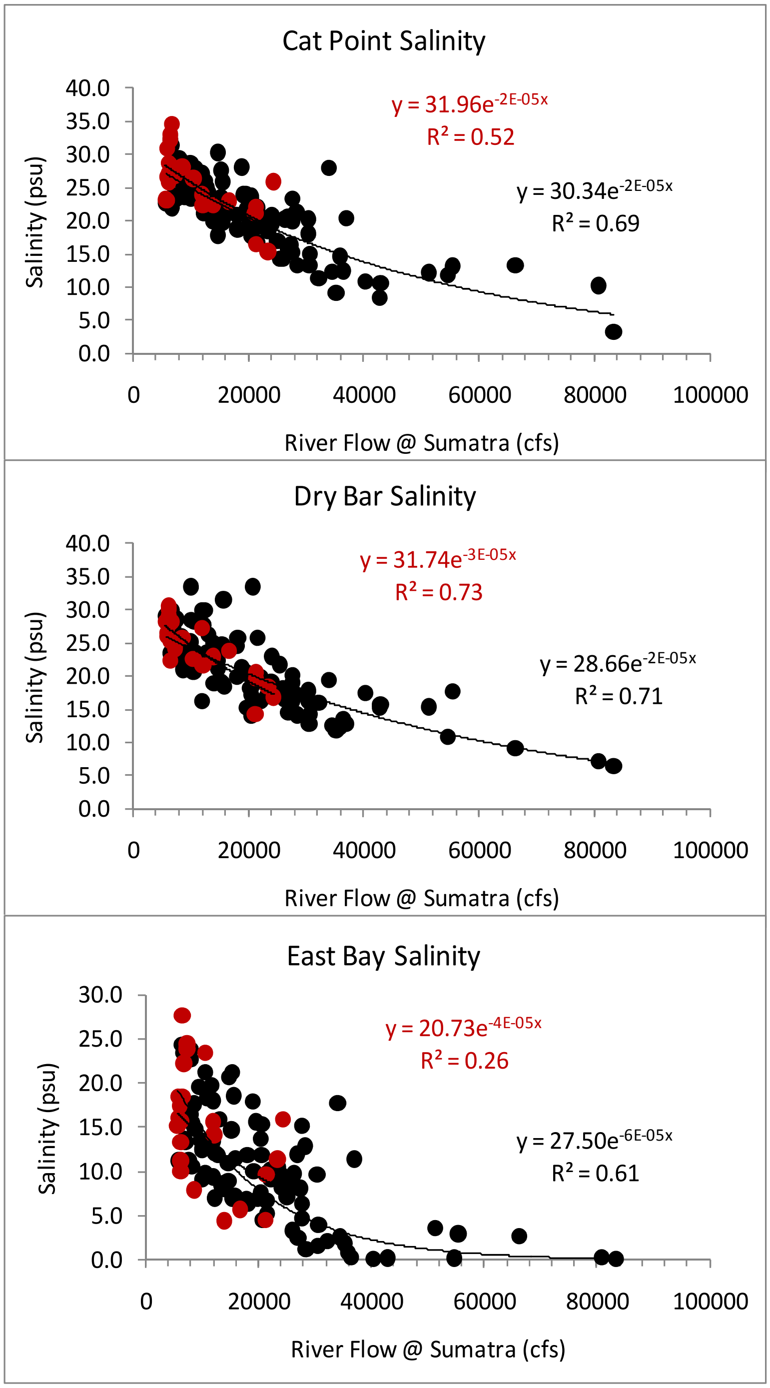


Figure 40. Simple exponential regressions between river flow at the Sumatra gage and salinity at three ANERR data logger sites: Cat Point (upper panel), Dry Bar (middle panel) and East Bay (lower panel). Regressions are based on monthly averaged flow and salinity measurements with drought years (2000, 2007 shown in red) separated from all other years (black).

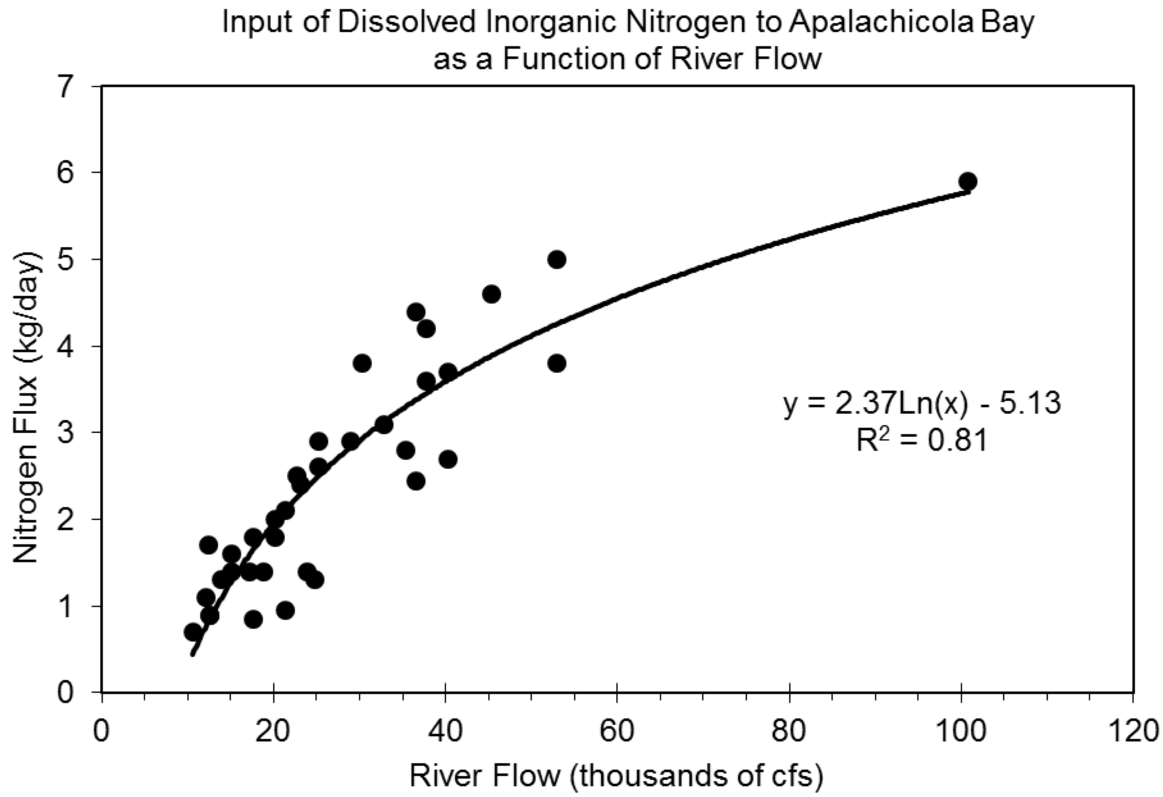


Figure 41. Relationship between dissolved inorganic nitrogen (DIN) and river flow in the Apalachicola River; data were taken from Mortazavi et al. (2000b).

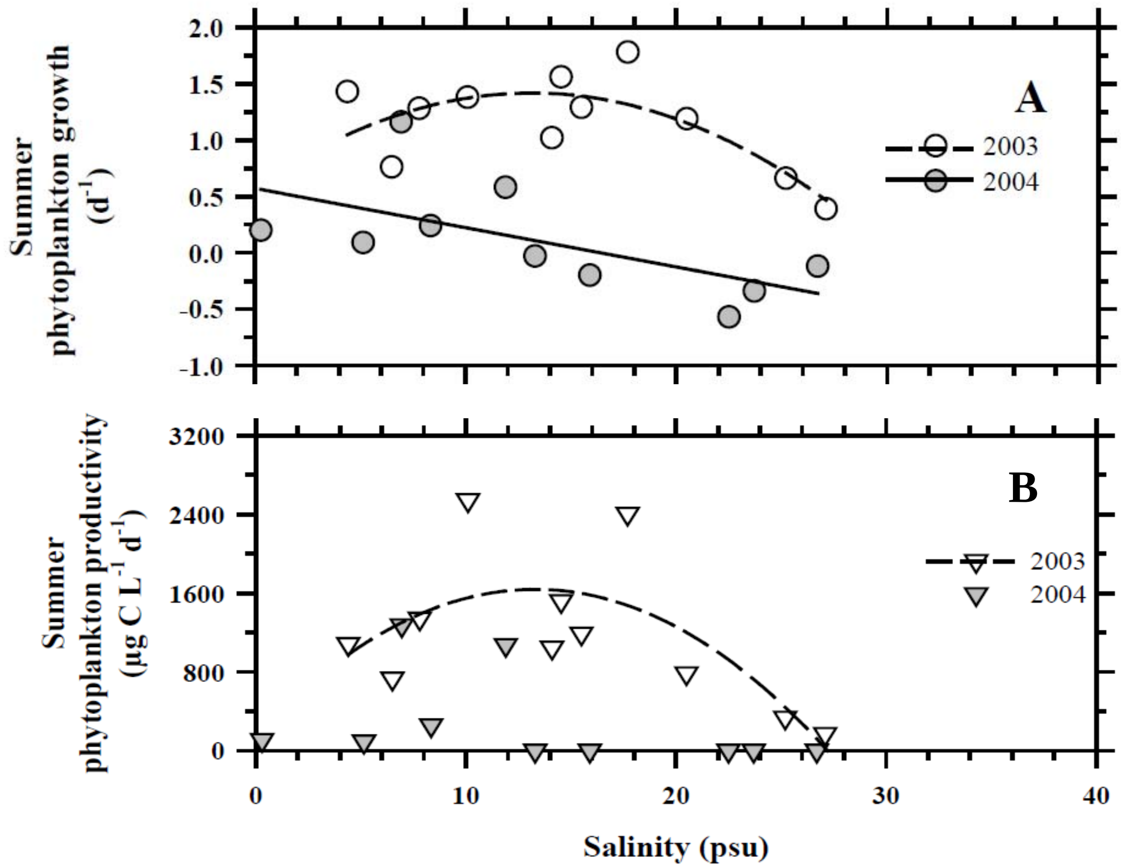


Figure 42. Phytoplankton (A) growth and (B) productivity during summer 2003 and 2004 relative to sea surface salinity (Putland 2005).

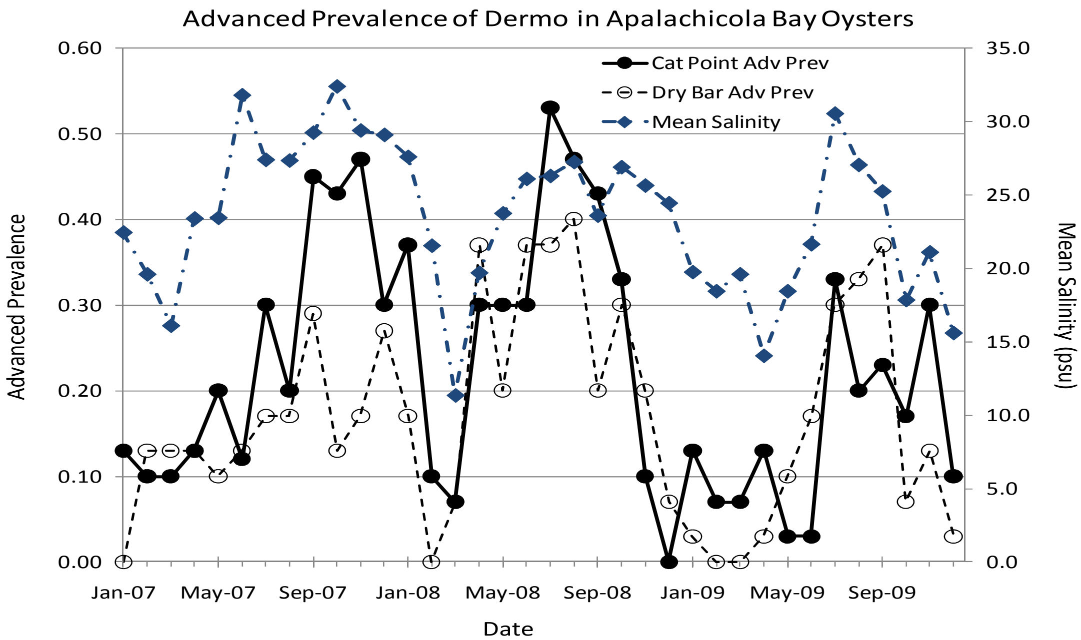


Figure 43. Dermo advanced prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to mean salinity at the two sites.

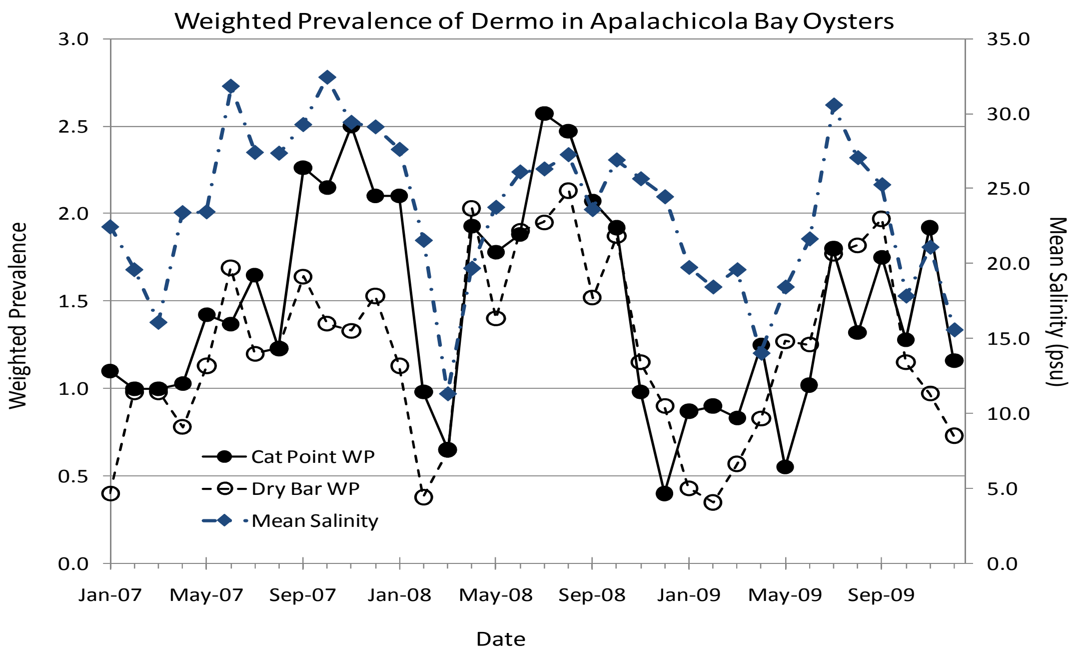


Figure 44. Dermo weighted prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to mean salinity at the two sites.

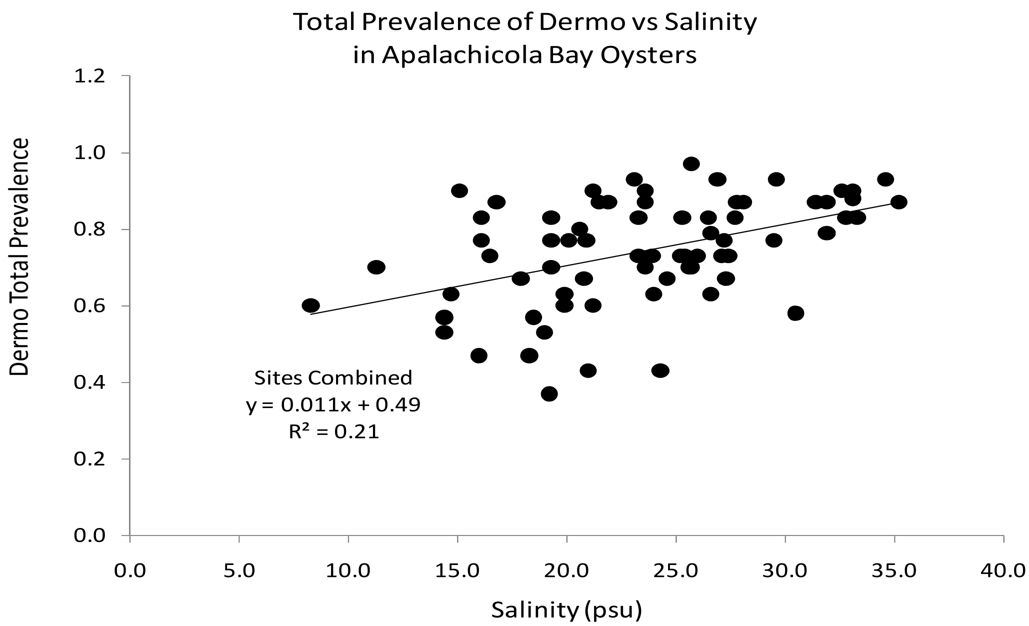


Figure 45. Dermo total prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to salinity at the two sites. A regression line is shown for the two sites combined; significance value $p < 0.05$.

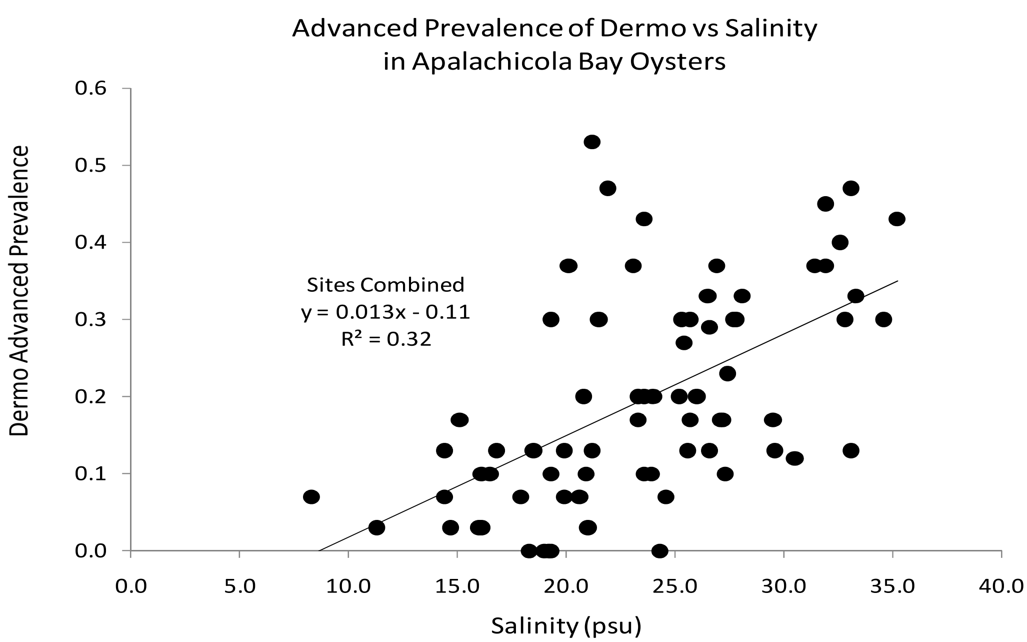


Figure 46. Dermo advanced prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to salinity at the two sites. A regression line is shown for the two sites combined; significance value $p < 0.05$.

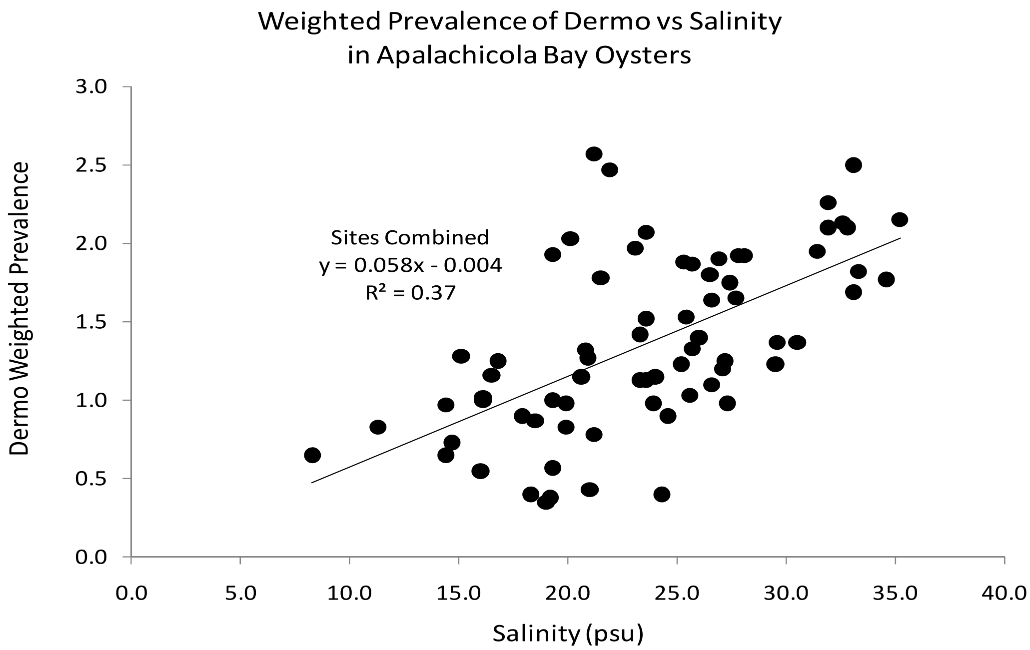
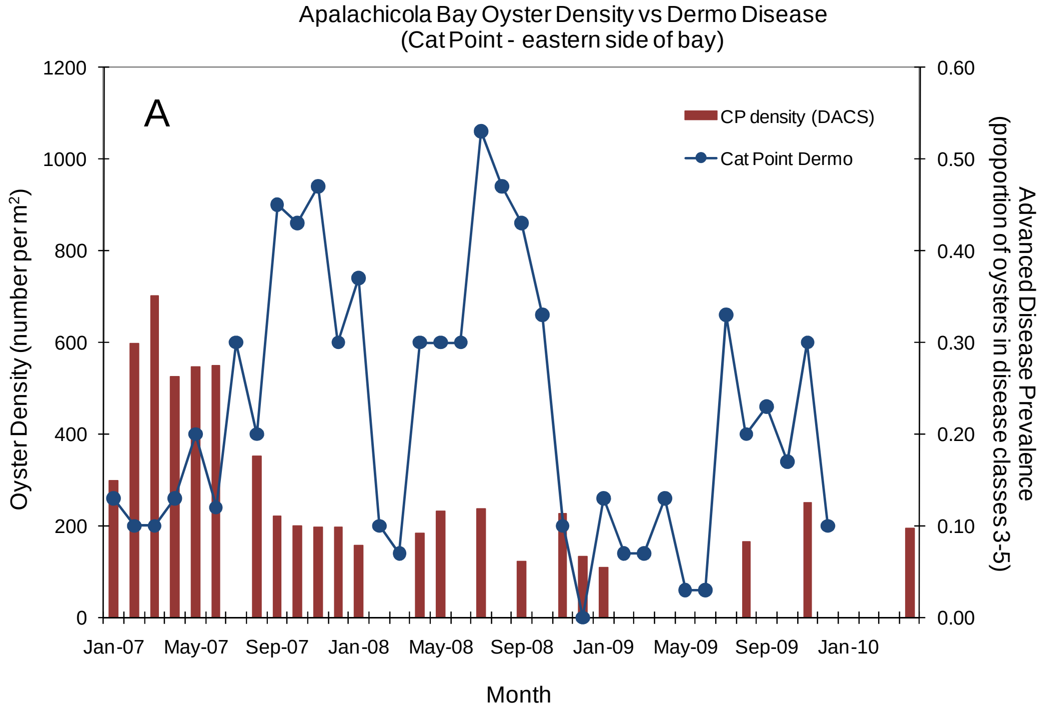


Figure 47. Dermo weighted prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to salinity at the two sites. A regression line is shown for the two sites combined; significance value $p < 0.05$.



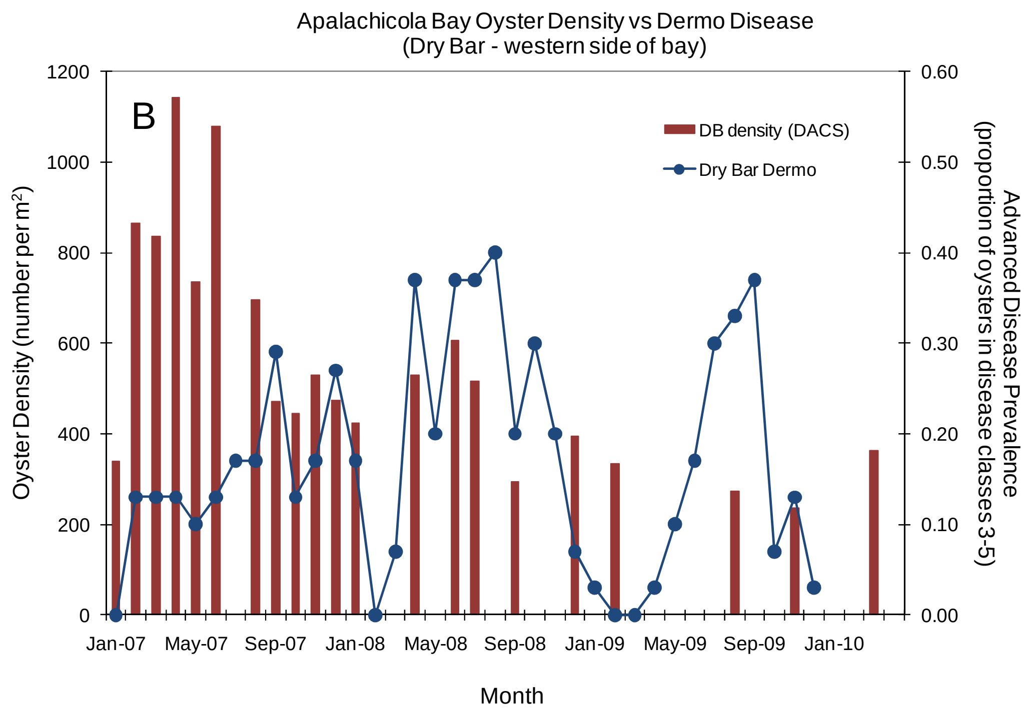


Figure 48. Oyster density and advanced Dermo prevalence at (A) Cat Point and (B) Dry Bar. Oyster density is given as number of oysters ≥25mm per m^2; oyster density source: DACS, Division of Aquaculture (2009).

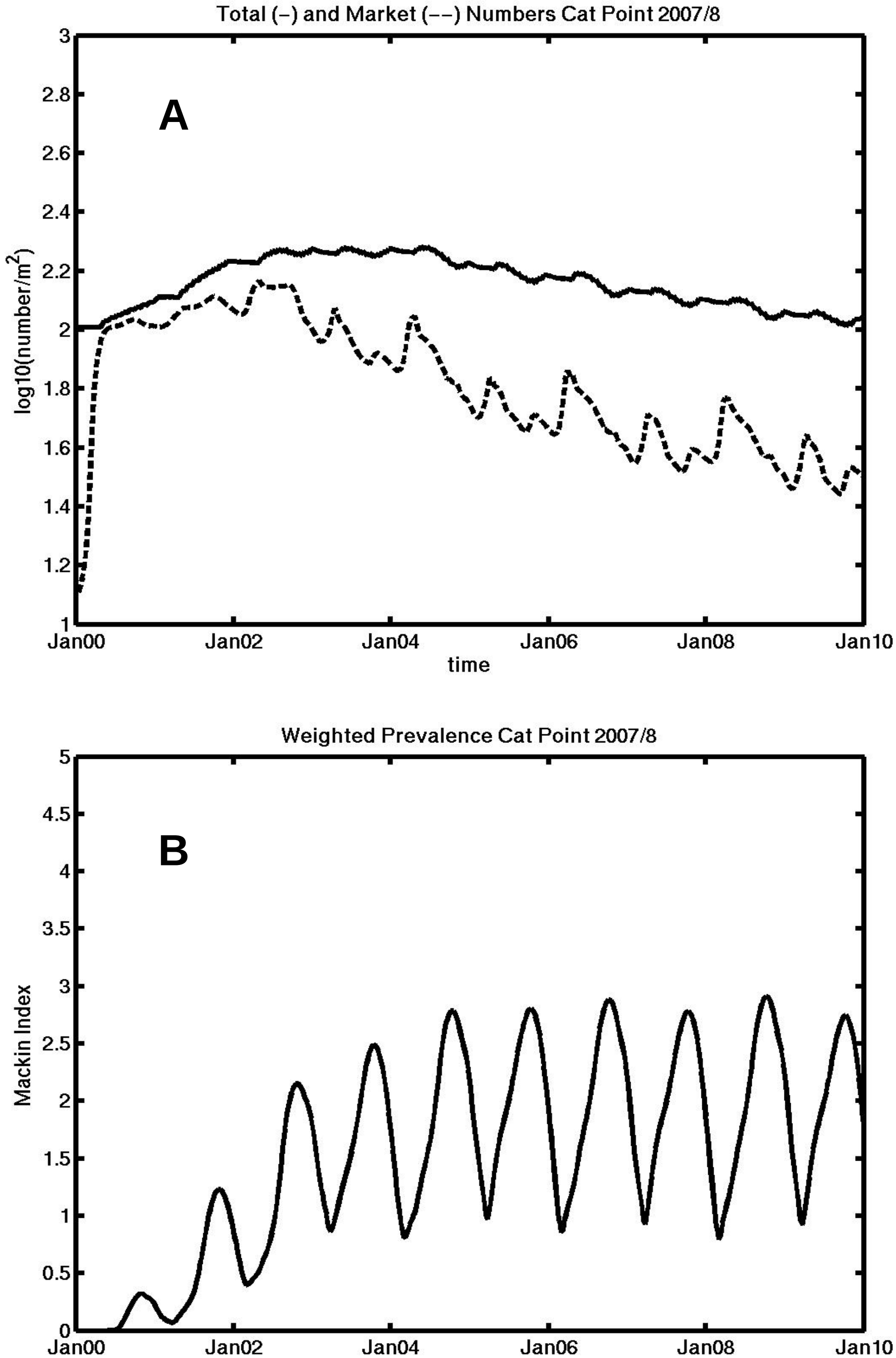
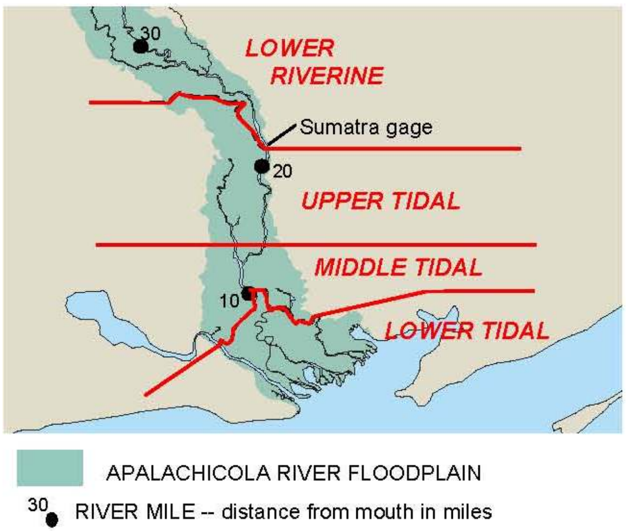


Figure 49. Time series of simulated (A) total and market-sized oysters, and (B) Dermo weighted prevalence at Cat Point.

Appendices

Appendix A. Channel lengths and wetland areas in riverine and tidal reaches of the Apalachicola River and floodplain.

Part 1. Tidal reach boundaries



Part 2. Channel lengths

Reach[1]	Length of channels in the Apalachicola River-floodplain system, in miles			
	Main channels		Floodplain sloughs, streams, and lakes[2] (length flowing through state-owned	
	Apalachicola River	Other rivers		
Upper riverine	28.9		24.6	*(0.8)*
Middle riverine	35.7		101.7	*(41.9)*
Lower riverine	21.2	16.5 (Lower Chipola)	104.2	*(98.3)*
Subtotal riverine	**85.8**	**16.5**	**230.5**	***(140.9)***
Upper tidal	6.6		38.9	*(36.4)*
Middle tidal	3.8	1.0 (Jackson River)	50.3	*(49.8)*
Lower tidal forests[4]	5.8		34.3	*(34.3)*
Lower tidal marshes[4]	4.4		54.7	*(48.0)*
Subtotal tidal	**20.6**	**1.0**	**178.2**	***(168.6)***
Total (all reaches)	**106.4**	**17.5**	**408.7**	***(309.4)***

Footnotes on next page.

Appendix A. Continued.

Part 3. Wetland areas

Reach[1]	Area of floodplain wetlands, in acres[5] *(area of state-owned lands in parentheses)* [3]					
	Bottomland hardwood forests		Swamp forests (tupelo-cypress)		Tidal marshes	
Upper riverine	12,500	*(203)*	3,590	*(85)*		
Middle riverine	32,200	*(9,420)*	4,130	*(396)*		
Lower riverine	15,800	*(15,538)*	14,550	*(13,624)*		
Subtotal riverine	**60,500**	***(25,160)***	**22,270**	***(14,106)***		
Upper and middle tidal	1,770	*(1,725)*	26,100	*(25,394)*		
Lower tidal	48	*(48)*	7,376	*(7,271)*	9,030	*(8,325)*
Subtotal tidal	**1,818**	***(1,773)***	**33,476**	***(32,665)***	**9,030**	***(8,325)***
Total (all reaches)	**62,318**	***(26,933)***	**55,746**	***(46,770)***	**9,030**	***(8,325)***

[1]Riverine and tidal reach boundaries shown in Part 1. Source of reach boundaries is forest map by Leitman (1984) except for river mile 14 boundary between upper and middle tidal reaches, which was developed specifically for channel length inventory in Part 2.

[2]Floodplain channel lengths in the riverine reach are from Light et al. (1998). Floodplain channel lengths in the tidal reach are from measurements of all mapped streams on USGS 7.5-minute quadrangle maps, compiled by Helen Light and Michael Nesius, 2008.

[3]State land ownership was determined from a map prepared in November 2008 by Bryan Shoaf, Division of State Lands, Florida DEP. Most of the state lands in the Apalachicola River and floodplain were acquired for conservation purposes.

[4]Boundary between forests and marshes in lower tidal reach is called the "tree line", and its location is shown with a dashed line in Appendix D.

[5]Wetland areas are from forest map by Leitman (1984).

Appendix B. List of high-flow, normal-flow, and low-flow years in two time periods based on ranking by mean annual discharge. Mean annual discharge was calculated from calendar-year (Jan 1-Dec 31) streamflow data in Apalachicola River at Chattahoochee, Florida (USGS 2010).

BASELINE PERIOD (1923-55)				**RECENT PERIOD (1975-2008)**		
Year	Mean annual discharge (cfs)	Rank (1 is lowest)		Year	Mean annual discharge (cfs)	Rank (1 is lowest)
1929	39,580	33		1975	35,344	34
1948	36,830	32		1998	31,505	33
1936	30,973	31		1994	31,333	32
1949	29,250	30	***HIGH-FLOW YEARS***	1983	30,286	31
1946	28,130	29	*Highest one-third of years*	2005	29,240	30
1928	27,424	28	*based on mean annual discharge*	1976	26,695	29
1947	27,197	27		2003	26,600	28
1944	26,672	26	← *11 years in each period* →	1984	26,108	27
1937	25,995	25		1979	23,971	26
1923	25,600	24		1978	23,868	25
1953	24,706	23		1980	23,802	24
1943	24,062	22		1990	23,652	23
1926	23,161	21		1991	23,616	22
1942	22,585	20		1997	23,566	21
1930	22,152	19	***NORMAL-FLOW YEARS***	1993	23,114	20
1925	21,860	18	*Middle one-third of years*	1992	22,875	19
1933	21,295	17	*based on mean annual discharge*	1995	22,283	18
1939	21,062	16		1977	22,233	17
1924	20,645	15	← *11 years in baseline period*	1982	22,117	16
1952	19,198	14	*12 years in recent period* →	1996	21,964	15
1945	19,122	13		1987	20,592	14
1932	19,038	12		1989	20,416	13
				2004	17,236	12
1940	18,987	11		2001	16,058	11
1938	17,004	10		1985	15,115	10
1934	15,130	9		2008	14,607	9
1950	15,102	8	***LOW-FLOW YEARS***	1986	13,995	8
1954	14,381	7	*Lowest one-third of years*	1988	13,745	7
1931	13,996	6	*based on mean annual discharge*	2006	13,093	6
1927	13,525	5		1981	12,082	5
1935	13,237	4	← *11 years in each period* →	1999	11,233	4
1951	12,949	3		2002	10,874	3
1941	12,417	2		2007	9,722	2
1955	11,223	1		2000	9,341	1

Appendix C. Apalachicola River flow and Chattahoochee-Flint basin precipitation during low-flow years in three time periods. Low-flow years are the lowest one-third of years in each time period based mean annual discharge in the Apalachicola River at Chattahoochee, Florida. Precipitation is from NCDC climate division data which has been area-weighted to represent the Chattahoochee and Flint River basins. (USGS 2010; US Dept of Commerce-NCDC 2009).

Time period	Year	Rank within period (1 is lowest)	Annual mean discharge (cfs)	Annual flow volume (acre-ft)	Annual precipitation (inches)	Annual precipitation volume (acre-ft)[1]	Flow/ precipitation ratio[2]	
Baseline Period 1923-1955 (33 years)	1927	5	13,525	9,791,722	39.86	36,952,602	0.2650	Variable 1[3]
	1931	6	13,996	10,132,582	39.14	36,292,387	0.2792	
	1934	9	15,130	10,953,878	49.28	45,691,114	0.2397	
	1935	4	13,237	9,582,843	46.50	43,110,671	0.2223	
	1938	10	17,004	12,310,235	42.09	39,024,677	0.3154	
	1940	11	18,987	13,783,934	49.16	45,581,961	0.3024	
	1941	2	12,417	8,989,805	44.11	40,897,478	0.2198	
	1950	8	15,102	10,933,408	43.79	40,599,458	0.2693	
	1951	3	12,949	9,374,340	46.43	43,046,554	0.2178	
	1954	7	14,381	10,411,716	31.20	28,927,825	0.3599	
	1955	1	11,223	8,125,210	42.70	39,584,809	0.2053	
	Average		**14,359**	**10,399,061**	**43.11**	**39,973,594**	**0.2601**	
Intervening Period 1956-1974 (19 years)	1956	1	13,785	10,007,524	50.82	47,112,896	0.2124	
	1957	4	17,540	12,698,658	55.24	51,219,292	0.2479	
	1963	5	18,108	13,109,296	51.16	47,429,838	0.2764	
	1968	2	15,194	11,030,420	42.65	39,545,105	0.2789	
	1969	3	16,553	11,983,676	47.82	44,335,163	0.2703	
	1970	6	19,467	14,093,197	51.55	47,797,347	0.2949	
	Average		**16,775**	**12,153,795**	**49.87**	**46,239,940**	**0.2628**	
Recent Period 1975-2008 (34 years)	1981	5	12,082	8,747,028	44.39	41,157,923	0.2125	Variable 2[3]
	1985	10	15,115	10,942,830	49.49	45,884,723	0.2385	
	1986	8	13,995	10,131,769	43.32	40,163,073	0.2523	
	1988	7	13,745	9,978,089	45.03	41,748,334	0.2390	
	1999	4	11,233	8,132,668	41.24	38,238,313	0.2127	
	2000	1	9,341	6,781,131	42.03	38,965,646	0.1740	
	2001	11	16,058	11,625,164	46.28	42,909,353	0.2709	
	2002	3	10,874	7,872,595	53.18	49,301,748	0.1597	
	2006	6	13,093	9,478,949	43.72	40,533,299	0.2339	
	2007	2	9,722	7,038,526	39.19	36,338,006	0.1937	
	2008	9	14,607	10,603,855	51.96	48,177,211	0.2201	
	Average		**12,715**	**9,212,055**	**45.44**	**42,128,875**	**0.2187**	

See footnotes on next page.

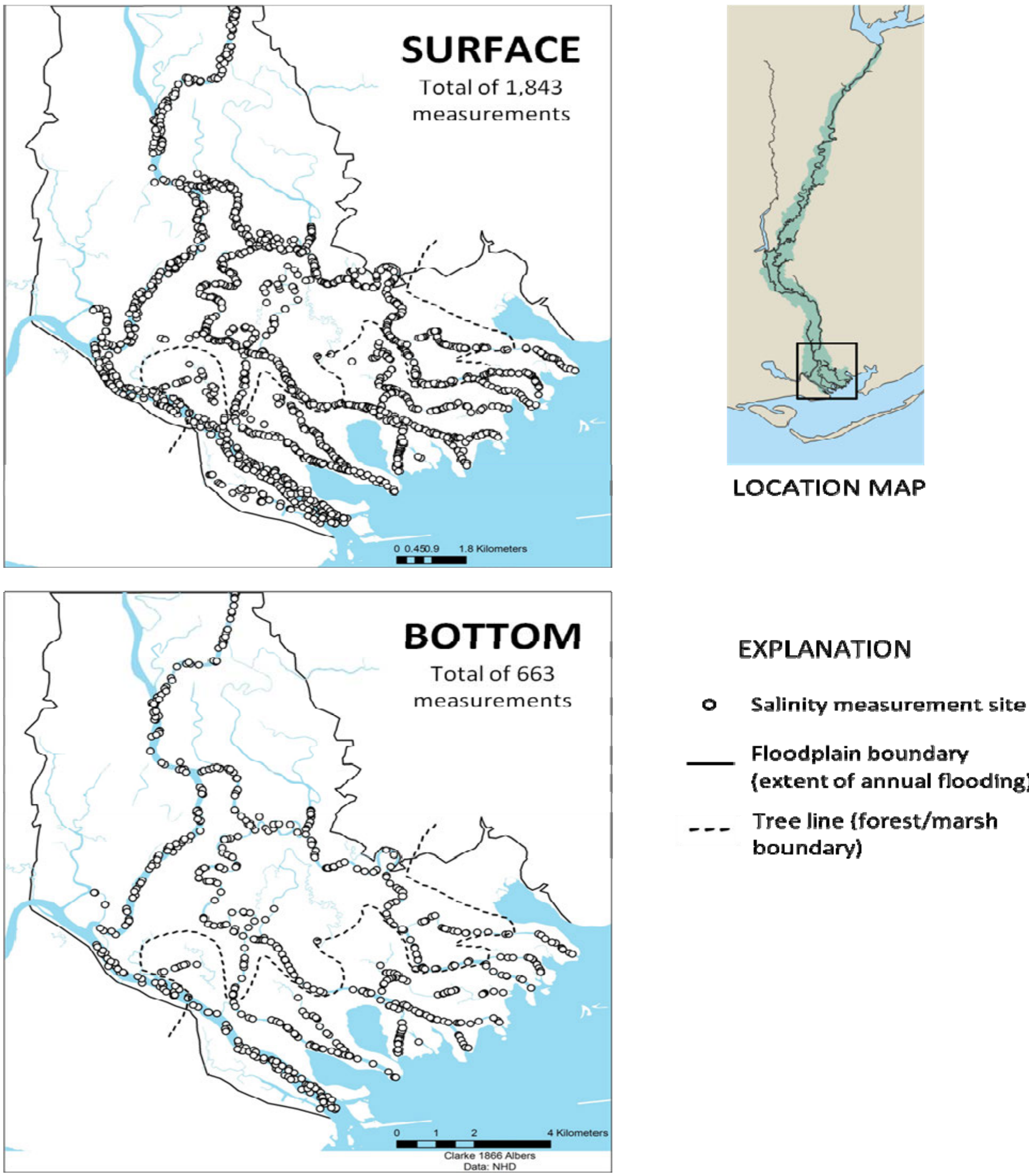
Appendix 2.C. Continued. (Footnotes)

[1]Precipitation volume for the basin upstream of Jim Woodruff Dam was calculated using an area of 11,125,739 acres.

[2]Flow/precipitation ratio is the annual flow volume (acre-ft) divided by the annual precipitation volume (acre-ft). It represents the approximate proportion of basin rainfall reaching the Apalachicola River as streamflow.

[3]**Variable 1** (baseline period) and **Variable 2** (recent period) are significantly different based on a two-sample t-Test with equal variance (p=0.0104). A one-tail t-Test was used because it was reasonable to expect that the flow/precipitation ratio in low-flow years has declined in the recent period (amount of anthropogenic consumption and evaporation has been large relative to the volume of flow). Variances were equal based on results of two-sample F-Test for variances.

Appendix D. Location of salinity measurements in the lower Apalachicola River and distributaries. Monthly measurements (randomly located within a network of grids) were made July 2000-Dec 2008 in association with fish monitoring collections by the Fish and Wildlife Research Institute of the Florida Fish and Wildlife Conservation Commission. Surface measurements were made during shoreline seine and trawl sampling at depths <= 0.5 m (mostly 0.2 m). Bottom measurements were made during trawl sampling only.



Appendix E. Species of fish known to occur in the Apalachicola River-floodplain system. Part 1. Species known to occur in the riverine reach (including species found in both riverine and tidal reaches). Part 2. Species known to occur in the tidal reach only.

Abbreviations:

TSN, Taxonomic Serial Number as listed in the Integrated Taxonomic Information System (ITIS) database. Numbers for additional species may be found using the ITIS online at www.itis.gov.

Type: A, anadromous; C, catadromous; F, freshwater; I, introduced; M, marine

Source (an attempt was made to list the earliest known source if multiple sources were available):

A85, Ager et al. 1985
B83, Bass 1983
B95, Bass 1995
B10, Bass and Hoehn 2010 (in prep)
H90, Hill et al 1990
L77, Livingston et al. 1977
P06, Pera et al. 2006
S09, Snelson et al. 2009
W06, Walsh et al. 2006
Y77, Yerger 1977
Other sources footnoted as needed

Floodplain collections:

AR, collected in Apalachicola River floodplain (based on summaries by Light et al. 1998 and Walsh et al. 2006)
E. US, collected in floodplains of other rivers of eastern United States (based on literature review by Light et al. 1995); presence in Apalachicola River floodplain is probable

tax. rev., taxonomic revision

Appendix E. -- Part 1. Species of fish known to occur in the riverine reach (including species found in both riverine and tidal reaches).

Family (scientific name)	Family (common name)	Species (scientific name)	Species (common name)	TSN	Type	Source	Floodplain collections
Petromyzontidae	Lampreys	Ichthyomyzon gagei	southern brook lamprey	159727	F	Y77	---
Acipenseridae	Sturgeon	Acipenser oxyrhynchus desotoi	Gulf of Mexico sturgeon	201894	A	Y77	---
Polyodontidae	Paddlefishes	Polyodon spathula	paddlefish	161088	F, I	[1]	---
Lepisosteidae	Gars	Lepisosteus oculatus	spotted gar	161095	F	Y77	AR
Lepisosteidae	Gars	Lepisosteus osseus	longnose gar	161094	F	Y77	AR
Amiidae	Bowfins	Amia calva	bowfin	161104	F	Y77	AR
Anguillidae	Freshwater eels	Anguilla rostrata	American eel	161127	C	Y77	AR
Clupeidae	Herrings	Alosa alabamae	Alabama shad	161705	A	Y77	---
Clupeidae	Herrings	Alosa chrysochloris	skipjack herring	161707	A	Y77	AR
Clupeidae	Herrings	Dorosoma cepedianum	gizzard shad	161737	F	Y77	AR
Clupeidae	Herrings	Dorosoma petenense	threadfin shad	161738	F	Y77	AR
Cyprinidae	Carps, minnows	Ctenopharyngodon idella	grass carp	163537	F, I	W06	AR
Cyprinidae	Carps, minnows	Cyprinella callitaenia	bluestripe shiner	163774	F	Y77	AR
Cyprinidae	Carps, minnows	Cyprinella leedsi	bannerfin shiner	163788	F	B83	E. US
Cyprinidae	Carps, minnows	Cyprinella venusta	blacktail shiner	163809	F	Y77	AR
Cyprinidae	Carps, minnows	Cyprinus carpio	common carp	163344	F, I	Y77	AR
Cyprinidae	Carps, minnows	Hybopsis sp. cf. H. winchelli	clear chub	163495	F	Y77	AR
Cyprinidae	Carps, minnows	Luxilus zonistius	bandfin shiner	163843	F	Y77	AR
Cyprinidae	Carps, minnows	Notemigonus crysoleucas	golden shiner	163368	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis amplamala (tax. rev. N. buccata)	longjaw minnow (formerly silverjaw minnow)	No TSN (formerly 163479)	F	Y77 (tax.rev. P06)	E. US
Cyprinidae	Carps, minnows	Notropis baileyi	rough shiner	163427	F	B95	---
Cyprinidae	Carps, minnows	Notropis chalybaeus	ironcolor shiner	163403	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis cummingsae	dusky shiner	163438	F	Y77	---
Cyprinidae	Carps, minnows	Notropis harperi	redeye chub	163444	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis longirostris	longnose shiner	163452	F	Y77	---
Cyprinidae	Carps, minnows	Notropis maculatus	taillight shiner	163454	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis petersoni	coastal shiner	163460	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis texanus	weed shiner	163420	F	Y77	AR

[1] FWC, 2007, unpublished, E.A. Long

Appendix E. -- Part 1. Riverine reach -- Continued

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**	**Floodplain collections**
Cyprinidae	Carps, minnows	Opsopoeodus emiliae	pugnose minnow	163876	F	Y77	AR
Cyprinidae	Carps, minnows	Pteronotropis grandipinnis	Apalachee shiner	689763	F	W06	AR
Cyprinidae	Carps, minnows	Pteronotropis signipinnus	flagfin shiner	201942	F	Y77	---
Cyprinidae	Carps, minnows	Pteronotropis welaka	bluenose shiner	201943	F	Y77	E. US
Cyprinidae	Carps, minnows	Semotilus thoreauianus (tax. rev. Semotilus atromaculatus)	Dixie chub (formerly creek chub)	163379	F	Y77	---
Catostomidae	Suckers	Carpiodes cyprinus	quillback	163917	F	Y77	AR
Catostomidae	Suckers	Carpoides velifer	highfin carpsucker	163920	F	[2]	---
Catostomidae	Suckers	Erimyzon sucetta	lake chubsucker	163922	F	Y77	AR
Catostomidae	Suckers	Minytrema melanops	spotted sucker	163959	F	Y77	AR
Catostomidae	Suckers	Moxostoma sp. cf. M. poecilurum	Apalachicola (grayfin) redhorse sucker	163927	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus brunneus	snail bullhead	164035	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus catus	white catfish	164037	F	Y77	E. US
Ictaluridae	Bullhead catfishes	Ameiurus natalis	yellow bullhead	164041	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus nebulosus	brown bullhead	164043	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus serracanthus	spotted bullhead	164047	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ictalurus furcatus	blue catfish	163997	F, I	[3]	---
Ictaluridae	Bullhead catfishes	Ictalurus punctatus	channel catfish	163998	F	Y77	AR
Ictaluridae	Bullhead catfishes	Noturus funebris	black madtom	164014	F	Y77	E. US
Ictaluridae	Bullhead catfishes	Noturus gyrinus	tadpole madtom	164003	F	Y77	AR
Ictaluridae	Bullhead catfishes	Noturus leptacanthus	speckled madtom	164019	F	Y77	AR
Ictaluridae	Bullhead catfishes	Pylodictis olivaris	flathead catfish	164029	F, I	A85	AR
Esocidae	Pikes	Esox americanus americanus	redfin pickerel	162141	F	Y77	AR
Esocidae	Pikes	Esox niger	chain pickerel	162143	F	Y77	AR
Aphredoderidae	Pirate perches	Aphredoderus sayanus	pirate perch	164405	F	Y77	AR
Mugilidae	Mullets	Agonostomus monticola	mountain mullet	170355	C	Y77	---
Mugilidae	Mullets	Mugil cephalus	striped mullet	170335	M	Y77	AR
Atherinopsidae	Silversides	Labidesthes sicculus	brook silverside	166016	F	Y77	AR

[2] Clemson University, 2005, unpublished, J. Isely, S. Young

[3] FWC, 1997, unpublished, R. Cailteux

Appendix E. -- Part 1. Riverine reach -- Continued

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**	**Floodplain collections**
Belonidae	Needlefishes	Strongylura marina	Atlantic needlefish	165551	A	Y77	AR
Fundulidae	Killifishes	Fundulus chrysotus	golden topminnow	165652	F	Y77	E. US
Fundulidae	Killifishes	Fundulus cingulatus	banded topminnow	165661	F	Y77	---
Fundulidae	Killifishes	Fundulus escambiae	russetfin topminnow (formerly eastern starhead topminnow)	165675	F	[4]	AR
Fundulidae	Killifishes	Fundulus notti	bayou/starhead topminnow	647286	F	Y77	---
Fundulidae	Killifishes	Fundulus olivaceus	blackspotted topminnow	165655	F	A85	AR
Fundulidae	Killifishes	Leptolucania ommata	pygmy killifish	165696	F	Y77	E. US
Fundulidae	Killifishes	Lucania goodei	bluefin killifish	165680	F	Y77	AR
Poeciliidae	Livebearers	Gambusia holbrooki	eastern mosquitofish	165896	F	Y77	AR
Poeciliidae	Livebearers	Heterandria formosa	least killifish	165915	F	Y77	AR
Moronidae	Temperate basses	Morone chrysops	white bass	167682	F, I	Y77	E. US
Moronidae	Temperate basses	Morone chrysops x M. saxatilis	sunshine bass	[hybrid]	F	A85	AR
Moronidae	Temperate basses	Morone saxatilis	striped bass	167680	A	Y77	E. US
Centrarchidae	Sunfishes	Ambloplites ariommus	shadow bass	168099	F	A85	---
Centrarchidae	Sunfishes	Centrarchus macropterus	flier	168102	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis gulosus (syn. Chaenobryttus gulosus)	warmouth	168138 (168139)	F	Y77	AR
Centrarchidae	Sunfishes	Enneacanthus gloriosus	bluespotted sunfish	168113	F	Y77	AR
Centrarchidae	Sunfishes	Enneacanthus obesus	banded sunfish	168117	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis auritus	redbreast sunfish	168131	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis cyanellus	green sunfish	168132	F, I	Y77	AR
Centrarchidae	Sunfishes	Lepomis humilis	orangespotted sunfish	168151	F, I	Y77	AR
Centrarchidae	Sunfishes	Lepomis macrochirus	bluegill	168141	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis marginatus	dollar sunfish	168152	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis microlophus	redear sunfish	168154	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis punctatus	spotted sunfish	168155	F	Y77	AR

[4] FWC, 1983, unpublished

Appendix E. -- Part 1. Riverine reach -- Continued

Family (scientific name)	Family (common name)	Species (scientific name)	Species (common name)	TSN	Type	Source	Floodplain collections
Centrarchidae	Sunfishes	Micropterus cataractae	shoal bass	564610	F	Y77	---
Centrarchidae	Sunfishes	Micropterus punctulatus	spotted bass	168161	F, I	Y77	AR
Centrarchidae	Sunfishes	Micropterus salmoides	largemouth bass	168160	F	Y77	AR
Centrarchidae	Sunfishes	Pomoxis annularis	white crappie	168166	F, I	W06	AR
Centrarchidae	Sunfishes	Pomoxis nigromaculatus	black crappie	168167	F	Y77	AR
Percidae	Perches	Ammocrypta bifascia	Florida sand darter	168514	F	A85	---
Percidae	Perches	Etheostoma edwini	brown darter	168390	F	Y77	E. US
Percidae	Perches	Etheostoma fusiforme	swamp darter	168358	F	Y77	AR
Percidae	Perches	Etheostoma parvipinne	goldstripe darter	168421	F	Y77	---
Percidae	Perches	Etheostoma swaini	Gulf darter	168439	F	Y77	AR
Percidae	Perches	Perca flavescens	yellow perch	168469	F, I	Y77	AR
Percidae	Perches	Percina nigrofasciata	blackbanded darter	168490	F	Y77	AR
Gerreidae	Mojarras	Eucinostomus harengulus (tax. rev. E. argenteus)	tidewater mojarra (formerly spotfin mojarra)	169025 (formerly 169015)	M	W06	AR
Elassomatidae	Pygmy sunfishes	Elassoma evergladei	Everglades pygmy sunfish	168169	F	Y77	AR
Elassomatidae	Pygmy sunfishes	Elassoma gilberti (tax. rev. E. okefenokee)	new species (formerly Okefenokee pygmy sunfish)	No TSN (formerly 168170)	F	Y77 (tax. rev. S09)	AR
Elassomatidae	Pygmy sunfishes	Elassoma zonatum	banded pygmy sunfish	168171	F	Y77	AR
Cichlidae	Cichlids	Oreochromis niloticus	Nile tilapia	553310	F, I	[5]	---
Paralichthyidae	Lefteye flounders	Paralichthys lethostigma	southern flounder	172738	M	Y77	---
Achiridae	Scrawed soles	Trinectes maculatus	hogchoker	172982	C	Y77	AR

[5] FWC, 2009, unpublished

Appendix E. -- Part 2. Species of fish known to occur in the tidal reach only.

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**
Carcharhinidae	Requiem sharks	Carcharhinus leucas	bull shark	160275	M	B83
Dasyatidae	Stingrays	Dasyatis sabina	Atlantic stingray	160953	M	B83
Elopidae	Tarpons	Elops saurus	ladyfish	161111	M	B83
Megalopidae	Tarpons	Megalops atlanticus	tarpon	161116	M	[6]
Ophichthidae	Snake eels	Myrophis punctatus	speckled worm eel	161453	M	B83
Engraulidae	Anchovies	Anchoa mitchilli	bay anchovy	161839	M	L77
Clupeidae	Herrings	Brevoortia patronus	Gulf menhaden	161734	M	L77
Ariidae	Sea catfishes	Ariopsis felis	hardhead catfish	164165	M	B83
Ariidae	Sea catfishes	Bagre marinus	gafftopsail catfish	164159	M	B83
Mugilidae	Mullets	Mugil curema	white mullet	170336	M	L77
Atherinopsidae	Silversides	Membras martinica	rough silverside	165989	M	H90
Atherinopsidae	Silversides	Menidia beryllina	inland silverside (alternate name: tidewater silverside)	165993	M	L77
Fundulidae	Killifishes	Adinia xenica	diamond killifish	165682	M	L77
Fundulidae	Killifishes	Fundulus confluentus	marsh killifish	165645	M	L77
Fundulidae	Killifishes	Fundulus grandis	Gulf killifish	165651	M	L77
Fundulidae	Killifishes	Fundulus seminolis	Seminole killifish	165667	F	B10
Fundulidae	Killifishes	Fundulus similis	longnose killifish	165657	M	L77
Fundulidae	Killifishes	Lucania parva	rainwater killifish	165679	F	L77
Poeciliidae	Livebearers	Poecilia latipinna	sailfin molly	165898	M	L77
Cyprinodontidae	Killifishes	Cyprinodon variegatus	sheepshead minnow	165631	F	L77
Syngnathidae	Pipefishes, seahorses	Syngnathus floridae	dusky pipefish	166446	M	B83
Syngnathidae	Pipefishes, seahorses	Syngnathus scovelli	Gulf pipefish	166458	M	B83
Carangidae	Jacks	Hemicaranx amblyrhynchus	bluntnose jack	168740	M	[7]
Carangidae	Jacks	Oligoplites saurus	leatherjacket	168673	M	A85
Carangidae	Jacks	Trachinotus falcatus	permit	168709	M	B95
Lutjanidae	Snappers	Lutjanus griseus	gray snapper (mangrove)	168848	M	L77
Gerreidae	Mojarras	Eucinostomus gula	silver jenny	169016	M	L77

[6] FWC, unpublished

[7] FWC, 1989, Statewide Stream Monitoring Data

Appendix E. -- Part 2. Tidal reach -- Continued

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**
Haemulidae	Grunts	Orthopristis chrysoptera	pigfish	169077	M	B83
Sparidae	Porgies	Archosargus probatocephalus	sheepshead	169189	M	L77
Sparidae	Porgies	Lagodon rhomboides	pinfish	169187	M	B83
Sciaenidae	Drums	Bairdiella chrysoura	silver perch	169259	M	L77
Sciaenidae	Drums	Cynoscion arenarius	sand seatrout	169243	M	L77
Sciaenidae	Drums	Cynoscion nebulosus	spotted seatrout	169239	M	B83
Sciaenidae	Drums	Leiostomus xanthurus	spot	169267	M	B83
Sciaenidae	Drums	Micropogonias undulatus	Atlantic croaker	169283	M	L77
Sciaenidae	Drums	Sciaenops ocellatus	red drum	169290	M	B83
Eleotridae	Sleepers	Eleotris amblyopsis (tax. rev. E. pisonis)	largescaled spinycheek sleeper (formerly spinycheek sleeper)	636827 (formerly 171932)	M	B95
Gobiidae	Gobies	Bathygobius soporator	frillfin goby	171820	M	B83
Gobiidae	Gobies	Ctenogobius boleosoma	darter goby	636799	M	B83
Gobiidae	Gobies	Ctenogobius shufeldti	freshwater goby	636837	M	H90
Gobiidae	Gobies	Gobiosoma bosc	naked goby	171789	M	L77
Gobiidae	Gobies	Gobiosoma robustum	code goby	171791	M	B83
Gobiidae	Gobies	Microgobius gulosus	clown goby	171808	M	L77

Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, FL

Draft Interim Report

By

Y. Peter Sheng, Ph.D.,
Justin R. Davis, Ph.D., and
Vladimir A. Paramygin, Ph.D.

Civil and Coastal Engineering Department
University of Florida

Presented to the

Fish and Wildlife Service
U.S. Department of Interior

April 27, 2011

Table of Contents

Introduction

The Apalachicola-Chatahoochee-Flint (ACF) system is an important watershed-riverine-estuarine ecosystem which encompasses the tri-state area of Georgia, Alabama, and Florida. Freshwater originates in northeast Georgia and flows through Chattahoochee River, Flint River, and Apalachicola River before reaching the Apalachicola Bay in Florida. While the freshwater is used for drinking and agriculture, it is also vital to the shellfish in the Apalachicola Bay. Reduced freshwater flow in the ACF system will result in higher salinity in the Apalachicola Bay which could adversely impact the oysters. Low salinity, on the other hand, may endanger the federally threatened Gulf sturgeon in the Bay. Therefore, it is important to develop quantitative understanding on how freshwater flow in the ACF system impacts the salinity in the Apalachicola Bay, so that the amount of freshwater flow necessary to maintain fish and wildlife in Bay can be better understood.

As a first step towards the development of an integrated modeling system of the ACF system to enable assessment of the impact of freshwater withdrawal and climate change on the salinity and biological species inside the Apalachicola Bay, Sheng and Paramygin (2010a) developed a hydrodynamic model to simulate the flow and salinity distribution inside Apalachicola Bay. Their model is based on the 3D curvilinear-grid hydrodynamic model CH3D (Sheng 1987, Sheng et al. 2008, Sheng and Paramygin 2010a) and was successfully applied to simulate the salinity dynamics in the Bay during the summer of 2004 when 5 hurricanes passed the region. The simulation captured the significant variation in salinity that occurred during the 2004 hurricane season. The CH3D model used by Sheng and Paramygin (2010a) has several advantages over the model used by Huang (2010) for Apalachicola Bay:

- It uses a boundary-fitted grid to accurately resolve the complex shorelines of the Apalachicola Bay system;
- It uses very high spatial grid resolution (~20 m) in the horizontal directions;
- It can simulate circulation driven by wind, tide, and density gradients, while allowing flooding and drying of the shorelines during hurricanes and storms;
- It can be coupled to a large scale circulation model of the Gulf of Mexico;
- It allows incorporation of various wind and precipitation fields; and
- It has been integrated with ecosystem models, CH3D-IMS (Sheng and Kim 2009), and inundation models, CH3D-SSMS (Sheng et al. 2010; Sheng and Paramygin 2010b).

Therefore in this study we used the CH3D model for Apalachicola Bay to study the impact of freshwater alteration on the salinity, Gulf sturgeon, and oyster population in the Apalachicola Bay.

Results of the hydrodynamic and salinity simulations can be used to simulate the oyster population inside the Apalachicola Bay. Hofmann et al. (1992), Klinck et al. (1992), Powell et al. (2003) developed an oyster population dynamic model for oysters in Galveston Bay, Texas. Since Apalachicola Bay and Galveston Bay have similar-sized adult oyster populations, Wang et al. (2008) applied the post-settlement population dynamic model of Powell, Hofmann, and Klinck to Apalachicola Bay with necessary modifications to account for the specific conditions in Apalachicola Bay. Post-settlement adult oysters are divided into four size groups, while oyster filtration rate is assumed to be dependent on salinity, temperature, and turbidity, spawning patterns are dependent on the relationship between temperature and food supply during critical feeding periods, the same temperature-dependent reproduction efficiency equations from Galveston Bay holds true, and no specific relationship exists between salinity and oyster growth rate. Thus, low salinity results in low oyster reproduction due to lower filtration rate and higher respiration. Livingston et al. (2000) also studied the oyster population in Apalachicola Bay.

Wang et al. (2008) simulated the oyster population between March 2004 and June 2005 at two sites: Dry Bar, a site with strong river influence located to the southwest of the Apalachicola River, and Cat Point, a site with little river influence located to the southeast of the River. Model results agreed well with data except during July and September 2004 when hurricanes were affecting the Apalachicola Bay. Nevertheless, Wang et al. (2008) suggested that, anticipating increased freshwater use upstream of the Apalachicola River, Apalachicola Bay will become increasingly saltier, causing a substantial decrease in oyster growth rates, particularly in summer when oyster growth rates are normally high in the Bay.

During this study, we constructed and validated an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it to the hydrodynamic-salinity model described above to assess the impact of freshwater alteration on oyster population in Apalachicola Bay.

Initial Model Setup and Verification

A CH3D model computational grid was developed for Apalachicola Bay and surrounding areas to simulate the salinity distribution in the bay, the grid, selected data sites, and bathymetry/topography values used in the model are shown in Figures 1 and 2. From hereon, this grid is referred to as the "fine" grid. A coarse grid has also been developed which has 4 times fewer grid cells. The "coarse" grid is obtained by merging 2 by 2 cell blocks of the fine grid into a single grid cell of the coarse grid and reapplying the bathymetry/topography interpolation.

CH3D is applied in a 3D mode with 8 vertical sigma-grid layers. The time step used for simulations is set to 1 minute which allows to 1 year to be simulated in approximately 1.2 days of wall clock time on a single CPU core (Intel Core i7 870 @ 2.93 Ghz).

The model has two open boundaries – at the west and south ends, tidal forcing (in a form of tidal constituents) is used at these boundaries to drive the tides inside the model domain. The tidal constituents are based on the data at the NOAA tidal gage (872-8690) located at the mouth of the Apalachicola River (Figure 1). Significant constituents (amplitudes > 1 cm) are K1, M2, O1, P1, S2, SA, and SSA.

A river flow boundary condition is introduced at the Apalachicola River (Sumatra gage) and the flows are based on the daily flow rates provided by the USACE. It is assumed that flow at the Sumatra gage is freshwater only, hence the river boundary value of salinity is set to 0 ppt.

Wind forcing over the domain is based on 6-hourly wind data from the NOGAPS model (https://www.fnmoc.navy.mil/public) and is linearly interpolated in time at the time step of the CH3D model.

The initial salinity field is based on interpolation of a HYCOM model snapshot of surface salinity; hence, the initial salinity profile is vertically uniform. Subsequently, all model simulations use a spin-up period of 3 months prior to starting the main simulation to ensure that there is time to establish a realistic (spatial and vertical) salinity distribution in the domain.

Apalachicola National Estuarine Research Reserve (ANERR) provides salinity data at several sites. Comparisons with observed data were done to verify the model, which showed satisfactory performance (Figure 3 and Figure 4) with the test year being simulated (2004).

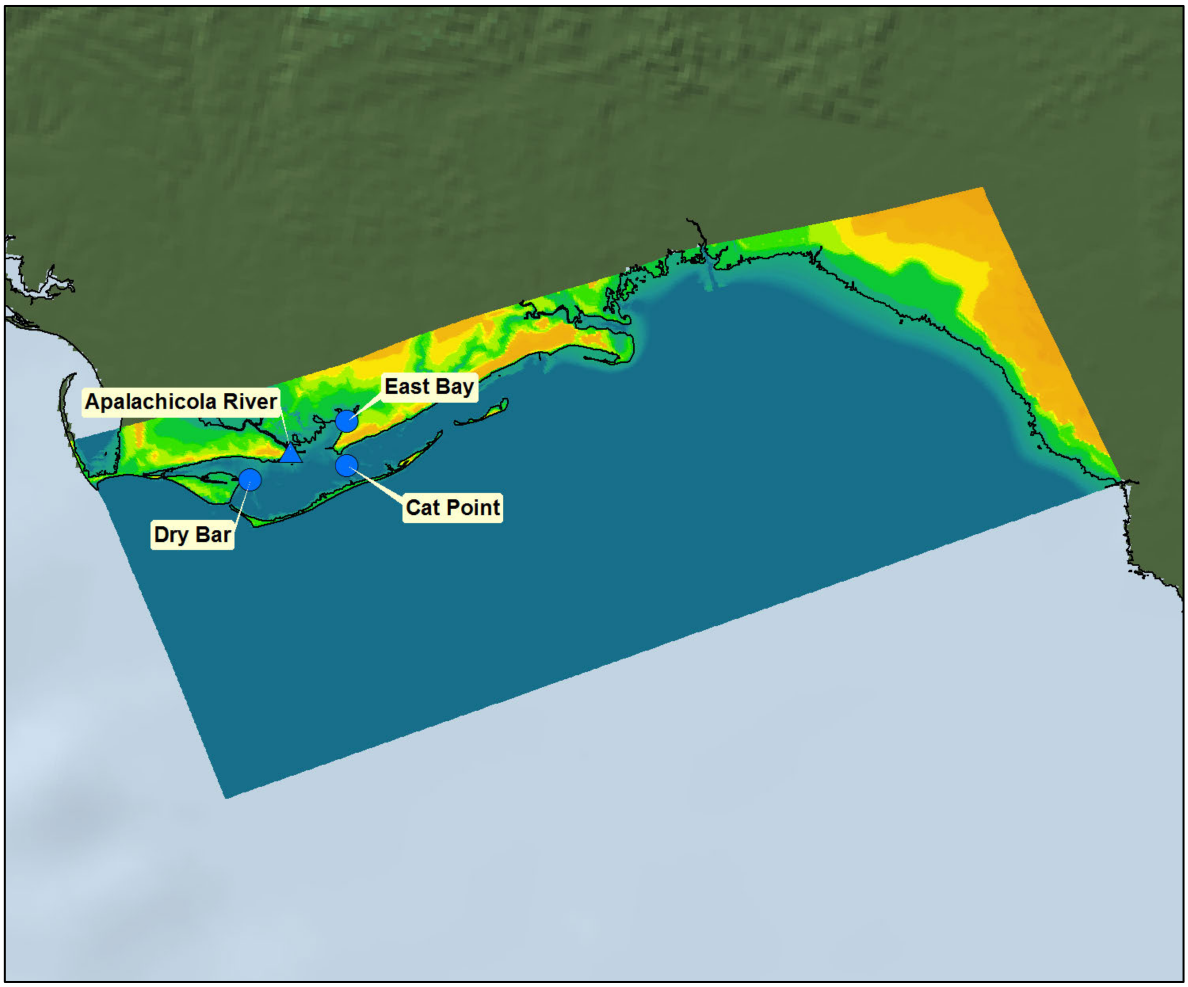


Figure 1. CH3D model grid and selected data sites

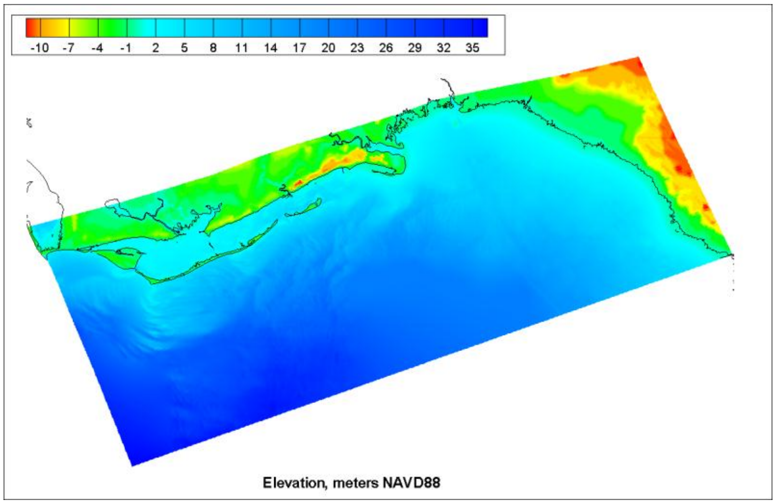


Figure 2. CH3D model grid bathymetry / topography

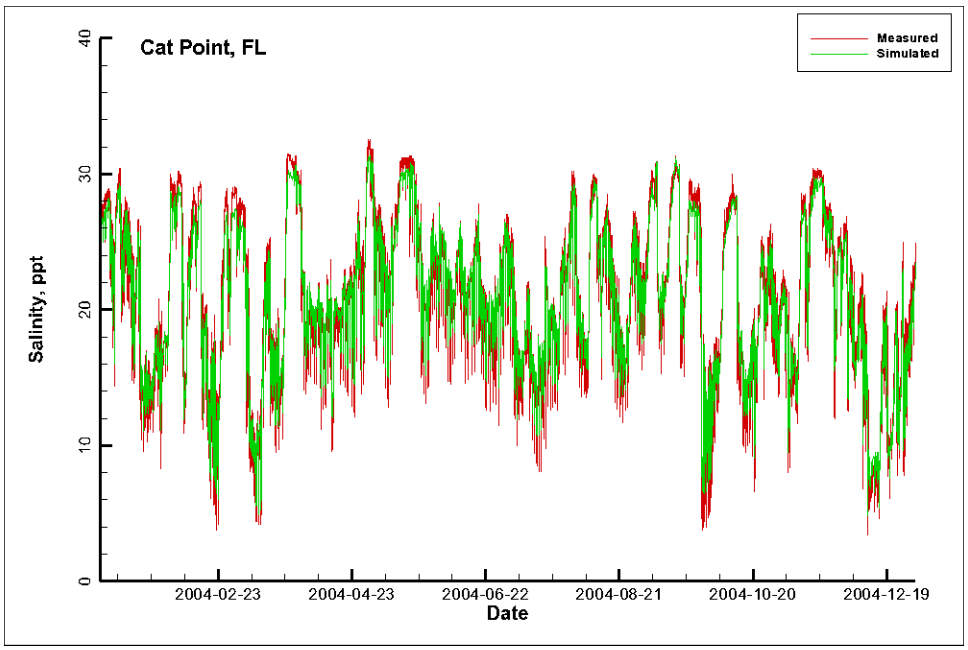


Figure 3. Simulated salinity at the Cat Point site during 2004

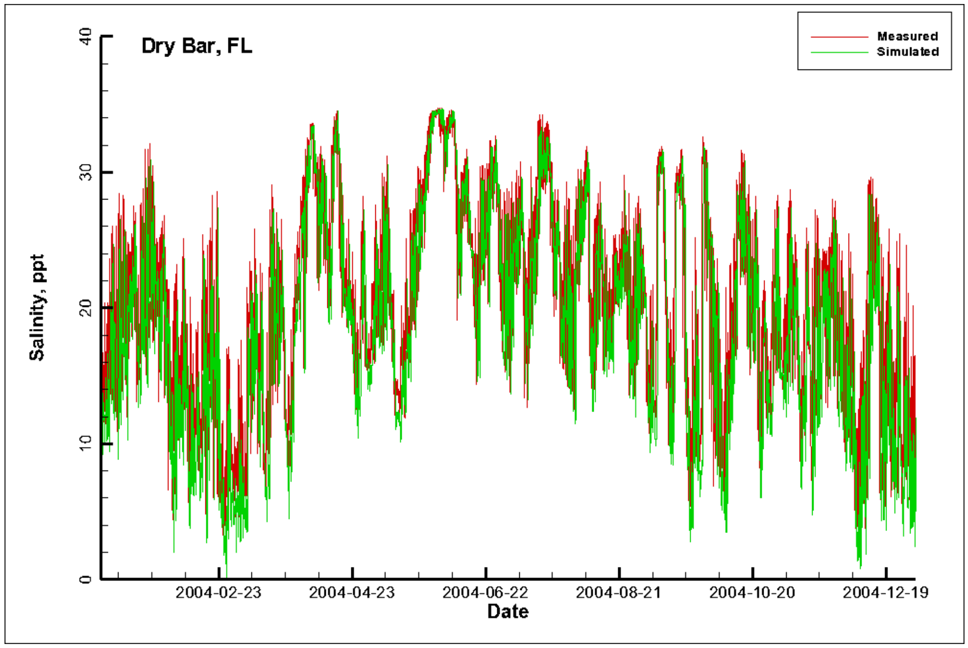


Figure 4. Simulated salinity at the Dry Bar site during 2004

10 Year Simulations

1999-2008. Fine grid

Four flow discharge scenarios were considered for the 10 year (1999-2008) simulations:

a) Observed

b) Current operations

c) Alternative #1

d) Alternative #2

Base scenario a) uses observed flow rates at the Sumatra gage provided by the USACE. Scenarios b), c) and d) use altered flows, statistics for the time series of flow rates are provided in Table 1.

With the exception of these flow rates all other model parameters and forcing remain the same for all scenarios.

Table 1. Statistics for the flow rates (m^3/s) at the Sumatra gage

	mean	mean %	std dev	std dev %	min	max
Observed	519.2		411.4		124.6	4700.6
Current	514.4	0.92	391.3	4.89	136.4	3965.7
Alt #1	515.9	0.64	391.4	4.86	136.4	3965.7
Alt #2	516.4	0.54	391.0	4.96	136.4	3965.7

Salinity for the observed scenario during 2004 is consistent with the results produced by the verification simulation displayed in Figure 3 and Figure 4. These results show that there is little difference in salinity inside Apalachicola Bay between the observed scenario and the current and alternate scenarios. However, due to reduced flow rates, simulated salinity in current and alternate scenarios results in slightly higher highs and lower lows as compared to the observed scenario.

1980-1989. Fine grid

Another 10 year time period was also considered (1980-1989). This period was chosen to correspond to the period used by Huang (2010). The same grid was used as in the previous simulations.

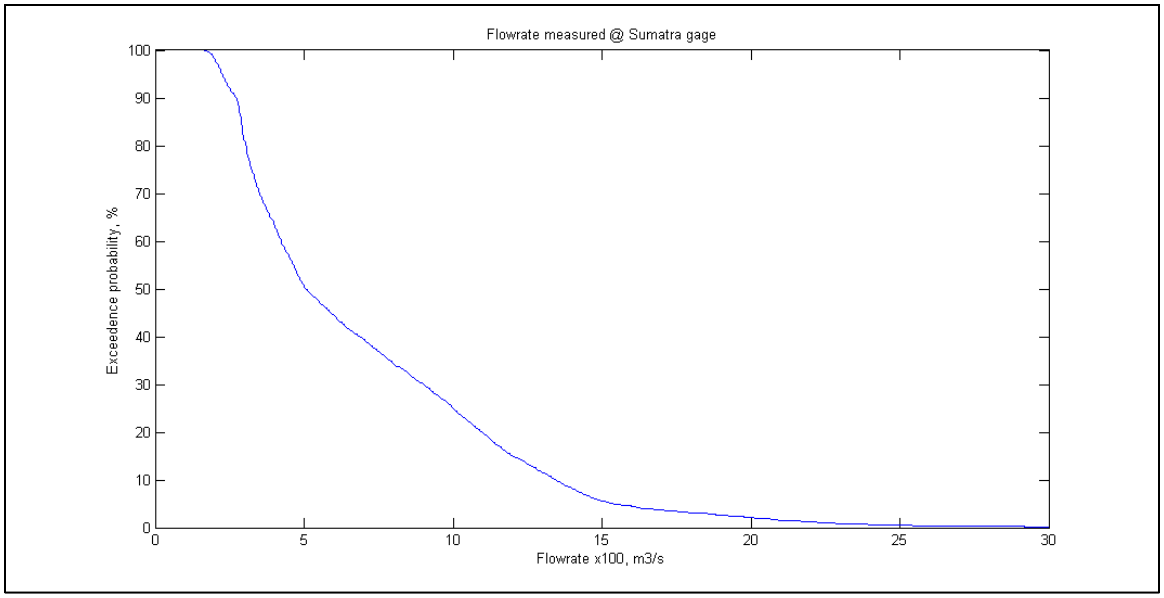


Figure 5. Obsereved flowrate probability of exceedence at the Sumatra gage

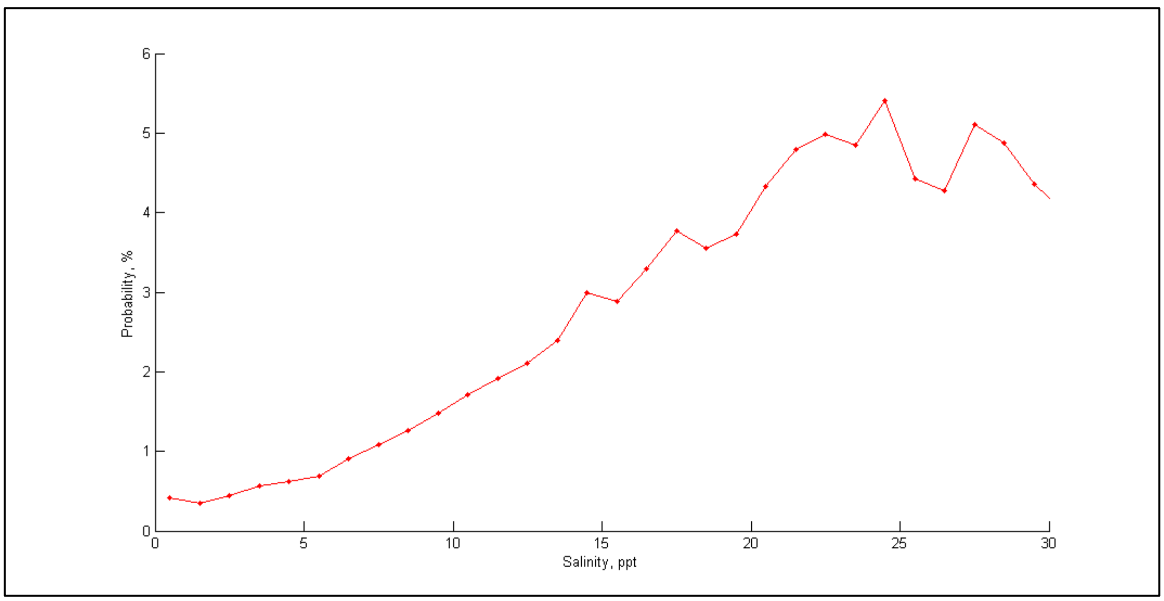


Figure 6. Probability density of simulated salinity at Cat Point

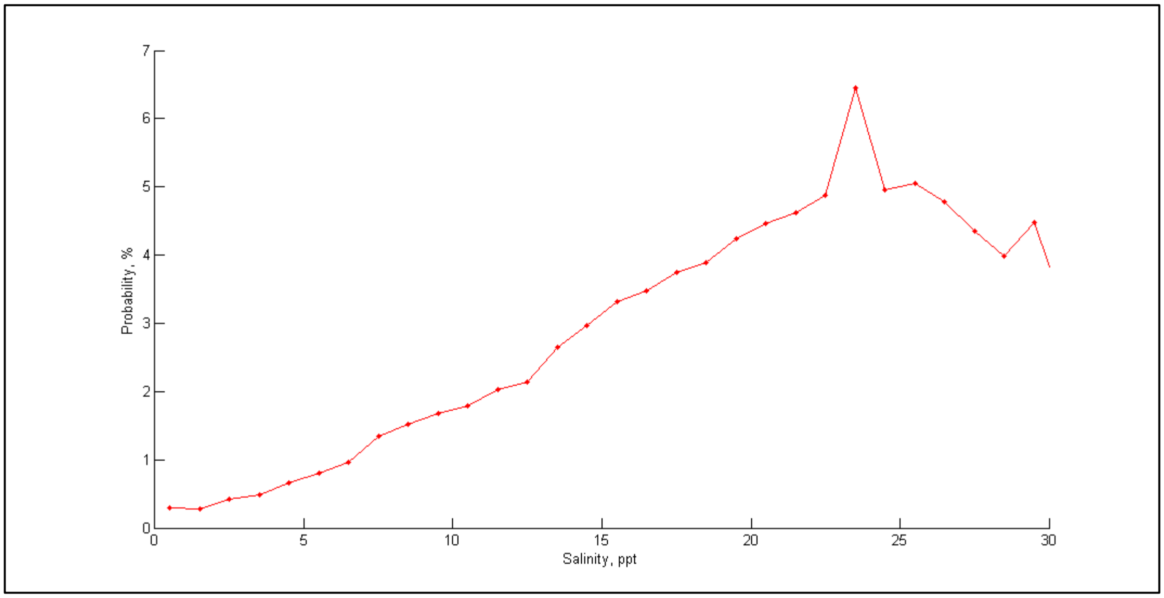


Figure 7. Probability density of simulated salinity at Dry Bar

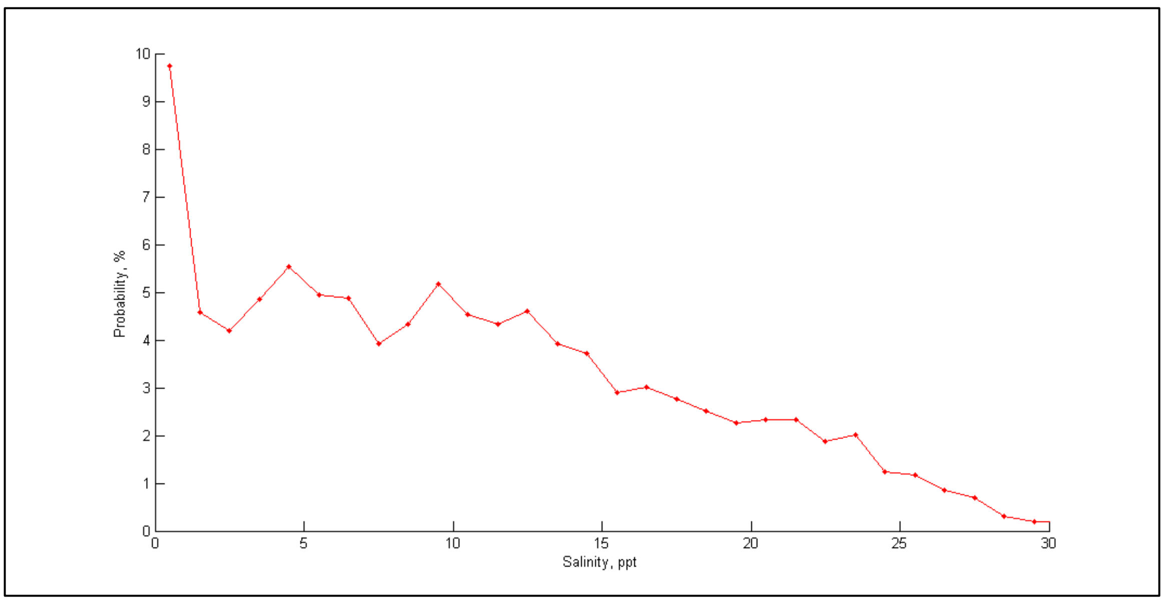


Figure 8. Probability density of simulated salinity at East Bay

1980-1989. Coarse grid

Due to the simulated salinity differing slightly from the results of Huang (2010) – a coarser grid was developed in an attempt to better reproduce Huang's two distinctive peaks in the probability of exceedance figures for salinity; however, results were similar to those produced by the finer grid model and aggregate functions (e.g. probability of exceedence, probability density, etc.) showed little difference compared to the fine grid model results.

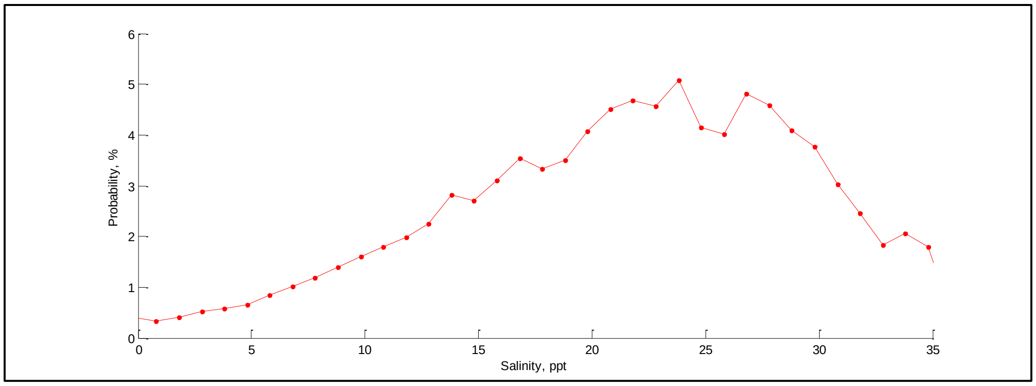


Figure 9. Probability density of simulated salinity at Cat Point

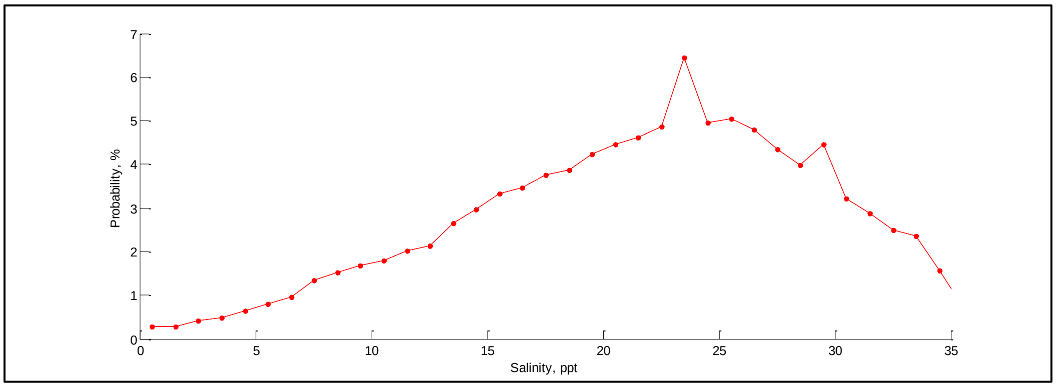


Figure 10. Probability density of simulated salinity at Dry Bar

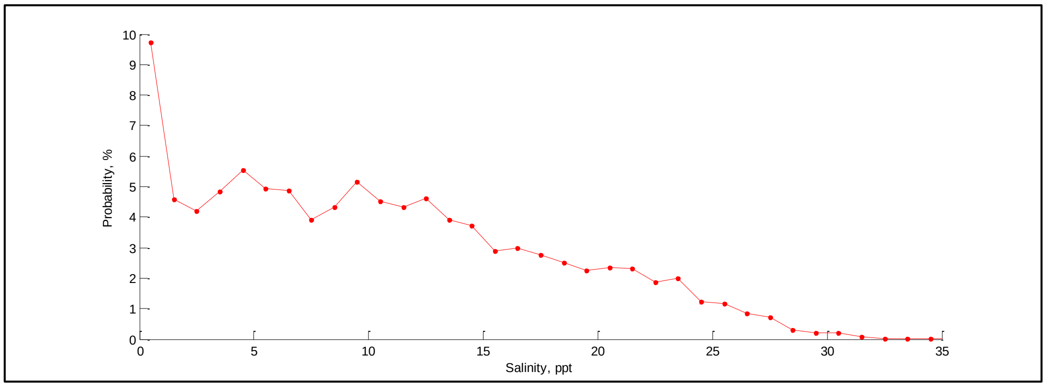


Figure 11. Probability density of simulated salinity at East Bay

Analysis Products

A number of model outputs were requested by the FWS – the complete list is available in Appendix B. This section comprises of the figures and tables that are dedicated to fulfilling the request and provide various information based on the results of simulations. All model results presented in this section are based on the 10 year simulation (1999-2008) fine grid using the four different flow scenarios. Given that the flow rate is the only parameter which changes – it is the only parameter that affects the differences in salinity and therefore results, generally, correlate well with the flow at Sumatra gage.

Figure 12 and Figure 13 show the exceedence probability at the Cat Point and Dry Bar sites, respectively, for the four scenarios. As it was mentioned previously – the observed scenario produces slightly higher highs and lower lows in salinity values and there is very little difference, however, between the Current, Alternative #1 and Alternative #2 scenarios.

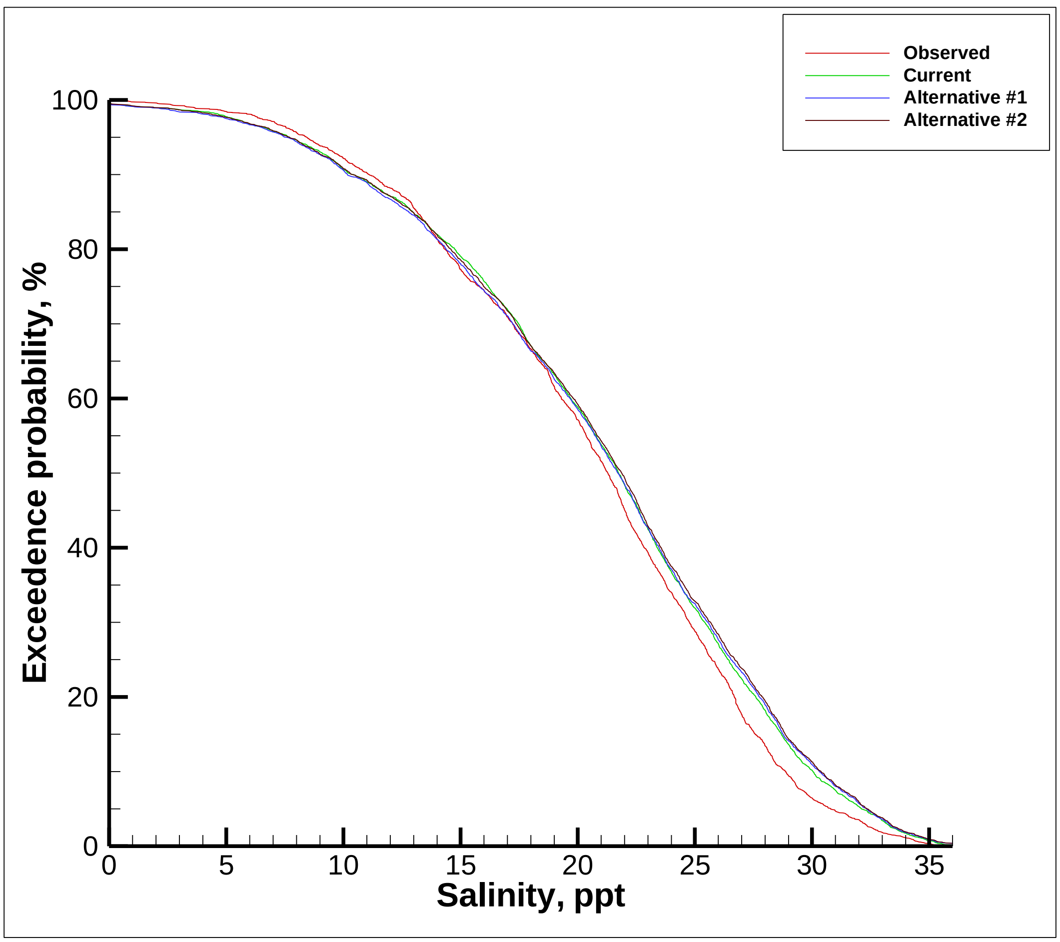


Figure 12. Probability of exceedence at the Cat Point site

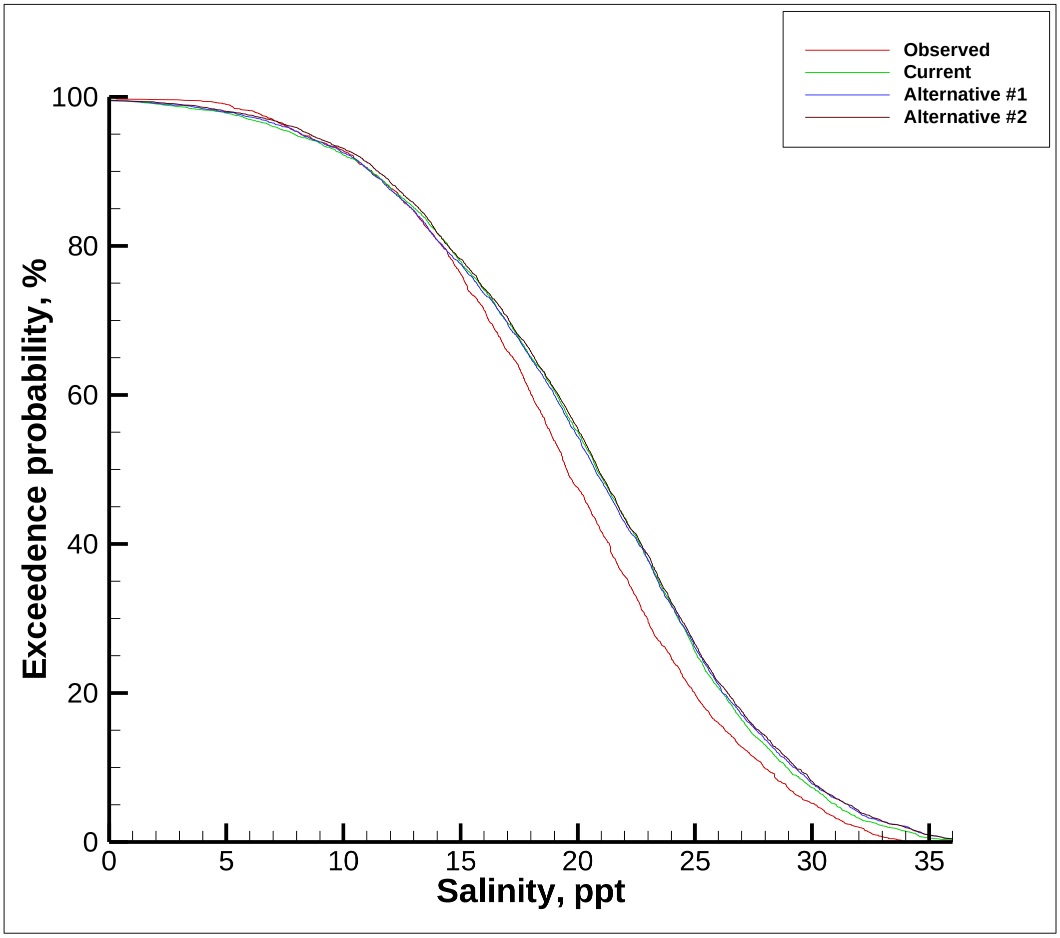


Figure 13. Probability of exceedence at the Dry Bar site

Summary statistics for growth rates of Class 4 (Marketable) oysters at the Cat Point and Dry Bar sites are presented in the tables and figures below. It can be clearly seen that the mean growth rate in August is significantly larger (3 to 4 times) as compared to the growth rate for the entire year at the Cat Point site and smaller for the Dry Bar site. Oyster population model results are based on the simulated bottom salinity at Cat Point and Dry Bar for the four flow scenarios.

Table 2. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Cat Point for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	1.78	5.79
	Current	1.41	4.66
	Alternate #1	1.30	4.31
	Alternate #2	1.31	4.35
Median	Observed	2.65	7.08
	Current	2.65	7.00
	Alternate #1	2.63	6.99
	Alternate #2	2.63	6.99
Standard Deviation	Observed	5.73	5.00
	Current	6.46	7.10
	Alternate #1	6.63	8.01
	Alternate #2	6.62	7.90
Interquartile Range	Observed	1.43	2.10
	Current	1.39	2.16
	Alternate #1	1.42	2.17
	Alternate #2	1.42	2.17

Table 3. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Dry Bar for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	2.92	2.19
	Current	2.42	0.81
	Alternate #1	2.39	0.69
	Alternate #2	2.44	0.78
Median	Observed	4.42	5.26
	Current	4.41	5.14
	Alternate #1	4.39	5.14
	Alternate #2	4.39	5.15
Standard Deviation	Observed	5.04	7.63
	Current	6.36	10.45
	Alternate #1	6.26	10.39
	Alternate #2	6.20	10.32
Interquartile Range	Observed	1.87	1.23
	Current	1.97	1.23
	Alternate #1	2.05	1.95
	Alternate #2	2.03	1.63

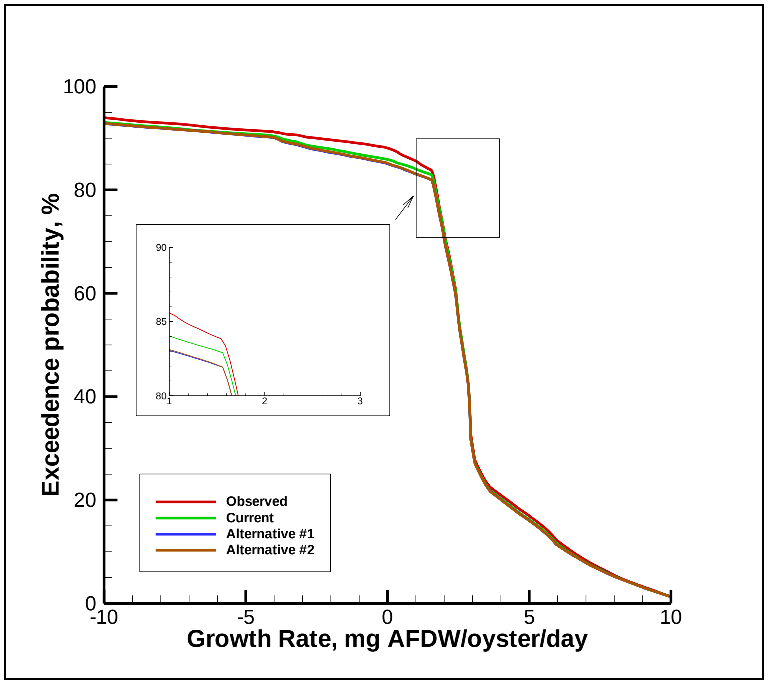


Figure 14. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

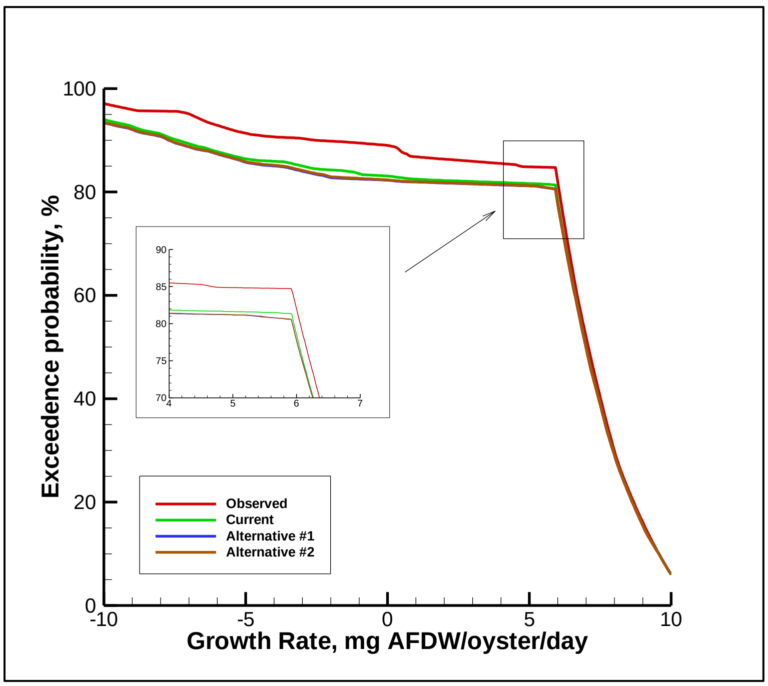


Figure 15. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

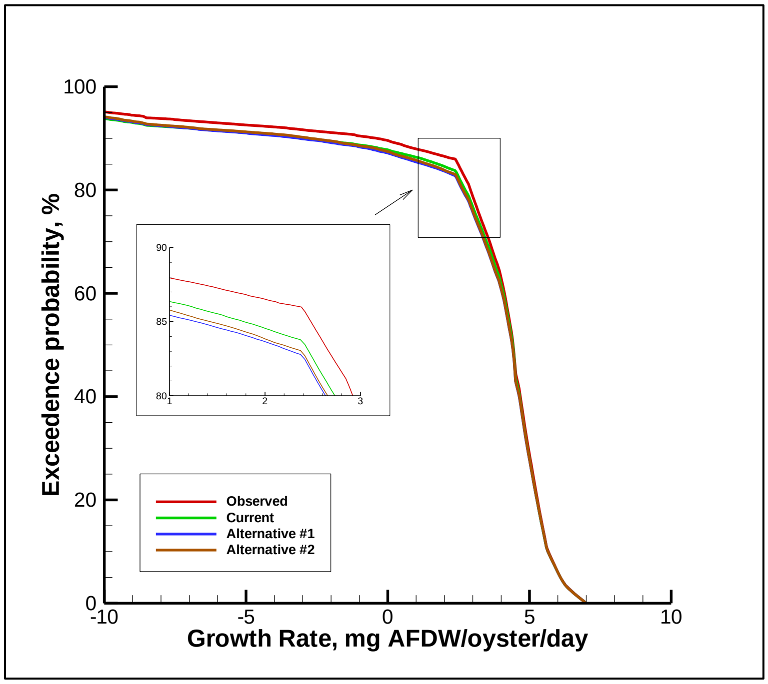


Figure 16. Exceedance probabilty at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

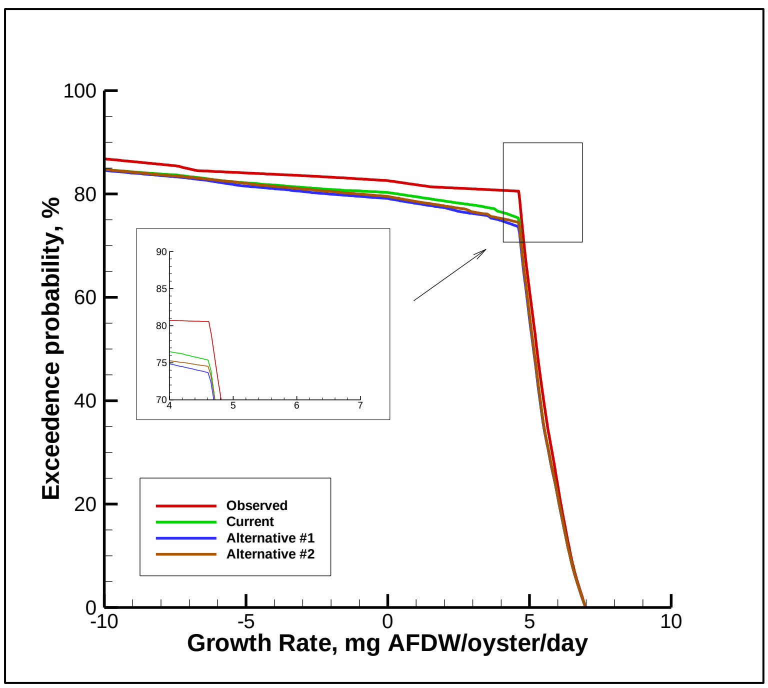
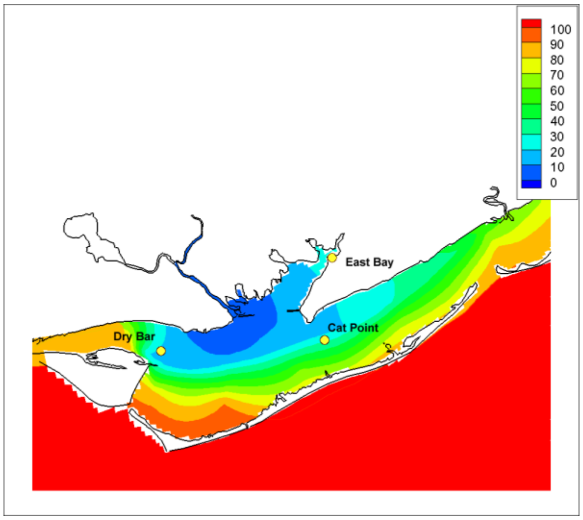
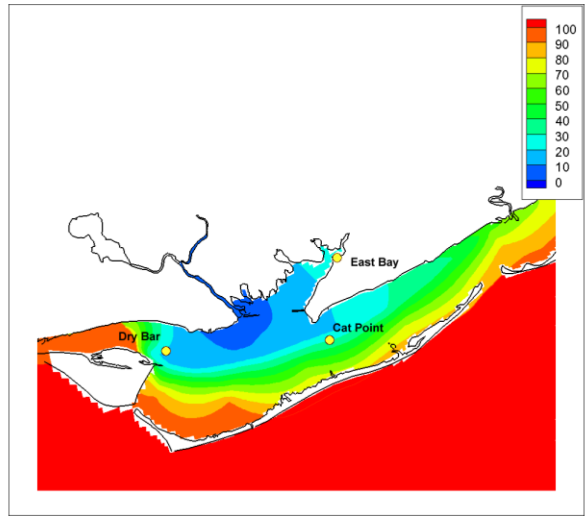


Figure 17. Exceedence probability at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

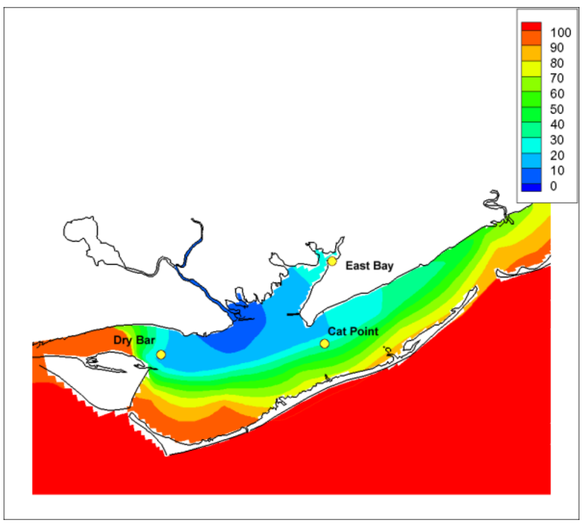
The following figures and tables present the number of days when salinity exceeds 26 ppt (important for oysters) and when the salinity exceeds 10 ppt (important for sturgeon).



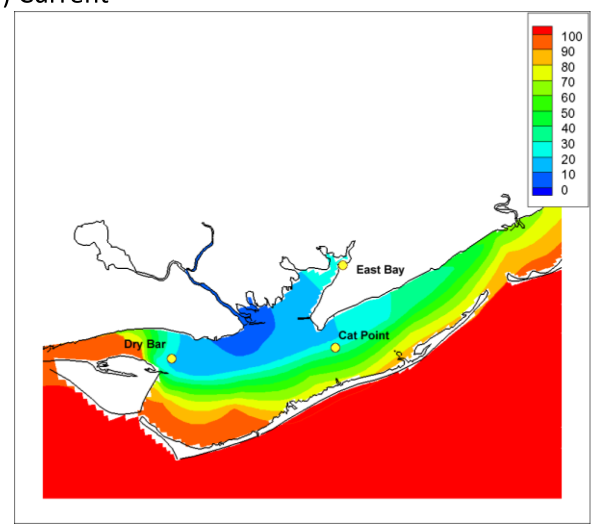
a) Observed



b) Current



c) Alternative #1

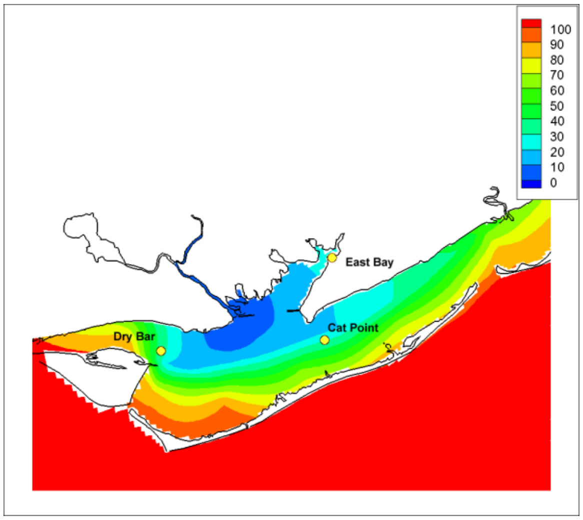


d) Alternative #2

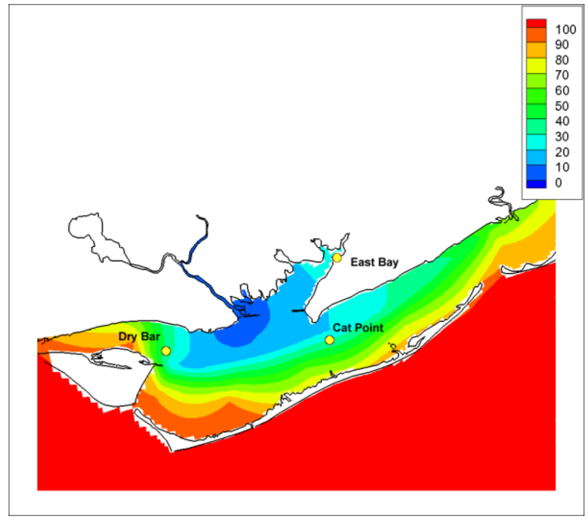
Figure 18. Percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

Table 4 Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

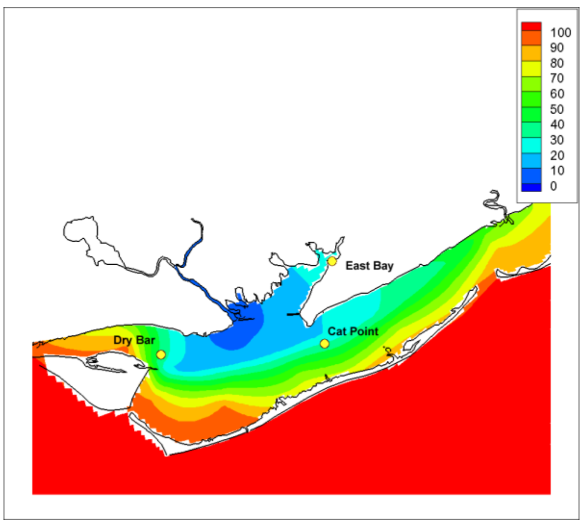
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	8682.77	5804.57	5499.89	5079.00
10-20	17059.82	17788.53	17818.89	17741.41
20-30	10170.56	10540.15	10608.20	10777.82
30-40	9461.74	9566.44	9603.08	9618.79
40-50	9057.60	9050.27	9019.90	9077.49
50-60	9839.71	9555.97	9539.22	9509.90
60-70	12861.35	12208.02	12175.56	12048.88
70-80	12351.46	12982.80	12978.61	13360.77
80-90	18268.06	10956.86	10889.85	10521.30



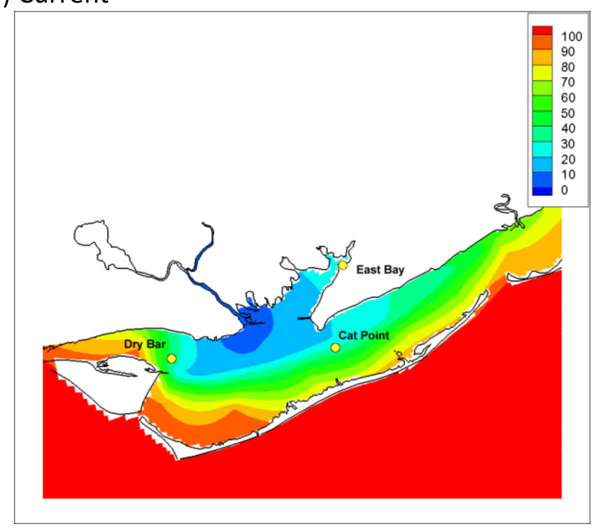
a) Observed



b) Current



c) Alternative #1

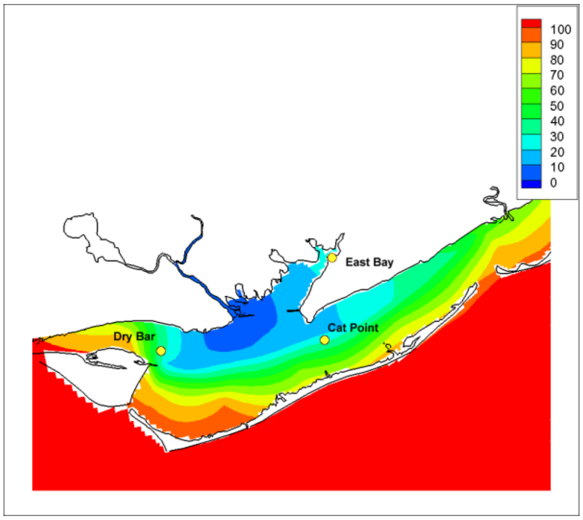


d) Alternative #2

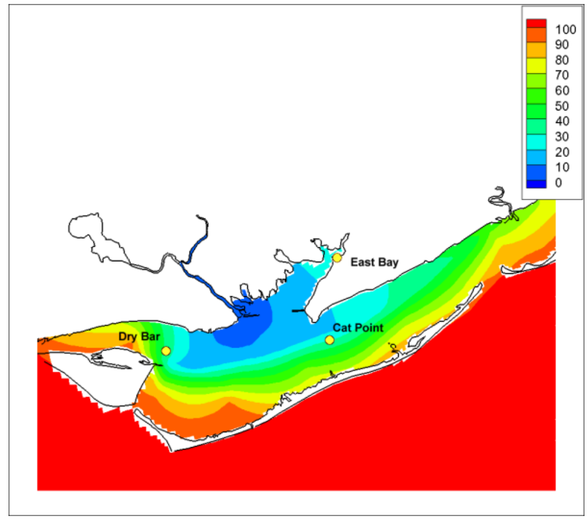
Figure 19. Percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual discharge) year (2005)

Table 5. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual flow) year (2005)

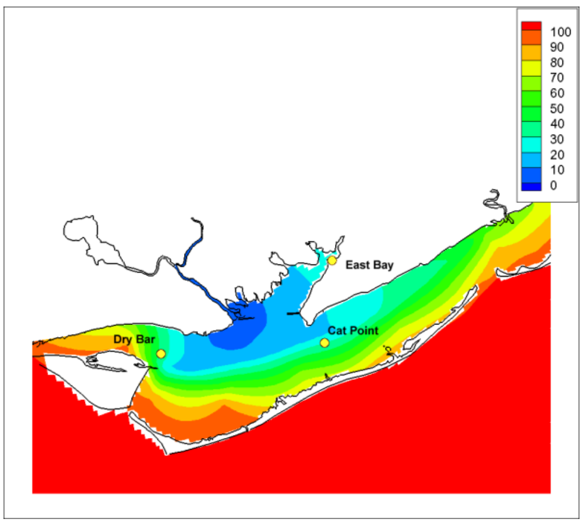
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7032.70	4895.77	4640.30	4420.43
10-20	15968.84	15783.53	15684.06	15553.18
20-30	10609.25	11019.67	11166.25	11263.63
30-40	9845.99	10061.67	10050.15	10084.70
40-50	9505.71	9453.36	9484.77	9463.83
50-60	10223.96	10063.76	9995.71	9976.86
60-70	13348.20	12568.19	12504.32	12366.12
70-80	13862.28	14223.49	14231.87	14372.17
80-90	15062.14	14692.55	14662.19	14608.79



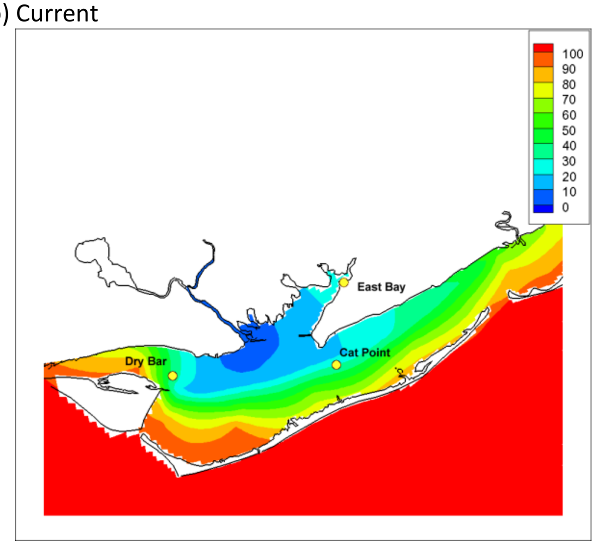
a) Observed



b) Current



c) Alternative #1

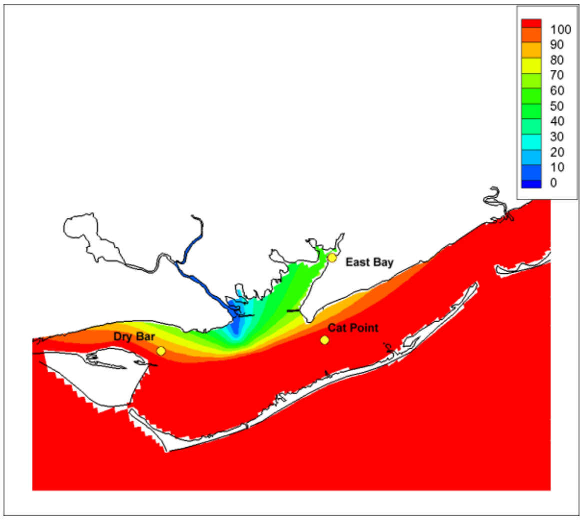


d) Alternative #2

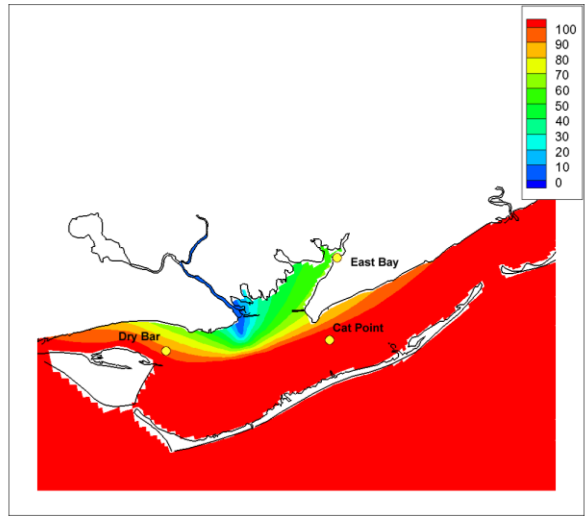
Figure 20. Percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

Table 6. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

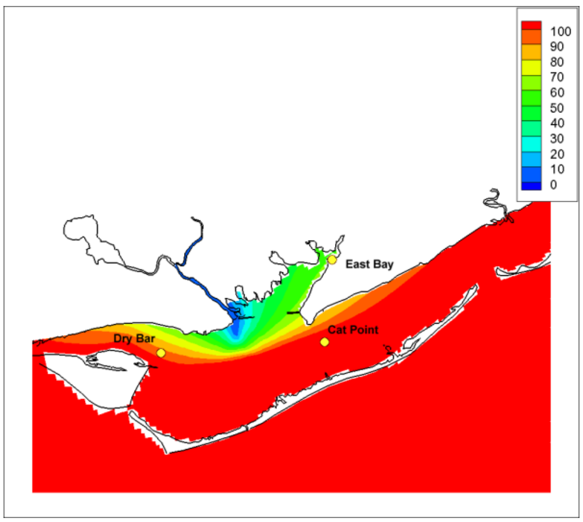
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7649.38	5406.71	5247.56	5290.49
10-20	16005.49	16189.76	16167.77	16163.59
20-30	10287.82	10636.47	10689.87	10681.49
30-40	9789.45	9850.18	9873.21	9867.97
40-50	9432.42	9459.64	9452.32	9468.02
50-60	10277.35	10073.19	10009.32	10011.41
60-70	13204.76	12466.63	12489.66	12479.19
70-80	13785.85	14188.94	14174.29	14171.14
80-90	14313.54	13396.37	13339.83	13367.05



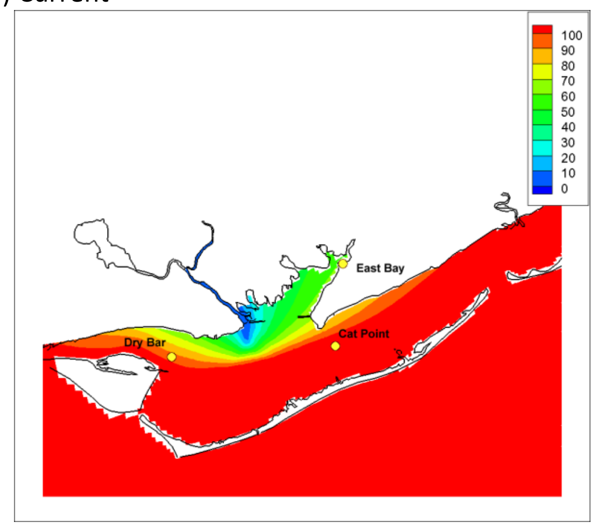
a) Observed



b) Current



c) Alternative #1

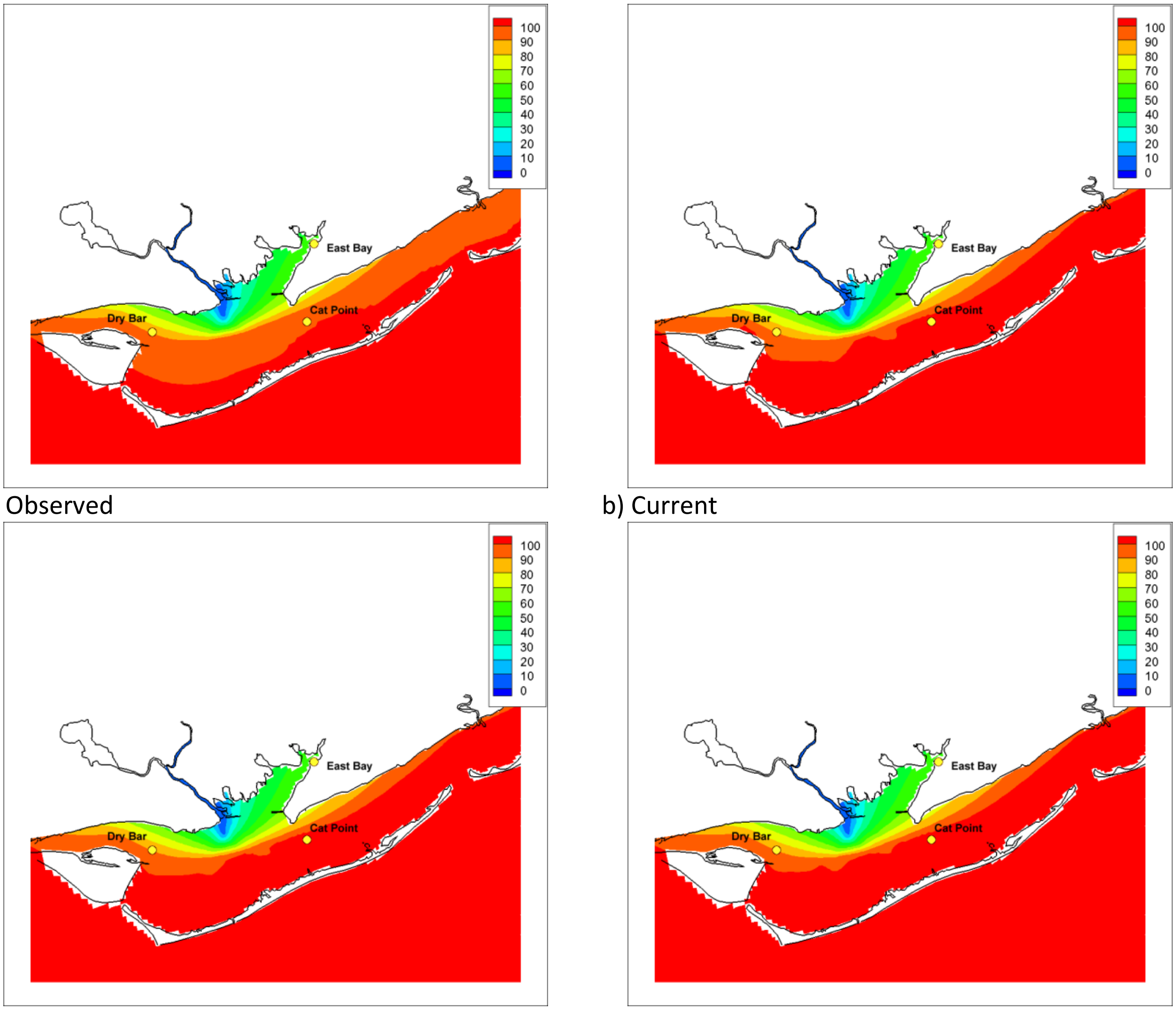


d) Alternative #2

Figure 21. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

Table 7. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	526.64	493.14	463.82	468.01
10-20	794.67	785.25	770.59	775.83
20-30	1045.95	1031.29	1022.92	1019.78
30-40	1460.56	1420.78	1383.09	1387.27
40-50	3085.51	2980.81	2884.48	2911.71
50-60	4935.56	4982.67	4887.40	4918.81
60-70	3075.04	3082.37	3226.85	3204.87
70-80	3390.19	3340.98	3351.45	3348.31
80-90	5305.15	5225.58	5049.68	5062.24



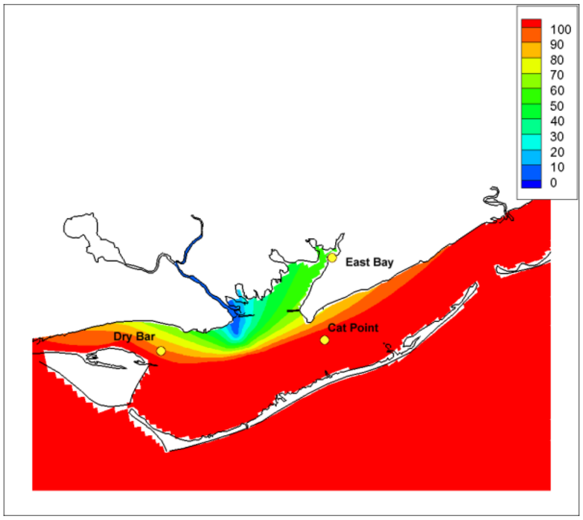
a) Observed b) Current

c) Alternative #1 d) Alternative #2

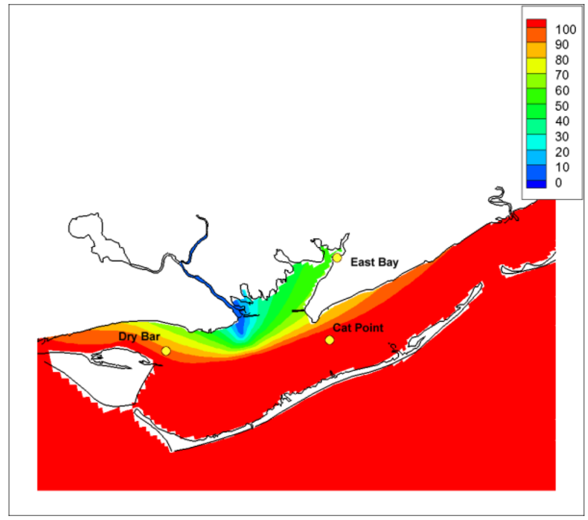
Figure 22. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

Table 8. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

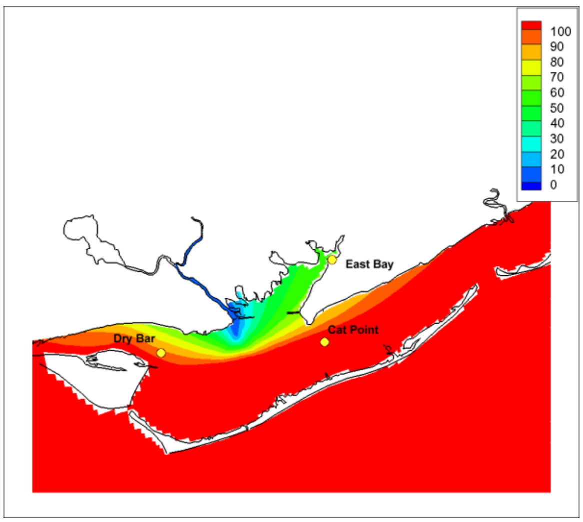
% of days	Observed	Current	Alternative #1	Alternative #2
0-10	571.66	506.75	505.70	488.95
10-20	899.37	885.76	854.35	855.40
20-30	1137.04	1105.63	1119.24	1109.82
30-40	1675.20	1614.47	1606.10	1570.50
40-50	3975.46	3800.61	3743.02	3727.32
50-60	4733.49	4844.47	4885.30	4913.57
60-70	3294.91	3284.44	3265.59	3269.78
70-80	4268.62	4090.63	4029.90	4010.01
80-90	7307.01	6996.05	6997.10	6869.37



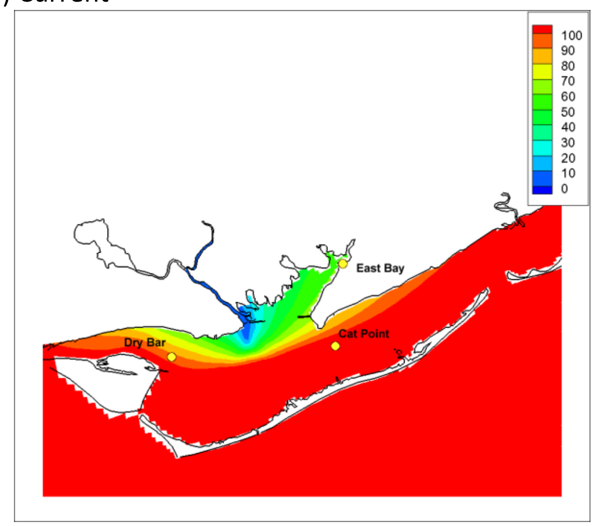
a) Observed



b) Current



c) Alternative #1



d) Alternative #2

Figure 23. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

Table 9. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	531.88	505.70	481.62	468.01
10-20	818.75	793.63	793.63	776.87
20-30	1052.23	1040.72	1040.72	1051.19
30-40	1464.75	1477.32	1454.28	1405.07
40-50	3229.99	3090.74	3046.77	3009.08
50-60	4983.72	4995.24	4995.24	5028.74
60-70	3073.99	3062.47	3107.50	3110.64
70-80	3455.10	3453.01	3418.45	3401.70
80-90	5599.36	5463.25	5407.75	5325.04

References

Chanley, P. E. (1958) "Survival of some juvenile bivalves in water of low salinity," Proc. Natl. Shellfish Assoc., 48, pp. 52-65.

Dame, R. F. (1972) "The ecological energies of growth, respiration and assimilation in the intertidal American Oyster *Crassotrea virginica*," Mar. Biol. (Berl.), 17, pp. 243-250.

Davis, H. C. and Calabrese, A. (1964) "Combined effects of temperature and salinity on development of eggs and growth of larve of *M. Mercenaria* and *C. Virginica*," Fishery Bulletin, 63(3), pp. 643-655.

Doering, P. H. and Oviatt, C. A. (1986) "Application of filtration rate models to field populations of bivalves: an assessment using experimental mesocosms," Marine Ecology - Progress Series, 21, pp. 265-275.

Hayes, P. F. and Menzel, R. W. (1981) "The reproductive cycle of early setting *Crassostrea virginica* (Gmelin) in the northern Gulf of Mexico, and its implications for population recruitment," Biological Bulletin, 160 (1), pp. 80-88.

Hofmann, E. E., Klinck, J. M., Kraeuter, J. N., Powell, E. N., Grizzle, R. E., Buckner, S. C. and Bricelj, V. M. (2006) "A population dynamics model of the hard clam, *Mercenaria Mercenaria*: Development of the age- and length-frequency structure of the population," Shellfish Research, 25(2), pp. 417-444.

Hofmann, E. E., Powell, E. N., Klinck, J. M. and Wilson, E. A. (1992) "Modeling oyster populations. III. Critical feeding periods, growth and reproduction," Journal of Shellfish Research, 11(2), pp. 399-416.

Hofmann, E. E., Klinck, J. M., Powell, E. N., Boyles, S. and Ellis, M. (1994) "Modeling oyster populations. II. Adult size and reproductive effort," Journal of Shellfish Research, 13(1), pp. pp. 165-182.

Huang, W. (2010) "Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science, 86 (2010), pp. 526-534.

Ingle, R. M and Dawson Jr., C. E. (1952) "Growth of the American Oyster *Crassostrea virginica* (Gmelin) in Florida waters," Bulletin of Marine Science, 2(2), pp. 393-404.

Klinck, J. M., Powell, E. N., Hofmann, E. E., Wilson, E. A. and Ray, S. M. (1992) "Modeling oyster populations: the effect of density and food supply on production," Proceedings of the Adv. Mar. Tech. Conf. 5, pp. 85-105.

Klinck, J. M., Hofmann, E. E., Powell, E. N. and Dekshenieks, M. M. (2002) "Impact of channelization on oyster production: a hydrodynamic-oyster population model for Galveston Bay, Texas," Environmental Modeling and Assessment, 7, pp. pp. 273-289.

Powell, E. N., Hofmann, E. E., Klinck, J. M. and Ray, S. M. (1992) "Modeling oyster populations. I. A commentary on filtration rate. Is faster always better?" Shellfish Research, 11(2), pp. 387-398.

Powell, E. N., Klinck, J. M. and Hofmann, E. E. (1996) "Modeling diseased oyster populations. II. Triggering mechanisms for *Perkinsus Marinus* epizootics," Journal of Shellfish Research, 15(1), pp. 141-165.

Powell, E. N., Klinck, J. M., Hofmann, E. E., Wilson-Ormond, E. A. and Ellis, M. S. (1995) "Modeling oyster populations. V. Declining phytoplankton stocks and the population dynamics of American Oyster (*Crassostrea virginica*) populations," Fisheries Research, 24, pp. 199-222.

Sheng, Y. P. (1990) "Evolution of a Three-Dimensional Curvilinear-Grid Hydrodynamic Model for Estuaries, Lakes and Coastal Waters: CH3D," Estuarine and Coastal Modeling, Proc. of Estuarine and Coastal Circulation and Pollution Transport Model Data Comparison Specialty Conference, ASCE, pp. 40-49.

Shumway, S. E. and Koehn, R. E. (1982) "Oxygen consumption in the American oyster *Crassostrea virginica*," Marine Ecology – Progress Series, 9, pp. 59-68.

Soniat, T. M., Powell, E. N., Hofmann, E. E. and Klinck, J. M. (1998) "Understanding the success and failure of oyster populations: the importance of sampled variables and sample timing," Journal of Shellfish Research, 17, pp. 1149-1166.

Soniat, T. M. and Ray, S. M. (1985) "Relationships between possible available food and the composition, condition and reproductive state of oysters from Galveston Bay, Texas," Contrib. Mar. Sci., 28, pp. 109-121.

Soniat, T. M., Ray, S. M. and Jeffrey, L. M. (1984) "Components of the seston and possible available food for oysters in Galveston Bay, Texas," Contrib. Mar. Sci., 27, pp. 127-141.

Thompson, R. J. and Bayne, B. L. (1974) "Some relationships between growth, metabolism and food in the mussel *Mytilus edulis*," Mar. Biol., 27, pp. 317-326.

Wang, H., Huang, W., Harwell, M. A., Edmiston, L., Johnson, E., Hsieh, P., Milla, K., Christensen, J., Stewart, J. and Liu, X. (2008) "Modeling oyster growth rate by coupling oyster population and hydrodynamic models for Apalachicola Bay, Florida, USA," Ecological Modelling, 211, pp. 77-89.

Winter, J. E., Acevedo, M. A. and Navarro, J. M. (1984) "Quempillén estuary, an experimental oyster cultivation station in southern Chile. Energy balance in *Ostrea chilensis*," Marine Ecology – Progress Series, 20, pp. 151-164.

Appendix A. Description of the Oyster Population Model

The time-dependent, post-settlement, oyster population model (e.g. Powell et al. 1992; Hofmann et al. 1992, 1994; Klinck et al. 1992, 2002) is based on the energy flow equation in which net production is calculated from the difference between assimilation and respiration and where the net production is the sum of somatic and reproductive tissue production.

Governing Equations

The governing equation is

$$NP_j = P_{gj} + P_{rj} = A_j - R_j$$

Where *j* is the size class, NP_j is the net production, P_{gj} is the somatic production, P_{rj} is the reproductive tissue production, A_j is the assimilation, and R_j is the respiration. The equation for each oyster class can be written as (Klinck et al. 2002)

$$\frac{dO_j}{dt} = -\alpha_j O_j + \beta_j O_{j+1} - \gamma_j O_j + \delta_j O_{j-1} - loss_j$$

where O_j is the somatic energy present in each class, j, of oysters in units of [cal/m^2]. Total energy is calculated by adding the reproductive portions to the amount calculated by the preceding equation.

Term	Representation
$\frac{dO_j}{dt}$	The time rate of change of O_j
$-\alpha_j O_j$	Loss from O_j to O_{j-1}
$\beta_j O_{j+1}$	Gain to O_j from O_{j+1}
$-\gamma_j O_j$	Loss from O_j to O_{j+1}
$\delta_j O_{j-1}$	Gain to O_j from O_{j-1}
$-loss_j$	Loss from O_j due to mortality, predation, etc.

This equation is then solved using a Crank-Nicholson approach. Assuming $\frac{dO_j}{dt} = F$, then

$$\frac{O_j^{n+1} - O_j^n}{\Delta t} = \frac{1}{2}[F^{n+1} + F^n]$$

where the equations for *F* are defined as

$$F^{n+1} = -\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1} - loss_j^n$$

$$F^n = -\alpha_j O_j^n + \beta_j O_{j+1}^n - \gamma_j O_j^n + \delta_j O_{j-1}^n - loss_j^n$$

Substituting these two equations into the equation for $\frac{O_j^{n+1} - O_j^n}{\Delta t}$ and rearranging terms such that the *n+1* terms are on the left and the *n* terms are on the right and multiplying by Δt yields

$$O_j^{n+1} - \frac{\Delta t}{2}\left[-\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1}\right]$$
$$= O_j^n + \frac{\Delta t}{2}\left[-\alpha_j O_j^n + \beta_j O_{j+1}^n - \gamma_j O_j^n + \delta_j O_{j-1}^n\right] - \Delta t * loss_j^n$$

which then can be rewritten as

$$O_j^{n+1}\left[1 + \frac{\Delta t}{2}\alpha_j + \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^{n+1}\left[-\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^{n+1}\left[-\frac{\Delta t}{2}\beta_j\right]$$
$$= O_j^n\left[1 - \frac{\Delta t}{2}\alpha_j - \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^n\left[\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^n\left[\frac{\Delta t}{2}\beta_j\right] - \Delta t * loss_j^n$$

where the transfer and loss rates are defined as

$$\alpha_j = \frac{w_j}{w_{j-1}}\frac{w_j}{w_j - w_{j-1}}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} < 0$$
$$\alpha_j = 0 \quad \text{for } NP_j^{n+1} \geq 0$$

$$\gamma_j = \frac{w_j}{w_{j+1}}\frac{w_j}{w_{j+1} - w_j}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} > 0$$
$$\gamma_j = 0 \quad \text{for } NP_j^{n+1} \leq 0$$

$$\beta_j = \frac{w_{j+1}}{w_j}\frac{w_j}{w_{j+1} - w_j}\left|NP_{j+1}^{n+1}\right| \quad \text{for } NP_{j+1}^{n+1} < 0$$
$$\beta_j = 0 \quad \text{for } NP_{j+1}^{n+1} \geq 0$$

$$\delta_j = \frac{w_{j-1}}{w_j}\frac{w_j}{w_j - w_{j-1}}\left|NP_{j-1}^{n+1}\right| \quad \text{for } NP_{j-1}^{n+1} > 0$$
$$\delta_j = 0 \quad \text{for } NP_{j-1}^{n+1} \leq 0$$

$$-\Delta t * loss_j^n = -\Delta t * MortalityRate * O_j^n$$

Assimilation Term

Size and Temperature

$$FR_j = \frac{L_j^{0.96} T^{0.95}}{2.95}$$

$$L_j = W_j^{0.317} 10^{0.669}$$

Where FR_j is the filtration rate (ml filtered per individual per min); L_j is the length in cm (Doering and Oviatt 1986), obtained from W_j, the ash-free dry weight (g); and T is the temperature in Celsius.

Salinity

$$FR_{sj} = \begin{cases} FR_j & S \geq 7.5 \text{ ppt} \\ \dfrac{FR_j(S-3.5)}{4} \quad \text{when} & 3.5 \text{ ppt} < S < 7.5 \text{ ppt} \\ 0 & S \leq 3.5 \text{ ppt} \end{cases}$$

where S is the ambient salinity in ppt.

Turbidity

$$FR_{\tau j} = FR_{sj}(1 - 0.01x)$$

where x is the percent reduction in filtration rate. The equation for total particulate content, τ, (inorganic + organic) (g/L) can be written as

$$\tau = (4.17 * 10^{-4}) * 10^{0.0418x}$$

This equation was printed incorrectly in several papers, e.g. Hofmann et al. (1992) and Powell et al. (1992), but later corrected in Powell et al. (1995). This equation can then be rewritten in terms of filtration rate as

$$x = \frac{\log_{10}\tau + 3.38}{0.0418}$$

Finally, the equation for filtration rate can then be rewritten as

$$FR_{\tau j} = FR_{sj}\left[1 - 0.01\left(\frac{\log_{10}\tau + 3.38}{0.0418}\right)\right]$$

This equation was written incorrectly in several papers, e.g. Powell et al. (1992) and Powell et al. (1996), but correct in Powell et al. (1995).

Ingestion

$$I_j = f * FR_{\tau j}$$

where f is the measured food value (mg/L) and I_j is the ingestion.

Assimilation

$$A_j = I_j * A_{eff}$$

where the assimilation efficiency, A_{eff}, is defined as 0.75 (Powell et al. 1992).

Respiration Term

Temperature and Weight

Respiration as a function of temperature and weight was obtained from Powell et al. (1992) via Dame (1972) as

$$R_{TW} = (69.7 + 12.6 * T)W_j^{b-1} \quad \text{where } b = 0.75$$

where R is defined in units of µL O_2 consumed per hr per g dry weight (Powell et al. 1992). These units are converted to calories using the relation 1 mL O_2=4.75 cal used by Winter et al. (1984) via Thompson and Bayne (1974).

Salinity

Salinity's effect on oyster respiration were parameterized using the Powell et al. (1992) formulation which used data provided in Shumway and Koehn (1982) as

$$R_r = \begin{cases} 0.007 * T + 2.099 & \text{when } T < 20\ ^\circ C \\ 0.0915 * T + 1.324 & T \geq 20\ ^\circ C \end{cases}$$

where R_r is the ratio of respiration at 10 ppt to respiration at 20 ppt.

$$R_r = \frac{R_{10\text{ ppt}}}{R_{20\text{ ppt}}}$$

Respiration

$$R_j = \begin{cases} R_{TW} & \text{S} \geq 15\text{ ppt} \\ R_{TW}\left(1 + \left[\dfrac{(15 - S) * (R_r - 1)}{5}\right]\right) \quad \text{when} & 10\text{ ppt} < S < 15\text{ ppt} \\ R_{TW}R_r & S \leq 10\text{ ppt} \end{cases}$$

Per Powell et al. (1992), Shumway and Koehn (1982) identified salinity's effect on respiration at 20 ppt; however, a 15 ppt cutoff is used to conform to Chanley's (1958) growth observations.

Reproduction

For adult oysters (e.g. those considered adult or marketable but not those considered spat or juvenile), net production is apportioned into growth and reproduction by using the following formulation

$$P_{rj} = R_{eff} * NP_j$$

where P_{rj} is the portion of new production in reproduction, R_{eff} is the temperature dependent reproductive efficiency defined as (Hofmann et al. 2006)

$$R_{eff} = R_1 * T - R_0$$

where R_1 and R_0 are constants. This equation is written incorrectly (temperature dependence is missing) in Powell et al. (1992). In general, the maximum value of R_{eff} is limited to some value R_{max} such that this equation can be rewritten as

$$R_{eff} = \min(R_1 * T - R_0,\ R_{max})$$

and min() represents the minimum value function.

Based on observations by Soniat and Ray (1985), the R_1 and R_0 constants have a seasonal component such that (Hofmann et al. 1992)

$$\begin{aligned} R_1 &= 0.054 \text{ and } R_0 = 0.729 \quad \text{for} \quad \text{January} - \text{June} \\ R_1 &= 0.047 \text{ and } R_0 = 0.809 \quad \quad \quad \text{July} - \text{December} \end{aligned}$$

These constants are defined correctly in Hofmann et al. (1992), Powell et al. (1992) and Powell et al. (1996) but incorrectly in Powell et al. (1995) and Wang et al. (2008) (R_1 was defined as 0.0047 instead of 0.047 for the July-December period).

Spawning

Following Wang et al. (2008), spawning occurs when the cumulative reproductive biomass (R_{total}) exceeds 20% of the total biomass and the temperature is greater than or equal to 25 degrees C (Ingle and Dawson 1952; Hayes and Menzel 1981). Once spawning occurs, reproductive biomass was divided into male (R_m) and female (R_f) biomass. The ratio of females to males (f_{ratio}) is calculated using

$$f_{ratio} = 0.021L_b - 0.62$$

where L_b is the shell length in mm. Then, the female portion of reproductive biomass can be calculated by combining the following two equations

$$f_{ratio} = \frac{R_f}{R_m}$$

$$R_{total} = R_f + R_m$$

to yield

$$R_f = \left(\frac{R_{total}}{1 + \frac{1}{f_{ratio}}} \right)$$

Then, the female portion of biomass can be converted into eggs spawned by

$$\text{Number of Eggs Spawned} = \left[R_f \left(\frac{6100 \text{ calories}}{\text{g dry weight}} \right)_{\text{oysters}} \right] \left(\frac{\text{g dry weight}}{6133 \text{ calories}} \right)_{\text{oyster eggs}} \left(\frac{1}{W_{\text{egg}}} \right)$$

where the term within the square brackets on the right hand side represents the female biomass converted to calories and the weight on an egg, W_{egg}, is 13 ng per egg (Powell et al. 1992 p. 393). Wang et al. (2008) and others (e.g. Powell et al. 1995, 1996) define the weight of an egg as

$$W_{\text{egg}} = 2.14 * 10^{-14} * V_{\text{egg}}$$

where V_{egg} is the oyster egg volume in (μm^3).

Larval Recruitment

Following Wang et al. (2008), larval life span was set to 15 days (Ingle and Dawson 1952), and larval to spat survival was set at $1/10^8$ (Powell et al. 1996)

$$\text{Number of New Spat per Spawn} = \frac{1}{10^8} * \text{Number of Larvae Recruited per Spawn}$$

It is not clear how larval life span is to be applied.

Mortality

Lavae

$$\text{Number of Larvae Recruited per Spawn} = s * \text{Number of Eggs Spawned}$$

where s, the survival rate per spawn is defined as (Davis and Calabrese 1964)

$$s = \begin{cases} 0.7 & for \quad 27.5\ ^{\circ}C \leq T \leq 32.5\ ^{\circ}C \text{ and } 10\ ppt \leq S \leq 27.5\ ppt \\ 0 & \text{otherwise} \end{cases}$$

The variable, s, is defined incorrectly in Wang et al. (2008) as mortality rate.

Post-settlement Population

Mortality of the post-settlement population follows the formulation of Wang et al. (2008)

$$\text{Number dying per time} = k_d(\text{number of living})$$

$$k_d = \begin{cases} 0 & \text{if} \quad \text{Winter or Spring (Sep} - \text{Apr)} \\ \text{Constant} & \text{otherwise} \end{cases}$$

where k_d is the daily mortality rate. However, because low salinity is a major cause of catastrophic mortality, the equation of daily mortality rate is modified as follows

$$k_d = (\alpha_1 S + \beta_1)T + (\alpha_2 S + \beta_2) \quad \text{if} \quad S < 6 \text{ ppt}$$

where α_1=-0.000348, β_1=0.01764, α_2=0.00232, and β_2=-0.3089 (Powell et al. 1996). α_1 is defined incorrectly in Wang et al. (2008) as -0.00034.

Growth Rate Formulation

$$(\text{Oyster Growth Rate})_j = (NP_{somatic})_j * W_j * \frac{1000 \text{ mg}}{\text{g}} * \frac{86400 \text{ s}}{\text{day}} \qquad \left[\frac{\text{mg AFDW}}{\text{oyster} * \text{day}}\right]$$

where Net Production is provided in units of [1/s] and W is the average oyster weight in units of [g AFDW/oyster]

Specific Relations for Apalachicola Bay Model

Size Classes

Characteristics of the size classes were based on Wang et al. (2008). Average length was from field measurement, while average biomass was determined from the following length-weight relationships:

$$\ln(Biomass) = C_1 * \ln(Length) + C_2$$

which can be solved for biomass as

$$Biomass = (Length)^{C_1} * e^{C_2}$$

where

Site	C_1	C_2	R^2
Cat Point	2.505	-10.980	0.83
Dry Bar	2.202	-9.125	0.90

Site	1 (Spat)	2 (Juvenile)	3 (Adult)	4 (Marketable)
Cat Point				
Initial Count	0	26	22	21
Average Length (mm)	12	36	66	85
Average Biomass (g AFDW)	0.0086	0.1349	0.6157	1.1605
Dry Bar				
Initial Count	0	26	22	21
Average Length (mm)	12	39	66	96
Average Biomass (g AFDW)	0.0259	0.3472	1.1059	2.5236

Total Particulate Content<>Turbidity

Based on a water quality analysis of storm-water inputs into Apalachicola Bay, Wang et al. (2008) defined the relation between total particulate content and turbidity as

$$\tau = 1.4593 * \text{Turbidity} + 0.904$$

where total particulate content, τ, is in units of mg/L and Turbidity is in NTU.

Food<>Chlorophyll-a

Following Wang et al. (2008), Chlorophyll-a was used as an index of available food following the formulas presented in (Soniat et al. 1984, 1998)

$$\text{Food} = 1.4593 * \text{Chlorophyll} - \text{a} + 0.520$$

where Food, is in units of mg dry weight/L (Soniat et al. 1998) and Chlorophyll-a is in units of μg/L (Soniat et al. 1998). The units of food are converted into calories using the caloric conversion of 5168 cal per g dry weight (Wang et al. 2008).

Reproduction

The maximum reproductive efficiency, R_{max}, was set to 0.8 (Wang et al. 2008). Furthermore, following the assumptions of Wang et al. (2008), when *NP* < 0, reproduction was assumed to be zero or there was no resorption of gonadal tissue.

Post-Settlement Mortality

For periods when salinity is greater than 6 ppt, the daily mortality rate, k_d, was defined as (Wang et al. 2008)

Site	Reference Year	High-Salinity Year	Low-Salinity Year
Cat Point	0.00020	0.00061	0.00014
Dry Bar	0.00079	0.00122	0.00038

Average/Reference Year Simulations

Using the average year data shown in Figure 3 of Wang et al. (2008), the average year was simulated and then compared to the reference year lines for marketable oysters of Figure 6 of Wang et al. (2008).

Cat Point

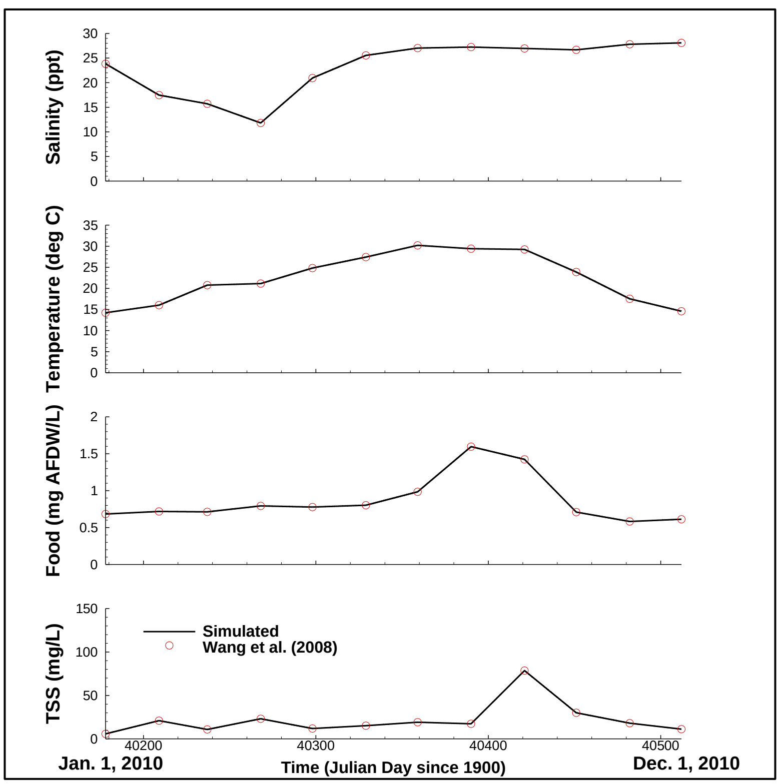


Figure 24. Forcing functions for the Cat Point reference year simulation

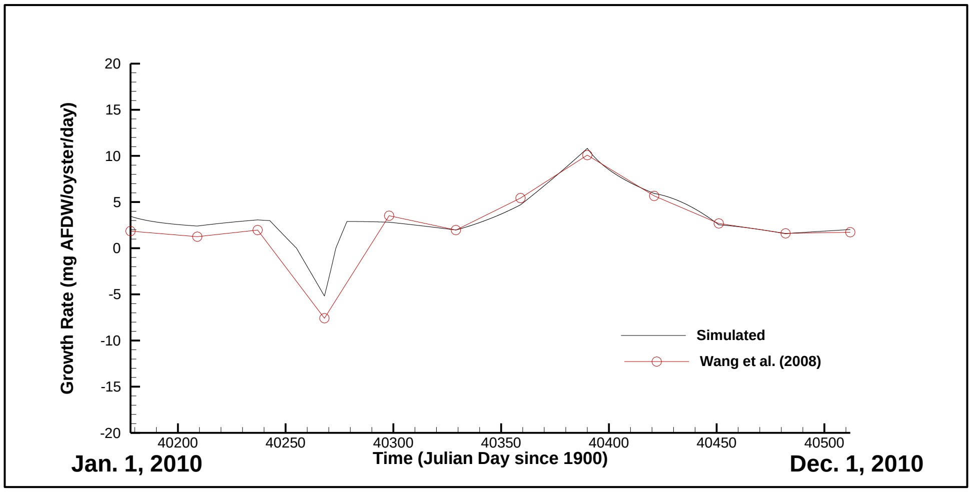


Figure 25. A comparison between the marketable oyster growth rate at Cat Point during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Dry Bar

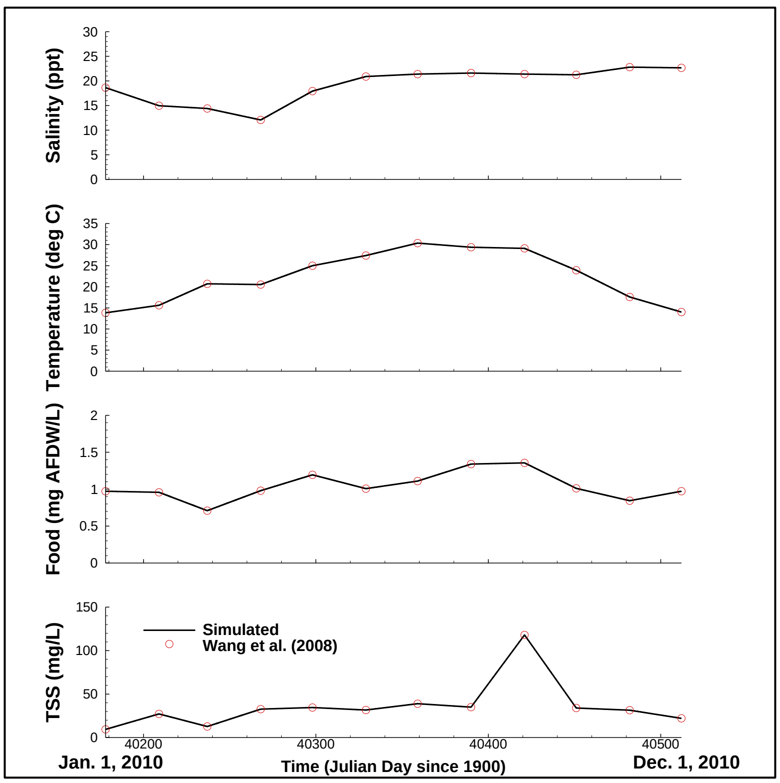


Figure 26. Forcing functions for the Dry Bar reference year simulation

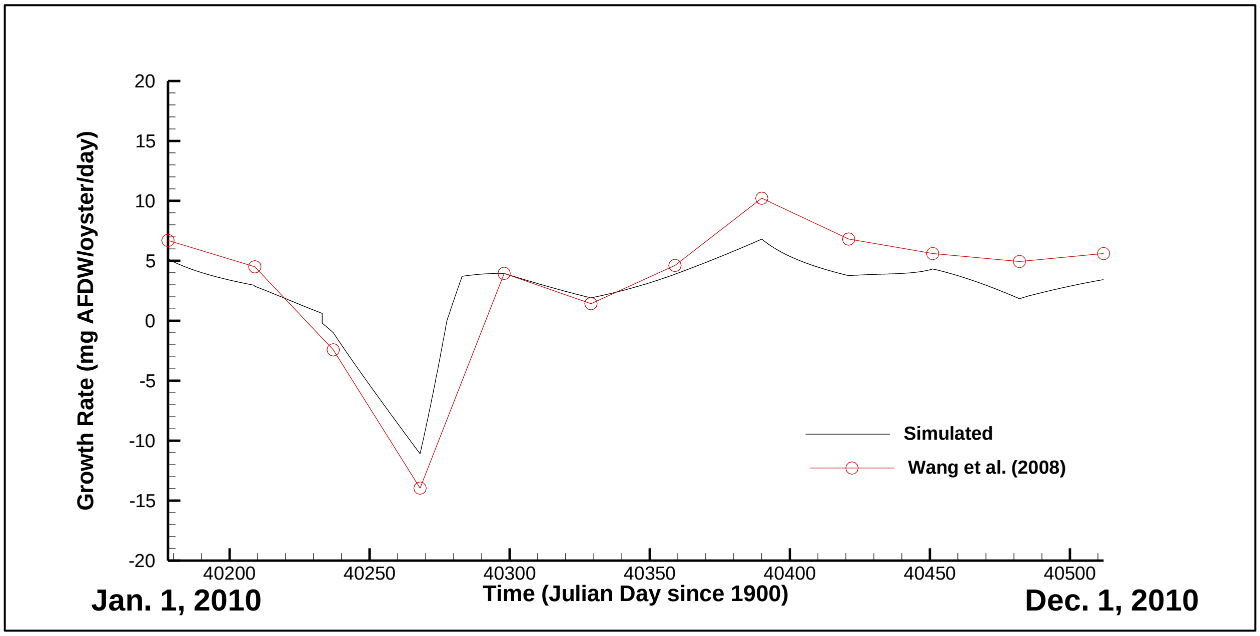


Figure 27. A comparison between the marketable oyster growth rate at Dry Bar during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Mar 2004 – June 2005 Cat Point Simulation

Using data obtained for the period of Mar. 2004 to June 2005, growth rate at Cat Point was simulated and compared to the total growth rate values shown in Figure 5a of Wang et al. (2008). Two sets of simulations were performed, one with the original observed salinity/temperature data and the second with daily averaged data.

Observed Salinity/Temperature

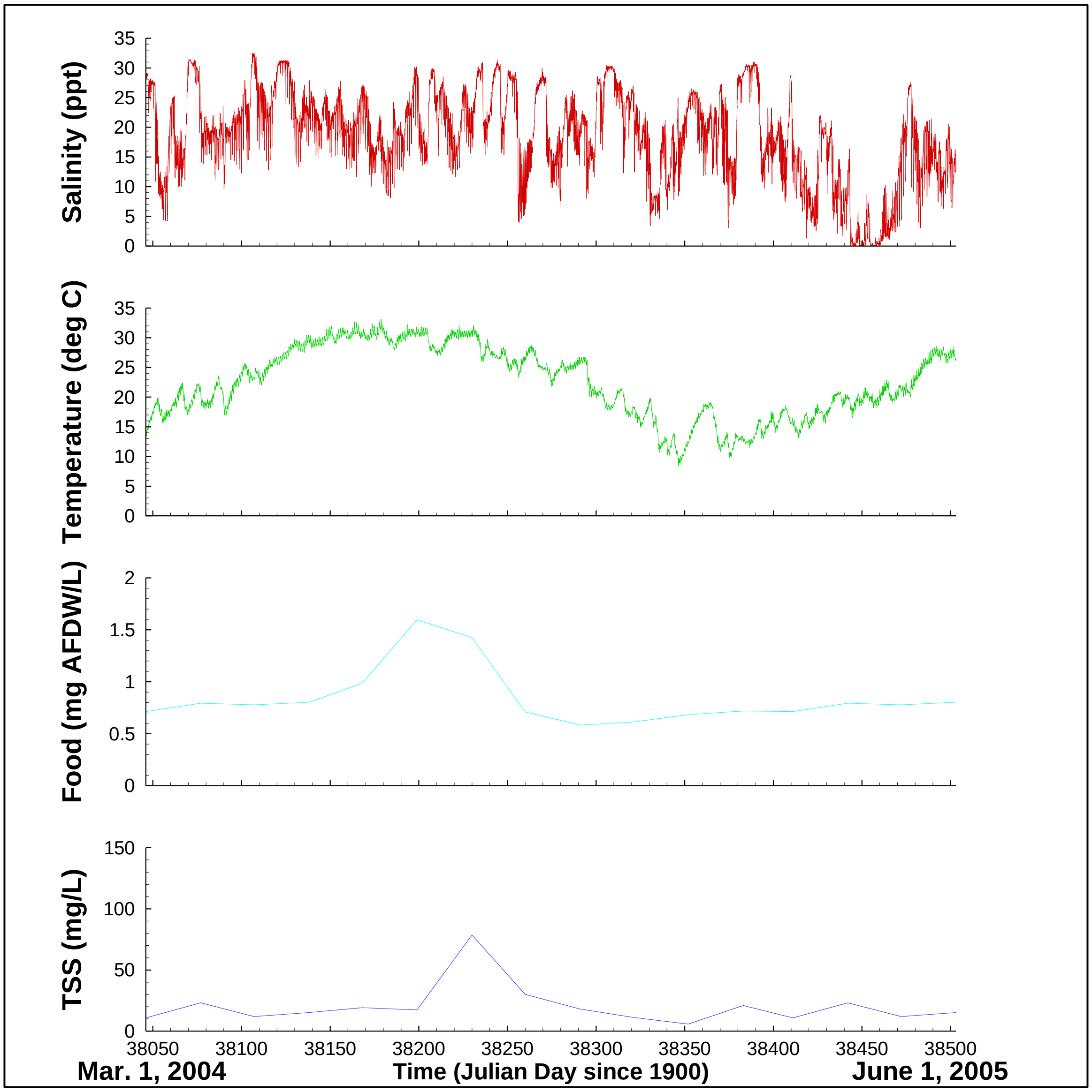


Figure 28. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the observed salinity/temperature data

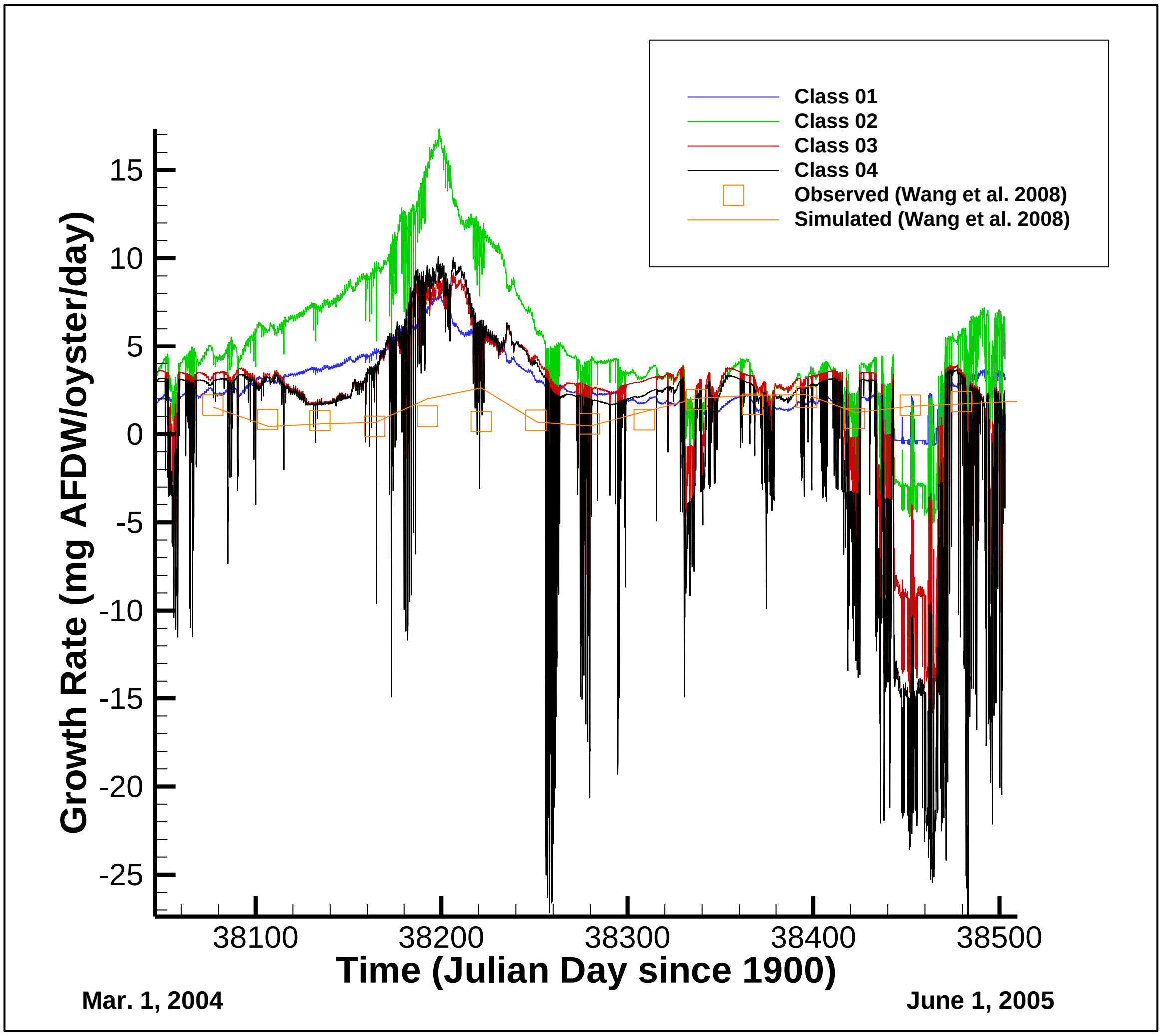


Figure 29. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the observed salinity/temperature data

Daily Averaged Salinity/Temperature Data

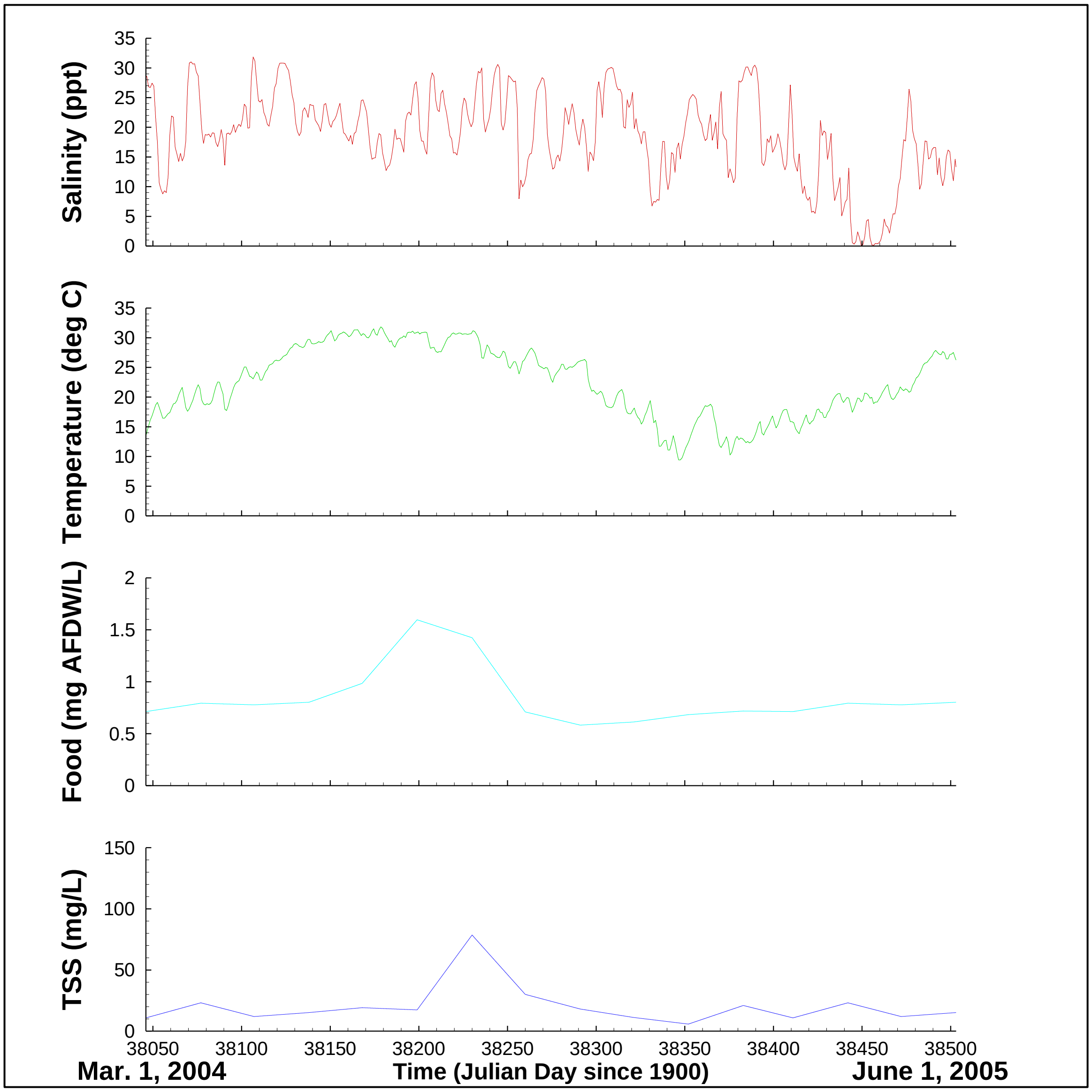


Figure 30. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the daily averaged salinity/temperature data

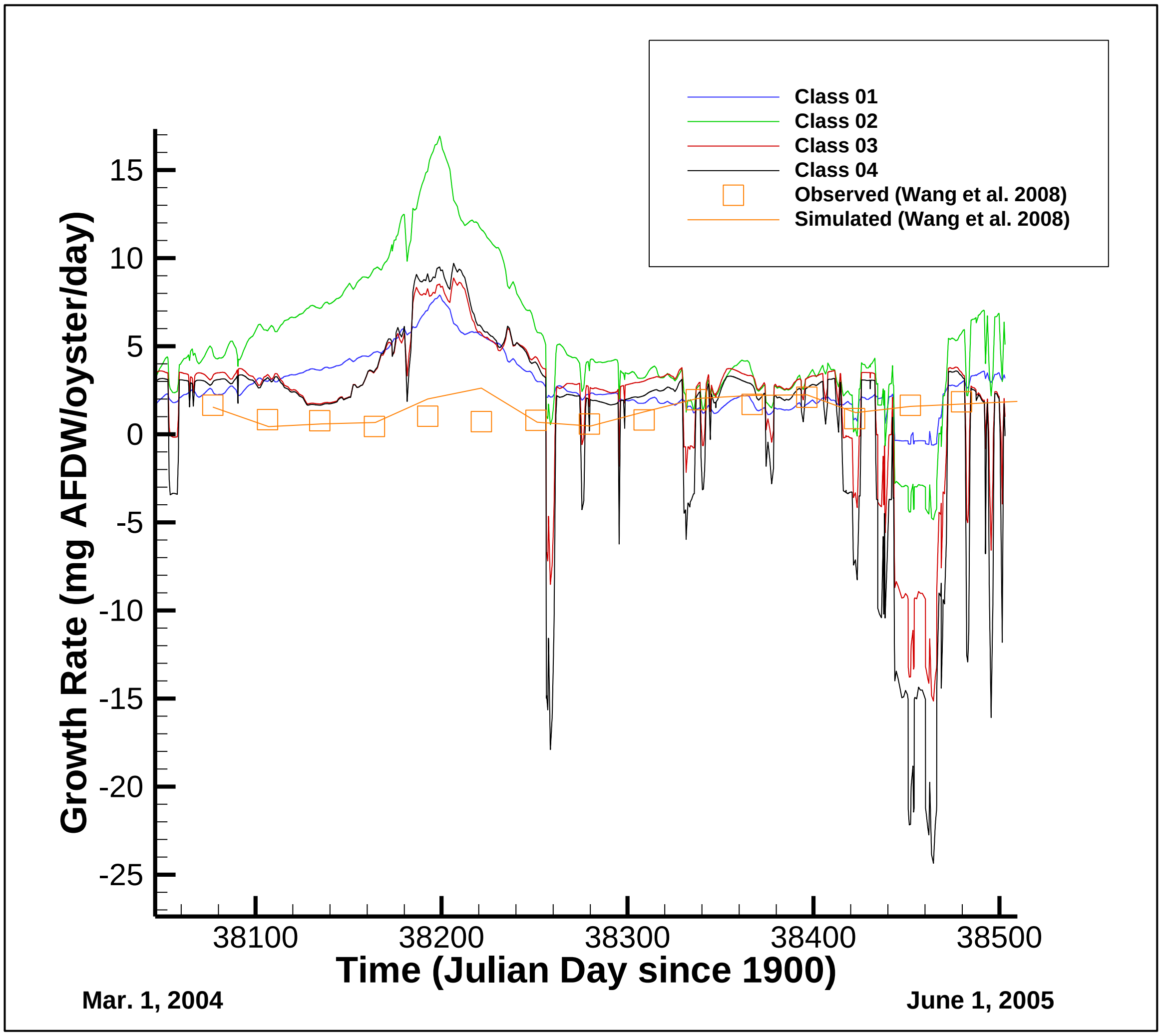


Figure 31. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the daily averaged salinity/temperature data

Appendix B. FWS Requested Results

The following revised list of requested results was email by Karen Herrington to Y. Peter Sheng on April 5, 2011. Items A1, B1, B2 and B4 were eliminated from an earlier larger list of requested results.

A. Oysters:

1.
2. Probability of exceedence at Cat Point and Dry Bar station for all 4 scenarios
3. Summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
4. Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
5. August (generally peak growth rates) summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
6. August Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
7. Salinity contour map for the total number of days salinity exceeds 26 ppt in the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2002 (based on ranked mean annual discharge)
    - Wet year = 2005
    - Average year = 2001

B. Sturgeon:

1.
2.
3. Salinity contour map for the total number of days salinity exceeds 10 ppt from 1 October- 31 March for the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2001 (based on ranked mean Oct-March discharge)
    - Wet year = 2009
    - Average year = 2004
4.

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4980 Wildlife Dr.
Townsend, Georgia 31331

March 12, 2015

Dear Mr. Sumner,

Thank you for your response to our Planning Aid Letter (PAL). We have reviewed the information provided to us in the Apalachicola-Chattahoochee-Flint Water Control Manual (WCM) Update Response to Planning Aid Letter received on January 30, 2015. The review and exchange of information between the United States Army Corps of Engineers (Corps) and the United States Fish and Wildlife Service (USFWS) is a continuation of coordination under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). This coordination will facilitate your National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 *et seq.*) analysis of the project.

Subsection 2(a) of the FWCA provides that the Federal agency constructing, permitting, or licensing a water resource development project "shall first consult" with the USFWS, with the principal procedural element to include the opportunity for continuing participation in planning that begins at the early stages such as at the reconnaissance stage. So that the Corps might give equal consideration to fish and wildlife, we recommended an alternative that would avoid and minimize adverse effects to fish and wildlife, and in some cases, enhance conditions for fish and wildlife affected by project operations. Your response indicated that you considered the alternative, but dismissed it in favor of the Proposed Action Alternative (PAA) that you will carry forward in your analysis to support a decision for a revised WCM.

The reasons for your dismissal of the PAL alternative and other alternatives are not clear; therefore, it is not evident whether the fish and wildlife benefits associated with our recommendations received the equal consideration mandated under Section 2 of the FWCA. Further, action agencies are required under NEPA regulations at 40 CFR 1502.14 to "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated." We are not aware of the process that the Corps has applied in dismissing or selecting alternatives, or will apply in making the final decision.

We request the following information to assist in our evaluation and report development, facilitate coordination with the States, and help ensure that the intent of the FWCA and NEPA is achieved:

1. Quantitative and operational measures (feature or activity) that defined each of the eight alternatives considered by the Corps, including reservoir drawdown and refill periods, action zone elevations, reservoir balancing methods, hydropower generation, drought operations, navigation, and environmental flow releases. The criteria used to compare and rank the alternatives will also assist our review.

2. Modeling parameters used to reproduce the USFWS alternative in Hydrologic Engineering Center-ResSim (ResSim), including a list of any changes made to the alternative since it was delivered to you and the rationale for such changes. Please also provide the water quality and hydrological model output for the USFWS alternative for all nodes in the Apalachicola, Chattahoochee, and Flint rivers.

3. DSS file(s) that includes the ResSim output for each node for each of the eight alternatives considered, including reservoir elevations, flows, and water quality.

4. Quantitative relationships among hydrology, temperature, and dissolved oxygen that were used to produce the dissolved oxygen and temperature graphs.

5. Modeled dissolved oxygen and temperature data for all Chattahoochee River nodes for all alternatives.

6. High flow guidelines for the PAA and No Action Alternative (NAA), or the data necessary for USFWS to produce them.

7. Clarification of the demands data that were used for Phase 1 and Phase 2 of your analysis. Please provide your analysis of demands scenarios that were considered.

8. Composite zones for the NAA and the other alternatives considered. Please confirm the method used to compute composite zones.

9. Estimates showing percent of days in Zones 1-4 and the drought zone for each alternative. Please include a table or graph showing the number of days required to transition from drought operations to Zone 1 for each alternative. Alternatively, you may provide USFWS with the requisite data and we will compute the statistics.

10. A description of how navigation was incorporated into ResSim. For example, was it a continuous navigation period for a period of 4-5 months, or several three-week periods

nested within the 4-5 month period? Please provide the discharge and duration values that were used, and clarify whether May was included in the modeling.

11. The analysis used to define action zone elevations.

We expect that many of the information needs that we identified are already available as DSS files, a format that should be efficient to transfer to us and that we are prepared to use. Additional information and data requests may be made in the future as part of the ongoing coordination with the States and the Corps. Please contact Will Duncan or Alice Lawrence at 706-613-9493, or Grant Webber at 850-769-0552 should you have questions regarding the requested information.

Sincerely,

Donald Imm

Comparison of ACOE Baseline HEC Res-Sim output and observed data for a comparable period

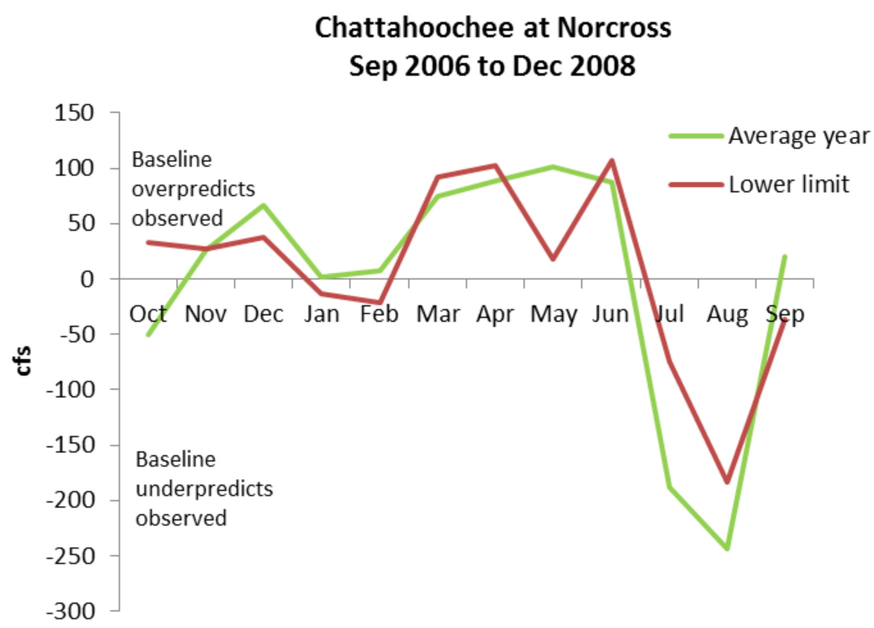
Based on the Corps' response to the Planning Aid Letter, the baseline model output from HEC Res-Sim represents current operations following implementation of the RIOP (post September 2006). Therefore, there should be good general agreement between baseline conditions and observed conditions since September 2006. In instances where the modeled data are statistically different from observed data (ie. black boxes in table below), users of the Res-Sim output should be cautious regarding comparisons and recommendations based on that aspect of the data. In instances where statistical significance was not detected (white boxes in table), there is support for using that aspect of the data for comparison of flow alternatives to the baseline model output.

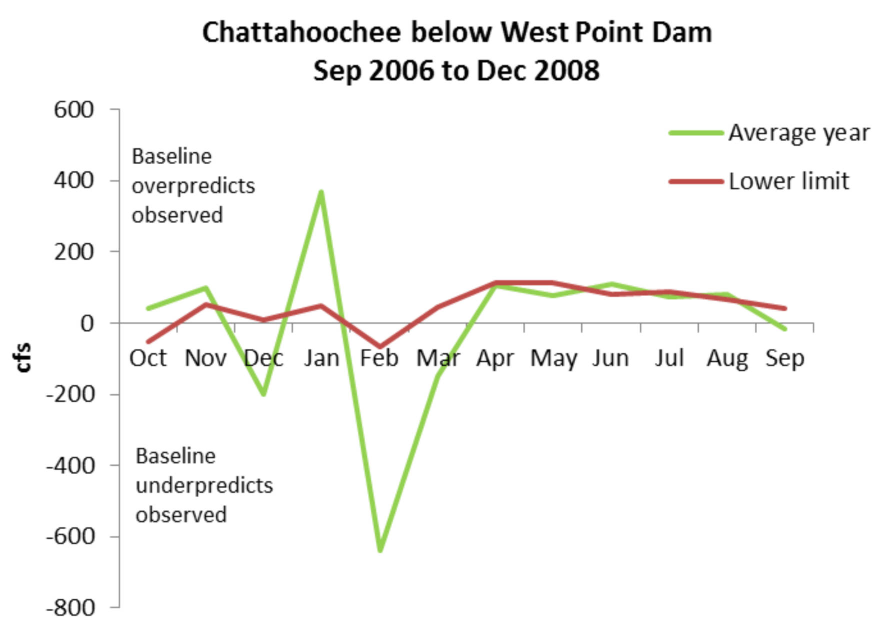
	Pulse Magnitude (cfs)	Pulse Duration (days)	Pulse Rise Rate (cfs/day)	Pulse Fall Rate (cfs/day)	Pulse Frequency (#/month)	Reversals (#/month)
Chattahoochee at Norcross	9*	2	-97	-108	-1.35	-2.6
Chattahoochee at West Point	-984*	2*	-483	-93	-0.18	-2.1
Apalachicola at Chattahoochee	-2791	7.7*	-1454*	-924*	-0.33	-4.7

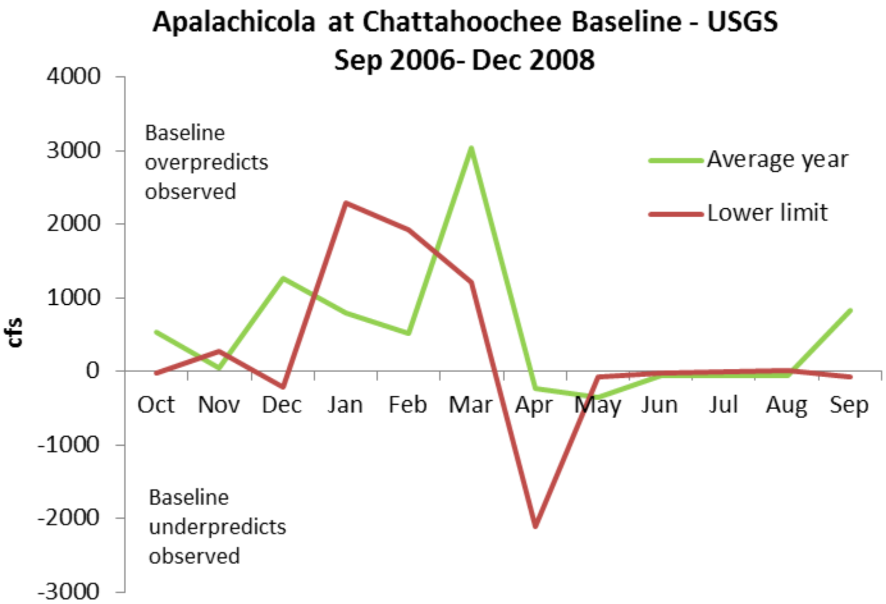
Statistics and nuances of the table: Tests of statistical differences between the ACOE modeled baseline scenario and observed discharge in the Chattahoochee and Apalachicola rivers are provided in the table. Black boxes depict statistical differences. For the purposes of this analysis, we assumed that pulses were independent of one another. Two-tailed t-tests were used to test for statistical significance, except paired t-tests were used for monthly pulse frequency and reversals. P-values < 0.05 were used as thresholds for statistical significance. Pooled variances were used except in instances when the Satterthwaite method was used for unequal variances (*). Numbers in the table are the mean baseline value minus the mean observed value.

In this analysis (Table above), pulses were defined as any pulse or flood greater than the 75th percentile of the modeled baseline scenario. Analysis period included Sep 01, 2006 to Dec 31, 2008, the period for which the baseline scenario (presumably reflective of current operations) was implemented and for which observed data can be compared.

Figures: Using the same period of record for modeled baseline and observed discharge, the low flow analysis was conducted using the 7 lowest flows observed for every month of every year. The lines on the graph are the differences between the baseline and the observed USGS data for the 50^{th} percentile (average year) and 10^{th} percentile (lower limit). Values less than 0 indicate that the baseline modeled discharge underpredicted observed discharge, and values greater than 0 indicate the converse. Beyond the graphical comparison, no statistics were calculated for low flows.


Chattahoochee at Norcross
Sep 2006 to Dec 2008
150
100
50
0
-50
-100
-150
-200
-250
-300
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Average year
Lower limit


Chattahoochee below West Point Dam
Sep 2006 to Dec 2008
600
400
200
0
-200
-400
-600
-800
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Average year
Lower limit



Apalachicola at Chattahoochee Baseline - USGS
Sep 2006- Dec 2008
4000
3000
2000
1000
0
-1000
-2000
-3000
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Average year
Lower limit

Problems regarding United States Army Corps of Engineers (Corps) alternatives selection process for the Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) update

July 31, 2015

The United States Fish and Wildlife Service (Service) has reviewed the methodology that the United States Army Corps of Engineers (Corps) used to select an alternative during Phase 1 of their analysis for the Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) update process. We support the Corps in their efforts to devise a transparent methodology, and their attempt to objectively select alternatives for analysis. Furthermore, the Service considers the Corps' effort to further refine their quantitative and transparent means of decision making a substantial improvement upon previous WCM updates. In our opinion, we have identified several problems with the Corps' methodology that render conclusions concerning the selection of an alternative for the Draft Environmental Impact Statement (DEIS) under this methodology questionable. Using the selection methodology provided to the Service means that the alternative selected by the Corps for consideration in the DEIS does not appear to accurately represent multiple project purposes, and does not appear to give fish and wildlife equal consideration because of the computational issues described below.[1]

The Service collaboratively discussed these findings and our conclusions during a conference call with the Corps on June 1, 2015 and our staff expressed an interest in "working with the Corps to identify errors and develop appropriate and transparent strategies for alternative selection" (Appendix A). The Service raised our concerns again on June 30, 2015. The Service's interpretation from the June 30, 2015, call is that the Corps is unable to make the necessary changes to the alternative selection methodology in advance of the forthcoming DEIS because:

1) The Corps acknowledged the Service's concerns, but stated that their ranking and evaluation methodology was chosen for its simplistic and transparent properties that they consider to be adequate for their selection process.
2) The time needed to make such changes would be much greater than the Service anticipates and would delay the process for adopting the ACF WCM;
3) The proposed action alternative (PAA) had been sent up the chain for review and approval; and

During our conference calls with the Corps, Service staff were told that the approach to selecting alternatives could not be changed at this time because this would result in considerable additional work if the selected alternative changes. While study schedule constraints have precluded completion of the many known planning and impact evaluation deficiencies; some of those errors and issues are likely of a lesser magnitude than those resulting from the potentially significant problems associated with plan selection methodology.

The FWCA is one of the major pieces of legislation aimed at ensuring that fish and wildlife resource issues, concerns, and opportunities are brought to the attention of decision makers and given *equal consideration in project planning*. The Service delivered scoping comments that included a management alternative for consideration, a revised alternative, and a Planning Aid Letter (PAL) to facilitate the Corps' development and evaluation of alternatives, collectively demonstrating the Service's involvement at multiple stages of the WCM update. However, had the Service had a greater role in the alternative formulation and evaluation process, including designing the criteria for selecting alternatives, our concerns with the process may have been resolved. Under the current timeline, the Corps is scheduled to release the DEIS based on a methodology that ultimately may have led to the possible incorrect selection of a PAA. The following summary of problems is not comprehensive, but serves to illustrate the severity of our concerns.

We recommend that the Corps work with the Service under the authorities of the FWCA to revise and improve the alternative selection methodology. It is the Service's understanding that this cannot be accomplished in advance of the forthcoming DEIS release. Therefore, we recommend that the Service and Corps work to improve the alternative selection methodology in advance of and future updates to the WCM. It is vital that the approach used in selecting alternatives be able to withstand inevitable scrutiny, given the long-term disputes over the management of the ACF basins' water resources. We strongly believe that it is important to undertake plan selection based on sound science and plan formulation principles.

Corps' ranking approach

The Service has three major concerns with the Corps' approach used in ranking and selecting alternatives:

- The current ranking approach obscures the actual range of differences between alternatives. Small differences within project purposes are treated the same as large differences when comparing alternatives.
- An incomplete set of fish and wildlife performance measures was used to score and then rank alternatives for the Fish and Wildlife project purpose. Based on the information provided to us, the set of fish and wildlife performance measures used by the Corps in the ranking do not fully capture the relationship between water management alternatives and their effect on fish and wildlife resources.
- There is no consideration regarding the uncertainty or precision of model output in the Corps' ranking process. When uncertainty and precision are considered, managers can robustly evaluate similarities and differences between alternatives.[2]

The details of these concerns are discussed below:

1) The Corps' approach to alternative selection involved the following basic steps. Modeled flow data from the Corps' HEC-ResSim model runs were used to calculate metrics related to each project purpose (i.e. water supply, recreation, hydropower, navigation, and fish and wildlife). Because metrics for each of these had different units of measurement [e.g., days versus megawatt hours (MWh)], the Corps then ranked each of the metrics on a scale of 1 to 7, with 7 being the worst. In statistical terms, the Corps converted the information-rich *ratio* data (e.g., days and MWh) to information-poor *ordinal* data (a 1-7 ranking). Rankings for each project purpose were summed, and the alternative with the smallest sum was selected as the best alternative. Ranking the data without regard to the numerical differences between alternatives fundamentally means that a) small differences within a project purpose are the same as large differences, b) a great amount of weight may be placed on inconsequential differences, and c) project purposes do not appear accurately represented when equal weight is given toward inconsequential and consequential differences among alternatives within a project purpose.

We illustrate this problem using two examples. Annual weekday hydropower and annual hydropower totals were used by the Corps to rank the seven alternatives for the hydropower project purpose (Table 1). For all alternatives considered, annual hydropower generation differs from the No Action Alternative (NAA) by less than 0.25%, and weekday hydropower by less than 1.30%. This illustrates that hydropower production for most of the alternatives is essentially the same, yet a < 1% difference results in Alternative 4 receiving a 7 and the NAA a 1. The Service questions whether the underlying data used to estimate hydropower production is so precise that these small differences in hydropower production are meaningful. If the differences in results are within the precision range of the empirical model, the alternatives could have simply been given the same ranking and the conclusion would have been that hydropower production under the different options was essentially the same. Under the ranking scheme used by the Corps, ranking the alternatives 1-7 when there is essentially no difference has a direct bearing on the final ranking of alternatives in that it accounts for 20% of the final score for each alternative, and therefore the alternative that is selected for the DEIS.

Table 1. Hydropower values used by the Corps to rank alternatives.

	Annual Hydropower Generation (MWh)	Annual Weekday Hydropower Generation (MWh)	Annual Hydropower Percent Change from NAA	Annual Weekday Hydropower Percent Change from NAA	Rank- Annual Hydropower Generation	Rank- Annual Weekday Hydropower Generation	Sum	Final rank
Alt 1/NAA	1,049,030	777,458			1	1	2	1
Alt 2	1,048,136	775,656	-0.09%	-0.23%	4	5	9	3
Alt 3	1,046,455	776,888	-0.25%	-0.07%	7	2	9	3
Alt 4	1,046,647	769,835	-0.23%	-0.98%	6	6	12	7
Alt 5	1,048,094	776,197	-0.09%	-0.16%	5	4	9	3
Alt 6	1,048,851	767,363	-0.02%	-1.30%	2	7	9	3
Alt 7	1,048,230	776,704	-0.08%	-0.10%	3	3	6	2

A second example of our concern is that inconsequential differences are also observed in other metrics such as the percent of years with Days < Flow, one metric intended to quantify the effects of Apalachicola River low flows on mussels. There is a 0.00% difference between the NAA and Alternative 4, yet they are ranked 2 and 3, respectively (Table 2). However, there is a 24.8% difference between the NAA and Alternative 6, yet they are ranked 1 and 2, respectively. In both comparisons, there is a 1 point difference in the ranking, meaning that a 24.8% improvement is equivalent to essentially no improvement.

The differences in hydropower among alternatives are minor compared to larger differences among alternatives for the mussel performance measure. Because of the ranking system used, the differences are treated the same. In our opinion, this does not represent a sensible approach to managing multiple project purposes.

Table 2. Values and rankings used by the Corps to represent one metric from the Apalachicola River Mussel Performance Measure (ARMPM).

	Percent of Years with Days < Flow	Percent Change from NAA	Ranking
Alt 1/NAA	3096		2
Alt 2	3178	2.65%	4
Alt 3	3534	14.16%	7
Alt 4	3096	0.00%	3
Alt 5	3274	5.75%	6
Alt 6	2329	-24.78%	1
Alt 7	3178	2.65%	4

2) The Service's 2013 PAL provided the Corps with performance measures that the Service recommended for use in the evaluation and selection of flow management alternatives. The performance measures included the Apalachicola River Mussel Performance Measures (ARMPMs), Fish Spawning Habitat Performance Measure (FSHPM), Sturgeon Spawning Habitat Performance Measure (SSHPM), Chattahoochee River Shoal Bass Performance Measure (CRSBPM), and Reservoir Fisheries Performance Measure (RFPM). Based on

discussions with the Corps (July 15, 2015), it is our understanding that the Corps used all of these during the earliest phases of alternative formulation, which led to the development of the seven water management alternatives that were later ranked at the end of Phase 1. Details regarding the earliest phases of alternative formulation were not available to the Service, and the scoring and ranking of alternatives at the end of Phase 1 only included the ARMPMs and FSHPM for the Fish and Wildlife project purpose. Although the results from the SSHPM, CRSBPM, and RFPM were either included or discussed in the supporting material provided by the Corps (ACOE 2015), they did not explicitly factor into the ranking and selection of alternatives, giving the appearance that the selection of alternatives is based on a fraction of the fish and wildlife metrics provided to the Corps.

3) There is no consideration regarding the uncertainty associated with model output in the Corps' current methodology. Quantitative models are useful in that they provide discrete numbers that can be used to compare alternatives. These numbers are generated based on empirically-derived mathematical relationships. There is standard error (uncertainty around the mean) associated with empirical relationships, meaning that numbers that appear different may actually be the same. As a solution, confidence intervals are an objective means of ascertaining whether two results are the same or different. In the hydropower example, taking standard error into consideration would likely show that most of the alternatives are the same and should not be ranked differently. When uncertainty is considered, managers can appropriately, robustly, and objectively evaluate similarities and differences between alternatives; not taking uncertainty into consideration could lead to erroneous conclusions.

Corps' use of the ARMPM

The Service developed the ARMPMs to enable the Corps to visually and quantitatively evaluate the effects on shallow water mussel habitats in the Apalachicola River.[3] The Excel workbooks produce multiple graphical outputs that show the interannual frequency of flow rates less than 5,000 cubic feet per second (cfs) to 10,000 cfs, median number of days per year less than 5,000 cfs to 10,000 cfs, median number of consecutive days per year less than 5,000 cfs to 10,000 cfs, and two others based on fall rates. The results are graphically displayed in 1,000 cfs intervals so that the user may readily evaluate a range of low flows for a suite of alternatives (Figure 1).

The Corps condensed each ARMPM into a single number that is used to represent effects on each of the three federally-listed mussels. The Corps did this by summing, for example, the percent of years in each of the flow intervals. The alternative with the smallest sum ranks better than an alternative with a higher sum. The summation technique used by the Corps is transparent and quantitative, but may unintentionally result in an inappropriate ranking of alternatives.

Mussel exposure and mortality increase as flows decrease below 10,000 cfs (Table 3), meaning that reducing the frequency and duration of flows < 5,000 cfs and < 6,000 cfs has a bigger effect than reducing flows < 9,000 cfs and < 10,000 cfs. However, because the <10,000 cfs interval always has a significantly higher value, its inclusion may obscure potential benefits from reducing the frequency or duration of flows < 5,000 cfs and < 6,000 cfs. There are solutions to the summation problem, including weighting the intervals based on the potential exposure of mussels at corresponding discharges (see Table 1), or potentially eliminating the 9,000 -10,000 cfs interval from the calculations. We tested one of these solutions and found that it has a substantial impact on the overall ranking of alternatives for the Fish and Wildlife project purpose, which accounts for 20% of the score in the Corps' final ranking of alternatives.[4]

Table 3. An estimate of the percentage of fat threeridge mussels that would be exposed to the atmosphere at various discharges in the Apalachicola River. Sites were grouped by location in the river where group A included RM 30.0, group B included RM 41.5, 46.8, 48.4, and 49.0, and group C included RM 73.3. Table taken from Table 3.5.2.2.D in the Service's 2008 Biological Opinion (Service 2008).

	Discharge (cfs)							
Location	3000	4000	5000	6000	7000	8000	9000	10000
A	55.0	47.0	19.1	0.0	0.0	0.0	0.0	0.0
B	100.0	85.1	77.0	59.8	15.4	0.0	0.0	0.0
C	84.1	66.5	46.3	33.9	14.8	7.4	0.0	0.0

Corps' use of FSHPM

The Service developed the FSHPM to enable the Corps to visually and quantitatively evaluate effects to fish spawning habitat in the Apalachicola River floodplain. The Excel workbooks produce graphical outputs that show the distribution of the annual maximum 30-day growing season floodplain connectivity for the modeled period of record. The Corps condensed the FSHPM into a single number that is used to represent effects to fish spawning and then to compare alternatives. This was done by summing the maximum 30-day acreages for all modeled years and multiplying by 0.01389. The summed acreages were then ranked.

The method that the Corps chose to represent and rank metrics for the Fish and Wildlife project purpose is biased toward the protection of mussels. Five metrics were chosen to represent mussels (interannual frequency of flow rates less than 5,000 cfs to 10,000 cfs, median number of days per year less than 5,000 cfs to 10,000 cfs, median number of consecutive days per year less than 5,000 cfs to 10,000 cfs, and two others based on fall rates) and only one was used to represent FSHPM. Because each metric received equal weight in the ranking, mussels account for 83.3% of the ranking, and FSHPM 16.6%. The math used by the Corps means that mussels are five times more important than floodplain inundation and fishes. This is inconsistent with the intent of our PALs and performance measures. We tested one solution (giving equal weight to the floodplain metric) and found that it changed the overall ranking of alternatives for the Fish and Wildlife component of the evaluation.[5]

Corps' initial modeling using 20 million gallons per day (MGD) at Lanier Reservoir

In the Corps' modeling, they used a phased approach in which the first phase consisted of the selection of a water management alternative. The best performing alternative selected from the first phase was then used in the second phase as a foundation upon which a suite of water supply scenarios were tested. The first phase included a 20 MGD withdrawal from Lanier Reservoir and no Glades Reservoir withdrawals as a standard across all alternatives considered. Based on our discussions with the Corps (July 15, 2015), we understand that there was a legal rationale for using 20 MGD in the initial modeling even though consumptive use in the model is about an order of magnitude less than current use.

We are concerned that some alternatives considered in Phase 1 may have performed differently than the one selected to proceed to Phase 2 if higher consumptive uses are incorporated into the modeling; using the unrealistic volume of consumptive withdrawals could insert some bias into the alternative selection process. Several of the metrics used to rank project purposes are contingent upon reservoir levels, refill time, and flow targets at various river locations, each of which are affected by the individual set of parameters used to model alternatives. Depending on how an alternative is parameterized in HEC-ResSim, some alternatives may be more resilient than others when consumptive uses are increased.[6]

Corps' Water Supply Measure

The seven alternatives considered during Phase 1 of the Corps' analysis evaluated the system's *ability* to meet the water supply project purpose. The evaluation consisted of seven metrics that are based on the modeled period of record:

1) Buford minimum pool elevation (ft);
2) Minimum conservation pool elevation (1035 ft) reached (Y/N);
3) Buford percent time storage >/= Zone 1 (%);
4) Buford years in or below Zone 3 by Dec 1st;
5) Percent time refill from Zone 3 to Zone 1 by May 1st the next year;
6) Buford percent time at full pool by May 1st (1071 ft); and
7) Percent time pool elevation > 1066 ft during period of record.

Based on our discussions with the Corps on July 15, 2015, it is our understanding that the Corps views these metrics as indicators of the system's *ability* to meet the water supply project purpose, not the system's *performance* from a water supply perspective. We are concerned about the use of these metrics, but encourage the Corps to continue to discuss the intent, use, and potential reconsideration of these metrics. An example of our concern is that water supply in Lanier Reservoir is not contingent upon the percent of time water levels are in Zone 1, at full pool, or greater than 1066 ft. Water intake locations for Cumming Utilities (1020 ft) and Gwinnett County (two at 1025 ft) are 10-15 ft below the bottom of the conservation pool (1035 ft, Figure 2). The lowest Lanier Reservoir level on record occurred in 2007 when water levels were as low as 1,050.75 ft (NOAA 2015), and municipal water supply was maintained. The Service recognizes the importance of testing multiple climate/drought scenarios on the system's ability to meet multiple project purposes, and the importance of defining an objective method for selecting an alternative. However, it is the Service's present view that to base the water supply evaluation and alternative selection upon multiple metrics that do not evaluate whether water supply was or was not maintained in HEC-ResSim modeling is concerning.

Water supply accounts for 20% of the score used to select an alternative after water supply metrics are combined and ranked. A ranking approach that acknowledges the performance of the system to meet the water supply project purpose is necessary, and a revision of the metrics would undoubtedly have an effect on the ranking of alternatives in Phase 1. The metrics selected and used by the Corps currently serve only to favor alternatives that keep reservoir water levels high, possibly at the cost of other project purposes.

Figure 2. Action zones for Lanier Reservoir for the NAA and PAA. Figure source: Corps 2015.

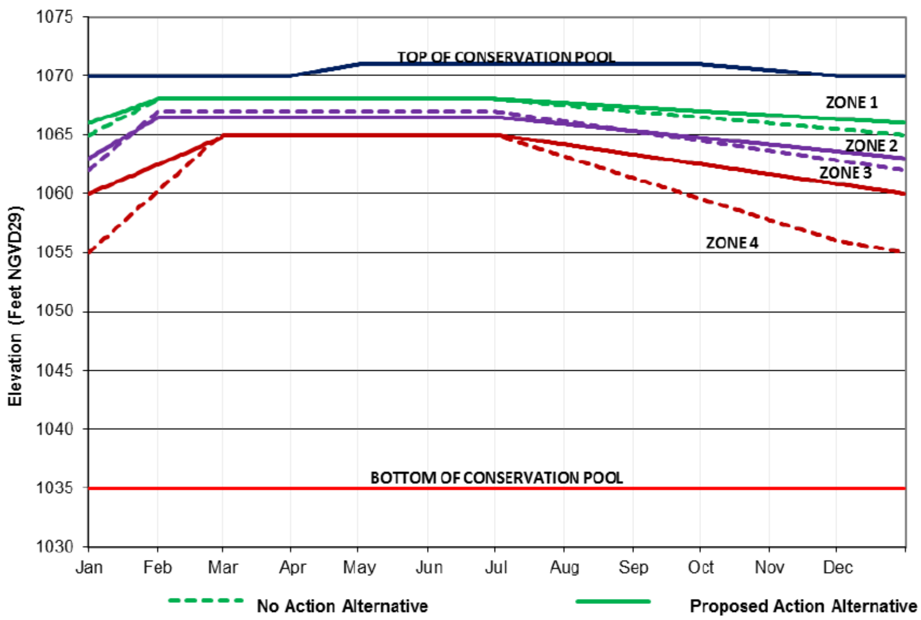


Figure 1.4-1. Lake Lanier water control action zones

Summary

As evidenced above, the alternative screening criteria used to select the PAA were based upon evaluations that do not reflect actual differences between alternatives, thus leading to our concern regarding the use of this method and the selection of the PAA. The Service recognizes the Corps' commitment to release the DEIS later this year. We support and recognize the importance of using a transparent methodology that is readily understandable by the public, and we acknowledge that the revised approach to alternative selection is probably an improvement upon previous attempts to update the WCM. However, we also expect that a more defensible methodology that is also transparent and understandable can be achieved. The Service is willing to work with the Corps to expeditiously identify and implement such methodology.

Citations

National Oceanic and Atmospheric Administration (NOAA). 2015. National Weather Service Advanced Hydrologic Prediction Service. Chattahoochee River at Lake Lanier. http://water.weather.gov/ahps2/hydrograph.php?wfo=ffc&gage=CMMG1

United States Army Corps of Engineers (Corps). 2015. ACF Water Control Manual Update Response to PAL. January 21, 2015.

United States Fish and Wildlife Service (Service). 2008. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. June 1, 2008. 225 p.

Footnotes

1. The Corps' perspective is that they have attempted to represent multiple project purposes. Much of this was done prior to the development of the ranking and scoring process.
2. The Corps acknowledges that some of the alternatives are similar and these alternatives were ranked differently. They also point out that the same ranking methodology was uniformly applied to all project purposes.
3. Recent USFWS mussel surveys show that the fat threeridge (*Amblema neislerii*) occurs at greater numbers and at a greater range of depths than previously known. Therefore, the ARMPM is presently treated as an indicator of effects to shallow water mussel habitats.
4. Discussions with the Corps on July 15, 2015 indicated that the Corps reviewed the alternatives and determined that there were not major differences between the alternatives and that the ranking methodology that converts to an "area under the curve" was sufficient and had the benefit of being transparent.
5. The Corps was consistent in their ranking approach across project purposes.
6. The Corps expects that the final ranking of alternatives would be the same between 20 MGD and current withdrawals, and based on that expectation, the decision was made to not invest in additional modeling to investigate this aspect of alternative formulation. Furthermore, the Corps indicated on July 15, 2015 that had any of the project purposes not been met at the end of Phase 2, they would have reconsidered the alternatives developed during Phase 1.

Appendix A. Excerpt from the Service's presentation to the Corps on June 1, 2015 regarding concerns with the Corps' ranking system used to select alternatives.

Concerns with Corp's ranking system used to select alternatives

June 1, 2015

Will Duncan

Steve Leitman

2. PAL identified priorities/performance metrics

Included

- ARMPM
- FSHPM (sort of)

Not included

- SSHPM
- CRSBPM
- RFPM

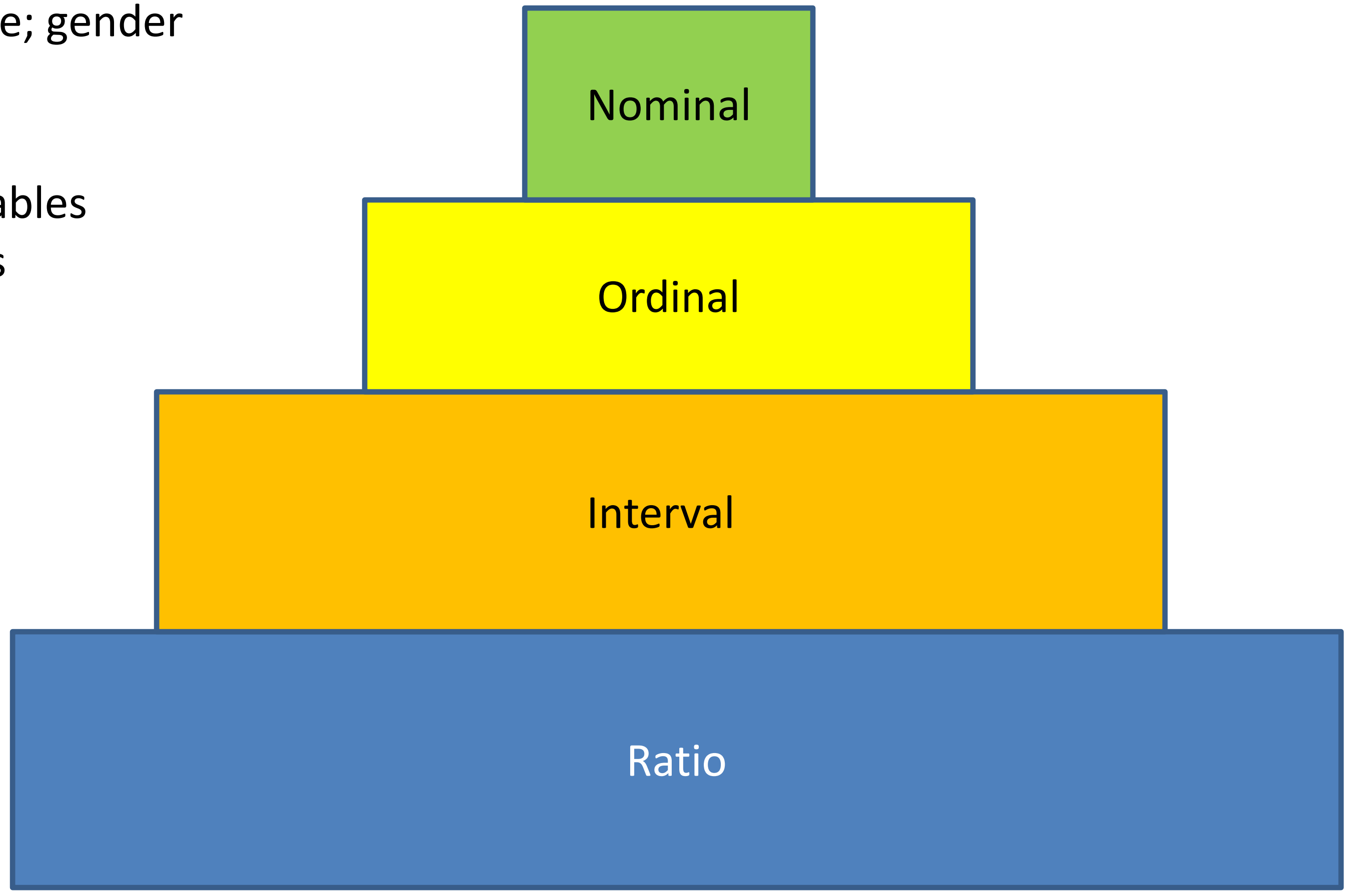
3. Conversion of ratio data to ordinal

Categorical data: no ordering; e.g. dark and light roast coffee; gender

Similar to categorical. Spacing between variables non-uniform; intervals unequal; e.g. ranking

Equally spaced intervals. \$10,000, \$15,000 and \$20,000.

Has a true “0”
Real values
Numbers can be compared
e.g. Weight



4. No consideration of standard error/model confidence

- Standard error- uncertainty around the estimate of the mean measurement
- Confidence intervals
- Two results that fall within the same confidence interval are essentially the same

Summary of concerns

- We are concerned about the errors. More are lurking.
- We are very concerned about the approach. We can help improve it.
  - Small differences within project purpose are the same as large differences
  - A great amount of weight placed on inconsequential differences
  - Leads to a problem with public perception of "balancing" project purposes AND the FWS Evaluation
  - Even within a project purpose, there may be weighting problems
- We would like to work with you to identify errors and develop appropriate and transparent strategies for alternative selection.

USACE August 2015 Response to Draft Fish and Wildlife Coordination Act Report July 2015

This page intentionally left blank

Response to U.S. Fish and Wildlife Service Draft Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

U.S. Army Corps of Engineers
MOBILE DISTRICT

August 2015

INTRODUCTION

The U.S. Army Corps of Engineers (Corps), Mobile District is updating the Water Control Manuals (WCMs) for the Apalachicola-Chattahoochee-Flint River Basin (ACF Basin). The WCM update process is to determine how the federal projects in the ACF Basin should be operated to meet all authorized purposes and to implement these operations through the means of the updated water control plans and manuals. Fish and wildlife conservation is an authorized purpose of the federal ACF system, and as good stewards of the environment and wanting to assure that the fish and wildlife interests were adequately considered, the Corps sought comment and analysis by the U.S. Fish and Wildlife Service (FWS) and state agencies of the Proposed Action Alternative (PAA) prior to release of the Draft EIS to the public. Although the PAA does not include any construction or structural modifications to the ACF project, nor is a report or a recommendation to Congress part of this effort, the Corps utilized the general framework of the Fish and Wildlife Coordination Act (FWCA) to solicit input from FWS and state agencies and to organize the information provided. On July 31, 2015, the FWS, Georgia Ecological Services Office, Athens, Georgia submitted the Draft *Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida* (DFWCAR) to the Corps, Mobile District. This report provides the Corps' detailed response to the questions and comments outlined in the DFWCAR.

The following comments regarding the WCM update purpose and scope are required to establish the appropriate context for the Corps' response to the DFWCAR. After that, the document is organized by first addressing the FWS's fish and wildlife conservation measures and recommendations; followed by discussion of the FWCA agency coordination, project impacts and evaluation methodology, the FWS's evaluation of the selected plan, and the FWS's position. Page numbers referencing the relevant information in the DFWCAR are provided.

The proposed action is to update the water control plans and manuals for the ACF Basin as directed by Secretary of the Army Pete Geren on January 30, 2008. Specifically, the purpose and need for the federal action is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through updated water control plans and manuals. Conditions in the basin (e.g., population, socioeconomic, land use, infrastructure, and demand for water resources) have changed substantially since the federal reservoirs were authorized and constructed, and a variety of applicable federal and state environmental laws have been passed and implemented. Operation of the federal reservoir projects in the basin both affect, and are affected by, current conditions in the basin and must comply with current laws and regulations. This action will result in an updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, that reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues.

On June 28, 2011, the U.S. Court of Appeals for the Eleventh Circuit issued an opinion that the authorizing documents for the Buford Dam project include water supply as an authorized purpose. Additionally, the 2011 decision ordered the Corps to reconsider whether it has the legal authority to operate the Buford Project to accommodate Georgia's request made in 2000 to adjust the operation of Lake Lanier, and to enter into agreements with the State, or water supply providers, to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta. The Corps provided a legal opinion in 2012, concluding that it has sufficient authority under applicable law to accommodate that request, but noting that any decision to take action on Georgia's request would require a separate analysis. On January 11, 2013, the Governor of the State of Georgia provided updated demographic and water demand data to confirm the continued need for 705 million gallons per day (mgd) to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040 rather than 2030 as specified in the 2000 request.

Because updating the water control plans and manuals requires making a decision on Georgia's water supply request, the Corps will consider, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013 requested from Lake Lanier and downstream at Atlanta.

During the WCM update process the Corps identified, documented, and evaluated the environmental effects of operating the federal projects in the ACF Basin under alternative management regimes that could reasonably be expected to accomplish the purpose and need of the proposed federal action. The range of actions, alternatives, and effects considered during the WCM update process are driven by the requirements set forth by Congress and Corps policies for project operation. Accordingly, the Corps considered operational changes within existing congressional authorities, as determined by recent court rulings, and delegated, discretionary authorities, and did not consider operational changes that would be expected to require additional congressional authority.

The analysis provided by the Corps to the FWS for the DFWCAR is consistent with the FWS guidance provided in the FWS's Planning Aid Letters (PAL) for the proposed WCM updates for the ACF River Basin in Georgia, Alabama, and Florida dated April 2, 2010, March 1, 2011, and August 29, 2013. The Corps submittal to the FWS on January 21, 2015 was based on the latest PAL guidance (August 29, 2013). The Corps' January 21, 2015, response to PAL provided the available information and was followed by multiple discussions with FWS, the submittal of the HEC-ResSim model results from both phases of the Corps' alternative formulation, and numerous Excel workbooks used by the Corps to evaluate the impacts of the alternatives. The Corps believes the information provided and the numerous discussions with the FWS regarding alternative formulation demonstrate that fish and wildlife were given equal consideration along with the other authorized project purposes.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

Fish and Wildlife Service Alternative Evaluation

Pg 36-37 - The FWS's revised WCM alternative dated July 19, 2013 (Appendix VIII of the DFWCAR) includes the same revised action zones as the PAA. The response to PAL the Corps provided to the FWS in January 2015 briefly described the alternative formulation process and noted that Phase I of the alternative formulation process evaluated the No Action Alternative (NAA) and six other Water Management Alternatives. One of those other Water Management Alternatives was the FWS's alternative as described in the July 19, 2013, letter. The Corps utilized a subset of performance metrics to evaluate the various alternatives' ability to meet the authorized project purposes and rank the ability of the alternatives to meet the objectives established for the WCM update. The water management alternative finally chosen represented the best balance of all authorized project purposes. The result of this formulation phase was the identification of the Water Management plan represented in the PAA. The Corps appreciates the FWS's extensive efforts to identify a system-wide operational plan for consideration during the WCM update process and fully evaluated the FWS's alternative during Phase I of the alternative formulation process. The FWS's concerns with the alternative selection process methodology are addressed in the SUMMARY AND FWS POSITION section at the end of this document.

Flow Regime

Pg 37-38 (FR1) – The FWS recommends that the Corps develop an alternative that maximizes benefits to fish and wildlife resources in light of other project purposes. The Corps maintains that the alternative formulation process accomplishes this request. Full details of the iterative process used in the alternative selection methodology as well as all project impacts of each alternative are provided in the DEIS (Sections 4 and 6 respectively).

The FWS reiterates their requests for the Corps to consider flow guidelines, pulse flow guidelines, and non-hydropower peaking windows in order to provide for some components of the natural hydrograph and states "To date, none of the natural flow regime components have been incorporated into the flow alternative development". In the 2011 response to PAL the Corps provided detailed discussion regarding the physical, safety, and logistical limitations to making operational changes that mimic a natural flow regime. This discussion is still valid and is incorporated here by reference (USACE 2011). The Corps maintains that operating to match the natural flow regime is not possible at the multipurpose Federal projects since they were designed and built to alter the natural flow regime. Operating in a manner that seriously impacts the congressionally authorized purposes of hydropower production and flood risk management would require additional study authorization that is outside the scope of a WCM update. The PAA includes seasonally varying minimum flow provisions and fall rate provisions at Jim Woodruff Lock and Dam designed to mimic a more natural flow regime in the Apalachicola River. The construction of the series of Federal and non-federal reservoir projects in the heavily regulated Chattahoochee arm of the river basin has resulted in an altered flow regime that significantly limits the Corps' ability to provide for some components of the natural hydrograph.

Pg 38-39 (FR2) – The FWS recommends that ecosystem flow analyses using the methodology cited in the FWS's PAL addendum be conducted at four nodes (below Buford Dam, West Point Dam, Walter F. George Lock and Dam, and Jim Woodruff Lock and Dam) for the NAA and PAA and compared with the FWS's ecosystem flow guidelines. The FWS' PAL addendum provided revised low and high flow guidelines based on the pre-dam gage data or simulated pre-dam conditions where gage data were not available. In developing the revised low flow guidelines the FWS used flow magnitude percentiles for each month to define the lower limit, dry year, average year, wet year, and upper limit, (10th, 25th, 50th, 75th, and 90th) respectively. The Corps agrees with this approach and notes that the 2015 response to PAL provides a monthly flow statistics analysis of the simulated NAA and PAA depicting this information at numerous locations throughout the basin. The Corps response to PAL did not include a comparison of these simulations to the revised FWS's low flow guidelines based on the monthly seven lowest values. To the extent this analysis is still desired the Corps will provide it during the DEIS public review period.

The FWS also continues to recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May. As described in the Corps' January 2011 response to PAL, non-hydropower peaking "windows" were considered and determined to not be prudent based on equipment limitations, safety concerns, and serious impacts to other authorized project purposes. The Corps maintains that all of the previously described reasons for not including non-hydropower peaking "windows" are still valid and incorporates them here by reference (USACE 2011).

The FWS states "fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production." The Corps believes that the needs of both project purposes can be managed cooperatively to achieve benefits to both resources. The Corps operations, including hydropower production, result in a mix of beneficial and adverse effects to aquatic fauna. The Corps notes previously discussed benefits to the striped bass and shoal bass fisheries in the reach below Buford Dam to West Point Dam which are met in conjunction with hydropower production at upstream projects. To the extent that restoration of some of the natural flow regime components can be accomplished to the benefit of fish and wildlife resources in light of other project purposes, the Corps believes the PAA adequately strikes this balance. It is the responsibility of the Corps to best determine water management operations that meet all of the congressionally authorized project purposes. As described in the purpose and need section of the DEIS, the purpose and need for the federal action is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through updated water control plans and manuals. The proposed action is not intended to maximize benefits to fish and wildlife resources or any other authorized project purposes, but to equably manage the federal projects for the benefit of all authorized project purposes. Accordingly, the alternatives considered in the DEIS do not address any proposed changes to water management practices that exceed existing congressional authority.

Pg 39-40 (FR3) – The FWS recommends evaluating the potential for reducing the magnitude of fall drawdowns and/or starting the spring refill earlier to provide inundation of the floodplain.

These actions would have serious implications for flood risk management. Considering the purpose and need for the proposed action, the Corps developed eight screening criteria to guide information gathering, to help identify solutions, and to formulate alternatives. One of these criteria requires maintaining at least the current level of flood risk management. The Corps operates projects in the ACF Basin to provide flood risk management, as Congress intended when authorizing the system and projects. Continued growth and development in the ACF Basin has resulted in the construction of homes and businesses in the floodplain. Any proposed action should not significantly alter the level of flood risk management intended by the Congress in its authorizing language or increase the current levels, frequency, and duration of flood damage. Accordingly, the alternatives considered in the DEIS do not address any proposed changes to water management practices that exceed existing congressional authority.

Pg 40 (FR4) – The FWS recommends that the Corps evaluate methods to provide the operational flexibility necessary for floodplain inundation including evaluating compensatory measures, such as elevating, moving, or purchase of structures, that would allow floodplain inundation. The Corps agrees that compensation actions could provide more flexibility regarding floodplain inundation, but maintains that they are not authorized or appropriate as part of a WCM update. These types of actions require separate study authority.

Pg 40 (FR5) – The FWS requests that the Corps evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines. The FWS reiterates that that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. In the 2011 response to PAL the Corps provided detailed discussion regarding the physical, safety, and logistical limitations to making operational changes that mimic a natural flow regime. This discussion specifically addresses the FWS's guidelines and it is still valid. That discussion is incorporated here by reference (USACE 2011). The Corps maintains that operating to match the natural flow regime is not possible at the multipurpose Federal projects since they were designed and built to alter the natural flow regime. Operating in a manner that seriously impacts the congressionally authorized purposes of hydropower production and flood risk management would require additional study authorization that is outside the scope of a WCM update.

Pg 41(FR6) – The FWS requests that the Corps participate in the development of appropriate hydrological and meteorological criteria needed to forecast future conditions as either dry, average, or wet. The Corps currently utilizes the NIDIS Low Flow Information System to alert other water management operators and basin stakeholders of low flow conditions. The Corps will continue to evaluate forecasting tools and is willing to meet with FWS to further discuss this issue.

<u>Floodplain inundation assessments</u>

Pg 41 (FP1) – The FWS requests that the Corps use LIDAR and stage-discharge relationships to compare floodplain inundation metrics. A full set of LIDAR data for the entire Apalachicola River may be available but has not been provided to the Corps during the numerous scoping periods. Further, the Corps is unaware that models or software that correlate the LIDAR data to

specific discharges from Jim Woodruff Dam currently exist. It is our understanding that Florida Fish and Wildlife Conservation Commission (FFWCC) was contemplating or had begun to develop such tools, but that they are not available yet. Accordingly, the Corps utilized the best available information consistent with the guidance provided in the FWS's PAL. The FWS previously stated in the DFWCAR (Pg 17, Floodplain connectivity) that "given that the NAA and PAA exceedance curves are nearly the same, we do not expect that using LIDAR data would lend additional insights. Chattahoochee River floodplain connectivity would be expected to be nearly the same between the NAA and PAA. Conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain. Therefore, we do not expect differences in floodplain inundation in the Chattahoochee River."

Dissolved Oxygen

Pg 41-42 (WQ1) – The FWS requests that the Corps ensure that releases from all five ACF dams meet or exceed water quality standards. Releases from the Corps' ACF dams are not subject to specific Clean Water Act effluent limitations. The Corps is not responsible for enforcing State water quality standards and cannot ensure that water quality standards are met. However, the Corps has given careful consideration to water quality standards and has evaluated the effects of each alternative on water quality. The Corps acknowledges the simulated DO results described by the FWS on pages 14-15 of the DFWCAR. These results are not surprising. Lower DO concentrations would be expected to occur below the major reservoirs under the NAA and PAA due to the low-oxygenated water being discharged from reservoirs. The DO concentrations found in the deeper portions of the reservoir may stay low because of stratification. As the water warms through the summer, the amount of DO in the water column would decrease in the deeper areas. Water released from the dams is from the deeper waters, where DO is depleted over time. Downstream from the immediate dam release, the large volume of water would result in greater velocities and reaeration, increasing oxygenation. These increased oxygen levels support fisheries downstream of the dams. The Corps has improved DO in the project tailraces through past efforts that included upgrading the venting capabilities of hydroelectric turbines, installation of siphons that release water with relatively higher DO levels from the top of the reservoir, and implementation of SOPs regarding monitoring DO levels and making special releases to temporarily improve tailrace DO. Not only was fish and wildlife conservation equally considered in the alternatives evaluation for the WCM, but as shown by these actions, the Corps has and continues to perform actions to benefit fish and wildlife in this system.

Pg 42 (WQ2) – The FWS recommends that the Corps evaluate the effectiveness of the upgraded venting capabilities at Buford turbines. This type of study requires separate study authority and is beyond the scope of this effort. The Corps agrees that alternative authorization and appropriation, such as Corps restoration authorities, would be necessary to fulfill this conservation recommendation and is willing to explore these opportunities with FWS.

Temperature

Pg 42 (WQ3) – With regards to the FWS request of the Corps to experiment with operational and/or structural modifications and follow up monitoring that improve temperature levels downstream of Corps reservoirs, such a study would require separate study authority and is beyond the scope of this effort.

Fish Passage

Pg 43 (FM1) – The FWS states that provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam. As stated previously, the Corps has adopted fish passage operations at Jim Woodruff Lock and Dam into the project's WCP. With regards to the other two projects, ongoing fish passage studies at Jim Woodruff Lock and Dam have demonstrated that very few fish that pass upstream travel up the Chattahoochee arm of the basin (recent genetic studies demonstrate that approximately 98% of the Alabama shad's natal waters were the Flint River). It appears that fish passage operations at George W. Andrews Lock and Dam and Walter F. George Lock and Dam would have limited success. However, the Corps maintains that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the project water control manuals does not preclude routine lock operations at George W. Andrews Lock and Dam or Walter F. George Lock and Dam which may benefit anadramous fish species.

Climate Change

Pg 43 (CC1) – As discussed during the coordination of the DFWCAR, the DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. The Corps, in response to relevant guidance and public interest and input, engaged the Institute for Water Resources (IWR) to develop a numerical model to evaluate the resilience and limitations of proposed ACF Basin water management scenarios in response to potential climate change conditions. The ACF numerical model was developed to correlate with the HEC-ResSim and HEC-5Q models for the ACF system. Simulating the IWR climate change projections in HEC-ResSim and HEC-5Q provided an indication of the effects of prospective climate change on hydrology and water quality in the ACF Basin. The objective of this effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management. The details of this analysis are provided in the DEIS (Section 6.8).

Navigation

Pg 43 (NV1) Navigation is an authorized project purpose and as such is included in the WCM update. The Corps' proposed action includes operations for a navigation season. The navigation season operations assume no channel maintenance activities will occur on the Apalachicola River as these activities have been indefinitely deferred due to denial of a Section 401 water quality certificate from the State of Florida and recent congressional language that limits funding for dredging operations in the ACF Basin. If channel maintenance activities are re-instated for the Apalachicola River portion of the navigation project, the Corps would address the evaluations requested by the FWS during the water quality certification process.

Reservoir and Riverine Fisheries Management

Pg 43-44 (FM2, FM3) – FWS recommends reviewing recent fisheries literature for additional information regarding impacts to riverine fish spawning during a 4-6 week stable or rising reservoir window to benefit reservoir fish spawning. Also recommended was to modify Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning. Lake regulation and coordination for fish management purposes is required by South Atlantic Division Regulation PDS-O-1 (31 May 2010). The Mobile District draft fish spawn SOP (2005) defines Corps operations for implementing this Division Regulation and includes requirements for an annual meeting with the various State and Federal fish and wildlife resource agencies. The purpose of the meeting is to evaluate the success or failures of executing the fish spawn operations during the previous year; share data including recent scientific investigations that support, modify, or reject the fish spawn operations; and identify potential refinements. The Corps believes this process can accomplish the goals identified by the FWS. The Corps welcomes the FWS's facilitation capabilities to better accomplish these goals as part of that process.

With regards to the FWS's request to investigate modifications to the fish spawn SOP to occasionally emphasize river spawning over reservoir spawning the Corps maintains that the existing language provides for this flexibility and specifically provides for "operational adjustments recommended by the interagency team to minimize impacts and/or enhance system-wide benefits". As described in the paragraph above, modifications to the SOP can be proposed and mutually agreed upon or rejected as part of the annual coordination meeting.

Pg 45 (FM4) The FWS recommends identifying fish and wildlife recreation facilities that need infrastructure improvement. As noted previously, infrastructure improvements and other construction activities require additional study authority and are outside the scope of the WCM update.

Apalachicola Bay

Pg 45 (AB1) - The Corps understands that the FWS is currently contracting with Dr. Peter Sheng to update the previously conducted hydrodynamic bay salinity modeling with simulated flow data from the HEC-ResSim modeling conducted for the WCM update. The Corps looks forward to reviewing this information if it is available prior to the release of the Final EIS. The Corps hopes this information will be available during the Section 7 consultation and completion of the National Environmental Policy Act (NEPA) process.

Pg 45 (AB2) – As described in the FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT section, the Corps disagrees with the relevancy of the impacts identified by the FFWCC in their analysis of the pre-dam and post-West Point periods of record. As previously discussed the appropriate without project condition for the purpose of this analysis is current operations, not a pre-dam condition. Congress previously authorized the construction and operation of the federal reservoirs to serve as a multi-purpose projects and they were built to achieve the congressionally authorized purposes.

Decision Support Model to Evaluate Changes to Corps' Operations

Pg 45/46 (DS1) – The DEIS includes a detailed description of the alternative development process for the WCM update. Considering the purpose and need for the EIS, the Corps developed eight screening criteria to guide information gathering, to help identify solutions, and to formulate alternatives. These screening criteria are described below:

Any proposed measure (or alternative) considered in the update process for the Master Manual should:
1. Meet the purpose and need of the proposed federal action
2. Address one or more of the congressionally authorized project purposes
3. Maintain at least the current level of flood risk management
4. Be consistent with the contemporary water resources needs of the basin to the extent practicable
5. Support the operation of the projects in the ACF Basin as a system
6. Not increase the risk to public safety in the facility or downstream of the project
7. Not exceed the physical limitations of or pose risks to the structural integrity of the projects
8. Not violate USACE responsibilities under the Endangered Species Act (ESA)

The 2010 guiding principles described in the DFWCAR were constraints identified early in the WCM update process. Considerable changes to the scope of the project have occurred since 2010 as a result of litigation. The screening criteria listed above are consistent with and evolved from the 2010 guiding principles listed in the DFWCAR. Although not specifically described in the screening criteria listed above, the fish spawn SOP (guiding principle 6) was included in all water management alternatives considered. Guiding principle 7 regarding reallocation of storage for water supply is not one of the screening criteria listed above; however, water supply needs were evaluated in conjunction with the water control manual update. Guiding principle 8 regarding water quality in Corps reservoirs is inherent within screening criteria 1 and 2.

Adaptive Management

Pg 46 (AMP1) – The Corps believes that the WCM guidance, fish spawn SOP, ESA compliance annual reports, and monthly coordination with the FWS regarding Apalachicola River flows achieve the goal of the formal adaptive management program the FWS recommends. The WCM guidance provides for operational flexibility to balance all project purposes over a wide variety of conditions.

Increasing Consumptive Demands

Pg 47 (CD1) As described above, the HEC-ResSim model includes standardized assumptions regarding consumptive demands (outside of the Atlanta area) that include the highest demand year (2007). These levels of consumptive demand were selected by the Corps because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands.

Evaluation of Alternative Models

Pg 47-48 (AM1) – The Corps will continue working with the states to improve the unimpaired flow development methodology and update the dataset accordingly. This Corps' analysis used "HEC-ResSim Version 3.2, Build 3.2.1.19". HEC-ResSim is a generalized reservoir operations modeling package. Per ECB 2007-6 (USACE, 2007) and EC 1105-2-407 (USACE, 2005b), HEC-ResSim falls under the category of "engineering models used in planning studies", leaving certification to the Science & Engineering Technology (SET) initiative associated with the Corps' Technical Excellence Network (TEN). The Corps' Hydrologic Engineering Center developed this software which is now the standard for Corps reservoir operations modeling. As of January 2010, the TEN guidance listed HEC-ResSim as "Community of Practice Preferred" for the purpose of reservoir system analysis.

The Water Control Manual Update team selected HEC-ResSim as the tool most capable of faithfully representing District water management practices as the culmination of a three-year model development and verification process. In 2006 Mobile District began working with HEC to create HEC-ResSim models based on established HEC-5 models simulating 1977, 1995, and 2006 physical and operational conditions. The three HEC-5 models hold significance as the tools "of record" used for analyses concerning the previous Environmental Impact Statement, the 1990's Comprehensive Study, and the Revised Interim Operating Plan (RIOP). After ensuring that the corresponding HEC-ResSim models could effectively reproduce the HEC-5 results, Mobile District and HEC created another HEC-ResSim model that captured the most significant operations as of 2008, including the RIOP rules and head limits constraints. This model was presented to stakeholders in October 2008 and generally accepted as a promising improvement to ACF reservoir system modeling. Other considerations factoring into Mobile District's selection of HEC-ResSim include ease of adaptation to other studies or operational use, availability of training, access to software developers for program enhancements, opportunity for linkage with water quality models, and ability to share with partners and stakeholders without licensing cost or restriction.

Since the Water Control Manual Update study was heavily accelerated but subject to unpredictable changes in scope, the long-standing relationship between Mobile District and HEC also afforded an important element of organizational trust that provided continuity.
The Mobile District's decision to use HEC-ResSim for modeling the ACF watershed represents a long term investment that continues to pay dividends. Completion of the ACF HEC-ResSim model for the initial water control manual update study in 2010 yielded a set of alternatives and associated results that satisfied the Corps' internal and external review processes. The model results continue to serve as a basis of debate among the stakeholders yet the Corps maintains that HEC-ResSim is the best available tool for evaluating alternative system wide operations and that it accurately reflects the resultant high and low flow conditions of these alternative operations. With regards to the FWS validation analysis, please reference the discussion in the PROJECT IMPACTS & EVALUATION METHODOLOGY section below.

Pg 48 (AM2) – The Precipitation-Runoff Modeling System (PRMS) is not available for use at this time.

Pg 48 (AM3) – The Corps is familiar with the Georgia Water Resources Institute (GWRI) models and maintains that HEC-ResSim is the best available tool for evaluating alternative system wide operations.

Pg 48 (AM4) – The Corps maintains that the HEC-5Q water quality model is appropriate for the WCM update. The HEC-5Q Water Quality Modeling Report included in the DEIS (Appendix K) provides a detailed description of the "Demonstration of Model Performance" conducted by the water quality modeling team. The demonstration included extensive comparison of modeled and observed time series (streams) and profiles (reservoirs) as well as a model sensitivity analysis.

Additional Conservation Measures Developed from the Corps' PAL Response

Pg 49 (FR7) - The FWS notes there are no minimum flow provisions downstream of Walter F. George Lock and Dam and the Corps should evaluate implementing a minimum flow provision at this project. The Walter F. George Lock and Dam project is a hydropower facility designed to meet peak demand that typically occurs during the weekday. During periods of normal flow Walter F. George Lock and Dam may not release water on the weekends if the Jim Woodruff flow provisions can be met without support from upstream reservoirs. Currently there is no authorized minimum flow requirement from Walter F. George Lock and Dam. Upstream projects (Buford and West Point) have small hydropower house units designed to provide a continuous minimum flow. Walter F. George Lock and Dam does not have a small hydropower house unit. To provide a continuous minimum flow, the project would have to spill water through the spillway. However, installation of siphons and occasional spillway releases assist with raising the dissolved oxygen level downstream of the project. The FWS mistakenly notes that minimum flow releases are already implemented at the other four ACF projects. This is not true for George W. Andrews Lock and Dam as it is a run of river project with no storage to support an at site minimum flow requirement. The discharge from George W. Andrews Lock and Dam matches the volume of inflow with some reregulation of the upstream Walter F. George Lock and Dam hydropower releases.

Pg 49 (FR8) –Drought operations under the PAA are triggered when the composite conservation storage drops into Zone 3 (not Zone 2 as indicated in the DFWCAR). The Corps notes that the Phase I alternative formulation process included alternative drought operation triggers to the one represented in the PAA.

Pg 49 (FM5) – The Corps utilized the Sturgeon Spawning Habitat Performance Measure (SSHPM) Excel workbook developed by the FWS and the Corps' response to PAL noted that there were no differences between the NAA and PAA (Section 2.7.1). The Corps provided the FWS with the workbook supporting this determination in March 2015.

Pg 49 (FM6) – The Corps will work closely with the FWS during the Section 7 consultation to ensure that the appropriate species are addressed. The Corps will utilize existing information for the species currently petitioned for listing and will work with FWS to identify opportunities to improve the understanding and future evaluation of project impacts on these species.

Pg 49 (NPS1) – The DEIS does address the impacts of the PAA to the NPS's Chattahoochee River National Recreation Area (Section 6).

Pg 49-50 (ES1) – The DEIS generally addresses ecosystem services in the numerous impact assessments conducted. The Corps currently does not have guidance on ecosystem services but is evaluating how to include consideration of ecosystem goods and services in Corps projects.

Mitigation Measures

Pg 50 (MIT1 and MIT2) - Mitigation includes measures to avoid, reduce, minimize, or compensate for adverse impacts that could result from a selected course of action. As potential water management measures were identified and alternatives were developed, potential actions to offset any adverse effects also were identified, analyzed and considered in the planning process. For example, increased water withdrawals from the Chattahoochee River to meet the needs of metropolitan Atlanta communities would result in a corresponding increase in treated wastewater returns to the river between Atlanta and West Point Lake. The impact analysis showed that the PAA would result in increased loadings of total phosphorus that would have a substantially adverse effect on water quality. The substantially adverse effects would also be expected downstream of West Point Lake to the headwaters of Walter F. George Lake. The adverse water quality effects in these portions of the Chattahoochee River would principally be associated with increased treated wastewater discharges to the river rather USACE project operations. The Georgia Environmental Protection Division may require changes to discharge permits for some facilities. After a thorough analysis of the impacts from the PAA and other alternatives, it was determined that specific compensatory mitigation measures for the Corps of Engineers were not required or necessary.

Water management inherently involves adapting to unforeseen conditions. Because adverse effects of the water control plan might occur in the future due to unforeseen conditions, actions would be taken within applicable authority and policies, and in coordination with other interests, to address such conditions when they occur through the implementation of temporary deviations to the water control plan, such as interim operation plans.

Pg50 (MIT3) – As described in the *Analyses of Apalachicola Bay* section below, the Corps believes that the PAA results in negligible impacts to the estuary. Therefore mitigation is not appropriate.

FWCA Agency Coordination

This section addresses comments provided to FWS from the Florida Fish and Wildlife Conservation Commission (FFWCC), Alabama Department of Conservation and Natural Resources (ADCNR), Georgia Department of Natural Resources, Wildlife Resources Division (GDNR-WRD) and National Oceanic and Atmospheric Administration (NOAA) regarding the DFWCAR. Please reference pages 1-3 of the DFWCAR.

FFWCC

The Corps believes that the PAA is the alternative that best balances authorized project purposes with the least environmental impact. Regarding coordination with FFWCC, in 2008 the Corps published a Notice of Intent to prepare an EIS in the Federal Register. That was followed by additional notices announcing additional information and meetings for the public scoping process. In 2009 scoping was reopened. The latest round of scoping occurred in 2012. During each of these scoping periods, FFWCC has had opportunity to participate. The FFWCC has also participated in both DFWCA report efforts related to the WCM update process. Additional opportunity to provide input to the Corps will be provided during the comment period upon public release of the DEIS. Fish and wildlife resources received equal consideration as other authorized purposes. The Corps believes its analysis includes impacts of current and projected consumptive water uses; the NAA compares current water demands to that of the PAA which includes an increase in consumptive water use.

ADCNR

The Corps analyzed a set of alternatives with an objective to balance all authorized project purposes. In accordance with the purpose and need of the proposed action, the Corps did not attempt to develop an alternative that would maximize and benefit the fish and wildlife resources of the State of Alabama. The proposed action is not intended to maximize benefits to fish and wildlife resources in any state, or any other authorized project purposes, but to equably manage the federal projects for the benefit of all authorized project purposes. Regarding water quality, the Corps will comply with all relevant laws and regulations. In regards to in-stream flow, the Corps believes that the PAA adequately balances all authorized project purposes. The FWS included discussion of consumptive demands, protected species minimum flows and fish passage at George W. Andrews Lock and Dam and Walter F. George Lock and Dam in the DFWCAR and those comments are addressed in the appropriate sections below.

GDNR-WRD

It is not clear from the GDNR-WRD comments whether or not the current or proposed operations result in water temperature conditions in the river segment between Buford Dam and West Point Lake incapable of supporting the trout and striped bass fisheries. They appear to favor a coldwater fishery in the upper portions of this reach, which currently exists and note the importance of cool water refugia to the survivability of adult striped bass. The impact analysis conducted by the Corps suggests that the proposed action will at worst maintain the current water temperature regime and may in fact improve water temperature for trout, striped bass, and shoal bass at critical transition zone locations below Morgan Falls Dam. The Corps acknowledges that the construction of dams impacts dissolved oxygen (DO) levels in the river that are important to aquatic resources. However, the Corps maintains that operational changes at the federal projects cannot substantially improve DO levels below Corps projects using existing infrastructure. At the request of the FWS the Corps previously evaluated the feasibility of operating the federal projects in a non-hydropower peaking manner to facilitate riverine fish spawn and replicate a seasonally varying baseflow hydrograph that more closely approximates natural conditions. The results of that evaluation were provided in the Corps' January 2011 response to PAL document and are further discussed below. As described in the description of the proposed action, the Corps will continue to implement the Draft Reservoir Regulation and Coordination for Fish Management Purposes Standard Operating Procedure (SOP) (SAM SOP 1130-2-9).

NOAA

NOAA states their support for the FWS comments on the evaluation of the PAA on Gulf Sturgeon, fish passage, and effects of freshwater inflow on Apalachicola Bay seagrass, fish and shellfish. The Corps addresses these comments in the appropriate sections below.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Pg 10/11 - The FWS describes the "fundamental component" of a FWCA report as the "evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated". Since the proposed action is not a construction project and is instead a change in operation for an existing system of projects, "without project" is more appropriately defined under the NEPA interpretation of No Action and the type of evaluation is different. However, the Corps believes the NAA accurately reflects the "existing condition" and the PAA accurately reflects "the future with the project" condition. The NEPA requires a comparison of the existing condition (No Action) to potential alternatives including the proposed action. The existing condition as described by the Corps (NAA) complies with The Council on Environmental Quality (CEQ) Regulations for Implementing NEPA which requires the inclusion of the "alternative of no action" in an EIS. The CEQ further defines what is meant by the "alternative of no action" in a document titled *NEPAs Forty Most Asked Questions* (Forty Questions). In that document they state, with regards to federal actions such as updates to existing plans where ongoing programs initiated under existing legislation and regulations will continue, even as new plans are developed the "no action" is "no change" from current management direction or level of management intensity. Therefore, the "no action" alternative may be thought of in terms of continuing with the present course of action until that action is changed. Consequently, projected impacts of alternative management schemes would be compared to those impacts projected for the existing plan. In light of this guidance the Corps has selected a NAA that is both appropriate and in accordance with applicable law.

For the PAA the Corps maintains that we have adequately represented conditions that are likely to exist during the life of the project relevant to the management of the Corps' projects. The 73-year period of historic hydrology upon which the simulated PAA is based represents the range of dry/normal/wet conditions that would be expected to occur during the life of the project. The FWS states that the PAA is not fully represented because it did not incorporate basinwide consumptive demand projections or climate change. The Corps does not agree with this conclusion. The PAA HEC-ResSim model includes standardized assumptions regarding consumptive demands (outside of the Atlanta area) that include the highest demand year (2007). These levels of consumptive demand were selected by the Corps because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands. The DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. The Corps, in response to relevant guidance and public interest and input, engaged the Institute for Water Resources (IWR) to develop a numerical model to evaluate the resilience and limitations of proposed ACF Basin water management scenarios in response to potential climate change conditions. The ACF numerical model was developed to correlate with the HEC-ResSim and HEC-5Q models for the ACF system. Simulating the IWR climate change projections in HEC-ResSim and HEC-5Q provides an indication of the effects of prospective climate change on hydrology and water quality in the ACF Basin. The objective of this effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management. The details of this analysis are provided in the DEIS. To the extent the PAA simulations and analysis provide in the Corps' response to PAL does not satisfy the FWS's needs; the Corps believes the analysis provided in the Climate Change Analysis section of the DEIS will.

Page 11/12 – Despite acknowledging that the interpretation provided by the FFWCC that past and current federal reservoir operations have affected a multitude of fish and wildlife resources is the opinion of the FFWCC and not the FWS, the FWS states that the "impacts identified (hypothesized, realized, or modeled) in FFWCCs correspondence are relevant because operational changes at Corps facilities have the potential to ameliorate, exacerbate, or have no effect on such project-induced impacts and impacts associated with other changes in future resource conditions". The Corps disagrees with the relevancy of these impacts identified by the FFWCC. The analyses and subsequent interpretation provided by FFWCC are in large part a reiteration of extra record material submitted on behalf of the Florida parties in the Middle District of Florida "Phase II" case that the Federal Defendants and other parties have refuted on both the technical merit of the analyses and the faulty conclusions drawn from them. A detailed accounting of the Federal Defendants comments on these analyses is available in the court record and need not be restated here. However, in general the interpretations regarding the impacts of federal reservoir operations on fish and wildlife resources consistently ignore annual changes in hydrology that have a real bearing on project releases. In particular, they ignore generally accepted realized changes in the seasonal pattern of rainfall between the pre-dam condition and the post-dam condition. These changes inherently impact the hydrology of the Apalachicola River regardless of the influence of Corps operations and therefore must also be considered when evaluating those impacts which are a result of Corps discretionary operations. This failure raises serious questions as to the relevancy of the FFWCC analyses and interpretation. Presumably, the FWS understood these inadequacies and thus did not adopt the FFWCC's interpretations. The Corps requests that FWS also re-visit their decision regarding their relevancy. Accordingly, we believe the impact analyses we provided, in accordance with the PAL guidance, are appropriate for evaluating the impacts of implementing the PAA.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Pg 13 – The FWS states that all models have limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. The FWS also provides again a statistical and qualitative analysis they conducted on the 2011 model data comparing observed and simulated data. The FWS cautions that interpretation of modeled hydrology focus on data trends, not on absolute magnitudes in comparisons of alternatives. These limitations are acknowledged by the Corps and are fully discussed in the DEIS.
With regards to the water quality analyses provided by the Corps, the FWS states "While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are lumped for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months". The Corps recognizes that a thorough understanding of the methodology used for the impact analysis is required to make interpretations or draw conclusions and again points out that the impact analyses were provided in accordance with the guidance provided in the FWS's PAL. Time series plots for the various water quality parameters are available and some are provided in the HEC-5Q modeling report included as an appendix to the DEIS.

The Corps acknowledges there are limitations and caveats associated with model development and use but do not agree that a misunderstanding of these demonstrates inadequacies of the model or its intended use. The HEC-ResSim and HEC-5Q models were evaluated to ensure that they exhibited the tendencies seen in the observed data and that they were sufficient to provide reasonable long-term estimates of water quantity and quality through the ACF system. The central focus of this modeling effort was to enable the EIS team to evaluate the differences in water quantity and quality between a continuation of the no action alternative and implementation of the proposed action. The Corps' internal model review process has conducted similar analyses to the one provided by FWS and agrees that the models produce a high degree of similarity for many of the water quantity and quality parameters at most locations. However, as the Corps has explained to the FWS on numerous occasions interpreting these differences as a deficiency on the part of the models is inappropriate. The HEC-ResSim and HEC-5Q models were not developed or ever intended to produce outputs that matched exactly the observed data. Given the multitude of operational variations that have occurred over the period of record when responding to real life situations (equipment malfunctions, gage errors, and approved variances to operating rules) it is not possible to produce such outputs in the HEC-ResSim model. In so much as the HEC-ResSim model provides flow data to the HEC-5Q model as an input it is also unreasonable to expect perfect correlation between the water-quality simulated data and the observed data. In addition, since daily discharge data and non-point source loading data are not available, the HEC-5Q model includes assumptions regarding these parameters and these assumptions were coordinated with the appropriate water supply providers and resource agencies to ensure they are reasonable. The benefit of using these models for these impact analyses is that they can simulate flow and water quality data with shared assumptions so that the only modeled difference between the alternatives can be accurately interpreted as impacts associated with a change in operations (i.e., implementation of the proposed action). Given that this is what our respective agencies are trying to evaluate, the Corps believes the models are uniquely qualified and appropriate.

Dissolved Oxygen

Pgs 14/15 and Pg 30 – The Corps acknowledges the stated DO impacts. However, it should be emphasized, as noted by FWS, simulated DO results between the PAA and NAA were similar with small differences between the alternatives being realized at low occurrence levels. For reasons discussed previously, modelled results should be broadly compared between alternatives and were not intended to provide absolute results for specific locations and conditions such as those noted downstream of Buford Dam. We note that the PAA and NAA results were generally similar, albeit where low DO currently exists that condition would likely continue in the PAA. While dissolved oxygen levels downstream of Buford Dam and West Point Dam are depressed at times as a result of hydroelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas as a result of low dissolved oxygen conditions. In the past, the Corps has made efforts to improve DO levels below the Federal projects with varying degrees of success. For example, during a major rehabilitation of all three hydropower generation units at Buford Dam during 2003 and 2004, self-aspirating turbines were installed to improve dissolved oxygen levels immediately downstream. The Walter F. George Lock and Dam project has experienced recurring instances of stress in the tailrace fishery and occasional fish kills due to low dissolved oxygen. Accordingly, USACE has implemented a SOP, established in 1988 and updated in 1993, to address conditions at the Walter F. George project when low dissolved oxygen values are observed in the tailrace. The SOP calls for spillway gates to be opened in accordance with a specific protocol until dissolved oxygen readings return to an acceptable level. Spillage siphons have also been constructed on the dam that can be used in lieu of spillway gate discharges.

As previously discussed with the FWS, studies to consider structural modifications to the Federal projects in order to improve DO and/or operational changes that result in serious impacts to one or more of the other authorized project purposes (such as significantly reducing or eliminating hydropower operations) are outside the scope of the WCM update. Furthermore these actions would require additional study authority and appropriation.

Water Temperature

Pg 15 and Pgs 30/31- The Corps agrees with the statements regarding the importance of water temperatures and with the conclusion that slight differences exist between the NAA and PAA. However, the Corps questions whether a 0.25-0.5°C increase in water temperature between Buford Dam and Norcross is biologically significant to the coldwater fishery in this reach. It is not clear from the GDNR or FWS comments whether or not the NAA or PAA result in water temperature conditions in the river segment between Buford Dam and West Point Lake incapable of supporting the trout and striped bass, and shoal bass fisheries. Both agencies appear to favor a coldwater fishery to support non-native trout in the reach between Buford Dam and Morgan Falls, which currently exists and note the importance of cool water refugia to the survivability of adult striped bass. Both agencies also appear to support warmer water temperatures downstream of Morgan Falls for the native shoal bass. The impact analysis conducted by the Corps, acknowledges that minor temperature deviations may occur, but suggests that the proposed action will at worst maintain the current water temperature regime at critical transition zone locations below Morgan Falls Dam and may result in slightly warmer water temperature in this reach. The FWS notes that cold water conditions during the spring have been identified as a limiting factor to striped bass spawning and egg/larvae survival near Morgan Falls Dam. Based on the current analysis, it would appear that the Corps' NAA and PAA do support both a coldwater fishery above Morgan Falls Dam and a warmwater fishery below it despite the many variables impacting water quality in this reach that the Corps has no control over, such as, nonpoint stormwater runoff from impervious surfaces in tributary watersheds. From the DFWCAR comments, it is not clear what the recommendation is for the Corps to better manage water temperature in the reach.

Wastewater

Pg 15 and 32 – The Corps believes, that the HEC-5Q water quality model is a quantitative model that describes water quality changes in response to flow management alternatives and has provided the water quality analyses prescribed in the FWS's PAL accordingly. The Corps agrees that evaluating percent wastewater can provide additional insight for interpreting the water quality data and has provided it in accordance with the FWS's PAL guidance. The higher percent wastewater observed between Atlanta and West Point Dam under the PAA simulation is not surprising since more water is being utilized for water supply and more is being returned as wastewater. Improved treatment and conservation measures in the future could alleviate some of the negative impacts to the aquatic environment associated with the percent wastewater evaluation. This is supported by statements from GDNR in the Chlorophyll- α section where they note that "nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements over the past two decades".

Chlorophyll-α

Pg 15 and 32– As described in the wastewater section above, increased water withdrawals from the Chattahoochee River to meet the needs of metropolitan Atlanta communities would result in a corresponding increase in treated wastewater returns to the river between Atlanta and West Point Lake. The impact analysis showed that the PAA would result in increased loadings of total phosphorus that would have a substantially adverse effect on water quality. The substantially adverse effects would also be expected downstream of West Point Lake to the headwaters of Walter F. George Lake. The adverse water quality effects in these portions of the Chattahoochee River would principally be associated with increased treated wastewater discharges to the river rather than USACE project operations. The Georgia Environmental Protection Division (GEPD) may require changes to discharge permits for some facilities. The Corps acknowledges and agrees that the PAA will result in relatively small increases in Chlorophyll-α throughout the river system in response to increased wastewater returns and associated nutrient loads. However, the Corps questions the biological significance of a 1-5 μg/L increase in Chlorophyll-α. The Corps also notes that GDNR has suggested that minor increases in Chlorophyll-α may be beneficial to the reservoir fishery.

Reservoir Retention Time

Pg 16 and 32 - The Corps believes it provided the requested information to the FWS in the response to PAL. The April 2, 2010 PAL requested that for each alternative the "average summer retention time (days)" should be evaluated. The PAL defines summer values as May through October. The Corps provided the monthly retention times for the water quality model period (2001 through 2011) at each of the Federal reservoir projects in tabular format. At the end of the table, an overall median retention time for each reservoir is provided as well as median and average retention times for the months of April – October (note April-October corresponds with the GEPD definition of growing season and includes the May-October growing season defined by the FWS). This data demonstrates that the average summer retention time at Lake Lanier under the PAA increased by 6 days; at West Point Lake it increased by 3 days; at Walter F. George Lake it decreased by 1 day; and that there was no difference in the average summer retention time at George W. Andrews and Lake Seminole.

Phosphorus

Pg 16 and 32 – The Corps acknowledges and agrees that the PAA will result in increased phosphorus throughout the river system. The higher phosphorus observed between Atlanta and West Point Dam under the PAA simulation is not surprising since more water is being utilized for water supply and more is being returned as wastewater. This increased loading is passed through the system. Improved treatment and conservation measures in the future could alleviate some of the negative impacts to the aquatic environment associated with elevated phosphorus loads. This is supported by statements from GDNR in the Chlorophyll- α section where they note that "nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements over the past two decades". The Corps also notes that GDNR has suggested that increases in phosphorus may be beneficial to the reservoir fishery. Notwithstanding this, the Corps generally agrees that increased phosphorus loads would be considered a negative impact.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

Pg 17 and Pgs 32/33 – FWS notes that the annual maximum 30-day growing season floodplain connectivity is essentially the same for the PAA and the NAA. However, they state that it is unknown whether the calculation is for consecutive days and point out that the Corps used the period from April through Sept, not October as specified in the Floodplain Spawning Habitat Performance Measure (FSHPM). The Corps inadvertently labeled the seasonal period as April – September rather than October. The Corps utilized the FSHPM Excel workbook developed by the FWS to analyze this performance metric. Therefore, the analysis should be consistent with what the FWS was seeking. The various workbooks used to create the charts provided in the response to PAL were provided to the FWS in March 2015. The Corps agrees with the statement that there would be little difference in floodplain connectivity in the Chattahoochee River.

Reservoir Fisheries

Pg 17-19 and 33 – The Corps utilized the Reservoir Fisheries Performance Measure (RFPM) Excel workbook developed by the FWS to analyze this performance metric. In response to GDNR comments, FWS stated they continue to recommend use of the RFPM. Therefore, the RFPM analysis provided in the Corps' response to PAL is sufficient. The Corps agrees with the statement that there would be low potential for realized fisheries differences between the two alternatives.

Riverine Fisheries

Pg 19 and 33 – The FWS's PAL addendum provided revised low and high flow guidelines based on the pre-dam gage data or simulated pre-dam conditions where gage data were not available. In developing the revised low flow guidelines the FWS used the 10th, 25th, 50th, 75th, and 90th percentiles for each month to define the lower limit, dry year, average year, wet year, and upper limit, respectively. The Corps agrees with this approach and notes that the 2015 response to PAL provides a monthly flow statistics analysis of the simulated NAA and PAA depicting this information at numerous locations throughout the basin. The Corps response to PAL did not include a comparison of these simulations to the FWS's revised low flow guidelines. To the extent this analysis is still desired the Corps will provide it during the DEIS public review period.

Chattahoochee River Shoal Bass Recruitment: FWS notes that the Corps utilized water temperature data simulated by HEC-5Q for the various alternatives rather than the relationship of observed flows and water temperature utilized in the FWS's Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM). The Corps previously discussed this change with FWS due to the relatively small data set (during drought conditions) used to develop the relationship in the FWS's CRSBPM. The Corps believes the use of the simulated water quality data that considers multiple influences on water temperature rather than just observed flow-temperature relationships provides a more robust analysis. The FWS notes that although HEC-5Q produces lower temperatures than the FWS methodology as a function of discharge the Shoal Bass abundance trend should remain the same. The FWS determined that the PAA results in a higher abundance of shoal bass than the NAA. The Corps agrees with this assessment.

Federally Protected Species

Pg 20 and 33 - Gulf Sturgeon

Frequency (% of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning. – The Corps utilized the SSHPM Excel workbook developed by the FWS for this analysis. The Corps' response to PAL noted that there were no differences between the NAA and PAA. The Corps provided the workbook supporting this determination in March 2015.

Frequency (% of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year,) March 1st through May 31st, at the two sites that support spawning. – The Corps utilized the SSHPM Excel workbook developed by the FWS for this analysis. The Corps provided the workbook supporting this determination in March 2015.

Daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. – The Corps agrees that daily fall rate results provided for the listed mussel species are specific to flows less than 10,000 cfs. The Corps notes that under the RIOP, fall rates are not limited for flows over 30,000 cfs consistent with safety requirements, flood control purposes, and equipment capabilities. The Corps also notes that the NAA and PAA include operational provisions that ensure river stage declines of 8 feet or more will not occur in less than 14 days when river flows are less than 40,000 cfs (March-May). This provision was developed by the FWS and the Corps to avoid any adverse effects to Gulf sturgeon during the spawning season. In the past this provision has satisfied the FWS's concerns regarding daily fall rates during the Gulf sturgeon spawning season. To the extent additional analysis is needed to evaluate daily fall rates and potential exposure of Gulf sturgeon eggs and larvae the Corps will work with FWS during the Section 7 consultation for the PAA.

Maximum number of consecutive days per year less than 16,000 cfs. – The Corps will provide the requested analysis during the Section 7 consultation for the PAA.

Departures from average water temperatures between March 1st to May 31st. – The Corps agrees with the FWS assessment.

While the Corps continues to believe that the information provided generally indicates that there will not be adverse impacts to the Gulf sturgeon, we acknowledge that additional information will be provided during the Section 7 consultation for the PAA.

Pg 21and Pgs 33/34 - Freshwater mussels

The FWS identified several flow parameters that could result in adverse impacts to mussels. Comparing these parameters individually and collectively, FWS stated that the PAA would result in flows that could have adverse impacts including increased mortality to mussels. The Corps agrees with this assessment and will continue to work with the FWS to evaluate impacts to listed mussel species during the Section 7 consultation for the PAA.

Analyses of Apalachicola Bay

Pgs 23-28 and 34 – The FWS states they used a combination of sources to evaluate effects to Apalachicola Bay. Taken together, the sources cited are inconclusive and the Corps disagrees that they suggest differences between the NAA and the PAA with regards to salinity levels in the bay and associated impacts.

FWS noted the HydroLogics Apalachicola Bay salinity model results (2012) indicate very limited differences between the RIOP and the then-proposed modifications to the RIOP. However, FWS did not relate that finding to the current proposed action. The Corps notes that the PAA and NAA simulated releases at Jim Woodruff Dam are similar and would likely yield the same conclusion if input to the HydroLogics Apalachicola Bay salinity model.

FWS stated that they relied on three lines of evidence for the suggested differences:

1. *The Apalachicola Bay Salinity Performance Measure (ABSPM)*. The FWS states that the ABSPM indicates a 1 part per thousand (ppt) increase in median salinity at East Bay (no difference at Cat Point and Dry Bar). The FWS acknowledges that differences among alternatives analyzed to date are relatively minor and states it may be due to the coarse temporal scale of the metric or the possibly that substantial changes in the bay salinity metric require large amounts of water. Given the small magnitude of the difference (1 ppt) and coarseness of the metric, the Corps questions the validity of the conclusion that the PAA negatively impacts salinities in the bay and juvenile Gulf sturgeon. The FWS also notes that fine resolution models of bay salinities also show little salinity differences between alternatives. Based on the FWS's assessment of the fine resolution models the Corps again questions the validity of the conclusion that the PAA negatively impacts salinities in the bay and juvenile Gulf sturgeon.

2. *Estuary Inflow Analysis*. In this analysis the FWS evaluated changes in estuary inflows using results from the Apalachicola River Mussel Performance Measure (ARMPM) and the salinity-discharge relationships in the ABSPM. The analysis did not compare bay salinities resulting from the NAA and PAA but rather assessed the change in salinity at incremental low flow discharges realized under the PAA. The Corps previously expressed concern over the use of the ABSPM due to the relatively weak correlation of the regression relationships the ABSPM uses to compute bay salinities. This analysis utilizes those same relationships. Therefore, the Corps does not agree that this line of evidence supports the suggested differences between the NAA and the PAA with regards to salinity levels in the bay.

3. The third line of evidence once again uses the ABSPM to compare the PAA bay salinities to one of the Corps' alternatives developed in 2011 (Alt2). The FWS noted that the 2011 flows were similar to the PAA flows and based on the results of the ABSPM determined that the PAA produced similar salinities to those generated from the 2011 alternative. The FWS therefore expects that the 3D salinity model for the PAA may produce similar salinity and oyster growth rate results as the 2011 (Alt2) 3D salinity model. If this assumption is true, then it stands to reason that the FWS' ongoing 3D salinity modeling will demonstrate that there is little difference in salinity or oyster growth rates between the NAA and PAA as this was the conclusion of the FWS in 2011 for the various alternatives considered (which included the same NAA and Alt2). The Corps does not see how this line of evidence supports the suggested differences between the NAA and the PAA with regards to salinity levels in the bay since the 2011 salinity modeling did not demonstrate a difference between alternatives.

   The FWS included information from their 2011 DFWCAR that they determined was relevant to the interpretation of the Apalachicola Bay salinity modeling and oyster and sturgeon responses. On pg 26 this information includes a discussion of the effects of the bay relative to historic operations. The Corps notes that the FWS omitted the actual discussion of the effects relative to historic operations. It is provided below in order to set the context for the Corps' response to the FWS's assessment of why those effects occurred.

> "There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data. However, in general, the Corps' simulated flow scenarios resulted in salinities that had slightly higher highs and lower lows than salinities estimated using Sumatra discharge data. Oyster growth rates were also slightly lower in the Corps' modeled scenarios compared to the observed Sumatra discharge data, especially in August, which is considered the peak growth period for oysters in Apalachicola Bay (Huang 2010). Similarly, the amount of habitat available for Gulf sturgeon was slightly lower in the no action and proposed action alternatives than the observed discharge data at Sumatra."

In the 2011 DFWCAR the FWS correctly states that "There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data". However, they incorrectly assume that these differences are entirely a result of changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives. Some or all of these differences are attributable to the comparison of modeled salinities based on observed river flows to those produced by the HEC-ResSim model. The 2011 (and 2015) HEC-ResSim model includes standardized assumptions regarding consumptive demands that include the highest demand year (2007). These levels of consumptive demand did not actually occur during the period used for the simulated salinities, but were selected by the Corps for the HEC-ResSim model because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands. It is inherent that these increased demands would result in lower simulated flows in the Apalachicola River than those observed, especially during the summer peak growth period for Oysters. For this reason, the appropriate analysis to focus on regarding impacts to Apalachicola Bay is the comparison of the simulated no action and proposed action alternatives which include the same assumptions regarding consumptive demands. When this is done, the negative impacts to oysters and Gulf sturgeon habitat are no longer realized.

The Corps is willing to consider additional impact assessments for juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species should the Fish and Wildlife Resources Agencies identify the appropriate analyses to utilize.

In the cited 2011 DFWCAR, the FWS recommends that the Corps "capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion". The DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. However, the Corps does not agree that it is responsible for minimizing or mitigating the impacts of salt water incursion resulting from these phenomena.

EVALUATION OF THE SELECTED PLAN

The Corps notes that the scoring of impacts (Table 2) technique utilized by the FWS to compare the PAA to the NAA is similar in design to the technique developed by the Corps to compare water management alternatives during phase I of the alternative formulation, which the FWS believes to have significant problems. In Table 2 the FWS determined that the Corps has not adequately evaluated the impacts to Reservoir Retention Time, Instream Flow Guidelines, and Gulf sturgeon. The Corps response to the EVALUATION OF THE SELECTED PLAN is provided in the relevant sections above.

SUMMARY AND FWS POSITION

Pg 50/51- The FWS provided six bulleted points summarizing its reasons for not fully supporting the PAA. Five of the bulleted points are reiterations of concerns raised earlier in the DFWCAR and were addressed in the discussion preceding this section. One concern that warrants further consideration is that of the Corps' alternative selection process which was described in a separate document (Appendix XV). The following summarizes the nature of that concern and provides the Corps' response. The document is unnumbered, so page 1 refers to title page of Appendix XV, *Problems regarding United States Army Corps of Engineers (Corps) alternatives selection process for the Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) update*.

Pg 2 – The FWS states three major concerns with the Corps water management ranking methodology.

1. *Small differences within project purposes are treated the same as large differences. FWS gives examples*. The Corps used a straightforward and transparent approach to ranking the alternatives. Since the Corps treats all authorized project purposes as equal, it would not be appropriate to weight some project purposes more than others. The Corps acknowledges that relatively small differences occurred between some of the alternatives. However, the Corps maintains that the HEC-ResSim model is capable of simulating these small differences and that these small differences may be significant to the relevant stakeholder for that resource. For example, small differences in hydropower production may translate to millions of dollars when comparing alternatives. Using a more robust statistical approach that scores and ranks alternatives with small differences the same fails to account for this.

2. *An incomplete set of fish and wildlife performance measures was used to score and then rank alternatives for the Fish and Wildlife project purpose.* Because the Corps used an equal ranking methodology, the number of performance measures for a particular project purpose becomes irrelevant. While the choice of the most appropriate performance measures is relevant, when averaged, a single number representing each project purpose is used in the final ranking. Because of the huge number of potential summary statistics that can be developed from a HEC-ResSim and HEC-5Q output dataset, along with other performance measures suggested by FWS, it becomes unfeasible to use more than a few

to represent the fish and wildlife project purpose. The Corps chose a number of performance measures that it believed represented the fish and wildlife project purpose.

3. *There is no consideration regarding the uncertainty or precision of model output in the Corps' ranking process.* This concern is essentially the same as number 1. Whether performance metrics are weighted according to magnitude of differences or analyzed statistically to compare those differences, both attempt to address the concern that small differences are treated the same as large differences. The Corps believes the ranking methodology has adequate precision to rank water management alternatives. It would go beyond the intent of the ranking of alternatives to attempt to use statistical comparisons in this case.

In summary, the Corps believes that the PAA balances all authorized project purposes including fish and wildlife conservation. We believe that the currently proposed alternative including the management of the water resources over which the Corps is responsible and for which the Corps has authority, would have little adverse impact to fish and wildlife resources compared to the existing condition. The Corps appreciates the FWS efforts in preparing the DFWCAR and looks forward to continuing cooperation.

In regards to the FWS statement that "the Service needs to be an integral member of the Corps' team when formulating and evaluating operational alternatives" the Corps acknowledges the benefits of collaborating with other agencies. However, due to the fact that a WCM update is inherently a Corps function, the nature of this being an operational change, and in view of ongoing litigation at the beginning of the process, it was decided not to involve other entities as Cooperating Agencies. The Corps will continue to include participation with FWS as much as possible under current authorities.

A Preliminary Report: "Simulating the response of estuarine salinity in Apalachicola Bay"

This page intentionally left blank

A Preliminary Report: "Simulating the response of estuarine salinity in Apalachicola Bay"

by

Vladimir A. Paramygin and Y. Peter Sheng

Coastal and Oceanographic Engineering Program

Engineering School of Sustainable Infrastructure and Environment

University of Florida

for

U.S. Fish and Wildlife Services

November 5, 2015

Contents

Introduction

The response of salinity in Apalachicola Bay, Florida to changes in water management operation alternatives is studied using an integrated hydrodynamic modeling system and probability analysis. Flow and salinity in the Apalachicola Bay are simulated with a CH3D-based modeling system, using a high spatial resolution estuarine domain and input from river inflow, ocean forcing, as well as forcing by a US Navy NOGAPS atmospheric model. The hydrodynamic model is verified with long-term water level and salinity data, including during the 2004 hurricane season when four hurricanes impacted the system. Strong freshwater flow from the Apalachicola River and good connectivity of the bay to the ocean allow the estuary to restore its normal salinity condition within a few days after a hurricane passage. Table 1 shows several scenarios (all spanning a period of 10 years) that differ in freshwater inflows at the Apalachicola River are analyzed. One of these is based on actual observed data, and three others (A1, A2, and A3) represent different consumption modes and respective ACF Basin hydrology and reservoir operations, provided to us in 2013. For a 10-year historical scenario, simulated long-term salinity agrees well with the observed values at stations. For two scenarios that reflect an increased water demand (~1%) upstream of the Apalachicola River, model results show slightly (less than 5%) increased salinity and decreased oyster growth rate inside the Bay. Two new scenarios (B1 and B2) are provided to us by the US FWS in 2015.

Table 1. Characteristics for the flow rates at the Sumatra gage

Scenario	Mean (cfs)	Standard deviation (cfs)	Minimum (cfs)	Maximum (cfs)
Base	18,334	14,529	4,400	166,000
A1	18,165	13,819	4,817	140,049
A2	18,217	13,821	4,817	140,049
A3	18,236	13,810	4,817	140,049
B1	18,308	14,134	4,817	168,939
B2	18,293	14,158	4,817	168,932

Observed data for model validation

Water level data (relative to the NAVD88 datum and with 6-min temporal resolution) is obtained from the NOAA (National Oceanic and Atmospheric Administration) CO-OPS (Center for Operational Oceanographic Products and Services) station NOS-8728690 located near the mouth of the Apalachicola River (Figure 1). NOAA also provides predictions of the tides based on the analysis of tidal constituents at the site, which is useful in identifying how well the model represents the tides. Regional tides are relatively low with three constituents (M2, S2 and K1) dominating the tidal signal.

The bay features several data collection sites that measure salinity, temperature and nutrient data. Salinity records are available at several locations near oyster bars: Cat Point, Dry Bar and East Bay (Figure 1) from 2002-2007. Near-surface salinity observations are available at 30-minute and 15-minute intervals depending on the time of collection.

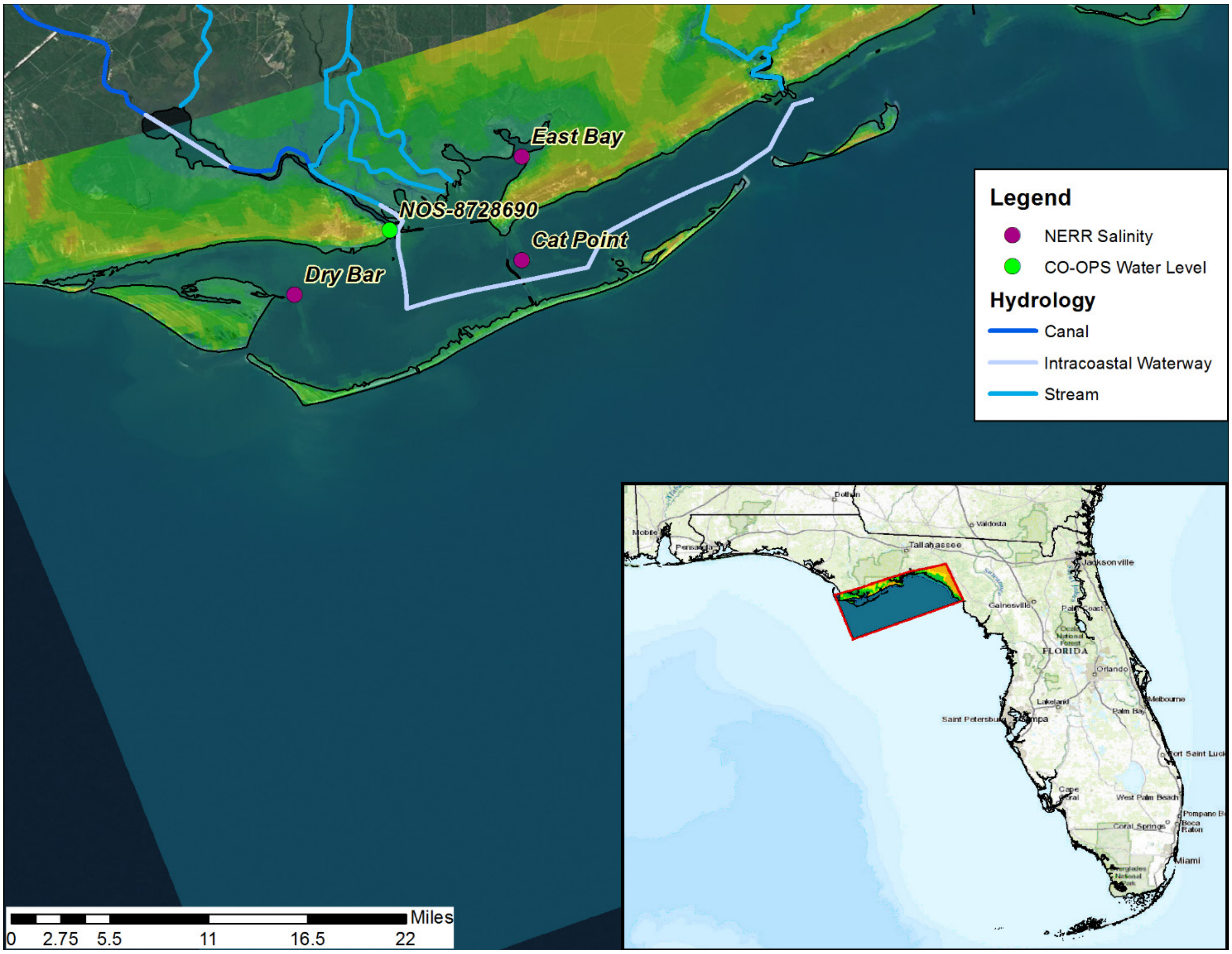


Figure 1. Apalachicola Bay system, data stations and CH3D model grid (outlined in red)

The Integrated Modeling System - Description and Setup

The hydrodynamic modeling system used in this study is based on the CH3D (Curvilinear-grid Hydrodynamics in 3D) model (Sheng 1987, Sheng 1990). CH3D had been used in numerous studies of complex shallow estuaries including Indian River Lagoon, Tampa Bay, Sarasota Bay, Roberts Bay, Florida Bay, Charlotte Harbor, West Florida Shelf, St. Johns River, Lake Okeechobee, and Lake Apopka, etc. (e.g. Sheng 2000, Sheng et al 2002, Sheng et al 2008, Sheng and Kim 2009. Kim et al. 2010).

CH3D uses a non-orthogonal horizontally boundary-fitted curvilinear grid and a vertically terrain-following sigma grid that accurately resolve coastal and nearshore waters with complex shoreline and bathymetry. The model contains a robust turbulence closure model (Sheng and Villaret 1989, Sheng et al. 2012) which enables accurate simulation of turbulent mixing and stratified flows. A fully integrated modeling system ACMS (Advanced Coastal Modeling System, formerly split into two subsystems: CH3D-IMS and CH3D-SSMS) has been developed and applied to several estuarine systems including the Indian River Lagoon (Sheng 2000, Sheng et al. 2002, Sheng and Kim 2009), Tampa Bay (Sheng 2003), and Charlotte Harbor (Kim et al. 2010). ACMS includes coupled models of circulation, wave, sediment transport, water quality, light attenuation and seagrass biomass. In addition, it has been used for simulations of storm surge and coastal inundation (Sheng et al. 2006, 2010a, 2010b). This modeling system is able to simulate 3D baroclinic flow with wetting and drying. It has the capability to use spatially and temporally varying wind fields such as tropical storms. It is also coupled to a wave model (Sheng and Liu 2011) and has the ability to obtain boundary conditions from a variety of sources including basin-scale models.

The computational grid developed for the bay and surrounding areas to simulate the salinity distribution is shown in Figure 2. The grid is 456 by 161 cells with the minimum cell size of 94 m and the average cell of 400 m. CH3D is coupled to the HYCOM (Bleck 2002, Chassignet et al. 2003) model for the entire Gulf of Mexico which provides time varying salinity at the open boundary. HYCOM is a generalized (hybrid isopycnal/σ/z) coordinate in vertical and curvilinear in horizontal direction ocean model. It is isopycnal in the open stratified ocean, but reverts to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates near the surface in the mixed layer. This generalized vertical coordinate approach is dynamic in space and time via the layered continuity equation, which allows a dynamical transition between the coordinate types. The Gulf of Mexico model has 1/25° equatorial resolution and latitudinal resolution of 1/25° cos(lat) or ~3.5 km for each variable at mid-latitudes and uses 20 vertical layers.

The domain has two open boundaries – at the west and south ends of the model grid (Figure 2) where tidal forcing is applied based on eight tidal constituents that are adjusted to match the predicted tidal water level at the NOAA station at that location. Open boundary salinity is obtained from the Gulf of Mexico HYCOM model for the period starting in 2003 and assumed as constant (34 ppt) before 2003 due to the lack of HYCOM data prior to that. The wind forcing is based on atmospheric data from the NOGAPS (U. S. Navy's Operational Global Atmospheric Prediction System) Model (Rosmond and Thomas, 1992).

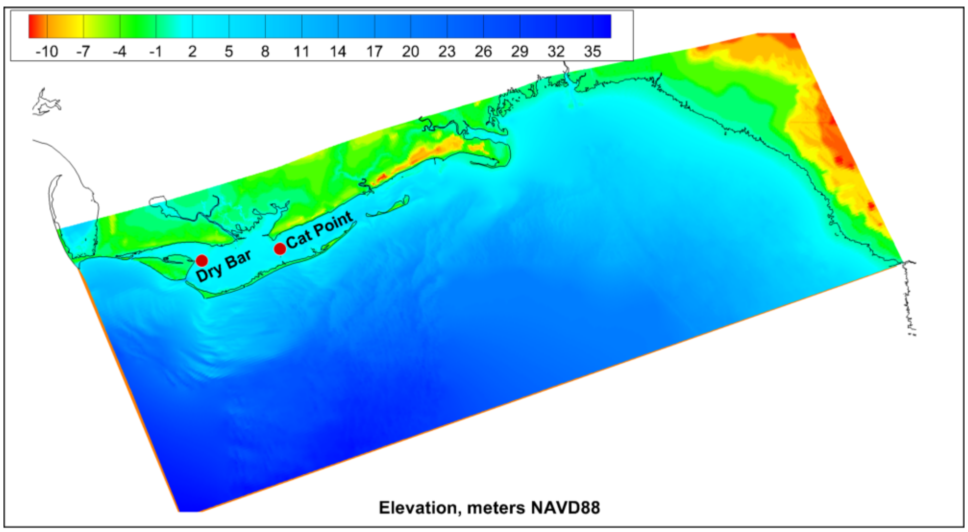


Figure 2. CH3D model grid bathymetry / topography, the orange lines at the south and west ends of the domain denote the model open boundary.

River Flow Scenarios

Freshwater inflow is introduced at the Apalachicola River based on the actual observed daily data from the Sumatra gage (Base Scenario) and several different daily flow rates provided by the USACE ResSim (Reservoir System Simulation) model representing the ACF Basin hydrology and reservoir operations. Table 1 shows the Baseline scenario plus three scenarios (A1, A2, and A3) provided to us in 2013 and two provided to us by US FWS in 2015: B1 (NOACTIONAX0) and B2 (ALT7_OPTHX0) shown in Figure 4.

The model is initialized using observed values of water level and salinity in October 1998, and the three-month period of October-December of 1998 is used as a spin up period for the model.

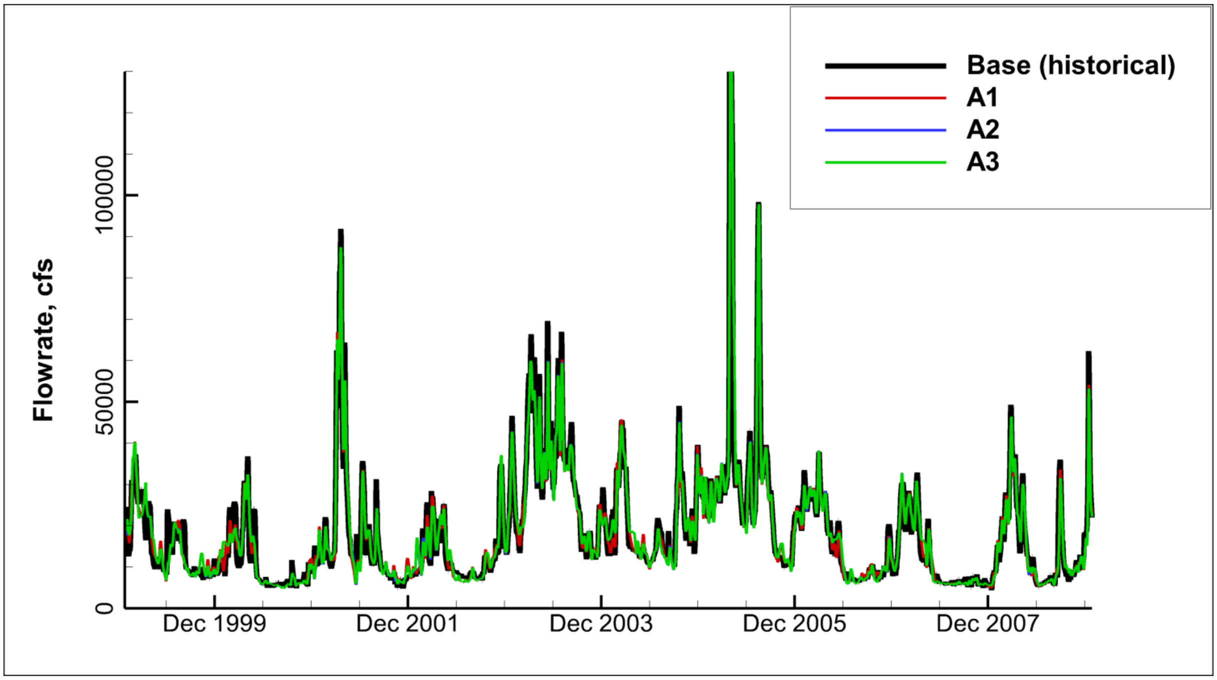


Figure 3. Flowrates for scenarios A1-A3

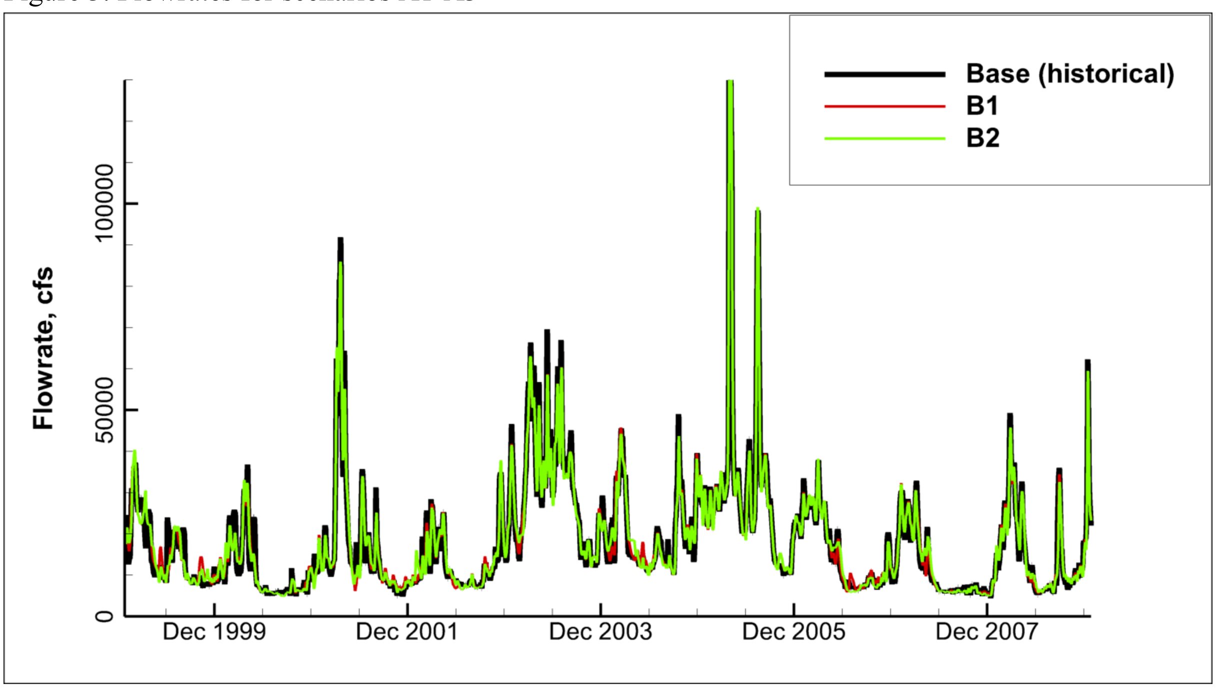


Figure 4. Flowrates for scenarios B1, B2

Model verification – Salinity during 2004

Simulated water level and salinity in 2004, a year during which four hurricanes (Dennis, Frances, Ivan and Jeanne) affected the area, are compared to observed data. Comparison of simulated water levels with 6-

minute data at the CO-OPS station at the mouth of the Apalachicola River gives a correlation value of 0.97. Simulated salinity values for the Base Scenario (historical data) compare well with observed salinity data at several ANERR data stations inside the Bay (Figure 5, Figure 6). Values of the root mean square (RMS) error and the correlation coefficient can be found in Table 2. It is believed that the reason for poorer comparisons at the East Bay station is the lack of flow data in the smaller streams around the East Bay location as salinity at this stations tends to be overestimated by the model due to the lack of sufficient fresh water inflow.

Table 2. Estimation of simulation error.

Station	Root mean square error	Correlation coefficient
Cat Point	1.3	0.87
Dry Bar	1.6	0.82
East Bay	2.4	0.71

Salinity at the ANEER stations shown in Figure 5 show salinity fluctuating between 3 ppt and 34 ppt. During the January and February periods salinity at both stations decreased due to the relatively large freshwater inflow from Apalachicola River. During the four major hurricanes, salinity initially decreased due to the increased precipitation and river inflow but quickly recovered to the pre-storm salinity values, due apparently to the good connectivity between the Apalachicola Bay and the ocean. In September of 2004 three tropical storms had a significant effect on salinity in the Bay – Hurricanes Frances, Ivan and Jeanne. Simulated salinity in the bay around the time of the storm indicates that it takes on the order of one to two weeks for the estuary to recover from the impact of the storm and restore the salinity regime established prior to the storm. This is consistent with the 3-9 days typical residence times found by Huang and Spaulding (2002) and can be attributed to a number of factors such as connectivity to the Gulf, large fresh water inflow from Apalachicola River and shallow depths in the bay.

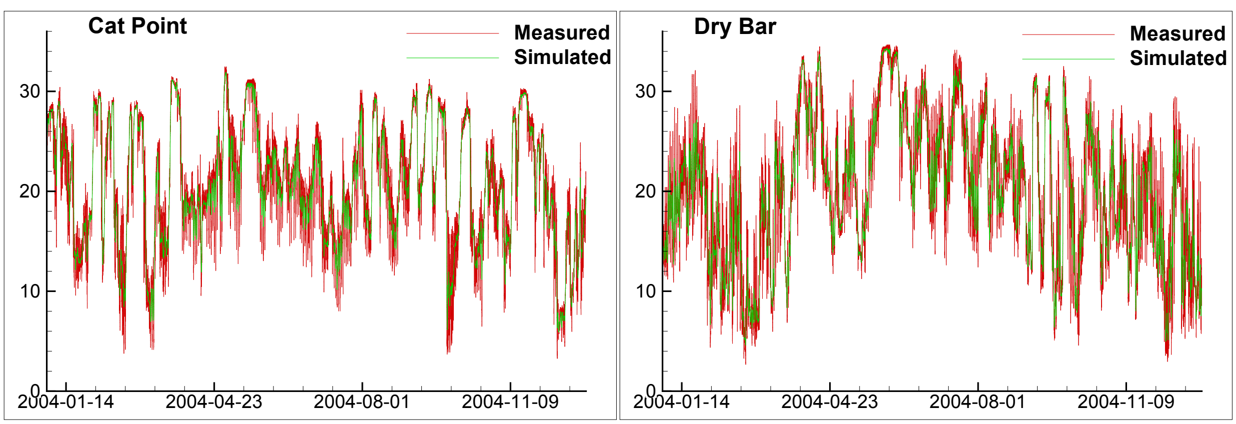


Figure 5. Simulated salinity at Cat Point and Dry Bar stations during 2004

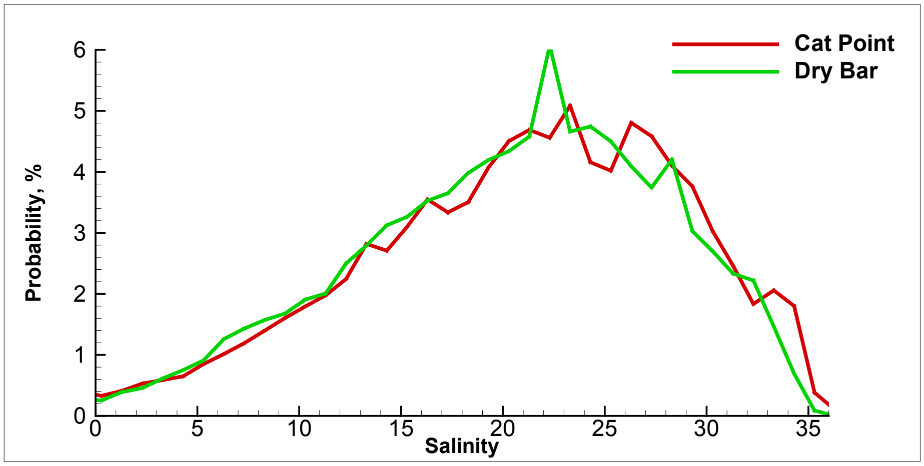


Figure 6. Probability distribution of salinity at Cat Point and Dry Bar

Model results for 1999-2008 period

Six scenarios of Apalachicola River discharge are considered for model simulations. Base Scenario, which uses the observed flow rates at the Sumatra gage provided by the USACE, serves as a reference for comparisons. All model parameters and forcing, except for this river flow rate, remained the same for all scenarios.

The simulated salinity results for the two scenarios provided by the FWS in 2015 look very similar to the historical (base) scenario, in fact they are slightly closer to the historical than the previous scenarios (A1-A3) developed by the USACE.

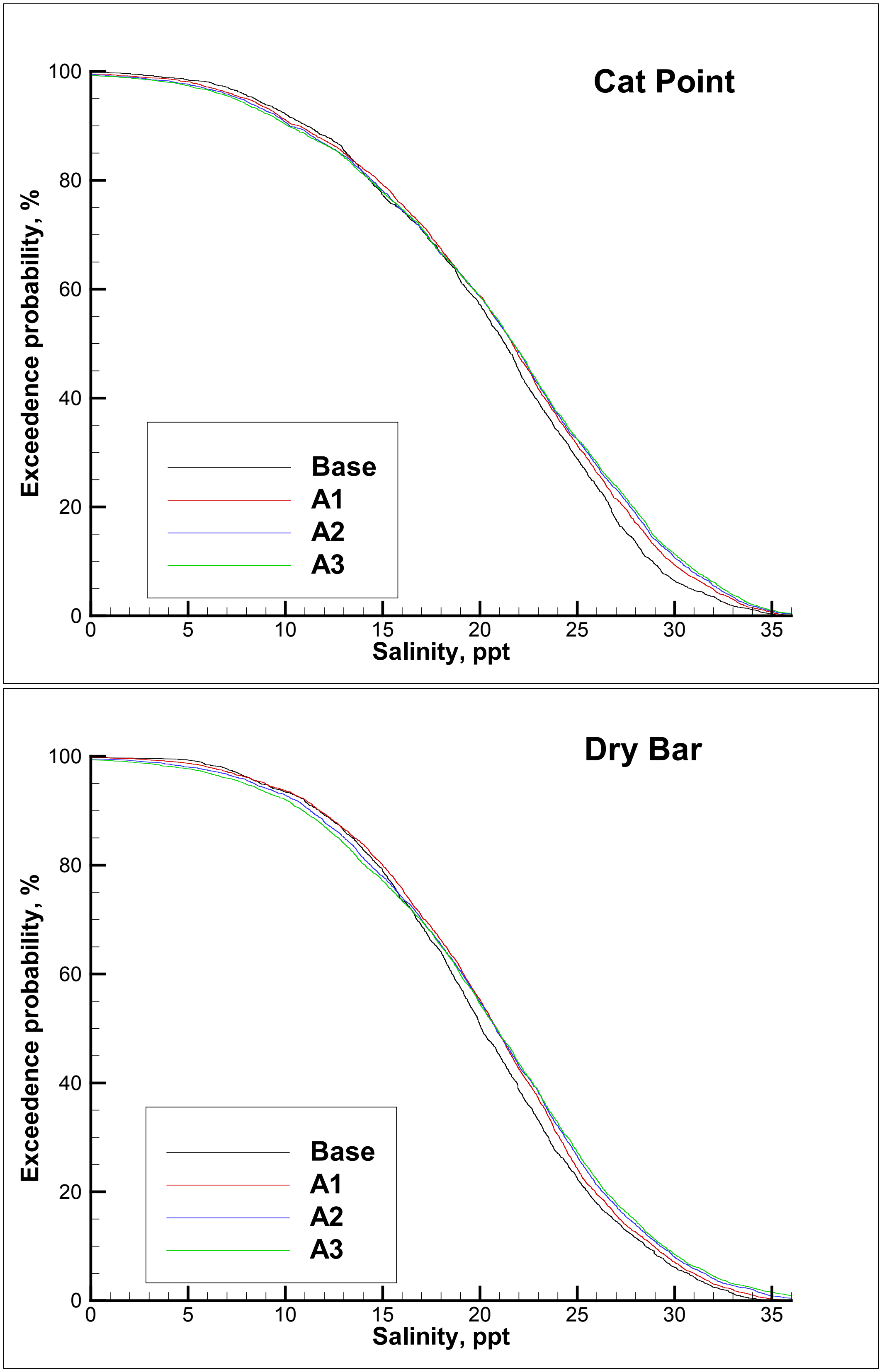
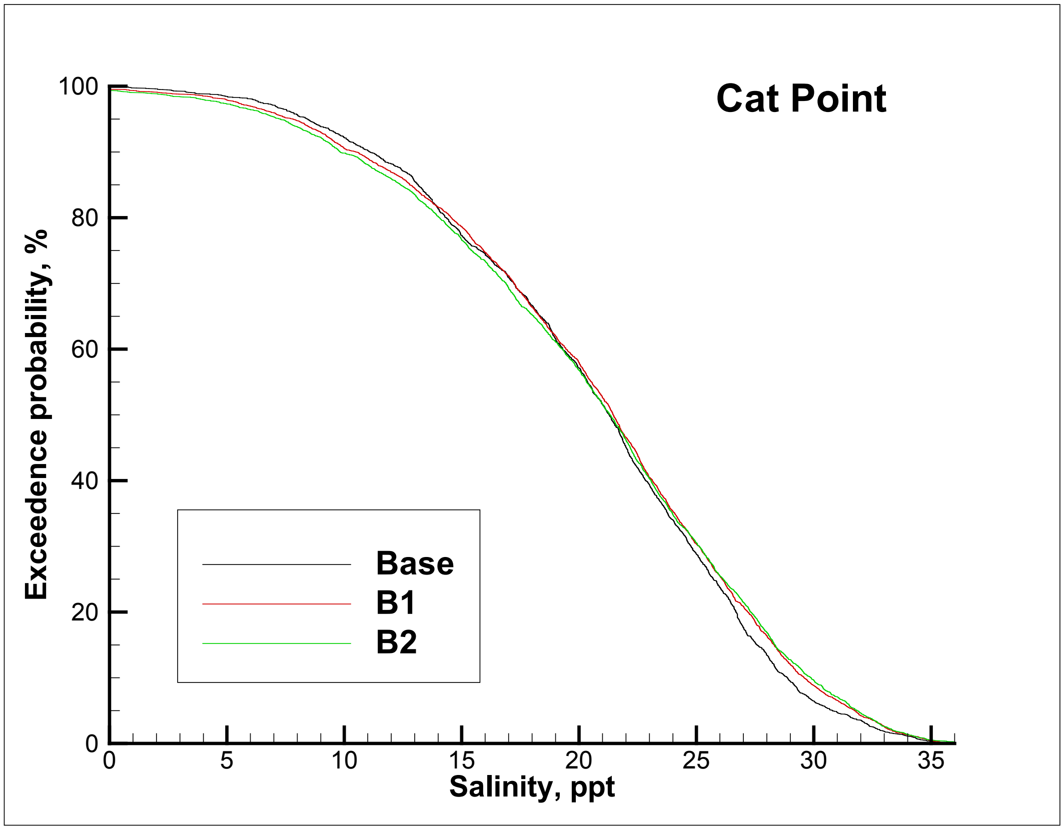


Figure 7. Exceedance rate of daily average salinity at Cat Point and Dry Bar stations for prior river flow scenarios (A1-A3)



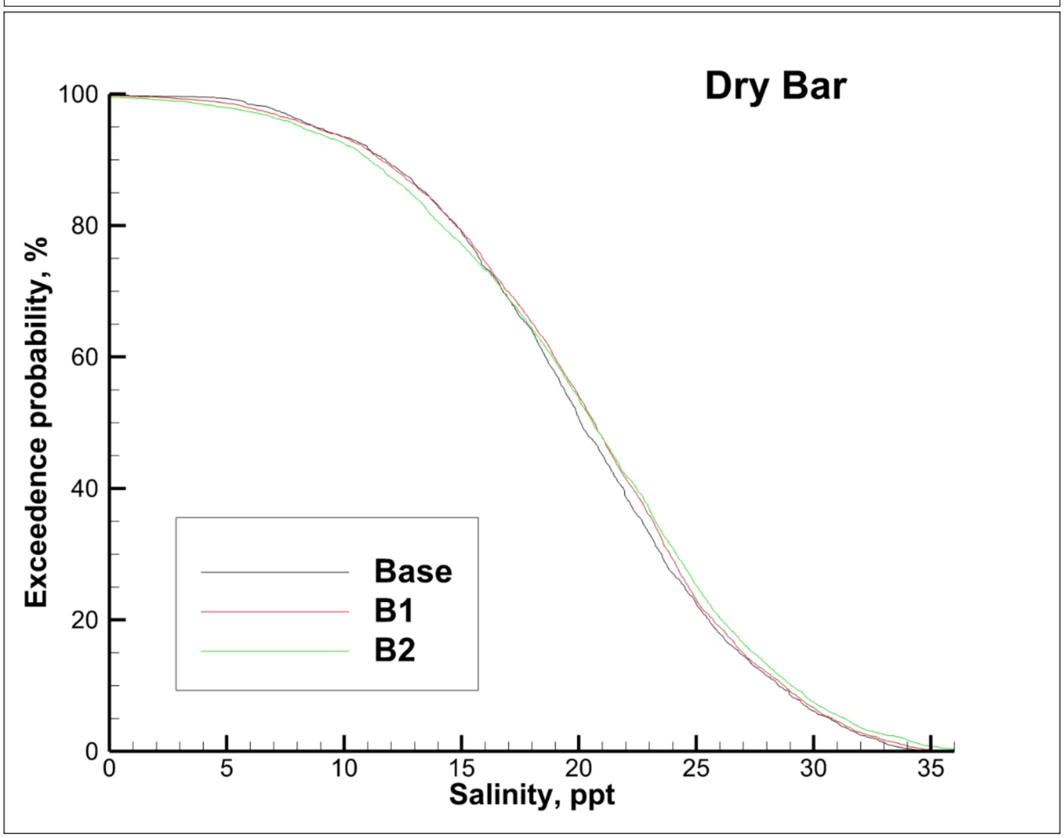


Figure 8. Exceedance rate of daily average salinity at Cat Point and Dry Bar stations for current river flow scenarios (B1, B2)

References

Altinok, I. and J.M. Grizzle. 2001. Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. Journal of Fish Biology 59:1142–1152.

Bleck, R., 2002. An oceanic general circulation model framed in hybrid isopycnic-cartesian coordinates. Ocean Modelling, 4, 55-88.

Chassignet, E. P.,Hurlburt, H. E., Smedstad, O. M., Halliwell, G. R., Hogan, P. J., Wallcraft, A. J., Baraille, R., Bleck, R., 2007. The HYCOM (HYbrid Coordinate Ocean Model) data assimilative system. Journal of Marine Systems, vol. 65, 60-83, 2007.

Cummings, J.A., 2005: Operational multivariate ocean data assimilation. Quart. J. Royal Met. Soc., Part C, 131(613), 3583-3604.

Davis, H. C. and Calabrese, A., 1964: Combined effects of temperature and salinity on development of eggs and growth of larve of M. Mercenaria and C. Virginica," Fishery Bulletin, 63(3), 643-655.

Edminston, H. L., 2008. A river meets the bay: A characterization of the Apalachicola River and Bay system. Apalachicola National Estuarine Research Reserver, December, 2008.

Edminston, H. L., Fahrny, S. A., Lamb, M. S., Levi, L. K., Want, J. M., Avant, J. S., Wren, K., Selly, N. C., 2008. Tropical Storm and Hurricane Impacts on a Gulf Coast Estuary: Apalachicola Bay, Florida. Journal of Coastal Research, 10055:38-49, 2008.

Florida Department of Environmental Protection (FDEP) 2011. Apalachicola National Estuarine Research Reserve. Management Plan, October 2011.

Huang, W., 2010. Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science, 86 (2010), 526-534.

Huang, W., Jones, W. K., and Wu, T. S., 2002. Modelling wind effects on subtidal salinity in Apalachicola Bay, Florida. Estuarine, Coastal and Shelf Science 55 (2002), 33-46.

Huang, W. and Spaulding, M, 2002. Modelling residence time response to freshwater input in Apalachicola Bay, Florida, USA. Hydrol. Processes, 16, 3051-3064 (2002). doi: 10.1002/hyp.1088

Kim, T., Sheng, Y.P., and Park, K., 2010. Modeling water quality and hypoxia dynamics in Upper Charlotte Harbor, Florida, U.S.A. during 2000. Estuarine Coastal and Shelf Science 90(4), 250-263.

Intergovernmental Panel on Climate Change (IPCC), 2007. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds.), Cambridge University Press, Cambridge, U.K. and New York, NY, USA.

Klinck, J. M., Powell, E. N., Hofmann, E. E., Wilson, E. A. and Ray, S. M., 1992: Modeling oyster populations: the effect of density and food supply on production, Proceedings of the Adv. Mar. Tech. Conf. 5, 85-105.

Klinck, J. M., Hofmann, E. E., Powell, E. N. and Dekshenieks, M. M., 2002: Impact of channelization on oyster production: a hydrodynamic-oyster population model for Galveston Bay, Texas, Environmental Modeling and Assessment, 7, 273-289.

Klipsh, J. D., Hurst, M. B., 2007. HEC-ResSim Reservoir System Simulation User's Manual, Version 3. US Army Corps of Engineers, Report, April 2007.

Livingston, R. J.; Lewis, F. G.; Woodsum, G. C.; Niu, X.-F.; Galperin, B.; Huang, W.; Christensen, J. D.; Monaco, M. E.; Battista, T. A.; Klein, C. J.; Howell IV, R. L.; Ray, G. L., 2000. Modeling oyster population response to freshwater inputs. Estuarine, Coastal and Shelf Science 50, 655–672.

Powell, E. N., Hofmann, E. E., Klinck, J. M. and Ray, S. M., 1992: Modeling oyster populations. I. A commentary on filtration rate. Is faster always better?, Journal of Shellfish Research, 11(2), 387-398.

Randall, M.T. and K.J. Sulak. 2007. Relationship between recruitment of Gulf sturgeon, Acipenser oxyrinchus desotoi, and water flow in the Suwannee River, Florida. American Fisheries Society Special Publication, Proceedings of Anadromous Sturgeon Symposium, Quebec City, Quebec, August 2003.

Rosmond, Thomas E., 1992: The Design and Testing of the Navy Operational Global Atmospheric Prediction System. Weather Forecasting, 7, 262–272.

Sheng, Y.P., 1987. On modeling three-dimensional estuarine and marine hydrodynamics. In: Nihoul, Jamart (Eds.), Three-dimensional Marine and Estuarine Hydrodynamics. Elsevier, Amsterdam, 35-54.

Sheng, Y.P., 1990. Evolution of a Three-Dimensional Curvilinear-Grid Hydrodynamic Model for Estuaries, Lakes and Coastal Waters: CH3D. Estuarine and Coastal Modeling, Proceedings of the Estuarine and Coastal Circulation and Pollution Transport Model Data Comparison Specialty Conference, ASCE, 40-49.

Sheng, Y.P., 2000. A framework for integrated modeling of hydrodynamic, sedimentary, and water quality processes. Estuarine and Coastal Modeling 6, 350-362.

Sheng, Y.P., 2003. An Integrated Modeling System for Forecasting the Response of Estuarine and Coastal Ecosystems to Anthropogenic and Climate Changes, in Ecological Forecasting: New Tools for Coastal and Marine Ecosystem Management, N. Valette-Silver and D. Scavia, Eds., NOAA Technical Memorandum NOS NCCOS 1, 203-210.

Sheng, Y.P., Davis, J.R., Sun, D., Qiu, C., Park, K., Kim, T., Zhang, Y., 2002. Application of an integrated modeling system for estuarine and coastal ecosystems to Indian River Lagoon, Florida. Estuarine and Coastal Modeling 7, 329-343.

Sheng, Y. P., V. A. Paramygin, V. Alymov, J. R. Davis (2006), A Real-Time Forecasting System for Hurricane Induced Storm Surge and Coastal Flooding. Estuarine and Coastal Modeling, Proc. Of the Ninth International Conference, ASCE, 585-602.

Sheng, Y. P., Paramygin, V. A., Zhang, Y., Davis, J. R., 2008. Recent enhancements and application of an integrated storm surge modeling system: CH3D-SSMS. Estuarine and Coastal Modeling, Proc. of the Tenth International Conference, ASCE, 879-892.

Sheng, Y.P., Tutak, B., Davis, J.R., Paramygin, V., 2008. Modeling circulation and flushing in the Guana-Tolomato-Matanzas national estuarine research reserve (GTMNERR), Florida. Journal of Coastal Research 55 (sp1), 9-25.

Sheng,Y.P., Kim, T., 2009. Skill assessment of an integrated modeling system for shallow estuarine and coastal ecosystems. Journal of Marine Systems 76, 212-243.

Sheng, Y. P., Villaret, C., 1989. Modeling the effect of suspended sediment stratification on bottom exchange process. Journal of Geophysical Research, 94, 14229-14444. Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Parauka, S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505–515.

United States Fish and Wildlife Service (USFWS). 2008. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. June 1, 2008. 225 p.

Wang, H., Huang, W., Harwell, M. A., Edmiston, L., Johnson, E., Hsieh, P., Milla, K., Christensen, J., Stewart, J. and Liu, X., 2008. Modeling oyster growth rate by coupling oyster population and hydrodynamic models for Apalachicola Bay, Florida, USA, Ecological Modelling, 211, 77-89.

Supplemental Information for Final Fish and Wildlife Coordination Act Report July 2016

This page intentionally left blank

ACF Water Control Manual Update Supplemental Information for Final Fish and Wildlife Coordination Act Report

U.S. Army Corps of Engineers
July 2016

Contents

1 Description of the Proposed Action and Alternatives

1.1 Introduction

On January 21, 2015 the U.S. Army Corps of Engineers (USACE) provided the U.S. Fish and Wildlife Service (Service) a description (USACE, 2015a) of a proposed updated Master Manual for the Apalachicola, Chattahoochee, and Flint River (ACF) Basin and a response to previous Planning Aid Letters (PAL) dated April 1, 2010; March 1, 2011; and August 29, 2013. On 2 October 2016, USACE released a Draft Environmental Impact Statement (DEIS) (USACE, 2015b) for the proposed action. The DEIS has been provided to the Service Panama City, Florida and Athens, Georgia field offices. A Draft Fish and Wildlife Coordination Act Report (DFWCAR) was provided by the Service Athens, Georgia Field Office, to USACE District Commander Jon Chytka, dated July 31, 2015. A response to the DFWCAR was provided by USACE in the DEIS. In addition, a Department of the Interior letter commenting on the DEIS dated January 29, 2016, provided Service as well as National Park Service comments on the proposed action.

After consideration of all comments submitted in response to release of the DEIS and a revised Water Supply Storage request by the State of Georgia, several modifications were made to the proposed action to be evaluated in the Final Environmental Impact Statement (FEIS). Although they will be discussed in more detail in the next section, the modifications are as follows:

1. The FEIS proposed action alternative analysis does not assume that Bear Creek Reservoir and Glades Creek Reservoir are constructed. The DEIS assumed they were constructed. Both of these permit applications have been withdrawn or suspended.

2. The FEIS proposed action alternative assumes a gross withdrawal of 242 MGD from Lake Lanier directly and 379 MGD downstream. The DEIS proposed action alternative assumes a gross withdrawal of 185 MGD from Lake Lanier directly and 408 MGD downstream.

3. The FEIS proposed action alternative analysis utilized the latest version of HEC-ResSim (the DEIS proposed action alternative used the previous HEC-ResSim version).

4. The FEIS proposed action alternative analysis used an updated Area Capacity Curve for Lake Lanier.

5. The FEIS analysis includes updates to the HEC-5Q based on comments received on the DEIS proposed action alternative.

Overall, there are few differences between the revised Proposed Action Alternative (PAA), Alternative7K (Alt7K), and the PAA as presented in the DEIS, Alt7H, or the impacts resulting from them. The proposed water management operations did not change, nor did the alternatives formulation process. This document will provide a new description of the PAA and discuss the changes in impacts from the PAA as presented in the DEIS. Therefore, except as otherwise noted, impacts are expected to be similar to those described in the January 21, 2015 Response to PAL.

1.2 Description of Proposed Action

Under the PAA, the USACE would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods. The intent would be to maintain a balanced use of conservation storage rather than to maintain the pools at or above certain predetermined elevations; however, in times of high-flow conditions, flood risk management regulation would supersede all other project functions. At all times, USACE would seek to conserve the water resources entrusted to its regulation authority. The PAA is consistent with the USACE's authority as set forth in the 2012 legal opinion (USACE, 2012). The PAA does not include construction of any new facilities or infrastructure. The following sections describe the PAA.

1.2.1 Guide Curves and Action Zones

In conjunction with meeting authorized project purposes, an important function of the reservoirs in the ACF Basin is to store water when there is an abundance of rain and to release water when there is less rain in an effort to ensure that all water needs can be met throughout the year. Water management in this context is a complex process that requires consideration of many competing demands for water in the basin, consideration of past and anticipated future hydrologic conditions, collaboration with agencies and stakeholders, and determination of the most appropriate operating conditions for all the reservoirs in the basin to meet both human and natural system needs. Water is managed in the reservoir projects in the ACF Basin for a variety of purposes, including flood risk management, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water supply, and water quality. Water demands can be consumptive or nonconsumptive. Consumptive demands involve withdrawal of water from the basin for some purpose and not returning it or any portion thereof, directly back to the basin. Municipal, industrial, and thermal power water supply consumes a portion of the withdrawn water and returns a portion of the water back to the basin as treated wastewater. For purposes of this analysis, agricultural water supply withdrawals are assumed to provide no return flows to the surface water streams. In contrast, hydroelectric power generation demand is a nonconsumptive use of water. It uses the flow in the river to drive hydroelectric power turbines to generate electricity, but no water is withdrawn or lost from the system. In considering basin water management, it is critical to account for the various withdrawals (losses) from and returns (gains) to the system. Water is lost to the system through evapotranspiration (the total of evaporation and plant transpiration), municipal and industrial (M&I) water withdrawals, thermal cooling water withdrawals, agricultural water withdrawals, groundwater transfers, and interbasin transfers. Water is returned, or added, to the basin through precipitation, treated M&I wastewater discharges, thermal power plant discharges, groundwater baseflow contributions, and interbasin transfers.

USACE releases water from its reservoirs primarily through hydropower generation and releases through the spillway gates. Hydropower generation is the preferred method and is generally used except in flood operations or in situations that prohibit the use of turbines, such as maintenance operations. In order to allow the most efficient use of its reservoirs for all project purposes, USACE has established guide curves that serve as target water levels during the year. The guide curves allow for lower reservoir levels during greater risk of flood conditions, typically the rainy winter and spring season, and higher reservoir level during drier periods. This allows storage of water during flood events and release of water during dry weather. Action zones within the conservation pool (area under the guide curve) allow the decision maker to best balance the authorized purposes as the reservoir is drawn down through increasingly critical levels.

Under the PAA, the USACE would not modify any guide curves of the ACF projects but would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The action zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes can be met. As lake levels decline, zones 2 through 4 define increasingly critical system status where purposes can no longer fully be met. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project.

The revised action zones were derived considering numerous factors, including the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects. Other factors or activities might cause the lakes to operate differently than the action zones are described, including exceptional flood risk management measures, fish spawn operations, approved deviations, maintenance and repair of turbines, emergency situations (such as a drowning and chemical spills), draw-downs because of shoreline maintenance, releases made to free grounded barges, and other special circumstances.

The storage projects (Lanier, West Point, and Walter F. George) would be operated to maintain their respective lake level in the same action zones concurrently. Because of the hydrologic and physical characteristics of the river system and factors mentioned above, however, there might be periods when one lake would be in a higher or lower action zone than another. When that occurs, the USACE would conduct operations to bring the lakes into balance with each other as soon as conditions allow. By doing so, effects within the river basin would be shared equitably among the projects. The action zones for the PAA are shown in Figures 1 through 3.

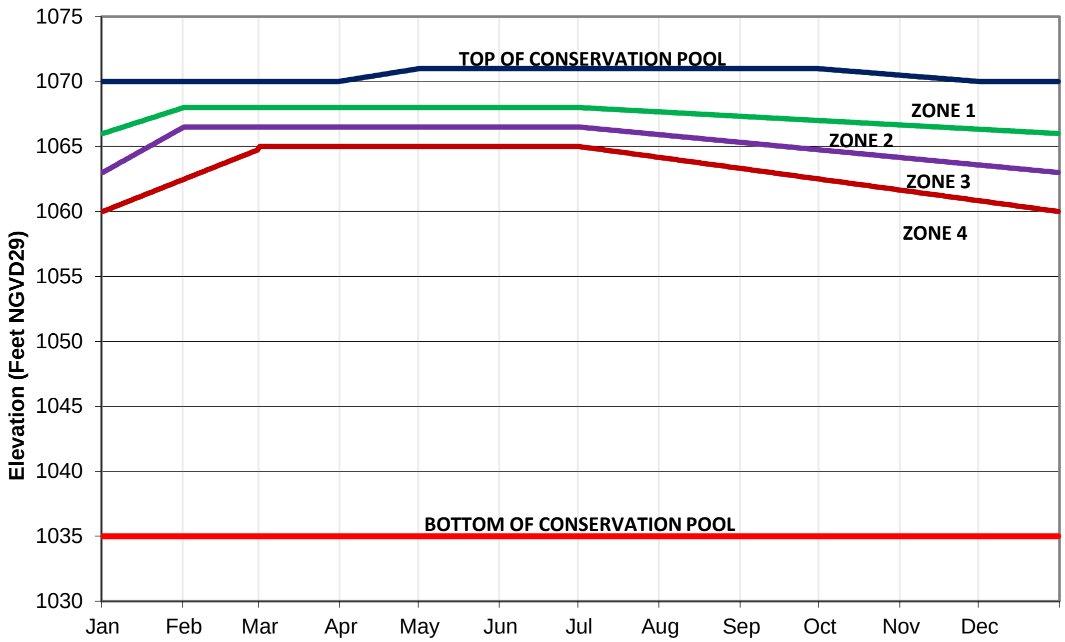


Figure 1. Lake Lanier Water Control Action Zones for the PAA

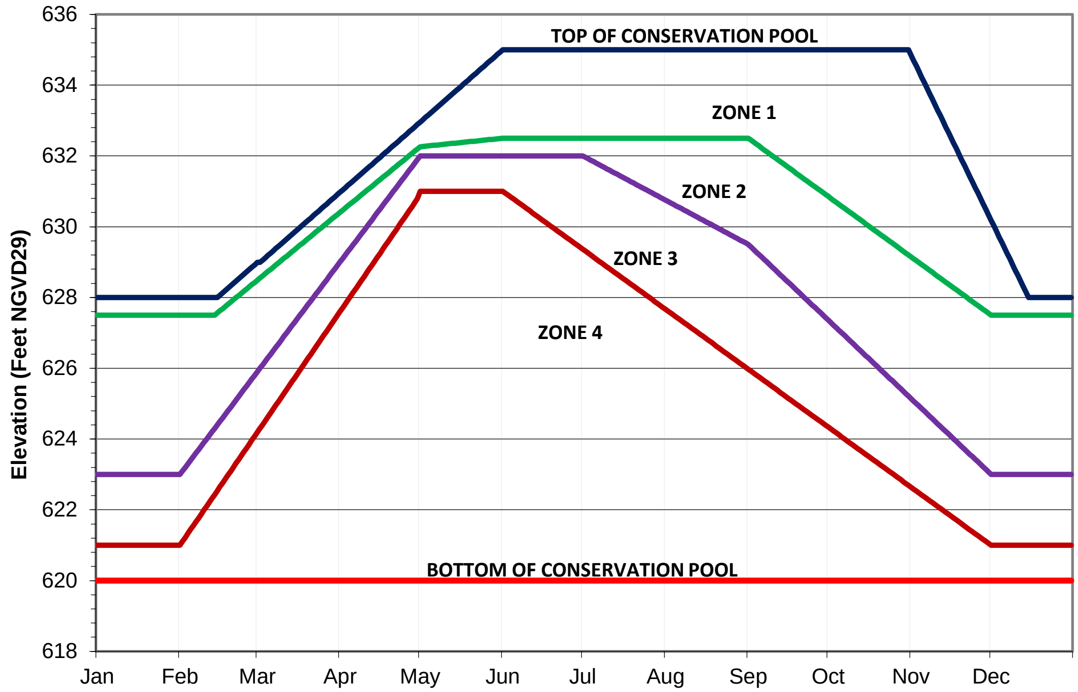


Figure 2. West Point Lake Water Control Action Zones for the PAA

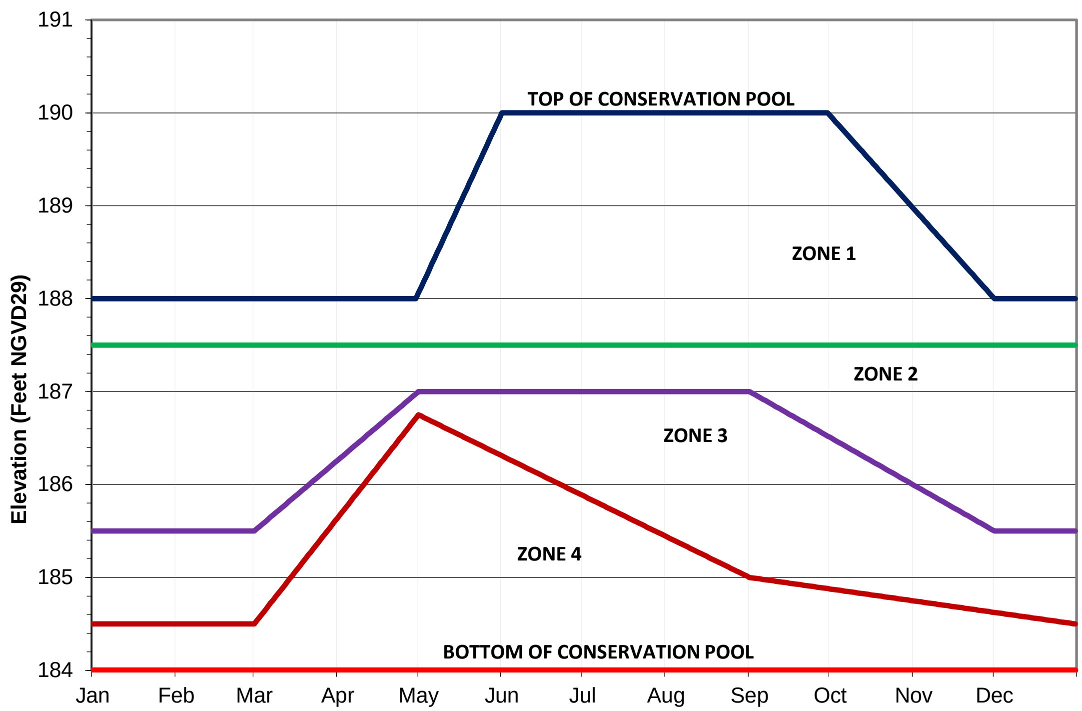


Figure 3. Walter F. George Lake Water Control Action Zones for the PAA

1.2.2 Fish and Wildlife Conservation

There is no single operation for fish and wildlife conservation, rather there are several related operations that are implemented in the PAA. West Point Dam is the only federal project in the ACF Basin with fish and wildlife conservation specifically included in its original congressional authorization. Nonetheless, the ACF Basin USACE reservoirs (i.e., Lanier, West Point, Walter F. George, Andrews, and Seminole lakes) operate to support fish and wildlife conservation pursuant to the authority in either the Fish and Wildlife Coordination Act or the Endangered Species Act. Generally, reservoir operations for fish and wildlife conservation consist of either maintaining pool elevations during fish spawns or making special releases to minimize the possibility of fish kills. Special drawdowns for specific environmental purposes may be specified from time to time, but only after coordination with state and federal resource agencies and others, as appropriate. Although the possibility of requiring water control actions may extend throughout a season, the actual actions are usually of short duration. In addition to fishery management, operations include aquatic plant control, waterfowl, and other terrestrial habitat management. The various projects in the basin have specific operations for fish and wildlife, which are described in the individual project WCMs. Specific fish and wildlife conservation activities on USACE ACF Basin projects are addressed in more detail in the following paragraphs.

Federally-Listed Species—Under the PAA, the USACE would continue to make releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows.

Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above in the Guide Curves and Action Zones section 1.2.1.

The USACE would manage releases from Jim Woodruff Dam to support the federally-protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. Daily releases to provide support for fish and wildlife conservation from Jim Woodruff Dam are dictated by two parameters: a minimum discharge (measured in cfs) and a maximum fall rate [measured in feet per day (ft/day)].

Minimum discharges from Jim Woodruff Dam would vary according to composite conservation storage, basin inflow per the 7-day moving average, and by month. Table 1 shows these minimum releases, which are measured as a daily average flow in cfs at the USGS gage at Chattahoochee, Florida. During normal and above normal hydrological conditions within the basin, releases greater than the minimum release provisions could occur consistent with the maximum fall rate schedule described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

During the spawning period (March to May), two sets of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in zones 1 and 2 or composite conservation storage in Zone 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included. The USACE would also operate Jim Woodruff Dam to avoid potential Gulf sturgeon take. Potential Gulf sturgeon take is defined as an 8-foot or greater drop in Apalachicola River stage over the last 14-day period (i.e., considering if today's stage is greater than 8 feet lower than the stage of any of the previous 14 days) when flows are less than 40,000 cfs.

During the non-spawning period (June to November), one set of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in zones 1 through 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included.

During the winter season (December to February), only one basin inflow threshold and corresponding minimum release (5,000 cfs) would exist while in composite conservation storage zones 1 through 4. That would provide the greatest opportunity to refill the storage reservoirs. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions.

When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations are triggered. Within Zone 4, the minimum flow is the same as in Zone 3. When the composite conservation storage drops further into the Drought Zone, the minimum flow from Jim Woodruff Dam is reduced to 4,500 cfs. A detailed description of the drought operations is provided in the Drought Operations section 1.2.3.

Table 1. Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge for Federally-Listed Species by Month and by Basin Inflow (BI) Rates

Months	Composite conservation storage zone	Basin inflow (BI)[a] (cfs)	Min. Releases from Jim Woodruff Lock and Dam[b] (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000 ≥ 16,000 and < 34,000 ≥ 5,000 and < 16,000 < 5,000	= 25,000 = 16,000+50% BI > 16,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>16,000
	Zone 3	≥ 39,000 ≥ 11,000 and < 39,000 ≥ 5,000 and < 11,000 < 5,000	= 25,000 = 11,000+50% BI > 11,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	≥ 22,000 ≥ 10,000 and < 22,000 ≥ 5,000 and < 10,000 < 5,000	= 16,000 = 10,000+50% BI > 10,000 = BI = 5,000	Up to 100% BI>16,000 Up to 50% BI>10,000
December–February	Zones 1, 2, and 3	≥ 5,000 < 5,000	= 5,000 = 5,000	Up to 100% BI > 5,000
If Drought Triggered	Zone 3	NA	= 5,000[d]	Up to 100% BI > 5,000
At all times	Zone 4	NA	= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	= 4,500[e]	Up to 100% BI > 4,500

Notes:

a. Basin inflow for composite conservation storage in zones 1, 2, and 3 is calculated using the 7-day moving average basin inflow. Basin inflow for composite conservation storage in drought operations, zones 3 and 4 or lower (Drought Zone) is calculated using the one-day basin inflow.

b. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

c. Drought plan is triggered when the composite conservation storage falls into Zone 3, the first day of each month represents a decision point.

d. Once drought operation triggered, reduce minimum flow to 5,000 cfs following the maximum ramp rate schedule.

e. Once composite storage falls below the top of the Extreme Drought Zone ramp down to a minimum release of 4,500 cfs at rate of 0.25 ft/day based on the USGS gage at Chattahoochee, Florida (02358000).

The federally-listed species operations of the PAA include a fall rate, also called down-ramping rate, defined as the vertical drop in river stage (water surface elevation) that occurs over a given period of time. The fall rates are expressed in units of ft/day measured at the USGS Chattahoochee, Florida, gage as the difference between the daily average river stage on consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The maximum fall rate schedule is provided in Table 2. When composite conservation storage falls into Zone 3, the drought operations plan would be implemented. A detailed discussion of fall rate management when the drought operations plan is implemented is provided in the Drought Operations section 1.2.3. Down-ramping rates are suspended during periods of prolonged low flow (flows less than 7,000 cfs for a period of more than 30 consecutive days). A prolonged low flow period would be considered over and down-ramping rates would be reinstated when flows are greater than 10,000 cfs for 30 consecutive days. When the maximum fall rate schedule is suspended due to prolonged low flow, down-ramping operations would be managed to match the one-day fall rate of the basin inflow. This prolonged low flow provision could occur under both normal and drought operations. Figure 4 provides an example of this scenario from the ResSim simulation of the PAA. In this example the simulated flows were less than 7,000 cfs for approximately 45 days before a storm system required an increase in releases. Once the storm event was complete the fall rates were managed to match the one day BI fall rate.

Table 2. Maximum Down-Ramping (Fall) Rate

Approximate release range (cfs)	Maximum fall rate (ft/day)	Maximum fall rate (cfs/day)
> 30,000 [a]	No ramping restriction [b]	
> 20,000 and ≤ 30,000 [a]	1.0 to 2.0	2,300 - 5,000
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [a]	0.5 to 1.0	1,060 – 2,300
Within Powerhouse Capacity and > 10,000 [a]	0.25 to 0.5	500 – 1,060
Within Powerhouse Capacity and ≤ 10,000 [a]	0.25 or less	220 - 500

Notes:

[a.] Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

[b.] For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control the down-ramping rate, and no ramping rate is required.

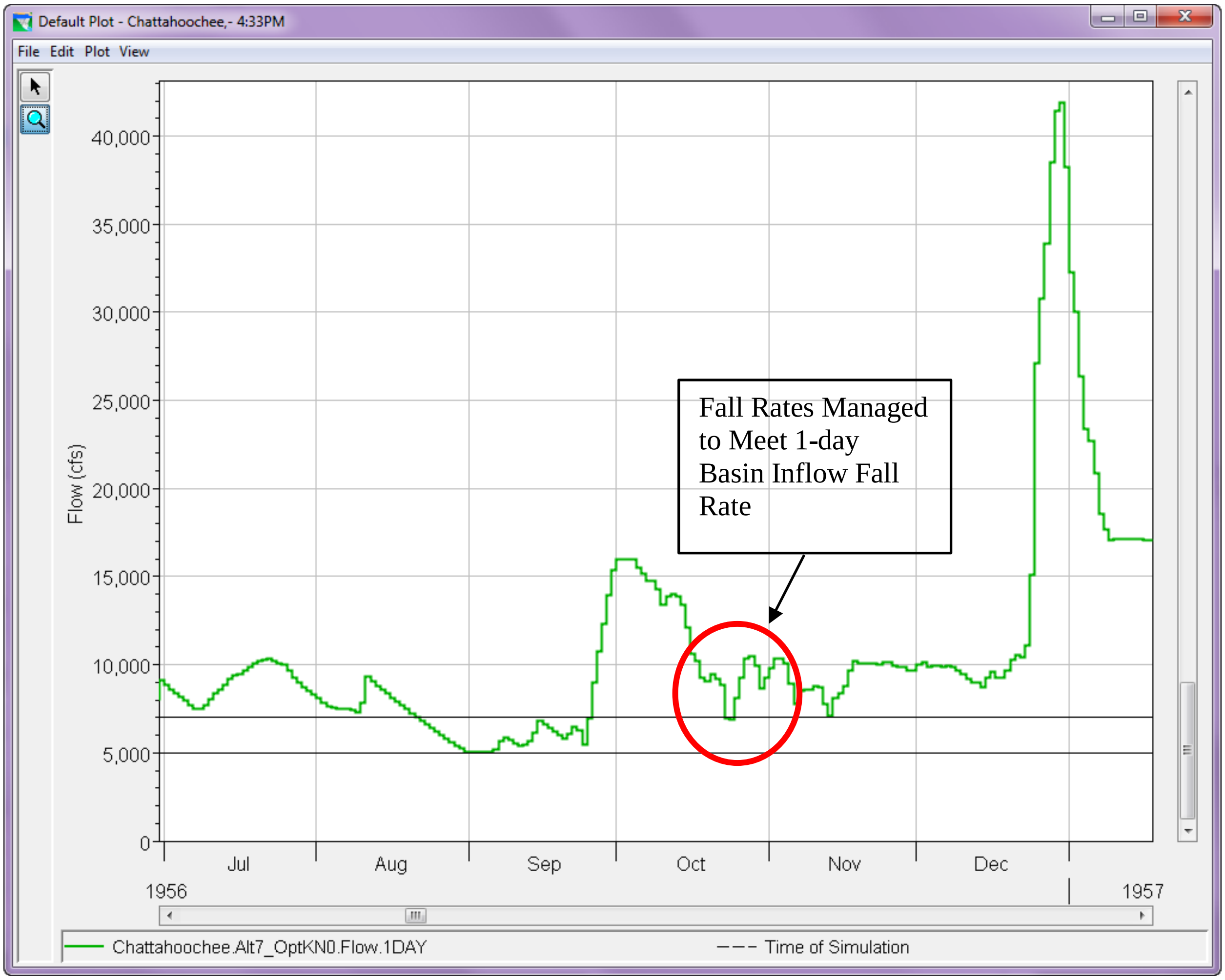


Figure 4. Example of Fall Rate Operations After Prolonged Low Flow

Reservoir Fish Spawning—USACE South Atlantic DR 1130-2-16 (March 30, 2001) and Mobile District Draft SOP 41 1130-2-9 (February 2005) were developed to address reservoir regulation and coordination for fish management purposes. South Atlantic DR 1130-2-16 has been updated and renumbered as South Atlantic DR PDS-O-1 (May 31, 2010), Project Operations, Lake Regulation and Coordination for Fish Management Purposes. It specifically applies to operations at Lake Lanier, West Point Lake, Walter F. George Lake, and Lake Seminole in the ACF Basin as well as other reservoirs in USACE South Atlantic Division. The draft Mobile District SOP (1) identifies designated periods of time within which operations to support fish spawning will be conducted at specific projects and on the Apalachicola River, (2) establishes protocols for coordination between the Service, state fisheries personnel, and USACE, and (3) provides for development of an annual plan for special water management operations by USACE (in coordination with the Service and state fisheries agencies) that would balance impacts and benefits to both reservoir and riverine fisheries during the spring spawning period. A major goal of the SOP is not to lower lake levels more than 6 inches in elevation during the principle fish spawning period to prevent stranding or exposing fish eggs. The protocols in these documents are consistent with the requirements for other project purposes and recognize that reservoir fish spawning operational goals may not be achieved during flood management operations or periods of extended drought.

Tailrace Dissolved Oxygen Levels—Reservoir stratification develops seasonally when surface water becomes warmer and less dense than deeper water, generally summer to late fall in the Southeast. This results in temperature-dependent density differences that prevent mixing and form isolated layers of water, each with their own distinct chemistry. Among the more common concerns is the depletion of oxygen in the deeper layers of lakes when stratified. Below the thermocline, dissolved oxygen is insufficient to support most aquatic life. When water is released from the lower regions of the reservoirs through hydroelectric power generation units and/or sluice gates during periods of reservoir stratification, low dissolved oxygen conditions may be experienced for a short distance downstream of dams, potentially causing stress in the tailrace fishery and occasional fish kills. While dissolved oxygen levels downstream of Buford Dam and West Point Dam are depressed at times as a result of hydroelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas as a result of low dissolved oxygen conditions. The Walter F. George Lock and Dam project has experienced recurring instances of stress in the tailrace fishery and occasional fish kills due to low dissolved oxygen. Accordingly, USACE has implemented a SOP, established in 1988 and updated in 1993, to address conditions at the Walter F. George project when low dissolved oxygen values are observed in the tailrace. The SOP calls for spillway gates to be opened in accordance with a specific protocol until dissolved oxygen readings return to an acceptable level. Spillage siphons have also been constructed on the dam that can be used in lieu of spillway gate discharges.

Fish Passage—In most years since the spring of 2005, USACE has operated the lock at Jim Woodruff Lock and Dam between March and May to facilitate downstream-to-upstream passage of Alabama shad (*Alosa alabamae*) and other anadromous fishes (those that return from the sea to the rivers where they were born to breed) in cooperation with pertinent state and federal agencies. In general, two fish locking cycles are performed each day between 0800–1600 hours, one in the morning and one in the afternoon. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change.

Management of Project Lands—The 11,184-acre Eufaula National Wildlife Refuge is operated by the Service in cooperation with USACE in the upper reaches of Walter F. George Lake within Barbour and Russell counties, Alabama, and Stewart and Quitman counties, Georgia. The refuge has an extensive system of pumps, dikes, and water control structures for water-level management in off-reservoir wetland areas. The refuge provides important habitat for migratory waterfowl and other birds, habitat for federally listed threatened and endangered species, and recreation and environmental education for the public. USACE manages much of the project land around its ACF reservoirs for the benefit of fish and wildlife resources, consistent with other project purposes. In some cases, project lands can be managed by state agencies (i.e., wildlife management areas or state parks) or local interests through leases. Additionally, GADNR operates a fish hatchery on the Chattahoochee River immediately below Buford Dam. USACE coordinates project operations with the fish hatchery staff.

1.2.3 Drought Operations

The drought plan included in the PAA would be triggered when the composite conservation storage falls below the bottom of Zone 2 into Zone 3 (Figure 5). The purpose for this modification is to facilitate a more proactive approach to drought management in order to better assure that storage is available to meet all project purposes throughout a prolonged drought period worse than has been realized to date. The drought plan specifies a minimum release from Jim Woodruff Dam and would temporarily suspend the normal minimum release and maximum fall rate provisions of the listed species operation (Table 1 and Table 2), until composite conservation storage in the basin could be replenished to a level that could support them (Zone 1).

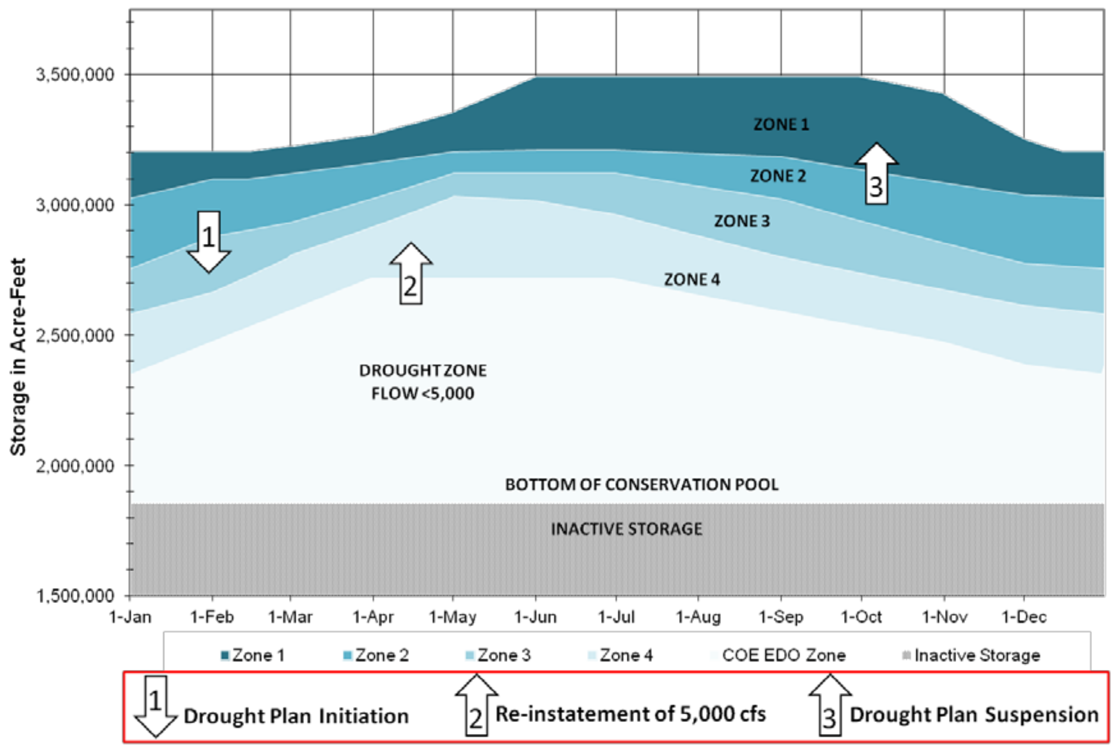


Figure 5. Composite Conservation Storage Zones and Drought Plan Triggers

Under the drought plan the minimum required release from Jim Woodruff Dam would be 5,000 cfs when the composite conservation storage is in zones 3 and 4. Under the drought plan, the maximum fall rate schedule is suspended. However, the suspension of the maximum fall rate schedule is delayed if releases from Jim Woodruff Dam have not yet reached the 5,000 cfs minimum flow when the drought plan is implemented. The purpose of maintaining the maximum fall rate schedule under these conditions is to facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that have not been recently dewatered. Figure 6 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on June 1, 2006 and the discharge from Jim Woodruff Dam is slowly reduced from 10,125 cfs to 5,050 cfs, over a 22 day period, according to the maximum fall rate schedule. In this example the 0.25 ft/day maximum fall rate provision is implemented when drought operations are triggered as the releases are less than 10,000 cfs.

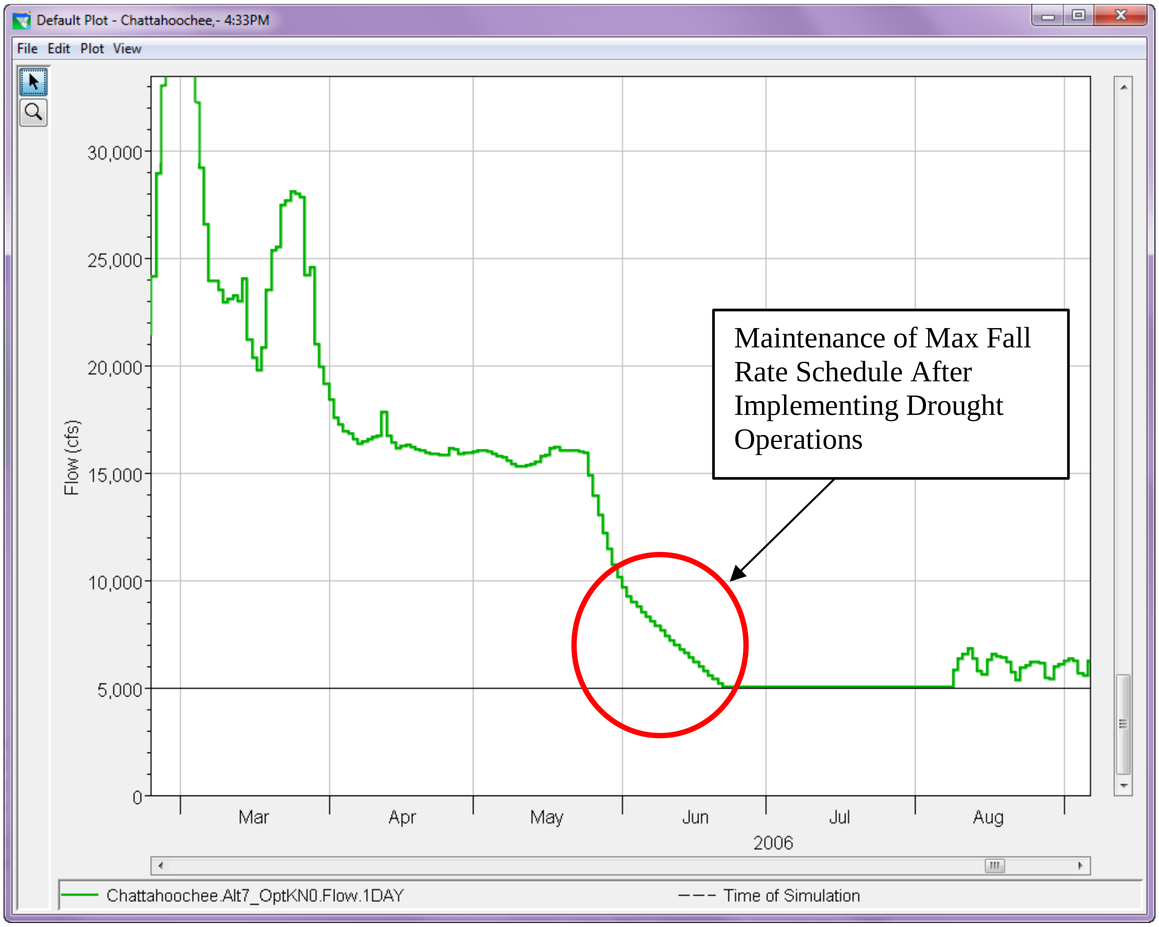


Figure 6. Example Down Ramping after Drought Operation Triggered

Occasionally uncontrolled high flow from the Flint River (resulting from a rainfall event) or hydropower releases from Walter F. George Dam could cause a temporary increase in Jim Woodruff Dam discharge as down ramping to 5,000 cfs occurs during the drought operation. In this case the Jim Woodruff Dam release ramps down using two ramping rates. The peak discharge would ramp down according to the one day basin inflow fall rate until the discharge prior to the temporary increase occurs. At that time, the releases would again be managed according to the maximum fall rate schedule until the minimum flow of 5,000 cfs occurs.

Figure 7 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on March 1, 2016 and releases from Jim Woodruff Dam are reduced according to the maximum fall rate schedule from 12,100 cfs to 8,490 cfs over an eight day period. At this time, conditions in the basin result in an increased release from Jim Woodruff Dam until a peak value of 21,750 cfs is reached on March 26, 2016. As releases are decreased following the peak, fall rates are managed according to the one day basin inflow fall rate until the release reaches 8,490 cfs. Because releases less than 8,490 cfs had not occurred prior to the temporary increase in river flow, on May 13, 2016 the maximum fall rate schedule resumes. In this example another temporary discharge increase occurs on May 16, 2016 and the maximum fall rate schedule resumes on May 21, 2016. Implementing the two phase down ramping allows USACE to conserve storage when reducing releases following a temporary increase in river flow and still facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that had not previously occurred. The temporary increases in river flow during the down ramping period are not of sufficient duration to allow mussels to recolonize habitats that were recently dewatered.

Figure 7. Example of Two Phase Down Ramping After Drought Operation Triggered

The drought plan would also include the option for a temporary waiver from the water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects to provide additional conservation storage for future needs, if conditions in the basin dictate the need for such action.

The drought plan of the PAA prescribes two minimum releases on the basis of composite conservation storage. One minimum release while in zones 3 and 4 and an additional minimum release while in the Drought Zone. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in Lake Lanier, West Point Lake, and Walter F. George Lake, plus Zone 4 storage in Lake Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within zones 3 and 4, but above the Drought Zone, the minimum release from Jim Woodruff Dam would be 5,000 cubic feet per second (cfs) and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam would be 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning for the first time from a minimum release of 5,000 to 4,500 cfs, fall rates would be limited to a maximum of 0.25 ft/day drop. Should conditions result in releases greater than 4,500 cfs while the composite conservation storage is still in the Drought Zone, fall rates will be determined by a computation based on the one-day basin inflow fall rate. The 4,500 cfs minimum release would be maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release would be immediately reinstated. The drought plan provisions would remain in place until conditions improve such that the composite conservation storage reaches Zone 1. At that time, the temporary drought plan provisions would be suspended and all the other provisions of the basin water control plan would be reinstated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) would be implemented to determine which operational triggers are applied. It was determined monthly decision points would be the minimum interval to effectively manage drought operations. A more frequent decision point would not allow assurance that a weather-based hydrologic trend was establishing and could result in short isolated periods of rain causing premature exit of drought operations during a prolonged drought.

In the event the composite conservation storage has not recovered to Zone 1 by 1 February, drought operations would be extended to the end of March, unless all the federal reservoirs are full. This provision is intended to ensure full recovery prior to implementing the higher minimum flow provisions in place during normal operations in the sturgeon spawning season. Because of high rainfall amounts, the month of March is typically characterized by higher flow and is critical to reservoir refill. Figure 8 is an example from the ResSim modeling of the PAA of continuing the drought operation through the month of March. In this example, the composite conservation storage enters Zone 1 on February 5, 1982, but drought operation is not suspended until April 1, 1982.

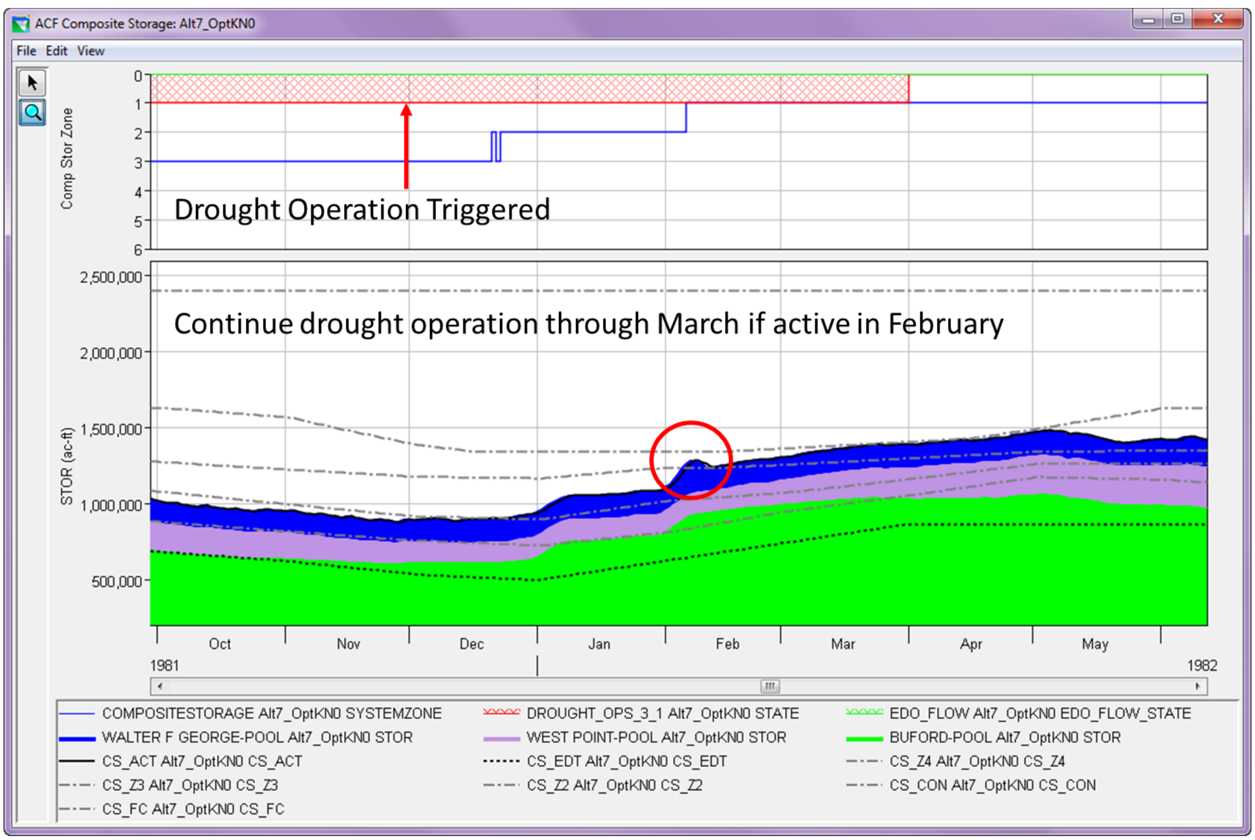


Figure 8. Drought Operation Continued Through Month of March

1.2.3.1 Extreme Drought Operations

When the remaining composite conservation storage is about 10 percent of the total capacity, additional emergency actions might be necessary. When conditions have worsened to that extent, use of the inactive storage must be considered. For example, such an occurrence could be contemplated in the second or third year of a drought. Inactive storage zones have been designated for the three federal projects with significant storage (Figure 9). Table 3 shows the inactive storage capacity within each inactive storage zone for each project. The use of inactive storage during extreme drought conditions would be based on the following actions:

(1) Inactive storage availability would be identified to meet specific critical water use needs within existing project authorizations.

(2) Emergency uses would be identified in accordance with emergency authorizations and through stakeholder coordination including emergency consultation under Section 7 of the ESA. Typical critical water use needs within the basin are associated with public health and safety.

(3) Weekly projections of the inactive storage water availability to meet the critical water uses from Buford Dam downstream to the Apalachicola River would be used when making water control decisions regarding withdrawals and water releases from the USACE reservoirs.

(4) The inactive storage action zones would be instituted as triggers to meet the identified priority water uses (releases will be restricted as storage decreases). Figure 9 lists the typical critical water uses for each inactive storage zone.

(5) Dam safety considerations would always remain the highest priority. The structural integrity of the dams due to static head limitations (Jim Woodruff, 38.5 feet; George W. Andrews, 26 feet; Walter F. George, 88 feet) would be maintained.

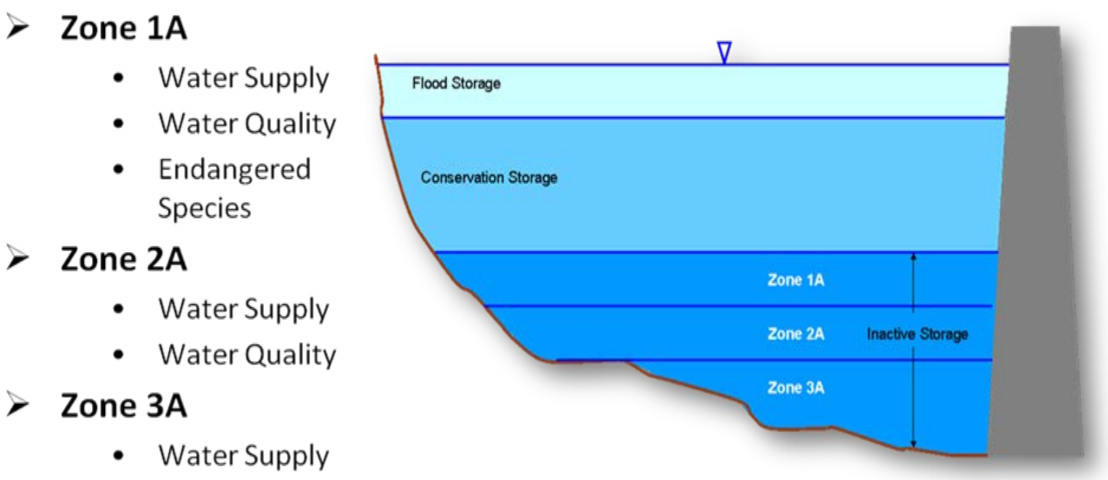


Figure 9. Inactive Storage Zones and Typical Water Use Needs

Table 3. Reservoir Inactive Storage Zone Capacities (ac-ft)

Project	Zone 1A	Zone 2A	Zone 3A	Unusable Inactive
Buford Dam	532,078	234,699	100,823	0
West Point Dam	53,620	138,331	33,344	73,101
Walter F. George Dam	314,799	178,501	0	196,700
Total	901,589	554,345	134,869	266,062

1.2.4 Flood Risk Management

When developing the PAA, flood risk management capabilities and capacities of reservoirs were not reduced. The objective of flood risk management operations (formerly referred to as flood control) is to impound excess flows, thereby reducing downstream river levels below flood stage. Whenever flood conditions occur, operation for flood risk management takes precedence over all other project functions. Only Buford and West Point dams have storage allocated for flood risk management operations. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower peak stages throughout the reservoir during major floods. George W. Andrews and Jim Woodruff lock and dams operate to pass inflows.

The timing of flood peaks in the ACF Basin is of considerable importance in determining the effectiveness of reservoir operations for flood risk management and the degree to which such operations can be coordinated. During a flood event, excess water above the guide curve is evacuated (released) consistent with other project needs as soon as downstream waters have receded enough that releases from the reservoirs will not increase the natural maximum flood heights downstream. This timely evacuation is necessary so that consecutive flood events will not cause floodwaters to exceed allocated storage capacities and endanger the integrity of the dam. Both turbines and spillways are used, as necessary, to evacuate floodwaters.

Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power generation demands are lower, the guide curve operation generally reflects this situation by specifying a lower elevation during this time period. Transitions between the seasonal levels are gradual to moderate increases or decreases in outflow. By drawing down the pool in late fall, either specifically for flood risk management as at the West Point Dam project or coincidentally for other purposes, additional storage is gained for containing floodwaters.

For flood risk management purposes, releases are reduced or terminated at Buford Dam, except for the small hydropower unit, as soon as it appears that downstream river stages will exceed flood stage. Key gaging stations in the vicinity are closely monitored to determine when floodwaters have begun to recede so that flood storage in the reservoir can be expeditiously evacuated in a manner consistent with other project functions without exacerbating downstream flooding.

In conclusion, no flood action zones have been defined for flood risk management storage at the Buford Dam project. Evacuation of the flood risk management pool at that project occurs only by way of releases through the tubines and the sluice gate at the bottom of the reservoir until the pool elevation reaches 1,085 ft, at which point flood waters also would begin to flow over the fixed crest emergency spillway.

The prime objective of flood risk management operations at the West Point Dam project is to reduce peak flows at West Point, Georgia, based on the downstream U.S. Geological Survey (USGS) Chattahoochee

River at West Point, Georgia, gage (# 02339500). This objective is met by regulating releases to maintain the USGS West Point, Georgia, gage within the nondamaging bankfull flow of 40,000 cfs until the induced surcharge schedule calls for greater release. The flood risk management pool at the West Point Dam project is designed to reduce the flood wave from small and moderate-sized floods. It does not have enough storage capacity to provide beneficial flood damage reduction for large flood events. During the early stages of a flood event, the outflow from West Point Dam is planned to control, or limit, the peak outflow as the flood develops. The basic plan for flood risk management is defined by three flood action zones (A, B, and C) within the flood risk management storage of the pool similar to manner in which conservation storage is defined by action zones to guide operations. The flood action zones are used to evacuate stored floodwater in a timely manner, either through the turbine units or the tainter gates, while allowing flexible scheduling for hydropower production. Detailed descriptions of the water management instructions within each flood zone are provided in the West Point Dam and Lake Water Control Manual.

The Walter F. George Dam operate according to specified flood risk management plans, as outlined in their WCM. Spillway gates are opened if necessary to assist the turbines in passing these flows.

Even though the traditional flood season spans several months, discrete incidences of flooding should have insignificant long-duration effects if pool elevations are maintained close to guide curve elevations. No pool is allowed to remain above its guide curve for any appreciable length of time without prior approval of a temporary deviation or variance by USACE, South Atlantic Division.

1.2.5 Hydroelectric Power Generation

The PAA includes the current hydroelectric power generation operations at West Point Dam, Walter F. George Dam, and Jim Woodruff Dam which call for a more flexible generation schedule in all action zones under non-drought conditions and a more constrained generation schedule under drier conditions. The Buford, West Point, and Walter F. George projects are operated as peaking plants, and provide electricity during the peak demand periods of each day and week. Hydroelectric power peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines. Typically, the Buford, West Point, and Walter F. George projects provide generation five days a week at plant capacity throughout the year, as long as their respective lake levels are above Zone 4 and drought operations have not been triggered. For example, demand for peak hydroelectric power at Buford Dam typically occurs on weekdays from 5:00 a.m. to 9:00 a.m. Central time and from 3:00 p.m. to 10:00 p.m. between 1 October and 31 March, and on weekdays from 1:00 p.m. to 7:00 p.m. between 1 April and 30 September. The typical hours represent releases that normally meet water system demands and provide the capacity specified in power marketing arrangements. During dry periods, generation could be eliminated or limited to conjunctive releases. Typical, but not required, hours of operation by action zone are depicted in Table 4.

Table 4. Typical hours of peaking hydroelectric power generation by federal project

Action zone	Buford Dam (hours of operation) normal ops/drought ops	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	3/2	4	4
Zone 2	2/1	2	2
Zone 3	2/1	2	2

Action zone	**Buford Dam (hours of operation)** **normal ops/drought ops**	**West Point Dam (hours of operation)**	**Walter F. George Dam (hours of operation)**
Zone 4*	0	0	0

*While hydropower would still be generated in Zone 4, it could not be generated on a regular peaking schedule under severe drought conditions

1.2.6 Navigation

When supported by ACF Basin hydrologic conditions, the PAA would provide a reliable navigation season. The water management objective for navigation is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). Figure 10 graphically represents the navigation season and its relationship to composite conservation storage. During the navigation season, the flows at the USGS gage at Blountstown, Florida, should be adequate to provide a minimum channel depth of 7 feet. The most recent channel survey and discharge-stage rating were used to determine the flow required to sustain a minimum navigation depth during the navigation season. Flows of 16,200 cfs provide a channel depth of 7 feet. Flows of 20,600 cfs provide a channel depth of 9 feet. USACE's capacity to support a navigation season would be dependent on actual and projected system-wide conditions in the ACF Basin before and during January, February, March, April, and May. Those conditions include the following:

- A navigation season can be supported only when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
- A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Navigation support will resume when the basin composite conservation storage level recovers to Zone 1.
- A navigation season will not be supported when drought operations are in effect. Navigation will not be supported until the ACF Basin composite conservation storage recovers to Zone 1.
- The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrologic conditions, meteorological forecasts, and basin-wide model forecasts. On the basis of an analysis of those factors, USACE will determine if the navigation season will continue through part or all of May.
- Down-ramping of flow releases will adhere to the Jim Woodruff Dam fall rate schedule (see Table 2) for federally listed threatened and endangered species during the navigation season.
- Releases that augment the flows to provide a minimum 7-foot navigation depth will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, because of diminishing inflows, downstream flows and depths must be reduced, notices would be issued to project users to give barge owners and other waterway users sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Lock and Dam to reduce releases.

Although special releases would not be standard practice, they could occur for a short duration to assist navigation during the navigation season. For instance, releases can be requested to achieve up to a 9-foot channel. Special releases could also occur outside of the navigation season. However, USACE would evaluate such request on a case-by-case basis, subject to applicable laws and regulations and the conditions above.

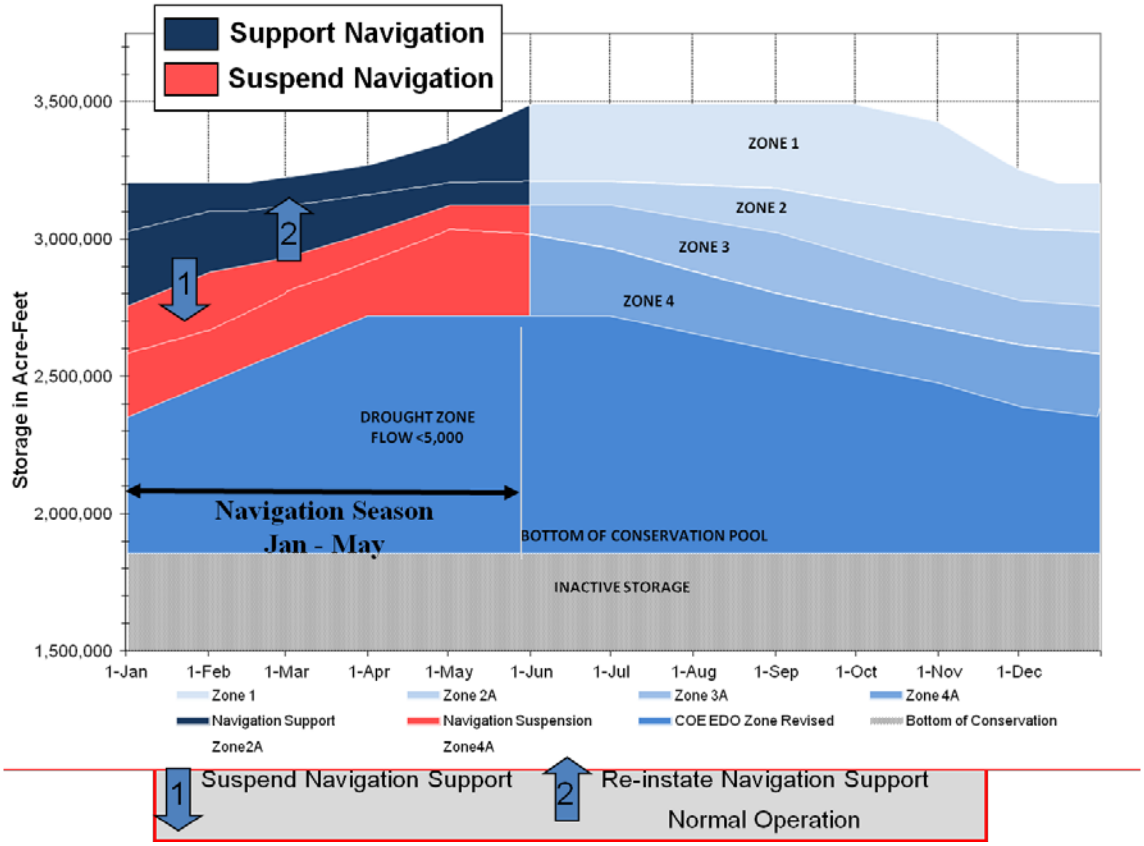


Figure 10. Composite Conservation Storage for Navigation

1.2.7 Recreation

Under the PAA, operations for recreation would remain the same as current operations. Recreation benefits would be maximized at the lakes to the extent possible consistent with meeting other project purposes by maintaining full or nearly full pools during the primary recreation season which are the warm summer months. In response to meeting other authorized project purposes, lake levels could decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 5). Recreational impact levels are not applicable to the George W. Andrews project due to the lack of conservation storage and the run-of-river operation at the project.

When pool levels must be lowered, the rates at which the draw-downs occur are as steady as possible. The action zones at Lake Lanier and West Point Lake are drawn down to correlate the line between Zone 2 and Zone 3 near the IIL at the beginning of the recreation season (May through early September). This is an attempt to maximize the time these projects are above the IIL during the recreation season.

Table 5. Recreation Impact Levels for federal projects in the ACF Basin

Project	IIL[a]	RIL[b]	WAL[c]
Lake Lanier	1,066 ft	1,063 ft	1,060 ft
West Point Lake	632.5 ft	629 ft	627 ft
Walter F. George	187 ft	185 ft	184 ft

Notes:
[a.] Initial Impact Level
[b.] Recreation Impact Level
[c.] Water Access Limited Level

1.2.8 Water Quality

Under the PAA, Buford, West Point, and Jim Woodruff dams would provide continuous minimum flow releases that would benefit the water quality immediately downstream of the dams. There would be no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen concentrations are observed below the dam, spillway gates would be opened until the dissolved oxygen concentrations return to an acceptable level. Occasional special releases would also be made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam.

At Buford Dam, the small turbine generator would run continuously to provide a minimum flow from the dam, which would range from approximately 500 to 700 cfs, depending on head conditions. This minimum flow from Buford Dam would help meet the seasonal minimum flow requirements of 650 cfs and 750 cfs at Atlanta, Georgia, in the Chattahoochee River just upstream of the confluence with Peachtree Creek. At West Point Dam, the minimum flow requirement is 670 cfs and a similar small generating unit would provide a continuous release of approximately 675 cfs. A varying minimum flow from 4,500 to 25,000 cfs, dependent upon basin conditions, would be maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which would assure an adequate water supply for downstream industrial use and water quality. Walter F. George Dam has two siphons on each spillway gate. The siphon discharge could range from about 15 cfs up to 200 cfs when all 12 are in use. Typically, the siphon tubes would be opened continuously from May through the end of September and all would be used at full capacity. The siphons would provide a gravity-fed, typically continuous, minimum flow that would benefit dissolved oxygen levels below the dam.

1.2.9 Water Supply

Under the PAA, the cities of Gainesville and Buford would continue to withdraw water directly from Lake Lanier under relocation agreements at rates not exceeding 8 mgd (net) and 2 mgd, respectively. Additionally, pursuant to the Water Supply Act of 1958, the PAA would reallocate 252,950 acre-feet in Lake Lanier for water supply. The amount of storage is estimated to yield 222 mgd during the critical drought (i.e., during the worst drought on record at the time the agreement was executed). The severity and frequency of droughts change over time, therefore, the yield of this storage may change over time. For the purpose of managing water supply storage, USACE would employ a storage accounting methodology that applies a proportion of inflows and losses, as well as direct withdrawals by specific users, to each account. The amount of water that may actually be withdrawn is ultimately dependent on the amount of water available in the storage account, which will naturally change over time.

Under the PAA releases from Buford Dam would be made to accommodate downstream water demands. Peaking hydroelectric power generation generally accommodates most water supply needs of communities currently withdrawing from the Chattahoochee River; however, under the 1946 Rivers and Harbors Act, generation can occur at non-peaking times to meet the downstream water supply needs, not to exceed 379 mgd. Figure 11 illustrates the current lake and river withdrawals occurring in the Metro Atlanta.

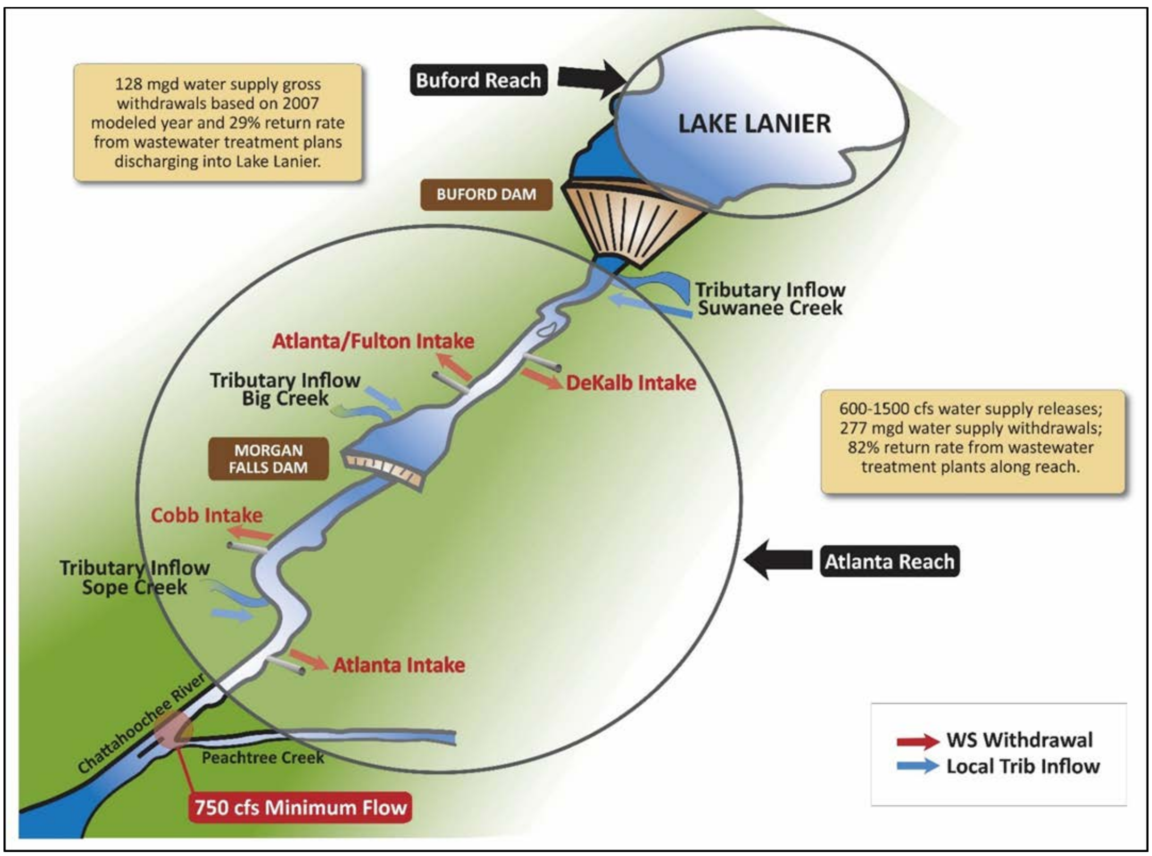


Figure 11. Illustration of Metro-Atlanta Water Supply Withdrawals

1.3 ALTERNATIVES CONSIDERED

The proposed action and alternatives identified in the DEIS make up a portion of the alternatives to the PAA that were considered. They are incorporated by reference. In addition to the alternatives described in the DEIS, the USACE also evaluated six new alternatives. The new alternatives consist of the No Action Alternative (NAA) or PAA water management operations combined with five new water supply options. The new water supply options are based on comments received for the DEIS and the State of Georgia 2015 revised water supply request. None of the new alternatives include the two non-federal water supply reservoirs (Glades Reservoir and Bear Creek Reservoir) considered in the DEIS. Both of the permit applications for these reservoirs have been withdrawn/suspended. Table 6 describes the six new alternatives considered (1L, 7I, 7J, 7K, 7L, and 7M), as well as alternatives previously described in the DEIS [NAA (1A), 7A, 7B, and the proposed action from the DEIS (7H)]. The PAA evaluated in this document is Alternative 7K (Alt7K).

Table 6. New Alternatives Considered Since Publication of the DEIS in October 2015

Water Management Measures											
		1A	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**
Guide Curves	Maintain existing guide curve	X	X	X	X	X	X	X	X	X	X
Action Zones	Maintain existing action zones	X	X								
	Revised Level 1 action zones			X	X	X	X	X	X	X	X
Drought Operations	Drought operations trigger *	Zone 4	Zone 4	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3
	Extreme drought operations	X	X	X	X	X	X	X	X	X	X
	Drought operations suspension trigger *	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1
Peachtree Creek Minimum Flows	Current (750 cfs)	X	X								
	Seasonal flow (750 cfs / 650 cfs)			X	X	X	X	X	X	X	X
Hydropower Generation	Current generation schedule	X	X								
	Modified generation schedule with drought operations			X	X	X	X	X	X	X	X
Navigation	Current-no navigation operations	X	X								
	4/5 Month			X	X	X	X	X	X	X	X
Basin Inflow	Current computational method	X	X	X	X	X	X	X	X	X	X
Fish and Wildlife	Current fish spawn and passage	X	X	X	X	X	X	X	X	X	X

Water Management Measures			1A	1L	7A	7B	7H	7I	7J	7K	7L	7M
Listed Species Management	RIOP May 2012		X	X								
	Ramping Rate	Current ramping rate**	X	X	X	X	X	X	X	X	X	X
		Suspend during prolonged low flow			X	X	X	X	X	X	X	X
		Suspend in drought*	X	X	X	X	X	X	X	X	X	X
	Current (seasonal) minimum flow provision**		X	X	X	X	X	X	X	X	X	X
Water Supply Options***	A – No action		L=128 D=277		L=128 D=277							
	B - Relocation contracts only (in Lake Lanier)					L=20 D=277						
	H – GA 2013 (projected return volume for 2035 with Glades Reservoir pumping)						L=185 G=40 D=408					
	I – 225 mgd lake withdrawal, GA 2015 Request Downstream							L=225 D=379				
	J – Future Without Project Condition-Revised								L=20 D=379			
	K – GA 2015 Request									L=242 D=379		
	L – Current lake withdrawals, GA 2015 Request Downstream			L=128 D=379							L=128 D=379	
	M – Option H for Lanier w/o Glades, GA 2015 Request Downstream											L=205 D=379

Notes:* Based upon composite conservation storage zones (cumulative conservation storage [by zone] for USACE ACF reservoirs [Lanier, West Point, and Walter F. George]).
**Component of the May 2012 RIOP.
***Numbers indicate withdrawals in mgd from Lake Lanier (L), Glades Reservoir (G), and the Chattahoochee River downstream (D) of Buford Dam.

2 ENVIRONMENTAL IMPACTS OF ALTERNATIVE 7K (PAA FOR FEIS) COMPARED TO ALTERNATIVE 7H (PAA FOR DEIS)

As discussed previously, the PAA has changed little from that of the DEIS. As a result, there were generally few measurable differences from the PAA, Alt7K, with the DEIS PAA, Alt7H. Changes from the DEIS PAA and Alt7H presented here include utilization of the latest version of HEC-ResSim, an updated Area Capacity Curve for Lake Lanier, and updates to the HEC-5Q based on comments received on the DEIS.

The results from the DEIS PAA, Alt7H, are presented along with the FEIS PAA, Alt7K, in the following discussion.

2.1 HEC-5Q Water Quality Model Output Analyses

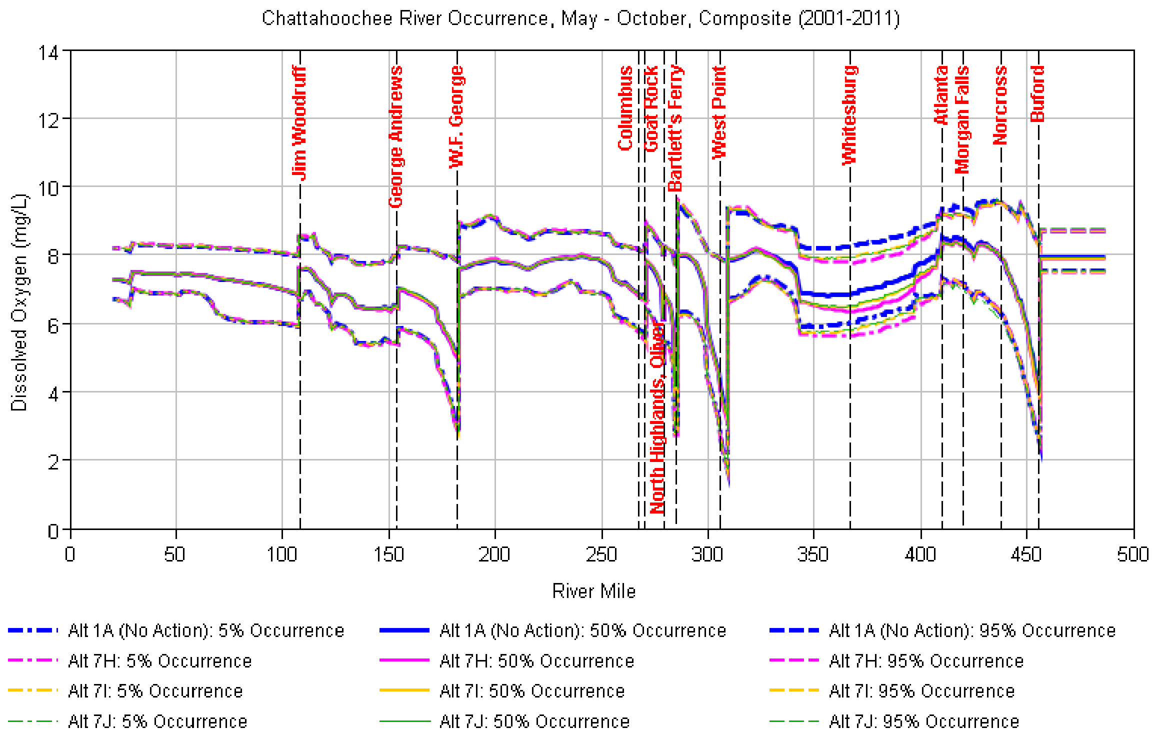
2.1.1 Dissolved Oxygen

a. Total number of days with DO below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters.

   There was no change from the DEIS and 2015 PAL response. Figures 12 and 13 present two plots illustrating Alt7H in the top figure and Alt7K in the bottom figure. These figures present variations of DO modeled along the Chattahoochee River. The figures do not explicitly define the number of days when concentrations are less than state standards (6 mg/L for secondary trout waters and 5 mg/L) but they do provide insight to where low DO concentrations occur for the period from May through October.

   Figures 14 through 19 present DO occurrence plots at Norcross, Georgia and Morgan Falls Dam. These locations are within the secondary trout waters and the figures illustrate the range of DO that would be expected in the PAA. Similar to Figures 12 and 13, two plots are presented to illustrate Alt7H and Alt7K, the PAA. Comparing DO in these occurrence plots illustrates that the lowest concentrations of the PAA would be expect to remain higher than the lowest concentrations of Alt7H.

   Figures 18 through 25 illustrate occurrences of DO at locations where, based on Figure 12 and Figure 13, median concentrations are less than state standards. These locations are downstream of Buford, West Point, Bartletts Ferry, and Walter F. George dams. Again, two plots are presented for each figure to illustrate Alt7H and the PAA, Alt7K.



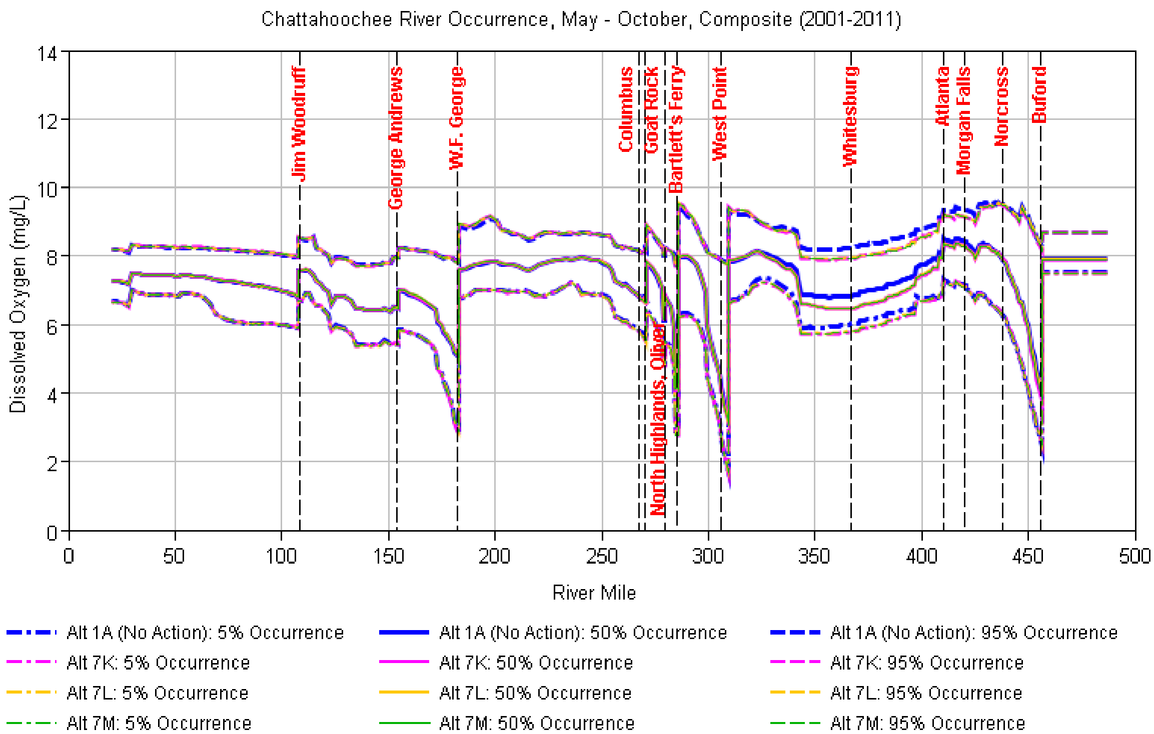
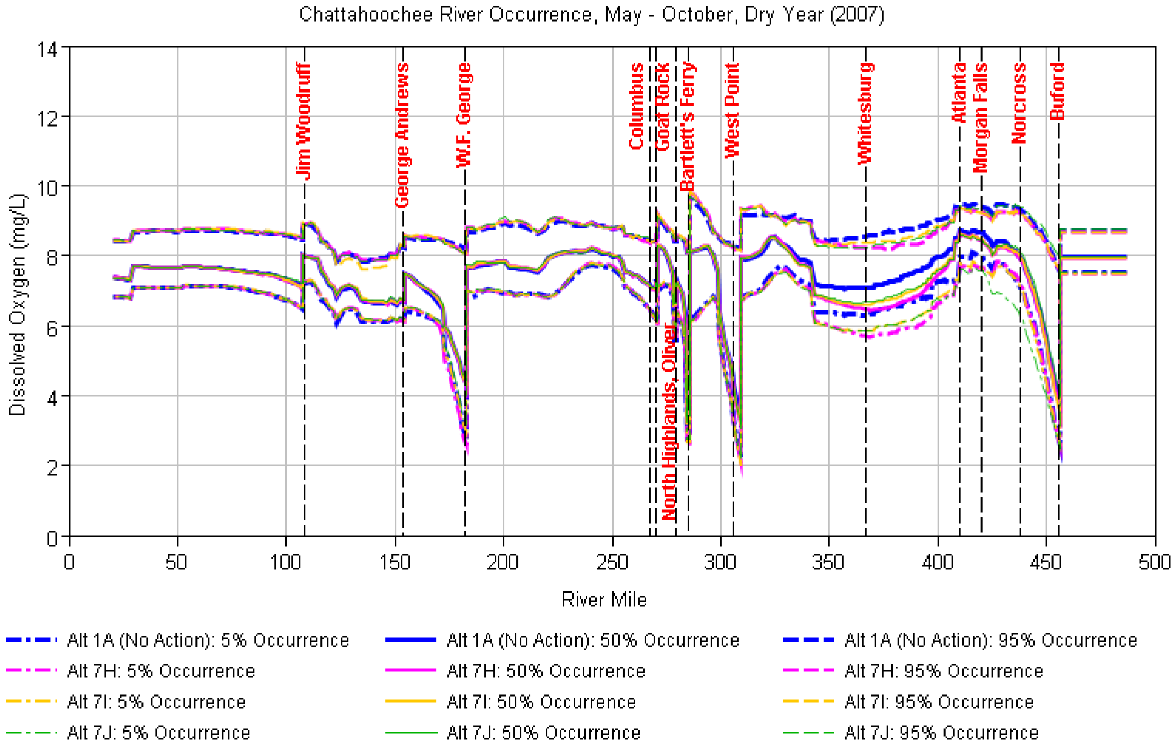


Figure 12. May through October DO for the modeled period from 2001 through 2011.



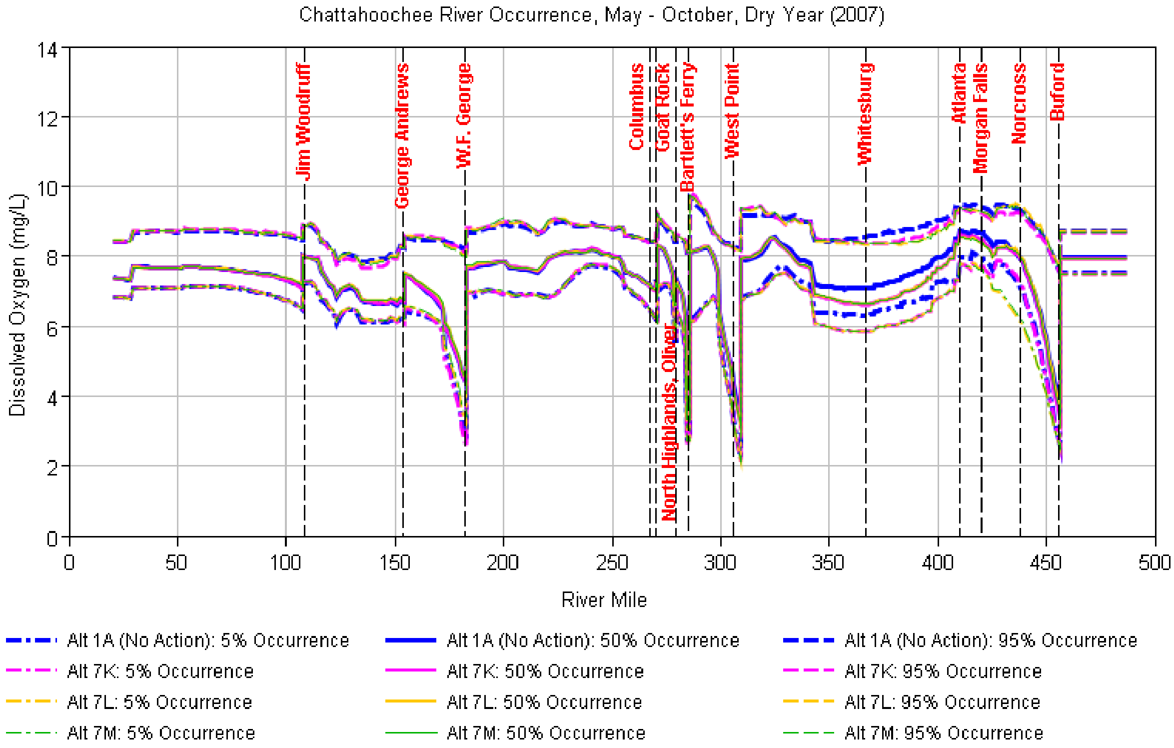
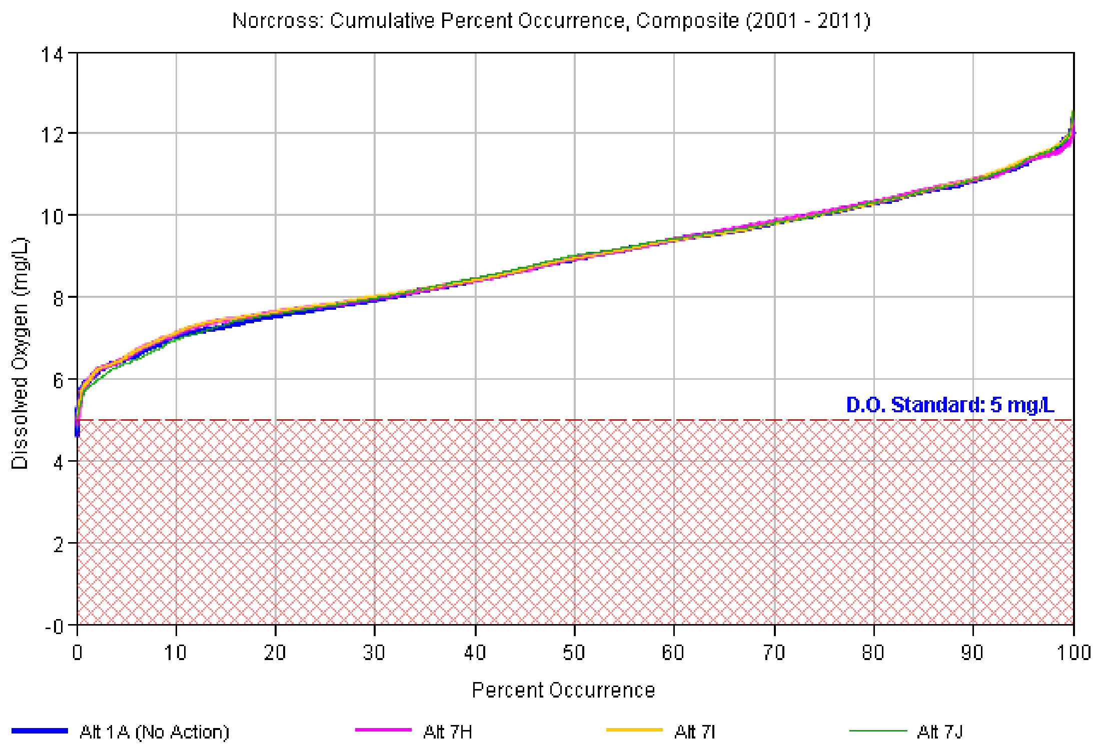


Figure 13. May through October DO modeled for a representative dry period (2007) when low concentrations would be expected.



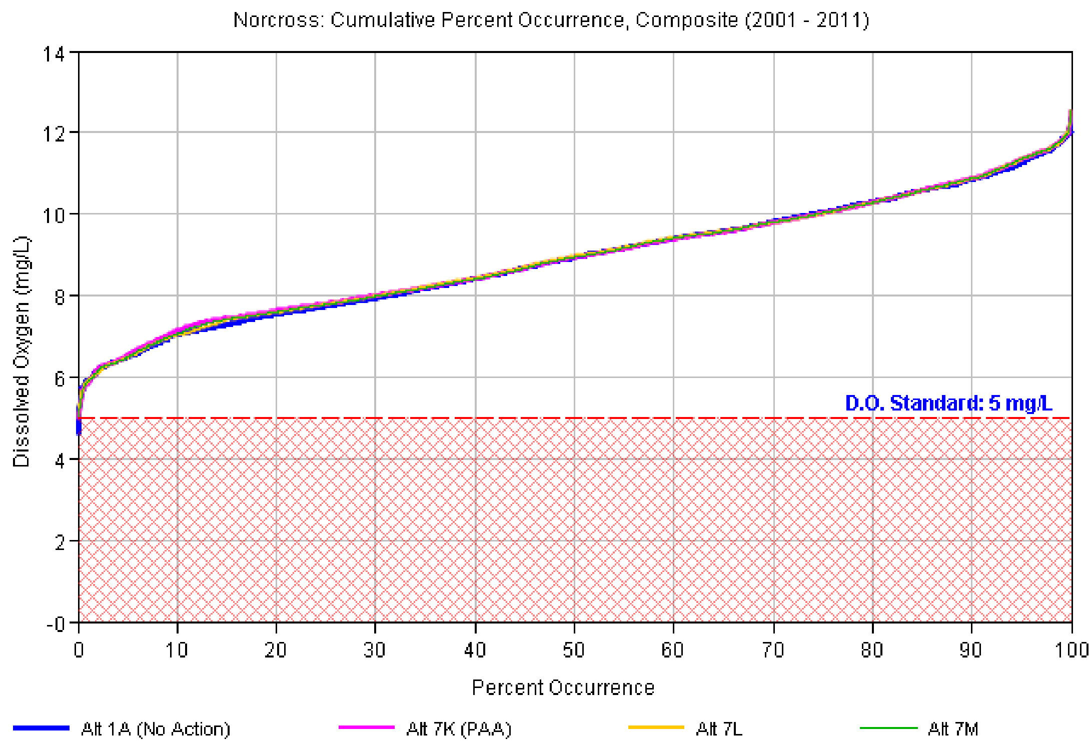


Figure 14. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for the period from 2001 through 2011.

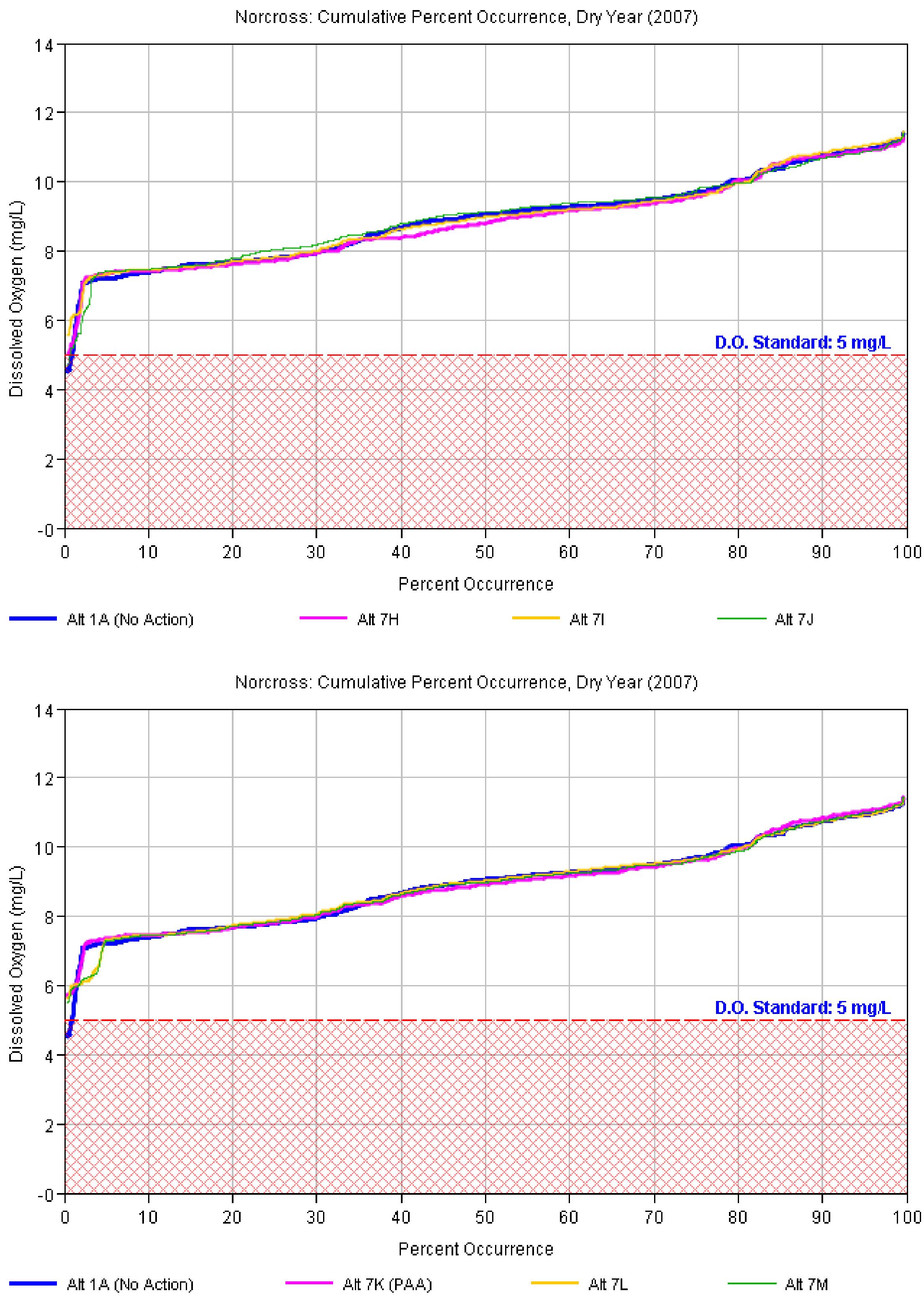
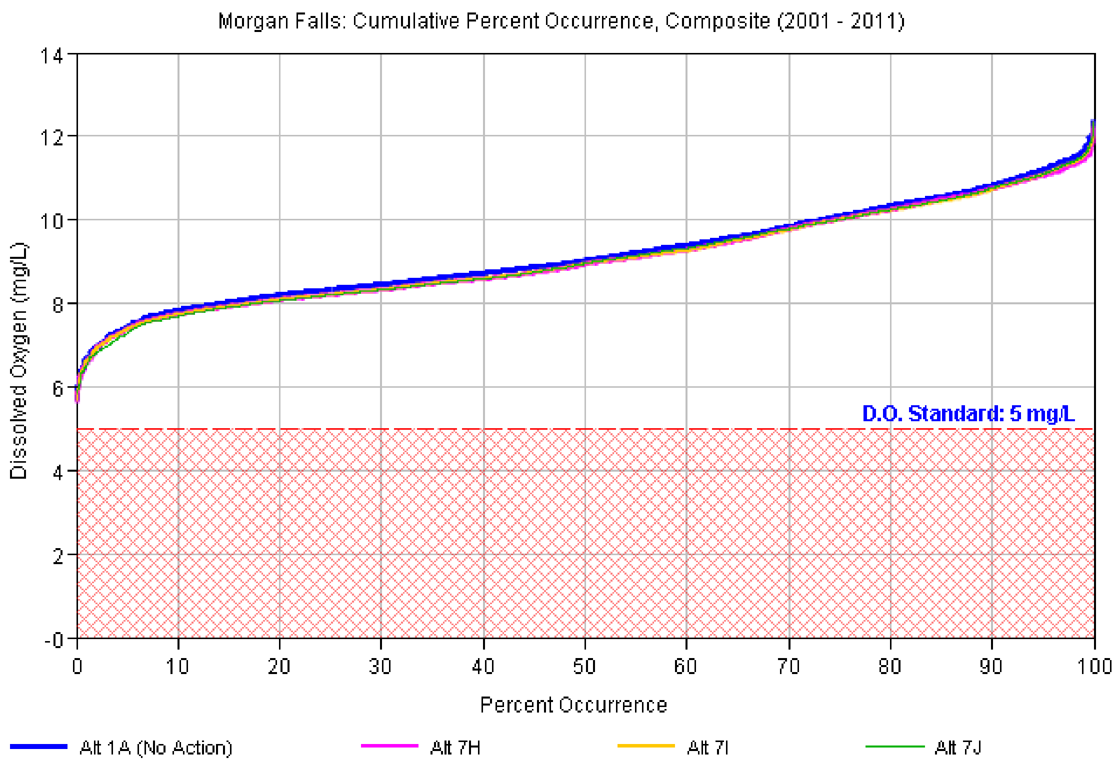


Figure 15. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for a representative dry year (2007).



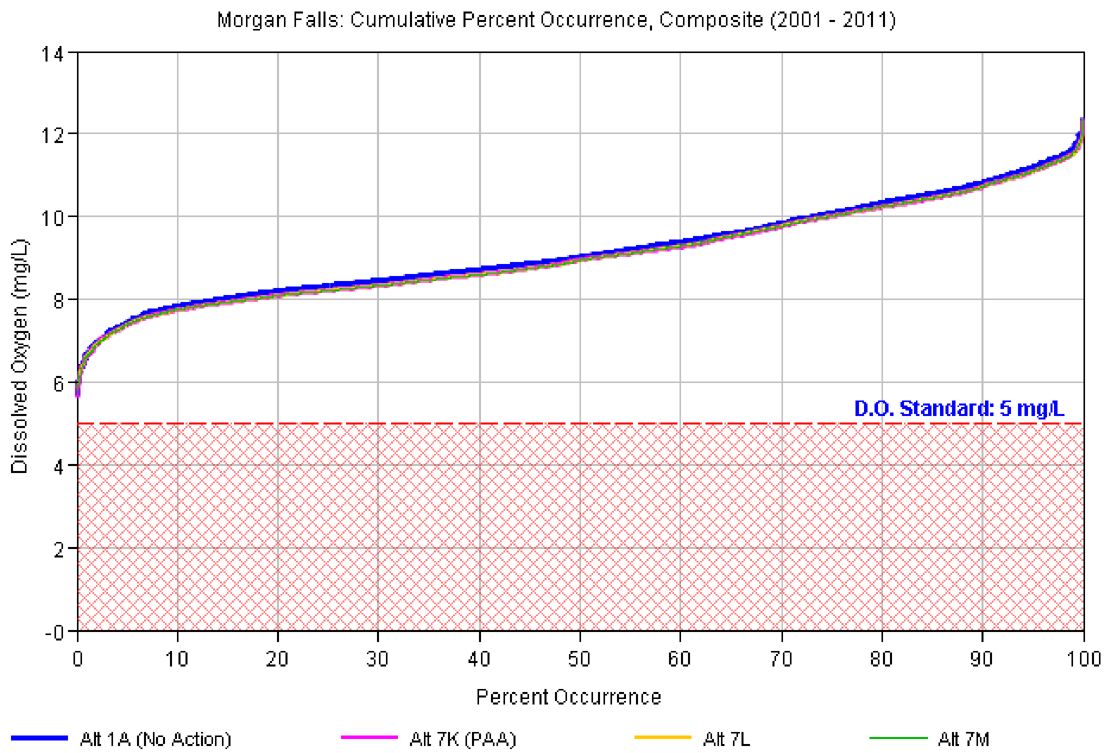
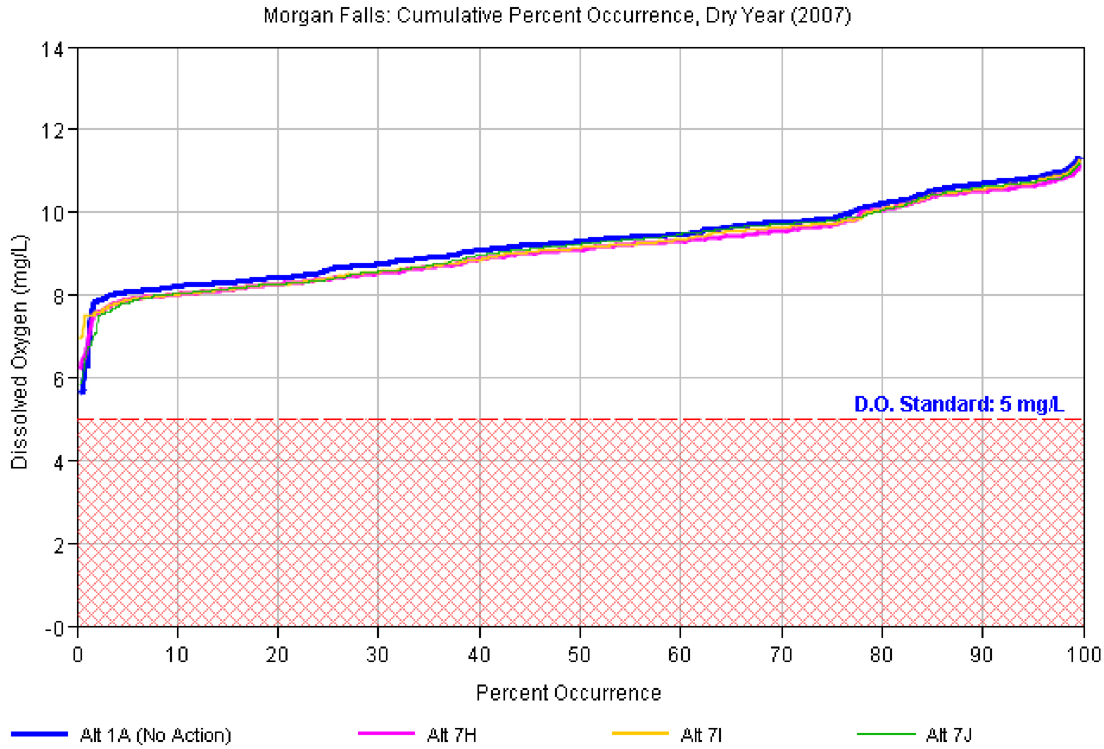


Figure 16. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for the period from 2001 through 2011.



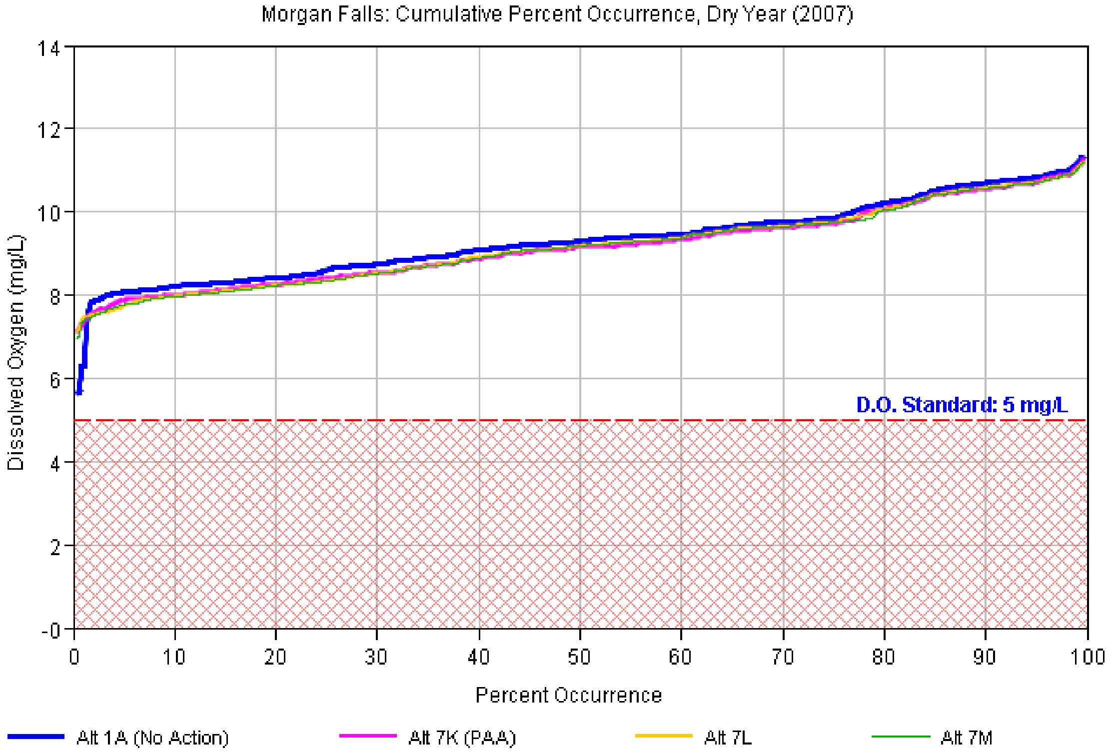
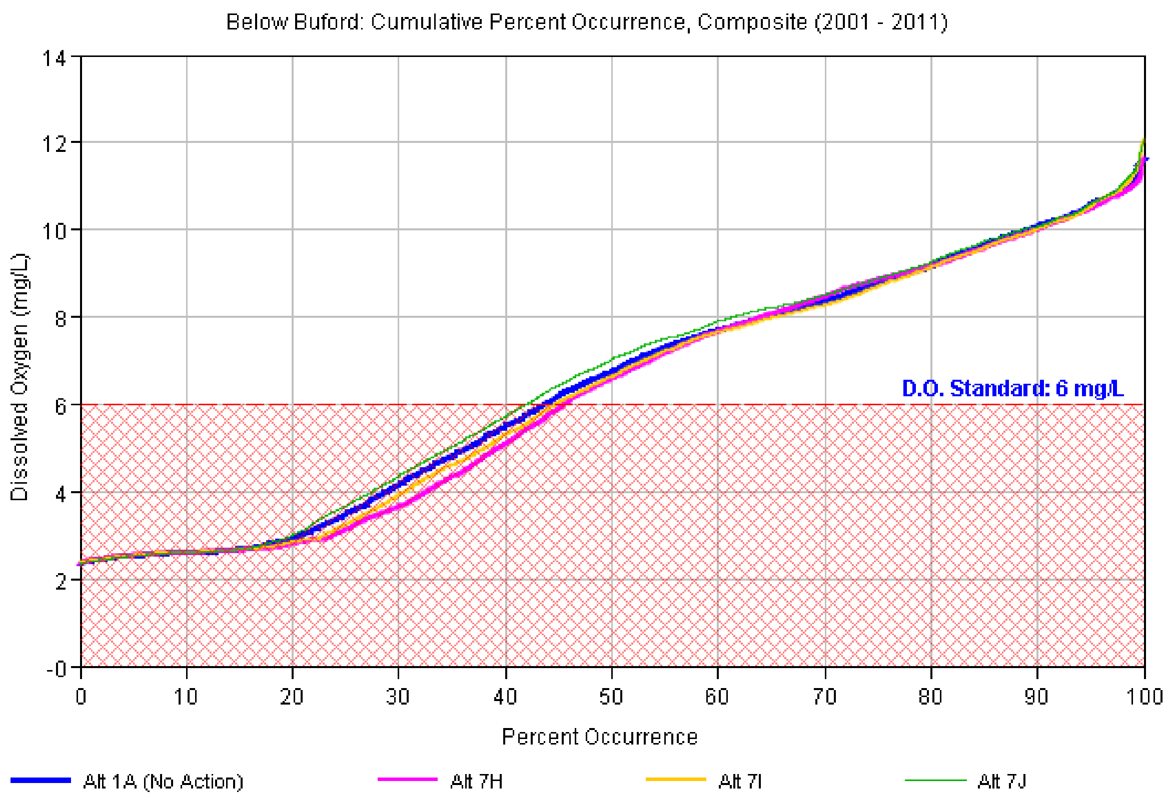


Figure 17. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for a representative dry year (2007).



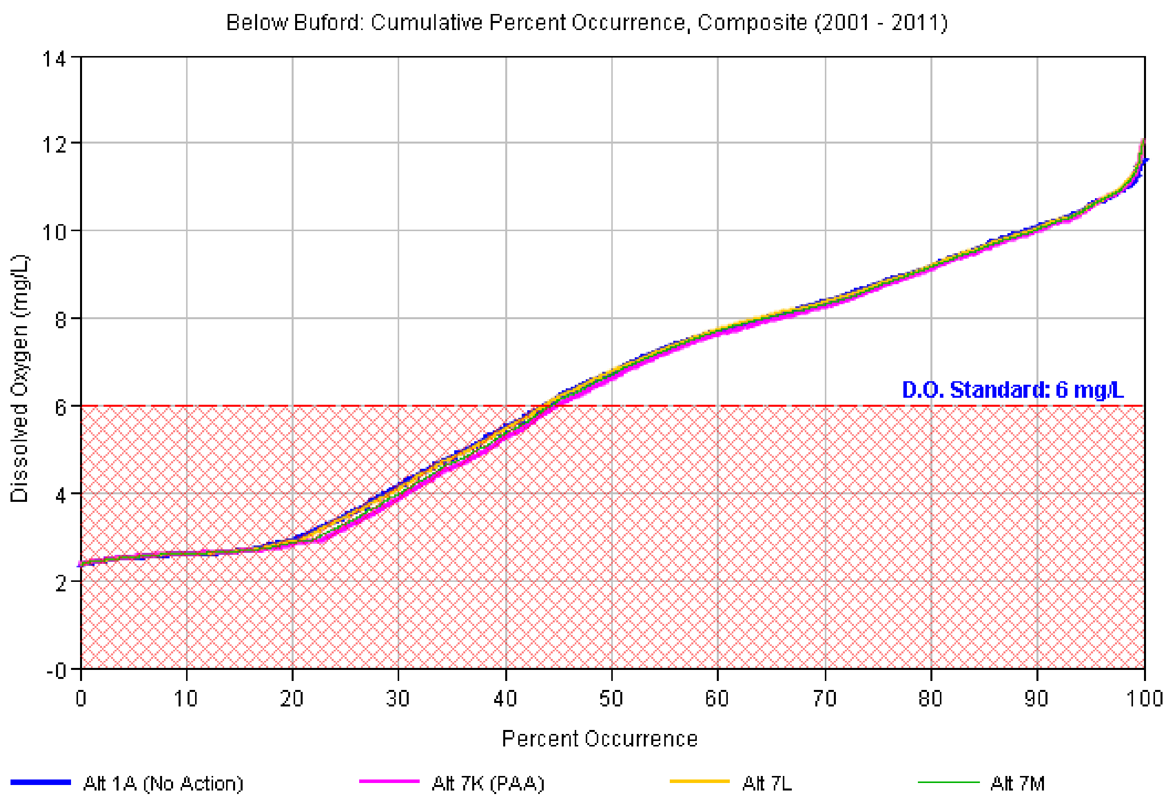
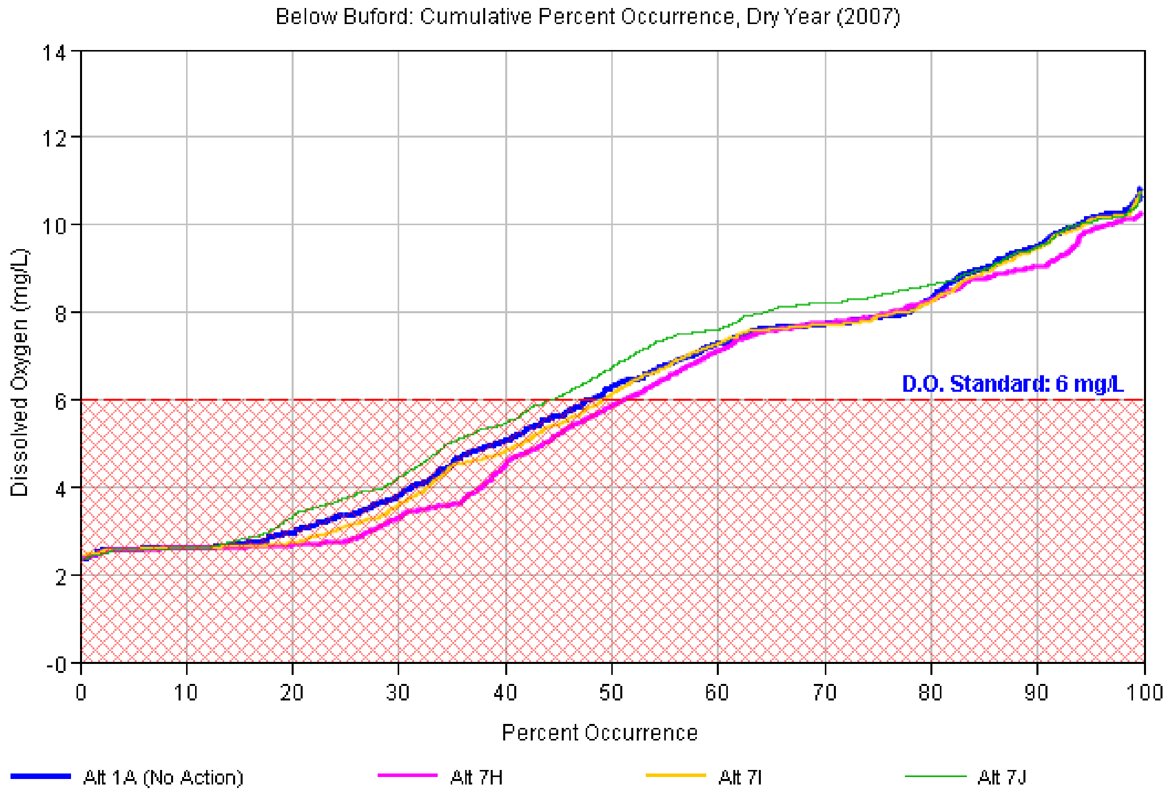


Figure 18. DO occurrence downstream of Buford Dam for the modeled period (2001 – 2011).



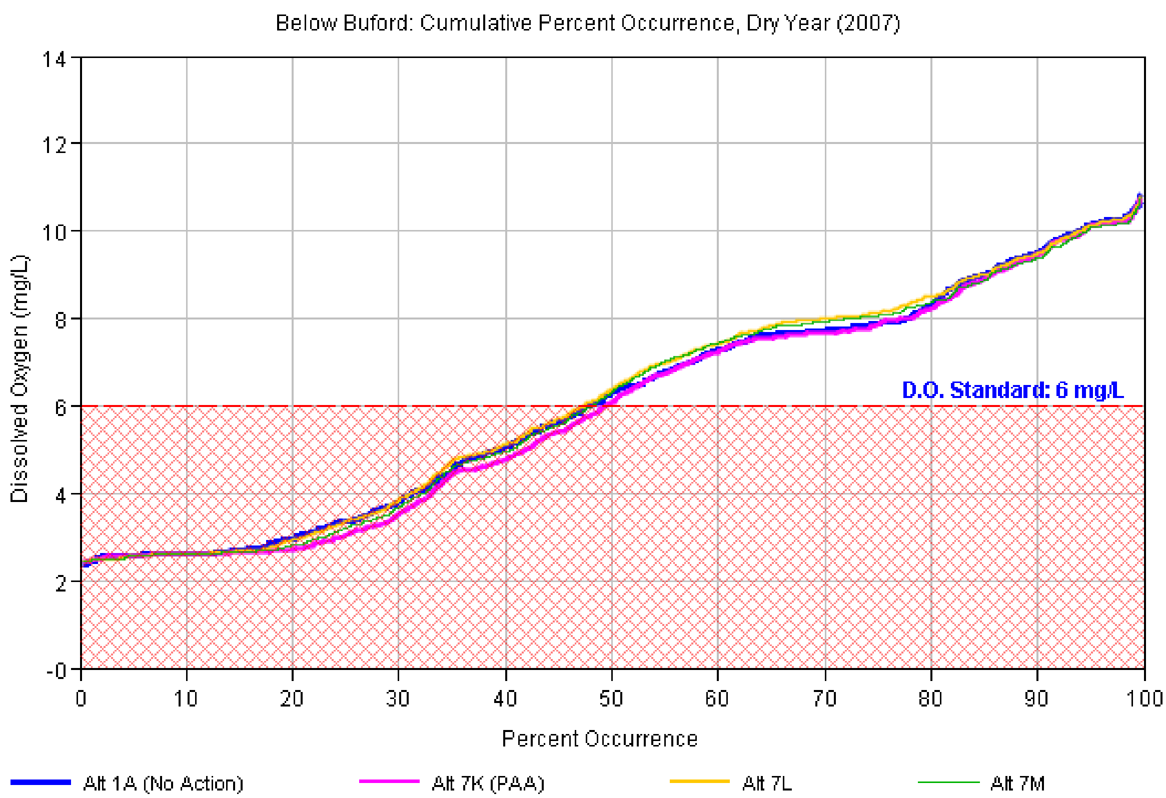
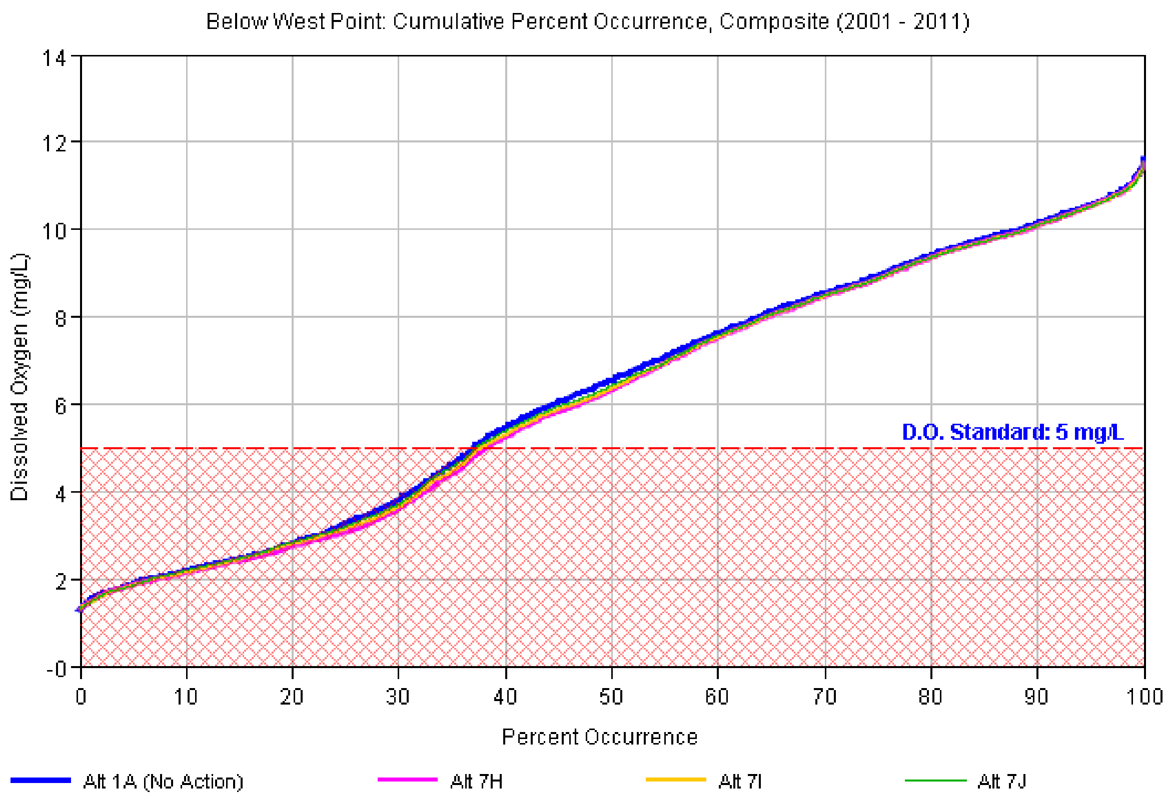


Figure 19. DO occurrence downstream of Buford Dam for a representative dry year (2007).



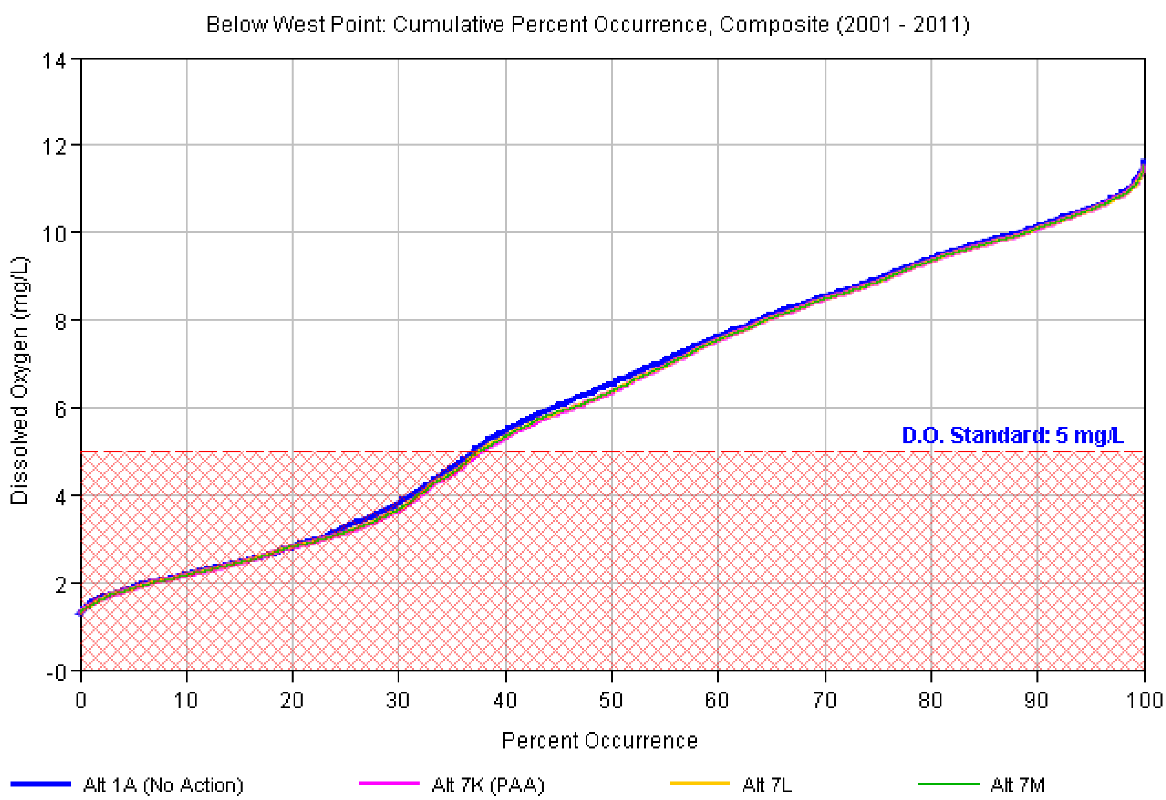
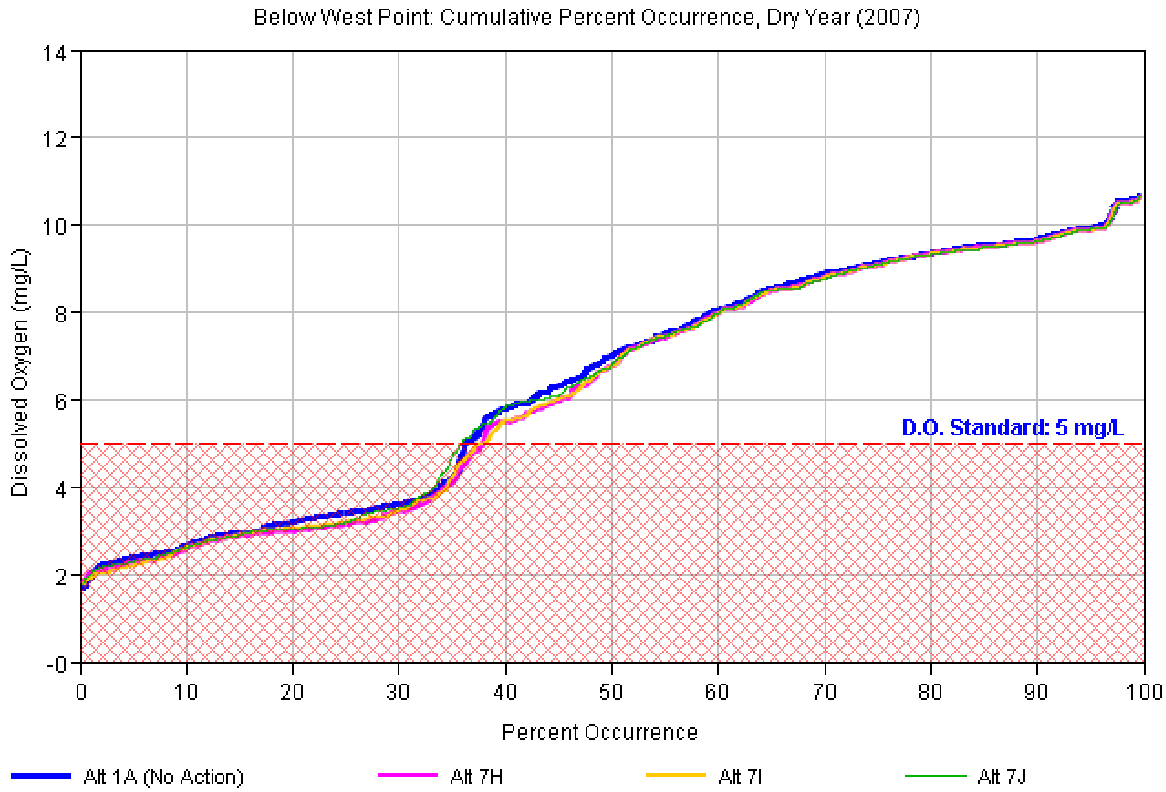


Figure 20. DO occurrence downstream of West Point Dam for the modeled period (2001 - 2011).



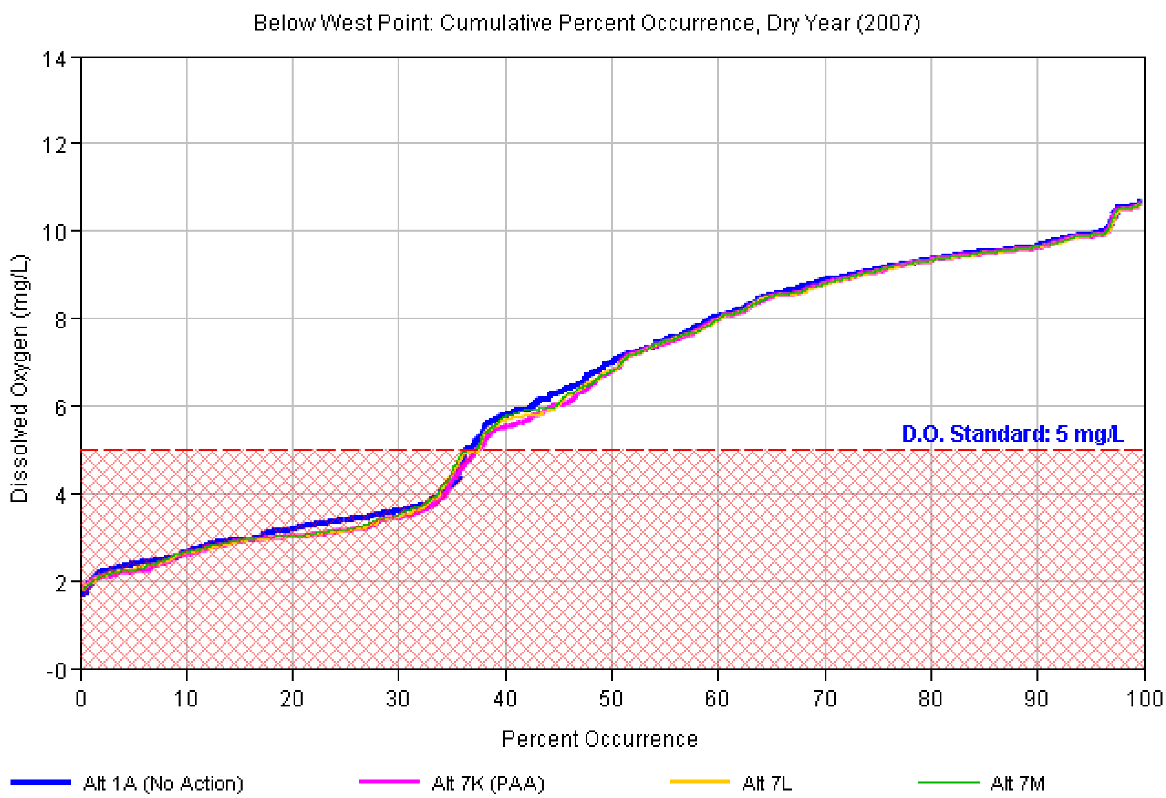
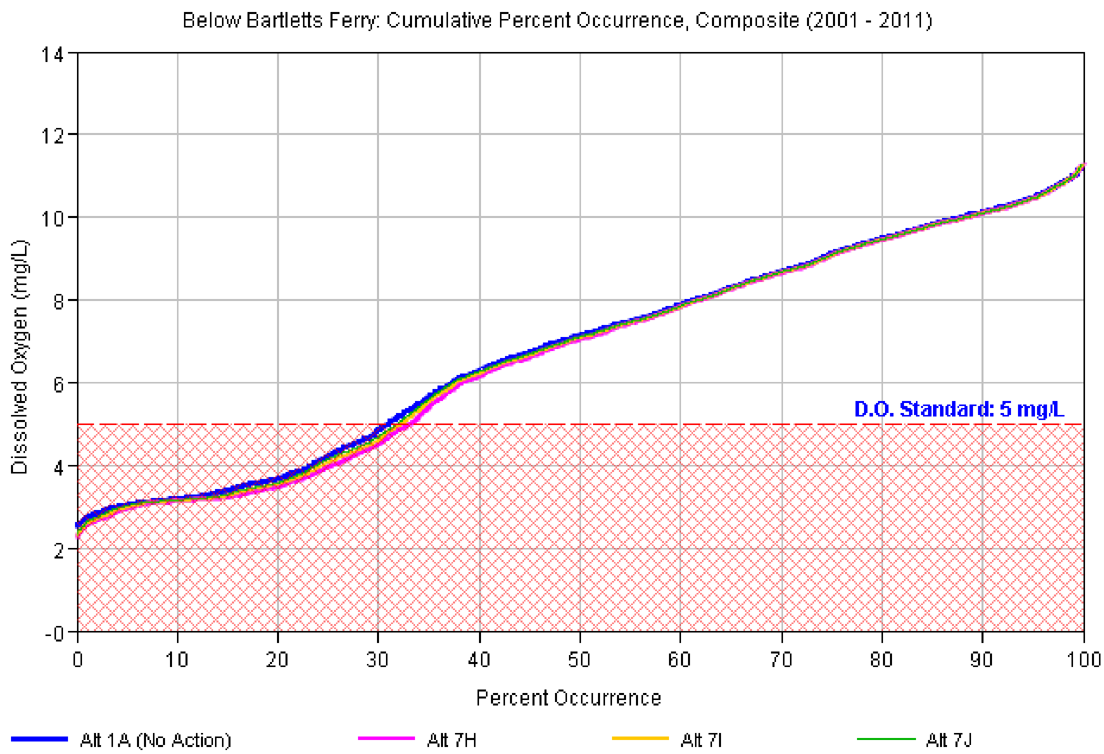


Figure 21. DO occurrence downstream of West Point Dam for a representative dry year (2007).



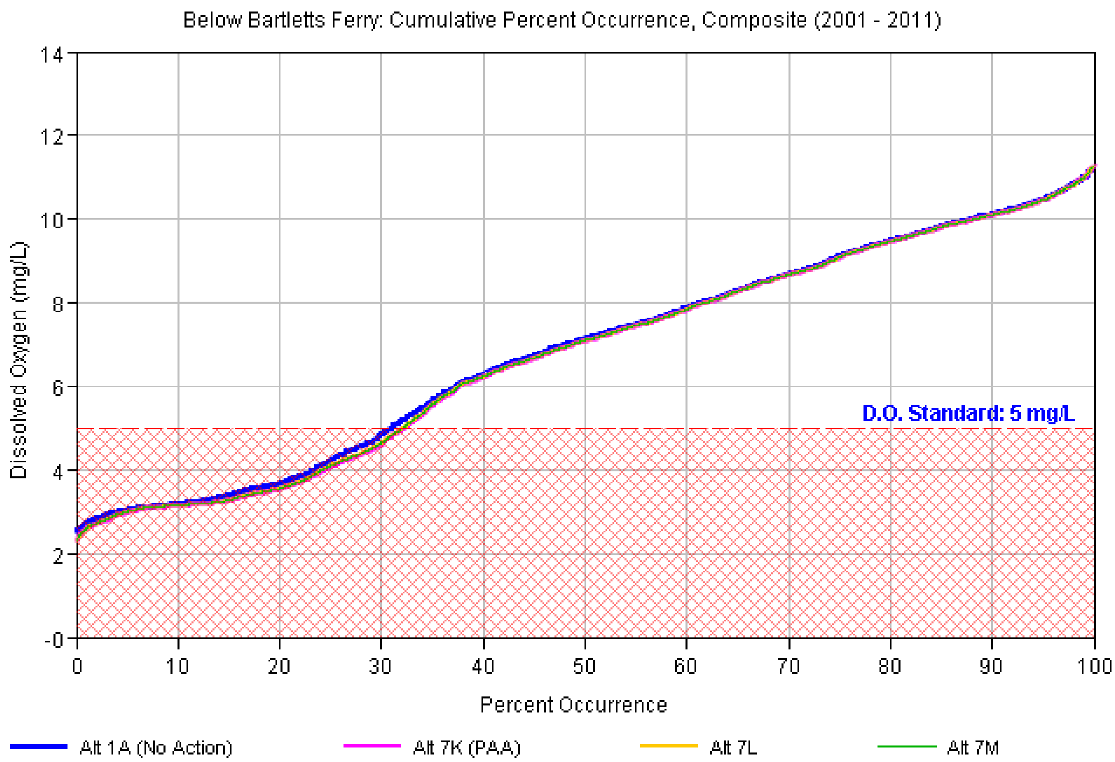
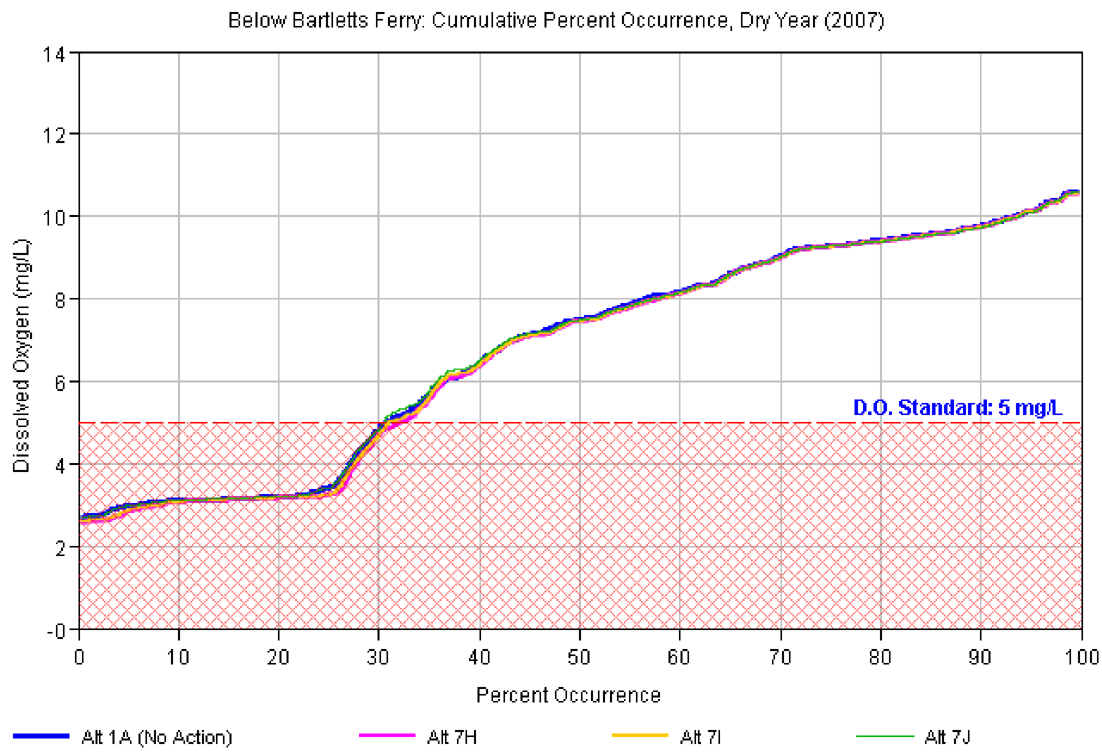


Figure 22. DO occurrence downstream of Bartletts Ferry Dam for the modeled period (2001 - 2011).



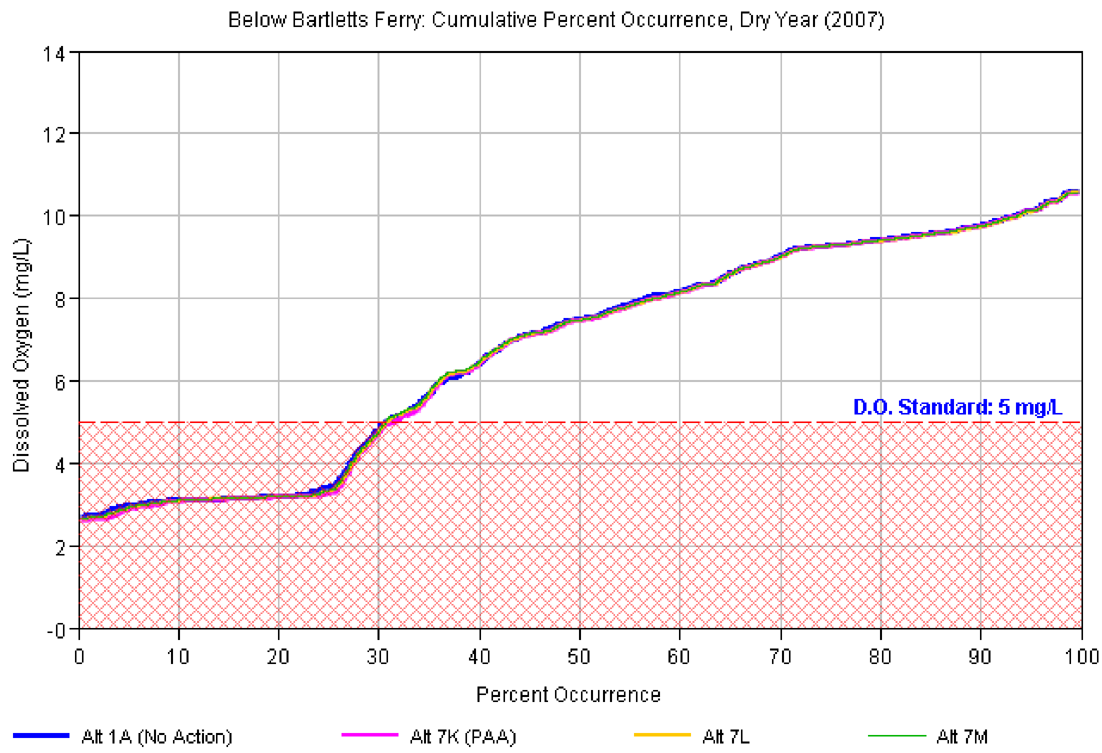
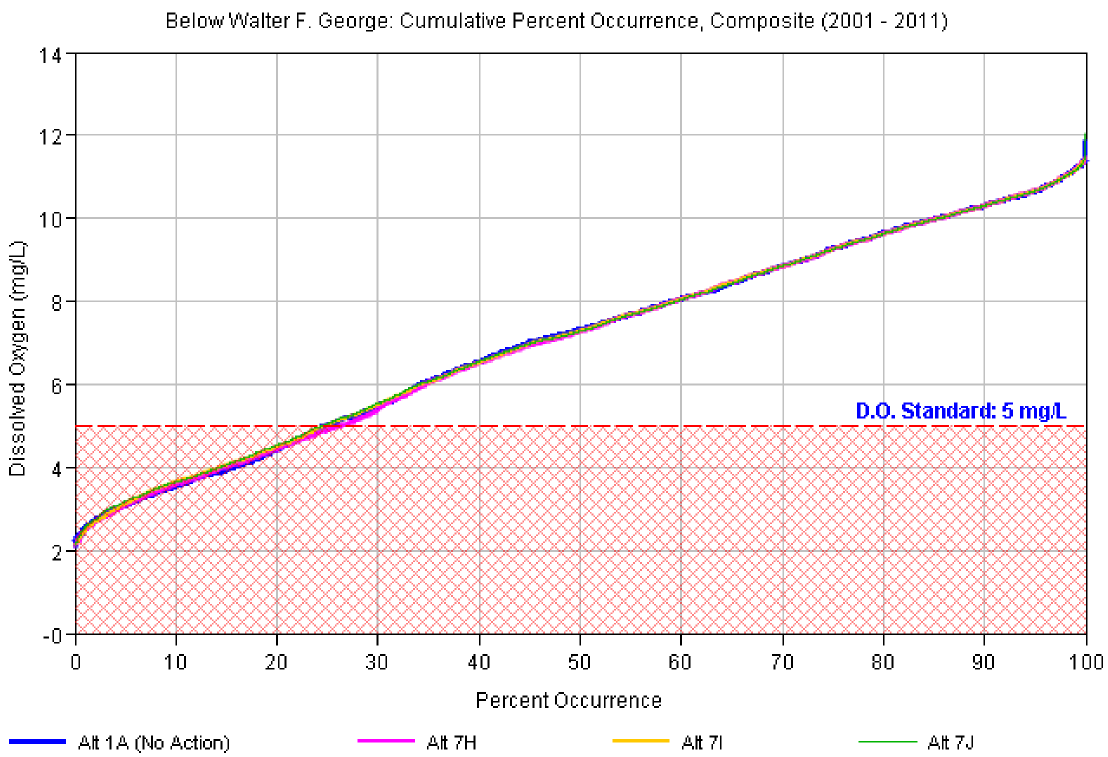


Figure 23. DO occurrence downstream of Bartletts Ferry Dam for a representative dry year (2007).



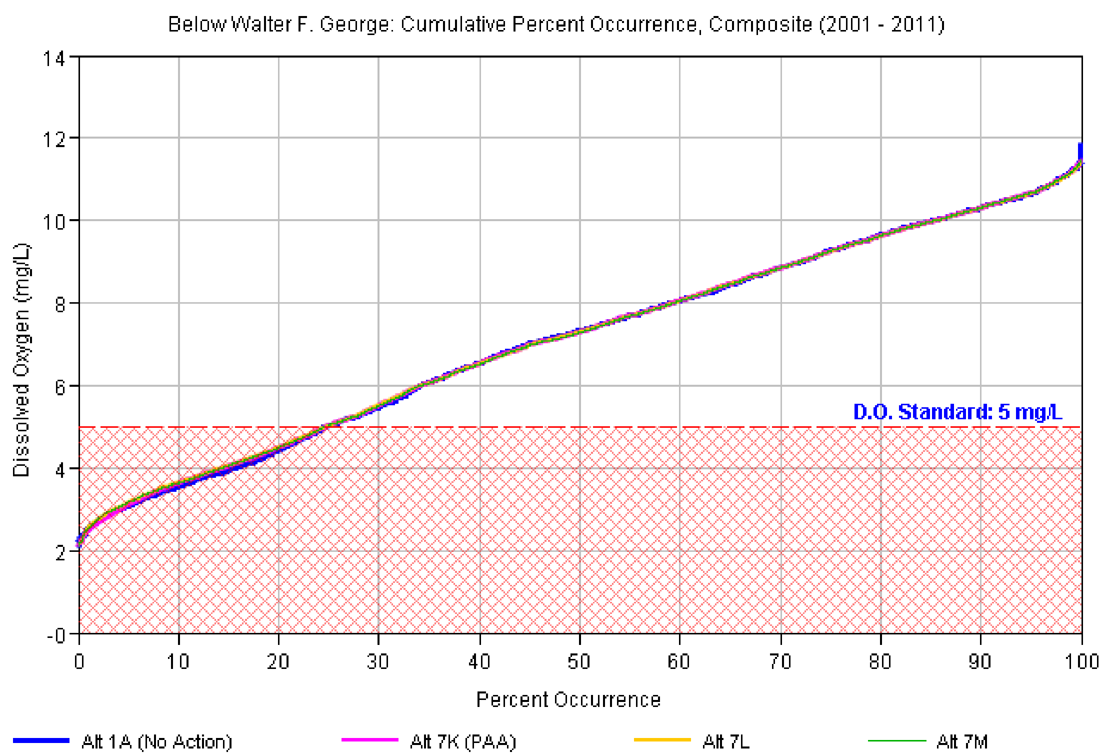
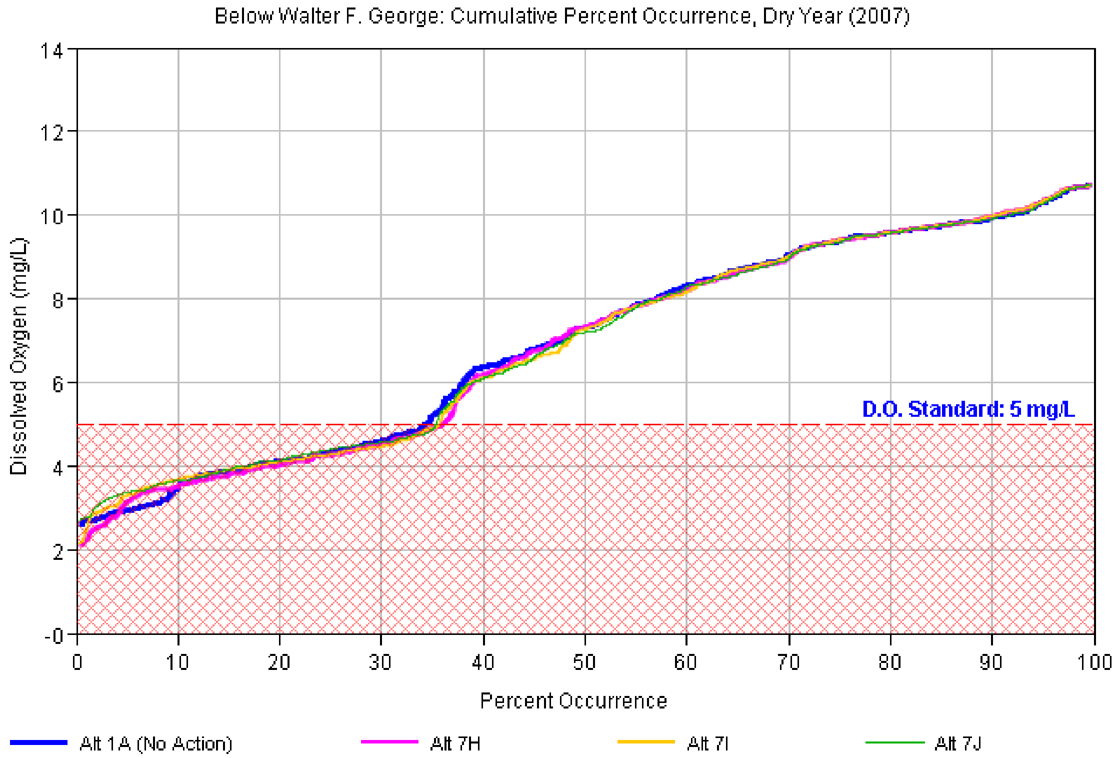


Figure 24. DO occurrence downstream of Walter F. George Dam for the modeled period (2001-2011).



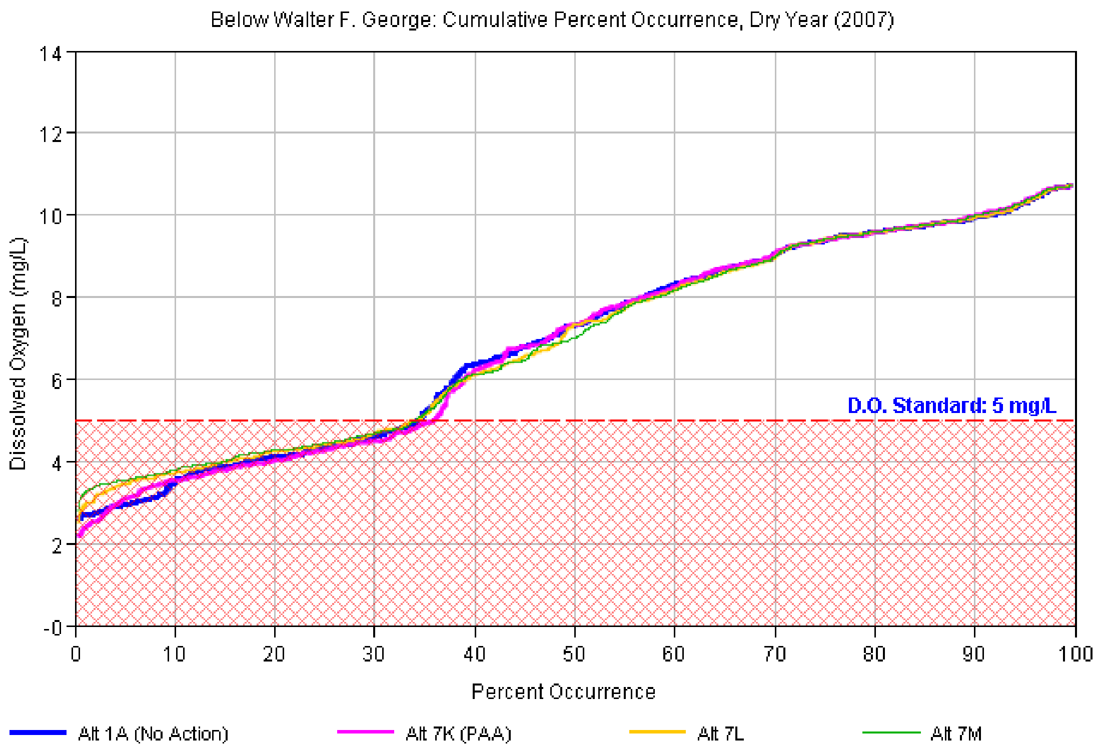


Figure 25. DO occurrence downstream of Walter F. George Dam for a representative dry year (2007).

b. Total number of instantaneous "measurements" less than 4 mg/L.

Instantaneous modeled results were not simulated. The river profile simulations suggest that DO values less than 4 mg/L are only expected at several tailrace locations (as illustrated in Figures 18 through 25). Time series plots for these locations are also provided below in Figure 26 through Figure 29.

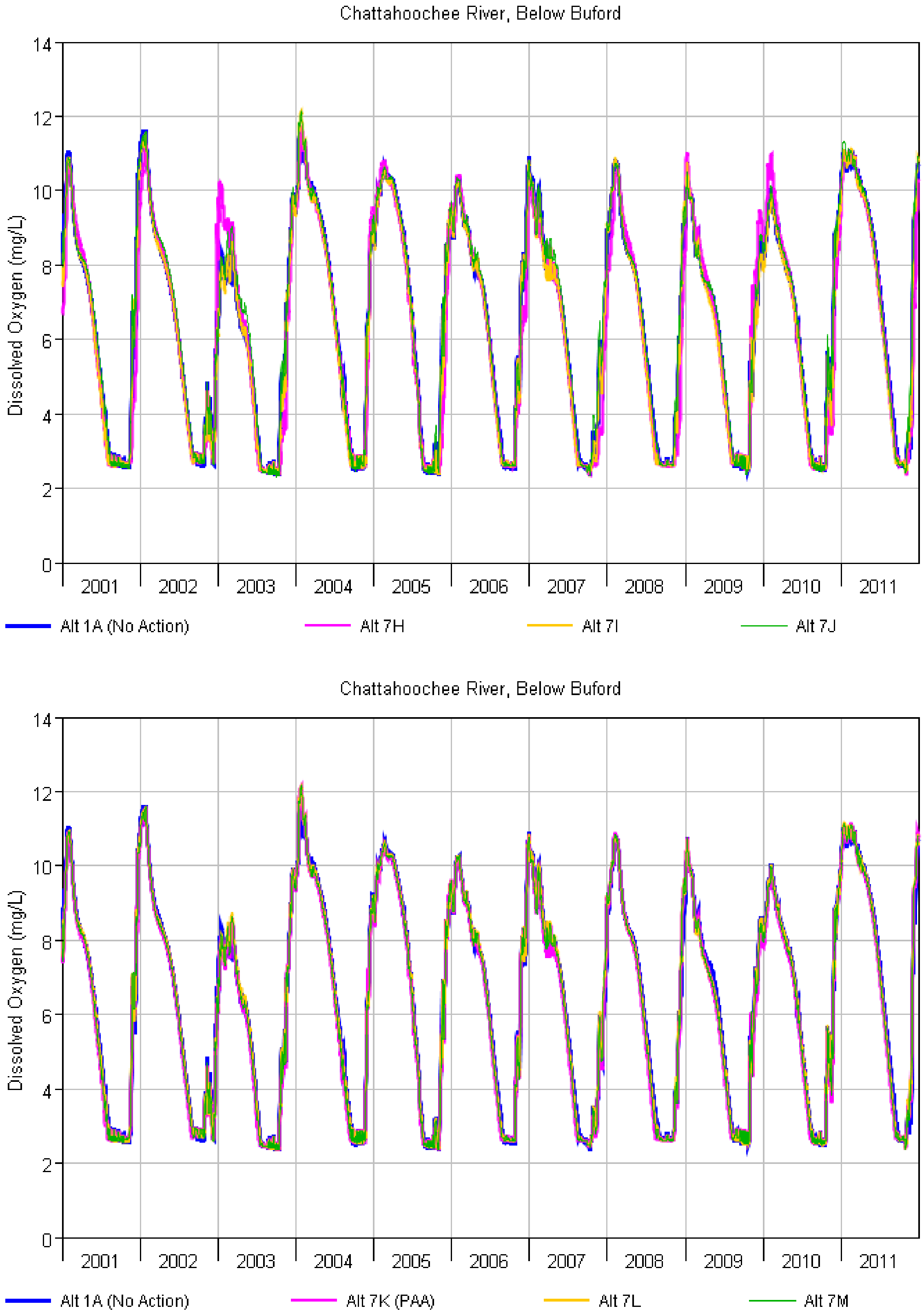
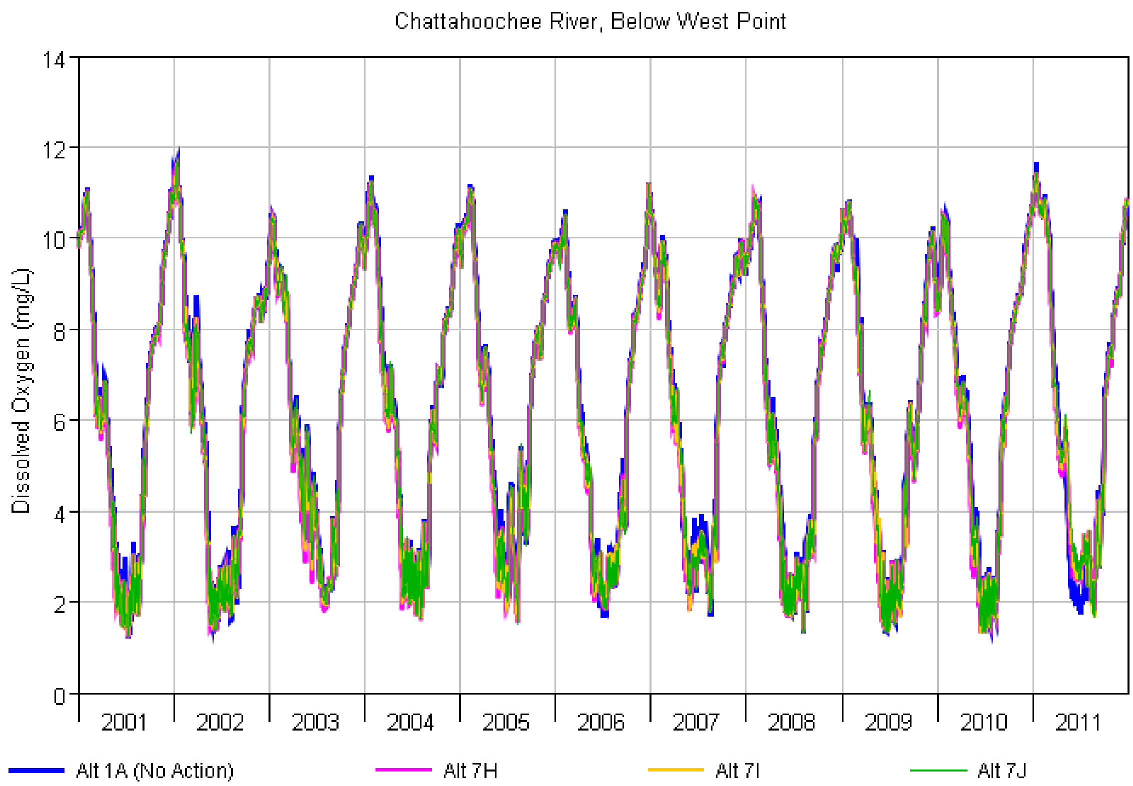


Figure 26. Time series DO from Buford Dam releases.



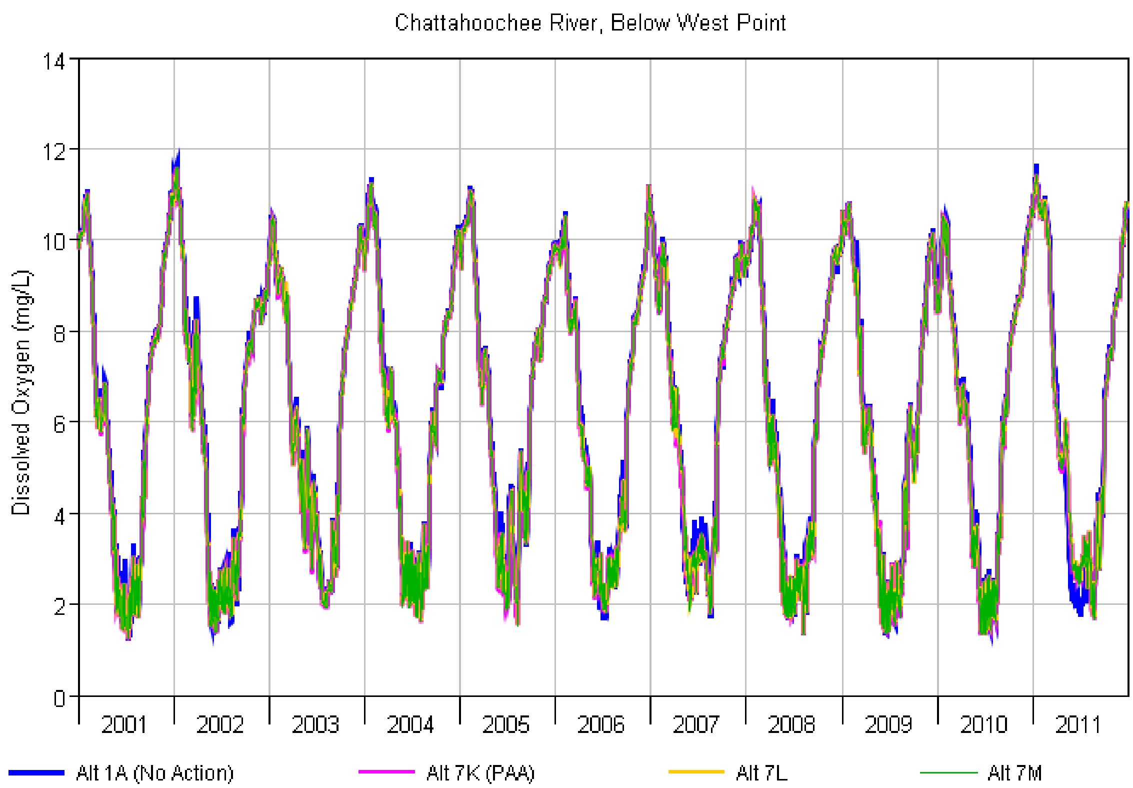
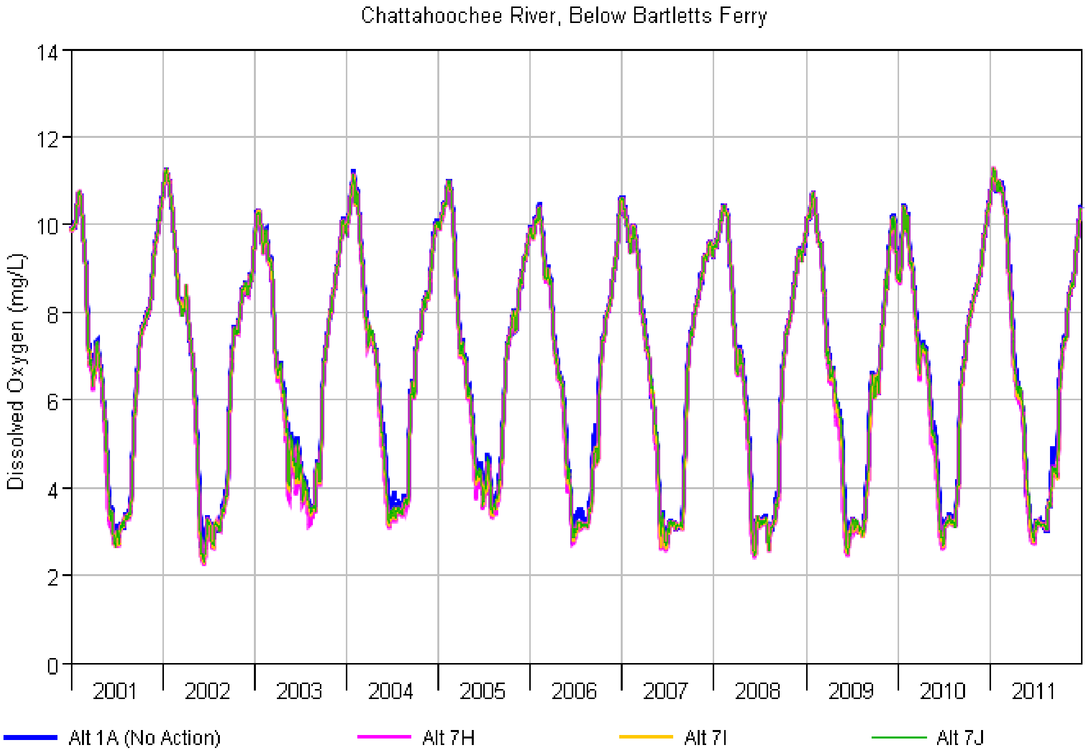


Figure 27. Time series DO from West Point Dam releases.



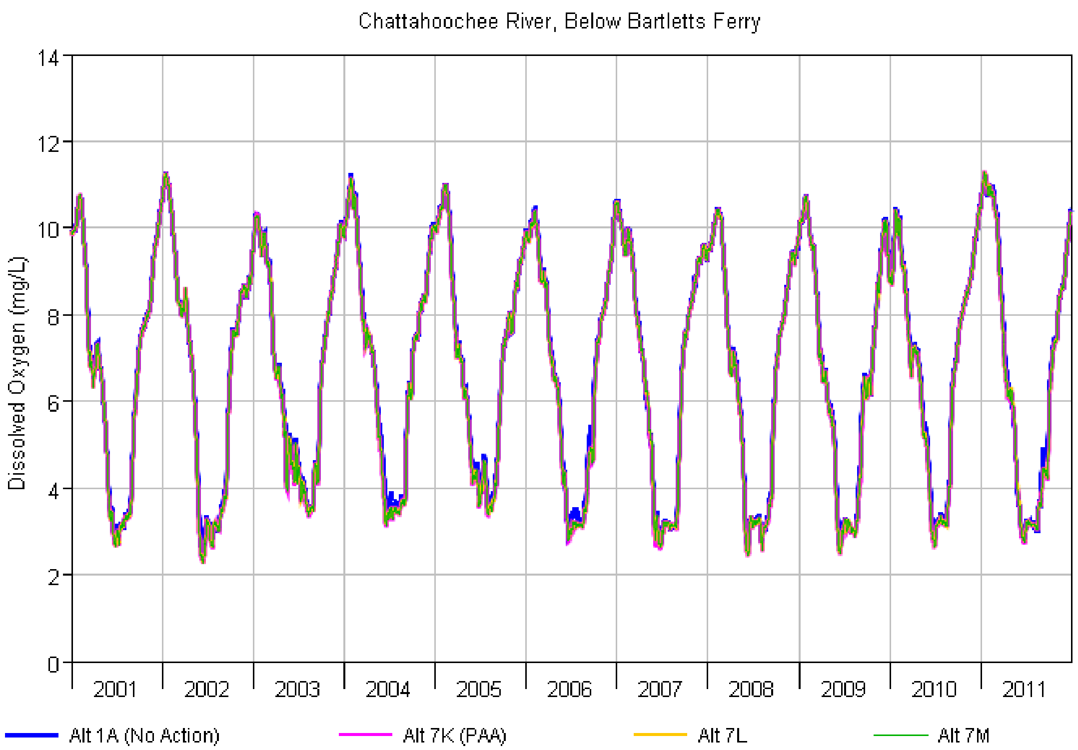
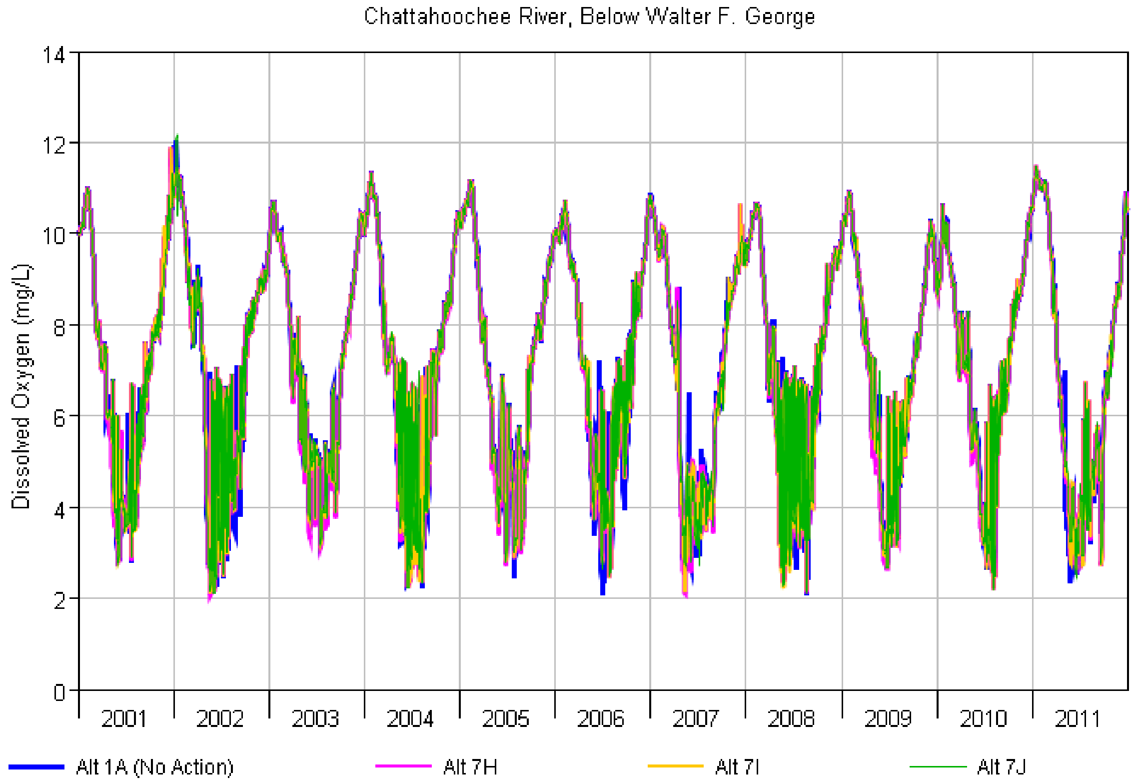


Figure 28. Time series DO from Bartletts Ferry Dam releases.



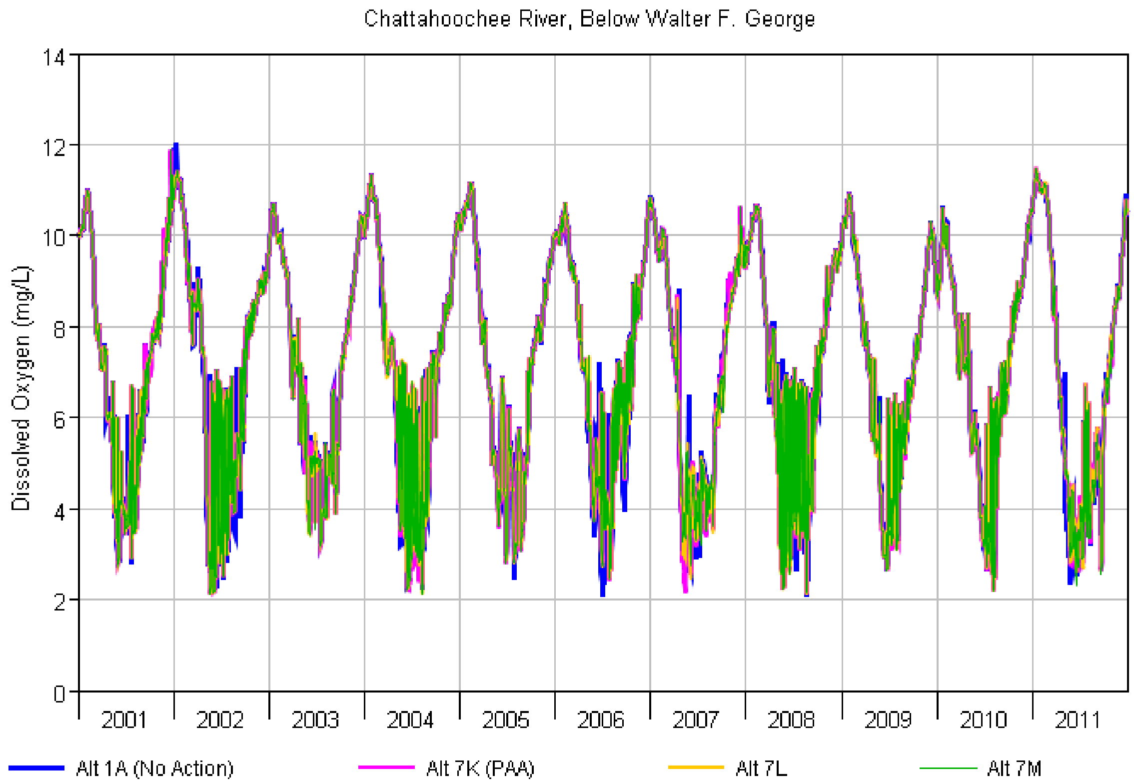
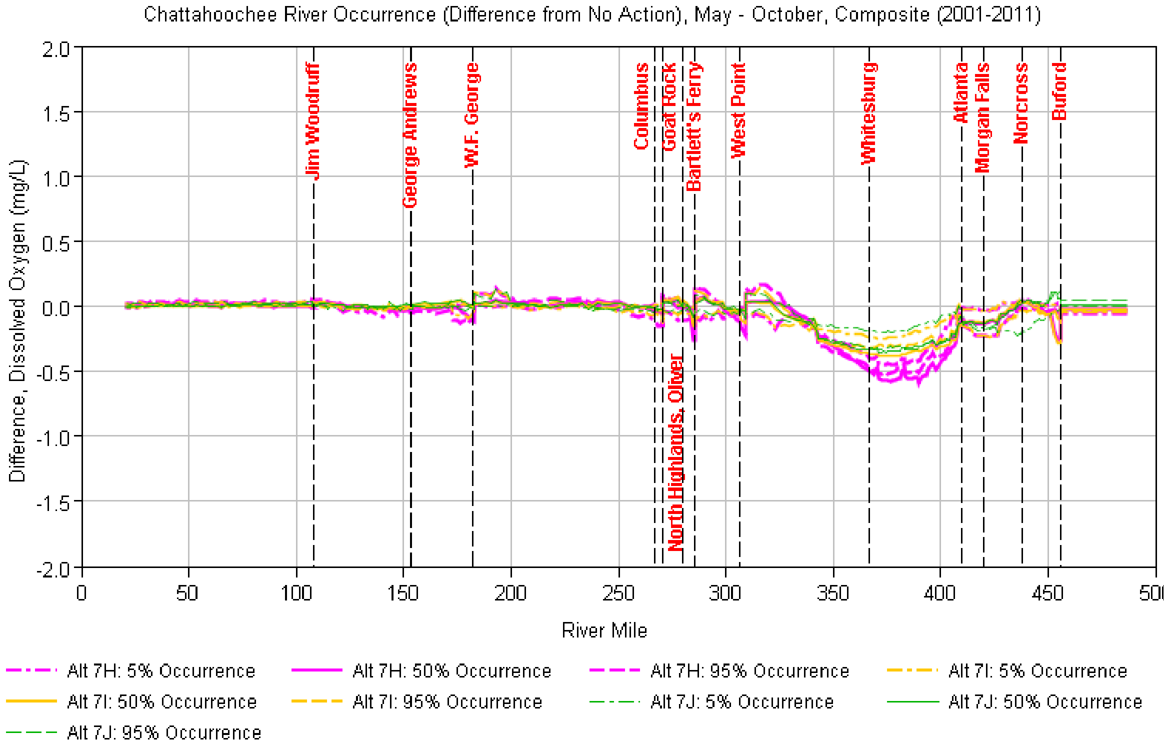


Figure 29. Time series DO from Walter F. George Dam releases.

c. Monthly exceedance figures and box plots with outliers for DO (mg/L).

As in previous PAL responses, monthly exceedance figures for DO were not generated. Figure 30 generally provides the same information in a format we believe is easier to communicate. Figure 30 illustrates the change in DO concentrations between the NAA and the PAA (PAA minus NAA is illustrated) at the 5th, 50th, and 95th percent occurrence intervals; both Alt7H and Alt7K are illustrated in the two plots provided. For these DO plots, the 95th percent occurrence interval means that the values are this number or lower 95 percent of the simulation at this location (i.e., only 5 percent of the time the value is higher than this – a rare occurrence). Conversely, the 5th percent occurrence interval means that the values are this number or lower 5 percent of the simulation at this location (i.e., 95 percent of the time the value is higher than this – this too is a rare occurrence). The 50th percent occurrence represents the median occurrence. Again, there were no notable differences from the modelling results presented in the DEIS PAA.



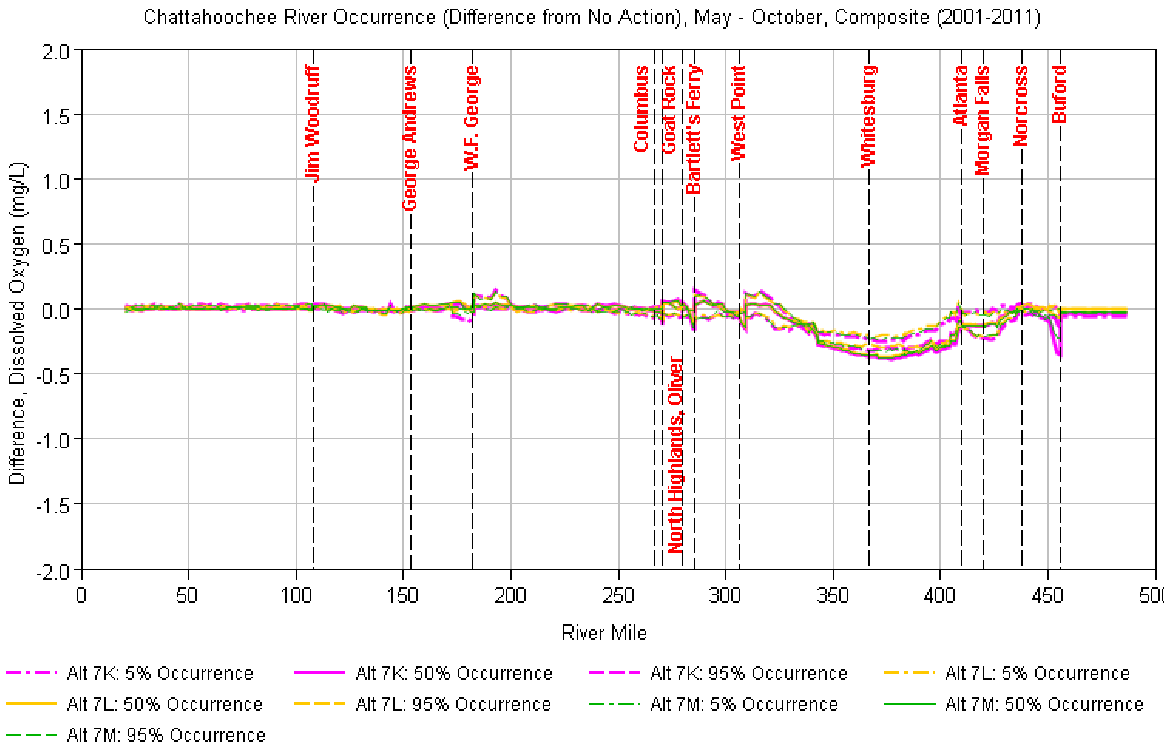


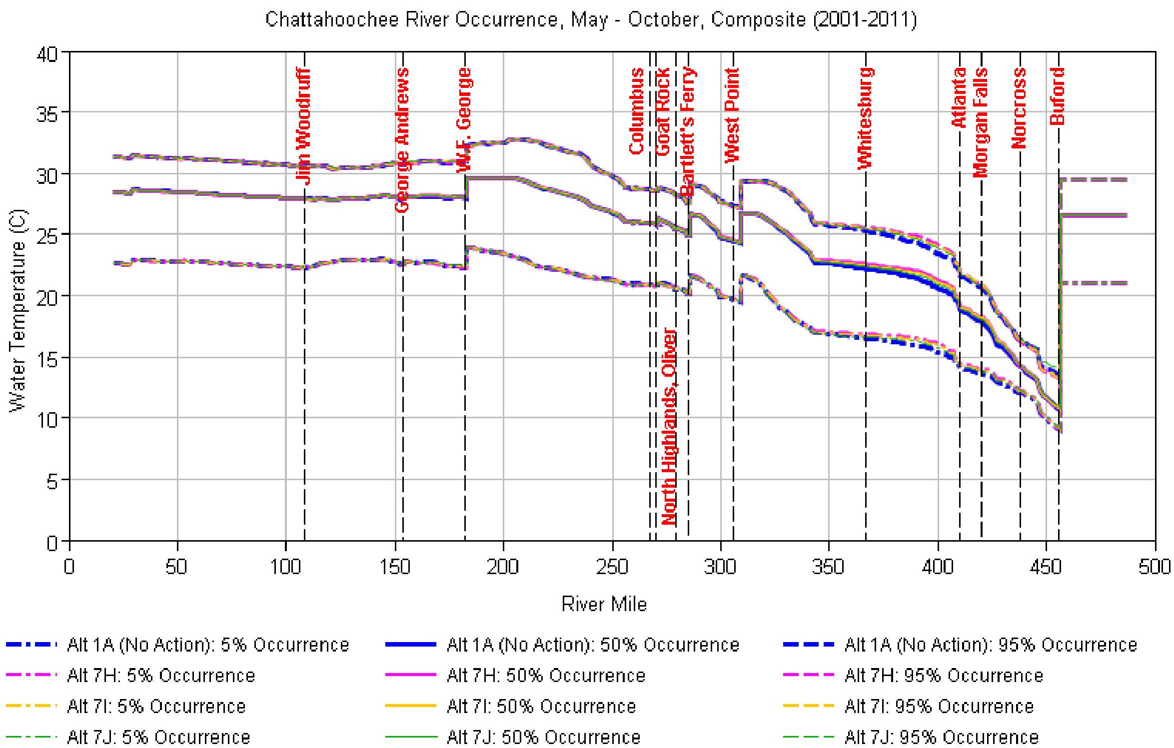
Figure 30. Changes in longitudinal DO in the Chattahoochee River for the May through October for the model period (2001 through 2011).

2.1.2 Water Temperature

a. Monthly exceedance figures and box plots with outliers for water temperature.

Similar to DO, monthly exceedance figures for temperature were not generated. Again, we believe that river profiles and occurrence plots illustrate this information more clearly than the box plots. Figures 31 through 34 illustrate temperatures along the riverine profile and Figures 35 through 38 illustrate the change in temperature from the NAA (PAA minus the NAA is illustrated). The delta profile plots clearly illustrate the magnitude of the change in water temperature of each of the alternatives as compared to the NAA. Similar to the dissolved oxygen discussion, there were no notable differences in impacts when comparing the proposed action from the DEIS to that proposed for the FEIS. Each figure includes two plots that top illustrate Alt7H and the bottom illustrate Alt7K, the PAA.

There are slight differences in Alt7H presented in Figures 36 and 38 and the PAA presented in the January 21, 2015 PAL (USACE, 2015a). These differences are illustrated in a representative normal weather year (2004) in the lowest (5^{th} percent occurrence) water temperatures downstream of Atlanta and in the median water temperatures downstream of Walter F. George Dam and in a representative dry weather year (2007) in the highest (95^{th} percent occurrence) and the lowest (5^{th} percent occurrence) in the reach from Atlanta into West Point Lake.



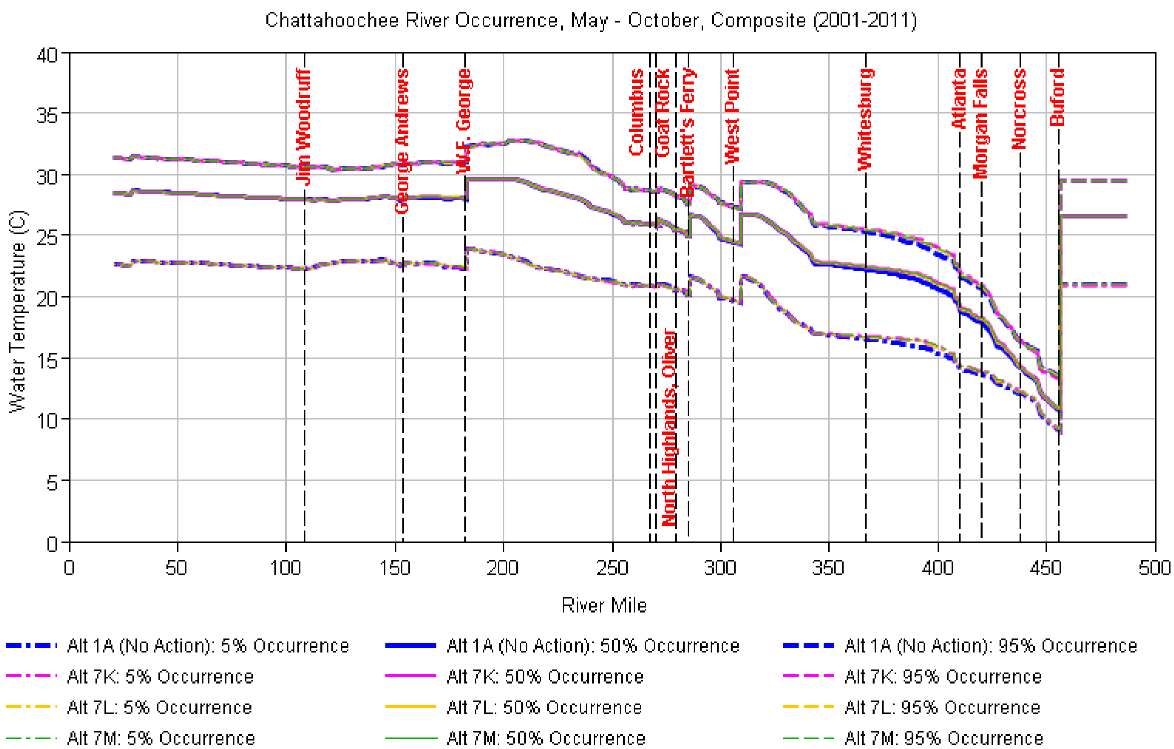
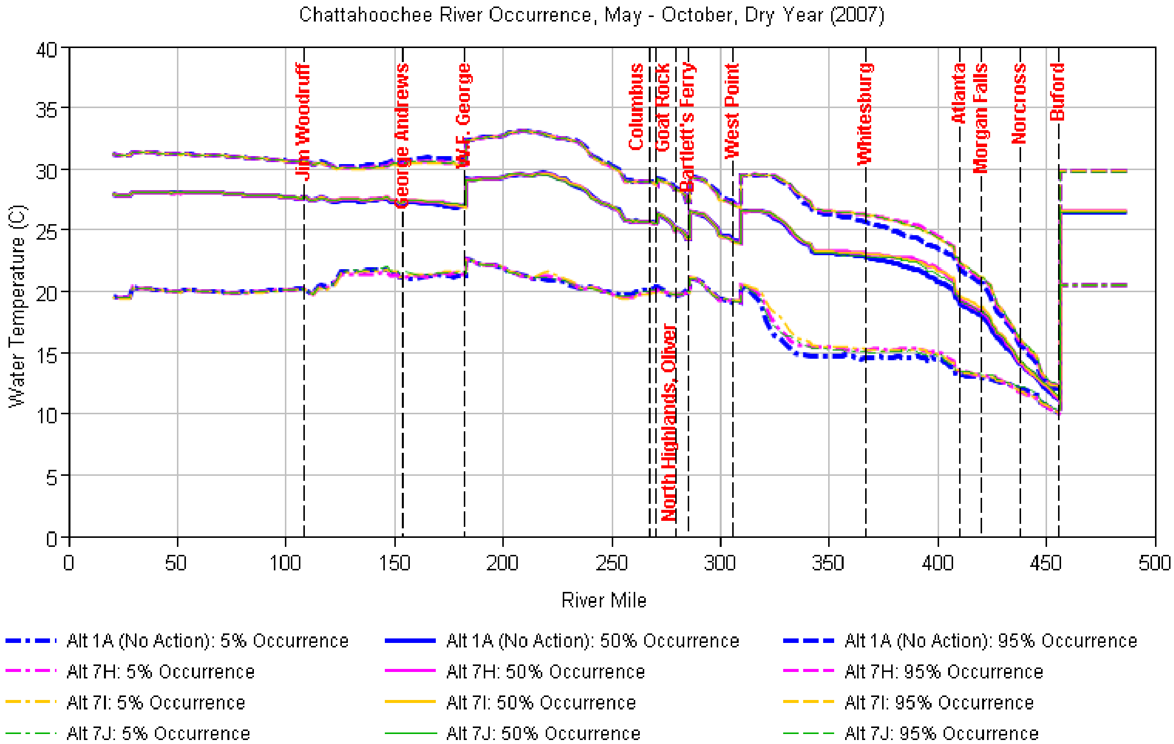


Figure 31. May through October water temperatures along the Chattahoochee River for the modeled period (2001-2011).



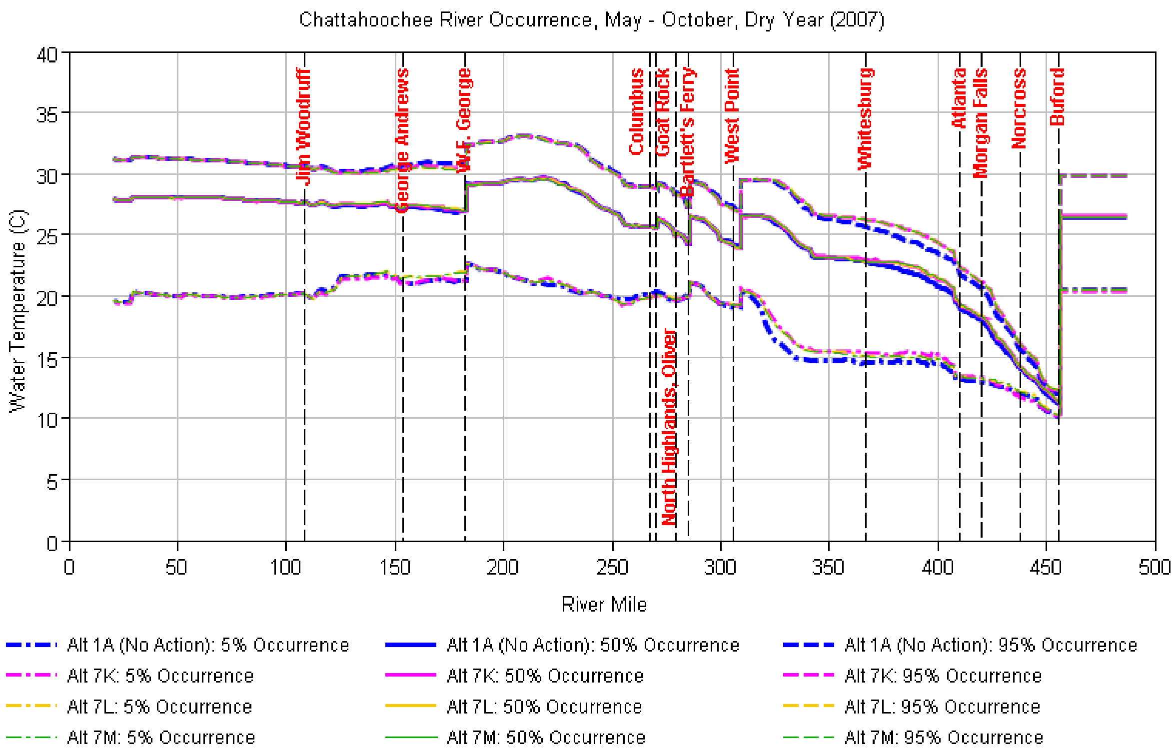


Figure 32. May through October water temperatures along the Chattahoochee River for a representative dry year (2007).

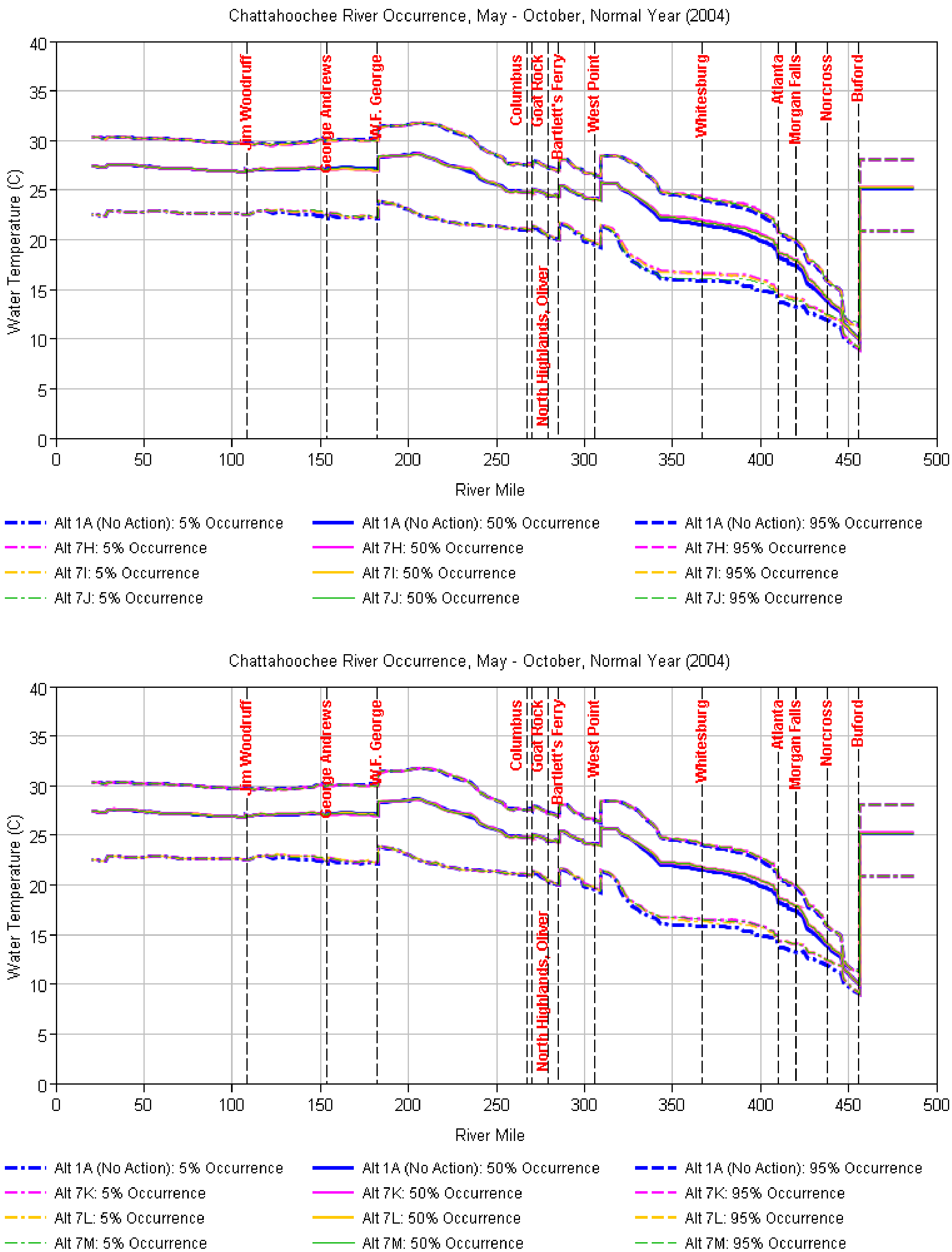
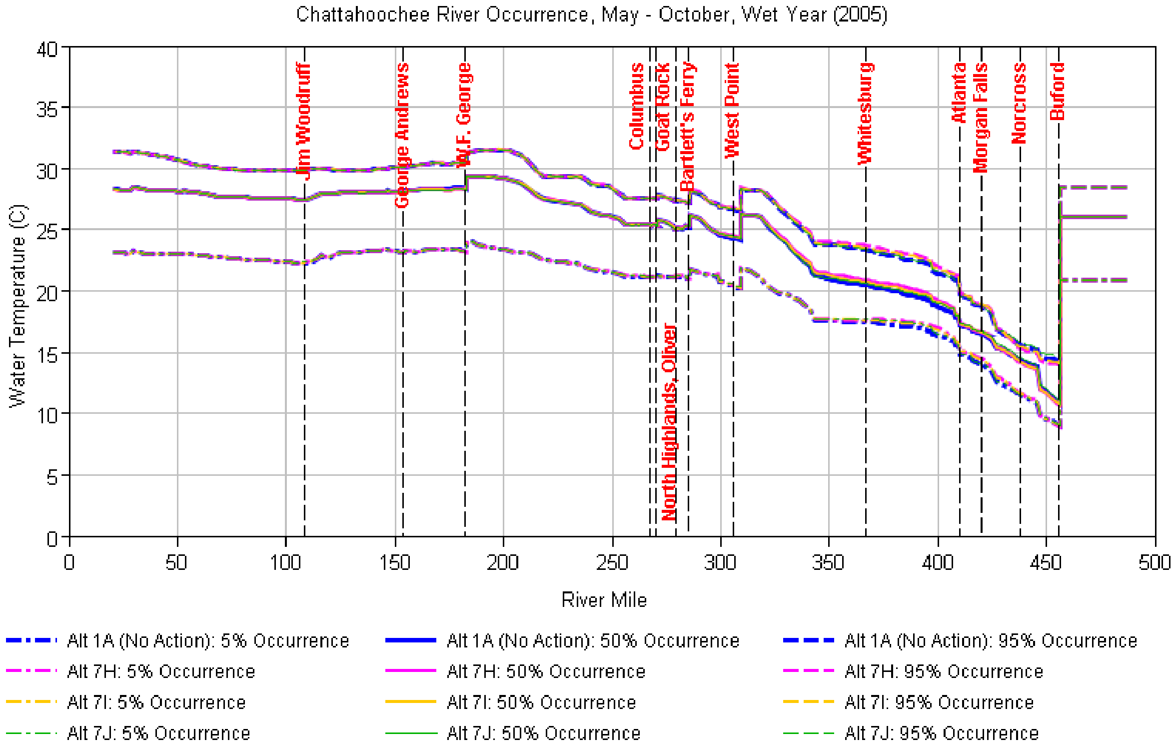


Figure 33. May through October water temperatures along the Chattahoochee River for a representative normal year (2004).



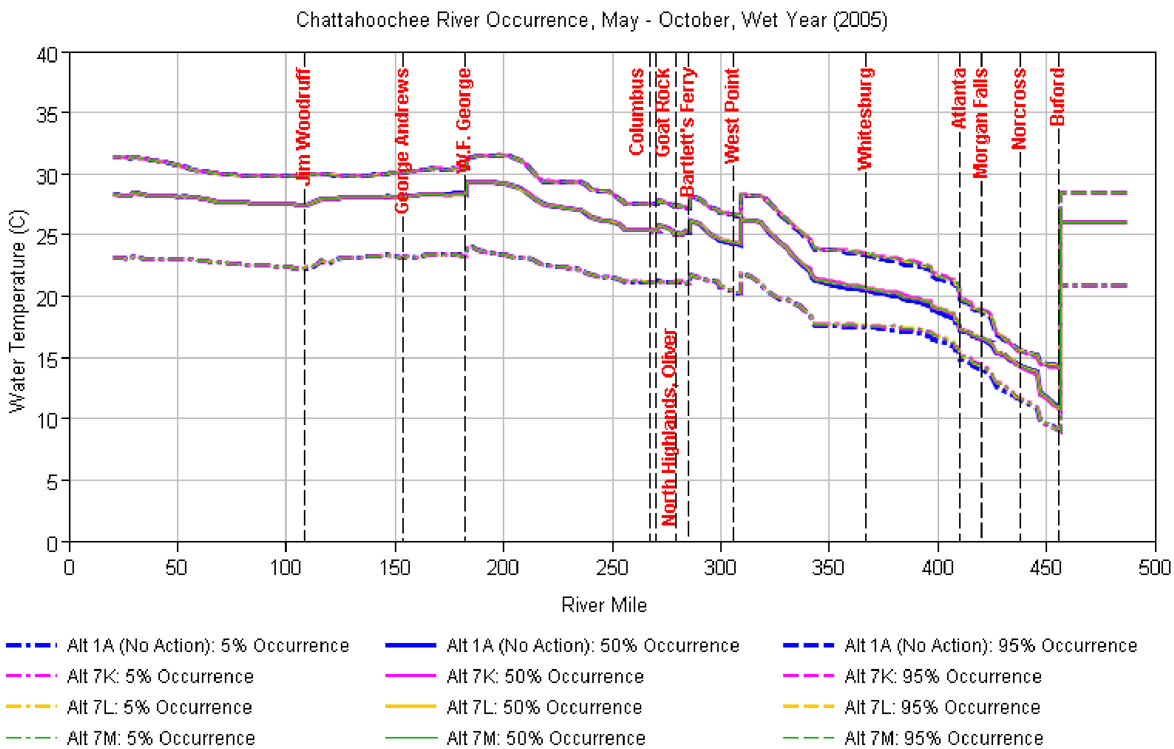


Figure 34. May through October water temperatures along the Chattahoochee River for a representative wet year (2005).

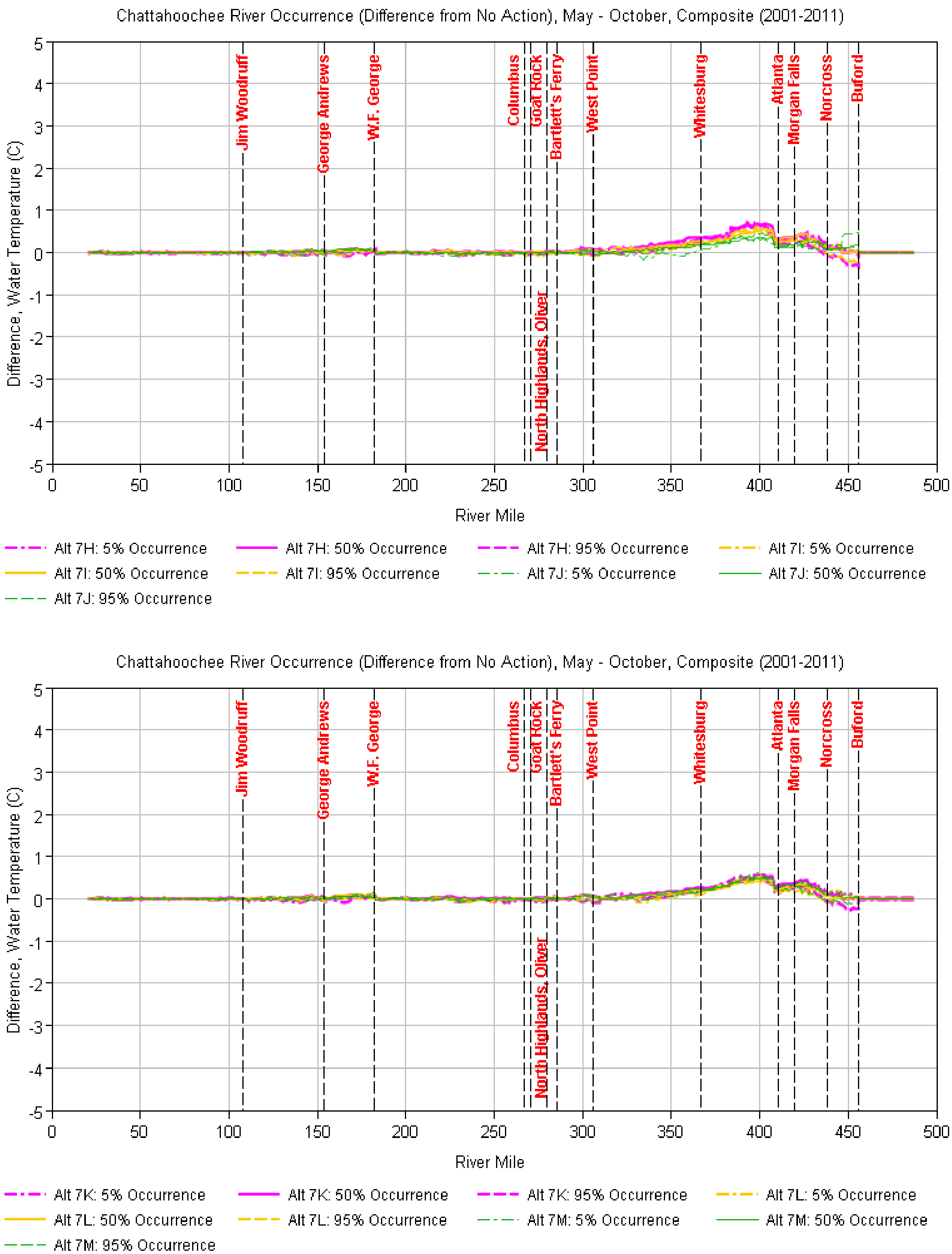
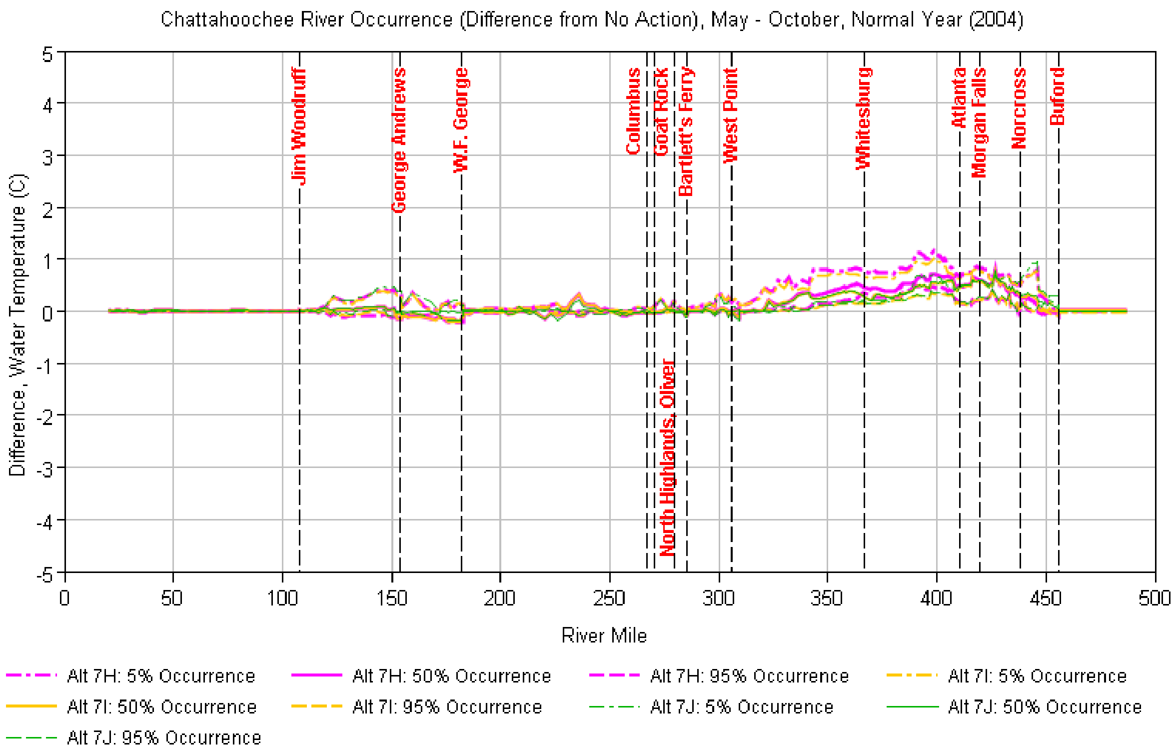


Figure 35. Changes in longitudinal water temperature in the Chattahoochee River for April through October for the modeled period from 2001 through 2011.



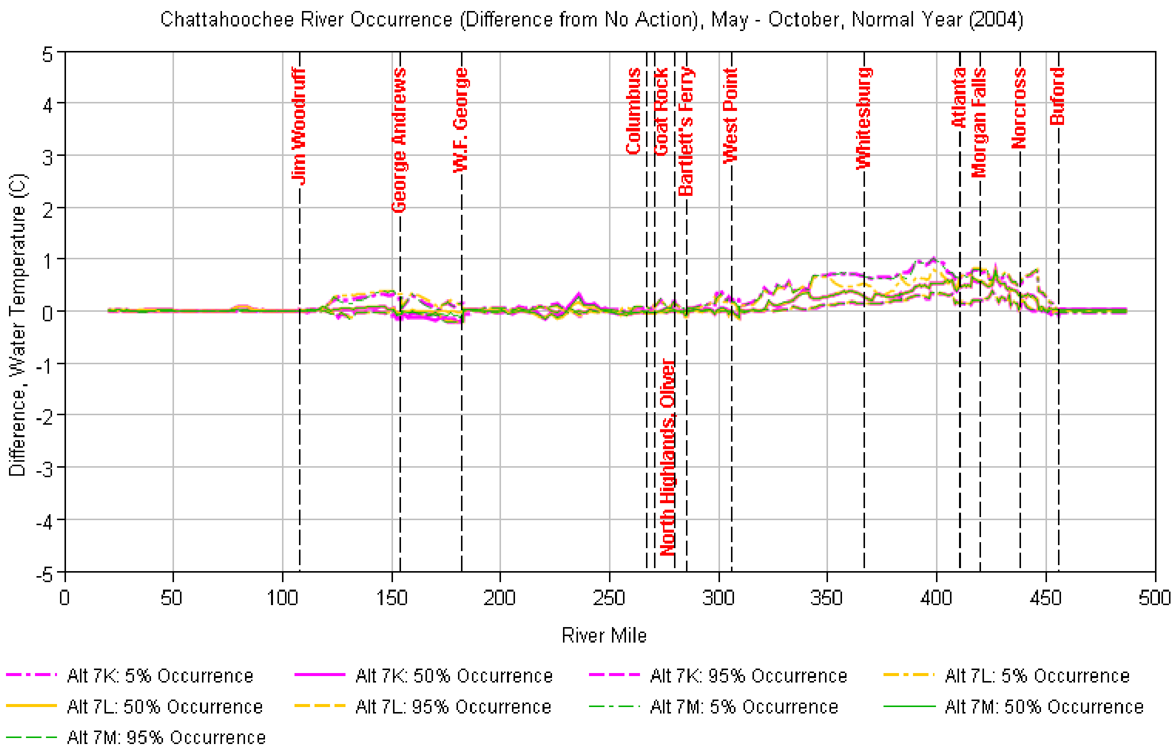


Figure 36. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a normal year (2004).

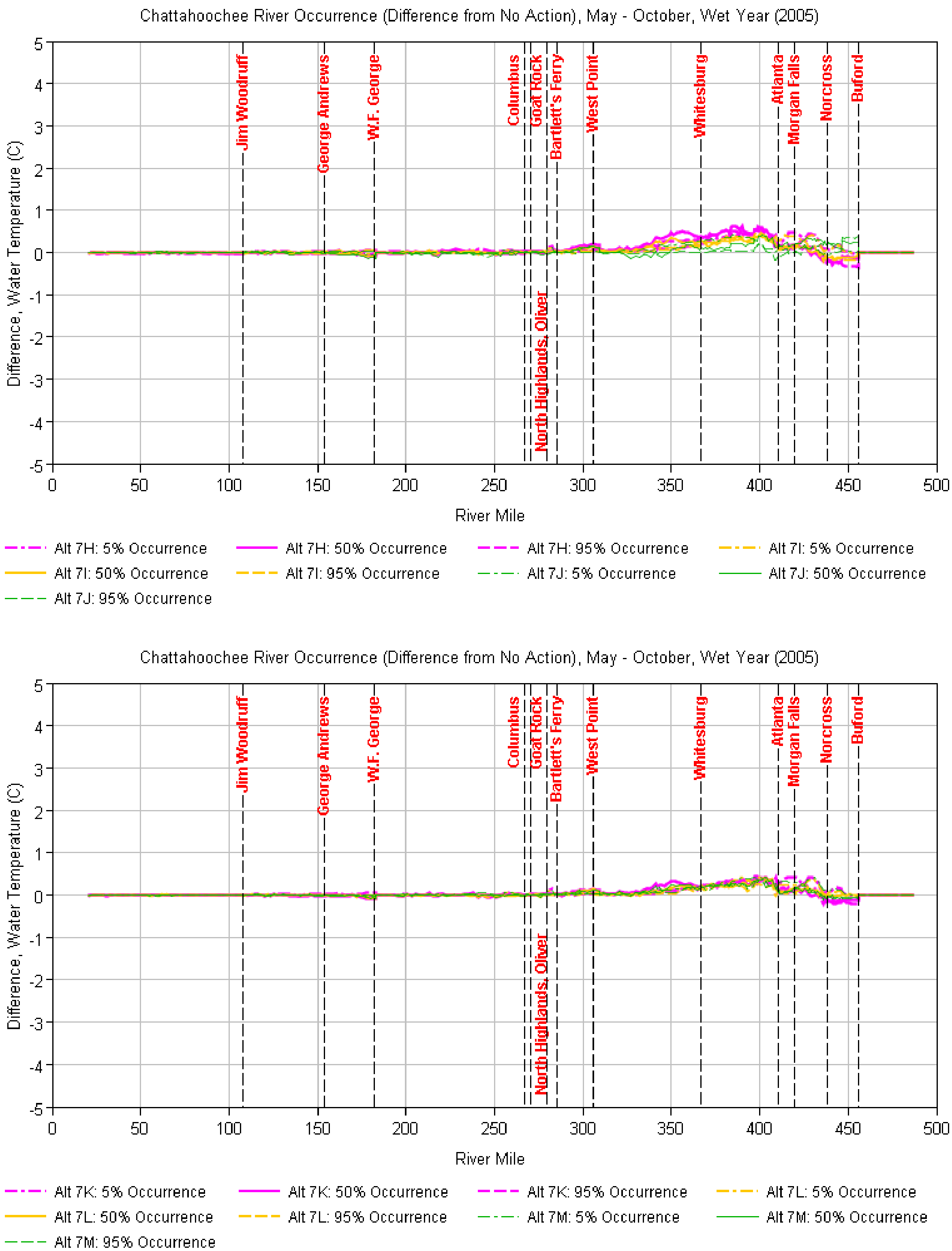
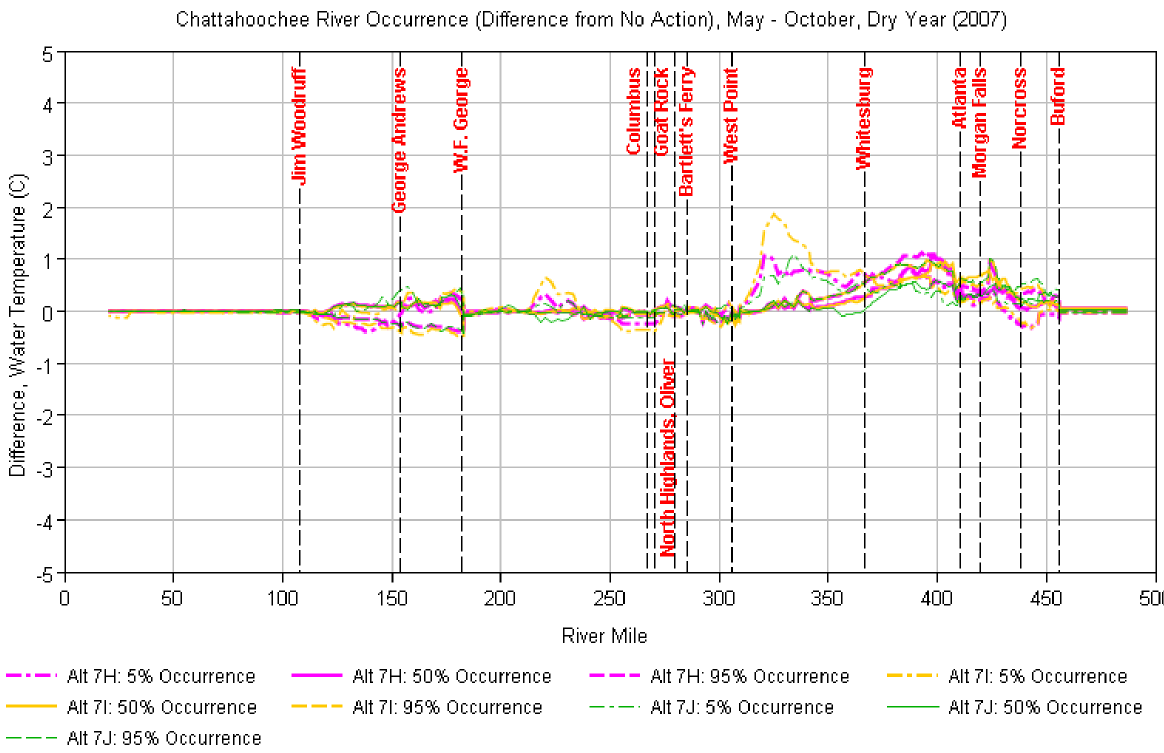


Figure 37. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a wet year (2005).



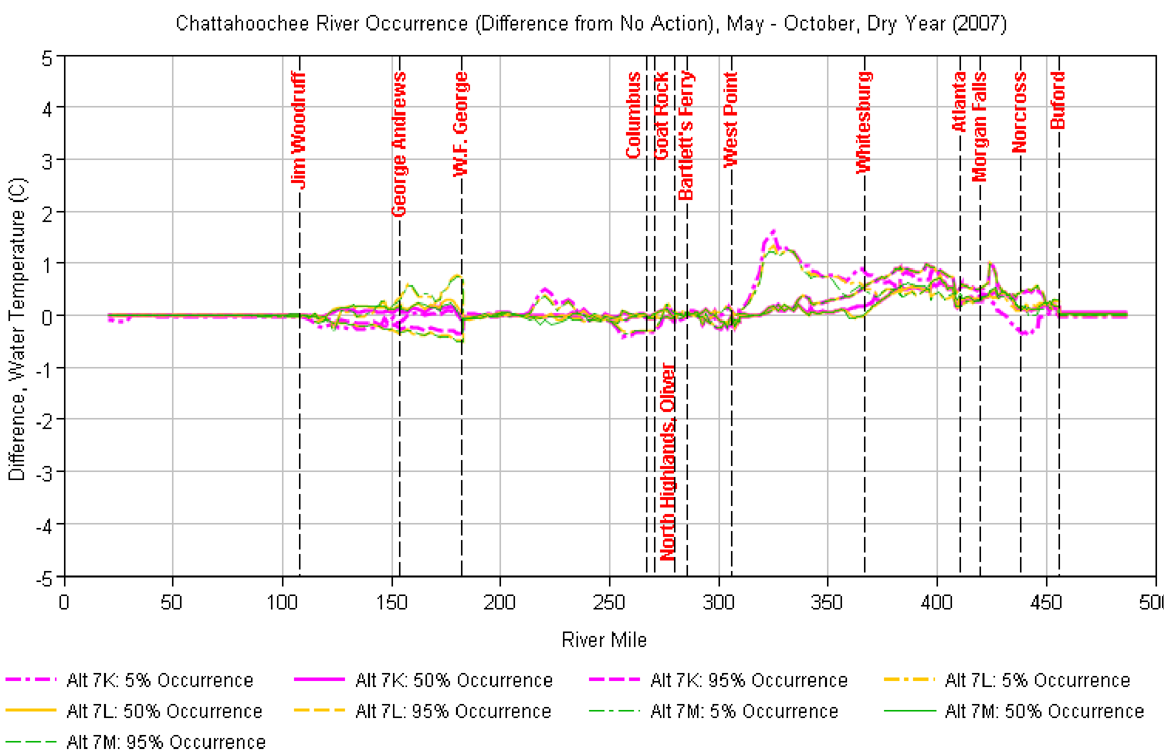


Figure 38. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a dry year (2007).

2.1.3 Wastewater

a. Average stream percent wastewater.

Average stream flow percent that is wastewater is presented for May through October in Figures 39 through 42; these figures also present the 5th and 95th percent occurrences. As shown, the percent wastewater is highest in the PAA (Alt7K) for all flow conditions including representative dry, normal, and wet weather years. The results of Alt7H presented here are also slightly higher than in the 2015 PAL response because of updates made to the HEC-5Q modeling based on the comments received. Comparing the two plots provided for each figure, the percent of flow that is wastewater for Alt7H and the PAA (Alt7K) are similar.

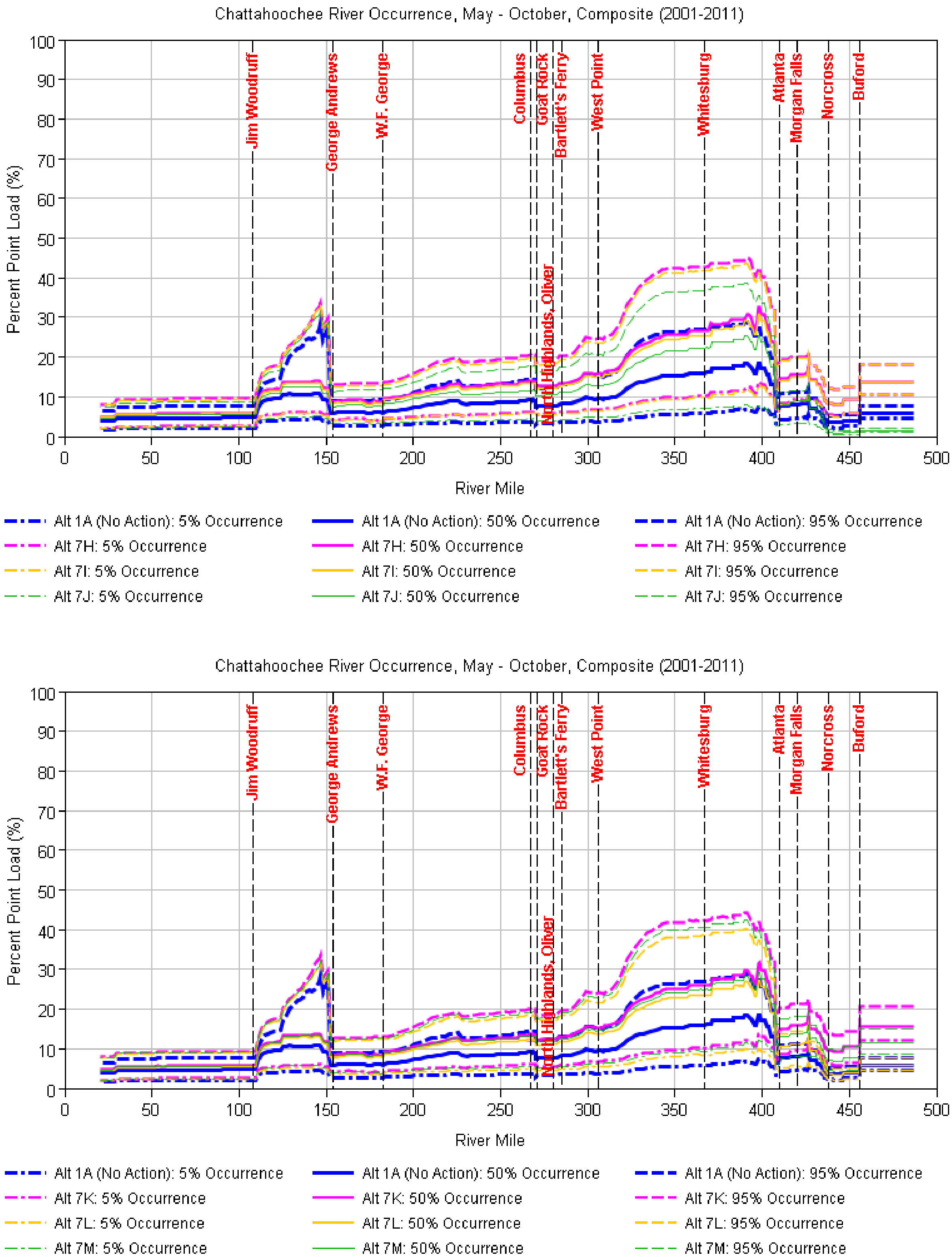
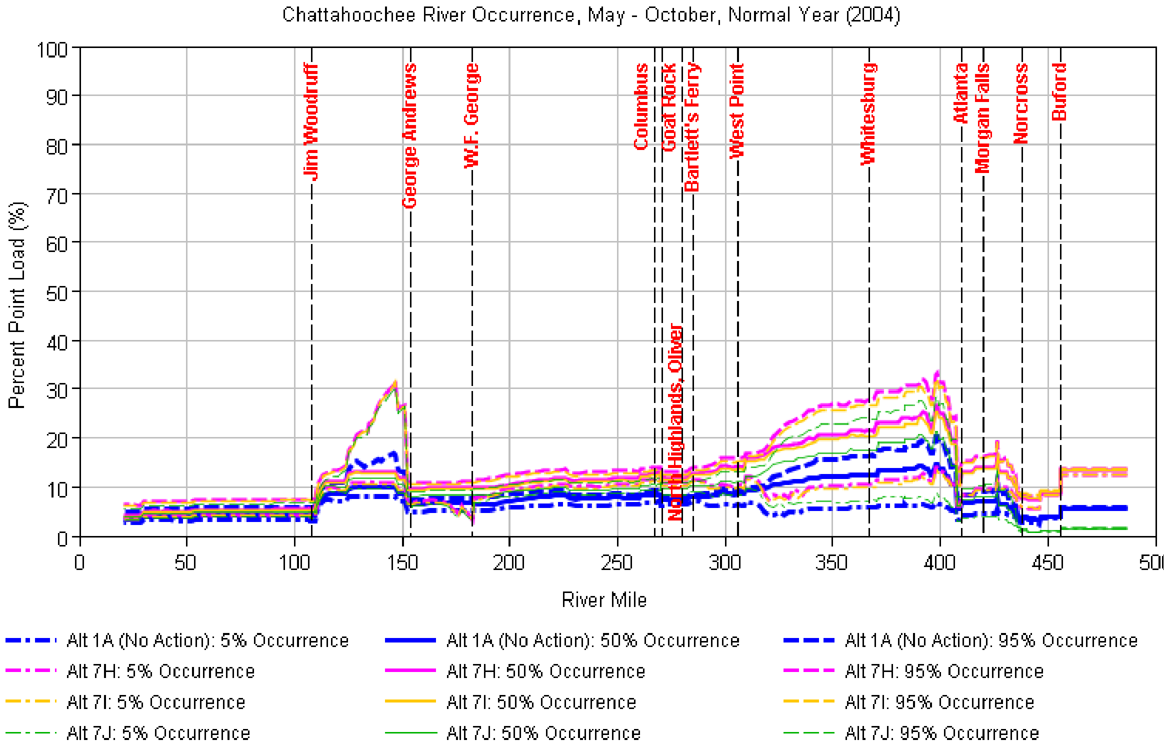


Figure 39. Percent of total flow that is wastewater along the Chattahoochee River for May through October of the modeled period (2001-2011).



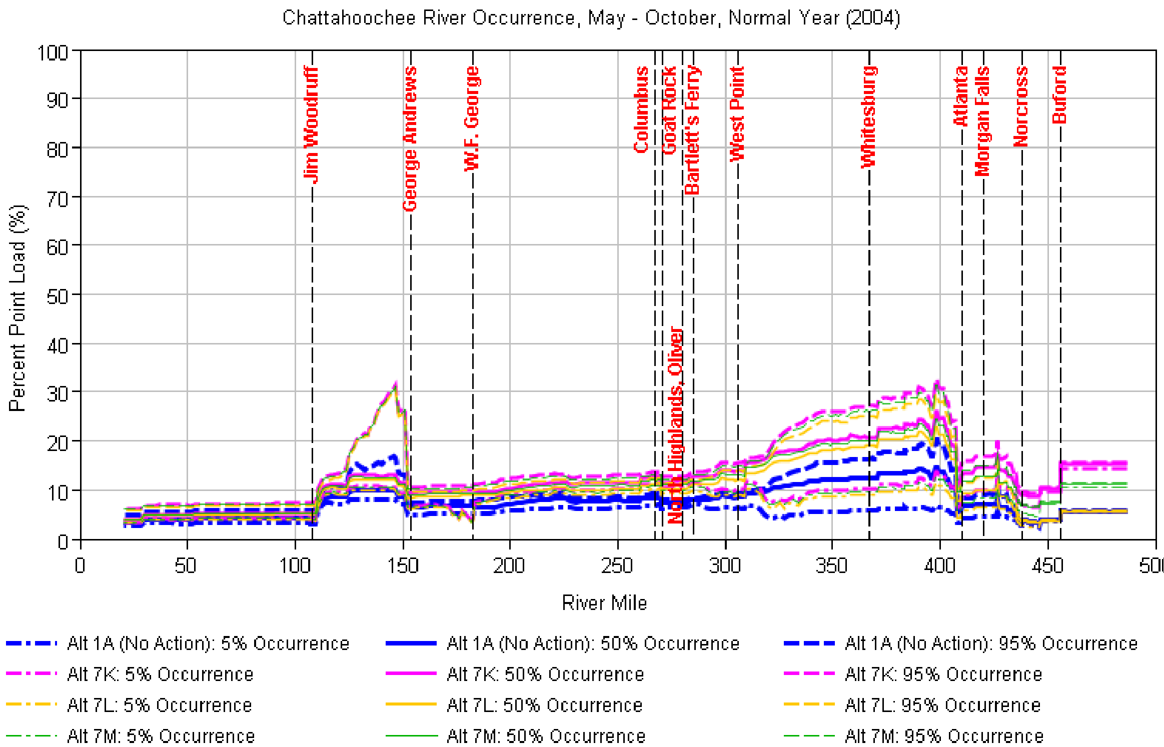
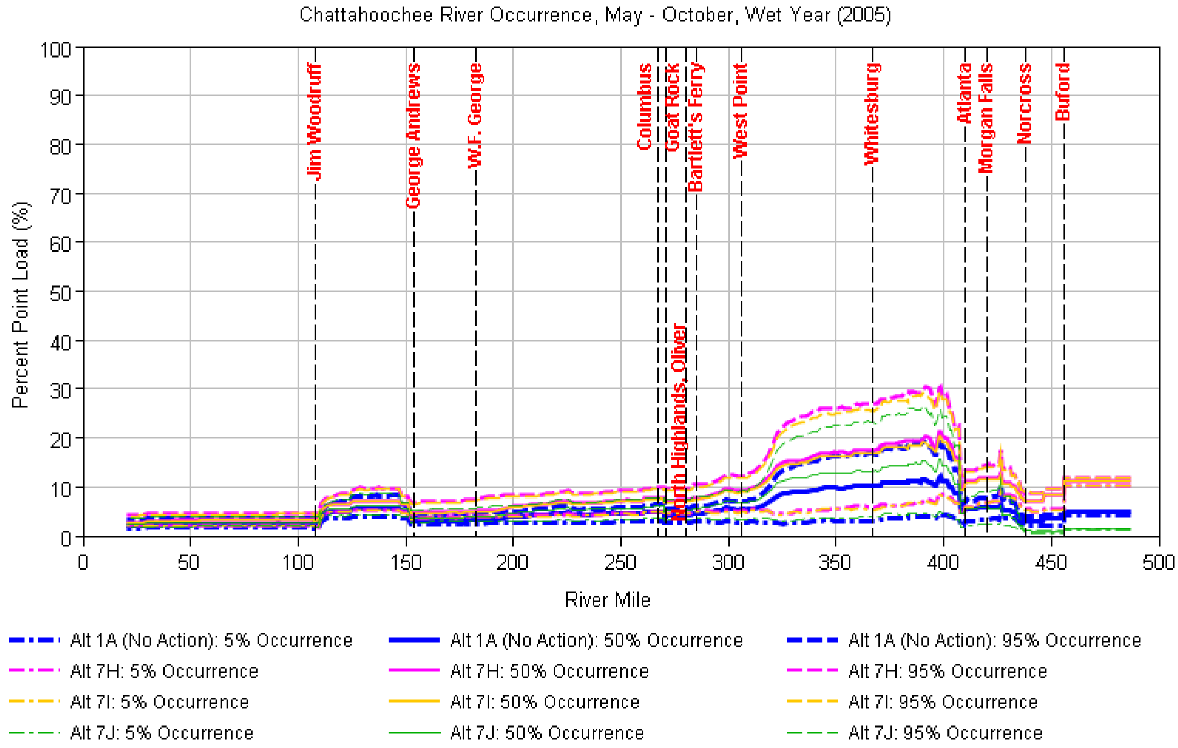


Figure 40. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative normal year (2004).



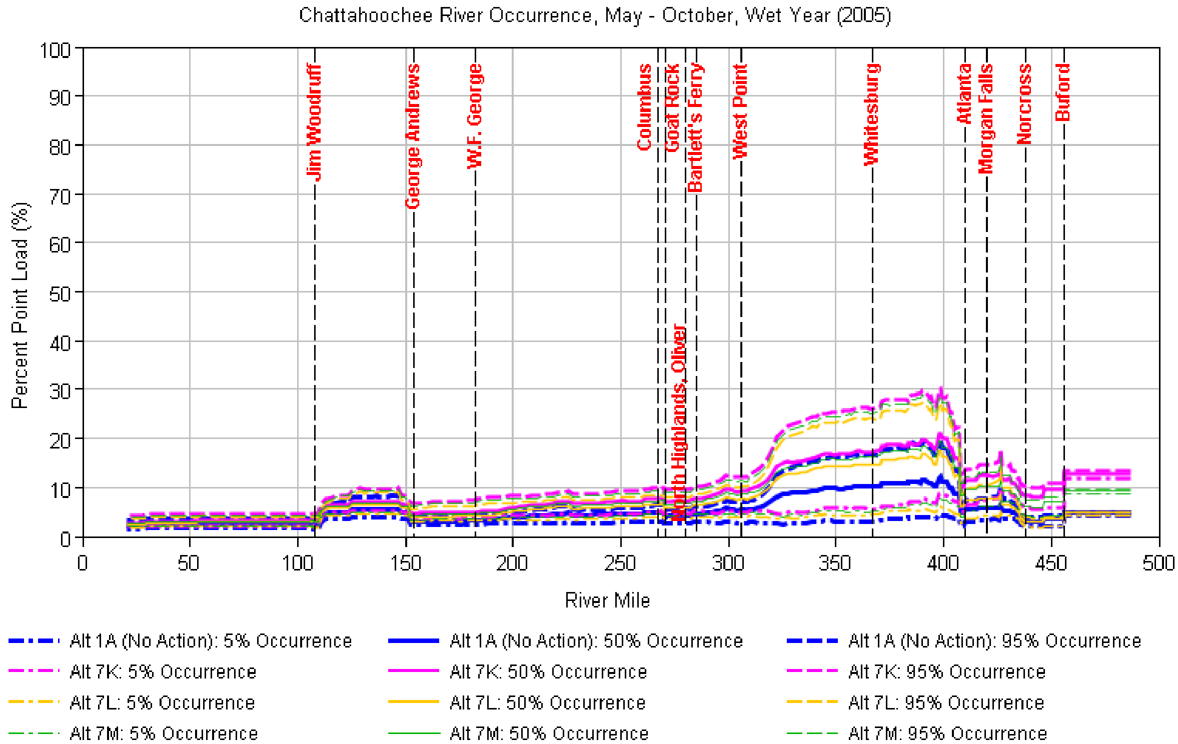
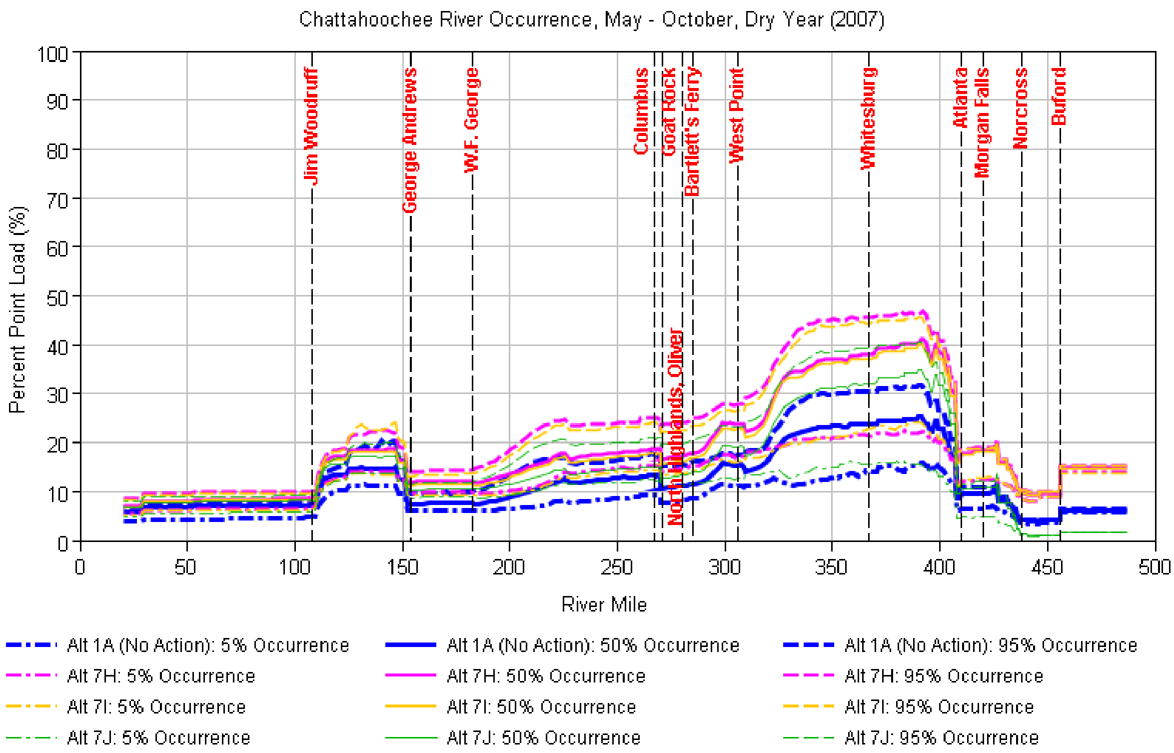


Figure 41. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative wet year (2005).



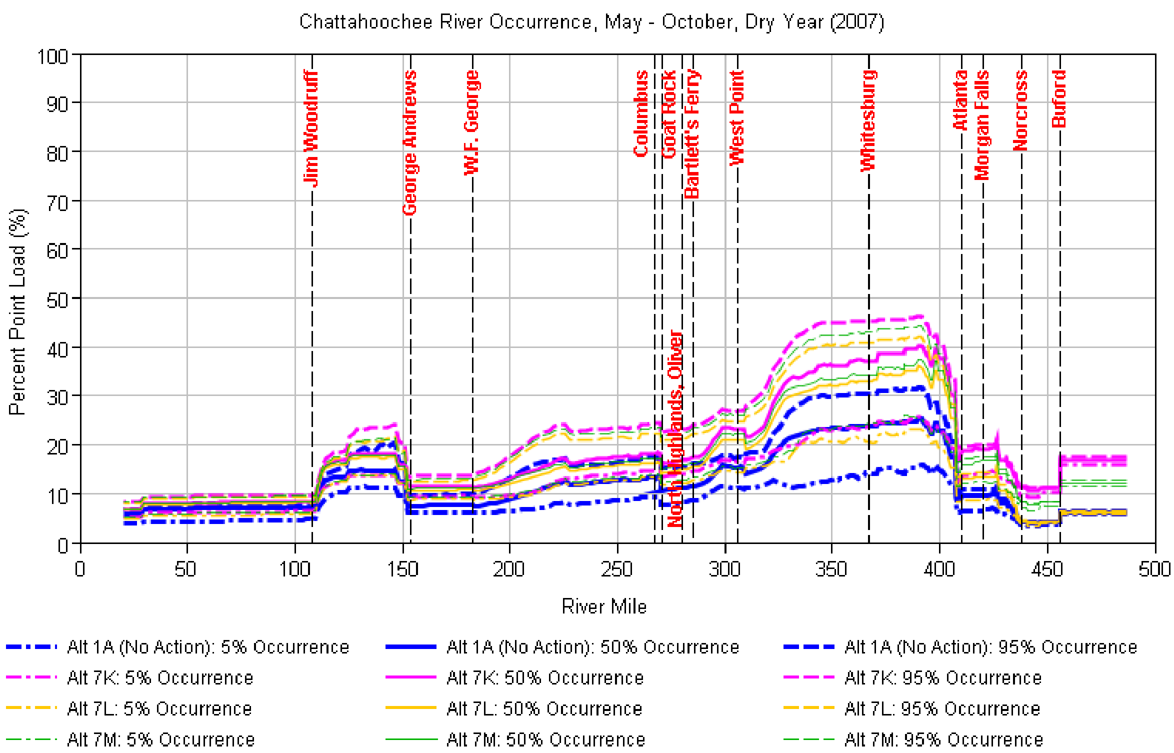


Figure 42. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative dry year (2007).

2.1.4 Chlorophyll a

a. Average values of summer Chlorophyll *a* (*u*g/L)

Chlorophyll *a* in various rainfall conditions is presented for the system in Figures 43 through 46. Figures 47 through 49 illustrate changes in chlorophyll *a* from the NAA in locations where the greatest changes would be expected. The greatest changes would be expected in West Point Lake, Bartletts Ferry Lake, and Walter F. George Lake in extreme conditions. Tables to follow presents the growing season (April through October) average (Table 7) and annual geometric mean (Table 8) of chlorophyll *a* in USACE reservoirs.

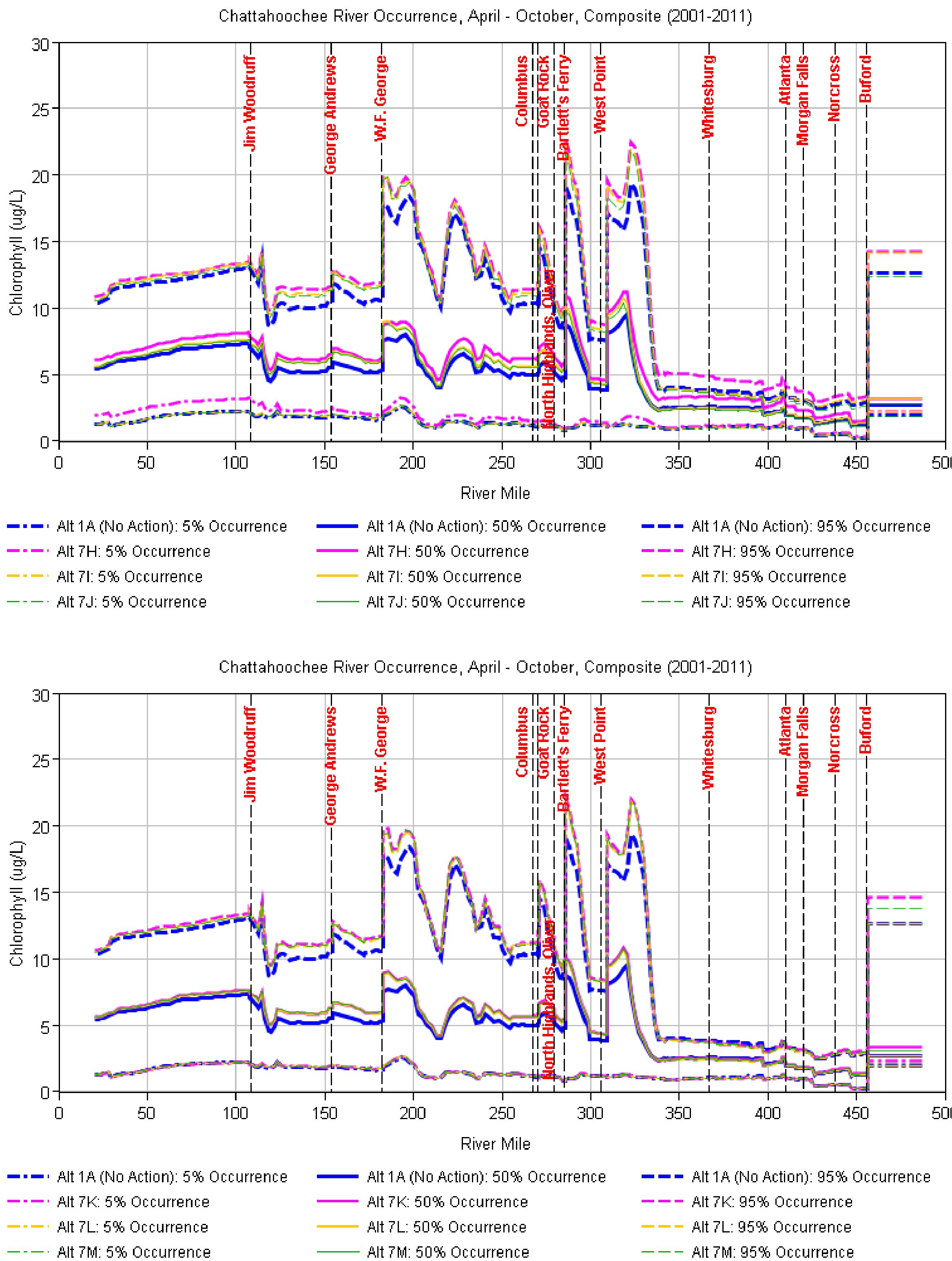


Figure 43. Chlorophyll *a* along the Chattahoochee River for April through October of the modeled period (2001-2011).

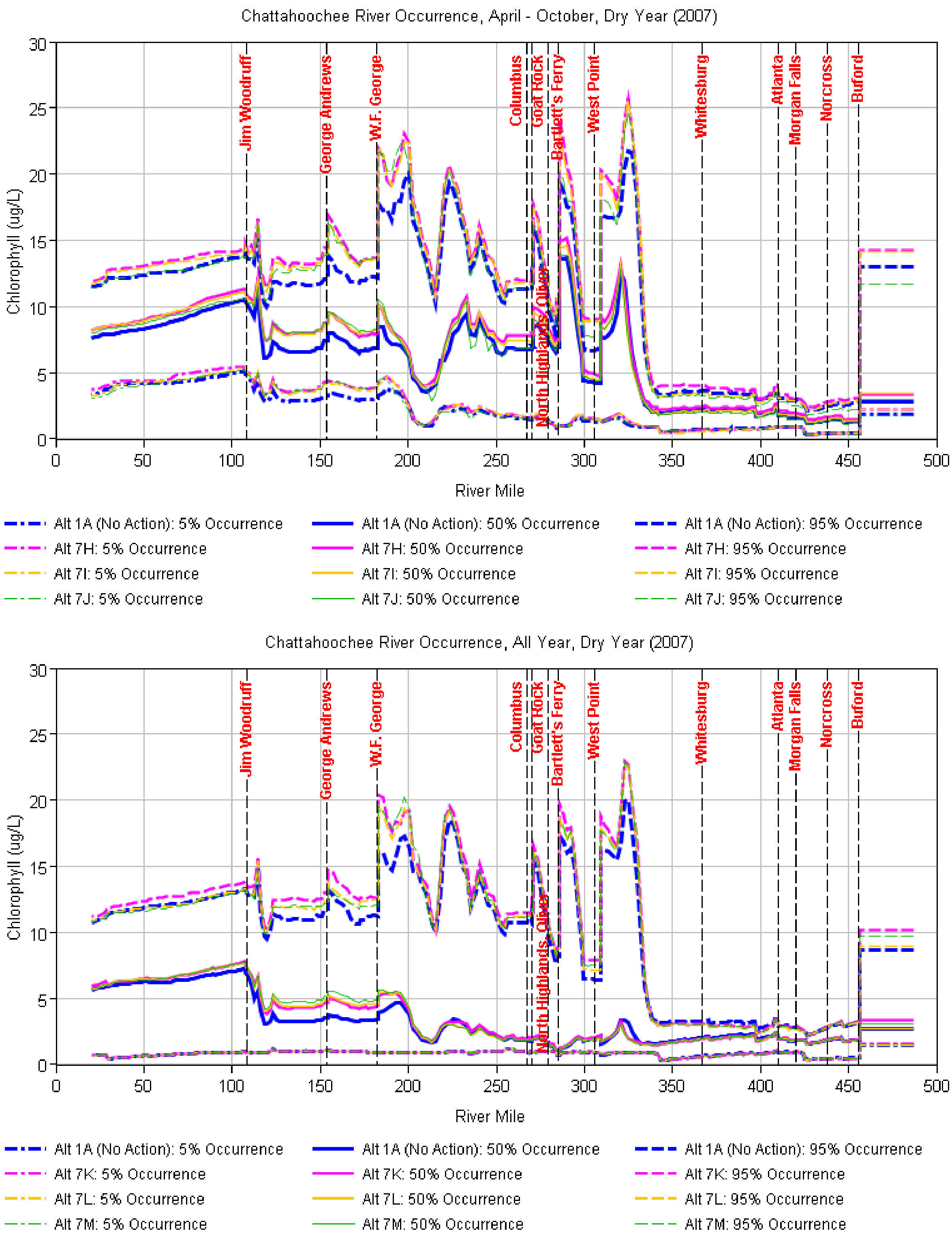


Figure 44. Chlorophyll *a* along the Chattahoochee River for April through October in a representative dry year (2007).

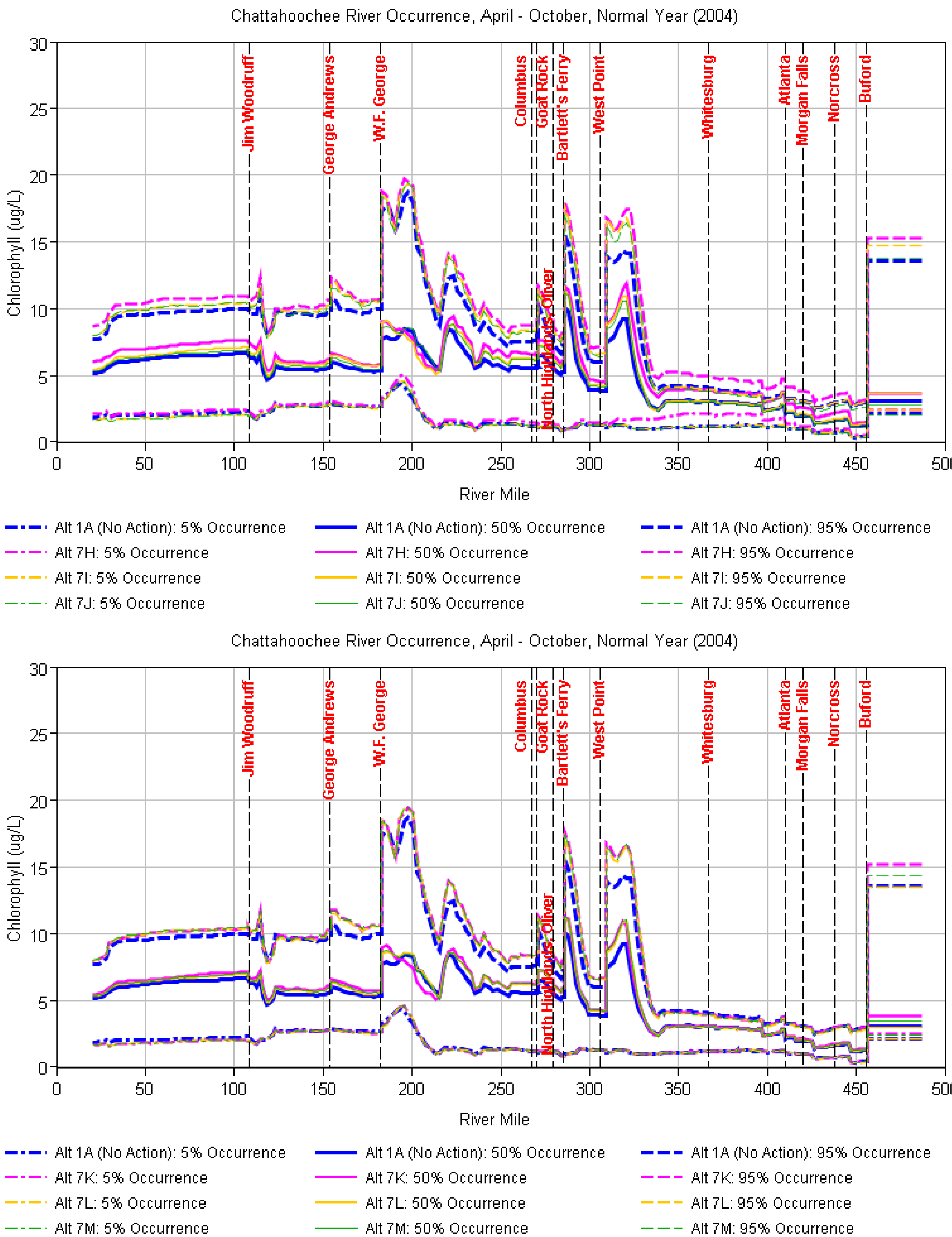
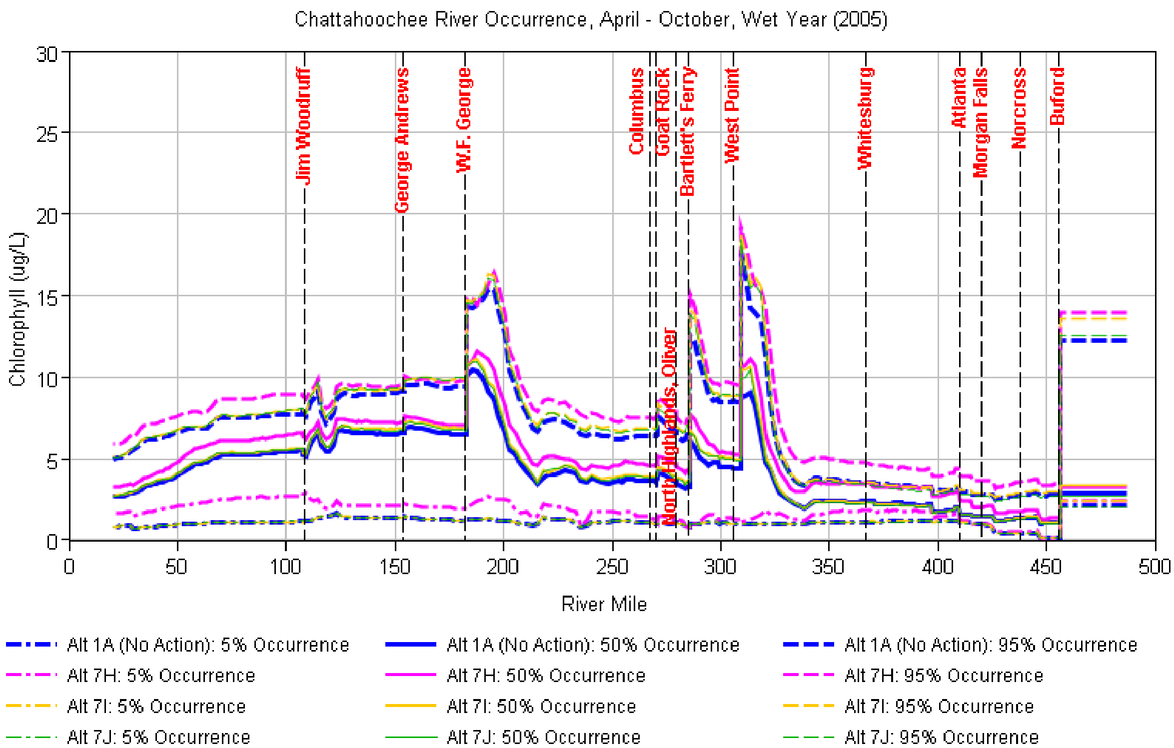


Figure 45. Chlorophyll *a* along the Chattahoochee River for April through October in a representative normal year (2004).



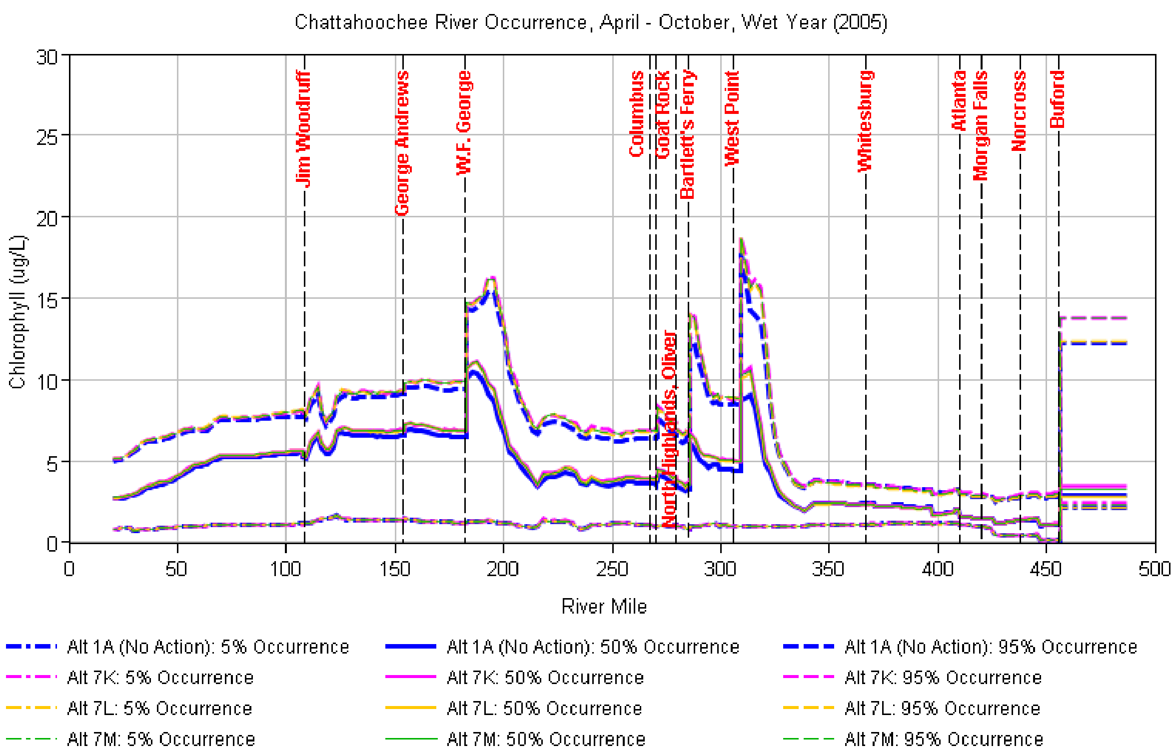
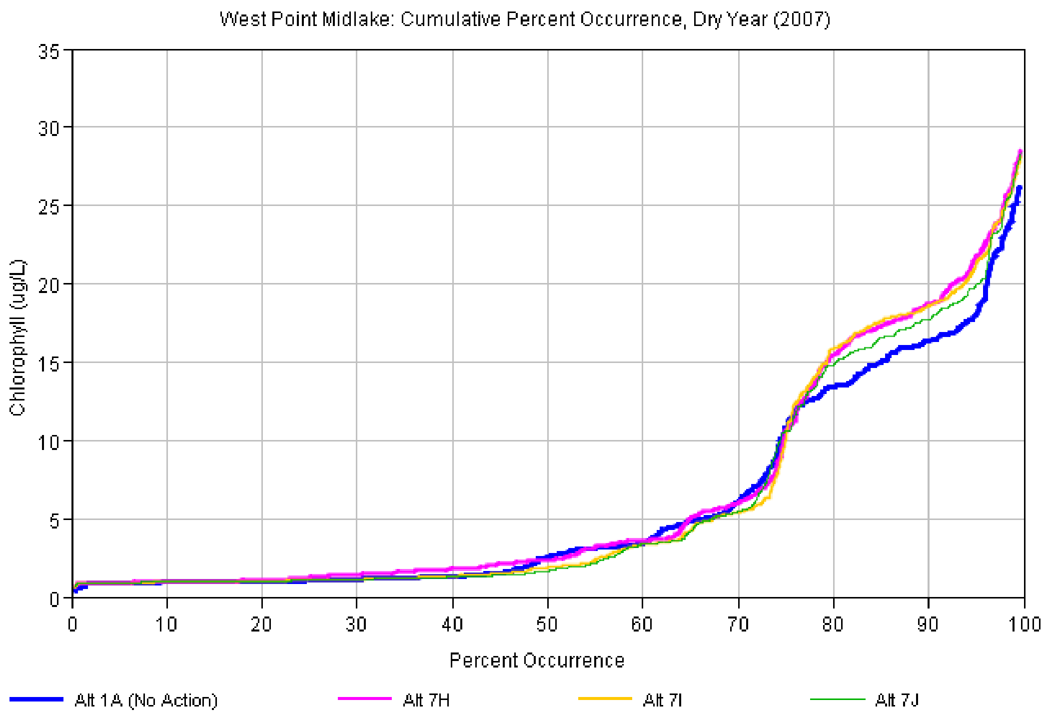


Figure 46. Chlorophyll *a* along the Chattahoochee River for April through October in a representative wet year (2005).



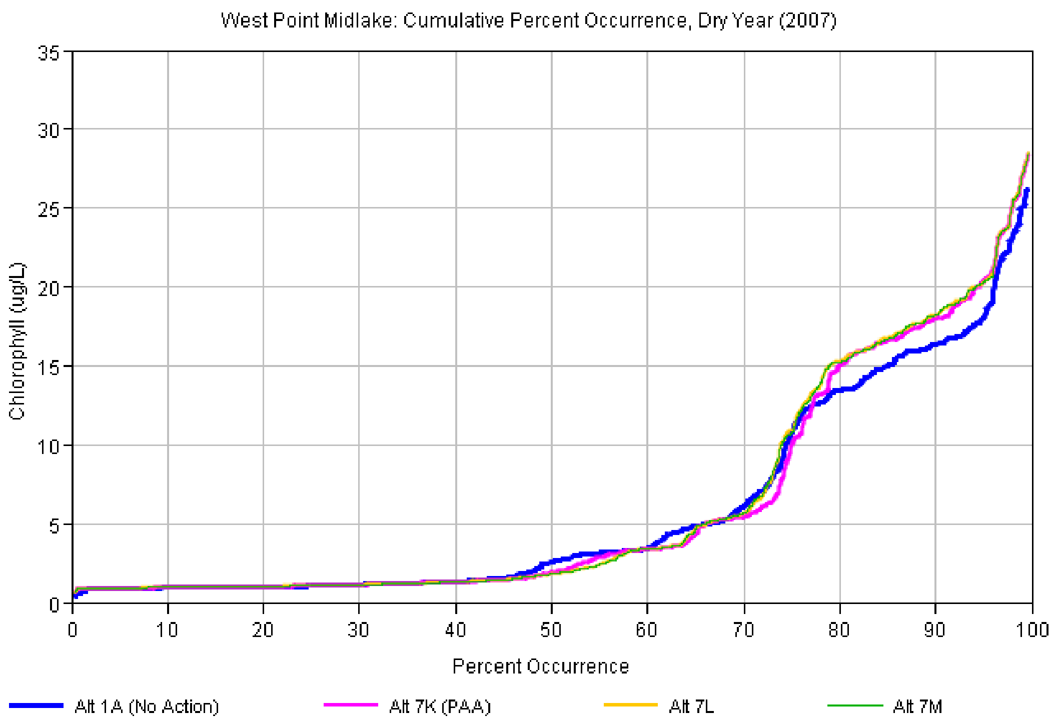
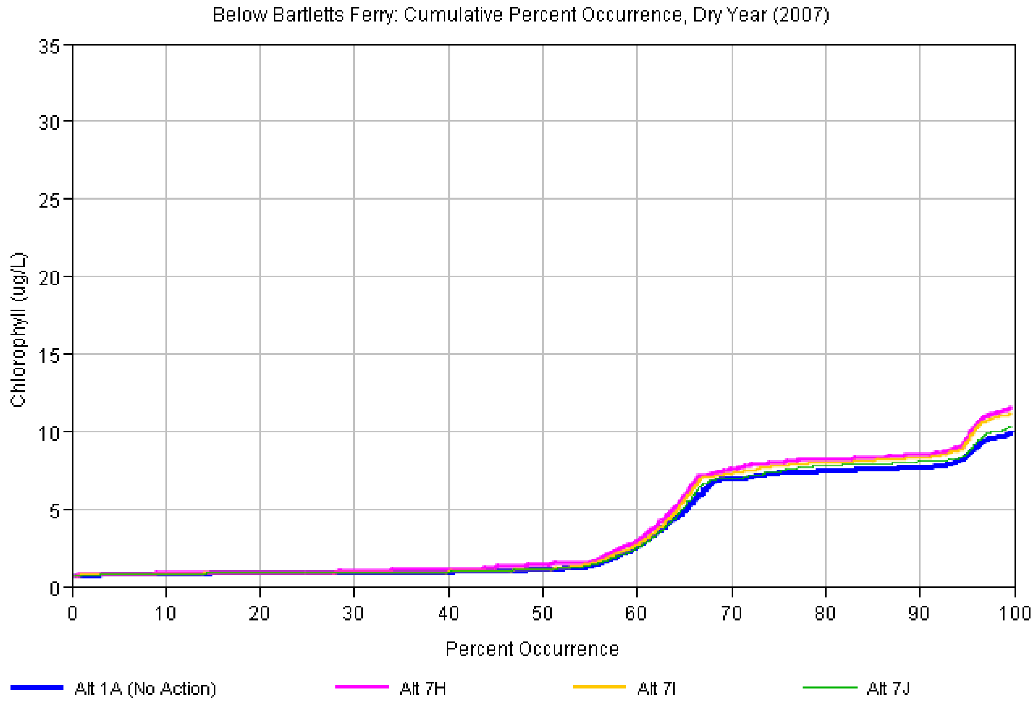


Figure 47. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of West Point Lake for a representative dry year (2007).



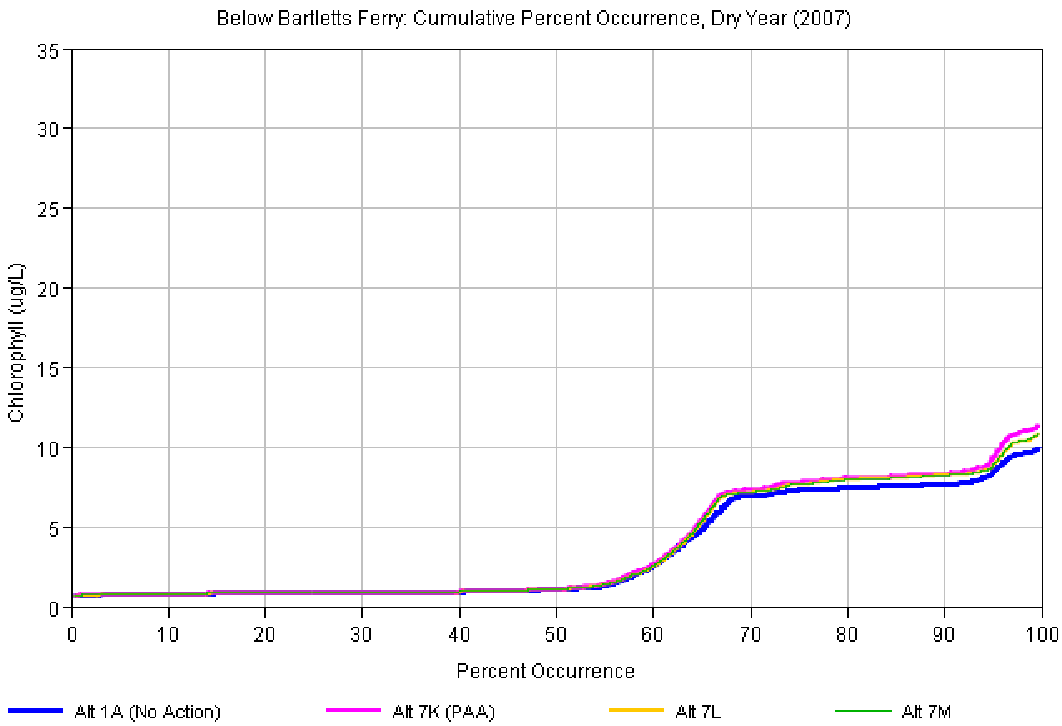
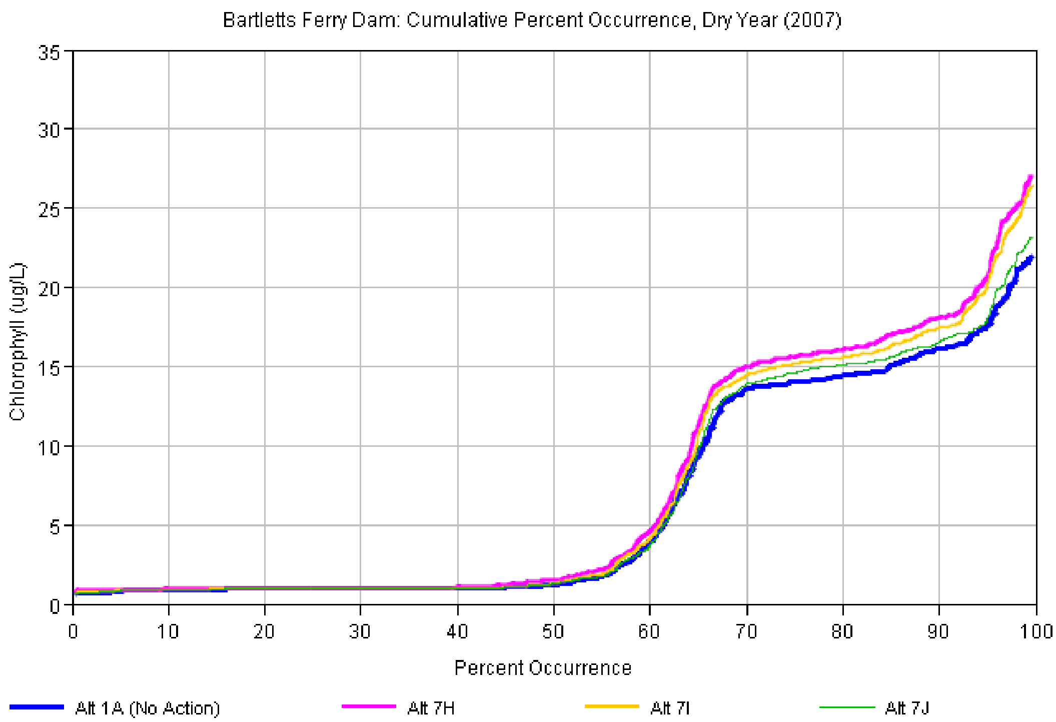


Figure 48a. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Bartletts Ferry Lake for a representative dry year (2007). [Note that the figure title from the 2015 PAL was consistent with the title here but the figures indicated that they were Below Bartlett's Ferry. Therefore, the figures presented here are Below Barletts Ferry.]



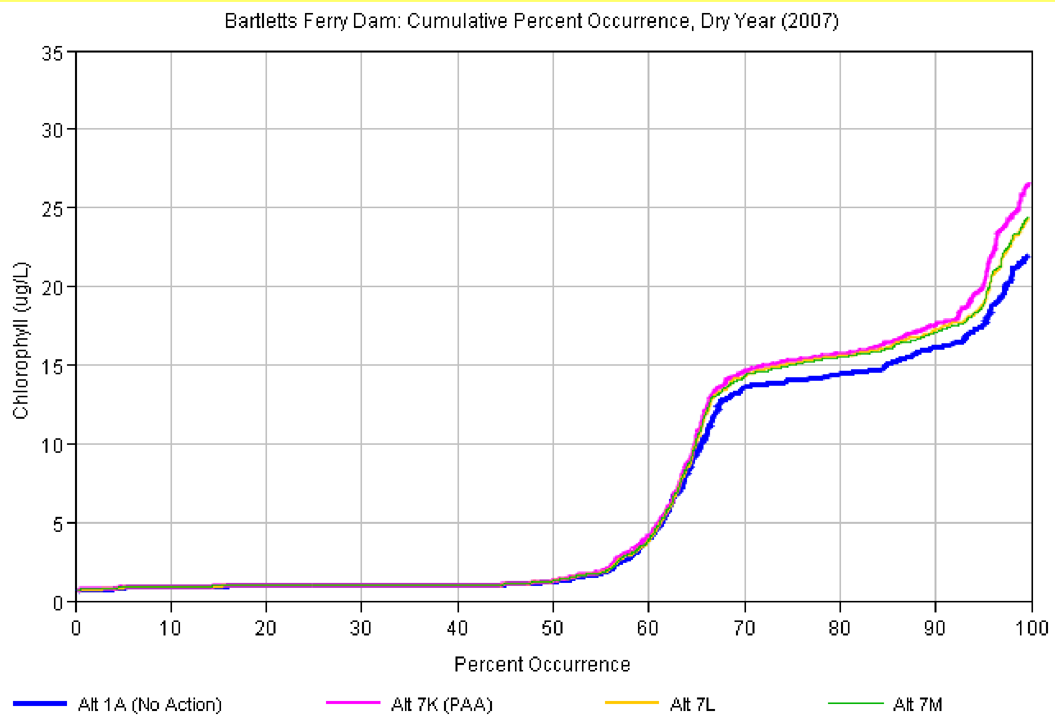
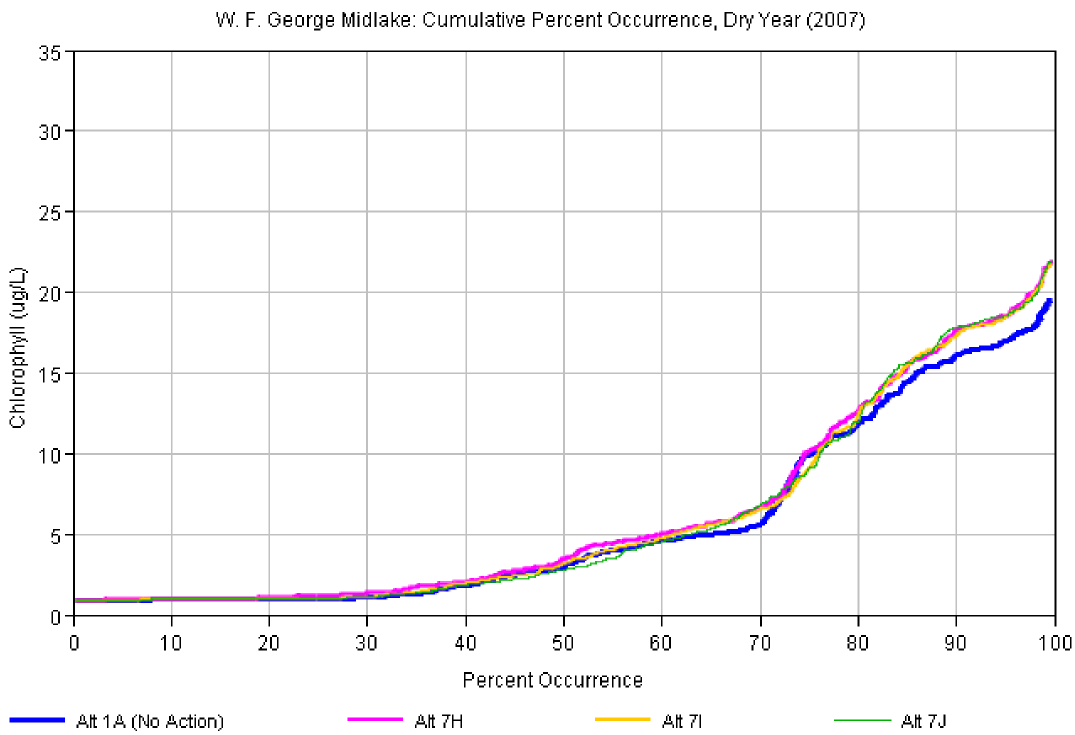


Figure 48b. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Bartletts Ferry Lake for a representative dry year (2007). [Note that this is a new figure that was not included in the 2015 PAL. This figure was added to present the highest modeled chlorophyll *a* conditions in Barletts Ferry Lake.]



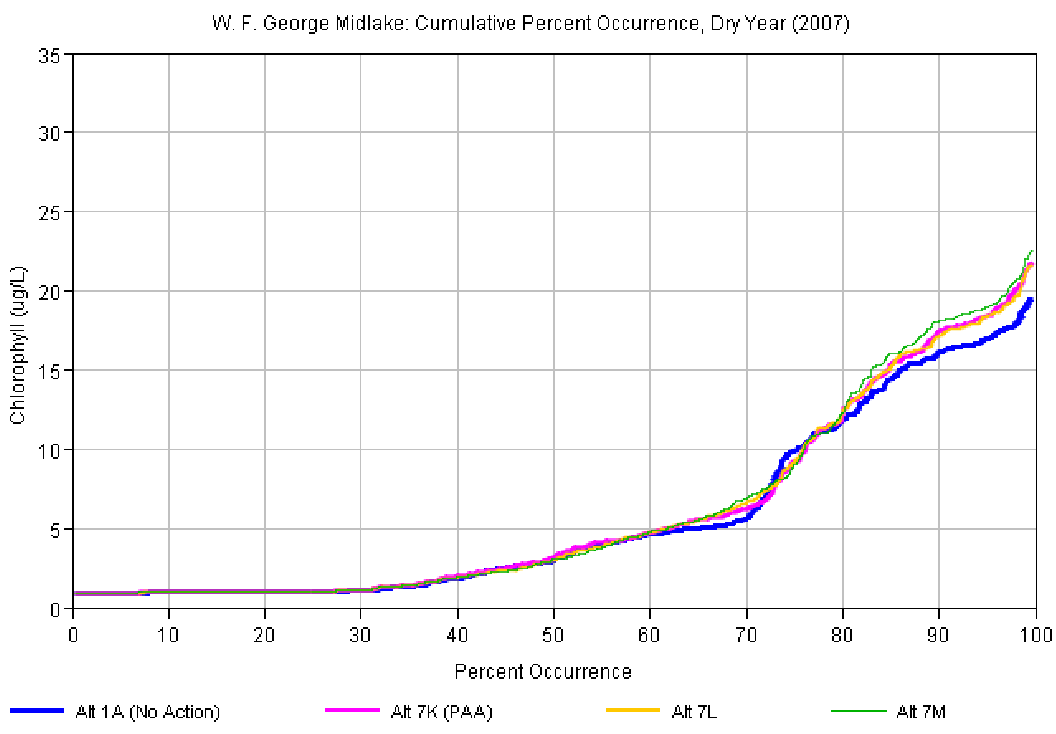


Figure 49. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Walter F. George Lake for a representative dry year (2007).

Table 7. Growing season (April-October) average of chlorophyll *a* at USACE reservoirs in the ACF Basin

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
Lake Lanier					
2000	5.2	5.7	5.8	0.5	0.7
2001	3.8	4.2	4.3	0.4	0.5
2002	4.2	4.9	5.1	0.7	0.9
2003	3.8	4.4	4.5	0.5	0.7
2004	4.6	5.2	5.4	0.7	0.8
2005	4.3	4.8	5.0	0.5	0.7
2006	4.1	4.7	4.9	0.6	0.8
2007	4.2	4.9	5.2	0.7	1.0
2008	4.0	4.7	5.0	0.7	0.9
2009	4.2	4.8	5.0	0.6	0.8
2010	4.0	4.6	4.7	0.7	0.7
2011	4.3	4.9	5.1	0.7	0.8
West Point MidLake					
2000	8.5	12.6	11.8	4.1	3.3
2001	7.1	8.3	7.0	1.2	-0.1
2002	10.8	12.0	11.1	1.3	0.3
2003	2.9	4.5	3.0	1.7	0.1
2004	4.6	6.5	5.1	1.9	0.6
2005	2.9	4.3	3.1	1.3	0.1
2006	6.3	7.6	6.7	1.3	0.4
2007	9.2	10.0	9.6	0.8	0.4
2008	10.0	11.3	10.4	1.3	0.3
2009	6.9	9.3	8.1	2.4	1.2
2010	5.3	6.7	5.7	1.5	0.5
2011	7.5	9.9	9.3	2.4	1.9
West Point Dam					
2000	9.8	11.2	10.9	1.4	1.1
2001	8.2	9.3	9.2	1.2	1.0

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2002	9.1	10.5	10.3	1.4	1.3
2003	8.4	10.0	9.3	1.6	0.9
2004	7.0	8.3	8.1	1.3	1.1
2005	7.8	9.0	8.7	1.2	0.9
2006	7.9	8.9	8.8	1.0	0.9
2007	7.7	8.8	8.6	1.1	0.9
2008	8.5	10.0	9.9	1.5	1.4
2009	7.0	8.2	7.9	1.2	0.9
2010	6.5	7.8	7.5	1.3	1.0
2011	8.0	9.4	9.1	1.4	1.2
Walter MidLake					
2000	9.1	10.0	9.6	0.9	0.5
2001	7.3	8.4	7.7	1.1	0.5
2002	8.0	9.0	8.7	1.0	0.7
2003	4.1	5.2	4.3	1.1	0.2
2004	6.9	7.8	7.3	1.0	0.4
2005	4.2	5.3	4.5	1.1	0.3
2006	8.1	9.3	9.0	1.2	0.9
2007	8.8	9.6	9.3	0.8	0.5
2008	9.1	10.2	9.8	1.1	0.7
2009	6.5	7.5	6.8	1.0	0.4
2010	5.6	6.4	5.9	0.8	0.4
2011	8.0	8.7	8.4	0.7	0.4
Lake Seminole MidLake					
2000	6.1	6.5	6.3	0.5	0.3
2001	3.8	4.5	4.1	0.7	0.3
2002	5.4	6.3	6.0	0.9	0.6
2003	5.5	6.4	5.7	0.9	0.2
2004	5.3	5.9	5.5	0.6	0.3
2005	5.2	5.9	5.4	0.8	0.2
2006	5.3	6.3	6.1	1.0	0.8

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2007	6.1	7.4	7.1	1.2	1.0
2008	5.4	6.3	6.1	1.0	0.7
2009	4.1	4.8	4.2	0.7	0.1
2010	4.4	4.9	4.6	0.6	0.2
2011	5.8	6.8	6.7	1.0	0.9

Table 8. Growing season (April-October) annual geometric mean of chlorophyll *a* at USACE reservoirs in the ACF Basin

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
Lake Lanier					
2000	4.1	4.6	4.7	0.5	0.7
2001	3.2	3.6	3.7	0.4	0.5
2002	3.4	4.0	4.2	0.6	0.7
2003	3.2	3.7	3.8	0.5	0.6
2004	3.7	4.3	4.5	0.6	0.7
2005	3.6	4.0	4.2	0.4	0.6
2006	3.4	3.9	4.1	0.5	0.7
2007	3.4	4.1	4.3	0.6	0.9
2008	3.2	3.8	4.0	0.6	0.8
2009	3.4	4.0	4.1	0.5	0.7
2010	3.3	3.9	3.9	0.5	0.6
2011	3.4	4.0	4.1	0.6	0.7
West Point MidLake					
2000	6.3	9.4	8.0	3.1	1.7
2001	5.8	7.2	5.8	1.4	0.0
2002	7.5	9.2	7.8	1.6	0.2
2003	2.5	4.1	2.6	1.6	0.1
2004	3.6	5.4	3.9	1.8	0.3
2005	2.6	3.8	2.7	1.3	0.1

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2006	5.1	6.3	5.3	1.2	0.2
2007	6.4	6.6	6.3	0.3	-0.1
2008	7.8	9.0	7.9	1.3	0.1
2009	4.4	6.8	5.0	2.3	0.6
2010	3.9	5.2	4.2	1.3	0.3
2011	5.7	7.3	6.5	1.6	0.7
West Point Dam					
2000	7.8	8.8	8.6	1.0	0.8
2001	5.7	6.8	6.3	1.1	0.5
2002	7.1	8.0	7.9	1.0	0.8
2003	6.1	7.3	6.7	1.2	0.6
2004	5.5	6.4	6.1	0.9	0.6
2005	5.4	6.4	5.9	1.0	0.5
2006	6.4	7.1	7.1	0.8	0.7
2007	5.8	6.6	6.4	0.8	0.6
2008	7.0	8.0	8.0	1.1	1.0
2009	5.0	5.9	5.5	0.9	0.5
2010	4.7	5.5	5.3	0.9	0.6
2011	6.8	7.9	7.7	1.2	1.0
Walter MidLake					
2000	7.0	8.1	7.4	1.1	0.4
2001	5.9	7.2	6.3	1.3	0.4
2002	6.4	7.2	6.9	0.9	0.5
2003	3.4	4.5	3.6	1.1	0.2
2004	5.5	6.4	5.6	0.9	0.2
2005	3.7	4.9	3.9	1.1	0.2
2006	6.6	7.8	7.3	1.1	0.7
2007	7.0	7.7	7.4	0.6	0.3
2008	7.3	8.5	7.9	1.2	0.6
2009	4.4	5.7	4.7	1.3	0.2
2010	4.2	5.1	4.5	0.9	0.3

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2011	6.5	7.4	6.9	0.8	0.4
Lake Seminole MidLake					
2000	5.4	6.0	5.7	0.6	0.3
2001	3.4	4.1	3.6	0.7	0.2
2002	4.8	5.7	5.4	0.9	0.6
2003	5.0	5.9	5.2	0.9	0.2
2004	5.0	5.6	5.2	0.6	0.3
2005	4.6	5.5	4.8	0.9	0.2
2006	4.9	5.9	5.6	1.0	0.7
2007	5.5	6.8	6.6	1.3	1.0
2008	5.1	6.0	5.8	1.0	0.7
2009	3.6	4.3	3.7	0.8	0.1
2010	4.0	4.5	4.2	0.5	0.2
2011	5.3	6.3	6.1	1.0	0.8

2.1.5 Retention

a. Average summer retention time (days).

Table 9 presents monthly retention times for the water quality model period (2001 through 2011).

Table 9a. Monthly retention times (in days) for reservoirs on the Chattahoochee River for the period from 2001 through 2011

Month-Year	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
	Days																				
Jan-01	1001	1238	1254	1	1	1	77	74	74	25	24	24	1	1	1	0	0	0	4	4	4
Feb-01	1182	1289	1308	1	1	1	68	67	67	20	20	20	1	1	1	0	0	0	3	3	3
Mar-01	1367	1290	1267	1	1	1	29	28	28	7	7	7	0	0	0	0	0	0	1	1	1
Apr-01	1219	955	961	1	1	1	65	60	60	14	14	14	1	1	1	0	0	0	2	2	2
May-01	1107	902	911	1	1	1	158	133	133	39	34	34	2	2	2	0	0	0	6	6	6
Jun-01	1270	709	714	1	1	1	82	78	78	24	22	22	1	1	1	0	0	0	4	4	4
Jul-01	884	702	699	1	1	1	110	99	99	30	27	27	1	1	1	0	0	0	5	4	4
Aug-01	664	658	662	1	1	1	104	107	107	32	32	32	1	1	1	0	0	0	5	5	5
Sep-01	669	801	805	1	1	1	101	104	104	38	39	39	2	2	2	0	0	0	6	7	7
Oct-01	608	821	845	1	1	1	76	125	128	36	54	56	2	2	3	0	0	0	6	9	9
Nov-01	587	858	884	1	1	1	82	126	125	31	37	37	1	2	2	0	0	0	5	6	6
Dec-01	615	915	833	1	1	1	87	127	125	35	42	41	2	2	2	0	0	0	6	7	7
Jan-02	890	1207	1226	1	1	1	78	51	51	29	20	20	1	1	1	0	0	0	5	3	3
Feb-02	1233	1308	1333	1	1	1	65	91	93	23	29	30	1	1	1	0	0	0	4	5	5
Mar-02	1371	1436	1436	1	1	1	113	97	97	25	22	22	1	1	1	0	0	0	4	4	4
Apr-02	1123	997	989	1	1	1	106	104	104	31	30	30	1	1	1	0	0	0	5	5	5
May-02	1108	891	899	1	1	1	110	91	93	37	31	31	2	1	1	0	0	0	6	5	5
Jun-02	942	836	858	1	1	1	167	170	169	54	54	54	2	2	2	0	0	0	9	9	9
Jul-02	873	782	806	1	1	1	147	154	153	45	45	45	2	2	2	0	0	0	7	7	7
Aug-02	712	648	664	1	1	1	133	144	142	52	53	52	2	2	2	0	0	0	9	9	9
Sep-02	845	886	904	1	1	1	140	153	150	45	45	45	2	2	2	0	0	0	7	7	7
Oct-02	633	1002	1021	1	1	1	91	103	106	23	25	25	1	1	1	0	0	0	4	4	4
Nov-02	692	956	959	1	1	1	58	57	58	15	14	14	1	1	1	0	0	0	2	2	2
Dec-02	694	924	914	1	1	1	34	35	35	10	11	11	0	0	0	0	0	0	2	2	2
Jan-03	663	626	617	1	1	1	68	60	60	20	18	18	1	1	1	0	0	0	3	3	3
Feb-03	744	645	625	1	1	1	48	47	47	12	12	12	1	1	1	0	0	0	2	2	2
Mar-03	326	280	281	0	0	0	32	30	30	8	7	7	0	0	0	0	0	0	1	1	1
Apr-03	460	476	476	0	0	0	53	53	53	10	10	10	0	0	0	0	0	0	2	2	2
May-03	292	296	297	0	0	0	20	21	21	5	5	5	0	0	0	0	0	0	1	1	1
Jun-03	292	302	303	0	0	0	24	24	24	6	6	6	0	0	0	0	0	0	1	1	1
Jul-03	302	310	311	0	0	0	35	35	35	9	9	9	0	0	0	0	0	0	1	1	1
Aug-03	479	493	493	0	0	0	68	69	69	16	16	16	1	1	1	0	0	0	3	3	3
Sep-03	620	609	612	1	1	1	106	104	105	27	26	26	1	1	1	0	0	0	4	4	4

Month-Year	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
	Days																				
Oct-03	606	597	599	1	1	1	107	104	105	31	30	30	1	1	1	0	0	0	5	5	5
Nov-03	503	579	581	0	1	1	37	38	38	12	12	12	1	1	1	0	0	0	2	2	2
Dec-03	538	542	545	1	1	1	37	36	36	15	15	15	1	1	1	0	0	0	2	2	2
Jan-04	633	293	292	1	0	0	51	36	36	17	13	13	1	1	1	0	0	0	3	2	2
Feb-04	390	676	676	0	1	1	33	39	39	10	11	11	0	0	0	0	0	0	2	2	2
Mar-04	467	422	424	0	0	0	69	64	64	19	18	18	1	1	1	0	0	0	3	3	3
Apr-04	511	354	349	1	0	0	89	62	62	22	17	17	1	1	1	0	0	0	4	3	3
May-04	562	950	957	1	1	1	85	137	139	23	33	34	1	2	2	0	0	0	4	6	6
Jun-04	753	969	970	1	1	1	128	126	127	28	28	28	1	1	1	0	0	0	5	5	5
Jul-04	756	721	722	1	1	1	100	115	115	22	23	24	1	1	1	0	0	0	4	4	4
Aug-04	752	716	718	1	1	1	117	113	114	23	22	23	1	1	1	0	0	0	4	4	4
Sep-04	582	693	693	0	0	0	54	54	54	12	12	12	1	1	1	0	0	0	2	2	2
Oct-04	557	632	633	1	1	1	91	100	101	22	24	24	1	1	1	0	0	0	4	4	4
Nov-04	440	635	635	0	0	0	29	31	31	9	9	9	0	0	0	0	0	0	1	2	2
Dec-04	290	290	295	0	0	0	27	27	27	9	9	10	0	0	0	0	0	0	2	2	2
Jan-05	573	584	584	1	1	1	53	51	51	16	16	16	1	1	1	0	0	0	3	3	3
Feb-05	341	360	360	0	0	0	31	31	31	9	9	9	0	0	0	0	0	0	2	2	2
Mar-05	303	309	309	0	0	0	26	26	26	6	6	6	0	0	0	0	0	0	1	1	1
Apr-05	394	400	401	0	0	0	34	34	34	8	8	8	0	0	0	0	0	0	1	1	1
May-05	390	442	442	0	0	0	65	69	69	16	17	17	1	1	1	0	0	0	3	3	3
Jun-05	421	407	409	0	0	0	69	67	67	15	14	15	1	1	1	0	0	0	2	2	2
Jul-05	297	304	305	0	0	0	22	22	22	6	6	6	0	0	0	0	0	0	1	1	1
Aug-05	295	302	303	0	0	0	44	44	44	11	11	11	0	0	0	0	0	0	2	2	2
Sep-05	506	519	520	1	1	1	96	98	98	26	27	27	1	1	1	0	0	0	4	4	4
Oct-05	635	623	626	1	1	1	122	119	120	33	32	32	1	1	1	0	0	0	5	5	5
Nov-05	608	604	606	1	1	1	57	56	56	20	19	19	1	1	1	0	0	0	3	3	3
Dec-05	599	600	603	1	1	1	43	43	43	17	16	16	1	1	1	0	0	0	3	3	3
Jan-06	393	439	440	0	0	0	31	32	32	13	13	13	1	1	1	0	0	0	2	2	2
Feb-06	461	473	474	0	0	0	34	34	34	11	11	11	1	1	1	0	0	0	2	2	2
Mar-06	497	500	502	0	0	0	52	52	52	13	13	13	1	1	1	0	0	0	2	2	2
Apr-06	436	381	380	0	0	0	75	63	63	22	19	19	1	1	1	0	0	0	4	3	3
May-06	465	322	322	1	0	0	75	56	57	24	19	19	1	1	1	0	0	0	4	3	3
Jun-06	696	890	916	1	1	1	120	117	117	36	37	38	2	2	2	0	0	0	6	6	6
Jul-06	665	717	737	1	1	1	96	138	139	37	54	54	2	2	2	0	0	0	6	9	9
Aug-06	646	787	811	1	1	1	148	147	145	50	50	50	2	2	2	0	0	0	8	8	8

Month-Year	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
										Days											
Sep-06	653	807	832	1	1	1	104	151	153	37	49	50	2	2	2	0	0	0	6	8	8
Oct-06	658	839	843	1	1	1	89	128	135	32	41	42	1	2	2	0	0	0	5	7	7
Nov-06	679	898	903	1	1	1	87	80	81	24	22	22	1	1	1	0	0	0	4	4	4
Dec-06	699	918	926	1	1	1	77	80	80	25	26	26	1	1	1	0	0	0	4	4	4
Jan-07	719	977	983	1	1	1	47	49	49	14	14	14	1	1	1	0	0	0	2	2	2
Feb-07	741	1010	1016	1	1	1	72	80	80	19	20	21	1	1	1	0	0	0	3	3	3
Mar-07	679	571	544	1	1	1	81	84	86	20	20	20	1	1	1	0	0	0	3	3	3
Apr-07	554	302	306	1	0	0	147	75	75	35	22	21	2	1	1	0	0	0	6	4	4
May-07	519	470	459	1	1	1	100	91	91	34	31	31	2	1	1	0	0	0	6	5	5
Jun-07	817	656	669	1	1	1	144	144	144	50	49	49	2	2	2	0	0	0	8	8	8
Jul-07	768	818	843	1	1	1	135	136	137	54	53	54	2	2	2	0	0	0	9	9	9
Aug-07	598	638	653	1	1	1	112	107	108	53	51	52	2	2	2	0	0	0	9	8	8
Sep-07	599	590	602	1	1	1	108	100	99	53	50	50	2	2	2	0	0	0	9	8	8
Oct-07	403	398	458	1	1	1	78	87	103	42	46	55	2	2	2	0	0	0	7	8	9
Nov-07	627	675	696	1	1	1	98	100	101	52	53	54	2	2	2	0	0	0	8	9	9
Dec-07	835	812	835	1	1	1	121	118	120	48	47	47	2	2	2	0	0	0	8	8	8
Jan-08	1008	965	997	1	1	1	89	107	106	26	28	28	1	1	1	0	0	0	4	5	5
Feb-08	1193	1134	1153	1	1	1	97	95	96	22	21	21	1	1	1	0	0	0	4	3	3
Mar-08	1306	1240	1257	1	1	1	88	83	83	22	21	21	1	1	1	0	0	0	4	3	3
Apr-08	1094	1015	1053	1	1	1	120	121	121	27	27	27	1	1	1	0	0	0	4	4	4
May-08	971	799	833	1	1	1	168	131	135	40	33	34	2	2	2	0	0	0	7	6	6
Jun-08	744	622	645	1	1	1	161	161	160	49	49	49	2	2	2	0	0	0	8	8	8
Jul-08	808	666	692	1	1	1	147	151	149	46	46	46	2	2	2	0	0	0	8	8	8
Aug-08	815	681	704	1	1	1	159	167	164	34	35	35	2	2	2	0	0	0	6	6	6
Sep-08	662	547	566	1	1	1	139	149	146	45	45	45	2	2	2	0	0	0	8	8	8
Oct-08	767	627	650	1	1	1	103	128	136	39	42	45	2	2	2	0	0	0	7	7	8
Nov-08	742	666	691	1	1	1	112	134	132	49	50	50	2	2	2	0	0	0	8	8	8
Dec-08	693	912	945	1	1	1	76	67	70	26	22	23	1	1	1	0	0	0	4	4	4
Jan-09	674	958	989	1	1	1	61	69	70	21	22	23	1	1	1	0	0	0	3	4	4
Feb-09	981	916	952	1	1	1	97	99	99	28	28	28	1	1	1	0	0	0	5	5	5
Mar-09	1333	1238	1269	1	1	1	43	41	41	9	9	9	0	0	0	0	0	0	2	1	1
Apr-09	1016	1254	1289	1	1	1	63	63	63	13	13	13	1	1	1	0	0	0	2	2	2
May-09	741	1036	1081	1	1	1	103	119	120	23	25	25	1	1	1	0	0	0	4	4	4
Jun-09	678	786	797	1	1	1	108	105	107	30	30	30	1	1	1	0	0	0	5	5	5
Jul-09	656	779	814	1	1	1	142	162	162	45	52	52	2	2	2	0	0	0	8	9	9

Month-Year	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
	Days																				
Aug-09	665	811	844	1	1	1	144	169	173	43	50	51	2	2	2	0	0	0	7	8	8
Sep-09	696	887	889	0	0	0	30	31	31	9	10	10	0	0	0	0	0	0	2	2	2
Oct-09	649	668	650	0	0	0	40	40	40	10	10	10	0	0	0	0	0	0	2	2	2
Nov-09	270	378	315	0	0	0	20	22	21	6	6	6	0	0	0	0	0	0	1	1	1
Dec-09	201	203	204	0	0	0	15	15	15	5	5	5	0	0	0	0	0	0	1	1	1
Jan-10	246	250	250	0	0	0	24	24	24	7	7	7	0	0	0	0	0	0	1	1	1
Feb-10	216	218	219	0	0	0	22	22	22	7	7	7	0	0	0	0	0	0	1	1	1
Mar-10	299	304	305	0	0	0	27	27	27	7	7	7	0	0	0	0	0	0	1	1	1
Apr-10	477	492	494	0	0	0	65	66	66	17	17	17	1	1	1	0	0	0	3	3	3
May-10	337	368	368	0	0	0	46	47	47	12	12	13	1	1	1	0	0	0	2	2	2
Jun-10	618	608	611	1	1	1	98	98	98	27	27	27	1	1	1	0	0	0	4	4	4
Jul-10	615	599	603	1	1	1	113	117	118	34	34	34	2	2	2	0	0	0	6	6	6
Aug-10	595	581	584	1	1	1	112	115	115	36	37	37	2	2	2	0	0	0	6	6	6
Sep-10	568	643	646	1	1	1	96	98	98	35	36	36	2	2	2	0	0	0	6	6	6
Oct-10	610	692	688	1	1	1	91	113	115	35	41	42	2	2	2	0	0	0	6	7	7
Nov-10	677	701	704	1	1	1	78	85	85	29	30	30	1	1	1	0	0	0	5	5	5
Dec-10	559	701	704	1	1	1	69	68	68	25	24	24	1	1	1	0	0	0	4	4	4
Jan-11	706	504	501	1	1	1	79	39	39	26	17	17	1	1	1	0	0	0	4	3	3
Feb-11	741	983	986	1	1	1	55	101	101	16	24	24	1	1	1	0	0	0	3	4	4
Mar-11	460	524	530	0	0	0	42	43	43	12	13	13	1	1	1	0	0	0	2	2	2
Apr-11	284	222	222	0	0	0	46	40	40	14	12	12	1	1	1	0	0	0	2	2	2
May-11	350	255	253	0	0	0	75	49	49	24	17	17	1	1	1	0	0	0	4	3	3
Jun-11	643	814	814	1	1	1	128	115	115	47	46	46	2	2	2	0	0	0	8	7	8
Jul-11	680	765	786	1	1	1	141	132	132	49	51	51	2	2	2	0	0	0	8	8	8
Aug-11	615	640	654	1	1	1	121	119	117	48	53	52	2	2	2	0	0	0	8	9	9
Sep-11	617	692	708	1	1	1	99	112	120	35	41	43	2	2	2	0	0	0	6	7	7
Oct-11	605	659	507	1	1	1	106	98	90	49	50	47	2	2	2	0	0	0	8	8	8
Nov-11	630	465	675	1	1	1	79	69	72	36	34	36	2	2	2	0	0	0	6	6	6
Dec-11	661	1121	1103	1	1	1	88	109	114	28	33	34	1	1	2	0	0	0	5	5	6
Overall Median	639	666	675	1	1	1	82	85	85	24	24	24	1	1	1	0	0	0	4	4	4
May-October Median	645	667	679	1	1	1	104	113	114	34	34	34	2	2	2	0	0	0	6	6	6
May-October Average	646	662	670	1	1	1	102	106	107	32	33	34	1	2	2	0	0	0	5	6	6
April-October Median	635	659	664	1	1	1	103	104	106	32	31	31	1	1	1	0	0	0	5	5	5
April-October Average	652	656	664	1	1	1	99	101	101	30	31	31	1	1	1	0	0	0	5	5	5

Table 9b. Monthly retention times (in days) for reservoirs on the Chattahoochee River for the period from 2001 through 2011

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year	Days								
Jan-01	73	72	72	1	1	1	14	14	14
Feb-01	70	70	70	1	1	1	16	15	15
Mar-01	15	15	15	0	0	0	3	3	3
Apr-01	35	34	34	1	1	1	5	5	5
May-01	169	134	136	3	2	2	21	19	19
Jun-01	68	69	69	1	1	1	11	11	11
Jul-01	130	116	116	2	2	2	17	15	15
Aug-01	129	115	116	2	2	2	21	20	20
Sep-01	146	155	155	3	3	3	23	24	24
Oct-01	116	140	140	2	3	3	25	27	27
Nov-01	114	134	135	2	3	3	26	29	29
Dec-01	130	151	151	3	3	3	23	24	24
Jan-02	93	67	66	2	1	1	21	15	15
Feb-02	64	78	79	1	1	2	14	16	16
Mar-02	66	63	62	1	1	1	13	13	13
Apr-02	75	72	73	2	1	1	13	12	12
May-02	164	106	107	3	2	2	24	22	22
Jun-02	295	230	230	5	4	4	34	32	32
Jul-02	195	182	182	4	4	4	32	32	32
Aug-02	223	242	242	4	5	5	32	32	32
Sep-02	165	235	235	3	5	5	24	28	28
Oct-02	147	150	153	3	3	3	21	21	21
Nov-02	64	65	66	1	1	1	11	11	11
Dec-02	42	43	43	1	1	1	10	10	10
Jan-03	77	67	67	1	1	1	12	10	10
Feb-03	38	39	39	1	1	1	8	9	9
Mar-03	25	24	24	0	0	0	4	4	4
Apr-03	34	33	33	1	1	1	6	6	6
May-03	25	25	25	0	0	0	5	5	5
Jun-03	25	25	25	0	0	0	5	5	5
Jul-03	30	30	30	1	1	1	6	6	6
Aug-03	53	53	53	1	1	1	8	8	8
Sep-03	111	110	111	2	2	2	14	14	14
Oct-03	90	88	88	2	2	2	16	16	16
Nov-03	51	52	52	1	1	1	13	14	14
Dec-03	57	57	57	1	1	1	12	12	12

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year	Days								
Jan-04	48	40	40	1	1	1	12	11	11
Feb-04	28	30	30	1	1	1	6	7	7
Mar-04	65	56	56	1	1	1	11	9	9
Apr-04	83	65	65	2	1	1	16	13	13
May-04	97	140	143	2	3	3	15	20	20
Jun-04	150	149	149	3	3	3	19	20	20
Jul-04	121	140	141	2	2	2	17	17	17
Aug-04	121	119	119	2	2	2	20	20	20
Sep-04	45	45	45	1	1	1	8	8	8
Oct-04	74	79	79	1	1	1	11	12	12
Nov-04	33	34	34	1	1	1	9	10	10
Dec-04	35	35	35	1	1	1	8	8	8
Jan-05	51	51	51	1	1	1	10	10	10
Feb-05	32	32	32	1	1	1	8	8	8
Mar-05	23	23	23	1	1	1	5	5	5
Apr-05	18	18	18	0	0	0	3	3	3
May-05	70	69	69	1	1	1	9	9	9
Jun-05	50	51	51	1	1	1	8	8	8
Jul-05	22	22	22	0	0	0	4	4	4
Aug-05	37	37	37	1	1	1	7	7	7
Sep-05	118	119	119	2	2	2	14	14	14
Oct-05	89	88	88	2	2	2	16	16	16
Nov-05	68	67	67	1	1	1	16	16	16
Dec-05	54	53	53	1	1	1	11	11	11
Jan-06	40	41	41	1	1	1	8	8	8
Feb-06	35	35	35	1	1	1	8	8	8
Mar-06	39	39	39	1	1	1	8	8	8
Apr-06	61	56	56	1	1	1	12	11	11
May-06	89	56	56	2	1	1	14	11	11
Jun-06	178	155	155	3	3	3	27	26	26
Jul-06	137	254	255	3	5	5	26	35	34
Aug-06	195	196	198	4	4	4	32	32	32
Sep-06	150	203	205	3	4	4	25	28	28
Oct-06	144	190	198	3	4	4	25	31	31
Nov-06	82	80	81	2	2	2	17	17	17
Dec-06	88	91	91	2	2	2	19	19	19
Jan-07	46	47	47	1	1	1	9	9	9
Feb-07	59	62	62	1	1	1	10	11	11

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year					Days				
Mar-07	52	54	54	1	1	1	9	10	10
Apr-07	79	56	56	2	1	1	13	10	10
May-07	160	125	123	3	3	3	25	22	22
Jun-07	191	182	182	4	4	4	33	33	33
Jul-07	195	200	200	4	4	4	32	33	33
Aug-07	156	153	153	3	3	3	33	33	33
Sep-07	175	171	172	4	4	4	33	33	32
Oct-07	183	183	230	4	4	5	33	33	37
Nov-07	169	200	210	4	4	5	34	38	38
Dec-07	255	264	250	5	5	5	32	33	33
Jan-08	71	73	73	1	1	1	12	12	12
Feb-08	46	46	46	1	1	1	7	7	7
Mar-08	55	54	54	1	1	1	8	8	8
Apr-08	64	64	64	1	1	1	9	10	10
May-08	250	146	146	4	3	3	25	21	21
Jun-08	276	207	213	5	4	4	32	30	31
Jul-08	217	202	201	4	4	4	30	30	30
Aug-08	109	143	143	2	2	2	16	17	17
Sep-08	147	146	146	3	3	3	18	18	18
Oct-08	141	141	140	3	3	3	24	24	24
Nov-08	94	99	102	2	2	2	19	20	20
Dec-08	45	43	43	1	1	1	7	7	7
Jan-09	58	61	61	1	1	1	11	11	11
Feb-09	80	82	85	2	2	2	15	16	16
Mar-09	25	24	24	1	1	1	6	6	6
Apr-09	23	23	23	0	0	0	3	3	3
May-09	61	63	63	1	1	1	9	9	9
Jun-09	96	99	99	2	2	2	12	12	12
Jul-09	147	146	145	3	3	3	20	20	20
Aug-09	159	162	161	3	3	3	21	21	21
Sep-09	38	41	41	1	1	1	10	11	11
Oct-09	33	33	33	1	1	1	9	9	9
Nov-09	19	20	19	0	0	0	5	6	5
Dec-09	11	11	11	0	0	0	3	3	3
Jan-10	20	20	20	0	0	0	4	4	4
Feb-10	19	19	19	0	0	0	3	3	3
Mar-10	23	22	23	0	0	0	5	5	5
Apr-10	54	54	54	1	1	1	10	10	10

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year	Days								
May-10	41	40	40	1	1	1	7	7	7
Jun-10	96	101	101	2	2	2	13	13	13
Jul-10	137	137	136	2	2	2	18	18	18
Aug-10	145	147	146	3	3	3	22	22	22
Sep-10	152	152	151	3	3	3	28	28	28
Oct-10	125	133	132	2	3	3	25	24	24
Nov-10	101	106	108	2	2	2	21	22	22
Dec-10	96	90	90	2	2	2	20	19	19
Jan-11	88	47	47	2	1	1	17	12	12
Feb-11	46	75	76	1	1	1	10	12	12
Mar-11	38	38	38	1	1	1	10	10	10
Apr-11	47	42	42	1	1	1	10	9	9
May-11	125	63	63	2	1	1	22	16	16
Jun-11	178	157	157	3	3	3	34	32	32
Jul-11	177	221	221	3	4	4	29	35	35
Aug-11	165	174	174	3	4	4	34	34	34
Sep-11	132	134	134	3	3	3	33	33	33
Oct-11	163	158	156	3	4	4	34	33	33
Nov-11	136	149	150	3	3	3	32	33	33
Dec-11	143	197	204	3	4	4	32	35	36
Overall Median	80	72	72	2	1	1	14	14	13
May-October Median	137	140	140	3	3	3	21	20	20
May-October Average	129	128	130	2	3	3	20	21	21
April-October Median	125	125	123	2	2	2	18	18	18
April-October Average	118	117	118	2	2	2	19	19	19

2.1.6 Phosphorus

a. Average summer phosphorus loading (pounds/acre/month).

The results presented here are consistent with the 2015 PAL response and are not average summer phosphorus loads as pounds per acre per month but are pounds per year instead.

Alabama, Florida, and Georgia have established criteria in the ACF Basin for total phosphorus (TP). The nutrient criteria for TP in major headwaters contributing to lakes in Georgia are based on annual loads in pounds. In accordance with the water quality standards set by Georgia, the TP annual loading for West Point Lake headwaters at Chattahoochee River at U.S. Highway 27 should not exceed 1,400,000 lbs and for Walter F. George Lake headwaters, the annual TP loading at Chattahoochee River at U.S. Highway 39 should not exceed 2,000,000 lbs. The calculated TP loads for the NAA and the PAA are shown in Table 10. The loads were calculated using the HEC-5Q model outputs of TP concentrations (mg/L) and modeled flows (cfs) with proper conversion factors applied to derive annual loads in lbs.

Violations of the water quality standard would be expected in the PAA when the NAA would be expected to meet water quality standards into the Walter F. George Lake headwaters. Therefore, both Alt7H and the PAA (Alt7K) would be expected to have substantially adverse effects on TP based on criteria established to define effects in the EIS. Review of a full range of alternatives in the EIS indicates that these violations would not be the results of water management activities but would be expected from increased wastewater returns downstream of Buford Dam.

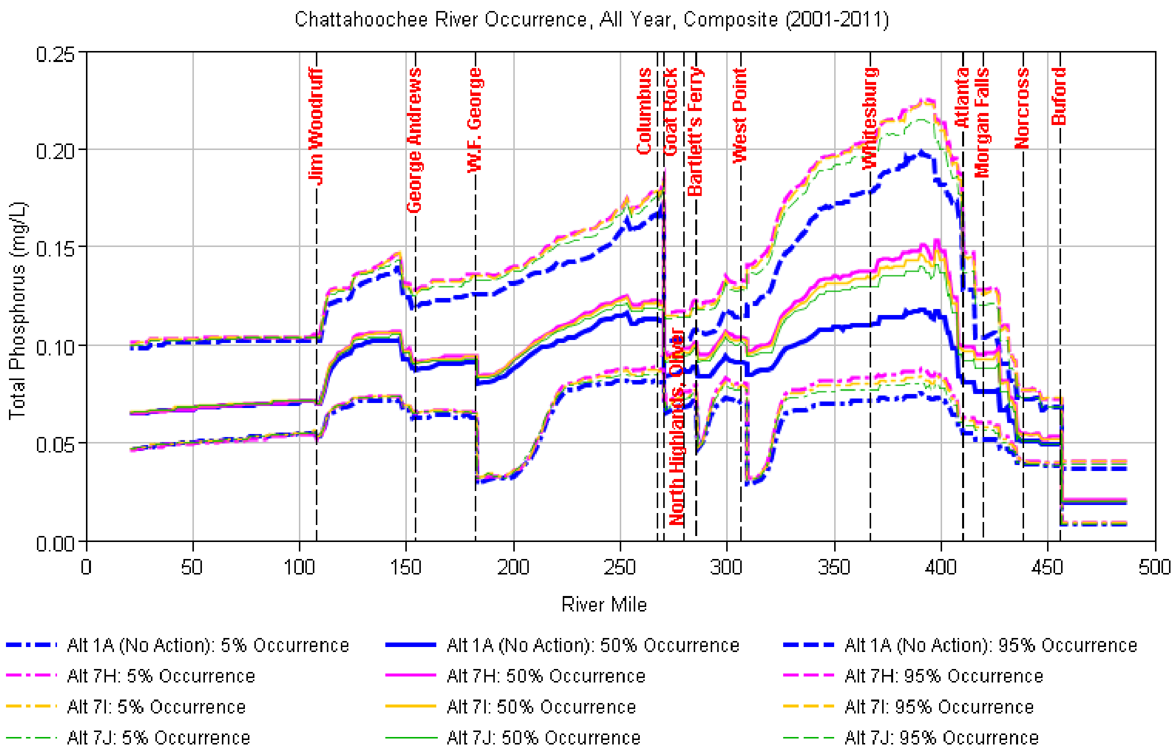
Longitudinal profiles were also used as an initial indication of changes that would be expected between the NAA and the PAA. Figure 50 through Figure 52 illustrates the response of TP to changes between the NAA and the PAA. Figure 53 and Figure 54 illustrate the change in TP between the NAA and the PAA for the modeled period and a representative dry year when the greatest variation would be expected.

Table 10. Total phosphorus loads (pounds per year) at West Point Lake headwaters and Walter F. George Lake headwaters for the modeled period (2001–2011)

Year	Location	NAA	Alt7H	Alt7K
			(pounds / year)	
2001	West Point Lake headwaters	754,935	843,924	832,053
	Walter F. George Lake headwaters	1,422,036	1,526,650	1,509,983
2002	West Point Lake headwaters	697,443	826,407	810,360
	Walter F. George Lake headwaters	1,106,039	1,229,652	1,213,543
2003	West Point Lake headwaters	1,283,557	1,445,418*	1,408,302*
	Walter F. George Lake headwaters	1,965,005	2,135,048*	2,090,889*

Year	Location	NAA	Alt7H	Alt7K
			(pounds / year)	
2004	West Point Lake headwaters	897,763	1,020,282	1,000,136
	Walter F. George Lake headwaters	1,465,636	1,597,801	1,573,490
2005	West Point Lake headwaters	1,129,805	1,265,768	1,241,756
	Walter F. George Lake headwaters	2,017,151*	2,181,822*	2,147,607*
2006	West Point Lake headwaters	720,284	824,021	805,049
	Walter F. George Lake headwaters	1,210,894	1,315,773	1,295,033
2007	West Point Lake headwaters	478,531	588,474	568,821
	Walter F. George Lake headwaters	931,830	1,049,054	1,027,777
2008	West Point Lake headwaters	452,391	539,860	527,146
	Walter F. George Lake headwaters	1,172,838	1,286,855	1,270,781
2009	West Point Lake headwaters	1,261,733	1,386,419	1,361,653
	Walter F. George Lake headwaters	2,413,272*	2,605,069*	2,561,774*
2010	West Point Lake headwaters	858,573	964,649	942,654
	Walter F. George Lake headwaters	1,555,842	1,672,748	1,644,284
2011	West Point Lake headwaters	641,421	763,766	744,398
	Walter F. George Lake headwaters	1,059,169	1,180,736	1,159,505

*indicates a water quality standard violation.



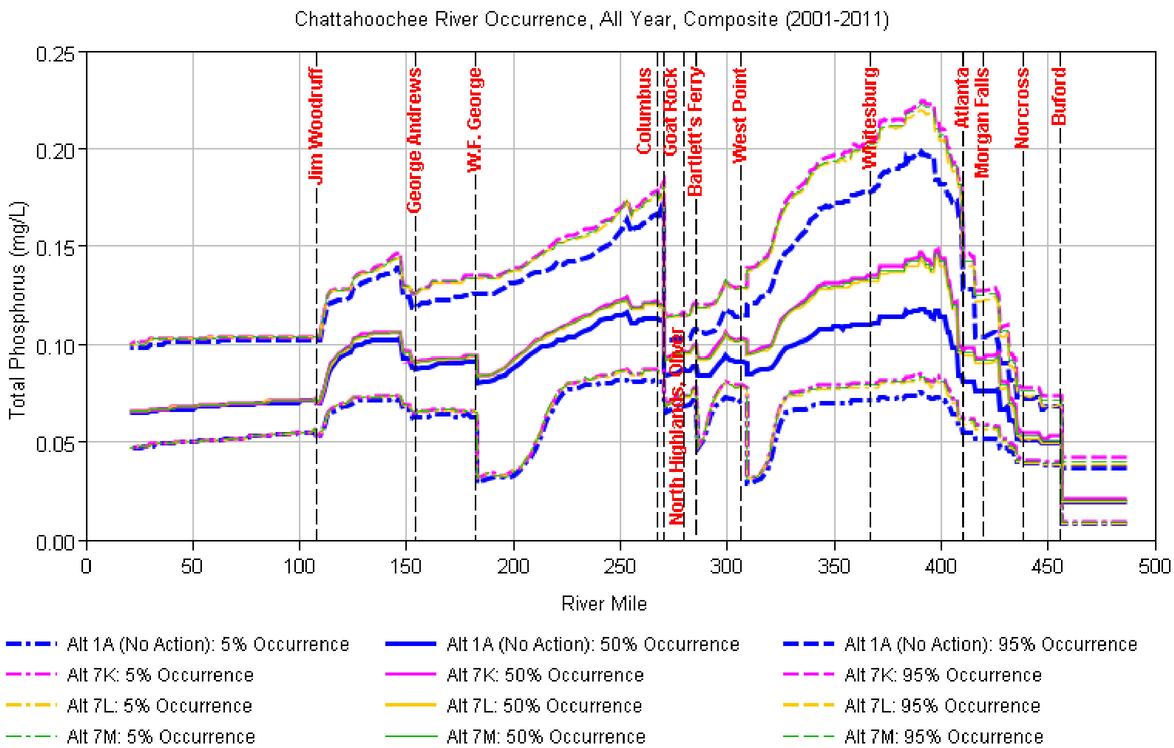
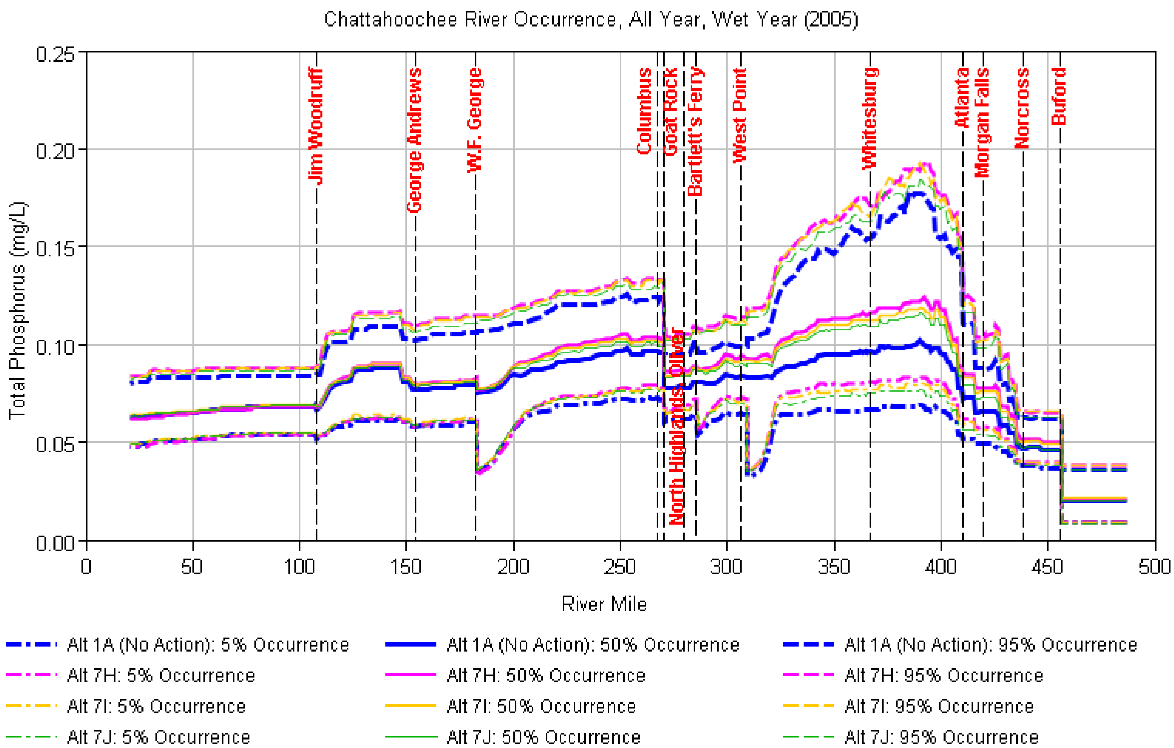


Figure 50. Longitudinal profile occurrence of daily average total phosphorus in the ACF Basin for the period 2001-2011 for the NAA and the PAA



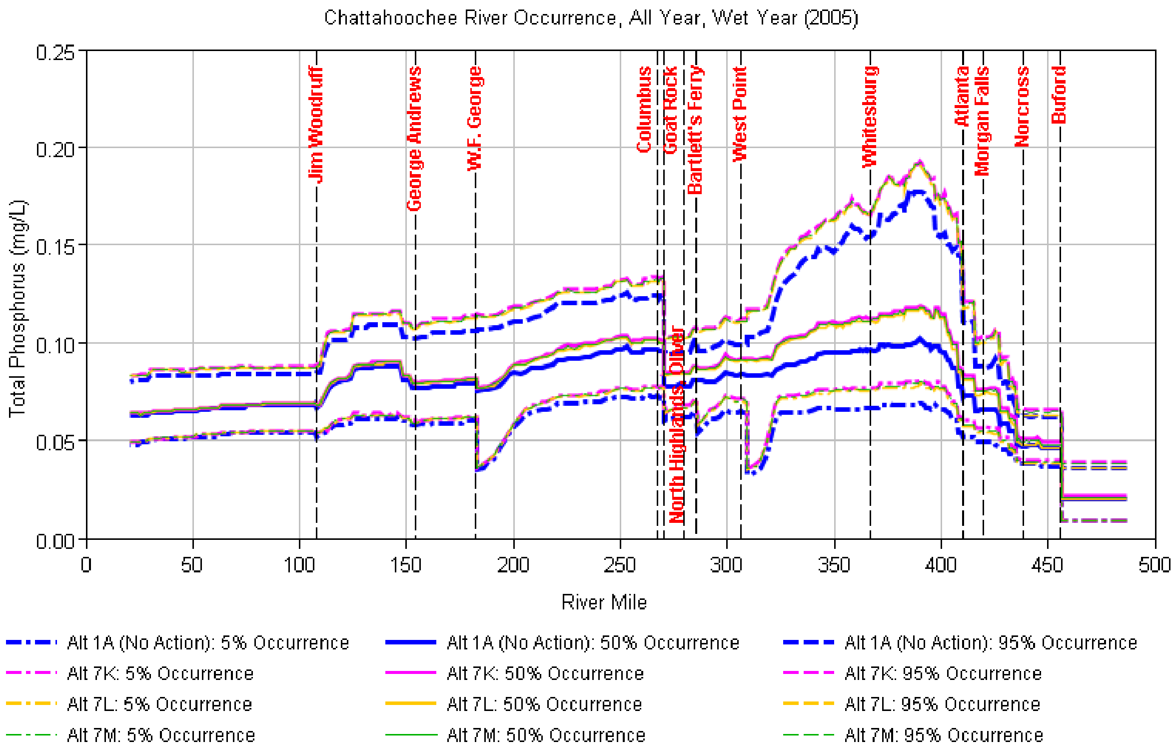


Figure 51. Longitudinal profile occurrence of daily average total phosphorus in the ACF Basin for a wet year (2005) for the NAA and the PAA

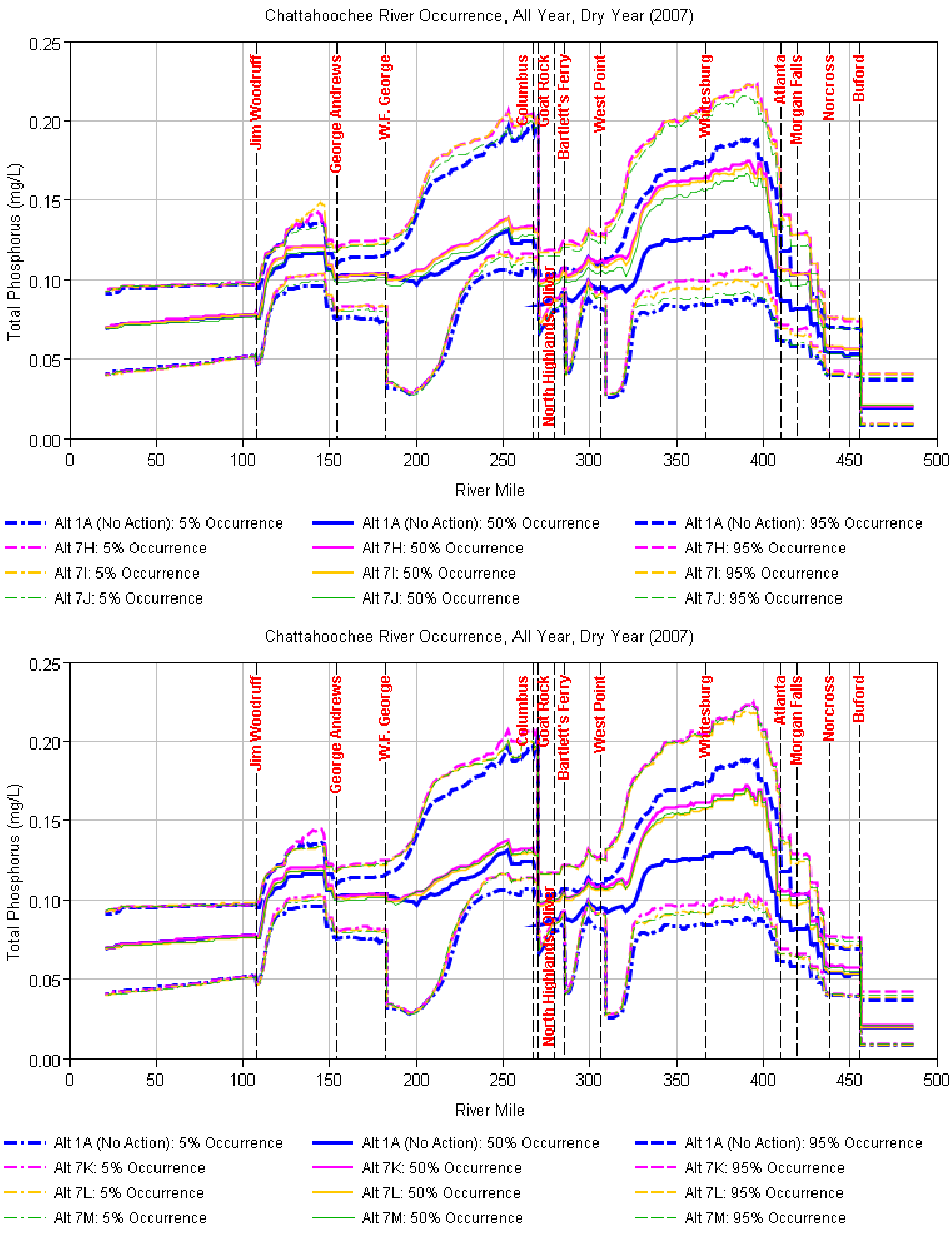


Figure 52. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a dry year (2007) for the NAA and the PAA

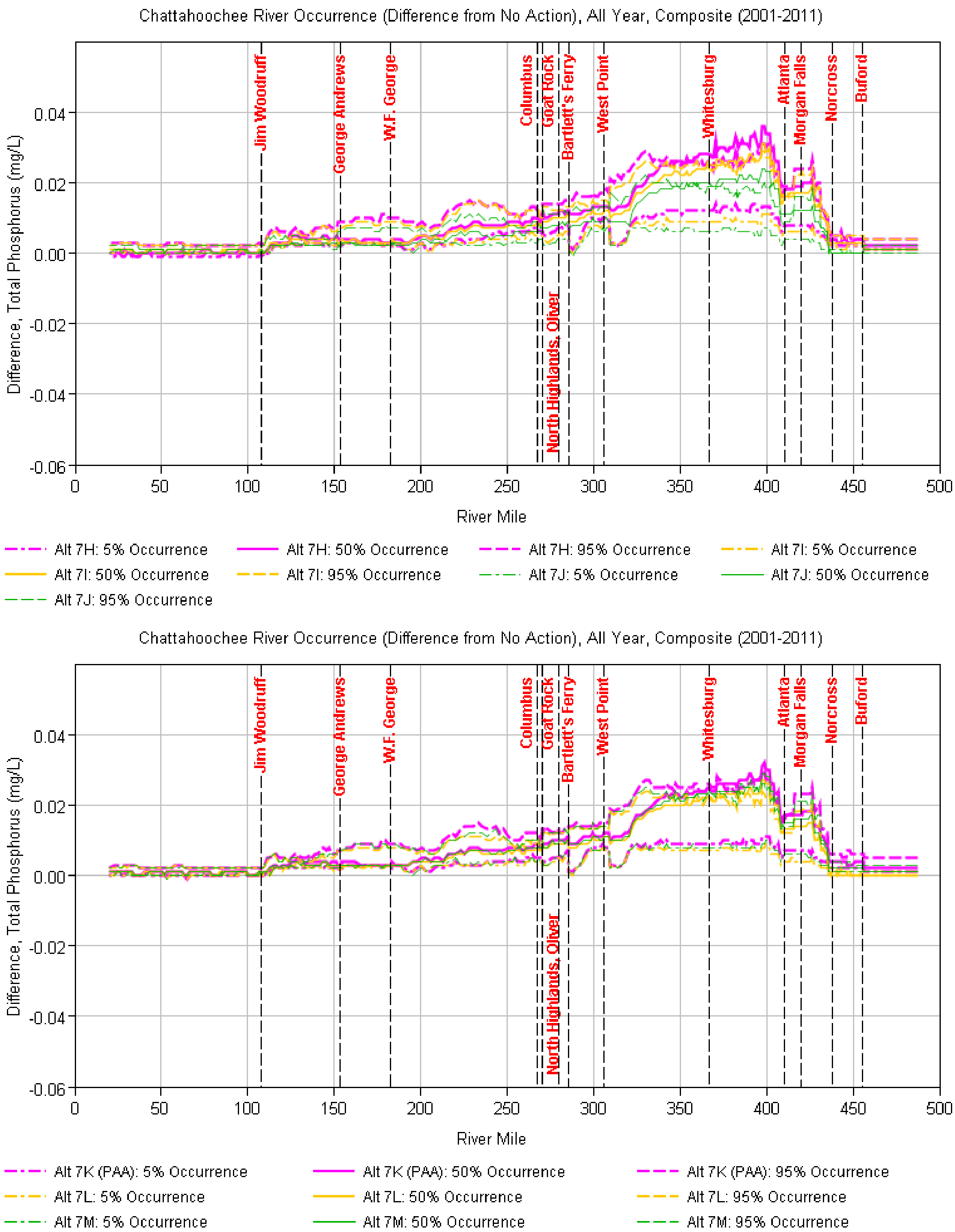


Figure 53. Longitudinal profile of change in daily average total phosphorus in the ACF Basin from the NAA for the PAA for the model period (2001-2011)

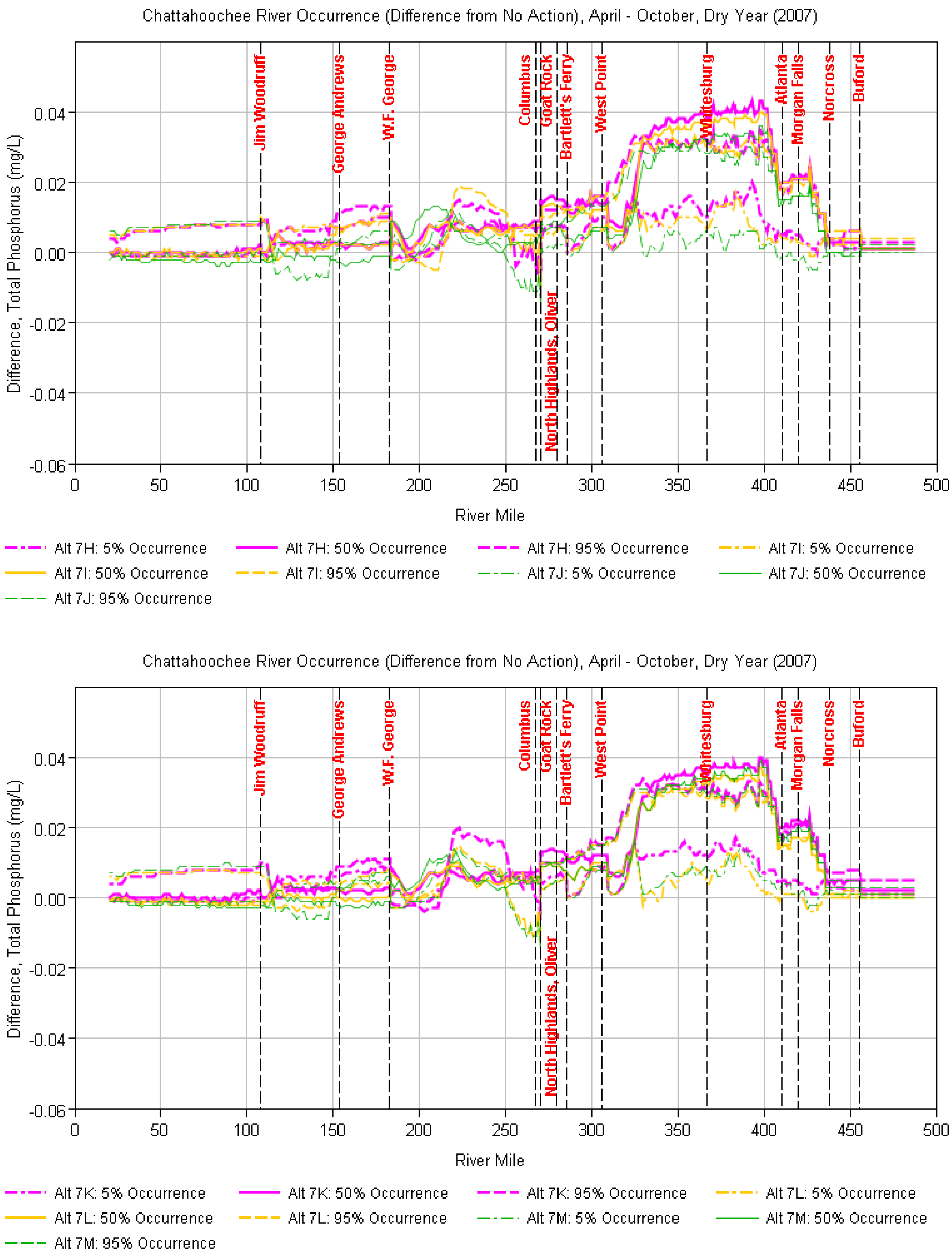


Figure 54. Longitudinal profile of change in daily average total phosphorus from the NAA in the ACF Basin during growing season (April through October) of a dry year (2007) for the PAA

2.2 Floodplain Connectivity Analyses

A complete set of the Apalachicola River floodplain LIDAR data is not available and therefore this was not used in this analysis. However, available data was used to determine the annual maximum 30-day growing season floodplain connectivity as described in the 2013 PAL. These results are illustrated in Figure 55 and Figure 56. Given that conditions in the PAA are very similar to those for the 2012 RIOP, little change would be expected.

Similar results would be expected along the Chattahoochee River; given that conditions in the PAA are very similar to the NAA, little change would be expected. The Chattahoochee River is essentially disconnected from its floodplain, so floodplain connectivity would not be influenced by the different alternatives. Changes in streamflow on the Chattahoochee River from Norcross to Columbus are minor and would not be expected to reach flows defined in Table 1 of the 2010 PAL. USACE manages operations to reduce flooding. Flood risk management operations would remain unchanged from those currently employed.

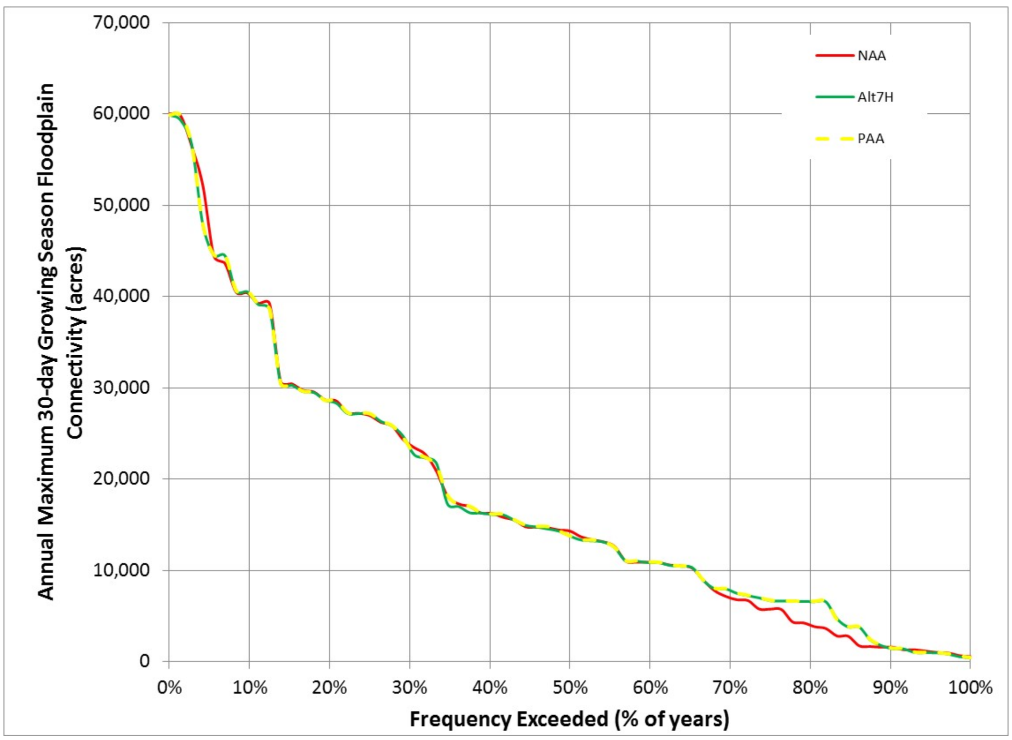


Figure 55. Frequency of annual maximum 30-day growing season (April through October) floodplain connectivity in acres for the NAA, Alt7H, and PAA over the modeled period [Note the change from the 2015 PAL which identified the period the growing season from April through September.]

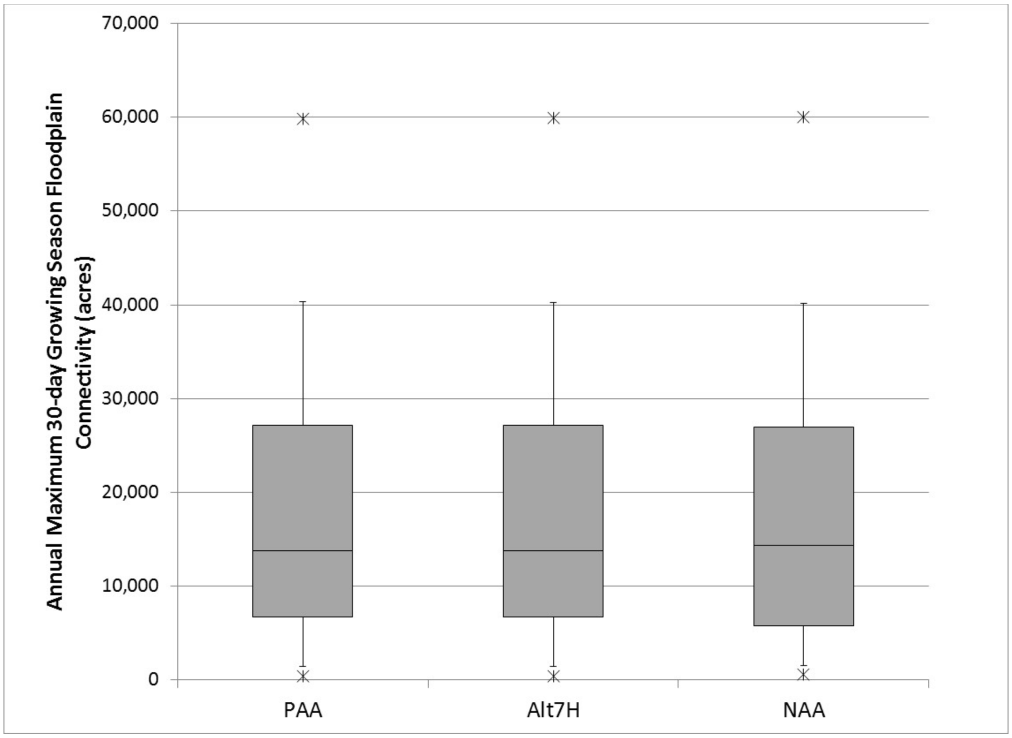


Figure 56. Statistics (minimum; 10th, 25th, 50th, 75th, and 90th percentiles; and maximum) for the annual maximum 30-day growing season (April through October) floodplain connectivity in acres for the NAA, Alt7H, and PAA over the modeled period [Note the change from the 2015 PAL which identified the period the growing season from April through September.]

2.3 Reservoir Fisheries Analyses

Reservoir fisheries were evaluated using methods described in the 2013 PAL. Previous work based on Ryder et al. (1995) was not used for this analysis.

Operational flow changes would affect habitat for reservoir fisheries and other aquatic resources mainly through changes in water levels, reservoir flushing rates (retention times), and associated changes in water quality parameters, such as nutrient loading and DO concentrations. Seasonal water level fluctuations can substantially change the area of shallow-water habitats and inundated shoreline vegetation in reservoirs and, in turn, influence the reproductive success of resident fish populations.

Substantial daily or weekly fluctuations in reservoir levels associated with hydroelectric power generation peaking operations could adversely affect reservoir fisheries by dewatering spawning and nursery habitats for littoral species, exposing nests and eggs deposited in shallow-water habitats, and reducing the availability of shoreline cover and its associated invertebrate food supply. Performance measures developed by the Service were used in this evaluation, specifically to assess reservoir fisheries habitat, based on the assumption that a greater departure of reservoir levels from optimum (e.g., littoral spawning, rearing) results in a greater effect on habitats, including loss. The Reservoir Fisheries Performance Measure (RFPM) was recommended by the Service because it specifically characterizes the spatial extent of the reservoir most likely to support successful fish survival and reproduction as a direct function of containing suitable habitat features.

The effect of the alternatives on reservoir fisheries was determined using the area (in acres) of productive zone inundated for more than 30 days during the spawning season, as calculated using the RFPM. The inundated productive zone was defined for each reservoir and is presented in Figure 57, Figure 58, and Figure 59. These figures illustrate little difference between median values of the productive zone between the NAA, Alt7H, and PAA.

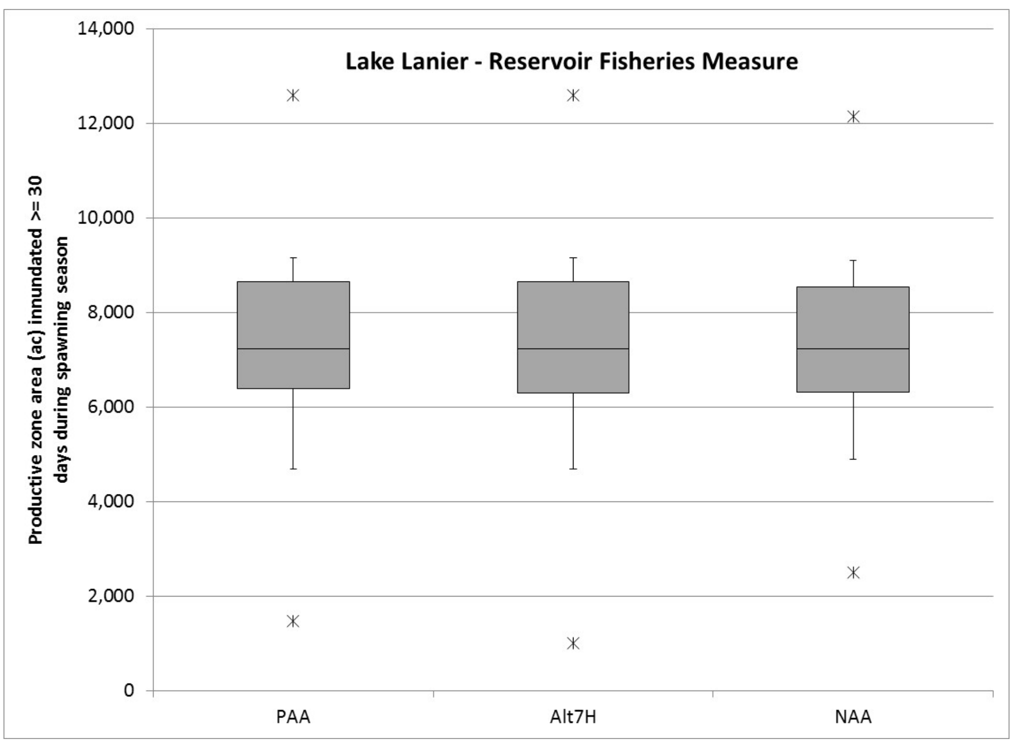


Figure 57. Reservoir fisheries performance measure results for the NAA and PAA at Lake Sidney Lanier

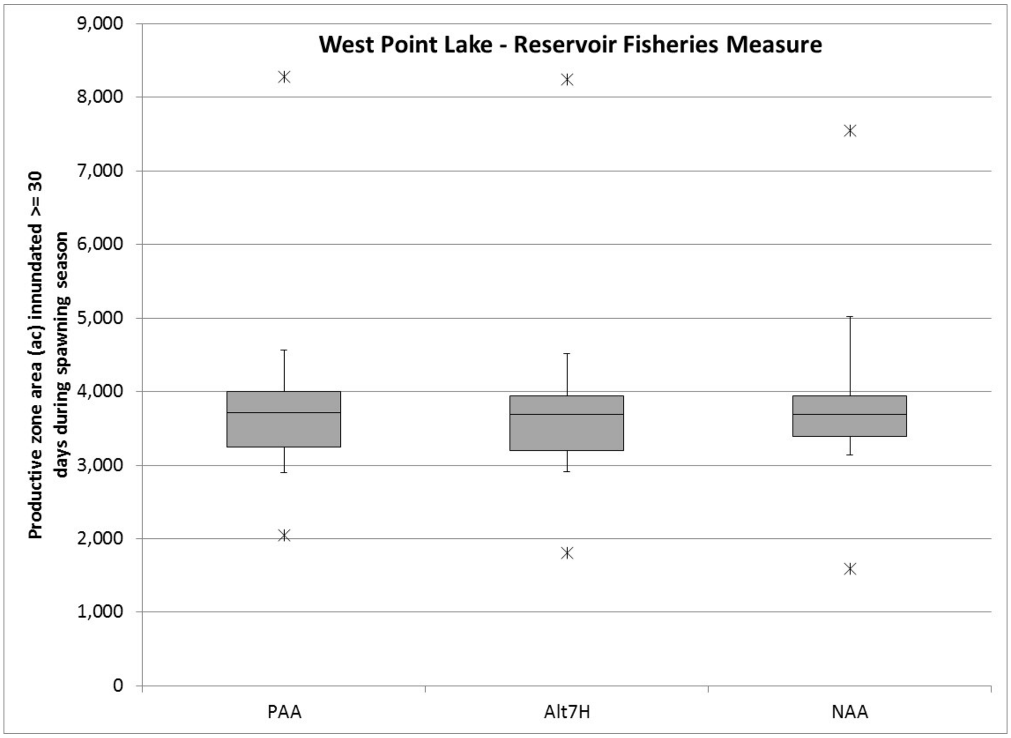


Figure 58. Reservoir fisheries performance measure results for the NAA, Alt7H, and PAA at West Point Lake

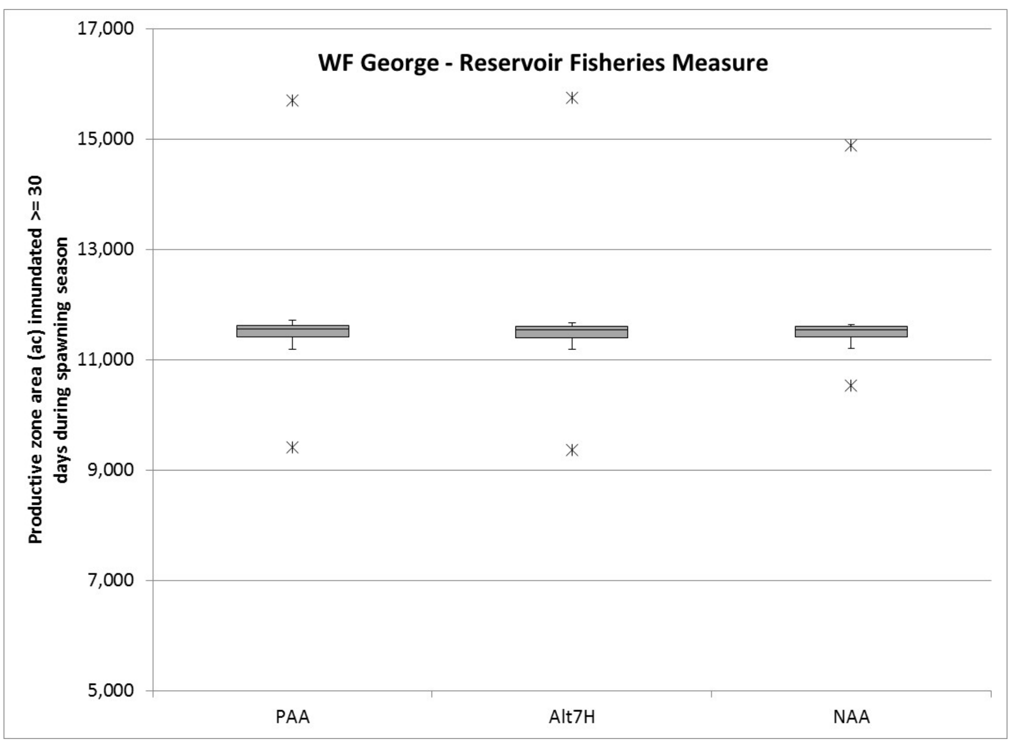


Figure 59. Reservoir fisheries performance measure results for the NAA, Alt7H, and PAA at Walter F. George Lake

2.4 Riverine Fisheries Analyses

Sport fisheries are important recreational and economic resources in the riverine portions of the ACF Basin, especially in the Apalachicola River. The survival and reproduction of many fishes are intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. There are existing effects of controlled flows in the ACF Basin on lateral connectivity and floodplain inundation. Before the Chattahoochee River became subjected to human controls, there were substantial flows with natural variability in magnitude and seasonal fluctuations. Because of the series of dams now present in the Chattahoochee River system, the Chattahoochee River is essentially disconnected from its floodplain. Fish and aquatic resources in the ACF Basin between Buford Dam and Apalachicola Bay will be affected differently due to differences in streamflow and water quality. Since water quality was described in response to specific requests by the Service in section 2.1, this section describes how streamflow may affect riverine fisheries.

The monthly flow range at the 10th, 25th, 50th, 75th and 90th percentile exceedance for the NAA, Alt7H, and PAA were compared and are presented in Figures 60 through 66. These flows were calculated from HEC-ResSim results at various points in the Chattahoochee River to represent the monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded).

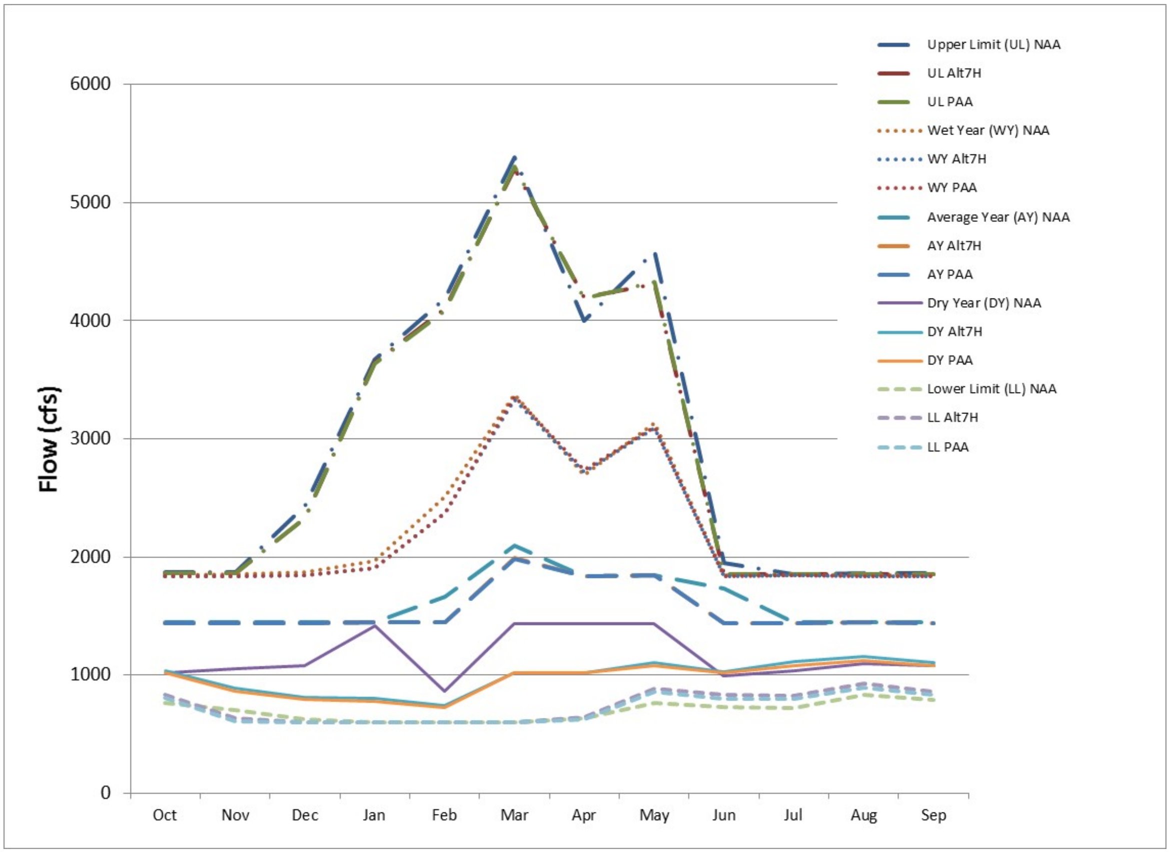


Figure 60. Buford Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

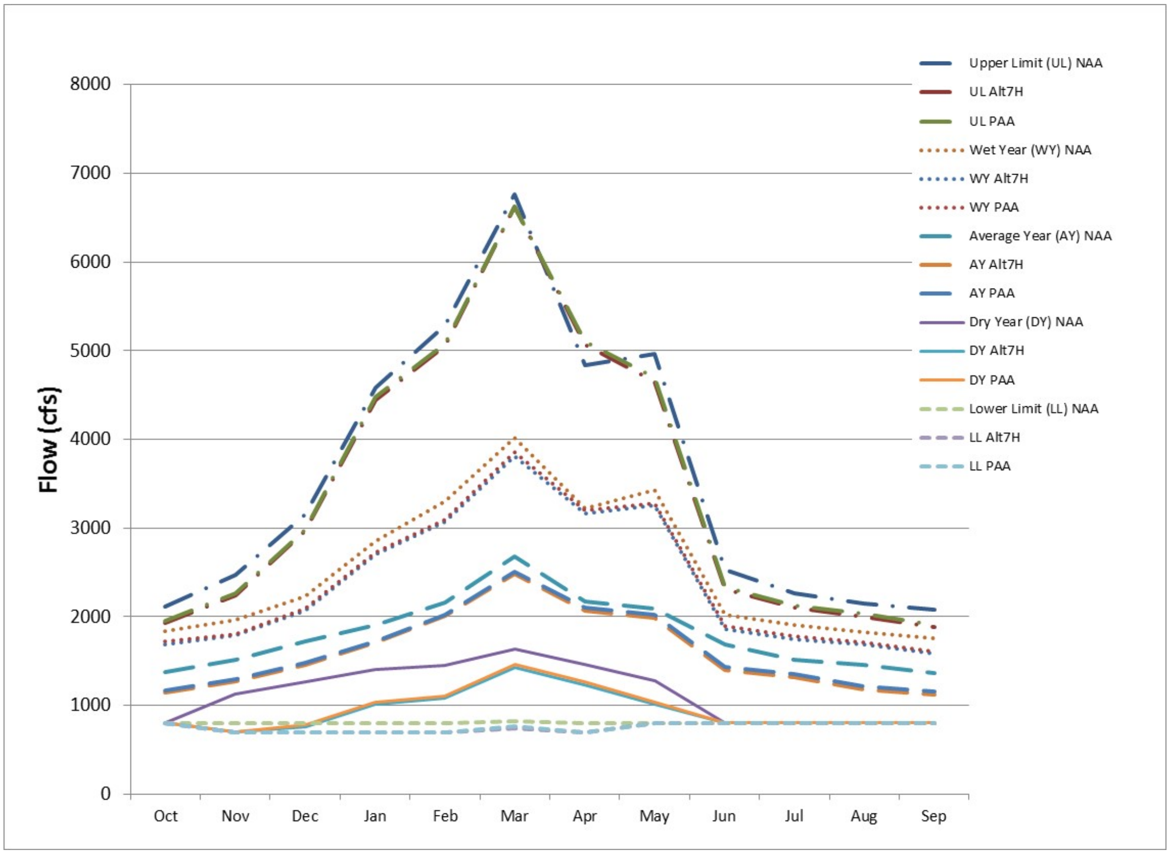


Figure 61. Atlanta, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

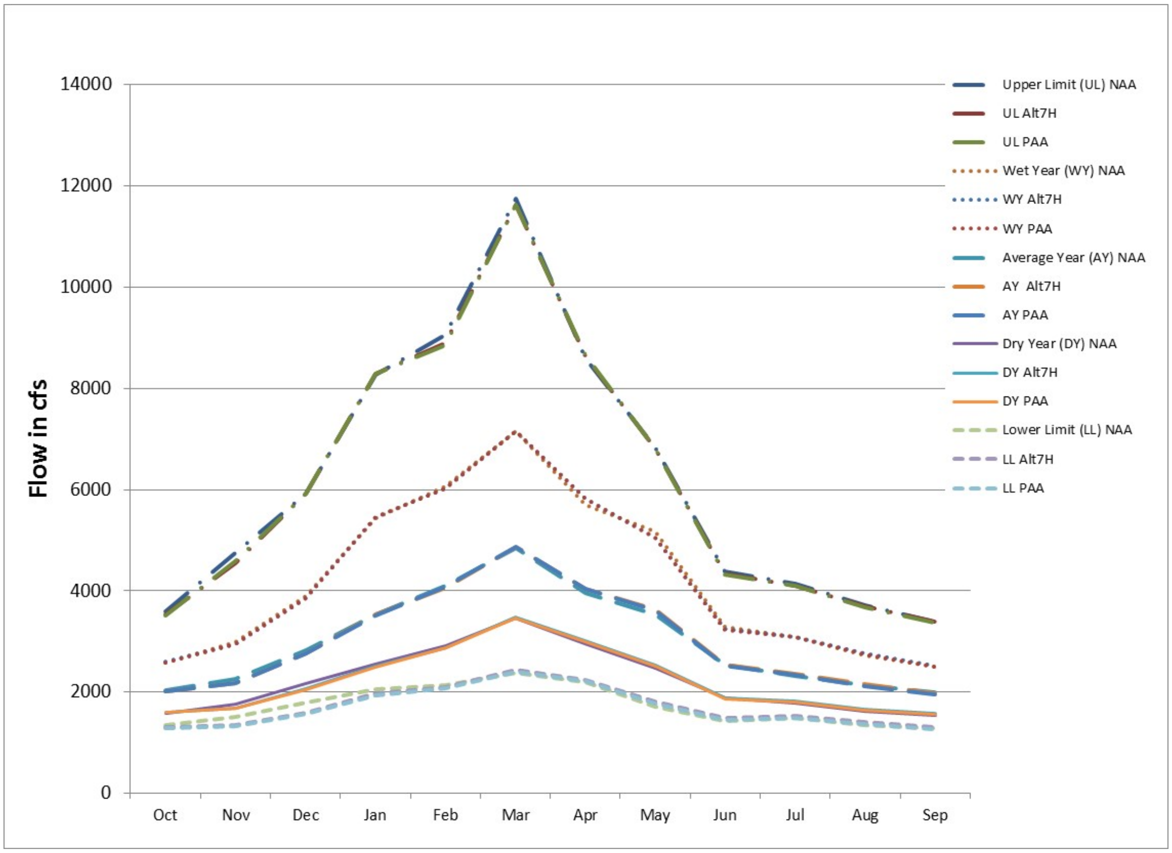


Figure 62. Whitesburg, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

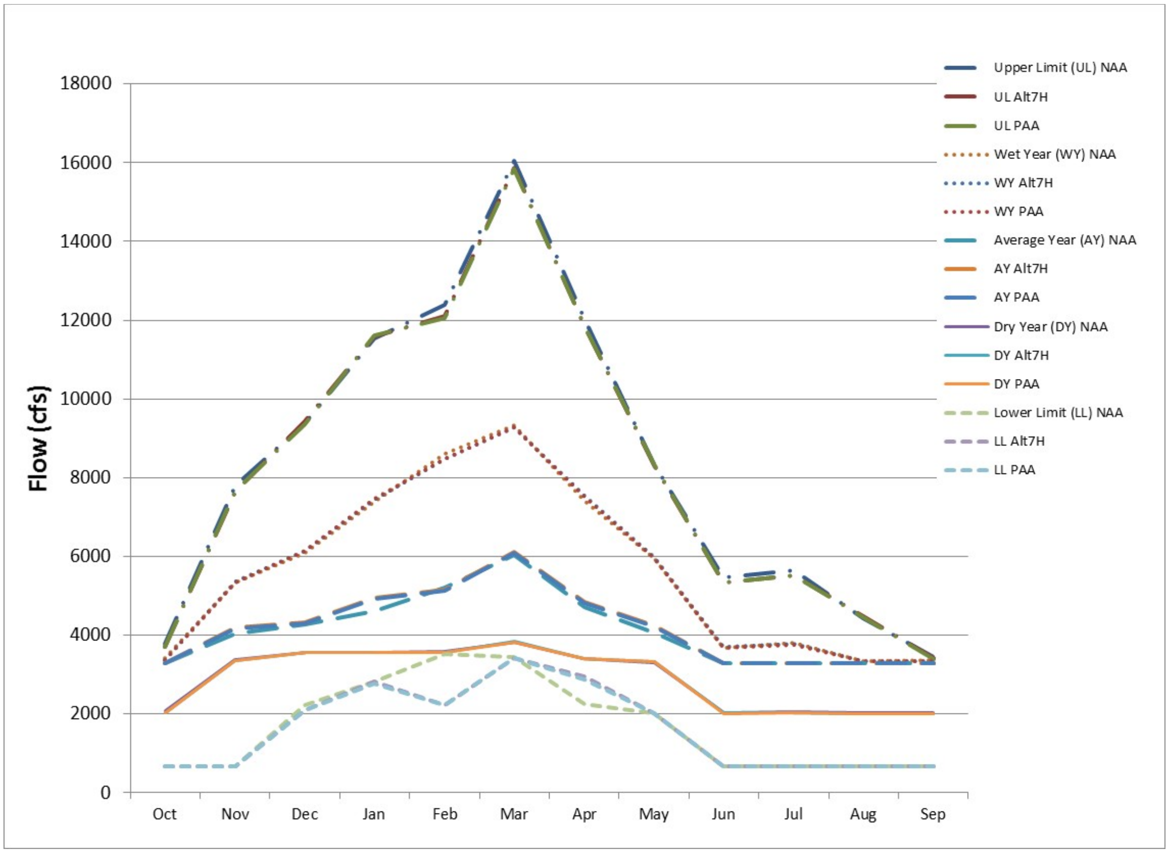


Figure 63. West Point Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

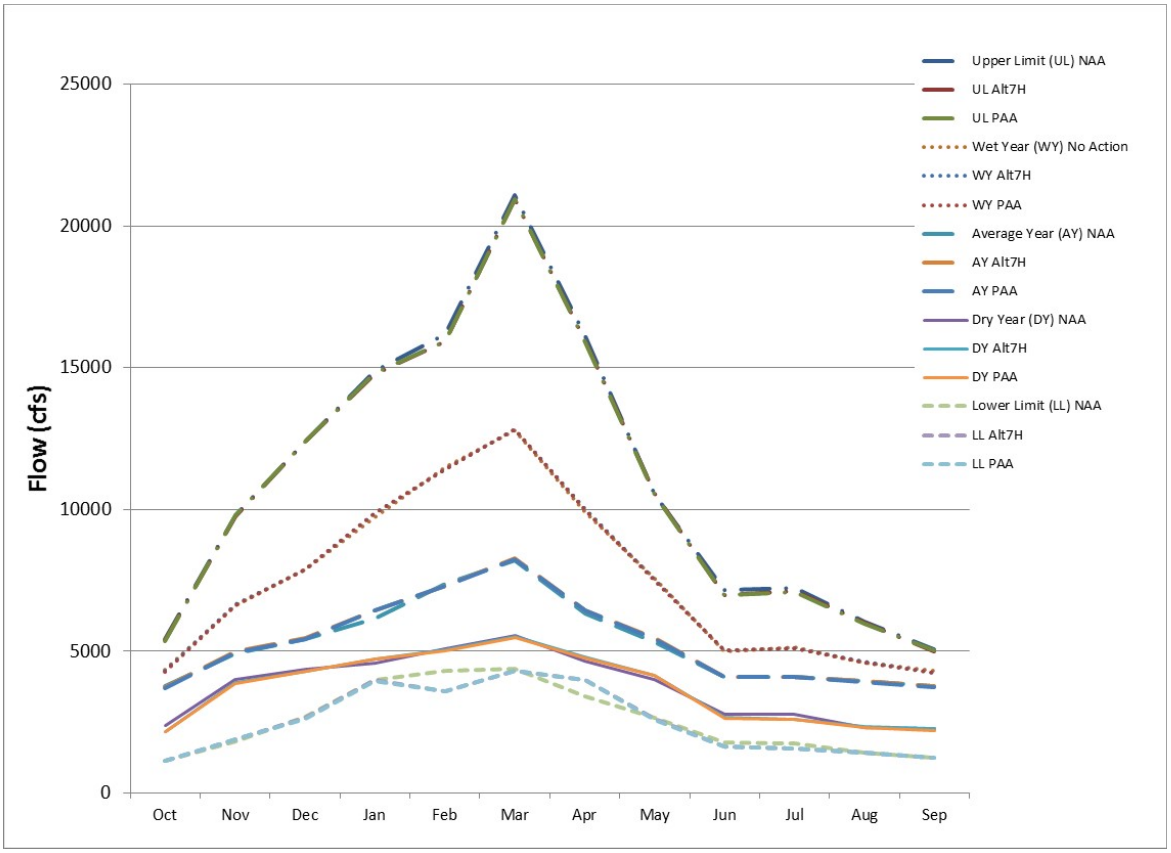


Figure 64. Columbus, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

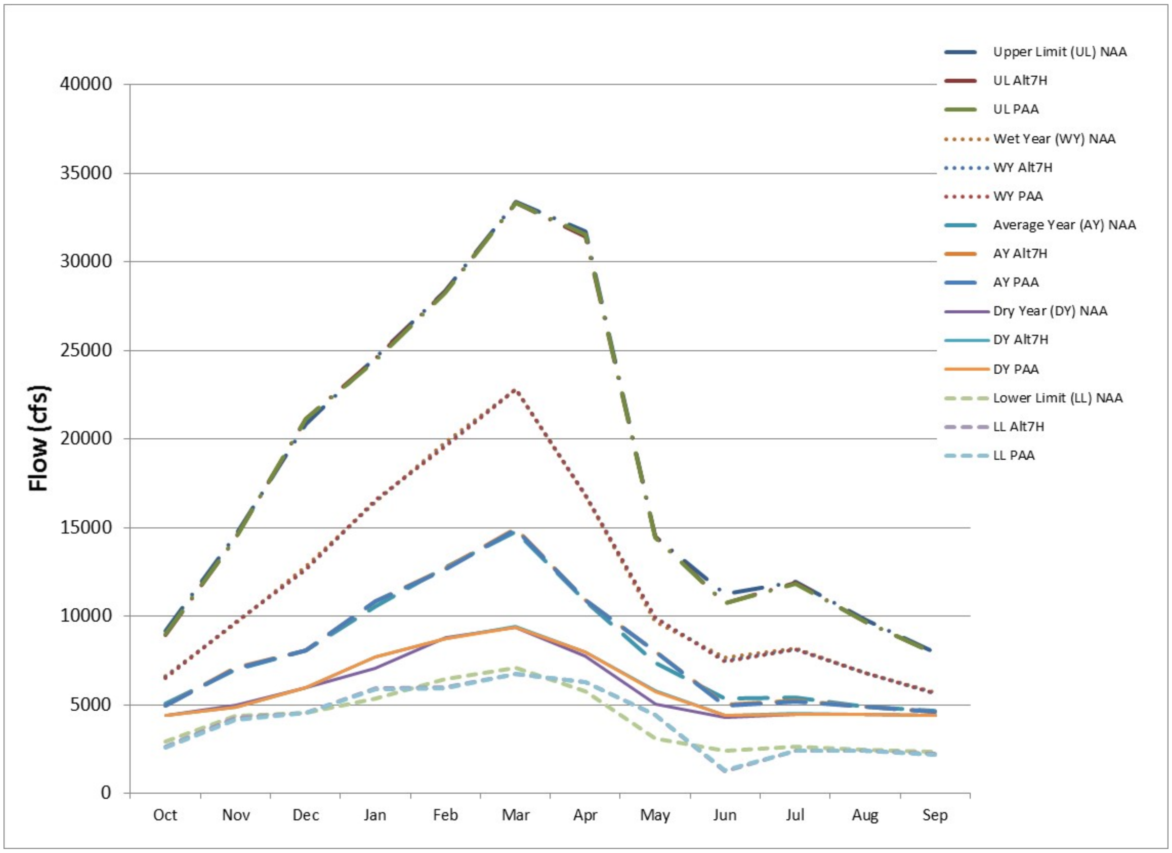


Figure 65. George Andrews Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

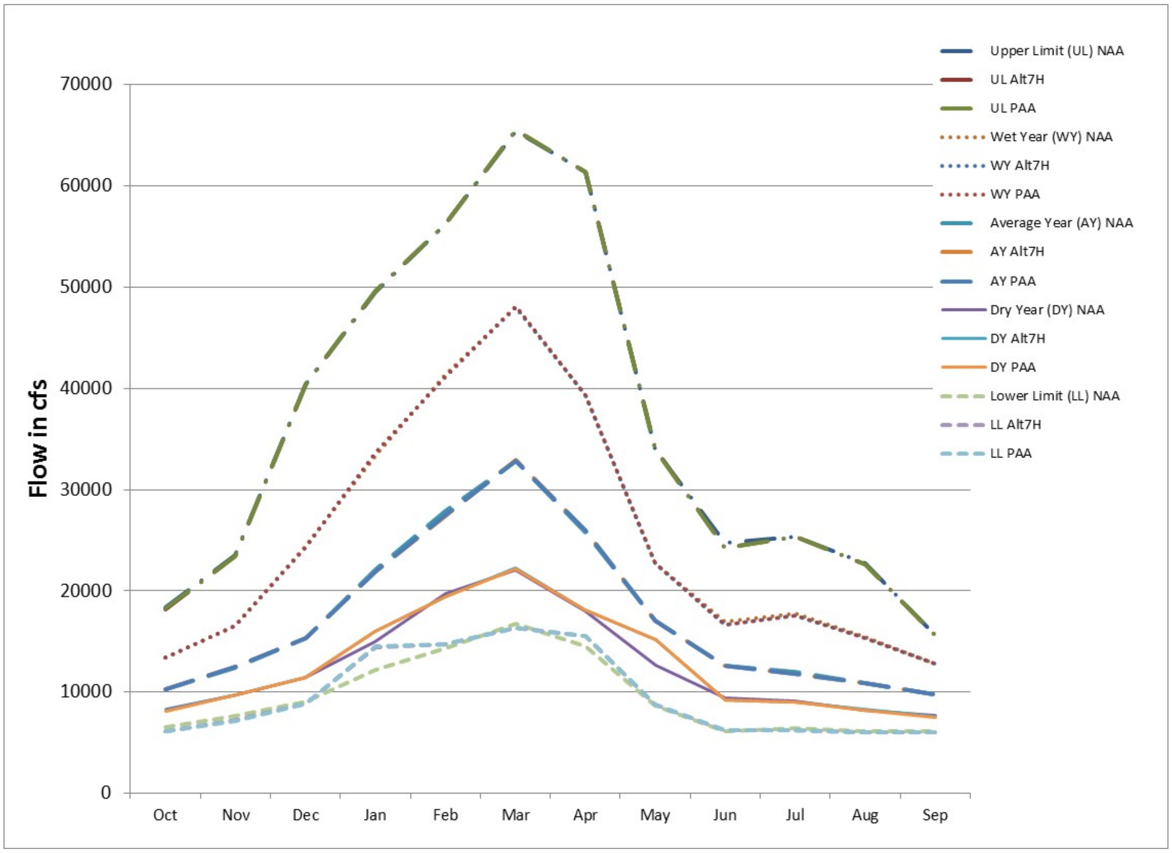


Figure 66. Chattahoochee, Florida monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

2.4.1 Chattahoochee River Shoal Bass Recruitment

As requested in the 2013 PAL, results from both the HEC-5Q and HEC-ResSim modeling efforts were used to evaluate the Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM). Shoal bass (*Micropterus cataratae*) are a fairly recently described species (Williams and Burgess, 1999) in the centrarchid (sunfish) family and is endemic to the ACF Basin. Shoal bass frequently occur in shoals (commonly co-occurring with other species) over rocky sediments in flows exceeding 0.66 ft per second. Recruitment of age-3 bass is of particular interest since this cohort has survived prevalent river conditions and has the potential to be stocked to support the recreational fishery. Recruitment success is largely dependent on surface water and spring temperature and is highly correlated with discharge.

The CRSBPM was evaluated in Atlanta, Georgia near river mile 410. The slightly higher median age-3 abundance from the PAA would be expected to be beneficial to shoal bass (Figure 67).

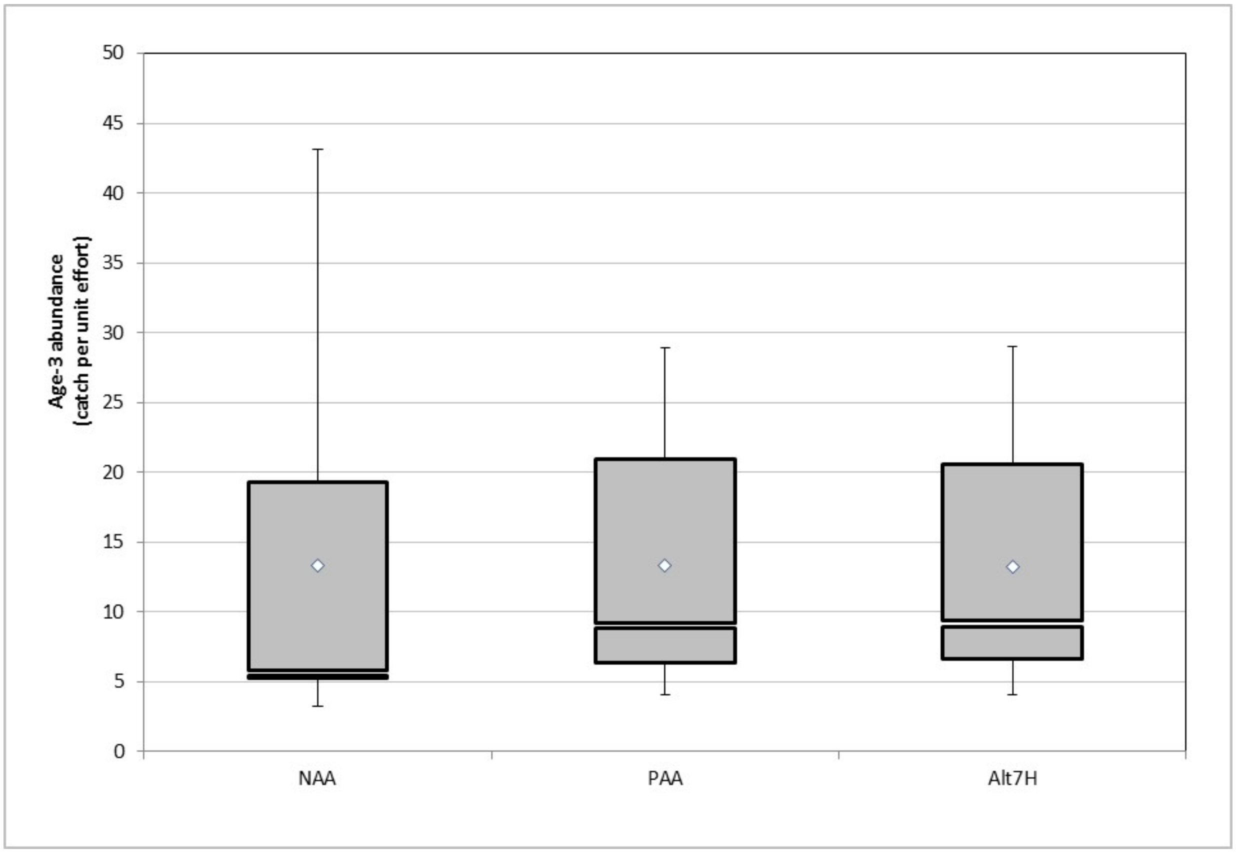


Figure 67. Shoal bass age-3 abundance at Atlanta, Georgia for the NAA and PAA (minimum; 25th, 50th, and 75th percentiles; maximum; and mean, where mean is represented by the diamond)

2.5 Apalachicola Bay Salinity Analyses

The Service contracted Dr. Peter Sheng to conducted salinity modeling of the Apalachicola Bay (Paramygin and Sheng, 2015). The preliminary results of salinity modeling provided by the Service to the USACE, indicated similar salinity levels in Apalachicola Bay between the NAA and the 2015 proposed action. It should be noted that the proposed action evaluated by Dr. Sheng is slightly different from the PAA presented here. However, the difference in the DEIS PAA (Alt7H) and the PAA (Alt7K) are limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than Alt7H. It is expected that salinity modeling results for the PAA would be similar to those presented in Paramygin and Sheng, 2015.

USACE reviewed the Service's model and concluded that, since there would be little change in the releases from Jim Woodruff Dam, little change in salinity in the Apalachicola Bay would be expected as a result of the PAA. Freshwater flows are also critical to the protection of the estuarine oyster fishery, which is sensitive to variations in salinity. The oyster fisheries in the estuarine portions of Apalachicola Bay experience impacts from drought and flooding as a result of both natural and unnatural flow variation. The PAA would present no anticipated change in the flows (wet, dry, or normal) to the estuary from the NAA, and therefore the PAA is not expected to change the current state of the oyster fishery.

Similarly, given the absence of appreciable changes in the flow dynamics from the NAA, additional impacts on other estuarine species and fisheries would not be expected.

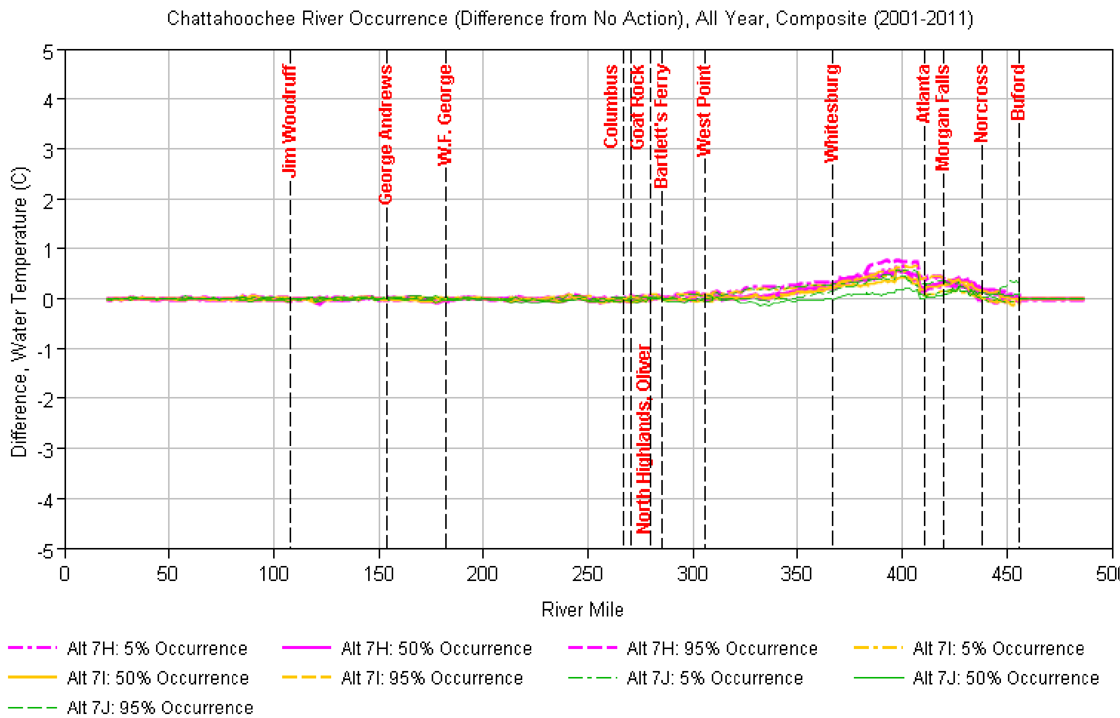
2.6 Federally-protected Species Analyses

As requested by the Service, the federally-protected species analysis is consistent with the evaluations completed for the 2012 RIOP.

2.6.1 Gulf Sturgeon Analysis

Applying the Sturgeon Spawning Habitat Performance Measure described in the 2013 PAL, USACE found that no effects on Gulf sturgeon would be expected as a result of implementing the PAA compared to the NAA. Gulf sturgeon spawning habitat was quantified at three locations known to support the species. The maximum amount of habitat available during inundation at 8.5 to 17.8 ft depths from March through May, as well as the amount of habitat available during which conditions range from 8.5 to 17.8 ft over a 30-day period to support the timing of three life stages (spawning, egg incubation, and early larval development) of Gulf sturgeon were evaluated. Collectively, these three stages have been estimated to occur over approximately 30 days in the ACF Basin (USFWS, 2008a; Pine et al., 2006). The effects of the alternatives were based on the change in median annual Gulf sturgeon spawning habitat from that available under the NAA, which is 18.17 acres. The median spawning habitat under the PAA and Alt7H, would be expected to be equal to the NAA at 18.17 acres.

This approach to evaluating Gulf sturgeon habitat was used in the 2015 PAL along with daily fall rates were evaluated for protection of mussels (section 2.6.2), maximum number of days per year with flows less than 10,000 cfs is discussed in section 2.6.2.3, and average water temperature between May and October. Figure 68 is provided consistent with the 2015 PAL response.



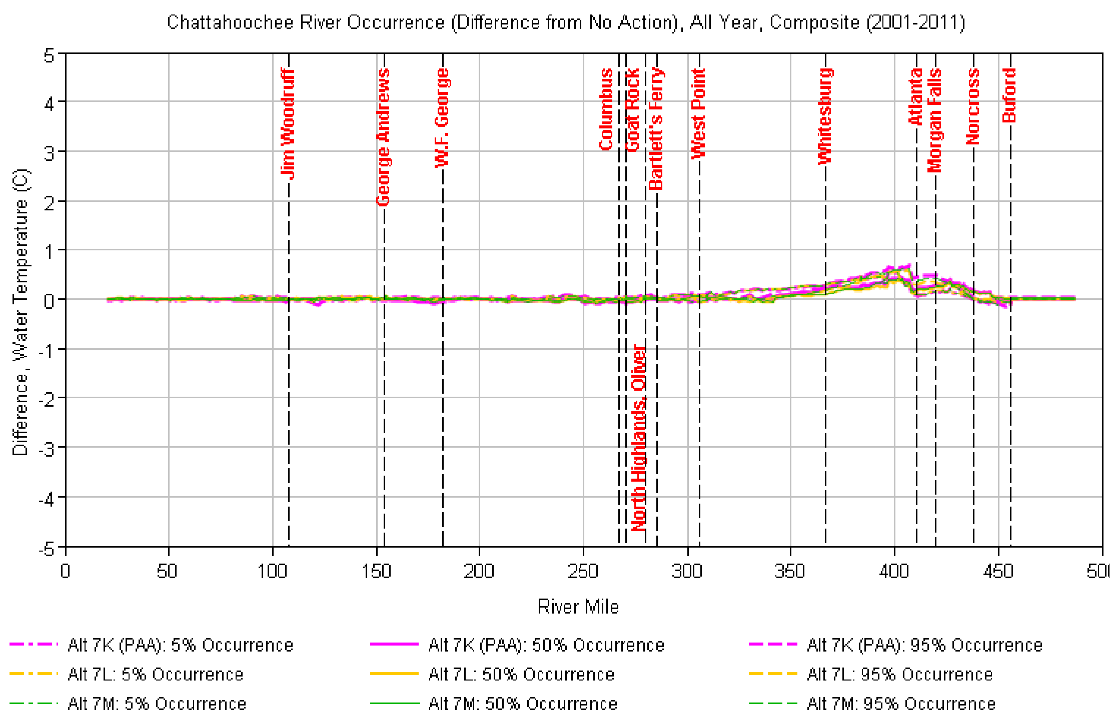


Figure 68. Change in water temperature for the modeled period 2001 through 2011

Additional analysis has been performed in updates to this Supplemental PAL based on comments on the DEIS (Figures 69 through 73). The FEIS defines effects of alternatives on Gulf sturgeon based on six specific metrics defined by the 2013 PAL:

1. The change in median annual Gulf sturgeon spawning habitat from that available under the NAA (18.17 acres), as described above
2. Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning
3. Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning
4. Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae
5. Maximum number of consecutive days per year less than 16,000 cfs
6. Departures from average water temperatures between March 1st to May 31st where changes less than 0.5 °C are acceptable

Young-of-the-year (YOY) Gulf sturgeon spend 6–10 months feeding in the river as they migrate downstream. They appear in the estuaries in December through February. Juveniles (< 6 years; except YOY) are believed to overwinter in the estuary, but telemetry studies and mark-recapture efforts are not available to confirm this. Juvenile Gulf sturgeon (304-890 mm FL) stay in the river for about the first two to three years and then move to the estuary where they forage until they reach sub-adult sized (891-1250 mm FL or three to four feet). Then they move to the barrier islands to forage, generally between December and March. It appears that juveniles, similar to adults, have a spatial distribution largely dictated by prey availability. As benthic feeders, areas within the river system that supports a prey base of benthic organisms is potential feeding grounds, and therefore considered critical habitat. Sulak and Clusston (1999) found that juvenile Gulf sturgeon are found primarily over bare sandy substrate, devoid of structural barriers such as submerged vegetation. Since little or no difference in flow conditions downstream of Jim Woodruff Lock and Dam would expected for any of the alternatives when compared to the NAA, no change in foraging habitat for Gulf sturgeon would be expected as well.

Overall, implementing the PAA (Alt7K), would be expected to have no effect on Gulf sturgeon. In addition to the median annual Gulf sturgeon spawning habitat available being the same as the NAA, the frequencies (percent of days and percent of years) of Gulf sturgeon spawning habitat on each day March 1st through May 31st, at the two sites that support spawning would be less than 2 percent difference between the PAA and the NAA. The maximum number of consecutive days on which flow would be less than 16,000 cfs would be 139, four additional days than the NAA. The departure from the average water temperature between March 1st to May 31st is less than 0.5 °C.

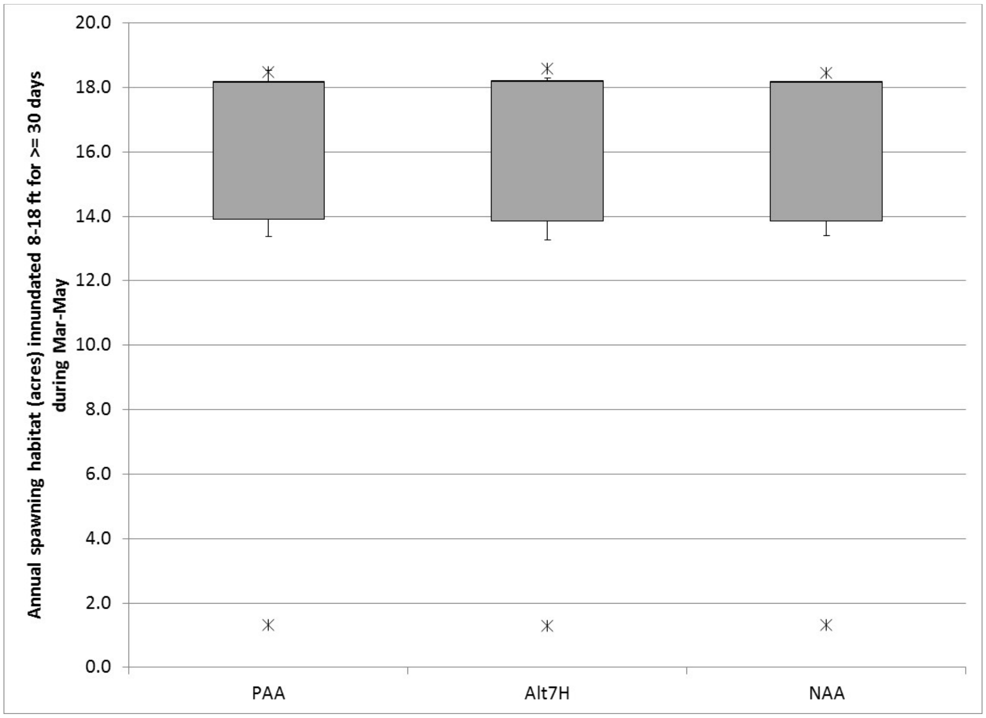


Figure 69. Change in Median annual Gulf Sturgeon spawning habitat over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and the PAA

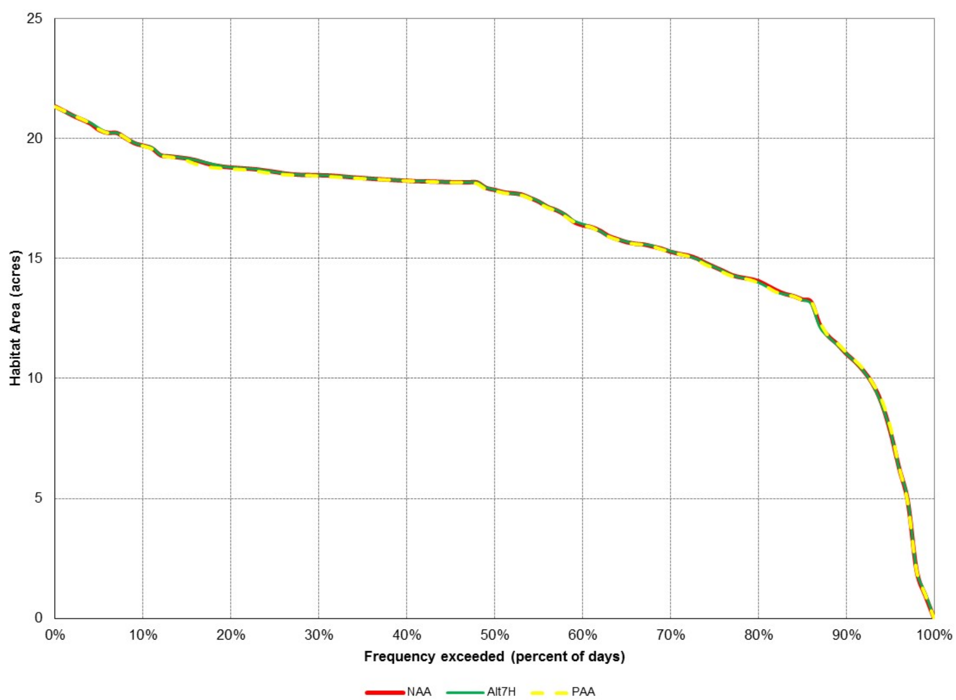


Figure 70. Frequency (percent of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and PAA

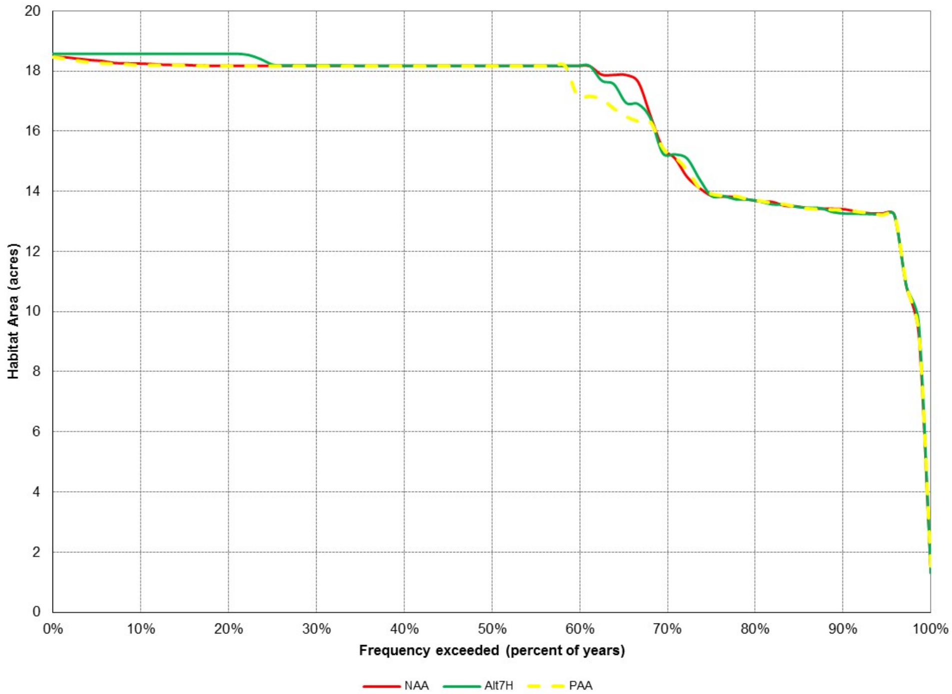


Figure 71. Frequency (percent of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and PAA

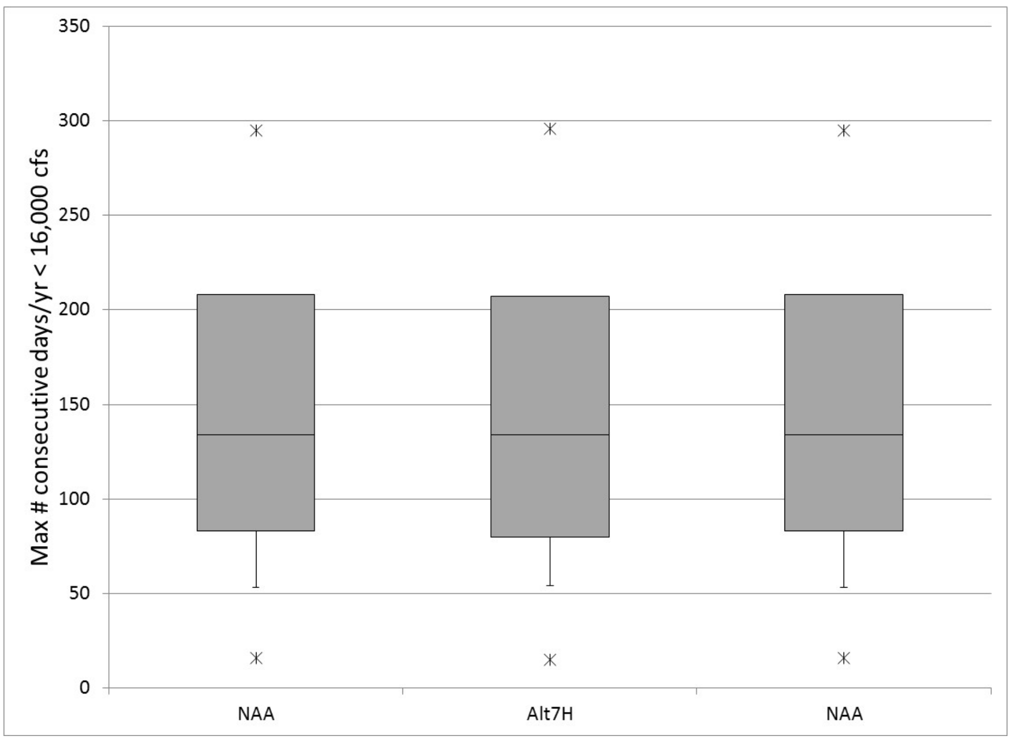


Figure 72. Maximum number of consecutive days per year less than 16,000 cfs over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and PAA

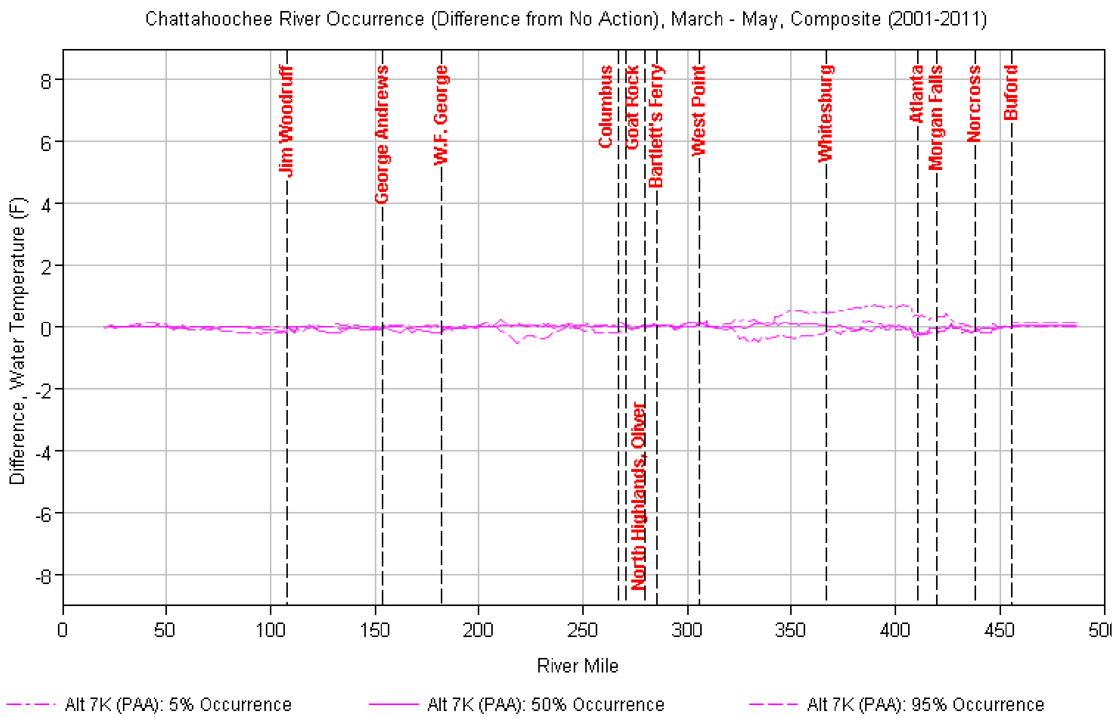


Figure 73. Departures from the NAA average water temperatures between March 1st to May 31st over the Modeled Period of Record (2001–2011) for the PAA

2.6.2 Freshwater Mussels Analysis

USACE applied several metrics developed by the Service (Apalachicola River Mussel Performance Measure) to evaluate the effects of the alternatives on mussel species in the Apalachicola River from exposure during low flow conditions. Interpretation of HEC-ResSim results provide the basis for the description of effects on mussels in the ACF Basin. River water levels (dependent on the discharge of Jim Woodruff Dam) largely dictate available habitat for Apalachicola River mussels.

The following subsections define the effects of alternatives on mussels based on specific metrics defined by the 2013 PAL:

1. Lowest daily flow for each year
2. Interannual frequency of flow rates less than 5,000 to 10,000 cfs
3. Maximum number of days flows per year are less than 5,000 – 10,000 cfs
4. Maximum number of consecutive days per year flows are less than 5,000 – 10,000 cfs
5. Median number of days flows per year are less than the thresholds of 5,000 and 10,000 cfs and median number of consecutive days per year flows are less than 5,000 to 10,000 cfs
6. Frequency (number of days) of daily stage changes (ft/day)
7. Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs
8. Median fall rate when flows are less than 10,000 cfs
9. Maximum fall rate when flows are less than 10,000 cfs

The results of the PAA on these metrics varies from slightly adverse to slightly beneficial. Therefore, overall, implementing the PAA would be expected to have negligible effect on mussels when compared with the NAA. The PAA would be expected to decrease flow rates greater than 5,000 cfs in 3 percent of years. An increase of one day would be expected for the median number of days per year with flows less than 10,000 cfs and an increase of 3 days would be expected for the median number of consecutive days per year with flow rates less than 10,000 cfs. The median and maximum fall rates remain the same for the PAA as the NAA. The lowest daily flow rate for each year over the modeled period, was less than 5,000 cfs in one year, 2007. The maximum number of days per year when the flow would be less than 10,000 cfs would increase by 2 days, compared to the NAA. The maximum consecutive days per year when the flow would be less than 10,000 cfs would decrease by 3 days for the PAA compared to the NAA. Additionally, the median and maximum fall rates remain the same for the PAA as the NAA. The number of days of daily stage changes between 0.25-2.00 ft/day would be 699, which is greater than a 5 percent increase from the NAA. Additionally, the percent of years of daily stage changes between 0.25-2.00 ft/day is greater than 10 percent, higher than the NAA.

2.6.2.1 Lowest Daily Flow Rate for Each Year

The lowest annual flows at Chattahoochee, Florida for the modeled period from 1939 through 2011 are presented in Table 11. The PAA would be expected to have minimum flows near 4,500 cfs in one year. During the same year the NAA would be expected to have minimum flows near 5,000 cfs, the minimum release under current operations.

Table 11.
Minimum modeled flow at Chattahoochee, Florida for each modeled year

Year	NAA	Alt7H	PAA (Alt7K)
1939	9444	9442	9443
1940	7288	6196	6263
1941	5010	5188	5189
1942	9619	9619	9619
1943	7835	7827	7828
1944	9163	9163	9162
1945	9035	9402	9368
1946	10401	10317	10309
1947	9887	9884	9887
1948	11906	11905	11905
1949	13453	13471	13463
1950	7766	7701	7690
1951	5353	5050	5050
1952	7182	7115	7036
1953	8852	8852	8852
1954	5406	5050	5050
1955	5009	5050	5050
1956	5338	5050	5050
1957	5622	5601	5583
1958	8258	8254	8255
1959	8456	8489	8493
1960	8806	8775	8764
1961	7873	7869	7870

Year	NAA	Alt7H	PAA (Alt7K)
1962	7419	7374	7391
1963	5678	5693	5669
1964	12695	12673	12674
1965	9406	9399	9409
1966	8453	8453	8453
1967	7550	7551	7531
1968	5634	5278	5238
1969	6067	5951	5948
1970	6996	6996	6996
1971	9823	9862	9834
1972	6797	6787	6789
1973	8531	8636	8636
1974	8505	8490	8451
1975	14254	14355	14324
1976	8157	8262	8169
1977	6344	6197	6167
1978	6918	6203	6203
1979	6694	6676	6652
1980	6449	6441	6444
1981	5020	5049	5049
1982	8368	8576	8353
1983	8324	8504	8504
1984	8292	8292	8292
1985	5858	6184	6159
1986	5049	5049	5049
1987	6277	6087	6081
1988	5050	5050	5050
1989	8242	6311	6317
1990	6017	5964	5971
1991	9001	9005	9004
1992	8374	7280	7299
1993	5610	5603	5838
1994	9027	10644	10635
1995	7120	7007	6972
1996	7637	7645	7642
1997	6027	5781	5810
1998	8296	7748	7717
1999	5050	5050	5050
2000	5050	5050	5050
2001	5288	5300	5301
2002	5050	5050	5050

Year	NAA	Alt7H	PAA (Alt7K)
2003	8907	8977	8975
2004	7006	5844	5457
2005	9131	9123	9124
2006	5050	5050	5050
2007	5050	4550	4550
2008	5050	5050	5050
2009	7306	7463	7451
2010	5723	5702	5712
2011	5050	5050	5050

2.6.2.2 Inter-annual Frequency of Flows less than 5,000–10,000 cfs

Mussels are susceptible to stranding at flows ranging from 5,000 to 10,000 cfs, particularly following high-flow events (> 100,000 cfs) that serve to move individuals into depositional areas (USFWS, 2008a). Inter-annual flows, expressed as the frequency of occurrence of the percent of years, were evaluated to address the potential for stranding (Figure 74).

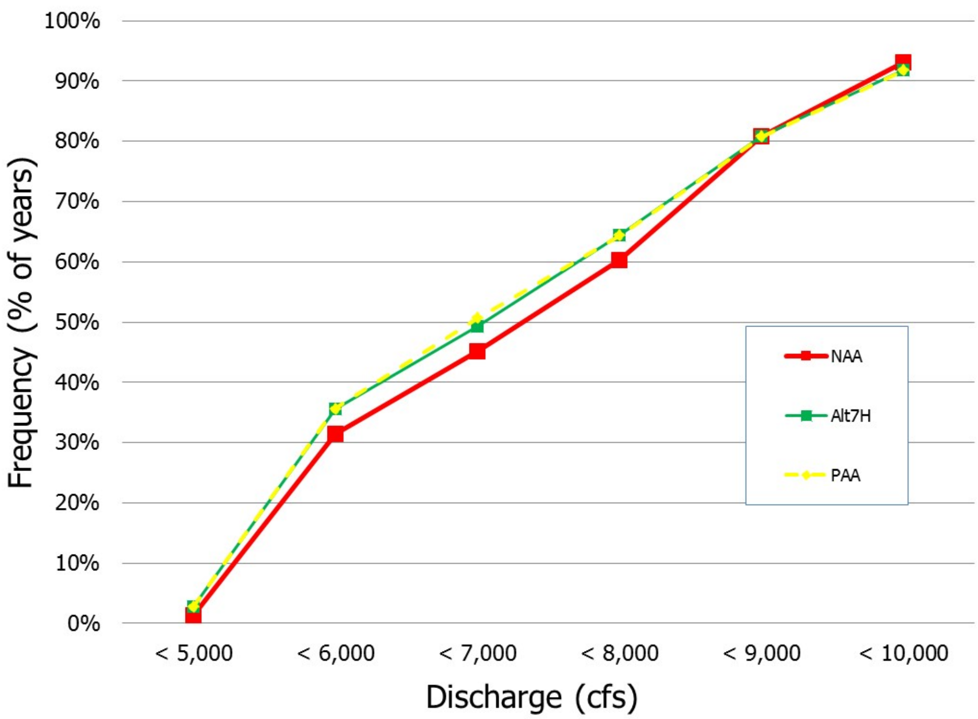


Figure 74. Inter-annual frequency of flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs based on 1939 – 2011 (*Figure 4.2.5.A.* from the 2008 Biological Opinion [BO] and *Figure 4.2.3.A.* from the 2012 BO)

2.6.2.3 Maximum Number of Days per Year Flows less than 5,000–10,000 cfs

The maximum number of days per year with flows less than 5,000–10,000 cfs provides an estimation of the most severe conditions aquatic biota will experience under the proposed flow regimes (Figure 75).

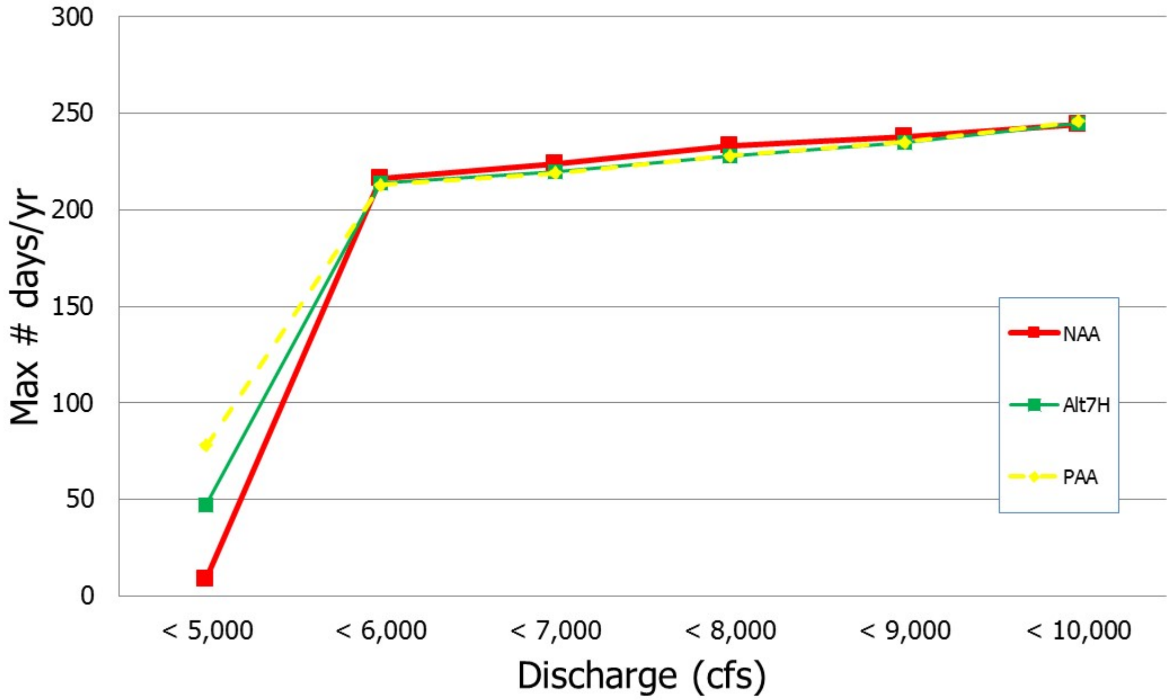


Figure 75. Maximum number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.B.* from the 2008 BO and *Figure 4.2.3.B.* from the 2012 BO*)*

2.6.2.4 Maximum Number of Consecutive Days less than 5,000 - 10,000 cfs

Mussels can survive brief periods of stranding by closing their shells or burrowing in substrate. Thus, without extreme water temperatures, mussel survival from stranding is most likely a function of exposure duration (USFWS, 2008a). To address that, the maximum number of consecutive days of flows between 5,000 and 10,000 cfs was evaluated. Figure 76 shows the maximum number of consecutive days of flows at less than 5,000–10,000 cfs.

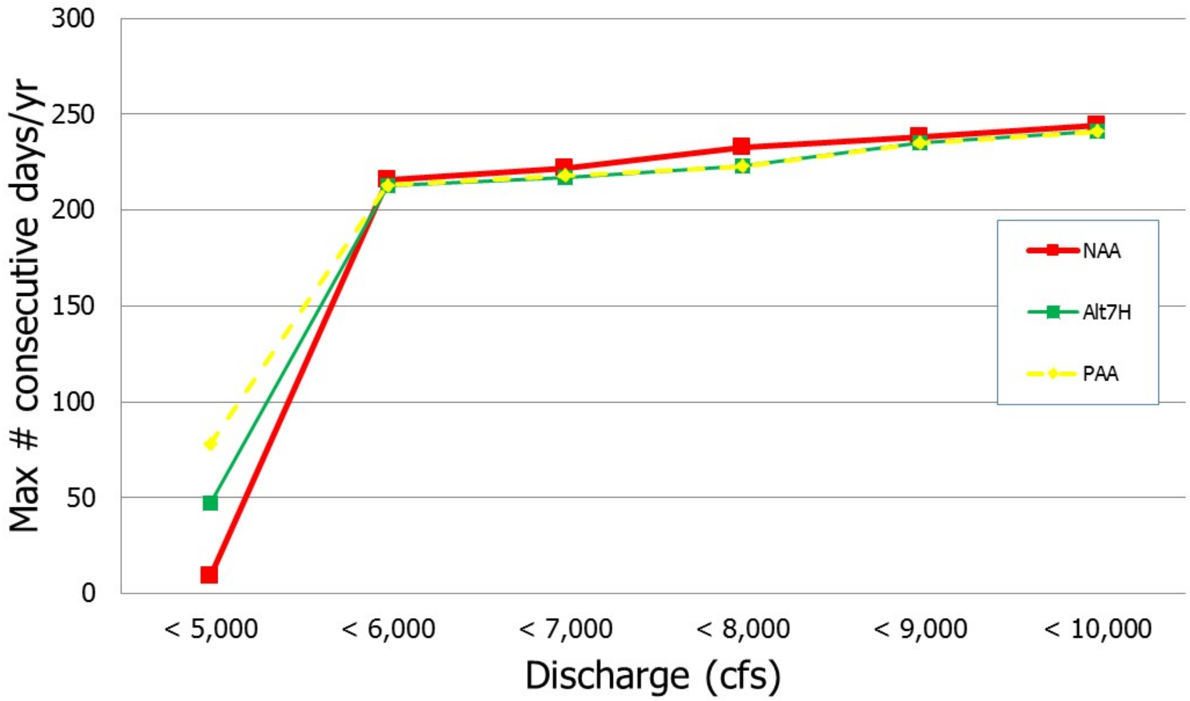


Figure 76. Maximum number of consecutive days with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.C.* from the 2008 BO and *Figure 4.2.3.C.* from the 2012 BO*)*

2.6.2.5 Median Number of Days per Year Flows less than 5,000–10,000 cfs

The duration of moderate low-flow periods are also an important consideration for the survival of mussels and other aquatic biota. Chronic low-flow events occur with greater frequency than extreme events and, despite the less severe conditions, serve to decrease habitat availability, increase physiological stress, and increase both exposure-related and predatory mortality. Median flows below 7,000 cfs would not be expected in the NAA and would only occur once in the PAA (Figure 77). The median number of consecutive days per year was also evaluated (Figure 78).

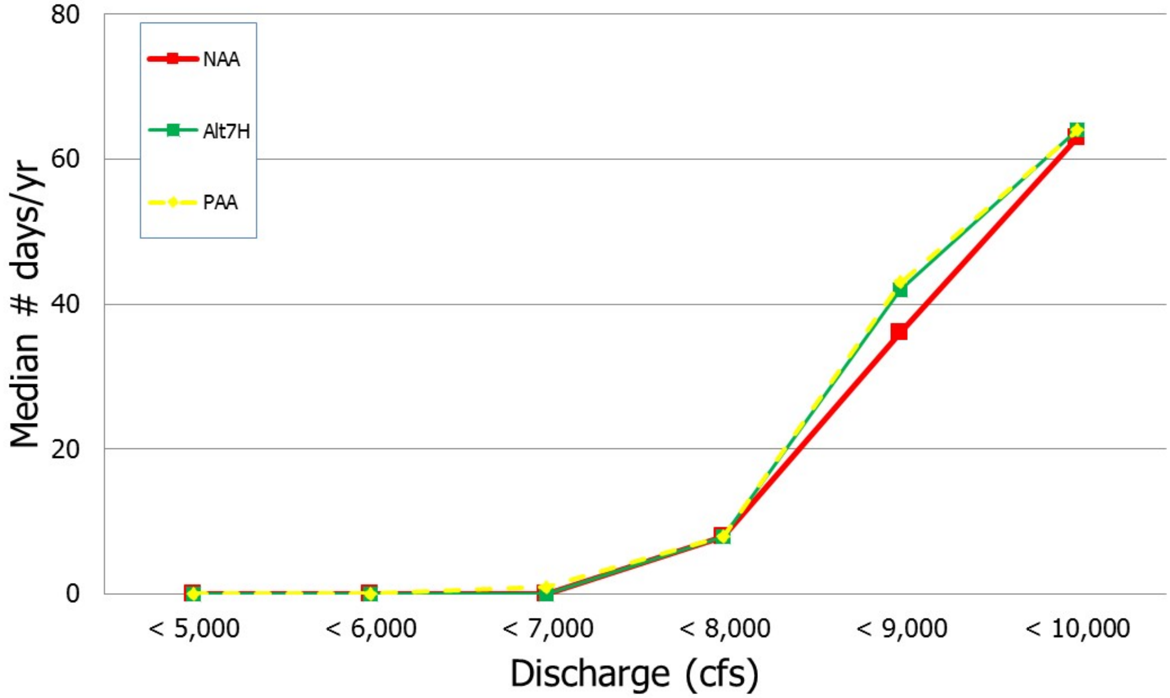


Figure 77. Median number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.D.* from the 2008 BO and *Figure 4.2.3.D.* from the 2012 BO*)*

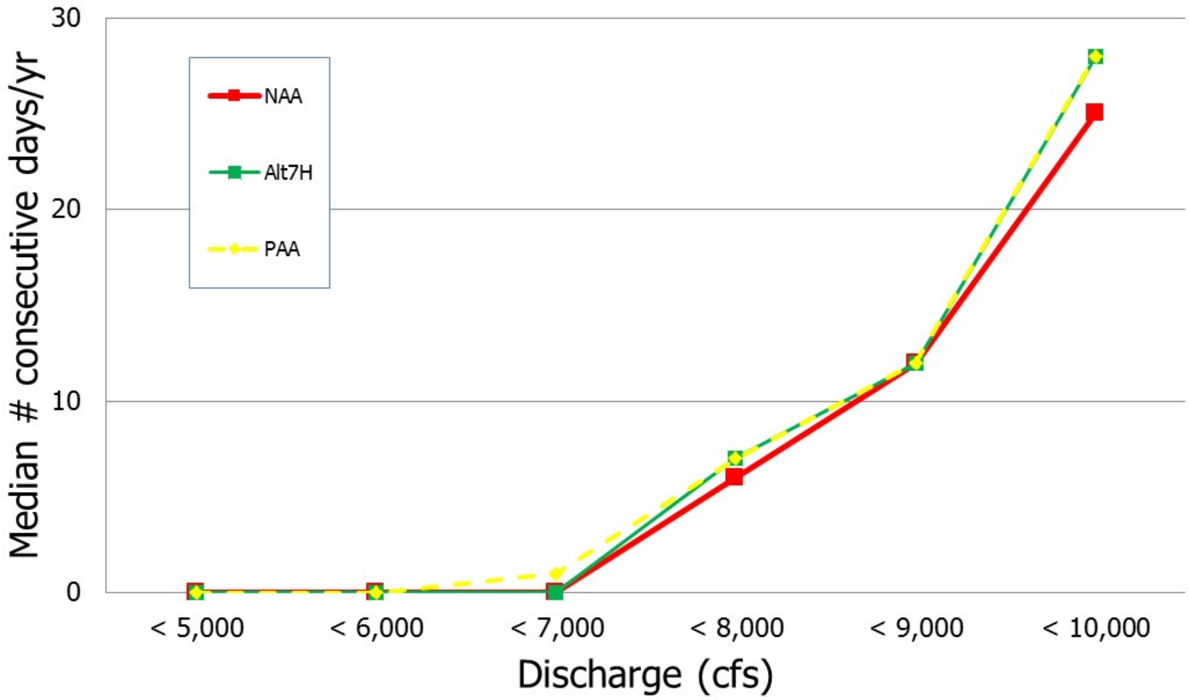


Figure 78. Median number of consecutive days per year with flows between 5,000-6,000; 6,000-7000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.3.E.* from the 2012 BO [Figure was not included in the 2008 BO])

2.6.2.6 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day

The 2012 RIOP maximum fall rate schedule was established to avoid extreme declines in daily river stage levels and decrease the risk of exposure or stranding of aquatic biota. Declining river stages are moderated by operating schedules to provide an attenuation of flows that allow for more gradual fall rates as flows decline. Those rates are not presented but results presented in previous sections, for releases from Woodruff Dam less than 10,000 cfs, would be expected to sufficiently illustrate differences between the NAA and PAA since the listed mussels generally do not occur at stages higher than those equivalent to 10,000 cfs.

2.6.2.7 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day when Releases at Woodruff Dam are less than 10,000 cfs

A fall rate analysis was performed to evaluate whether an increase in the percentage of days with rates greater than 0.25 ft/day would affect federally listed mussel species. The evaluation is restricted to periods when releases from Jim Woodruff Dam are less than 10,000 cfs. The results are illustrated in Figure 79.

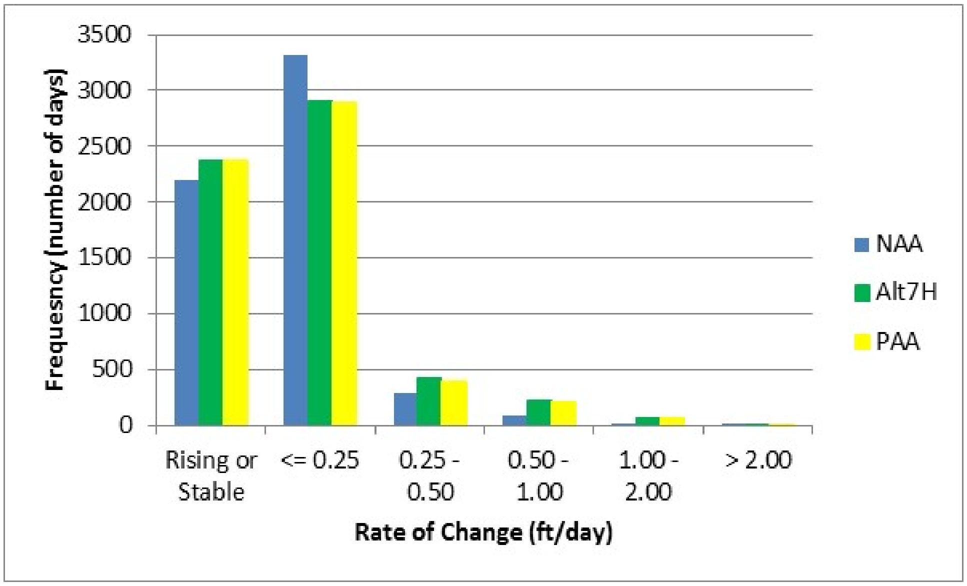


Figure 79. Frequency (number of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs from 1939-2011. (*Figure 4.2.5.F.* from the 2008 BO and *Figure 4.2.3.G.* from the 2012 BO*)*

2.7 Additional Analysis - Fish and Wildlife Management Facilities

2.7.1 Eufaula National Wildlife Refuge

The potential impacts on Eufaula National Wildlife Refuge (ENWR) are primarily related to reservoir level fluctuations at W.F. George Lake, influencing the refuge in three critical areas (USFWS, 2008b): (1) direct effects on habitat availability for wildlife; (2) effects on vegetation communities, particularly with respect to invasive species; and (3) the availability of water during October and November to off-reservoir impoundments that support waterfowl habitat management.

The USACE considered the Service's request to cycle Walter F. George Lake between the highest levels (190 ft) in late winter/early spring to the lowest levels (185 ft) in late summer to accommodate ENWR operations (Figure 80). As proposed, the option would require operation of the reservoir at its highest pool levels during winter-spring, when flood releases are typically the greatest. That would reduce the ability of the project to attenuate approximately 87,000 ac-ft of potential downstream flooding. By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased, resulting in bank erosion and channel modifications below the project. Similarly, to operate the project at its lowest levels during the summer is contrary to what is required to meet the highest demands for recreation, hydroelectric power, and flow augmentation. Essentially, such an option would remove Walter F. George Lock and Dam from the system approach to operations across the basin and eliminate approximately 100,000 ac-ft of conservation storage that could be used to meet authorized project purposes in the summer. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant adverse effects on the authorized project purposes and the structural stability and safety of the dam. For these reasons, operations to manage Walter F. George Lake to benefit the Eufaula Wildlife Refuge operations were not considered further.

The differences between the median daily water surface elevations at Walter F. George Lake are negligible between the NAA and PAA (Figure 81).

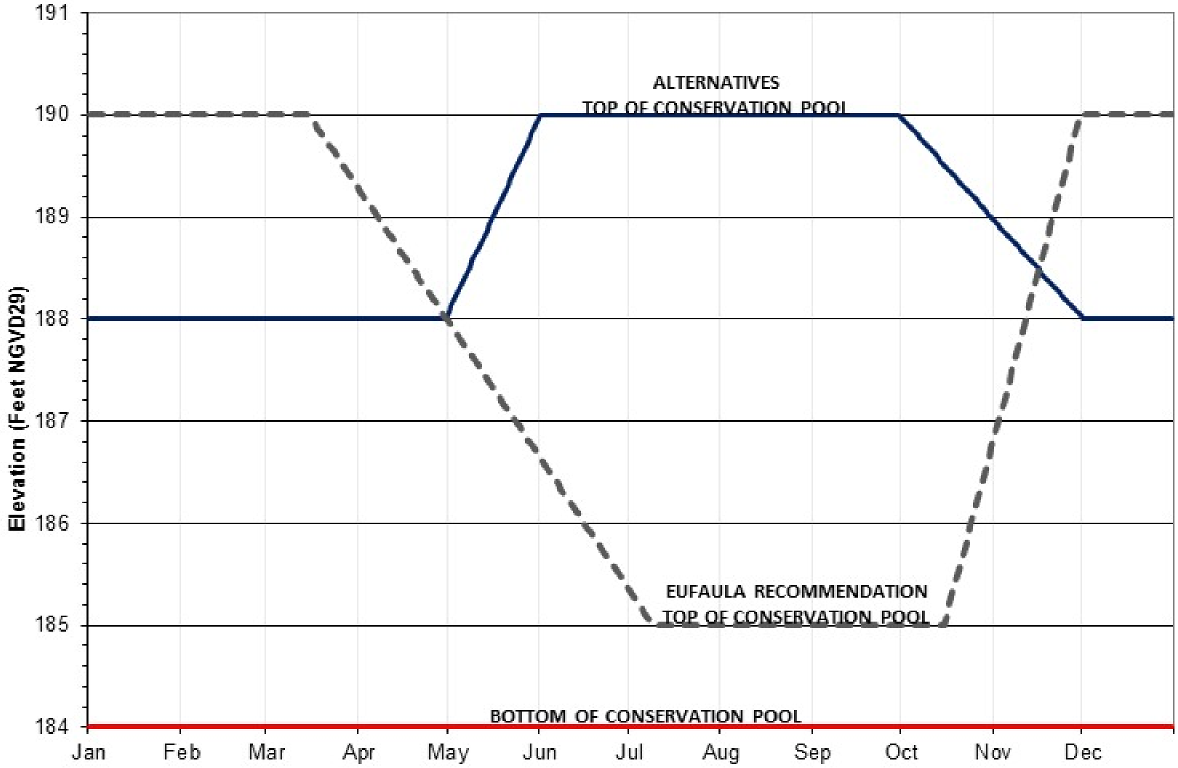


Figure 80. Eufaula National Wildlife Refuge recommended water surface elevation compared with the NAA and PAA top of conservation pool elevation.

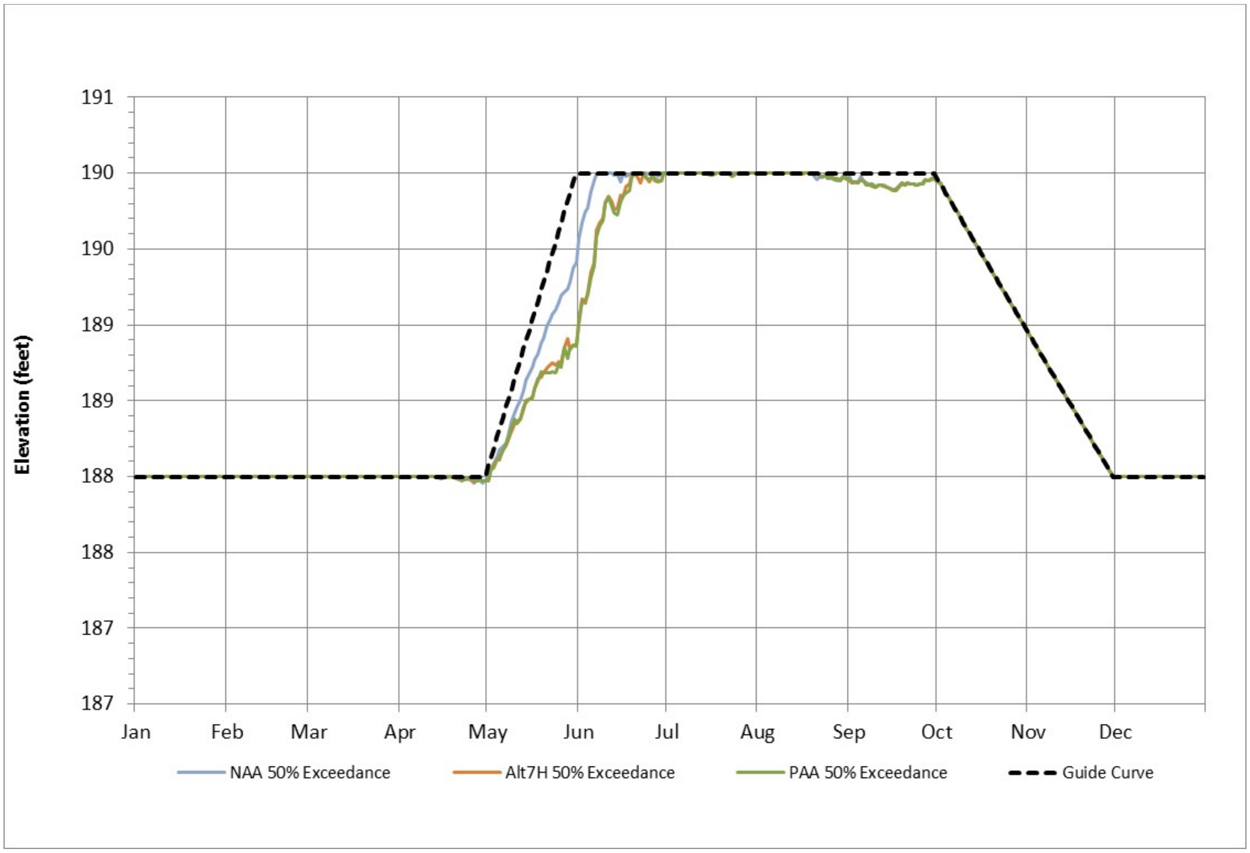


Figure 81. Walter F. George Lake, median daily water surface elevation over the modeled period of record (1939-2011) for the NAA and PAA

2.7.2 Fish hatcheries

Four major fish hatcheries are in the ACF Basin. Buford Trout Hatchery is the only fish hatchery in the ACF Basin that relies on surface flows for its operations, and it is the largest user of water. Changes in flow on the Chattahoochee River are negligible between alternatives, and would not be expected to affect operations at the Buford Trout Hatchery (Figure 82).

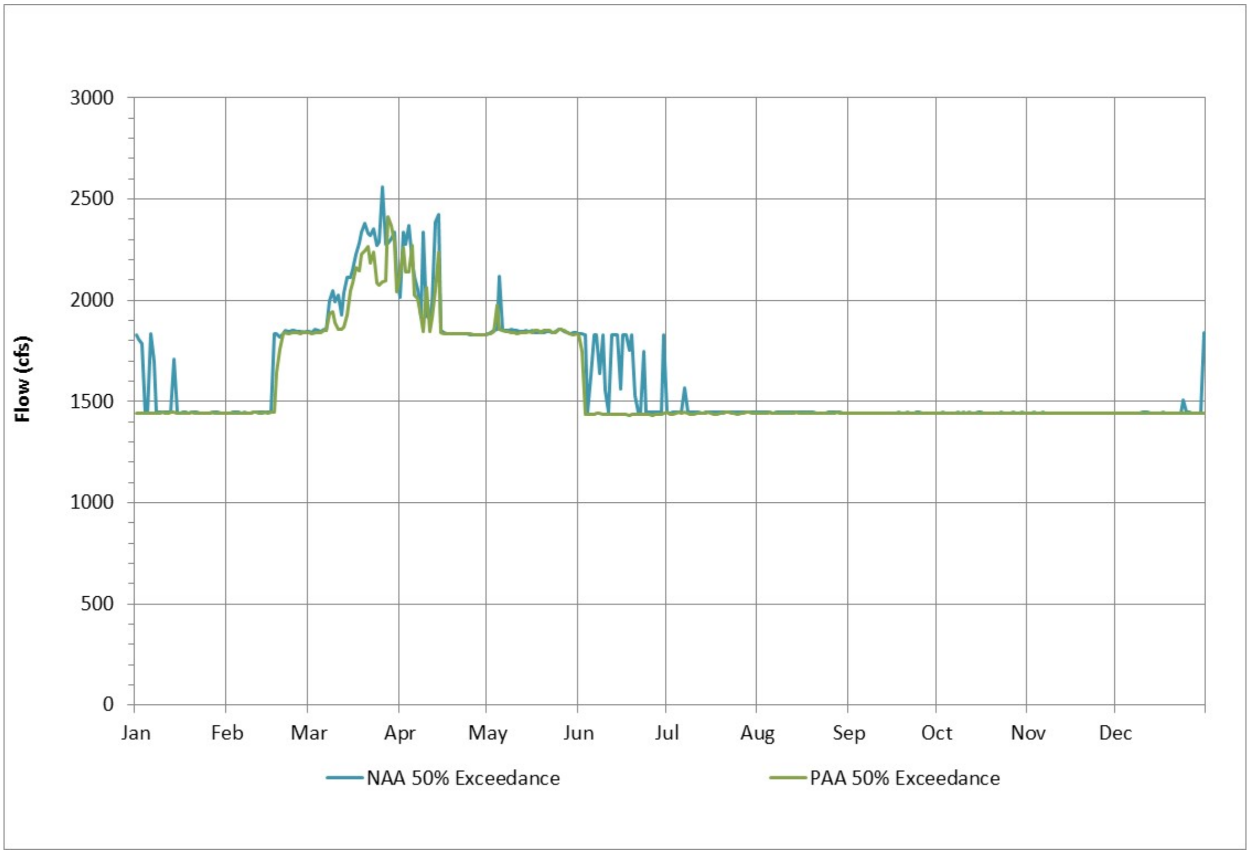


Figure 82. Chattahoochee River—median daily flows below Buford Dam, Georgia (RM 348.1) for the NAA and PAA

3 References

Paramygin, V.A. and Sheng, Y.P. 2015. A Preliminary Report: Simulating the response of estuarine salinity in Apalachicola Bay. Prepared for U.S. Fish and Wildlife Service. Prepared by Engineering School of Sustainable Infrastructure and Environment, University of Florida.

Patton, T., & Lyday, C. (2008). Ecological succession and fragmentation in a reservoir: Effects of sedimentation on habitats and fish communities. *American Fisheries Society Symposium, 62*, 147–167.

Pine, W.E., H.J. Flowers, K.G. Johnson, and M.L. Jones. 2006. *An Assessment of Gulf Sturgeon Movement, Spawning Site Selection, and Post-Spawn Holding Areas in the Apalachicola River, Florida*. Final report submitted to the Florida Fish and Wildlife Conservation Commission. University of Florida, Gainesville.

Ryder, S., J. Taylor, and J.H. Crance. 1995. *Relations between Reservoir Surface Water Elevations and Reservoir Fisheries*. Comprehensive Study ACT/ACF River Basins. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

Sulak, K. J. and J. P. Clugston. 1999. *Recent advances in life history of Gulf of Mexico sturgeon, Acipenser oxyrinchus desotoi, in the Suwannee river, Florida, USA: a synopsis.* Journal of Applied Ichthyology. 15:116-128.

USFWS (U.S. Fish and Wildlife Service). 2008a. *Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River*. U.S. Fish and Wildlife Service, Panama City, FL.

USFWS (U.S. Fish and Wildlife Service). 2008b. *Draft Comprehensive Conservation Plan and Environmental Assessment for Eufaula National Wildlife Refuge, Barbour and Russell Counties, AL, and Stewart and Quitman Counties, GA.* U.S. Fish and Wildlife Service, Southeast Regional Office, Atlanta, GA.

USACE (U.S. Army Corps of Engineers). 2012, August 7. Chief of Engineers memorandum regarding reissuance of the U.S. Army Corps of Engineers Environmental Operating Principles. Accessed October 2014. http://www.usace.army.mil/Portals/2/docs/Environmental/EAB/eop_coe_reissuedeop_07aug2012.pdf.

USACE (U.S. Army Corps of Engineers). 1989. *Apalachicola-Chattahoochee-Flint Basin, Water Control Plan*. Draft. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

USACE (U.S. Army Corps of Engineers). 2015a. *ACF Water Control Manual Update Response to Planning Aid Letter*. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

USACE (U.S. Army Corps of Engineers). 2015b. *Draft Environmental Impact Statement Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment*. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

Williams, J.D., and G.H. Burgess. 1999. A new species of bass, *Micropterus cataractae* (Teleostei: Centrarchidae), from the Apalachicola River Basin in Alabama, Florida and Georgia. *Bulletin of the Florida Museum of Natural History* 42(2):80–114.

Final Fish and Wildlife Coordination Act Report September 2016

This page intentionally left blank

Final Fish and Wildlife Coordination Act Report

On

Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

Georgia Ecological Services
Athens, Georgia

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia
September 2016

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4980 Wildlife Dr.
Townsend, Georgia 31331

September 14, 2016

Colonel James A. DeLapp
Commander and District Engineer
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel DeLapp:

We are providing your agency with the final Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida in fulfillment of Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 et seq.). The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from U.S. Army Corps of Engineers (Corps) reservoirs. We submit the following comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 et seq.), the Migratory Bird Treaty Act (MBTA) (49 Stat. 755, as amended; 16 U.S.C. § 702 et seq.), and the FWCA. Our revised FWCAR is an update of that submitted July 31st, 2015, and considers comments that were submitted during the EIS process, as well as project level changes that led to the development of the proposed action alternative (PAA) in comparison to the no action alternative (NAA). As you're aware, a separate consultation is ongoing regarding the potential impacts of the Corps' proposal on federally-listed threatened and endangered fish and wildlife species protected under the ESA.

In 2015, a draft version of the DFWCAR was distributed to the National Oceanic and Atmospheric Administration (NOAA), Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), and Florida Fish and Wildlife Conservation Commission (FFWCC). The Service subsequently received comments from FFWCC, ADCNR, NOAA, and GDNR-WRD. Since the Service received comments on the DFWCAR, and based on new information received from the Corps, the Service has recently developed an additional Appendix to the DFWCAR

(Appendix XV) that has not yet been reviewed by the State wildlife agencies and NOAA. If these agencies have comments on Appendix XV, which pertains to the Corps' alternatives selection process, we respectfully ask that they supply their comment letters regarding Appendix XV directly to the Corps and copy the Service on their correspondence.

The problems with the methodology that the Corps used to select alternatives, detailed in Appendix XV, are considered to be significant by the Service. When several corrections were made by the Service, the ranking of alternatives changed. Regardless, the Service provides this DFWCAR in the event the Corps proceeds with the alternative that they have selected.

The DFWCAR outlines the fish and wildlife concerns and planning objectives that were provided in our April 2, 2010, Planning Aid Letter (PAL), March 1, 2011, PAL addendum, July 19, 2013, submission of the United States Fish and Wildlife Service's (Service) revised alternative, and August 29, 2013, PAL to you, along with our understanding of the Corps' responses to our concerns and objectives.

Following the draft EIS process, and after consideration of all comments, the Corps has revised the Proposed Action Alternative. Further, a revised Water Supply Storage request by the State of Georgia, several modifications were made to the proposed action to be evaluated in the Final Environmental Impact Statement (FEIS).

1. The FEIS proposed action alternative analysis does not assume that Bear Creek Reservoir and Glades Creek Reservoir are constructed. The DEIS assumed they were constructed. Both of these permit applications have been withdrawn or suspended.

2. The FEIS proposed action alternative assumes a gross withdrawal of 242 MGD from Lake Lanier directly and 379 MGD downstream. The DEIS proposed action alternative assumes a gross withdrawal of 185 MGD from Lake Lanier directly and 408 MGD downstream.

3. The FEIS proposed action alternative analysis utilized the latest version of HEC-ResSim (the DEIS proposed action alternative used the previous HEC-ResSim version).

4. The FEIS proposed action alternative analysis used an updated Area Capacity Curve for Lake Lanier.

5. The FEIS analysis includes updates to the HEC-5Q based on comments received on the DEIS proposed action alternative.

Subsequently, the Corps provided supplemental material (July 2016) to the Service to further evaluate the revised action alternatives (NAA, PAA). This information was shared with the state agencies (ADCNR, GDNR, FFWCC) and NOAA/NMFS. Additional comments were received from GDNR and FFWCC and then incorporated into the revised FWCAR.

Enclosed is the revised FWCAR describes the alternatives and evaluates the anticipated impacts of the selected plan. As was the case with our draft FWCAR (July 2015), the Service does not fully support the Corps' proposed alternative. However, our report provides the Corps with fish and wildlife conservation measures, recommendations, and methodologies that would address our concerns.

We urge the Corps, in cooperation with the Service and the State wildlife agencies, consider additional alternatives for analysis and analyses of potential impacts that would address our concerns about water quality in project tailraces, alterations of flow regimes that adversely affect fish and wildlife, etc., and that could lead to formulation of an environmentally preferable alternative in the Corps' decision-making process for the operations of the ACF Corps' reservoirs.

The Service recognizes the Corps' desire to complete this study in a timely manner but believes that a more informed alternative selection methodology and impact analysis should be utilized. The Service is willing to work with the Corps to expeditiously identify and implement such recommendations. If you have any questions, please contact Georgia Ecological Services supervisor Donald W. Imm, PhD. at (706) 613-9493, Panama City Ecological Services supervisor Catherine Phillips, PhD. at (850) 769-0552, or Southeast Regional Office staff biologist David Walther at (337) 291-3122.

Sincerely,

Donald Imm, PhD.
Field Supervisor

cc: C. Phillips, USFWS, Panama City, FL
D. Walther, USFWS, Lafayette, LA
B. Pearson, USFWS, Daphne, AL
B. Zettle, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
T. Litts, GDNR-WRD, Social Circle, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
N. Kajumba, EPA, Atlanta, GA
B. Cox, NPS, Atlanta, GA
P. Wilber, NOAA, Charleston, SC

EXECUTIVE SUMMARY

The United States Army Corps of Engineers (Corps) proposes to prepare an updated Master Manual for the Apalachicola-Chattahoochee-Flint (ACF) Basin. The purpose of the Water Control Manual (WCM) updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. This Fish and Wildlife Coordination Act Report (FWCAR) outlines the United States Fish and Wildlife Service (Service)'s fish and wildlife concerns and planning objectives, describes the alternatives, and evaluates the anticipated project impacts of the selected plan. The attached document is a revision to the draft FWCAR (DFWAR) that was signed July 2015.

Following the draft EIS process, and after consideration of all comments, the Corps has revised the Proposed Action Alternative. Further, a revised Water Supply Storage request was submitted by the State of Georgia, resulting modifications that were made to the proposed action, these were evaluated in the Final Environmental Impact Statement (FEIS). Based on information provided by the Corps, these modifications include;

1. The FEIS proposed action alternative analysis does not assume that Bear Creek Reservoir and Glades Creek Reservoir are constructed. The DEIS assumed they were constructed. Both of these permit applications have been withdrawn or suspended.

2. The FEIS proposed action alternative assumes a gross withdrawal of 242 MGD from Lake Lanier directly and 379 MGD downstream. The DEIS proposed action alternative assumes a gross withdrawal of 185 MGD from Lake Lanier directly and 408 MGD downstream.

3. The FEIS proposed action alternative analysis utilized the latest version of HEC-ResSim (the DEIS proposed action alternative used the previous HEC-ResSim version).

4. The FEIS proposed action alternative analysis used an updated Area Capacity Curve for Lake Lanier.

5. The FEIS analysis includes updates to the HEC-5Q based on comments received on the DEIS proposed action alternative.

The Corps' proposed action alternative (PAA) would modify the action zones for Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir. The Corps states in general, the action zones would be revised upward in the winter months at Lanier Reservoir and at West Point Reservoir and downward in the summer months at Walter F. George Reservoir.

The proposed drought plan would be similar to the No Action Alternative (NAA), except drought operations would be "triggered" when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3 in the PAA. Under the NAA, drought operations are currently "triggered" when composite conservation storage falls below the bottom of Zone 3 into Zone 4.

The PAA proposes no changes to the NAA flood risk management operations. Under the PAA, the hours of hydropower generation would continue to vary by action zone, but a greater range of hourly production would be incorporated for operational flexibility in all action zones except for Zone 4 at West Point Reservoir and Walter F. George Reservoir.

Under the PAA, the Corps would provide a reliable navigation season if hydrologic conditions allow, typically extending from January through April or May. Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The Corps' determination to extend the navigation season beyond April would depend on inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. Down ramping of flow releases would adhere to the Jim Woodruff fall rate schedule for federally-listed species, regardless of period in the navigation season. Augmenting flow releases to provide a 7-foot navigation channel would be dependent on channel conditions that ensure safe navigation. In addition, special releases may occur for a short duration to assist navigation during the navigation season.

Under the PAA, there would be no changes to the NAA for fish spawn, fish passage, or recreation operations. Releases for federally-listed species below Jim Woodruff would be modified in that the ramping rate would be suspended during prolonged low flow. The ramping rate would be suspended when basin inflow is less than 7,000 cubic feet per second (cfs) for 30 days and would be resumed when basin inflow is greater than 10,000 cfs for 30 days.

The PAA would include releases from Buford Dam, when considered in combination with contribution of local drainage between the dam and the city of Atlanta and reregulation of Georgia Power Company's Morgan Falls Dam, to be sufficient to provide a minimum flow at Peachtree Creek of 750 cfs during May through October and 650 cfs during November through April. In contrast, the NAA includes releases from Buford Dam that provide a minimum flow at Peachtree Creek of 750 cfs year-round.

The PAA would continue to accommodate net withdrawals of 8 million gallons per day (mgd) by the City of Gainesville and withdrawals of 2 mgd by the City of Buford from Lanier Reservoir under relocation agreements. In addition to the relocation contract amount, 20 mgd gross, the PAA proposes storage that would yield approximately 222 MGD from Lake Lanier. The Corps would also make releases from Lake Lanier to provide 379 MGD from the Chattahoochee River downstream at Atlanta by 2040. All other water supply operations would remain the same as the NAA.

The Service does not fully support the Corps' adoption of the PAA for the following reasons:

- the Corps' alternatives selection process (Service 2015; Appendix XV),
- a failure to adequately address conservation measures identified in the Service's PAL (Service 2010; Appendix V), PAL addendum (Service 2011; Appendix VI), and the Service's 2011 DFWCAR (Service 2011) and subsequently included in this report,
- increased frequency of low flows causing negative impacts to at-risk and federally-listed species, and
- Possibly slightly higher salinities (1 ppt) to the mouth of the Apalachicola River and East Bay.

Our previous DFWAR (2015) indicated modeling developed from limited consumptive use scenarios without sufficiently considering climate change and future increase in consumptive demands; however, these topics were more adequately addressed in a letter responding to the DFWCAR, and during the EIS process. The Service continues to believe that improved scenarios to address future impacts of climate change and potential increases in consumptive use are still needed; but, improved forecasting is limited by the availability of more comprehensive scientific information and improved assessments of water demands in the future. Our recommendation is, through partnerships, continue to develop basin-wide adaptive management strategies to address impacts of climate change.

We do, however, provide the Corps with recommendations intended to benefit fish and wildlife at the end of this document. The Service has suggested evaluations and analyses that address flow, water quality, fish passage, climate change, reservoir and riverine fisheries management, Apalachicola Bay resources, the inclusion of a decision support model and adaptive management, federally-petitioned species under the Endangered Species Act (ESA), impacts to the National Park Service (NPS)'s Chattahoochee River National Recreation Area, and ecosystem services. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes that may be associated with climate change. The intent of these evaluations and analyses is to inform the development of alternatives and to address the impacts of the PAA.

TABLE OF CONTENTS

Appendices

I. FFWCC's June 15, 2015, review of the Service's draft DFWCAR.

II. ADCNR's June 16, 2015, review of the Service's draft DFWCAR.

III. GDNR's June 25, 2015, review of the Service's draft DFWCAR.

IV. NOAA's June 18, 2015, review of the Service's draft DFWCAR.

V. Service's April 2, 2010, Planning Aid Letter to Corps.

VI. Service's March 1, 2011, Planning Aid Letter addendum to Corps.

VII. Service's January 11, 2013, Scoping comments to Corps.

VIII. Service's July 19, 2013, Revised Alternative to Corps.

IX. Service's August 29, 2013, Performance Measures PAL to Corps.

X. Service's November 13, 2013, Request for information from State wildlife agencies.

XI. FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011.

XII. University of Florida's April 27, 2011, Draft interim report to the Service entitled, *Simulating the impact of USACE operating alternatives on salinity and oyster populations in Apalachicola Bay, FL.*

XIII. Service's March 12, 2015, Questions regarding the Corps' January 21, 2015, Response to Service's PAL.

XIV. Service's 2011 comparison of the Corps baseline model output and observed data for a comparable period.

XV. Service's 2015 comments regarding the Corps' alternatives selection process.

XVI. GDNR Response Letter RE: ACF River Basic Water Control Manual update supplemental information for Final FWCA Report (August, 2016)

XVII. GDNR Response Letter RE: ACF River Basic Water Control Manual update supplemental information for Final FWCA Report (September, 2016)

XVIII. PAL Supplemental Response Plots v4. (provided by the Corps) (June 2016)

XIX. ACF Water Control Manual Update Support Information Comparison for the Final Fish and Wildlife Coordination Act Report (July 2016)

XX. Response to U.S. Fish and Wildlife Service DFWCAR on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida (August 2015)

INTRODUCTION

Purpose, Scope, & Authority

The following is taken from the United States Army Corps of Engineers (Corps)' response to the United States Fish and Wildlife Service (Service)'s Planning Aid Letter (PAL) (Corps 2015a):

> "The Corps proposes to prepare an updated Master Manual for the ACF River Basin. A draft Master Manual was proposed in 1989 along with certain changes to the project manuals, as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. The Corps has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would be five project-level water control manuals, presented as appendices that would specify how the various reservoir projects will be operated as a balanced system.
>
> …Water control manuals also contain drought operations plans and divide the amount of water in storage into action zones to assist federal water managers in knowing when to reduce or increase reservoir releases and conserve storage in the Corps reservoirs, and how to ensure the safety of dams during extreme conditions such as floods. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines, and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions.
>
> …the updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, will reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues."

The Service's involvement in this project is authorized by the Fish and Wildlife Coordination Act (FWCA). The FWCA establishes fish and wildlife conservation as a co-equal purpose or objective of federally-funded or permitted water resource development proposals or projects.

This Final Fish and Wildlife Coordination Act Report (FWCAR) are presented in fulfillment of FWCA and constitutes the final report of the Secretary of the Interior as required by Section 2(b) of the FWCA.

FWCA Agency Coordination

The Service distributed a draft of the DFWCAR on May 19, 2015, to Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), Florida Fish and Wildlife Conservation Commission (FFWCC), and National Oceanographic and Atmospheric Administration (NOAA) for their review. We received comments from FFWCC on June 15, 2015, ADCNR on June 16, 2015, NOAA on June 18, 2015, and from GDNR on June 25, 2015. The Service also received comments from GDNR-Environmental Protection Division (GDNR-EPD) on June 5, 2015. However, because the FWCA requires that the Service coordinate with fish and wildlife agencies to ensure that fish and wildlife needs receive equal consideration, we have addressed GDNR-EPD's comments in a June 18, 2015, correspondence separate from the FWCA process. The Service completed and submitted the initial draft FWCAR to the Corps of Engineers on July 31, 2015. The draft FWCAR was then included as part of the Draft EIS (DEIS), which was released for comment October 2015. The Service provided comments on the DEIS to the Dept. of Interior on January 27th, 2016.

Subsequently, after consideration of all comments submitted in response to release of the DEIS and a revised Water Supply Storage request by the State of Georgia, several modifications were made to the proposed action to be evaluated in the Final Environmental Impact Statement (FEIS). Based on information provided by the Corps, these modifications include;

1. The FEIS proposed action alternative analysis does not assume that Bear Creek Reservoir and Glades Reservoir are constructed. The DEIS assumed they were constructed. Both of these permit applications have been withdrawn or suspended.

2. The FEIS proposed action alternative assumes a gross withdrawal of 242 MGD from Lake Lanier directly and 379 MGD downstream. The DEIS proposed action alternative assumes a gross withdrawal of 185 MGD from Lake Lanier directly and 408 MGD downstream.

3. The FEIS proposed action alternative analysis utilized the latest version of HEC-ResSim (the DEIS proposed action alternative used the previous HEC-ResSim version).

4. The FEIS proposed action alternative analysis used an updated Area Capacity Curve for Lake Lanier.

5. The FEIS analysis includes updates to the HEC-5Q based on comments received on the DEIS proposed action alternative.

Overall, there are few differences between the revised Proposed Action Alternative (PAA), and the PAA as presented in the DEIS. The proposed water management operations did not change, nor did the alternatives formulation process. However, because of these changes, the Corps of Engineers provided supplemental information (July 2016) to support the identified changes and allow for further comparison and analysis between the no action alternative (NAA) and the revised proposed action alternative. This information was then shared with the states (ADCNR, GDNR, FFWCC), and NOAA to allow for additional review and develop additional comments for the final version of the FWCAR. We received comments from FFWCC on September 1, 2016, and from GDNR on August 19, 2016. No additional comments were received from NOAA or ADCNR.

We encourage the Corps to review these agency correspondences and consider them in their decision-making process. The agency responses are attached as Appendices I-IV, XVII, XVIII; a summary of the correspondences is as follows:

<u>FFWCC</u>

As previously noted in the draft FWCAR (July 2015), FFWCC shares a number of key concerns with the Service. FFWCC emphasizes the importance of consistent, transparent communication among the Corps, Service, and FFWCC. FFWCC notes that the Corps is required to consult with the Service *and* FFWCC, but this has not occurred; FFWCC requests the relevant datasets supporting the Corps' analyses. Until the relevant datasets are provided to FFWCC, they state that they cannot fully and effectively provide detailed comments as requested. After reviewing the Corps' datasets they will provide additional comments on these materials, as well as the DFWCAR, in accordance with FWCA. FFWCC notes that they, as well as the Service, earlier asked the Corps to address the impacts of current and projected consumptive water uses as part of the WCM Update process. The FFWCC states that the Corps has not offered any such analysis, and based on information being developed supporting litigation captioned *Florida vs. Georgia*, No 142 Orig., they "reject the Service's apparent interim conclusion that upstream consumptive uses are not having a significant effect on Florida's fish and wildlife resources."

Service Response: Per FFWCC's request, we have provided FFWCC with all relevant information that we have been provided by the Corps. The Service contacted FFWCC representatives/counsel to gain clarification regarding FFWCC's last sentence (cited above). FFWCC stated that this refers to the Service's statement in the DFWCAR that, "based on model results provided by the Corps, the negative effects of the PAA on fish and wildlife resources are, in part, a consequence of reservoir system operation changes. They are not solely the result of increases in consumptive demands that are part of the PAA." The Service does not consider this particular comment as necessarily addressing the issue of significance; rather that effects are jointly caused by both reservoir operations and increased consumptive demands. In this Final version of the FWCAR we have tried to clarify the meaning of our statement.

Recent comments (September 1, 2016) from FFWCC indicate that Florida continues to oppose the revised PAA and contends that the revised PAA allows for Georgia to have even greater cumulative withdrawals from the system.

After review of the supplemental information, FFWCC raised two additional issues:

(1) Florida is concerned that the Corps has failed to address a number of important issues the Service raised in the July 2015 Draft Fish and Wildlife Coordination Act Report.

(2) Florida is concerned that recent techniques used to evaluate suitable habitat and densities of at-risk and listed mussels have limited application. Specifically, the concern is focused on the evaluation of suitable habitat associated with main-channel habitats of the Apalachicola River.

Overall, Florida agrees with several concerns raised in the draft FWCAR. As the Service explained, "the negative effects of the PAA on fish and wildlife resources are a consequence of reservoir system operation changes *and increases in consumptive demands* that are part of the PAA. FFWCC's assessment is that the revised PAA, will further increase the negative effects of the PAA on fish and wildlife resources. Secondly, FFWCC believes the Corps utilized flawed methodology and data for ranking and selecting alternatives because the methodology used placed greater weight on other project purposes such as water supply and hydropower, over downstream fish and wildlife purposes.

Florida agrees with the Service (FWCAR, July 2015) that:

- Ranking methodology treated small differences between alternatives the same as large differences between alternatives. Therefore, project purposes do not appear accurately represented when equal weight is given toward inconsequential and consequential differences among alternatives within a project purpose.
- An incomplete set of fish and wildlife performance measures was used to score and then rank alternatives.
- Inconsistency in ranking alternatives between Phase 1 and Phase 2. Had the ranking approach been consistent, an alternative PAA may have resulted.

Florida believes that more analysis regarding mussel mortality is necessary prior to finalizing the Master Water Control Manual. Specifically, there are concerns that periodic high-flow and prolonged low-flow events may destabilize previously assumed suitable habitat conditions for at-risk and listed mussel species. Therefore, evaluation of impacts of the PAA on the listed species may be flawed. FFWCC's recommendation is to implement a more detailed study to better inform the evaluation of effects of the PAA and NAA on the listed and at-risk mussel species.

Service Response: Currently, under section 7 of the Endangered Species Act (1973), as amended (16 U.S.C. § 1531 et seq.); a Biological Opinion is being developed to address the impacts of the PAA associated with the revised Water Control Manual for the ACF. These issues will be more appropriately and more adequately addressed during the consultation process. To date, this process continues to be on-going.

Finally, as required by the Fish and Wildlife Coordination Act, Florida asks for improved consistency and transparency in communication between the Corps, the Service, and the FWC. Florida believes that the PAA still can be improved to both address the concerns and enhance benefits to fish and wildlife if the Corps engages with the Service and FWC on these critical issues.

ADCNR

As previously noted in the draft FWCAR (July 2015), ADCNR encourages the Corps to fully develop and analyze alternatives or suites of alternatives that will maximize and benefit fish and wildlife resources of the State of Alabama. They also encourage decision support models, in an adaptive management framework, to evaluate these alternatives.

Specific concerns highlighted in ADCNR's correspondence include water quality, instream flow, increasing consumptive demand, State-protected aquatic species, and drought conditions and impacts. In terms of water quality, ADCNR agrees that releases from the Corps' ACF dams should meet or exceed State water quality standards and that water quality issues should be a priority for the protection of aquatic resources. Assessments for improvement should be fully considered in the suites of evaluated alternatives and the PAA. ADCNR agrees with the Service that alternative water quality assessment methods should be used to evaluate the effects of Corps' operations on water quality. ADCNR believes improvements to current Corps' facilities are within the scope of the WCM update process and recommend they be addressed while analyzing alternatives.

In terms of instream flow, ADCNR states that the responsibility of the Corps' water control operations must include a flow regime that maintains ecological integrity to protect the physical, chemical, and biological functions of waters flowing into the State of Alabama. Per their Instream Flow Policy implemented in 2012, ADCNR states that it is their policy to advocate for the protection of instream flow requirements in all water allocation decisions.

ADCNR requests the Corps a conduct comprehensive analysis of increasing consumptive demands in the ACF Basin and include those with the suite of considered alternatives. ADCNR states that increased demands including increased water supply withdrawals, increased volume storage, and changes in industrial, municipal, and agricultural practices could impact hydrologic conditions.

ADCNR states that potential impacts to State-protected species by Corps operations should be avoided and minimized. Impacts should be fully assessed and potential impacts from operating under the PAA should not be greater than operating under the NAA.

In terms of drought conditions and impacts, ADCNR is concerned that minimum flows during drought conditions under the PAA would have significant negative impacts on aquatic species. They recommend an analysis of alternative instream flow regimes be conducted such that minimum flows during drought conditions under the PAA are not lower than under the NAA.

ADCNR also recommends an anadromous fish passage plan be developed for George W. Andrews Lock & Dam (GWLD) and Walter F. George Lock & Dam (WFGLD).

<u>GDNR</u>

As previously noted in the draft FWCAR (July 2015), GDNR's comments pertain primarily to water temperature, fishery performance measures, fish passage, and water quality. In terms of water temperature, GDNR states that the thermal regime below Buford Dam is of importance to GDNR and to recreational anglers. An introduced trout fishery is supported from Buford Dam to Bull Sluice Reservoir and this section of the Chattahoochee River receives approximately 90,000 angler trips per year. GDNR suggests that downstream recreation should be considered as a coequal consideration in the WCM update process. They note that increased hydropeaking operations at Buford Dam would reduce available recreational opportunities in NPS' Chattahoochee River National Recreation Area, which are typically limited to times of minimum flows.

GDNR states that increased water temperatures would have different impacts on trout populations depending on the distance from Buford Dam. Water temperature is not expected by GDNR to be a concern at the Buford Trout Hatchery intake, with one possible exception being an increased frequency of 2-unit generations during the fall, when water drawn from the thermocline, pre-turnover, can lead to drastic temperature increases in a short time, leading to shock. South of the Norcross gage, GDNR states that small temperature increases may lead to localized stress and mortality if water temperatures exceed 22°C for any considerable length of time; it is only currently a concern during summer months, which experience the most impact on water temperatures due to warmwater tributary inputs and solar radiation. Because research by GDNR indicates limited trout movement in the Chattahoochee River, a localized mortality event could lead to extended, severely reduced angler opportunities in a given section.

GDNR clarifies that summer habitat for striped bass in West Point Reservoir can be very marginal and the cool flows in the Morgan Falls tailrace mitigate for the lack of summer coolwater, high oxygen habitat. The Service had stated in the DFWCAR that spring coldwater releases may have a critical inhibiting impact on the West Point Reservoir striped bass reproduction, based on Hess and Jennings (1999). Hess and Jennings (1999) suggest temperature as possibly an inhibiting factor for reproduction, but also mention low flows as another potential inhibiting factor; therefore, GDNR states that it may not be appropriate to view higher flows/low temperatures as negative in an evaluation of riverine fish habitat.

In terms of fishery performance measures, GDNR reiterates the importance of individualizing the response of vegetation to water level management at Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir as part of the Reservoir Fishery Performance Measure (RFPM). They are concerned about using a single metric for three very different reservoirs. GDNR hopes to continue to work with the Service to refine the RFPM to more accurately model the fishery-related effects of water levels in each reservoir.

GDNR considers the continuation of the Corps' fish spawn management procedures as critically important for reservoir fisheries. As a Conservation Measure in the DFWCAR, the Service suggests investigate modifying the Fish Spawn Standard Operation Procedures (SOPs) to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. GDNR would like to understand this Conservation Measure in more detail and state that conditions to meet this goal may be difficult in most years; in addition, the per-unit impacts in water management choices may not be uniform between rivers and reservoirs.

GDNR states that it is appropriate to use water temperature as the driving factor related to shoal bass abundance in the Chattahoochee River Shoal Bass Performance Measure (CRBPM) for the Morgan Falls tailwater. However, GDNR states that thermal impacts farther downstream, between Peachtree Creek and West Point Reservoir, are likely minimal relative to shoal bass reproduction and recruitment in normal years. Apparent limited shoal bass abundance in this reach could be due to other limiting factors that should be addressed and considered when using the CRBPM to inform flow regimes.

In terms of fish passage, GDNR agrees that improved fish passage would provide benefits to multiple species (e.g., increased habitat availability for Gulf Sturgeon and Striped Bass).

In terms of water quality, GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from increased residence time or nutrient loading. GDNR states that Lanier Reservoir and Walter F. George Reservoir have not historically had problems of algal mats and/or fish kills due to chlorophyll-*a* or phosphorous loading, and West Point Reservoir nutrient levels have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. When classifying water quality changes as positive or negative, potential benefits from increases in residence time or nutrient loading that can lead to increases biomass and improved fishing should be considered.

GDNR agrees that increased dissolved oxygen levels below Corps' dams would have positive benefits to tailwater fisheries. The State water quality standard at Norcross and Morgan Falls both fall within State-listed trout waters, and as such, were incorrectly cited in the Corps' response to the Service's PAL (Corps 2015a) and subsequently the Service's DFWCAR as a daily average of 5.0 mg/L instead of 6.0 mg/L. An increase in dissolved oxygen at Buford Trout Hatchery in the late summer and fall pre-turnover period would alleviate stress on trout held in hatchery raceways. Increases in dissolved oxygen levels below West Point Dam should provide a benefit to shoal bass populations. Electrofishing surveys below WFGLD have indicated that low dissolved oxygen may severely impact recreational fishing opportunities for several miles downstream.

GDNR also clarifies that Buford Trout Hatchery's withdrawal, listed as 7 mgd, is a pass-through system and the net withdrawal is negligible on downstream flows (limited to evaporation).

GDNR recent correspondence indicates that after reviewing the supplemental information, they have no additional comments beyond those previously submitted for past FWCAR (2011, 2015), as well as those comments submitted to address issues and concerns relative to the draft EIS (October 2015).

NOAA

As previously noted in the draft FWCAR (July 2015), NOAA is supportive of the Service's comments addressing the current inadequacy of the evaluation of the PAA on Gulf Sturgeon and recommends the Corps provide a more thorough evaluation of the effects of implementing the PAA on Gulf Sturgeon. NOAA is supportive of the Service's comments that fish passage provisions, with operational flexibility, should be incorporated at not only Jim Woodruff Lock and Dam (JWLD), but also at the two Corps facilities upstream of JWLD, GWLD and WFGLD.

In addition, NOAA states that additional examinations are needed to determine how variations in freshwater inflow to Apalachicola Bay affect seagrass, fish, and shellfish abundances. NOAA recommends the Corps coordinate with FFWCC to complete analyses and include an updated Apalachicola Bay salinity model for predicting oyster mortality and growth in the WCM.

Prior Studies and Reports

The following studies and/or reports are the most pertinent documents involved in producing this DFWCAR:

- Corps' April 15, 2008, description of proposed action modification to the Interim Operations Plan at Jim Woodruff Dam;
- Service's 2008 and 2012 biological opinions for the Corps' Revised Interim Operations Plan;
- Service's April 2, 2010, PAL to the Corps (Appendix V);
- Corps' January 18, 2011, response to the Service's PAL;
- FFWCC's February 22, 2011, correspondence to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps titled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems (*Appendix XI*);*
- Service's March 1, 2011, PAL addendum to the Corps (Appendix VI);
- University of Florida's April 27, 2011, draft interim report to the Service entitled, *Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, Florida* (Sheng et al. 2011; Appendix XII);
- Service's June 2011 DFWCAR to the Corps;
- Service's July 19, 2013, Revised alternative for consideration in the ACF River Basin WCM to the Corps (Appendix VIII);
- Service's August 29, 2013, PAL to the Corps (Appendix IX);
- Corps' February 6, 2014, HEC5Q and Service water temperature model comparisons; and
- Corps' January 21, 2015, response to the Service's PAL
- USFWS Draft FWCAR (July 2015)
- Draft EIS Report (October 2015)
- USFWS Draft EIS comments (January 2016)
- NOAA/National Marine Fisheries Service Draft EIS comments (January 2016)
- National Park Service Draft EIS comments (January 2016)
- PAL Supplemental Response Plots (provided by the Corps) (June 2016)
- ACF Water Control Manual Update Supplemental Information for the Final Fish and Wildlife Coordination Act Report (July 2016)

DESCRIPTION OF PROJECT AREA

The 19,910 square mile (mi^2) ACF River basin stretches from north central Georgia to the eastern border of Alabama to the Gulf coast through the central Florida panhandle. The drainage principally comprises the Chattahoochee (8,770 mi^2) and Flint (8,460 mi^2) rivers, which meet to form the Apalachicola River (2,680 mi^2) near the border of Florida and Georgia. Water resources in the ACF River basin have been developed to meet various demands for municipal and industrial water supply, flood control, hydropower, navigation, fish and wildlife conservation, recreation, and agricultural water supply (Corps 1998).

There are currently 14 reservoirs impounding the mainstem ACF river system, of which five are federally-owned and 9 are privately-owned projects. Eleven reservoirs are located on the Chattahoochee River, two on the Flint River, and one, JWLD, is located near the confluence of the Chattahoochee and Flint rivers which forms the Apalachicola River. The federally-owned projects include JWLD, as well as four projects along the mainstem Chattahoochee River: GWALD, WFGLD, West Point Dam, and Buford Dam (Figure 1).

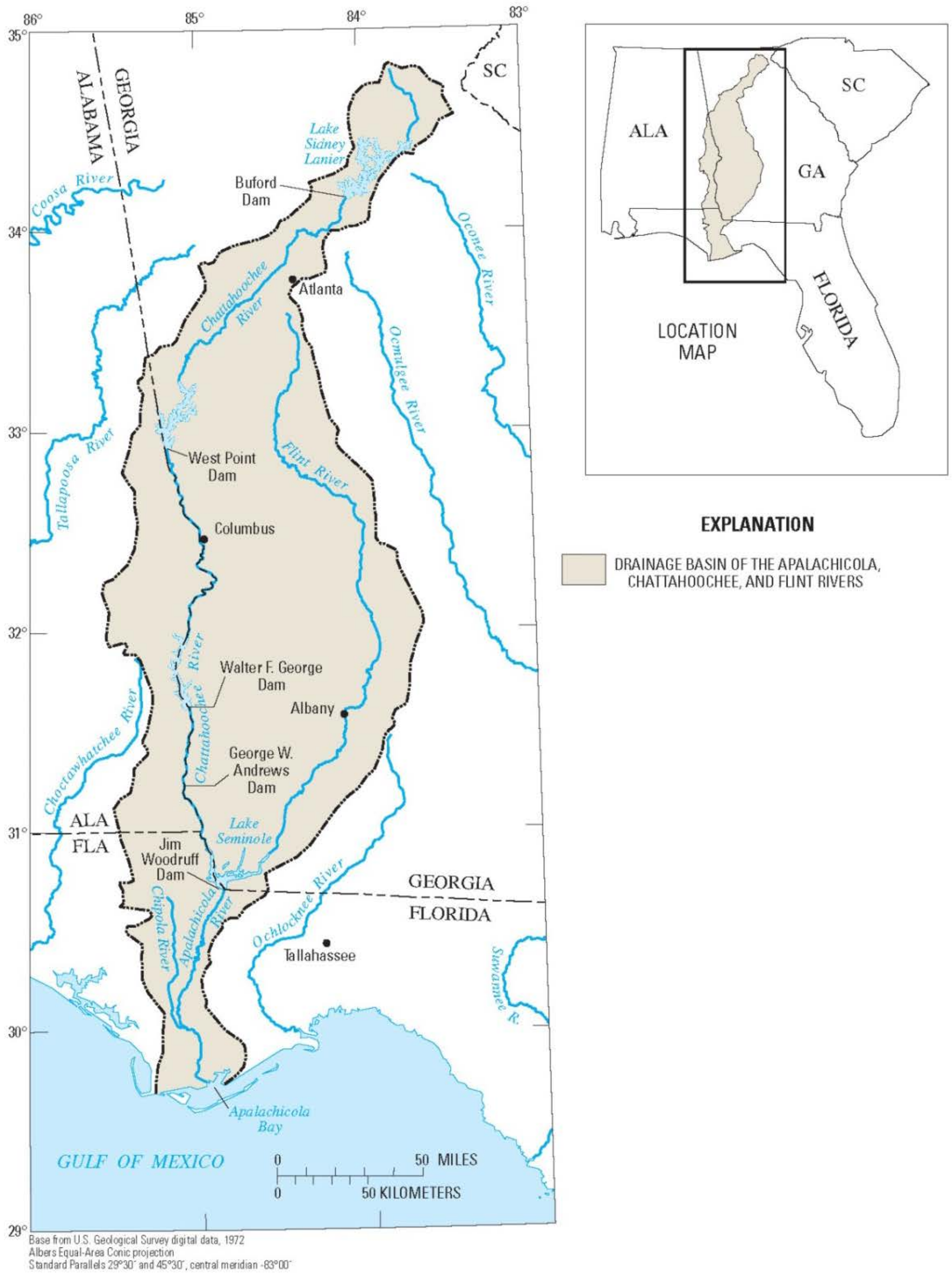


Figure 1. Map of the ACF Basin showing location of the Corps' dams (source: Light et al. 2006).

FISH AND WILDLIFE CONCERNS AND PLANNING OBJECTIVES

The Service's fish and wildlife concerns, planning objectives, recommendations and requested analyses have been previously described in detail to the Corps in our 2010 PAL (Service 2010; Appendix V) and 2011 PAL addendum (Service 2011; Appendix VI). Some of our concerns and planning objectives were represented in our scoping comments (Service 2013; Appendix VII), revised alternative (Service 2013; Appendix VIII), and 2013 PAL (Service 2013; Appendix IX). Our overarching planning objective is to identify negative impacts to aquatic ecosystems, and provide considerations for improving, protecting, and mitigating for losses to aquatic resources associated with the revision of the Corps' Water Control Manual.

In the Fish and Wildlife Conservation Measures and Recommendations Section we have included a summary of our current understanding of the Corps' position on each issue, as well as additional conservation measures and recommendations developed from the Corps' 2011 response to the Service's PAL and more recent conservation and mitigation measures. These more recent measures include recommendations for the Corps' to consider the effects of the PAA on species in the ACF Basin that have been petitioned for Federal listing under the ESA, impacts to NPS' Chattahoochee River National Recreation Area, and ecosystem services, as well as the development of appropriate mitigation.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Project impacts should be identified by comparing future resource conditions under the NAA to future conditions with the Corps' PAA. Impacts can theoretically be beneficial, adverse, or have no appreciable differences, but are limited to fish and wildlife resources that could be affected by Corps project operation changes. Thus, the intent of this section is to describe effects of project operations on biologically relevant parameters. The overall biological interpretation of the results (e.g. descriptions of whether the PAA is beneficial, adverse, or no difference compared to the NAA) is reserved for the *Evaluation of the Selected Plan* section below.

DESCRIPTION OF CORPS' NO ACTION ALTERNATIVE AND SELECTED PLAN

No Action Alternative

The Corps' NAA represents continuation of the current water control operations at each of the Federal projects in the ACF Basin. There is not one comprehensive document that reflects the Corps' current operational practices; instead they are described in multiple Corps documents including:

- 1989 Draft ACF Water Control Plan;
- June 2008, Revised Interim Operations Plan (RIOP) and Environmental Assessment, as modified by the updated RIOP/EA (May 2012);
- May 2010, South Atlantic Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes and February 2005, Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan (SAM SOP 1130-2-9);
- February 1991, Chattahoochee River Management System as described in the

Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA; and
- Project WCM s for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects.

The NAA as it dictates general system operations, action zones, and authorized project purposes is described in detail in the Corps' response to the Service's PAL (Corps 2015a, Corps 2016). The NAA also includes current water supply operations including withdrawals directly from Lanier Reservoir and Buford Dam releases for downstream withdrawal.

Previous Proposed Action Alternative (pre-DEIS)

The previous PAA dictates general system operations, action zones, and authorized project purposes is also described in detail in the Corps' response to the Service's PAL (Corps 2015a, Corps 2016). In light of the July 2011 Eleventh Circuit Court of Appeals ruling, the Corps is considering current levels of water supply withdrawals and a portion (165 mgd) of Georgia's 2040 water supply need within Lanier Reservoir, assuming an additional 40 mgd would be withdrawn from projected construction and use of Glades Reservoir. Releases from Buford Dam would provide for water supply withdrawals of up to 408 mgd from the Chattahoochee River at Atlanta. The PAA provides a minimum flow rate of 750 cfs at Peachtree Creek from May through October and 650 cfs from November through April.

Under the PAA, the Corps would modify the action zones for Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir. Specifically, the action zones in Lanier Reservoir and West Point Reservoir are shifted upward in the fall and winter months and the action zones are shifted downward in Walter F. George Reservoir, primarily during summer months.

The hours of hydropower generation under the PAA would continue to vary by action zone, but a greater range of hourly production would be incorporated in all action zones at Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir except for Zone 4 at West Point Reservoir and Walter F. George Reservoir. This operational flexibility appears that it would result in potentially more variability in hydropower production at Buford Dam and less hydropower production at West Point Dam and Walter F. George Dam.

Under the PAA, the Corps would provide a reliable navigation season. If hydrologic conditions allow, a typical navigation season would extend from January through April or May. During this navigation season the flows at the Blountstown, Florida USGS gage would provide at least a 7-foot channel, which corresponds to 16,200 cfs at Blountstown (Corps 2015b). Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The determination to extend the navigation season beyond April would depend on inflows, climatic and hydrological conditions, and meteorological and basin-wide forecasts. Down-ramping of flow releases would adhere to the JWLD fall rate schedule. Releases to provide for the 7-foot navigation channel would also be dependent on navigation channel conditions that ensure safe navigation.

Under the PAA, there would be no changes to flood damage reduction, fish spawn, fish passage, or recreational operations. Releases for federally-listed species below JWLD would be modified in that the ramping rate would be suspended during prolonged low flows. Use of ramping rate rules would be suspended when basin inflow has been less than 7,000 cfs for 30 days, and would be resumed when basin inflow is greater than 10,000 cfs for 30 days.

The PAA would include a drought plan that would be similar to the NAA, but drought operations would be "triggered" when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3. Under the NAA, drought operations are currently "triggered" when composite conservation storage falls below the bottom of Zone 3 into Zone 4. Under both the NAA and PAA, drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2. Additionally, reshaping of the action zones, including the Drought Zone, will affect both the duration and magnitude of flow releases throughout the system of reservoirs.

Revised Proposed Action Alternative (post-DEIS)

On January 21, 2015 the U.S. Army Corps of Engineers (USACE) provided the U.S. Fish and Wildlife Service (Service) a description (USACE, 2015a) of a proposed updated Master Manual for the Apalachicola, Chattahoochee, and Flint River (ACF) Basin and a response to previous Planning Aid Letters (PAL) dated April 1, 2010; March 1, 2011; and August 29, 2013. On 2 October 2016, USACE released a Draft Environmental Impact Statement (DEIS) (USACE, 2015b) for the proposed action. The DEIS has been provided to the Service Panama City, Florida and Athens, Georgia field offices. A Draft Fish and Wildlife Coordination Act Report (DFWCAR) was provided by the Service Athens, Georgia Field Office, to USACE District Commander Jon Chytka, dated July 31, 2015. A response to the DFWCAR was provided by USACE in the DEIS. In addition, a Department of the Interior letter commenting on the DEIS dated January 29, 2016, provided Service as well as National Park Service comments on the proposed action.

After consideration of all comments submitted in response to release of the DEIS and a revised Water Supply Storage request by the State of Georgia, several modifications were made to the proposed action to be evaluated in the Final Environmental Impact Statement (FEIS). Although they will be discussed in more detail in the next section, the modifications are as follows:

1. The FEIS proposed action alternative analysis does not assume that Bear Creek Reservoir and Glades Creek Reservoir are constructed. The DEIS assumed they were constructed. Both of these permit applications have been withdrawn or suspended.

2. The FEIS proposed action alternative assumes a gross withdrawal of 242 MGD from Lake Lanier directly and 379 MGD downstream. The DEIS proposed action alternative assumes a gross withdrawal of 185 MGD from Lake Lanier directly and 408 MGD downstream.

3. The FEIS proposed action alternative analysis utilized the latest version of HEC-ResSim (the DEIS proposed action alternative used the previous HEC-ResSim version).

4. The FEIS proposed action alternative analysis used an updated Area Capacity Curve for Lake Lanier.

5. The FEIS analysis includes updates to the HEC-5Q based on comments received on the DEIS proposed action alternative.

Overall, there are few differences between the revised Proposed Action Alternative (PAA), Alternative7K (Alt7K), and the PAA as presented in the DEIS, Alt7H, or the impacts resulting from them. The proposed water management operations did not change, nor did the alternatives formulation process. This document will provide a new description of the PAA and discuss the changes in impacts from the PAA as presented in the DEIS. Therefore, except as otherwise noted, impacts are expected to be similar to those described in the January 21, 2015 Response to PAL.

DESCRIPTION OF PROPOSED ACTION

Under the proposed action alternative (PAA), the USACE would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods. The intent would be to maintain a balanced use of conservation storage rather than to maintain the pools at or above certain predetermined elevations; however, in times of high-flow conditions, flood risk management regulation would supersede all other project functions. At all times, USACE would seek to conserve the water resources entrusted to its regulation authority. The PAA is consistent with the USACE's authority as set forth in the 2012 legal opinion. The following sections describe the PAA.

Guide Curves and Action Zones

Under the PAA, the USACE would not modify any guide curves of the ACF projects but would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes can be met. As lake levels decline, Zones 2 through 4 define increasingly critical system status where purposes can no longer fully be met. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project.

The revised action zones were derived considering numerous factors, including the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects. Other factors or activities might cause the lakes to operate differently than the action zones are described, including exceptional flood risk management measures, fish spawn operations, approved deviations, maintenance and repair of turbines, emergency situations (such as a drowning and chemical spills), draw- downs because of shoreline maintenance, releases made to free grounded barges, and other special circumstances.

The storage projects (Lanier, West Point, and Walter F. George) would be operated to maintain their respective lake level in the same action zones concurrently. Because of the hydrologic and physical characteristics of the river system and factors mentioned above, however, there might be periods when one lake would be in a higher or lower zone than another. When that occurs, the USACE would conduct operations to bring the lakes into balance with each other as soon as conditions allow. By doing so, effects within the river basin would be shared equitably among the projects. The action zones for the PAA are shown in Figure 2-4. A more complete discussion of the action zones of the PAA may be found in section VII of the Master Manual and each project manual found in Appendix A of the DEIS.

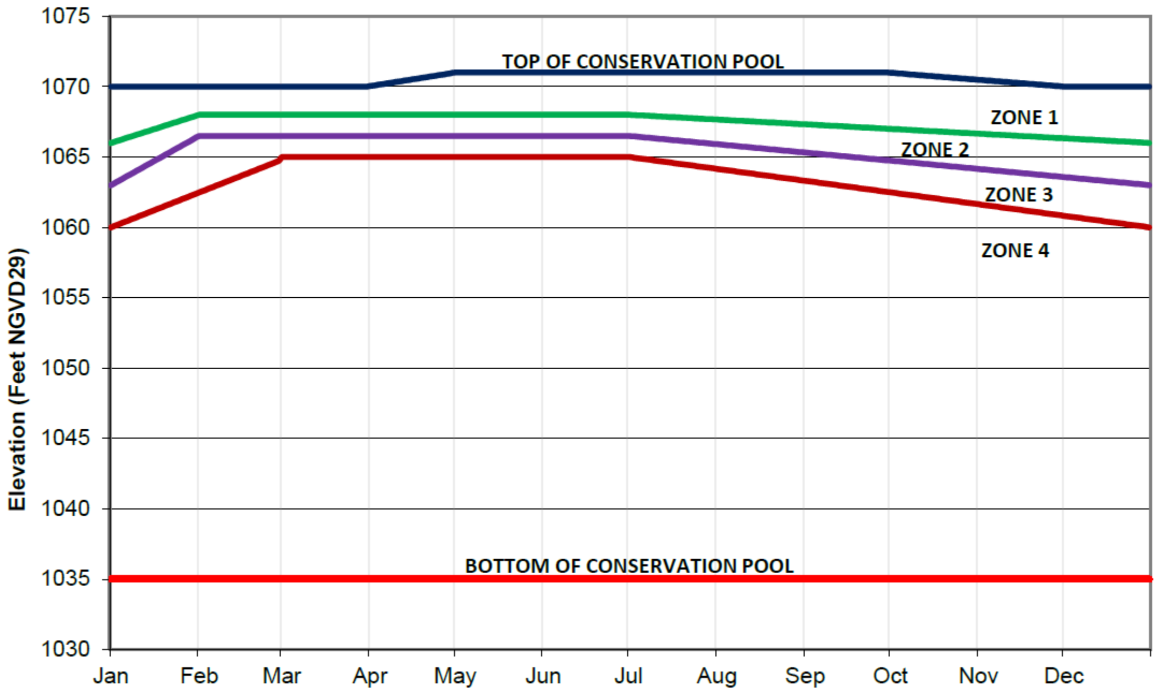


Figure 2. Lake Lanier Water Control Action Zones for the Proposed Action Alternative

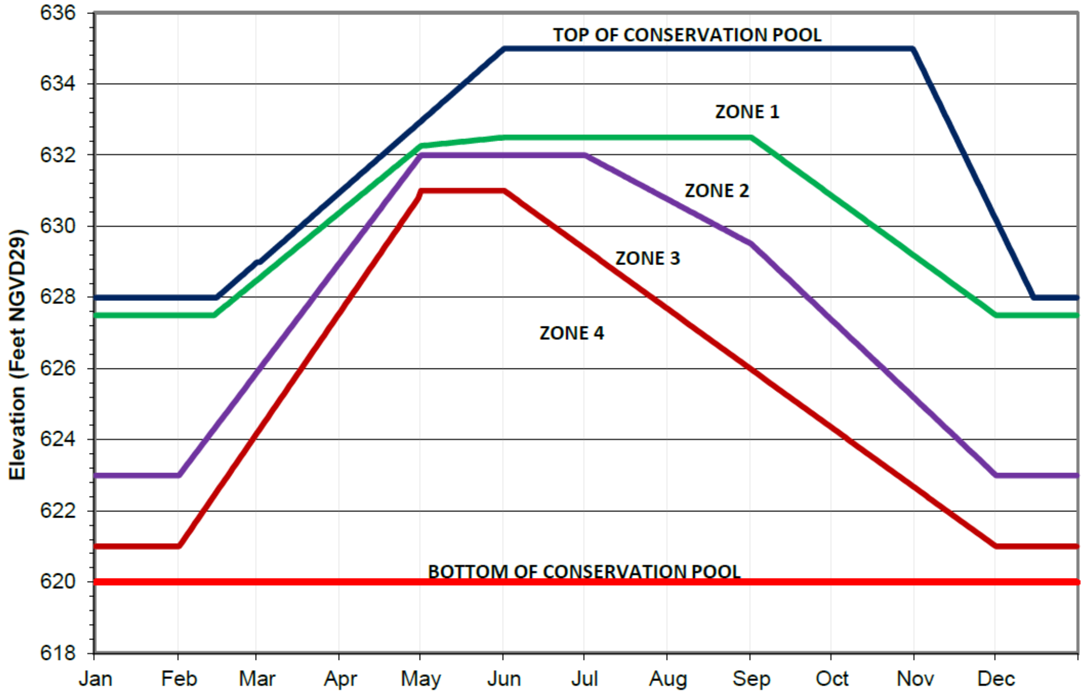


Figure 3. West Point Lake Water Control Action Zones for the Proposed Action Alternative

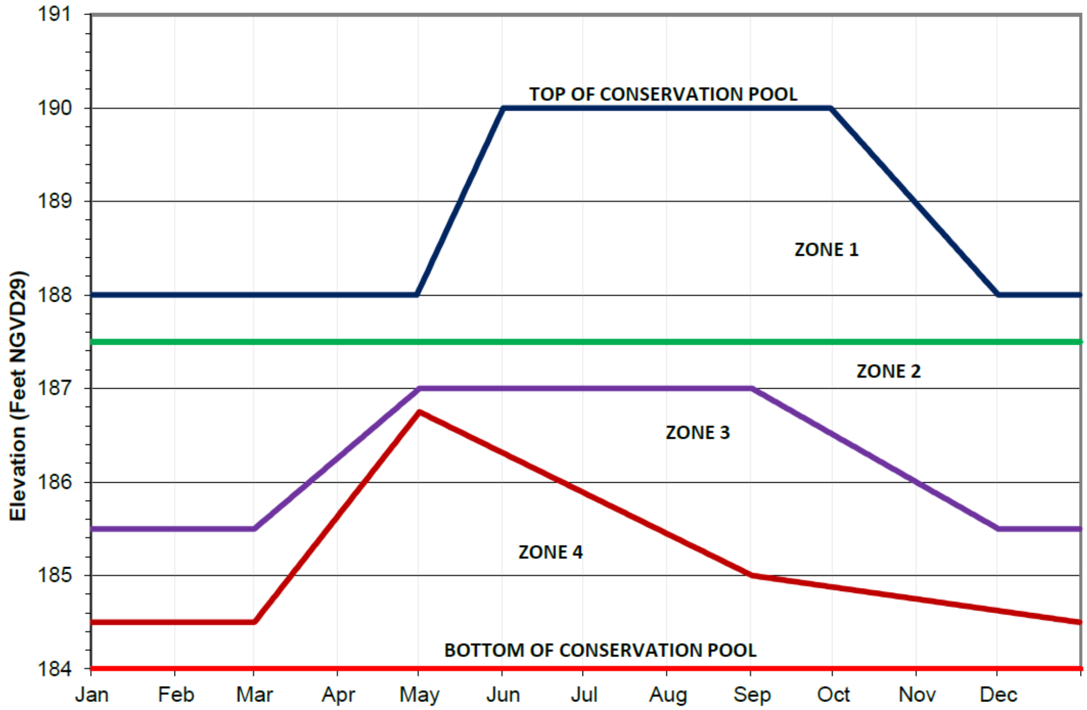


Figure 4. Walter F. George Water Control Action Zones for the Proposed Action Alternative

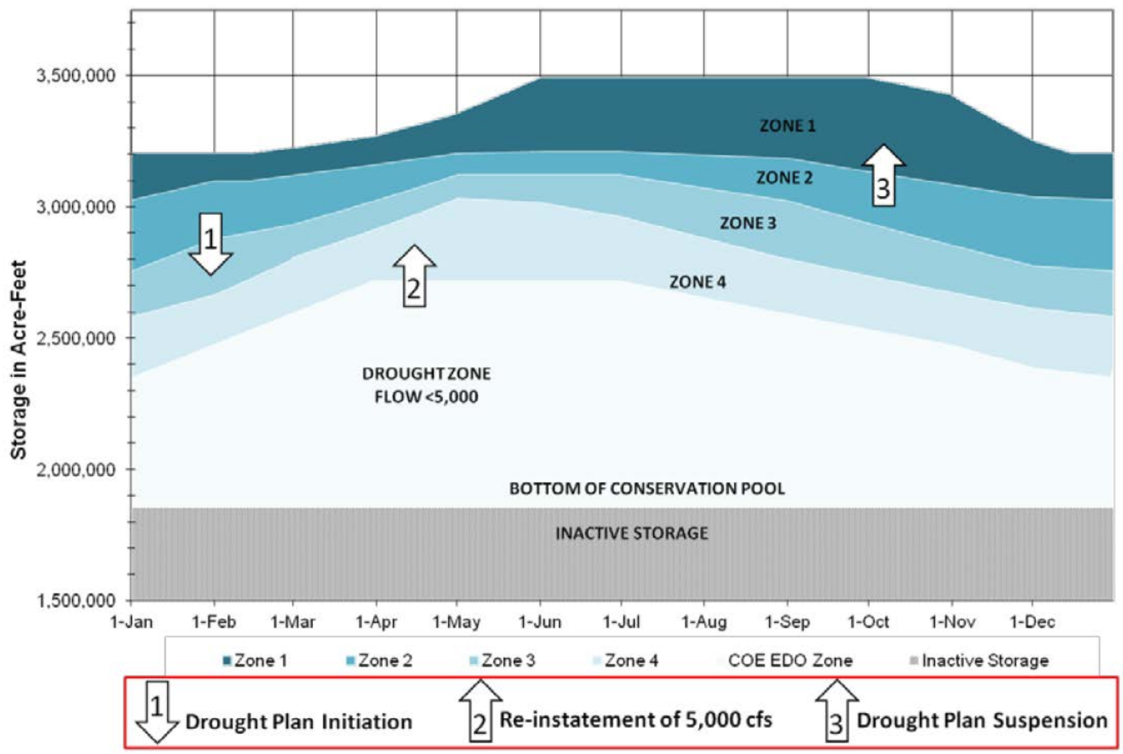


Figure 5. Composite Conservation Storage Zones and Drought Plan Triggers

Drought Operations

The drought plan included in the PAA specifies a minimum release from Jim Woodruff Dam and would temporarily suspend the normal minimum release and maximum fall rate provisions of the listed species operation (described below in the Fish and Wildlife Conservation section), until composite conservation storage in the basin could be replenished to a level that could support them. Under the drought plan, minimum discharge would be determined in relation to the composite conservation storage. The drought plan would be triggered when the composite conservation storage falls below the bottom of Zone 2 into Zone 3 (Figure 5). At that time, all the provisions for composite conservation storage Zones 1 and 2 (seasonal storage limitations, maximum fall rate schedule, and minimum flow thresholds) would be suspended, and management decisions would be based on the provisions of the drought plan. The drought plan would include the option for a temporary waiver from the water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects to provide additional conservation storage for future needs, if conditions in the basin dictate the need for such action.

The drought plan of the PAA prescribes two minimum releases on the basis of composite conservation storage in Zones 3 and 4 and an additional zone referred as the Drought Zone. The

Drought Zone delineates a volume of water roughly equivalent to the inactive storage in Lake Sidney Lanier, West Point Lake, and Walter F. George Lake, plus Zone 4 storage in Lake Sidney Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zones 3 and 4, but above the Drought Zone, the minimum release from Jim Woodruff Dam would be 5,000 cubic feet per second (cfs) and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam would be 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates would be limited to 0.25 ft/day drop. The 4,500 cfs minimum release would be maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release would be reinstated.

The drought plan provisions would remain in place until conditions improve such that the composite conservation storage reaches Zone 1. At that time, the temporary drought plan provisions would be suspended and all the other provisions of the basin water control plan would be reinstated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) would be implemented to determine which operational triggers are applied. In the event the composite conservation storage has not recovered to Zone 1 by 1 March, drought operations would be extended to the end of March, unless all the federal reservoirs are full.

Extreme Drought Operations

When the remaining composite conservation storage is about 10 percent of the total capacity, additional emergency actions might be necessary. When conditions have worsened to that extent, use of the inactive storage must be considered. For example, such an occurrence could be contemplated in the second or third year of a drought.

Inactive storage zones have been designated for the three Federal projects with significant storage (Figure 6). Table 2 shows the inactive storage capacity within each inactive storage zone for each project. The use of inactive storage during extreme drought conditions would be based on the following actions:

(1) Inactive storage availability would be identified to meet specific critical water use needs within existing project authorizations.

(2) Emergency uses would be identified in accordance with emergency authorizations and through stakeholder coordination. Typical critical water use needs within the basin are associated with public health and safety.

(3) Weekly projections of the inactive storage water availability to meet the critical water uses from Buford Dam downstream to the Apalachicola River would be used when making water control decisions regarding withdrawals and water releases from the USACE reservoirs

(4) The inactive storage action zones would be instituted as triggers to meet the identified priority water uses (releases will be restricted as storage decreases). Figure 5 lists the typical critical water uses for each inactive storage zone.

(5) Dam safety considerations would always remain the highest priority. The structural integrity of the dams due to static head limitations (Jim Woodruff, 38.5 feet; George W. Andrews, 26 feet; Walter F. George, 88 feet) would be maintained.

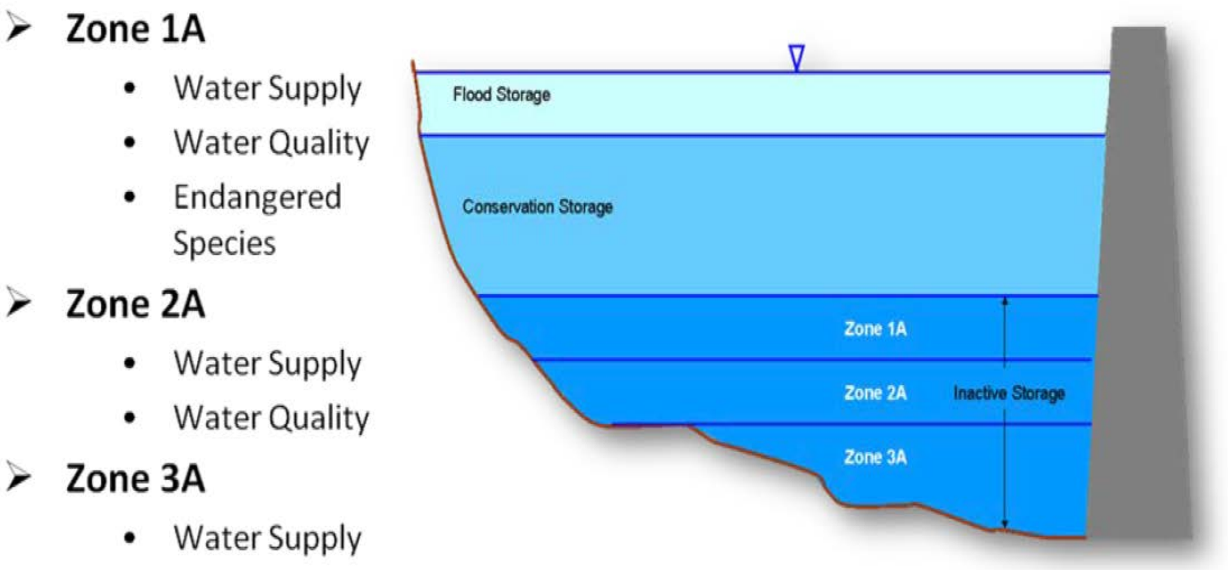


Figure 6. Inactive Storage Zones and Typical Water Use Needs

Table 2. Reservoir Inactive Storage Zone Capacities (ac-ft)

Project	Zone 1A	Zone 2A	Zone 3A	Unusable Inactive
Buford Dam	532,078	234,699	100,823	0
West Point Dam	53,620	138,331	33,344	73,101
Walter F. George	314,799	178,501	0	196,700
Total	901,589	554,345	134,869	266,062

Flood Risk Management

When developing the PAA, flood risk management capabilities and capacities of reservoirs were not reduced. The current flood operations described in the DEIS (USACE 2015) would remain unchanged.

Hydroelectric Power Generation

The PAA would result in changes to hydroelectric power generation operations at West Point Dam, Walter F. George Lock and Dam, or Jim Woodruff Dam to call for a more flexible generation schedule in all action zones under non-drought conditions and a more constrained generation schedule under drier conditions. The Buford, West Point, and Walter F. George Projects are operated as peaking plants, and provide electricity during the peak demand periods of each day and week. Hydroelectric power peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines. Typically, the Buford, West Point, and Walter F. George Projects provide generation five days a week at plant capacity throughout the year, as long as their respective lake levels are above Zone 4 and drought operations have not been triggered. For example, demand for peak hydroelectric power at Buford Dam typically occurs on weekdays from 5:00 a.m. to 9:00 a.m. Central time and from 3:00 p.m. to 10:00 p.m. between 1 October and 31 March, and on weekdays from 1:00 p.m. to 7:00 p.m. between 1 April and 30 September. The typical hours represent releases that normally meet water system demands and provide the capacity specified in power marketing arrangements. During dry periods, generation could be eliminated or limited to conjunctive releases. Typical, but not required, hours of operation by action zone are depicted in Table 3.

Table 3. Typical hours of peaking hydroelectric power generation by federal project

Action zone	Buford Dam(hours of operation) normal ops/drought ops	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	3/2	4	4
Zone 2	2/1	2	2
Zone 3	2/1	2	2
Zone 4*	0	0	0

*While hydropower would still be generated in Zone 4, it could not be generated on a regular peaking schedule under severe drought conditions

Navigation

When supported by ACF Basin hydrologic conditions, the PAA would provide a reliable navigation season. The water management objective for navigation is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). Figure 6 graphically represents the navigation season and its relationship to composite conservation storage. During the navigation season, the flows at the USGS gage at Blountstown, Florida, should be adequate to provide a minimum channel depth of 7 feet. The most recent channel survey and discharge-stage rating were used to determine the flow required to sustain a minimum navigation depth during the navigation season. Flows of 16,200 cfs provide a channel depth of 7 feet. Flows of 20,600 cfs provide a channel depth of 9 feet. USACE's capacity to support a navigation season would be dependent on actual and projected system-wide conditions in the ACF Basin before and during January, February, March, April, and May. Those conditions include the following:

- A navigation season can be supported only when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
- A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Navigation support will resume when basin composite conservation storage level recovers to Zone 1.
- A navigation season will not be supported when drought operations are in effect. Navigation will not be supported until the ACF Basin composite conservation storage recovers to Zone 1.
- The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrologic conditions, meteorological forecasts, and basin-wide model forecasts. On the basis of an analysis of those factors, USACE will determine if the navigation season will continue through part or all of May.
- Down-ramping of flow releases will adhere to the Jim Woodruff Dam fall rate schedule (see Table 4) for federally listed threatened and endangered species during the navigation season.
- Releases that augment the flows to provide a minimum 7-foot navigation depth will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, because of diminishing inflows, downstream flows and depths must be reduced, notices would be issued to project users to give barge owners and other waterway user's sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Lock and Dam to reduce releases. Although special releases would not be standard practice, they could occur for a short duration to assist navigation during the navigation season. For instance, releases can be requested to achieve up to a 9-foot channel. USACE would evaluate such request on a case-by-case basis, subject to applicable laws and regulations and the conditions above.

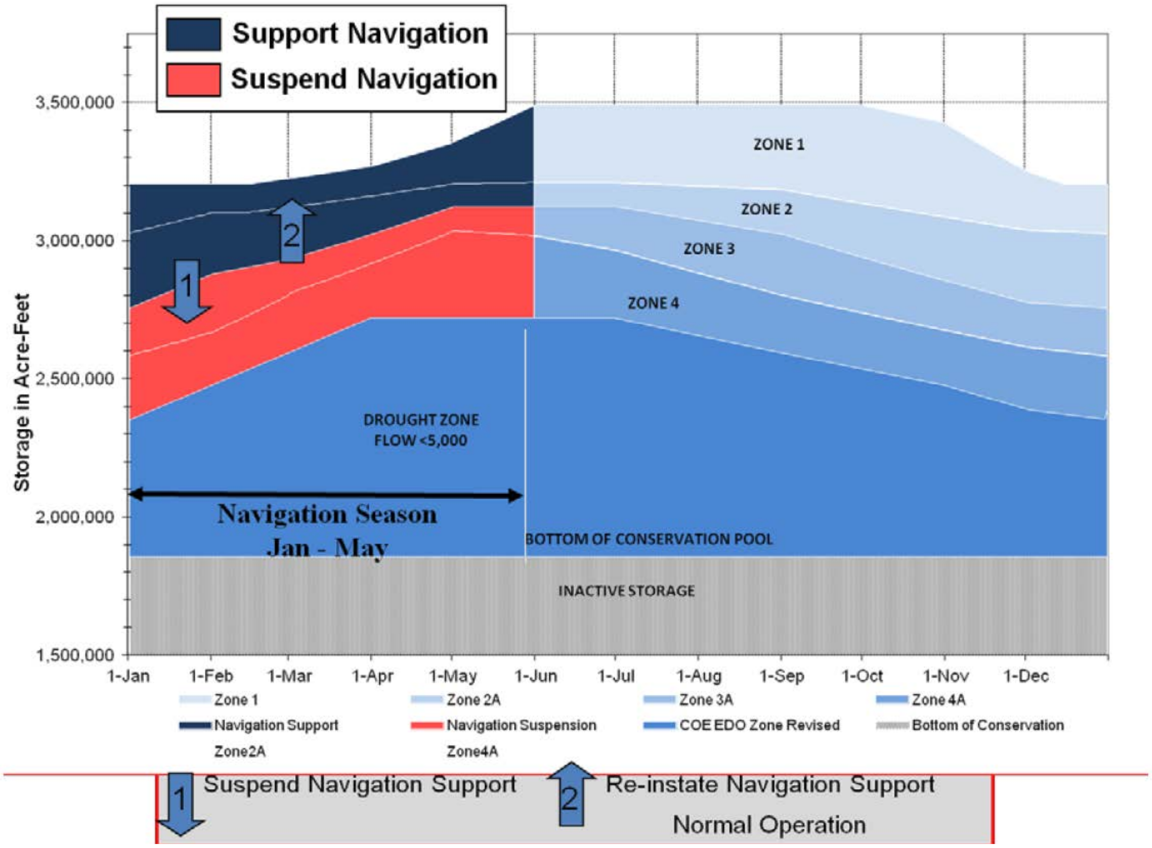


Figure 7. Composite Conservation Storage for Navigation

Fish and Wildlife Conservation

Under the PAA, the current fish spawn or fish passage operations would continue as described in the DEIS (USACE 2015).

Federally-Listed Species—Under the PAA, the USACE would continue to make releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows.

Release requirements dictated by composite conservation storage (Figure 7) would be in accordance with the revised action zones discussed above in the Guide Curves and Action Zones section.

The USACE would manage releases from Jim Woodruff Dam to support the federally- protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. Daily releases to provide support for fish and wildlife conservation from Jim Woodruff Dam are dictated by two parameters: a minimum discharge (measured in cfs) and a maximum fall rate [measured in feet per day (ft/day)]. Minimum discharges from Jim Woodruff Dam would vary according to composite conservation storage (Figure 4), basin inflow per the 7-day moving average, and by month. Table 4 shows these minimum releases, which are measured as a daily average flow in cfs at the USGS gage at Chattahoochee, Florida. During normal and above normal hydrological conditions within the basin, releases greater than the minimum release provisions could occur consistent with the maximum fall rate schedule described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

During the spawning period (March to May), two sets of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in Zones 1 and 2 or composite conservation storage in Zone 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 are also included. The USACE would also operate Jim Woodruff Dam to avoid potential Gulf sturgeon take. Potential Gulf sturgeon take is defined as an 8-foot or greater drop in Apalachicola River stage over the last 14-day period (i.e., considering if today's stage is greater than 8 feet lower than the stage of any of the previous 14 days) when flows are less than 40,000 cfs.

During the non-spawning period (June to November), one set of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in Zones 1 - 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 are also included.

During the winter season (December to February), only one basin inflow threshold and corresponding minimum release (5,000 cfs) would exist while in composite conservation storage Zones 1–4. That would provide the greatest opportunity to refill the storage reservoirs. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions.

When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations are triggered. Within Zone 4, the minimum flow is the same as in Zone 3. When the composite conservation storage drops further into the Drought Zone, the minimum flow from Jim Woodruff Dam is reduced to 4,500 cfs. A description of the drought operations is provided in the Drought Operations section above.

Table 4. Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge for Federally-Listed Species by Month and by Basin Inflow (BI) Rates

Months	Composite conservation storage zone	Basin inflow (BI)a (cfs)	Min. Releases from Jim Woodruff Lock and Damb (cfs)	BI available for storage a
March–May	Zones 1 and 2	☐ 34,000 ☐ 16,000 and < 34,00(☐ 5,000 and < 16,000 < 5,000	= 25,000 = 16,000+50% BI > = BI = 5,000	Up to 100% Up to 50% BI>16,000
	Zone 3	☐ 39,000 ☐ 11,000 and < 39,00(☐ 5,000 and < 11,000 < 5,000	= 25,000 = 11,000+50% BI > = BI = 5,000	Up to 100% Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	☐22,000 ☐ 10,000 and < 22,00(☐ 5,000 and < 10,000 < 5,000	= 16,000 = 10,000+50% BI > = BI = 5,000	Up to 100% Up to 50% BI>10,000
December–February	Zones 1, 2,	☐ 5,000 < 5,000	= 5,000 = 5,000	Up to 100% BI > 5,000
If Drought Triggered	Zone 3	NA	= 5,000d	Up to 100% BI > 5,000
At all times	Zone 4	NA	= 5,000	Up to 100% BI >
At all times	Drought	NA	= 4,500e	Up to 100% BI >

Notes:

a. Basin inflow for composite conservation storage in Zones 1, 2, and 3 is calculated using the 7-day moving average basin inflow. Basin inflow for composite conservation storage in Drought Operations, Zones 3 and 4 or lower (Drought Zone) is calculated using the one-day basin inflow.

b. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

c. Drought plan is triggered when the composite conservation storage falls into Zone 3, the first day of each month represents a decision point.

d. Once drought operation triggered, reduce minimum flow to 5,000 cfs following the maximum ramp rate schedule.

e. Once composite storage falls below the top of the Extreme Drought Zone ramp down to a minimum release of 4,500 cfs at rate of 0.25 ft/day based on the USGS gage at Chattahoochee, Florida (02358000).

The federally-listed species operations of the PAA include a fall rate, also called down- ramping rate, defined as the vertical drop in river stage (water surface elevation) that occurs over a given period of time. The fall rates are expressed in units of ft/day measured at the USGS Chattahoochee, Florida, gage as the difference between the daily average river stage on consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The maximum fall rate schedule is provided in Table 5. When composite conservation storage falls into Zone 3, the drought operations plan would be implemented, the maximum fall rate schedule would be suspended and more conservative drought contingency operations begin. Down-ramping rates are also suspended during periods of prolonged low flow (flows less than 7,000 cfs for a period of more than 30 consecutive days). A prolonged low flow period would be considered over and down-ramping rates would be reinstated when flows are greater than 10,000 cfs for 30 consecutive days. Unless the extreme drought operations described above are triggered, fall rates under drought contingency and prolonged low flow operations would be managed to match the fall rate of the basin inflow.

Table 5. Maximum Down-Ramping (Fall) Rate

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 a	No ramping restriction b
> 20,000 and □ 30,000 a	1.0 to 2.0
Exceeds Powerhouse Capacity (~ 16,000) and □	0.5 to 1.0
Within Powerhouse Capacity and > 10,000 a	0.25 to 0.5
Within Powerhouse Capacity and □ 10,0	0.25 or less

Notes:
a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.
b. For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control the down-ramping rate, and no ramping rate is required.

Recreation

Under the PAA, operations for recreation would remain the same as current operations. Recreation benefits would be maximized at the lakes to the extent possible consistent with meeting other project purposes by maintaining full or nearly full pools during the primary recreation season which are the warm summer months. In response to meeting other authorized project purposes, lake levels could decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 6).

Recreational impact levels are not applicable to the George W. Andrews project due to the lack of conservation storage and the run-of-river operation at the project.

When pool levels must be lowered, the rates at which the draw-downs occur are as steady as possible. The action zones at Lake Sidney Lanier and West Point Lake are drawn down to correlate the line between Zone 2 and Zone 3 near the IIL at the beginning of the recreation season (May through early September). This is an attempt to maximize the time these projects are above the IIL during the recreation season.

Table 6. Recreation Impact Levels for Federal Projects in the ACF Basin

Project	**IILa**	**RILb**	**WALc**
Lake Lanier	1,066 ft	1,063 ft	1,060 ft
West Point Lake	632.5 ft	629 ft	627 ft
Walter F. George	187 ft	185 ft	184 ft

Notes:
a. Initial Impact Level
b. Recreation Impact Level
c. Water Access Limited Level

Water Quality

Under the PAA, Buford, West Point, and Jim Woodruff dams would provide continuous minimum flow releases that would benefit the water quality immediately downstream of the dams. There would be no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen values are observed below the dam, spillway gates would be opened until the dissolved oxygen readings return to an acceptable level. Occasional special releases would also be made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam.

At Buford Dam, the small turbine generator would run continuously to provide a minimum flow from the dam, which would range from approximately 500 to 700 cfs, depending on head conditions. This minimum flow from Buford Dam would help meet the seasonal minimum flow requirements of 650 cfs and 750 cfs at Atlanta, Georgia, in the Chattahoochee River just upstream of the confluence with Peachtree Creek. At West Point Dam, the minimum flow requirement is 670 cfs and a similar small generating unit would provide a continuous release of approximately 675 cfs as measured at the city of West Point. A varying minimum flow from 4,500 to 25,000 cfs, dependent upon basin conditions, would be maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which would assure an adequate water supply for downstream industrial use and water quality. Walter F. George Dam has two siphons on each spillway gate. The siphon discharge could range from about 15 cfs up to 200 cfs when all 12 are in use. Typically, the siphon tubes would be opened continuously from May through the end of September and all would be used at full capacity. The siphons would provide a gravity-fed, typically continuous, minimum flow that would benefit dissolved oxygen levels below the dam.

Water Supply

Under the PAA, the cities of Gainesville and Buford would continue to withdraw water directly from Lake Sidney Lanier under relocation agreements at rates not exceeding 8 mgd (net) and 2 mgd, respectively. Additionally, pursuant to the Water Supply Act of 1958, the PAA would reallocate 252,950 acre-feet in Lake Sidney Lanier for water supply. The amount of storage is estimated to yield 222 mgd during the critical drought (i.e., during the worst drought on record at the time the agreement was executed). The severity and frequency of droughts change over time, therefore, the yield of this storage may change over time. For the purpose of managing water supply storage, USACE would employ a storage accounting methodology that applies a proportion of inflows and losses, as well as direct withdrawals by specific users, to each account. The amount of water that may actually be withdrawn is ultimately dependent on the amount of water available in the storage account, which will naturally change over time.

Under the PAA releases from Buford Dam would be made to accommodate downstream water demands. Peaking hydroelectric power generation generally accommodates most water supply needs of communities currently withdrawing from the Chattahoochee River; however, under the 1946 Rivers and Harbors Act, generation can occur at non-peaking times to meet the downstream water supply needs, not to exceed 379 mgd.

ALTERNATIVES CONSIDERED

The proposed action and alternatives identified in the DEIS make up a portion of the alternatives to the PAA that were considered. They are incorporated by reference. In addition to the alternatives described in the DEIS, the USACE also evaluated six new alternatives. The new alternatives consist of the NAA or PAA water management operations combined with five new water supply options. The new water supply options are based on comments received for the DEIS and the State of Georgia 2015 revised water supply request. None of the new alternatives include the two non-federal water supply reservoirs (Glades Reservoir and Bear Creek Reservoir) considered in the DEIS. Both of the permit applications for these reservoirs have been withdrawn/suspended.

Table 7 describes the six new alternatives considered (1L, 7I, 7J, 7K, 7L, and 7M), as well as alternatives previously described in the DEIS [NAA (1A), 7A, 7B, and the proposed action from the DEIS (7H)]. The PAA evaluated in this document is alternative 7K.

Table 7. New Alternatives Considered Since Publication of the DEIS in October 2015

Water Management Measures			**1A**	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**
Guide Curves	Maintain existing guide curve		X	X	X	X	X	X	X	X	X	X
Action Zones	Maintain existing action zones		X	X								
	Revised Level 1 action zones				X	X	X	X	X	X	X	X
Drought Operations	Drought operations trigger *		Zone 4	Zone 4	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3
	Extreme drought operations		X	X	X	X	X	X	X	X	X	X
	Drought operations suspension trigger *		Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1
Peachtree Creek Minimum Flows	Current (750 cfs)		X	X								
	Seasonal flow (750 cfs / 650 cfs)				X	X	X	X	X	X	X	X
Hydropower Generation	Current generation schedule		X	X								
	Modified generation schedule with drought operations				X	X	X	X	X	X	X	X
Navigation	Current-no navigation operations		X	X								
	4/5 Month				X	X	X	X	X	X	X	X
Basin Inflow	Current computational method		X	X	X	X	X	X	X	X	X	X
Fish and Wildlife	Current fish spawn and passage		X	X	X	X	X	X	X	X	X	X
Listed Species Management	RIOP May 2012		X	X								
	Ramping Rate	Current ramping rate**	X	X	X	X	X	X	X	X	X	X
		Suspend during prolonged low flow			X	X	X	X	X	X	X	X

Table 7. (Continued)

Water Management Measures		**1A**	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**
	Suspend in drought*	X	X	X	X	X	X	X	X	X	X
	Current (seasonal) minimum flow provision**	X	X	X	X	X	X	X	X	X	X
Water Supply Options***	A – No action	L=128 D=277		L=128 D=277							
	B - Relocation contracts only (in Lake Lanier)				L=20 D=277						
	H – GA 2013 (projected return volume for 2035 with Glades Reservoir pumping)					L=185 G=40 D=408					
	I – 225 mgd lake withdrawal, GA 2015 Request Downstream						L=225 D=379				
	J – Future Without Project Condition-Revised							L=20 D=379			
	K – GA 2015 Request								L=242 D=379		
	L – Current lake withdrawals, GA 2015 Request Downstream		L=128 D=379							L=128 D=379	
	M – Option H for Lanier w/o Glades, GA 2015 Request Downstream										L=205 D=379
		1A	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**

Notes:* Based upon composite conservation storage zones (cumulative conservation storage [by zone] for USACE ACF reservoirs [Lanier, West Point, and Walter F. George]).
**Component of the May 2012 RIOP.
***Numbers indicate withdrawals in mgd from Lake Lanier (L), Glades Reservoir (G), and the Chattahoochee River downstream (D) of Buford Dam.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

A fundamental component of the FWCA Report is the evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated. It is standard practice for such analyses to include evaluations and comparisons of long- and short-term future resource conditions with and without the project and for mitigation to be based on projections of future resource conditions (Figure 8).

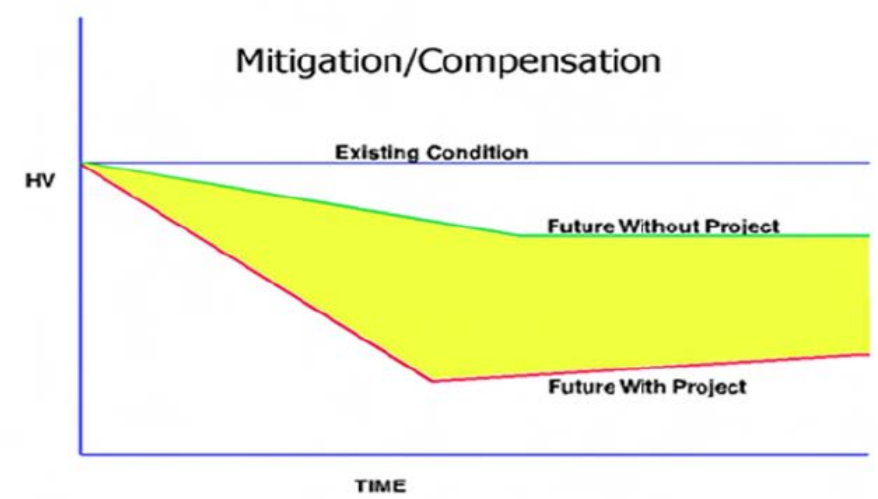


Figure 8. Mitigation and compensation of habitat values (HV) lost for a hypothetical water resource project. Yellow area projects future habitat values lost and mitigation/compensation needs.

The Corps combined multiple changes to operations at Corps projects with increased allocation of water for the Atlanta area in order to formulate the PAA. Although the PAA consists of multiple changes to the existing WCM, the PAA represents a single action (formulation of a new WCM) that describes “the project.” In order to discuss and evaluate mitigation measures, we defined the following terms based on our understanding of the Corps’ actions:

> *Existing condition* is defined as the condition of the system without the modification to existing operations or additional consumptive uses.
>
> *Future without the project* is defined as the condition of the system without changes to Corps projects or additional increases in allocation for the Atlanta area. The future without the project should include forecasts for climate change and increased municipal, industrial, and agricultural consumptive demands from elsewhere in the ACF Basin.

> *Future with the project* is defined as the condition of the system with changes to Corps projects and an increased allocation for the Atlanta area. The future with the project should include forecasts for climate change and increased municipal, industrial, and agricultural consumptive demands from elsewhere in the ACF Basin.

The *existing condition (blue line)* has been modeled by the Corps as the NAA, not including future consumptive demands and climate change. No *future without the Project* (green line) scenario was provided in the Corps' analyses. The *future without the Project* should include existing operations of Corps projects, with projected consumptive demands and climate change. Similarly, the *future with the project (red line)* is not fully represented. The PAA included proposed changes to operations and future consumptive demands through 2040 for the Atlanta area, but did not incorporate basin-wide consumptive demand projections or climate change.

Changes in future resource conditions include changes related to water consumption, water quality, climate change, and associated effects on habitat and biota. For these reasons, we asked the Corps in the 2010 PAL (Service 2010; Appendix V) to include in their modeling efforts multiple future climate scenarios that could affect reservoir levels, river discharges, and estuary inflow. After review of the DFWCAR (2015), the Corps provided further analysis and modeling to address these scenarios (Corps 2015c, Appendix XX). These analyses and modeling efforts were limited to the information available at the time, thus, sufficient to address our previous comments; however, are likely to be insufficient in evaluating future impacts of climate change and changes in water supply demands. Further work is needed in the future to address these developing concerns.

Previously, the Corps did incorporate increased consumptive water use in the Atlanta area in response to the ruling of the Eleventh Circuit Court, thereby incorporating, in part, a component that is necessary to evaluate the *Future with the Project*. Consequently, we have no option but to use the NAA to evaluate future fish and wildlife resources without the PAA, and to use the PAA as a proxy for future with the project.

A multitude of fish and wildlife resources are dependent upon discharge and have been affected by long-term discharge changes. FFWCC provided a summary and comparison of pre-Buford Dam and post-West Point Dam conditions that exhibit discharge and salinity changes in the Apalachicola River and Bay ecosystems (FFWCC 2011; Appendix XI). Apalachicola River and Bay impacts addressed in the FFWCC letter (2011) include:

- Long-term decreases in river flow, especially spring and summer low flows during dry conditions
- Decreases in floodplain inundation and associated changes in forest composition, ichthyofauna, and invertebrates
- Gulf sturgeon spawning and rearing habitat reductions, and population effects as a consequence of barrier construction (JWLD) and flow reductions

- Fish spawning habitat reductions as a consequence of reduced river flows
- Mussel habitat reductions and population effects
- Modeled estuary salinity changes as a response to Apalachicola River discharge changes and upstream flow depletions
- Influence of floodplain organic matter on oyster diet and estuary productivity
- Changes in oyster drill (*Dermocystidium marinum*) prevalence in oysters as a function of estuary inflow and salinity over multiple years.

Negative impacts of current operations on aquatic resources in other portions of the basin include:

- Loss of riverine habitat and fluvial species assemblages, including federally-listed mussel species and Gulf sturgeon that are now thought to be extirpated from the mainstem Chattahoochee River
- Loss of unimpeded passage for migratory fishes
- Fragmentation of aquatic populations in the mainstem and tributaries
- Significantly altered dissolved oxygen and temperature regimes
- Highly altered flow regimes that affect assemblages of riverine aquatic biota in the remaining flowing river segments below dams.

It is reasonable to expect that future conditions exhibiting the cumulative combination of increased population growth, consumptive demands, wastewater input, changes in climate, and continued operation of Federal projects will show increasing impacts to these natural resources. Based on correspondence with the Corps and with the States as part of the FWCA process, we have addressed or are currently addressing the types of impacts that could potentially occur as a consequence of changes in current project operations. The Corps has included projected increases in consumptive uses. Because of future uncertainty associated with consumptive use through-out the basin, comprehensive climate change impacts, and sea-level rise an adaptive strategy is need to address these concerns and better quantify impacts associated with the project.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Project impacts should be identified by comparing future resource conditions under the NAA to future conditions with the Corps' PAA. Impacts can theoretically be beneficial, adverse, or have no appreciable differences, but are limited to fish and wildlife resources that could be affected by Corps project operation changes. Thus, the intent of this section is to describe effects of project operations on biologically relevant parameters. The overall biological interpretation of the results (e.g. descriptions of whether the PAA is beneficial, adverse, or no difference compared to the NAA) is reserved for the *Evaluation of the Selected Plan* section below.

Analyses provided by the Corps prior to the DFWCAR (2015)

In response to the Service's April 2, 2010, PAL, March 1, 2011, PAL addendum, and August 29, 2013, PAL, the Corps completed several requested analyses to support the comparison of the NAA and PAA (Corps 2015a, Corps 2016a, Corps 2016b). The Corps relied on HEC-ResSim to simulate management alternatives and evaluate the resulting effects to reservoir levels, river stages, and river discharge. Our understanding is that calculations of basin inflow from January 1939 through December 2008 were determined and anthropogenically-influenced variables (e.g. consumption levels, reservoir evaporation and release schedules) were used to create synthetic flow and discharge datasets that simulate expected conditions under the NAA and PAA. Datasets through 2008 were used for phase one of the Corps' alternatives formulation; datasets thorough 2011 were subsequently available and were used for phase two of the Corps' alternatives formulation. The phased approach to the Corps' formulation of alternatives is described in greater detail in the Corps' response to the Service's PAL (page 1-4, Corps 2015a).

As with any model, there are limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. As an example, we have provided the results of a statistical and qualitative analysis that evaluates congruency between actual operations as measured by discharge at USGS gages and model output of existing operations (i.e., the NAA) for the comparable post-RIOP period (Service 2011; Appendix XIV). The analysis shows a high degree of similarity for many components of the hydrograph at most locations, but also several exceptions. Statistical differences between measured discharge and modeled discharge for existing operations include:

Chattahoochee at Norcross: pulse duration and frequency, and number of reversals;

Chattahoochee at West Point: pulse magnitude, duration, and rise rate, and number of reversals;

Apalachicola at Chattahoochee: number of reversals.

The intent of HEC-ResSim is not to perfectly replicate existing operations. HEC-ResSim results are particularly useful for comparing trends, not necessarily absolute magnitudes. Therefore, it is recommended to the reader and analyst that interpretation of the aforementioned parameters is focused on data trends, not absolute magnitudes, during comparisons of alternatives.

HEC-5Q was used to model water quality. Impacts assessed at multiple locations throughout the basin using HEC-5Q included effects on dissolved oxygen, water temperature, wastewater, chlorophyll-*a*, reservoir retention time, and phosphorus. For many of the analyses, the Corps evaluated a composite period from 2001-2011, but also extracted a subset of the data to represent dry (2007), normal (2004), and wet (2005) hydrologic year types. Data were further extracted to examine only the months of April or May (depending on the analysis) through October in order to examine effects during critical low flow and fish spawning periods. While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are combined for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months. For example, daily values within a month for modeled chlorophyll-*a* could actually be higher than the values represented on graphs that combine multiple months. We emphasize that this is not a failing of the Corps' analysis, but it does identify an area of investigation for which additional model data are available. We recommend that time series plots also be used (similar to dissolved oxygen plots in Figures 2.2-15 to 2.2-18 of the Corps' 2015 response to PAL) to illustrate variation that is likely to occur.

Using the recommended performance measures included in the Service's PAL (Service 2013; Appendix IX), floodplain connectivity, reservoir fisheries, and Chattahoochee River shoal bass recruitment analyses were performed by the Corps. Federally-protected species analyses on the Apalachicola River included Gulf Sturgeon and freshwater mussels. Effects on shoreline vegetation and wildlife at Eufaula National Wildlife Refuge (NWR), as well as flows at Buford Fish Hatchery were also assessed.

Below, we assess impacts of the PAA relative to the NAA using the Corps analyses. General descriptions of the analyses are presented, but more thorough descriptions of the Corps methodologies and graphical depictions of output may be found in the Corps' response to the Service's PAL (Corps 2015a, Corps 2016a). Values presented below are approximations based on visual interpretations of graphs provided by the Corps.

Post DFWCAR Analyses Provided by the Corps

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

With regards to the water quality analyses provided by the Corps, the FWS states "While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are lumped for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a single month may be obscured by the data associated with all other months". The Corps recognizes that a thorough understanding of the methodology used for the impact analysis is required to make interpretations or draw conclusions and again points out that the impact analyses were provided in accordance with the guidance provided in the FWS's PAL. Time series plots for the various water quality parameters are available and some are provided in the HEC-5Q modeling report included as an appendix to the DEIS.

The Corps also acknowledged there are limitations and caveats associated with model development and use, but does not agree that a misunderstanding of these demonstrates inadequacies of the model or its intended use. The HEC ResSim and HEC-5Q models were evaluated to ensure that they exhibited the tendencies seen in the observed data and that they were sufficient to provide reasonable long-term estimates of water quantity and quality through the ACF system. The central focus of this modeling effort was to enable the EIS team to evaluate the differences in water quantity and quality between a continuation of the no action alternative and the implementation of the proposed action.

The Corps' internal model review process has conducted similar analyses to the one provided by FWS and agrees that the models produce a high degree of similarity for many of the water quantity and quality parameters at most locations. However, as the Corps has explained to FWS on numerous occasions interpreting these differences as a deficiency on the part of the models is inappropriate. The HEC-ResSim and HEC-5Q models were not developed or ever intended to produce outputs that matched exactly the observed data.

Given the multitude of operations variations that have occurred over the period of record when responding to real life situations (equipment malfunctions, gage errors, and approved variances to operating rules) it is not possible to produce such outputs in the HEC ResSim model. In so much as the HEC-ResSim model provides flow data to the HEC-5Q model as an input it is also unreasonable to expect perfect correlation between the water-quality simulated data and the observed data. In addition, since daily discharge data and non-point source loading data are not available, the HEC-5Q model includes assumptions regarding these parameters and these assumptions were coordinated with the appropriate water supply providers and resource agencies to ensure they are reasonable. The benefit of using these models for these impact analyses is that they can simulate flow and water quality data with shared assumptions so that the only modeled difference between the alternatives can be accurately interpreted as impacts associated with a change in operations (ie. Implementation of the proposed action). Given that this is what our respective agencies are trying to evaluate, the Corps believes the models are uniquely qualified and appropriate.

Dissolved Oxygen

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the previously evaluated PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b) are negligible or insignificant.

Suitable dissolved oxygen levels are critical for fish and invertebrates. The Corps' simulation of dissolved oxygen includes 4 measurements per day. The Corps then summarized these data as daily average occurrence plots. Daily average dissolved oxygen values varied along the longitudinal river profile, with May-October median dissolved oxygen values in both the NAA and PAA analyses falling below State standards below Corps projects at Buford Dam, West

Point Dam, and Walter F. George Dam. Generally, dissolved oxygen levels were similar in the NAA and PAA. The largest differences between the NAA and PAA occurred in the dry year (2007) simulation, with the greatest differences below Buford Dam stretching from Atlanta to below Whitesburg on the Chattahoochee River. We emphasize that the results provided by the Corps represent modeled data. Results may differ from observed dissolved oxygen values that occur during similar weather and hydrological conditions.

Buford Dam downstream: The PAA and NAA results were similar. Both were less than the State standard of 6 mg/L at 45% occurrence for the composite 2001-2011 period and 50% occurrence for a dry year (2007). The NAA produced 1.0 mg/L higher dissolved oxygen at the 35% occurrence for both the composite period and a dry year simulation. This represents the largest deviation between the NAA and PAA. Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L.

Norcross: The PAA and NAA results were similar and generally remained above the 6.0 mg/L State standard, except for approximately 2% of both the composite (2001-2011) and dry (2007) modeled period.

Morgan Falls: The PAA and NAA results were similar and remained above the 6.0 mg/L State standard, except for <1% of the composite (2001-2011) modeled period.

West Point Dam downstream: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~38% occurrence for the composite (2001-2011) period and dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 1.7 mg/L.

Bartletts Ferry: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~32% occurrence for the composite (2001-2011) period and dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L. However, it should be noted that this modeled data will not likely accurately reflect dissolved oxygen values in Bartletts Ferry tailrace. As a result of Georgia Power Company (GPC)'s recent Federal Energy Regulatory Commission (FERC) relicensing process, GPC has recently initiated installing stoplogs to improve dissolved oxygen levels in their tailrace during summer months each year (FERC 2014). GPC's monitoring results to date indicate dissolved oxygen levels in Bartletts Ferry tailrace meet State water quality standards as a result of this methodology.

Walter F. George downstream: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~25% occurrence for the composite (2001-2011) period and 35% occurrence for the dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps acknowledges that low dissolved oxygen (DO) levels exist downstream from Buford Dam and the potential for impacts; however, the Corps reiterated that simulated differences between the PAA and NAA were small and the consequences of low DO would exist with the proposed action (PAA), or without the proposed action (NAA).
2) The Corps acknowledged that DO levels are depressed downstream of Buford Dam and West Point Dam as a result of hydrolelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas resulting from low DO conditions. Further, past efforts have been made to minimize such impacts.
3) As previously discussed with the FWS, studies to consider structural modification to the federal project in order to improve DO and/or operational changes that result in serious impacts to one or more authorized project purposes (eg. significant reducing or eliminating hydropower operations) are outside the scope of the WCM update. Furthermore, these actions would require additional study authority and appropriation.

<u>Water Temperature</u>

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the previously evaluated PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b) are negligible or insignificant.

Alteration of water temperature can greatly affect the persistence and abundance of aquatic species in a given location. Most notably, suitable water temperatures are critical for reproduction. Simulated water temperature for the NAA and PAA varied along the longitudinal river profile, with the largest temperature drops below Buford Dam (17 °C) and West Point Dam (3 °C) for modeled period between 2001-2011 in May through October. The NAA and PAA model results were similar along the longitudinal river profile in wet, dry, and normal years and in the 2001-2011 composite from May through October, with modeled warmer water temperatures (less than 1°C) most spatially prevalent in normal and dry years.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps agrees with the statements regarding the importance of water

temperatures and with the conclusion that slight differences exist between the NAA and PAA.
2) However, the Corps questions the slight difference (0.25-0.5°C) is biologically significant in the reach below Buford Dam and Norcross.
3) The Corps indicates that contrasting statements were made within the DFWCAR concerning the desire to both support a coldwater sport fishery (eg. non-native trout) and suitable conditions for warmer water species (eg. shoal bass) below Morgan Falls.

<u>Wastewater</u>

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the previously evaluated PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b) are negligible or insignificant.

In the absence of quantitative models that describe water quality changes in response to flow management alternatives, percent wastewater can serve as a proxy. As percent wastewater increases, wastewater-associated substances are expected to increase along with negative impacts to the aquatic environment. Simulated average stream percent wastewater from May through October varied along the longitudinal river profile, with the largest percent wastewater between Atlanta and West Point Dam (the maximum reported NAA value was 28% wastewater for the 95% occurrence value) and below George W. Andrews Dam (the maximum reported NAA value was 28% wastewater for the 95% occurrence value) for the 2001 - 2011 composite period. Similar trends were observed in representative wet, dry and normal years. Percent wastewater in the PAA was approximately 15% greater than the NAA in the river segment between Atlanta and West Point Dam, making average conditions under the PAA more similar to drought conditions under the NAA. These trends persist along the longitudinal river profile, but the magnitude of the differences between the NAA and PAA decline in a downriver direction.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps believes that the HEC-5Q water quality model sufficiently describes water quality changes relative to flow management alternatives.
2) 2) The Corps agrees that evaluating percent wastewater would provide valuable insight for interpreting water quality data.
3) The Corps acknowledges the high percent of wastewater observed between Atlanta and West Point Dam under the PAA simulation, especially at low flow levels.
4) The Corps agrees that improved treatment and conservation measures are needed in

the future and could alleviate some of the negative impacts to the aquatic system.

Chlorophyll *a*

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Chlorophyll-*a* is correlated with algal biomass. Because algal mats can cause nuisance conditions in lakes and river shoals, it is often considered to be undesirable. Chlorophyll-*a* is also an indicator of eutrophication, stemming from increases in organic matter or nutrients and potentially causing water quality problems. Simulated chlorophyll-*a* varied along the longitudinal river profile during the April through October modeled period, with peak concentrations in reservoirs. Similar trends were observed in the 2001-2011 composite and in the wet, dry, and normal years. Results were similar between the NAA and PAA, with any differences between the two resulting in higher chlorophyll-*a* values as a result of the PAA. However, in dry and normal years, as well as for the composite period, the PAA 95% occurrence had daily average algal concentrations 1-5 μg/L higher than the NAA in Walter F. George Reservoir, West Point Reservoir and Bartletts Ferry Reservoir. The 50% and 5% occurrences for the NAA and PAA in the composite period and all year types were similar.

In their comments on the Service's DFWCAR (GDNR 2015; Appendix III), GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from nutrient loading. They state that algal mats and fish kills related to chlorophyll-*a* have not historically been a problem at Lanier Reservoir or Walter F. George Reservoir, and that the nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. If not at critical levels, GDNR states that an increase could lead to increased biomass and improved fishing within these three reservoirs. GDNR states that when classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps acknowledge that increased water withdrawals from the Chattahoochee River to meet consumptive demands of Atlanta would result in a corresponding increase in treated wastewater returns downstream from Atlanta.
2) These increases would result in additional nutrient loading, that would have adverse effects on water quality, and would be reflected as increased Chlorophyll-a.

3) The Corps questions the biological significance of a 1-5 ug/L increase in Chlorophyll-a; and notes that this may be beneficial to the downstream reservoir fishery.

Reservoir Retention Time

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

We requested average summer retention times at each Corps reservoir. Data were provided in hard copy, tabular format for each month. Reviewing a subset of the data, June through August retention times at West Point Reservoir was generally similar between the NAA and PAA between 2001 and 2011. However, qualitative evaluation of the PAA showed higher retention times in 2002 (max= 9 days higher in August), 2006 (max= 42 days higher in July), 2008 (max= 5 days higher in August), and 2009 (max= 27 days higher in August).

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, data demonstrated that the PAA would increase average summer retention time at Lake Lanier by 6 days; at West Point Lake by 3 days; one additional day at Walter F. George, and no difference in average summer retention time at George W. Andrews or Lake Seminole.

Phosphorus

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Algal growth is stimulated by increases in phosphorus. Total phosphorus loads over the modeled period (2001-2011) at both of the selected locations, the headwaters of West Point Reservoir and Walter F. George Reservoir, both increased in the PAA when compared to the NAA. Simulated total phosphorus varied along the longitudinal river profile, with peak concentrations downstream from Atlanta and Columbus. Similar trends were observed in the 2001-2011 composite and in the wet and dry year longitudinal profiles; a normal year longitudinal profile was not included. Results were similar between the NAA and PAA during the composite period and within each year type; however, any differences observed between the PAA and NAA resulted in higher total phosphorus levels in the PAA analysis. Model output frequently produced concentrations 0.01-0.03 mg/L greater in the PAA analysis than the NAA analysis in the composite period and up to 0.05 mg/L greater during a dry year.

In their comments on the Service's DFWCAR (GDNR 2015; Appendix III), GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from nutrient loading. They state that algal mats and fish kills related to phosphorus have not historically been a problem at Lanier Reservoir or Walter F. George Reservoir, and that the nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. If not at critical levels, GDNR states that an increase could lead to increased biomass and improved fishing within these three reservoirs. GDNR states that when classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps acknowledges and agrees that the PAA will result in increased Phosphorus throughout the river system. The higher phosphorus observed between Atlanta and West Point Dam under the PAA simulation was expected because of greater wastewater return associated with greater water consumption.
2) Improved treatment and conservation measures in the future could alleviate some of the negative impacts associated with elevated Phosphorus on the aquatic ecosystem.
3) Though some reservoir fishery benefits may result from elevated nutrient loads, the Corps acknowledges and agrees that increased Phosphorus loads would be considered a negative impact.

Floodplain Connectivity

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. However, as part of the current consultation under section 7 of the Endangered Species Act, these data are being re-evaluated to better represent impacts to listed species.

The Apalachicola River and floodplain ecosystems depend on seasonal flooding and connectivity to maintain forest community structure, ensure availability of spawning and rearing habitats, export detritus and nutrients to fuel higher trophic levels in the river and estuary, and support biodiversity in the region. Floodplain connectivity can result in functions such as regulation of soil and water chemistry, flood storage and displacement of energy, and carbon sequestration. Consequently, effects of project operations on the frequency, magnitude and timing of floods were evaluated. The Service developed the Floodplain Spawning Habitat Performance Measure

(FSHPM) to assist in this evaluation. The measure calculates the maximum amount of spawning habitat available for at least 30 consecutive days during the months of April through October. It is unclear whether the Corps used the FSHPM to develop the graphical comparison. As described by the Corps, it is unknown whether they calculated *consecutive* days. The Corps used the period from April through September, not April through October as specified by the FSHPM. We suspect that the results would be similar, but clarification and corrections should be made. The annual maximum 30-day growing season floodplain connectivity is the same for the NAA and PAA for the April through September period, with the exception of slightly higher connected acreage at the 80th percentile of years.

The State of Florida previously suggested that LIDAR (Light Detection and Ranging) data were available and should be used in this analysis. We agree that LIDAR data likely would be informative, especially regarding quantification of acreage connected at a range of discharges in the Apalachicola River. However, given that the NAA and PAA exceedance curves are nearly the same, we do not expect that using LIDAR data would lend additional insights.

Chattahoochee River floodplain connectivity would be expected to be nearly the same between the NAA and PAA. Conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain. Therefore, we do not expect differences in floodplain inundation in the Chattahoochee River.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps noted that information provided had inadvertently been labeled as the seasonal period being from April thru September as opposed to October. This labeling error did not affect the analyses.
2) The Corps agrees that little difference in floodplain connectivity in the Chattahoochee River exists between the PAA and NAA.

Reservoir Fisheries

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

The Reservoir Fisheries Performance Measure (RFPM) was used to quantify the effects of the NAA and PAA on reservoir fisheries for the entire period of record. The RFPM uses the acreage of productive zone inundated for more than 30 days during the spawning season, and gives weight to inundated habitats that have potentially been colonized by terrestrial vegetation. The RFPM is fully described in the Service's PAL (Service 2013; Appendix IX). Differences between the NAA and PAA are small at each Corps reservoir (Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir). Results from the reservoir retention time analysis (2001-2011) indicate that there may be an improvement in reservoir fisheries in some years, given that retention times may increase and reservoir fisheries may respond positively.

GDNR expressed concern to the Service regarding use of the RFPM. Concerns included a) additional analyses that rely on more current fisheries data could lend additional insights, b) the length of time necessary for terrestrial vegetation to colonize previously exposed shoreline may be longer than allowed for in the performance measure, representing a potential future refinement, and c) giving extra weight to re-inundated habitat could be construed as a recommendation to intentionally reduce reservoir levels.

We generally agreed with the first concern, if more current fisheries data were to be provided. However, in GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III) they state that the currency of the data may not be the issue as the datasets span a 20+ year timeframe. Instead, the ability of currently-used sampling gears may be limited for this particular data need.

Based on GDNR's observations, we also agree that the length of time necessary for terrestrial vegetation to colonize previously exposed shoreline may be longer, especially for Lanier Reservoir. With regards to weighting re-inundated habitat, the process that was originally used to define optimal reservoir levels for fisheries (the Delphi process) included the following expert opinion from biologists in Georgia, Alabama, and Florida representing State wildlife agencies, power companies, universities, the Service, and the Corps:

> "The fisheries experts noted throughout the survey process that reservoir levels are only part of what affect reservoir fisheries. Spawning will take place at a number of reservoir levels and what matters most are fluctuations from that level, with avoidance of drawdowns during spawning (and rearing) being paramount. However, ideal reservoir levels for spawning (usually full-pool) ensure that the greatest spawning area is available for fish."

The 2013 RFPM takes drawdowns into account by calculating the "minimum" elevation and acreage continuously available for at least 30 days per year. Fluctuations above the minimum do not provide benefits, and 'dips' below the minimum count against the measure for that year. Thus, years with more continuously inundated acreage are considered better and are quantified as such in the performance measure. Finally, the Delphi approach emphasized maximizing "spawning area," but relied on expert opinion to derive water levels and effects of lower levels. The 2013 RFPM improved upon the Delphi approach by using a direct measure of acreage in the calculation.

Following a meeting requested by GDNR (January 15, 2015), we further investigated GDNR's concern regarding the inclusion of re-inundated acreage. We compared RFPM results from existing operations to the alternative submitted by the Service using both including and excluding re-inundated acreage. We found that both alternatives produce similar RFPM results. However, differences between averages and medians for including versus excluding re-inundated acreage techniques, although relatively small, can potentially lead to divergent conclusions regarding the effects to reservoir fisheries.

We requested that GDNR compile information and draft correspondence that can be used to refine the RFPM on January 15, 2015. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they state that most of their concerns surround the use of a single metric for three very different reservoirs (Lanier, West Point, and Walter F. George Reservoirs). Most of the fish habitat at Walter F. George Reservoir is in the form of submerged and emergent aquatic vegetation, versus Lanier Reservoir, and similarly West Point Reservoir, in which the majority of the flooded vegetation is terrestrial. Therefore, reservoir operations may have differing responses to vegetative growth in each of the three reservoirs. We would like to work with GDNR to incorporate refinement to the RFPM. We continue to recommend use of the RFPM until new information is developed and incorporated as appropriate.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps utilized the Reservoir Fisheries Performance Measure workbook developed by the FWS
2) The Corps agrees that there would be the potential for actual differences between the two alternatives in reservoir fishery habitat and guilds.

<u>Riverine Fisheries</u>

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

The riverine fisheries analysis includes comparisons to the Service's ecosystem flow guidelines (Service 2011; Appendix VI) and the Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM) (Service 2013; Appendix IX).

Instream Flow Guidelines:

The exceedance graphs supplied by the Corps are not calculated in a manner that is comparable to the Service's ecosystem flow guidelines. The Corps has indicated that they will not be providing additional analyses of the NAA and PAA in the manner requested by the Service. If we have the time to produce comparisons between the NAA and PAA using the ecosystem flow guidelines, they will be integrated in subsequent Service reports.

Chattahoochee River Shoal Bass Recruitment:

The status of Shoal Bass in the Chattahoochee River between West Point Reservoir and Atlanta is less studied than in Chattahoochee River tributaries and the river near Morgan Falls Dam, although habitat appears suitable. Shoal Bass are a warmwater species of black bass native to the ACF Basin; because water temperatures increase to a level that could support a warmwater fishery in river shoals of the mainstem Chattahoochee River from Morgan Falls Dam to West Point Reservoir, Shoal Bass are of interest to natural resource managers. Their co-occurrence with other warmwater species may make them a useful sentinel species for warmwater fish communities. The CRSBPM (Chattahoochee River Shoal Bass Performance Measure) relies on the relationship between Shoal Bass recruitment and water temperature in the spring (Service 2013; Appendix IX). Water temperature decreases as flow increases. The CRSBPM shows that the PAA results in higher abundance (catch per unit effort) of shoal bass than the NAA.

The CRSBPM is used to quantify effects of the NAA and PAA on shoal bass recruitment from Morgan Falls Dam to West Point Reservoir. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they state that using water temperature as the driving factor related to shoal bass abundance is appropriate for the upper stretch of the Morgan Falls tailwater. They state that thermal impacts below Peachtree Creek are likely minimal to shoal bass reproduction and recruitment in normal years. Despite this, shoal bass abundance appears to be limited between Peachtree Creek and West Point Reservoir and it is possible that there are additional limiting factors that should be addressed and considered when using the CRSBPM to inform flow regimes. GDNR states that this measure should be updated as new information becomes available.

It should be noted that the CRSBPM results generated by the Corps use simulated water temperatures from the HEC-5Q model. HEC-5Q provides consistently lower values for seasonal mean temperatures (~2° Celsius at flows less than 1000 cfs) than observed data at Atlanta (Corps 2014); the CRSBPM developed by the Service used observed data. Although HEC-5Q produces lower temperatures as a function of discharge than the Service's methodology used to develop the CRSBPM, the Shoal Bass abundance trend should remain the same.

The Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps agrees with the revised low and high flow guidelines based on the pre-

dam gage data, or simulated pre-dam conditions where gage data is unavailable.

2) The Corps agrees with the Service-proposed revised seasonal guidelines (PAL, 2015). The Service used monthly lower limits, dry year, average year, wet year, and upper limits. These guidelines provided an appropriate evaluation of the NAA and PAA.
3) The Corps believes the use of simulated water quality data, as opposed to actual observed data, provides for a more robust analysis.
4) The Corps agrees that the PAA results in a higher abundance of shoal bass than the NAA.

<u>Federally-protected Species in the Apalachicola River</u>

As of this date, through Section 7 of the Endangered Species Act, this project is being reviewed through consultation. Because the process is ongoing between the Service and the Corps of Engineers (Panama City FO; COE/SAD/Mobile) revised metrics may be developed to evaluate impacts of the proposed action on federally listed species and associated critical habitat. The information provided below is based on previously evaluated metrics.

Gulf Sturgeon:

The following analyses were requested in the Service's 2010 PAL (Appendix V) and recommended in the Service's 2013 PAL (Appendix IX). In addition, the Service's 2013 PAL also recommended use of the Sturgeon Spawning Habitat Performance Measure (SSHPM. Following the analysis descriptions below (in italics), we provide a summary of available information and identify remaining information gaps.

Frequency (% of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning. The Service's 2013 PAL provided the SSHPM as an addition to the analyses recommended in the Service's 2010 PAL. The Corps indicated that they used the SSHPM and concluded that there were no differences between the NAA and PAA based on the median annual spawning habitat availability. The SSHPM results were not provided to us, so we are unable to evaluate effects beyond the median at this time.

Frequency (% of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning. The SSHPM computes the annual spawning habitat available for 30 days, and plots the distribution of annual spawning habitat as boxplots. The distribution of data displayed by the SSHPM informs interpretation of annual spawning acreage frequency. Therefore, the SSHPM results should be prepared, shared, and incorporated to help inform an interannual analysis of sturgeon spawning habitat effects.

Daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. Regarding daily fall rates, the Corps referenced the daily fall rate results provided for mussels. Mussel fall rate results are specific to flows less than 10,000 cfs all year for every year. Furthermore, as referenced in the Service's 2013 PAL, the maximum amount of sturgeon spawning habitat available occurs between 10,000 and 50,000 cfs, a range not encompassed by the fall rates computed for mussels. We recommend that the analysis be specific to the sturgeon spawning and early life stages that include the larger range of flows that encompass sturgeon spawning.

Maximum number of consecutive days per year less than 16,000 cfs. The Corps referenced the mussel analysis that evaluates the maximum number of days per year with flows less than 10,000 cfs. The maximum number of consecutive days <16,000 cfs was calculated because discharges <16,000 cfs cause estuary salinity levels to increase above 10 ppt at some locations, thereby creating suboptimal conditions for juvenile Gulf Sturgeon growth at those locations. This analysis was not provided and therefore, we cannot evaluate differences between the PAA and NAA for this metric.

Departures from average water temperatures between March 1st to May 31st. The Corps referenced the HEC-5Q water temperature differences from the NAA, for a year-round composite period (2001-2011). Other data referenced by the Corps include analyses during May-October for a composite period (2001-2011) and all year types. These analyses show no difference between the NAA and PAA below JWLD. Although the March 1st to May 31st period wasn't specifically evaluated, these results suggest that there are no temperature differences in average water temperature between March 1st and May 31st.

Freshwater Mussels:

Low flows in the Apalachicola River have the potential to reduce habitat, and expose and strand freshwater mussels. Lower flows may result in changes in flow energy, dissolved oxygen, water temperatures, and differences in availability of suitable substrate and food. Thus, we requested that the Corps provide several low flow analyses, similar to those provided in the 2008 and 2012 biological opinions (Service 2008, Service 2012). The following analyses were requested in the Service's 2010 PAL (Appendix V) and were recommended again in the Service's 2013 PAL (Appendix IX). The Service's 2013 PAL also recommended use of the Apalachicola River Mussel Performance Measure (ARMPM), which is included in the analyses below. Following the analysis descriptions below (in italics), we provide a summary of available information.

Lowest daily flow for each year. The effects to mussels are more extreme at the lower range of flows. In the Apalachicola River, federally-listed mussel species are generally known to occur from JWLD [located at approximately River Mile (RM) 106] down to lower reaches, with the highest densities currently located from approximately RM 50 to RM 34. When considering flows less than 6,000 cfs, PAA annual minimum flows were lower than the NAA by more than 50 cfs in 10 years, greater in 5 years, and similar in 11 years. When considering the entire period of record (1939-2011), the PAA resulted in lower annual minimum flows than the NAA in 38 years, identical annual minimum flows in 13 years, and greater annual minimum flows in 22 years. During the 2007 drought, PAA flows were projected to be lower (4,550 cfs) than the NAA (5,050 cfs). These results demonstrate that overall annual minimum flows under the PAA are lower, and in droughts they are likely to be more extreme.

Inter-annual frequency of flows less than 5,000-10,000 cfs;
Maximum number of days per year with flows less than 5,000 – 10,000 cfs; and
Maximum number of consecutive days less than 5,000 – 10,000 cfs. These three metrics showed similar trends. The percent of years when flows were below 5,000-6,000 cfs, 6,000-7,000 cfs, and 7,000-8,000 cfs is greater under the PAA. The maximum number of days/year and the maximum number of consecutive days per year that flows are less than 5,000 cfs is approximately 35 days greater under the PAA. These results demonstrate that the PAA results in more frequent lower flows that remain low for longer periods compared to the NAA, thereby creating conditions that could increase mortality of both common and federally-listed mussels.

Median number of days per year less than 5,000 – 10,000 cfs; and
Median number of consecutive days per year less than 5,000 – 10,000 cfs (added to the ARMPM). The PAA and NAA were similar, although at flows between 7,000-10,000 cfs the PAA had a slightly greater median number of days per year. Because the median is a measure of central tendency, these results demonstrate that the PAA and NAA perform similarly when considering a large range of hydrologic year types. However, the PAA's trend of slightly lower medians in relation to the NAA mirrors that of the previous set of metrics, thereby creating conditions that could increase mortality of both common and federally-listed mussels.

Frequency (percent of days) of daily stage changes (ft/day); and
Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs. River stage fall rates were examined because rapidly declining river stages have the potential to increase the risk of mussel exposure and stranding. The Corps did not evaluate the former, which includes the entire range of flows, because federally-listed mussels generally do not occur at stages higher than those equivalent to 10,000 cfs. The Corps' histogram comparing fall rates for the NAA and PAA for the modeled period of record (1939-2011) below JWLD when releases are less than 10,000 cfs indicate a high degree of similarity, with the $\leq$ 0.25 ft/day category comprising the largest proportion of fall rates. The NAA had approximately 450 more days when fall rates were $\leq$ 0.25 ft/day. The PAA had approximately 400 more days in the higher fall rate categories compared to the NAA. Collectively, the fall rate results indicate that the PAA results in flows that have a higher potential to strand mussels. These results may reflect the Corps' fall rate modification as part of the PAA. When basin inflow has been less than 7,000 cfs for 30 days, the use of the 0.25 ft/day fall rate will be suspended and will be resumed when basin inflow has been greater than 10,000 cfs for 30 days. The slow rate of federally-listed mussel recolonization into re-inundated habitat means that few mussels occupy habitats that were exposed over the previous 30 days. Slow ramping rates for

declining flows that would expose these recently re-inundated habitats may provide limited benefits to mussels, and may come at a cost to reservoir storage.

National Wildlife Refuges and Fish Hatcheries

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

The Service requested several analyses of impacts to Eufaula National Wildlife Refuge (NWR) and hatcheries (Service 2010; Appendix V), and an evaluation of potential management options that could benefit Eufaula NWR. In response to that request, the Corps provided the following (Corps 2015a, Corps 2016a):

> *Eufaula NWR:* "The USACE considered the USFWS request to cycle Walter F. George Lake between the highest levels (190 ft) in late winter/early spring to the lowest levels (185 ft) in late summer to accommodate Eufaula National Wildlife Refuge operations (Figure 2.8-1). As proposed, the option would require operation of the reservoir at its highest pool levels during winter-spring, when flood releases are typically the greatest. That would reduce the ability of the project to attenuate approximately 87,000 ac-ft of potential downstream flooding. By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased, resulting in bank erosion and channel modifications below the project. Similarly, to operate the project at its lowest levels during the summer is contrary to what is required to meet the highest demands for recreation, hydroelectric power, and flow augmentation. Essentially, such an option would remove Walter F. George Lock and Dam from the system approach to operations across the basin and eliminate approximately 100,000 ac-ft of conservation storage that could be used to meet authorized project purposes in the summer. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant adverse effects on the authorized project purposes and the structural stability and safety of the dam. For these reasons, operations to manage Walter F. George Lake to benefit the Eufaula Wildlife Refuge operations were not considered further."
>
> *Fish Hatcheries:* "Four major fish hatcheries are in the ACF Basin. Buford Trout Hatchery is the only fish hatchery in the ACF Basin that relies on surface flows for its operations, and it is the largest user of water. Changes in flow on the

> Chattahoochee River are negligible between alternatives, and would not be expected to affect operations at the Buford Trout Hatchery (Figure 2.8-3)."

Buford Trout Hatchery withdraws about 7 mgd (11 cfs) of flow from the Chattahoochee River below Buford Dam year-round (Corps 2011). In their comments on the DFWCAR, GDNR has clarified that this is a pass-through system and the net withdrawal of water is limited to evaporation, thus is negligible on downstream flows (GDNR 2015; Appendix III). It appears from the Corps' analysis of median daily flows below Buford Dam that changes in flow are negligible between alternatives; however, the period of record is not specified but should be provided. We also suggest that flows below the median be analyzed, as they are more likely to impact the hatchery than median flows. The results of the HEC-5Q water quality modeling indicate only minor changes in water temperature and dissolved oxygen at this location as a result of the PAA in comparison to the NAA.

Analyses of Apalachicola Bay

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. However, as part of the current consultation under section 7 of the Endangered Species Act, these data are being re-evaluated to better represent impacts to listed species and other at-risk species. Though data are not currently available, other studies evaluating impacts to Apalachicola Bay are ongoing (Paramygin and Sheng, 2015, and others).

We used a combination of sources to evaluate effects to Apalachicola Bay. The Corps provided the Apalachicola Bay salinity model results from HydroLogics (2012) that included a comparison between the RIOP and proposed changes to the RIOP described in the February 2012 Biological Assessment by the Corps of Engineers. HydroLogics found very limited differences between the two operational scenarios. The Service previously relied upon the University of Florida's 3D hydrodynamic salinity modeling for Apalachicola Bay to interpret effects to salinities, oysters, and juvenile sturgeon. Because of the length of time necessary to conclude the University of Florida 3D hydrodynamic salinity modeling in Apalachicola Bay, it was not possible to include those results in this report. However, if results become available, we will provide them in the future. In place of those results, however, we identify three lines of evidence that suggest differences between the NAA and PAA:

1) The Apalachicola Bay Salinity Performance Measure (ABSPM) shows no difference in salinities between the NAA and PAA at Cat Point and Dry Bar, but a 1.0 ppt increase in the median salinity at East Bay;

2) Low flows in the Apalachicola River at the Chattahoochee gage are lower in the PAA than in the NAA. Differences in low flows most likely manifest themselves in relatively

minor salinity shifts, but may exceed salinity thresholds for juvenile Gulf Sturgeon and oysters; and

3) The range of flows used previously in the hydrodynamic salinity model [2011 Alternative 2 (Alt2)] are similar to the PAA, and the 2011 Alt2 resulted in slightly slower, but nearly identical, oyster growth rates at Cat Point compared to the 2011 NAA. It also resulted in lower acreage suitable for juvenile sturgeon compared to the 2011 NAA. Each of these lines of evidence is treated in the subsections below.

ABSPM. The ABSPM is described fully in the Service's 2013 PAL (Appendix IX). In that document we state, "Differences among the alternatives that we have analyzed to date are relatively minor. This may be due to the coarse temporal scale of the metric or the possibility that substantial changes in the bay salinity metric require large amounts of water..." We continue to view the ABSPM as a coarse metric and expect that additional statistical approaches currently unavailable to us may help the Corps and Service decipher whether different results are *statistically* different or meaningful. We also suggest that fine resolution models of bay salinities also show little salinity difference between alternatives previously considered (Sheng et al. 2011; Appendix XII). The Service calculated the ABSPM using the Corps' 2015 data. Results show that there is no predicted salinity difference between the PAA and NAA at Cat Point or Dry Bar, and a 1.0 ppt increase in the median at East Bay (Figure 9).

Estuary inflow analysis. Salinities in the estuary increase as Apalachicola River discharge decreases (Service 2013; Appendix IX). We evaluated changes in estuary inflows using results from the ARMPM which specifically evaluates differences between the NAA and PAA at a range of low flows. A description of the results is provided in the freshwater mussel section. The salinity difference between inflows of 5000 cfs and 8000 cfs is 1.6 ppt at Cat Point, 1.5 ppt at Dry Bar, and 2.6 ppt at East Bay (Table 8). We stress that the trend lines upon which the salinity estimates are based account for a large proportion of the variance in the discharge salinity relationship. However, the University of Florida 3D modeling should provide a better spatial depiction and quantification of impacts to salinity throughout the estuary. That said, although it appears that changes in discharge at low flows manifest themselves in relatively minor salinity shifts in magnitude at these monitoring points, these shifts may exceed the salinity thresholds we identified in our 2013 PAL (Service 2013; Appendix IX).

Table 8. Apalachicola Bay salinities (ppt) predicted by the salinity-discharge relationships in the ABSPM.

Chattahoochee Gage Discharge (cfs)	Cat Point	Dry Bar	East Bay
5000	26.6	25.0	15.6

6000	26.1	24.5	14.6
7000	25.6	24.0	13.8
8000	25.0	23.5	13.0
9000	24.6	23.0	12.2
10,000	24.1	22.6	11.5

Hydrodynamic salinity model. During the evaluation of alternatives in 2011, we used a 3D curvilinear-grid hydrodynamic salinity model to simulate the flow and salinity dynamics inside Apalachicola Bay (Sheng et al. 2011; Appendix XII). The modeling effort (described below) that we anticipate including in this report is the same as the one developed in 2011, but with a revised inflow dataset. The 2011 salinity modeling considered years 1999-2008. The range of flows used previously in the hydrodynamic salinity model (2011 Alt2) are similar to the 2015 PAA. Using the inflow data from the 2011 modeling, we compared estuary salinities (from the ABSPM) to the 2015 PAA for the 1999-2008 period of record. We found that the 2015 PAA produced similar salinities to those generated from the 2011 Alternative 2 based on salinity responses at Cat Point, Dry Bar, and East Bay (Figure 10). Consequently, we expect that the 3D salinity model for the 2015 PAA may produce similar salinity and oyster growth rate results as the 2011 Alt2. The 2011 Alt2 3D salinity model resulted in slightly higher, but nearly identical, salinities at Cat Point and Dry Bar. Salinity changes resulted in a 0.10 mg ash free dry weight (AFDW)/oyster/day decreased growth rate (a 7.1% decrease) at Cat Point compared to the NAA, and a 0.02 mg AFDW/oyster/day increased growth rate (a 0.8% increase) at Dry Bar (based on a comparison of means for all months). It also resulted in less acreage considered suitable for juvenile sturgeon at Cat Point and Dry bar during dry, average, and wet years. Effects to juvenile Gulf Sturgeon in East Bay were not evaluated using the 3D hydrodynamic salinity model because the model over-predicts salinities in East Bay (Sheng et al. 2011; Appendix XII).

The following information was included in the Service's 2011 DFWCAR and is relevant to the interpretation of Apalachicola Bay salinity modeling and oyster and sturgeon responses:

> "The model showed satisfactory performance with observed salinity collected by the Apalachicola National Estuarine Research Reserve in 2004. Specific details on model development and performance are provided in the report. The authors also developed an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it with the hydrodynamic-salinity model to assess the impact of freshwater alteration on oyster populations in Apalachicola Bay. Four discharge scenarios were considered in the 10 year (1999-2008) simulations: 1) observed data from the USGS gaging station 02359170 near Sumatra, Florida, 2) no action alternative (i.e., current operations), 3) proposed alternative minimum flow scenario 1 (550 cfs target at Peachtree Creek), and 4) proposed alternative minimum flow scenario 2 (750 cfs target at Peachtree Creek).

The Service requested that the authors provide various analyses of model output specific to oysters and Gulf sturgeon with the assumption that optimal salinities for oysters are less than 26 ppt (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Sulak et al. 2009). To assess the impacts of the four discharge scenarios on oysters, we requested that comparisons be made at Dry Bar (an oyster bar with strong river influence) and Cat Point (an oyster bar with little river influence). These analyses included salinity exceedance probabilities, summary statistics and exceedance probabilities for oyster growth rates, and salinity contour maps with associated acreages for the total number of days when salinity exceeded 26 ppt in a wet, dry, and average year. For Gulf sturgeon, we requested salinity contour maps describing the total number of days salinity exceeded 10 ppt from 1 October- 31 March for the following years for all 4 scenarios in a dry, wet, and average year.

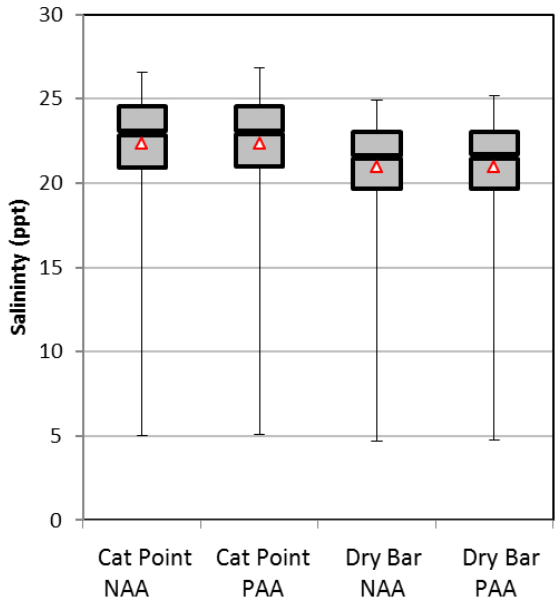
Analyses indicate that there will be no appreciable difference in the magnitude or timing of estuary freshwater inflow between the no action and proposed action alternatives (Sheng et al. 2011). There is little difference in salinity or oyster growth rates in any of the various analyses.

These effects on the bay relative to historic operations result from changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives, and less so to apparent changes in consumptive water uses. Historic basin inflow rates (the Corps' reported daily project inflow data) from 1976 to 2008 are roughly equivalent with the basin inflow data used in the modeled scenarios (unimpaired flow minus consumptive water uses), and the modeled basin inflow data is actually slightly higher overall (period-of-record average daily basin inflow values are 34 to 103 cfs greater) than the historic data. Therefore, the differences in the bay salinity results do not appear related to any simulated increase in consumptive water demands. However, average annual releases (1976-2008) from Woodruff Dam are about 400 to 500 cfs less than historic under the no-action and proposed alternatives, and average monthly composite reservoir storage is about 35,000 to 111,000 acre feet greater than historic levels in the months of August through October. Although salinities and oyster growth rates are similar between the no action and proposed action alternatives, all model outputs indicate that flows will continue to be lower than what historically and even recently occurred (i.e., pre-IOP in 2006) and thereby continuing suboptimal conditions for oysters, Gulf sturgeon, and other fish and wildlife in Apalachicola Bay.

In their May 23, 2011, correspondence to the Service, FFWCC states that there should be additional analyses of the impact of proposed and existing operations on juvenile Gulf sturgeon in Apalachicola Bay. They generally agree with the conclusions contained in the Apalachicola Bay section of the Service's DFWCAR, but would like to see additional details about potential impacts to estuarine sentinel species, such as eastern oysters or

> white shrimp. The Service agrees with FFWCC that additional datasets should be sought or generated to quantify impacts to juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species. The Service searched for additional analyses and new datasets prior to drafting the PAL but located few. Thus, the Service welcomes additional information that FFWCC can provide to assess impacts of proposed and existing operations.
>
> FFWCC also states that the DFWCAR should address the minimum flows needed to mitigate the impacts of saltwater incursion due to sea level rise. Thus, we recommend that the Corps capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion. This modeling effort should include both short- and long-term planning horizons."

The Service agrees with FFWCC's 2011 comment that additional biological information should be sought to inform an assessment of impacts associated with proposed and existing operations.



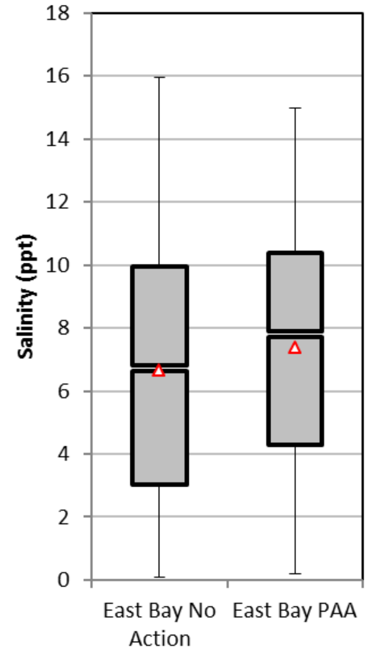


Figure 9. Salinity results for the Apalachicola Bay Salinity Performance Measure (ABSPM) for the NAA and PAA. These data include 1939-2008.

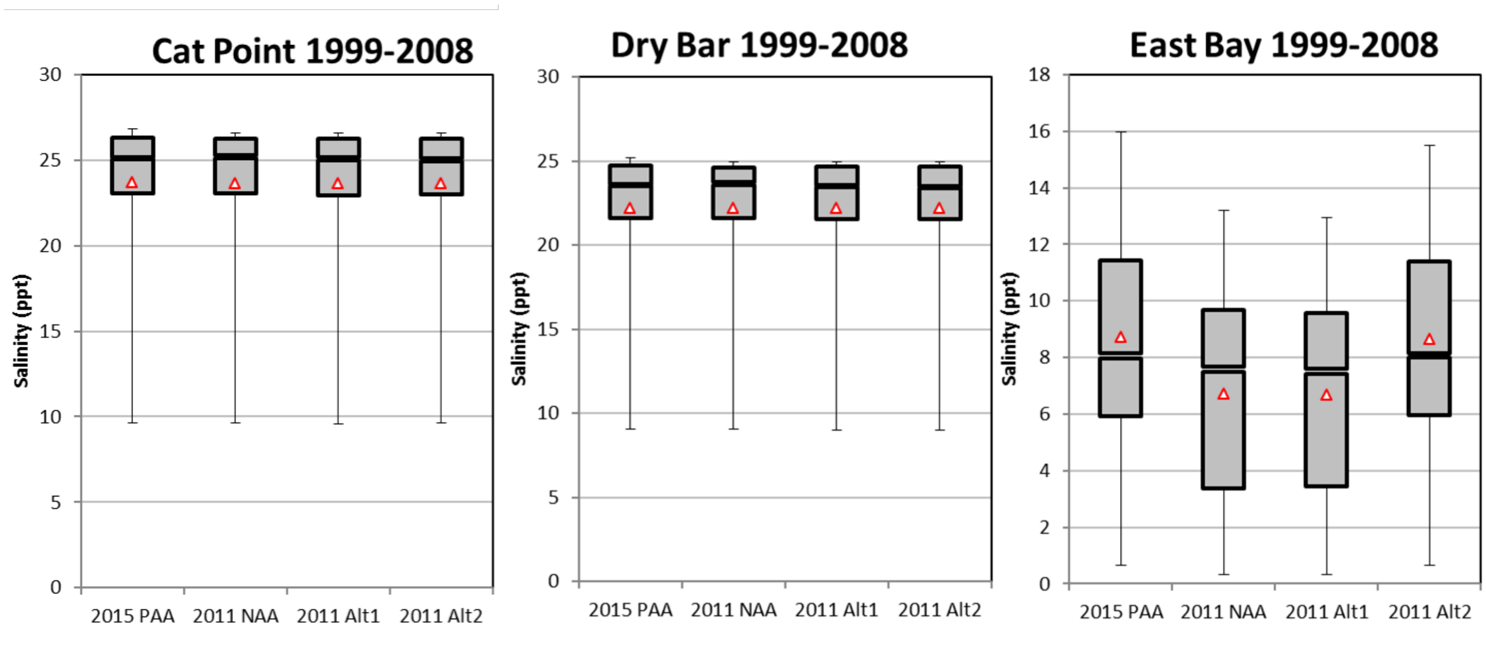


Figure 10. Salinities as predicted from the ABSPM for the PAA in 2015 and for comparison, the alternatives proposed in 2011. The period 1999-2008 represents the period used in the 2011 estuary modeling, which showed no difference between the NAA, 2011 Alt1, and 2011 Alt2.

Again, as part of the current consultation under section 7 of the Endangered Species Act, these data are being re-evaluated to better represent impacts to listed species and other at-risk species. However, the Corps provided a written response (Corps 2015c) following the release of the DFWAR (2015), these responses are provided in Appendix XX, and in summary, included the following;

1) The Corps contends that differences between the NAA and PAA would only result in marginal seasonal and spatial differences in salinity, and result in minimal biological impacts.
2) The Corps contends that the model results and interpretation are partially flawed and have limited value in interpreting the differences between the NAA and PAA.
3) The Corps contends that even if the presented results are accurate and representative, the Corps has limited responsibility in minimizing and mitigating for the impacts of salt water incursion.

EVALUATION OF THE SELECTED PLAN

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

The purpose of this section is to evaluate the relative merits of the NAA and PAA and ultimately determine their acceptability from the standpoint of the Service's responsibilities under the FWCA and our mission to conserve, protect, and enhance fish and wildlife resources. To that end, we succinctly describe the impacts of the PAA relative to the NAA in terms of each biological and/or habitat parameter considered. Each parameter is described as an improvement (+), a negative impact (-), or no change (0) over the NAA, regardless of the magnitude of the difference between the NAA and PAA. We emphasize that this approach is one method to evaluate the PAA, and it is not meant to be the sole deciding factor in the Service's evaluation. Rationales for the individual assignment of signs are provided in the text below Table 9. The Corps provided the Service limited interpretation of their analyses in their 2015 response to the Service's PAL (Corps 2015a); the evaluation below is solely based on the Service's interpretation.

Table 9. Scoring of impacts to fish and wildlife resources resulting from the Corps' PAA relative to the NAA. The PAA is better (+), worse (-), or the same (0) as the NAA for fish, wildlife or habitat. NAE indicates that the Corps has not adequately evaluated the parameter, sufficient information is not available, or the analysis is ongoing, and N/A indicates that the analysis is not applicable. All symbols are applicable to the reach below the dam, except variables shaded in grey are applicable to the reservoir upstream from the dam.

	Buford	West Point	W.F. George	J. Woodruff

Dissolved Oxygen	-	0	0	0
Temperature		0	0	0
Coldwater fishery	-	N/A	N/A	N/A
Warmwater fish community	+	0	0	0
Wastewater	-	-	-	-
Chlorophyll-*a*	-	-	-	-
Reservoir Retention Time	NAE	NAE	NAE	NAE
Phosphorus	-	-	-	-
Floodplain connectivity:				
Chattahoochee	0	0	0	N/A
Apalachicola	N/A	N/A	N/A	0
Reservoir Fisheries	0	0	0	N/A
Riverine Fisheries				
Shoal bass	+	N/A	N/A	N/A
Flow guidelines	NAE	NAE	NAE	NAE
Salinity	N/A	N/A	N/A	-
Gulf sturgeon	N/A	N/A	N/A	NAE
Freshwater mussels	N/A	N/A	N/A	-
Eufaula NWR	N/A	N/A	0	N/A
Buford Fish Hatchery	0	N/A	N/A	N/A

Dissolved Oxygen

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Higher dissolved oxygen levels are considered to be better for fish and invertebrates, but frequently fell below State standards for both the NAA and PAA below Buford Dam, West Point Dam, and WFGLD. For the composite period, compared to the NAA, the PAA exhibited lower dissolved oxygen levels immediately below Buford Dam and then transitioned to similar dissolved oxygen levels below Atlanta. However, the differences between the alternatives were small and occurred at low occurrence levels, meaning that both the NAA and PAA frequently provide poor conditions for fish and wildlife directly below the dams.

Water Temperature

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps

(2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Temperatures were expected to be similar throughout the ACF Basin, with differences between the NAA and PAA fluctuating between -0.25 and 0.5°C for the composite period. However, when normal, wet, and dry years are separated, the PAA shows the most drastic deviation from the NAA from Norcross to West Point Reservoir. In this reach, temperatures under the PAA were expected to warm up to ~0.5°C from the NAA with the greatest temperature difference exhibited between Atlanta and West Point Reservoir. The following fisheries information is taken largely from Georgia Power Company (2006):

Historically a warmwater river, the mainstem Chattahoochee River tailrace became an artificially created coldwater river following the construction of Buford Dam. Bottom releases from Buford Dam create coldwater releases suitable for a non-native brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) fishery in a 48-mile section of river extending downstream to Peachtree Creek.

GDNR has historically stocked this section of river with rainbow and brown trout and manages the trout fishery in two distinct segments: the Buford Dam tailwater extending 30 river miles downstream to Georgia Highway 400; and the Morgan Falls Dam tailwater extending 12 miles downstream to Peachtree Creek. The first segment is colder with greater flow fluctuations and the second segment is warmer with less fluctuations.

Water temperature is of great concern to GDNR in this section of the Chattahoochee River. They are very interested in maintaining the cold temperature regime for the trout fishery, the most popular sport fishery in this section of the Chattahoochee River. They report that high summer water temperatures potentially detrimental to trout have been occurring more frequently in recent years in the Morgan Falls Dam tailwater, and that nonpoint stormwater runoff from impervious surfaces in tributary watersheds appears to contribute to these conditions. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they note that increased water temperatures will have different impacts on the trout population depending on the distance from Buford Dam. As an example, GDNR states that temperature is not expected to be of concern at Buford Trout Hatchery, located approximately two miles downstream of Buford Dam, except for possibly an increased frequency of 2-unit generations during the fall pre-turnover period, when water drawn from the thermocline of Lanier Reservoir can lead to drastic temperature increases in a short time, leading to shock. Currently a concern during summer months, south of the Norcross gage small temperature increases may lead to localized stress and mortality if water temperature exceeds 22ºC for any considerable length of time.

As summer maximum water temperatures have become more marginally suitable for trout, GDNR has diversified its management objectives downstream of Morgan Falls Dam to include restoration of native shoal bass (*Micropterus cataractae*), a warmwater bass species endemic to the ACF River basin. Under the NAA, GDNR considers the reach to be a transition zone capable of supporting both coldwater and warmwater fisheries and initiated a stocking program for shoal bass in the reach of the Chattahoochee River below Morgan Falls Dam. GDNR, along with other State and Federal agencies including ADCNR, the Service, and the National Park

Service (NPS) have been involved with restoration and research activities to improve the status of the species.

GDNR has also reintroduced striped bass (*Morone saxatilis*) into what is now West Point Reservoir. Striped bass restoration in the ACF Basin is a collaborative effort between the conservation agencies in Georgia, Alabama, Florida, and the Service, with the goal of restoring a self-sustaining population to the maximum extent possible. The group meets on an annual basis to set goals and discuss ongoing management and research for striped bass in the ACF system. West Point Reservoir is currently designated as a potential broodfish repository and is one of the highest priority reservoirs to receive stocked striped bass.

Because striped bass exhibit upstream migrations to spawn in riverine conditions, a striped bass fishery has developed in the Chattahoochee River downstream of Morgan Falls Dam, the first upstream barrier to striped bass migrating upstream from West Point Reservoir. Persistence of a small population in West Point Reservoir suggests that striped bass in the river are capable of limited natural reproduction. However, coldwater releases from Buford Dam during the spring spawning period of striped bass, and abrupt decreases in water temperature that occur with Buford Dam peaking operations, have been identified as critical factors inhibiting striped bass spawning and adversely affecting survival of eggs and larvae in the upper Chattahoochee River near Morgan Falls Dam (Hess and Jennings 1999). GDNR clarified in their comments on the Service's DFWCAR that Hess and Jennings (1999) also mentioned low flows as another potential inhibiting factor to reproduction (GDNR 2015; Appendix III). Striped bass movement upstream to Morgan Falls increases as summer progresses, indicating that the water temperatures in the summer serve as a coolwater refuge. GDNR-WRD considers this "coolwater refuge" effect to be of significant importance to the survivability of adult striped bass.

Because the PAA exhibits slightly warmer water temperatures below Buford Dam to Norcross, the PAA is less favorable than the NAA for the coldwater fishery. Water temperatures are warmer between Whitesburg and West Point, which is an improvement for the warmwater fish community including shoal bass. The Service proposes that elements of both a cold-cool water and warmwater fishery potentially could be supported if water quality and flows are improved. The PAA has the potential to benefit the warmwater fishery without compromising the coldwater fishery strictly from a temperature aspect.

Wastewater

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and thee PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant.

The NAA and PAA model results were similar along the longitudinal river profile within each scenario, with the average stream percent wastewater in the PAA model output typically greater than the NAA. These modeled results suggest that the PAA would be slightly less favorable than the NAA.

Chlorophyll-*a*

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Chlorophyll-*a* is correlated with algal biomass, which may cause nuisance conditions in aquatic ecosystems. Chlorophyll-*a* was higher in the PAA than the NAA throughout the river system, but differences were relatively small. This indicates that the PAA is slightly less favorable when compared to the NAA.

Reservoir Retention Time

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Higher retention rates may result in decreased reservoir water quality. We requested average summer retention times at each Corps reservoir. Data was provided in hard copy, tabular format for each month. At West Point Reservoir, June through August retention times were generally similar between the NAA and PAA between 2001 and 2011. However, qualitative evaluation of the PAA showed higher retention times in 2002 (max= 9 days higher in August), 2006 (max= 42 days higher in July), 2008 (max= 5 days higher in August), and 2009 (max= 27 days higher in August). Additional analyses utilizing a broader array of water quality indices is needed to further evaluate differences between the PAA and NAA; however, we currently expect these differences to be small.

Phosphorus

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Algal growth is stimulated by increases in phosphorus. Thus, phosphorus levels were modeled and compared between the NAA and PAA. Total phosphorus loads at both of the selected locations, the headwaters of West Point Reservoir and Walter F. George Reservoir, both increased in the PAA when compared to the NAA. Any differences observed between the PAA and NAA in the longitudinal profiles resulted in higher total phosphorus levels in the PAA.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. However, as part of the current consultation under section 7 of the Endangered Species Act, these data are being re-evaluated to better represent impacts to listed species. Our previous assessments (USFWS 2015) provided the following comments:

The Service developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation. The measure calculates the maximum amount of spawning habitat available for at least 30 consecutive days during the months of April through October. It is unclear whether the Corps used the FSHPM to develop the graphical comparison. As described by the Corps, it is unknown whether they calculated *consecutive* days. The Corps used the period from April through September, not April through October as specified by the FSHPM.

Apalachicola River floodplain connectivity, evaluated using the annual maximum 30-day acreage during the April through September growing season, is nearly identical between the NAA and PAA. Chattahoochee River floodplain connectivity would be expected to be nearly identical between the NAA and PAA; conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain.

Indicated previously, the Corps has not yet provided output from the ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford period. The Corps should provide output from the ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford period.

Reservoir Fisheries

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

RFPM differences between the NAA and PAA were generally small, suggesting low potential for realized fisheries differences between the two alternatives. However, slightly higher reservoir temperature profiles may have slightly adverse effects on sport fish species.

Riverine Fisheries

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

It appears the riverine fisheries analysis provided by the Corps relied on percentiles that do not separate low and high flows. Output from the revised ecosystem flow guideline methodology recommended in the Service's PAL addendum (Service 2011; Appendix VI) has not yet been provided by the Corps for the comparison of the NAA, PAA, and pre-Buford Dam period. Therefore, the Corps should provide output from the revised ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford Dam period.

The CRSBPM shows that the PAA results in higher abundance of Shoal Bass than the NAA. This may indicate that for the river section upstream from West Point Reservoir, conditions are more favorable for the native warmwater fish community. Based on modeled water temperatures, there are small anticipated effects to the coldwater fish community below Buford Dam.

Federally-protected Species in the Apalachicola River

As of this date, through Section 7 of the Endangered Species Act, this project is being reviewed through consultation. Because the process is ongoing between the Service and the Corps of Engineers (Panama City FO; COE/SAD/Mobile) revised metrics may be developed to evaluate impacts of the proposed action on federally listed species and associated critical habitat. Our previous comments as part of the DFWCAR (2015) were;

Gulf Sturgeon

Effects to Gulf Sturgeon were not adequately assessed, as described in the *Project Impacts & Evaluation Methodology* section above. For the Service to adequately assess the Corps' future determination of the proposed action under the ESA, we will need to review suitable analyses of the effects of the proposed action.

Freshwater mussels

The only freshwater mussel analysis was for the river segment below JWLD. The PAA results in lower flows that remain low for longer periods compared to the NAA, thereby creating conditions that are less hospitable for mussel communities, including federally-listed mussels. Mussel population viability is intricately tied to host fish density (Watters 1997; Haag and Warren 1998). Because many of the fish species dependent on the floodplain serve as host fish to freshwater mussels in the Apalachicola River, freshwater mussels may also be impacted by fall rates that occur at higher flow magnitudes. Although high flow fall rates were not evaluated, other mussel indicators show negative impacts to freshwater mussels, making the PAA less preferable for mussels.

National Wildlife Refuges and Fish Hatcheries

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that our previous comments (USFWS, 2015) remain valid. The Service feels any slight differences that we have identified between the current PAA and the PAA previously evaluated by the DFWAR (USFWS 2015), or was identified by the Corps (2016a, 2016b), are negligible or insignificant. Our previous assessments (USFWS 2015) provided the following comments:

Eufaula NWR

The Service had requested the examination of alternate Walter F. George Reservoir management strategies to accommodate the request and freshwater needs of Eufaula NWR. The Corps indicated that they are unable to meet that request, meaning that there is no change in reservoir levels and therefore, no change to Eufaula NWR.

Fish Hatcheries

Buford Fish Hatchery relies on a freshwater intake below Buford Dam to support fish rearing. There is similar water availability for Buford Fish Hatchery for both alternatives. Dissolved oxygen levels and temperatures were nearly identical. Therefore, effects of the PAA on Buford Fish Hatchery are the same as the NAA.

Analyses of Apalachicola Bay

Based on our reassessment of the data and analysis provided (Corps 2016a, Corps 2016b), we have determined that some of our previous comments (USFWS, 2015) remain valid. However, as part of the current consultation under section 7 of the Endangered Species Act, these data are being re-evaluated to better represent impacts to listed species and other at-risk species. Though data are not currently available, other studies evaluating impacts to Apalachicola Bay are ongoing (Paramygin and Sheng, 2015, and others).

The most recent report, suggests that the PAA may result in slightly greater Apalachicola Bay salinities when compared to the NAA. The ABSPM shows no difference in salinities between the NAA and PAA at Cat Point and Dry Bar, but a 1.0 ppt increase in the median salinity at East Bay. Additionally, low flows in the Apalachicola River at Chattahoochee are lower in the PAA than in the NAA.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

The intent of this section is to identify measures that should be taken to prevent the loss of or damage to fish and wildlife resources and to provide for the improvement of such resources. In the Service's 2010 PAL and 2011 PAL addendum, we identified resources and analyses that would be necessary in order to address planning objectives. Although some planning objectives were addressed by Corps analyses as described in prior sections, several were not adequately addressed. We review our current understanding of the Corps' position on each issue (italicized text) and note whether the planning objectives were adequately addressed. Those planning objectives that were not adequately addressed are conveyed here as conservation measures, or recommendations, that should be taken to reduce impacts and benefit fish and wildlife (Table 10).

The conservation measures provided in the Service's 2011 DFWCAR included the development of an alternative or a suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. The Corps indicated that it is difficult and labor intensive to try alternative management scenarios, and as such, we encouraged the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim (Service 2011).

We investigated a suite of operational alternatives that could provide benefits to fish and wildlife resources; a Service-developed alternative was provided to the Corps as part of our scoping comments (Service 2013; Appendix VII). We provide a discussion of our alternative in this section because its formulation stems from our previously recommended conservation measures, including, "Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes" and "Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams."

Table 10. Fish and wildlife conservation measures and recommendations.

Fish and Wildlife Service Alternative Evaluation:		
	ALT1	Clarify the criteria required for an alternative to warrant full consideration
Conservation Measures Included from the Service's 2010 PAL & 2011 PAL Addendum:		
Flow Regime		
	FR1	Develop a suite of flow alternatives
	FR2	Conduct ecosystem flow analyses using guidelines
	FR3	Provide fish access to and inundation of the floodplain
	FR4	Evaluate methods to provide the operational flexibility necessary for floodplain inundation
	FR5	Evaluate the operational feasibly of implementing environmental flow measures
	FR6	Develop appropriate predictive hydrological and meteorological criteria
Floodplain Inundation Assessment		
	FP 1	Utilize LIDAR to evaluate floodplain inundation
Water Quality		
	WQ1	Improve and monitor dissolved oxygen
	WQ2	Evaluate/upgrade venting capabilities at Buford turbines
	WQ3	Improve and monitor water temperatures
Fish Passage		
	FM1	Improve fish passage
Climate Change		
	CC1	Include multiple future climate scenarios into modeling
Navigation		
	NV1	Evaluate the effects of channel maintenance activities
Reservoir and Riverine Fishes/Fisheries Management		
	FM2	Review recent fisheries literature
	FM3	Modify Fish Spawn SOPs to occasionally emphasize river spawning

		over reservoir spawning
	FM4	Implement fish and wildlife recreation facility improvements
Apalachicola Bay		
	AB1	Incorporate an updated Apalachicola Bay salinity model
	AB2	Determine freshwater inflow effects on benthic communities of Apalachicola Bay
Decision Support Model to Evaluate Changes to Corps' Operations		
	DS1	Incorporate a decision support model into the WCM update process
Adaptive Management		
	AMP1	Develop an adaptive management program
Increasing Consumptive Demands		
	CD1	Consider the impacts of increasing consumptive water demands
Evaluation of Alternative Models		
	AM1	Use alternative models to better represent flow
	AM2	Precipitation-Runoff Modeling System as an evaluation system
	AM3	New models to explicitly address climate-based operational flexibility
	AM4	Alternative water quality assessment methods
Conservation Measures Developed from the Corps' 2011 PAL Response:		
	FR7	Minimum flow provisions downstream of WFGLD
	FR8	Drought zone trigger changes
Additional Conservation Measures:		
	FM5	Evaluate effects to Gulf Sturgeon
	FM6	Evaluate effects to petitioned species
	NPS1	Evaluate effects to NPS' Chattahoochee River National Recreation Area
	ES1	Ecosystem services impacts should be described and quantified
Mitigation Measures:		
	MIT1	Identify a mitigation approach
	MIT2	Habitat-based evaluation techniques
	MIT3	Mitigate estuary impacts

Fish and Wildlife Service Alternative Evaluation

Discussions with the Corps (as cited in Service 2013; Appendix VIII) indicated that to warrant full consideration, an alternative would need to: 1) accommodate a navigation season, and 2) retain the storage action zones to ensure a balanced system operation. Consequently, we addressed both criteria in subsequent modeling and submitted a revised alternative to the Corps. Subsequently, the Corps considered the Services' alternative during its Phase 1 formulation analysis.

Table 11. Summary of conclusions drawn by the Corps' evaluation criteria and rankings used to select the PAA and a qualitative comparison of the Service's alternative to the PAA.

Evaluation Criteria by project purpose	Difference relative to PAA
Water Quality/Peachtree Creek Q >750	Better
Hydropower (System)	Worse
Navigation (System)	Better
Recreation (Buford, WP, WFG)	Worse
Fish and Wildlife (Apalachicola)	Worse

Additionally, the Service reviewed information from the Corps in 2015 regarding their alternatives selection process and we are greatly concerned with the methodology used by the Corps. Our concerns are described in detail in Appendix XV; due to the fact that Appendix XV has been recently developed, these concerns have not yet been reviewed as part of the DFWCAR by the State wildlife agencies and NOAA in relation to their responsibilities under FWCA.

Conservation Measures Included from the Service's 2010 PAL & 2011 PAL Addendum

Flow Regime

FR1) Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes.

> *This has not been completed and should be developed. Iterative development should consider a range of operational changes, including changes to action zones, flow triggers, target and minimum flows, and flows identified for navigation, conservation, hydropower, and recreation purposes. Additionally, the Service provided the Corps sets of low and pulse flow guidelines to aid in flow alternative development and evaluation (Service 2011; Appendix VI). Flow guidelines were not used to develop or evaluate alternatives. Since providing the flow guidelines, we developed the CRSBPM to assist with the evaluation of flow alternatives in the Chattahoochee River. We continue to recommend use of both the flow guidelines and the CRSBPM. As additional performance metrics become available for the Chattahoochee River, we can reconsider the use of flow guidelines in the Chattahoochee River.*
>
> *Although the Service's 2011 PAL addendum provided sets of low and pulse flow guidelines from which alternatives could be developed and compared, and the Service's 2010 PAL included requests for modeling non-hydropower peaking windows, the Corps did not develop alternatives based on those guidelines because of management limitations cited in their response to the Service's PAL (Corps 2011). However, within the Service's 2010 PAL, we stated:*
>
> *"We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation."*

We reiterate to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. To date, none of the natural flow regime components have been incorporated into the flow alternative development…"

FR2) Conduct ecosystem flow analyses using the methodology cited in the Service's 2011 PAL addendum, composed of analyses at four nodes (below Buford, West Point, WFGLD, and JWLD) for the NAA and PAA. Subsequently, compare the results with the Service's ecosystem flow guidelines. We also recommend the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March-May.

In the Service's 2011 PAL addendum, we provided updated ecosystem flow guidelines representing natural conditions, as well as updated methodology for the Corps to analyze their low and high flow releases under the NAA and PAA. Such analyses have not been provided to the Service.

FFWCC generally supports the Service's guidelines, but also recommends a modified approach to the development of low flow guidelines (FFWCC 2011). The Service used the seven lowest values from every month in every year to characterize low flows in dry, average, and wet months for the pre-Buford period. FFWCC proposed that daily exceedance values based on all the pre-Buford hydrology, including baseflows, pulses, and floods, be used to develop guidelines. Subsequent analyses by the Service show that the 90% exceedance roughly corresponds to the lower limit and dry month flow guidelines, and the 50% exceedance values track the wet year flow guidelines, with the exception of the wetter months, lending some support to this alternative approach. We agree with FFWCC that this type of analysis has merit for comparing flow alternatives and characterization of flow data. However, the Service views this method as complementary but not substitutive for flow guideline development, because:

1. *Exceedance plots include all flows including pulses and floods. Therefore, low flow guidelines that could come from exceedance plots are potentially influenced by high flows, thereby inflating low flow guideline values. This is particularly evident with exceedance probabilities less than 75%, and in wetter months. One intent of the Service's flow guideline development was to separate multiple flow components (low flows, pulses, and floods) and illustrate the inter- and intra-annual variation in flows. Exceedance plots blur the distinction between low flows, and pulses and floods which is one reason why exceedance plots were not used initially.*

2. *Daily exceedance plots show a large amount of daily variation. Similar to the Service's flow guidelines, this variation illustrates that a range of low flow values may be beneficial for fish and wildlife resources. However, one intention of the Service's guidelines was to provide managers and modelers real values to evaluate and/or incorporate into a flow alternative. Although selecting the seven lowest values for every month of every year to characterize dry, average, and wet months is*

a simplification of the pre-Buford hydrology, the Service expects that there is a higher likelihood of successful incorporation of the Service's 60 low flow guideline values (represented by the lower and upper limit, and dry, average, and wet conditions for each of 12 months), than the 365 values required for one year type using the exceedance probability method.

The Corps addressed the feasibility of providing non-hydropower peaking windows from March to May (4-6 weeks) at Buford Dam and West Point Dam in their response to the Service's PAL (Corps 2011). The Corps states that a loss of hydropower production, as well as physical, safety, and logistical limitations would prohibit the implementation of non-hydropower peaking windows at these facilities. We note that fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production. While the Corps has repeatedly stated that revised water control operations shall reflect existing structural and physical constraints (e.g., no consideration of structural improvements), there is no funding for structural improvements, and such improvements are outside the WCM update process, the Service continues to recommend that the Corps explore options to alter downstream flow releases to minimize impacts to or benefit riverine aquatic resources below their projects in the ACF Basin. Such changes in operation do not necessarily come at the cost of reduced hydropower production.

FR3) Evaluate the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain.

The PAA proposes zone changes in Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir, but incorporates no changes to the top of the conservation pool guide curves. We continue to recommend the Corps address and evaluate all of these options listed above.

FR4) Evaluate methods to provide the operational flexibility necessary for floodplain inundation, which could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation, and/or 2) the purchase of structures built in the historic floodplain so that the Corps could intentionally provide flows that inundate the floodplain.

This has not been completed. In the past the Corps has stated that one of their guiding principles for the WCM update process is that the flood control capabilities and capacities of the reservoirs will not be reduced (see Decision Support Model to Evaluate Changes to Corps' Operations below). Corps projects are managed in part for flood damage reduction, the objective of which is "storage of excess flows thereby reducing *downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally." The methods suggested by the Service would not reduce the flood control capabilities and capacities of the reservoirs. First identifying and then protecting or purchasing structures that may be impacted by floods at naturally-occurring discharges could actually reduce potential flood damage, increase operational flexibility, as well as benefit aquatic resources. Thus, we encourage the Corps to continue investigating those methods listed above.*

FR5) Evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines.

These analyses have not been conducted by the Corps. The Corps stated in their 2011 PAL Response that "Defining a real life operation that meets the authorized project purposes and better meets the "natural" hydrograph and then translating that operation into code for the reservoir simulation is a large undertaking. To the extent that FWS feels more needs to be done, we request additional guidance and support."

As stated in the 2010 PAL, we stress to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. The specific components of the ecosystem flow guidelines were meant to be reviewed and considered for implementation on an individual basis by the Corps rather than collectively considered as a whole.

Updated ecosystem flow guidelines for four locations in the ACF Basin were provided to the Corps in our 2011 PAL addendum. We agree that it is a potentially large undertaking to include flow guidelines, but we emphasize that the WCM update is itself a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental flow measures.

FR6) Work with the Service and others to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

In the past, the Corps has stated that they have been engaged in conversations with entities such as the National Weather Service, but indicated that they do not have the reliable science to accurately make these predictions for operation of the ACF Basin system. We have recommended that the Corps work with the Service so that we may collectively develop reasonable methods for defining hydrological conditions useful for reservoir and ecosystem management. To date, these conversations have not occurred.

Floodplain inundation assessments

FP1) Use LIDAR and stage-discharge relationships to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River to compare the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation in the NAA, PAA, and pre- Buford period.

> *The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. When the data are available, the Corps should use LIDAR, if applicable, to supplement existing analyses of floodplain inundation in the Apalachicola River.*

<u>Dissolved Oxygen</u>

WQ1) Ensure that releases from all five ACF dams meet or exceed water quality standards, including monitoring water quality upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve water quality, and conducting post-modification water quality monitoring to ensure that levels have been improved to State water quality standards.

> *The Corps has stated that they currently monitor water temperature, pH, conductivity, and DO below Buford Dam and West Point Dam, and DO seasonally below WFGLD. They have stated that one of their guiding principles for the WCM update process is that revised water control operations shall reflect existing structural and physical constraints [e.g., no consideration of structural improvements, there is no funding for structural improvements, and such improvements are outside the WCM update process (see Decision Support Model to Evaluate Changes to Corps' Operations below)]. Subsequently, because the NAA and PAA significantly affect water quality, do not comply with State standards, and do not meet the designated project purpose of fish and wildlife, we continue to request that as part of the WCM update the Corps outline the steps that would be necessary on part of the Federal government and other entities to improve water quality below Federal projects in the ACF Basin.*

> *The Corps should make it a priority to ensure that releases from all five ACF dams meet or exceed DO, temperature, and other applicable water quality standards. In GDNR's 2011 comments on the Service's DFWCAR (Service 2011), GDNR-WRD agrees that improvement of DO downstream of Corps reservoirs is important and would be beneficial to aquatic resources. We are available to assist the Corps in exploring alternate funding opportunities, including Corps restoration authorities (e.g., Section 1135 or 216) to address these impacts.*

WQ2) Evaluate the effectiveness of the upgraded venting capabilities at Buford turbines.

> *The Corps has stated that research is outside the scope of the WCM update process. As stated above, we continue to recommend that the Corps needs to make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. We are available to assist the Corps in exploring alternate funding opportunities, including Corps restoration authorities (e.g., Section 1135 or 216) to address these impacts.*

Temperature

WQ3) Monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved.

> *As noted above, the Corps has stated that the revised water control operations shall reflect existing structural and physical constraints, that there is no funding for structural improvements, and such improvements are outside the WCM update process. The Corps needs to make it a priority to manage temperature levels to benefit aquatic life in accordance with resource agency management objectives. We are available to assist the Corps in exploring alternate funding opportunities.*

Fish Passage

FM1) Provisions for fish passage should be incorporated in the WCM for JWLD, GWALD, and WFGLD, while maintaining the need for operational flexibility.

> *Although the Corps has included formal language in the WCM update for fish locking at JWLD, they have not included similar language for GWALD or WFGLD. They have stated that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the manual does not preclude lockings at GWALD or WFGLD. However, we continue to recommend formal language be included in the WCM update. There is ample evidence that fish passage operations at the lock at JWLD are passing Alabama shad upstream, and the species may benefit from passage at these other Corps lock and dam facilities. In FFWCC's 2011 comments on the Service's 2011 DFWCAR (Service 2011), FFWCC also agrees that the Corps should explore fish passage operations for anadromous fish species, such as the Alabama shad as part of the WCM update.*

Climate Change

CC1) In addition to considering sea level rise, include multiple future climate scenarios into modeled discharge scenarios and Corps alternatives and create flow provisions for dry, average, and wet years in order to account for current climate variability.

> *The Corps states that they have considered climate change to some extent in the form of sea level rise. Their evaluations have determined that sea level rise is not projected to affect JWLD, the lowermost Corps' project in the ACF Basin. No consideration has been given to the impact of climate change on hydrology. However, because climate change will potentially affect river flows and Corps operations, the Corps should include future climate scenarios over short and long terms, and flow provisions for dry, average, and wet years. Available sources that have been brought to our attention and may be of use are the National Climate Change Viewer*

(http://www.usgs.gov/climate_landuse/clu_rd/nex-dcp30.asp) and the National Climate Assessment (http://nca2014.globalchange.gov/downloads).

Navigation

NV1) If navigation is included in the WCM update, evaluate the effects of channel maintenance activities required for navigation support by including an analysis of dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis.

A navigation season has been included in the Corps' PAA to achieve a 7-foot channel at Blountstown, Florida from January through April or May. The Corps states that though special releases will not be standard practice, they may occur as a result of case-by-case requests to the Corps for a short duration to assist navigation during the navigation season (e.g., to achieve a 9-foot channel). Dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis have not been included by the Corps in an evaluation of the effects of the PAA. Therefore, we assume there are no plans for dredging in the Apalachicola or Chattahoochee Rivers related to the PAA. If the Corps anticipates that maintenance dredging will need to occur in the future, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support as indirect or cumulative impacts within the NEPA documentation.

Reservoir and Riverine Fisheries Management

FM2) Review recent fisheries literature for additional information regarding detrimental impacts to riverine fish spawning due to a 4-6 week stable or rising reservoir window, per the Corps' draft Standard Operating Procedure (SOP) for "Lake Regulations and Coordination For Fish Management Purposes."

The purpose of this literature search is to critically evaluate the relative merits and costs of operating projects for the benefit of reservoir and riverine fisheries so that the best available science can be integrated into an informed management approach.

In past ResSim model simulations that were run by the Corps using the entire period of record at the time, the fish spawn SOP governed less than 1% of releases at Corps reservoirs in the ACF Basin. The Corps states this is because fish spawn operations are largely the same as operations that are already conducted for higher priority purposes at their reservoirs.

The Corps states that the fish spawn SOP has been in operation since the 1970's and the operating windows were based on water temperatures. The Corps states that the window is determined by dates because it is labor intensive to base the window on water temperatures. A reservoir fisheries literature search was recently conducted for the Corps by TetraTech but no pertinent research was found. In the past, GDNR-WRD has stated that the fish spawn SOP is important and should continue. However, given *potential changes to the system and news insights since the 1970's, we recommend that additional data should be collected and analyses conducted to ensure that no modifications or improvements to this management strategy are needed concurrent with SOP implementation.*

A literature search has not been conducted regarding downstream flows during the fish spawn SOP period and the resulting impacts to riverine fish spawning. However, FFWCC recently provided the Corps and the Service with riverine spawning information specifically for the Apalachicola River (FFWCC 2011; Appendix XI). The report details how decreased spring flows have resulted in less aquatic floodplain habitats in the Apalachicola River floodplain system during critical spawning and nursery periods.

We continue to recommend a literature search be conducted for additional supporting information, especially applicable to areas upstream of the Apalachicola River.

FM3) Investigate modifying the Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes.

The Corps states that the existing fish spawn SOP language already indicates they can or will emphasize benefits to river spawning over reservoir spawning if riverine fishes have experienced unfavorable conditions for several years. The existing language in the fish spawn SOP is as follows:

"An imbalance of prey and forage fish could occur following the second or third year of poor or unsuccessful spawning and recruitment, leading to poor sport fishing. Areas where the spawns were recently unsuccessful should be given higher priority for fish management operations under low water conditions." It is unclear in the documentation provided by the Corps how determinations will be made to ensure that river spawning takes precedence over reservoir spawning, and how operations will be modified to facilitate river spawning. To the Service, the existing language does not seem to pertain to riverine habitats and instead appears to remain focused on reservoir fisheries. Per our recommendation in the PAL, periodic emphasis of riverine spawning should be included in the fish spawn SOP. We are available to work with the Corps to develop specific SOP revisions that recognize both reservoir and riverine habitat management.

FM4) Identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

The Corps has stated that one of their guiding principles for the WCM update process is that revised operations shall reflect existing structural and physical constraints. They have also stated that there is no funding for structural improvements and such improvements are outside the WCM update process. However, this recommendation could lead to increased operational flexibility for the Corps in the future. We are available to assist the Corps in exploring alternate funding opportunities.

Apalachicola Bay

AB1) Incorporate an updated Apalachicola Bay salinity model in the WCM update process to predict effects to oyster mortality and growth.

Previous modeling results (Sheng et al. 2011; Appendix XII) are incorporated into this FWCAR (above). If updated results are produced in an allowable timeframe, we recommend that the Corps incorporate Sheng's modeling results not only to evaluate effects of their project operations, but also to inform their development of a PAA.

AB2) Coordinate with FFWCC's Fish and Wildlife Research Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

FFWCC provided pertinent analyses to the Service and to the Corps comparing the pre-dam and post-West Point periods of record, but did not include analyses for future actions, such as the WCM proposed alternatives or other future Corps' proposed actions. In that correspondence FFWCC provides updated research that raises "significant hydrologic and biological concerns applicable to any alternative [Corps] operation departing from the historic flow regime of the Apalachicola River" (FFWCC 2011; Appendix XI). We recommend the Corps move forward by coordinating with FFWCC and the Service's Panama City Field Office to complete similar analyses on the WCM proposed alternatives and other future Corps' proposed actions.

Decision Support Model to Evaluate Changes to Corps' Operations

DS1) Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams.

The Corps has stated that they have used a decision support approach on a coarse scale; they subsequently shared a synopsis of their decision-making process with the Service in 2010. This synopsis from the Corps indicated that at the time, their Modeling Team and Project Delivery Team had developed internal guiding principles for the revised WCM and an iterative process for the development of their alternative(s), which relied heavily on ResSim outputs. The Corps' guiding principles at that time were as follows:

1. *Flood control capabilities and capacities of the reservoirs will not be reduced (e.g. no measure is acceptable if it raises the likelihood, frequency, or severity of flooding).*
2. *The ACF will continue to be operated as a system. The balancing of water control operations to achieve each of the project purposes will continue to vary between the individual projects and the time of year. Operation of the projects*

will continue to usually be performed in a manner which represents a consideration of these oftentimes competing purposes and, whenever possible, reservoir operations are scoped to accommodate these purposes in a complimentary fashion (balancing).

3. *The revised water control operations shall be within existing project purposes and authorities.*
4. *The revised water control operations shall reflect existing structural and physical constraints (e.g. no consideration of structural improvements).*
5. *The revised water control operations shall meet the existing Endangered Species Act requirements.*
6. *The fish spawn SOP will continue to be implemented within the reservoirs.*
7. *Reallocation of storage to meet current water supply demands [where current equaled the highest levels of consumption experienced to date] at Lake Sidney Lanier for municipal and industrial (M&I) water supply shall be evaluated in conjunction with revised water control operations. (This guiding principle was subsequently revised to account for a district court ruling in Phase 1 of the consolidated ACF litigation, 17 July 2010 ("Phase I Ruling").*
8. *The revised water control operations will not adversely alter the water quality in Corps reservoirs.*

We request that the Corps provide updated guiding principles if they have changed.

Adaptive Management

AMP1) Develop an adaptive management program, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam.

The Corps states that the periodic updating of the WCM is a form of adaptive management and should be practiced. We urge the Corps to consider a management approach that fosters implementation of an operational strategy with clearly defined goals or hypotheses, an evaluation to assess outcomes of the operation, and integration of the knowledge gained from that operation into management. The adaptive management program should be interdisciplinary and include multiple agencies and organizations representing stakeholders within the ACF Basin.

Increasing Consumptive Demands

CD1) Recognize and consider the impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin and incorporate it into analysis of operational alternatives along with climate-driven hydrologic variability. Quantify the relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes. Include metrics regarding water supply withdrawals, including potential increases, in the alternatives analysis. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

In the PAA the Corps included future M&I water withdrawals to accommodate a projected 2040 water supply need in the Atlanta area. However, this does not include future consumptive use projections for the same time period at other locations in the basin (e.g., municipal, industrial, and agricultural increases in the Chattahoochee below the Atlanta area, increases in the Flint Basin). Therefore, projected future increases including all categories of withdrawals across the ACF, as well as predictions for climate-driven hydrologic variability, should be included in the Corps' analyses. In addition, a "Future without project" that incorporated such future consumptive water demands was not evaluated in the Corps response to the Service's PAL (Corps 2015a; Appendix X), making comparisons between a more accurate representation of an "Existing condition", "Future without project", and the "Future with Project" not possible.

Evaluation of Alternative Models

AM1) Investigate the use of alternative models to develop better unimpaired flow and alternative flow datasets. Compared to the USGS gage data, the unimpaired flow dataset does not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes.

Fundamental differences in output between the USGS gage data and the NAA (e.g., current operations) are described in Appendix XIV. In the past, the Corps has stated that at this point in the process they are locked into using ResSim and HEC-5Q. The Corps has indicated that it is difficult and labor intensive to try alternative management scenarios. We encourage the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim. We recommend the use of alternative models be investigated as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.

AM2) If the United States Geological Survey's (USGS) Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, use it as an additional evaluation tool to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions.

It is our understanding that the PRMS model is not ready for use at this time. However, if and when it is developed specifically for the ACF it should be used by the Corps as an *additional evaluation tool for the WCM update process and future Corps' proposed actions.*

AM3) Coordinate with USGS and Georgia Water Resources Institute (GWRI) regarding new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

We continue to recommend that the Corps coordinate directly with GWRI to address climate-based operational flexibility as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.

AM4) Consider alternative water quality assessment methods to accurately evaluate effects of flow alternatives on water quality. Because the HEC-5Q water quality model outputs are not expected to accurately predict either the water quality values or the range of values that are likely to occur in response to hourly discharge changes, consider using existing alternative water quality models or develop regression models to accurately predict water quality parameters using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure).

The Corps states that HEC-5Q is advantageous because it considers the system holistically and also cite similar results between their simulated output to their observed tailrace data. Because HEC-5Q relies on daily average flow it does not accurately reflect water quality values that are likely to occur in response to hourly discharge changes. We continue to recommend alternative water quality assessment methods to accurately evaluate the effects of Corps operations on water quality.

Conservation Measures Developed from the Corps' 2011 PAL Response

FR7) There are no minimum flow provisions downstream of WFGLD. When low dissolved oxygen values are observed below the dam, the Corps states that spillway gates are opened until the dissolved oxygen readings return to an acceptable level. The Service has not seen actual data that exhibit an improvement in dissolved oxygen levels using this methodology. However, if this methodology is in fact effective, the Corps should evaluate modifying WFGLD's operations to provide a continuous minimum flow release instead of operating in a "reactive response" mode. Continuous minimum flow releases are already implemented at the other four other Corps' ACF Basin projects.

FR8) Consider other options for operational flexibility that do not include changing the drought zone trigger from Zone 3 to Zone 2, and postponing the reinstatement of normal operations until Zone 1 is reached. While these changes enable the Corps to operate the reservoir system in a more conservative manner, they likely result in an increased frequency and duration of low flows in the Apalachicola River.

Additional Conservation Measures

FM5) Evaluation of effects to Gulf Sturgeon was specified in our PAL's. The Service developed the SSHPM to facilitate the Corps' analysis, but this information was not included in the information provided to the Service. Effects to Gulf Sturgeon should be included in the development and evaluation of alternatives.

FM6) The impacts of the PAA to species in the ACF Basin currently petitioned for Federal listing under the ESA should also be described and quantified. Updated surveys and quantitative relationships between Corps operations and population or habitat effects for many of these species are lacking; effort should be expended to update surveys and quantify effects of proposed future actions to these species. This information will improve our understanding and future evaluation of project impacts on a larger variety of species that inhabit a broader set of ecosystems and river segments.

NPS1) The impacts of the PAA to NPS' Chattahoochee River National Recreation Area should be described and quantified. NPS' January 14, 2013 scoping comments to the Corps include information and recommendations associated with the Corps' flow releases from Lanier reservoir that should be considered.

ES1) The impacts of the PAA to ecosystem services should be described and quantified. Ecosystem services are the benefits that humans derive from ecosystems. These services provided by riverine ecosystems are diverse, such as water filtration provided by aquatic invertebrates and carbon sequestration provided by floodplain connectivity. In addition, riverine habitats can provide excellent recreational opportunities. These are among the ecosystem services that are, to some extent, affected by flow management.

Mitigation Measures

MIT1) In the Corps' NEPA documentation, the impacts of the PAA on fish and wildlife resources should not only be described and quantified, but the Corps should also outline an approach to mitigation. Mitigation measures should be based upon more accurate projections of future projected resource conditions with and without the project.

MIT2) Development of mitigation measures should be scientifically formulated, and based on the future with and future without the project scenarios, and a determination of the net change between the two. The Service's Mitigation Policy (FR 46(15):7644-7663; January 23, 1981) calls for evaluation using habitat-based evaluation techniques wherever possible. The Habitat Evaluation Procedures (HEP) developed by the Service are specified for use as a basic tool for evaluating project impacts and as a basis for formulating subsequent recommendations for mitigation. It can yield data that can be used effectively in comparing alternatives and conditions. Other available "standard" techniques that may be applicable include the Habitat Evaluation

System (HES) and Wetland Evaluation Technique (WET) developed by the Corps of Engineers, and the Hydromorphologic Methodology (HGM). Where instream flows are involved, the Service's Instream Flow Incremental Methodology (IFIM) may be able to provide information in making mitigation recommendations. Other updated evaluation systems may be used, provided they conform to the policies contained in the Mitigation Policy.

MIT3) Impacts to the estuary that result from lower inflow and higher salinities have been quantified using empirical relationships and models. Mitigation for these impacts should be determined and implemented, and we recommend that the Corps consult with the State of Florida and the Service's Panama City Field Office.

Other Analyses Needed to better represent the overall impacts of the PAA

Issue 1: Basin-wide Corps' operations coupled with forecasted climate change impacts are likely to lead to additional challenges in achieving Corps' objectives and compliance with regulatory requirements. Though most climate models slight disagree on forecasted changes in annual precipitation amounts and seasonal patterns; all generally accepted models predict additional consumptive and non-consumptive basin-wide loses and greater frequency of intense storm events, and prolonged dry periods and droughts. These projections indicate greater likelihood of volatile instream-flows, and reduced capacity to ameliorate these differences through storage and release from reservoirs.

Concern 1: The Corps' capacity to meet planned objectives is likely to be challenged when consideration is given to climate change impacts coupled with; 1) greater withdrawal demands (municipal and industrial) from the basin and upstream reservoirs, 2) more frequent dry periods that limit in-stream flows and elevate agricultural consumption in both the Flint and Chattahoochee basins, and 3) the continued need to comply with regulatory standards and meet other authorizations. Though the Corps provided an evaluation of climate change in response to our DFWAR, a more comprehensive model reflecting watershed dynamics across the basin is needed.

The combined and interactive influences of climate change impacts coupled with Corps' operations are likely to result in disproportionate consequences toward achieving Corps' objectives. These future consequences may have adverse impacts on the capacity for the Corps to meet their authorities and public expectations, as well as consequences on the fish & wildlife conservation and the overall state and condition of the natural environment. These expectations, coupled with additional demands, may create unrealistic expectations during dry years for a basin that has limited storage, less predictable precipitation, and ever increasing demands near the headwater areas. These coupled effects have yet to be adequately evaluated.

With the limits of basin-wide storage capacity in mind, one of the consequences of the PAA will be lower average flows to downstream areas for more extended periods, particularly during the summer months when water demands are high. Lower flows during critical periods may, 1) disrupt life history sequences that are necessary for a particular species, 2) alter food-web dynamics and functioning to support species during critical periods, or 3) result in the loss of needed connectivity of between source/sink populations that have significant value at the species level. These impacts result in a corresponding series of change in ecological communities and habitat settings.

In addition to changes in habitat conditions and patterns of occurrence (eg. Fewer acres or stream miles of a particular habitat), the loss of wetland acres will also result from prolonged periods without flooding. The loss of wetland acres will result in reductions in carbon storage. Wetlands and swamps function as carbon "sinks", and provide stable chemical storage environments. As these wetlands dry, or are repeatedly rewetted and dried, stored carbon is lost through decomposition processes and released as greenhouse gases (carbon dioxide, methane, etc.).

Mineralization of the soil also reduces the capacity of the soil to store nutrients, and other chemical compounds that may pose a risk to wildlife. The released nutrients, coupled with changes in weather patterns, hydrology, and species tolerance may accentuate changes in habitat characteristics and suitability, as well as resistance and resilience to further ecological change. Though these changes may not become expressed for a few decades, once these changes are initiated they become difficult to redirect and have unexpected consequences that can't be easily curtailed. Therefore, consideration of altered or loss of wetland habitat (carbon storage) and wetland function associated with Corps' operations should be fully evaluated.

Recommendation 1: With other stakeholders, develop a basin-wide adaptive management strategy that has differential objectives that can accommodate prolonged dry periods, normal periods, and wet periods. Adjustable objectives will require additional metrics to evaluate successful basin-wide operations that are in concert with other stakeholder operations. In partnership, adjustable objectives can be appropriately prioritized depending on current and forecasted basin-wide meteorological conditions. Currently, several research initiatives are on-going to address this issue, and the available results could be used to better evaluate climate change issues.

As an example, the Apalachicola River, floodplain, and Bay are nationally and internationally recognized as being a globally significant natural resource, "hot spot" for diversity, and carbon storage "sink". Therefore, increased focus on impacts to the Apalachicola ecosystem could have important conservation benefits toward minimizing and mitigating for potential future change.

We recommend that the Corps consider elevated attention of impacts from Corps' operations and climate change should be given to this system; and through partnership, a coordinated strategy is needed to minimize future impacts.

Issue 2: Further analysis of consequences of operations toward water quality associated with proposed Corps' operations is needed. In addition to potential impacts to the overall environment, changes in water quality may also have impacts to fish and wildlife conservation.

Concern 2: River flow is regulated by Corps' operations, variation in flow (water quantity) at various time scales (daily variation to annual variation) influences water quality. Though regulated by state agencies, water quality impacts are influenced by Corps activities through WCM operations that influence water quantity. Therefore, the capacity of the river to stay within water quality standards (TMDL), and at appropriate concentrations, is influenced by patterns of water release. Therefore, changes in minimum flows from Lake Lanier from 750 cfs to 650 cfs should be evaluated to determine the likelihood of exceeding various TMDL's, and other clean water standards associated with NPDES permits.

The Service feels that the limited benefit of storing 100 cfs of water in Lake Lanier may be outweighed by the potential risks associated with reduced water quality. In addition to risks to public health and wildlife; these changes may disrupt state permitted discharge releases (NPDES) further downstream, and potentially disrupt downstream recreational opportunities.

Further, contaminants bound to bed- and bank-sediments or stabilized within floodplain soils can become re-suspended or re-dissolved depending on flow patterns and volumes. The Corps' preferred alternative is focused on a more conservative water storage approach, thus, resulting in lower flows, and reduced likelihood of short-term floods. In the absence of flooding, wet soils begin to dry and re-oxygenate. Oxygenation then leads to a chemical conversion of reduced soils and otherwise stable contaminants. Of greatest concern is the reintroduction of compounds such as mercury, heavy metals, and organic compounds that are otherwise stabilized, and removed from the food chain. Therefore, future flood events that will periodically occur when inflow exceeds the capacity for water storage in upstream reservoirs, will allow for suspended contaminants and chemically-active contaminants to re-enter the river system from bank erosion, bed sediment suspension, and discharge from flooded swamp and floodplain sources. Though the Corps does not regulate flood discharges, the preferred alternative will minimize or eliminate periodic low-impact flood events and allow for greater risk of contaminant movement.

Though the likelihood of potential impacts from these issues during normal flow years may be considered to be low, that had not been adequately addressed. Further, these risks; 1) vary from year to year with weather patterns, 2) are often cumulative, and 3) should be expected to be magnified with expected climate change impacts. Therefore, the Service feels that additional analysis is needed to evaluate the proposed alternatives and associated risk in meeting water quality standards across the entire basin, as well as the potential cumulative costs (local, state, federal) of minimizing these risks by other means in the future.

Recommendation 2: With other state and federal agencies, conduct a full evaluation of water quality concerns that may be associated with Corps' operations. These evaluations will consider risks, and identify adaptive measures that can be implemented to eliminate or minimize consequences associated with water quality issues.

Issue 3: The Service considers the PAA to be an incomplete effort in evaluating the preferred and proposed alternatives relative to the economic impacts associated with recreational opportunities as well as the capacity of federal and state agencies in meeting their legally mandated purposes and authorities. Various federal and state agencies have properties and associated recreational initiatives that are dependent upon seasonal patterns of river flow to achieve identified purposes. These state and federal initiatives include fisheries programs to stock sport fish species (rainbow trout, striped bass, etc.) and native species; as well as associated water recreation activities at various federal locations such as Chattahoochee River National Recreation Area, Fort Benning-Uchee Creek recreation area, Eufaula National Wildlife Refuge, Apalachicola National Forest, and influence on recreational opportunities associated with St. Vincent's National Wildlife Refuge. In addition to these, each of the three states (AL, GA, FL) have various publicly accessible areas such as wildlife management areas and state parks across the basin.

Concern 3:

The Chattahoochee River National Recreation Area was established with the dependency on appropriate water releases to meet their legally mandated authorities and mission objectives. Similarly, the Eufuala NWR is highly dependent on reservoir operations in meeting their mission objectives. The Service believes that during alternatives analysis and evaluation of the preferred alternative, greater consideration should be given to federal and state agencies with mission authorizations and objectives that are co-dependent on Corps' operations. These analyses should include a likelihood analysis of violating dependent-authorizations, as well as the identification of potential mitigation actions.

Recreation across the basin generates hundreds of millions of dollars annually. As an example, based on information received from National Park Service, cumulative direct and indirect income from recreation at the Chattahoochee River National Recreation Area is estimated to be more than 100 million dollars annually, and that value greatly exceeds the economic return from hydropower generation at Buford Dam. However, these benefits and the capacity to optimize on recreational opportunities were not fully considered by the Corps during alternatives analysis or in the development of the PAA. Clearly, in the development of the PAA, full consideration should be given to the collective sum from recreational opportunities across the entire basin.

Aquatic and wetland invasive species as well as the effectiveness of control measures is highly dependent upon reservoir operations and flow regimes. Further, the cost and consequences of addressing invasive species has significant impacts on the capacity to meet mission objectives. Some examples include *Phragmites* and other freshwater marsh invasive species that have little or no wildlife value to migratory waterfowl. *Phragmites* also quickly displaces native freshwater marsh species that have high wildlife value. Invasive macrophyte species such as Eurasian milfoil, *Hydrilla*, and water hyacinth which create thick weedbeds; and after dying, as the biomass decomposes, biological oxygen demand (BOD) increases and dissolved oxygen (DO) is reduced. These changes greatly alter habitat conditions by creating an anoxic layer below shallow surface waters. Because of longer growing seasons and shallow lake profiles that allow for greater expansion from shore, problems associated with invasive species will be most strongly expressed in Coastal Plain riverine environments and reservoirs. To control the establishment and expansion of invasive species, significant financial and labor resources are needed. Without control, these species can quickly limit the capacity for management agencies to meet mission objectives by greatly reducing recreational values, as well as benefits to ecological function and wildlife value.

Similarly, water conservation measures that reduce or eliminate growing season inundation of swamp areas allow invasive species to become established. Chinese tallow-tree and Asian privet species, in the absence of periodic inundation, become established in floodplains and swamps. Once established, both species quickly spread and begin to influence ecosystem processes and habitat suitability for native wetland species and migratory birds. Ultimately, these changes influence nutritional quality of detrital material and the rate of decompositional processes, including carbon storage. During infrequent flood events, the altered (quantity, quality) detrital material is then transported to the aquatic system, and may have unexpected consequences on the food chain including aquatic invertebrates, mussels, and fish as well as those species in Apalachicola bay. Altered floodplain conditions already exist in the lower Chattahoochee and Apalachicola rivers, and these species are already established and spreading. Control measures have been ineffective, and the absence of flooding, these species will continue to spread. However, conservative water storage operations that limit the likelihood of growing season floods are likely to amplify the problem and allow the species to become established in previously flooded areas. The influence on habitat will increase, and the need for control of these species will be expanded. Therefore, the direct and indirect costs may be substantial.

Recommendation 3: A more comprehensive evaluation of the consequences of Corps operations relative to the purposes and authorizations of other federal and state agencies. Further, these evaluations should clearly identify how Corps operations will impact the mission objectives, and the potential consequences or costs associated with these impacts.

Issue 4: The Service believes there was incomplete analysis and evaluation of alternatives relative to other fish and wildlife measures that include biodiversity metrics, and habitat conditions associated with at-risk species that may be subject to federal listing in the future. Biological and ecological metrics need to be considered for the entire basin to evaluate impacts of operations, and evaluate basin-wide differences between alternatives. These evaluations should also include at-risk species assessments. These species may become federally listed without proactive conservation to minimize threats, and may potentially avoid the need to list these species, and thus, additional regulatory requirements.

Concern 4: The alternatives analysis did not consider basin-wide impacts on At-Risk species, or other ecological services that are necessary for maintaining a healthy and sustainable riverine and floodplain ecosystem. Because the Corps regulates water flow through water storage across nearly the entire Chattahoochee basin and roughly 2/3 of the inflow into the Apalachicola, the Service feels that it is necessary to adequately address the impacts to fish and wildlife for the entire area, and in doing so, evaluate the consequences on sustainable natural resources that have important economic value in various sections of the river.

As indicated in table 1, in addition to the four (4) federally listed species, fifteen (15) petitioned at-risk species occur within the project area. These species occur across the basin from Lake Lanier/Buford Dam to the Sumatra Gage along the Apalachicola River, and each would be impacted differently by Corps' operations. Evaluation of these impacts for each alternative is needed, as well as a determination of what each at-risk species may potentially represent as an indicator of operational performance. The status, stability, and threats associated with these species in the basin will strongly influence future Service decisions on listing. Therefore, an evaluation of status, potential impacts, and possible conservation measures that can be implemented to potentially avoid listing. If a single at-risk species or a collection of at-risk species become listed, that may result in further regulatory basin-wide restrictions that could be sympatric or asympatric with current or proposed Corps' operations.

Compared to the Corps' evaluation of alternatives, the Service's evaluation of alternatives that was used to develop the DFWCAR considered three additional metrics that the represented riverine ecosystem functions as well as recreational opportunities within the various reservoirs. As noted in concerns section for Performance Metrics (Issue #3), three additional metrics included; 1) salinity in Apalachicola bay, 2) gulf sturgeon reproductive success, and 3) adult shoal bass population recruitment between West Point Lake to Lake Lanier.

Table 1. Petitioned At-Risk Species within the Project Area		Chattahoochee River			Apalachicola River
species group	Species Name	Upper (Lanier to West Point)	Middle (West Point to Eufuala)	Lower (Eufuala to Seminole)	Entire
crayfish	*Cambarus harti*	X	x		
fish	*Anguilla rostrata*		x	X	x
fish	*Cyprinella callitaenia*	X	x	X	x
fish	*Percina crypta*	X			
fish	*Pteronotropis euryzonus*		X	X	
insect	*Cordulegaster sayi*				x
insect	*Oecetis parva*				x
insect	*Oxyethira setosa*				x
mussel	*Anodonta heardi*		X		
mussel	*Anodontoides radiatus*			x	
mussel	*Elliptio arctata*		X		
salamander	*Amphiuma pholeter*				x
salamander	*Eurycea chamberlaini*		X	x	x
turtle	*Graptemys barbouri*			x	x
turtle	*Macrochelys temmincki*		X	x	x

Recommendation 4: A broader range of fish and wildlife conservation metrics are needed. These metrics should be used to evaluate potential changes resulting from Corps' operations, and should be indicative of impacts resulting from Corps' operations, and representative of targeted conservation conditions. Full consideration of impacts to At-Risk species, including, but not limited to those recently petitioned. A full evaluation is needed to determine the risk to these species, and identify any possible conservation action that may be implemented to eliminate or minimize the threat to a species.

SUMMARY AND FWS POSITION

The Service does not fully support the Corps' adoption of the PAA for the following reasons:

- the Corps' alternatives selection process (Service 2015; Appendix XV),
- a failure to adequately address conservation measures identified in the Service's PAL (Service 2010; Appendix V), PAL addendum (Service 2011; Appendix VI), and the Service's 2011 DFWCAR (Service 2011) and subsequently included in this report,
- increased frequency of low flows causing negative impacts to basin-wide distributed at-risk and federally-listed species, and
- possibly slightly higher salinities (1 ppt) to the mouth of the Apalachicola River and East Bay.

Our previous DFWAR (2015) indicated modeling developed from limited consumptive use scenarios without sufficiently considering climate change and future increase in consumptive demands; however, these topics were more adequately addressed in a letter responding to the DFWCAR, and during the EIS process. The Service continues to believe that improved scenarios to address future impacts of climate change and potential increases in consumptive use are still needed; but, improved forecasting is limited by the availability of more comprehensive scientific information and improved assessments of water demands in the future. Our recommendation is, through partnerships, continue to develop basin-wide adaptive management strategies to address impacts of climate change.

In accordance with the FWCA and Service mitigation policy (FR 46(15):7644-7663; January 23, 1981), we identified steps that should be taken to ensure that fish and wildlife resources are protected or improved. We identified additional conservation measures and steps that should be taken as part of an update to the WCM. We emphasize again that the WCM update is a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental measures.

The Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, and therefore direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for 'with the project' and 'without the project' scenarios based on more accurate projections of future conditions.

We also emphasize that the Corps' impact to water quality, primarily dissolved oxygen, below several projects in the ACF Basin is unacceptable. The Corps needs to seek authorization and appropriations to ensure that water quality standards are met below these projects.

To ensure sustainability for these resources, and especially those that are imperiled, the Service will continue to work cooperatively with the Corps and all stakeholders. In particular, the Service needs to be an integral member of the Corps' team when formulating and evaluating operational alternatives. We encourage the Corps to follow the recommendations and conservation measures included in this document and are ready to assist in the development of a WCM that balances protection of fish and wildlife resources in the ACF River Basin with other project purposes.

LITERATURE CITED

Altinok, I. and J.M. Grizzle. 2001. Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. Journal of Fish Biology 59:1142–1152.

Federal Energy Regulatory Commission. 2014. Order issuing new license. Project No. 485-065. December 22, 2014. 58 pp.

Florida Fish and Wildlife Conservation Commission (FFWCC). 2011. Florida Fish and Wildlife Conservation Commission Comments on Draft Fish and Wildlife Coordination Act Report. 27 pp.

Georgia Power Company. 2006. Resource Study Report Fisheries and Aquatic Resources, Morgan Falls Project (FERC No. 2237). Prepared with GeoSyntec Consultants. March 2006.

Haag, W.R., and M.L. Warren, Jr. 1998. Role of ecological factors and reproductive strategies in structuring freshwater mussel communities. Canadian Journal of Fisheries and Aquatic Sciences 55:297-306.

Hess, B.J., and C.A. Jennings. 1999. Reproductive success of stocked striped bass (*Morone saxatilis*) in the Chattahoochee River above West Point Lake: implications for the Morone stocking program. Final Report, prepared for Georgia Department of Natural Resources, Wildlife Resources Division, Fisheries Management Section, Social Circle, Georgia. September 1999.

Huang, W. 2010. Hydrodynamic modeling and ecohydrological analysis of river inflow effects on Apalachicola Bay, Florida, USA. Estuarine, Coastal and Shelf Science 86:526-534.

HydroLogics. 2012. Memorandum from Dean Randall and Megan Wiley Rivera, HydroLogics, Inc., May 21, 2012, Re: Apalachicola Bay salinity model and OASIS.Light, H.M., K.R. Vincent, M.R. Darst, and F.D. Price. 2006. Water-level decline in the Apalachicola River, Florida, from 1954 to 2004, and effects on floodplain habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.

Livingston, R.J., F.G. Lewis, G.C. Woodsum, X.F. Niu, B. Galperin, W. Huang. 2000. Modeling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50:655–672.

Paramygin, V.A. and Sheng, Y.P. 2015. A Preliminary Report: Simulating the response of estuarine salinity in Apalachicola Bay. Prepared for U.S. Fish and Wildlife Service. Prepared by Engineering School of Sustainable Infrastructure and Environment, University of Florida. Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Parauka, S. Bolden, and

R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505–515.

United States Army Corps of Engineers. 1998. Draft Environmental Impact Statement Water Allocation for the Apalachicola-Chattahoochee-Flint (ACF) River Basin Main Report, September 1998, Mobile District, Mobile, Alabama.

United States Army Corps of Engineers. 2011. ACF Water Control Manual Update Response to PAL. January 18, 2011.

United States Army Corps of Engineers. 2014. HEC5Q and FWS water temperature model comparisons. Prepared by Evan Heisman, NWW Hydrology Section. 7 pp.

United States Army Corps of Engineers. 2015a. ACF Water Control Manual Update Response to PAL. January 21, 2015.

United States Army Corps of Engineers. 2015b. Apalachicola-Chattahoochee-Flint (ACF) Watershed HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment. Appendix K – Development of Alternatives. June 2014

United States Army Corps of Engineers. 2015c. Draft Environmental Impact Statement Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment. U.S. Army Corps of Engineers, Mobile District, Mobile, AL. United States Fish and Wildlife Service. United States Army Corps of Enginers. 2015d. Response to U.S. Fish and Wildlife Service DFWCAR on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida. August 2015. 26 pp.

United States Army Corps of Engineers. 2016a. ACF Water Control Manual Update Supplemental Information for Final Fish and Wildlife Coordination Act Report. July 2016, 122 pp.

United States Army Corps of Engineers. 2016b. PAL Response Plots, Version 4. June 2016, 53 pp.

United States Fish and Wildlife Service. 2008. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. June 1, 2008. 225 p.

United States Fish and Wildlife Service. 2011. Draft Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida. Southeast Region, Atlanta, Georgia, June 2011. 41 pp.

United States Fish and Wildlife Service. 2012. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. May 22, 2012. 117 p.

United States Fish and Wildlife Service. 2015. Draft Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida. Southeast Region, Atlanta, Georgia, July 2015. 73 pp.

Wang, H., W. Huang, M.A. Harwell, L. Edmiston, E. Johnson, P. Hsieh, K. Milla, J. Christensen, J. Stewart, and X. Liu. 2008. Modeling oyster growth rate by coupling oyster population and hydrodynamic models for Apalachicola Bay, Florida, USA. Ecological Modeling 211: 77-89.

Watters, G.T. 1997. Individual-based models of mussel-fish interactions: a cautionary study. Pages 45-62 in: K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, editors, Conservation and management of freshwater mussels II: initiatives for the future. Proceedings of an Upper Mississippi River Conservation Committee symposium, October 1995, St. Louis, MO.

Appendices I through XV are included in the Draft Fish and Wildlife Coordination Act Report July 2015 in this appendix (appendix J) of the EIS for the ACF WCM Update.

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
MARK WILLIAMS, COMMISSIONER

August 19, 2016

Donald W. Imm, State Supervisor
U.S. Fish and Wildlife Service
Georgia Ecological Services
105 West Park Drive, Suite D
Athens, GA 30606

Re: Apalachicola-Chattahoochee-Flint (ACF) River Basin
Water Control Manual Update Supplemental Information for Final Fish and Wildlife Coordination Act Report

Dear Mr. Imm,

We appreciate the opportunity to provide comment on the ACF Water Control Manual Update Supplemental Information for Final Fish and Wildlife Coordination Act Report. As you know, we have been engaged in this process for nearly a decade and have consistently outlined objectives and concerns through comment on various iterations of the ACF Water Control Manual Update (2008, 2013) and Draft Fish and Fish Wildlife Coordination Act Reports (2011, 2015). These comments are included by reference in the Comments of the State of Georgia, dated January 29, 2016, on the Apalachicola-Chattahoochee-Flint River Basin Water Control Manual and Draft Environmental Impact Statement (October 2015). Our staff has reviewed the supplemental information provided and we ask that the comments referenced above are considered during the US Fish and Wildlife Service's development of the Final Fish and Wildlife Coordination Act Report.

If you require additional information or copies of the referenced documents, please contact Thom Litts at (706) 918-6406.

Sincerely,

Mark Williams

cc: Rusty Garrison
Gail Cowie
Thom Litts

Florida Fish and Wildlife Conservation Commission

Commissioners
Brian Yablonski
Chairman
Tallahassee

Aliese P. "Liesa" Priddy
Vice Chairman
Immokalee

Ronald M. Bergeron
Fort Lauderdale

Richard Hanas
Oviedo

Bo Rivard
Panama City

Charles W. Roberts III
Tallahassee

Robert A. Spottswood
Key West

Executive Staff
Nick Wiley
Executive Director

Eric Sutton
Assistant Executive Director

Jennifer Fitzwater
Chief of Staff

Office of the Executive Director
Nick Wiley
Executive Director

(850) 487-3796
(850) 921-5786 FAX

Managing fish and wildlife resources for their long-term well-being and the benefit of people.

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850) 488-4676

Hearing/speech-impaired:
(800) 955-8771 (T)
(800) 955-8770 (V)

MyFWC.com

September 6, 2016

Mr. Don Imm
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606

Re: Florida Fish and Wildlife Conservation Commission's Comments on the Final Fish and Wildlife Coordination Act Report

Dear Mr. Imm:

The State of Florida, through the Florida Fish and Wildlife Conservation Commission (FWC) submits the following comments on the Final Fish and Wildlife Coordination Act Report. Florida previously submitted comments on the U.S. Army Corps of Engineers' (Corps) Draft Environmental Impact Statement, Update of the Master Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Alabama, Florida, and Georgia and a Water Supply Assessment. Since that time, the Corps has updated the proposed action alternative (PAA) to allow Georgia even greater cumulative gross withdrawals from the system. Florida continues to oppose the revised PAA, and incorporates by reference all of its prior comments on and objections to the PAA and accompanying documentation, none of which comments and objections appear to have been addressed to date.

We are writing to address two additional issues: (1) Florida is concerned that the Corps has failed to address a number of important issues the U.S. Fish and Wildlife Service (Service) raised in the July 2015 Draft Fish and Wildlife Coordination Act Report; and (2) Recent joint sampling efforts of the FWC and Service demonstrate a shift in mussel main channel "meso-habitats" and underscore the urgent need for more detailed evaluation of the stability of deep water habitats before management decisions impacting the mussels, including in the PAA, are made. This information also demonstrates the significant limitations of prior low-cost side-scan sonar studies of mussels—Florida strongly urges the Corps not rely upon these prior studies.

The Corps is updating the Master Water Control Manual, among other reasons, "to adjust the operation of Lake Lanier, and to enter into agreements with [Georgia] or water supply providers to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta"[1] on the Chattahoochee River to meet Georgia's projected demand through 2040. The Corps has historically managed its facilities on the ACF basin in a way that facilitates Georgia's consumption of water even when it interferes with downstream uses; the Corps is doing the same again here. As you know, Florida is litigating in the original action, Florida v. Georgia, and that litigation is separate and unrelated to the master water control manual revisions. In the litigation, Florida is prepared to show that Georgia's consumption has reduced Apalachicola River flows by thousands of cubic feet per second (cfs) over the past decades, materially altering the hydrology of the region. As a result of Georgia's consumption, the volume of water available for Corps project purposes, including protection of downstream fish and wildlife resources, is significantly restricted. Despite these constraints, the Corps' revised PAA facilitates even more upstream consumptive uses at the expense of downstream resources and other operating purposes.

The Corps Failed to Address Important Concerns Raised by the Service in the 2015 Draft Fish and Wildlife Coordination Act Report

[1] 80 Fed. Reg. 59,741 (Oct. 2, 2015).

Florida agrees with a number of important concerns the Service raised in its July 2015 Draft Fish and Wildlife Coordination Act Report. As the Service explained, "the negative effects of the PAA on fish and wildlife resources are a consequence of reservoir system operation changes *and increases in consumptive demands* that are part of the PAA."[2] This is even more so with the increase in Georgia's cumulative gross consumptive uses. Yet, the Corps' flawed methodology and data for ranking and selecting alternatives for the draft environmental impacts statement provided greater weight to upstream project purposes, including water supply and hydropower, over downstream fish and wildlife purposes.

Florida shares the Service's concerns regarding significant flaws in the Corps' ranking methodology, including that "[u]sing the selection methodology provided to the Service means that the alternative selected by the Corps for consideration in the DEIS does not appear to accurately represent multiple project purposes, and does not appear to give fish and wildlife equal consideration . . . ."[3] Florida agrees with the Service that:

- The Corps' ranking methodology treats "small differences within a project purpose" the same as "large differences." Therefore, "[p]roject purposes do not appear accurately represented when equal weight is given toward inconsequential and consequential differences among alternatives within a project purpose."[4]
- "[A]n incomplete set of fish and wildlife performance measures was used to score and then rank alternatives for the Fish and Wildlife project purpose." As a result, "the set of fish and wildlife performance measures used by the Corps in the ranking do not fully capture the relationship between water management alternatives and their effect on fish and wildlife resources."[5]
- "Some alternatives considered in Phase 1 may have performed differently than the one selected to proceed in Phase 2 if higher consumptive uses are incorporated into the modeling; using the unrealistic volume of consumptive withdrawals could insert some bias into the alternative selection process." This is important because "[d]epending on how an alternative is parameterized in HEC-ResSim, some alternatives may be more resilient than others when consumptive uses are increased."[6]

Florida does not believe any of these concerns were adequately addressed in the revised PAA. Florida also agrees with the Service's finding regarding the draft environmental impact statement that "[e]ffects to Gulf Sturgeon were not adequately assessed"[7] and Florida does not believe an adequate assessment has been made to date.

In the revised Master Water Control Manual, the Corps has the opportunity to improve upon conditions in the ACF Basin and management of the ACF system, but the PAA, which facilitates increased upstream consumption, will only make conditions worse. The PAA does nothing to advance the Service's conservation recommendation in the 2012 Biological Opinion for Woodruff Dam that the Corps "[w]ork in consultation with the states and other stakeholders to assist in identifying ways to reduce overall depletions in the ACF basin, particularly the Flint

---

[2] U.S. Fish and Wildlife Service, Draft Fish and Wildlife Coordination Act Report, 15 (July 2015) (emphasis added) (hereinafter "Draft FWCA Report").

[3] Draft FWCA Report Appendix XV at 1.

[4] *Id.* at 3.

[5] *Id.* at 2, 4-5.

[6] *Id.* at 7

[7] Draft FWCA Report at 33.

River."[8] You recognized the benefit of decreased depletions on listed mussel species, but the Corps has not taken steps to advance this important goal. Florida agrees with the Service's warning that "the PAA results in more frequent lower flows that remain low for longer periods compared to the NAA, thereby creating conditions that could increase mortality of both common and federally-listed mussels."[9]

Recent Sampling Shows there is Inadequate Information on Mussels in the Main Channel and there is an Urgent Need for More Information Prior to Finalizing the Update

Florida believes that more analysis regarding mussel mortality is necessary prior to finalizing the Master Water Control Manual. In past years, peak high flows in the Apalachicola River have raised concerns regarding impacts to the main-channel population of endangered fat threeridge mussel. We believe similar impacts may have occurred this year when flows peaked at nearly 170,000 cfs. We have seen evidence of adverse impacts during previous flooding events, and this recent flood is substantial in both magnitude and duration. These high flows are among the highest on record.

From August 17 through 21, 2016, FWC and Service biologists, and FWC-contracted divers, conducted surveys to estimate population densities of the fat threeridge mussels inhabiting the Apalachicola River. This new data collection was done to enable comparisons of current densities with density estimates obtained by the Service in 2012. In this recent effort there was a particular focus on the mussel habitat that may have been at risk in the wake of historic high flows in the Apalachicola River this past winter, which peaked at nearly 170,000 cubic feet per second (cfs). The data is showing that there were likely impacts caused by these flows.

The mussel surveys were done primarily in the middle reach of the Apalachicola River (river mile 60 downstream to confluence with Chipola River) and several surveys were conducted about 5 river km downstream of the Chipola River confluence. The new quantitative data collection included 36 discrete 10 m^2 benthic radial plots at water depths ranging from 7 to 15 feet. Methods used were identical to those used by the Service in 2012. Qualitative shallow-water shoreline "grubbing" samples were also obtained at 20 of the 36 locations. Some areas surveyed retained densities of mussels similar to previous surveys, however a number of deep water habitats had significantly lower densities than previous surveys. Of particular concern, some areas had none of the mussel species that were previously present during the 2012 survey.

Florida has previously expressed a concern regarding the potential impacts of the high flow event on mussel populations in marginal habitats like the deep water habitats in the main-channel. FWC believes that the new data supports a conclusion that the winter high flows may have changed habitat characteristics and are responsible for reduction of observed mussel densities. This confirms that while low-cost side-scan sonar is an important tool, there are significant limitations on using single scanning event side-scan sonar and subsequent GIS processing to provide accurate estimates of the fat threeridge mussel populations in shifting habitats. Thus, the recent shift in the "meso-habitats" confirmed by our new data renders the Service's previous delineations inaccurate and in need of updating. The Corps must not rely upon this outdated information.

FWC believes the survey results demonstrate that it is necessary to re-evaluate former stable locations of habitat to see if deep water habitats prove more unstable than previously thought. It is likely that shallow water mussel communities in the river sloughs and channel margins are the

---

[8] U.S. Fish and Wildlife Service, Biological Opinion for Woodruff Dam RIOP, p. 151 (May 22, 2012).

[9] *Id.* at 21.

most stable and serve as the source population for deep water habitats during successive years of low to moderate flows. If, as this new data suggests, deep water habitats prove more unstable than previously thought, higher management priorities should be assigned to shallow water mussel communities. Accordingly, expanded sampling and comparison to previous surveys at these locations is needed before the Corps makes any management decisions, including with respect to the PAA.

Since our May 2011 letter, Florida has asked for consistent and transparent communication among the Corps, the Service, and the FWC, as required by the Fish and Wildlife Coordination Act. Such coordination and consultation has not occurred sufficiently to date, but Florida urges the Service to continue to press the Corps to address the important fish and wildlife concerns raised by FWC and the Service. Florida believes that the PAA still can be improved to both address the concerns and enhance benefits to fish and wildlife if the Corps engages with the Service and FWC on these critical issues.

Sincerely,

Nick Wiley

Nick Wiley
Executive Director

cc: Gary Frazer
Larry Williams
Cindy Dohner
Jerry Ziewitz
Adam Kaeser
Colonel Delapp, Army Corps of Engineers, Mobile District
Jonathan P. Steverson, Secretary, Florida Department of Environmental Protection

List of Figures

List of Tables

Dissolved Oxygen

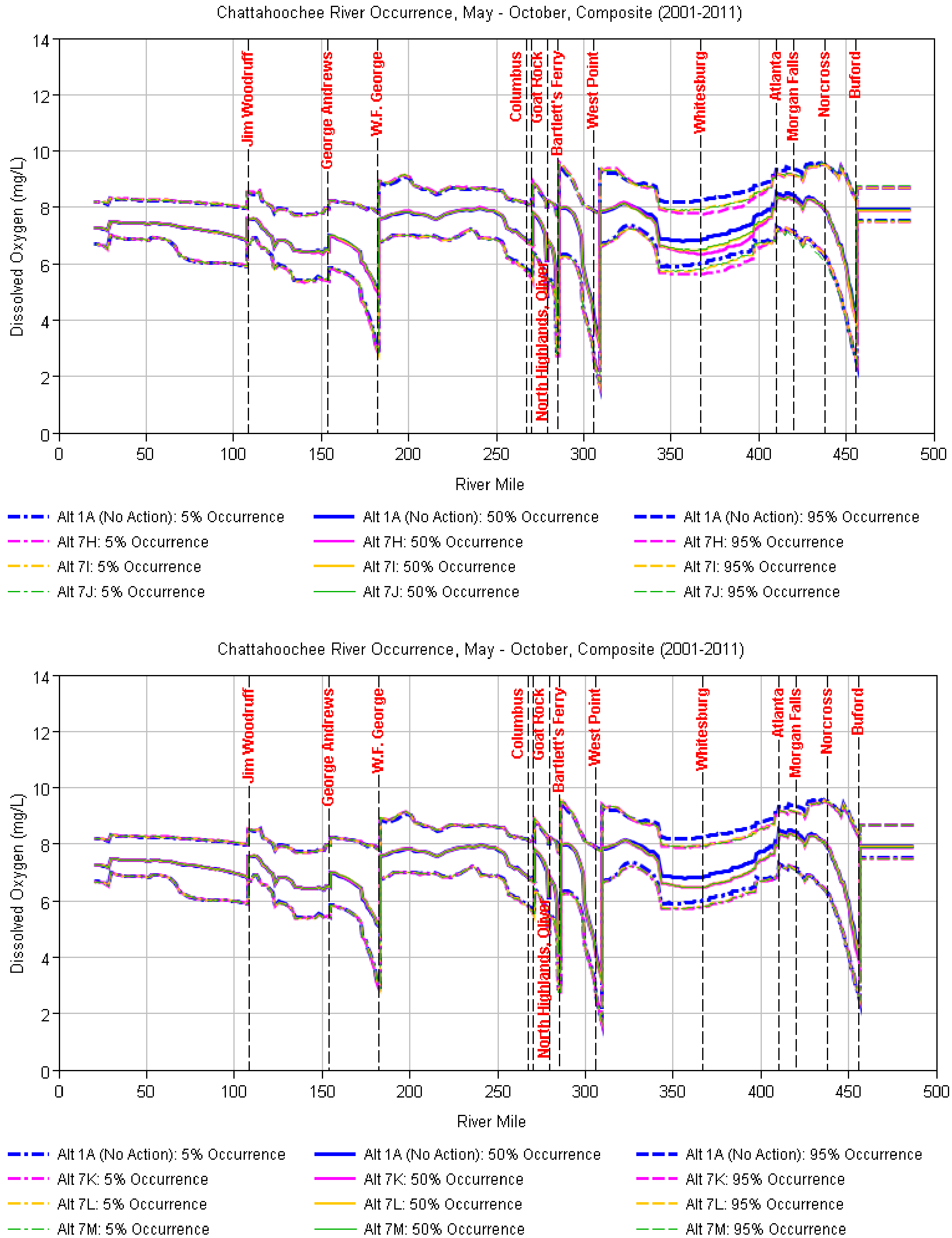


Figure 2.2-1. May through October DO for the modeled period from 2001 through 2011

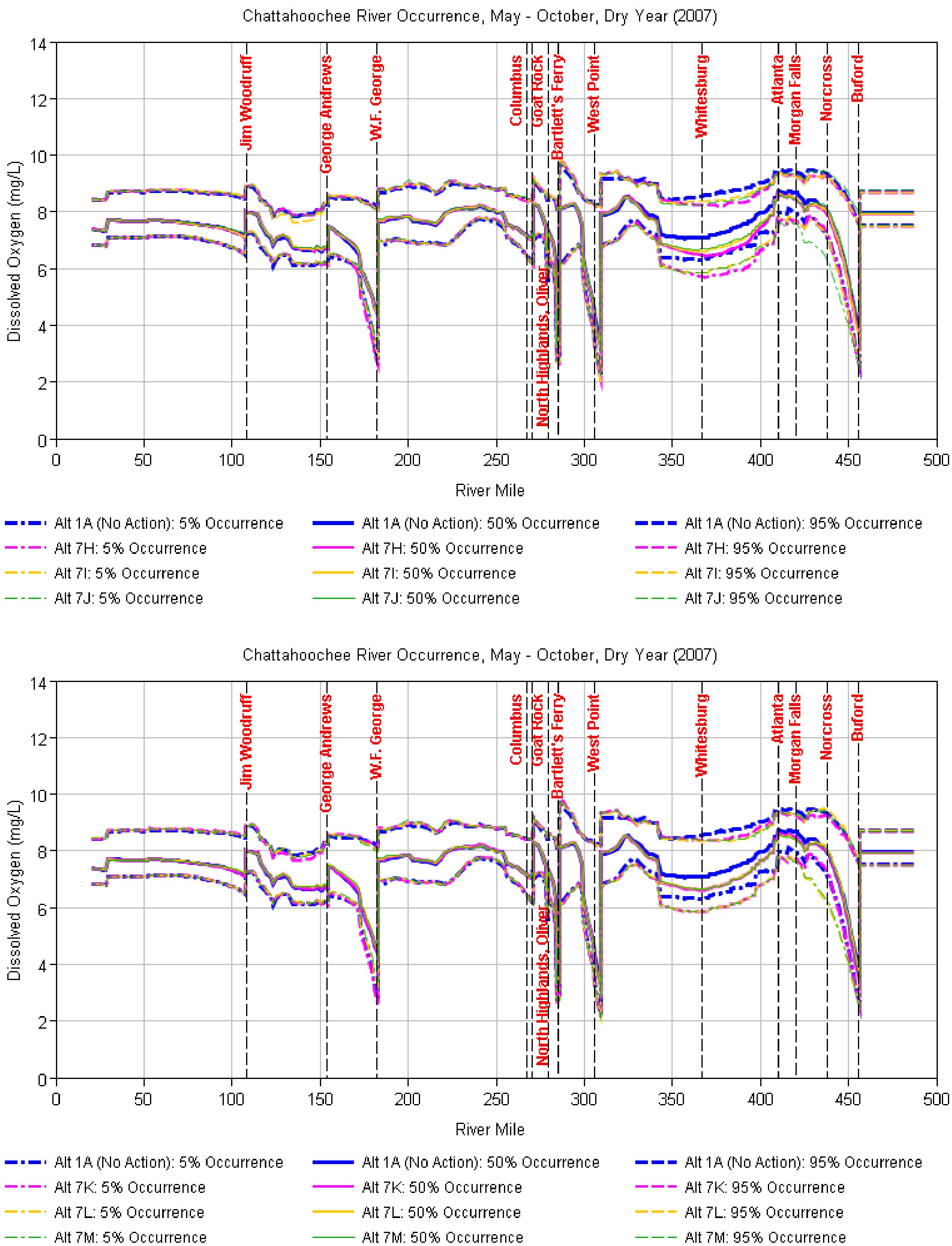
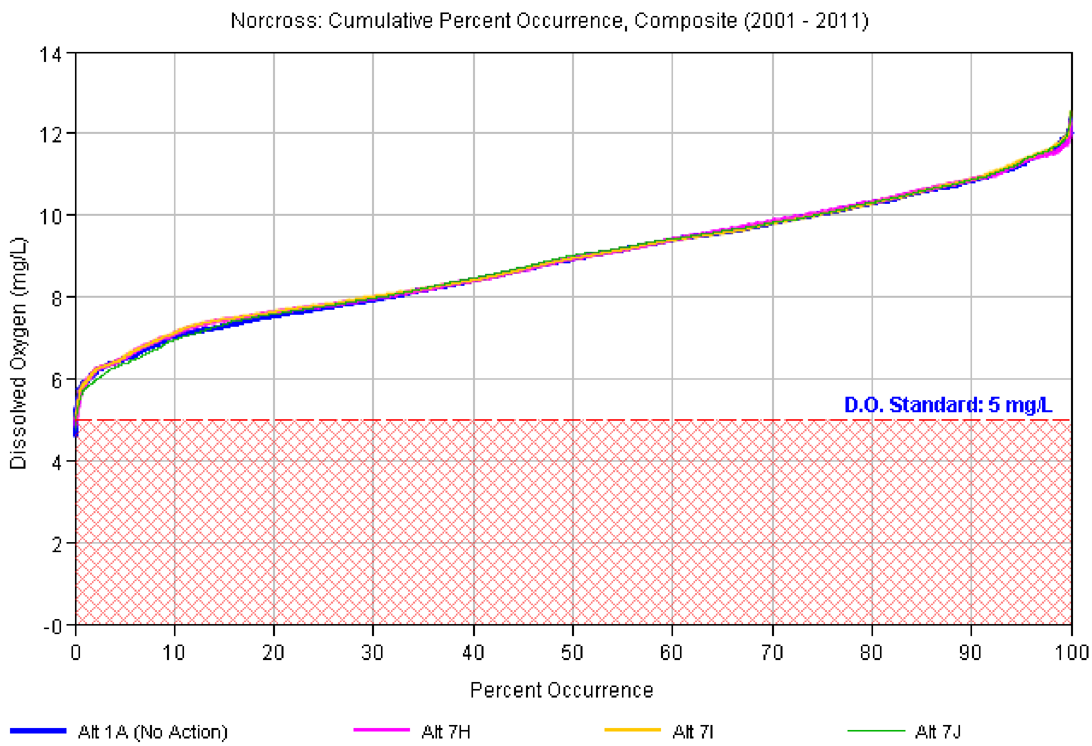


Figure 2.2-2. May through October DO modeled for a representative dry period (2007) when low concentrations would be expected



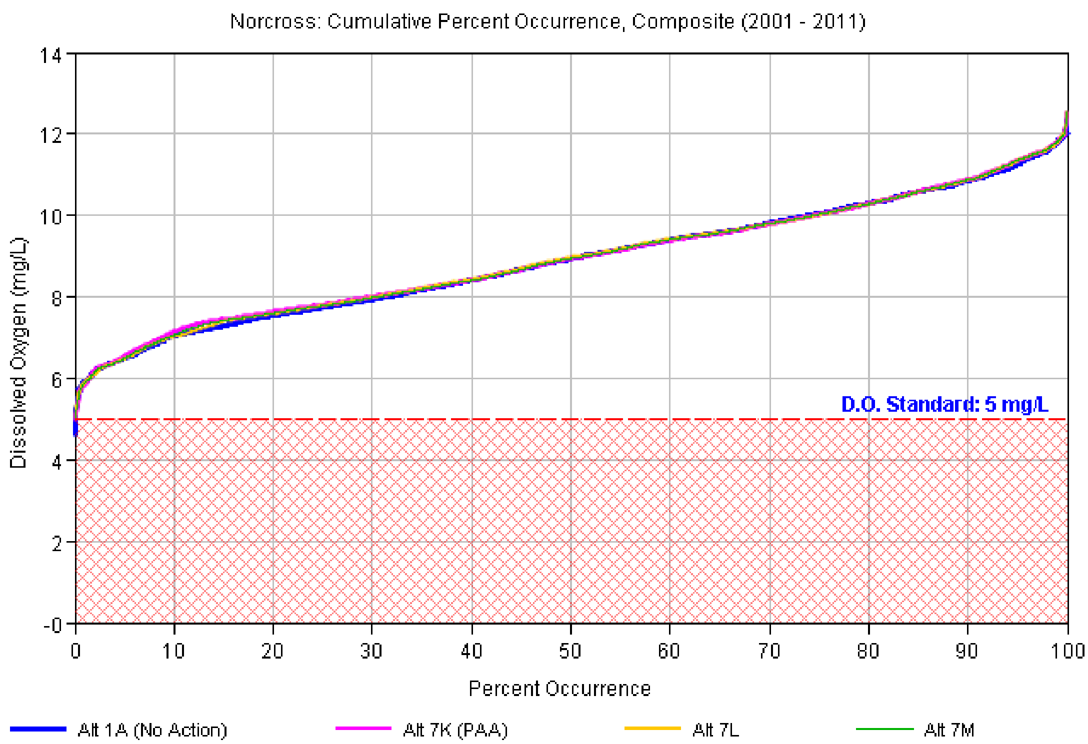
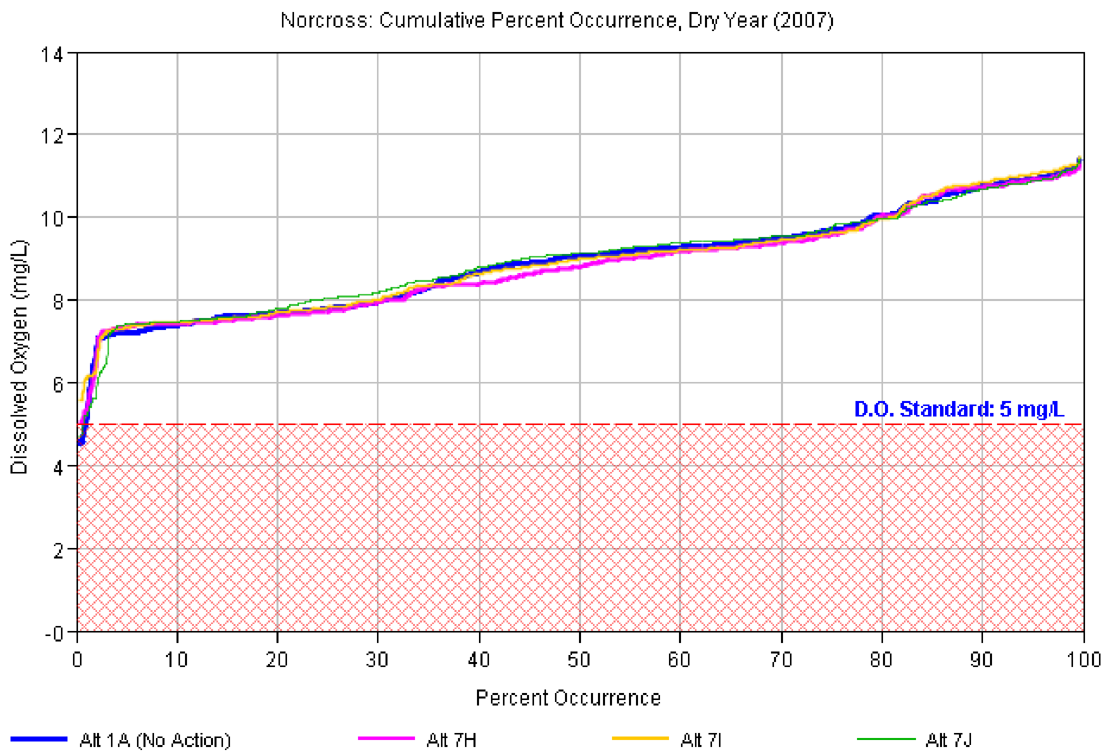


Figure 2.2-3. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for the period from 2001 through 2011



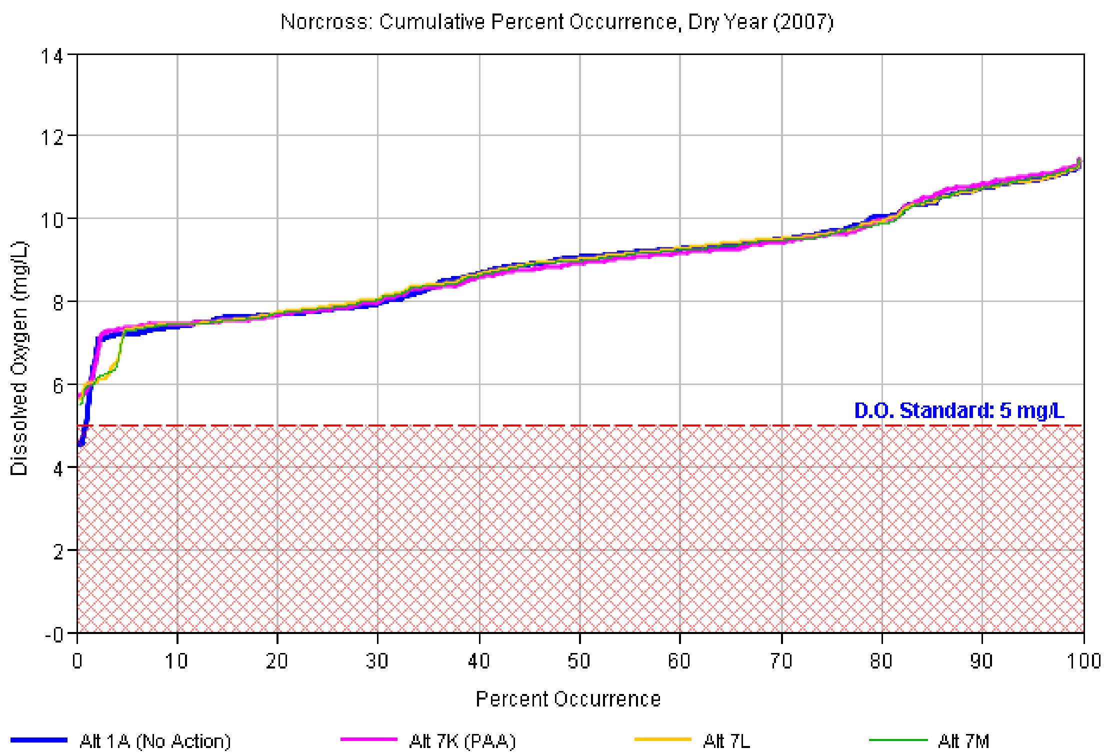
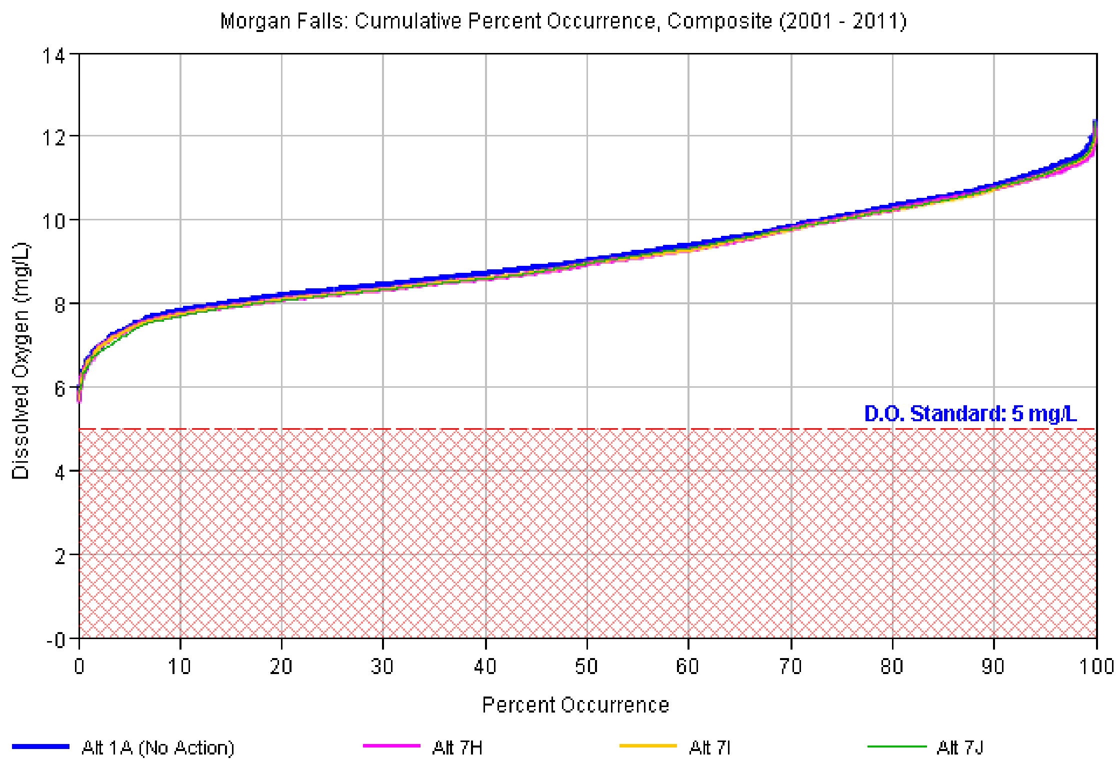


Figure 2.2-4. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for a representative dry year (2007)



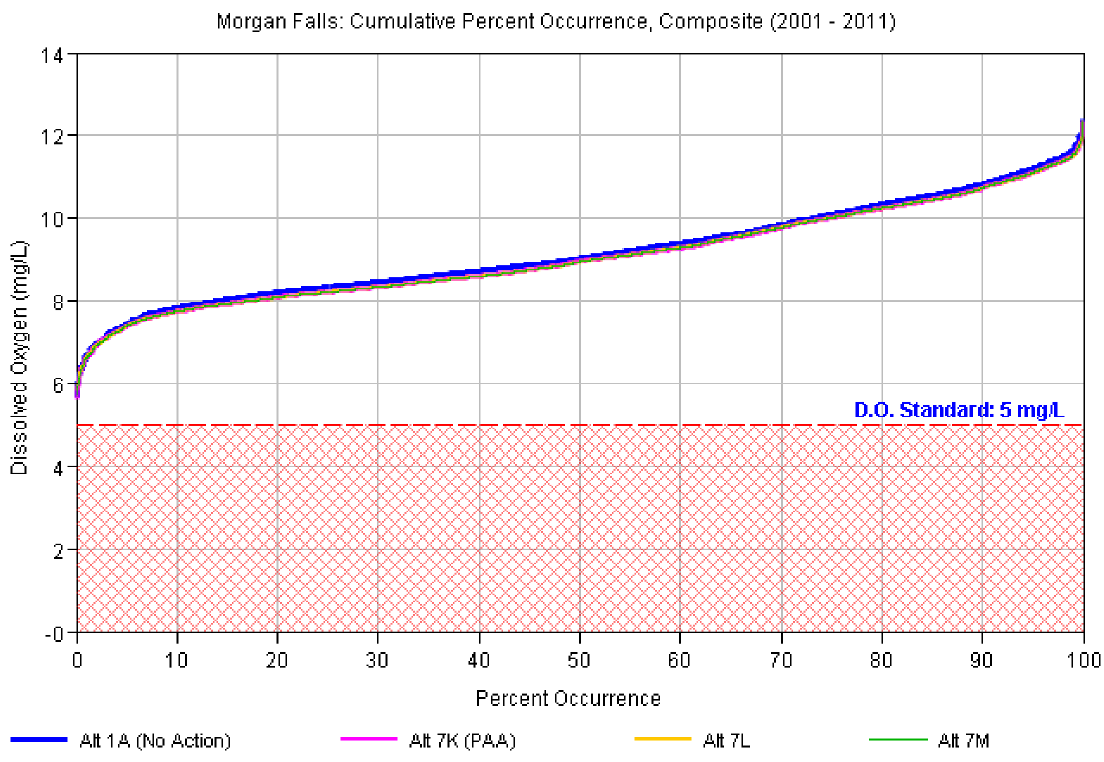


Figure 2.2-5. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for the period from 2001 through 2011

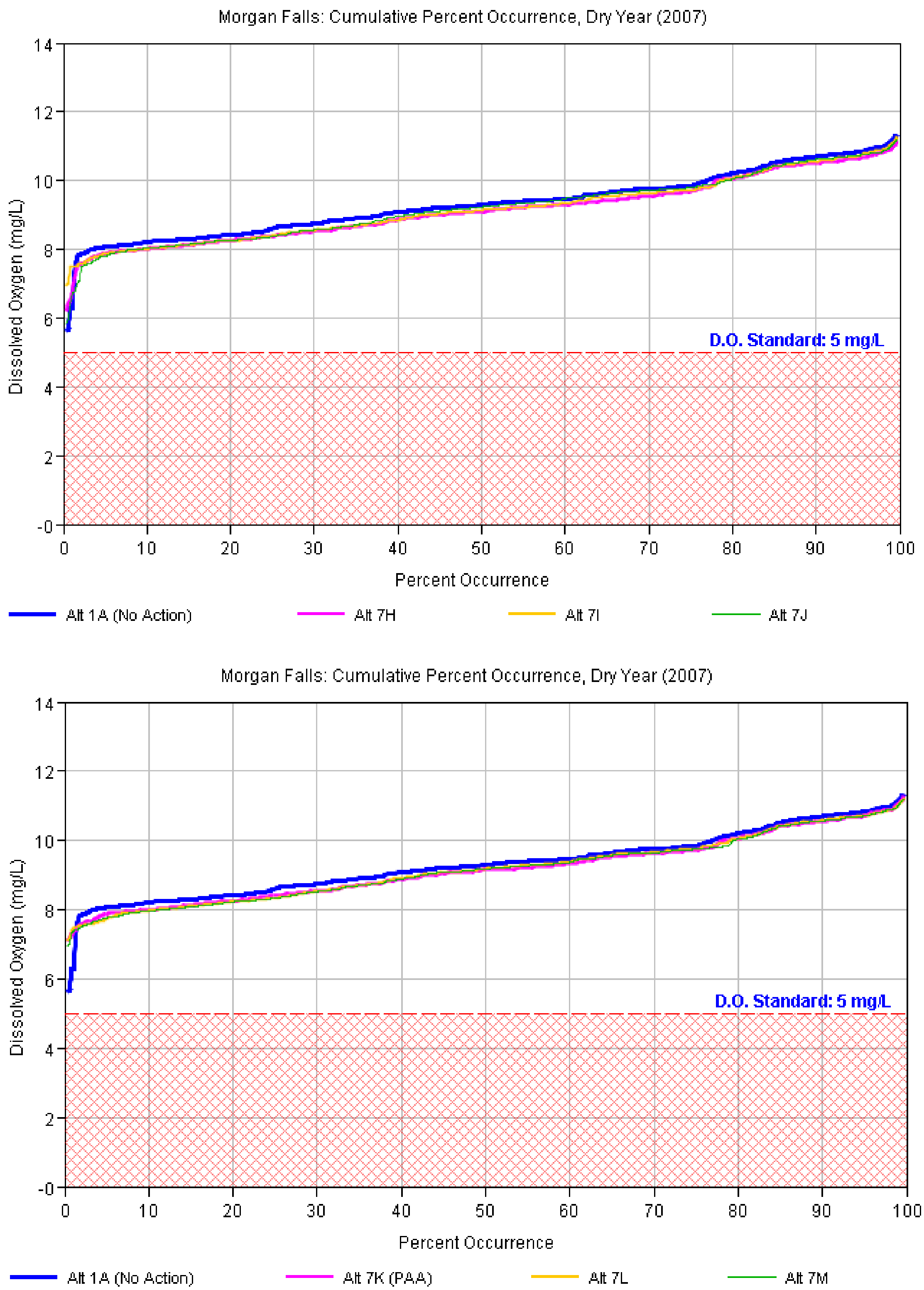
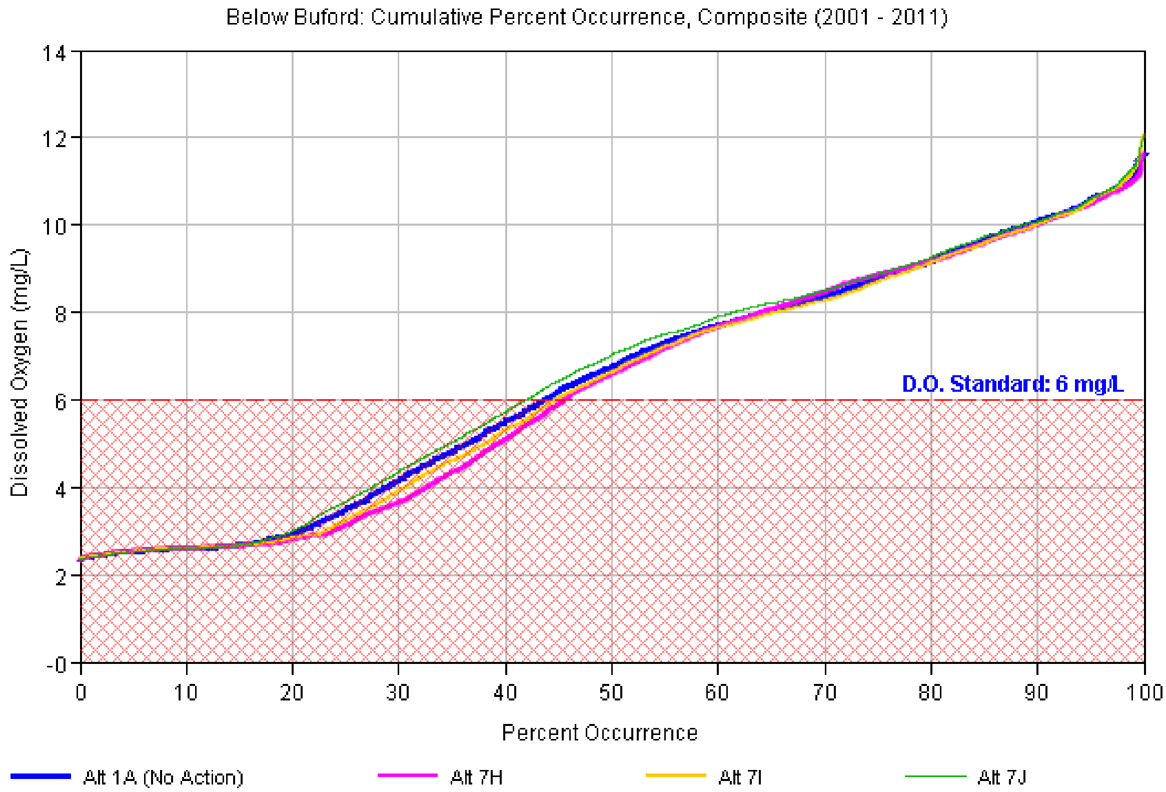


Figure 2.2-6. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for a representative dry year (2007)



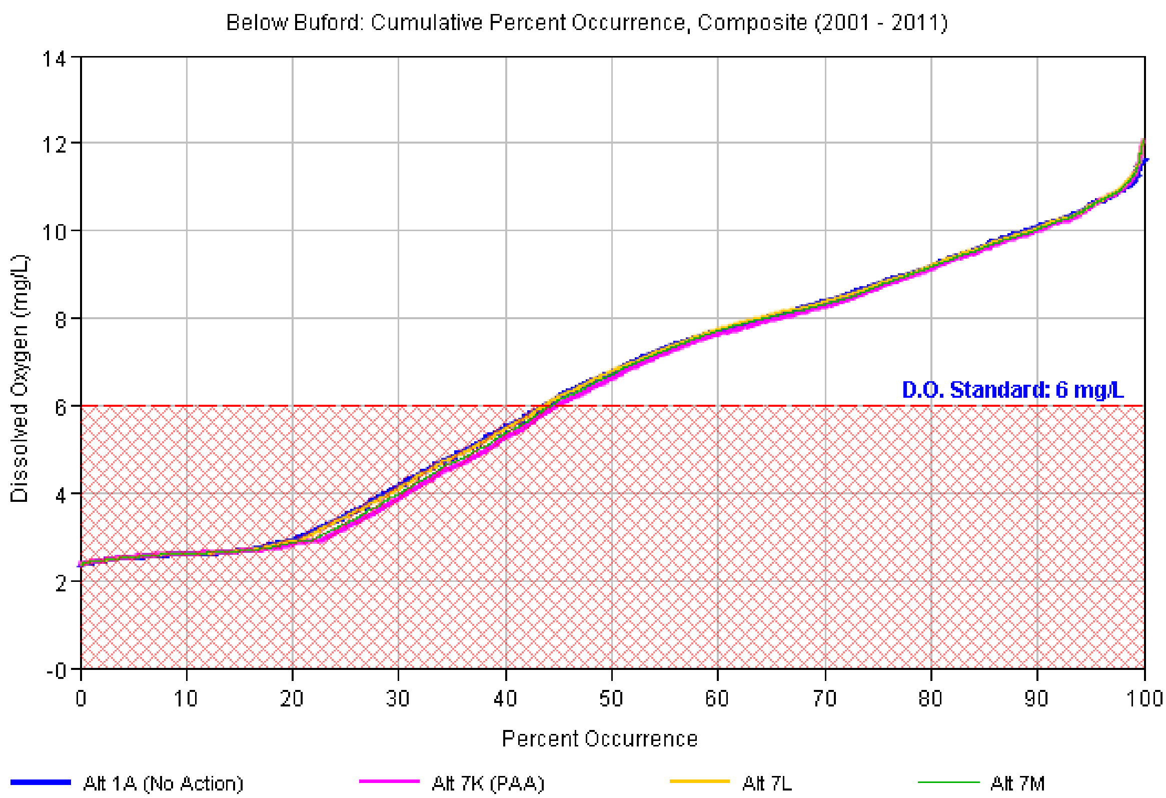


Figure 2.2-7. DO occurrence downstream of Buford Dam for the modeled period (2001 – 2011)

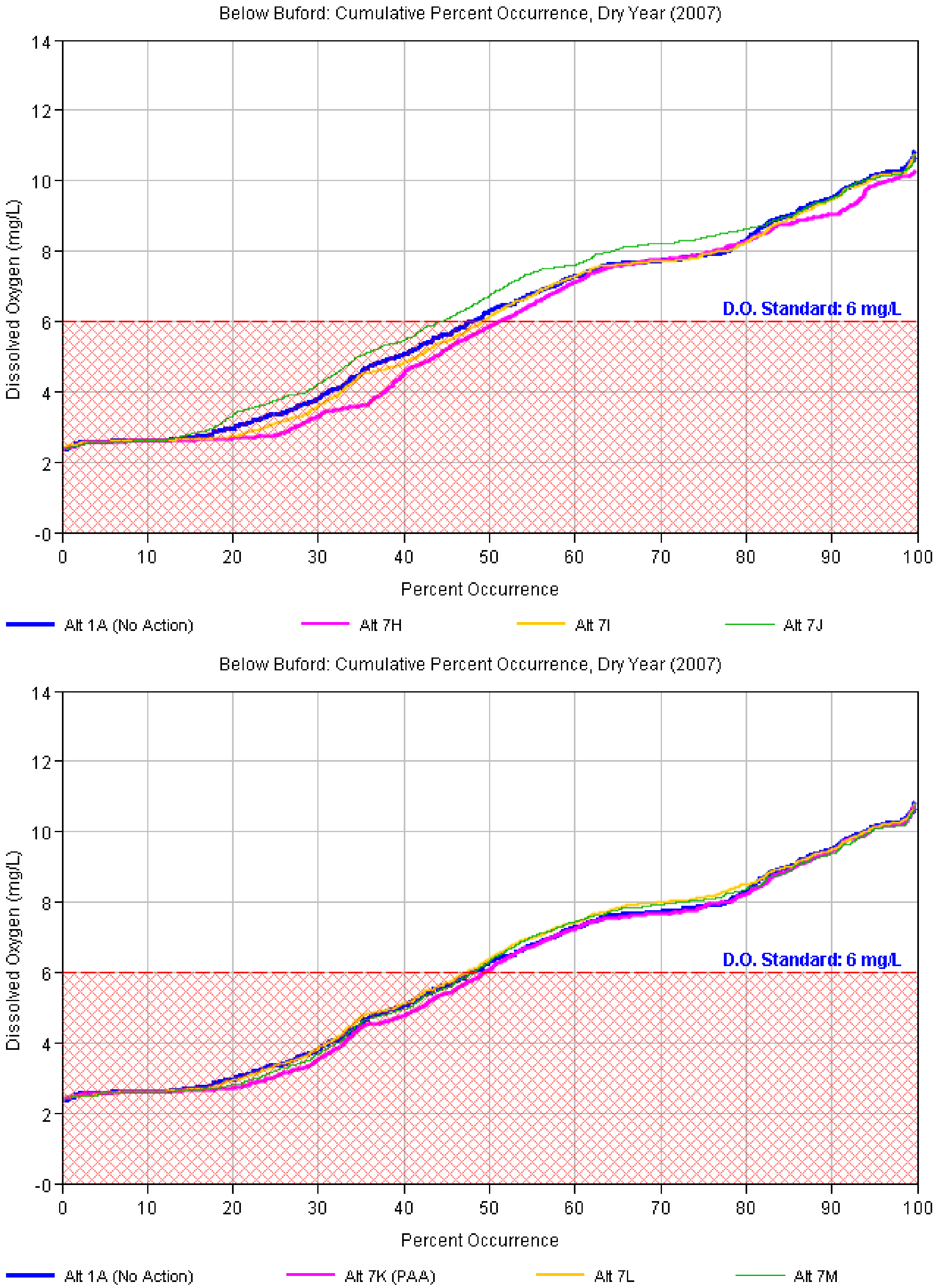
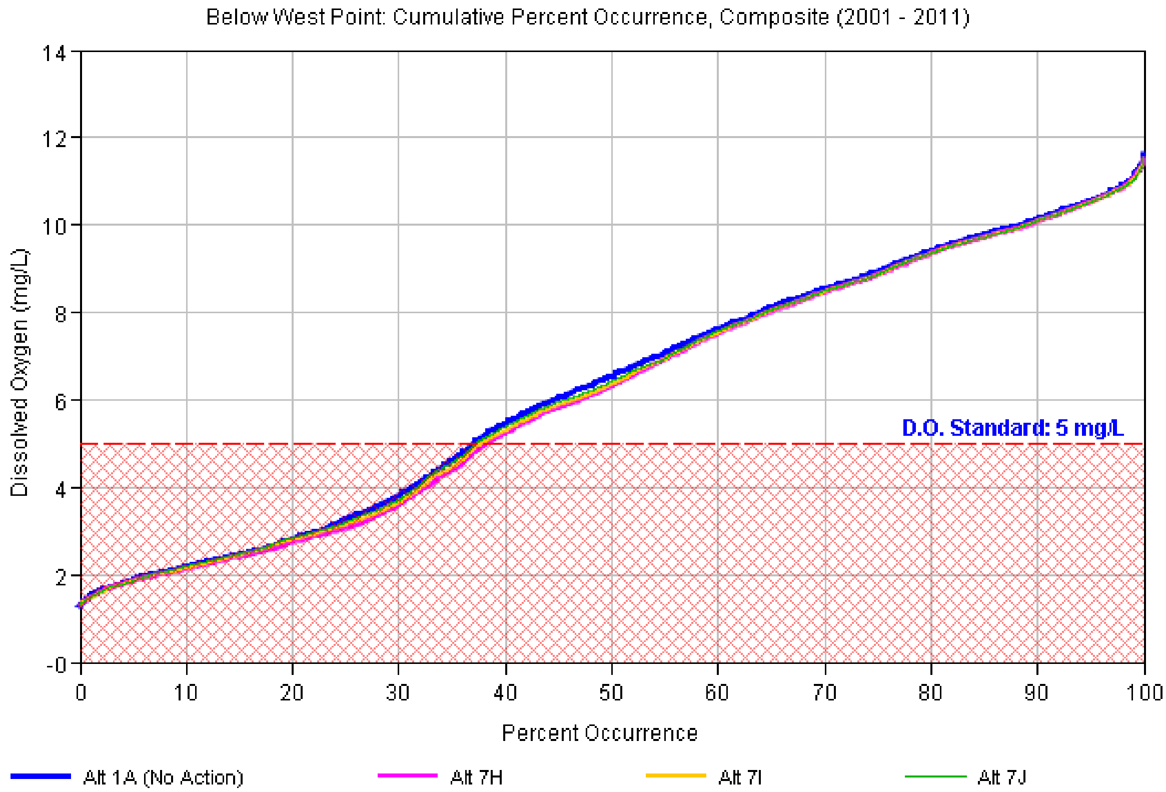


Figure 2.2-8. DO occurrence downstream of Buford Dam for a representative dry year (2007)



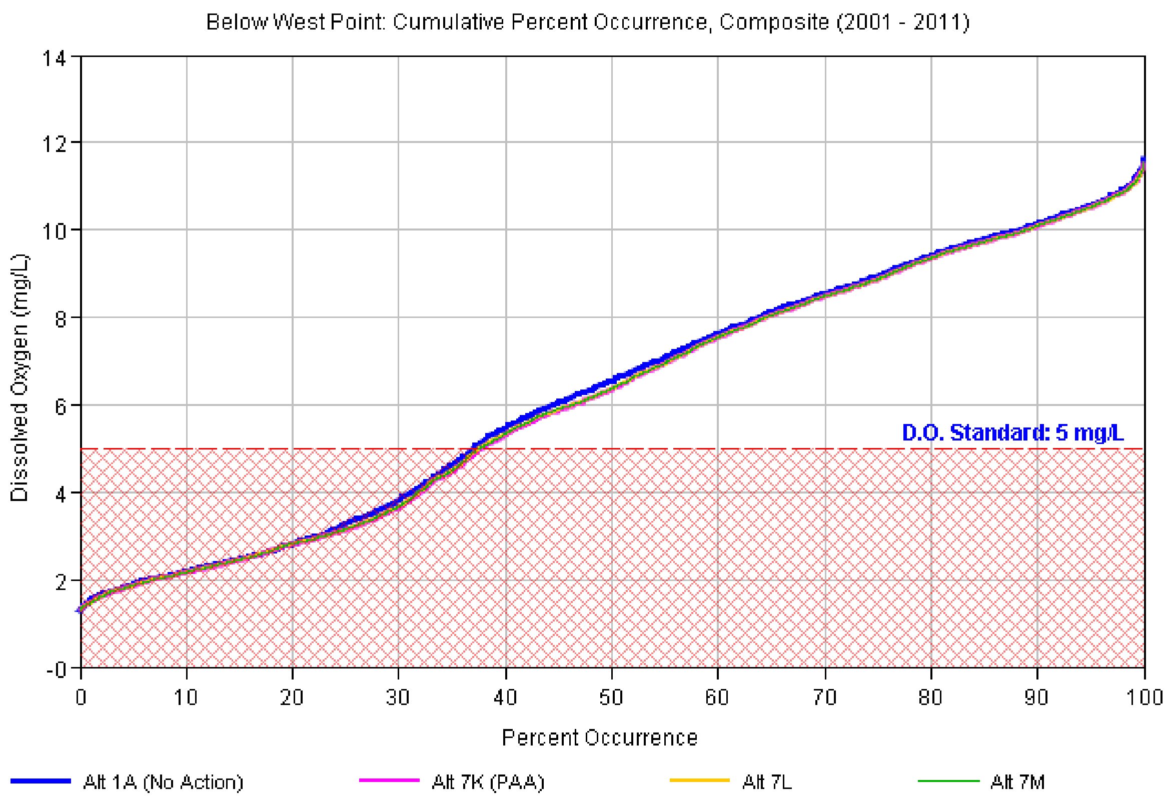
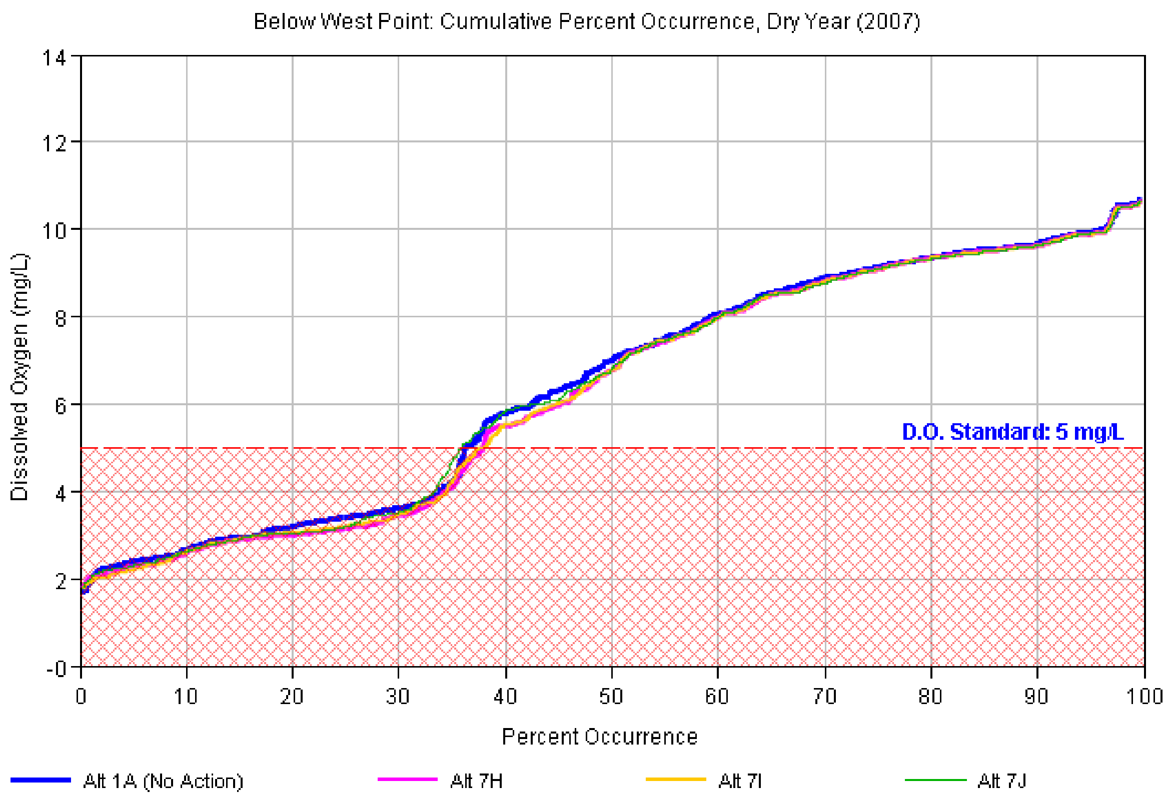


Figure 2.2-9. DO occurrence downstream of West Point Dam for the modeled period (2001 - 2011)



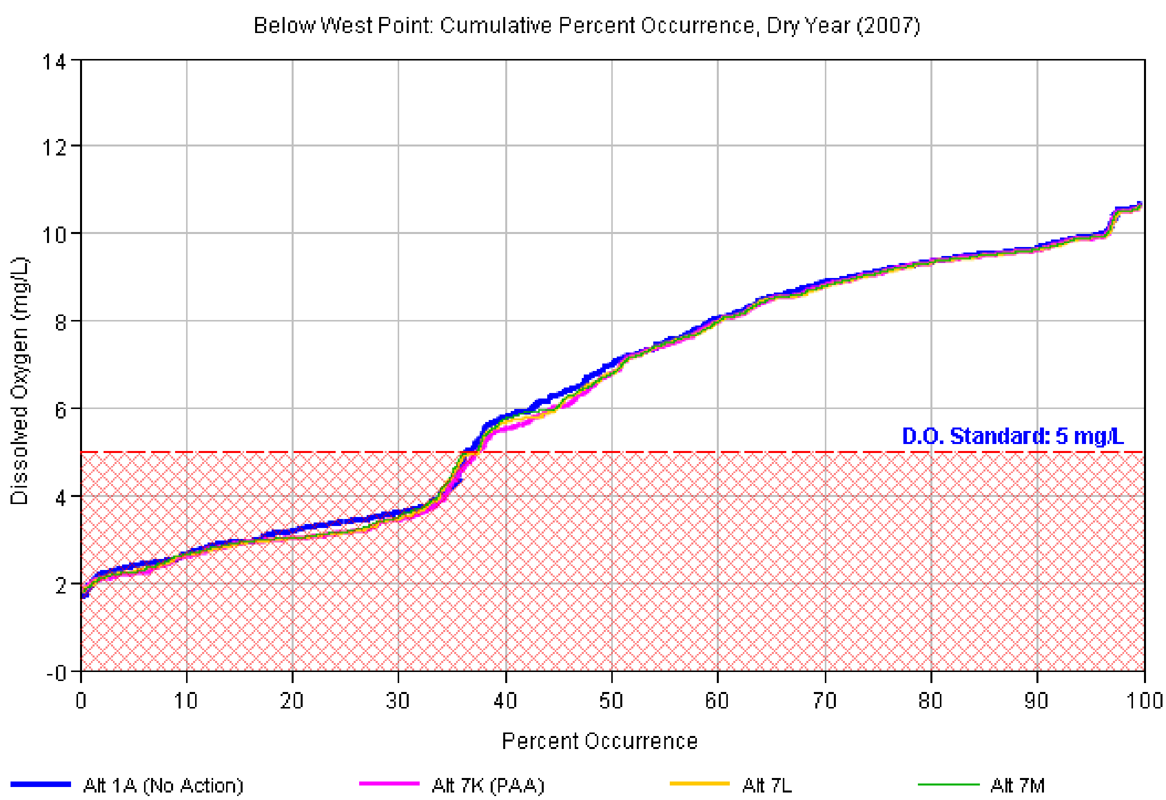
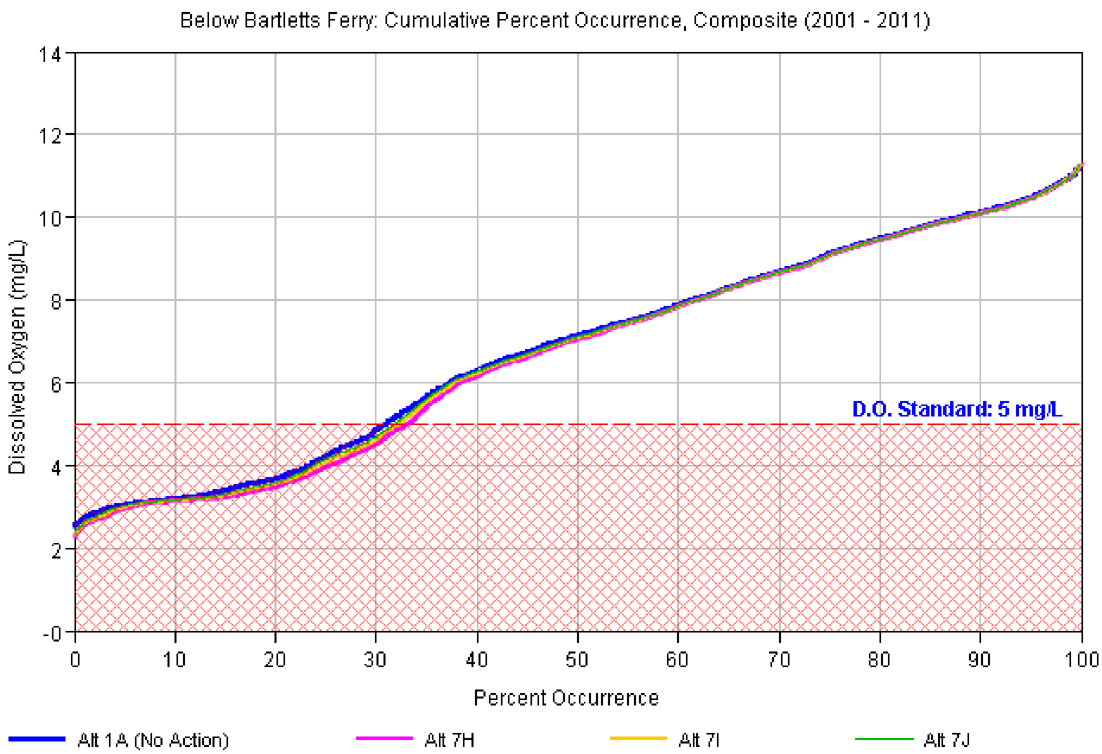


Figure 2.2-10. DO occurrence downstream of West Point Dam for a representative dry year (2007)



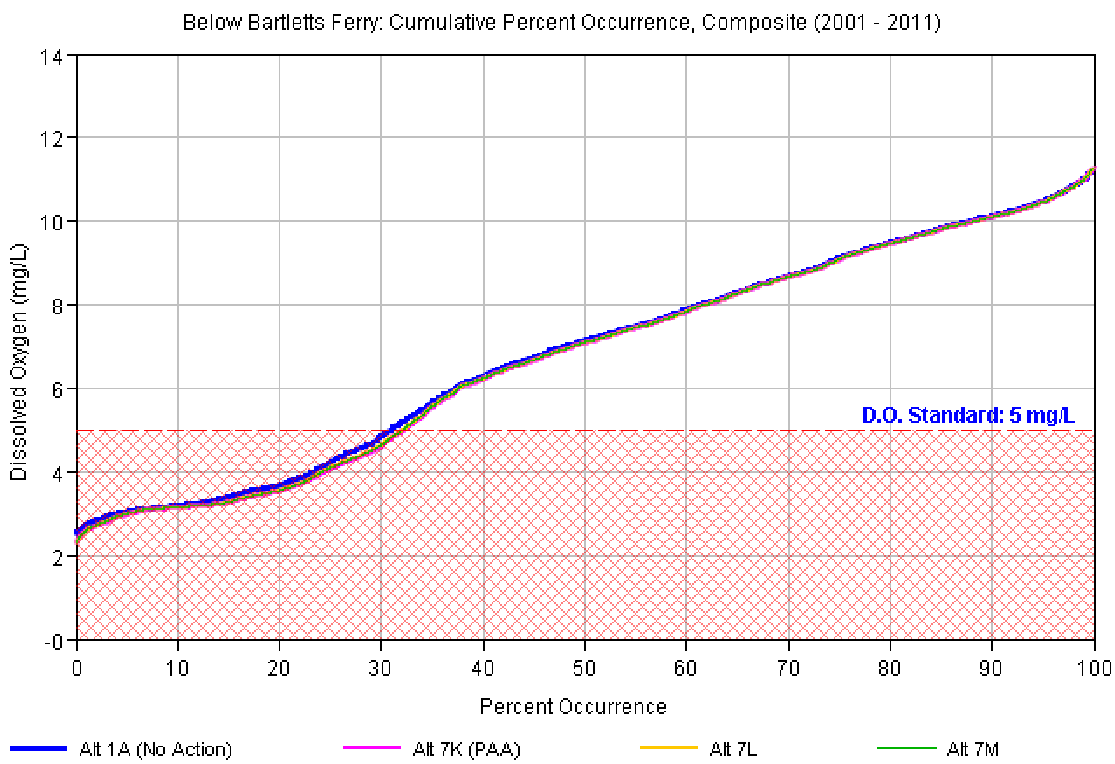
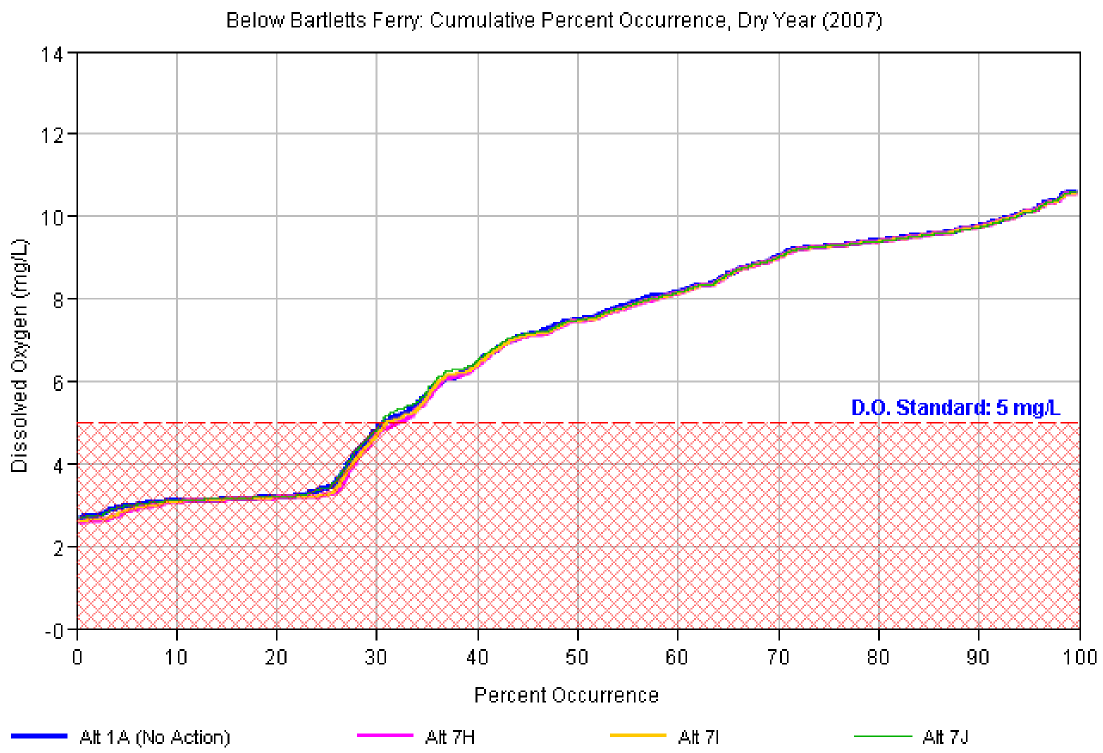


Figure 2.2-11. DO occurrence downstream of Bartletts Ferry Dam for the modeled period (2001 - 2011)



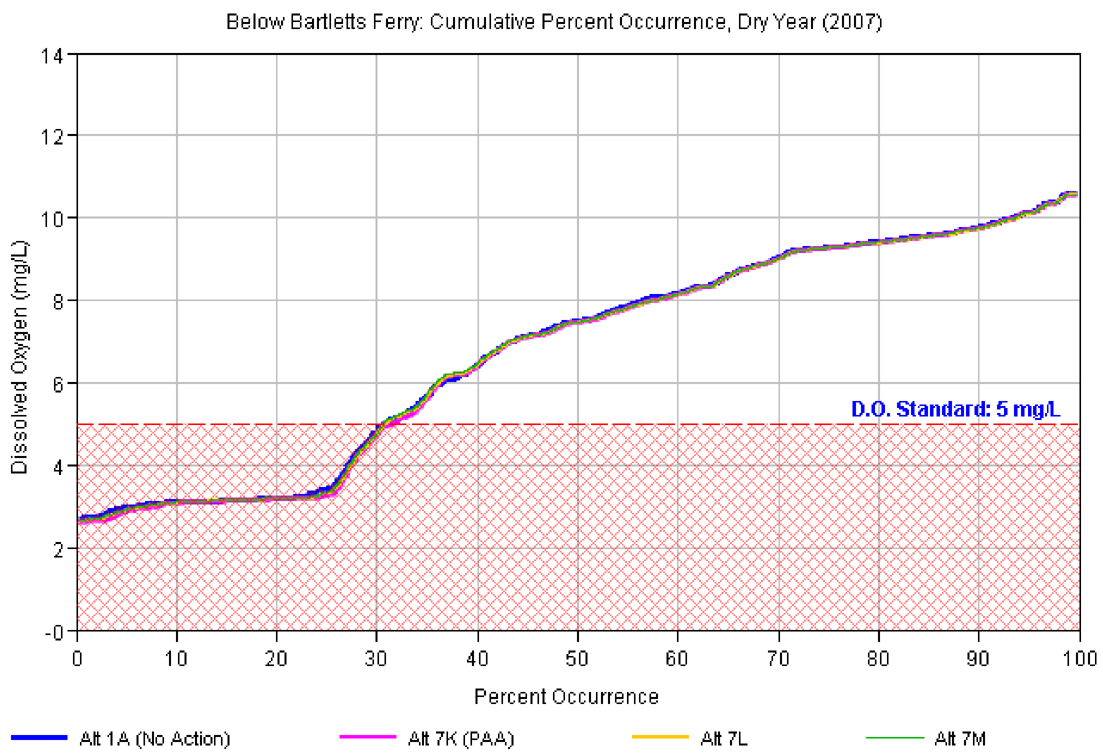
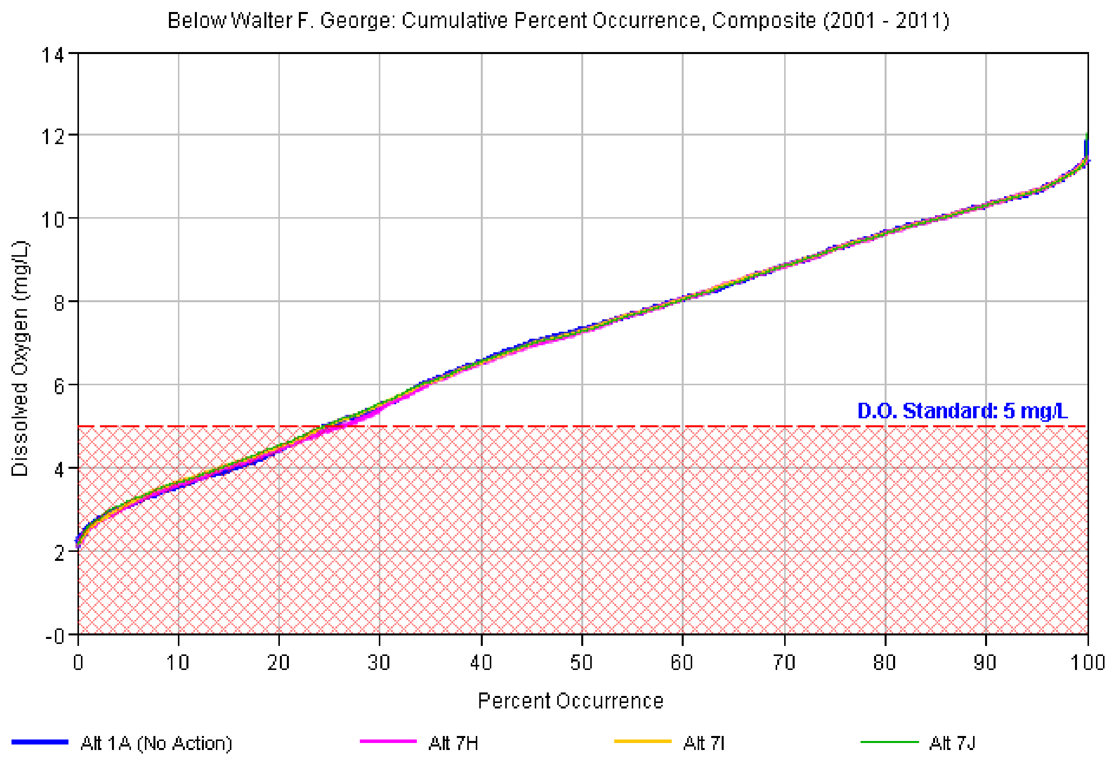


Figure 2.2-12. DO occurrence downstream of Bartletts Ferry Dam for a representative dry year (2007)



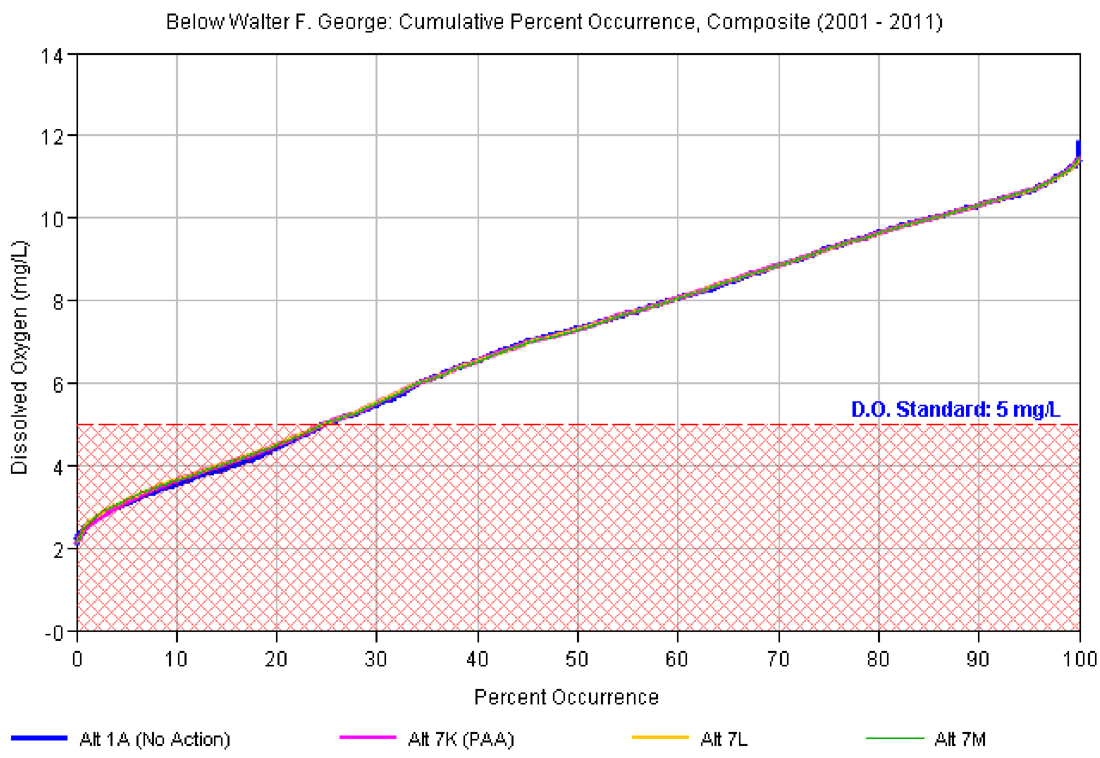
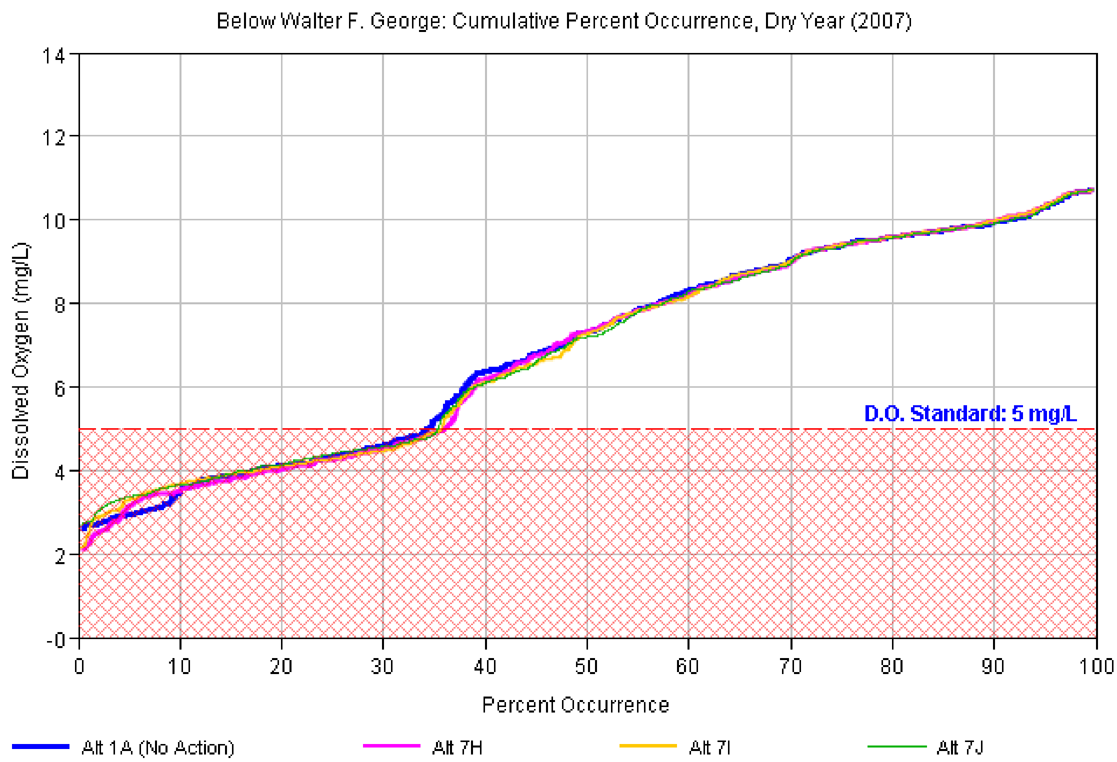


Figure 2.2-13. DO occurrence downstream of Walter F. George Dam for the modeled period (2001-2011)



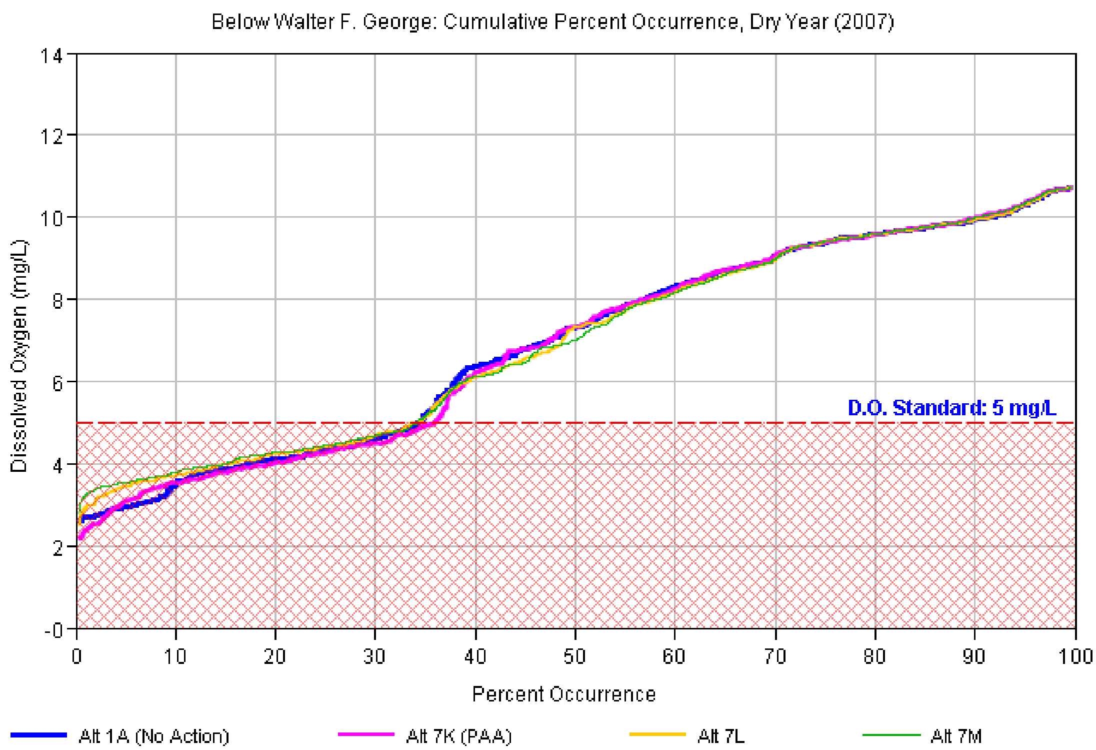


Figure 2.2-14. DO occurrence downstream of Walter F. George Dam for a representative dry year (2007)

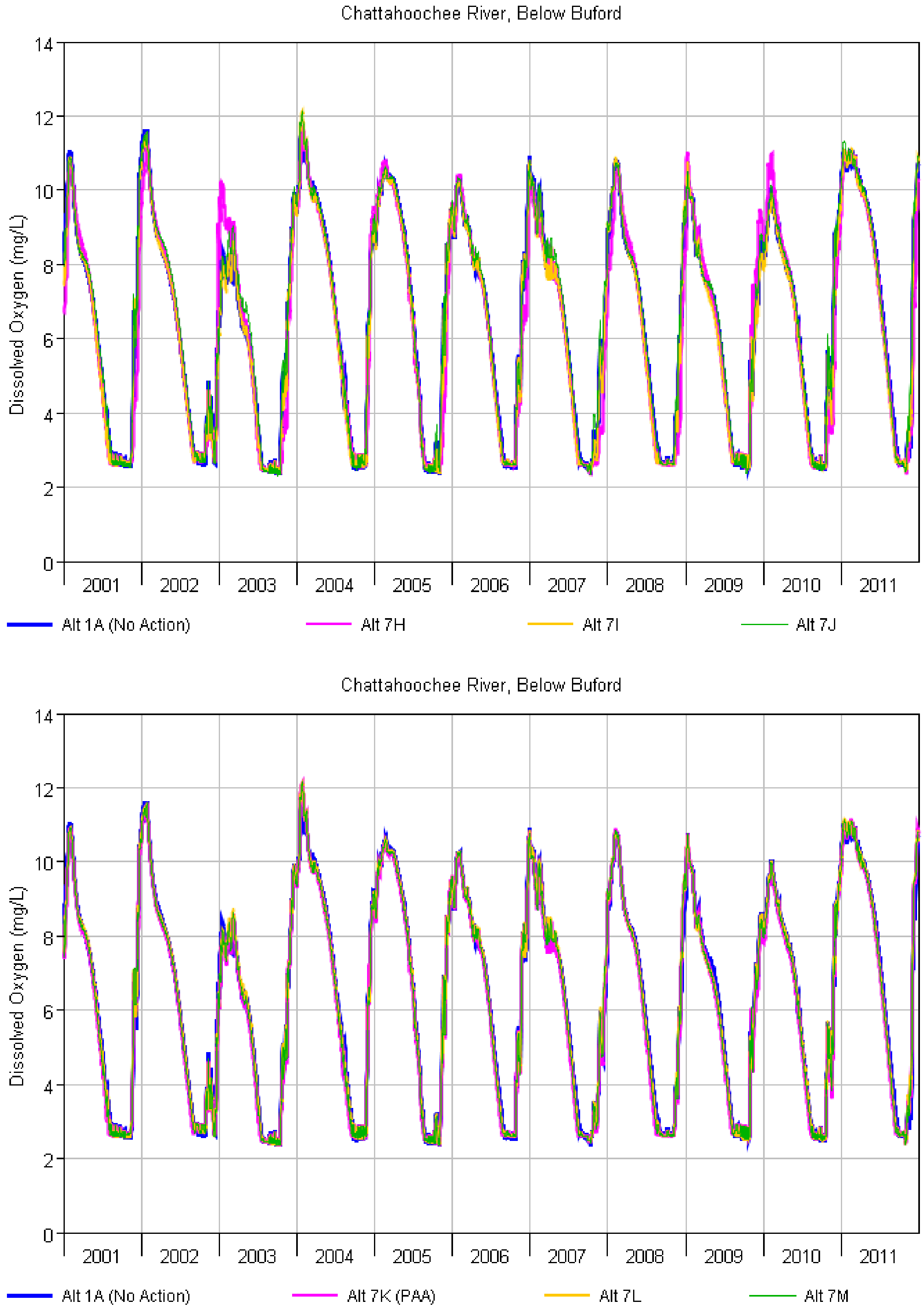


Figure 2.2-15. Time series DO from Buford Dam releases

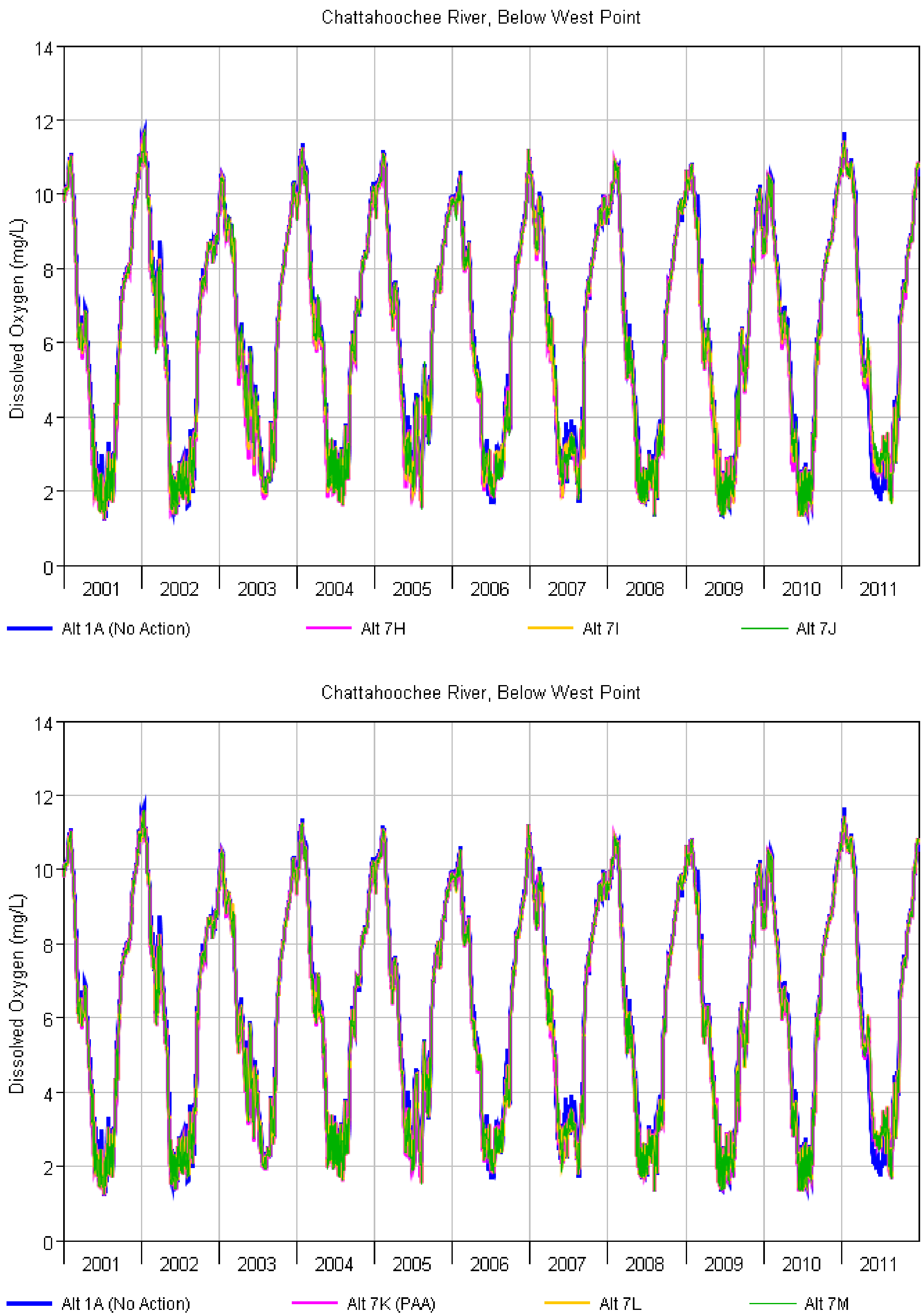


Figure 2.2-16. Time series DO from West Point Dam releases

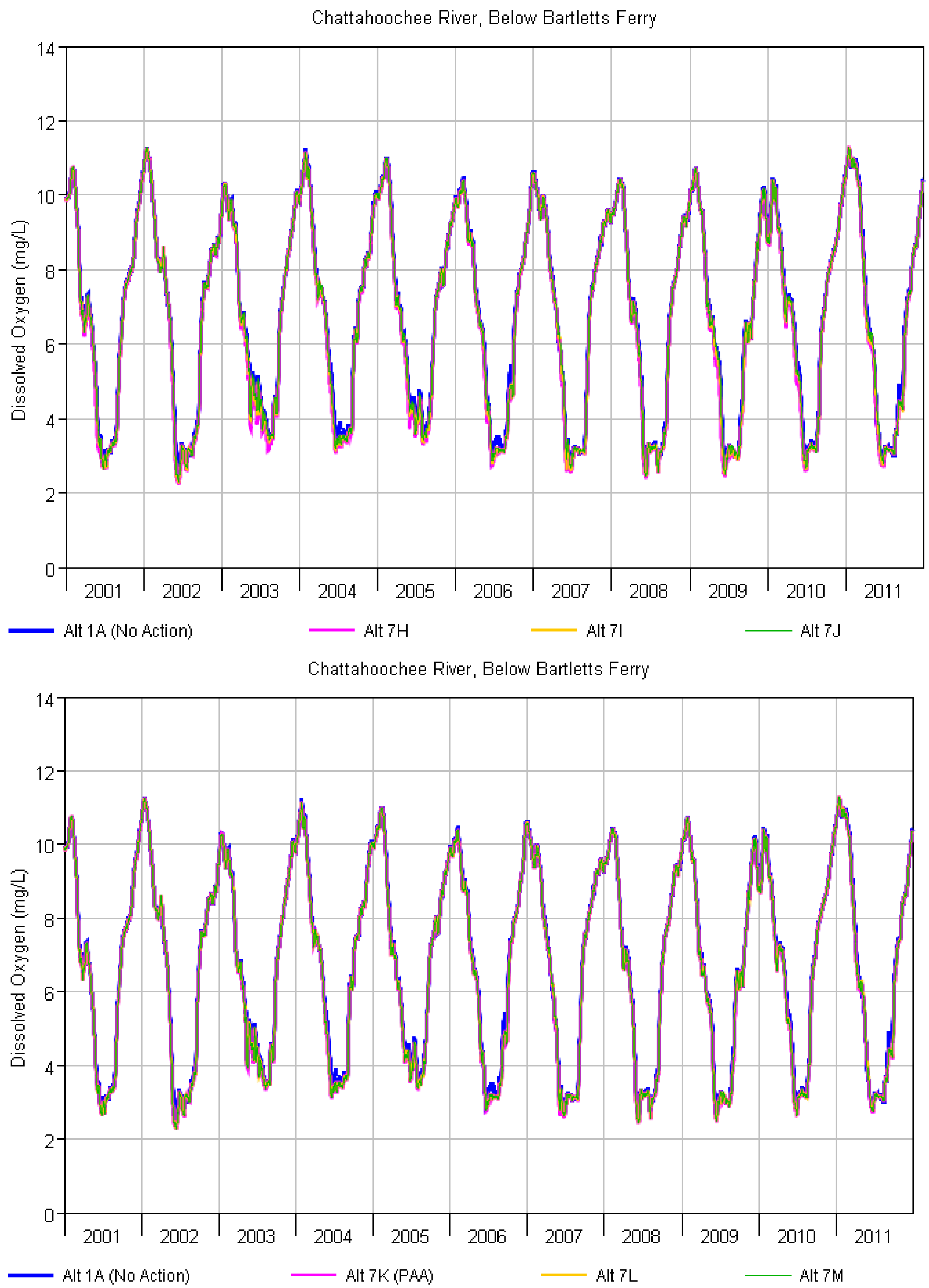


Figure 2.2-17. Time series DO from Bartletts Ferry Dam releases

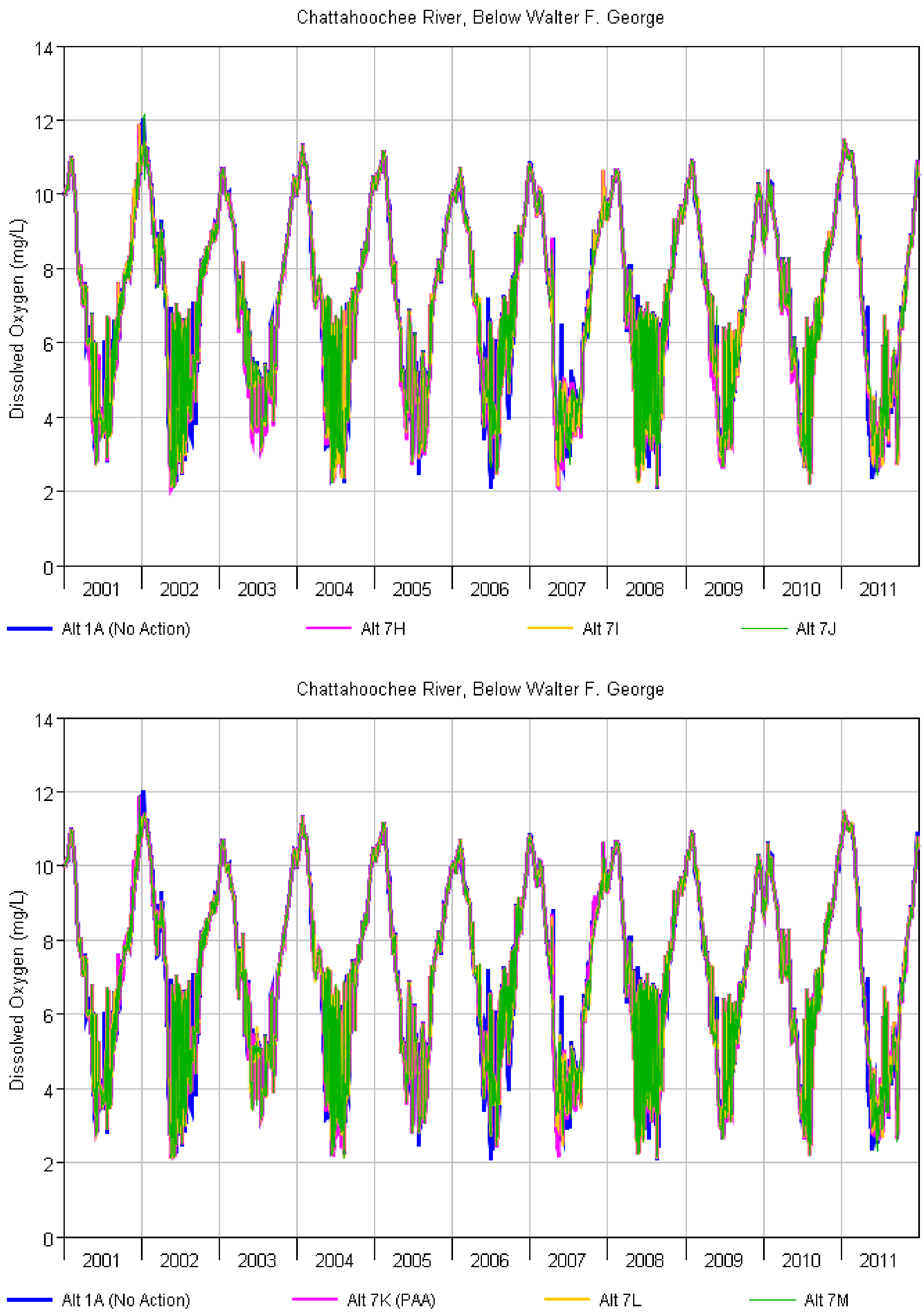
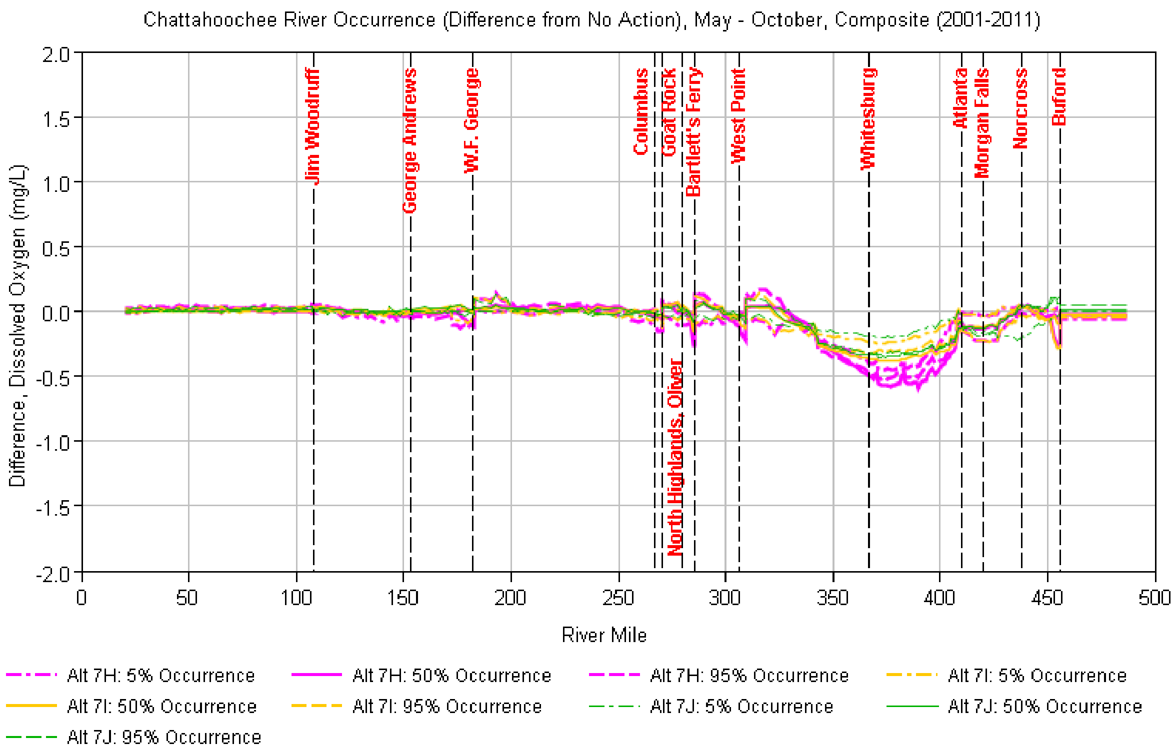


Figure 2.2-18. Time series DO from Walter F. George Dam releases



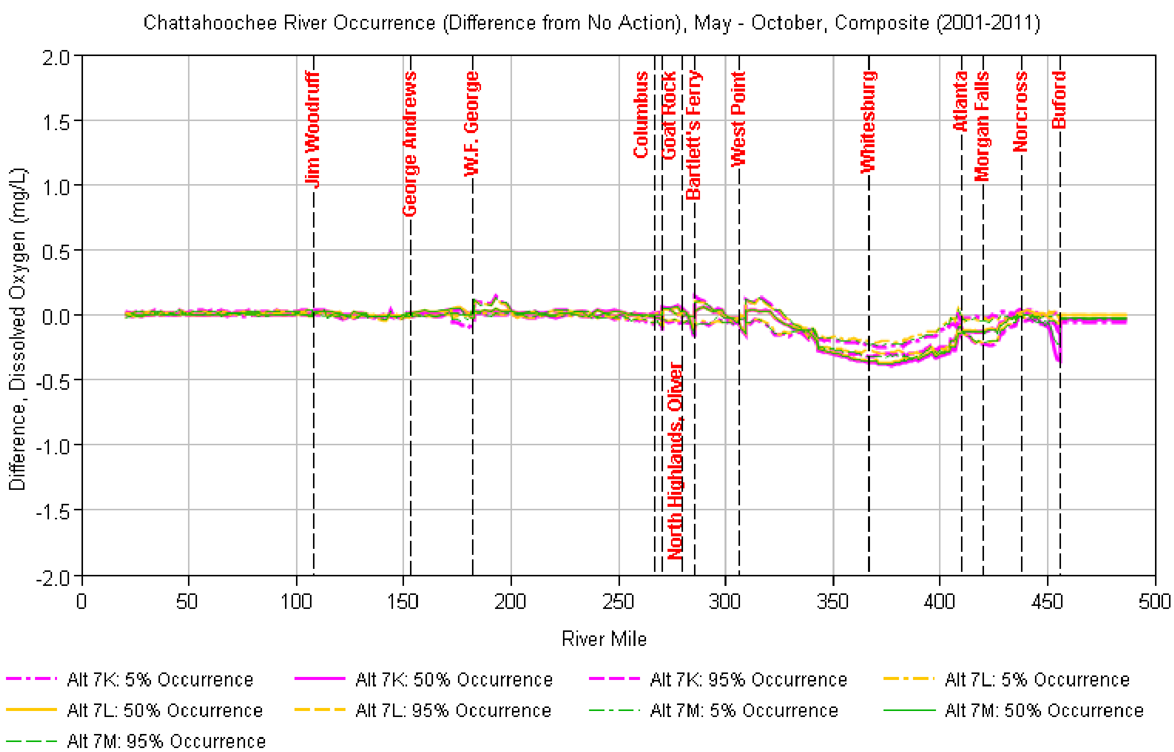
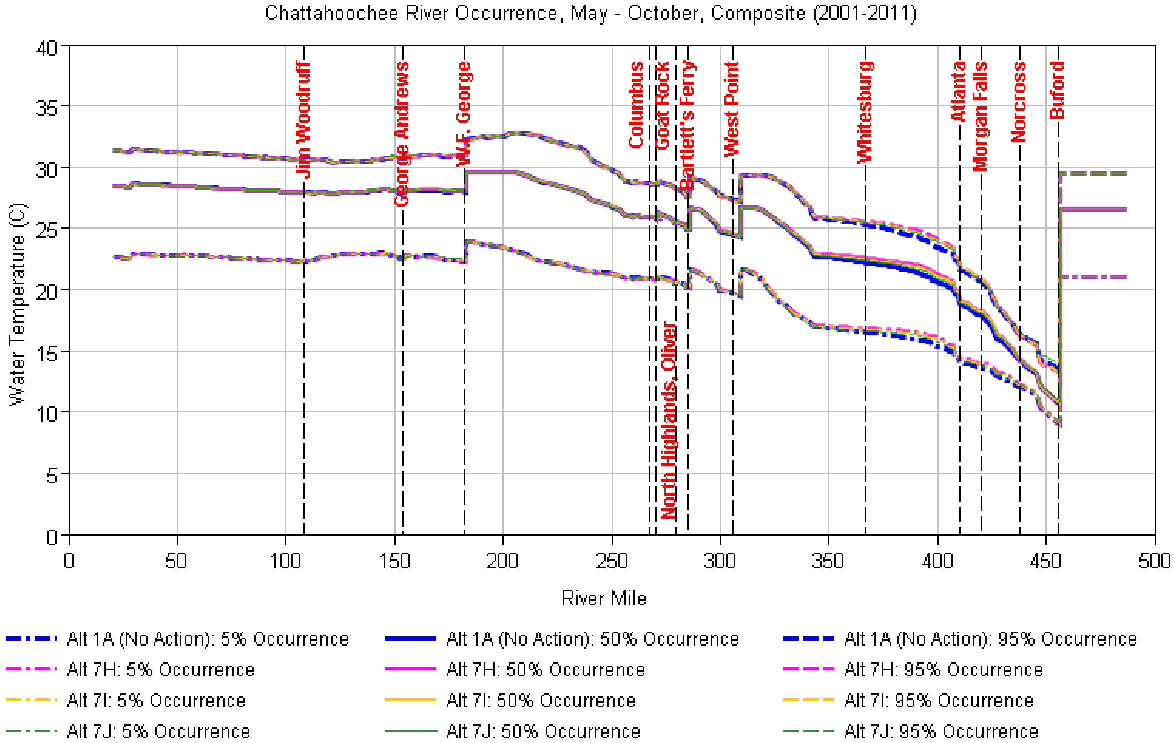


Figure 2.2-19. Changes in longitudinal DO in the Chattahoochee River for the May through October for the model period (2001 through 2011)

Water Temperature



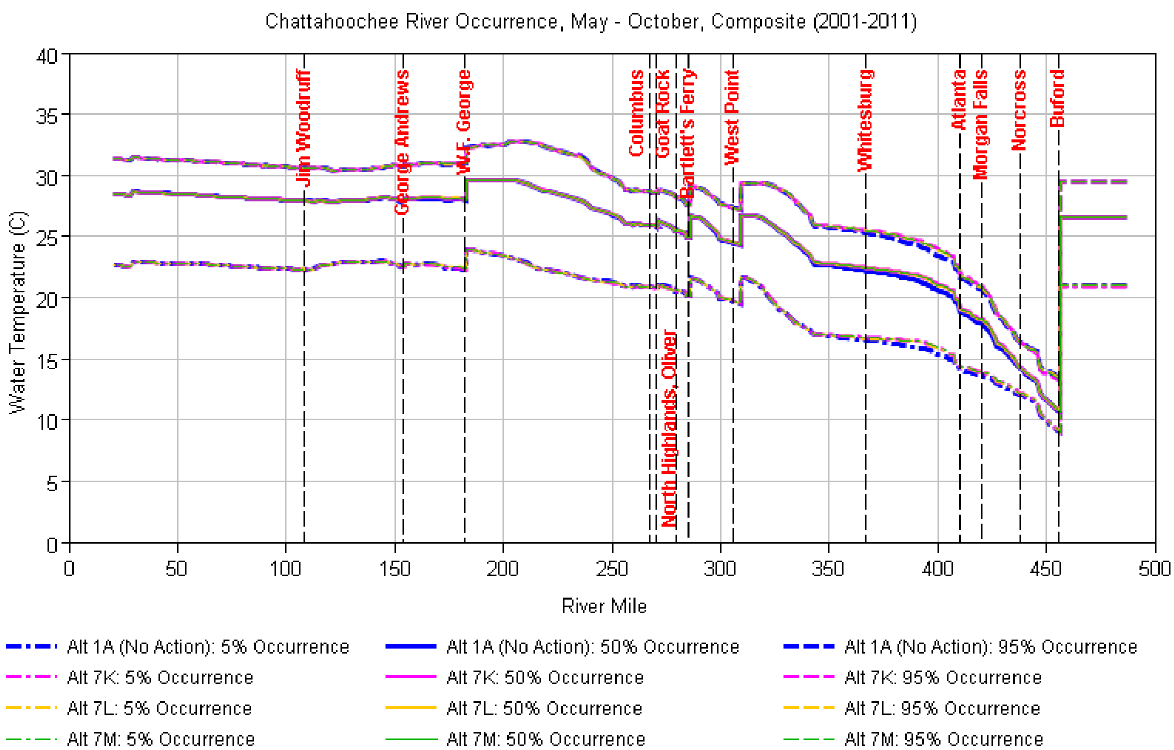


Figure 2.2-20. May through October water temperatures along the Chattahoochee River for the modeled period (2001-2011)

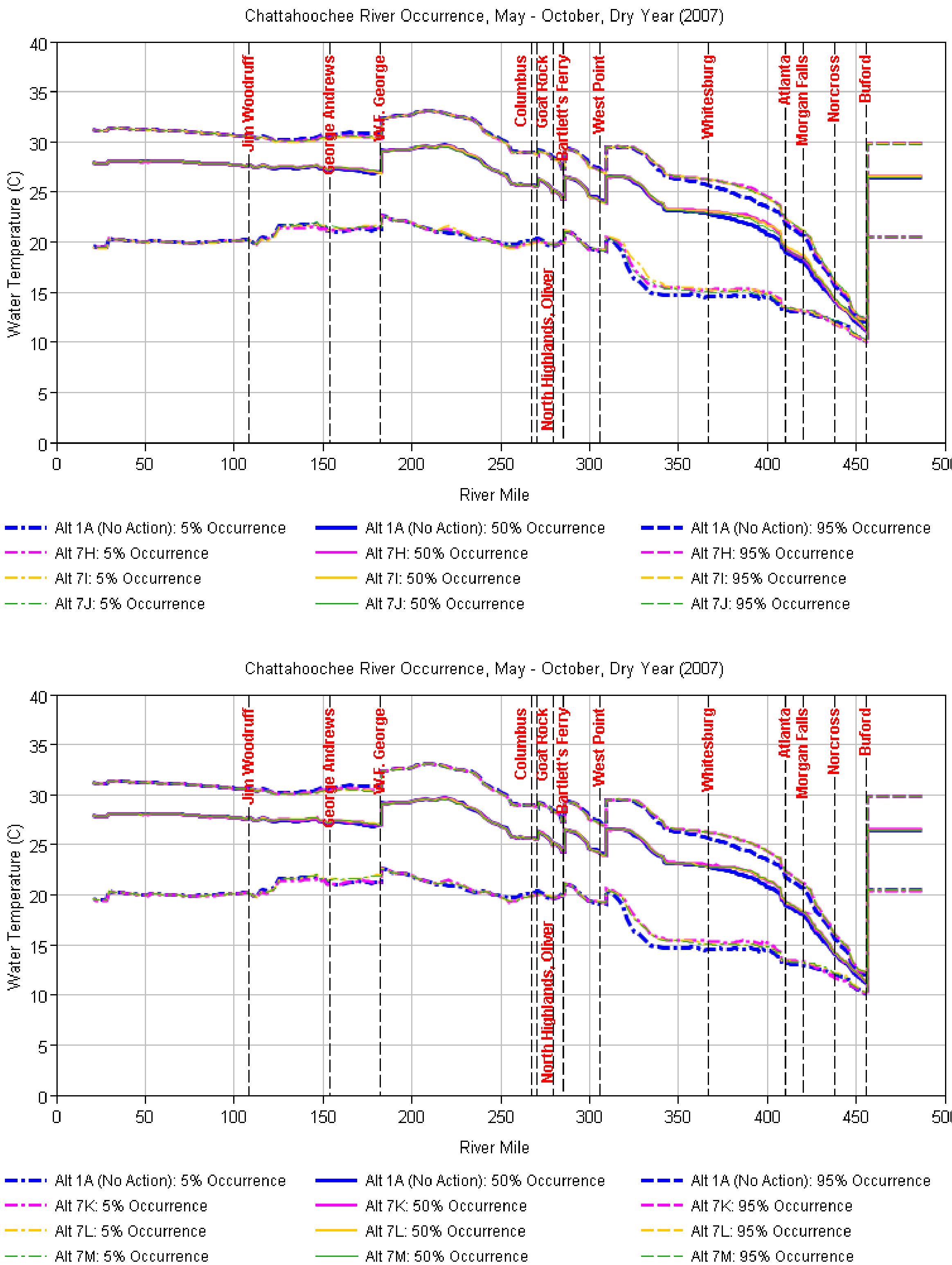
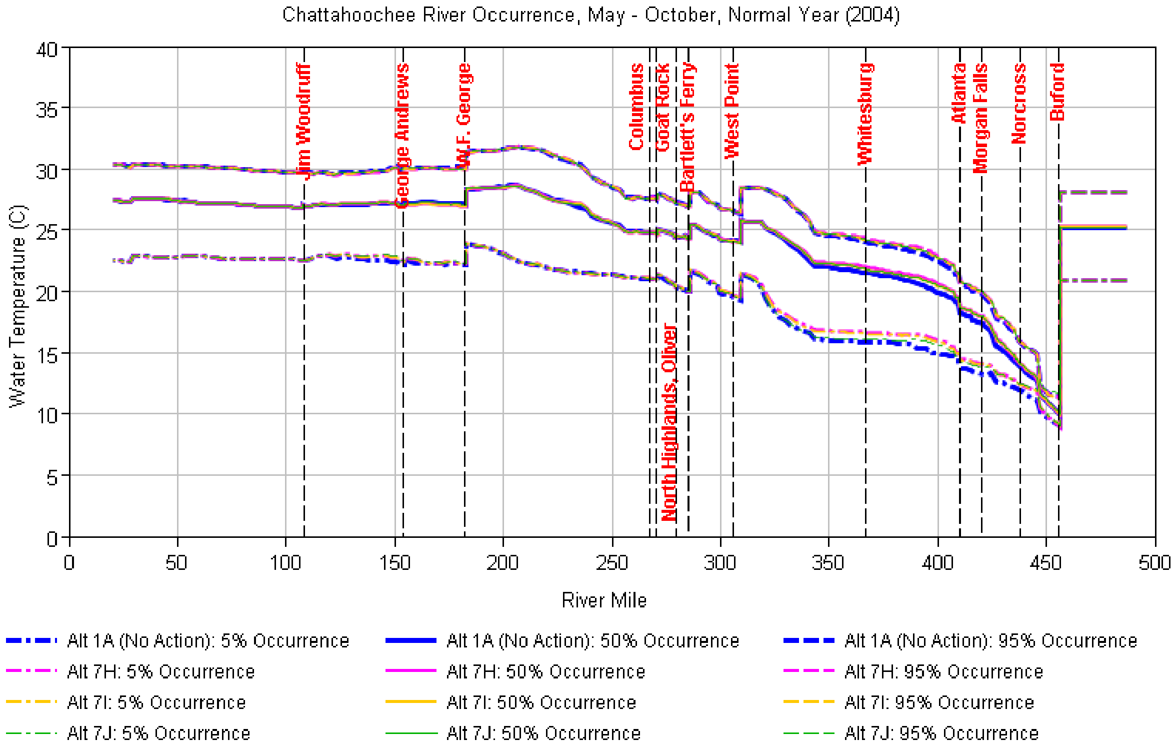


Figure 2.2-21. May through October water temperatures along the Chattahoochee River for a representative dry year (2007)



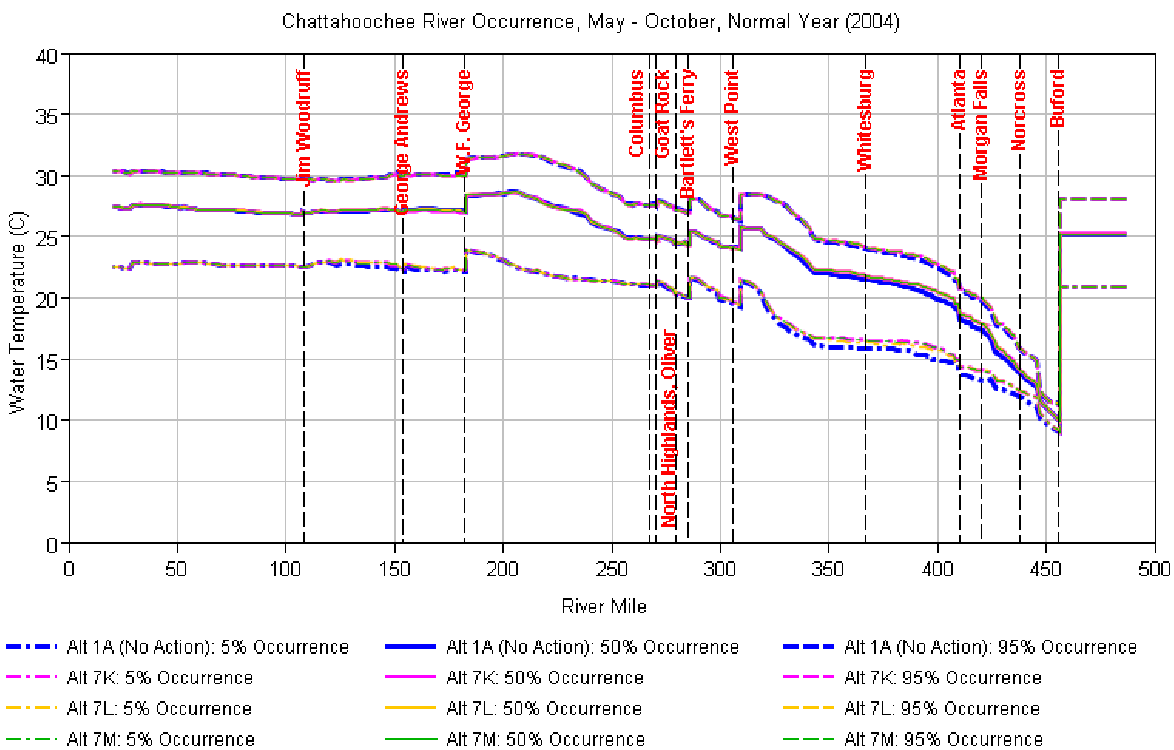
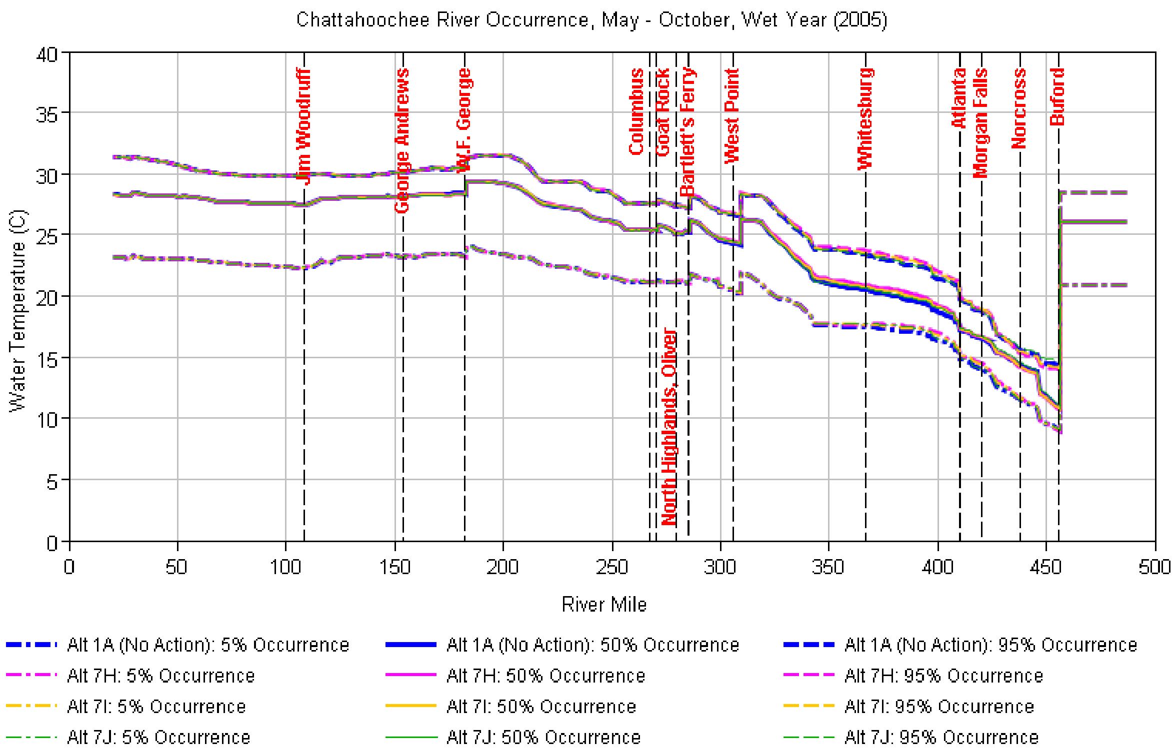


Figure 2.2-22. May through October water temperatures along the Chattahoochee River for a representative normal year (2004)



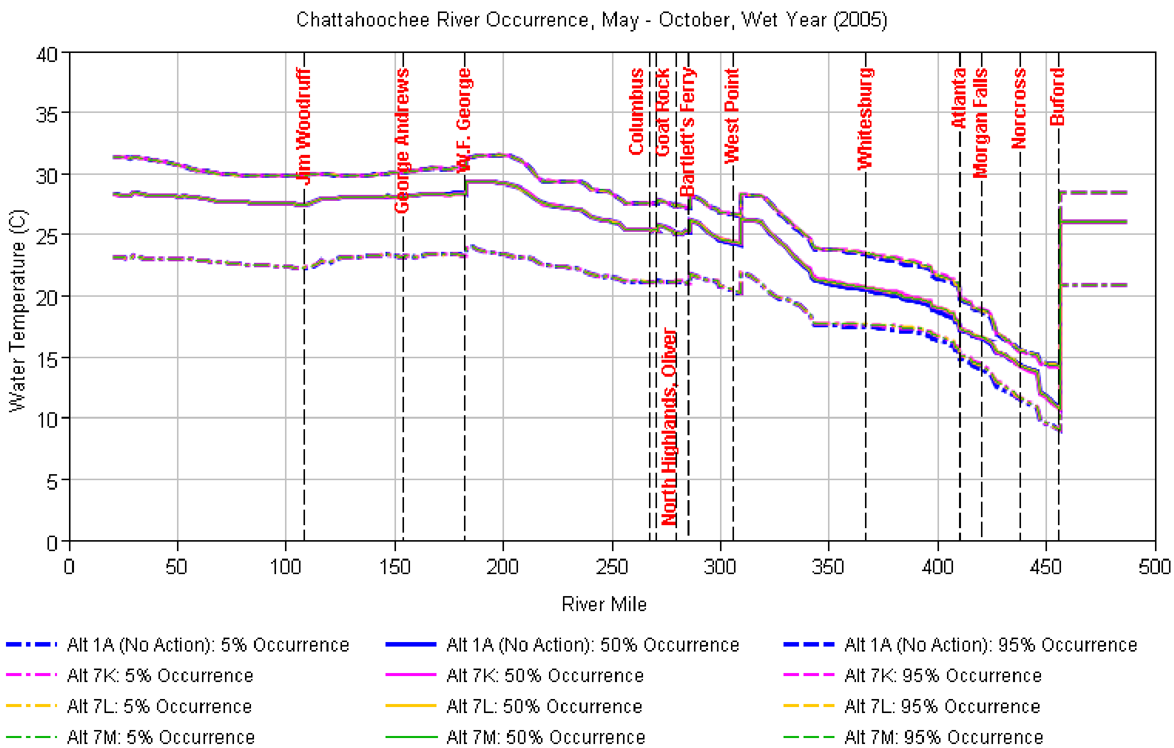
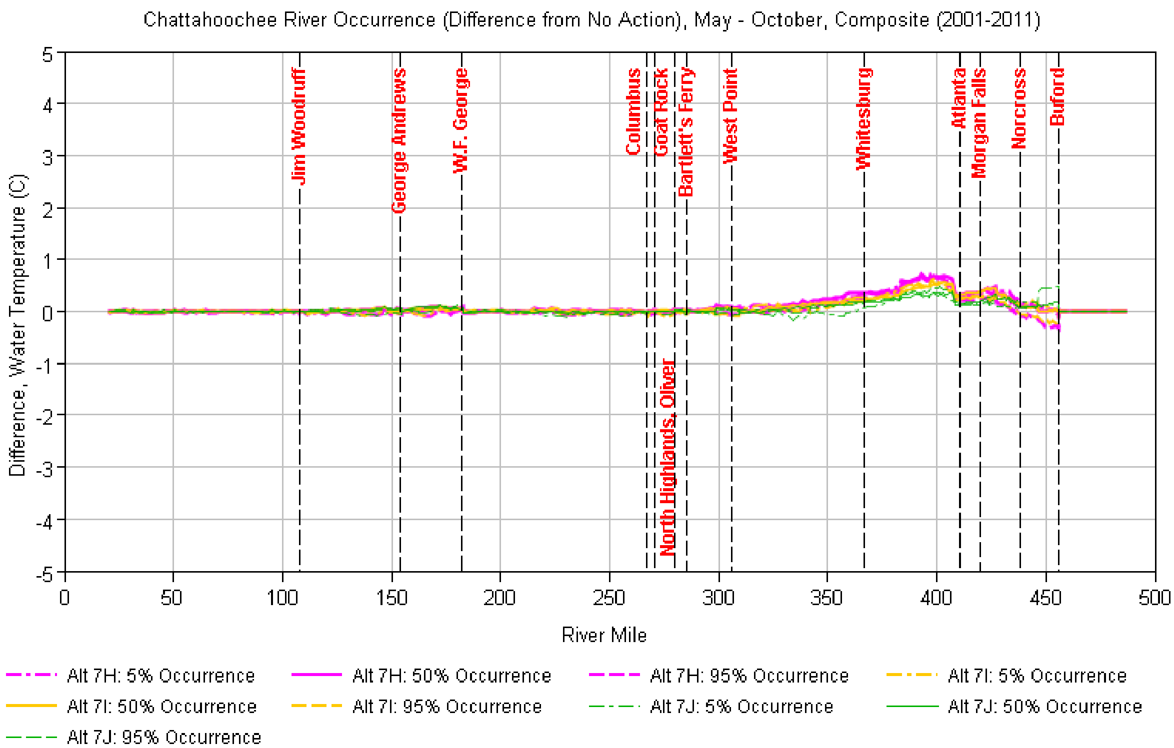


Figure 2.2-23. May through October water temperatures along the Chattahoochee River for a representative wet year (2005)



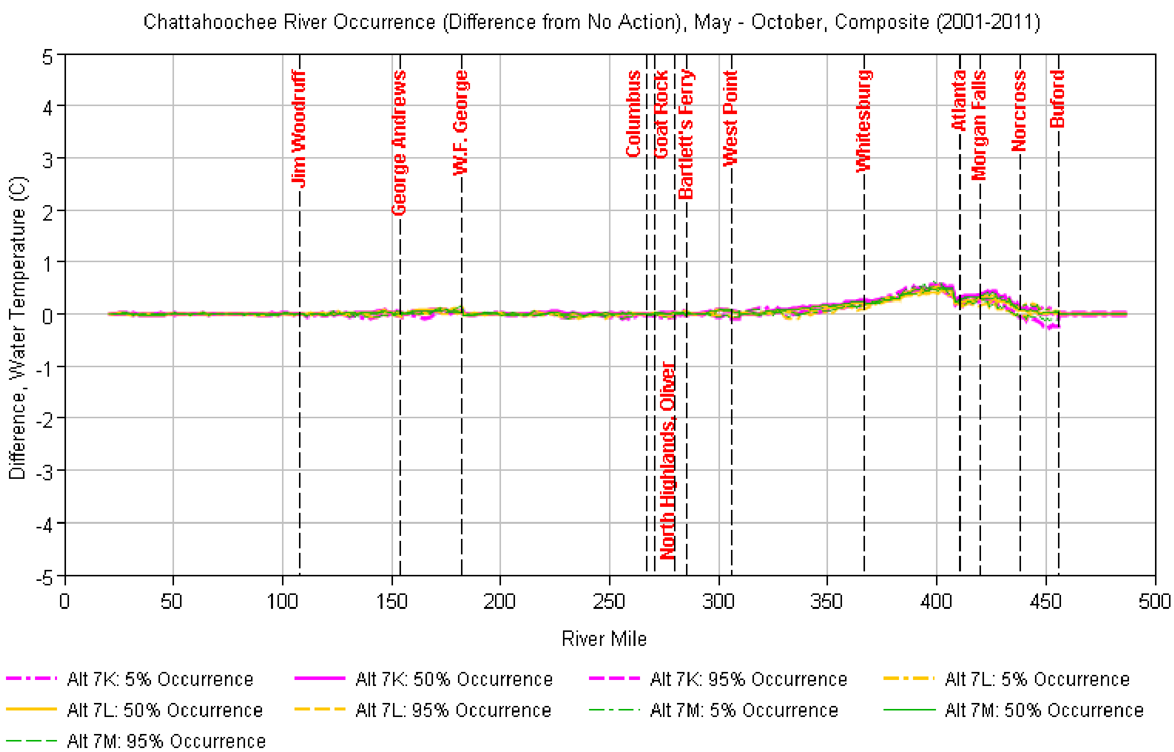
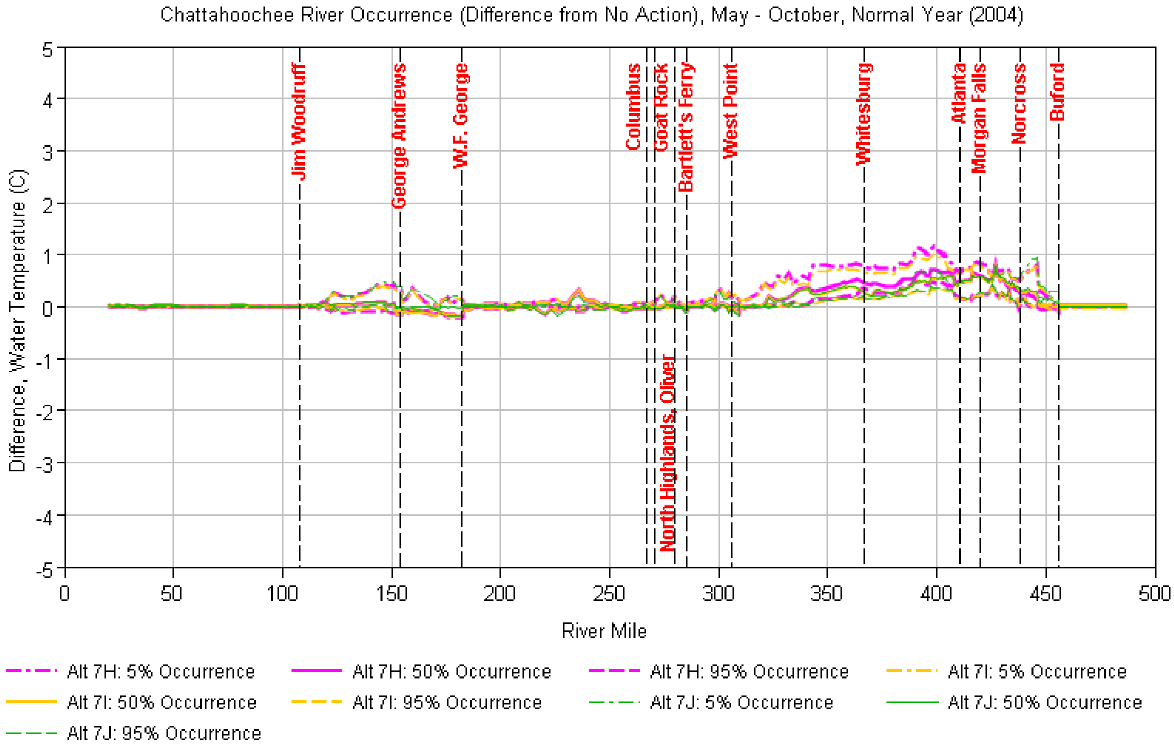


Figure 2.2-24. Changes in longitudinal water temperature in the Chattahoochee River for May through October for the modeled period from 2001 through 2011



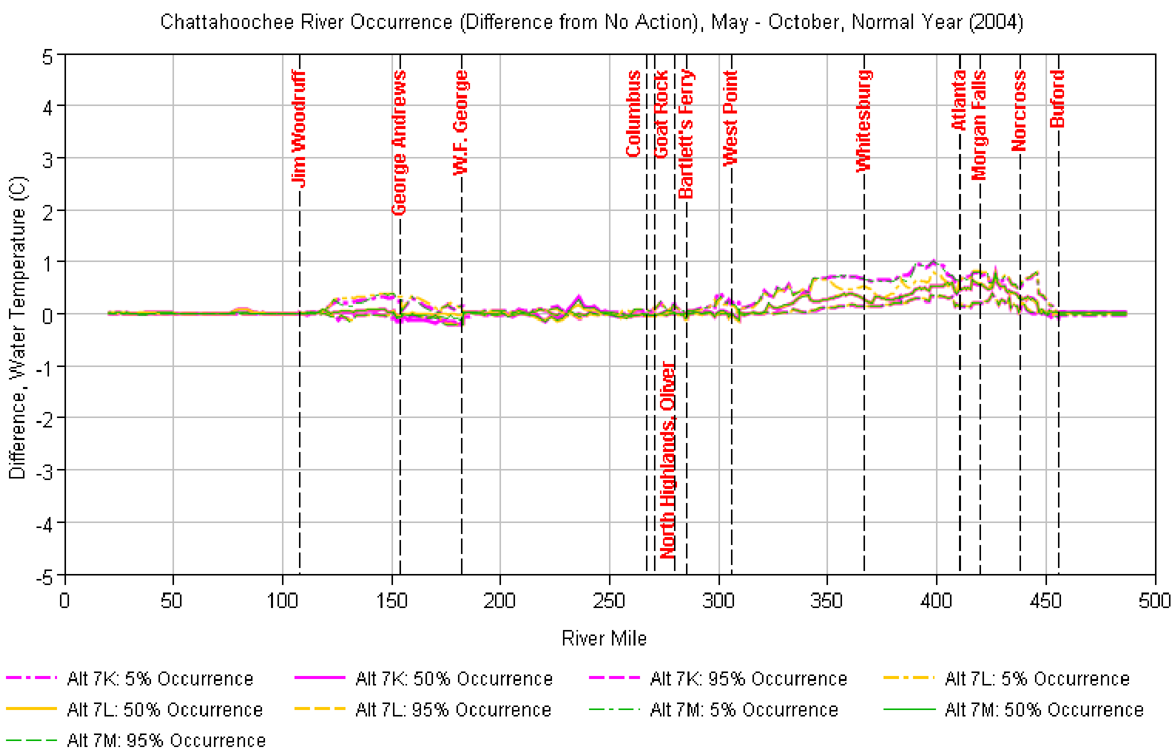
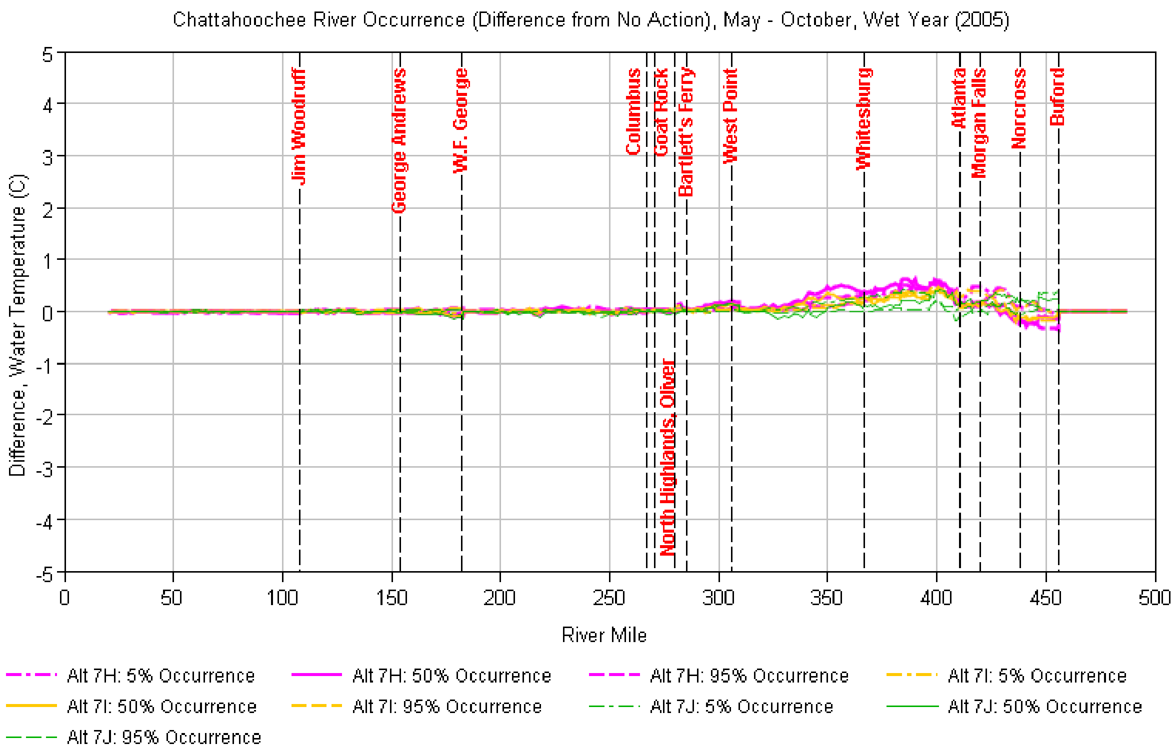


Figure 2.2-25. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a normal year (2004)



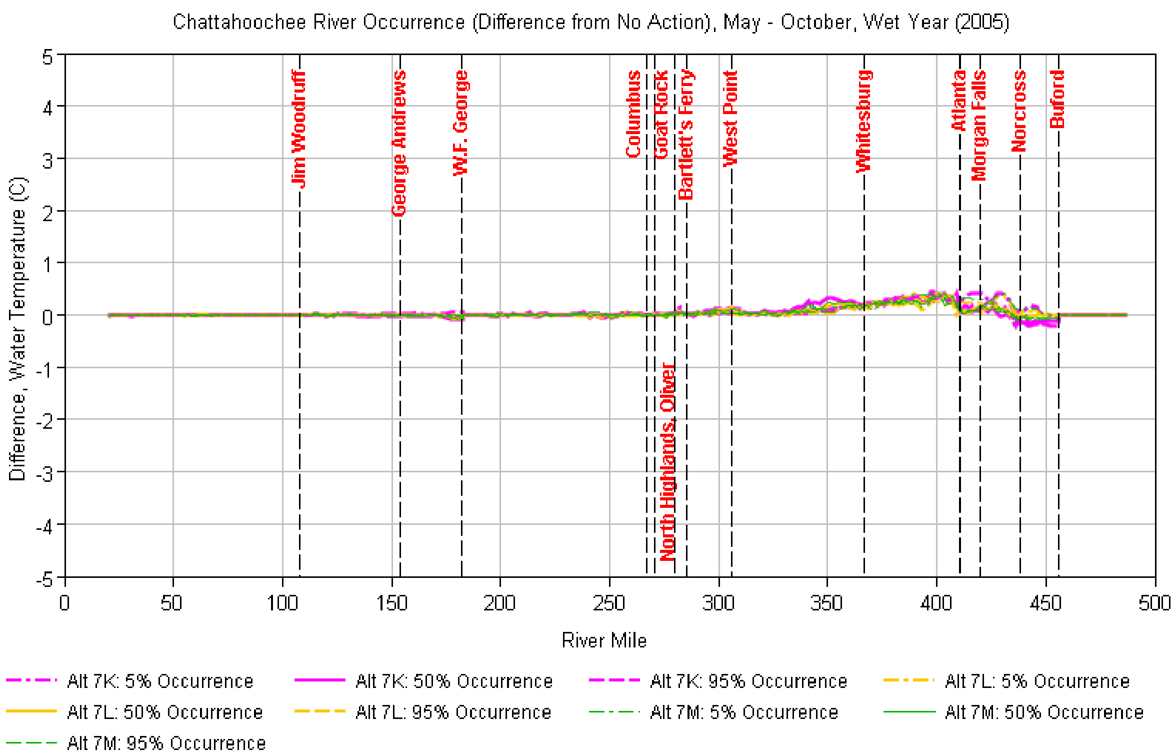


Figure 2.2-26. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a wet year (2005)

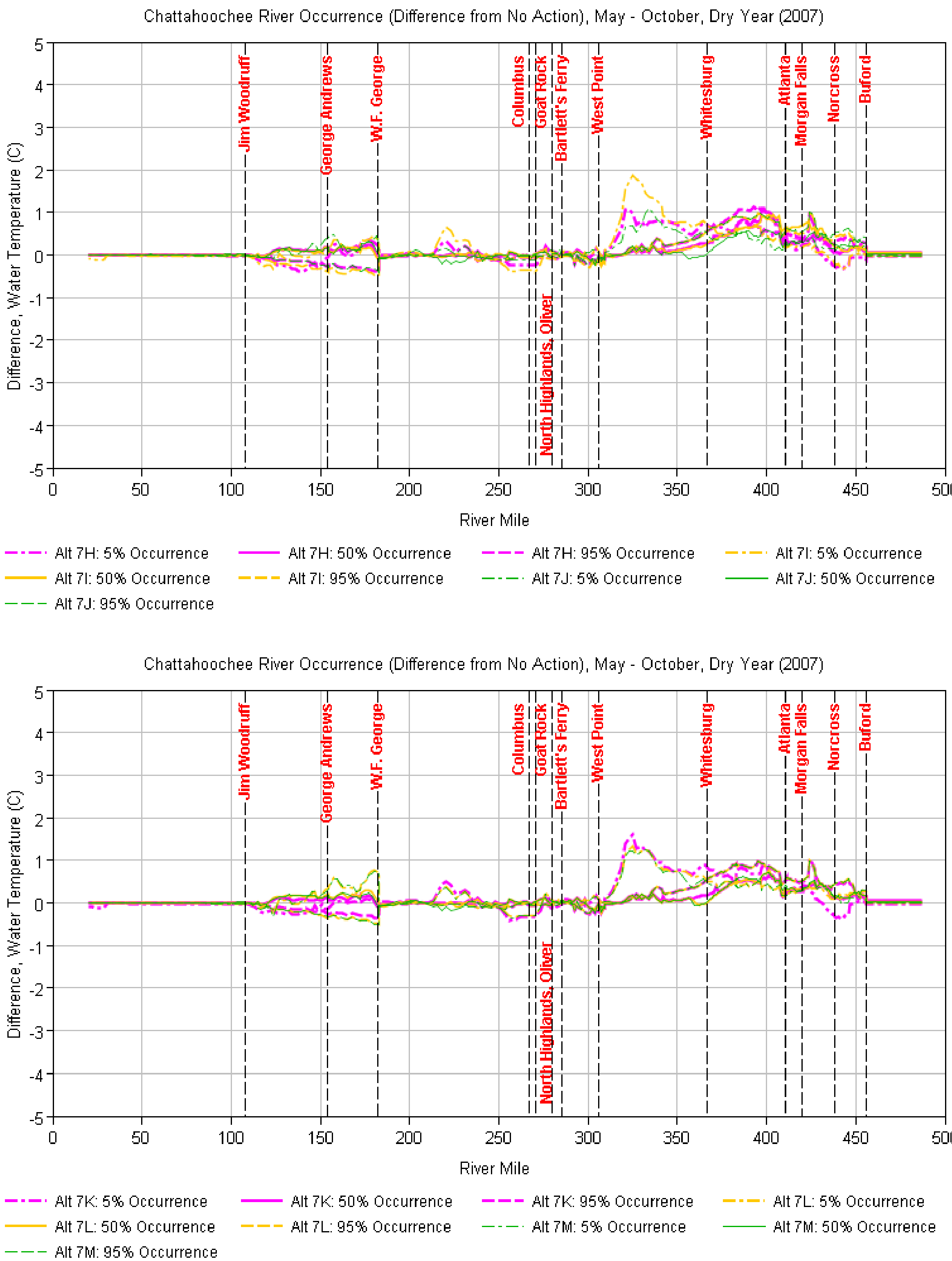
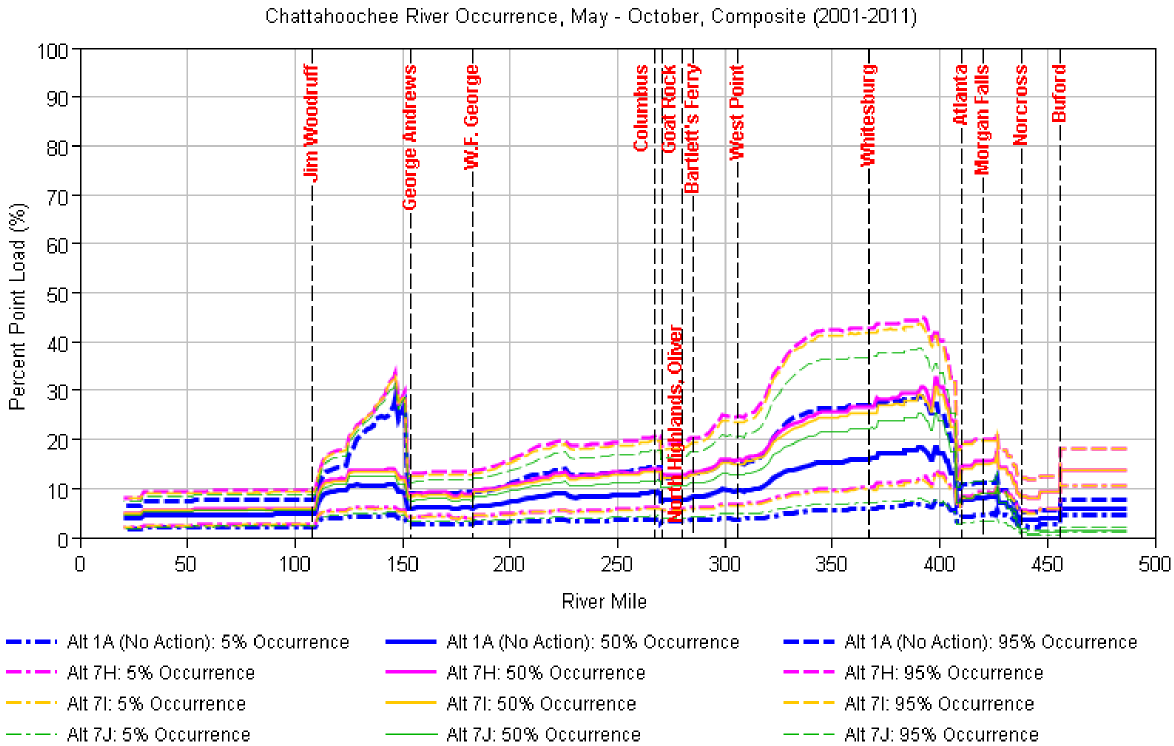


Figure 2.2-27. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a dry year (2007)

Wastewater



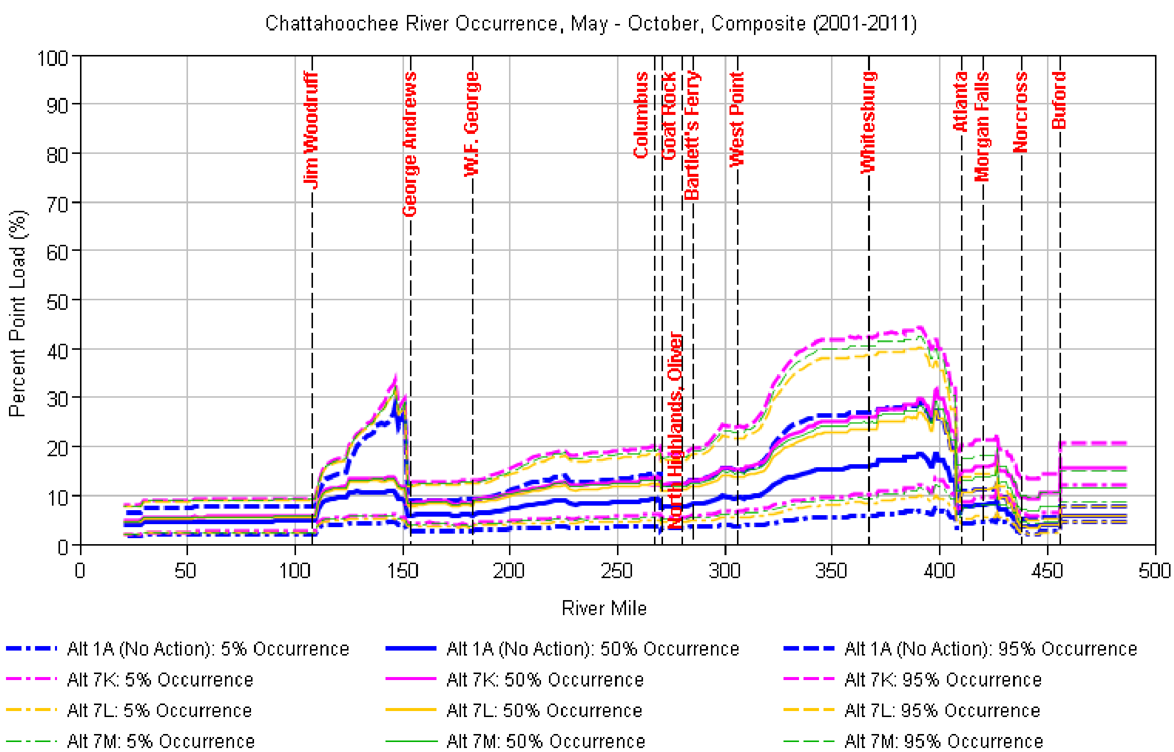
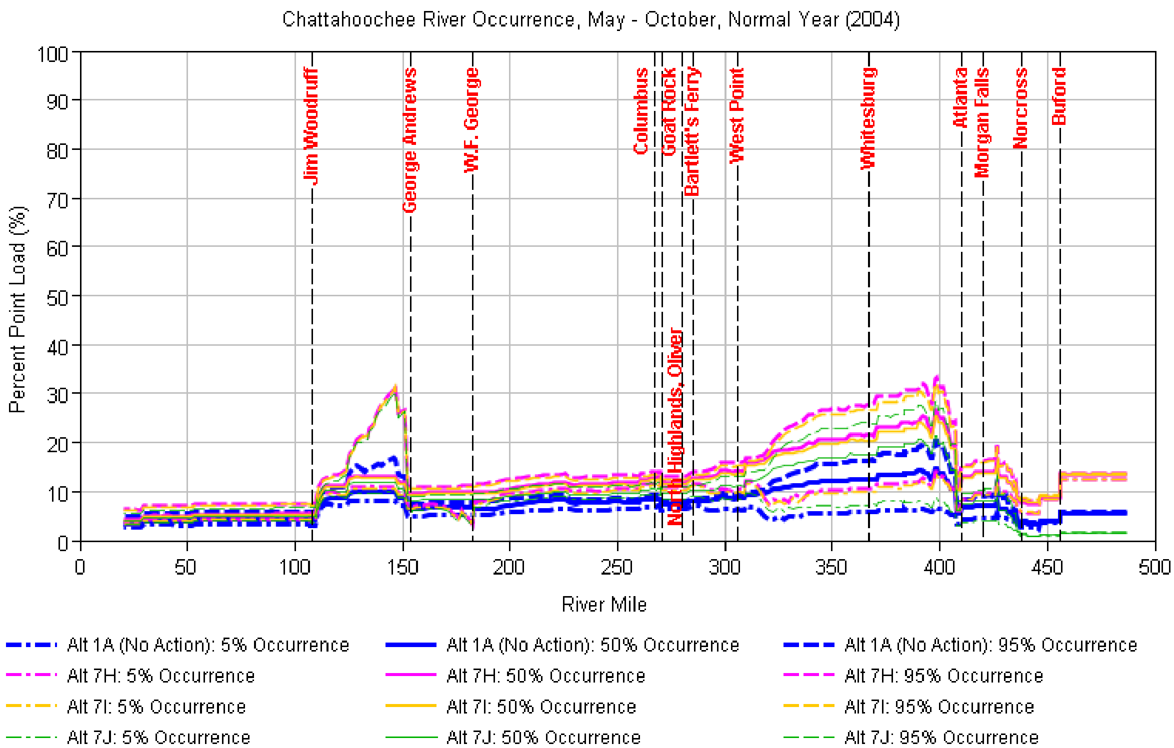


Figure 2.2-28. Percent of total flow that is wastewater along the Chattahoochee River for May through October of the modeled period (2001-2011)



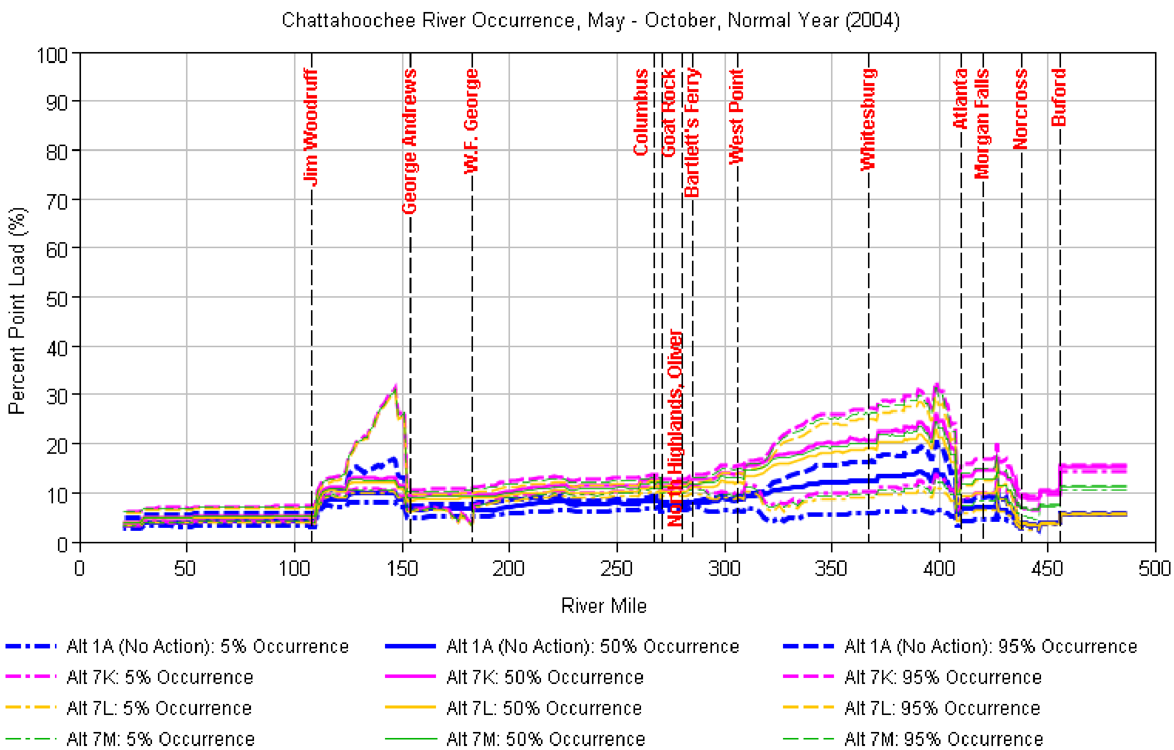


Figure 2.2-29. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative normal year (2004)

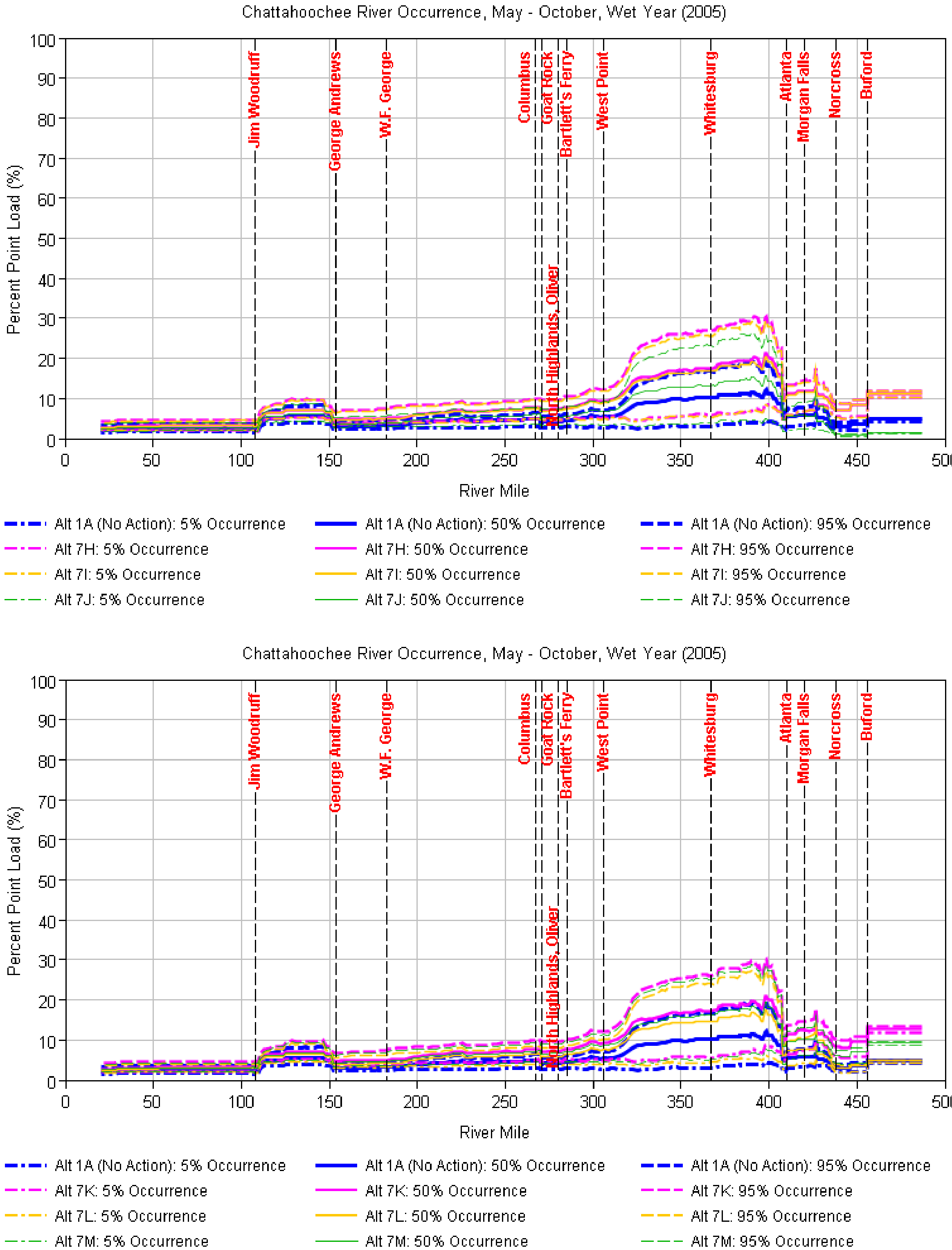
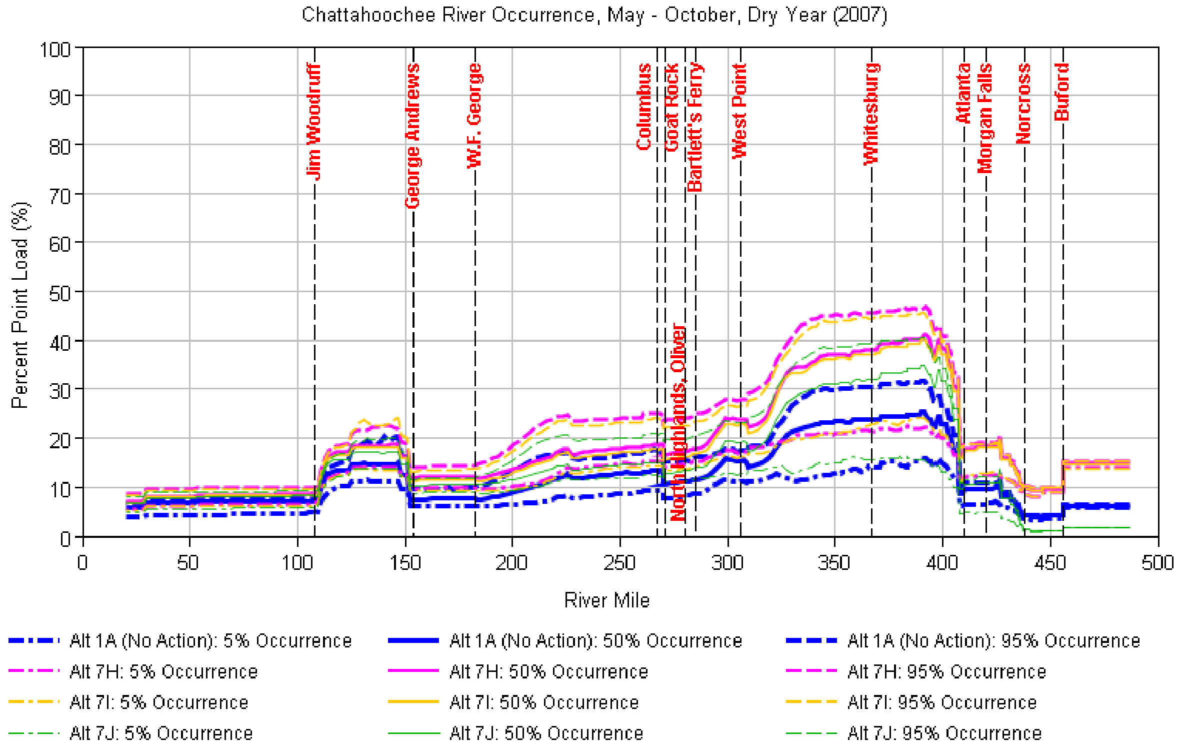


Figure 2.2-30. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative wet year (2005)



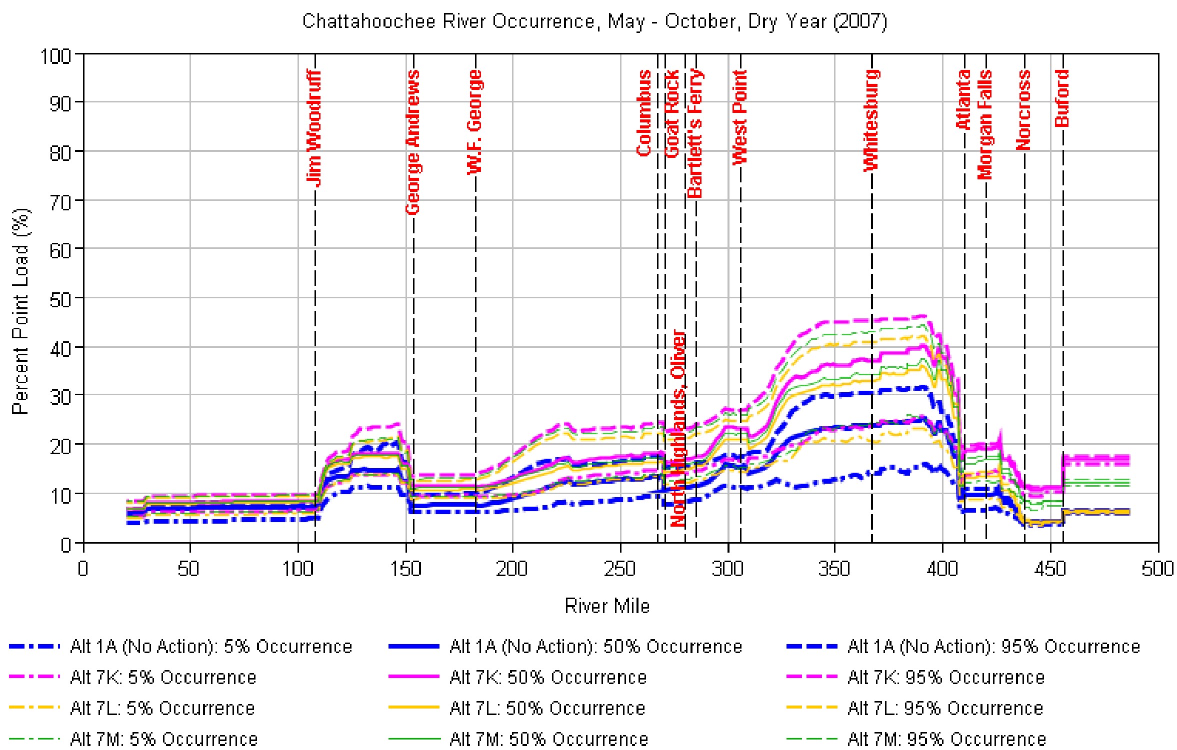


Figure 2.2-31. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative dry year (2007)

Chlorophyll a

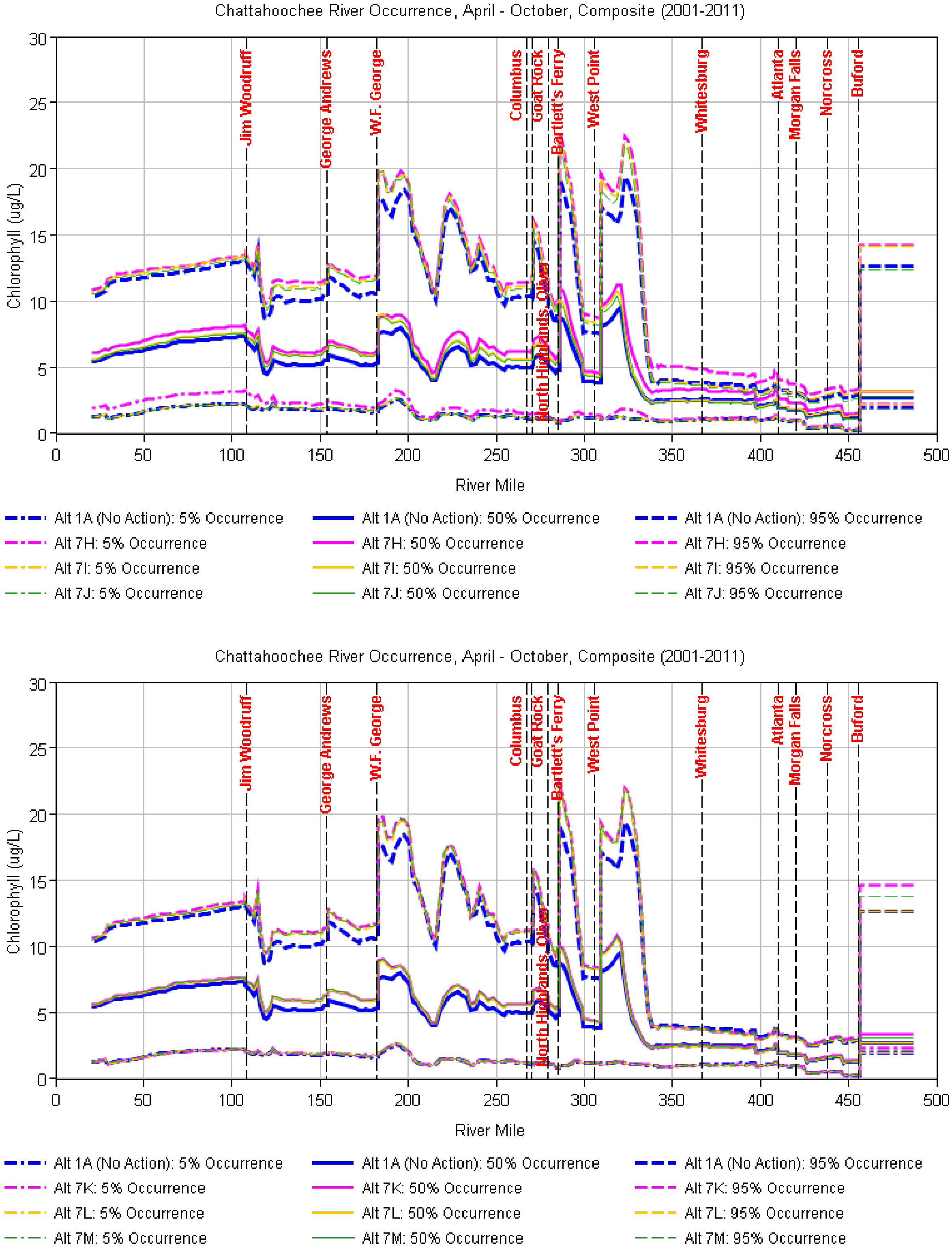
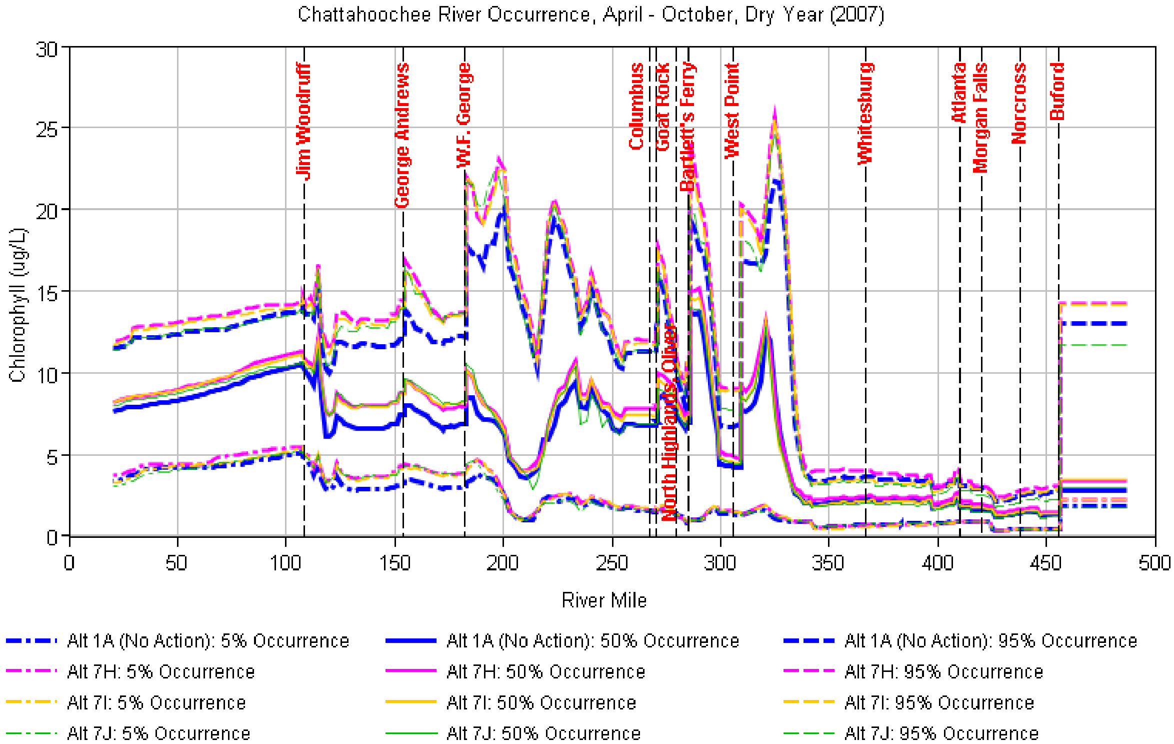


Figure 2.2-32. Chlorophyll a along the Chattahoochee River for April through October of the modeled period (2001-2011)



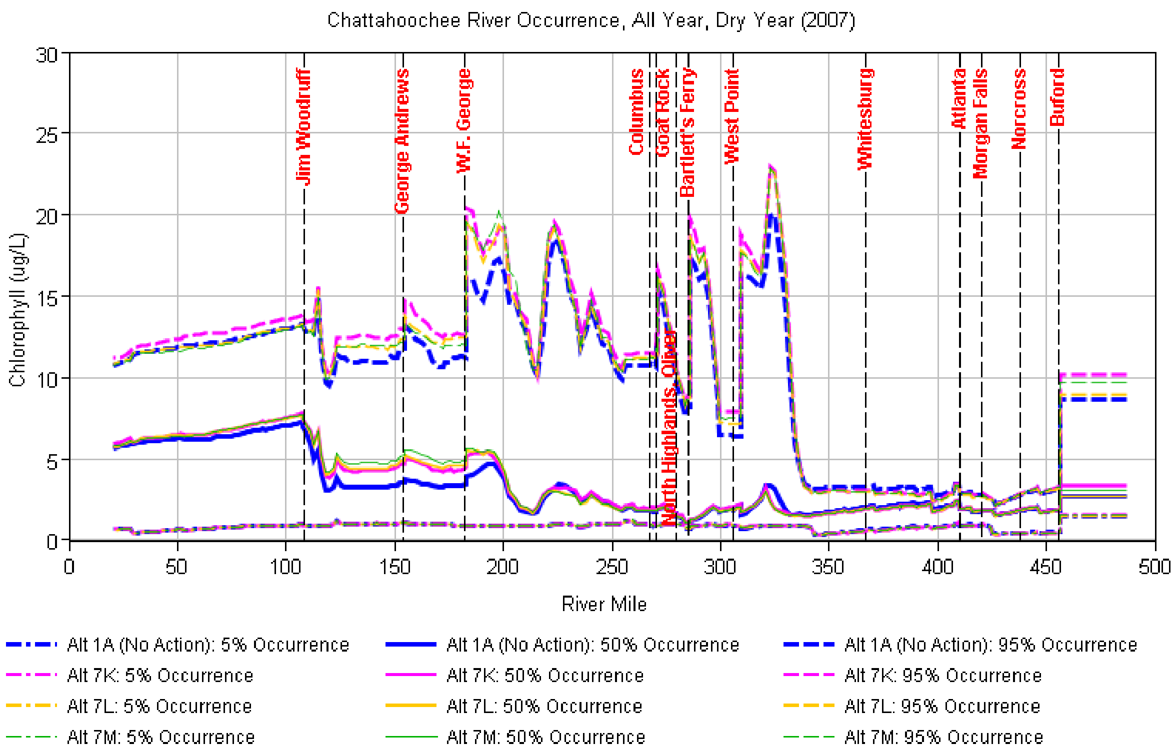


Figure 2.2-33. Chlorophyll a along the Chattahoochee River for April through October in a representative dry year (2007)

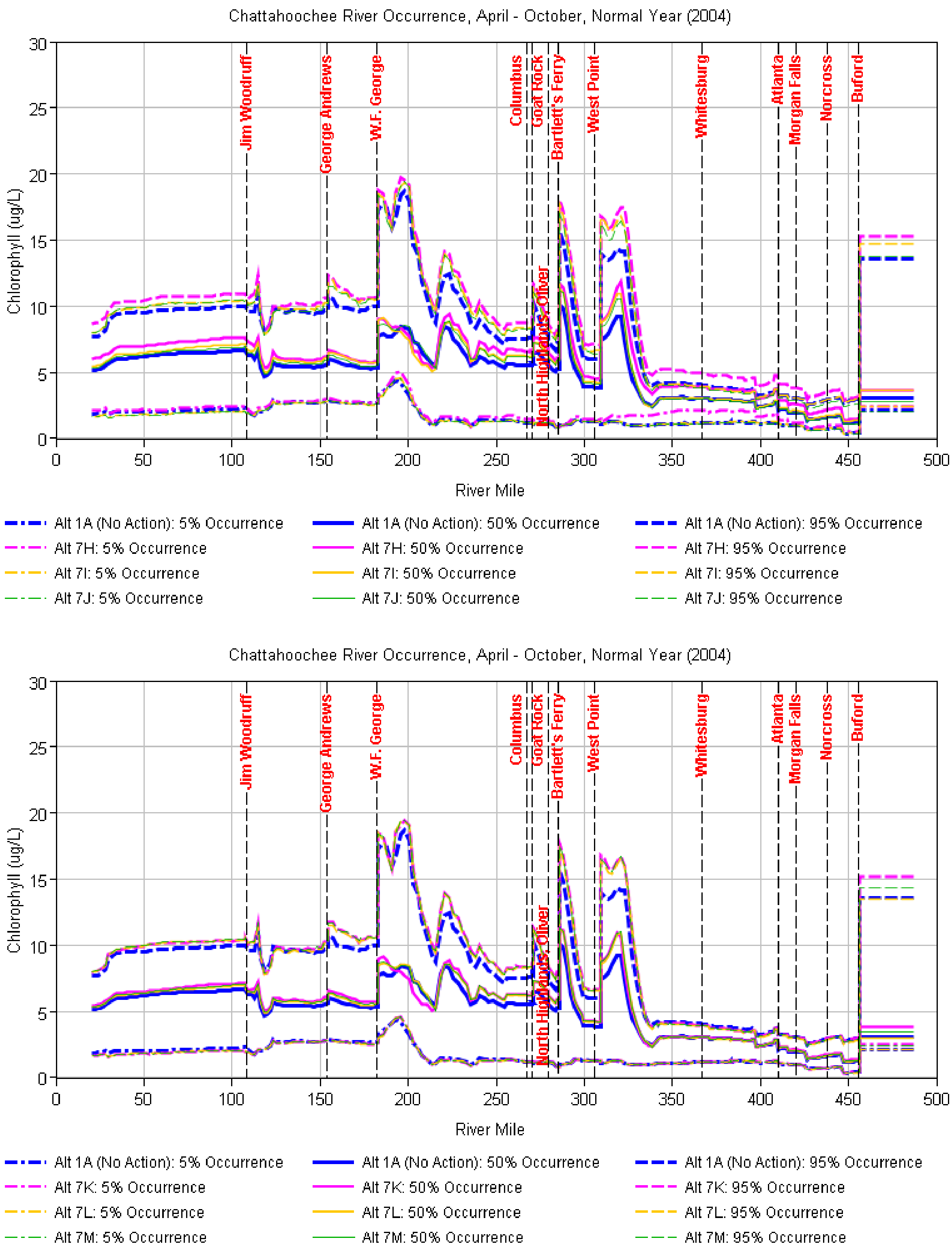


Figure 2.2-34. Chlorophyll a along the Chattahoochee River for April through October in a representative normal year (2004)

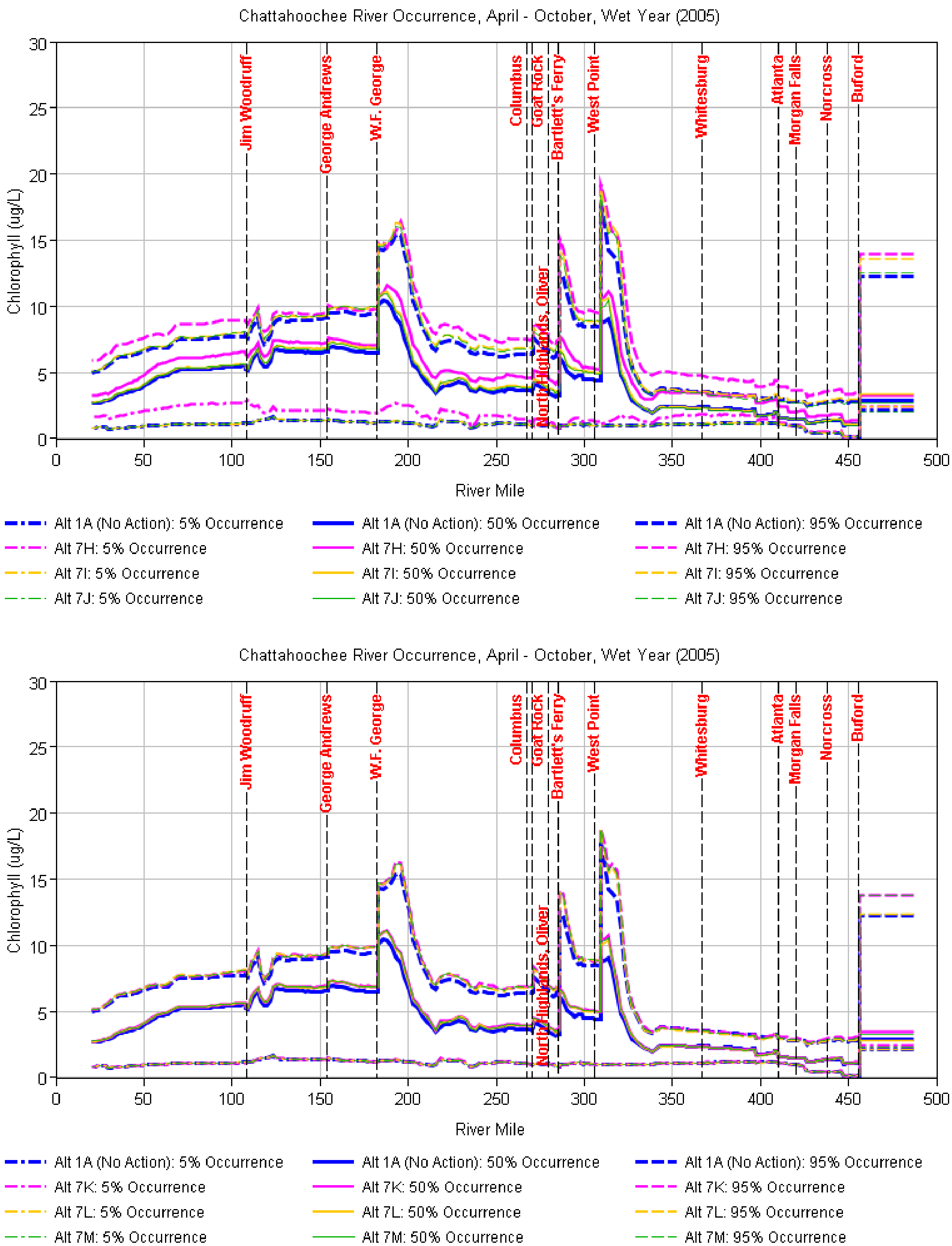
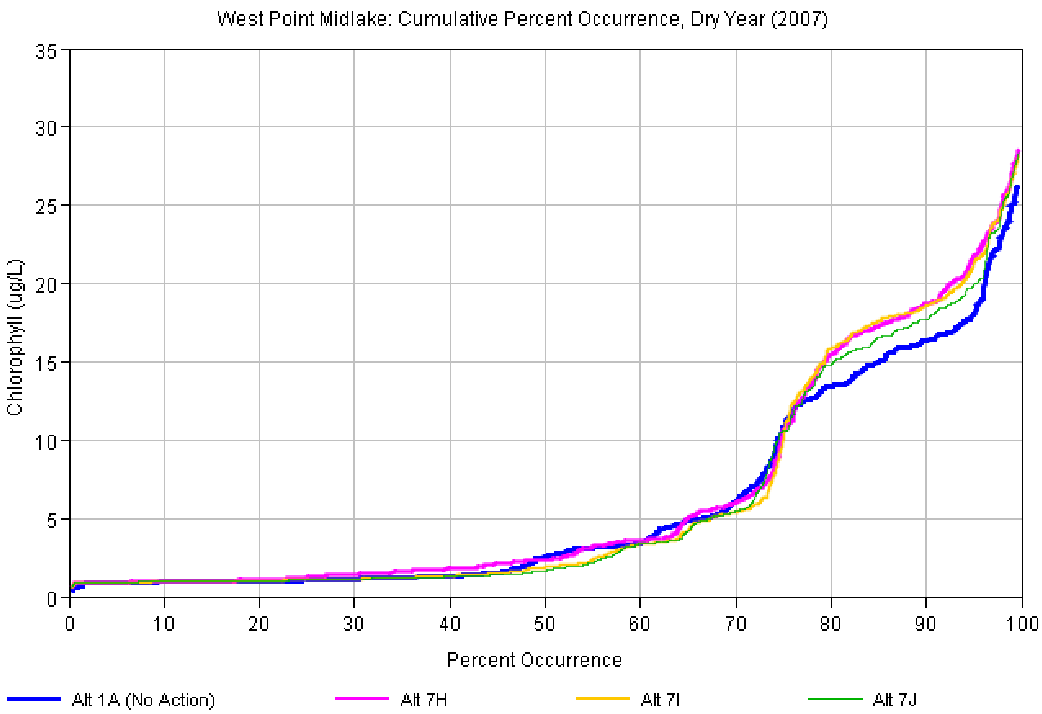


Figure 2.2-35. Chlorophyll a along the Chattahoochee River for April through October in a representative wet year (2005)



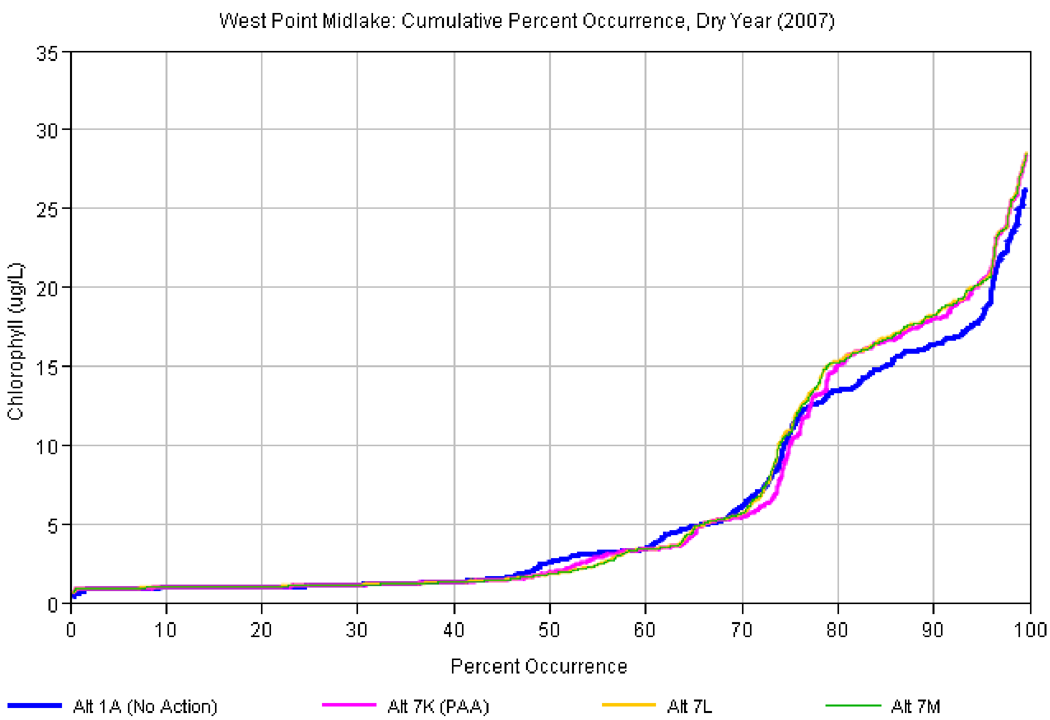
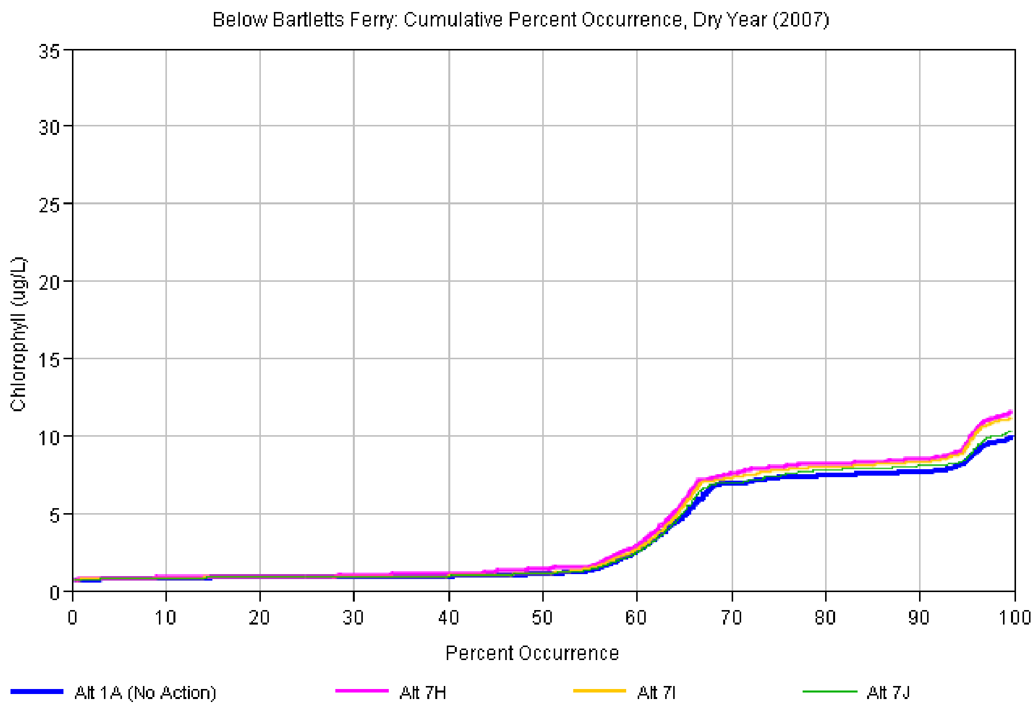


Figure 2.2-36. Occurrence of daily average chlorophyll a in a mid-reservoir location of West Point Lake for a representative dry year (2007)



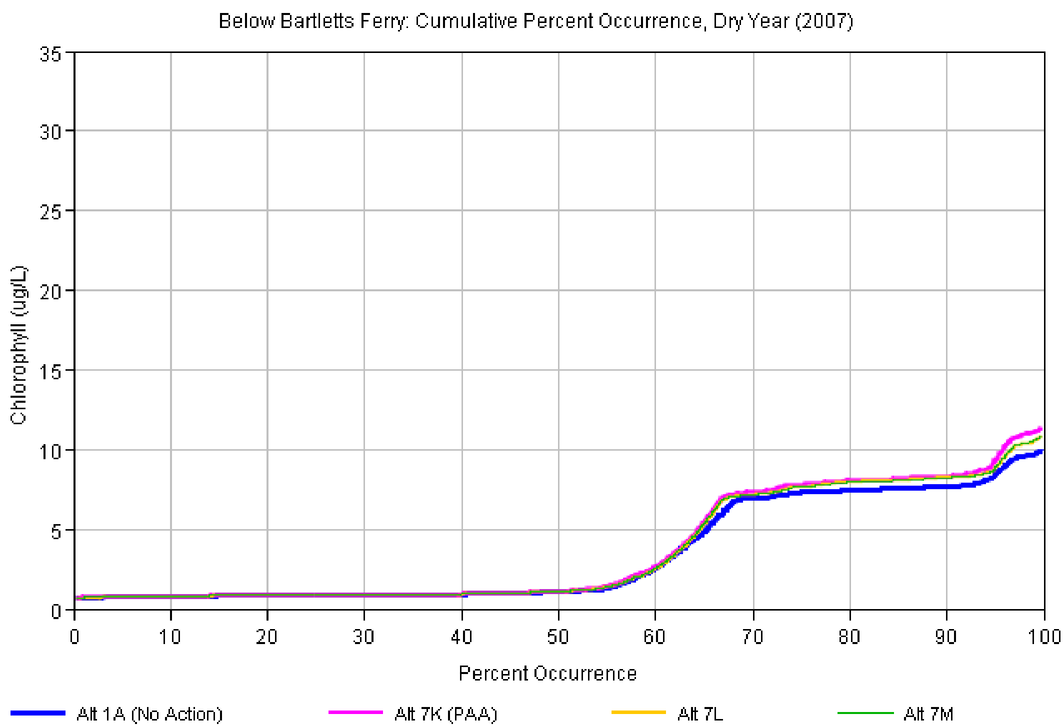
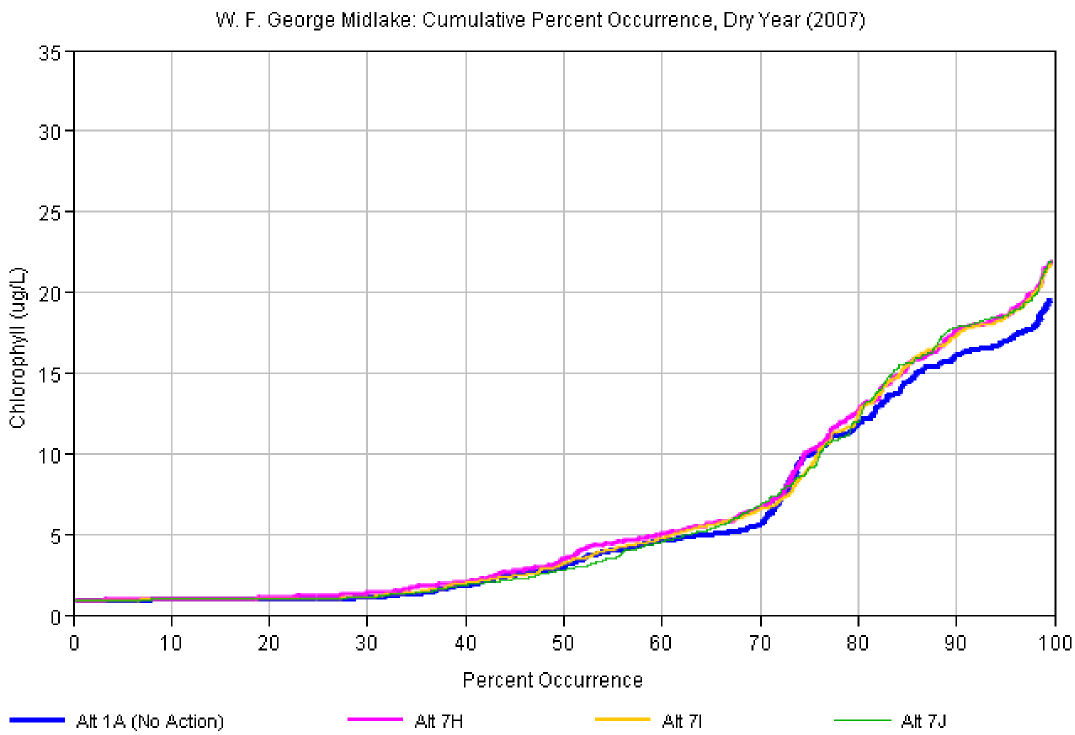


Figure 2.2-37. Occurrence of daily average chlorophyll a in a mid-reservoir location of Bartletts Ferry Lake for a representative dry year (2007) [Note that the figure title from the previous PAL was consistent with the title here but the figures indicated that they were Below Bartlett's Ferry. Therefore, the figures presented here are Below Barletts Ferry.]



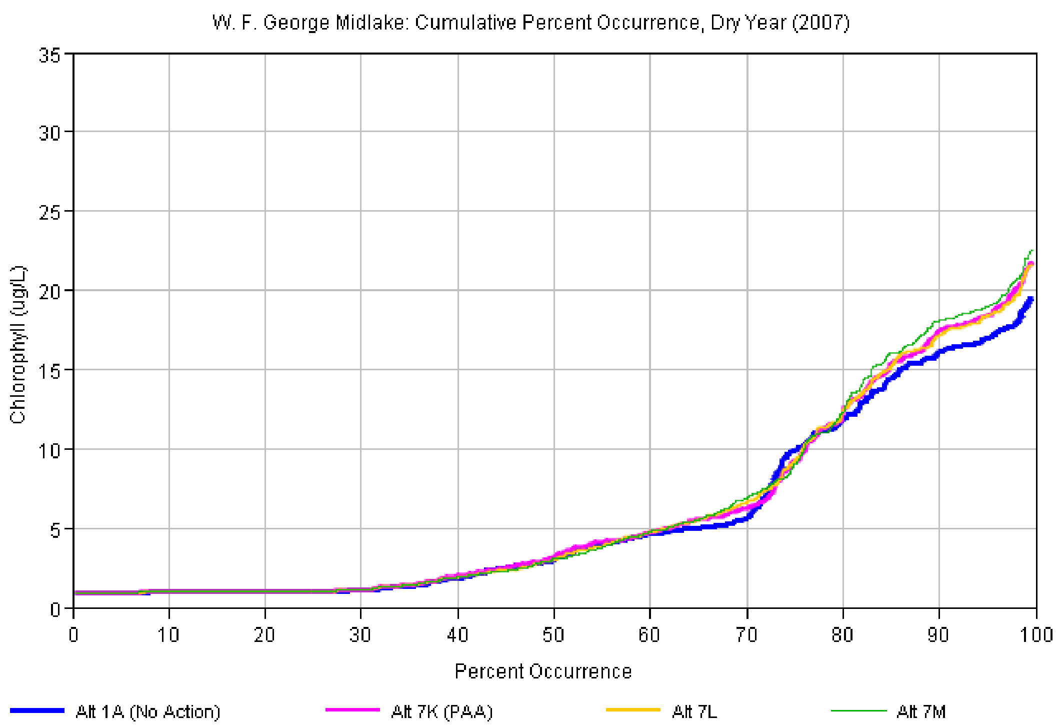


Figure 2.2-38. Occurrence of daily average chlorophyll a in a mid-reservoir location of Walter F. George Lake for a representative dry year (2007)

Table 2.2-1a. Growing season (April through October) annual average of chlorophyll a at USACE reservoirs in the ACF Basin

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
Lake Lanier					
2000	5.2	5.7	5.8	0.5	0.7
2001	3.8	4.2	4.3	0.4	0.5
2002	4.2	4.9	5.1	0.7	0.9
2003	3.8	4.4	4.5	0.5	0.7
2004	4.6	5.2	5.4	0.7	0.8
2005	4.3	4.8	5.0	0.5	0.7
2006	4.1	4.7	4.9	0.6	0.8
2007	4.2	4.9	5.2	0.7	1.0
2008	4.0	4.7	5.0	0.7	0.9
2009	4.2	4.8	5.0	0.6	0.8
2010	4.0	4.6	4.7	0.7	0.7
2011	4.3	4.9	5.1	0.7	0.8
West Point MidLake					
2000	8.5	12.6	11.8	4.1	3.3
2001	7.1	8.3	7.0	1.2	-0.1
2002	10.8	12.0	11.1	1.3	0.3
2003	2.9	4.5	3.0	1.7	0.1
2004	4.6	6.5	5.1	1.9	0.6
2005	2.9	4.3	3.1	1.3	0.1
2006	6.3	7.6	6.7	1.3	0.4
2007	9.2	10.0	9.6	0.8	0.4
2008	10.0	11.3	10.4	1.3	0.3
2009	6.9	9.3	8.1	2.4	1.2
2010	5.3	6.7	5.7	1.5	0.5
2011	7.5	9.9	9.3	2.4	1.9
West Point Dam					
2000	9.8	11.2	10.9	1.4	1.1
2001	8.2	9.3	9.2	1.2	1.0
2002	9.1	10.5	10.3	1.4	1.3
2003	8.4	10.0	9.3	1.6	0.9
2004	7.0	8.3	8.1	1.3	1.1
2005	7.8	9.0	8.7	1.2	0.9
2006	7.9	8.9	8.8	1.0	0.9
2007	7.7	8.8	8.6	1.1	0.9
2008	8.5	10.0	9.9	1.5	1.4
2009	7.0	8.2	7.9	1.2	0.9
2010	6.5	7.8	7.5	1.3	1.0
2011	8.0	9.4	9.1	1.4	1.2
Walter MidLake					
2000	9.1	10.0	9.6	0.9	0.5
2001	7.3	8.4	7.7	1.1	0.5
2002	8.0	9.0	8.7	1.0	0.7
2003	4.1	5.2	4.3	1.1	0.2
2004	6.9	7.8	7.3	1.0	0.4
2005	4.2	5.3	4.5	1.1	0.3
2006	8.1	9.3	9.0	1.2	0.9
2007	8.8	9.6	9.3	0.8	0.5

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2008	9.1	10.2	9.8	1.1	0.7
2009	6.5	7.5	6.8	1.0	0.4
2010	5.6	6.4	5.9	0.8	0.4
2011	8.0	8.7	8.4	0.7	0.4
Lake Seminole MidLake					
2000	6.1	6.5	6.3	0.5	0.3
2001	3.8	4.5	4.1	0.7	0.3
2002	5.4	6.3	6.0	0.9	0.6
2003	5.5	6.4	5.7	0.9	0.2
2004	5.3	5.9	5.5	0.6	0.3
2005	5.2	5.9	5.4	0.8	0.2
2006	5.3	6.3	6.1	1.0	0.8
2007	6.1	7.4	7.1	1.2	1.0
2008	5.4	6.3	6.1	1.0	0.7
2009	4.1	4.8	4.2	0.7	0.1
2010	4.4	4.9	4.6	0.6	0.2
2011	5.8	6.8	6.7	1.0	0.9

Table 2.2-1b. Growing season (April through October) annual geometric mean of chlorophyll a at USACE reservoirs in the ACF Basin

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
Lake Lanier					
2000	4.1	4.6	4.7	0.5	0.7
2001	3.2	3.6	3.7	0.4	0.5
2002	3.4	4.0	4.2	0.6	0.7
2003	3.2	3.7	3.8	0.5	0.6
2004	3.7	4.3	4.5	0.6	0.7
2005	3.6	4.0	4.2	0.4	0.6
2006	3.4	3.9	4.1	0.5	0.7
2007	3.4	4.1	4.3	0.6	0.9
2008	3.2	3.8	4.0	0.6	0.8
2009	3.4	4.0	4.1	0.5	0.7
2010	3.3	3.9	3.9	0.5	0.6
2011	3.4	4.0	4.1	0.6	0.7
West Point MidLake					
2000	6.3	9.4	8.0	3.1	1.7
2001	5.8	7.2	5.8	1.4	0.0
2002	7.5	9.2	7.8	1.6	0.2
2003	2.5	4.1	2.6	1.6	0.1
2004	3.6	5.4	3.9	1.8	0.3
2005	2.6	3.8	2.7	1.3	0.1

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2006	5.1	6.3	5.3	1.2	0.2
2007	6.4	6.6	6.3	0.3	-0.1
2008	7.8	9.0	7.9	1.3	0.1
2009	4.4	6.8	5.0	2.3	0.6
2010	3.9	5.2	4.2	1.3	0.3
2011	5.7	7.3	6.5	1.6	0.7
West Point Dam					
2000	7.8	8.8	8.6	1.0	0.8
2001	5.7	6.8	6.3	1.1	0.5
2002	7.1	8.0	7.9	1.0	0.8
2003	6.1	7.3	6.7	1.2	0.6
2004	5.5	6.4	6.1	0.9	0.6
2005	5.4	6.4	5.9	1.0	0.5
2006	6.4	7.1	7.1	0.8	0.7
2007	5.8	6.6	6.4	0.8	0.6
2008	7.0	8.0	8.0	1.1	1.0
2009	5.0	5.9	5.5	0.9	0.5
2010	4.7	5.5	5.3	0.9	0.6
2011	6.8	7.9	7.7	1.2	1.0
Walter MidLake					
2000	7.0	8.1	7.4	1.1	0.4
2001	5.9	7.2	6.3	1.3	0.4
2002	6.4	7.2	6.9	0.9	0.5
2003	3.4	4.5	3.6	1.1	0.2
2004	5.5	6.4	5.6	0.9	0.2
2005	3.7	4.9	3.9	1.1	0.2
2006	6.6	7.8	7.3	1.1	0.7
2007	7.0	7.7	7.4	0.6	0.3
2008	7.3	8.5	7.9	1.2	0.6
2009	4.4	5.7	4.7	1.3	0.2
2010	4.2	5.1	4.5	0.9	0.3
2011	6.5	7.4	6.9	0.8	0.4
Lake Seminole MidLake					
2000	5.4	6.0	5.7	0.6	0.3
2001	3.4	4.1	3.6	0.7	0.2
2002	4.8	5.7	5.4	0.9	0.6
2003	5.0	5.9	5.2	0.9	0.2
2004	5.0	5.6	5.2	0.6	0.3
2005	4.6	5.5	4.8	0.9	0.2

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2006	4.9	5.9	5.6	1.0	0.7
2007	5.5	6.8	6.6	1.3	1.0
2008	5.1	6.0	5.8	1.0	0.7
2009	3.6	4.3	3.7	0.8	0.1
2010	4.0	4.5	4.2	0.5	0.2
2011	5.3	6.3	6.1	1.0	0.8

Table 2.2-2. Monthly retention times (in days) for reservoirs on the Chattahoochee River for the period from 2001 through 2011

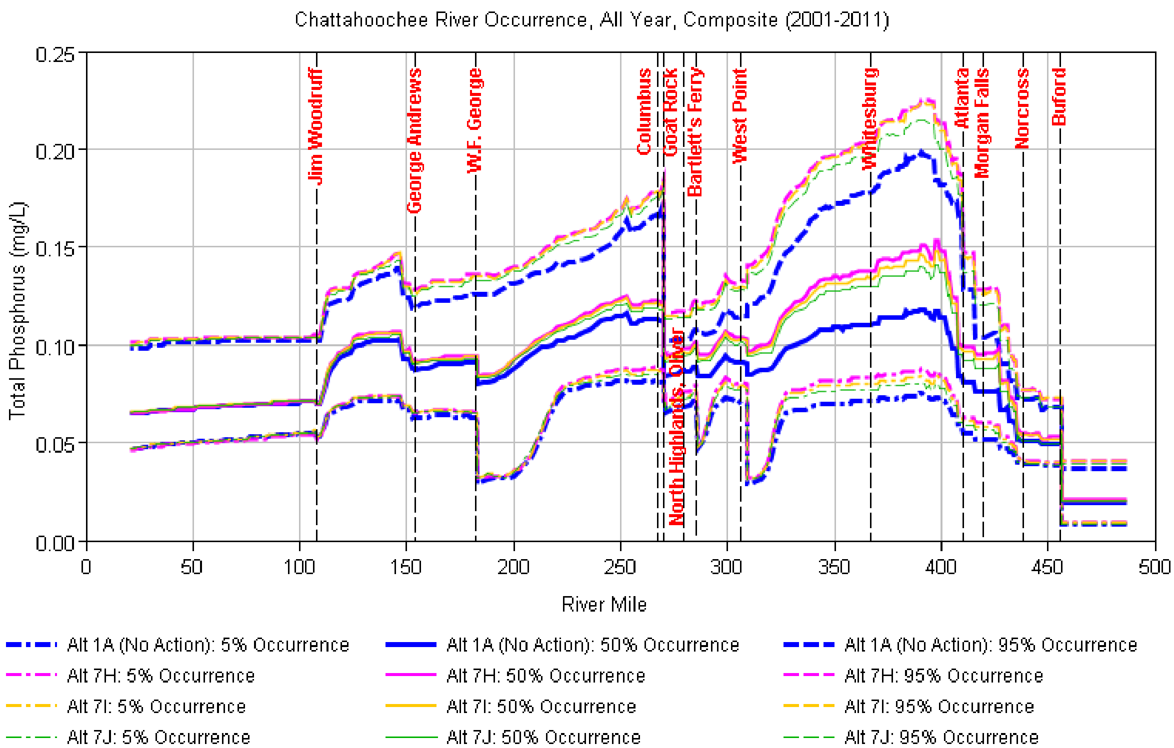
See attached spreadsheet.

Total phosphorus

Table 2.2-3. Total phosphorus loads at West Point Lake headwaters and Walter F. George Lake headwaters for the modeled period (2001–2011)

Year	Location	NAA	A7_H	A7_K
2001	West Point Lake headw aters	754,935	843,924	832,053
	Walter F. George Lake headw aters	1,422,036	1,526,650	1,509,983
2002	West Point Lake headw aters	697,443	826,407	810,360
	Walter F. George Lake headw aters	1,106,039	1,229,652	1,213,543
2003	West Point Lake headw aters	1,283,557	1,445,418	1,408,302
	Walter F. George Lake headw aters	1,965,005	2,135,048	2,090,889
2004	West Point Lake headw aters	897,763	1,020,282	1,000,136
	Walter F. George Lake headw aters	1,465,636	1,597,801	1,573,490
2005	West Point Lake headw aters	1,129,805	1,265,768	1,241,756
	Walter F. George Lake headw aters	2,017,151	2,181,822	2,147,607
2006	West Point Lake headw aters	720,284	824,021	805,049
	Walter F. George Lake headw aters	1,210,894	1,315,773	1,295,033
2007	West Point Lake headw aters	478,531	588,474	568,821
	Walter F. George Lake headw aters	931,830	1,049,054	1,027,777
2008	West Point Lake headw aters	452,391	539,860	527,146
	Walter F. George Lake headw aters	1,172,838	1,286,855	1,270,781
2009	West Point Lake headw aters	1,261,733	1,386,419	1,361,653

Year	Location	NAA	A7_H	A7_K
	Walter F. George Lake headw aters	2,413,272	2,605,069	2,561,774
2010	West Point Lake headw aters	858,573	964,649	942,654
	Walter F. George Lake headw aters	1,555,842	1,672,748	1,644,284
2011	West Point Lake headw aters	641,421	763,766	744,398
	Walter F. George Lake headw aters	1,059,169	1,180,736	1,159,505



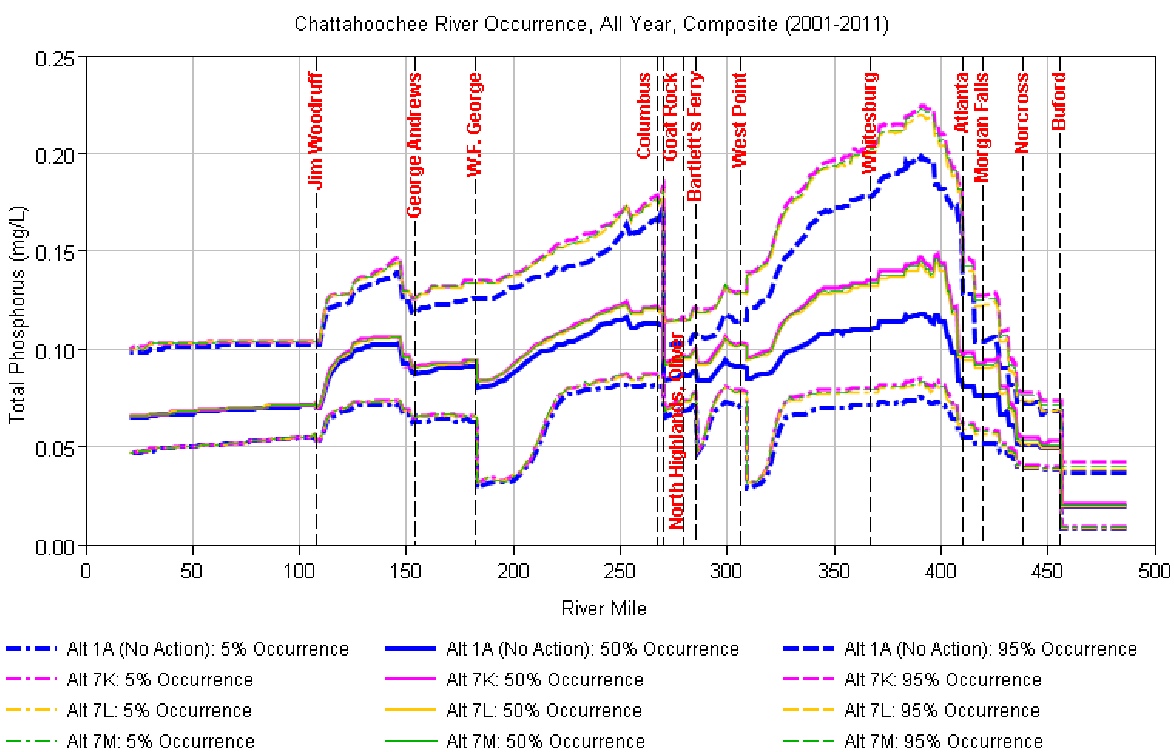
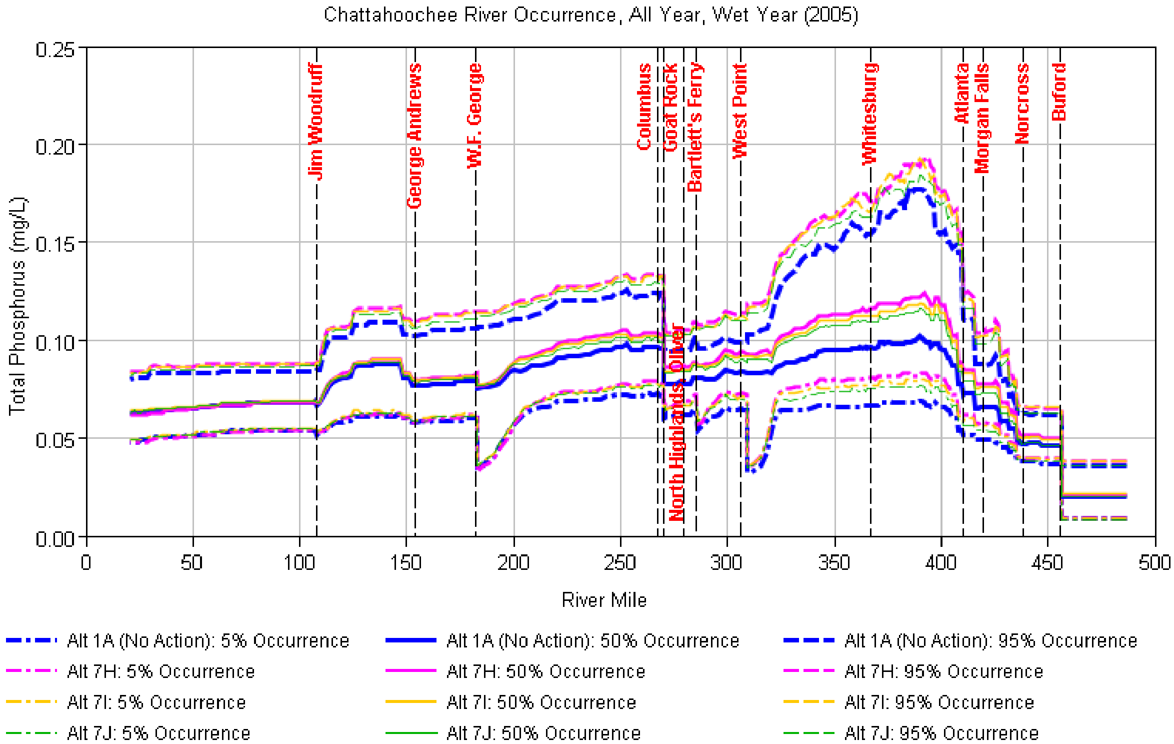


Figure 2.2-39. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for the period 2001-2011 for the NAA, Alt7H, and the PAA (Alt7K)



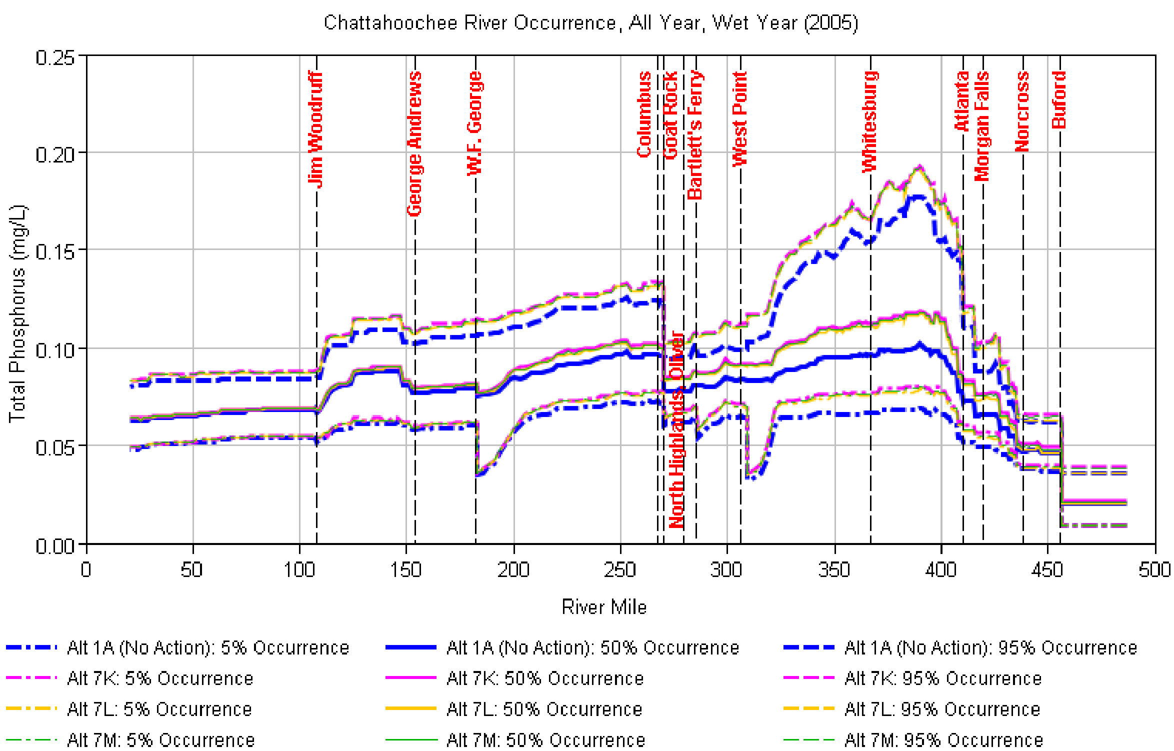
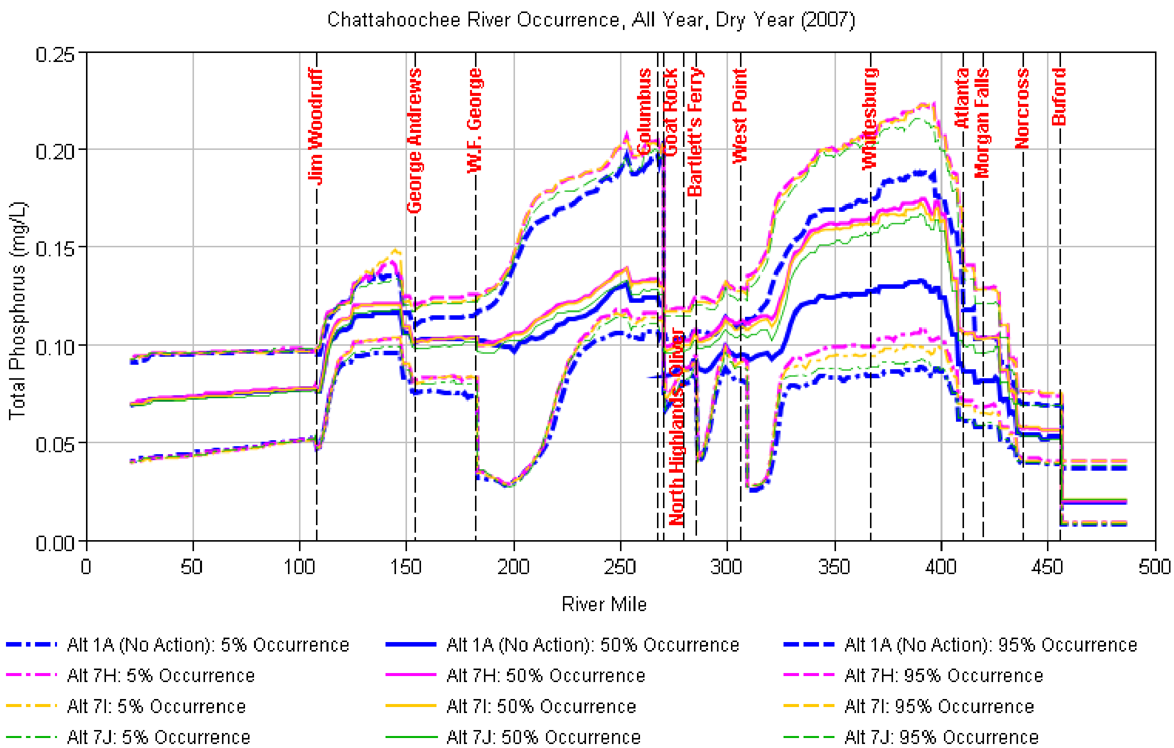


Figure 2.2-40. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a wet year (2005) for the NAA, Alt7H, and the PAA (Alt7K)



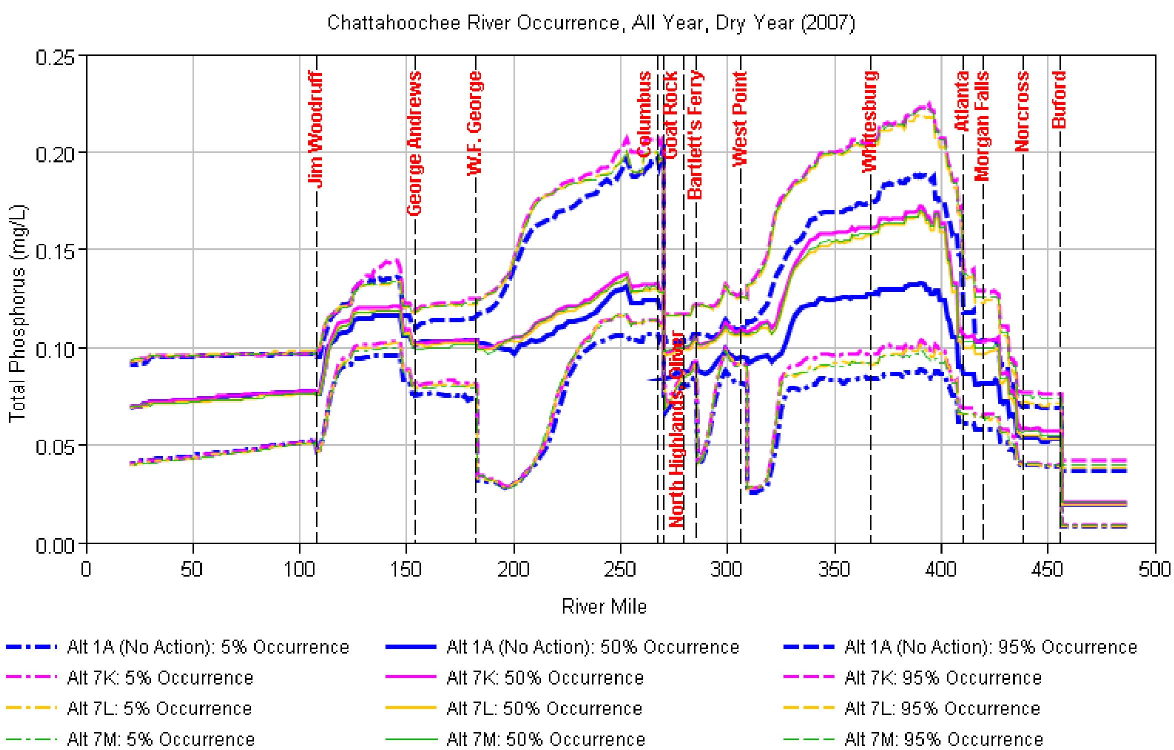


Figure 2.2-41. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a dry year (2007) for the NAA, Alt7H, and the PAA (Alt7K)

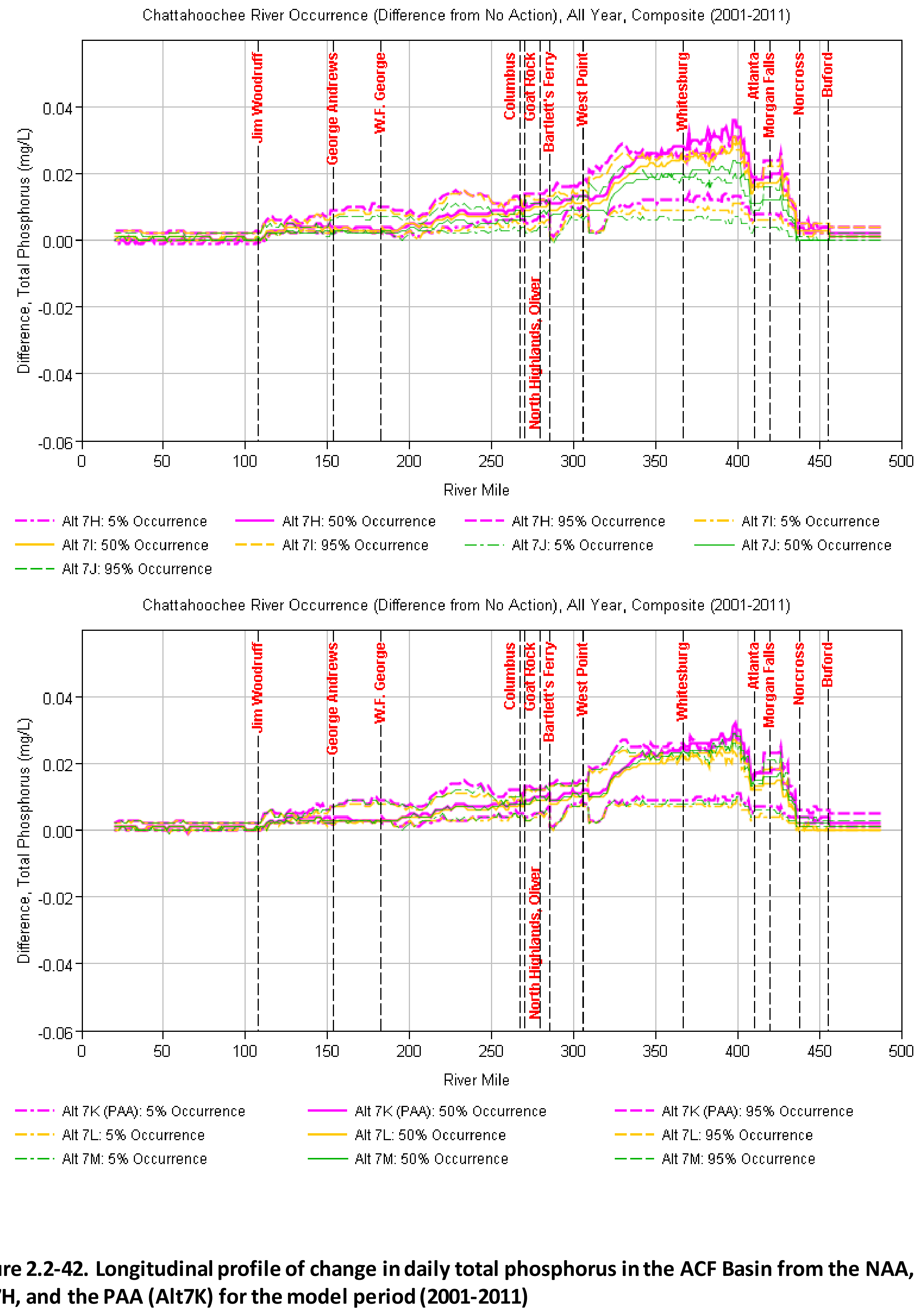
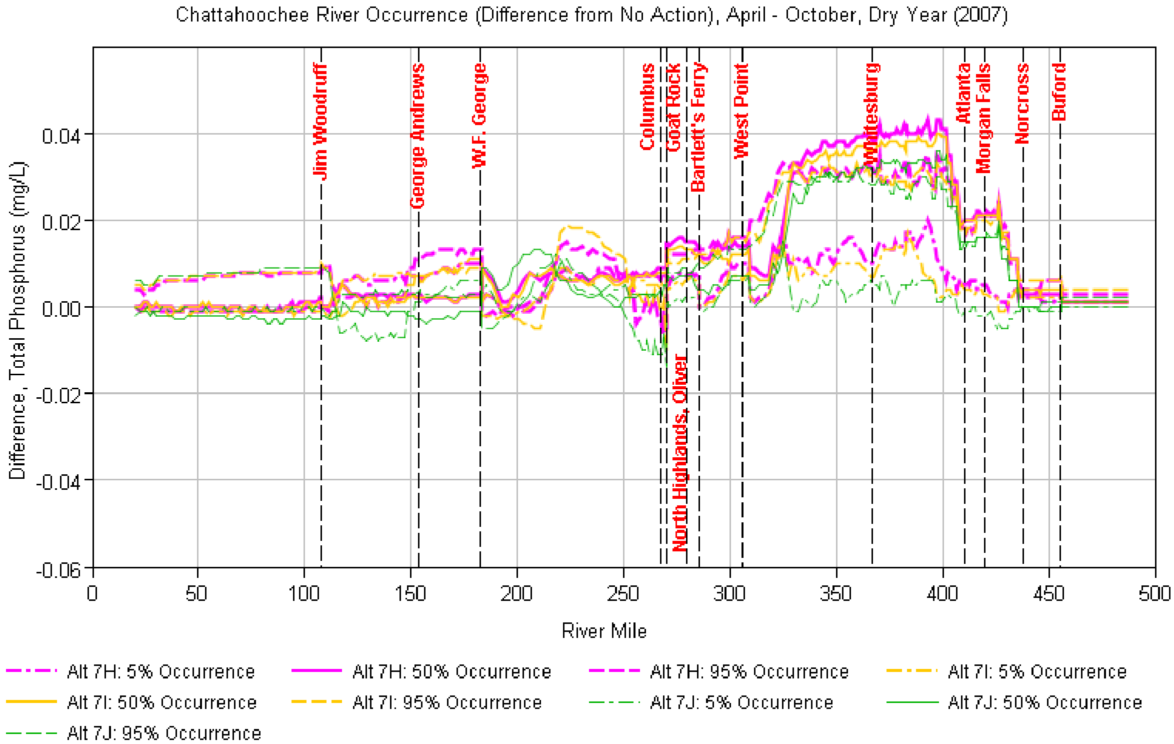


Figure 2.2-42. Longitudinal profile of change in daily total phosphorus in the ACF Basin from the NAA, Alt7H, and the PAA (Alt7K) for the model period (2001-2011)



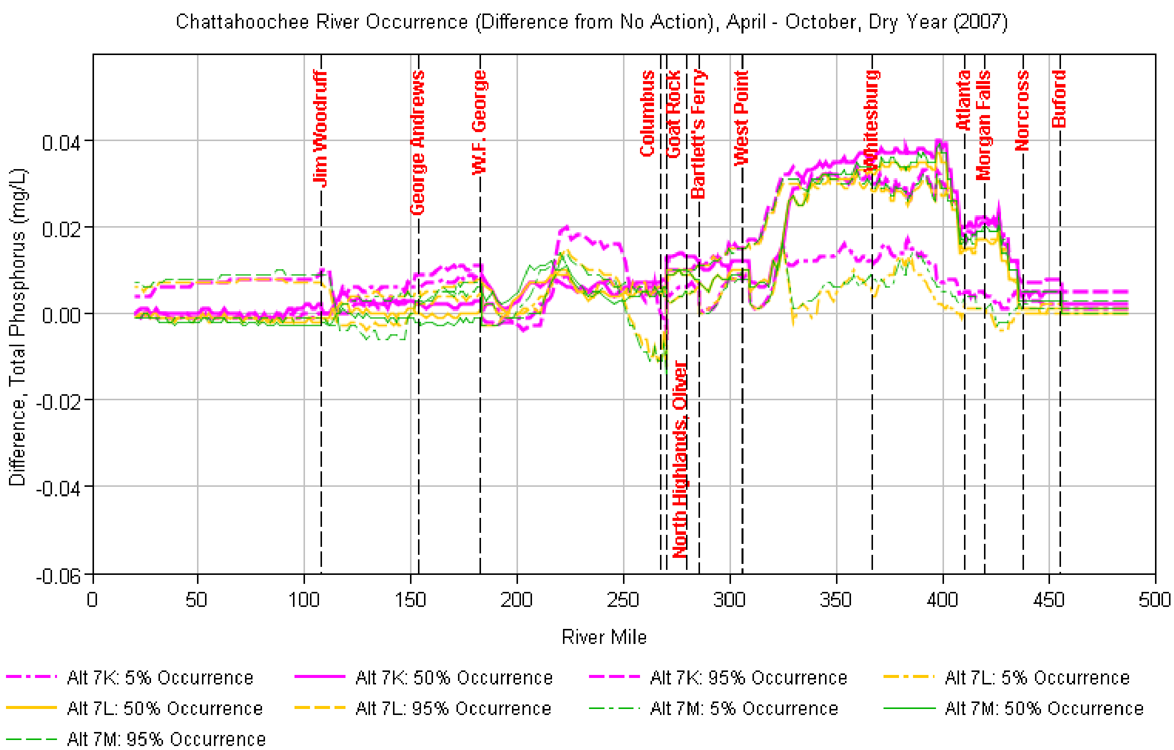


Figure 2.2-43. Longitudinal profile of change in daily total phosphorus from the NAA in the ACF Basin during growing season (April through October) of a dry year (2007) for the Alt7H and the PAA (Alt7K)

ACF Water Control Manual Update Supplemental Information for Final Fish and Wildlife Coordination Act Report

U.S. Army Corps of Engineers
July 2016

Contents

1 Description of the Proposed Action and Alternatives

1.1 Introduction

On January 21, 2015 the U.S. Army Corps of Engineers (USACE) provided the U.S. Fish and Wildlife Service (Service) a description (USACE, 2015a) of a proposed updated Master Manual for the Apalachicola, Chattahoochee, and Flint River (ACF) Basin and a response to previous Planning Aid Letters (PAL) dated April 1, 2010; March 1, 2011; and August 29, 2013. On 2 October 2016, USACE released a Draft Environmental Impact Statement (DEIS) (USACE, 2015b) for the proposed action. The DEIS has been provided to the Service Panama City, Florida and Athens, Georgia field offices. A Draft Fish and Wildlife Coordination Act Report (DFWCAR) was provided by the Service Athens, Georgia Field Office, to USACE District Commander Jon Chytka, dated July 31, 2015. A response to the DFWCAR was provided by USACE in the DEIS. In addition, a Department of the Interior letter commenting on the DEIS dated January 29, 2016, provided Service as well as National Park Service comments on the proposed action.

After consideration of all comments submitted in response to release of the DEIS and a revised Water Supply Storage request by the State of Georgia, several modifications were made to the proposed action to be evaluated in the Final Environmental Impact Statement (FEIS). Although they will be discussed in more detail in the next section, the modifications are as follows:

1. The FEIS proposed action alternative analysis does not assume that Bear Creek Reservoir and Glades Creek Reservoir are constructed. The DEIS assumed they were constructed. Both of these permit applications have been withdrawn or suspended.

2. The FEIS proposed action alternative assumes a gross withdrawal of 242 MGD from Lake Lanier directly and 379 MGD downstream. The DEIS proposed action alternative assumes a gross withdrawal of 185 MGD from Lake Lanier directly and 408 MGD downstream.

3. The FEIS proposed action alternative analysis utilized the latest version of HEC-ResSim (the DEIS proposed action alternative used the previous HEC-ResSim version).

4. The FEIS proposed action alternative analysis used an updated Area Capacity Curve for Lake Lanier.

5. The FEIS analysis includes updates to the HEC-5Q based on comments received on the DEIS proposed action alternative.

Overall, there are few differences between the revised Proposed Action Alternative (PAA), Alternative7K (Alt7K), and the PAA as presented in the DEIS, Alt7H, or the impacts resulting from them. The proposed water management operations did not change, nor did the alternatives formulation process. This document will provide a new description of the PAA and discuss the changes in impacts from the PAA as presented in the DEIS. Therefore, except as otherwise noted, impacts are expected to be similar to those described in the January 21, 2015 Response to PAL.

1.2 Description of Proposed Action

Under the PAA, the USACE would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods. The intent would be to maintain a balanced use of conservation storage rather than to maintain the pools at or above certain predetermined elevations; however, in times of high-flow conditions, flood risk management regulation would supersede all other project functions. At all times, USACE would seek to conserve the water resources entrusted to its regulation authority. The PAA is consistent with the USACE's authority as set forth in the 2012 legal opinion (USACE, 2012). The PAA does not include construction of any new facilities or infrastructure. The following sections describe the PAA.

1.2.1 Guide Curves and Action Zones

In conjunction with meeting authorized project purposes, an important function of the reservoirs in the ACF Basin is to store water when there is an abundance of rain and to release water when there is less rain in an effort to ensure that all water needs can be met throughout the year. Water management in this context is a complex process that requires consideration of many competing demands for water in the basin, consideration of past and anticipated future hydrologic conditions, collaboration with agencies and stakeholders, and determination of the most appropriate operating conditions for all the reservoirs in the basin to meet both human and natural system needs. Water is managed in the reservoir projects in the ACF Basin for a variety of purposes, including flood risk management, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water supply, and water quality. Water demands can be consumptive or nonconsumptive. Consumptive demands involve withdrawal of water from the basin for some purpose and not returning it or any portion thereof, directly back to the basin. Municipal, industrial, and thermal power water supply consumes a portion of the withdrawn water and returns a portion of the water back to the basin as treated wastewater. For purposes of this analysis, agricultural water supply withdrawals are assumed to provide no return flows to the surface water streams. In contrast, hydroelectric power generation demand is a nonconsumptive use of water. It uses the flow in the river to drive hydroelectric power turbines to generate electricity, but no water is withdrawn or lost from the system. In considering basin water management, it is critical to account for the various withdrawals (losses) from and returns (gains) to the system. Water is lost to the system through evapotranspiration (the total of evaporation and plant transpiration), municipal and industrial (M&I) water withdrawals, thermal cooling water withdrawals, agricultural water withdrawals, groundwater transfers, and interbasin transfers. Water is returned, or added, to the basin through precipitation, treated M&I wastewater discharges, thermal power plant discharges, groundwater baseflow contributions, and interbasin transfers.

USACE releases water from its reservoirs primarily through hydropower generation and releases through the spillway gates. Hydropower generation is the preferred method and is generally used except in flood operations or in situations that prohibit the use of turbines, such as maintenance operations. In order to allow the most efficient use of its reservoirs for all project purposes, USACE has established guide curves that serve as target water levels during the year. The guide curves allow for lower reservoir levels during greater risk of flood conditions, typically the rainy winter and spring season, and higher reservoir level during drier periods. This allows storage of water during flood events and release of water during dry weather. Action zones within the conservation pool (area under the guide curve) allow the decision maker to best balance the authorized purposes as the reservoir is drawn down through increasingly critical levels.

Under the PAA, the USACE would not modify any guide curves of the ACF projects but would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The action zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes can be met. As lake levels decline, zones 2 through 4 define increasingly critical system status where purposes can no longer fully be met. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project.

The revised action zones were derived considering numerous factors, including the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects. Other factors or activities might cause the lakes to operate differently than the action zones are described, including exceptional flood risk management measures, fish spawn operations, approved deviations, maintenance and repair of turbines, emergency situations (such as a drowning and chemical spills), draw-downs because of shoreline maintenance, releases made to free grounded barges, and other special circumstances.

The storage projects (Lanier, West Point, and Walter F. George) would be operated to maintain their respective lake level in the same action zones concurrently. Because of the hydrologic and physical characteristics of the river system and factors mentioned above, however, there might be periods when one lake would be in a higher or lower action zone than another. When that occurs, the USACE would conduct operations to bring the lakes into balance with each other as soon as conditions allow. By doing so, effects within the river basin would be shared equitably among the projects. The action zones for the PAA are shown in Figures 1 through 3.

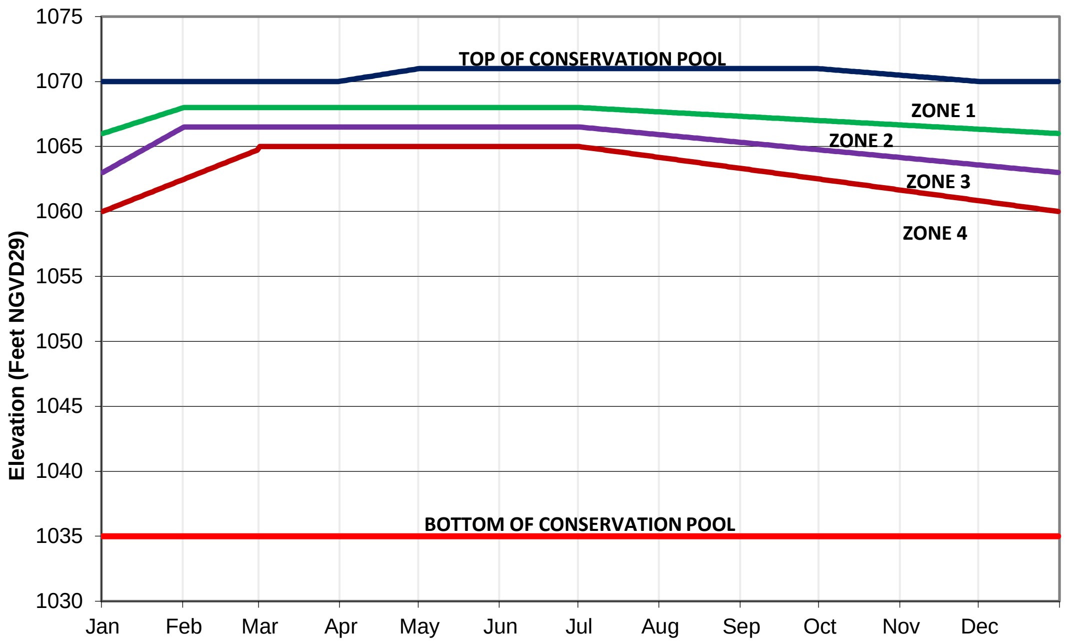


Figure 1. Lake Lanier Water Control Action Zones for the PAA

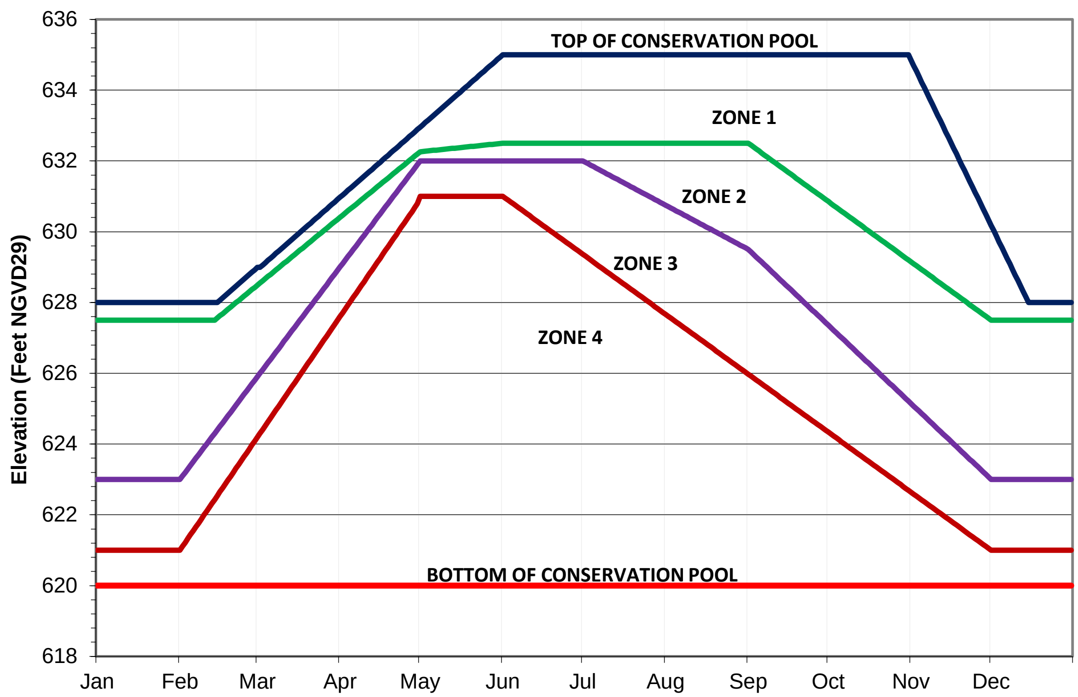


Figure 2. West Point Lake Water Control Action Zones for the PAA

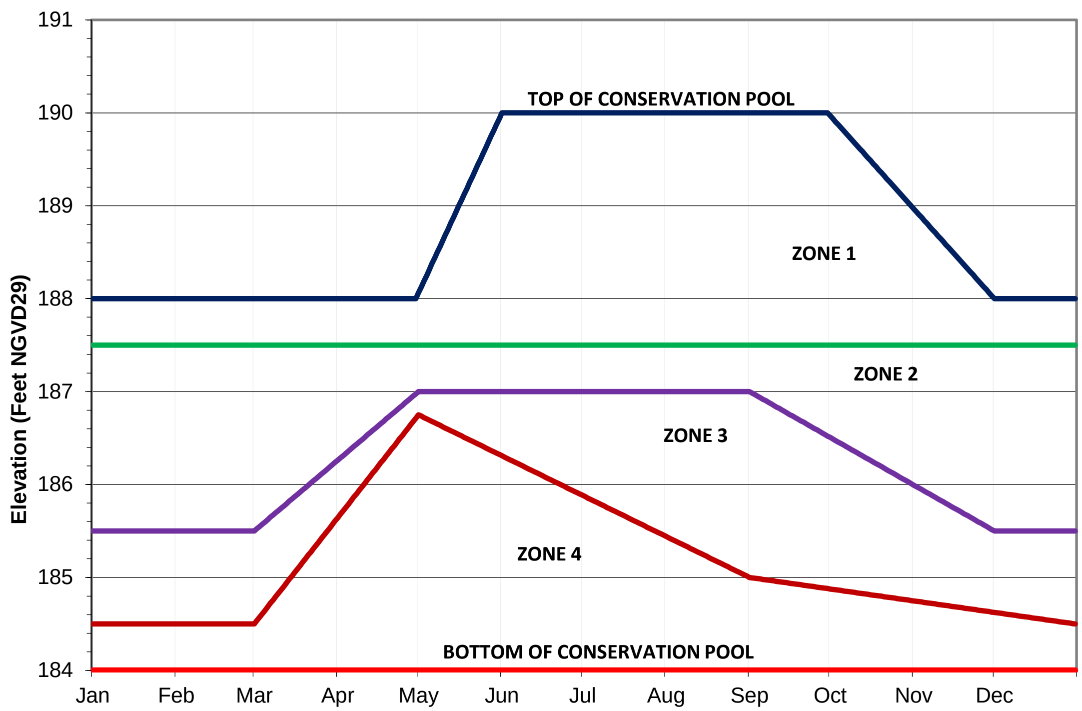


Figure 3. Walter F. George Lake Water Control Action Zones for the PAA

1.2.2 Fish and Wildlife Conservation

There is no single operation for fish and wildlife conservation, rather there are several related operations that are implemented in the PAA. West Point Dam is the only federal project in the ACF Basin with fish and wildlife conservation specifically included in its original congressional authorization. Nonetheless, the ACF Basin USACE reservoirs (i.e., Lanier, West Point, Walter F. George, Andrews, and Seminole lakes) operate to support fish and wildlife conservation pursuant to the authority in either the Fish and Wildlife Coordination Act or the Endangered Species Act. Generally, reservoir operations for fish and wildlife conservation consist of either maintaining pool elevations during fish spawns or making special releases to minimize the possibility of fish kills. Special drawdowns for specific environmental purposes may be specified from time to time, but only after coordination with state and federal resource agencies and others, as appropriate. Although the possibility of requiring water control actions may extend throughout a season, the actual actions are usually of short duration. In addition to fishery management, operations include aquatic plant control, waterfowl, and other terrestrial habitat management. The various projects in the basin have specific operations for fish and wildlife, which are described in the individual project WCMs. Specific fish and wildlife conservation activities on USACE ACF Basin projects are addressed in more detail in the following paragraphs.

Federally-Listed Species—Under the PAA, the USACE would continue to make releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows.

Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above in the Guide Curves and Action Zones section 1.2.1.

The USACE would manage releases from Jim Woodruff Dam to support the federally-protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. Daily releases to provide support for fish and wildlife conservation from Jim Woodruff Dam are dictated by two parameters: a minimum discharge (measured in cfs) and a maximum fall rate [measured in feet per day (ft/day)].

Minimum discharges from Jim Woodruff Dam would vary according to composite conservation storage, basin inflow per the 7-day moving average, and by month. Table 1 shows these minimum releases, which are measured as a daily average flow in cfs at the USGS gage at Chattahoochee, Florida. During normal and above normal hydrological conditions within the basin, releases greater than the minimum release provisions could occur consistent with the maximum fall rate schedule described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

During the spawning period (March to May), two sets of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in zones 1 and 2 or composite conservation storage in Zone 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included. The USACE would also operate Jim Woodruff Dam to avoid potential Gulf sturgeon take. Potential Gulf sturgeon take is defined as an 8-foot or greater drop in Apalachicola River stage over the last 14-day period (i.e., considering if today's stage is greater than 8 feet lower than the stage of any of the previous 14 days) when flows are less than 40,000 cfs.

During the non-spawning period (June to November), one set of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in zones 1 through 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included.

During the winter season (December to February), only one basin inflow threshold and corresponding minimum release (5,000 cfs) would exist while in composite conservation storage zones 1 through 4. That would provide the greatest opportunity to refill the storage reservoirs. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions.

When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations are triggered. Within Zone 4, the minimum flow is the same as in Zone 3. When the composite conservation storage drops further into the Drought Zone, the minimum flow from Jim Woodruff Dam is reduced to 4,500 cfs. A detailed description of the drought operations is provided in the Drought Operations section 1.2.3.

Table 1. Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge for Federally-Listed Species by Month and by Basin Inflow (BI) Rates

Months	Composite conservation storage zone	Basin inflow (BI)[a] (cfs)	Min. Releases from Jim Woodruff Lock and Dam[b] (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000 ≥ 16,000 and < 34,000 ≥ 5,000 and < 16,000 < 5,000	= 25,000 = 16,000+50% BI > 16,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>16,000
	Zone 3	≥ 39,000 ≥ 11,000 and < 39,000 ≥ 5,000 and < 11,000 < 5,000	= 25,000 = 11,000+50% BI > 11,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	≥ 22,000 ≥ 10,000 and < 22,000 ≥ 5,000 and < 10,000 < 5,000	= 16,000 = 10,000+50% BI > 10,000 = BI = 5,000	Up to 100% BI>16,000 Up to 50% BI>10,000
December–February	Zones 1, 2, and 3	≥ 5,000 < 5,000	= 5,000 = 5,000	Up to 100% BI > 5,000
If Drought Triggered	Zone 3	NA	= 5,000[d]	Up to 100% BI > 5,000
At all times	Zone 4	NA	= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	= 4,500[e]	Up to 100% BI > 4,500

Notes:

a. Basin inflow for composite conservation storage in zones 1, 2, and 3 is calculated using the 7-day moving average basin inflow. Basin inflow for composite conservation storage in drought operations, zones 3 and 4 or lower (Drought Zone) is calculated using the one-day basin inflow.

b. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

c. Drought plan is triggered when the composite conservation storage falls into Zone 3, the first day of each month represents a decision point.

d. Once drought operation triggered, reduce minimum flow to 5,000 cfs following the maximum ramp rate schedule.

e. Once composite storage falls below the top of the Extreme Drought Zone ramp down to a minimum release of 4,500 cfs at rate of 0.25 ft/day based on the USGS gage at Chattahoochee, Florida (02358000).

The federally-listed species operations of the PAA include a fall rate, also called down-ramping rate, defined as the vertical drop in river stage (water surface elevation) that occurs over a given period of time. The fall rates are expressed in units of ft/day measured at the USGS Chattahoochee, Florida, gage as the difference between the daily average river stage on consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The maximum fall rate schedule is provided in Table 2. When composite conservation storage falls into Zone 3, the drought operations plan would be implemented. A detailed discussion of fall rate management when the drought operations plan is implemented is provided in the Drought Operations section 1.2.3. Down-ramping rates are suspended during periods of prolonged low flow (flows less than 7,000 cfs for a period of more than 30 consecutive days). A prolonged low flow period would be considered over and down-ramping rates would be reinstated when flows are greater than 10,000 cfs for 30 consecutive days. When the maximum fall rate schedule is suspended due to prolonged low flow, down-ramping operations would be managed to match the one-day fall rate of the basin inflow. This prolonged low flow provision could occur under both normal and drought operations. Figure 4 provides an example of this scenario from the ResSim simulation of the PAA. In this example the simulated flows were less than 7,000 cfs for approximately 45 days before a storm system required an increase in releases. Once the storm event was complete the fall rates were managed to match the one day BI fall rate.

Table 2. Maximum Down-Ramping (Fall) Rate

Approximate release range (cfs)	Maximum fall rate (ft/day)	Maximum fall rate (cfs/day)
> 30,000 [a]	No ramping restriction [b]	
> 20,000 and ≤ 30,000 [a]	1.0 to 2.0	2,300 - 5,000
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [a]	0.5 to 1.0	1,060 – 2,300
Within Powerhouse Capacity and > 10,000 [a]	0.25 to 0.5	500 – 1,060
Within Powerhouse Capacity and ≤ 10,000 [a]	0.25 or less	220 - 500

Notes:

[a.] Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

[b.] For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control the down-ramping rate, and no ramping rate is required.

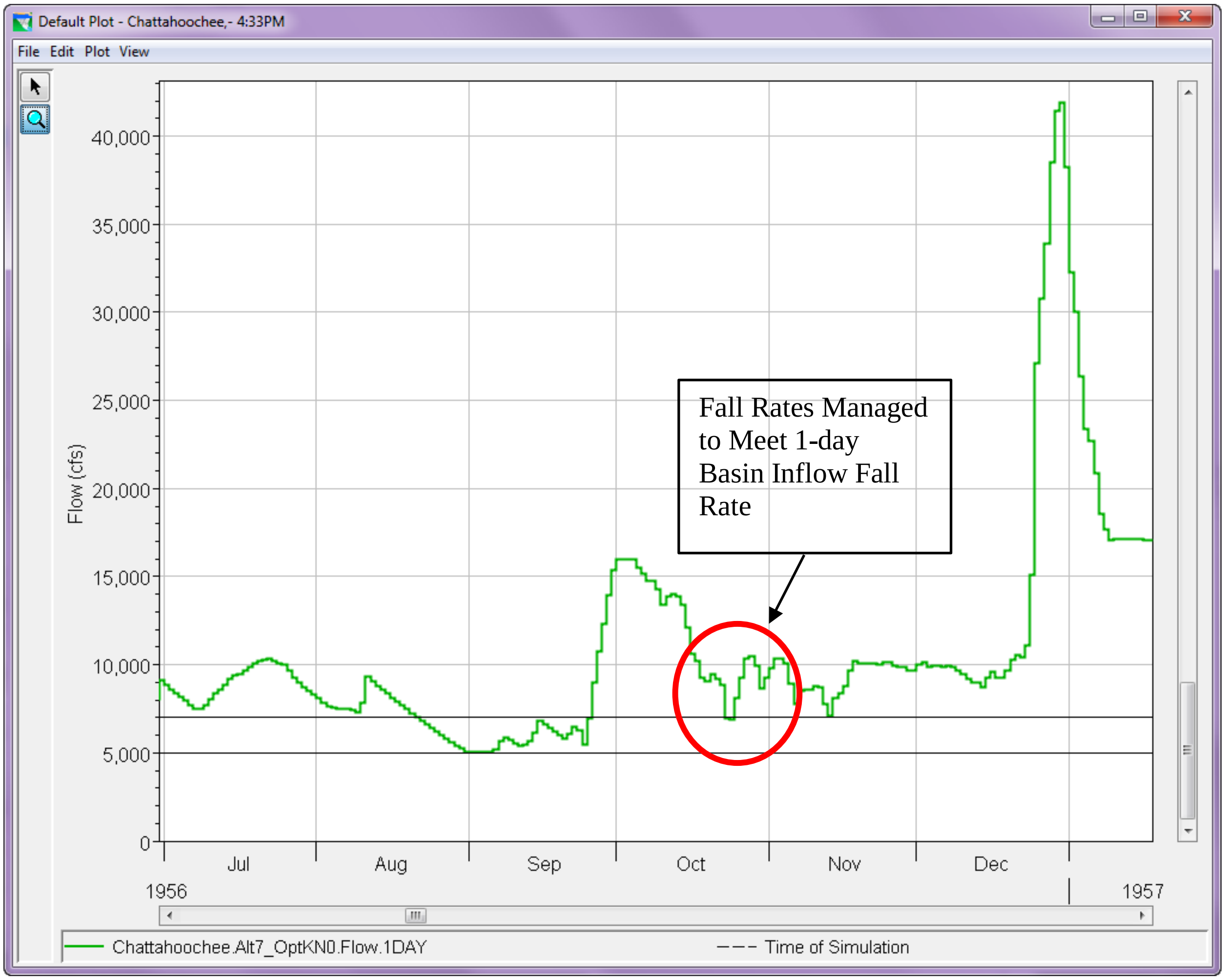


Figure 4. Example of Fall Rate Operations After Prolonged Low Flow

Reservoir Fish Spawning—USACE South Atlantic DR 1130-2-16 (March 30, 2001) and Mobile District Draft SOP 41 1130-2-9 (February 2005) were developed to address reservoir regulation and coordination for fish management purposes. South Atlantic DR 1130-2-16 has been updated and renumbered as South Atlantic DR PDS-O-1 (May 31, 2010), Project Operations, Lake Regulation and Coordination for Fish Management Purposes. It specifically applies to operations at Lake Lanier, West Point Lake, Walter F. George Lake, and Lake Seminole in the ACF Basin as well as other reservoirs in USACE South Atlantic Division. The draft Mobile District SOP (1) identifies designated periods of time within which operations to support fish spawning will be conducted at specific projects and on the Apalachicola River, (2) establishes protocols for coordination between the Service, state fisheries personnel, and USACE, and (3) provides for development of an annual plan for special water management operations by USACE (in coordination with the Service and state fisheries agencies) that would balance impacts and benefits to both reservoir and riverine fisheries during the spring spawning period. A major goal of the SOP is not to lower lake levels more than 6 inches in elevation during the principle fish spawning period to prevent stranding or exposing fish eggs. The protocols in these documents are consistent with the requirements for other project purposes and recognize that reservoir fish spawning operational goals may not be achieved during flood management operations or periods of extended drought.

Tailrace Dissolved Oxygen Levels—Reservoir stratification develops seasonally when surface water becomes warmer and less dense than deeper water, generally summer to late fall in the Southeast. This results in temperature-dependent density differences that prevent mixing and form isolated layers of water, each with their own distinct chemistry. Among the more common concerns is the depletion of oxygen in the deeper layers of lakes when stratified. Below the thermocline, dissolved oxygen is insufficient to support most aquatic life. When water is released from the lower regions of the reservoirs through hydroelectric power generation units and/or sluice gates during periods of reservoir stratification, low dissolved oxygen conditions may be experienced for a short distance downstream of dams, potentially causing stress in the tailrace fishery and occasional fish kills. While dissolved oxygen levels downstream of Buford Dam and West Point Dam are depressed at times as a result of hydroelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas as a result of low dissolved oxygen conditions. The Walter F. George Lock and Dam project has experienced recurring instances of stress in the tailrace fishery and occasional fish kills due to low dissolved oxygen. Accordingly, USACE has implemented a SOP, established in 1988 and updated in 1993, to address conditions at the Walter F. George project when low dissolved oxygen values are observed in the tailrace. The SOP calls for spillway gates to be opened in accordance with a specific protocol until dissolved oxygen readings return to an acceptable level. Spillage siphons have also been constructed on the dam that can be used in lieu of spillway gate discharges.

Fish Passage—In most years since the spring of 2005, USACE has operated the lock at Jim Woodruff Lock and Dam between March and May to facilitate downstream-to-upstream passage of Alabama shad (*Alosa alabamae*) and other anadromous fishes (those that return from the sea to the rivers where they were born to breed) in cooperation with pertinent state and federal agencies. In general, two fish locking cycles are performed each day between 0800–1600 hours, one in the morning and one in the afternoon. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change.

Management of Project Lands—The 11,184-acre Eufaula National Wildlife Refuge is operated by the Service in cooperation with USACE in the upper reaches of Walter F. George Lake within Barbour and Russell counties, Alabama, and Stewart and Quitman counties, Georgia. The refuge has an extensive system of pumps, dikes, and water control structures for water-level management in off-reservoir wetland areas. The refuge provides important habitat for migratory waterfowl and other birds, habitat for federally listed threatened and endangered species, and recreation and environmental education for the public. USACE manages much of the project land around its ACF reservoirs for the benefit of fish and wildlife resources, consistent with other project purposes. In some cases, project lands can be managed by state agencies (i.e., wildlife management areas or state parks) or local interests through leases. Additionally, GADNR operates a fish hatchery on the Chattahoochee River immediately below Buford Dam. USACE coordinates project operations with the fish hatchery staff.

1.2.3 Drought Operations

The drought plan included in the PAA would be triggered when the composite conservation storage falls below the bottom of Zone 2 into Zone 3 (Figure 5). The purpose for this modification is to facilitate a more proactive approach to drought management in order to better assure that storage is available to meet all project purposes throughout a prolonged drought period worse than has been realized to date. The drought plan specifies a minimum release from Jim Woodruff Dam and would temporarily suspend the normal minimum release and maximum fall rate provisions of the listed species operation (Table 1 and Table 2), until composite conservation storage in the basin could be replenished to a level that could support them (Zone 1).

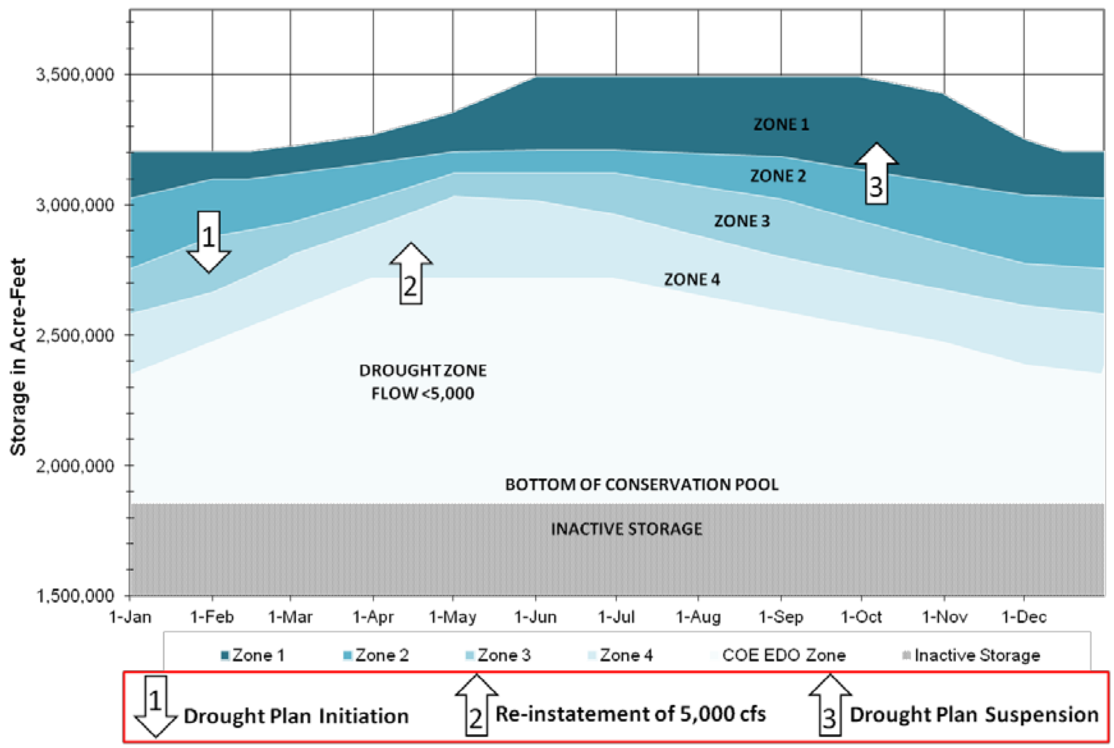


Figure 5. Composite Conservation Storage Zones and Drought Plan Triggers

Under the drought plan the minimum required release from Jim Woodruff Dam would be 5,000 cfs when the composite conservation storage is in zones 3 and 4. Under the drought plan, the maximum fall rate schedule is suspended. However, the suspension of the maximum fall rate schedule is delayed if releases from Jim Woodruff Dam have not yet reached the 5,000 cfs minimum flow when the drought plan is implemented. The purpose of maintaining the maximum fall rate schedule under these conditions is to facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that have not been recently dewatered. Figure 6 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on June 1, 2006 and the discharge from Jim Woodruff Dam is slowly reduced from 10,125 cfs to 5,050 cfs, over a 22 day period, according to the maximum fall rate schedule. In this example the 0.25 ft/day maximum fall rate provision is implemented when drought operations are triggered as the releases are less than 10,000 cfs.

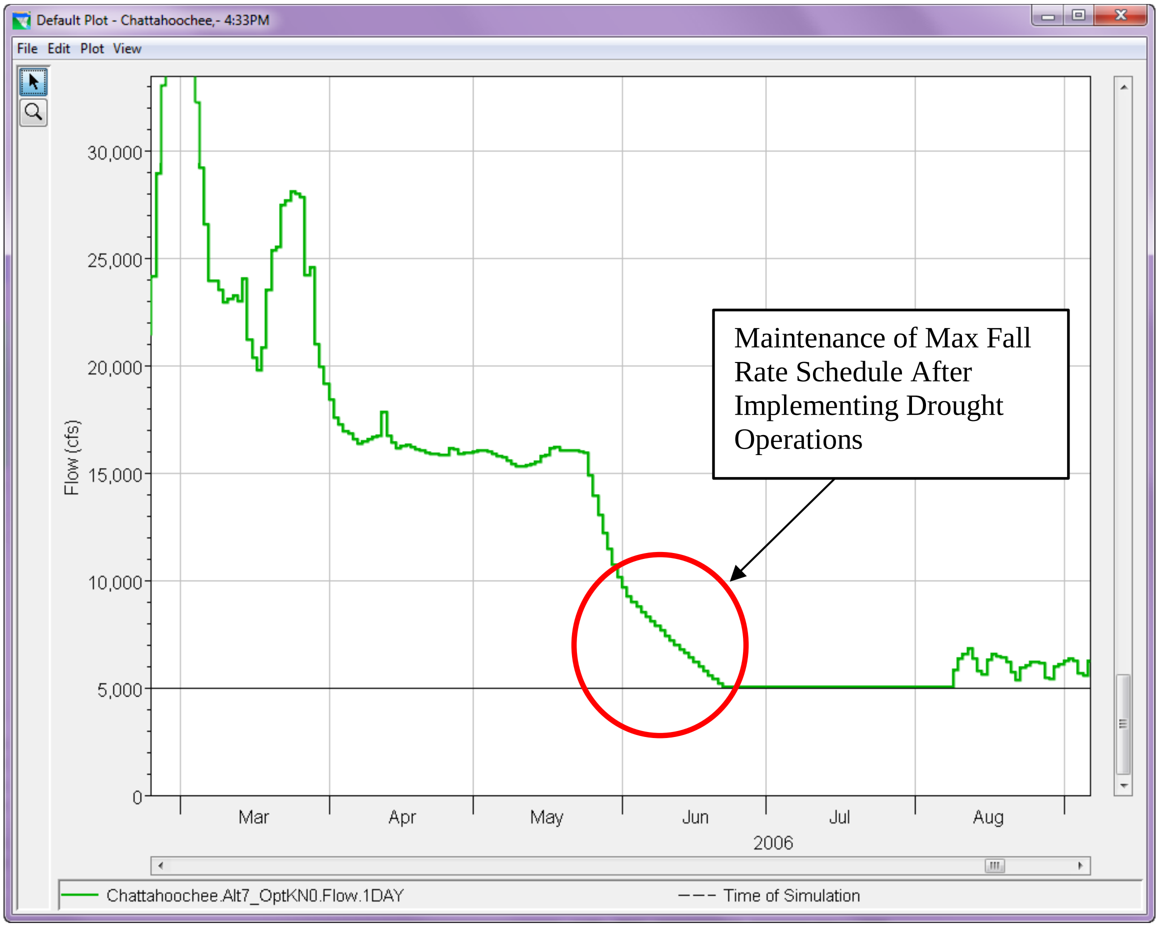


Figure 6. Example Down Ramping after Drought Operation Triggered

Occasionally uncontrolled high flow from the Flint River (resulting from a rainfall event) or hydropower releases from Walter F. George Dam could cause a temporary increase in Jim Woodruff Dam discharge as down ramping to 5,000 cfs occurs during the drought operation. In this case the Jim Woodruff Dam release ramps down using two ramping rates. The peak discharge would ramp down according to the one day basin inflow fall rate until the discharge prior to the temporary increase occurs. At that time, the releases would again be managed according to the maximum fall rate schedule until the minimum flow of 5,000 cfs occurs.

Figure 7 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on March 1, 2016 and releases from Jim Woodruff Dam are reduced according to the maximum fall rate schedule from 12,100 cfs to 8,490 cfs over an eight day period. At this time, conditions in the basin result in an increased release from Jim Woodruff Dam until a peak value of 21,750 cfs is reached on March 26, 2016. As releases are decreased following the peak, fall rates are managed according to the one day basin inflow fall rate until the release reaches 8,490 cfs. Because releases less than 8,490 cfs had not occurred prior to the temporary increase in river flow, on May 13, 2016 the maximum fall rate schedule resumes. In this example another temporary discharge increase occurs on May 16, 2016 and the maximum fall rate schedule resumes on May 21, 2016. Implementing the two phase down ramping allows USACE to conserve storage when reducing releases following a temporary increase in river flow and still facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that had not previously occurred. The temporary increases in river flow during the down ramping period are not of sufficient duration to allow mussels to recolonize habitats that were recently dewatered.

Figure 7. Example of Two Phase Down Ramping After Drought Operation Triggered

The drought plan would also include the option for a temporary waiver from the water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects to provide additional conservation storage for future needs, if conditions in the basin dictate the need for such action.

The drought plan of the PAA prescribes two minimum releases on the basis of composite conservation storage. One minimum release while in zones 3 and 4 and an additional minimum release while in the Drought Zone. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in Lake Lanier, West Point Lake, and Walter F. George Lake, plus Zone 4 storage in Lake Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within zones 3 and 4, but above the Drought Zone, the minimum release from Jim Woodruff Dam would be 5,000 cubic feet per second (cfs) and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam would be 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning for the first time from a minimum release of 5,000 to 4,500 cfs, fall rates would be limited to a maximum of 0.25 ft/day drop. Should conditions result in releases greater than 4,500 cfs while the composite conservation storage is still in the Drought Zone, fall rates will be determined by a computation based on the one-day basin inflow fall rate. The 4,500 cfs minimum release would be maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release would be immediately reinstated. The drought plan provisions would remain in place until conditions improve such that the composite conservation storage reaches Zone 1. At that time, the temporary drought plan provisions would be suspended and all the other provisions of the basin water control plan would be reinstated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) would be implemented to determine which operational triggers are applied. It was determined monthly decision points would be the minimum interval to effectively manage drought operations. A more frequent decision point would not allow assurance that a weather-based hydrologic trend was establishing and could result in short isolated periods of rain causing premature exit of drought operations during a prolonged drought.

In the event the composite conservation storage has not recovered to Zone 1 by 1 February, drought operations would be extended to the end of March, unless all the federal reservoirs are full. This provision is intended to ensure full recovery prior to implementing the higher minimum flow provisions in place during normal operations in the sturgeon spawning season. Because of high rainfall amounts, the month of March is typically characterized by higher flow and is critical to reservoir refill. Figure 8 is an example from the ResSim modeling of the PAA of continuing the drought operation through the month of March. In this example, the composite conservation storage enters Zone 1 on February 5, 1982, but drought operation is not suspended until April 1, 1982.

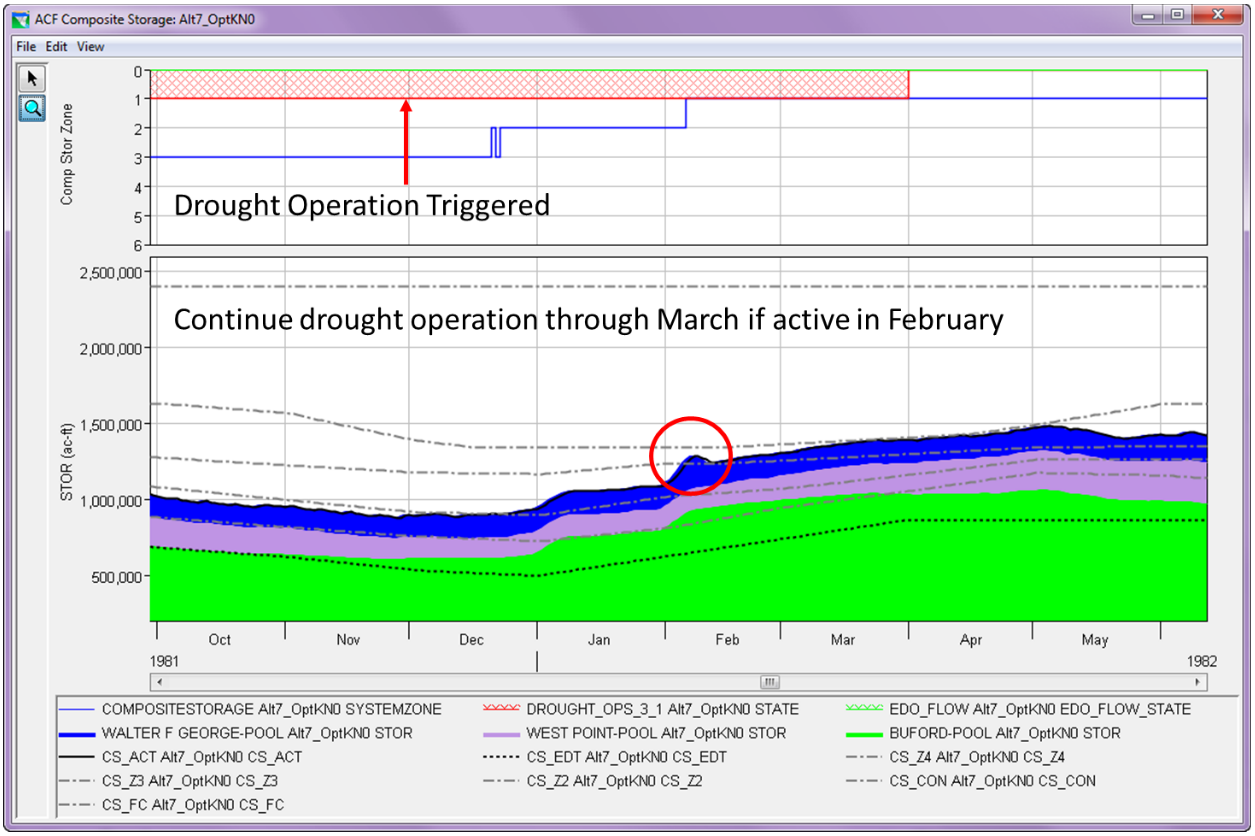


Figure 8. Drought Operation Continued Through Month of March

1.2.3.1 Extreme Drought Operations

When the remaining composite conservation storage is about 10 percent of the total capacity, additional emergency actions might be necessary. When conditions have worsened to that extent, use of the inactive storage must be considered. For example, such an occurrence could be contemplated in the second or third year of a drought. Inactive storage zones have been designated for the three federal projects with significant storage (Figure 9). Table 3 shows the inactive storage capacity within each inactive storage zone for each project. The use of inactive storage during extreme drought conditions would be based on the following actions:

(1) Inactive storage availability would be identified to meet specific critical water use needs within existing project authorizations.

(2) Emergency uses would be identified in accordance with emergency authorizations and through stakeholder coordination including emergency consultation under Section 7 of the ESA. Typical critical water use needs within the basin are associated with public health and safety.

(3) Weekly projections of the inactive storage water availability to meet the critical water uses from Buford Dam downstream to the Apalachicola River would be used when making water control decisions regarding withdrawals and water releases from the USACE reservoirs.

(4) The inactive storage action zones would be instituted as triggers to meet the identified priority water uses (releases will be restricted as storage decreases). Figure 9 lists the typical critical water uses for each inactive storage zone.

(5) Dam safety considerations would always remain the highest priority. The structural integrity of the dams due to static head limitations (Jim Woodruff, 38.5 feet; George W. Andrews, 26 feet; Walter F. George, 88 feet) would be maintained.

- **Zone 1A**
  - Water Supply
  - Water Quality
  - Endangered Species
- **Zone 2A**
  - Water Supply
  - Water Quality
- **Zone 3A**
  - Water Supply

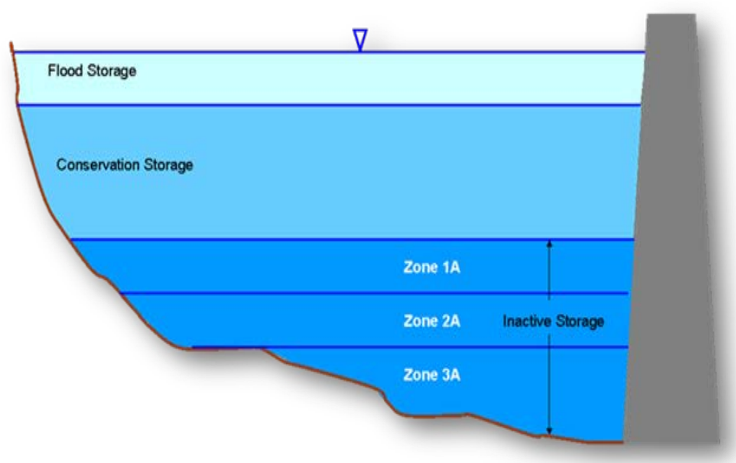


Figure 9. Inactive Storage Zones and Typical Water Use Needs

Table 3. Reservoir Inactive Storage Zone Capacities (ac-ft)

Project	Zone 1A	Zone 2A	Zone 3A	Unusable Inactive
Buford Dam	532,078	234,699	100,823	0
West Point Dam	53,620	138,331	33,344	73,101
Walter F. George Dam	314,799	178,501	0	196,700
Total	901,589	554,345	134,869	266,062

1.2.4 Flood Risk Management

When developing the PAA, flood risk management capabilities and capacities of reservoirs were not reduced. The objective of flood risk management operations (formerly referred to as flood control) is to impound excess flows, thereby reducing downstream river levels below flood stage. Whenever flood conditions occur, operation for flood risk management takes precedence over all other project functions. Only Buford and West Point dams have storage allocated for flood risk management operations. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower peak stages throughout the reservoir during major floods. George W. Andrews and Jim Woodruff lock and dams operate to pass inflows.

The timing of flood peaks in the ACF Basin is of considerable importance in determining the effectiveness of reservoir operations for flood risk management and the degree to which such operations can be coordinated. During a flood event, excess water above the guide curve is evacuated (released) consistent with other project needs as soon as downstream waters have receded enough that releases from the reservoirs will not increase the natural maximum flood heights downstream. This timely evacuation is necessary so that consecutive flood events will not cause floodwaters to exceed allocated storage capacities and endanger the integrity of the dam. Both turbines and spillways are used, as necessary, to evacuate floodwaters.

Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power generation demands are lower, the guide curve operation generally reflects this situation by specifying a lower elevation during this time period. Transitions between the seasonal levels are gradual to moderate increases or decreases in outflow. By drawing down the pool in late fall, either specifically for flood risk management as at the West Point Dam project or coincidentally for other purposes, additional storage is gained for containing floodwaters.

For flood risk management purposes, releases are reduced or terminated at Buford Dam, except for the small hydropower unit, as soon as it appears that downstream river stages will exceed flood stage. Key gaging stations in the vicinity are closely monitored to determine when floodwaters have begun to recede so that flood storage in the reservoir can be expeditiously evacuated in a manner consistent with other project functions without exacerbating downstream flooding.

In conclusion, no flood action zones have been defined for flood risk management storage at the Buford Dam project. Evacuation of the flood risk management pool at that project occurs only by way of releases through the tubines and the sluice gate at the bottom of the reservoir until the pool elevation reaches 1,085 ft, at which point flood waters also would begin to flow over the fixed crest emergency spillway.

The prime objective of flood risk management operations at the West Point Dam project is to reduce peak flows at West Point, Georgia, based on the downstream U.S. Geological Survey (USGS) Chattahoochee

River at West Point, Georgia, gage (# 02339500). This objective is met by regulating releases to maintain the USGS West Point, Georgia, gage within the nondamaging bankfull flow of 40,000 cfs until the induced surcharge schedule calls for greater release. The flood risk management pool at the West Point Dam project is designed to reduce the flood wave from small and moderate-sized floods. It does not have enough storage capacity to provide beneficial flood damage reduction for large flood events. During the early stages of a flood event, the outflow from West Point Dam is planned to control, or limit, the peak outflow as the flood develops. The basic plan for flood risk management is defined by three flood action zones (A, B, and C) within the flood risk management storage of the pool similar to manner in which conservation storage is defined by action zones to guide operations. The flood action zones are used to evacuate stored floodwater in a timely manner, either through the turbine units or the tainter gates, while allowing flexible scheduling for hydropower production. Detailed descriptions of the water management instructions within each flood zone are provided in the West Point Dam and Lake Water Control Manual.

The Walter F. George Dam operate according to specified flood risk management plans, as outlined in their WCM. Spillway gates are opened if necessary to assist the turbines in passing these flows.

Even though the traditional flood season spans several months, discrete incidences of flooding should have insignificant long-duration effects if pool elevations are maintained close to guide curve elevations. No pool is allowed to remain above its guide curve for any appreciable length of time without prior approval of a temporary deviation or variance by USACE, South Atlantic Division.

1.2.5 Hydroelectric Power Generation

The PAA includes the current hydroelectric power generation operations at West Point Dam, Walter F. George Dam, and Jim Woodruff Dam which call for a more flexible generation schedule in all action zones under non-drought conditions and a more constrained generation schedule under drier conditions. The Buford, West Point, and Walter F. George projects are operated as peaking plants, and provide electricity during the peak demand periods of each day and week. Hydroelectric power peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines. Typically, the Buford, West Point, and Walter F. George projects provide generation five days a week at plant capacity throughout the year, as long as their respective lake levels are above Zone 4 and drought operations have not been triggered. For example, demand for peak hydroelectric power at Buford Dam typically occurs on weekdays from 5:00 a.m. to 9:00 a.m. Central time and from 3:00 p.m. to 10:00 p.m. between 1 October and 31 March, and on weekdays from 1:00 p.m. to 7:00 p.m. between 1 April and 30 September. The typical hours represent releases that normally meet water system demands and provide the capacity specified in power marketing arrangements. During dry periods, generation could be eliminated or limited to conjunctive releases. Typical, but not required, hours of operation by action zone are depicted in Table 4.

Table 4. Typical hours of peaking hydroelectric power generation by federal project

Action zone	Buford Dam (hours of operation) normal ops/drought ops	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	3/2	4	4
Zone 2	2/1	2	2
Zone 3	2/1	2	2

Action zone	**Buford Dam (hours of operation)** **normal ops/drought ops**	**West Point Dam (hours of operation)**	**Walter F. George Dam (hours of operation)**
Zone 4*	0	0	0

*While hydropower would still be generated in Zone 4, it could not be generated on a regular peaking schedule under severe drought conditions

1.2.6 Navigation

When supported by ACF Basin hydrologic conditions, the PAA would provide a reliable navigation season. The water management objective for navigation is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). Figure 10 graphically represents the navigation season and its relationship to composite conservation storage. During the navigation season, the flows at the USGS gage at Blountstown, Florida, should be adequate to provide a minimum channel depth of 7 feet. The most recent channel survey and discharge-stage rating were used to determine the flow required to sustain a minimum navigation depth during the navigation season. Flows of 16,200 cfs provide a channel depth of 7 feet. Flows of 20,600 cfs provide a channel depth of 9 feet. USACE's capacity to support a navigation season would be dependent on actual and projected system-wide conditions in the ACF Basin before and during January, February, March, April, and May. Those conditions include the following:

- A navigation season can be supported only when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
- A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Navigation support will resume when the basin composite conservation storage level recovers to Zone 1.
- A navigation season will not be supported when drought operations are in effect. Navigation will not be supported until the ACF Basin composite conservation storage recovers to Zone 1.
- The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrologic conditions, meteorological forecasts, and basin-wide model forecasts. On the basis of an analysis of those factors, USACE will determine if the navigation season will continue through part or all of May.
- Down-ramping of flow releases will adhere to the Jim Woodruff Dam fall rate schedule (see Table 2) for federally listed threatened and endangered species during the navigation season.
- Releases that augment the flows to provide a minimum 7-foot navigation depth will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, because of diminishing inflows, downstream flows and depths must be reduced, notices would be issued to project users to give barge owners and other waterway users sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Lock and Dam to reduce releases.

Although special releases would not be standard practice, they could occur for a short duration to assist navigation during the navigation season. For instance, releases can be requested to achieve up to a 9-foot channel. Special releases could also occur outside of the navigation season. However, USACE would evaluate such request on a case-by-case basis, subject to applicable laws and regulations and the conditions above.

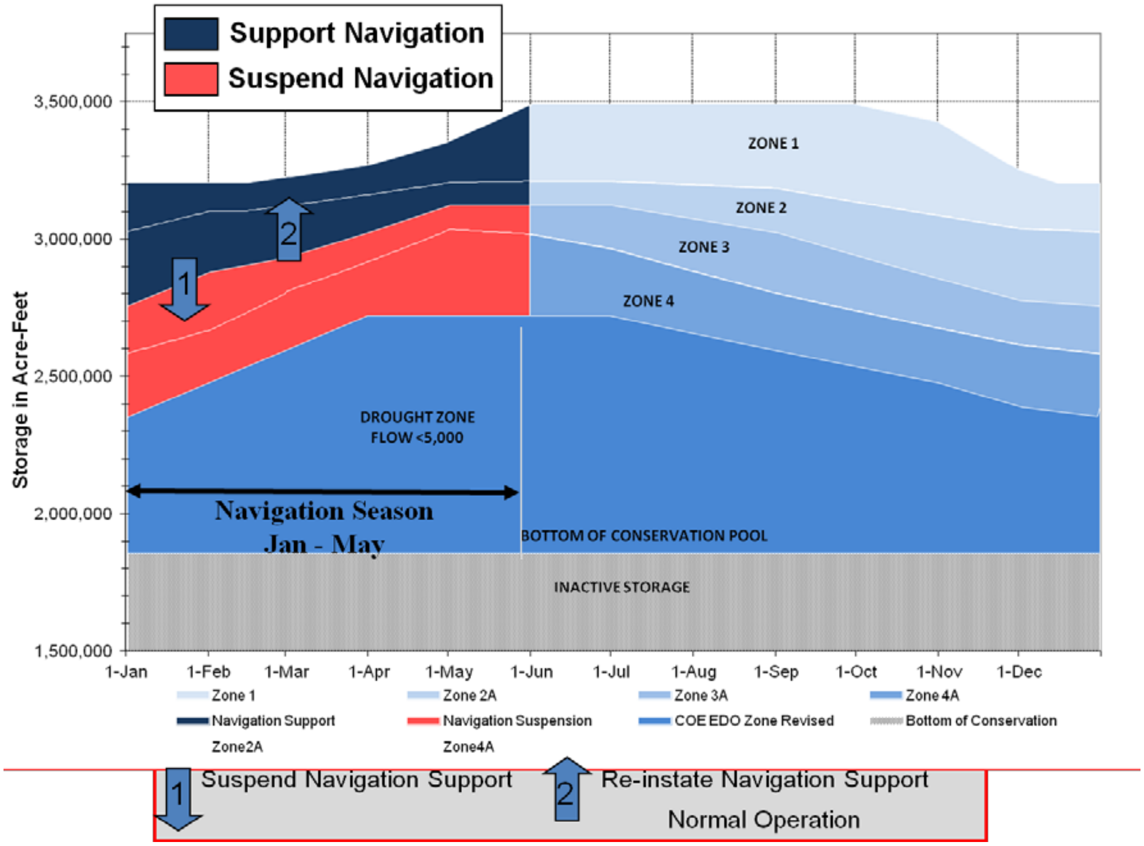


Figure 10. Composite Conservation Storage for Navigation

1.2.7 Recreation

Under the PAA, operations for recreation would remain the same as current operations. Recreation benefits would be maximized at the lakes to the extent possible consistent with meeting other project purposes by maintaining full or nearly full pools during the primary recreation season which are the warm summer months. In response to meeting other authorized project purposes, lake levels could decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 5). Recreational impact levels are not applicable to the George W. Andrews project due to the lack of conservation storage and the run-of-river operation at the project.

When pool levels must be lowered, the rates at which the draw-downs occur are as steady as possible. The action zones at Lake Lanier and West Point Lake are drawn down to correlate the line between Zone 2 and Zone 3 near the IIL at the beginning of the recreation season (May through early September). This is an attempt to maximize the time these projects are above the IIL during the recreation season.

Table 5. Recreation Impact Levels for federal projects in the ACF Basin

Project	IIL[a]	RIL[b]	WAL[c]
Lake Lanier	1,066 ft	1,063 ft	1,060 ft
West Point Lake	632.5 ft	629 ft	627 ft
Walter F. George	187 ft	185 ft	184 ft

Notes:
[a.] Initial Impact Level
[b.] Recreation Impact Level
[c.] Water Access Limited Level

1.2.8 Water Quality

Under the PAA, Buford, West Point, and Jim Woodruff dams would provide continuous minimum flow releases that would benefit the water quality immediately downstream of the dams. There would be no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen concentrations are observed below the dam, spillway gates would be opened until the dissolved oxygen concentrations return to an acceptable level. Occasional special releases would also be made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam.

At Buford Dam, the small turbine generator would run continuously to provide a minimum flow from the dam, which would range from approximately 500 to 700 cfs, depending on head conditions. This minimum flow from Buford Dam would help meet the seasonal minimum flow requirements of 650 cfs and 750 cfs at Atlanta, Georgia, in the Chattahoochee River just upstream of the confluence with Peachtree Creek. At West Point Dam, the minimum flow requirement is 670 cfs and a similar small generating unit would provide a continuous release of approximately 675 cfs. A varying minimum flow from 4,500 to 25,000 cfs, dependent upon basin conditions, would be maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which would assure an adequate water supply for downstream industrial use and water quality. Walter F. George Dam has two siphons on each spillway gate. The siphon discharge could range from about 15 cfs up to 200 cfs when all 12 are in use. Typically, the siphon tubes would be opened continuously from May through the end of September and all would be used at full capacity. The siphons would provide a gravity-fed, typically continuous, minimum flow that would benefit dissolved oxygen levels below the dam.

1.2.9 Water Supply

Under the PAA, the cities of Gainesville and Buford would continue to withdraw water directly from Lake Lanier under relocation agreements at rates not exceeding 8 mgd (net) and 2 mgd, respectively. Additionally, pursuant to the Water Supply Act of 1958, the PAA would reallocate 252,950 acre-feet in Lake Lanier for water supply. The amount of storage is estimated to yield 222 mgd during the critical drought (i.e., during the worst drought on record at the time the agreement was executed). The severity and frequency of droughts change over time, therefore, the yield of this storage may change over time. For the purpose of managing water supply storage, USACE would employ a storage accounting methodology that applies a proportion of inflows and losses, as well as direct withdrawals by specific users, to each account. The amount of water that may actually be withdrawn is ultimately dependent on the amount of water available in the storage account, which will naturally change over time.

Under the PAA releases from Buford Dam would be made to accommodate downstream water demands. Peaking hydroelectric power generation generally accommodates most water supply needs of communities currently withdrawing from the Chattahoochee River; however, under the 1946 Rivers and Harbors Act, generation can occur at non-peaking times to meet the downstream water supply needs, not to exceed 379 mgd. Figure 11 illustrates the current lake and river withdrawals occurring in the Metro Atlanta.

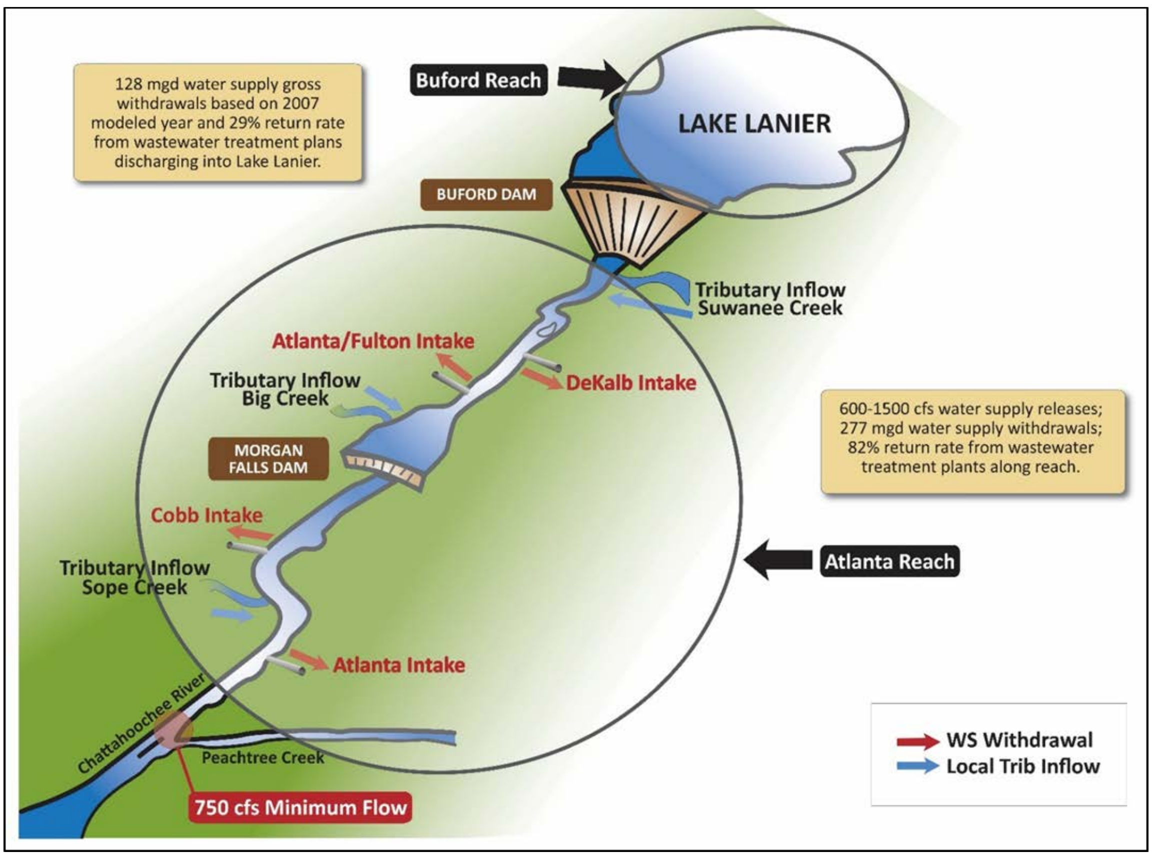


Figure 11. Illustration of Metro-Atlanta Water Supply Withdrawals

1.3 ALTERNATIVES CONSIDERED

The proposed action and alternatives identified in the DEIS make up a portion of the alternatives to the PAA that were considered. They are incorporated by reference. In addition to the alternatives described in the DEIS, the USACE also evaluated six new alternatives. The new alternatives consist of the No Action Alternative (NAA) or PAA water management operations combined with five new water supply options. The new water supply options are based on comments received for the DEIS and the State of Georgia 2015 revised water supply request. None of the new alternatives include the two non-federal water supply reservoirs (Glades Reservoir and Bear Creek Reservoir) considered in the DEIS. Both of the permit applications for these reservoirs have been withdrawn/suspended. Table 6 describes the six new alternatives considered (1L, 7I, 7J, 7K, 7L, and 7M), as well as alternatives previously described in the DEIS [NAA (1A), 7A, 7B, and the proposed action from the DEIS (7H)]. The PAA evaluated in this document is Alternative 7K (Alt7K).

Table 6. New Alternatives Considered Since Publication of the DEIS in October 2015

Water Management Measures											
		1A	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**
Guide Curves	Maintain existing guide curve	X	X	X	X	X	X	X	X	X	X
Action Zones	Maintain existing action zones	X	X								
	Revised Level 1 action zones			X	X	X	X	X	X	X	X
Drought Operations	Drought operations trigger *	Zone 4	Zone 4	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3
	Extreme drought operations	X	X	X	X	X	X	X	X	X	X
	Drought operations suspension trigger *	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1
Peachtree Creek Minimum Flows	Current (750 cfs)	X	X								
	Seasonal flow (750 cfs / 650 cfs)			X	X	X	X	X	X	X	X
Hydropower Generation	Current generation schedule	X	X								
	Modified generation schedule with drought operations			X	X	X	X	X	X	X	X
Navigation	Current-no navigation operations	X	X								
	4/5 Month			X	X	X	X	X	X	X	X
Basin Inflow	Current computational method	X	X	X	X	X	X	X	X	X	X
Fish and Wildlife	Current fish spawn and passage	X	X	X	X	X	X	X	X	X	X

Water Management Measures			**1A**	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**
Listed Species Management	RIOP May 2012		X	X								
	Ramping Rate	Current ramping rate**	X	X	X	X	X	X	X	X	X	X
		Suspend during prolonged low flow			X	X	X	X	X	X	X	X
		Suspend in drought*	X	X	X	X	X	X	X	X	X	X
	Current (seasonal) minimum flow provision**		X	X	X	X	X	X	X	X	X	X
Water Supply Options***	A – No action		L=128 D=277		L=128 D=277							
	B - Relocation contracts only (in Lake Lanier)					L=20 D=277						
	H – GA 2013 (projected return volume for 2035 with Glades Reservoir pumping)						L=185 G=40 D=408					
	I – 225 mgd lake withdrawal, GA 2015 Request Downstream							L=225 D=379				
	J – Future Without Project Condition-Revised								L=20 D=379			
	K – GA 2015 Request									L=242 D=379		
	L – Current lake withdrawals, GA 2015 Request Downstream			L=128 D=379							L=128 D=379	
	M – Option H for Lanier w/o Glades, GA 2015 Request Downstream											L=205 D=379

Notes:* Based upon composite conservation storage zones (cumulative conservation storage [by zone] for USACE ACF reservoirs [Lanier, West Point, and Walter F. George]).
**Component of the May 2012 RIOP.
***Numbers indicate withdrawals in mgd from Lake Lanier (L), Glades Reservoir (G), and the Chattahoochee River downstream (D) of Buford Dam.

2 ENVIRONMENTAL IMPACTS OF ALTERNATIVE 7K (PAA FOR FEIS) COMPARED TO ALTERNATIVE 7H (PAA FOR DEIS)

As discussed previously, the PAA has changed little from that of the DEIS. As a result, there were generally few measurable differences from the PAA, Alt7K, with the DEIS PAA, Alt7H. Changes from the DEIS PAA and Alt7H presented here include utilization of the latest version of HEC-ResSim, an updated Area Capacity Curve for Lake Lanier, and updates to the HEC-5Q based on comments received on the DEIS.

The results from the DEIS PAA, Alt7H, are presented along with the FEIS PAA, Alt7K, in the following discussion.

2.1 HEC-5Q Water Quality Model Output Analyses

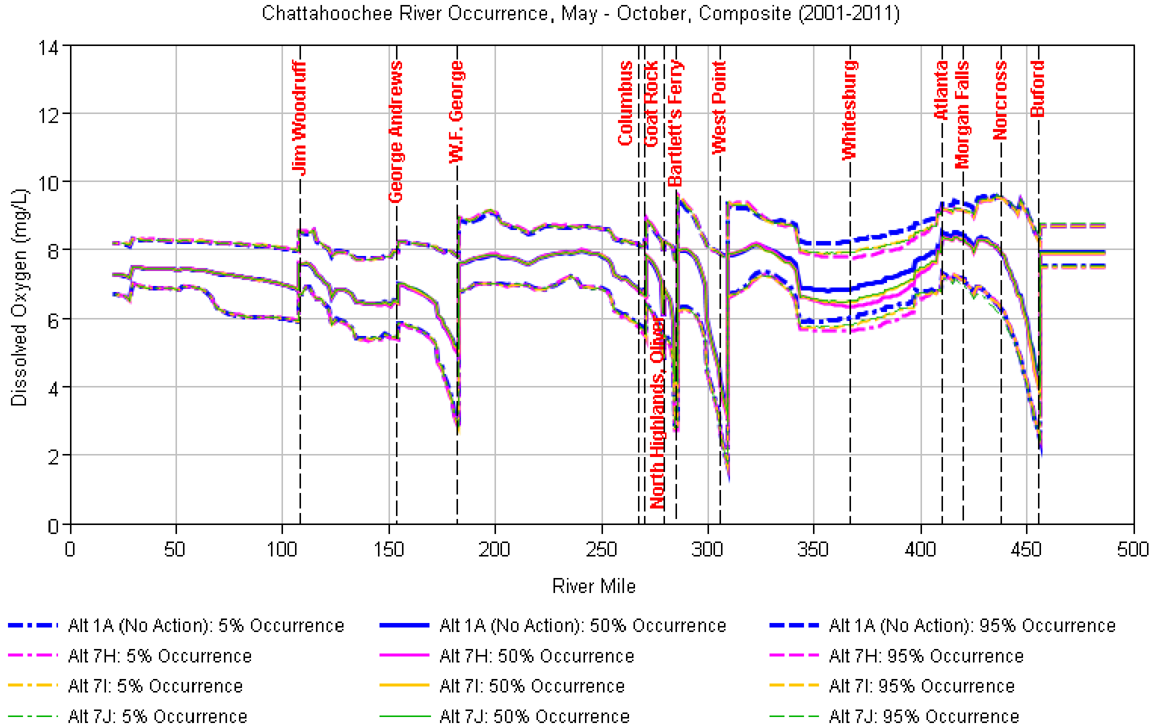
2.1.1 Dissolved Oxygen

a. Total number of days with DO below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters.

   There was no change from the DEIS and 2015 PAL response. Figures 12 and 13 present two plots illustrating Alt7H in the top figure and Alt7K in the bottom figure. These figures present variations of DO modeled along the Chattahoochee River. The figures do not explicitly define the number of days when concentrations are less than state standards (6 mg/L for secondary trout waters and 5 mg/L) but they do provide insight to where low DO concentrations occur for the period from May through October.

   Figures 14 through 19 present DO occurrence plots at Norcross, Georgia and Morgan Falls Dam. These locations are within the secondary trout waters and the figures illustrate the range of DO that would be expected in the PAA. Similar to Figures 12 and 13, two plots are presented to illustrate Alt7H and Alt7K, the PAA. Comparing DO in these occurrence plots illustrates that the lowest concentrations of the PAA would be expect to remain higher than the lowest concentrations of Alt7H.

   Figures 18 through 25 illustrate occurrences of DO at locations where, based on Figure 12 and Figure 13, median concentrations are less than state standards. These locations are downstream of Buford, West Point, Bartletts Ferry, and Walter F. George dams. Again, two plots are presented for each figure to illustrate Alt7H and the PAA, Alt7K.



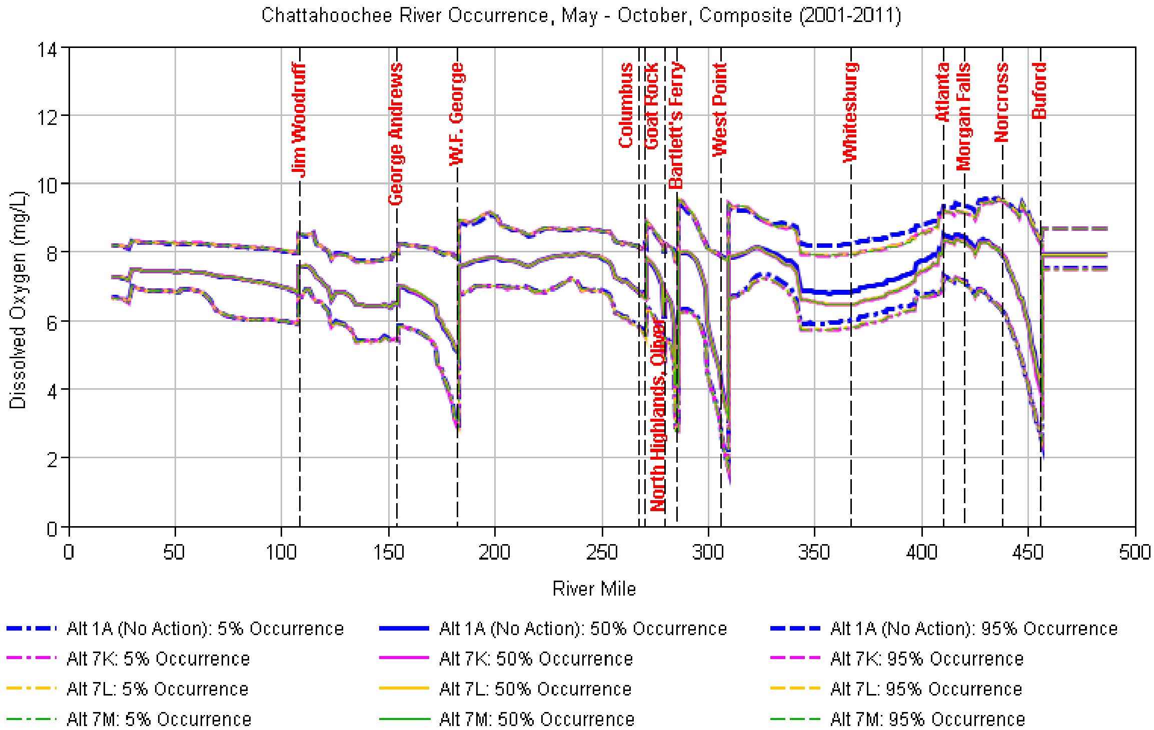
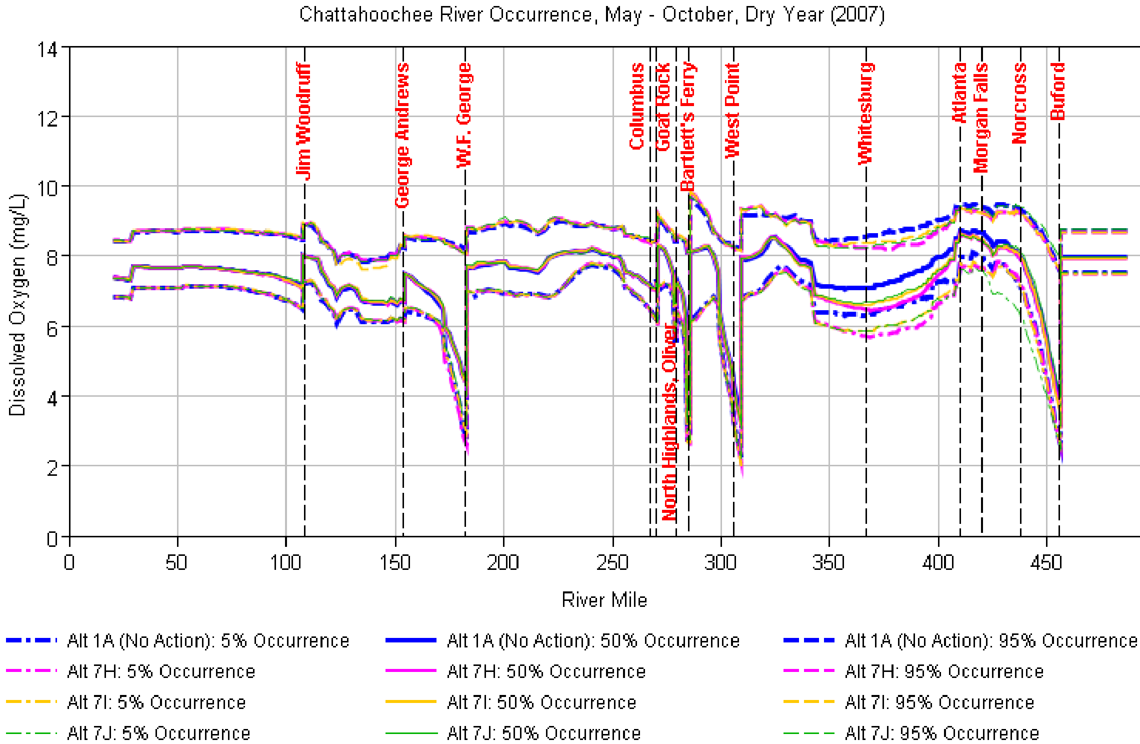


Figure 12. May through October DO for the modeled period from 2001 through 2011.



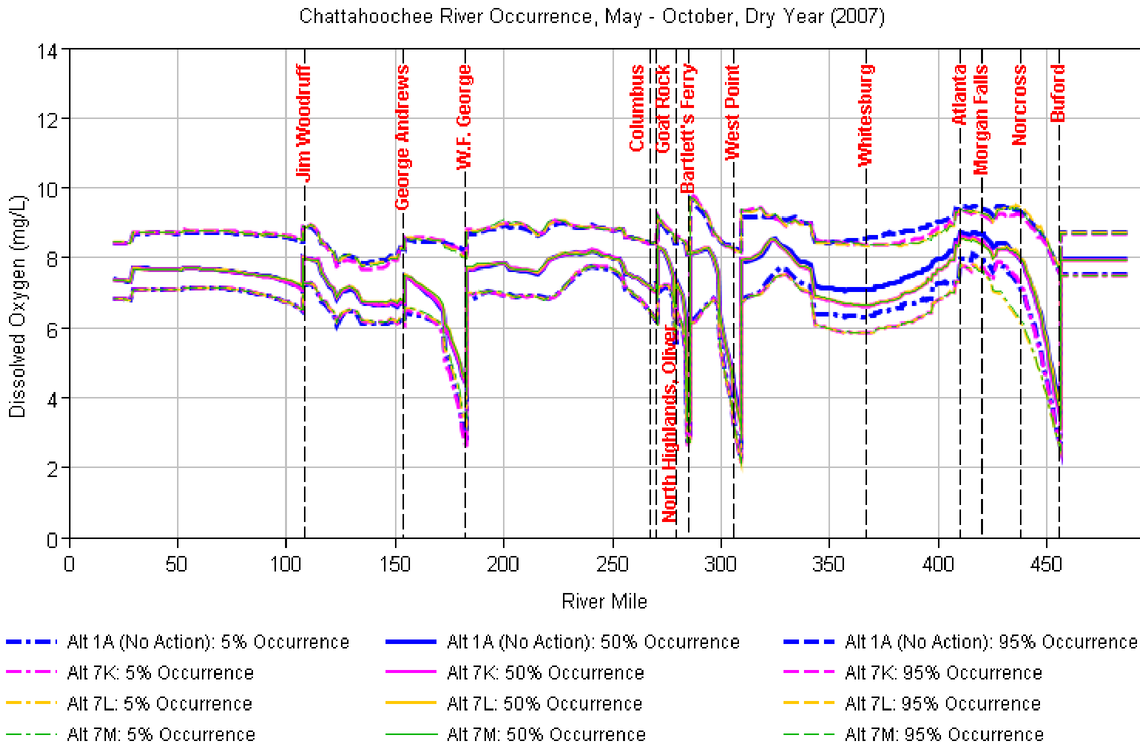
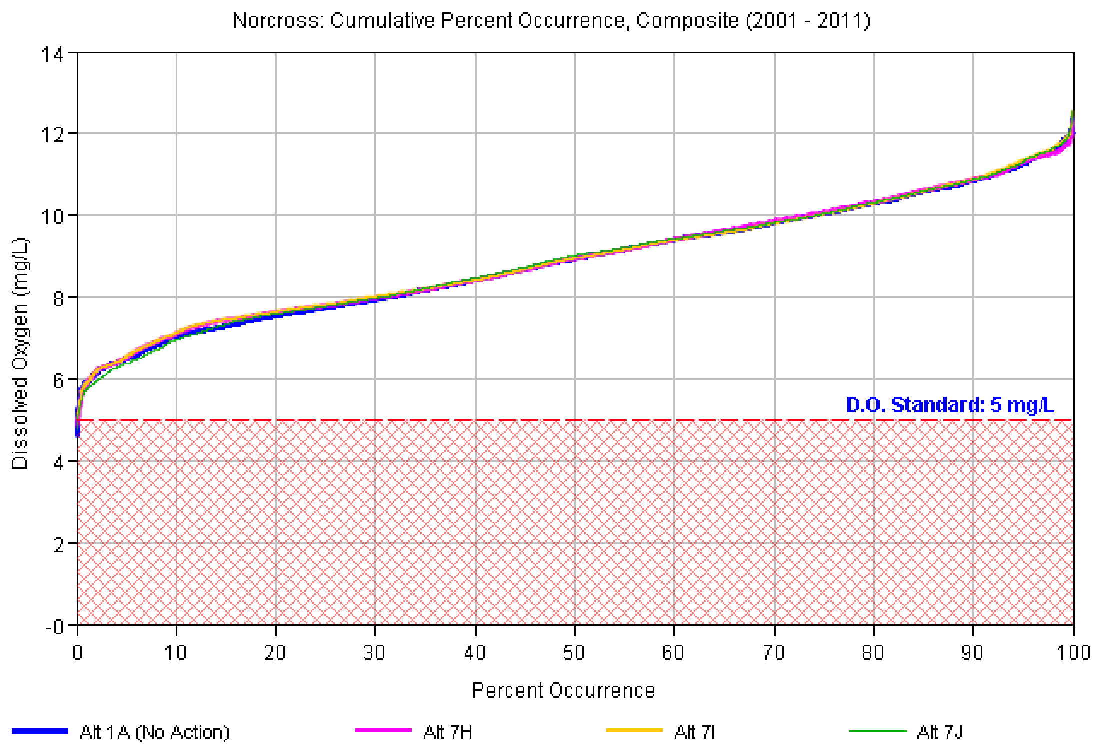


Figure 13. May through October DO modeled for a representative dry period (2007) when low concentrations would be expected.



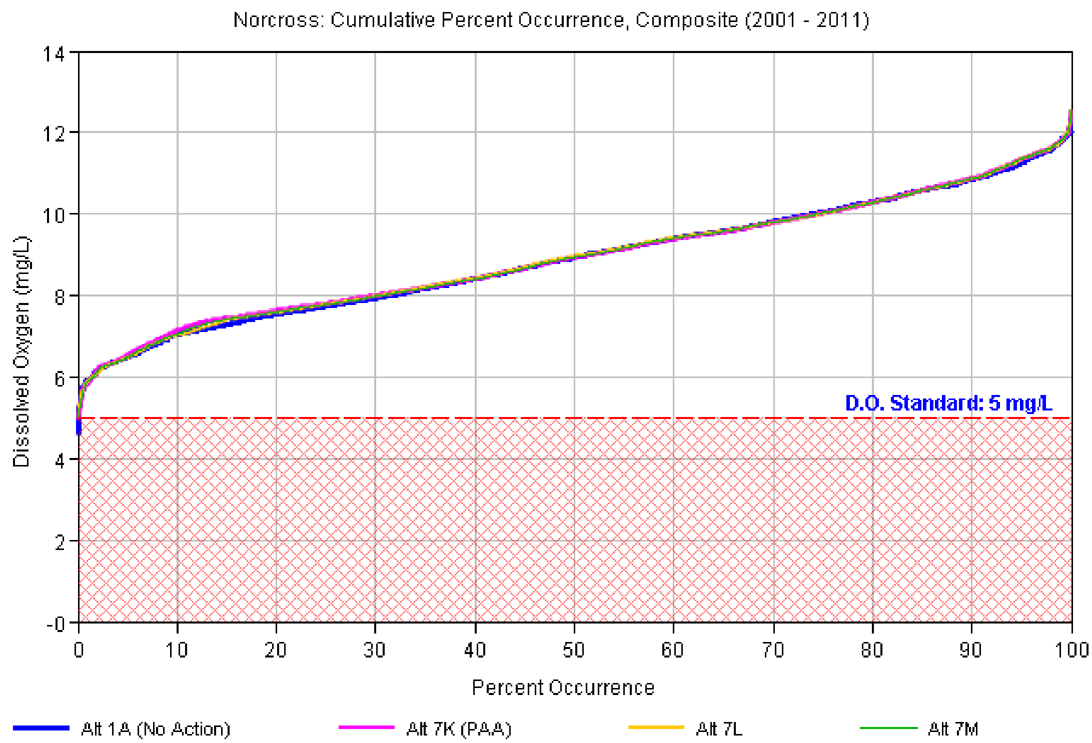


Figure 14. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for the period from 2001 through 2011.

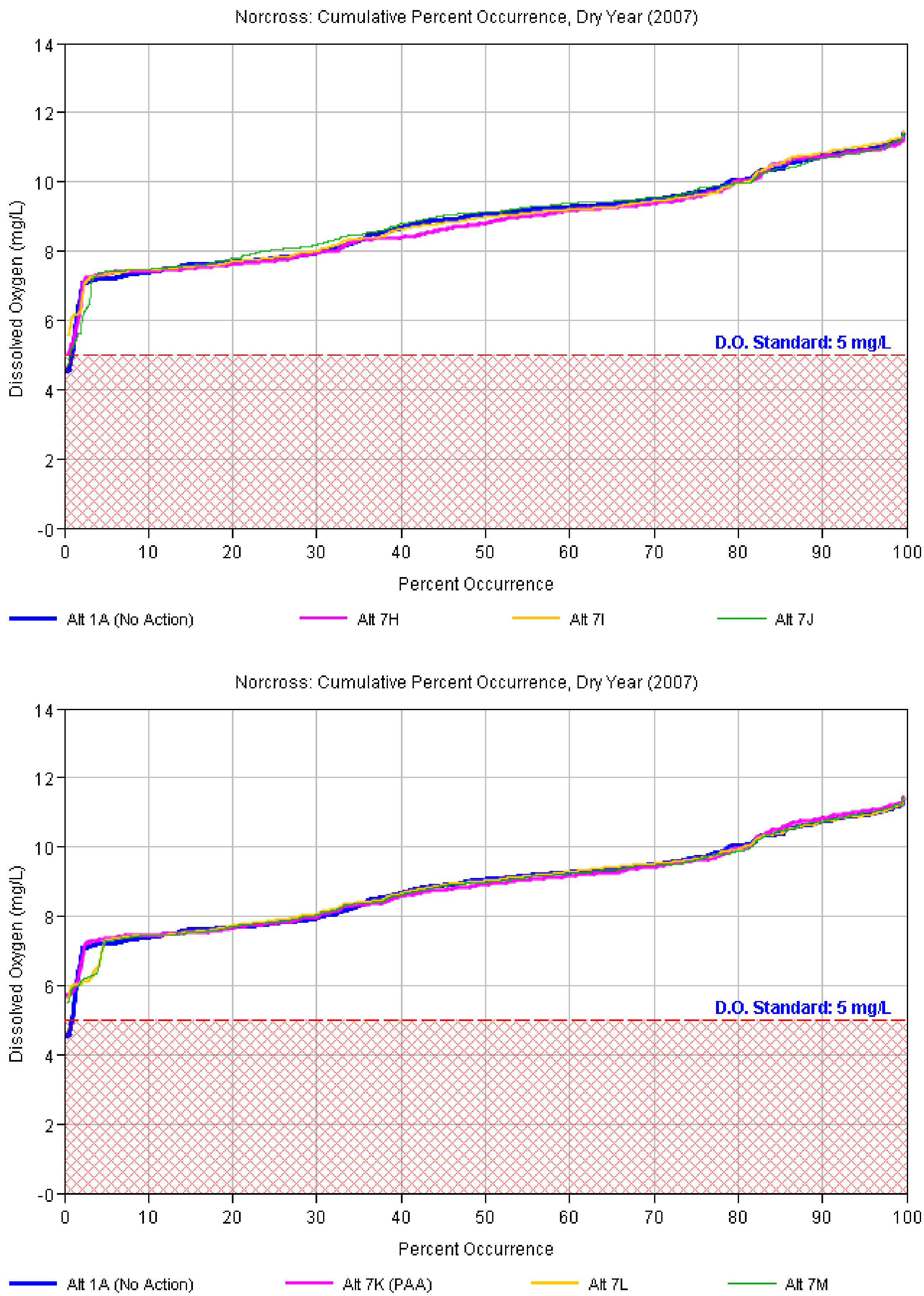
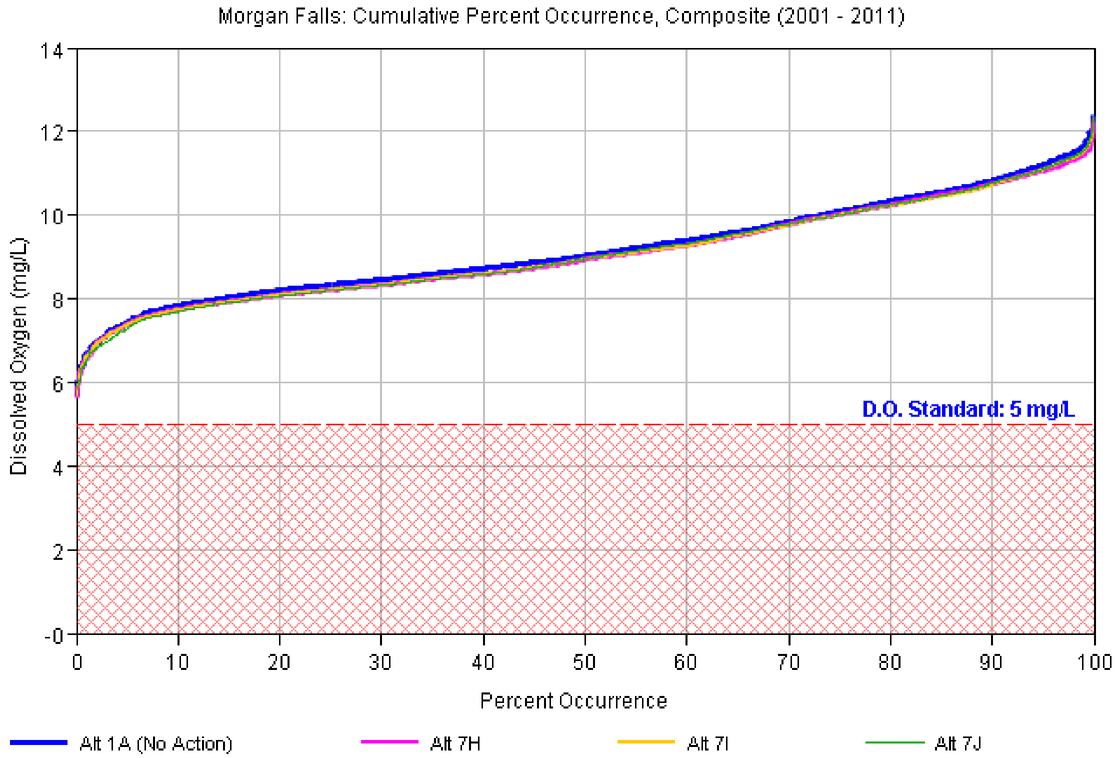


Figure 15. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for a representative dry year (2007).



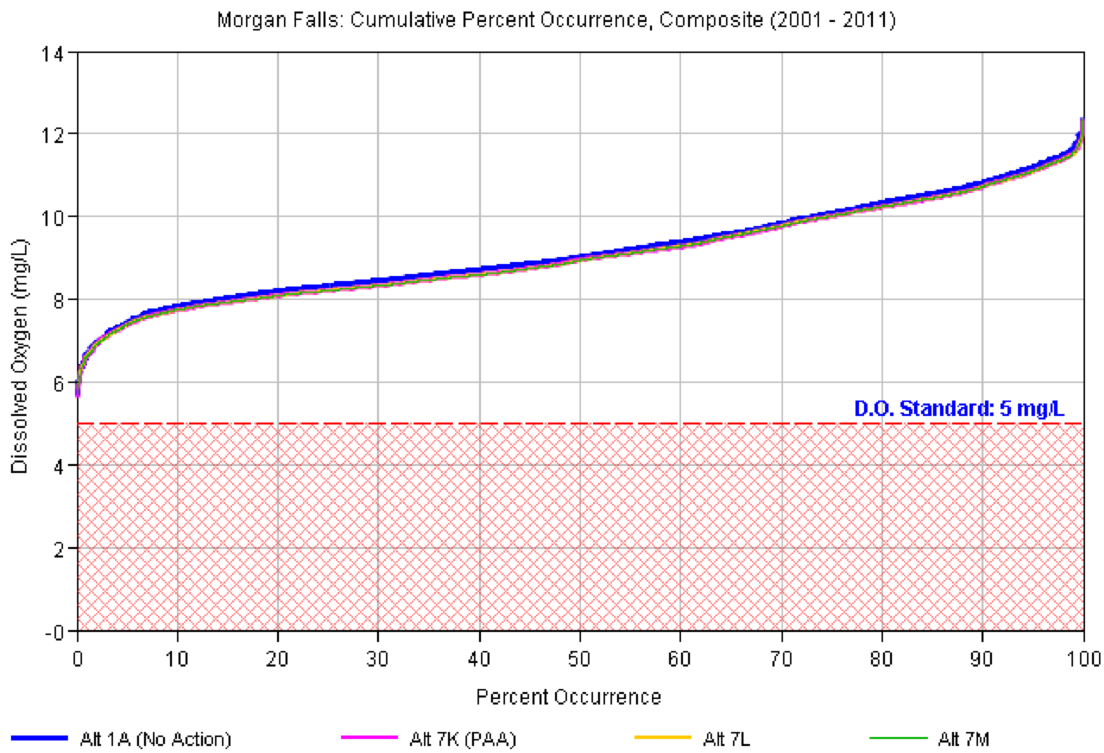
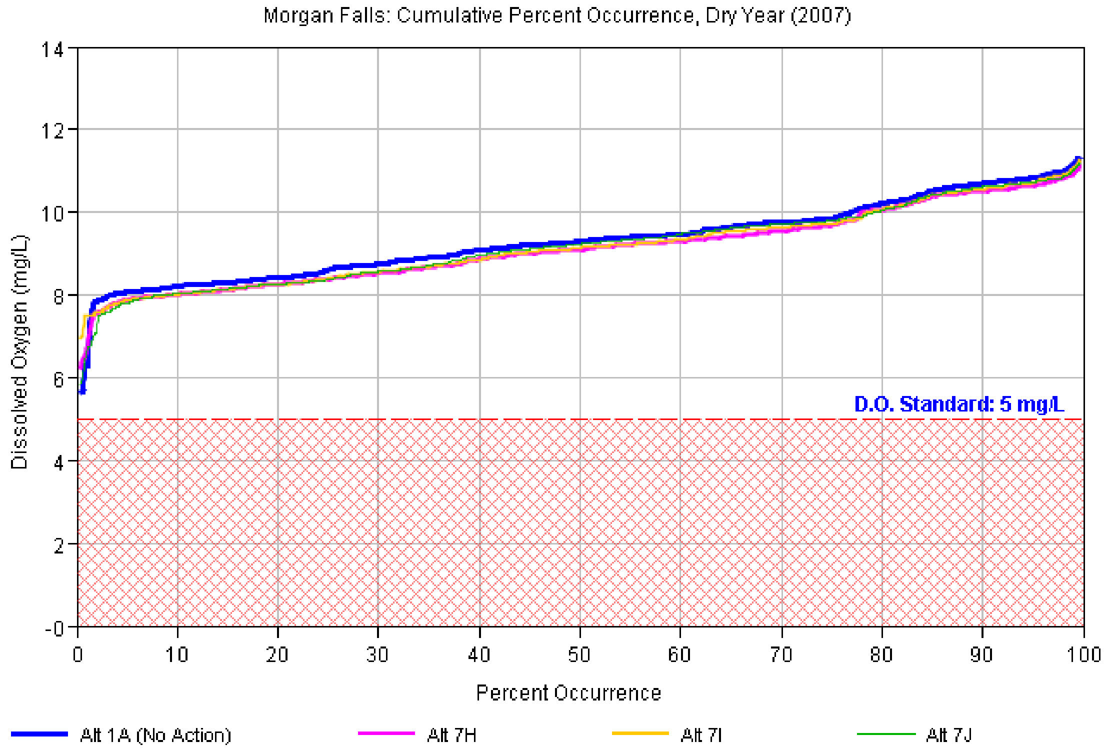


Figure 16. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for the period from 2001 through 2011.



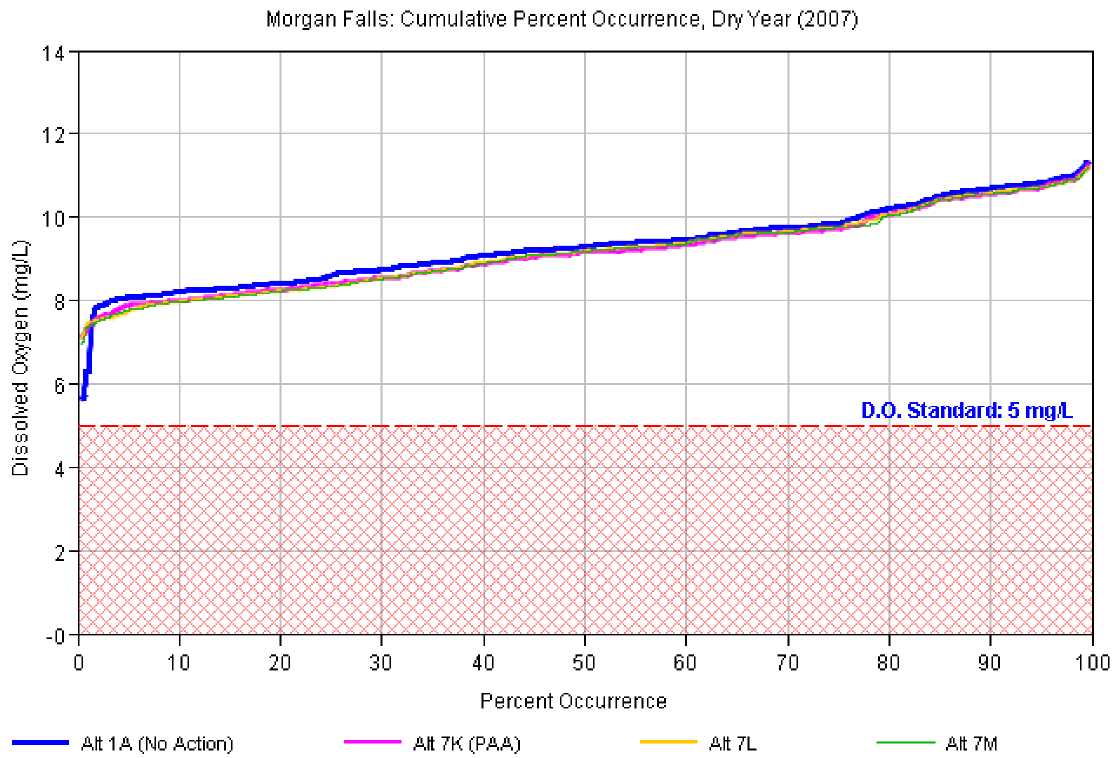
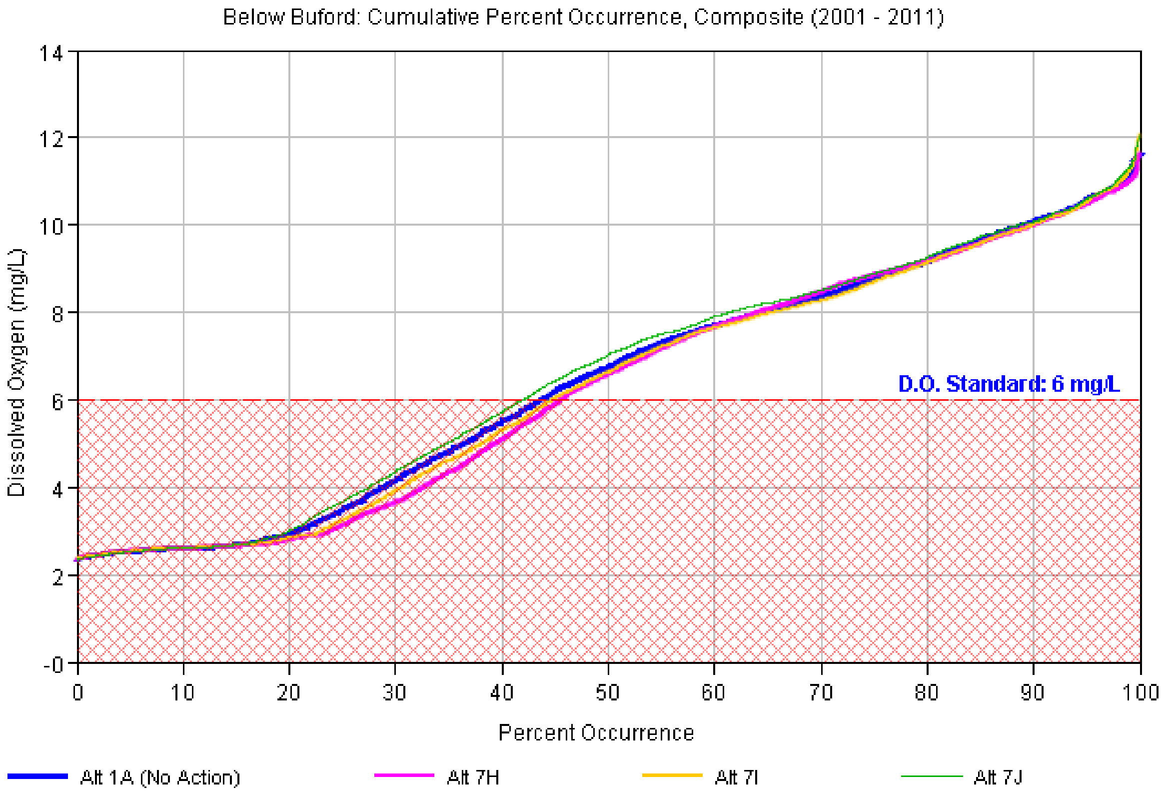


Figure 17. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for a representative dry year (2007).



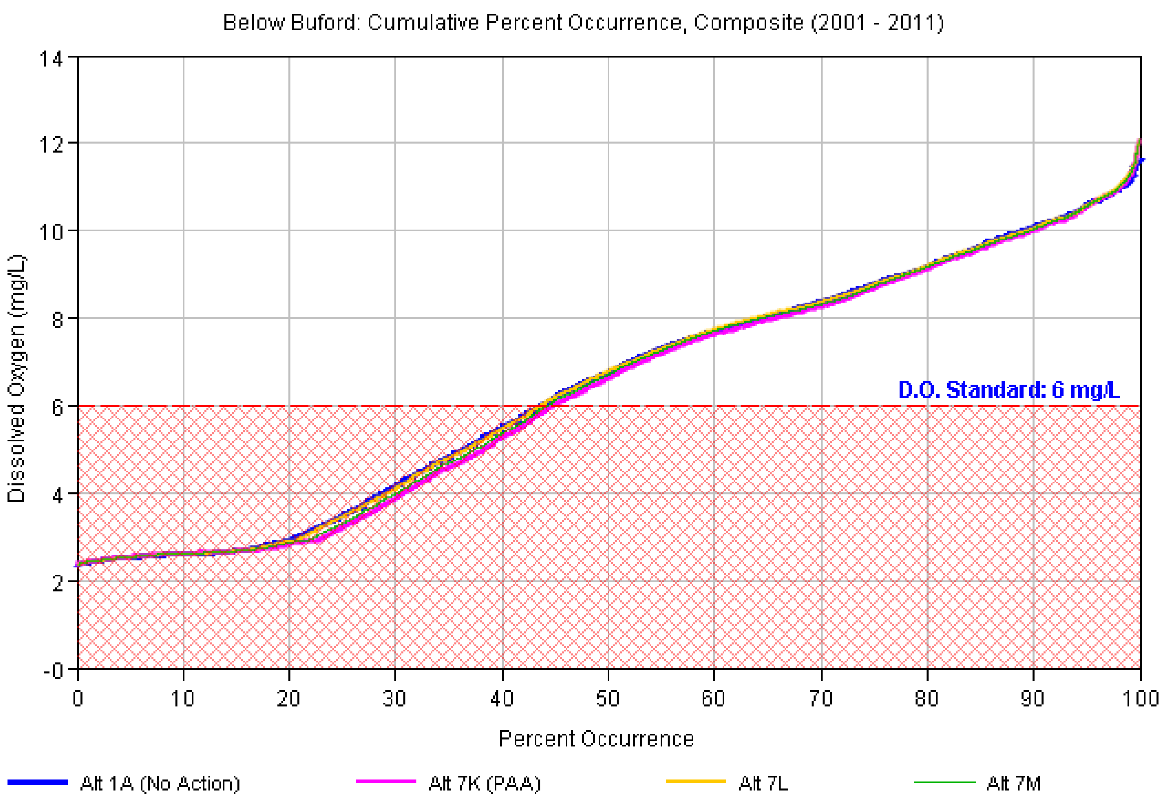
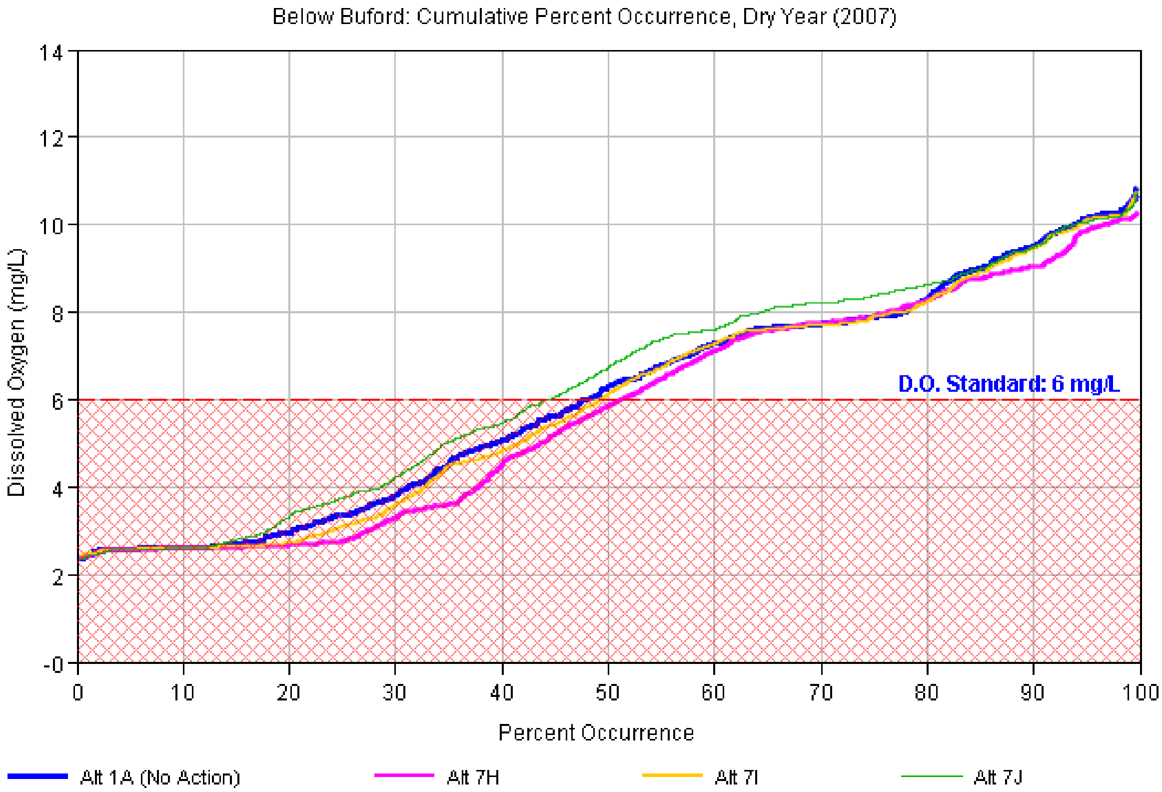


Figure 18. DO occurrence downstream of Buford Dam for the modeled period (2001 – 2011).



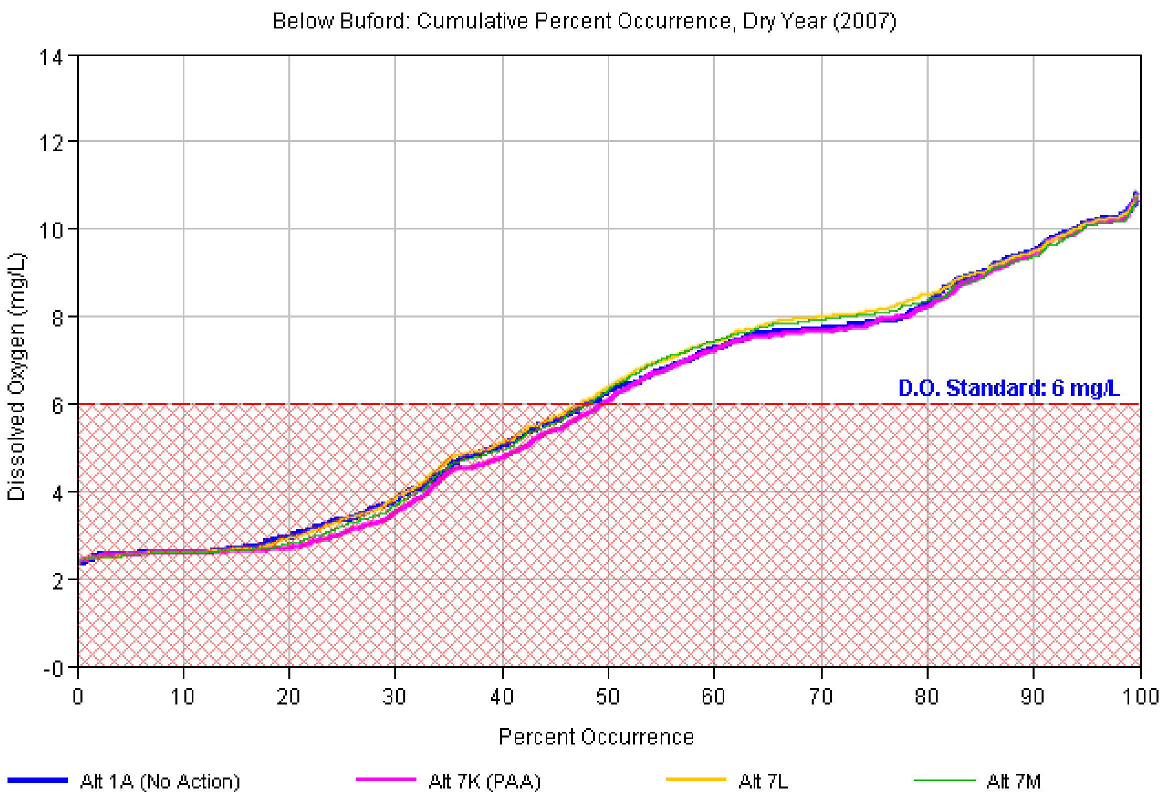
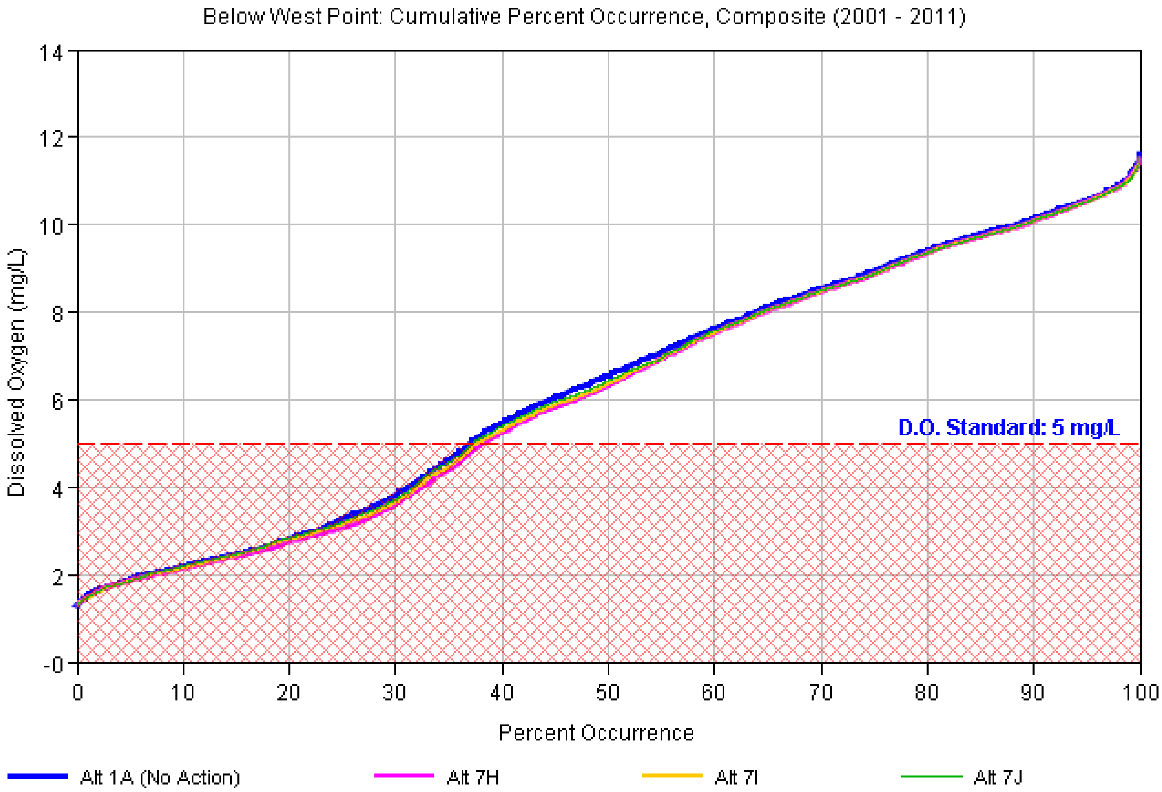


Figure 19. DO occurrence downstream of Buford Dam for a representative dry year (2007).



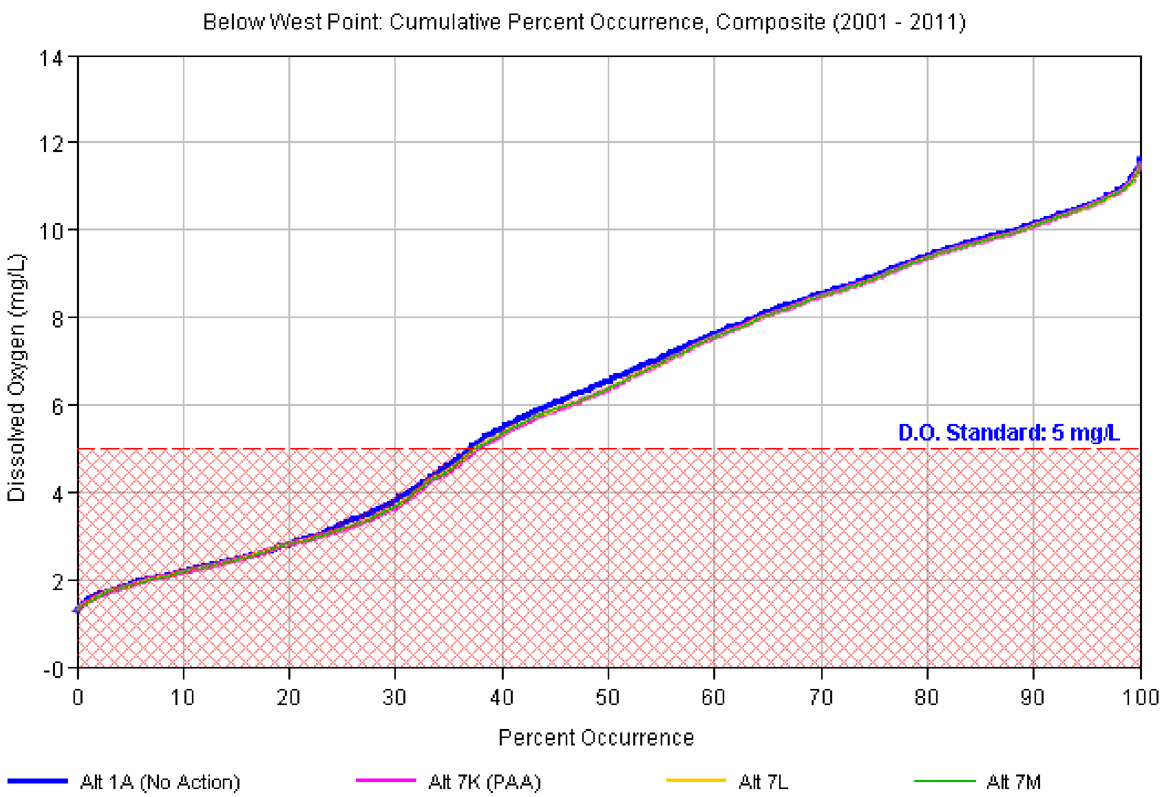
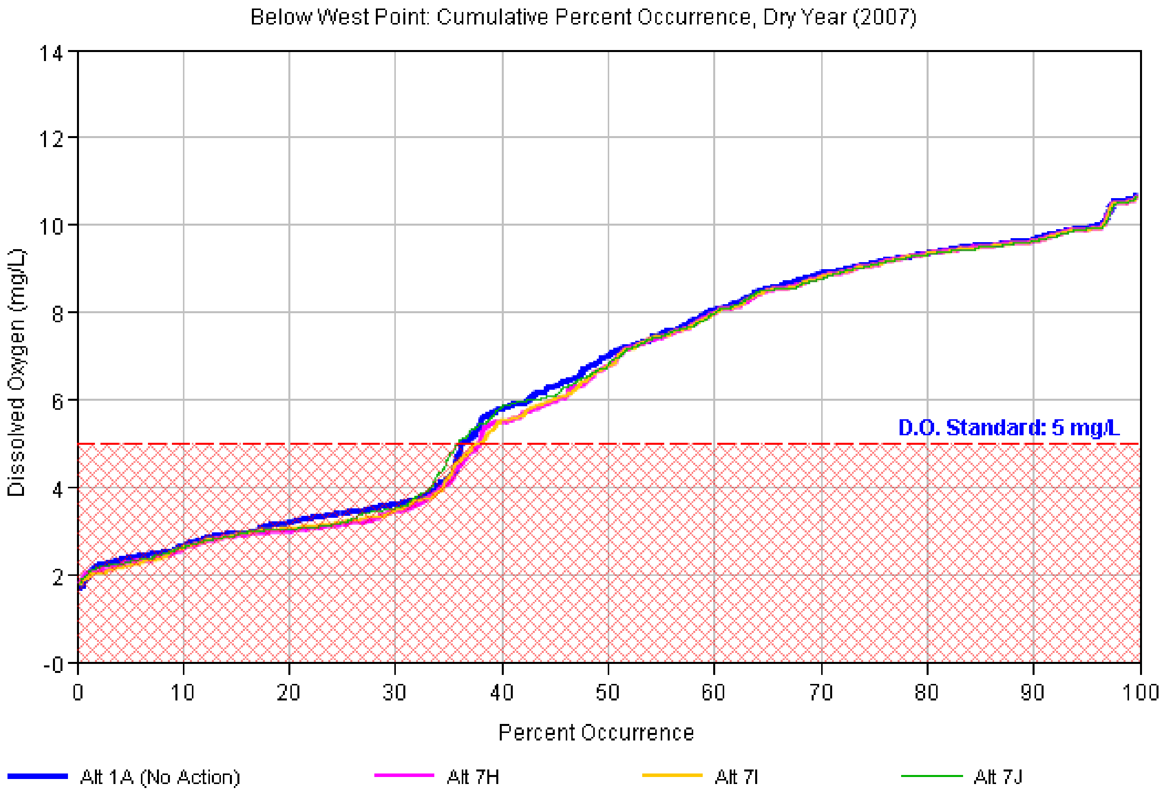


Figure 20. DO occurrence downstream of West Point Dam for the modeled period (2001 - 2011).



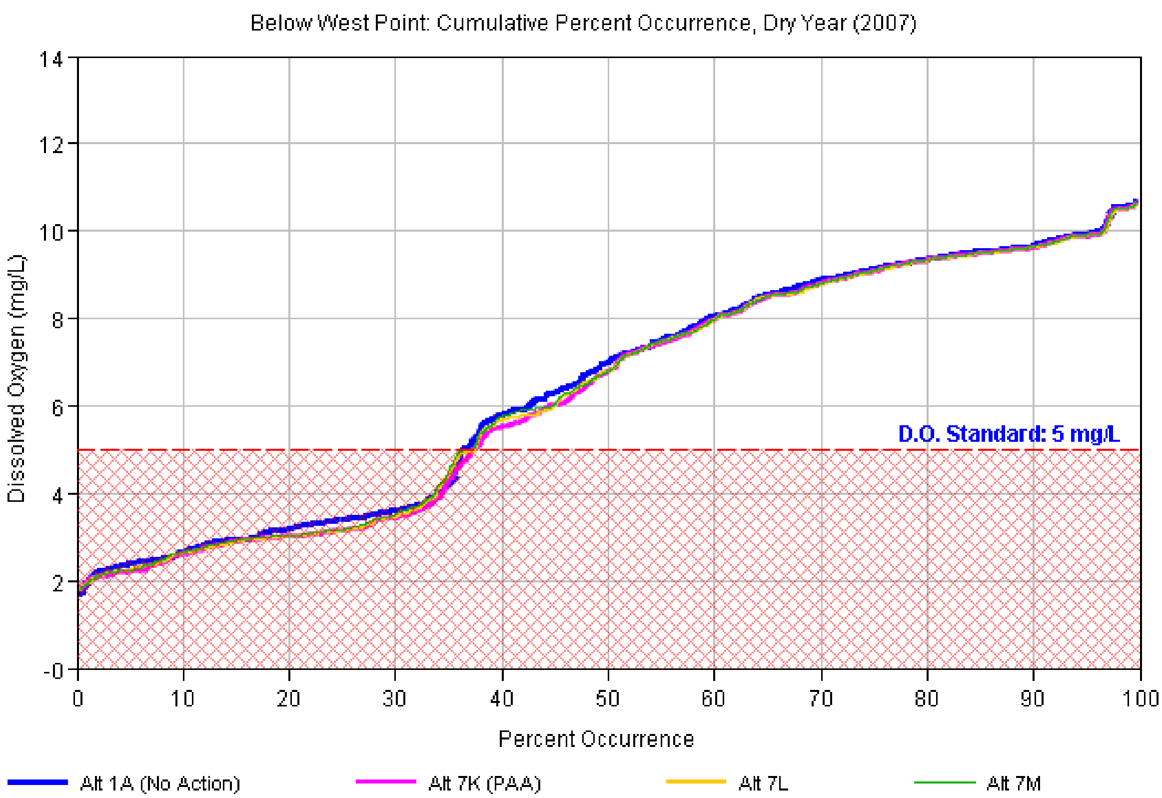
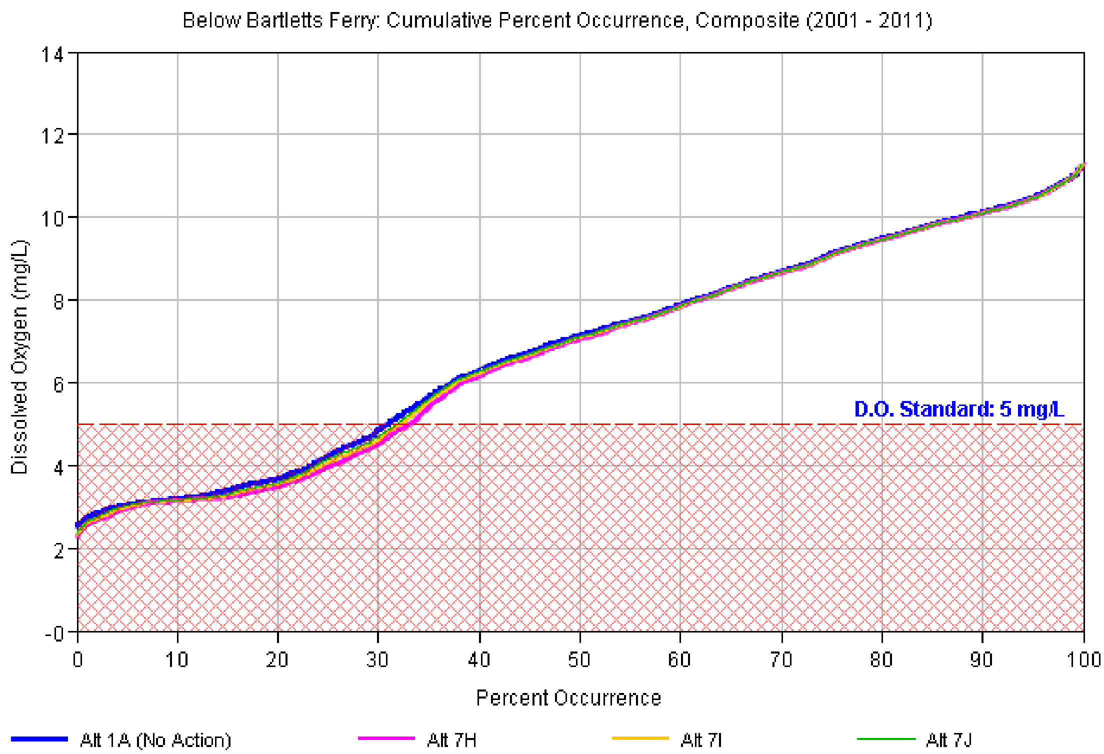


Figure 21. DO occurrence downstream of West Point Dam for a representative dry year (2007).



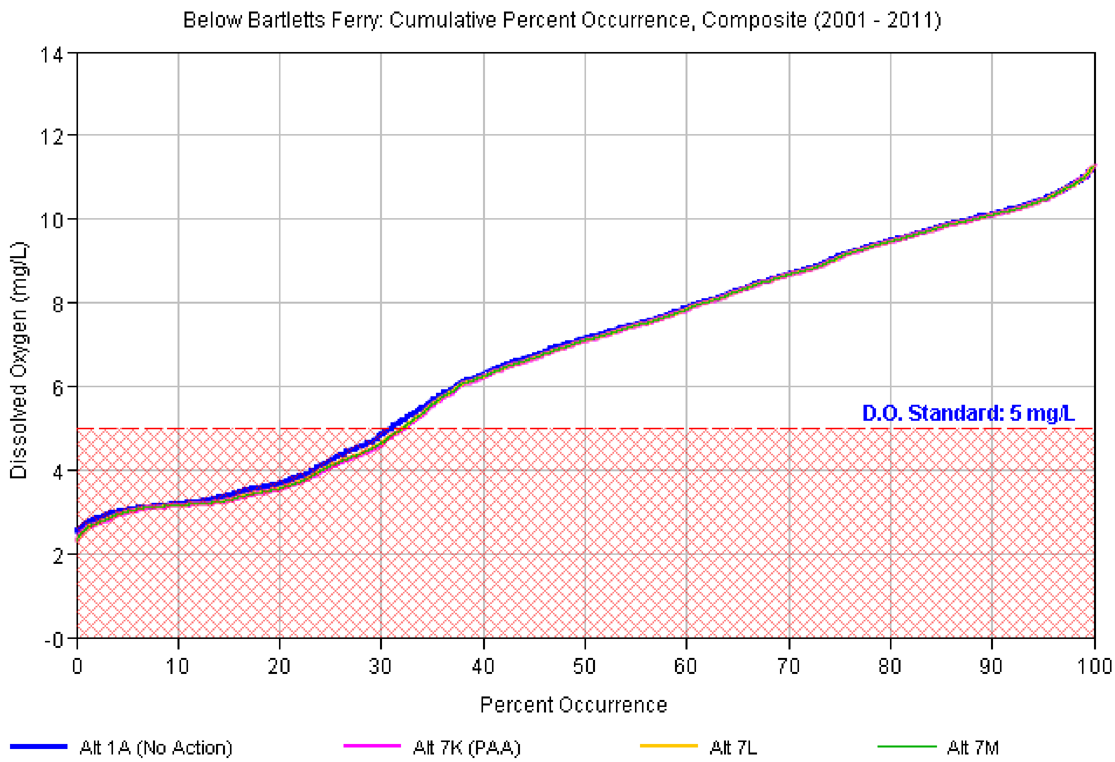
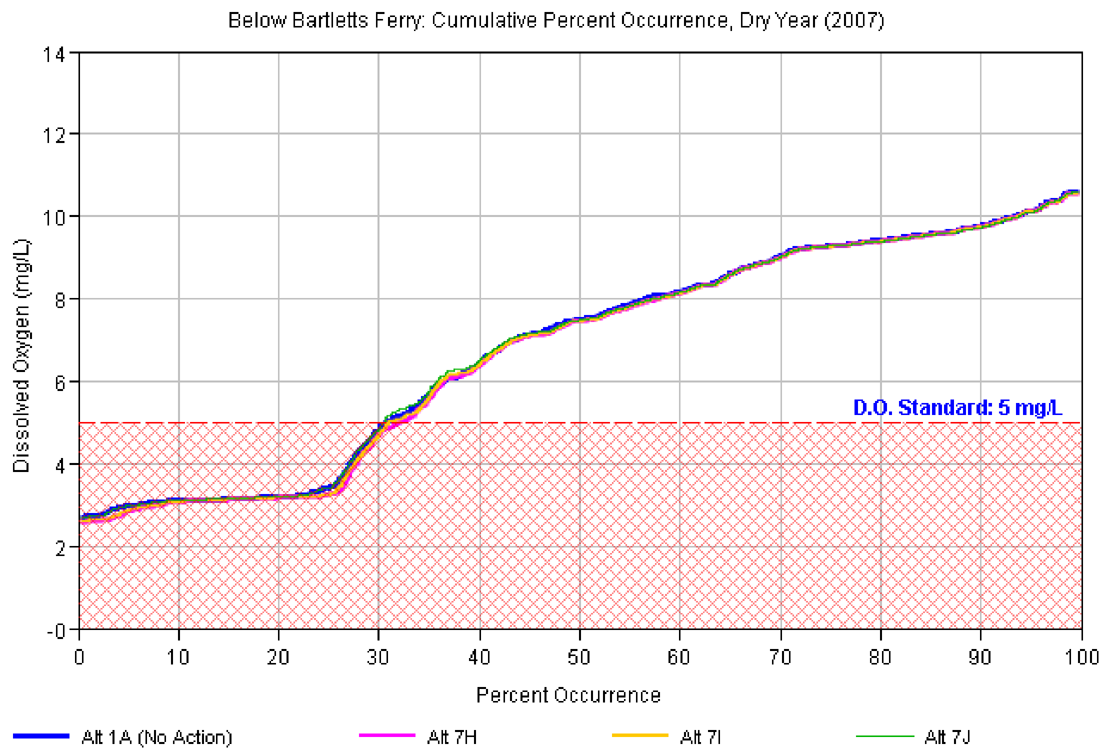


Figure 22. DO occurrence downstream of Bartletts Ferry Dam for the modeled period (2001 - 2011).



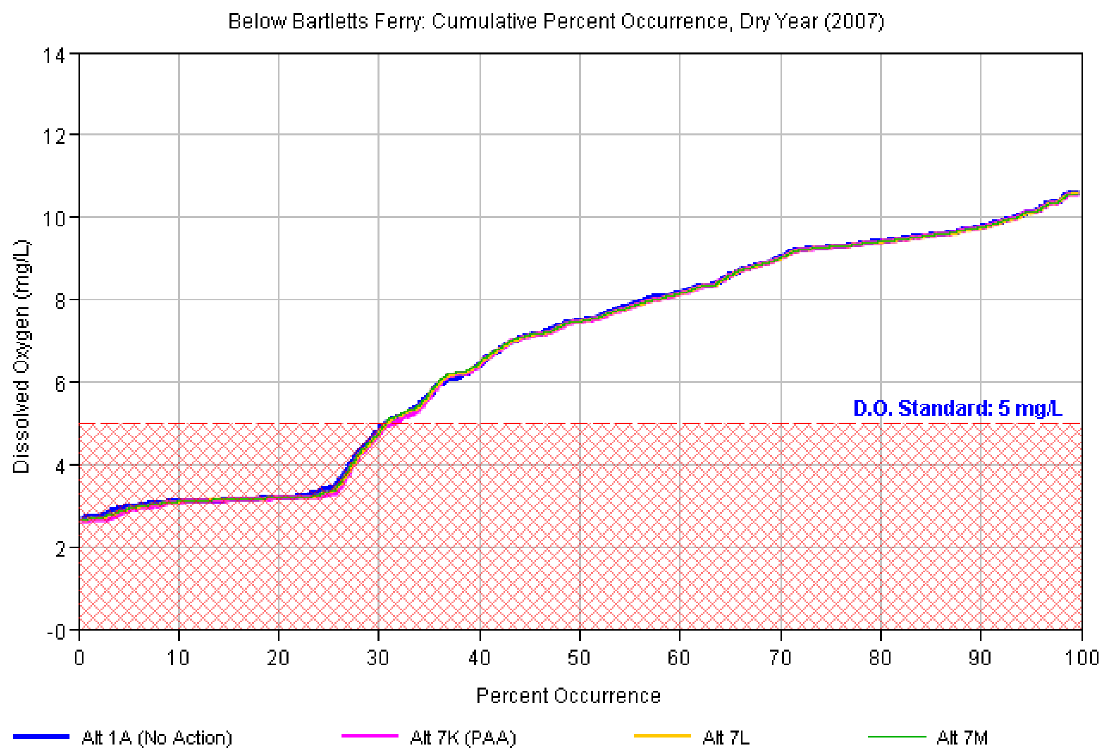
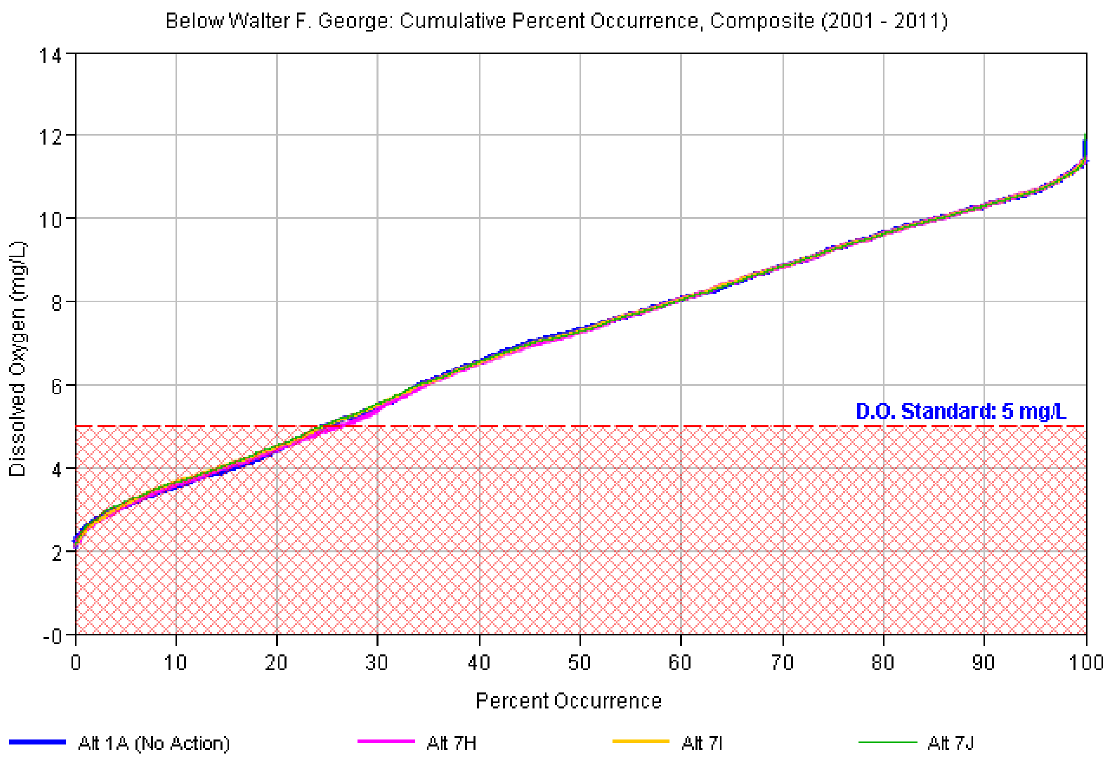


Figure 23. DO occurrence downstream of Bartletts Ferry Dam for a representative dry year (2007).



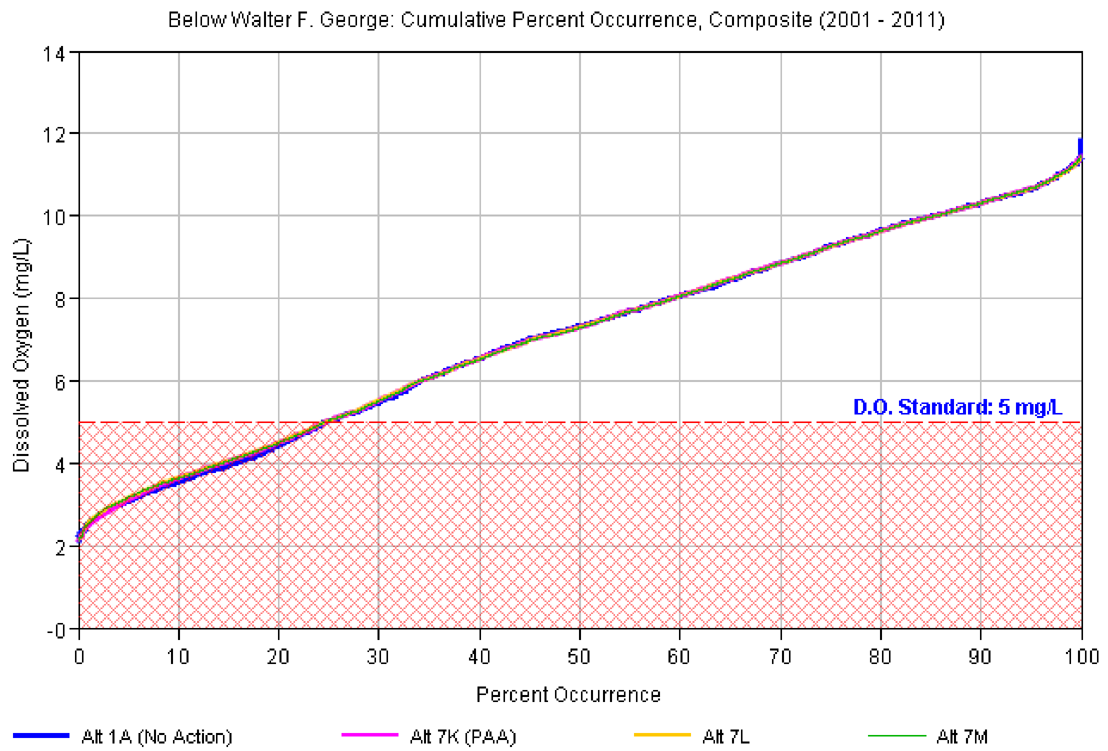
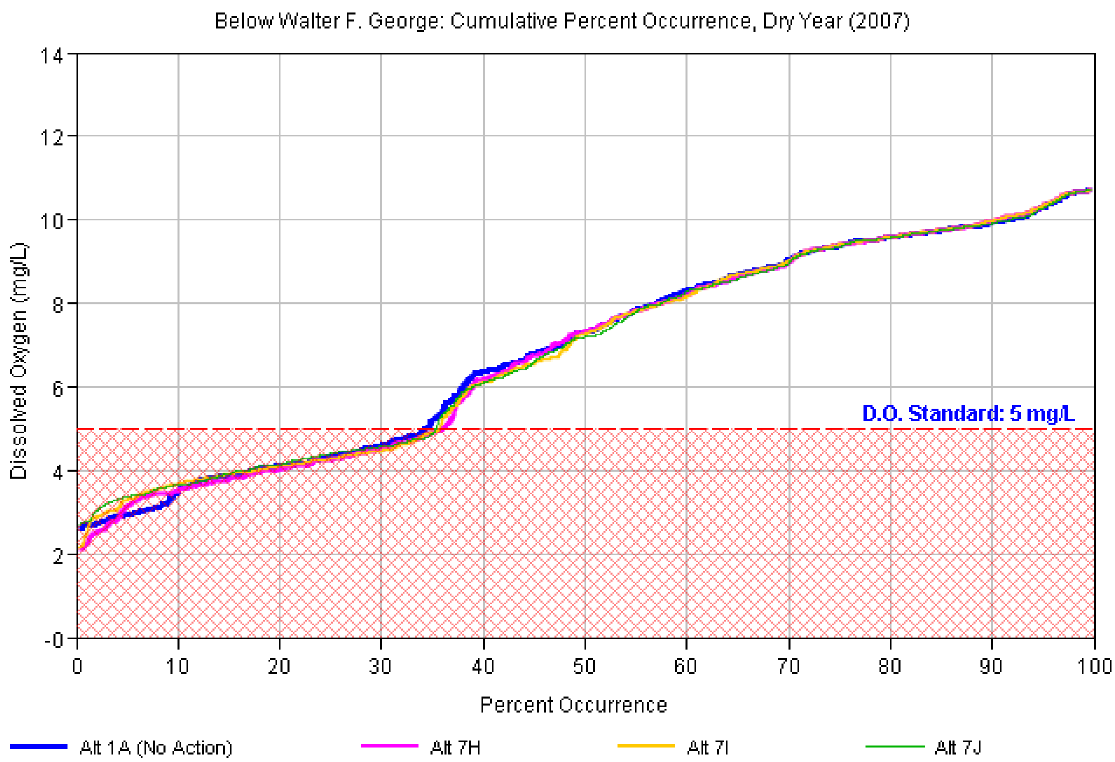


Figure 24. DO occurrence downstream of Walter F. George Dam for the modeled period (2001-2011).



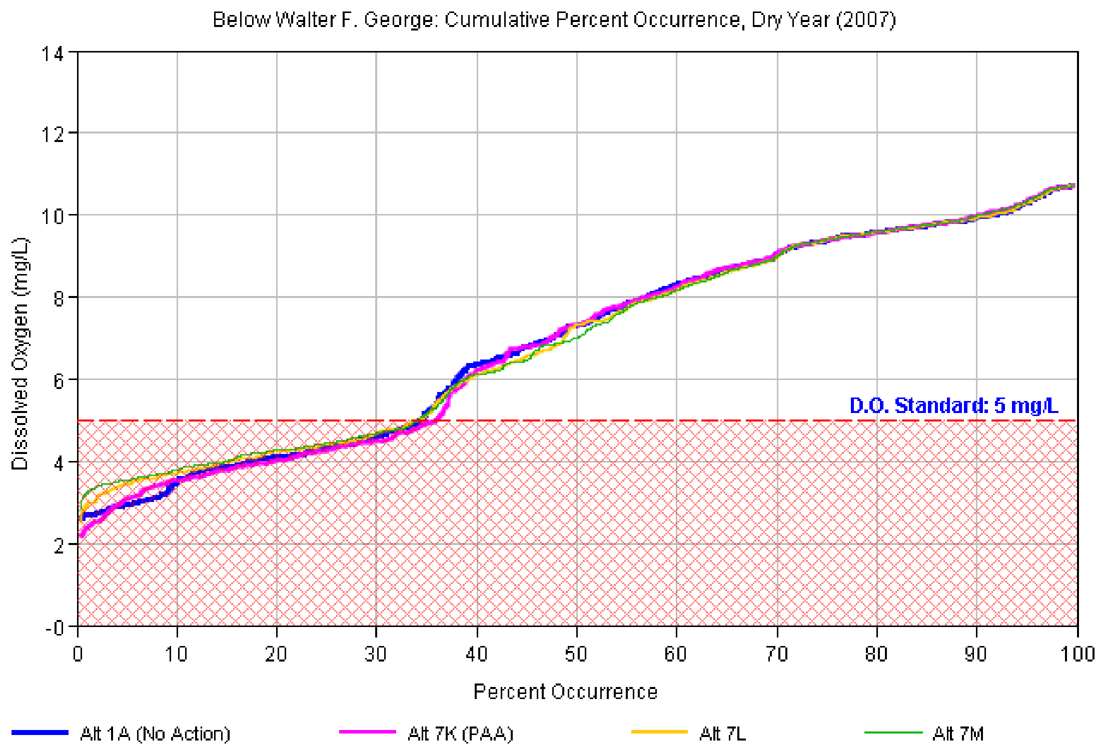
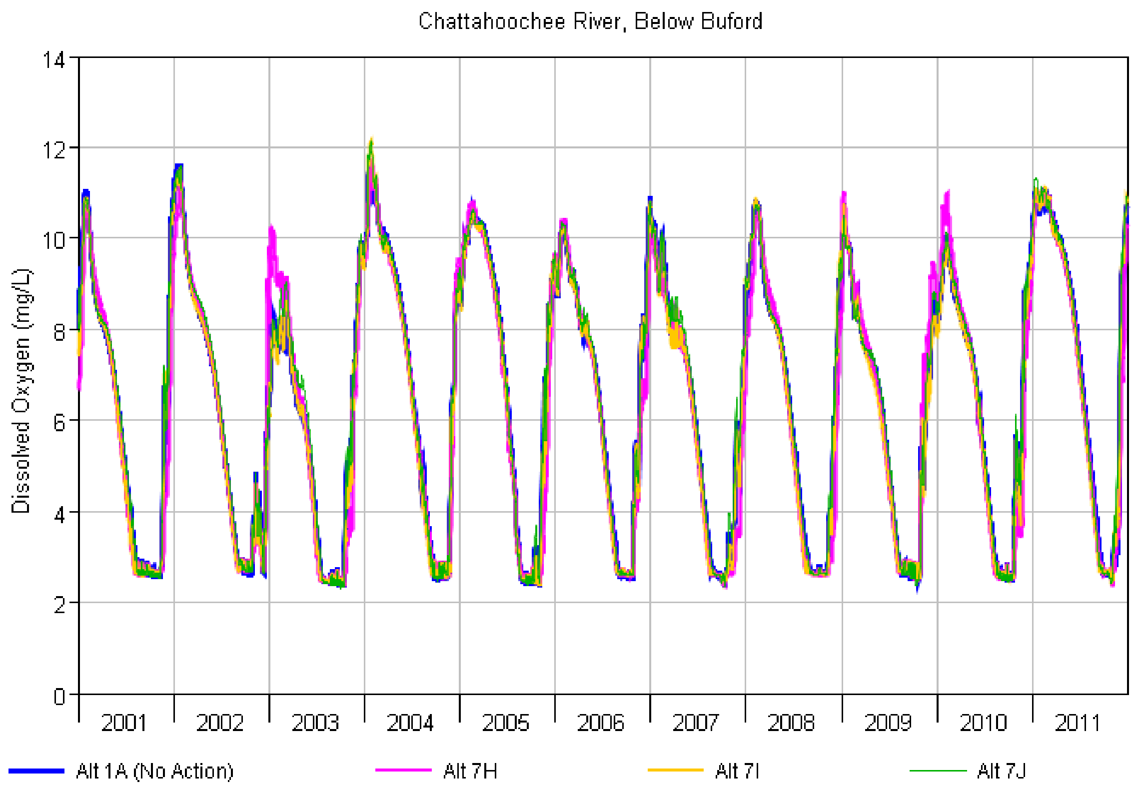


Figure 25. DO occurrence downstream of Walter F. George Dam for a representative dry year (2007).

b. Total number of instantaneous “measurements” less than 4 mg/L.

Instantaneous modeled results were not simulated. The river profile simulations suggest that DO values less than 4 mg/L are only expected at several tailrace locations (as illustrated in Figures 18 through 25). Time series plots for these locations are also provided below in Figure 26 through Figure 29.



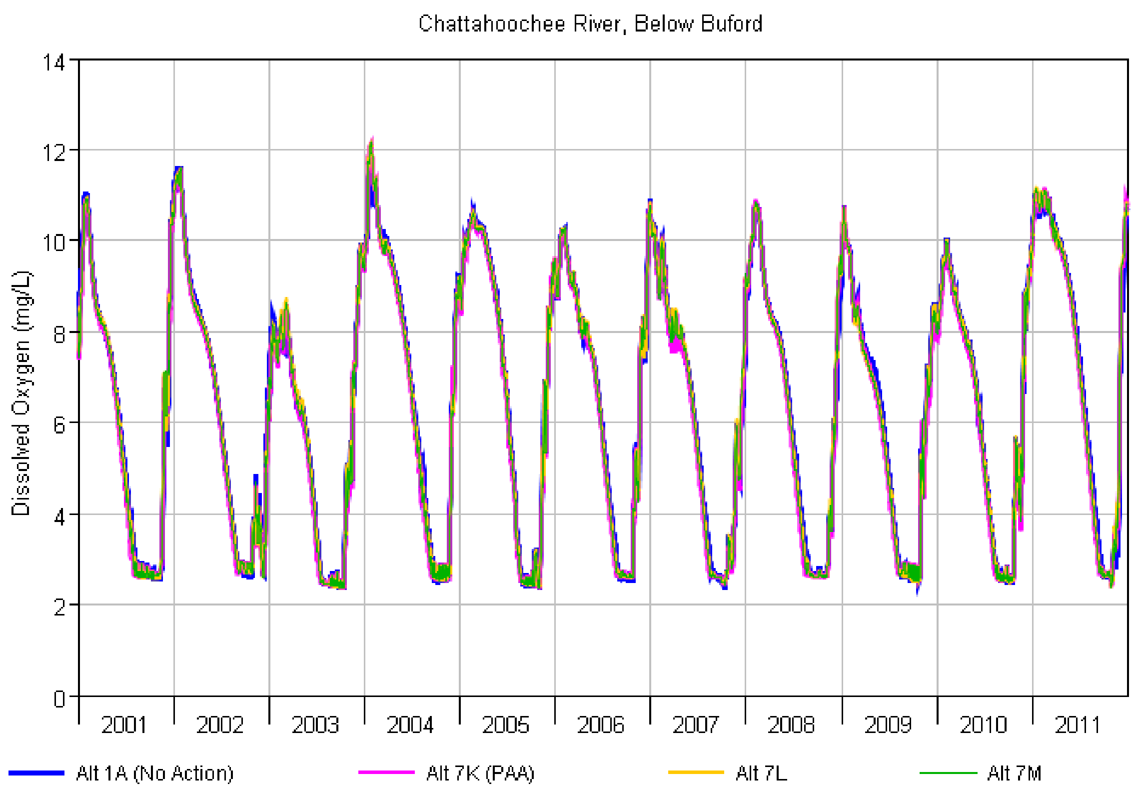
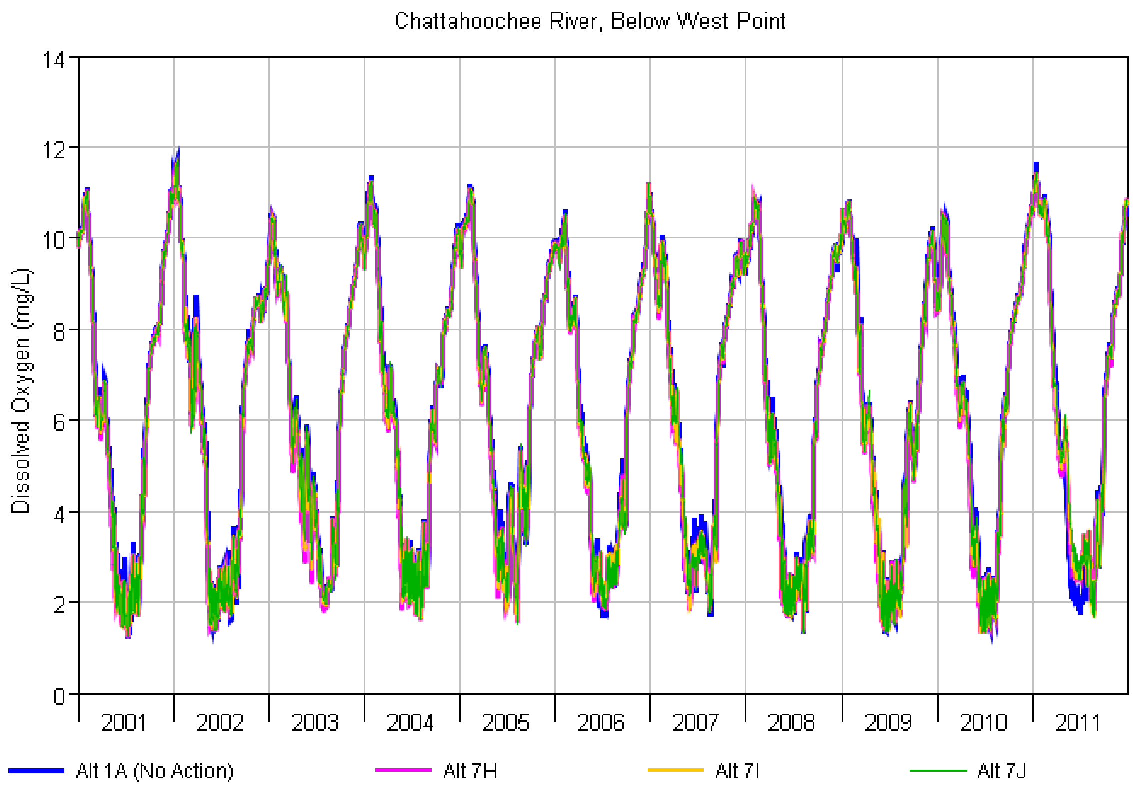


Figure 26. Time series DO from Buford Dam releases.



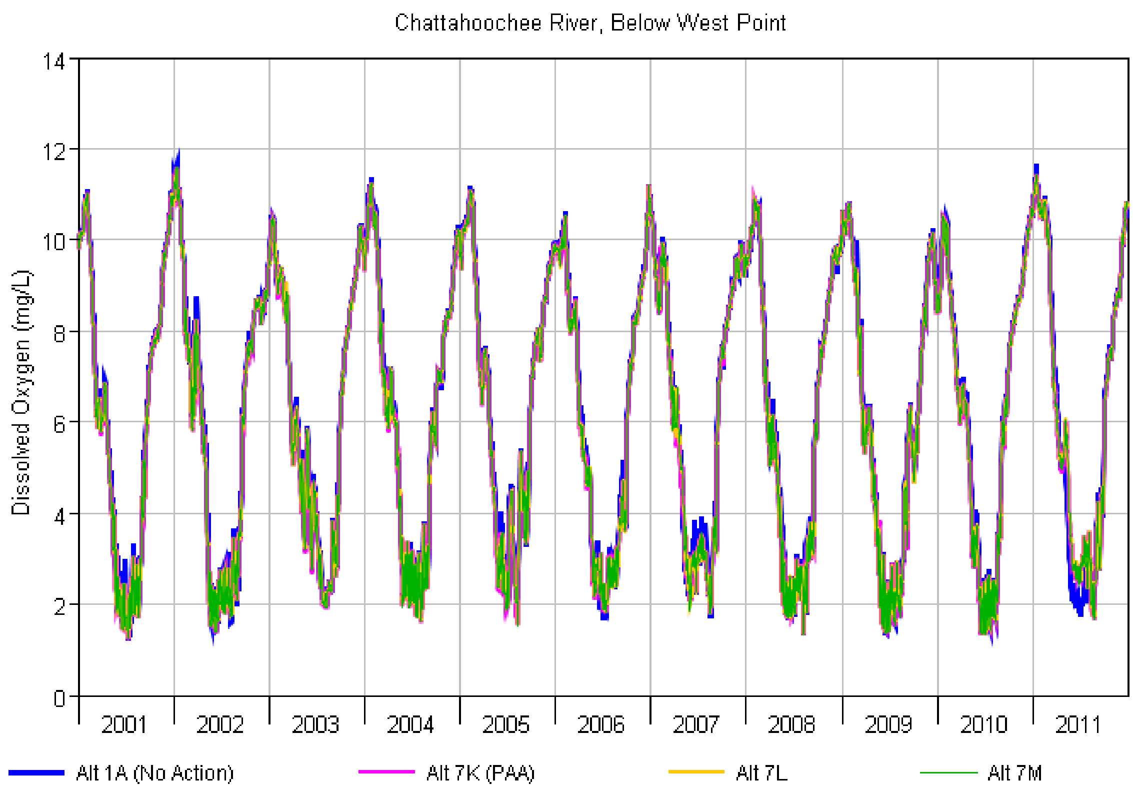


Figure 27. Time series DO from West Point Dam releases.

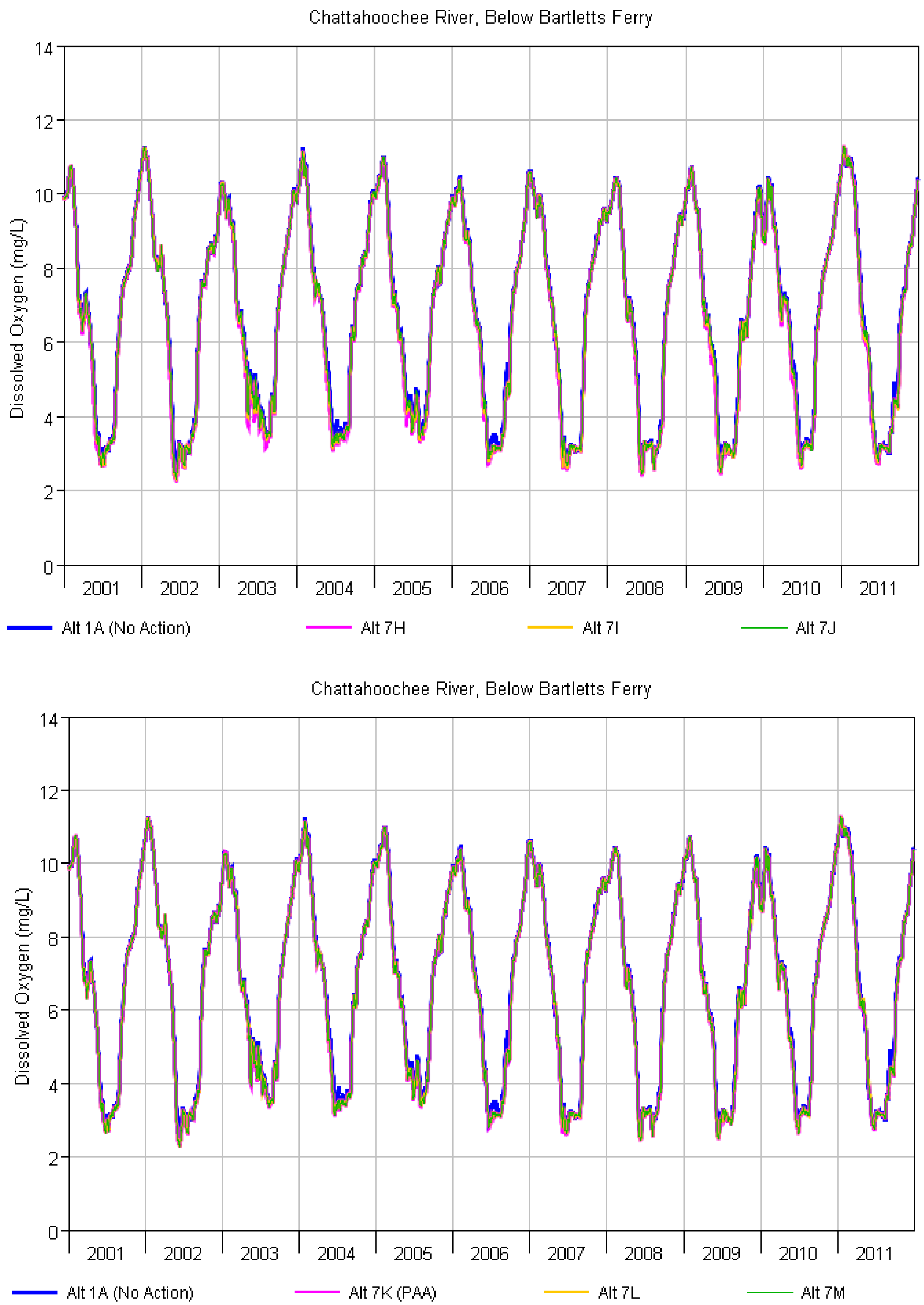
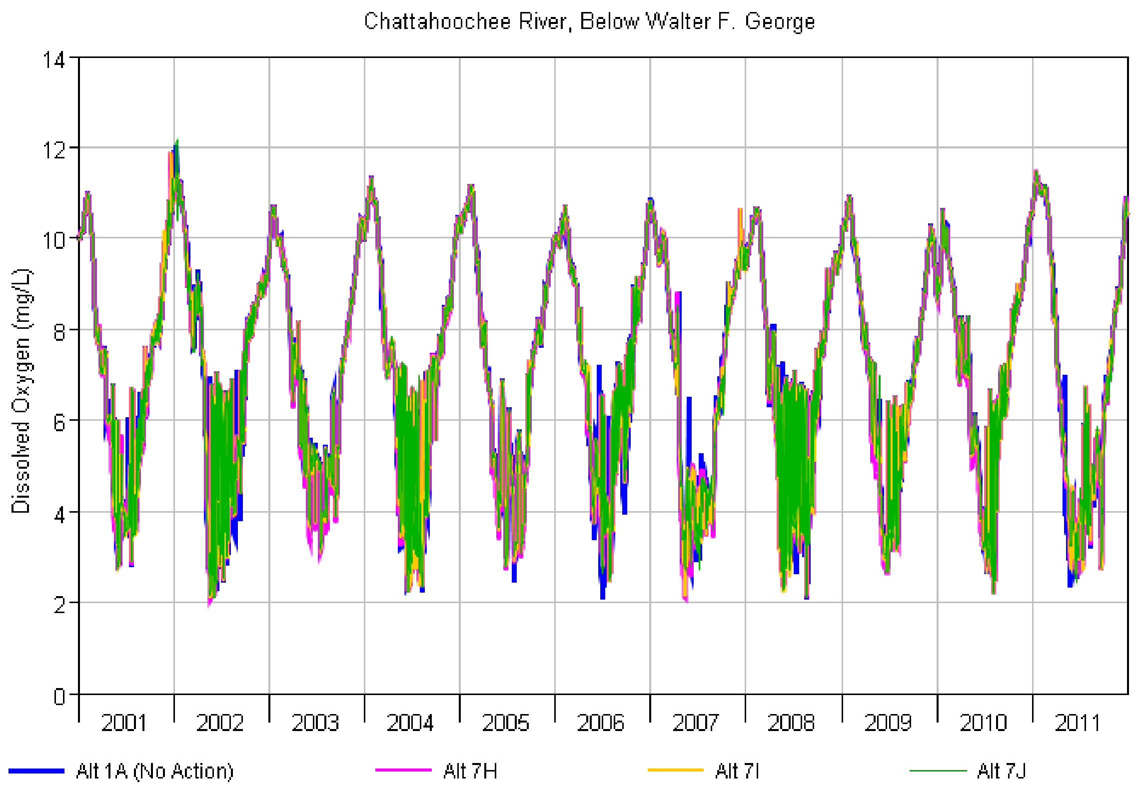


Figure 28. Time series DO from Bartletts Ferry Dam releases.



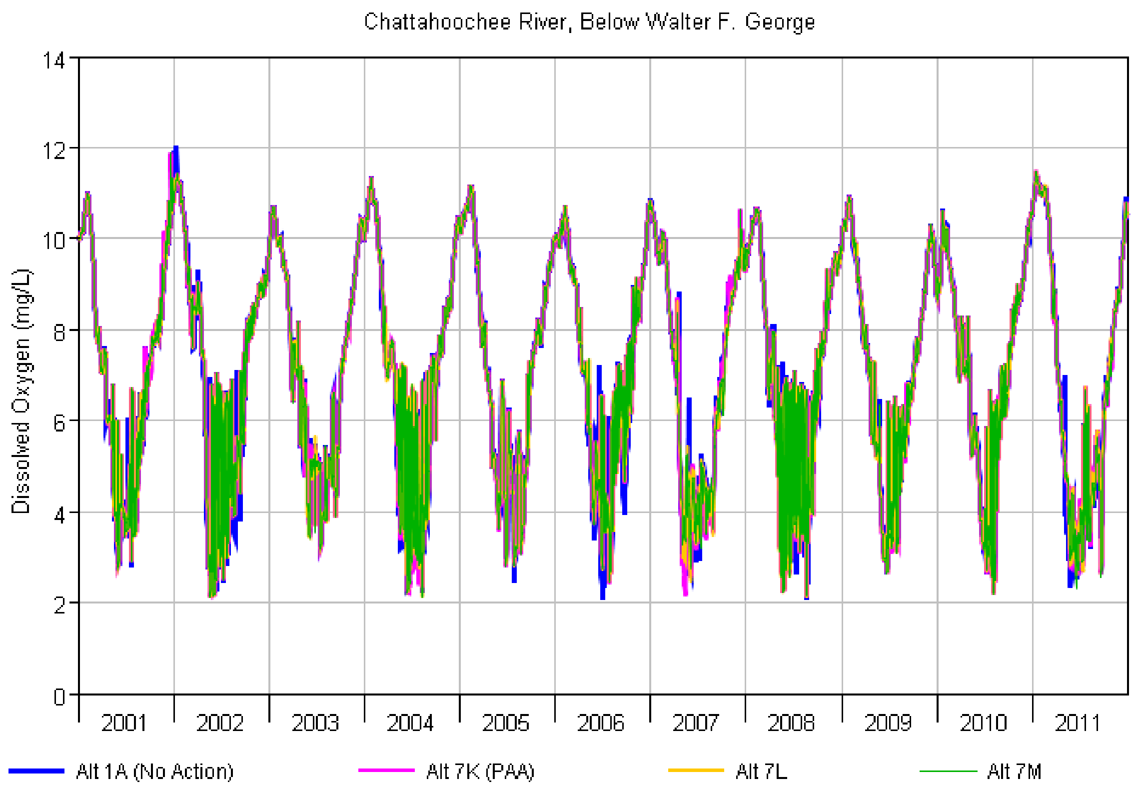
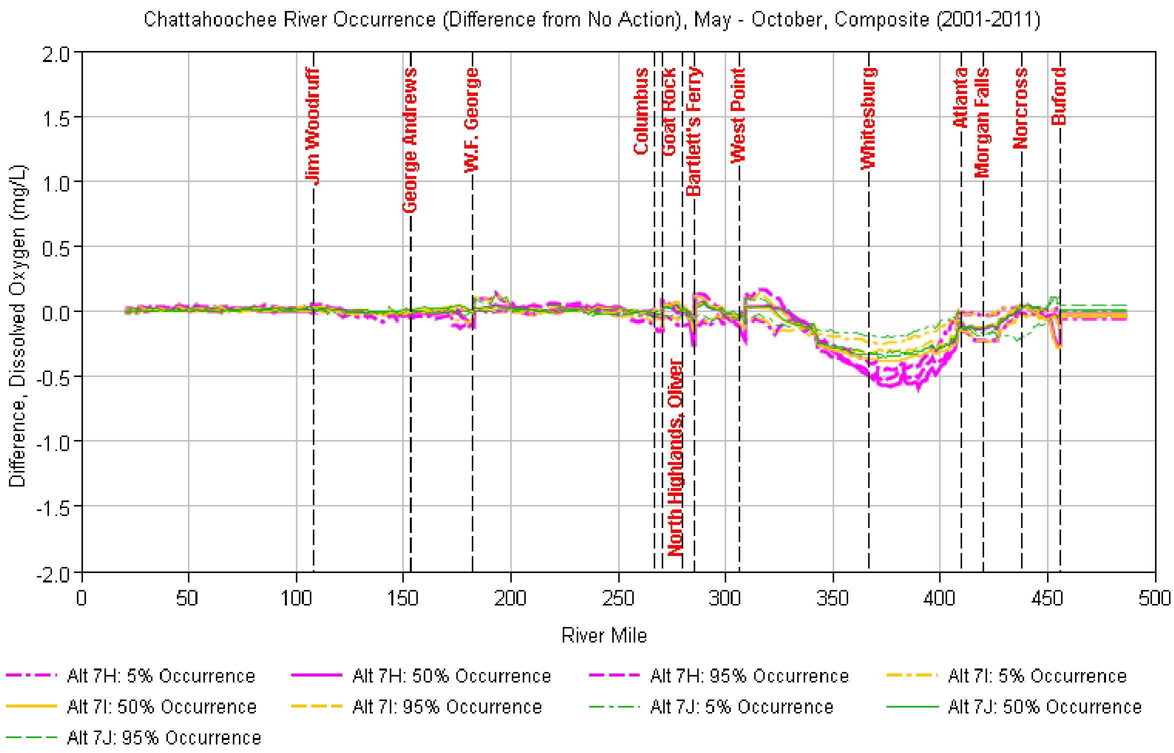


Figure 29. Time series DO from Walter F. George Dam releases.

c. Monthly exceedance figures and box plots with outliers for DO (mg/L).

As in previous PAL responses, monthly exceedance figures for DO were not generated. Figure 30 generally provides the same information in a format we believe is easier to communicate. Figure 30 illustrates the change in DO concentrations between the NAA and the PAA (PAA minus NAA is illustrated) at the 5^{th}, 50^{th}, and 95^{th} percent occurrence intervals; both Alt7H and Alt7K are illustrated in the two plots provided. For these DO plots, the 95^{th} percent occurrence interval means that the values are this number or lower 95 percent of the simulation at this location (i.e., only 5 percent of the time the value is higher than this – a rare occurrence). Conversely, the 5^{th} percent occurrence interval means that the values are this number or lower 5 percent of the simulation at this location (i.e., 95 percent of the time the value is higher than this – this too is a rare occurrence). The 50^{th} percent occurrence represents the median occurrence. Again, there were no notable differences from the modelling results presented in the DEIS PAA.



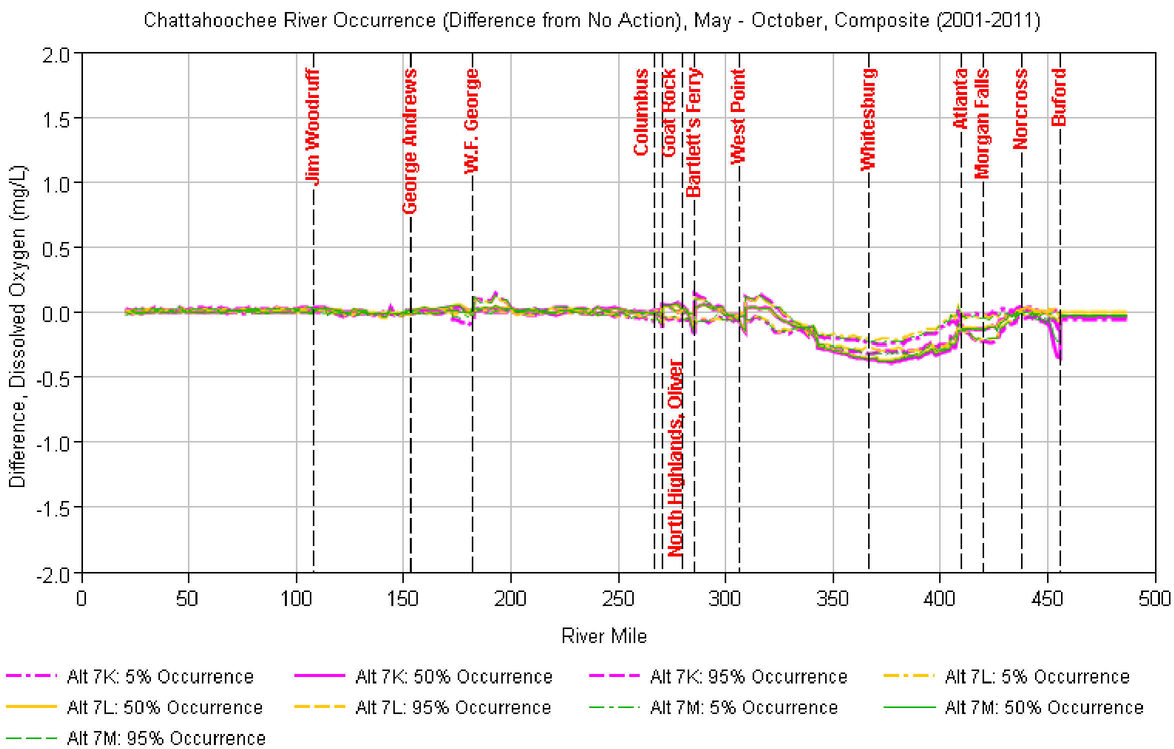


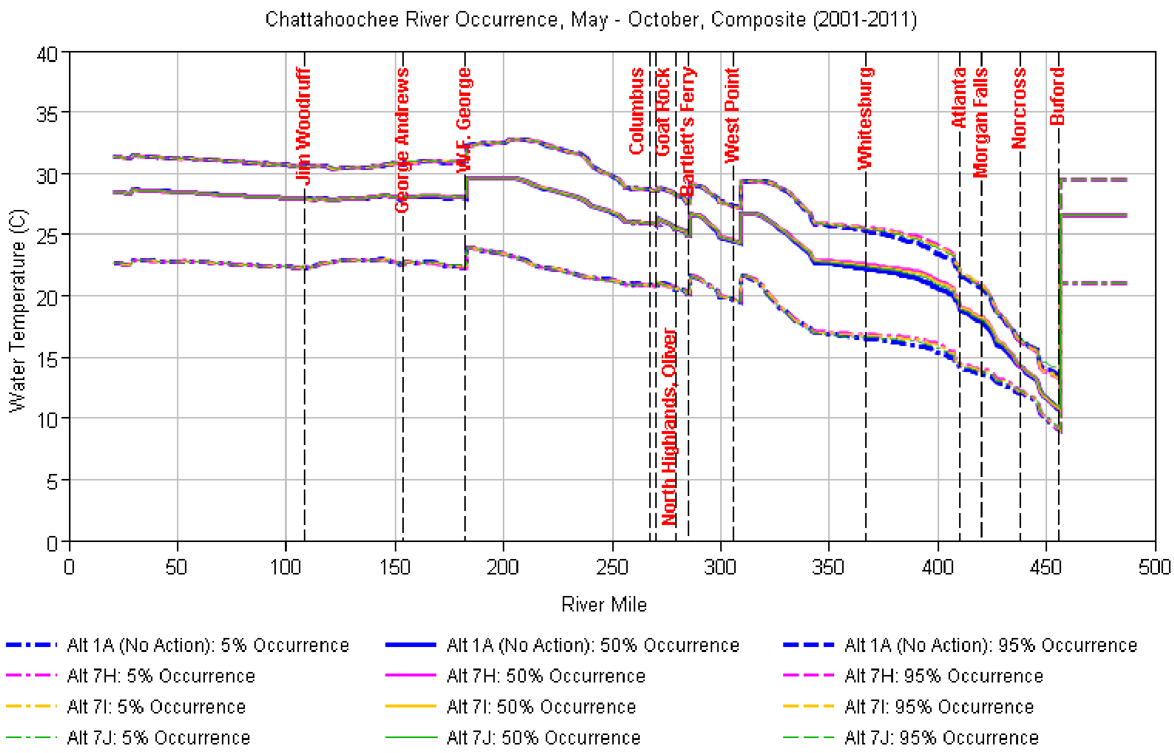
Figure 30. Changes in longitudinal DO in the Chattahoochee River for the May through October for the model period (2001 through 2011).

2.1.2 Water Temperature

a. Monthly exceedance figures and box plots with outliers for water temperature.

Similar to DO, monthly exceedance figures for temperature were not generated. Again, we believe that river profiles and occurrence plots illustrate this information more clearly than the box plots. Figures 31 through 34 illustrate temperatures along the riverine profile and Figures 35 through 38 illustrate the change in temperature from the NAA (PAA minus the NAA is illustrated). The delta profile plots clearly illustrate the magnitude of the change in water temperature of each of the alternatives as compared to the NAA. Similar to the dissolved oxygen discussion, there were no notable differences in impacts when comparing the proposed action from the DEIS to that proposed for the FEIS. Each figure includes two plots that top illustrate Alt7H and the bottom illustrate Alt7K, the PAA.

There are slight differences in Alt7H presented in Figures 36 and 38 and the PAA presented in the January 21, 2015 PAL (USACE, 2015a). These differences are illustrated in a representative normal weather year (2004) in the lowest (5^{th} percent occurrence) water temperatures downstream of Atlanta and in the median water temperatures downstream of Walter F. George Dam and in a representative dry weather year (2007) in the highest (95^{th} percent occurrence) and the lowest (5^{th} percent occurrence) in the reach from Atlanta into West Point Lake.



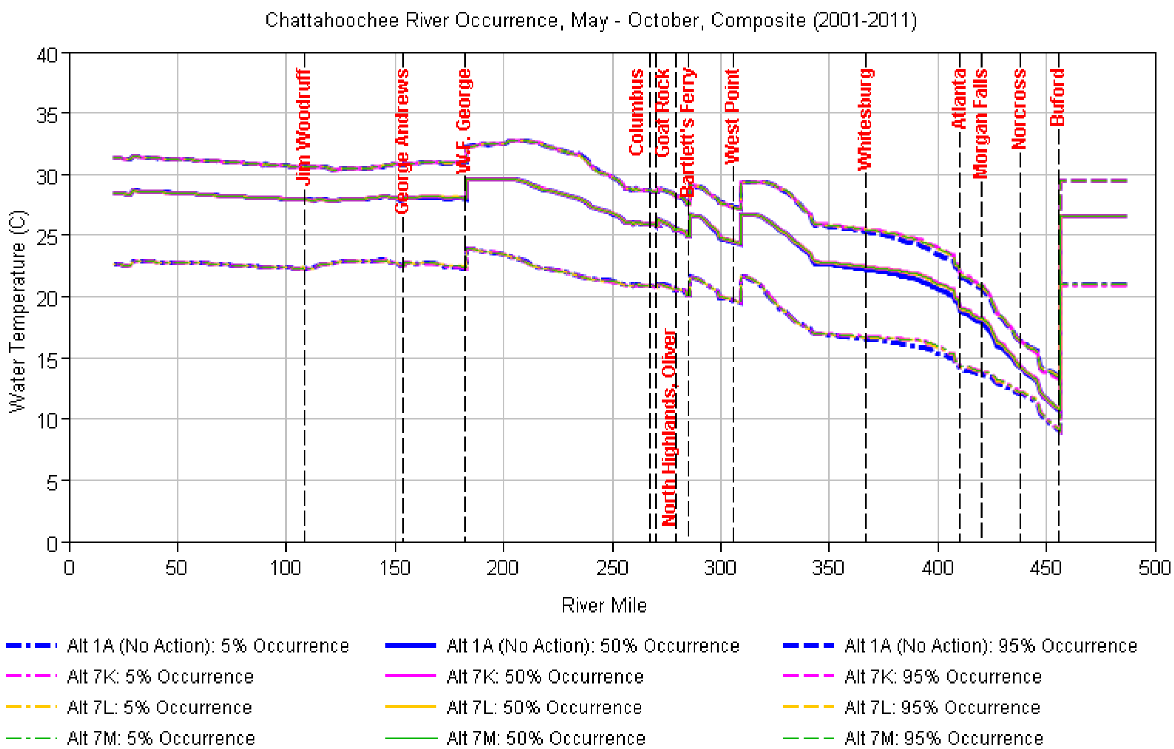
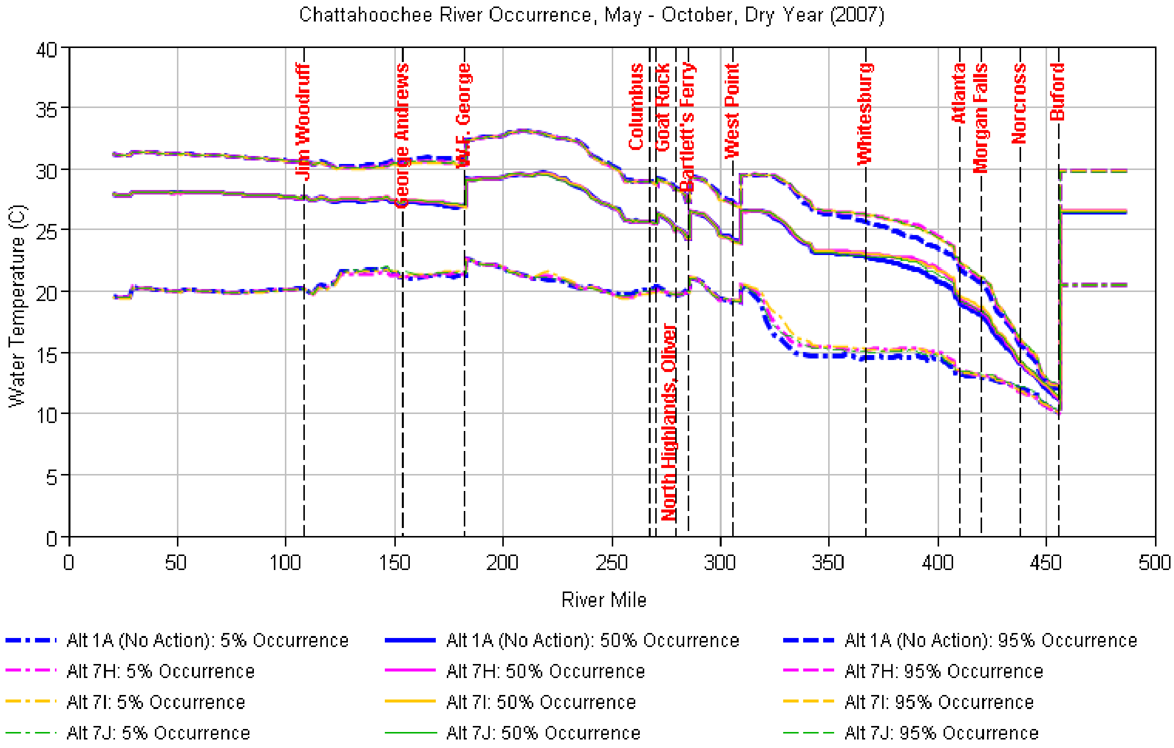


Figure 31. May through October water temperatures along the Chattahoochee River for the modeled period (2001-2011).



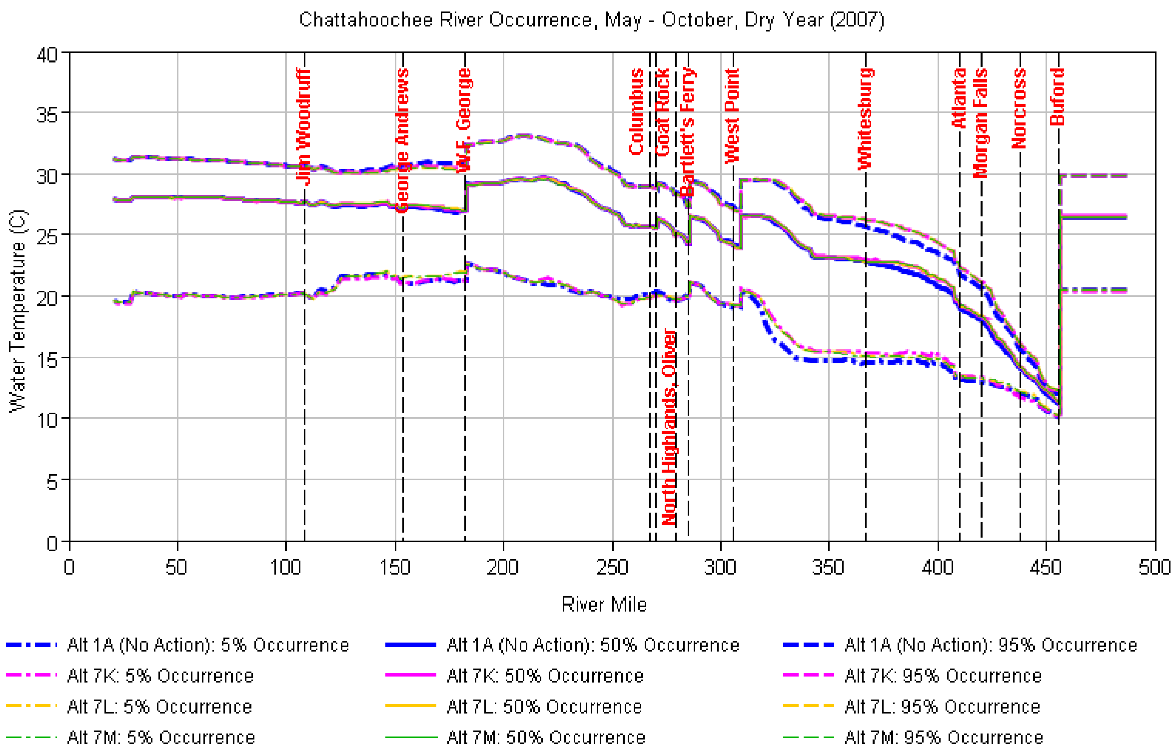
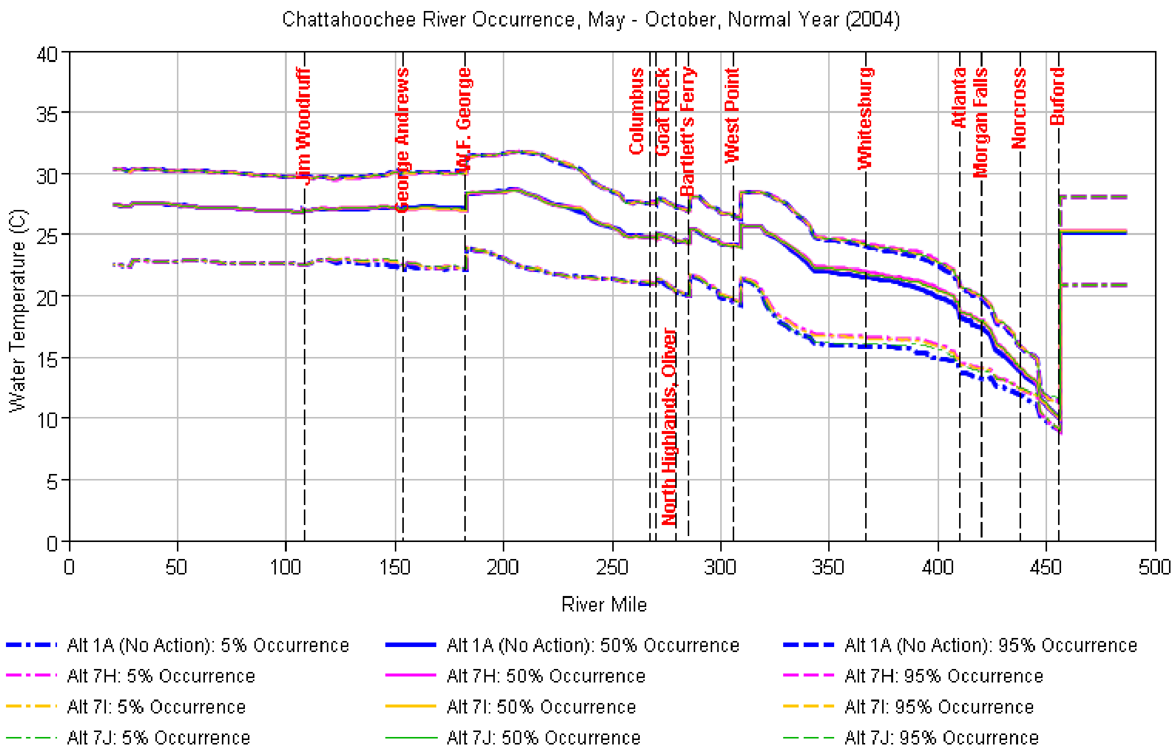


Figure 32. May through October water temperatures along the Chattahoochee River for a representative dry year (2007).



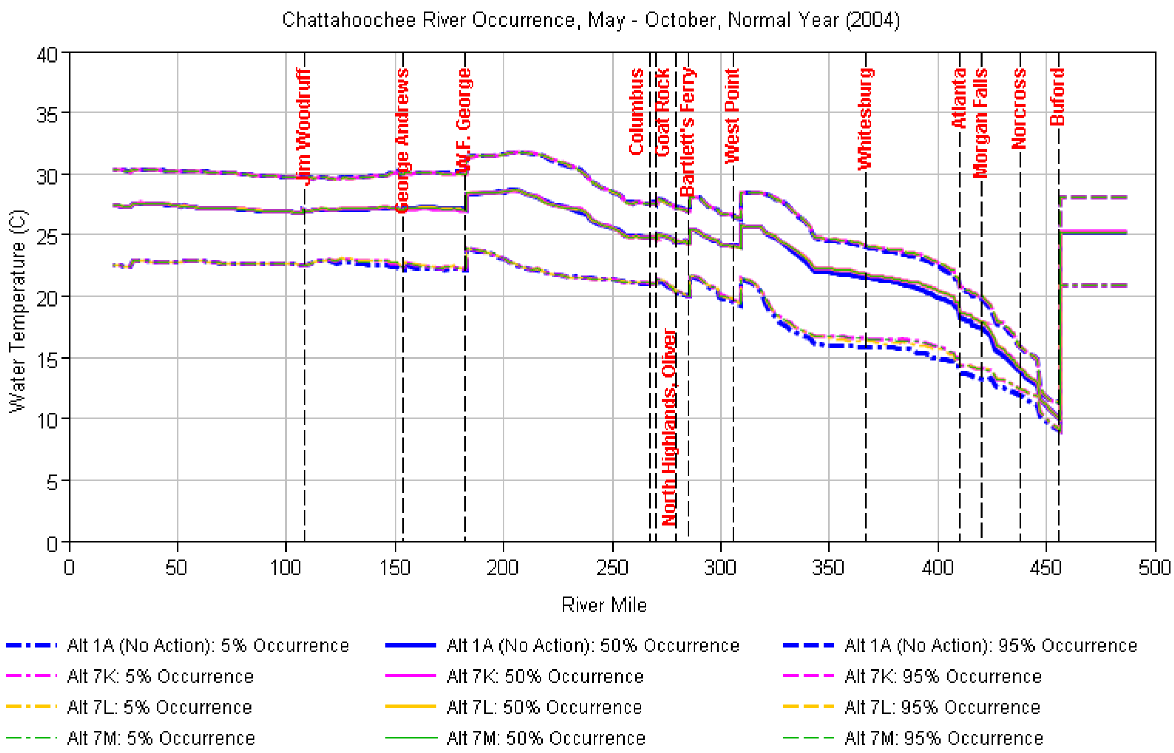


Figure 33. May through October water temperatures along the Chattahoochee River for a representative normal year (2004).

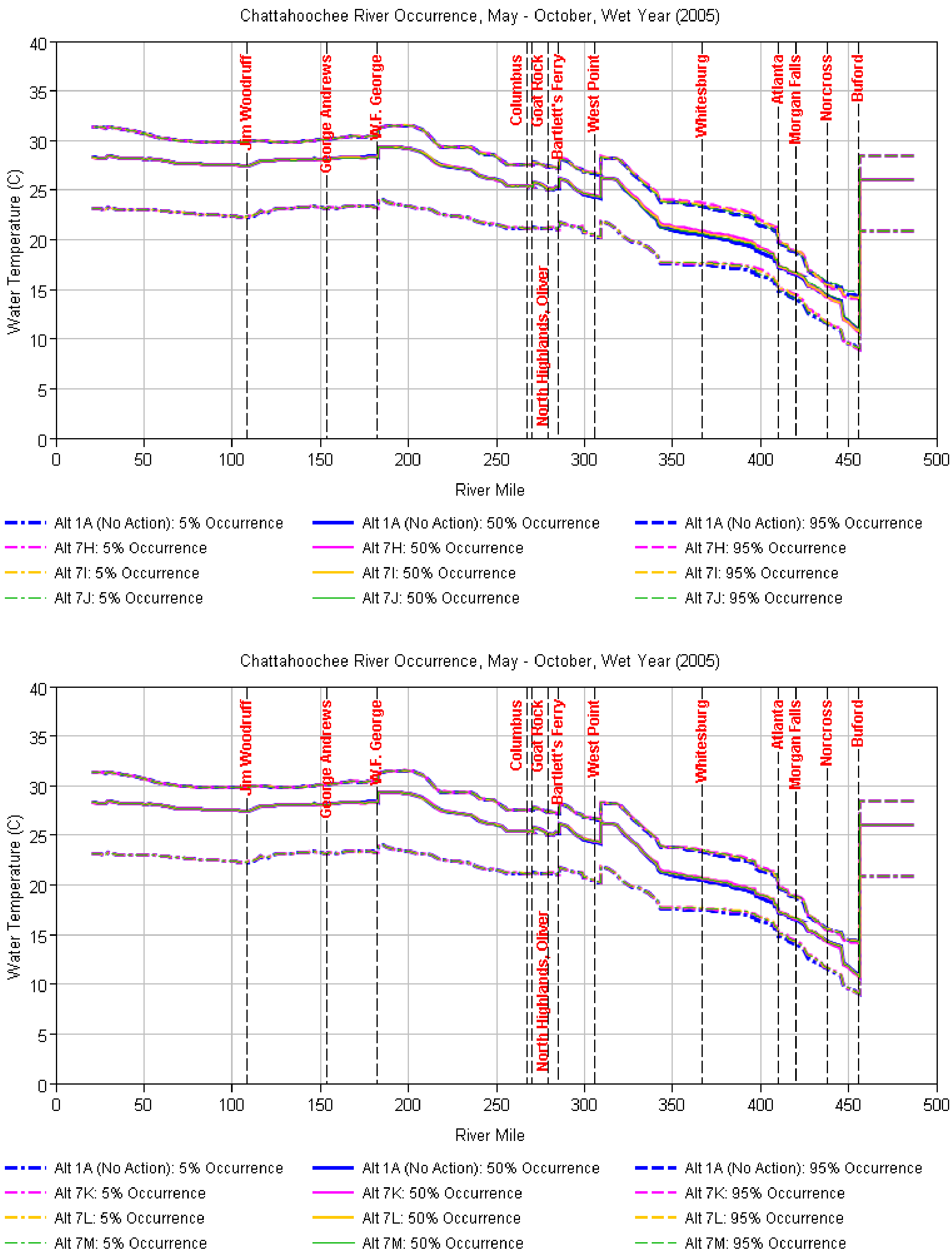
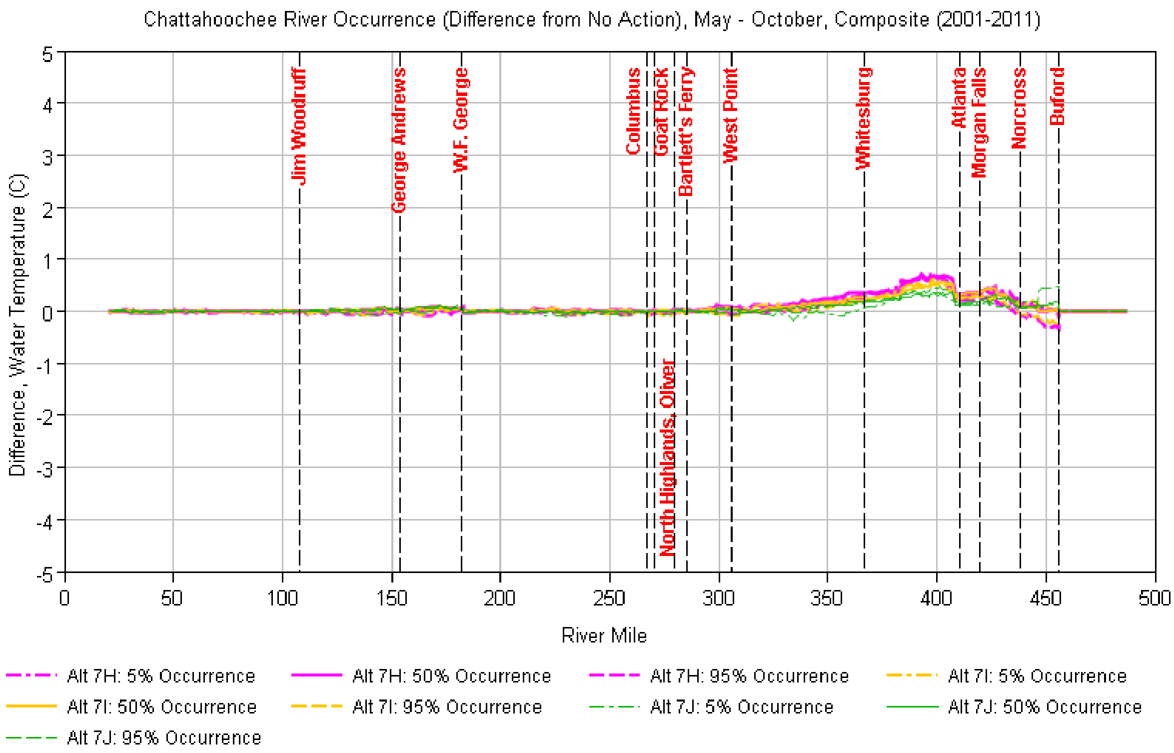


Figure 34. May through October water temperatures along the Chattahoochee River for a representative wet year (2005).



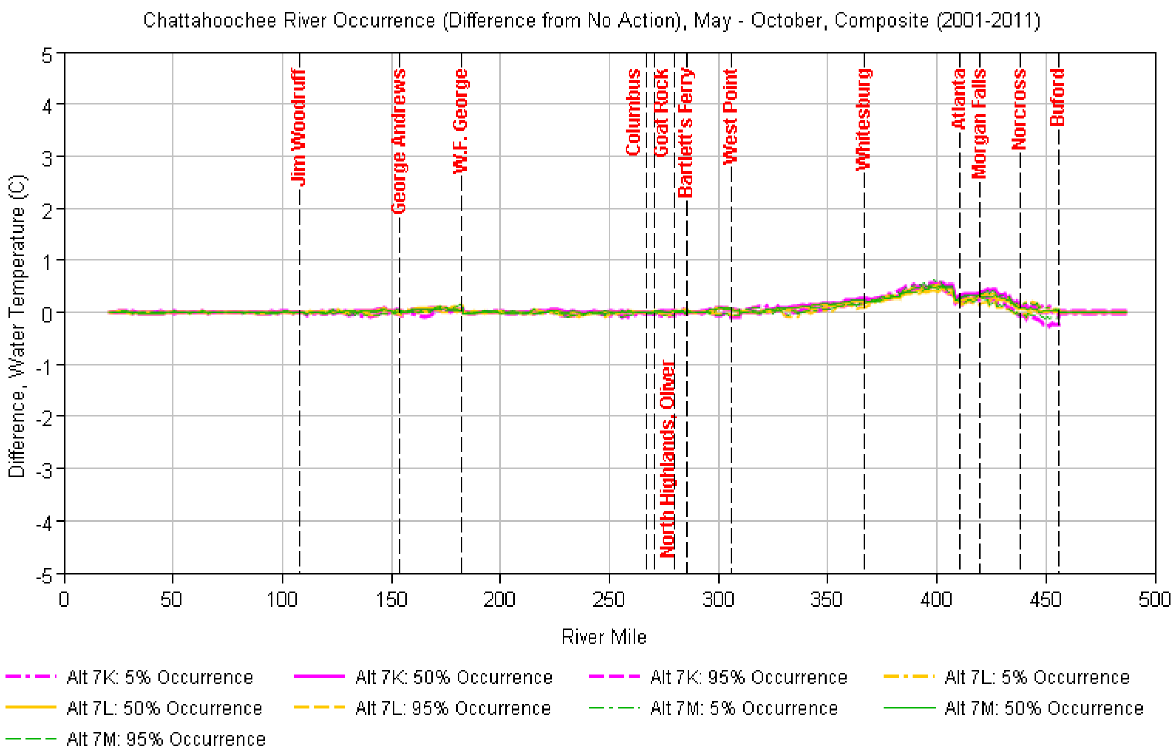
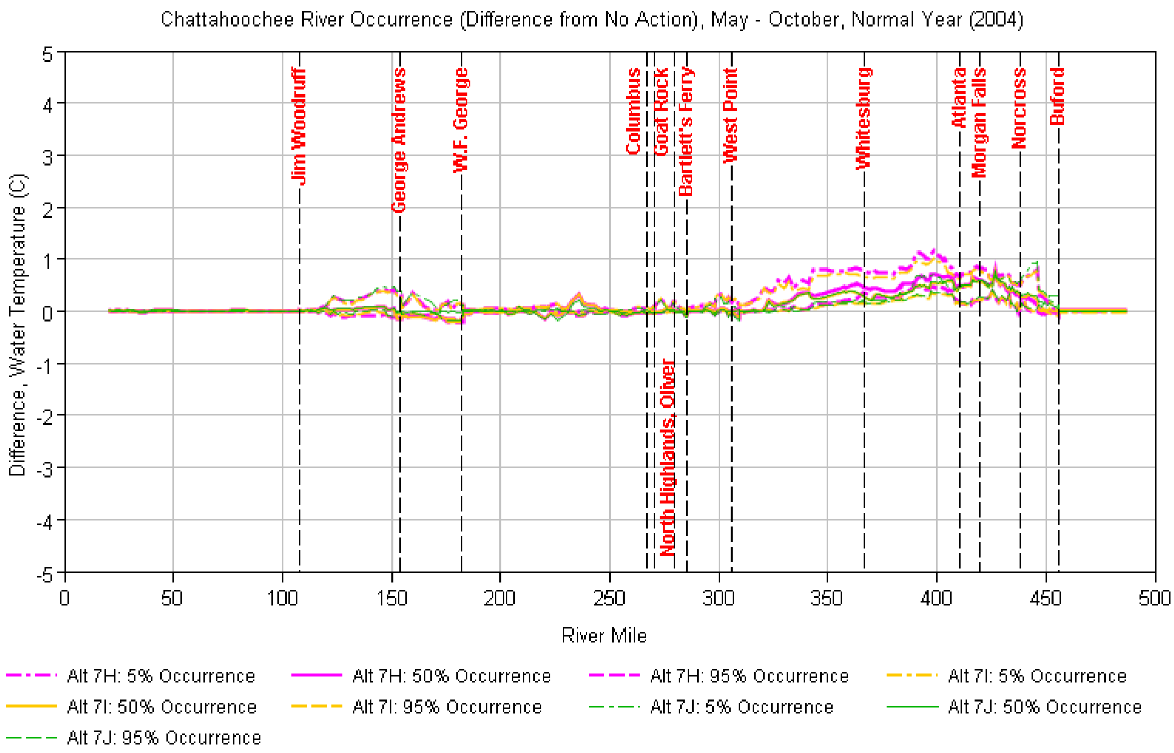


Figure 35. Changes in longitudinal water temperature in the Chattahoochee River for April through October for the modeled period from 2001 through 2011.



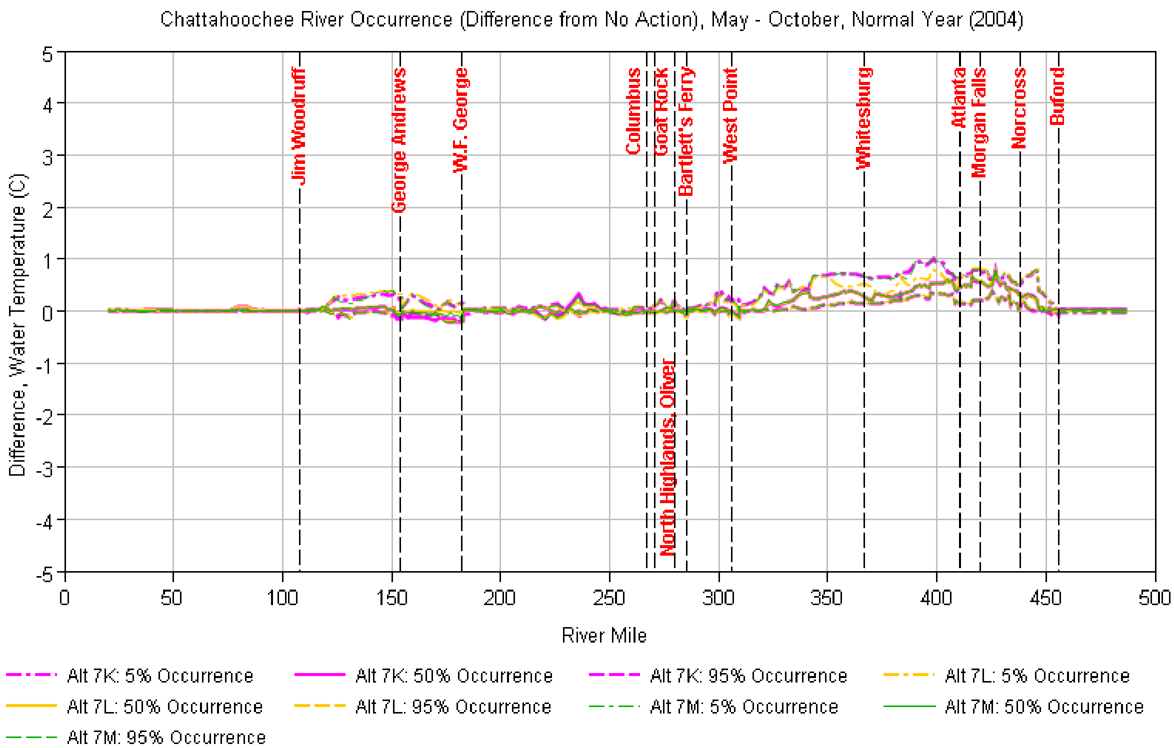
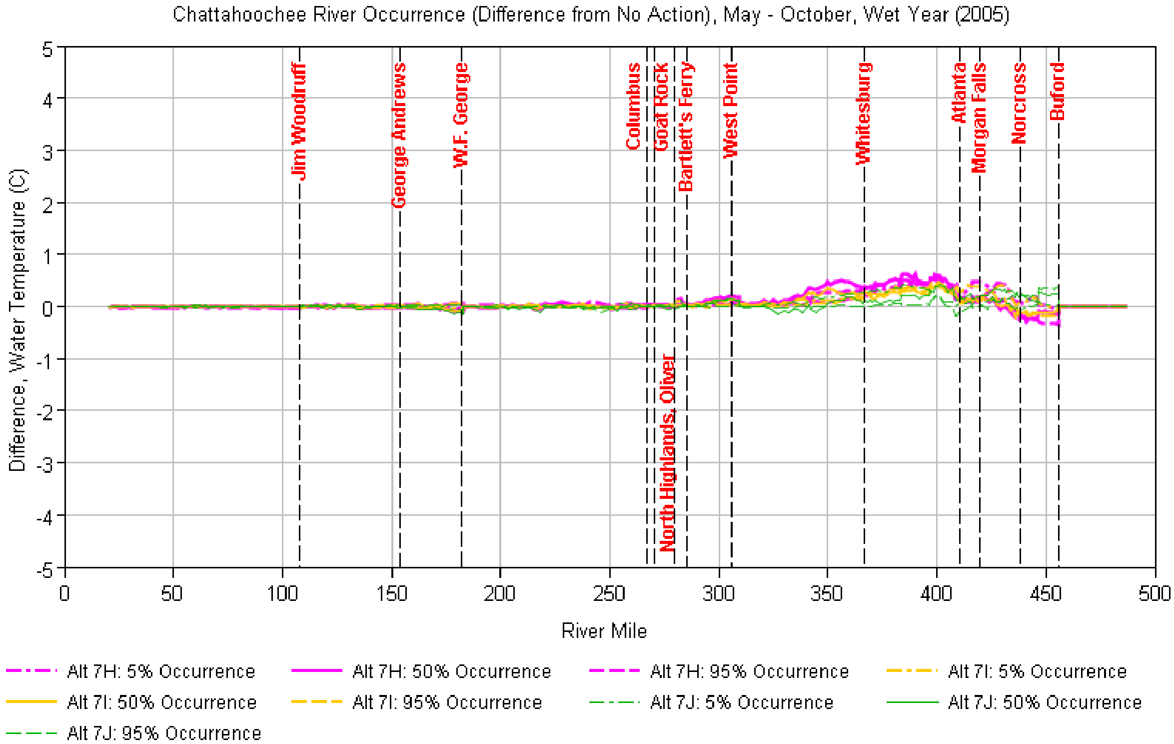


Figure 36. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a normal year (2004).



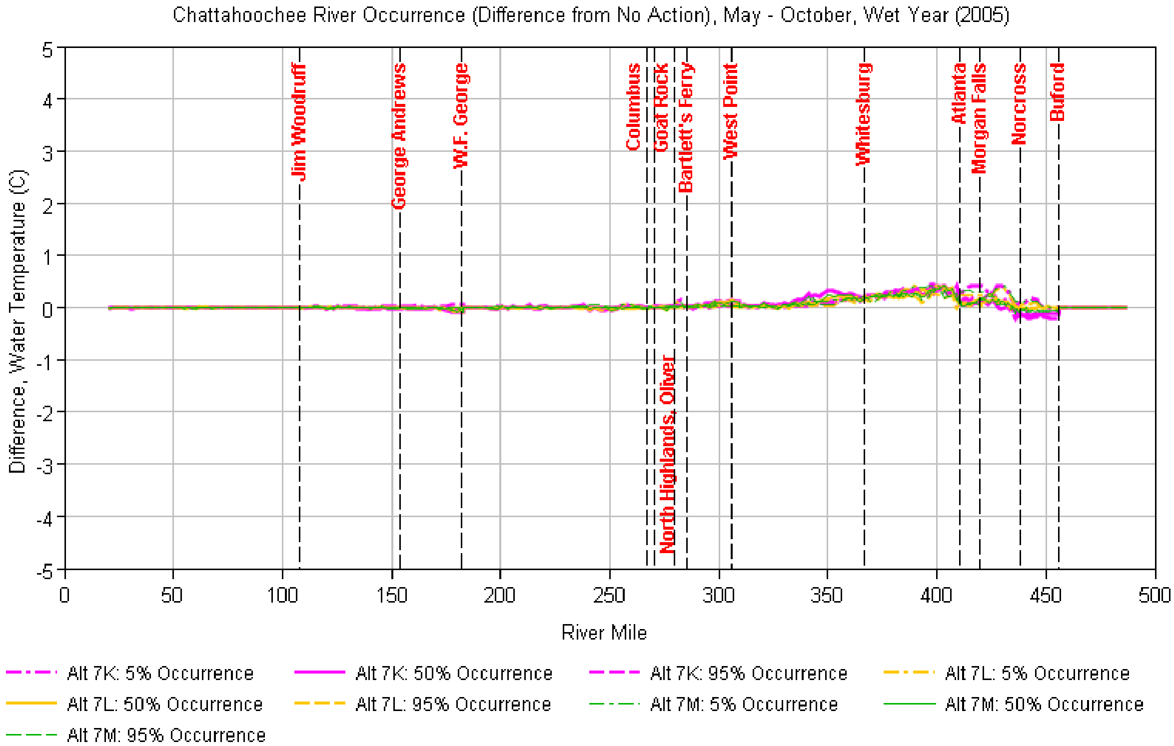


Figure 37. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a wet year (2005).

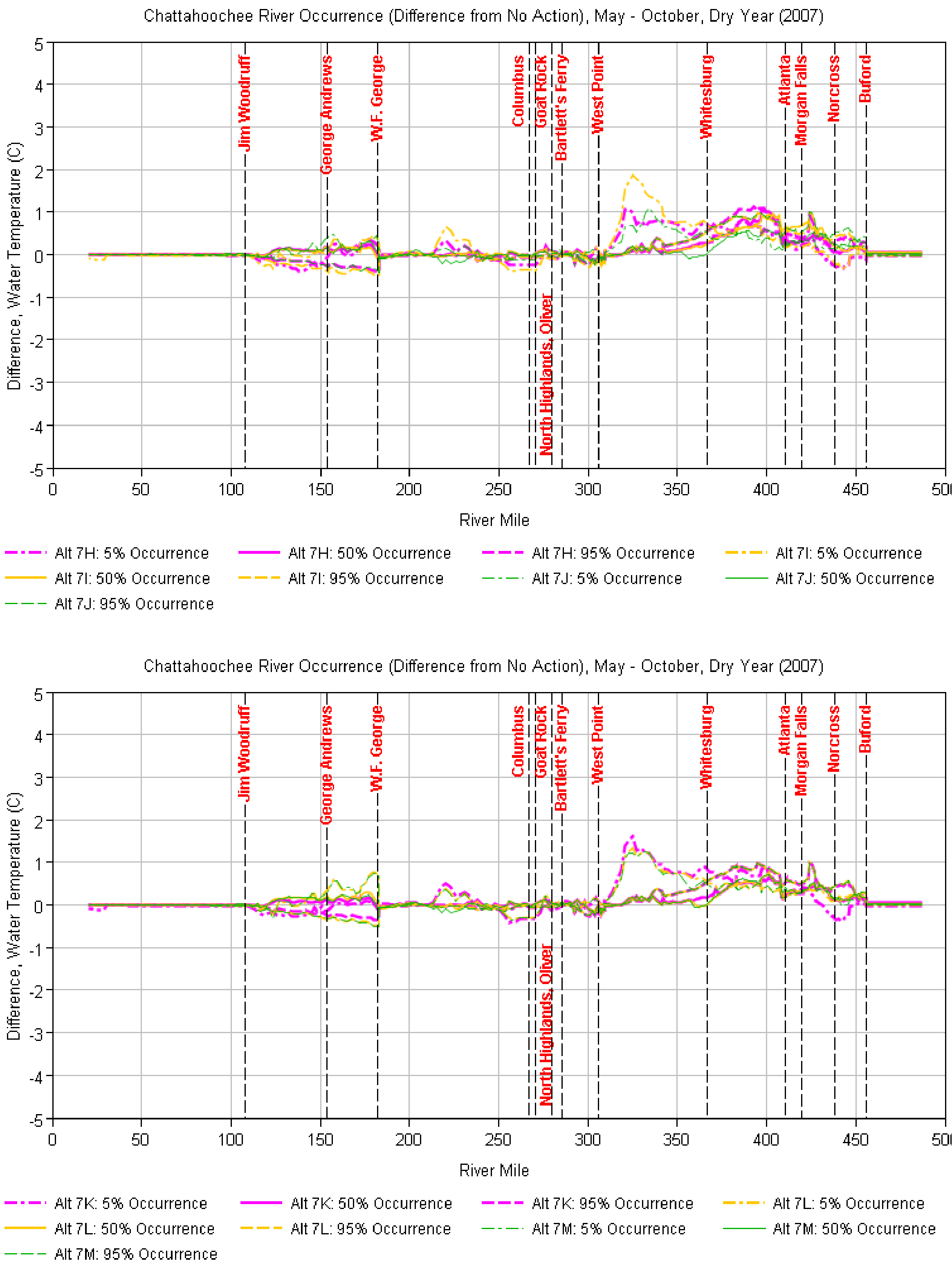
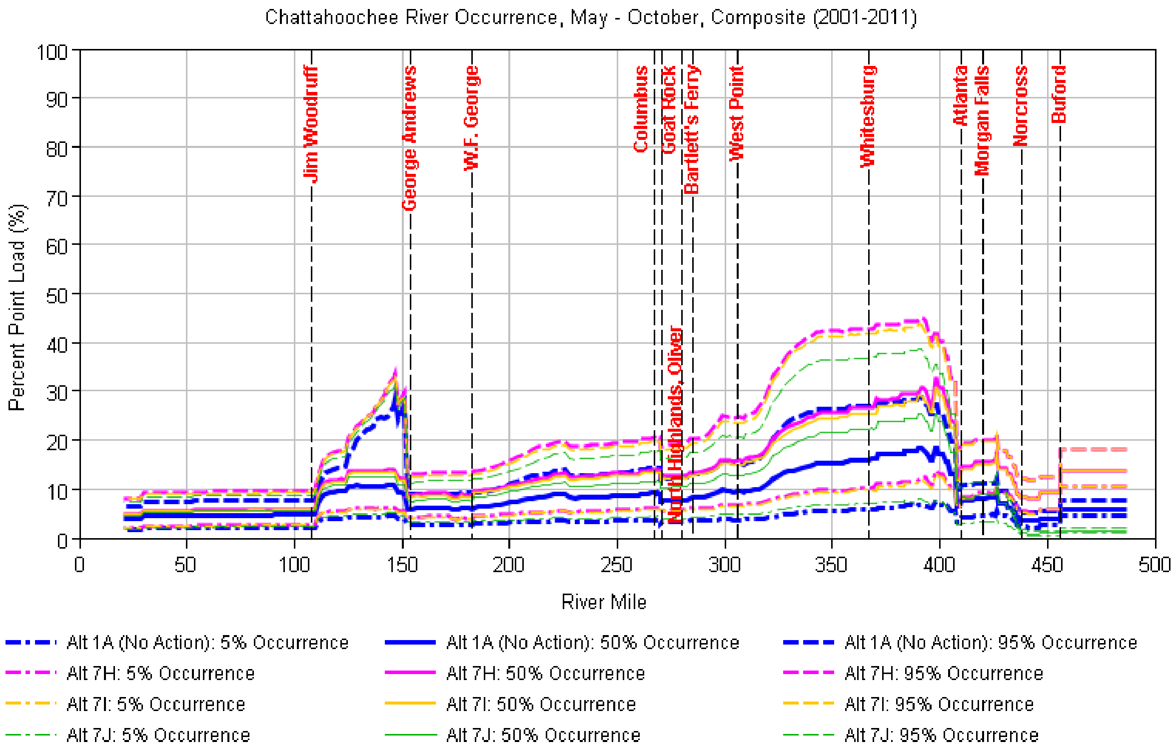


Figure 38. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a dry year (2007).

2.1.3 Wastewater

a. Average stream percent wastewater.

Average stream flow percent that is wastewater is presented for May through October in Figures 39 through 42; these figures also present the 5th and 95th percent occurrences. As shown, the percent wastewater is highest in the PAA (Alt7K) for all flow conditions including representative dry, normal, and wet weather years. The results of Alt7H presented here are also slightly higher than in the 2015 PAL response because of updates made to the HEC-5Q modeling based on the comments received. Comparing the two plots provided for each figure, the percent of flow that is wastewater for Alt7H and the PAA (Alt7K) are similar.



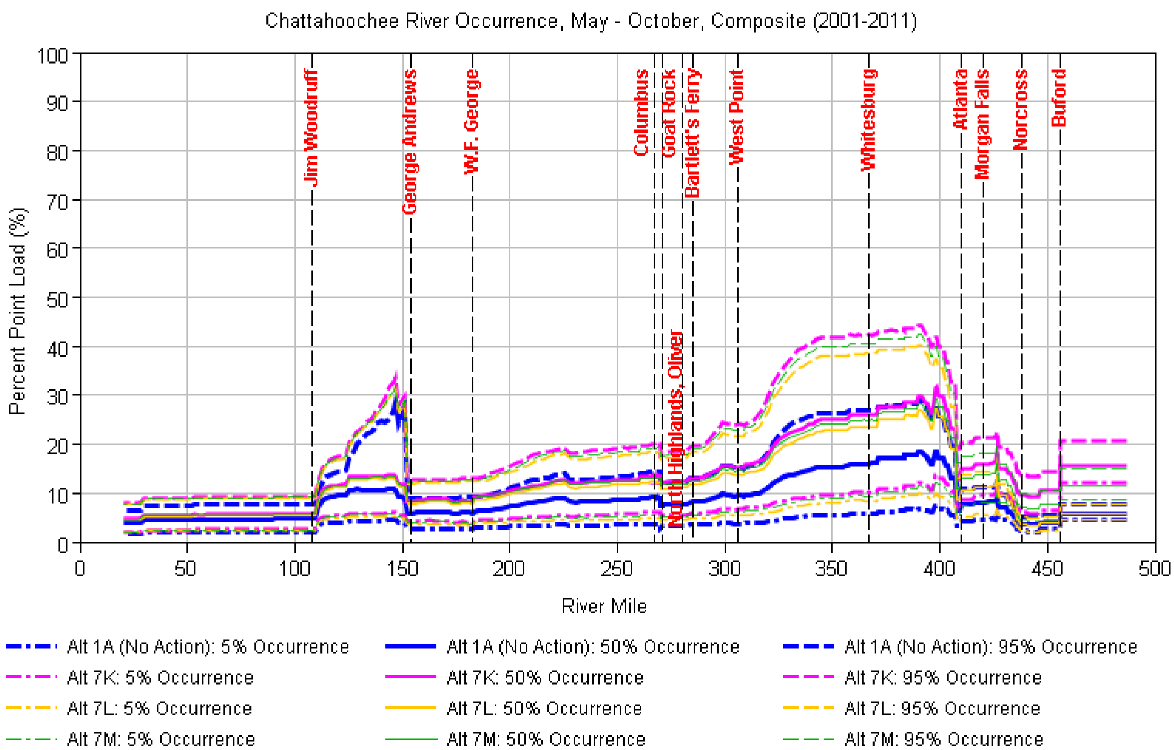
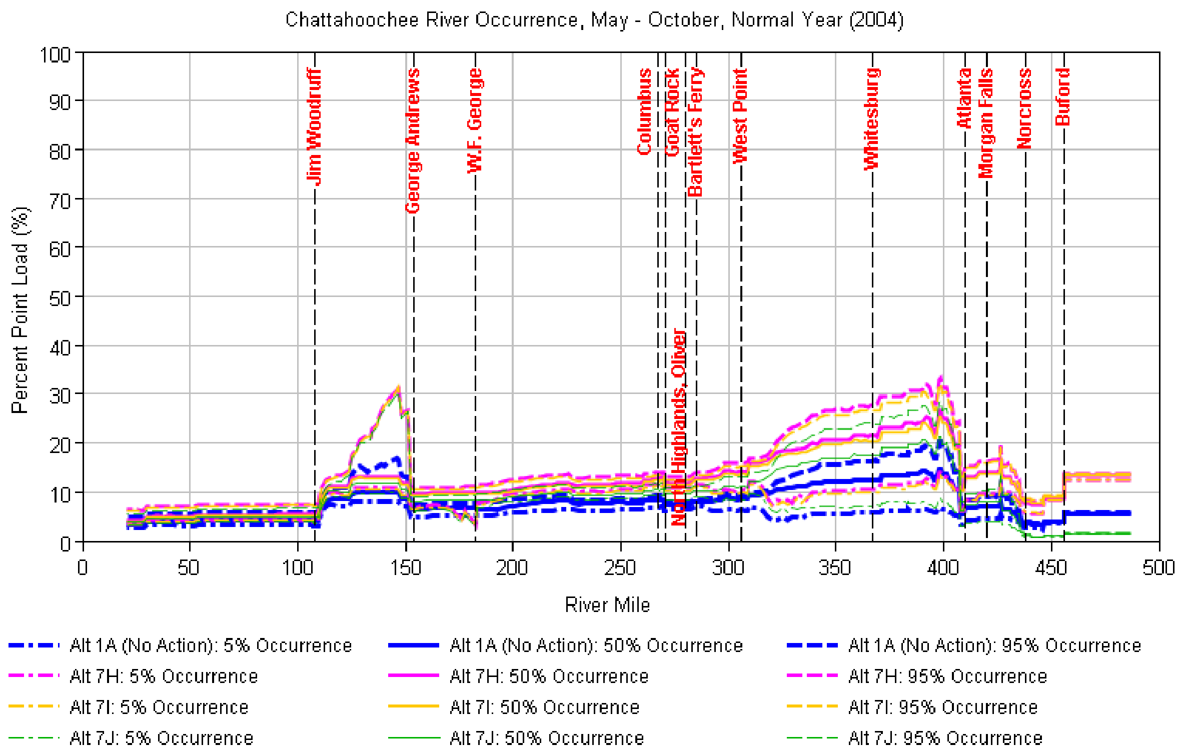


Figure 39. Percent of total flow that is wastewater along the Chattahoochee River for May through October of the modeled period (2001-2011).



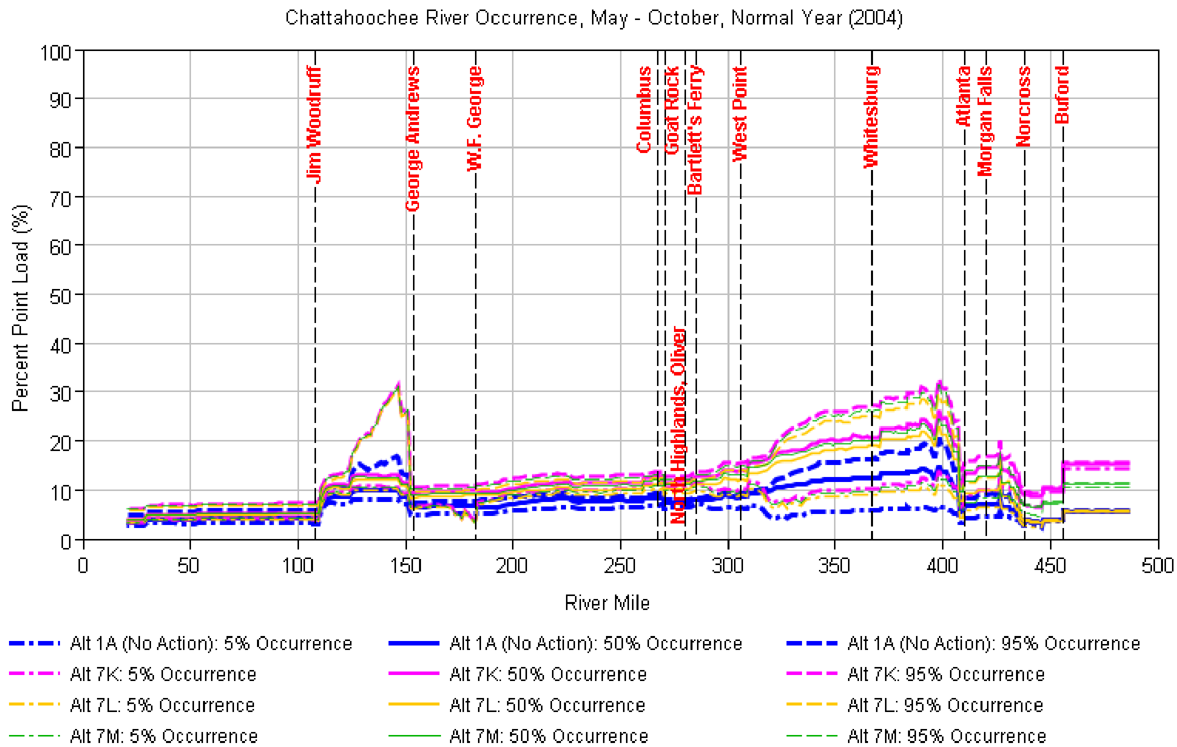
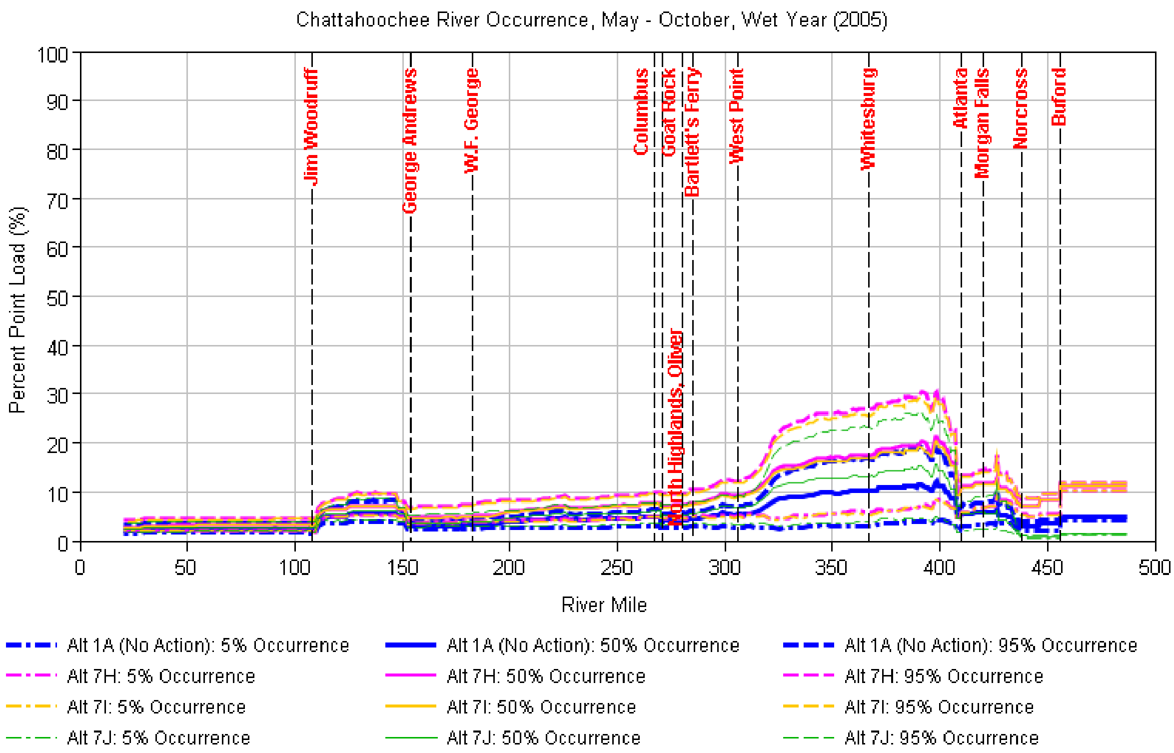


Figure 40. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative normal year (2004).



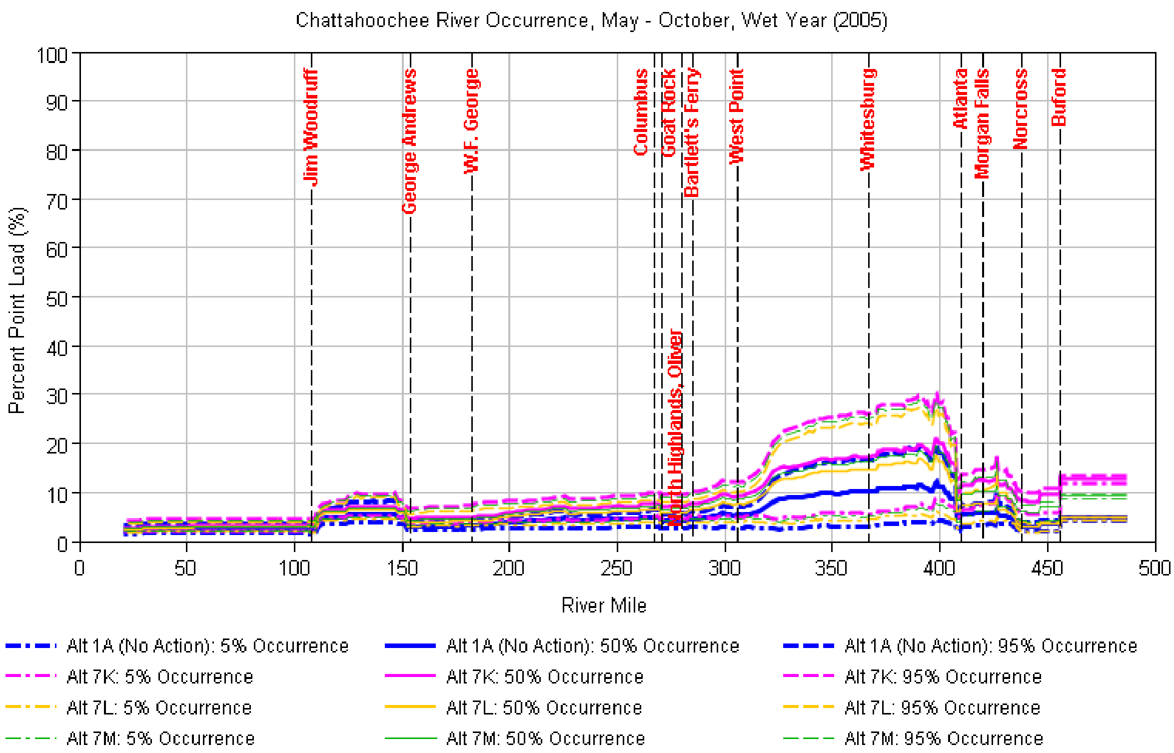
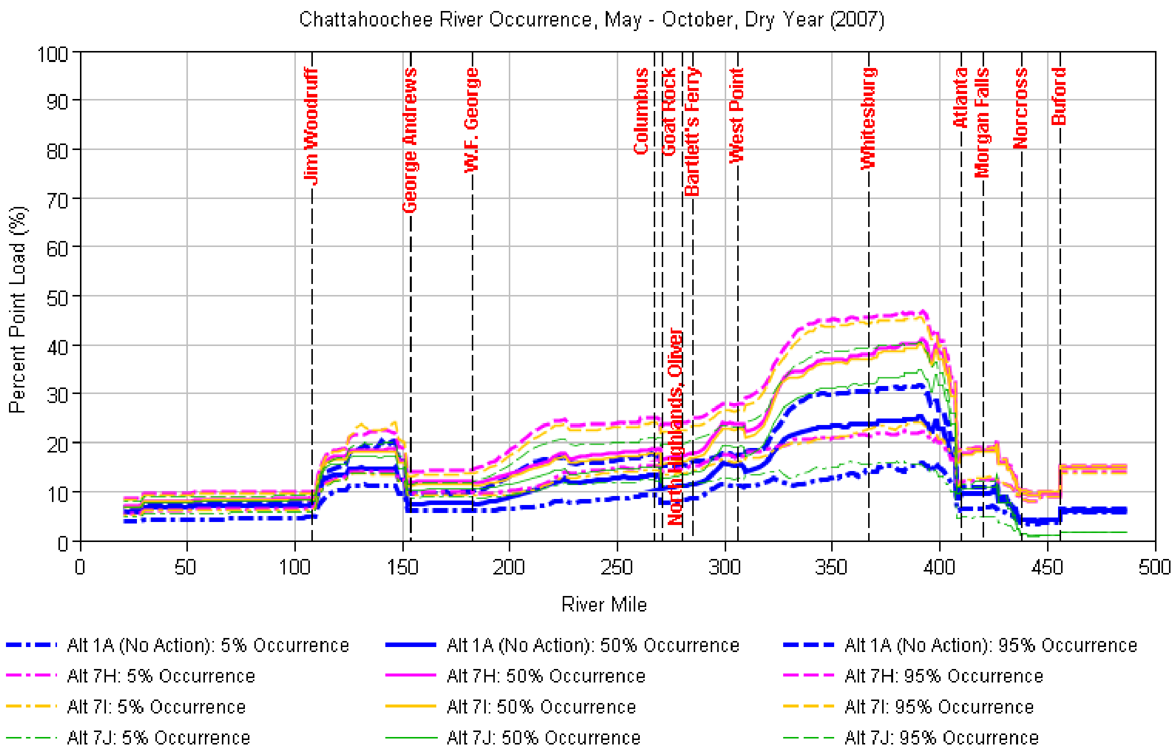


Figure 41. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative wet year (2005).



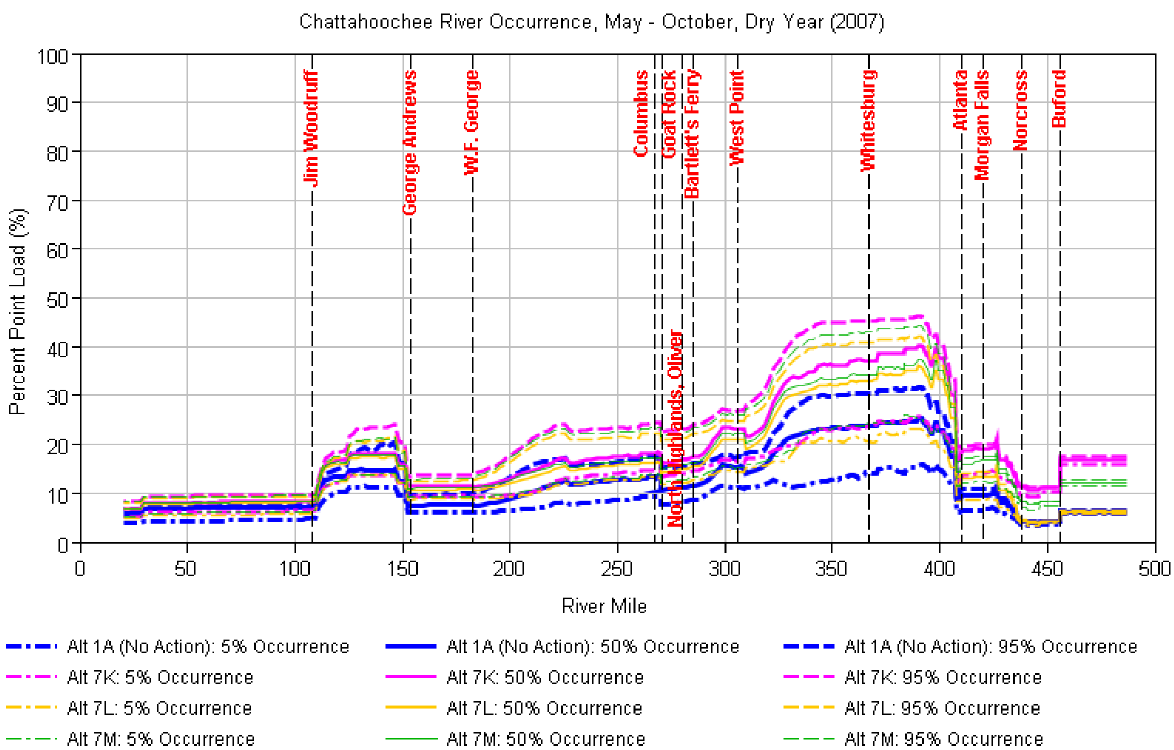
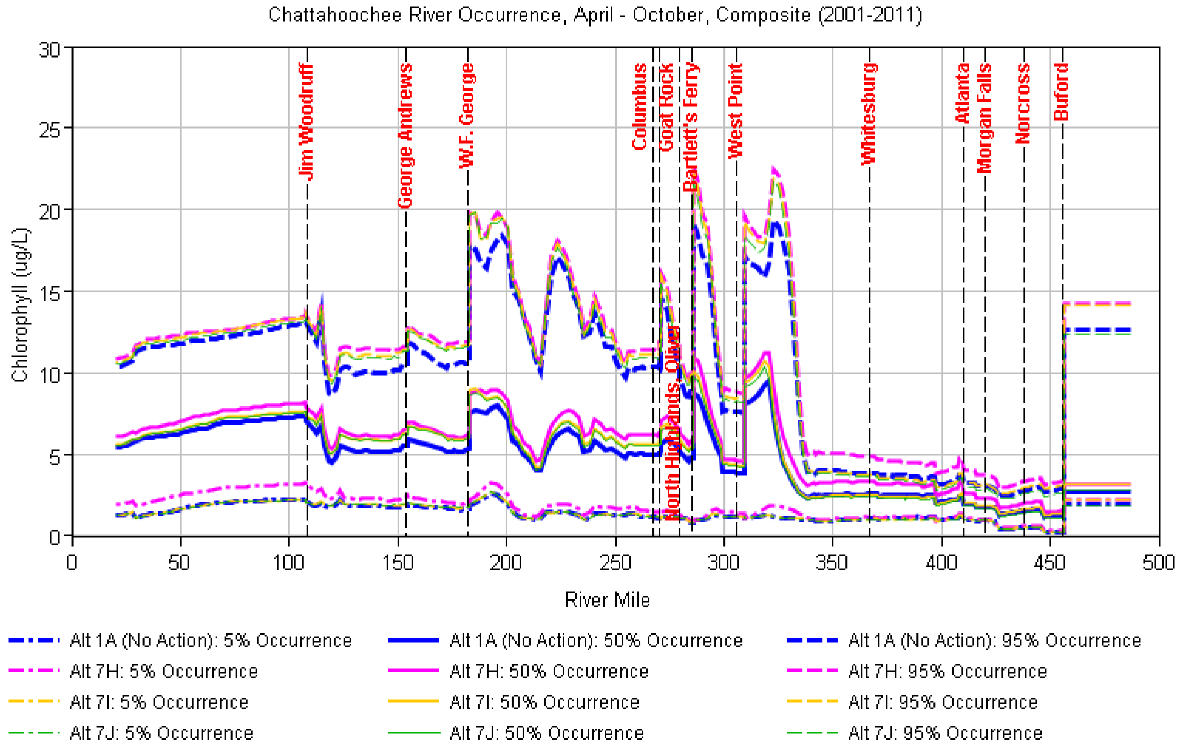


Figure 42. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative dry year (2007).

2.1.4 Chlorophyll a

a. Average values of summer Chlorophyll *a* (*u*g/L)

Chlorophyll *a* in various rainfall conditions is presented for the system in Figures 43 through 46. Figures 47 through 49 illustrate changes in chlorophyll *a* from the NAA in locations where the greatest changes would be expected. The greatest changes would be expected in West Point Lake, Bartletts Ferry Lake, and Walter F. George Lake in extreme conditions. Tables to follow presents the growing season (April through October) average (Table 7) and annual geometric mean (Table 8) of chlorophyll *a* in USACE reservoirs.



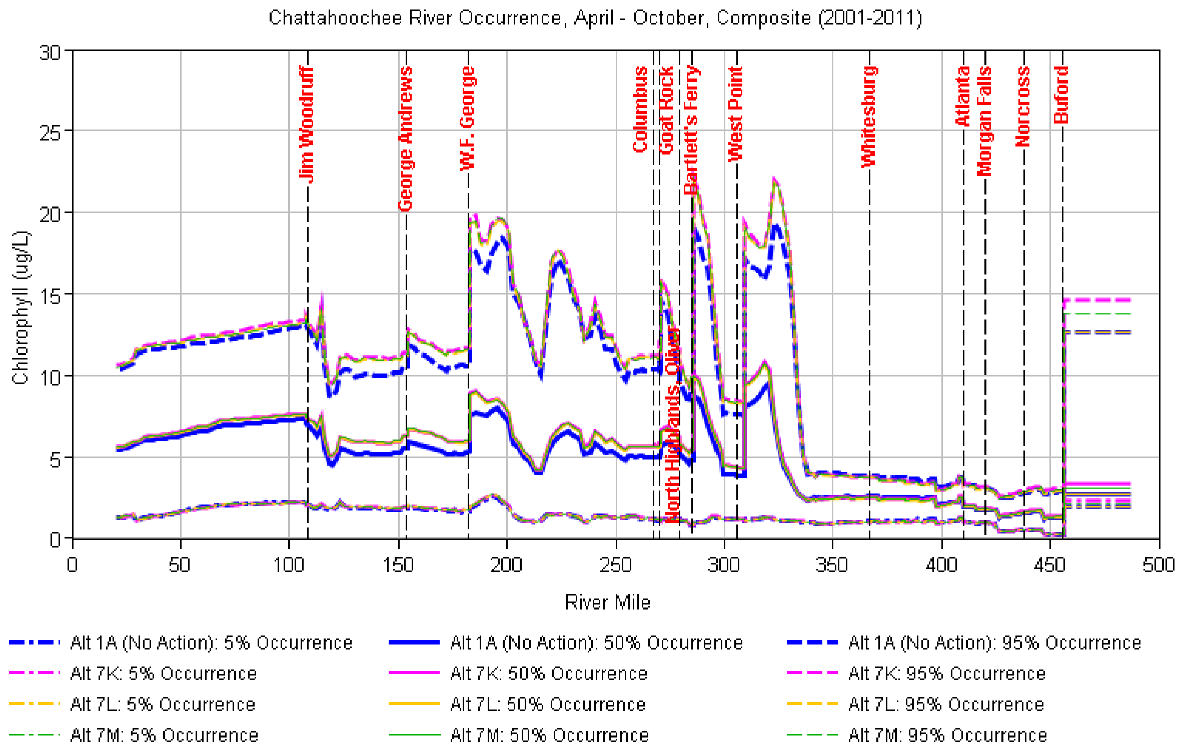


Figure 43. Chlorophyll *a* along the Chattahoochee River for April through October of the modeled period (2001-2011).

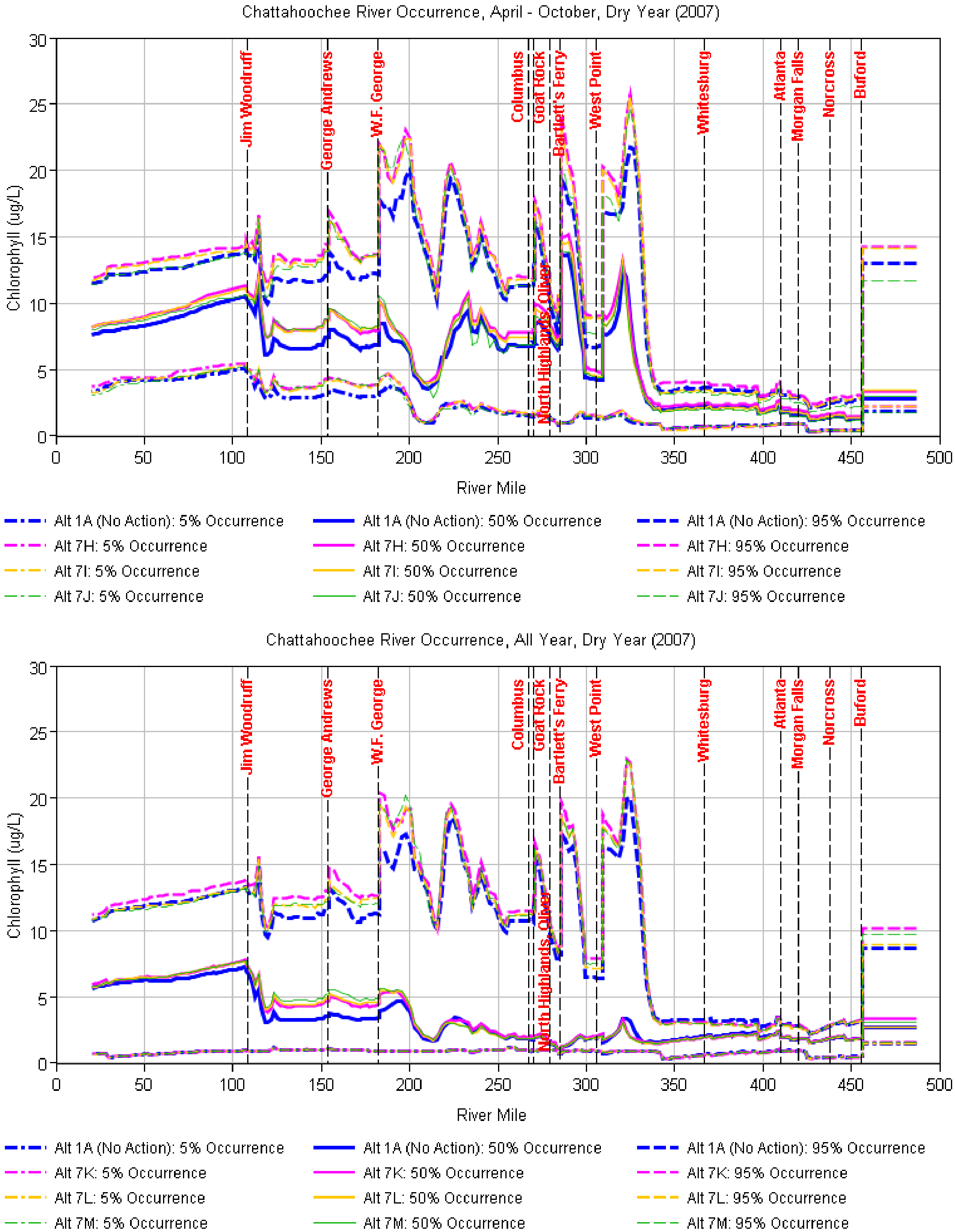


Figure 44. Chlorophyll *a* along the Chattahoochee River for April through October in a representative dry year (2007).

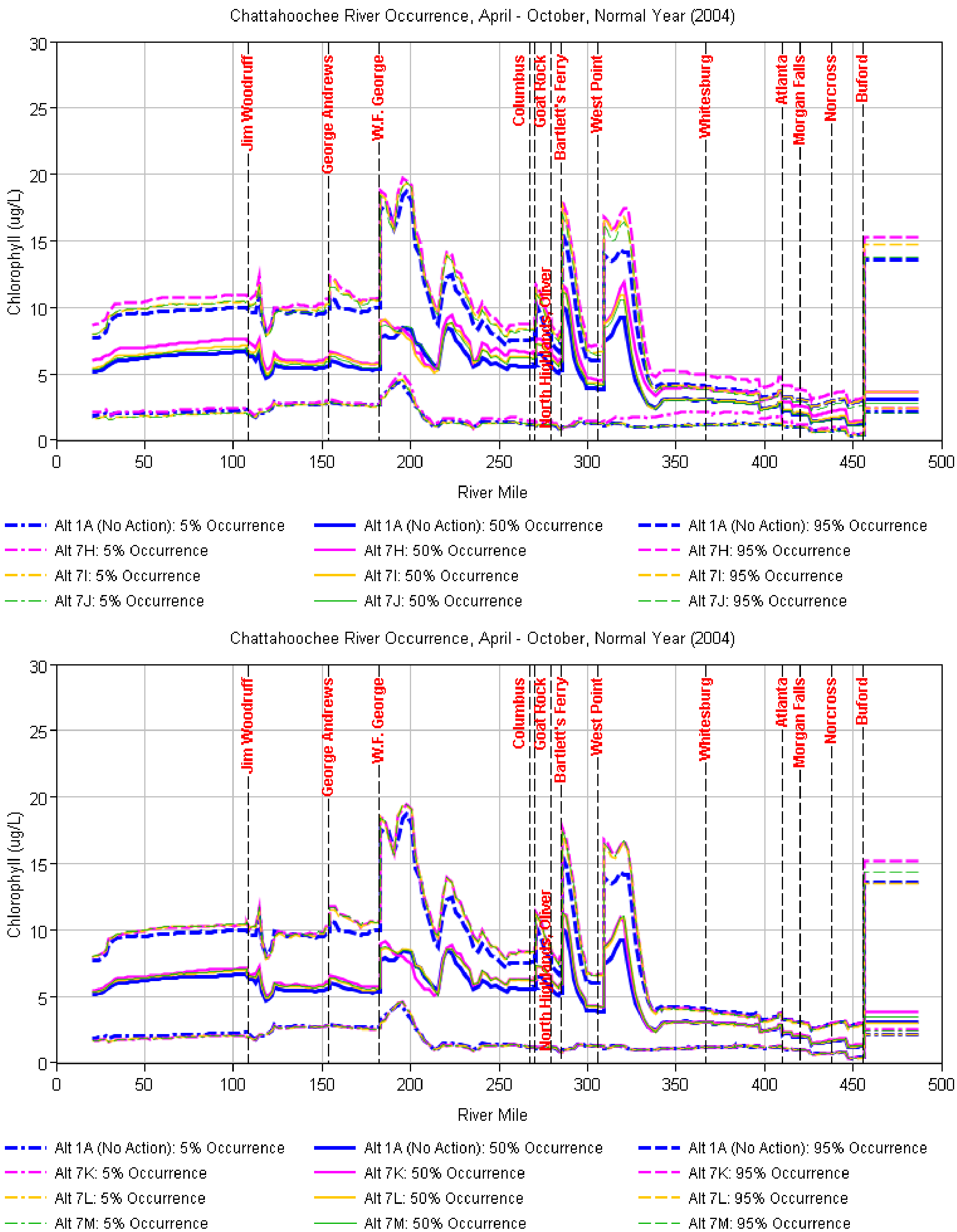


Figure 45. Chlorophyll *a* along the Chattahoochee River for April through October in a representative normal year (2004).

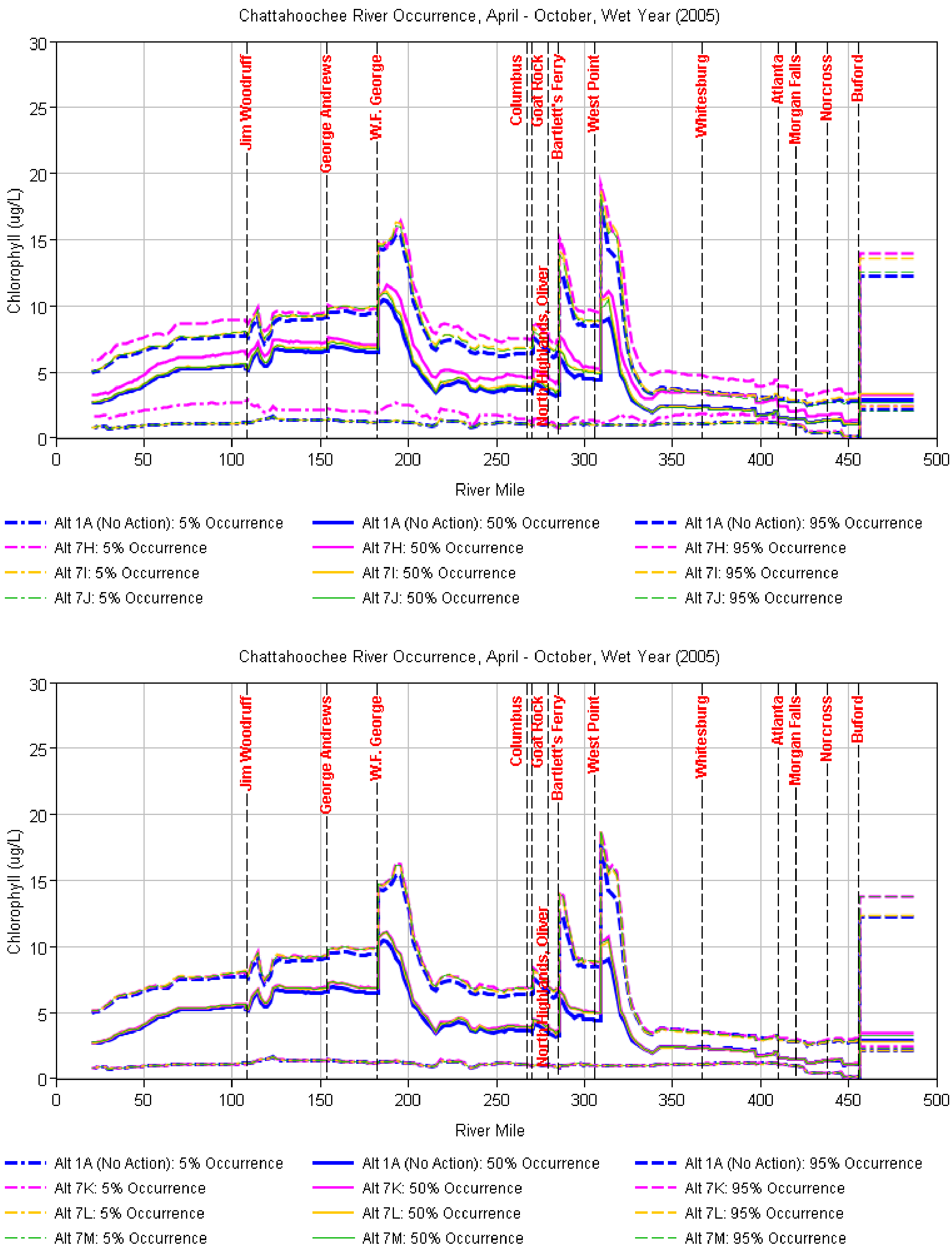
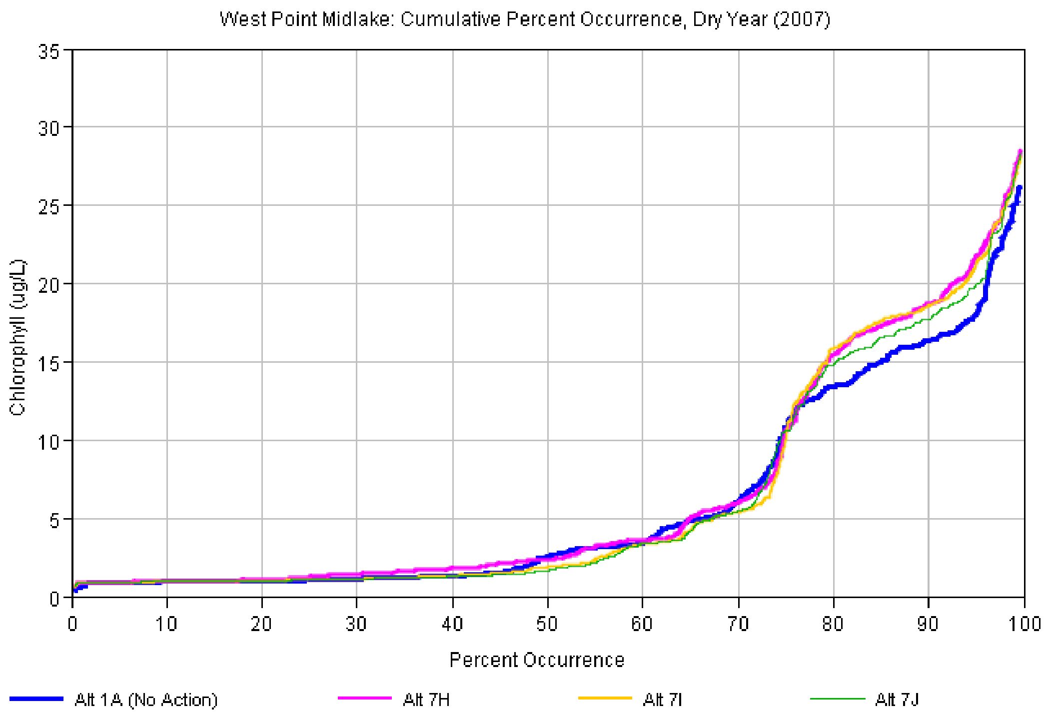


Figure 46. Chlorophyll *a* along the Chattahoochee River for April through October in a representative wet year (2005).



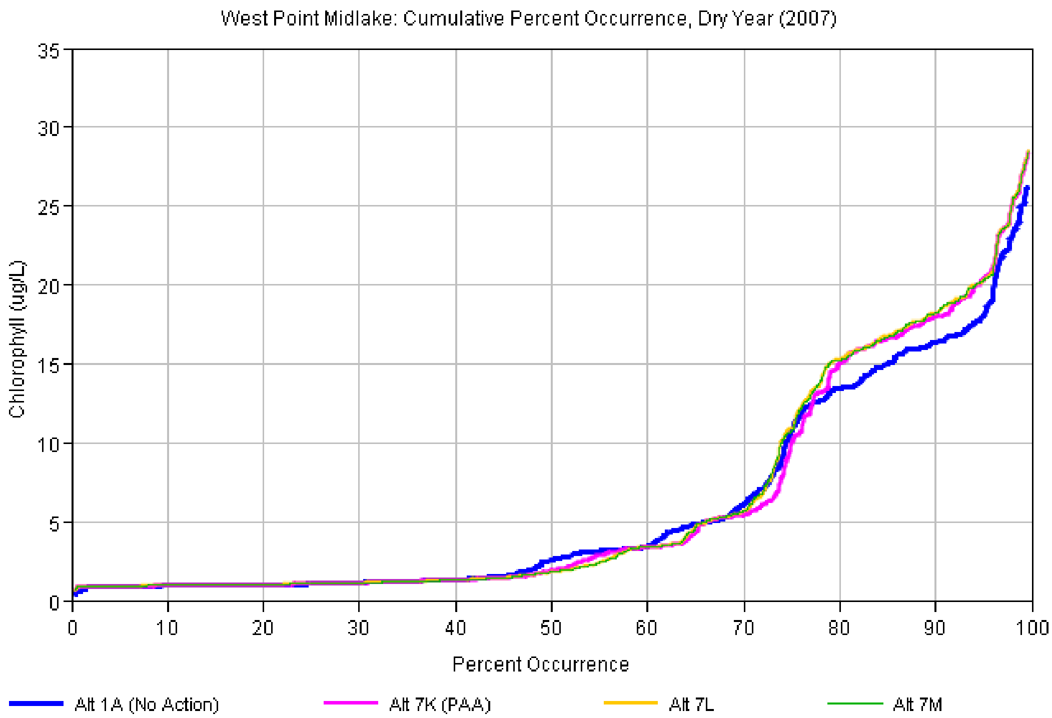
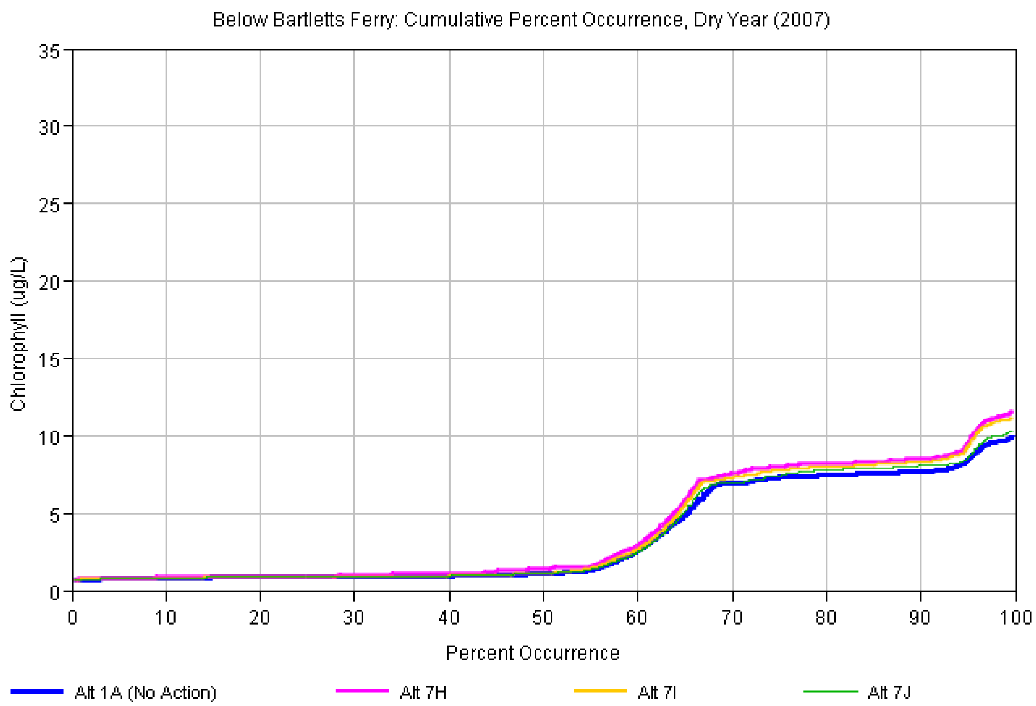


Figure 47. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of West Point Lake for a representative dry year (2007).



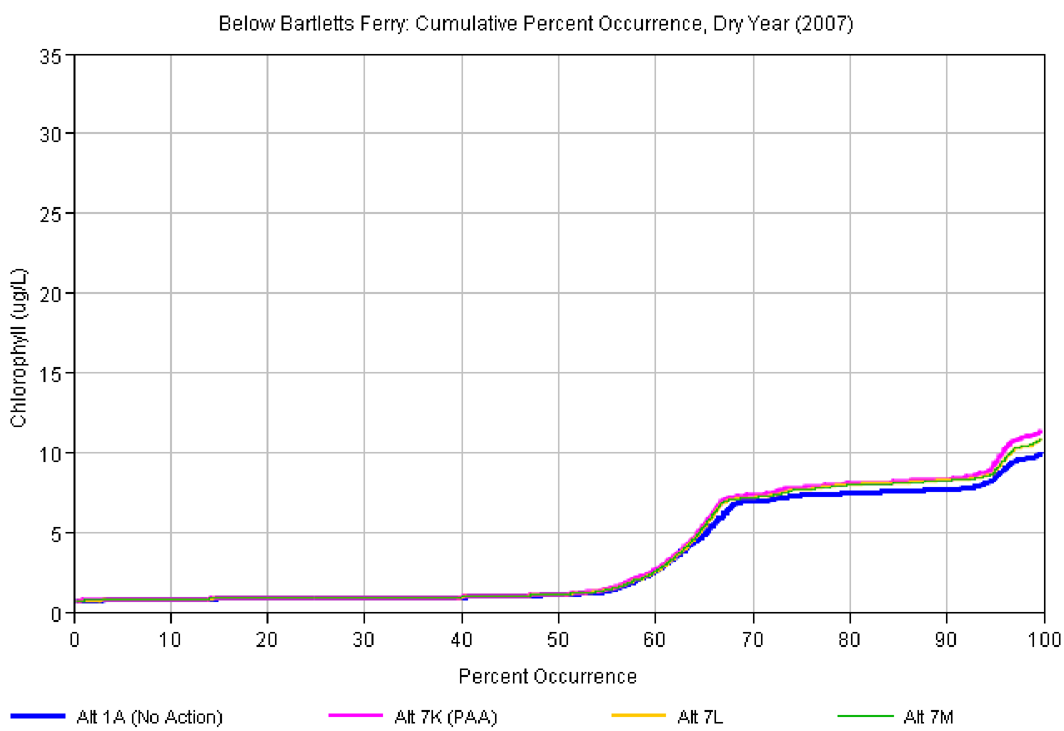


Figure 48a. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Bartletts Ferry Lake for a representative dry year (2007). [Note that the figure title from the 2015 PAL was consistent with the title here but the figures indicated that they were Below Bartlett's Ferry. Therefore, the figures presented here are Below Barletts Ferry.]

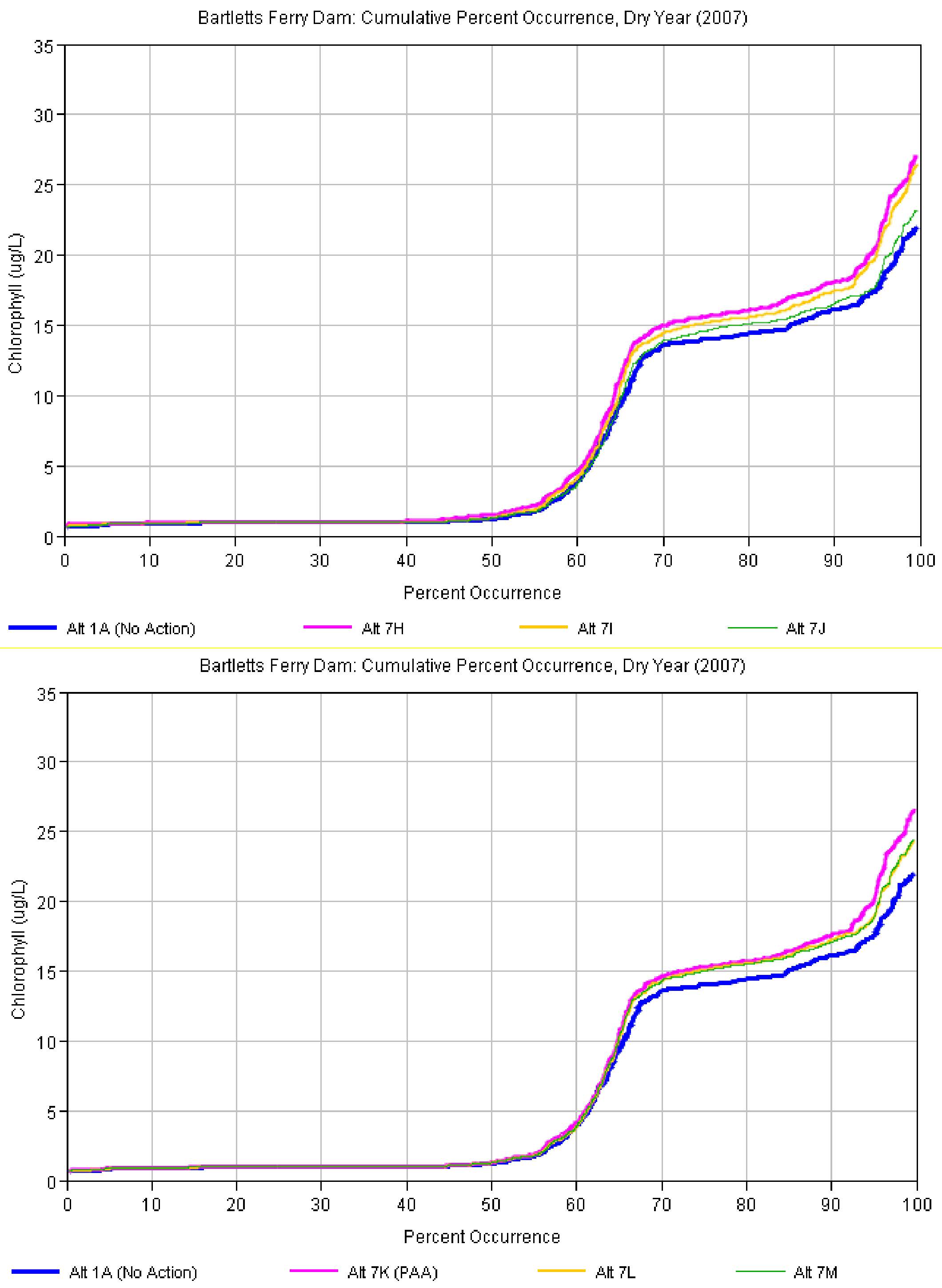


Figure 48b. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Bartletts Ferry Lake for a representative dry year (2007). [Note that this is a new figure that was not included in the 2015 PAL. This figure was added to present the highest modeled chlorophyll *a* conditions in Barletts Ferry Lake.]

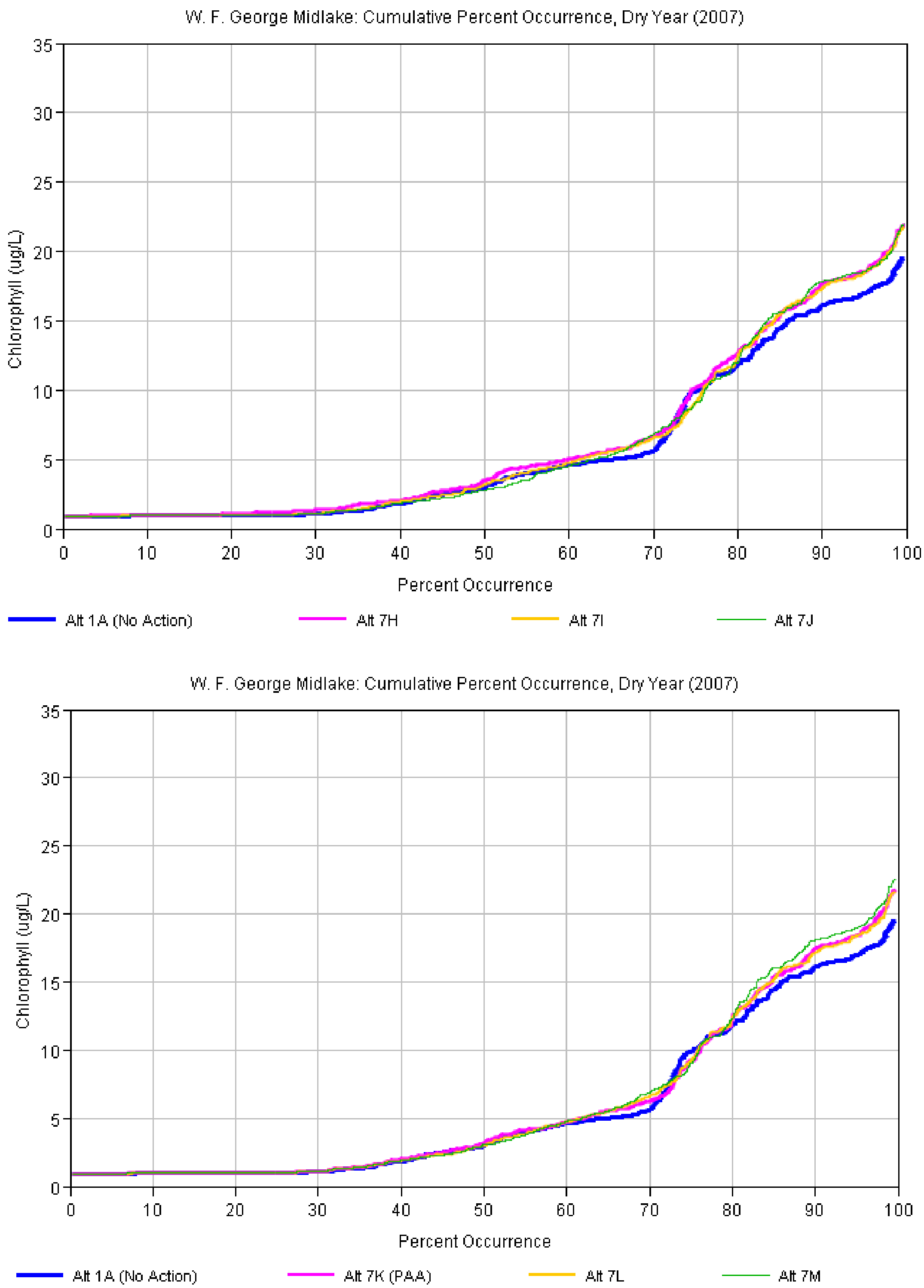


Figure 49. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Walter F. George Lake for a representative dry year (2007).

Table 7. Growing season (April-October) average of chlorophyll *a* at USACE reservoirs in the ACF Basin

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
Lake Lanier					
2000	5.2	5.7	5.8	0.5	0.7
2001	3.8	4.2	4.3	0.4	0.5
2002	4.2	4.9	5.1	0.7	0.9
2003	3.8	4.4	4.5	0.5	0.7
2004	4.6	5.2	5.4	0.7	0.8
2005	4.3	4.8	5.0	0.5	0.7
2006	4.1	4.7	4.9	0.6	0.8
2007	4.2	4.9	5.2	0.7	1.0
2008	4.0	4.7	5.0	0.7	0.9
2009	4.2	4.8	5.0	0.6	0.8
2010	4.0	4.6	4.7	0.7	0.7
2011	4.3	4.9	5.1	0.7	0.8
West Point MidLake					
2000	8.5	12.6	11.8	4.1	3.3
2001	7.1	8.3	7.0	1.2	-0.1
2002	10.8	12.0	11.1	1.3	0.3
2003	2.9	4.5	3.0	1.7	0.1
2004	4.6	6.5	5.1	1.9	0.6
2005	2.9	4.3	3.1	1.3	0.1
2006	6.3	7.6	6.7	1.3	0.4
2007	9.2	10.0	9.6	0.8	0.4
2008	10.0	11.3	10.4	1.3	0.3
2009	6.9	9.3	8.1	2.4	1.2
2010	5.3	6.7	5.7	1.5	0.5
2011	7.5	9.9	9.3	2.4	1.9
West Point Dam					
2000	9.8	11.2	10.9	1.4	1.1
2001	8.2	9.3	9.2	1.2	1.0

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2002	9.1	10.5	10.3	1.4	1.3
2003	8.4	10.0	9.3	1.6	0.9
2004	7.0	8.3	8.1	1.3	1.1
2005	7.8	9.0	8.7	1.2	0.9
2006	7.9	8.9	8.8	1.0	0.9
2007	7.7	8.8	8.6	1.1	0.9
2008	8.5	10.0	9.9	1.5	1.4
2009	7.0	8.2	7.9	1.2	0.9
2010	6.5	7.8	7.5	1.3	1.0
2011	8.0	9.4	9.1	1.4	1.2
Walter MidLake					
2000	9.1	10.0	9.6	0.9	0.5
2001	7.3	8.4	7.7	1.1	0.5
2002	8.0	9.0	8.7	1.0	0.7
2003	4.1	5.2	4.3	1.1	0.2
2004	6.9	7.8	7.3	1.0	0.4
2005	4.2	5.3	4.5	1.1	0.3
2006	8.1	9.3	9.0	1.2	0.9
2007	8.8	9.6	9.3	0.8	0.5
2008	9.1	10.2	9.8	1.1	0.7
2009	6.5	7.5	6.8	1.0	0.4
2010	5.6	6.4	5.9	0.8	0.4
2011	8.0	8.7	8.4	0.7	0.4
Lake Seminole MidLake					
2000	6.1	6.5	6.3	0.5	0.3
2001	3.8	4.5	4.1	0.7	0.3
2002	5.4	6.3	6.0	0.9	0.6
2003	5.5	6.4	5.7	0.9	0.2
2004	5.3	5.9	5.5	0.6	0.3
2005	5.2	5.9	5.4	0.8	0.2
2006	5.3	6.3	6.1	1.0	0.8

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2007	6.1	7.4	7.1	1.2	1.0
2008	5.4	6.3	6.1	1.0	0.7
2009	4.1	4.8	4.2	0.7	0.1
2010	4.4	4.9	4.6	0.6	0.2
2011	5.8	6.8	6.7	1.0	0.9

Table 8. Growing season (April-October) annual geometric mean of chlorophyll *a* at USACE reservoirs in the ACF Basin

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
Lake Lanier					
2000	4.1	4.6	4.7	0.5	0.7
2001	3.2	3.6	3.7	0.4	0.5
2002	3.4	4.0	4.2	0.6	0.7
2003	3.2	3.7	3.8	0.5	0.6
2004	3.7	4.3	4.5	0.6	0.7
2005	3.6	4.0	4.2	0.4	0.6
2006	3.4	3.9	4.1	0.5	0.7
2007	3.4	4.1	4.3	0.6	0.9
2008	3.2	3.8	4.0	0.6	0.8
2009	3.4	4.0	4.1	0.5	0.7
2010	3.3	3.9	3.9	0.5	0.6
2011	3.4	4.0	4.1	0.6	0.7
West Point MidLake					
2000	6.3	9.4	8.0	3.1	1.7
2001	5.8	7.2	5.8	1.4	0.0
2002	7.5	9.2	7.8	1.6	0.2
2003	2.5	4.1	2.6	1.6	0.1
2004	3.6	5.4	3.9	1.8	0.3
2005	2.6	3.8	2.7	1.3	0.1

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2006	5.1	6.3	5.3	1.2	0.2
2007	6.4	6.6	6.3	0.3	-0.1
2008	7.8	9.0	7.9	1.3	0.1
2009	4.4	6.8	5.0	2.3	0.6
2010	3.9	5.2	4.2	1.3	0.3
2011	5.7	7.3	6.5	1.6	0.7
West Point Dam					
2000	7.8	8.8	8.6	1.0	0.8
2001	5.7	6.8	6.3	1.1	0.5
2002	7.1	8.0	7.9	1.0	0.8
2003	6.1	7.3	6.7	1.2	0.6
2004	5.5	6.4	6.1	0.9	0.6
2005	5.4	6.4	5.9	1.0	0.5
2006	6.4	7.1	7.1	0.8	0.7
2007	5.8	6.6	6.4	0.8	0.6
2008	7.0	8.0	8.0	1.1	1.0
2009	5.0	5.9	5.5	0.9	0.5
2010	4.7	5.5	5.3	0.9	0.6
2011	6.8	7.9	7.7	1.2	1.0
Walter MidLake					
2000	7.0	8.1	7.4	1.1	0.4
2001	5.9	7.2	6.3	1.3	0.4
2002	6.4	7.2	6.9	0.9	0.5
2003	3.4	4.5	3.6	1.1	0.2
2004	5.5	6.4	5.6	0.9	0.2
2005	3.7	4.9	3.9	1.1	0.2
2006	6.6	7.8	7.3	1.1	0.7
2007	7.0	7.7	7.4	0.6	0.3
2008	7.3	8.5	7.9	1.2	0.6
2009	4.4	5.7	4.7	1.3	0.2
2010	4.2	5.1	4.5	0.9	0.3

				change from NAA	
	NAA	Alt7H	Alt7K	Alt7H	Alt7K
2011	6.5	7.4	6.9	0.8	0.4
Lake Seminole MidLake					
2000	5.4	6.0	5.7	0.6	0.3
2001	3.4	4.1	3.6	0.7	0.2
2002	4.8	5.7	5.4	0.9	0.6
2003	5.0	5.9	5.2	0.9	0.2
2004	5.0	5.6	5.2	0.6	0.3
2005	4.6	5.5	4.8	0.9	0.2
2006	4.9	5.9	5.6	1.0	0.7
2007	5.5	6.8	6.6	1.3	1.0
2008	5.1	6.0	5.8	1.0	0.7
2009	3.6	4.3	3.7	0.8	0.1
2010	4.0	4.5	4.2	0.5	0.2
2011	5.3	6.3	6.1	1.0	0.8

2.1.5 Retention

a. Average summer retention time (days).

Table 9 presents monthly retention times for the water quality model period (2001 through 2011).

Table 9a. Monthly retention times (in days) for reservoirs on the Chattahoochee River for the period from 2001 through 2011

	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
Month-Year	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
	Days																				
Jan-01	1001	1238	1254	1	1	1	77	74	74	25	24	24	1	1	1	0	0	0	4	4	4
Feb-01	1182	1289	1308	1	1	1	68	67	67	20	20	20	1	1	1	0	0	0	3	3	3
Mar-01	1367	1290	1267	1	1	1	29	28	28	7	7	7	0	0	0	0	0	0	1	1	1
Apr-01	1219	955	961	1	1	1	65	60	60	14	14	14	1	1	1	0	0	0	2	2	2
May-01	1107	902	911	1	1	1	158	133	133	39	34	34	2	2	2	0	0	0	6	6	6
Jun-01	1270	709	714	1	1	1	82	78	78	24	22	22	1	1	1	0	0	0	4	4	4
Jul-01	884	702	699	1	1	1	110	99	99	30	27	27	1	1	1	0	0	0	5	4	4
Aug-01	664	658	662	1	1	1	104	107	107	32	32	32	1	1	1	0	0	0	5	5	5
Sep-01	669	801	805	1	1	1	101	104	104	38	39	39	2	2	2	0	0	0	6	7	7
Oct-01	608	821	845	1	1	1	76	125	128	36	54	56	2	2	3	0	0	0	6	9	9
Nov-01	587	858	884	1	1	1	82	126	125	31	37	37	1	2	2	0	0	0	5	6	6
Dec-01	615	915	833	1	1	1	87	127	125	35	42	41	2	2	2	0	0	0	6	7	7
Jan-02	890	1207	1226	1	1	1	78	51	51	29	20	20	1	1	1	0	0	0	5	3	3
Feb-02	1233	1308	1333	1	1	1	65	91	93	23	29	30	1	1	1	0	0	0	4	5	5
Mar-02	1371	1436	1436	1	1	1	113	97	97	25	22	22	1	1	1	0	0	0	4	4	4
Apr-02	1123	997	989	1	1	1	106	104	104	31	30	30	1	1	1	0	0	0	5	5	5
May-02	1108	891	899	1	1	1	110	91	93	37	31	31	2	1	1	0	0	0	6	5	5
Jun-02	942	836	858	1	1	1	167	170	169	54	54	54	2	2	2	0	0	0	9	9	9
Jul-02	873	782	806	1	1	1	147	154	153	45	45	45	2	2	2	0	0	0	7	7	7
Aug-02	712	648	664	1	1	1	133	144	142	52	53	52	2	2	2	0	0	0	9	9	9
Sep-02	845	886	904	1	1	1	140	153	150	45	45	45	2	2	2	0	0	0	7	7	7
Oct-02	633	1002	1021	1	1	1	91	103	106	23	25	25	1	1	1	0	0	0	4	4	4
Nov-02	692	956	959	1	1	1	58	57	58	15	14	14	1	1	1	0	0	0	2	2	2
Dec-02	694	924	914	1	1	1	34	35	35	10	11	11	0	0	0	0	0	0	2	2	2
Jan-03	663	626	617	1	1	1	68	60	60	20	18	18	1	1	1	0	0	0	3	3	3
Feb-03	744	645	625	1	1	1	48	47	47	12	12	12	1	1	1	0	0	0	2	2	2
Mar-03	326	280	281	0	0	0	32	30	30	8	7	7	0	0	0	0	0	0	1	1	1
Apr-03	460	476	476	0	0	0	53	53	53	10	10	10	0	0	0	0	0	0	2	2	2
May-03	292	296	297	0	0	0	20	21	21	5	5	5	0	0	0	0	0	0	1	1	1
Jun-03	292	302	303	0	0	0	24	24	24	6	6	6	0	0	0	0	0	0	1	1	1
Jul-03	302	310	311	0	0	0	35	35	35	9	9	9	0	0	0	0	0	0	1	1	1
Aug-03	479	493	493	0	0	0	68	69	69	16	16	16	1	1	1	0	0	0	3	3	3
Sep-03	620	609	612	1	1	1	106	104	105	27	26	26	1	1	1	0	0	0	4	4	4

	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
Month-Year	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
	Days																				
Oct-03	606	597	599	1	1	1	107	104	105	31	30	30	1	1	1	0	0	0	5	5	5
Nov-03	503	579	581	0	1	1	37	38	38	12	12	12	1	1	1	0	0	0	2	2	2
Dec-03	538	542	545	1	1	1	37	36	36	15	15	15	1	1	1	0	0	0	2	2	2
Jan-04	633	293	292	1	0	0	51	36	36	17	13	13	1	1	1	0	0	0	3	2	2
Feb-04	390	676	676	0	1	1	33	39	39	10	11	11	0	0	0	0	0	0	2	2	2
Mar-04	467	422	424	0	0	0	69	64	64	19	18	18	1	1	1	0	0	0	3	3	3
Apr-04	511	354	349	1	0	0	89	62	62	22	17	17	1	1	1	0	0	0	4	3	3
May-04	562	950	957	1	1	1	85	137	139	23	33	34	1	2	2	0	0	0	4	6	6
Jun-04	753	969	970	1	1	1	128	126	127	28	28	28	1	1	1	0	0	0	5	5	5
Jul-04	756	721	722	1	1	1	100	115	115	22	23	24	1	1	1	0	0	0	4	4	4
Aug-04	752	716	718	1	1	1	117	113	114	23	22	23	1	1	1	0	0	0	4	4	4
Sep-04	582	693	693	0	0	0	54	54	54	12	12	12	1	1	1	0	0	0	2	2	2
Oct-04	557	632	633	1	1	1	91	100	101	22	24	24	1	1	1	0	0	0	4	4	4
Nov-04	440	635	635	0	0	0	29	31	31	9	9	9	0	0	0	0	0	0	1	2	2
Dec-04	290	290	295	0	0	0	27	27	27	9	9	10	0	0	0	0	0	0	2	2	2
Jan-05	573	584	584	1	1	1	53	51	51	16	16	16	1	1	1	0	0	0	3	3	3
Feb-05	341	360	360	0	0	0	31	31	31	9	9	9	0	0	0	0	0	0	2	2	2
Mar-05	303	309	309	0	0	0	26	26	26	6	6	6	0	0	0	0	0	0	1	1	1
Apr-05	394	400	401	0	0	0	34	34	34	8	8	8	0	0	0	0	0	0	1	1	1
May-05	390	442	442	0	0	0	65	69	69	16	17	17	1	1	1	0	0	0	3	3	3
Jun-05	421	407	409	0	0	0	69	67	67	15	14	15	1	1	1	0	0	0	2	2	2
Jul-05	297	304	305	0	0	0	22	22	22	6	6	6	0	0	0	0	0	0	1	1	1
Aug-05	295	302	303	0	0	0	44	44	44	11	11	11	0	0	0	0	0	0	2	2	2
Sep-05	506	519	520	1	1	1	96	98	98	26	27	27	1	1	1	0	0	0	4	4	4
Oct-05	635	623	626	1	1	1	122	119	120	33	32	32	1	1	1	0	0	0	5	5	5
Nov-05	608	604	606	1	1	1	57	56	56	20	19	19	1	1	1	0	0	0	3	3	3
Dec-05	599	600	603	1	1	1	43	43	43	17	16	16	1	1	1	0	0	0	3	3	3
Jan-06	393	439	440	0	0	0	31	32	32	13	13	13	1	1	1	0	0	0	2	2	2
Feb-06	461	473	474	0	0	0	34	34	34	11	11	11	1	1	1	0	0	0	2	2	2
Mar-06	497	500	502	0	0	0	52	52	52	13	13	13	1	1	1	0	0	0	2	2	2
Apr-06	436	381	380	0	0	0	75	63	63	22	19	19	1	1	1	0	0	0	4	3	3
May-06	465	322	322	1	0	0	75	56	57	24	19	19	1	1	1	0	0	0	4	3	3
Jun-06	696	890	916	1	1	1	120	117	117	36	37	38	2	2	2	0	0	0	6	6	6
Jul-06	665	717	737	1	1	1	96	138	139	37	54	54	2	2	2	0	0	0	6	9	9
Aug-06	646	787	811	1	1	1	148	147	145	50	50	50	2	2	2	0	0	0	8	8	8

Month-Year	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
	Days																				
Sep-06	653	807	832	1	1	1	104	151	153	37	49	50	2	2	2	0	0	0	6	8	8
Oct-06	658	839	843	1	1	1	89	128	135	32	41	42	1	2	2	0	0	0	5	7	7
Nov-06	679	898	903	1	1	1	87	80	81	24	22	22	1	1	1	0	0	0	4	4	4
Dec-06	699	918	926	1	1	1	77	80	80	25	26	26	1	1	1	0	0	0	4	4	4
Jan-07	719	977	983	1	1	1	47	49	49	14	14	14	1	1	1	0	0	0	2	2	2
Feb-07	741	1010	1016	1	1	1	72	80	80	19	20	21	1	1	1	0	0	0	3	3	3
Mar-07	679	571	544	1	1	1	81	84	86	20	20	20	1	1	1	0	0	0	3	3	3
Apr-07	554	302	306	1	0	0	147	75	75	35	22	21	2	1	1	0	0	0	6	4	4
May-07	519	470	459	1	1	1	100	91	91	34	31	31	2	1	1	0	0	0	6	5	5
Jun-07	817	656	669	1	1	1	144	144	144	50	49	49	2	2	2	0	0	0	8	8	8
Jul-07	768	818	843	1	1	1	135	136	137	54	53	54	2	2	2	0	0	0	9	9	9
Aug-07	598	638	653	1	1	1	112	107	108	53	51	52	2	2	2	0	0	0	9	8	8
Sep-07	599	590	602	1	1	1	108	100	99	53	50	50	2	2	2	0	0	0	9	8	8
Oct-07	403	398	458	1	1	1	78	87	103	42	46	55	2	2	2	0	0	0	7	8	9
Nov-07	627	675	696	1	1	1	98	100	101	52	53	54	2	2	2	0	0	0	8	9	9
Dec-07	835	812	835	1	1	1	121	118	120	48	47	47	2	2	2	0	0	0	8	8	8
Jan-08	1008	965	997	1	1	1	89	107	106	26	28	28	1	1	1	0	0	0	4	5	5
Feb-08	1193	1134	1153	1	1	1	97	95	96	22	21	21	1	1	1	0	0	0	4	3	3
Mar-08	1306	1240	1257	1	1	1	88	83	83	22	21	21	1	1	1	0	0	0	4	3	3
Apr-08	1094	1015	1053	1	1	1	120	121	121	27	27	27	1	1	1	0	0	0	4	4	4
May-08	971	799	833	1	1	1	168	131	135	40	33	34	2	2	2	0	0	0	7	6	6
Jun-08	744	622	645	1	1	1	161	161	160	49	49	49	2	2	2	0	0	0	8	8	8
Jul-08	808	666	692	1	1	1	147	151	149	46	46	46	2	2	2	0	0	0	8	8	8
Aug-08	815	681	704	1	1	1	159	167	164	34	35	35	2	2	2	0	0	0	6	6	6
Sep-08	662	547	566	1	1	1	139	149	146	45	45	45	2	2	2	0	0	0	8	8	8
Oct-08	767	627	650	1	1	1	103	128	136	39	42	45	2	2	2	0	0	0	7	7	8
Nov-08	742	666	691	1	1	1	112	134	132	49	50	50	2	2	2	0	0	0	8	8	8
Dec-08	693	912	945	1	1	1	76	67	70	26	22	23	1	1	1	0	0	0	4	4	4
Jan-09	674	958	989	1	1	1	61	69	70	21	22	23	1	1	1	0	0	0	3	4	4
Feb-09	981	916	952	1	1	1	97	99	99	28	28	28	1	1	1	0	0	0	5	5	5
Mar-09	1333	1238	1269	1	1	1	43	41	41	9	9	9	0	0	0	0	0	0	2	1	1
Apr-09	1016	1254	1289	1	1	1	63	63	63	13	13	13	1	1	1	0	0	0	2	2	2
May-09	741	1036	1081	1	1	1	103	119	120	23	25	25	1	1	1	0	0	0	4	4	4
Jun-09	678	786	797	1	1	1	108	105	107	30	30	30	1	1	1	0	0	0	5	5	5
Jul-09	656	779	814	1	1	1	142	162	162	45	52	52	2	2	2	0	0	0	8	9	9

Month-Year	BUFORD-POOL			MORGAN FALLS-POOL			WEST POINT-POOL			BARTLETTS FERRY-POOL			GOAT ROCK-POOL			NORTH HIGHLANDS-POOL			OLIVER-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
										Days											
Aug-09	665	811	844	1	1	1	144	169	173	43	50	51	2	2	2	0	0	0	7	8	8
Sep-09	696	887	889	0	0	0	30	31	31	9	10	10	0	0	0	0	0	0	2	2	2
Oct-09	649	668	650	0	0	0	40	40	40	10	10	10	0	0	0	0	0	0	2	2	2
Nov-09	270	378	315	0	0	0	20	22	21	6	6	6	0	0	0	0	0	0	1	1	1
Dec-09	201	203	204	0	0	0	15	15	15	5	5	5	0	0	0	0	0	0	1	1	1
Jan-10	246	250	250	0	0	0	24	24	24	7	7	7	0	0	0	0	0	0	1	1	1
Feb-10	216	218	219	0	0	0	22	22	22	7	7	7	0	0	0	0	0	0	1	1	1
Mar-10	299	304	305	0	0	0	27	27	27	7	7	7	0	0	0	0	0	0	1	1	1
Apr-10	477	492	494	0	0	0	65	66	66	17	17	17	1	1	1	0	0	0	3	3	3
May-10	337	368	368	0	0	0	46	47	47	12	12	13	1	1	1	0	0	0	2	2	2
Jun-10	618	608	611	1	1	1	98	98	98	27	27	27	1	1	1	0	0	0	4	4	4
Jul-10	615	599	603	1	1	1	113	117	118	34	34	34	2	2	2	0	0	0	6	6	6
Aug-10	595	581	584	1	1	1	112	115	115	36	37	37	2	2	2	0	0	0	6	6	6
Sep-10	568	643	646	1	1	1	96	98	98	35	36	36	2	2	2	0	0	0	6	6	6
Oct-10	610	692	688	1	1	1	91	113	115	35	41	42	2	2	2	0	0	0	6	7	7
Nov-10	677	701	704	1	1	1	78	85	85	29	30	30	1	1	1	0	0	0	5	5	5
Dec-10	559	701	704	1	1	1	69	68	68	25	24	24	1	1	1	0	0	0	4	4	4
Jan-11	706	504	501	1	1	1	79	39	39	26	17	17	1	1	1	0	0	0	4	3	3
Feb-11	741	983	986	1	1	1	55	101	101	16	24	24	1	1	1	0	0	0	3	4	4
Mar-11	460	524	530	0	0	0	42	43	43	12	13	13	1	1	1	0	0	0	2	2	2
Apr-11	284	222	222	0	0	0	46	40	40	14	12	12	1	1	1	0	0	0	2	2	2
May-11	350	255	253	0	0	0	75	49	49	24	17	17	1	1	1	0	0	0	4	3	3
Jun-11	643	814	814	1	1	1	128	115	115	47	46	46	2	2	2	0	0	0	8	7	8
Jul-11	680	765	786	1	1	1	141	132	132	49	51	51	2	2	2	0	0	0	8	8	8
Aug-11	615	640	654	1	1	1	121	119	117	48	53	52	2	2	2	0	0	0	8	9	9
Sep-11	617	692	708	1	1	1	99	112	120	35	41	43	2	2	2	0	0	0	6	7	7
Oct-11	605	659	507	1	1	1	106	98	90	49	50	47	2	2	2	0	0	0	8	8	8
Nov-11	630	465	675	1	1	1	79	69	72	36	34	36	2	2	2	0	0	0	6	6	6
Dec-11	661	1121	1103	1	1	1	88	109	114	28	33	34	1	1	2	0	0	0	5	5	6
Overall Median	639	666	675	1	1	1	82	85	85	24	24	24	1	1	1	0	0	0	4	4	4
May-October Median	645	667	679	1	1	1	104	113	114	34	34	34	2	2	2	0	0	0	6	6	6
May-October Average	646	662	670	1	1	1	102	106	107	32	33	34	1	2	2	0	0	0	5	6	6
April-October Median	635	659	664	1	1	1	103	104	106	32	31	31	1	1	1	0	0	0	5	5	5
April-October Average	652	656	664	1	1	1	99	101	101	30	31	31	1	1	1	0	0	0	5	5	5

Table 9b. Monthly retention times (in days) for reservoirs on the Chattahoochee River for the period from 2001 through 2011

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year	Days								
Jan-01	73	72	72	1	1	1	14	14	14
Feb-01	70	70	70	1	1	1	16	15	15
Mar-01	15	15	15	0	0	0	3	3	3
Apr-01	35	34	34	1	1	1	5	5	5
May-01	169	134	136	3	2	2	21	19	19
Jun-01	68	69	69	1	1	1	11	11	11
Jul-01	130	116	116	2	2	2	17	15	15
Aug-01	129	115	116	2	2	2	21	20	20
Sep-01	146	155	155	3	3	3	23	24	24
Oct-01	116	140	140	2	3	3	25	27	27
Nov-01	114	134	135	2	3	3	26	29	29
Dec-01	130	151	151	3	3	3	23	24	24
Jan-02	93	67	66	2	1	1	21	15	15
Feb-02	64	78	79	1	1	2	14	16	16
Mar-02	66	63	62	1	1	1	13	13	13
Apr-02	75	72	73	2	1	1	13	12	12
May-02	164	106	107	3	2	2	24	22	22
Jun-02	295	230	230	5	4	4	34	32	32
Jul-02	195	182	182	4	4	4	32	32	32
Aug-02	223	242	242	4	5	5	32	32	32
Sep-02	165	235	235	3	5	5	24	28	28
Oct-02	147	150	153	3	3	3	21	21	21
Nov-02	64	65	66	1	1	1	11	11	11
Dec-02	42	43	43	1	1	1	10	10	10
Jan-03	77	67	67	1	1	1	12	10	10
Feb-03	38	39	39	1	1	1	8	9	9
Mar-03	25	24	24	0	0	0	4	4	4
Apr-03	34	33	33	1	1	1	6	6	6
May-03	25	25	25	0	0	0	5	5	5
Jun-03	25	25	25	0	0	0	5	5	5
Jul-03	30	30	30	1	1	1	6	6	6
Aug-03	53	53	53	1	1	1	8	8	8
Sep-03	111	110	111	2	2	2	14	14	14
Oct-03	90	88	88	2	2	2	16	16	16
Nov-03	51	52	52	1	1	1	13	14	14
Dec-03	57	57	57	1	1	1	12	12	12

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year	Days								
Jan-04	48	40	40	1	1	1	12	11	11
Feb-04	28	30	30	1	1	1	6	7	7
Mar-04	65	56	56	1	1	1	11	9	9
Apr-04	83	65	65	2	1	1	16	13	13
May-04	97	140	143	2	3	3	15	20	20
Jun-04	150	149	149	3	3	3	19	20	20
Jul-04	121	140	141	2	2	2	17	17	17
Aug-04	121	119	119	2	2	2	20	20	20
Sep-04	45	45	45	1	1	1	8	8	8
Oct-04	74	79	79	1	1	1	11	12	12
Nov-04	33	34	34	1	1	1	9	10	10
Dec-04	35	35	35	1	1	1	8	8	8
Jan-05	51	51	51	1	1	1	10	10	10
Feb-05	32	32	32	1	1	1	8	8	8
Mar-05	23	23	23	1	1	1	5	5	5
Apr-05	18	18	18	0	0	0	3	3	3
May-05	70	69	69	1	1	1	9	9	9
Jun-05	50	51	51	1	1	1	8	8	8
Jul-05	22	22	22	0	0	0	4	4	4
Aug-05	37	37	37	1	1	1	7	7	7
Sep-05	118	119	119	2	2	2	14	14	14
Oct-05	89	88	88	2	2	2	16	16	16
Nov-05	68	67	67	1	1	1	16	16	16
Dec-05	54	53	53	1	1	1	11	11	11
Jan-06	40	41	41	1	1	1	8	8	8
Feb-06	35	35	35	1	1	1	8	8	8
Mar-06	39	39	39	1	1	1	8	8	8
Apr-06	61	56	56	1	1	1	12	11	11
May-06	89	56	56	2	1	1	14	11	11
Jun-06	178	155	155	3	3	3	27	26	26
Jul-06	137	254	255	3	5	5	26	35	34
Aug-06	195	196	198	4	4	4	32	32	32
Sep-06	150	203	205	3	4	4	25	28	28
Oct-06	144	190	198	3	4	4	25	31	31
Nov-06	82	80	81	2	2	2	17	17	17
Dec-06	88	91	91	2	2	2	19	19	19
Jan-07	46	47	47	1	1	1	9	9	9
Feb-07	59	62	62	1	1	1	10	11	11

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year	Days								
Mar-07	52	54	54	1	1	1	9	10	10
Apr-07	79	56	56	2	1	1	13	10	10
May-07	160	125	123	3	3	3	25	22	22
Jun-07	191	182	182	4	4	4	33	33	33
Jul-07	195	200	200	4	4	4	32	33	33
Aug-07	156	153	153	3	3	3	33	33	33
Sep-07	175	171	172	4	4	4	33	33	32
Oct-07	183	183	230	4	4	5	33	33	37
Nov-07	169	200	210	4	4	5	34	38	38
Dec-07	255	264	250	5	5	5	32	33	33
Jan-08	71	73	73	1	1	1	12	12	12
Feb-08	46	46	46	1	1	1	7	7	7
Mar-08	55	54	54	1	1	1	8	8	8
Apr-08	64	64	64	1	1	1	9	10	10
May-08	250	146	146	4	3	3	25	21	21
Jun-08	276	207	213	5	4	4	32	30	31
Jul-08	217	202	201	4	4	4	30	30	30
Aug-08	109	143	143	2	2	2	16	17	17
Sep-08	147	146	146	3	3	3	18	18	18
Oct-08	141	141	140	3	3	3	24	24	24
Nov-08	94	99	102	2	2	2	19	20	20
Dec-08	45	43	43	1	1	1	7	7	7
Jan-09	58	61	61	1	1	1	11	11	11
Feb-09	80	82	85	2	2	2	15	16	16
Mar-09	25	24	24	1	1	1	6	6	6
Apr-09	23	23	23	0	0	0	3	3	3
May-09	61	63	63	1	1	1	9	9	9
Jun-09	96	99	99	2	2	2	12	12	12
Jul-09	147	146	145	3	3	3	20	20	20
Aug-09	159	162	161	3	3	3	21	21	21
Sep-09	38	41	41	1	1	1	10	11	11
Oct-09	33	33	33	1	1	1	9	9	9
Nov-09	19	20	19	0	0	0	5	6	5
Dec-09	11	11	11	0	0	0	3	3	3
Jan-10	20	20	20	0	0	0	4	4	4
Feb-10	19	19	19	0	0	0	3	3	3
Mar-10	23	22	23	0	0	0	5	5	5
Apr-10	54	54	54	1	1	1	10	10	10

	WALTER F GEORGE-POOL			GEORGE ANDREWS-POOL			JIM WOODRUFF-POOL		
	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K	NAA	Alt7H	Alt7K
Month-Year	Days								
May-10	41	40	40	1	1	1	7	7	7
Jun-10	96	101	101	2	2	2	13	13	13
Jul-10	137	137	136	2	2	2	18	18	18
Aug-10	145	147	146	3	3	3	22	22	22
Sep-10	152	152	151	3	3	3	28	28	28
Oct-10	125	133	132	2	3	3	25	24	24
Nov-10	101	106	108	2	2	2	21	22	22
Dec-10	96	90	90	2	2	2	20	19	19
Jan-11	88	47	47	2	1	1	17	12	12
Feb-11	46	75	76	1	1	1	10	12	12
Mar-11	38	38	38	1	1	1	10	10	10
Apr-11	47	42	42	1	1	1	10	9	9
May-11	125	63	63	2	1	1	22	16	16
Jun-11	178	157	157	3	3	3	34	32	32
Jul-11	177	221	221	3	4	4	29	35	35
Aug-11	165	174	174	3	4	4	34	34	34
Sep-11	132	134	134	3	3	3	33	33	33
Oct-11	163	158	156	3	4	4	34	33	33
Nov-11	136	149	150	3	3	3	32	33	33
Dec-11	143	197	204	3	4	4	32	35	36
Overall Median	80	72	72	2	1	1	14	14	13
May-October Median	137	140	140	3	3	3	21	20	20
May-October Average	129	128	130	2	3	3	20	21	21
April-October Median	125	125	123	2	2	2	18	18	18
April-October Average	118	117	118	2	2	2	19	19	19

2.1.6 Phosphorus

a. Average summer phosphorus loading (pounds/acre/month).

The results presented here are consistent with the 2015 PAL response and are not average summer phosphorus loads as pounds per acre per month but are pounds per year instead.

Alabama, Florida, and Georgia have established criteria in the ACF Basin for total phosphorus (TP). The nutrient criteria for TP in major headwaters contributing to lakes in Georgia are based on annual loads in pounds. In accordance with the water quality standards set by Georgia, the TP annual loading for West Point Lake headwaters at Chattahoochee River at U.S. Highway 27 should not exceed 1,400,000 lbs and for Walter F. George Lake headwaters, the annual TP loading at Chattahoochee River at U.S. Highway 39 should not exceed 2,000,000 lbs. The calculated TP loads for the NAA and the PAA are shown in Table 10. The loads were calculated using the HEC-5Q model outputs of TP concentrations (mg/L) and modeled flows (cfs) with proper conversion factors applied to derive annual loads in lbs.

Violations of the water quality standard would be expected in the PAA when the NAA would be expected to meet water quality standards into the Walter F. George Lake headwaters. Therefore, both Alt7H and the PAA (Alt7K) would be expected to have substantially adverse effects on TP based on criteria established to define effects in the EIS. Review of a full range of alternatives in the EIS indicates that these violations would not be the results of water management activities but would be expected from increased wastewater returns downstream of Buford Dam.

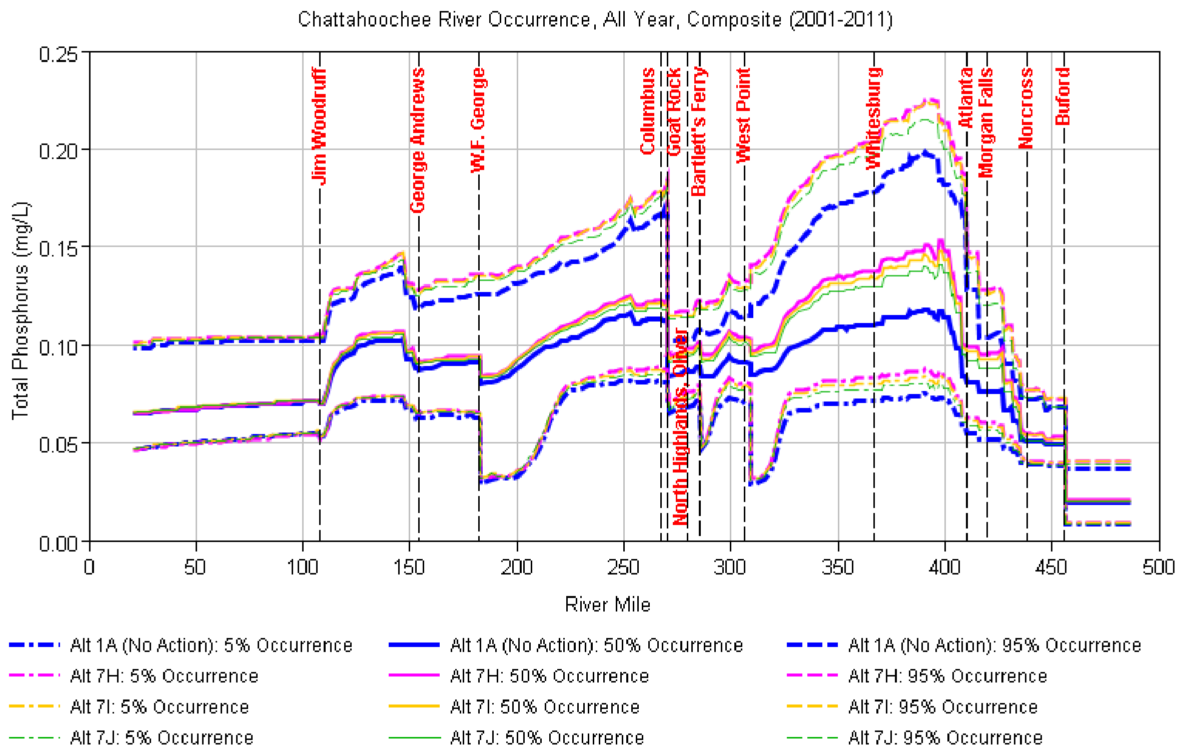
Longitudinal profiles were also used as an initial indication of changes that would be expected between the NAA and the PAA. Figure 50 through Figure 52 illustrates the response of TP to changes between the NAA and the PAA. Figure 53 and Figure 54 illustrate the change in TP between the NAA and the PAA for the modeled period and a representative dry year when the greatest variation would be expected.

Table 10. Total phosphorus loads (pounds per year) at West Point Lake headwaters and Walter F. George Lake headwaters for the modeled period (2001–2011)

Year	Location	NAA	Alt7H	Alt7K
			(pounds / year)	
2001	West Point Lake headwaters	754,935	843,924	832,053
	Walter F. George Lake headwaters	1,422,036	1,526,650	1,509,983
2002	West Point Lake headwaters	697,443	826,407	810,360
	Walter F. George Lake headwaters	1,106,039	1,229,652	1,213,543
2003	West Point Lake headwaters	1,283,557	1,445,418*	1,408,302*
	Walter F. George Lake headwaters	1,965,005	2,135,048*	2,090,889*

Year	Location	NAA	Alt7H	Alt7K
			(pounds / year)	
2004	West Point Lake headwaters	897,763	1,020,282	1,000,136
	Walter F. George Lake headwaters	1,465,636	1,597,801	1,573,490
2005	West Point Lake headwaters	1,129,805	1,265,768	1,241,756
	Walter F. George Lake headwaters	2,017,151*	2,181,822*	2,147,607*
2006	West Point Lake headwaters	720,284	824,021	805,049
	Walter F. George Lake headwaters	1,210,894	1,315,773	1,295,033
2007	West Point Lake headwaters	478,531	588,474	568,821
	Walter F. George Lake headwaters	931,830	1,049,054	1,027,777
2008	West Point Lake headwaters	452,391	539,860	527,146
	Walter F. George Lake headwaters	1,172,838	1,286,855	1,270,781
2009	West Point Lake headwaters	1,261,733	1,386,419	1,361,653
	Walter F. George Lake headwaters	2,413,272*	2,605,069*	2,561,774*
2010	West Point Lake headwaters	858,573	964,649	942,654
	Walter F. George Lake headwaters	1,555,842	1,672,748	1,644,284
2011	West Point Lake headwaters	641,421	763,766	744,398
	Walter F. George Lake headwaters	1,059,169	1,180,736	1,159,505

*indicates a water quality standard violation.



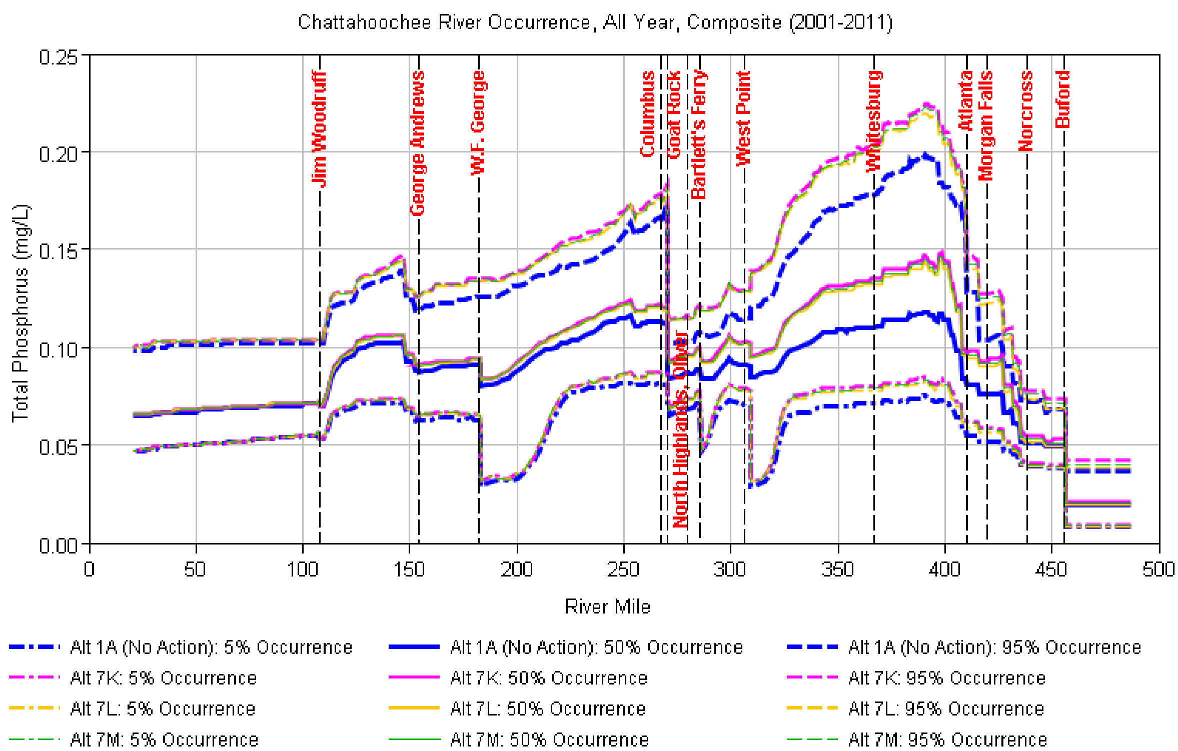


Figure 50. Longitudinal profile occurrence of daily average total phosphorus in the ACF Basin for the period 2001-2011 for the NAA and the PAA

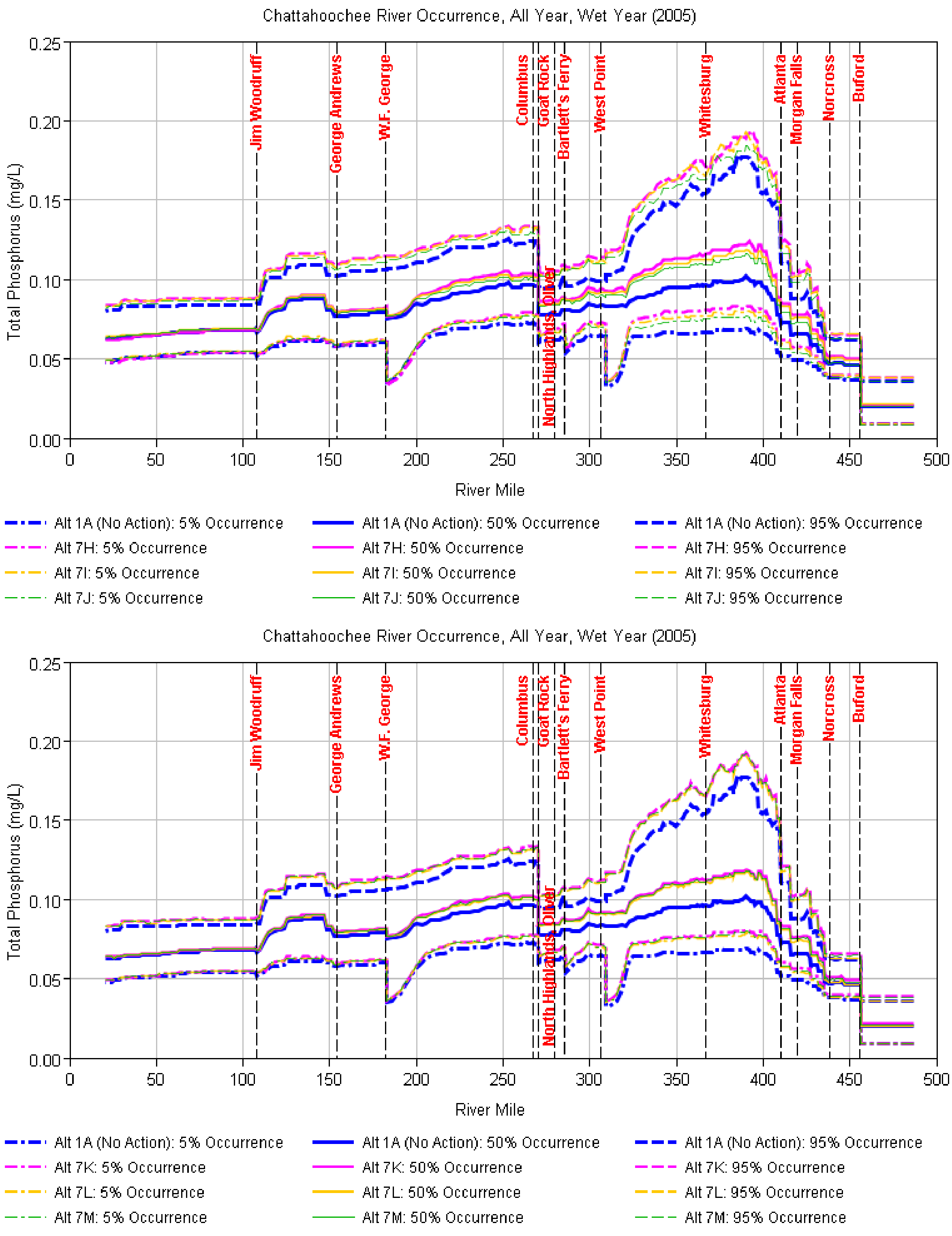
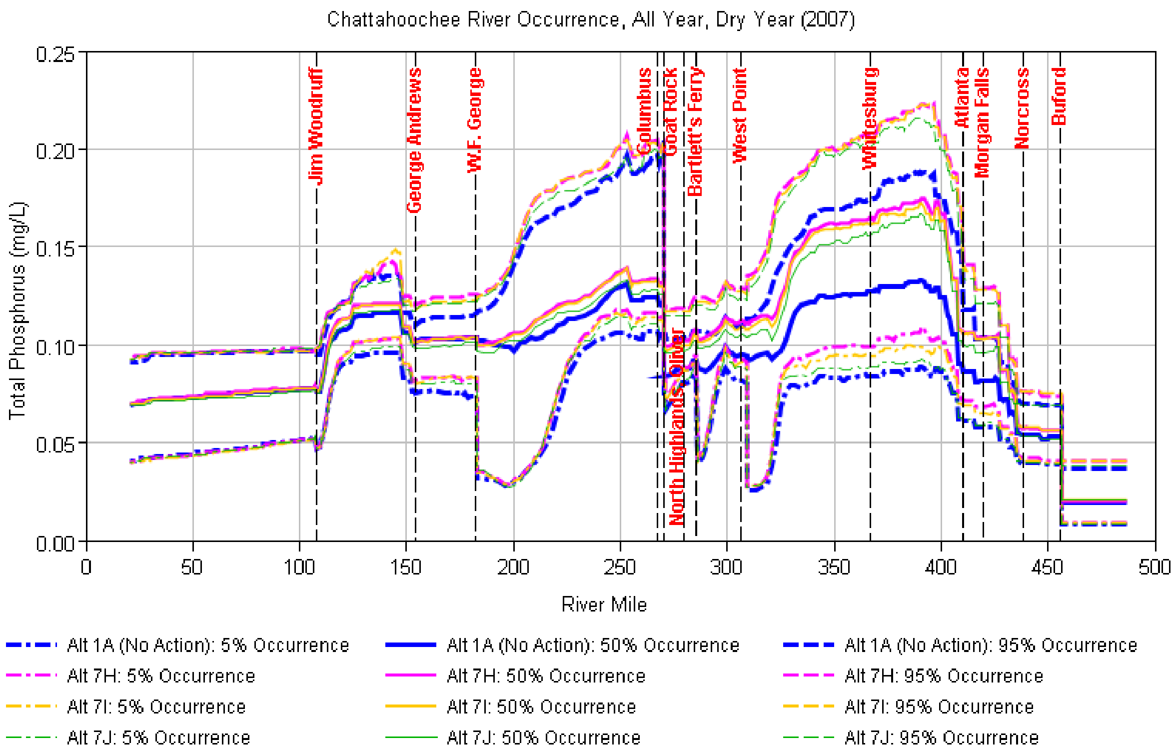


Figure 51. Longitudinal profile occurrence of daily average total phosphorus in the ACF Basin for a wet year (2005) for the NAA and the PAA



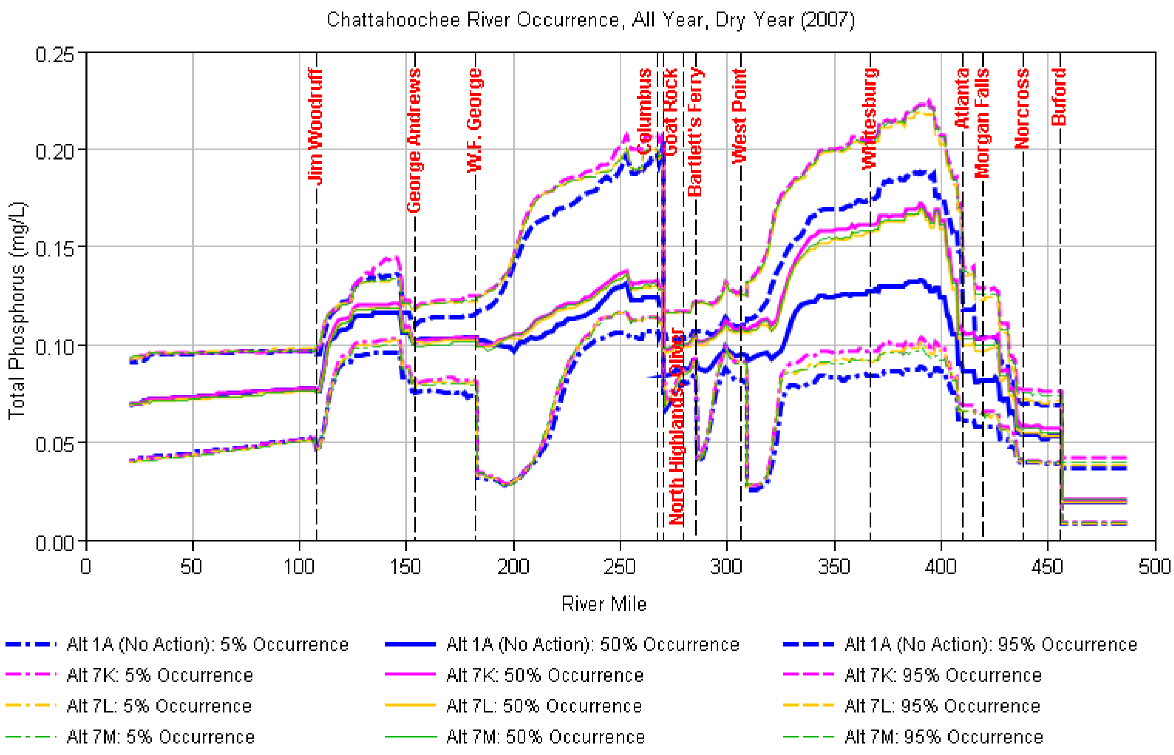


Figure 52. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a dry year (2007) for the NAA and the PAA

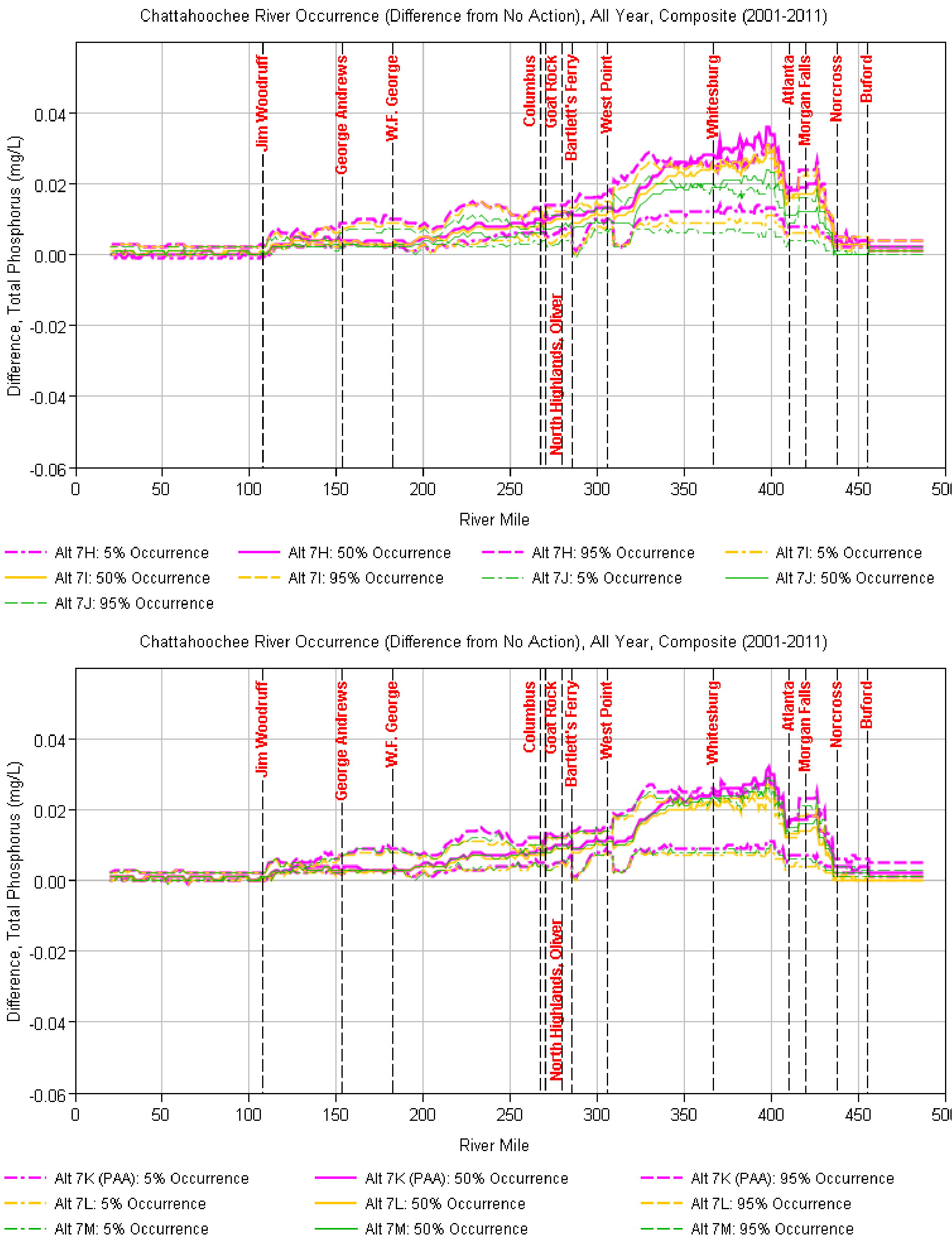


Figure 53. Longitudinal profile of change in daily average total phosphorus in the ACF Basin from the NAA for the PAA for the model period (2001-2011)

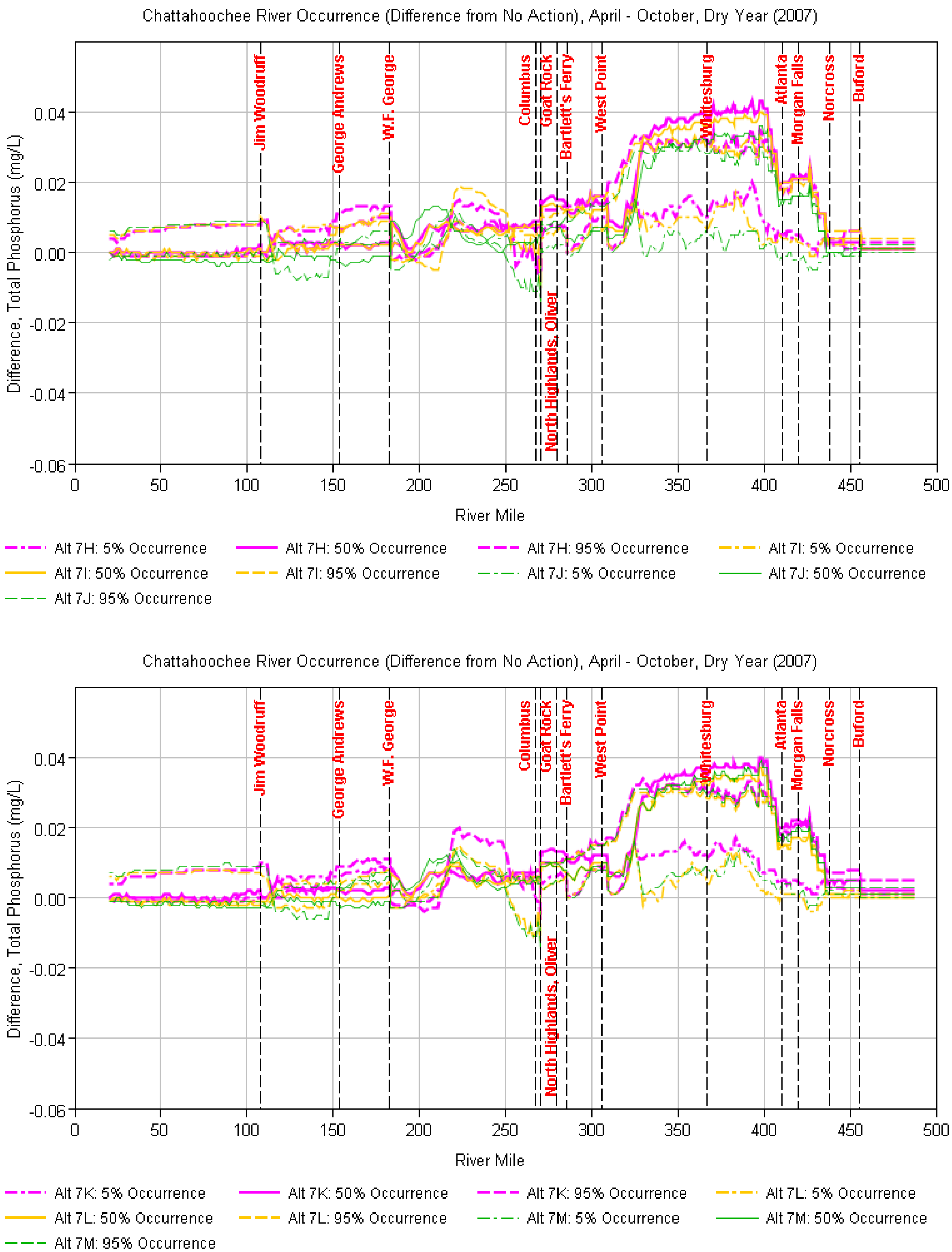


Figure 54. Longitudinal profile of change in daily average total phosphorus from the NAA in the ACF Basin during growing season (April through October) of a dry year (2007) for the PAA

2.2 Floodplain Connectivity Analyses

A complete set of the Apalachicola River floodplain LIDAR data is not available and therefore this was not used in this analysis. However, available data was used to determine the annual maximum 30-day growing season floodplain connectivity as described in the 2013 PAL. These results are illustrated in Figure 55 and Figure 56. Given that conditions in the PAA are very similar to those for the 2012 RIOP, little change would be expected.

Similar results would be expected along the Chattahoochee River; given that conditions in the PAA are very similar to the NAA, little change would be expected. The Chattahoochee River is essentially disconnected from its floodplain, so floodplain connectivity would not be influenced by the different alternatives. Changes in streamflow on the Chattahoochee River from Norcross to Columbus are minor and would not be expected to reach flows defined in Table 1 of the 2010 PAL. USACE manages operations to reduce flooding. Flood risk management operations would remain unchanged from those currently employed.

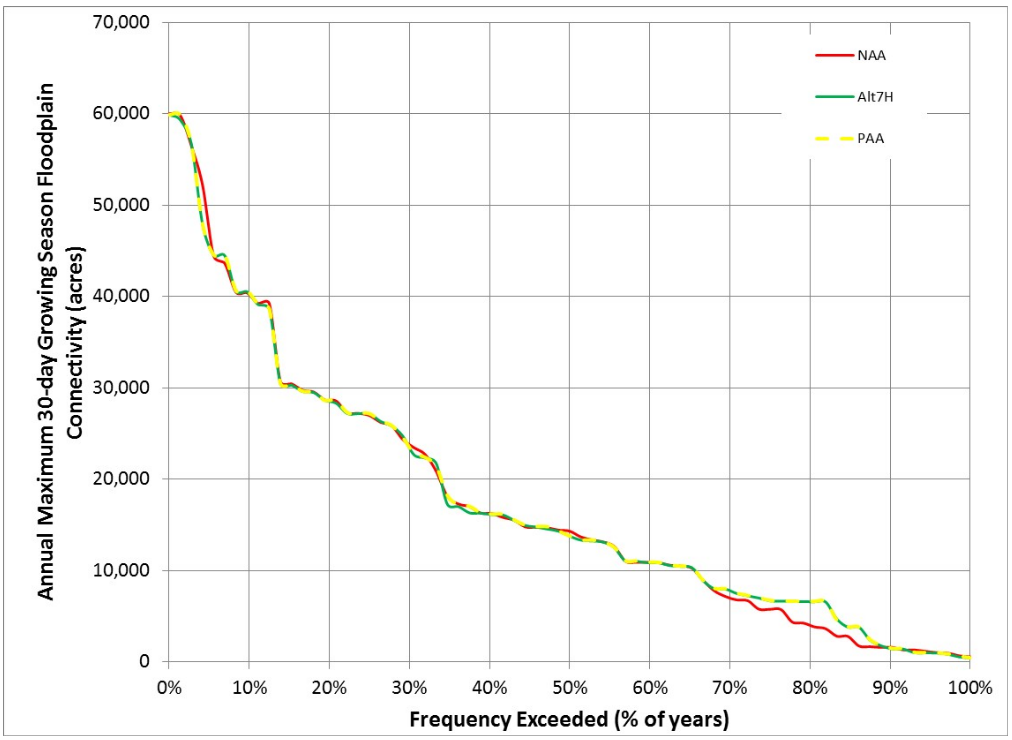


Figure 55. Frequency of annual maximum 30-day growing season (April through October) floodplain connectivity in acres for the NAA, Alt7H, and PAA over the modeled period [Note the change from the 2015 PAL which identified the period the growing season from April through September.]

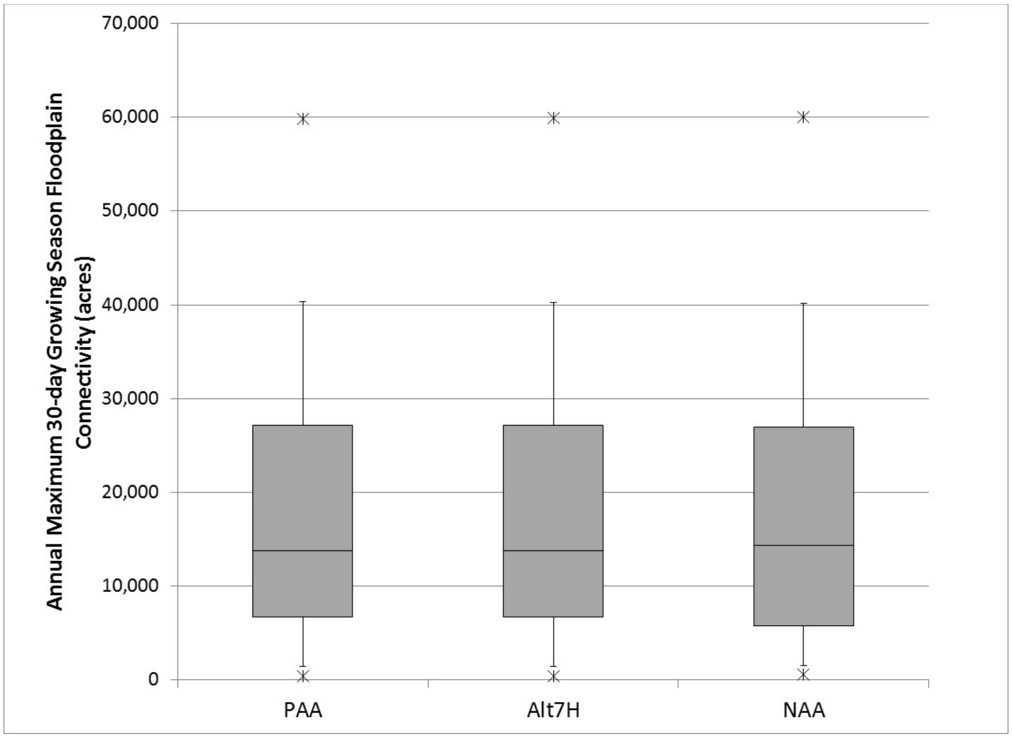


Figure 56. Statistics (minimum; 10th, 25th, 50th, 75th, and 90th percentiles; and maximum) for the annual maximum 30-day growing season (April through October) floodplain connectivity in acres for the NAA, Alt7H, and PAA over the modeled period [Note the change from the 2015 PAL which identified the period the growing season from April through September.]

2.3 Reservoir Fisheries Analyses

Reservoir fisheries were evaluated using methods described in the 2013 PAL. Previous work based on Ryder et al. (1995) was not used for this analysis.

Operational flow changes would affect habitat for reservoir fisheries and other aquatic resources mainly through changes in water levels, reservoir flushing rates (retention times), and associated changes in water quality parameters, such as nutrient loading and DO concentrations. Seasonal water level fluctuations can substantially change the area of shallow-water habitats and inundated shoreline vegetation in reservoirs and, in turn, influence the reproductive success of resident fish populations.

Substantial daily or weekly fluctuations in reservoir levels associated with hydroelectric power generation peaking operations could adversely affect reservoir fisheries by dewatering spawning and nursery habitats for littoral species, exposing nests and eggs deposited in shallow-water habitats, and reducing the availability of shoreline cover and its associated invertebrate food supply. Performance measures developed by the Service were used in this evaluation, specifically to assess reservoir fisheries habitat, based on the assumption that a greater departure of reservoir levels from optimum (e.g., littoral spawning, rearing) results in a greater effect on habitats, including loss. The Reservoir Fisheries Performance Measure (RFPM) was recommended by the Service because it specifically characterizes the spatial extent of the reservoir most likely to support successful fish survival and reproduction as a direct function of containing suitable habitat features.

The effect of the alternatives on reservoir fisheries was determined using the area (in acres) of productive zone inundated for more than 30 days during the spawning season, as calculated using the RFPM. The inundated productive zone was defined for each reservoir and is presented in Figure 57, Figure 58, and Figure 59. These figures illustrate little difference between median values of the productive zone between the NAA, Alt7H, and PAA.

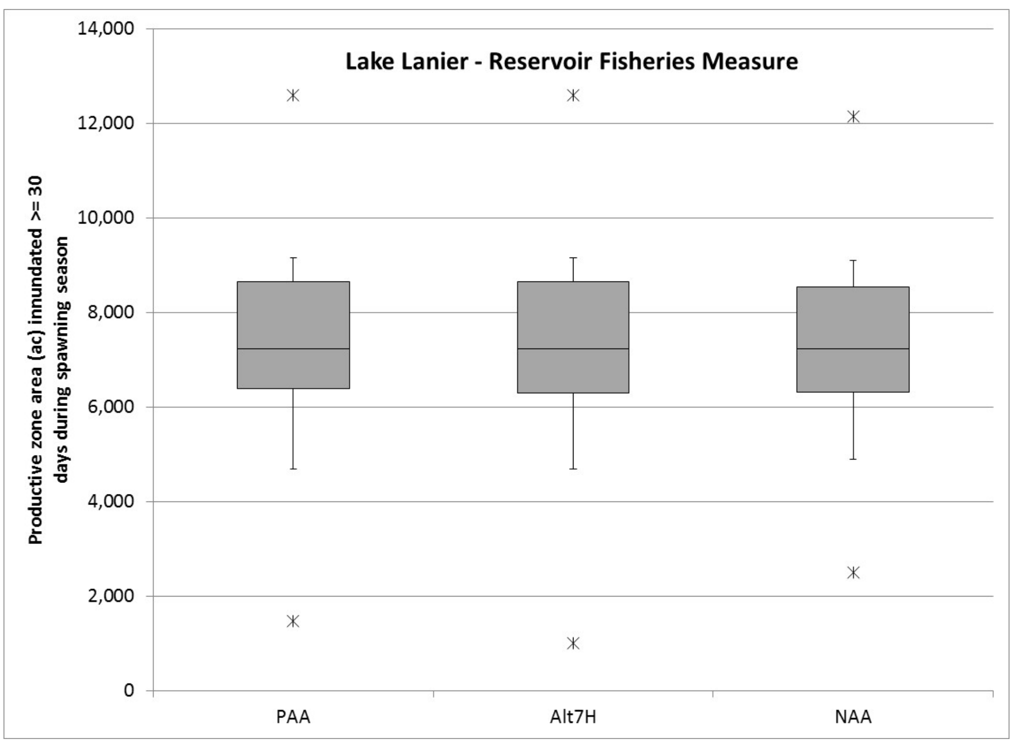


Figure 57. Reservoir fisheries performance measure results for the NAA and PAA at Lake Sidney Lanier

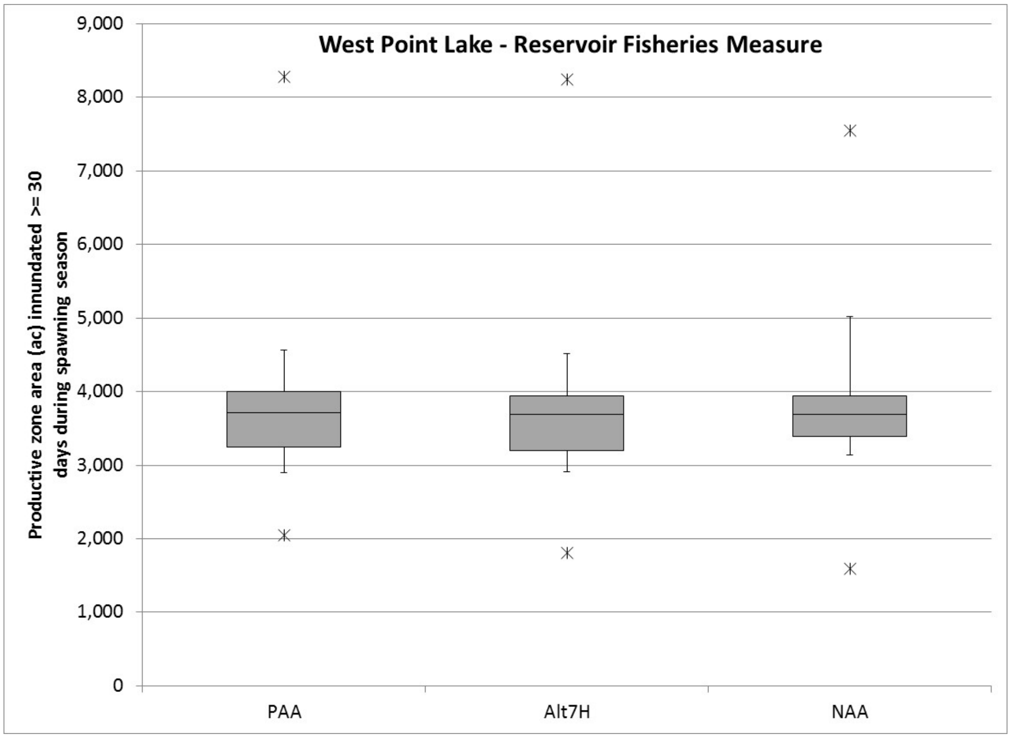


Figure 58. Reservoir fisheries performance measure results for the NAA, Alt7H, and PAA at West Point Lake

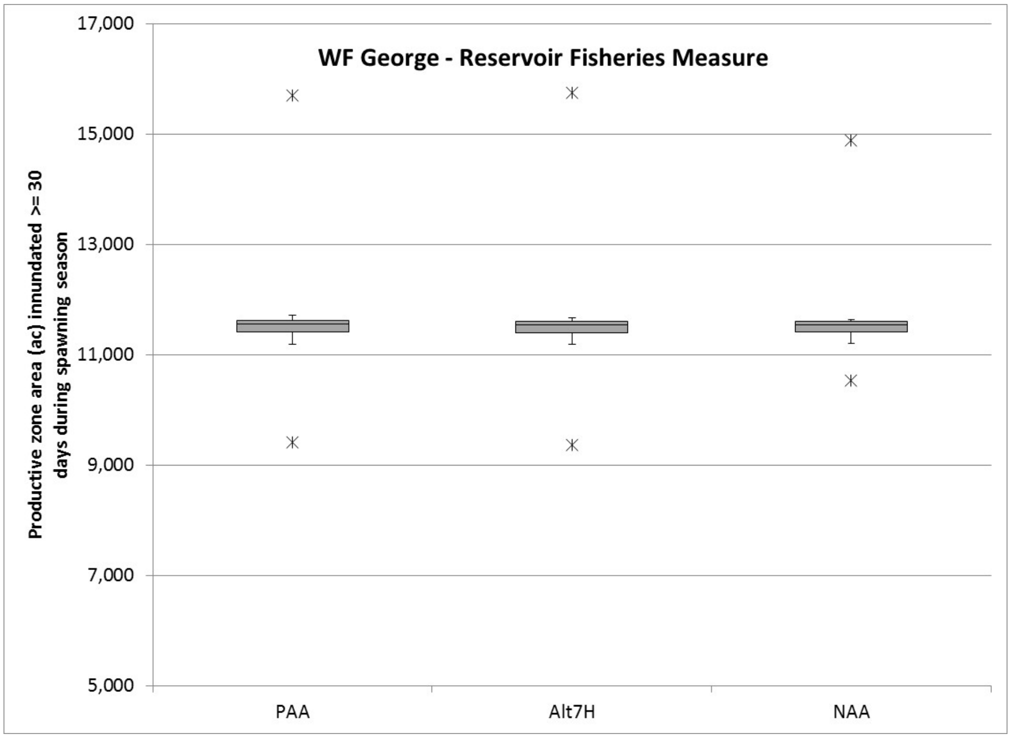


Figure 59. Reservoir fisheries performance measure results for the NAA, Alt7H, and PAA at Walter F. George Lake

2.4 Riverine Fisheries Analyses

Sport fisheries are important recreational and economic resources in the riverine portions of the ACF Basin, especially in the Apalachicola River. The survival and reproduction of many fishes are intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. There are existing effects of controlled flows in the ACF Basin on lateral connectivity and floodplain inundation. Before the Chattahoochee River became subjected to human controls, there were substantial flows with natural variability in magnitude and seasonal fluctuations. Because of the series of dams now present in the Chattahoochee River system, the Chattahoochee River is essentially disconnected from its floodplain. Fish and aquatic resources in the ACF Basin between Buford Dam and Apalachicola Bay will be affected differently due to differences in streamflow and water quality. Since water quality was described in response to specific requests by the Service in section 2.1, this section describes how streamflow may affect riverine fisheries.

The monthly flow range at the 10th, 25th, 50th, 75th and 90th percentile exceedance for the NAA, Alt7H, and PAA were compared and are presented in Figures 60 through 66. These flows were calculated from HEC-ResSim results at various points in the Chattahoochee River to represent the monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded).

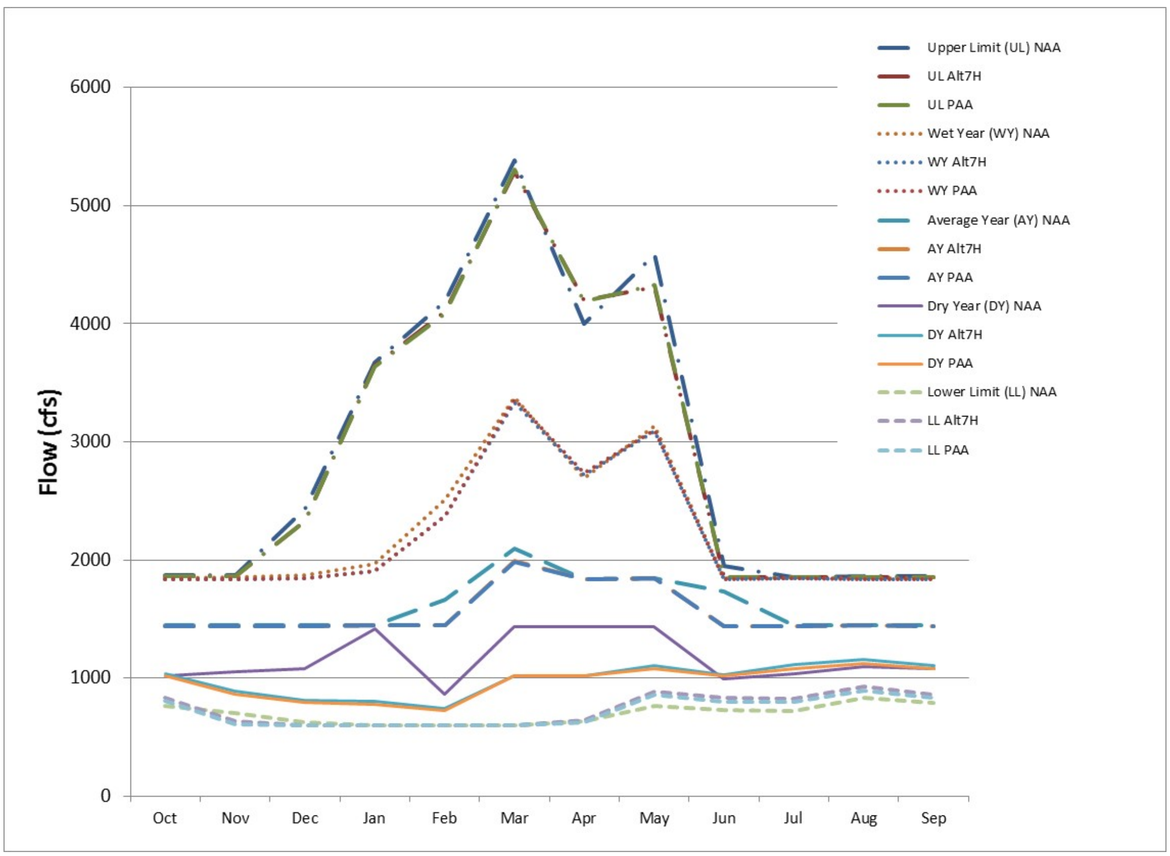


Figure 60. Buford Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

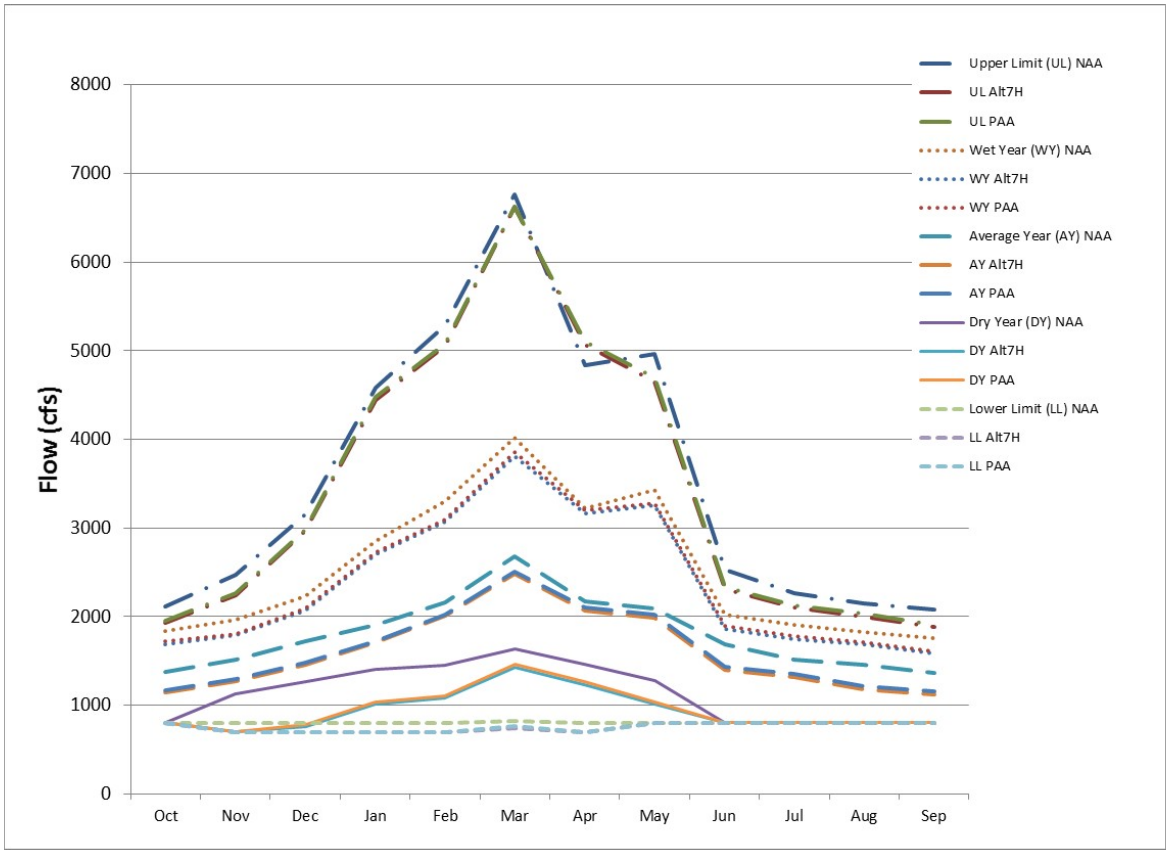


Figure 61. Atlanta, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

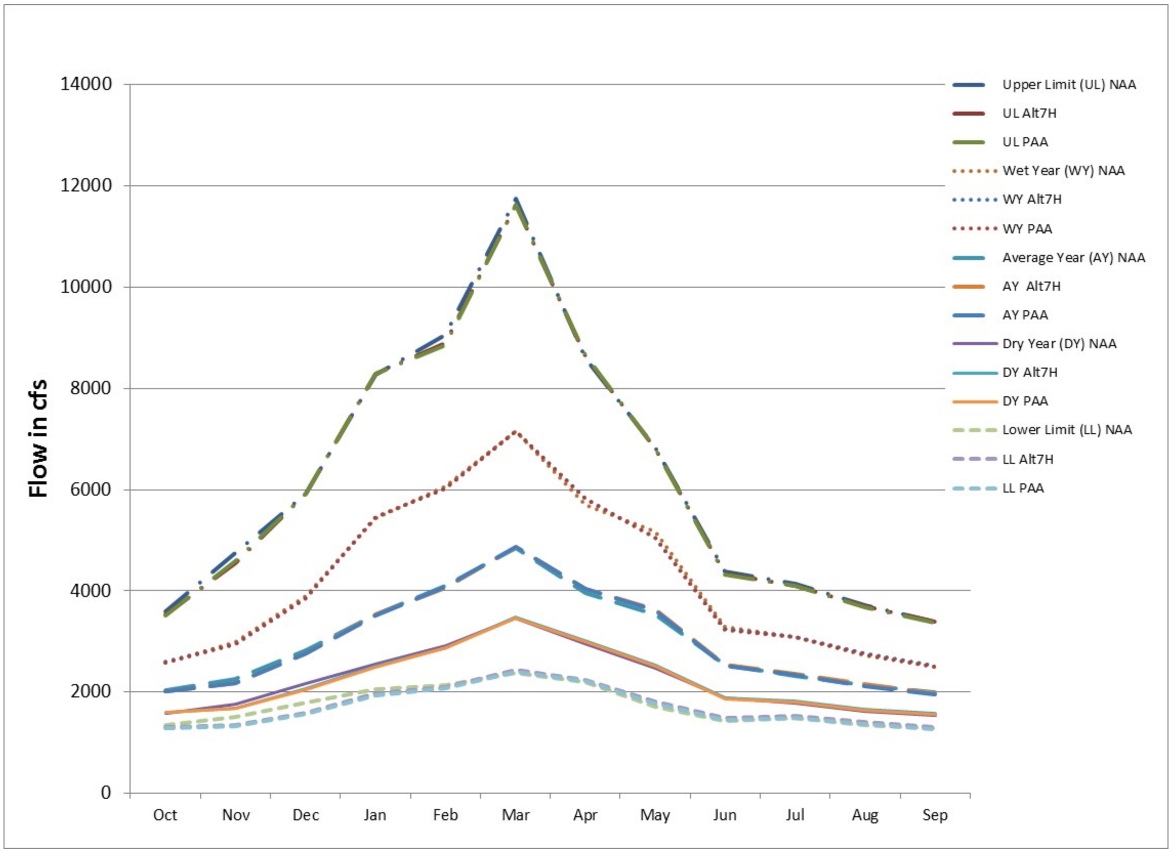


Figure 62. Whitesburg, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

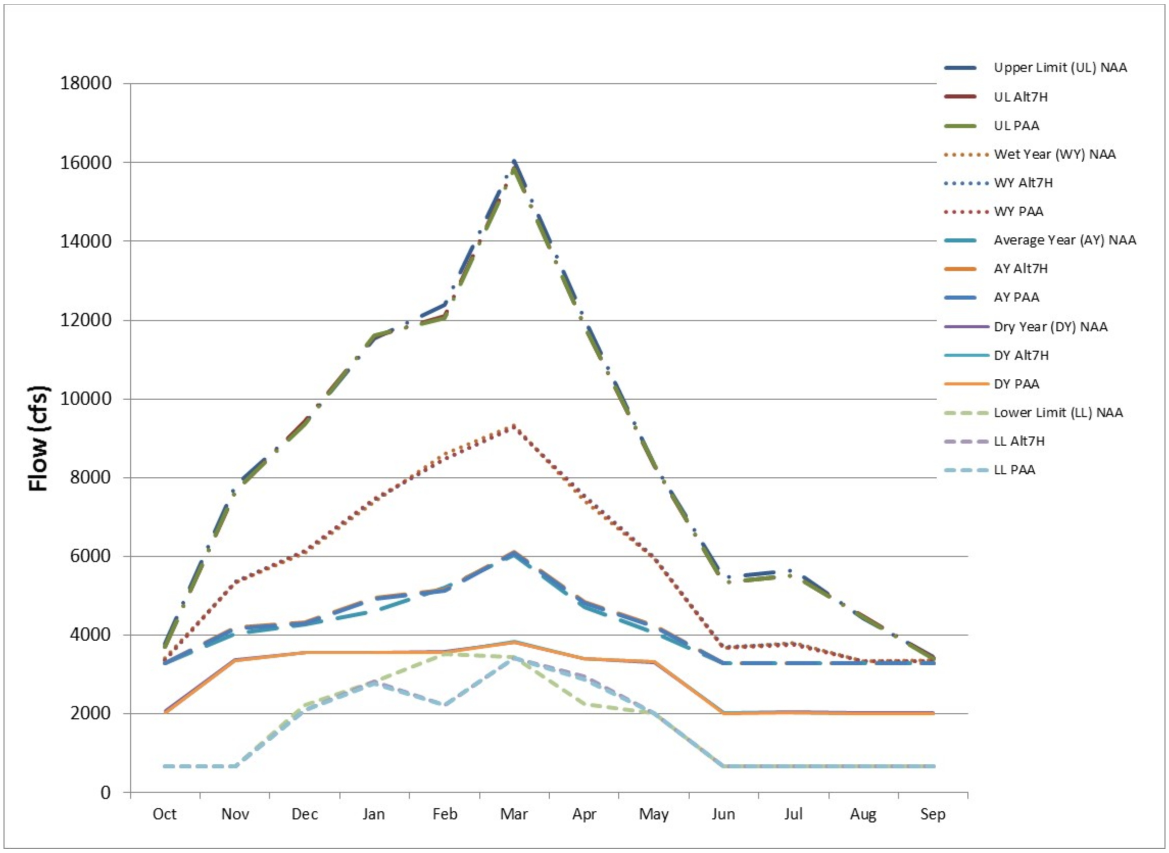


Figure 63. West Point Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

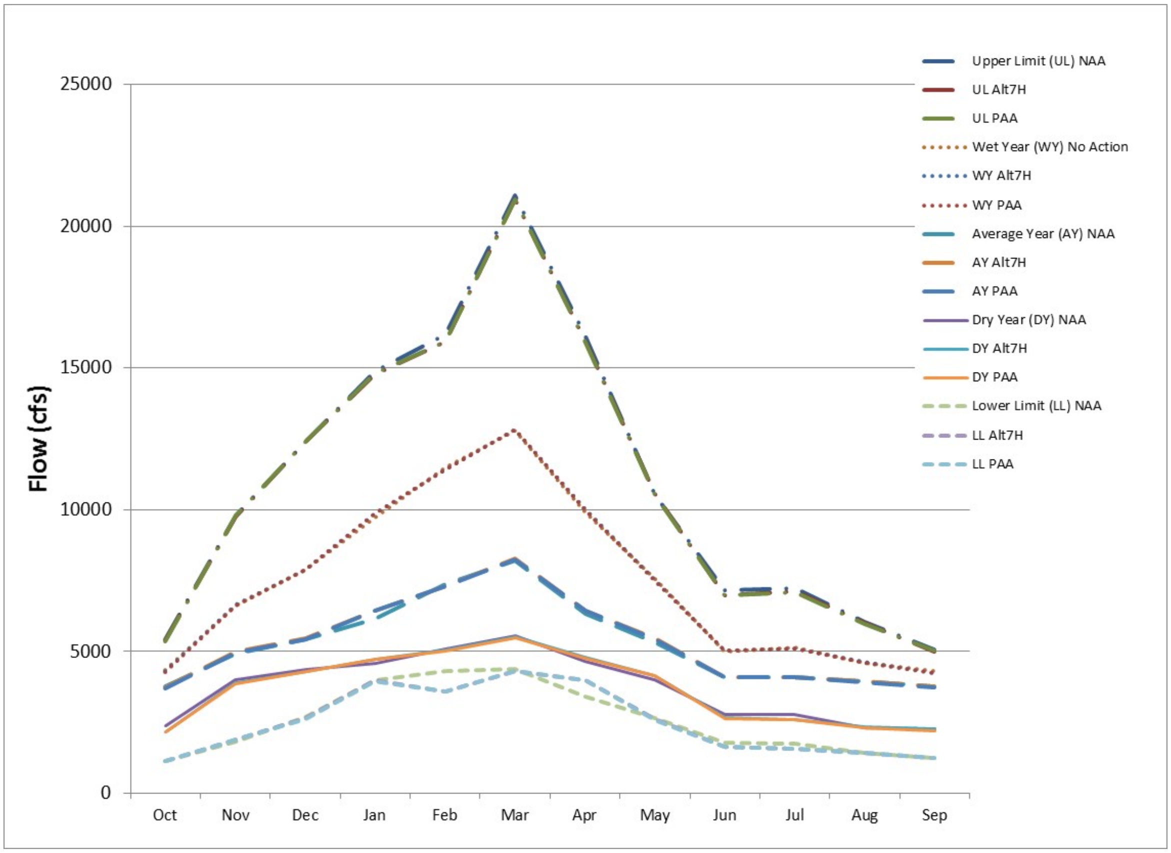


Figure 64. Columbus, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

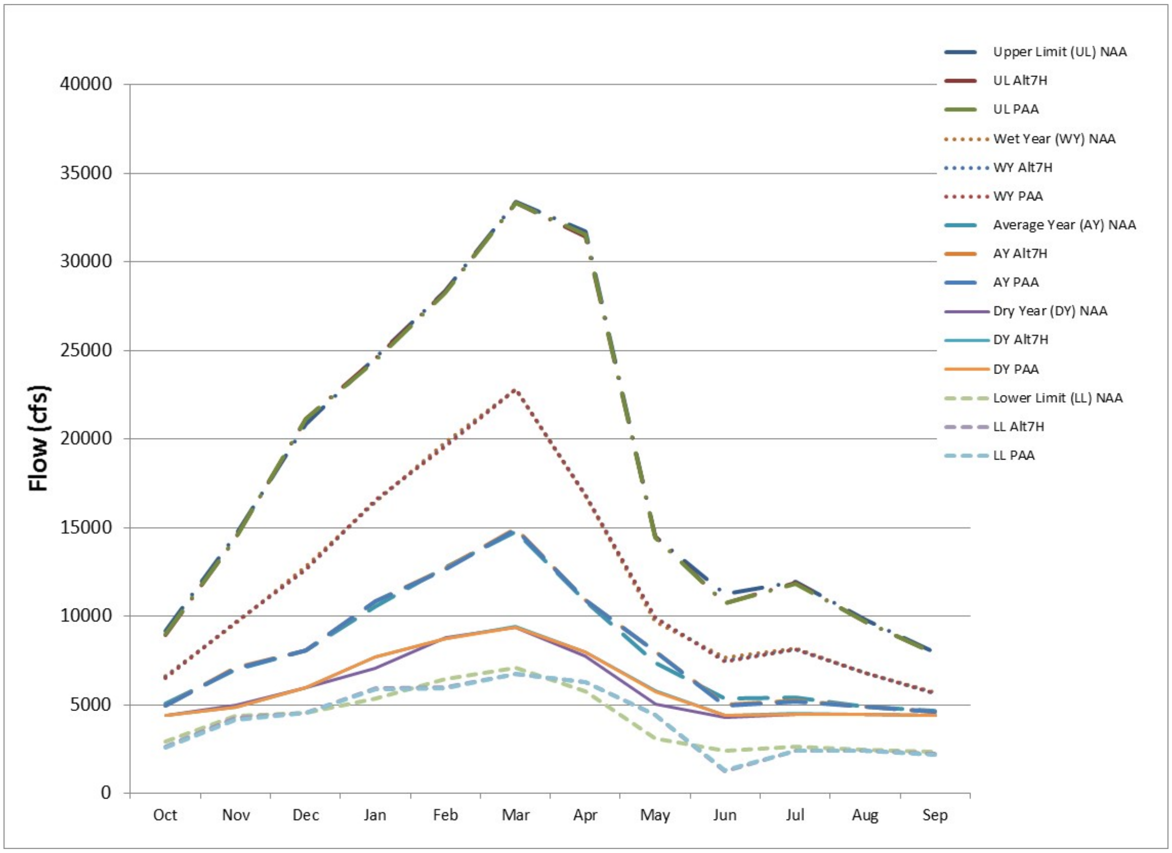


Figure 65. George Andrews Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

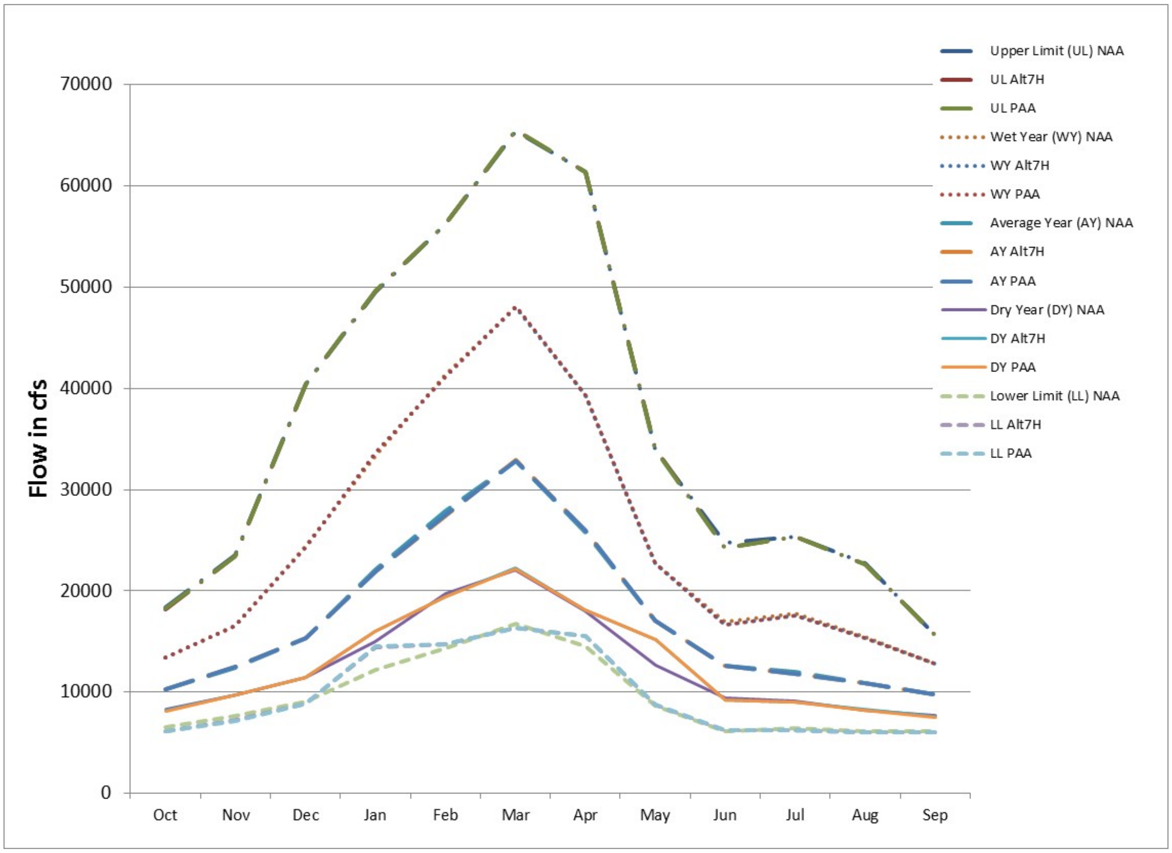


Figure 66. Chattahoochee, Florida monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

2.4.1 Chattahoochee River Shoal Bass Recruitment

As requested in the 2013 PAL, results from both the HEC-5Q and HEC-ResSim modeling efforts were used to evaluate the Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM). Shoal bass (*Micropterus cataratae*) are a fairly recently described species (Williams and Burgess, 1999) in the centrarchid (sunfish) family and is endemic to the ACF Basin. Shoal bass frequently occur in shoals (commonly co-occurring with other species) over rocky sediments in flows exceeding 0.66 ft per second. Recruitment of age-3 bass is of particular interest since this cohort has survived prevalent river conditions and has the potential to be stocked to support the recreational fishery. Recruitment success is largely dependent on surface water and spring temperature and is highly correlated with discharge.

The CRSBPM was evaluated in Atlanta, Georgia near river mile 410. The slightly higher median age-3 abundance from the PAA would be expected to be beneficial to shoal bass (Figure 67).

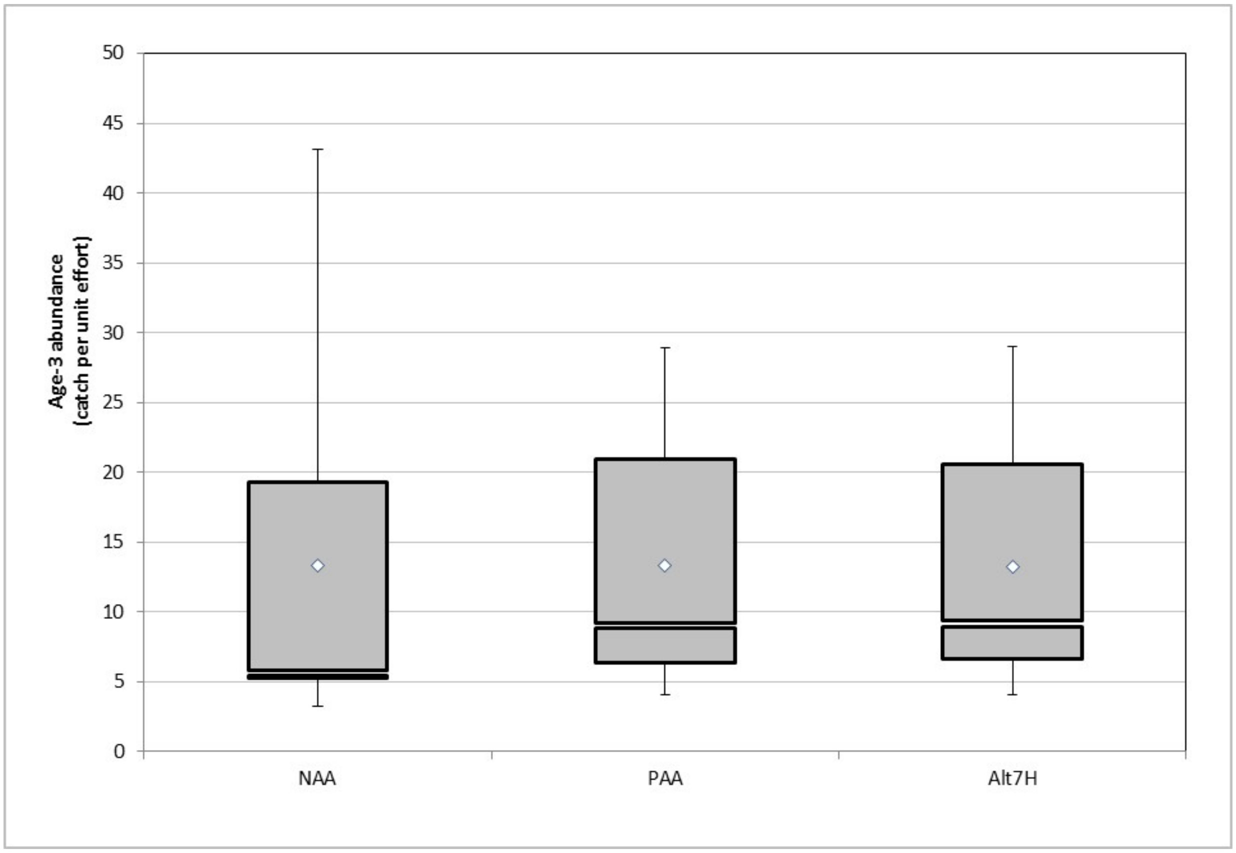


Figure 67. Shoal bass age-3 abundance at Atlanta, Georgia for the NAA and PAA (minimum; 25th, 50th, and 75th percentiles; maximum; and mean, where mean is represented by the diamond)

2.5 Apalachicola Bay Salinity Analyses

The Service contracted Dr. Peter Sheng to conducted salinity modeling of the Apalachicola Bay (Paramygin and Sheng, 2015). The preliminary results of salinity modeling provided by the Service to the USACE, indicated similar salinity levels in Apalachicola Bay between the NAA and the 2015 proposed action. It should be noted that the proposed action evaluated by Dr. Sheng is slightly different from the PAA presented here. However, the difference in the DEIS PAA (Alt7H) and the PAA (Alt7K) are limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than Alt7H. It is expected that salinity modeling results for the PAA would be similar to those presented in Paramygin and Sheng, 2015.

USACE reviewed the Service's model and concluded that, since there would be little change in the releases from Jim Woodruff Dam, little change in salinity in the Apalachicola Bay would be expected as a result of the PAA. Freshwater flows are also critical to the protection of the estuarine oyster fishery, which is sensitive to variations in salinity. The oyster fisheries in the estuarine portions of Apalachicola Bay experience impacts from drought and flooding as a result of both natural and unnatural flow variation. The PAA would present no anticipated change in the flows (wet, dry, or normal) to the estuary from the NAA, and therefore the PAA is not expected to change the current state of the oyster fishery.

Similarly, given the absence of appreciable changes in the flow dynamics from the NAA, additional impacts on other estuarine species and fisheries would not be expected.

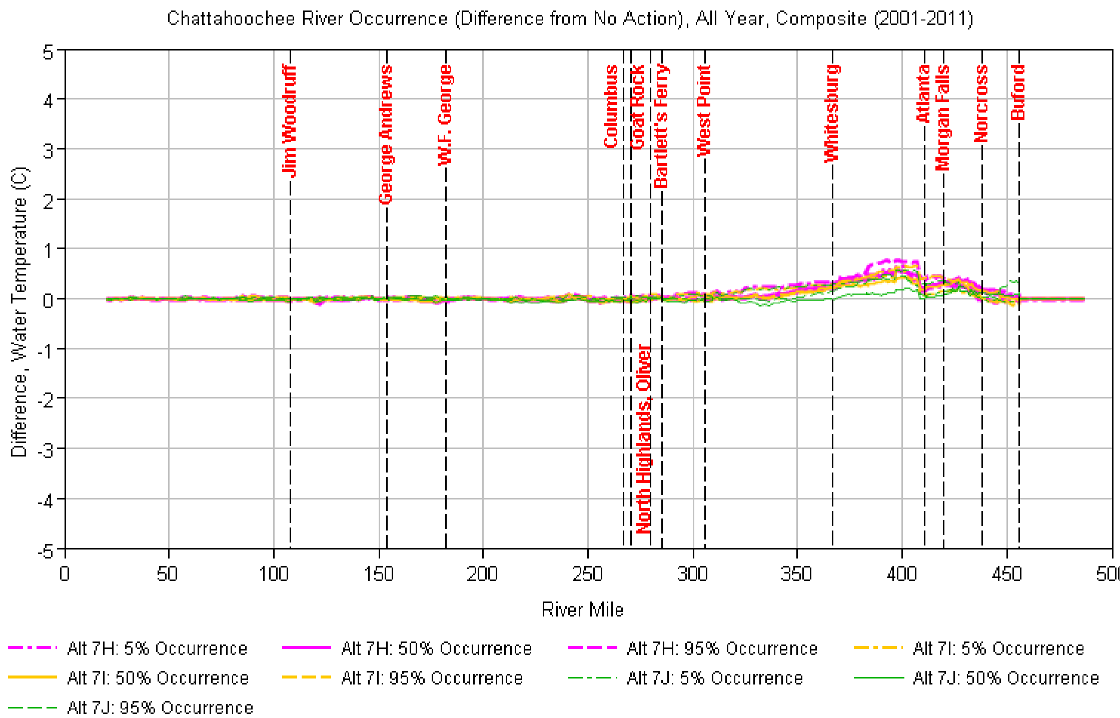
2.6 Federally-protected Species Analyses

As requested by the Service, the federally-protected species analysis is consistent with the evaluations completed for the 2012 RIOP.

2.6.1 Gulf Sturgeon Analysis

Applying the Sturgeon Spawning Habitat Performance Measure described in the 2013 PAL, USACE found that no effects on Gulf sturgeon would be expected as a result of implementing the PAA compared to the NAA. Gulf sturgeon spawning habitat was quantified at three locations known to support the species. The maximum amount of habitat available during inundation at 8.5 to 17.8 ft depths from March through May, as well as the amount of habitat available during which conditions range from 8.5 to 17.8 ft over a 30-day period to support the timing of three life stages (spawning, egg incubation, and early larval development) of Gulf sturgeon were evaluated. Collectively, these three stages have been estimated to occur over approximately 30 days in the ACF Basin (USFWS, 2008a; Pine et al., 2006). The effects of the alternatives were based on the change in median annual Gulf sturgeon spawning habitat from that available under the NAA, which is 18.17 acres. The median spawning habitat under the PAA and Alt7H, would be expected to be equal to the NAA at 18.17 acres.

This approach to evaluating Gulf sturgeon habitat was used in the 2015 PAL along with daily fall rates were evaluated for protection of mussels (section 2.6.2), maximum number of days per year with flows less than 10,000 cfs is discussed in section 2.6.2.3, and average water temperature between May and October. Figure 68 is provided consistent with the 2015 PAL response.



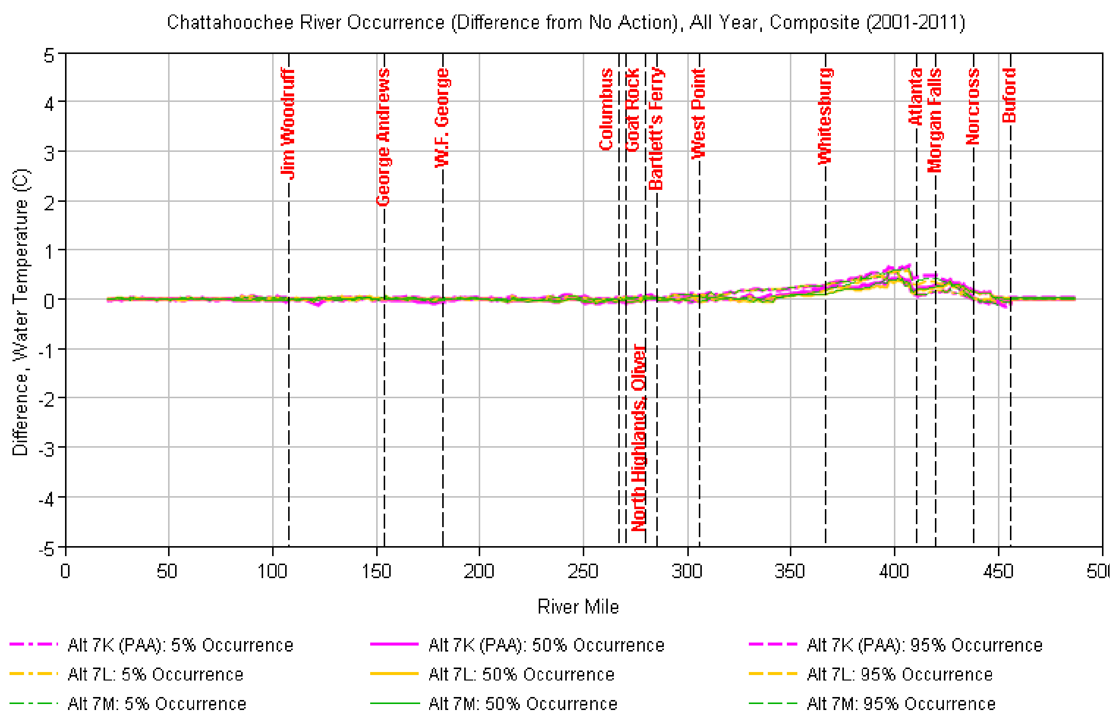


Figure 68. Change in water temperature for the modeled period 2001 through 2011

Additional analysis has been performed in updates to this Supplemental PAL based on comments on the DEIS (Figures 69 through 73). The FEIS defines effects of alternatives on Gulf sturgeon based on six specific metrics defined by the 2013 PAL:

1. The change in median annual Gulf sturgeon spawning habitat from that available under the NAA (18.17 acres), as described above
2. Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning
3. Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning
4. Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae
5. Maximum number of consecutive days per year less than 16,000 cfs
6. Departures from average water temperatures between March 1st to May 31st where changes less than 0.5 °C are acceptable

Young-of-the-year (YOY) Gulf sturgeon spend 6–10 months feeding in the river as they migrate downstream. They appear in the estuaries in December through February. Juveniles (< 6 years; except YOY) are believed to overwinter in the estuary, but telemetry studies and mark-recapture efforts are not available to confirm this. Juvenile Gulf sturgeon (304-890 mm FL) stay in the river for about the first two to three years and then move to the estuary where they forage until they reach sub-adult sized (891-1250 mm FL or three to four feet). Then they move to the barrier islands to forage, generally between December and March. It appears that juveniles, similar to adults, have a spatial distribution largely dictated by prey availability. As benthic feeders, areas within the river system that supports a prey base of benthic organisms is potential feeding grounds, and therefore considered critical habitat. Sulak and Clusston (1999) found that juvenile Gulf sturgeon are found primarily over bare sandy substrate, devoid of structural barriers such as submerged vegetation. Since little or no difference in flow conditions downstream of Jim Woodruff Lock and Dam would expected for any of the alternatives when compared to the NAA, no change in foraging habitat for Gulf sturgeon would be expected as well.

Overall, implementing the PAA (Alt7K), would be expected to have no effect on Gulf sturgeon. In addition to the median annual Gulf sturgeon spawning habitat available being the same as the NAA, the frequencies (percent of days and percent of years) of Gulf sturgeon spawning habitat on each day March 1st through May 31st, at the two sites that support spawning would be less than 2 percent difference between the PAA and the NAA. The maximum number of consecutive days on which flow would be less than 16,000 cfs would be 139, four additional days than the NAA. The departure from the average water temperature between March 1st to May 31st is less than 0.5 °C.

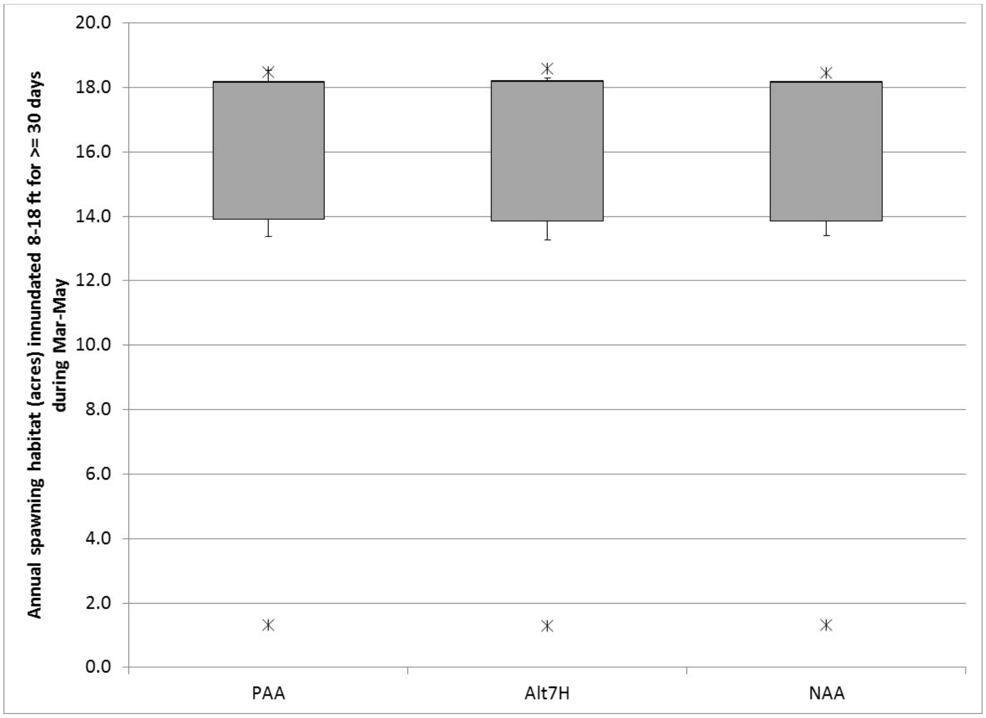


Figure 69. Change in Median annual Gulf Sturgeon spawning habitat over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and the PAA

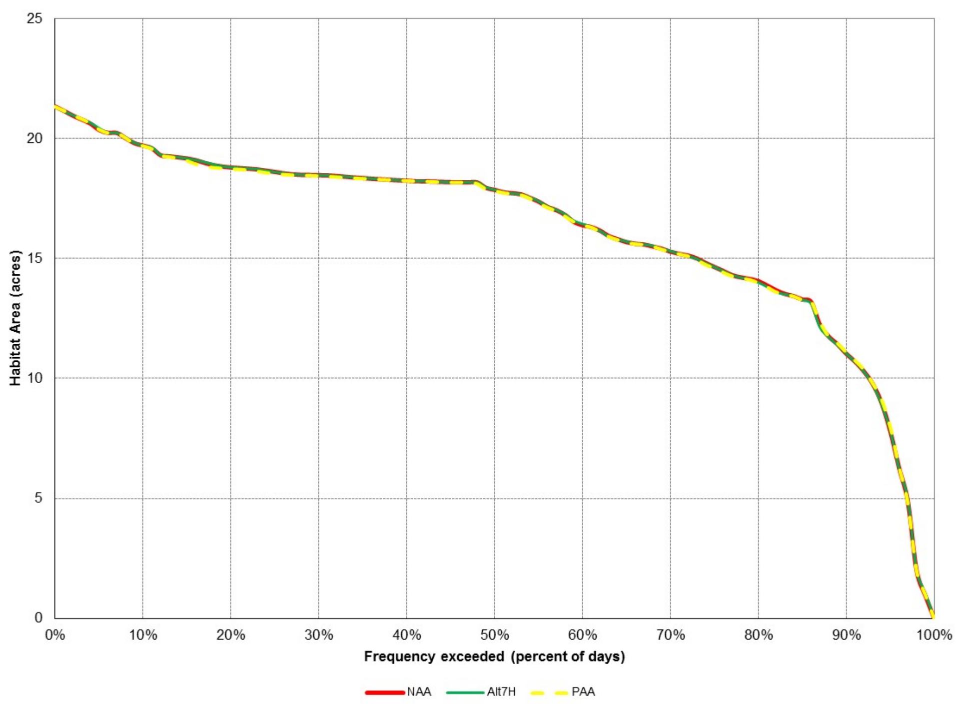


Figure 70. Frequency (percent of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and PAA

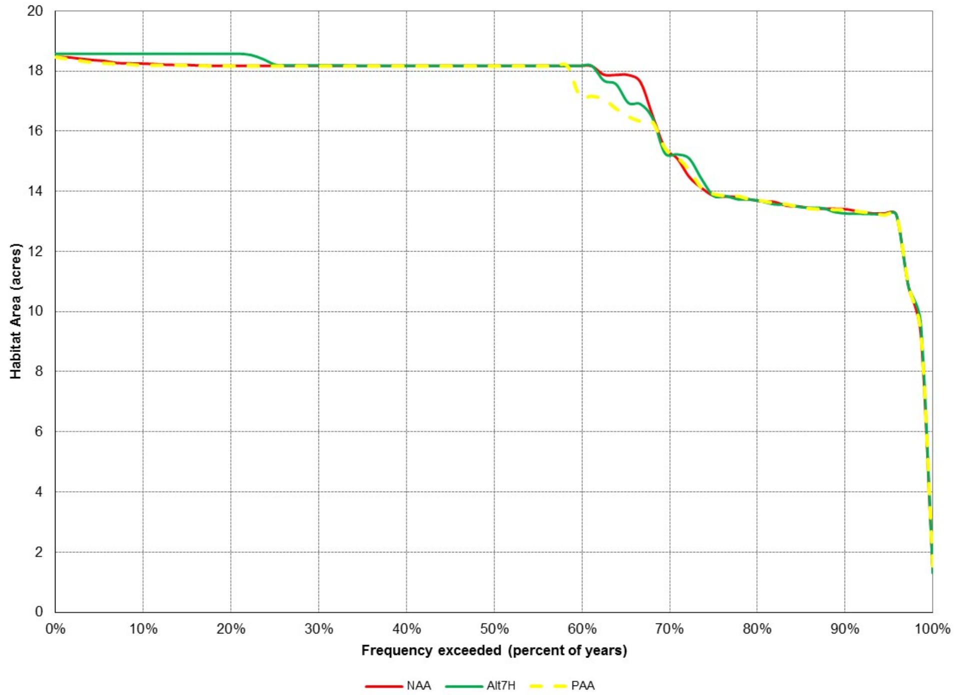


Figure 71. Frequency (percent of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and PAA

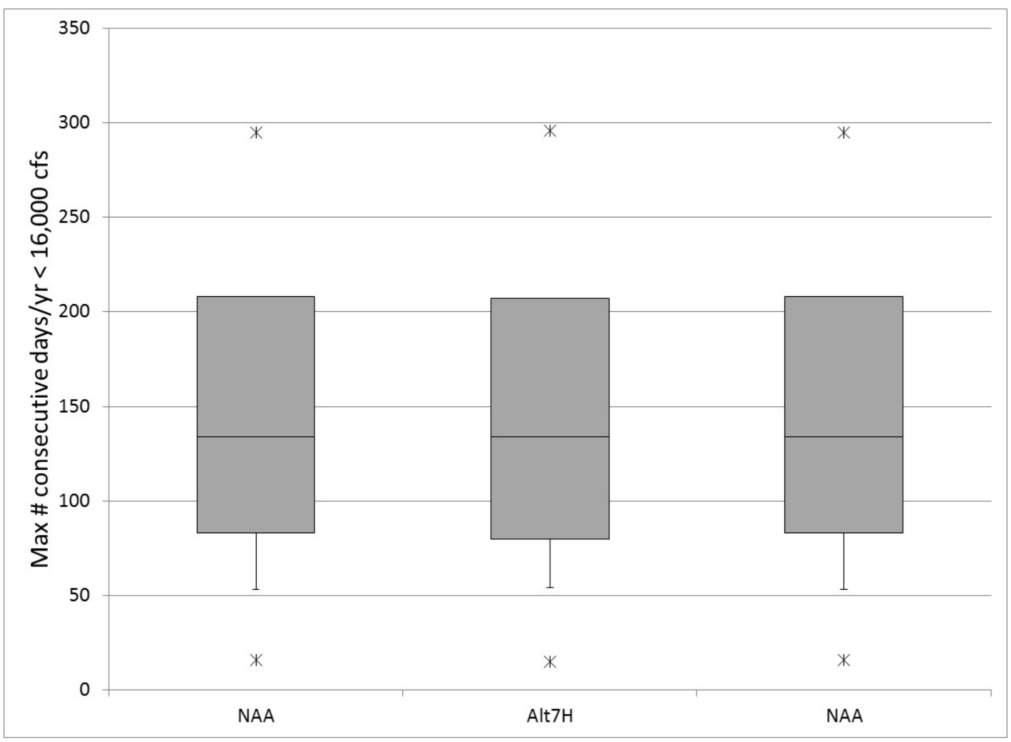


Figure 72. Maximum number of consecutive days per year less than 16,000 cfs over the Modeled Period of Record (1939–2011) for NAA, Alt7H, and PAA

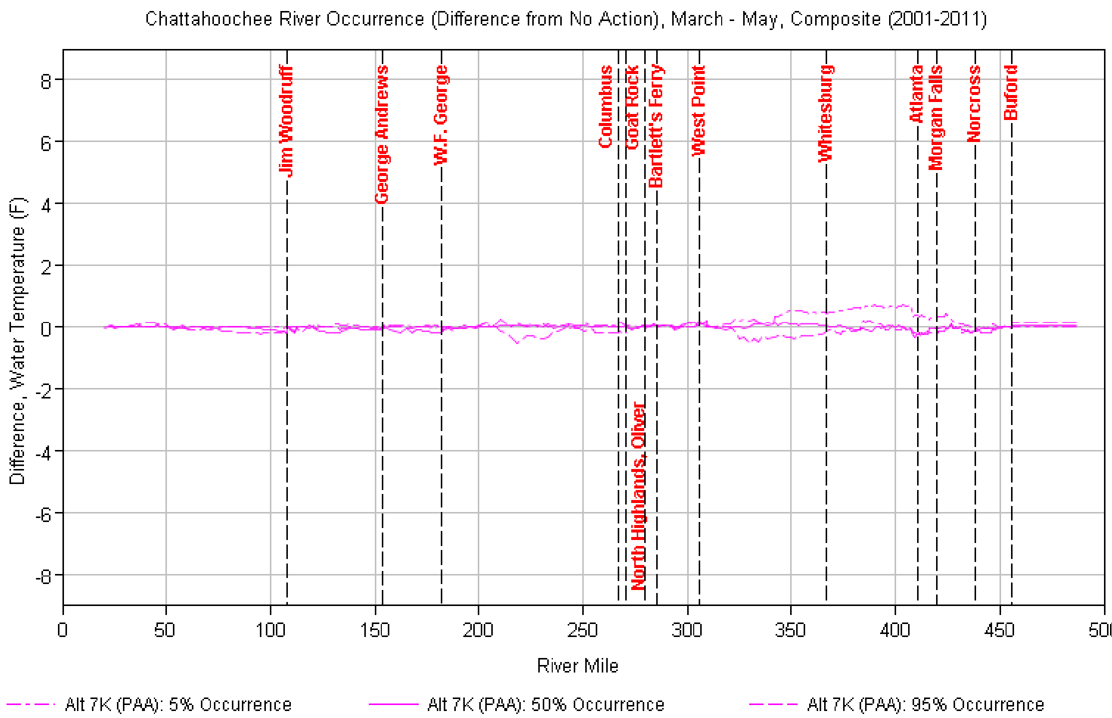


Figure 73. Departures from the NAA average water temperatures between March 1st to May 31st over the Modeled Period of Record (2001–2011) for the PAA

2.6.2 Freshwater Mussels Analysis

USACE applied several metrics developed by the Service (Apalachicola River Mussel Performance Measure) to evaluate the effects of the alternatives on mussel species in the Apalachicola River from exposure during low flow conditions. Interpretation of HEC-ResSim results provide the basis for the description of effects on mussels in the ACF Basin. River water levels (dependent on the discharge of Jim Woodruff Dam) largely dictate available habitat for Apalachicola River mussels.

The following subsections define the effects of alternatives on mussels based on specific metrics defined by the 2013 PAL:

1. Lowest daily flow for each year
2. Interannual frequency of flow rates less than 5,000 to 10,000 cfs
3. Maximum number of days flows per year are less than 5,000 – 10,000 cfs
4. Maximum number of consecutive days per year flows are less than 5,000 – 10,000 cfs
5. Median number of days flows per year are less than the thresholds of 5,000 and 10,000 cfs and median number of consecutive days per year flows are less than 5,000 to 10,000 cfs
6. Frequency (number of days) of daily stage changes (ft/day)
7. Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs
8. Median fall rate when flows are less than 10,000 cfs
9. Maximum fall rate when flows are less than 10,000 cfs

The results of the PAA on these metrics varies from slightly adverse to slightly beneficial. Therefore, overall, implementing the PAA would be expected to have negligible effect on mussels when compared with the NAA. The PAA would be expected to decrease flow rates greater than 5,000 cfs in 3 percent of years. An increase of one day would be expected for the median number of days per year with flows less than 10,000 cfs and an increase of 3 days would be expected for the median number of consecutive days per year with flow rates less than 10,000 cfs. The median and maximum fall rates remain the same for the PAA as the NAA. The lowest daily flow rate for each year over the modeled period, was less than 5,000 cfs in one year, 2007. The maximum number of days per year when the flow would be less than 10,000 cfs would increase by 2 days, compared to the NAA. The maximum consecutive days per year when the flow would be less than 10,000 cfs would decrease by 3 days for the PAA compared to the NAA. Additionally, the median and maximum fall rates remain the same for the PAA as the NAA. The number of days of daily stage changes between 0.25-2.00 ft/day would be 699, which is greater than a 5 percent increase from the NAA. Additionally, the percent of years of daily stage changes between 0.25-2.00 ft/day is greater than 10 percent, higher than the NAA.

2.6.2.1 Lowest Daily Flow Rate for Each Year

The lowest annual flows at Chattahoochee, Florida for the modeled period from 1939 through 2011 are presented in Table 11. The PAA would be expected to have minimum flows near 4,500 cfs in one year. During the same year the NAA would be expected to have minimum flows near 5,000 cfs, the minimum release under current operations.

Table 11.
Minimum modeled flow at Chattahoochee, Florida for each modeled year

Year	NAA	Alt7H	PAA (Alt7K)
1939	9444	9442	9443
1940	7288	6196	6263
1941	5010	5188	5189
1942	9619	9619	9619
1943	7835	7827	7828
1944	9163	9163	9162
1945	9035	9402	9368
1946	10401	10317	10309
1947	9887	9884	9887
1948	11906	11905	11905
1949	13453	13471	13463
1950	7766	7701	7690
1951	5353	5050	5050
1952	7182	7115	7036
1953	8852	8852	8852
1954	5406	5050	5050
1955	5009	5050	5050
1956	5338	5050	5050
1957	5622	5601	5583
1958	8258	8254	8255
1959	8456	8489	8493
1960	8806	8775	8764
1961	7873	7869	7870

Year	NAA	Alt7H	PAA (Alt7K)
1962	7419	7374	7391
1963	5678	5693	5669
1964	12695	12673	12674
1965	9406	9399	9409
1966	8453	8453	8453
1967	7550	7551	7531
1968	5634	5278	5238
1969	6067	5951	5948
1970	6996	6996	6996
1971	9823	9862	9834
1972	6797	6787	6789
1973	8531	8636	8636
1974	8505	8490	8451
1975	14254	14355	14324
1976	8157	8262	8169
1977	6344	6197	6167
1978	6918	6203	6203
1979	6694	6676	6652
1980	6449	6441	6444
1981	5020	5049	5049
1982	8368	8576	8353
1983	8324	8504	8504
1984	8292	8292	8292
1985	5858	6184	6159
1986	5049	5049	5049
1987	6277	6087	6081
1988	5050	5050	5050
1989	8242	6311	6317
1990	6017	5964	5971
1991	9001	9005	9004
1992	8374	7280	7299
1993	5610	5603	5838
1994	9027	10644	10635
1995	7120	7007	6972
1996	7637	7645	7642
1997	6027	5781	5810
1998	8296	7748	7717
1999	5050	5050	5050
2000	5050	5050	5050
2001	5288	5300	5301
2002	5050	5050	5050

Year	NAA	Alt7H	PAA (Alt7K)
2003	8907	8977	8975
2004	7006	5844	5457
2005	9131	9123	9124
2006	5050	5050	5050
2007	5050	4550	4550
2008	5050	5050	5050
2009	7306	7463	7451
2010	5723	5702	5712
2011	5050	5050	5050

2.6.2.2 Inter-annual Frequency of Flows less than 5,000–10,000 cfs

Mussels are susceptible to stranding at flows ranging from 5,000 to 10,000 cfs, particularly following high-flow events (> 100,000 cfs) that serve to move individuals into depositional areas (USFWS, 2008a). Inter-annual flows, expressed as the frequency of occurrence of the percent of years, were evaluated to address the potential for stranding (Figure 74).

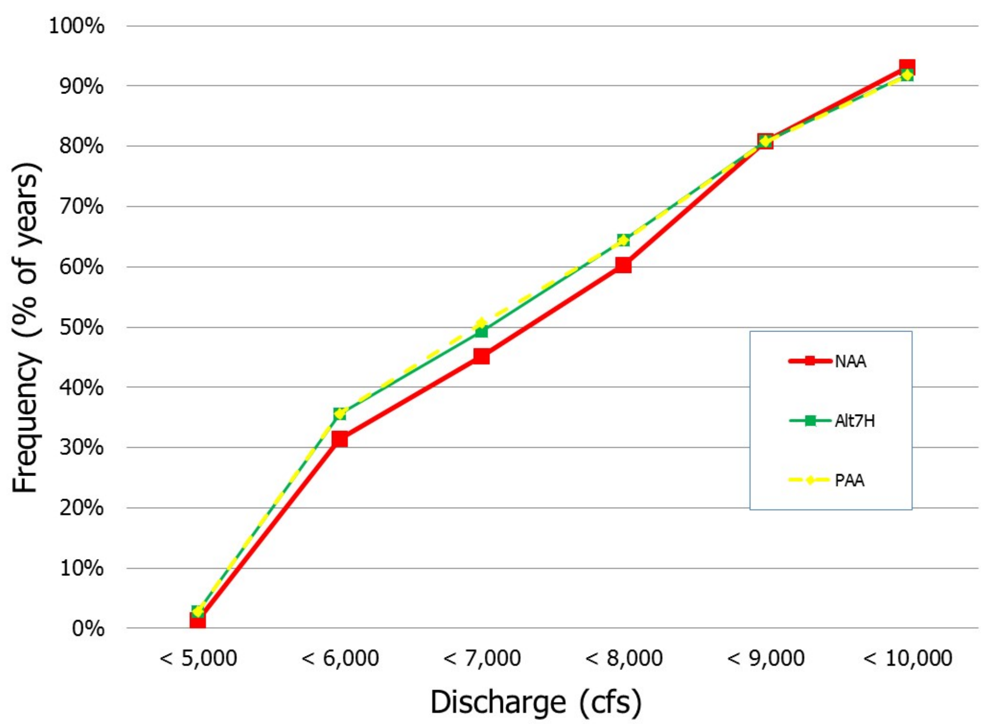


Figure 74. Inter-annual frequency of flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs based on 1939 – 2011 (*Figure 4.2.5.A.* from the 2008 Biological Opinion [BO] and *Figure 4.2.3.A.* from the 2012 BO)

2.6.2.3 Maximum Number of Days per Year Flows less than 5,000–10,000 cfs

The maximum number of days per year with flows less than 5,000–10,000 cfs provides an estimation of the most severe conditions aquatic biota will experience under the proposed flow regimes (Figure 75).

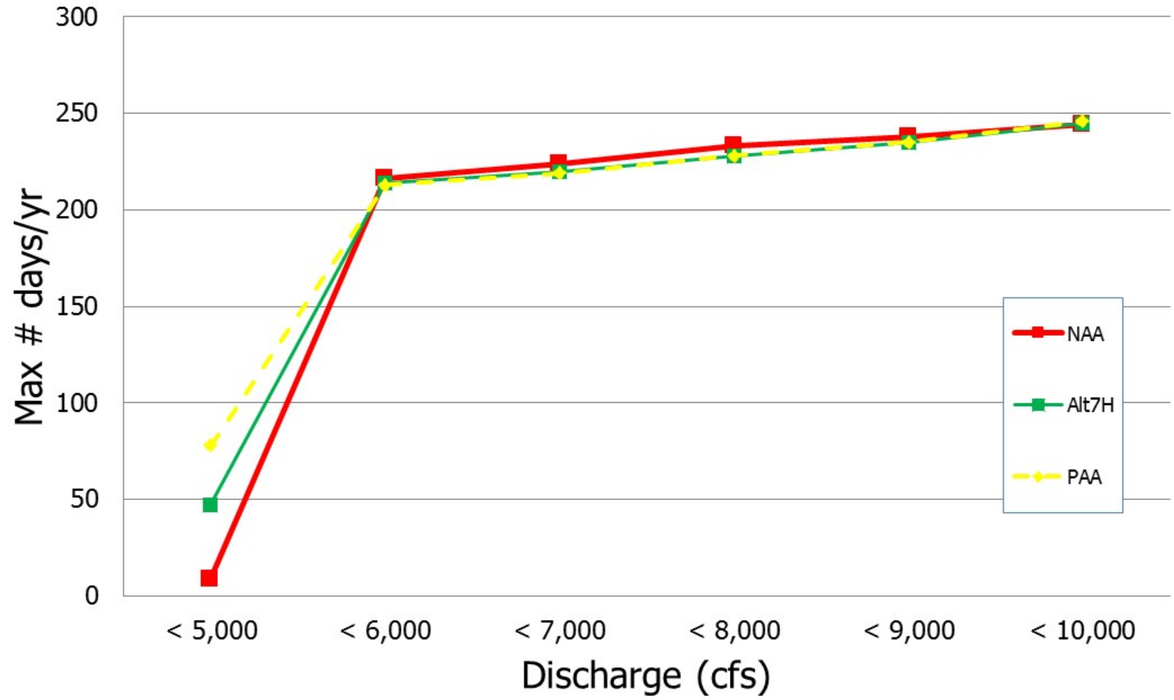


Figure 75. Maximum number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.B.* from the 2008 BO and *Figure 4.2.3.B.* from the 2012 BO*)*

2.6.2.4 Maximum Number of Consecutive Days less than 5,000 - 10,000 cfs

Mussels can survive brief periods of stranding by closing their shells or burrowing in substrate. Thus, without extreme water temperatures, mussel survival from stranding is most likely a function of exposure duration (USFWS, 2008a). To address that, the maximum number of consecutive days of flows between 5,000 and 10,000 cfs was evaluated. Figure 76 shows the maximum number of consecutive days of flows at less than 5,000–10,000 cfs.

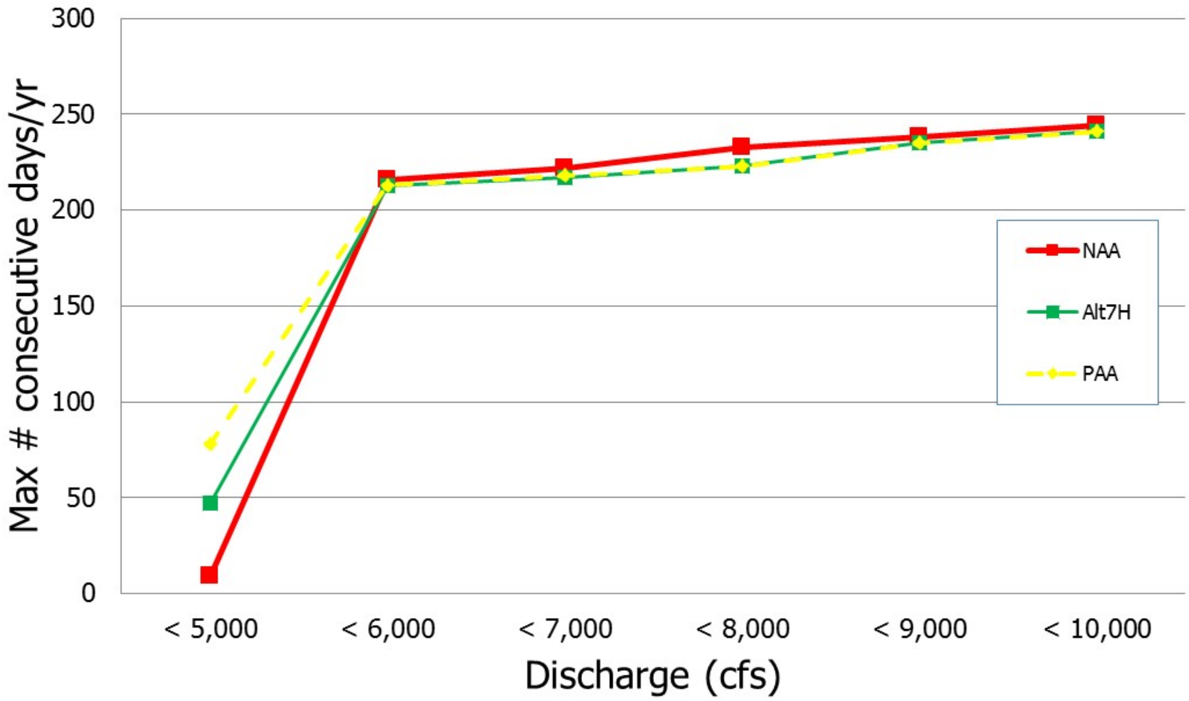


Figure 76. Maximum number of consecutive days with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.C.* from the 2008 BO and *Figure 4.2.3.C.* from the 2012 BO*)*

2.6.2.5 Median Number of Days per Year Flows less than 5,000–10,000 cfs

The duration of moderate low-flow periods are also an important consideration for the survival of mussels and other aquatic biota. Chronic low-flow events occur with greater frequency than extreme events and, despite the less severe conditions, serve to decrease habitat availability, increase physiological stress, and increase both exposure-related and predatory mortality. Median flows below 7,000 cfs would not be expected in the NAA and would only occur once in the PAA (Figure 77). The median number of consecutive days per year was also evaluated (Figure 78).

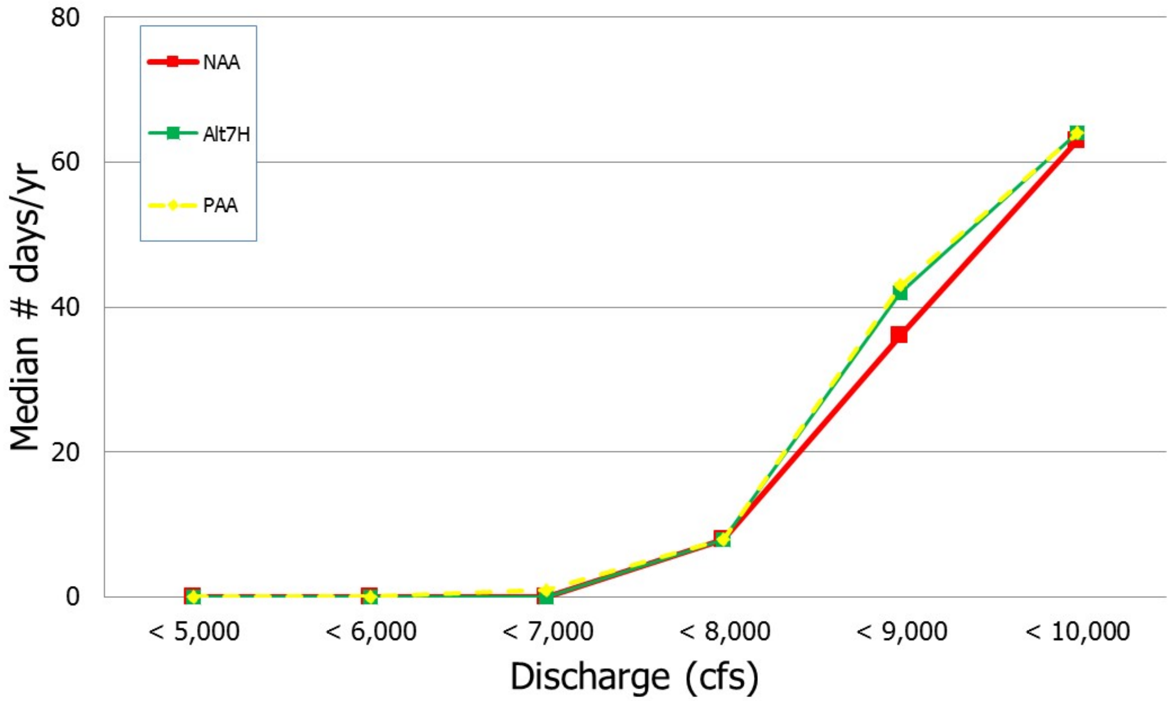


Figure 77. Median number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.D.* from the 2008 BO and *Figure 4.2.3.D.* from the 2012 BO*)*

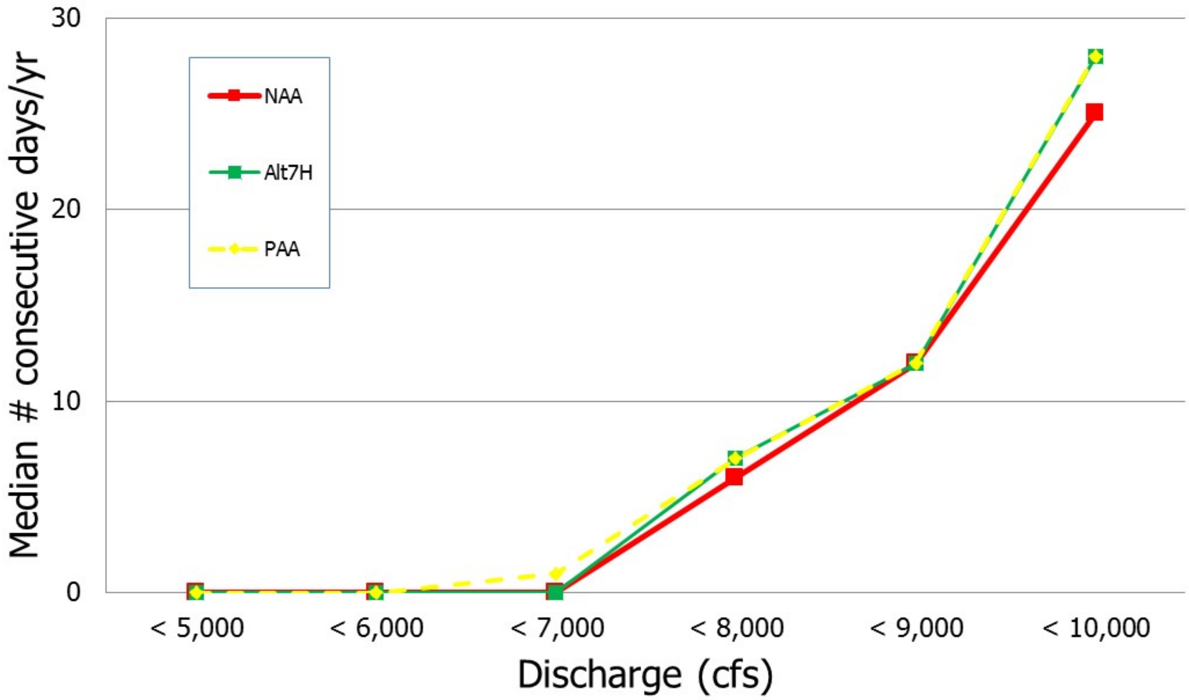


Figure 78. Median number of consecutive days per year with flows between 5,000-6,000; 6,000-7000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.3.E.* from the 2012 BO [Figure was not included in the 2008 BO]*)*

2.6.2.6 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day

The 2012 RIOP maximum fall rate schedule was established to avoid extreme declines in daily river stage levels and decrease the risk of exposure or stranding of aquatic biota. Declining river stages are moderated by operating schedules to provide an attenuation of flows that allow for more gradual fall rates as flows decline. Those rates are not presented but results presented in previous sections, for releases from Woodruff Dam less than 10,000 cfs, would be expected to sufficiently illustrate differences between the NAA and PAA since the listed mussels generally do not occur at stages higher than those equivalent to 10,000 cfs.

2.6.2.7 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day when Releases at Woodruff Dam are less than 10,000 cfs

A fall rate analysis was performed to evaluate whether an increase in the percentage of days with rates greater than 0.25 ft/day would affect federally listed mussel species. The evaluation is restricted to periods when releases from Jim Woodruff Dam are less than 10,000 cfs. The results are illustrated in Figure 79.

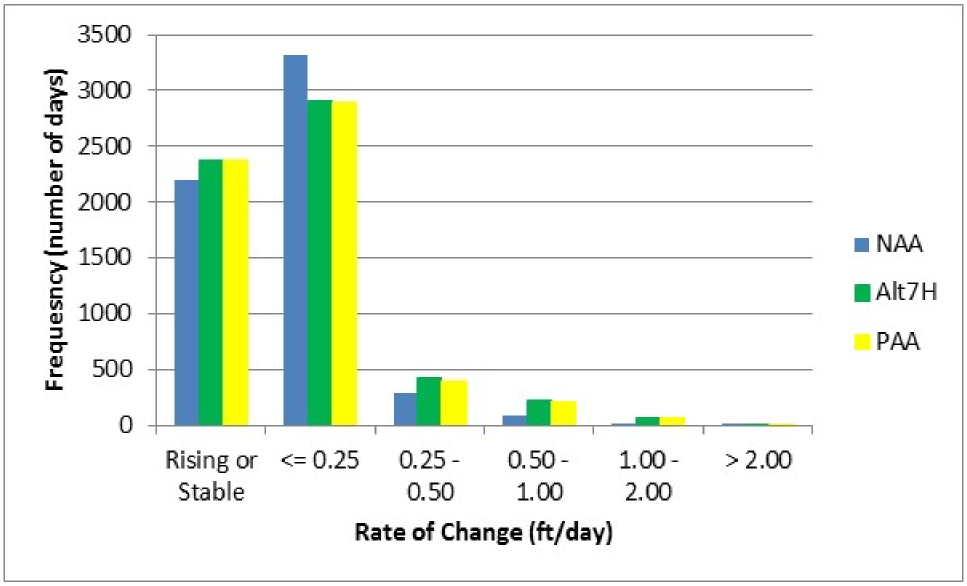


Figure 79. Frequency (number of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs from 1939-2011. (*Figure 4.2.5.F.* from the 2008 BO and *Figure 4.2.3.G.* from the 2012 BO*)*

2.7 Additional Analysis - Fish and Wildlife Management Facilities

2.7.1 Eufaula National Wildlife Refuge

The potential impacts on Eufaula National Wildlife Refuge (ENWR) are primarily related to reservoir level fluctuations at W.F. George Lake, influencing the refuge in three critical areas (USFWS, 2008b): (1) direct effects on habitat availability for wildlife; (2) effects on vegetation communities, particularly with respect to invasive species; and (3) the availability of water during October and November to off-reservoir impoundments that support waterfowl habitat management.

The USACE considered the Service's request to cycle Walter F. George Lake between the highest levels (190 ft) in late winter/early spring to the lowest levels (185 ft) in late summer to accommodate ENWR operations (Figure 80). As proposed, the option would require operation of the reservoir at its highest pool levels during winter-spring, when flood releases are typically the greatest. That would reduce the ability of the project to attenuate approximately 87,000 ac-ft of potential downstream flooding. By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased, resulting in bank erosion and channel modifications below the project. Similarly, to operate the project at its lowest levels during the summer is contrary to what is required to meet the highest demands for recreation, hydroelectric power, and flow augmentation. Essentially, such an option would remove Walter F. George Lock and Dam from the system approach to operations across the basin and eliminate approximately 100,000 ac-ft of conservation storage that could be used to meet authorized project purposes in the summer. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant adverse effects on the authorized project purposes and the structural stability and safety of the dam. For these reasons, operations to manage Walter F. George Lake to benefit the Eufaula Wildlife Refuge operations were not considered further.

The differences between the median daily water surface elevations at Walter F. George Lake are negligible between the NAA and PAA (Figure 81).

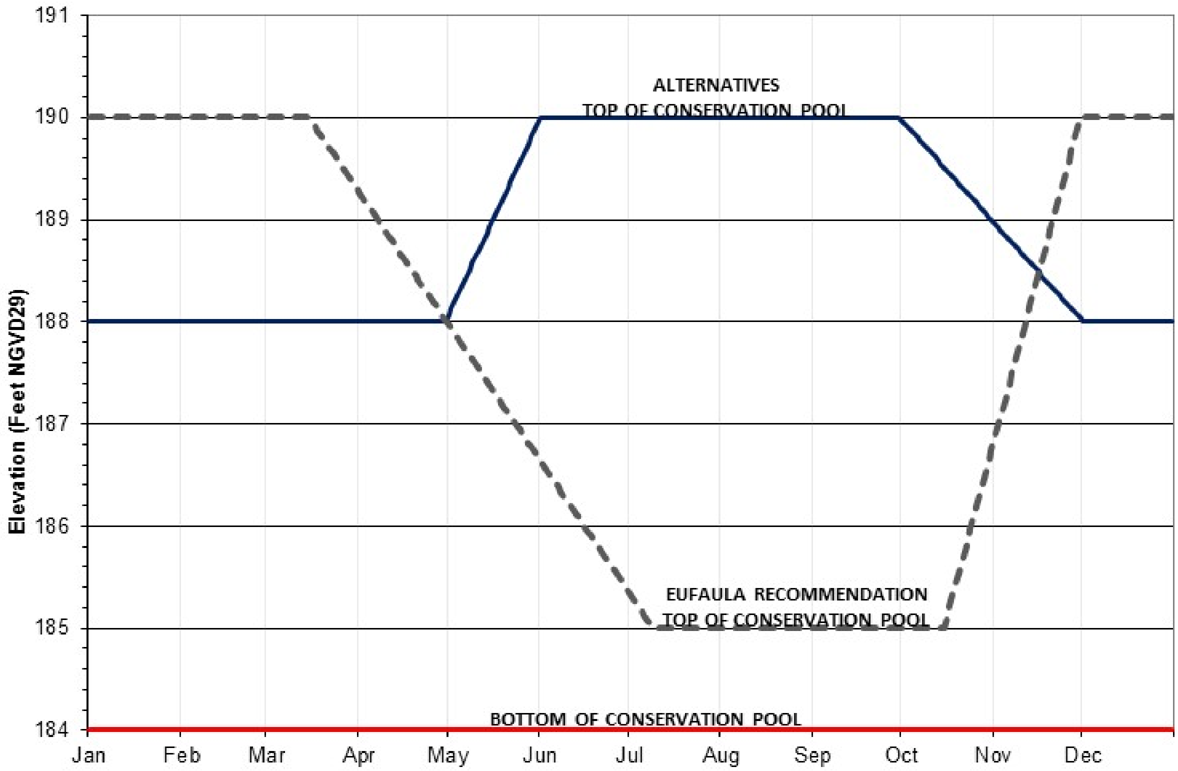


Figure 80. Eufaula National Wildlife Refuge recommended water surface elevation compared with the NAA and PAA top of conservation pool elevation.

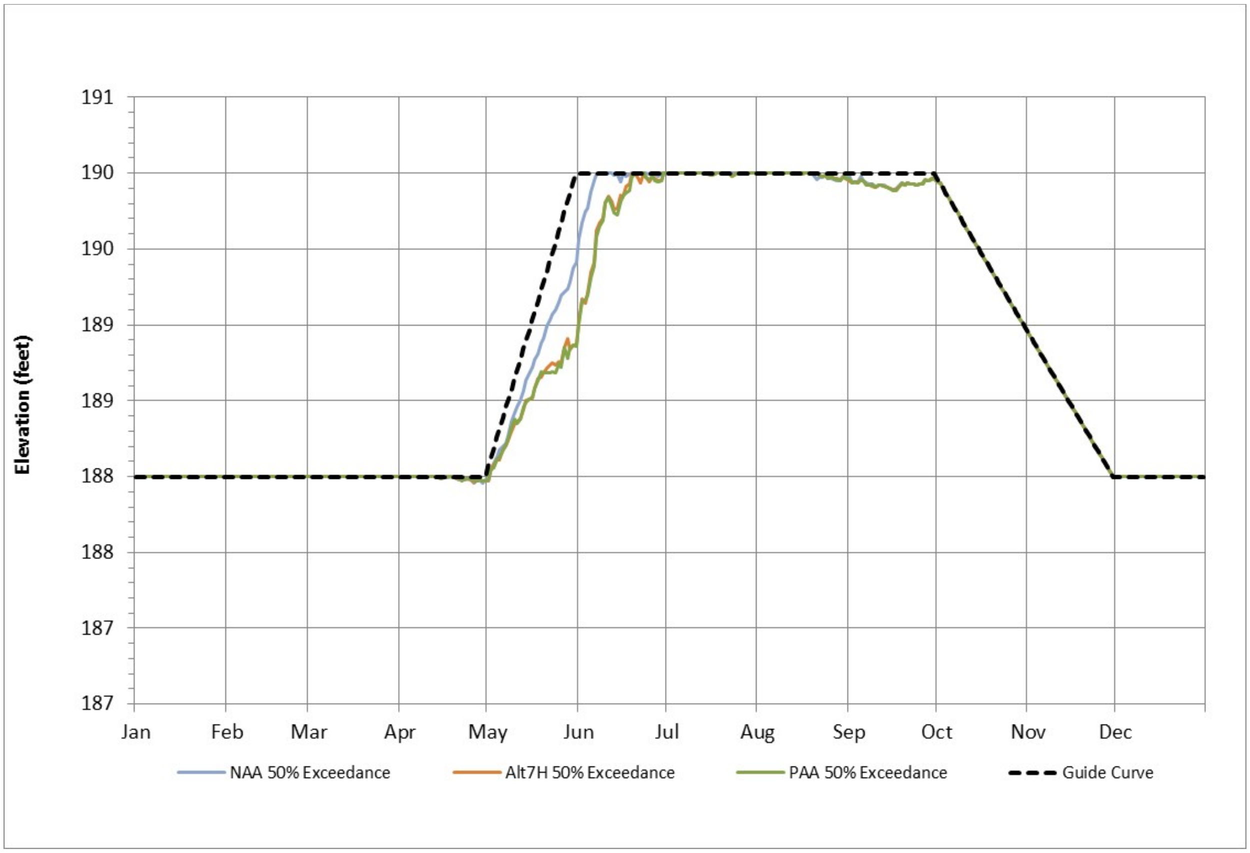


Figure 81. Walter F. George Lake, median daily water surface elevation over the modeled period of record (1939-2011) for the NAA and PAA

2.7.2 Fish hatcheries

Four major fish hatcheries are in the ACF Basin. Buford Trout Hatchery is the only fish hatchery in the ACF Basin that relies on surface flows for its operations, and it is the largest user of water. Changes in flow on the Chattahoochee River are negligible between alternatives, and would not be expected to affect operations at the Buford Trout Hatchery (Figure 82).

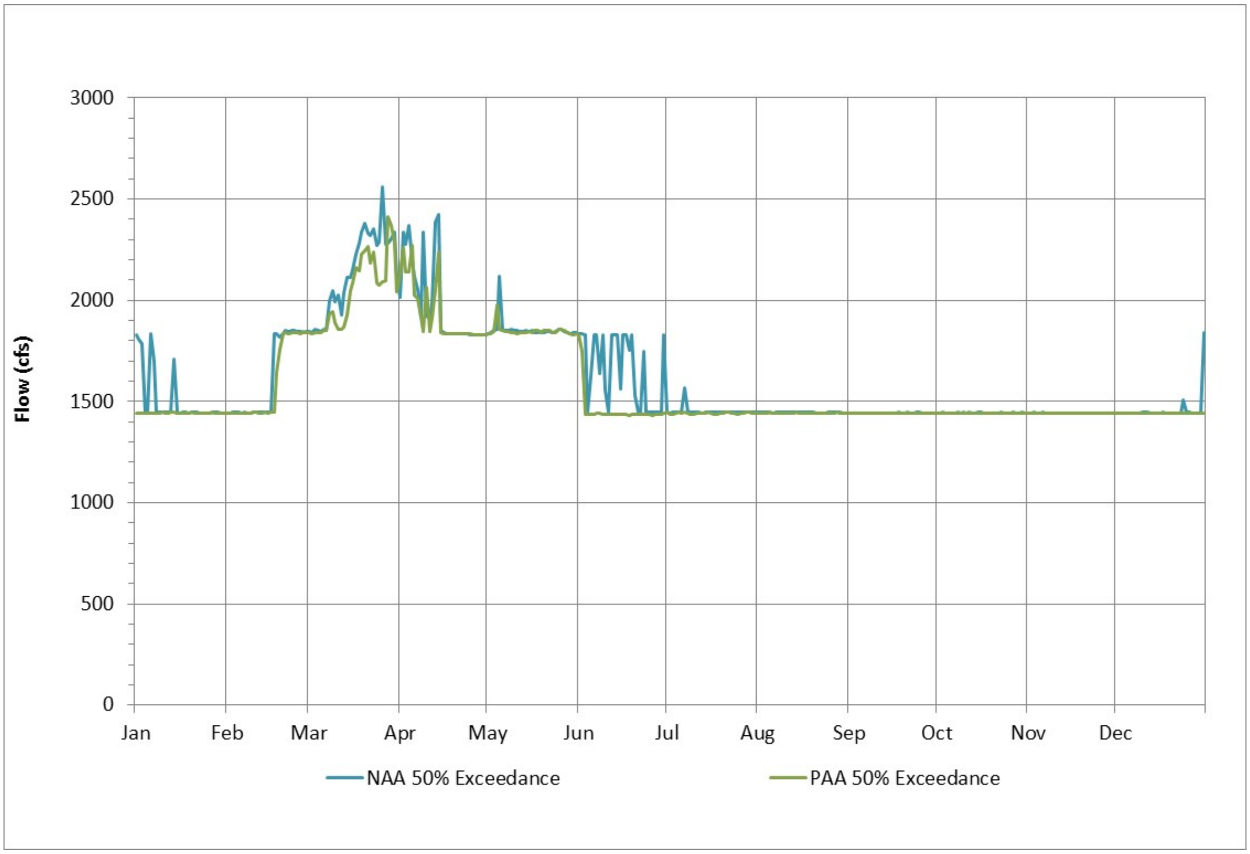


Figure 82. Chattahoochee River—median daily flows below Buford Dam, Georgia (RM 348.1) for the NAA and PAA

3 References

Paramygin, V.A. and Sheng, Y.P. 2015. A Preliminary Report: Simulating the response of estuarine salinity in Apalachicola Bay. Prepared for U.S. Fish and Wildlife Service. Prepared by Engineering School of Sustainable Infrastructure and Environment, University of Florida.

Patton, T., & Lyday, C. (2008). Ecological succession and fragmentation in a reservoir: Effects of sedimentation on habitats and fish communities. *American Fisheries Society Symposium*, *62*, 147–167.

Pine, W.E., H.J. Flowers, K.G. Johnson, and M.L. Jones. 2006. *An Assessment of Gulf Sturgeon Movement, Spawning Site Selection, and Post-Spawn Holding Areas in the Apalachicola River, Florida*. Final report submitted to the Florida Fish and Wildlife Conservation Commission. University of Florida, Gainesville.

Ryder, S., J. Taylor, and J.H. Crance. 1995. *Relations between Reservoir Surface Water Elevations and Reservoir Fisheries*. Comprehensive Study ACT/ACF River Basins. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

Sulak, K. J. and J. P. Clugston. 1999. *Recent advances in life history of Gulf of Mexico sturgeon, Acipenser oxyrinchus desotoi, in the Suwannee river, Florida, USA: a synopsis.* Journal of Applied Ichthyology. 15:116-128.

USFWS (U.S. Fish and Wildlife Service). 2008a. *Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River*. U.S. Fish and Wildlife Service, Panama City, FL.

USFWS (U.S. Fish and Wildlife Service). 2008b. *Draft Comprehensive Conservation Plan and Environmental Assessment for Eufaula National Wildlife Refuge, Barbour and Russell Counties, AL, and Stewart and Quitman Counties, GA.* U.S. Fish and Wildlife Service, Southeast Regional Office, Atlanta, GA.

USACE (U.S. Army Corps of Engineers). 2012, August 7. Chief of Engineers memorandum regarding reissuance of the U.S. Army Corps of Engineers Environmental Operating Principles. Accessed October 2014. http://www.usace.army.mil/Portals/2/docs/Environmental/EAB/eop_coe_reissuedeop_07aug2012.pdf.

USACE (U.S. Army Corps of Engineers). 1989. *Apalachicola-Chattahoochee-Flint Basin, Water Control Plan*. Draft. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

USACE (U.S. Army Corps of Engineers). 2015a. *ACF Water Control Manual Update Response to Planning Aid Letter*. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

USACE (U.S. Army Corps of Engineers). 2015b. *Draft Environmental Impact Statement Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment*. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

Williams, J.D., and G.H. Burgess. 1999. A new species of bass, *Micropterus cataractae* (Teleostei: Centrarchidae), from the Apalachicola River Basin in Alabama, Florida and Georgia. *Bulletin of the Florida Museum of Natural History* 42(2):80–114.

Response to U.S. Fish and Wildlife Service Draft Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

U.S. Army Corps of Engineers
MOBILE DISTRICT

August 2015

INTRODUCTION

The U.S. Army Corps of Engineers (Corps), Mobile District is updating the Water Control Manuals (WCMs) for the Apalachicola-Chattahoochee-Flint River Basin (ACF Basin). The WCM update process is to determine how the federal projects in the ACF Basin should be operated to meet all authorized purposes and to implement these operations through the means of the updated water control plans and manuals. Fish and wildlife conservation is an authorized purpose of the federal ACF system, and as good stewards of the environment and wanting to assure that the fish and wildlife interests were adequately considered, the Corps sought comment and analysis by the U.S. Fish and Wildlife Service (FWS) and state agencies of the Proposed Action Alternative (PAA) prior to release of the Draft EIS to the public. Although the PAA does not include any construction or structural modifications to the ACF project, nor is a report or a recommendation to Congress part of this effort, the Corps utilized the general framework of the Fish and Wildlife Coordination Act (FWCA) to solicit input from FWS and state agencies and to organize the information provided. On July 31, 2015, the FWS, Georgia Ecological Services Office, Athens, Georgia submitted the Draft *Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida* (DFWCAR) to the Corps, Mobile District. This report provides the Corps' detailed response to the questions and comments outlined in the DFWCAR.

The following comments regarding the WCM update purpose and scope are required to establish the appropriate context for the Corps' response to the DFWCAR. After that, the document is organized by first addressing the FWS's fish and wildlife conservation measures and recommendations; followed by discussion of the FWCA agency coordination, project impacts and evaluation methodology, the FWS's evaluation of the selected plan, and the FWS's position. Page numbers referencing the relevant information in the DFWCAR are provided.

The proposed action is to update the water control plans and manuals for the ACF Basin as directed by Secretary of the Army Pete Geren on January 30, 2008. Specifically, the purpose and need for the federal action is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through updated water control plans and manuals. Conditions in the basin (e.g., population, socioeconomic, land use, infrastructure, and demand for water resources) have changed substantially since the federal reservoirs were authorized and constructed, and a variety of applicable federal and state environmental laws have been passed and implemented. Operation of the federal reservoir projects in the basin both affect, and are affected by, current conditions in the basin and must comply with current laws and regulations. This action will result in an updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, that reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues.

On June 28, 2011, the U.S. Court of Appeals for the Eleventh Circuit issued an opinion that the authorizing documents for the Buford Dam project include water supply as an authorized purpose. Additionally, the 2011 decision ordered the Corps to reconsider whether it has the legal authority to operate the Buford Project to accommodate Georgia's request made in 2000 to adjust the operation of Lake Lanier, and to enter into agreements with the State, or water supply providers, to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta. The Corps provided a legal opinion in 2012, concluding that it has sufficient authority under applicable law to accommodate that request, but noting that any decision to take action on Georgia's request would require a separate analysis. On January 11, 2013, the Governor of the State of Georgia provided updated demographic and water demand data to confirm the continued need for 705 million gallons per day (mgd) to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040 rather than 2030 as specified in the 2000 request.

Because updating the water control plans and manuals requires making a decision on Georgia's water supply request, the Corps will consider, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013 requested from Lake Lanier and downstream at Atlanta.

During the WCM update process the Corps identified, documented, and evaluated the environmental effects of operating the federal projects in the ACF Basin under alternative management regimes that could reasonably be expected to accomplish the purpose and need of the proposed federal action. The range of actions, alternatives, and effects considered during the WCM update process are driven by the requirements set forth by Congress and Corps policies for project operation. Accordingly, the Corps considered operational changes within existing congressional authorities, as determined by recent court rulings, and delegated, discretionary authorities, and did not consider operational changes that would be expected to require additional congressional authority.

The analysis provided by the Corps to the FWS for the DFWCAR is consistent with the FWS guidance provided in the FWS's Planning Aid Letters (PAL) for the proposed WCM updates for the ACF River Basin in Georgia, Alabama, and Florida dated April 2, 2010, March 1, 2011, and August 29, 2013. The Corps submittal to the FWS on January 21, 2015 was based on the latest PAL guidance (August 29, 2013). The Corps' January 21, 2015, response to PAL provided the available information and was followed by multiple discussions with FWS, the submittal of the HEC-ResSim model results from both phases of the Corps' alternative formulation, and numerous Excel workbooks used by the Corps to evaluate the impacts of the alternatives. The Corps believes the information provided and the numerous discussions with the FWS regarding alternative formulation demonstrate that fish and wildlife were given equal consideration along with the other authorized project purposes.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

Fish and Wildlife Service Alternative Evaluation

Pg 36-37 - The FWS's revised WCM alternative dated July 19, 2013 (Appendix VIII of the DFWCAR) includes the same revised action zones as the PAA. The response to PAL the Corps provided to the FWS in January 2015 briefly described the alternative formulation process and noted that Phase I of the alternative formulation process evaluated the No Action Alternative (NAA) and six other Water Management Alternatives. One of those other Water Management Alternatives was the FWS's alternative as described in the July 19, 2013, letter. The Corps utilized a subset of performance metrics to evaluate the various alternatives' ability to meet the authorized project purposes and rank the ability of the alternatives to meet the objectives established for the WCM update. The water management alternative finally chosen represented the best balance of all authorized project purposes. The result of this formulation phase was the identification of the Water Management plan represented in the PAA. The Corps appreciates the FWS's extensive efforts to identify a system-wide operational plan for consideration during the WCM update process and fully evaluated the FWS's alternative during Phase I of the alternative formulation process. The FWS's concerns with the alternative selection process methodology are addressed in the SUMMARY AND FWS POSITION section at the end of this document.

Flow Regime

Pg 37-38 (FR1) – The FWS recommends that the Corps develop an alternative that maximizes benefits to fish and wildlife resources in light of other project purposes. The Corps maintains that the alternative formulation process accomplishes this request. Full details of the iterative process used in the alternative selection methodology as well as all project impacts of each alternative are provided in the DEIS (Sections 4 and 6 respectively).

The FWS reiterates their requests for the Corps to consider flow guidelines, pulse flow guidelines, and non-hydropower peaking windows in order to provide for some components of the natural hydrograph and states "To date, none of the natural flow regime components have been incorporated into the flow alternative development". In the 2011 response to PAL the Corps provided detailed discussion regarding the physical, safety, and logistical limitations to making operational changes that mimic a natural flow regime. This discussion is still valid and is incorporated here by reference (USACE 2011). The Corps maintains that operating to match the natural flow regime is not possible at the multipurpose Federal projects since they were designed and built to alter the natural flow regime. Operating in a manner that seriously impacts the congressionally authorized purposes of hydropower production and flood risk management would require additional study authorization that is outside the scope of a WCM update. The PAA includes seasonally varying minimum flow provisions and fall rate provisions at Jim Woodruff Lock and Dam designed to mimic a more natural flow regime in the Apalachicola River. The construction of the series of Federal and non-federal reservoir projects in the heavily regulated Chattahoochee arm of the river basin has resulted in an altered flow regime that significantly limits the Corps' ability to provide for some components of the natural hydrograph.

Pg 38-39 (FR2) – The FWS recommends that ecosystem flow analyses using the methodology cited in the FWS's PAL addendum be conducted at four nodes (below Buford Dam, West Point Dam, Walter F. George Lock and Dam, and Jim Woodruff Lock and Dam) for the NAA and PAA and compared with the FWS's ecosystem flow guidelines. The FWS' PAL addendum provided revised low and high flow guidelines based on the pre-dam gage data or simulated pre-dam conditions where gage data were not available. In developing the revised low flow guidelines the FWS used flow magnitude percentiles for each month to define the lower limit, dry year, average year, wet year, and upper limit, (10th, 25th, 50th, 75th, and 90th) respectively. The Corps agrees with this approach and notes that the 2015 response to PAL provides a monthly flow statistics analysis of the simulated NAA and PAA depicting this information at numerous locations throughout the basin. The Corps response to PAL did not include a comparison of these simulations to the revised FWS's low flow guidelines based on the monthly seven lowest values. To the extent this analysis is still desired the Corps will provide it during the DEIS public review period.

The FWS also continues to recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May. As described in the Corps' January 2011 response to PAL, non-hydropower peaking "windows" were considered and determined to not be prudent based on equipment limitations, safety concerns, and serious impacts to other authorized project purposes. The Corps maintains that all of the previously described reasons for not including non-hydropower peaking "windows" are still valid and incorporates them here by reference (USACE 2011).

The FWS states "fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production." The Corps believes that the needs of both project purposes can be managed cooperatively to achieve benefits to both resources. The Corps operations, including hydropower production, result in a mix of beneficial and adverse effects to aquatic fauna. The Corps notes previously discussed benefits to the striped bass and shoal bass fisheries in the reach below Buford Dam to West Point Dam which are met in conjunction with hydropower production at upstream projects. To the extent that restoration of some of the natural flow regime components can be accomplished to the benefit of fish and wildlife resources in light of other project purposes, the Corps believes the PAA adequately strikes this balance. It is the responsibility of the Corps to best determine water management operations that meet all of the congressionally authorized project purposes. As described in the purpose and need section of the DEIS, the purpose and need for the federal action is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through updated water control plans and manuals. The proposed action is not intended to maximize benefits to fish and wildlife resources or any other authorized project purposes, but to equably manage the federal projects for the benefit of all authorized project purposes. Accordingly, the alternatives considered in the DEIS do not address any proposed changes to water management practices that exceed existing congressional authority.

Pg 39-40 (FR3) – The FWS recommends evaluating the potential for reducing the magnitude of fall drawdowns and/or starting the spring refill earlier to provide inundation of the floodplain.

These actions would have serious implications for flood risk management. Considering the purpose and need for the proposed action, the Corps developed eight screening criteria to guide information gathering, to help identify solutions, and to formulate alternatives. One of these criteria requires maintaining at least the current level of flood risk management. The Corps operates projects in the ACF Basin to provide flood risk management, as Congress intended when authorizing the system and projects. Continued growth and development in the ACF Basin has resulted in the construction of homes and businesses in the floodplain. Any proposed action should not significantly alter the level of flood risk management intended by the Congress in its authorizing language or increase the current levels, frequency, and duration of flood damage. Accordingly, the alternatives considered in the DEIS do not address any proposed changes to water management practices that exceed existing congressional authority.

Pg 40 (FR4) – The FWS recommends that the Corps evaluate methods to provide the operational flexibility necessary for floodplain inundation including evaluating compensatory measures, such as elevating, moving, or purchase of structures, that would allow floodplain inundation. The Corps agrees that compensation actions could provide more flexibility regarding floodplain inundation, but maintains that they are not authorized or appropriate as part of a WCM update. These types of actions require separate study authority.

Pg 40 (FR5) – The FWS requests that the Corps evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines. The FWS reiterates that that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. In the 2011 response to PAL the Corps provided detailed discussion regarding the physical, safety, and logistical limitations to making operational changes that mimic a natural flow regime. This discussion specifically addresses the FWS's guidelines and it is still valid. That discussion is incorporated here by reference (USACE 2011). The Corps maintains that operating to match the natural flow regime is not possible at the multipurpose Federal projects since they were designed and built to alter the natural flow regime. Operating in a manner that seriously impacts the congressionally authorized purposes of hydropower production and flood risk management would require additional study authorization that is outside the scope of a WCM update.

Pg 41(FR6) – The FWS requests that the Corps participate in the development of appropriate hydrological and meteorological criteria needed to forecast future conditions as either dry, average, or wet. The Corps currently utilizes the NIDIS Low Flow Information System to alert other water management operators and basin stakeholders of low flow conditions. The Corps will continue to evaluate forecasting tools and is willing to meet with FWS to further discuss this issue.

<u>Floodplain inundation assessments</u>

Pg 41 (FP1) – The FWS requests that the Corps use LIDAR and stage-discharge relationships to compare floodplain inundation metrics. A full set of LIDAR data for the entire Apalachicola River may be available but has not been provided to the Corps during the numerous scoping periods. Further, the Corps is unaware that models or software that correlate the LIDAR data to

specific discharges from Jim Woodruff Dam currently exist. It is our understanding that Florida Fish and Wildlife Conservation Commission (FFWCC) was contemplating or had begun to develop such tools, but that they are not available yet. Accordingly, the Corps utilized the best available information consistent with the guidance provided in the FWS's PAL. The FWS previously stated in the DFWCAR (Pg 17, Floodplain connectivity) that "given that the NAA and PAA exceedance curves are nearly the same, we do not expect that using LIDAR data would lend additional insights. Chattahoochee River floodplain connectivity would be expected to be nearly the same between the NAA and PAA. Conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain. Therefore, we do not expect differences in floodplain inundation in the Chattahoochee River."

Dissolved Oxygen

Pg 41-42 (WQ1) – The FWS requests that the Corps ensure that releases from all five ACF dams meet or exceed water quality standards. Releases from the Corps' ACF dams are not subject to specific Clean Water Act effluent limitations. The Corps is not responsible for enforcing State water quality standards and cannot ensure that water quality standards are met. However, the Corps has given careful consideration to water quality standards and has evaluated the effects of each alternative on water quality. The Corps acknowledges the simulated DO results described by the FWS on pages 14-15 of the DFWCAR. These results are not surprising. Lower DO concentrations would be expected to occur below the major reservoirs under the NAA and PAA due to the low-oxygenated water being discharged from reservoirs. The DO concentrations found in the deeper portions of the reservoir may stay low because of stratification. As the water warms through the summer, the amount of DO in the water column would decrease in the deeper areas. Water released from the dams is from the deeper waters, where DO is depleted over time. Downstream from the immediate dam release, the large volume of water would result in greater velocities and reaeration, increasing oxygenation. These increased oxygen levels support fisheries downstream of the dams. The Corps has improved DO in the project tailraces through past efforts that included upgrading the venting capabilities of hydroelectric turbines, installation of siphons that release water with relatively higher DO levels from the top of the reservoir, and implementation of SOPs regarding monitoring DO levels and making special releases to temporarily improve tailrace DO. Not only was fish and wildlife conservation equally considered in the alternatives evaluation for the WCM, but as shown by these actions, the Corps has and continues to perform actions to benefit fish and wildlife in this system.

Pg 42 (WQ2) – The FWS recommends that the Corps evaluate the effectiveness of the upgraded venting capabilities at Buford turbines. This type of study requires separate study authority and is beyond the scope of this effort. The Corps agrees that alternative authorization and appropriation, such as Corps restoration authorities, would be necessary to fulfill this conservation recommendation and is willing to explore these opportunities with FWS.

Temperature

Pg 42 (WQ3) – With regards to the FWS request of the Corps to experiment with operational and/or structural modifications and follow up monitoring that improve temperature levels downstream of Corps reservoirs, such a study would require separate study authority and is beyond the scope of this effort.

Fish Passage

Pg 43 (FM1) – The FWS states that provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam. As stated previously, the Corps has adopted fish passage operations at Jim Woodruff Lock and Dam into the project's WCP. With regards to the other two projects, ongoing fish passage studies at Jim Woodruff Lock and Dam have demonstrated that very few fish that pass upstream travel up the Chattahoochee arm of the basin (recent genetic studies demonstrate that approximately 98% of the Alabama shad's natal waters were the Flint River). It appears that fish passage operations at George W. Andrews Lock and Dam and Walter F. George Lock and Dam would have limited success. However, the Corps maintains that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the project water control manuals does not preclude routine lock operations at George W. Andrews Lock and Dam or Walter F. George Lock and Dam which may benefit anadramous fish species.

Climate Change

Pg 43 (CC1) – As discussed during the coordination of the DFWCAR, the DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. The Corps, in response to relevant guidance and public interest and input, engaged the Institute for Water Resources (IWR) to develop a numerical model to evaluate the resilience and limitations of proposed ACF Basin water management scenarios in response to potential climate change conditions. The ACF numerical model was developed to correlate with the HEC-ResSim and HEC-5Q models for the ACF system. Simulating the IWR climate change projections in HEC-ResSim and HEC-5Q provided an indication of the effects of prospective climate change on hydrology and water quality in the ACF Basin. The objective of this effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management. The details of this analysis are provided in the DEIS (Section 6.8).

Navigation

Pg 43 (NV1) Navigation is an authorized project purpose and as such is included in the WCM update. The Corps' proposed action includes operations for a navigation season. The navigation season operations assume no channel maintenance activities will occur on the Apalachicola River as these activities have been indefinitely deferred due to denial of a Section 401 water quality certificate from the State of Florida and recent congressional language that limits funding for dredging operations in the ACF Basin. If channel maintenance activities are re-instated for the Apalachicola River portion of the navigation project, the Corps would address the evaluations requested by the FWS during the water quality certification process.

Reservoir and Riverine Fisheries Management

Pg 43-44 (FM2, FM3) – FWS recommends reviewing recent fisheries literature for additional information regarding impacts to riverine fish spawning during a 4-6 week stable or rising reservoir window to benefit reservoir fish spawning. Also recommended was to modify Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning. Lake regulation and coordination for fish management purposes is required by South Atlantic Division Regulation PDS-O-1 (31 May 2010). The Mobile District draft fish spawn SOP (2005) defines Corps operations for implementing this Division Regulation and includes requirements for an annual meeting with the various State and Federal fish and wildlife resource agencies. The purpose of the meeting is to evaluate the success or failures of executing the fish spawn operations during the previous year; share data including recent scientific investigations that support, modify, or reject the fish spawn operations; and identify potential refinements. The Corps believes this process can accomplish the goals identified by the FWS. The Corps welcomes the FWS's facilitation capabilities to better accomplish these goals as part of that process.

With regards to the FWS's request to investigate modifications to the fish spawn SOP to occasionally emphasize river spawning over reservoir spawning the Corps maintains that the existing language provides for this flexibility and specifically provides for "operational adjustments recommended by the interagency team to minimize impacts and/or enhance system-wide benefits". As described in the paragraph above, modifications to the SOP can be proposed and mutually agreed upon or rejected as part of the annual coordination meeting.

Pg 45 (FM4) The FWS recommends identifying fish and wildlife recreation facilities that need infrastructure improvement. As noted previously, infrastructure improvements and other construction activities require additional study authority and are outside the scope of the WCM update.

Apalachicola Bay

Pg 45 (AB1) - The Corps understands that the FWS is currently contracting with Dr. Peter Sheng to update the previously conducted hydrodynamic bay salinity modeling with simulated flow data from the HEC-ResSim modeling conducted for the WCM update. The Corps looks forward to reviewing this information if it is available prior to the release of the Final EIS. The Corps hopes this information will be available during the Section 7 consultation and completion of the National Environmental Policy Act (NEPA) process.

Pg 45 (AB2) – As described in the FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT section, the Corps disagrees with the relevancy of the impacts identified by the FFWCC in their analysis of the pre-dam and post-West Point periods of record. As previously discussed the appropriate without project condition for the purpose of this analysis is current operations, not a pre-dam condition. Congress previously authorized the construction and operation of the federal reservoirs to serve as a multi-purpose projects and they were built to achieve the congressionally authorized purposes.

Decision Support Model to Evaluate Changes to Corps' Operations

Pg 45/46 (DS1) – The DEIS includes a detailed description of the alternative development process for the WCM update. Considering the purpose and need for the EIS, the Corps developed eight screening criteria to guide information gathering, to help identify solutions, and to formulate alternatives. These screening criteria are described below:

Any proposed measure (or alternative) considered in the update process for the Master Manual should:
1. Meet the purpose and need of the proposed federal action
2. Address one or more of the congressionally authorized project purposes
3. Maintain at least the current level of flood risk management
4. Be consistent with the contemporary water resources needs of the basin to the extent practicable
5. Support the operation of the projects in the ACF Basin as a system
6. Not increase the risk to public safety in the facility or downstream of the project
7. Not exceed the physical limitations of or pose risks to the structural integrity of the projects
8. Not violate USACE responsibilities under the Endangered Species Act (ESA)

The 2010 guiding principles described in the DFWCAR were constraints identified early in the WCM update process. Considerable changes to the scope of the project have occurred since 2010 as a result of litigation. The screening criteria listed above are consistent with and evolved from the 2010 guiding principles listed in the DFWCAR. Although not specifically described in the screening criteria listed above, the fish spawn SOP (guiding principle 6) was included in all water management alternatives considered. Guiding principle 7 regarding reallocation of storage for water supply is not one of the screening criteria listed above; however, water supply needs were evaluated in conjunction with the water control manual update. Guiding principle 8 regarding water quality in Corps reservoirs is inherent within screening criteria 1 and 2.

Adaptive Management

Pg 46 (AMP1) – The Corps believes that the WCM guidance, fish spawn SOP, ESA compliance annual reports, and monthly coordination with the FWS regarding Apalachicola River flows achieve the goal of the formal adaptive management program the FWS recommends. The WCM guidance provides for operational flexibility to balance all project purposes over a wide variety of conditions.

Increasing Consumptive Demands

Pg 47 (CD1) As described above, the HEC-ResSim model includes standardized assumptions regarding consumptive demands (outside of the Atlanta area) that include the highest demand year (2007). These levels of consumptive demand were selected by the Corps because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands.

Evaluation of Alternative Models

Pg 47-48 (AM1) – The Corps will continue working with the states to improve the unimpaired flow development methodology and update the dataset accordingly. This Corps' analysis used "HEC-ResSim Version 3.2, Build 3.2.1.19". HEC-ResSim is a generalized reservoir operations modeling package. Per ECB 2007-6 (USACE, 2007) and EC 1105-2-407 (USACE, 2005b), HEC-ResSim falls under the category of "engineering models used in planning studies", leaving certification to the Science & Engineering Technology (SET) initiative associated with the Corps' Technical Excellence Network (TEN). The Corps' Hydrologic Engineering Center developed this software which is now the standard for Corps reservoir operations modeling. As of January 2010, the TEN guidance listed HEC-ResSim as "Community of Practice Preferred" for the purpose of reservoir system analysis.

The Water Control Manual Update team selected HEC-ResSim as the tool most capable of faithfully representing District water management practices as the culmination of a three-year model development and verification process. In 2006 Mobile District began working with HEC to create HEC-ResSim models based on established HEC-5 models simulating 1977, 1995, and 2006 physical and operational conditions. The three HEC-5 models hold significance as the tools "of record" used for analyses concerning the previous Environmental Impact Statement, the 1990's Comprehensive Study, and the Revised Interim Operating Plan (RIOP). After ensuring that the corresponding HEC-ResSim models could effectively reproduce the HEC-5 results, Mobile District and HEC created another HEC-ResSim model that captured the most significant operations as of 2008, including the RIOP rules and head limits constraints. This model was presented to stakeholders in October 2008 and generally accepted as a promising improvement to ACF reservoir system modeling. Other considerations factoring into Mobile District's selection of HEC-ResSim include ease of adaptation to other studies or operational use, availability of training, access to software developers for program enhancements, opportunity for linkage with water quality models, and ability to share with partners and stakeholders without licensing cost or restriction.

Since the Water Control Manual Update study was heavily accelerated but subject to unpredictable changes in scope, the long-standing relationship between Mobile District and HEC also afforded an important element of organizational trust that provided continuity.
The Mobile District's decision to use HEC-ResSim for modeling the ACF watershed represents a long term investment that continues to pay dividends. Completion of the ACF HEC-ResSim model for the initial water control manual update study in 2010 yielded a set of alternatives and associated results that satisfied the Corps' internal and external review processes. The model results continue to serve as a basis of debate among the stakeholders yet the Corps maintains that HEC-ResSim is the best available tool for evaluating alternative system wide operations and that it accurately reflects the resultant high and low flow conditions of these alternative operations. With regards to the FWS validation analysis, please reference the discussion in the PROJECT IMPACTS & EVALUATION METHODOLOGY section below.

Pg 48 (AM2) – The Precipitation-Runoff Modeling System (PRMS) is not available for use at this time.

Pg 48 (AM3) – The Corps is familiar with the Georgia Water Resources Institute (GWRI) models and maintains that HEC-ResSim is the best available tool for evaluating alternative system wide operations.

Pg 48 (AM4) – The Corps maintains that the HEC-5Q water quality model is appropriate for the WCM update. The HEC-5Q Water Quality Modeling Report included in the DEIS (Appendix K) provides a detailed description of the "Demonstration of Model Performance" conducted by the water quality modeling team. The demonstration included extensive comparison of modeled and observed time series (streams) and profiles (reservoirs) as well as a model sensitivity analysis.

Additional Conservation Measures Developed from the Corps' PAL Response

Pg 49 (FR7) - The FWS notes there are no minimum flow provisions downstream of Walter F. George Lock and Dam and the Corps should evaluate implementing a minimum flow provision at this project. The Walter F. George Lock and Dam project is a hydropower facility designed to meet peak demand that typically occurs during the weekday. During periods of normal flow Walter F. George Lock and Dam may not release water on the weekends if the Jim Woodruff flow provisions can be met without support from upstream reservoirs. Currently there is no authorized minimum flow requirement from Walter F. George Lock and Dam. Upstream projects (Buford and West Point) have small hydropower house units designed to provide a continuous minimum flow. Walter F. George Lock and Dam does not have a small hydropower house unit. To provide a continuous minimum flow, the project would have to spill water through the spillway. However, installation of siphons and occasional spillway releases assist with raising the dissolved oxygen level downstream of the project. The FWS mistakenly notes that minimum flow releases are already implemented at the other four ACF projects. This is not true for George W. Andrews Lock and Dam as it is a run of river project with no storage to support an at site minimum flow requirement. The discharge from George W. Andrews Lock and Dam matches the volume of inflow with some reregulation of the upstream Walter F. George Lock and Dam hydropower releases.

Pg 49 (FR8) –Drought operations under the PAA are triggered when the composite conservation storage drops into Zone 3 (not Zone 2 as indicated in the DFWCAR). The Corps notes that the Phase I alternative formulation process included alternative drought operation triggers to the one represented in the PAA.

Pg 49 (FM5) – The Corps utilized the Sturgeon Spawning Habitat Performance Measure (SSHPM) Excel workbook developed by the FWS and the Corps' response to PAL noted that there were no differences between the NAA and PAA (Section 2.7.1). The Corps provided the FWS with the workbook supporting this determination in March 2015.

Pg 49 (FM6) – The Corps will work closely with the FWS during the Section 7 consultation to ensure that the appropriate species are addressed. The Corps will utilize existing information for the species currently petitioned for listing and will work with FWS to identify opportunities to improve the understanding and future evaluation of project impacts on these species.

Pg 49 (NPS1) – The DEIS does address the impacts of the PAA to the NPS's Chattahoochee River National Recreation Area (Section 6).

Pg 49-50 (ES1) – The DEIS generally addresses ecosystem services in the numerous impact assessments conducted. The Corps currently does not have guidance on ecosystem services but is evaluating how to include consideration of ecosystem goods and services in Corps projects.

Mitigation Measures

Pg 50 (MIT1 and MIT2) - Mitigation includes measures to avoid, reduce, minimize, or compensate for adverse impacts that could result from a selected course of action. As potential water management measures were identified and alternatives were developed, potential actions to offset any adverse effects also were identified, analyzed and considered in the planning process. For example, increased water withdrawals from the Chattahoochee River to meet the needs of metropolitan Atlanta communities would result in a corresponding increase in treated wastewater returns to the river between Atlanta and West Point Lake. The impact analysis showed that the PAA would result in increased loadings of total phosphorus that would have a substantially adverse effect on water quality. The substantially adverse effects would also be expected downstream of West Point Lake to the headwaters of Walter F. George Lake. The adverse water quality effects in these portions of the Chattahoochee River would principally be associated with increased treated wastewater discharges to the river rather USACE project operations. The Georgia Environmental Protection Division may require changes to discharge permits for some facilities. After a thorough analysis of the impacts from the PAA and other alternatives, it was determined that specific compensatory mitigation measures for the Corps of Engineers were not required or necessary.

Water management inherently involves adapting to unforeseen conditions. Because adverse effects of the water control plan might occur in the future due to unforeseen conditions, actions would be taken within applicable authority and policies, and in coordination with other interests, to address such conditions when they occur through the implementation of temporary deviations to the water control plan, such as interim operation plans.

Pg50 (MIT3) – As described in the *Analyses of Apalachicola Bay* section below, the Corps believes that the PAA results in negligible impacts to the estuary. Therefore mitigation is not appropriate.

FWCA Agency Coordination

This section addresses comments provided to FWS from the Florida Fish and Wildlife Conservation Commission (FFWCC), Alabama Department of Conservation and Natural Resources (ADCNR), Georgia Department of Natural Resources, Wildlife Resources Division (GDNR-WRD) and National Oceanic and Atmospheric Administration (NOAA) regarding the DFWCAR. Please reference pages 1-3 of the DFWCAR.

FFWCC

The Corps believes that the PAA is the alternative that best balances authorized project purposes with the least environmental impact. Regarding coordination with FFWCC, in 2008 the Corps published a Notice of Intent to prepare an EIS in the Federal Register. That was followed by additional notices announcing additional information and meetings for the public scoping process. In 2009 scoping was reopened. The latest round of scoping occurred in 2012. During each of these scoping periods, FFWCC has had opportunity to participate. The FFWCC has also participated in both DFWCA report efforts related to the WCM update process. Additional opportunity to provide input to the Corps will be provided during the comment period upon public release of the DEIS. Fish and wildlife resources received equal consideration as other authorized purposes. The Corps believes its analysis includes impacts of current and projected consumptive water uses; the NAA compares current water demands to that of the PAA which includes an increase in consumptive water use.

ADCNR

The Corps analyzed a set of alternatives with an objective to balance all authorized project purposes. In accordance with the purpose and need of the proposed action, the Corps did not attempt to develop an alternative that would maximize and benefit the fish and wildlife resources of the State of Alabama. The proposed action is not intended to maximize benefits to fish and wildlife resources in any state, or any other authorized project purposes, but to equably manage the federal projects for the benefit of all authorized project purposes. Regarding water quality, the Corps will comply with all relevant laws and regulations. In regards to in-stream flow, the Corps believes that the PAA adequately balances all authorized project purposes. The FWS included discussion of consumptive demands, protected species minimum flows and fish passage at George W. Andrews Lock and Dam and Walter F. George Lock and Dam in the DFWCAR and those comments are addressed in the appropriate sections below.

GDNR-WRD

It is not clear from the GDNR-WRD comments whether or not the current or proposed operations result in water temperature conditions in the river segment between Buford Dam and West Point Lake incapable of supporting the trout and striped bass fisheries. They appear to favor a coldwater fishery in the upper portions of this reach, which currently exists and note the importance of cool water refugia to the survivability of adult striped bass. The impact analysis conducted by the Corps suggests that the proposed action will at worst maintain the current water temperature regime and may in fact improve water temperature for trout, striped bass, and shoal bass at critical transition zone locations below Morgan Falls Dam. The Corps acknowledges that the construction of dams impacts dissolved oxygen (DO) levels in the river that are important to aquatic resources. However, the Corps maintains that operational changes at the federal projects cannot substantially improve DO levels below Corps projects using existing infrastructure. At the request of the FWS the Corps previously evaluated the feasibility of operating the federal projects in a non-hydropower peaking manner to facilitate riverine fish spawn and replicate a seasonally varying baseflow hydrograph that more closely approximates natural conditions. The results of that evaluation were provided in the Corps' January 2011 response to PAL document and are further discussed below. As described in the description of the proposed action, the Corps will continue to implement the Draft Reservoir Regulation and Coordination for Fish Management Purposes Standard Operating Procedure (SOP) (SAM SOP 1130-2-9).

NOAA

NOAA states their support for the FWS comments on the evaluation of the PAA on Gulf Sturgeon, fish passage, and effects of freshwater inflow on Apalachicola Bay seagrass, fish and shellfish. The Corps addresses these comments in the appropriate sections below.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Pg 10/11 - The FWS describes the "fundamental component" of a FWCA report as the "evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated". Since the proposed action is not a construction project and is instead a change in operation for an existing system of projects, "without project" is more appropriately defined under the NEPA interpretation of No Action and the type of evaluation is different. However, the Corps believes the NAA accurately reflects the "existing condition" and the PAA accurately reflects "the future with the project" condition. The NEPA requires a comparison of the existing condition (No Action) to potential alternatives including the proposed action. The existing condition as described by the Corps (NAA) complies with The Council on Environmental Quality (CEQ) Regulations for Implementing NEPA which requires the inclusion of the "alternative of no action" in an EIS. The CEQ further defines what is meant by the "alternative of no action" in a document titled *NEPAs Forty Most Asked Questions* (Forty Questions). In that document they state, with regards to federal actions such as updates to existing plans where ongoing programs initiated under existing legislation and regulations will continue, even as new plans are developed the "no action" is "no change" from current management direction or level of management intensity. Therefore, the "no action" alternative may be thought of in terms of continuing with the present course of action until that action is changed. Consequently, projected impacts of alternative management schemes would be compared to those impacts projected for the existing plan. In light of this guidance the Corps has selected a NAA that is both appropriate and in accordance with applicable law.

For the PAA the Corps maintains that we have adequately represented conditions that are likely to exist during the life of the project relevant to the management of the Corps' projects. The 73-year period of historic hydrology upon which the simulated PAA is based represents the range of dry/normal/wet conditions that would be expected to occur during the life of the project. The FWS states that the PAA is not fully represented because it did not incorporate basinwide consumptive demand projections or climate change. The Corps does not agree with this conclusion. The PAA HEC-ResSim model includes standardized assumptions regarding consumptive demands (outside of the Atlanta area) that include the highest demand year (2007). These levels of consumptive demand were selected by the Corps because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands. The DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. The Corps, in response to relevant guidance and public interest and input, engaged the Institute for Water Resources (IWR) to develop a numerical model to evaluate the resilience and limitations of proposed ACF Basin water management scenarios in response to potential climate change conditions. The ACF numerical model was developed to correlate with the HEC-ResSim and HEC-5Q models for the ACF system. Simulating the IWR climate change projections in HEC-ResSim and HEC-5Q provides an indication of the effects of prospective climate change on hydrology and water quality in the ACF Basin. The objective of this effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management. The details of this analysis are provided in the DEIS. To the extent the PAA simulations and analysis provide in the Corps' response to PAL does not satisfy the FWS's needs; the Corps believes the analysis provided in the Climate Change Analysis section of the DEIS will.

Page 11/12 **–** Despite acknowledging that the interpretation provided by the FFWCC that past and current federal reservoir operations have affected a multitude of fish and wildlife resources is the opinion of the FFWCC and not the FWS, the FWS states that the "impacts identified (hypothesized, realized, or modeled) in FFWCCs correspondence are relevant because operational changes at Corps facilities have the potential to ameliorate, exacerbate, or have no effect on such project-induced impacts and impacts associated with other changes in future resource conditions". The Corps disagrees with the relevancy of these impacts identified by the FFWCC. The analyses and subsequent interpretation provided by FFWCC are in large part a reiteration of extra record material submitted on behalf of the Florida parties in the Middle District of Florida "Phase II" case that the Federal Defendants and other parties have refuted on both the technical merit of the analyses and the faulty conclusions drawn from them. A detailed accounting of the Federal Defendants comments on these analyses is available in the court record and need not be restated here. However, in general the interpretations regarding the impacts of federal reservoir operations on fish and wildlife resources consistently ignore annual changes in hydrology that have a real bearing on project releases. In particular, they ignore generally accepted realized changes in the seasonal pattern of rainfall between the pre-dam condition and the post-dam condition. These changes inherently impact the hydrology of the Apalachicola River regardless of the influence of Corps operations and therefore must also be considered when evaluating those impacts which are a result of Corps discretionary operations. This failure raises serious questions as to the relevancy of the FFWCC analyses and interpretation. Presumably, the FWS understood these inadequacies and thus did not adopt the FFWCC's interpretations. The Corps requests that FWS also re-visit their decision regarding their relevancy. Accordingly, we believe the impact analyses we provided, in accordance with the PAL guidance, are appropriate for evaluating the impacts of implementing the PAA.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Pg 13 – The FWS states that all models have limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. The FWS also provides again a statistical and qualitative analysis they conducted on the 2011 model data comparing observed and simulated data. The FWS cautions that interpretation of modeled hydrology focus on data trends, not on absolute magnitudes in comparisons of alternatives. These limitations are acknowledged by the Corps and are fully discussed in the DEIS. With regards to the water quality analyses provided by the Corps, the FWS states "While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are lumped for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months". The Corps recognizes that a thorough understanding of the methodology used for the impact analysis is required to make interpretations or draw conclusions and again points out that the impact analyses were provided in accordance with the guidance provided in the FWS's PAL. Time series plots for the various water quality parameters are available and some are provided in the HEC-5Q modeling report included as an appendix to the DEIS.

The Corps acknowledges there are limitations and caveats associated with model development and use but do not agree that a misunderstanding of these demonstrates inadequacies of the model or its intended use. The HEC-ResSim and HEC-5Q models were evaluated to ensure that they exhibited the tendencies seen in the observed data and that they were sufficient to provide reasonable long-term estimates of water quantity and quality through the ACF system. The central focus of this modeling effort was to enable the EIS team to evaluate the differences in water quantity and quality between a continuation of the no action alternative and implementation of the proposed action. The Corps' internal model review process has conducted similar analyses to the one provided by FWS and agrees that the models produce a high degree of similarity for many of the water quantity and quality parameters at most locations. However, as the Corps has explained to the FWS on numerous occasions interpreting these differences as a deficiency on the part of the models is inappropriate. The HEC-ResSim and HEC-5Q models were not developed or ever intended to produce outputs that matched exactly the observed data. Given the multitude of operational variations that have occurred over the period of record when responding to real life situations (equipment malfunctions, gage errors, and approved variances to operating rules) it is not possible to produce such outputs in the HEC-ResSim model. In so much as the HEC-ResSim model provides flow data to the HEC-5Q model as an input it is also unreasonable to expect perfect correlation between the water-quality simulated data and the observed data. In addition, since daily discharge data and non-point source loading data are not available, the HEC-5Q model includes assumptions regarding these parameters and these assumptions were coordinated with the appropriate water supply providers and resource agencies to ensure they are reasonable. The benefit of using these models for these impact analyses is that they can simulate flow and water quality data with shared assumptions so that the only modeled difference between the alternatives can be accurately interpreted as impacts associated with a change in operations (i.e., implementation of the proposed action). Given that this is what our respective agencies are trying to evaluate, the Corps believes the models are uniquely qualified and appropriate.

Dissolved Oxygen

Pgs 14/15 and Pg 30 – The Corps acknowledges the stated DO impacts. However, it should be emphasized, as noted by FWS, simulated DO results between the PAA and NAA were similar with small differences between the alternatives being realized at low occurrence levels. For reasons discussed previously, modelled results should be broadly compared between alternatives and were not intended to provide absolute results for specific locations and conditions such as those noted downstream of Buford Dam. We note that the PAA and NAA results were generally similar, albeit where low DO currently exists that condition would likely continue in the PAA. While dissolved oxygen levels downstream of Buford Dam and West Point Dam are depressed at times as a result of hydroelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas as a result of low dissolved oxygen conditions. In the past, the Corps has made efforts to improve DO levels below the Federal projects with varying degrees of success. For example, during a major rehabilitation of all three hydropower generation units at Buford Dam during 2003 and 2004, self-aspirating turbines were installed to improve dissolved oxygen levels immediately downstream. The Walter F. George Lock and Dam project has experienced recurring instances of stress in the tailrace fishery and occasional fish kills due to low dissolved oxygen. Accordingly, USACE has implemented a SOP, established in 1988 and updated in 1993, to address conditions at the Walter F. George project when low dissolved oxygen values are observed in the tailrace. The SOP calls for spillway gates to be opened in accordance with a specific protocol until dissolved oxygen readings return to an acceptable level. Spillage siphons have also been constructed on the dam that can be used in lieu of spillway gate discharges.

As previously discussed with the FWS, studies to consider structural modifications to the Federal projects in order to improve DO and/or operational changes that result in serious impacts to one or more of the other authorized project purposes (such as significantly reducing or eliminating hydropower operations) are outside the scope of the WCM update. Furthermore these actions would require additional study authority and appropriation.

Water Temperature

Pg 15 and Pgs 30/31- The Corps agrees with the statements regarding the importance of water temperatures and with the conclusion that slight differences exist between the NAA and PAA. However, the Corps questions whether a 0.25-0.5^{o}C increase in water temperature between Buford Dam and Norcross is biologically significant to the coldwater fishery in this reach. It is not clear from the GDNR or FWS comments whether or not the NAA or PAA result in water temperature conditions in the river segment between Buford Dam and West Point Lake incapable of supporting the trout and striped bass, and shoal bass fisheries. Both agencies appear to favor a coldwater fishery to support non-native trout in the reach between Buford Dam and Morgan Falls, which currently exists and note the importance of cool water refugia to the survivability of adult striped bass. Both agencies also appear to support warmer water temperatures downstream of Morgan Falls for the native shoal bass. The impact analysis conducted by the Corps, acknowledges that minor temperature deviations may occur, but suggests that the proposed action will at worst maintain the current water temperature regime at critical transition zone locations below Morgan Falls Dam and may result in slightly warmer water temperature in this reach. The FWS notes that cold water conditions during the spring have been identified as a limiting factor to striped bass spawning and egg/larvae survival near Morgan Falls Dam. Based on the current analysis, it would appear that the Corps' NAA and PAA do support both a coldwater fishery above Morgan Falls Dam and a warmwater fishery below it despite the many variables impacting water quality in this reach that the Corps has no control over, such as, nonpoint stormwater runoff from impervious surfaces in tributary watersheds. From the DFWCAR comments, it is not clear what the recommendation is for the Corps to better manage water temperature in the reach.

Wastewater

Pg 15 and 32 – The Corps believes, that the HEC-5Q water quality model is a quantitative model that describes water quality changes in response to flow management alternatives and has provided the water quality analyses prescribed in the FWS's PAL accordingly. The Corps agrees that evaluating percent wastewater can provide additional insight for interpreting the water quality data and has provided it in accordance with the FWS's PAL guidance. The higher percent wastewater observed between Atlanta and West Point Dam under the PAA simulation is not surprising since more water is being utilized for water supply and more is being returned as wastewater. Improved treatment and conservation measures in the future could alleviate some of the negative impacts to the aquatic environment associated with the percent wastewater evaluation. This is supported by statements from GDNR in the Chlorophyll- α section where they note that "nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements over the past two decades".

Chlorophyll-α

Pg 15 and 32– As described in the wastewater section above, increased water withdrawals from the Chattahoochee River to meet the needs of metropolitan Atlanta communities would result in a corresponding increase in treated wastewater returns to the river between Atlanta and West Point Lake. The impact analysis showed that the PAA would result in increased loadings of total phosphorus that would have a substantially adverse effect on water quality. The substantially adverse effects would also be expected downstream of West Point Lake to the headwaters of Walter F. George Lake. The adverse water quality effects in these portions of the Chattahoochee River would principally be associated with increased treated wastewater discharges to the river rather than USACE project operations. The Georgia Environmental Protection Division (GEPD) may require changes to discharge permits for some facilities. The Corps acknowledges and agrees that the PAA will result in relatively small increases in Chlorophyll-α throughout the river system in response to increased wastewater returns and associated nutrient loads. However, the Corps questions the biological significance of a 1-5 µg/L increase in Chlorophyll-α. The Corps also notes that GDNR has suggested that minor increases in Chlorophyll-α may be beneficial to the reservoir fishery.

Reservoir Retention Time

Pg 16 and 32 - The Corps believes it provided the requested information to the FWS in the response to PAL. The April 2, 2010 PAL requested that for each alternative the "average summer retention time (days)" should be evaluated. The PAL defines summer values as May through October. The Corps provided the monthly retention times for the water quality model period (2001 through 2011) at each of the Federal reservoir projects in tabular format. At the end of the table, an overall median retention time for each reservoir is provided as well as median and average retention times for the months of April – October (note April-October corresponds with the GEPD definition of growing season and includes the May-October growing season defined by the FWS). This data demonstrates that the average summer retention time at Lake Lanier under the PAA increased by 6 days; at West Point Lake it increased by 3 days; at Walter F. George Lake it decreased by 1 day; and that there was no difference in the average summer retention time at George W. Andrews and Lake Seminole.

Phosphorus

Pg 16 and 32 – The Corps acknowledges and agrees that the PAA will result in increased phosphorus throughout the river system. The higher phosphorus observed between Atlanta and West Point Dam under the PAA simulation is not surprising since more water is being utilized for water supply and more is being returned as wastewater. This increased loading is passed through the system. Improved treatment and conservation measures in the future could alleviate some of the negative impacts to the aquatic environment associated with elevated phosphorus loads. This is supported by statements from GDNR in the Chlorophyll- α section where they note that "nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements over the past two decades". The Corps also notes that GDNR has suggested that increases in phosphorus may be beneficial to the reservoir fishery. Notwithstanding this, the Corps generally agrees that increased phosphorus loads would be considered a negative impact.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

Pg 17 and Pgs 32/33 – FWS notes that the annual maximum 30-day growing season floodplain connectivity is essentially the same for the PAA and the NAA. However, they state that it is unknown whether the calculation is for consecutive days and point out that the Corps used the period from April through Sept, not October as specified in the Floodplain Spawning Habitat Performance Measure (FSHPM). The Corps inadvertently labeled the seasonal period as April – September rather than October. The Corps utilized the FSHPM Excel workbook developed by the FWS to analyze this performance metric. Therefore, the analysis should be consistent with what the FWS was seeking. The various workbooks used to create the charts provided in the response to PAL were provided to the FWS in March 2015. The Corps agrees with the statement that there would be little difference in floodplain connectivity in the Chattahoochee River.

Reservoir Fisheries

Pg 17-19 and 33 – The Corps utilized the Reservoir Fisheries Performance Measure (RFPM) Excel workbook developed by the FWS to analyze this performance metric. In response to GDNR comments, FWS stated they continue to recommend use of the RFPM. Therefore, the RFPM analysis provided in the Corps' response to PAL is sufficient. The Corps agrees with the statement that there would be low potential for realized fisheries differences between the two alternatives.

Riverine Fisheries

Pg 19 and 33 – The FWS's PAL addendum provided revised low and high flow guidelines based on the pre-dam gage data or simulated pre-dam conditions where gage data were not available. In developing the revised low flow guidelines the FWS used the 10th, 25th, 50th, 75th, and 90th percentiles for each month to define the lower limit, dry year, average year, wet year, and upper limit, respectively. The Corps agrees with this approach and notes that the 2015 response to PAL provides a monthly flow statistics analysis of the simulated NAA and PAA depicting this information at numerous locations throughout the basin. The Corps response to PAL did not include a comparison of these simulations to the FWS's revised low flow guidelines. To the extent this analysis is still desired the Corps will provide it during the DEIS public review period.

Chattahoochee River Shoal Bass Recruitment: FWS notes that the Corps utilized water temperature data simulated by HEC-5Q for the various alternatives rather than the relationship of observed flows and water temperature utilized in the FWS's Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM). The Corps previously discussed this change with FWS due to the relatively small data set (during drought conditions) used to develop the relationship in the FWS's CRSBPM. The Corps believes the use of the simulated water quality data that considers multiple influences on water temperature rather than just observed flow-temperature relationships provides a more robust analysis. The FWS notes that although HEC-5Q produces lower temperatures than the FWS methodology as a function of discharge the Shoal Bass abundance trend should remain the same. The FWS determined that the PAA results in a higher abundance of shoal bass than the NAA. The Corps agrees with this assessment.

Federally Protected Species

Pg 20 and 33 - Gulf Sturgeon

Frequency (% of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning. – The Corps utilized the SSHPM Excel workbook developed by the FWS for this analysis. The Corps' response to PAL noted that there were no differences between the NAA and PAA. The Corps provided the workbook supporting this determination in March 2015.

Frequency (% of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year,) March 1st through May 31st, at the two sites that support spawning. – The Corps utilized the SSHPM Excel workbook developed by the FWS for this analysis. The Corps provided the workbook supporting this determination in March 2015.

Daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. – The Corps agrees that daily fall rate results provided for the listed mussel species are specific to flows less than 10,000 cfs. The Corps notes that under the RIOP, fall rates are not limited for flows over 30,000 cfs consistent with safety requirements, flood control purposes, and equipment capabilities. The Corps also notes that the NAA and PAA include operational provisions that ensure river stage declines of 8 feet or more will not occur in less than 14 days when river flows are less than 40,000 cfs (March-May). This provision was developed by the FWS and the Corps to avoid any adverse effects to Gulf sturgeon during the spawning season. In the past this provision has satisfied the FWS's concerns regarding daily fall rates during the Gulf sturgeon spawning season. To the extent additional analysis is needed to evaluate daily fall rates and potential exposure of Gulf sturgeon eggs and larvae the Corps will work with FWS during the Section 7 consultation for the PAA.

Maximum number of consecutive days per year less than 16,000 cfs. – The Corps will provide the requested analysis during the Section 7 consultation for the PAA.

Departures from average water temperatures between March 1st to May 31st. – The Corps agrees with the FWS assessment.

While the Corps continues to believe that the information provided generally indicates that there will not be adverse impacts to the Gulf sturgeon, we acknowledge that additional information will be provided during the Section 7 consultation for the PAA.

Pg 21and Pgs 33/34 - <u>Freshwater mussels</u>

The FWS identified several flow parameters that could result in adverse impacts to mussels. Comparing these parameters individually and collectively, FWS stated that the PAA would result in flows that could have adverse impacts including increased mortality to mussels. The Corps agrees with this assessment and will continue to work with the FWS to evaluate impacts to listed mussel species during the Section 7 consultation for the PAA.

<u>Analyses of Apalachicola Bay</u>

Pgs 23-28 and 34 – The FWS states they used a combination of sources to evaluate effects to Apalachicola Bay. Taken together, the sources cited are inconclusive and the Corps disagrees that they suggest differences between the NAA and the PAA with regards to salinity levels in the bay and associated impacts.

FWS noted the HydroLogics Apalachicola Bay salinity model results (2012) indicate very limited differences between the RIOP and the then-proposed modifications to the RIOP. However, FWS did not relate that finding to the current proposed action. The Corps notes that the PAA and NAA simulated releases at Jim Woodruff Dam are similar and would likely yield the same conclusion if input to the HydroLogics Apalachicola Bay salinity model.

FWS stated that they relied on three lines of evidence for the suggested differences:

1. *The Apalachicola Bay Salinity Performance Measure (ABSPM)*. The FWS states that the ABSPM indicates a 1 part per thousand (ppt) increase in median salinity at East Bay (no difference at Cat Point and Dry Bar). The FWS acknowledges that differences among alternatives analyzed to date are relatively minor and states it may be due to the coarse temporal scale of the metric or the possibly that substantial changes in the bay salinity metric require large amounts of water. Given the small magnitude of the difference (1 ppt) and coarseness of the metric, the Corps questions the validity of the conclusion that the PAA negatively impacts salinities in the bay and juvenile Gulf sturgeon. The FWS also notes that fine resolution models of bay salinities also show little salinity differences between alternatives. Based on the FWS's assessment of the fine resolution models the Corps again questions the validity of the conclusion that the PAA negatively impacts salinities in the bay and juvenile Gulf sturgeon.

2. *Estuary Inflow Analysis*. In this analysis the FWS evaluated changes in estuary inflows using results from the Apalachicola River Mussel Performance Measure (ARMPM) and the salinity-discharge relationships in the ABSPM. The analysis did not compare bay salinities resulting from the NAA and PAA but rather assessed the change in salinity at incremental low flow discharges realized under the PAA. The Corps previously expressed concern over the use of the ABSPM due to the relatively weak correlation of the regression relationships the ABSPM uses to compute bay salinities. This analysis utilizes those same relationships. Therefore, the Corps does not agree that this line of evidence supports the suggested differences between the NAA and the PAA with regards to salinity levels in the bay.

3. The third line of evidence once again uses the ABSPM to compare the PAA bay salinities to one of the Corps' alternatives developed in 2011 (Alt2). The FWS noted that the 2011 flows were similar to the PAA flows and based on the results of the ABSPM determined that the PAA produced similar salinities to those generated from the 2011 alternative. The FWS therefore expects that the 3D salinity model for the PAA may produce similar salinity and oyster growth rate results as the 2011 (Alt2) 3D salinity model. If this assumption is true, then it stands to reason that the FWS' ongoing 3D salinity modeling will demonstrate that there is little difference in salinity or oyster growth rates between the NAA and PAA as this was the conclusion of the FWS in 2011 for the various alternatives considered (which included the same NAA and Alt2). The Corps does not see how this line of evidence supports the suggested differences between the NAA and the PAA with regards to salinity levels in the bay since the 2011 salinity modeling did not demonstrate a difference between alternatives.

   The FWS included information from their 2011 DFWCAR that they determined was relevant to the interpretation of the Apalachicola Bay salinity modeling and oyster and sturgeon responses. On pg 26 this information includes a discussion of the effects of the bay relative to historic operations. The Corps notes that the FWS omitted the actual discussion of the effects relative to historic operations. It is provided below in order to set the context for the Corps' response to the FWS's assessment of why those effects occurred.

> "There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data. However, in general, the Corps' simulated flow scenarios resulted in salinities that had slightly higher highs and lower lows than salinities estimated using Sumatra discharge data. Oyster growth rates were also slightly lower in the Corps' modeled scenarios compared to the observed Sumatra discharge data, especially in August, which is considered the peak growth period for oysters in Apalachicola Bay (Huang 2010). Similarly, the amount of habitat available for Gulf sturgeon was slightly lower in the no action and proposed action alternatives than the observed discharge data at Sumatra."

In the 2011 DFWCAR the FWS correctly states that "There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data". However, they incorrectly assume that these differences are entirely a result of changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives. Some or all of these differences are attributable to the comparison of modeled salinities based on observed river flows to those produced by the HEC-ResSim model. The 2011 (and 2015) HEC-ResSim model includes standardized assumptions regarding consumptive demands that include the highest demand year (2007). These levels of consumptive demand did not actually occur during the period used for the simulated salinities, but were selected by the Corps for the HEC-ResSim model because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands. It is inherent that these increased demands would result in lower simulated flows in the Apalachicola River than those observed, especially during the summer peak growth period for Oysters. For this reason, the appropriate analysis to focus on regarding impacts to Apalachicola Bay is the comparison of the simulated no action and proposed action alternatives which include the same assumptions regarding consumptive demands. When this is done, the negative impacts to oysters and Gulf sturgeon habitat are no longer realized.

The Corps is willing to consider additional impact assessments for juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species should the Fish and Wildlife Resources Agencies identify the appropriate analyses to utilize.

In the cited 2011 DFWCAR, the FWS recommends that the Corps "capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion". The DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. However, the Corps does not agree that it is responsible for minimizing or mitigating the impacts of salt water incursion resulting from these phenomena.

EVALUATION OF THE SELECTED PLAN

The Corps notes that the scoring of impacts (Table 2) technique utilized by the FWS to compare the PAA to the NAA is similar in design to the technique developed by the Corps to compare water management alternatives during phase I of the alternative formulation, which the FWS believes to have significant problems. In Table 2 the FWS determined that the Corps has not adequately evaluated the impacts to Reservoir Retention Time, Instream Flow Guidelines, and Gulf sturgeon. The Corps response to the EVALUATION OF THE SELECTED PLAN is provided in the relevant sections above.

SUMMARY AND FWS POSITION

Pg 50/51- The FWS provided six bulleted points summarizing its reasons for not fully supporting the PAA. Five of the bulleted points are reiterations of concerns raised earlier in the DFWCAR and were addressed in the discussion preceding this section. One concern that warrants further consideration is that of the Corps' alternative selection process which was described in a separate document (Appendix XV). The following summarizes the nature of that concern and provides the Corps' response. The document is unnumbered, so page 1 refers to title page of Appendix XV, *Problems regarding United States Army Corps of Engineers (Corps) alternatives selection process for the Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) update*.

Pg 2 – The FWS states three major concerns with the Corps water management ranking methodology.

1. *Small differences within project purposes are treated the same as large differences. FWS gives examples*. The Corps used a straightforward and transparent approach to ranking the alternatives. Since the Corps treats all authorized project purposes as equal, it would not be appropriate to weight some project purposes more than others. The Corps acknowledges that relatively small differences occurred between some of the alternatives. However, the Corps maintains that the HEC-ResSim model is capable of simulating these small differences and that these small differences may be significant to the relevant stakeholder for that resource. For example, small differences in hydropower production may translate to millions of dollars when comparing alternatives. Using a more robust statistical approach that scores and ranks alternatives with small differences the same fails to account for this.

2. *An incomplete set of fish and wildlife performance measures was used to score and then rank alternatives for the Fish and Wildlife project purpose.* Because the Corps used an equal ranking methodology, the number of performance measures for a particular project purpose becomes irrelevant. While the choice of the most appropriate performance measures is relevant, when averaged, a single number representing each project purpose is used in the final ranking. Because of the huge number of potential summary statistics that can be developed from a HEC-ResSim and HEC-5Q output dataset, along with other performance measures suggested by FWS, it becomes unfeasible to use more than a few

to represent the fish and wildlife project purpose. The Corps chose a number of performance measures that it believed represented the fish and wildlife project purpose.

3. *There is no consideration regarding the uncertainty or precision of model output in the Corps' ranking process.* This concern is essentially the same as number 1. Whether performance metrics are weighted according to magnitude of differences or analyzed statistically to compare those differences, both attempt to address the concern that small differences are treated the same as large differences. The Corps believes the ranking methodology has adequate precision to rank water management alternatives. It would go beyond the intent of the ranking of alternatives to attempt to use statistical comparisons in this case.

In summary, the Corps believes that the PAA balances all authorized project purposes including fish and wildlife conservation. We believe that the currently proposed alternative including the management of the water resources over which the Corps is responsible and for which the Corps has authority, would have little adverse impact to fish and wildlife resources compared to the existing condition. The Corps appreciates the FWS efforts in preparing the DFWCAR and looks forward to continuing cooperation.

In regards to the FWS statement that "the Service needs to be an integral member of the Corps' team when formulating and evaluating operational alternatives" the Corps acknowledges the benefits of collaborating with other agencies. However, due to the fact that a WCM update is inherently a Corps function, the nature of this being an operational change, and in view of ongoing litigation at the beginning of the process, it was decided not to involve other entities as Cooperating Agencies. The Corps will continue to include participation with FWS as much as possible under current authorities.

Part 2: Endangered Species Act

This page intentionally left blank

USACE Request for Reinitiating of Consultation
July 2014

This page intentionally left blank

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, MOBILE DISTRICT
CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

July 22, 2014

Inland Environment Team
Planning and Environmental Division

Dr. Catherine T. Phillips
Acting Project Leader
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405

Dear Dr. Phillips:

This letter is to inform you that the U.S. Army Corps of Engineers (USACE) is requesting to reinitiate consultation of the Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River (BO) dated May 22, 2012. In the BO it was believed that the Chipola slabshell is less vulnerable to low-flow related mortality than the fat three ridge or purple bankclimber because of its thinner shell and likely higher mobility, as well as the generally steeper bank slopes in the Chipola River. Previous Chipola slabshell mortality had not been observed and based on limited survey data, it was assumed that flow reductions could affect less than 1% of the slabshell population estimated to be 2,650 individuals. Therefore, it was determined that a total of six Chipola slabshell may be exposed in the Chipola River downstream of the Chipola Cutoff.

Currently the USACE is approaching the incidental take limit as defined in the 2012 BO. The USACE has conducted incidental take monitoring during the summer and fall of 2013 and summer of 2014. We have observed a total of five Chipola slabshell mortalities at the monitoring sites as well as one additional mortality in similar habitat area near a monitoring site. During the 2013 incidental take monitoring period we observed a total of one Chipola slabshell and have observed four slabshell thus far in the 2014 incidental take monitoring period. All of these occurrences were observed at the same monitoring site within the Chipola Cutoff labeled as site C9. It was on July 16, 2014 that an additional mortality was observed after spot checking similar habitat downstream of site C9. Once the field data is extrapolated for the entire Chipola River downstream of the Chipola Cutoff, the incidental take for Chipola slabshell will most likely exceed the incidental take limit.

We believe the BO underestimated the level of incidental take for the Chipola slabshell and are reinitiating consultation in order to request additional take. Should you have any questions, comments, or recommendations, please contact Mr. Brian Zettle, (251) 690-2115, Email: brian.a.zettle@sam.usace.army.mil.

Sincerely,

Curtis M. Flakes
Chief, Planning and Environmental
Division

USFWS August 2014 Amendment to May 2012 Biological Opinion

This page intentionally left blank

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Field Office
1601 Balboa Avenue
Panama City, FL 32405-3721
Tel: (850) 769-0552
Fax: (850) 763-2177

IN REPLY REFER TO:

August 07, 2014

Mr. Curtis M. Flakes
Chief, Planning and Environmental Division
U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

Dear Mr. Flakes:

This document constitutes an amendment to the U. S. Fish and Wildlife Service's May 22, 2012 Biological Opinion (BO) and Incidental Take Statement (ITS) for the Revised Interim Operating Plan (RIOP) for Jim Woodruff Dam which addresses water management operations at Jim Woodruff Dam and the associated releases to the Apalachicola River. The U.S. Army Corps of Engineers (USACE) requested reinitiation of this Endangered Species Act (Act) section 7(a)(2) consultation by letter dated July 22, 2014 because the amount of take for the Chipola slabshell may exceed authorized levels during the 2014 monitoring period. This letter responds to your request.

The reinitiation request states that the USACE is approaching the incidental take limit for Chipola slabshell provided in the 2012 BO. The USACE has conducted incidental take monitoring during the summer and fall of 2013 and summer of 2014 and has observed a total of 6 Chipola slabshell exposures and mortalities. One live slabshell was found exposed during the 2013 monitoring period and 5 dead have been documented thus far in 2014. All were observed at or near site C9, the only monitoring site on the Chipola Cut. When extrapolated for the entire lower Chipola River and Cutoff, the incidental take of 6 Chipola slabshell is likely exceeded.

In the 2012 BO, we concluded that a total of 6 Chipola slabshell may be exposed in the Chipola River downstream of the Chipola Cutoff when the releases from Woodruff are reduced to 4,500 cfs. We believed the Chipola slabshell to be less vulnerable to low-flow related mortality because of the generally steeper bank slopes (>20%) in the Chipola River, and because its thinner shell made it more mobile than the fat threeridge or purple bankclimber. In the BO, we noted that no slabshell mortality was documented during the low flow conditions of 2006-2008 and 2010-2011. Although we did not observe slabshell mortality, we assumed that some low-flow mortality had occurred.

At the time of the BO, the Chipola slabshell's known range within the action area was limited to the Chipola River downstream of the Chipola Cutoff as the species was not known to occur in the Chipola Cutoff. Limited recent (1990 to 2012) surveys in the Cutoff have documented other mussels species including Fat threeridge and Purple bankclimber, but not Chipola slabshell. A survey conducted in the Cutoff at site C9 during October 2008 found 154 mussels of 9 species, but slabshells were not detected (Gangloff 2011 unpub. data). The first documented collection of slabshell in the Cutoff was in summer 2013 during take monitoring at the C9 site. During monitoring in summer 2014, four additional slabshells were found at the site, and one slabshell was found approximately 50 meters downstream of the monitoring site, in an area with similar habitat features. All 6 individuals were less than 60 mm in length. We do not have length-at-age data for Chipola slabshell from which to infer the age of these mussels, however, external shell annuli indicate they are young individuals–likely less than 3 years old when found. Therefore, recent recruitment to the site may partially explain why none were detected during the 2008 sampling.

The C9 site is one of the few areas in the Chipola Cutoff with a relatively shallow bankslope (mean slope of 0.20, Gangloff 2011 unpub. data), a feature known to cause mussel stranding and mortality (USFWS 2011). The C9 monitoring site is approximately 80 meters in length and the shallow bank habitat appears (in aerials) to extend at least another 80 meters downstream of the monitoring site. A spot-check in the downstream reach found one stranded slabshell, and additional, undetected strandings have likely occurred in this area. We conservatively estimate that at least10 individuals (5 observed in the upstream reach and 5 estimated in the downstream reach) were stranded in this area of the Cutoff. The exposures at the C9 site indicate that slabshells may be more prone to stranding than previously believed.

This amendment to the 2012 BO revises our original take estimate for Chipola slabshell, and adds the Chipola Cutoff as part of its known range within the action area. We have no qualitative survey data or habitat data to use as a basis to calculate the number of mussels that may become stranded in the Cutoff reach. We relied upon limited survey data, results of the 2013 and 2014 monitoring, and habitat conditions in the Chipola River and Cutoff to provide a basis for a conservative, not-likely-to-exceed, take estimate. In total, we anticipate that a maximum of 100 Chipola slabshells may be exposed in the Chipola Cutoff and Chipola River downstream of the Cutoff, during each of these events. We anticipate take of not more than 50 Chipola slabshell if flows are reduced to 4,500 cfs, and 50 if they recolonize areas above elevations associated with flows of 5,000 cfs and are exposed when flows are again reduced to >= 5,000 cfs

This number is considerably higher than anticipated in the 2012 BO, however, the majority of the species' range is in the Chipola River upstream of the action area, and take of 100 Chipola slabshells is still much less than 1% of the population. Therefore, this increase in the amount of incidental take does not change the conclusion of the original BO–we still conclude that water management operations at Jim Woodruff Dam due to the RIOP will not jeopardize the continued existence of the Chipola slabshell.

All other sections of the BO and ITS remain unchanged, and all terms and conditions apply. Thank you for you cooperation during this consultation. If you have any questions or concerns, please feel free to contact me or Ms. Sandra Pursifull of this office at 850-769-0552.

Sincerely,

Dr. Catherine T. Phillips
Acting Project Leader

USACE Request for Reinitiation of Consultation 31 May 2016

This page intentionally left blank

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

May 31, 2016

Inland Environmental Team
Planning and Environmental Division

Dr. Catherine Phillips
Field Supervisor
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405-3721

Dear Dr. Phillips:

This letter is to request the initiation of formal consultation pursuant to Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq), on the U.S. Army Corps of Engineers, Mobile District (USACE) Update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama and Florida and Water Supply Storage Assessment. The enclosed Biological Assessment (BA) describes the proposed action alternative and evaluates potential effects to the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and critical habitat for the Gulf sturgeon; the endangered fat threeridge mussel (*Amblema neislerii*); the threatened purple bankclimber mussel (*Elliptoideus sloatianus*); the threatened Chipola slabshell mussel (*Elliptio chipolaensis*) and critical habitat for the listed mussels.

We request your concurrence with our determinations regarding Gulf sturgeon, Gulf sturgeon critical habitat, and listed mussels critical habitat and that you review the BA and provide your biological opinion on the fat threeridge, purple bankclimber, and Chipola slabshell. As discussed during the May 23, 2016 teleconference between our agencies, the USACE stands ready to provide any additional assistance needed and will continue to work closely with your staff to assist in concluding the consultation process and reaching consensus on any reasonable or prudent measures that may be appropriate.

If you have any questions regarding the consultation or information provided, please contact Mr. Brian Zettle, Chief of the Inland Environment Team, (251) 690-2115, or email:brian.a.zettle@usace.army.mil. We look forward to continued progress as we work with you and your staff to complete our respective consultation responsibilities.

Sincerely,

Curtis M. Flakes
Chief, Planning and Environmental
Division

USFWS Request for additional information 10 June 2016

This page intentionally left blank

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Field Office
1601 Balboa Avenue
Panama City, Florida 32405
Tel: (850) 769-0552
Fax: (850) 763-2177

June 10, 2016

Curtis M. Flakes, Chief
Planning and Environmental Division
Mobile District, Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001

Attn: Mr. Brian Zettle

Re: FWS Log No. 04EF3000-2016-F-0181
Applicant: U.S. Department of the Army, Corps of Engineers (ACOE)
Project: ACF Master Water Control Manual Update
Action area: Alabama, Florida, Georgia

Dear Mr. Flakes:

This letter acknowledges the United States Fish and Wildlife Service (USFWS) receipt on June 1, 2016 of your May 31, 2016 letter requesting formal consultation under section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). The consultation concerns possible effects as described in the Biological Assessment (BA) entitled "Biological Assessment Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment" (May 31, 2016) on the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and critical habitat for the Gulf sturgeon; the endangered fat threeridge mussel (*Amblema neislerii*); the threatened purple bankclimber mussel (*Elliptoideus sloatianus*); the threatened Chipola slabshell mussel (*Eliptio chipolaensis*) and critical habitat for these three listed mussel species.

At this time, USFWS has not received all the information to necessary to initiate formal consultation on this BA as outlined in the regulations governing interagency consultations (50 CFR §402.14). The Panama City Field Office, as lead office for this consultation, has determined that the additional information outlined below is necessary to initiate the consultation. Additionally, please see the attached fact sheet that covers our expectations for content in a biological assessment. More details on the consultation process can be found in our consultation handbook (USFWS & NMFS 1998). Overall, we recommend a revision of the BA so that it can stand alone in its analysis of the effects of the action on the listed species.

1. A description of the action to be considered – 402.14(c)(1).

- In general, the description of the action in your May 31, 2016 BA is inadequate to allow a thorough and fundamental understanding of the action. Please provide a complete description of the action so that we can make sure we understand your proposal, its temporal and geographic scope and breath. Numerous references are made to the Draft Environmental Impact Statement (October 2015), but the specifics of the action for assessment in the BA lacks the clarity to allow the USFWS to understand spatial and temporal scope of the action in adequate detail to independently assess the effects of the action on the species. For each reference to the DEIS made in the BA, please include the relevant material from the DEIS in the BA to allow an adequate understanding of the action being considered in the BA. Explicitly describe in the BA the complete range of your action that USFWS needs to consider. Also, be explicit as to the rules, thresholds, timing and discretion with which the Water Control Manual guides operation. The action description in each BA should stand alone in its completeness.
- At a minimum, two additional details on the drought operations are required. First, the revision of the trigger for initiating the drought operations from Composite zone 4 to 3 has not been analyzed (page 6). Provide an analysis that documents effects of this change. Especially, how does the revising the trigger for initiating drought operations change the frequency and duration of the occurrence of drought operations? Please clarify when the decision is made to cease drought operations (i.e., is this decision made daily, monthly, etc?). Second, the description of the fall rate exemption under drought operations is an important detail that needs to be clarified. The statements and analyses on pages 6, 23, and 36 are contradictory and confusing. Provide these specifics of the rules governing the fall rates under drought operations and an explanation of the reason(s) why fall rates higher than allowed occur in Fig 18.
- As a third example of additional information needed, there is a statement in the BA that river bed degradation has stabilized based on the 2012 BO (page 19). Provide an analysis of rating curves for the Chattahoochee, Blountstown and Sumatra gages that examines whether river bed degradation has stabilized. If trends are detected in this data, please describe the pattern and potential effects on river bed stabilization.

2. A description of any species or critical habitat that may be affected by the action – 402.14(c)(3).

- The BA only includes a single paragraph description of the four species and their critical habitat in the action area by reference to the 2012 BO, DEIS, and 2015 Annual Report describing take monitoring (page 17). This section requires an update based on the based on a review of relevant new literature and reports from 2012-present. A review of all current literature and best available information for these species or closely related species (when data is lacking) should be included in the species descriptions. For each reference to the aforementioned sources, please include the relevant material from these documents in the BA. Again, the description in each BA should stand alone in its completeness.

- As one example of updated species information required in the BA, there is a statement in the BA that mussels can survive periods of 40 days of exposure (page 33). This contradicts our knowledge of the 3 mussel species and data collected in 2012 (see comment #1). Which analyses (include citations or reports) provide support for this statement? The change from 34 to 79 days of flows < 5000 cfs is a concerning increase and could result in added take depending on the exposure of mussels. Explain how your analysis incorporated this 40-day window into the potential added exposure.
- USFWS has provided some additional information to include in your update (Fritts and Bringolf 2014, Fritts et al. 2012, Kaeser and Herrington 2011, Smit 2014). We are willing to continue to help you develop an update to this section.

<u>3. A description of the manner in which the action may affect listed species or critical habitat and an analysis of cumulative effects – 402.14(c)(4).</u>

- In general, the BA is lacking a complete analysis of the effects of the action on the listed species. The current action and its effects on the listed species needs to be evaluated on its own standing instead of citing past decisions as the basis for the effects determinations. Be clear in your analysis of how the current proposed action will affect the listed species and their habitat given the current and best available scientific information.
- Two additional details on the datasets used for unimpaired flow data and the consumptive demand data are required to understand the analyses (page 22). First, the 2011 - 2012 drought is the most severe drought in the period of record and represents an extreme condition that should be included in the analysis (Leitman et al. *in press*). It is our understanding that data for 2012 are partially complete yet was not included because of lack of accurate demand data from the states. We recommend including the demand data from 2011 as a proxy for 2012 in the analysis. This addition to your dataset would greatly improve the range of the analysis by including this historic drought. Second, in our 2012 BO, we compared flows under the RIOP (what is now the NAA) simulated with actual reported water demands with observed flows (baseline) to minimize differences due to variable demands. Describe and include what demand data was included for the PAA and NAA and include a description of the assumptions made for demand data under the PAA.
- In general, additional details on the climate change analyses are required in the BA. Again, the description in each BA should stand alone in its completeness. Describe the scenarios run in adequate detail. For example, in the DEIS (page N-32), it is stated that there are two sets of unimpaired flows which were used in the climate analysis: one set which included the negative unimpaired flow set and one set in which the negative values were eliminated. Describe the set of unimpaired flows that was used in developing the climate information used in the BA, how this dataset was generated, and how these analyses were performed. Calculate similar metrics and show similar outputs as used to analyze the effects of the action on the species based on the added variation seen from these climate runs.

In summary, we recommend a revision of the BA to meet the above concerns and so that the BA stands alone in its effects determinations on the species in regards to the proposed action. The formal consultation process for the project will not begin until we receive all of the necessary information. At that time, we will inform you if the additional information you provide is adequate and identify a timeline for initiation of formal consultation. If formal consultation is initiated, our notification letter will also outline the dates within which formal consultation should be complete and the biological opinion delivered on the proposed action.

If you have any questions about these comments and additional information needs, please contact myself (ext. 242) or my Deputy Field Supervisor for Ecological Services, Dr. Sean Blomquist (ext. 233), for additional information and coordination regarding this project.

Sincerely,

Dr. Catherine T. Phillips
Project Leader

cc: (electronic and copies)
Assistant Regional Director, Ecological Services (Leopoldo Miranda)
Florida State Supervisor for Ecological Services (Larry Williams)
Alabama Ecological Services Field Office, AL (Bill Pearson)
Georgia Ecological Services Field Office, GA (Donald Imm)

Attachment:
Contents of a Biological Assessment

References

Fritts, A.K. and Bringolf, R.B. 2014. Host fishes for four federally endangered freshwater mussels (Unionidae) in the Apalachicola-Chattahoochee-Flint Basin. Walkerana 17(2):51-59.

Fritts, A.K., Fritts, M.W. II, Peterson, D.L., Fox, D.A. and Bringolf, R.B. 2012. Critical linkage of imperiled species: Gulf Sturgeon as host for Purple Bankclimber mussels. Freshwater Science 31(4):1223-1232.

Kaeser, A.J. and Herrington, K. 2011. An investigation of movement, exposure, and mortality of fat threeridge mussels (*Amblema neislerii*) at Apalachicola and Chipola River sites. U. S. Fish and Wildlife Service, Panama City, Florida. 28p.

Leitman, S., Pine, W.E. III, and Kiker, G. Management options during the 2011–2012 drought on the Apalachicola River: a systems dynamic model evaluation. Environmental Management *in press*, DOI 10.1007/s00267-016-0712-4

Smit, R.B. 2014. Using sonar habitat mapping and GIS analyses to identify freshwater mussel habitat and estimate population size of a federally endangered freshwater mussel species, *Amblema neislerii*, in the Apalachicola River, FL. Master's thesis. Auburn University, Auburn, Alabama. 101p.

USFWS and NMFS [Fish and Wildlife Service and the National Marine Fisheries Service]. 1998. Endangered Species Act Section 7 Consultation Handbook. US Fish and Wildlife Service and the National Marine Fisheries Service. Endangered Species Act Section 7 Consultation Handbook. 315p. Available at: https://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf

Contents of a Biological Assessment

Biological Assessments (BA) may serve multiple purposes, but the primary role is to document an agency's conclusions and the rationale to support those conclusions regarding the effects of their proposed actions on protected resources. The recommended elements of a BA are identified at 50 CFR §402.12(f). The below highlights the elements that are essential for our review of your project.

- Project description - Describe the what, when, where, and how of the project. Describe (1) **what** the project or action is; (2) **where** the project is (refer to attached maps); (3) **when** the action is going to take place, time line/implementation schedules; (4) **who** is going to do the action and under what authority, include name and address of the applicant; and (5) **how** the action will be accomplished–*e.g.*, bulldozer, pile driver, feller-buncher, chain saw, steam roller. If it is multi-phased, describe the what, when, where and how of each phased separately. Identify any conservation measures that will be implemented to avoid, reduce, or eliminate adverse effects or that would benefit the protected species or critical habitat.

- Describe the project area - For determining whether a species or critical habitat "may be present," it is necessary to delineate the "action area." Action area is defined as all areas that may be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. It encompasses the geographic extent of environmental changes (i.e., the physical, chemical and biotic effects) that will result directly and indirectly from the action. Action area is typically larger than the area directly affected by of the action.

- Describe the physical and biological attributes of the action area (e.g., topography, vegetation, condition and trend). It is helpful to include a map delineating where the action will occur. Also, identify any management or activities already occurring in the area.

- Identify listed or proposed species that "may be present." List all species that "may be present" in the area and where you obtain this information. You may submit your own list to the Service or request a list from the Service. We recommend including candidate species, in addition to proposed and listed species and proposed and designated critical habitat. If you determined that a particular species that may be present in the general area, *but not in the action area*, it is helpful to identify that species and to explain why it is not present in the action area. This serves two purposes. First, it will provide documentation for your administrative record. Second, it will avoid need for additional correspondence with us regarding that particular species. If a species is missing from the list, we will either ask you for an explanation of why the species would not be present in the action area or why they are likely to be present.

- For each species that "may be present," describe the current habitat conditions within the action area. If known, include population status and trend. For critical habitat, identify the primary constituent elements that occur in the action area. For a description of the primary constituent elements, refer to the rule in the Federal Register that designated the critical habitat.

- Describe how the action may affect each protected resource - This section should document your conclusion and supporting rationale. Document your analysis of the what, when and how the protected resources will be exposed to and how such individuals or habitat are likely to respond to this exposure. Remember that you must consider effects that may occur later in time (e.g., after completion of initial construction). If species experts were contacted, include a summary of the conversations/conclusions reached. Include the references for the literature that your analysis relied upon.

Following this analysis, you need to make a Section 7 finding for proposed or listed species and proposed or designated critical habitat that may be present in the action area. Your section 7 conclusion should be explicit. Generally, one of the following three determinations will apply[4]. For additional guidance in making a Section 7 determination, please see our Section 7(a)(2) Process (Steps 1-3) website.

- "No effect" means there will be no impacts, positive or negative, to listed or proposed resources. Generally, this means no listed resources will be exposed to action and its environmental consequences. Concurrence from the Service is not required.
- "May affect, but not likely to adversely affect" means that all effects are beneficial, insignificant, or discountable. Beneficial effects have contemporaneous positive effects without any adverse effects to the species or habitat. Insignificant effects relate to the size of the impact and include those effects that are undetectable, not measurable, or cannot be evaluated. Discountable effects are those extremely unlikely to occur. These determinations require written concurrence from the Service.
- "May affect, and is likely to adversely affect" means that listed resources are likely to be exposed to the action or its environmental consequences and will respond in a negative manner to the exposure.
- Include relevant reports- Results from species or habitat surveys should be included. If a survey was conducted, include a description of the survey methodology. It is important to note the specifics of your methodology. Explain the scope of the survey; did the survey cover the entire action area or only part of it? Identify who did the survey and when.

Supporting documents, such as environmental assessments or other planning documents, are very helpful for our review.

USACE Amended Biological Assessment June 2016

This page intentionally left blank

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

INTRODUCTION

On 2 October 2016, the U.S. Army Corps of Engineers, Mobile District (USACE) released a Draft Environmental Impact Statement (DEIS) (USACE, 2015) for an Update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama and Florida. The DEIS has been provided to the U.S. Fish and Wildlife Service (Service) Panama City, Florida and Athens, Georgia field offices. Other relevant communication between our agencies include a Service Planning Aid Letter (PAL) to USACE District Commander Byron Jorns dated April 2, 2010, an addendum to the PAL to USACE District Commander Stephen Roemhildt dated March 1, 2011, a Service scoping comment letter to USACE District Commander Stephen Roemhildt, dated January 11, 2013, a PAL from the Service to USACE Planning and Environmental Division Chief Curtis Flakes dated August 29, 2013, a response to the 2013 PAL from USACE Mobile District Planning Division and Environmental Chief Curtis Flakes dated January 21, 2015, and a Draft Fish and Wildlife Coordination Act Report (DFWCAR) provided by the Service Athens, Georgia Field Office, to USACE District Commander Jon Chytka, dated July 31, 2015. A response to the DFWCAR was provided by USACE in the DEIS. In addition, a Department of the Interior letter commenting on the DEIS dated January 29, 2016, provided Service as well as National Park Service comments on the proposed action.

Previous to the current effort to update the WCM, USACE coordinated with the Service on interim water management operations at Jim Woodruff Dam. On May 22, 2012, the Service released a Biological Opinion (BO) on the USACE, Revised Interim Operating Plan (RIOP) for Jim Woodruff Dam and the associated releases to the Apalachicola River (USFWS 2012). The BO addressed the effects of USACE operations at Jim Woodruff Dam on Federally listed endangered or threatened species and critical habitat for those species. The species addressed in the BO include the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and critical habitat for the Gulf sturgeon; the endangered fat threeridge mussel (*Amblema neislerii*); the threatened purple bankclimber mussel (*Elliptoideus sloatianus*); the threatened Chipola slabshell mussel (*Eliptio chipolaensis*) and critical habitat for the listed mussels. As described in the BO, the operations regarding releases to the Apalachicola River were identified in a revised interim plan, since consultation on the overall project operations for the ACF system would be deferred until future efforts to update the water control plans and basin manual for the system. This Biological Assessment (BA) considers the affects to listed species of the updated ACF WCM and the associated Water Supply Storage Assessment at Lake Lanier. Once approved, the WCM will supersede the RIOP with regards to releases from Jim Woodruff Dam.

The ACF Basin supports a wide variety of wildlife and is home to approximately 166 species that are protected or included as candidate species by the states and the federal government. Of those, 37 are federally listed as Threatened or Endangered (Table 1). However, effects of the proposed action are limited to those that depend primarily on riverine habitat. Except for the temporary waiver of winter drawdown requirements during drought conditions, the proposed action does not change the top of the flood control pools, conservation pools, or the rule curves of the upstream projects. Therefore, the proposed action will have no effect or an insignificant effect (i.e., any impacts should never reach the scale where take occurs) on all but the riverine- and estuarine-dependent species. Two species of sea turtles and the West Indian manatee may sometimes occur in Apalachicola Bay or the lower Apalachicola River; however, any effects of the proposed action to these species would be insignificant also, due to their low numbers and only occasional seasonal residence in the river and bay. Three of the 37 ACF listed species are freshwater mussels that do not occur in areas downstream of the Federal ACF projects: the shiny-rayed pocketbook, Gulf moccasinshell, and oval pigtoe. The proposed action will have no effect on these mussel species. Altogether, the proposed action will have either no effect or an insignificant effect on 33 of the species listed below; therefore, these species are not further discussed in this BA. Listed species that may be affected by the proposed action include the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and critical habitat for the Gulf sturgeon; the endangered fat threeridge mussel (*Amblema neislerii*); the threatened purple bankclimber mussel (*Elliptoideus sloatianus*); the threatened Chipola slabshell mussel (*Eliptio chipolaensis*) and critical habitat for the listed mussels. This BA considers the effects of the proposed action on these four species and their critical habitat.

Table 1. Listed Species Known to Occur Within the ACF River Basin

Frosted flatwoods salamander (*Ambystoma cingulatum*)
Reticulated flatwoods salamander (*Ambystoma bishopi*)
Loggerhead turtle (*Caretta caretta caretta*)
Eastern indigo snake (*Drymarchon corais couperi*)
Atlantic ridley (*Lepidochelys kempi*)
Piping plover (*Charadrius melodus*)
Wood stork (*Mycteria americana*)
Gray bat (*Myotis grisescens*)
Indiana bat (*Myotis sodalis*)
West Indian manatee (*Trichechus manatus*)
Shiny-rayed pocketbook (*Lampsilis subangulata*)
Gulf moccasinshell (*Medionidus penicillatus*)
Oval pigtoe (*Pleurobema pyriforme*)
Little amphianthus (*Amphianthus pusillus*)
Apalachicola rosemary (*Conradina glabra*)
Telephus spurge (*Euphorbia telephioides*)
Harper's beauty (*Harperocallis flava*)
Black-spored quillwort (*Isoetes melanospora*)
Pondberry (*Lindera melissifolia*)
White birds-in-a-nest (*Macbridea alba*)
Canby's dropwort (*Oxypolis canbyi*)
Godfrey's butterwort (*Pinguicula ionantha*)
Harperella (*Ptilimnium nodosum)*
Chapman's rhododendron (*Rhododendron chapmanii*)
Michaux's sumac (*Rhus michauxii*)
Green pitcherplant (*Sarracenia oreophila*)
American chaffseed (*Schwalbea Americana*)
Florida skullcap (*Scutellaria floridana*)

Fringed campion (*Silene polypetala*)
Gentian pinkroot (*Spigelia gentianoides*)
Cooley meadowrue (*Thalictrum cooleyi*)
Florida torreya (*Torreya taxifolia*)
Relict trillium (*Trillium reliquum*)
Gulf sturgeon (*Acipenser oxyrinchus desotoi*)
Fat threeridge (*Amblema neislerii*)
Purple bankclimber (*Elliptoideus sloatianus*)
Chipola slabshell (*Eliptio chipolaensis*)

The effects analysis described in the BA utilizes updated HEC-ResSim modeling that reflects the basin operations and water supply storage contained in the proposed action. This BA builds upon the previous efforts and BOs and is based on numerous conference calls and coordination meetings between the USACE and the Service since preparation of the first RIOP.

DESCRIPTION OF PROPOSED ACTION

Under the proposed action alternative (PAA), the USACE would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods. The intent would be to maintain a balanced use of conservation storage rather than to maintain the pools at or above certain predetermined elevations; however, in times of high-flow conditions, flood risk management regulation would supersede all other project functions. At all times, USACE would seek to conserve the water resources entrusted to its regulation authority. The PAA is consistent with the USACE's authority as set forth in the 2012 legal opinion (USACE 2012). The PAA does not include construction of any new facilities or infrastructure. The following sections describe the PAA.

Guide Curves and Action Zones

In conjunction with meeting authorized project purposes, an important function of the reservoirs in the ACF Basin is to store water when there is an abundance of rain and to release water when there is less rain in an effort to ensure that all water needs can be met throughout the year. Water management in this context is a complex process that requires consideration of many competing demands for water in the basin, consideration of past and anticipated future hydrologic conditions, collaboration with agencies and stakeholders, and determination of the most appropriate operating conditions for all the reservoirs in the basin to meet both human and natural system needs. Water is managed in the reservoir projects in the ACF Basin for a variety of purposes, including flood risk management, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water supply, and water quality. Water demands can be consumptive or nonconsumptive. Consumptive demands involve withdrawal of water from the basin for some purpose and not returning it or any portion thereof, directly back to the basin. Municipal, industrial, and thermal power water supply consumes a portion of the withdrawn water and returns a portion of the water back to the basin as treated wastewater. For purposes of this analysis, agricultural water supply withdrawals are assumed to provide no return flows to the surface water streams. In contrast, hydroelectric power generation demand is a nonconsumptive use of water. It uses the flow in the river to drive hydroelectric power turbines to generate electricity, but no water is withdrawn or lost from the system. In considering basin water management, it is critical to account for the various withdrawals (losses) from and returns (gains) to the system. Water is lost to the system through evapotranspiration (the total of evaporation and plant transpiration), Municipal and Industrial (M&I) water withdrawals, thermal cooling water withdrawals, agricultural water withdrawals, groundwater transfers, and interbasin transfers. Water is returned, or added, to the basin through precipitation, treated M&I wastewater discharges, thermal power plant discharges, groundwater baseflow contribution, and interbasin transfers.

USACE releases water from its reservoirs primarily through hydropower generation and releases through the spillway gates. Hydropower generation is the preferred method and is generally used except in flood operations or in situations that prohibit the use of turbines, such as maintenance operations. In order to allow the most efficient use of its reservoirs for all project purposes, USACE has established guide curves that serve as target water levels during the year. The guide curves allow for lower reservoir levels during greater risk of flood conditions, typically the rainy winter and spring season, and higher reservoir level during drier periods. This allows storage of water during flood events and release of water during dry weather. Action Zones within the conservation pool (area under the guide curve) allow the decision maker to best balance the authorized purposes as the reservoir is drawn down through increasingly critical levels.

Under the PAA, the USACE would not modify any guide curves of the ACF projects but would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes can be met. As lake levels decline, Zones 2 through 4 define increasingly critical system status where purposes can no longer fully be met. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project.

The revised action zones were derived considering numerous factors, including the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects. Other factors or activities might cause the lakes to operate differently than the action zones are described, including exceptional flood risk management measures, fish spawn operations, approved deviations, maintenance and repair of turbines, emergency situations (such as a drowning and chemical spills), draw-downs because of shoreline maintenance, releases made to free grounded barges, and other special circumstances.

The storage projects (Lanier, West Point, and Walter F. George) would be operated to maintain their respective lake level in the same action zones concurrently. Because of the hydrologic and physical characteristics of the river system and factors mentioned above, however, there might be periods when one lake would be in a higher or lower zone than another. When that occurs, the USACE would conduct operations to bring the lakes into balance with each other as soon as conditions allow. By doing so, effects within the river basin would be shared equitably among the projects. The action zones for the PAA are shown in Figure 1-3.

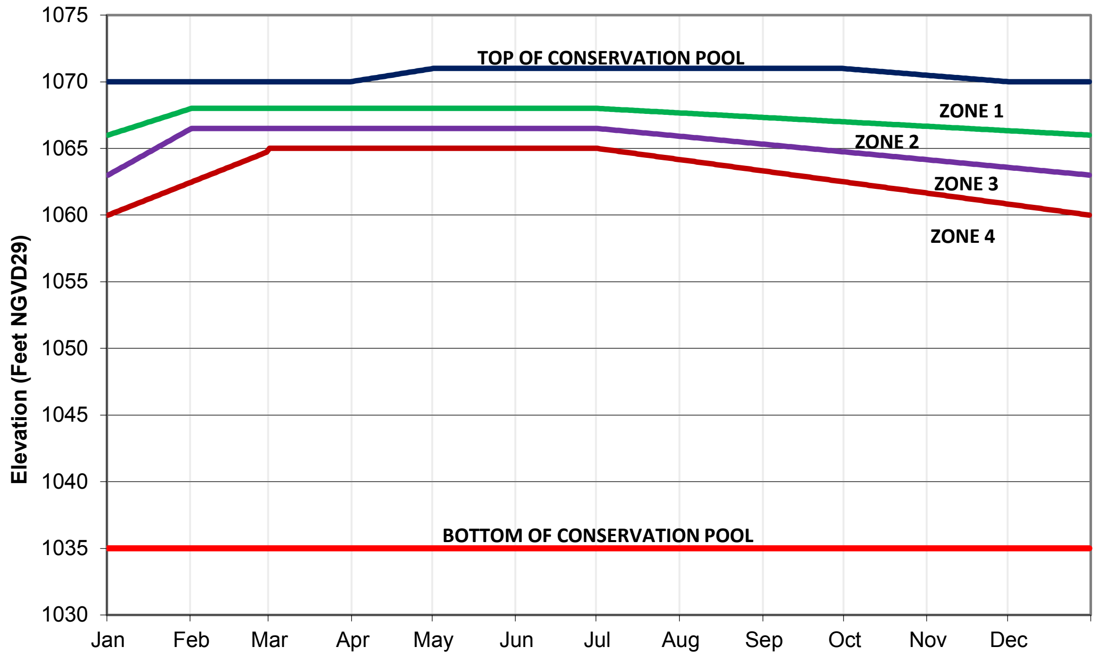


Figure 1. Lake Lanier Water Control Action Zones for the Proposed Action Alternative

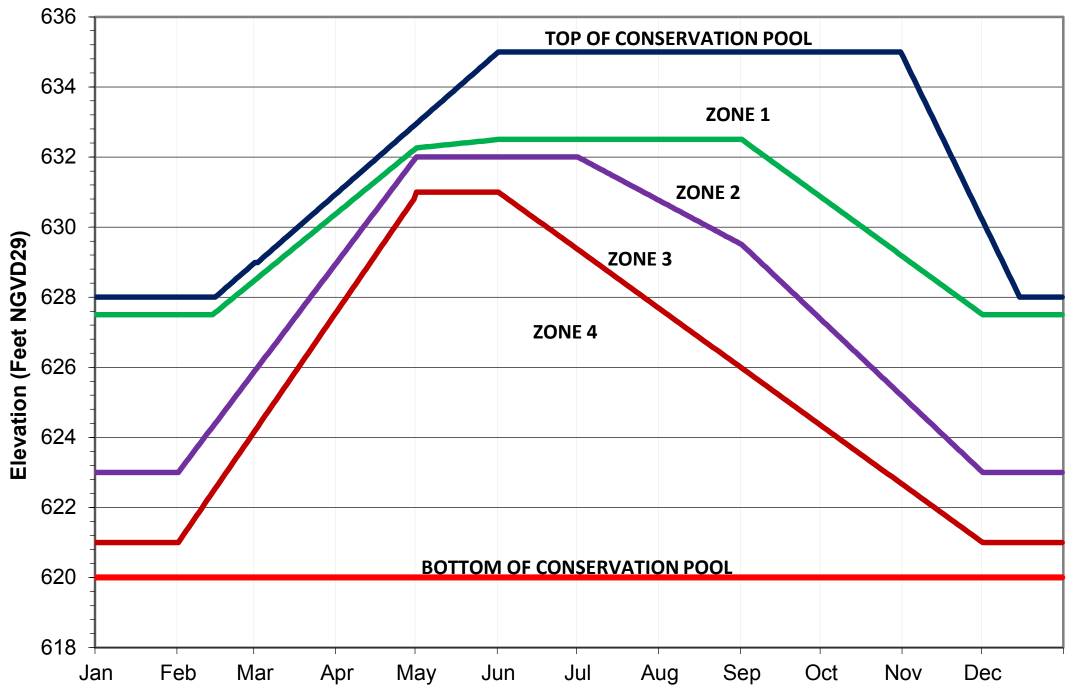


Figure 2. West Point Lake Water Control Action Zones for the Proposed Action Alternative

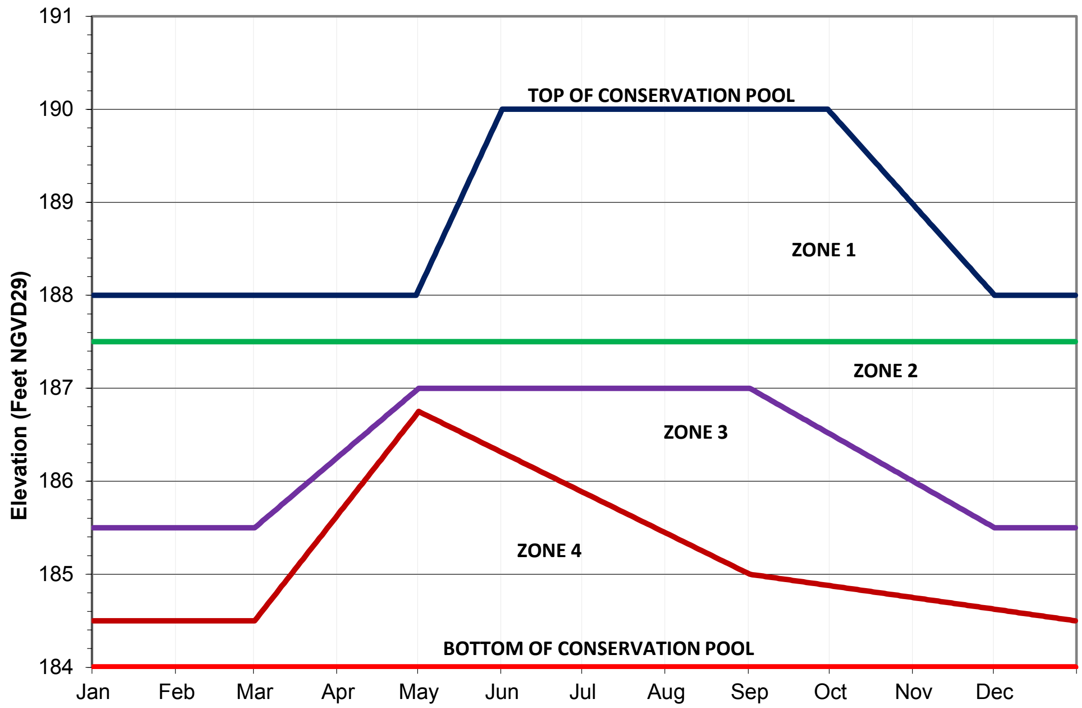


Figure 3. Walter F. George Lake Water Control Action Zones for the Proposed Action Alternative

Fish and Wildlife Conservation

There is no single operation for fish and wildlife conservation, rather there are several related operations that are implemented in the PAA. West Point Dam is the only federal project in the ACF Basin with fish and wildlife conservation specifically included in its original congressional authorization. Nonetheless, the ACF Basin USACE reservoirs (i.e., Lanier, West Point, Walter F. George, Andrews, and Seminole lakes) operate to support fish and wildlife conservation pursuant to the authority in either the Fish and Wildlife Coordination Act or the Endangered Species Act. Generally, reservoir operations for fish and wildlife conservation consist of either maintaining pool elevations during fish spawns or making special releases to minimize the possibility of fish kills. Special drawdowns for specific environmental purposes may be specified from time to time, but only after coordination with state and federal resource agencies and others, as appropriate. Although the possibility of requiring water control actions may extend throughout a season, the actual actions are usually of short duration. In addition to fishery management, operations include aquatic plant control, waterfowl, and other terrestrial habitat management. The various projects in the basin have specific operations for fish and wildlife, which are described in the individual project WCMs. Specific fish and wildlife conservation activities on USACE ACF Basin projects are addressed in more detail in the following paragraphs.

Federally-Listed Species—Under the PAA, the USACE would continue to make releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows.

Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above in the Guide Curves and Action Zones section.

The USACE would manage releases from Jim Woodruff Dam to support the federally-protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. Daily releases to provide support for fish and wildlife conservation from Jim Woodruff Dam are dictated by two parameters: a minimum discharge (measured in cfs) and a maximum fall rate [measured in feet per day (ft/day)].

Minimum discharges from Jim Woodruff Dam would vary according to composite conservation storage, basin inflow per the 7-day moving average, and by month. Table 2 shows these minimum releases, which are measured as a daily average flow in cfs at the USGS gage at Chattahoochee, Florida. During normal and above normal hydrological conditions within the basin, releases greater than the minimum release provisions could occur consistent with the maximum fall rate schedule described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

During the spawning period (March to May), two sets of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in Zones 1 and 2 or composite conservation storage in Zone 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included. The USACE would also operate Jim Woodruff Dam to avoid potential Gulf sturgeon take. Potential Gulf sturgeon take is defined as an 8-foot or greater drop in Apalachicola River stage over the last 14-day period (i.e., considering if today's stage is greater than 8 feet lower than the stage of any of the previous 14 days) when flows are less than 40,000 cfs.

During the non-spawning period (June to November), one set of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in Zones 1 - 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included.

During the winter season (December to February), only one basin inflow threshold and corresponding minimum release (5,000 cfs) would exist while in composite conservation storage Zones 1–4. That would provide the greatest opportunity to refill the storage reservoirs. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions.

When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations are triggered. Within Zone 4, the minimum flow is the same as in Zone 3. When the composite conservation storage drops further into the Drought Zone, the minimum flow from Jim Woodruff Dam is reduced to 4,500 cfs. A detailed description of the drought operations is provided in the Drought Operations section below.

Table 2. Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge for Federally-Listed Species by Month and by Basin Inflow (BI) Rates

Months	Composite conservation storage zone	Basin inflow (BI)[a] (cfs)	Min. Releases from Jim Woodruff Lock and Dam[b] (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000 ≥ 16,000 and < 34,000 ≥ 5,000 and < 16,000 < 5,000	= 25,000 = 16,000+50% BI > 16,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>16,000
	Zone 3	≥ 39,000 ≥ 11,000 and < 39,000 ≥ 5,000 and < 11,000 < 5,000	= 25,000 = 11,000+50% BI > 11,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	≥ 22,000 ≥ 10,000 and < 22,000 ≥ 5,000 and < 10,000 < 5,000	= 16,000 = 10,000+50% BI > 10,000 = BI = 5,000	Up to 100% BI>16,000 Up to 50% BI>10,000
December–February	Zones 1, 2, and 3	≥ 5,000 < 5,000	= 5,000 = 5,000	Up to 100% BI > 5,000
If Drought Triggered	Zone 3	NA	= 5,000[d]	Up to 100% BI > 5,000
At all times	Zone 4	NA	= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	= 4,500[e]	Up to 100% BI > 4,500

Notes:

a. Basin inflow for composite conservation storage in Zones 1, 2, and 3 is calculated using the 7-day moving average basin inflow. Basin inflow for composite conservation storage in Drought Operations, Zones 3 and 4 or lower (Drought Zone) is calculated using the one-day basin inflow.

b. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

c. Drought plan is triggered when the composite conservation storage falls into Zone 3, the first day of each month represents a decision point.

d. Once drought operation triggered, reduce minimum flow to 5,000 cfs following the maximum ramp rate schedule.

e. Once composite storage falls below the top of the Extreme Drought Zone ramp down to a minimum release of 4,500 cfs at rate of 0.25 ft/day based on the USGS gage at Chattahoochee, Florida (02358000).

The federally-listed species operations of the PAA include a fall rate, also called down-ramping rate, defined as the vertical drop in river stage (water surface elevation) that occurs over a given period of time. The fall rates are expressed in units of ft/day measured at the USGS Chattahoochee, Florida, gage as the difference between the daily average river stage on consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The maximum fall rate schedule is provided in Table 3. When composite conservation storage falls into Zone 3, the drought operations plan would be implemented. A detailed discussion of fall rate management when the drought operations plan is implemented is provided in the Drought Operations section below. Down-ramping rates are suspended during periods of prolonged low flow (flows less than 7,000 cfs for a period of more than 30 consecutive days). A prolonged low flow period would be considered over and down-ramping rates would be reinstated when flows are greater than 10,000 cfs for 30 consecutive days. When the maximum fall rate schedule is suspended due to prolonged low flow, down-ramping operations would be managed to match the one-day fall rate of the basin inflow. This prolonged low flow provision could occur under both normal and drought operations. Figure 4 provides an example of this scenario from the ResSim simulation of the PAA. In this example the simulated flows were less than 7,000 cfs for approximately 45 days before a storm system required an increase in releases. Once the storm event was complete the fall rates were managed to match the one day BI fall rate.

Table 3. Maximum Down-Ramping (Fall) Rate

Approximate release range (cfs)	**Maximum fall rate (ft/day)**	**Maximum fall rate (cfs/day)**
> 30,000 [a]	No ramping restriction [b]	
> 20,000 and ≤ 30,000 [a]	1.0 to 2.0	2,300 - 5,000
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [a]	0.5 to 1.0	1,060 – 2,300
Within Powerhouse Capacity and > 10,000 [a]	0.25 to 0.5	500 – 1,060
Within Powerhouse Capacity and ≤ 10,000 [a]	0.25 or less	220 - 500

Notes:

a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

b. For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control the down-ramping rate, and no ramping rate is required.

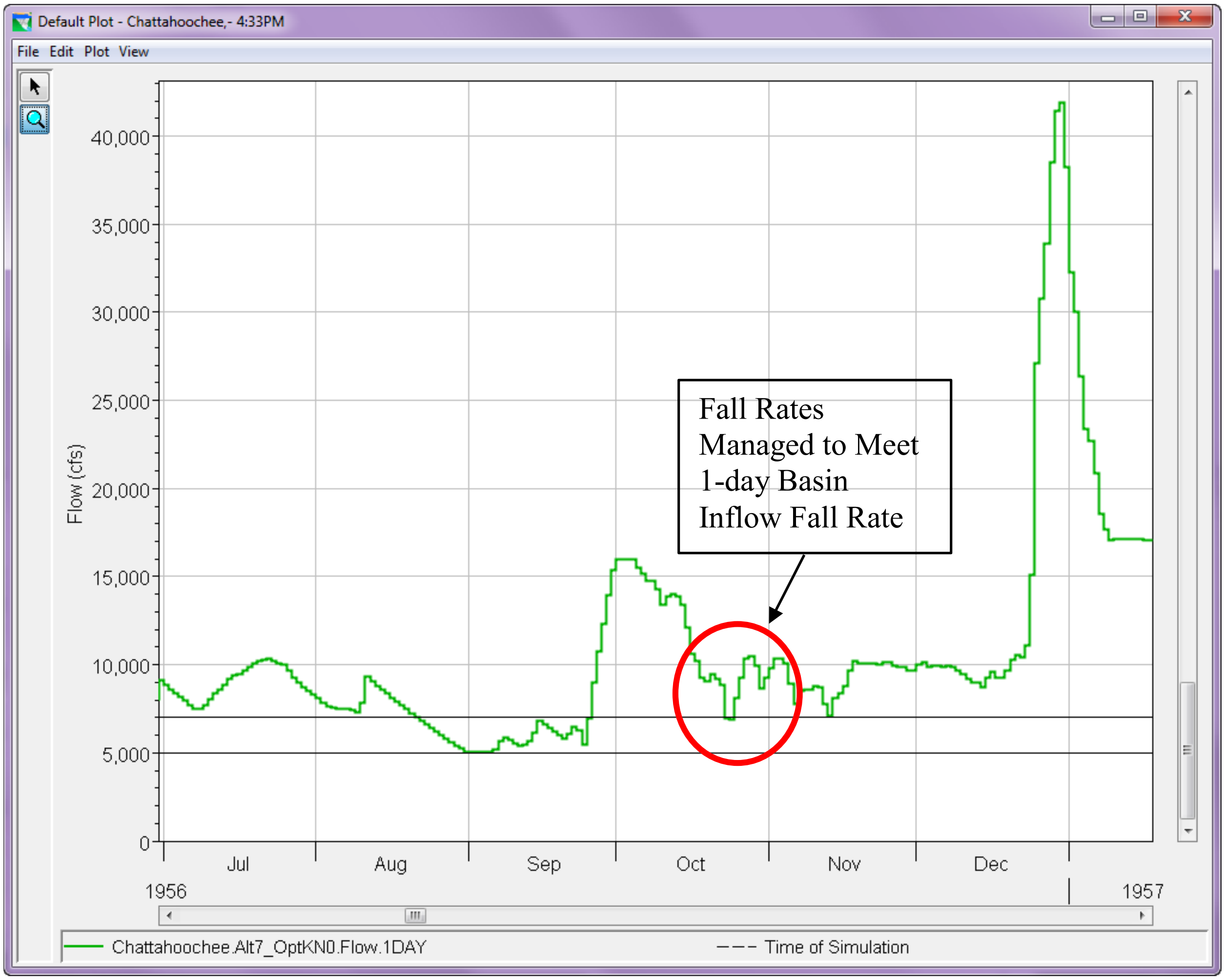


Figure 4. Example of Fall Rate Operations After Prolonged Low Flow

Reservoir Fish Spawning—USACE South Atlantic DR 1130-2-16 (March 30, 2001) and Mobile District Draft SOP 41 1130-2-9 (February 2005) were developed to address reservoir regulation and coordination for fish management purposes. South Atlantic DR 1130-2-16 has been updated and renumbered as South Atlantic DR PDS-O-1 (May 31, 2010), Project Operations, Lake Regulation and Coordination for Fish Management Purposes. It specifically applies to operations at Lake Lanier, West Point Lake, Walter F. George Lake, and Lake Seminole in the ACF Basin as well as other reservoirs in USACE South Atlantic Division. The draft Mobile District SOP (1) identifies designated periods of time within which operations to support fish spawning will be conducted at specific projects and on the Apalachicola River, (2) establishes protocols for coordination between the USFWS, state fisheries personnel, and USACE, and (3) provides for development of an annual plan for special water management operations by USACE (in coordination with USFWS and state fisheries agencies) that would balance impacts and benefits to both reservoir and riverine fisheries during the spring spawning period. A major goal of the SOP is not to lower lake levels more than 6 inches in elevation during the principle fish spawning period to prevent stranding or exposing fish eggs. The protocols in these documents are consistent with the requirements for other project purposes and recognize that reservoir fish spawning operational goals may not be achieved during flood management operations or periods of extended drought.

Tailrace Dissolved Oxygen Levels—Reservoir stratification develops seasonally when surface water becomes warmer and less dense than deeper water, generally summer to late fall in the Southeast. This results in temperature-dependent density differences that prevent mixing and form isolated layers of water, each with their own distinct chemistry. Among the more common concerns is the depletion of oxygen in the deeper layers of lakes when stratified. Below the thermocline, dissolved oxygen is insufficient to support most aquatic life. When water is released from the lower regions of the reservoirs through hydroelectric power generation units and/or sluice gates during periods of reservoir stratification, low dissolved oxygen conditions may be experienced for a short distance downstream of dams, potentially causing stress in the tailrace fishery and occasional fish kills. While dissolved oxygen levels downstream of Buford Dam and West Point Dam are depressed at times as a result of hydroelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas as a result of low dissolved oxygen conditions. The Walter F. George Lock and Dam project has experienced recurring instances of stress in the tailrace fishery and occasional fish kills due to low dissolved oxygen. Accordingly, USACE has implemented a SOP, established in 1988 and updated in 1993, to address conditions at the Walter F. George project when low dissolved oxygen values are observed in the tailrace. The SOP calls for spillway gates to be opened in accordance with a specific protocol until dissolved oxygen readings return to an acceptable level. Spillage siphons have also been constructed on the dam that can be used in lieu of spillway gate discharges.

Fish Passage—In most years since the spring of 2005, USACE has operated the lock at Jim Woodruff Lock and Dam between March and May to facilitate downstream-to-upstream passage of Alabama shad (*Alosa alabamae*) and other anadromous fishes (those that return from the sea to the rivers where they were born to breed) in cooperation with pertinent state and federal agencies. In general, two fish locking cycles are performed each day between 0800–1600 hours, one in the morning and one in the afternoon. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change.

Management of Project Lands—The 11,184-acre Eufaula National Wildlife Refuge is operated by the Service in cooperation with USACE in the upper reaches of Walter F. George Lake within Barbour and Russell counties, Alabama, and Stewart and Quitman counties, Georgia. The refuge has an extensive system of pumps, dikes, and water control structures for water-level management in off-reservoir wetland areas. The refuge provides important habitat for migratory waterfowl and other birds, habitat for federally listed threatened and endangered species, and recreation and environmental education for the public. USACE manages much of the project land around its ACF reservoirs for the benefit of fish and wildlife resources, consistent with other project purposes. In some cases, project lands can be managed by state agencies (i.e., wildlife management areas or state parks) or local interests through leases. Additionally, GADNR operates a fish hatchery on the Chattahoochee River immediately below Buford Dam. USACE coordinates project operations with the fish hatchery staff.

Drought Operations

The drought plan included in the PAA would be triggered when the composite conservation storage falls below the bottom of Zone 2 into Zone 3 (Figure 5). The purpose for this modification is to facilitate a more proactive approach to drought management in order to better assure that storage is available to meet all project purposes throughout a prolonged drought period worse than has been realized to date. The drought plan specifies a minimum release from Jim Woodruff Dam and would temporarily suspend the normal minimum release and maximum fall rate provisions of the listed species operation (Table 2 and Table 3), until composite conservation storage in the basin could be replenished to a level that could support them (Zone 1).

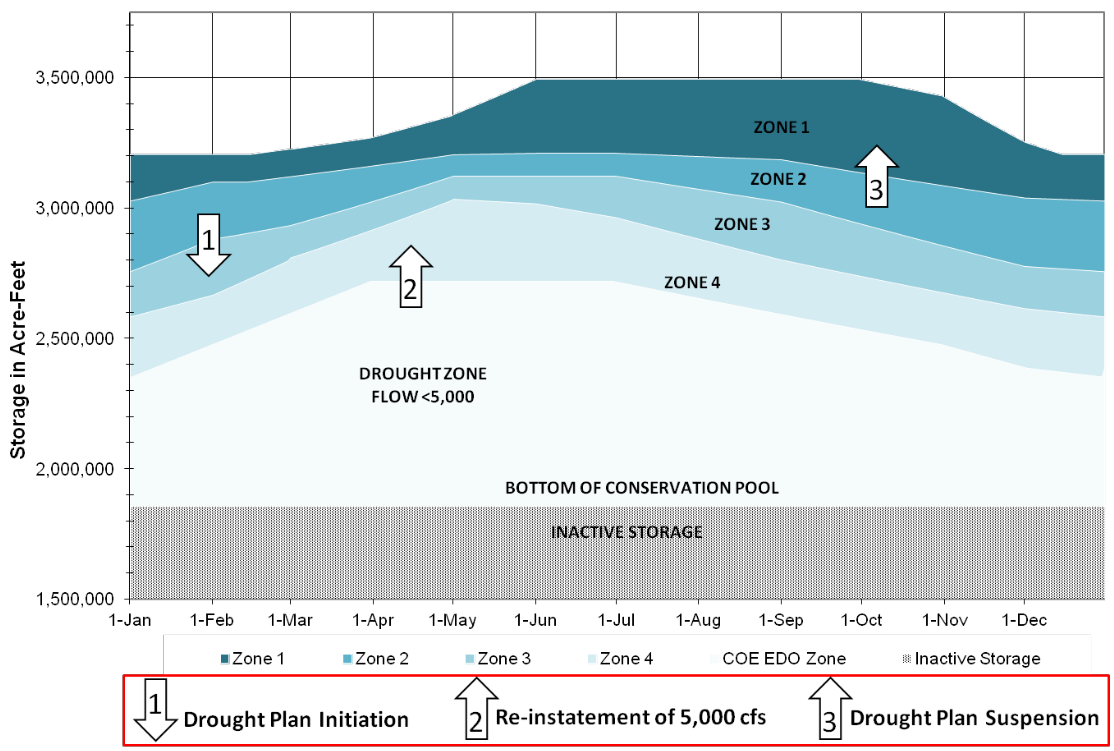


Figure 5. Composite Conservation Storage Zones and Drought Plan Triggers

Under the drought plan the minimum required release from Jim Woodruff Dam would be 5,000 cfs when the composite conservation storage is in Zones 3 and 4. Under the drought plan, the maximum fall rate schedule is suspended. However, the suspension of the maximum fall rate schedule is delayed if releases from Jim Woodruff Dam have not yet reached the 5,000 cfs minimum flow when the drought plan is implemented. The purpose of maintaining the maximum fall rate schedule under these conditions is to facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that have not been recently dewatered. Figure 6 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on June 1, 2006 and the discharge from Jim Woodruff Dam is slowly reduced from 10,125 cfs to 5,050 cfs, over a 22 day period, according to the maximum fall rate schedule. In this example the 0.25 ft/day maximum fall rate provision is implemented when drought operations are triggered as the releases are less than 10,000 cfs.

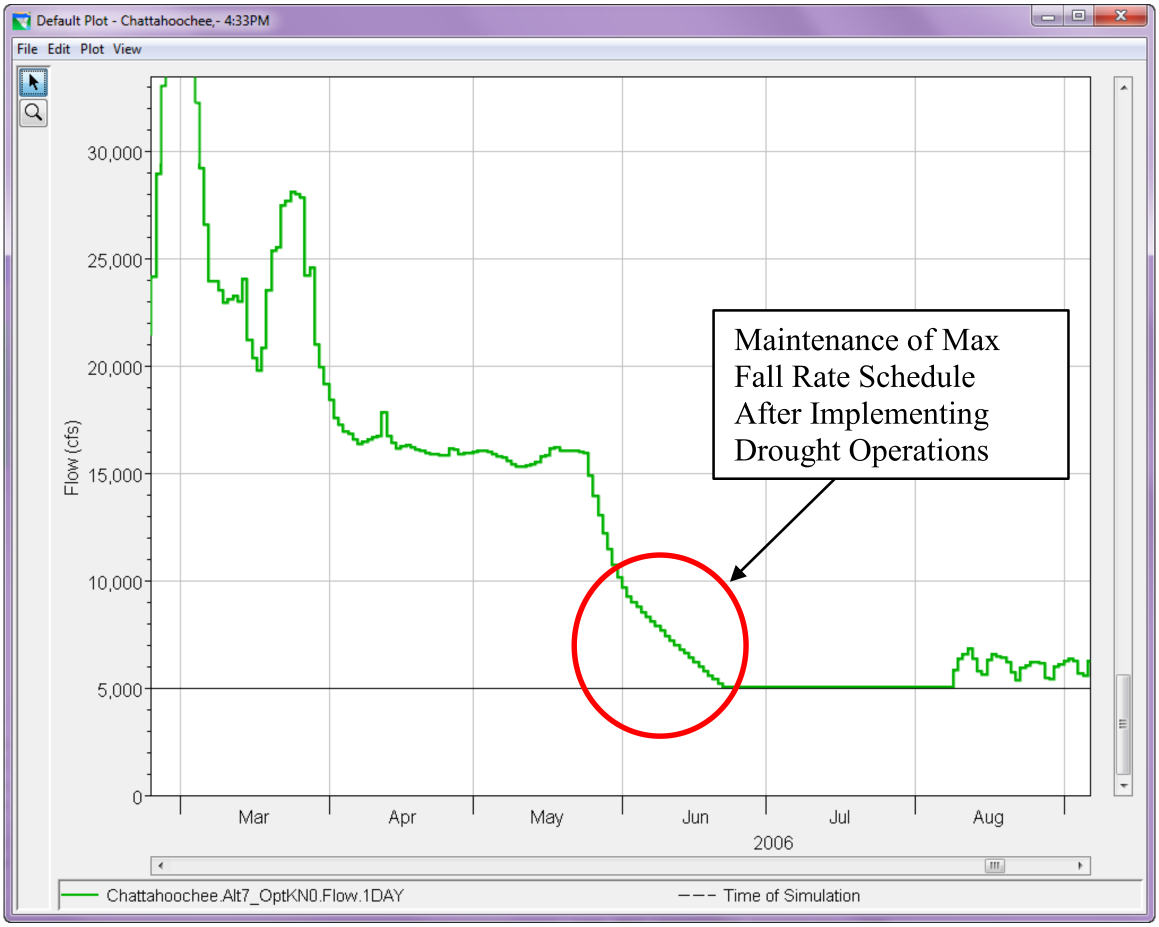


Figure 6. Example Down Ramping after Drought Operation Triggered

Occasionally uncontrolled high flow from the Flint River (resulting from a rainfall event) or hydropower releases from Walter F. George could cause a temporary increase in Jim Woodruff Dam discharge as down ramping to 5,000 cfs occurs during the drought operation. In this case the Jim Woodruff release ramps down using two ramping rates. The peak discharge would ramp down according to the one day basin inflow fall rate until the discharge prior to the temporary increase occurs. At that time, the releases would again be managed according to the maximum fall rate schedule until the minimum flow of 5,000 cfs occurs.

Figure 7 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on March 1, 2016 and releases from Jim Woodruff Dam are reduced according to the maximum fall rate schedule from 12,100 cfs to 8,490 cfs over an eight day period. At this time, conditions in the basin result in an increased release from Jim Woodruff Dam until a peak value of 21,750 cfs is reached on March 26, 2016. As releases are decreased following the peak, fall rates are managed according to the one day basin inflow fall rate until the release reaches 8,490 cfs. Because releases less than 8,490 cfs had not occurred prior to the temporary increase in river flow, on May 13, 2016 the maximum fall rate schedule resumes. In this example another temporary discharge increase occurs on May 16, 2016 and the maximum fall rate schedule resumes on May 21, 2016. Implementing the two phase down ramping allows USACE to conserve storage when reducing releases following a temporary increase in river flow and still facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that had not previously occurred. The temporary increases in river flow during the down ramping period are not of sufficient duration to allow mussels to recolonize habitats that were recently dewatered.

Figure 7. Example of Two Phase Down Ramping After Drought Operation Triggered

The drought plan would also include the option for a temporary waiver from the water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects to provide additional conservation storage for future needs, if conditions in the basin dictate the need for such action.

The drought plan of the PAA prescribes two minimum releases on the basis of composite conservation storage. One minimum release while in Zones 3 and 4 and an additional minimum release while in the Drought Zone. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in Lake Sidney Lanier, West Point Lake, and Walter F. George Lake, plus Zone 4 storage in Lake Sidney Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zones 3 and 4, but above the Drought Zone, the minimum release from Jim Woodruff Dam would be 5,000 cubic feet per second (cfs) and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam would be 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning for the first time from a minimum release of 5,000 to 4,500 cfs, fall rates would be limited to a maximum of 0.25 ft/day drop. Should conditions result in releases greater than 4,500 cfs while the composite conservation storage is still in the Drought Zone, fall rates will be determined by a computation based on the one-day basin inflow fall rate. The 4,500 cfs minimum release would be maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release would be immediately reinstated. The drought plan provisions would remain in place until conditions improve such that the composite conservation storage reaches Zone 1. At that time, the temporary drought plan provisions would be suspended and all the other provisions of the basin water control plan would be reinstated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) would be implemented to determine which operational triggers are applied. It was determined monthly decision points would be the minimum interval to effectively manage drought operations. A more frequent decision point would not allow assurance that a weather-based hydrologic trend was establishing and could result in short isolated periods of rain causing premature exit of drought operations during a prolonged drought.

In the event the composite conservation storage has not recovered to Zone 1 by 1 February, drought operations would be extended to the end of March, unless all the federal reservoirs are full. This provision is intended to ensure full recovery prior to implementing the higher minimum flow provisions in place during normal operations in the sturgeon spawning season. Because of high rainfall amounts, the month of March is typically characterized by higher flow and is critical to reservoir refill. Figure 8 is an example from the ResSim modeling of the PAA of continuing the drought operation through the month of March. In this example, the composite conservation storage enters Zone 1 on February 5, 1982, but drought operation is not suspended until April 1, 1982.

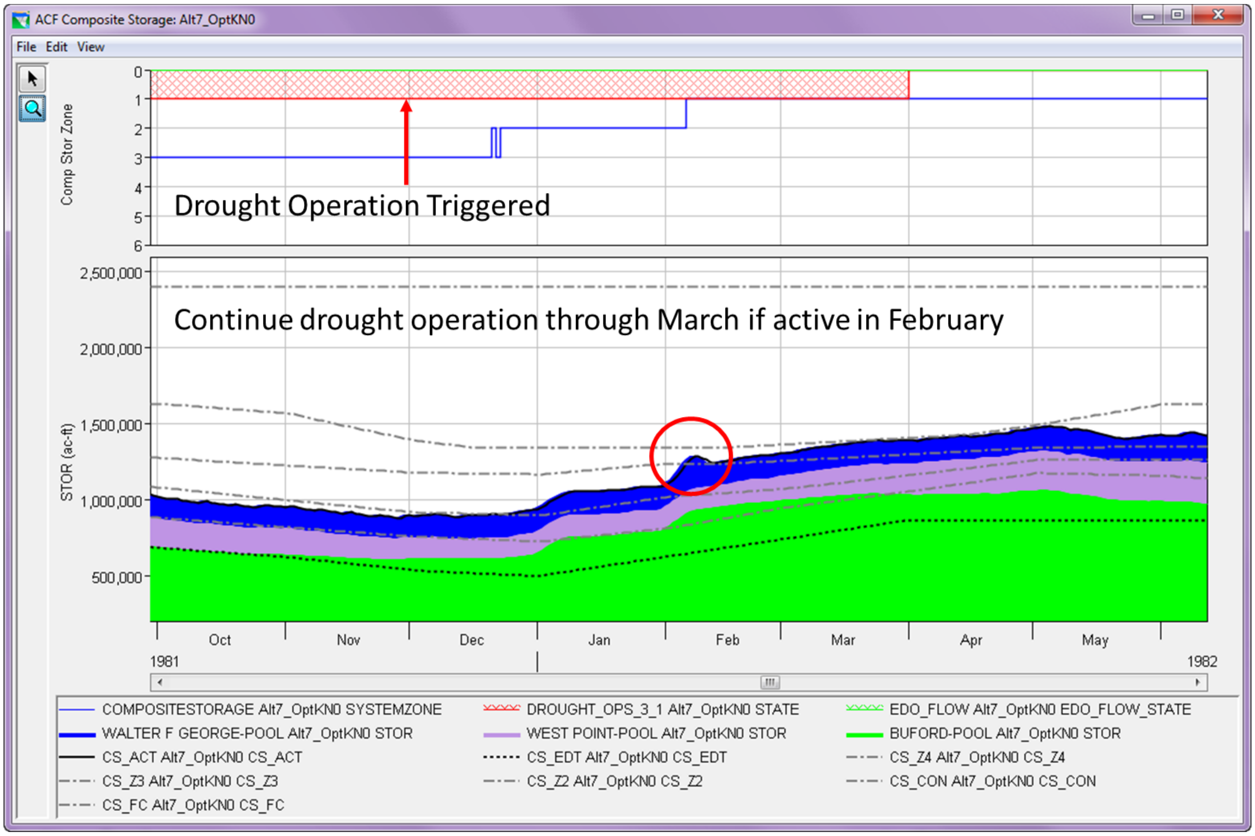


Figure 8. Drought Operation Continued Through Month of March

Extreme Drought Operations

When the remaining composite conservation storage is about 10 percent of the total capacity, additional emergency actions might be necessary. When conditions have worsened to that extent, use of the inactive storage must be considered. For example, such an occurrence could be contemplated in the second or third year of a drought. Inactive storage zones have been designated for the three Federal projects with significant storage (Figure 9). Table 4 shows the inactive storage capacity within each inactive storage zone for each project. The use of inactive storage during extreme drought conditions would be based on the following actions:

(1) Inactive storage availability would be identified to meet specific critical water use needs within existing project authorizations.
(2) Emergency uses would be identified in accordance with emergency authorizations and through stakeholder coordination including emergency consultation under Section 7 of the ESA. Typical critical water use needs within the basin are associated with public health and safety.
(3) Weekly projections of the inactive storage water availability to meet the critical water uses from Buford Dam downstream to the Apalachicola River would be used when making water control decisions regarding withdrawals and water releases from the USACE reservoirs.

(4) The inactive storage action zones would be instituted as triggers to meet the identified priority water uses (releases will be restricted as storage decreases). Figure 5 lists the typical critical water uses for each inactive storage zone.

(5) Dam safety considerations would always remain the highest priority. The structural integrity of the dams due to static head limitations (Jim Woodruff, 38.5 feet; George W. Andrews, 26 feet; Walter F. George, 88 feet) would be maintained.

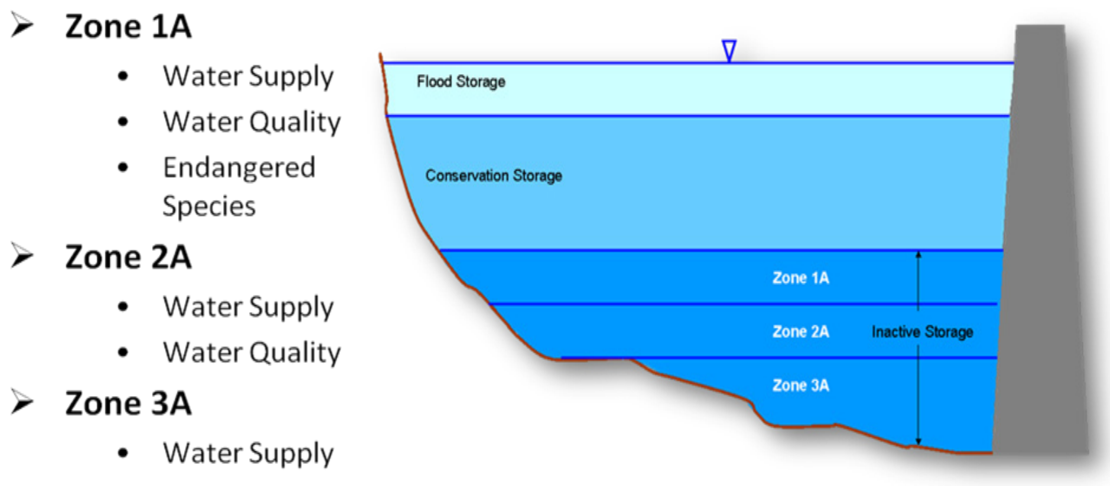


Figure 9. Inactive Storage Zones and Typical Water Use Needs

Table 4. Reservoir Inactive Storage Zone Capacities (ac-ft)

Project	**Zone 1A**	**Zone 2A**	**Zone 3A**	**Unusable Inactive**
Buford Dam	532,078	234,699	100,823	0
West Point Dam	53,620	138,331	33,344	73,101
Walter F. George Dam	314,799	178,501	0	196,700
Total	901,589	554,345	134,869	266,062

Flood Risk Management

When developing the PAA, flood risk management capabilities and capacities of reservoirs were not reduced. The objective of flood risk management operations (formerly referred to as flood control) is to impound excess flows, thereby reducing downstream river levels below flood stage. Whenever flood conditions occur, operation for flood risk management takes precedence over all other project functions. Only Buford and West Point dams have storage allocated for flood risk management operations. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower peak stages throughout the reservoir during major floods. George W. Andrews and Jim Woodruff lock and dams operate to pass inflows. The timing of flood peaks in the ACF Basin is of considerable importance in determining the effectiveness of reservoir operations for flood risk management and the degree to which such operations can be coordinated. During a flood event, excess water above the guide curve is evacuated (released) consistent with other project needs as soon as downstream waters have receded enough that releases from the reservoirs will not increase the natural maximum flood heights downstream. This timely evacuation is necessary so that consecutive flood events will not cause floodwaters to exceed allocated storage capacities and endanger the integrity of the dam. Both turbines and spillways are used, as necessary, to evacuate floodwaters. Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power generation demands are lower, the guide curve operation generally reflects this situation by specifying a lower elevation during this time period. Transitions between the seasonal levels are gradual to moderate increases or decreases in outflow. By drawing down the pool in late fall, either specifically for flood risk management as at West Point or coincidentally for other purposes, additional storage is gained for containing floodwaters. For flood risk management purposes, releases are reduced or terminated at Buford Dam, except for the small hydropower unit, as soon as it appears that downstream river stages will exceed flood stage. Key gaging stations in the vicinity are closely monitored to determine when floodwaters have begun to recede so that flood storage in the reservoir can be expeditiously evacuated in a manner consistent with other project functions without exacerbating downstream flooding. Projects on the middle and lower portion of the basin pass flood waters once the pool has reached the top of the conservation pool. West Point and Walter F. George dams operate according to specified flood risk management plans, as outlined in their WCMs. Spillway gates are opened if necessary to assist the turbines in passing these flows. Even though the traditional flood season spans several months, discrete incidences of flooding should have insignificant long-duration effects if pool elevations are maintained close to guide curve elevations. No pool is allowed to remain above its guide curve for any appreciable length of time without prior approval of a temporary deviation or variance by USACE, South Atlantic Division.

Hydroelectric Power Generation

The PAA includes the current hydroelectric power generation operations at West Point Dam, Walter F. George Dam, and Jim Woodruff Dam which call for a more flexible generation schedule in all action zones under non-drought conditions and a more constrained generation schedule under drier conditions. The Buford, West Point, and Walter F. George Projects are operated as peaking plants, and provide electricity during the peak demand periods of each day and week. Hydroelectric power peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines. Typically, the Buford, West Point, and Walter F. George Projects provide generation five days a week at plant capacity throughout the year, as long as their respective lake levels are above Zone 4 and drought operations have not been triggered. For example, demand for peak hydroelectric power at Buford Dam typically occurs on weekdays from 5:00 a.m. to 9:00 a.m. Central time and from 3:00 p.m. to 10:00 p.m. between 1 October and 31 March, and on weekdays from 1:00 p.m. to 7:00 p.m. between 1 April and 30 September. The typical hours represent releases that normally meet water system demands and provide the capacity specified in power marketing arrangements. During dry periods, generation could be eliminated or limited to conjunctive releases. Typical, but not required, hours of operation by action zone are depicted in Table 5.

Table 5. Typical hours of peaking hydroelectric power generation by federal project

Action zone	Buford Dam (hours of operation) normal ops/drought ops	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	3/2	4	4
Zone 2	2/1	2	2
Zone 3	2/1	2	2
Zone 4*	0	0	0

*While hydropower would still be generated in Zone 4, it could not be generated on a regular peaking schedule under severe drought conditions

Navigation

When supported by ACF Basin hydrologic conditions, the PAA would provide a reliable navigation season. The water management objective for navigation is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). Figure 10 graphically represents the navigation season and its relationship to composite conservation storage. During the navigation season, the flows at the USGS gage at Blountstown, Florida, should be adequate to provide a minimum channel depth of 7 feet. The most recent channel survey and discharge-stage rating were used to determine the flow required to sustain a minimum navigation depth during the navigation season. Flows of 16,200 cfs provide a channel depth of 7 feet. Flows of 20,600 cfs provide a channel depth of 9 feet. USACE's capacity to support a navigation season would be dependent on actual and projected system-wide conditions in the ACF Basin before and during January, February, March, April, and May. Those conditions include the following:

- A navigation season can be supported only when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
- A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Navigation support will resume when basin composite conservation storage level recovers to Zone 1.
- A navigation season will not be supported when drought operations are in effect. Navigation will not be supported until the ACF Basin composite conservation storage recovers to Zone 1.
- The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrologic conditions, meteorological forecasts, and basin-wide model forecasts. On the basis of an analysis of those factors, USACE will determine if the navigation season will continue through part or all of May.
- Down-ramping of flow releases will adhere to the Jim Woodruff Dam fall rate schedule (see Table 4) for federally listed threatened and endangered species during the navigation season.
- Releases that augment the flows to provide a minimum 7-foot navigation depth will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, because of diminishing inflows, downstream flows and depths must be reduced, notices would be issued to project users to give barge owners and other waterway users sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Lock and Dam to reduce releases.

Although special releases would not be standard practice, they could occur for a short duration to assist navigation during the navigation season. For instance, releases can be requested to achieve up to a 9-foot channel. Special releases could also occur outside of the navigation season. However, USACE would evaluate such request on a case-by-case basis, subject to applicable laws and regulations and the conditions above.

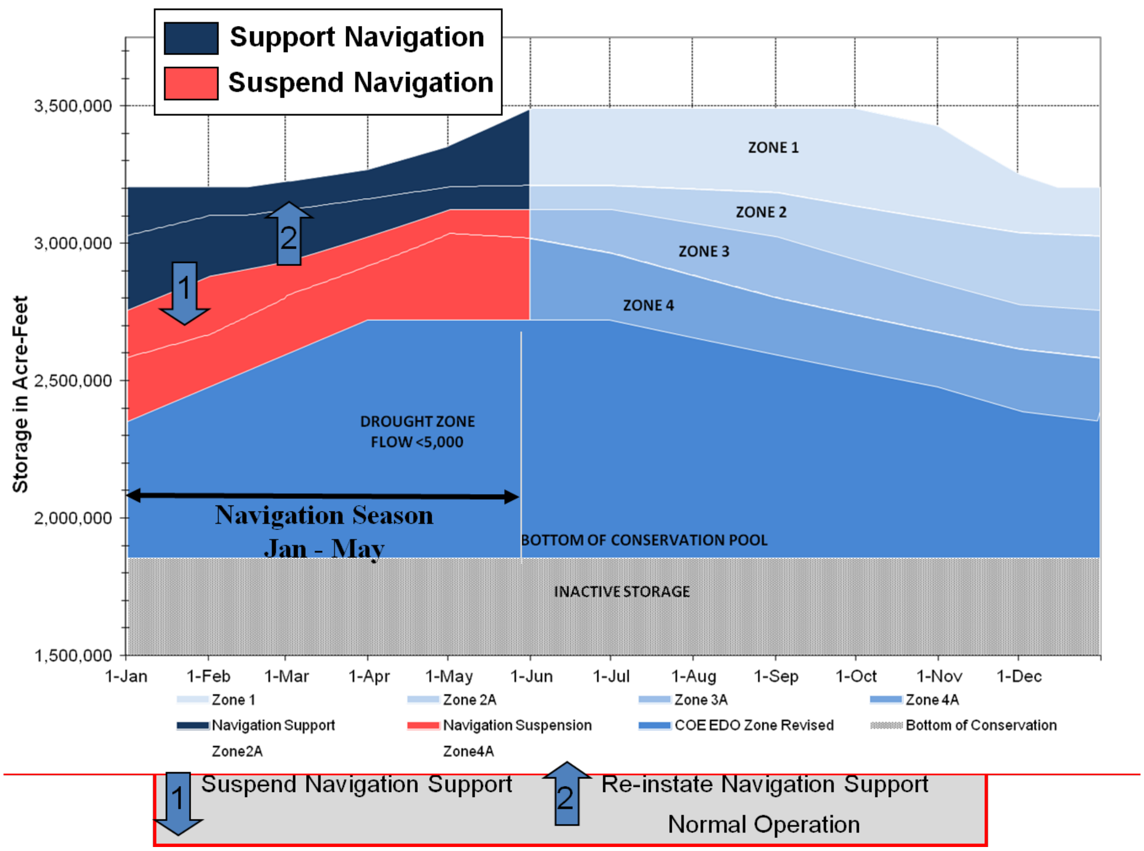


Figure 10. Composite Conservation Storage for Navigation

Recreation

Under the PAA, operations for recreation would remain the same as current operations. Recreation benefits would be maximized at the lakes to the extent possible consistent with meeting other project purposes by maintaining full or nearly full pools during the primary recreation season which are the warm summer months. In response to meeting other authorized project purposes, lake levels could decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 6). Recreational impact levels are not applicable to the George W. Andrews project due to the lack of conservation storage and the run-of-river operation at the project.

When pool levels must be lowered, the rates at which the draw-downs occur are as steady as possible. The action zones at Lake Sidney Lanier and West Point Lake are drawn down to correlate the line between Zone 2 and Zone 3 near the IIL at the beginning of the recreation season (May through early September). This is an attempt to maximize the time these projects are above the IIL during the recreation season.

Table 6. Recreation Impact Levels for Federal Projects in the ACF Basin

Project	IIL[a]	RIL[b]	WAL[c]
Lake Lanier	1,066 ft	1,063 ft	1,060 ft
West Point Lake	632.5 ft	629 ft	627 ft
Walter F. George	187 ft	185 ft	184 ft

Notes:
[a.] Initial Impact Level
[b.] Recreation Impact Level
[c.] Water Access Limited Level

Water Quality

Under the PAA, Buford, West Point, and Jim Woodruff dams would provide continuous minimum flow releases that would benefit the water quality immediately downstream of the dams. There would be no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen values are observed below the dam, spillway gates would be opened until the dissolved oxygen readings return to an acceptable level. Occasional special releases would also be made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam.

At Buford Dam, the small turbine generator would run continuously to provide a minimum flow from the dam, which would range from approximately 500 to 700 cfs, depending on head conditions. This minimum flow from Buford Dam would help meet the seasonal minimum flow requirements of 650 cfs and 750 cfs at Atlanta, Georgia, in the Chattahoochee River just upstream of the confluence with Peachtree Creek. At West Point Dam, the minimum flow requirement is 670 cfs and a similar small generating unit would provide a continuous release of approximately 675 cfs. A varying minimum flow from 4,500 to 25,000 cfs, dependent upon basin conditions, would be maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which would assure an adequate water supply for downstream industrial use and water quality. Walter F. George Dam has two siphons on each spillway gate. The siphon discharge could range from about 15 cfs up to 200 cfs when all 12 are in use. Typically, the siphon tubes would be opened continuously from May through the end of September and all would be used at full capacity. The siphons would provide a gravity-fed, typically continuous, minimum flow that would benefit dissolved oxygen levels below the dam.

Water Supply

Under the PAA, the cities of Gainesville and Buford would continue to withdraw water directly from Lake Sidney Lanier under relocation agreements at rates not exceeding 8 mgd (net) and 2 mgd, respectively. Additionally, pursuant to the Water Supply Act of 1958, the PAA would reallocate 252,950 acre-feet in Lake Sidney Lanier for water supply. The amount of storage is estimated to yield 222 mgd during the critical drought (i.e., during the worst drought on record at the time the agreement was executed). The severity and frequency of droughts change over time, therefore, the yield of this storage may change over time. For the purpose of managing water supply storage, USACE would employ a storage accounting methodology that applies a proportion of inflows and losses, as well as direct withdrawals by specific users, to each account. The amount of water that may actually be withdrawn is ultimately dependent on the amount of water available in the storage account, which will naturally change over time.

Under the PAA releases from Buford Dam would be made to accommodate downstream water demands. Peaking hydroelectric power generation generally accommodates most water supply needs of communities currently withdrawing from the Chattahoochee River; however, under the 1946 Rivers and Harbors Act, generation can occur at non-peaking times to meet the downstream water supply needs, not to exceed 379 mgd. Figure 10 illustrates the current lake and river withdrawals occurring in the metro-Atlanta area.

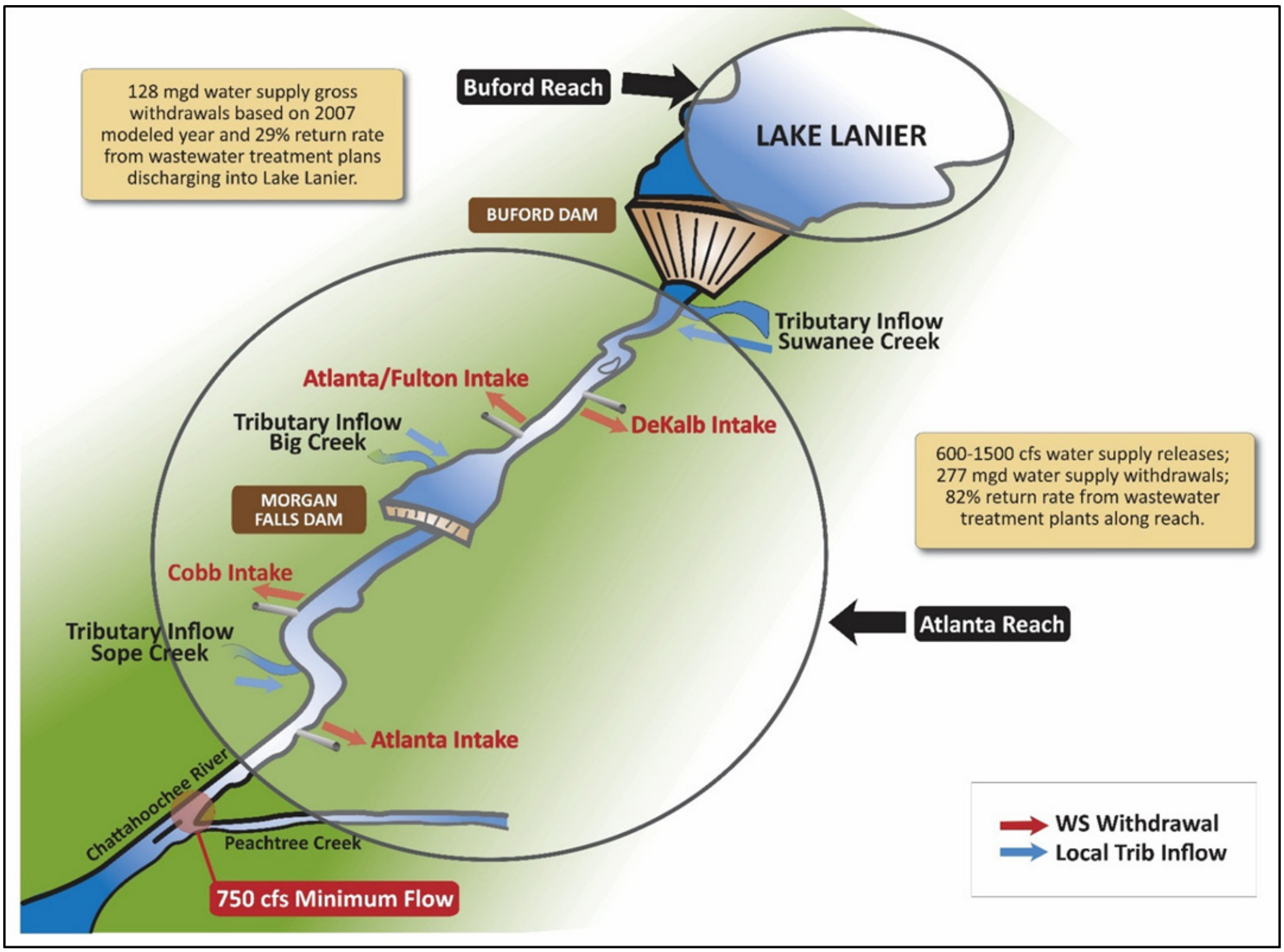


Figure 11. Illustration of Metro-Atlanta Water Supply Withdrawals

ALTERNATIVES CONSIDERED

The proposed action and alternatives identified in the DEIS make up a portion of the alternatives to the PAA that were considered. They are incorporated by reference. In addition to the alternatives described in the DEIS, the USACE also evaluated six new alternatives. The new alternatives consist of the No Action Alternative (NAA) or PAA water management operations combined with five new water supply options. The new water supply options are based on comments received for the DEIS and the State of Georgia 2015 revised water supply request. None of the new alternatives include the two non-federal water supply reservoirs (Glades Reservoir and Bear Creek Reservoir) considered in the DEIS. Both of the permit applications for these reservoirs have been withdrawn/suspended. Table 7 describes the six new alternatives considered (1L, 7I, 7J, 7K, 7L, and 7M), as well as alternatives previously described in the DEIS [NAA (1A), 7A, 7B, and the proposed action from the DEIS (7H)]. The PAA evaluated in this document is alternative 7K.

Table 7. New Alternatives Considered Since Publication of the DEIS in October 2015

Water Management Measures			1A	1L	7A	7B	7H	7I	7J	7K	7L	7M
Guide Curves	Maintain existing guide curve		X	X	X	X	X	X	X	X	X	X
Action Zones	Maintain existing action zones		X	X								
	Revised Level 1 action zones				X	X	X	X	X	X	X	X
Drought Operations	Drought operations trigger *		Zone 4	Zone 4	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3	Zone 3
	Extreme drought operations		X	X	X	X	X	X	X	X	X	X
	Drought operations suspension trigger *		Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1	Zone 1
Peachtree Creek Minimum Flows	Current (750 cfs)		X	X								
	Seasonal flow (750 cfs / 650 cfs)				X	X	X	X	X	X	X	X
Hydropower Generation	Current generation schedule		X	X								
	Modified generation schedule with drought operations				X	X	X	X	X	X	X	X
Navigation	Current-no navigation operations		X	X								
	4/5 Month				X	X	X	X	X	X	X	X
Basin Inflow	Current computational method		X	X	X	X	X	X	X	X	X	X
Fish and Wildlife	Current fish spawn and passage		X	X	X	X	X	X	X	X	X	X
Listed Species Management	RIOP May 2012		X	X								
	Ramping Rate	Current ramping rate**	X	X	X	X	X	X	X	X	X	X
		Suspend during prolonged low flow			X	X	X	X	X	X	X	X
		Suspend in drought*	X	X	X	X	X	X	X	X	X	X
	Current (seasonal) minimum flow provision**		X	X	X	X	X	X	X	X	X	X

Water Management Measures											
		1A	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**
Water Supply Options***	A – No action	L=128 D=27 7		L=128 D=27 7							
	B - Relocation contracts only (in Lake Lanier)				L=20 D=277						
	H – GA 2013 (projected return volume for 2035 with Glades Reservoir pumping)					L=185 G=40 D=408					
	I – 225 mgd lake withdrawal, GA 2015 Request Downstream						L=225 D=379				
	J – Future Without Project Condition-Revised							L=20 D=379			
	K – GA 2015 Request								L=242 D=379		
	L – Current lake withdrawals, GA 2015 Request Downstream		L=128 D=37 9							L=128 D=379	
	M – Option H for Lanier w/o Glades, GA 2015 Request Downstream										L=205 D=379
		1A	**1L**	**7A**	**7B**	**7H**	**7I**	**7J**	**7K**	**7L**	**7M**

Notes:* Based upon composite conservation storage zones (cumulative conservation storage [by zone] for USACE ACF reservoirs [Lanier, West Point, and Walter F. George]).
**Component of the May 2012 RIOP.
***Numbers indicate withdrawals in mgd from Lake Lanier (L), Glades Reservoir (G), and the Chattahoochee River downstream (D) of Buford Dam.

STATUS OF THE SPECIES/CRITICAL HABITAT

Much of the following information has been previously documented and is taken from the STATUS OF THE SPECIES/CRITICAL HABITAT section (Section 2) of the May 22, 2012 *Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River* (USFWS 2012), the 2015 Annual Report -January 31, 2016 (USACE 2016), and the DEIS Section 2.5.4. The detailed information provided in Section 2 of the BO and the 2015 Annual Report represent the best scientific information available on the listed mussel species occurring in the action area and provided the basis for determining the flow regime characteristics identified as relevant to the listed species and their habitats during development of the RIOP and considered during development of the proposed action. The DEIS (Section 2.5.4) provides a summary of the status of all listed species in the ACF basin. The Service also has additional information regarding the status of the species that will be updated as part of this consultation.

Mussels

Life History

The fat threeridge, purple bankclimber and Chipola slabshell are bivalve mussels of the family Unionidae. Unionid mussels live embedded in the bottom of rivers, streams, and other bodies of freshwater. Sexes in unionid mussels are usually separate. Most unionid mussel species have a parasitic stage during which the immature mussels, called glochida, must attach to a host to transform into a juvenile. Females release glochidia either separately or in masses termed conglutinates, depending on the mussel species. Life spans vary by species, but some unionid mussels are very long-lived, up to several decades.

Feeding Habits

Adult freshwater mussels are filter-feeders, orienting themselves on or near the substrate surface to take in food and oxygen from the water column (Kraemer 1979). They siphon water into their shells and across four gills that are specialized for respiration and food collection. Food items include detritus (disintegrated organic debris), algae, diatoms, and bacteria (Strayer et al. 2004). Juvenile mussels typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994; Gatenby et al. 1996).

Freshwater mussels generally have separate sexes, although hermaphroditism is known for some species (van der Schalie 1970; Downing et al. 1989). The age of sexual maturity for mussels is variable, usually requiring from 3 to 12 years (Zale and Neves 1982; McMahon and Bogan 2001). Spawning appears to be temperature dependent (Zale and Neves 1982; Bruenderman and Neves 1983), but may also be influenced by stream discharge (Hove and Neves 1994). Males release sperm into the water column, which females take in through their siphons during feeding and respiration. Fertilization takes place inside the shell. The eggs are retained in the gills of the female until they develop into mature larvae called glochidia.

Mussels may be particularly susceptible to exposure by low flows during the spawning season. Once the water warms and the days become longer, mature mussels move vertically to the substrate surface (Balfour and Smock 1995; Amyot & Downing 1998; Watters et al. 2001; Perles et al. 2003). Watters et al. (2001) studied eight freshwater mussel species and found that all of the species surfaced during the spring to spawn. Mussels also aggregate via horizontal movement to enhance recruitment (Amyot & Downing 1998). Spawning itself requires substantial energy expenditure for female mussels, and therefore, females may move less than males during the reproductive season (Amyot and Downing 1998). For this reason, females may be relatively more susceptible than males to exposure-induced mortality.

After a variable incubation period, mature glochidia, which may number in the tens of thousands to several million (Surber 1912; Coker et al. 1921; Yeager and Neves 1986), are released by the female mussel. The glochidia of most freshwater mussel species, including the fat threeridge, purple bankclimber, and Chipola slabshell, must come into contact with specific species of fish, whose gills, fins, or skin they temporarily attach to in order to transform into a juvenile mussel. Depending on the mussel species, females release glochidia either individually in net-like mucoid strands that entangles fish (Haag and Warren 1997), or as discreet packets termed conglutinates (Barnhart et al. 2008), or in one large mass known as a superconglutinate (Haag et al. 1995; O'Brien and Brim Box 1999; Roe and Hartfield 2005). Glochidia failing to contact a suitable fish host will survive for only a few days (Sylvester et al. 1984; Neves and Widlak 1988; O'Brien and Williams 2002). Host specificity appears to be common in mussels (Neves 1993), with most species utilizing only a few host fishes (Lefevre and Curtis 1912; Zale and Neves 1982; Yeager and Saylor 1995). The duration of the parasitic stage, which varies by mussel species, generally lasts a few weeks (Neves et al. 1985; O'Brien and Williams 2002), but possibly much longer (Yeager and Saylor 1995; Haag and Warren 1997), and is temperature dependent (Watters and O'Dee 2000). When the transformation is complete, the newly metamorphosed juveniles drop from their fish host and sink to the stream bottom where, given suitable conditions, they grow and mature into adults.

Glochidial parasitism serves two purposes: nutrition for larval development and dispersal. Substances within the blood serum of the host fish are necessary for the transformation of a glochidium into a juvenile mussel (Isom and Hudson 1982). Parasitism also serves as a means of dispersal for this relatively sedentary faunal group (Neves 1993). The intimate relationship between mussels and their host fish has therefore played a major role in mussel distributions on both a landscape (Watters 1992) and community (Haag and Warren 1998) scale. Haag and Warren (1998) determined that mussel community composition was more a function of fish community pattern variability than of microhabitat variability, and that the type of strategy used by mussels for infecting host fishes was the determining factor.

Habitat

Adult mussels are generally found in localized patches (beds) in streams and almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Neves and Widlak 1987; Leff et al. 1990). Physical qualities of the sediments (*e.g.,* texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediments, may also influence mussel densities (Brim Box 1999; Brim Box and Mossa 1999).

Stream geomorphic and substrate stability is especially crucial for the maintenance of diverse, viable mussel beds (Vannote and Minshall 1982; Hartfield 1993; Di Maio and Corkum 1995). Where substrates are unstable, conditions are generally poor for mussel habitation. Strayer (1999) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that displayed little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. Strayer thought that features commonly used in the past to explain the spatial patchiness of mussels (*e.g.,* water depth, current speed, sediment grain size) were poor predictors of where mussels actually occur in streams.
Williams and Butler (1994) and Williams et al. (2008) discussed the habitat features associated with the fat threeridge, purple bankclimber, and Chipola slabshell including stream size, substrate, and current velocity. Brim Box and Williams (2000) also provided habitat information, particularly substrate associations. Following is a summary of this information, and of other recent studies.

The construction of the Jim Woodruff Dam and other dams in the basin and their associated impoundments of water presents a significant barrier to aquatic organism migration as well as a disturbance to free-flowing riverine habitat. The three mussel species have been impacted as well, by reduced habitat within the boundaries of Lake Seminole and limited migration of host fish upstream of the dam. This has resulted in extirpated or possibly extirpated populations above the dam or where populations still exist, isolation from current populations below the dam.

Fat threeridge

The fat threeridge (*Amblema neislerii*) is reported from the main channels of the Apalachicola, Flint, and Chipola rivers, and a few tributaries and distributaries of the Apalachicola in Florida and southwest Georgia (Clench and Turner 1956; Williams and Butler 1994; Williams et al. 2008). There are no records of the species in the Chattahoochee Basin. **The species prefers** the main channel of small to large rivers in slow to moderate current, and can be found in a variety of substrates from gravel to cobble to a mixture of sand, mud, silt, and also clay (Williams and Butler 1994; Brim Box and Williams 2000;. The most abundant populations are found in moderately depositional areas along bank margins at depths of around 1 meter (3.3 ft.) (Miller and Payne 2005, 2006; EnviroScience 2006a; Gangloff 2011). Recently, however, fat threeridge were found in deeper habitats in depths of up to 5 meters (16.4 ft.)

The fat threeridge is locally common, the population is seemingly large, and recruitment is occurring. Although the drought-induced mortality may be causing some localized population declines, the species' status overall appears to be stable or improving (see **Information after 2012 BO**, below). O'Brien and Williams (2002) studied various aspects of the life history of the fat threeridge, determining that it is likely a short-term summer brooder of its glochidia. Females appear to be gravid in Florida when water temperatures reach 75 degrees F, in late May and June, suggesting that the species expels glochidia in the summer. The glochidia are viable for two days after release. The fat threeridge lacks mantle modifications or other morphological specializations that would serve to attract host fishes and appears to be a host-fish generalist that may infect fishes of at least three different fish families. Five potential host fishes have been identified: weed shiner (*Notropis texanus*), bluegill (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), largemouth bass (*Micropterus salmoides*), and blackbanded darter (*Percina nigrofasciata*). Fat threeridge age and growth data suggest females reach sexual maturity at three years of age.

Purple bankclimber

The purple bankclimber is endemic to the Apalachicola Basin in Alabama, Georgia, and Florida, and the Ochlockonee River drainage in Georgia and Florida (Brim Box and Williams 2000; Williams et al. 2008). The species is historically known from the main channels of the Apalachicola, Chattahoochee, Flint, Chipola, and Ochlockonee rivers, and also from two tributaries in the Flint River system. Heard (1979) erroneously reported it from the Escambia River system (Williams and Butler 1994). Presently, the purple bankclimber occurs in much of it historical range. However, it is extirpated from localized areas, and it has likely been completely extirpated from the Chattahoochee River. Within the Flint and Ochlockonee river drainages, the species is relatively common, but occurs at fewer sites than it did historically due in part to two mainstem dams on the Flint River and one on the Ochlockonee River. The purple bankclimber no longer occurs in the portion of the Apalachicola and Flint rivers that is now submerged in the reservoir created by Jim Woodruff Lock and Dam. The population numbers are reduced in the Apalachicola River compared to historical observations. The purple bankclimber inhabits medium to large river channels in substrates of sand or sand mixed with mud or fine gravel, often near limestone outcrops (Brim Box and Williams 2000; Williams et al. 2008). ACF Basin collections by Brim Box and Williams (2000) were often in waters more than 3 meters (10 ft.) in depth. Recent upper Apalachicola River collections, when water levels were low, found purple bankclimbers generally in depths of 0.5 to 5.0 meters (1.6 to16 ft.)

Similar to fat threeridge, considerable purple bankclimber mortality also occurred in the Apalachicola River in 2006-2007 and 2011 when water levels dropped as a result of drought. Most of the mortality occurred at Race Shoals on the Apalachicola River where movement to deeper water is difficult given the irregular substrate nature of the shoal habitat.

Females of the purple bankclimber with viable glochidia were found in the Ochlockonee River from late February through mid-April (O'Brien and Williams 2002); in the Apalachicola River, in mid-

March and in the Flint River from late-March through mid-June (Hartzog 2011). The species is presumably a short-term brooder.

Native fish that have effectively transformed glochidia of the purple bankclimber during laboratory infections include the eastern mosquitofish (*Gambusia holbrooki*), blackbanded darter, holiday darter (*Etheostoma brevirostrum*), lake sturgeon (*Acipenser fluvescens*), shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), and Gulf sturgeon (*Acipenser oxyrinchus desotoi*) (O'Brien and Williams 2002; Hartzog 2011). The eastern mosquitofish occupies stream margins in slower (or slack) currents, and is considered a secondary host fish since the purple bankclimber is more of a main-channel species (Williams and Butler 1994). The black banded darter was identified as a host fish in two separate laboratory studies where transformation rates ranged from 36 to 49% (Hartzog 2011). The Gulf sturgeon is the only sturgeon species that co-occurs with the purple bankclimber, and it also serves as a primary glochidial host for the species.

Chipola slabshell

The Chipola slabshell is known only from the Chipola River system in Florida and Alabama, and from a tributary of the lower Chattahoochee River in southeastern Alabama, where it is represented by a single museum specimen from Howard's Mill Creek (Williams et al. 2008). The historical range of this ACF Basin endemic is centered throughout much of the Chipola River main stem and several of its headwater tributaries. The Chipola slabshell is one of the most narrowly distributed species in the drainages of the northeast Gulf of Mexico.

Currently, the Chipola slabshell occurs in nearly all of its historical range, with the exception of Howards Mill Creek. A single individual was recently collected by Service biologists in the Apalachicola River main channel; however, it appears that the species does not normally occur in that mainstem. The Chipola slabshell inhabits sandy substrates mixed with silt, clay, and occasionally gravel in slow to moderate current, often along stream margins (Williams and Butler 1994; Williams et al. 2008).

Chipola slabshell females were found to be gravid in June to early July (Brim Box and Williams 2000; Priester 2008). The species is presumably a short-term brooder (Williams et al. 2008). Researchers from Columbus State University (CSU) conducted laboratory studies on Chipola slabshell reproduction and found that glochidia were expelled in conglutinates approximately 13 mm long and 3 mm wide and resemble insect larva (Priester 2008). The study documented the successful transformation of glochidia on redbreast sunfish and bluegill. Sixty percent of the bluegill and 80% of the redbreast sunfish successfully transformed *E. chipolaensis* glochidia into juvenile mussels (Priester 2008).

Recent surveys (1990 to present) have documented many new sites, but found the species population is generally stable, but occurs in relatively low abundance, with 64% of sites sampled yielding five or fewer individuals. Only three surveys yielded more than 40 individuals and two of those were extensive dive surveys.

Critical Habitat Description

On November 15, 2007, the Service designated 11 stream segments (units) as critical habitat for seven threatened or endangered mussel species including the fat threeridge, the Chipola slabshell and purple bankclimber (USFWS 2007).

Fat threeridge
Three units are designated as fat threeridge critical habitat. These units encompass approximately 786.6 km (488.8 mi) of river in the Lower Flint River in Georgia, Chipola River Basin in Alabama and Florida, and the Apalachicola River in Florida.

Purple bankclimber
Six units are designated as purple bankclimber critical habitat. (These units encompass approximately 1,493.5 km (928.0 mi) of river in the Flint River Basin in Georgia, Apalachicola River Basin in Florida and the Ochlockonee River Basin in Florida and Georgia.

Chipola slabshell
One unit is designated as Chipola slabshell critical habitat.This unit encompasses approximately 228.8 km (142.2 mi) of river in the Chipola River Basin in Alabama and Florida.

Primary Constituent Elements
Each of the designated critical habitat units for these three listed mussels contains one or more of the Primary Constituent Elements (PCEs) that the Service describes as essential to the conservation of the species, and which may require special management considerations or protection. The PCEs of fat threeridge, purple bankclimber, and Chipola slabshell designated critical habitat are:

- A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without an aggrading or degrading bed elevation);
- A predominantly sand, gravel, and/or cobble stream substrate;
- Permanently flowing water;
- Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceed the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251-1387); and
- Fish hosts (such as native basses, sunfishes, minnows, darters, and sturgeon) that support the larval life stage of the mussels.

Gulf Sturgeon
Life History. The Gulf sturgeon (*Acipenser oxyrincyhus*) is an anadromous fish, inhabiting several rivers of the northern Gulf of Mexico coast from Louisiana to Florida. It breeds in the freshwater rivers during the summer months and migrates to overwinter in estuaries, bays and the Gulf of Mexico. It is considered a primitive fish embedded with bony plates or scutes. The Gulf sturgeon is a subspecies (*A. o. oxyrinchus*) that is geographically disjunct from another subspecies (*A. o. desotoi*). The latter, restricted to the Atlantic coast, is distinguishable morphologically and through DNA.

Migratory behavior in the Gulf Sturgeon is influenced by sex, reproductive status, water temperature and river flow. Downstream migration from fresh to saltwater begins in September and continues through November (Huff 1975; Wooley and Crateau 1985; Foster and Clugston 1997) In early spring sturgeon begin moving into freshwater rivers, spawn in appropriate habitat and return to nearshore marine habitat in the fall. Young fish spend the first two years in the river mouth while adults may enter the Gulf of Mexico. Returning adults show significant fidelity to their natal river.

Feeding Habits
Gulf sturgeon feed on a variety of benthic prey including invertebrates and small fishes. Feeding may occur only during the winter and spring in offshore and estuarine areas. Preferred feeding habitat is reported as sandy substrates that support a variety of burrowing prey such as ghost shrimp, and small crabs, amphipods, polychaete worms and small bivalve mollusks (Williams et al. 1989)

Habitat
Historically, the Gulf sturgeon migrated up to several hundred miles upstream to its spawning areas. In the Apalachicola River, riverine habitat is restricted to that below the Jim Woodruff dam; it is highly unlikely that there is any passage upstream through the navigation locks. In the river, the sturgeon require bedrock and clean gravel or cobble as a substrate for egg adhesion and shelter for larvae. Young fish prefer open sand-bottomed habitat. Riverine habitat includes medium to large rivers with low to moderate gradients.

Critical Habitat Description
There are fourteen designated Critical Habitat Units that are composed of major river systems, including freshwater rivers, estuaries and marine systems. Gulf sturgeon use rivers for spawning, larval and juvenile feeding, resting and moving between the areas supporting their life history. They use the lower riverine, estuarine, and marine environment during winter months primarily for feeding and, more rarely, for inter-river movements. The designated unit affected by this action is Unit 6, the Apalachicola and Brothers Rivers in Florida.

Primary Constituent Elements

• Abundant food items, such as detritus and invertebrate prey, within riverine habitats for larval and juvenile life stages; and abundant prey items, such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or crustaceans, within estuarine and marine habitats and substrates for subadult and adult life stages;

• Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone, or hard clay;

• Riverine aggregation areas, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during freshwater residency;

• A flow regime (*i.e.,* the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging, and for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging;

• Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

• Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and

• Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats.

Information after 2012 BO

In addition to the species description provided by the 2012 BO, there have been recent additions to available information. As found by Kaeser and Herrington (2011), higher exposure rates of fat threeridge mussels occur at flows less than 5,000 cfs. Fat threeridge may move up to 100 cm per day, with a maximum of 2.9 meters to avoid exposure, but shorter distances are typical. Seventy percent of exposed mussels may survive up to 6 days following exposure. Around 8% of fat threeridge may bury completely to avoid exposure and thereby survive up to 27 days. Fritts and Bringolf (2014) found that while fat threeridge is a host generalist, capable of metamorphosis on many fish, including 27 fish species in 14 families, consistently high success was found only on darters. Fritts et al. (2012) found that the purple bankclimber depends primarily on another listed species, the Gulf sturgeon as a host fish.

The 2012 BO indicated that the population of fat threeridge was more abundant than previously believed and could be growing. The estimate at that time, based on then current studies placed the total population from 826,000 to 1,144,000. Since that time additional studies have indicated that the species has both a greater range than previously thought as well as significantly higher populations. Smit (2014) found that fat threeridge can occur at much deeper water depths than previously thought indicating that the species may have a greater range of habitat and thus be relatively less susceptible to mortality during falling water levels. Kaeser (2016 pers. comm.) stated that the total population of fat threeridge in the action area may be as high as 14 million (2-4 million in the river mile 50 reach and 7-10 million in the Chipola Cutoff and lower Chipola River).

According to the 2015 Annual Report submitted to the Service, since incidental take monitoring began under the current RIOP conditions, there has been a cumulative take estimate of 8,374 fat threeridge, 24 Chipola slabshell, and 40 purple bankclimber. For the fat threeridge this represents a total of approximately 0.06% of the population or 0.015% annually. Currently, the Service is preparing a 5-year status review of the fat threeridge to determine if it should be down-listed to a threatened status or delisted (Kaeser, 2016 pers. comm.)
The Service has been conducting studies over the last four years to assess Gulf sturgeon year class strength (Kaeser, 2016 pers. comm.).The available data thus far (2013-2015) indicates that there is a wide variability in the numbers of young-of-year fish observed each year (150, 210, and 54 respectively). Variability among year classes has been well documented. However, it is unknown why a river the size of the Apalachicola, with suitable spawning habitat available yields relatively low numbers of young fish.

ACTION AREA

The "action area" includes all areas affected directly or indirectly by the federal action and not merely the immediate area involved in the action. The listed species considered in this BA are limited to those inhabiting the Apalachicola River which is governed by releases from Jim Woodruff Dam, the downstream-most project among the USACE ACF reservoirs. However, these releases are accomplished through the collective operations of all of the USACE ACF reservoirs. Therefore, the action area includes all aquatic habitats that are downstream of the USACE upstream-most ACF project, Lake Lanier/Buford Dam, ending with and including Apalachicola Bay. The only aquatic listed species that is known to occur in this action area upstream of Jim Woodruff Dam is a single purple bankclimber found in Goat Rock Reservoir in 2000 (USFWS 2012). The proposed action is not anticipated to result in any physical changes to the environment of this individual animal. Therefore, while the action area includes all aquatic habitats that are downstream of the USACE upstream-most ACF project, Lake Lanier/Buford Dam, ending with and including Apalachicola Bay, the effects of the action are limited to the aquatic habitats downstream of Jim Woodruff Dam ending with and including Apalachicola Bay. Hereafter, use of the term “action area” refers to this limited portion of the broader action area.

ENVIRONMENTAL BASELINE

As described in the 2012 BO (Section 3, pg 35) the environmental baseline is a "snapshot" of a species' health at a specified point in time. It does not include the effects of the proposed action, but rather provides an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area. Section 3 of the 2012 BO provides a description of the environmental baseline prior to implementation of the RIOP. This detailed information represents the best scientific information available at that time regarding the listed species occurring in the action area. However, the environmental baseline for the PAA must also consider the effects of operating under the previous RIOPs and especially since the 2012 RIOP. Some of the factors contributing to the environmental baseline, such as the general description of the action area, have not changed significantly since the time the BO was written and USACE incorporates this information by reference to Section 3 of the BO. The FWS will further update the Environmental Baseline section as part of this consultation.

EFFECTS ANALYSIS

This section is an analysis of the effects of the PAA on the species and critical habitat. The “Environmental Baseline” section describes the effects of the current operations including the RIOP over the past four years. This section addresses the future direct and indirect effects of implementing the PAA.

FACTORS CONSIDERED

There are three principal components of the species’ environment in the action area: channel morphology, flow regime, and water quality. Physical habitat conditions for the listed species in the action area are largely determined by flow regime, and channel morphology sets the context for the flow regime. The channel morphology has changed relative to the pre-dam period in the Apalachicola River, but the rate of change has slowed and appears to have entered a somewhat dynamic equilibrium condition (USFWS 2012). At the request of the Service, we requested that the USGS review the stage/discharge data collected at the three gages in the action area (Chattahoochee gage, Blountstown Gage, and Sumatra Gage) since 2012 in order to determine if the channel morphology still reflects a somewhat dynamic equilibrium condition. At this time, this information is pending and we will provide it as soon as it is available. It is our understanding that the Service also has a similar request pending. We have no ability at this time to predict specific effects on channel morphology due to the influence of the PAA on the flow regime. The PAA relates to water management at federal projects in the ACF basin and includes limits on the extent to which the USACE alters basin inflow into the Apalachicola River via operations of the ACF dams and reservoirs; therefore, the primary focus of this analysis is the flow regime of the Apalachicola River with and without the PAA. Consistent with the BO for the RIOP, our analysis of flow regime alteration relative to the listed species and critical habitats considers the following factors. The analyses in the BA focus on specific life history flow parameters for the listed species, but do not address all life history elements. The Service and USACE mutually agreed prior to the development of the BA that the effects analyses should be consistent with those previously developed during the various IOP/RIOP consultations. The Service is developing additional metrics that further capture the various life history flow parameters as part of this consultation. If appropriate they will be described in the BO.

Proximity of the action: The PAA may affect habitat occupied by all life stages of Gulf sturgeon in both the Apalachicola River and Bay, which are designated as critical habitat. The PAA will also affect habitat known to be occupied by the purple bankclimber, Chipola slabshell, and fat threeridge mussels. These mussel species spend their entire lives within the action area, all of which is designated as critical habitat for the mussels. The PAA includes releases from Jim Woodruff Dam and affects some of the species' life history stages and habitat features from as close as immediately below the dam to more than 100 miles downstream.

Distribution: The PAA could alter flows in the Apalachicola River and its distributaries downstream of the dam, and alter freshwater inflow to Apalachicola Bay. The Gulf sturgeon may occur throughout the river and bay in suitable habitats, and occasionally in the Chipola River downstream of Dead Lake. The Action area includes most of the known range of the fat threeridge, about one third of the range of the purple bankclimber, and a small fraction of the range of the Chipola slabshell. This analysis examines how the PAA may variously affect different portions of the action area according to the distribution of the species and important habitat features in the action area.

Timing: The PAA could alter flows in the Apalachicola River and into Apalachicola Bay at all times of the year. It will reduce flows when increasing composite conservation storage in the ACF reservoirs and increase flows when decreasing composite conservation storage. Gulf sturgeon occupy the Apalachicola River year-round as larval and juvenile fish, and then seasonally as subadults and adults, spawning in the Apalachicola River around May. Subadults and adult Gulf sturgeon likewise occupy Apalachicola Bay seasonally, during the coldest months of the year. The three mussel species occupy the action area year-round and during all life phases. The fat threeridge, a species that occupies a wide variety of aquatic habitats, including shallower waters, may be more susceptible to effects of low flows during the breeding period, in late spring/early summer. Consistent with the 2012 BO, we examine how the PAA may alter the seasonal timing of biologically relevant flow regime features in our analysis.

Nature of the effect: The PAA will reduce flows in the Apalachicola River when increasing composite storage in the ACF reservoirs and increase flows when decreasing composite reservoir storage. Two of the Gulf sturgeon primary constituent elements of designated critical habitat may be affected by the actions: flow regime and water quality. Permanently flowing water and water quality are also two of five primary constituent elements of designated critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell. The PAA may also affect a third element of designated critical habitat for the mussels: host fish. Consistent with the 2012 BO, we examine how the PAA may affect the listed species and critical habitat elements through specific analyses focused on relevant habitat features, such as spawning substrate, floodplain inundation, and vulnerability to exposure by low flows. All three mussel species are vulnerable to falling water levels and exposure to air. As obligate aquatic species, exposure to air for sustained periods of time may be lethal. As shown by Kaeser and Herrington (2011), mortality may result through desiccation and predation. In addition, survivors may be stressed by desiccation, lack of oxygen, lowered reproduction, and lack of feeding.

Duration: This PAA replaces the current interim operations plan (RIOP) at Jim Woodruff Dam and the operations described under the PAA are applicable until revised or until a future updated Water Control Plan is adopted. Although the duration of the PAA is indefinite, the nature of its effects is such that none are permanent. The USACE can alter its reservoir operations at any time; therefore, flow alterations that may result from the PAA will not result in permanent impacts to the habitat of any of the listed species. Consistent with the 2012 BO, we examine how implementation of the PAA may alter the duration of high flows and low flows that are relevant to the listed species and critical habitats.

Disturbance frequency: The PAA is applicable year round, with specified monthly flows; therefore, changes to the flow regime and water quality parameters may occur at any time and/or continuously until such time as the PAA is revised or until an updated Water Control Plan is adopted. Consistent with the 2012 BO, we examine how implementation of the PAA may alter the frequency of high flows and low flows that are relevant to the listed species and critical habitats.

Disturbance intensity and severity: The PAA may variously affect the flow regime depending on time of year, basin inflow, and composite conservation storage levels as defined in the DESCRIPTION OF PROPOSED ACTION section above. Like the current RIOP, the PAA maintains a minimum flow of 5,000 cfs except during severe drought events and maintains a minimum flow of 4,500 cfs at all times. Consistent with the 2012 BO, we examine how the PAA affects the magnitude of flow events relative to the baseline (observed flows) and the NAA.

ANALYSIS FOR EFFECTS OF THE ACTION

The Effects Analysis for the PAA is generally consistent with that of the 2012 BO. Details about the ResSim model are provided below in the MODEL DESCRIPTION section. A description of the changes to the assumptions regarding consumptive demands follows.

Consistent with the 2012 BO, we determine the future effect of project operations, as prescribed by the PAA, by comparing the environmental conditions expected to occur under the PAA to the environmental baseline. In the BO for the RIOP, the flow regime of the environmental baseline was described using post-1975 flow records, because this period represented the complete hydrology of the current configuration of the ACF federal reservoir projects. This effects analysis uses the same baseline.

MODEL DESCRIPTION

The HEC-ResSim model was used to simulate flow operations in the ACF Basin. HEC-ResSim is a state-of-the-art tool for simulating flow operations in managed systems. It was developed by the USACE Hydrologic Engineering Center (HEC) to aid engineers and planners performing water resources studies in predicting the behavior of reservoirs and to help reservoir operators plan releases in real time during day-to-day and emergency operations. This effects analysis used the most current HEC-ResSim Version 3.3 Dev "Build 3.3.1.32R".

HEC-ResSim has a graphical user interface designed to follow Windows® software development standards. The model's interface can be learned without extensive tutorials. Familiar data entry features make model development easy, and localized mini plots graph the data entered in most tables so that errors can be seen and corrected quickly. A variety of default plots and reports, along with tools to create customized plots and reports, facilitate output analysis.

HEC-ResSim provides a realistic view of the physical river/reservoir system using a map-based schematic. The program's user interface allows the user to draw the network schematic as a stick figure or as an overlay on one or more geo-referenced maps of the watershed. HEC-ResSim represents a system of reservoirs as a network composed of four types of physical elements: junctions, routing reaches, diversions, and reservoirs. By combining those elements, the HEC-ResSim modeler is able to build a network capable of representing anything from a single reservoir on a single stream to a highly developed and interconnected system like that of the ACF Basin. A reservoir is the most complex element of the reservoir network and is composed of a pool and a dam. HEC-ResSim assumes that the pool is level (i.e., it has no routing behavior), and its hydraulic behavior is completely defined by an elevation-storage-area table. The real complexity of HEC-ResSim's reservoir network begins with the dam.

Most reservoirs are constructed for one or more of the following purposes: flood risk management, power generation, navigation, water supply, recreation, and environmental quality. Those purposes typically define the goals and constraints that describe the reservoir's release objectives. Other factors that might influence the objectives include time of year, hydrologic conditions, water temperature, current pool elevation (or zone), and simultaneous operations by other reservoirs in a system. HEC-ResSim uses an original rule-based description of the operational goals and constraints that reservoir operators must consider when making release decisions.

To provide a potential range of flows that might be experienced while the PAA scenarios are in effect, the ResSim model simulates river flow and reservoir levels using a daily time series of unimpaired flow data as input for a certain period of record. Whereas basin inflow is computed to remove the effects of reservoir operations from observed flow, unimpaired flow is developed to remove the effects of both reservoir operations and consumptive demands from observed flow. The ResSim model imposes reservoir operations and consumptive demands onto the unimpaired flow time series to simulate flows and levels under those operations and demands. The unimpaired flow data set is the product of the Tri-State Comprehensive Study, in which the States of Alabama, Florida, and Georgia, participated.

The current unimpaired flow data set represents the years 1939 to 2011. The USACE has not yet computed unimpaired flow for 2012-current day. Unimpaired flow computations require actual water use data from the three States and 2011 is the most recent year of this data provided to the USACE. Although there is partial data available for the year 2012, it is incomplete. Consideration was given to extrapolating from the partial data or using the available 2012 data combined with 2011 data. However, this approach was rejected since 2012 is classified as a drought year. Using anything other than the actual data for 2012 could mischaracterize the severity of the 2012 drought and influence conclusive statements in both the BA and the EIS. For purposes of evaluating the proposed action, a 73-year unimpaired flow hydrologic period of record (1939 through 2011) was used to run the simulations. However, for the purposes of this effects analysis, we focus on the data from 1975-2011, because this period represents the complete hydrology of the current physical configuration of the ACF federal and private reservoir projects with an unimpaired flow computation.

MODEL SIMULATIONS

USACE simulated the 1975 – 2011 ACF project operations under the NAA and PAA using the HEC-ResSim hydrologic simulation software. The 1975-2011 observed daily flows at the Chattahoochee gage represent the Baseline.

To ensure comparisons that are most likely to reveal anthropogenic differences between the sets of environmental conditions (NAA, PAA, and Baseline) and not hydrologic differences between years, we use the output from the ResSim models for the period that is also represented in the baseline, which is 1975 to 2011 (36 years). Using only the latter 36 years of the ResSim results removes 36 years of model results from our analysis, including a drought during the 1950's. However, the later 36 years of the simulated period appear to represent the most "critical" period for the model, as this is when reservoir levels and flows reach their lowest levels in the simulation. Further, the basin experienced below normal precipitation and basin inflow levels from 2006 through much of 2012 and record low composite conservation storage levels were recorded per calendar date in 2007 and 2008.

For this BA, the consumptive water demands used in the models are the actual reported municipal and industrial (M&I) depletions for the period of 1980-2011, estimated agricultural water use, and estimated evaporative losses from the basin's largest reservoirs (Table 8). Consumptive water-use values prior to 1980 were hindcast based on census population data. The method for estimating agricultural water use varied by month and by year (wet, normal, dry). If these reported values and estimates of consumptive use differ substantially from the actual historical values, then the simulated flows would be influenced accordingly.

Table 8. Summary of Depletions (cfs) to Basin Inflow Upstream of Woodruff Dam Used in the ResSim Model

	M&I				Agriculture				Reservoir Evaporation				Total			
	Dry	Normal	Wet	All years	Dry	Normal	Wet	All years	Dry	Normal	Wet	All years	Dry	Normal	Wet	All years
Jan	334	300	331	312	1	1	0	1	-183	-279	-416	-273	152	22	-85	40
Feb	302	263	295	276	23	3	0	7	-78	-159	-168	-141	246	107	127	142
Mar	345	254	257	276	94	41	31	53	153	-39	-197	-12	592	257	92	316
Apr	453	332	317	359	212	103	83	126	567	389	194	408	1,231	825	594	893
May	615	457	340	480	586	344	292	395	672	573	338	569	1,873	1,374	970	1,444
Jun	715	494	406	536	793	439	368	514	666	485	329	509	2,173	1,419	1,104	1,559
Jul	700	525	382	550	903	587	506	651	477	387	-61	356	2,080	1,499	827	1,557
Aug	710	532	429	562	955	578	486	656	484	409	321	416	2,149	1,519	1,236	1,634
Sep	592	500	485	520	672	328	259	401	418	358	478	386	1,682	1,186	1,222	1,307
Oct	552	466	461	486	251	130	105	156	316	315	265	310	1,119	912	831	951
Nov	435	378	388	392	192	90	70	112	33	-128	66	-67	660	339	525	437
Dec	399	337	358	354	168	79	62	98	-130	-186	-63	-158	437	230	356	293
Average	514	404	371	426	406	228	190	266	284	179	91	193	1,204	811	652	885

Dry years: 1981, 1986, 1988, 1990, 1999, 2000, 2006, and 2007.
Wet years: 1975, 1991, 1994, and 2003.
All other years in this period were classified as "normal."
Negative values for reservoir evaporation indicate a net gain from precipitation.

The Service and USACE previously agreed that this method for simulating the NAA and PAA provides a more useful comparison to the baseline (observed) condition, as these simulations more accurately reflect the influences of reservoir evaporative losses, inter-basin water transfers, and consumptive water uses that also influenced the observed Apalachicola River flows during the baseline period of record (1975-2011). Therefore, difference between the Baseline and simulated flow regimes reflect the net effect of operational changes under the NAA or PAA relative to historical operations, as all other influences that are unrelated to project operations (hydrology, evaporation, consumptive water use, land use, and climate change) are the same in both. The differences in the observed and simulated flows are influenced by the consumptive water use assumptions included in ResSim. At this time we cannot differentiate between flow differences attributable to USACE discretionary operations and those attributable to potential inaccuracies in the model assumptions; thus, it was mutually agreed to conservatively attribute all the differences to the NAA or PAA operations.

Actual down-ramping operations are more conservative than those reflected in the maximum fall rate schedule due to limitations of the equipment and careful operations to avoid violating the maximum fall rate schedule when the most conservative fall rates are prescribed. These fall rates are associated with down-ramping events when releases are less than 10,000 cfs. Actual fall rates (based on observed data) in this range, since the maximum fall rate schedule has been in place (5 September 2006) have averaged 0.13 ft/day. The average fall rate when releases are less than 10,000 cfs during the Baseline period (1975-2008) is 0.16 ft/day. Therefore, at the request of the USFWS, the USACE simulated the PAA and the NAA utilizing a standard 0.13 ft/day fall rate when flows are less than 10,000 cfs. The Corps is not eliminating the 0.25 ft/day fall rate provision for releases less than 10,000 cfs, described in the maximum fall rate schedule (Table 5) for the PAA. Rather, due to the limitations of the simulation software to represent the actual conservative down-ramping operations for releases in this range, a flat fall rate that better simulates releases expected as operations are conducted in accordance with the maximum fall rate schedule has been adopted. This is consistent with previous and current simulations that establish a minimum flow slightly higher than 5,000 cfs (5,050 cfs) in the model simulation rules to better reflect actual conservative operations in place to avoid violating the 5,000 cfs minimum flow provision.

FREQUENCY AND DURATION OF DROUGHT OPERATIONS

Data on the frequency and duration of drought operations under the NAA and PAA are presented at the request of the Service. However, it must be noted that entering and exiting drought operation is a water management decision based on hydrologic triggers and is therefore part of the NAA or PAA, not an impact resulting from that decision. As described previously, the PAA drought operations plan was developed to be a proactive approach to water management that better positions the USACE projects to withstand multi-year droughts. Therefore, there would be no direct impacts to any species. Species would be impacted only indirectly through impacts such as low flow frequencies and durations which were discussed previously.

Because the PAA would enter drought operations sooner than the NAA (Zone 3 vs Zone 4) and therefore requiring more time to return to normal operations there would be more frequent and longer lasting drought operations. Again, this would allow a proactive approach to conserve water for all project purposes. Table 9 provides the number, duration and percent time in drought operations and Extreme Drought Operation EDO for the NAA and PAA.

Table 9. Frequency and Duration of Drought Operation

	No Action	PAA
Number of Times Drought Operation Triggered	2	13
Total Duration of Drought Operation (Months)	52	121
Percent of Time Drought Operation Triggered	12%	28%
Number of Times EDO Operation Triggered	1	2
Total Duration of EDO Operation (Months)	1	4

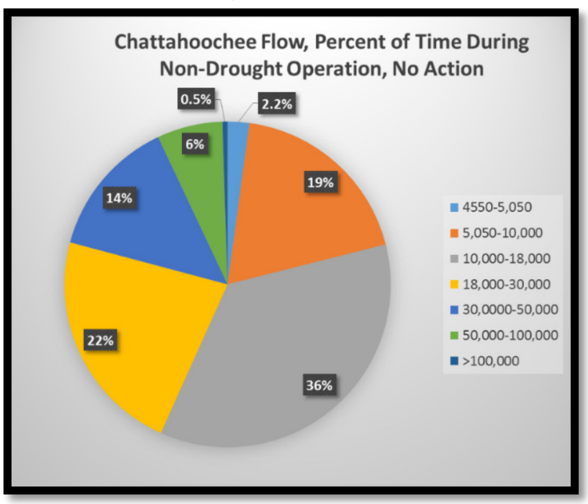
The Service requested a review of the flow at Chattahoochee gage during normal (non-drought) operation and drought operation. We examined the percent of time the flow was within various ranges that are related the Jim Woodruff operation, Table 10 describes the flow ranges used for comparison.

Table 10. Apalachicola River at Chattahoochee gage comparison flow range description

Flow Range	Description
4,550 – 5,550	Minimum flow
5,050 – 10,000	Initial mussel monitoring
10,000 – 18,000	Within Powerhouse capacity
18,000 – 30,000	Upper Range of Down Ramping Requirement
30,000 – 50,000	High Flow Releases
50,000 – 100,000	Moderate Flood Releases
>100,000	Extreme Flood Releases

Figure 12 is a comparison of the Chattahoochee flow during normal operation. The PAA results in a slight reduction in the percent of time the flow is less than 10,000 cfs (the two low flow ranges). Figure 13, during drought operations demonstrates a greater reduction in percent of time flows are at or below 5,050 cfs and increase of flows between 5,050 cfs and 10,000. This shift of increasing flows above the bottom threshold is an anticipated consequence of triggering drought operation sooner. Initiating a more conservative operation sooner provides the opportunity to sustain beneficial flows for longer periods during extended dry periods. The highlighted area in Figure 14 is another illustration of flows above the minimum threshold occurring a greater percent of time.

Figure 12. Chattahoochee Flow during Normal (Non-Drought) Operation



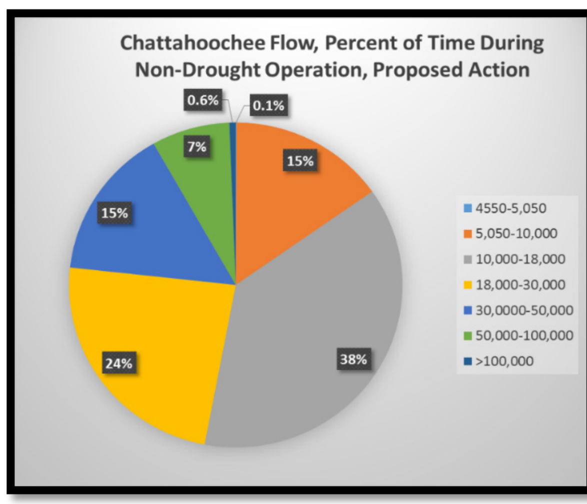


Figure 13. Chattahoochee Flow During Drought Operation

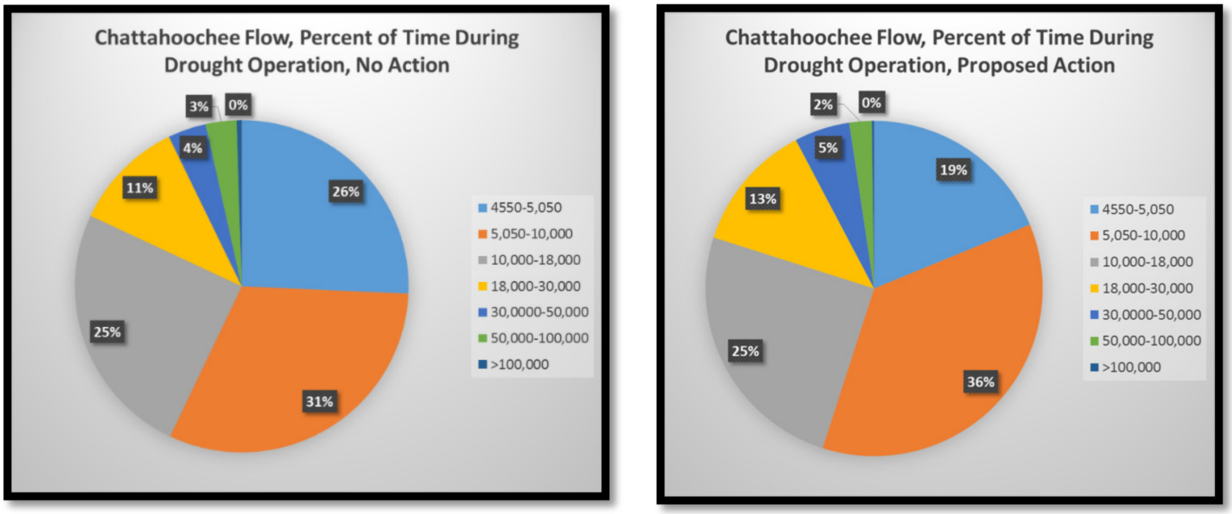
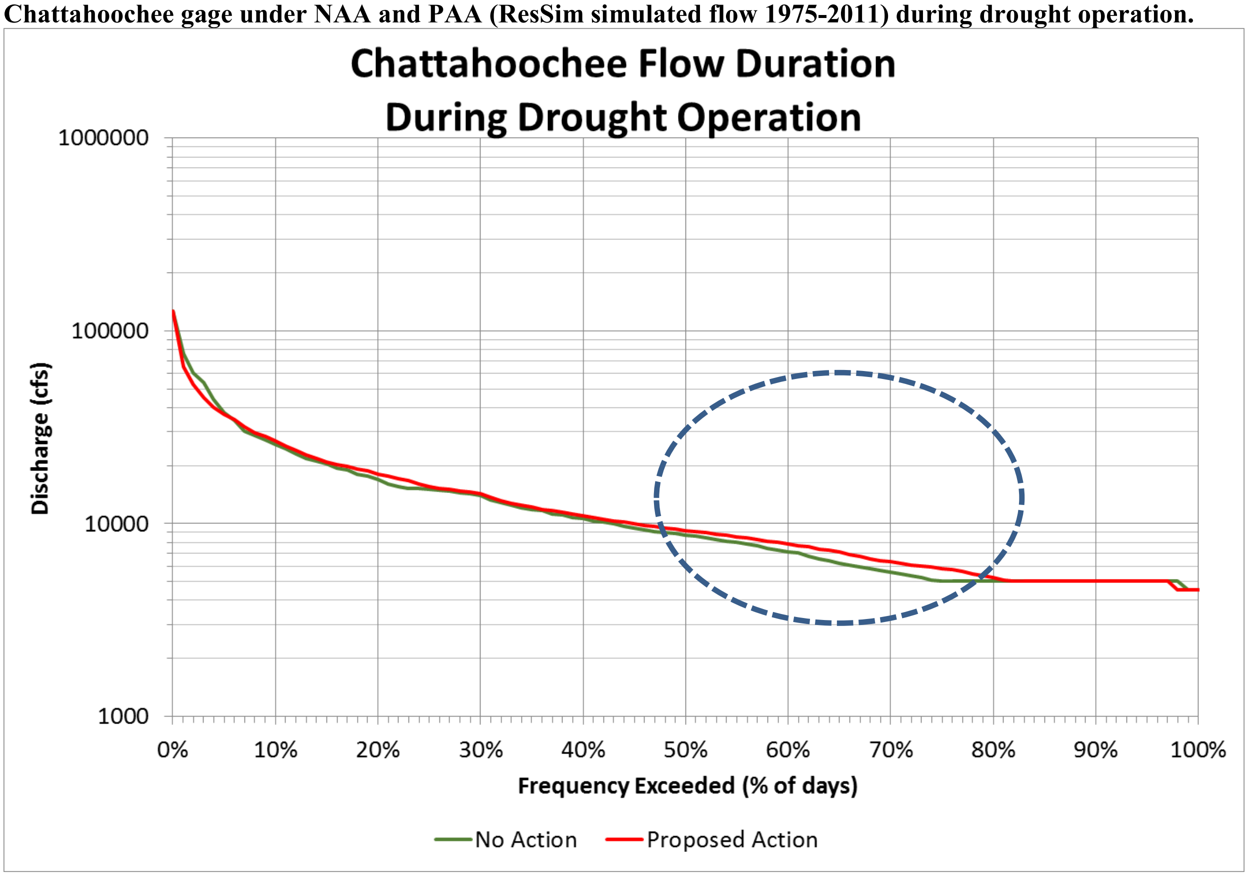


Figure 14. **Simulated flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA and PAA (ResSim simulated flow 1975-2011) during drought operation.**



GENERAL EFFECTS ON THE FLOW REGIME

The effects of the PAA on the flow regime is evaluated by comparing the Apalachicola River flow frequencies for the various conditions (PAA, NAA, and Baseline).

Figure 15 displays the frequency analysis (percent of days flow exceeded) for the three flow regimes, to illustrate the flow differences between them. The PAA, NAA, and Baseline flow regimes are all comparable with very little difference between the PAA and NAA. The PAA curve crosses the Baseline curve at multiple locations, thus providing a mix of beneficial and adverse effects.

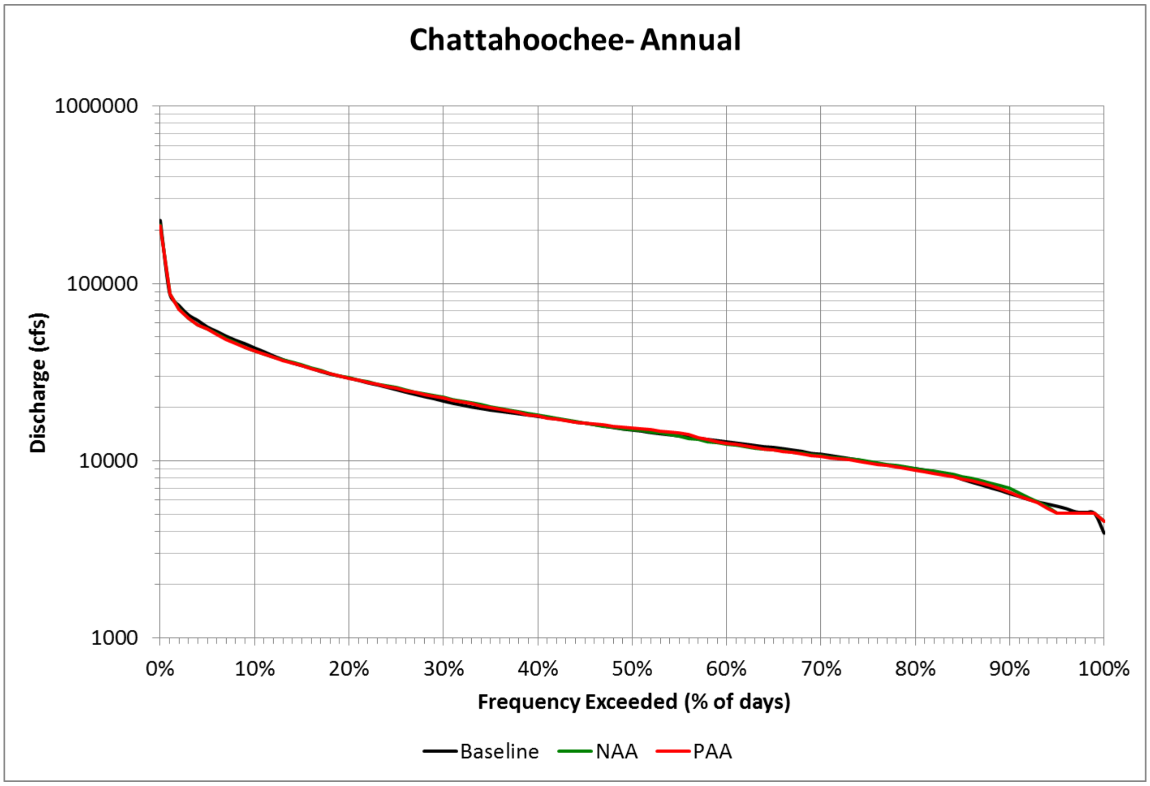


Figure 15. Observed and simulated flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Figure 16 displays the frequency analysis for flows that are exceeded at least 80% of the time (i.e., the lowest flows), to illustrate the low-flow differences between the various flow regimes. These low flow events represent the most severe flow conditions for the aquatic biota in the river. The PAA, NAA, and Baseline flow regimes are all comparable with very little difference between the PAA and NAA. The PAA curve crosses the Baseline curve at multiple locations, thus providing a mix of beneficial and adverse effects. The PAA and NAA simulations both result in one event where the 4,500 cfs minimum flow is triggered. However, the PAA includes the added benefit of never resulting in flows less than 4,500 cfs, which occurred under the Baseline.

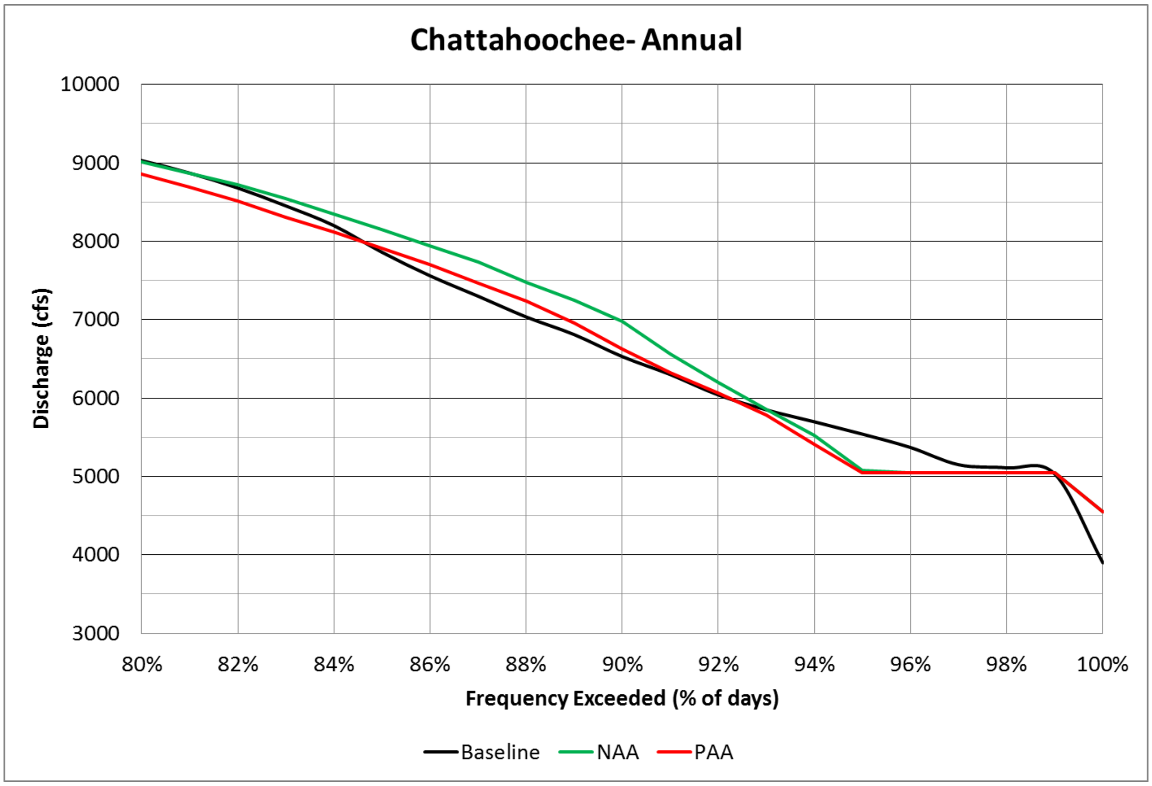


Figure 16. Observed and simulated low flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Figure 17 displays the frequency analysis for flows that are exceeded 20% to 80% of the time (i.e., the normal flow range), to illustrate the moderate-flow differences between the various flow regimes. These moderate flow events represent the normal flow conditions for the aquatic biota in the river. The PAA, NAA, and Baseline flow regimes are all comparable with very little difference between the PAA and NAA. The PAA curve crosses the Baseline curve at 10,000 cfs to 16,000 cfs range; slightly lower in the range 10,000 to 13,000 and conversely slightly higher in the range 13,000 cfs to 16,000 cfs. The PAA and NAA simulations both result in slightly higher flows in the 18,000 to 27,000 cfs flow range. The differences are very small, thus providing a mix of beneficial and adverse effects.

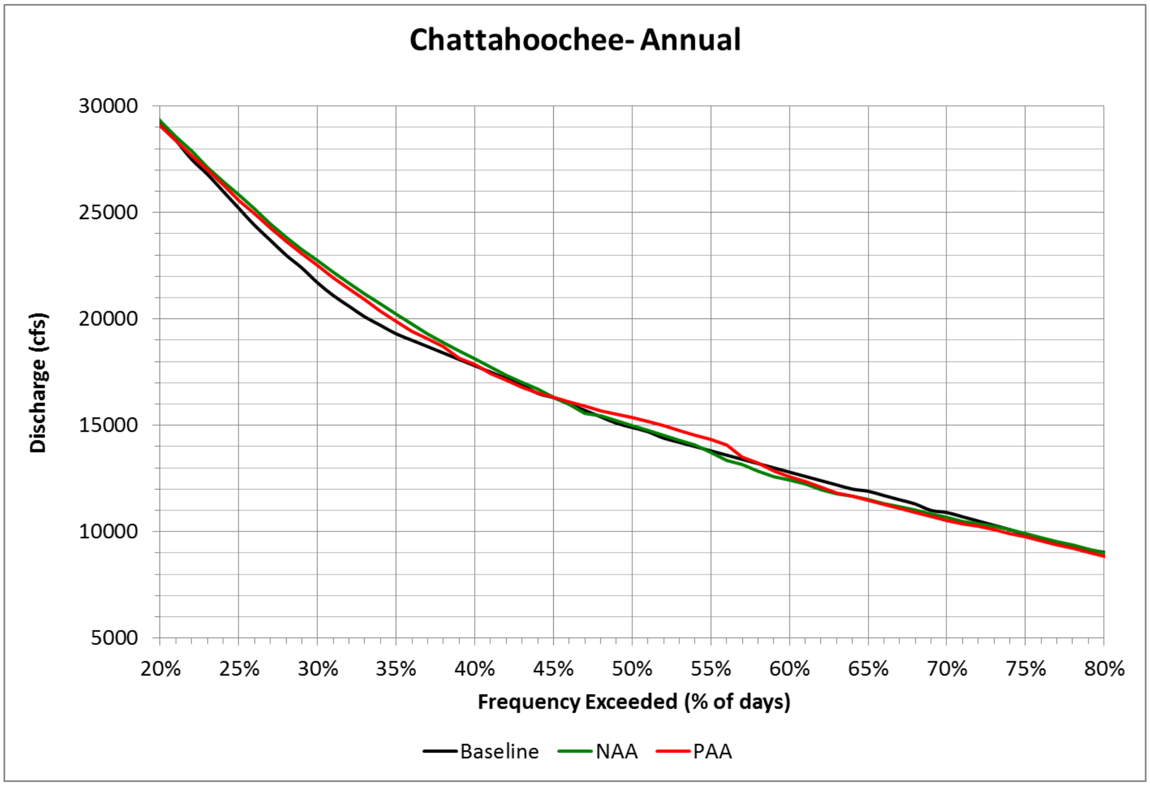


Figure 17. Observed and simulated low flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011), 20%-80% range.

GULF STURGEON EFFECTS ANALYSIS

This section provides the effects analysis of the PAA on flow dependent habitat characteristics relevant to Gulf sturgeon.

Submerged Hard Bottom

The principal analysis for effects of the PAA on Gulf sturgeon consists of comparing the amount of potential spawning habitat available under the various conditions. The method for calculating the amount of habitat in Figure 18 below is the same as the Sturgeon Spawning Habitat Performance Metric (SSHPM) developed by the Service and provided to USACE in the August 29, 2013 PAL. The box limits represent the 25th and 75th percentiles. All three flow regimes provide similar amounts of spawning habitat at the appropriate depth for at least 30 consecutive days (median habitat availability of approximately 18 acres). The range between the 25th and 75th percentiles is from approximately 14 to 18 acres in each case. Habitat availability under the PAA flow regime is nearly identical to that provided by the NAA flow regime. Both the NAA and the PAA provide at least 13 acres of habitat, while the Baseline provides a minimum of approximately 10 acres. Regarding this flow-dependent habitat parameter, the PAA continues to provide a beneficial effect to Gulf sturgeon realized by the RIOP by providing more 30-day continuous habitat in the appropriate depth range than the Baseline. This benefit may be the most biologically significant during the most extreme spring low flow events where the PAA provides for approximately 3.5 acres more than the baseline condition.

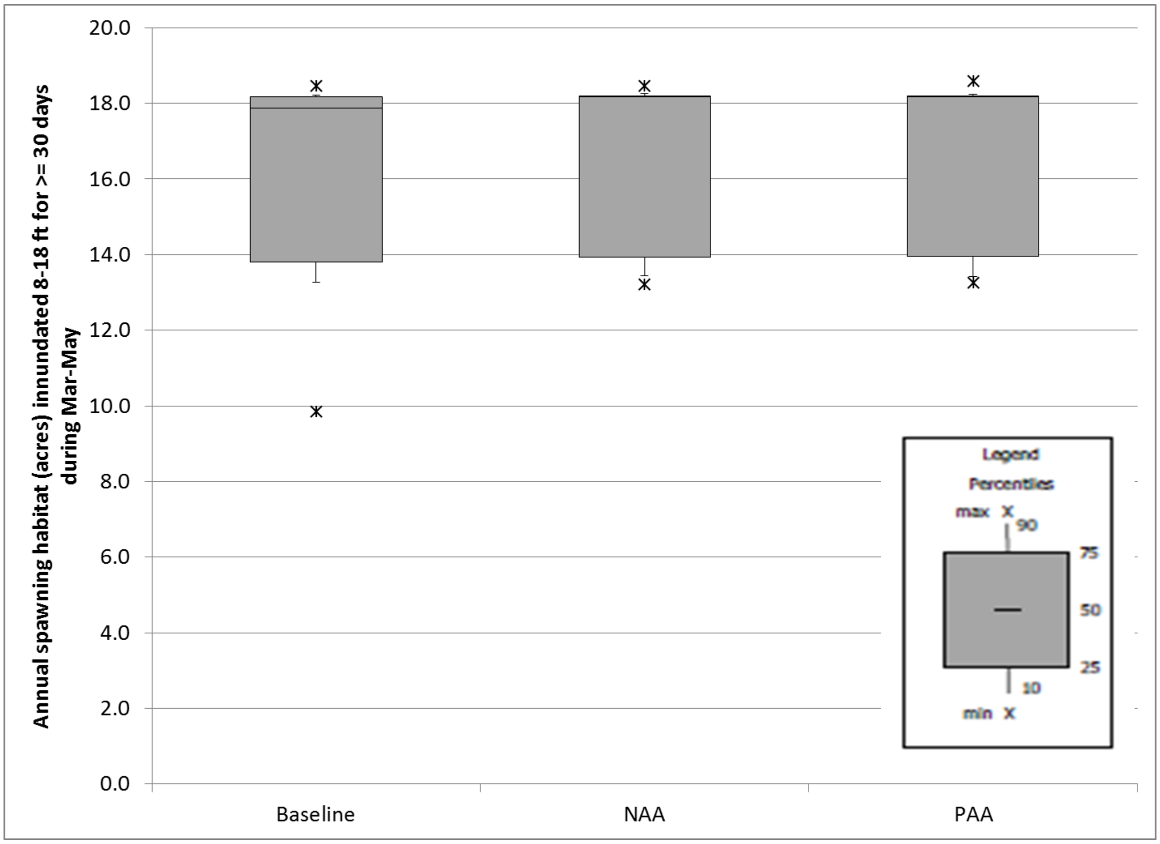


Figure 18. Frequency (% of days) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days) March 1 through May 31, at the three sites known to support spawning, NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

In the 2008 BO the Service determined that rapid declines in river stage (greater than 8 ft in a 14 day period) when flows are less 40,000 cfs may potentially result in take of Gulf sturgeon eggs and/or larvae. In accordance with RPM 2008-4 of the 2008 BO the Corps evaluated the circumstances leading to the two potential take events (one during the 2007 spawning season and the other during the 2008 spawning season) and determined that they can be avoided through minor proactive adjustments to releases from upstream reservoirs and Jim Woodruff Dam. Like the NAA, the PAA includes provisions for these minor proactive adjustments and the simulated flow regimes do not include any of these potential take events.

Gulf Sturgeon Potential Fall Spawning

Randall and Sulak (2012) documented autumn spawning in the Suwannee River, FL. Although, autumn spawning has not been documented in the Apalachicola River, it is common for tagged fish from the Suwannee River and other Gulf drainages to be found there and thus it is possible that some limited autumn spawning occurs in the Apalachicola River also. In order to assess potential effects of the PAA on fall spawning activity we analyzed the September through December monthly flow durations of the simulated flow regimes under the NAA and PAA as compared to the baseline (observed flows 1975-2011).

The median flow values for the NAA, PAA, and Baseline are provided in Table 9 below. The median flow values for all three flow regimes are generally comparable with the Modified RIOP providing slightly lower median flows in September and October and greater median flows in November as compared to the Baseline.

Table 9. Median monthly Apalachicola River flow (Sep-Nov) under the NAA (ResSim simulated flow 1975-2011); PAA (ResSim simulated flow 1975-2011); and Baseline (observed flow 1975-2011).

	NAA (cfs)	PAA (cfs)	Baseline (cfs)
September	9,770	9,500	10,900
October	10,350	10,240	10,600
November	12,900	12,900	11,400
December	15,800	15,800	15,100

All of these median flow values yield about 20 acres of potentially suitable sturgeon spawning habitat that is at least 8 feet deep. It is unlikely that the September through November flow regime expected to occur under the PAA will affect Gulf sturgeon autumn spawning activity if it occurs in the Apalachicola River. Figures 19-22 also provide the frequency of river flows for each of the three flow regimes for each month (September-December).

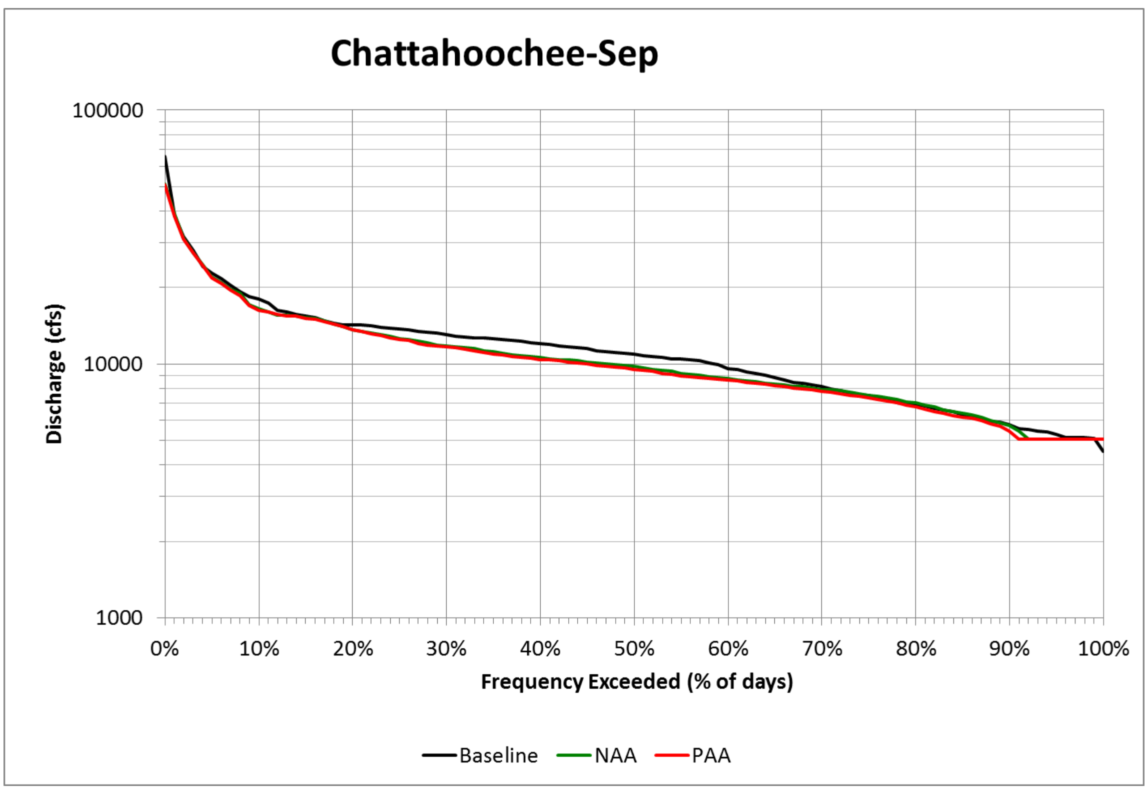


Figure 19. Observed and simulated September flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

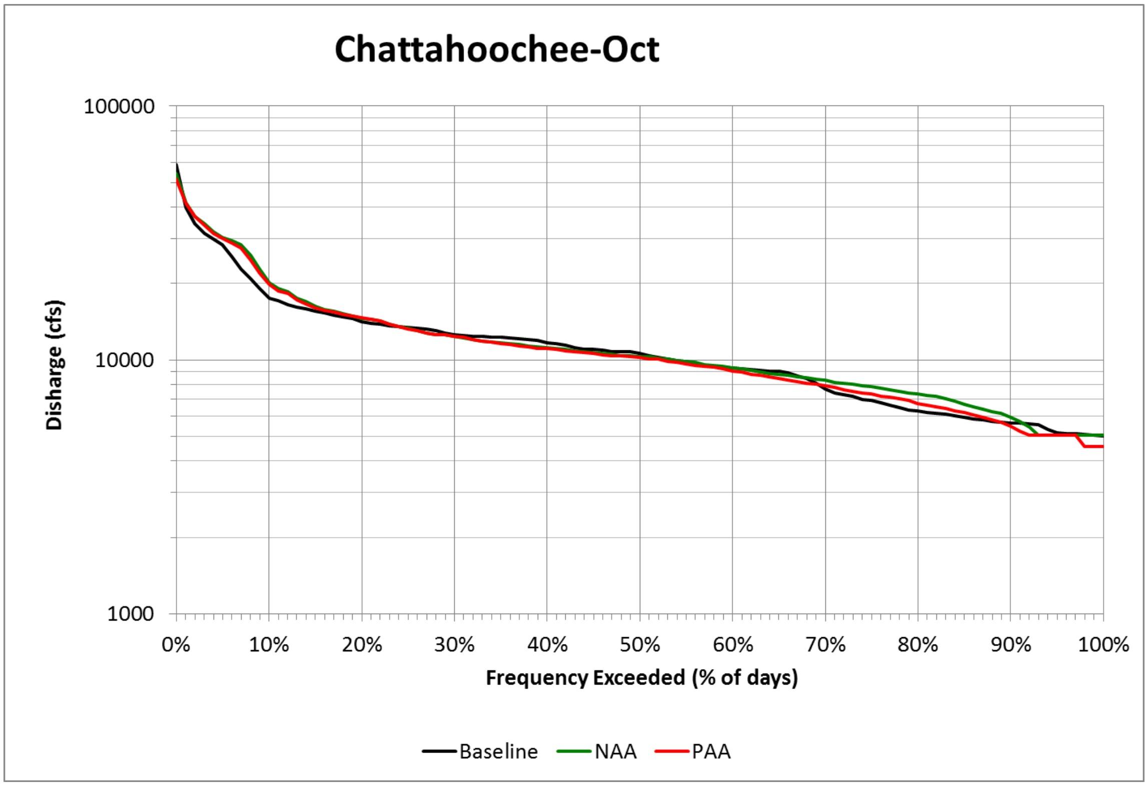


Figure 20. Observed and simulated October flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

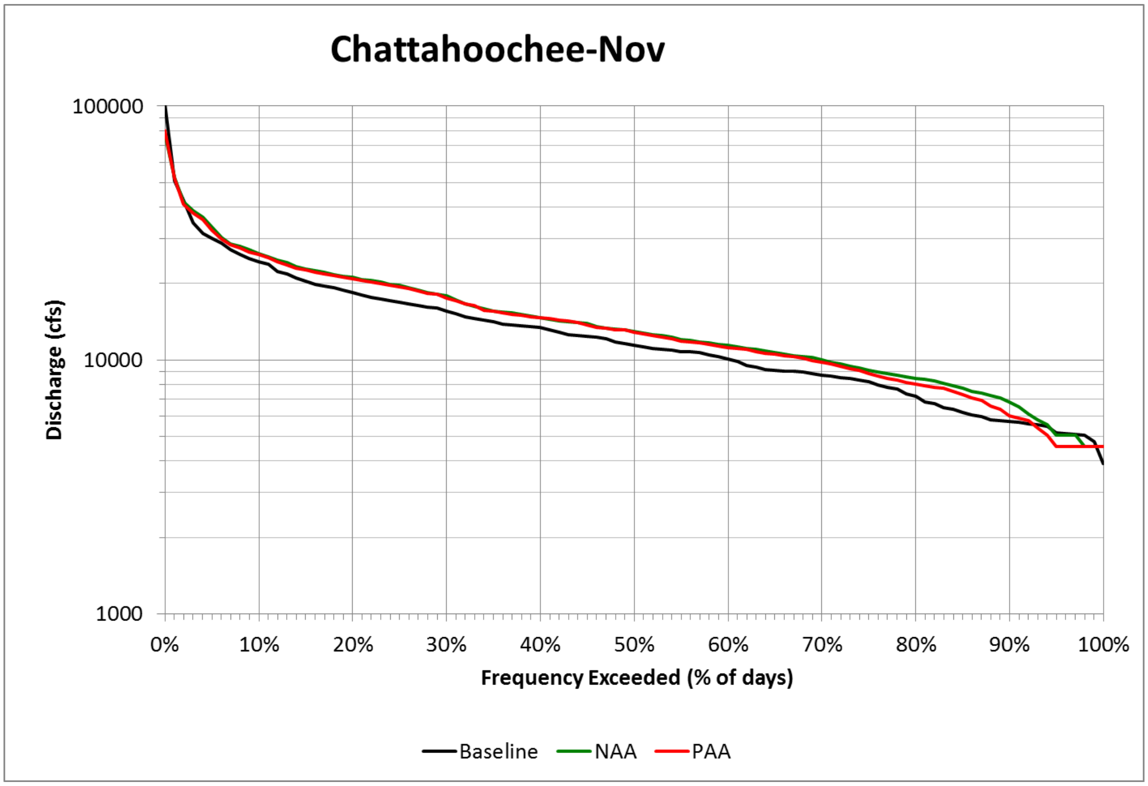


Figure 21. Observed and simulated November flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

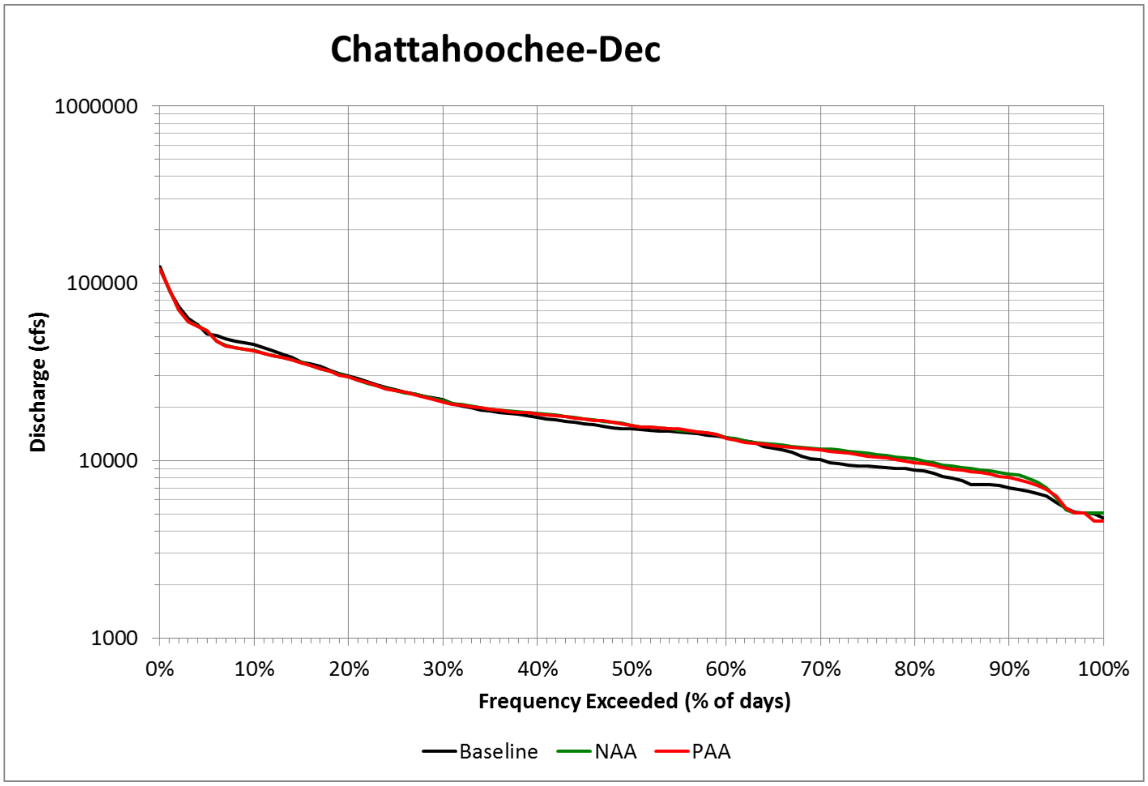


Figure 22. Observed and simulated December flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Changes in Water Temperature

Gulf sturgeon eggs and larvae are sensitive to water temperature levels. Laboratory experiments indicated optimal water temperature for survival of Gulf sturgeon larvae is between 15 and 20 Celsius (°C) (59 and 68 Fahrenheit (°F)), with low tolerance to temperatures above 25°C (77°F) (Chapman and Carr 1995). Water temperatures at egg collection sites in the Apalachicola and Suwannee Rivers range from 18.2 to 25.3 degrees °C (64.8 to 75.0 °F) (Fox et al. 2000; Ross et al. 2000; Craft et al. 2001; USFWS unpub. data 2005; Pine et al. 2006).

In addition to the HEC-ResSim model described earlier, the water quality effects, including water temperature, associated with the water management alternatives and water supply storage options in the ACF Basin were analyzed with the HEC-5Q model developed by the USACE Hydrologic Engineering Center. For the simulation of water quality conditions under the various alternatives, HEC-5Q inputs included in-stream flows, tributary flows and water quality data, withdrawals, reservoir operations, and other point and nonpoint source flows and quality loads to the system. The HEC-5Q model was linked with the HEC-ResSim model through an input of flows by reach. In addition to the BASINS model loadings developed in previous modeling efforts, observed data was used to represent the nonpoint inputs to the HEC-5Q model for the period of record from 2001 through 2011. The HEC-5Q model also included nontributary inflows, wastewater treatment dischargers, and cooling water returns. Inputs for wastewater treatment discharges were based on discharge monitoring reports (DMRs). When DMRs were not available, permitted limits, concentrations representative of the type of discharge, or an average of DMRs was used. The point source inputs considered only dischargers that contributed more than 1 mgd. Because of limited observed water temperature data, we could not compare simulated data to the baseline (observed) condition. Therefore, the NAA (simulated) was compared to the PAA.

Figure 23 provides the range of simulated water temperatures under the PAA during the Gulf sturgeon spawning season (March-May). Water temperature under the PAA generally ranges from about 15ºC to 21ºC in the reach of Apalachicola River below Jim Woodruff Dam known to support Gulf sturgeon spawning. This range of water temperatures is consistent with the range described as optimal in laboratory experiments. In order to determine to what extent (if any) the changes in the PAA influence water temperature below Jim Woodruff Dam we also analyzed the difference in water temperature between the NAA and PAA HEC-5Q simulations during the Gulf sturgeon spawning season (March-May). Figure 24 illustrates this difference and indicates that only very minor reductions in water temperature (approximately 0.1ºC) are realized under the PAA in the reach of Apalachicola River below Jim Woodruff Dam known to support Gulf sturgeon spawning. It is unlikely that this reduction in water temperature would result in any adverse effects to Gulf sturgeon eggs or larvae.

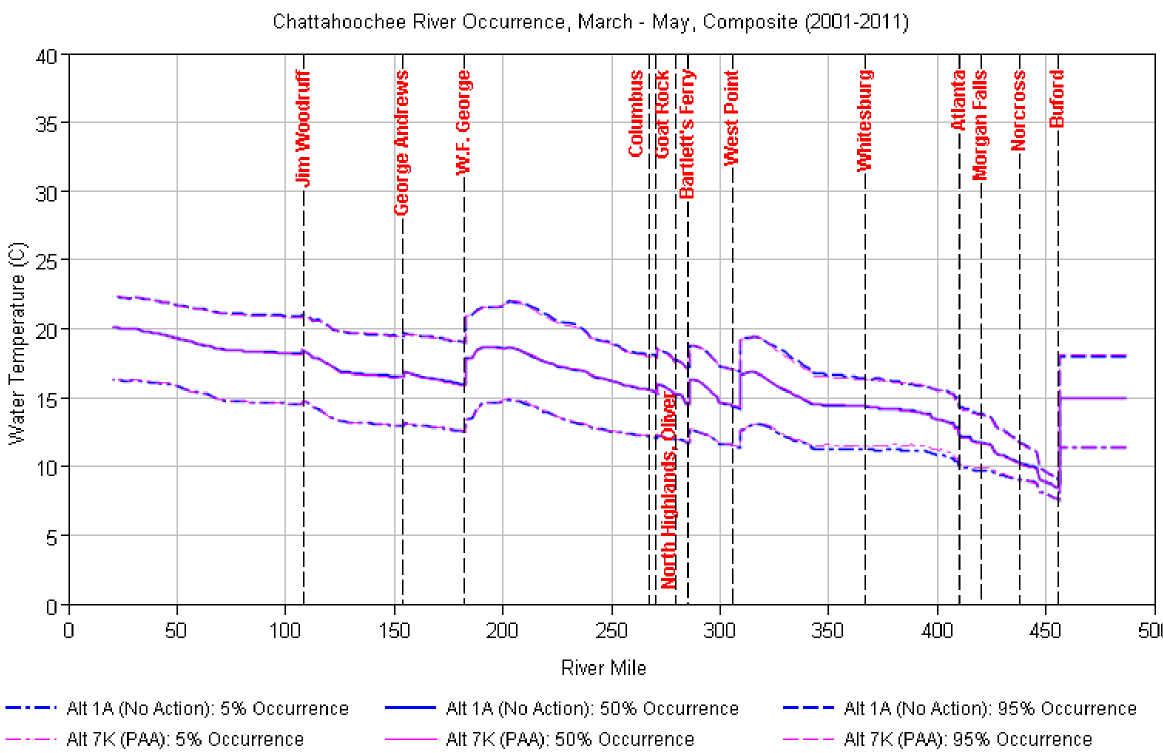


Figure 23. HEC-5Q Simulated Water Temperature (Degrees Celsius) Under the PAA (ResSim simulated flow 1975-2011).

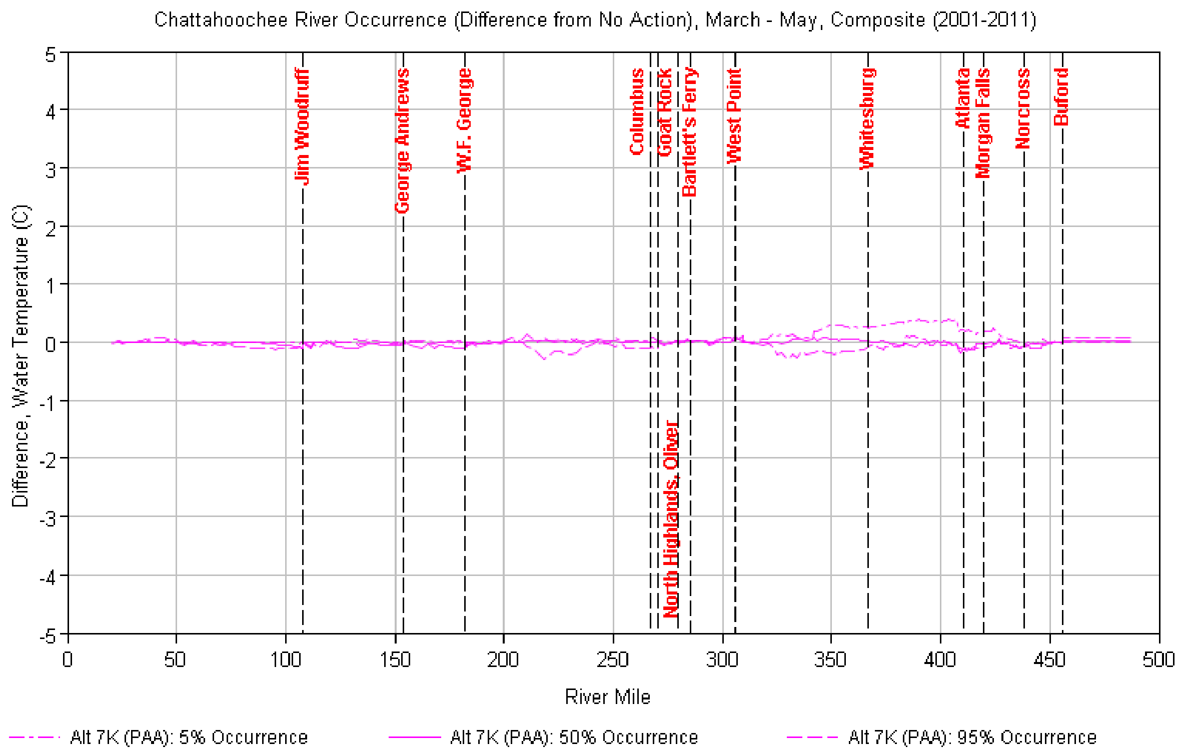


Figure 24. Difference in Water Temperature (Degrees Celsius) Between the NAA (ResSim simulated flow 1975-2011) and PAA (ResSim simulated flow 1975-2011).

Because Gulf sturgeon may also spawn in the Apalachicola River in the Fall, we also analyzed simulated water temperature data between September and December. Figure 25 provides the range of simulated water temperatures under the PAA during the Gulf sturgeon spawning season (September-November). Water temperature under the PAA generally ranges from about 17°C to 28°C in the reach of Apalachicola River below Jim Woodruff Dam. This range of water temperatures is warmer than the March-May temperatures discussed above and somewhat above optimal in laboratory experiments. However, warmer temperatures in the Fall are expected compared to the Spring. In order to determine to what extent (if any) the changes in the PAA influence Fall water temperature below Jim Woodruff Dam we also analyzed the difference in water temperature between the NAA and PAA simulations during the Gulf sturgeon Fall spawning season (September-November). Figure 26 illustrates this difference and indicates that essentially no changes occur under the PAA in the reach of Apalachicola River below Jim Woodruff Dam known to support Gulf sturgeon spawning. It is unlikely that these temperature differences would result in any adverse effects to Gulf sturgeon eggs or larvae when comparing the PAA to the NAA.

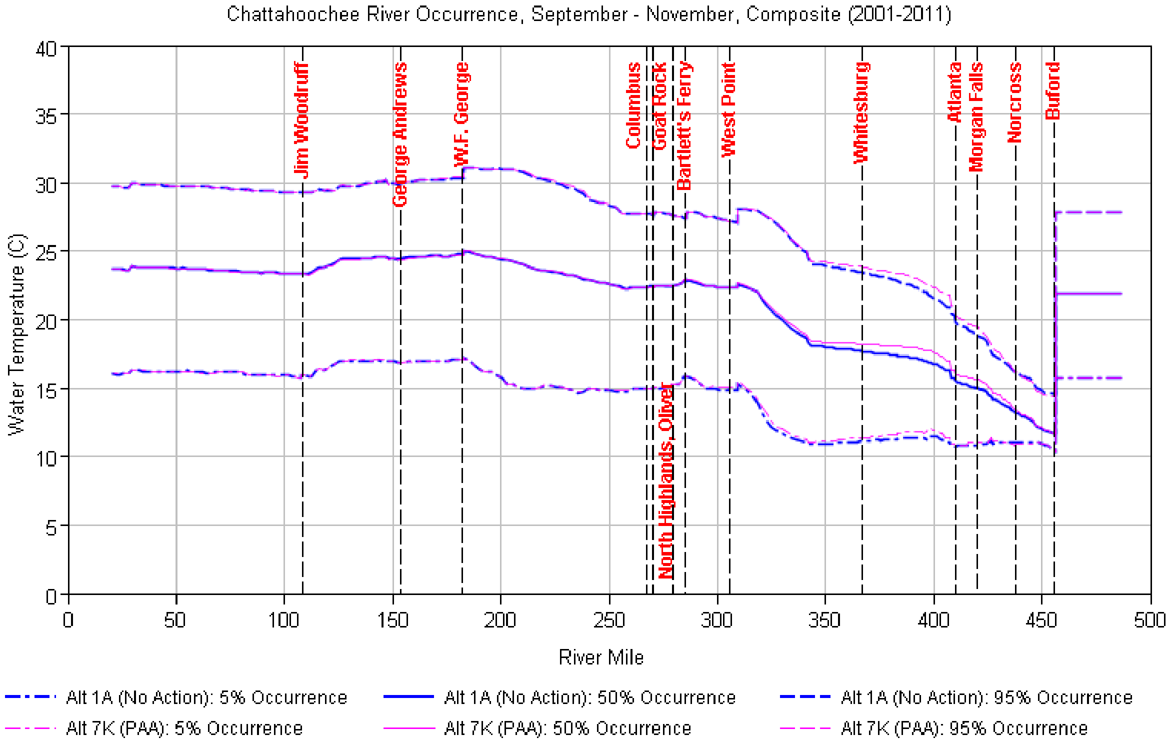


Figure 25. HEC-5Q Simulated Water Temperature (Degrees Celsius) Under the PAA (Sep-Dec)(ResSim simulated flow 1975-2011).

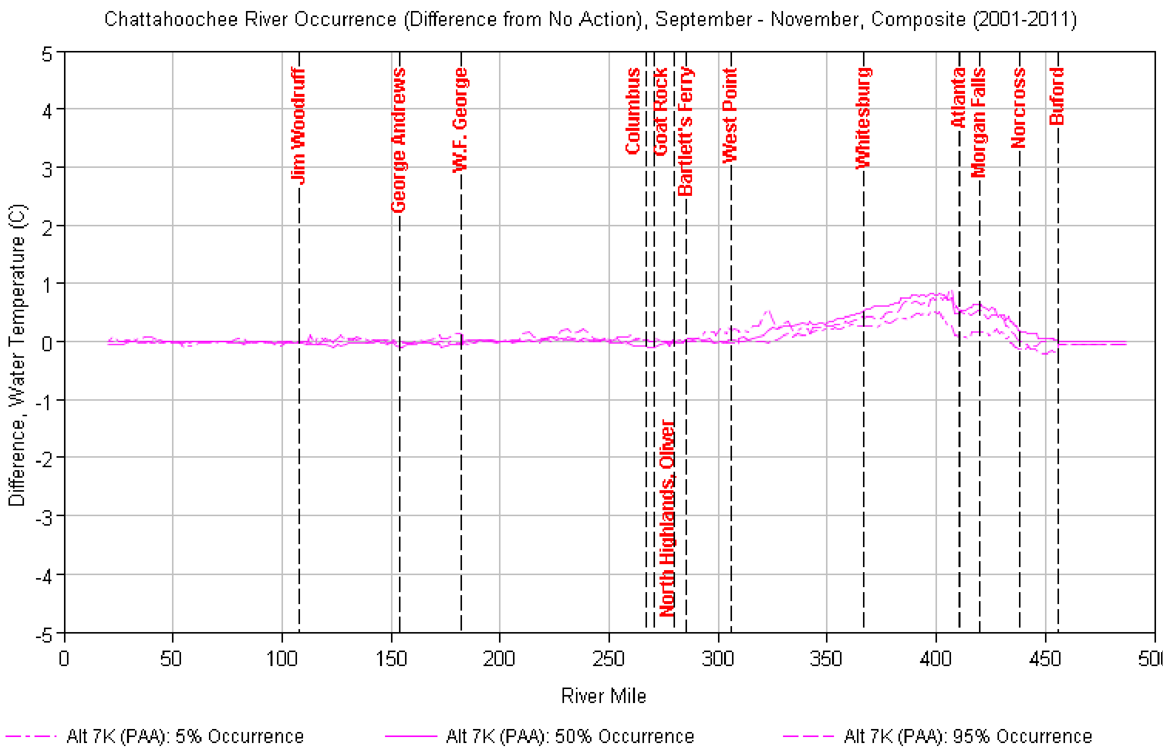


Figure 26. Difference in Water Temperature (Degrees Celsius) Between the NAA (ResSim simulated flow 1975-2011) and PAA (Sep-Dec) (ResSim simulated flow 1975-2011).

Changes in Salinity and Invertebrate Populations in Apalachicola Bay

Very little is known about Gulf sturgeon feeding behavior and habitat selection in Apalachicola Bay. However, Gulf sturgeon studies in other systems, known life history patterns, and other studies of the role of freshwater inflow in estuarine ecology can be used to evaluate the possibility of effects of the PAA on Gulf sturgeon in Apalachicola Bay.

Studies indicate that most adult and sub-adult sturgeon limit feeding almost exclusively to estuarine and marine environments upon departing the river and do not feed much, if at all, during the months of riverine residency. Juvenile Gulf sturgeon studies have also established that direct transition from fresh water into salinities greater than 30 ppt is lethal, and gradual acclimation to seawater with higher salinities (34 ppt) is required. Juvenile growth rates are highest at 9 ppt salinity (USFWS 2008, USFWS 2012).

Since Apalachicola Bay is the first estuarine habitat that both juvenile fish and older fish encounter upon departing the river, substantial alteration of flow regime features may directly relate to sturgeon and sturgeon critical habitat elements in the bay and should be minimized or avoided. Adverse impacts to ecological processes in the bay critical to sturgeon can be evaluated by comparing the number of consecutive days per year that flows less than 16,000 cfs occurred for the various flow time series. Figure 27 illustrates this comparison and indicates that the PAA is comparable to the Baseline flow regime. The PAA provides slightly greater maximum numbers of consecutive days per year less than 16,000 cfs (median 134 consecutive days) than the Baseline (median 128 consecutive days). However, given the similarities of the two flow regimes with regards to this flow-dependent habitat parameter, it appears effects (if any at all) are a continuation of the baseline condition.

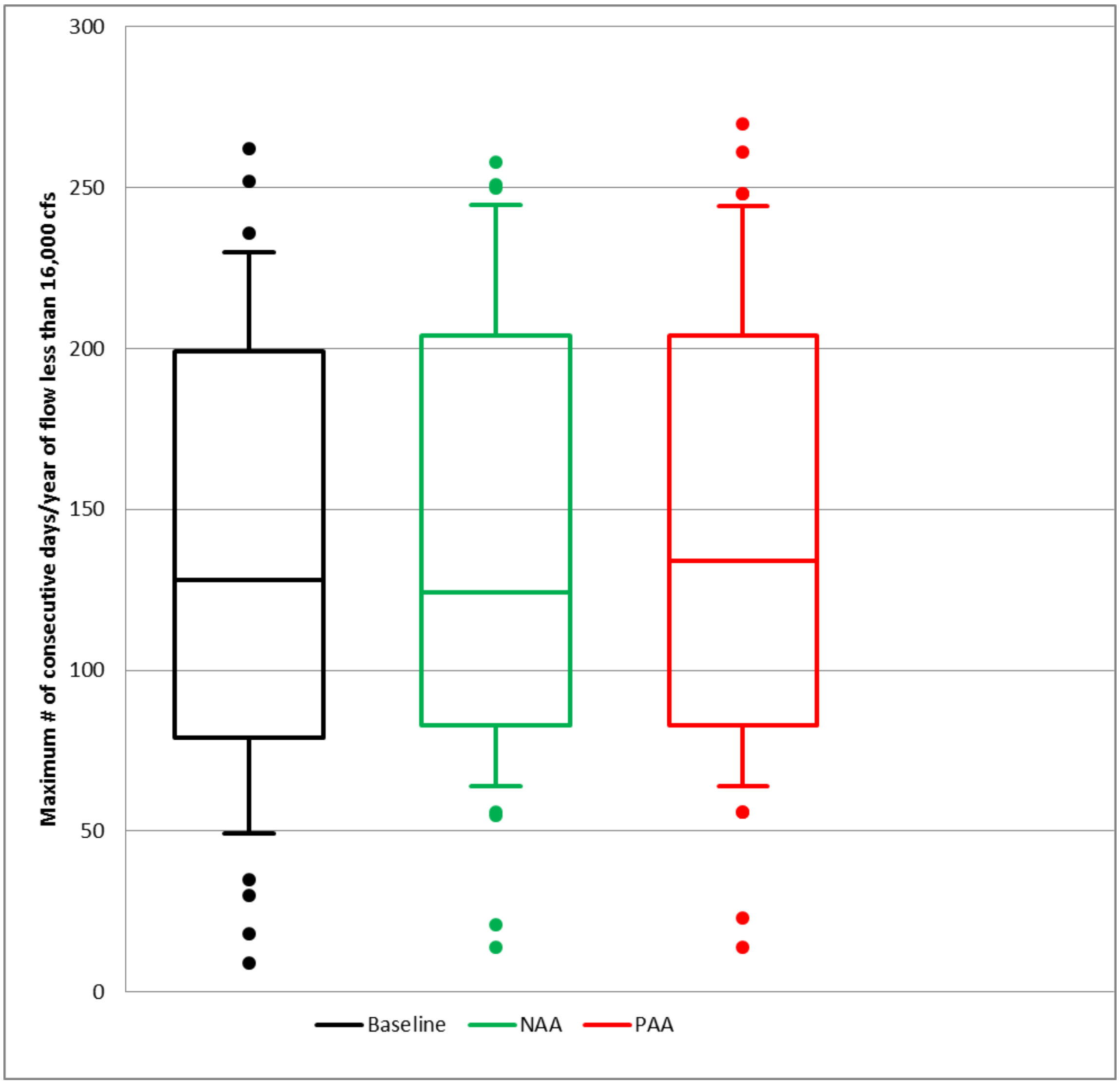


Figure 27. Maximum number of consecutive days/year of flow less than 16,000 cfs under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Since Gulf sturgeon do not utilize the bay year-round, but rather occupy it seasonally (October through March), we also conducted this same evaluation but used only observed and simulated data from the months sturgeon are known to actively forage in the Apalachicola Bay. Since the October – March season includes data from two calendar years; the results are presented as the maximum number of consecutive days per season of flow less than 16,000 cfs. Figure 28 presents the results of this analysis. Again, the NAA and PAA scenarios yield results consistent with the Baseline. However, when focusing on the months when sturgeon are known to utilize the bay, the PAA reduces the maximum number of consecutive days with flows less than 16,000 cfs as compared to the Baseline flow regime. This would be beneficial to Gulf sturgeon and their prey resources in the bay.

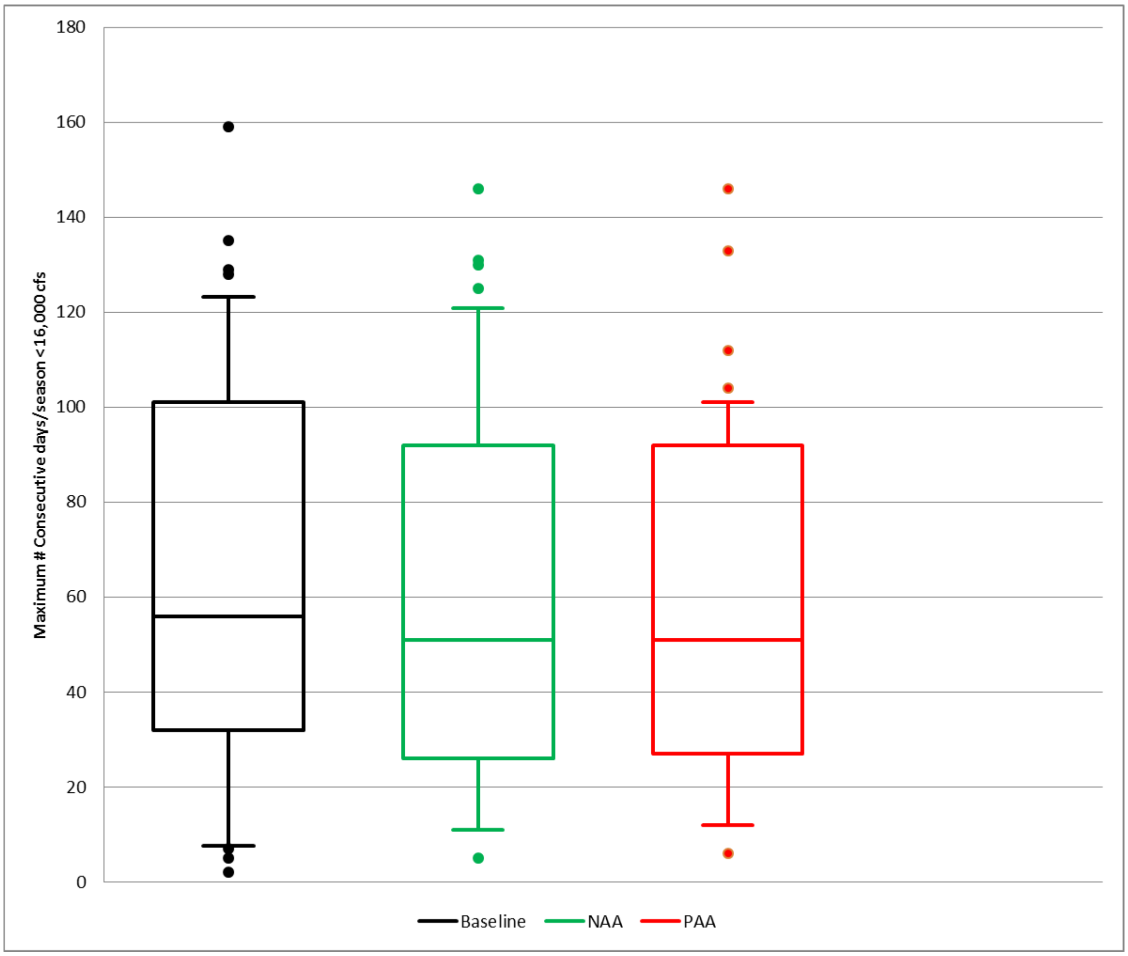


Figure 28 Maximum number of consecutive days/season of flow less than 16,000 cfs (October-March) under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

In addition to the analysis presented above, preliminary results of salinity modeling provided by the Service to the USACE, conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the Baseline and the 2015 proposed action (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA presented here. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in the metro-Atlanta area. The PAA provides for less water supply in the metro-Atlanta area than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those of the 2015 proposed action.

LISTED MUSSEL SPECIES EFFECTS ANALYSIS

This section focuses on direct effects to listed mussels by potential exposure during low-flow conditions. During the summer of 2006 and fall of 2010, and 2013-2015, listed mussels were found exposed and stranded at elevations up to approximately 10,000 cfs. Therefore, consistent with previous BOs, impacts to listed mussel species will be evaluated by analyzing the differences between the flow regimes in the range of flow less than 10,000 cfs.

Table 10 lists the lowest daily flow each year for the NAA, PAA and Baseline flow regimes. The NAA and PAA simulations result in similar annual 1-day minimum flows. The NAA includes one year (2007) with flows less than 5,000 cfs and the PAA includes two years (2007 and 2011). The Baseline includes eight occurrences of 1-day minimum flows less than 5,000 cfs. With regards to this flow-dependent habitat parameter, the proposed action provides a mix of beneficial and adverse effects.

Table 10. Annual 1-day Minimum Flow (cfs) of the Apalachicola River at the Chattahoochee Gage for the NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Year	Min of Baseline	Min of NAA	Min of PAA
1975	12400	15091	15072
1976	11600	9233	9266
1977	9220	7035	6991
1978	8190	7215	6599
1979	9590	7977	7322
1980	8790	6957	6875
1981	4980	5191	5183
1982	11500	9091	9092
1983	10800	8877	8877
1984	10300	8380	8380
1985	8550	7031	6581
1986	4430	5049	5049
1987	3900	6273	6435
1988	4430	5133	5050
1989	9140	8504	6112
1990	5540	6331	6308
1991	6580	9081	9082
1992	7650	8974	7825
1993	5150	6252	5814
1994	7590	9564	10816
1995	7130	7287	7173
1996	6350	7834	7784
1997	6250	5938	5911
1998	8130	8450	8416
1999	5280	5050	5050
2000	4530	5050	5050
2001	5360	5250	5194
2002	5250	5050	5050
2003	8050	9054	9080
2004	7360	7187	6250
2005	8670	9240	9235
2006	5030	5049	5050
2007	4760	4550	4550
2008	4940	5050	5050
2009	5650	7001	7483
2010	5080	5706	5732
2011	4340	5015	4550
median	6580	7031	6581
mean	7094	7162	7009
count<5K	8	1	2
% of yrs	21.6	2.7	5.4

Submerged Habitat Below 10,000 cfs

Figure 29 shows the inter-annual frequency (percent of years) of flow rates less than 5,000 to 10,000 cfs in the three flow regimes. The PAA generally provides for a higher inter-annual frequency of flow events less than 10,000 cfs. However, the PAA results in a lower occurrence of flows less than about 6,500 cfs and limits flows less than 5,000 cfs to two years (5%). Flows less than 5,000 cfs occurred in approximately 22% of the years under the Baseline flow regime. By reducing the frequency of the most extreme low flows, the PAA provides a beneficial effect. With regards to this flow-dependent habitat parameter, the PAA again provides a mix of beneficial and adverse effects as compared to the Baseline.

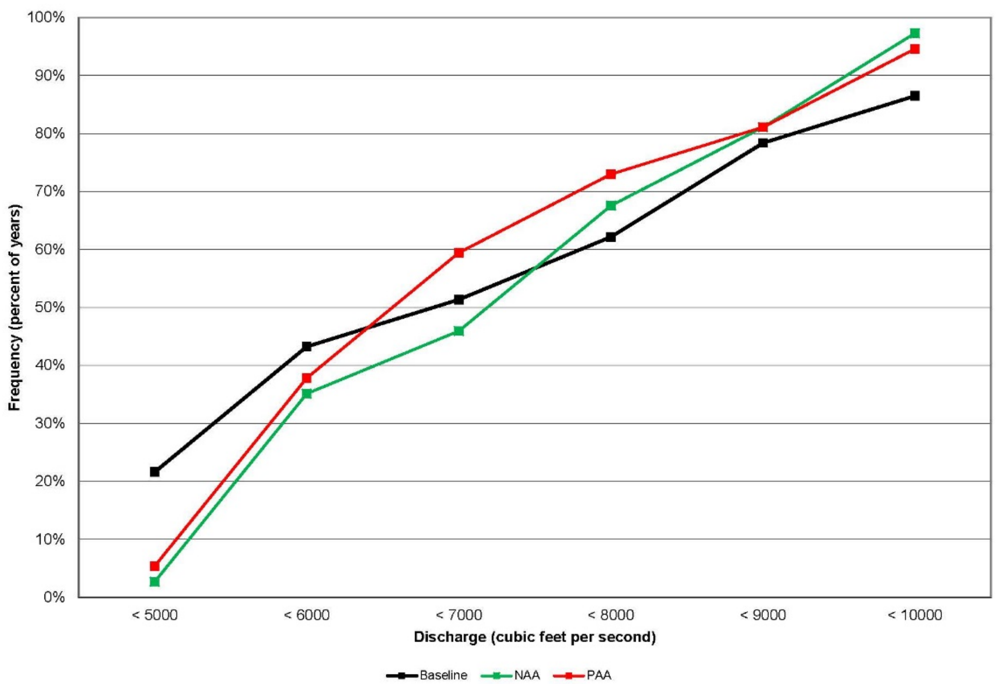


Figure 29. Inter-annual frequency (% of years) of discharge events less than 5,000 to 10,000 cfs under NAA, PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Consistent with the previous BOs, we use the maximum number of days per year with flows less than 5,000 to 10,000 cfs as a measure of the most severe year for aquatic biota under each flow scenario (Figure 30). The NAA and PAA have nearly identical results with regard to this flow-dependent habitat parameter; except for flows less than 5,000 cfs. All of the flow regimes include more than 200 days during the driest year at all flow levels except the <5,000 cfs level. The maximum annual duration of flow less than 5,000 cfs is 79 days and occurs in the PAA flow regime compared to the Baseline value of 34 days, which is an adverse effect to mussels. The maximum number of days less than 6,000 cfs is slightly greater than the Baseline for both the

NAA and PAA flow regimes. However, the NAA and PAA provide slightly less maximum number of days per year at all flow levels between 7,000 and 10,000 cfs than the Baseline, which is a beneficial effect for mussels. A mix of beneficial and adverse effects is realized.

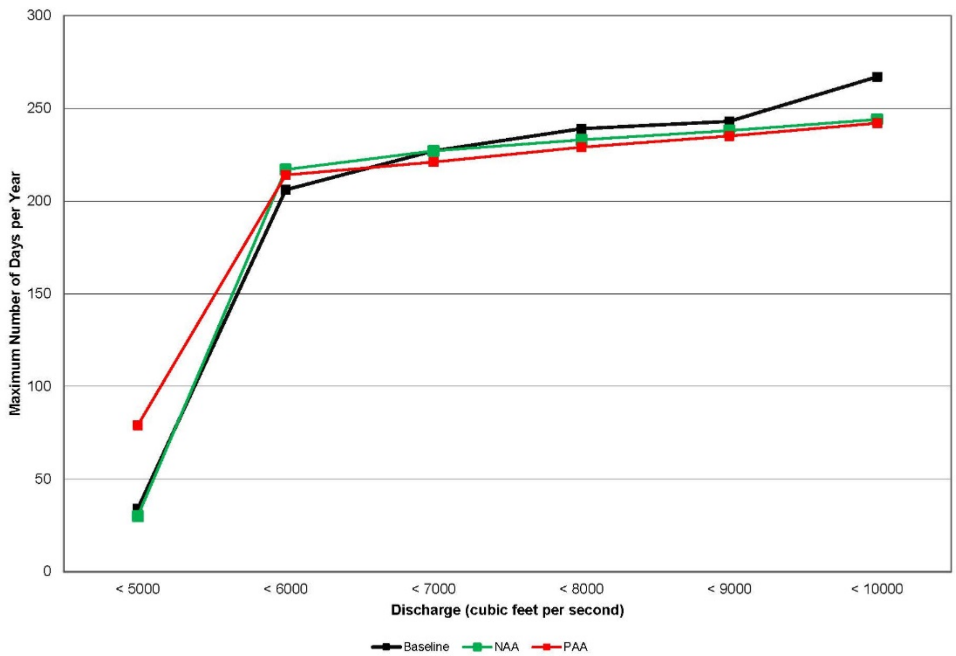


Figure 30. Maximum number of days per year of discharge less than 5,000 to 10,000 cfs NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

On multiple occasions in recent years, the Service has observed mussels surviving brief periods of exposure by closing their shells tightly or burrowing into the substrate (USFWS 2008; K. Herrington Pers. Comm. 2011). Those observations were documented in a study by the Service (Kaeser and Herrington, 2011) who found that 70% of fat three ridge survive seven days or less of exposure. A smaller percentage of approximately 8% survived from 7-27 days by burying themselves completely into the substrate. Typically, unless water temperature is extreme, the stress of exposure is most likely a function of exposure duration. Figure 31 illustrates a most-severe event analysis, consistent with the previous BO, by computing the maximum number of consecutive days of flow less than the 5,000 to 10,000 cfs. The PAA and NAA have similar results with regard to this flow-dependent habitat parameter; except for flows less than 5,000 cfs. All of the flow regimes include periods of consecutive days with flows less than 5,000 cfs. However, the PAA provides for the greatest maximum number of consecutive days less than 5,000 cfs. The PAA and NAA flow regimes also have an adverse effect at the 6,000 cfs level. Both flow regimes substantially increases the maximum number of consecutive days per year for flows less than 6,000 cfs over the Baseline. For all the other flow categories the PAA and NAA yield a lower maximum number of consecutive days than the Baseline flow regime. These results are consistent with the effects of the previous RIOPs and BOs. However, all of the flow regimes have an extreme effect on mussels at the 6,000 cfs level and greater, because it is unlikely that mussels would survive an exposure under even the best of the flow regimes, the Baseline, with 104 consecutive days. As noted above, the maximum number of consecutive days below 5,000 cfs is 34 for the Baseline, which slightly exceeds the maximum survivable exposure time found by Kaeser and Herrington (2011). Because the most-severe events result in consecutive days that exceed the maximum survivability for all the flow regimes, it is unlikely that increased take due to exposure would occur under the PAA.

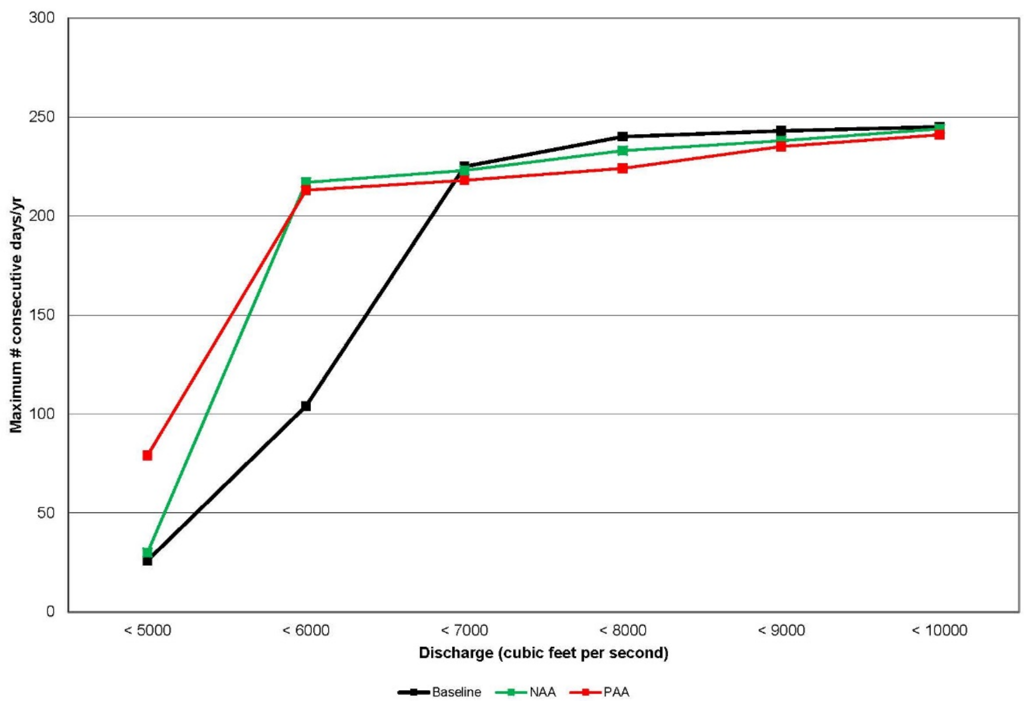


Figure 31. Maximum number of consecutive days per year of discharge less than 5,000 to 10,000 cfs under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Similar to the evaluation in the 2012 BA (USACE 2012), we analyzed the less severe, but more frequent exposure events to determine if the PAA was comparable or improved upon the Baseline condition. This analysis consisted of computing the median number of consecutive days of flow less than the 5,000 to 10,000 cfs. Figure 32 displays the results of this analysis. All of the flow regimes resulted in event durations short enough to potentially allow mussels to survive exposure by closing their shells tightly or burrowing into the substrate (less than approximately 27 days) for flows less than about 9,500 cfs. For flows greater than 9,500 cfs, all the flow regimes resulted in event durations of greater than 27 days. It appears with regards to this flow dependent parameter that effects of the PAA (if any) are a continuation of the baseline effect.

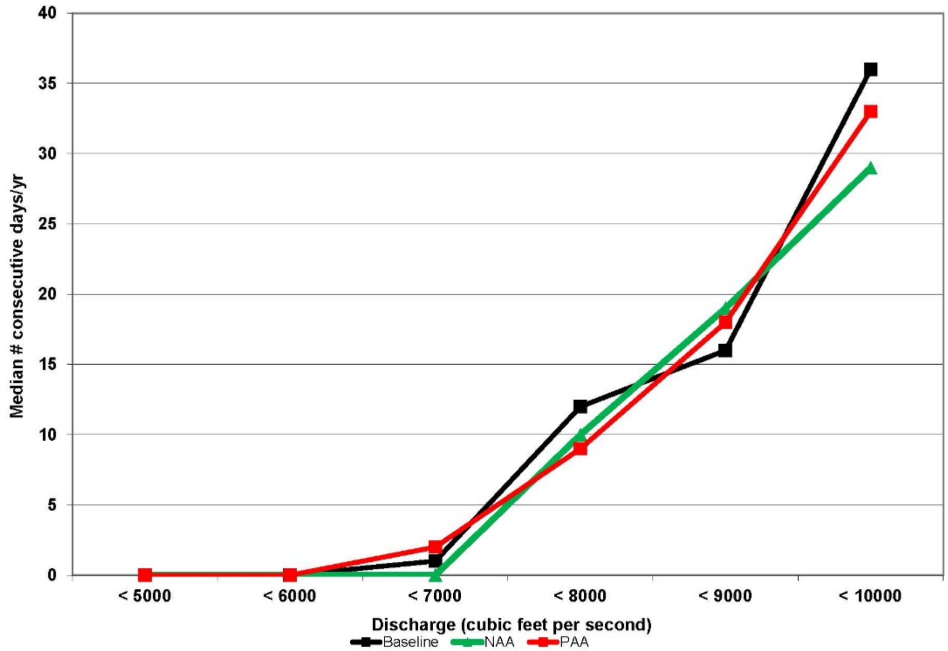


Figure 32. Median number of consecutive days per year of discharge less than 5,000 to 10,000 cfs under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011) and Baseline (observed flow 1975-2011).

Although the PAA flow regime potentially results in a mix of adverse and beneficial effects to listed mussels, the overall result for this metric appears to be a continuation of the effects realized under the baseline condition.

Consistent with the 2012 BA (USACE 20102) we analyzed the median total number of days per year less than the thresholds of 5,000 to 10,000 cfs (Figure 33). Similar to median number of consecutive days, the median total number of days resulted in all flow regimes being similar across all flow categories. No differences were found at the less than 5,000 and 6,000 cfs flow levels. Despite the similarity, the PAA resulted in slightly greater median number of days for all other flow levels compared to either the NAA or the Baseline. This is a slight difference but represents a greater adverse effect to listed mussels than the current operation.

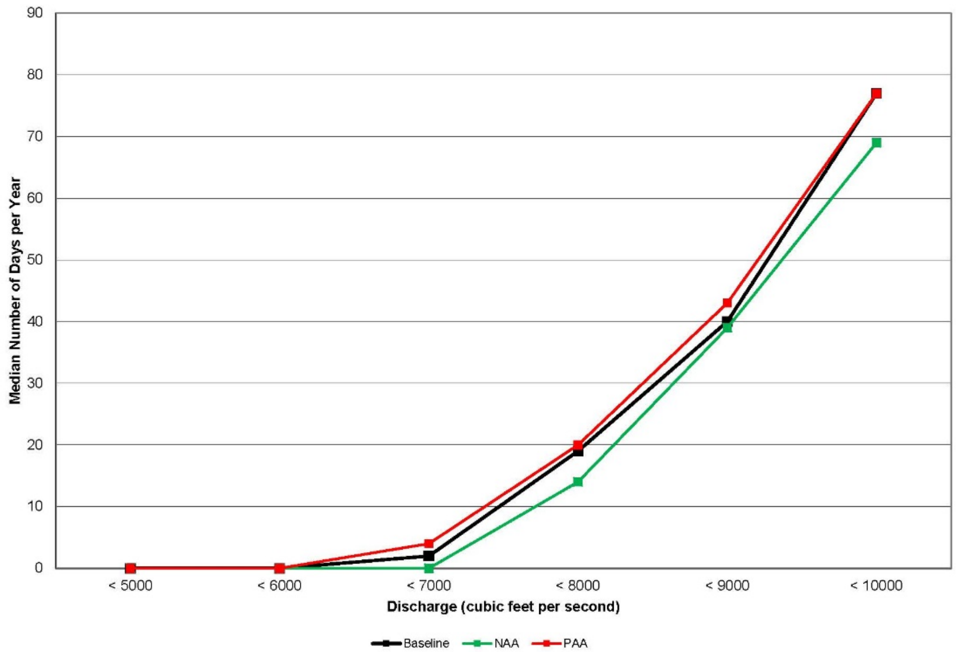


Figure 33. Median number of days per year of discharge less than 5,000 to 10,000 cfs under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011), and Baseline (observed flow 1975-2011).

As described in the DESCRIPTION OF PROPOSED ACTION section above, the proposed action continues to utilize the RIOP maximum fall rate schedule, with the exception that the maximum fall rate would be suspended when the basin composite storage falls below Zone 2 (Under the NAA the maximum fall rate schedule is suspended when the basin composite storage falls below Zone 3). As previously described the suspension of the maximum fall rate schedule during the drought plan does not occur until the minimum release of 5,000 cfs is met. The maximum fall rate schedule limits operations to more gradual fall rates as flow declines to the river stages where listed mussels may occur in order to facilitate, as much as possible, the movement of mussels and other aquatic biota from higher to lower elevation habitats. The general intent of the schedule is to avoid extreme daily declines in river stage and thereby lessen the potential for exposing or stranding listed mussels, their host fish, and other aquatic biota. Consistent with the previous BOs, the effects of altered fall rates were analyzed by comparing the daily average fall rates observed at the Chattahoochee gage (Baseline) to those computed for the simulated daily flows under the PAA and the NAA. The methodology for computing the daily average fall rates is the same.

Figure 34 is a frequency histogram of the rate of change results, which lumps all stable or rising days into one category and uses the ranges that correspond to the maximum fall rate schedule as categories for the falling days (<=0.25 ft/day, > 0.25 to <= 0.50 ft/day, > 0.50 to <= 1.00 ft/day, > 1.00 to <= 2.00 ft/day, and > 2.00 ft day). The PAA includes the current maximum fall rate schedule with the previously described modification. Since the listed mussels are known to occur at flows between 5,000 and 10,000 cfs, preservation of the more conservative maximum fall rates should facilitate the movement of mussels as river stages decline. The most critical fall rate category is likely the 0.25 or less ft/day category which corresponds to the maximum fall rate provision for flows ≤ 10,000 cfs. Among the falling days, rates less than 0.25 ft/day are the most common occurrence in all of the flow regimes. The NAA has a higher frequency of days when fall rates are in the less than 0.25 ft/day range compared to the Baseline and PAA. The PAA results in slightly less frequent fall rates than the Baseline in this important fall rate category. The PAA has slightly higher frequencies than the Baseline for all other fall rate categories except the fall rate greater than 2.00 ft/day category.

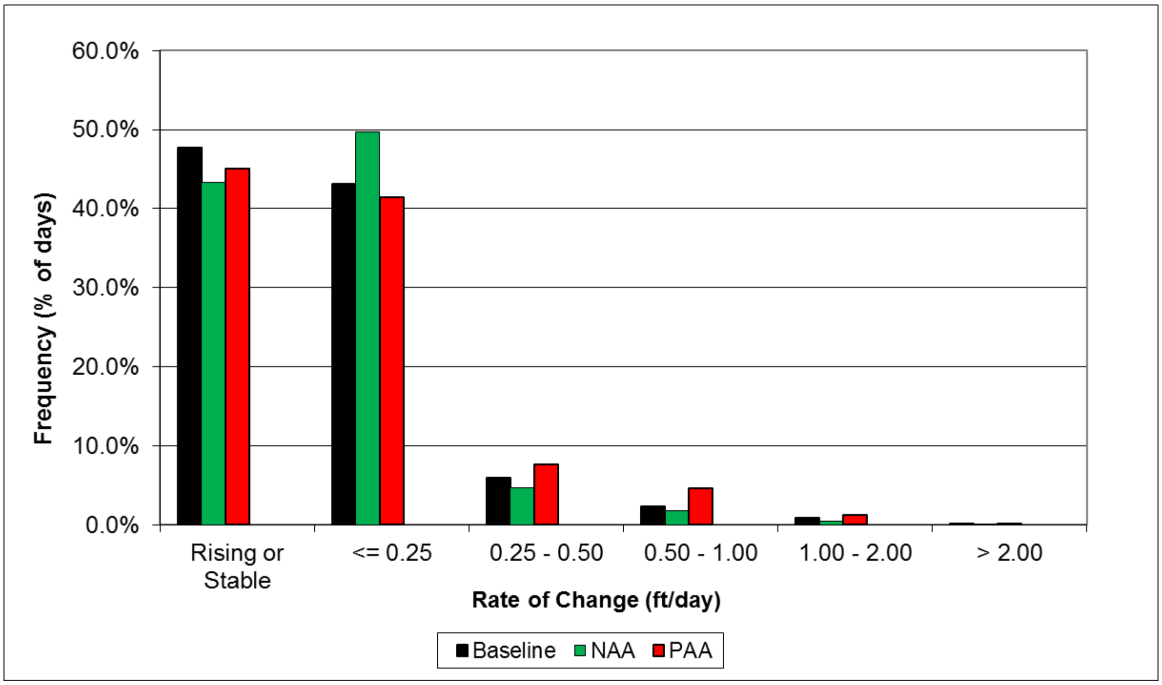


Figure 34. Frequency (percent of days) of daily stage changes (ft/day) under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011), and Baseline (observed flow 1975-2011).

In the most extreme fall rate categories, > 2.00 ft/day, the PAA and NAA result in essentially the same frequency as the Baseline (0.1%, 0.0% and 0.1%, respectively). The shift of the PAA to the higher fall rate categories occurring more frequently is a result of changes to the drought operation plan that result in drought operations and the suspension of the maximum fall rate schedule being implemented more frequently. The PAA drought operations plan was developed to be a proactive approach to water management that better positions the USACE projects to withstand multi-year droughts. With regards to this flow-dependent habitat parameter, the PAA results in adverse effects as compared to the Baseline.

As noted in the 2012 BO, the Service has observed mussels exposed at stages as high as about 10,000 cfs (USFWS 2012). Therefore, listed mussels could potentially be directly impacted by increases in the number of days that fall rates greater than 0.25 ft/day occur and flows are less than 10,000 cfs. Figure 35 shows a count of days in the various rate-of-change categories when flow was less than 10,000 cfs. The methodology for conducting the analysis is the same as that used in the 2012 BO.

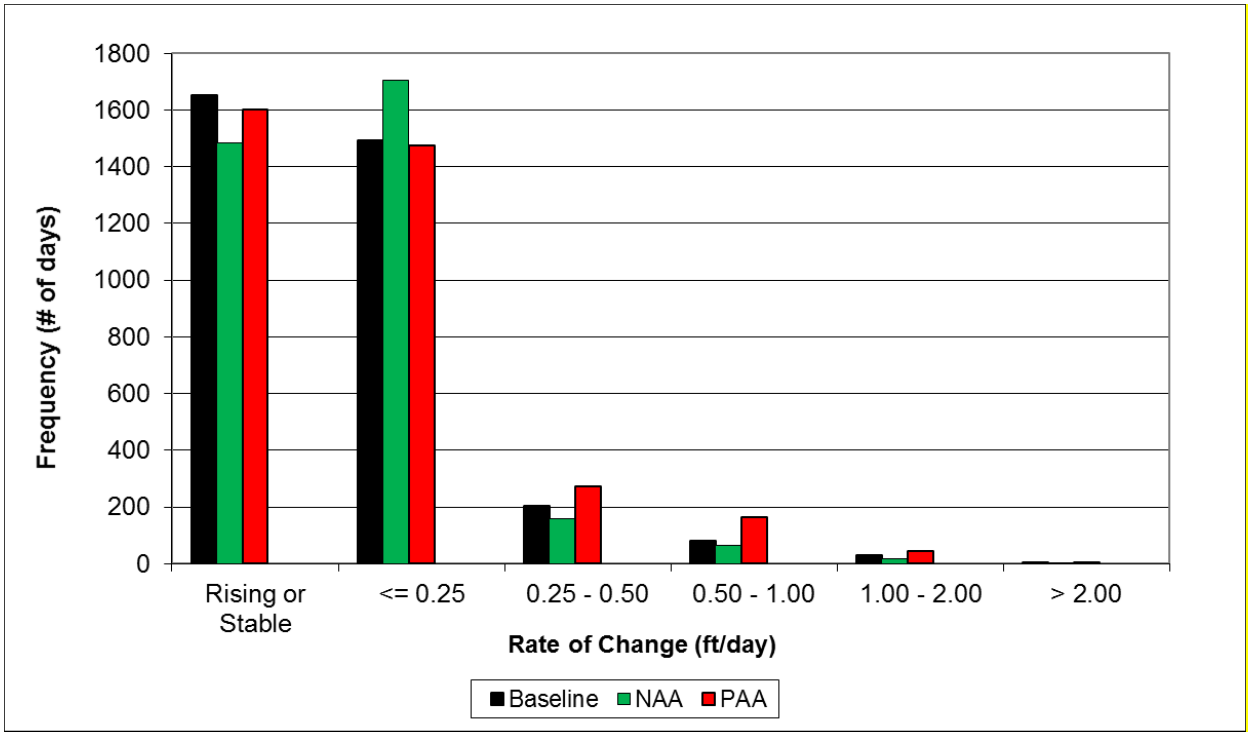


Figure 35. Frequency (number of days) of daily stage changes (ft/day) when releases from Woodruff Dam are less than 10,000 cfs under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011), and Baseline (observed flow 1975-2011).

Similar to the previous analysis, among the falling days, rates less than 0.25 ft/day are the most common occurrence in all of the flow regimes. The number of days in the greater than 0.25 ft/day categories for the PAA is greater than the Baseline (481 and 316 days respectively). This is an adverse effect to the listed mussels as it increases the number of days that the greater fall rates are occurring. Table 9 presents a comparison of the maximum and average daily fall rates for each fall rate category under the PAA simulation and the Baseline flow regimes. The maximum and average daily fall rates under both flow regimes are comparable.

Table 9. Maximum and average daily fall rates (ft/day) for each fall rate category when releases from Woodruff Dam are less than 10,000 cfs under Modified RIOP (ResSim simulated flow 1975-2008) and Baseline (observed flow 1975-2008).

	PAA		Baseline	
Fall Rate Range (ft/day)	Maximum Fall Rate (ft/day)	Average Fall Rate (ft/day)	Maximum Fall Rate (ft/day)	Average Fall Rate (ft/day)
<=0.25	0.25	0.12	0.25	0.07
>0.25 - <=0.5	0.50	0.35	0.50	0.34
>0.5 - <=1.0	1.00	0.68	1.00	0.70
>1.0 - <=2.00	1.99	1.28	2.00	1.37
>2.00	4.48	2.07	6.10	2.21

FLOODPLAIN CONNECTIVITY AND SYSTEM PRODUCTIVITY

The Apalachicola River floodplain is a highly productive area that likely provides spawning and rearing habitats for one or more of the host fishes of the listed mussel species. Floodplain inundation is also critical to the movement of organic matter and nutrients into the riverine feeding habitats of both the mussels and juvenile sturgeon, and into the estuarine feeding habitats of juvenile and adult sturgeon (USFWS 2012). Therefore, listed mussels and sturgeon can be indirectly affected by changes to the frequency, timing, and duration of floodplain habitat connectivity and inundation.

To assess these effects we compare the flow regimes on the timing and duration of floodplain habitat connectivity and inundation. Consistent with the previous BOs, this is accomplished by utilizing the relationship documented by Light *et al.* (1998) between total area of non-tidal floodplain area inundated and discharge at the Chattahoochee gage (USFWS 2008, USFWS 2012). Figure 36 displays a frequency analysis of the results of transforming the daily discharge time series during the growing season months (April – October) to connected floodplain area. All three flow regimes provide for essentially the same frequency of floodplain habitat inundation, with the NAA and PAA resulting in nearly identical frequencies. The median amount of connected habitat under the PAA (acres inundated for half of the growing season days 1975-2011) is 1,766 acres, compared to 2,200 and 1,747 acres for the Baseline and NAA flow regimes. However, the curves for the proposed action and the Baseline flow regimes cross each other several times. Therefore, with regards to this flow dependent habitat parameter, it appears that effects (if any at all) are likely a continuation of the Baseline effect.

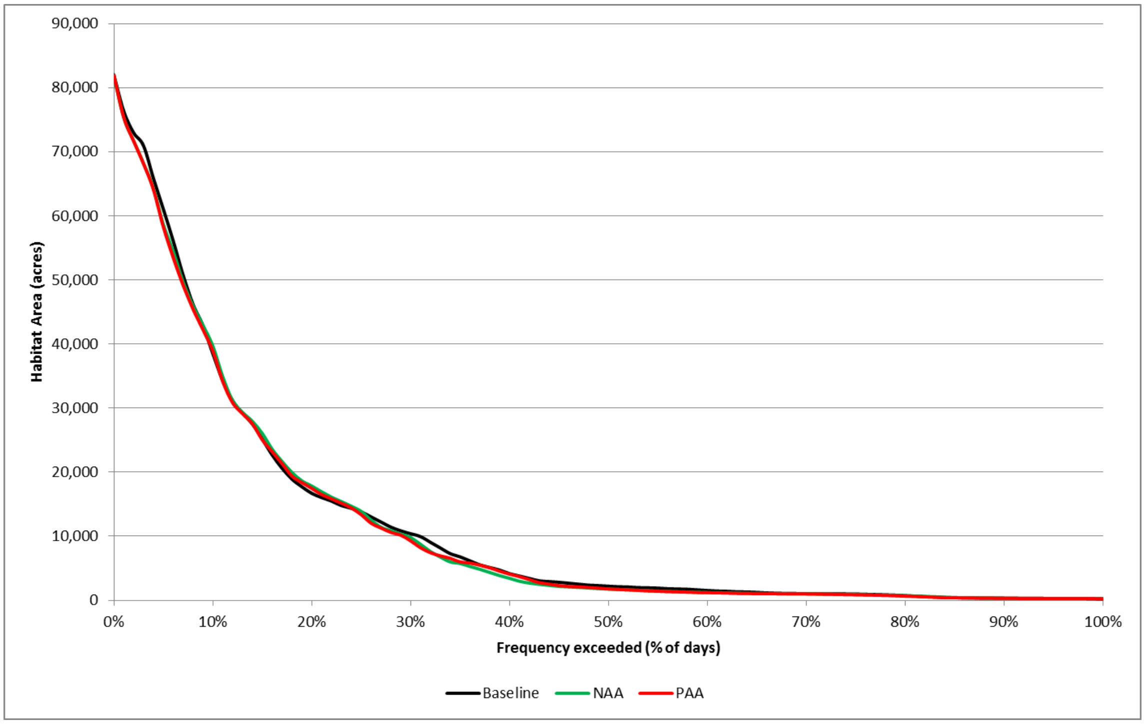


Figure 36. Frequency (percent of days) of growing-season (April-October) floodplain connectivity (acres) to the main channel under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011), and Baseline (observed flow 1975-2011).

In order to interpret biological effects related to the temporal pattern of floodplain inundation we evaluate the annual 30-day continuous floodplain habitat inundation consistent with the methodology described in the previous BOs and the August 29, 2013 PAL. Figure 37 displays the results of this analysis. The PAA and the NAA provide similar annual 30-day continuous connectivity. The PAA generally results in more annual 30-day continuous connectivity than the Baseline flow regime. The median amount of 30-day continuous connected habitat under the PAA (acres inundated for at least 30 days in half of the years 1975-2011) is 11,153 acres, compared to 11,128 and 11,242 acres for the Baseline and NAA flow regimes, respectively. However, the Baseline flow regime includes a greater maximum and minimum number of acres inundated for at least 30 days than the PAA. Therefore, with regards to this flow dependent habitat parameter, it appears that effects (if any at all) are likely a continuation of the Baseline effect.

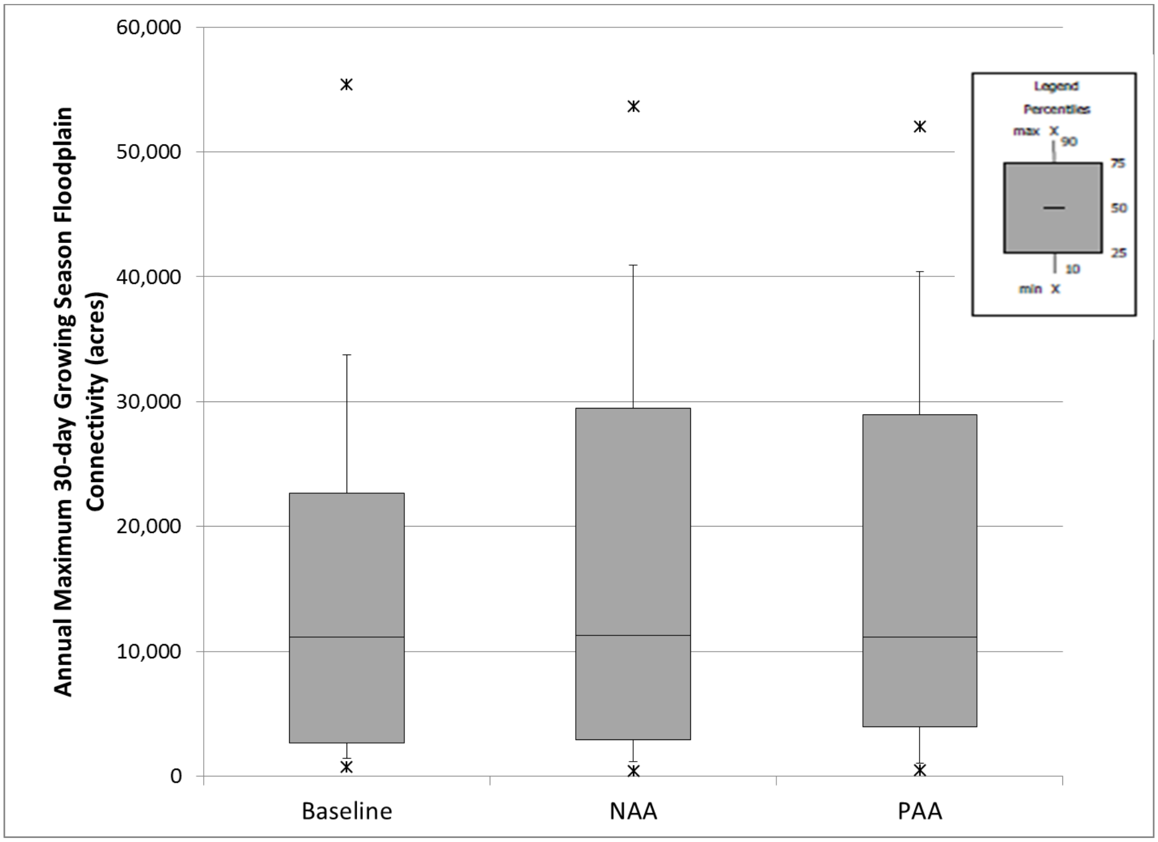


Figure 37. Frequency distribution of annual maximum 30-day continuous floodplain habitat availability during the growing season (April-October) under NAA (ResSim simulated flow 1975-2011), PAA (ResSim simulated flow 1975-2011), and Baseline (observed flow 1975-2011).

CLIMATE CHANGE

Scientific evidence from the immediately preceding decades demonstrates that natural climate variability may be changing. These anticipated changes may reflect shifts in the average or baseline conditions, regional meteorological phenomena, and the range of variability of those phenomena. These potential changes have potential implications regarding the capacity of USACE projects and operations to accommodate different climatological baselines, greater climatological variation, and a wider range of meteorological conditions.

The ACF Master WCM project delivery team, in response to USACE guidance and public interest and input, engaged the Institute for Water Resources (IWR) to develop a numerical model to evaluate the resilience and limitations of proposed ACF Basin water management scenarios in response to potential climate change conditions. The ACF numerical model was developed to correlate with the HEC-ResSim model for the ACF system. Simulating the model-projected critical yield in HEC-ResSim would provide an indication of the effects of prospective climate change on hydrology in the ACF Basin. The objective of this effort was a quantitative analysis of potential climate change in ACF Basin hydrology and ACF Basin management. This climate change analysis capitalized on existing data and methodologies developed by a coalition of agencies and academic institutes as part of the Coupled Model Intercomparison

Project, Phase 5 (CMIP5) (LLNL 2015). In broad terms, a general circulation model (GCM) numerically representing the physical processes (e.g., atmospheric, land surface) of the ACF Basin was employed to estimate basin climate change due to human influences. The GCM outputs were statistically scaled to a finer time and space scale, and bias corrected. The scaled and corrected GCM outputs were applied to a variable infiltration capacity (VIC) model. The Liang VIC model is a globally applied, open-source, macroscale hydrologic model that solves for water-energy balance (University of Washington 2015).

The methodologies applied for the ACF Basin climate change analysis and the approach by which the results were used in the HEC-ResSim models are described in detail in the documentation presented in Appendix N of the DEIS (USACE 2015), included here as Appendix A. The smoothed local incremental flow set was used in the Climate Change ResSim modeling effort. Local incremental flows are smoothed using a 3, 5, or 7 day center moving average to eliminate the occurrence of negative cumulative unimpaired flows. This resulting cumulative flow data set was used in the climate change analysis. Monthly factors were applied to the 1978-2009 cumulative data set to estimate the forecasted climate change flow data set.

For the purposes of this climate change analysis, the climate change-affected unimpaired flow (UIF) results for 2021–2050 were used in the ACF Basin HEC-ResSim model to compute a range of outputs for discharge measured at the Chattahoochee gage that may be expected should climate change trends continue. Years 2021–2050 most closely match the anticipated project lifespan for the Master WCM update/WSSA analyses. A 30-year period of record (1978-2008) was simulated for the PAA under three basin hydrologic conditions (10th percentile [wet], 50th percentile [median], and 90th percentile [dry]). The results of the simulations can be compared to the Baseline results for the same period of record to assess how the listed species are affected under future climate conditions with the PAA implemented.

Figure 38 displays the frequency analysis (percent of days flow exceeded) at the Chattahoochee gage for the four flow regimes (Baseline, PAA wet, PAA median, and PAA dry), to illustrate the flow differences between them. The PAA wet flow regime results in higher discharges than the Baseline flow regime. The PAA median and PAA dry flow regimes generally provide comparable or higher discharges than the Baseline flow regime for half of the record and lower discharges than the Baseline flow regime for the other half of the record. The PAA median and PAA dry flow regimes result in lower discharges occurring more frequently than occurred under the Baseline flow regime.

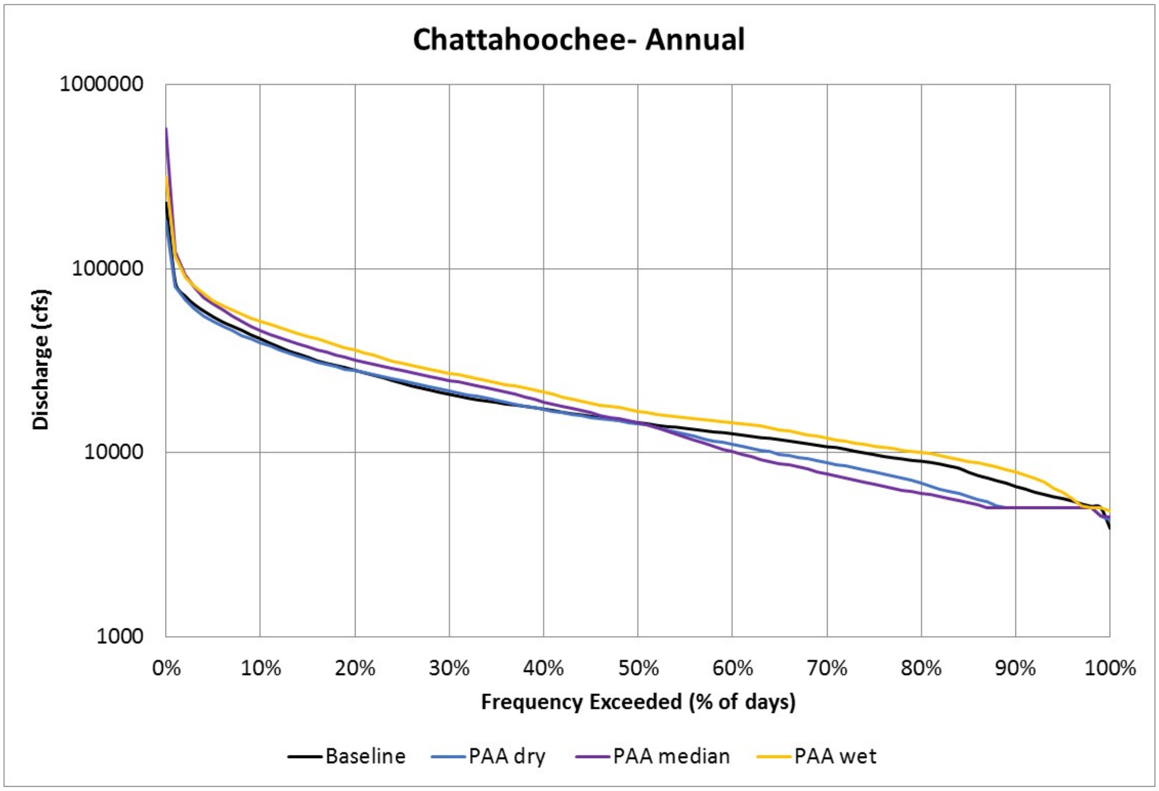


Figure 38. Observed and simulated flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage under PAA Dry (ResSim simulated flow 1978-2008), PAA Median (ResSim simulated flow 1978-2008), PAA Wet (ResSim simulated flow 1978-2008), and Baseline (observed flow 1978-2008).

CUMULATIVE EFFECTS

In previous BAs, we considered the cumulative effects of implementing a proposed action by focusing on the effects of increased water depletions due to an increase in M&I use. This was accomplished by applying a projected increase in M&I depletions to the ResSim model simulation (i.e., a 27% increase to M&I was applied in the 2012 BA). The PAA includes water supply depletions at Lake Lanier and from the Chattahoochee River downstream of Buford Dam consistent with the 2040 projected amounts identified in the State of Georgia's 2015 request. Since the PAA includes the 2040 M&I water supply demands, the analysis above provides insight into the cumulative effects of implementing the PAA. In addition, the climate change analysis provides additional insight into potential flow conditions in the Apalachicola River through the year 2050.

In general, all of the PAA flow regime scenarios evaluated increase the frequency and duration of flows less than 10,000 cfs as compared to the Baseline. However, the PAA continues to offset the impact of an increase in depletions or climate change by maintaining minimum releases of 5,000 cfs from Jim Woodruff Dam in all but two of the simulated years (when releases drop to 4,500 cfs). Both of these years represent critical droughts for the basin. The 2007 drought was a 1-in-200 year event. The Baseline condition includes flows as low as 3,900 cfs. Furthermore, water conservation programs implemented by the State of Georgia, should extend the time until full implementation of the 2040 demand assumption.

CONCLUSIONS

Gulf Sturgeon

Based on the effects analyses described above, the USACE has determined that the PAA may affect but is not likely to adversely affect Gulf sturgeon and that it may affect but is not likely to adversely modify Gulf sturgeon critical habitat. Therefore, we request concurrence with this determination per section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*).

Fat Threeridge

The PAA presents a new basin-wide water management plan and water withdrawal assumption. The PAA also includes efforts to minimize the potential for "take" of fat threeridge mussels when releases are less than 10,000 cfs while continuing to meet authorized project purposes. In the 2012 BO, the Service determined that "take" of listed mussel species occurs when releases from Jim Woodruff Dam are less than 5,000 cfs and when releases are between 5,000 and 10,000cfs. The PAA still includes a provision for releases as low as 4,500 cfs and implements minimization measures, but does not eliminate adverse effects to the species when releases are between 5,000 and 10,000 cfs and mussels have re-colonized at stages in this flow range. The period of record simulation (1975-2011) of the PAA includes two years with releases less than 5,000 cfs which occur in multiple years under the Baseline flow regime. Limiting the frequency of flows less than 5,000 cfs is a beneficial effect. "Take" of fat threeridge when releases are between 5,000 and 10,000 cfs is dependent upon re-colonization of the species at stages in this flow range and discretionary operations by the USACE that influence these flows. The effects analyses above do not presume that mussels are always present at river stages equivalent to flows between 5,000 and 10,000 cfs, but rather evaluate to what extent USACE operations are influencing flows as compared to the Baseline. Incidental take monitoring has occurred three times since the 2012 BO was signed. Fat threeridge were observed exposed at stages greater than 5,000 cfs in 2013 (383 individuals), 2014 (680 individuals), and 2015 (195 individuals). Discharges less than 10,000 cfs have not occurred to date in 2016. The effects analyses above, illustrate that the PAA results in a mix of beneficial and adverse effects to fat threeridge mussels when releases are between 5,000 and 10,000 cfs. Therefore, we have determined that the proposed action may adversely affect fat threeridge. However, it is not evident that the PAA would appreciably change the quantity or quality of the designated Critical Habitat primary constituent elements (PCE) for the listed mussel species compared to the Baseline. Droughts substantially change the nature of all of these PCEs compared to normal flows. Therefore, we have determined that the PAA may affect but is not likely to adversely modify fat threeridge mussel designated Critical Habitat.

PURPLE BANKCLIMBER

The flow regime changes discussed in the effects analyses for listed mussel species apply to the purple bankclimber as well, but probably to a lesser extent, because the data suggests that this species appears to occur more often in deeper portions of the river channel than the fat threeridge. Purple bankclimber exposure was not observed during 2006, or 2010 when exposed fat threeridge were observed at stages greater than 5,000 cfs. One purple bankclimber was observed exposed at the shoals below Jim Woodruff Dam in 2011 when an inadvertent release of less than 5,000 cfs occurred. Five purple bankclimber were observed exposed at stages greater than 5,000 cfs in 2014. The proposed action simulation resulted in two years with a reduction of flows below 5,000 cfs. A small number of purple bankclimber could also be exposed under this condition and this is an adverse effect. Therefore, we have determined that the proposed action may adversely affect purple bankclimber. The PCE discussion above also applies to purple bankclimber and therefore, we have determined that the proposed action may affect but is not likely to adversely modify purple bankclimber mussel designated Critical Habitat.

CHIPOLA SLABSHELL

Like the purple bankclimber, Chipola slabshell exposure was not observed during 2006, 2010, or 2011 when exposed fat threeridge were observed at stages greater than 5,000 cfs. Chipola slabshell exposure was observed in 2013 (1 individual), 2014 (5 individuals), and 2015 (4 individuals) at stages greater than 5,000 cfs. Additional incidental take for the Chipola slabshell was granted by the Service in a letter dated August 7, 2014 to allow for a maximum of 100 Chipola slabshell exposure in the Chipola Cutoff and Chipola River downstream of the Cutoff. This incidental take consisted of not more than 50 Chipola slabshell if flows are reduced to 4,500 cfs, and not more than 50 if they recolonize areas at stages greater than 5,000 cfs.

The Chipola slabshell known range within the action area is limited to the Chipola Cutoff and the Chipola River downstream of the Chipola Cutoff. As discussed in previous BOs, channel morphology appears less altered in the Chipola River than the Apalachicola River and the USACE influence on flow regime in the Chipola River is likely reduced due to the narrower channel and contributions from the Chipola River upstream of the cutoff (approximately 132 miles). Flowing water from the Apalachicola River influences flow in the Chipola River and Chipola Cutoff under the full range of flows simulated in the PAA flow regime. Therefore, the effects analyses above for the fat threeridge apply also to the Chipola slabshell, but probably to a lesser extent. The PAA simulation resulted in two years with a reduction of flows below 5,000 cfs. A small number of Chipola slabshell could also be exposed under this condition and this is an adverse effect. Therefore, we have determined that the PAA may adversely affect Chipola slabshell. The PCE discussion above also applies to Chipola slabshell and therefore, we have determined that the PAA may affect but is not likely to adversely modify Chipola slabshell mussel designated Critical Habitat.

CITATIONS

Amyot, J. P. and J.A. Downing. 1998. Locomotion in Elliptio complanata (Mollusca: Unionidae): a reproductive function? Freshwater Biology 39: 351-358.

Balfour, D.L., and L.A. Smock. 1995. Distribution, age structure, and movements of the freshwater mussel Elliptio complanata (Mollusca: Unionidae) in a headwater stream. Journal of Freshwater Ecology 10:254-268.

Barnhart, C.M., Haag, W.R., Roston, W.N. 2008. Adaptations to host infection and larval parasitism in Unionoida. Journal of The North American Benthological Society. 27(2):370–394

Brim Box, J. 1999. Community structure of freshwater mussels (Bivalvia: Unionidae) in Coastal Plain streams of the southeastern United States. Unpublished Ph.D. Dissertation, University of Florida, Gainesville. 107 pp.

Brim Box, J., and J. Mossa. 1999. Sediment, land use, and freshwater mussels: prospects and problems. Journal of the North American Benthological Society 18(1):99-117.

Brim Box, J., and J.D. Williams. 2000. Unionid mollusks of the Apalachicola Basin in Alabama, Florida, and Georgia. Bulletin of the Alabama Museum of Natural History No. 22. 143 p.

Bruenderman, S.A., and R.J. Neves. 1993. Life history of the endangered fine-rayed pigtoe, *Fusconaia cuneolus* (Bivalvia: Unionidae) in the Clinch River, Virginia. American Malacological Bulletin 10(1):83-91

Clench, W.J., and R.D. Turner. 1956. Freshwater mollusks of Alabama, Georgia, and Florida from the Escambia to the Suwannee River. Bulletin of the Florida State Museum, Biological Sciences 1(3):97-239.

Coker, R.E., A.F. Shira, H.W. Clark, and A.D. Howard. 1921. Natural history and propagation of freshwater mussels. Bulletin of the U.S. Bureau of Fisheries 37:77-181.

Di Maio, J., and L.D. Corkum. 1995. Relationship between the spatial distribution of freshwater mussels (Bivalvia: Unionidae) and the hydrological variability of rivers. Canadian Journal of Zoology 73:663-671.

Downing, J.A., J.-P. Amyot, M. Pérusse, and Y. Rochon. 1989. Visceral sex, hermaphroditism, and protandry in a population of the freshwater mussel *Elliptio complanata*. Journal of the North American Benthological Society 8(1):92-99.

Foster, A.M. and J.P. Clugston. 1997. Seasonal migration of Gulf sturgeon in the Suwannee River, Florda. Transactions of the American Fisheries Society 126:302-308.

Fritts, Andrea K. and Robert B. Bringolf. 2014. Host Fishes for Four Federally Endangered Freshwater Mussels (Unionidae) in The Apalachicola-Chattahoochee-Flint Basin. Walkerana 17(2):51-59.

Fritts, Andrea K., Mark W. Fritts, II, Douglas L. Peterson, Dewayne A. Fox, and Robert B. Bringolf. 2012. Critical Linkage of imperiled species: Gulf Sturgeon as host for Purple Bankclimber mussels. Freshwater Science 31(4): 1223-1232.

Gatenby, C.M., R.J. Neves, and B.C. Parker. 1996. Influence of Sediment and Algal Food on Cultured Juvenile Freshwater Mussels. Journal of the North American Benthological Society 15(4):597-609.

Haag, W.R., and M.L. Warren, Jr. 1997. Host fish and reproductive biology of six freshwater mussel species from the Mobile Basin, USA. Journal of the North American Benthological Society 16:576-585.

Haag, W.R., and M.L. Warren, Jr. 1998. Role of ecological factors and reproductive strategies in structuring freshwater mussel communities. Canadian Journal of Fisheries and Aquatic Sciences 55:297-306.

Haag, W.R., R.S. Butler, and P.D. Hartfield. 1995. An extraordinary reproductive strategy in freshwater bivalves: prey mimicry to facilitate larval dispersal. Freshwater Biology 34:471-476.

Hartfield, P.D. 1993. Headcuts and their effect on freshwater mussels. Pages 131-141 *in*: K.S. Cummings, A.C. Buchanan, and L.M. Koch, eds. Conservation and management of freshwater mussels. Proceedings of an symposium, October 1992, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Heard, W.H. 1979. Identification manual of the freshwater clams of Florida. Unpublished report, Florida Department of Environmental Regulation Technical Series 4. 83 pp.

Hove, M.C., and R.J. Neves. 1994. Life history of the endangered James spinymussel *Pleurobema collina* (Conrad, 1837) (Mollusca: Unionidae). American Malacological Bulletin 11(1):29-40.

Huff, J.A. 1975. Life History of the Gulf of Mexico Sturgeon, Acipenser oxrhynchus desotoi in Suwannee River, Florida. Mar. Res. Publ. No. 16. 32 pp.

Isom, B.G., and R.G. Hudson. 1982. In Vitro culture of parasitic freshwater mussel glochidia. The Nautilus 96(4):147-151.

Kaeser, Adam J. and Karen Herrington. United States Fish and Wildlife Service (USFWS). 2011. An investigation of movement, exposure, and mortality of fat threeridge mussels (*Ambema neislerii*) at Apalachicola and Chipola River sites. Summary Report. Panama City Fish and Wildlife Conservation Office.

Kaeser, Adam J. 2016. Personal communication with Brian A. Zettle, Chief, Planning and Environmental Division, Inland Environment Section, Mobile District, U.S. Army Corps of Engineers

Kraemer, L.R. 1979. *Corbicula* (Bivalvia: Sphaeriacea) *vs*. indigenous mussels (Bivalvia: Unionacea) in U.S. rivers: a hard case for interspecific competition? American Zoologist 19:1085-1096.

Lefevre, G., and W.C. Curtis. 1912. Studies on the reproduction and artificial propagation of freshwater mussels. Bulletin of the U.S. Bureau of Fisheries 30:105-201.

Leff, L.G., J.L. Burch, and J.V. McArthur. 1990. Spatial distribution, seston removal, and potential competitive interactions of the bivalves *Corbicula fluminea* and *Elliptio complanata*, in a Coastal Plain stream. Freshwater Biology 24:409-416.

Lewis, J.B., and P.N. Riebel. 1984. The effect of substrate on burrowing in freshwater mussels (Unionidae). Canadian Journal of Zoology 62:2023-2025.

Light, H.M, M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida. U.S. Geological Survey Professional Paper 1594.

McMahon, R. F. & A. E. Bogan. 2001. Mollusca: Bivalvia. *In* J. H. Thorpe & A. P. Covich. Ecology and Classification of North American Freshwater Invertebrates, 2nd edn. Academic Press, 331–429.

Miller, A.C. and B.S. Payne. 2006. The fat threeridge (Amblema neislerii), the surprisingly common endangered mussel in the Apalachicola River, Florida. Environmental Laboratory, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Miller, A.C. and B.S. Payne. 2005. Depth distribution of the fat threeridge mussel *Amblema neislerii*, during low flow stages on the Apalachicola River. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Unpublished draft report, 31 p.

Neves, R.J. 1993. A state-of-the-unionids address. Pages 1-10 *in*: K.S. Cummings, A.C. Buchanan, and L.M. Koch, eds. Conservation and management of freshwater mussels. Proceedings of an Upper Mississippi River Conservation Committee symposium, October 1992, St. Louis, Missouri. UMRCC, Rock Island, Illinois.

Neves, R.J., and J.C. Widlak. 1987. Habitat ecology of juvenile freshwater mussels (Bivalvia: Unionidae) in a headwater stream in Virginia. American Malacological Union Bulletin 5(1):1-7.

Neves, R.J., and J.C. Widlak. 1988. Occurrence of glochidia in stream drift and on fishes of the upper North Fork Holston River, Virginia. American Midland Naturalist 119(1):111-120.

Neves, R.J., L.R. Weaver, and A.V. Zale. 1985. An evaluation of host fish suitability for glochidia of *Villosa vanuxemi* and *V. nebulosa* (Pelecypoda: Unionidae). American Midland Naturalist 113(1):13-19.

O'Brien, C.A., and J. Brim Box. 1999. Reproductive biology and juvenile recruitment of the shinyrayed pocketbook, *Lampsilis subangulata* (Bivalvia: Unionidae) in the Gulf Coastal Plain. American Midland Naturalist 142:129-140.

O'Brien, C.A. and J.D. Williams. 2002. Reproductive biology of four freshwater mussels (Bivalvia: Unionidae) endemic to the eastern Gulf Coastal Plain drainages of Alabama, Florida, and Georgia. American Malacological Bulletin 17(1/2):147-158. Biological Opinion for Woodruff Dam RIOP May 22, 2012

Perles, S. J., A. D. Christian, D. J. Berg. 2003. Vertical migration, orientation, aggregation, and fecundity of the freshwater mussel Lampsilis siliquoidea. Ohio Journal of Science 103(4): 73-78.

Priester, L. 2008. Life History Observations and Determination of Potential Host Fish Species for Chipola Slabshell, *Elliptio chipolaensis*. Masters Thesis, Columbus State University, Columbus, Georga, pp. 51.

Roe, K.J. and P.D. Hartfield. 2005. Hamiota, a new genus of freshwater mussel (Bivalvia: Unionidae) from the Gulf of Mexico drainages of the southeastern United States. Nautilus 119(1):1-10.

Smit, Reuben B. 2014. Using sonar habitat mapping and GIS analyses to identify freshwater mussel habitat and estimate population size of a federally endangered freshwater mussel species, Amblema neislerii, in the Apalachicola River, FL. Masters Thesis. Auburn University, Auburn Alabama.

Strayer, D.L. 1999. Use of flow refuges by unionid mussels in rivers. Journal of the North American Benthological Society 18(4):468-476.

Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, and S.J. Nichols. 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. BioScience 54:429–439.

Surber, T. 1912. Identification of the glochidia of freshwater mussels. U.S. Bureau of Fisheries Document No. 771. 10 pp.

Sylvester, J.R., L.E. Holland, and T.K. Kammer. 1984. Observations on burrowing rates and comments on host specificity in the endangered mussel *Lampsilis higginsi*. Journal of Freshwater Ecology 2(6):555-559.

United States Fish and Wildlife Service (USFWS). 2007. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Federal Register 72:64286-64340.

United States Fish and Wildlife Service (USFWS). 2008. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River.

United States Fish and Wildlife Service (USFWS). 2012. Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River.

United States Army Corps of Engineers (USACE). 2015. Draft Environmental Impact Statement, Update of the Water Control Manual for the Apalachicola-Chattahoochee –Flint River Basin in Alabama, Florida, Georgia and a Water Supply Storage Assessment.

Vannote, R.L., and G.W. Minshall. 1982. Fluvial processes and local lithology controlling abundance, structure, and composition of mussel beds. Proceedings of the National Academy of Sciences 79:4103-4107.

van der Schalie, H. 1970. Hermaphroditism among North American freshwater mussels. Malacologia 10(1):93-112.

Watters, G.T. 1992. Unionids, fishes, and the species-area curve. Journal of Biogeography 19:481-490.

Watters, G.T., and S.H. O'Dee. 2000. Glochidial release as a function of water temperature: beyond bradyticty and tachyticty. Pages 135-140 i*n*: R.A. Tankersley, D. Warmolts, G.T. Watters, B. Armitage, P.D. Johnson, and R.S. Butler eds. Freshwater Mollusk Symposia Proceedings--Part I: Conservation, Captive Care, and Propagation symposium, March 1998, Columbus, Ohio. Ohio Biological Survey, Columbus, Ohio.

Watters G. T., O'Dee S. H., Chordas S. 2001. Patterns of vertical migration in freshwater mussels (Bivalvia: Unionida). Journal of Freshwater Ecology 16: 541-550.

Williams, J.D., and R.S. Butler. 1994. Class Bivalvia, freshwater bivalves. Pages 53-128, 740-742 *in*: R. Ashton, ed. Rare and endangered biota of Florida. Volume 6. Invertebrates. University of Florida Press, Gainesville.

Williams, J.D., Garner, J.T., and Bogan, A.E. 2008. Freshwater mussels of Alabama and the Mobile Basin in Georgia, Mississippi & Tennessee. The University of Alabama Press; Tuscaloosa, Alabama.

Wooley, C.M. and EJ. Crateau. 1985. Movement5, microhabitat, exploitation, and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. North American Journal of Fisheries Management. 5:590-605.

Yeager, B.L., and R.J. Neves. 1986. Reproductive cycle and fish hosts of the rabbit's foot mussel, *Quadrula cylindrica strigillata* (Mollusca: Unionidae) in the upper Tennessee River drainage. American Midland Naturalist 116:329-340.
Yeager, B.L., and C.F. Saylor. 1995. Fish hosts for four species of freshwater mussels (Pelecypoda: Unionidae) in the upper Tennessee River drainage. American Midland Naturalist 133:1-6.

Yeager, M.M., D.S. Cherry, and R.J. Neves. 1994. Feeding and burrowing behaviors of juvenile rainbow mussels, Villosa iris (Bivalvia: Unionidae). Journal of the North American Benthological Society 13(2):217-222.

Zale, A.V., and R.J. Neves. 1982. Fish hosts of four species of lampsiline mussels (Mollusca: Unionidae) in Big Moccasin Creek, Virginia. Canadian Journal of Zoology 60:2535-2542.

APPENDIX A TO BIOLOGICAL ASSESSMENT - UPDATE OF THE WATER CONTROL MANUAL FOR THE APLACHICOLA-CHATTAHOOCHEE-FLINT RIVER BASIN IN ALABAMA, FLORIDA, AND GEORGIA AND A WATER SUPPLY STORAGE ASSESSMENT.

Appendix N

USACE Institute for Water Resources
ACF Climate Change Support Analysis

This page intentionally left blank

Scientific evidence from the immediately preceding decades demonstrates that the natural climate might be changing (Stocker et al. 2013[1]), and the changes are expected to continue over the course of the 21st century. The anticipated changes might reflect shifts in the average or baseline conditions, regional meteorological phenomena, and the range of variability of those phenomena. The potential changes are raising concerns about the capacity of U.S. Army Corps of Engineers (USACE) projects and operations to accommodate different climatological baselines, greater climatological variation, and a wider range of meteorological conditions.

In response to public interest and USACE guidance, the Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual Update Project Delivery Team engaged the Institute for Water Resources (IWR) to develop a numerical modeling analysis that can be used to evaluate the resilience and limitations of proposed ACF water management scenarios in relation to climate change. The ACF numerical model was written to correlate with the Hydrologic Engineering Center-Reservoir System Simulation (HEC-ResSim) and System Water Quality Modeling (HEC-5Q) of the ACF system. The HEC-ResSim and HEC-5Q software was developed by the USACE Hydrologic Engineering Center (HEC) and is now the standard for USACE reservoir operations modeling. Allowing the model-projected unimpaired flow (UIF) to be run in HEC-ResSim and HEC-5Q would give a sense of the effects of prospective climate change on hydrology and water quality in the ACF Basin. (UIF is also used interchangeably with antecedent data in this summary.) The objective of the IWR effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management.

The effort capitalized on existing data and analysis developed by a coalition of agencies and academic institutes as part of the Coupled Model Intercomparison Project phase 5 (CMIP5). In broad terms, an atmospheric general circulation model (GCM) numerically representing the physical processes (e.g., atmospheric, ocean, land surface) was employed to estimate the potential range of climate change due to man-made influences. The GCM outputs were statistically scaled to a finer time and space scale, and bias-corrected to describe anticipated conditions in the ACF Basin. The scaled and bias-corrected GCM outputs were applied to a variable infiltration capacity (VIC) model to predict rainfall-runoff relationships for the basin (Liang et al. 1994[2]). The Liang VIC model is a globally applied, open-source, macroscale hydrologic model that solves full water-energy balances (Liang et al. 1994). VIC model output for future climate model projections has been calculated for the contiguous U.S. and is available

[1] Stocker, T.F., D. Qin, G.-K. Plattner, L.V. Alexander, S.K. Allen, N.L. Bindoff, F.-M. Bréon, J.A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J.M. Gregory, D.L. Hartmann, E. Jansen, B. Kirtman, R. Knutti, K. Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G.A. Meehl, I.I. Mokhov, S. Piao, V. Ramaswamy, D. Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L.D. Talley, D.G. Vaughan, and S.-P. Xie, 2013: Technical summary. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Doschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, Eds. Cambridge University Press, 33-115, doi:10.1017/CBO9781107415324.005.

[2] Liang, X., Lettenmaier, D.P., Wood, E.F., Burges, S.J. (1994). *A simple hydrologically based model of land surface water and energy fluxes for general circulation models*. Journal of Geophysical Research, Volume 99, No. D7, Pages 14,415-428.) retrieved from http://www.hydro.washington.edu/Lettenmaier/Models/VIC/index.shtml

at http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/. It should be noted that these models have not been certified in accordance with USACE model certification guidance.

The U.S. Geological Survey (USGS) has classified watershed drainage areas using a hierarchical system in which each contiguous drainage area is assigned a hydrologic unit code (HUC). The first two levels of the hierarchy identify the region (HUC 2) and subregion (HUC 4). The U.S. contains 222 HUC 4s with an average size of 16,800 mi^2. To detail the ACF numerical model, the hydrological features of the HUC 4 for the ACF Basin were employed as the UIF. The VIC model, building from the UIF, generated local and cumulative flow projections of the ACF HUC 4.

The CMIP5 global carbon projects evaluated a number of different representative concentration pathways (RCPs) that describe different trajectories of greenhouse gas emissions (i.e., carbon dioxide, methane, nitrous oxide, and fluorocarbons). For the ACF Basin, the range of hydrologic responses produced from different GCMs is larger than the difference among RCPs; therefore, the decision was made not to select specific RCPs but rather to treat them all as equally plausible for this analysis.

The full set of 100 available ACF Basin HUC 4 hydrologic projections was tabulated for two future time periods: Years 2021–2050 and years 2061–2090. An empirical cumulative distribution function (ECDF) was developed for both sets of hydrologic projections (i.e., 2021–2050 and 2061–2090). The purpose of the ECDF is to support an estimate of the frequency and degree of climate change occurrences throughout the period of analysis.

With regard to ACF Basin analysis, the ECDF approximates potential changes in volume of runoff from in the basin. The approximations are used to develop monthly volumes that can be compared to the ACF Basin UIF antecedent flow set (1970–1999). ECDF change ratios were created by dividing the 30-year hydrologic projections (2021–2050 and 2061–2090) by the antecedent UIF for 1970–1999 to establish a ratio for each HUC 4 data point.

The ECDF-generated ratio values were plotted against three quantiles representing basin hydrologic conditions (10th percentile [wet], 50th percentile [median], and 90th percentile [dry]) (see Figure 1). These values were further subdivided to create plots that represented each quantile by month for both the 2021–2050 and the 2061–2090 hydrologic projections.

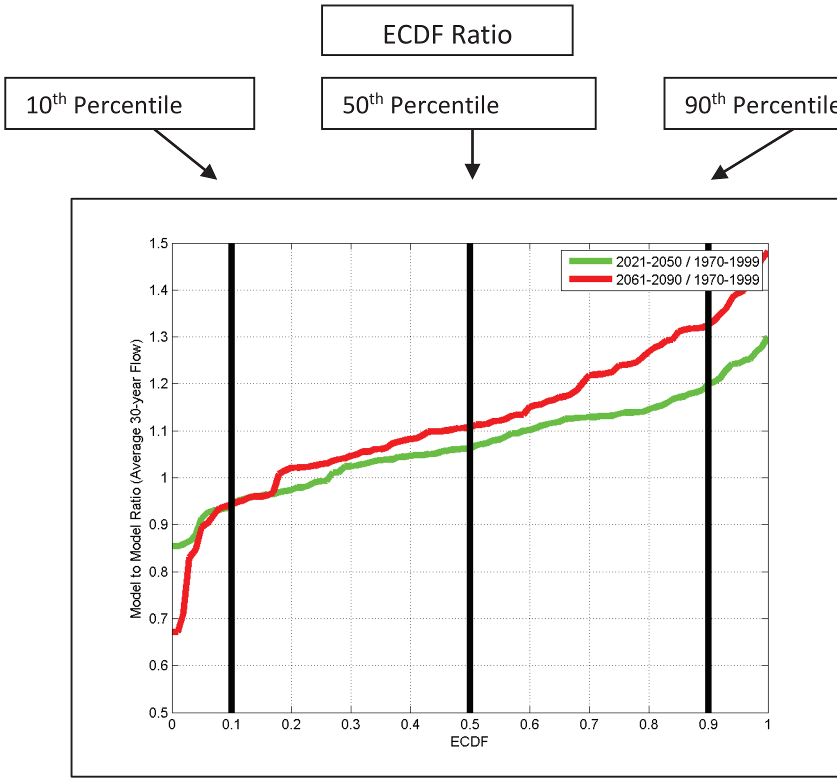


Figure 1. ECDF-generated model to model ratio for two time periods

The UIF antecedent data set was averaged by month, then the monthly average flows were mapped to the appropriate quantile plot. This process yielded a series of plots that represented the future hydrologic ECDF ratios and the antecedent UIF ECDF for each month in each quantile, resulting in a visual representation of the same drainage location in the same month (see Figure 2 for an example of the 10th percentile [Quartile 1] dry projection for 2021–2050 [Time Period 1]). The projected future ECDF HUC 4 data point was divided by the newly positioned antecedent ECDF data point to yield a new ratio. The new ratio was applied to the antecedent UIF to produce a new UIF that reflects climate change conditions.

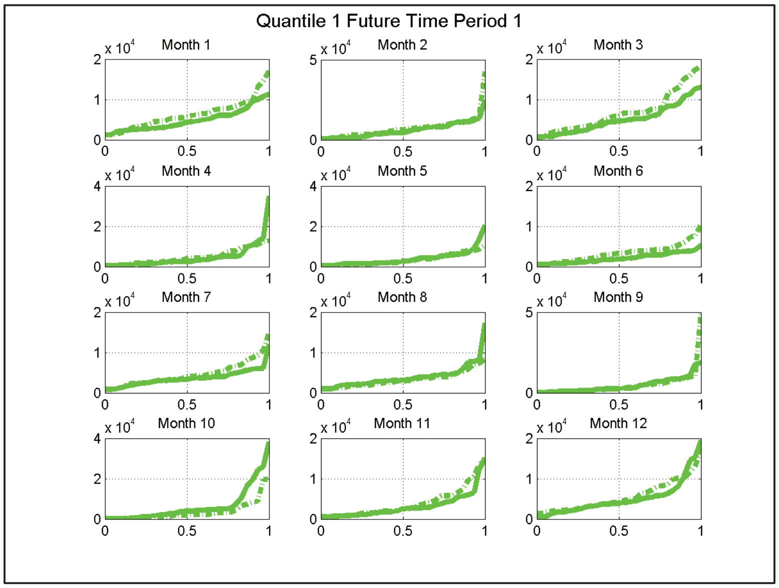


Figure 2. Example of the 10th Percentile (Quartile 1) Dry Projection for 2021–2050 (Time Period 1)

To ensure compatibility with the HEC-ResSim and HEC-5Q models, it was necessary to convert the climate change-affected UIF monthly values produced to a daily time step. A monthly ratio was applied to the UIF daily value for each month. The process output was a climate change-adjusted UIF adapted to a daily time step that can be used in the HEC-ResSim model to speculate how climate change might affect the ACF Basin. This climate change-affected UIF was run in the ACF HEC-ResSim model to generate outputs that approximate the effects of ACF water management scenarios under the climate change-influenced hydrology.

Details of this process are provided in *Apalachicola-Chattahoochee-Flint Climate Change Support Analysis*, performed by USACE Institute for Water Resources, and authored by Dr. David Raff, PhD, P.E., D.WRE, and Dr. Jeff Arnold, PhD.

For the purposes of the ACF Master Water Control Manual Update climate change analysis, only the climate change-affected UIF for 2021–2050 was carried forward. Years 2021–2050 most closely match the anticipated project lifespan used in the National Environmental Policy Act documentation and in the water supply storage assessment analyses. The climate change-affected UIF was used in the ACF HEC-ResSim model to craft a hydrologic range that might occur if climate change trends continue.

This analysis generally assesses the capacity of the operations described as the Proposed Action Alternative (PAA)—or Alt7H—to meet the congressionally authorized purposes of the ACF system of federal reservoirs under climate change-adjusted conditions. The analysis, using water quality as an analytic proxy, also makes a general appraisal of impacts to biological resources.

The PAA and No Action Alternative (NAA) were plotted against the climate change-adjusted UIF to ascertain if operational scenarios could be supported by the projected future hydrology. The plots indicated that the climate change-adjusted flows are sufficient to support current water management activities as well as water management activities described in the PAA, illustrating that either operational scenario would be achievable given the ACF system's climate-adjusted flows.

The plotting analysis brought to light no noteworthy deviations between the baseline (i.e., the NAA) and the PAA (see Figure 3 through Figure 16). This finding implies that the effects of operating under the PAA are essentially the same as those resulting from operating under the NAA. Both scenarios are sufficiently resilient to effectively management the federal projects for congressionally authorized purposes under the climate change-affected UIFs.

The climate-adjusted UIF follows the same seasonal trends as the present-day UIF. However, the climate change-adjusted UIF high and low boundaries show greater extremes. Comparing the climate change-adjusted high and low extremes to the period of record identify no conditions that were consistently more severe than those that have been historically experienced in the ACF Basin.

HEC-5Q water quality model outputs were developed to provide a general sense of environmental impacts when the PAA was run under climate change-affected conditions. The dry (90th percentile) scenarios yielded ACF flows similar to actual flows experienced in 2001–2011. This result implies that more water could be in the ACF system under climate change conditions.

Concentrations of water quality constituents in the PAA and those projected to occur in 2050 are similar; median concentrations during wet years are generally less. Figure 17 through Figure 25 illustrate this finding for various water quality parameters. The ranges are reasonable for the parameters considered. The chlorophyll *a* range is also reasonable, but can be expected to be a function of nutrient loads in the ACF system.

The climate change-adjusted water quality scenario displayed increased water temperature throughout the length of the ACF Basin. The systemwide consistency of the increased temperatures implies that it is the function of a systemic condition that is outside the influence of the NAA or PAA. For the purposes of modeling and analysis of the model outputs, it was assumed that the increased water temperature was attributable to the increased air temperature projected in the climate change model.

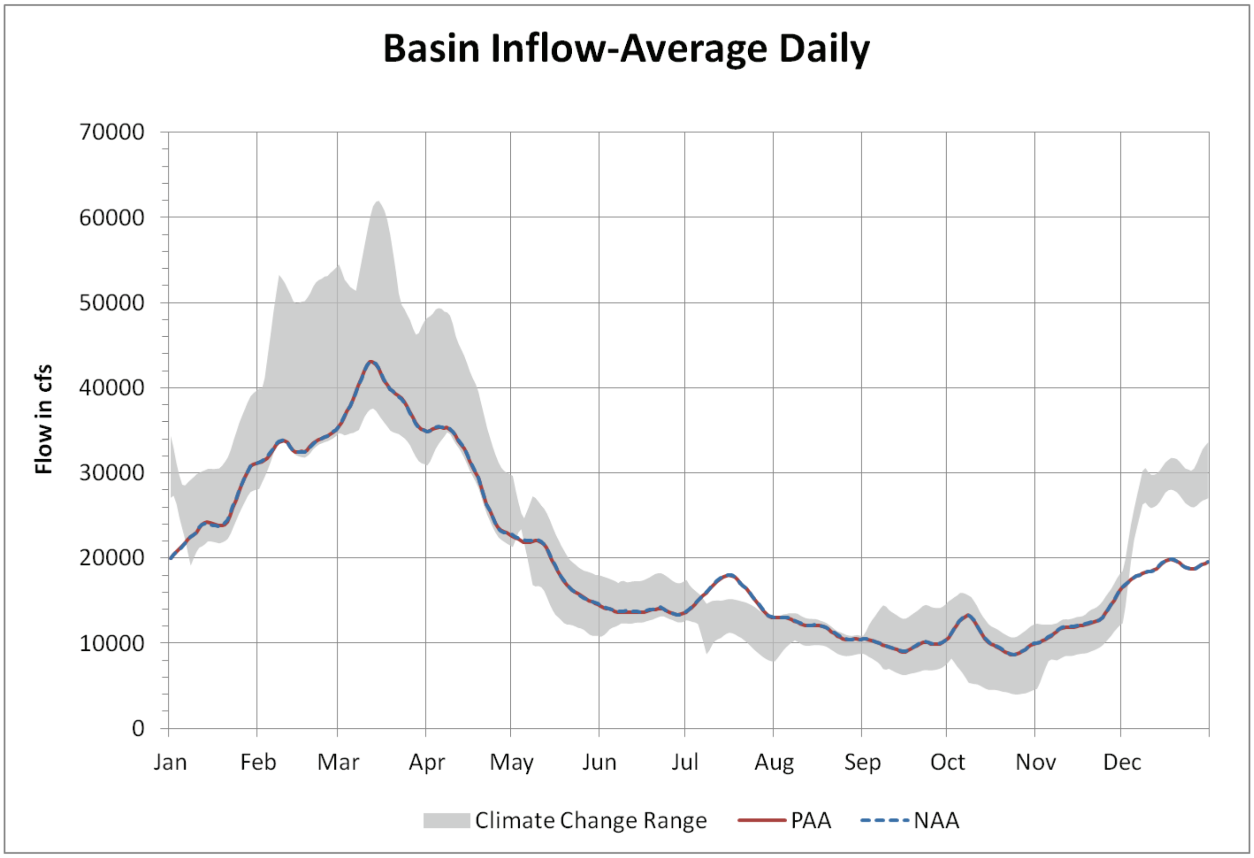


Figure 3. Comparison of Daily Average Basin Inflow between the NAA, PAA and Range of Climate Change

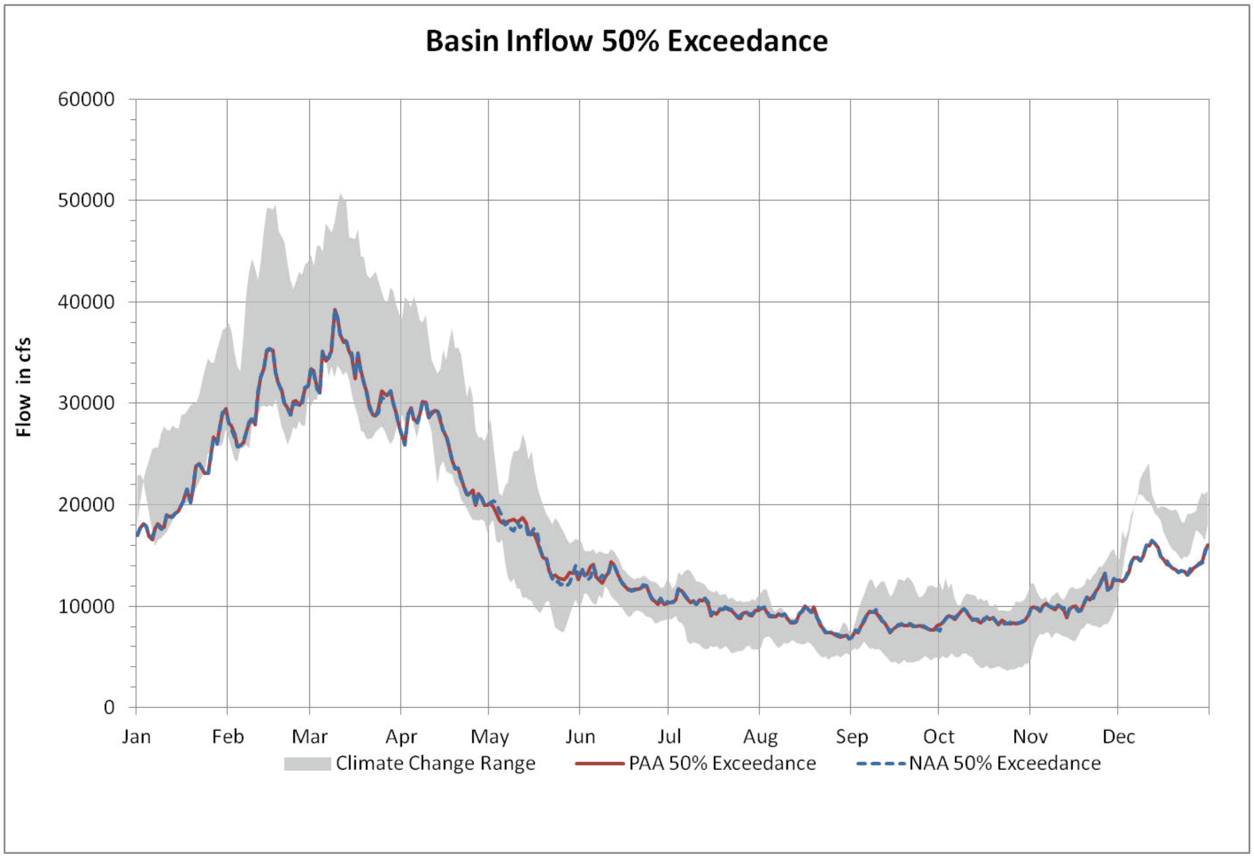


Figure 4. Comparison of Basin Inflow Median Exceedance between the NAA, PAA and Range of Climate Change

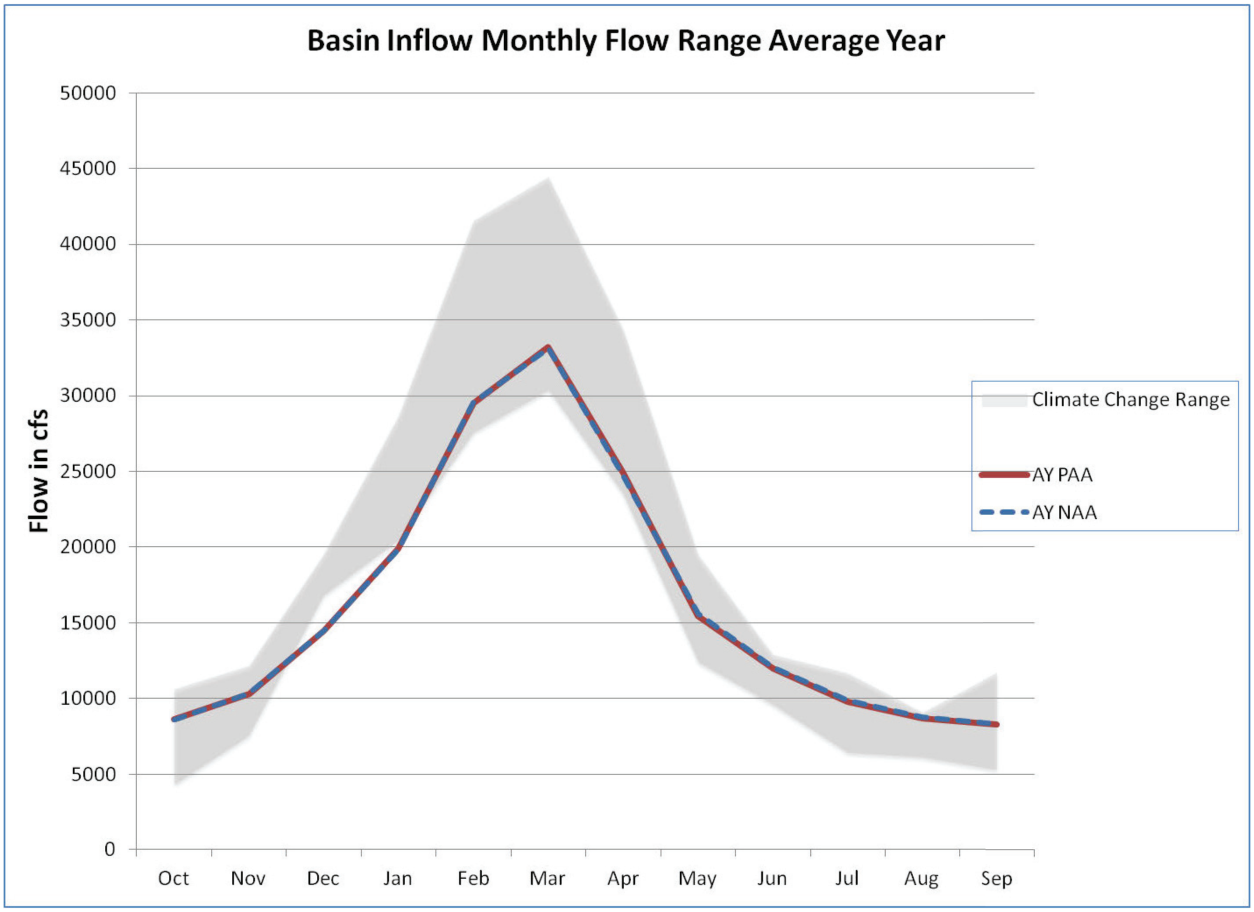


Figure 5. Comparison of Monthly Basin Inflow in an Average Year between the NAA, PAA and Range of Climate Change

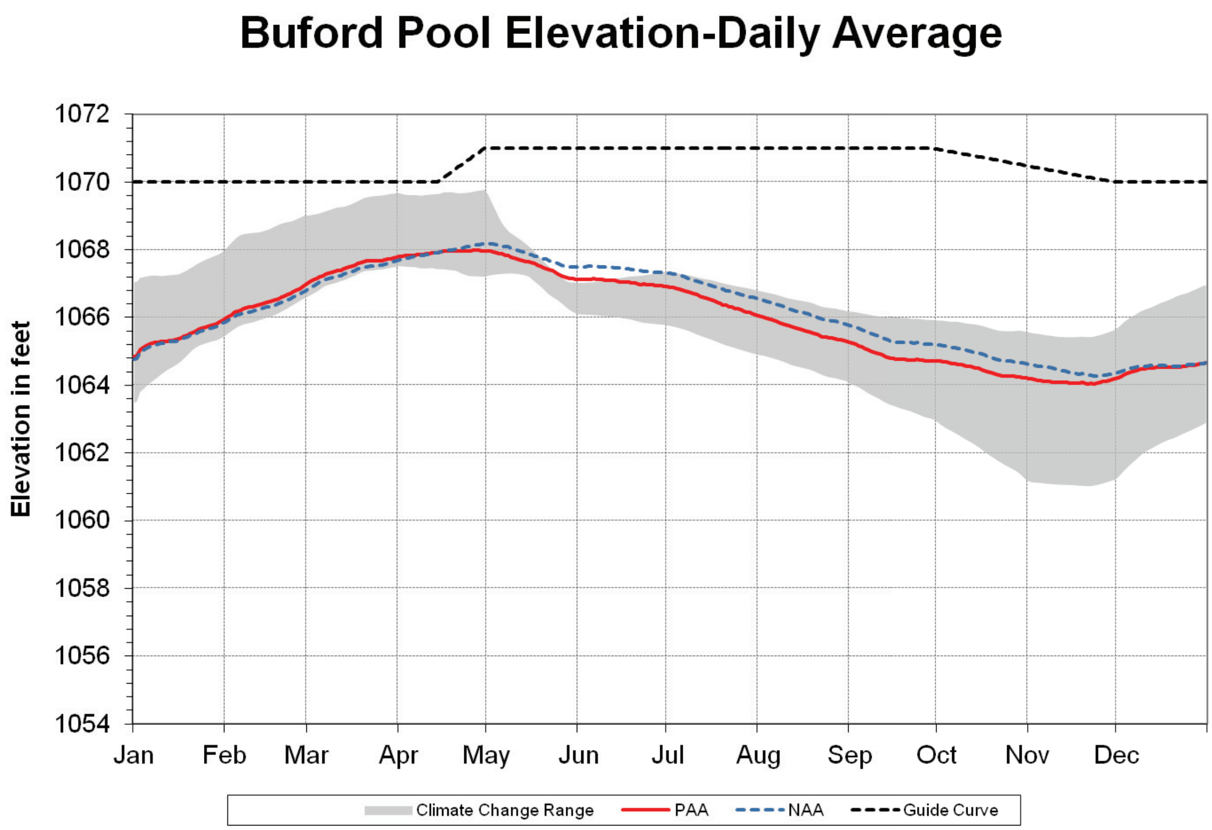


Figure 6. Comparison of Daily Average Buford Pool Elevation between the NAA, PAA and Range of Climate Change

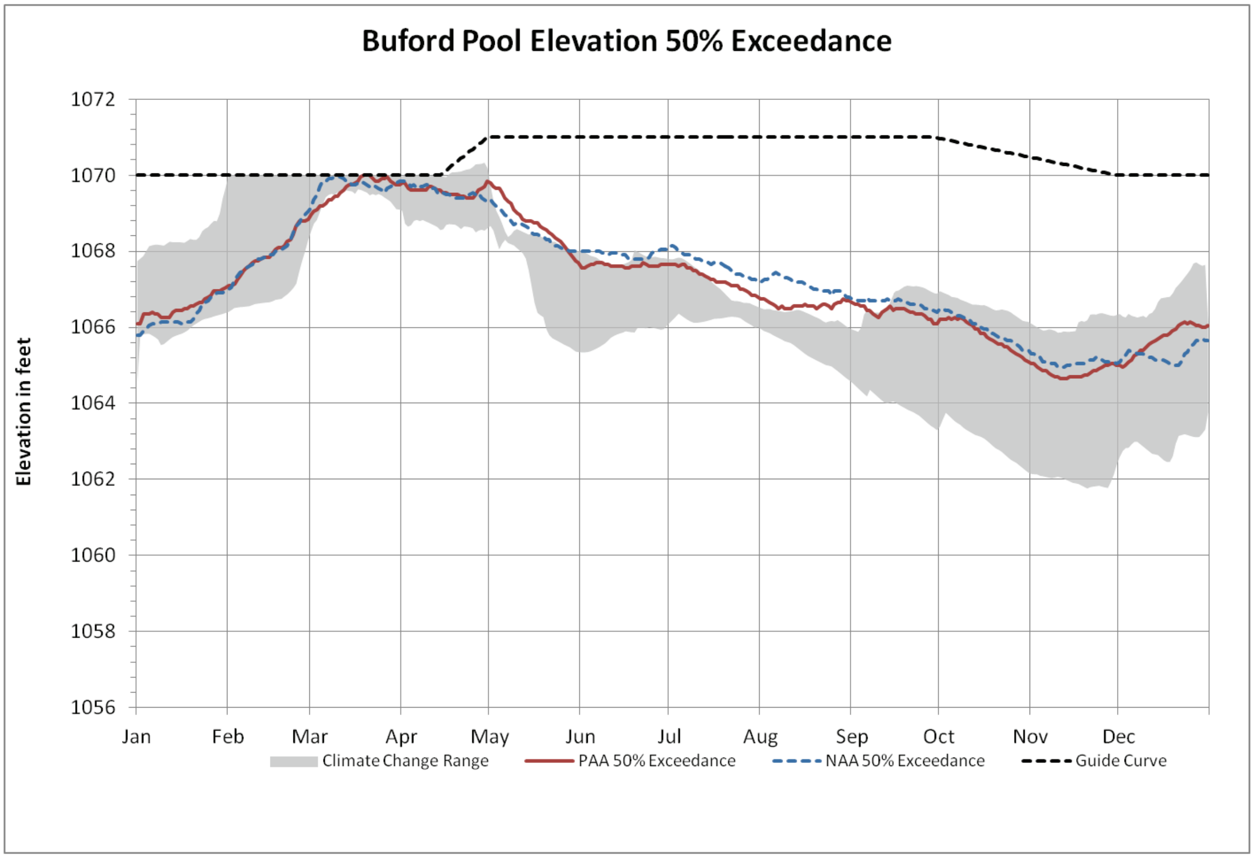


Figure 7. Comparison of Median Exceedance of Buford Pool Elevation between the NAA, PAA and Range of Climate Change

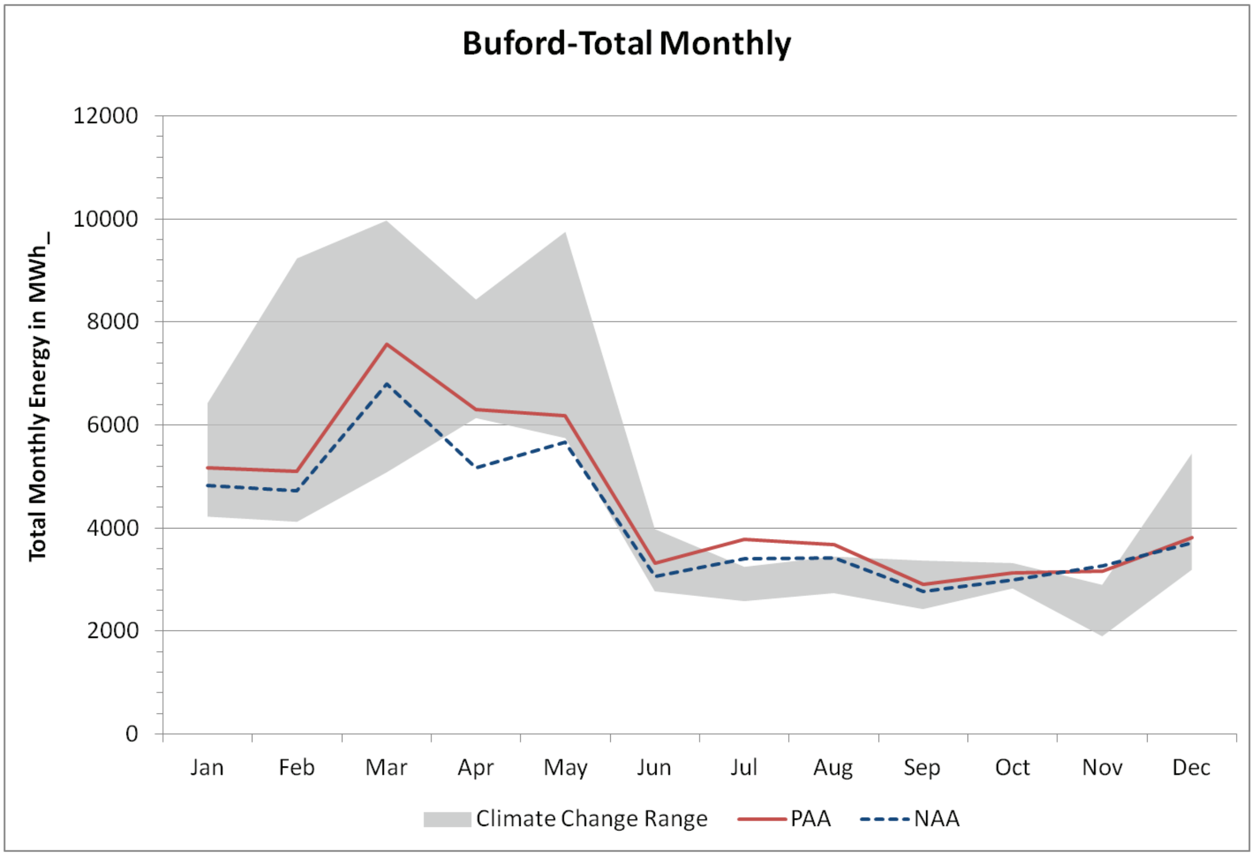


Figure 8. Comparison of Total Monthly Energy Generated in Megawatt Hours from the Buford Pool between the NAA, PAA and Range of Climate Change

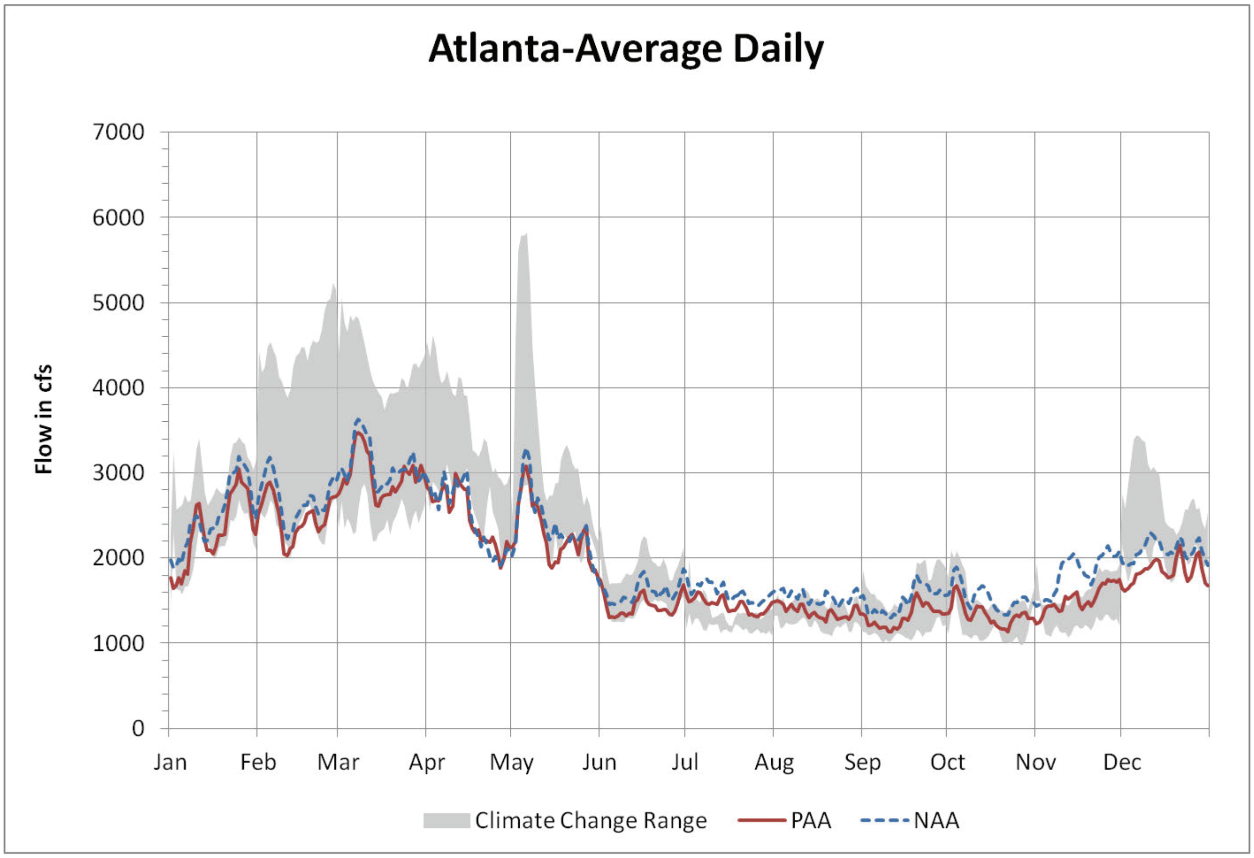


Figure 9. Comparison of Daily Average Flow between the NAA, PAA and Range of Climate Change in Atlanta, Georgia

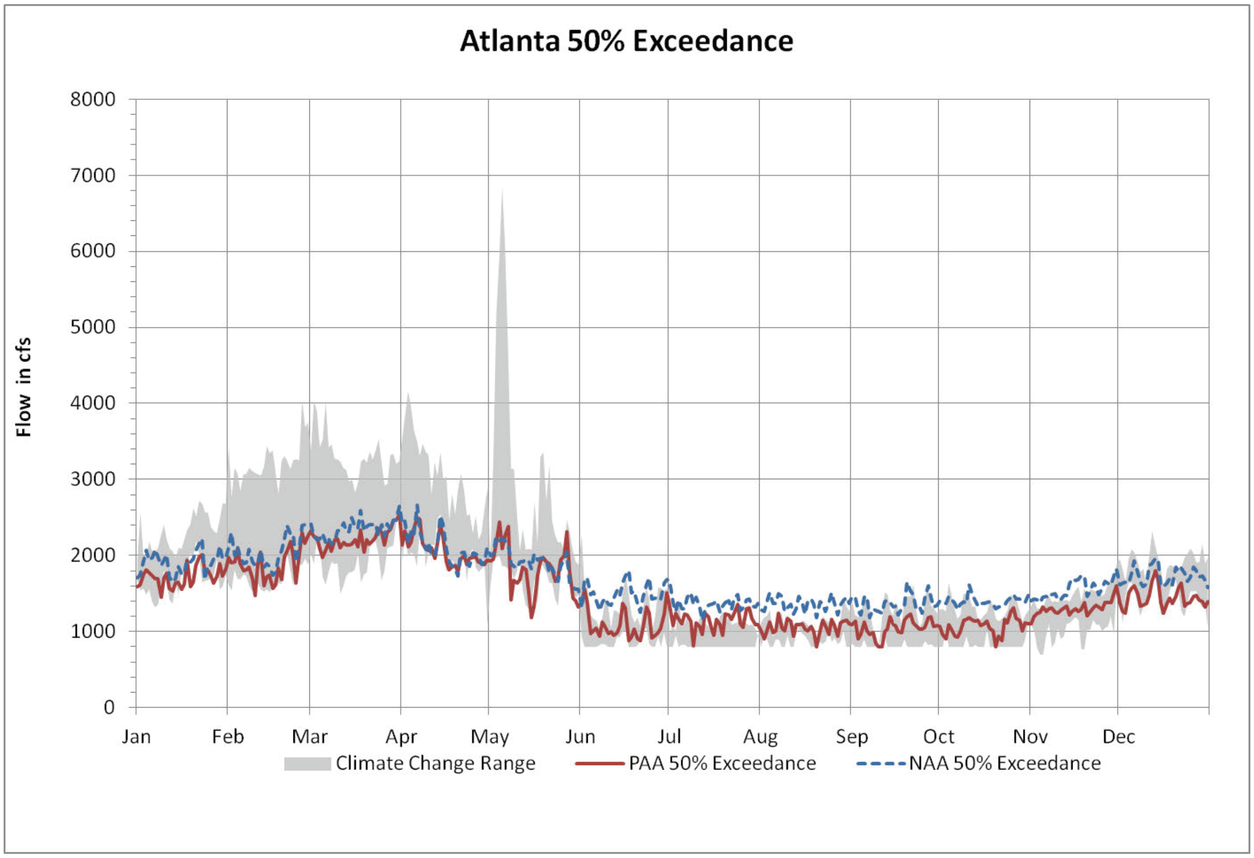


Figure 10. Comparison of the Median Exceedance of Flow between the NAA, PAA and Range of Climate Change in Atlanta, Georgia

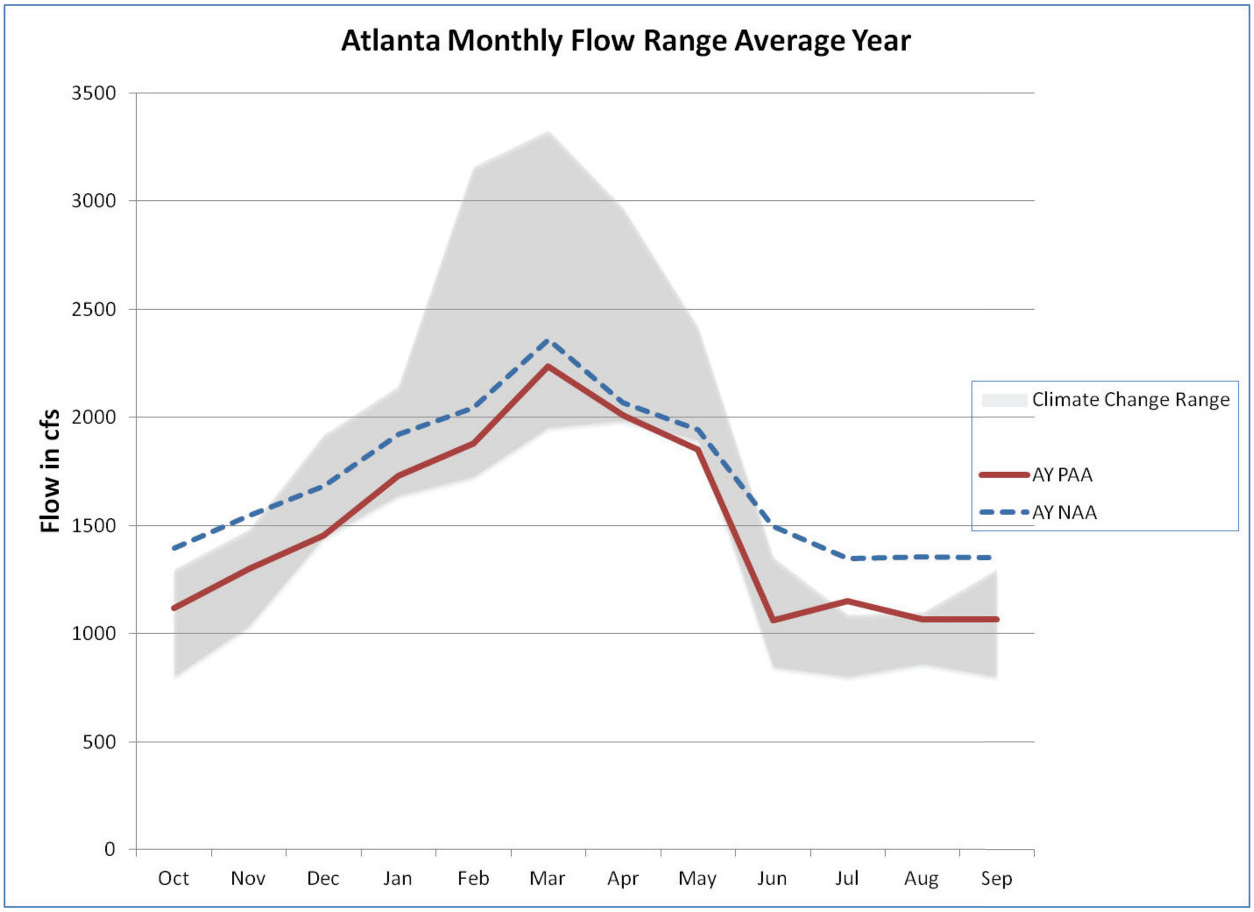


Figure 11. Comparison of Monthly Flow in Atlanta, Georgia in an Average Year between the NAA, PAA and Range of Climate Change

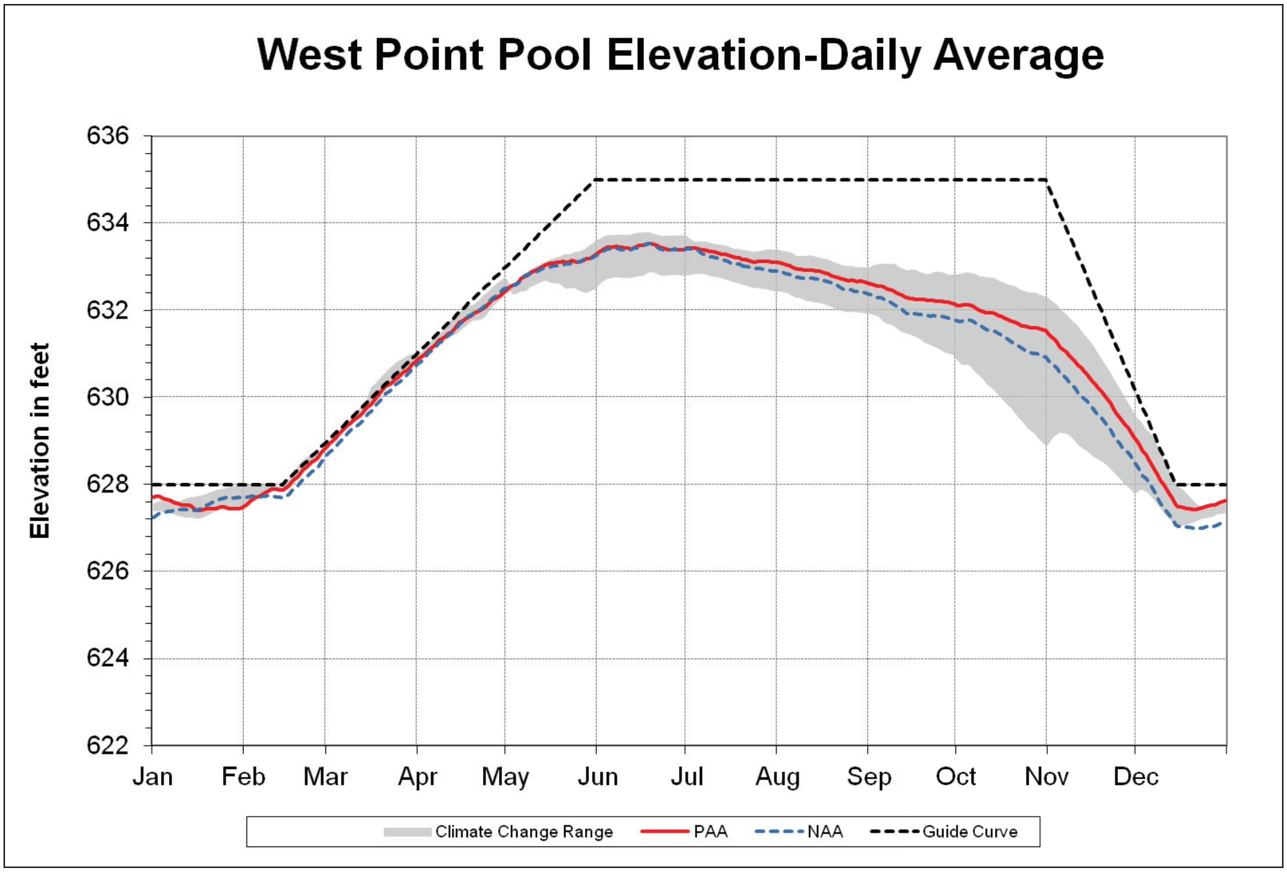


Figure 12. Comparison of Daily Average West Point Pool Elevation between the NAA, PAA and Range of Climate Change

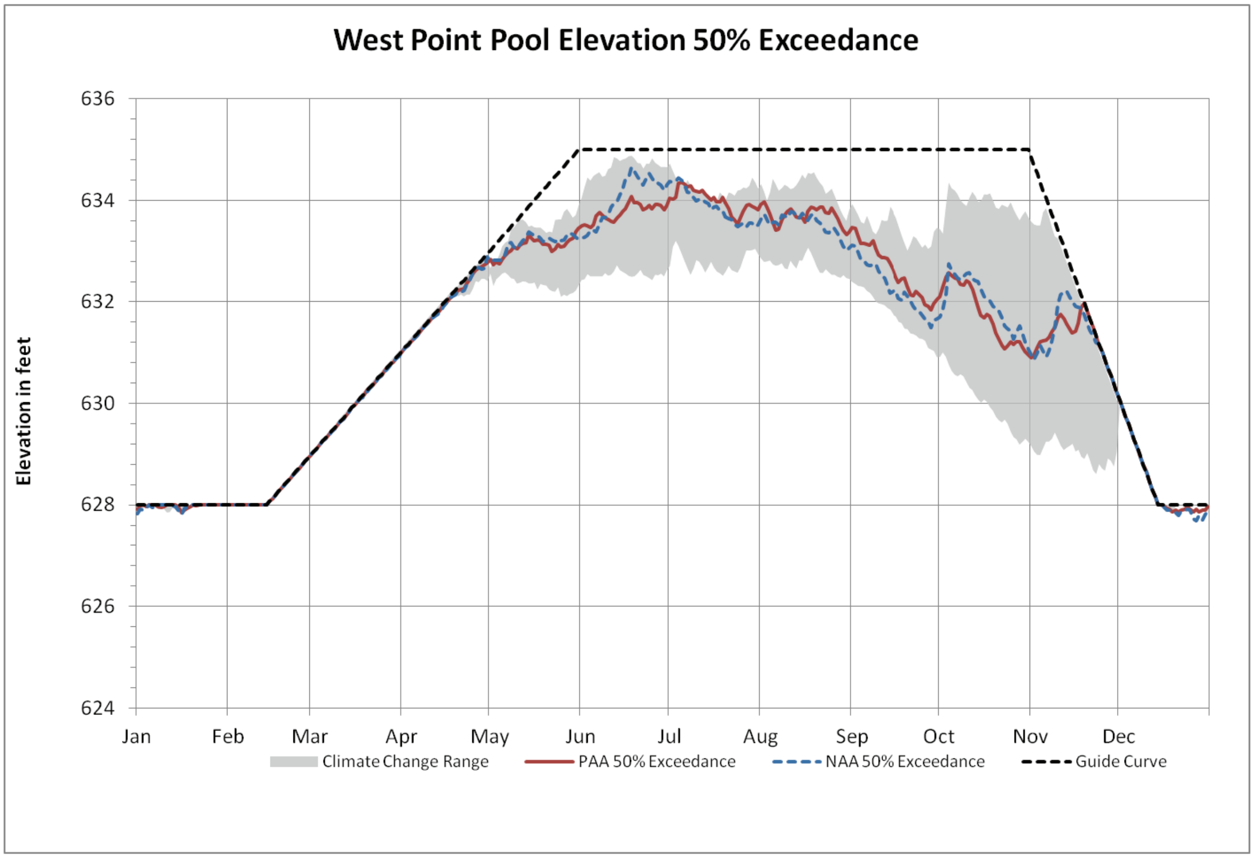


Figure 13. Comparison of Median Exceedance of West Point Pool Elevation between the NAA, PAA and Range of Climate Change

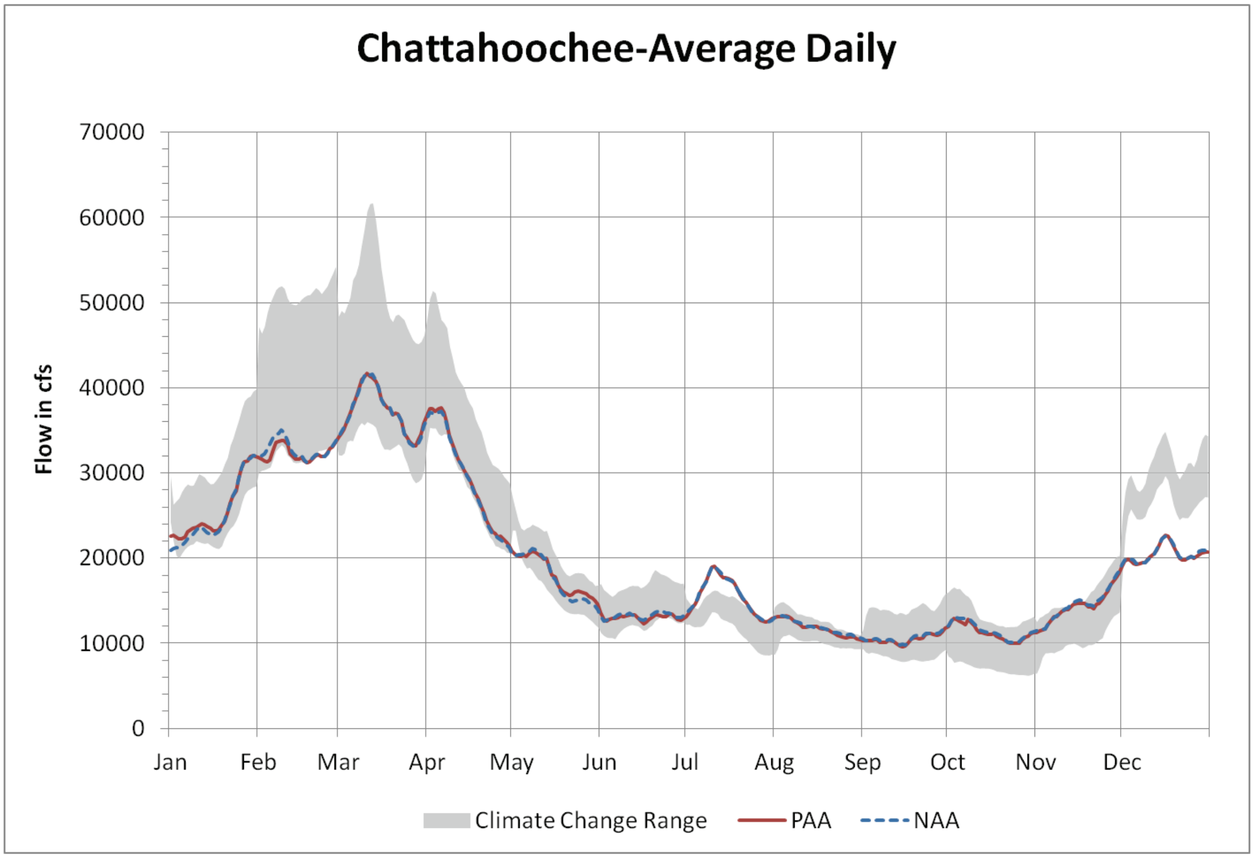


Figure 14. Comparison of Daily Average Flow between the NAA, PAA and Range of Climate Change in Chattahoochee, Florida

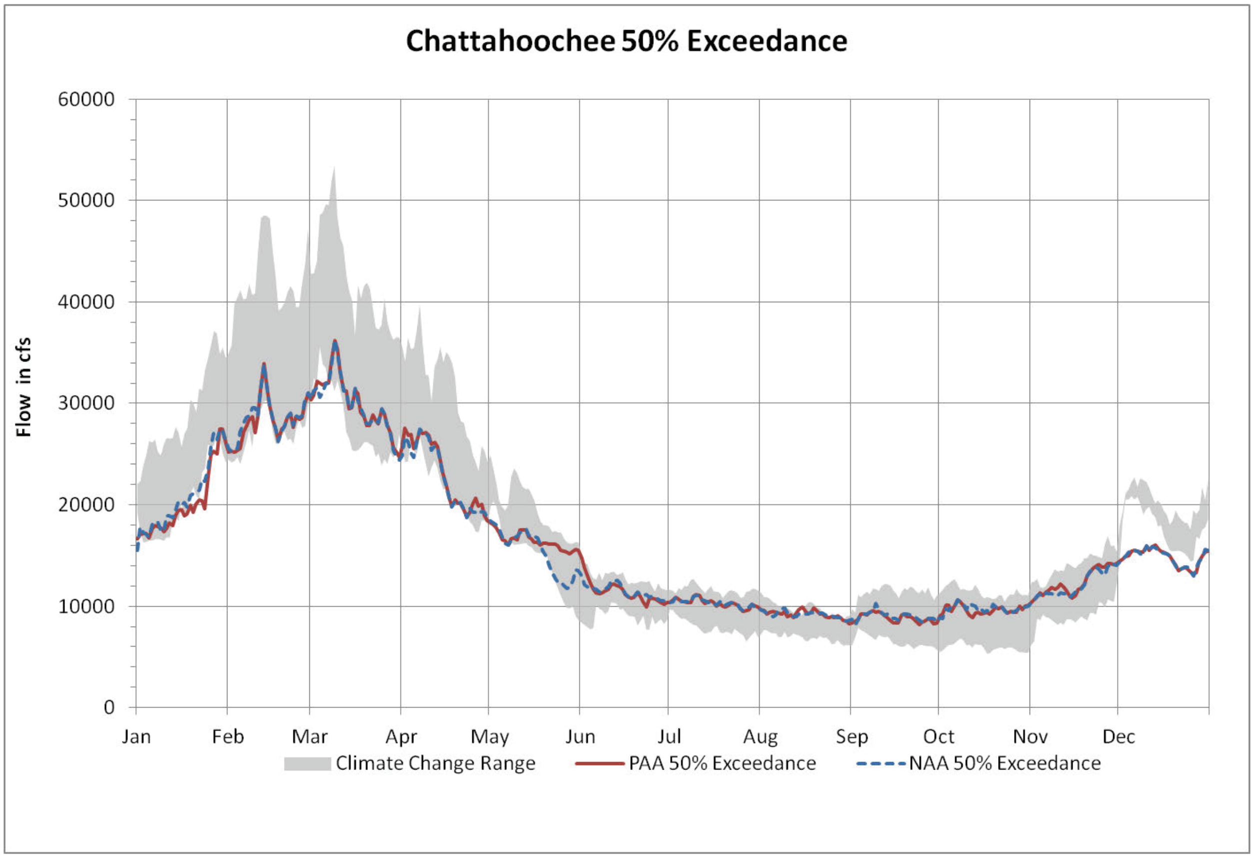


Figure 15. Comparison of the Median Exceedance of Flow between the NAA, PAA and Range of Climate Change in Chattahoochee, Florida

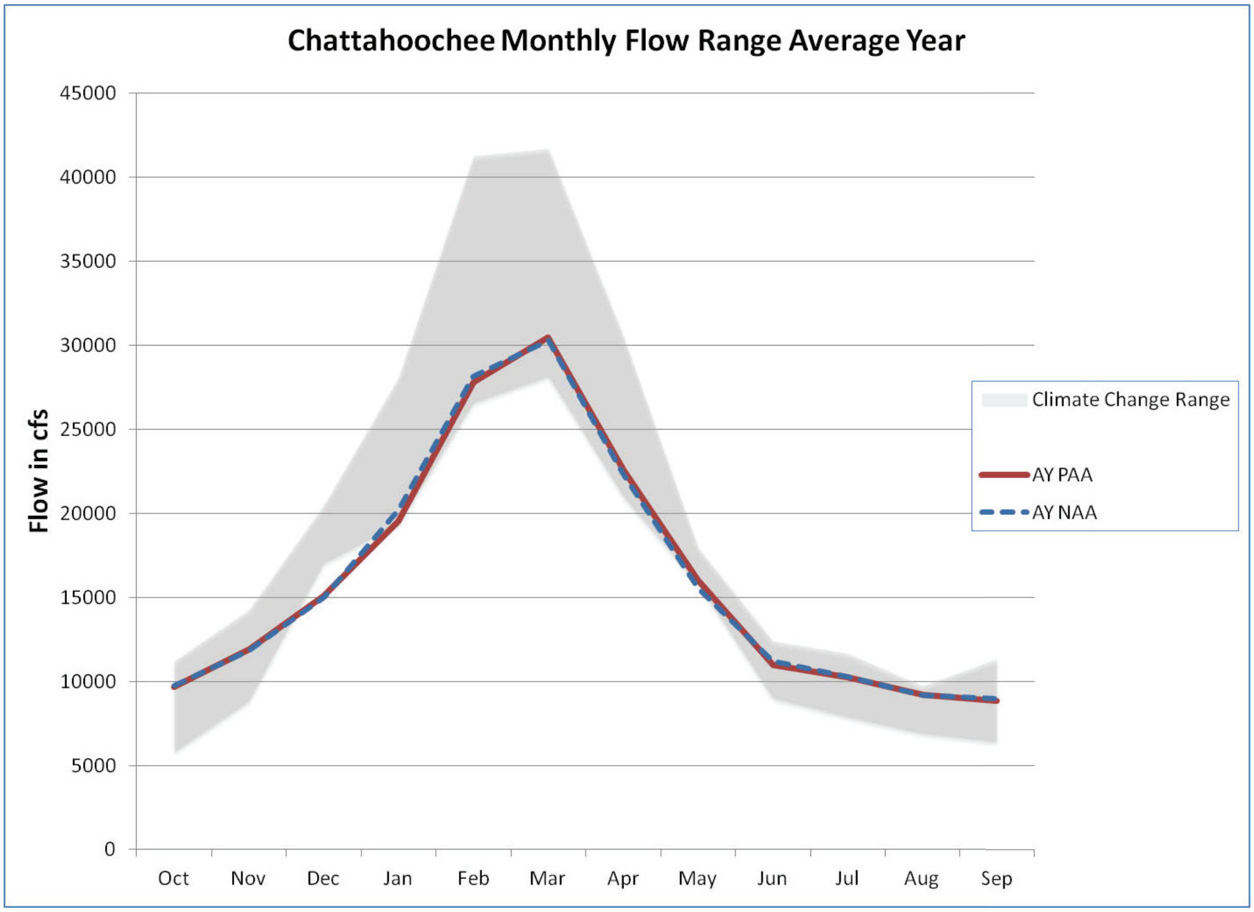


Figure 16. Comparison of Monthly Flow in Chattahoochee, Florida in an Average Year between the NAA, PAA and Range of Climate Change

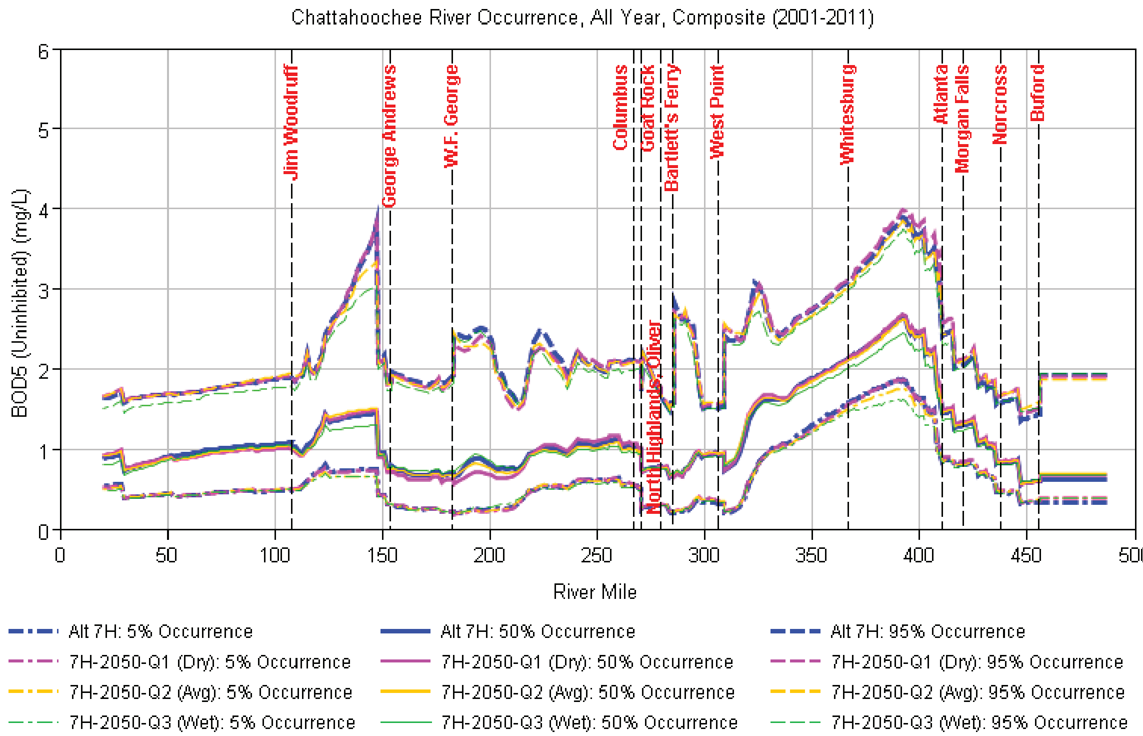


Figure 17. Longitudinal Profile of Modeled BOD5 in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

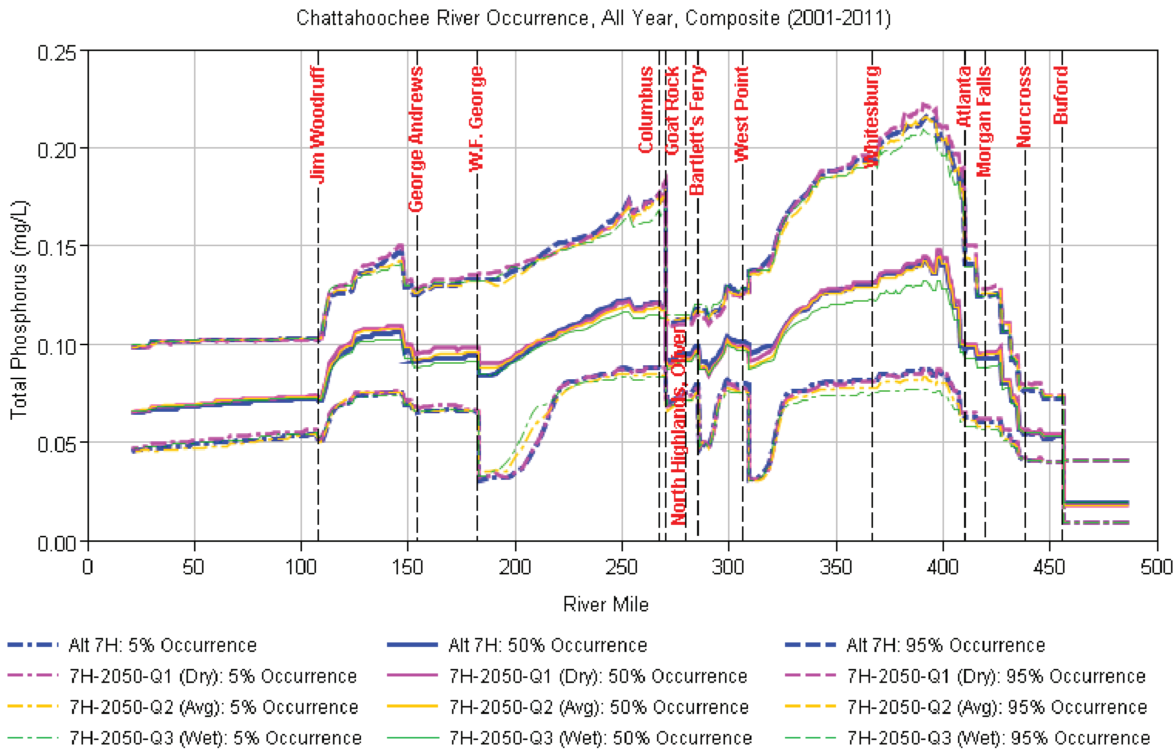


Figure 18. Longitudinal Profile of Modeled Total Phosphorus in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

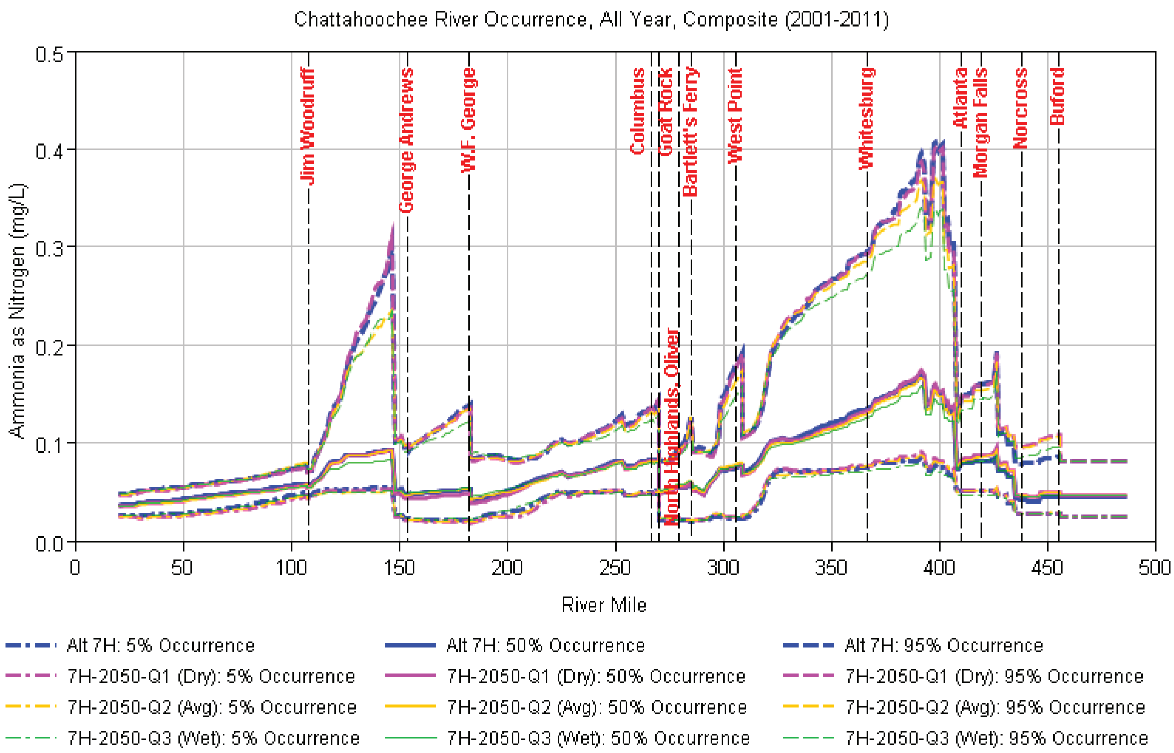


Figure 19. Longitudinal Profile of Modeled Ammonia in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

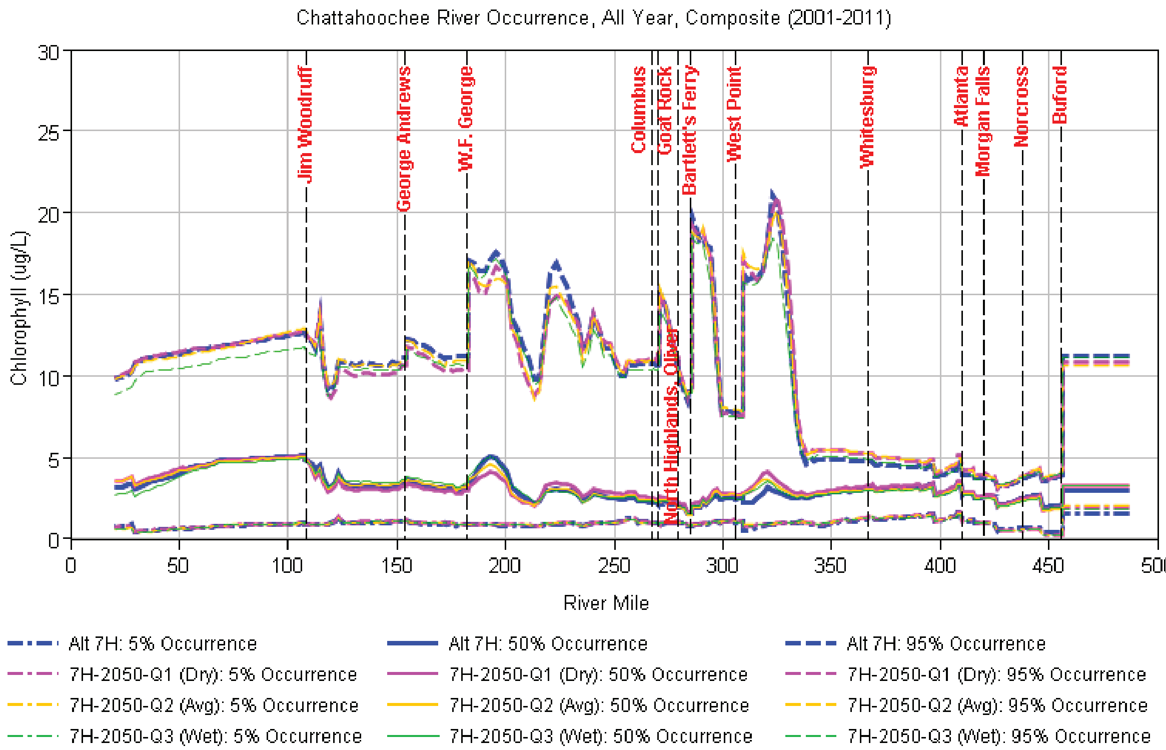


Figure 20. Longitudinal Profile of Modeled Chlorophyll in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

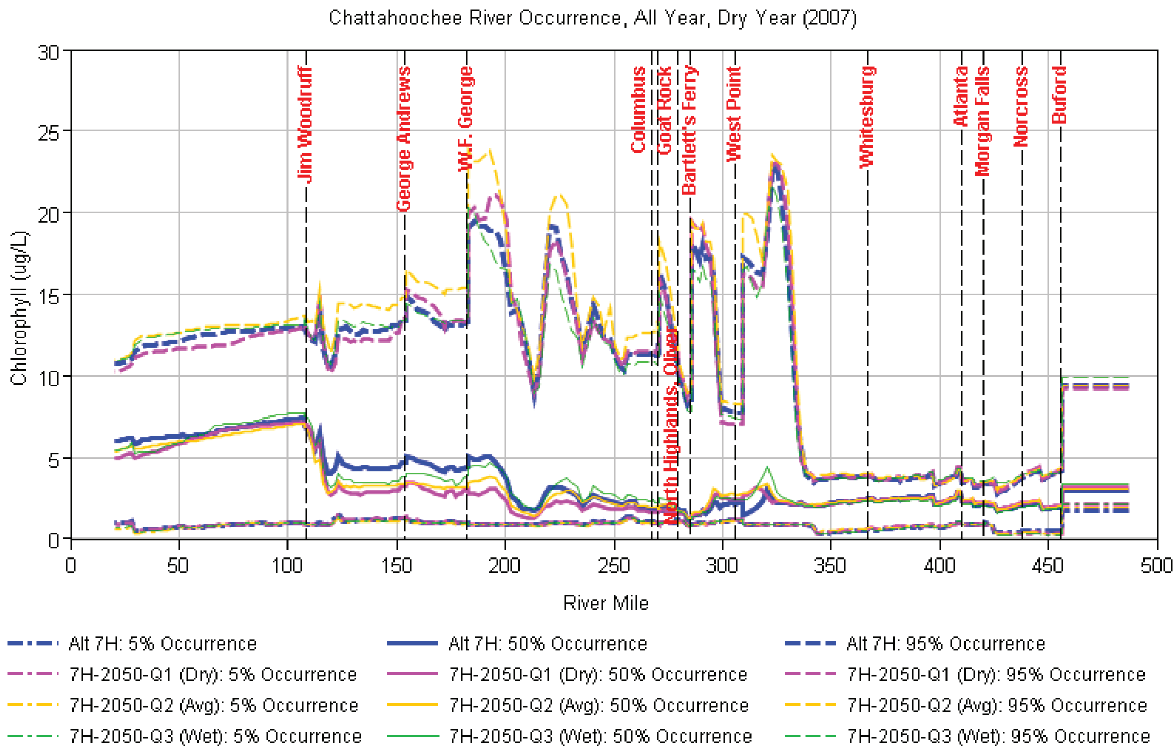


Figure 21. Longitudinal Profile of Modeled Chlorophyll in ACF Basin for Representative Dry Period (2007) for PAA (Alt7H) and Three Climate Scenarios

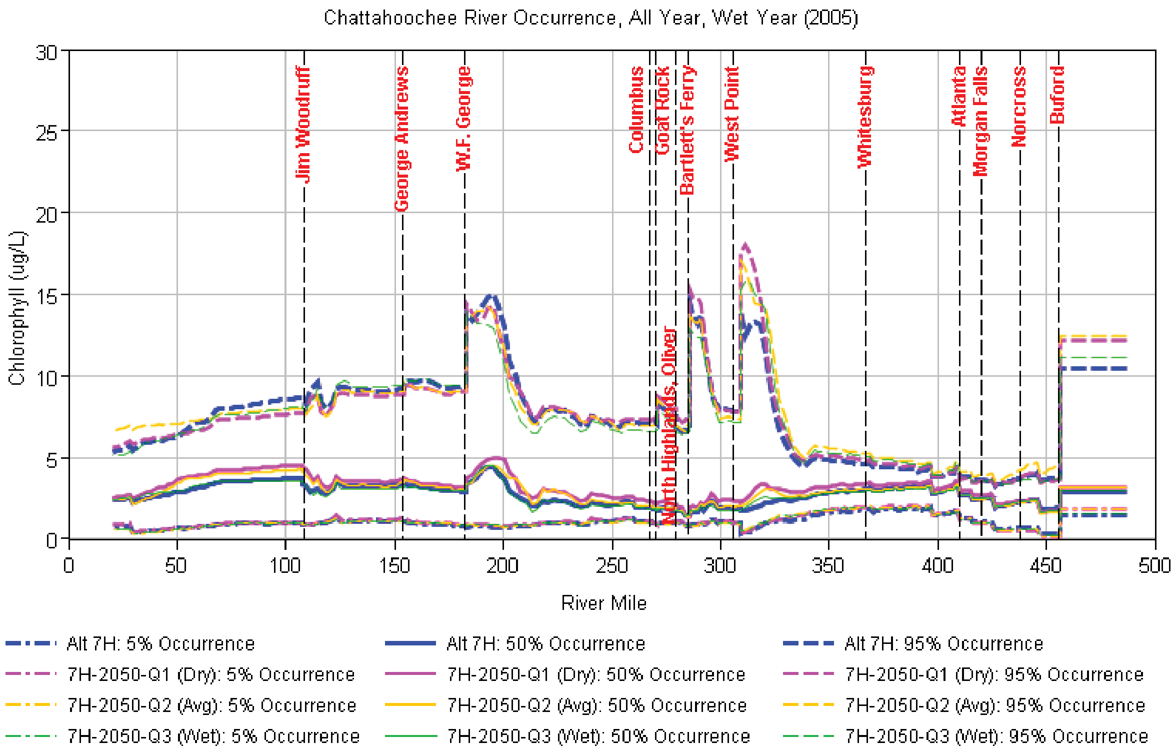


Figure 22. Longitudinal Profile of Modeled Chlorophyll in ACF Basin for Representative Wet Period (2005) for PAA (Alt7H) and Three Climate Scenarios

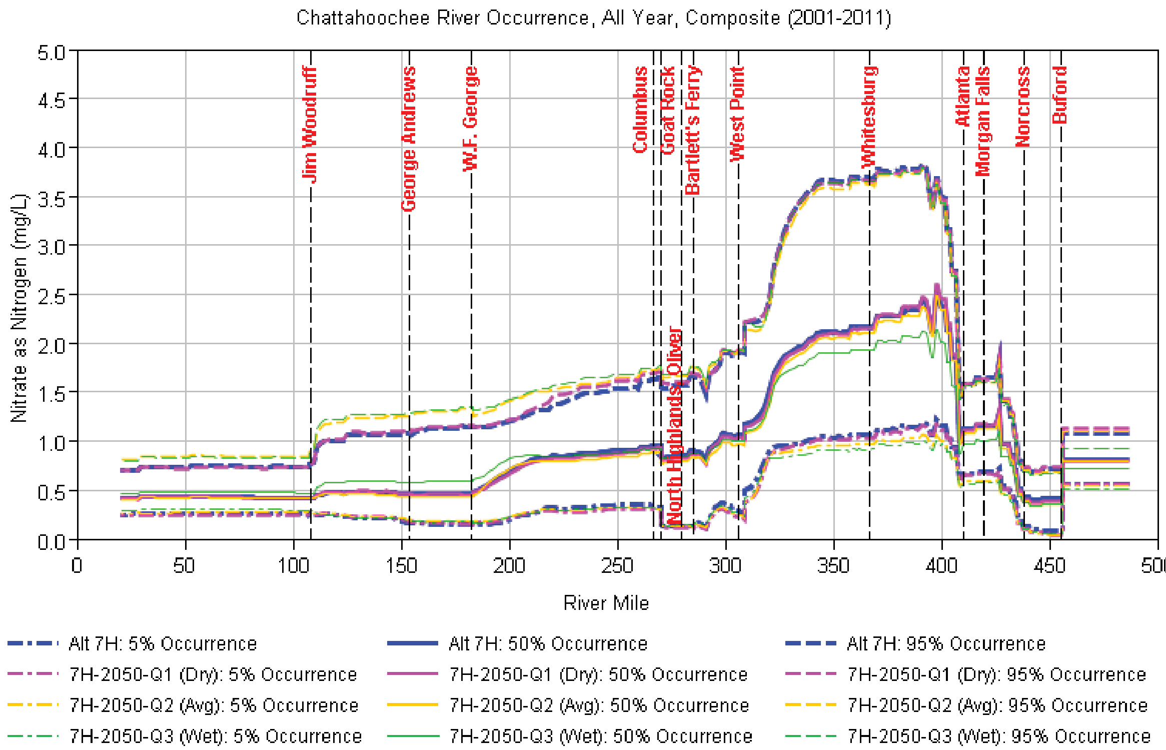


Figure 23. Longitudinal Profile of Modeled Nitrate as Nitrogen in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

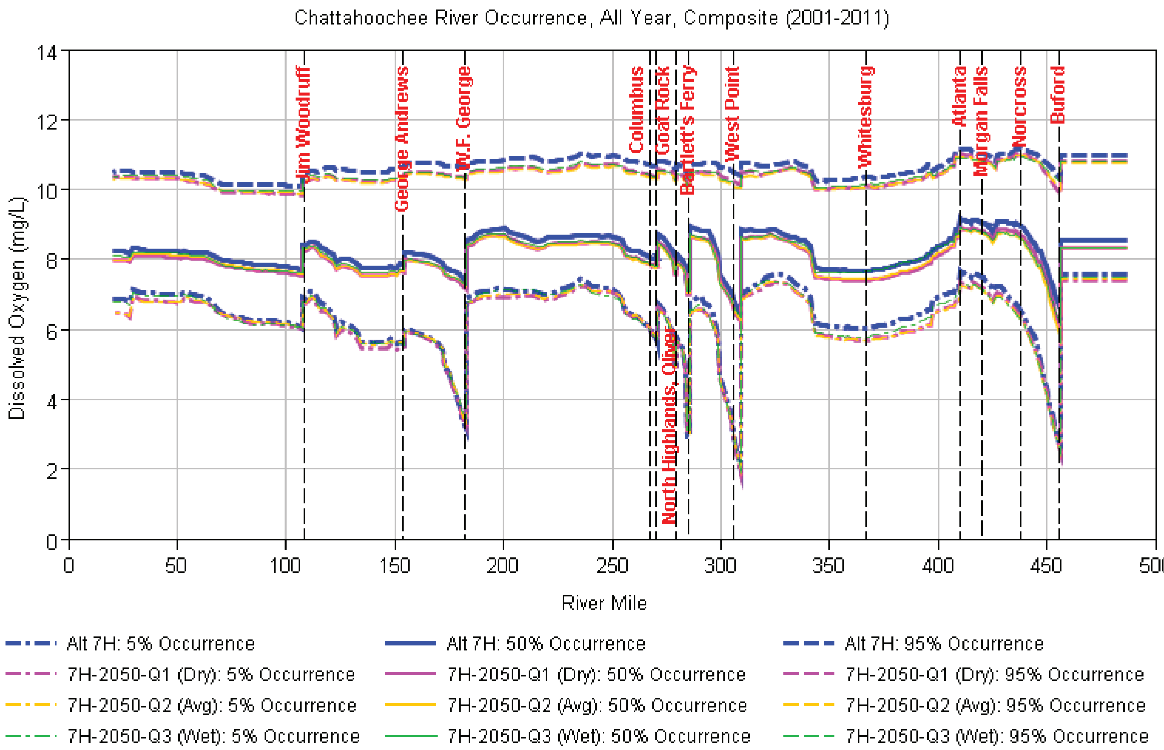


Figure 24. Longitudinal Profile of Modeled Dissolved Oxygen in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

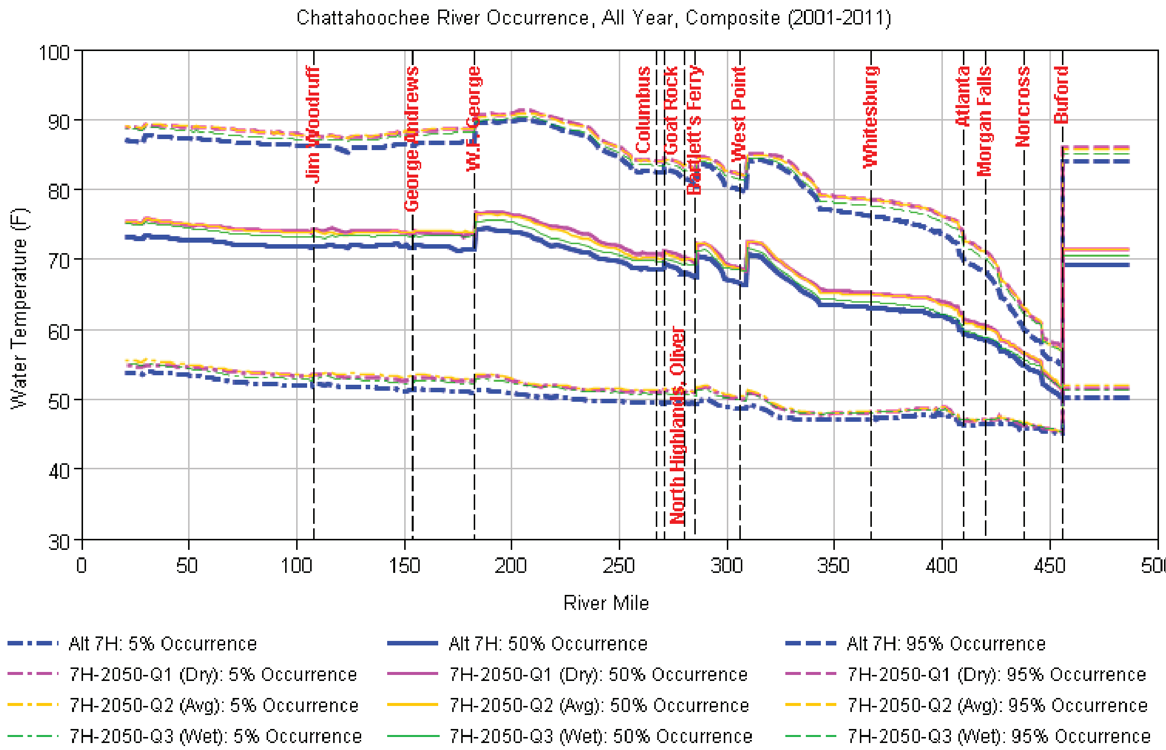


Figure 25. Longitudinal Profile of Modeled Water Temperature in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

Apalachicola-Chattahoochee-Flint Climate Change Support Analysis

Performed by USACE Institute for Water Resources
POC: David Raff, PhD, PE, D.WRE (david.raff@usace.army.mil)
Jeff Arnold, PhD (jeffrey.r.arnold@usace.army.mil)

Introduction: USACE SAM is currently in the process of producing an environmental impact statement (EIS) for the Apalachicola-Chattahoochee-Flint (ACF) watershed and is interested in including the potential impacts from climate change within that EIS. There is currently an expectation both within USACE as well as with stakeholders in the watershed that climate change be considered within the development of project alternatives and ultimately decision making processes.

Dr. David Raff (IWR) briefed SAD in October 2013 on upcoming climate change inland hydrology guidance intended to go beyond current expectations for considering climate change but which describes the requirements of inclusion of climate change within USACE inland hydrology projects and studies. After this briefing Beverley Stout (SAM) contacted David to discuss possibilities for supporting the ACF EIS. Dr. Jeff Arnold (IWR) joined a series of ACF working team meetings to discuss various approaches ranging from a strictly qualitative presentation of climate change information to a quantitative analysis of climate change impacts on hydrology and operations within the basin. All types of approaches are consistent with the qualitative approaches to be required by the forthcoming USACE climate change guidance. Following these discussions, SAM would like to proceed with a numerical modeling assessment of firm yield impacts due to climate change that can be included within the EIS. A scope of work – attached here as Appendix A - for USACE IWR support was developed and approved in December 2013 that outlines the climate change analysis steps that can support the firm yield impacts desired by SAM.

The form of this project report follows the order of tasks in that scope of work. The individual tasks represented by the scope have been accomplished and climate change hydrologic projections have been transmitted to SAM.

The analysis includes a set of readily available hydrologic projection data developed by USACE in cooperation with the National Center for Atmospheric Research (NCAR) as well as utilizing and leveraging cooperative analysis performed with the Department of Interior Bureau of Reclamation and US Geological Survey, Lawrence Livermore National Laboratory, Santa Clara University, Climate Central, and Scripps Institution of Oceanography. The hydrologic projections utilize numerical model outputs from the Coupled Model Intercomparison Project, phase 5 (CMIP5) (Taylor et al. 2011) organized by the World Meteorological Organization. Model outputs from CMIP5 are used in very many climate change applications including in support of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5). This represents the latest generation of General Circulation Models (GCMs) used to create projections of climate change due to anthropogenic forcings. For CMIP5, the experimental design utilized four projections of anthropogenic atmospheric forcings called representative concentration pathways (RCPs) which are identified by their 2100 radiative forcings from 2.6, 4.5, 6.0, and 8.5 W/m^2, respectively (van Vuuren et al. 2011). For this work on the ACF, GCM projections, which consist of an antecedent period from 1950 – 2010 and projections from 2011 – 2099, were bias corrected and spatially downscaled (BCSD) in conjunction with an ongoing archive of projections for use within water management agencies (Reclamation 2013). The BCSD projections were used as external forcings with the Variable Infiltration Capacity (VIC) (Liang, X. et al. 1994) model to generate Hydrologic Unit Code level 4 (HUC4) hydrologic projections.

The hydrologic projections consist of total runoff for each HUC4 within the continental United States (as well as transboundary basins for much of the NLDAS domain) and were computed for each HUC4 basin (local) and for cumulative totals relevant for the SAM application to the ACF (cumulative). The change in HUC4 hydrologic projections against the modeled historical flows were computed for two future time periods:

- Time Period 1: 2021 - 2050
- Time Period 2: 2061 - 2090

Delta values were calculated relative to the equivalent 30 year antecedent period 1970 – 1999; that comparison of projections to modeled antecedent conditions is the basis for making assertions about potential future climate changed altered hydrology for the ACF.

Outline Step 1. Information provided by SAM on December 12, 2013, via email from Ryan Crane. That information set included two sets of flow data for the ACF. Both sets were for 22 sites within the basin and were cumulative values at those sites, including all upstream flows. One site included naturalized flows that allowed negative numbers, assumed for mass balance purposes, the second data set was "smoothed" and eliminated any negative values.

Following a presentation of interim status held on Tuesday, January 14th, 2014, Mr. James Hathorn (SAM), Chief, Water Management Section, requested that the analysis be performed on local flows in addition to a single set of cumulative flows. This required an additional data transfer which took place on Wednesday January 15th, 2014. The hydrologic outputs that used the localized flows and the single set of cumulative flows described here and which accompany this project report supersede any previous analysis and presentation of interim results.

Outline Step 2. In order to access the appropriate HUC 4 hydrologic projections produced by USACE with NCAR, the sites provided by SAM were placed within a GIS layer of HUC4 boundaries. All sites provided by SAM are located within a single HUC 4 (0313 - Apalachicola).

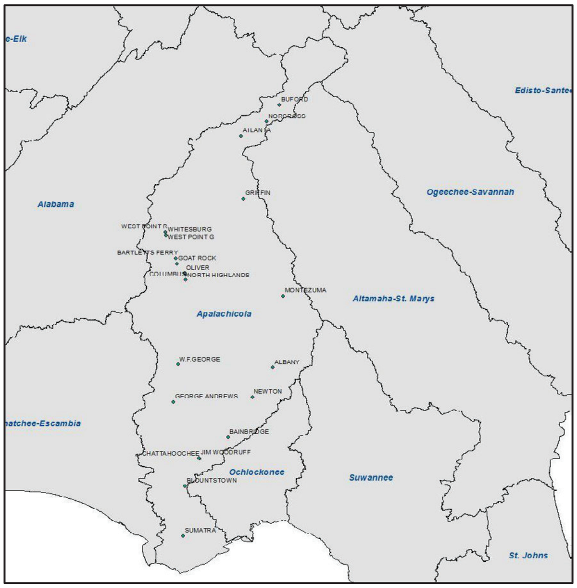


Figure 1: Map of input nodes provided by USACE SAM to be evaluated as part of the ACF Climate Change project. All nodes exist within HUC4 – 0313 – Apalachicola.

Outline Step 3.

The HUC4 - 0313 data is accessed from the hydrologic projection total data set. Before making a selection about which projections to consider (Outline Step 4) an intermediate step was deemed prudent given the substantially wide range of radiative forcings considered within the CMIP5 experiment. The HUC4 hydrologic responses were evaluated to determine the degree and type of differences as a function of RCPs to determine whether all or only selected RCPs needed to be used. The two figures below show this analysis. The first indicates the range of all hydrologic projections (yellow band) and the RCP medians at each month for the entire antecedent and future time periods considered wtihin the USACE-NCAR project. The second figure is a box and whiskers plot for each RCP as well as the dataset as a whole. Based upon visual inspection of these figures it was determined that for this location, the hydrologic projection responses computed using these methods are not obviously dependent on RCP. Therefore, there is no reason to sub-select from the RCPs but rather to treat them all as equally plausible for this analysis.

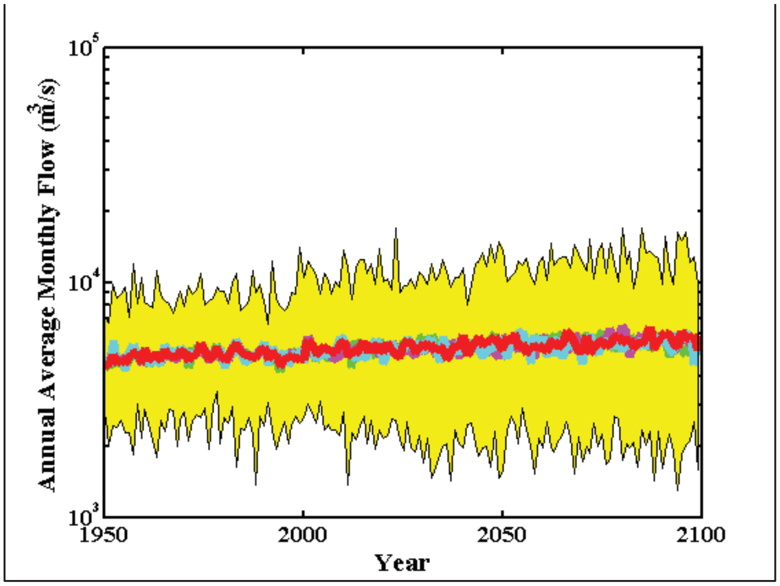


Figure 2: Full spread (yellow shading) of the 100 monthly hydrologic simulations that were developed as part of the VIC CMIP5 project at the HUC 4 level. The mean values at each month for each RCP are shown as the four solid (overlapping) lines. Visual evaluation indicates that the mean trends are indistinguishable across the various RCPs used in the analysis.

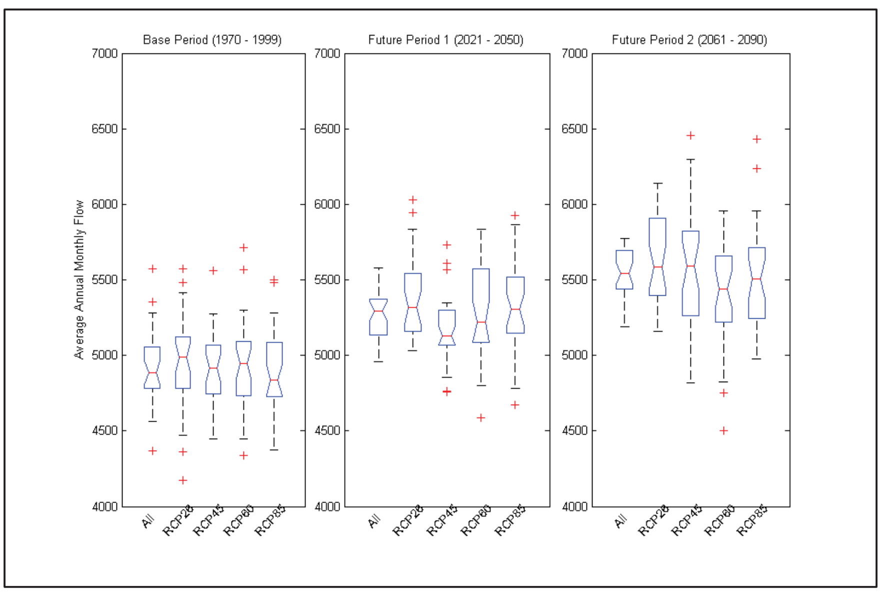


Figure 3: For each of the two time periods (2021 – 2050, 2061-2090) being explored for this climate change analysis GCM-projected spread for each RCP is presented. Visual analysis indicates no clear trend in the different W/m^2 at 2100 radiative forcings for this HUC 4 hydrologic analysis.

Outline Step 4.

Based upon the determination to consider all 100 projections equally plausible, empirical cumulative distribution functions (ECDFs) were developed for a climate change metric for the two future time periods (2021-2050, 2061-2090). The ECDFs represent the mean of all months for each of the 100 hydrologic projections within the 30-year time period ratioed against the mean of all months from the same model for the antecedent time period. Selection of the particular hydrologic projections to be utilized further was made by determining a "Dry", "Median", and "Wet Condition" for the two future time periods which are the 10th, 50th, and 90th quantiles, respectively (shown in Figure 4 by the black vertical lines).

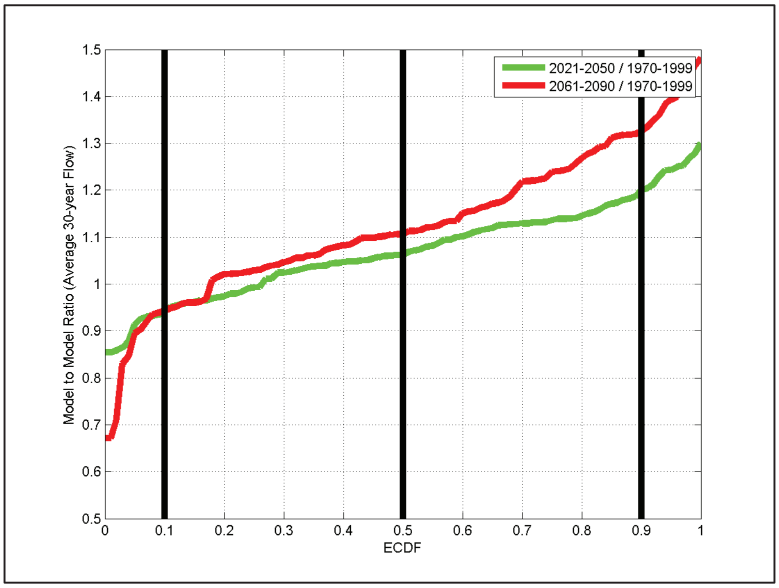


Figure 4: Empirical Distribution Functions for the 100 available HUC4 hydrologic projections for the Apalachicola. The ratios represent model to model of future period to antecedent period 30 year average monthly values.

Table 1: Selected hydrologic projections for further analysis.

	10% Quantile (DRY)	50% Quantile (AVERAGE)	90% Quantile (WET)
Time Period			
2021 - 2050	HadGEM2-ES.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc	HadGEM2-CC.rcp85.monthly.runoff.1950-2099.HUC4.SUM.nc	CCSM4.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc
2061 - 2090	HadGEM2-AO.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc	ACCESS1-0.rcp85.monthly.runoff.1950-2099.HUC4.SUM.nc	CCSM4.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc

We acknowledge the World Climate Research Programme's Working Group on Coupled Modeling, which is responsible for CMIP, and we thank the climate modeling groups listed in Table 2 of this documentation for producing and making available their model output. For CMIP, the U.S. Department of Energy's Program for Climate Model Diagnostics and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals.

Table 2: Recognition of climate modeling groups within the World Climate Research Programme's Working Group on Coupled Modeling being utilized within final analyses.

WCRP CMIP5 Climate Modeling Group[1]	WCRP CMIP5 Climate Model ID	RCP 2.6 Runs	RCP 4.5 Runs	RCP 6.0 Runs	RCP 8.5 Runs
Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	HadGEM2-AO	0	0	1	0
	HadGEM2-CC	0	0	0	1
	HadGEM2-ES	0	0	1	0
Commonwealth Scientific and Industrial Research Organization and Bureau of Meteorology, Australia	ACCESS1-0	0	0	0	1
National Center for Atmospheric Research	CCSM4	0	0	1	0

[1] http://cmip-pcmdi.llnl.gov/cmip5/docs/CMIP5_modeling_groups.pdf

Outline Step 5.

For each of the three selected hydrologic projections for each time period ECDF maps are created for the full 30 year projection period against the full 30 year selected retrospective material for each month separately. An example of those maps is provided as Figure 5. The "map" that will be utilized to scale the ACF naturalized flows is created by taking each future ECDF point and dividing by the equivalent plotting position from the antecedent ECDF point. The remaining maps are provided within Monthly_VIC_Figs.zip.

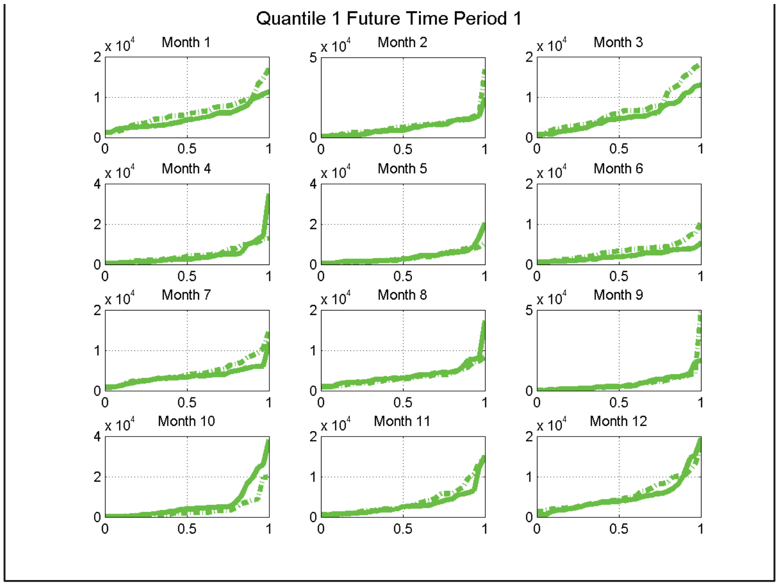


Figure 5. Example ECDF map for Quantile 1 (Dry 10% Projection) for Future Time Period 1 (2021 – 2050). Dashed line within each month figure represents the antecedent ECDF and the solid line represents the future ECDF.

Outline Step 6.

Utilizing the maps created in Outline Step 5 each of the 22 ACF sites is scaled by the appropriate monthly map. To accomplish this, each of the 22 ACF sites is subdivided into months utilizing the monthly average flow from the naturalized data set provided by SAM. An example for Jim Woodruff for future time period 1 (2021 – 2050) for quantile 1 (Dry 10%) is provided as Figure 6 for local flows and an example for Chattahoochee for future time period 1 for quantile 1 is provided as Figure 7. The remaining scaled flows for site 1 are provided as Monthly _ACF_Figs.zip.

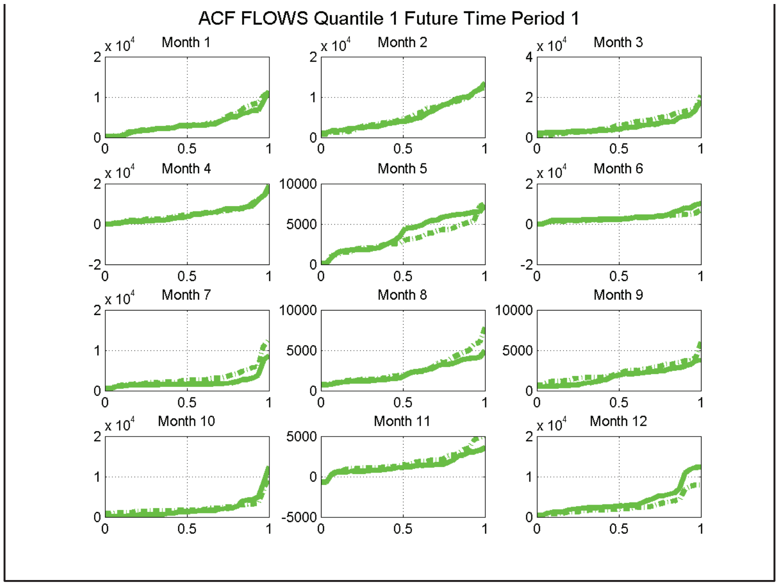


Figure 6. Example scaling of monthly flows for the local naturalized flows at Jim Woodruff. The dashed line indicates the naturalized ECDF flows for Jim Woodruff for each month and the solid line represents the climate changed ECDF flows.

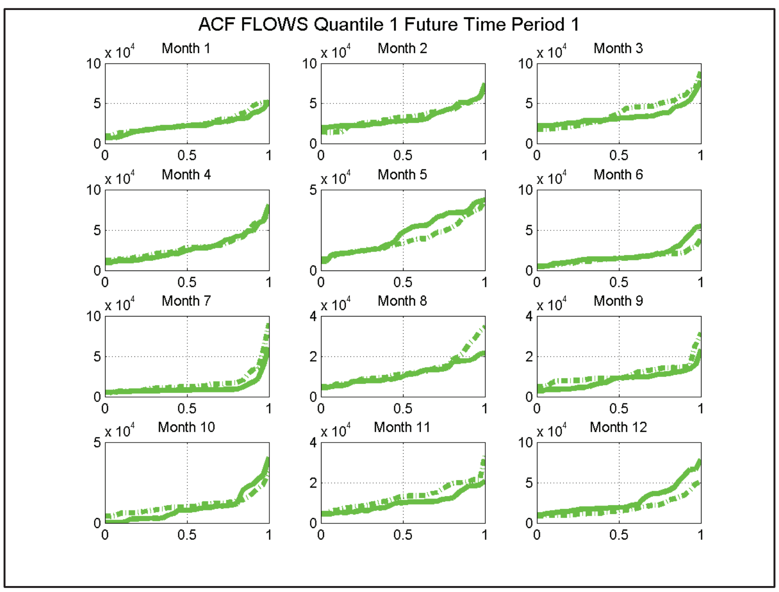


Figure 7. Example scaling of monthly flows for the cumulative naturalized flows at Chattahoochee. The dashed line indicates the naturalized ECDF flows for Chattahoochee for each month and the solid line represents the climate changed ECDF flows.

Outline Step 7.

Reconstituting the climate changed flows by ACF node site requires reassigning the appropriate month from the ECDF into chronological order. At this point that has been accomplished to the monthly basis. An example time series for Chattahoochee utilizing the cumulative flows is shown within Figure 8.

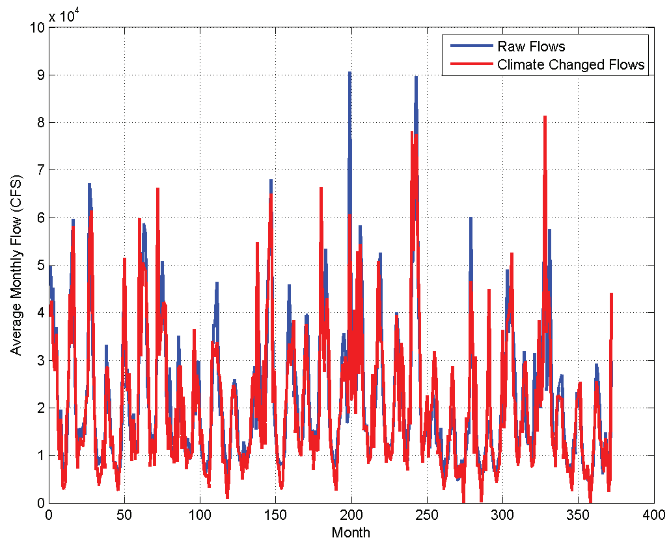


Figure 8. Example Monthly time series reconstituted from climate changed ECDF for the cumulative flows for Chattahoochee. The blue line represents the raw naturalized flows received from SAM averaged for the month. The red line represents the average monthly values reconstituted from the climate changed flows.

As a measure of quality control and assurance, as well as for communication purposes, the climate-altered monthly flows for each site were compared to the original projection selection represented within Figure 4. For each site the ratio of average monthly values for the future period was taken with respect to the antecedent period. The comparisons are shown within Figure 9 and Figure 10 for the local and cumulative naturalized flows, respectively. Sites, individually and collectively, may not match exactly the model-to-model ratio that was initially utilized to select quantiles for analysis. Upon further investigation it was determined that this is due, in some part, to the skew of the VIC flows relative to the skew of the naturalized raw flows. When the skews do not match and the quantile map is applied flows get "pulled" either wetter or drier depending on whether the skew of the VIC is greater than the skew of the raw naturalized flows, or vice versa.

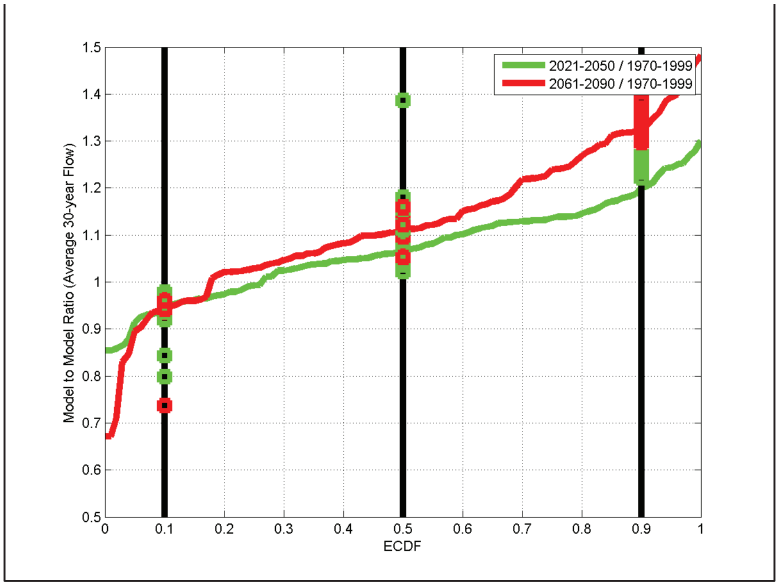


Figure 9. Figure shows the average monthly values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change local naturalized flows. The green open circle values are for time period 1 (2021 – 2050) and the red open circle values are for time period 2 (2061 – 2090). The distribution of site ratios is indicative of differences amongst "skew" of the flow data with respect to the skew of the VIC quantile maps as described just above.

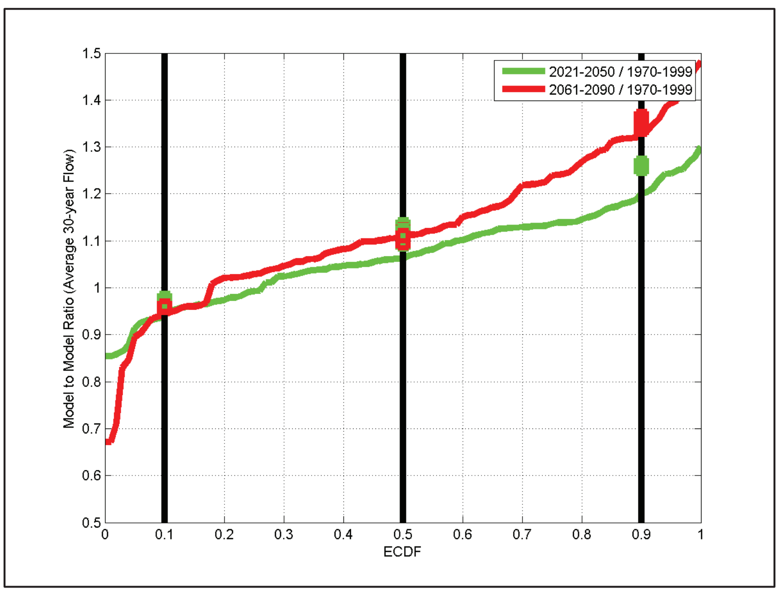


Figure 10. As for Figure 9 but here for cumulative naturalized flows.

Outline Step 8.

In order to utilize the climate-changed hydrology within the operational models of the ACF, which is the goal of the project on sensitivity analysis, it is required to reconstitute daily values from the monthly values created within Outline Step 7. Daily values for each site for each month were calculated by assigning the same daily percentage of monthly flows that were represented within the original naturalized flow files for both the local and cumulative values. In this manner the same day for the same month represents the same percentage of monthly flows within the climate-changed analysis. An example of the daily scaling is provided within Figure 11 for the cumulative flows at Chattahoochee for time period 1 and quantile 1. The figure represents the first January scaled to the climate-changed values. The daily values were then exported to an excel file in the same order of sites as was the original data. There is one excel file for each quantile for each of two time periods. Therefore, there are 6 total files of daily values for the climate change local naturalized flows and 6 total files of daily values for the climate change cumulative naturalized flows.

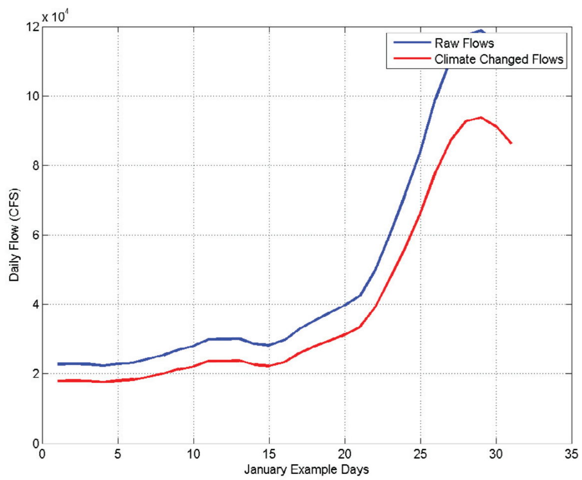


Figure 11: Example reconstitution of daily values for the first January in the time series for the cumulative flows at Chattahoochee for time period 1 and quantile 1. The blue line represents the raw daily values and the red line represents the climate changed values.

As a measure of quality control and assurance, the final daily values were compared to the original projection selection represented within Figure 4 as well as to the expectation of monthly flows represented within Figures 9 and 10. The ratio of the average daily values for the 30 year period of future to antecedent was taken for each site and these values are shown within Figure 12 and Figure 13 for the local and cumulative naturalized flows, respectively.

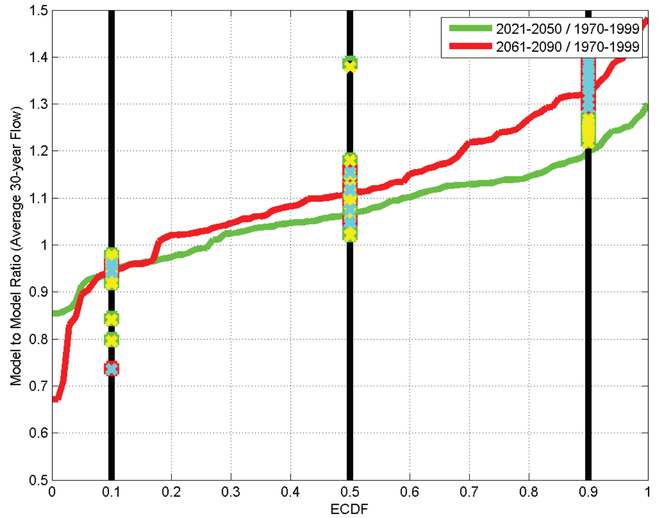


Figure 12. Figure shows the average daily values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change local naturalized flows. The yellow “X” values are for time period 1 (2021 – 2050) and the blue “X” values are for time period 2 (2061 – 2090). The agreement between the “X” values and the “O” values (monthly ratios) is indicative of the daily disaggregation achieving the desired outcome.

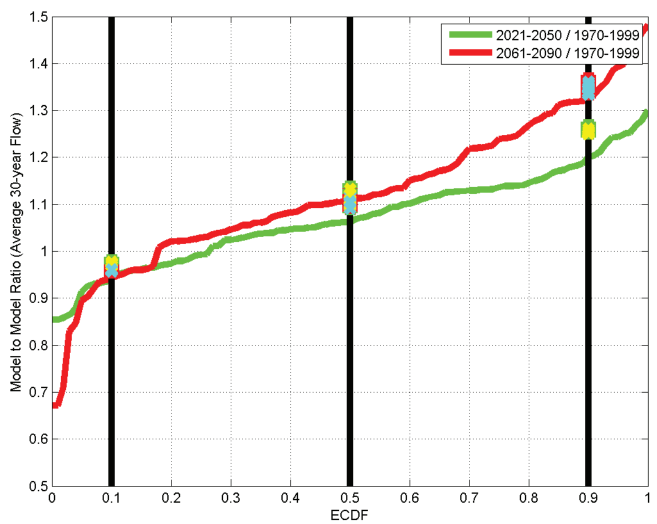


Figure 13. Figure shows the average daily values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change cumulative naturalized flows. The yellow “X” values are for time period 1 (2021 – 2050) and the blue “X” values are for time period 2 (2061 – 2090). The agreement between the “X” values and the “O” values (monthly ratios) is indicative of the daily disaggregation achieving desired outcome.

References:

Liang, X., D.P. Lettenmaier, E.F. Wood, and S.J. Burges, 1994. A Simple Based Model of Land Surface Water and Energy Fluxes for GSMs, J. Geophys. Res., 99(D7), 14, 415-14,428.

Reclamation, 2013. Downscaled CMIP3 and CMIP5 Climate Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with Preceding Information, and Summary of User Needs. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado, 116 p. available at: http://gdo-dcp.ucllnnl.org/downscaled_cmip_projections/techmemo/downscaled_climate.pdf.

Taylor, K.E., R.J. Stouffer, and G.A. Meehl, 2011. A Summary of the CMIP5 Experiment Design. january 22, 2011, 33 p., available at: http://cmip-pcmdi.llnl.gov/cmip5/docs/Taylor_CMIP5_design.pdf.

van Vuuren, D.P., J. Edmonds, M. Kainuma, K. Riahi, A. Thomson, K. Hibbard, G.C. Hurtt, T. Kram, V. Krey, J-F Lamarque, T. Masui, M. Meinshausen, N. Nakicenovic, S.J. Smith, and S.K. Rose, 2011. "The Representative Concentration Pathways: An Overview," Climatic Change, 109:5-31.

Appendix A: Scope of Work for IWR support of climate change analysis for ACF EIS 2014.

Climate Change Analysis Support Apalachicola-Chattahoochee-Flint (ACF) Study
Scope of Work – Prepared by Dr. David Raff (IWR)
11/19/2013

Background: Dr. David Raff (IWR) briefed SAD on upcoming climate change inland hydrology guidance in October 2013. Following that presentation Beverley Stout (SAM) contacted David to discuss possibilities for including a climate change analysis within an ongoing EIS for the ACF. Dr. Jeff Arnold (IWR) joined a series of ACF working team meetings to discuss various approaches including a strictly qualitative presentation of climate change information through a quantitative analysis of climate change impacts on hydrology and operations within the basin. All types of approaches are consistent with the qualitative approaches to be required by the forthcoming climate change guidance. Following these discussions SAM would like to proceed with a numerical modeling assessment of firm yield impacts due to climate change that can be included within the EIS.

Outline Numerical Modeling Assessment.

1. Identify input nodes to HEC ResSim used within SAM ACF planning model.
2. Map input notes to HUC 4s.
3. Access BCSD – VIC HUC 4 hydrological simulations for the HUC 4s identified in 2. Simulations are those created as part of Responses to Climate Change and Actions for Change work with National Center for Atmospheric Research developed in 2013. No additional activity assumed to be necessary to develop hydrologic simulations.
4. For each future time periods 2020 – 2050 and 2060 – 2090 identify 3 VIC simulations that represent dry, median, and wet conditions for those time periods based on average annual flows across all HUC 4s. ** Want to use the same model for all subbasins in each run. Option is to identify key subbasins and use those for identifying a series of dry, median, and wet conditions -> could lead to more than 3 total. **
5. For those models selected on a monthly basis identify the future to base cumulative distribution function (CDF) shift for each of the models identified in 4.
6. Rank (create empirical distribution function) a 30 year sequence of unimpaired flows currently used by SAM for current modeling efforts.
7. Using the CDF shifts of 5 alter the unimpaired flows of 6 on a monthly basis such that the new CDFs match the projected shifts from 5.
8. Take the altered unimpaired flows from 7 and run through HEC ResSim model to identify range of firm yield impacts.
9. QA / QC of all work completed
10. Documentation for work performed.

IWR Scope of Work.

Outline Step	Responsibility	Product	Cost 1,000$ (IWR)	Proposed Completion
1	SAM	SAM will provide IWR with lat / long of nodes. SAM will provide IWR with a chosen 30 year sequence of unimpaired flows at all nodes	N/A	December 15, 2013
2	IWR	Matrix of HUC 4s for nodes	2	December 21, 2013
3	IWR	100 hydrology simulations for each HUC 4	2	January 5, 2013
4	IWR / SAM	3 hydrology simulations for all HUC 4s	2	January 10, 2013
5	IWR	CDF Maps	7	January 31, 2013
6	IWR	EDF for unimpaired flows	2	February 7, 2013
7	IWR	Altered unimpaired flows in same format as those provided by SAM to IWR in step 1. Passed to SAM.	4	February 19, 2013
8	SAM / HEC*			March 7, 2013
9	SAM / IWR		5	March 14, 2013
10	SAM / IWR		7	March 21, 2013
Total			31	

*HEC – Assumed this is HEC support of firm yield modeling.

This page intentionally left blank

USFWS July 2016 Letter

This page intentionally left blank

CMF YD-EI

IN REPLY REFER TO:

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Field Office
1601 Balboa Avenue
Panama City, FL 32405-3721
Tel: (850) 769-0552
Fax: (850) 763-2177

July 29, 2016

Mr. Curtis Flakes
Chief, Planning and Environmental Division
U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

Dear Mr. Flakes:

This letter acknowledges the United States Fish and Wildlife Service (USFWS) receipt on June 1, 2016 of your May 31, 2016 letter requesting formal consultation under section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). The consultation concerns possible effects as described in the Biological Assessment (BA) entitled "Biological Assessment Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment" (May 31, 2016, supplemented with additional information on June 30, 2016) on the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and critical habitat for the Gulf sturgeon; the endangered fat threeridge mussel (*Amblema neislerii*); the threatened purple bankclimber mussel (*Elliptoideus sloatianus*); the threatened Chipola slabshell mussel (*Elliptio chipolaensis*) and critical habitat for these three listed mussel species.

At this time, USFWS has received all the information (either included with your letter or otherwise accessible for our consideration and reference) necessary to initiate formal consultation on this BA as outlined in the regulations governing interagency consultations (50 CFR §402.14).

Section 7 allows the USFWS up to 90 calendar days to conclude formal consultation with your agency and an additional 45 calendar days to prepare our biological opinion (unless we mutually agree to an extension). However, we expect to provide you with our biological opinion well before then.

As a reminder, the Endangered Species Act requires that after initiation of formal consultation, the Federal action agency may not make any irreversible or irretrievable commitment of resources that limits future options. This practice insures agency actions do not preclude the formulation or implementation of reasonable and prudent alternatives that avoid jeopardizing the continued existence of endangered or threatened species or destroying or modifying their critical habitats.

If you have any questions or concerns about this consultation or the consultation process in general, please contact me at 850/769-0552 (ext. 242).

Sincerely,

Dr. Catherine Phillips
Field Supervisor

cc:
Regional Office (Leopoldo Miranda)
Florida State Supervisor for Ecological Services (Larry Williams)
Alabama Ecological Services Field Office, AL (Bill Pearson)
Georgia Ecological Services Field Office, GA (Donald Imm)

USFWS September 2016 Biological Opinion

This page intentionally left blank

Biological Opinion

Endangered Species Act
Section 7 Consultation

on the

U.S. Army Corps of Engineers
Mobile District

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

Prepared by:
U.S. Fish and Wildlife Service
Panama City Field Office, Florida
September 14, 2016

USFWS Log No: 04EF3000-2016-F-0181

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Panama City Field Office
1601 Balboa Avenue
Panama City, Florida 32405
Tel: (850) 769-0552
Fax: (850) 763-2177

September 14, 2016

Curtis M. Flakes, Chief
Planning and Environmental Division
Mobile District, Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001

Attn: Mrs. Kristina Mullins

Re: FWS Log No. 04EF3000-2016-F-0181
Applicant: U.S. Department of the Army, Corps of Engineers (ACOE)
Project: ACF Master Water Control Manual Update
Action area: Alabama, Florida, Georgia

Dear Mr. Flakes:

This document is the Fish and Wildlife Service's (Service) biological opinion (BO) of the Update of the Water Control Manual (WCM and Water Supply Storage Assessment for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia (ACF). The action addresses water management operations at the five federal projects within the basin and the associated releases to the Apalachicola River. The Service recognizes that the ACF River basin is a working river that provides water, transportation and livelihood for residents of three states, and the USACE uses its WCM to balance multiple project purposes including: recreation, water supply, navigation, hydroelectric generation, flood control, drought reduction, fish and wildlife habitat, and endangered species. This opinion is provided in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*) and provides considerations for provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*).

In your request for consultation, you determined the proposed action may adversely affect the fat threeridge (*Amblema neislerii*), purple bankclimber (*Elliptoideus sloatianus*), and Chipola slabshell (*Elliptio chipolaensis*), but is not likely to adversely affect (NLAA) their designated critical habitat. Additionally, you determined that the proposed action may affect, but is NLAA, the Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and its designated critical habitat.

The Service has reviewed the project description and evaluation of project effects, and concurs with your determination that the proposed action may adversely affect the fat threeridge, purple bankclimber, and Chipola slabshell. After bringing additional information and the latest science to bear in the analysis, with the acknowledgement and understanding of USACE, the Service finds that the proposed action may adversely affect the Gulf sturgeon and its designated critical habitat as well as designated critical habitat for the three listed mussels; thus, we do not concur with the USACE's determination of NLAA. However, it is the USFWS' biological opinion (BO) that the proposed action: 1) will not jeopardize the continued existence of the Gulf sturgeon, the fat threeridge, purple bankclimber, and Chipola slabshell; and 2) will not destroy or adversely modify designated critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell.

We appreciate the cooperation and the partnership of your staff in preparing this BO. We look forward to working closely with you in implementing its provisions and other conservation actions for the listed species and critical habitat of the ACF Basin ecosystem. If you have any questions about these comments or additional information needs, please contact myself (ext. 242) or Deputy Field Supervisor for Ecological Services, Dr. Sean Blomquist (ext. 233).

Sincerely,

//s//Dr. Catherine T. Phillips

Dr. Catherine T. Phillips
Project Leader

cc:
Assistant Regional Director, Ecological Services (Leopoldo Miranda)
Florida State Supervisor for Ecological Services (Larry Williams)
Alabama Ecological Services Field Office, AL (Bill Pearson)
Georgia Ecological Services Field Office, GA (Donald Imm)

1 attachment (Biological Opinion)

EXECUTIVE SUMMARY

The action evaluated in this consultation is the U.S. Army Corps of Engineers' (USACE) Update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint River Basin (ACF) in Alabama, Florida, and Georgia. The proposed action is primarily the operation of the five federal facilities, individually and in concert, under the WCM. The USFWS recognizes that the ACF River basin is a working river basin that provides water, transportation and livelihood for residents of three states. The USACE uses its WCM to balance these uses, for recreation, water supply, navigation, hydroelectric generation, flood control, drought reduction, fish and wildlife habitat, and endangered species.

The USACE determined in its Biological Assessment (BA) that the proposed action may adversely affect the fat threeridge, purple bankclimber, and Chipola slabshell, but is not likely to adversely affect (NLAA) their designated critical habitat. Additionally, USACE determined that the proposed action may affect, but is NLAA, the Gulf sturgeon and its designated critical habitat. The USFWS incorporated new information and analysis for Gulf sturgeon and does not concur with the USACE's determination of NLAA for the Gulf sturgeon and its designated critical habitat. Therefore, mussel and sturgeon effects on the species and their critical habitats are addressed in this biological opinion (BO).

In the WCM, the USACE adopts a modified version of its preferred alternative action (PAA) from the Draft Environmental Impact Statement (DEIS). The WCM includes actions for fish and wildlife conservation, including actions for federally-listed species (e.g., water releases below Woodruff Dam on the basis of spawning, non-spawning, and winter requirements), tailrace dissolved oxygen levels, fish passage, reservoir fish spawning, and management of Eufaula National Wildlife Refuge. The WCM also includes actions for drought operations, flood risk management, hydroelectric power generation, navigation, recreation, water quality, and water supply. Compared to existing management, the USACE proposes to modify 1) the action zones, 2) drought operations, 3) storage relocation at Lake Lanier, 4) ramping during prolonged flow, and 5) navigation.

The current status of Gulf sturgeon and the three mussel species and the critical habitat for all four species is discussed in detail in this BO. The principal factor we examine is the flow regime of the Apalachicola River and how the flow regime affects habitat conditions for the listed species. In the BA, environmental baseline was defined as the observed flows of the river since the full complement of the USACE's reservoirs were completed and for which an unimpaired data set was available, so that the proposed action could be modeled (calendar years 1975 to 2012). In this BO, an alternative strategy is being employed as discussed in the Environmental Baseline – Physical Environment section. Under this approach, the modeled effects of the WCM are compared to the modeled effects of the USACE's no action alternative (NAA) for 1939-2012. The NAA includes the RIOP management implemented from 2012-present and is the baseline for this consultation.

Relative to the baseline, the proposed update to the WCM provides both beneficial and adverse effects to the species and designated critical habitats we have assessed. The WCM will

negatively affect Gulf sturgeon by providing more time under which appropriate flow conditions for hydropeaking will occur during the spring spawning season and less inundation of floodplain habitats in late summer, fall, and winter. The WCM may affect four of the six primary constituent elements (PCEs) of sturgeon critical habitat: 1) food items in the riverine and estuarine environments, 2) riverine spawning areas, 3) flow regime, and 4) water quality. However, the WCM would not appreciably change the quantity or quality of the PCEs to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role. It is the U.S. Fish and Wildlife Service's (USFWS) biological opinion (BO) that the proposed action: 1) will not jeopardize the continued existence of the Gulf sturgeon, and 2) will not destroy or adversely modify designated critical habitat for the Gulf sturgeon.

The WCM will negatively affect all three mussel species by providing longer durations of low flows (<5,000 cfs). The WCM may affect three of the five PCEs of mussel critical habitat: 1) permanently flowing water, 2) water quality, and 3) fish hosts. The WCM does appear to reduce the amount of floodplain habitat available to fish hosts for spawning. However, the WCM would not appreciably change the quantity or quality of the PCEs to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role. It is the USFWS' biological opinion that the proposed action: 1) will not jeopardize the continued existence of the fat threeridge, purple bankclimber, and Chipola slabshell; and 2) will not destroy or adversely modify designated critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell.

The Incidental Take Statement issued exempts USACE from take under the Act. During conditions appropriate for hydropeaking during the Gulf sturgeon spawning season and during late summer, fall and winter by decreasing floodplain inundation, take of Gulf sturgeon will occur and the magnitude of this take will be estimated using surrogate measures and monitored. Hydropeaking will not occur on more than 32 days on average during the sturgeon spawning season. Floodplain inundation will not be reduced below 655,000 ac-day on average during late summer and fall or below 131 days on average during winter and spring. During each low flow event (flow reduction to 4,500 cfs and exposure at > 5,000 cfs following recolonization) and due to reduced floodplain inundation, a maximum of the following mussel species may be taken: 34,000 fat threeridge total, 90 purple bankclimbers total, and 106 Chipola slabshell total.

The biological opinion also outlines three mandatory, reasonable, and prudent measures necessary and appropriate to minimize the impacts of incidental take of Gulf sturgeon and the three mussel species. 1) Adaptive management, where USACE will identify ways to avoid and minimize take and implement alternative management strategies within the scope of the authorities of the WCM as new information is collected. For example, USACE will provide pulses of water in late summer, fall and winter months to inundate the floodplain and monitor the effects of these releases on Gulf sturgeon food production and mussel host fish populations. 2) Water flow and water quality stations, where USACE will develop and implement a monitoring program associated with permanent monitoring stations in the Apalachicola, Chattahoochee, and Flint rivers. Discharge, stage, temperature, dissolved oxygen, and salinity will be monitored related to listed species and critical habitat effects. 3) Species monitoring, where USACE will monitor the level of take associated with the WCM by monitoring the distribution, abundance, survival, growth, and fecundity of the listed mussels and Gulf sturgeon in the action area. RPMs to address the effects of hydropeaking during the Gulf sturgeon spawning season are not included as part of this BO because this activity is nondiscretionary at this time. These effects will be addressed through later consultation with the Southeast Power Administration.

This BO evaluates the WCM, with a consideration that the WCM is reviewed every 5 years pursuant to USACE South Atlantic Division policy; therefore, we issue this BO with the understanding that the WCM may be revised or updated within 5 years (i.e., in 2021), and that this BO will be reviewed, or consultation reinitiated at that time. No further consultation is needed unless the USACE operates its projects covered in the WCM in a way that is different than described in its BA, new information indicates that the WCM may affect listed species or their critical habitat to an extent not considered in the BO, a new species is listed in the basin that may be affected by the action, or if more mussels or sturgeon are taken under the USACE's operations than anticipated. Furthermore, the proactive adaptive management approach adopted under the BO will allow the USACE to continue to improve how it implements the WCM to protect endangered species and their habitats in response to changing flows, and changing climate. This is an opportunity for the USACE to better understand the impacts of its operations, and to contribute to the recovery of these species and conservation of their habitats in the ACF Basin.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

CONSULTATION HISTORY

May 22, 2012	USFWS issues BO on the USACE, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River (RIOP)
July 19, 2013	USFWS issues letter to USACE outlining the USFWS' revised alternative for water control operations
August 29, 2013	USFWS issues Planning Aid Letter (PAL) to USACE for Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) Updates
June 19, 2014	USACE notifies USFWS of flow loss at Jim Woodruff Dam that occurred on June 11, 2014 due to a lightning strike. This strike resulted in a temporary flow loss but the daily average remained within accordance to the RIOP.
July 22, 2014	Re-consultation request for the 2012 BO
August 7, 2014	Amendment to RIOP for Chipola slabshell take exceedance
January 30, 2015	USACE's submission of the 2014 annual report
March 12, 2015	USFWS sends USACE letter requesting additional information to assist with the Fish and Wildlife Coordination Act (FWCA) report
April 20, 2015	USACE sends USFWS memo outlining phone discussion on April 17, 2015 regarding the USFWS' March 12
May 20, 2015	USACE requests, through email, temporary deviation from RIOP to begin June 1 release provisions 10 days early
May 20, 2015	USFWS agrees with temporary deviation in email
July 31, 2015	USFWS submission of Draft FWCA Report for the proposed WCM updates for the ACF River Basin
August 19, 2015	USACE responds to USFWS' Draft FWCA Report
January 29, 2016	USACE's submission of the 2015 annual report
May 31, 2016	USACE's submission of a Biological Assessment for Update of the WCM and Water Supply Storage Assessment for the ACF River Basin in Alabama, Florida, and Georgia
June 10, 2016	Letter from USFWS to USACE acknowledging receipt of May 31, 2016 request for formal consultation, but requesting additional information is needed to initiate formal consultation
June 23, 2016	Email from USACE submitting part of an amended BA
June 28, 2016	Email from USACE submitting part of an amended BA

June 30, 2016	Email from USACE submitting an amended BA
July 29, 2016	Letter from USFWS to USACE initiating formal consultation
August 12, 2016	Email from USACE submitting an amendment to the BA
August 19, 2016	Discussion with USACE and SEPA describing hydropeaking and hydropower production contract with Duke Energy and consultation
August 24, 2016	Email from USACE submitting an amendment to the BA
August 30, 2016	Email from USACE submitting an amendment to the BA

BIOLOGICAL OPINION

A Biological Opinion (BO) is the document required under section 7 the Endangered Species Act (Act) that states the opinion of the USFWS as to whether a federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat. This BO addresses the effects resulting from the U.S. Army Corps of Engineers' (USACE) proposed Update of the Water Control Manual (WCM or Master Manual) for the Apalachicola-Chattahoochee-Flint River Basin (ACF) in Alabama, Florida, and Georgia, including a Water Supply Storage Assessment (WSSA) for a reallocation of storage in Lake Sidney Lanier (Lake Lanier). We analyze the effects of this proposed action on the Gulf sturgeon, fat threeridge, purple bankclimber, Chipola slabshell, and their designated critical habitats.

"*Jeopardize the continued existence of*" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species (50 CFR §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 CFR §402.02).

This opinion supersedes the BO and associated Incidental Take Statement dated May 22, 2012, which addressed the effects of the similar Revised Interim Operating Plan (RIOP), and all other previous BOs with USACE for the ACF Basin. The USACE has described its proposed changes to the WCM and the effects of these changes in the revised amended Biological Assessment (BA) dated June 30, 2016. Where appropriate, we have incorporated its descriptions and analysis into this BO. The USFWS acknowledges the Florida v. Georgia case pending before the U.S. Supreme Court, in which Florida is seeking an equitable apportionment of the waters of the shared ACF Basin. The outcome of this case will likely influence future water use in the basin.

This BO is based on best scientific and commercial data available, including information provided in the USACE BA, analysis of modeling output, published peer-reviewed research, and additional information as cited herein. A complete administrative record of this consultation is on file in the USFWS Panama City, Florida, Ecological Services Field Office.

1 DESCRIPTION OF PROPOSED ACTION

Construction of the dams and associated impoundments in the ACF River Basin pre-date the Act. Therefore, USFWS and USACE staffs agree that the effects of those actions to federally listed species and designated critical habitats are part of the environmental baseline. The action considered in this BO is the *operation* of those facilities, individually and in concert, under the proposed WCM.

The action evaluated in this consultation is the adoption and implementation by USACE of a new WCM for the ACF (referred to in the BA as the Preferred Alternative [WCM]). This Action is limited to the updated ACF WCM and the associated Water Supply Storage Assessment at Lake Lanier. The WCM includes guidelines for continued operation of projects in the ACF Basin in a balanced manner to *achieve all authorized project purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods*. The intent would be to maintain a balanced use of its reservoirs in times of normal, high-flow, and drought conditions. At all times, USACE would seek to conserve the water resources entrusted to its regulation authority. USACE operates and manages those projects as a system to meet their authorized purposes, which include flood risk management, hydropower, navigation, fish and wildlife conservation, recreation, water quality, and water supply (USACE 2015 p. 1-1). The WCM is consistent with the USACE's authority as set forth in the 2012 legal opinion and described in the Draft Environmental Impact Statement (DEIS) (USACE 2015).

For reasons that will be explained and discussed in later sections of this BO, the USFWS has described the action area to include that portion of the ACF on which USACE water control projects were constructed, and their associated tailwater reaches (Figure 1.1). Table 1.1 shows the five projects which are included in this BO. Reaches of rivers upstream from the upper limits of the impoundments created by the uppermost dams (e.g., Lake Lanier, Chattahoochee River) are not included because operation and maintenance activities do not affect those upstream river reaches. No new construction is proposed as part of this action. The USACE considered other alternatives to the proposed action pursuant to the National Environmental Policy Act (NEPA) in the DEIS (USACE 2015). We do not explicitly analyze any of those alternatives or variants here, but focus solely on the operational scheme described in the new WCM, as adopted under the preferred alternative action (PAA) as modified in the amended BA (USACE 2016).

The USACE operates five dams in the ACF Basin: Buford, West Point, Walter F. George, George W. Andrews, and Jim Woodruff (Figure 1.1, Table 1.1). All are located wholly on the Chattahoochee River arm of the basin except Woodruff, the downstream-most dam, which is located at the confluence of the Chattahoochee and Flint rivers on the Apalachicola River. Andrews is a lock and dam without any appreciable water storage, and Lake Seminole formed by Jim Woodruff Dam has very limited storage capacity. Both are essentially operated as run-of-river reservoirs (i.e., what goes in comes out without being stored for any substantial amount of time). The impoundments of Buford, West Point, and Walter F. George dams, however, provide for combined conservation storage of approximately 1.5 million acre-feet, relative to the top of each reservoir's full summer pool and the bottom of the conservation pool, which is potentially available to support water management operations.

The USACE operates the ACF reservoirs as a system, and releases from Jim Woodruff Dam reflect the downstream end-result of system-wide operations. The proposed action under the WCM includes:

- Fish and Wildlife Conservation including:
    - Federally-Listed Species - water releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter),
    - Reservoir Fish Spawning,
    - Tailrace Dissolved Oxygen Levels,
    - Fish Passage,
    - Management of Project Lands (Eufaula National Wildlife Refuge),
- Drought Operations,
- Extreme Drought Operations,
- Navigation,
- Flood Risk Management,
- Hydroelectric Power Generation,
- Recreation,
- Water Quality,
- Water Supply.

1.1 Action Area

USFWS regulations define “action area” as all areas affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR §402.02). The action area includes all aquatic habitats that are downstream of the USACE's upstream-most ACF project, Lake Lanier/Buford Dam, ending with and including Apalachicola Bay (Figure 1.1). Therefore, while the action area includes all aquatic habitats that are downstream of the USACE's upstream-most ACF project, Lake Lanier/Buford Dam, ending with and including Apalachicola Bay, the effects of the action to listed species and designated critical habitats are limited primarily to the aquatic habitats downstream of Woodruff Dam including Apalachicola Bay. Therefore, our use of the term “action area” hereafter refers to this limited portion of the broader action area. We refer to locations in the action area by river mile (RM), which is the distance from the mouth of the river as noted on USGS 7.5-minute topographic maps.

Table 1.1 Reservoirs on the mainstem ACF Basin rivers including the five federal projects assessed by this consultation (USACE 2015).

Basin/river/project name	Owner/state/ year initially completed	Drainage area (sq mi)	Reservoir size (ac)	Total storage (ac-ft)[a]	Conservation storage (summer elev) (ac-ft)	Power capacity (kW)	Normal (summer) lake elev (ft)	Authorized purposes for USACE-owned projects[b]
Chattahoochee River		*8,708*						
Buford Dam/Lake Sidney Lanier	USACE/GA/1957	1,034	38,542	2,554,000	1,087,600	127,000	1,071	FRM, HP, NAV, FW, REC, WQ, WS[c]
Morgan Falls Dam/Bull Sluice Lake	GPC/GA/1903	1,360	580	2,450	0	16,800	866	
West Point Dam and Lake	USACE/GA/1975	3,440	25,864	774,798	306,131	87,000	635	FRM, HP, NAV, FW, REC, WQ
Langdale Dam and Lake	GPC/GA/1860	3,640	152	NA[d]	0	1,040	547.7	
Riverview Dam and Lake	GPC/GA/1902	3,661	75	NA[d]	0	480	530.5	
Bartletts Ferry Dam/Lake Harding	GPC/GA/1926	4,240	5,850	181,000	0	173,000	521	
Goat Rock Dam and Lake	GPC/GA/1912	4,510	1,050	11,000	0	38,600	404	
Oliver Dam/Lake Oliver	GPC/GA/1959	4,630	2,150	32,000	0	60,000	337	
North Highlands Dam and Lake	GPC/GA/1900	4,630	131	1,500	0	29,600	269	
Walter F. George Lock, Dam, and Lake	USACE/GA/1963	7,460	45,181	934,400	244,400	168,000	190	HP, NAV, FW, REC, WQ
George W. Andrews Lock, Dam, and Lake	USACE/GA/1963	8,210	1,540	18,180	0	None	102	NAV, FW, REC, WQ
Flint River		*8,456*						
Warwick Dam/Lake Blackshear	Crisp Co./ GA/1930	3,770	8,700	144,000	0	15,200	237	
Flint River Dam/Lake Worth	GPC/GA/1920	5,290	1,400	NA[d]	0	5,400	182.3	
Apalachicola River		*2,409*	*(Total ACF Basin – 19,573 sq mi)*					
Jim Woodruff Lock and Dam/ Lake Seminole	USACE/FL/1954	17,164	37,500	367,318	0	43,350	77	HP, NAV, FW, REC, WQ

Notes:
a. Measured at top of storage for flood risk management.
b. As used in this table, the term *authorized purposes* includes purposes expressly identified in the project authorizing documents; incidental benefits recognized in projection authorizations; and objectives that result from other authorities, such as general authorities contained in congressional legislation, for which USACE operates each listed project as of 2009. FRM = flood risk management; HP = hydroelectric power generation; NAV = navigation; FW = fish and wildlife conservation; REC = recreation; WQ = water quality; WS = municipal & industrial water supply.
c. USACE operates the Buford Dam/Lake Sidney Lanier project in a manner that accommodates water supply withdrawals from Lake Lanier and from the Chattahoochee River downstream of Buford Dam.
d. NA = not available.

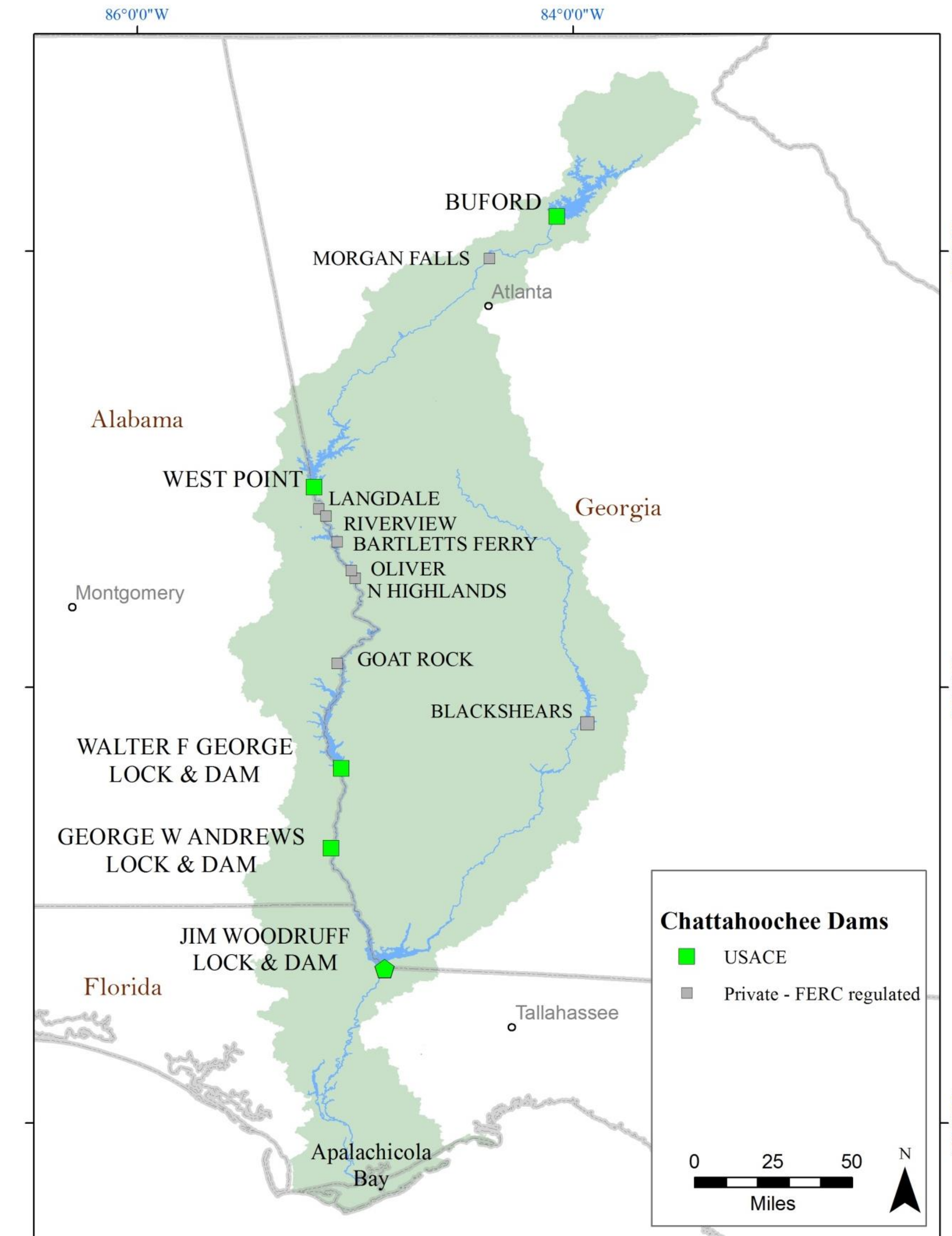


Figure 1.1 Apalachicola - Chattahoochee - Flint River Basin showing the five USACE projects included in this consultation and other federally regulated projects in the basin.

1.2 Guide Curves and Action Zones

As described in the BA, the USACE would not modify any guide curves of the ACF projects but would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake under the WCM. The zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes can be met. As lake levels decline, Zones 2 through 4 define increasingly critical system status where purposes can no longer fully be met. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project.

The action zones were derived considering numerous factors, including the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects. Other factors or activities might cause the lakes to operate differently than the action zones are described, including exceptional flood risk management measures, fish spawn operations, approved deviations, maintenance and repair of turbines, emergency situations (such as a drowning or chemical spill), drawdowns for shoreline maintenance, releases made to free grounded barges, and other special circumstances.

The storage projects (Lanier, West Point, and Walter F. George) are operated to maintain their respective lake level in the same action zones concurrently. Because of the hydrologic and physical characteristics of the river system and factors mentioned above, there might be periods when one lake is in a higher or lower zone than another. When that occurs, the USACE conducts operations to bring the lakes into balance with each other as soon as conditions allow. By doing so, effects within the river basin are shared equitably among the projects. The action zones for the WCM are shown in Figures 1.2 through 1.4.

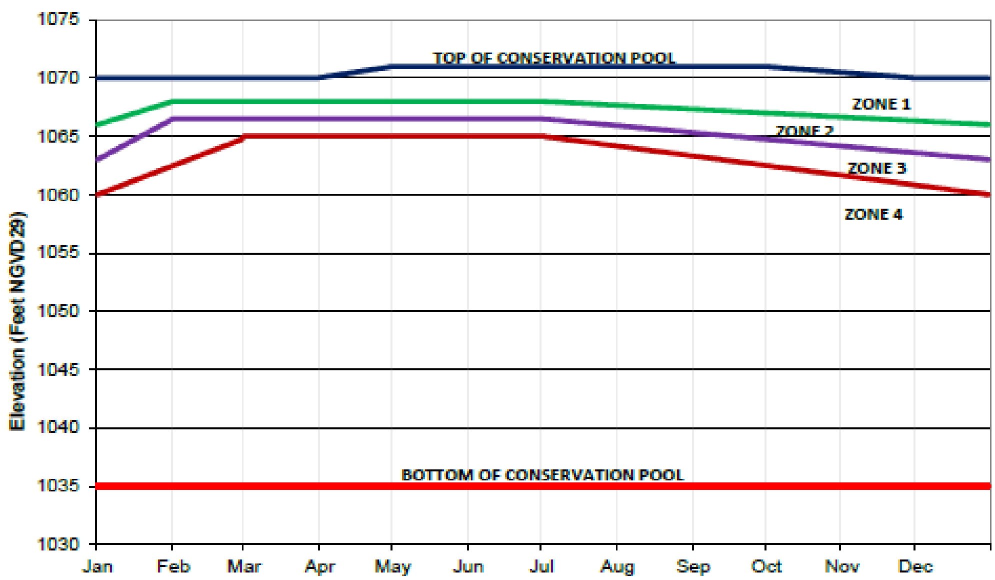


Figure 1.2 Lake Lanier Water Control Action Zones

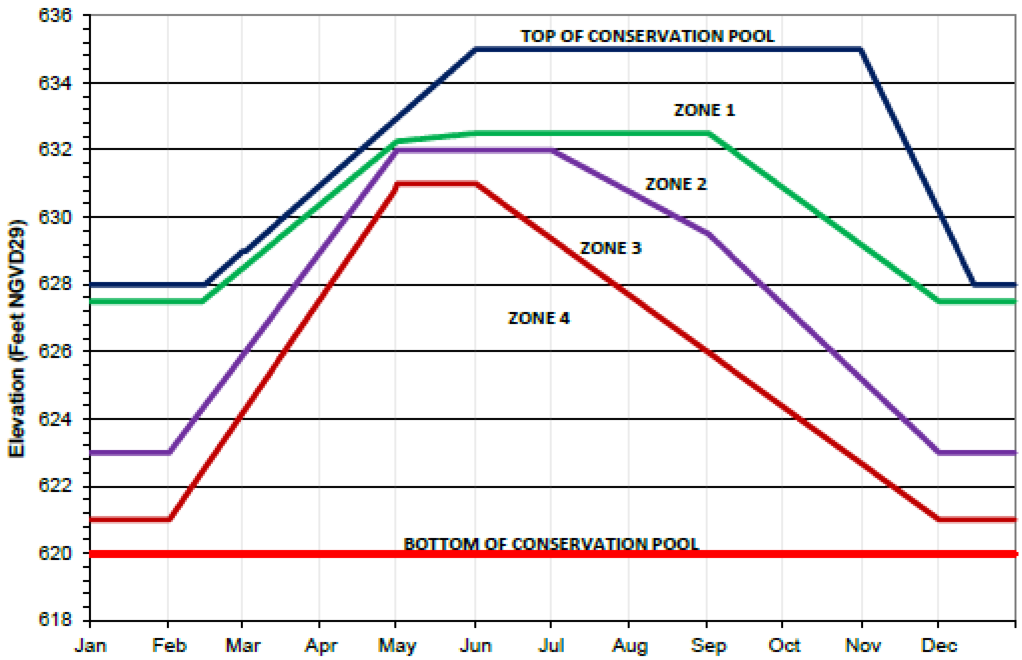


Figure 1.3 West Point Lake Water Control Action Zones

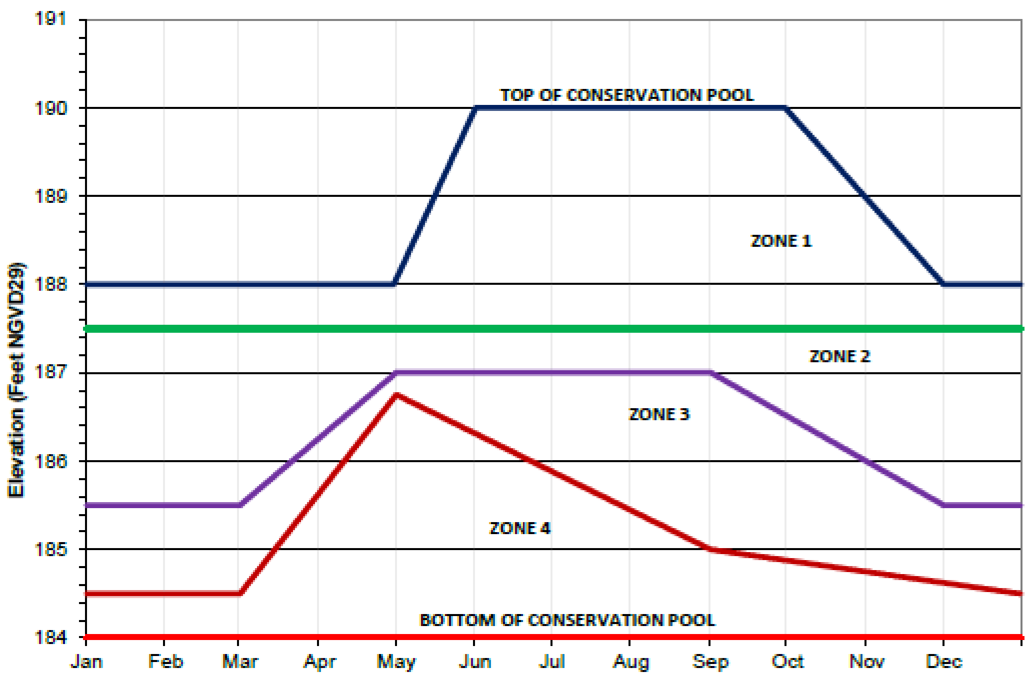


Figure 1.4 Walter F. George Lake Water Control Action Zones

1.3 Drought Operations

The drought plan included in the WCM specifies a minimum release from Jim Woodruff Dam and a temporary suspension of the normal minimum release and maximum fall rate provisions of the listed species operation, until combined reservoir storage of Lanier, West Point, and Walter F. George (hereafter referred to as composite conservation storage) in the basin are replenished to a level that could support these releases. Under the drought plan, minimum discharge is determined in relation to the composite conservation storage. The drought plan is triggered when the composite conservation storage falls below the bottom of Zone 2 into Zone 3 (Figure 1.5). At that time, all the provisions for composite conservation storage Zones 1 and 2 (seasonal storage limitations, maximum fall rate schedule, and minimum flow thresholds) are suspended, and management decisions are based on the provisions of the drought plan. The drought plan includes an option for a temporary waiver from the water control plan to allow temporary storage at the Walter F. George and West Point projects to provide additional conservation storage for future needs, if conditions in the basin dictate the need for such action.

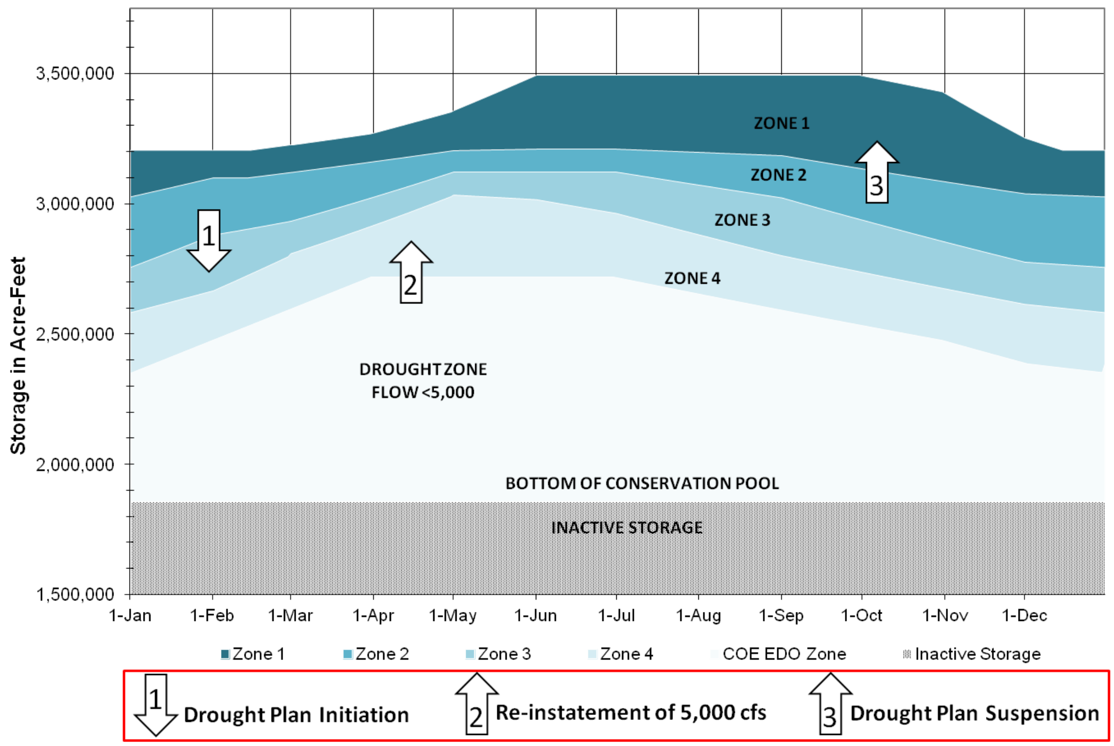


Figure 1.5 Composite Conservation Storage Zones and Drought Plan Triggers

The drought plan of the WCM prescribes two minimum releases on the basis of composite conservation storage in Zones 3 and 4 and an additional zone referred as the Drought Zone. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in Lake Sidney Lanier, West Point Lake, and Walter F. George Lake, plus Zone 4 storage in Lake Sidney Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zones 3 and 4, but above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cubic feet per second (cfs) and all basin inflow above 5,000 cfs may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates are limited to 0.25 ft/day drop. The 4,500 cfs minimum release is then maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is reinstated. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches Zone 1. At that time, the temporary drought plan provisions are suspended and all the other provisions of the basin water control plan reinstated. During the drought contingency operations, a monthly monitoring plan tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) to determine which operational triggers are applied. In the event the composite conservation storage has not recovered to Zone 1 by 1 March, drought operations are extended to the end of March, unless all the federal reservoirs are full.

1.4 Extreme Drought Operations

When the remaining composite conservation storage is about 10 percent of the total capacity, additional emergency actions might be necessary. When conditions have worsened to that extent, use of the inactive storage must be considered. For example, such an occurrence could be contemplated in the second or third year of a drought. Inactive storage zones have been designated for the three reservoirs with significant storage (Figure 1.6). The "endangered species" priority for Zone 1a simply means that reservoirs would be managed to provide for minimum flows at Woodruff (USACE 2015). Table 1.2 shows the inactive storage capacity within each inactive storage zone for each project. The use of inactive storage during extreme drought conditions is based on the following actions:

1. Inactive storage availability is identified to meet specific critical water use needs within existing project authorizations.
2. Emergency uses are identified in accordance with emergency authorizations and through stakeholder coordination. Typical critical water use needs within the basin are associated with public health and safety.
3. Weekly projections of the inactive storage water availability to meet the critical water uses from Buford Dam downstream to the Apalachicola River are used when making water control decisions regarding withdrawals and water releases from the USACE reservoirs.
4. The inactive storage action zones are instituted as triggers to meet the identified priority water uses (releases will be restricted as storage decreases). Figure 1.6 lists the typical critical water uses for each inactive storage zone.
5. Dam safety considerations always remain the highest priority. The structural integrity of the dams due to static head limitations (Jim Woodruff, 38.5 feet; George W. Andrews, 26 feet; Walter F. George, 88 feet) is maintained.

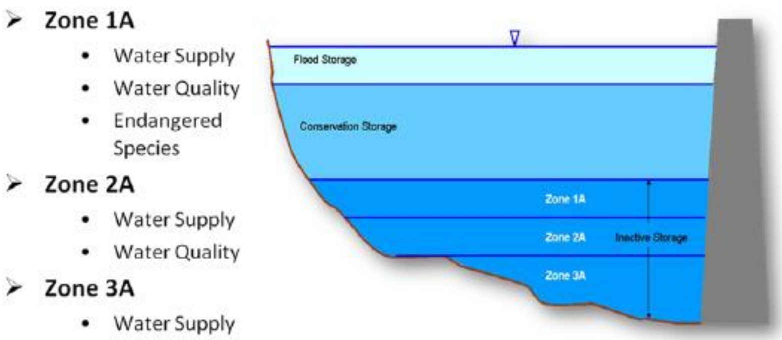


Figure 1.6 Inactive Storage Zones and Typical Water Use Needs

Table 1.2 Reservoir Inactive Storage Zone Capacities (ac-ft)

Project	Zone 1A	Zone 2A	Zone 3A	Unusable Inactive
Buford Dam	532,078	234,699	100,823	0
West Point Dam	53,620	138,331	33,344	73,101
Walter F. George Dam	314,799	178,501	0	196,700
Total	901,589	554,345	134,869	266,062

1.5 Navigation

When supported by ACF Basin hydrologic conditions, the WCM provides a reliable navigation season. The water management objective for navigation is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season begins in January of each year and continues 4 to 5 consecutive months (through April or May). Figure 1.7 graphically represents the navigation season and its relationship to composite conservation storage. During the navigation season, the flows at the USGS gage at Blountstown, Florida, should be adequate to provide a minimum channel depth of 7 feet. The WCM used the most recent channel survey and discharge-stage ratings to determine the flow required to sustain a minimum navigation depth during the navigation season. Flows of 16,200 cfs provide a channel depth of 7 feet. Flows of 20,600 cfs provide a channel depth of 9 feet. USACE's capacity to support a navigation season depends on actual and projected system-wide conditions in the ACF Basin before and during January, February, March, April, and May. Those conditions include the following:

- A navigation season can be supported only when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
- A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Navigation support will resume when basin composite conservation storage level recovers to Zone 1.

- A navigation season will not be supported when drought operations are in effect. Navigation will not be supported until the ACF Basin composite conservation storage recovers to Zone 1.
- The determination to extend the navigation season beyond April depends on ACF Basin inflows, recent climatic and hydrologic conditions, meteorological forecasts, and basin-wide model forecasts. USACE analyzes those factors to determine if the navigation season will continue through part or all of May.
- Down-ramping of flow releases adhere to the Jim Woodruff Dam fall rate schedule (see Table 1.5) for federally listed threatened and endangered species during the navigation season.
- Releases that augment the flows to provide a minimum 7-foot navigation depth also depend on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, because of diminishing inflows, downstream flows and depths must be reduced, the USACE will issue notices in order to give barge owners and other waterway user's sufficient time to make arrangements to lighten loads or remove their vessels before action is taken at Jim Woodruff Lock and Dam to reduce releases.

Although special releases are not standard practice, they may occur for a short duration to assist navigation during the navigation season. For instance, releases can be requested to achieve up to a 9-foot channel. USACE evaluates such requests on a case-by-case basis, subject to applicable laws and regulations and the conditions above.

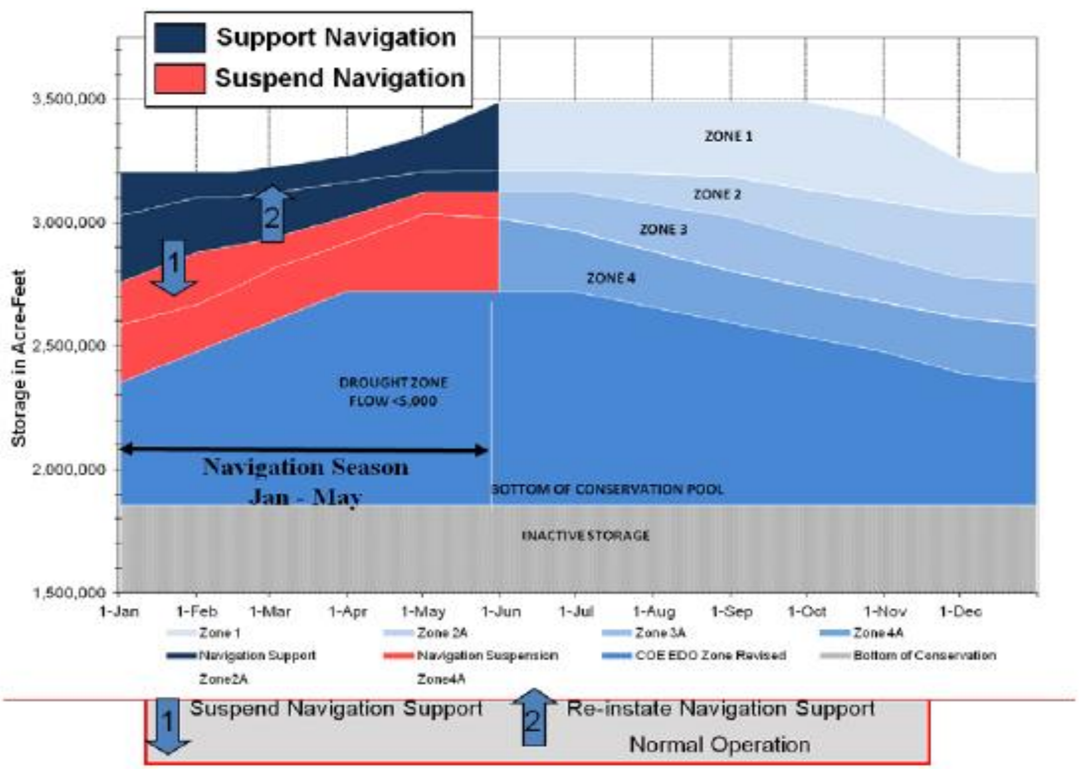


Figure 1.7 Composite Conservation Storage for Navigation

1.6 Fish Spawn/Passage Operations

According to the DEIS (USACE 2015), the USACE's South Atlantic Division Regulation DR 1130-2-16 (31 May 2010) and Mobile District Draft Standard Operating Procedure (SOP) 1130-2-9 (February 2005) were developed to address lake regulation and coordination for fish management purposes. The SOP addresses procedures necessary to gather and disseminate water temperature data and manage lake levels during the annual fish spawning period between March and June, primarily targeted at largemouth bass. The major goal of the operation is to not lower the lake level more than six inches in elevation during the reproduction period to prevent stranding or exposing fish eggs. The lake elevation that exists at the time spawning begins becomes the datum for the downward fluctuation. The beginning and ending of the spawning season is determined by the Mobile District biologists in cooperation with the fish and game personnel of the states concerned. The expected timing for fish spawning at each of the USACE lakes and the Apalachicola River ranges from mid-March through May.

In most years since the spring of 2005, USACE has operated the lock at Jim Woodruff Lock and Dam between March and May to facilitate downstream-to-upstream passage of Alabama shad (*Alosa alabamae*) and other anadromous fishes (those that return from the sea to the rivers where they were born to breed) in cooperation with pertinent state and federal agencies. In general, two fish locking cycles are performed each day between 0800–1600 hours, one in the morning and one in the afternoon. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change.

1.7 Flood Risk Management

As described in the BA and DEIS, the flood risk management capabilities and capacities of reservoirs remain unchanged from present operations in the revised WCM. The flood risk management purposes at certain reservoirs require drawing down reservoirs in the fall through winter months to store possible flood waters. Because actions taken at the upstream portion of the basin affect conditions downstream, the ACF projects are operated in a coordinated manner to the maximum extent possible rather than as a series of individual, independent projects. In times of high-flow conditions, flood risk management regulation supersedes all other project functions.

As described in the DEIS, the objective of flood risk management operations on the ACF System is to store excess flows thereby reducing downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally. Whenever flood conditions occur, operation to reduce flood damage takes precedence over all other project functions. Of the five USACE reservoirs, only Buford and West Point dams have storage allocated for flood risk management operations. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower peak stages throughout the reservoir during major floods. Annual drawdown of reservoir storage is 1 foot at Lake Sidney Lanier, 7 feet at West Point Lake, and 2 feet at Walter F. George Lake in the fall through winter to provide additional capacity to protect life and property in the basin. The George W. Andrews and Jim Woodruff Dams operate to pass inflows, while the Walter F.

George Dam operates according to specified schedules for flood risk management. The timing of flood peaks in the ACF System is of considerable importance in determining the effectiveness of reservoir flood risk management operations and the degree to which such operations can be coordinated. During a flood event, excess water above normal pool elevation, or guide curve, should be evacuated through the use of the turbines and spillways in a manner consistent with other project needs as soon as downstream waters have receded sufficiently so that releases from the reservoirs do not cause flows to exceed bankfull capacity or maximum, non-damaging, channel capacities. Stored floodwater can be released up to the maximum, non-damaging, downstream channel capacities, consistent with regulation procedures, provided the releases do not exceed peak inflow of that event into the reservoir(s). Under certain instances, induced surcharge operations might be required to ensure project integrity, which could result in flows that exceed bankfull capacity.

1.8 Hydropower Peaking at Jim Woodruff Dam

The hydropower facility at Jim Woodruff Dam has a power capacity of 43,350 kilowatts. The maximum capacity for the turbines at the facility is approximately 16,000 to 18,300 cfs, above which gates are used to discharge water downstream of the dam. For inflows between 6,700 and 16,000 cfs the USACE releases water during a portion of the day when there is peak demand for electricity.

In the BA, the USACE states that the WCM includes the current hydroelectric power generation operations at West Point Dam, Walter F. George Dam, and Jim Woodruff Dam which call for a more flexible generation schedule in all action zones under non-drought conditions and a more constrained generation schedule under drier conditions. The Jim Woodruff Dam includes a limited peaking operation compared to the other two facilities, and the generation schedule for Jim Woodruff Dam is described below in an amendment to the BA.

The Jim Woodruff project is operated to provide the maximum possible load (on the line), depending on unit availability, for one hour on a daily basis. This operation meets the minimum capacity under the Southeastern Power Administration (SEPA) contract obligations. This applies only at times the power plant is operating at less than the maximum unit capacity. This operation occurs daily during the 1600 to 1700 hours (OT). Immediately prior to 1600 (OT) the unit(s) will be loaded to deliver maximum capacity and continue until 1700. The load will then be reduced to achieve the target flow as directed by Water Management.

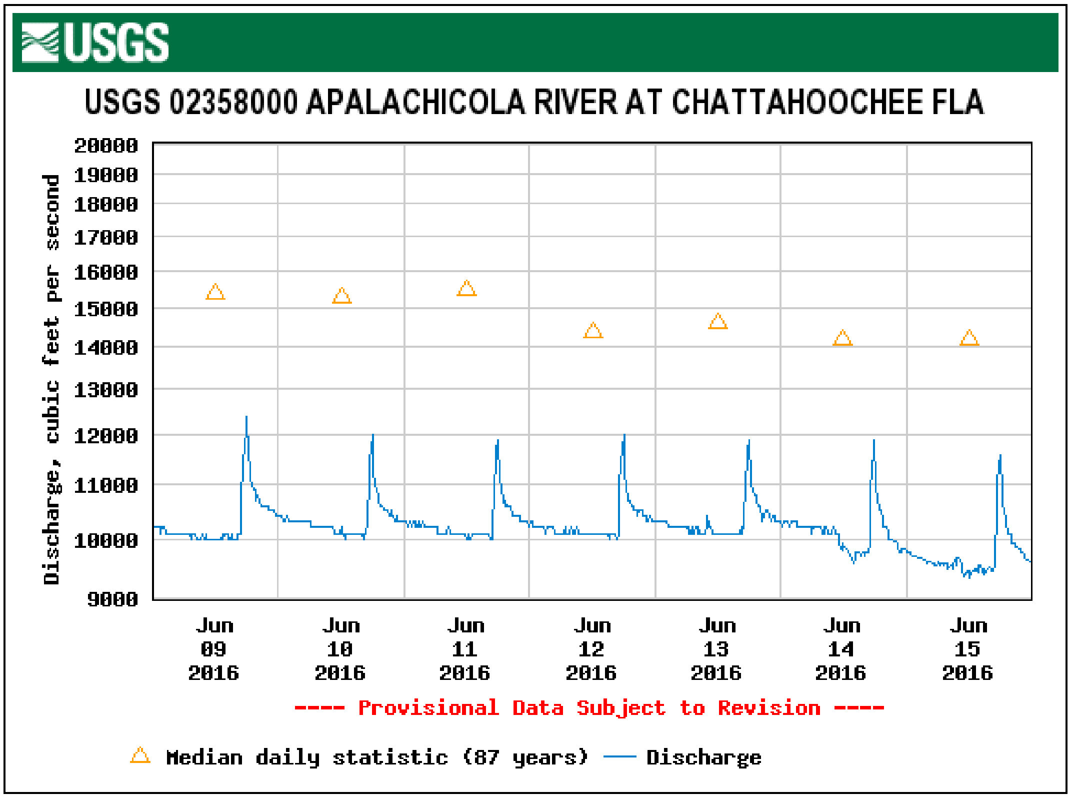
Changes in discharge to provide the one hour maximum capacity depend on the initial discharge prior to the peak operation and the operating head. The lower the initial discharge value the greater the change in discharge. For example under normal operating head if the initial United States Geological Survey (USGS) Apalachicola River at Chattahoochee, Florida gage discharge is approximately 7,000 cubic feet per second (cfs), then the discharge will increase to approximately 10,000 cfs from peak operation and if there is a higher initial discharge of approximately 11,000 cfs, then the discharge will increase to approximately 12,800 cfs from peak operation.

The river stage recorded at the Chattahoochee gage typically rises continually during the one hour peak generation. River stages at the Chattahoochee gage begin to fall once the peaking operation ends. It may take up 6-10 hours for the river to return to the stage prior to the start of the one hour peaking generation. However, the majority of the reduction in river stage takes place within the first two hours of ending peak generation.

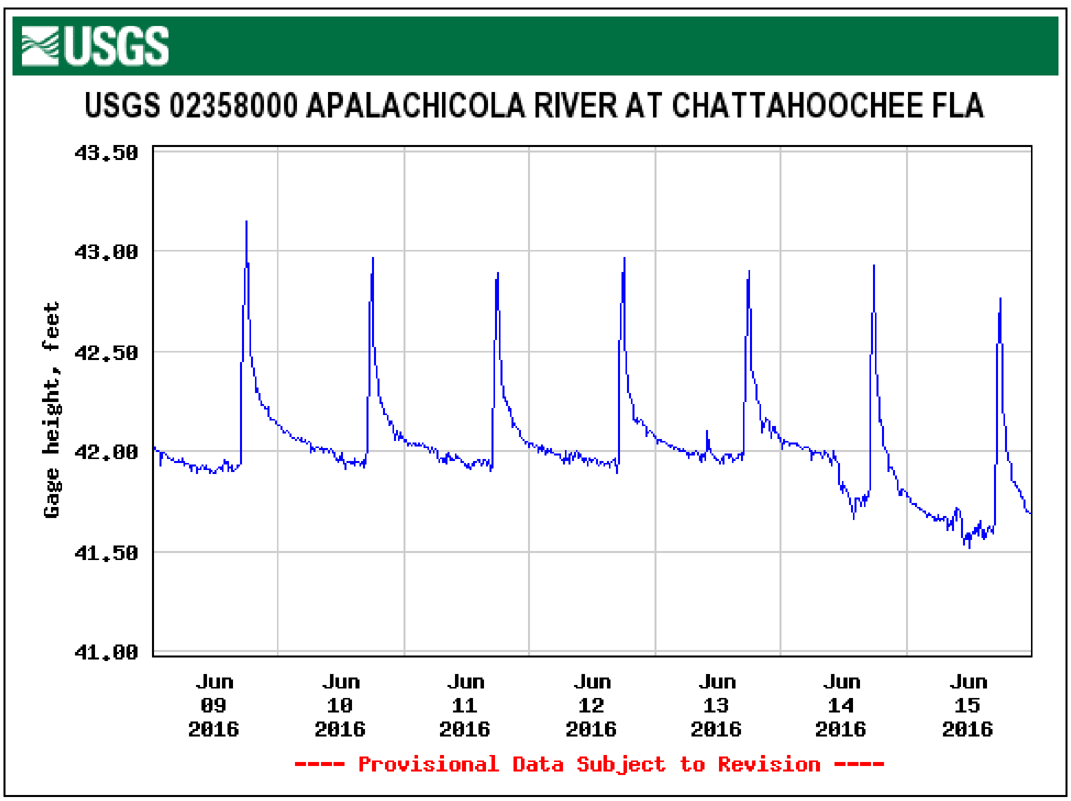
Peaking operations at the Jim Woodruff Plant are suspended as average daily releases approach 6,700 cfs, to maintain instantaneous releases greater than or equal to the 5,000 cfs minimum flow requirement. There is a range of discharges that is beyond the capacity of any one unit. One unit max is around 5,900 cfs. Two units can deliver discharges beyond 5,900 cfs. For discharges ranging from 5,900 to 6,800 cfs, an operation that combines one unit and the spillway trash gate adjacent to the powerhouse at 1/2 step is utilized. The 1/2 step provides approximately 900 to 1,000 cfs.

Whenever the reservoir inflow exceeds the discharge capacity of the turbines (about 16,000 to 18,300 cfs for three turbines) the excess will be released through the gated spillway up to its capacity in order to prevent the pool from rising above elevation 77.8 feet NGVD29 at the dam.

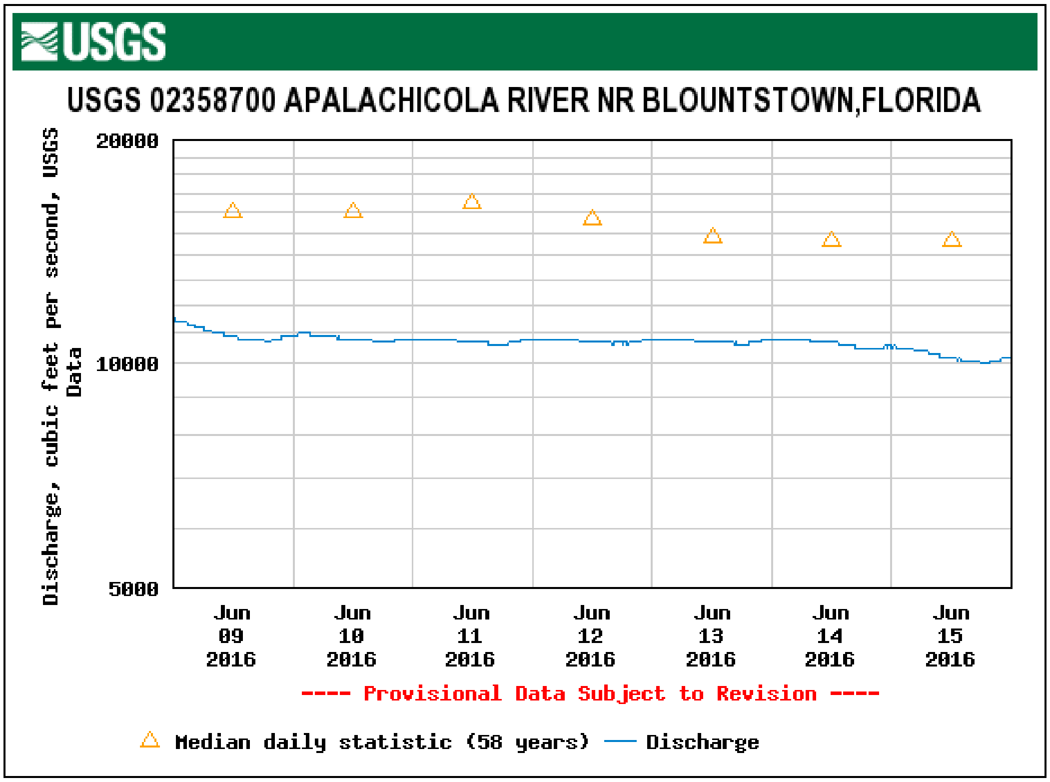
Figure 1.8A (discharge) and Figure 1.8B (stage) chart the Chattahoochee gage flow and stage conditions for June 9-15, 2016. During the peaking operation, the maximum discharge increases by about 2,000 cfs resulting in an approximate 2 feet change in stage. The change in stage is attenuated to about 0.15 feet (Figure 4) at the Blountstown gage located 28.3 miles downstream of the Jim Woodruff Dam.


USGS
USGS 02358000 APALACHICOLA RIVER AT CHATTAHOOCHEE FLA
Discharge, cubic feet per second
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
Jun 09 2016
Jun 10 2016
Jun 11 2016
Jun 12 2016
Jun 13 2016
Jun 14 2016
Jun 15 2016
---- Provisional Data Subject to Revision ----
Median daily statistic (87 years)
Discharge

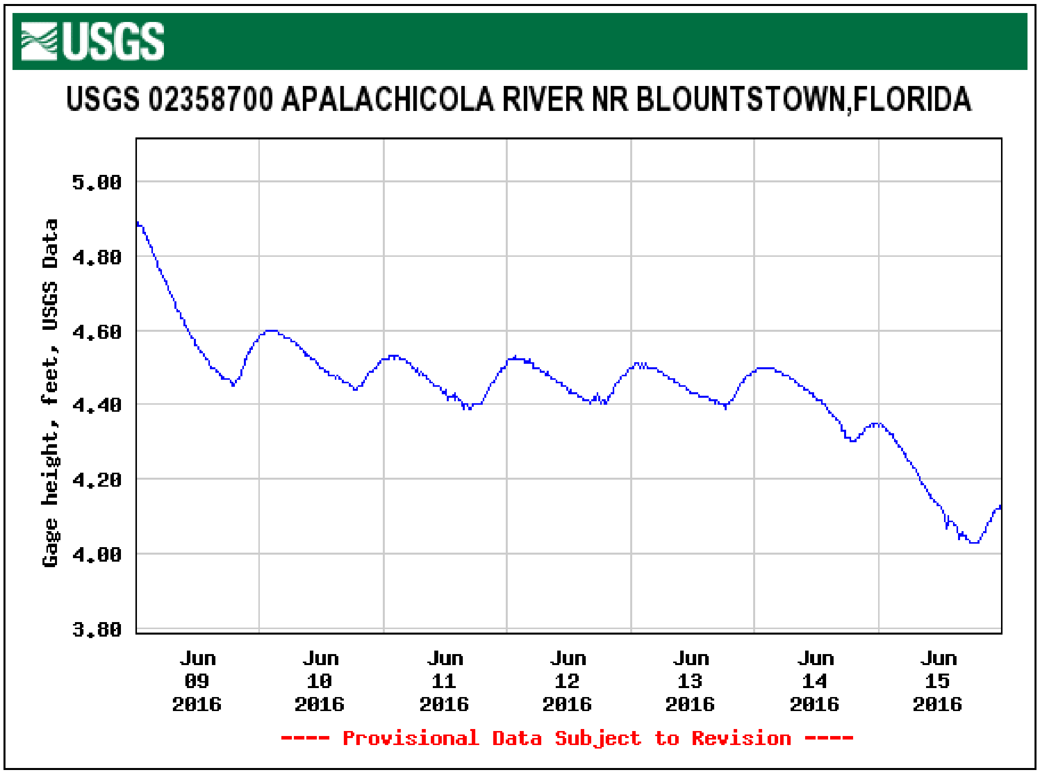
A


USGS
USGS 02358000 APALACHICOLA RIVER AT CHATTAHOOCHEE FLA
Gage height, feet
43.50
43.00
42.50
42.00
41.50
41.00
Jun 09 2016
Jun 10 2016
Jun 11 2016
Jun 12 2016
Jun 13 2016
Jun 14 2016
Jun 15 2016
---- Provisional Data Subject to Revision ----

B


USGS
USGS 02358700 APALACHICOLA RIVER NR BLOUNTSTOWN,FLORIDA
Discharge, cubic feet per second, USGS Data
20000
10000
5000
Jun 09 2016
Jun 10 2016
Jun 11 2016
Jun 12 2016
Jun 13 2016
Jun 14 2016
Jun 15 2016
---- Provisional Data Subject to Revision ----
Median daily statistic (58 years)
Discharge

C


USGS
USGS 02358700 APALACHICOLA RIVER NR BLOUNTSTOWN,FLORIDA
Gage height, feet, USGS Data
5.00
4.80
4.60
4.40
4.20
4.00
3.80
Jun 09 2016
Jun 10 2016
Jun 11 2016
Jun 12 2016
Jun 13 2016
Jun 14 2016
Jun 15 2016
---- Provisional Data Subject to Revision ----

D

Figure 1.8 An example of hydropeaking at the USGS stream gage for the Apalachicola River at Chattahoochee for discharge (A) and gage height (B) and downstream flow at Blountstown for discharge (C) and gage height (D)

1.9 Recreation

Under the PAA, operations for recreation would remain the same as current operations. Recreation benefits would be maximized at the lakes to the extent possible consistent with meeting other project purposes by maintaining full or nearly full pools during the primary recreation season which are the warm summer months. In response to meeting other authorized project purposes, lake levels could decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 6). Recreational impact levels are not applicable to the George W. Andrews project due to the lack of conservation storage and the run-of-river operation at the project.

When pool levels must be lowered, the rates at which the draw-downs occur are as steady as possible. The action zones at Lake Sidney Lanier and West Point Lake are drawn down to correlate the line between Zone 2 and Zone 3 near the IIL at the beginning of the recreation season (May through early September). This is an attempt to maximize the time these projects are above the IIL during the recreation season.

Table 1.3 Recreation Impact Levels for Federal Projects in the ACF Basin

Project	IIL[a]	RIL[b]	WAL[c]
Lake Lanier	1,066 ft	1,063 ft	1,060 ft
West Point Lake	632.5 ft	629 ft	627 ft
Walter F. George	187 ft	185 ft	184 ft

Notes:
[a.] Initial Impact Level
[b.] Recreation Impact Level
[c.] Water Access Limited Level

1.10 Water Quality

Under the WCM, Buford, West Point, and Jim Woodruff dams would provide continuous minimum flow releases that would benefit the water quality immediately downstream of the dams. There would be no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen values are observed below the dam, spillway gates would be opened until the dissolved oxygen readings return to an acceptable level. Occasional special releases would also be made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam.

At Buford Dam, the small turbine generator would run continuously to provide a minimum flow from the dam, which would range from approximately 500 to 700 cfs, depending on head conditions. This minimum flow from Buford Dam would help meet the seasonal minimum flow requirements of 650 cfs and 750 cfs at Atlanta, Georgia, in the Chattahoochee River just upstream of the confluence with Peachtree Creek. At West Point Dam, the minimum flow requirement is 670 cfs and a similar small generating unit would provide a continuous release of approximately 675 cfs. Walter F. George Dam has two siphons on each spillway gate. The siphon discharge could range from about 15 cfs up to 200 cfs when all 12 are in use. Typically, the siphon tubes would be opened continuously from May through the end of September and all would be used at full capacity. The siphons would provide a gravity-fed, typically continuous, minimum flow that would benefit dissolved oxygen levels below the dam. A varying minimum flow from 4,500 to 25,000 cfs, dependent upon basin conditions, would be maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which would assure an adequate water supply for downstream industrial use and water quality.

1.11 Water Supply

As described in the BA, the cities of Gainesville and Buford continue to withdraw water directly from Lake Lanier under reallocation agreements at rates not exceeding 8 million gallons per day (mgd) (net) and 2 mgd, respectively. Additionally, pursuant to the Water Supply Act of 1958, the WCM reallocates 252,950 acre-feet in Lake Sidney Lanier to water supply. The amount of storage is estimated to yield 222 mgd during the critical drought (i.e., during the worst drought on record at the time the agreement was executed). The severity and frequency of droughts change over time, therefore, the yield of this storage may change over time. For the purpose of managing water supply storage, USACE uses a storage accounting methodology that applies a proportion of inflows and losses, as well as direct withdrawals by specific users, to each account. The amount of water that may actually be withdrawn is ultimately dependent on the amount of water available in the storage account, which will naturally change over time.

Under the WCM, releases from Buford Dam are made to accommodate downstream water demands. Peaking hydroelectric power generation at Buford Dam generally accommodates most water supply needs of communities currently withdrawing from the Chattahoochee River; however, under the 1946 Rivers and Harbors Act, generation can occur at non-peaking times to meet the downstream water supply needs, not to exceed 379 mgd.

1.12 Conservation Measures

Conservation measures are actions that benefit or promote the recovery of a listed species that a Federal agency includes as an integral part of its proposed action and that are intended to minimize or compensate for potential adverse effects of the action on the listed species.

As described in the BA, the USACE plans to make water releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows. Release requirements are dictated by composite conservation storage (Figure 1.7) in accordance with the revised action zones discussed above in the Guide Curves and Action Zones section.

The USACE manages water releases from Jim Woodruff Dam to support the federally-protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. Daily releases to provide support for fish and wildlife conservation from Jim Woodruff Dam are dictated by two parameters: a minimum discharge (measured in cfs) and a maximum fall rate (measured in feet per day [ft/day]).

1.11.1 Minimum Discharge

Minimum discharges from Jim Woodruff Dam vary according to composite conservation storage (Figure 1.7), basin inflow per the 7-day moving average, and by month. Table 1.4 shows these minimum releases, which are measured as a daily average flow in cfs at the USGS gage at Chattahoochee, Florida. During normal and above normal hydrological conditions within the basin, releases greater than the minimum release provisions occur consistent with the maximum fall rate schedule described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

During the spawning period (March to May), the WCM includes two sets of four basin inflow thresholds and corresponding releases according to composite conservation storage in Zones 1 and 2 or composite conservation storage in Zone 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included. The USACE also operates Jim Woodruff Dam to avoid potential Gulf sturgeon take (USFWS 2008, 2012). Potential Gulf sturgeon take has been defined as an 8-foot or greater drop in Apalachicola River stage over the last 14-day period (i.e., if today's stage is greater than 8 feet lower than the stage of any of the previous 14 days) when flows are less than 40,000 cfs.

The WCM includes one set of four basin inflow thresholds and corresponding releases during the non-spawning period (June to November), according to composite conservation storage in Zones 1 - 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the WCM drought contingency operations are triggered. However, since the decision to implement drought contingency operations occurs monthly, the WCM also includes a minimum flow provision while in composite conservation Zone 3.

During the winter season (December to February), the WCM includes only one basin inflow threshold and corresponding minimum release (5,000 cfs) while in composite conservation storage Zones 1–4. This feature of the WCM provides the greatest opportunity to refill the storage reservoirs. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions.

Table 1.4 Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge for Federally-Listed Species by Month and by Basin Inflow (BI) Rates

Months	Composite conservation storage zone	Basin inflow (BI)[a] (cfs)	Min. Releases from Jim Woodruff Lock and Dam[b] (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000 ≥ 16,000 and < 34,000 ≥ 5,000 and < 16,000 < 5,000	= 25,000 = 16,000+50% BI > 16,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>16,000
	Zone 3	≥ 39,000 ≥ 11,000 and < 39,000 ≥ 5,000 and < 11,000 < 5,000	= 25,000 = 11,000+50% BI > 11,000 = BI = 5,000	Up to 100% BI>25,000 Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	≥ 22,000 ≥ 10,000 and < 22,000 ≥ 5,000 and < 10,000 < 5,000	= 16,000 = 10,000+50% BI > 10,000 = BI = 5,000	Up to 100% BI>16,000 Up to 50% BI>10,000
December–February	Zones 1, 2, and 3	≥ 5,000 < 5,000	= 5,000 = 5,000	Up to 100% BI > 5,000
If Drought Triggered	Zone 3	NA	= 5,000[d]	Up to 100% BI > 5,000
At all times	Zone 4	NA	= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	= 4,500[e]	Up to 100% BI > 4,500

Notes:

a. Basin inflow for composite conservation storage in Zones 1, 2, and 3 is calculated using the 7-day moving average basin inflow. Basin inflow for composite conservation storage in Drought Operations, Zones 3 and 4 or lower (Drought Zone) is calculated using the one-day basin inflow.

b. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

c. Drought plan is triggered when the composite conservation storage falls into Zone 3, the first day of each month represents a decision point.

d. Once drought operation triggered, reduce minimum flow to 5,000 cfs following the maximum ramp rate schedule.

e. Once composite storage falls below the top of the Drought Zone ramp down to a minimum release of 4,500 cfs at rate of 0.25 ft/day based on the USGS gage at Chattahoochee, Florida (02358000).

1.11.2 Maximum Fall Rate

When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations are triggered. Within Zone 4, the minimum flow is the same as in Zone 3. When the composite conservation storage drops further into the Drought Zone, the minimum flow from Jim Woodruff Dam is reduced to 4,500 cfs. A description of the drought operations is provided in the Drought Operations section above.

The federally-listed species operations of the WCM includes a guideline for maximum fall rate, also called down-ramping rate, defined as the vertical drop in river stage (water surface elevation) that occurs over a given period of time. The fall rates are expressed in units of ft/day measured at the USGS Chattahoochee, Florida gage as the difference between the daily average river stages on consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The maximum fall rate schedule is provided in Table 1.5. When composite conservation storage falls into Zone 3, the drought operations plan would be implemented, the maximum fall rate schedule would be suspended and more conservative drought contingency operations begin. Down-ramping rates are also suspended during periods of prolonged low flow (flows less than 7,000 cfs for a period of more than 30 consecutive days).

A prolonged low flow period would be considered over and down-ramping rates would be reinstated when flows are greater than 10,000 cfs for 30 consecutive days. Unless the extreme drought operations described above are triggered, fall rates under drought contingency and prolonged low flow operations would be managed to match the fall rate of the basin inflow.

Table 1.5 Maximum Down-Ramping (Fall) Rate at Jim Woodruff Dam

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 [a]	No ramping restriction [b]
> 20,000 and ≤ 30,000 [a]	1.0 to 2.0
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [a]	0.5 to 1.0
Within Powerhouse Capacity and > 10,000 [a]	0.25 to 0.5
Within Powerhouse Capacity and ≤ 10,000 [a]	0.25 or less

Notes:

[a] Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

[b] For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control the down-ramping rate, and no ramping rate is required.

2 ENVIRONMENTAL BASELINE - PHYSICAL ENVIRONMENT

The environmental baseline for consultation purposes is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the listed species, their habitat (including critical habitat), and ecosystem within the action area. The environmental baseline is a "snapshot" of the species' health in the action area at the time of the consultation, and does not include the effects of the action under review. This section provides a description of the baseline physical environment that is common to all listed species and designated critical habitats considered in the BO. We provide species- and critical-habitat-specific analyses of the environmental baseline in sections that immediately follow a description of the status of each species/critical habitat.

2.1 General Description of the Action Area

As discussed above, the ACF Basin comprises 19,573 square miles in Alabama, Florida, and Georgia. USACE operates five reservoir projects in the ACF Basin: Buford Dam and Lake Lanier; West Point Dam and Lake; Walter F. George Lock, Dam, and Lake; George W. Andrews Lock, Dam, and Lake; and Jim Woodruff Lock and Dam and Lake Seminole. In this section, we discuss the changes to the ACF Basin that are included in the environmental baseline that may have ongoing effects on the basin and its aquatic communities. We focus on changes in hydrology and flow regime and how these changes have affected and may continue to affect the status of the species in the action area.

2.1.1 Major Rivers and Hydrology

Hydrologic characteristics of the basin are defined by various parameters, including precipitation and transpiration, runoff, land use, geology, and man-made structures to manage water resources. The mean annual rainfall in the Flint River Basin (Georgia) and Chattahoochee River Basin (Alabama and Georgia) generally ranges from about 50 to 55 inches per year (in/yr). In the Apalachicola River Basin (Florida), the mean annual rainfall generally is above 55 in/yr and may be as high as 66 in/yr in certain locations (USACE 2015 p. 2-2).

During the past 8 decades, the ACF Basin has experienced numerous droughts, several of which are considered severe. In recent years, droughts have been experienced in 1980-1982, 1985-1989, 1998 – 2003, 2007 – 2008 and 2011 – 2012 (USACE 2015, p 2.8 – 2.9). Since 1999, the six of the seven lowest-flow years (1999, 2000, 2002, 2007, 2011 and 2012) in terms of average annual flow in the period of record (1923 – present) for the Apalachicola River at Chattahoochee have occurred. The impacts of each drought have varied across the basin as the location, severity and duration of each drought has varied.

An important question with regard to the preparation of this document is whether the occurrence of multiple "rare events" in the past 30 years is an anomaly or should droughts of this magnitude be expected more regularly in the future with changing climate. Long-term climate records suggest that decade-long "mega-droughts" have occurred periodically during the past 1,000 years in the southeastern US, including in the ACF (Stahle et al., 2007). Projections for the ACF watershed indicate that future droughts are likely to be more intense (Yao and Georgakakos 2011). This suggests that while the recently observed droughts in 2006-2008 and 2010-2012 were exceptional based on our recent <100-year period of record, they may not be exceptional compared to historic episodes (Pederson et al., 2012). Gibson et al. (2005) used multiple future climate scenarios, combined with increasing water demand from human users, to predict that future river discharge conditions could include lower high discharge events and lower low flow events. From the 1940s to the 1990s (the majority of the period of record for gages in the ACF), the southeastern US was in a persistent, unusually wet period compared to the previous millennium (Seager et al., 2009). This is the period of time during which most of the reservoir and human development has occurred in the ACF and from which we derive flow assessments. The relative infrequency of severe drought events during this period may provide unrealistic expectations for future conditions.

Within the ACF Basin, rainfall occurs throughout the year, but is less abundant in August through November. The amount of rainfall that actually contributes to streamflow varies much more than the rainfall. Several factors such as plant growth and seasonal rainfall patterns contribute to the volume of runoff. In severe droughts in the upper Chattahoochee River Basin, the runoff from significant (3+ inches) rain events can be as low as 5 percent of the rainfall. The mountainous areas in the headwaters of the basin exhibit flashier runoff characteristics and somewhat higher percentages of runoff, ranging from about 28 to 60 percent of rainfall depending on the time of year. In contrast, runoff as a percent of rainfall between Blountstown, Florida, and Columbus, Georgia, ranges from about 16 to 53 percent depending on the time of year. In all portions of the ACF Basin, runoff as a percentage of rainfall is lowest in July through September (USACE 2015 p. 2-9).

The Apalachicola River has the highest annual discharge of any river in Florida. It is the fifth-largest river basin in the continental United States, as measured by annual discharge to the sea (Leopold 1994). Together with the Chattahoochee and Flint rivers, its two largest tributaries, the Apalachicola drains southeastern Alabama (15%), northwestern Florida (11%), and central and western Georgia (74%). The basin extends approximately 385 miles from the Blue Ridge Mountains to the Gulf of Mexico, and has an average width of 50 miles. The ACF Basin spans 50 counties in Georgia, 8 in Florida, and 10 in Alabama (USFWS 2012).

ACF Basin spans four level III ecoregions (Bailey 1983). The northern-most portion of the upper Chattahoochee River Basin lies in the Blue Ridge ecoregion, constituting only about 1 percent of the ACF Basin. This ecoregion is characterized by mountain ridges ranging up to about 3,500 ft in elevation. The balance of the upper Chattahoochee River Basin and the upper Flint River Basin are in the Piedmont ecoregion. Most streams in the Chattahoochee River have trellised and rectangular drainage patterns due to the Brevard fault. The Flint River and streams in its basin have dendritic drainage patterns, resembling a branching tree. The streams in the Piedmont are fast flowing and are characterized by rapids and riffles, making them ideal for hydroelectric power generation. The Southeastern Plains begin at the "Fall Line", which is the contact point between the crystalline bedrock of the Piedmont and unconsolidated sediments of the Plains. The area is highly dissected by streams, especially in the northern Georgia Sand Hills. The Dougherty Plain district in the south is underlain by limestone, and its karst topography is very flat and has numerous sinkhole-created marshes and wetlands. Streams in the Southeastern Plains are relatively low-gradient and sandy bottomed, and rivers are wide and sinuous with large floodplains. The Southeastern Plains has little runoff because annual precipitation and evapotranspiration rates are similar. During times of heavy rainfall events, the wide floodplains are able to store large quantities of water. The Southern Coastal Plain is a flat, lowland area that contains barrier islands, coastal lagoons, marshes, and swampy lowlands. Soils in the area are generally hydric and have a high capacity to hold and store water. The Southern Coastal Plain is dominated by large alluvial rivers, such as the Apalachicola River, which has a broad floodplain that ranges from 1 to 5 miles in width and is dominated by substantial flooding (USACE 2015 p. 2-11).

Streams in the ACF basin can be deeply entrenched into aquifers, and many receive significant contributions from groundwater from one of five major aquifers including the surficial aquifer system, the Upper Floridan aquifer system, the Claiborne aquifer, the Clayton aquifer, the Providence aquifer, and the crystalline rock aquifer. The Upper Floridan aquifer is hydraulically connected to the Flint River and, consequently, groundwater discharge contributes more significantly to baseflow in the Flint River than in the Chattahoochee River. Groundwater discharge to the Chattahoochee River is roughly 20 percent of the amount discharged to the Flint River (USACE 2015 p. 2-53).

The Chattahoochee River has a drainage area of 8,708 sq mi. The drainage area of the Flint River measures 8,456 sq mi. The remaining 2,409 sq mi of the ACF Basin drain directly into the Apalachicola River. Rivers in the ACF Basin include both natural (unregulated) rivers and regulated rivers. The natural rivers exhibit a more consistent pattern, responding to precipitation and drought periods as expected with short periods of high flows and prolonged periods of low flows, respectively. Regulated streams exhibit a variable pattern, with daily variations due to hydroelectric power generation operations (most prominent below peaking projects), navigation releases, lower flood peaks, and higher sustained minimum flows through dry periods as the upstream reservoirs augment low flows. Flow patterns (i.e., mean daily discharge) for the regulated Chattahoochee River over a year are illustrated in Figure 2.1, and for the unregulated Flint River are illustrated in Figure 2.2. Although the two rivers have only slightly different drainage areas, the figures demonstrate the distinctive characteristics of flow in the two watersheds (USACE 2015 p. 2-15). These differences are the result of both the regulated nature of the Chattahoochee basin and the differences in the contribution groundwater inflow to the base flow of the watershed. The significant groundwater contribution to the Flint River complicates water management in this basin because of uncertainties in the surface-groundwater interactions in the mid to lower Flint basin as well as effects on groundwater and spring discharge from groundwater withdrawals (Jones and Torak 2006, Rugel et al. 2015). During low flow periods, the Flint basin is typically an important contributor to meeting the USACE's minimum releases to the Apalachicola River. The inability of the Flint basin to play this flow mitigation role during the 2011-2012 drought led to the record low flows experienced in Apalachicola River in 2012 (Leitman et al. 2016).

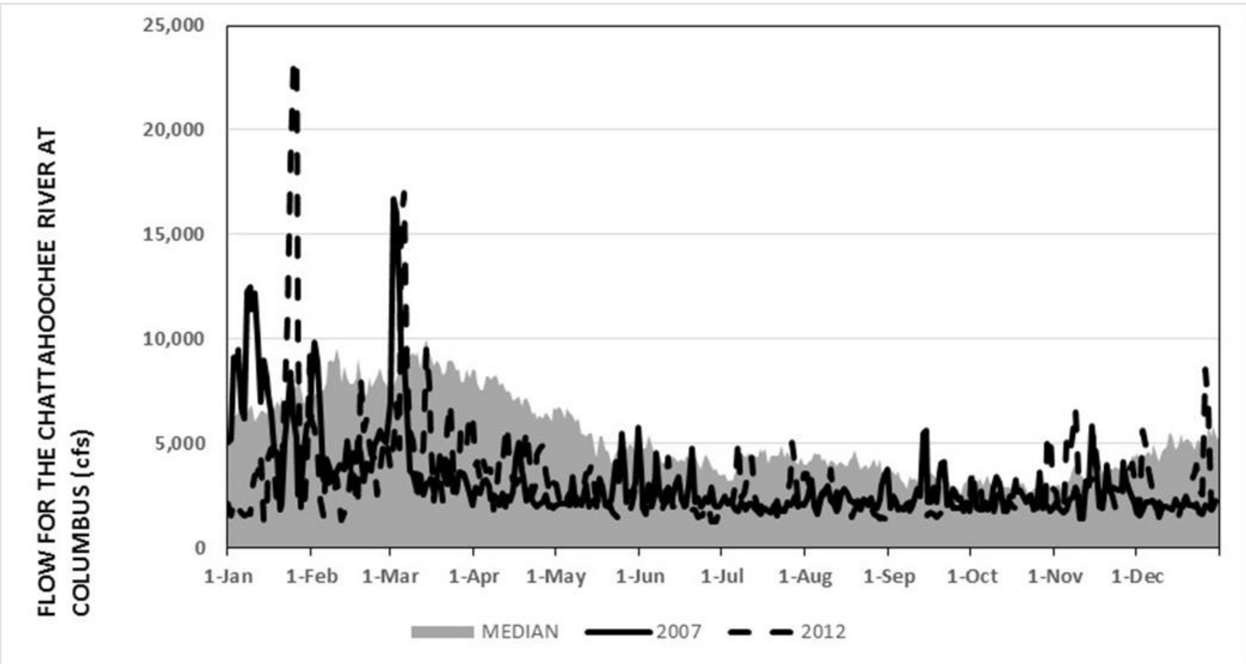


Figure 2.1 Median daily discharge from the Chattahoochee River at Columbus, GA (1939-2012) from USGS web data (http://waterdata.usgs.gov/ga/nwis).

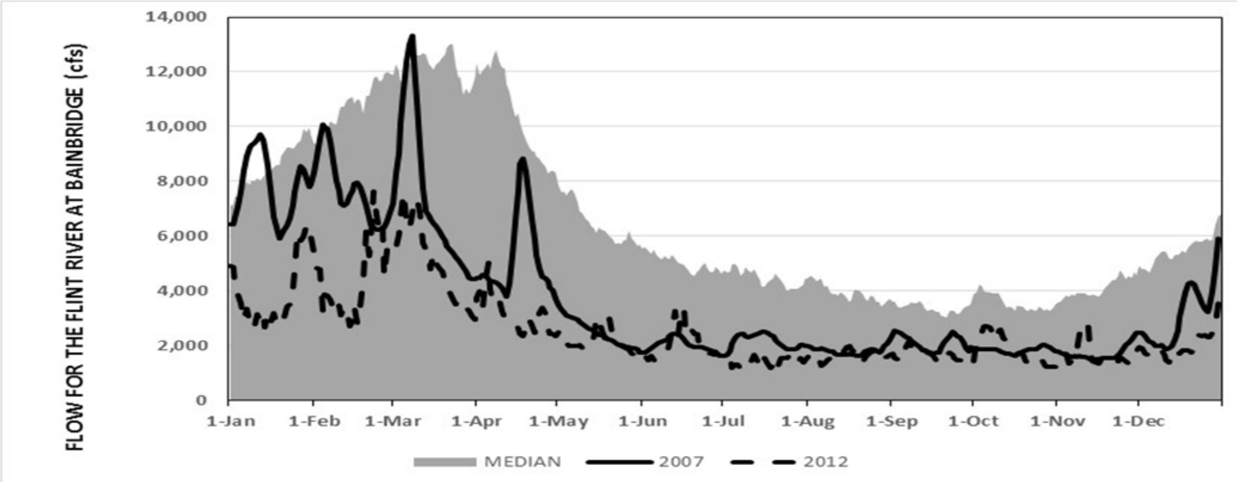


Figure 2.2 Median daily discharge from the Flint River at Bainbridge, GA (1939-2012) from USGS web data (http://waterdata.usgs.gov/ga/nwis).

The Chattahoochee River originates in the Blue Ridge Mountains of north Georgia, near the westernmost tip of South Carolina, and extends to the southwest corner of the state. The Chattahoochee River covers a distance of 434 mi from the Blue Ridge Mountains to Lake Seminole. It flows out of the mountains, past Metro Atlanta, and reaches the Georgia-Alabama border, at which point it forms the border between the two states. From there, the Chattahoochee River flows south to its confluence with the Flint River at Lake Seminole and into the Apalachicola River. Over most of its length, the mainstem of the Chattahoochee River is controlled by dams, with navigation locks and hydroelectric plants, that provide for navigational use of the river, release water for the production of hydroelectric power generation, temporarily store water for flood risk management, and serve other purposes. The slope of the Chattahoochee River for 50 mi above Buford Dam is approximately 4 ft/mi. The Chattahoochee River is free-flowing only in the headwaters upstream of Lake Lanier. Between Buford Dam and West Point Dam, the slope is fairly uniform and averages about 2.7 ft/mi. Downstream of Buford Dam, the river is affected by dam and reservoir operations. The river's slope becomes quite steep through the Fall Line hydroelectric power generation projects, from West Point Dam to Columbus, Georgia, averaging about 10 ft/mi. Downstream of Columbus to Jim Woodruff Lock and Dam, the slope of the river is relatively flat at 1.2 to 0.6 ft/mi. The capacity of the Chattahoochee River within its banks is about 10,000 cfs between Lake Lanier and Norcross, about 18,000 cfs from Atlanta to Whitesburg, and about 47,500 cfs near West Point and Columbus. Historically, flows at the USGS gage on the Chattahoochee River at Columbus have been as low as 480 cfs (in October 1931) and as high as 120,000 cfs (in February 1961). Many of the dams and hydroelectric plants operate in a peaking mode, which can result in daily water level fluctuations in the river of 4 ft or more. Storage for flood risk management at several of the larger reservoirs reduces the peak flow in the river by storing much of the flood flow. In contrast to the mainstem of the river, the numerous tributaries of the Chattahoochee River are free flowing. These streams typically have higher sustained flows during winter months and show sharper responses to storm events throughout the year (USACE 2015 p. 2-15 - 2-16).

The Flint River originates just south of Atlanta and flows about 350 mi in a southerly direction, curving to the west to join the Chattahoochee River at Lake Seminole in the southwest corner of Georgia. The Flint River drainage basin has an average width of about 40 mi. The Flint River is generally fed by groundwater from its headwaters to its mouth, and there is a substantial groundwater-to-surface water transfer in the lower portions of the Flint River, which helps to sustain higher winter flows in the river. North of the Fall Line, the Flint River receives groundwater by diffuse leakage into the river bottom; south of the Fall Line, groundwater flow from springs becomes more prevalent. In the upper reach of the Flint River, above the Fall Line, the slope of the river averages about 2 ft/mi. For about 55 mi across the Fall Line, in the general vicinity of Thomaston, Georgia, the slope averages about 6.7 ft/mi. The lower portion of the Flint River has an average slope of about 1.0 ft/mi (USACE 2015). There are only two limited-storage-capacity reservoirs on the Flint River (i.e., Lake Blackshear and Lake Worth), and they do not substantially modify the flow in the river. The capacity of the Flint River within its banks ranges from about 30,000 cfs near Montezuma to about 35,000 cfs near Bainbridge, in the headwaters of Lake Seminole. Historically, flows at the Albany gage, which is about midway between Lake Seminole and the Flint River's headwaters, have been as low as 327 cfs (in August 1930) and as high as 119,000 cfs (in July 1994 as a result of Tropical Storm Alberto) (USACE 2015 p. 2-17).

The Flint and Chattahoochee rivers converge at Lake Seminole, which is formed by the Jim Woodruff Lock and Dam. Together, they form the Apalachicola River, which is entirely within the State of Florida and flows unimpeded for approximately 106 mi from the dam near the Florida-Georgia state line to the Gulf of Mexico at Apalachicola Bay. The river drains about 2,409 sq mi, and its shallow estuary covers about 208 sq mi. Tides in the Gulf of Mexico influence the Apalachicola River over approximately the lower 25 mi of the river. The tides have a mean range of 2 ft. The width of the river ranges from several hundred feet when confined to its banks to nearly 4.5 mi during flood flows. The discharge of the Apalachicola River accounts for 35 percent of the freshwater flow on the western coast of Florida. The slope of the Apalachicola River is fairly flat at 0.5 to 0.7 ft/mi over its entire length (USACE 2015 p. 2-22).

Lidstone and Anderson, Inc. (1989) described general morphological features of the Apalachicola River, which we summarize here. Almost the entire floodplain is forested and averages 1-2 miles in width in the upper river (> RM 77.5), 2-3 miles in the middle river (RM 77.5-41.8), and 2.5 to 4.5 miles in the lower river (RM 41.8-20.6). Limestone outcrops are found within the channel from river mile RM 86 to RM 105, where slope averages 0.424 ft per mile, and channel width averages 670 ft. The middle river has a slope of 0.495 ft per mile, is about 600 ft wide, and includes several abandoned river channels and oxbow lakes. In the lower river, both tidal and nontidal portions, slope is 0.334 ft per mile with an average width of 533 ft.

The Chipola River is the only sizable tributary to the Apalachicola River besides the Flint and Chattahoochee rivers. The Chipola River Basin drains 1,270 sq mi, which accounts for about one-half of the Apalachicola River's drainage area in Florida. The Chipola River is a spring-fed river with baseflow derived principally from aquifers. The capacity of the Apalachicola River within its banks is approximately 100,000 cfs at Chattahoochee, Florida. Historically, flows at the Chattahoochee gage ranged from a low of 3,900 cfs (during the 1986 to 1987 drought period) to a peak of 291,000 cfs in 1929 before many of the upstream reservoirs were built. More recently, flows have been as high as 203,000 cfs in July 1994 after Tropical Storm Alberto brought heavy rains to Georgia. Mean daily discharge at two gages, Chattahoochee and Blountstown, Florida are illustrated in Figure 2.3 and 2.4 respectively. The differences in high flow between before and after reservoir construction is due to climate, not reservoir management. The volume of storage in the watershed is not adequate to store flows from rain events with runoff greater than 200,000 cfs, because: (a) the total conservation storage capacity of the basin at full summer pool is about 800,000 cfs-days; (b) the Flint basin is unregulated; and (c) the reservoir at the confluence of the Flint and Chattahoochee Rivers has very limited storage (USACE 2015 p. 2-24). Similar to the pattern exhibited by the Chattahoochee and Flint rivers, flows on the Apalachicola River are highest in spring and lowest in late summer. The large seasonal fluctuation in flow in the Apalachicola River is important to the ecological function of the river and its estuary (USACE 2015 p. 2-22).

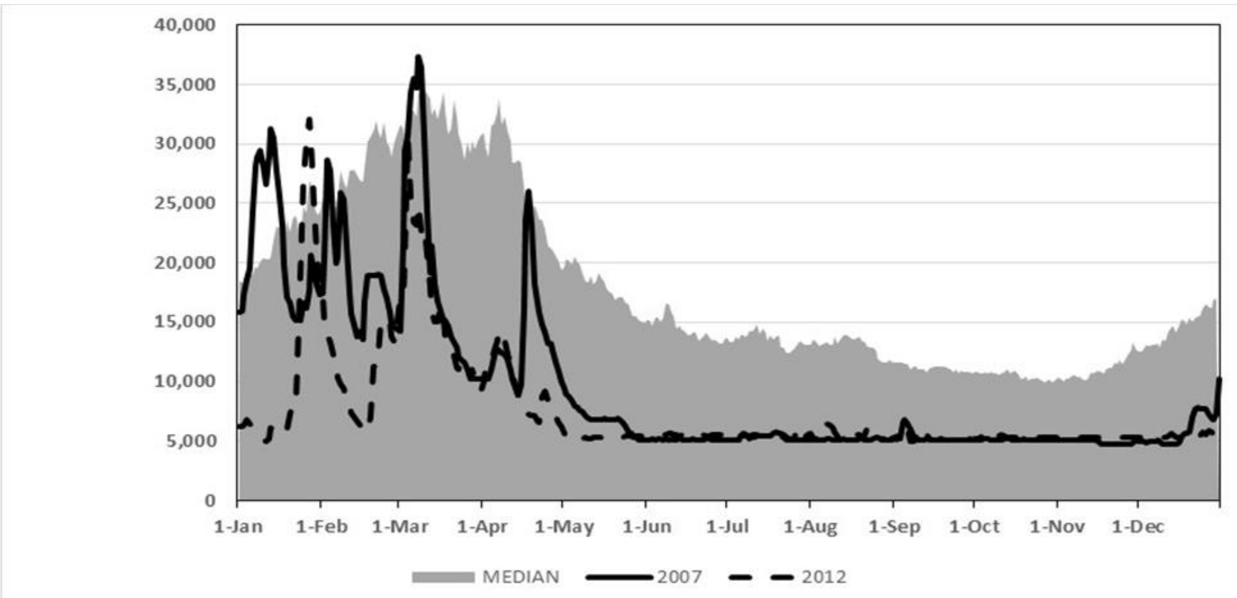


Figure 2.3 Median daily discharge from the Apalachicola River at Chattahoochee, FL (1923-2012) from USGS (http://waterdata.usgs.gov/fl/nwis/rt).

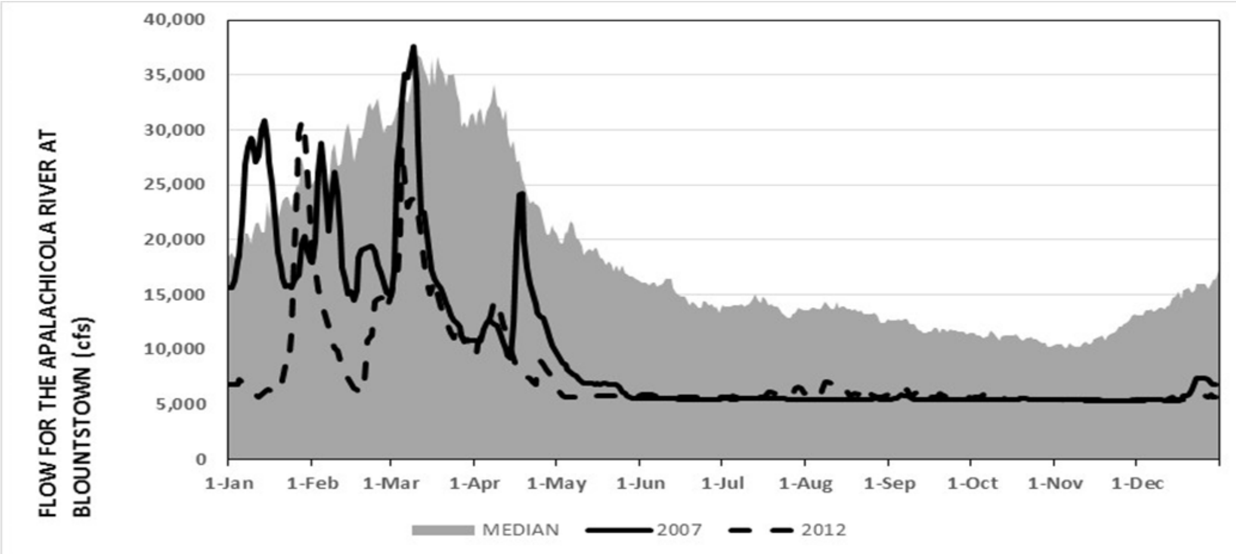


Figure 2.4 Median daily discharge from the Apalachicola River at Blountstown, FL (1939-2012) from USGS (http://waterdata.usgs.gov/fl/nwis/rt) and USACE HEC-ResSim data base.

As a sand-bed alluvial river, the Apalachicola is a dynamic system constantly changing by ongoing processes of erosion and deposition. Historically, the river included large meanders and tree-lined banks. The river banks were dominated by cohesive sediments that include large quantities of silt and clay (Lidstone and Anderson, Inc., 1989). Winter floods deposited tons of tree limbs, trunks, and stumps in the main channel. Jeanne (2002) noted that the extensive tree growth in the subtropical environment required constant trimming to reduce hazards to steamboats that plied the river in the 1800s.

The flow of the Apalachicola is carried by a complex of channels that includes the main channel and various distributaries. The upstream-most distributary is a "loop stream" called The Bayou, which departs the main channel at RM 86 and returns to the main channel at RM 78. Loop streams like this become increasingly more common downstream, particularly downstream of the river gage near Wewahitchka, Florida (~RM 42). These loop streams carry a substantial portion of the total flow of the river at medium and high flows (Light et al. 2006). The Chipola Cutoff is a more complex loop stream because the Cutoff receives about 34% of the flow of the Apalachicola River but then enters the Chipola River, which is a large tributary of the Apalachicola River (Biedenharn 2007). Therefore, flows in the Chipola River downstream of the Chipola Cutoff are directly affected by flows in the Apalachicola River. Distributaries that do not loop back to the main channel and instead carry water directly to Apalachicola Bay begin at RM 14.

2.1.2 Land use Changes and Associated Changes in Hydrology

Nearly 50 percent of the ACF Basin is forested, down from 55 percent in the 1990s (USACE 2015). A large portion of the precipitation on forested lands is intercepted and prevented from quickly reaching surface water streams through infiltration and evapotranspiration processes. Following pine plantation harvesting, water yields can increase as much as 35 percent due to decreases in interception and evapotranspiration. Forested ecosystems have high stream baseflows and low, lengthy storm peaks compared to other common land uses because of high infiltration and permeability rates. Forest cover (e.g., leaves and mulch) reduces raindrop velocities, allowing for higher infiltration, and soils have organic concentrations with higher porosities, allowing for higher permeability. During high storm flows, wetland forests, often streamside, can store large quantities of water and reduce downstream flooding impacts. The intensity of drought and wet periods is exacerbated by changes in land use and population demand on resources. From 1970 to 1990, water use for public supply in the ACF Basin, which includes metropolitan Atlanta, more than tripled to almost 460 mgd. Demand continued to more than double between 1990 and 2010, and demand under current operations is 958 mgd (Appendix A). Severe droughts and increased development in the area have resulted in shortages and restrictions on limited surface water supplies. Concurrently, various conservation measures have been instituted and periodically strengthened to curb the increased demand and per capita water use (USACE 2015 p. 2-13).

Total agricultural land in the ACF Basin has decreased over the past two decades due to urbanization and farm abandonment, but more than 20 percent of the land cover is still used for agricultural purposes. A large majority of the irrigated area in the ACF basin above Jim Woodruff Dam occurs in Georgia, about 77% of which occurs in the Flint basin (excluding Spring Creek sub-basin), 21% in the Spring Creek sub-basin of the Flint, and only 2% in the Chattahoochee basin (Hook et al. 2010). Agriculture in the ACF Basin uses both surface water and groundwater for crop irrigation and livestock watering. In the Flint River Basin, groundwater supplies nearly all of the water needed for crop irrigation, whereas in the Chattahoochee River Basin, groundwater supplies only 44 percent of the water needed for crop irrigation. Livestock agricultural uses are throughout the basin, and farmers use both groundwater and surface water to water livestock. Water used for crop irrigation is considered to be 100 percent consumptive because it is incorporated into crops or lost through evapotranspiration. Compared to forested land use, agricultural land uses produce larger storm flows during rain events because of the reduced soil cover. The runoff rates from agricultural areas are similar to the rates from low- and medium-density residential areas (USACE 2015 p. 2-13).

Urban areas significantly affect water quantity because of the high percentage of impervious cover and increases in water consumption. Rainfall on impervious surfaces is immediately transported to streams, causing high peak flows. Urban areas also have large areas of land with significantly reduced infiltration and permeability rates, such as grassy and barren land. These areas also shed water extremely quickly during storm events. Because less infiltration occurs in residential and industrial areas, very little groundwater recharge occurs and stream baseflows are reduced (USACE 2015 p. 2-13).

Most water removed from the basin for municipal and industrial water demands is returned to the basin as treated waste, but demands can alter natural channel flow. In the Chattahoochee River Basin, approximately 82 percent of the water withdrawn is returned, although the range may be

60 to 80 percent. Water is lost from the system through evapotranspiration, interbasin transfers, and thermal water demands. Municipal water suppliers use both surface water and groundwater, depending on supply levels. Water is often returned downstream of the supply source, and groundwater is often returned to the system as surface water. Water use for hydroelectric power generation is nonconsumptive, but hydroelectric dams can alter natural flow regimes because large releases occur during peak power demand periods. Water used for thermoelectric power generation (i.e., fossil fuels and nuclear) is moderately consumptive to nonconsumptive (USACE 2015 p. 2-14).

Under the baseline (NAA) and WCM (PAA) alternatives examined in the EIS, consumptive demands for the basin are identical except for in the metropolitan Atlanta area (see Table 7 in BA). Under the baseline, releases from Buford Dam would be sufficient to provide for the current need of 277 mgd for downstream withdrawals by metropolitan Atlanta water providers, with current withdrawals of 128 mgd directly from Lake Lanier, including 20 mgd for the reallocation contracts (USACE, 2015, p. 5-12). In the BA, it is stated that under the WCM, the cities of Gainesville and Buford would continue to withdraw water directly from Lake Sidney Lanier under relocation agreements at rates not exceeding 8 mgd (net) and 2 mgd, respectively. Additionally, pursuant to the Water Supply Act of 1958, the WCM would reallocate 252,950 acre-feet in Lake Lanier to water supply. This amount of storage is estimated to yield 222 mgd during the critical drought (i.e., during the worst drought on record at the time the agreement was executed). Under the WCM, releases from Buford Dam would be made to accommodate downstream water demands. Peaking hydroelectric power generation generally accommodates most water supply needs of communities currently withdrawing from the Chattahoochee River; however, under the 1946 Rivers and Harbors Act, generation can occur at non-peaking times to meet the downstream water supply needs, not to exceed 379 mgd. Under the baseline, the total net consumptive withdrawals from the ACF basin used in the modeling of the alternatives was about 958 mgd, and under WCM, the total consumptive withdrawals was about 1,102 mgd (Appendix A).

2.1.3 Dams and Changes to River Morphology and Water Quality

The history of dam construction on the Chattahoochee River dates back to the early 1800s. Projects on the river at and above Columbus, Georgia, were built to take advantage of the natural stream gradients for power production. The earliest dam constructed and still in operation was the Langdale Dam and Lake owned and operated by the State of Georgia and Georgia Power Company in 1860. Federal interest in the ACF Basin also dates back to the 1800s. Navigation improvements were authorized under the River and Harbor Act of 1874. Later, flood control and hydroelectric power generation interests were addressed. The River and Harbor Acts of 1945 and 1946 provided for the construction of a series of locks, dams, and reservoirs within the ACF Basin by USACE as part of a general plan to provide systemwide benefits for multiple purposes including navigation, flood control (flood risk management), hydropower generation, water supply, water quality, recreation, and fish and wildlife conservation. Modifications of this plan resulted in the completion of five USACE dams—four on the Chattahoochee River and one at the confluence of the Chattahoochee and Flint rivers. Operations of the ACF system and of the individual projects within it are governed by the original authorizing legislation, as amended, and by other general authorities and applicable law. There are 14 reservoirs on the mainstems of the ACF Rivers: five are federally owned, USACE projects and nine are privately owned projects. Of the 14 reservoirs, 11 are on the Chattahoochee River, two are on the Flint River, and one is on the Apalachicola River. The five USACE projects were completed in the following years: Buford Dam and Lake Lanier in 1957; West Point Dam and Lake in 1975; Walter F. George Lock, Dam, and Lake in 1963; George W. Andrews Lock, Dam, and Lake in 1963; and Jim Woodruff Lock and Dam and Lake Seminole in 1954 (USACE 2015 p. 2-23 - 2-24).

Prior to construction of the reservoir system in the ACF Basin, aquatic communities were structured by water quality and physical habitat condition, which were driven by the physiographic region and climate described in the previous sections. The construction of the USACE reservoir system significantly altered both the water quality and physical environment of the Chattahoochee and Apalachicola Rivers. Protection of aquatic resources was generally not a consideration for many types of river projects at that time because flood control, navigation, and low-cost hydroelectric power for economic stimulation were more highly valued.

In general, the construction of the USACE's dams, which preceded the Act and the listing actions for the sturgeon and mussels and are considered a part of the environmental baseline, continue to affect the ACF Basin and its aquatic species. As with other reservoir systems throughout the Southeast, the primary impact of the reservoir system was to convert free-flowing river habitat into reservoir pools. Virtually all of the mainstem Chattahoochee River was impounded to meet project purposes and the downstream Apalachicola River was influenced by the effects of these upstream impoundments. Completion of the entire water control system (both federal and non-federal) as well as increased consumption on the Flint River and other demands on the ACF Basin described above likely resulted in the following impacts to the aquatic system:

1) conversion of riverine habitat to reservoir pool habitat;
2) loss of riverine habitat and associated species;
3) conversion of floodplain to reservoir pool;
4) loss of seasonal floodplain habitat and associated species;
5) fragmentation of riverine sections;
6) disruption of fish migrations, including the Gulf sturgeon itself and several host fishes for listed mussels;
7) seasonal fluctuations of pool levels;
8) seasonal drying of habitat which reduces abundance and diversity of species;
9) strong stratification (layering) of temperature for certain dam types and change in thermal regime for the main channel rivers;
10) stress or mortality of organisms or sensitive life stages;
11) seasonal dissolved oxygen depletion in temperature stratified water;
12) ammonia release created by presence of dissolved oxygen-depleted water;
13) disruption of stream transport of sediment;
14) trapping of sediment that would otherwise move as bed load through the system;
15) altered channel morphology;
16) capture of toxic substances associated with substrate;
17) toxic substances release created by presence of dissolved oxygen-depleted water; and

18) enrichment of nutrients (eutrophication) with consequent increases in productivity, plant and algae growth, and changes in habitat quality and associated species.

Although all 18 of these changes are important to the biota of the ACF Basin, changes in channel morphology and sediment transport and changes in the water quality of the rivers merit further discussion here, and changes in flows will be summarized in the next section.

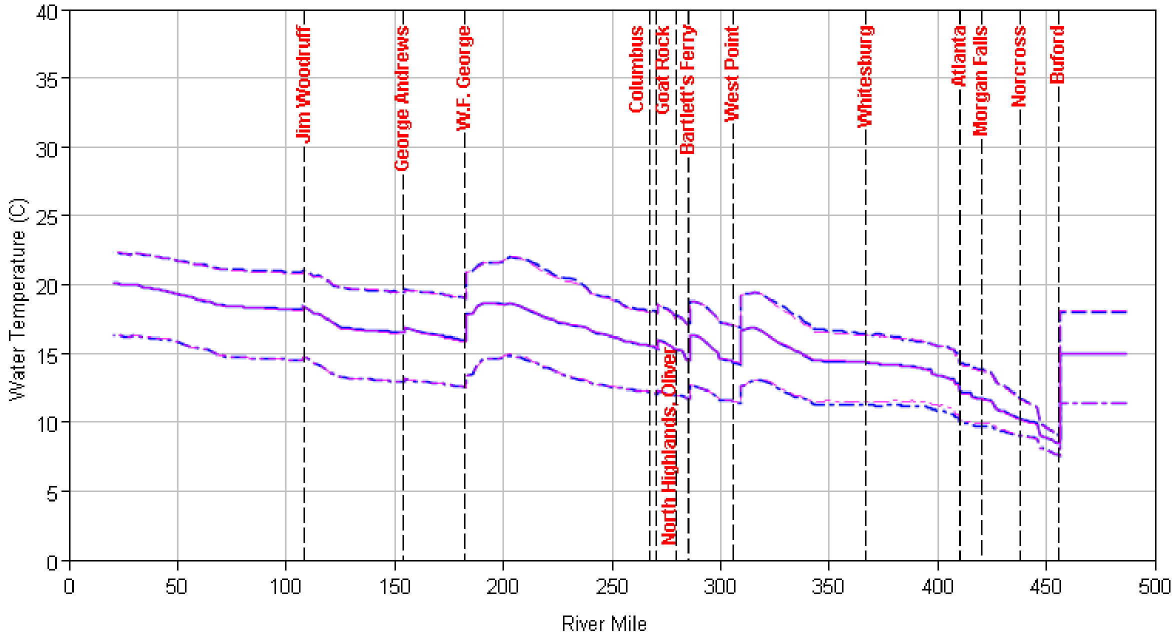
Channel morphology sets the context for the flow regime. The morphology of the Chattahoochee and Apalachicola rivers was altered by land use changes, upstream impoundments, consumptive use of water, and tectonic movement, as well as channel alterations such as the construction of dike fields, meander cutoffs, and channel dredging and snagging operations (Hupp 2000, Light et al. 2006, Price et al. 2006). The channel morphology has changed relative to the pre-dam period in the Apalachicola River. The Apalachicola River has not followed the normal pattern of lateral migration in which erosion and deposition are balanced so that the channel maintains a relatively constant width and bed elevation (Light et al. 2006). In the past 50 years, many portions of the Apalachicola have substantially declined in elevation (incised) and/or become substantially wider. However, the rate of change has slowed and appears to have entered a somewhat dynamic equilibrium condition (USFWS 2012). Mean bed elevation declined to some degree from 1960 to 2001 at 42 of 51 cross sections measured by the USACE throughout the nontidal portion of the Apalachicola River (Price et al. 2006). This decline is greatest in the upper river (> RM 77.5). During the period 1954 to 2004, the stage equivalent to 10,000 cfs declined 4.8 ft. During the period 1960 to 2001, in the upper 41 miles of the river, mean bed elevation declined an average of 2.2 ft at 26 cross sections measured in this reach. Channel width, measured as the distance between the treeline of opposite banks on aerial photography, has significantly increased since 1941. The mean increase in width of the nontidal river has been 77 ft, using 2004 aerial photography as the most recent measure. Relative increases were greater going downstream. Most of the widening occurred between 1959 and 1979, and appears to have stabilized between 1979 and 1999, with the exception of some minor widening in the middle (RM 77.5-41.8) and non-tidal lower reaches (RM 41.8-20.6) that continued between 1999 and 2004 and warrants continued monitoring.

The probable cause of the channel morphology changes is sediment sequestration in the reservoirs and changes in flow regime (sediment transport patterns) following construction of dams. Additionally, the USACE previously maintained the navigational channel by snagging and dredging. However, except for limited dredging in 2001, the USACE has not maintained the channel since 1999 and dredging is not included in the action evaluated currently. Despite the loss of sediments that would naturally replenish downstream ecosystems, continued erosion appears to be part of the natural down-valley meander migration which is common to most alluvial streams and may not be the result of continuing post-dam system-wide adjustments. It appears unlikely that erosion rates will increase over time (Beidenharn 2007, Harvey 2007), and channel profile data collected in 2009 indicate a state of relative equilibrium (USACE, Mobile District, B. Zettle, pers. comm. 6/21/2016). However, USFWS does not have adequate data to assess the channel profile stability. During development of the BO, the USACE requested that the USGS review the stage/discharge data collected at the three gages in the action area (Chattahoochee, Blountstown, and Sumatra) since 2012 in order to determine if the channel morphology still reflects a somewhat dynamic equilibrium condition. These gage ratings at the

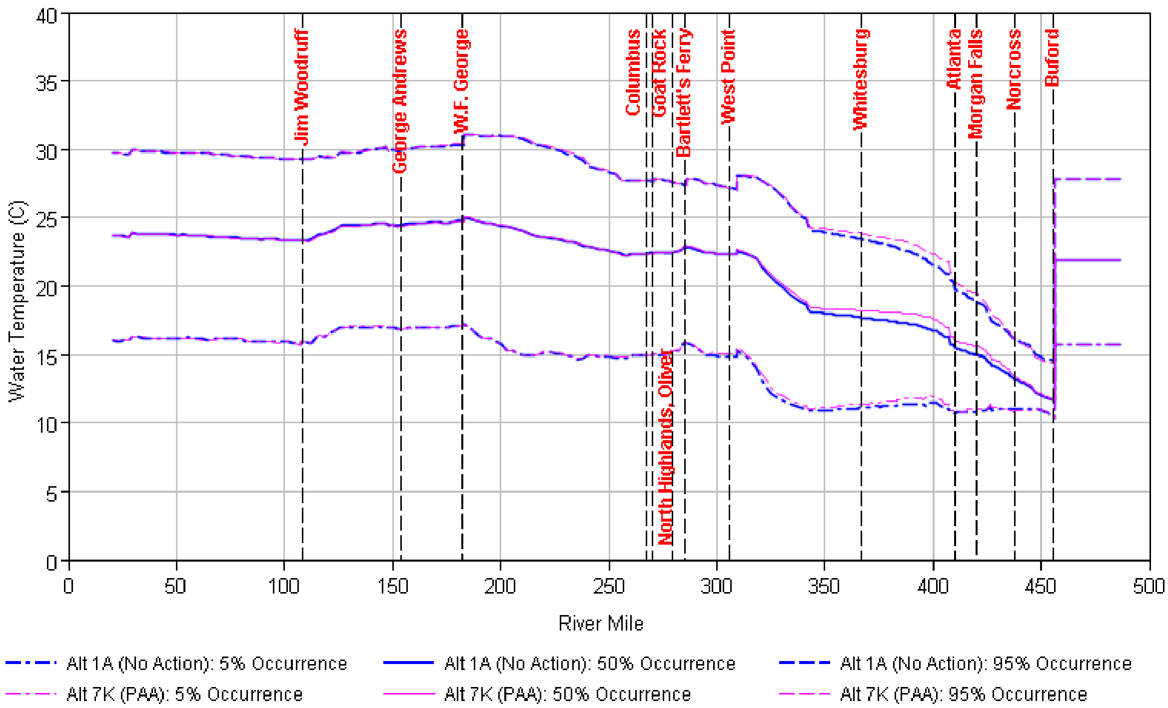
Chattahoochee gage are corrected on a regular basis. As an indicator of the state of relative equilibrium, USACE will examine the shifts in the rating curves from 2012 to present. The pattern of directional shift will be analyzed as an indicator that the state of relative equilibrium is likely to continue. The USGS has conducted a review of the measurements made at the Apalachicola River Chattahoochee, Blountstown and Sumatra gages as requested by USACE. Although several measurements have been collected at each location since 2012, the measurements are not always made in the same location. While the exact location of the measurement in the channel does not adversely affect the computed discharge for the site, it does make comparison of channel characteristics impractical. It is the USGS's opinion that a determination as to stability or degradation of the channel based upon discharge measurements cannot be made (USACE, Mobile District, B. Zettle, pers. comm. 8/26/2016).

Differences in purposes and, consequently, operation of reservoirs became important factors in determining water quality and associated impacts on resident aquatic communities downstream. Water temperature changes as it moves through river drainage system. In an unimpounded system, surface water temperature gradually warms as it moves downstream. However, surface water temperature varies greatly depending on the inputs of groundwater through the system. Little empirical data from the ACF basin on water temperature is available for analysis. In the amended BA (6/30 p. 48-51), USACE modeled water quality including water temperature throughout the basin associated with the water management alternatives and water supply storage options in the ACF Basin using the HEC-5Q model developed by the USACE Hydrologic Engineering Center. For the simulation of water quality conditions under the various alternatives, HEC-5Q inputs included main-channel flows, tributary flows, water quality data, withdrawals, and point and non-point pollutant loads to the system. The HEC-5Q model was linked with the HEC-ResSim model through an input of flows by reach. Pollutant loading included both observed and simulated data developed using the BASINS model for period of record from 2001 through 2011. The HEC-5Q model also included nontributary inflows, wastewater treatment dischargers, and cooling water returns. Inputs for wastewater treatment discharges were based on discharge monitoring reports (DMRs). When DMRs were not available, permitted limits, concentrations representative of the type of discharge, or an average of DMRs was used. The point-source inputs considered only dischargers that contributed more than 1 mgd.

This modeling indicates that the temperature regime of the river has changed since the five USACE projects were completed during both the spring (March-May; Figure 2.5A) and fall (Sept-Dec; Figure 2.5B) periods. Distinct drops in temperature can be seen downstream of Buford, West Point, W.F. George, which are managed by USACE as well as Bartlett's Ferry. These drops are from cool water released from each of these reservoirs and represent changes in water temperature that would have otherwise warmed gradually as it moved through the basin. Spring water temperature under both the baseline and the WCM generally ranges from about 15°C to 21°C in the reach of Apalachicola River below Jim Woodruff Dam known to support Gulf sturgeon spawning, but range from about 17°C to 28°C in the fall (6/30 amended BA p. 50).



A



B

Figure 2.5 HEC-5Q Simulated Water Temperature (Degrees Celsius) in Spring (A) and Fall (B) Under the WCM (PAA) and Baseline (No Action) based on ResSim simulated flow (1975-2011).

2.1.4 Changes to River Flows

Prior to dam construction, stream flow was proportional to rainfall, and flow regime followed the same trends as the annual rainfall and evapo-transpiration patterns. Flow established physical habitat conditions (e.g., depth, velocity) within a stream and maintained stream shape and other habitat condition, including substrate. Floods were common during spring, and flows decreased throughout the year with the lowest flows typically occurring August through October, the warmest part of the year. Spring flooding was an important component in the life cycles of some fish species that use flooded overbank areas for spawning or nursery areas. Meeting the purposes of USACE-system dams and reservoirs, such as water supply and flood control throughout the Chattahoochee and Apalachicola Rivers, required modifying the river environment described above to which the pre-impoundment aquatic community was adapted. For example, riverine habitat was eliminated by impoundments, and seasonal flow patterns were greatly modified by capturing high spring flows in upstream impoundments and increased late summer/fall flows with drawdown releases from those reservoirs.

To compare pre- and post-dam conditions, we used the observed 27-year pre-Lanier flow record of the Chattahoochee gage from 1929 to 1955 and the post-West Point construction period (1975-2012) flow record of the same gage (see USFWS 2012 for a more detailed comparison). Here, we summarize differences between the two time periods from that analysis in terms of annual flow, high flows, low flows, seasonality of flows, and rates of change in the system. Differences between the pre-Lanier and post-West Point periods may result from climatic as well as the anthropogenic differences described earlier. These changes due to the dams are important as context for changes to the downstream action area and as context for what the biota have experienced leading to their current status, which is reviewed in subsequent sections.

Annual Flows: To better understand the effects of climate versus operations, we begin with a general comparison of the annual flow for the two periods. Figure 2.6 shows frequency-duration curves for pre-dam and post-West Point periods for observed flows for the pre-dam period (1923 – 1955) and the post West Point construction period (1975 – 2012). This figure shows that in the pre-dam period there was relatively more flow than in the post-West Point period. In the post-West Point period, the five lowest-flow years (2000, 2002, 2007, 2011 and 2012) and seven of the 10 lowest-flow years in terms of average annual flow occur. The occurrence of these lowest-flow years in the later period may be due to differences in precipitation patterns; however, historical precipitation data (NOAA 2016) in the Chattahoochee and Flint basins suggest that, despite the occurrence of the lowest-flow years in the post-West Point period, the amount of annual precipitation was generally similar in these two periods (post-West Point median of 52.15 inches vs. pre-Lanier median of 49.31 inches). The driest 10 years are divided equally between the pre-Lanier and post-West Point periods.

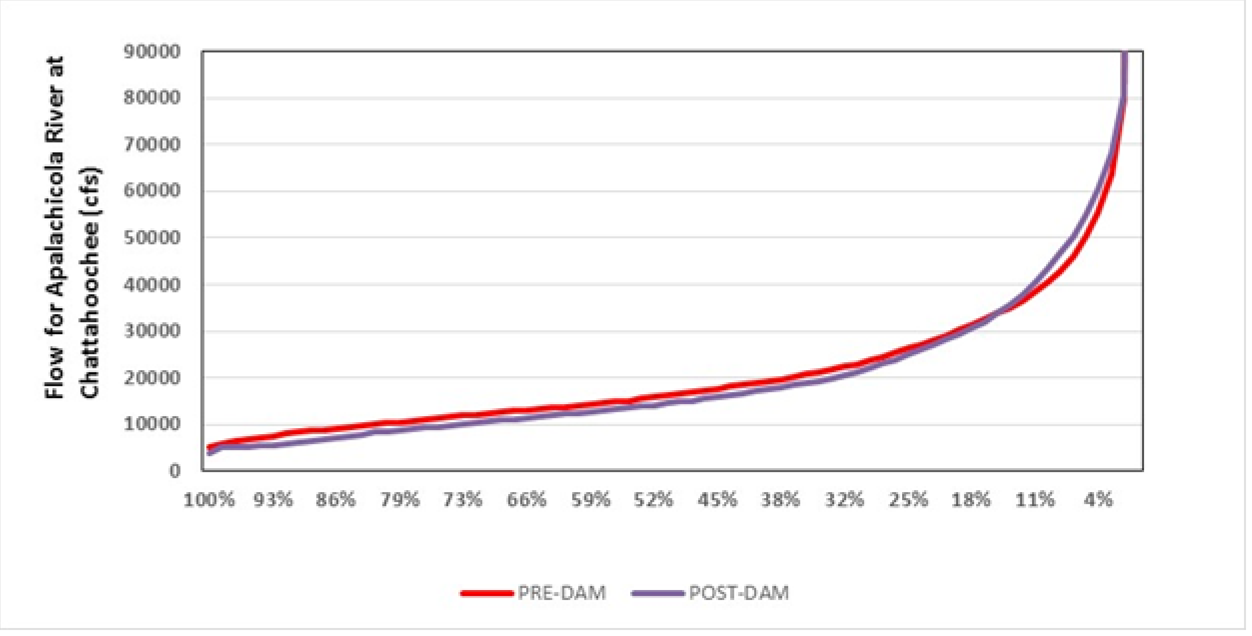


Figure 2.6 Frequency-duration curves for pre-dam and post-West Point periods for the Apalachicola River based on the Chattahoochee gage.

High Flows: High flows (e.g., flows greater than 50,000 cfs) perform many functions that are vital to the maintenance of riverine and estuarine ecological integrity, including:

1) the maintenance of channel and floodplain features by transporting sediment;
2) the export of organic matter;
3) nutrients, and organisms from the floodplain to the main channel and the estuary;
4) removing and transporting fine sediments, clearing interstitial spaces in gravel bars used for fish spawning;
5) importing woody debris into the channel, creating new high-quality habitat for fish and invertebrates;
6) scouring floodplain soils, which rejuvenates habitat for early-successional plant species;
7) reducing estuarine salinity, which provides nursery habitat for many marine species with early life stages that are intolerant of high salinity, and prevents the permanent intrusion of marine predators, such as oyster drills, that are intolerant of low salinity;
8) connecting the main channel to the floodplain, providing access to spawning habitats, nursery areas, and food sources; and
9) maintaining flood-resistant, disturbance-adapted communities (USFWS and USEPA 1999).

Because of the small volume of storage in the ACF basin relative to flow in the Apalachicola River, there is a very limited capacity to influence high flows through the management of the federal reservoirs and hence through the WCM.

Bankfull discharge tends to occur almost annually (1.1-year recurrence interval) in the coastal plain portions of Alabama, north Florida, and Georgia (Metcalf et al. 2009), and these relatively frequent events move the greatest sediment volume over time. Bankfull flow in mid to lower portions of the Apalachicola River is about 14,000 to 15,000 cfs (Light et al. 2006; Figure 2.7). Using the full record of annual instantaneous peak flow data downloaded from the USGS Chattahoochee gage website, the 1.1- and 1.5-year recurrence peak flows for the Apalachicola River are 45,600 cfs and 72,000 cfs. Flow did not exceed 50,000 cfs, a threshold between the 1.1-1.5 peak flows, in about 18% of the years in both periods; however, the median number of days ≥ 50,000 cfs was greater in the post-West Point period (25 days vs. 15 days) (USFWS 2012). This shift in the inter-annual duration of high flows suggests a relatively greater potential for sediment transport in the later period. One effect of bed degradation and channel widening as discussed in the previous section has been to reduce the amount of floodplain inundation associated with a given discharge (Light et al. 1998, Light et al. 2006). For example, the amount of floodplain habitat inundated by a flow of 30,000 cfs was about 46,500 acres in the pre-Lanier period and about 35,000 acres in the post-West Point period (a 25% reduction).

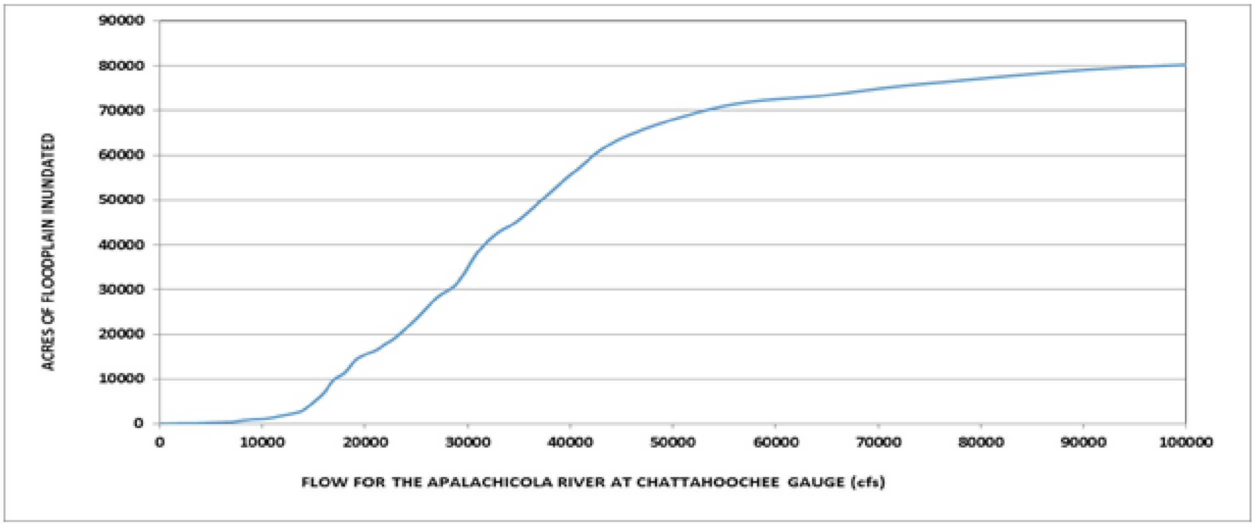


Figure 2.7 Relationship between flow and acres of floodplain inundation in the Apalachicola River based on the Chattahoochee gage (from Light et al. 1998).

Low Flows: Extreme low flows are likely among the most stressful natural events faced by riverine biota (Cushman 1985, Kingsolving and Bain 1993). Low flow constricts available habitat and portions of the channel become dry. Aquatic animals that are unable to move to remaining pools or burrow into the moisture of the streambed itself perish. Others become concentrated in pools, where small-bodied species are more vulnerable to aquatic predators and large-bodied species are more vulnerable to terrestrial predators, particularly birds and raccoons. During warm months, extreme low water levels are accompanied by higher-than-normal water temperatures and low dissolved oxygen levels, further stressing river biota. Given the physical and biological harshness of extreme low-flow conditions, decreasing the magnitude, increasing the duration, or increasing the inter-annual frequency of low-flow events is likely to cause detrimental effects on native riverine biota, including the listed species.

Because consumptive demands are a relatively greater percentage of flow at extreme low flows, consumptive withdrawals have the greatest influence on the flow regime and the need for augmentation release at these low flows. Under the WCM, the average total consumptive withdrawals from the basin are >1,700 cfs/day or about 1/3 the minimum release called for under the 5,000 cfs drought trigger release. The average daily consumptive withdrawals under the baseline (NAA) are 1,484 cfs/day.

Seasonality: A seasonally variable flow regime is for many reasons vital to the health of the riverine ecosystem. Many riverine organisms have life history features that are adapted to seasonal patterns of river flow (Poff et al. 1997). Seasonal flow adaptations of mussels have not been investigated, but the habits of many fish species, some of which may serve as hosts for the listed species, are seasonal and flow dependent (Angermeir 1987, Schlosser 1985).

As discussed earlier, the natural seasonality in precipitation in the ACF Basin with lower flows during the late summer and early fall period (USACE 2015 p. 2-9). In general, the distributions of monthly flow for January, June, September, October, and December are similar between the two periods (see Figures 3.3.3.A and 3.3.3.B in USFWS 2012), but median monthly flow is higher in February and March and lower in April, May, July, August, and November in the post-West Point period.

Rate of Change: Riverine rate of change is the rise and fall of river stage over time. Rapid changes in river stage may wash out or strand aquatic species (Cushman 1985, Petts 1984). By capturing high flows in storage, reservoirs typically accelerate the drop in stage compared to pre-reservoir conditions by closing spillway gates during flood recession, which may reduce germination and survival of riparian tree seedlings that colonize banks and sandbars by drying these areas out too fast (Rood et al. 1995).

2.2 Baseline Flow Regime

Because the proposed action is an operational plan that prescribes the reservoir release rules which define flow of the river, the habitat characteristic of greatest relevance to this consultation is the flow of the river, which is highly variable over time. A river's flow varies in its magnitude, seasonality, duration, frequency, and rate of change, and collectively, this variability is called its flow regime. The environmental baseline is a "snapshot" of a species health and habitat suitability within the action area (USFWS 1998b), but to capture intra- and inter-annual variability, the flow regime of the environmental baseline is necessarily a depiction of river flow that begins at an appropriate date in the past and concludes at the present. Determining effects to the species and their habitat in the baseline flow regime is an evaluation of the degree to which the natural flow regime in the action area has been altered to date by all anthropogenic factors, including past operations of the USACE's ACF projects. Determining effects of the proposed action is an evaluation of the degree to which the baseline flow regime may be further altered by operations under the WCM.

As noted in the "Description of Proposed Action" section, USGS stream gage number 02358000 at Chattahoochee, Florida, which is located 0.6 mi downstream of Woodruff Dam, is the point at which the dam releases and ramping rates under the WCM are measured. We use this gage also as the source of data for describing the historical flow regime and for estimating characteristics of the natural flow regime of the river. The continuous discharge record of this gage begins in 1922, with 1923 as the first complete calendar year of record. The flow of the Apalachicola River has been altered over time by land use changes, reservoirs, and various consumptive water uses, and in combination these alterations contribute to the environmental baseline.

The only other ACF main-channel dam that has appreciable storage capacity is Bartlett's Ferry Reservoir on the Chattahoochee River. The capacity of Bartlett's Ferry is less than 10% of Lanier's capacity, and less than 5% of the total capacity of the USACE's ACF projects. The USACE's full complement of ACF projects were not completed until October 1974, when operations of West Point Reservoir began.

In the BA, the USACE presents the observed flow regime from the post-West Point years, 1975 to 2011 (37 years), as the environmental baseline for consultation purposes. This period represents the full history of the present configuration of the USACE's ACF projects through 2011, which is the last year used in simulations of alternatives for the EIS. This approach is consistent with the approach of previous BOs for the Apalachicola River (USFWS 2008, 2012). The USACE's modeling of alternatives (see Appendix A) used hydrologic data ending in 2011, but they recognize that the environmental baseline also includes the years from 2011 to the present.

The use of observed flows since 1975 as the baseline presents a challenge for interpreting the effects of management alternatives relative to no action, because USACE's operations have changed incrementally over the post-West Point period. The earliest changes were documented in a draft WCM in 1989. Additional changes in water control operations have occurred since 1989, some of which are reflected in the current operations and in the proposed WCM. Except in very general terms, it is not possible to describe a single set of reservoir operations that apply to the entire post-West Point period. Also embedded in observed flows are changes in land use, water demands, and other factors. Recognizing the challenge of interpreting effects of proposed operations relative to observed flows, the USACE also provides simulated flows for NAA in the BA. The NAA flows are a model simulation of the current operations and levels of water demands used to manage the ACF projects since the 2012 BO projected onto the 1975-2011 period of record in the BA, and onto the 1939-2011 period of record in the EIS.

The USACE's modeling of the NAA and the proposed management changes in the BA (i.e., WCM), rests on the calculation of an unimpaired flow (UIF) data set. The following is an excerpt from the DEIS (USACE 2015, p 2-101).

> "The unimpaired flow data set is historically observed flows, adjusted for some of the human influences within the basin. Man-made changes influence water flow characteristics and are reflected in measured flow records. Determining critical yield [UIF] requires removing from the observed flow measurements any identifiable and quantifiable man-made changes, such as municipal and industrial water withdrawals and returns, agricultural water use, and increased evaporation and runoff due to the construction of federal surface water reservoirs. These quantities are used to extrapolate diversions, defined as the difference between water withdrawn and water returned to the system. A diversion is a net volume or quantity assumed to be permanently lost from the

> water system. The unimpaired flow data set is not a perfect representation of conditions that would exist without the influence of human activities or a precise measure of natural flow conditions. Not all human influences, such as land use changes, are accounted for, and many flow-set adjustments are estimates based on assumptions, not direct measurements of the human influences. The unimpaired flow data set in the updated 2014 analysis for the ACF Basin includes data for the period from 1939 through 2012."

Although observed flows are those that the action area, listed species, and designated critical habitat therein have actually experienced, we must recognize the advantages of comparing simulated flows for the NAA with simulated flows for the WCM (the proposed action) to estimate the effects of the proposed action. Such simulation to simulation comparisons of flows computed from the same model, both relying on the same UIF data set, removes the complication of determining whether changes apparent in the simulated flows for the WCM relative to the observed flows are due to operations, demands, and/or other factors that have varied over the period of record. Additionally, simulation comparisons from the same model will isolate the number of differences between the baseline and WCM since the only differences between the baseline and WCM will be the proposed operational changes. Historical flows have different consumptive demands each year and variable reservoir operations over time and other factors that have varied over the period of records; therefore, complicating the interpretation of the effects of the operational changes in the WCM. Using the NAA simulation as the environmental baseline allows more straightforward and clearer interpretation of the changes in management described in the WCM.

Another advantage of using simulated flows under the NAA as environmental baseline is the potential to use the full period of record for the UIF (1939-2012), which incorporates 74 years of the basins' hydrologic variability, including the lowest observed average annual flow year, 2012. Rather than focusing on the 1975-2011 period as in the USACE BA, we use the entire range of the unimpaired flow data set for the ACF Basin from 1939 through 2012. We use simulated flows for these 74 years under the no action alternative management scenario as the environmental baseline. Since flows in 2013 – 2015 were not as exceptional as in 2012, and we have no estimate of unimpaired flows for these years, we do not include these years in the baseline flow regime.

The major distinguishing feature of the 2012 drought was the extreme low discharge experienced in the Flint River basin (Leitman et al. 2016). Average annual discharge for the Flint River at Bainbridge, Georgia (USGS gage#0235800) was about 73.5 cms (cubic meters per second) (2,597 cubic feet per second), which is only 33% of the average annual flow 1939 to 2012 (this time period includes both observed and synthesized flows to fill in data gaps). This discharge is lower than in recent droughts, such as in 2007 when average annual discharge was about 69% of the average annual flow from 1939 to 2012. Although the USACE computed and provided the USFWS unimpaired flow data for 2012, the USACE did not rely on these data for the EIS or the BA, because they have not received consumptive water use data from Alabama and Florida necessary to finalize the data set (USACE, Mobile District, James Hathorn Jr., pers. comm. 6/6/2016). USFWS estimated Alabama and Florida water use data for 2012 instead based on 2011 data (Appendix A).

We have elected to use the 2012 unimpaired data provided by the USACE in our analyses for this BO. We believe that the lack of availability of the Alabama and Florida demands for 2012 does not negate the value of using the lowest-flow-year of record in our analyses. We base this decision on the following considerations regarding demands in those reaches of the basin that include Alabama and/or Florida:

1) the bulk of the demands in the Whitesburg reach (the northernmost reach affected by Alabama demands) are associated with Georgia water users, most notably the City of LaGrange, Georgia;
2) users in the West Point reach are in both Georgia and Alabama;
3) the bulk of the water use in the Columbus reach is by the City of Columbus, Georgia;
4) the bulk of the water use in the Woodruff reach is from agricultural users in the lower Flint Basin and in Spring Creek, both entirely in Georgia; and
5) all of the Florida demands are withdrawn downstream of Jim Woodruff Dam, and do not influence reservoir operations at Jim Woodruff Dam.

All of the withdrawals in the Flint Basin are associated with Georgia demands. The combined total demands for 2011, which were replicated for computing 2012 UIF data, are an annual average of 1,482 cfs, which is approximately 33% percent of the USACE's releases of 4,500 cfs during extreme drought conditions. Even if applying 2011 Alabama and Florida demands to the 2012 UIF computations is off by an order of magnitude, which is unlikely, this inaccuracy is not significant in our analysis, which compares the simulated flows under the WCM to NAA as the baseline. USACE provided USFWS with the 2012 HEC-ResSim data to facilitate comparison of model outputs under both the HEC-ResSim and ACF STELLA models (see details in Appendix A) for the full period of record (USACE, Mobile District, James Hathorn Jr., pers. comm. 8/30/2016). USFWS acknowledges that these 2012 HEC-ResSim data remain provisional until Alabama and Florida provide demand data. Any error in the estimated 2012 Alabama and Florida demands data is the same error in both simulations, and relative differences between the two inform our interpretation of the effects of the proposed action. Further, any error in the 2012 UIF data does not perpetuate through subsequent years of the simulation, since 2012 is the last year in the period of record.

2.3 Related Federal Actions

2.3.1 Navigation Channel Maintenance

The ACF navigation project consists of a 9- by 100-ft navigation channel along 107 miles of the Apalachicola River between the Gulf Intracoastal Waterway and Jim Woodruff Lock and Dam. From there the navigation channel extends 155 miles up the Chattahoochee River to Columbus, Georgia, and Phenix City, Alabama, and 28 miles up the Flint River to Bainbridge, Georgia. Jeanne (2002) summarized the USACE's history of activity associated with navigation on the Apalachicola River, which began with clearing obstructions to navigation in the river in 1832. The first navigation improvement project was authorized in 1873. At that time, work began on jetties and wing dams to control sand and gravel bars, snag removal, and rock blasting to widen and deepen shoals. Snags were cleared annually on the Apalachicola River to provide for a channel 100 ft wide by 6 ft deep at low water. In 1874, the USACE bypassed six miles of the main channel by widening and straightening an alternate channel through the River Styx and Moccasin Slough.

By 1881, the USACE recognized that these various attempted improvements to navigability in the basin were temporary fixes in the highly dynamic alluvial river system (Jeanne 2002). Dredged areas filled in more rapidly than anticipated, especially in channels near the mouth of the river. This “excessive silting” eliminated the town of Apalachicola from consideration as the area’s deepwater port (Jeanne 2002). Despite these difficulties, a federal navigation project on the Apalachicola has continued for over 100 years, during which several major federal reservoir projects were authorized and constructed, all of them linked in some way to the navigation project.

The navigation channel on the Apalachicola River was last dredged in 2001, but the dredge ran aground due to low flow, and the job was not completed. The last complete cycle of dredging a 100-ft by 9-ft channel occurred in 1998 (in 1999, dredging was discontinued in the middle of the dredging season due to lack of dredged material disposal capacity). In 2005, the State of Florida denied the USACE's application to renew its certification under section 401 of the Clean Water Act for maintaining the navigation channel. In July of 2006, the USACE concurred with the decision to defer dredging of the subject project in light of the permit denial. Although navigation remains an authorized purpose for the ACF system, the ability to provide a navigational channel is limited to releases from storage to provide a 7- or 9-ft channel. In the past, releases to support navigation were a principal motivation for augmenting river flow. Supporting a seasonal navigation channel with flows is a feature of the proposed WCM. At this time, the USFWS is unaware of any intentions for the USACE to resubmit an application to maintain the navigation channel with dredging.

2.3.2 Other Authorized Reservoir Purposes

In addition to navigation, the ACF federal dams and reservoirs are authorized for several other purposes, including flood control, hydropower, water supply, water quality, recreation, and fish and wildlife conservation. Hydropower generated at the ACF projects is marketed through the Southeastern Power Administration (SEPA), which has contracts with power customers. All project purposes must share the water resources within the conservation pool of the reservoirs with the exception of Flood Risk Management, which has a dedicated flood pool at West Point and Lake Lanier. Under the Water Supply Act of 1958, the USACE may enter into contracts for storage with municipal and industrial water users. There are several water supply contracts in the ACF that were intended to compensate the municipalities for the inundation of their existing intakes on the river. Other than these contracts, there are currently no water supply contracts in the ACF basin. Previous contracts were allowed to expire in 1989-1990 and have not been renewed due to ongoing litigation. The municipalities are currently withdrawing under the terms of the expired contracts under water withdrawal permits issued by the State of Georgia. No allocation of storage in the upstream reservoirs has been made in support of water supply, and no contracts from the USACE authorize water withdrawals or provide for storage in support of water supply. Water storage contracts do not authorize use of the water, *per se*, only use of the reservoir storage that could provide a source of water supply.

Each of these authorized purposes receives operational consideration, and the operational decisions stemming from such consideration affect how basin inflow is stored and released from the dams. The releases from Woodruff Dam are the downstream end result of all of these decisions, for which the action evaluated in this consultation provides the sideboards of a minimum flow and a maximum fall rate schedule relative to basin inflow and composite storage. Significant changes in any operations described above that would appreciably alter the effects analysis of this BO would require reinitiation of this consultation.

2.4 Unrelated Federal Actions

The following section describes Federal projects in the action area that have completed formal or informal consultation under section 7 of the Act. Federal actions affecting the same species or critical habitat that have completed for which formal or informal consultation has been completed represent part of the NAA environmental baseline, as are do Federal and other actions within the action area that may benefit listed species or critical habitat.

The USACE administers section 10 of the Rivers and Harbors Act and section 404 of the Clean Water Act. These permit programs regulate dredge, fill, and construction activities in waters of the United States. Construction activities regulated by the permit programs include: agricultural, municipal, rural, and industrial water intakes; residential, marina, and recreational developments; storm-water and waste-water outlet works; cable, pipeline, and transmission line crossings; bridges; piers; docks; navigational aids; platforms; sand and gravel operations; small dams for recreation and/or water supply; and bank stabilization projects. From 1992 to 2007, four new reservoirs have been constructed in the ACF under these permit programs, including Lake McIntosh (Fayette County, GA), Griffin Reservoir (Pike County, GA), Yahoola Creek Reservoir (Lumpkin County, GA), and Shoal Creek Reservoir (Clayton County, GA).

The National Pollutant Discharge Elimination System (NPDES) permit program authorized by the Clean Water Act regulates point-source discharges of pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. The USEPA oversees the NPDES program, but the States of Alabama, Florida, and Georgia have each been authorized to administer the permitting process.

All these unrelated Federal actions will be assessed by the appropriate Federal agencies to determine if consultation under the Act is required. At this point, the collective effects of these actions are relatively minor compared to the USACE operations of the reservoirs of the ACF. Nevertheless, they are part of the body of activities that affect listed species and designated critical habitat in the action area.

2.5 Contemporaneous Non-Federal Actions

Water use in the basin is regulated independently by each of the three states within their boundaries. Water use in Alabama and Georgia affects basin inflow to Woodruff Dam, which affects the USACE's operations of the federal reservoir projects. Water use in Florida, with the possible exception of water use in Jackson County along the west side of Lake Seminole, does not affect the USACE's operations, but may influence flow downstream of Woodruff Dam. As is addressed later in this document, historical and ongoing water use, including that for agricultural, industrial, and municipal uses, has a substantial impact during droughts on the availability of water for use by the USACE in their reservoir operations.

3 GULF STURGEON - STATUS OF THE SPECIES

3.1 Species Description

The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is an anadromous fish (it breeds in freshwater after migrating up rivers from marine and estuarine environments) that inhabits coastal rivers from Louisiana to Florida during the warmer months and over-wintering in estuaries, bays, and the Gulf of Mexico. It is a nearly cylindrical primitive fish covered by bony plates or scutes. The head ends in a hard, extended snout; the mouth is inferior (bottom oriented) and protrusible (capable of being extended) and is preceded by four conspicuous barbels. The caudal fin (tail) is heterocercal (upper lobe is longer than the lower lobe). Adults range from 1.2 to 2.4 m (4 to 8 ft) in length, with adult females larger than males. The Gulf sturgeon is distinguished from the geographically disjunct Atlantic coast subspecies (*A. o. oxyrinchus*) by its longer head, pectoral fins, and spleen (Vladykov 1955, Wooley 1985). King et al. (2001) documented substantial divergence between *A. o. oxyrinchus* and *A. o. desotoi* using microsatellite DNA testing.

Within the species, Gulf sturgeon exhibit river fidelity (USFWS 1995). Stabile et al. (1996) identified five regional or river-specific stocks (from west to east): (1) Lake Pontchartrain and Pearl River, (2) Pascagoula River, (3) Escambia and Yellow Rivers, (4) Choctawhatchee River, and (5) Apalachicola, Ochlockonee, and Suwannee Rivers. Dugo et al. (2004) reported that genetic structure occurs at the drainage level for the Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, and Apalachicola rivers (no samples were taken from the Suwannee population). Additional genetic studies by Brian Kreiser at the University of Southern Mississippi indicate that there is strong population structure in all rivers across its range, and a clear difference between populations east and west of Mobile Bay. Gulf sturgeon do make some inter-river movements (USFWS unpublished data), and more genetic research is needed to determine if inter-stock movement is resulting in inter-stock reproduction.

3.2 Critical Habitat Description

The USFWS and National Marine Fisheries Service (NMFS) jointly designated Gulf sturgeon critical habitat effective April 18, 2003 (68 FR 13370, March 19, 2003). Gulf sturgeon critical habitat includes areas within the major river systems defined in each unit as the ordinary high water line on each bank of the associated rivers and shorelines that support the seven currently reproducing subpopulations and associated estuarine and marine habitats. Gulf sturgeon use river habitats during spawning, larval and juvenile feeding, adult resting and staging, and moving between the areas that support these life history components. Gulf sturgeon use the lower riverine, estuarine, and marine environment during winter months primarily for feeding and for inter-river movements.

Fourteen areas (units) are designated as Gulf sturgeon critical habitat (Figure 3.1). Critical habitat units encompass approximately 2,783 km (1,729 mi) of riverine habitats and 6,042 km^2 (2,333 mi^2) of estuarine and marine habitats, and include portions of the following Gulf of Mexico rivers, tributaries, estuarine and marine areas:

Unit 1	Pearl and Bogue Chitto Rivers in Louisiana and Mississippi;
Unit 2	Pascagoula, Leaf, Bowie, Big Black Creek and Chickasawhay Rivers in Mississippi;
Unit 3	Escambia, Conecuh, and Sepulga Rivers in Alabama and Florida;
Unit 4	Yellow, Blackwater, and Shoal Rivers in Alabama and Florida;
Unit 5	Choctawhatchee and Pea Rivers in Florida and Alabama;
Unit 6	Apalachicola and Brothers Rivers in Florida;
Unit 7	Suwannee and Withlacoochee River in Florida;
Unit 8	Lake Pontchartrain (east of causeway), Lake Catherine, Little Lake, the Rigolets, Lake Borgne, Pascagoula Bay and Mississippi Sound systems in Louisiana and Mississippi, and sections of the state waters within the Gulf of Mexico;
Unit 9	Pensacola Bay system in Florida;
Unit 10	Santa Rosa Sound in Florida;
Unit 11	Nearshore Gulf of Mexico in Florida;
Unit 12	Choctawhatchee Bay system in Florida;
Unit 13	Apalachicola Bay system in Florida; and
Unit 14	Suwannee Sound in Florida.

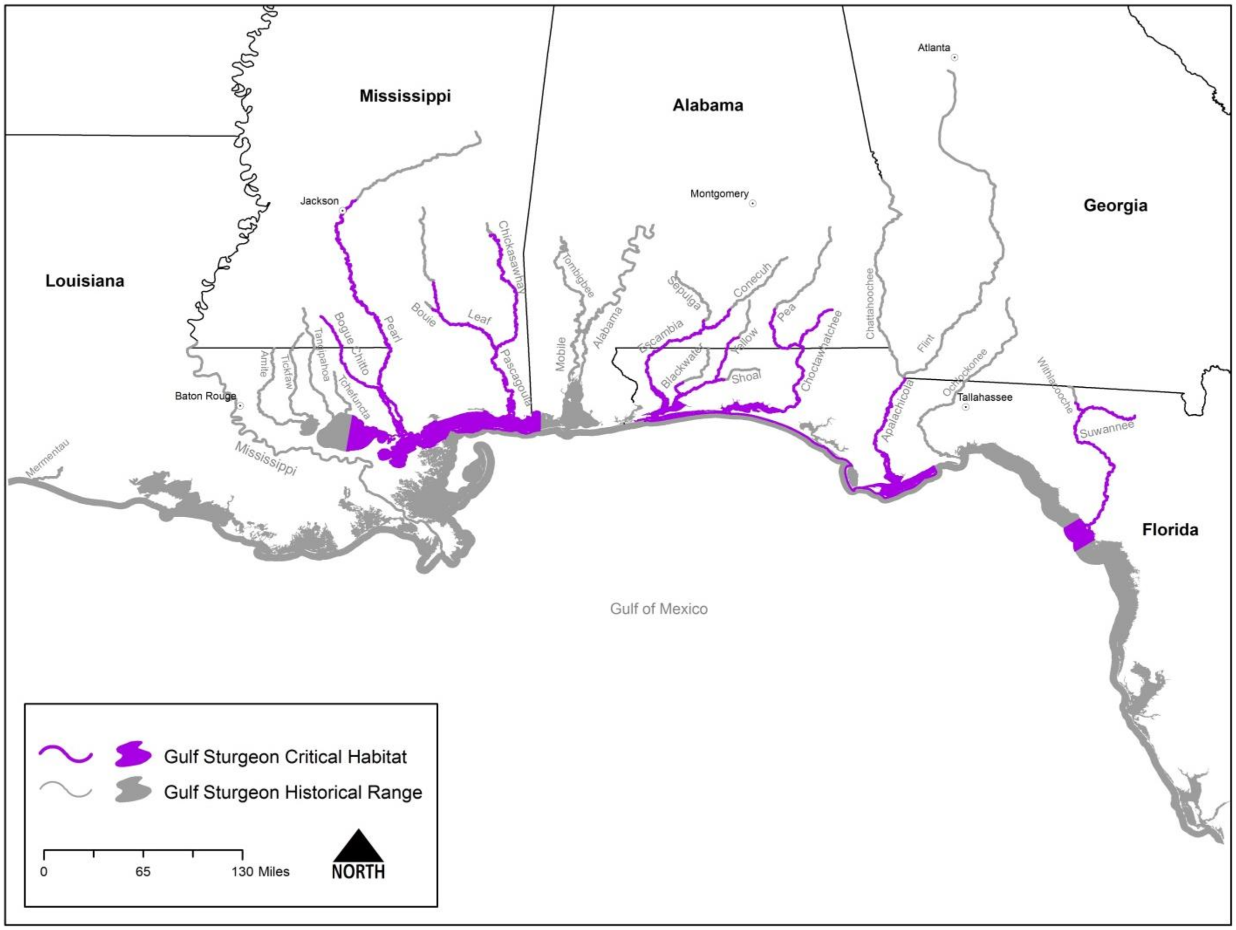


Figure 3.1. Designated critical habitat and historic range of Gulf sturgeon.

Critical habitat determinations focus on those physical and biological features (primary constituent elements [PCEs]) that are essential to the conservation of the species (50 CFR 424.12). Federal agencies must ensure that their activities are not likely to result in the destruction or adverse modification of designated critical habitats. Therefore, proposed actions that may affect designated critical habitat require an analysis of potential impacts to the PCEs. The PCEs of Gulf sturgeon critical habitat are:

- Abundant food items, such as detritus, aquatic insects, worms, and/or mollusks, within riverine habitats for larval and juvenile life stages; and abundant prey items, such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, mollusks and/or crustaceans, within estuarine and marine habitats and substrates for subadult and adult life stages;
- Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone, or hard clay;
- Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, generally, but not always, located in holes below normal

riverbed depths, believed necessary for minimizing energy expenditures during freshwater residency and possibly for osmoregulatory functions;
- A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging, and for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging;
- Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;
- Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and
- Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g., an unobstructed river or a dammed river that still allows for passage).

3.3 Life History

Lifespan: Like most sturgeons, the Gulf sturgeon is characterized by large size, longevity, delayed maturation, high fecundity, and far-ranging movements. Gulf sturgeon typically live for 20-25 years, but can reach ages of at least 42 years old (Huff 1975). Age at sexual maturity ranges from 8-12 years for females and 7-9 years for males (Huff 1975). High fecundity has been demonstrated by Chapman et al. (1993), who estimated that mature female Gulf sturgeon weighing between 29 and 51 kg (64 and 112 lb) produce an average of 400,000 eggs, although females do not spawn annually (Sulak and Clugston 1999, Pine et al. 2001). Long-range migrations from the open Gulf of Mexico to bays and estuaries to coastal rivers are also common. Migratory behavior of the Gulf sturgeon is likely influenced by sex and reproductive status (Fox et al. 2000), change in water temperature (Wooley and Crateau 1985, Chapman and Carr 1995, Foster and Clugston 1997), and increased river flow (Chapman and Carr 1995, Heise et al. 1999a, b, Sulak and Clugston 1999, Ross et al. 2000 and 2001b, Parauka et al. 2001).

Reproduction: In general, Gulf sturgeon migrate into rivers in the spring (from late February to May), where sexually mature sturgeon spawn when the river temperature rises to between 17-25°C. Similar to Atlantic sturgeon, Gulf sturgeon are believed to exhibit a long inter-spawning period, with male Gulf sturgeon capable of annual spawning, but females requiring more than one year between spawning events (Huff 1975, Fox et al. 2000) and only a small percentage of females spawn in a given year (Sulak and Clugston 1999, Pine et al. 2001). Therefore, Gulf sturgeon population viability is highly sensitive to changes in adult female mortality and abundance (Pine et al. 2001, Flowers 2008).

Spawning occurs in the upper reaches of rivers, at least 100 km (62 miles) upstream of the river mouth (Sulak et al. 2004), in habitats consisting of one or more of the following: limestone bluffs and outcroppings, cobble, limestone bedrock covered with gravel and small cobble, gravel, and sand (Marchant and Shutters 1996, Sulak and Clugston 1999, Heise et al. 1999a, Fox et al. 2000, Craft et al. 2001, Pine et al. 2006, USFWS unpublished data). These hard bottom substrates are required for egg adherence and shelter for developing larvae (Sulak and Clugston 1998). Documented spawning depths range from 1.4 to 7.9 m (4.6 to 26 ft) (Fox et al. 2000, Ross et al. 2000, Craft et al. 2001, Pine et al. 2006, USFWS unpublished data).

Some adult Gulf sturgeon may also spawn in the fall (around September), as suggested from collection of migrating ripe males and females and length-at-age data of spring juveniles, and telemetry data in the Suwannee River, Florida (Sulak and Clugston 1998, Randall and Sulak 2012). Studies in the closely related Atlantic sturgeon have also demonstrated a fall spawning run in multiple major river drainages (Collins et al. 2000, Balazik and Musick 2015, Balazik et al. 2012, Smith et al. 2015). It is likely that Gulf sturgeon populations, throughout the range, or at least portions of some river strains, may spawn in the fall.

Eggs and larvae: Gulf sturgeon eggs are demersal (sink to or near the river bed) and adhesive, and require at least 2 to 4 days to hatch (Parauka et al. 1991, Chapman et al. 1993). After hatching, larval Gulf sturgeon are particularly sensitive to water temperatures above 25°C (Chapman and Carr 1995). Young-of-year fish disperse widely throughout the river and remain in freshwater for 10 to 12 months after spawning occurs (Sulak and Clugston 1999). They are typically found in open sand-bottom habitat away from the shoreline and vegetated habitat.

Holding areas: Throughout early spring to late autumn, Gulf sturgeon of all ages remain in freshwater until fall (6 to 9 months) (Odenkirk 1989, Foster 1993, Clugston et al. 1995, Fox et al. 2000, Sulak et al. 2009). They typically occupy discrete areas either near the spawning grounds (Wooley and Crateau 1985, Ross et al. 2001b) or downstream areas referred to as holding areas. These holding areas vary in depth, ranging from 2 to 19 m (6.6 to 62.3 ft) deep (Wooley and Crateau 1985, Morrow et al. 1996, Ross et al. 2001a, b, Craft et al. 2001, Hightower et al. 2002), and frequently near (not in) natural springs (Clugston et al. 1995, Foster and Clugston 1997, Hightower et al. 2002). The substrates consist of mixtures of limestone and sand (Clugston et al. 1995), sand and gravel (Wooley and Crateau 1985, Morrow et al. 1996), or just sandy substrate (Hightower et al. 2002).

Migration: Non-young of year begin to migrate downstream from fresh to saltwater around September (at about 23°C [73°F]) through November (Huff 1975, Wooley and Crateau 1985, Foster and Clugston 1997), and they spend the cool months in estuarine areas, bays, or in the Gulf of Mexico (Odenkirk 1989, Foster 1993, Clugston et al. 1995, Fox et al. 2002). During the fall migration, Gulf sturgeon may require a period of physiological acclimation to changing salinity levels, referred to as osmoregulation or staging (Wooley and Crateau 1985). This period may be short (Fox et al. 2002) as sturgeon develop an active mechanism for osmoregulation and ionic balance by age 1 (Altinok et al. 1998).

Feeding: With the exception of young of year fish, Gulf sturgeon do not typically feed during freshwater residency (Mason and Clugston 1993; Gu et al. 2001). Sulak et al. (2012) reported that the vast majority (~94%) of juvenile, subadult, and adult Gulf sturgeon sampled from the Suwannee River exhibited complete feeding cessation for the 8-9 month summer residency; however, a small percentage (~6%) of juveniles and subadults did feed in freshwater.

Throughout fall and winter, juveniles feed in the lower salinity areas in the river mouth and estuary (Sulak and Clugston 1999, Sulak et al. 2009), while subadults and adults migrate and feed in the estuaries and nearshore Gulf of Mexico habitat (Foster 1993, Foster and Clugston 1997, Edwards et al. 2003, Edwards et al. 2007, Parkyn et al. 2007). Some Gulf sturgeon may also forage in the open Gulf of Mexico (Edwards et al. 2003).

The Gulf sturgeon is a benthic (bottom dwelling) suction feeder; it feeds mostly upon small invertebrates in the substrate using its highly protrusible tubular mouth. The type of invertebrates ingested varies by habitat but are mostly soft-bodied animals that occur in sandy substrates. Young-of-the-year Gulf sturgeon feed on freshwater aquatic invertebrates, mostly insect larvae and detritus (Mason and Clugston 1993, Sulak and Clugston 1999, Sulak et al. 2009). Juveniles (less than 5 kg (11 lbs), ages 1 to 6 years) forage in lower salinity habitats near the river mouth and in the estuaries, and subadults and adults feed in the estuary and nearshore feeding grounds in the Gulf of Mexico (Foster 1993, Foster and Clugston 1997, Edwards et al. 2003, Edwards et al. 2007, Parkyn et al. 2007). Prey in estuarine and marine habitats include amphipods, brachiopods, lancelets, polychaetes, gastropod mollusks, shrimp, isopods, bivalve mollusks, and crustaceans (Huff 1975, Mason and Clugston 1993, Carr et al. 1996, Fox et al. 2000, Fox et al. 2002). Ghost shrimp (*Lepidophthalmus louisianensis*) and haustoriid amphipods (e.g., Lepidactylus spp.) are strongly suspected to be important prey for adult Gulf sturgeon over 1 m (3.3 ft) in length (Heard et al. 2000, Fox et al. 2002).

Marine movement, habitat, and feeding data indicate that Gulf sturgeon prefer open, sandy habitat containing high abundances of known benthic prey (Fox et al. 2002, Parauka et al. 2001, Harris et al. 2005). In bays and estuaries, Gulf sturgeon generally prefer shallow areas (depths less than 3.5 m, 11.5 ft) (Parauka et al. 2001, Craft et al. 2001) or deep holes near passes (Craft et al. 2001). Gulf sturgeon using nearshore Gulf of Mexico areas are generally found at depths less than 6-10 m (33 ft) (Ross et al. 2001a, Fox et al. 2002, Rogillio et al. 2002). Generally, fish are found in nearshore areas off Perdido Bay and between Pensacola and Apalachicola bays (Fox et al. 2002, USFWS unpublished data) and in the Mississippi Sound along the barrier islands, where they are relocated most often at the passes between islands (Ross et al. 2001a, Rogillio et al. 2002). Telemetry-tagged Gulf sturgeon from different natal river systems are regularly detected in the same marine foraging areas.

3.4 Population Status

Historically, the Gulf sturgeon occurred from the Mississippi River east to Tampa Bay (Figure 3.1). Its present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Sporadic occurrences have been recorded as far west as the Rio Grande River between Texas and Mexico, and as far east and south as Florida Bay (Wooley and Crateau 1985, Reynolds 1993).

In the late 19th century and early 20th century, the Gulf sturgeon supported an important commercial fishery, providing eggs for caviar, flesh for smoked fish, and swim bladders for isinglass, which is a gelatin used in food products and glues (Huff 1975, Carr 1983). Gulf sturgeon numbers declined due to overfishing throughout most of the 20th century. The decline was exacerbated by habitat loss associated with the construction of dams and sills (low dams), mostly after 1950. In several rivers throughout the species' range, dams and sills have severely restricted sturgeon access to historic migration routes and spawning areas (Wooley and Crateau 1985, McDowall 1988).

On September 30, 1991, the USFWS and the National Marine Fisheries Service (NMFS) listed the Gulf sturgeon as threatened under the Act (56 FR 49653). Threats and potential threats identified in the listing rule included: construction of dams, modifications to habitat associated with dredging, dredged material disposal, de-snagging (removal of trees and their roots) and other navigation maintenance activities; incidental take by commercial fishermen; poor water quality associated with contamination by pesticides, heavy metals, and industrial contaminants; aquaculture and incidental or accidental introductions; and the Gulf sturgeon's long maturation and limited ability to recolonize areas from which it is extirpated.

The USFWS and NMFS conducted a 5 year status review in 2009 concluding that the following threats continue to affect Gulf sturgeon and its habitat: impacts to habitats by dams, dredging, point and nonpoint discharges, climate change, bycatch, red tide, and collisions with boats (USFWS and NMFS 2009). Additional threats may include ship strikes and potential hybridization due to accidental release of non-native sturgeon. These threats persist to varying degrees in different portions of the species range. The juvenile stage of Gulf sturgeon life history is the least understood, and perhaps the most vulnerable as this cohort remains in the river for the first years of its life and is therefore exposed to most of the threats faced by the species and its habitat. Further, the species long-lived, late-maturing, intermittent spawning characteristics make recovery a slow process.

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. There is little interchange of individuals across rivers, so it is important to maintain populations within each of the rivers. Table 3.1 lists these rivers and most-recent estimates of population size. Abundance numbers indicate a roughly stable or slightly increasing population trend over the last decade in the eastern river systems (Florida), with a much stronger increasing trend in the Suwannee River and a possible decline in the Escambia River. Populations in the western portion of the range (Mississippi and Louisiana) have never been nearly as abundant in recent history, and their current status is unknown because comprehensive surveys have not occurred in the past ten years.

At this time, the USFWS characterizes the overall status of the species, and the status of the Apalachicola River system population, as "stable", although the status of populations in the Pearl and Pascagoula rivers is uncertain. We do not have current population estimates for these two rivers that have recently been threatened by flooding and riparian alteration from the effects of hurricanes, the Deepwater Horizon oil spill, and a recent pot-liquor spill in the Pearl River. The Gulf sturgeon continues to meet the definition of a threatened species. While some riverine populations number in the thousands, abundance of most populations is estimated in the hundreds. Loss of a single year class could be catastrophic to some riverine populations with low abundance. Data are not yet available to determine if Gulf sturgeon recovery is currently most limited by factors affecting recruitment (e.g., spawning habitat quantity or quality), adult survival (e.g., incidental catch in fisheries directed at other species), or the late-maturing, intermittent reproductive characteristics of the species.

Table 3.1. Estimated size of known reproducing subpopulations of Gulf sturgeon.

River	Year of data collection	Abundance Estimate*	Lower Bound 95% CI	Upper Bound 95% CI	Source
Pearl	2001	430	323	605	Rogillio et al. 2001
Pascagoula	2000	216	124	429	Ross et al. 2001
Escambia**	2015	373	241	576	USFWS unpublished data
Yellow	2011	1,036	724	1,348	USFWS unpublished data
Blackwater***	2013	437	362	550	USFWS unpublished data
Choctawhatchee	2008	3,314	NR	NR	USFWS 2009
Apalachicola	2014	1,288	1,081	1,606	USFWS unpublished data
Suwannee	2012	7,228	5,375	9,771	Randall 2013

*CI = confidence interval. NR = not reported.
**This estimate includes only fish >90 cm fork length.
***The Blackwater River is not one of the seven known reproducing subpopulations. It is considered part of the Yellow River spawning population.

3.5 Analysis of the Species/Critical Habitat Likely to be Affected - Gulf sturgeon

This BO addresses effects of the USACE's water management operations under the WCM and the associated releases to the Apalachicola River on the Gulf sturgeon and its designated critical habitat. These listed species are found in the Apalachicola River and distributaries downstream of Woodruff Dam, which is the downstream-most federal reservoir within the ACF system.

The Apalachicola River and Apalachicola Bay are designated as critical habitat for the Gulf sturgeon. Of the 14 designated critical habitat units, the Apalachicola River is identified as Unit 6, and Apalachicola Bay is Unit 13 (68 FR 13370, March 19, 2003). Unit 6 includes the Apalachicola and Brothers Rivers in Florida. Unit 13 includes the main body of Apalachicola Bay and its adjacent sounds, bays, and the nearshore waters of the Gulf of Mexico. Therefore, we limit this analysis of effects on Gulf sturgeon critical habitat to Unit 6, and those portions of Unit 13 affected by operation of Woodruff Dam under the WCM.

4 GULF STURGEON - ENVIRONMENTAL BASELINE

The environmental baseline is a "snapshot" of a species' health at a specified point in time. It does not include the effects of the action under review in the consultation. In the case of an ongoing water project, such as USACE's update to the WCM, the total effects of all past activities, including the effects of its construction and past operation, current non-federal activities, and federal projects with completed section 7 consultations, forms the environmental baseline (USFWS 1998b). Within the action area, various federal, state, and private actions affect the ACF basin ecosystem and the listed species considered in this opinion. Section 2 and Appendix A of this opinion have a detailed description of the effects of past and ongoing human and natural factors representing the physical baseline of the action area including hydrology, land use, river morphology, and water quality. This section describes current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area and is intended to set the stage for the analysis of the effects of the action.

4.1 Status of the Species within the Action Area

This portion of the environmental baseline section focuses on each listed species, describing what we know about its spatial distribution, population status, and trends within the action area.

Current Distribution in the Action Area

Our knowledge of the status and distribution of Gulf sturgeon in the action area is continually updated with regular population monitoring and increased efforts in mark-recapture, passive acoustic monitoring, and side scan sonar since the original IOP BO in 2006 on flow management from Jim Woodruff Dam and subsequent consultations on revisions to the interim operating procedures (USFWS 2006, 2008, 2012).

Population Status and Trends in the Action Area

Total ACF Population

- 2014 data - 1,288 (95% CI = 1,081to 1,606; includes all Age 1+ fish, does not include young-of-the-year)
- Population considered stable – no downward/upward population trends will be considered in baseline
- Population abundance considered below recovery objectives; population considered to be small relative to historic abundance

Total Spawning Adults

- Males can spawn every year
- Females require more than one year between spawning events
- Small percentage of females spawn in a given year

Eggs

- Number of eggs not identified in baseline

- Female produces average of 400,000 eggs

Young-of-the-year

- Unknown numbers produced in recent cohorts; methods to reliably estimate YOY abundance not available at this time

Juveniles

- Juveniles represent Age 1 to 6
- Year class abundance has been estimated at Age 1 for the past 4 years (2013-2016); cohort abundance ranges from ~50-200 fish per year

4.2 Factors Affecting Species Environment within the Action Area

Gulf sturgeon spawning: The life cycle of the Gulf sturgeon begins at spawning. Gulf sturgeon deposit adhesive eggs onto hard bottom substrates such as limestone, claystone, cobble, and gravel primarily during spring (Sulak and Clugston 1999). Recent work has provided some evidence of possible spawning during the fall in the Suwannee River (Randall and Sulak 2012). Studies conducted 2006-2008 identified nine discrete areas of hard bottom substrate in the upper Apalachicola River; spawning was confirmed at 3 of these locations by collecting sturgeon eggs (Flowers et al. 2009, Parauka and Giorgianni 2002, Pine et al. 2006, Scollan and Parauka 2008, Wooley et al. 1982, 1985, Ziewitz 2006; Table 4.1).

Table 4.1 Known spawning sites and areas of hard bottom substrate appropriate for spawning.

	Site	RM
1*	Woodruff Tailrace – Race Shoals*	104.7 -106.3
2	Jackson County Port	103.5
3*	Flat Creek / I-10	100.2 – 100.3
4*	Aspalaga Landing	99.0 – 99.2
5	Short Creek	95.2
6	Ocheesee	93.48 – 93.5
7	Rock Bluff Landing	92.2 – 92.7
8	Alum Bluff	83.7 – 84.5
9	Bristol Bluff	80.3 – 81.2

* known spawning sites

Post-spawning early life stages- egg incubation to larval dispersal and foraging: Gulf sturgeon have been observed to spawn in the Apalachicola within a range of temperatures of 17 to 25 C (USFWS 2008); spawning in the Suwannee River has been observed between 17 and 23 C (Sulak and Clugston 1999). Using water temperature data from the Chattahoochee gage, analyzed and presented in USFWS (2008), the mean date by which water temperature rises to 17 C in the Apalachicola River is March 26 (range: January 23 to April 14) and to 25 C is May 23 (range: May 12 to June 29) (Figure 4.1). Based on the average dates, Gulf sturgeon egg deposition potentially encompasses this 58-day period. The USACE in their BA developed a HEC-5Q model to analyze WCM effects to water temperature. Figure 2.5 provides a representation of WCM annual effects to stream temperature in spring and fall. There is anecdotal evidence of a fall spawning run in the Apalachicola River (USFWS unpublished data). The temperatures experienced by sturgeon during the fall spawning season (Sept.-Nov.) are near lethal limits during the fall. Additional data on temperature fluctuations are needed to assess this possible effect.

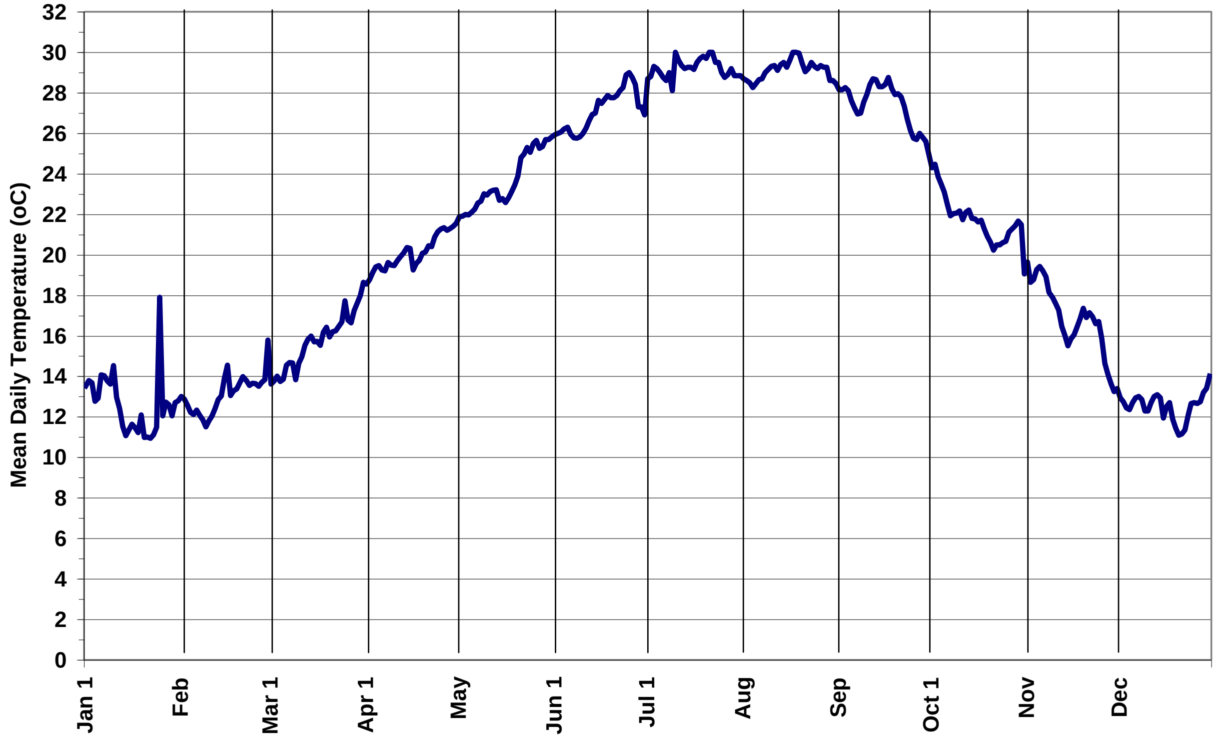


Figure 4.1 Mean daily water temperature (°C) by calendar date of the Apalachicola River near Chattahoochee, FL, calculated from available records 1974-1978 and 1996-1997 (source: USGS).

After deposition, Gulf sturgeon eggs hatch following an incubation period of a few days. Development of sturgeon eggs and embryos is likely to be most influenced by water temperature (Hardy and Litvak 2003), an association common to fish (Chambers and Leggett 1987). Hatching time for artificially spawned Gulf sturgeon eggs ranged from 85.5 hr at 18.4 C to 54.4 hr at 23.0 C (Parauka et al. 1991) and 3.5 d at 20.0 C (Chapman et al. 1993). Chapman and Carr (1995) reported high mortality of Gulf sturgeon eggs (28% hatched) and embryos (those that hatched subsequently died) at an incubation temperature of 25 C. In contrast, eggs incubated at a temperature of 20 C exhibited a hatching success of 48.5%, and eggs incubated at 15 C had a hatching success of 73% (Chapman and Carr 1995). Gulf sturgeon were observed by Scollan and Parauka (2008) to spawn in the Apalachicola River as late as May 14 (2008) at a median daily temperature of 24.22 C. These authors reported the greatest number of eggs collected on egg pads on April 18, 2008 (107 eggs) at a mean water temperature of 19-20 C; within 7 days mean water temperature at the spawning sites had reached 23 C. Pine et al. (2006) reported temperatures ranging from 20.27 to 25.31 C on days when sturgeon eggs were collected in the Apalachicola River. The successful hatching of eggs deposited during warmer water periods in the Apalachicola River is unknown, but questionable, based on laboratory evidence. Along these lines, Sulak and Clugston (1999) suggested that years of protracted, cooler conditions during the spawning period may result strong year classes of sturgeon.

Upon hatching, Gulf sturgeon embryos likely remain on the bottom in the substrate and develop into exogenously feeding larvae after 110.3 Cumulative Temperature Units (CTUs) (Parker and Kynard 2004). According to this relationship, embryos would develop into larvae in 5 days if reared at a mean daily temperature of 22 C. Parker and Kynard (2004) reported hyperactivity, cessation of feeding activity, equilibrium loss, and even some mortality of day 70-80 juvenile sturgeon when temperature increased from 21 to 23 C over a 5-hour period in the laboratory, thus the sensitivity of young sturgeon to elevated water temperatures may extend well past the larval stage.

Considering spawning observations and laboratory results, stream temperature may be critically important to sturgeon survival during the period of egg deposition, incubation and hatching, and early rearing of larval Gulf sturgeon within the upper reaches of the Apalachicola River. The importance of stream temperature to early life history stages requires an evaluation of the realized effects of water control operations on stream temperature in the zone of spawning and rearing habitat. Data on seasonal stream temperature in the Apalachicola River are limited. In order to evaluate stream temperature effects on early life stages of Gulf sturgeon we need to establish a long-term water quality monitoring program in the upper Apalachicola River.

In the amended BA, USACE provided results of water temperature simulations (see Figure 2.5 above). Although this analysis showed no difference between the WCM and baseline in terms of simulated water temperatures below Jim Woodruff Lock and Dam, the resolution of the analysis (i.e., scaled to the entire river basin), and lack of empirical, fine-scale (temporal and spatial) data feeding the analysis, suggests this assessment was inadequate to evaluate potential effects of the WCM on Gulf sturgeon within the spawning and rearing reaches of the upper Apalachicola River. The simulation results do illustrate, however, the anticipated warming of ambient water temperature that occurs as the Chattahoochee River transitions into Lake Seminole and through Woodruff Lock and Dam, between river miles ~120 to 106 (Figure 2.5). Water temperatures are likely elevated as a result of increased solar radiation acting upon the surface of the reservoir, and the change in retention time (i.e., a significant decrease in rate of streamflow through the reservoir and to the outlet at the dam). The simulation results suggest an increase in median water temperature of ~2 degrees C occurring at the Jim Woodruff Dam outlet. This warm water is subsequently released by USACE operations during the spawning and rearing period of Gulf sturgeon; the release of water with elevated temperatures is likely to affect the survival of early life stages of Gulf sturgeon, potentially resulting in a mismatch in spawning cues, egg/larval development, and/or prey availability. This warming is most prevalent in the fall, and a fall spawning run has not been documented in the ACF Basin.

The survival of Gulf sturgeon eggs and embryos at spawning sites is likely influenced by the quality and availability of heterogeneous, rocky substrates that provide adequate interstitial spaces (i.e., crevices) for hiding from predators and shelter from high flows (Crossman and Hildebrand 2014). Gulf sturgeon develop into larvae within ~8 days following egg deposition, although this rate is influenced by ambient water temperature. Importantly, sturgeon eggs and embryos remain in the substrate at the spawning site for this entire period of development (Sulak and Clugston 1999, Kynard and Parker 2004). Much of the documented spawning habitat utilized by Gulf sturgeon in the upper Apalachicola can be characterized as scoured, limestone outcroppings. Many of these outcropping were subject to historical dredging efforts for purposes of maintaining a navigation channel, an activity that may have reduced the quality and availability of heterogeneous rocky matrices for the successful development of sturgeon eggs and embryos. Unfortunately, access to a myriad of rocky patches that include gravel, cobble, and boulder substrates upstream in the Flint River (Kaeser et al. 2013) is currently blocked by Jim Woodruff Lock and Dam.

Enhancement of spawning substrate via the addition of various rocky materials (e.g., gravel, cobble, boulder) has been shown to increase the retention and growth of sturgeon embryos (McAdam 2010, Crossman and Hildebrand 2014), and provide benefits to all life history stages (Dumont et al. 2011, Roseman et al. 2011). Flows alterations during egg incubation and embryonic development may influence the retention and survival of early life stages of Gulf sturgeon, particularly in sub-optimal benthic habitats. The consequences of flow alteration (e.g., hydropeaking) during these life history phases is unknown in the upper Apalachicola River.

Upon developing into larvae, Gulf sturgeon were observed to begin slowly moving downstream, with no early peak in migration intensity as observed in other sturgeon species (Kynard and Parker 2004). These authors also observed that larval sturgeon suspended above the bottom of the artificial stream channel, exhibiting what they described as “the strongest response for this behavior we have seen in any sturgeon population”. They further suggested that this behavior may be an adaptation for feeding upon drifting invertebrates in the water column during the early stages of downstream migration; this adaptation may be a response to limited benthic forage in rearing reaches occupied by Gulf sturgeon larvae. Since larval Gulf sturgeon cannot migrate upstream past Jim Woodruff Dam, they must obtain adequate nutrition by consuming organisms in the drift or along the river bottom. Given the behavior of larval sturgeon during early exogenous foraging and dispersal, this life history stage may be particularly vulnerable to the effects of flow alteration (e.g., hydropeaking). Flow alteration may manifest in impacts to 1) the availability of habitat for invertebrate prey, 2) the timing, density, and ability to capture drifting invertebrate prey, and 3) a disruption and/or mechanical displacement of larval sturgeon in the downstream direction as they attempt to disperse from spawning areas. To date, little data are available to evaluate the effects of environmental conditions on the foraging success, survival, and dispersal of larval Gulf sturgeon in a field setting.

Gulf sturgeon larvae from the first day of dispersal are good swimmers and their downstream movement is directed swimming (Boyd Kynard, BK-Riverfish LLC, pers. comm. 8/19/16). They actively swim downstream alternating moving to the bottom to forage for several minutes with swimming downstream in the water column within a meter of so of the bottom. All evidence from shortnose sturgeon (which we have studied larval behavior for several generations) is that the duration of dispersal (number of days) is genetically set, so fish in different populations , same species, will disperse for 5-7 days, or 12-17 days, etc. (e.g., Richmond and Kynard 1995, Kynard and Horgan 2002). Natural selection likely selects for dispersal time, but like many genetic behaviors, one can reasonably hypothesize that river flow in the form of velocity detected by larvae can affect dispersal time (and thus, dispersal distance). Without a feedback mechanism from river flow (i.e., velocity), larvae might move too far downstream in high flows, enter saline water, and die. No data are available on the ability of larvae of any sturgeon species to detect and alter dispersal rate in response to flow or velocity.

Despite the lack of information on early life stages in the Apalachicola River system, the effects of flow alteration and regulation on aquatic organisms, including early life stages of other species, has been the focus of much research and discussion in the literature. Aquatic invertebrates, and habitat for these organisms, are sensitive to both long-term and short-term/episodic changes in river hydrology (Bunn and Arthington 2002, Graf 2006, Dewson et al. 2007, Bruno et al. 2010, Bruno et al. 2013, Castro et al. 2013, Bruno et al. 2016, Poff and Schmidt 2016). A study of invertebrate communities in rivers affected by dams and associated hydropeaking operations with velocity changes from ~700-7,000 cfs found that such systems are often characterized by a simplified invertebrate community (Kennedy et al. 2016). Changes in the density and abundance of certain clades of invertebrates were associated with hydropeaking operations and the effect of these operations on cycles of inundation and drying of river margin habitat (Kennedy et al. 2016). Additional effects of hydropeaking operations include coarsening of the river bed substrate, and a reduction in the supply of fine sediments and particulate organic matter to downstream areas; these effects reduce the amount of stable, fine sediment habitat inhabited by infaunal invertebrates such as oligochaetes and chironomids, and reduce the supply of organic matter that forms the base of the food web for these organisms (Merritt and Cummins 1996). The effects of hydropeaking on larval sturgeon food resources, and the subsequent effects on the growth and survival of larval Gulf sturgeon has not been examined; these are critical data gaps for Gulf sturgeon.

The dispersal of larval Gulf sturgeon within an artificial stream environment was described by Kynard and Parker (2004). These authors observed that larval Gulf sturgeon begin downstream movements after completing the free embryo stage. Some larvae moved slowly downstream for months, whereas others discontinued downstream dispersal. Movements were directed as larvae migrated head first downstream rather than drifting passively. Kynard and Parker (2004) suggested that this dispersal behavior is likely to result in the occurrence of larval and juvenile sturgeon throughout the river system; this conceptual model is supported by field observations of YOY sturgeon in natal rivers.

While making directed movements downstream, larval sturgeon may be affected by unexpected and sharp increases in discharge associated with hydropeaking operations. Hydropeaking was observed to influence the movement of juvenile White sturgeon in a field setting (Geist et al. 2005), and the probability of pallid sturgeon occurrence was lower with variability in diel flow patterns, such as when hydropeaking was present (Hamel et al. 2014). The magnitude and consequences of these effects in the Apalachicola River system has not been investigated, however the relationship between discharge and/or flow regulation and embryonic or larval sturgeon dispersal and recruitment success, and juvenile sturgeon habitat use has been discussed or examined for other sturgeon species (Kynard 1997, Beamesderfer and Farr 1997, Duke et al. 1999, Braaten et al. 2008, Hamel et al. 2014), and for other imperiled or native fishes and their habitat (Poff et al. 1997, Humphries and Lake 2000, Freeman et al. 2001, Schiemer et al. 2001, Bowen et al. 2003, Schiemer et al. 2003, King et al. 2005, Schludermann et al. 2012). Generally, sturgeon show both behavioral, physiological and population level effects to hydropeaking with velocity changes as low as 308 cfs (Aeur 1996). These effects are similar to the results in other fish and invertebrate species (Table 4.2), but responses to velocity changes as low as 176 cfs have been documented in wild populations (Leibig 1999).

Gulf sturgeon are likely to experience high mortality during their first year of life. Gross et al. (2002) highlighted the high potential for increasing population growth rate of sturgeons by focusing on improving survival of the YOY age class. These authors discussed the relevance of habitat improvements that increase survival of YOY and other juvenile age classes for improving overall population growth. Habitat improvements may include recommendations that alter the current flow management guidelines in a way that improves the overall survival of YOY Gulf sturgeon. Research is currently directed toward improving our knowledge of juvenile Gulf sturgeon in the Apalachicola River system, yet our understanding of effects prior to reaching Age 1 remains limited. Thus far, the year class abundance of Age 1 sturgeon observed during the second summer of life (~12-16 month old fish) is low relative to some Atlantic sturgeon populations that have been similarly monitored (Marbury 2016), indicating that the population may be experiencing one or more bottlenecks during early life phases.

Table 4.2 Summary of hydropeaking (A) and flow alteration effects (B) on sturgeon and other aquatic organisms.

A

Common name	Scientific name	Type of study	Location	Description of species effect	Citation
			Sturgeons		
White sturgeon	*Acipenser transmontanus*	Field, analysis of flow juvenile response	Snake River, Idaho	behavior and physiologial, distances moved similar at all flows; oxygen use doubled	Geist et al. 2005
Pallid sturgeon	*Scaphirhynchus albus*	Field sampling and model, adult presence	lower Platte and Loup River, Nebraska	occurrence was always lower when variability in diel flow patterns was high (i.e. hydropeaking)	Hamel et al. 2014
Lake sturgeon	*Acipenser fulvenscens*	Field, adult sampling	Sturgeon River, Michigan	management with run of river flows resulted in less time at spawning sites, 74% increase in abundance, and 68% increase in number of females	Auer 1996
			Other fishes and their habitat		
Native fish and benthic invertebrates		Field, fish and aquatic invertebrate sampling	several Austrian rivers	Biomass - reduction in benthic invertebrate biomass of between 75 and 95% was observed within the first few kilometres of river length; reduction of between 40 and 60% of biomass compared with undisturbed areas could be detected within the following 20–40 km; reduction of the fish fauna is within the same order of magnitude and correlates well with the amplitude of the flow fluctuations	Moog 1993
Brown trout	*Salmo trutta*	Field, fish sampling	River Oriege, France	reduced densities of juveniles and changed habitat use up to 700 m below dam	Liebig 1999
Native fishes		Field, response of young of year native fishes to flow regulation for hydropower	Tallapoosa River, Alabama	abundances were negatively correlated with 1-h maximum flow in summer (five species). all correlations >-0.9	Freeman et al. 2001
Zoobenthic community		Field, aquatic invertebrate sampling	Noce Bianco stream, Trentino, Italy	Abundance and species composition - As a mean value, total density decreased by 13 times downstream; loss of adult of all species; loss of 4 species entirely	Maiolini et al. 2007
Atlantic salmon	*Salmo salar*	Synthesis	Newfoundland, Canada	flow changes are energetically costly potentially affecting over-winter survival which is related to energy reserves obtained during summer	Scruton et al. 2008
Rainbow trout	*Oncorhynchus mykiss*	Field, fish sampling and Lab, otolith analysis	Colorado River, Arizona	behavioral and growth -catch rates of age-0 rainbow trout in nearshore areas were at least two- to fourfold higher at the daily minimum flow than at the daily maximum; atypical increments in otoliths were 25% wider than the adjacent increments and were indicative of significant short-term increases in otolith growth that corresponded to a reduction in the extent of hourly flow fluctuations on Sundays during the growing season	Korman and Campana 2009
Rainbow trout	*Oncorhynchus mykiss*	Field, telemetry and modeling	American River, California	behavioral and physiological - fish swimming speed estimates increased during the increasing flow stage, while the associated mean oxygen consumption rates also increased at this stage;	Cocherell et al. 2011

A (cont.)

Common name	Scientific name	Type of study	Location	Description of species effect	Citation
River fishes		Review and meta-analysis		behavioral - positive effect of river discharge on non-migratory movements; fishes made larger and (or) more frequent movements during periods of elevated discharge. Furthermore, non-salmonids were more affected by river flow than salmonids.	Taylor and Cooke 2012
Brown trout and rainbow trout	*Salmo trutta, Oncorhynchus mykiss*	Field, fish sampling and modeling	29 rivers in western US	recruitment was negatively correlated with high water velocity and daily fluctuations in flow 37 (i.e., hydropeaking)	Dibble et al. 2015
Aquatic Insects		Review, synthesis; Experiment and model	western US	dessication of eggs due to peaking waves; aquatic insect diversity was strongly and negatively related to the degree of hydropeaking across the 16 rivers	Kennedy et al. 2016

B

Common name	Scientific name	Type of study	Location	Type of effect	Description of flow change	Description of species effect	Citation
				Sturgeons			
Shovelnose and pallid sturgeon	*Scaphirhynchus platorynchus* and *S. albus*	Field experiments and model, larval drift	Missouri River, Montana	Habitat, flow	experimental water velocity in side channels	drift rate and distance depended on velocity	Braaten et al. 2012
Shortnosed sturgeon	*Acipenser brevirostrum*	Review, status review	Eastern US	Habitat, flow	High discharge during spawning season	Reduced spawning behavior	Kynard 1997
All North American species		Review, metaanalysis and expert elicitation	North America	Habitat, flow	Restore hydrograph	2nd ranked action by experts to restore sturgeon habitat	Beamesderfer and Farr 1997
White sturgeon	*Acipenser transmontanus*	Review, recovery planning	Kootenay River Basin	Habitat, flow	multi-day pulse of water	reduced survival due to reduced cover and food resources	Duke et al. 1999
				Other fishes and their habitat			
Large river fish and aquatic organisms		Review and synthesis		Habitat, flow	Rapid changes in river stage, Increased variation in magnitude and frequency	Wash-out and stranding of aquatic species	Poff et al. 1997
Large river fishes		Field, analysis of flow regime and fish community	Murray-Darling Basin, Australia	Habitat, diversion of flows for irrigation	Summer diversion of flows	loss of species from basin; loss of larval fish presence and reduced abundance due to change in daily flow patterns	Humphries and Lake 2000
Large river fish and aquatic organisms		Field, analysis of physiographic conditions within the inshore zone	Austrian Danube	Habitat, structural properties and retention of the inshore zone	Changing water levels will lead to wash-out effects, causing high mortality and a unidirectional, downstream shift of the fish fry population	reduced productivity of riverine zooplankton, larval fish-growth, and the downstream export and population loss of 0+ fish due to drift and wash-out effects.	Schiemer et al. 2001
Large river fishes		Field, habitat mapping	Yellowstone River and Missouri River	Habitat, availability of shallow habitat patches with slow current velocity (SSCV)	Regulation of flow in rivers results in reduced SSCV	Indirect; reduced food resources and reduction in survival of age 0 fish	Bowen et al. 2003
Nase carp	*Chondrostoma nasus*	Review	River Danube, Austria	Habitat, flow	current velocity in the inshore microhabitats swimming costs and an increased risk of wash-out effects.	key factor for growth and survival of the larvae of riverine fish related to higher food availability for drift feeding larvae vs. increased	Schiemer et al. 2003

B (cont.)

Common name	Scientific name	Type of study	Location	Type of effect	Description of flow change	Description of species effect	Citation
Large river fishes		Field, egg and larval fish sampling in regulated rivers	Murray and Goulburn Rivers, Australia	Habitat, diversion of flows for irrigation	Regulation of flow in rivers results in loss of recruitment	no eggs or larvae sampled in Golden Perch and Silver Perch	King et al. 2005
Nase carp	*Chondrostoma nasus*	Field experiment and model, analyzed the influence of the hydraulic conditions on larval dispersal	River Danube, Austria	Habitat, flow	differences in the temporal drift pattern were due to significant differences in the hydrodynamic characteristics of the release location	behavioral, dispersal and drift influenced by hydraulics	Schludermann et al. 2012

In this section, we have outlined several areas of inquiry associated with environmental conditions at or near the spawning sites, and YOY survival. Beyond impacts related to temperature during spawning, incubation, and embryonic development, and the availability of drifting and benthic forage for larval sturgeon, the potential effects of flow on other key processes like larval dispersal into suitable habitats, the provision of fine particulate organic matter for invertebrate nutrition, and other key water quality parameters like dissolved oxygen warrant future investigation. In addition, the suitability of interstitial substrate habitat that provides cover for eggs and embryos from predators and protects against flow displacement, and the potential effects of predator concentration at the few, regularly utilized spawning sites also deserves investigation. Given that spawning areas in the fragmented ACF were altered by in-channel dredging and rock removal, the potential to enhance these habitats should be investigated, with a restoration goal of providing ample substrate with suitable cover for early life stages in mind.

Juvenile sturgeon riverine foraging: Juvenile Gulf sturgeon appear to distribute widely throughout the entire mainstem river channel during the period following hatching based upon behavior observed in laboratory studies (Parker and Kynard 2004) and empirical observations of young-of-year sturgeon in river systems (Sulak and Clugston 1998, 1999). Exhaustive surveys using a variety of gear types have resulted in few captures of young of year sturgeon; these juveniles are usually captured individually (i.e., their distribution is not aggregated). In addition, Gulf sturgeon have not been reported in off-channel, inundated areas of the floodplain (Light et al. 1998). While young of year sturgeon are distributed throughout the main channel, likely seeking benthic prey, we would potentially find juvenile sturgeon in areas where stable organic matter accumulations provide the habitat to support invertebrate communities. Under this conceptual model, we suspect that our comparisons of floodplain inundation during the Winter-Spring period, and during the late growing season, may be used to assess the role that stream regulation under the WCM plays in recruiting organic matter to the main channel, and recruiting additional nutrients and phytoplankton to the main channel thereby stimulating or enhancing the production of benthic invertebrate prey in main channel habitats.

Juvenile sturgeon estuarine foraging - abiotic and biotic conditions: Access to high-quality benthic foraging habitat in the upper estuary, particularly during the first year of life, may affect the growth, survival, and resulting Age-1 year class strength of Gulf sturgeon (Sulak et al. 2007). Ability to access foraging habitat is thought to be influenced by the abiotic conditions of the upper estuary environment during the winter period. Importantly, very young juvenile (i.e., 55-

day old) Gulf sturgeon have a lower tolerance for saline conditions than sub-adult or adult sturgeon (Foster et al. 1994). Kynard and Parker (1994) observed 100% mortality of 72 day old juvenile sturgeon when exposed to 10 ppt salinity. Age 1+ juvenile sturgeon are believed to accompany sub-adults and adult sturgeon during the migration from riverine habitats to the upper estuary between late fall to early winter (Sulak and Clugston 1998). Unlike older juveniles, Sulak and Clugston (1998) found that young of year (9-10 month old) Gulf sturgeon relocated to the river mouth/estuary environment in late winter (late January-February). Thus abiotic conditions (i.e., lower salinity in foraging areas) during late winter may be vitally important to the growth and survival of young of year juvenile sturgeon during their first winter of life.

In a laboratory study of 4-month old juvenile Gulf sturgeon (~8 cm long), Altinok and Grizzle (2001) observed that growth and energy absorption efficiency was highest at both 3 and 9 parts per thousand (ppt) salinity. In a separate laboratory study, Altinok et al. (1998) observed that juvenile sturgeon (Age 13 months) were capable of slowly acclimating to higher salinity; the ability to adapt to saltwater appeared to be related to body size, with larger fish adapting more easily. Therefore, juvenile sturgeon may grow best during winter foraging in lower salinity environments. In turn, the growth of a juvenile sturgeon, and its overall body size (not age) when it first encounters a more saline environment, may affect its tolerance and ability to forage into more saline portions of the upper estuary, or under conditions of more rapidly fluctuating salinity levels.

It remains unclear whether juvenile sturgeon will choose to venture into higher salinity environments after a period of acclimation, or whether foraging will be primarily carried out in areas that offer salinity less than some threshold (e.g., 10 ppt). Age ≤2 juveniles likely do not venture into higher salinity environments, and some very limited observations based on telemetry of 3 juvenile sturgeon in Apalachicola Bay indicated that fish remained close to the river and distributary mouths, and within East Bay (typically a lower salinity area of the upper estuary) during the winter of 2006-2007 (Sulak et al. 2009). The average daily flow for November 2006 through March 2007 was about 16,200 cfs, compared with an average for the period of record (1922 – 2012) of 26,400 cfs. Discharge during winter 2006-2007 was typically below median values, with peak flows of only ~33,000 cfs observed at the Sumatra gage (USGS gage 02359170). USFWS has scheduled research for the winter 2016-2017 and 2017-2018 to better understand these relationships.

Low salinity in the benthic environment may simply provide access to foraging habitat in the upper estuary. Once there, juvenile sturgeon must find and consume benthic prey to meet their nutritional needs for growth and survival. The standing crop of invertebrate prey, or sturgeon food items, is likely to be influenced by estuarine conditions occurring prior to the winter foraging period.

Studies of the invertebrate fauna in Apalachicola Bay reported highest invertebrate biomass in regions of the upper estuary, associated with muddy sediments and lower salinities (USFWS 2008, see also Sulak et al. 2009). Benthic organisms near the river mouth/upper estuary setting of the Apalachicola River system (i.e., secondary producers) appear to rely on both allochthonous input of detritus from the river, and on *in-situ* phytoplankton production within the estuary (Livingston et al. 1997). The timing of inputs of organic matter and nutrients to the estuary is relatively important. High flows during winter-spring sequesters allochthonous detritus from the floodplain and delivers this organic material to the estuary at a time when high turbidity limits *in-situ* primary productivity. Freshwater input in late summer and early fall delivers nutrients to the upper estuary to stimulate autochthonous, phytoplankton production (Chanton and Lewis 2002).

Freshwater delivery of nutrients to the estuary during the period of high estuarine primary productivity (i.e., summer-early fall), in concert with the effects on salinity regime and trophic food-webs, may control the production of sturgeon prey resources through a “bottom-up” pathway in concert with predator/prey interactions. Nutrients are converted to primary production (phytoplankton), which stimulates secondary production of invertebrates (Livingston et al. 1997) that are prey to juvenile Gulf sturgeon including: infaunal polychaete worms, amphipods, isopods, bivalve mollusks, lancelets, shrimp, and gastropods.

The relationship between freshwater input to Apalachicola Bay, and the trophic organization and density and biomass of prey items like infaunal macroinvertebrates is complex. In a long term study of trophic organization in East Bay (one area suspected to be foraging habitat for juvenile Gulf sturgeon), Livingston (1997) and Livingston et al. (1997) documented a substantial increase in the biomass and proportional representation of infaunal macroinvertebrate herbivores (i.e., sturgeon prey) at 1 to 1.5 years into a drought cycle. The authors attributed this increase to bottom-up processes mediated by increased light penetration and stimulation of primary production resulting from reduced freshwater inflow. At a lag time of about 2 years into the drought phase, herbivore biomass plummeted; the authors postulated that nutrient limitation ultimately occurred following prolonged decrease in freshwater nutrient delivery. These effects highlight the complexity of trophic dynamics in the estuary that may play a role in the availability of food for juvenile Gulf sturgeon. The effects of drought may actually increase the food available to juvenile fish, provided that lower salinities occur at some point during the winter to permit access. In other river systems, the lagged effects of prolonged drought, as nutrient limitations affect the trophic organization of the estuary, may manifest in years following the drought, perhaps depending on the duration, frequency, timing, and magnitude of freshwater delivery to the estuary following the cessation of the drought (e.g., Schemel et al. 2004, Valett et al. 2005, Wrona et al. 2007).

Riverine aggregation areas and trophic dormancy during summer: In late spring through early fall (May-October), Gulf sturgeon aggregate in discrete reaches of river systems during a prolonged period of trophic dormancy (i.e., they do not feed). Many reports indicate that adult and subadult Gulf sturgeon lose a substantial percentage of their body weight while in freshwater (Wooley and Crateau 1985, Mason and Clugston 1993, Clugston et al. 1995) and then compensate the loss during winter-feeding in the estuarine and marine environments (Wooley and Crateau 1985, Clugston et al. 1995). Gu et al. (2001) tested the hypothesis that subadult and adult Gulf sturgeon do not feed significantly during their annual residence in freshwater by comparing stable carbon isotope ratios of tissue samples from subadult and adult Suwannee River Gulf sturgeon with their potential freshwater and marine food sources. A large difference in isotope ratios between freshwater food sources and fish muscle tissue suggests that subadult and adult Gulf sturgeon do not feed significantly in freshwater. The isotope similarity between Gulf sturgeon and marine food resources strongly indicates that this species relies almost entirely on the marine food web for its growth (Gu et al. 2001).

In summer, aggregation areas are important as thermal refugia for Gulf sturgeon and likely affect bioenergetics, fitness, and survival (Foster 1993, Foster and Clugston 1997, Hightower et al. 2002). During the summer period, sub-adult and adult sturgeon do not actively feed and progressively lose body mass, thus this is a period of trophic dormancy and energy conservation for Gulf sturgeon. Several interrelated features appear to be associated with aggregation area selection including (but not limited to) channel slope, water depth, velocity, and temperature. Summer aggregation areas are variably occupied by sturgeon within season and across years; movement between areas is common and has been extensively documented. Aggregations of sturgeon can number in the tens to hundreds of fish. In the Apalachicola River system, these so-called holding or resting areas have been identified in a variety of ways including fishing, observation of jumping sturgeon, sonic telemetry, and side scan sonar surveys. There are approximately 12 discrete reaches where Gulf sturgeon are known to aggregate in the Apalachicola system; 4 of these areas are located in the Brothers River, a tributary (Table 4.3).

Table 4.3 Known riverine aggregation sites in the Apalachicola River and tributaries.

	Site Name	RM
1	Lower Brothers River	1-2
2	Bearman Creek (Brothers R.)	3-4
3	Houseboats (Brothers R.)	5-6
4	Lillypads (Brothers R.)	8.5-9.5
5	Powerlines (Brothers R.)	11.5-13.5
6	Owl Creek to Brushy Creek	24-26
7	Bluff	94-95
8	Ocheesee Landing	96
9	Jackson Blue Spring	100
10	Below Interstate 10	101
11	Gulf Power Plant	105
12	Jim Woodruff Lock and Dam	108

The preference and selection of discrete holding areas may involve multiple variables and scales, with trade-offs among interrelated factors (affecting bioenergetics, fitness, and survival) such as water depth, 3D current velocity profiles, water temperature, dissolved oxygen, water chemistry and clarity, ease of access, longitudinal position in the river system, site history (e.g., recent fishing activity), learned behavior, and in-situ group behavioral dynamics. Through telemetry and behavioral observations, species experts surmise that sturgeon know exactly how to locate the holding areas; in many cases sturgeon that have been captured and relocated will immediately return to the exact point of capture following their release.

An investigation of the multivariate factors associated with holding area habitat selection across the range of Gulf sturgeon has yet to be conducted. In addition, the influence of river flows and regulation on the suitability of holding area habitat is largely unknown at this time. Resting habitat use does vary within season and across years, presumably in response to fluctuating environmental conditions.

Outmigration to marine environments and winter foraging: In response to declining water temperature and/or increased discharge, Gulf sturgeon sub-adults and adults emigrate from freshwater coastal rivers in late September through November to overwinter and feed in estuarine areas, bays, and the Gulf of Mexico (Sulak and Clugston 1999). There are currently no known physical impediments to outmigration from the Apalachicola River system, although the role of freshwater delivery to the estuary during the fall outmigration period when sturgeon must acclimate to higher salinity conditions has not been investigated.

Inmigration to riverine environments and spawning runs: Most adult and sub-adult sturgeon return to freshwater river systems from March through May. Adult Gulf sturgeon spawn in the upper reaches of rivers, at least 100 km (62 miles) upstream of the river mouth (Sulak et al. 2004), when water temperature rises to between about 17-25 °C. Gulf sturgeon eggs are demersal (they are heavy and sink to the bottom), adhesive, and vary in color from gray to brown to black (Huff 1975, Parauka et al. 1991). Chapman et al. (1993) estimated that mature female Gulf sturgeon weighing between 29 and 51 kg (64 and 112 lb) produce an average of 400,000 eggs.

River flow may serve as an environmental cue that governs both sturgeon migration and spawning (Chapman and Carr 1995, Ross et al. 2001b). If the flow rate is too high, sturgeon in several life-history stages can be adversely affected. Data describing the sturgeon's swimming ability in the Suwannee River strongly indicates that they cannot continually swim against prevailing currents of greater than 1 to 2 m per second (3.2 to 6.6 ft per second) (Wakeford 2001). If the flow is too strong, eggs might not be able to settle on and adhere to suitable substrate (Wooley and Crateau 1985). Flows that are too low can cause clumping of eggs, which leads to increased mortality from asphyxiation and fungal infection (Wooley and Crateau 1985). Flow velocity requirements for YOY sturgeon may vary depending on substrate type. Chan et al. (1997) found that YOY Gulf sturgeon under laboratory conditions exposed to water velocities over 12 cm/s (0.4 ft/s) preferred a cobble substrate, but favored water velocities under 12 cm/s (0.4 ft/s), and then used a variety of substrates (sand, gravel, and cobble).

5 GULF STURGEON - EFFECTS OF THE ACTION

This section is an analysis of the effects of the WCM on the species and its critical habitat. In most consultations, the USFWS typically evaluates a project that has not been constructed or implemented. In this consultation, the USFWS is evaluating the effects of adoption of a new system of operation of already constructed facilities that is an ongoing refinement of existing protocols. The previous "Environmental Baseline" section described the effects of all past activities, including the effects of past construction and operation of the USACE ACF projects, current non-federal activities, and federal projects with completed section 7 consultations. For purposes of this section the analysis of charts will compare the effects of operation under the proposed WCM to the baseline.

5.1 Factors to be Considered

The USFWS has applied concepts from Jacobsen et al. (2015), which developed a conceptual ecological model for pallid sturgeon. The model identified the unique life stages for the pallid sturgeon and identified factors that would affect the ability to of individuals to transition from one life stage to the next. For example, a reduction of spawning habitat may limit pallid sturgeon egg laying.

The environmental baseline was used to identify the critical life stages for Gulf sturgeon. The USFWS then reviewed the BA and available scientific literature to itemize the potential effects of the WCM that could limit the ability of an individual Gulf sturgeon to transition to the subsequent life stage. The following summarizes the relationship between Gulf sturgeon life stages and potential effects of the WCM that we assess in section 5.2.

Spawning Adult to Egg

- Potential increase/decrease in eggs deposited due to WCM increase/decrease of spawning habitat
- Duration of potential effect - March 1 through May 31

Egg to Young of Year

- Egg hatching is generally not limited by flow quantity where spawning habitat is deep (except extreme reduction in flows that lead to stranding and desiccation of nests with eggs or larvae in shallower spawning habitat). Hatching success evaluated for hydropeaking.
- Potential change egg hatch rates due to change in stream temperatures in the Apalachicola River
- Duration of potential effect - March 1 through May 31

Young of Year to Juvenile (Age 1 to Age 6)

- Potential beneficial/adverse effects to body condition and/or WCM effects to food production in the Apalachicola River
    - Duration of potential effect - Majority of the year except early summer (June-July)
- Potential beneficial/adverse effects to body condition and/or mortality from WCM effects to low salinity, estuarine habitat
    - Duration of potential effect - January 1 through March 15
- Potential beneficial/adverse effects in body condition and/or mortality due to WCM hydropeaking-related forage limitations in the Apalachicola River
- Potential change in mortality rates due to WCM effects to stream temperatures in the Apalachicola River

Juvenile to Non-Reproductive Adult

- Potential beneficial/adverse effects to body condition and/or mortality from WCM effects to invertebrate food production in the Apalachicola River
    - Duration of potential effect - Majority of the year except June 2 through July 14
- Potential beneficial/adverse effects to body condition and/or mortality from WCM effects to low salinity, estuarine habitat
    - Duration of potential effect - November 1 through March 15

Non-Reproductive Adult to Spawning Adult

- Potential beneficial/adverse effects to body condition and/or mortality from WCM effects to low salinity, estuarine habitat
- Potential beneficial/adverse effects to body condition and/or mortality from WCM effects to invertebrate food production in the estuary as delivered via the Apalachicola River
- Potential beneficial/adverse effects to reproductive potential due to WCM effects to invertebrate food production in the estuary as delivered via the Apalachicola River

5.2 Analysis for Effects of the Action

We describe our analytical approach using the STELLA and ResSim models and the general changes to the flow regime due to the action in detail in Appendix A. In general, we used both models to look for greatest negative effect on Gulf sturgeon and its critical habitat. The following section evaluates the effects of the WCM to Gulf sturgeon hydroecological metrics (Table 5.1).

Table 5.1 Summary of the hydroecological metrics and the effect of the WCM on Gulf sturgeon.

Metric ID	Hydroecological Metric Title	Species Ecology	Interpretation	WCM effect
GS 1	Floodplain Inundation and Organic Matter Supply (Total Days) - Nov 24-Jun 1	Estuarine Invertebrate Production	more days of inundation beneficial	negative
GS 2	Floodplain Inundation and Organic Matter Supply (Total Acre-days) - Nov 24-Jun 1	Estuarine Invertebrate Production	more acre-days of inundation beneficial	no effect
GS 3	Floodplain Inundation and Nutrient Supply (Total Days) - July 15 - Nov 24	Estuarine Invertebrate Production	more days of inundation beneficial	no effect
GS 4	Floodplain Inundation and Nutrient Supply (Total Acre-days) - July 15 - Nov 24	Estuarine Invertebrate Production	more acre-days of inundation beneficial	negative
GS 5	Floodplain Inundation and Nutrient Supply (Total Pulses) - July 15 - Nov 24	Estuarine Invertebrate Production	more inundation pulses beneficial	slight negative

GS 6	Low Salinity for all Juvenile Access to Foraging Habitat (Total Days) - Nov 1-Mar 15	Habitat Suitability	more days of flows >threshold beneficial	positive/ no effect
GS 7	Low Salinity for YOY Access to Foraging Habitat (Total Days) - Jan 1-Mar 15	Habitat Suitability	more days of flows >threshold beneficial	positive/ no effect
GS 8	Low Salinity for all Juvenile Access to Foraging Habitat (Max Consecutive Days) - Nov 1-Mar 15	Habitat Suitability	fewer consecutive days < threshold beneficial	positive/ no effect
GS 9	Spawning Habitat Inundation (ac)	Spawning Habitat Availability & Quality	flows with greater depths better for spawning	no effect
GS Q1	Hydropeaking at Woodruff	Spawning Habitat Availability & Quality	more stability in daily flows better for survival, recruitment, growth	negative
GS Q2	Temperature changes downstream of Woodruff	Spawning Habitat Availability & Quality	temps below lethal limits good	negative

We assessed floodplain inundation for organic matter supply estuarine invertebrate production during the winter and spring months (GS2), floodplain inundation for organic matter supply estuarine invertebrate production during the summer and fall months (GS 3), and flows to maintain adequate depth over spawning substrate for reproduction during the spawning season (GS9). However, we found no differences or slight positive effects of the WCM compared to baseline, and we do not discuss them further. We also assessed effects on habitat suitability by providing low salinity environment in the bay for juvenile access to foraging habitat in the winter months (GS6-GS8). We found little effect to a slightly beneficial effect in these metrics, and holding flows for navigation may have an ancillary beneficial effect by providing a lower salinity environment in the bay for juvenile sturgeon (GS6-GS8). We do not discuss these effects further. We discuss analyses of estuarine invertebrate production (GS1, GS4, GS5) and spawning habitat availability and quality (GSQ1, GSQ2) below.

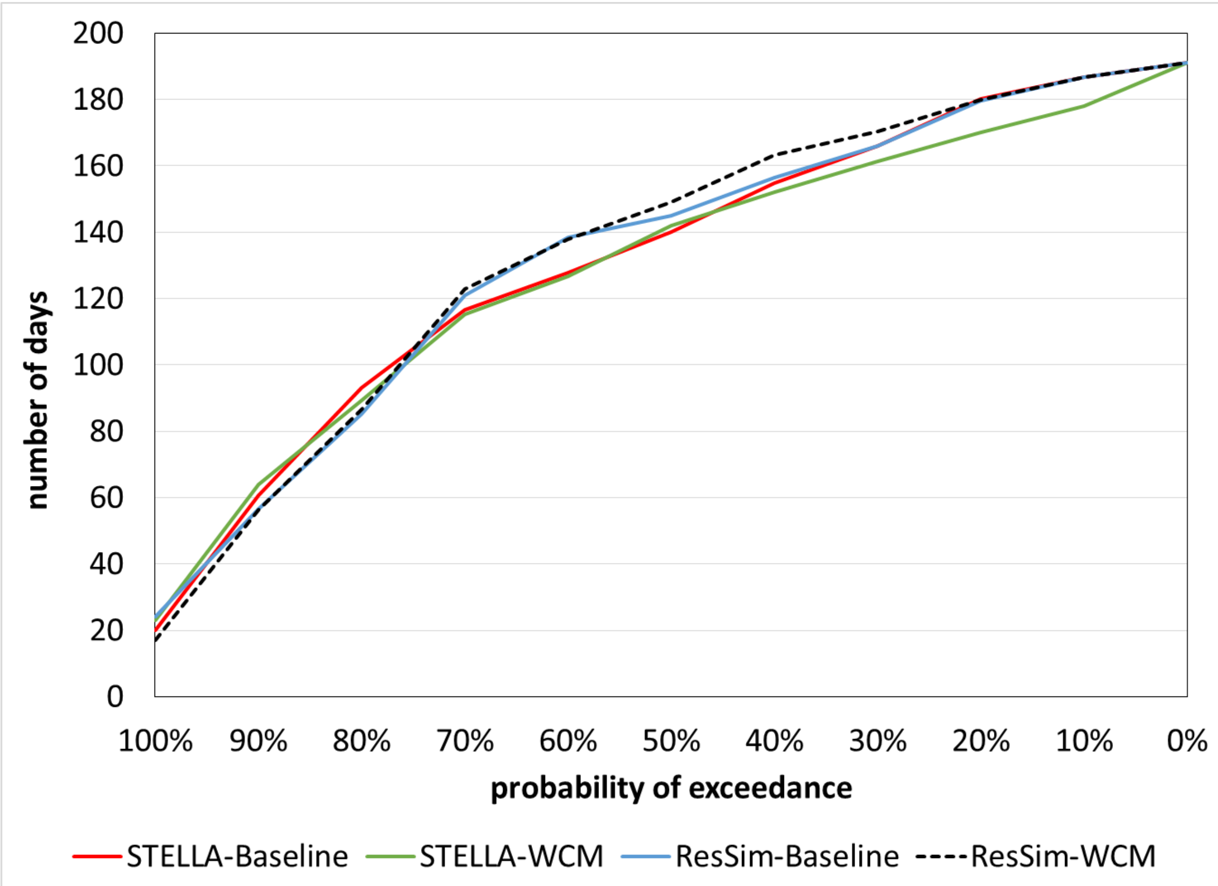
5.2.1 Flows for Estuarine Invertebrate Production

Gulf Sturgeon Hydroecological Metric 1 (GS 1) - General Floodplain Forest Inundation and Organic Matter Supply (Total Days)

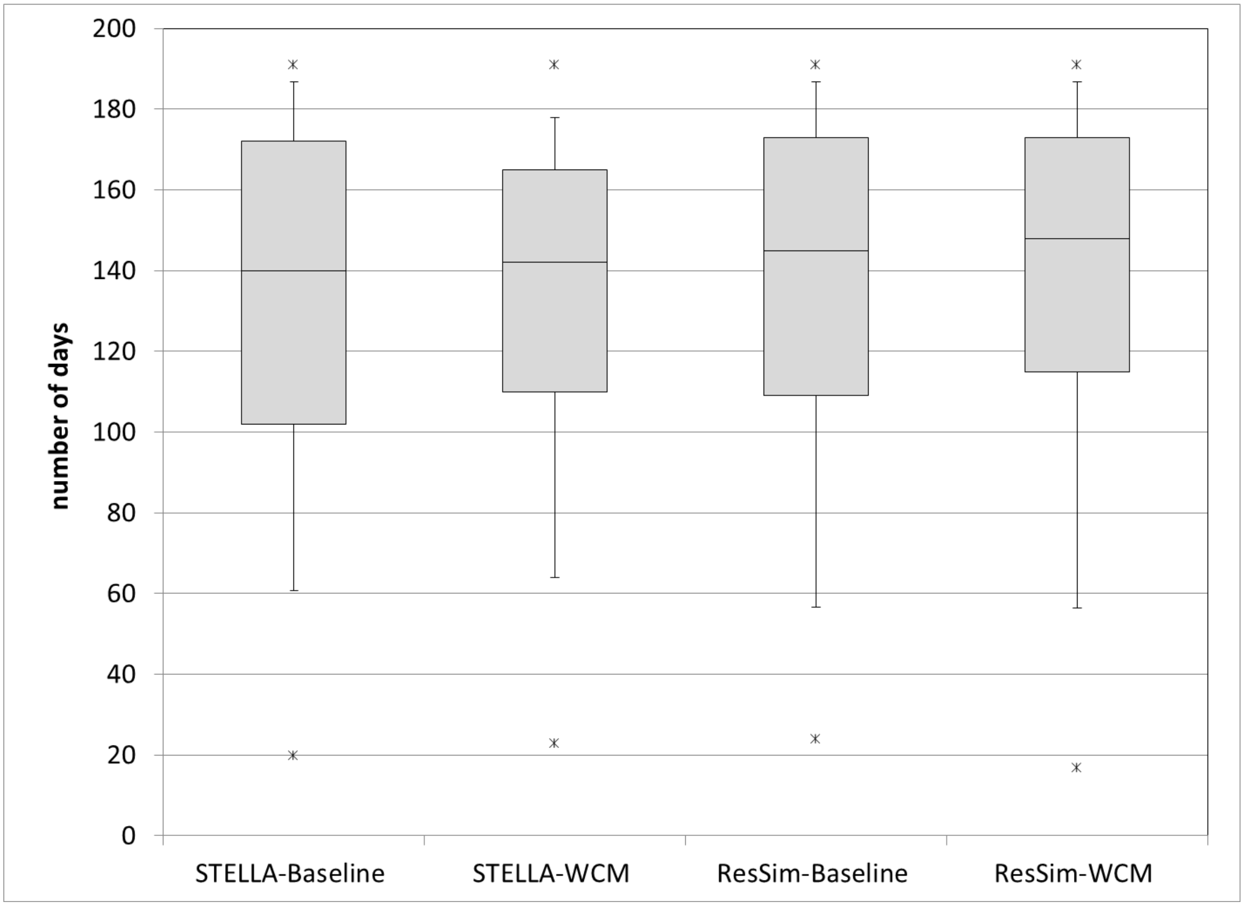
Description of Metric: We are concerned that changes in the supply of organic material from the Apalachicola River floodplain could reduce prey base for Gulf Sturgeon foraging in the estuary. To evaluate the potential effects of the proposed action on the supply of organic material to the upper estuary we determined the total number of days between November 24 and June 1 (per annual cycle) when discharge at Chattahoochee, FL was ≥16,200 cfs. At 16,200 cfs, approximately 10% of the available floodplain is inundated (Light et al. 1998). November 24 represents the median date of the first freeze observed at Quincy, FL (Light et al. 1998), considered here to be the first day of the dormant season. Episodes of floodplain inundation between November 24 and June 1 were assumed to sequester detrital organic material that had accumulated on the forest floor during the dormant season.

Our analysis emphasized the importance of floodplain inundation to the entrainment of organic material and export of this material to the estuary; organic matter supply to the estuary supports growth and production of infaunal and epifaunal invertebrates (i.e., sturgeon food). We focused on the duration, or total amount of time the floodplain is inundated. We considered that more days of floodplain inundation would deliver greater quantities of organic matter to the estuary, thereby supporting the production of a larger standing crop of benthic invertebrates. Thus, a greater total number of days of floodplain inundation was considered a benefit to Gulf sturgeon; fewer days of floodplain inundation was considered an adverse effect.

Results: The total number of days of Apalachicola River floodplain inundation (Woodruff discharge ≥16,200 cfs) between November 24 and June 1 is presented as a probability of exceedance plot (Figure 5.1A). The ResSim model showed no difference between the baseline and WCM, but the STELLA model showed an overall decrease of 176 days (of 14,060 across 74 years) and an average decrease from 133.4 days under the baseline to 131.0 days under the WCM. According to this model, we observed very little discernable difference in the number of days of inundation between the WCM and baseline management plans during years characterized by fewer days of floodplain inundation (i.e., range of 50-100% exceedance probability). During years of greater floodplain inundation, we observed a reduction in the total number of days of inundation under the WCM relative to the baseline. A maximum difference of approximately 7 days of floodplain inundation was observed between the WCM and baseline; this difference occurred within the 10-20% probability of exceedance range. The box plots provided in Figure 5.1B further illustrate the reduction in total number of days of inundation during wet years; the upper 75th and 90th percentiles represent fewer days of inundation under the WCM plan versus the baseline.


200
180
160
140
120
100
80
60
40
20
0
number of days
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
probability of exceedance
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

A



B

Figure 5.1 Total days inundated for all flows ≥16,200 cfs during the period of November 24 to June 1.

Interpretation: Operation under the WCM reduced the total number of days of floodplain inundation, especially during years with higher inundations (i.e., wetter years). The WCM caused a 1% reduction (avg. 2.4 days or 12.1 days over 5 years) of floodplain inundation. Fewer days of floodplain inundation may result in a reduction of organic matter supply to the estuary needed to support the production of benthic invertebrates consumed by juvenile Gulf sturgeon during winter foraging.

Gulf Sturgeon Hydroecological Metric 4 (GS 4) - General Floodplain Forest Inundation and Nutrient Supply (Cumulative Acre-days)

Description of Metric: We estimated the cumulative amount of floodplain acres inundated between July 15 and November 24, per year when discharge at Chattahoochee, FL was ≥16,200 cfs, in order to evaluate the potential effects of the proposed action on the supply of nutrients to the upper estuary. To calculate the quantity of acres inundated on a daily basis we used the relationship between discharge at Chattahoochee, FL and floodplain acres inundated as determined by Light et al. (1998). We estimated the cumulative number of acres inundated during each day between July 15 to November 24. The result is expressed in terms of cumulative acre-days. At discharges of 16,200 cfs from Woodruff, approximately 10% of the available floodplain is inundated (Light et al. 1998; Figure 2.7). We selected July 15 to represent a mid-summer date that coincided with both the end date for our Mussel Recruitment Metric, and a beginning date for the late growing season period. November 24 represents the median date of the first freeze observed at Quincy, FL (Light et al. 1998), considered here to be the last day of the late growing season. Episodes of floodplain inundation between July 15 and November 24 were assumed to sequester nutrients from the floodplain and deliver these nutrients downstream to the estuary.

Floodplain inundation is important to the entrainment of nutrients and export of nutrients to the estuary; nutrient supply to the estuary during the late growing season supports growth and production of infaunal and epifaunal invertebrates (i.e., sturgeon food). Designed to complement metric GS-3, we focused our analysis on the magnitude of floodplain inundation in terms of total acres inundated. Greater areas of floodplain inundation deliver greater quantities of nutrients to the estuary, thereby supporting the production of a larger standing crop of benthic invertebrates. Thus, we considered a greater cumulative total of floodplain acres inundated as a beneficial effect on the Gulf sturgeon; fewer acres of inundated floodplain was considered an adverse effect.

Results: The total number of acre-days of floodplain inundation at ≥16,200 cfs between July 15 and November 24 occurring under the two management alternatives is presented as a probability of exceedance plot in Figure 5.2. Overall, the WCM reduced ac-days of floodplain inundation under both the ResSim and STELLA models (1,398,900 of app. 781 mil or 0.13%, ResSim; 691,412 of app. 781 mil or 0.11%, STELLA). Based on the ResSim model, 654,284 ac-days/yr on average are inundated and this represented an average reduction of 18,904 ac-days/yr. During years characterized by lower (>83% exceedance) as well as average to higher (<61%) seasonal flows, operation under the WCM provided on average 23,093 ac-days (4.7%) less floodplain inundation than the baseline, but this reduction ranged up to 98,781 ac-days or 20%. Most importantly, in the years with already low floodplain inundation (>83% exceedance), the WCM reduced inundation by 6.3%. In summary, we would expect an approximately 92,125 ac-day reduction during the WCM in 5 years, and this is expected to be an adverse effect to Gulf sturgeon food production.

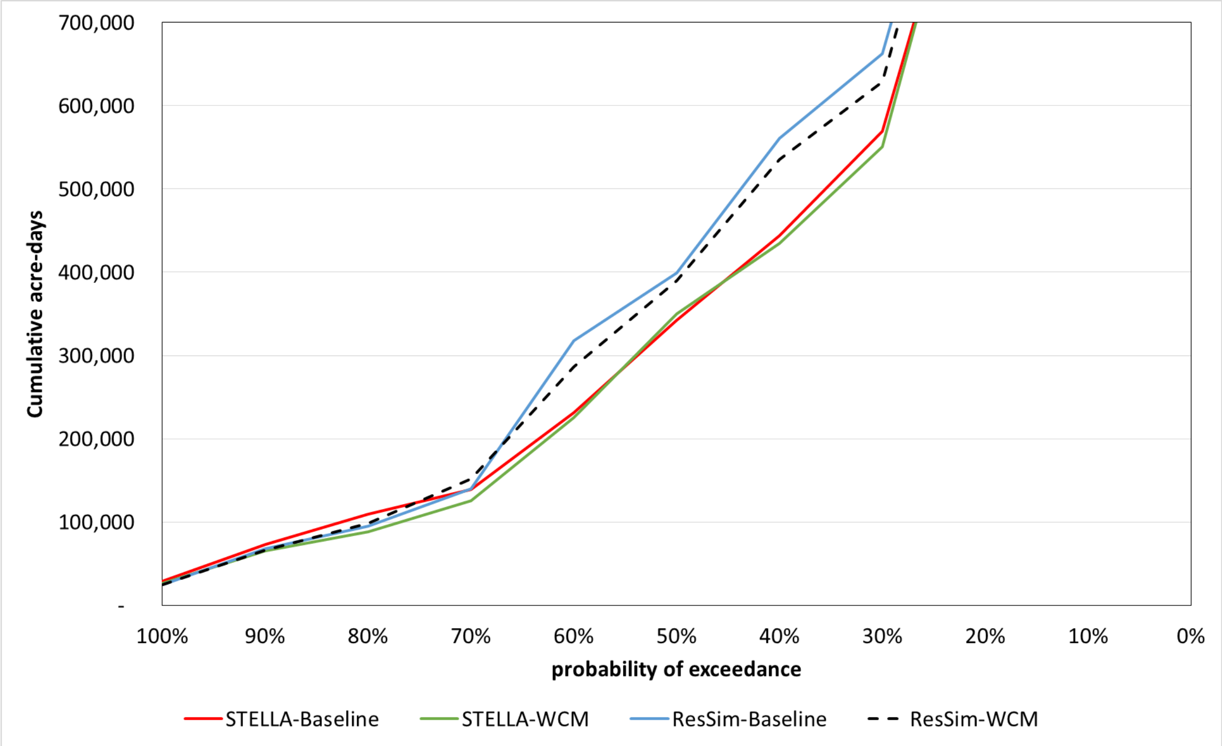


Figure 5.2 Total number of acre-days of floodplain inundation at ≥16,200 cfs between July 15 and November 24 under baseline and WCM

Interpretation: During July 15 - November 24, the WCM provides less floodplain inundation than the baseline. The reduction is most prevalent at years with the lowest flows and intermediate to higher flows and averages 4.7%. Given the importance of freshwater delivery of nutrients to the estuary during seasonal dry periods of the year (i.e., the late growing season) to support the production of forage for juvenile sturgeon, reduced floodplain inundation under the WCM has an adverse effect on Gulf sturgeon. A 6.3% reduction in area inundated occurs in the driest 17% of years, which in turn would reduce food production during those dry years (or those with lower inundation anyway).

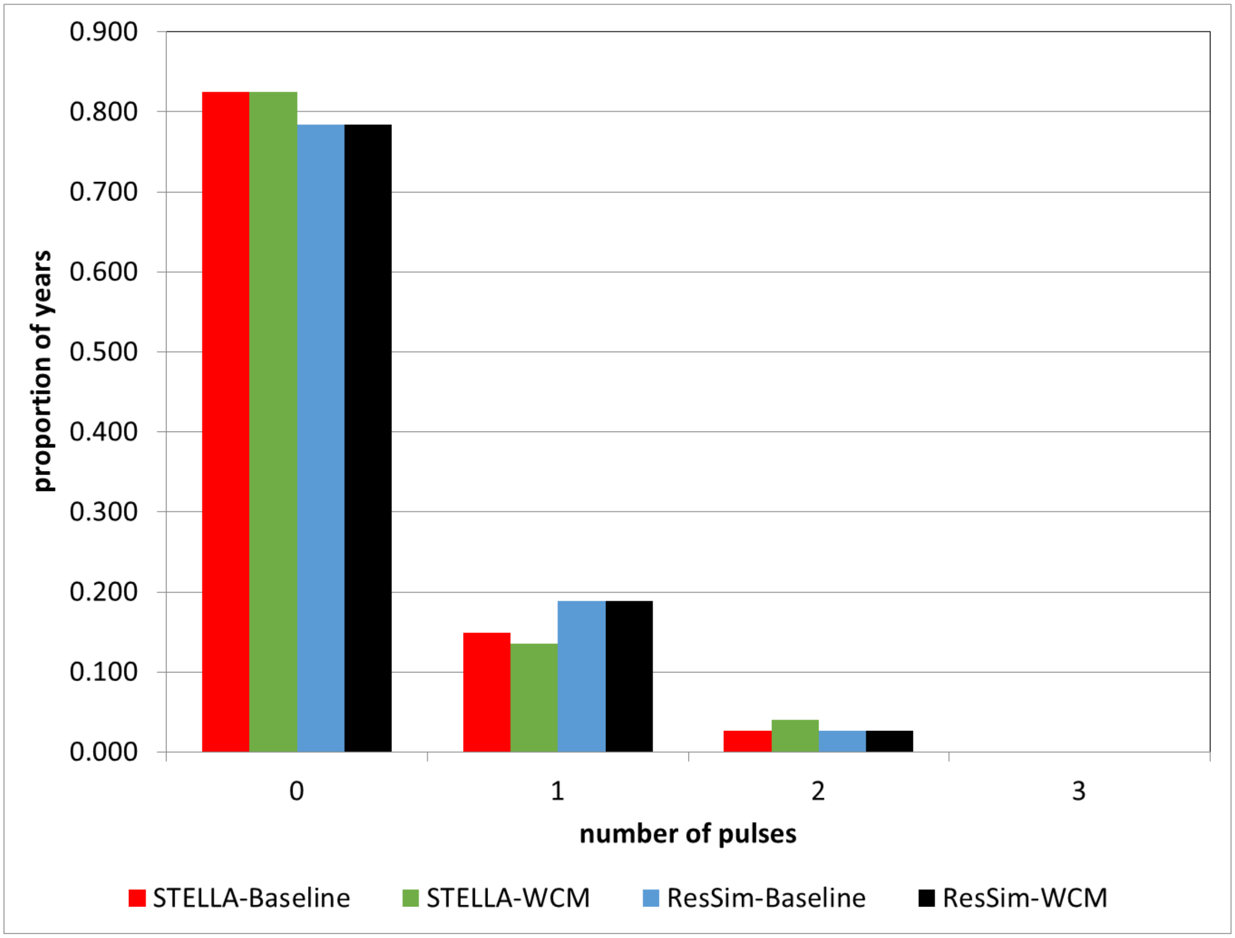
The combination of food and access, based on appropriate salinity conditions, during the first winter of life is critical for Gulf sturgeon. These effects may lead to increased foraging demand on juvenile sturgeon. The annual cohort of juvenile Gulf sturgeon that experience this increased foraging demand will have lower body condition, reduced growth, and potentially lower survival over the winter period.

Gulf Sturgeon Hydroecological Metric 5 (GS 5) - Pulsed Floodplain Forest Inundation and Nutrient Supply (Number of pulses)

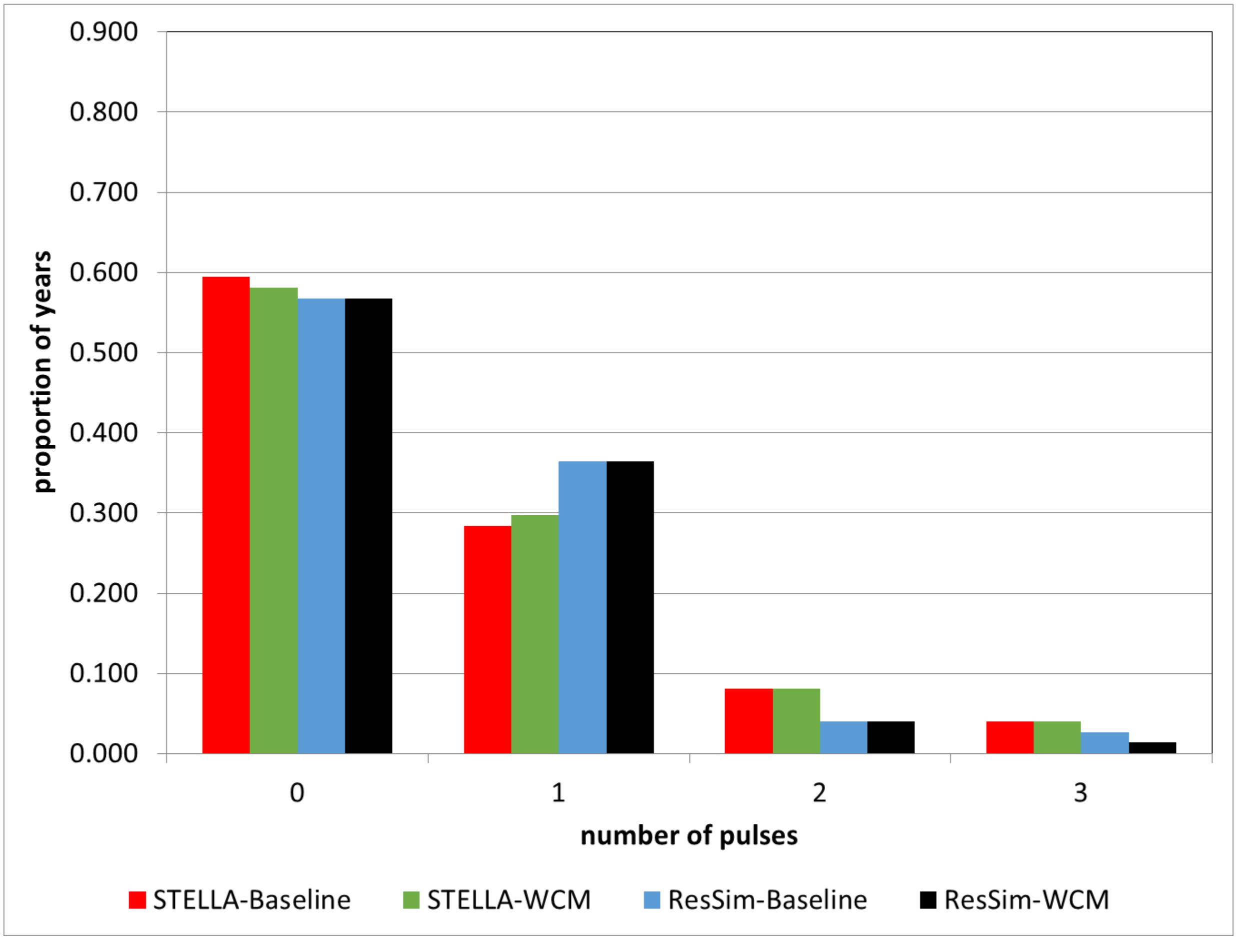
Description of Metric: In order to evaluate the potential effects of the proposed action on the supply of nutrients to the estuary, we determined the total number of floodplain pulses occurring between July 15 and November 24 each year. We defined a flood pulse as a discrete discharge event with flows exceeding 16,200 cfs for a period of at least 15 days, followed by a period of flows <16,200 for a period of at least 7 days. At 16,200 cfs, approximately 10% of the available floodplain is inundated (Light et al. 1998). We selected July 15 to represent a mid-summer date that coincided with both the end date for our Mussel Recruitment Metric, and a beginning date for the late growing season period. November 24 represents the median date of the first freeze observed at Quincy, FL (Light et al. 1998), considered here to be the last day of the late growing season. Episodes of floodplain inundation between July 15 and November 24 were assumed to sequester nutrients from the floodplain and deliver these nutrients downstream to the estuary.

Regular floodplain inundation is important to the entrainment of nutrients and export of nutrients to the estuary; nutrient supply to the estuary during the late growing season supports growth and production of infaunal and epifaunal invertebrates (i.e., sturgeon food). Designed to complement other floodplain metrics (GS 1 & 2), our analysis focused on the total number of floodplain inundation pulses. More floodplain inundation pulses deliver greater quantities of nutrients to the estuary, thereby supporting the production of a larger standing crop of benthic invertebrates. Thus, a larger number of inundation pulses benefit Gulf sturgeon; fewer pulses were considered an adverse effect.

Results: The proportion of years with 30-day (A) and 15-day (B) floodplain pulses between July 15 and November 24 occurring under the 2 flow regimens (baseline, WCM) is presented in Figure 10.7. The models showed differing results, and the ResSim model showed a negative effect. The WCM and baseline provided the same number of years with at least one 30-day pulse across the 74 year record (16 years or 22% of the time during the WCM), but the WCM provided one less year with a 15-day pulse compared to the baseline (31 years or 42% of the time). Across the 74-year record, the WCM provided one less year with three 15-day pulses (1.4% of the time during the WCM) than the baseline.


0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
proportion of years
0
1
2
3
number of pulses
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

A



B

Figure 5.3 The proportion of years in the 74 year period of record with 30-day (A) and 15-day (B) floodplain pulses between July 15 and November 24 occurring under the baseline and WCM flow regimes

Interpretation: Although these are rare events in the record, providing one less year with three 15-day pulses once every 74 years (1.4% decrease) is slightly negative effect of the WCM. Under the WCM (as well as the baseline), we expect 1 year with at least a 30-day pulse and 2 years with a 15-day pulse in 5 years. We expect that slight decrease in the frequency of floodplain pulses will decrease the supply of nutrients to the estuary to support the production of invertebrate prey for sturgeon.

5.2.2 Effects on Spawning Habitat Availability and Quality

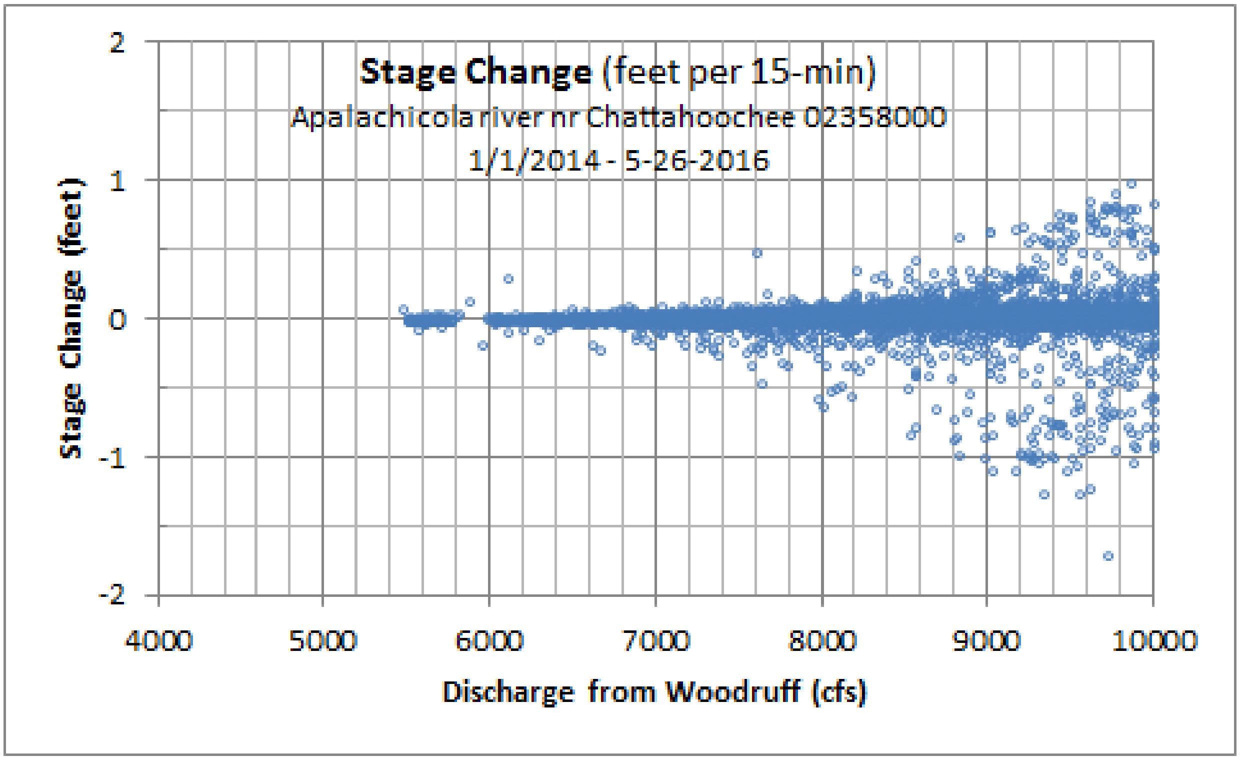
Gulf Sturgeon Egg and Fry Exposure and Survival during Hydropeaking (GS Q1)

Description of Metric: In order to evaluate the potential effects of the proposed action on exposure, and survival of eggs and recently hatched fry during hydropeaking, we calculated the frequency (in percent of days) of 15-minute stage changes (ft/15-min) for all flows during the sturgeon spawning season (March 1-May 31) and when releases from Jim Woodruff Dam are

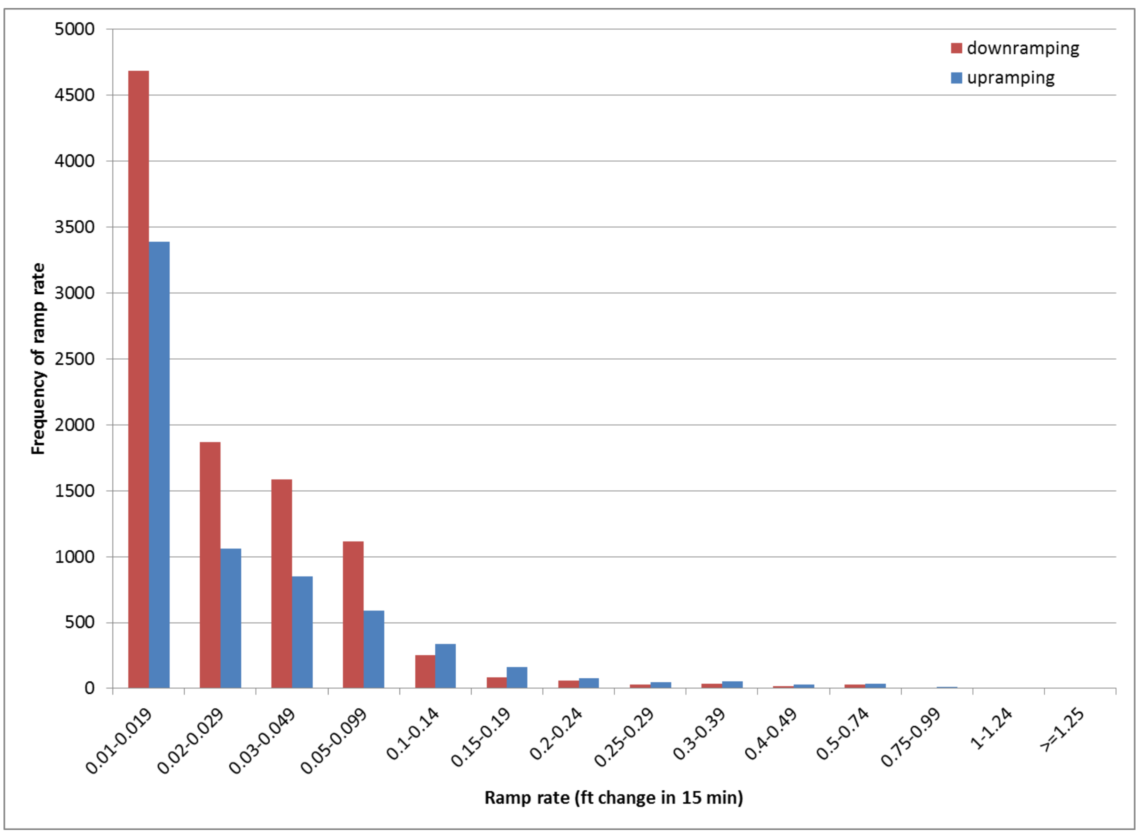
6,700-18,300 cfs based on 15-minute gage height data from 2008-2015 at the Chattahoochee gage. In order to evaluate how often conditions for hydropeaking occur during the sturgeon spawning season (March 1-May 31), we calculated the annual number of days between two thresholds (6,700 cfs and 18,300 cfs) for the Apalachicola River by year of record using the ACF STELLA model and 74-year record.

As discussed in section 1, peaking operations at Jim Woodruff Dam occur between 6,700 cfs and 18,300 cfs. We used 15-minute data from USGS gage 02358000 to analyze the effect of peaking activity on stage and discharge each afternoon (i.e., short durations of increases and decreases in flows lasting 2-6 hrs) from approximately 4:00 p.m. to 10:00 p.m. The large, rapid changes in volume of water from hydropeaking may adversely modify the flow regime PCE for Gulf sturgeon critical habitat and may affect sturgeon egg and fry survival as well as behavior and growth (Table 4.2).

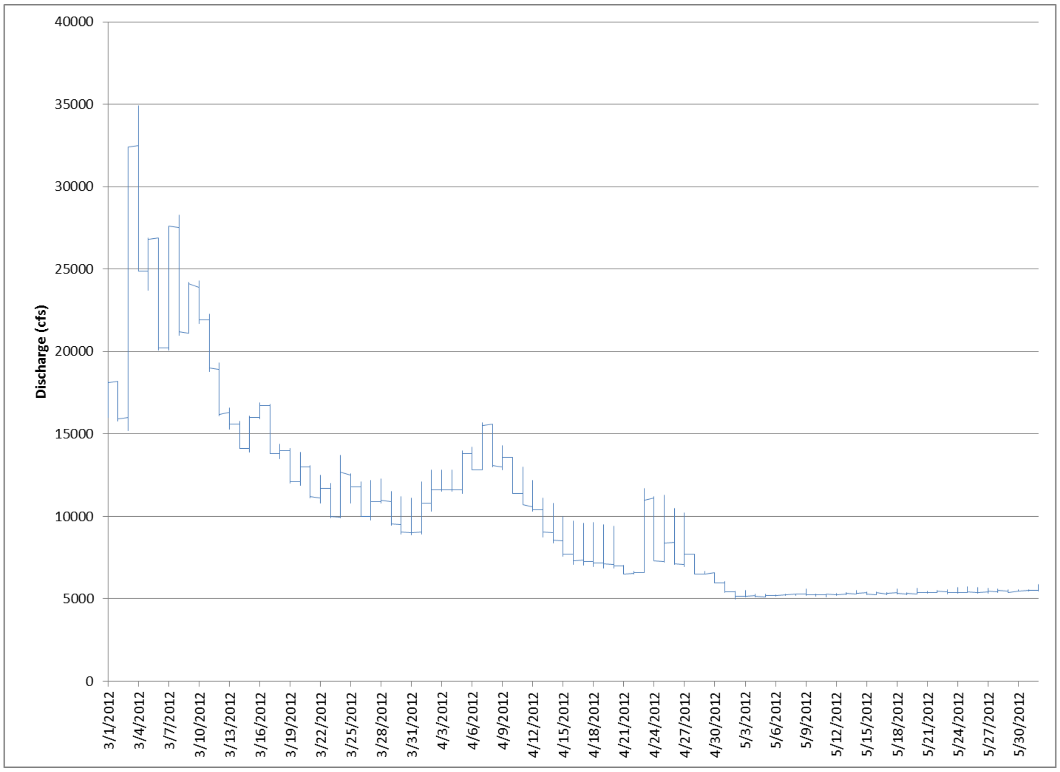
Results: Examples of evidence of peaking operations and effects on sturgeon habitat are presented in Figure 5.4. In general, stage changes of nearly 2 feet in 15 minutes occur when discharges are below 10,000 cfs (Figure 5.3A). Sub-daily, 15-minute discharge and gage height data from the Chattahoochee gage for 8 years (2008-2015) show down ramping rates of up to 0.98 ft/15 min and up ramping rates of up to 1.33 ft/15 min overall and when flows are between 6,700 and 18,300 cfs during the spawning season (Figure 5.4B). In general, discharge changes of 2000-3000 cfs in 15 minutes exist when discharges are between 6,700 and 18,300 cfs as the example of 2012 sturgeon spawning season shows (Figure 5.4C), and days with appropriate conditions to hydropeak occurred on 238 of 736 days (34%) during the 8 spawning seasons. We summarized these data in order to quantify the prevalence and magnitude of peaking activity for hydropower production on sturgeon each afternoon between 4 pm and 10 pm from Mar. 1 – May 31 (Figure 5.4D). This analysis showed down ramp rates up to 3.02 ft/6 hrs and up ramping rates of up to 3.19 ft/6 hrs while hydropeaking activities are occurring, and 86% of down ramps and 73% of up ramps are above 0.25 ft/day, the daily ramp rate threshold. Further, some change of flow occurred during the peaking window of time each afternoon approximately 70% of the time when flows are between 6,700 and 18,300 cfs during the spawning season. These abrupt changes in stage may be an adverse effect of the WCM.



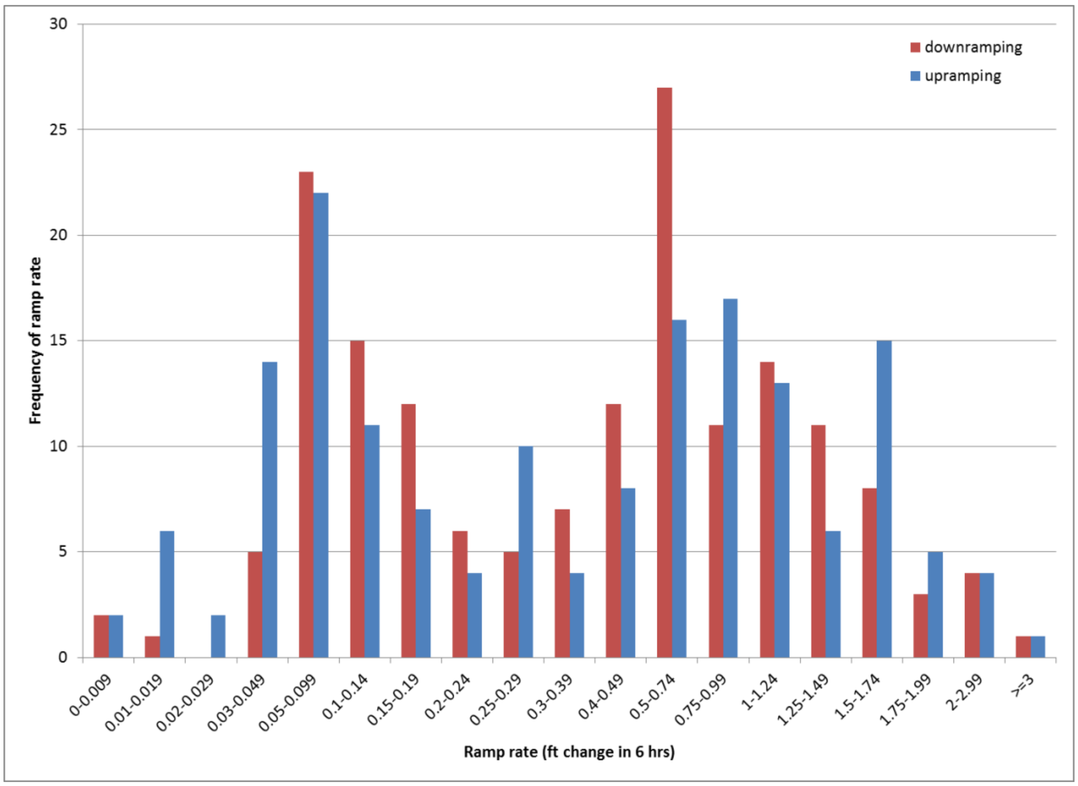
A. Example stage changes below 10,000 cfs.



B. Sturgeon season 15-minute ramp rates



C. 2012 sturgeon season discharges showing peaking



D. Sturgeon spawning season peaking ramp rates

Figure 5.4 Examples of peaking operations when flows are 5,900-18,300 cfs at Jim Woodruff Dam based on available USGS data.

The correlation among daily average flows from the Chattahoochee and Blountstown gages is 0.983 for the same period, but drops to 0.974 for 15-minute data analyzing the available 15-minute data for Blountstown gage (Aug. 2013 - Oct. 2015) (Figure 5.5). This reduction in correlation may be attributed to tributary input, floodplain effects and other factors, but also supports attenuation of peaking waves.

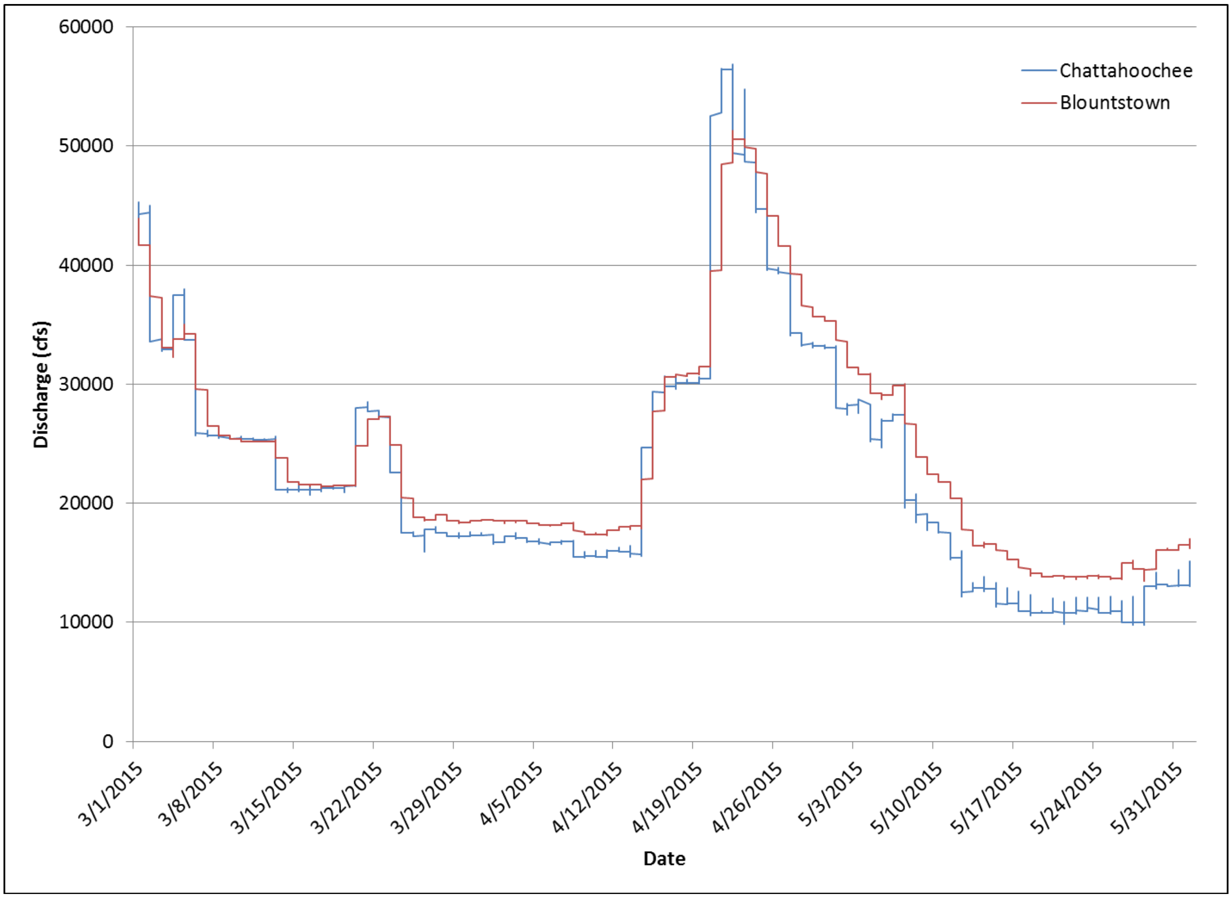
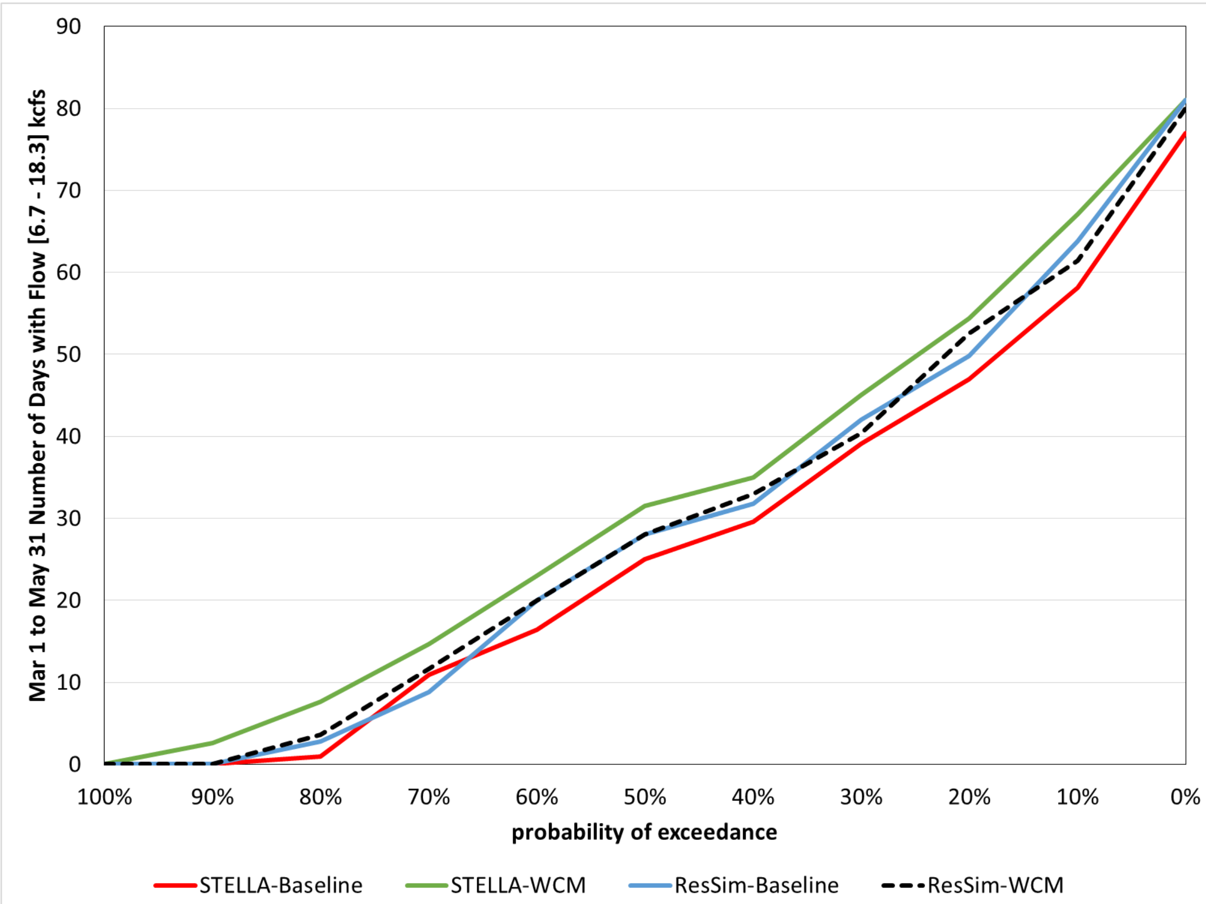
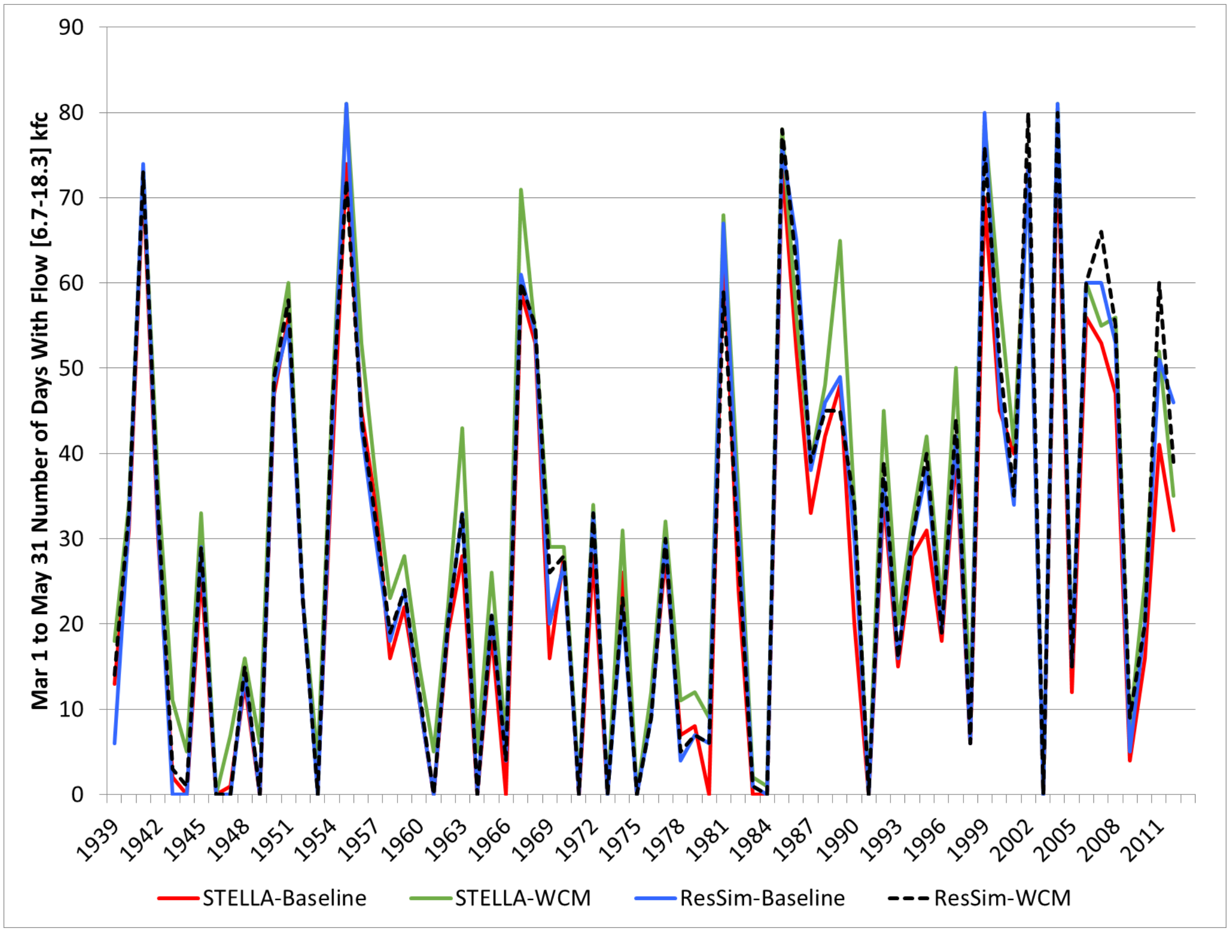


Figure 5.5 Chattahoochee and Blountstown gage comparison for March 1-June 1 2015.

The total number of days at flows between 6,700 and 18,300 cfs between March 1 and May 31 occurring under the 2 flow regimens (baseline, WCM based on both models) is presented as a probability of exceedance plot (Figure 5.6A) and a summary of the days per year (Figure 5.6B). Both models showed the same pattern (i.e., that the WCM increased the amount of time appropriate for hydropeaking), but the STELLA model showed the greater effect. According to this model, the WCM provides 395 days more of appropriate conditions for hydropeaking compared to the baseline across the 74 years (i.e., 5.3 days on average or 26 day average increase during the WCM). Additionally, the WCM increases the probability of conditions when hydropeaking may occur at least once during the year by about 12% (81% to 93% at zero intercept), and overall, from 29% to 35% (2377 of 6808 days). Therefore, we expect the chance of hydropeaking to increase from 4 of 5 years under the baseline to a 4.7 of 5 years of the WCM and expect hydropeaking to occur on average 32 days each year (160 days over 5 years). This may be an adverse effect for the sturgeon population by increasing the time when conditions are appropriate for hydropeaking during the sturgeon spawning season.



A



B

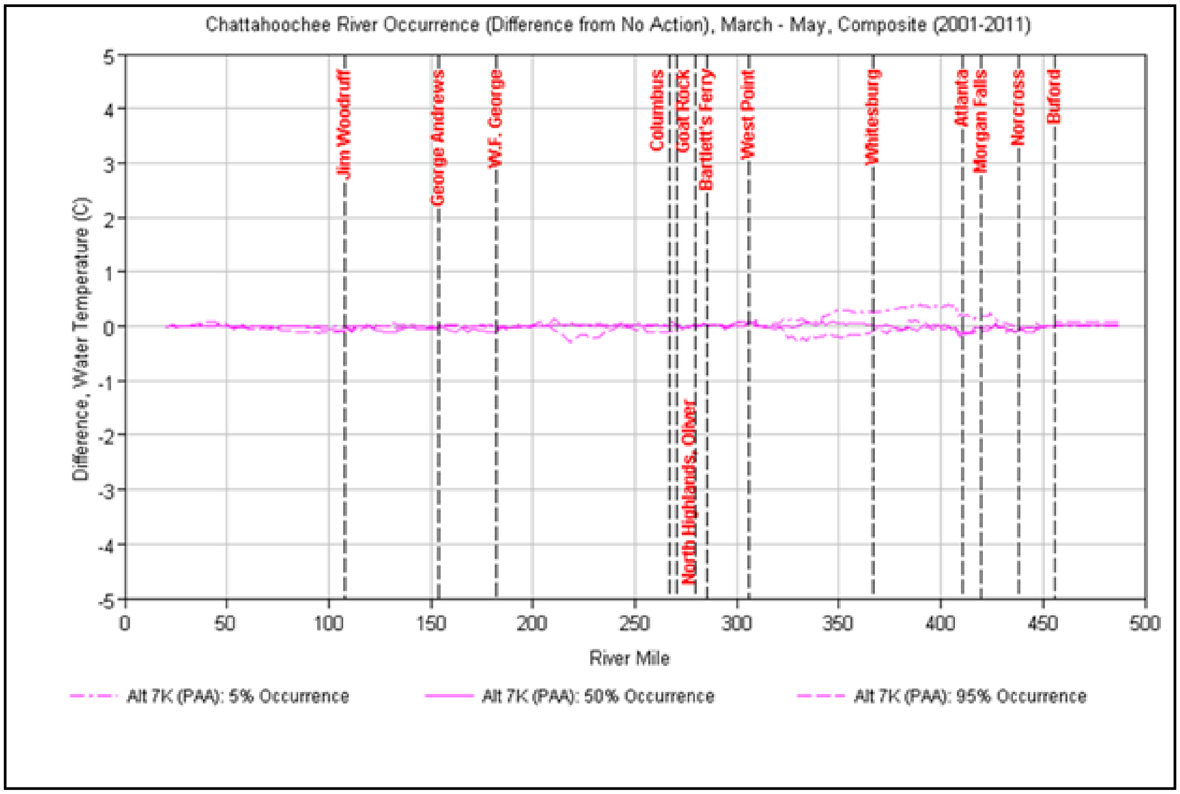
Figure 5.6 Number of days when conditions are correct to allow peaking operations at Jim Woodruff Dam during the 92-day sturgeon spawning season presented as a probability of exceedance plot (A) and count of days (B).

Interpretation: Operation of the hydropower units in peaking mode results in short-term water level fluctuations (i.e., stage changes) that affect the food and flow regime PCEs for Gulf sturgeon and may have the most influence at the known spawning locations. While these short-term variations in water stage and discharge attenuate further downstream, the known spawning sites for Gulf sturgeon are immediately downstream of Woodruff Dam, at limestone outcrops found within the channel from river mile RM 86 to RM 105. Between 6,500 and 18,500 cfs there are 11.1-19.3 ac of spawning habitat of the appropriate depth (8.5 to 17.8 ft). Based on the discharge-spawning habitat acreage relationship developed for GS9, a 3,000 cfs change in discharge in this range of flows may change the spawning habitat available for spawning from -1.1 ac to 5.6 ac for 6-10 hours. This may disrupt egg laying cues by adult females. The food PCE for Gulf sturgeon requires abundant food items, and drifting invertebrates that are key resources for larval sturgeon are adversely affected by hydropeaking. The flow regime PCE for Gulf sturgeon requires a regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging, and for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging. The hydropeaking operation under the WCM likely modifies these PCEs of critical habitat immediately downstream of the dam. Hydropeaking could affect Gulf sturgeon during the spawning season, especially while larvae are dispersing from the spawning sites. Peaking operations during the spawning season may affect survival, development, and growth of sturgeon larvae and juveniles approximately 5 days after hatching when fry begin dispersal from spawning sites. Larvae may experience reduced survival by being washed downriver into unsuitable habitat during late spring and early summer peaking releases and experience reduced growth and development by have drifting invertebrate prey reduced. However, additional data are needed to assess the magnitude these effects.

Although the daily average stage limits evaluated in the BA obscure the actual conditions experienced by sturgeon eggs and larvae in the Apalachicola River, increasing the time when conditions are appropriate to hydropeak by an average of 5.3 days (or 26 days for the WCM in 5 years) as well as the probability that conditions will be appropriate to hydropeak at least once during the spawning season by 12% and overall by 6% are adverse effects of the WCM on Gulf sturgeon. These may also be adverse effects to purple bankclimber because Gulf sturgeon is a key host fish for this mussel species.

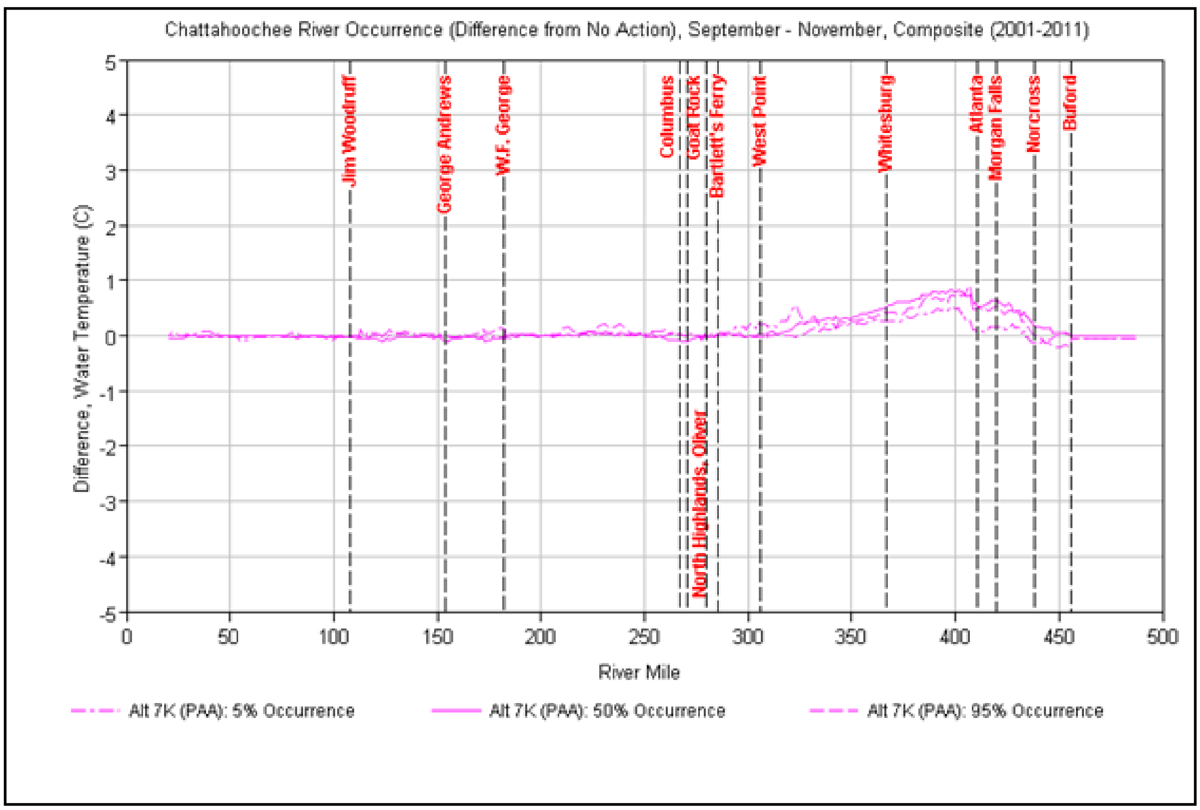
River Temperatures on Gulf Sturgeon Spawning (GS Q2)

The USACE in its BA developed a HEC-5Q model to analyze WCM effects to water temperature. Figure 2.5 (above) provides a representation of WCM annual effects to stream temperature in spring and fall. Figure 5.7 shows the difference between the WCM (labeled as PAA) and no action (i.e., baseline) at Jim Woodruff Dam. WCM operations are predicted to result in changes to temperatures of less than 1 degrees C both in spring (Figure 5.7A) and fall (Figure 5.7B). The temperatures experienced by sturgeon during the fall spawning season in other rivers (Sept.-Nov.) are near lethal limits. Additional data on temperature fluctuations are needed to assess this possible effect.



Chattahoochee River Occurrence (Difference from No Action), March - May, Composite (2001-2011)
Difference, Water Temperature (C)
River Mile
Jim Woodruff
George Andrews
W.F. George
Columbus
Goat Rock
North Highlands, Oliver
Bartlett's Ferry
West Point
Whitesburg
Atlanta
Morgan Falls
Norcross
Buford
Alt 7K (PAA): 5% Occurrence
Alt 7K (PAA): 50% Occurrence
Alt 7K (PAA): 95% Occurrence

A



Chattahoochee River Occurrence (Difference from No Action), September - November, Composite (2001-2011)
Difference, Water Temperature (C)
River Mile
Jim Woodruff
George Andrews
W.F. George
Columbus
Goat Rock
North Highlands, Oliver
Bartlett's Ferry
West Point
Whitesburg
Atlanta
Morgan Falls
Norcross
Buford
Alt 7K (PAA): 5% Occurrence
Alt 7K (PAA): 50% Occurrence
Alt 7K (PAA): 95% Occurrence

B

Figure 5.7 Difference in Water Temperature (Degrees Celsius) Between the Baseline and WCM (labeled as PAA) (Sep-Dec) based on ResSim simulated flow 1975-2011 in spring (A) and fall (B).

5.3 Interrelated and Interdependent Actions

We must consider along with the effects of the action the effects of other federal activities that are interrelated to, or interdependent with, the proposed action (50 CFR sect. 402.02). Interrelated actions are part of a larger action and depend on the larger action for their justification. Interdependent actions have no independent utility apart from the proposed action. At this time, the USFWS is aware of only two actions that satisfy the definitions of interrelated and interdependent actions. These will both undergo section 7 consultation in the future, but are worthy of mention because they address possible reasonable and prudent measures and terms and conditions for addressing effects of hydropeaking and salinity in distributary rivers of the Apalachicola River. The contract between Southeast Power Administration and Duke Energy will undergo section 7 in the future. This contract addresses hydropower production and hydropeaking at Jim Woodruff Dam and other USACE dams in this consultation. The USACE operations for maintenance of the Gulf Intracoastal Waterway from Apalachicola Bay to Lake Wimico will undergo section 7 in the future.

6 GULF STURGEON - CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered in this BO. Future federal actions that are unrelated to the action are not considered in this section because they require separate consultation under section 7 of the Act. Based on the USACE policy for review of WCMs, the timeframe for the applicability of the WCM is five years. Therefore, we have considered potential non-federal activities that may also change the primary factors considered in Appendix A, as well as any other non-federal actions that may affect the listed species during this five-year period. Cumulative effects for the ACF Basin are discussed below. These cumulative effects are expected be similar for all listed species.

Non-federal government and private actions may include changes in land and water use patterns, including ownership and intensity, any of which could affect listed species or their habitat. It is difficult, and perhaps speculative, to analyze the effects of such actions, considering the broad geographic landscape covered by this BO, the geographic and political variation in the action area, extensive private land holdings, the uncertainties associated with State and local government and private actions, and ongoing changes in the region’s economy. Adverse effects to riverine habitat in the basin from continued urbanization in the Atlanta metropolitan area as discussed in section 2 are reasonably certain to occur. However, state and local governments have regulations in place to minimize these effects to listed species, including regulations regarding construction best management practices, storm water control, and treatment of wastewater, and these regulations are reviewed in the DEIS (USACE 2015, p. 2-123 – 2-149).

7 GULF STURGEON - CONCLUSION

The proposed action provides both beneficial and adverse effects to Gulf sturgeon and designated critical habitats we have assessed. We attribute all differences between the baseline and WCM simulated flow regime to the USACE's discretionary operations, with the acknowledgement that the Rivers and Harbors Act release requirements for water supply in downstream Atlanta are not discretionary. Differences between the baseline and WCM are summarized in general form below (for more details, see sections 4 and 5).

7.1 Summary of Effects

Spawning Adult to Egg:

- Spawning habitat inundation
    - ***Neutral*** – no effect on 30-day inundation (GS 9)

Egg to Young of Year:

- Increased opportunity for hydropeaking at Woodruff from Mar 1-May 31 (GS Q2)
    - ***Negative*** – increase conditions for hydropeaking and chance of washing fry from foraging areas after hatching and larvae begin swimming (GS Q1)
- Operational effects to stream temperature
    - ***Neutral*** - No distinguishable differences in WCM operation on stream temperatures in the Apalachicola River (GS Q2)

Young of Year to Juvenile:

- Forage availability while in freshwater from Nov 24 to Jun 1 (190 days)
    - ***Negative*** – Floodplain inundation (total days) (GS 1)
        - Negative effect in 10% of the years
        - During times of high flow (10-20% probability of exceedance range)
        - Up to 10 days reduction for the 190 day period
    - ***Neutral*** – Floodplain inundation (acre days) (GS 2)
- Forage availability while in freshwater from Jul 15 to Nov 24 (183 days)
    - ***Neutral*** – Floodplain inundation (total days) (GS 3)
    - ***Negative*** – Floodplain inundation (acre days) (GS 4)
        - At >83% exceedance probability
            - Average of 6.3% less floodplain inundation per year
        - Overall
            - Average of 18,904 acre days less floodplain inundation per year
    - ***Slight negative*** – Floodplain inundation (total pulses) (GS 5)
        - One fewer 15-day pulse across the 74-yr record
    - ***Negative*** – Hydropeaking at Woodruff from Mar 1-May 31 (GS Q2)
        - Under WCM operations, changes in river stage of up to three feet have been observed within a six hour time period and peaking conditions increased to about 35% of the spawning season.
- Young of Year Access to Foraging Habitat from Jan 1 through Mar 15 (74 days)

- ○ ***Neutral/Positive*** – young of year access to foraging habitat (GS7)

Juvenile to Non-Reproductive Adult:

- Estuarine Invertebrate Production from Nov 24 to Jun 1 (190 days)
  - ***Negative*** – Floodplain inundation (total days) (GS 1)
    - Negative effect in 10% of the years evaluated
    - Negative effect occurs during times of high flow (10-20% probability of exceedance range)
    - Up to 10 days reduction in floodplain inundation for the 190 day period
  - ***Neutral*** – Floodplain inundation (acre days) (GS 2)
- Estuarine Invertebrate Production while in freshwater from Jul 15 to Nov 24 (183 days)
  - ***Neutral*** – Floodplain inundation (total days) (GS 3)
  - ***Negative*** – Floodplain inundation (acre days) (GS 4)
    - At >83% exceedance probability
      - Average of 6.3% less floodplain inundation per year
    - Overall
      - Average of 18,904 acre days less floodplain inundation per year
  - ***Slight negative*** – Floodplain inundation (total pulses) (GS 5)
    - One fewer 15-day pulse across the 74-yr record
  - ***Negative*** – Hydropeaking at Woodruff from Mar 1-May 31 (GS Q2)
    - Under WCM operations, changes in river stage of up to three feet have been observed within a six hour time period and peaking conditions increased to about 35% of the spawning season.
- Juvenile Access to Foraging Habitat from Nov 1 through Mar 15 (135 days)
  - ***Neutral/Positive*** – General Low Salinity Conditions for Access to Foraging Habitat (GS 6)
  - ***Neutral/Positive*** – Unsuitable Salinity Conditions for Access to Foraging Habitat (GS 8)
    - Reduced the consecutive number of days flows below 16,200 cfs
    - Improvements for the hydroecological metric were realized for approximately 20% of the years evaluated

The current population of Gulf sturgeon in the Apalachicola River appears to be stable, although this population is not showing the patterns of recovery and increasing trends in adjacent rivers. The principal effects to the Gulf sturgeon in the action area are:

1) Woodruff Dam precludes migratory movements to additional spawning habitat located in the Flint and Chattahoochee basins.
2) Substantial changes to both the low and high ends of the flow regime in the post-West Point period compared to the pre-Lanier period may have adversely affected estuarine habitat availability and/or suitability for sturgeon feeding.
3) The analysis shows a small adverse effect that is measurable and detectable on estuarine invertebrate production (GS1, GS4, GS5), but it is difficult at this time evaluate this change in terms of reduced growth, survival, or distribution of juveniles because data on this period of sturgeon life history are lacking.

4) The magnitude of reduction in benthic invertebrates (i.e., sturgeon food) that results from a reduction in floodplain inundation in the Apalachicola River is unknown, and the WCM may have slightly beneficial effects by increasing the number of pulses and increasing the number of consecutive days/year ≥ 16,200 cfs in the winter months. Until better data is available, we could conclude that this effect on estuarine invertebrate production is insignificant. Therefore, we anticipate only minor changes in salinity regimes or estuarine habitat due to the WCM. The effect of depletions on the sturgeon's estuarine habitats in the distributary rivers of the Apalachicola is unknown at this time pending results of studies of sturgeon use of the bay and estuary and application of appropriate hydrodynamic models and water quality monitoring that may predict and validate salinity regime changes and benthic food resource responses. The only existing model by Dr. Peter Sheng is based on salinity monitoring at three points in the bay and may not accurately predict the flow and salinity relationship in the Gulf sturgeon's estuarine habitats in the distributary rivers of the Apalachicola.
5) Take of Gulf sturgeon eggs and larvae due to the WCM may occur when river conditions are between 6,700 and approximately 18,000 cfs in March through May due to hydropeaking flow. The effects of the proposed WCM on spawning habitat were not analyzed with fine scale daily fluctuation data, but previous flow-habitat relationships illustrate the sensitivity of these habitats to changes in discharge, especially during low-flow events (Flowers et al. 2009, Ziewitz 2006). In turn, these habitat conditions may influence Gulf sturgeon courtship and spawning behavior, fertilization rates, egg and larval development, and age-class representation in the population. Some of these sites may be exposed and desiccated at lower discharges from Woodruff (Figure 7.1). We are unable to reliably estimate the extent of Gulf sturgeon take due to hydropeaking at this time. The following calculation is an example of the data required to be able to calculate take of the population due to hydropeaking. USFWS (unpublished data) captured and sized 295 sturgeon in 2014 and of these 96 fish (33%) were of adult breeding size (>150 cm fork length). The 2014 population estimate of 785 fish yields 255 fish of breeding size. If we use fecundity information from the Suwanee River that 0.25-1% of the population are females in spawning condition (USGS, Ken Sulak, pers. comm. 8/22/16), then 1-3 females per year spawn. If each of these females lays 400,000 eggs, then 400,000-1.2 million eggs are laid in the river. From 2013-2015, USFWS (unpublished data) captured 51-200 juvenile sturgeon after 1 year, which would indicate a survival rate of 0.0043-0.05% in the river. Of this theoretical >99.9% mortality, it is unknown what proportion is due to hydropeaking as opposed to other factors that may affect survival during this first year of life including food availability in the river, food availability in the estuary, predation, and water quality.

Figure 7.1 Race shoals spawning site (RM 104.7) exposed at lower discharges (app. 5500-5700 cfs) from Woodruff Dam. (USFWS, Sept. 10, 2010)

The change in metrics (GS1, GS4, GSQ1) will be used as surrogate measures of take for this consultation (i.e., days and ac-days of floodplain inundation, day of hydropeaking conditions). However, we believe it is necessary to further evaluate the effects of hydropeaking and floodplain inundation on sturgeon eggs and larval survival in the next spawning seasons when peaking occurs and next winters when foraging effects may occur. The effects of hydropeaking may affect spawning and riverine site conditions and food resources and survival of Gulf sturgeon swimming larvae after hatching. This altered flow regime may also alter the normal behavior of adults during site selection, courtship, egg fertilization at shallower areas of spawning sites and may affect the growth and survival of eggs during egg attachment and development, and larval staging. USFWS will work with USACE to monitor the effects of the WCM on spawning, hatching, larval growth and juvenile growth for Gulf sturgeon.

7.2 Critical Habitat

As discussed above, designated critical habitat for the Gulf sturgeon in the action area includes the Apalachicola River unit, and the Apalachicola Bay unit. In the effects analysis, we discussed how the WCM may affect four of the PCEs of sturgeon critical habitat: 1) food items in both the riverine and estuarine environments; 2) riverine spawning areas; 3) flow regime, and 4) water quality. Of the effects of WCM, hydropeaking has the potential to affect food resources in the river for young (5-day old) sturgeon larvae and the reduction in floodplain inundation in the fall and winter has the potential to further reduce food resources for juvenile sturgeon overwintering for the first time in the bay and estuary. Spawning areas may be affected by the sub-daily flow and velocity changes from hydropeaking. The flow regime may be altered by operations under the WCM by changing floodplain inundating flows and sub-daily fluctuations from hydropeaking. The water quality, especially salinity, in the distributary rivers may affect the ability to effectively forage by young of year and juveniles in the winter. However, the WCM would not appreciably change the quantity or quality of the PCEs to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role.

7.3 Determination

After reviewing the current status of the listed species and designated critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the USFWS' biological opinion that the proposed action: 1) will not jeopardize the continued existence of the Gulf sturgeon; and 2) will not destroy or adversely modify designated critical habitat for the Gulf sturgeon.

The WCM is intended to apply until a new WCM is adopted. Given the USACE's current timeline, the findings of this BO shall apply for five years until September 14, 2021, or until amended through a reinitiation of consultation or superseded with a new opinion for a new proposed action.

8 MUSSELS - STATUS OF THE SPECIES

8.1 Species Description

Fat threeridge

The fat threeridge (*Amblema neislerii*) is a medium-sized, heavy-shelled mussel that reaches a length of about 100 millimeters (mm) (4.0 inches (in)). Large specimens are highly inflated. The dark brown to black shell is oval to quadrate and strongly sculptured with seven to nine prominent horizontal parallel plications (ridges). The umbo (the raised, rounded portion near the shell hinge) is in the anterior quarter of the shell. The inside surface of the shell (nacre) is white to bluish white. As typical of the genus, no sexual dimorphism is displayed in shell characters (Williams and Butler 1994, Williams et al. 2008).

Purple bankclimber

The purple bankclimber (*Elliptoideus sloatianus*) is a large, heavy-shelled mussel that reaches a length of 205 mm (8.0 in). The shell is dark brown to black, quadrate to rhomboidal in shape, and sculptured by several irregular plications that vary greatly in development. A well-developed posterior ridge extends from the umbo to the posterior ventral margin of the shell. The umbos are low, extending just above the dorsal margin of the shell. Nacre color is whitish near the center of the shell becoming deep purple towards the margin and iridescent posteriorly. No sexual dimorphism is displayed in purple bankclimber shell characters (Williams and Butler 1994; Williams et al. 2008). Fuller and Bereza (1973) described aspects of its soft anatomy, and characterized *Elliptoideus* as being an "extremely primitive" genus.

Chipola slabshell

The Chipola slabshell (*Elliptio chipolaensis)* is a medium-sized mussel that reaches a length of 85 mm (3.3 in). The shell is moderately thin and moderately inflated. The shell exterior is light to dark brown in color and smooth, and typically with dark concentric circles. The umbos are prominent, well above the hinge line. Internally, the umbo cavity is wide and shallow, and the nacre color is white to bluish white, sometimes with a salmon tint. No sexual dimorphism is displayed in shell characters (Williams et al. 2008).

8.2 Critical Habitat Description

On November 15, 2007 (72 FR 64286), the USFWS designated 11 stream segments (units) as critical habitat for the endangered fat threeridge, and the threatened Chipola slabshell and purple bankclimber pursuant to the Act (USFWS 2007a). These units include portions of the Econfina Creek (Florida), ACF (Alabama, Florida, and Georgia), Ochlockonee (Florida and Georgia), and Suwannee (Florida portion only) river basins. The total length of streams designated is approximately 1,909 river kilometers (km) (1,185.9 river miles (mi)). The rule became effective on December 17, 2007.

Fat threeridge

Three units are designated as fat threeridge critical habitat (Table 8.1). These units encompass approximately 786.6 km (488.8 mi) of river in the Lower Flint River in Georgia, Chipola River Basin in Alabama and Florida, and the Apalachicola River in Florida.

Purple bankclimber

Six units are designated as purple bankclimber critical habitat (Table 8.1). These units encompass approximately 1,493.5 km (928.0 mi) of river in the Flint River Basin in Georgia, Apalachicola River Basin in Florida and the Ochlockonee River Basin in Florida and Georgia.

Chipola slabshell

One unit is designated as Chipola slabshell critical habitat (Table 8.1). This unit encompasses approximately 228.8 km (142.2 mi) of river in the Chipola River Basin in Alabama and Florida.

Table 8.1 Critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell.

Species, Critical Habitat Unit, and State(s)	Miles
Fat threeridge	
2. Chipola River, AL, FL	142.1
7. Lower Flint River, GA	246.5
8. Apalachicola River, FL	100.2
Total	*488.8*
Purple bankclimber	
5. Upper Flint River, GA	236.4
6. Middle Flint River, GA	187.8
7. Lower Flint River, GA	246.5
8. Apalachicola River, FL	100.2
9. Upper Ochlockonee River, FL, GA	110.2
10. Lower Ochlockonee River, FL	46.9
Total	*928.0*
Chipola slabshell	
2. Chipola River, AL, FL	142.2
Total	*142.2*

Primary Constituent Elements

Each of the designated critical habitat units for these three listed mussels contains one or more of the PCEs that the USFWS describes as essential to the conservation of the species, and which may require special management considerations or protection. The PCEs of fat threeridge, purple bankclimber, and Chipola slabshell designated critical habitat are:

- A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without an aggrading or degrading bed elevation);
- A predominantly sand, gravel, and/or cobble stream substrate;
- Permanently flowing water;
- Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceed the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251-1387); and
- Fish hosts (such as native basses, sunfishes, minnows, darters, and sturgeon) that support the larval life stage of the mussels.

8.3 Life History

8.3.1 Lifespan

In general, some freshwater mussels are long-lived and slow-growing, while others grow quickly and have short life spans. Growth in freshwater mussels tends to be relatively rapid for the first few years (Chamberlain 1931, Negus 1966), and then slows appreciably (Bruenderman and Neves 1993, Hove and Neves 1994). The abrupt slowing in growth rate occurs at sexual maturity, probably due to the diversion of energy to gamete production. Growth rates vary among species; heavy-shelled species grow slowly relative to thin-shelled species (Coon et al. 1977, Hove and Neves 1994). Also, heavy-shelled species generally tend to reach higher maximum ages (Stansbery 1961, 1971). Longevity studies conducted by Haag and Rypel (2010) on 57 freshwater mussel species, mostly from the southern US, found maximum ages ranged from 4 to 190 years. They observed a very tight relationship between longevity and growth rate, finding that slow growing species (e.g., Margaritiferidae, Amblemini, Pleurobemini, and Quadrulini) being longer lived than fast growing species (e.g., Andontini).

Fat threeridge

The USFWS has studied age of fat threeridge, primarily aging shells by counting internal shell annuli via thin-sectioning, but also through validation with stable oxygen isotope variability in the shell. Our data indicate that the internal line method may overestimate age by counting less significant growth bands (false annuli) interspersed within larger growth increments (greater accuracy in younger individuals). However, a growing body of evidence supports the production of annual shell rings in freshwater mussels (McCuaig and Green 1983, Neves and Moyer 1988, Haag and Commens-Carson 2008, Rypel et al. 2008). Annulus formation likely occurs in the winter when growth slows or ceases (Haag and Commens-Carson 2008). Results of Arnold et al. (2011) confirm that fat threeridge growth slows in the winter. The time of spawning indicates that the formation of the first annulus may occur before the mussel is one year old.

Although we acknowledge that our ages may be overestimated using the internal line method, we rely on the work of Haag and Commens-Carson (2008) and Rypel et al. (2008), which indicate that validated shell rings can provide accurate estimates of growth. Preliminary results of ongoing field validation of annual ring formation indicate that fat threeridge may form annual rings but further validation is necessary. To date, the USFWS has aged 236 individuals including the 31 individuals the Panama City Field Office aged in 2007. The majority of these shells were collected freshly dead during the droughts in 2006-2007 and 2010-2011 from the RM 40-50 reach of the main channel. Some were also collected in Swift Slough and the Chipola Cutoff. Sizes ranged from 11-86 mm total length and estimated ages ranged from 1 to 24 years old. Our results indicate that the fat threeridge exhibits low to moderate growth and intermediate longevity relative to other mussel species (Haag and Rypel 2010).

Purple bankclimber

EnviroScience, Inc. (2006a) provided age and growth information for the purple bankclimber. They aged 11 individuals ranging from 80-184 mm total length. Ages range from 3 years old (80 mm) to 15 years old (184 mm). In addition, a specimen that was likely dead for at least one year, but still in good shape for aging, measured 63 mm and was 4 years old. A von Bertalanffy growth curve does not fit these data. Although the sample size is very small, the relationship between age and total length appears to be exponential (see Figure 2.3.2.B in USFWS 2012).

Chipola slabshell

No age or growth information is available for the Chipola slabshell.

8.3.2 Reproduction

The fat threeridge, purple bankclimber and Chipola slabshell are bivalve mussels of the family Unionidae. Sexes in unionid mussels are usually separate (van der Schalie 1970, Downing et al. 1989). Most unionid mussel species have a parasitic stage during which the immature mussels, called glochidia, must attach to a host to transform into a juvenile (Figure 8.1). Females release glochidia either separately or in masses termed "conglutinates", depending on the mussel species.

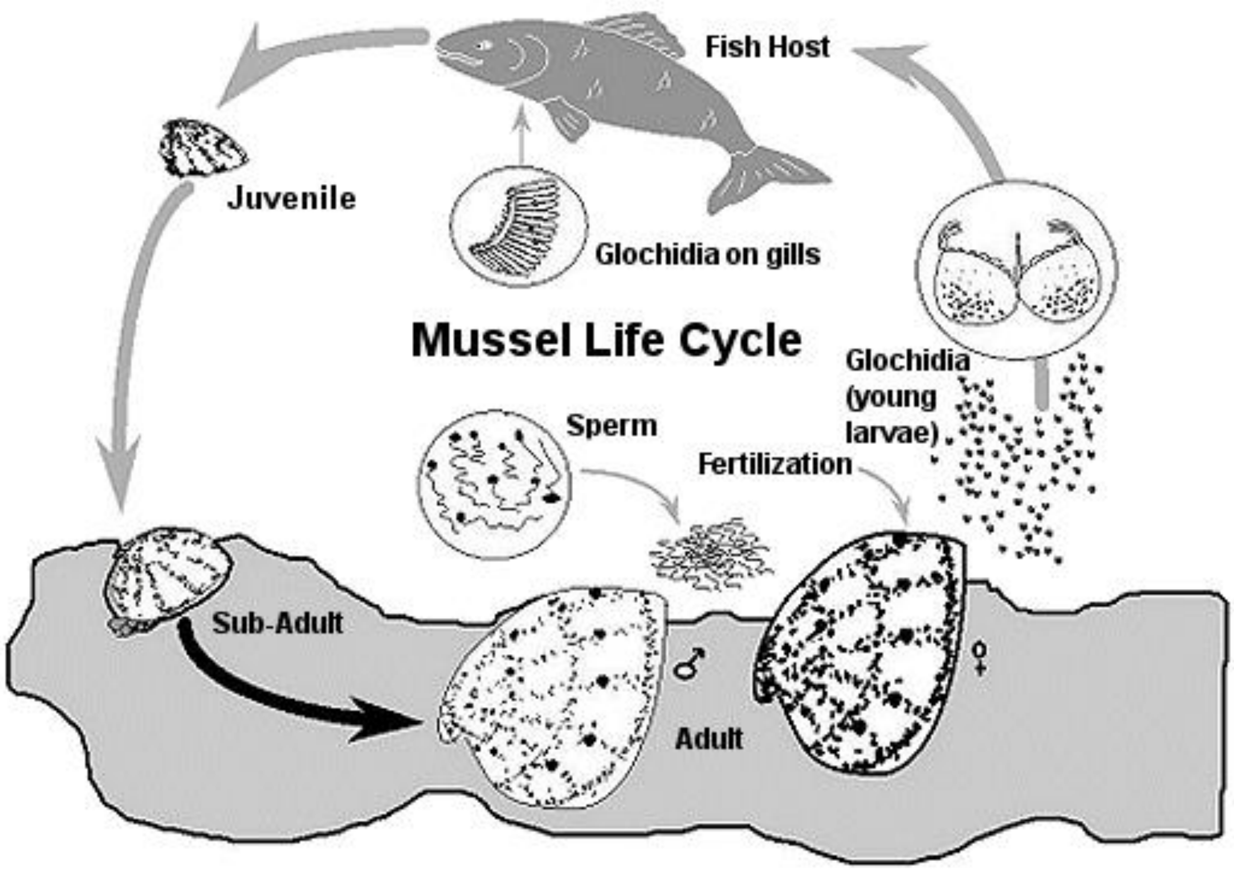


Figure 8.1 Freshwater mussel life cycle (IMT 2002).

The age of sexual maturity for mussels is variable, usually requiring from 3 to 12 years (Zale and Neves 1982, McMahon and Bogan 2001). Spawning appears to be temperature dependent (Zale and Neves 1982, Bruenderman and Neves 1993), but may also be influenced by stream discharge (Hove and Neves 1994). Males release sperm into the water column, which females take in through their siphons during feeding and respiration. Fertilization takes place inside the shell.

The eggs are retained in the gills of the female until they develop into mature larvae called glochidia.

Mussels may be particularly susceptible to exposure by low flows during the spawning season. Once the water warms and the days become longer, mature mussels move vertically to the substrate surface (Balfour and Smock 1995, Amyot and Downing 1998, Watters et. al 2001, Perles et al. 2003). Watters et al. (2001) studied eight freshwater mussel species and found that all of the species surfaced during the spring to spawn. Mussels also aggregate via horizontal movement to enhance recruitment (Amyot and Downing 1998). Spawning itself requires substantial energy expenditure for female mussels, and therefore, females may move less than males during the reproductive season (Amyot and Downing 1998). For this reason, females may be relatively more susceptible than males to exposure-induced mortality.

After a variable incubation period, mature glochidia, which may number in the tens of thousands to several million (Surber 1912, Coker et al. 1921, Yeager and Neves 1986), are released by the female mussel. The glochidia of most freshwater mussel species, including the fat threeridge, purple bankclimber, and Chipola slabshell, must come into contact with specific species of fish, whose gills, fins, or skin they temporarily attach to in order to transform into a juvenile mussel. Depending on the mussel species, females release glochidia either individually in net-like mucoid strands that entangles fish (Haag and Warren 1997), or as discreet packets termed conglutinates (Barnhart et al. 2008), or in one large mass known as a superconglutinate (Haag et al. 1995, O'Brien and Brim Box 1999, Roe and Hartfield 2005). Glochidia failing to contact a suitable fish host will survive for only a few days (Sylvester et al. 1984, Neves and Widlak 1988, O'Brien and Williams 2002). Host specificity appears to be common in mussels (Neves 1993), with most species utilizing only a few host fishes (Lefevre and Curtis 1912, Zale and Neves 1982, Yeager and Saylor 1995). The duration of the parasitic stage, which varies by mussel species, generally lasts a few weeks (Neves et al. 1985, O'Brien and Williams 2002), but possibly much longer (Yeager and Saylor 1995, Haag and Warren 1997), and is temperature dependent (Watters and O'Dee 2000). When the transformation is complete, the newly metamorphosed juveniles drop from their fish host and sink to the stream bottom where, given suitable conditions, they grow and mature into adults.

Glochidial parasitism serves two purposes: nutrition for larval development and dispersal. Substances within the blood serum of the host fish are necessary for the transformation of a glochidium into a juvenile mussel (Isom and Hudson 1982). Parasitism also serves as a means of dispersal for this relatively sedentary faunal group (Neves 1993). The intimate relationship between mussels and their host fish has therefore played a major role in mussel distributions on both a landscape (Watters 1992) and community (Haag and Warren 1998) scale. Haag and Warren (1998) determined that mussel community composition was more a function of fish community pattern variability than of microhabitat variability, and that the type of strategy used by mussels for infecting host fishes was the determining factor.

Villella et al. (2004) described the general unionid life history strategy as a hybrid between an *r*-strategist (high output of glochidia, lower survival of young, no parental care) and a *K*-strategist (longevity and high adult survival). It is possible that continuous (though low) reproduction during a long adult lifespan can be beneficial for unionids and may be an evolutionary strategy in response to uncertain larval and juvenile survival.

Fat threeridge

O'Brien and Williams (2002) studied various aspects of the life history of the fat threeridge, determining that it is likely a short-term summer brooder of its glochidia. Females appear to be gravid in Florida when water temperatures reached 23.9°C, in late May and June, suggesting that the species expels glochidia in the summer. Fat threeridge glochidia are released in a white, sticky, web-like mass, which expands and wraps around a fish, thus facilitating attachment. The glochidia are viable for two days after release.

The fat threeridge lacks mantle modifications or other morphological specializations that would serve to attract host fishes and appears to be a host-fish generalist that may infect fishes of at least seven different fish families, albeit with varying degrees of success to transformation (O'Brien and Williams 2002, Fritz and Bringoff 2014). Fritz and Bringolf (2014) reported transformation of fat threeridge on 23 species of fish, including such commonly occurring species as bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*). Potential host fishes with the highest transformation success (Fritz and Bringoff 2014) included: the migratory striped bass (*Morone saxatilus*), the percids swamp darter (*Etheostoma fusiforme)*, turquoise darter (*E. inscriptum)*, and tesselated darter (*E. olmsteadi)*, the centrarchids green sunfish (*Lepomis cyanellus*), and longear sunfish (*L. megalotis*), and the cyprinids flagfin shiner (*Pteronotropis grandipinnis*) and yellowfin shiner (*Notropis lutipinnis*). Transformation of the glochidia on host fishes required 10 to 18 days (O'Brien and Williams 2002, Fritz and Bringoff 2014). Fritz and Bringoff (2014) confirmed earlier work that the fat threeridge is a host generalist.

Fat threeridge age and growth data suggest females reach sexual maturity at three years of age (USFWS unpublished data). These results are preliminary and research is ongoing; however, these findings agree with studies conducted on a closely related congener, *Amblema plicata*, whose age at sexual maturity was determined also to be three years (Haag and Staton 2003).

Purple bankclimber

Female purple bankclimber with viable glochidia were found in the Ochlockonee River from late February through mid-April (O'Brien and Williams 2002); in the Apalachicola River, in mid-March; and in the Flint River from late-March through mid-June (Hartzog 2011). The species is presumably a short-term brooder. Females expel narrow lanceolate-shaped conglutinates (10-15 mm long) that are viable for three days after release (O'Brien and Williams 2002). The white structures, which are two glochidia thick, are generally released singly, although some are attached to each other at one end and released in pairs (O'Brien and Williams 2002).

Fishes that have effectively transformed glochidia of the purple bankclimber during laboratory infections include the eastern mosquitofish (*Gambusia holbrooki*), blackbanded darter (*Percina nigrofasciata*), halloween darter (*Percina crypta*), holiday darter (*Etheostoma brevirostrum*), lake sturgeon (*Acipenser fluvescens*), shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), and Gulf sturgeon (*Acipenser oxyrinchus desotoi*) (O'Brien and Williams 2002, Fritts et al. 2012, Hartzog 2011). The eastern mosquitofish occupies stream margins in slower (or slack) currents, and is considered a secondary host fish since the purple bankclimber is more of a main-channel species (Williams and Butler 1994). The black banded darter was identified as a host fish in two separate laboratory studies where transformation rates ranged from 36 to 49% (Fritts et al. 2012, Hartzog 2011). The highest rate of transformation occurred in the four sturgeon species which ranged from 79 to 89%. The Gulf sturgeon is the only sturgeon species that co-occurs with the purple bankclimber, and it also serves as a primary glochidial host for the species.

Chipola slabshell

Chipola slabshell females were found to be gravid in June to early July (Brim Box and Williams 2000, Preister 2008). The species is presumably a short-term brooder (Williams et al. 2008). Researchers from Columbus State University (CSU) conducted laboratory studies on Chipola slabshell reproduction and found that glochidia were expelled in conglutinates approximately 13 mm long and 3 mm wide and resemble insect larva (Preister 2008). The study documented the successful transformation of glochidia on redbreast sunfish and bluegill. Sixty percent of the bluegill and 80% of the redbreast sunfish successfully transformed *E. chipolaensis* glochidia into juvenile mussels (Preister 2008).

Feeding: Adult freshwater mussels are filter-feeders, orienting themselves on or near the substrate surface to take in food and oxygen from the water column (Kraemer 1979). They siphon water into their shells and across four gills that are specialized for respiration and food collection. Food items include detritus (disintegrated organic debris), algae, diatoms, and bacteria (Strayer et al. 2004). Juvenile mussels typically burrow completely beneath the substrate surface and are pedal (foot) feeders (bringing food particles inside the shell for ingestion that adhere to the foot while it is extended outside the shell) until the structures for filter feeding are more fully developed (Yeager et al. 1994, Gatenby et al. 1996).

8.4 Habitat and Population Status

Adult mussels are generally found in localized patches (beds) in streams and almost completely burrowed in the substrate with only the area around the siphons exposed (Balfour and Smock 1995). The composition and abundance of mussels are directly linked to bed sediment distributions (Neves and Widlak 1987, Leff et al. 1990). Physical qualities of the sediments (e.g., texture, particle size) may be important in allowing the mussels to firmly burrow in the substrate (Lewis and Riebel 1984). These and other aspects of substrate composition, including bulk density (mass/volume), porosity (ratio of void space to volume), sediment sorting, and the percentage of fine sediments, may also influence mussel densities (Brim Box 1999, Brim Box and Mossa 1999).

Stream geomorphic and substrate stability is especially crucial for the maintenance of diverse, viable mussel beds (Vannote and Minshall 1982, Hartfield 1993, Di Maio and Corkum 1995).

Where substrates are unstable, conditions are generally poor for mussel habitation. Strayer (1999) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that displayed little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. Strayer thought that features commonly used in the past to explain the spatial patchiness of mussels (e.g., water depth, current speed, sediment grain size) were poor predictors of where mussels actually occur in streams.

Williams and Butler (1994) and Williams et al. (2008) discussed the habitat features associated with the fat threeridge, purple bankclimber, and Chipola slabshell including stream size, substrate, and current velocity. Brim Box and Williams (2000) also provided habitat information, particularly substrate associations. Finally, Smit (2014) and Smit and Kaeser (in press) and additional work by USFWS resulted in a comprehensive and quantitative study via the use of side scan sonar habitat mapping to create species distribution models for the fat threeridge in Apalachicola and the Chipola rivers. Following is a summary of this information, and of other recent studies.

Fat threeridge

The fat threeridge is reported from the main channels of the Apalachicola, Flint, and Chipola rivers, and a few tributaries and distributaries of the Apalachicola in Florida and southwest Georgia (Clench and Turner 1956, Williams and Butler 1994, Williams et al. 2008). There are no records of the species in the Chattahoochee Basin.

Distribution: The USFWS listed the fat threeridge as an endangered species in 1998 (USFWS 1998a). Currently, the fat threeridge is found throughout much of its historical range (Figure 8.2); however, it is extirpated from localized portions of the Apalachicola and Chipola rivers. The fat threeridge presumably no longer occurs in the portion of the Apalachicola and Flint rivers that is now unsuitable habitat, submerged in the reservoir created by Jim Woodruff Lock and Dam. Clench and Turner (1956) reported it common (56 specimens collected in 1954) from a now submerged Apalachicola River site. Also, the population below Woodruff dam appears to be reduced for quite some distance downstream (Brim Box and Williams 2000, Gangloff 2011, USFWS unpublished data). It was extirpated from much of the Dead Lake area in the Chipola River. Although the low-head dam was removed in 1987, Dead Lake has aggraded with sediment, which may have contributed to the localized extirpation of the fat threeridge (Brim Box and Williams 2000).

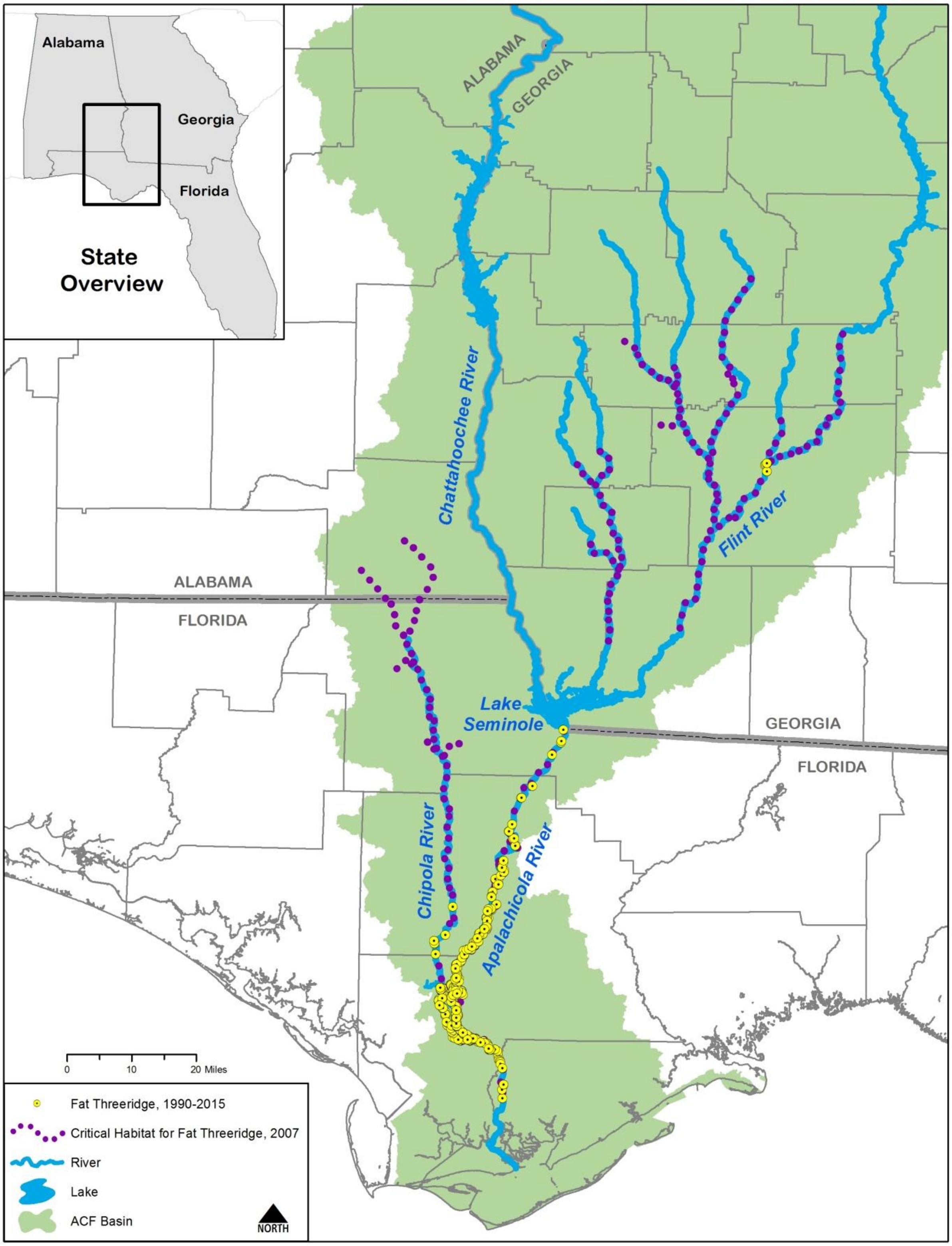


Figure 8.2 Current (1990-2015) occurrences of fat threeridge throughout its range.

Although the species persists in the Flint River, it appears to be extremely rare and localized. Since 2006, biologists from the Georgia Department of Natural Resources (GDNR) and USFWS found live adults near the Highway 37 bridge. The 2011 survey was part of a larger study by the GDNR which examined 110 km of the Flint River from the backwaters of Lake Seminole to the Albany dam. Thirty-nine stations were surveyed, and several rare species were found, however, fat threeridge were collected only near the Highway 37 bridge.

Habitat: The fat threeridge is documented in numerous recent collections from many main channel sites on the Apalachicola River and lower Chipola River, both upstream and downstream of Dead Lake. Surveys conducted recently in these areas include studies by Miller and Payne in 2003 and 2007; EnviroScience in 2005, 2006, 2007, and 2010; Florida Fish and Wildlife Conservation Commission (FFWCC) in 2007, 2011, and 2016; Gangloff in 2008, 2010 and 2011, and the USFWS in the years 2006 thru 2015. In most instances, these studies took place during drought conditions when water levels were moderately to extremely low.

The fat threeridge inhabits the main channel of small to large rivers in slow to moderate current, and can be found in a variety of substrates from gravel to cobble to a mixture of sand, mud, silt, and also clay (Williams and Butler 1994, Brim Box and Williams 2000, Gangloff 2011). Earlier work found the most abundant populations in moderately depositional areas along bank margins at depths of around 1 meter (3.3 ft.) (Miller and Payne 2005, Miller and Payne 2006, EnviroScience 2006a; Gangloff 2011). However, recent studies have expanded on our knowledge of fat threeridge mesohabitat use, and mussels were documented in mesohabitats (Garcia et al. 2012) not well sampled in past studies such as pool/outerbank mesohabitat (Smit 2014, Smit and Kaeser *in press*). The pool/outerbank mesohabitat which occurred at depths between 2.3-8.5m was defined as the second largest class identified in the river, characterized by imagery with a smooth/plane bedform and presence of large woody debris (Smit 2014, Smit and Kaeser *in press*). The average density in this mesohabitat class was nearly equal to densities of other known habitat types (inner and outer recirculation zones described earlier by others as moderately depositional areas), and this knowledge, as well as, documentation in other mesohabitat types (main channel and point bar) resulted in a population estimate in the Apalachicola river (Smit 2014).

Considerable fat threeridge mortality occurred in the Apalachicola and Chipola rivers and Swift Slough in 2006-2007 and 2010-2011 when water levels dropped as a result of drought. Most of the mortality occurred in areas where movement to deeper water was not possible or where shallow slopes prevented the mussels from tracking the receding water. We further discuss the effects of mortality on the fat threeridge population later sections.

Abundance: The fat threeridge is locally common, the population is seemingly large, and recruitment is occurring. Although periodic drought-induced mortality may cause some localized population declines, we currently consider the species' status to be stable or improving. In suitable habitat, the fat threeridge is common to abundant and recruitment is occurring.

Purple bankclimber

The purple bankclimber is endemic to the Apalachicola Basin in Alabama, Georgia, and Florida, and the Ochlockonee River drainage in Georgia and Florida (Brim Box and Williams 2000, Williams et al. 2008). The species is historically known from the main channels of the Apalachicola, Chattahoochee, Flint, Chipola, and Ochlockonee rivers, as well as from two tributaries in the Flint River system. Heard (1979) erroneously reported it from the Escambia River system (Williams and Butler 1994). Based on museum records, the species was relatively common in the lower Flint, upper Apalachicola, and upper Ochlockonee Rivers (Brim Box and Williams 2000). The USFWS listed the purple bankclimber as a threatened species in 1998 (USFWS 1998a).

Distribution: Presently, the purple bankclimber occurs in much of it historical range (Figure 8.3); however, it is extirpated from localized areas, and it has likely been completely extirpated from the Chattahoochee River. We had only historical collections of purple bankclimber in the Chattahoochee River until 2001, when a single, live and old specimen was found in the upper portion of Goat Rock Reservoir. Within the Flint and Ochlockonee river drainages, the species is relatively common, but occurs at fewer sites than historically due in part to two mainstem dams and reservoirs on the Flint River and one on the Ochlockonee River. The purple bankclimber no longer occurs in the portion of the Apalachicola and Flint rivers that is now unsuitable habitat, submerged in the reservoir created by Jim Woodruff Lock and Dam. The population numbers are reduced in the Apalachicola River compared to historical observations. Heard (1975) considered the species to be common in the Apalachicola River in the 1960s, but that population sizes by the mid-1970s, particularly below Jim Woodruff Lock and Dam, had been “drastically reduced.”

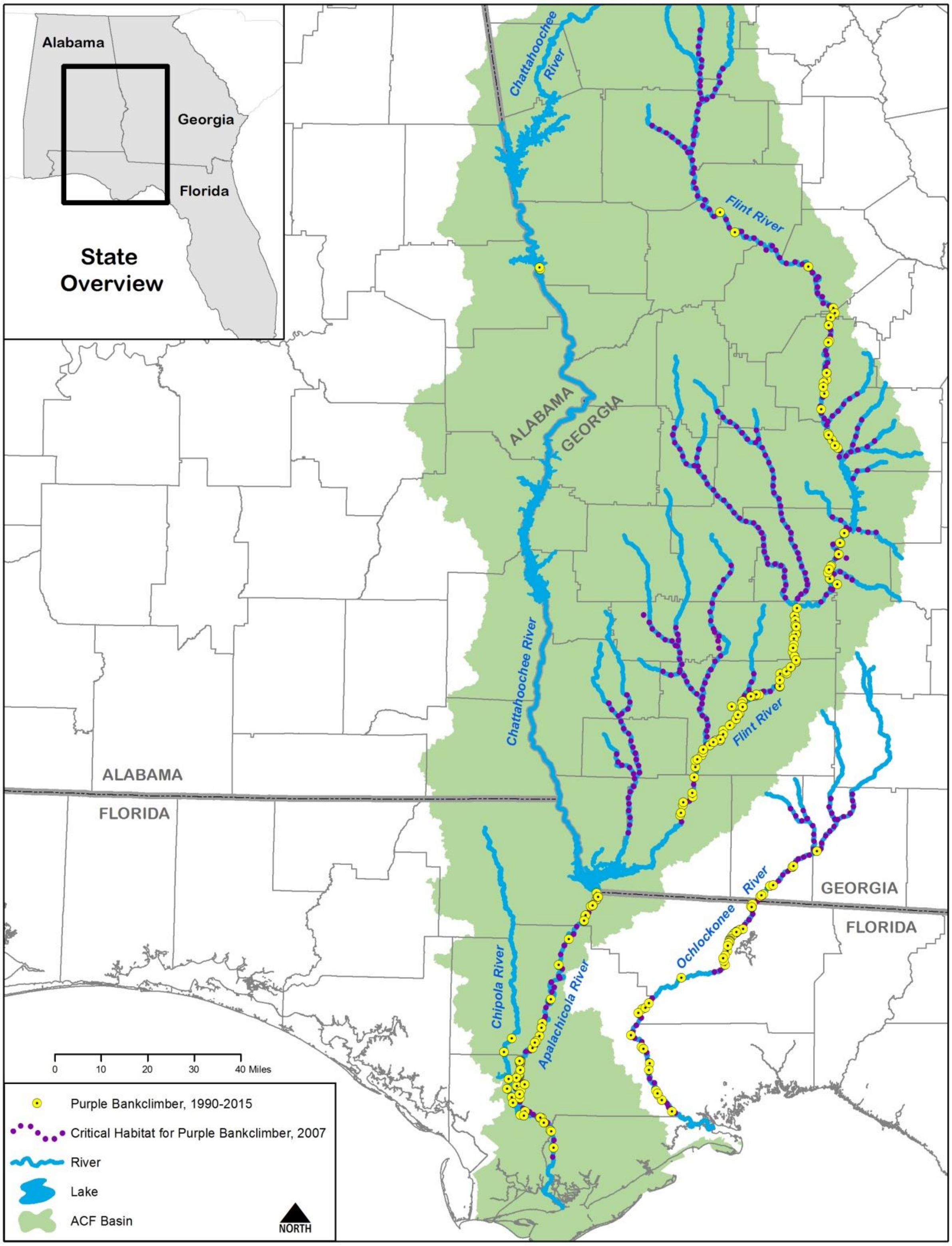


Figure 8.3 Current (1990-2015) occurrences of purple bankclimber throughout its range.

The purple bankclimber inhabits medium to large river channels in substrates of sand or sand mixed with mud or fine gravel, often near limestone outcrops (Brim Box and Williams 2000, Williams et al. 2008). ACF Basin collections by Brim Box and Williams (2000) were often in waters more than 3 meters (10 ft.) in depth. Recent upper Apalachicola River collections, when water levels were low, found purple bankclimbers generally in depths of 0.5 to 5.0 meters (1.6 to16 ft.) (Gangloff 2011).

The purple bankclimber has been collected recently from the Apalachicola, Flint, and Ochlockonee rivers. A survey of five sites in the main channel of the Flint River between Warwick Dam and Lake Worth found that the purple bankclimber was the most abundant among nine species collected, but very few small individuals were observed (McCann 2005). A GDNR survey of the Flint River examined 110 km of the lower river from the backwaters of Lake Seminole to the dam near Albany, GA. The purple bankclimber was found at 19 of the 39 stations surveyed, and shell length data showed good size variation and also the presence of small (23, 30, 41 mm) individuals. Apalachicola and lower Chipola River dive surveys of deeper habitat when water levels were very low found purple bankclimbers in depths ranging from 0.5 to 5 meters (1.6 to 16.4 ft.) (Gangloff 2011). These collections were mostly in the Apalachicola River in the vicinity of Race Shoals (RM 105.5), though several were located in a deep bed near Apalachicola RM 47. Very few juvenile bankclimber were found, and of 113 individuals collected, only five were less than 100 mm in length. During surveys of the Ochlockonee River conducted from 2007 to 2011, the USFWS identified purple bankclimbers at 29 sites, many of which represented new locations for the species. At sites where the species was present, an average of 15 purple bankclimbers were collected. Few small and medium-sized individuals were found, although juveniles and small adults of other species were collected regularly (USFWS unpublished data). Recent (2015) sampling efforts by USFWS to quantify mussels in the Apalachicola River resulted in very few purple bankclimber collected in the study area.

Like fat threeridge, considerable purple bankclimber mortality also occurred in the Apalachicola River in 2006-2007 and 2011 when water levels dropped as a result of drought. Most of the mortality occurred at Race Shoals on the Apalachicola River where movement to deeper water is difficult given the complex nature of the shoal habitat. We further discuss the effects of mortality on the Apalachicola River population in later sections. Drought-induced mortality was also observed on the Flint and Ochlockonee rivers in 2011.

Abundance: The lack of small and medium-sized individuals in the studies described above of the Apalachicola and Ochlockonee rivers, and portions of the Flint River, suggests that either recruitment is occurring at very low rates or sampling methods are not suited to detecting juveniles of this species. Studies to verify recruitment, by an age-structure analysis of the adult population and by detecting juveniles in the field, are needed to adequately assess the purple bankclimber’s status. Although past studies have indicated that the species range and abundance are relatively unchanged, we currently consider the species’ status to be declining over the short term as a result of the possible poor recruitment and recent mortality due to droughts.

Chipola slabshell

The Chipola slabshell is known only from the Chipola River system in Florida and Alabama, and from a tributary of the lower Chattahoochee River in southeastern Alabama, where it is represented by a single museum specimen from Howard's Mill Creek (Williams et al. 2008). The historical range of this ACF Basin endemic is centered throughout much of the Chipola River mainstem and several of its headwater tributaries. The Chipola slabshell is one of the most narrowly distributed species in the drainages of the northeast Gulf of Mexico. In 1998, the USFWS listed it as a threatened species (USFWS 1998a).

Distribution: Currently, the Chipola slabshell occurs in nearly all of its historical range, with the exception of Howards Mill Creek (Figure 8.4). The species was re-discovered in the Alabama reaches of the Chipola drainage in 2007 where it had not been reported since 1916 (Garner et al. 2007). In addition, since 2010, live individuals and fresh dead have been collected in the Apalachicola River main channel near the Chipola Cutoff.

The Chipola slabshell inhabits sandy substrates mixed with silt, clay, and occasionally gravel in slow to moderate current, often along stream margins (Williams and Butler 1994; Williams et al. 2008). It primarily occurs in the main channel of the Chipola River.

Abundance: Recent surveys (1990 to present) have documented many new sites, but found the species generally occurs in relatively low abundance, with 64% of sites sampled yielding five or fewer individuals. Only three surveys yielded more than 40 individuals and two of those were extensive dive surveys. We have no evidence that these populations are currently declining and we consider the Chipola slabshell status to be stable.

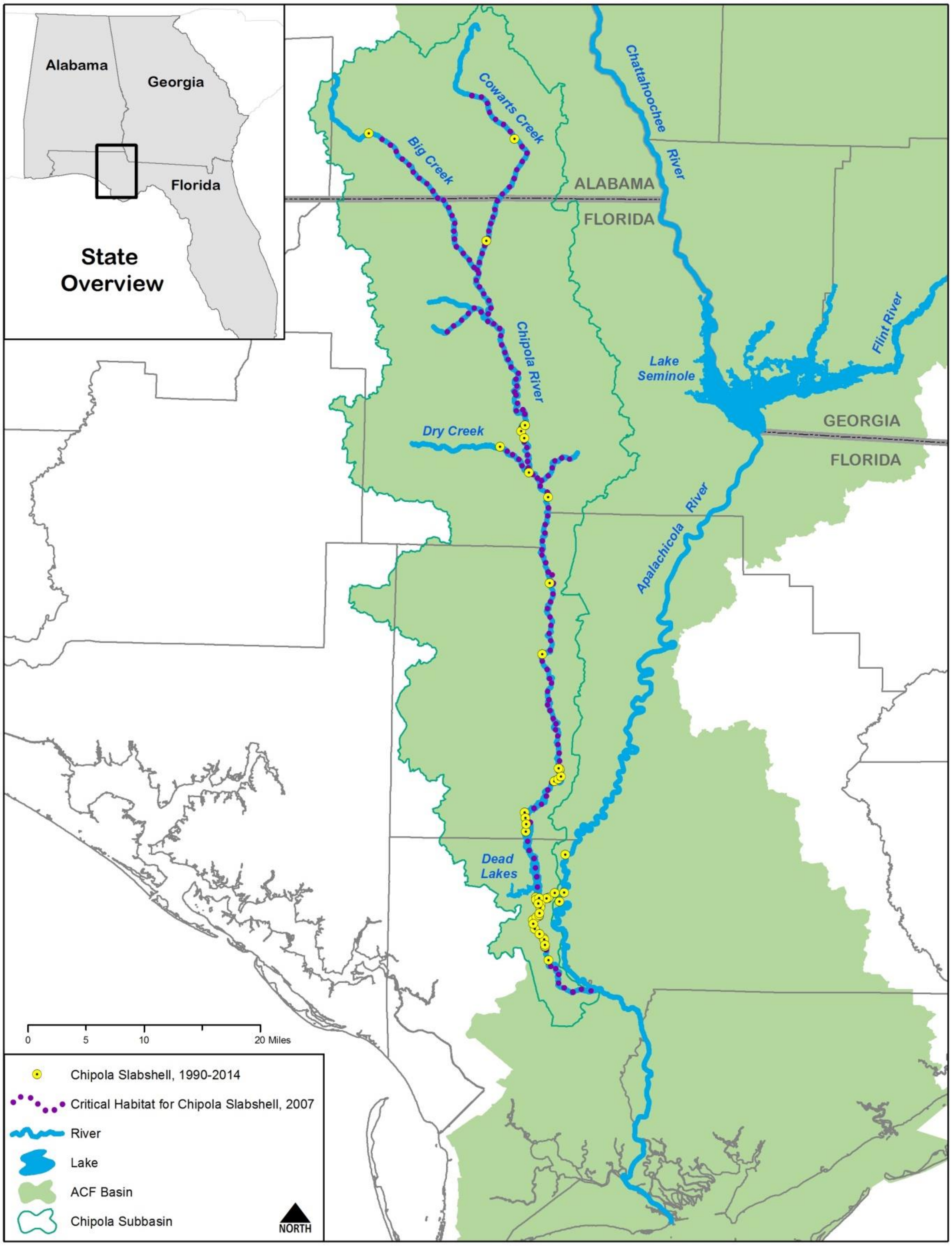


Figure 8.4 Current (1990-2014) occurrences of Chipola slabshell throughout its range.

8.5 Analysis of the Species/Critical Habitat Likely to be Affected for Mussels

This BO addresses effects of the USACE's water management operations under the WCM and the associated releases to the Apalachicola River on the fat threeridge, purple bankclimber, and Chipola slabshell and their designated critical habitats. The Apalachicola River is designated as critical habitat for the fat threeridge and purple bankclimber. It is included as Unit 8 of 11 critical habitat units (USFWS 2007a). Unit 8 includes the mainstem of the Apalachicola River, two distributaries: the Chipola Cutoff downstream to its confluence with the Chipola River and Swift Slough downstream to its confluence with the River Styx; and one tributary: the downstream-most portion of River Styx. Kennedy Creek and Kennedy Slough do not receive flow from the Apalachicola River, but could receive backwater inundation from the river. The Chipola River is designated as critical habitat for the fat threeridge, shinyrayed pocketbook, Gulf moccasinshell, oval pigtoe, and Chipola slabshell. It is part of Unit 2, which includes the Chipola River mainstem and several of its tributaries, including the portion of the Chipola River that is within the action area downstream of Dead Lake and the Chipola Cutoff. Therefore, we limit our analysis of effects to critical habitat to Unit 8 (fat threeridge and purple bankclimber) and Unit 2 (fat threeridge and Chipola slabshell).

9 MUSSELS - ENVIRONMENTAL BASELINE

9.1 Status of the Species within the Action Area

9.1.1 Fat threeridge

Our knowledge of the status and distribution of fat threeridge in the action area has improved in recent years. Recent survey techniques using SCUBA and habitat mapping using side-scan sonar have resulted in much higher estimates of population size, and a better understanding of the habitat for and vertical distribution of fat threeridge (Smit 2014, Smit and Kaeser *in press*). The sonar mapping approach identified twice as many patches and ten times the quantity of suitable habitat than identified using traditional approaches. This BO considers the most current distribution and status information that has been collected since the 2012 BO. The status of fat threeridge is scheduled to be fully reviewed and evaluated in 2019.

9.1.1.1 Current Distribution in the Action Area

Almost the entire currently occupied range of the fat threeridge falls within the action area of this consultation. The current range of the fat threeridge is about 75% of its historical range, and it is locally rare in the upper Apalachicola River (e.g., upstream of RM 90) and locally abundant in middle and lower portions of the Apalachicola River. Two portions of the species' current range are outside the action area: the upstream end of Dead Lake on the Chipola River, and sites on the lower Flint River, may be less affected by USACE actions than other areas. These sites are on the upstream fringe of the species' extant range and likely support a very small percentage of its total population.

Known current locations of fat threeridge in the action area (Figure 8.2) result from recent surveys conducted in the Apalachicola River and its tributaries and distributaries including Miller and Payne (2005, 2006, 2007), EnviroScience (2006a, 2006b, 2011), Columbus State University (Preister 2008), FFWCC (2007, 2011, 2016 unpublished data), Gangloff (2008, 2011), and USFWS (unpublished data, Smit 2014, Smit and Kaeser *in press*). The fat threeridge occurs in the main channels of the Apalachicola and Chipola rivers and near the mouths of a few tributaries and distributaries, with the exception of Swift Slough, where the upper 1.5 miles of the distributary is known to contain fat threeridge (EnviroScience 2006b, USFWS 2012, USFWS unpublished data). During 2012-2015 surveys by Smit (2014) and continued by USFWS staff, 7,454 individuals were collected from the middle (Table 9.1) and lower (Table 9.2) Apalachicola River and lower Chipola River (Table 9.3). The largest portion of the population (61%) occurs in the Chipola Cutoff and lower Chipola River downstream of Dead Lake, and this portion of the Chipola receives about 34% of the flow from the Apalachicola River (Biendenharn 2007); therefore, flows in the Apalachicola River affect flows in the Chipola River and fat threeridge populations in this area. The remaining population occurs in the middle (34%), lower (5%), and upper (<1%) Apalachicola River.

Table 9.1 Mussel species collected during surveys of the middle Apalachicola River in 2012-2014.

			Relative frequency of occurrence			
Species*	Total collected	% freq of total collected	Among samples from IRZ, ORZ, and POB	% freq	Among samples from MC and PB	% freq
Amblema neislerii	3958	0.345	90	0.882	8	0.129
Elliptoideus sloatianus	24	0.002	13	0.127	0	0
Elliptio chipolaensis	1	0.0001	1	0.010	0	0

*Mussels are listed in order of decreasing relative frequency of occurrence among samples collected in the Inner Recirculation Zone (IRZ), Outer Recirculation Zone (ORZ), and Pool/Outer Bend (POB) mesohabitats. The acronyms MC and PB refer to the Mid channel and Pool/Outer Bend mesohabitats, respectively. Each sample represents a collection of mussels within a 10 m^2 radial plot.

Table 9.2 Mussel species collected during surveys of the lower Apalachicola River in 2015.

			Relative frequency of occurrence			
Species*	Total	% freq of	Among	% freq	Among	%

	collected	total collected	samples from SBA		samples from MC	freq
Amblema neislerii	265	0.32	34	0.56	0	0
Elliptoideus sloatianus	2	0.0024	2	0.033	0	0

*Mussels are listed in order of decreasing relative frequency of occurrence among all samples. The acronyms SBA and MC refer to the Smooth/Bank Attached and Mid Channel mesohabitats, respectively. Each sample represents a collection of mussels within either a 5 or 10 m^2 radial plot.

Table 9.3 Mussel species collected during surveys of the lower Chipola River in 2012-2014.

			Relative frequency of occurrence			
Species*	Total collected	% freq of total collected	Among samples from SBA	% freq	Among samples from MC	% freq
Amblema neislerii	3591	0.7011	55	0.89	3	0.3
Elliptio chipolaensis	64	0.0125	18	0.29	0	0
Elliptoideus sloatianus	5	0.0010	3	0.05	1	0.1

*Mussels are listed in order of decreasing relative abundance among all samples. The acronyms SBA and MC refer to the Smooth/Bank Attached and Mid Channel mesohabitats, respectively. Each sample represents a collection of mussels within a 5 m^2 radial plot.

Recently, fat threeridge were found in deeper habitats in depths of up to 5 meters (16.4 ft.) (Gangloff 2011). Smit (2014) and continued work by USFWS (unpublished data) documented that fat threeridge can occur at much deeper water depths. This study is underway and all results are preliminary, but results indicate that some fat threeridge do occur in deeper, stable habitats in the Wewa and Chipola reaches where fat threeridge are known to be abundant (Gangloff 2011). These results indicate that the species may have a greater range of habitat and thus may be relatively less susceptible to mortality during falling water levels.

Smit (2014) and Smit and Kaeser (*in press*) used side-scan sonar to identify the following 5 distinct habitat classes as occurring within the main river channel of the study area in the middle and lower Apalachicola (river mile 65-35): Point Bar (PB), Inner Recirculation Zone (IRZ), Outer Recirculation Zone (ORZ), Mid-Channel (MC), and Pool/Outer Bend (POB) (Figure 9.1; Table 9.4).

Sampling of MC and PB habitats by Smit (2014) and Smit and Kaeser (*in press*) typically resulted in either no mussels (47/62 samples) or very few individuals collected (138 mussels of all species total; 1.2% of total collection). When mussels were encountered in these habitats, *A. neislerii*, was one of the most common. When mussels were found in the MC, the sampling locations were typically very close to a smooth-bedform mesohabitat boundary. Five of the 7 MC samples containing mussels were < 5 meters from a boundary; the maximum distance from a boundary was 7.6 meters. Mussels of all species were commonly encountered in IRZ, ORZ, and POB habitats; 94% of all samples collected from these habitats contained mussels. Total mussel counts (all species) varied widely among smooth/plane bedform habitats, from a low of 0 mussels to a maximum of 1,011 mussels (i.e., 101 mussels/m^2) collected at a single IRZ sampling location.

In August 2016, FFWCC, in cooperation with USFWS, sampled 31 sites at reaches of the lower Apalachicola River that were sampled in 2012 and 2015. Generally, some sites showed densities similar to previous work (e.g., RM 46.3-46.8), while others showed lower densities (e.g., the IRZ and ORZ sampling at RM 42.1-42.6). USFWS staff, in collaboration with FFWCC, plan to continue data collection, analysis, and to compare the mesohabitats.

Table 9.4 Composition of the March 2012 map of mesohabitats along with average depth and substrate observed within habitats during the mussel survey.

Mesohabitat Class*	Total # of polygons	Average area per polygon (ha)	Total area (ha)	% of Total habitat	Average depth (m)	Mean substrate score
Point Bar	49	1.03	50.6	7.3	0.6	3.3
Inner Recirculation Zone	49	0.55	27.1	3.9	1.2	1.7
Outer Recirculation Zone	49	0.34	15.7	2.3	1.2	2.3
Mid-Channel	50	10.0	498.6	71.6	2.3	3.6
Pool/Outer Bend	50	2.1	104.3	15.0	4.3	2.8

*Area values are reported in hectares (ha), and depth in meters (m). The mean substrate score represents the average of all substrate scores associated with samples obtained within a habitat where a score of 1= fines, 2= mix of mud, silt, and fine sand, 3= fine sand, and 4= coarse sand. (Smit 2014)

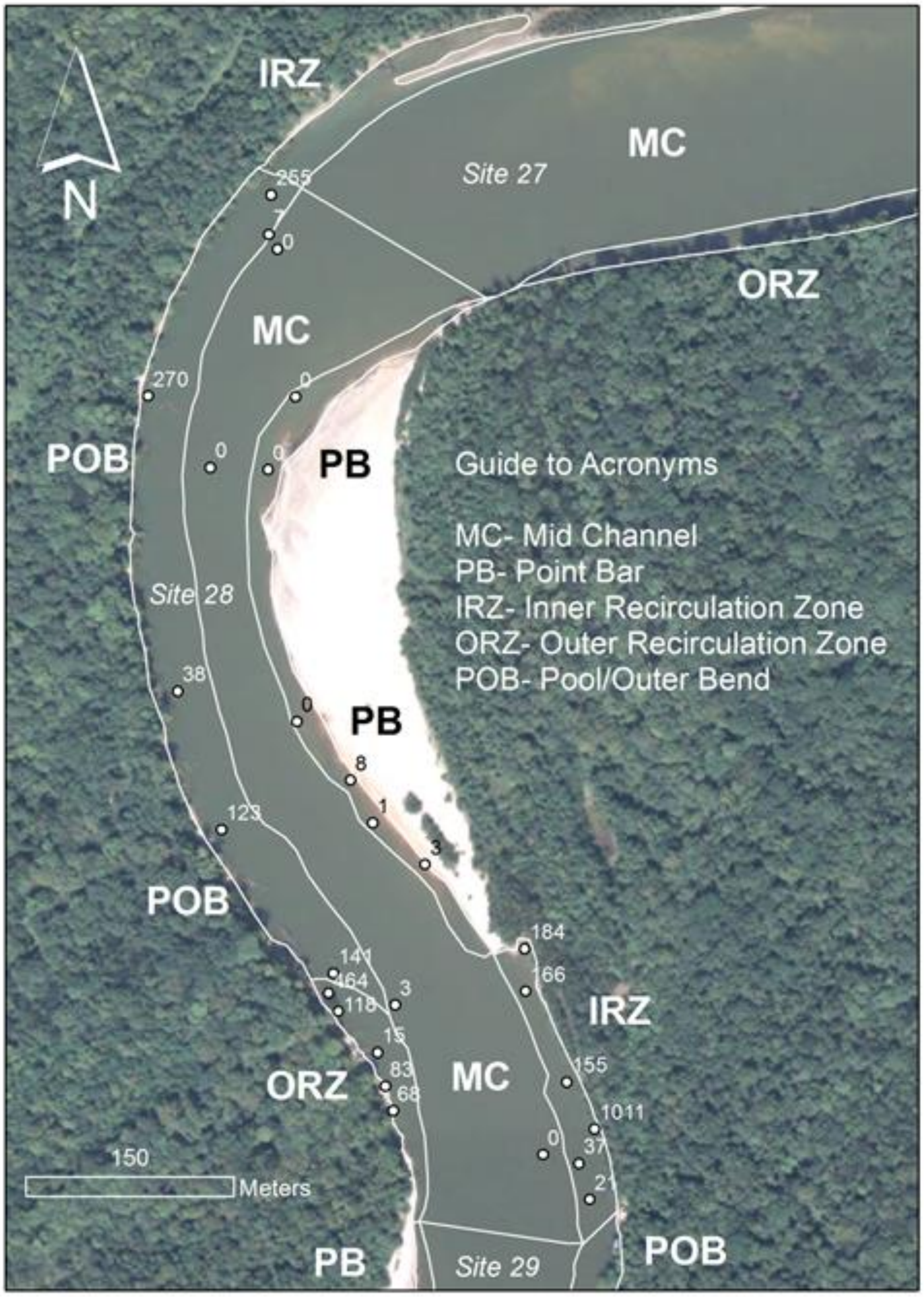


Figure 9.1 Map of sampling site 28 from Smit (2014) and USFWS (unpublished data) showing habitat classes.

9.1.1.2 Population Status and Trends in the Action Area

In the 2012 BO, we provided an estimate of fat threeridge in near-bank habitats, those areas most affected by the operations at Jim Woodruff Dam only. Recent survey techniques using SCUBA and habitat mapping using side-scan sonar throughout the known range in the ACF Basin have increased our knowledge of the population size of fat threeridge (Smit 2014, Smit and Kaeser *in press*). The sonar mapping approach identified twice as many patches and ten times the quantity of suitable habitat than identified using traditional approaches and SCUBA sampling identified high densities of mussels. Fat threeridge was the most abundant mussel in terms of frequency collected of the 18 mussel species detected during surveys (Smit 2014, Smit and Kaeser *in press*). During these 2012-2015 surveys, 7,454 individuals were collected from the lower Chipola River and lower and middle Apalachicola River (Table 9.1, 9.2, 9.3). Recent surveys all reported evidence of fat threeridge recruitment in the Apalachicola River based on size class information (Gangloff 2011, Smit 2014, Smit and Kaeser *in press*).

The highest densities of fat threeridge occur in the lower Chipola River and between RM 27-50 of middle Apalachicola River with mean densities ranging from 2.1 to 11.2 individuals/sq. m, but densities ranged up to 19.5 individuals/sq. m in optimal habitat in the lower Chipola River. Densities varied with habitat class and IRZ, ORZ, and POB generally having the highest densities (Table 9.5). Based on these densities and the area of habitat mapped in each river reach, current estimates of the population size of fat threeridge in the action area range from about 6,009,000 to 18,650,000 individuals, with a mean of approximately 12,167,000. According to the 2015 Annual Report for USACE, incidental take monitoring began under the current RIOP conditions, there has been a cumulative take estimate of 8,374 fat threeridge. For the fat threeridge this represents a total of approximately 0.07% of the population.

Table 9.5 Population estimates based on densities sampled in each habitat (Smit 2014, Smit and Kaeser *in press*).

River	Habitat Class	Mapped area (m^2)	Mean Density	lower 95% CI	upper 95% CI	Population Estimate	lower 95% CI	upper 95% CI
Middle Apalachicola River	IRZ	270,698	4.6	2.0	6.9	1,239,797	527,861	1,867,816
	ORZ	157,183	4.8	3.0	6.4	754,478	474,693	1,007,543
	POB	1,043,241	2.1	1.0	3.0	2,169,941	1,084,971	3,077,561
	PB	505,010	0.1	0.0	1.3	30,301	0	656,513
	MC	4,985,217	0.0	0.0	0.0	0	0	0
	River Total	6,961,349				4,194,517	2,087,524	6,609,433
Lower Apalachicola River	SBA	681,500	0.9			599,720		
Lower Chipola River	SBA	381,803	11.2	6.9	15.6	4,276,195	2,618,406	5,953,074
	POB	281,579	11.0	2.5	19.5	3,097,370	703,948	5,488,539
	MC	1,265,849	0.2	0.0	0.5	202,536	0	632,925
	River Total	1,929,231				7,373,564	3,322,353	11,441,613
Total		9,572,080				12,167,801	6,009,598	18,650,766

As found by Kaeser and Herrington (USFWS 2011), higher exposure rates of fat threeridge mussels occur at flows less than 5,000 cfs. Fat threeridge may move up to 100 cm per day, with a maximum of 2.9 meters to avoid exposure, but shorter distances are typical. Seventy percent of exposed mussels may survive up to 6 days following exposure. Around 8% of fat threeridge may bury completely to avoid exposure and thereby survive up to 27 days. Fat threeridge were observed moving 50-100 cm per day to keep up with falling water levels, but we documented several instances where the individual failed to move downslope, burrowed or became exposed (8%). The majority (70%) of exposed mussels survived between 1 and 6 days following exposure. Mussel mortality occurs at fall rates less than 0.25 ft/day, and slower fall rates will facilitate movement and likely reduce mortality (USFWS 2011). Because the ability to respond to receding water levels is related to bank slope (WDNR et al. 2006, USFWS 2011), a greater number of individuals were stranded at low gradient sites during drawdowns. In general, fat threeridge habitats have slopes of less than 40%, and an average slope of about 25%. Because low slope mussel habitat is a relatively flat plane, a small decline in river stage exposes a broad area of habitat. We found that mussels at sites with a mean slope of <20% were at a much higher risk of experiencing mortality >1% of the local population. Mussel sites in the Chipola River generally have slopes >20%; therefore, mortality appears to be limited in the Chipola River. The mortality due to low flows observed from 2006-2015 may also depend on preceding hydrologic conditions: if flows are high for long periods (2002-2006), then mortality tends to be higher (2% in 2006-2007) and if the high water periods are shorter, then mortality is lower (2008-2010, 2010 mortality <1% of the population).

Fritts and Bringolf (2014) found that while fat threeridge is a host generalist, capable of metamorphosis on many fish, including 27 fish species in 14 families, consistently high success was found only on darters. Fat threeridge has approximately a 25-80% metamorphic success across all species. This work emphasizes the importance of the floodplain habitat for the recruitment of these fish populations and fat threeridge (Dutterer et al. 2012, Burgess et al. 2013). Striped bass (*Morone saxatilis*) were also found to be a host fish for fat threeridge. The ability of fat threeridge to metamorphose robustly on the migratory suggests that population structure may be influenced by long distance dispersal to a greater extent than mussel species that are specialists on more sedentary fish species. Studies of the suitability of other migratory species such as sturgeons, Skipjack Herring (*Alosa chrysochloris*), and Alabama Shad (*Alosa alabamae*) as hosts are needed (Fritts and Bringolf 2014).

Considering the recent information, the fat threeridge population in the action area appears stable and may be increasing in size. Fat threeridge are abundant in the middle Apalachicola and the lower Chipola rivers. Additional work in the lower Apalachicola River is ongoing and needed to refine population estimates.

9.1.2 Purple bankclimber

9.1.2.1 Current Distribution in the Action Area

About 23% of the currently occupied range of the purple bankclimber (104.6 river miles) falls within the action area of this consultation, where it is currently known from about 35 locations (Figure 8.3). Purple bankclimber occur primarily in the main channel of the Apalachicola River from the Woodruff Dam (RM 106) downstream to RM 17.7. The species has also been collected in the Chipola River (below Dead Lake), the Chipola Cutoff, Swift Slough, River Styx, and a distributary that flows into Brushy Creek.

Information about current distribution is based on recent collections by Miller, EnviroScience, the FFWCC, the USFWS, and Gangloff. In these surveys, as in previous surveys of the action area (Brim Box and Williams 2000), bankclimbers were found to be locally abundant at Race Shoals, a long limestone outcropping in the upper Apalachicola River near RM 105, but somewhat rare and sporadic from RM 22 to 103. By far, the majority of individuals collected in the action area are from the upper river. Very few individuals have been collected in the lower Chipola River (below Dead Lake), the Chipola Cutoff, Swift Slough, or the River Styx. The status of purple bankclimber is scheduled to be fully reviewed and evaluated in 2019.

The purple bankclimber is characterized as preferring the deeper portions of main channels, often at depths greater than 3 m (10 ft), in larger rivers (Brim Box and Williams 2000). One exception is a flat area at the north end of Race Shoals, which becomes quite shallow in low flow, where bankclimbers are often found in depths of less than 0.5 m. Because deep-water habitats have not been adequately sampled for listed mussels, we contracted dive surveys in the deeper portions of the Apalachicola and Chipola main channels. This study found purple bankclimbers in depths ranging from 0.5 to 5 meters (1.6 to16 ft) relative to the water surface (Gangloff 2011). FFWCC surveys near Race Shoals similarly found purple bankclimbers at depth ranges of 0 to 4 m (0 to 13 ft), and most were at depths of 0.6 m (2 ft) or less (FFWCC unpublished data). Both surveys were conducted when water levels were very low (4,400 and 5,140 cfs, respectively). Gangloff's surveys were conducted during the inadvertent release of less than 5,000 cfs in May and June of 2011.

9.1.2.2 Population Status and Trends in the Action Area

We do not have complete population estimates for the purple bankclimber in the entire action area or sufficient length-at-age data from which to infer population structure, annual survival rates, or year class strength. This is mainly because purple bankclimber occur sporadically and in relatively low numbers, in deeper habitats. For example, no purple bankclimber were collected in the quantitative surveys by Gangloff (2011) of near shore habitats at depths less than 2 m, despite collecting over 8,400 mussels. Therefore, much of the available data has typically been qualitative and only catch-per-unit-effort data is available. This qualitative data suggests that the purple bankclimber may be one of the rarest members of the Apalachicola River mussel fauna, as it comprised less than 2% of the total mussels sampled between the years 1996 to 2007 (Miller and Payne 2005, EnviroScience 2006a, Smit 2014, USFWS unpublished data).

Surveys by Gangloff in June 2011 provide some quantitative data for the Race Shoals area, the expected location of the majority of the population in the action area. The study sampled near-shore and deep-water habitats along the long limestone outcropping on the left descending bank. Flows were very low (4,400 cfs) at the time of the surveys and a few purple bankclimbers had become exposed just prior to the survey. The study site is approximately 580 m in length and the width of the habitat averaged 141 m, resulting in a total habitat area of about 81,780 m^2. The deep-water habitat comprised about 63% of the total area. Right-bank habitats were not sampled and this habitat is included in the shallow-water habitat estimate. Initially, a dredge was used to sample 0.25 m^2 quadrats in shoreline transects, but proved too time consuming, and a timed search of a discrete area was used instead. For near-shore habitats (<1.5 m deep) 2-m wide linear transects placed perpendicular to the bank were searched, and in deeper water habitats, radial transects (area = 19.5 m^2) were searched. The mean density of purple bankclimbers in near-shore transects was 0.17 m^2 and the mean density in deep-water transects was 0.48 m^2. Extrapolating from these densities across the total area of the shoals produces an estimate of 24,984 bankclimbers in deep water habitats and 5,127 bankclimbers at depths <1.5 m on the left bank, and an estimated 30,111 purple bankclimbers within the survey reach, 95% of which, were in deeper (>1.5 m) portions of the channel. This estimate may vary depending on the density of purple bankclimbers in the unsampled right-bank habitats.

No population estimates are available for other areas of the Apalachicola main channel. Very few individuals have been collected in the lower Chipola (below Dead Lake, the Chipola Cutoff, Swift Slough, or the River Styx. In total, 13 purple bankclimbers were recently collected from these areas altogether during these surveys. Only 31 individuals were collected during 2012-2015 surveys of the middle and lower Apalachicola and lower Chipola River (Table 9.1, 9.2, and 9.3). According to the 2015 Annual Report submitted to the USFWS, since incidental take monitoring began under the current RIOP conditions, there has been a cumulative take estimate of 40 purple bankclimbers.

Recruitment in the species appears to be occurring at very low levels. Only eight relatively small (<100 mm) purple bankclimbers have been collected in the action area recently. Five of these were found during the June 2011 surveys by Gangloff (3 RM 47, 1 Chipola, 1 Race Shoals). Sizes ranged from 29 to 93 mm (Gangloff 2011), and based on known-age individuals, all are probably at least three years old. The lack of young individuals suggests either poor reproductive success or sampling methods that are not suited to detecting juveniles of this species.

We have no evidence that purple bankclimber move to avoid exposure. We conducted a purple bankclimber movement study at Race Shoals while flows were less than 5,000 cfs in November and December of 2007. A total of 46 bankclimbers were collected and tagged in the flat upstream portion of the shoal. FFWCC also separately collected and tagged 93 additional bankclimbers in approximately the same location. We and FFWCC returned to this location separately to assess movement of tagged individuals and found no evidence of movement for almost all of the recaptured tagged bankclimbers. A few individuals were relocated less than a foot from their original tagging location, but we later learned that FFWCC may have inadvertently moved these during their sampling. Substrate in these areas consists of a shallow and unconsolidated layer on top of limestone. This firm substrate may explain why many shoal bankclimbers are found lying on their side; once in this position these large mussels are unable to upright or move.

Purple bankclimber mortality occurred at several sites in the Apalachicola River and Swift Slough during the low flows of 2006-2007, although the extent of the mortality in 2006 was not adequately quantified. In 2007, when releases were less than 5,000 cfs at the Chattahoochee gage, the USACE implemented surveys to estimate listed mussel mortality associated with the flow reductions. No purple bankclimber were observed to be fully exposed in habitat areas surveyed during the monitoring effort; therefore, the USACE estimated that no purple bankclimber take resulted from the reduction in flow. After the USACE's surveys, the FFWCC found that at least three had died at the shoal in December of 2007.

In 2008, we observed a large die-off of Asian clams (*Corbicula fluminea*) at Race Shoals which resulted in dead Asian clams floating into shallow areas where purple bankclimbers were present. This area of the Apalachicola has an extremely high abundance of Asian clams, a species which is intolerant of low DO and high temperatures. There may have been some effects associated with poor water quality that resulted in purple bankclimber mortality, however, these effects are difficult to assess. Also, in the summer of 2008, we relocated some of the 46 bankclimbers tagged for the movement study in 2007. Eight had died during this time, although the cause is unknown.

A single site visit to the Race Shoals area, when flows were around 5,500 cfs, revealed numerous purple bankclimbers in shallow water, but no exposed or dead individuals. On this visit, as in others, the limestone outcropping was littered with the shells of several species. During the September 2010 visit, we observed dozens of bankclimber and washboard shells that were smashed open. When water levels are low, anglers harvest purple bankclimbers and other species for use as bait.

Purple bankclimbers were exposed and mortalities occurred in 2011 when Woodruff releases were below 5,000 cfs at the Chattahoochee gage. On three visits to the Race Shoals area during the period of June 6-16, five freshly dead purple bankclimbers were discovered. Three of these were as a direct result of exposure, and were found very near the water margin. The other two had apparently been harvested for bait, either that day or the day before. The USACE provided an estimate of purple bankclimber take based on Gangloff's quantitative study. They estimate that 39 bankclimbers were killed during the June 2011 low-water event. However, this take estimate is based on only one dead individual. Combined, the amount of observed take was six individuals. Since all dead individuals were within the reach of Gangloff's study, we used his population estimate to examine mortality, and estimate that much less than 1% of the population within the reach perished, regardless of which mortality count is used. No other purple bankclimber mortality was observed in the action area in 2011. We did not quantify take on the right descending bank so it is unknown if bankclimbers were exposed on this bank. We observed only two harvested purple bankclimbers during our visits; however, this number may be much higher. Gangloff noted that anglers were very active (10-20 observed every day) during his surveys at the shoals and were using exposed mussels for bait. Although anglers appeared to primarily use *Corbicula*, fractured shells indicated that some native mussels were also used for bait.

Although the population of purple bankclimbers at the shoal is relatively large, the species is apparently rare in the rest of the river and may be experiencing poor recruitment. However, more surveys are necessary in stable, deep water habitats throughout the river to more fully understand the population's status in the river.

9.1.3 Chipola slabshell

9.1.3.1 Current Distribution in the Action Area

About 14% of the currently occupied range of the Chipola slabshell area (13.8 river miles) falls within the action area of this consultation, where it is currently known from about eight locations on the lower Chipola River (downstream of Dead Lake) and from three locations on the Apalachicola main channel (Figure 8.4). Since 2010, live individuals and one shell (fresh dead) have been collected in the Apalachicola River main channel. The status of Chipola slabshell is scheduled to be fully reviewed and evaluated in 2019.

9.1.3.2 Population Status and Trends in the Action Area

We do not yet have enough data to make an accurate population estimate for the Chipola slabshell in the action area. The survey conducted by Gangloff provided a population estimate of 2,645 slabshell in bank margin habitats <2 m deep (USFWS 2012). This estimate, however, is based on only 10 individuals collected at two sites. Individuals were collected from depths >0.5 m in 2008 when flows were low and at depths > 1 m in 2010 when flows were higher.

A survey conducted in 2011 in a small boat ramp basin on the Chipola River prior to dredging the basin yielded a total of 21 Chipola slabshell. It is possible that this species (and/or its fish hosts) utilizes slow-flowing habitats more than previously understood.

Both studies found variation in sizes. In the quantitative survey by Gangloff, lengths ranged from 22.1 to 56.4 mm; and individuals from the boat ramp basin location ranged from 31.0 to 60.5 mm. We do not have length-at-age data for Chipola slabshell from which to infer the age of these mussels, however, presence of small individuals and a variety of sizes likely indicates that Chipola slabshell are reproducing.

Only 65 individuals were collected during 2012-2015 surveys of the lower Chipola River and middle Apalachicola River (Table 9.1 and 9.2). According to the 2015 Annual Report submitted to the USFWS, since incidental take monitoring began under the RIOP conditions, there has been a cumulative take estimate of 24 Chipola slabshell.

We found no evidence of Chipola slabshell mortality at flows above 5,000 cfs during surveys of the Cutoff during 2006, and no mortality was reported in the Chipola River in 2006 or 2007. In addition, none were found exposed or dead in any of the recent low water events occurring in 2010 or 2011, even when flows were less than 5,000 cfs in 2011. The USACE estimated that no Chipola slabshell take resulted from the reduction in flows below 5,000 cfs in 2011.

The lack of mortality may be attributed to its selected depth and ability to move. Members of the genus *Elliptio* have smooth and relatively thin shells, shell characteristics associated with an ability to move more easily (Watters 1994). Another factor that may explain the lack of mortality is that bank slopes are generally >20% in the Chipola River. As explained in Appendix A, we believe these higher slopes also explain why little fat threeridge mortality has been observed in the Chipola River. Finally, water levels may not drop as quickly or as much in the lower Chipola River as flow declines from Woodruff are attenuated by tributary discharges from the Chipola main channel.

9.2 Status of the Critical Habitat within the Action Area

This portion of the environmental baseline section focuses on the designated critical habitats for the listed species, describing what we know about the physical and biological features that are essential to the species' conservation within the action area.

The entire length of the Apalachicola unit designated as critical habitat for the fat threeridge and purple bankclimber is within the action area. The downstream-most 13.8 miles of the Chipola unit designated as critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell is within the action area. The action area contains all of the PCEs that we described as features of occupied critical habitat that are essential to these species' conservation. The following is a summary of what is known about the status of these PCEs in the action area.

9.2.1 Channel Stability

> *A geomorphically stable stream channel (a channel that maintains its lateral dimensions, longitudinal profile, and spatial pattern over time without an aggrading or degrading bed elevation);*

Studies of freshwater mussels have found that mussel distributional patterns are influenced by river bed stability (e.g., Vannote and Minshall 1982, Strayer and Ralley 1993, di Maio and Corkum 1995). Generally, mussels can withstand some changes in the river bed due to floods by burrowing deeper into the bed (di Maio and Corkum 1995). On the River Kerry in Scotland, Hastie et al. (2001) found that a large number of mussels were moved and killed following a flood. However, upon further inspection of previously surveyed sites, they found that most of the mussel population had survived, and that mortality was highest in geomorphically unstable portions of the river.

We summarized channel morphology changes in the Apalachicola River previously and have no indication that channel morphology has changed in general (USFWS 2012). USACE agreed to provide access to cross-sectional data as it was available from USGS (USACE, Mobile District, Brian Zettle, pers. comm., 6/21/16). Entrenchment following dam construction and various activities associated with the federal navigation channel, such as dredging, snagging and the construction of dike fields, changed channel stability, and likely reduced habitat availability for the fat threeridge, as it is now rare in the upstream-most 30 miles of the river (Layzer and Scott 2006). In the RM 35-50 reach channel instability related to water diversion into the Chipola Cutoff and recovery from maintenance dredging may be affecting mussel habitat and contributing to stranding, especially in Swift Slough, which occurs in an area that required regular maintenance. We believe this reach remains unstable and susceptible to substantial changes as the river reaches equilibrium relative to the Chipola Cutoff. However, most of the river does not likely share this characterization. The USACE's dredging records show that since 1992, 84.1 miles of the 105.4 miles between Woodruff Dam and RM 1.0 were not dredged, suggesting that these portions of the river transport the sediment they receive without substantial aggradation, though remain slightly entrenched from past navigation dredging spoil along the banks.

The overall amount of stable riverine habitat available for the listed mussels may vary from year to year due to the dynamic nature of the river. Our observations in the RM 40-50 reach in 2010 and 2011 indicate that the depositional habitat downstream of large point bars has shifted downstream since 2007, which is consistent with patterns of actively meandering rivers. As a meander bend of the channel migrates downstream, the point bar upstream of the bend moves with it. The bar migrates downstream with aggradation of sediments at the downstream end of the bar. It appears that the redistribution of habitat is not changing the overall quantity of habitats, but geomorphic monitoring should quantify the relative rates of aggradation and degradation at micro-, meso-, and reach-scales along the Apalachicola River.

Many changes in the channel affect individual mussels, but conservation of the species depends on sufficient stable instream habitat. Strayer (1999) suggested that mussels might generally be found in areas with stable habitat at flows with 3 to 30 year recurrence intervals. Morales et al. (2006) developed a model to predict substrate stability that coincided with reported mussel locations. They noted that large areas that seemed stable under low flow conditions have active sediment motion at high and medium flows that would render the locations unsuitable for mussels. They hypothesized that annual peak flows most often limit the spatial distribution of freshwater mussel communities. The concepts developed by Morales et al. suggest to us that the moderately depositional areas that support fat threeridge mussels remain stable during high flows. Recent survey data documenting fat threeridge and purple bankclimber mussels in deep-water habitat (Gangloff 2011, Smit 2014, Smit and Kaeser *in press*) suggests that mussels are capable of finding or seeking refuge within this habitat during high flow conditions, perhaps by burrowing or by occupying microhabitat refugia created by submerged woody debris. It is possible that the observed changes in annual peak flows have reduced the available stable habitat, but the relative amount is unknown. Additional channel morphology and sediment transport studies of the Apalachicola could estimate the amount of stable mussel habitat and how it changes with time and with changes in flow regime.

The river channel in Unit 8 (Apalachicola River) appears to be continuing to change (Light et al. 2006, Price et al. 2006) as meander bends migrate down-valley. At this time, we are unable to quantify the amount of stable habitat or the rate of change that might alter the status of the mussel beds found in the river. Based on the species persistence in the river during past periods of instability affecting the entire river, we believe that sufficient stable instream habitat exists in the main channel of Unit 8 for the conservation of the species, though limited in the upper reach nearest Woodruff Dam. There is no specific information available for Unit 2 (Chipola River); however, we are unaware of any factors that may change channel stability and limit the ability of the critical habitat to function for the conservation of the species, since this stream is not regulated and the past effects of the Dead River sediment discharge have stabilized.

9.2.2 Substrate

A predominantly sand, gravel, and/or cobble stream substrate.

We describe the substrate and habitat preference for all three mussel species in previous sections. As described above, mussels need stable substrates. Because substrate stability and channel stability are interrelated, the substrate in the critical habitat units is affected in the same manner as described above. More information is needed to quantify the amount of stable substrate and the rate of change that might affect the quality of mussel habitat. Based on the current distribution of mussels and the new data collected showing occupation of pool/outer bend habitats by mussels (Gangloff 2011, Smit 2014, Smit and Kaeser *in press*), we believe that substrate condition and stability in units 2 and 8 are sufficient for the conservation of the species. We are unaware of specific substrate alterations that may limit the ability of the critical habitat to function for the conservation of the species.

9.2.3 Permanently flowing water

Permanently flowing water.

Although highly regulated, the main channel of the Apalachicola River has consistently contained permanently flowing water, but loop streams, backwaters, tributaries, and distributaries require specific discharges to retain connectivity to the main channel. Flowing water is important because it transports food items to the sedentary juvenile and adult life stages, provides oxygen for mussel respiration, and with enough depth, it provides protection from terrestrial predators. Flowing water is also likely essential for reproduction through suspension of glochidia or conglutinates (O’Brien and Williams 2000). Above normal flows can affect overall recruitment and where juvenile mussels settle (Hardison and Layzer 2001). The magnitude and duration of flows can have a long-term effect on population dynamics (Vannote and Minshall 1982, di Maio and Corkum 1995).

This constituent element is also necessary for host fishes that spawn in the floodplain. According to Light et al. (1998, 2006) and analyses presented in this BO (see Appendix A), the frequency and duration of main channel-floodplain disconnections has increased over time, and these disconnections are exacerbated by low flows associated with droughts (Walsh et al. 2006). There has been about a 25% reduction in floodplain habitat available to spawning fish during April and May. See subsequent sections for additional analysis regarding abundance of host fish.

Mussels will survive and reproduce best in specific areas that consistently provide all of the PCEs, but do not necessarily persist permanently in any one area given the dynamic nature of the riverine environment. Interrupted flow due to the accumulation of sediment in the bed of Swift Slough recently led to substantial mortality of listed mussels during periods of low-flow in the Apalachicola River (USFWS 2012). Stream bed aggradation in Swift Slough signals the need for special management of the channel stability PCE in at least the Swift Slough portion of the Apalachicola River. Because the area at the inlet of Swift Slough continues to aggrade, we do not know the exact current flow necessary to keep Swift Slough connected to the main channel. A recent site visit indicates that it was still connected at a Wewa gage height of 11.65, which corresponds to a Chattahoochee flow of around 5,460.

Because mussels inhabit the river margins and are often found in shallower areas, permanently flowing water is also an issue in the main channel, especially when flows decline and there is an obstacle to movement such as in a shallow sand bar or low site slope. The elevations where mussels are found along the river margin in any particular year may be influenced by hydrological conditions prior to the survey (USFWS 2012). Therefore, we expect that continued mortality resulting from low flows will occur at flows above 5,000 cfs when hydrologic conditions allow for movement of mussels into higher bank elevations. We also continue to expect mortality at flows less than 5,000 cfs if composite storage reaches the drought zone and the minimum flow is 4,500 cfs.

Although the low flows in 2006-2008 and 2010-2011 have resulted in areas without permanently flowing water that exhibited mussel mortality, we do not believe that the low flows have permanently limited the designated critical habitat to function for the conservation of the species in Unit 8 or Unit 2. Our data illustrate that mussels recolonize these areas (including Swift Slough), and the habitat is not permanently lost.

9.2.4 Water quality

> *Water quality (including temperature, turbidity, dissolved oxygen, and chemical constituents) that meets or exceed the current aquatic life criteria established under the Clean Water Act (33 U.S.C. 1251-1387).*

A wealth of evidence supports the dependency of the mussels on good water quality. As animals with limited mobility, mussels must tolerate the full range of water quality parameters to persist in a stream. Most mussels are considered sensitive to low dissolved oxygen (DO) levels, high temperatures, and unionized ammonia (Fuller 1974, Johnson et al. 2001, Sparks and Strayer 1998, Augspurger et al. 2003). The Florida Department of Environmental Protection (FDEP) Water Quality Assessment Report for the Apalachicola River system described the river's water quality (FDEP 2005). Although based on a limited number of water quality sampling stations and somewhat dated, the basin has relatively good water quality. This has been attributed to a low urban and industrial growth rate, the large floodplain, and large areas of forested public lands (FDEP 2005).

Although the basin generally has good water quality, the 2005 Water Quality Assessment identified potential impairments in the action area for biology, coliforms, DO, turbidity and potentially unionized ammonia and other nutrients (FDEP 2005). As a result, several segments of the Apalachicola River area are included on the Verified List of Impaired Waters that failed to fully meet their designated uses. The sources of the nutrient loadings may be related to the violations of the water quality standards observed for coliforms, DO, and unionized ammonia

(FDEP 2002). Elevated coliform bacteria counts are not known to harm freshwater mussels; however, elevated unionized ammonia and low DO are associated with adverse effects to fish and mussels (Secor and Niklitschek 2001, Fuller 1974, Sparks and Strayer 1998, Johnson et al. 2001, Augspurger et al. 2003). Mercury-based fish consumption advisories have been issued for portions of the river, and organochlorine pesticides have previously been found at levels that have exceeded chronic exposure criteria for the protection of aquatic life (FDEP 2002, Frick et al. 1998), but these have not been linked to impacts on these species in the Apalachicola River to date. Both point and non-point sources of pollution have reportedly contributed to these water quality impairments in the Apalachicola River (FDEP 2005).

State water quality assessments are based on Florida's water quality standards. Generally, State standards, adopted to be consistent with or more stringent than the U.S. Environmental Protection Agency (EPA) water quality criteria, generally represent levels that are safe for mussels. The currently available data indicate that most numeric standards for pollutants and water quality parameters (for example, dissolved oxygen, turbidity and pH) represent levels that are essential to the conservation of these species; however, current EPA criteria for copper and ammonia are not protective of mussels (USFWS 2007b). The USFWS is currently in consultation with the EPA to evaluate the protectiveness of some criteria for threatened and endangered species and their critical habitats as described in the Memorandum of Agreement that our agencies signed in 2001 (66 FR 11201, February 22, 2011).

Other factors that can episodically influence the attainment of water quality standards include droughts, heavy rains and resulting nonpoint-source runoff from adjacent land surfaces (e.g., excessive amounts of sediments, nutrients, or pesticides), errant point-source discharges from municipal and industrial wastewater treatment facilities (e.g., excessive amounts of ammonia, chlorine, and metals), accidental spills, or unregulated discharge events. For this reason, the State's water quality monitoring program includes measures for monitoring and enforcement to achieve attainment of designated uses (meeting water quality standards) in State waters. Of particular relevance for this BO is the influence of drought conditions when flows are depressed and pollutants are more concentrated.

Most mussels are considered sensitive to low DO levels and high temperatures (Fuller 1974, Johnson et al. 2001, Sparks and Strayer 1998). Higher water temperatures also result in lower dissolved oxygen potential. Walsh et al. (2006) reported that the middle reach of the main channel of the Apalachicola River had relatively low DO, and the lowest yearly DO values occurred during mid- to late summer (July to September) when temperatures were highest and flows were lowest (Walsh et al. 2006). The authors also reported a negative relationship between DO and decreased flow and connectivity in distributaries to the main river.

Sensitivity to low DO and high temperature may be particularly pronounced during drought. A study conducted in the Flint River basin during the 1999-2002 drought found there was accelerated mussel mortality as DO levels dropped below 5 mg/L, and DO levels between 0 and 3 mg/L resulted in variable mortality up to 76% (Johnson et al. 2001, Golladay et al. 2004). We have limited water temperature and DO data from recent droughts in 2006-2008 and 2010-2011, and it varies by location. Water quality data from Swift Slough indicate that DO and water temperature varied in isolated, stagnant pools from 0.9-6.7 mg/L and from 20.9-31.1°C (70-88°F), respectively (FFWCC unpublished data). Swift Slough is relatively shaded and receives ground water input. In shallow backwater areas on the main channel, DO was relatively high when measured in the middle of the day (7.7 mg/L to 7.9 mg/L); however, water temperature was very high (33-41°C (92-106°F) (FFWCC unpublished data; USFWS unpublished data). Mid-day DO was also high (7.4-11.0 mg/L) in isolated pools containing purple bankclimbers on Race Shoals at RM 105, but water temperatures were cooler ranging from 21-28°C (70-83°F) resulting from observed groundwater seepage. Our temperature records from the summer of 2011 showed a substantial difference between water and air temperatures experienced by mussels during the 2011 exposure event. Water temperatures were between 27-32ºC (81-90°F) during the study, but air temperatures (experienced by mussels exposed on river banks) reached daily maximums of approximately 38ºC. Mussel mortality that may have resulted from low DO and/or high temperatures was observed in the water at all of these locations.

Low DO concentrations during droughts may also be further reduced in response to the decay of soft organs of dead mussels. For instance, the invasive Asian clam (*Corbicula fluminea*) is intolerant to drought conditions and further exacerbates hypoxic conditions (McMahon 1979, Johnson et al. 2001). In the presence of the Asian clam, DO levels are lowered at an accelerated rate, and may contribute to increased competition amongst unionids for limited supplies of DO (Johnson et al. 2001). Many study sites along the Apalachicola have extremely high abundance of Asian clams, and low DO levels during drought conditions are likely to be exacerbated by mortality of Asian clams. We observed this phenomenon at Race Shoals where a summer die-off resulted in massive numbers of dead, floating Asian clams being washed into shallow areas where purple bankclimbers were present (USFWS unpublished data). FFWCC (2011) noted a personal observation from Greg Zimmerman (EnviroScience) where an Asian clam die-off appeared to be associated with suspected poor water quality that may have resulted in purple bankclimber mortality at Race Shoals.

Spawning may also be affected by high water temperatures, as seen in 2006 when fat threeridge were observed expelling glochidia in the absence of fish hosts at high water temperatures. The fat threeridge spawning period begins when water temperatures are 23°C $\pm$ 1.5°C (Brim Box and Williams 2000). USGS has recorded water temperature intermittently at the Chattahoochee gage. Records were available from 1974-1978 and 1996-1997, which range from average to high flow years. Using these data, the mean date by which water temperature rises to 21.5°C was May 1 (range: April 5 to May 14) and to 24.5°C was May 22 (range: April 14 to June 30). Some spawning in 2006 and 2007 was probably still underway when water temperatures in the very shallow areas exceeded 30°C, which may have resulted in reproductive failure in some individuals.

Low DO and high temperatures occur in the action area during periods of low flows. While these temporary changes in water quality do not permanently limit the designated critical habitat, they are modification that could negatively affect the conservation of the species in Unit 8 or Unit 2.

9.2.5 Fish hosts

> *Fish hosts* (*such as native basses, sunfishes, minnows, darters, and sturgeon*) *that support obligate parasitic larval life stages of the mussels.*

The distribution and diversity of unionids is strongly related to the distribution and diversity of fish species (Watters 1992, Haag and Warren 1998). Bogan (1993) identified the dependency of mussels on fish hosts as one of several contributing causes in the extinction of several unionid species worldwide. Host fish availability and density are significant factors influencing where certain mussel populations can persist (Haag and Warren 1998), and simulations of fish-mussel interactions indicate that mussel populations are extirpated if a threshold host fish density is not exceeded (Watters 1997). Challenging this threshold density, riverine fish populations in the Southeast have been adversely affected by the same habitat alterations that have contributed to the decline of the mussel fauna (Etnier 1997, Neves et al. 1997, Warren et al. 1997). As described by Dutterer (2011), the structure of biotic communities in lotic (flowing) environments is strongly influenced by streamflow (Poff and Ward 1989, Poff et al. 1997), including species distribution (Stanford and Ward 1983, Rogers et al.2005), growth (Sammons and Maceina 2009), reproduction (Smith et al. 2005), and mortality (Tramer 1978). A growing body of research has described aquatic ecosystem responses to modified streamflows (Murchie et al. 2008).

Successful host fish trials have been conducted for all three mussels (Fritts and Bringloff 2014). Potential host fishes for these three mussel species that occur in the action area include the weed shiner, bluegill, redear sunfish, redbreast sunfish, largemouth bass, eastern mosquitofish, blackbanded darter, and Gulf sturgeon. With the exception of the fat threeridge, it is not known whether these species are host generalists or specialist. The fat threeridge is considered a host-fish generalist. Watters (1997) found that generalists attained higher population sizes than specialists when host fish density was high, but declined when host fish density declined. However, Haag and Warren (1998) found that densities of host-generalist and host-specialist mussels with elaborate host-attracting mechanisms were independent of host-fish densities.

The FFWCC monitored the fish assemblage in the main channel of the Apalachicola River at four fixed stations from 1984-1993 and 2000-2003. Data from these boat electrofishing surveys were taken from the summary provided by Walsh et al. (2006). One of the four monitoring stations was in the middle reach of the Apalachicola River (RM 37.5 to 40.9). Because this general area of the Apalachicola River has the highest main channel abundance of the fat threeridge, we focused on data from this station. All five known fat threeridge host fish species were collected here from 1984-1993 and 2000-2003. When data from all years are combined, all fat threeridge host fish were considered dominant species. The weed shiner was the most abundant species collected (28.2% of the total catch), and bluegill was the third most abundant species collected (10.4%). The blackbanded darter was rarely encountered (0.7% composition), but that is not surprising given the collection method, as small benthic fishes are difficult to capture via electrofishing in a large river. These data indicate that known fat threeridge host fish are present in the main channel in areas where the mussels occur, and, with the possible exception of the blackbanded darter, they comprise relatively large proportions of the fish assemblage (particularly weed shiners and bluegills).

Gulf sturgeon are also known to occur in the main channel of the Apalachicola River. Although the population is relatively small, it is currently believed to be slowly increasing relative to levels observed in the 1980s and early 1990s (Pine and Allen 2005). Their primary spawning site at Race Shoals (RM 105) also has the largest known purple bankclimber population of about 30,000 individuals, potentially resulting from frequent contact with host fish delayed by lack of passage at Woodruff.

Although mussels are not generally found in seasonally dry floodplain habitats, their host fish species are likely to use floodplain habitats during flood events, and as previously mentioned, mussel population viability is likely dependent on fish host population density. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes (Guillory 1979, Welcomme 1979, Kilgore and Baker 1996, Raibley et al. 1997, Gutreuter et al. 1999, Ribeiro et al. 2004). For example, the largemouth bass is known to use seasonally inundated floodplain habitats for spawning and rearing (Kilgore and Baker 1996). Walsh et al. (2006) documented 64 species of fishes (including all five known fat threeridge host species) using floodplain habitats in the middle reaches of the Apalachicola River and demonstrated the importance of these habitats for spawning adults and young-of-the-year fishes.

The FFWCC and USGS (Walsh et al. 2006) monitored the fish assemblage in floodplain habitats (i.e., loop streams, backwaters, tributaries, and distributaries) in the middle reach of the Apalachicola River using backpack and boat electrofishing from 1983-1985 (FFWCC) and 2001-2004 (USGS). Results of sampling indicate that bluegill, largemouth bass, and redear sunfish were common in Poloway Cutoff, Iamonia Lake, Florida River, and River Styx. Weed shiner and blackbanded darter were not detected at these locations by the FFWCC in 1983-1984. From 2001 to 2004, bluegill, weed shiner, and largemouth bass were common. Redear sunfish and blackbanded darter were not as common, but they were collected.

Results from Walsh et al. (2006) confirm that three components of the hydrologic cycle are especially important for Apalachicola River fishery resources: the timing, extent, and duration of floodplain inundation immediately preceding, during, and following the spawning, early growth, and survival phases. For instance, young-of-year bluegill and weed shiners were collected in the floodplain over an extended period of time (March to September), indicating prolonged spawning periods. These species are characterized as floodplain exploitative species, which often have breeding seasons that extend well beyond the time of spring flooding (Ross and Baker 1983, Walsh et al. 2006). Therefore, flow connectivity for some portion of the floodplain or adjacent shallow-water, main-channel habitat may be beneficial to fish reproduction in the summer months, beyond the typical spring spawning months. Results of analyses presented in section 6 indicate that floodplain connectivity is substantially lower since the construction of dams in the ACF Basin, due primarily to channel morphology changes.

A subsequent Apalachicola River assessment by Dutterer et al. (2011), further established that better reproductive years for host fish species were related to higher flows for river influenced habitats, as previously was reported for rivers (Bonvechio and Allen 2004, Smith et al. 2005) and large river floodplain systems (Raibley et al. 1997, Janac et al. 2011). In their report they compared multiple years of fall electrofishing for largemouth bass (sampled 2003-2010), redear sunfish (2005-2010), and spotted sucker (2005-2010) to spring and summer river flow data. Results showed a positive, significant relationship between fish recruitment (measured by age-0 catch in fall) and spring-summer discharge measures, but were less conclusive for back-calculated age-0 catch rates or total length comparisons. The conclusions further supported the findings of Walsh et al. (2009) showing the interconnection of fish recruitment, streamflow, and floodplain inundation with fish community health in the Apalachicola River. In the Walsh et al. (2009) report, extensive use of floodplain habitat by larval stream fish during spring and summer was shown, and Pine et al. (2006) reported high use of inundated floodplain habitat by adult stream fish that was coincident with appearance of larval fishes in the floodplain. Combined, these results provide evidence that floodplain connectivity provided by higher river flows is important for stream fish communities in the Apalachicola River (Dutterer et al. 2012).

Additional decreases in floodplain connectivity may further contribute to decreases in productivity of several species of fish (Kilgore and Baker 1996, Raibley et al. 1997, Walsh et al. 2006), including some that serve as hosts for the listed mussels. However, the effect to the critical habitat and listed mussels is unknown, as the relationship of fish host densities to mussel densities is unknown at this time.

9.3 Factors Affecting Species Environment within the Action Area

Section 2 describes factors affecting the physical environment of the species and critical habitat in the action area. The environmental baseline includes state, tribal, local, and private actions already affecting the species or that will occur contemporaneously with the consultation in progress. Related and unrelated federal actions affecting the same species and critical habitat that have completed formal or informal consultation are also part of the environmental baseline, as are federal and other actions within the action area that may benefit listed species or critical habitat. Over time and to some degree, these actions have influenced the environment of the listed species in the action area, and these influences are reflected in the flow regime, the channel morphology, and other physical and biological features discussed as the baseline for this consultation.

10 MUSSELS - EFFECTS OF THE ACTION

10.1 Factors to be Considered

We describe our analytical approach using the STELLA and ResSim models and the general changes to the flow regime due to the action in detail in Appendix A. In general, we used both models to look for greatest negative effect on the mussel species and their critical habitat. Here, we summarize the key factors we considered in our analysis.

Proximity of the action: The proposed action will affect habitat occupied by the purple bankclimber, Chipola slabshell, and fat threeridge mussels. These mussels spend their entire lives within the action area, most of which is designated as their critical habitat. The proposed action is implemented through releases from Woodruff Dam, which affect species and habitat features from immediately below the dam to as far as 100 miles downstream.

Distribution: The proposed action could alter flows in the Apalachicola River and its distributaries downstream of Woodruff Dam. The action area includes most of the current range of the fat threeridge, about one third of the range of the purple bankclimber, and a small fraction of the range of the Chipola slabshell. We examine how the WCM may variously affect different portions of the action area according to the distribution of the species and important habitat features in the action areas.

Timing: The proposed action could alter flows in the Apalachicola River at all times of the year. It will reduce flows when increasing composite storage in the ACF reservoirs and increase flows when decreasing composite reservoir storage. All three mussels occur in the action area year-round and during all life phases. The fat threeridge, a species that tends to occupy shallower waters, may be more susceptible to effects of low flows during late spring through fall. We examine how the WCM may alter the seasonal timing of biologically relevant flow regime features in our analysis.

Nature of the effect: The proposed action will reduce flows in the Apalachicola River when increasing composite storage in the ACF reservoirs and increase flows when decreasing composite reservoir storage. Three of the five PCEs of designated mussel critical habitat may primarily be affected by the actions: permanently flowing water, water quality, and host fish. We examine how the WCM may affect the listed species and critical habitat elements through specific analyses focused on relevant habitat features, such as vulnerability to exposure by low flows and floodplain inundation.

Duration: This proposed action is applicable until the WCM is modified. According to USACE policy, Water Control Manuals are intended to be updated every five years; however, the Master WCM for the ACF Basin has not been updated since the attempt to update it in 1989. This attempt resulted in legal action and the subsequent IOP and RIOPs that have guided operations since that time. Although the duration of the WCM is indefinite, the nature of its effects is such that none are permanent. The USACE may conceivably alter its reservoir operations at any time; therefore, flow alterations that may result from the proposed action will probably not result in permanent impacts to the habitat of any of the listed species. However, we examine how the proposed WCM may alter, while it is implemented, the duration of high flows and low flows that are relevant to the listed species and critical habitats.

Disturbance frequency: The proposed WCM is applicable year round; therefore, changes to the flow regime and relevant water quality parameters may occur within the scope of the WCM at any time and/or continuously until such time as the WCM is revised or a new plan is adopted. However, we examine how the proposed WCM may alter, while it is implemented, the frequency of high flows and low flows that are relevant to the listed species and critical habitats.

Disturbance intensity and severity: As proposed, the WCM may variously affect the flow regime depending on time of year, basin inflow conditions, and composite storage levels as defined in Table 1.4, but maintains a minimum flow of 5,000 cfs during most times and 4,500 cfs at all times. We examine how the WCM affects the magnitude of flow events relative to the baseline.

10.2 Analyses for Effects of the Action

We calculated a series of performance metrics based on changes in flows or other PCEs for critical habitat. We calculated nine metrics based on changes in daily flow across the 74-year record (1939-2012) as described in Appendix A. We also describe two qualitative metrics by summarizing available information on temperature and sub-daily flows.

10.2.1 Freshwater Mussel Hydroecological Metrics

This section focuses on direct and indirect effects to listed mussels by potential exposure during low-flow conditions. During the summer of 2006 and fall of 2010 by USFWS and 2013-2015 during USACE take monitoring, listed mussels were found exposed and stranded at elevations up to approximately 10,000 cfs. The analysis in previous BOs for operations at Jim Woodruff Dam (USFWS 2006, 2008, 2012) assessed impacts to listed mussel species by analyzing the differences between the flow regimes in the range of flow less than 10,000 cfs using seven metrics based on annual flows. In this BO, we developed nine metrics to assess the effects of flow at targeted times during the annual cycle that correspond to five different phases of the mussel life cycle. For several flow effects, we calculated flows with different time windows (e.g., March 1-November 24 and March 1-August 15) or at different flow thresholds that were thought to be important (e.g., <10,000 cfs, <7,500 cfs) resulting in nine rather than 5 metrics. We first present the conceptual foundation for each metric in the context of the mussel life cycle and then present the analysis, results and interpretation for each metric.

Mussel Life Cycle: Freshwater mussels have a complex life-cycle that involves infection of fish hosts by a larval stage called glochidia (Figure 10.1). The fish host provides a mechanism for dispersal (short and long-range depending on host behavior) within the aquatic system. Without susceptible fish hosts, mussels cannot complete their life cycle. The infection of a fish host is an important, contact-related phenomenon. Following transformation on the fish host, the settlement of juvenile mussels in suitable riverine habitat may be an important determinant of year class strength. Both infection and settlement success may be influenced by discharge, or rates of change in discharge, in the Apalachicola River, but more data are necessary to inform our understanding of the mechanics.

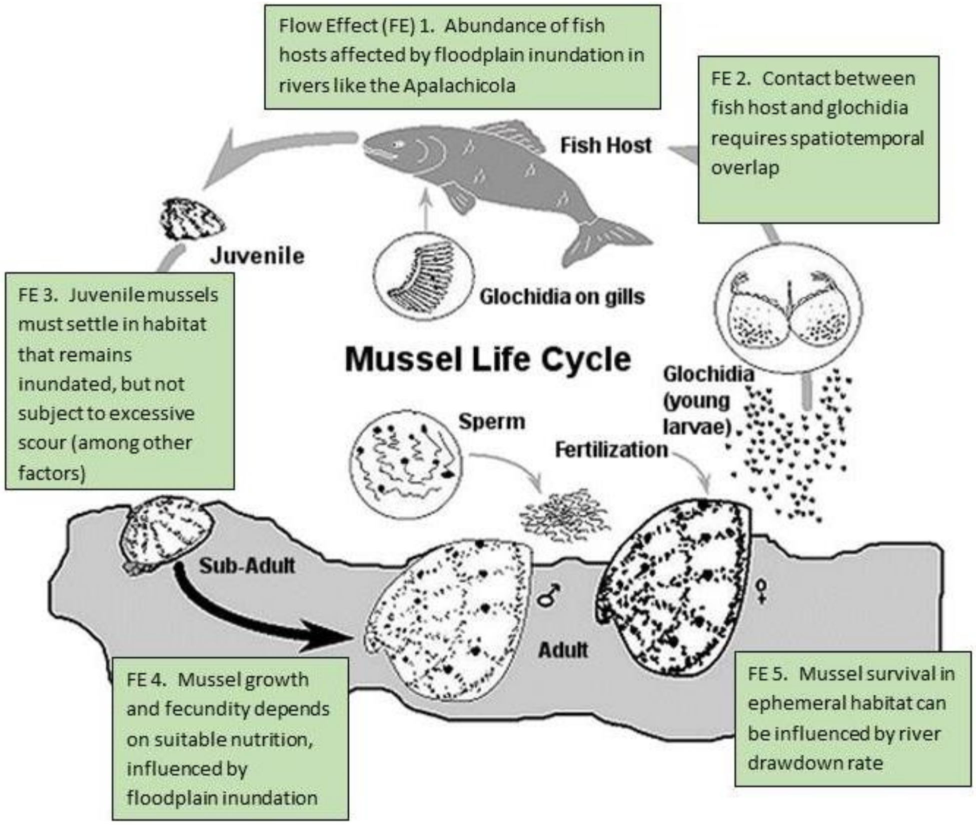


Figure 10.1 Conceptual links between changes in river flow and key points in mussel life history (diagram modified from IMT 2002)

Distribution and Abundance of Freshwater Mussels: Unlike fish, adult mussels do not disperse rapidly into higher elevation habitats with rising water levels. Rather, their distribution and abundance is largely influenced by the annual, or semi-annual recurrence of low flows (i.e., flows <~7,000 cfs) during dry periods. Low flow events physically define the portion of the channel that remains permanently inundated; low flow events thereby define the extent of suitable mussel habitat. In this sense, habitats existing above the seasonally recurring low flow threshold of ~5,000 cfs can be considered ephemeral.

In a 2012 study of mussel distribution and abundance in the middle reach of the Apalachicola (river miles 35 to 65), Smit (2014) documented the occurrence of mussels in 3 primary mesohabitats in the main river channel: Inner Recirculation Zone (IRZ), Outer Recirculation Zone (ORZ), and Pool/Outer Bend (POB). Two of these habitats, the IRZ and ORZ, are associated with relatively shallower depths, and lower bank slopes. Although mussels were documented to occur throughout these habitats, the abundance of mussels was positively correlated with distance to the 5,000 cfs bank boundary (elevation). The increased density of mussels in proximity to this boundary may be a function of enhanced growth and survival, settlement rates, and/or dynamics associated with retreat into this zone by mussels previously settled at higher elevations, under periods of elevated discharge. The resulting high density "band" of mussels often found adjacent to the low flow river margin has been frequently targeted during mussel surveys (Gangloff 2012). Until recently, the prevailing paradigm associated with mussel distribution in the river identified this band of shallow, near bank habitat as the primary mussel habitat throughout the main river channel.

We now know that mussels are also distributed in deep, outer bend (pool) habitats of the river (Smit 2014). These habitats are characterized by the presence of submerged timber (large woody debris). Smit (2014) observed that mussel occurrence was identical to that of inner and outer recirculation zones; mean density was similar but slightly lower than density in the IRZ and ORZ.

Flow Effect 1 - Flows for Host Fish Production: The abundance of a variety of fish (i.e., susceptible hosts) in large, low gradient, floodplain river systems like the Apalachicola is strongly related to connectivity and inundation of the floodplain (Burgess et al. 2013, Dutterer et al. 2012). Indeed, seasonal access to inundated floodplain habitats is a critical link in the ecology of many fish species inhabiting large river-floodplain systems including the Apalachicola (Junk et al. 1989, Burgess et al. 2013, Reckendorfer et al. 2013).

The fat threeridge is a host generalist, and has been shown to transform on a variety of fishes that inhabit the Apalachicola, including Centrarchids such as bluegill, redbreast sunfish, and largemouth bass. Additionally, several species of darters, minnows, and striped bass support the transformation of some species of mussel glochidia into juveniles (Fritts and Bringolf 2014). Fritts and Bringolf (2014) discussed the potential importance of darters as hosts for fat threeridge in terms of the consistently high metamorphosis success, and benthic habitat use associated with darters. The Weed shiner (*Notropis texanus*) was identified as a suitable host (O'Brien and Williams 2002) although transformation success was quite low; however, Fritts and Bringolf (2014) did not observe transformation occurring on this fish host. During light trap studies of larval fish in the Apalachicola River and floodplain, the Weed shiner was the most abundant larval fish captured during both 2003 and 2007 (59% and 39% composition of catch, respectively; Walsh et al. 2009).

Less is known about the fish hosts of the other two mussel species. The Chipola slabshell has been documented to transform on bluegill and redbreast sunfish (Preister 2008). The purple bankclimber is considered to be a host specialist, and has been documented to transform only on Sturgeons, and Blackbanded and Halloween darters (Fritts et al. 2012).

Many of these host fish species utilize inundated floodplain habitats of the Apalachicola River system for spawning, rearing, foraging, and sheltering (Walsh et al. 2009). However, the susceptibility of fish hosts to infection by mussel glochidia is also a function of the exposure history (i.e., age) and size of the host fish, with younger (i.e., naïve) and smaller fish being more susceptible (references provided in Strayer 2008). These fish host population characteristics have been shown to be influenced by flows and floodplain connectivity. For example, the abundance of Age 0 (young-of-the-year) largemouth bass and redear sunfish as observed during fall sampling was positively correlated with the proportion of days between March 1 and September 30 exhibiting flows >460 m^3/s (16,400 cfs) at Chattahoochee, FL (Dutterer et al. 2012).

Thus, strong cohorts of young, naive fish hosts may be expected to occur in years with above average floodplain inundation and connectivity during the growing season, and conversely, years with below average floodplain inundation are associated with smaller cohorts of susceptible Age 0 fish hosts. Three hydroecological metrics were used to measure the effects of WCM flows on fish host production.

Flows Effect 2 - Glochidial Infection of Susceptible Fish Hosts: Some of the freshwater mussels inhabiting the Apalachicola and lower Chipola River, including fat threeridge and Chipola slabshell, indiscriminately release or broadcast their glochidia to the water column. Infection is suspected to occur when a susceptible fish host passively contacts a waterborne glochidial mass. This broadcast strategy differs fundamentally from one that involves display mechanisms that attract or lure a host fish into contact with glochidia, thereby enhancing infection rates above what might be expected based upon random contact alone. However, it is worth noting, the glochidial mass of Chipola slabshell resembles a small insect larva (Preister 2008), and this resemblance may enhance contact with fish hosts over species with a broadcast strategy alone. Further, infection of fish hosts by broadcasting glochidia is likely to be influenced by the spatiotemporal overlap of glochidia-releasing female mussels and susceptible fish hosts.

For Flow Effect 2, our key assumption is that infection rates will be maximized when the greatest number of susceptible fish are in close proximity to the greatest number of glochidia-releasing mussels under conditions of low, stable flow. The spatial location of susceptible fish hosts, and the timing of habitat use, is likely to vary as a function of discharge (Burgess et al. 2013). Fish hosts may follow or track the inshore edge of the aquatic environment, or "moving littoral" (*sensu* Junk et al. 1989), as rising water levels permit access to food and cover in adjacent, higher elevation riparian and floodplain habitats. The density of glochidia-releasing mussels, regardless of river stage, will be greatest within main channel habitats were mussels are located. Whether the appropriate host fish are present in the "infection zone" (i.e., in close proximity to glochidia-releasing mussels), will thus depend on river discharge.

Infection of suitable fish hosts may be conceptualized and modeled as a contact phenomenon. Other contact-infection processes have been modeled (in 2D and 3D) for various parasites and communicable diseases of wildlife, providing support and inspiration for this conceptual hypothesis (Hassell 2000, Mundt et al. 2009). The following parameters are key to modeling the host infection process:

- Density of susceptible fish hosts within the "infection zone" as a function of the density of each fish species and age and/or infection history of the hosts;
- Concentration of glochidial web-masses in the water column as a function of the density of female mussels releasing glochidia, duration of glochidial viability, and water temperature and other factors influencing species specific timing; and
- Discharge within the "infection zone" as it influences the overlap, and rate of contact between fish and glochidia.

The release of glochidia to the water column would be closely associated with this period of gravidity, and the viability of glochidia once released to the water column is limited to 2 days (O'Brien and Williams 2002). Fat threeridge have been observed as gravid and supporting mature glochidia during field collections between late May and late June (USFWS observations 2014-2015, O'Brien and Williams 2002). Chipola slabshell are presumed to be short-term brooders (Williams et al. 2008) and have been found to be gravid in June-early July (Brim Box and Williams 2000, Preister 2008). Purple bankclimber were found to be gravid from late February through mid-April (O'Brien and Williams 2002), a period that coincides with spawning of Gulf sturgeon and darter host species.

Higher rates of host infection will lead to greater reproductive success and higher production of juvenile mussels, although empirical evidence on this topic is lacking. From 3-13% of fish can be infected by mussels (Braun et al. 2014), and fat threeridge has approximately a 25-80% metamorphic success after infection (Fritts and Bringolf 2014).

Flows Effect 3 - Settlement Success - Survival of Juvenile Mussels after Release from Fish Hosts: After a period of encystment and transformation, juvenile mussels drop off the fish host and settle on the river bottom. In laboratory settings, transformation of fat threeridge glochidia on fish hosts required 10 to 14 days at 23 $\pm$ 1.5 C (73.4 $\pm$ 2.7 F) (O'Brien and Williams 2002). In a study of 24 fish hosts, transformation of fat threeridge required 10 to 18 days at water temperatures of 22-23 C (71.6-73.4 F) (Fritts and Bringolf 2014).

Although relatively little is known about factors affecting dispersal and settlement of juvenile mussels in large rivers, insights into the role of velocity, velocity gradients, and distance of the fish host above the river bottom during juvenile mussel drop have been provided by hydrologic modeling (Daraio et al. 2012). Habitat preferences of host fish are likely to influence where juvenile mussels settle in the river bed. The role of settling velocity in a turbulent river was examined by Schwalb et al. (2012a,b) using controlled field experiments.

Survival of juvenile mussels may depend on the physical location of settlement and associated factors such as: substrate type, porosity, water quality conditions of the microhabitat, food availability in the substrate, and the potential for physical scour or displacement by shear forces of the river current acting upon the area of settlement (Strayer 2008, French and Ackerman 2014).

Using a 2D model of hydrologic variables in a reach of the Upper Mississippi River, Morales et al. (2006) identified areas of the channel associated with low shear stress as places where small particles (like juvenile mussels) would settle and collect. These areas corresponded to documented locations of mussel beds. Alternatively, these locations might represent areas of flow refuge where juvenile mussels settled, and subsequently survived because they were not displaced by river currents during their descent, or dislodged from the habitat.

After settling, juvenile mussels burrow into the sediment. Juvenile mussels may lack the capacity to migrate in response to follow water levels, and thus would be subject to desiccation and mortality if settlement occurred at higher elevations, in ephemeral habitat. Ephemeral habitats, or river margin and floodplain areas that are only seasonally inundated, may represent sinks for juvenile mussels (Singer and Gangloff 2011, Gates et al. 2015).

Given the relationship between fish host habitat use and river discharge, low stable flows during the period of juvenile mussel drop (~2 weeks post-infection) should favor the successful establishment and recruitment of juveniles to the mussel population. We used two hydroecological metrics to measure the effect of the WCM on the infection and settlement process (Flow Effects 2 & 3).

Flows Effect 4 - Mussel Growth and Fecundity with respect to Floodplain Inundation: Mussels filter feed to obtain nutrition in the form of phytoplankton (algae) and suspended, bacterial rich, fine particulate organic matter (McMahon and Bogan 2001, Strayer et al. 2004, Vaughn et al. 2008). Mussels also obtain nutrition by deposit feeding, or extraction of food from the river sediments they inhabit (discussed in Haag 2012). Pulsed inundation of the floodplain during the growing season may stimulate primary production within backwater areas, and contribute phytoplankton, fine particulate organic matter, and bacteria to the water column (Junk et al. 1989), thereby enhancing the food resources available to mussels, and in turn, enhancing growth and survival of mussels. Although more research is needed to investigate the coupling of floodplain inundated and mussel growth in the Apalachicola River system, mussel fecundity may be a function of size of the female mussel, and therefore, conditions that support increased mussel growth likewise enhance fecundity (Strayer 2008). Floodplain inundation may have both individual and population level effects via the supply of mussel food to the system. We used one hydroecological metric to test the effect of the WCM on the floodplain process during the growing season.

Flows Effect 5 - River Drawdown and Mussel Survival in Ephemeral Habitats: Field studies have documented the ability of mussels like fat threeridge to relocate to lower elevations as water level declines in the Apalachicola River (USFWS 2011). Since mussels are relatively slow moving, their ability to retreat during water level declines is a function of site slope and the rate of water surface elevation decline (USFWS 2011, Newton et al. 2015). Mussels inhabiting deeper areas of the IRZ, ORZ, and POB are not at-risk of exposure and mortality during these episodes because these habitats are continuously inundated throughout the year. Maintaining slow drawdown rates when river discharge is falling from 10,000 to 5,000 cfs provides the greatest opportunity for successful escapement of ephemeral habitat by mussels that inhabit the "moving littoral" zone of the river.

At the average drawdown rate from 2006-present of 0.13 ft/day (USACE 2016), the sites that are most at risk of experiencing some exposure and mortality of freshwater mussels are those with the lowest bank slopes, slopes of <20%, as observed across a multitude of sites in the Apalachicola River and lower Chipola River (USFWS 2011). We used three hydroecological metrics to test the effect of the WCM on the river drawdown process.

The following section evaluates the effects of the WCM to these hydroecological metrics (Table 10.1). Appendix A details the effects of the WCM to the critical habitat in the action area of which a summary is incorporated in the below sections.

Table 10.1 Summary of the hydroecological metrics and the effect of the WCM on mussels.

Metric ID	Hydroecological Metric Title	Species Ecology	Interpretation	WCM effect
M1	Floodplain Access for Spawning- % days inundated (Mar 1-Nov 24)	Host Fish Production	higher % days of floodplain inundation better for host fish	negative
M2	Floodplain Access for Spawning- % days inundated (Mar 1-Aug 15)	Host Fish Production	higher % days of floodplain inundation better for host fish	negative
M3	Floodplain Access for Spawning, 30-day inundation acres (Mar 1-Aug 15)	Host Fish Production	more acres inundated better for host fish	negative
M4	Low Flow during Infection and Settlement (Jun 1-Jul 15)	Host Fish Infection	greater # of low flow days = higher infection/survival of juveniles	negative
M5	Stable Flows during Infection and Settlement, max days <7.5 k cfs (Jun 1-Jul 15)	Host Fish Infection	greater # consecutive days of low flow better	slight negative
M6	Pulsed Inundation during late growing season, 30 days and 15 days (Jul 15-Nov 24)	Mussel Growth	more pulses is better for mussel growth	very slight negative
M7	Mussel Survival during Extreme Low Flow, annual 1 day minimum flow	Mussel Survival	fewer days of flow <5kcfs better for survival	negative
M8	Mussel Survival during Extreme Low Flow, annual total # days <5kcfs and <5.1 kcfs	Mussel Survival	fewer days of flow <5.0 kcfs better for survival	negative
M9	Mussel Survival during Drawdown, freq of stage changes all flows and flows <10kcfs	Mussel Survival	fewer stage changes >0.25 foot/day better for survival	slight negative
MQ1	Temperature changes downstream of Woodruff	Habitat Availability & Quality	temps below lethal limits good	inconclusive
MQ2	Hydropeaking at Woodruff	Habitat Availability & Quality	more stability in daily flows better for survival, recruitment, growth	neutral (FTR, CS only)

10.2.1.1 Flows for Host Fish Production (FE1)

Freshwater Mussel Hydroecological Metric 1 - Access to Floodplain for Spawning and Rearing of Host Fish

Metric Description: To evaluate the potential effects of the proposed action on the ability of adult host fish to access the floodplain for spawning and juvenile host fish to hatch and mature in the floodplain, we calculated the number of days between March 1 and November 24 exhibiting flows ≥16,200 cfs.

This metric was used by Dutterer et al. (2012) in a study of fish recruitment and floodplain inundation in the Apalachicola River. March represents the onset of spawning for stream fish in the Apalachicola River (Pine et al. 2006, Walsh et al. 2009, Burgess et al. 2013). At 16,200 cfs, approximately 10% of the available floodplain is inundated (Light et al. 1998). Light et al. (2006) defined the growing season for floodplain vegetation (Mar 1-Nov 24) based on historic records of first and last freeze observed at Quincy, FL. This 268-day time frame includes most of the growing season that includes spawning, rearing, growth, and survival of fishes utilizing the inundated floodplain. At least 30 days of inundation are required to provide adequate duration of time for spawning to occur for many of the host fishes for fat threeridge and Chipola slabshell. This metric emphasizes the general precept that a greater number of days of floodplain inundation equates to improved host fish recruitment.

Results: The total number of days of floodplain inundation at ≥16,200 cfs between March 1 and November 24 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.2. Both models showed the same pattern (i.e., that the WCM decreased the days of floodplain inundation), but the STELLA model showed the greater effect. Compared to the baseline, the WCM results in 819 days less of floodplain inundation for the 74 year record (i.e., a 10 day reduction annually) and an overall 4% reduction in inundation from 8267 under baseline to 7448 of 19832 days based on the STELLA model. During years characterized by an intermediate range of days of floodplain inundation (i.e., range of 60-40% exceedance probability), we observed the most discernable difference in the number of days of inundation between the WCM and baseline management plans with 42 days less of inundation during this range and a maximum of 15 days less of inundation under the WCM at 40% probability of exceedance. To get at least 30 days of inundation which is needed for host fish to spawn successfully, the WCM reduces the probability of getting at least 30 days of inundation from 96% under the baseline to 85%. In other words, host fish may not reproduce in the floodplain 11 years under the WCM compared to 3 years of a 74 year record under the baseline (i.e., an 11% chance that host fish won't spawn during the WCM).

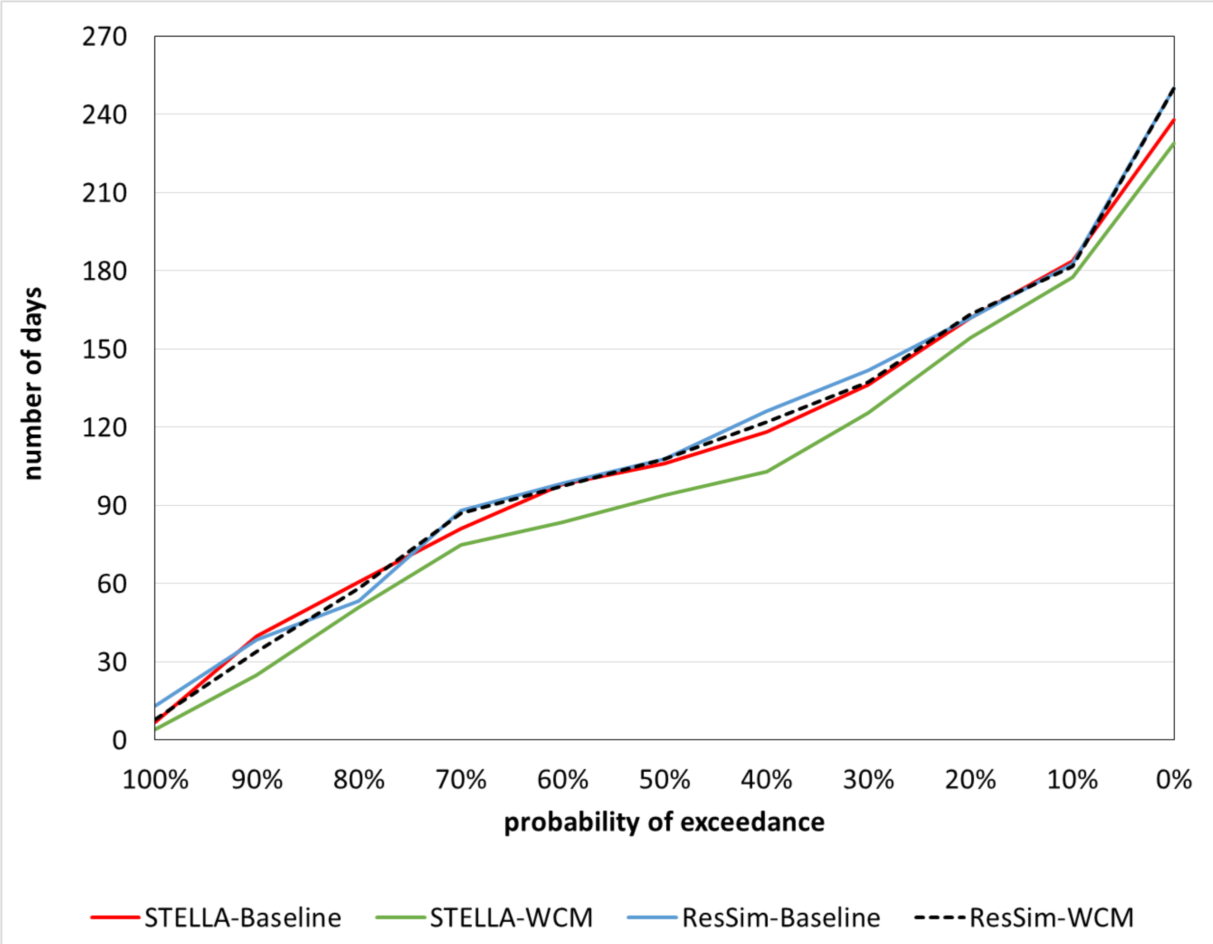


Figure 10.2 Probability of exceedance plot showing the number of days between March 1 and November 24 with flows ≥16,200 cfs under the baseline and WCM flow regimes

Interpretation: The results of this analysis indicated that the WCM exhibited an adverse effect relative to the baseline by reducing the total number of days of floodplain inundation by 15% and result in 11% fewer years with adequate number of days for host fish to spawn. Fewer days of floodplain inundation is expected to result in a reduction of access to the floodplain by adult host fish, lower fish host populations, and a subsequent reduction in recruitment of mussels.

Freshwater Mussel Hydroecological Metric 2 - Access to Floodplain for Spawning of Host Fish

Metric Description: To evaluate the potential effects of the proposed action on the ability of adult host fish to access the floodplain for spawning, we calculated the number of days between March 1 and August 15 exhibiting flows ≥16,200 cfs.

This metric was used by Dutterer et al. (2012) in a study of fish recruitment and floodplain inundation in the Apalachicola River. March represents the onset of spawning for stream fish in the Apalachicola River (Pine et al. 2006, Walsh et al. 2009, Burgess et al. 2013). August 15 represents the approximate end of the spawning season for most of the host fish species, and this this 167-day time frame includes most of the early growing season that includes spawning of fishes utilizing the inundated floodplain. Similar to Freshwater Mussel Hydroecological Metric 1, this metric emphasizes the general precept that a greater number of days of floodplain inundation equates to improved host fish recruitment, but focuses on access for spawning alone.

Results: The total number of days of floodplain inundation at ≥16,200 cfs between March 1 and August 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.3. Both models showed the same pattern (i.e., that the WCM decreased the days of floodplain inundation), but the STELLA model showed the greater effect. Compared to the baseline, the WCM results in 848 days less of floodplain inundation (i.e., an average of 11 days or 18% reduction annually for the 74 year record) and overall reduces floodplain inundation by 6% (6244 of 12358 days). During years characterized by higher and intermediate range of days of floodplain inundation (i.e., range of 90-40% exceedance probability, drier to intermediate years), we observed the most discernable difference in the number of days of inundation between the WCM and baseline management plans with 89 days less of inundation during this range and a maximum of 19 days less of inundation under the WCM at 90% and 50% probability of exceedance (i.e., in drier and average years). To achieve at least 30 days of inundation which is needed for host fish to spawn successfully, the WCM reduces the probability of getting at least 30 days of inundation from 93% under the baseline to 84%. In other words, host fish may not reproduce in the floodplain 14 years under the WCM compared to 5 years of the 74 year record under the baseline (i.e., a 9% chance that fish host won’t spawn in the floodplain during the WCM). However, this is an estimate of the minimum number of days required because this metric did not calculate the number of continuous days required by host fish to successfully spawn.

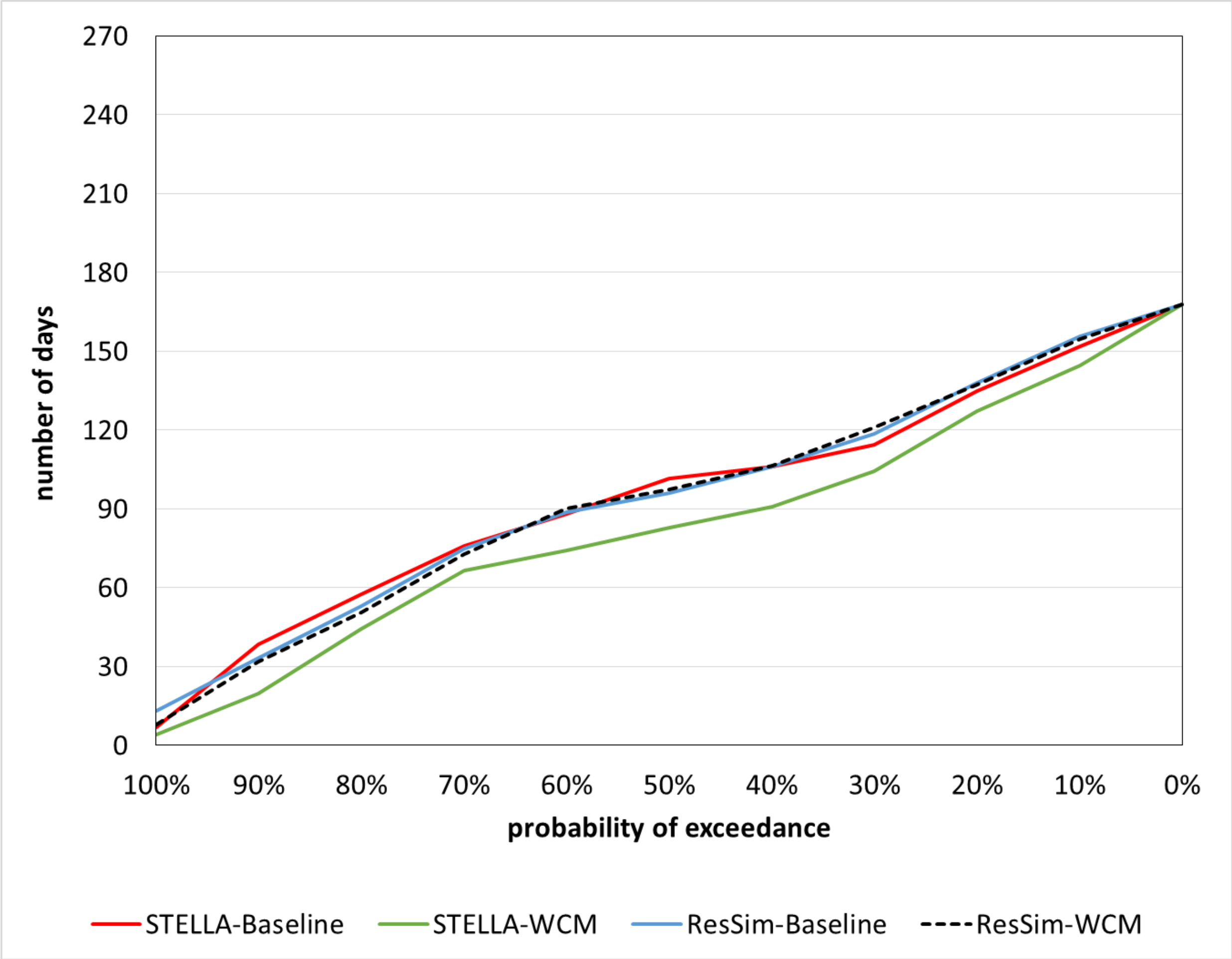


Figure 10.3 Probability of exceedance plot showing the number of days between March 1 and August 15 with flows ≥16,200 cfs under the baseline and WCM flow regimes

Interpretation: The results of this analysis indicated that the WCM exhibited an adverse effect relative to the baseline by reducing the total number of days of floodplain inundation by 17% and reduce the chance of host fish having adequate time to spawn in the floodplain by 12%. Fewer days of floodplain inundation is expected to result in a reduction of access to the floodplain by adult host fish, lower fish host populations, and ultimately a reduction in recruitment of mussels.

Freshwater Mussel Hydroecological Metric 3 - Access to Floodplain for Spawning of Host Fish

Metric Description: To evaluate the potential effects of the proposed action on the ability of adult host fish to access the floodplain for spawning, we calculated the maximum continuous 30-day inundation of the floodplain by flows ≥16,200 cfs between March 1 and August 15.

This metric measures large pulses of water during growing season and represents a measure of the maximum number of acres continuously inundated by a single floodplain inundation episode (i.e., a pulse). Continuous inundation is likely to be maximized by the largest runoff pulse occurring within the specified temporal window. This metric emphasizes the spatial aspect of the area of floodplain inundated and the temporal aspect of duration (30-days) to provide continuous inundation for completion of spawning activities (as with the previous two metrics in this set). This metric has been used previously (USFWS 2012) and was presented in BA by USACE, but as with Freshwater Mussel Hydroecological Metric 2, we have reduced the window of time to focus on the critical time for spawning host fishes to access the floodplain. The maximum amount of floodplain acres that can be inundated is approximately 80,000 acres; an inundation of this magnitude occurs at flows of ~125,000 cfs (Light et al. 2006; Figure 2.7).

Results: The maximum number of continuous days of floodplain inundation at ≥16,200 cfs between March 1 and August 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.4. Both models showed the same pattern (i.e., that the WCM decreased the ac-days of floodplain inundation), but the STELLA model showed the greater effect. Compared to the baseline, the WCM results in 32,788 ac less of floodplain inundation (of app. 5.92 mil ac, 0.55% reduction) for the 74 year record total, but an average of a 433 ac/year (i.e., 6% reduction annually). Further, this overall pattern, masks more nuanced shifts (i.e., lower and intermediate acres of floodplain inundation). During years characterized by lower acres of floodplain inundation (i.e., range of 97-73% exceedance probability, the 19 years with lower inundation), the WCM reduces floodplain inundation by an average of 2,794 ac/yr (38% decrease), but conversely increases inundation by 1,169 ac/yr in intermediate years (i.e., 72-34% exceedance probability, the 28 years with intermediate inundation). We observed the most discernable difference in the number of acres of inundation between the WCM and baseline management plans with a maximum of 4,174 ac less of inundation under the WCM at 90% probability of exceedance. The WCM will reduce the amount of pulsed floodplain inundation by 2,215 ac on average in 5 years.

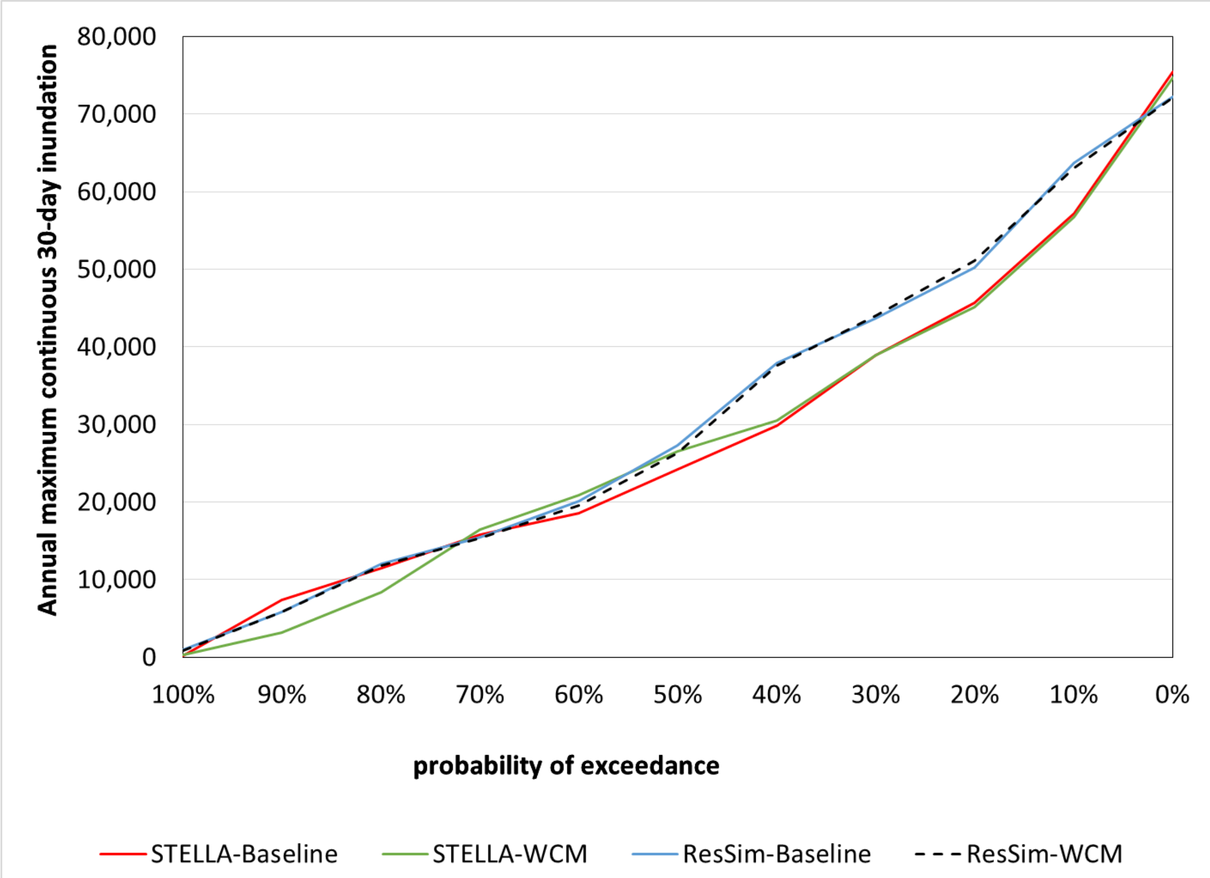


Figure 10.4 Probability of exceedance plot showing the maximum acres inundated continuously for 30 days between March 1 and August 15 with flows ≥16,200 cfs under the baseline and WCM flow regimes

Interpretation: The results of this analysis indicated that the WCM exhibited a slight adverse effect relative to the baseline by reducing the total acres of floodplain inundated during pulsed flows by 6% or 433 ac/yr on average, but by 38% or 2,794 ac/yr in the 19 years with the lowest inundation. The WCM will reduce the amount of pulsed floodplain inundation by 2,215 ac on average in 5 years. This reduction in acres of floodplain inundation is expected to result in a reduction of spawning habitat for adult host fish, reduced recruitment in fish host populations, and consequently a reduction in fish hosts available for mussel infection. Lower fish host populations will subsequently reduce recruitment of mussels.

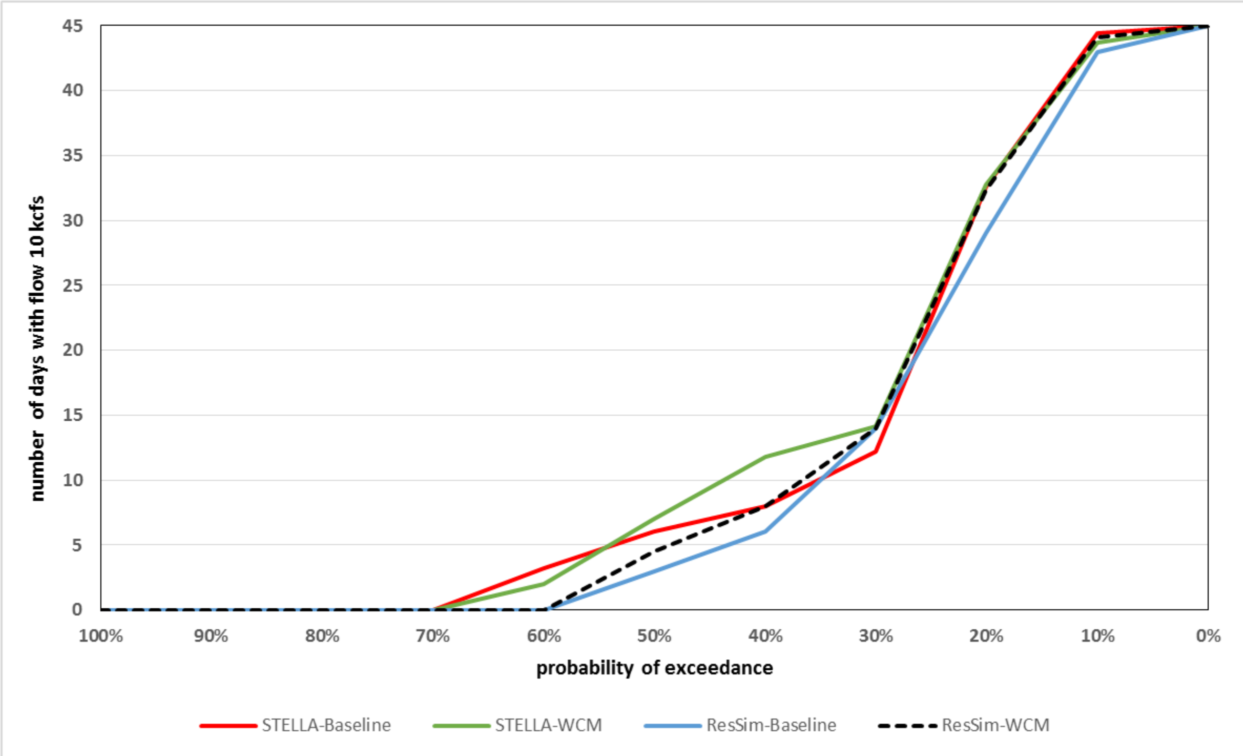
10.2.1.2 Flows for Host Fish Infection (FE2) and Juvenile Mussel Recruitment (FE3)

Freshwater Mussel Hydroecological Metric 4 - Low Flows during Host Infection and Juvenile Settlement

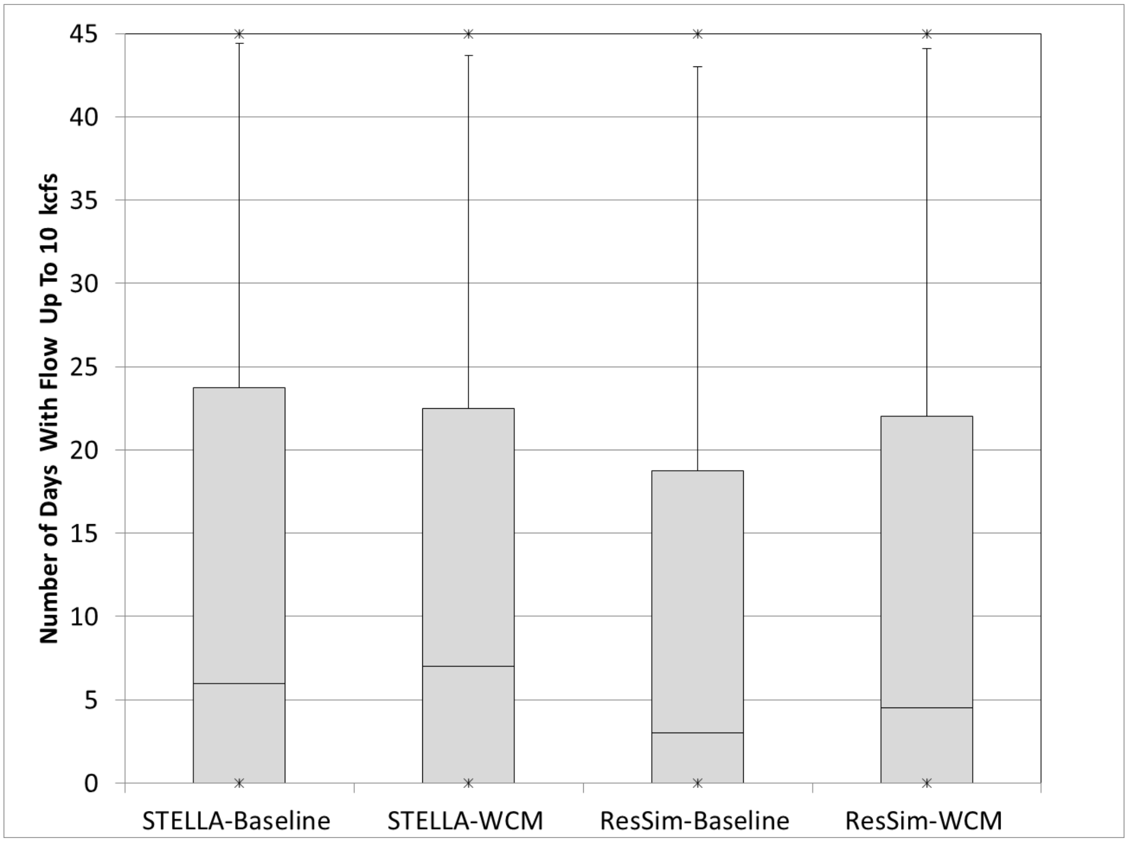
Metric Description: To evaluate the potential effects of the proposed action on the ability of adult host fish to be infected and juvenile mussels to drop in appropriate locations for high survival, we calculated the number of days between June 1 and July 15 exhibiting low and very low flows (<5, 5-6, 6-7.5, and 7.5-10 kcfs).

This metric reflects the number of days during the infection and juvenile drop cycle that flows are low or very low and almost entirely contained within the main channel of the river. Note, this metric only apply to species that are gravid, releasing glochidia, and experiencing juvenile drop in June through early July, such as *A. neislerii, E. chipolaensis,* and other non-listed species. This metric assumes that low flows during this 45-day time period will consolidate host fishes in the main river channel during the time of glochidial release and juvenile drop and that juvenile drop in the main river channel will lead to higher survival of juvenile mussels and higher recruitment to the adult mussel population. We have adopted the definition of very low flows of <5,000 cfs in the Apalachicola River used by Light et al. (1998). This metric assumes that the zone of stability and highest survival for mussels is near the 5,000 cfs waterline and flows below that will harm the mussel population. Further, mussel drop near this 5,000 cfs waterline will result in the highest survival of juvenile mussels and settlement further from this 5,000 cfs waterline will result in lower survival. To further focus on effects occurring within a range of flows identified as thresholds for ephemeral habitat between 5,000 and 10,000 cfs, we conducted a series of analyses that summarized total number of days during the period June 1 and July 15 when flows were: <5,000, 5,000-5,999, 6,000-7,499, and 7,500-10,000 cfs. The 74 year record has 3,330 days between June 1 and July 15. These flows quantify the ephemeral habitat available to mussels within the Apalachicola River.

Results: We compared the total number of days overall when flows are ≤10,000 cfs between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM), presented as a probability of exceedance plot in Figure 10.5A. Both models showed the same pattern (i.e., that the WCM increased the days of flows <10,000 cfs), but the STELLA model showed the greater effect. Overall, the WCM provides an additional 5 days compared to the baseline when flows are <10,000 cfs. However, the median is only one day higher on the box plot Figure 10.5B and the 50% box and the 90% whiskers both are slightly reduced compared to the baseline. Although the differences among alternatives are only visible in the years with more days of flow <10,000 cfs (i.e., the drier years), a more detailed look at this change in management shows both these beneficial and adverse effects of the WCM compared to the baseline.


45
40
35
30
25
20
15
10
5
0
number of days with flow 10 kcfs
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
probability of exceedance
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

A


45
40
35
30
25
20
15
10
5
0
Number of Days With Flow Up To 10 kcfs
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

B

Figure 10.5 Probability of exceedance plot (A) and box plot (B) showing total number of days overall when flows are ≤10,000 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

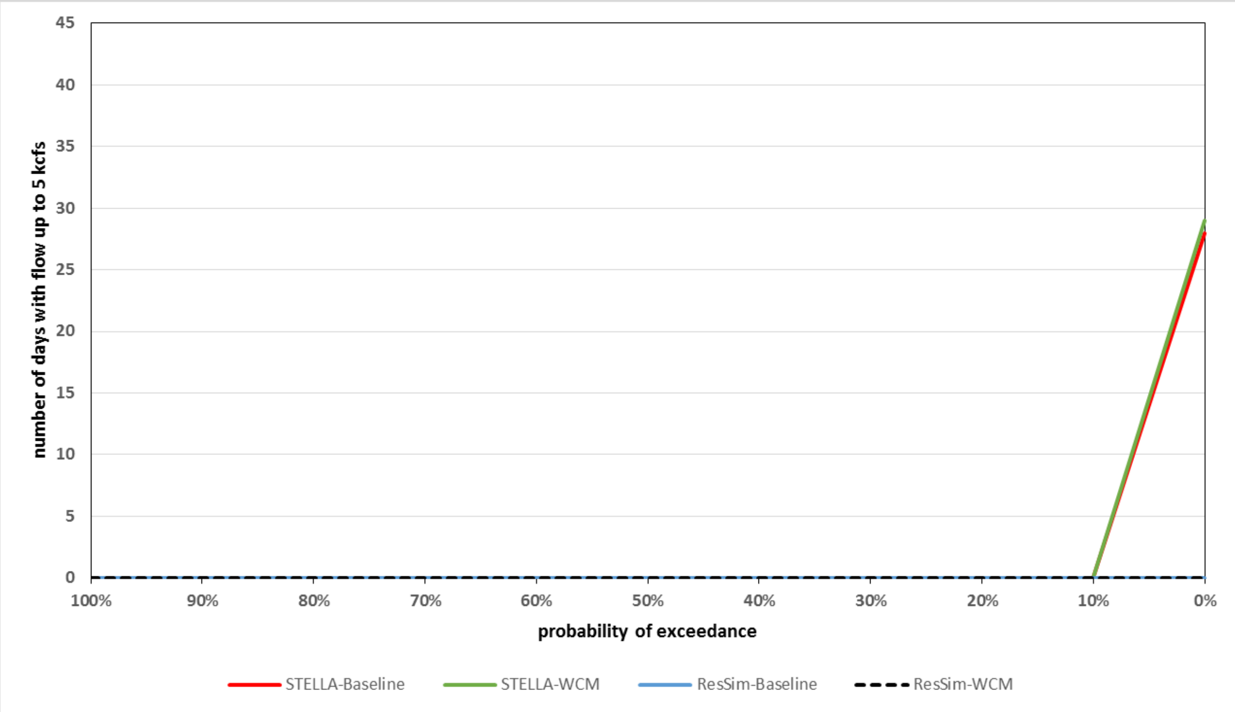


Figure 10.5C Probability of exceedance plot showing total number of days overall when flows are <5,000 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

The total number of days at flows <5,000 cfs between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.5C. Because the WCM and baseline have nearly identical rules for when to drop below 5,000 cfs, the 29 days below 5,000 cfs is a one day increase in the number of days below 5,000 cfs across the 74 year record compared to the baseline (1/3,330 days = 0.03% change). The WCM would on average increase the days < 5,000 cfs by 0.2% in 5 years. This would be an adverse effect on the mussel population by dropping flows below the normal zone of stability dictated by the 5,000 cfs management threshold.

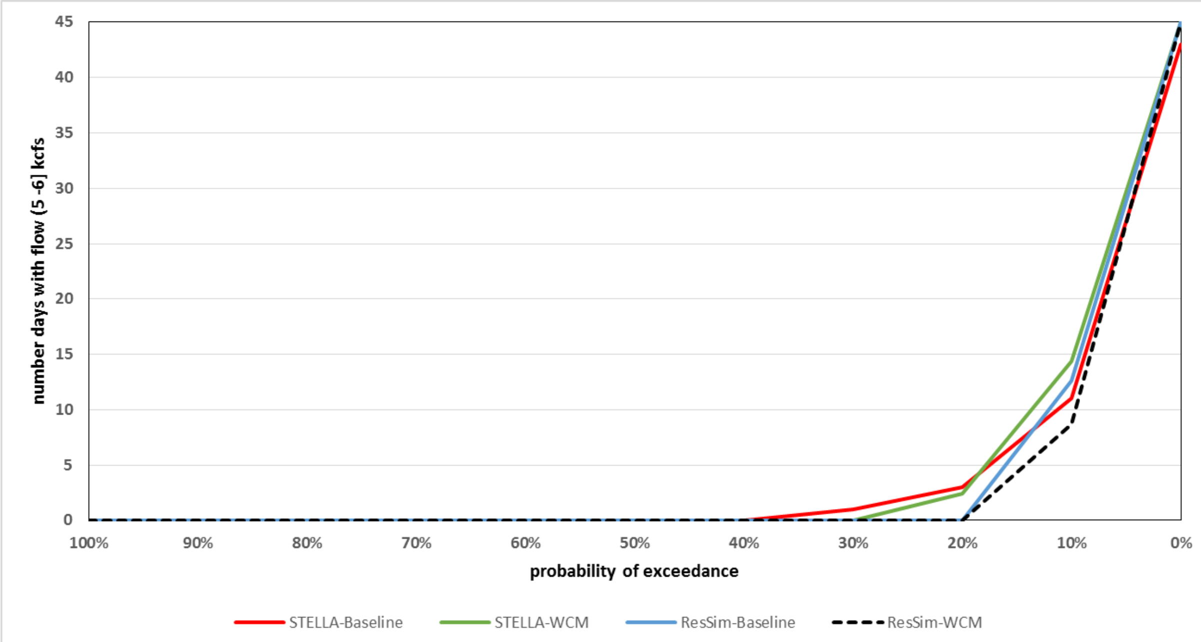


Figure 10.5D Probability of exceedance plot showing total number of days overall when flows are 5,000-5,999 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

The total number of days at flows 5,000-5,999 cfs between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.5D. The WCM provides an additional 30 days over the 74 year record compared to the baseline during this range of flows (30/3,330 days = 0.9% change). The WCM would on average increase the days at 5,000-5,999 cfs by 4.5% in 5 years. This may be a slight benefit for the mussel population by increasing the time for juvenile mussels to drop and settle in this more stable habitat near 5,000 cfs.

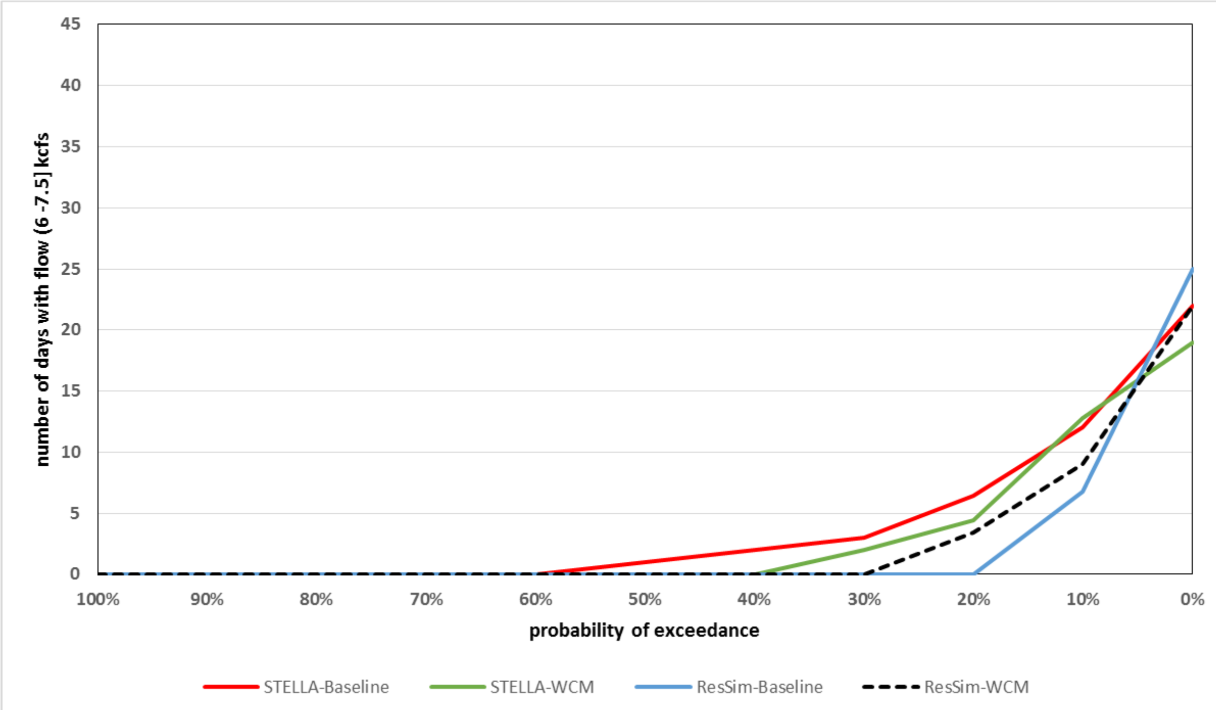


Figure 10.5E Probability of exceedance plot showing total number of days overall when flows are 6,000-7,499 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

The total number of days at flows 6,000-7,499 cfs between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.5E. The WCM provides 51 days less over the 74 year record compared to the baseline during this range of flows (51/3,330 days = 1.5% change). The WCM would on average change the days at 6,000-7,499 cfs by 7.6% in 5 years. This may be a slight adverse effect for the mussel population by decreasing the time for juvenile mussels to drop and settle in this better ephemeral habitat closer to the more stable 5,000 cfs stable zone.

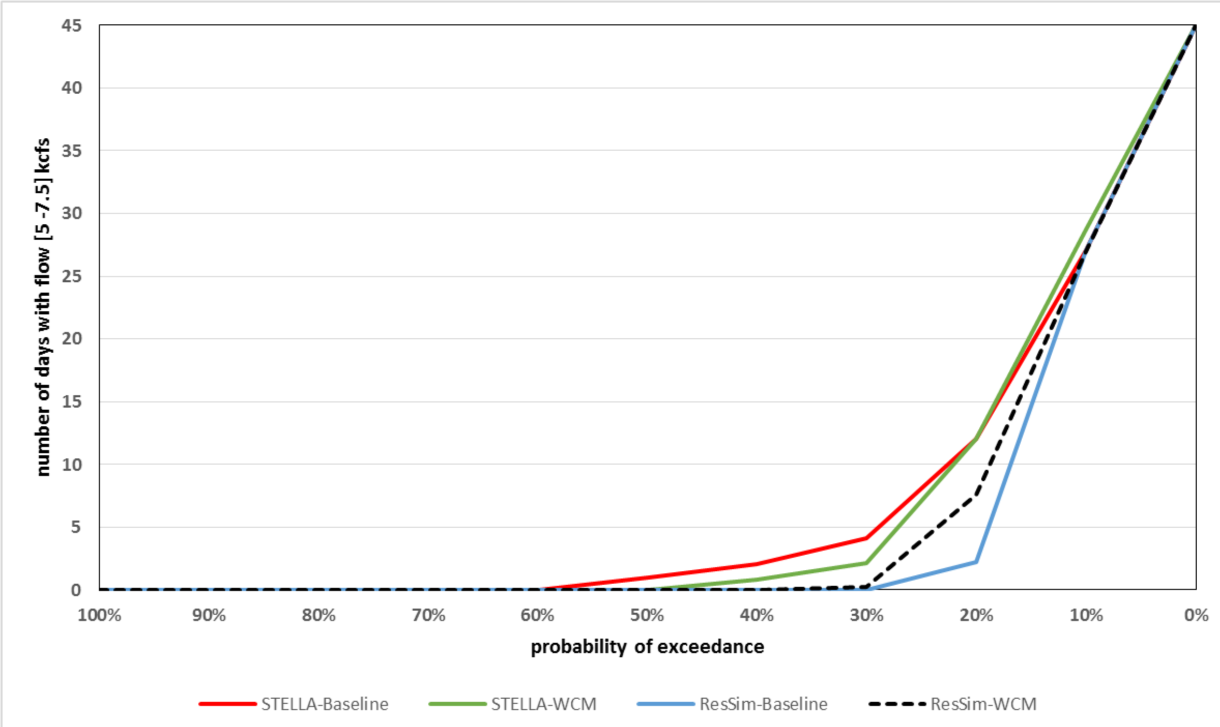


Figure 10.5F Probability of exceedance plot showing total number of days overall when flows are 5,000-7,499 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

For flows 5,000-7,499 cfs, the total number of days at flows between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.5F. The WCM provides 21 days less over the 74 year record compared to the baseline during this range of flows (21/3,330 days = 0.6% change). The WCM would on average change the days at 5,000-7,499 cfs by 3.1% in 5 years. This may be a slight adverse effect for the mussel population by decreasing the time for juvenile mussels to drop and settle in this better ephemeral habitat closer to the more stable 5,000 cfs stable zone.

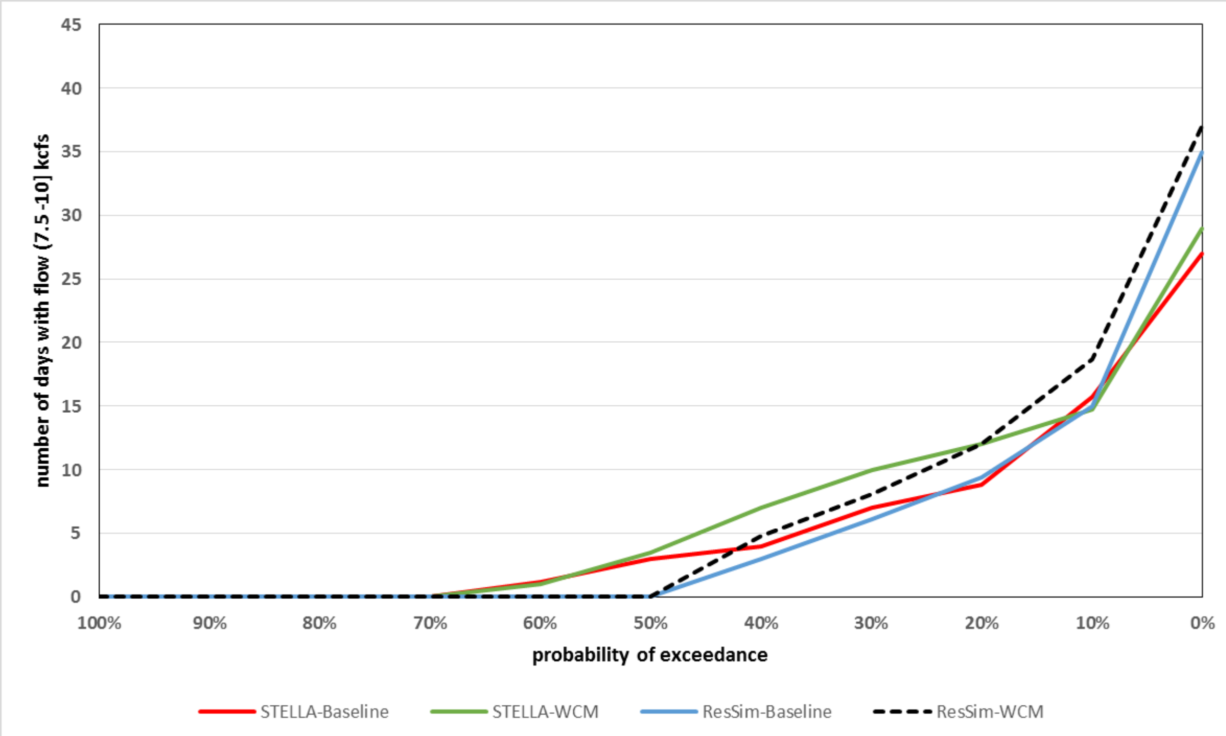


Figure 10.5G Probability of exceedance plot showing total number of days overall when flows are 7,500-10,000 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

The total number of days at flows 7,500-10,000 cfs between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.5G. The WCM provides 48 days more across the 74 years compared to the baseline during this range of flows (48/3,330 days = 1.4% change). The WCM would on average change the days at 7,500-10,000 cfs by 7.2% in 5 years. This may be an adverse effect for the mussel population by increasing the time for juvenile mussels to drop and settle in this ephemeral habitat further from the more stable 5,000 cfs stable zone.

These basic patterns of very slight differences between the baseline and WCM can also been seen on the flow duration curve. The flow between June 1 and July 15 when flows are between 4,500 and 10,000 cfs occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.5H. The WCM has a slightly lower probability of a flow <6,500 cfs and slightly higher probability of flows >7,000 cfs than the baseline.

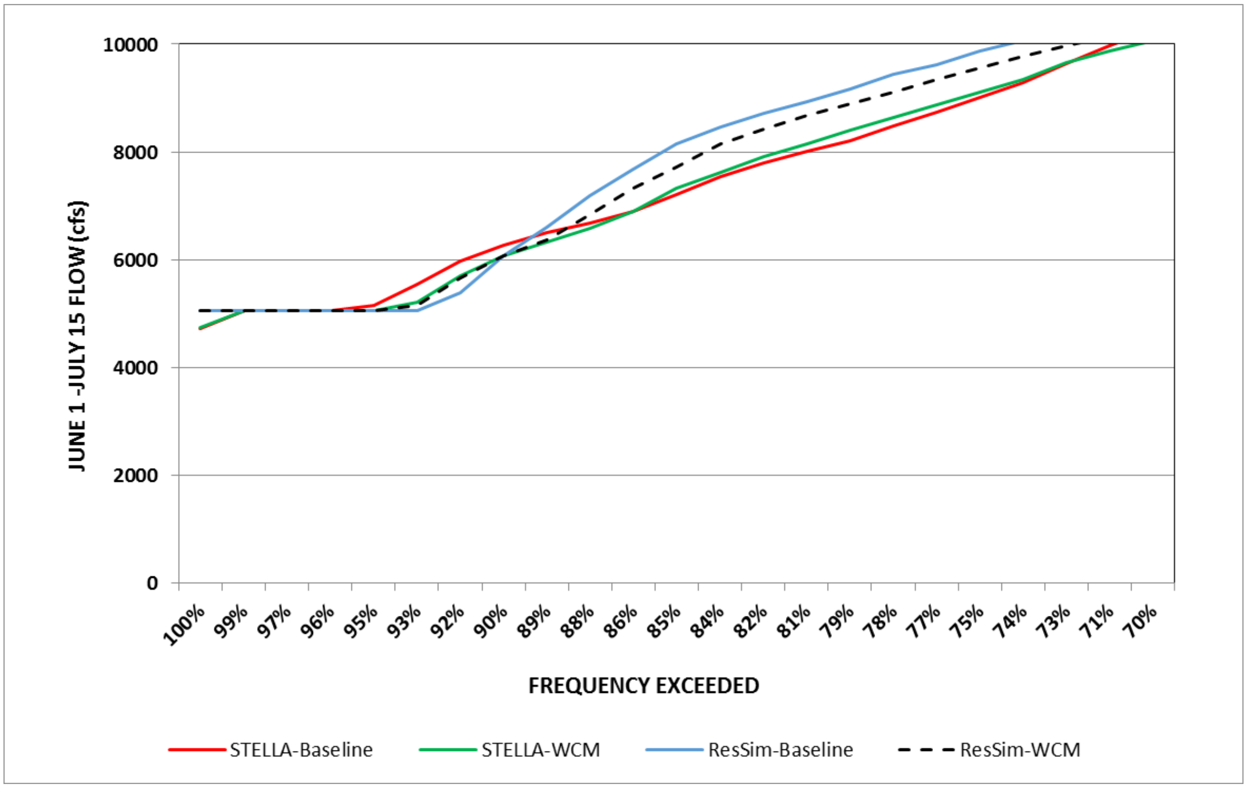


Figure 10.5H Probability of exceedance plot showing flows (cfs) <10,000 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

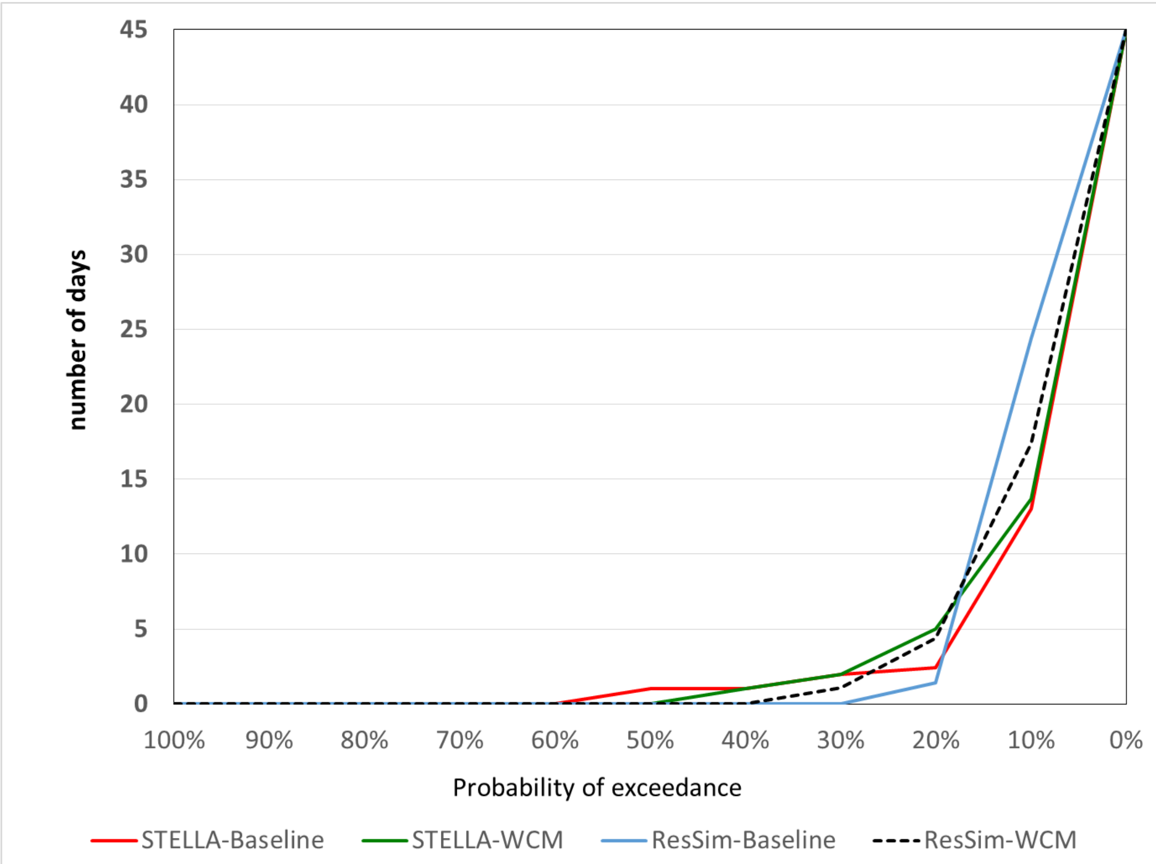
Interpretation: The WCM provides a mix of beneficial and adverse effects compared to the baseline. Overall, the greater number of low flow days during the infection and drop cycle may correspond to higher infection rates and survival of juvenile mussels following release from the fish host. The WCM's slight benefit of a 30-day increase (0.9%) in the number of days in the 5,000-5,999 cfs range during June 1-July 15 infection and drop cycle may correspond to slightly higher infection rates, settlement of juvenile mussels in this zone near the 5,000 cfs management threshold, and increased survival of juvenile mussels following settlement in this relatively stable zone. However, these slight benefits may be outweighed by the 1-day increase (0.03%) in the number of days below 5,000 cfs, the 51-day drop (1.5%) in number of days in the 6,000-7,499 cfs range, and the 48 additional days (1.4%) in the 7,500-10,000 cfs range.

Freshwater Mussel Hydroecological Metric 5 - Stable Low Flows during Host Infection and Juvenile Settlement

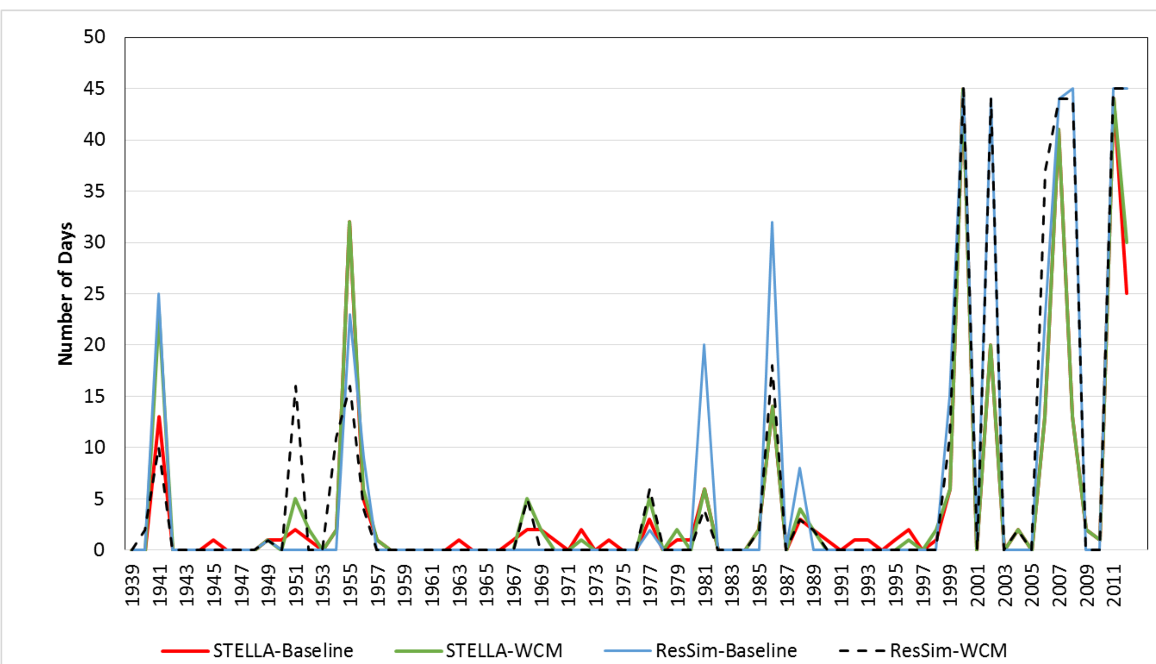
Metric Description: To evaluate the potential effects of the proposed action on the ability of adult host fish to be infected and juvenile mussels to drop in appropriate locations for high survival, we calculated the maximum number of consecutive days between June 1 and July 15 exhibiting flows <7,500 cfs.

Designed to complement Freshwater Mussel Hydroecological Metric 4, this metric reflects the number of days during the infection and juvenile drop cycle that flows are low or very low and almost entirely contained within the main channel of the river. However, this metric emphasizes the consistency, or stability of low flows occurring during the infection and drop cycle. Low, stable flows during this 45-day time period, rather than intermittent, short-term increases in discharge due to natural or anthropogenic effects, are considered beneficial for the infection of host fish and for settlement of juvenile mussels in areas of the channel most likely to remain inundated year-round. This metric assumes that the zone of stability and highest survival for mussels is near the 5,000 cfs waterline, and mussel drop closer to this 5,000 cfs waterline will result in the highest survival of juvenile mussels and settlement farther from this 5,000 cfs waterline will result in lower survival. We use <7,500 cfs to represent this higher survival, better ephemeral habitat. Note, this metric only apply to species that are gravid, releasing glochidia, and experiencing juvenile drop in June through early July, such as *A. neislerii, E. chipolaensis,* and other non-listed species.

Results: The total number of days at flows <7,500 cfs between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.6A and a summary of the days per year (Figure 10.6B). Both models showed different patterns, and the ResSim model showed a negative effect. Based on the ResSim models, the WCM provides 10 days less of consecutive flows <7,500 cfs compared to the baseline across the 74 years (i.e., 0.3 days on average), and this effect is mostly visible in the years with more days of flow <7,500 cfs (i.e., the drier years). Again, this pattern can be seen in the flow duration curve where the WCM has a slightly lower probability of flows between 5,000 and 7,000 than the baseline Figure 10.5H. This may be slightly negative effect for the mussel population by decreasing the time for juvenile mussels to drop and settle in this ephemeral habitat closer to the more stable 5,000 cfs stable zone.


45
40
35
30
25
20
15
10
5
0
number of days
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Probability of exceedance
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

A


50
45
40
35
30
25
20
15
10
5
0
Number of Days
1939
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

B

Figure 10.6 Probability of exceedance plot (A) and an annual summary (B) showing total number of days when flows are continuously <7,500 cfs between June 1 and July 15 occurring under the baseline and WCM flow regimes

Interpretation: The WCM provides a slight negative effect compared to the baseline. Higher number of consecutive low flow days during the infection and drop cycle may correspond to higher infection rates and higher survival of juvenile mussels following release from the fish host. The WCM's slightly negative effect of a 0.3 day average decrease in the number of consecutive days <7,500 cfs during June 1-July 15 infection and drop cycle may correspond to slightly lower infection rates, settlement of juvenile mussels in this zone near the 5,000 cfs management threshold, and decreased survival of juvenile mussels following settlement in this relatively stable zone.

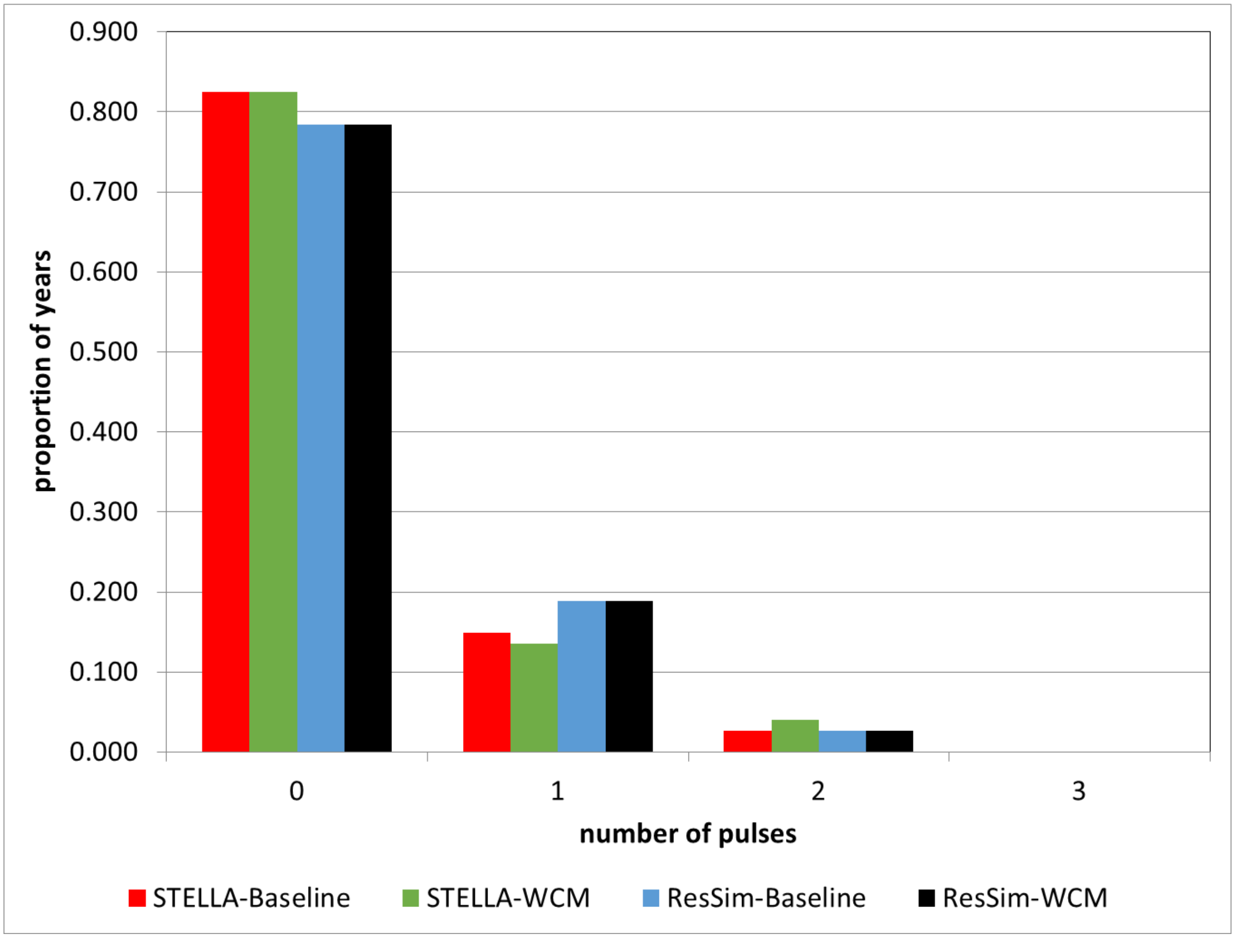
10.2.1.3 Flows for Mussel Growth and Fecundity with respect to Floodplain Inundation (FE4)

Freshwater Mussel Hydroecological Metric 6 - Pulsed Floodplain Inundation during Summer-Fall

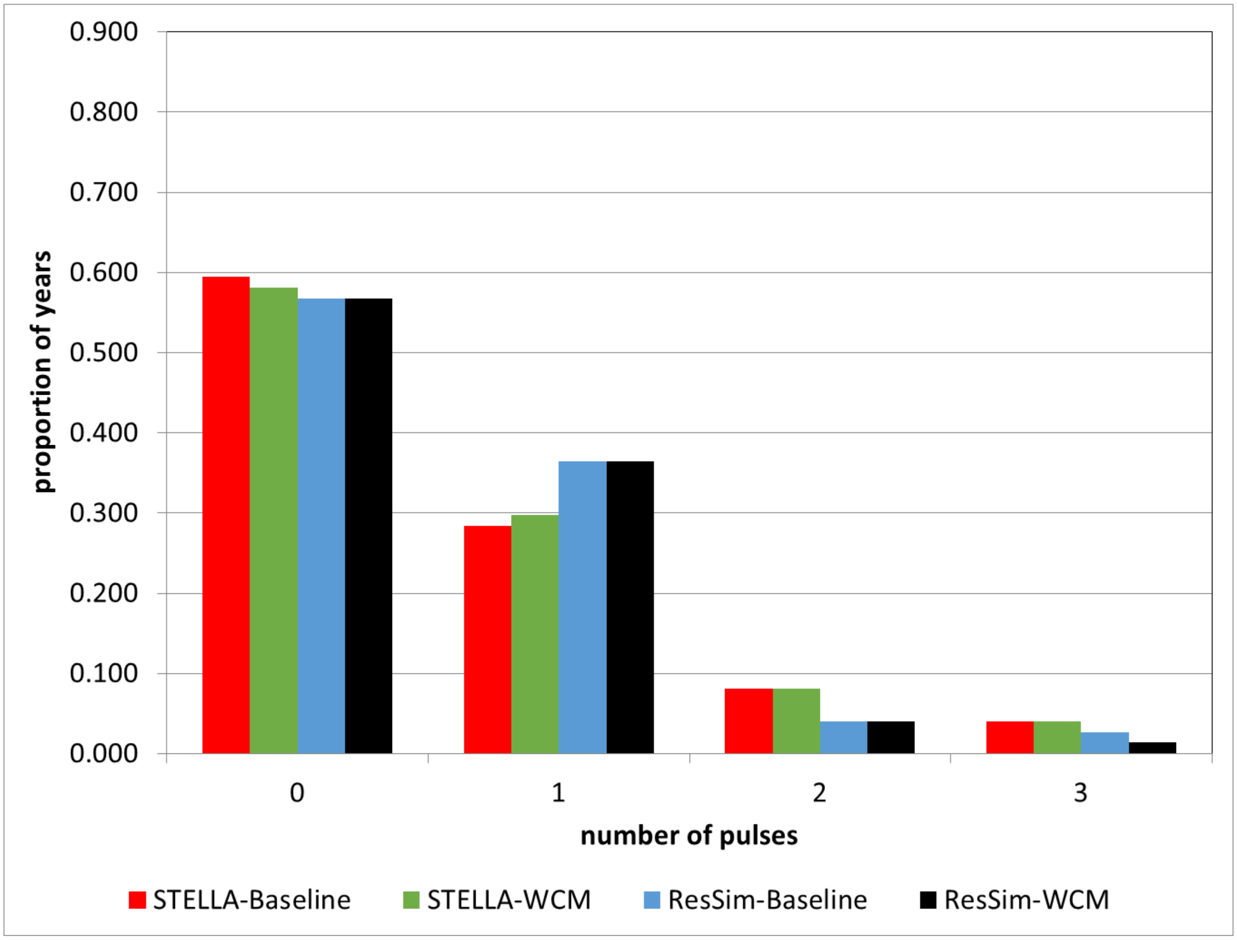
Metric Description: To evaluate the potential effects of the proposed action on the contribution of the floodplain to nutrients for food production for mussel growth and fecundity, we calculated the total number of floodplain pulse episodes between July 15 and November 24.

This metric emphasizes the role of floodplain inundation pulses during the mid- to late- growing season after mussel drop, rather than focus singularly on the amount of time the floodplain is inundated. A flood pulse is a discrete discharge episode with flows continuously ≥16,200 cfs for a period of at least 15 or 30 of days, followed by a period of flows <16,200 cfs for a period of at least 7 days. As with other hydroecological metrics, we used 16,200 cfs as an approximate flow threshold where substantial floodplain inundation occurs, although the maximum inundation of the floodplain occurs at approximately 125,000 cfs. Cycles of inundation followed by drying may stimulate productivity, and recruitment of carbon to the main channel (Junk et al. 1989) where mussels are filter feeding. This time period is important for growth of juvenile mussels and growth and fecundity of adult female mussels (Strayer 2008). The inundation period must be sufficient to allow for primary production to occur. Because there is uncertainty surrounding the duration of time the floodplain needs to be inundated to stimulate this primary productivity and carbon recruitment to the main channel of the river where most of the mussel population will survive and reproduce, we calculated both a 15-day and a 30-day pulse to bracket the potential durations of time. This metric calculates the proportion of years in the 74 year record with 0, 1, 2, and 3 floodplain pulses.

Results: The proportion of years with 30-day (A) and 15-day (B) floodplain pulses between July 15 and November 24 occurring under the 2 flow regimens (baseline, WCM) is presented in Figure 10.7. The models showed differing results, and the ResSim model showed a negative effect. The WCM and baseline provided the same number of years with at least one 30-day pulse across the 74 year record (16 years or 22% of the time), but the WCM provided one less year with a 15-day pulse compared to the baseline (31 years or 42% of the time). Across the 74-year record, the WCM provided one less year with three 15-day pulses (1.4% of the time) 15-day pulses than the baseline.



A



B

Figure 10.7 The proportion of years in the 74 year period of record with 30-day (A) and 15-day (B) floodplain pulses between July 15 and November 24 occurring under the baseline and WCM flow regimes

Interpretation: Although these are rare events in the record, providing one less year with three 15-day pulses once every 74 years (1.4% decrease) are slightly negative effects of the WCM. Under the WCM (as well as the baseline), we expect 1 year with at least a 30-day pulse and 2 years with a 15-day pulse in 5 years. This reduction in pulses of nutrients may provide less carbon and consequently primary productivity to the main channel of the river where the majority of the mussel population resides. This may reduce food resources for the mussel population may decrease juvenile mussel growth and female mussel fecundity in these rare years.

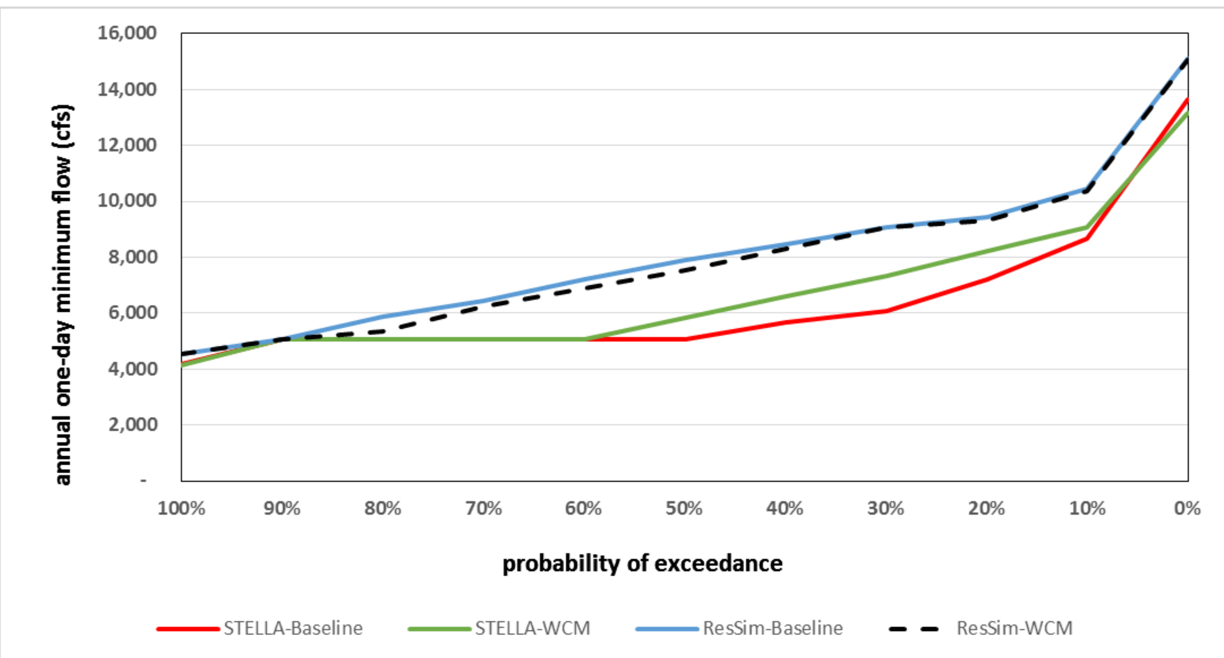
10.2.1.4 Flows for River Drawdown and Mussel Survival in Ephemeral Habitats (FE5)

Freshwater Mussel Hydroecological Metric 7 - Mussel Exposure and Survival during Extreme Low Flows

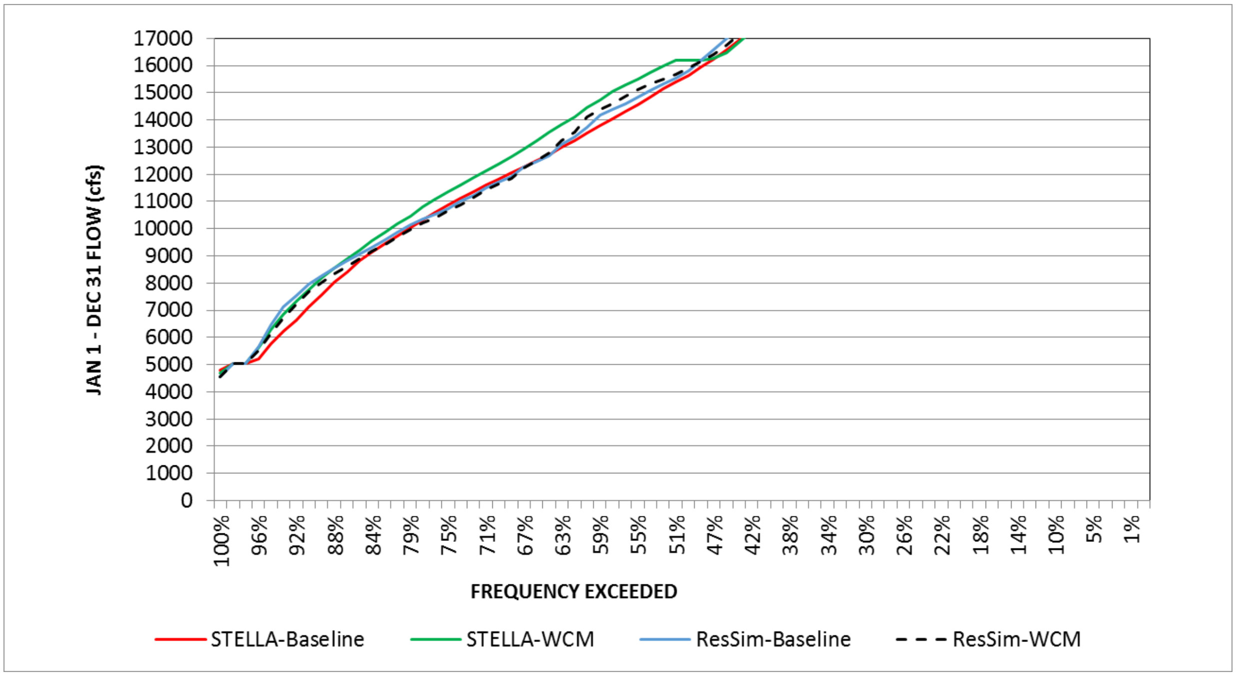
Metric Description: To evaluate the potential effects of the proposed action on mussel exposure and survival during extreme low flows, we calculated the annual 1-day minimum flow for the Apalachicola River across the 74 years of record.

This metric emphasizes the importance of the low flow experienced by the mussel population each year and the probability of experiencing very low flows (i.e., <5,000 cfs). Since mussels are relatively slow moving, their ability to retreat during water level declines is a function of site slope and the rate of water surface elevation decline (USFWS 2011, Newton et al. 2015). However, field studies have documented the ability of mussels like *A. neislerii* to relocate to lower elevations as water level declines in the Apalachicola River (USFWS 2011). Minimum flows and how the rules in the baseline and WCM management plans are implemented are important, especially as the flows reach and drop below the relatively stable 5,000 cfs minimum in the rule sets that govern each management plan. In both plans, the drought operations allow flows to drop to 4,500 cfs in drought situations. These thresholds are important because they provide the habitat stability during low flows that mussels require (Strayer 2008). Note that a version of this metric is presented in tabular form for the 1975-2011 time period in the BA (Table 10 in 6/30 BA).

Results: The annual minimum flow occurring under the 2 flow regimens (baseline, WCM) is presented as a probability of exceedance plot in Figure 10.8A. The models showed the different patterns, but the ResSim model showed a negative effect (i.e., that the WCM increased the chance of flows ≤5,000 cfs). The WCM increased the chance of minimum flows below 5,000 cfs to approximately 3%. The WCM provides an additional 1% of years that the annual minimum flow is ≤5,000 cfs compared to the baseline. During the WCM, we would expect to have a 3% chance to reach ≤5000 cfs. This effect can also be seen in the annual flow duration curve in which the WCM provides lower flows in the approximately 96% to 50% exceedance range Figure 10.8B.



A



B

Figure 10.8 Probability of exceedance plots showing the annual one-day minimum flow (A) and annual flows (cfs) ≤17,000 cfs (B) occurring under the baseline and WCM flow regimes

Interpretation: Fewer years with flows less than 5,000 cfs should benefit mussel populations since this commonly recurring low flow or inundation elevation (wetted perimeter) is associated with the minimum flow rules in each management plan. When viewed in conjunction with the stable flows for settlement of mussels in early summer, flows at or above the 5,000 cfs threshold should allow mussel populations to grow in the relatively stable environment created by this threshold. Consequently, increasing the probability of time at or below this threshold by 1% under the WCM should adversely affect mussel populations. During the WCM, we would expect a 3% chance to reach flows ≤5,000 cfs.

Freshwater Mussel Hydroecological Metric 8 - Mussel Exposure and Survival during Extreme Low Flows

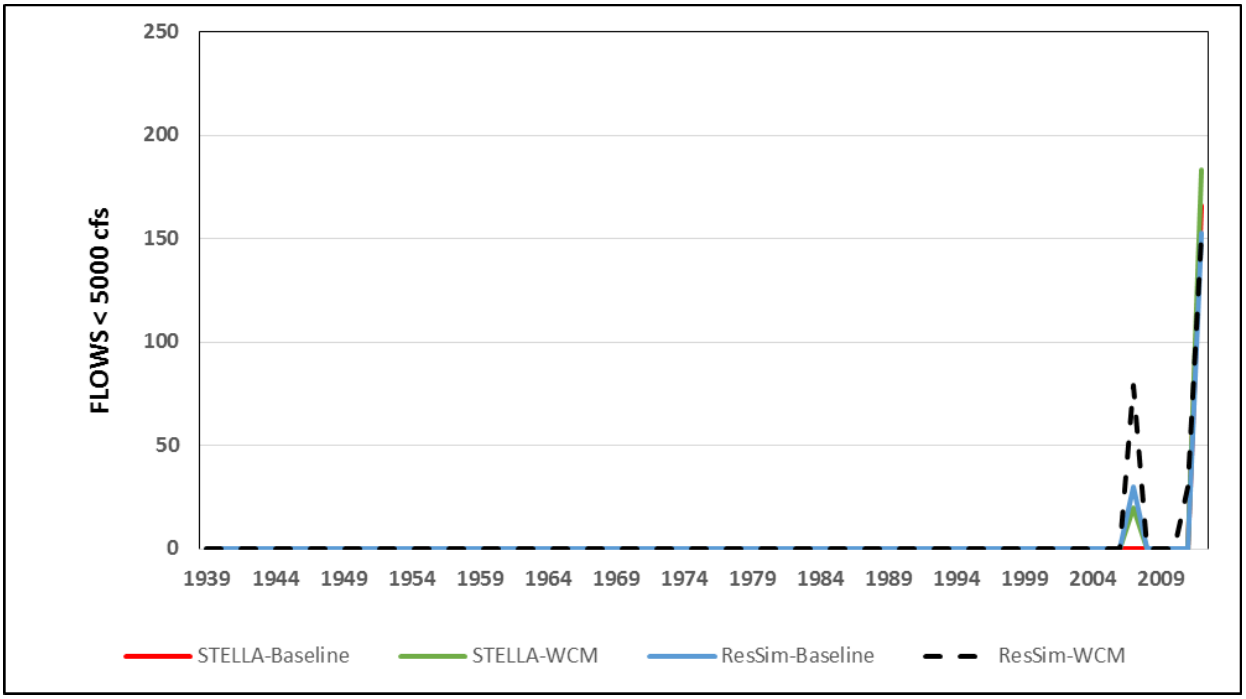
Metric Description: To evaluate the potential effects of the proposed action on mussel exposure and survival during extreme low flows, we calculated the annual 1-day minimum flow at two thresholds (<5,000 cfs and <5,100 cfs) for the Apalachicola River by year of record.

This metric emphasizes response to drought and the importance of the low flows near (<5,100 cfs) and less than the minimum management threshold of 5,000 cfs. It was designed to complement mussel metric 7. Since mussels are relatively slow moving, their ability to retreat during water level declines is a function of site slope and the rate of water surface elevation decline (USFWS 2011, Newton et al. 2015). However, field studies have documented the ability of mussels like fat threeridge to relocate to lower elevations as water level declines in the Apalachicola River (USFWS 2011). Minimum flows and how the rules in the baseline and WCM management plans are implemented are important, especially as the flows reach and drop below the relatively stable 5,000 cfs minimum in the rule sets that govern each management plan. In both plans, the drought operations allow flows to drop to 4,500 cfs in drought situations. These thresholds are important because they provide the habitat stability during low flows that mussels require (Strayer 2008).

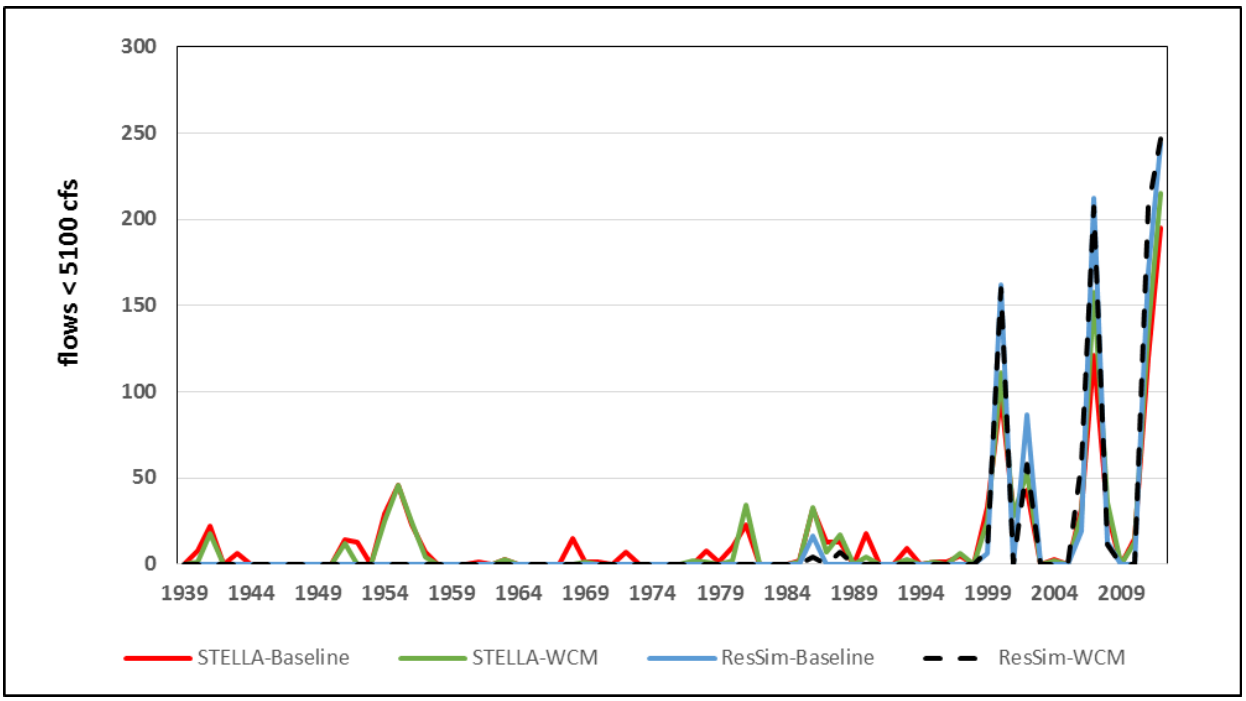
Results: The total number of days when flows are <5,000 cfs occurring under the 2 flow regimens (baseline, WCM) is by year of record in Figure 10.9A. Both models showed similar patterns. However, the ResSim model showed a stronger negative effect when flows are <5,000. The WCM and baseline provide essentially identical management with flows not dropping below 5,000 cfs across the period of record with the exception of the response to the recent droughts in which the WCM spent 79 days <5,000 cfs and the baseline 30 days in 2007 and the WCM spent 29 days more (182 vs 153) than the baseline < 5,000 cfs in 2011-2012 (1.4% increase in number of years). Under the WCM, we would expect flows < 5000 cfs in 4.1% of years or an 8.1% chance in one of five years.

When we calculate the total number of days when flows are <5,100 cfs occurring under the 2 flow regimens (baseline, WCM) by year of record (Figure 10.9B), we see more discrimination between the WCM and baseline management plans. The WCM increased the number of days <5,100 cfs by 39 days across the 74 years with flows below 5,100 cfs, but the WCM had 10 years (13.5%) where flows dropped below 5,100 cfs while the baseline had 9 years (12.2%). Under the WCM, we would expect flows < 5,100 cfs in one of five years.

It is worth noting that the recent hydrographic record has been drier and resulted in a pattern of increasing prevalence of low flows. This potential challenge to management is evident in the recent record from 1999 to 2012 and is especially visible in Figure 10.9B. Flows never went below 5000 cfs from 1939-2006, but did three times in the last 6 years of the record. Similarly, flows never went below 5100 cfs from 1939-1985, but did 10 times in the last 27 years of the record.



A



B

Figure 10.9 An annual summary of the total number of days when flows are continuously <5,000 cfs (A) and <5,100 (B) occurring under the baseline and WCM flow

Interpretation: Fewer years experiencing flows less than or near 5,000 cfs should benefit mussel populations since this commonly recurring low flow is associated with the minimum flow rules in each management plan. When viewed in conjunction with the stable flows for settlement of mussels in early summer, flows at or above the 5,000 cfs threshold should allow mussel populations to grow in the relatively stable environment created by this threshold. The increased year in which time was spent below 5,000 cfs and increased 78 days during these two droughts may have highly detrimental effects to the mussel population because it disrupts the otherwise stable habitat maintained by the 5,000 cfs threshold. Under the WCM, we would expect flows < 5,100 cfs in one year and an 8.1% chance to drop < 5000 cfs in one of five years.

Freshwater Mussel Hydroecological Metric 9 - Mussel Exposure and Survival during Drawdown

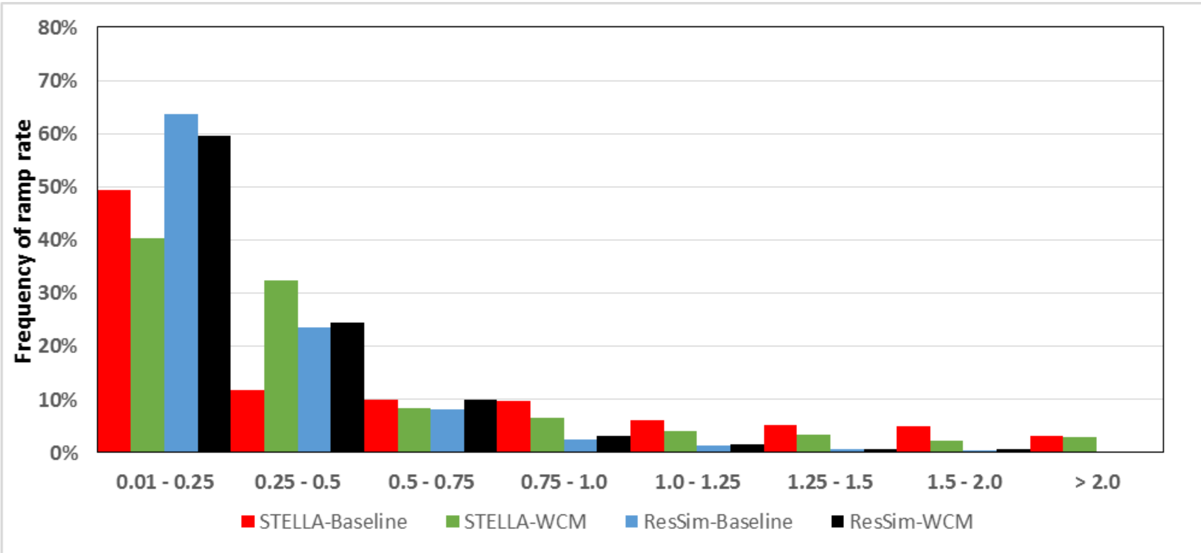
*Metric Descriptio*n: To evaluate the potential effects of the proposed action on mussel exposure and survival during drawdown, we calculated the frequency (in percent of days) of daily stage changes (ft/day) for all flows and when releases from Jim Woodruff Dam are less than 10,000 cfs.

This metric emphasizes response to drought and the importance of the ramp rate (i.e., change in flow while flows are decreasing) when moving toward low flows and especially the ramp rate as water is drawn down from 10,000 to 5,000 cfs. It was designed to complement mussel metrics 7 & 8. Since mussels are relatively slow moving, their ability to retreat during water level declines is a function of site slope and the rate of water surface elevation decline (USFWS 2011, Newton et al. 2015). However, field studies have documented the ability of mussels like *A. neislerii* to relocate to lower elevations as water level declines in the Apalachicola River (USFWS 2011).

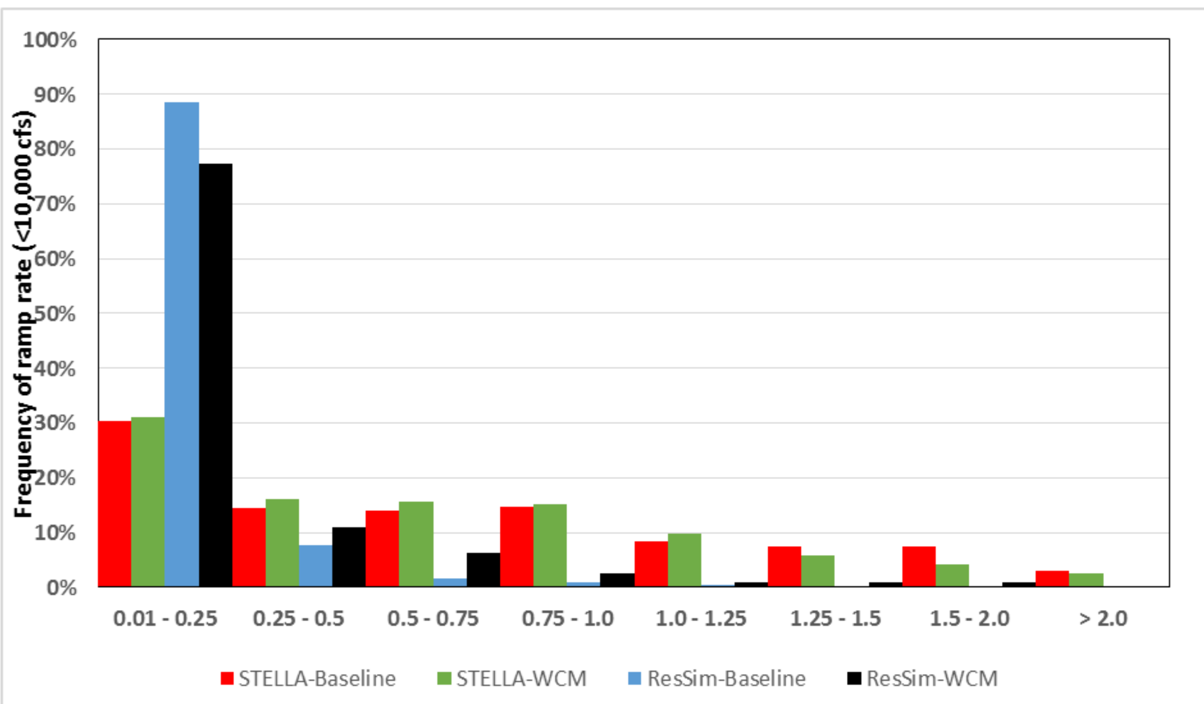
At the daily drawdown rate of 0.25 feet/day (app. 220-500 cfs/day) included in the conservation measures (Table 1.4), the sites that are most at risk of experiencing some exposure and mortality of freshwater mussels are those with the lowest bank slopes- slopes of <0.2 (i.e., 20%), as observed across a multitude of sites in the Apalachicola River and lower Chipola River (USFWS 2011). Maintaining slow drawdown rates when river discharge is falling from 10,000 to 5,000 cfs provides the greatest opportunity for successful escapement of ephemeral habitat by mussels that inhabit the "moving littoral" zone of the river. How the maximum ramp rates rules in the baseline and WCM management plans are implemented is important, especially as the flows reach and drop toward and below the relatively stable 5,000 cfs minimum.

This metric is essentially a check of the rules in the management plans and is presented for continuity with previous BOs for Jim Woodruff Dam operations (USFWS 2008, 2012). Note that a version of this metric is presented in Figure 34 & 35 for the 1975-2011 time period in the BA (6/30 version).

Results: The frequency (in percent of days) of daily stage changes (ft/day) for all flows occurring under the 2 flow regimens (baseline, WCM) is presented in Figure 10.10A. Both models showed the same pattern (i.e., that the WCM and baseline showed little change in daily ramp rates), but the ResSim model showed the greater effect. The WCM has 4% fewer days with ramp rates ≤0.25 ft/day than the baseline when looking at all flows. When flows are <10,000 cfs, the frequency (in percent of days) of daily stage changes (ft/day) occurring under the 2 flow regimens (baseline, WCM) is presented in Figure 10.10B. In this case, the WCM has 11% fewer days with ramp rates ≤0.25 ft/day than the baseline.



A



B

Figure 10.10 The frequency of days across the 74-year record with decreasing flow ramp rates < 0.25 ft/day and in categories >0,25 ft/day at all flows (A) and when flows are <10,000 (B) occurring under the baseline and WCM flow regimes

Interpretation: Lower ramp rates should result in less stranding and lower mortality of mussels especially when dropping from 10,000 to 5,000 cfs. Thus, the WCM provides a slight negative effect with the 11% decrease in days with daily ramp rates $\leq$0.25 ft/day. However, these figures must be interpreted with caution because the data is based on daily averages. The Jim Woodruff Dam hydrogeneration schedule does result in stage changes *within* each day, not obvious from the "average daily flow" reported, but certainly extreme within each day. These within day stage changes could result in stranding of aquatic organisms, including mussels, fish hosts, and Gulf sturgeon (as discussed in the previous section). These effects on mussels are discussed in the next section.

10.2.1.5 Other Effects of the WCM on Mussel Life History and Critical Habitat

The hydroecological metrics calculated to assess effects on daily flow do not cover other effects of the action. Two other effects that are worthy of discussion and qualitative analysis are changes in temperature and sub-daily flows for hydropower generation (hydropeaking).

Freshwater Mussel Qualitative Metric 1 - Mussel Growth and Survival at Increased Temperatures

As described earlier, mussels are very sensitive to changes in temperature and rely on temperature cues to initiate spawning. In addition, temperature is correlated with DO levels and die offs of other mussels have been documented in the ACF downstream of the dam.

The USACE in its BA developed a HEC-5Q model to analyze WCM effects to water temperature. Figure 2.5 provide a representation of WCM effects on stream temperature when compared to the baseline in March - May and September through December time frames, respectively. Examining the area of interest downstream of Jim Woodruff Dam, the upper limits of the temperature experienced by the mussels are near levels at which they experience thermal stress. However, WCM operations would result in no discernable change to temperatures based on this model (Figure 5.7).

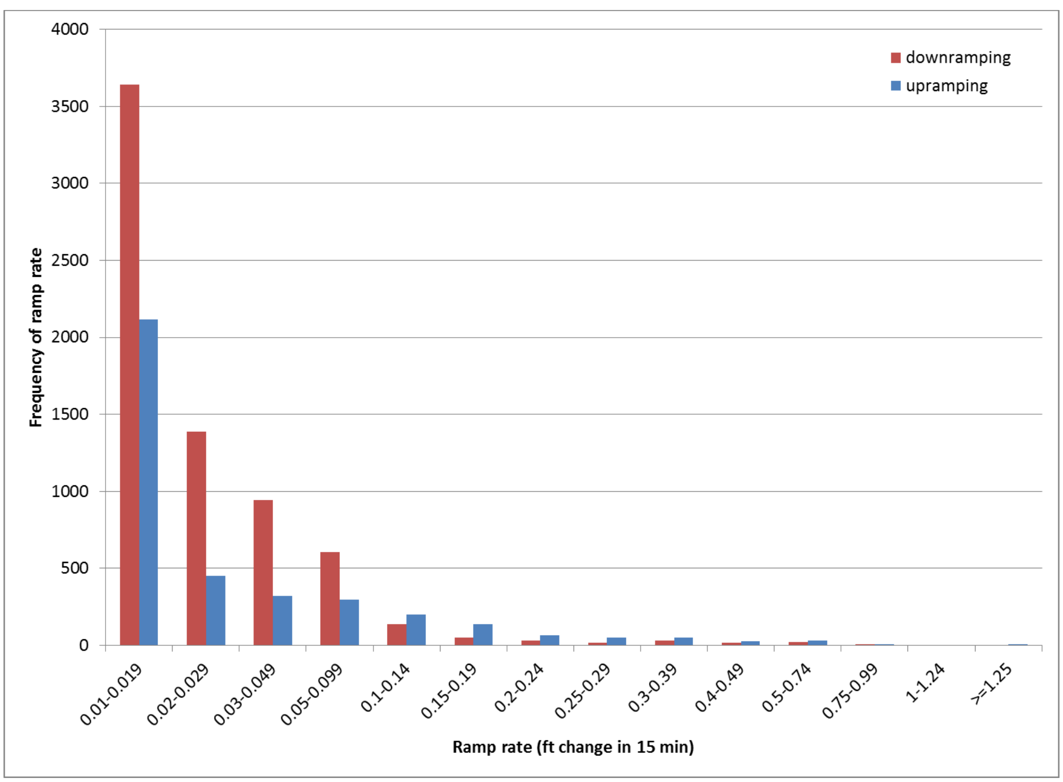
Empirical data on temperature are limited. Only 270 records of temperature ranging from October 1960 to July 2011 are available from the Chattahoochee gage from the USGS website (accessed July 15, 2016). These temperatures average 20.5 C (min 7 degrees C, max 31 degrees C). Additional data are needed to better assess changes in temperature, validate the USACE HEC-5Q model, and assess the effects of these temperature changes on mussels.

Freshwater Mussel Qualitative Metric 2 - Mussel Exposure, Survival, and Habitat Loss during Hydropeaking

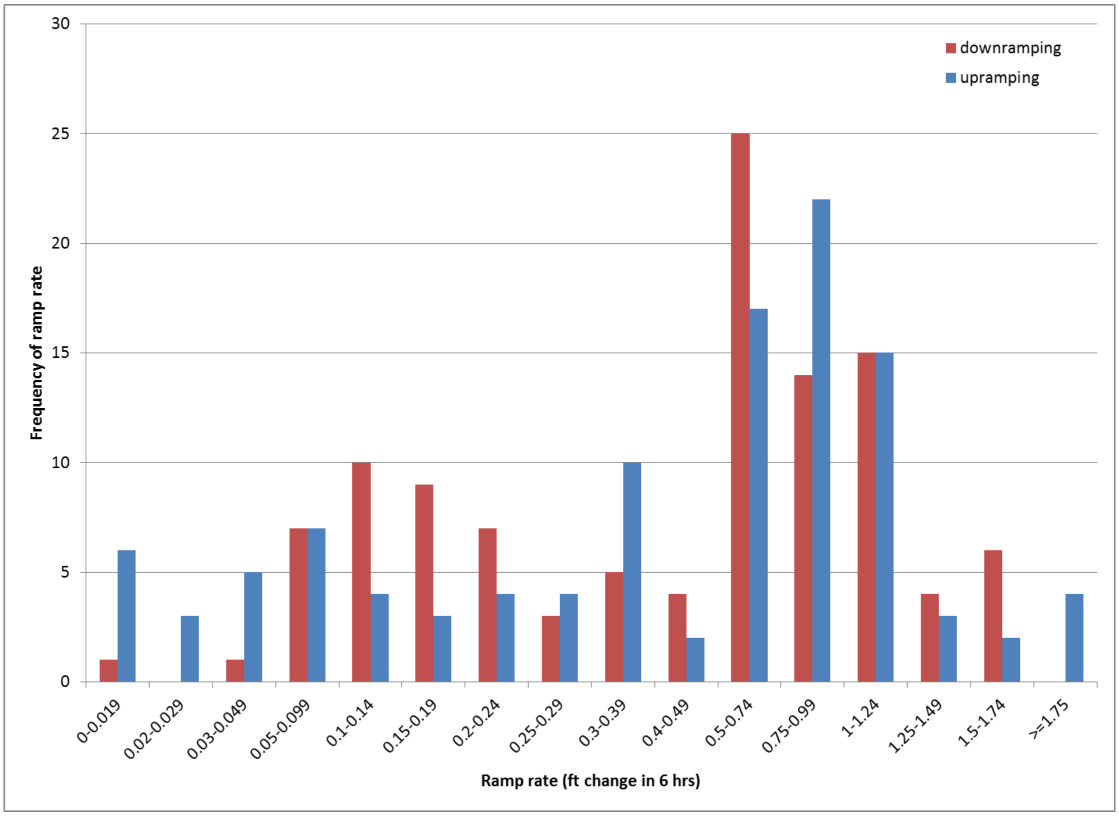
*Metric Descriptio*n: In order to evaluate the potential effects of the proposed action on glochidial infection and juvenile drop during hydropeaking, we calculated the frequency (in percent of days) of 15-minute stage changes (ft/15-min) for all flows during the glochidial infection and drop season (June 1-July 15) and when releases from Jim Woodruff Dam are 6,700-18,300 cfs based on 15-minute gage height data from 2008-2015 at the Chattahoochee gage. In order to evaluate how often conditions for hydropeaking occur during the infection and drop season, we calculated the annual number of days between two thresholds (6,700 cfs and 18,300 cfs) for the Apalachicola River by year of record using the ACF STELLA model and 74-year record.

As discussed in section 1, peaking operations at Jim Woodruff Dam occur between 6,700 cfs and 18,300 cfs. We used 15-minute data from USGS gage 02358000 to analyze the effect of peaking activity on stage and discharge each afternoon (i.e., short durations of increases and decreases in flows lasting 2-6 hrs) from approximately 4:00 p.m. to 10:00 p.m. The large, rapid changes in volume of water from hydropeaking may affect the success of glochidial infection and juvenile drop.

Results: Sub-daily, 15-minute discharge and gage height data from the Chattahoochee gage for 8 years (2008-2015) are summarized in Figure 10.11. These data show down ramping up to 0.92 ft/15 min and up to 0.97 ft/15 min up ramping when flows are between 6,700 cfs and 18,300 cfs during the infection and drop season (Figure 10.11A), although the vast majority (95%) of flows are below the 0.25 ft/day ramp rate threshold. To quantify the prevalence and magnitude of peaking activity for hydropower production, we summarized the data by 6 hour intervals each afternoon between 4 pm and 10 pm (Figure 10.11B). This analysis showed down ramp rates up to 1.6 ft/6 hrs and up ramping rates of up to 1.8 ft/6 hrs while hydropeaking activities are occurring, and 91% of down ramps and 77% of up ramps are above 0.25 ft/day, which is the daily average ramp rate conservation measure. Further, some change of flow occurred during the peaking window of time each afternoon approximately 63% of the time when flows are 6,700-18,300 cfs.

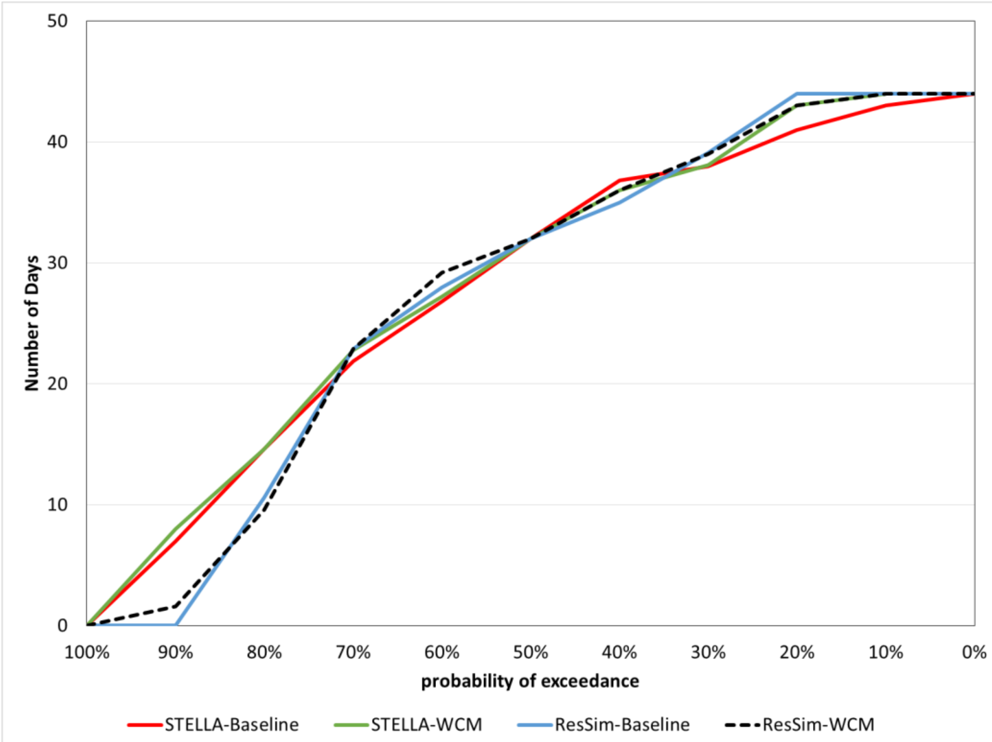


A



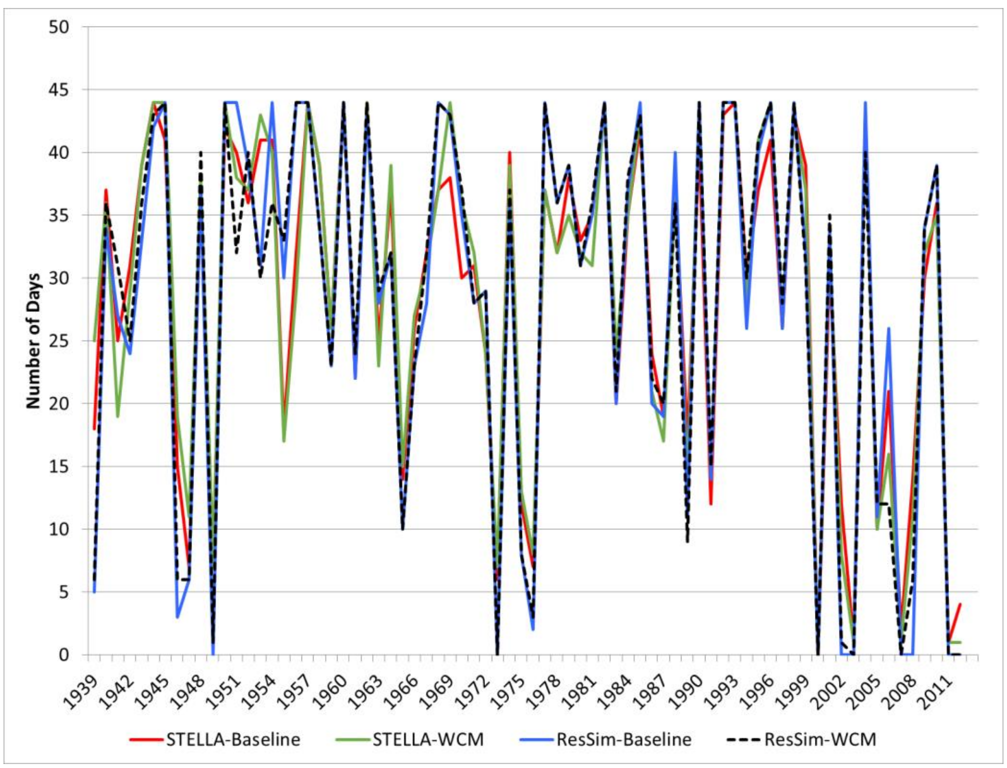
B

Figure 10.11 The frequency of observed 15-minute ramp rates during the mussel infection and drop season (June 1-July 15) (A) and 6-hr ramp rates when flows are (B) from 2008-2015.



50
40
30
20
10
0
Number of Days
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
probability of exceedance
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

A



50
45
40
35
30
25
20
15
10
5
0
Number of Days
1939
1942
1945
1948
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
STELLA-Baseline
STELLA-WCM
ResSim-Baseline
ResSim-WCM

B

Figure 10.12 Number of days when conditions are correct to allow peaking operations at Jim Woodruff Dam during the 44-day mussel infection and drop season presented as a probability of exceedance plot (A) and count of days (B).

The total number of days at flows between 6,700 and 18,300 cfs between June 1 and July 15 occurring under the 2 flow regimens (baseline, WCM from both models) is presented as a probability of exceedance plot (Figure 10.12A) and a summary of the days per year (Figure 10.12B). Both models showed the same pattern (i.e., that the WCM increased the amount of time appropriate for hydropeaking), but the STELLA model showed the greater effect. According to this model, the WCM provides 11 days more of appropriate conditions for hydropeaking compared to the baseline across the 74 years (i.e., 0.4 days on average or 2 day increase during the WCM). Based on 8 years of 15-minute data, peaking occurs 65% of the time under both regimes. Essentially, the WCM represents no change or, perhaps, a very slight increase (<1%) the probability of conditions when hydropeaking may occur, and therefore, we expect no change from the baseline under the WCM for mussel infection and drop for fat threeridge and Chipola slabshell.

Interpretation: In other rivers, peaking hydropower operations cause fluctuations in water levels that results in erosion of the riverbanks and sedimentation of the river, increases habitat instability, and results in thermal changes. This effect can be seen for miles downstream in other rivers and likely results in mortality due to exposure as well as thermal shock to the aquatic fauna in the river including mussels during the juvenile drop and settlement season (USFWS 2011). In addition, glochidia masses may be washed downriver into unsuitable habitat during late spring and early summer peaking releases. However, many of the changes in the ACF Basin may have already occurred, and there is little information to connect these expectations to fat threeridge and Chipola slabshell ecology. Additionally, there is little change in the conditions appropriate for hydropeaking under the WCM, so we expect no change from the baseline.

10.2.2 Climate Change Considerations

As described in Appendix B, we used climate model projections, downscaled and validated for the ACF basin, in order to estimate (using the STELLA model) results of WCM for period 2020-2069. This time frame begins during the period of the proposed WCM operation, and provides a horizon that should include a full range of climate effects to evaluate. Our estimated climate change factors were based on the overall changes in median flow volume for each calendar month, and did not account for changes in the distribution of flows (i.e., for the possibility that, for example, increased median flows may be accompanied by lower low flows and higher high flows). The results from applying these climate change factors to the UIF represent a conservative estimate of the likely range of responses that can be expected during the foreseeable future. The results from climate projections for mussel metrics show a large spread of outcomes associated with the range of climate projections. However, the general patterns between WCM and baseline were similar to that of the observed hydrology for the 1939-2012 period of record and both management actions typically fell near the median predicted flows from the 97 climate models (Appendix B).

10.3 Species' Response to the Action

The previous section on Analysis of the Effects of the Action discussed the effects of flow regime alteration on the listed mussels at several life history stages including juvenile and adult survival, and juvenile recruitment as well as habitat effects including host fish production, and water quality. The following sections interpret these effects on the listed mussels in light of studies on the spatial distribution and biology of the mussels and their host fishes. We summarize the effects on each of these PCEs and each mussel species below (see also Table 10.1).

10.3.1 Critical Habitat

As described above, the PCEs that may primarily be affected by the WCM include permanently flowing water, water quality, and host fish.

Permanently flowing water: Low flows are dictated by rules in the WCM at 5,000 cfs with a minimum of 4,500 cfs under drought operations. For river drawdown and low flows, the three hydroecological metrics indicate the WCM is expected to have adverse effects for mussel exposure and survival during drawdown and low flows compared to the baseline. The WCM provides slight negative effects by increasing the probability of spending time ≤ 5,000 cfs by 1% resulting in 3 - 8.1% chance that the flows will drop below this threshold (M7 and M8). These changes may have highly detrimental effects to the mussel population because it disrupts the otherwise stable habitat maintained by the 5,000 cfs threshold. Additionally, the WCM provides an 11% decrease in days with daily ramp rates ≤0.25 ft/day (M9B) when flows are <10,000 cfs, which may result in slightly more stranding and higher mortality of mussels during drawdown. However, mussels persist in the areas below 4,500 cfs, and the dewatered habitat is not permanently lost. Accordingly, we do not expect that the low flows will permanently limit the ability of the designated critical habitat to function for the conservation of the species.

For higher flows inundating the floodplain, the WCM is expected to have slightly negative effects for mussel growth and fecundity during the late growing season compared to the baseline. Although these are rare events in the record, providing one less 15-day pulse once every 74 years (1.4% decrease) (M6B) is slightly negative effects of the WCM. Under the WCM, we expect 1 year with at least a 30-day pulse and 2 years with a 15-day pulse in 5 years. This slight reduction in pulses of nutrients may provide less carbon and consequently primary productivity to the main channel of the river where it may reduce food resources for the mussel population.

Hydropeaking occurs about 63% of time when conditions are appropriate and results in fluctuations in flow of up to about 1.8 ft/6 hrs (MQ2). This action in other rivers has resulted in erosion of the riverbanks and sedimentation of the river changing the dynamics of the two other PCEs (geomorphically stable stream channel; predominantly sand, gravel or cobble substrate). These effects may be more permanent and increase habitat instability for mussels. WCM operations essentially did not change the conditions when hydropeaking can occur and changes to the channel habitat are part of the baseline, so we expect no permanent change to the flow regime PCE.

Water quality: We expect localized water quality impacts (low DO and high temperatures) to continue to occur in the action area especially during periods of low flows. Water quality modeling (Figure 2.5) indicates the WCM operations would result in little to no change in temperatures. However, the upper limits of the temperature experienced by the mussels are near that at which they experience thermal stress. Data on water temperature and DO are needed to further assess these modeled results, but these temporary changes in water quality are not anticipated to permanently limit the ability of the critical habitat to function for the conservation of the species.

Host fish: Fish hosts may also be affected by the WCM operations. As described earlier, host fishes for these three mussel species that occur in the action area include the weed shiner, bluegill, redear sunfish, redbreast sunfish, largemouth bass, eastern mosquitofish, blackbanded darter, and Gulf sturgeon. Many of these species are known to extensively use floodplain habitats for spawning and rearing. Fish are affected by low-flow events due to constriction of habitat, elevated temperature, reduced dissolved oxygen in backwaters, etc.

The three hydroecological metrics for fish hosts for fat threeridge and Chipola slabshell indicate these hosts will be adversely affected by reduction in floodplain inundation during their spawning season. Overall, the WCM is expected to have an adverse effect on host fish populations compared to the baseline by reducing access to the floodplain during critical times in the growing season for host fish spawning and rearing for fat threeridge and Chipola slabshell. The WCM reduced the total number of days of floodplain inundation by 11% between March 1 and November 24 each year resulting in 11% fewer years with adequate number of days for host fish to spawn (M1), and 13% between March 1 and August 15 each year resulting in 12% fewer years with adequate number of days for host fish to spawn (M2). These reduction equate to approximately a 50% chance that host fish will not reproduce in one year of 5-yr WCM. In addition, the WCM also reduced the total acres of floodplain inundated during 30-day pulsed flows between March 1 and August 15 by 6% or 433 ac/yr on average but by 38% or 2794 ac/yr in the 19 years with the lowest inundation (M3). The WCM will reduce the amount of pulsed floodplain inundation by 2,215 ac on average in 5 years. Fewer days of floodplain inundation combined with the reduction in acres of floodplain inundation is expected to result in a reduction of spawning habitat for adult host fish, reduced growth and recruitment in fish host populations, and consequently a reduction in fish hosts available for mussel infection (Burgess et al. 2013). For example, a 30% reduction in flows during the spawning period resulted in a reduction in recruitment of 19-62% in redbreast sunfish (Sammons and Maceina 2009).

The two hydroecological metrics for infection of fish hosts for fat threeridge and Chipola slabshell indicate there will be a mix of adverse and slightly beneficial effects on infection of these hosts during the late spring and early summer infection and drop period. The WCM provided one slight benefits with a 30-day increase (0.9%) in the number of days in the 5,000-5,999 cfs range during June 1-July 15 infection and drop window (M4B). However, there is an adverse effect of the 1-day (0.03%) increase in the number of days below 5,000 cfs (M4C) and the 51-day (1.5%) drop in number of days in the 6,000-7,499 cfs range (M4E) as well as the 0.3 day average decrease (i.e., 1.3 day decrease during the WCM) in the number of consecutive days

<7,500 cfs (M5). These slightly lower number of low flow days (5000-7500 cfs) and consecutive low flow days during the infection and drop cycle may correspond to slightly lower infection rates, settlement of juvenile mussels in this zone near the 5,000 cfs management threshold, and decreased survival of juvenile mussels following release from the fish host in this relatively stable zone. Additionally, the 1-day increase in time below 5,000 cfs will have a destabilizing effect on the majority of the mussel population near the stable habitat zone defined by 5,000 cfs.

For purple bankclimber, the Gulf sturgeon is the key fish host and, as discussed earlier, the five hydroecological metrics indicate this species is not likely to be affected by the small changes in most of these metrics. There may be a slight negative affect because the WCM provides 10 days (0.3%) and on average 23,093 ac-days (4.7%) less floodplain inundation (GS 1, GS 4). However, the magnitude of this measurable effect of these changes on Gulf sturgeon populations is difficult to quantify. Increasing the time when conditions are appropriate to hydropeak by an average of 5.3 days (or 26 days for the WCM over 5 years) as well as the probability that conditions will be appropriate to hydropeak at least once during the spawning season by 12% and overall by 6% are all adverse effects of the WCM on Gulf sturgeon (GS Q1). These may also be adverse effects to purple bankclimber because Gulf sturgeon is a key host fish for this mussel species.

10.3.2 Fat threeridge

The current range of the fat threeridge is about 75% of its historical range, and its range may continue to decline as it now appears rare in the upper river and almost entirely absent upstream of RM 90. However, as described in section 8.1.1, the fat threeridge population in the action area appears stable. Recent survey techniques using SCUBA and habitat mapping using side-scan sonar have resulted in better sampling of populations and higher population estimates, as well as a better mapping of the habitat for and assessment of the vertical distribution of fat threeridge (Smit 2014). The sonar mapping approach identified twice as many patches and ten times the quantity of suitable habitat than identified using traditional approaches.

Current estimates of the population size of fat threeridge in the action area range from about 6,009,000 to 18,650,000 animals with a mean of approximately 12,167,000. Fat threeridge is the most abundant mussel in terms of frequency collected of the 18 mussel species detected during surveys (Smit 2014; Smit and Kaeser *in press*). During 2012-2015 surveys, 7,454 individuals were collected from the lower Chipola River and lower and middle Apalachicola River (Table 8.1, 8.2, 8.3; Smit 2014, Smit and Kaeser *in press*). The highest densities of fat threeridge occur between RM 27-50 of middle Apalachicola River and lower Chipola River with densities ranging from 3.7 to 7.0 individuals/sq. m, but densities ranged up to 11.2 individuals/sq. m in optimal habitat in the lower Chipola River. The largest portion of the population (61%) occurs in the Chipola Cutoff and lower Chipola River downstream of Dead Lake. This portion of the Chipola River receives about 34% of the flow from the Apalachicola River (Biendenharn 2007); therefore, flows in the Apalachicola River affect flows in the Chipola River and fat threeridge populations in this area. The remaining population occurs in the middle (34%), lower (5%), and upper (<1%) Apalachicola River.

Our analyses indicate fat threeridge may be negatively affected by low flows and effects on fish host populations. The effects of the mussel metrics are summarized by life stage below:
Glochidia production = slight negative, year round

- Very slight negative (M6)
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years

Fish host infection and drop = negative

- Negative (M1-4) Mar - Nov
    - M1-3 = app 50% chance that host fish won't reproduce in the floodplain in one year of 5-yr WCM and floodplain inundation reduced by 2,215 ac.
    - M4 = 1-day increase (0.03%) in the number of days below 5,000 cfs, the 51-day drop (1.5%) in number of days in the 6,000-7,499 cfs range
- Slight negative (M5) Jun - Jul
    - 0.3 day average decrease in the number of consecutive days <7,500 cfs during June 1-July 15

Juvenile growth and survival = mixed effects, mostly negative

- Slightly negative (M6) year round
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years
- Slight negative (M7) year round but mostly in summer
    - Increase probability of spending time ≤5,000 threshold by 1%
    - During the WCM, we expect a 3% chance to reach ≤5,000 cfs
- Negative (M8) year round but mostly in summer
    - 8.1% chance to drop < 5,000 cfs in one of the years of WCM
- Neutral near dam (MQ2) year round, mostly in summer
    - peaking occurs about 63% of days and results in fluctuations in flow of up to app 1.6 ft / 6hrs
    - No change in occurrence of conditions appropriate for peaking from baseline

Adult survival, growth and fecundity = mixed effects, mostly negative

- Slightly negative (M6) year round
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years
- Slight negative (M7) year round but mostly in summer
    - Increase probability of spending time ≤5,000 threshold by 1%
    - During the WCM, we expect a 3% chance to reach ≤5,000 cfs
- Negative (M8) year round but mostly in summer
    - 8.1% chance to drop < 5000 cfs in one of the years of WCM
- Neutral near dam (MQ2) year round, June 1-July 15
    - peaking occurs about 63% of days and results in fluctuations in flow of up to app 1.6 ft / 6hrs
    - No change in occurrence of conditions appropriate for peaking from baseline

The fat threeridge population was affected by low flows between 5,000 to 10,000 cfs in 2006-2007 and 2010-2011 as well as by flows less than 5,000 cfs during 2007 and 2011-2012. Since then, there has been a cumulative take estimate of 8,374 fat threeridge. These low flows affect adult survival, growth and fecundity and juvenile growth and survival.

Fat threeridge move in response to declines in river stage, but mussels need time to move with declining flows and these led to the fall rates conservation measures in the WCM. Fat threeridge were observed moving 50-100 cm per day to keep up with falling water levels, but we documented several instances where the individual failed to move downslope, burrowed or became exposed (8%). The majority (70%) of exposed mussels survived between 1 and 6 days following exposure. Mussel mortality occurs at fall rates less than 0.25 ft/day, and slower fall rates will facilitate movement and likely reduce mortality (USFWS 2011). Because the ability to track receding water levels is related to bank slope (WDNR et al. 2006; USFWS 2011), a greater number of individuals were stranded at low gradient sites during drawdowns. Updating our earlier work (USFWS 2012) with increased understanding of occupied habitats, we found that sites with a mean slope of <20% were at a much higher risk of experiencing mortality 0.02% of the local population. Mussel sites in the Chipola River generally have slopes >20%; therefore, mortality appears to be limited in the Chipola River. The mortality due to low flows observed from 2006-2015 may also depend on preceding hydrologic conditions: if flows are high for long periods (2002-2006), then mortality tends to be higher (0.03% in 2006-2007) and if the high water periods are shorter, then mortality is lower (2008-2010, 2010 mortality <0.01% of the population). Therefore, it is difficult to predict the relative impact of these events in time. For the purposes of these analyses, we assume that the events from 2006-2015 have captured the range of variability in mortality rates, and we assume mortality that occurs at flows less than 5,000 cfs would occur in addition to natural mortality. It is probable longer durations of higher flows facilitate the movement of more mussels into higher habitats, and based on previous work (USFWS 2012), we conservatively attribute these mortality events to the USACE's discretionary actions.

Previously, we used a PVA to assess the potential impacts of low-flow events (i.e., mortality occurring at flows > 5,000 cfs) and extreme low-flow events (i.e., mortality resulting from flows less than 5,000 cfs) on the future viability of the fat threeridge (USFWS 2012, Miller 2011a,b). Although the results from the PVA for low-flow events between 5,000 - 10,000 cfs is outdated due to our current understanding of the distribution of fat threeridge and its habitat, the PVA results remain robust that an isolated extreme low-flow event (< 5,000 cfs) with a low probability of occurrence and a high severity does not appear to pose a major threat to fat threeridge in the Apalachicola River or Chipola River. As discussed earlier, we believe the fat threeridge population in the action area is stable and probably increasing.

Loss of host fish affects the ability of fat threeridge to reproduce. There is approximately a 50% chance that fish will fail to reproduce successfully in portions of the floodplain in one year of 5-yr WCM and floodplain inundation reduced by 2,165 ac. Fewer days of floodplain inundation combined with the reduction in acres of floodplain inundation is expected to result in a reduction of spawning habitat for adult fish, reduced growth and recruitment in fish populations, and consequently a reduction in fish hosts available for mussel infection (Dutterer et al. 2012, Burgess et al. 2013). We assume this effect will be very small (<0.02% of the population). However, we provide an example below to show the data needs for calculating this effect.

For example, a 30% reduction in flows during the spawning period resulted in a reduction in recruitment of 19-62% in redbreast sunfish (Sammons and Maceina 2009). We assume this combined effect will reduce host fish populations by 20% during 1 year of the WCM. The frequency of female mussel gravidity during the reproductive season ranges from 3-56% in other mussels (Price and Eads 2011), and from 3-13% of fish can be infected by mussels (Braun et al. 2014). However, the presence of glochidia on a fish does not necessarily indicate that the fish is a host because glochidia will attach to non-hosts. Fat threeridge has approximately a 25-80% metamorphic success (Fritts and Bringolf 2014), but success on wild fish will be lower due to predation and other stressors that may lead to mortality in infected fish. If we assume an equal sex ratio, only 25% of the population of 12,000,000 are reproductive females, 25% of reproductive females are gravid, a 8% infection rate, and a 50% metamorphic success rate, then approximately 2,600 juvenile mussels may be lost due to this effect in at most 1 year of the WCM. However, these calculations are based on information from other mussel species and genera and should be interpreted with caution. More data to validate these many assumptions are required to refine this estimate.

We estimate that there are currently about 6,009,000 to 18,650,000 fat threeridge (a mean of approximately 12,167,000) in the middle and lower Apalachicola River and lower Chipola River and our understanding of fat threeridge populations in this area has improved greatly in the last 4 years. We anticipate incidental take of fat threeridge if flows are reduced to 4,500 cfs. Take estimates of 0.17%, 1.2%, 0.09% fat threeridge population have been documented in the middle and lower Apalachicola and lower Chipola, respectively, when flows were reduced below 5,000 cfs in the past. If we conservatively assume that 0.09-1.2% of the population would again recolonize that area of habitat between 4,500 and 5,000, a reduction in flow to 4,500 cfs could potentially affect approximately 22,000 individuals. The USACE cumulative take estimate of 8,374 fat threeridge since take monitoring began for the RIOP when flows were reduced to 5,000 cfs is approximately 0.07% of the population. Based on these take estimate, we conservatively expect that no more than 0.1% of the population would recolonize the elevations above 5,000 cfs during the 5-year timeframe of this action, so we also anticipate that 12,000 individuals may be affected if fat threeridge recolonize area above elevations of 5,000 cfs and subsequent mortality occurs at low flows.

10.3.3 Purple bankclimber

Although purple bankclimber is currently known from about 35 locations, the only known location where the purple bankclimber is locally abundant is the limestone shoal at RM 105 (Race Shoals), where we estimated in 2011 that about 30,000 individuals occur. Very few individuals have been collected from the remainder of the river, and only 31 individuals were collected during 2012-2015 surveys by USFWS staff of the lower Chipola River and middle Apalachicola River (Table 8.1, 8.2, 8.3). We were unable to quantify the amount of mortality at elevations above 5,000 cfs in 2006-2007, and we did not observe any dead purple bankclimbers at elevations above 5,000 cfs during our surveys in 2010-2011. However, limited purple bankclimber mortality occurred in 2007 and 2011 when flows were less than 5,000 cfs (three individuals in 2007 and 6 to 39 individuals in 2011). No mortality due to exposure from low flows was recorded in 2006-2008 or 2010-2011, but there has been a cumulative take estimate of 40 purple bankclimber since incidental take monitoring began.

The effects of the mussel metrics are summarized by life stage below for purple bankclimber:
Glochidia production = slight negative, year round

- Very slight negative (M6)
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years

Fish host infection and drop = negative

- Negative (GS1 – floodplain inundation) winter and spring
    - Negative effect in 10% of the years
    - During times of high flow (10-20% probability of exceedance range)
    - Up to 10 days reduction for the 190 day period
- Slightly negative (M6) year round
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years

Juvenile growth and survival = negative

- Slightly negative (M6) year round
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years
- Slight negative (M7) year round but mostly in summer
    - Increase probability of spending time ≤5,000 threshold by 1%
    - During the WCM, we expect a 3% chance to reach ≤5,000 cfs
- Negative (M8) year round but mostly in summer
    - 8.1% chance to drop < 5000 cfs in one of the years of WCM
- Neutral near dam (MQ2) year round, mostly in summer
    - peaking occurs about 63% of days and results in fluctuations in flow of up to app 1.6 ft / 6hrs
    - No change in occurrence of conditions appropriate for peaking from baseline

Adult survival, growth and fecundity = negative

- Slightly negative (M6) year round
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years
- Slight negative (M7) year round but mostly in summer
    - Increase probability of spending time ≤5,000 threshold by 1%
    - During the WCM, we expect a 3% chance to reach ≤5,000 cfs
- Negative (M8) year round but mostly in summer
    - 8.1% chance to drop < 5000 cfs in one of the years of WCM

- Negative near dam (GSQ1) during spawning season for sturgeon March 1-May 31
  - Under WCM operations, changes in river stage of up to three feet have been observed within a six hour time period and peaking conditions increased to about 35% of the spawning season.

Changes in the flow regime due to the WCM that affect the frequency and duration of flows greater than 4,500 cfs are unlikely to affect the purple bankclimber. Unlike the fat threeridge, it does not appear that purple bankclimber recolonized elevations above 5,000 cfs between 2008-2011 or after the recent drought in 2011-2012. Movement at Race Shoals is probably very difficult for mussels due to the highly irregular and jagged nature of the limestone substrate. This is further supported by a lack of movement observed during studies in 2007. Based on Gangloff's surveys of the Race Shoals, it is unlikely that there are currently any live purple bankclimbers at elevations above 4,500 cfs. Gangloff estimated that about 95% of purple bankclimbers surveyed at the shoal occurred at depths greater than 1.5 m (~5 ft) when flows were about 4,400 cfs, and mean density in these areas was 0.17/m^2 vs. 0.48/m^2 in water deeper than 1.5 m. Purple bankclimbers located in shallow water may be at higher risk of collection. It is evident that they are being harvested by fishermen and used for bait at Race Shoals. It is possible that these elevations will be recolonized in the future with new recruitment if flows are higher than 5,000 cfs for sufficient periods. Purple bankclimbers in shallow water are also subjected to stress from high temperatures and low dissolved oxygen, because the shallow portions of the shoal become a nearly stagnant pool environment with excessive algae growth during extended periods of low flow. Decreasing water levels further may harm some fraction of the bankclimber population at this site, but it is difficult to determine from available information.

Unlike for fat threeridge and Chipola slabshell, the Gulf sturgeon is a key fish host for purple bankclimber and the five hydroecological metrics indicate this species is not likely to be affected by the small changes in these metrics. There may be a slight negative affect during the years with the lowest and highest inundation (i.e., dry years), but the biological effect of these changes on Gulf sturgeon is unknown.

We do not have a good recent population estimate for the purple bankclimber in the whole Apalachicola River and Chipola River, but we estimated that about 30,000 individuals may occur at Race Shoals, although the distribution of this estimate is limited and perhaps has low reliability. The species is more detectable, and probably much more abundant, in other parts of its range, such as the Flint River and the Ochlockonee River. If bankclimbers recolonize the habitats >5,000 cfs, they might be affected by the provision to reduce flows to 4,500 cfs and changes in the flow regime that affect the frequency and duration of flows greater than 5,000 cfs. It remains difficult to quantify how many individuals might recolonize bank elevations above 4,500 cfs. We anticipate incidental take of a small number of purple bankclimbers if flows are reduced to 4,500 cfs, primarily at Race Shoals. This is based on the USACE's estimate of incidental take of 39 individuals in 2011 when flows were inadvertently reduced below 5,000 cfs and the 40 individuals detected during take monitoring, which is together approximately 0.2% of the population. If we conservatively assume that 0.2% of the population again recolonize the area of habitat, reducing flows to 4,500 cfs could potentially result in incidental take of 60 individuals. Similarly, we expect that approximately 0.1% of the population would recolonize the elevations above 5,000 cfs during the timeframe of this action, so we also anticipate that 30 individuals would be incidentally taken if purple bankclimber recolonize area above elevations associated with flows of 5,000 cfs and subsequent mortality occurs at low flows.

10.3.4 Chipola slabshell

The surveys conducted by Gangloff (2011) provided a population estimate of 2,645 slabshell in bank margin habitats <2 m deep; however, this estimate may be low because it is based on only 10 individuals collected at two low-density sites. Only 65 individuals were collected during 2012-2015 surveys by USFWS staff of the lower Chipola River and middle Apalachicola River (Table 8.1 and 8.3). No mortality due to exposure from low flows was recorded in 2006-2008 or 2010-2011, but there has been a cumulative take estimate of 24 Chipola slabshell since take monitoring began. The lack of mortality may be attributed to its depth and the slope of the banks in the Chipola River, which are generally steep enough to facilitate mussel movement (Appendix A). Chipola slabshell may also be highly mobile, as other members of the genus *Elliptio* have been shown to be (Watters 1994), which may additionally facilitate movement in these areas.

The effects of the mussel metrics are summarized by life stage below:
Glochidia production = slight negative, year round

- Very slight negative (M6)
  - 1.4% decrease in 15-day pulses
  - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years

Fish host infection and drop = negative

- Negative (M1-4) Mar - Nov
  - M1-3 = app 50% chance that host fish won't reproduce in the floodplain in one year of 5-yr WCM and floodplain inundation reduced by 2,215 ac.
  - M4 = 1-day increase (0.03%) in the number of days below 5,000 cfs, the 51-day drop (1.5%) in number of days in the 6,000-7,499 cfs range
- Slight negative (M5) Jun - Jul
  - 0.3 day average decrease in the number of consecutive days <7,500 cfs during June 1-July 15

Juvenile growth and survival = mixed effects, mostly negative

- Slightly negative (M6) year round
  - 1.4% decrease in 15-day pulses
  - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years
- Slight negative (M7) year round but mostly in summer
  - Increase probability of spending time ≤5,000 threshold by 1%
  - During the WCM, we expect a 3% chance to reach ≤5,000 cfs
- Negative (M8) year round but mostly in summer
  - 8.1% chance to drop < 5,000 cfs in one of five years of the WCM
- Neutral near dam (MQ2) year round, mostly in summer

    - peaking occurs about 63% of days and results in fluctuations in flow of up to app 1.6 ft / 6hrs
    - No change in occurrence of conditions appropriate for peaking from baseline

Adult survival, growth and fecundity = mixed effects, mostly negative

- Slightly negative (M6) year round
    - 1.4% decrease in 15-day pulses
    - During the WCM, we expect 1 year with a 30-day pulse and 1 year with a 15-day pulse in 5 years
- Slight negative (M7) year round but mostly in summer
    - Increase probability of spending time ≤5,000 threshold by 1%
    - During the WCM, we expect a 3% chance to reach ≤5,000 cfs
- Negative (M8) year round but mostly in summer
    - 8.1% chance to drop < 5000 cfs in one of five years of the WCM
- Neutral near dam (MQ2) year round, June 1-July 15
    - peaking occurs about 63% of days and results in fluctuations in flow of up to app 1.6 ft / 6hrs
    - No change in occurrence of conditions appropriate for peaking from baseline

Changes in the flow regime due to the WCM that affect the frequency and duration of flows greater than 4,500 cfs are unlikely to affect the Chipola slabshell, except through effects to host fish. However, it is possible that the species went undetected due to undersampling or that individuals may have been stranded and overlooked during surveys. If so, undetected mortality may be occurring at an undefined rate. Support for this came from USACE monitoring and discovery of additional Chipola slabshell mortality in July 2014 and subsequent revision of take coverage. Being a more mobile species, we expect some recolonization of areas >5,000 cfs and subsequent mortality when flows are again reduced to this level. We still expect exposure mortality for the Chipola slabshell is less than for the fat threeridge or purple bankclimber because it is probably more mobile and site slopes are generally >0.20 in the Chipola River (most fat threeridge are stranded when slopes are <0.20) (section 9.1).

We expect that the Chipola slabshell is less vulnerable to low-flow related mortality than the fat threeridge or purple bankclimber because of its thinner shell and likely higher mobility and the generally steeper bank slopes (>20%) in the Chipola River. Low-flow Chipola slabshell mortality was observed in 2014, and we assume that some low-flow mortality may be occurring. Based on limited survey data and take monitoring, we assume that flow reductions to 4,500 cfs could affect less than 1% of the Chipola slabshell population. Because of the 10 Chipola slabshell that recolonized and were exposed in 2014, we also estimate a take rate of 0.4%. However, given the mobility of the species, these likely underestimate low-flow-related mortality. Further, our current population estimate of about 2,650 is likely an under-estimate in the action area. In combination, these assumptions provide a basis for a conservative, not-likely-to-exceed, take estimate of 2% of the population that recognizes the data uncertainties. Additionally, Chipola slabshell may experience harm through reduced recruitment. However, the magnitude of this effect is currently unknown and expected not to be appreciable.

10.4 Interrelated and Interdependent Actions

We must consider along with the effects of the action the effects of other federal activities that are interrelated to, or interdependent with, the proposed action (50 CFR sect. 402.02). By definition, interrelated actions are part of a larger action and depend on the larger action for their justification. Interdependent actions have no independent utility apart from the proposed action. At this time, the USFWS is aware of only one action that satisfy the definitions of interrelated and interdependent actions that will not themselves undergo section 7 consultation in the future, or that are not already included in the Baseline or our representations of flows under the WCM. This action will undergo section 7 consultation in the future, but is worthy of mention because they address possible reasonable and prudent measures and terms and conditions for addressing effects of hydropeaking. The USACE contract with Southeast Power Administration and Duke Energy will undergo section 7 in the future. This contract controls hydropower production and hydropeaking.

11 MUSSELS - CUMULATIVE EFFECTS

Cumulative effects for mussels are anticipated to be similar to those for Gulf sturgeon.

12 MUSSELS - CONCLUSION

The proposed action provides both beneficial and adverse effects to the species and their designated critical habitats. To the extent that the consumptive use assumptions are accurate, differences between the Baseline and the simulated flows of the WCM are due to differences in reservoir operations, as the model is driven by the observed hydrology. Therefore, we attribute all differences between the Baseline and WCM simulated flow regime to the USACE's discretionary operations. Differences between the Baseline and WCM are summarized for each of the species below (for more details, see section 10).

Most of these effects, both beneficial and adverse, derive from relatively minor differences between the WCM and Baseline. Generally, it appears that USACE would store water more often and augment flows less often under the WCM than has occurred under current management. The WCM uses some of this stored water to maintain a minimum flow of 5,000 cfs, but the frequency of flows less than 10,000 cfs and less than 7,500 cfs is increased. Additionally, floodplain inundation during spring and summer is reduced. The remainder of this section summarizes and consolidates our findings in the previous sections for each listed species and critical habitat in the action area.

12.1 Fat threeridge

Based on best available information, we believe the population of fat threeridge in the action area is stable and possibly increasing. The population appears to be doing well despite the principal effects to the fat threeridge in the action area that we described in section 8, Mussels -

Environmental Baseline. The inter-annual frequency and the intra-annual duration of low flows in the pre-Lanier period substantially increased in the post-West Point period. Flows under the WCM will further increase the frequency and duration of low flows. Flows less than 5,000 cfs were not recorded in the pre-Lanier period. The WCM supports a minimum flow of 5,000 cfs, which benefits the fat threeridge, except when drought operations are triggered that provide for minimum-flow support of 4,500 cfs. Supporting a minimum flow of 5,000 cfs in the future with less basin inflow as demands increase would require greater storage releases from the reservoirs, which could trigger the 4,500 cfs minimum flow provision of the WCM more frequently. The results of an earlier PVA indicated that the population can sustain reductions of 1-2%, and this magnitude of population reduction occurred in the past at a probability less than expected in the WCM. However, the PVA also indicates that increasing the frequency of such events results in a greater impact to long-term population viability, and the WCM increases the probability from once to twice in 74 years. As such, we need to continue to monitor the frequency and severity of these events. If the events occur with greater frequency, it may be necessary to reinitiate consultation.

Therefore, our analysis indicates that the WCM would have a negative, but not appreciable, impact on the survival and recovery of the fat threeridge due to mortality and other adverse effects if flows are reduced to 4,500 cfs or if additional recolonization and subsequent mortality occurs at flows above 5,000 cfs. Further, the WCM would have a negative, but not appreciable, impact on the survival and recovery of the fat threeridge due to reduced recruitment if flows inundate the floodplain for less than 30 consecutive days between March and August.

12.2 Purple bankclimber

The core of the known population of purple bankclimbers in the action area is at the Race Shoals (the limestone shoal at RM 105), but the species is apparently rare in the rest of the river and may be experiencing poor recruitment. Little recent information in the action area is available on the species with only 31 individuals collected during 2012-2015 surveys and 40 detected during take monitoring, but the species is much more detectable and probably much more abundant in other parts of its range, such as the Flint River and the Ochlockonee River. A whole river population estimate is not available, but the population at Race Shoals was estimated to be 30,000. The principal effects to the purple bankclimber in the action area are those we described in section 8, Mussels - Environmental Baseline. Channel morphology changes may have contributed to a decline of the species in the upstream-most 30 miles of the river, although the species is still found in this reach in relatively high numbers at Race Shoals. Flow regime alterations discussed above for the fat threeridge apply also to purple bankclimber with the exception that purple bankclimbers are rarely found at stages greater than 4,500 cfs in the Apalachicola River. We have observed limited mortality of the population during low flows from 2008-2015 with 39 individuals in 2011 when flows were inadvertently reduced below 5,000 cfs and 40 individuals detected during USACE take monitoring.

Therefore, our analysis indicates that the WCM would have a negative, but not appreciable, impact on the survival and recovery of the purple bankclimber. This impact is due to mortality and other adverse effects if flows are reduced to 4,500 cfs or if additional recolonization and subsequent mortality occurs at flows above 5,000 cfs.

12.3 Chipola slabshell

Surveys from 1990 to present have documented many occurrences but found that the species generally occurs in relatively low abundance. We have no evidence that these populations are currently declining, and we consider the Chipola slabshell status to be stable. Many of the effects we described in section 8, Mussels - Environmental Baseline do not apply to the Chipola slabshell, as its known range within the action area is almost entirely limited to the Chipola River downstream of the Chipola Cutoff. Most of the species range is in the Chipola River upstream of the action area. Channel morphology appears less altered in the Chipola River than the Apalachicola River. Flow regime alterations discussed for the fat threeridge apply also to the Chipola slabshell, but probably to a lesser extent in the narrower channel and higher bank slopes of the Chipola River. No Chipola slabshell mortality was documented during the low flows of 2006-2008 and 2010-2011, but there has been a cumulative take estimate of 24 Chipola slabshell under USACE take monitoring. We also expect the mortality of the Chipola slabshell to be less than the expected for the fat threeridge or purple bankclimber because of its expected higher mobility.

Therefore, our analysis indicates that the WCM would have a negative, but not appreciable, impact on the survival and recovery of the Chipola slabshell due mortality and other adverse effects if flows are reduced to 4,500 cfs or if additional recolonization and subsequent mortality occurs at flows above 5,000 cfs. Further, the WCM would have a negative, but not appreciable, impact on the survival and recovery of the Chipola slabshell due to reduced recruitment if flows inundate the floodplain for less than 30 consecutive days between March and August.

12.4 Critical Habitat

Designated critical habitat for the fat threeridge and purple bankclimber in the action area includes most of the Apalachicola River unit, and the downstream-most part of the Chipola River Unit. Designated habitat for the Chipola slabshell only occurs within the downstream-most part of the Chipola River Unit. In the effects analysis, we discussed how the WCM may affect the three of the five PCEs of the mussel critical habitat: 1) permanently flowing water; 2) water quality; and 3) fish hosts.

The WCM increased the probability of reducing flows <5,000 cfs, although this is still a very infrequent event (3 of 74 years in the record). This would occur under drought operations, and droughts substantially change the nature of all of these PCEs compared to normal flows. At higher flows inundating the floodplain, the WCM is expected to have slightly negative effects for mussel growth and fecundity during the late growing season compared to the baseline. Although these are also rare events in the record (1 of 74 years in the record), one less pulse of nutrients may provide less carbon and consequently primary productivity to the main channel of the river to the majority of the mussel population. Additional data on the effects of up to 1.8 ft sub-daily fluctuations in flows, but these changes are not anticipated to permanently limit the ability of the critical habitat to function for the conservation of the three species.

The temporary changes in water quality (temperature and DO) are not anticipated to permanently limit the ability of the critical habitat to function for the conservation of the three species. Data on water quality are needed to further assess the USACE's modeled results in the future.

The WCM reduces the amount of floodplain habitat available to fish hosts for fat threeridge and Chipola slabshell, which likely rely upon floodplain habitats for spawning and rearing habitat. Fewer days of floodplain inundation combined with the reduction in acres of floodplain inundation is expected to result in a reduction of spawning habitat for adult host fish, reduced growth and recruitment in fish host populations, and consequently a reduction in fish hosts available for fat threeridge and Chipola slabshell infection. For purple bankclimber, the Gulf sturgeon is the key fish host and our analysis indicates this species also likely to be affected by the additional conditions available for hydropeaking under the WCM.

The WCM is not expected to appreciably change the quantity or quality of the PCEs to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role.

12.5 Determinations

After reviewing the current status of the listed species and designated critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the USFWS' biological opinion that the proposed action: 1) will not jeopardize the continued existence of the fat threeridge, purple bankclimber, and Chipola slabshell; and 2) will not destroy or adversely modify designated critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell.

The WCM is intended to apply until a new WCM is adopted. Given the USACE's current timeline, the findings of this BO shall apply for five years until September 14, 2021, or until amended through a reinitiation of consultation or superseded with a new opinion for a new proposed action.

13 INCIDENTAL TAKE STATEMENT

Section 9 of the Act and federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the USFWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the USFWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering [50 CFR §17.3]. Incidental take is defined as take that is incidental to, and not the purpose of, an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement (ITS).

The measures described below are non-discretionary, and the USACE must insure that they become binding conditions of any contract or permit issued to carry out the proposed action for the exemption in section 7(o)(2) to apply. The USACE has a continuing duty to regulate the action covered by this incidental take statement. If the USACE: (1) fails to assume and implement the terms and conditions or, (2) fails to require any contracted group to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USACE must report the progress of the action and its impact on the species to the USFWS as specified in the ITS [50 CFR §402.14(I)(3)].

13.1 AMOUNT OR EXTENT OF TAKE ANTICIPATED

The extent of the take is described below based on the effects analyses presented in sections 5 for Gulf sturgeon and 10 for mussels. Two forms of take are expected for Gulf sturgeon and two for the three mussel species.

13.1.1 Gulf sturgeon

Take of Gulf sturgeon eggs and larvae may occur due to rapid increases and decreases in stage and discharge associated with hydropeaking operations at Jim Woodruff Dam during the spawning season (March 1-May 31). The form of this take is injury or mortality of fertilized eggs and larvae caused by sudden alteration of water depth and velocity, which disrupts normal hatching and dispersal patterns and reduces food resources for larval sturgeon. The take will occur during and shortly after spawning and hatching, as spawning habitats potentially become temporarily unsuitable during the months of March, April, and May. Our analysis in section 5.2.2 indicates that hydropeaking events causing this form of take will occur on average 32 days per spawning season or up to 160 days in the next five spawning seasons; however, we are unable to estimate the number of individual eggs and larvae affected.

The second form of take of Gulf sturgeon is caused by WCM operations reducing the estuarine invertebrate production, which is critical to juvenile sturgeon growth and survival in the first winter of life. The take will occur in in the late summer and fall (July 15-November 24) as well as winter and spring periods (November 24-June1). Our analysis in section 5.2.1 indicates that the floodplain inundation critical to developing these food resources will be reduced on average from 674,000 ac-days per year to 655,000 ac-day per year in the late summer and fall period (i.e., by 19,000 ac-day per year or up to 95,000 ac-day per year in the next five years) and on average by 2.4 days or (i.e., 12.1 days over five years) during the winter and spring periods; however, we are unable to estimate the number of individual juveniles affected.

The USFWS anticipates the incidental taking of Gulf sturgeon associated with WCM operations will be difficult to detect for the following reasons:

- Gulf sturgeon are wide-ranging;
- they occur in habitats and at low densities that make finding a dead or impaired specimen unlikely, and
- changes to fitness parameters (e.g., decreased growth or recruitment) are difficult to assess in the small population in the ACF Basin.

Therefore, USACE will monitor the extent of Gulf sturgeon take using 1) the aggregate number of days in which hydropeaking occurs (i.e., number of days with flows between 6,700 and 18,300 cfs between March 1 and May 31) not to exceed an average 32 days per spawning season or up to 160 days in the next five spawning seasons; and 2) the floodplain inundation will not be reduced below 655,000 ac-day per summer and fall period on average (or a reduction of up to 95,000 ac-days over the next five summer and fall periods) or below 135 days during the winter and spring period on average (or a reduction of up to 12 days over the next five winter and spring periods). These are surrogate measures that indicate the frequency of conditions created by WCM operations that cause the anticipated taking. Exceeding these surrogate measures of the levels of incidental take for Gulf sturgeon shall prompt a reinitiation of this consultation.

13.1.2 Mussels

Take of listed mussels due to the WCM may occur when conditions are such that USACE reduces the releases from Woodruff Dam below 10,000 cfs. The form of this take is mortality that results from habitat modification leading to oxygen stress, temperature stress, and/or increased predation. These conditions may result in immediate or delayed mortality, and as such, mussels that are able to move and remain submerged may still be found dead in the water after the reduction in flows. The take may occur in microhabitats that become exposed or isolated from flowing water when releases from Woodruff Dam are less than 10,000 cfs. In addition, take includes harm that occurs as a result of reduced growth and/or reproduction due to the high temperatures and low dissolved oxygen that has been shown to occur in these habitats. Take of fat threeridge and Chipola slabshell due to the WCM may also occur when conditions are such that USACE reduces the floodplain inundation to less than 30 consecutive days between March 1 and August 15. The form of this take is harm through reduction in host fish populations and mortality of glochidia. These conditions may result in reduced recruitment of fat threeridge and Chipola slabshell in the subsequent year. Our analysis in section 10.2.1.1 indicates that the 30-day floodplain inundation critical to host fish production will be reduced on average by 12.3% per year. The magnitude of this effect is currently unknown, but we believe it to be very small (i.e., <0.02% of the population).

Our analysis in section 10.2.1.4 indicate a 3-8.1% chance of implementing a reduction in flows less than 5,000 cfs, because the 1939-2012 simulations trigger the 4,500 minimum flow of the WCM three times (in 2007, 2011, and 2012). Therefore, we expect that incidental take of listed mussels attributable to the reduction in flow to 4,500 cfs could at most consist of one event in the next five years. We also anticipate that mussels could recolonize habitats greater than 5,000 cfs and be incidentally taken during subsequent low flows. Our model results indicate that incidental take of listed mussels attributable to the reduction flows greater than 5,000 cfs occur with a 13.5% chance, and one event of this nature is likely to occur at flows above 5,000 cfs in the next five years.

We expect a maximum of 34,000 fat threeridge may be exposed in the Apalachicola River, Chipola Cutoff, and Chipola River downstream of the Chipola Cutoff when the minimum flow is reduced to 4,500 cfs (22,000 individuals) and when individuals recolonize habitats greater than 5,000 cfs followed by stranding during subsequent low flows (12,000 individuals). We expect a maximum of 90 purple bankclimbers (60 if flows are reduced to 4,500 cfs; 30 in habitats greater than 5,000 cfs) may be exposed on the rock shoal near RM 105 and at a few locations elsewhere in the action area during each of these events. We expect a maximum of 106 Chipola slabshell (53 if flows are reduced to 4,500 cfs; 53 in habitats greater than 5,000 cfs) may be exposed in the Chipola River downstream of the Chipola Cutoff and middle Apalachicola during this event. USACE will monitor the extent of this form of take based on observed mortality. Additionally, fat threeridge and Chipola slabshell may experience harm through reduced recruitment. USACE will monitor the extent of this form of take using a surrogate measure that indicates the frequency of conditions created by WCM operations that cause the anticipated taking; a year with less than 30 consecutive days of at least 31,000 ac of floodplain inundation between March 1 and August 15 will not occur more than once in the next five years. Exceeding this level of incidental take for these three mussel species shall prompt a reinitiation of this consultation.

13.2 EFFECT OF THE TAKE

In the accompanying BO, the USFWS determined that the level of anticipated take for declining fall rates and reductions in flow as low as 4,500 cfs, or when individuals recolonize habitats greater than 5,000 cfs, would not result in jeopardy to the species or destruction or adverse modification of designated or proposed critical habitat, assuming no more than reduction in flow to 4,500 cfs and no more than one reduction in flow to 5,000 cfs occur within the duration of the BO.

13.3 REASONABLE AND PRUDENT MEASURES

The USFWS believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take of Gulf sturgeon, fat threeridge, purple bankclimber, and Chipola slabshell on the Apalachicola River. The measures described below supersede the measures described in previous BOs. The numbering system used in this opinion includes the year in order to avoid confusion with the previous opinions.

RPM 2016-1. Adaptive Management. Identify ways to avoid and minimize take and implement alternative management strategies within the scope of the authorities of WCM as new information is collected.

Rationale: Additional information will be collected to address uncertainties about the listed species and their critical habitat PCEs in the action area, water use upstream, and climatic conditions. This information needs to be evaluated to determine if actions to avoid and minimize take associated with the USACE's water management operations are effective or could be improved within the scope of the WCM. Appendix C and Appendix D present possible uncertainties about USACE actions and a preliminary assessment of actions to be assessed through adaptive management identified by USFWS. Putting this information in the proper decision context of USACE's operations is the fundamental basis for adaptive management according to policy and guidance under both USACE and USFWS (PARMS 2004, Williams et al. 2007, Williams and Brown 2012, USACE 2013, USACE 2015b). Formalizing the adaptive management process will provide a framework for assessing management options that are within the authority of USACE Mobile District under the WCM as well as setting the appropriate decision context for future updates to the WCM as appropriate.

RPM 2016-2. Water Quantity and Water Quality Stations. Develop and implement a monitoring program associated with USGS, NOAA or other similar monitoring stations within the ACF Basin for water quantity and water quality parameters.

Rationale: Gaging of water quantity and quality within the ACF Basin will be used to inform estimates of take and management options to be assessed through adaptive management (RPM 2016-1). Improved water quality information is also essential to understanding the influences of USACE management on key water quality parameters associated with PCEs for critical habitat of listed mussels and sturgeon.

RPM 2016-3. Species Monitoring. Monitor the level of take associated with the WCM and evaluate ways to avoid and minimize take by monitoring the distribution and abundance of the listed species in the action area.

Rationale: Monitoring populations and relevant habitat conditions associated with take of listed species within the ACF Basin will serve the USACE's information needs for future consultations on updates to the WCM and associated activities. Further, as habitat conditions change, it is necessary to monitor the numbers and spatial distribution of the populations to determine the accuracy of the take estimates. Monitoring will inform the adaptive management framework developed for RPM 2016-1.

13.4 TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the USACE must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are mandatory. Adaptive management, monitoring, and other conditions in the RPMs and conservation measures are subject to the availability of funds by Congress, or revenue from the project operations. The USACE will exercise its best efforts to secure funding for those activities. In the event the necessary funding is not obtained to accomplish the RPM activities by the dates established, the USACE will reinitiate consultation with USFWS. Upon the signing of a Record of Decision, these terms and conditions supersede those of the previous BO and its amendments. These terms and conditions are effective until replaced by a BO or amended BO in the ACF basin.

13.4.1 Adaptive Management (RPM 2016-1)

a) **Develop an Adaptive Management Framework.** The USACE and USFWS will develop an adaptive management framework for identifying ways to minimize take as new information is collected. Implementation of these adaptive management strategies will begin by March 14, 2017 or within 60 days of the Record of Decision being signed, whichever comes later. The framework will:

i) Outline the adverse effects identified in the BO.

ii) Specify objectives to assess those effects and identify possible alternative actions to minimize those effects. Appendix C and D provide examples of uncertainties and a preliminary assessment of actions that identified providing more floodplain inundation, reducing opportunities for hydropeaking, and reducing frequency of low flows as general outcomes of actions that would address the adverse effects.

iii) Identify specific, measureable attributes to monitor progress toward the objectives, the sampling design(s) for measuring those attributes, and the period over which monitoring will be conducted.

iv) Describe process for evaluating the adverse effects and developing, implementing, and assessing the recommended actions to further avoid and minimize take of listed species included in this consultation.

b) **Establish an Adaptive Management Technical Team.** In order to accomplish a), USACE will establish an informal, multi-agency technical team. This team will consist of technical staff from USACE and USFWS. Technical representatives from other Federal agencies (e.g., National Marine Fisheries Service, USGS) may be asked to participate as mutually agreed upon by USACE and USFWS. This team will develop and implement the adaptive management framework.

This adaptive management technical team will meet as needed, but at least annually during the next five years, or until a new BO is issued, to review and discuss the monitoring efforts established in the adaptive management plan. As appropriate and based on the data collected and analyses done pursuant to the management/work plans described in a), the technical advisory team will identify potential conservation measures, within the scope of the WCM, to further avoid and minimize take of listed species in the river reaches included as part of this consultation.

c) **Minimize Foraging Effects on Juvenile Gulf Sturgeon:** To minimize the negative effects of the WCM on food production for juvenile Gulf sturgeon and adverse modification to critical habitat, USACE will inundate the floodplain with a magnitude of at least 100,000 ac in pulses of at least 15 consecutive days in July 15-November 24 over 5 years (based on metrics GS4 and GS5 in section 5.2.1). Additional water will be added to the floodplain during the November 24-June 1 for an average of 12 days (based on GS1). USACE will monitor the biological effect of these proposed actions (e.g., starting by monitoring primary productivity in the Apalachicola River), and the details of how and when in these time periods the floodplain is inundated will be explored within the authority of the WCM through adaptive management. Through an incremental approach over 5 years, the result of adaptive management will be a set of management rules and targeted monitoring to meet these criteria. For example, if a 30-day pulse in July-August is provided, this may also benefit mussel host fish populations (based on M2, M3 in section 10.2.1.1). The adaptive management technical team will begin analyzing food production in the lower Apalachicola River as measured at the Sumatra gage. Use of chlorophyll a and turbidity monitoring will be reviewed by the adaptive management team to determine if it would capture the effects of the action on the food production or to determine if another monitoring regime in the vicinity of the Sumatra gage is more efficient and effective than chlorophyll a and turbidity monitoring at the gage.

d) **Implement Adaptive Management Recommendations.** The USACE shall assume responsibility for implementing the monitoring actions that the adaptive management technical team recommends and that the USFWS agrees are reasonable and necessary to understand, avoid, and minimize take resulting from the actions taken under USACE's WCM.

e) **Review WCM Implementation.** The USACE shall organize semi-annual meetings with USFWS to review implementation of the WCM and adaptive management framework including new data and results, information needs and methods to address those needs, evaluations and monitoring specified in this ITS, formulate actions that minimize take of listed species, and monitor the effectiveness of those actions.

f) **Provide Annual Report.** The USACE shall provide an annual report to USFWS on or before January 31 each year documenting (1) compliance with the terms and conditions of this ITS during the previous year, (2) any conservation measures implemented for listed species in the action area; and (3) recommendations for actions in the coming year to minimize take of listed species.

g) **Provide Monthly Status Update.** The USACE shall provide by email or other timely electronic means to USFWS on a monthly basis the status of WCM implementation including the hydrology of the system, composite system storage, and any data related to any other adopted criteria.

13.4.2 Water Quantity and Water Quality Stations (RPM 2016-2)

a) **Monitor Water Quantity and Water Quality.** USACE and USFWS will work with USGS to develop and implement a monitoring program that supplements current monitoring stations within the ACF Basin. USACE, in collaboration with USGS, will begin implementation of additional gaging by March 14, 2017 or within 60 days of the Record of Decision being signed, whichever comes later. The supplemental information to be collected will include additional water quantity and/or water quality parameters related to PCEs for critical habitat of the listed species, including flow, water temperature, salinity, and dissolved oxygen. The USACE will be responsible for funding the annual maintenance costs associated with the supplemental data collected at these existing gage locations for the duration of the BO to aid in monitoring abiotic conditions tied to the baseline and potential changes in take. Through the adaptive management approach the USFWS and USACE will assess the need to increase, reduce, or change the monitoring locations set forth in these terms and conditions. Additional to the species monitoring described in RMP 2016-3, the following gages will be monitored for discharge, stage, water temperature, dissolved oxygen at a minimum, with other water quality parameters as needed (pH, conductivity, turbidity, salinity) to assess the status and possible adverse modification of PCEs for critical habitat and associated take for listed mussels and sturgeon. Each gage shall monitor river conditions at 15-minute or other appropriate intervals and seasons as agreed by USFWS with data transmitted via satellite to the USGS office, for display on the USGS web page in real-time, and available in regular reports. The Chattahoochee and Sumatra gages will be monitored at least monthly. If the latest measurement suggests that the Chattahoochee gage height less than the current unshifted rating curve value corresponds to a discharge of 5,000 cfs, do not reduce releases until the USGS verifies discharge via field measurement or until coordination with the USFWS and USGS indicates that a discharge measurement is unnecessary. All data will be shared with the USFWS at least annually in the report described for RPM 2016-1. Parameters currently missing from gage stations or additional parameters required (if any) are indicated next to the gage name:

a. Chattahoochee River
    i. MI 46 near Columbia (USGS 02343805) - water temperature, dissolved oxygen
b. Tributaries to Lake Seminole
    i. Spring Creek near Reynoldsville (USGS 02357150) - dissolved oxygen
    ii. Flint River at Bainbridge (USGS 02356000) - dissolved oxygen
c. Apalachicola River
    i. Apalachicola River at Chattahoochee (USGS 02358000) - water temperature, dissolved oxygen
    ii. Apalachicola River at Sumatra (USGS 02359170) - water temperature, dissolved oxygen, salinity (and possibly chlorophyll a and turbidity as assessed by the adaptive management technical team)

b) **Establish New Gage Stations.** Additional gages (Figure 13.1 and section 14) may be established if the scientific information obtained from monitoring leads the adaptive management technical team to determine additional gages downstream are necessary to capture the effect of the action on food production or foraging access for Gulf sturgeon.

13.4.3 Species Monitoring (RPM 2016-3)

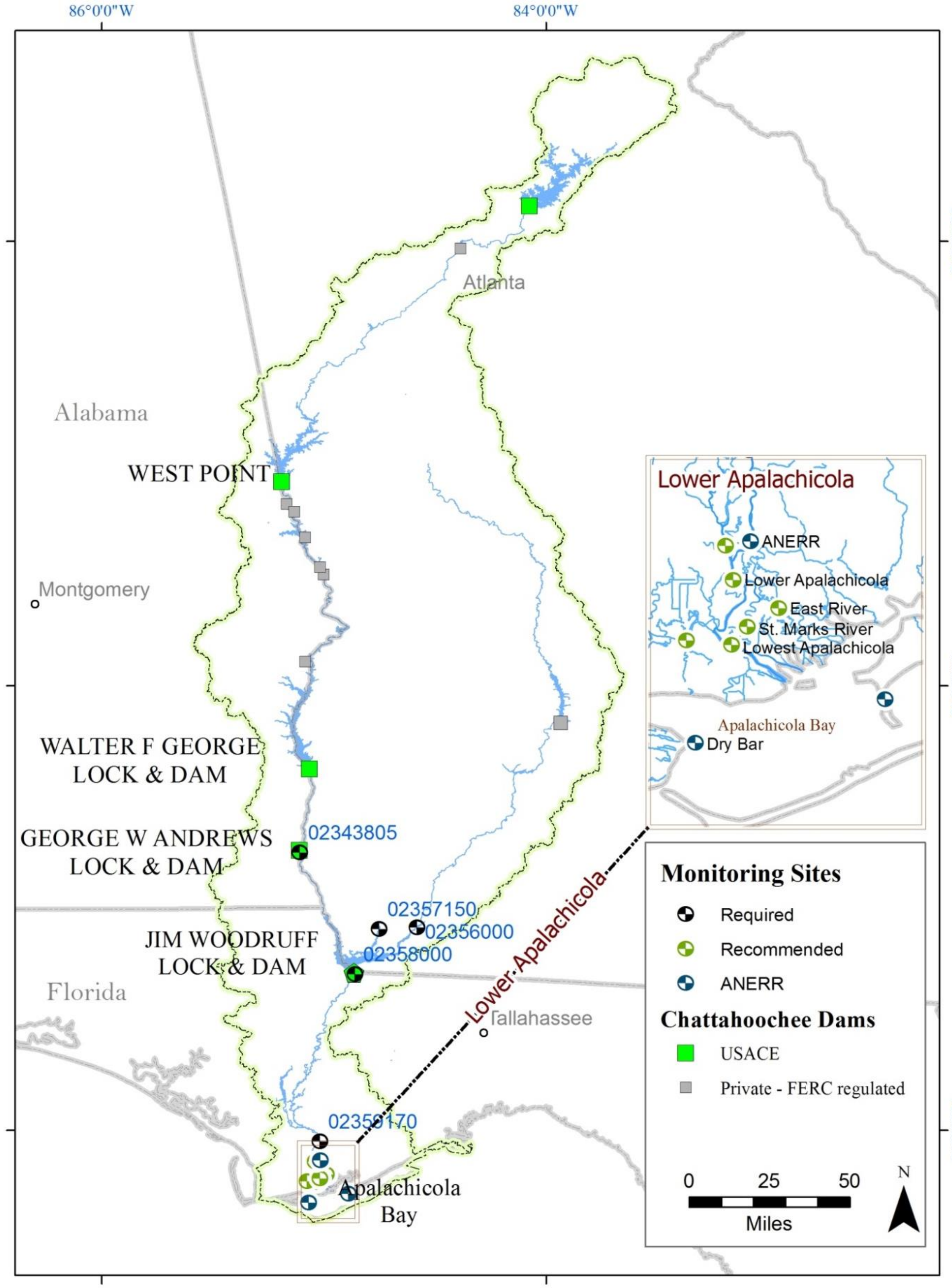
In consultation with the USFWS, the USACE shall plan and implement the following monitoring efforts relative to the endangered and threatened species, their habitats, designated critical habitat that will develop information necessary to understand the impact of incidental take and to ensure that the anticipated levels of incidental take are not exceeded.

a) **Monitoring and Reporting Take**

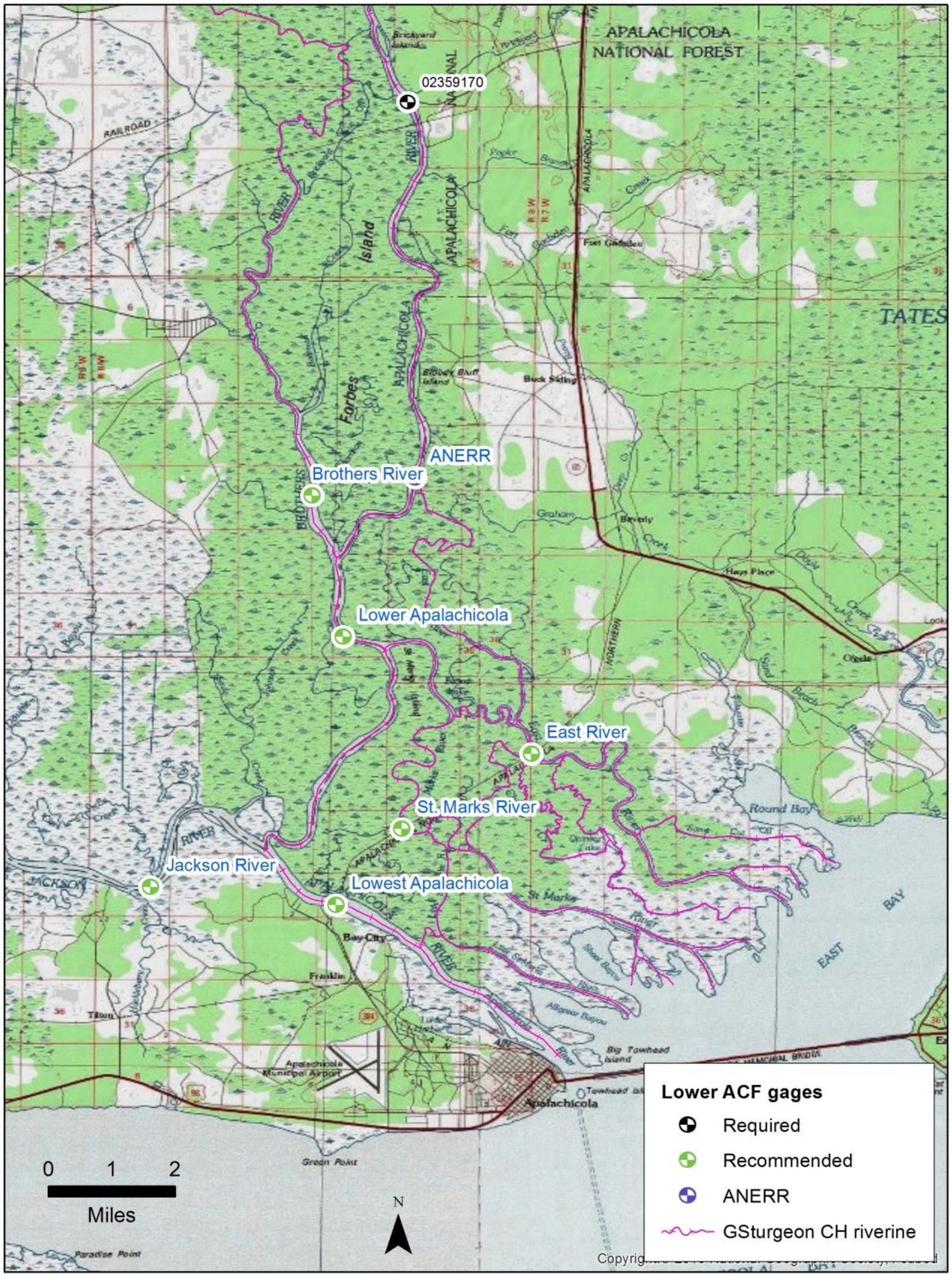
a. USACE will, in coordination with USFWS and the adaptive management technical team, develop and implement monitoring programs to establish baselines and track changes in abundance, density, and frequency of occurrence of fat threeridge, Chipola slabshell and purple bankclimber within the aquatic habitats downstream of Woodruff Dam. This species monitoring is additional to and complements the water quality monitoring as part of RPM 2016-2. Reports and data will be provided to the USFWS at least annually and will be shared with the adaptive management technical team as needed. These monitoring plans will be completed and implemented by March 14, 2017 or within 60 days of the Record of Decision being signed, whichever comes later.
   i. Take of mussels due to exposure from declining minimum releases shall be monitored in accordance with the monitoring plan developed by USACE and approved by USFWS to ensure that the anticipated level of take (section 13.1) is not exceeded.
   ii. Take of mussels due to a reduction in floodplain inundation during the host fish spawning/rearing season shall be monitored in accordance with the monitoring plan developed by USACE and approved by USFWS to ensure the anticipated level of take (section 13.1) is not exceeded. Possible monitoring parameters include, but are not limited to, host fish availability and glochidial infection rates.

b. In coordination and collaboration with USFWS and the adaptive management technical team, USACE will develop and implement a plan to create opportunities within existing operations to monitor the outcome of actions to minimize potential effects of hydropeaking at Jim Woodruff Dam and reduction in floodplain inundation on Gulf sturgeon. This species monitoring is additional to and complements the water quality monitoring as part of RPM 2016-2. USACE will submit a draft plan for USFWS review and approval by January 1, 2017 or 60 days before the first Gulf sturgeon spawning season after the Record of Decision is signed, whichever comes later. Reports and data will be provided to the USFWS at least annually. Monitoring objectives and design will be linked to assessment of take and to assessment of the success of the adaptive management actions (i.e., targeted monitoring for adaptive management).
   i. Based on 13.4.1 c), possible monitoring parameters for floodplain inundation include, but are not limited to, young of year and juvenile Gulf sturgeon survival and growth.
   ii. Possible monitoring parameters for hydropeaking include, but are not limited to, available spawning habitat, spawning behavior, egg viability, larval survival and growth.

b) **Adapt Monitoring:** Coordinate monitoring results with the adaptive management technical team and, if needed, adapt the monitoring according to the adaptive management technical team recommendations and the formal adaptive management framework developed for RPM 2016-1.


86°0'0"W
84°0'0"W
34°0'0"N
32°0'0"N
30°0'0"N
Atlanta
Alabama
Montgomery
Florida
Tallahassee
WEST POINT
WALTER F GEORGE
LOCK & DAM
GEORGE W ANDREWS
LOCK & DAM
JIM WOODRUFF
LOCK & DAM
02343805
02357150
02356000
02358000
02359170
Apalachicola
Bay
Lower Apalachicola
Lower Apalachicola
ANERR
Lower Apalachicola
East River
St. Marks River
Lowest Apalachicola
Apalachicola Bay
Dry Bar
Monitoring Sites
Required
Recommended
ANERR
Chattahoochee Dams
USACE
Private - FERC regulated
0 25 50
Miles
N

A



B

Figure 13.1 Apalachicola - Chattahoochee - Flint River Basin (A) and estuary rivers (B) showing a potential water quantity and water quality monitoring design for RPM 2016-2 and Conservation Recommendation 2 in reference to the five USACE projects included in this consultation and other federally regulated projects in the basin.

14 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by conducting conservation programs for the benefit of endangered and threatened species. Towards this end, conservation recommendations are discretionary activities that are within an action agency's authority may undertake to minimize or avoid the adverse effects of a proposed action, help implement recovery plans, or develop information useful for the conservation of listed species. The following conservation measures are an update of the measures listed in our previous opinions.

The USFWS recommends that the Mobile District of the USACE:

1. Work with the USFWS to formalize a 7a(1) agreement that works towards recovery of listed, candidate, and at risk species in the basin. The species in the ACF are recoverable, but cannot be recovered without key partners. USACE controls water operations in the system and this has implications for the aquatic species. Effort spent on conservation actions now should result in a greater return on conservation investment and allow for more operational flexibility in the future. In addition, an appropriately designed 7a(1) program will promote recovery and facilitate future interagency 7a(2) interactions.
2. In collaboration with the USFWS, implement Gulf sturgeon monitoring with emphasis on WCM operations whose effect to Gulf sturgeon is highly uncertain. Monitoring includes but is not limited to the following:
   a. An evaluation of WCM effects to stream temperature during the spawning season that could include: 1) varying inflows to Lake Seminole; 2) Jim Woodruff Dam release alternatives; or 3) changes to the local environment that could reduce stream temperatures during the spawning season.
   b. Support of USFWS research on young-of-year telemetry and habitat use.
   c. Young-of-year and juvenile invertebrate forage studies and/or models that: 1) describe the taxonomy of food items consumed by both life stages; 2) evaluate the availability of food items; and 3) relate food resource availability to condition of each respective life stage.
   d. Quantitatively assess invertebrate production in the floodplain resulting from high magnitude peak flow events.
   e. Estuarine salinity models that spatially assesses the effects of Apalachicola River inflows on estuary salinity with a focus on East Bay.
   f. An evaluation of spawning substrate enhancement at known spawning location(s).
   g. Water quality monitoring at (Figure 13.1):
      i. Chattahoochee River
         1. Buford Dam (USGS 02334430) - dissolved oxygen
         2. Atlanta (USGS 02336000) - dissolved oxygen
         3. GA 280 near Atlanta (USGS 02336490) - water temperature, dissolved oxygen
         4. Fairburn (USGS 02337170)

5. West Point (USGS 02339500) - water temperature, dissolved oxygen
6. Ft Gaines (USGS 0234332415)

ii. Apalachicola River
1. Apalachicola River at Blountstown (USGS 02358700) - water temperature, dissolved oxygen
2. Wewahitchka (USGS 02358754) - water temperature, dissolved oxygen

iii. Chipola River
1. Marianna (USGS 02358789) - water temperature, dissolved oxygen
2. Altha (USGS 02359000) - water temperature, dissolved oxygen

iv. Jackson River / Gulf Intracoastal Waterway (new gage vicinity of StM 345)

v. Lower Apalachicola River and its distributary rivers (new gages)
1. Lower Apalachicola River (vicinity of RM 4.5, USGS tidal gage 02359230)
2. Lower Apalachicola River (vicinity of RM 11.0, -84.031, 29.827)
3. St. Marks River (vicinity of old trestle, -85.017, 29.783)
4. East River (vicinity of old trestle, -84.988, 29.80)

3. In collaboration with the USFWS, continue to develop and assess potential adjustments to water management decisions under the WCM in response to increased knowledge of listed species effects and develop additional conservation measures and management options for the ACF Basin to promote recovery of listed species. In particular, the USFWS has already identified potential management adjustments in an operating alternative portrayed in Appendix D; this operational alternative represents another option to manage the basin in consideration of fish and wildlife resources.
4. In collaboration with the USFWS, improve measures of success in reaching explicit objectives for both fish and wildlife resources and other project purposes prior to the next update of the WCM.
5. Develop a report using the best available science that describes how predicted changes in climate could affect WCM operations. The USFWS suggests that the report be updated once every five years.
6. Implement Gulf sturgeon and freshwater mussel recovery actions, including but not limited to, developing habitat suitability indices, conducting life history and population studies, restoring reaches to provide suitable habitat, and assessing sediment quality. From mussel recovery plan (USFWS 2003):
   a. Secure extant subpopulations and currently occupied habitats and ensure subpopulation viability.
   b. Search for additional subpopulations of the species and suitable habitat.
   c. Determine through research and propagation technology the feasibility of augmenting extant subpopulations and reintroducing or reestablishing the species into historical habitat.
   d. Develop and implement a program to evaluate efforts and monitor subpopulation levels and habitat conditions of existing subpopulations, as well as newly discovered, reintroduced, or expanding subpopulations.
   e. Develop and utilize a public outreach and environmental education program.
   f. Assess the overall success of the recovery program and recommend actions.

From Gulf sturgeon recovery plan (USFWS 1995)

a. Determine essential ecosystems, identify essential habitats, assess population status, and refine life history investigations in management unit rivers.
b. Identify essential habitats important to each life stage in river basin and contiguous estuarine and neritic waters.
c. Conduct and refine field investigations to locate important spawning, feeding, and developmental habitats.
d. Characterize riverine, estuarine, and neritic areas that provide essential habitat.
e. Conduct life history studies on the biological and ecological requirements of little known or inadequately sampled life stages.
f. Assess the relationship between groundwater pumping and reduction of groundwater flows into management units, and quantify loss of riverine habitat related to reduced groundwater in-flows.
g. Restore, enhance, and provide access to essential habitats: Identify dam and lock sites that offer the greatest feasibility for successful restoration of and to essential habitats (i.e., up-river spawning areas). Evaluate, design, and provide means for Gulf sturgeon to bypass migration restrictions within essential habitats. Operate and/or modify dams to restore the benefits of historical flow patterns and processes of sedimentation. Identify potential modifications to specific navigation projects to minimize impacts which alter riverine habitats or modify thermal or substrate characteristics of those habitats.
h. Restore the benefits of natural riverine habitats.
i. Seek optimum consistency between the purposes of federal and state authorized reservoirs, flood control projects, navigation projects, hydropower projects, and federal and state mandated restorations of fish populations.

7. Improve the public understanding of water management of the ACF system, the related conservation needs of listed species, and the management of the multiple purposes of the federal reservoirs.
8. Identify and implement water conservation measures in the basin to avoid impacts to fish and wildlife resources by working with municipal, agricultural, and industrial water users to reduce consumptive uses to develop additional drought response strategies.
9. Assist stakeholders to plan future water management to minimize water consumption thus minimizing detrimental effects to species.
10. Update, as soon as practicable, tools for assessing the effects of ongoing and future system operations, including estimates of basin inflow and consumptive demands. The tools should assist in identifying flows that provide sufficient magnitude, duration, frequency, and rate of change to support the survival and recovery of the listed species in the ACF.

In order for the USFWS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the USFWS requests notification of the implementation of any conservation recommendations in the annual report required in section 9.

15 REINITIATION NOTICE

This concludes formal consultation on the action outlined in the BO. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information shows that the action may affect listed species in a manner or to an extent not considered in this BO; (3) the action is subsequently modified in a manner that causes an effect to the listed species not considered in this BO; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

16 FISH AND WILDLIFE COORDINATION ACT PLANNING ASSISTANCE

In accordance with the planning aid provisions of the FWCA, the USFWS has been coordinating with you and the States on the development of updated WCM for the ACF River Basin. The USFWS's fish and wildlife concerns, planning objectives, recommendations and requested analyses have been previously described in detail to the USACE in our August 29, 2013 PAL. We also submitted a final FWCA report on September 9, 2016. Our recommendations in this letter and report still apply, and we encourage the USACE to follow the recommendations and conservation measures included in these documents. We encourage the USACE to work closely with USFWS to develop alternatives that are protective of fish and wildlife resources in the ACF Basin, and we stand by ready to assist.

17 APPENDIX A. EFFECTS OF THE ACTION - PHYSICAL ENVIRONMENT

17.1 Factors Considered

The WCM defines releases into the Apalachicola River via operations of the Jim Woodruff Dam; therefore, the primary focus of our analysis is the flow regime of the Apalachicola River under the baseline compared to the flow regime expected under the WCM. Physical habitat conditions for the listed species in the action area are largely determined by flow regime, and channel morphology partially sets the context for the flow regime. In the Environmental Baseline – Physical Environment section, we outlined two principal components of the species' environment in the action area: channel morphology and flow regime. Channel morphology has changed relative to the pre-dam period in the Apalachicola River, but the rate of change has slowed and may have entered a somewhat dynamic equilibrium condition (USFWS 2012). USACE will continue to evaluate this rate of change as discussed in the Environmental Baseline – Physical Conditions section. We have no ability at this time to predict specific effects on channel morphology that may result from the influence of the WCM. We considered water quality parameters but do not have enough information to determine whether WCM implementation will itself alter the baseline water quality of the action area; however, we recognize a potential for localized dissolved oxygen changes through flow stagnation or more temperature extremes resulting from shallower waters. Our analysis of flow regime alteration relative to the listed species and critical habitats considers the following factors.

17.2 Analyses for Effects of the Action

To determine the future effect of continued project operations as prescribed by the WCM, we must compare the environmental conditions expected under the WCM to the environmental baseline. The principal factor we examine is the flow regime of the Apalachicola River and how the flow regime affects habitat conditions for the listed species. In the 2008 and 2012 BOs environmental baseline (a.k.a. baseline) was defined as the observed flows of the river since the full complement of the USACE's reservoirs were completed and for which an unimpaired data set was available, so that the proposed action could be modeled (calendar years 1975 to 2012). In this BO, an alternative strategy is being employed as discussed in the Environmental Baseline section. Under this approach, the modeled effects of the WCM are compared to the modeled effects of the USACE's no action alternative (NAA) for 1939-2012. The NAA (and baseline for this consultation) is the RIOP management implemented from 2012-present.

In analyzing the effects of the proposed action, the fact that the storage capacity of the ACF basin reservoirs is small relative to flow in the Apalachicola River was taken into account. The ACF basin has about 1,640,000 acre-feet of conservation storage at full summer pool (USACE, 2015 p2-24). The majority of the basin's storage capacity (65%) is at Lake Lanier which only impounds 6% of the basin. Lake Lanier is therefore managed conservatively because in being a headwater reservoir it is difficult to refill and because the reservoir plays an integral role in supplying water to Metro Atlanta. Consequently, since the completion of Lake Lanier in 1955, the minimum elevation ever experienced at the reservoir is about 1050.79 msl in December 2007 (USACE 2016), which is about 15 feet above the bottom of the conservation pool.

To account for this limitation of the reservoir system in the ACF basin to either store or release water, when analyzing the effects of the proposed action the USFWS focuses on lower portion of the flow regime. Analysis of modeling results suggests that under operations called for in both the WCM and baseline, the reservoir system has the greatest capacity to effect on discharge in the Apalachicola River in the flow range below 30,000 cfs discharge from Jim Woodruff Dam and the capacity of the reservoir system to influence flow declines as flows approach 30,000 cfs. Because of the importance of floodplain inundation to the aquatic ecosystem and the fact that at flows above 15,000 cfs the area of inundation increases more rapidly, the analysis of effects will focus on the flow range of 15,000 to 30,000 cfs.

17.2.1 Model Descriptions

The USACE used "HEC-ResSim Version 3.2, Build 3.2.1.19" (USACE, 2013) to simulate flow operations in the ACF Basin. HEC-ResSim is a tool for simulating flow operations in managed systems developed by the USACE's Hydrologic Engineering Center (HEC) to predict the behavior of reservoirs and to help reservoir operators plan releases in real time during day-to-day and emergency operations. HEC-ResSim provides a realistic view of the physical river/reservoir system using a map-based schematic and represents a system of reservoirs as a network composed of four types of physical elements: junctions, routing reaches, diversions, and reservoirs. By combining these elements, a network was built to represent the ACF Basin. A reservoir is the most complex element of the reservoir network and is composed of a pool and a dam. ResSim assumes that the pool is level (i.e., it has no routing behavior), and its hydraulic behavior is completely defined by an elevation-storage-area table. It also uses a rule-based description of the operational goals and constraints that reservoir operators must consider when making release decisions. HEC-ResSim for the ACF is described in detail by USACE (2014, 2015 Appendix E).

For purposes of this BO, the USFWS choose to use an additional river-reach model to simulate the flow operations in the ACF basin, the ACF STELLA model. The ACF-STELLA model was an existing model first developed during the ACF Comprehensive Study and was used for this analysis because: 1) the ACF-STELLA model has been shown to calibrate well with previous versions of the HEC ResSim model (Leitman and Kiker 2015), 2) the ACF-STELLA model has a much shorter run-time than the HEC ResSim model (< 5 minutes versus ~25 minutes) (Leitman and Kiker 2015), and 3) the modeling demand of this analysis, including the climate change analyses found later in the BO required over three hundred model runs. The USFWS previously used a version of this model to develop an alternative which was submitted to the USACE as an alternative to be considered in developing the Water Control Manual (USFWS 2013).

Other system-wide water models of the ACF have been developed to explore management alternatives for different agencies, municipalities and stakeholders (Sheer et al. 2013, Sauchyn et al. 2016, USACE-HEC 2016, Kistenmacher and Georgakakos 2011, Kistenmacher and Georgakakos 2015). The ACF-STELLA was first developed in the ACF Basin Comprehensive Study as part of a shared-vision stakeholder process (Palmer 1998). The ACF-STELLA model used for the BO was tested by comparing predictions with the HEC-ResSim model used by the USACE to formally evaluate ACF basin management alternatives. The two models were compared using 70 years of daily output (1939–2008; n = 25,668) for eight different ACF gage sites (five flow stations and three reservoir elevations) using the 2012 RIOP management inputs (Leitman and Kiker 2015). The comparison between the two models showed a strong match (p<0.01 rejection significance) between the daily outputs for six of the eight sites, with median Nash–Sutcliffe coefficient of efficiencies (Ritter and Carpena 2013) ranging from 0.732 to 0.979 (Note: a Nash-Sutcliffe value > 0.65 indicates acceptable, > 0.8 good and > 0.9 very good). The one gage site matched 7 day moving average flows with a Nash-Sutcliffe coefficient of efficiency of 0.788 (p<0.01 rejection significance) and the one reservoir elevation (W.F. George) matched with a Nash-Sutcliffe coefficient of 0.833 (p<0.01 rejection significance) when anomalous maximum elevations were filtered from the HEC-ResSim output (Leitman and Kiker 2015). In the model simulations which were done for the Water Control Manual, the anomalous elevations at WF George were removed from the HEC-ResSim analysis.

To provide a potential range of flows that might be experienced while the proposed action scenarios are in effect, the ACF-STELLA model simulates river flow and reservoir levels using a daily time series of unimpaired flow data as input for a certain period of record. Whereas basin inflow is computed to remove the effects of reservoir operations from observed flow, unimpaired flow is developed to remove the effects of both reservoir operations and consumptive demands from observed flow. The ResSim model imposes reservoir operations and consumptive demands onto the unimpaired flow time series to simulate flows and levels under those operations and demands.

The current, official unimpaired flow data set represents the years 1939 to 2011. Unimpaired flow computations require actual water use data from the three States. USACE provided provisional UIF for 2012, but with the acknowledgment that 2011 is the most recent year of this data provided to the USACE from all three of the States. Georgia has supplied water use data for 2012, but Florida and Alabama do not have complete water use data (James Hathorn, USACE, personal communication, 6/21/16). This situation created a dilemma for the USFWS in preparing the BO since 2012 was the most severe drought in the period-of-record for the ACF basin and therefore would provide the most severe test of the WCM in regard to both impacts upon designated species and reservoir storage, yet the unimpaired flow 2012 was not completed. Since the major driver of the 2012 drought having such low flows in the Apalachicola River was the extreme low flows in the Flint basin whose withdrawals are completely within Georgia, and that the consumptive demands in Alabama and Florida are quite small relative to the flow in the Apalachicola River (Leitman et al. 2016), a decision was made to include the partially complete 2012 unimpaired flow data in the analyses done with the ACF-STELLA and ResSim models for the BO.

As described above, the consumptive demands used in the models are summarized in Table 17.1. A 74-year unimpaired flow hydrologic period of record (1939 through 2012) was used to run the simulations. The data in these tables was taken from the USACE's HEC-ResSim database and it the identical data used in the ResSim modeling and represents both net municipal and industrial demands and agricultural demands effects on streamflow. The baseline data represents current demands and the WCM represents forecasted future demands for Metro Atlanta and current demands for the balance of the basin. The average annual demands for the ACF basin under the baseline is 958 mgd and for the WCM 1,102 mgd.

Table 17.1 Consumptive demands used in the ACF-STELLA model for the WCM (A) and baseline (B).

A

	BUFORD	ATLANTA	WHITESBURG	WEST POINT	COLUMBUS	WF GEORGE	ANDREWS	MONTEZUMA	ALBANY	NEWTON	BAINBRIDGE	WOODRUFF	BLOUNTSTOWN	SUMATRA
JAN	175.21	401.81	-427.72	68.18	70.31	1.36	-8.69	21.33	68.18	-11.97	1.36	-9.28	1.6	0.01
FEB	186.25	391.76	-377.81	71.69	65.4	8.6	-8.2	14.65	71.69	-13.2	8.6	-0.48	1.6	0.02
MAR	195.77	398.24	-409.99	80.69	65.63	27.56	-5.66	21.82	80.69	5.38	27.56	58.42	1.5	-11.76
APR	234.62	476.33	-369.63	85.52	74.27	68.45	-4.99	31.93	85.52	13.61	68.45	52.61	1.7	-28.17
MAY	256.56	505.77	-354.31	87.43	87.69	223.17	0.84	53.41	87.43	53.33	223.17	191.97	2	-1
JUN	275.75	508.69	-348.94	100.01	98.7	328.4	2.51	63.1	100.01	68.05	328.4	260.22	1.7	0.05
JUL	272.43	541.66	-372.85	100.4	101.93	348.79	4.99	79.59	100.4	65.92	348.79	263.55	1.7	1.55
AUG	236.9	516.66	-360.67	101.69	101.64	372.53	1.48	85.87	101.69	66.76	372.53	255.43	1.8	0.68
SEP	226.97	492.51	-348.1	95.64	89.89	377.57	-1.78	45.55	95.64	70.81	377.57	188.68	1.8	0
OCT	207.03	447.27	-373.5	80.21	89.36	160.36	-4.11	21.14	80.21	40.19	160.36	71.98	1.7	0.18
NOV	199.67	430.81	-366.96	72.32	79.79	121.06	-5.26	23.59	72.32	31.28	121.06	47.76	1.5	3.78
DEC	181.52	404.5	-388.97	75.11	73.14	88.86	-7.33	31.76	75.11	21.18	88.86	29.09	1.5	3.44
ANNUAL AV.	220.72	459.67	-374.95	84.91	83.15	177.23	-3.02	41.15	84.91	34.28	177.23	117.50	1.68	-2.60

B

	BUFORD	ATLANTA	WHITESBURG	WEST POINT	COLUMBUS	WF GEORGE	ANDREWS	MONTEZUMA	ALBANY	NEWTON	BAINBRIDGE	WOODRUFF	BLOUNTSTOWN	SUMATRA
JAN	72.26	215.08	-200.48	68.18	70.31	1.36	-8.69	21.33	68.18	-11.97	1.36	-9.28	1.6	0.01
FEB	77.37	209.71	-177.95	71.69	65.4	8.6	-8.2	14.65	71.69	-13.2	8.6	-0.48	1.6	0.02
MAR	81.19	213.17	-192.28	80.69	65.63	27.56	-5.66	21.82	80.69	5.38	27.56	58.42	1.5	-11.76
APR	98.06	254.97	-174.39	85.52	74.27	68.45	-4.99	31.93	85.52	13.61	68.45	52.61	1.7	-28.17
MAY	107.54	270.73	-168.9	87.43	87.69	223.17	0.84	53.41	87.43	53.33	223.17	191.97	2	-1
JUN	116.28	272.3	-165.45	100.01	98.7	328.4	2.51	63.1	100.01	68.05	328.4	260.22	1.7	0.05
JUL	114.93	289.95	-175.35	100.4	101.93	348.79	4.99	79.59	100.4	65.92	348.79	263.55	1.7	1.55
AUG	99.03	276.55	-170.6	101.69	101.64	372.53	1.48	85.87	101.69	66.76	372.53	255.43	1.8	0.68
SEP	95.26	263.63	-164.3	95.64	89.89	377.57	-1.78	45.55	95.64	70.81	377.57	188.68	1.8	0
OCT	85.68	239.42	-173.86	80.21	89.36	160.36	-4.11	21.14	80.21	40.19	160.36	71.98	1.7	0.18
NOV	83.93	230.59	-170.56	72.32	79.79	121.06	-5.26	23.59	72.32	31.28	121.06	47.76	1.5	3.78
DEC	75.63	216.52	-180.03	75.11	73.14	88.86	-7.33	31.76	75.11	21.18	88.86	29.09	1.5	3.44
ANNUAL AV.	92.26	246.05	-176.18	84.91	83.15	177.23	-3.02	41.15	84.91	34.28	177.23	117.50	1.68	-2.60

The fall rates used in the ResSim model for the BO and the 2016 BA followed the maximum fall rate schedule. However, the USACE believes that when flows are less than 10,000 cfs, the observed fall rates are more conservative than those reflected in the BA due to the limitations of the equipment and careful operations to avoid violating the maximum fall rate schedule when flows are less than 10,000 cfs. During the 2012 BO, the ResSim model was modified to reflect the actual down ramping operation which is more conservative than the maximum fall rate schedule. The ACF-STELLA model simulated the baseline (NAA) and WCM (PAA) using a standard 0.13 ft/day fall rate (see section 1), which is the average fall rate in this range of flows since the USACE implemented the maximum fall rate schedule in September 2006. This is consistent with previous simulations for the 2012 BO that use a slightly higher minimum flow than 5,000 cfs (5,050 cfs) in the model simulation rules to better reflect actual conservative operations in place to avoid violating the 5,000 cfs minimum flow provision.

In sections 5 and 10 of this BO, we draw inference from both ACF STELLA model and the HEC-ResSim ACF model. The remainder of section 17.2 draws inference from the STELLA model only. Similar analyses are presented using the HEC-ResSim model in the DEIS (USACE 2015). We further compare the two models in section 17.3.

17.2.2 General Effects on the Flow Regime

The USACE alters the flow regime of the Apalachicola River by storing and releasing water from its reservoirs. Figure 17.1 shows a frequency-duration curve for the WCM (PAA) and baseline (NAA) for Jim Woodruff outflow for 1939 – 2012 modeled in ACF-STELLA. In comparing these two model runs it should be noted that in the baseline current levels of demands are used in the model run whereas in the WCM future demands are used. This figure shows that under the WCM operations, when the entire spectrum of flow is considered there appears to be minimal differences between the two operation approaches. Figure 17.1B shows that if the range of flows is reduced to the range that can be affected by reservoir operations in the ACF basin (roughly 30,000 cfs) that differences between the two operational approaches are apparent at flows in the 16,000 to 20,000 cfs range.

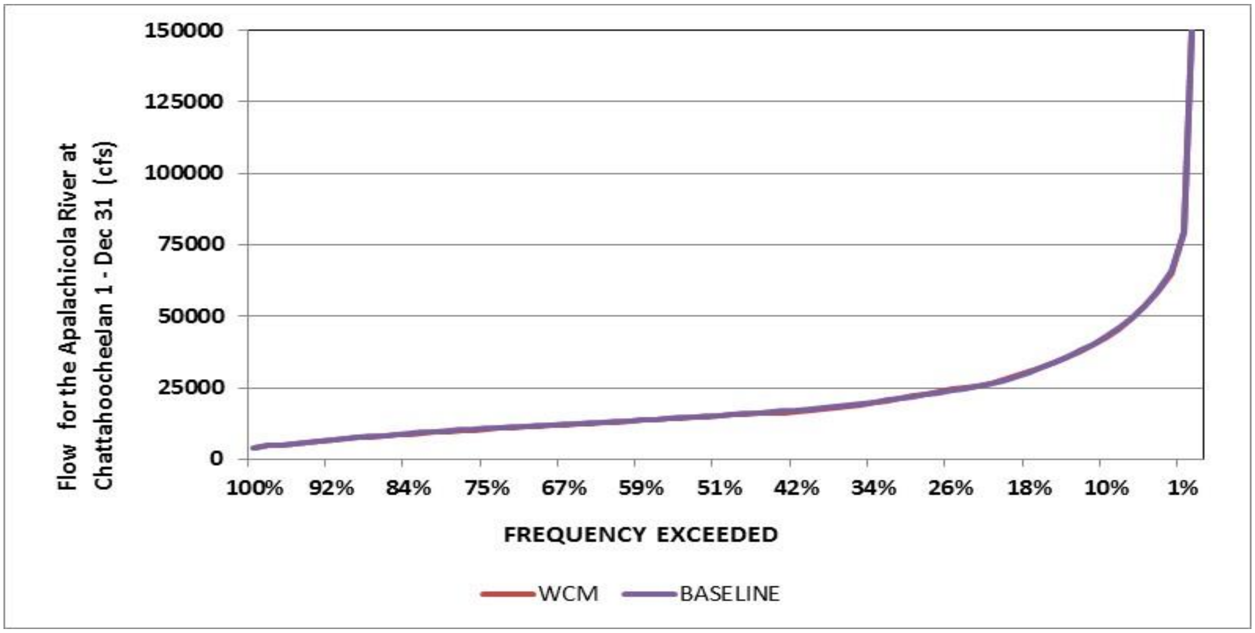


Figure 17.1A. Flow duration curve comparing baseline and WCM.

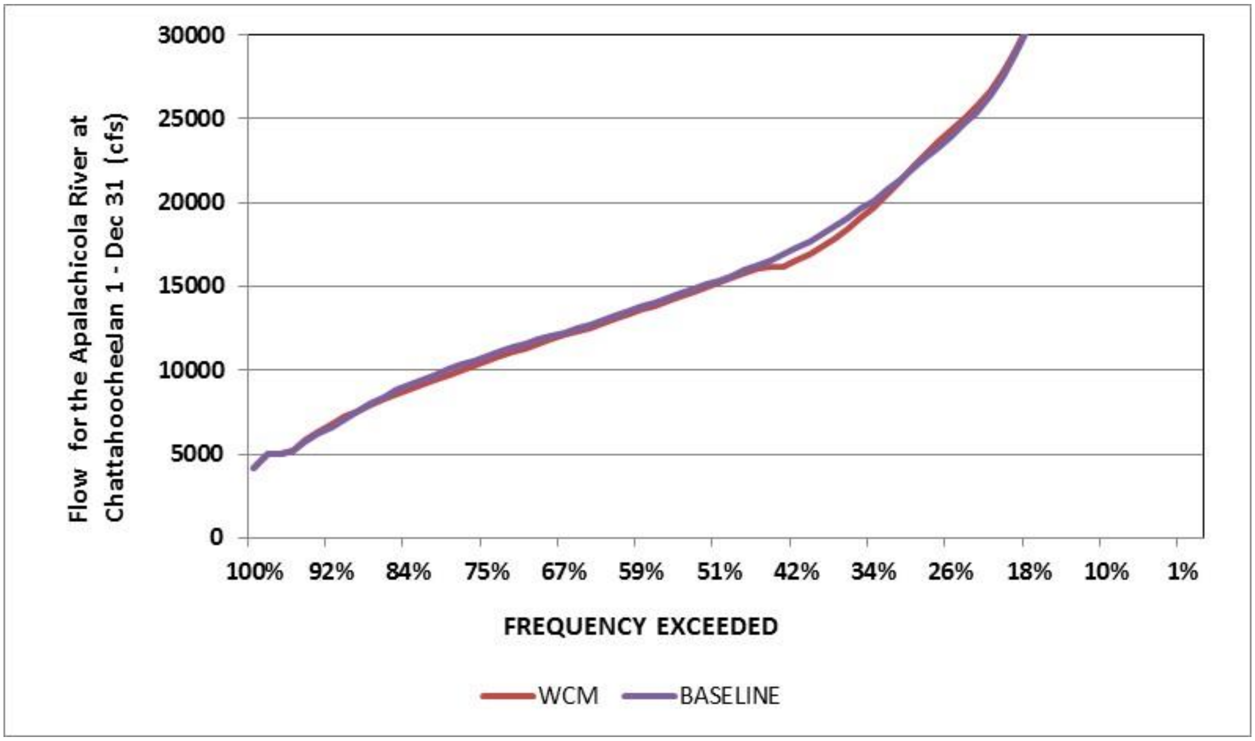


Figure 17.1B. Flow duration curve comparing baseline and WCM when flows are <30,000 cfs.

The composite storage of water in three largest ACF basin (Lanier, West Point, and W.F. George) plays an integral role in defining releases both under the WCM and baseline. The composite storage is seldom stable for extended periods, and follows a general pattern of increasing storage from January through June or July, and decreasing storage thereafter. The expected general pattern of flow alteration, therefore, is depletion during the first half of the year during periods of relatively high flow and augmentation during the second half of the year during periods of relatively low flow.

Figure 17.2 shows the magnitude of this annual cycle of re-fill and draw-down by comparing the January-to-June maximum composite storage level with the July-to-December minimum composite storage level for the baseline and WCM. Figures 17.3A, B, C and D show the median, 75% exceeded, 90% exceeded and 100% exceeded storage volume for each of the year for values for the years 1939 to 2012. These figures show that for the WCM the median volume of water in storage decreases relative to the baseline in the winter and increases in the Spring. For the 75% exceeded volumes the WCM decreases in the winter into the Spring, but stores more water in the Summer. For the 90% exceeded volumes the WCM operations result in less storage in the winter and for the 100% exceeded volumes the WCM generally resulted in less storage throughout the year.

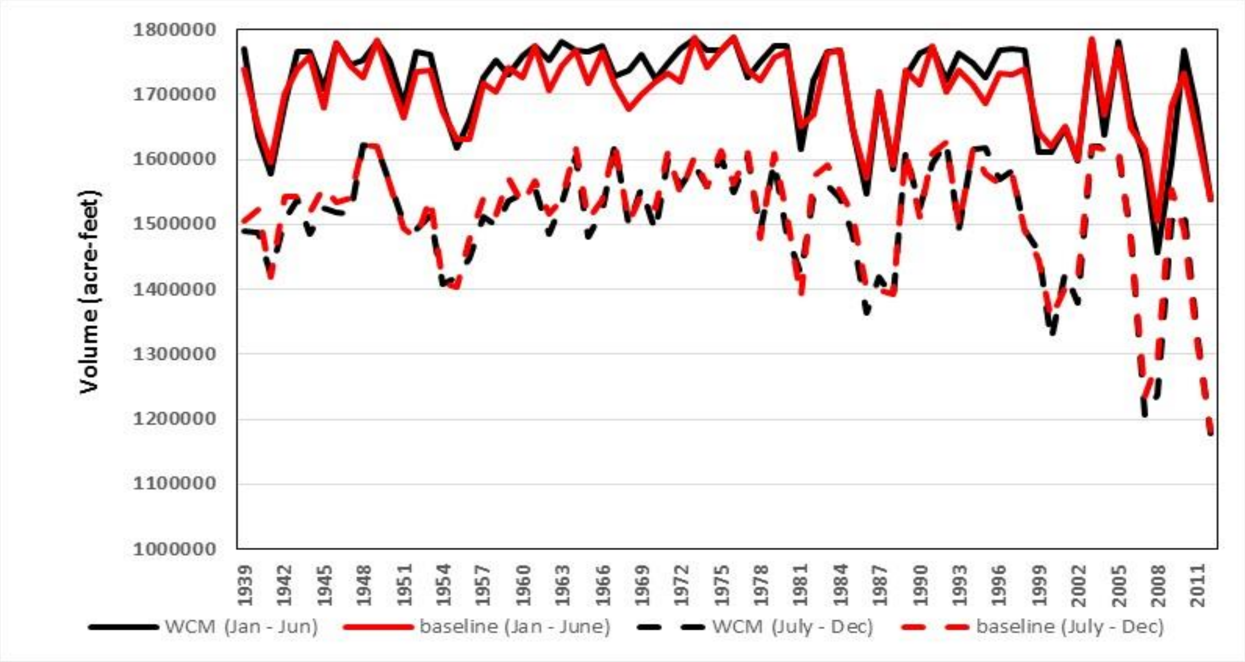


Figure 17.2. Annual range of reservoir composite storage (excluding inactive storage) as measured by the January-to-June maximum storage versus the July-to-December minimum storage level comparing the baseline and WCM.

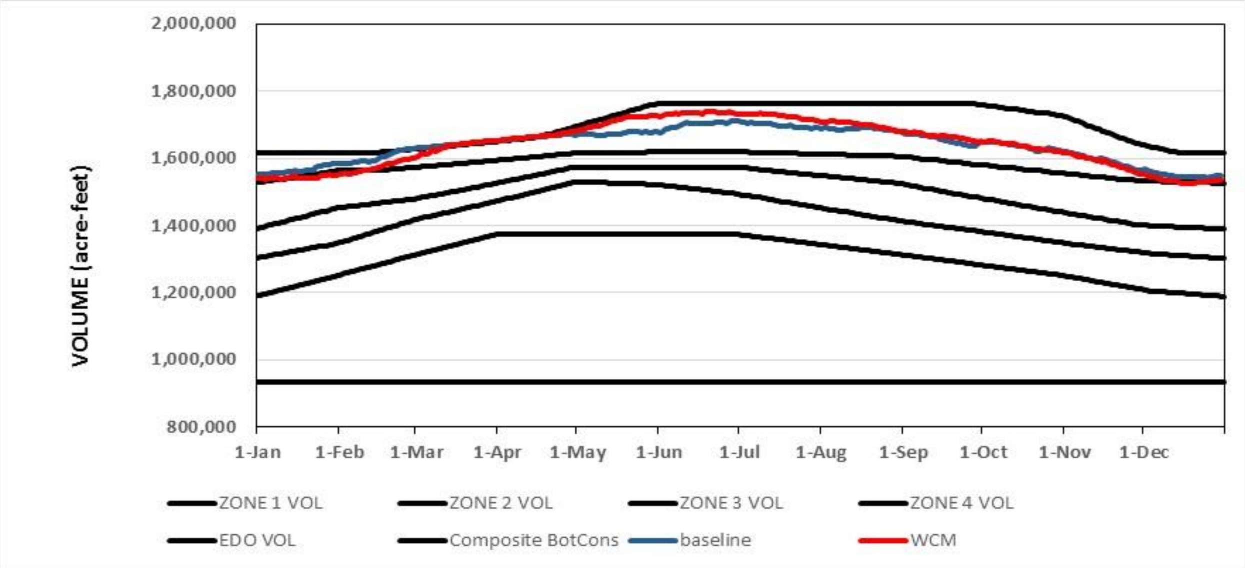


Figure 17.3A. The median conservation storage volume under the baseline and WCM for each of the year for values for the years 1939 to 2012.

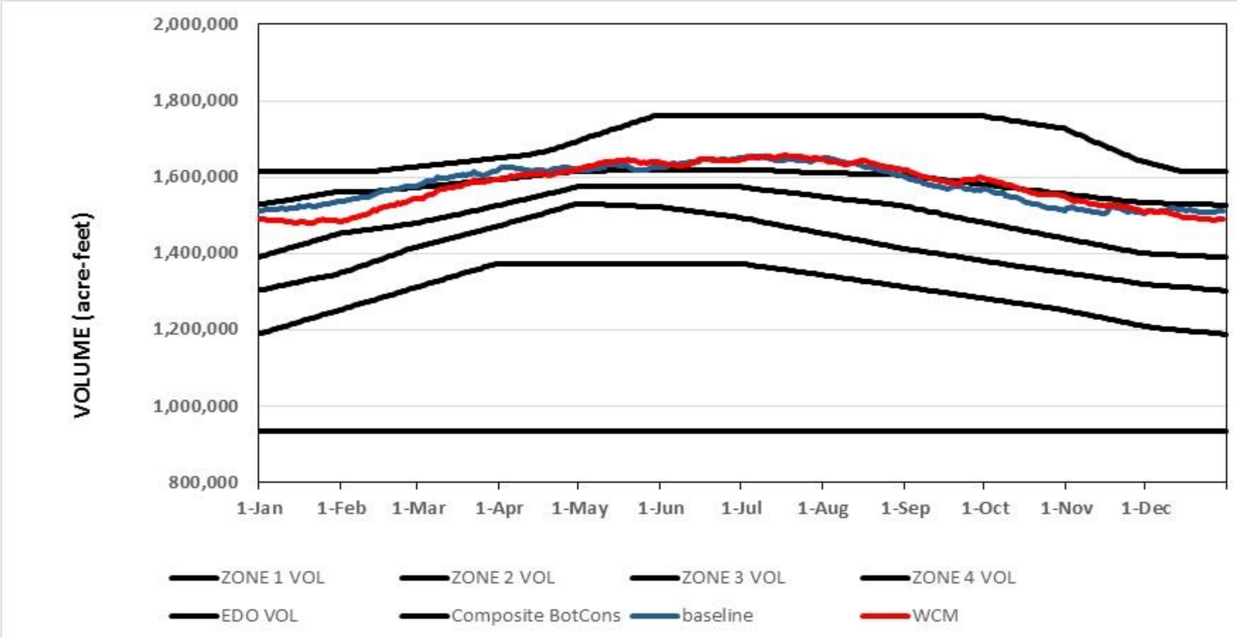


Figure 17.3B. The 75% exceeded conservation volume under the baseline and WCM for each of the year for values for the years 1939 to 2012

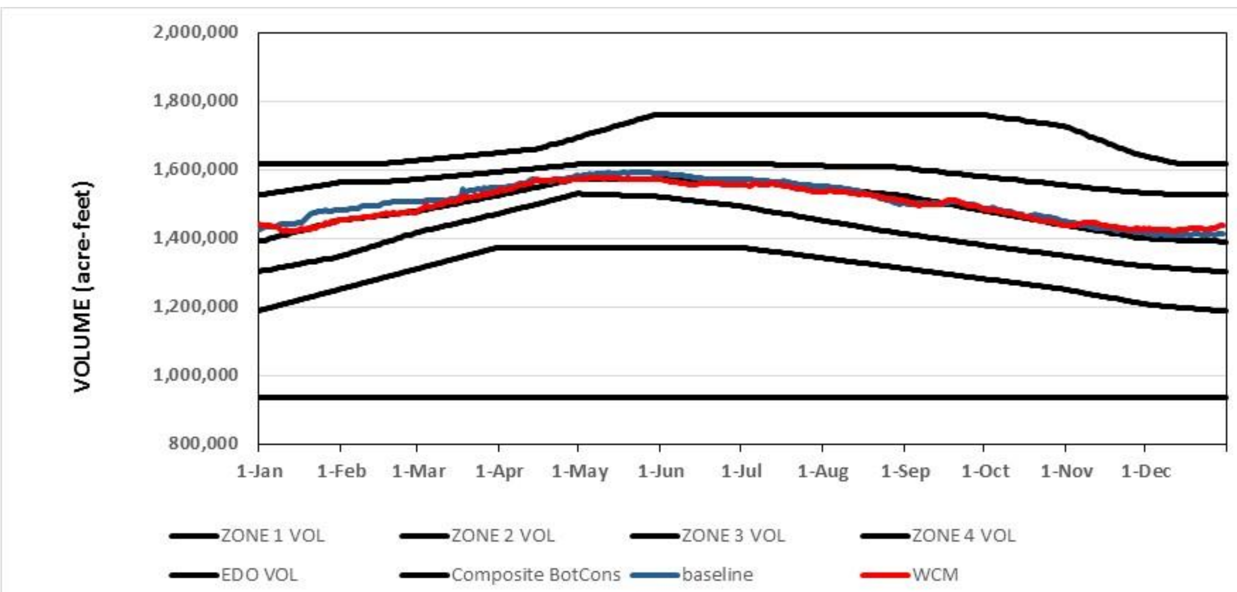


Figure 17.3C. The 90% exceeded conservation volume under the baseline and WCM for each of the year for values for the years 1939 to 2012

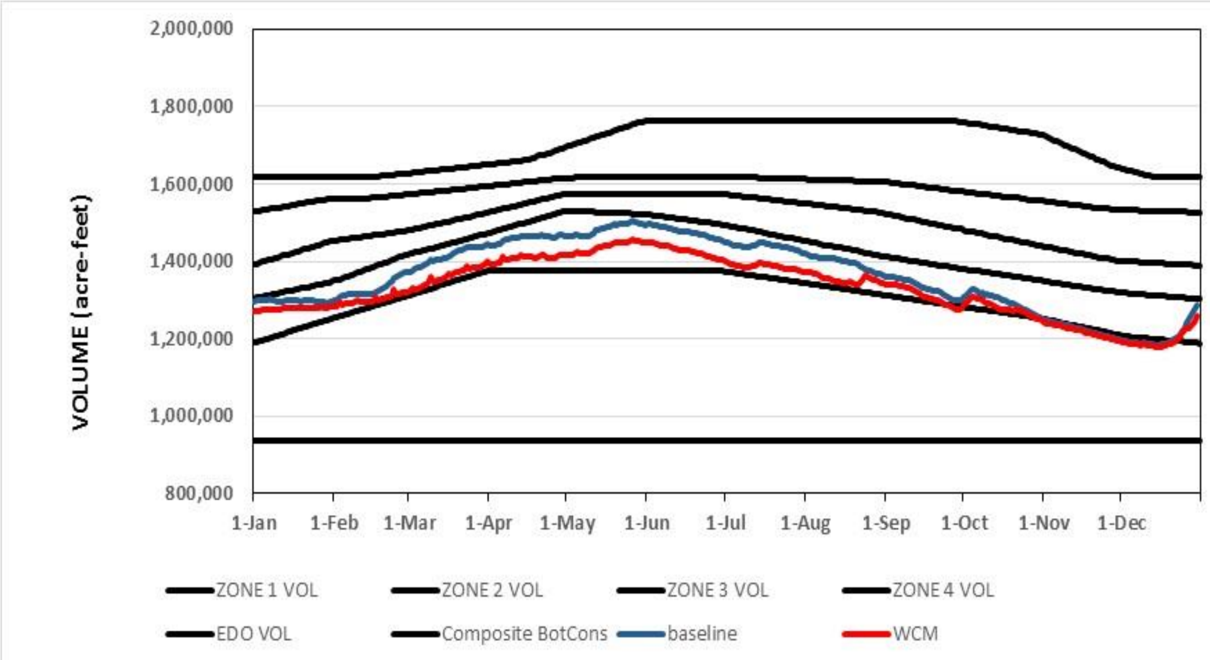
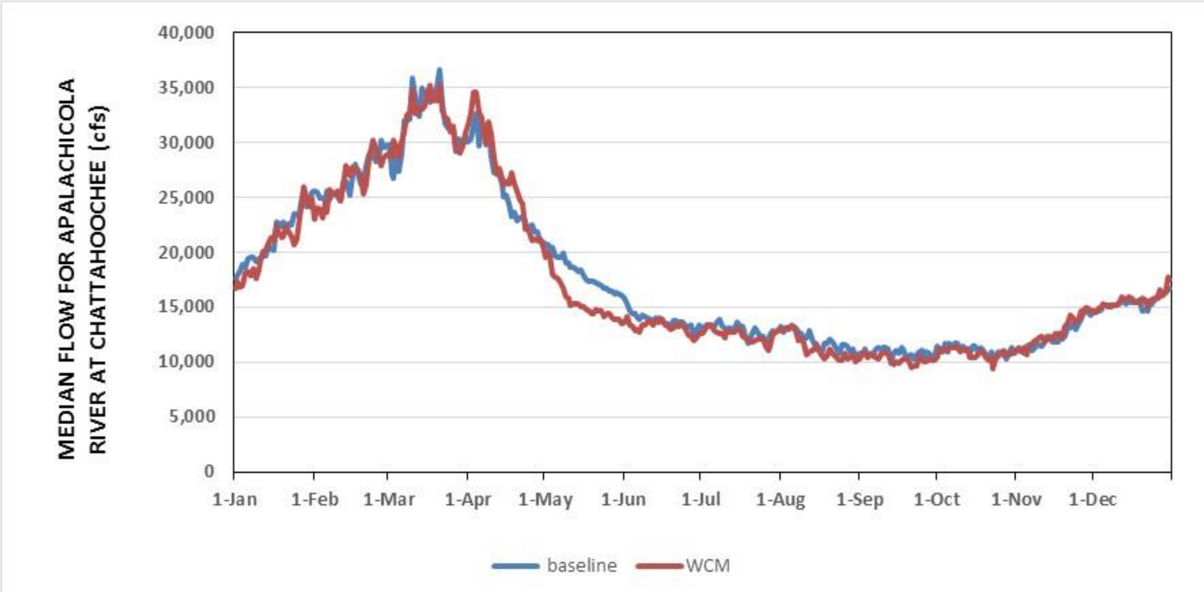
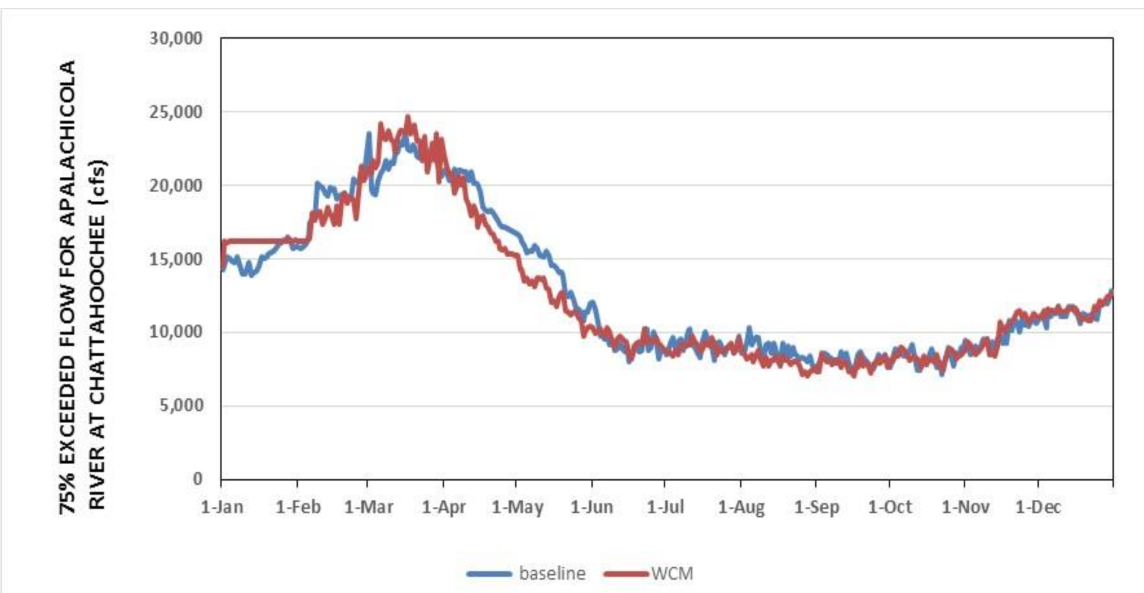


Figure 17.3D. The minimum conservation volume under the baseline and WCM for each of the year for values for the years 1939 to 2012

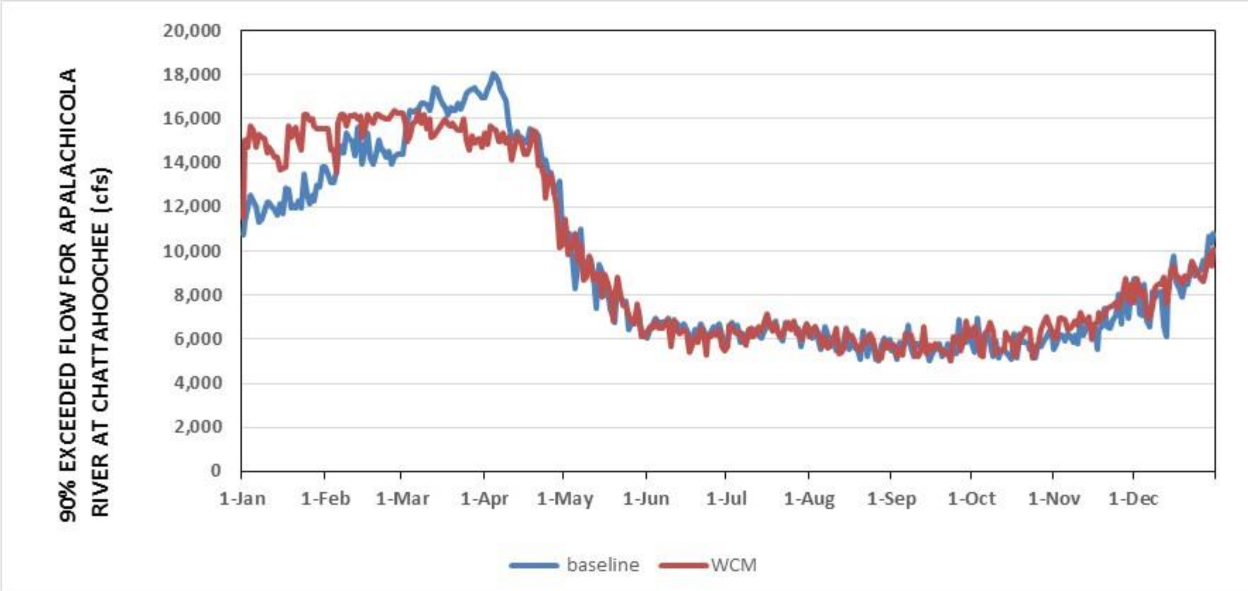
Figures 17.4A-D compare the flow for the Apalachicola River at Chattahoochee (i.e., Jim Woodruff outflow) for WCM and baseline for median, 75% exceeded, 90% exceeded and 100% exceeded values for 1939 - 2012 using the ACF-STELLA model and therefore show the seasonal timing and magnitude frequency of the modeled flow of the Apalachicola River for the baseline and WCM. These figures show for median and 75% exceeded flows the volume of water at this gage was greater in late Spring under the baseline and for the 90% exceeded flows the baseline provided a greater volume of water in late winter-early spring period. Under 100% exceeded flows (minimum flows) there were only minor differences between the baseline and WCM.



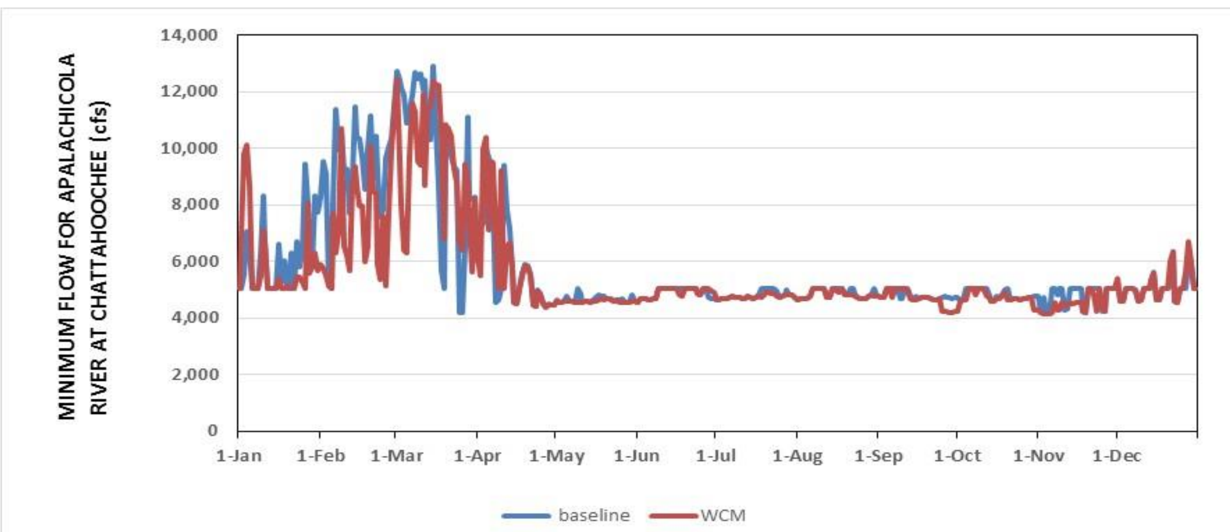
Figures 17.4A. The median exceeded flow in the Apalachicola River under the baseline and WCM for each day of the year for 1939 to 2012



Figures 17.4B. The 75% exceeded flow in the Apalachicola River under the baseline and WCM for each day of the year for 1939 to 2012



Figures 17.4C. The 90% exceeded flow in the Apalachicola River under the baseline and WCM for each day of the year for 1939 to 2012



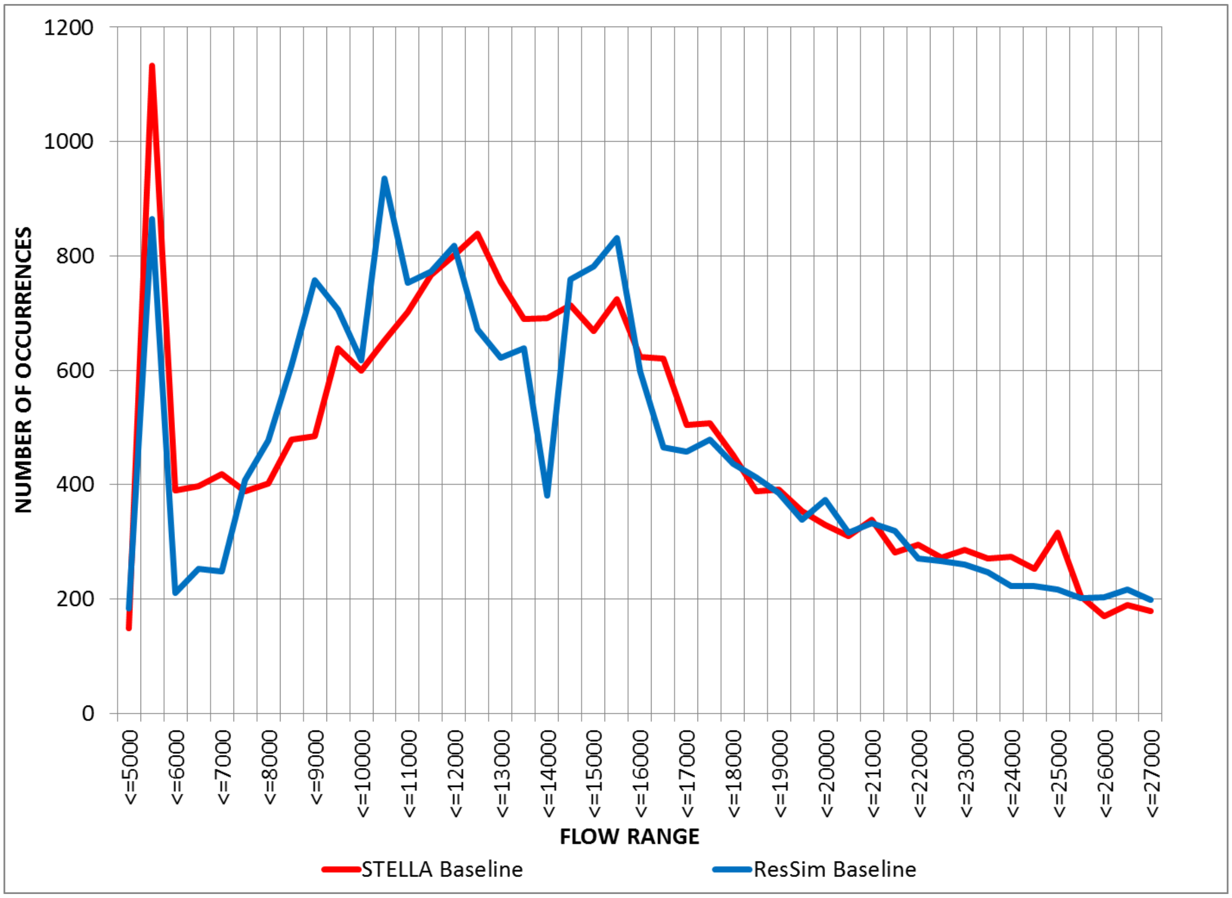
Figures 17.4D. The minimum flow in the Apalachicola River under the baseline and WCM for each day of the year for 1939 to 2012

The WCM model maintains a minimum release from Woodruff Dam of between 4,550 and 5,050 cfs, a flow range which occurs about 3.5% of the time (950 days) in the years 1939-2012 under the WCM and 3.6% of the time under the baseline (966 days). The WCM is intended to support the minimum flow 5,000 cfs until composite storage falls into the "drought zone" of Zone 4, which occurred 86 days under the WCM (25 days in 2007 and 61 days in 2012) and 50 days under the baseline (50 days in 2012).

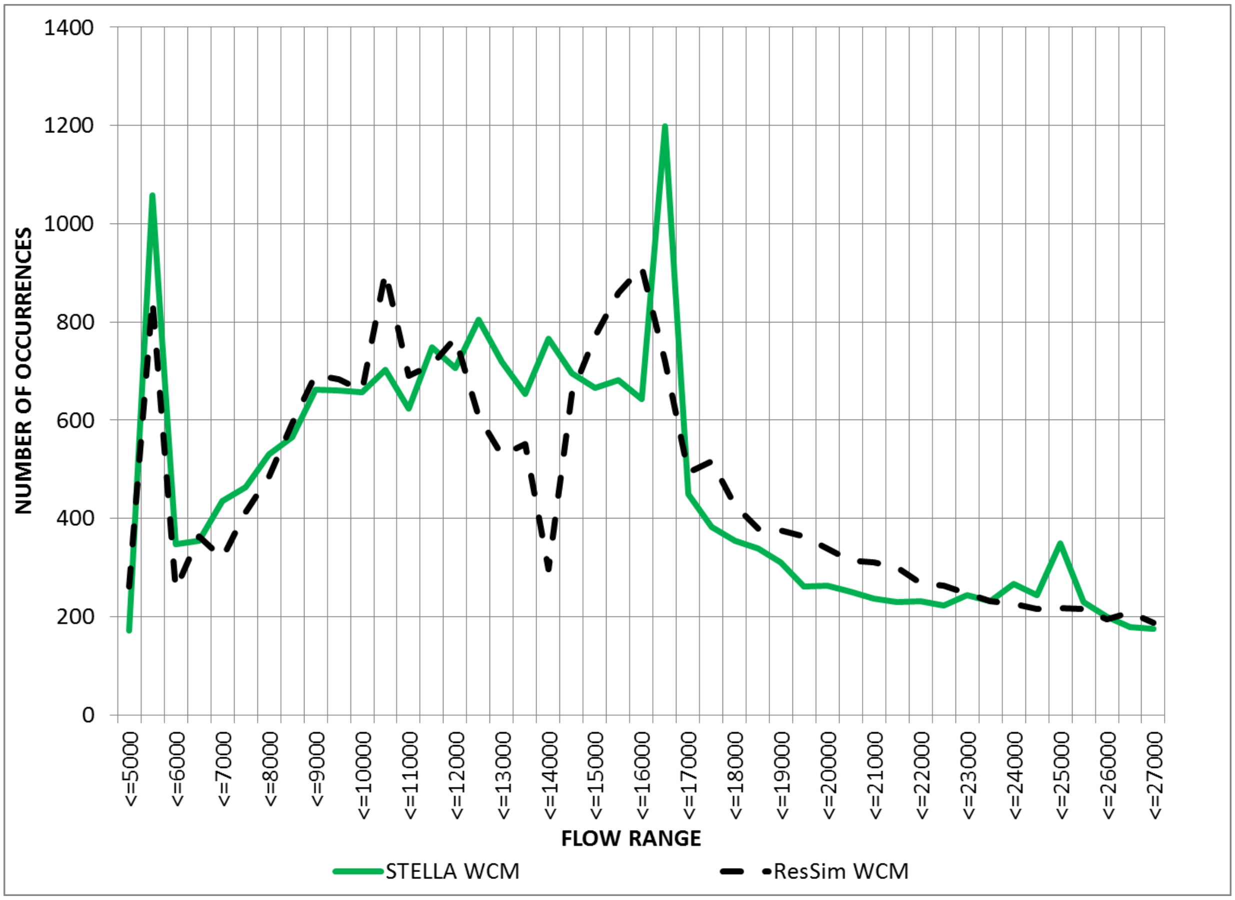
We examine the possible effects of these various changes to the flow regime to the listed species and their habitats in sections 5 and 10.

17.3 Comparison of HEC-ResSim and STELLA modeling approaches

The HEC-ResSim and STELLA models were developed independently to mirror USACE operations within the ACF Basin independently as described above and in the BA (USACE 2016; see also USACE 2015, Appendix E; USACE 2014). Using a simple comparison of counts of occurrence of flows in 500 cfs flow ranges (Figure 17.5), two differences between the models were identified and allowed to remain in the models are described below. 1) The way each model addresses balancing pool and tailwater elevations to ensure maintenance of the head limit of Woodruff Dam differed (i.e., the difference in the peaks between 5,000-6,000 cfs on Figure 17.5A & B). 2) The way each model incorporated the flows to maintain the 7-foot navigation channel differed (i.e., the difference in the peaks at about 10,000 and 16,000 cfs on Figure 17.5B). Here, we provide a summary of those differences.



A



B

Figures 17.5 Predicted frequency of flows in 500 cfs categories under the baseline (A) and WCM (B) from the HEC-ResSim and STELLA models for 1939 to 2012

17.3.1 Head limit

ResSim: The following is an excerpt from USACE 2015 (p. E-1, E-21). "The Jim Woodruff lock and spillway have a maximum head limit due to structural stability. In addition, the Jim Woodruff project complies with a number of very significant and complex environmental requirements, including actions contained in the Revised Interim Operations Plan (RIOP) at Jim Woodruff Dam, Gulf Sturgeon Spawning Operational Consideration, and Fish Spawning Operational Consideration for Lake Seminole and the Apalachicola River. These operational requirements often trigger system operations to use storages on a basin-wide basis.

This rule (see [Figure 17.3.1]) represents the physical operation constraint of the maximum head limit at Jim Woodruff Dam. A head limit curve, which was provided by the Mobile District, defines the minimum tailwater elevation necessary to adequately limit the head difference for a given reservoir pool elevation. A state variable, "Woodruff_MinTailwater", is created to determine the minimum tailwater elevation based on the head limit curve. Using the pool elevation at the previous time step, the state variable script computes the minimum tailwater elevation for the current time step. In the ResSim model, the minimum tailwater elevation is converted to a discharge value based on the tailwater stage-discharge rating curve at the downstream USGS Chattahoochee gage and is used as a minimum release from Jim Woodruff. This head limit rule is placed at the top of each zone indicating the highest rule priority for each zone. The state variable that determines the minimum tailwater is explained in detail Appendix H, page H-34-35."

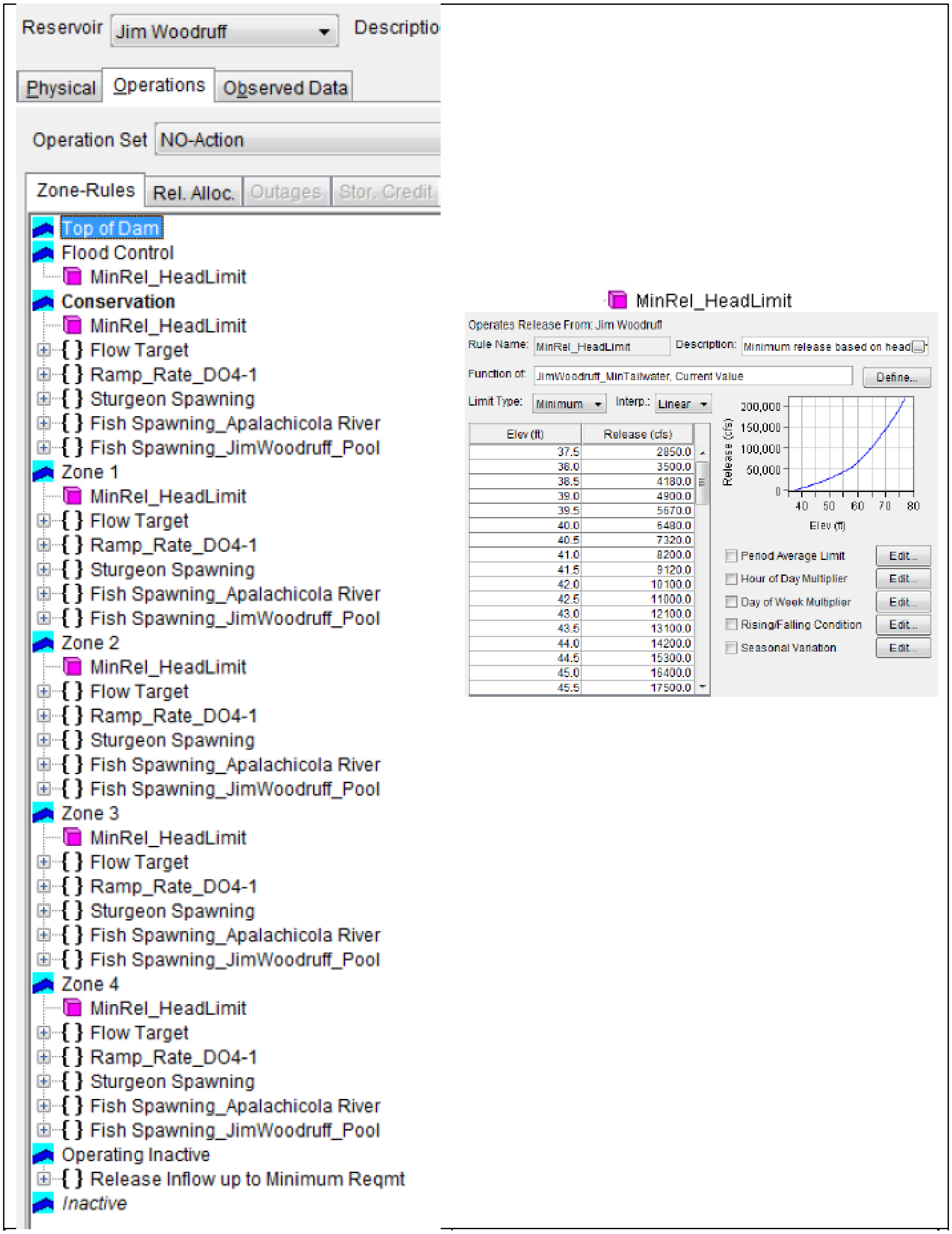


Figure 17.3.1 Reservoir Editor- Network 2014: Operations Tab – NO-Action OpSet – Zones and Rules

STELLA: For dam safety purposes, limitations are placed on the head limit at Jim Woodruff Dam (i.e., the elevation difference between the pool elevation in Lake Seminole and the elevation in the tailwater). In the ACF STELLA model head limitation requirements are implemented by lowering the rule curve or rule elevation in Lake Seminole (i.e., the elevation which marks the top of a reservoir's conservation pool) as releases from Jim Woodruff Dam decrease. The resultant lowering of the rule curve reduces the volume of water in the conservation pool at Lake Seminole which in turn requires greater releases from W.F. George reservoir to allow the required minimum release from Woodruff to be met. The relationship between elevations at Lake Seminole and releases from Jim Woodruff (which would define the elevation of the tailwater) was supplied by the USACE. The STELLA rules are as follows:
JW RULE REQ = IF (LakeSeminole_cfsd>JWRuleVol_cfsd) THEN
MAX((LakeSeminole_cfsd-JWRuleVol_cfsd)/5+JWInActual-NetWithWFGJW,
JW_OUTFLOW_DELAY - JW_RAMPING_LIMIT, 0) ELSE
Max(LakeSeminole_cfsd+(JWInActual)-NetWithWFGJW-JWRuleVol_cfsd,0)
WHERE:
JWRuleVol_cfsd = 6.86186255E2*JWRuleElev^2 -8.65850908E4*JWRuleElev+2.78378753E6
(Volume corresponding to the rule curve in the units of cfs-days)
WHERE:
JWRuleElev = The flow from JW in the previous time step is converted to an elevation based on the following relationship. Units cfs. The resultant elevation becomes the rule elevation for the reservoir.

flow	elevation
5000	76
7600	76.25
10200	76.5
12800	76.75
15400	77
18000	77.25
20600	77.5
23200	77.75
25800	78
28400	78
31000	78

17.3.2 Navigation flows

ResSim: The following is an excerpt from USACE 2014 (p. 57-58). "The provision of reliable navigation has always been a challenging task in the ACF System. A navigation measure considered was the concept of a definite navigation season (January through May). In developing this measure, USACE balanced use of storage for navigation versus the use of storage for other authorized project purposes and considered the effects on other needs and requirements in the system such as hydroelectric power generation and recreation. Assessment of the frequency of channel availability and the number of drought operations triggered by the implementation of navigation showed that navigation options are only feasible when the composite system storage is in Zones 1 or 2. [Figure 1.7] shows the conservation storage in a navigation season. The goal of the navigation operation rules is to maintain a flow rate of 16,200 cfs at the Blountstown gage as much as possible, which represents 7 ft of minimum navigation depth.

Nested conditional statements use existing RIOP state variables as well as one named *NavigationSeason*, which indicates whether the release decision occurs during January-May. If true, and if the system composite storage zone is 1 or 2 and not under drought operations then the minimum release rule *MinRel_Navigation* specifies release. The settings are shown in [Figure 17.3.2] and [Figure 17.3.3]. Description of the state variables can be found in Appendix H."

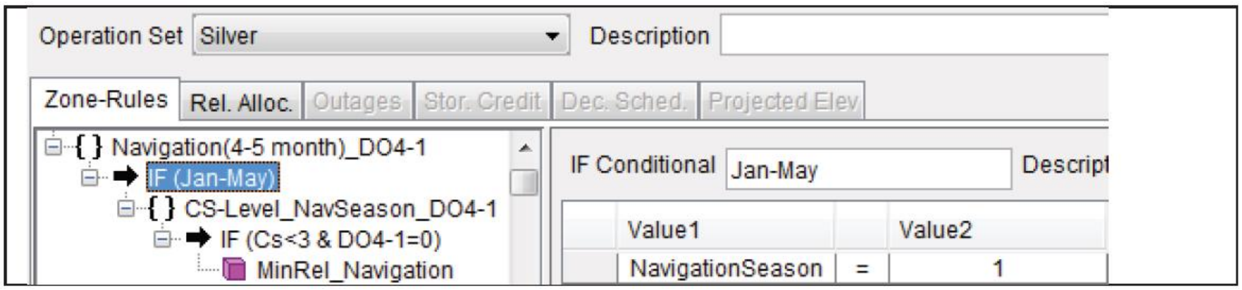


Figure 17.3.2 Conditional Blocks for Navigation (4-5 month)_DO4-1 Rule

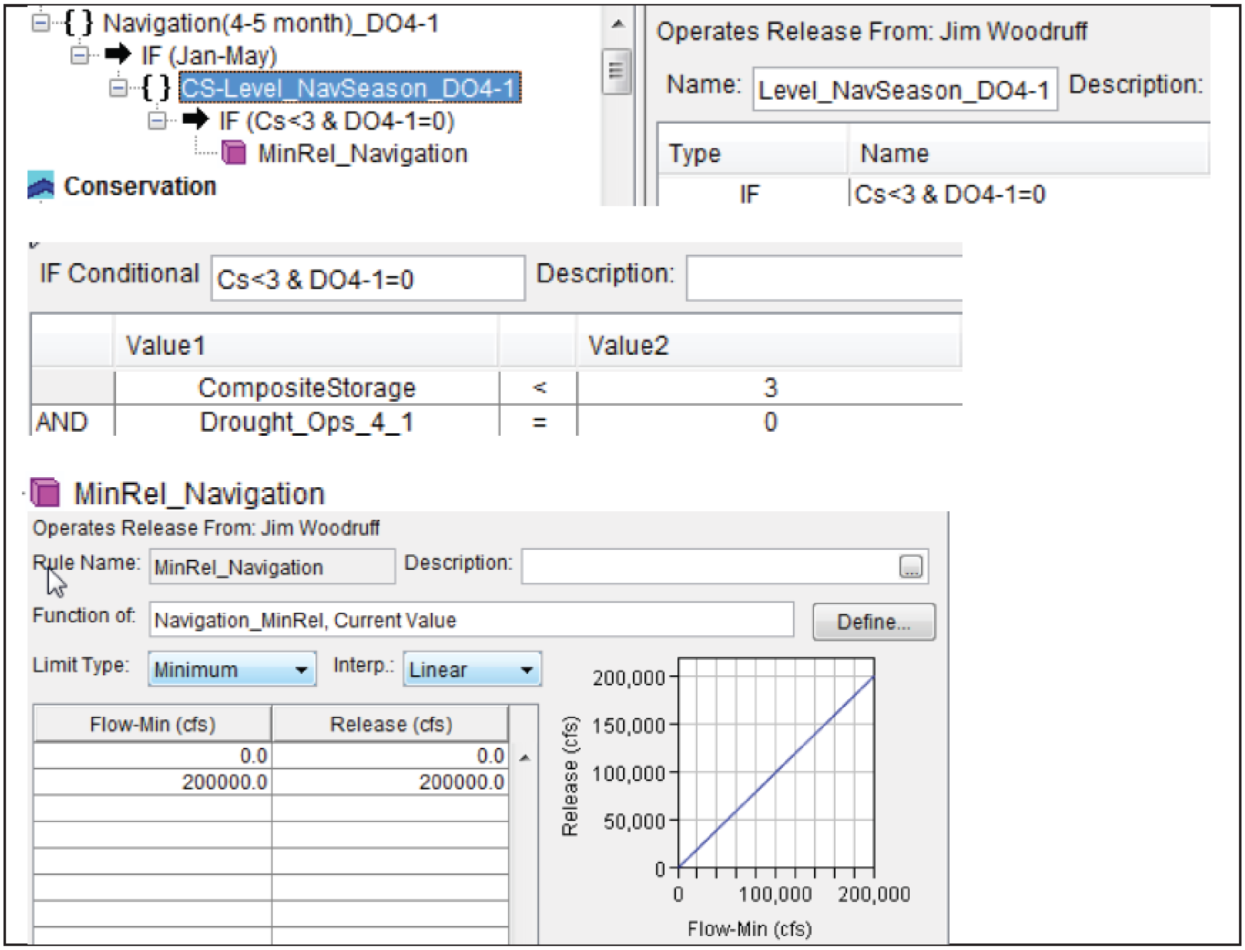


Figure 17.3.3 Release Rules for Navigation(4-5month)_DO4-1 Rule

STELLA: The approach to modeling the navigation release in the ACF-STELLA model is based on providing a 16,200 cfs release from Jim Woodruff Dam to support providing a 7-foot navigation channel in January through May provided that: 1) the composite storage for the ACF basin is either in Zone 1 or 2 and 2) drought relief is not in effect. The STELLA rules are as follows:

JW PAA PRELIM = IF month >=3 AND month <= 5 THEN PAA_MARCH_TO_MAY
ELSE IF month >= 6 AND month <=11 THEN PAA_JUNE_TO_NOV
ELSE PAA_DEC_TO_FEB
WHERE:
PAA_DEC_TO_FEB = IF drought trigger = 1 THEN 5050 ELSE IF MONTH < 3 AND Composite Zone < 3 THEN 16200 ELSE 5050
PAA_MARCH_TO_MAY = IF drought trigger = 1 THEN 5050 ELSE IF Composite_Zone <= 2 THEN
IF JW_Basin_inflow_7_day >= 34000 THEN 25000
ELSE IF JW_Basin_inflow_7_day >= 16000 THEN MIN (16,200, (16000 + 0.5 * (JW_Basin_inflow_7_day - 16000)))
ELSE IF JW_Basin_inflow_7_day >=5050 THEN JW_Basin_inflow_7_day

ELSE IF JW_Basin_inflow_7_day < 5050 THEN 5050
ELSE IF Composite Zone = 3
THEN IF JW_Basin_inflow_7_day >= 39000 THEN 25000
ELSE IF JW_Basin_inflow_7_day >= 11000 THEN 11000 + 0.5 * (JW_Basin_inflow_7_day - 11000)
ELSE MAX (JW_Basin_inflow_7_day, 5050)
ELSE 5050
ELSE 5050

18 APPENDIX B. CLIMATE MODEL PROJECTIONS: IMPLEMENTATION AND MODELING RESULTS

18.1 Climate model projections

The most recent set of climate projections for the globe come from the Coupled Model Intercomparison Project (CMIP5), an international, multi-institutional, coordinated Global Climate Model (GCM) project that developed simulations of the long-term atmospheric response under a set of pre-defined scenarios of evolving greenhouse gas concentrations (representative concentration pathways (RCPs). The GCM output is available at a relatively coarse resolution (on the order of 100km) over the entire globe, and consists of meteorological variables (e.g., temperature and precipitation), typically with a daily time step. The suite of GCM model output provides an estimate of the uncertainty in climate response that stems from incomplete knowledge and numerical representation of atmospheric and oceanic processes that shape the climate response to changes in greenhouse gas concentrations. Simulations are made both for a historical period (e.g., 1950-2000) under prescribed historical greenhouse gas concentrations, and for a future period (e.g., out to 2100) in which the greenhouse gas concentrations are prescribed to evolve according to a pre-defined scenario. The simulations for temperature, precipitation, and other variables for the historical period are compared to observed values for these variables, in order to estimate the systematic errors of each model, i.e., the model bias. This bias can then be removed from the future period projections, resulting in a bias-corrected set of projected fields.

Modeling the impacts of climate change on the ACF flow under different management options requires an estimate of the projected changes in unimpaired flows at local scales. The environmental input to the STELLA model for the ACF consists of unimpaired flow (UIF) contributed at several reaches. To construct the projected changes in the UIF at these reaches under climate change, we used the results from 97 Bias-corrected, spatially disaggregated (BCSD) climate projections representing 31 CMIP5 climate models and 4 RCPs, that had been further fed into a Variable Infiltration Capacity (VIC) hydrologic model to simulate future hydrology (Brekke et al. 2014). The resulting downscaled hydrologic simulations for runoff were available as monthly time series for 1950-2099 on a grid over the contiguous US with 0.125-degree (approximately 12.5km) latitude and longitude resolution.

18.2 Validation of model-simulated runoff as a proxy for unimpaired flow

Before proceeding to implementation of the runoff projections to modeling, we needed to evaluate how well the historical (1950-1999) downscaled runoff projections compared to the historical UIF for that period. This evaluation has to be done in a statistical sense, rather than as time series, because by their nature, climate runs do not represent specific years, but rather the statistical behavior of the atmospheric system within a given period. For each reach (Figure 18.1) we constructed the median annual cycle for runoff for each model, and for historical UIF. Similarly, we constructed the annual cycles for standard deviations of runoff for each model and for the UIF. Figure 18.2 shows an example of this comparison for one of the reaches (Middle Flint). The annual cycles of median runoff and UIF are generally very strongly correlated

(Figure 18.2C and Table 18.1) proving that annual cycles of median monthly simulated runoff are in very good agreement with the annual cycle of median monthly UIF for all reaches with the exception of Sumatra. The annual cycles of standard deviations are strongly correlated, although the strength of the relationship is slightly lower, especially in reaches that contained an outlier caused by tropical storm Alberto in July of 1994; if the outlier month is excluded from consideration, correlations significantly increase.

This validation step showed that simulated runoff tends to be an overestimate of the UIF, but that the shape of the seasonal cycle for runoff is very similar to that of UIF, suggesting that despite the differences between simulated runoff and historical UIF, a proportionality between the two exists. To evaluate whether this is the case, we next calculated the regression fit between UIF and simulated runoff and in ranked pairs of monthly means. For the median model projection within a given calendar month (e.g., January) and a given reach, the monthly runoff values for 1950-1999 were arranged from smallest to largest; similarly, the UIF values for that calendar month and reach were arranged from smallest to largest. A regression fit between UIF and runoff was calculated assuming (a) linear relationship of the form UIF=A*runoff+B and (b) linear relationship of the form UIF=C*runoff. An example is shown in Figure 18.3 for the Middle Flint reach in July. A comparison between the R^2 coefficients of the two fits (Table 18.2) shows strong support for the assumption that within a given calendar month UIF can be considered proportional to runoff.

18.3 Incorporating climate change projections of runoff into STELLA

The findings described in the preceding section support the viability of the assumption that projected UIFs for each month can be constructed on the basis of Future UIF=Historical UIF * (Projected Future Runoff):(Simulated Historical Runoff). There are a number of ways to implement Future UIF=Historical UIF * (Projected Future Runoff):(Simulated Historical Runoff).

One option, which was followed by ACF Draft EIS (USACE 2015) is the following:

- For every calendar month, rank the monthly mean UIFs, the projected runoff, and the historical runoff; Calculate the ratio of projected to historical runoff from the values in the N-ranked position, and multiply the N-ranked past UIF value by this ratio
- This approach has the benefit of allowing for the possibility that minimum monthly flows become lower, and at the same time maximum flows become larger (or vice versa), but the downside of basing the ratios on single data points which would show undue influence of chance, especially at the lower and higher ends.

As a more robust alternative, we have chosen the following approach:

- Multiply each past UIF value by a change factor = the ratio of the median projected runoff to the median historical runoff value for that calendar month
- This has the downside of not allowing for the lowest and highest monthly flows to change in opposite directions, but the benefit of not being unduly influenced by chance realizations

A further necessary decision is which model projections to use for developing of the climate change scenarios for unimpaired flows. The ACF Draft EIS approach was to use a subset of three models, representing a dry, median and wet scenario, selected on the basis of ranking of the projected changes of total annual volume of runoff for the basin. This does not account for the possibility that (a) different models may rank differently in terms of projected change for different months and (b) that this ranking may vary along the basin. In our approach we make use of the information contained in each projection separately (since we are not limited by model run time to just three scenarios). With this we would expect to see a more accurate range of the possible outcomes implied by the downscaled model projections. In addition to individual models, we consider the overall 0th (minimum) through 100th (maximum) percentile of projected changes for each month, in increments of 10 percentiles.

The time frame chosen for the projections was 2020-2079. An examination of the climate projections indicated no clear separation between the four greenhouse gas concentration scenarios (RCPs), consistent with the ACF Draft EIS. This is likely due to the fact that both temperature and precipitation tend to increase with higher RCPs so that the contribution to projected runoff by increase in precipitation is likely partially offset by increased evaporation due to increased projected temperatures. As a result, we have chosen to consider the model projections stemming from different RCPs as part of the same envelope.

Change factors for each reach were developed as described above were calculated for each month, and for each individual climate model projection as well as for the climate model projections' envelope at 11 levels: 0th (Minimum), 10th, 20th, 30th, 40th, 50th (Median), 60th, 70th, 80th, 90th and 100th (Maximum) percentiles of change, based on the models' 2020-2069 climatology relative to their 1950-1999 climatology.

Amongst the climate model projections it is often the case that increased median flows can be accompanied with lower low flows and higher high flows. It should be underscored that the climate change factors calculated here are based on the overall changes in flow volume for a given calendar month, and not for changes in the distribution of flows. The results from applying these climate change factors to the UIF will result in a conservative estimate of the likely range of responses that can be expected in reality.

The change factors for the 9 reaches (Figure 18.1) for the envelope percentiles are shown in Figure 18.3. The UIF climate change envelope is narrower during January-June and broader during July-December. For all reaches and all months, the median of all models' projections is greater than one. This means that more than half of the climate model projections produce higher median runoff for the future period than in the historical period. The minimum of the climate envelopes (the driest edge of the climate envelope) is an over 25% reduction of the median flows; the maximum (wettest edge of the climate envelope) is more variable across reaches and calendar months, ranging from an approximately 25%-50% increase of median flows in January-March for the upper reaches, to over 75% for the lower reaches in July and October.

These climate change factors were used to proportionally modify the daily UIF time series from 1939-2012, resulting in a set of projections for the basin. Results presented in the Section 18.4 discuss changes in flow and reservoir elevations for the 11 levels of the climate change envelope under three operation rules (baseline, WCM, and USFWS). USFWS alternative is provided to inform adaptive management alternative actions that may be possible within the authority of the WCM. Results presented in Sections 18.5 and 18.6 compare select mussel and sturgeon metrics, respectively, for the 11 levels of the climate change envelope under two of the operation rules (baseline, WCM).

18.4 Results for flow and reservoir elevations

Figure 18.4 illustrates the spread of the projected climate change envelope for 90% exceeded flows at Jim Woodruff Dam for the three sets of operation rules. The spread of the envelopes for any given calendar day is on the order of 5,000 cfs, which underscores the large range of uncertainty in the projected future, and the need for flexibility in developing suitable operation rules for the future. Similar results occurred for the 10% exceeded, 25% exceeded, median, 75% exceeded and 100% exceeded flows.

Figure 18.5 compares the 90% exceeded flows at Jim Woodruff Dam under the baseline, WCM, and USFWS, for five levels of the climate change envelope: envelope minimum, 10%, median, 90% and maximum. During the low flow period (roughly May to December) the WCM tends to provide higher low flows than the baseline, and the USFWS tends to provide higher low flows than both WCM and baseline, except at the maximum level of the climate envelope when the operating rules perform similarly.

Figure 18.6 illustrates the spread of the projected climate change envelope for 90% exceeded elevations at Lake Lanier for the three sets of operation rules. The spread of the envelopes for any given calendar day is on the order of 15 ft. Results are similar in nature for other exceedance levels, and for the reservoirs at W.F. George and West Point.

Figure 18.7 compares the 90% exceeded elevations at Lake Lanier under the baseline, WCM, and USFWS, for five levels of the climate change envelope: envelope minimum, 10%, median, 90% and maximum. Elevations are highest under the baseline, followed by WCM, followed by USFWS operations. The difference between elevations under baseline, WCM and USFWS is largest for the lower (drier) end of the climate envelope.

18.5 Results for Mussel Metrics

Four mussel metrics were selected for examining the impact of projected climate change under baseline and WCM. Below is a list of these metrics' abbreviated names and their description:

- M2: Annual number of days between March 1 and August 15 with flows ≥16,200 cfs (measure of the access to floodplain for spawning and rearing)
- M3: Annual maximum continuous inundation (measure of access to floodplain during spawning and rearing)

- M4: Annual number of days between June 1 and July 15 with flows greater than 5,000 cfs and less-than-or-equal-to 7,500 cfs (measure of low flows during host infection and juvenile settlement) Note that this metric excludes flows ≤ 5,000 cfs so some low flows are not counted.
- M7: Annual 1-day minimum flow (measure of exposure during extreme low flows)

The remaining metrics are shown in Figures 18.M1, 18.M5, 18.M6, 18.M8, and 18.M9.

Figure 18.8 illustrates the response of M2 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. Also shown for comparison are the values of the metric for the 1939-2012 period. The median metric values for baseline range from 75 (minimum of the climate change envelope) to 149 days (maximum of the climate change envelope); for WCM this range is 60 to 136 days.

Figure 18.9 compares the response of M2 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. It shows that while the probability distribution of the number of days between March 1 and August 15 exhibiting flows ≥16,200 cfs is dependent on the climate envelope level, for any given level of the climate envelope baseline provides better access to the floodplain for spawning and rearing than the WCM. An additional/alternative way to describe this can be that any given value of the metric is more frequently exceeded under baseline than under WCM.

Figure 18.10 illustrates the response of M3 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. The median metric values for baseline range from about 17,700 to 39,300 acres; for WCM this range is very similar, from about 15,600 to 40,600 acres.

Figure 18.11 compares the response of M3 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. For all levels of the climate envelope, the 100% exceedance values for WCM are greater than or equal to those for baseline. The 90% exceedance values for WCM are smaller than those for baseline for all but the minimum levels of the climate envelope. Results are mixed at other exceedance levels.

Figure 18.12 illustrates the response of M4 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. Since this metric represents fairly low flows, its median values are fairly small, ranging from 0 days (maximum level of the climate envelope) to 3 days (minimum level of the climate envelope) for baseline, and 0 to 2 days in the WCM. At the 10% exceeded level, the metric values range from 4 to 31 days for the baseline, and from 14 to 35 days for the WCM.

Figure 18.13 compares the response of M4 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. Largest differences are seen for the 90% and maximum levels of the climate envelope, at the 20%, 10% and 0% exceedance levels, where the WCM provides significantly larger values of this metric than does baseline.

Figure 18.14 illustrates the response of M7 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. Median values for M11 for baseline range between 5,050 (minimum level of the climate envelope) and about 8,000 cfs (maximum level of the climate envelope; for WCM this range is 5,050 to about 8,400 cfs.

Figure 18.15 compares the response of M7 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. The annual minimum flows under WCM tend to be similar to or higher than those under baseline at most exceedance levels and for most levels of the climate envelope. Annual minimum flow of 6,000 cfs is systematically more frequently exceeded under WCM than under baseline for any given level of the climate envelope.

18.6 Results for Sturgeon Metrics

Three sturgeon metrics were selected for examining the impact of projected climate change under baseline and WCM. Below is a list of these metrics' abbreviated names and their description:

- S1: Annual number of days between November 24 and June 1 exhibiting flows ≥16,200 cfs (measure of general floodplain forest inundation and nutrient supply)
- S4: Annual cumulative acre-days inundated during the period July 15 through November 24 (measure of general floodplain forest inundation and nutrient supply)
- S6a: Annual number of days during the period November 1 through March 15 exhibiting flows ≥16,700 cfs (measure of general low salinity conditions for sturgeon access to foraging habitat)
- SQ1: Annual number of days during the period March 1 through May 31 exhibiting flows between 5,000 cfs and 16,700 cfs (measure of how frequently sturgeon spawning may be affected by hydropeaking)

The remaining metrics are shown in Figures 18.S2, 18.S3, and 18.S5 - 18.S8.

Figure 18.16 illustrates the response of S1 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. The median annual number of days for S1 under baseline ranges between 112 (minimum level of the climate envelope) to 169 (maximum level of the climate envelope); under WCM this range is 107 to 168 days.

Figure 18.17 compares the response of S1 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. At the highest levels of exceedance (corresponding to the driest years) for most levels of the climate envelope WCM tends to provide higher values of S1 than does baseline. For the lower levels of exceedance (wetter years) the opposite is true: WCM tends to provide lower values of S1 than does baseline.

Figure 18.18 illustrates the response of S4 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. Median S4 values for baseline range between approximately 151,500 (minimum level of the climate envelope) to 1,053,000 acre-days (maximum level of the climate envelope); for WCM this range is approximately 137,200 to 1,044,000 acre-days.

Figure 18.19 compares the response of S4 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. The S4 metric values are generally lower under WCM than under baseline, with a few exceptions.

Figure 18.20 illustrates the response of S6a to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. The median annual number of days for S6a under baseline ranges between 56 (minimum level of the climate envelope) and 109 (maximum level of the climate envelope); under WCM this range is 57 to 109 days.

Figure 18.21 compares the response of S6a to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. For highest levels of exceedance (corresponding to dryer years) WCM tends to provide lower S6a values than does baseline at most levels of the climate envelope; results are mixed for lower levels of exceedance (wetter years).

Figure 18.22 illustrates the response of SQ1 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. The median annual number of days for SQ1 under baseline ranges between 22 (minimum level of the climate envelope) and 0 (maximum level of the climate envelope); under WCM this range is 36 to 10 days.

Figure 18.23 compares the response of SQ1 to the minimum, 10%, median, 90%, and maximum levels of the climate envelope under baseline and WCM. The WCM tends to provide higher SQ1 values than does baseline at nearly all levels of the climate envelope.

18.7 Figures and Tables for Appendix B

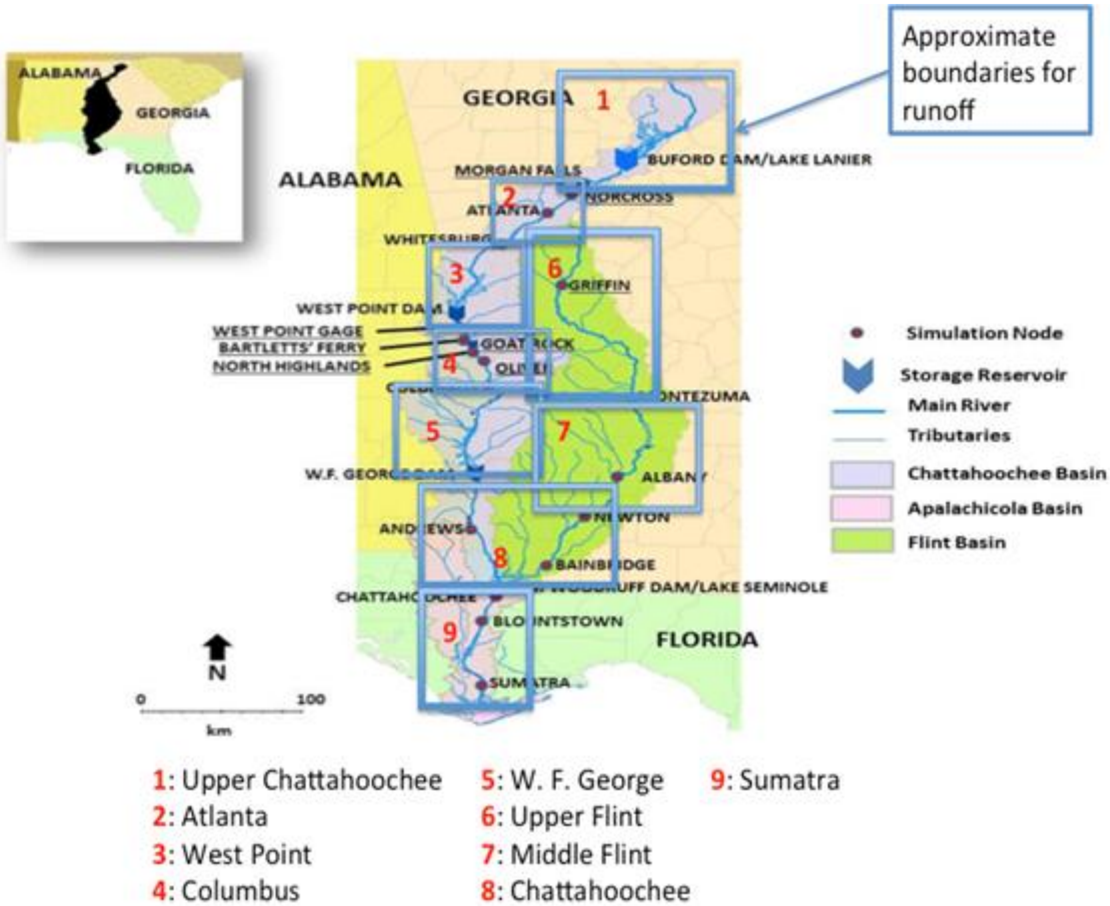


Figure 18.1: Delineation of reaches and approximate boundaries for runoff

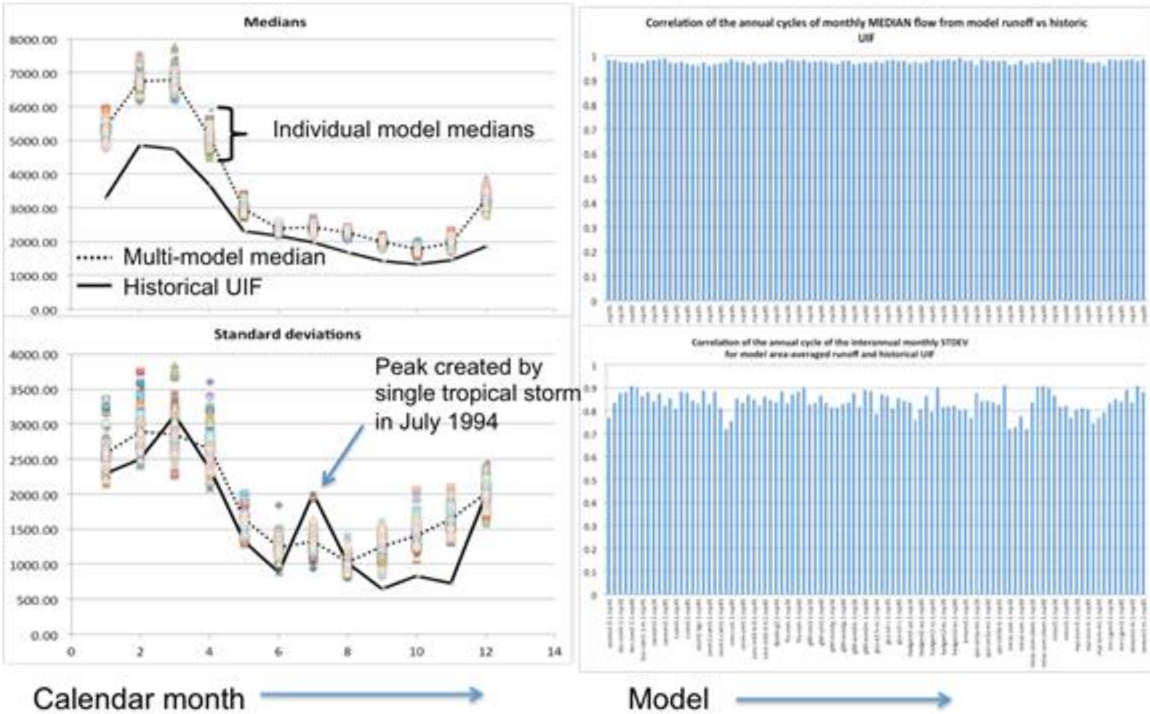


Figure 18.2: Comparison of annual cycles of median runoff/median UIF and standard deviation of runoff/UIF for the Middle Flint reach

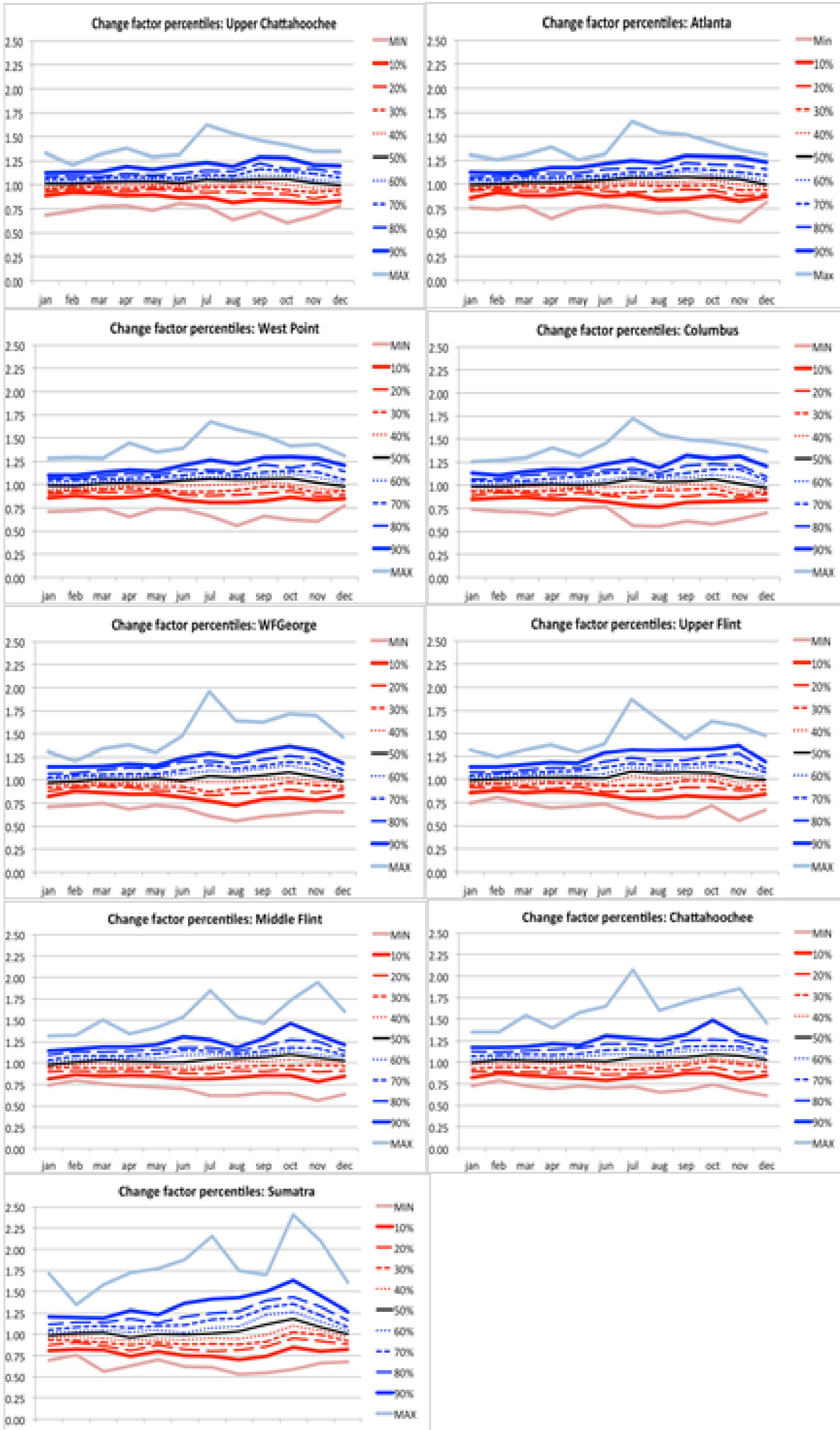


Figure 18.3: Change factors for UIF, January through December, for all reaches, at various levels of the climate change models' envelope

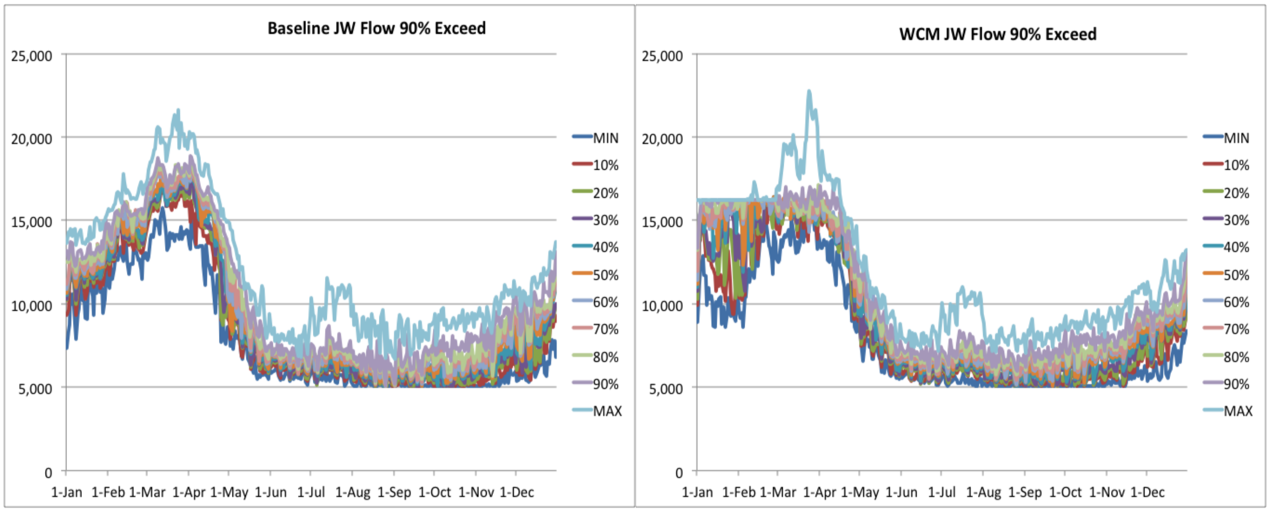


Figure 18.4: Comparison of the climate change envelopes for the 90% exceeded flows at Jim Woodruff Dam for a) baseline, b)WCM, and c) USFWS operation rules.

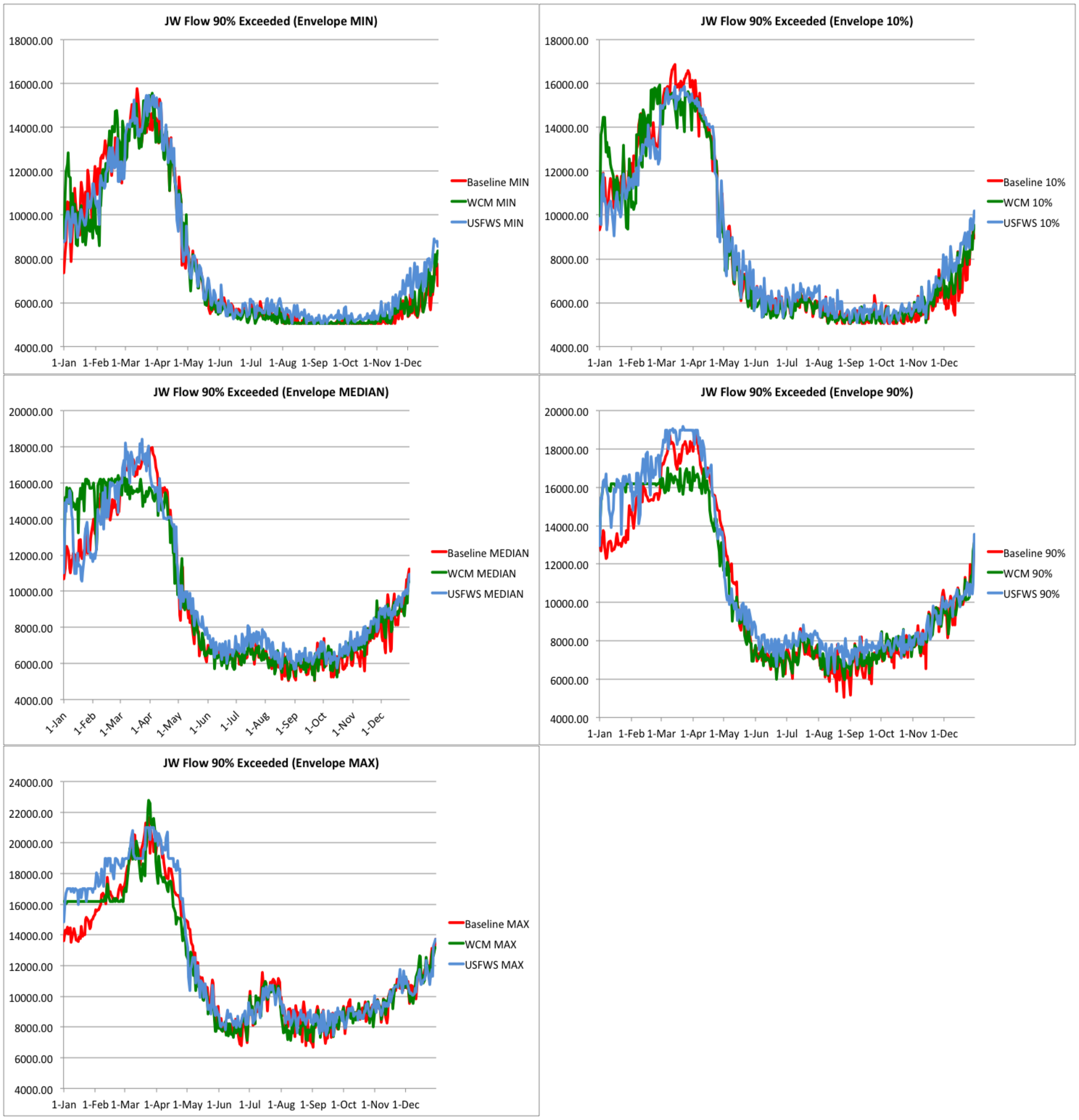


Figure 18.5: Comparison of the 90% exceeded flows at Jim Woodruff Dam under baseline, WCM and USFWS operating rules for the a) Minimum, b) 10%, c) Median, d) 90% and e) Maximum of the climate change envelope

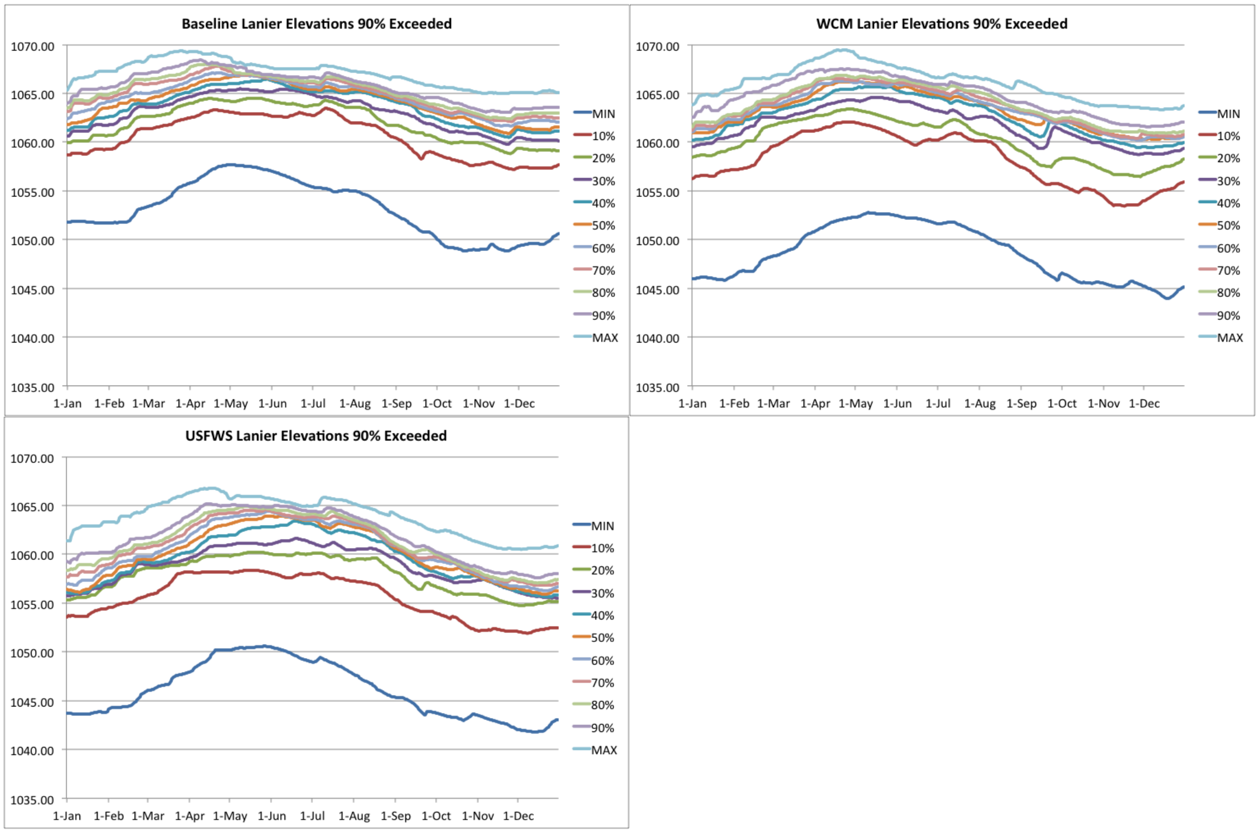


Figure 18.6: Comparison of the climate change envelopes for the 90% exceeded elevations at Lake Lanier for a) baseline, b) WCM, and c) USFWS operation rules.

Figure 18.7: Comparison of the 90% exceeded elevations at Lake Lanier under baseline, WCM and USFWS operating rules for the a) Minimum, b) 10%, c) Median, d) 90% and e) Maximum of the climate change envelope

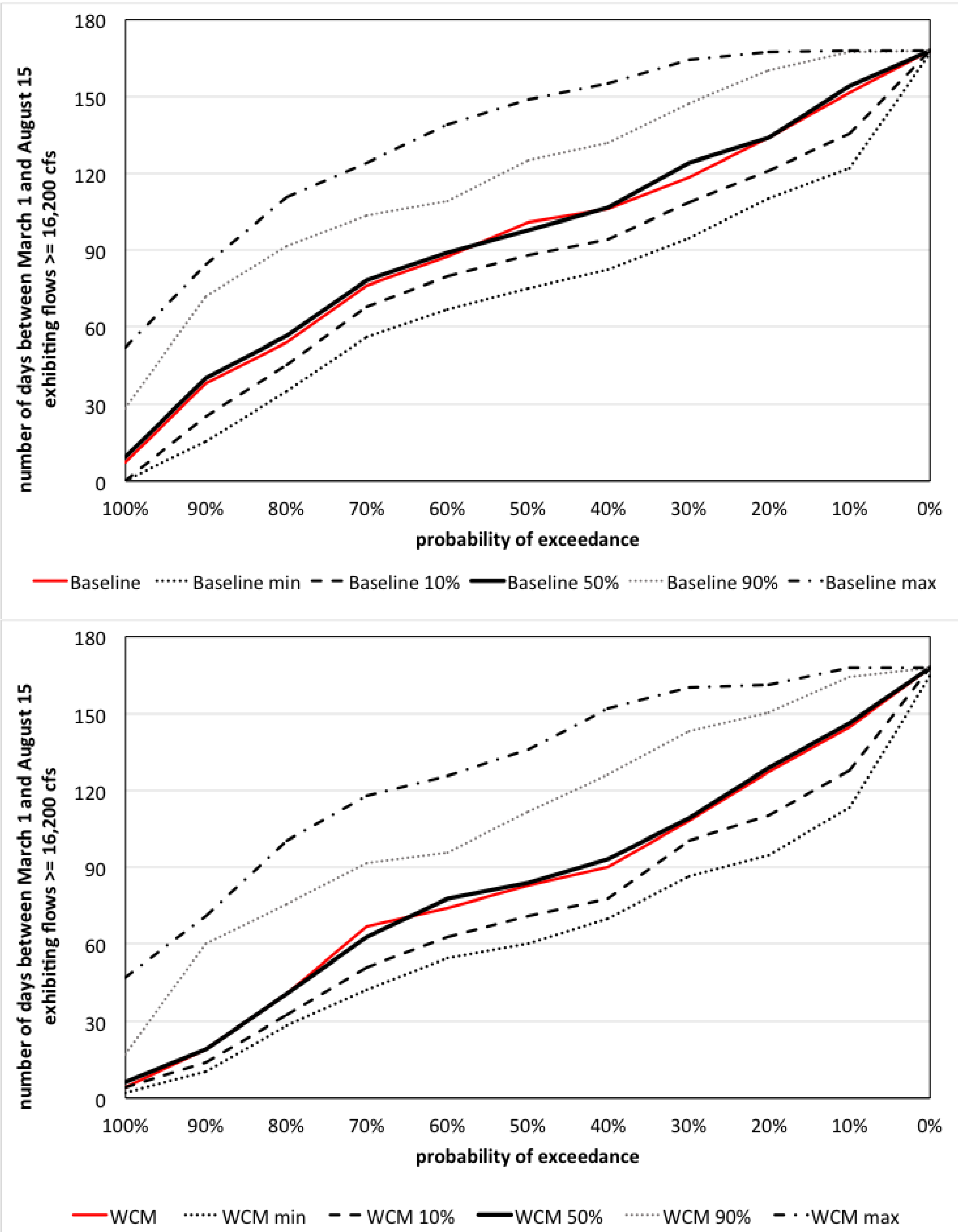


Figure 18.8: Response of metric M2 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

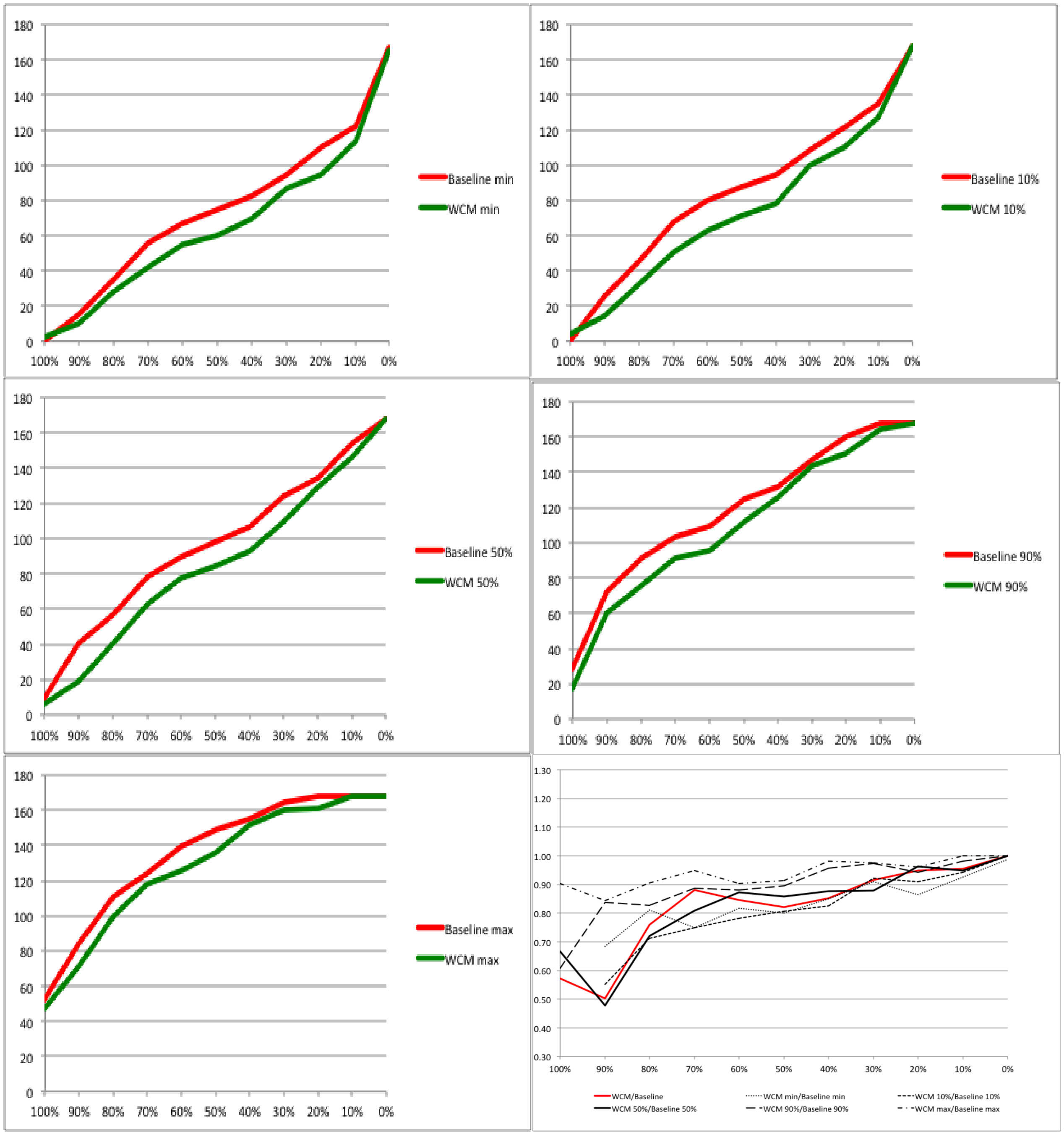


Figure 18.9 Comparison of M2 metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope. Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line).

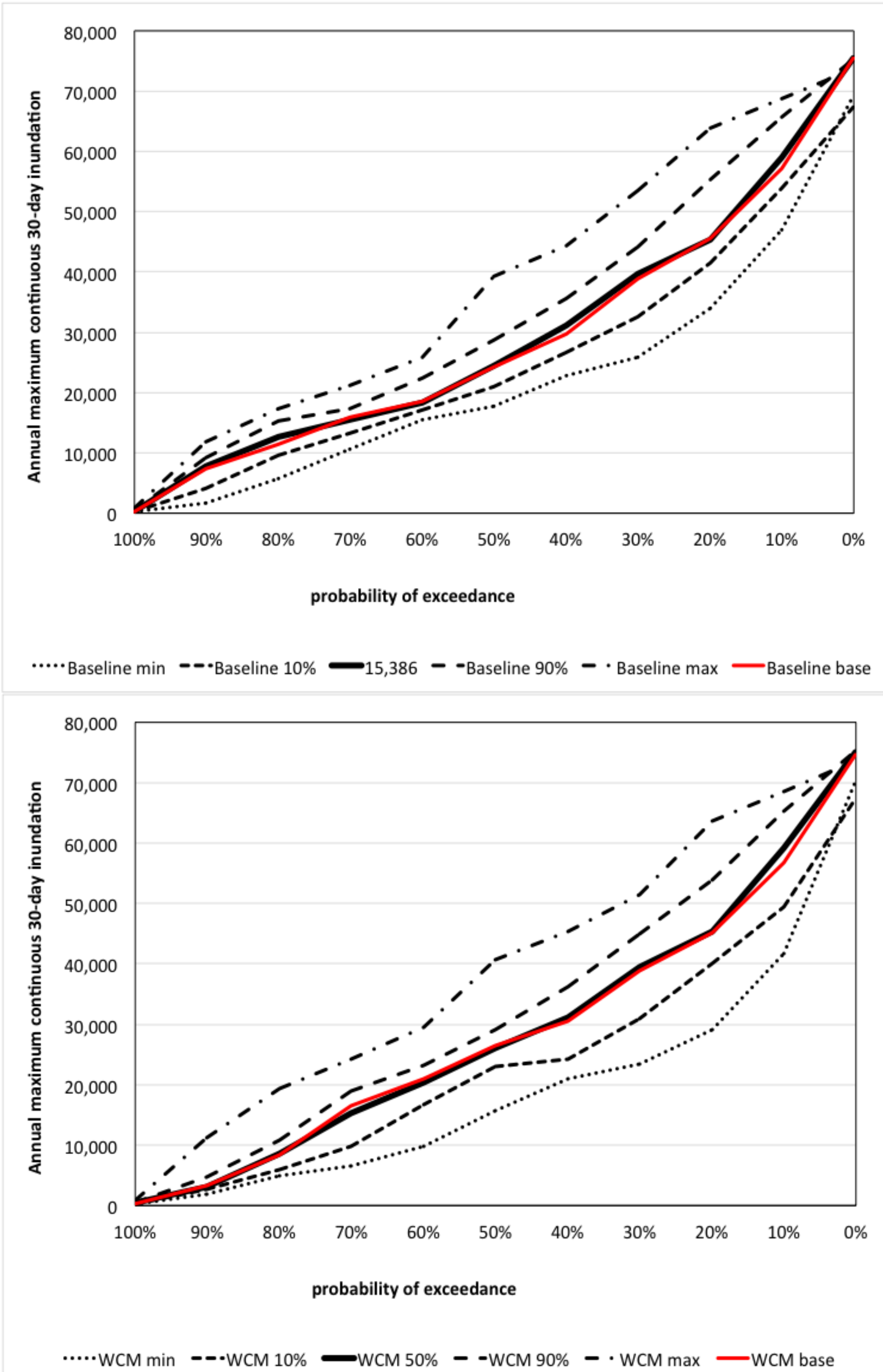


Figure 18.10: Response of metric M3 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

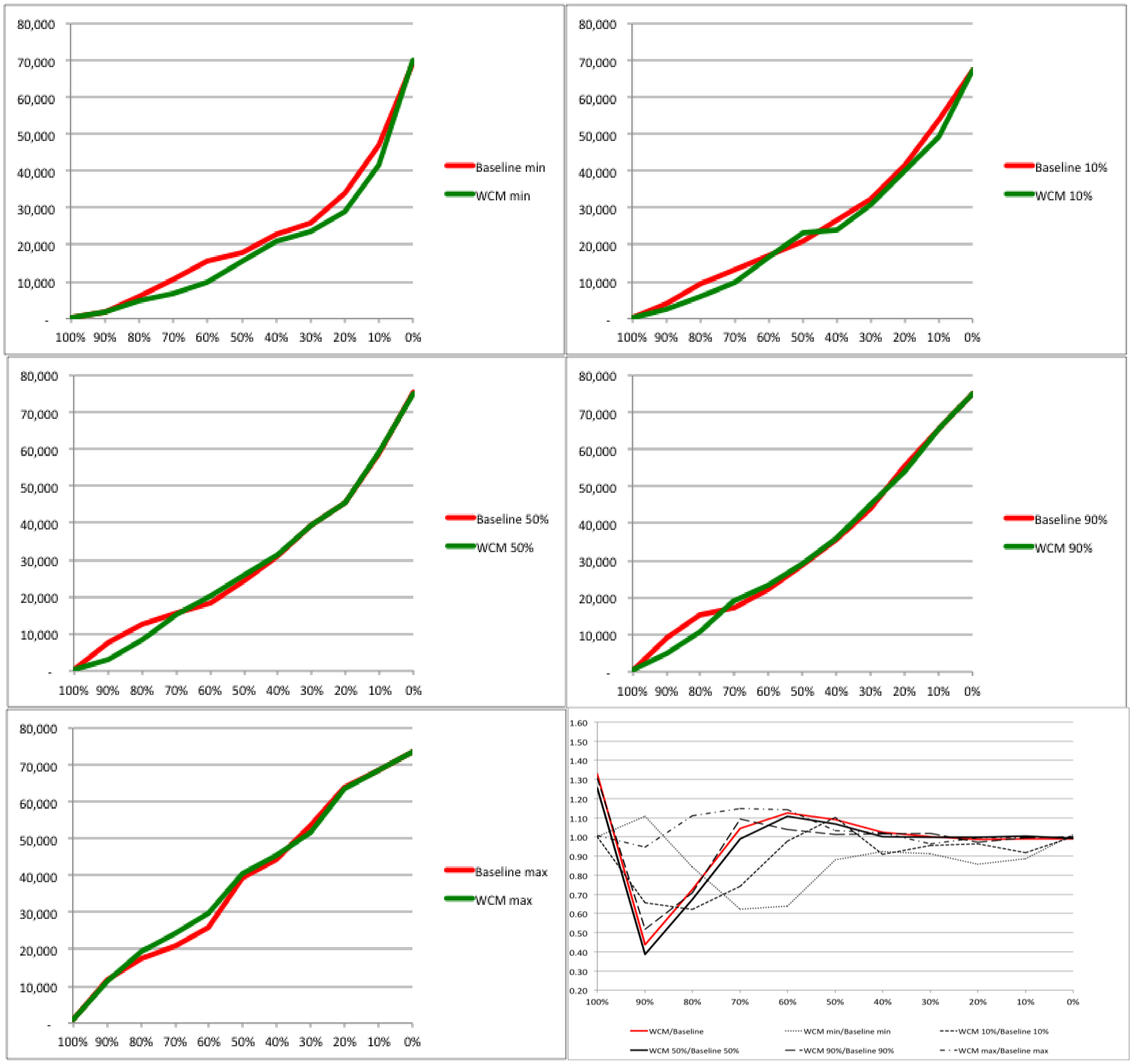


Figure 18.11 Comparison of M3 metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope. Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line).

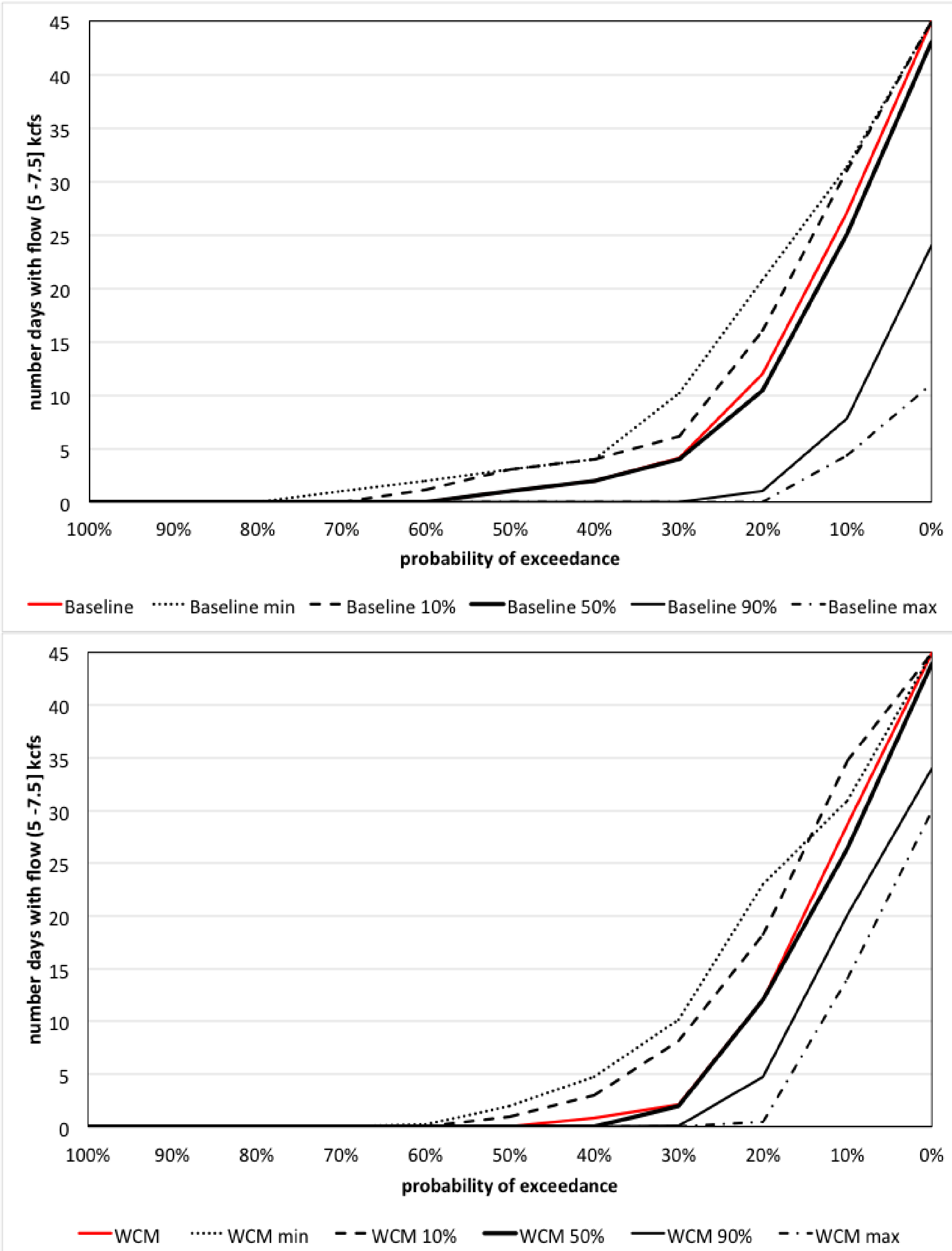


Figure 18.12: Response of metric M4 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

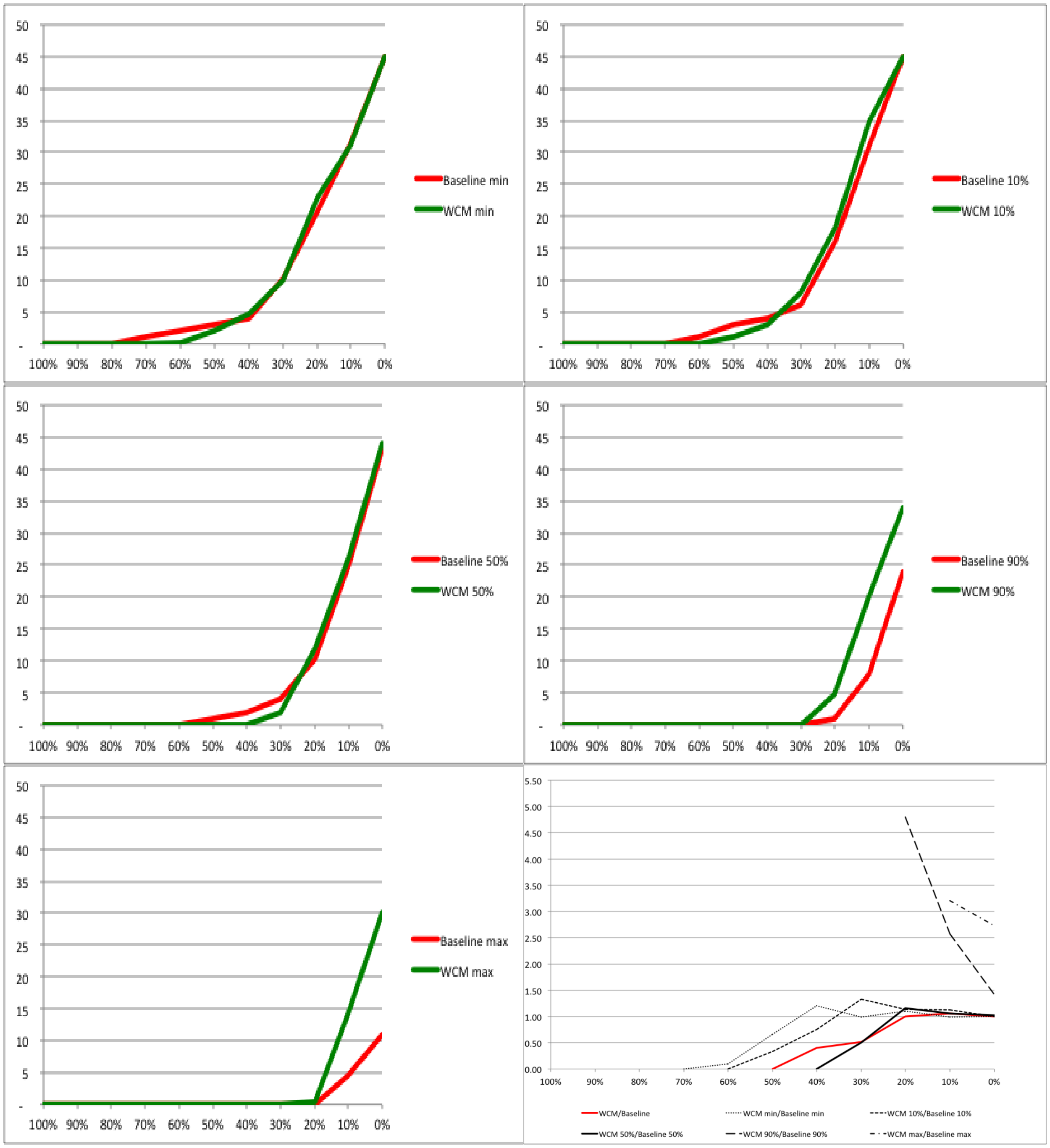
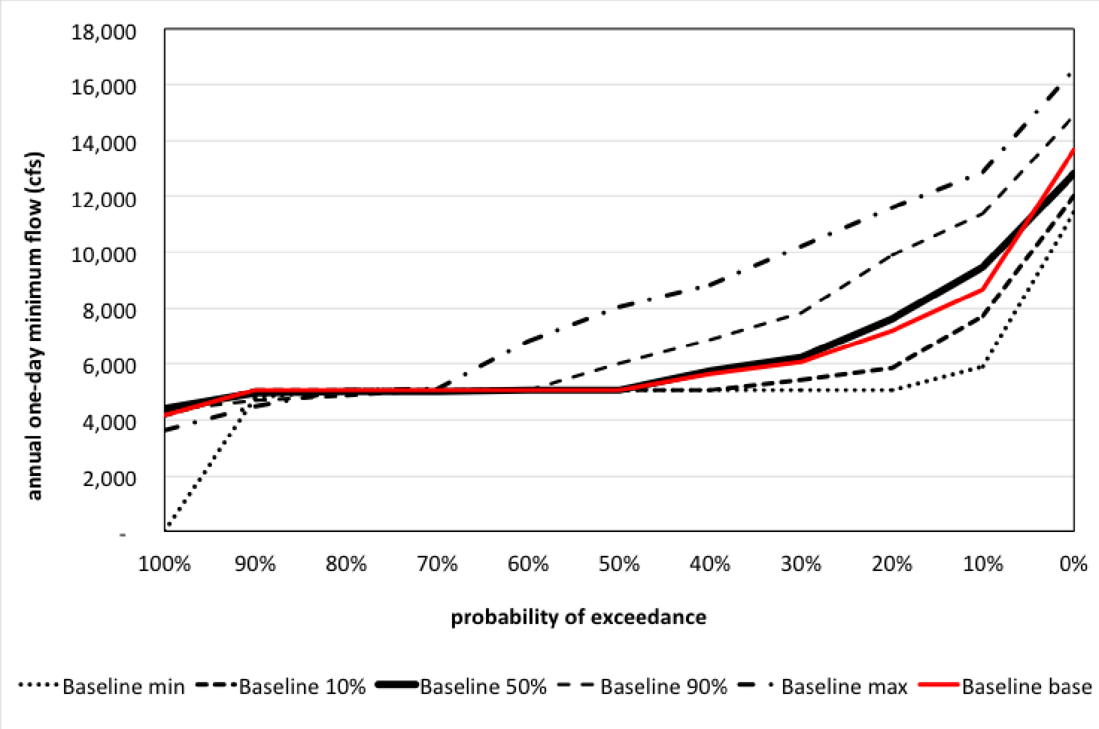


Figure 18.13 Comparison of M4 metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope. Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line). Note that due to the small number of days and large number of 0 values in some parts of the curves, panel f) is to be interpreted with caution; for the 90% and maximum levels of the climate envelope, exceedances for levels above 10% involve division by 0, hence no values are shown.



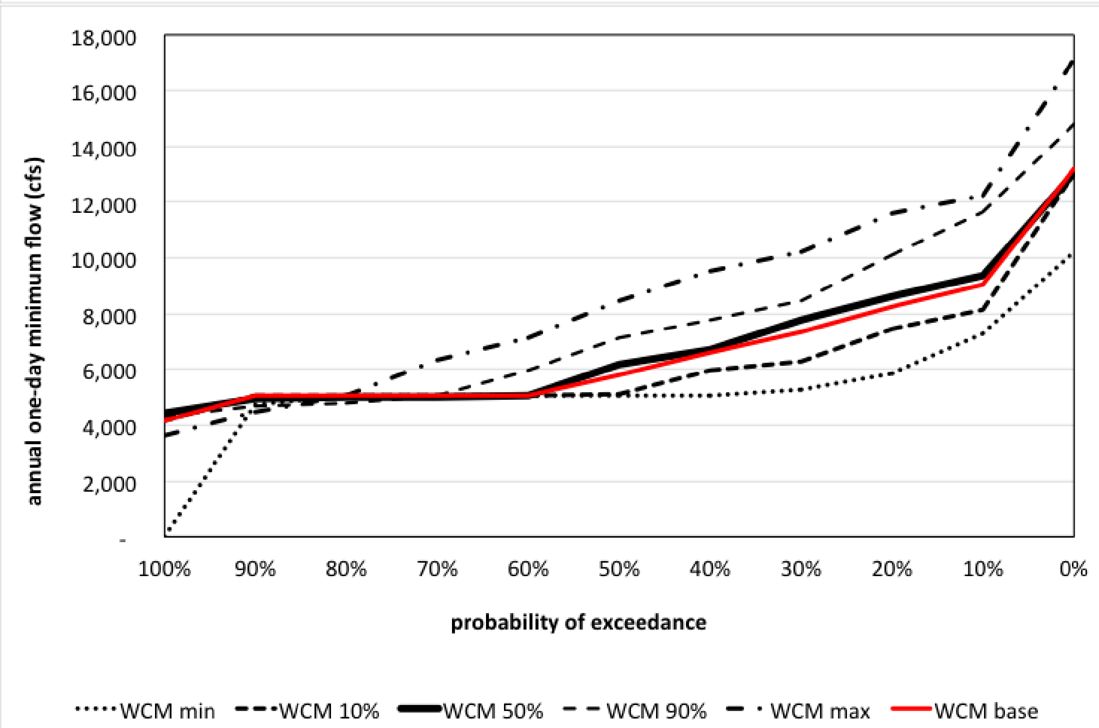


Figure 18.14 Response of metric M7 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

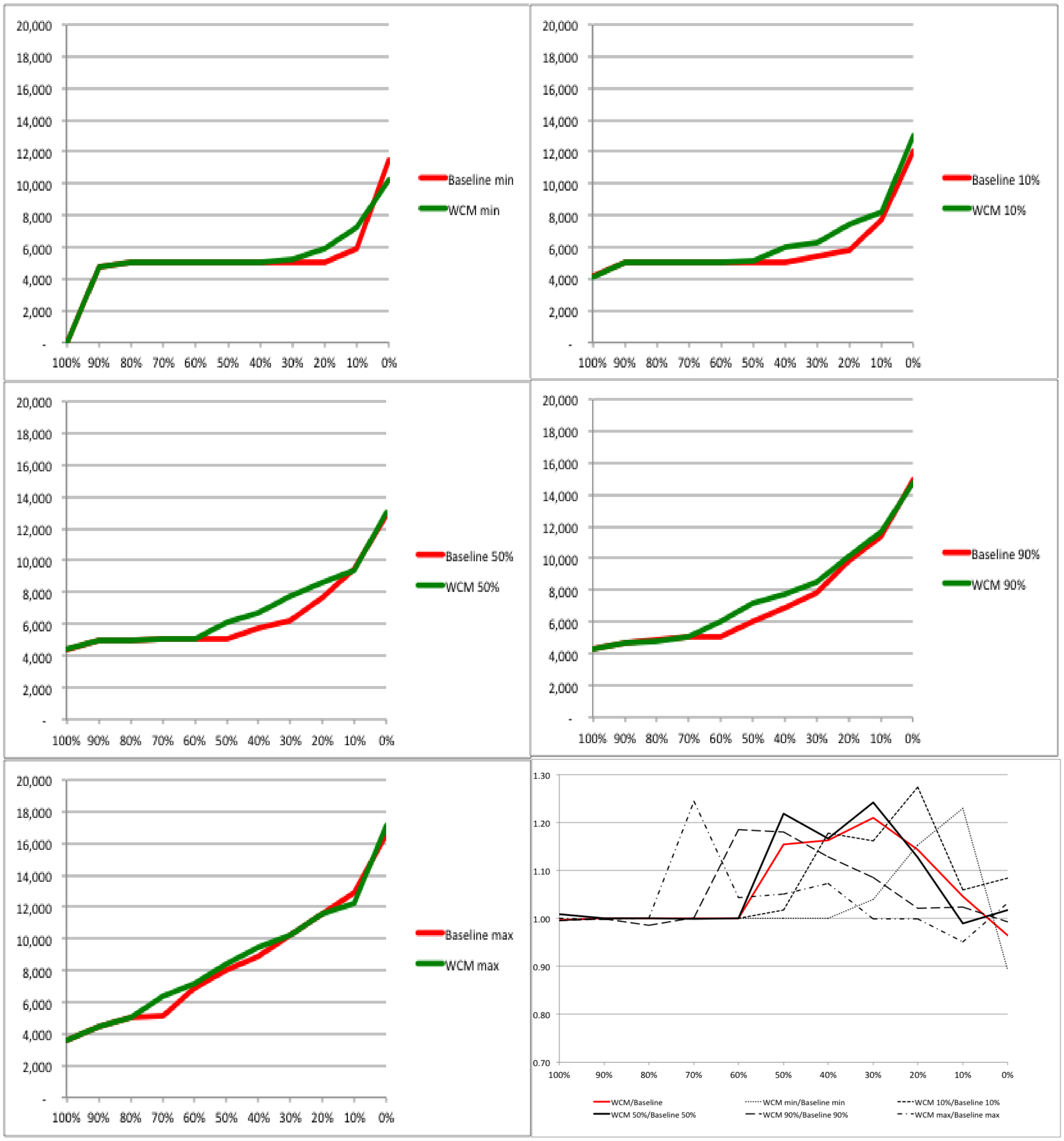


Figure 18.15 Comparison of M7 metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope. Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line).

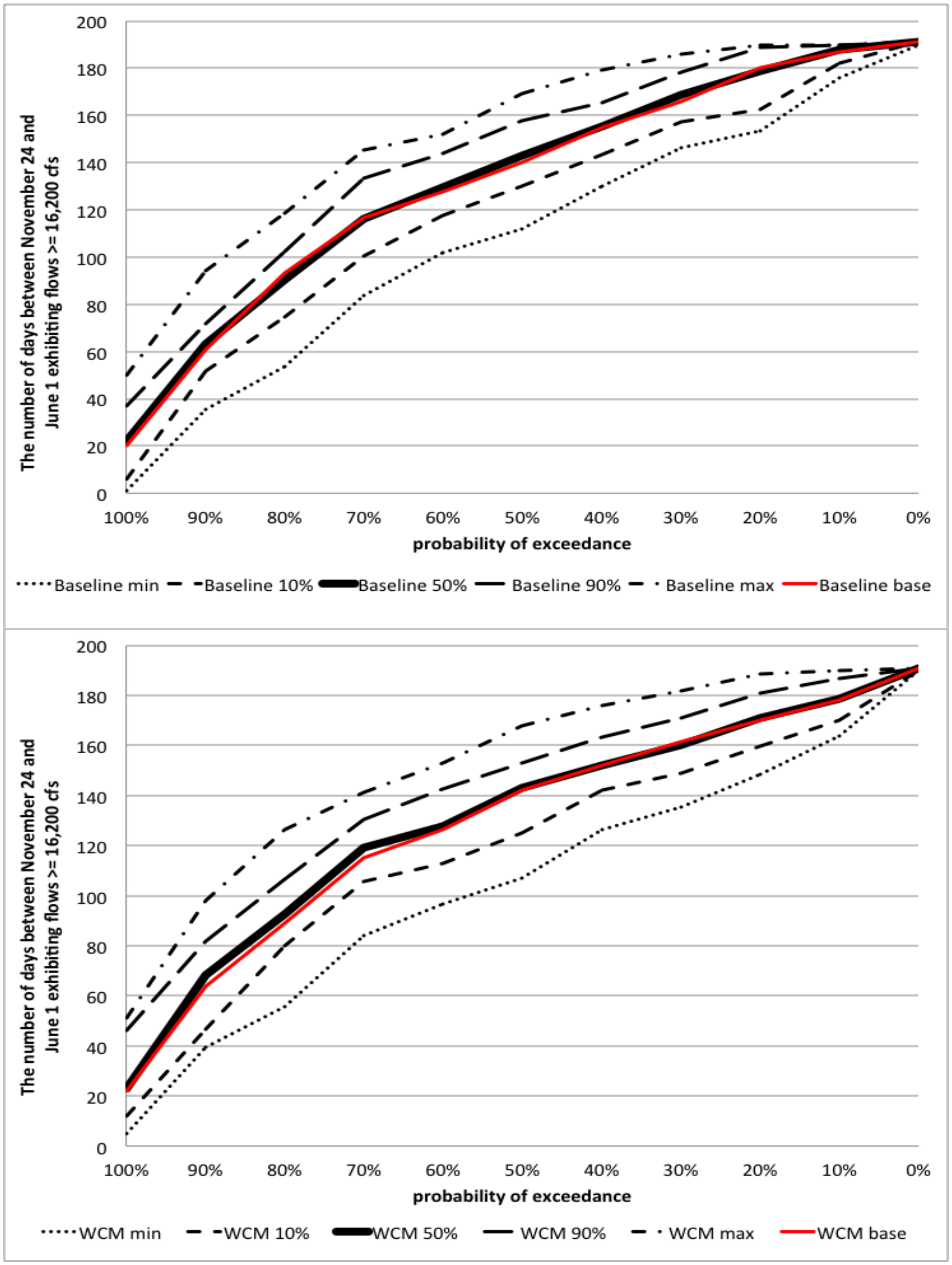


Figure 18.16 Response of metric S1 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

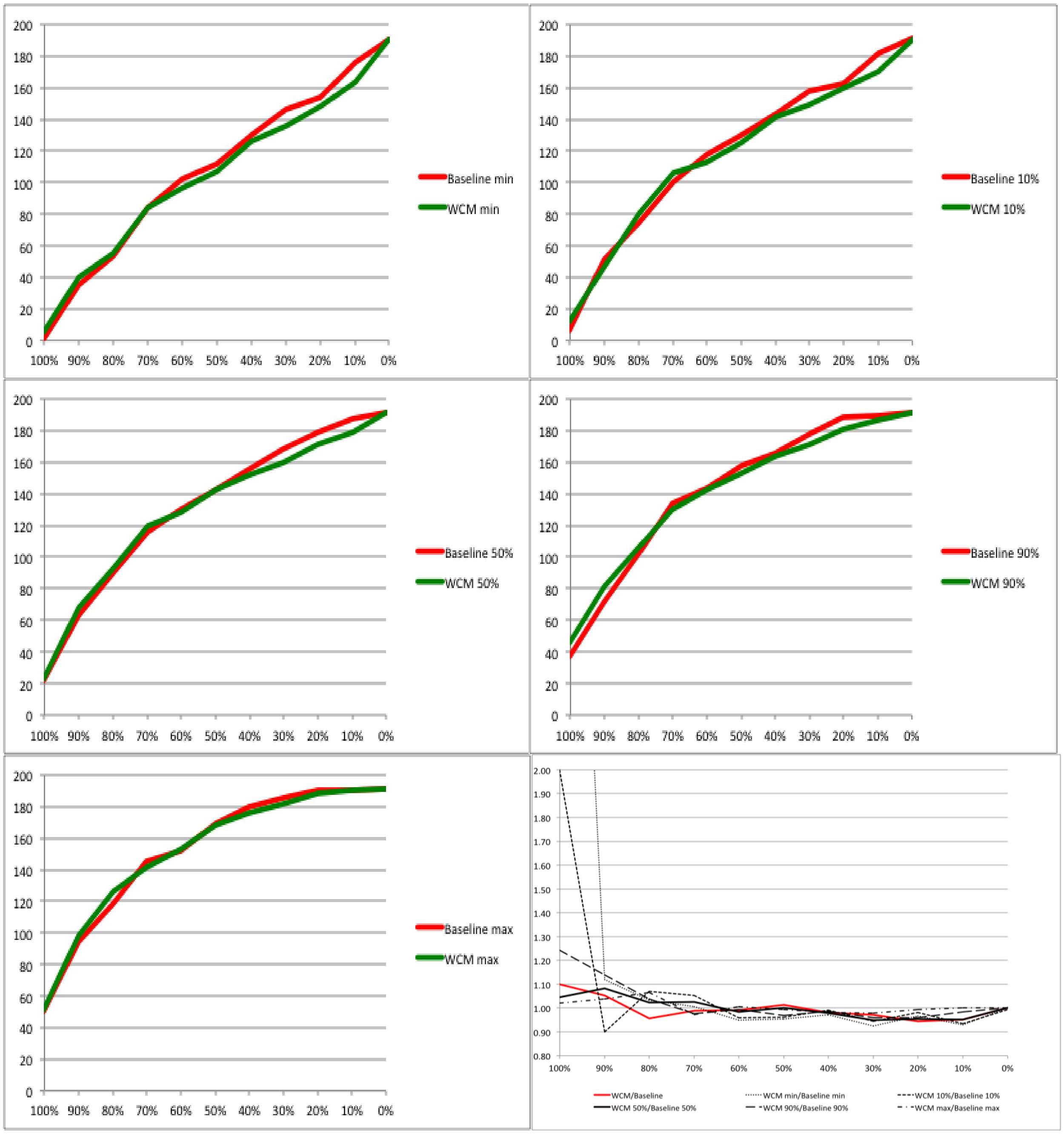
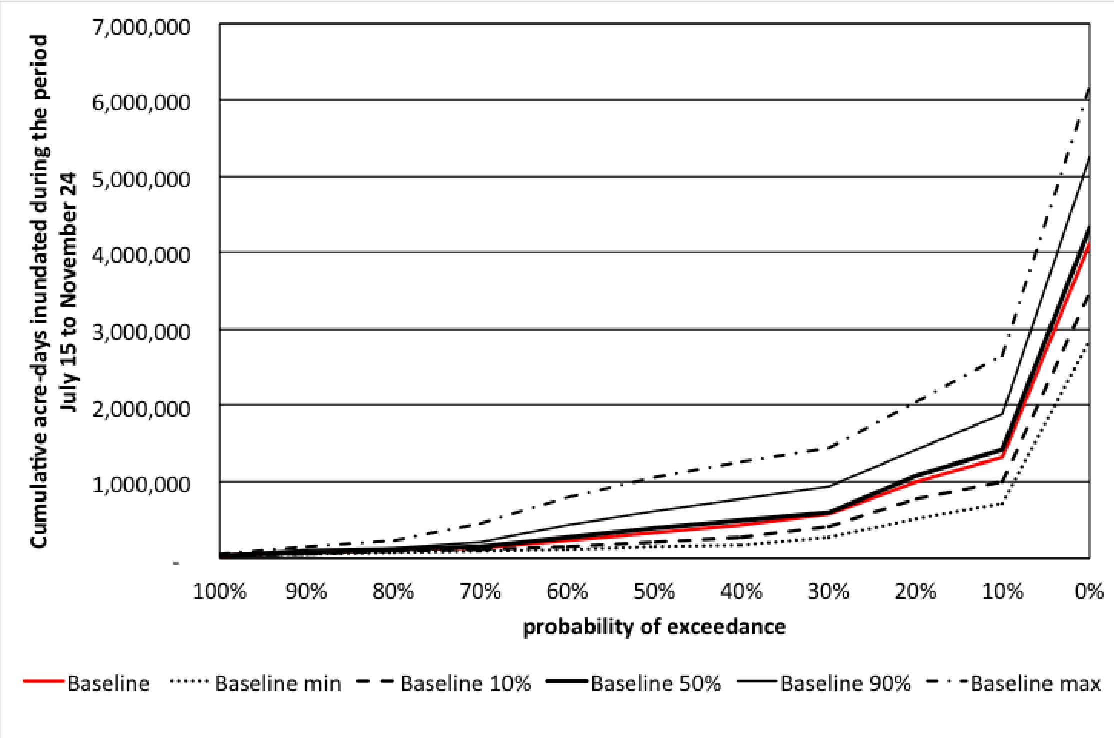


Figure 18.17 Comparison of S1 metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope. Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line).



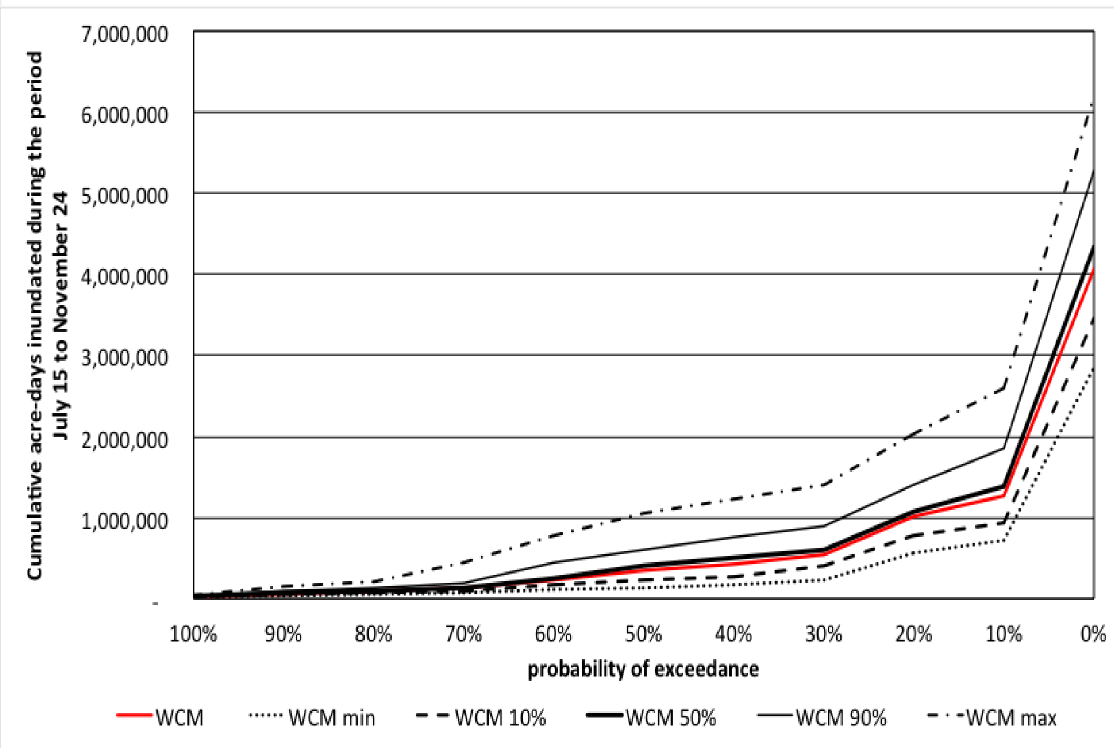


Figure 18.18 Response of metric S4 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

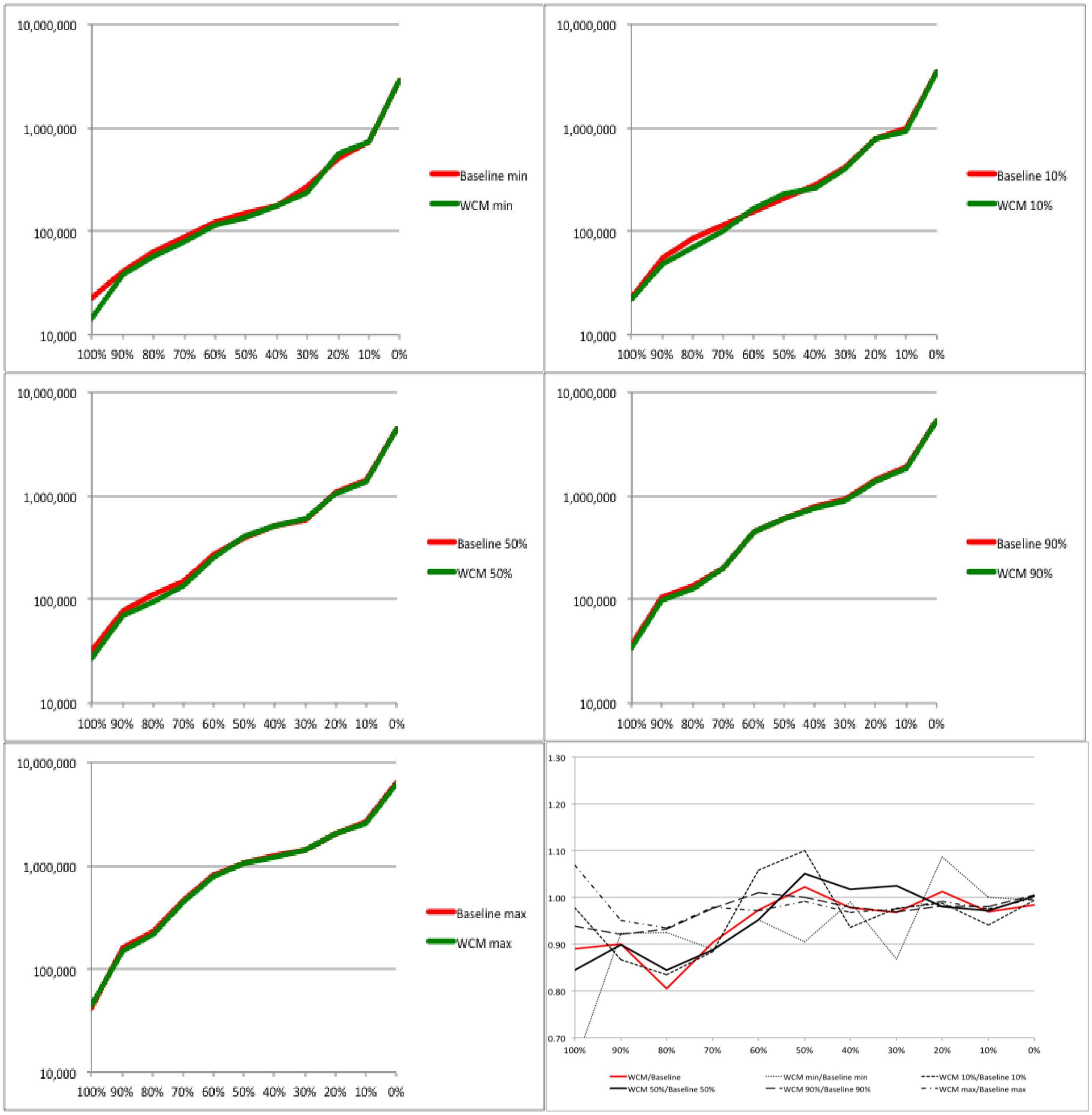


Figure 18.19 Comparison of S4 metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope (note logarithmic scale). Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line).

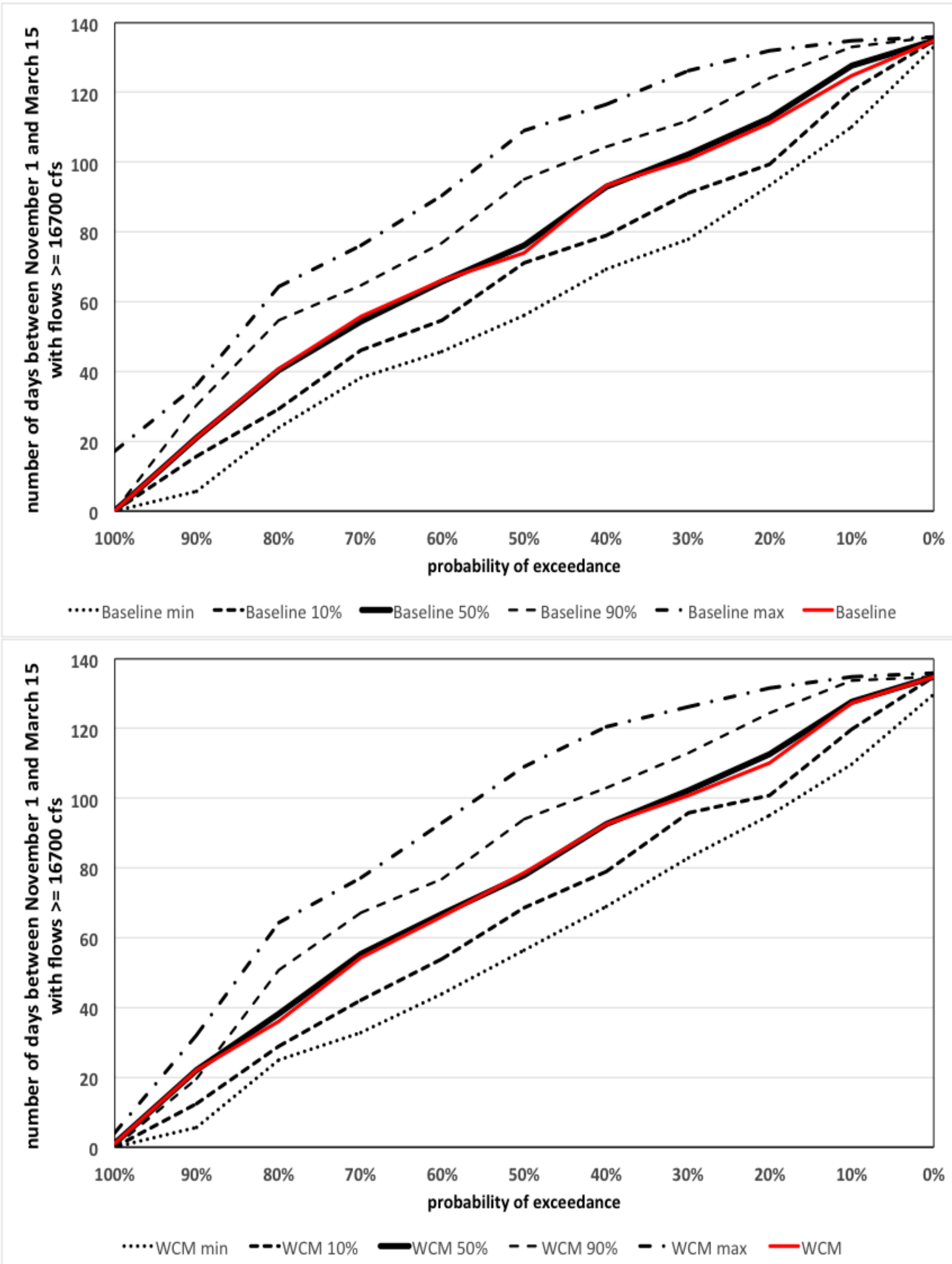


Figure 18.20 Response of metric S6a to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

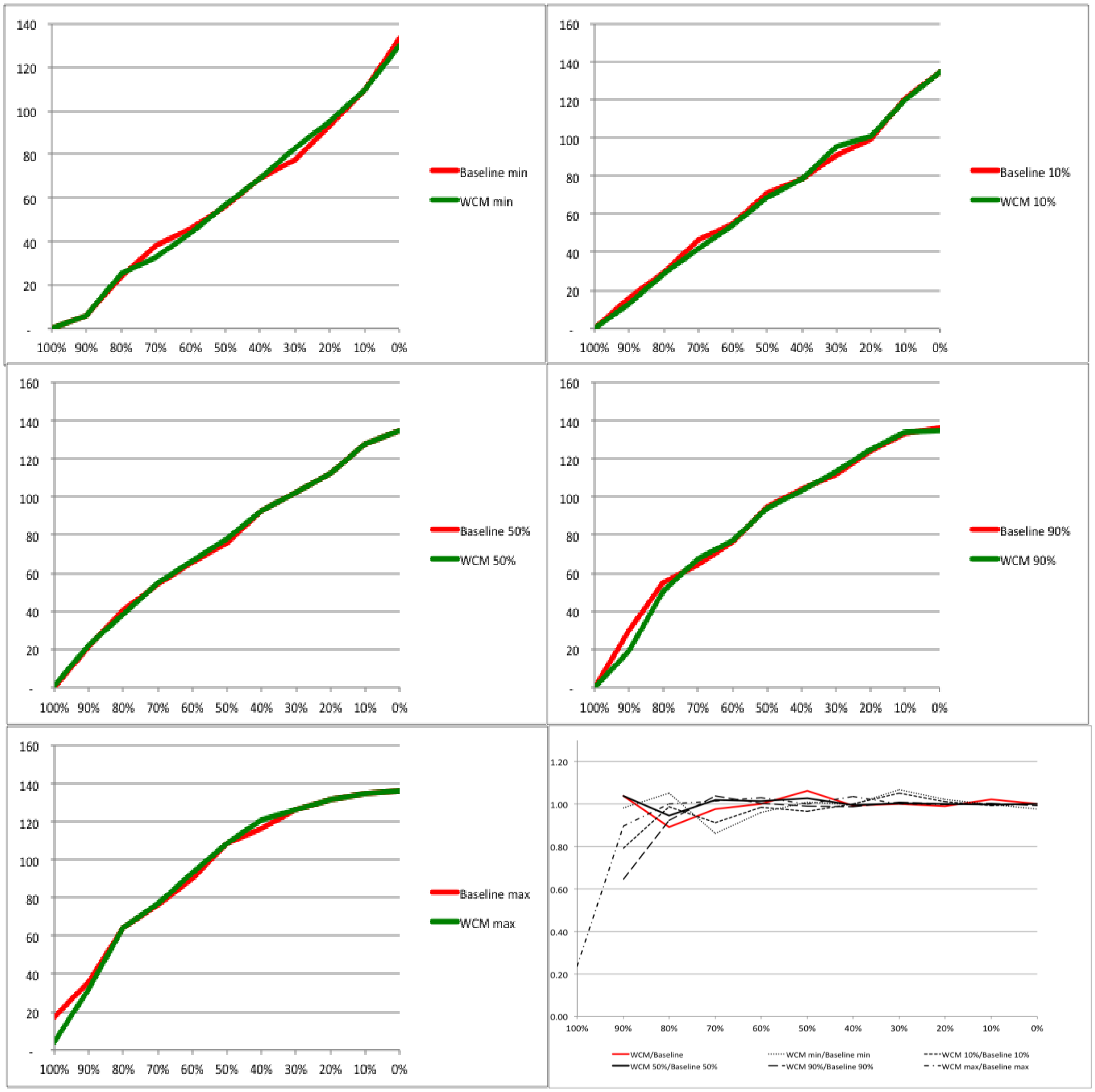


Figure 18.21 Comparison of S6a metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope. Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line).

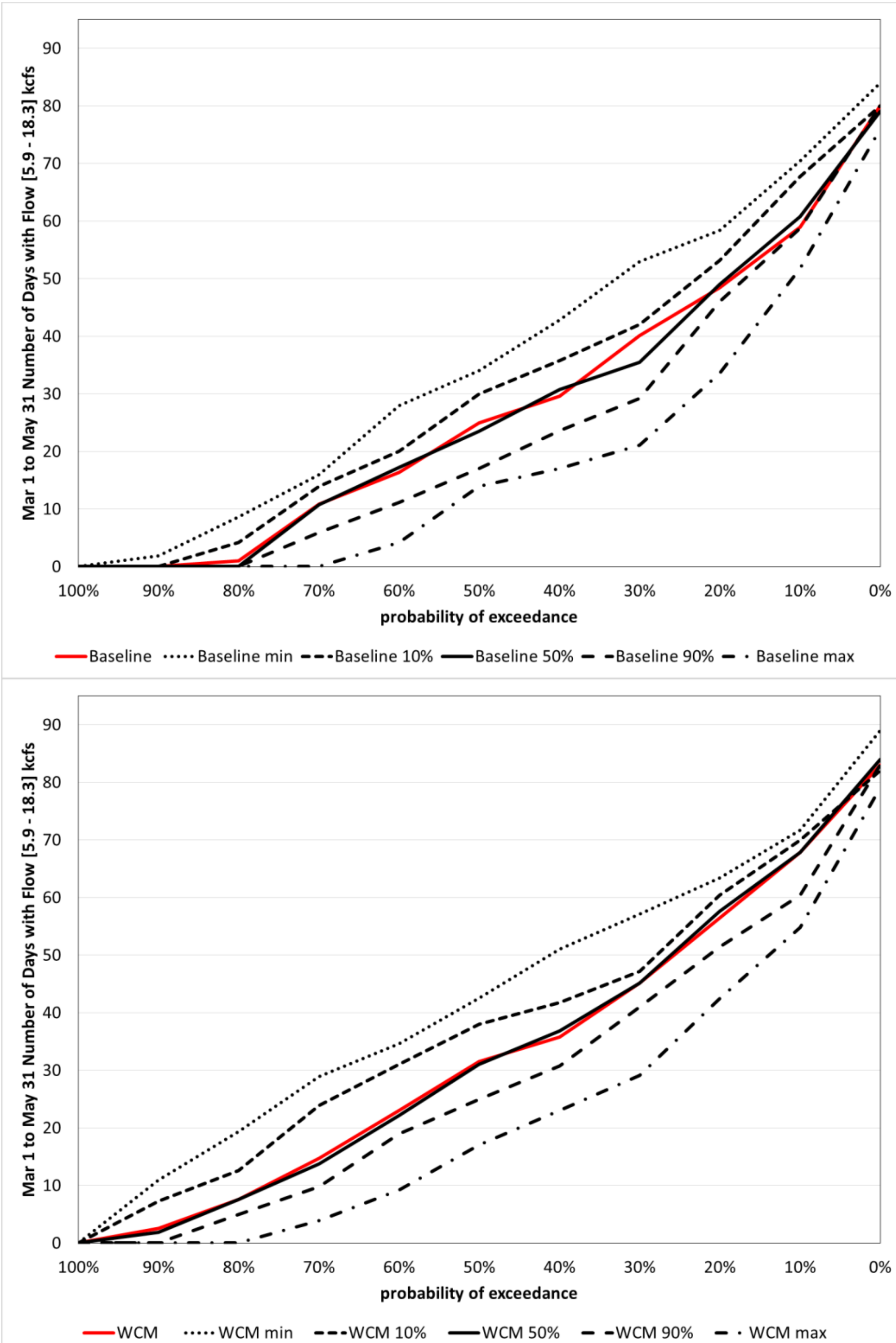


Figure 18.22 Response of metric SQ1 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

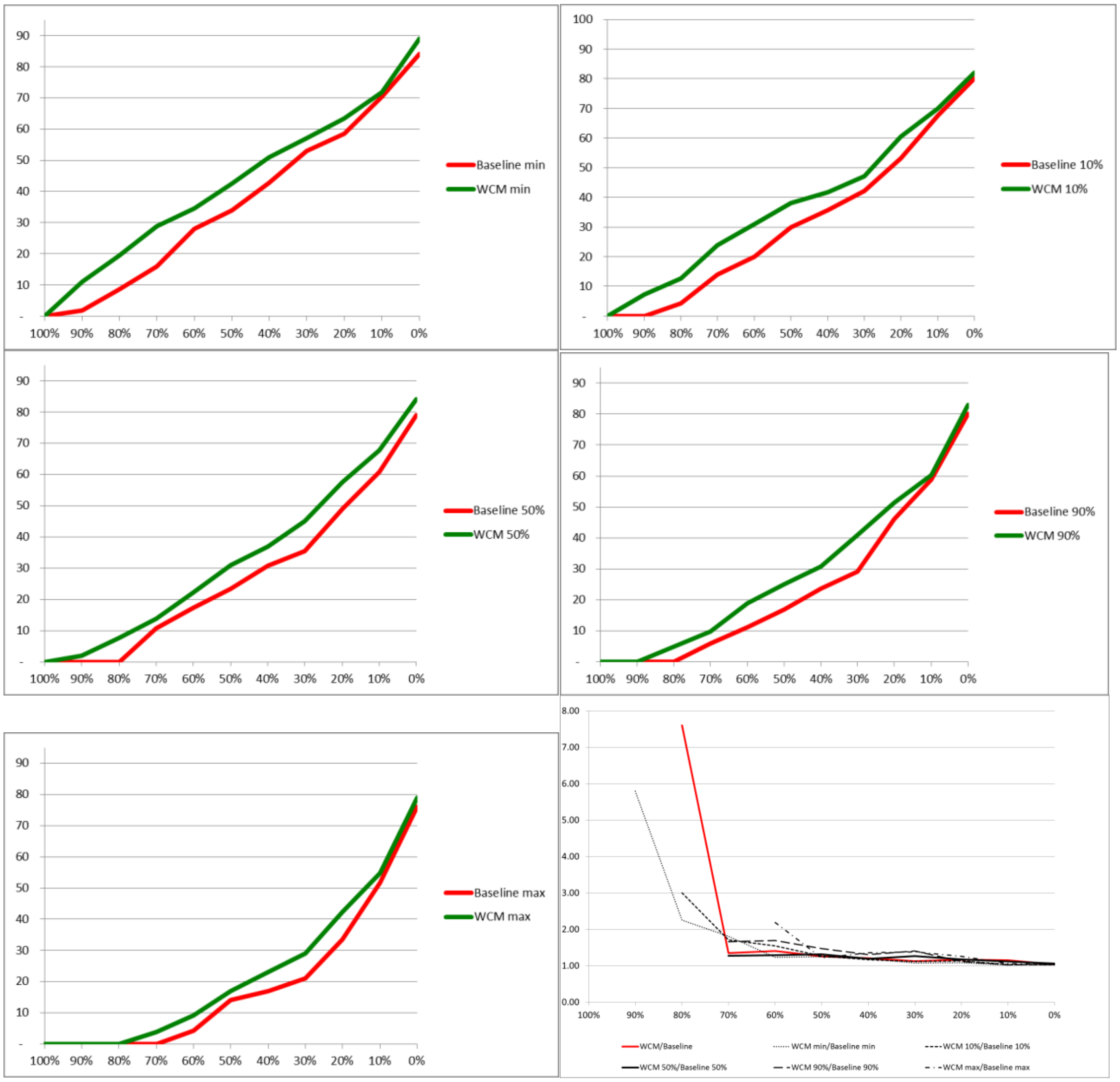


Figure 18.23 Comparison of SQ1 metric performance of baseline and WCM for the a) minimum, b) 10%, c) median, d) 90%, and e) maximum levels of the climate change envelope. Panel f) is the ratio (WCM/baseline) of the metric values at a given exceedance level for the minimum, 10%, median, 90% and maximum levels of the climate envelope (black lines) along with the ratio (WCM/baseline) with no climate change (red line).

Table 18.1: Median (across all available models) correlation of annual cycles for reaches 1-9 delineated in Figure 18.1

a) Median runoff vs. median UIF

region	1	2	3	4	5	6	7	8	9
value	0.92	0.98	0.96	0.96	0.98	0.99	0.98	0.93	0.56

b) Standard deviation of runoff vs. standard deviation of UIF

region	1	2	3	4	5	6	7	8	9
value	0.88	0.91	0.88	0.92	0.78	0.62	0.83	0.81	0.12

Table 18.2: R^2 values for regression fit between monthly unimpaired flow and runoff for reaches 1-9 delineated in Figure 18.1

a) R^2 values for a regression fit UIF = A*runoff+B

region	1	2	3	4	5	6	7	8	9
Jan	0.98	0.99	0.98	0.99	0.96	0.98	0.95	0.88	0.96
Apr	0.97	0.97	0.97	0.98	0.99	0.98	0.97	0.99	0.85
Jul	0.99	0.97	0.98	0.96	0.98	0.93	0.96	0.98	0.96
Oct	0.98	0.95	0.89	0.96	0.97	0.91	0.89	0.93	0.95

b) R^2 values for a regression fit UIF = C*runoff

region	1	2	3	4	5	6	7	8	9
Jan	0.91	0.90	0.89	0.97	0.91	0.98	0.91	0.88	0.94
Apr	0.96	0.95	0.94	0.97	0.88	0.96	0.96	0.99	0.84
Jul	0.98	0.87	0.91	0.73	0.91	0.93	0.96	0.93	0.96
Oct	0.98	0.86	0.78	0.92	0.88	0.91	0.85	0.88	0.95

The figures showing the sensitivity to climate changes for the remaining mussel and sturgeon metrics are show in the following figures.

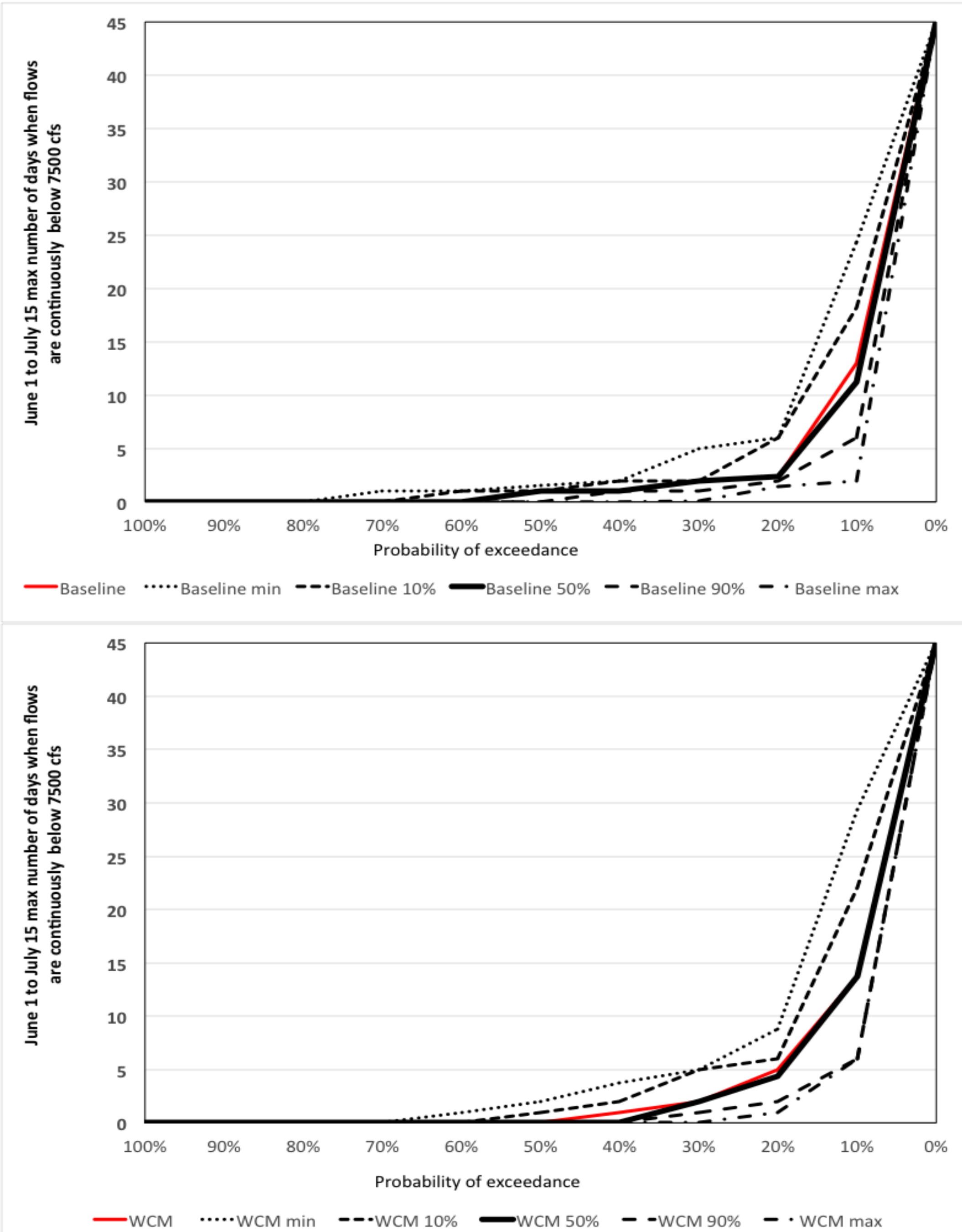


Figure 18.M9. Response of metric M9 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

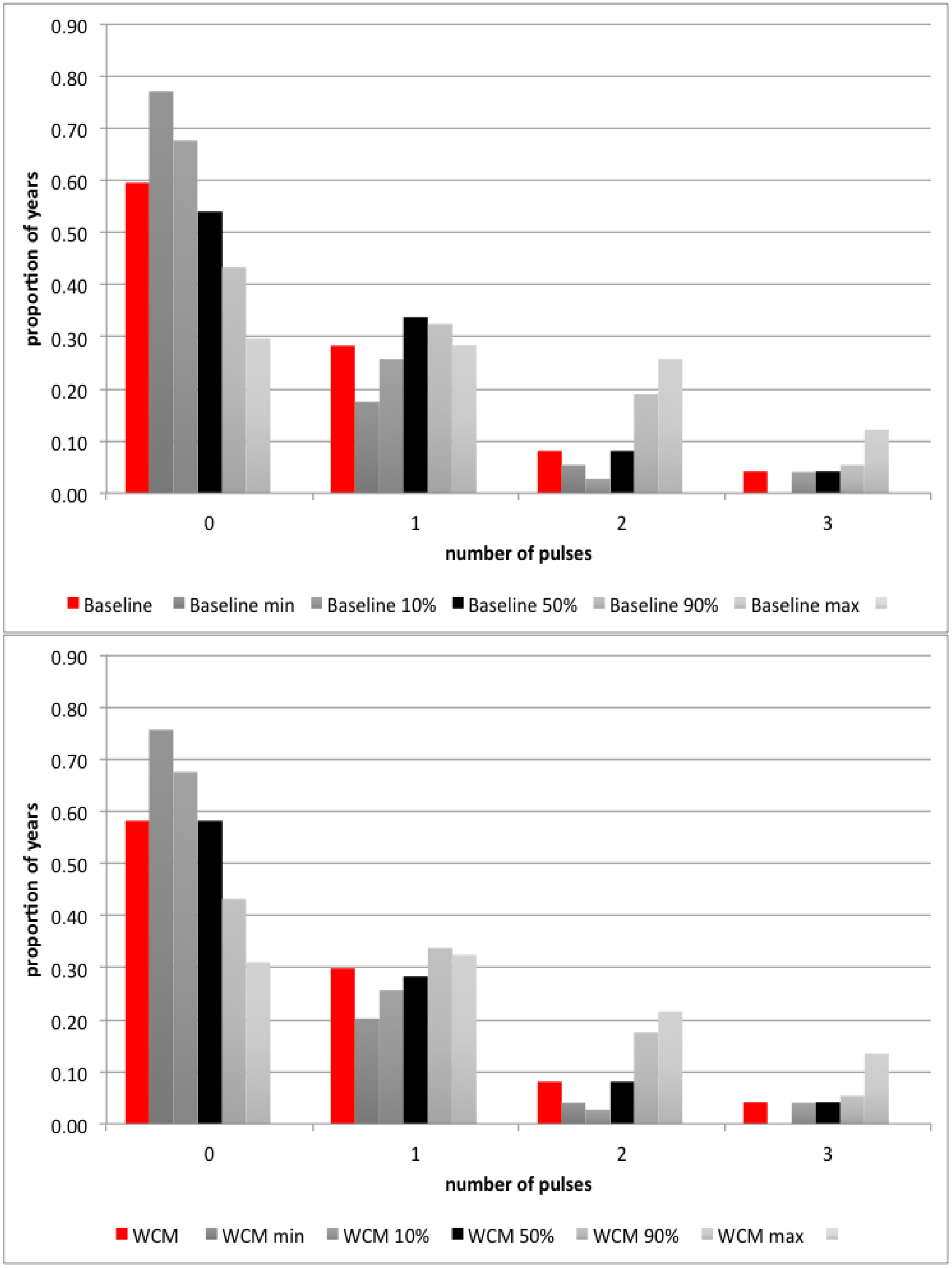


Figure 18.M6. Response of metric M6B to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red bar).

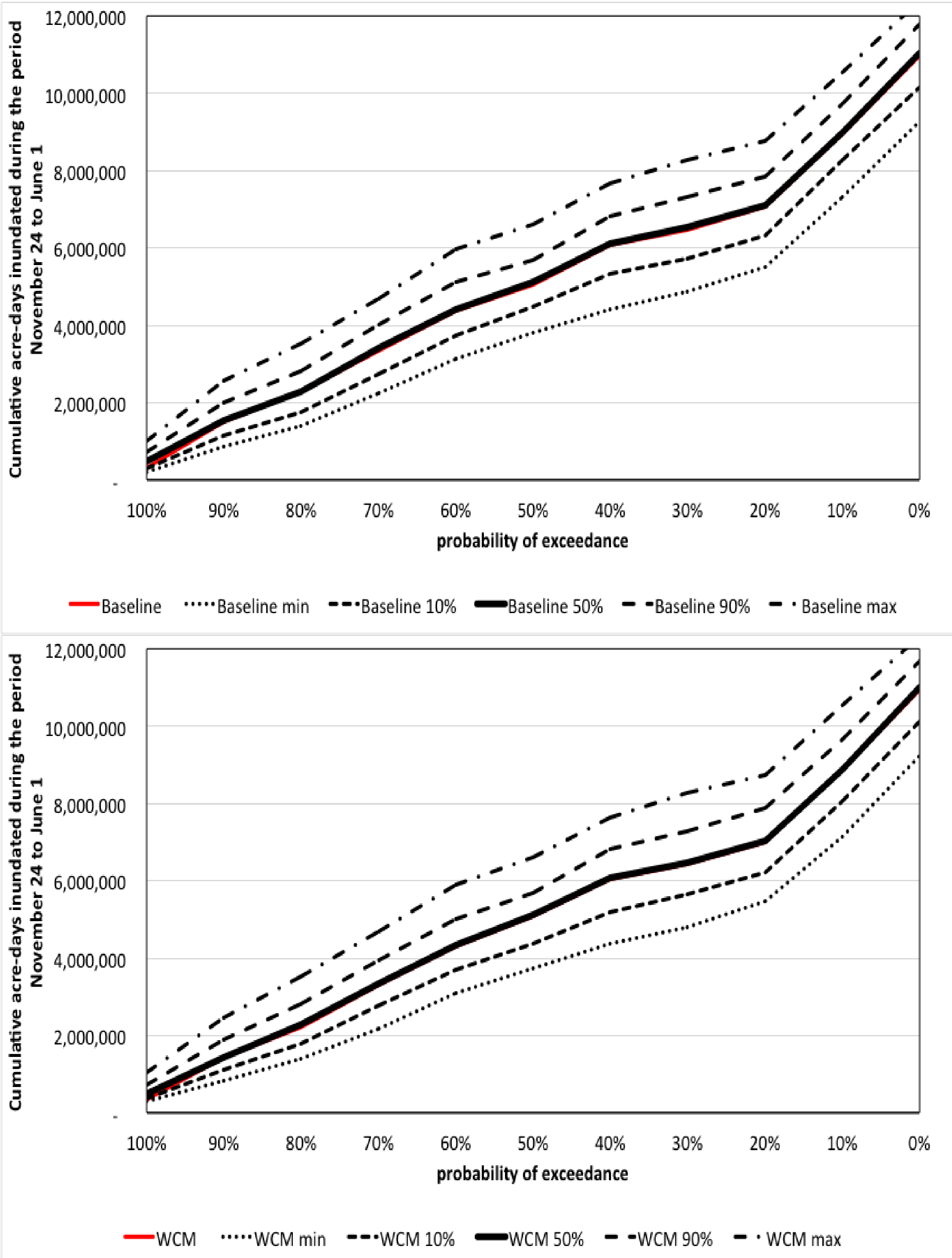


Figure 18.S2. Response of metric S2 to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

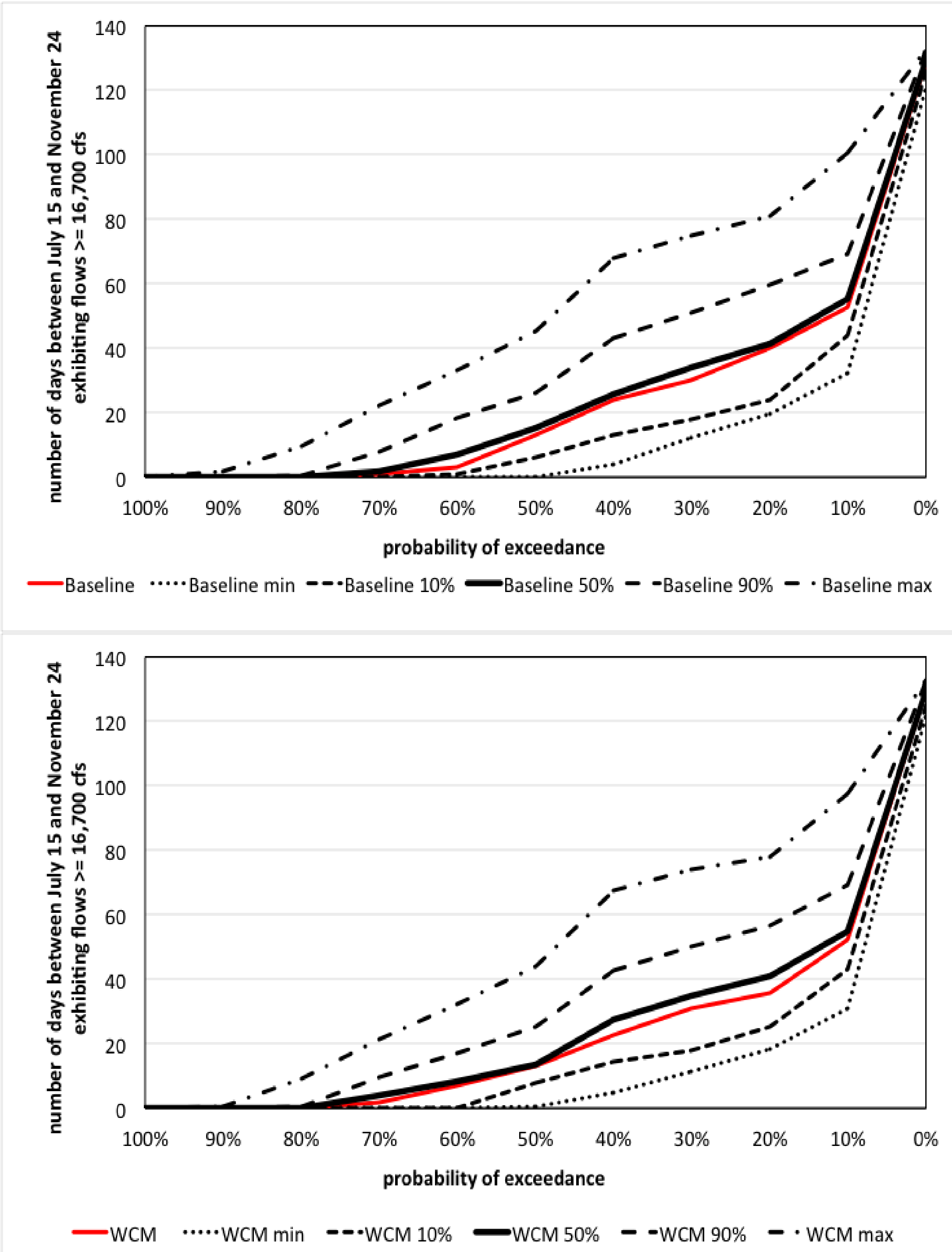


Figure 18.S3. Response of metric S3a to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

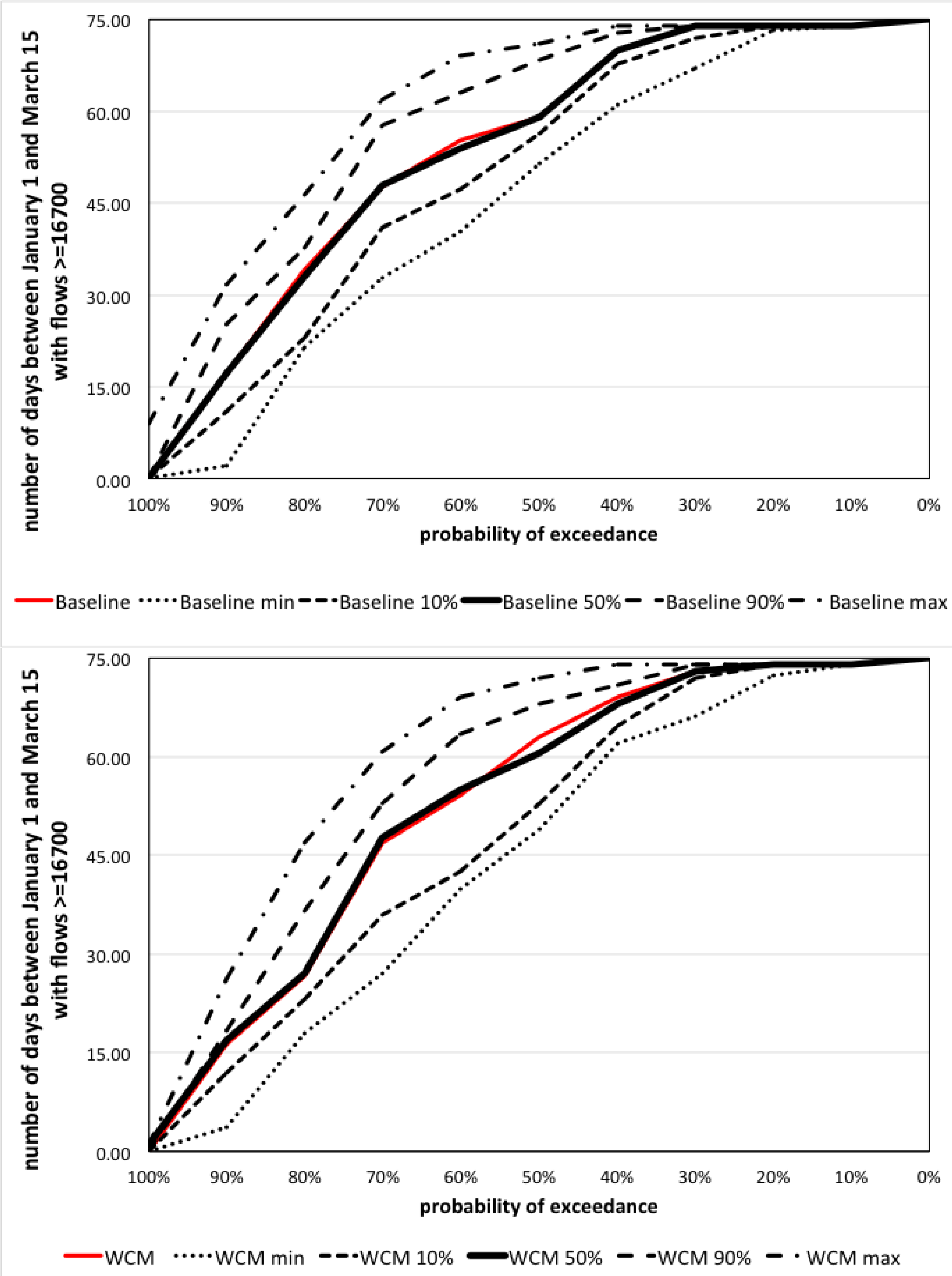


Figure 18.S7 Response of metric S7a to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

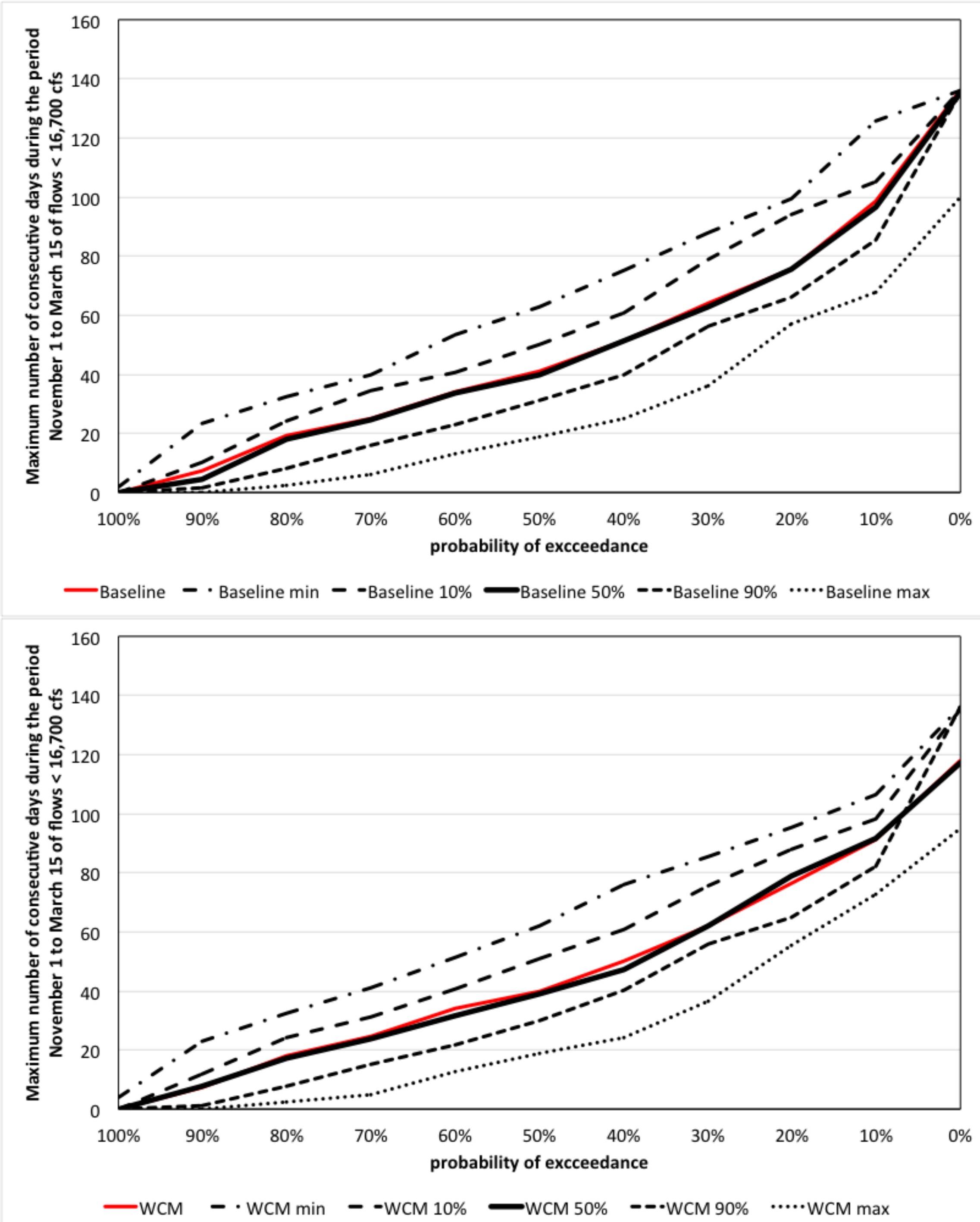


Figure 18.S8 Response of metric S8a to the minimum, 10%, median, 90%, and maximum of the climate change envelope for a) baseline, and b) WCM. The metric values for 1939-2012 (no climate change) are provided for comparison (red line).

19 APPENDIX C. USFWS IDENTIFIED ECOLOGICAL GAPS FOR ADAPTIVE MANAGEMENT

For consideration with Term and Condition 9.4.1, Adaptive management, the following uncertainties about ACF basin system dynamics should be evaluated by the adaptive management working group for inclusion in the adaptive management framework:

Supporting mussels and sturgeon uncertainties related to action

1. What are the upstream and downstream passage requirements of Gulf Sturgeon, Alabama shad and Gulf striped bass (all identified or proposed mussel hosts) at USACE dams in the ACF Basin. These uncertainties surround entrainment, both upstream and downstream adult and juvenile passage, and consider spill, flow attraction, and temperature.
2. How does hydropeaking affect listed mussel and sturgeon habitat near Woodruff?
3. How does water temperature affect listed species and can operations influence temperature?
    1. What is thermal availability of habitat in the Apalachicola?
    2. What is thermal habitat in Flint & Apalachicola and changes in reservoirs?
    3. What is relationship between flow and air temperature across the ACF basin?
    4. What happens at RM 55-60 to cause changes in DO & temp? see Harvey et al. report from 2008 or 2009 and make it a great spot for mussels

Mussel spp. uncertainties related to action

1. Do juvenile mussels have cues for dropping off of fish hosts?
    a. Are there cues that cause them to drop in mass in certain locations? (Examine in purple bankclimber)
2. What is effect of 2-3 ft/15 min drop in water level on mussel survival, and other life history characteristics
    a. What are daily stranding rates on this fine a scale? (i.e., how long can you hold your breath?)
    b. How far down the river before these pulses are attenuated and what does this mean for floodplain inundation and stranding?
3. What is the role of inter-annual variation in structuring mussel populations?
    a. Do several wet years make floodplains good mussel habitat and do these big production years drive the viability of the population?
4. What is duration of refill under drought conditions that mussels can recolonize?
5. How do mussels respond to temperature variances in habitat? Can they behaviorally thermo-regulate? (can do caged studies)
6. What is the ratio of number of host fishes to viable juvenile mussels in the Apalachicola?
7. What makes habitat in the lower Chipola River more ideal for mussels than the Apalachicola?
8. What is the proportion of the mussel population that is gravid?

Gulf sturgeon uncertainties related to action

4. Effect of flow on salinity in the bay on juvenile sturgeon
    1. How does this change foraging habitat available for juvenile sturgeon?
5. What is relationship between flow in winter and juvenile sturgeon survival (year class strength)?
6. What is the effect of temperature on spawning, holding areas, and foraging for sturgeon?
7. Are there seasonal shifts in juvenile sturgeon diet across the year and what range does floodplain inundation play in structuring this available food?

Supporting biology of the overall system

1. Hydrological uncertainties
    a. What is the relationship of groundwater and precipitation in each sub-basin?
    b. What is the respective contribution of the reservoirs vs. rivers vs. groundwater?
2. Climate change uncertainties
    a. How does climate change structure and regulate growth of the floodplain system?
    b. How does uncertainty about precipitation and evapotranspiration in the basin influence management?

20 APPENDIX D. POTENTIAL ACTIONS FOR ADAPTIVE MANAGEMENT

In the process of the WCM being prepared, the USFWS internally developed an alternative for consideration (USFWS 2013a). This alternative (labeled USFWS in the figures below) was developed based on a set of performance metrics which represented the best scientific understanding of what was needed to protect Gulf sturgeon, mussels and the associated floodplain of the Apalachicola River. Since development of this alternative the scientific understanding of what is needed to protect these species has advanced and a new set of metrics have been developed which are included in this BO to aid in identifying potential actions that could be addressed within the authority of the WCM through adaptive management under RPM 2016-1. The analyses in this appendix should be revisited once the STELLA model calibration is complete as described in Appendix A.

Identical metrics calculated for the mussel metrics were calculated to show five flow regimes (Baseline [NAA], WCM [PAA], USFWS, UIF, and where applicable pre-dam conditions). We present modified versions of the figures presented in sections 5 and 10 with comparison of the USFWS alternative to the other flow regimes.

The intention of including the USFWS alternative in the following figures is to illustrate that it is possible to better protect these species if management is designed to accomplish this task. In the future, an alternative approach to managing the basin can be designed based on the current set of environmental metrics. This USFWS alternative as well as UIF and pre-dam conditions can be used to inform and explore potential actions to be considered by the adaptive management technical team under RPM 2016-1. Based on the insights from the USFWS alternative, the adaptive management technical team should explore potential actions that relative to the baseline in this consultation:

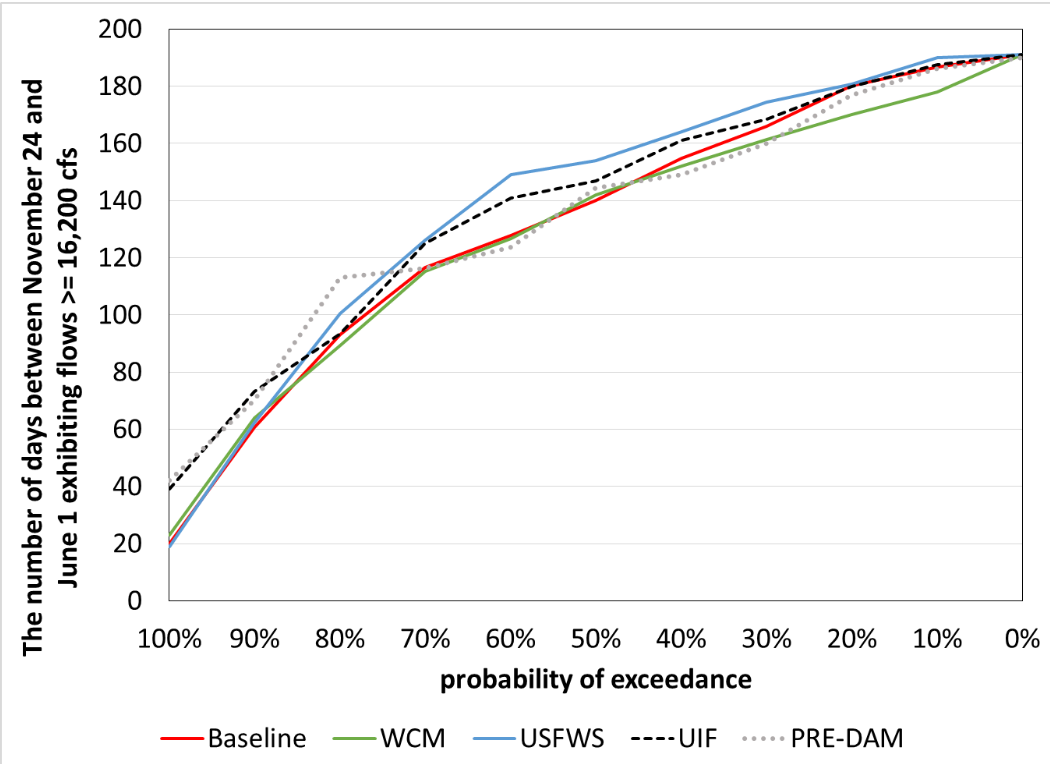
1) Provide more floodplain inundation
    a. ~10 days more in the winter (GS1)
    b. ~1% more (in terms of acres) (GS4), and ~10% more 15-day pulses (GS5, M6) in the summer and fall
    c. ~20 more days during the growing season (M1-M3)
2) Reduce the conditions appropriate for hydropeaking at Jim Woodruff
    a. ~3% fewer days during spring (GSQ1)
3) Maintain more stability near the low flow threshold (e.g., 5,000 cfs) when flows are below 10,000 cfs (M4-M8)

20.1 Sturgeon Analyses

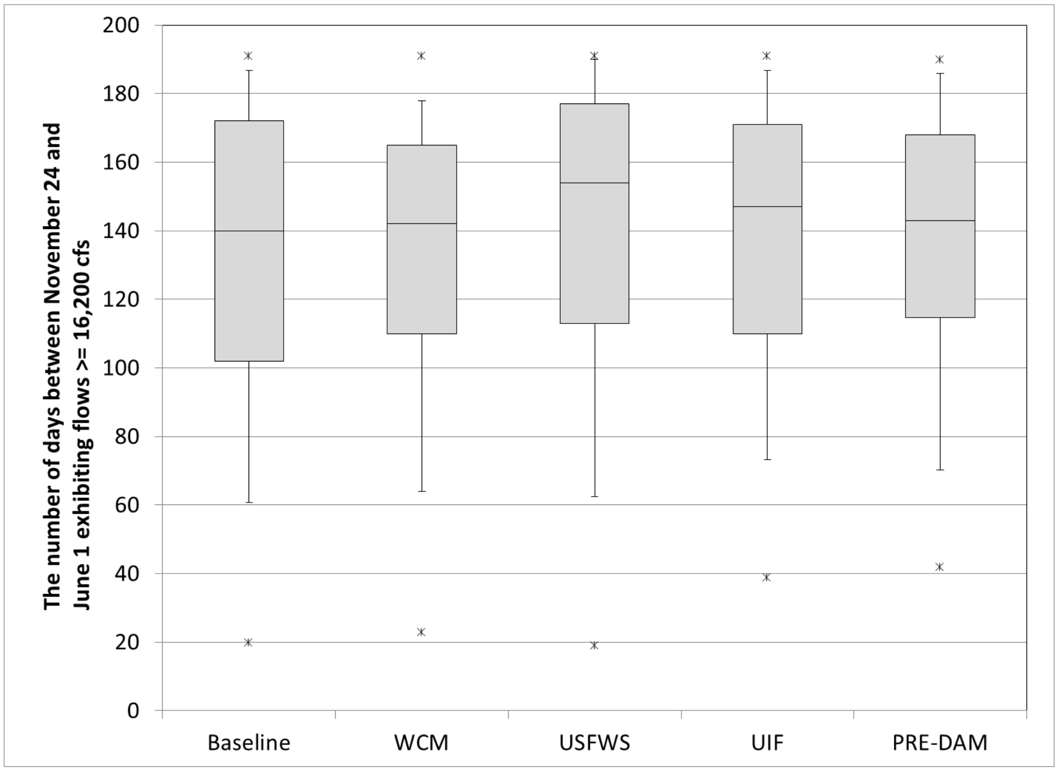
20.1.1 Flows for Estuarine Invertebrate Production

Gulf Sturgeon Hydroecological Metric 1 (GS 1) - General Floodplain Forest Inundation and Organic Matter Supply (Total Days)

The USFWS plan provides on average 6.7 days (505 days across the 74 years) more of floodplain inundation during November 24 to June 1 than the baseline. In the average year (i.e., 50% exceedance), the USFWS plan exhibited a benefit of 14 more days of floodplain inundation compared to the baseline and overall provided 4% more days of floodplain inundation than the baseline (10243 of 19832 days vs. 9738 days under the baseline). Additionally, the USFWS plan provided floodplain inundation similar to that expected under the Unimpaired Flow scenario (on average <1 days more) or pre-dam conditions (on average 3.5 days more).



A



B

Figure 20.1.1: Number of days with flows ≥16,200 cfs for the Apalachicola River at Chattahoochee between November 24 and June 1 as a probability of exceedance plot (A) and box plot (B)

Gulf Sturgeon Hydroecological Metric 4 (GS 4) - General Floodplain Forest Inundation and Nutrient Supply (Cumulative Acre-days)

The USFWS plan was not designed to provide inundation at this timing. The USFWS plan provides on average 747,059 acre-days (of 781 mil total) less of floodplain inundation during July 15 and November 24 than the baseline. As with the WCM, this difference comes primarily in years with lower inundation (i.e., 90-70% exceedance). Additionally, the USFWS plan provided less floodplain inundation to that expected under the Unimpaired Flow scenario (about 1.2% less) as did the baseline and WCM.

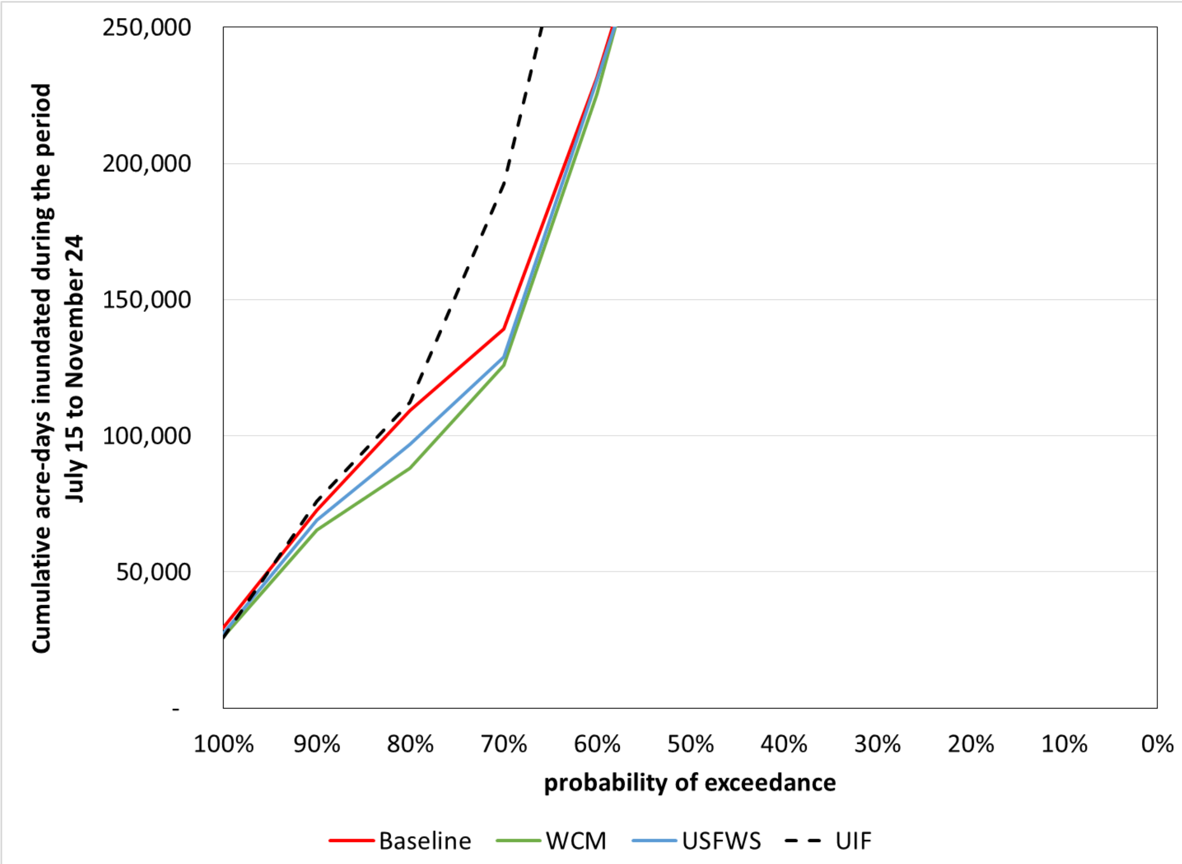
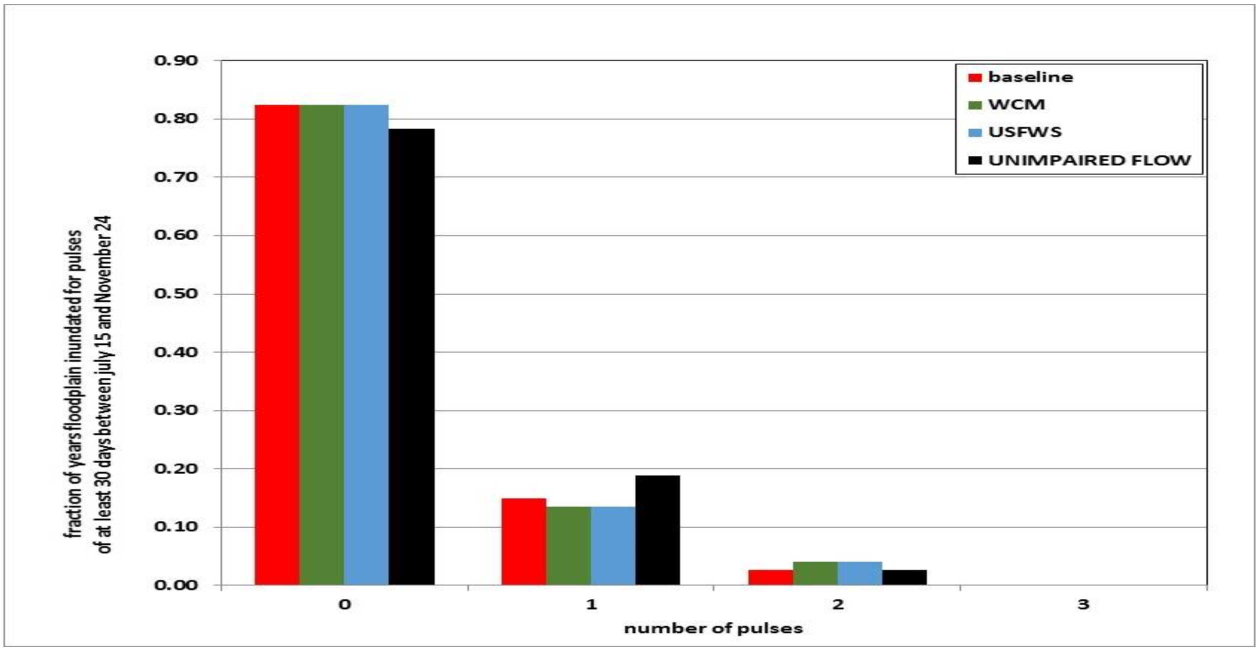


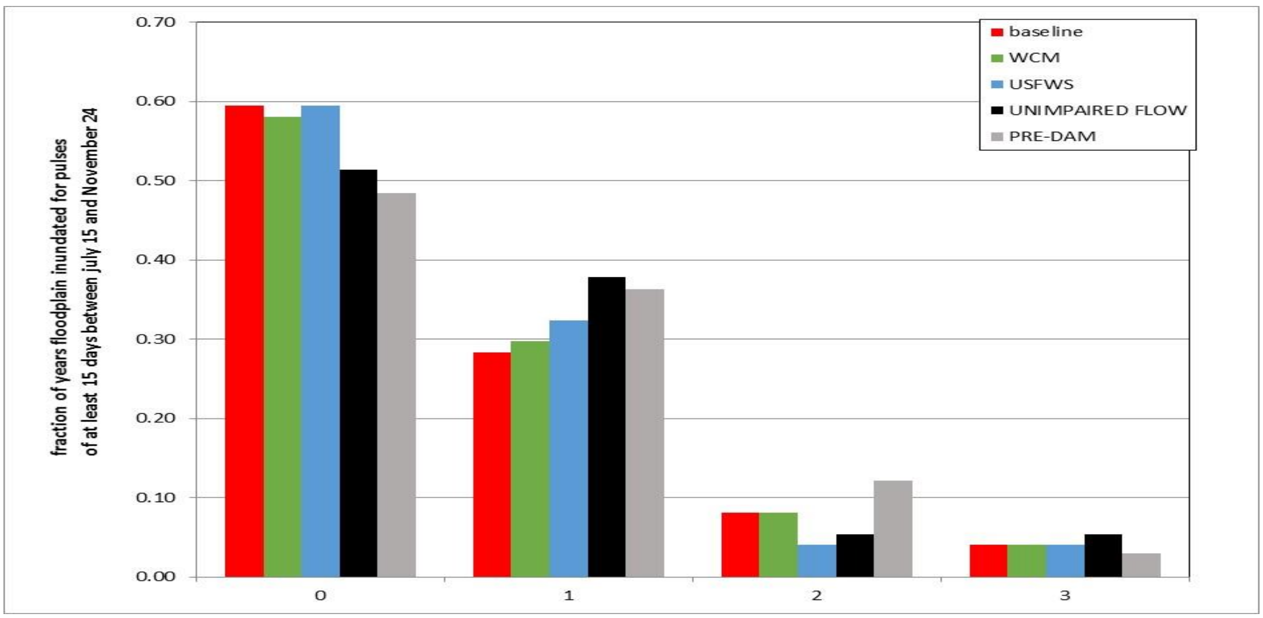
Figure 20.1.2: Total number of acre-days of floodplain inundation at ≥16,200 cfs between July 15 and November 24 for the Apalachicola River at Chattahoochee

Gulf Sturgeon Hydroecological Metric 5 (GS 5) - Pulsed Floodplain Forest Inundation and Nutrient Supply (Number of pulses)

The USFWS management plan provides an identical number of years as the WCM with one and two 30-day floodplain pulses between July 15 and November 24 across the 74-year record (13 years or 18% of the time) and one fewer years with a single 30-day pulse and one more year with two 30-day pulses than the baseline. These 30-day pulses are equivalent to the pre-dam record, but represent a decrease from the UIF scenario (16 years or 22%). Looking at the shorter 15-day pulses provides a different picture when comparing to the baseline and WCM or the pre-dam record or UIF scenarios. The USFWS management plan provides one fewer years than the WCM with one, two, or three 15-day floodplain pulses between July 15 and November 24 across the 74-year record and an equivalent number of years with 15-day pulses as the baseline (30 years or 41% of the time). It provides the pulses as three additional years with single 15-day pulses. These 15-day pulses represent an 11% drop (8 years) from the pre-dam record and a 8% drop (6 years) from the UIF scenario. Thus, we see fewer 15-day pulses than we did historically or if flows through the basin were unimpaired.



A



B

Figure 20.1.3: Fraction of years the Apalachicola River's floodplain was inundated by pulses of at least 30 days (A) and 15 days (B) between July 15 and November 24.

20.1.2 Effects on Spawning Habitat Availability and Quality

Gulf Sturgeon Egg and Fry Exposure and Survival during Hydropeaking (GS Q1)

The USFWS plan provides on average 2.3 days (225 days across the 74 years) less opportunity to hydropeak during the March 1-May 31 sturgeon spawning season than the baseline. In the average year (i.e., 50% exceedance), the USFWS plan exhibited a benefit of 15 fewer days of hydropeaking compared to the baseline and overall provided 3% less opportunity to hydropeak than the baseline (1757 of 6808 days vs. 1982 days under the baseline). In addition, the USFWS plan provided floodplain inundation similar to that expected under the Unimpaired Flow scenario (on average <1 days less) or pre-dam conditions (on average 1.6 days less).

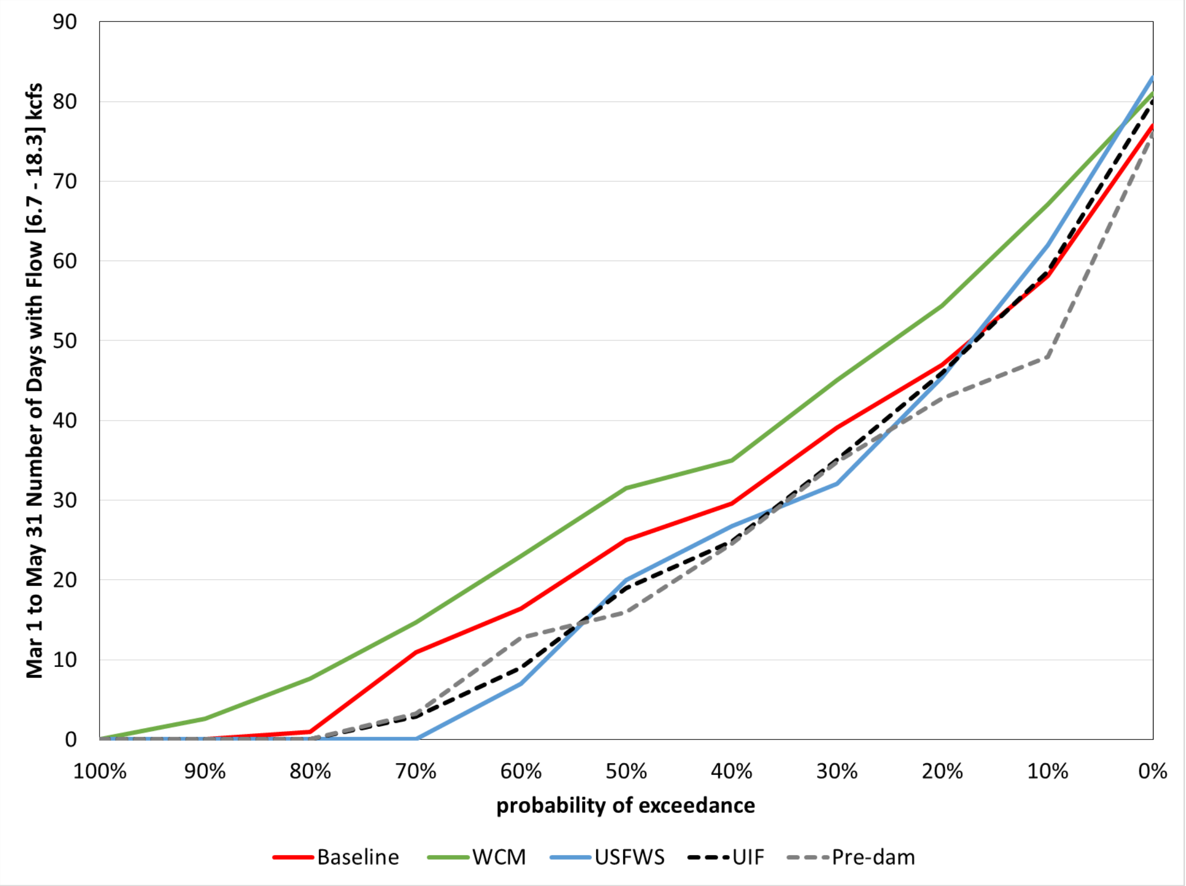


Figure 20.1.4: Number of days with flows between 6,700 and 18,300 cfs for the Apalachicola River at Chattahoochee between March 1 and May 31

20.2 Mussel Analyses

20.2.1 Flows for Mussel Host Fish Production

Freshwater Mussel Hydroecological Metric 1 - Access to Floodplain for Spawning and Rearing of Host Fish

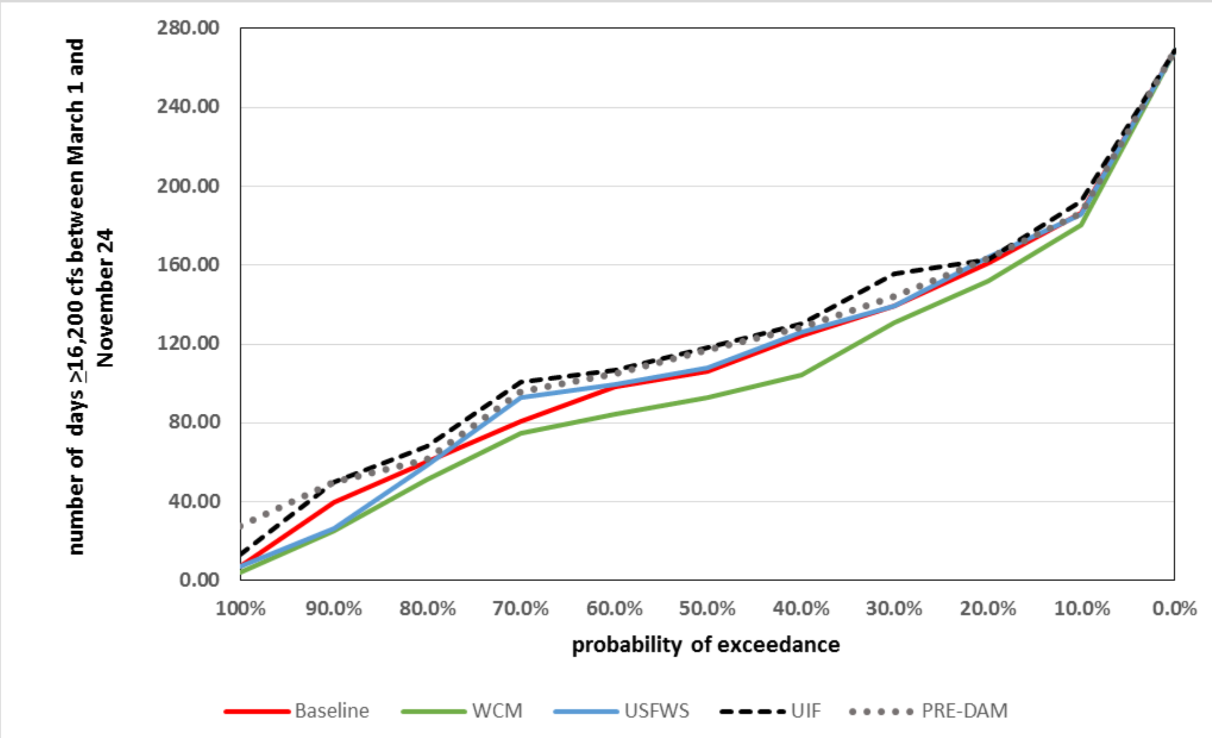


Figure 20.2.1: number of days' flow for the Apalachicola River at Chattahoochee ≥ 16,200 cfs between March 1 and Nov 24

The USFWS management plan provided for greater number of days of floodplain inundation across most years of examination compared to the WCM (140 day increase total, 12 day average increase per exceedance probability decile) and baseline (21 day increase total, 2 day average increase per exceedance probability decile), with the exception of those years exhibiting the lowest number of days of inundation (i.e., the driest years; probability of exceedance range 80-100%). During years of low floodplain inundation, the USFWS management plan results were similar to that of the WCM and baseline. The USFWS plan exhibited the highest benefit with an added 12 days of floodplain inundation compared to the baseline at 70% probability of exceedance. However, the USFWS plan did not provide floodplain inundation similar to that expected under the Unimpaired Flow scenario (99 days less) or pre-dam conditions (96 days less).

Freshwater Mussel Hydroecological Metric 2 - Access to Floodplain for Spawning of Host Fish

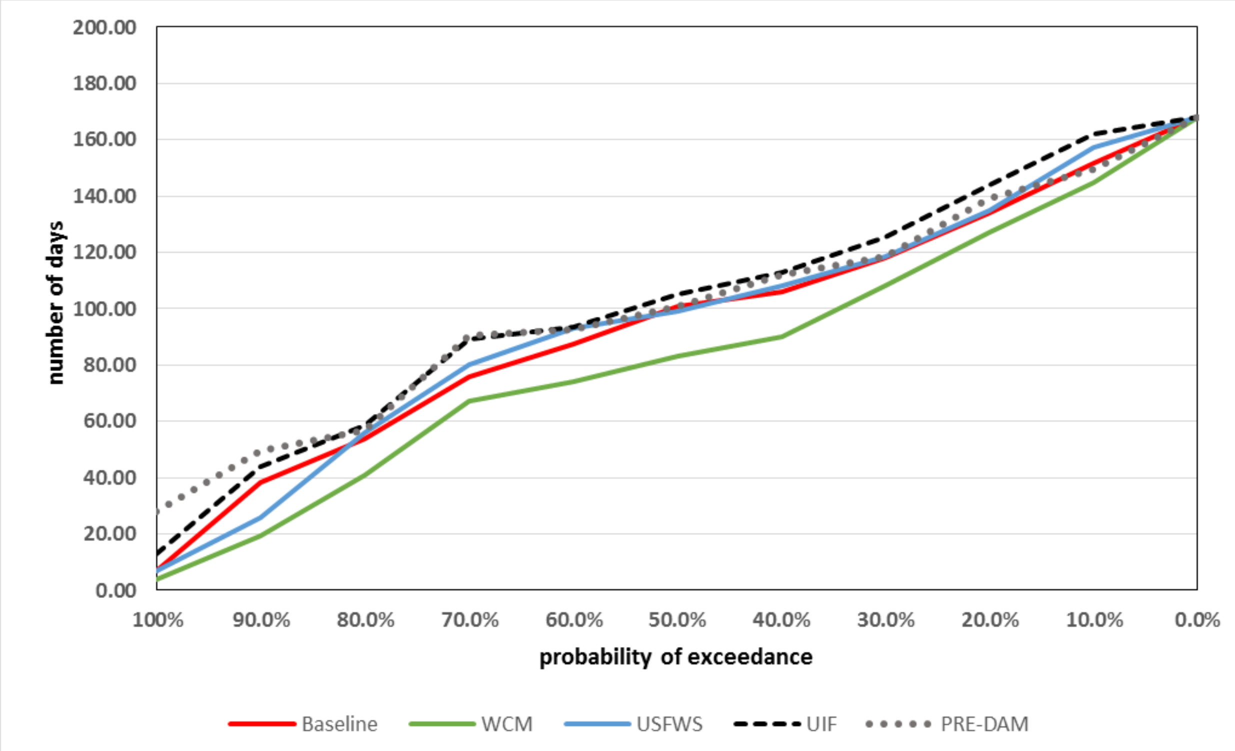
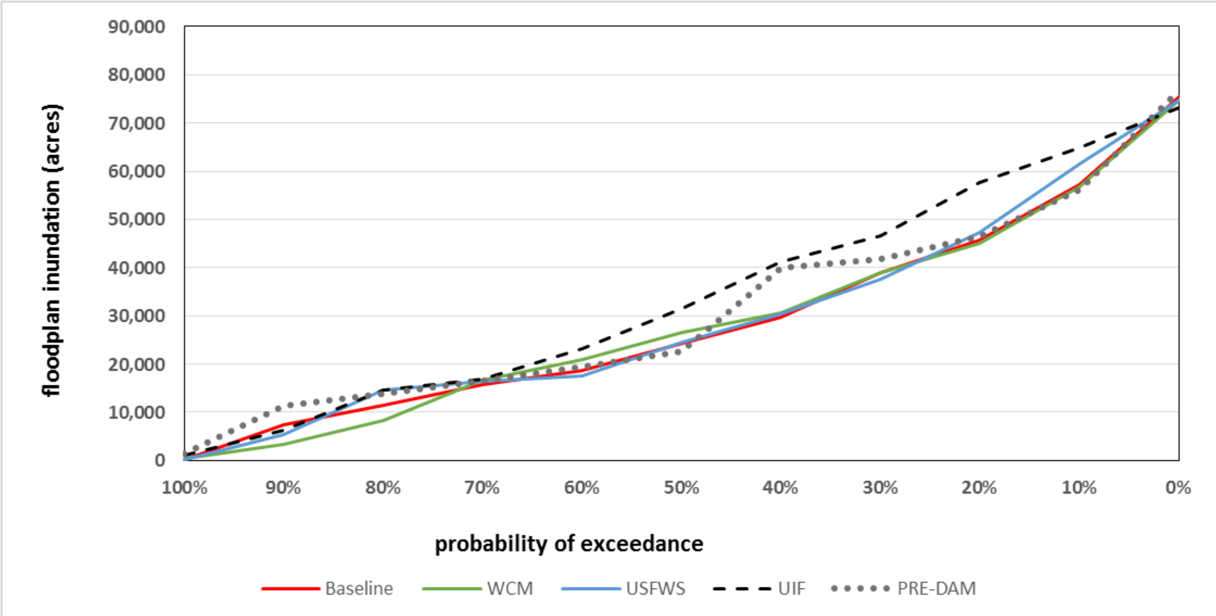


Figure 20.2.2: number of days' flow for the Apalachicola River at Chattahoochee ≥ 16,200 cfs between March 1 and Aug 15

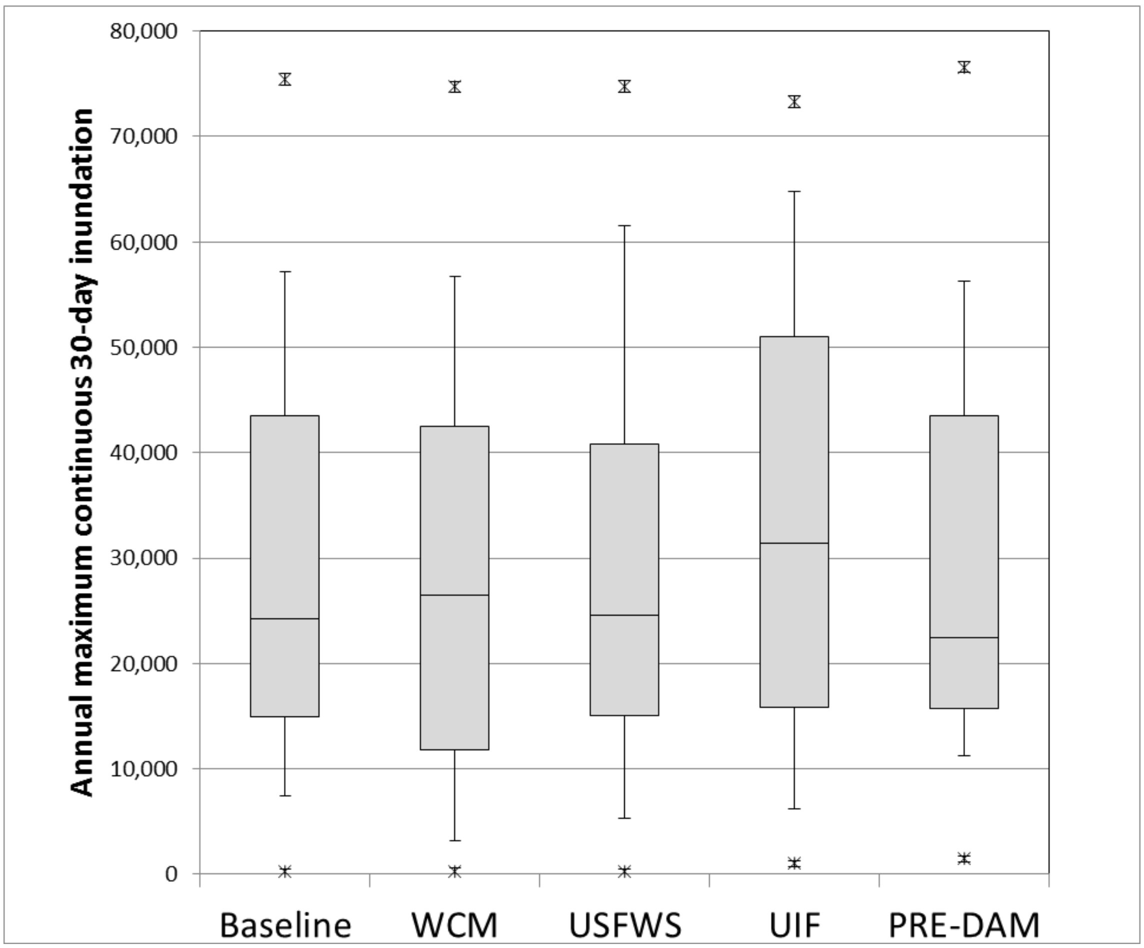
The USFWS management plan provided for greater a number of days of floodplain inundation across most years of examination compared to the WCM (119 day increase, 11 days on average per exceedance probability decile) and baseline (3 day increase, 0.3 days on average per exceedance probability decile), with the exception of those years exhibiting the lowest number of days of inundation (i.e., the driest years; probability of exceedance range 90-100%). During years of low floodplain inundation, the USFWS management plan results were similar to that of the WCM and baseline. The USFWS plan exhibited the highest benefit with an added 5 days of floodplain inundation compared to the baseline at 60% probability of exceedance. However, the USFWS plan did not provide floodplain inundation similar to that expected under the Unimpaired Flow scenario (68 days less) or pre-dam conditions (58 days less).

Freshwater Mussel Hydroecological Metric 3 - Access to Floodplain for Spawning of Host Fish



90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
floodplan inundation (acres)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
probability of exceedance
Baseline
WCM
USFWS
UIF
PRE-DAM

A



80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Annual maximum continuous 30-day inundation
Baseline
WCM
USFWS
UIF
PRE-DAM

B

Figure 20.2.3: Floodplain acres inundated between March 1 and Aug 15 as a probability of exceedance plot (A) and box plot (B)

The USFWS management plan provided for greater floodplain inundation compared to the WCM (8159 ac increase) and baseline (5088 ac increase), and provided only a 298 ac increase at the median. However, similar to the WCM, the USFWS plan had both beneficial and adverse effects across the range of wet to dry years. During years of low floodplain inundation (i.e., drier years), the USFWS management plan results were similar to that of the WCM and baseline. The USFWS plan reduced floodplain inundation by 2113 ac compared to the baseline at 90% probability of exceedance (i.e., the driest years) and reduced by 1367 ac at 30% probability of exceedance (i.e., slightly wetter years). The USFWS plan exhibited the highest benefits with an added 3000 ac of floodplain inundation compared to the baseline at 80% probability of exceedance (i.e., drier years) and an added 4351 ac at 10% probability of exceedance (i.e., wetter years). Further, the USFWS plan did not provide floodplain inundation similar to that expected under the Unimpaired Flow scenario (46,927 ac less) or pre-dam conditions (15,891 ac less).

20.2.2 Flows for Mussel Host Fish Infection and Juvenile Mussel Recruitment

Freshwater Mussel Hydroecological Metric 4 - Low Flows during Host Infection and Juvenile Settlement

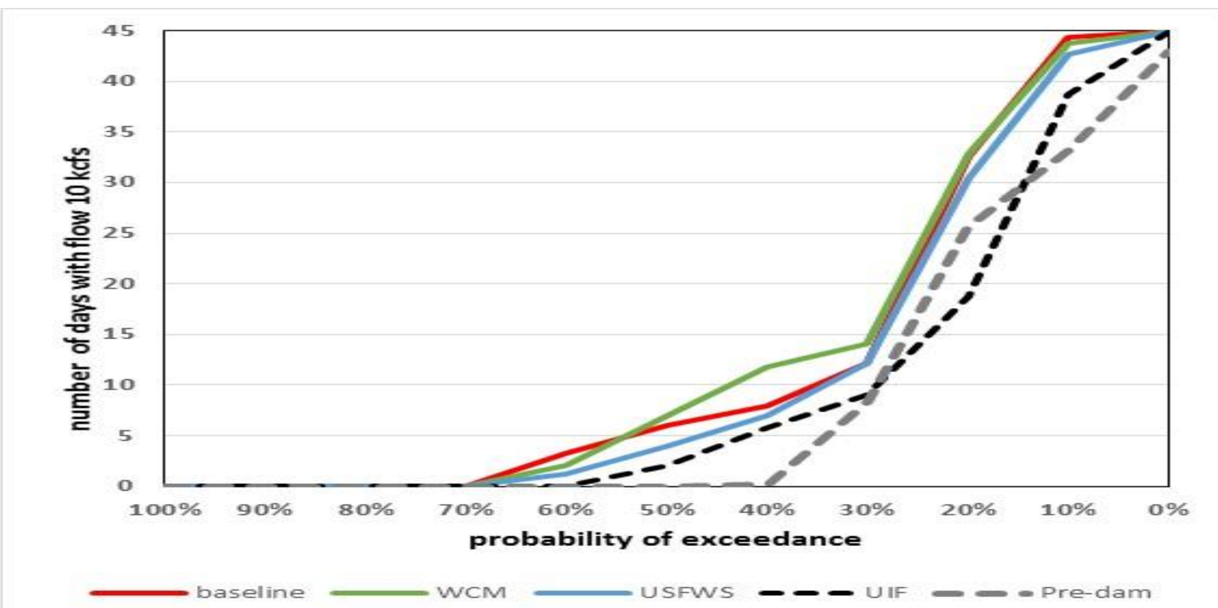


Figure 20.2.4: Number of days flows for the Apalachicola River at Chattahoochee are less than 10,000 cfs between June 1 and July 15.

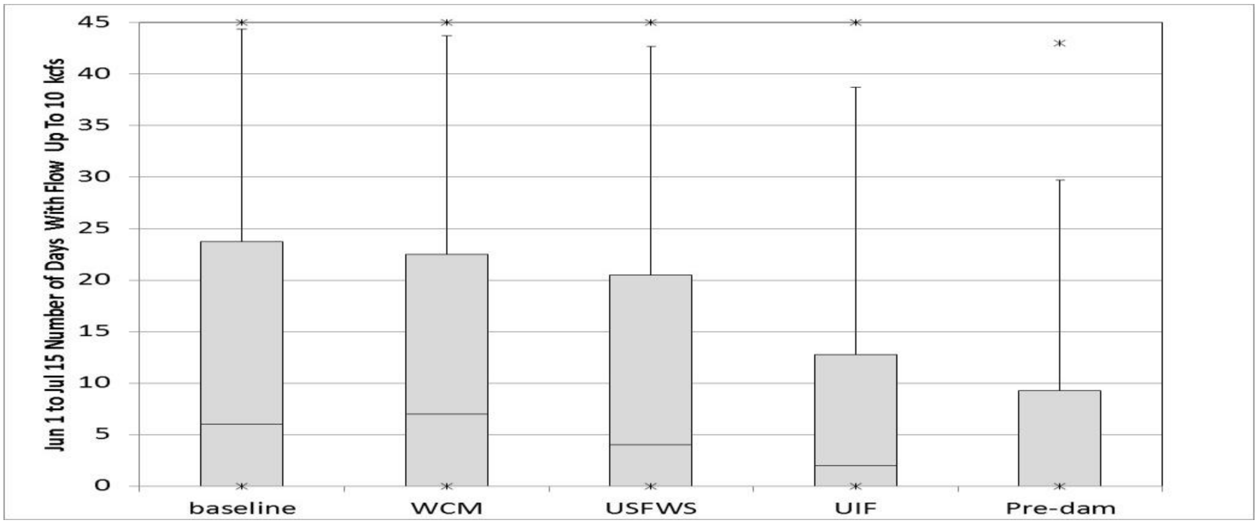


Figure 20.2.5: Number of days flows for the Apalachicola River at Chattahoochee are less than 10,000 cfs between June 1 and July 15.

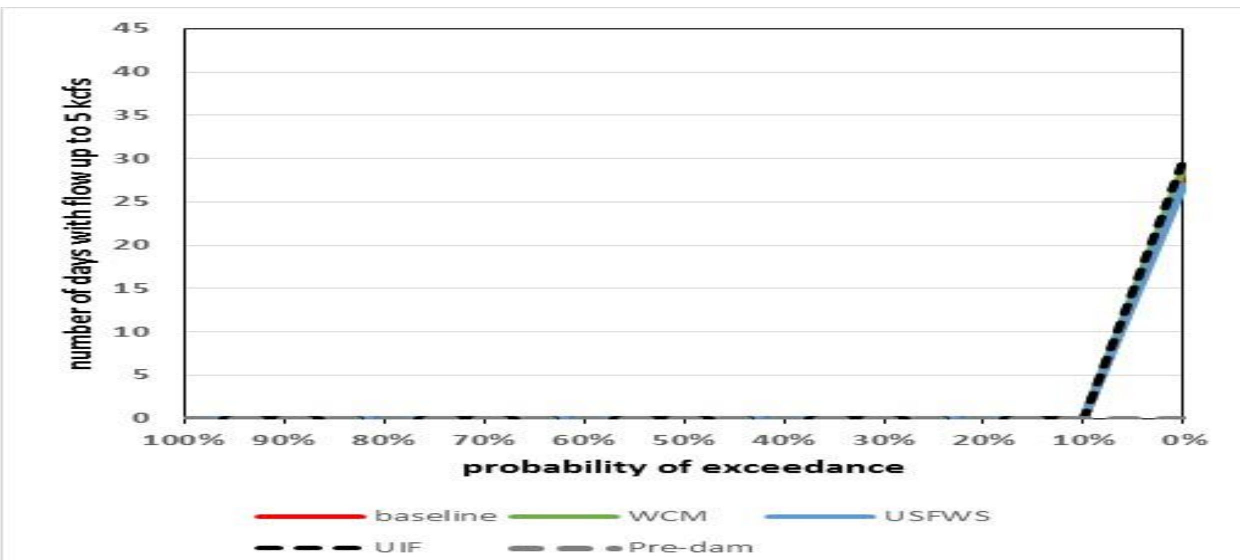


Figure 20.2.6: Number of days flows for the Apalachicola River at Chattahoochee are less than 5,000 cfs between June 1 and July 15.

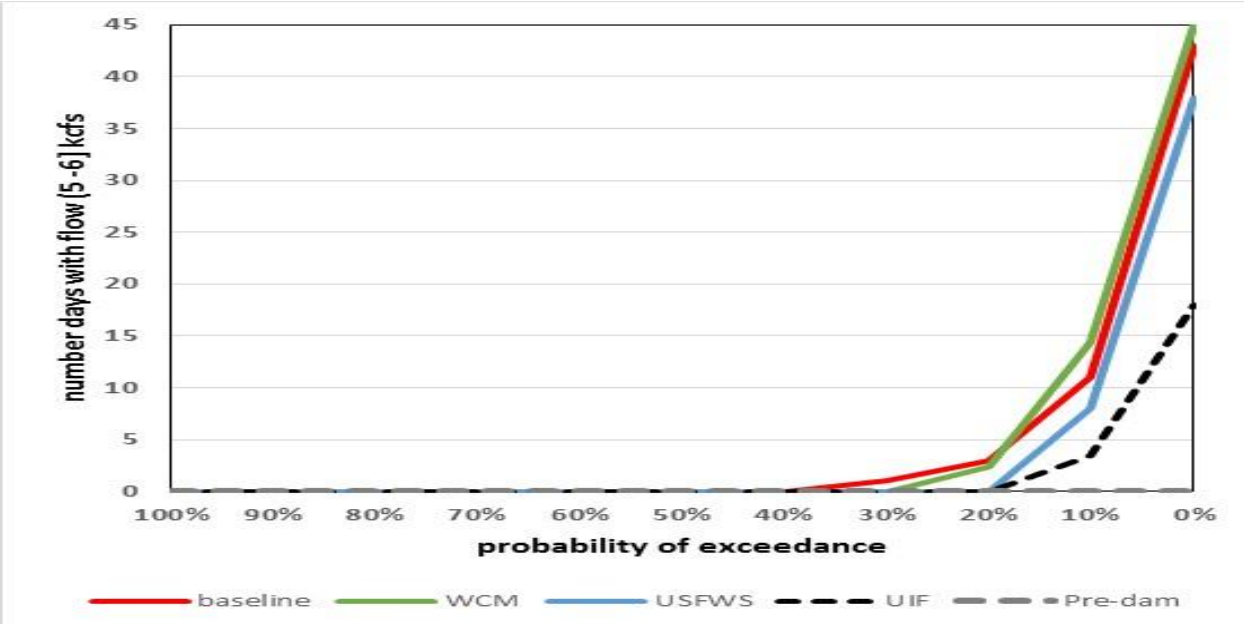


Figure 20.2.7: Number of days flows for the Apalachicola River at Chattahoochee are between 5,000 and 6,000 cfs between June 1 and July 15.

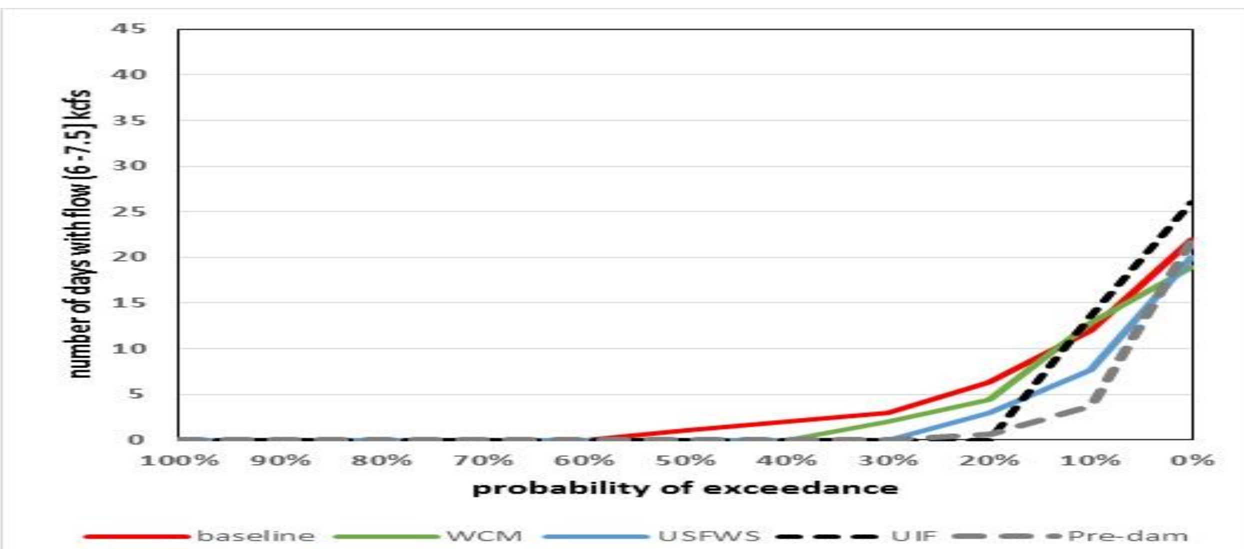


Figure 20.2.8: Number of days flows for the Apalachicola River at Chattahoochee are between 6,000 and 7,500 cfs between June 1 and July 15.

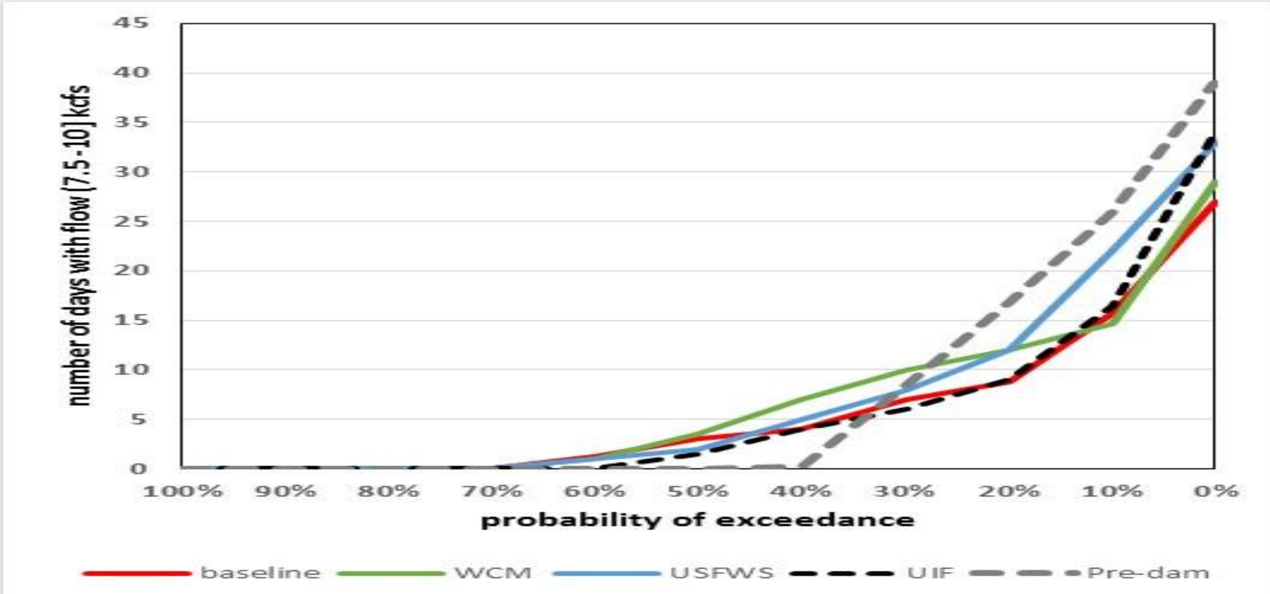


Figure 20.2.9: Number of days flows for the Apalachicola River at Chattahoochee are between 7,500 and 10,000 cfs between June 1 and July 15.

The USFWS management plan was designed to generally provide higher flows and generally avoid flows <10,000 cfs and not surprisingly provides mostly adverse effects compared to the WCM and baseline. At very low flows <5,000 cfs, the USFWS management plan results were similar to that of the WCM and baseline, but it provided 12 fewer days than the baseline at flows in the 5,000-5,999 cfs range, 16 fewer days than the baseline at flows in the 6,000-7,499 cfs range, and 16 more days than the baseline at flows in the 7,500-10,000 cfs range. However, it is worth noting that the USFWS plan, the baseline, or the WCM did not provide flows in these ranges similar to that expected under the Unimpaired Flow scenario or pre-dam conditions. Generally, both unimpaired flow and pre-dam scenarios have fewer days in the low and very low flow ranges (<7,500 cfs).

Freshwater Mussel Hydroecological Metric 5 - Stable Low Flows during Host Infection and Juvenile Settlement

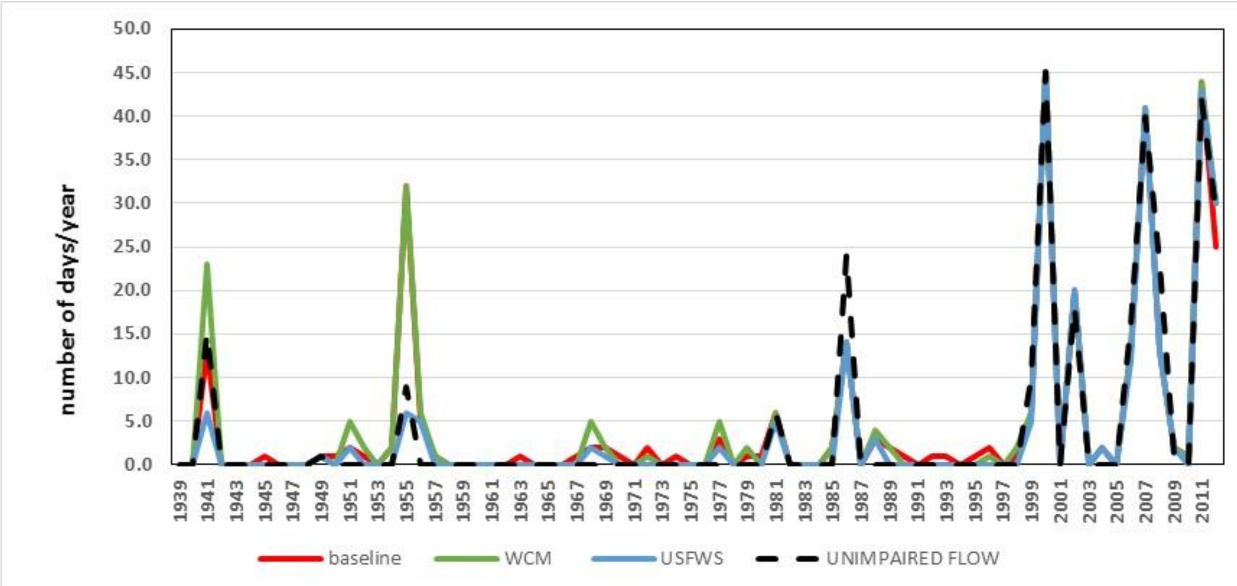


Figure 20.2.10: Number of days per year flows for the Apalachicola River at Chattahoochee are below 7,500 between June 1 and July 15.

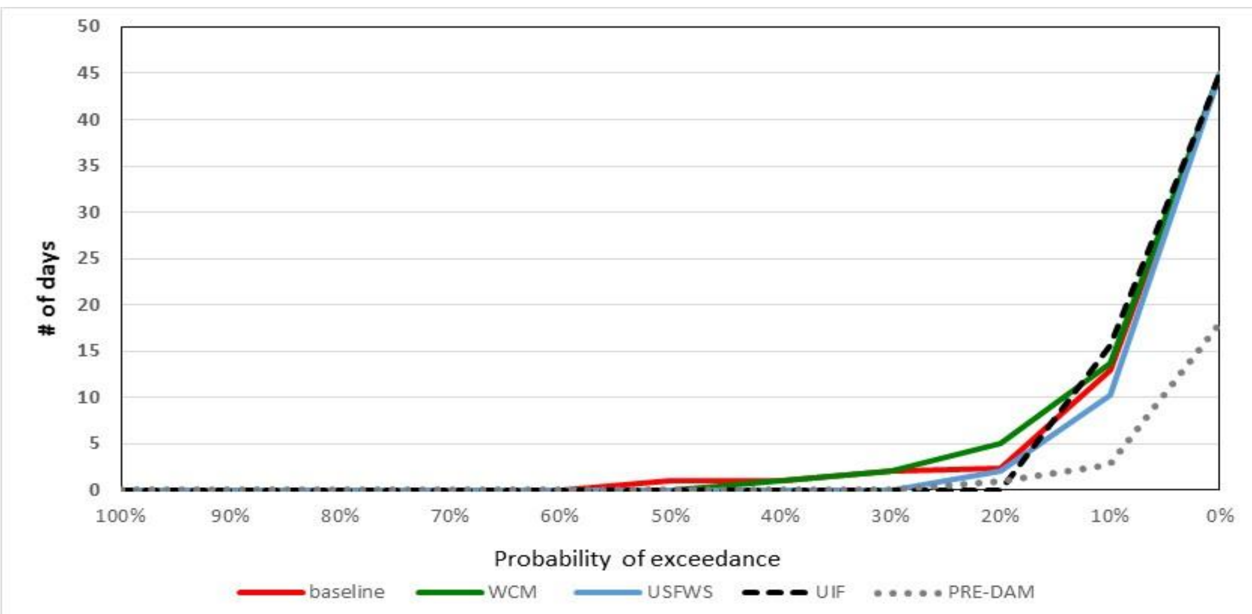
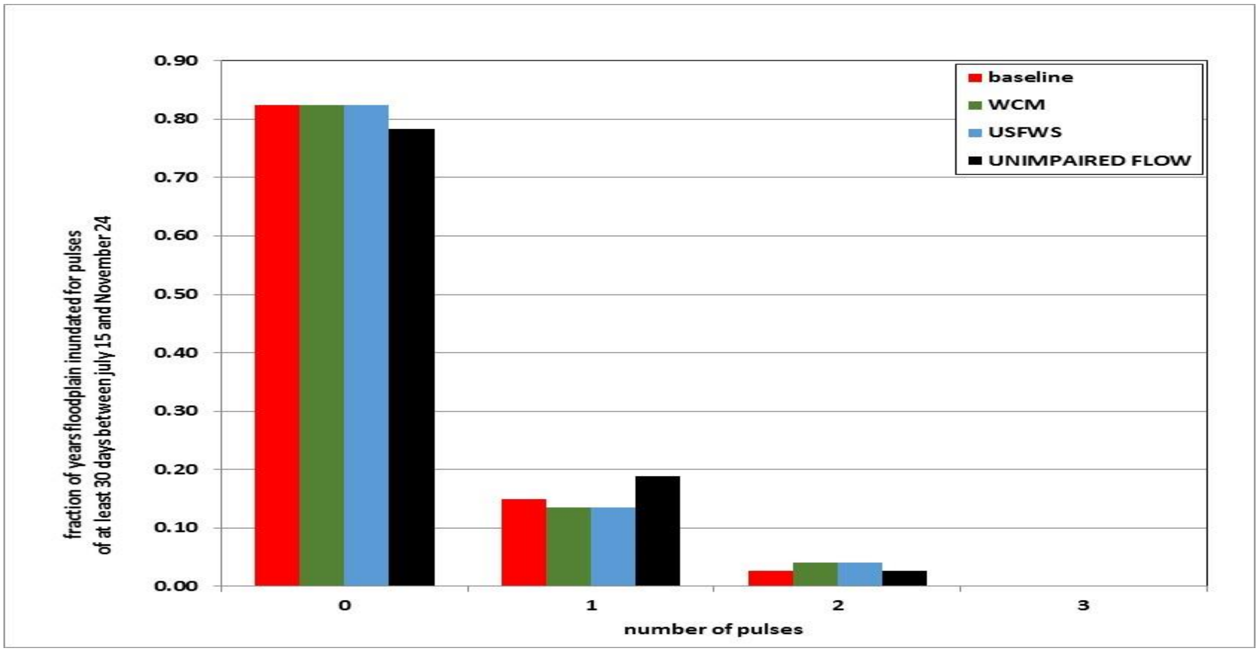


Figure 20.2.11: Number of days per year flows for the Apalachicola River at Chattahoochee are below 7,500 between June 1 and July 15.

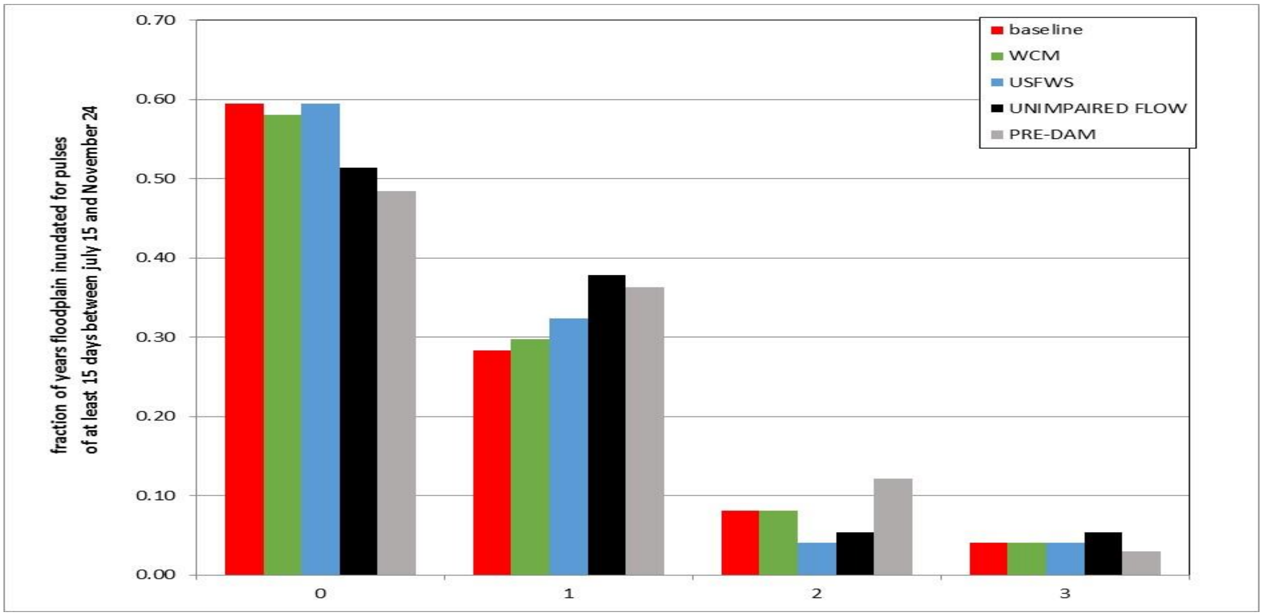
The USFWS management plan was designed to generally provide higher flows and generally avoid flows <10,000 cfs and not surprisingly provides mostly adverse effects compared to the WCM and baseline. The USFWS management plan provided 7 fewer days of consecutive flows <7,500 cfs range compared to the baseline and 9 fewer compared to the WCM. However, it is worth noting that the USFWS plan, the baseline, or the WCM did not provide flows in these ranges similar to that expected under the Unimpaired Flow scenario or pre-dam conditions. Generally, both unimpaired flow and pre-dam scenarios have fewer days in the low and very low flow ranges (<7,500 cfs).

20.2.3 Flows for Mussel Growth and Fecundity with respect to Floodplain Inundation

Freshwater Mussel Hydroecological Metric 6 - Pulsed Floodplain Inundation during Summer-Fall



A



B

Figure 20.2.12: Fraction of years the Apalachicola River's floodplain was inundated by pulses of at least 30 days (A) and 15 days (B) between July 15 and November 24.

The USFWS management plan provides an identical number of years as the WCM with one and two 30-day floodplain pulses between July 15 and November 24 across the 74-year record (13 years or 18% of the time) and one fewer years with a single 30-day pulse and one more year with two 30-day pulses than the baseline. These 30-day pulses are equivalent to the pre-dam record, but represent a decrease from the UIF scenario (16 years or 22%). Looking at the shorter 15-day pulses provides a different picture when comparing to the baseline and WCM or the pre-dam record or UIF scenarios. The USFWS management plan provides one fewer years than the WCM with one, two, or three 15-day floodplain pulses between July 15 and November 24 across the 74-year record and an equivalent number of years with 15-day pulses as the baseline (30 years or 41% of the time). It provides the pulses as three additional years with single 15-day pulses. These 15-day pulses represent an 11% drop (8 years) from the pre-dam record and a 8% drop (6 years) from the UIF scenario. Thus, we see fewer 15-day pulses than we did historically or if flows through the basin were unimpaired.

20.2.4 Flows for River Drawdown and Mussel Survival in Ephemeral Habitats

Freshwater Mussel Hydroecological Metric 7 - Mussel Exposure and Survival during Extreme Low Flows

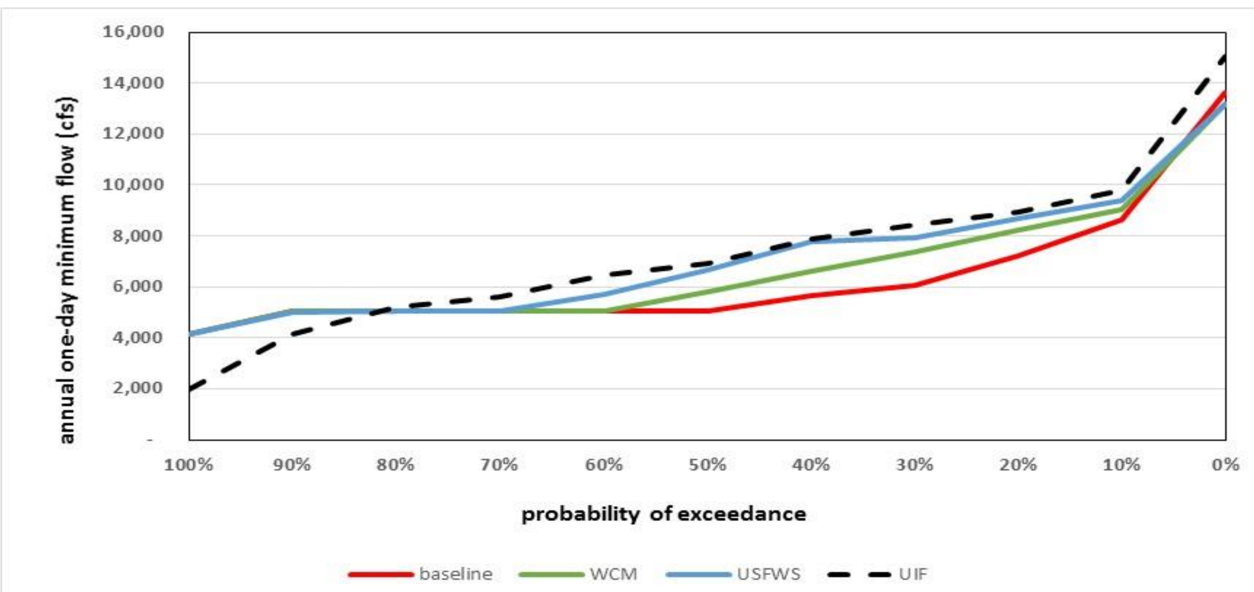


Figure 20.2.13: Frequency of annual one-day minimum flows for the Apalachicola River at Chattahoochee for 1939 - 2012.

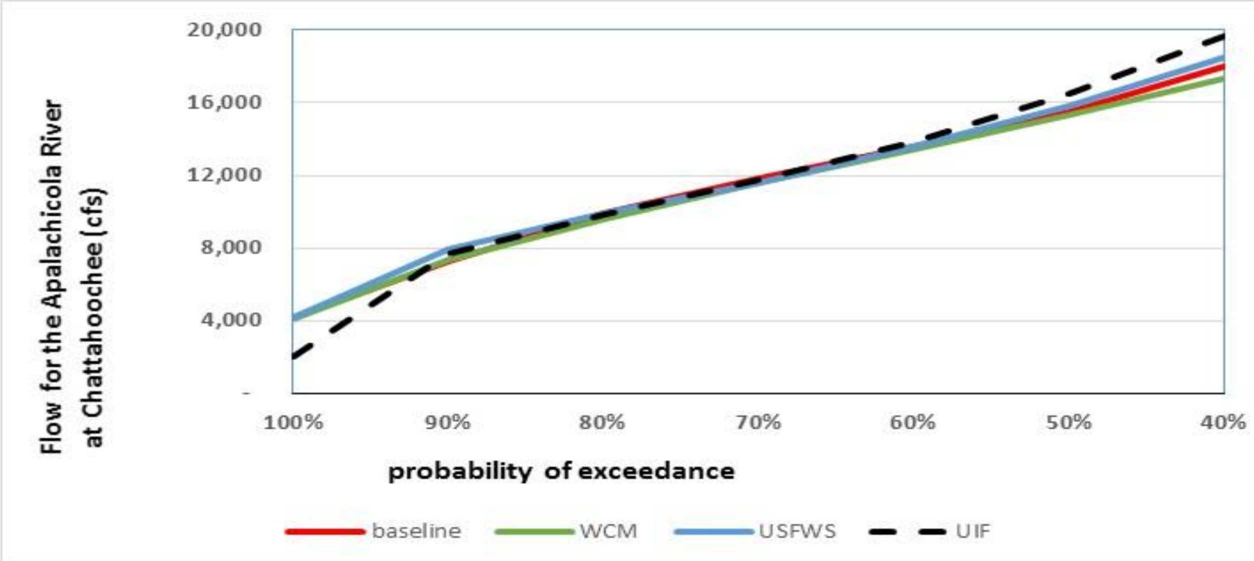
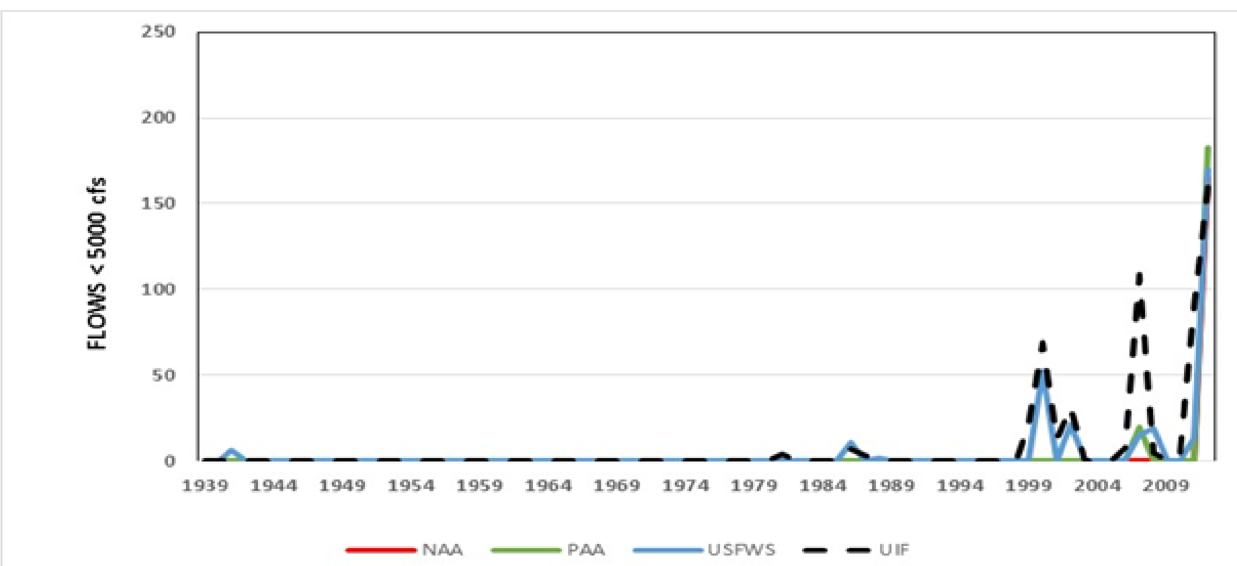


Figure 20.2.14: Probability of exceedance of flow for the Apalachicola River at Chattahoochee (1939 – 2012).

The USFWS, WCM and baseline management plans provides an identical minimum flows as per the rule set in each management plan and approximately a 10% probability of minimum flows below 5,000 cfs compared to the WCM and 20% reduction in probability of minimum flows compared to the WCM. The USFWS plan provides a higher absolute minimum flow but a 10% increase in probability of minimum flows at or below 5,000 cfs compared to the unimpaired flow dataset.

Freshwater Mussel Hydroecological Metric 8 - Mussel Exposure and Survival during Extreme Low Flows



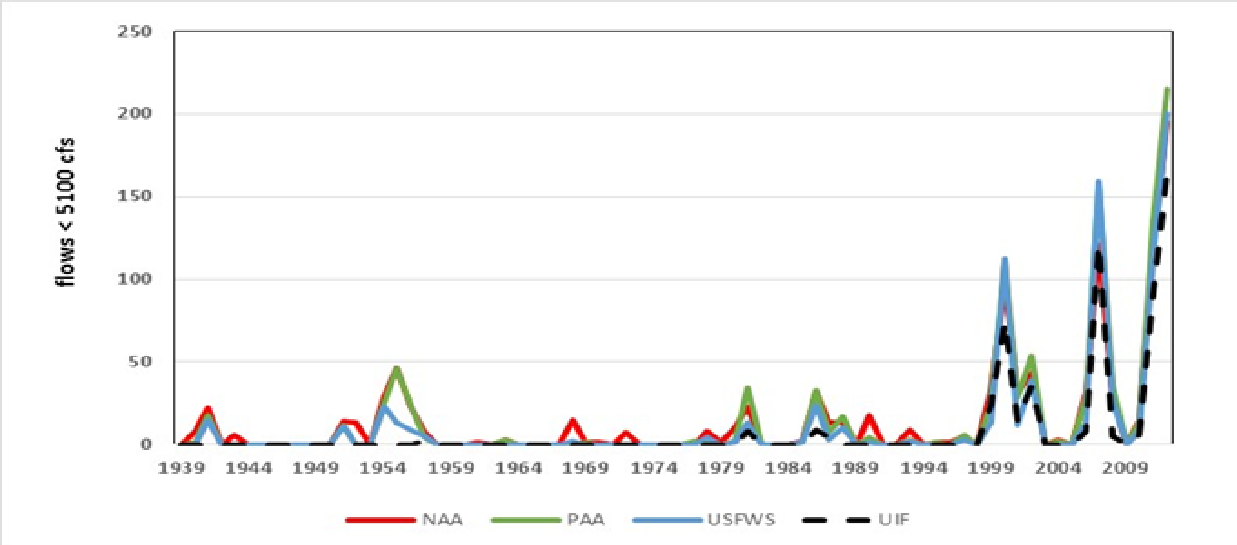


Figure 20.2.15: Number of days of flow <5,000 and <5,100 for the Apalachicola River at Chattahoochee (1939 – 2012).

The USFWS management plan allows drop below 5,000 cfs more frequently than both the WCM and baseline with 10 years and a total of 311 days across the 74 year record. However, when we calculate the total number of days when flows are <5,100 cfs, we see a different pattern. The USFWS pan spends only 27 years (36%) and 837 days total below 5,100 cfs across the 74 year record. All three management plans spent more days (567) and years (14 or 19%) below 5,100 cfs than the unimpaired flow dataset indicating that they manage for flows near this threshold.

Freshwater Mussel Hydroecological Metric 9 - Mussel Exposure and Survival during Drawdown

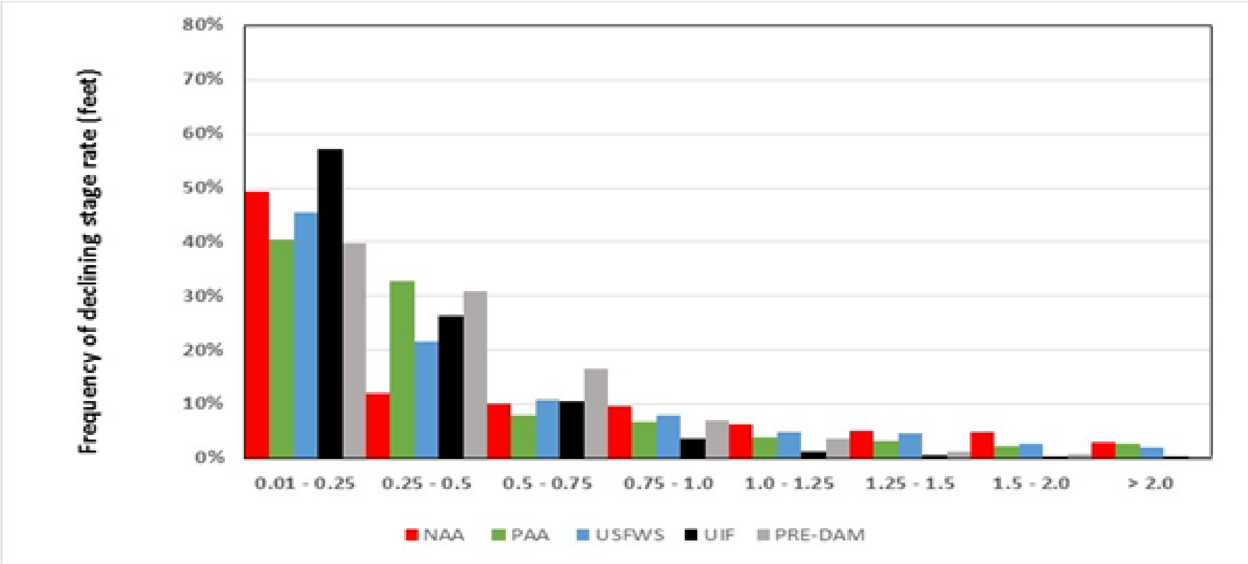


Figure 20.2.16: Frequency of occurrence of declining stages for the Apalachicola River at Chattahoochee for 1939 – 2012

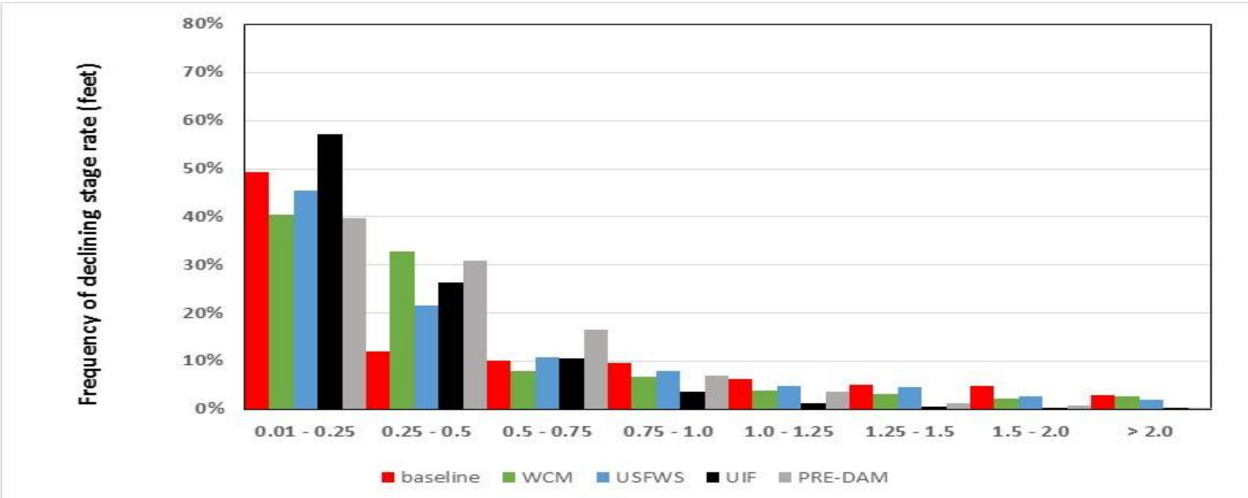


Figure 20.2.17: Frequency of occurrence of declining stages for the Apalachicola River at Chattahoochee for 1939 – 2012 when flow is less than 10,000 cfs

USFWS management plan has 4% fewer days with ramp rates ≤0.25 ft/day and 10% more days at ramp rates 0.26-0.5 ft/day than the baseline when looking at all flows. When flows are <10,000 cfs, the USFWS plan has 2% more days with ramp rates ≤0.25 ft/day and 1% less days at ramp rates 0.26-0.5 ft/day than the baseline. The biggest insight from the analysis of flows <10,000 cfs is that both the UIF and pre-dam conditions had much higher frequencies of ramp rates ≤0.25 ft/day than any of the management plans when flows are <10,000 cfs. The WCM provides ramp rates ≤0.25 ft/day approximately 30, 31, and 32% of the time while the UIF and pre-dam conditions have those ramp rates approximately 75 and 58% respectively. This indicates water levels recede approximately twice as fast as they did before the ACF Basin dams were installed.

20.2.5 Other Effects of the WCM on Mussel Life History and Critical Habitat

Freshwater Mussel Qualitative Metric 2 - Mussel Exposure, Survival, and Habitat Loss during Hydropeaking

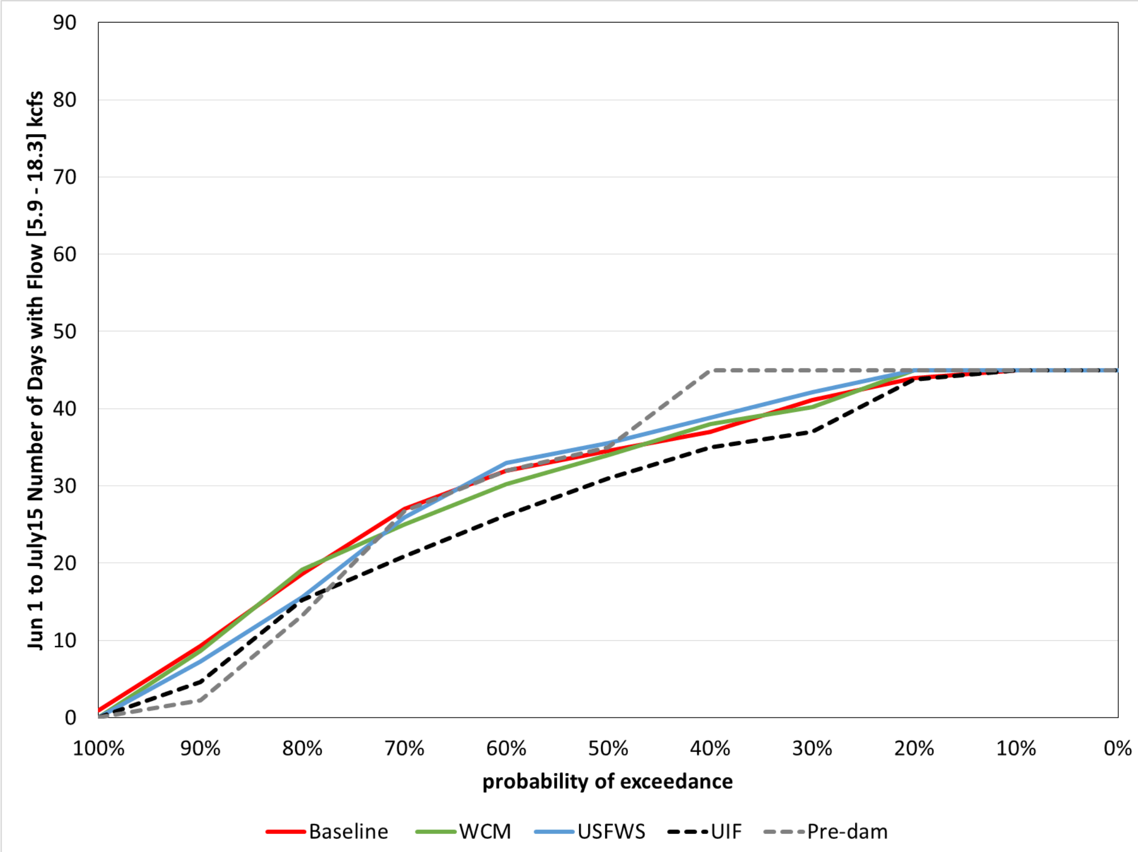


Figure 20.2.18: Probability of exceedance of flow for the Apalachicola River at Chattahoochee (1939 – 2012).

The total number of days at flows between 5,900 and 18,300 cfs between June 1 and July 15 occurring under the 5 flow regimens (baseline, WCM, USFWS, UIF, pre-dam) is presented as a probability of exceedance plot. The USFWS plan provides 12 days fewer of appropriate conditions for hydropeaking compared to the baseline across the 74 years (i.e., 0.1 days on average). Essentially, the USFWS plan represents no change the probability of conditions when hydropeaking may occur. The biggest insight from the analysis is that the baseline, WCM, and USFWS are similar to pre-dam conditions in average to dry years, (exceedance >50%) but in drier years. In addition, the UIF met the conditions for hydropeaking in 229 fewer days across the 74 years. This indicates water levels recede approximately twice as fast as they did before the ACF Basin dams were installed.

21 LITERATURE CITED

1. Altinok, I., and J. M. Grizzle. 2001. Effects of brackish water on growth, feed conversion and energy absorption efficiency by juvenile euryhaline and freshwater stenohaline fishes. Journal of Fish Biology 59:1142-1152.
2. Altinok, I., S.M. Galli, and F.A. Chapman. 1998. Ionic and osmotic regulation capabilities of juvenile Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*. Comparative Biochemistry and Physiology 120:609-616.
3. Amyot, J. P. and J.A. Downing. 1998. Locomotion in *Elliptio complanata* (Mollusca: Unionidae): a reproductive function? Freshwater Biology 39:351-358.
4. Angermeir, P.L. 1987. Spatiotemporal variation in habitat selection by fishes in small Illinois streams. Pp. 52-60 in: W. Matthews and D. Heins, editors. Community and Evolutionary Ecology of North American Stream Fishes. University of Oklahoma Press, Norman, Oklahoma.
5. Arnold, E.A, N.M. Rankin, K.J. Herrington, M. Brenner, J.H. Curtis, A. Dutton. 2011. Comparison of the oxygen isotope method and the internal line technique for age determination in *Amblema neislerii* mussels. Unpublished final report submitted to the U.S. Fish and Wildlife Service, Panama City Field Office, 20 pp.
6. Auer, N.A. 1996. Importance of habitat and migration to sturgeons with emphasis on lake sturgeon. Canadian Journal of Fisheries and Aquatic Sciences 53:152-160.
7. Augspurger T., A. Keller, M. Black, W. Cope, and F. Dwyer. 2003. Water quality guidance for protection of freshwater mussels (Unionidae) from ammonia exposure. Environmental Toxicology and Chemistry 22(11):2569-2575.
8. Bailey, R.G. 1983. Delineation of ecosystem regions. Environmental Management 7:365-373.
9. Balazik, M.T., G.C. Garman, J.P. Van Eenennaam, J. Mohler, and L.C. Woods III. 2012. Empirical evidence of fall spawning by Atlantic sturgeon in the James River, Virginia. Transactions of the American Fisheries Society 141:1465-1471.
10. Balazik, M.T., and J.A. Musick. 2015. Dual annual spawning races in Atlantic Sturgeon. PLoS ONE 10(5):e0128234.
11. Balfour, D.L., and L.A. Smock. 1995. Distribution, age structure, and movements of the freshwater mussel *Elliptio complanata* (Mollusca: Unionidae) in a headwater stream. Journal of Freshwater Ecology 10:254-268.
12. Barnhart, C.M., W.R. Haag, and W.N. Roston. 2008. Adaptations to host infection and larval parasitism in Unionoida. Journal of the North American Benthological Society. 27(2):370-394.
13. Beamesderfer, R.C.P., and R.A. Farr. 1997. Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48:407-417.
14. Biedenharn, D.S. 2007. Cursory geomorphologic evaluation of the Apalachicola River in support of the Jim Woodruff Dam Interim Operations Plan. Summary of Findings, pp. 13.
15. Bogan, A.E. 1993. Freshwater bivalve extinctions (Mollusca: Unionoida): a search for causes. American Zoologist 33:599-609.
16. Bonvechio, T.F., and M.S. Allen. 2004. Relations between hydrological variables and year-class strength of sportfish in eight Florida waterbodies. Hydrobiologia 532:193-207.

17. Bowen, Z.H., K.D. Bovee, and T J. Waddle. 2003. Effects of flow regulation on shallow-water habitat dynamics and floodplain connectivity. Transactions of the American Fisheries Society 132:809-823.
18. Braaten, P.J., D.B. Fuller, L.D. Holte, R.D. Lott, W. Viste, T.F. Brandt, and R.B. Legare. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in a natural side channel of the Upper Missouri River, Montana. North American Journal of Fisheries Management 28:808-826.
19. Braun, C.L., C.L. Stevens, P.D. Echo-Hawk, N.A. Johnson, and J.B. Moring. 2014. Abundance of host fish and frequency of glochidial parasitism in fish assessed in field and laboratory settings and frequency of juvenile mussels or glochidia recovered from hatchery-held fish, central and southeastern Texas, 2012-13. USGS Scientific Investigations Report 2014-5217. DOI: 10.3133/sir20145217.
20. Brekke, L., A. Wood, and T. Pruitt. 2014. Downscaled CMIP3 and CMIP5 Hydrology Projections: Release of Hydrology Projections, Comparison with Preceding Information, and Summary of User Needs. Bureau of Reclamation. [Available at: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/techmemo/BCSD5HydrologyMemo.pdf].
21. Brim Box, J. 1999. Community structure of freshwater mussels (Bivalvia: Unionidae) in Coastal Plain streams of the southeastern United States. Unpublished Ph.D. Dissertation, University of Florida, Gainesville. 107 pp.
22. Brim Box, J., and J. Mossa. 1999. Sediment, land use, and freshwater mussels: prospects and problems. Journal of the North American Benthological Society 18(1):99-117.
23. Brim Box, J., and J.D. Williams. 2000. Unionid mollusks of the Apalachicola Basin in Alabama, Florida, and Georgia. Bulletin of the Alabama Museum of Natural History No. 22. 143 p.
24. Bruenderman, S.A., and R.J. Neves. 1993. Life history of the endangered fine-rayed pigtoe, *Fusconaia cuneolus* (Bivalvia: Unionidae) in the Clinch River, Virginia. American Malacological Bulletin 10(1):83-91.
25. Bruno, M.C., B. Maiolini, M. Carolli, and L. Silveri. 2010. Short time-scale impacts of hydropeaking on benthic invertebrates in an Alpine stream (Trentino, Italy). Limnologica - Ecology and Management of Inland Waters 40:281-290.
26. Bruno, M.C., A. Siviglia, M. Carolli, and B. Maiolini. 2013. Multiple drift responses of benthic invertebrates to interacting hydropeaking and thermopeaking waves. Ecohydrology 6(4):511-522.
27. Bruno, M.C., M.J. Cashman, B. Maiolini, S. Biffi, and G. Zolezzi. 2016. Responses of benthic invertebrates to repeated hydropeaking in semi-natural flume simulations. Ecohydrology 9:68-82.
28. Bunn, S. E., and A. H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30:492-507.
29. Burgess, O.T., W.E. Pine III, and S.J. Walsh. 2013. Importance of floodplain connectivity to fish populations in the Apalachicola River, Florida. River Research and Applications 29:718-733.
30. Burkett, V.R. 2008. Statement of chief scientist for global change research before the Committee on Energy and Natural Resources regarding findings of the U.S. Climate Change Science Program Study (SAP 4.7: Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I) May 13, 2008.

31. Carr, A. 1983. All the way down upon the Suwannee River. Audubon Magazine. p. 80-101.
32. Carr, S.H, F. Tatman, and F.A. Chapman. 1996. Observations on the natural history of the Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi*, Vladykov 1955) in the Suwannee River, southeastern United States. Ecology of Freshwater Fisheries 5:169-174.
33. Castro, D.M.P., R.M. Hughes, and M. Callisto. 2013. Effects of flow fluctuations on the daily and seasonal drift of invertebrates in a tropical river. International Journal of Limnology 49:169-177.
34. Chamberlain, T.K. 1931. Annual growth of freshwater mussels. Bulletin of the U.S. Bureau of Fisheries 46:713-739.
35. Chambers, R.C., and W.C. Leggett. 2011. Size and age at metamorphosis in marine fishes: an analysis of laboratory-reared winter flounder (*Pseudopleutonectes americanus*) with a review of variation in other species. Canadian Journal of Fisheries and Aquatic Sciences 44(11):1936-1947.
36. Chanton, J., and F.G. Lewis. 2002. Examination of coupling between primary and secondary production in a river-dominated estuary: Apalachicola Bay, Florida, U.S.A. Limnology and Oceanography 47(3):683-697.
37. Chapman, F.A. and S.H. Carr. 1995. Implications of early life stages in the natural history of the Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*. Environmental Biology of Fishes 43:407-413.
38. Chapman, F.A., S.F. O'Keefe, and D.E. Campton. 1993. Establishment of parameters critical for the culture and commercialization of Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*. Fisheries and Aquatic Sciences Dept., Food Science and Human Nutrition Dept., University of Florida, Gainesville, FL. Project Final Report. NOAA No. NA27FD0066-01. National Marine Fisheries Service. St. Petersburg, FL.
39. Clench, W.J., and R.D. Turner. 1956. Freshwater mollusks of Alabama, Georgia, and Florida from the Escambia to the Suwannee River. Bulletin of the Florida State Museum, Biological Sciences 1(3):97-239.
40. Clugston, J.P., A.M. Foster, and S.H. Carr. 1995. Gulf sturgeon, *Acipenser oxyrinchus desotoi*, in the Suwannee River, Florida. Pp. 215-224 in A.D. Gershanovich and T.I.J. Smith, editors. Proceedings of International Symposium on Sturgeons. Moscow, Russia. September 6- 11, 1993, 370 pp.
41. Cocherell, S.A., D.E., Cocherell, G.J. Jones, J.B. Miranda, L.C. Thompson, J.J Cech, and A.P. Klimley. 2011. Rainbow trout *Oncorhynchus mykiss* energetic responses to pulsed flows in the American River, California, assessed by electromyogram telemetry. Environmental Biology of Fishes 90:29-41.
42. Coker, R.E., A.F. Shira, H.W. Clark, and A.D. Howard. 1921. Natural history and propagation of freshwater mussels. Bulletin of the U.S. Bureau of Fisheries 37:77-181.
43. Collins, M.R., T.I.J. Smith, W.C. Post, and O. Pashuk. 2000. Habitat utilization and biological characteristics of adult Atlantic sturgeon in two South Carolina rivers. Transactions of the American Fisheries Society 129:982-988.
44. Coon, T.G., J.W. Eckblad, and P.M. Trygstad. 1977. Relative abundance and growth of mussels (Mollusca: Eulamellibranchia) in pools 8, 9, and 10 of the Mississippi River. Freshwater Biology 7:279-285.

45. Craft, N.M., B. Russell, and S. Travis. 2001. Identification of Gulf sturgeon spawning habitats and migratory patterns in the Yellow and Escambia River systems. Final Report to the Florida Marine Research Institute, Fish and Wildlife Conservation Commission. 19 pp.
46. Crossman, J.A., and L.R. Hildebrand. 2012. Evaluation of spawning substrate enhancement for white sturgeon in a regulated river: effects on larval retention and dispersal. River Research and Applications 30:1-10.
47. Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5:330-339.
48. Daraio, J.A., L.J. Weber, S.J. Zigler, T.J. Newton, and J.M. Nestler. 2012. Simulated effects of host fish distribution on juvenile unionid mussel dispersal in a large river. River Research and Applications 28:594-608.
49. Dewson, Z.S., A.B.W. James, and R.G. Death. 2007. A review of the consequences of decreased flow for instream habitat and macroinvertebrates. Journal of the North American Benthological Society 26(3):401-415.
50. Di Maio, J., and L.D. Corkum. 1995. Relationship between the spatial distribution of freshwater mussels (Bivalvia: Unionidae) and the hydrological variability of rivers. Canadian Journal of Zoology 73:663-671.
51. Dibble, K.L., C.B. Yackulic, T.A. Kennedy, and P. Budy. 2015. Flow management and fish density regulate salmonid recruitment and adult size in tailwaters across western North America. Ecological Applications 25(8):2168-2179.
52. Downing, J.A., J.-P. Amyot, M. Pérusse, and Y. Rochon. 1989. Visceral sex, hermaphroditism, and protandry in a population of the freshwater mussel *Elliptio complanata*. Journal of the North American Benthological Society 8(1):92-99.
53. Duke, S., P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, R. Lauzier, L. Lockhard, B. Marotz, V.L. Paragamian, and R. Westerhof. 1999. Recovery plan for Kootenai River white sturgeon (*Acipenser transmontanus*). Journal of Applied Ichthyology 15:157-163.
54. Dumont, P., J. D'Amours, S. Thibodeau, N. Dubuc, R. Verdon, S. Garceau, P. Bilodeau, Y. Mailhot, and R. Fortin. 2011. Effects of the development of a newly created spawning ground in the Des Prairies River (Quebec, Canada) on the reproductive success of lake sturgeon (*Acipenser fulvescens*). Journal of Applied Ichthyology 27:394-404.
55. Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman Company, San Francisco. 818 pp.
56. Dutterer, A.C., C. Mesing, R. Cailteux, M.S. Allen, W.E. Pine III, and P.A. Strickland. 2012. Fish recruitment is influenced by river flows and floodplain inundation at Apalachicola River, Florida. River Research and Applications 29:1110-1118.
57. Edwards, R.E., K.J. Sulak, M.T. Randall, and C.B. Grimes. 2003. Movements of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in nearshore habitat as determined by acoustic telemetry. Gulf of Mexico Science 21(1):59-70.
58. Edwards, R.E., F.M. Parauka, and K.J. Sulak. 2007. New insights into marine migration and winter habitat for Gulf sturgeon. Pp. 183-196 in: J. Munro, J.E. Hightower, K. McKown, K.J. Sulak, A.W. Kahnle, and F. Caron, editors. Anadromous sturgeons:

habitats threats, and management. American Fisheries Society Symposium 56. Bethesda, Maryland.

59. EnviroScience. 2006a. Freshwater mussel and habitat surveys of the Apalachicola River, Chipola River and selected sloughs/tributaries. Unpublished final report submitted to the Florida Department of Environmental Protection.
60. EnviroScience. 2006b. Swift Slough Population (Abundance) Estimate for the federally endangered *Amblema neislerii* (Fat Threeridge) and federally threatened *Elliptoideus sloatianus* (Purple Bankclimber). Unpublished draft report submitted to the Fish and Wildlife Conservation Commission.
61. EnviroScience. 2011. Status Report: 2010 Swift Slough Habitat and Population Status Survey for the federally endangered *Amblema neislerii* (Fat Threeridge). Unpublished final report submitted to the Fish and Wildlife Conservation Commission.
62. Etnier, D.A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pp. 87-104 in: G.W. Benz and D.E. Collins, editors, Aquatic Fauna in Peril. Southeast Aquatic Research Institute, Special Publication 1. Lenz Design and Communications, Decatur, GA.
63. Florida Department of Environmental Protection (FDEP). 2002. Division of Water Resource Management, Basin Status Report, Northwest District, Group 2 Basin, Apalachicola-Chipola.
64. Florida Department of Environmental Protection (FDEP). 2005. Division of Water Resource Management, Water Quality Assessment Report, Northwest District, Group 2 Basin, Apalachicola-Chipola.
65. Florida Fish and Wildlife Conservation Commission (FFWCC). 2011. The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems. Letter from Harold Vielhauer to (FFWCC) to Dr. Donald Imm (USFWS) and Major General Todd Semonite (USACE) dated February 22, 2011.
66. Flowers, H.J. 2008. Age-structured population model for evaluating Gulf sturgeon recovery on the Apalachicola River, Florida. M.S. Thesis, University of Florida, Gainesville.
67. Flowers, H.J., W.E. Pine III, A.C. Dutterer, K.G. Johnson, J.W. Ziewitz, M.S. Allen, and F.M. Parauka. 2009. Spawning site selection and potential implications of modified flow regimes on viability of Gulf sturgeon populations. Transactions of the American Fisheries Society 138:1266-1284.
68. Foster, A.M. 1993. Movement of Gulf sturgeon, *Acipenser oxyrinchus desotoi* in the Suwannee River, Florida. Master Thesis, University of Florida, Gainesville, FL. 131 pp.
69. Foster, A.M., and J.P. Clugston. 1997. Seasonal migration of Gulf sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 126:302-308.
70. Foster, A.M., C.F. Jordan, and J.P. Clugston. 1994. Salinity tolerance of juvenile Gulf sturgeon identifies habitat limitations. Research Information Bulletin 63, Southeastern Biological Science Center. Gainesville, Florida.
71. Fox, D.A., J.E. Hightower, and F.M. Parauka. 2000. Gulf sturgeon spawning migration and habitat in the Choctawhatchee river system. Alabama-Florida. Transactions of the American Fisheries Society129:811-826.

72. Fox, D.A., J.E. Hightower, and F.M. Parauka. 2002. Estuarine and nearshore marine habitat use by Gulf sturgeon from the Choctawhatchee River system, Florida. Pp. 111-126 in: W. Van Winkle, P.J. Anders, D.H. Secor, and D.A. Dixon, editors. Biology, protection, and management of North American sturgeon. American Fisheries Society, Symposium 28. Bethesda, Maryland.
73. Freeman, M.C., Z.H. Bowen, K.D. Bovee and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11(1):179-190.
74. French, S.K. and J.D. Ackerman. 2014. Responses of newly settled juvenile mussels to bed shear stress: implications for dispersal. Freshwater Science 33(1):46-55.
75. Frick, E.A., D.J. Hippe, G.R. Buell, C.A. Couch, E.H. Hopkins, D.J. Wangsness, and J.W. Garrett. 1998. Water quality in the Apalachicola-Chattahoochee-Flint River basin, Georgia, Alabama, and Florida, 1992-95. U.S. Geological Survey Circular 1164. 38 p.
76. Fritts, A.K., M.W. Fritts, D.L. Peterson, D.A. Fox, and R.B. Bringolf. 2012. Critical linkage of imperiled species: Gulf Sturgeon as host for Purple Bankclimber mussels. Freshwater Science 31:1223-1232.
77. Fritts, A.K. and R.B. Bringoff 2014. Host fishes for four federally endangered freshwater mussels (Unionidae) in the Apalachicola-Chattahoochee-Flint River basin. Walkerana 17(2):51-59.
78. Fuller, S.L.H. 1974. Clams and mussels (Mollusca: Bivalvia). Pp. 215-273 in: C.W. Hart and S.L.H. Fuller, editors. Pollution ecology of freshwater invertebrates. Academic Press, New York.
79. Fuller, S.L.H., and D.J. Bereza. 1973. Recent additions to the naiad fauna of the eastern Gulf drainage (Bivalvia: Unionoida: Unionidae). Association of Southeastern Biologists Bulletin 20(2):53.
80. Gangloff, M.M. 2011. Fat threeridge (*Amlema neislerii*) and Chipola slabshell (*Elliptio chipolaensis*) population size and depth distribution study in the Apalachicola and Lower Chipola rivers. Unpublished draft report prepared for U.S. Army Corps of Engineers, Mobile District, Mobile, AL. and Aerostar Environmental Services, Inc., Jacksonville, FL.
81. Gangloff, M.M. 2012. Population size and depth distribution of three federally-protected mussels in the Apalachicola and lower Chipola rivers. Final Report to the U.S. Army Corps of Engineers, Mobile District, Mobile, Alabama.
82. Garcia, X.F., I. Schnauder, and M.T. Pusch. 2012. Complex hydromorphology of meanders can support benthic invertebrate diversity in rivers. Hydrobiologia 685:49-68.
83. Garner, J.T., T. Tarpley, M. Buntin, S.W. McGregor. 2007. Chipola River headwaters mussel survey. Section 6 fiscal year 2006-2007 annual report. Alabama Department of Conservation and Natural Resources Division of Wildlife and Freshwater Fisheries and Geological Survey of Alabama.
84. Gatenby, C.M., R.J. Neves, and B.C. Parker. 1996. Influence of sediment and algal food on cultured juvenile freshwater mussels. Journal of the North American Benthological Society 15(4):597-609.
85. Gates, K.K., C.C. Vaughn, and J.P. Julian. 2015. Developing environmental flow recommendations for freshwater mussels using the biological traits of species guilds. Freshwater Biology 60:620-635.

86. Geist, D.R., R.S. Brown, V. Cullinan, S.R. Brink, K. Lepla, P. Bates, and J.A. Chandler. 2005. Movement, swimming speed, and oxygen consumption of juvenile White Sturgeon in response to changing flow, water temperature, and light level in the Snake River, Idaho. Transactions of the American Fisheries Society 134(4):803-816
87. Gibson, C.A., J.L. Meyer, N.L. Poff, L.E. Hay, and A. Georgakakos. 2005. Flow regime alterations under changing climate in two river basins: implications for freshwater ecosystems. River Research and Applications 21:849-864.
88. Golladay, S.W., P. Gagnon, M. Kearns, J.M. Battle, and D.W. Hicks. 2004. Response of freshwater mussel assemblages (Bivalvia:Unionidae) to a record drought in the Gulf Coastal Plain of Southwestern Georgia. Journal of the North American Benthological Society 23(3):494-506.
89. Graf, W.L. 2006. Downstream hydrologic and geomorphic effects of large dams on American rivers. Geomorphology 79:336-360.
90. Gross, M.R., J. Repka, C.T. Robertson, D.H. Secor, and W. Van Winkle. 2002. Sturgeon conservation: insights from elasticity analysis. American Fisheries Society Symposium 28:13-30.
91. Gu, B., D.M. Schell, T. Frazer, M. Hoyer, and F.A. Chapman. 2001. Stable carbon isotope evidence for reduced feeding of Gulf of Mexico sturgeon during their prolonged river residence period. Estuarine, Coastal, and Shelf Science 53:275-280.
92. Guillory, V. 1979. Utilization of an inundated floodplain by Mississippi River fishes. Florida Scientist 42:222-228.
93. Gutreuter, S., A.D. Bartles, K. Irons, and M.B. Sandheinrich. 1999. Evaluation of the flood-pulse concept based on statistical models of growth of selected fishes of the upper Mississippi River. Canadian Journal of Fisheries and Aquatic Sciences 56:2282-2291.
94. Haag, W.R. 2012. North American freshwater mussels: natural history, ecology, and conservation. Cambridge University Press.
95. Haag, W.R., and A.M. Commens-Carson. 2008. Testing the assumption of annual shell ring deposition in freshwater mussels. Canadian Journal of Fisheries and Aquatic Science 65:493-508.
96. Haag, W.R., and J.L. Staton. 2003. Variation in fecundity and other reproductive traits in freshwater mussels. Freshwater Biology 48:2118-2130.
97. Haag, W.R., and M.L. Warren, Jr. 1997. Host fish and reproductive biology of six freshwater mussel species from the Mobile Basin, USA. Journal of the North American Benthological Society 16:576-585.
98. Haag, W.R., and M.L. Warren, Jr. 1998. Role of ecological factors and reproductive strategies in structuring freshwater mussel communities. Canadian Journal of Fisheries and Aquatic Sciences 55:297-306.
99. Haag, W.R., and M.L. Warren. 2008. Effects of severe drought on freshwater mussel assemblages. Transactions of the American Fisheries Society 137:1165-1178.
100. Haag, W.R., R.S. Butler, and P.D. Hartfield. 1995. An extraordinary reproductive strategy in freshwater bivalves: prey mimicry to facilitate larval dispersal. Freshwater Biology 34:471-476.
101. Haag, W.R., and A.L. Rypel. 2010. Growth and longevity in freshwater mussels: evolutionary and conservation implications. Biological Reviews 86:225-247.

102. Hamel, M.J., J.J. Spurgeon, M.A. Pegg, J.J. Hammen, and M.L. Rugg. 2014. Hydrologic variability influences local probability of Pallid Sturgeon occurrence in a Missouri River tributary. River Research and Applications 32(3):320-329.

103. Hardison, B.S., and J.B. Layzer. 2001. Relations between complex hydraulics and the localized distribution of mussels in three regulated rivers. Regulated Rivers: Research and Management 17:77-84.

104. Hardy, R.S., and Litvak, and M.K. 2004. Effects of temperature on the early development, growth, and survival of Shortnose Sturgeon, *Acipenser brevirostrum*, and Atlantic Sturgeon, *Acipenser oxyrhynchus*, yolk-sac larvae. Environmental Biology of Fishes 70:145-154.

105. Harris, J.E., D.C. Parkyn, and D.J. Murie. 2005. Distribution of Gulf of Mexico sturgeon in relation to benthic invertebrate prey resources and environmental parameters in the Suwannee River estuary, Florida. Transactions of the American Fisheries Society 134:975-990.

106. Hartfield, P.D. 1993. Headcuts and their effect on freshwater mussels. Pp. 131-141 in: K.S. Cummings, A.C. Buchanan, and L.M. Koch, editors. Conservation and management of freshwater mussels. Proceedings of a symposium, October 1992, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

107. Hartzog, A. 2011. Host fish assessment and gravidity for the mussel *Elliptoideus sloatianus*. Unpublished final report prepared for the US Fish and Wildlife Service, Warm Springs National Fish Hatchery, Warm Springs, Georgia.

108. Harvey, M.D. 2007. Cursory fluvial geomorphic evaluation of the Apalachicola River in support of the Jim Woodruff Dam Interim Operations Plan: Summary of Findings, pp. 25.

109. Hassell, M.P. 2000. Host-parasitoid populations dynamics. Journal of Animal Ecology 69:543-566.

110. Hastie, L.C., P.J. Boon, M.R. Young, and S. Way. 2001. The effect of a major flood on an endangered freshwater mussel population. Biological Conservation 98:107-115.

111. Heard, W.H. 1975. Determination of the endangered status of freshwater clams of the Gulf and Southeastern United States. Terminal Report for the Office of Endangered Species, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior (Contract 14-16-000-8905).

112. Heard, W.H. 1979. Identification manual of the freshwater clams of Florida. Unpublished report, Florida Department of Environmental Regulation Technical Series 4. 83 pp.

113. Heard, R.W., J.L. McLelland, and J.M. Foster. 2000. Benthic invertebrate community analysis of Choctawhatchee bay in relation to Gulf sturgeon foraging: an overview of year 1. Interim report to the Florida Fish and Wildlife Conservation Commission, St. Petersburg.

114. Heise, R.J., S.T. Ross, M.F. Cashner, and W.T. Slack. 1999a. Movement and habitat use of the Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the Pascagoula drainage of Mississippi: year 3. Museum Technical Report No. 74. Funded by U.S. Fish and Wildlife Service, Project No. E-1, Segment 14.

115. Heise, R.J., S.T. Ross, M.F. Cashner, and W.T. Slack. 1999b. Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the Pascagoula Bay and Mississippi Sound. Museum Technical Report No. 76.
116. Hightower, J.E., K.P. Zehfuss, D.A. Fox, and F.M. Parauka. 2002. Summer habitat use by Gulf sturgeon in the Choctawhatchee River, Florida. Journal of Applied Ichthyology 18:595-600.
117. Hook, J.E., G. Hoogenboom, J. Paz, J. Mullen, J. Bergstrom, and P. Risse. 2010. Agricultural irrigation water demand: Georgia's major and minor crops 2011 – 2050. [Available at: http://www.nespal.org/SIRP/waterinfo/State/AWD/AgWaterDemand.htm and http://gfvga.org/wp-content/uploads/2010/03/3.-Forecasting-Georgias-Irrigation-Water-Needs.pdf].
118. Hove, M.C., and R.J. Neves. 1994. Life history of the endangered James spinymussel *Pleurobema collina* (Conrad, 1837) (Mollusca: Unionidae). American Malacological Bulletin 11(1):29-40.
119. Huff, J.A. 1975. Life History of the Gulf of Mexico Sturgeon, *Acipenser oxyrhynchus desotoi* in Suwannee River, Florida. Mar. Res. Publ. No. 16. 32 pp.
120. Humphries, P., and P.S. Lake. 2000. Fish larvae and the management of regulated rivers. Regulated Rivers: Research and Management 16:421-432.
121. Hupp, C.R. 2000. Hydrology, geomorphology, and vegetation of coastal plain rivers in the south-eastern USA. Hydrological Processes 14:2991-3010.
122. Iowa Mussel Team (IMT). 2002. Freshwater Mussels of Iowa. [Available at: https://www.fws.gov/midwest/mussel/documents/freshwater_mussels_of_iowa.pdf].
123. Isom, B.G., and R.G. Hudson. 1982. In Vitro culture of parasitic freshwater mussel glochidia. The Nautilus 96(4):147-151.
124. Jacobson, R.B., M.J. Parsley, M.L. Annis, M.E. Colvin, T.L. Welker, and D. James. 2015. Development of conceptual ecological models linking management of the Missouri River to pallid sturgeon population dynamics: U.S. Geological Survey Open-File Report 2015-1038. 47 p. [Available at http://dx.doi.org/10.3133/ofr20151038].
125. Janac, M., M. Ondrackova, P. Jurajda, Z. Valova, and M. Reichard. 2010. Flood duration determines the reproduction success of fish in artificial oxbows in a floodplain of a potamal river. Ecology of Freshwater Fish 19:644-655.
126. Jeanne, D.G. 2002. A history of the Mobile District USACE of Engineers, 1815-1985. U.S. Army Corps of Engineers, Mobile District. 119+pp.
127. Johnson, P.M., A.E. Liner, S.W. Golladay, and W.K. Michener. 2001. Effects of drought on freshwater mussels and instream habitat in coastal plain tributaries of the Flint River, southwest Georgia (July-October, 2000). Jones Ecological Research Center, unpublished report to The Nature Conservancy dated February 1, 2001, Newton, GA.
128. Jones, L.E., and L.J. Torak. 2006. Simulated effects of seasonal ground-water pumpage for irrigation on hydrologic conditions in the Lower Apalachicola-Chattahoochee-Flint River Basin, Southwestern Georgia and parts of Alabama and Florida, 1999-2002. US Geologic Survey Scientific Investigations Report 2006-5234.
129. Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems, Pp. 110-127 in: D. P. Dodge, editor. Proceedings of the International Large River Symposium. Canadian Special Publication of Fisheries and Aquatic Sciences106.

130. Kaeser, A.J., T.L. Litts, and T.W. Tracy. 2013. Using low-cost side-scan sonar for benthic mapping throughout the Lower Flint River, Georgia, USA. River Research and Applications 29(5):634-644.

131. Kennedy, T.A., J.D. Muehlbauer, C.B. Yackulic, D.A. Lytle, S.W. Miller, K.L. Dibble, E.W. Kortenhoeven, A.N. Metcalfe and C.V. Baxter. 2016. Flow management for hydropower extirpates aquatic insects, undermining river food webs. BioScience doi:10.1093/biosci/biw059.

132. Kilgore, K.J., and J.A. Baker. 1996. Patterns of larval fish abundance in a bottomland hardwood wetland. Wetlands 16(3):288-295.

133. King T.L., B.A. Lubinski, and A.P. Spidle. 2001. Microsatellite DNA variation in Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and cross-species amplification in the Acipenseridae. Conservation Genetics 2(2):103-119.

134. King, A.J., D.A. Crook, W.M. Koster, J. Mahoney, and Z. Tonkin. 2005. Comparison of larval fish drift in the Lower Goulburn and mid-Murray Rivers. Ecological Management and Restoration 6(2):136-139.

135. Kingsolving A.D., and M.B. Bain. 1993. Fish assemblage recovery along a riverine disturbance gradient. Ecological Applications 3:531-544.

136. Kistenmacher, M., and A.P. Georgakakos. 2011. Environmental Flow and Ecological Impacts of Alternative Regulation Scenarios for the ACF River Basin. Proceedings of the 2011 Georgia Water Resources Conference, April 11, 12, and 13, 2011, Athens, Georgia. [Available at: https://smartech.gatech.edu/handle/1853/46111].

137. Kistenmacher, M., and A.P. Georgakakos. 2015. Assessment of reservoir system variable forecasts. Water Resources Research 51(5):3437-3458.

138. Korman, J. and S.E. Campana. 2009. Effects of hydropeaking on nearshore habitat use and growth of age-0 rainbow trout in a large regulated river. Transactions of the American Fisheries Society138:76-87

139. Kraemer, L.R. 1979. *Corbicula* (Bivalvia: Sphaeriacea) *vs*. indigenous mussels (Bivalvia: Unionacea) in U.S. rivers: a hard case for interspecific competition? American Zoologist 19:1085-1096.

140. Kynard, B. 1997. Life history, latitudinal patterns, and status of the shortnose sturgeon, *Acipenser brevirostrum*. Environmental Biology of Fishes 48:319-334.

140.1. Kynard, B., and M. Horgan. 2002. Ontogenetic Behavior and Migration of Atlantic Sturgeon, *Acipenser oxyrinchus oxyrinchus*, and Shortnose Sturgeon, *A. brevirostrum*, with Notes on Social Behavior. Environmental Biology of Fishes 63:137-150.

141. Kynard, B. and E. Parker. 2004. Ontogenetic behavior and migration of Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*, with notes on body color and development Environmental Biology of Fishes70:43-55.

142. Layzer, J., and E.M. Scott. 2006. Restoration and colonization of freshwater mussels and fish in a southeastern United States tailwater. River Research and Applications 22(4):475-491.

143. Lefevre, G., and W.C. Curtis. 1912. Studies on the reproduction and artificial propagation of freshwater mussels. Bulletin of the U.S. Bureau of Fisheries 30:105-201.

144. Leff, L.G., J.L. Burch, and J.V. McArthur. 1990. Spatial distribution, seston removal, and potential competitive interactions of the bivalves *Corbicula fluminea* and *Elliptio complanata*, in a Coastal Plain stream. Freshwater Biology 24:409-416.

145. Leitman S., W. Pine, and G. Kiker. 2016. Management options during the 2011-2012 drought on the Apalachicola River: a systems dynamic model evaluation. Journal of Environmental Management 58(2):193-207.
146. Leitman, S., and G.A. Kiker. 2015. Development and comparison of integrated river/reservoir models in the Apalachicola-Chattahoochee-Flint basin, USA. Environment, Systems and Decisions 35:410-423.
147. Leopold, L.B. 1994. A view of the river. Harvard University Press, Cambridge, MA. 298 pp.
148. Leopold, L.B., and M.G. Wolman. 1957. River channel patterns: braided, meandering, and straight. U.S. Geological Survey, Professional Paper 282B.
149. Lewis, J.B., and P.N. Riebel. 1984. The effect of substrate on burrowing in freshwater mussels (Unionidae). Canadian Journal of Zoology 62:2023-2025.
150. Lidstone and Anderson, Inc. 1989. An Investigation of the Effects of Apalachicola River Training Dikes on Sediment Transport and Bank Erosion. Unpublished final report submitted to the U.S. Army Corps of Engineers.
151. Liebig, H., R. Cereghino, P. Lim, A. Belaud, and S. Lek. 1999. Impact of hydropeaking on the abundance of juvenile brown trout in a Pyrenean stream. Archiv fur Hydrobiologie 144(4):49-454.
152. Light, H.M, M.R. Darst, and J.W. Grubbs. 1998. Aquatic habitats in relation to river flow in the Apalachicola River floodplain, Florida. U.S. Geological Survey Professional Paper 1594.
153. Light, H.M., K.R. Vincent, M.R. Darst, and F.D. Price. 2006. Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173, 83 p., plus CD.
153.1. Livingston, R.J. 1997. Trophic response of estuarine fishes to long-term changes in river runoff. Bulletin of Marine Science 60(3):984-1004.
154. Livingston, R.J., X. Niu, G.F. Lewis, G.C. Woodsum. 1997. Freshwater input to a Gulf estuary: long-term control of trophic organization. Ecological Applications 17:277-299.
155. Maiolini, B., L. Silveri, and V. Lencioni. 2007. Hydroelectric power generation and disruption of the natural stream flow: effects on the zoobenthic community. Studi trentini di scienze naturali, Acta biologia 83:21-26.
156. Marbury, J.A. 2016. Assessing Gulf sturgeon recruitment in the Apalachicola-Chattahoochee-Flint River Basin. Masters Thesis. University of Georgia, Athens. 114 p.
157. Marchant, R.S., and M.K. Shutters. 1996. Artificial substrates collect Gulf sturgeon eggs. North American Journal of Fisheries Management 16:445-447.
158. Mason, W.T. and J.P. Clugston. 1993. Foods of the gulf sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 122:378-385.
159. McAdam, S.O. 2011. Effects of substrate condition on habitat use and survival by white sturgeon (*Acipenser transmontanus*) larvae and potential implications for recruitment. Canadian Journal of Fish and Aquatic Science 68:812-822.
160. McCann, M.T. 2005. Survey for the threatened purple bankclimber (*Elliptoideus sloatianus*) in the middle reach of the Flint River, Georgia. Abstract from the 4th Biennial

Symposium of the Freshwater Mollusk Conservation Society, St. Paul, Minnesota, May 15-18, 2005.

161. McCuaig, J.M. and R.H. Green. 1983. Unionid growth curves derived from annual growth rings: a baseline model for Long Point Bay, Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences 40:436-442.

162. McDowall, R.M. 1988. Diadromy in fishes migrations between freshwater and marine environments. Truder Press and Croom Helm. 308pp.

163. McMahon, R.F. 1979. Response to temperature and hypoxia in the oxygen consumption of the introduced Asiatic freshwater clam, *Corbicula fluminea* (Muller). Comparative Biochemistry and Physiology 63A:383-388.

164. McMahon, R.F., and A.E. Bogan. 2001. Bivalves. Pp 331-428 in: J.H. Thorp and A.P. Covich, editors. Ecology and classification of North American freshwater invertebrates. Second edition. Academic Press, New York, NY.

165. Merritt, R.W. and K.W. Cummins. 1996. An introduction to the aquatic insects of North America. Third Edition. Kendall/Hunt Publishing Company, Dubuque, IA.

166. Metcalf, A.L. 1983. Mortality in unionacean mussels in a year of drought. Transactions of the Kansas Academy of Science 86:89-92.

167. Metcalf, C.K., S.D. Wilkerson, and W.A. Harman. 2009. Bankfull regional curves for North and Northwest Florida streams. Journal of the American Water Resources Association 45(5):1260-1272.

168. Miller, P.S. 2008. Preliminary Population Viability Analysis for Fat Threeridge Mussel (*Amblema neislerii*). Unpublished final report. IUCN / SSC Conservation Breeding Specialist Group. 21 pp.

169. Miller, A.C. 2011a. Comments on the reinitiated consultation concerning the U.S. Army Corps of Engineers' Revised Interim Operations Plan for Jim Woodruff Lock and Dam. Letter from to Dr. Donald Imm (USFWS) dated August 21, 2011.

170. Miller, P.S. 2011b. Revised Population Viability Analysis for the Fat Threeridge Mussel (*Amblema neislerii*). Unpublished final report. IUCN / SSC Conservation Breeding Specialist Group. 23 pp.

171. Miller, A.C., and B.S. Payne. 2005. Depth distribution of the fat threeridge mussel *Amblema neislerii*, during low flow stages on the Apalachicola River. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Unpublished draft report, 31 p.

172. Miller, A.C., and B.S. Payne. 2006. The fat threeridge (*Amblema neislerii*), the surprisingly common endangered mussel in the Apalachicola River, Florida. Environmental Laboratory, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

173. Miller, A.C., and B.S. Payne. 2007. Factors determining abundance and distribution of the endangered fat threeridge mussel, *Amblema neislerii*, in the Apalachicola River, Florida. Ecological Applications Tallahassee, Florida, and Environmental Laboratory, US Army Engineer Research and Development Center, Vicksburg, Mississippi.

174. Moog, O. 1993. Quantification of peak hydropower effects on aquatic fauna and management to minimize environmental impacts. Regulated Rivers: Research and Management 8:5-14.

175. Morales, Y., L. J. Weber, A.E. Mynett, and T.J. Newton. 2006. Effects of substrate and hydrodynamic conditions on the formation of mussel beds in a large river. Journal of the North American Benthological Society 25(3):664-676.
176. Morrow, J.V, K.J. Killgore, J.P. Kirk, and H.E. Rogillio. 1996. Distribution and population attributes of Gulf sturgeon in the lower Pearl River System, Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 50:79-90.
177. Mundt, C.C., L.D. Sackett, L.D. Wallace, C. Cowger, and J.P. Dudley. 2009. Long-distance dispersal and accelerating waves of disease: empirical relationships. American Naturalist 173:456-466.
178. Murchie, K.J., K.P.E. Hair, C.E. Pullen, T.D. Redpath, H.R. Stephens, and S.J. Cooke. 2008. Fish response to modified flow regimes in regulated rives: research methods, effects and opportunities. River Research and Applications 24:197-217.
179. National Oceanic and Atmospheric Administration (NOAA). 2016. National Climatic Data Center. Asheville, NC. [Available at: http://www.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgr.html].
180. Negus, C.L. 1966. A quantitative study of growth and production of unionid mussels in the River Thames at Reading. Journal of Animal Ecology 35:513-532.
181. Neves, R.J. 1993. A state-of-the-unionids address. Pp 1-10 in: K.S. Cummings, A.C. Buchanan, and L.M. Koch, editors. Conservation and management of freshwater mussels. Proceedings of an Upper Mississippi River Conservation Committee symposium, October 1992, St. Louis, Missouri. UMRCC, Rock Island, Illinois.
182. Neves, R.J., and S.N. Moyer. 1988. Evaluation of techniques for age determination of freshwater mussels (Unionidae). American Malacological Bulletin Vol. 6(2):179-188.
183. Neves, R.J., and J.C. Widlak. 1987. Habitat ecology of juvenile freshwater mussels (Bivalvia: Unionidae) in a headwater stream in Virginia. American Malacological Bulletin 5(1):1-7.
184. Neves, R.J., and J.C. Widlak. 1988. Occurrence of glochidia in stream drift and on fishes of the upper North Fork Holston River, Virginia. American Midland Naturalist 119(1):111-120.
185. Neves, R.J., L.R. Weaver, and A.V. Zale. 1985. An evaluation of host fish suitability for glochidia of *Villosa vanuxemi* and *V. nebulosa* (Pelecypoda: Unionidae). American Midland Naturalist 113(1):13-19.
186. Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, and P.D. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pp. 43-85 in: G.W. Benz and D.E. Collins, editors, Aquatic fauna in peril: the southeastern perspective. Southeast Aquatic Research Institute, Special Publication 1, Lenz Design and Communications, Decatur, GA.
187. Newton, T.J., S.J. Zigler, and B.R. Gray. 2015. Mortality, movement and behaviour of native mussels during a planned water-level drawdown in the Upper Mississippi River. Freshwater Biology 60:1-15.
188. O'Brien, C.A., and J. Brim Box. 1999. Reproductive biology and juvenile recruitment of the shinyrayed pocketbook, *Lampsilis subangulata* (Bivalvia: Unionidae) in the Gulf Coastal Plain. American Midland Naturalist 142:129-140.

189. O'Brien, C.A., and J.D. Williams. 2002. Reproductive biology of four freshwater mussels (Bivalvia: Unionidae) endemic to the eastern Gulf Coastal Plain drainages of Alabama, Florida, and Georgia. American Malacological Bulletin 17(1/2):147-158.
190. Odenkirk, J.S. 1989. Movement of Gulf of Mexico sturgeon in the Apalachicola River, Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 43:230-238.
191. Palmer, R.N. 1998. A History of Shared Vision Modeling in the ACT-ACF Comprehensive Study: A Modeler's Perspective. Pp. 221-226. in: W. Whipple Jr., editor. Proceedings of Special Session of ASCE's 25th Annual Conference on Water Resources Planning and Management and the 1998 Annual Conference on Environmental Engineering. Chicago, IL.
192. Panel on Adaptive Management for Resource Stewardship (PAMRS) 2004. Adaptive Management for Water Resources Project Planning. Panel on Adaptive Management for Resource Stewardship, Committee to Assess the U.S. Army Corps of Engineers Methods of Analysis and Peer Review for Water Resources Project Planning, National Research Council. National Academies Press, Washington, DC. pp. 138.
193. Parauka, F.M., S.K. Alam, and D.A. Fox. 2001. Movement and habitat use of subadult Gulf sturgeon in Choctawhatchee Bay, Florida. Proceedings Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 55:280-297.
194. Parauka, F.M., W.J. Troxel, F.A. Chapman, and L.G. McBay. 1991. Hormone-induced ovulation and artificial spawning of Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*. Progressive Fish-Culturist 53:113-117.
195. Parkyn, D.C., D.J. Murie, J.E. Harris, D.E. Colle, and J.D. Holloway. 2007. Seasonal movements of Gulf of Mexico sturgeon in the Suwannee River and estuary. Pp. 51-68 in: J. Munro, D. Hatin, J. E. Hightower, K. McKown, K. J. Sulak, A. W. Kahnle, and F. Caron, editors. Anadromous sturgeons: habitats, threats, and management. American Fisheries Society Symposium 56. Bethesda, Maryland.
196. Pederson N., A.R. Bell, T.A. Knight, C. Leland, N. Malcomb, K.J. Anchukaitis, K. Tackett, J. Scheff, A. Brice, B. Cantron, W. Blozan, J. Riddle. 2012. A long-term perspective on a modern drought in the American Southeast. Environmental Research Letters 7(1):014034.
197. Perles, S. J., A.D. Christian, D.J. Berg. 2003. Vertical migration, orientation, aggregation, and fecundity of the freshwater mussel *Lampsilis siliquoidea*. Ohio Journal of Science 103(4):73-78.
198. Petts, G.E. 1984. Impounded rivers: perspectives for ecological management. John Wiley and Sons, New York.
199. Pine III, W.E and M.S. Allen. 2005. Assessing the impact of reduced spawning habitat on Gulf sturgeon recruitment and population viability in the Apalachicola Bay system. Unpublished final report to the U.S. Fish and Wildlife Service. Agreement NO: 401814G069 34 pp.
200. Pine III, W.E., M.S. Allen, and V.J. Dreitz. 2001. Population viability of the Gulf of Mexico sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 130:1164-1174.
201. Pine III, W. E., O.T. Burgess, S.J. Walsh, A.C. Dutterer. 2006. Examination of fish spawning, movement, and habitat utilization patterns in the Battle Bend region of the

Apalachicola River, Florida. Unpublished final report to the Florida Fish and Wildlife Conservation Commission, Tallahassee, FL 39pp.

202. Poff, N.L., and J.V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: a regional analysis of streamflow patterns. Canadian Journal of Fisheries and Aquatic Sciences 46:1805-1818.

202.1. Poff, N.L., and J.C. Schmidt. 2016. How dams can go with the flow. Science 353(6304):1099-1100.

203. Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime. BioScience 47:769-784.

204. Preister, L. 2008. Life History Observations and Determination of Potential Host Fish Species for Chipola Slabshell, *Elliptio chipolaensis*. Masters Thesis, Columbus State University, Columbus, Georgia pp. 51.

205. Price, J.E., and C.B. Eads. 2011. Brooding patterns in three freshwater mussels of the genus *Elliptio* in the Broad River, South Carolina. American Malacological Bulletin 29:121-126.

206. Price, F.D., H.M. Light, M.R. Darst, E.R. Griffin, K.R. Vincent, and J.W. Ziewitz. 2006. Change in channel width from 1941 to 2004, and change in mean bed elevation from 1960 to 2001, in the nontidal Apalachicola River, Florida. U.S. Geological Survey. [Available at: http://fl.water.usgs.gov/Water_data/ApalachRchannel_change.html].

207. Raibley, P.T., T.M. O'Hara, K.S. Irons, K.D. Blodgett, and R.E. Sparks. 1997. Largemouth bass size distributions under varying annual hydrological regimes in the Illinois River. Transactions of the American Fisheries Society 126:850-856.

208. Randall, M.T., and K.J. Sulak. 2012. Evidence of autumn spawning in Suwannee River Gulf sturgeon, *Acipenser oxyrinchus desotoi* (Vladykov, 1955). Journal of Applied Ichthyology 28:489-495.

209. Reckendorfer, W., A. Funk, C. Gschopf, T. Hein, and F. Schiemer. 2013. Aquatic ecosystem functions of an isolated floodplain and their implications for flood retention and management. Journal of Applied Ecology 50:119-128.

210. Reynolds, C.R. 1993. Gulf sturgeon sightings, historic and recent - a summary of public responses. U.S. Fish and Wildlife Service. Panama City, Florida. 40pp.

211. Ribeiro, F., P.K. Crain, and P.B. Moyle. 2004. Variation in condition factor and growth of young-of-year fishes in floodplain and riverine habitats of the Consumnes River California. Hydrobiologia 527(1):77-84.

211.1. Richmond, A.M., and B. Kynard. 1995. Ontogenetic behavior of shortnose sturgeon, *Acipenser brevirostrum*. Copeia 1995(1):172-182.

212. Ritter, A., and R. Muñoz-Carpena. 2013. Predictive ability of hydrological models: objective assessment of goodness-of-fit with statistical significance. Journal of Hydrology 480(1):33-45.

213. Roe, K.J. and P.D. Hartfield. 2005. Hamiota, a new genus of freshwater mussel (Bivalvia: Unionidae) from the Gulf of Mexico drainages of the southeastern United States. Nautilus 119(1):1-10.

214. Rogers, M.W., M.S. Allen, and M.D. Jones. 2005. Relationship between river surface level and fish assemblage in the Ocklawaha River, Florida. River Research and Applications 21:501-511.

215. Rogillio, H.E., E.A. Rabalais, J.S. Forester, C.N. Doolittle, W.J. Granger, and J.P. Kirk. 2002. Status, movement and habitat use study of Gulf sturgeon in the Lake Pontchartrain Basin, Louisiana. Louisiana Department of Wildlife and Fisheries. 43pp.
216. Rood, S.B., J.M. Mahoney, D.E. Reid, and L. Zilm. 1995. Instream flows and the decline of riparian cottonwoods along the St. Mary River, Alberta. Canadian Journal of Botany 73:1250-1260.
217. Roseman, E.F., B. Manny, J. Boase, M. Child, G. Kennedy, J. Craig, K. Soper, and R. Drouin. 2011a. Lake sturgeon response to a spawning reef constructed in the Detroit River. Journal of Applied Ichthyology 27:66-76.
218. Roseman, E.F., J. Boase, G. Kennedy, J. Craig, and K. Soper. 2011b. Adaptation of egg and larvae sampling techniques for lake sturgeon and broadcast spawning fishes in a deep river. Journal of Applied Ichthyology 27:89-92.
219. Ross, S.T., and J.A. Baker. 1983. The response of fishes to periodic spring floods in a southeastern stream. American Midland Naturalist 109(1):1-14.
220. Ross, S.T., R.J. Heise, W.T. Slack, J.A. Ewing, III, and M. Dugo. 2000. Movement and habitat use of the Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the Pascagoula drainage of Mississippi: year 4. Mississippi Department of Wildlife, Fisheries, and Parks and Museum of Natural Science. Funded by U.S. Fish and Wildlife Service, Project No. E-1, Segment 15. 58 pp.
221. Ross, S.T., R.J. Heise, W.T. Slack, and M.A. Dugo. 2001a. Gulf sturgeon habitat in the Gulf of Mexico. Annual Report, Submitted to Mississippi Alabama Sea Grant Consortium, project NA86RG0039-4.
222. Ross, S.T., R.J. Heise, W.T. Slack, and M. Dugo. 2001b. Habitat requirements of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the northern Gulf of Mexico. Final Report submitted to the Shell Marine Habitat Program, National Fish and Wildlife Foundation, Washington, D.C.
223. Rugel, K., S.W. Golladay, C.R. Jackson, and T.C. Rasmussen. 2016. Delineating groundwater/surface water interaction in a karst watershed: lower Flint River basin, SW Georgia, USA. Journal of Hydrology: Regional Studies 5:1-19.
224. Rypel, A.L., W.R. Haag, and R.H Findlay. 2008. Validation of annual growth rings in freshwater mussel shells using crossdating. Canadian Journal of Fisheries and Aquatic Science 65:2224-2232.
225. Sammons, S.M., and M.J. Maceina. 2009. Effects of river flows on growth of redbreast sunfish *Lepomis auritus* (Centrarchidae) in Georgia rivers. Journal of Fish Biology 74:1580-1593.
226. San Migel, E., S. Monserrat, C. Fernandez, R. Amaro, M. Hermida, P. Ondina, and C. R. Altaba. 2004. Growth models and longevity of freshwater pearl mussels (*Margaritifera margaritifera*) in Spain. Canadian Journal of Zoology 82:1370-1379.
227. Sauchyn, D.J., J.M. St-Jacques, E. Barrow, M.W. Nemeth, R.J MacDonald, A.M.S. Sheer, and D.P. Sheer. 2016. Adaptive water resources planning in the South Saskatchewan river basin: Use of scenarios of hydroclimate variability and extremes. Journal of the American Water Resources Association 52(1):222-240.
227.1. Schemel, L.E., T.R. Sommer, A.B. Muller-Solger, and W.C. Harrell. 2004. Hydrologic variability, water chemistry, and phytoplankton biomass in a large floodplain of the Sacramento River, CA, U.S.A. Hydrobiologia 513:129-139.

228. Schiemer F., H. Keckeis, W. Reckendorder, and G. Winkler. 2001. The “inshore retention concept” and its significance for large rivers. Archiv für Hydrobiologie, Supplement 12:509-516.

229. Schiemer F., H. Keckeis, and E. Kamler. 2003. The early life history stages of riverine fish: ecophysiological and environmental bottlenecks. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 133:439-449.

230. Schlosser, I.J. 1985. Flow regime, juvenile abundance, and the assemblage structure of stream fishes. Ecology 66:1484-1490.

231. Schludermann E., M. Tritthart, P. Humphries, and H. Keckeis. 2012. Dispersal and retention of larval fish in a potential nursery habitat of a large temperate river: an experimental study. Canadian Journal of Fisheries and Aquatic Sciences 69:1302-1315.

232. Schwalb, A.S., T.J. Morris, N.E. Mandrak, and K. Cottenie. 2012a. Distribution of unionid freshwater mussels depends on the distribution of host fishes on a regional scale. Diversity and Distributions 2012:1-9.

233. Schwalb, A.S., T.J. Morris, and J.D. Ackerman. 2012b. The effect of settling velocity on the transport of mussel larvae in a cobble-bed river: Water column and near-bed turbulence. Limnology and Oceanography: Fluids and Environments 2:28-40.

234. Scollan, D. and F.M. Parauka. 2008. Documentation of Gulf sturgeon spawning in the Apalachicola River, Florida. U. S. Fish and Wildlife Service, Panama City, Florida.

235. Scruton, D.A., C.J. Pennell, L.M.N. Ollerhead, K. Alfredsen, M. Stickler, A. Harby, M.J. Robertson, K.D. Clarke, and L.J. LeDrew. 2008. A synopsis of ‘hydropeaking’ studies on the response of Juvenile Atlantic Salmon to experimental flow alteration. Hydrobiologia 609:263-275.

236. Seager, R., A. Tzanova, and J. Nakamura. 2009. Drought in the southeastern United States: causes, variability over the last millennium, and the potential for future hydroclimate change. Journal of Climate 22:5021-5045.

237. Secor, D.H., and E.J. Niklitschek. 2001. Hypoxia and sturgeons. Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science. Technical Report Series, No. TS-314-01-CBL.

238. Sheer, A.M.S., M.W. Nemeth, D.P. Sheer, M. Van Ham, M. Kelly, D. Hill, and S.D. Lebherz. 2013. Developing a new operations plan for the Bow River basin using river basin collaborative modeling for decision support. Journal of the American Water Resources Association 49(3):654-668

239. Singer, E.E., and M.M. Gangloff. 2011. Effects of a small dam on freshwater mussel growth in an Alabama (U.S.A.) stream. Freshwater Biology 56:1904-1915.

240. Smit, R.B. 2014. Using sonar habitat mapping and GIS analyses to identify freshwater mussel habitat and estimate population size of a federally endangered freshwater mussel species, *Amblema neislerii*, in the Apalachicola River, FL. M.S. thesis Auburn University. 93pp.

241. Smit, R.B. and A.J. Kaeser. *In press.* Defining freshwater mussel mesohabitat associations in an alluvial, Coastal Plain river. Freshwater Science.

242. Smith, S. M., J.S. Odenkirk, and S.J. Reeser. 2005. Smallmouth bass recruitment variability and its relation to stream discharge in three Virginia rivers. North American Journal of Fisheries Management 25:1112-1121.

243. Smith, J.A., H.J. Flowers, and J.E. Hightower. 2015. Fall spawning of Atlantic Sturgeon in the Roanoke River, North Carolina. Transactions of the American Fisheries Society 144:48-54.
244. Sparks, B.L., and D.L. Strayer. 1998. Effects of low dissolved oxygen on juvenile *Elliptio complanata* (Bivalvia: Unionidae). Journal of the North American Benthological Society 17(1):129-134.
245. Stabile J., J.R. Waldman, F. Parauka, and W. Wirgin. 1996. Stock structure and homing fidelity in Gulf of Mexico Sturgeon (*Acipenser oxyrinchus desotoi*) based on restriction fragment length polymorphism and sequence analysis of mitochondrial DNA. Genetics 144:767-775.
246. Stahle, R.W., F.W. Fye, E.R. Cook, and R.D. Griffin. 2007. Tree-ring reconstructed mega droughts over North America since A.D. 1300. Climatic Change 83(1-2):133-149.
247. Stanford, J. A., and J.V. Ward. 1983. Insect species diversity as a function of environmental variability and disturbance in streams. Pp. 265-278 in: J.R. Barnes, and G.W. Minshall, editors. Stream Ecology: Application and Testing of General Ecological Theory. Plenum Press, New York, NY.
248. Stansbery, D.H. 1961. The naiads (Mollusca, Pelecypoda, Unionacea) of Fishery Bay, South Bass Island, Lake Erie. Sterkiana 5:1-37.
249. Stansbery, D.H. 1971. Rare and endangered molluscs in the eastern United States. Pp. 5-18 in: S.E. Jorgensen and R.W. Sharpe, editors. Proceedings of a symposium on rare and 121 endangered mollusks (naiads) of the United States. U.S. Fish and Wildlife Service, Twin Cities, Minnesota.
250. Strayer, D.L. 1999. Use of flow refuges by unionid mussels in rivers. Journal of the North American Benthological Society 18(4):468-476.
251. Strayer, D.L. 2008. Freshwater mussel ecology: a multifactor approach to distribution and abundance. University of California Press, Berkeley. 204pp.
252. Strayer, D.L., and J. Ralley. 1993. Microhabitat use by an assemblage of stream-dwelling unionaceans (Bivalvia), including two rare species of *Alasmidonta*. Journal of the North American Benthological Society 12(3):247-258.
253. Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, and S.J. Nichols. 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. BioScience 54:429-439.
254. Sulak, K.J., and J.P. Clugston. 1998. Early life history stages of the Gulf sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 127:758-771.
255. Sulak, K.J., and J.P. Clugston. 1999. Recent advances in life history of the Gulf of Mexico sturgeon *Acipenser oxyrinchus desotoi*, in the Suwannee River, Florida, USA: a synopsis. Journal of Applied Ichthyology 15:166-128.
256. Sulak, K.J., M. Randall, J. Clugston, and W.H. Clark. 2004. Critical spawning habitat, early life history requirements, and other life history and population aspects of the Gulf sturgeon in the Suwannee River. Final Report to the Florida Fish and Wildlife Conservation Commission, Nongame Wildlife Program. U.S. Geological Survey, Gainesville, FL.
257. Sulak, K.J., R.A. Brooks, and M.T. Randall. 2007. Seasonal refugia and trophic dormancy in Gulf sturgeon: test and refutation of the thermal barrier hypothesis. Pp. 19-

50 in: J. Munro, D. Hatin, J. E. Hightower, K. McKown, K. J. Sulak, A. W. Kahnle, and F. Caron, editors. Anadromous sturgeons: habitats, threats, and management. American Fisheries Society Symposium 56. Bethesda, Maryland.

258. Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Paruaka, S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf Sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology 25:505-515.
259. Sulak, K.J., M.T. Randall, and J.J. Berg. 2012. Feeding habitats of the Gulf sturgeon, *Acipenser oxyrinchus desotoi*, in the Suwannee and Yellow rivers, Florida, as identified by multiple stable isotope analyses. Environmental Biology of Fishes 95:237-258.
260. Surber, T. 1912. Identification of the glochidia of freshwater mussels. U.S. Bureau of Fisheries Document No. 771. 10pp.
261. Sylvester, J.R., L.E. Holland, and T.K. Kammer. 1984. Observations on burrowing rates and comments on host specificity in the endangered mussel *Lampsilis higginsi*. Journal of Freshwater Ecology 2(6):555-559.
262. Taylor, M.K., and S.J. Cooke. 2012. Meta-analyses of the effects of river flow on fish movement and activity. Environmental Reviews 20:211-219.
263. Tramer, E.J. 1978. Catastrophic mortality of stream fishes tapped in shrinking pools. American Midland Naturalist 115:667-695.
264. Turner, T.F., J.P. Wares, and J.R. Gold. 2002. Genetic effective size is three orders of magnitude smaller than adult census size in an abundant, estuarine-dependent marine fish (*Sciaenops ocellatus*). Genetics 162:1329-1339.
265. Turner, T.F., M.J. Osborne, G.R. Moyer, M.A. Benavides, and D. Alò. 2006. Life history and environmental variation interact to determine the effective population to census size ratio. Proceedings of the Royal Society Series B 273:3065-3073.
266. U.S. Army Corps of Engineers (USACE). 2013. Benchmarks for Incorporating Adaptive Management into Water Project Designs, Operational Procedures, and Planning Strategies. Report I. Federal Agency Inventory of Adaptive Management Practices and Policies. U.S. Army Engineer Institute for Water Resources, Alexandria, Virginia. 28pp.
267. U.S. Army Corps of Engineers (USACE). 2014. Apalachicola-Chattahoochee-Flint (ACF) Watershed: HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Supply Storage Assessment. Prepared by US Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center for the Mobile District, Planning and Environmental Division, Mobile, Alabama. 730pp.
268. U.S. Army Corps of Engineers (USACE). 2015a. Draft Environmental Impact Statement. Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment. Prepared Tetra Tech for the Mobile District, Planning and Environmental Division, Mobile, Alabama. 794pp.
269. U.S. Army Corps of Engineers (USACE). 2015b. Sustainable Solutions To America's Water Resource Needs: Civil Works Strategic Plan 2014-2018. U.S. Army Corps of Engineers, Washington, DC.
270. U.S. Army Corps of Engineers (USACE). 2016. Revised Amended Biological Assessment: Update of the Water Control Manual for the Apalachicola-Chattahoochee-

Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment. Prepared by the Mobile District, Planning and Environmental Division, Mobile, Alabama. 75 + 7 + 2pp.

271. U.S. Fish and Wildlife Service (USFWS) and Gulf States Marine Fisheries Commission. 1995. Gulf Sturgeon Recovery Plan. Atlanta, Georgia. 170pp.
272. U.S. Fish and Wildlife Service (USFWS). 1998a. Endangered and threatened wildlife and plants; determination of endangered status for five freshwater mussels and threatened status for two freshwater mussels from the eastern Gulf Slope drainages of Alabama, Florida, and Georgia. Federal Register 63:12664-12687.
273. U.S. Fish and Wildlife Service (USFWS). 1998b. Final Endangered Species Act Section 7 Consultation Handbook, March 1998. U.S. Government Printing Office ISBN 0-16-049596-2.
274. U.S. Fish and Wildlife Service (USFWS). 2003. United States Fish and Wildlife Service. Recovery plan for endangered fat threeridge (*Amblema neislerii*), shinyrayed pocketbook (*Lampsilis subangulata*), Gulf moccasinshell (*Medionidus penicillatus*), Ochlockonee moccasinshell (*Medionidus simpsonianus*), and oval pigtoe (*Pleurobema pyriforme*); and threatened Chipola slabshell (*Elliptio chipolaensis*), and purple bankclimber (*Elliptoideus sloatianus*). Atlanta, Georgia.
275. U.S. Fish and Wildlife Service (USWFS). 2006. Biological opinion and conference report on the U.S. Army Corps of Engineers, Mobile District, interim operation plan for Jim Woodruff Dam and the associated released to the Apalachicola River. Prepared by the USFWS Panama City Field Office, Florida. 165pp.
276. U.S. Fish and Wildlife Service (USFWS). 2007a. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages. Federal Register 72:64286-64340.
277. U.S. Fish and Wildlife Service (USFWS). 2007b. United States Fish and Wildlife Service. Fat Threeridge (*Amblema neislerii*) Shinyrayed Pocketbook (*Lampsilis subangulata*) Gulf Moccasinshell (*Medionidus penicillatus*) Ochlockonee Moccasinshell (*Medionidus simpsonianus*) Oval Pigtoe (*Pleurobema pyriforme*) Chipola Slabshell (*Elliptio chipolaensis*) Purple Bankclimber (*Elliptoideus sloatianus*); 5-Year Review: Summary and Evaluation.
278. U.S. Fish and Wildlife Service (USWFS). 2008. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, interim operation plan for Jim Woodruff Dam and the associated released to the Apalachicola River. Prepared by the USFWS Panama City Field Office, Florida. 225pp.
279. U.S. Fish and Wildlife Service (USFWS). 2011a. An investigation of movement, exposure, and mortality of fat threeridge mussels (*Amblema neislerii*) at Apalachicola and Chipola River sites. Prepared by A. J. Kaeser and K.J. Herrington of the USFWS Panama City Field Office, Florida. 28pp.
280. U.S. Fish and Wildlife Service (USWFS). 2012. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, interim operation plan for Jim Woodruff Dam and the associated released to the Apalachicola River. Prepared by the USFWS Panama City Field Office, Florida. 166pp.

281. U.S. Fish and Wildlife Service (USFWS). (2013a). July 19, 2013 letter from Donald Imm, Project Leader, U.S. Fish and Wildlife Service, Panama City Area Office to Curtis Flakes, Chief of Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District.

282. U.S. Fish and Wildlife Service (USFWS). (2013b). Planning Aid Letter, Apalachicola-Chattahoochee-Flint Water Control Manual Update. August 29, 2013 letter from Robin Goodloe, Acting Field Supervisor, U.S. Fish and Wildlife Service, Athens, Georgia sub-office to Curtis Flakes, Chief of Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District.

283. U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 2009. Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region. Panama City Ecological Services Field Office, Panama City, Florida. 49pp.

284. U.S. Fish and Wildlife Service (USFWS) and U.S. Environmental Protection Agency (USEPA). 1999. Instream flow guidelines for the Act and ACF Basins interstate water allocation formula. USFWS and USEPA, Atlanta, GA, unpublished report transmitted to L. Thomas, Federal Commissioner, Act and ACF River Basins Commissions, by letter dated October 25, 1999. 13pp + appendices.

284.1. Valett, H.M., M.A. Baker, J.A. Morrice, C.S. Crawford, M.C. Molles, Jr., C. Dahm, D.L. Moyer, J.R. Thibault, and L.M. Ellis. 2005. Biogeochemical and metabolic responses to the flood pulse in a semiarid floodplain. Ecology 86(1):220-234.

285. van der Schalie, H. 1970. Hermaphroditism among North American freshwater mussels. Malacologia 10(1):93-112.

286. Vannote, R.L., and G.W. Minshall. 1982. Fluvial processes and local lithology controlling abundance, structure, and composition of mussel beds. Proceedings of the National Academy of Sciences 79:4103-4107.

287. Vaughn, C.C., S.J. Nichols, and D.E. Spooner. 2008. Community and foodweb ecology of freshwater mussels. Journal of the North American Benthological Society 27:409-423.

288. Villella, R.F., D.R. Smith, and D.P Lemarie. 2004. Estimating survival and recruitment in a freshwater mussel population using mark-recapture techniques. American Midland Naturalist 151:114-133.

289. Vladykov, V.D. 1955. A comparison of Atlantic sea sturgeon with a new subspecies from the Gulf of Mexico (*Acipenser oxyrhynchus desotoi*). Journal of the Fisheries Research Board of Canada12:754-761.

290. Wakeford, A. 2001. State of Florida conservation plan for gulf sturgeon (*Acipenser oxyrinchus desotoi*). Florida Marine Research Institute Technical Report TR-8. 100pp.

291. Walsh, S.J., W.B. Tate, M.A. Burgess. 2006. Fishes of the Apalachicola River floodplain: role of habitat and hydrology to recruitment. U. S. Geological Survey. Unpublished final report submitted to the Florida Fish and Wildlife Conservation Commission. 124pp.

292. Walsh, S.J., Buttermore, E.N., O.T. Burgess, and W.E. Pine, III. 2009. Composition of age-0 fish assemblages in the Apalachicola River, River Styx, and Battle Bend, Florida. U.S. Geological Service Open-File Report. 2011-1145. 28pp.
293. Warren, M.L., Jr., P.L. Angermeier, B.M. Burr, and W.R. Haag. 1997. Decline of a diverse fish fauna: patterns of imperilment and protection in the southeastern United States. Pp. 105-164 in: G.W. Benz and D.E. Collins, editors. Aquatic Fauna in Peril. Southeast Aquatic Research Institute, Special Publication 1, Lenz Design and Communications, Decatur, GA.
294. Watters, G.T. 1992. Unionids, fishes, and the species-area curve. Journal of Biogeography 19:481-490.
295. Watters, G.T. 1994. An annotated bibliography of the reproduction and propagation of the Unionoidea (primarily of North America). Ohio Biological Survey Miscellaneous Contributions No. 1. 158pp.
296. Watters, G.T. 1997. Individual-based models of mussel-fish interactions: a cautionary study. Pp. 45-62 in: K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, editors. Conservation and management of freshwater mussels II: initiatives for the future. Proceedings of an Upper Mississippi River Conservation Committee symposium. October 1995, St. Louis, MO.
297. Watters, G.T., and S.H. O'Dee. 2000. Glochidial release as a function of water temperature: beyond bradyticty and tachyticty. Pp. 135-140 in: R.A. Tankersley, D. Warmolts, G.T. Watters, B. Armitage, P.D. Johnson, and R.S. Butler, editors. Freshwater Mollusk Symposia Proceedings-Part I: Conservation, Captive Care, and Propagation symposium, March 1998, Columbus, Ohio. Ohio Biological Survey, Columbus, Ohio.
298. Watters G. T., O'Dee S. H., Chordas S. 2001. Patterns of vertical migration in freshwater mussels (Bivalvia: Unionida). Journal of Freshwater Ecology 16:541-550.
299. Welcomme, R.L. 1979. Fisheries ecology of floodplain rivers. Longman. New York, NY.
300. White, D.S. 1979. The effects of lake level fluctuations on Corbicula and other pelecypods in Lake Texoma, Texas and Oklahoma. Pp. 82-88 in: J.C. Britton, editor. Proceedings of the first international Corbicula symposium. Texas Christian University Research Foundation, Fort Worth.
301. Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. 84 pp.
302. Williams, B.K., and E.D. Brown. 2012. Adaptive Management: The U.S. Department of the Interior Applications Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. 136pp.
303. Williams, J.D., and R.S. Butler. 1994. Class Bivalvia, freshwater bivalves. Pp. 53-128 and 740-742 in: R. Ashton, editor. Rare and endangered biota of Florida. Volume 6. Invertebrates. University of Florida Press, Gainesville.
304. Williams, J.D., J.T. Garner, and A.E. Bogan. 2008. Freshwater mussels of Alabama and the Mobile Basin in Georgia, Mississippi, and Tennessee. The University of Alabama Press, Tuscaloosa.
305. Wisconsin Department of Natural Resources (WDNR), Minnesota Department of Natural Resources and the U. S. Army Corps of Engineers, St. Paul District. 2006.

Preliminary Report on the Effects of the 2005 Pool 5, Mississippi River Drawdown on Shallow-water native mussels.

306. Wooley, C.M. 1985. Evaluation of morphometric characters used in taxonomic separation of Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*. Pp. 97-103 in: F.P. Binkowski and S.I. Doroshov, editors. North American Sturgeons: Biology and Aquaculture Potential, Dr W. Junk Publishers, Dordrecht.

307. Wooley, C.M., and E.J. Crateau. 1982. Observations of Gulf of Mexico sturgeon (*Acipenser oxyrhynchus desotoi*) in the Apalachicola River, Florida. Florida Scientist 45:244-248.

308. Wooley, C.M., and E.J. Crateau. 1985. Movement, microhabitat, exploitation and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. North American Journal of Fisheries Management 5: 590-605.

308.1. Wrona, A., D. Wear, J. Ward, R. Sharitz, J. Rosenzweig, J.P. Richardson, D. Peterson, S. Leach, L. Lee, C.R. Jackson, J. Gordon, M. Freeman, O. Flite, G. Eidson, M. Davis, and D. Batzer. 2007. Restoring ecological flows to the Lower Savannah River: a collaborative scientific approach to adaptive management. Proceedings of the 2007 Georgia Water Resources Conference, held March 27–29, 2007, at the University of Georgia. Institute of Ecology, University of Georgia, Athens.

309. Yao, H., and A. Georgakakos. 2011. ACF river basin: climate and demand change impacts and mitigation measures. Proceedings of the 2011 Georgia Water Resources Conference, Apri1 11-13, 2011, at the University of Georgia.

310. Yeager, B.L., and R.J. Neves. 1986. Reproductive cycle and fish hosts of the rabbit’s foot mussel, *Quadrula cylindrica strigillata* (Mollusca: Unionidae) in the upper Tennessee River drainage. American Midland Naturalist 116:329-340.

311. Yeager, B.L., and C.F. Saylor. 1995. Fish hosts for four species of freshwater mussels (Pelecypoda: Unionidae) in the upper Tennessee River drainage. American Midland Naturalist 133:1-6.

312. Yeager, M.M., D.S. Cherry, and R.J. Neves. 1994. Feeding and burrowing behaviors of juvenile rainbow mussels, *Villosa iris* (Bivalvia: Unionidae). Journal of the North American Benthological Society 13(2):217-222.

313. Zale, A.V., and R.J. Neves. 1982. Fish hosts of four species of lampsiline mussels (Mollusca: Unionidae) in Big Moccasin Creek, Virginia. Canadian Journal of Zoology 60:2535-2542.

314. Ziewitz. J. 2006. Gulf sturgeon spawning habitat availability on the Apalachicola River. Presentation at the 8th Annual Sturgeon Meeting. October 11-13, 2006. White Springs, Florida.