Appendix A

Biological Assessment dated 1 November 2007

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

November 1, 2007

REPLY TO
ATTENTION OF

Inland Environment Team
Planning Environmental Division

Ms. Gail Carmody
Ecological Services
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405-3721

Dear Ms. Carmody:

This letter is to request the initiation of formal consultation pursuant to Section 7 of the Endangered Species Act of 1973 (ESA), on the U.S. Army Corps of Engineers (Corps), Mobile District proposed drought contingency management operations for the Apalachicola, Chattahoochee, Flint Rivers (ACF) projects, and the associated releases from Jim Woodruff Dam to the Apalachicola River. Mobile District completed Section 7 consultation with the U.S. Fish and Wildlife Service (USFWS) on September 5, 2006 for our Interim Operations Plan (IOP) at Jim Woodruff Dam in support of federally-listed species and critical habitat on the Apalachicola River. The findings of this consultation was that the proposed operations, as defined in the IOP, would not result in jeopardy of the federally-listed species, or adverse modification or destruction of critical habitat, and an Incidental Take Statement was issued to allow a limited amount of potential take of mussels under certain flow conditions.

The Biological Opinion (BO) issued for the completed consultation included a Reasonable and Prudent Measure No. 3 (RMP3) requiring the development of modifications to the IOP that would provide for higher desired minimum flows when hydrological and climatic conditions would allow, and identification of a "drought provision" that would determine when it would be reasonable and prudent to revert to the required minimum flow of 5,000 cfs (as required in the current ACF water control plan) in order to conserve storage for prolonged low flow conditions. A "drought provision" modification to the IOP was submitted by Mobile District on February 16, 2007, and the modified IOP operation was approved by the USFWS on February 28, 2007.

The IOP was developed to accommodate drought conditions within the basin, based on previous modeling of hydrological conditions associated with previous droughts of record. However, the severe and prolonged drought conditions being experienced in the ACF basin this year have been determined to represent an exceptional drought, and we are experiencing impacts to the basin and composite storage within the basin that were unanticipated by the previous IOP modeling. Therefore, in accordance with the adaptive management provisions of RPM1 of the BO, Mobile District has identified additional drought contingency measures we believe are necessary to prepare the reservoir system to continue to provide support for the multiple project purposes in the basin, including continued support to listed endangered and threatened species and critical habitat.

The Apalachicola River is known to support three federally listed species: Gulf sturgeon (*Acipenser oxyrhinchus desotoi*), fat threeridge mussel (*Amblema neislerii*), and purple bankclimber mussel (*Elliptoideus sloatianus*). The Chipola slabshell mussel (*Eliptio chipolaensis)* has also occasionally been found on the river. The USFWS and National Marine Fisheries Service (NMFS) listed the Gulf sturgeon as threatened on September 30, 1991 (56 FR 49653). The USFWS listed the fat threeridge mussel as endangered and the purple bankclimber mussel as threatened on March 16, 1998 (Federal Register, vol. 63, no. 50, pp. 12664–12687). The USFWS and NMFS designated critical habitat for the Gulf sturgeon on March 19, 2003 (Federal Register, vol. 68, no. 53, pg. 13370). Critical Habitat Unit 6 includes the main stem of the Apalachicola River from the Jim Woodruff Lock and Dam, Gadsden and Jackson Counties, Florida, downstream to its discharge at East Bay or Apalachicola Bay, Franklin County, Florida. Critical habitat was also proposed by USFWS on June 6, 2006 for seven mussels within four Northeast Gulf Drainages (Federal Register, vol. 71, no. 108, pp. 32746-32795). Critical Habitat Unit 2 on the Chipola River (proposed for the fat threeridge and Chipola slabshell) and Unit 8 (on the Apalachicola River (proposed for the fat threeridge mussel and purple bankclimber mussel) occur within the action areas for the subject project operations. A final listing of critical habitat for the mussels is expected to be published before the end of this year.

Jim Woodruff Dam was constructed in 1957 and represents the most downstream Federal reservoir project within the Apalachicola, Chattahoochee, Flint Rivers (ACF) system. The reservoir projects in the ACF system include Jim Woodruff Dam (Lake Seminole), George W. Andrews Dam and Lake, Walter F. George Dam and Lake, West Point Dam and Lake, and Buford Dam (Lake Sidney Lanier). The ACF system is authorized and operated for multiple project purposes, including flood control, hydropower generation, navigation, water quality, fish and wildlife conservation, water supply and recreation. The Mobile District operates the reservoirs within the ACF system in a balanced manner in an attempt to benefit all project purposes. Retention of water in reservoir storage is used for the benefit of these multiple project purposes. Storage also provides a source for augmentation flows in support of downstream needs during periods of extended dry conditions or drought. The Jim Woodruff project is essentially a "run-of-river" project with very limited storage capabilities. Therefore, storage in upstream reservoirs must often be released in order to make controlled releases from Jim Woodruff Dam to meet downstream flow needs. Current operations under the draft ACF water control plan require a minimum flow of 5,000 cfs on the Apalachicola River to meet minimum water supply and fish and wildlife needs during low flow conditions. This 5,000 cfs minimum flow is also incorporated into the approved IOP operations.

The ACF basin is experiencing the second year of severe drought conditions within the basin. The National Weather Service has classified significant portions of the basin as in exceptional drought, and predictions are that drought conditions will likely continue throughout the winter and spring of 2008. As a result of the significantly reduced inflows to ACF Basin and continued releases necessary to meet minimum flow requirements downstream, there is concern that Lake Lanier may deplete its conservation storage if severe drought conditions continue through the end of the year and into 2008. The two lower storage projects in the basin (West Point Lake and Walter F. George Lake) are already essentially at the bottom of their conservation storage. Therefore, in September, the Corps and USFWS initiated discussions regarding the need to temporarily modify the IOP in response to the exceptional drought conditions and rapidly declining conservation storage in the system. Our intensive discussions and shared modeling of the basin and predicted conditions have led to formulation of a proposed drought contingency modification to the IOP, which we have termed the Exceptional Drought Operations (EDO).

The proposed EDO represents a temporary modification of the existing IOP approved by USFWS on February 28, 2007. The intent of this modification to the IOP is to minimize adverse impacts to listed species in the Apalachicola River due to drought conditions while making allowances for increased storage opportunities and/or reductions in the demand on composite storage in order to conserve storage which can be used to provide continued support to authorized project purposes and minimize impacts to other water users during a severe multi-year drought.

Consistent with the existing IOP which uses Composite Storage to trigger whether the desired minimum flow (6,500 cfs) or the required minimum flow (5,000 cfs) is maintained; the proposed action also uses Composite Storage to determine when it is reasonable and prudent to activate the EDO. Composite Storage is calculated by combining the storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Each of the individual storage reservoirs consists of four Zones. These Zones are determined by the operational guide curve for each project. The Composite Storage utilizes the four-Zone concept as well. Composite Zone 4 indicates that all federal storage reservoirs have reached a critical storage level. While in Zone 4, the most conservative operation is enacted and releases are only made for water supply and water quality. Navigation is not supported and hydropower demands will be met at minimum levels.

Additional generation solely to meet system hydropower demands will not be made. The EDO is "triggered" whenever the Composite Storage falls below the bottom of Zone 3 into Zone 4. At that time the temporary provisions of the IOP are suspended and management decisions are based on the provisions of the EDO. The provisions of the EDO remain in place until conditions improve such that the Composite Storage reaches a level above the top of Zone 3 (i.e., within Zone 2). At that time, the EDO provisions are suspended, and the provisions of the IOP are re-instated. As described above the EDO is triggered by the status of composite storage within the basin, not by any determination on drought status by the National Weather Service or other drought indicators.

The EDO includes the following provisions and triggers:

- Immediate suspension of all IOP provisions including seasonal storage limitations, down ramping restrictions, and minimum flow thresholds, and volumetric balancing accounting whenever the Composite Storage falls below the bottom of Zone 3 into Zone 4;

- Immediate reduction of the 5,000 cfs minimum flow requirement in the Apalachicola River, as measured at the Chattahoochee gage, to a 4,150 cfs minimum flow requirement (the reduction in flows would be implemented gradually consistent with the IOP maximum ramping down rate schedule);

- Implementation of a monthly monitoring plan that tracks Composite Storage in order to determine the appropriate water management operations (the first day of each month will represent a decision point) and whether EDO triggers are applied;

- Re-instatement of the 5,000 cfs minimum flow requirement, but none of the other IOP provisions, once conditions improve such that the Composite Storage reaches a level above the top of Zone 4 (i.e., within Zone 3);

- Suspension of all EDO provisions and re-instatement of the normal IOP provisions once conditions improve such that the Composite Storage reaches a level above the top of Zone 3 (i.e., within Zone 2).

Composite Storage is currently within Zone 4. For the 63 year simulated period used in our modeling analyses, there were only two other previous severe drought years (1986 and 2000) that would have resulted in Composite Storage below Zone 3 for which the proposed EDO operations would have been enacted.

The proposed EDO provides a means to minimize adverse impacts to the species on the Apalachicola River while providing continued support to other critical basin water uses during an exceptional basin-wide drought. The EDO should enhance the probability for the reservoirs in the basin to refill and improves the probability that we will be able to sustain minimum basin needs into next year in the face of a multi-year drought. Although the EDO will be tracking composite storage to measure benefits of the drought contingency measures, our modeling indicates that the most benefit from the EDO will be potential for refill of the downstream reservoirs, West Point Lake and Walter F. George Lake, which will allow these reservoirs to again provide support for the downstream augmentation flow needs. Lake Lanier will benefit to some degree due to relief from providing sole support for downstream flows, but would still be burdened to provide water supply and water quality flows below the dam. Other critical basin water resource needs would continue to be met, including municipal and industrial water supply, wastewater assimilation for water quality, and power plant cooling waters. If implemented, the EDO would still be able to provide some level of flow augmentation support and will likely avoid the potential for more severe impacts that would occur to the listed species in the event composite storage within the basin becomes depleted and augmentation flows can no longer be sustained. This scenario is predicted by our models to occur in 2008 if no drought contingency measures are implemented and if the severe drought conditions continue as predicted.

Due to the exceptional drought conditions and impacts already being experienced on composite storage within the basin, the Corps and USFWS have agreed to expedite the formal consultation procedures to reach a BO as early as November 15, 2007. Both agencies are continuing to jointly consult on the proposed Exceptional Drought Operation and are sharing modeling results and data on resource impacts as it is being developed. We have enclosed a Biological Assessment (BA) including our evaluations completed to date of impacts on the listed species and the primary constituent elements of critical habitat. We intend to continue our intensive consultation discussions and sharing of additional information as it becomes available as we continue through the expedited consultation process. We have determined in the enclosed BA that our proposed EDO operations will likely adversely affect Gulf sturgeon and listed mussels, and host fish for listed mussels. Efforts by the Mobile District to continue to augment flows to maintain a minimum flow above the basin inflow will provide mitigation for declining basin inflow and will benefit the federally protected species. There will, however, be trade-offs between minimal impacts to Gulf sturgeon spawning activities or critical habitat area, or to host species life cycle needs during the spring or summer months, in order to conserve sufficient storage in upstream reservoirs to provide for future augmentation flows in the summer or fall months to protect listed mussels from exposure. There would also be adverse impact to mussels for certain hydrological conditions. Mobile District believes that any such trade-off impacts will be less severe than potential impacts that could occur in the event exceptional drought condition continue and no action is taken to conserve storage and avoid depletion of composite storage within the system. However, it is understood that our consultation discussions over the next couple of weeks could identify additional reasonable and prudent measures that could provide for additional minimization of harm to the species, including the consideration of incremental reductions in the flow.

We request you review of the enclosed information with respect to ESA compliance and provide your biological opinion, and any necessary conference report. We will continue our close coordination over the next couple of weeks to assist in concluding the consultation process and reaching consensus on any reasonable or prudent measures that may be appropriate. Should you have any questions, comments, or recommendations, please contact Ms. Joanne Brandt at (251) 690-3260 or Mr. Brian Zettle at (251) 690-2115.

Sincerely,

Curtis M. Flakes
Chief, Planning and Environmental
Division

Enclosures

BIOLOGICAL ASSESSMENT
TEMPORARY MODIFICATIONS TO THE INTERIM OPERATING PLAN FOR JIM WOODRUFF DAM AND THE ASSOCIATED RELEASES TO THE APALACHICOLA RIVER

INTRODUCTION

On 7 March 2006, the U.S. Army Corps of Engineers, Mobile District (Corps), submitted a request to initiate formal consultation pursuant to Section 7 of the Endangered Species Act (ESA) regarding the impact of releases from the Jim Woodruff dam to the Apalachicola River, under the existing water control plan operations, on Federally listed endangered or threatened species and critical habitat for those species. Operations regarding releases to the Apalachicola River were described in an Interim Operations Plan (IOP) for Jim Woodruff Dam, since consultation on the overall project operations for the Apalachicola, Chattahoochee, Flint Rivers (ACF) system would be deferred until future efforts to update the water control plans and basin manual for the system. Species of concern 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*); and the Chipola slabshell mussel (*Eliptio chipolaensis*). During the consultation process, a proposed revision to the IOP plan was developed and submitted for consideration on 12 June 2006. A final Biological Opinion (BO) for the Jim Woodruff Dam IOP (as described in the 12 June 2006 letter) was issued by the U.S. Fish and Wildlife Service (USFWS), Panama City Field Office on 5 September 2006, and incorporated additional modifications to the IOP in order to avoid or minimize incidental take of listed mussels.

The BO included five reasonable and prudent measures (RPMs) for further limiting the amount of incidental take associated with water management operations at Jim Woodruff Dam. For each of the five RPMs, the BO also included specific terms and conditions which must be met in order to assure compliance with the RPMs. In accordance with RPM3 of the BO, the IOP was further modified to include a drought provision measure that identifies the reservoir, climatic, hydrologic, and/or listed species conditions that allow supporting a higher minimum flow in the Apalachicola River, and water management measures to be implemented when conditions reach the identified drought trigger point(s). A biological assessment (BA) describing the drought provision modifications and associated impacts was submitted to USFWS on 16 February 2007. On 28 February 2007 the USFWS approved the drought provision modifications to the IOP. We are currently operating under the provisions of this version of the IOP. The IOP specifies two parameters applicable to the daily releases from Woodruff: a minimum discharge (Table 1) in relation to average basin inflows (daily average in cubic feet per second [cfs]) and maximum fall rate (vertical drop in river stage [ft/day]) (Table 2), with incorporation of a desired minimum flow (6,500cfs) and the required minimum flow (5,000 cfs), and a drought “trigger” to determine those conditions when the required

Table 1. IOP Minimum Discharge from Woodruff Dam by Month and by Basin Inflow (BI) Rates

Months		Basin Inflow (cfs)[a]	Releases from Woodruff Dam (cfs)
March - May	High	>= 35,800	not less than 25,000
	Mid	>= 18,000 and < 35,800	>= 70% BI; not less than 18,000
	Low	< 18,000	>= BI; not less than 6,500 (Desired Flow)[b] >= BI; not less than 5,000 (Required Flow)
June - February	High	>= 23,000	not less than 16,000
	Mid	>= 10,000 and < 23,000	>= 70% BI; not less than 10,000
	Low	< 10,000	>= BI; not less than 6,500 (Desired Flow)[b] >= BI; not less than 5,000 (Required Flow)

[a] The running 7-day average daily inflow to the Corps ACF reservoir projects, excluding releases from project storage.

[b] Drought Provision: When Composite Storage is within Zones 1 and 2, then the higher minimum release of 6,500 cfs would be maintained. When Composite Storage falls below the top of Zone 3, then release will be reduced to the 5,000 cfs minimum; when Composite Storage is restored to above the top of Zone 2 (i.e., within Zone 1), then the higher minimum release of at least 6,500 cfs would again be maintained. Composite Storage is the combined conservation storage of Lake Sidney Lanier, West Point Lake, and Walter F. George.

Table 2. IOP Maximum Fall Rate for Discharge from Woodruff Dam by Release Range

Approximate Release Range (cfs)	Maximum Fall Rate (ft/day)
≥ 30,000[a]	Fall rate is not limited[b]
≥ 20,000 and < 30,000	1.0 to 2.0
> 16,000 and < 20,000	0.5 to 1.0
> 8,000 and ≤ 16,000	0.25 to 0.5
≤ 8,000	0.25 or less

[a] Consistent with safety requirements, flood control purposes, and equipment capabilities, the IOP indicates that the Corps will attempt to limit fall rates to the lower value specified for each release range.

[b] For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control down ramping rate, and no ramping rate is required.

minimum flow would be more prudent than the desired minimum flow. The drought trigger is based upon Composite Storage within the ACF system. The Composite Storage is calculated by combining the storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Each of the individual storage reservoirs consists of four Zones. These Zones are determined by the operational guide curve for each project. The Composite Storage utilizes the four Zone concept as well; i.e., Zone 1 of the Composite Storage represents the combined storage available in Zone 1 for each of the three storage reservoirs.

Consistent with the operational decisions approved in the BO, the current IOP also includes a volumetric balancing of releases in cases where storage is used to follow the ramping rates specified in the IOP. Following rain events, the required ramping rates are often more gradual than the actual decline in basin inflows, and potential over-releases and additional drain on reservoir storage could occur, especially when trying to match releases to the computed 7-day average basin inflow. In order to avoid over-releases and conserve storage during critical periods, the volume of releases can be balanced during and following rain events. Releases after the rainfall events are adjusted to account for any computed under-release or over-release, to assure that net releases are balanced to meet the computed volume of basin inflow over time. The volumetric balancing computations do not include releases for flood control or other special releases not prescribed by the IOP, but primarily account for possible over-releases that occur due to the ramping rate restrictions. Due to a significant credit accumulating in the Corps volumetric balancing account since September 2006 (attributable to down ramping) and subsequent volumetric balancing activities in April 2007, the Corps and USFWS mutually agreed that improvements in the tracking procedures that more clearly address the goals of volumetric balancing (generally assure required releases are made while recognizing the complexities of water management) were needed. Therefore, by letter dated 16 May 2007 the Corps submitted documentation of these clarifications to the volumetric balancing accounting system that simplified a complex computation procedure and refined the decision and accounting system to more clearly demonstrate the impacts on storage and whether releases meet the IOP flow releases schedule.

The IOP was developed in consultation with the USFWS to provide for releases in support of federally listed species on the Apalachicola River, consistent with the requirements of the current water control plan (1989 Draft Water Control Plan for the ACF Basin). During development of the IOP it was agreed that HEC-5 hydrologic modeling data for the 1939-2001 period would be used to analyze the impact of the IOP on listed species. The results of this analysis indicated that the IOP would manage composite storage in the federal reservoirs in a manner that met the needs of consumptive demands and minimum releases through the worst drought of record (1999-2001 drought representing the critical period). However, in the current year (2007) throughout much of the ACF Basin various precipitation and drought indices have reached record lows and reservoir elevations at the federal projects are lower than were observed or simulated with the IOP in place during this time of year for the critical period evaluated.

Throughout this summer the Corps has monitored the composite storage within the system and the forecast of an exceptionally severe and long lasting drought. Appendix A includes a recent memo drafted by our staff meteorologist that documents the severity of the current drought and forecasts of a dry winter and spring. Appendix B includes a presentation documenting the National Oceanic and Atmospheric Administration's (NOAA) drought analysis and winter forecast.

In early September the Corps and USFWS began informal consultation discussions regarding the potential need to modify the IOP to allow temporary deviations due to the extraordinary drought conditions occurring in the ACF Basin this year and the likelihood of these conditions persisting throughout the remainder of this year and the following year. As discussed between the Corps and USFWS, in conformance with the Draft Water Control Plan (1989) for the ACF Basin and the provisions of the IOP, the Corps has been releasing a minimum flow of at least 5,000 cfs from Jim Woodruff Dam since late May 2007. The 7-day basin inflows during this same period were considerably lower than 5,000 cfs for substantial periods (average approximately 2,500 cfs during July - September) resulting in a substantial reduction in storage from the upstream reservoirs. In mid October, the Corps informed USFWS that recent 7-day basin inflows were averaging less than 2,000 cfs and that the composite storage for the system was in Zone 4 (lowest zone) and projected to continue to drop significantly over the next 30-60 days. Lake Lanier was the only Federal reservoir within the ACF basin with conservation storage remaining to support downstream water users and the 5,000 cfs minimum flow and the extremely dry conditions were resulting in rapidly declining availability of this storage. Due to the likelihood of current conditions continuing through the end of this year and into the winter and spring of 2008, and only a limited amount of conservation storage being available to support the 5,000 cfs minimum flow, we agreed to consider immediate measures to reduce the continuing drawdown of Composite Storage and to maintain the Corps' ability to serve the various authorized project purposes for the federal reservoirs including fish and wildlife conservation.

As we discussed, some of the drought contingency measures under consideration would require further evaluation and consultation discussion, but certain measures could be implemented at that time without causing adverse effects to the listed species. Therefore, both agencies agreed on 17 October 2007 to use volumetric balancing credits to allow storage of inflows greater than 5,000 cfs (storage volume limited to account balance) in the event of rainfall within the basin. Also, by letter dated 19 October 2007, the Corps requested a temporary modification of the IOP consisting of an immediate suspension of the maximum fall rate schedule (Table 2) until 1 March 2008. As described in the letter, elimination of the down-ramping provision would improve our ability to conserve storage to the maximum extent practicable. The Corps determined that this temporary modification of the IOP may affect, but was not likely to adversely effect the threatened Gulf sturgeon, endangered fat threeridge mussel, threatened purple bankclimber mussel, and threatened Chipola slabshell; and would not result in destruction or adverse modification of habitat designated and proposed as critical habitat for the Gulf sturgeon and the mussels. By letter dated 19 October 2007 the USFWS concurred with this determination and approved the temporary modification of the IOP.

As described above, we recognized that additional temporary modifications of the IOP would be necessary in order to avoid depleting the conservation storage in the system. At that point, no storage would remain in the conservation pool at Lake Lanier or the other Federal reservoirs and our ability to serve the various authorized project purposes for the federal reservoirs, including fish and wildlife conservation would be significantly limited. It should be noted that bottom of conservation pool does not equate to no water remaining in the reservoirs. The inactive storage at each of the reservoirs combined still contains 1,856,550 acre-feet of water. However, operational flexibility regarding water management within the basin is acutely impaired within the inactive storage pool and the Apalachicola River would experience flows significantly lower than previously recorded. Adverse impacts to listed species (especially the listed mussel species) are reasonably certain to occur as flows on the Apalachicola River drop below 5,000 cfs. The intent of any modification to the IOP would be to minimize adverse impacts to listed species in the Apalachicola River while making allowances for increased storage opportunities and/or reductions in the demand of storage in order to provide continued support to project purposes, minimize impacts to other water users, and have greater assurance of future ability to sustain flows for listed species during a severe multi-year drought, as currently being experienced in the ACF basin. The extremely dry conditions experienced this year have resulted in an urgent need for additional temporary modifications to the existing IOP protocols in order to replenish storage in the Federal reservoirs in order to avoid potentially significant impacts to endangered species in the Apalachicola River. This BA has been prepared to address the potential effects of the proposed temporary modification to the IOP. In addition, a description of several alternatives considered during development of the proposed action is provided; as well as, discussion on why these alternatives failed to meet the intent of the temporary modification.

DESCRIPTION OF PROPOSED ACTION

The proposed action (referred to as Exceptional[1] Drought Operations (EDO) throughout this assessment) is a temporary modification of the existing IOP as approved by USFWS on 28 February 2007. As described above, the intent of any modification to the IOP would be to minimize adverse impacts to listed species in the Apalachicola River while making allowances for increased storage opportunities and/or reductions in the demand of storage in order to provide continued support to project purposes, minimize impacts to other water users, and provide greater assurance of future sustained flows for species and other users during a severe multi-year drought, currently being experienced in the ACF basin.

Consistent with the IOP which uses Composite Storage to trigger whether the desired minimum flow (6,500 cfs) or the required minimum flow (5,000 cfs) is maintained; the proposed action also uses Composite Storage to determine when the EDO is required. The Composite Storage is calculated by combining the storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Each of the individual storage reservoirs consists of four Zones. These Zones are determined by the operational guide curve for

[1] The term "exceptional" is used to distinguish these drought operations from those in the existing IOP. The term is not intended to adopt the permutations of the same term used by the National Weather Service.

each project. The Composite Storage utilizes the four Zone concept as well; i.e., Zone 1 of the Composite Storage represents the combined storage available in Zone 1 for each of the three storage reservoirs. Figure 1 illustrates the acre-feet of storage available for Composite Zones 1-4 throughout the year; as well as, the current Composite Storage. The EDO is "triggered" whenever the Composite Storage falls below the bottom of Zone 3 into Zone 4. At that time the provisions of the IOP are suspended and management decisions are based on the provisions of the EDO. The provisions of the EDO remain in place until conditions improve such that the Composite Storage reaches a level above the top of Zone 3 (i.e., within Zone 2). At that time, the temporary EDO provisions are suspended, and the provisions of the IOP are re-instated.

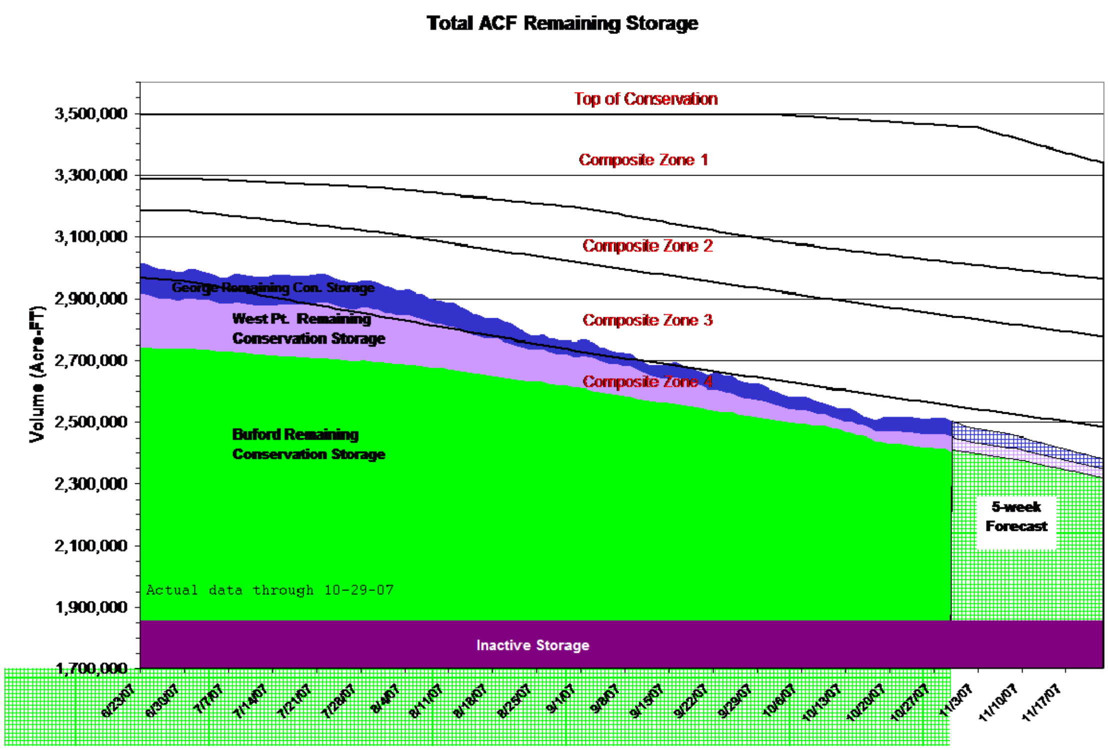

Figure 1. Composite Storage and Associated Zones in Acre-Feet

The EDO includes the following provisions and triggers:

- Immediate suspension of all existing IOP provisions including seasonal storage limitations, maximum fall rate schedule, minimum flow thresholds, and volumetric balancing accounting whenever the Composite Storage falls below the bottom of Zone 3 into Zone 4 (fall rates would be managed to match the fall rate of the basin inflow);

- Immediate reduction of the 5,000 cfs minimum flow requirement in the Apalachicola River, as measured at the Chattahoochee gage, to a 4,150 cfs minimum flow requirement (the reduction to this minimum flow would be implemented gradually, consistent with the IOP maximum fall rate schedule);

- Implementation of a monthly monitoring plan that tracks Composite Storage in order to determine water management operations (the first day of each month will represent a decision point) and whether EDO triggers are applied;

- Re-instatement of the 5,000 cfs minimum flow requirement, but none of the other IOP provisions once conditions improve such that the Composite Storage reaches a level above the top of Zone 4 (i.e., within Zone 3); and

- Suspension of all EDO provisions and re-instatement of the existing IOP provisions once conditions improve such that the Composite Storage reaches a level above the top of Zone 3 (i.e., within Zone 2).

The Chattahoochee gage (USGS number 02358000) is the point at which Jim Woodruff Dam releases are measured under the proposed action. Composite Zone 4 was selected as the trigger for implementation of the EDO based on a review of the HEC-5 IOP simulated reservoir conditions for the period of record (1939-2001). The simulated conditions were developed by applying the provisions of the IOP to the unimpaired flow daily time series data for the 63 year period and modeling the resultant reservoir and river conditions. By analyzing the Composite Storage simulated for each year during this period, we were able to identify a Composite Storage trigger that coincided with exceptional drought conditions such as those currently being experienced in the ACF basin. Composite Zone 4 indicates that all federal storage reservoirs have reached a critical storage level. The most conservative operation is enacted when in Composite Zone 4 and releases are only made for water supply and water quality. Navigation is not supported and hydropower demands will be met at minimum levels incidental to releases for water supply and water quality. Additional generation, solely to meet system hydropower demands will not be made. Composite Storage is currently within Zone 4. For the 63 year simulated period, there was only two other years (1986 and 2000) that resulted in Composite Storage below Zone 3. As described above, the year 2000 represented exceptional drought conditions and served as the critical period during the IOP analysis. It should be noted that the period of record simulated included severe droughts in 1941, 1954-55, 1981, 1986-89, 1999-2001. Based on this analysis, Composite Storage Zone 4 appears to be an appropriate indicator of exceptional drought conditions. Therefore, the EDO would be triggered immediately since the Composite Storage of the system is currently within Zone 4.

ALTERNATIVES CONSIDERED

A. <u>"No Action"</u> - Based on the nature of the proposed action, "no action" represents "no change" from the current management direction or level of management intensity. This alternative would represent the current water control operations at Jim Woodruff Dam (i.e., implementing the provisions of the IOP as described in the 23 March 2007 letter to USFWS). This alternative is not feasible given the intensity of the drought and the forecast for worsening conditions. Based on our modeling of the no action alternative under an extreme drought hydrology, the Composite Conservation Storage of the system would be depleted thus "breaking" the system in the event of a multi-year drought which has a reasonable chance of occurring given current meteorological forecasts. The Effects Analysis section includes a detailed description of this. Therefore, additional alternatives were considered.

B. Suspend Down Ramping Requirement Until 1 March 2008 – This alternative represents the IOP operations at Jim Woodruff Dam since 19 October 2007. At that time the Corps requested and the USFWS approved a temporary modification of the IOP consisting of an immediate suspension of the maximum fall rate schedule (Table 2) until 1 March 2008. Under this temporary modification, fall rates would be managed to match the fall rate of the basin inflow. As described in the request letter, elimination of the down ramping provision would improve our ability to conserve storage to the maximum extent practicable. However, it was noted that additional temporary modifications to the IOP would likely be required in order to avoid depletion of the composite storage in the system. The suspension of the down-ramping requirements would address the situation when increased flows in the system begin to decline and ramp-down occurs. However, this alternative does not address the situation when adequate rainfall does not occur and there is not significant increase in flows to the point that water can be stored in the system. If this does not occur, there may not be many opportunities to take advantage of the suspension in down ramping. Based on the modeling results for the no action alternative, it is apparent that suspension of the down ramping provision alone fails to avoid depletion or near depletion of the composite storage in the system. Therefore, additional modifications were considered.

C. Maintain 5,000 cfs Minimum Release at Jim Woodruff Dam and Eliminate All Other Provisions of IOP Until Composite Storage Enters Zone 2. The period of June through December is the most critical period during a dry year. This generally represents the period where significant amounts of storage are required to augment the basin inflow to meet the 5,000 cfs minimum flow. Our analysis indicates this period provides the maximum opportunity to conserve storage (not refill) during a drought of the current severity. An opportunity to reduce flow below the 5,000 cfs minimum during this time is necessary. This alternative did not provide sufficient opportunity to conserve storage until basin inflows increase to a level where storage recovery can begin. Furthermore, extended periods with Composite Storage in Zone 4 (the current level) and especially those with Composite Storage levels significantly lower than the top of Zone 4 greatly limit our ability to respond to drought conditions as severe as and more severe than are currently occurring. This alternative was deemed not a fair balance between providing more opportunities to conserve storage for future augmentation flows and continued flow support to threatened and endangered species and the multiple project purposes in the basin. Therefore, additional alternatives were considered.

D. Maintain 5,000 cfs Minimum Release at Jim Woodruff Dam and Eliminate All Other Provisions of IOP Until Composite Storage Enters Zone 2; On 1 June 2008 See if Trigger to 4,150 cfs Flow is Met. Although this alternative is very similar to the two previous alternatives, the minimum flow reduction decision is delayed until next summer. As described above, immediate consideration to lowering the minimum flow must be taken due to the continued need to use storage to augment the basin inflow to meet the 5,000 cfs minimum flow over the next few months and to optimize storage conservation and the likelihood of reservoir refill. Reservoir refill to Composite Storage levels above Zone 4 is critical to our ability to manage the system during an extended drought period and delaying the decision until 1 June, 2008 would also miss the opportunity for supplementing storage during the normally wetter periods (January – April), that occur prior to June. This alternative was deemed not a fair balance between providing more opportunities to conserve storage for future augmentation flows and continued flow support to threatened and endangered species and the multiple project purposes in the basin. Under this operation, more preference was given to immediate support to threatened and endangered species than reservoir refill. Therefore, additional alternatives were considered.

E. Maintain 4,150 cfs Minimum Release at Jim Woodruff Dam and Eliminate All Other Provisions of IOP Until Composite Storage Enters Zone 2. This alternative provided great benefit to storage conservation and reservoir refill. However, model results indicate prolonged periods of flows equal to 4,150 cfs would occur under this operation. This alternative was deemed not a fair balance between providing more opportunities to conserve storage for future augmentation flows and continued flow support to threatened and endangered species and the multiple project purposes in the basin. More preference was given to storage conservation and reservoir refill than to support to threatened and endangered species. Therefore, additional alternatives were considered.

F. Georgia Environmental Protection Division (GAEPD) Recommendation – By letter dated 12 October 2007, the GAEPD requested a temporary modification of the IOP. A copy of the letter is provided in Appendix C. The GAEPD recommends that these modifications remain in place until 1 March 2008 at which time additional modifications would likely be required. The GAEPD recommended plan consisted of temporary modifications of the IOP that include changes to two parameters applicable to the daily releases from Jim Woodruff Dam: a minimum discharge in relation to average basin inflows and a maximum fall rate. The recommended changes include:

- Immediate suspension of 5,000 cfs minimum release requirement at Jim Woodruff Dam. Minimum releases from the dam would match basin inflow while basin inflow values are less 5,000 cfs.

- If basin inflow values are 5,000 cfs or higher, then the maximum release from Jim Woodruff Dam would be 5,000 cfs.

- Immediate suspension of maximum fall rate schedule.

GAEPD subsequently revised the proposed modifications in a Motion for Preliminary Injunction filed in the United States District Court Middle District of Florida Jacksonville Division on 19 October 2007. A copy of this document is provided in Appendix D. GAEPD states in the motion that these emergency changes to the IOP would remain in effect until the earlier of: 1) 1 March 2008; 2) a decision on the merits of Georgia II; or 3) further order of this Court, with the understanding that motions for modification of this relief may be appropriate in the event that conditions improve and the threat of depletion of reservoir system conservation storage is materially reduced. The revised temporary modifications include:

- Immediate suspension of 5,000 cfs minimum release requirement at Jim Woodruff Dam. Minimum releases from the dam would match the adjusted basin inflow while the adjusted basin inflow values are less 5,000 cfs, as measured at the Chattahoochee gage.

- If the adjusted basin inflow values are 5,000 cfs or higher, then the maximum release from Jim Woodruff Dam would be that required to maintain a 5,000 cfs flow measured at the Chattahoochee gage.

- Immediate suspension of maximum fall rate schedule.

As defined in the motion, “Adjusted Basin Inflow” is “the amount of water that would flow by Jim Woodruff Dam during a given time period if all of the Corps' reservoirs maintained a constant water surface elevation during that period, plus Georgia's municipal and industrial consumptive demands from the Chattahoochee River and Lake Lanier (which are deemed for purposes of this order to be 457 cfs during October, 369 cfs during November, 352 cfs during December, 302 cfs during January, and 345 cfs during February)”. Due to the similarity of the proposed modifications, we address the most recent recommendation in this alternative discussion.

We have incorporated aspects of the Georgia proposal into the proposed action, such as the suspension of maximum fall rate schedule; the storage of all basin inflows above 5,000 cfs; and the reduction of the 5,000 cfs flow if certain triggers are reached. The immediate suspension of the 5,000 cfs flow to match the adjusted basin inflows was not incorporated because it may not provide the benefits to Lake Lanier that are key to maintaining storage in the system. It could be beneficial to the lower project but could present a problem with holding the additional storage in the lower projects if they exceed the top of conservation or even a designated level within the flood zone. The provision to match minimum releases to basin inflows when flows are below 5,000 cfs would be more detrimental to the species than the reduction designated in the proposed action. The proposed action provides a reduction in flow if certain triggers are reached but does not reduce the flows to a level that could occur under this proposal.

G. ARC Recommendation– By letter dated 25 October 2007, the Atlanta Regional Commission (ARC) provided a three-phase Reservoir Recovery Plan that included an Emergency Operations Plan as phase 1. The other two phases include actions that would require additional consultation apart from the intent of the current consultation and therefore are not included in this alternative description. A copy of the letter is provided in Appendix E. The ARC recommends that the Emergency Operations Plan remain in place until 1) composite storage within the system is recovered; 2) a new IOP and/or updated Water Control Plan are completed; or 3) composite storage within the system is in Zone 4 on 1 February 2008 (at which time additional modifications would be required). The Emergency Operations Plan consists of temporary modifications of the IOP that include changes to two parameters applicable to the daily releases from Jim Woodruff Dam: a minimum discharge in relation to average basin inflows and a maximum fall rate. In addition, the Emergency Operations Plan includes a temporary waiver of the seasonal drawdown at the West Point and Walter F. George projects (for 2007-2008 only). The recommended minimum discharge changes include:

During the non-spawning season (June-February):

- When Basin Inflow is greater than 5,000 cfs, all flows in excess of those required to meet the 2,000 cfs minimum flow target at Farley Nuclear Plant should be stored in the Chattahoochee reservoirs to the extent possible.

- When Basin Inflow is less than 5,000 cfs, (or whatever alternative minimum flow FWS determines to be appropriate) storage should be released from the Chattahoochee reservoirs to meet the minimum flow.

During the spawning season (March-May):

- When Basin Inflow is greater than 11,000 cfs, all flows in excess of those required to meet the 2,000 cfs minimum flow target at Farley Nuclear Plant should be stored in the Chattahoochee reservoirs to the extent possible.

- When Basin Inflow is between 5,000 cfs and 11,000 cfs, Woodruff Outflow should equal Basin Inflow.

- When Basin Inflow is less than 5,000 cfs, (or whatever alternative minimum flow FWS determines to be appropriate) storage should be released from the Chattahoochee reservoirs to meet the minimum flow.

The ARC Emergency Operation Plan includes a modification of the IOP maximum fall rate schedule that determines maximum fall rate based on (1) the Basin Inflow fall rate; or (2) the IOP maximum fall rate schedule. The recommendation is that the maximum fall rate schedule should follow the higher of these two fall rates.

We have incorporated aspects of the ARC proposal such as storing basin inflow; maintaining the 5,000 cfs minimum flow if certain triggers do not call for a reduction in the minimum flow; storing basin inflow while meeting the minimum target flow for Farley Nuclear Plant and adjustments to the maximum fall rate. The condition in the ARC proposal to provide releases equal to basin inflow when Basin Inflow is between 5,000 cfs and 11,000 cfs was not incorporated into the proposed action because it does not provide enough opportunities to store water during the periods that fall into that range. This may occur more frequently during a dry winter and spring and would represent opportunities missed to supplement storage.

STATUS OF THE SPECIES/CRITICAL HABITAT

Please refer to the STATUS OF THE SPECIES/CRITICAL HABITAT section (Section 2) of the September 5, 2006 Biological Opinion and Conference Report on the U.S. Army Corps of Engineers, Mobile District, Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River (USFWS 2006). The detailed information provided in Section 2 represents the best scientific information available on the listed 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 IOP. Additional studies pertaining to listed mussel species in the Apalachicola River have occurred since the BO was signed. The findings of these studies are summarized in the Environmental Baseline section below.

ENVIRONMENTAL BASELINE

As described in the BO, 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 BO provides a description of the environmental baseline prior to implementation of the IOP. 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 proposed action must also consider the effects of operating under the IOP for the past 12 months. 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 we incorporate this information by reference to Section 3 of the BO. The following discussion will focus on new information relevant to the three principal components of the species' environment in the action area: channel morphology, flow regime, and water quality; as well as new information regarding the status of the species/critical habitat within the action area. This information is considered supplemental to that previously described in the BO.

CHANNEL MORPHOLOGY ALTERATIONS

As described in the BO, in 2006 Light et al. determined that 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. This determination was based on studies that suggest that in the past 50 years, many portions of the Apalachicola River have substantially declined in elevation (incised) and/or become substantially wider.

In accordance with RPM4 of the BO, the Corps conducted an evaluation of the sediment dynamics and channel morphology trends on the Apalachicola River in order to improve our understanding of dynamic conditions and monitor the zone at which take may occur, and to identify possible alternatives to minimize effects to listed mussels in vulnerable locations. By letter dated 30 August 2007, the Corps provided the findings of this evaluation to the USFWS. A copy of this letter and the accompanying enclosures is provided in Appendix F. The RPM4 Terms and Conditions described in the BO specify that Mobile District and USFWS will consult with experts, jointly identified by both agencies, to assist in identifying the current status of sediment transport and channel stability in the Apalachicola River as it relates to the distribution of listed mussels and their vulnerability to low-flow conditions. The goals of the evaluation are to identify: 1) feasible water and/or habitat management actions that would minimize listed mussel mortality; 2) current patterns and trends in morphological changes; and 3) additional information needed, if any, to predict morphological changes that may affect the listed mussels. This evaluation is to be based on available information and tools and best professional judgment. The USFWS and Corps mutually identified specialists with specific river sediment transport and morphology expertise and malacologists with extensive experience regarding freshwater mussels in the Apalachicola River and other large river systems to assist in the evaluation.

Based on review of existing information, the reconnaissance field trip, presentations and discussions at the technical workshop, and the summary of findings reports prepared by the river specialists and malacologist, the Corps determined that the current version of the IOP adequately met the intended goal of minimizing or avoiding adverse impacts or providing support to listed species occurring in the Apalachicola River. As documented in the BO, the flow regime in the Apalachicola River has not been changed significantly between the pre- and post- dam periods. The river appears to be in a relatively stable dynamic equilibrium. The morphology of the river could have been impacted over time by land use changes, upstream impoundments and consumptive use of water, and tectonic movement, as well as channel alterations, meander cutoffs, and channel dredging and snagging operations. Obvious channel degradation impacts were noted below Jim Woodruff Lock and Dam immediately after construction. However, these impacts appear to be reduced through time. Data from the Blountstown and Wewahitchka gages downstream of the dam indicate that there was a small change in low flow water surface elevations at those sites in response to Jim Woodruff construction, but the changes appear to have stabilized. Field observations and data analysis by the river specialists suggests that the river is not continuing to degrade and that it may have attained a state of relative equilibrium. This is consistent with the findings of Light et al. (2006) who concluded that channel conditions had been relatively stable for the a ten year period (1995-2004). Although a large portion of the middle river (Nautical Mile (NM) 78 to NM 35) is very sinuous and actively meandering, maximum erosion rates on the outside of the bends in this reach are extremely low compared to other large alluvial rivers and appear to be part of the natural down-valley meander migration which is common to most meandering streams. This does not appear to be the result of continuing post-dam system-wide adjustment such as degradation, aggradation, or channel widening. It appears unlikely that erosion rates will increase over time unless there are significant changes of the flow regime or reduction in sediment supply, which do not appear likely to occur under the provisions of the IOP. This evaluation did not include analysis of Apalachicola River flows less than 5,000 cfs. However, generally channel morphology alterations are more closely associated with increased duration and frequency of high flow events rather than low flow events as have occurred throughout this year.

FLOW REGIME ALTERATIONS

The proposed action is an operational plan that prescribes the flow of the river. Therefore, as described in the BO, the habitat characteristic of greatest relevance to this analysis is the flow regime of the river, which is highly variable over time, due to fluctuations in magnitude, seasonality, duration, frequency, and rate of change. In the BO, the USFWS describes the environmental baseline as a "snapshot" of a species health and habitat within the action area. However, in order to capture the intra- and inter-annual variability, the flow regime of the environmental baseline is necessarily a "video" of river flow that begins at an appropriate date in the past and concludes at the present (USFWS 2006). Therefore, this analysis provides an update of the "video" incorporating the conditions experienced over the last year since the BO was completed. 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 and current IOP operations of the Corps' 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 proposed action.

As noted in the "Description of Proposed Action" section, the Chattahoochee gage (USGS number 02358000) is the point at which Jim Woodruff Dam releases under the proposed action are measured. This gage is also the source of data for describing the baseline flow regime. Although the IOP attempts to mimic a natural flow regime, the flow of the Apalachicola River has been altered to some degree during the implementation period by provisions for storage of basin inflow, augmentation to maintain the 5,000 cfs minimum flow, and consumptive water uses which affect the basin inflow calculation. These alterations contribute to the environmental baseline.

As described above, the environmental baseline for the proposed action must also consider the effects of operating under the IOP for the past 12 months. Table 3 illustrates the average annual discharge statistics from the BO for the pre-Lanier and post-West Point periods and the calculated average annual discharge for the September 2006-September 2007 period. Since the last column only includes one year of data, the mean value is the only statistic provided. The average annual discharge value for the September 2006-September 2007 period is approximately half that observed in the other periods. This is a reflection of the severe drought conditions experienced during much of the past year. The USGS Apalachicola River discharge data (Chattahoochee gage) used to calculate the average annual discharge for the past year is considered provisional and is subject to change and final approval.

Average Annual Discharge Statistics

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Sep. 2006 - Sep. 2007*
Mean	21287.8	21677.3	10793.0
Median	20130.1	22283.0	
Standard Deviation	7387.5	6375.5	
Minimum	11223.2	9341.0	
Maximum	39579.6	35344.4	

Table 3. Average annual discharge statistics for the pre-Lanier (1922-1955), post-West Point (1975-2005), and September 2006-September 2007 periods.

As described in the BO, “The discharge generally associated with the greatest volume of sediment movement over time is the bankfull discharge, which is typically the annual peak flow event that occurs an average of two out of three years (1.5-year recurrence interval) (Dunne and Leopold 1978). Bankfull discharge tends to occur almost annually in the coastal plain portions of Alabama, north Florida, and Georgia (Metcalf 2004). Although higher flow rates than the 1.0- to 1.5-year recurrence peaks move more sediment per unit time, these more frequent events move the greatest sediment volume over time. Using 85 years of annual instantaneous peak flow data from the Chattahoochee gage, the 1.0- and 1.5-year recurrence peak flows for the Apalachicola River are 23,400 cfs and 72,100 cfs” (USFWS 2006). During the September 2006-September 2007 period, the maximum discharge value recorded was approximately 37,000 cfs.

Tables 4 - 6 compare the distribution of monthly average flow in the pre-Lanier, post-West Point, and September 2006-September 2007 periods. The average monthly discharge values for the September 2006-September 2007 period are considerably lower than observed in the other periods. This is a reflection of the severe drought conditions experienced during much of the past year. The average monthly discharge values for the September 2006-September 2007 period would have been significantly lower if conservation storage had not been available to augment basin inflow to meet the 5,000 cfs minimum flow at Jim Woodruff Dam.

Table 7 compares the total annual precipitation (inches) for the pre-Lanier, post-West Point, and September 2006-September 2007 periods. The total annual precipitation for the September 2006-September 2007 period is approximately 10 inches less than the average observed in the other periods. This further supports the severity of the drought conditions experienced during much of the past year.

Average Monthly Discharge Statistics

January

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Jan. 2007*
Mean	27136.5	26115.5	21307.3
Median	23432.3	21103.2	
Standard Deviation	13929.1	12772.9	
Minimum	10748.4	9035.8	
Maximum	62467.7	50896.8	

February

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Feb. 2007*
Mean	29599.1	34350.5	18930.8
Median	28658.6	33196.4	
Standard Deviation	13097.0	13916.8	
Minimum	11233.6	10423.2	
Maximum	64917.2	67314.3	

March

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Mar. 2007*
Mean	40474.2	40827.4	19452.2
Median	32764.5	44600.0	
Standard Deviation	29883.5	18693.5	
Minimum	12780.6	14573.2	
Maximum	171632.3	90332.3	

April

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Apr. 2007*
Mean	34332.5	31342.2	13525.9
Median	31423.3	27553.3	
Standard Deviation	16434.1	16694.8	
Minimum	16750.0	10884.7	
Maximum	80703.3	71786.7	

Table 4. Average monthly discharge statistics (January-April) for the pre-Lanier, post-West Point, and September 2006-September 2007 periods.

Average Monthly Discharge Statistics

May

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*May-07*
Mean	22921.6	20204.7	6855.9
Median	19938.7	17093.5	
Standard Deviation	9990.5	9890.8	
Minimum	9840.3	8325.8	
Maximum	44977.4	43038.7	

June

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Jun. 2007*
Mean	15918.6	16303.0	5148.7
Median	15633.3	14626.7	
Standard Deviation	5403.0	7079.8	
Minimum	7147.7	4825.7	
Maximum	27670.0	37116.7	

July

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Jul. 2007*
Mean	16959.1	18453.0	5350.3
Median	15587.1	12740.0	
Standard Deviation	7060.2	16550.7	
Minimum	9009.7	5116.8	
Maximum	37854.8	87780.6	

August

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Aug. 2007*
Mean	15660.5	14807.5	5138.3
Median	14977.4	12138.7	
Standard Deviation	5569.7	7844.1	
Minimum	8129.0	4750.0	
Maximum	29254.8	32348.4	

Table 5. Average monthly discharge statistics (May-August) for the pre-Lanier, post-West Point, and September 2006-September 2007 periods.

Average Monthly Discharge Statistics

September

	Pre Lanier (1922-1955)	Post West Point (1975-2005)	Sep. 2006
Mean	12174.7	12390.1	6996.5
Median	12003.3	11605.7	
Standard Deviation	3669.0	4958.4	
Minimum	6092.0	5888.7	
Maximum	19716.7	28414.0	

October

	Pre Lanier (1922-1955)	Post West Point (1975-2005)	Oct. 2006
Mean	11787.9	12346.1	6165.6
Median	10574.2	11325.8	
Standard Deviation	6540.8	5749.8	
Minimum	5319.4	5658.7	
Maximum	37509.7	30367.7	

November

	Pre Lanier (1922-1955)	Post West Point (1975-2005)	Nov. 2006
Mean	12696.8	14214.2	12103.9
Median	9960.0	12723.3	
Standard Deviation	7129.3	6371.1	
Minimum	5524.0	5613.7	
Maximum	28990.0	31790.0	

December

	Pre Lanier (1922-1955)	Post West Point (1975-2005)	Dec. 2006
Mean	19450.6	20585.6	9153.9
Median	14870.0	16793.5	
Standard Deviation	13794.5	12570.3	
Minimum	7990.6	7336.8	
Maximum	70393.5	51664.5	

Table 6. Average monthly discharge statistics (September-December) for the pre-Lanier, post-West Point, and September 2006-September 2007 periods.

Total Annual Precipitation (Inches)

	Pre Lanier (1922-1955)	*Post West Point (1975-2005)*	*Sep. 2006 - Sep. 2007*
Mean	51.6	52.9	42.9
Median	49.3	52.9	
Standard Deviation	9.2	7.4	
Minimum	31.2	41.3	
Maximum	72.4	68.2	

Table 7. Total annual precipitation (inches) statistics for the pre-Lanier, post-West Point, and September 2006-September 2007 periods.

WATER QUALITY

As described in the BO, although the State standards adopted consistent with the U.S. Environmental Protection Agency (EPA) criteria generally represent levels that are safe for sturgeon and mussels, these standards are sometimes violated. Point and non-point source pollution have contributed to impaired water quality in the Apalachicola and Chipola rivers resulting in several segments of the rivers within the action area failing to fully serve the designated uses. The impairments identified include turbidity, coliforms, total suspended solids, dissolved oxygen (DO), biology, and unionized ammonia (FDEP 1998 and 2003). Elevated coliform bacteria counts are not known to harm Gulf sturgeon or freshwater mussels; however, elevated unionized ammonia and low DO are associated with adverse effects to fish and mussels (USFWS 2006). In addition, the 5-Year Review for seven listed mussel species (including the three occurring in the action area) published by the USFWS this summer states that recent studies have demonstrated early life stages of mussels are generally more sensitive to copper and ammonia than other organisms and that current EPA criteria for copper and ammonia are not protective of mussels (USFWS 2007). The 5-Year Review also notes that these early life stages may be particularly sensitive to pesticides and herbicides such as glyphosate and atrazine (USFWS 2007). We lack sufficient information to determine if implementation of the IOP has altered the baseline water quality of the action area. However, we recognize that the extraordinary drought conditions experienced during much of the IOP implementation period, have resulted in salinity changes in Apalachicola Bay and increased water temperatures and associated localized dissolved oxygen changes due to extended periods of low flow (approximately 5,000 cfs).

Livingston (1984) noted that the salinity distribution in the Apalachicola Bay system at any given time is affected primarily by river flow, local rainfall, basin configuration, wind speed and direction, and water currents. Low bay salinities coincide with high river flows generally experienced during winter, spring, and tropical storm events in the summer. The bay system can generally be divided into two main provinces 1) the relatively high salinity open Gulf waters of eastern St. George Sound and Alligator Harbor (greater than 30 parts per thousand (ppt) most of the year); and 2) the brackish (river-diluted) portions of western St. George Sound, Apalachicola Bay, St. Vincent Sound (varying from 5-18 ppt to 18-30 ppt), and East Bay (0.5-5 ppt most of the year). The Florida Department of Environmental Protection (FDEP) has been monitoring salinity levels at several locations in the Apalachicola bay system throughout the year. Preliminary data provided by USFWS (J. Ziewitz, pers. comm.) provides some insight into the impact of this year's extended low river flow on salinity levels in the bay. Dataloggers located at Cat Point (an oyster bar on the western end of St. George Sound), Dry Bar (an oyster bar on the eastern end of St. Vincent Sound), and Upper East Bay (the northeastern end of East Bay) continuously (15 minute intervals) collected data throughout the summer. All of these locations occur in areas Livingston (1984) characterized as brackish. Preliminary data indicates that all three locations experienced relatively high salinity levels throughout the recording period (July – September). The Cat Point data indicates salinity levels generally in the range of 23-33 ppt; the Dry Bar data indicated salinity levels generally in the range of 24-35 ppt; and the Upper East Bay data indicated salinity levels generally in the range of 14-23 ppt. This data is consistent with anecdotal information provided by the Shellfish Group at the Florida Department of Agriculture, which observed significant oyster mortality, beginning in late March, in the western portions of the bay and spread eastward throughout the summer to areas closer to the mouth of the river (Cat Point). They attribute this mortality to dermo (disease) and predation which is exacerbated by the high salinities and high water temperatures which are also attributed to the lack of fresh water flows from the river that cool down the bay (J. Ziewitz, pers. comm.). The high salinity levels experienced in Apalachicola Bay this summer may impact juvenile and adult Gulf sturgeon entering the bay this fall/winter. A discussion of salinity alterations on sturgeon is provided in the Status of the Species section below.

Although we do not have water temperature or DO data from this year, it is reasonable to assume that the maintenance of an approximately 5,000 cfs flow in the Apalachicola River for an unprecedented duration (generally from late May to present) during the hottest months of the year has resulted in increased water temperature and localized declines in DO. These alterations could be particularly damaging to the mussels species since their movement capabilities are slow and limited. The most extreme examples of this would occur in shallow backwater areas with little or no connection to the main channel of the river and in shallow isolated pool habitat occurring in distributaries that no longer have a hydrological connection to the main channel of the river (eg., Swift Slough). Generally, mussels occurring in habitats along the margins of the main channel where flowing water is present do not experience temperature and DO changes at a significant impact level. However, observations made by USFWS field personnel this summer, indicate that mussels found in isolated pools or shallow slack water habitats are showing signs of stress or mortality likely due to high temperatures and low DO (J. Ziewitz, pers. comm.). It should be noted that the exceptional drought conditions would have resulted in "natural flows" less than 5,000 cfs if the storage from the upstream reservoirs had not been used to augment basin inflow in order to maintain the 5,000 cfs minimum flow. Significant reductions in river flow below 5,000 cfs would likely exacerbate the temperature and DO conditions observed this year; as well as substantially increase in the risk of stranding aquatic organisms.

STATUS OF THE SPECIES/CRITICAL HABITAT WITHIN THE ACTION AREA

This portion of the environmental baseline section focuses on new information relative to each listed species' spatial distribution, population status, and trends within the action area, as well as, any new information relative to designated and proposed critical habitats.

GULF STURGEON

Very little new sturgeon data is available since the time the IOP BO was signed. In spring 2007, Dr. Bill Pine collected Gulf sturgeon migration data in conjunction with an FWCC funded research study on fish movement and spawning patterns in the Battle Bend region of the Apalachicola River. The study included monitoring an array of several passive receivers located at strategic positions along the river to document movement patterns of 13 sturgeon with known viable acoustic tags. Preliminary data from the study indicates that several of the tagged sturgeon migrated up to the documented spawning habitat near NM 105 and at least one of the tagged sturgeon migrated up to the documented spawning habitat near Torreya State Park (B. Pine, pers. comm.). A full analysis of the data has not been completed yet and funding is required to complete the effort. This preliminary data indicates that although March flows this year were lower (maximum approximately 37,000 cfs) than the average observed post-West Point March flows (approximately 45,000 cfs) described in the BO (reference Figure 3.3.3A), flows were still of a sufficient magnitude to trigger migratory movements. This represents between 4 and 9 acres of suitable spawning habitat at the rock ledge site at NM 105, and between 5 and 19 acres of suitable spawning habitat at the combined two known spawning sites (NM 105 and NM 99.5). However, there is no data available regarding whether or not spawning occurred or if it was successful.

The U.S. Geological Survey (USGS) also conducted a study during October 2006-May 2007 tracking the movement of juvenile sturgeon within the East Bay-Apalachicola Bay area. Similar to the methods described above, USGS deployed an array of 14 passive receivers and tracked the movement of four juvenile sturgeon (age 1-2 fish) in the size range of 350-750 mm total length (TL). Of the tagged sturgeon, three (429-680 mm TL) reported back numerous times to individual receivers; no reports were obtained for the fourth fish. Additionally, the receivers collected data on larger adult Gulf sturgeon with viable tags from separate studies. A detailed report on this data has not been completed. However, the preliminary data indicates that these juvenile sturgeon remained very close to shore (within 1-3 km), and mostly in the East Bay area. After October 2006, no data was collected from receivers within the Apalachicola River proper or East River proper (until late March, when the fish were moving in). Over the whole monitoring period, no data was obtained from 3 receivers deployed further offshore in the bay. This suggests that early juveniles appear to be utilizing primarily very shallow, nearshore areas as winter feeding grounds. Based on NOAA benthos data, these same areas have high densities of polychaetes and amphipods (important prey items), relative to lower values in deeper bay waters. The USGS also noted that based on the juvenile sturgeon tracking data and the adult sturgeon tracking data, it appears that the really small juveniles stay very close to shore, and are heavily using the East Bay area, while the larger sturgeon are using the same areas, but also additional areas farther out into the bay proper. This further supports the importance of the East Bay area to juvenile sturgeon as it appears that other areas provide suitable foraging habitat as well, but are not being utilized. The USGS study information was provided by USFWS based on discussions with Ken Sulak (USGS).

As described in the BO, juvenile sturgeon develop a tolerance to higher salinity gradually during the first year of life, and thereafter exhibit optimum growth at a salinity level of about 9 ppt. Estuarine and later marine habitats provide the primary feeding areas for the species at some point during the first year hatching; therefore, the salinity regime of Apalachicola Bay is likely an important factor in defining juvenile feeding habitat (USFWS 2006). The high salinity levels observed in Apalachicola Bay (especially the East Bay area) throughout the summer of 2007 likely continued through October. FDEP reported that the East Bay surface datalogger had not recorded salinity values below 12 ppt since July of this year (J. Ziewitz, pers. comm.). Given the apparent importance of the East Bay area to sturgeon (particularly juveniles) and the continuing high salinities, it is possible that juvenile and to some extent adult sturgeon could be impacted by both delayed entry to the feeding areas of the bay and potential reduction in productivity of these normally rich feeding areas. This could result in poor growth and/or lower survival of juvenile sturgeon. Adult sturgeon appear to be better adapted to the higher salinity levels and may be able to exploit other feeding areas in the bay and the Gulf. As noted above, portions of the bay appear to provide high value feeding habitat to juvenile and adult sturgeon. Since the sturgeon do not feed while in the riverine spawning and holding areas, these foraging areas are of particular importance as they provide the first opportunity for feeding when exiting the river. In her dissertation, Putland (2005) analyzed the ecology of phytoplankton and microzooplankton in Apalachicola Bay relative to changes in salinity. The analysis indicated that higher salinity levels in the bay, associated with low river discharge periods, resulted in decreased ingestion and production of microzooplankton. Because microzooplankton are key constituents of the estuarine food web in Apalachicola Bay, the analysis suggests that lower discharges in the river that result in lower nutrients and higher salinity (>20 psu, which is roughly equivalent to 20 ppt) in the bay could reduce higher trophic level productivity as a consequence of reduced microzooplankton production (Putland 2005).

FAT THREERIDGE

In the 5-Year Review for the seven mussels (USFWS 2007) concluded the status of the fat threeridge is considered declining. This determination is based in part on the significant drought-induced mortality that occurred in 2006 (USFWS 2007). In addition, they also describe fat threeridge as a species with a high degree of threat and low recovery potential.

By letter dated 30 March 2007, the USFWS granted an extension of the RPM4 and RPM5 completion date to 30 August 2007 and requested that the Corps conduct mussel sampling surveys this summer in order to evaluate the potential risk of exposure to listed mussels located in vulnerable microhabitats should basin inflows fall below 10,000 cfs. Therefore, with USFWS guidance, the Corps obtained the services of Dr. Drew Miller (malacologist formerly employed by the Corps Engineering Research Development Center) to conduct a mussel survey to collect information on density and relative species abundance of *A. neislerii* at sites that appeared to provide appropriate water depth, velocity, and substratum. The survey was conducted on 7-11 July 2007 at 25 locations between NM 40 and 50 on the Apalachicola River. No divers were used; all collecting was done by wading. Survey design and sampling stations were developed based on discussions with representatives of the Mobile District, US Fish and Wildlife Service (USFWS), and the Florida Game and Freshwater Fish Commission (FWCC), as described below.

A reconnaissance field trip was conducted by representatives of the Corps, USFWS, and FWCC in late May. Following the field trip, personnel of the USFWS identified 25 study areas between NM 40 and 50 along the Apalachicola River which either supported, or appeared likely to support *A. neislerii*. The USFWS randomly selected 10 sites for detailed study. Detailed field studies were conducted at the 10 sites and partial studies were conducted at most remaining sites (23). In addition, one new site (DS01) was added at a disposal area of interest. This site was added because of a desire to obtain sediment and elevation data at a disposal area that appeared to have little or no value to mussels. The 25 sites chosen by USFWS had one or more of the following characteristics: 1) stable, gently sloping banks primarily vegetated with newly established black willow, 2) dense and species-rich mussel assemblages, 3) firm substratum consisting of silty sand, and 4) signs of recent mussel mortality from low water in 2006 and 2007. Virtually every one of these areas was along a moderately depositional reach that was immediately downriver of a point bar. Eddies, which are swirling and reverse currents in rivers, are created when water flows past upstream obstacles such as point bars. These eddies create favorable conditions for mussel assemblages since they encourage deposition of fine particulate matter and glochidia larvae.

A detailed description of the survey methods and results is provided in the mussel report enclosure to the RPM4 and RPM5 submittal letter in Appendix F. At the 10 areas where detailed studies were conducted, six evenly spaced transects were established perpendicular to shore. Mussels were collected with a 0.25 m^2 quadrat at three sites along each transect moving from near- to far-shore. The three sampling sites along each transect generally corresponded to depths of 1, 2, and 3 feet. A theodolite was used to obtain distance and elevation data along each transect and a sediment sample was taken at the midshore location along each transect. A total of 18 quantitative samples were obtained at each of the 10 areas; therefore, 180 quantitative samples were taken. Additionally, a 10- or 20-minute timed search for mussels was conducted between two of the transect lines in the center of each area. At the remaining 15 areas only two transect lines were established perpendicular to shore. Sediment samples were collected, and elevation and distance measures were obtained along each transect. Mussels were collected for 10 minutes in the area bounded by transects in order to calculate Catch per Unit Effort (CPUE) values for these qualitatively sampled areas.

Based upon qualitative sampling, *A. neislerii* was found at 23 of the 25 areas between NM 40 and 50 including all 10 areas surveyed using quantitative methods. CPUE for all mussels at the 25 sites ranged from 0 to 1,080 (average = 312), and CPUE for *A. neislerii* ranged from 0.0 to 774 (average = 162). The qualitative and quantitative data were used to predict density of *A. neislerii* from CPUE using a regression equation ($Y = 0.28X - 0.77$; $R^2 = 0.59$) for the 15 sites where only CPUE data were obtained. Mean *A. neislerii* density ranged from 0.2 to 12.7 individuals/m^2 (average = 3.7, standard deviation = 3.7) and total unionid density ranged from 2.4 to 36.0 (average = 11.9, standard deviation = 11.2). Total shell length for *A. neislerii* ranged from 11.7 to 76.4 mm, and there was evidence of strong recruitment with cohorts centered at 17.5 and 42.5 mm.

The pooled within site density data for the 10 quantitatively sampled areas was evaluated to determine if within site density distribution exhibited significant differences moving upriver to downriver or near to far shore. Only minor differences were observed. Although the mid-shore sample sites did have slightly higher mean densities than the near- and far-shore sample sites. The 2003 study data also noted higher mean densities at the mid-shore sample sites. Results of both surveys suggest that *A. neislerii* (and most other mussel species in this river) generally inhabit a fairly narrow band along the shore in reaches with suitable water velocity and substrate. Assuming only a 1meter wide strip (to a water depth of approximately 50 cm) of live *A. neislerii* existed along the shore at each location surveyed between NM 40 and 50; this data indicates that the total population size at all 25 sites would be 19,000 individuals. However, it should be noted that density estimates based on this type of qualitative data could considerably over- or under-estimate the actual population density. Additionally, it is likely that the mussel "bed" or strip is wider than 1 meter and extends further into deeper water. In fact the data at some of the sites suggests that the band of mussels may extend into more far-shore, deeper habitat (DM16). Results of a study conducted in 2003 indicated that while maximum densities were at 1.2 m, *A. neislerii* could be found up to 2.7 m deep (river flows at the time of the study were considerably higher than those observed in 2007). This is an additional 1.5 m of depth beyond that which was sampled during the present survey. Therefore, the total population of *A. neislerii* at these 25 locations probably exceeds 19,000 individuals. In addition, this estimation does not include other sites both in and outside the study reach (NM 40-50) that also support *A. neislerii*.

These recent mussel surveys indicate that the main channel habitats favored by the fat threeridge are moderately depositional areas generally associated with eddies. Eddies shift location over time through the process of lateral channel migration. When the shift is abrupt, mussels may be stranded in areas that are later exposed. It is possible the mortality event observed in 2006 was partially a result of this phenomenon. The surveys conducted in 2007 suggest that the stranding sites are becoming terrestrial habitat and mussels are found in high numbers in the existing eddy habitat downstream. It is important to note that this system is dynamic and mussels are adapted to some degree of habitat change. However, additional analysis is needed to determine if the observed rate of change is consistent with a natural process or if it is accelerated by other activities (USFWS 2007).

In early October 2007, Dr. Miller conducted additional analysis on the mussel depth distribution data collected during the 2003 and 2007 studies (Appendix G). The following summarizes this analysis and unless otherwise noted is attributable to the 15 October 2007 report he authored. Essentially the same sampling strategy was used in 2003 and 2007. Since mussels were collected at 1-foot (ft) depth increments, results (density or relative abundance) could be expressed in terms of water depth or elevation. At each collecting site, water elevation data were converted to discharge by Corps personnel based on recent ratings data provided by the USGS in order to estimate the number of *A. neislerii* that could be exposed to the atmosphere if water level and discharge declined. It should be noted that mussels exposed to the atmosphere during low flow will not necessarily be killed; an unknown number will likely move into deeper water if flows decline slowly enough to facilitate movement. In addition, studies suggest that some exposed mussels could survive for days or weeks if they are shaded and partially buried in moist sediment. However, mussels exposed or located in extremely shallow water would likely experience more stress due to low water quality and high temperature and would be more susceptible to predation and mortality.

A. neislerii density estimates were higher in 2007 than in 2003 in the same river reach. The maximum estimated density in 2003 was 2.0 individuals/m^2, recorded at NM 41.5, at a depth of 4 ft. In 2007 the maximum estimated density was 22.7 individuals / m^2, recorded at NM 43.9 at a depth of 2 ft. Since none of the sites studied in 2003 were re-surveyed in 2007, a direct comparison between study years cannot be done. It is possible that the areas surveyed in 2007 were located in better habitat than those studied in 2003 and therefore supported more mussels. However, it is also possible that the higher densities recorded in 2007 could have been the result of a large number of mussels moving to lower elevations in response to lower flows.

The 2007 survey data indicated similar densities of *A. neislerii* could be exposed to the atmosphere if water level and discharge declined at the 10 quantitatively sampled and 15 qualitatively sampled survey locations. The results of the depth distribution analysis for the 15 qualitative sites indicated that a 1-ft loss in water level, below a discharge of 5,150 cfs, to an equivalent flow of approximately 4,150 cfs, could expose approximately 20 percent of the *A. neislerii*. A 2-ft decline in water level at these same sites, corresponding to a flow of 3,200 cfs, could expose approximately 65 percent of the *A. neislerii* (Figure 2). The results of the depth distribution analysis for the 10 quantitative sites indicated that a 1-ft loss in water level, below a discharge of 5,150 cfs, to an equivalent flow of approximately 4,150 cfs, could expose approximately 20 percent of the *A. neislerii*. A 2-ft decline in water level at these same sites, corresponding to a flow of 3,200 cfs, could expose approximately 65 percent of the *A. neislerii* (Figure 3). As stated above, all exposed mussels would not necessarily be killed by reductions in water level; some could move into deeper water and survive, and as long as water levels remained low, these mussels would likely do well in these previously unoccupied areas. However, it is uncertain if habitat conditions in the deeper water areas would provide suitable habitat under higher flow conditions due to potential differing geomorphic conditions. In the future when water discharge and velocity increase, some of the mussels located in the deeper water could be vulnerable to sheer stress far in excess of what they can tolerate, resulting in mussels being eroded out of the substratum and being displaced downriver. It is possible that some of these individuals could be carried to suitable areas and survive, although others (potentially significant numbers) could be deposited in the main channel or other unsuitable habitat and be killed.

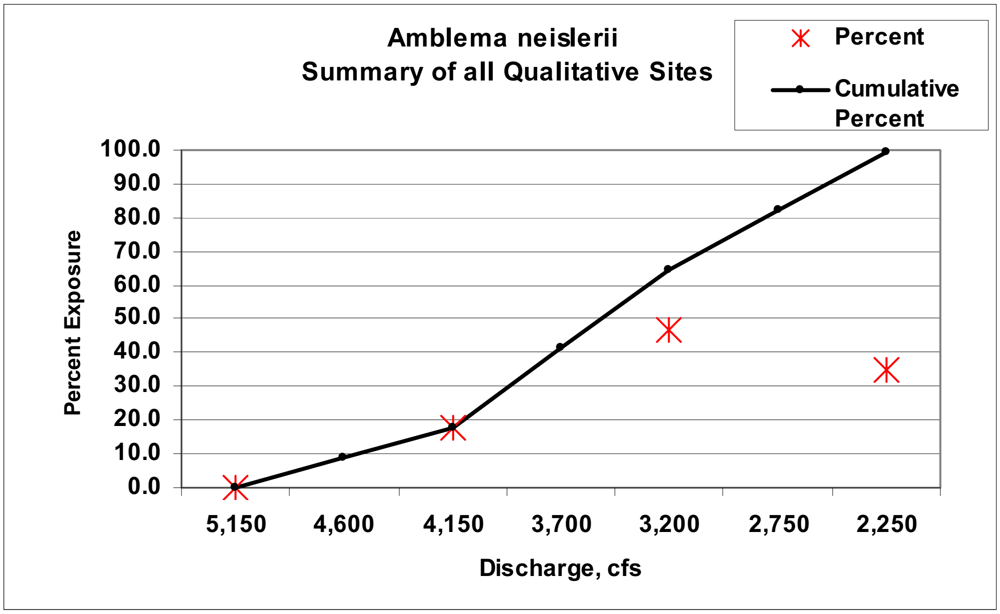

Figure 2. Percent Exposure Potential for Incremental Flows at the Qualitative Sampled Sties

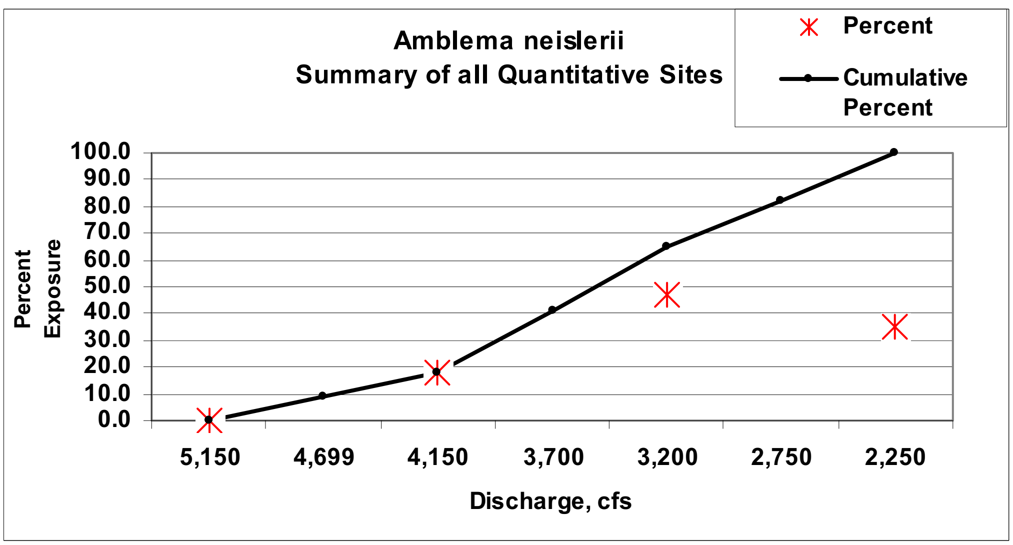

Figure 3. Percent Exposure Potential for Incremental Flows at the Quantitative Sampled Sties

PURPLE BANKCLIMBER

There is very little new data relative to purple bankclimber mussels. In the 5-Year Review for the seven mussels (USFWS 2007) the USFWS concluded the status of the purple bankclimber is considered stable based on persisting populations. However, they also describe purple bankclimber as a species with a moderate degree of threat and low recovery potential.

As described in the BO, the purple bankclimber is characterized as a species preferring the deeper portions of main channels (often at depths greater than 3 m) in the larger rivers within its range. Although portions of the Apalachicola River contain deep-water habitat in relatively stable condition, these areas have been inadequately sampled for listed mussels. The Corps is unaware of any additional sampling in deep-water habitat than what was described in the BO. However, the USFWS did observe several purple bankclimber mussels approximately six inches below the water surface elevation at the limestone rock outcrop (NM 105) below the dam earlier this summer (J. Ziewitz, pers. comm.).

CHIPOLA SLABSHELL

There is very little new data relative to Chipola slabshell mussels. In the 5-Year Review for the seven mussels (USFWS 2007) the USFWS concluded the status of the Chipola slabshell is considered unknown due to lack of new data. However, they also describe Chipola slabshell as a species with a moderate degree of threat and low recovery potential. USFWS is currently funding a mussel survey to determine the status and distribution of Chipola slabshell and other species in the Chipola Basin. Thus far over 300 individual mussels from ten new subpopulations and six previously documented subpopulations have been collected (USFWS 2007).

HOST FISH FOR THE MUSSEL SPECIES

As described in the BO, lab-confirmed host fish species for the fat threeridge include the weed shiner, bluegill, redear sunfish, largemouth bass, and blackbanded darter. No host fish species have been confirmed for the purple bankclimber (USFWS 2006). Recently, researchers also confirmed that bluegill can serve as a host fish species for Chipola slabshell (USFWS 2007).

Monitoring data from FWCC indicates that some species of native shiners, redbreast sunfish, madtoms, and bullhead catfish have declined in catch and percent abundance numbers. Some species have become increasingly rare in several river basins within Florida. Preliminary information also indicates that largemouth bass, bluegill, redear sunfish, spotted suckers, and redbreast sunfish year-class and abundance numbers are affected by flow regime in the Apalachicola River (USFWS 2007).

EFFECTS ANALYSIS

This section is an analysis of the effects of the proposed action on the species and critical habitat. The previous “Environmental Baseline” section described the effects of the IOP over the past year. This section addresses the future direct and indirect effects of the proposed action.

FACTORS CONSIDERED

In the "ENVIRONMENTAL BASELINE" section, we described three principal components of the species' environment in the action area: channel morphology, flow regime, and water quality. We lack sufficient information to determine if implementation of the IOP has altered the baseline water quality of the action area described in the BO. However, we recognize that the extraordinary drought conditions experienced during much of the IOP implementation period, and perhaps the IOP itself, have resulted in salinity changes in the bay and localized dissolved oxygen changes due to extended periods of low flow (approximately 5,000 cfs). As described in the BO, 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. As described above, based on the evaluation of the sediment dynamics and channel morphology trends on the Apalachicola River conducted this summer, the Corps determined that the river appears to be in a relatively stable dynamic equilibrium, and that the current version of the IOP adequately met the intended goal of minimizing or avoiding adverse impacts or providing support to listed species occurring in the Apalachicola River. We have no ability at this time to predict specific effects on channel morphology due to the influence of the proposed action on the flow regime. However, generally channel morphology alterations are more closely associated with increased duration and frequency of high flow events rather than low flow events as have occurred throughout this year. The IOP and the proposed action define limits on the extent to which the Corps 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 proposed action. Consistent with the BO for the IOP, our analysis of flow regime alteration relative to the listed species and critical habitats considers the following factors.

Proximity of the action: The proposed action will affect habitat occupied by all life stages of Gulf sturgeon in both the Apalachicola River and Bay, which are designated as critical habitat. The proposed action 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 proposed as critical habitat for the mussels. The proposed action is implemented through 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 proposed action 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. Most of the known range of the fat threeridge is included within the action area on the Apalachicola and Chipola Rivers. The purple bankclimber is known to occur within the Apalachicola River, while only one individual Chipola slabshell is known from the Chipola River downstream of the confluence with the Chipola cutoff within the action area. This analysis examines how the proposed action may variously affect different portions of the action area according to the distribution of the species and important habitat features in the action area.

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 Gulf sturgeon primary constituent elements of designated critical habitat may be affected by the action: riverine spawning sites, flow regime, and water quality. Permanently flowing water and water quality are also two of the five primary constituent elements of proposed critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell. The proposed action may also affect a third element of proposed critical habitat for the mussels: host fish. We examine how the proposed action 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.

Duration: This proposed action is a temporary modification to the IOP applicable until revised or until the drought is over (composite storage returns to zone 2) and the nature of its effects is such that none are permanent. Reservoir operations may conceivably be altered at any time; therefore, flow alterations that may result from the proposed action will not result in permanent impacts to the habitat of any of the listed species. However, we examine how the proposed action 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 action is applicable year round; therefore, changes to the flow regime and water quality parameters may occur at any time and/or continuously until such time as it is revised or until the drought is over (composite storage returns to zone 2). However, we examine how the proposed action 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: The proposed action provides for potentially substantial discretionary alteration of the flow regime when basin inflow is greater than 4,150 cfs, but maintains a minimum flow of 4,150 cfs from Jim Woodruff Dam. We examine how the proposed action affects the magnitude of flow events relative to the baseline or no action condition.

ANALYSIS FOR EFFECTS OF THE ACTION

To determine the future effect of project operations as prescribed by the proposed action, we must compare the environmental conditions expected to occur under the EDO to the environmental baseline. As described above, the principal factor examined in determining effects for the alternative operations is the flow regime of the Apalachicola River and how the flow regime affects habitat conditions for the listed species.

In the BO for the IOP, 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. The USFWS compared the flow regime expected under the IOP to this historic flow record to identify changes in flows that were relevant to the listed species and their habitats. To isolate the effects of the present level of consumptive water use on the flow regime in the foreseeable future from the effects of implementing the IOP, the USFWS also examined environmental conditions that would result if project operations were not continued, *i.e.,* the effects of no action on the part of the Corps. This flow regime was termed the run-of-river (RoR) regime. By comparing all three flow regimes, baseline, IOP, and RoR, the USFWS identified effects relative to the Baseline attributable to the IOP apart from effects attributable to an increase in depletions due to consumptive losses in the basin since 1975.

Because the proposed action is a temporary response to extraordinary drought conditions, it is not appropriate to compare the flow-regime effects of the EDO to a longer-term historical baseline, as included in the BO for the IOP. For the proposed action, the current IOP, as described in the 23 March 2007 letter to USFWS, represents the environmental baseline condition, and the impact we must evaluate is how a short-term proposed change to the IOP may affect listed species and designated critical habitat. Because the proposed action applies only until the drought is over (composite storage returns to zone 2), isolating the effects of increasing consumptive uses in the basin over time from the effects of the proposed action is not necessary in this analysis as it was for evaluating the IOP. The current level of consumptive uses is part of the baseline and will be part of the proposed action also. Whereas the effects analysis in the IOP BO compared 27 years of historic flows with 27 years of simulated IOP flows and 27 years of simulated run-of-river (no action) flows, this effects analysis compares only two operational schemes, the IOP and the proposed action, over the course of approximately two years. However, we simulate that two year period at two possible levels of drought conditions in the basin. Therefore, the environmental baseline is the suite of environmental conditions expected if the Corps would continue operating according to the IOP for the next two years. For the purposes of this analysis, we assume that drought conditions will continue for the next two years and have synthesized two flow regime scenarios to represent a range of possible conditions that could be experienced under the proposed action and the baseline. It should be noted that these synthesized flow regimes are based on continuing drought conditions and thus the hydrological data input into the model represents reasonable “worst case scenario” hydrological conditions. A detailed description of how this hydrological input data for the model was developed is provided in the model description section below.

MODEL DESCRIPTION

A simulation of ACF project operations under the proposed action and the baseline using the HEC-5 hydrologic simulation software is provided. This version of the HEC-5 model represents the EDO operations (described in the “Description of Proposed Action” section above) and the baseline (current IOP, as described in the 23 March 2007 letter to USFWS or “no action”).

As described in the BO, basin inflow is the amount of water that would flow by Jim Woodruff Dam during a given time period if all of the Corps reservoirs maintained a constant water surface elevation during that period, such that the reservoirs would only release the net inflow into the dam. Basin inflow is not the natural flow of the basin at the site of Jim Woodruff Dam, because it reflects the influences of reservoir evaporative losses, inter-basin water transfers, and consumptive water uses, such as municipal water supply and agricultural irrigation. The baseline and EDO scenarios include these influences, and use the same estimates of reservoir evaporation and current water demands; therefore, the difference between these scenarios is the net effect of continued operation under each scenario including the effect of influences that are unrelated to project operations.

The consumptive water demands used in the models represent an estimate of year 2000 levels of the net depletion due to municipal, industrial, and agricultural water uses and evaporative losses from the four largest reservoirs, Lanier, George, West Point, and Seminole. These depletions vary by month and in the case of agricultural demands and reservoir evaporation, also by year (wet, normal, dry). These consumptive demand estimates and the other model settings and techniques are consistent with those utilized during the development of the IOP.

To provide a potential range of flows that might be experienced under continuing drought conditions while the proposed action is in effect, we have synthesized two flow scenarios. The HEC-5 model simulates river flow and reservoir levels using a daily time series of synthesized flow data for a certain period of record. For the purposes of this analysis we selected hydrological conditions that represent 1) an unprecedented, exceptional drought applied across the entire ACF basin and continuing without relief for a two year period (referred to as the 10 percent hydrology); and 2) an exceptional drought that reflects differences in precipitation within the basin but is still more severe (20 percent reduction) than observed during the critical period prior to the current drought (referred to as the 1999-2001 20 percent reduced hydrology).

The unimpaired flow data set is a product of the Tri-State Comprehensive Study, and has been extended to include water years through 2001. Whereas basin inflow is computed to remove the effects of reservoir operations from observed flow, unimpaired flow is computed to remove the effects of both reservoir operations and consumptive demands from observed flow.

The model simulation period is October 8, 2007 to December 31, 2009 (26 months). The observed elevation for October 7, 2007 is used as the initial elevation for the four ACF reservoirs; Lake Lanier, West Point Lake, Walter F. George Lake and Lake Seminole. The HEC-5 reservoir simulation model uses unimpaired local flow at 25 control points (nodes) as the flow data input for the ACF Model. The Corps' HEC-DSS Vue tool is used to compute the daily 10th percentile local flows at every control point. This synthetic flow data set assumes a uniform distribution of flow throughout the basin based on the local percentile flow. In other words the daily local 10th percentile flow occurs at every location on the same day. The result is a one-year daily time series of the local

10th percentile flows. The one year flow series is repeated for each year during the simulation period. The 1999 to 2001 period represents the driest consecutive 3 year period in the unimpaired flow data set. To increase the drought severity to represent exceptional drought conditions, these flows were further reduced by 20 percent. This reduction was selected to capture an intermediate condition between the 10th percentile and the driest single year in 2000. The annual basin inflow for the "10th percentile" flow and the year 2000 basin inflow is 5,322 cfs and 8,853 cfs respectively. The resulting 20 percent reduction in the 2000 basin inflow is 7,082 cfs and captures an intermediate hydrology. It is unlikely that the actual hydrology occurring over the next two years will match closely these simulated hydrological conditions. However, with the growing threat of LaNina conditions this fall and winter and the resultant continuing exceptional drought conditions, it is likely that whatever hydrology occurs could result in a continuation of significant depletion of Composite Storage within the system.

The HEC-5 model imposes reservoir operations and consumptive demands onto the synthesized flow-time series to simulate flows and levels under those operations and demands. As described above, the minimum flow for the EDO is 4,150 cfs and the minimum flow for the IOP is 5,000 cfs. However, in order to more closely represent the actual operations for releases from Jim Woodruff Dam, we impose slightly higher minimum flow rules in the model. For the EDO we use 4,200 cfs as the minimum flow rule and for the no action we use 5,130 cfs as the minimum flow rule in the model. These values are based on what the operators actually release in order to avoid violating minimum flow floors, and reflect the physical operational constraints and limitations of the dam and powerhouse.

GENERAL EFFECTS ON THE FLOW REGIME

Consistent with the analysis conducted in the BO, the effects of the proposed action on the flow regime is evaluated by comparing the Apalachicola River flow frequencies for the various conditions. The no action simulation represents the Baseline condition, or the simulated flow of the river under the operational rules of the IOP. EDO is the simulated flow of the river under the operational rules of the proposed action. The Baseline and EDO frequencies represent those simulated by the HEC-5 model for the 10 percent and 1999-2001 reduced hydrological conditions over the next two years.

Table 8 displays the maximum, minimum, and average Apalachicola River discharge for the four flow regimes. Generally, the EDO and no action flow regimes are similar regarding maximum daily flow and average daily flow under the two hydrological flow scenarios. The no action regime generally has the highest flow associated with the lowest exceedance frequencies, and the lowest flow associated with the highest exceedance frequencies. However, the minimum flow values under the no action flow regimes are significantly lower than those of the EDO.

	10% EDO	10% No Action	20% Reduction No Action	20% Reduction EDO
Max	10536	12595	64404	64404
Min	4200	2104	3370	4200
Avg	5440	5669	9867	9378

Table 8. Simulated maximum, minimum, and average daily discharge of the Apalachicola River at the Chattahoochee gage for the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

Figure 4 displays in greater detail the frequency analysis of the various flow regimes. By focusing on the lowest flows (flows that are exceeded at least 65 percent of the time), we can compare the low-flow differences between the four regimes. These low flow events represent the most severe flow conditions for the aquatic biota in the river. The no action flow regime results in higher frequencies of flows less than 4,150 cfs than the EDO flow regimes. This is due to maintenance of the 5,000 cfs minimum flow in the river until conservation storage is depleted; at which time, this minimum flow can no longer be met and the Apalachicola River flow is essentially limited to the basin inflow when basin inflows are less than 5,000 cfs.

The fat threeridge depth distribution data, described in the Environmental Baseline section above, suggests that a significant percentage of mussels could be exposed at river flows less than 4,150 cfs. We recognize that listed mussel (purple bankclimber and fat threeridge) mortality could and likely would result when river flows are reduced below 5,000 cfs. The depth distribution data suggests that approximately 20 percent of the fat threeridge mussels occurring at the sites sampled this summer would be in areas exposed at flows of 4,150 cfs. However, this data also suggests that flows of 3,200 cfs would expose approximately 65 percent of the fat threeridge mussels. Flows as low as 2,000 cfs would expose 100 percent of the fat threeridge mussels at these same sites. USFWS is currently conducting additional analysis at these sites regarding mussel densities and percent exposure. However this data is not completed and therefore could not be used in this effects analysis. As stated above, all exposed mussels would not necessarily be killed by reductions in water level; some could move into deeper water and survive, and as long as water levels remained low, these mussels would likely do well in these previously unoccupied areas. However, it is uncertain if habitat conditions in the deeper water areas would provide suitable habitat under higher flow conditions due to potential differing geomorphic conditions. In the future when water discharge and velocity increase, these mussels could be vulnerable to sheer stress far in excess of what they can tolerate, resulting in mussels being eroded out of the substratum and being displaced downriver. It is possible that some individuals could be carried to suitable areas and survive, although others (potentially significant numbers) could be deposited in the main channel or other unsuitable habitat and be killed. Modeling shows that with no action, flows could be reduced to 2,000 cfs if conservation storage is depleted and augmentation flows could no longer be provided. The potential adverse biological effect of a flow as low as 2,000 cfs versus a flow of 4,150 cfs or greater during an extended drought period is substantial. Therefore, we have determined that the overall effect of the proposed action is beneficial with respect to the no action conditions for this measure of a flow-dependent habitat feature.

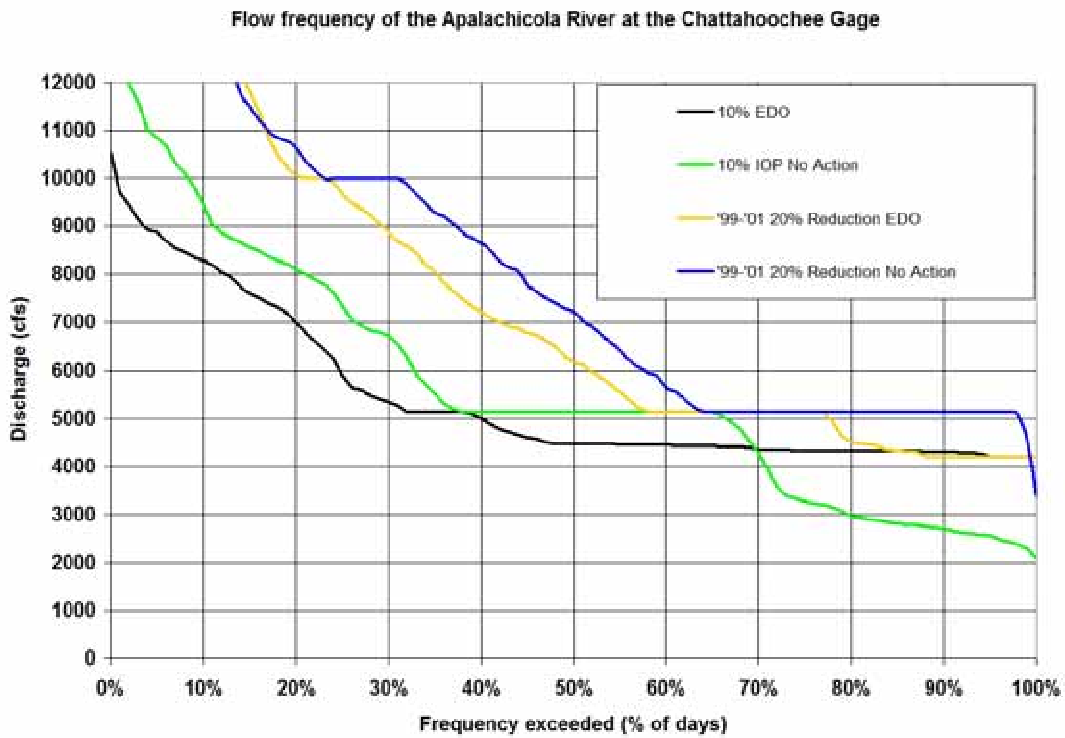

Figure 4. Flow frequency (% of days flow exceeded) of the Apalachicola River at the Chattahoochee gage for the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

SUBMERGED HARD BOTTOM

As described in the BO, the principal analysis for effects of the proposed action on sturgeon consists of comparing the amount of potential spawning habitat available under the various operational scenarios. This is accomplished by combining hard bottom area versus discharge relationship with the time series of daily flow values from the four flow regimes to obtain time series of available habitat area. A frequency analysis of these habitat availability time series for the two known Apalachicola River spawning sites, located at NM 105 and NM 99, is shown in Figure 5. This figure represents how much hard-bottom habitat was inundated to depths of 8.5 to 17.8 feet (the range of 80 percent of sturgeon egg collections in 2005 and 2006) during the months of March, April, and May, under each of the flow time series. Although the four curves cross each other multiple times over the full range of 0 to about 20 acres, habitat availability under the no action flow regimes is generally greater (median daily habitat availability of approximately 13 to 15 acres) than habitat availability under the EDO (median daily habitat availability of approximately 12 acres). A reduction in habitat availability of 1-2 acres (10 percent reduction) may not represent a biologically significant effect.

Spawning habitat availability has not been identified as a limiting factor to Gulf sturgeon recovery and the population is currently considered stable to increasing. Spring flows providing similar habitat availability values have occurred in the past (less than 12 acres of habitat availability occurred during 15 percent of the observed flow record 1975-2001; reference Figure 4.2.3.A of the BO). In order to determine the effect of only 12 acres or less of habitat availability, strength of year class data is needed for the years this occurs. This data is not available. Therefore, we have determined that the proposed action results in an adverse effect on Gulf sturgeon with regards to this flow-dependent habitat feature as compared to the no action.

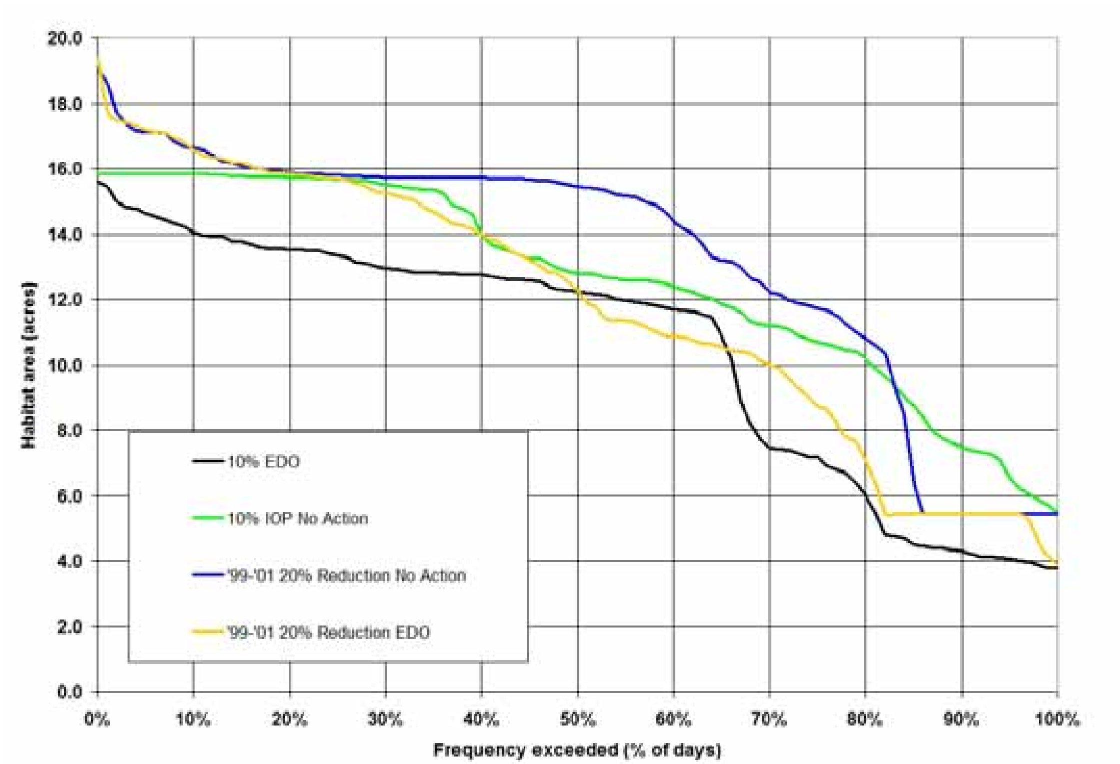

Figure 5. Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet), on each day March 1 through May 31, at the two sites known to support spawning, under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

The analysis shown in Figure 5 above, combines data from the two years of each time series into a single pool for frequency computations and does not examine differences between years or the pattern of habitat availability within a year. However, as described in the BO, it is also important to ascertain whether the proposed action would produce exceptionally low and high habitat availability between years or within a year. Since the simulated flow regimes only extend out two years, it is not appropriate to draw conclusions regarding habitat availability between years. However, the simulated flow conditions can provide insight into the amount of habitat inundated to the 8.5 to 17.8 ft depth range for at least 30 consecutive days each year, March through May, under the four flow time series. This flow-dependent habitat feature is important based on the limited sturgeon spawning data recorded in the river. As described in the BO, studies indicate that Gulf sturgeon spawning generally begins when water temperature reaches about 17°C and is concluded by the time temperature reaches about 25 °C. Based on available data from the Chattahoochee gage, the mean dates for these events in the Apalachicola River are March 26 and May 23, respectively, a span of 58 days. Sturgeon egg collections during 2005 and 2006 spanned a period of 17 and 27 days, respectively. Hatching requires at least 2 days in this temperature range, and several more days are required for larvae to develop a free-swimming ability (USFWS 2006). Based on this phenomenon, we further analyze the effect of the proposed action on Gulf sturgeon spawning success by comparing the average spawning habitat availability (maximum amount of habitat inundated to the 8.5 to 17.8 ft depth range for at least 30 consecutive days each year), March through May, under the four flow time series (Table 9).

Habitat Acres				
YEAR	10% EDO	10% IOP No Action	20% Reduction No Action	20% Reduction EDO
2008	12.7	15.6	15.7	8.1
2009	11.6	12.1	13.1	13.8
AVG	**12.2**	**13.8**	**14.4**	**11.0**

Table 9. Average 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 no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

Generally the no action flow regimes provide for more acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), during the spawning season, at the two known spawning sites than the two EDO flow regimes. Therefore, we have determined that the proposed action results in an adverse effect on Gulf sturgeon with regards to this flow-dependent habitat feature as compared to the no action.

During coordination and development of the proposed action, the Corps and USFWS recognized that trade offs of the quantity and intensity of direct adverse effects to listed species would likely be required in order to facilitate the intent of the EDO, which is to minimize adverse impacts to listed species in the Apalachicola River while making allowances for increased storage opportunities and/or reductions in the demand of storage in order to provide continued support to project purposes and minimize impacts to other water users during a severe multi-year drought. Generally, reproductive adults represent the most critical individuals relative to management decisions for species with small populations and limited distribution. The effects described above should not result in the direct mortality of reproductive adult Gulf sturgeon. Therefore, we acknowledge that Gulf sturgeon may be directly or indirectly adversely affected to some extent by the proposed action as we attempt to avoid or minimize the loss of reproductive age fat threeridge and purple bankclimber mussels.

CHANGES IN SALINITY AND INVERTEBRATE POPULATIONS IN APALACHICIOLA 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 proposed action on Gulf sturgeon in Apalachicola Bay (see discussion in the Water Quality section of the Environmental Baseline section above).

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 2006). The 2006 observed flow regime included significant periods of approximately 5,000 cfs discharge, which as described above, preliminary data indicates has resulted in significantly higher salinity values in the Apalachicola Bay than normally observed.

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. Based on the analysis in the BO, 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 6 illustrates this comparison and indicates that the EDO does not significantly alter the number of consecutive days per year of flows less than 16,000 cfs from that of the no action for the 10 percent hydrology, and provides fewer number of consecutive days per year of flows less than 16,000 cfs than the no action for the 1999-2001 20 percent reduced hydrology. Therefore, we have determined that the proposed action is not likely to have an appreciable effect on sturgeon estuarine habitat and may have a beneficial effect as compared to the no action alternative. It should be noted that all the simulated flow regimes result in considerably high numbers of consecutive days of flows less than 16,000 cfs and this would likely result in bay salinity levels similar to those experienced this summer. These high salinity levels could impact juvenile, and to some extent adult sturgeon, by both delayed entry to the feeding areas of the bay and potential reduction in productivity of these normally rich feeding areas. This could result in poor growth and/or lower survival of juvenile sturgeon. However, due to the similarity of the flow regime data relevant to this measure it is deemed that this impact is attributable to a projection of continuing extreme drought conditions and not discretionary actions on the part of the Corps. Also, since the proposed action (and no action until storage is depleted) supports minimum discharges that are higher than basin inflow during significant portions of the simulated period, the proposed action may benefit ecological processes within the bay.

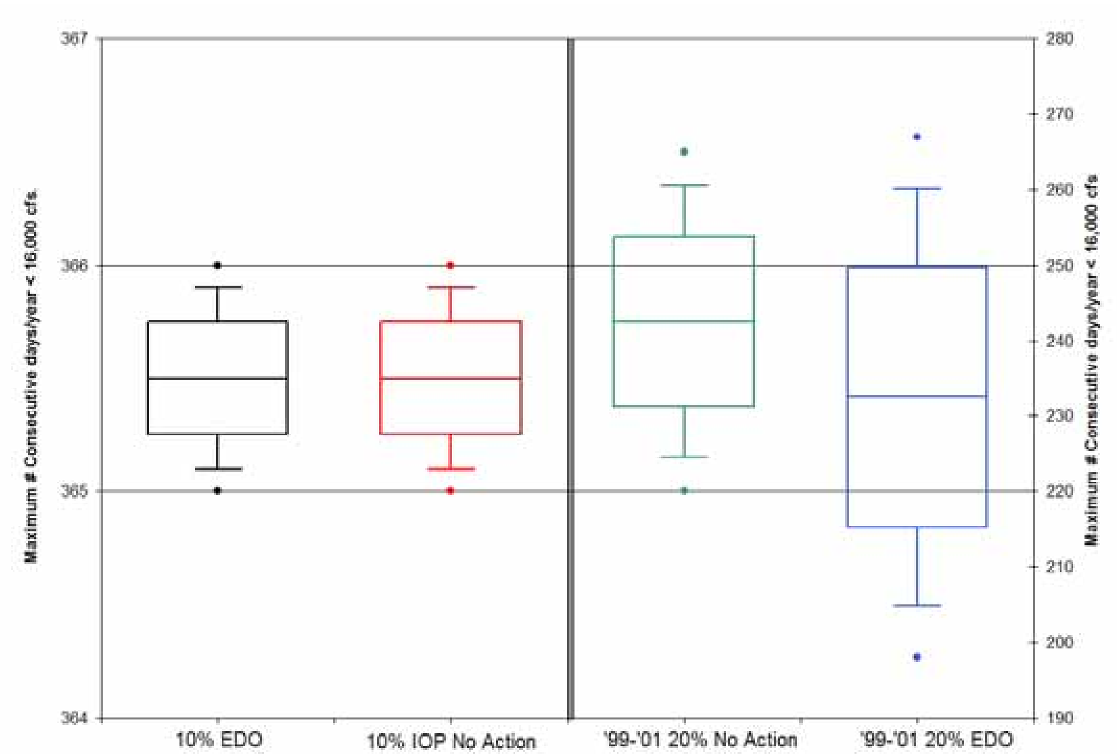

Figure 6. Maximum number of consecutive days/year of flow less than 16,000 cfs under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

SUBMERGED HABITAT BELOW 10,000 CFS

This section focuses on direct effects to listed mussels by exposure during low-flow conditions. During the summer of 2006, listed mussels were found exposed and stranded at elevations up to approximately 10,000 cfs. Therefore, consistent with the BO, impacts to listed mussel species will be evaluated by analyzing the differences between the no action and EDO flow regimes in the range of flow less than 10,000 cfs. During the summer of 2007 Apalachicola River flows remained at approximately 5,000 cfs from late May to present. It is unlikely that many live mussels exist at elevations higher than 5,000 cfs. Therefore this analysis will focus primarily on simulated flows of 5,000 cfs or less as these are the most relevant to assessing impacts to listed mussel species.

An analysis of the inter-annual frequency of flow rates between 1,000 and 10,000 cfs in the no action and EDO flow regimes is not included. Since the simulated flow regimes only extend out two years, it is not appropriate to draw conclusions regarding habitat availability between years.

We use the maximum number of days per year with flows less than 1,000 to 10,000 cfs as a measure of the most severe year for aquatic biota under each flow scenario (Figure 7). The 10 percent hydrology simulated flow regimes for the no action and EDO generally provide for the highest maximum number of days per year with flows less than 5,000 cfs; which is expected since this hydrology represents an unprecedented exceptional drought extending over a two year period. However, the EDO includes no days with flows less than 4,150 cfs compared to the no action flow regime which includes approximately 175 days with flows less than 4,150 cfs per year and has days with flows as low as approximately 2,000 cfs. In this respect, the EDO provides a beneficial effect as compared to the no action flow regime. As described above, the fat threeridge depth distribution analysis conducted earlier this year indicates that significant exposure occurs at flows less than 4,150 cfs and flows of 2,000 cfs would result in exposure and likely mortality of all fat threeridge mussels occurring at the sites sampled. An impact of this nature would seriously impair the likelihood of recovery of this species. The 1999-2001 20 percent reduced hydrology simulated flow regimes for the no action and EDO do not include days with flows less than 4,150 cfs. However, the no action simulated flow regime eliminates days with flows less than 5,000 cfs by maintaining this minimum flow throughout the two year period. The EDO simulated flow regime under this hydrology includes approximately 250 days per year with flows between 4,150 and 5,000 cfs by maintaining the lower minimum flow (4,150 cfs) throughout the two year period. In this respect, the EDO results in an adverse effect as compared to the no action flow regime. As described above, the fat threeridge depth distribution analysis conducted earlier this year indicates that up to approximately 20 percent of the fat threeridge mussels occurring at the sites sampled would be exposed at flows between 4,150 and 5,000 cfs.

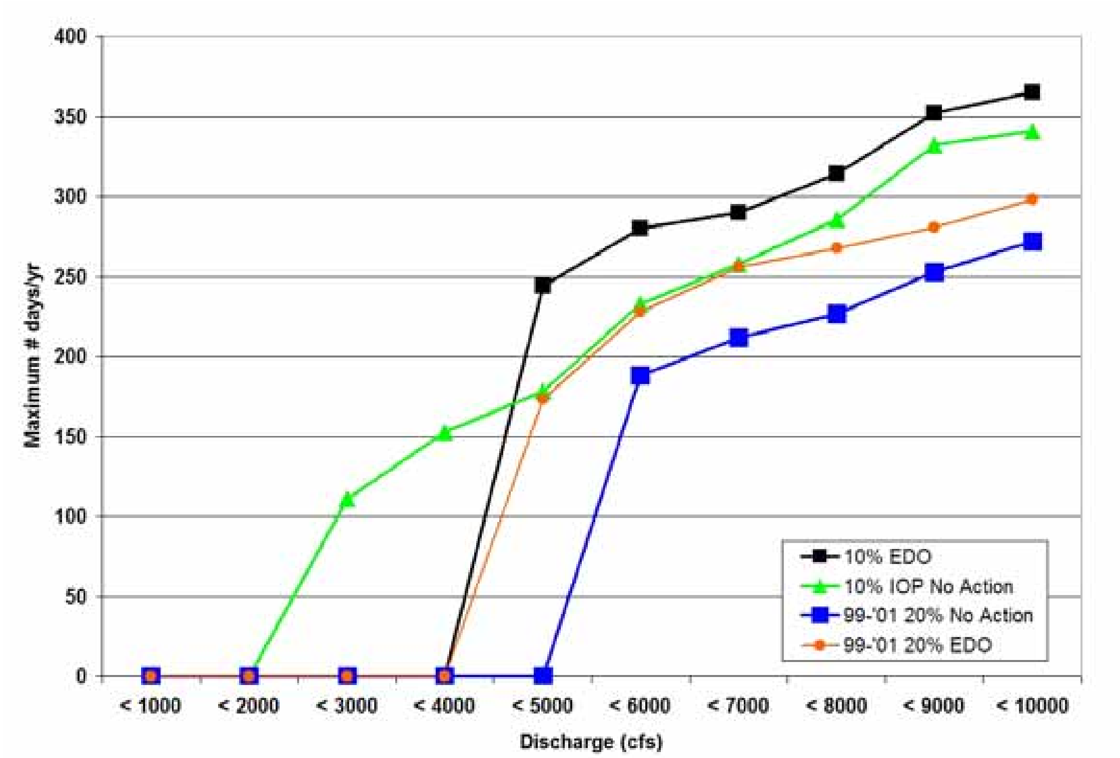

Figure 7. Maximum number of days per year of discharge less than 1,000 to 10,000 cfs under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

As observed in 2006, some mussels may survive brief periods of exposure by closing their shells tightly or burrowing into the substrate. Therefore, unless water temperature is extreme, the stress of exposure is most likely a function of exposure duration (USFWS 2006). Figure 8 illustrates a most-severe event analysis by computing the maximum number of consecutive days of flow less than the 1,000 to 10,000 cfs. The results of this analysis are consistent with the maximum number of days per year of discharge less than 1,000 to 10,000 cfs analysis. The 10 percent hydrology simulated flow regimes for the no action and EDO generally provide for the highest maximum number of consecutive days per year with flows less than 5,000 cfs. However, the EDO includes no consecutive days with flows less than 4,150 cfs compared to the no action flow regime which includes approximately 150 consecutive days with flows less than 4,150 cfs per year and has days with flows as low as approximately 2,000 cfs. In this respect, the EDO provides a beneficial effect as compared to the no action flow regime. The 1999-2001 20 percent reduced hydrology simulated flow regimes for the no action and EDO do not include consecutive days with flows less than 4,150 cfs. However, the no action simulated flow regime eliminates consecutive days with flows less than 5,000 cfs by maintaining this minimum flow throughout the two year period. The EDO simulated flow regime under this hydrology includes approximately 175 consecutive days per year with flows between 4,150 and 5,000 cfs by maintaining the lower minimum flow (4,150 cfs) throughout the two year period. In this respect, the EDO results in an adverse effect as compared to the no action flow regime.

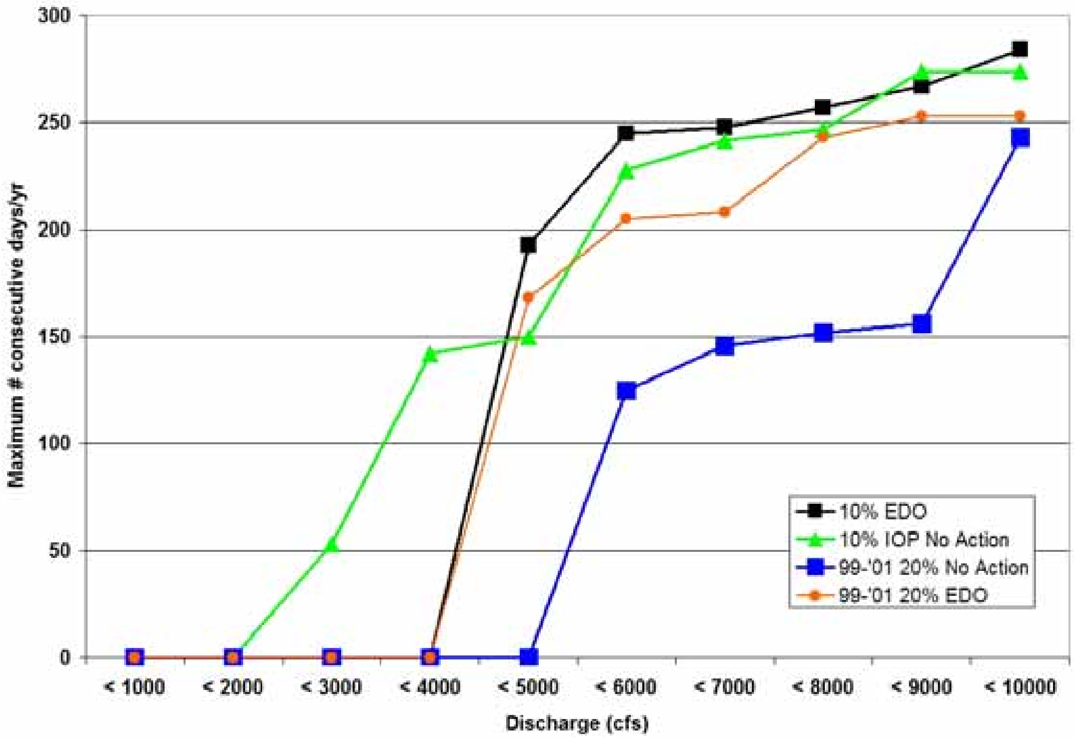

Figure 8. Maximum number of consecutive days per year of discharge less than 1,000 to 10,000 cfs under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

"Because moderately low flows, not just the most extreme events, constrict aquatic habitat availability and are generally stressful to mussels and other aquatic biota, it is appropriate to also consider the more common low-flow condition, *i.e.,* the magnitude and duration of low flows that occur in half the years of the flow regime. If the common low-flow conditions become even more common or more severe, it would reduce the amount of habitat available to mussels and would increase their vulnerability to exposure-related mortality, including increased predation by terrestrial predators" (USFWS 2006). Figure 9 displays the median number of days per year less than the thresholds of 1,000 to 10,000 cfs. The results of this analysis are also consistent with those of the other two flow parameters considered. The EDO provides a beneficial effect as compared to the no action flow regime under the 10 percent hydrology simulations by eliminating days of flows less than 4,150 cfs. The EDO results in an adverse effect as compared to the no action flow regime under the 1999-2001 20 percent reduced hydrology simulations by including days of flows less than 5,000 cfs.

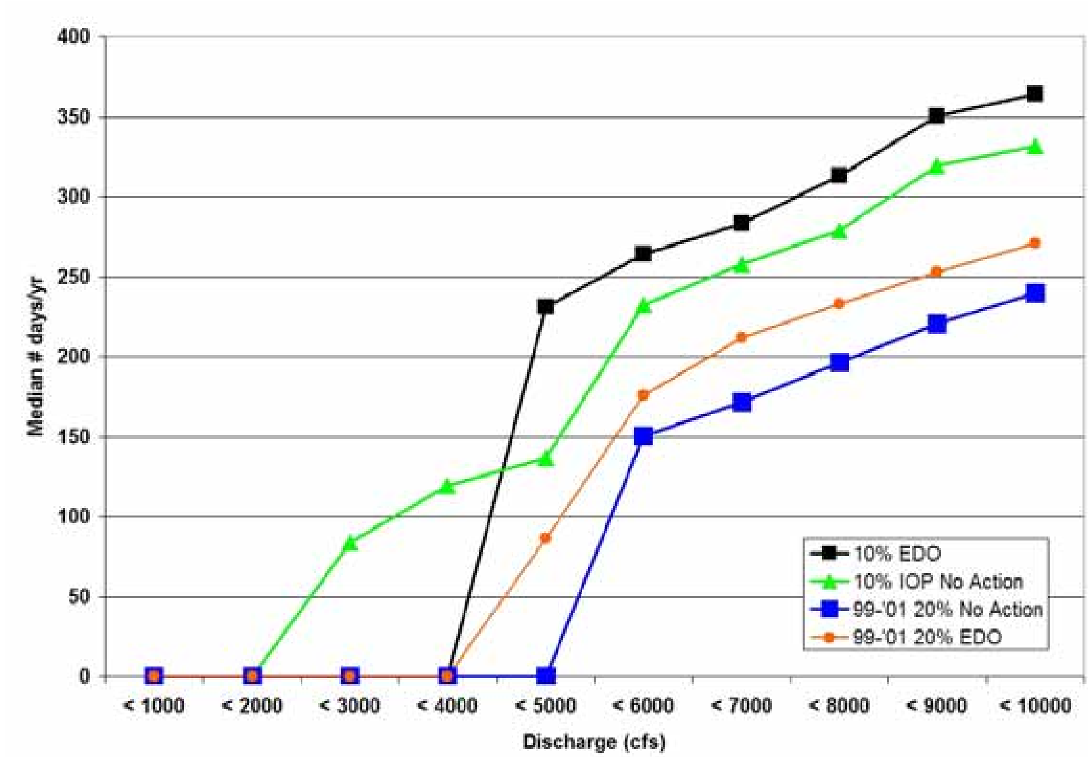

Figure 9. Median number of days per year of discharge less than 1,000 to 10,000 cfs under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

The no action (IOP) plan utilizes a maximum fall rate schedule (Table 2). The 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. The EDO does not include a maximum fall rate schedule, but includes the provision that fall rates would be managed to match the fall rate of the basin inflow.

To analyze effects due to elimination of the maximum fall rate schedule for the modeled flow regimes, we used the Chattahoochee gage rating curve that characterizes the stage/discharge relationship during recent years (Light *et al.* 2006) to compute the gage heights associated with simulated daily flows, and then computed change rates as the difference between each pair of consecutive daily values (previous day gage height minus current day gage height = change rate associated with current day).

Figure 10 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). As described above, since essentially all live mussels occur in habitats inundated at an approximately 5,000 cfs flow due to an extended period of flows at this level, that still persist, the most critical fall rate category is the 0.25 or less ft/day category which corresponds to the maximum fall rate provision for flows ≤ 8,000 cfs. Among the falling days, rates less than 0.25 ft day are the most common occurrence in the four simulated flow regimes which is generally beneficial to listed mussels and other aquatic biota. However, the EDO flow regimes have a higher percentage of days in the 0.25 to 0.50 ft/day category than the no action flow regimes. Collectively, the EDO flow regime has a very slightly higher percentage of days in the fall rate categories of greater than 0.25 ft/day than the no action (20.0 percent versus 19.9 percent respectively). This shift increases the relative risk of stranding and exposure of aquatic organisms over the no action; however, most of the shift is confined to the 0.25-0.50 ft/day category and not the more extreme categories. Based on the very minor difference in frequency of fall rate categories of greater than 0.25 ft/day between the two actions, and this difference being mainly attributable to the less extreme 0.25-0.50 ft/day category, we have determined that the EDO has no effect on listed mussels with regards to this flow-dependent habitat parameter as compared to the no action plan.

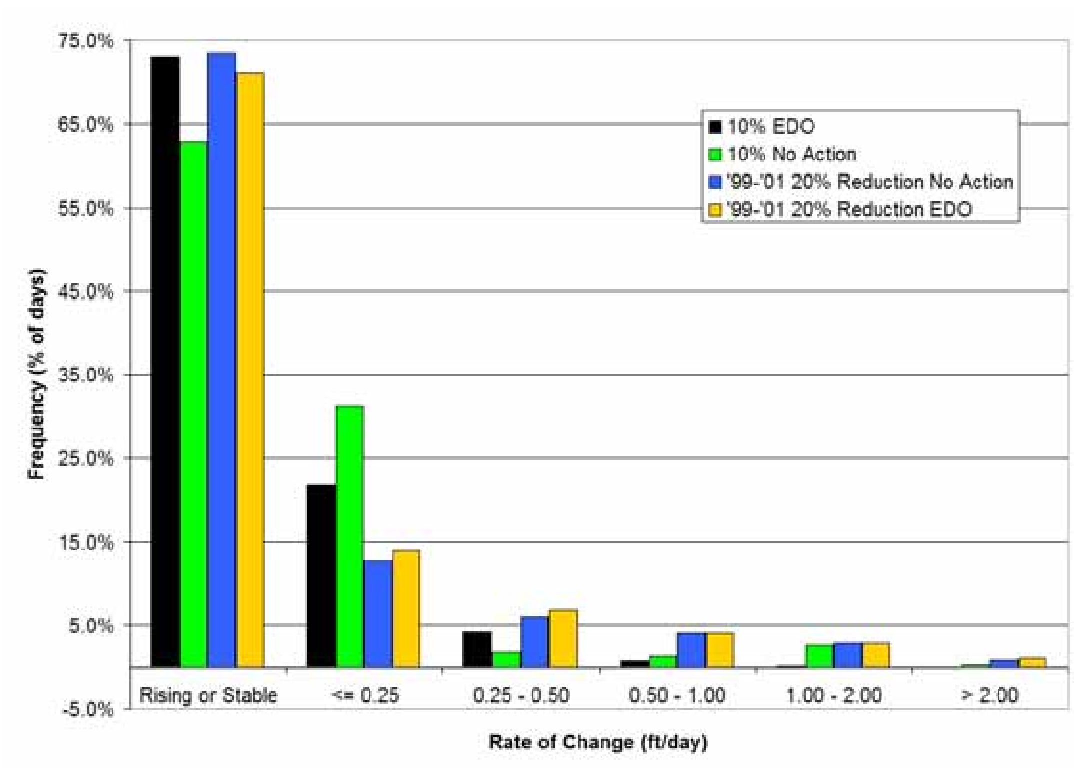

Figure 10. Frequency (percent of days) of daily stage changes (ft/day) under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

As noted in the BO, the USFWS observed mussels exposed at stages as high as about 10,000 cfs during the summer of 2006 (USFWS 2006). Therefore, listed mussels could potentially be directly impacted by increases in the percentage of days that fall rates greater than 0.25 ft/day occur and flows are less than 10,000 cfs. Figure 11 shows a count of days in the various rate-of-change categories when flow was less than 10,000 cfs. For this analysis, the flow associated with the rate of change on a given day is the flow of the previous day. A count of days is utilized here for the vertical scale of this figure instead of a percentage of days as in Figure 10, because each flow regime has a different number of days less than 10,000 cfs, and this difference is relevant to the effects analysis. Similar to the previous analysis, the numbers of days of daily stage changes for fall rates greater than 0.25 ft/day under the four simulated flow regimes are generally similar within each category. Among the falling days, rates less than 0.25 ft/day are the most common occurrence in the four simulated flow regimes. The collective number of days in the greater than 0.25 ft/day categories for the EDO flow regime is 98, slightly lower than the number in the no action flow regime (101). The EDO improves upon the no action with regards to this flow-dependent habitat parameter; however, since the difference between the two actions is so minor we have determined that the EDO has no effect on listed mussels with regards to this flow-dependent habitat parameter.

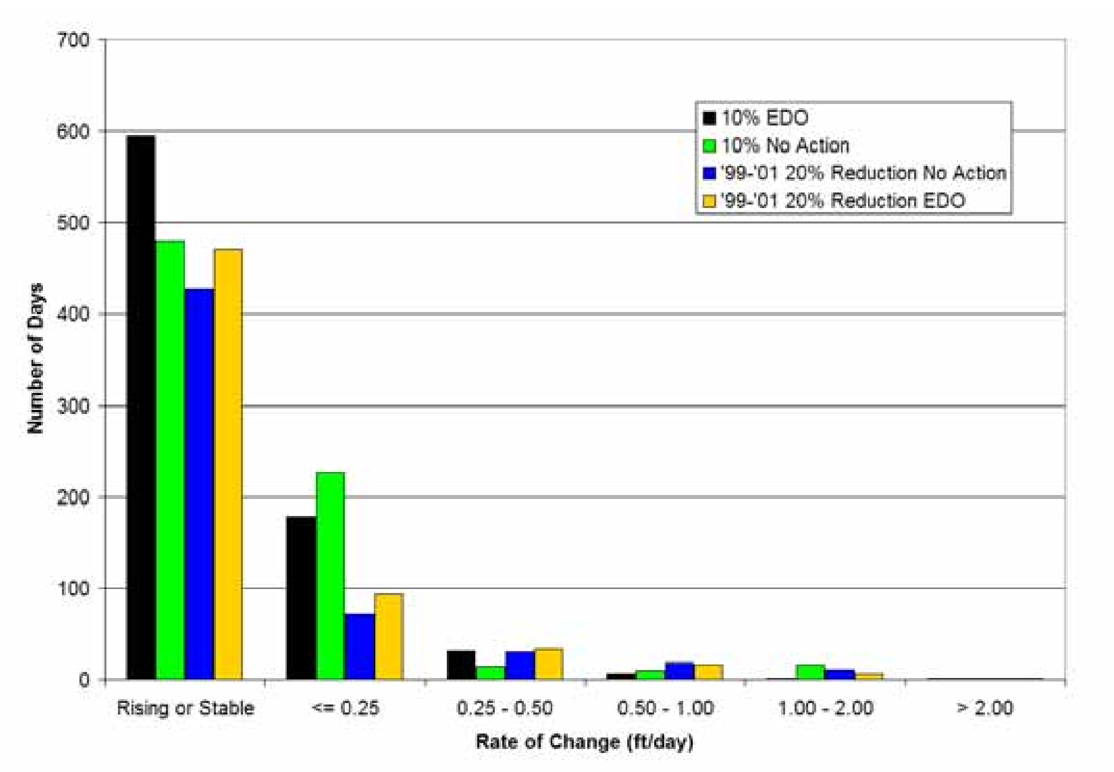

Figure 11. Frequency (number of days) of daily stage changes (ft/day) when releases from Woodruff Dam are less than 10,000 cfs under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

FLOODPLAIN CONNECTIVITY AND SYSTEM PRODUCTIVITY

Listed mussels and sturgeon can be indirectly affected by changes to the frequency, timing, and duration of floodplain habitat connectivity/inundation. 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 purple bankclimber and fat threeridge. 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 2006).

Therefore, we must compare the impact of the proposed action to the no action on the timing, and duration of floodplain habitat connectivity and inundation. As described in the BO, 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 2006). Figure 12 displays a frequency analysis of the results of transforming the four daily discharge time series during the growing season months (April – October) to connected floodplain area. The overall area/frequency pattern of the proposed action is similar for the median daily value as compared to the no action. However, the no action flow regime generally provides more acres of floodplain connectivity to the main channel than the EDO. This discrepancy between the EDO and no action flow regimes is due to operational provisions allowing for storage of all basin inflow above that required to meet the minimum flow discharge under the EDO and limitations to storage during the months of April and May under the no action (especially when basin inflow is less than 18,000 cfs which allows for no storage). Therefore, we have determined that the proposed action results in an adverse effect on listed species in the Apalachicola River with regards to this flow-dependent habitat feature as compared to no action.

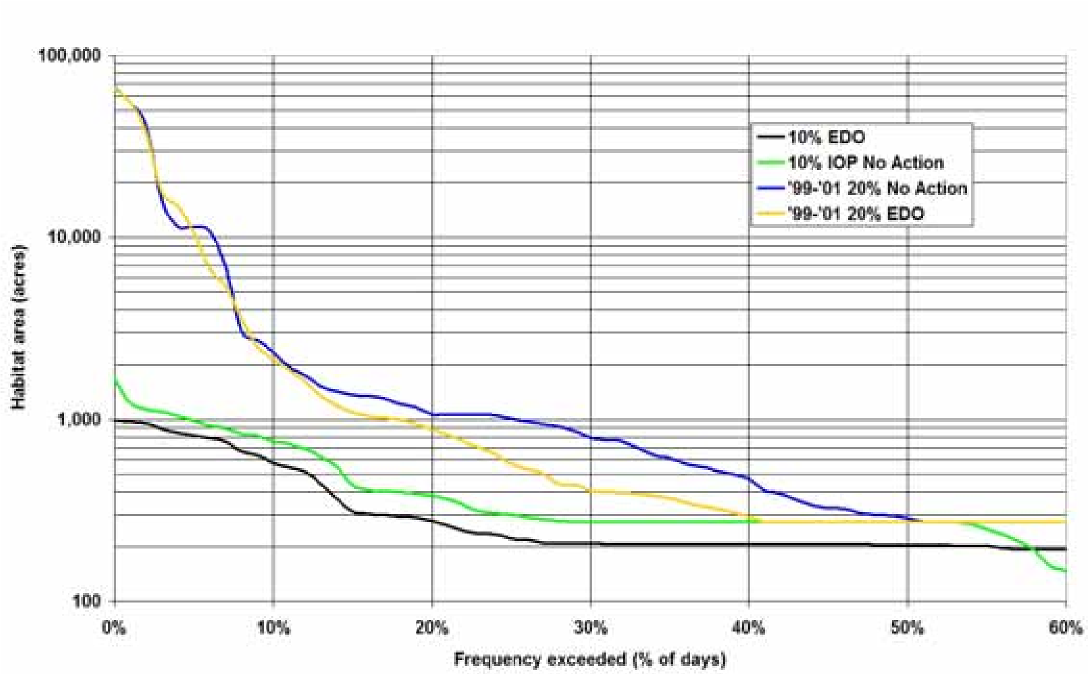

Figure 12. Frequency (percent of days) of growing-season (April-October) floodplain connectivity (acres) to the main channel under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

A period of continual inundation is required for successful spawning and rearing of host fishes of the listed mussel species. Therefore, we used a 30-day moving minimum to represent this aspect of habitat availability, identifying the maximum acreage inundated during the growing-season for at least 30 consecutive days each year. Table 10 illustrates the results of this analysis by comparing the maximum amount of growing season 30-day continuous connected floodplain habitat per year for the four flow regimes.

Maximum Acreage				
YEAR	10% EDO	10% No Action	20% Reduction No Action	20% Reduction EDO
2008	330	713	390	270
2009	405	552	1464	1003

Table 10. Maximum acreage of 30-day continuous floodplain connectivity to the main channel (per year) during the growing-season (April-October) under the no action (10% hydrology HEC-5 simulated flow), no action (1999-2001 20% reduction hydrology HEC-5 simulated flow), EDO (10% hydrology HEC-5 simulated flow), and EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

The EDO provides less maximum acreage of 30-day continuous connectivity per year than the no action under both hydrology simulations. Therefore we have determined that the EDO results in an adverse effect with regards to this flow-dependent habitat parameter as compared to the no action.

CONCLUSIONS

Generally, the analysis for determining adverse effects of the EDO compared to the no action (IOP) results in some adverse effects to listed species for the flow dependent habitat parameters considered. However, for several of the parameters considered (especially those relative to direct impacts to listed mussel species) it appears that an adverse effect determination is dependent on the severity of the hydrology input into the model. For the purposes of this analysis we selected hydrological conditions that represent 1) an unprecedented, exceptional drought applied across the entire ACF basin and continuing without relief for a two year period (10 percent hydrology); and 2) an exceptional drought that reflects differences in precipitation within the basin but is still more severe than observed during the critical period prior to the current drought (1999-2001 hydrology). It is unlikely that the actual hydrology occurring over the next two years will match closely these simulated hydrological conditions. It may be better than simulated or it may be worse than simulated. With the growing threat of LaNina conditions this fall and winter and the predicted resultant continuing exceptional drought conditions, it is likely that whatever hydrology occurs could result in significant reduction of Composite Storage within the system. If this reduction is severe and depletes the conservation storage in the system, the no action plan would result in extremely low flows on the Apalachicola River as the ability to augment flow above basin inflows would cease or be severely limited, and the river flow would essentially be limited to basin inflow. Therefore, in order to analyze the likelihood of this occurring, and determine if the adverse effects of the proposed action relative to the no action are justified, we have evaluated the Composite Storage values for the no action and EDO under the 1999-2001 20 percent reduced flow regimes. The 10 percent flow regime of the no action includes depletion of the Composite Conservation Storage within the system and therefore is not further considered. Since Composite Storage Zone 4 is the trigger for the EDO and represents a period when operations are the most conservative, we focus on the amount of storage available within this Zone and the duration spent in this Zone to illustrate the clear need for the proposed action. Figure 13 illustrates the simulated Composite Storage under the EDO flow regime. Figure 14 illustrates the simulated Composite Storage under the no action flow regime.

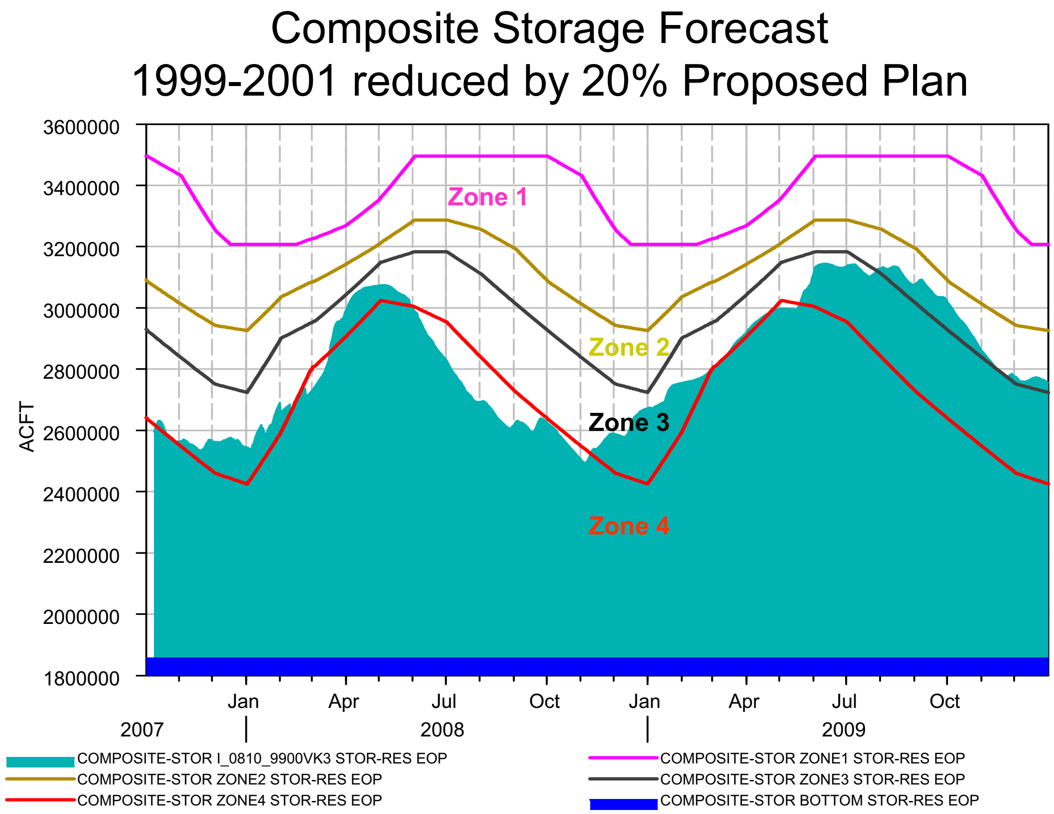

Figure 13. Composite Storage under the EDO (1999-2001 20% reduction hydrology HEC-5 simulated flow).

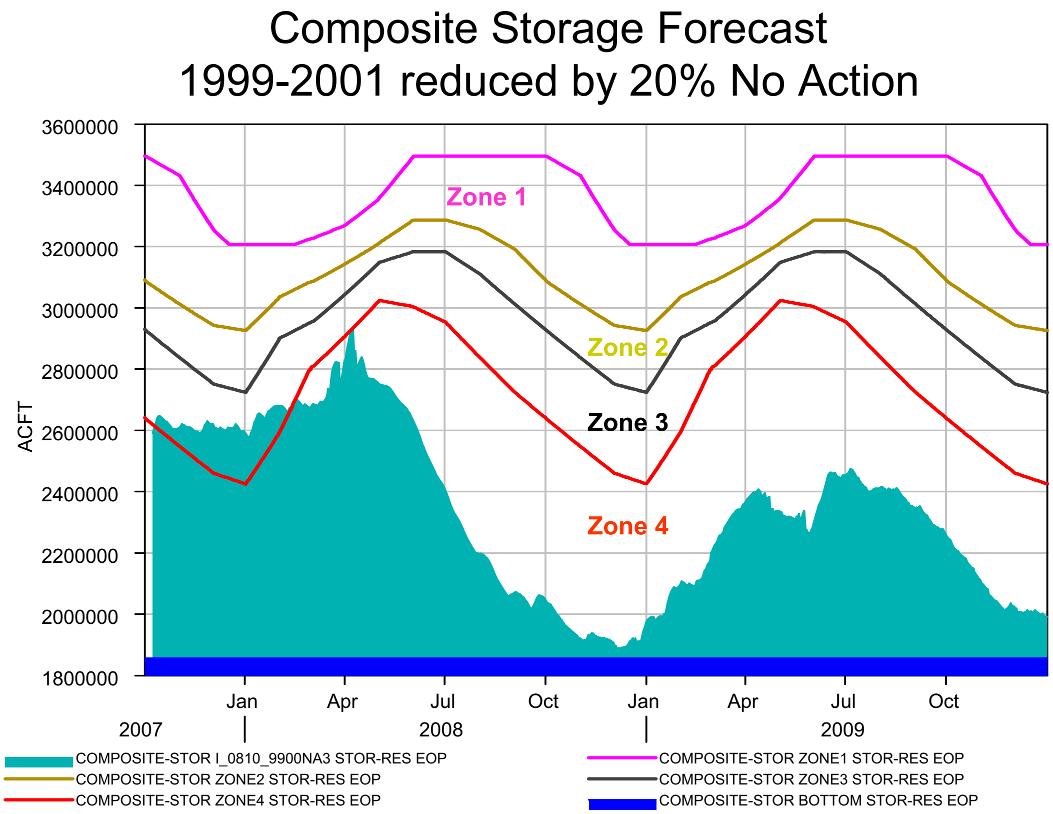

Figure 14. Composite Storage under the no action (1999-2001 20% reduction hydrology HEC-5 simulated flow).

Figure 14 clearly demonstrates the threat of continuing to operate under the IOP during this extended drought period. The no action flow regime under this hydrological condition very nearly results in depletion of Composite Conservation Storage within the system (as occurred in the 10 percent hydrology). Furthermore, the low level of Composite Conservation Storage that persists from summer 2008 through 2009 greatly limits our ability to respond to continued or repeated drought conditions more severe than those input into the model simulation. Given the current severity and projected prolongation of the existing drought conditions, we submit that responsible operation of the system cannot realistically be based on an expectation of any appreciable recovery in the near future. The EDO flow regime under this hydrological condition greatly reduces the severity of reductions in the Composite Conservation Storage within Zone 4 and the duration of time spent in Composite Zone 4, thus improving our ability to respond to drought conditions more severe than those input into the model simulation. Therefore, we have determined that although the EDO results in some immediate adverse effects to listed species (especially fat threeridge and purple bankclimber mussels), it is necessary (and beneficial) to prevent more severe adverse and long-lasting effects that have a high probability of occurring if we continue to operate under the IOP during the current exceptional drought.

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United States Fish and Wildlife Service (USFWS). 2007. Fat Threeridge (*Amblema neislerii*) Shinyrayed Pocketbook (*Lampsillis subangulata*) Gulf Monccasinshell (*Medionidus penicillatus*) Ochlockonee Moccasinshell (*Medionidus simpsonianus*) Oval Pigtoe (*Pleurobema pyriforme*) Chipola Slabshell (*Elliptio chipolaensis*) Purple Bankclimber (*Elliptoideus sloatianus*); 5-Year Review: Summary and Evaluation.

APPENDIX A

STAFF METEOROLOGIST MEMO

The 2007 Southeastern U.S. Drought – How rare an event is it?

The unusually severe and prolonged Southeastern drought of 2007 is among the most devastating in recent history, contributing to water shortages, wildfires and ecological damage.

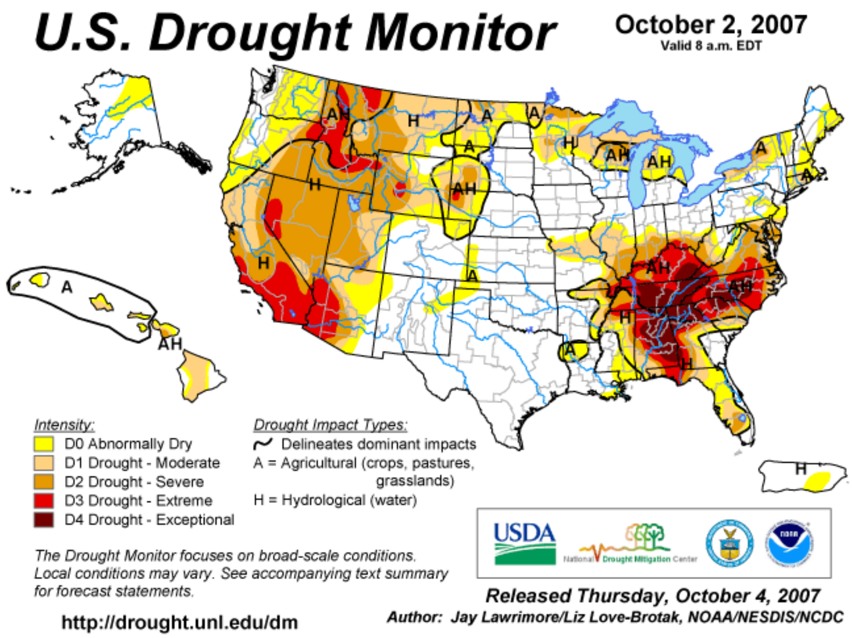

Figure 1

Fig.1 above delineates the geographical extent and intensity of the present drought status.

For eastern Alabama, northern and western Georgia and Tennessee…this drought is the direct result of the most extreme rainfall deficiencies in modern (1892-present) weather records.

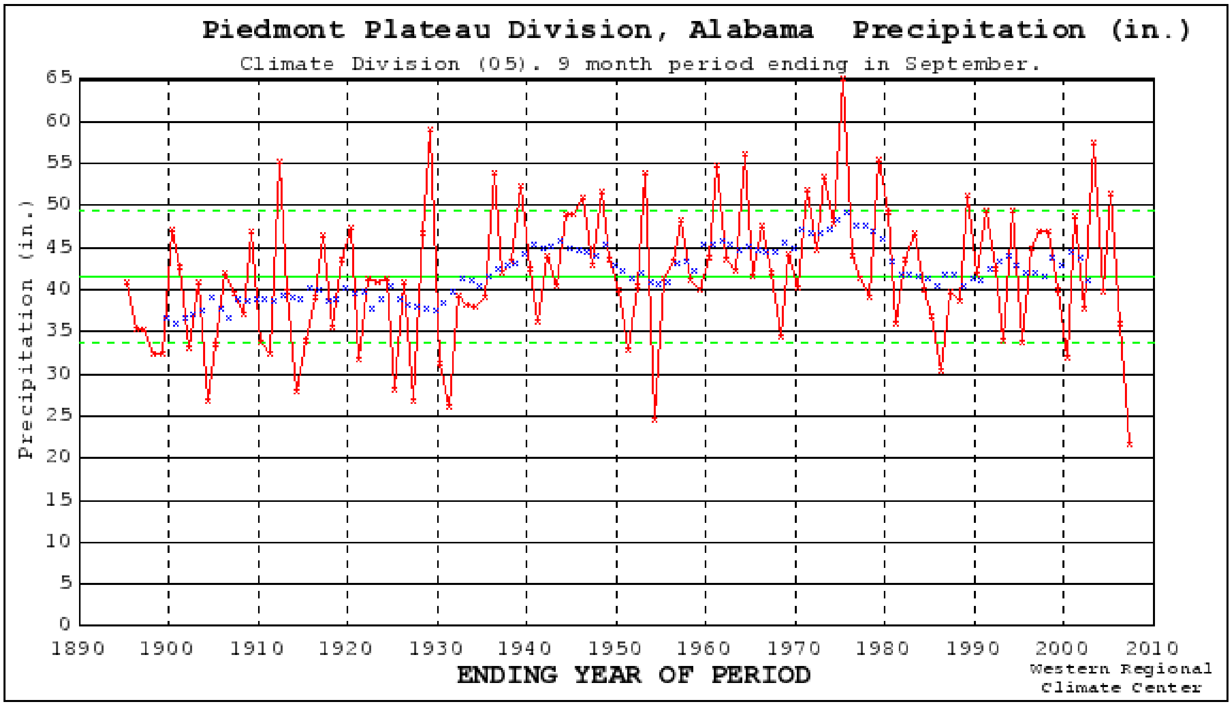

Figure 2

Fig.2 illustrates this graphically for the Eastern Valley Climate Division of Alabama, which borders Georgia and the middle Chattahoochee River Basin. This graph shows the January 1-September 30(9-month) rainfall for every year since 1895.

The limitation of rainfall records is that they encompass a relatively short period of time. Climatologist have recently overcome this through the use of various proxy data, tree rings being among the foremost.

The pioneering work of Stahle et.al.(1988) and Stahle and Cleaveland(1992) utilizing 1700-year old baldcypress tree rings in the Carolina`s and Georgia successfully reconstructed the Palmer Drought Severity Index with yearly resolution.

Recently, the construction of a gridded network(2.5 latitude by 2.5 longitude) of summer PDSI values from 835 exactly dated tree rings for the contiguous United States has been completed(Cook et. al. 1999; Cook and Krusie., 2004). This provides access to 286 annual drought reconstructions extending as far back as 1,992 years into the past.

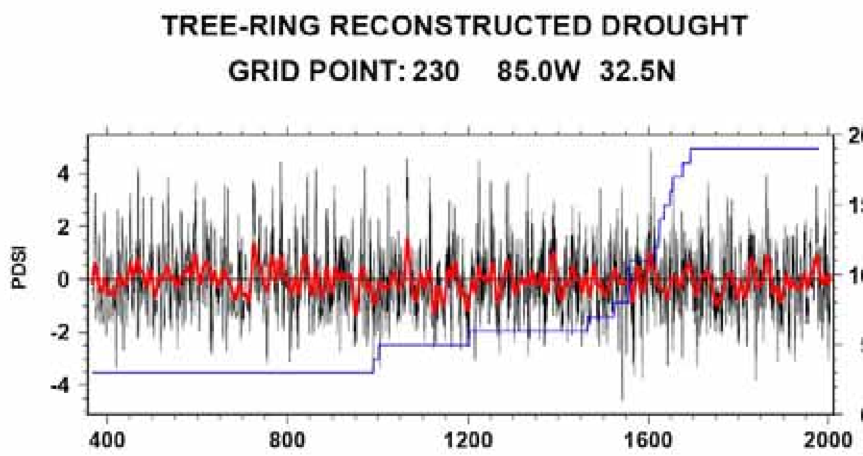

Figure 3

Fig. 3 is grid point number 230… showing the summer (June-August) PDSI for the Alabama/Georgia central Chattahoochee Valley from circa 400 A.D. to 2003.

Plainly evident is the recent severe drought of 2000. But, the 2007 estimated PDSI of approximately -4 exceeds all years back to 1839. This drought is well documented in early Alabama history. Settlers reported that the Warrior River at Tuscaloosa was very nearly dried up, resulting in the death of a great many fishes. The Alabama River was too low for navigation. The total rainfall for the year at Huntsville was only 29.08 inches, and at Savannah, Georgia 25.93 inches(Owens, 1890).

Also shown are the so called Megadroughts which affected much of North America in the 16th Century with unprecidented duration and severity(Stahle, et. al. 2000).

Recently, climate models forced by the observed history of tropical Pacific Sea Surface temperatures have been able to successfully simulate all of the major North American droughts of the last 150 years. In each case, cool "La Nina-like" conditions are consistent with North American drought (Herweijer et. al. 2007).

If so…the Southeastern United States drought will become a multi-year event. Recently, the Southeastern Climate Consortium(composed of the State Climatologist for Florida, Georgia and Alabama) issued a first ever "La Nina Watch" for the coming winter and next spring.

For south and central Alabama and Georgia…there is an 80 percent probability of below normal rainfall from Oct. 2007-Mar. 2008. This includes a 30 percent probability of MUCH BELOW normal rainfall…a 50 percent probability of BELOW normal rain…and a mere 20 percent probability of ABOVE normal rainfall.

Nature bats last!

Rob Erhardt

Meteorologist
U.S. Army Corps of Engineer`s

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APPENDIX B

NOAA DROUGHT ANALYSIS

29 OCTOBER 2007

ENSO Cycle: Recent Evolution, Current Status and Predictions

Update prepared by
Climate Prediction Center / NCEP
October 29, 2007

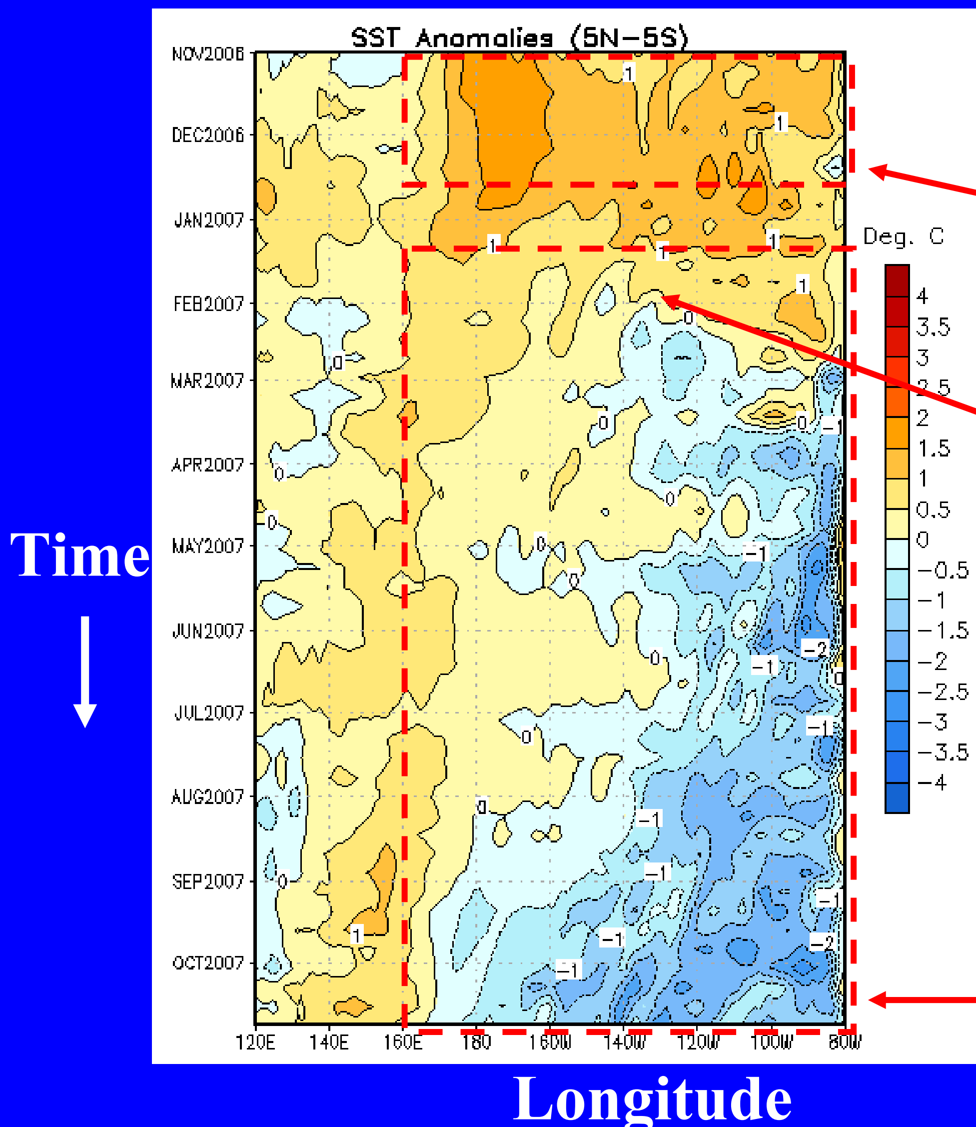
Outline

- Overview
- Recent Evolution and Current Conditions
- Oceanic Niño Index (ONI) – "Revised 1 March 2004"
- Pacific SST Outlook
- U.S. Seasonal Precipitation and Temperature Outlooks
- Summary
- Temperature and precipitation La Niña composites

Overview

- La Niña is present across the tropical Pacific.
- Negative SST anomalies extend along the equator from the Date Line eastward to the South American coast.
- Recent equatorial Pacific SST trends and model forecasts indicate La Niña will continue through early 2008.

Recent Evolution of Equatorial Pacific SST Departures (ºC)



Between May 2006 and December 2006, positive SST anomalies increased across the equatorial Pacific between 160ºE and the South American coast.

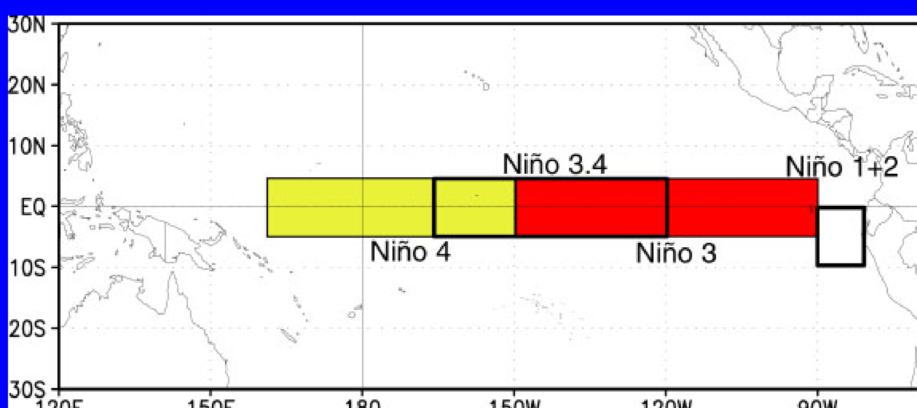
The SST anomalies decreased rapidly in January 2007 everywhere east of the Date Line.

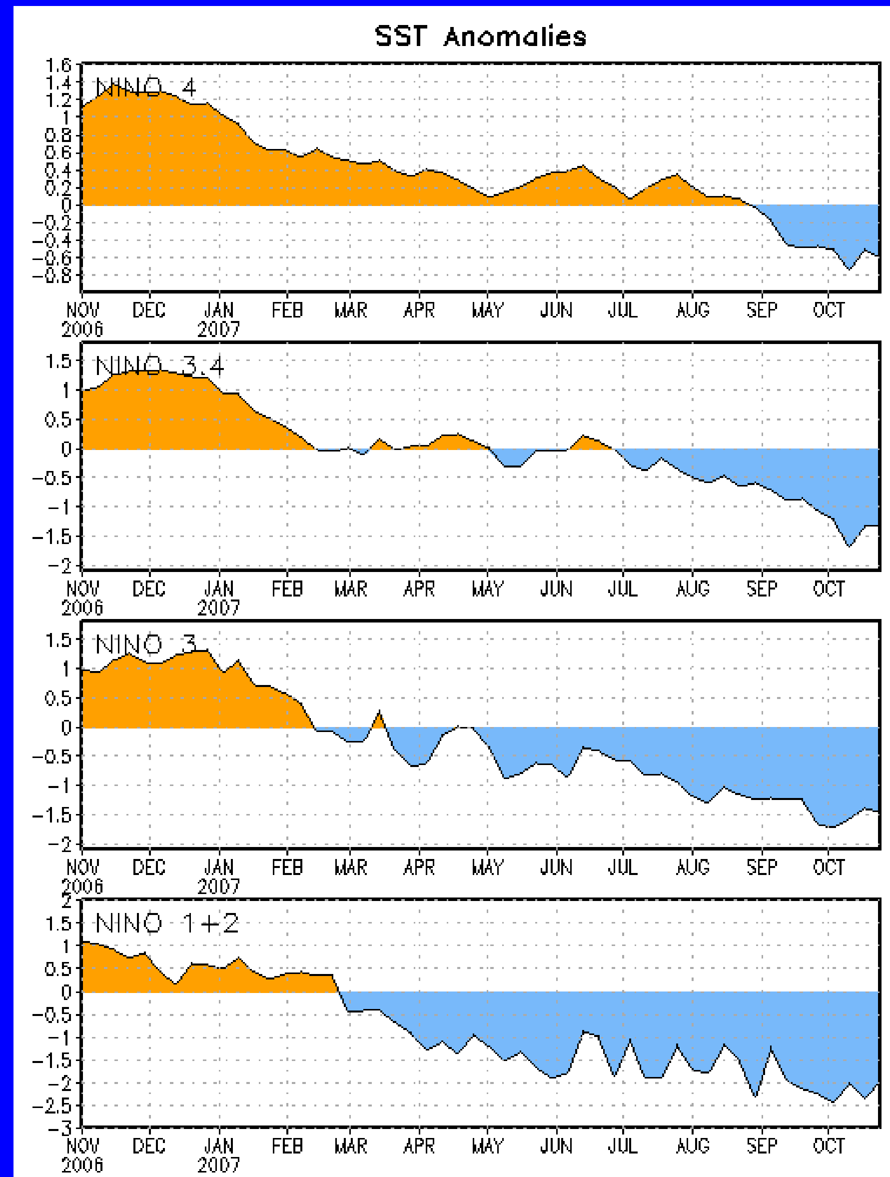
Over the past several months, below average SSTs have expanded westward, and negative anomalies now extend from west of the Date Line to the west coast of South America.

Niño Region SST Departures (ºC)
Recent Evolution

The latest weekly SST departures are:

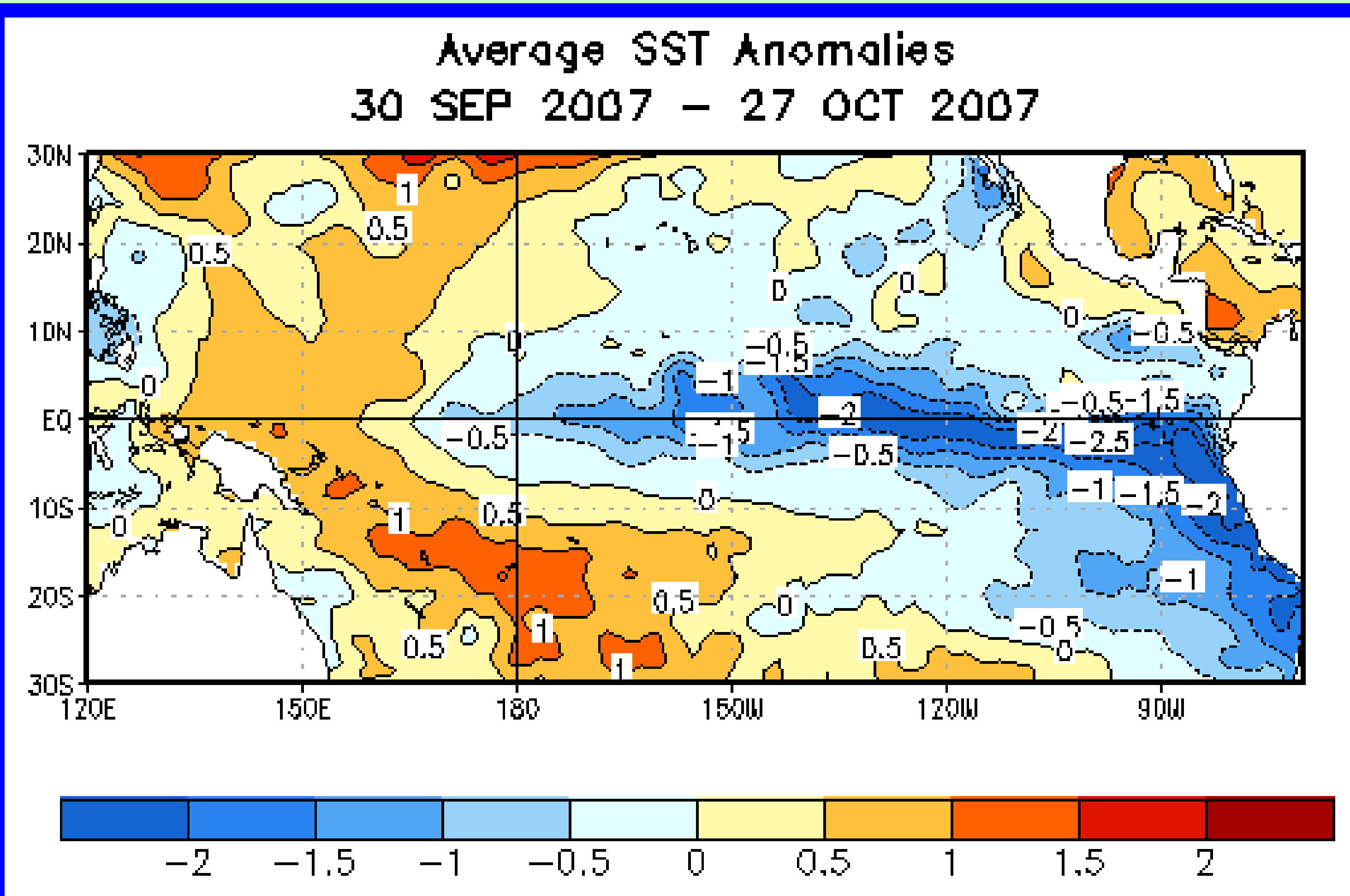
Niño 4	**-0.6ºC**
Niño 3.4	**-1.3ºC**
Niño 3	**-1.4ºC**
Niño 1+2	**-1.9ºC**



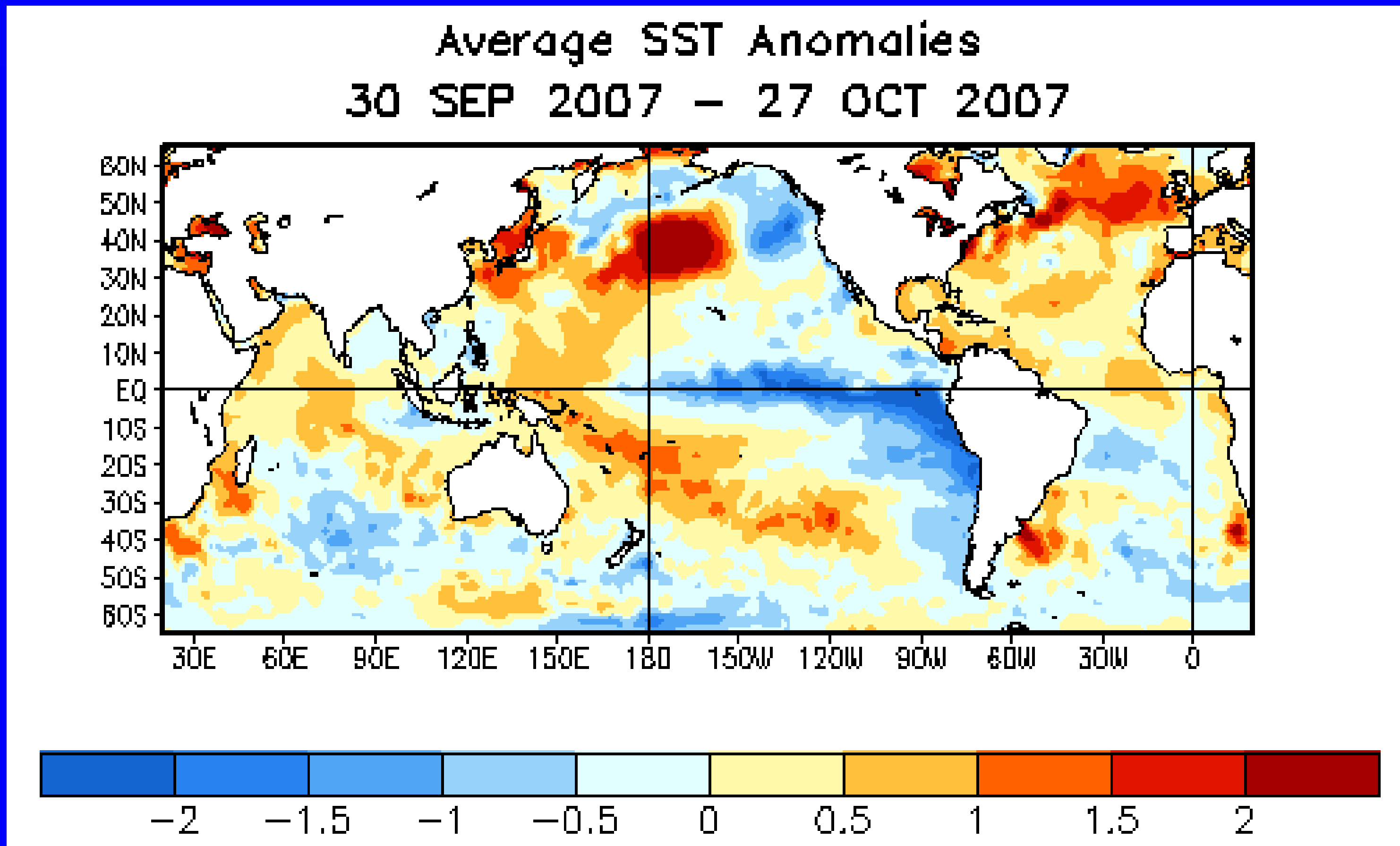


SST Departures (°C) in the Tropical Pacific During the Last 4 Weeks

During the last four weeks, equatorial Pacific SSTs were generally more than -2°C below average east of 140°W, and more than -1°C below average east of 175°W. SSTs remained more than +0.5°C above average between 130°E and 160°E.

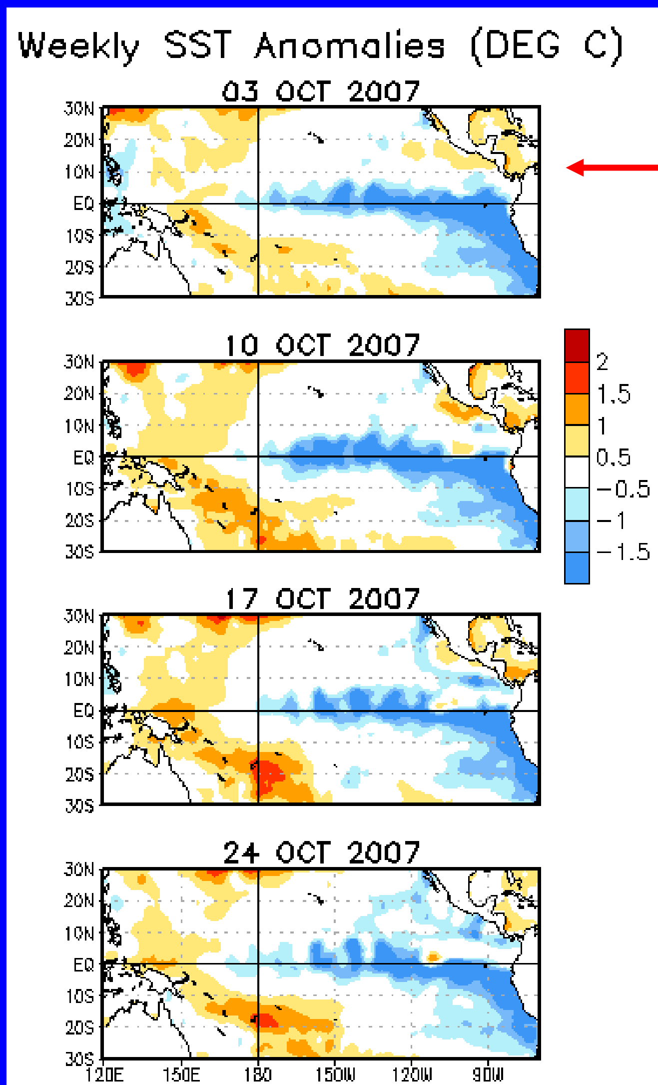


Global SST Departures (°C)

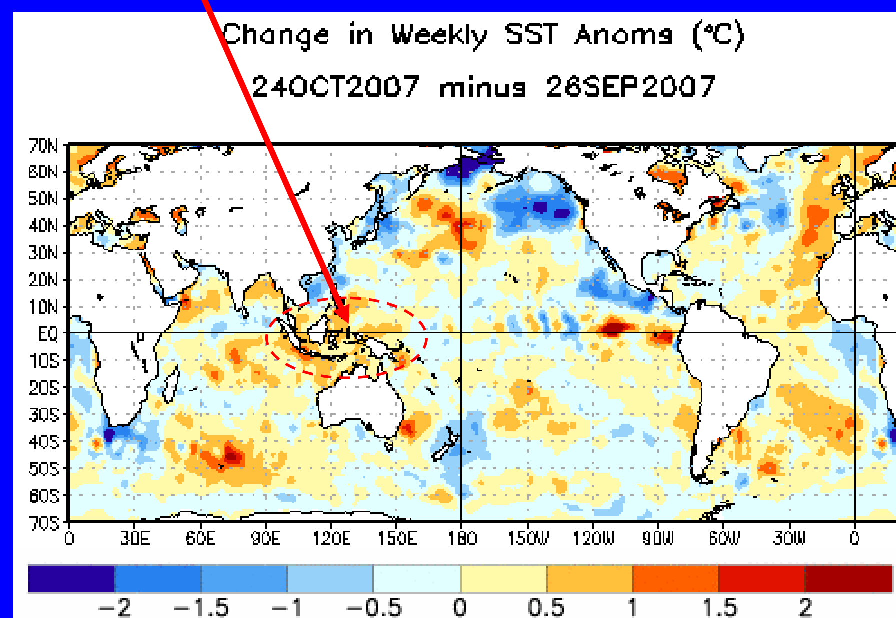


Equatorial SSTs remained below average across the central and eastern equatorial Pacific Ocean, and above average in the western Pacific Ocean, the Indian Ocean, and the Atlantic Ocean. A horseshoe-shaped pattern of positive anomalies spanned the Pacific Ocean of both hemispheres. Positive anomalies also covered the northernmost latitudes of the Atlantic Ocean.

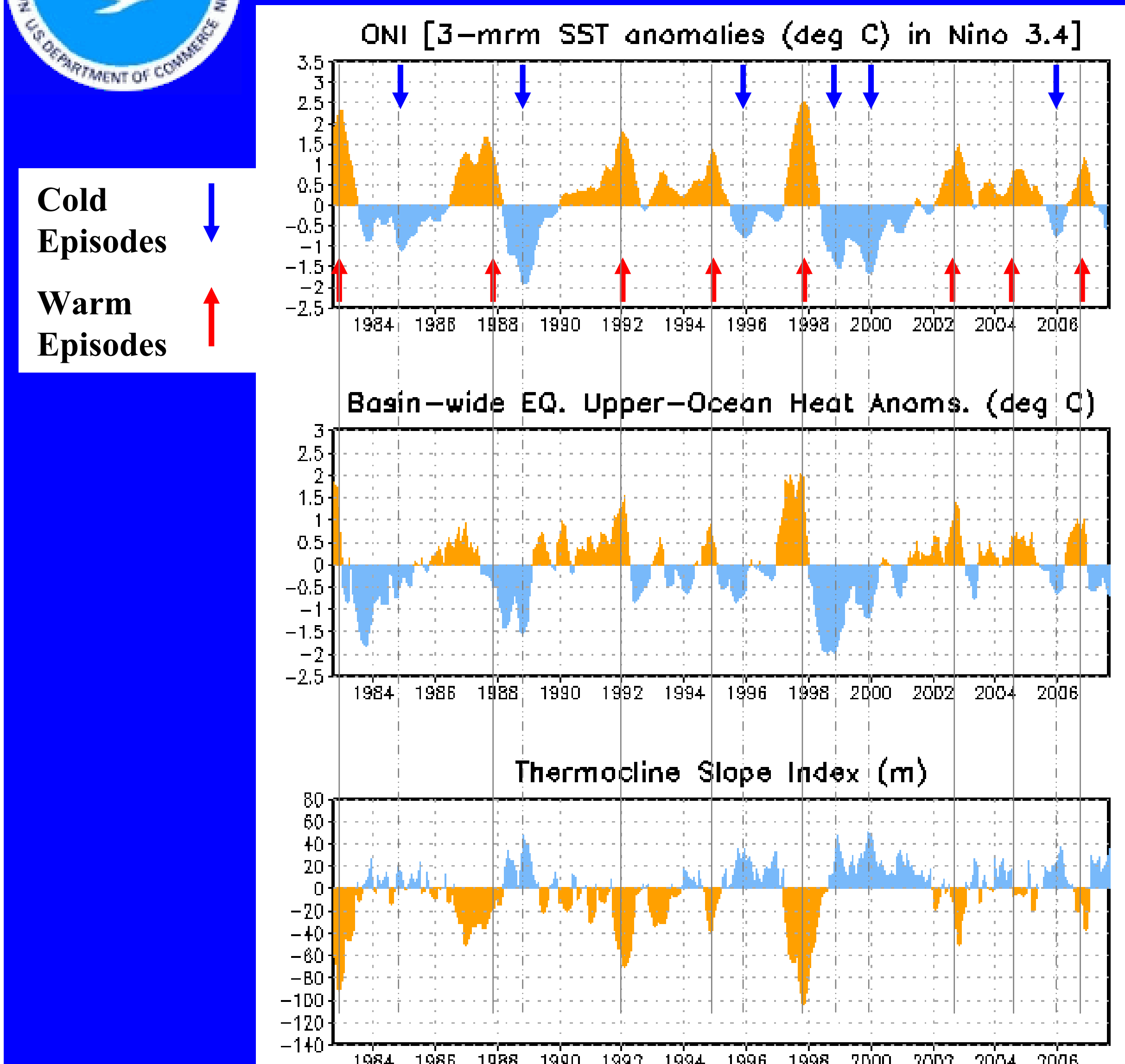
Weekly SST Departures (ºC) for the Last Four Weeks



- During October 2007 negative SST departures spanned the central and eastern equatorial Pacific.
- Over this 4-week period equatorial SST anomalies changed little in the area east of the Date Line, and increased near the Maritime Continent.



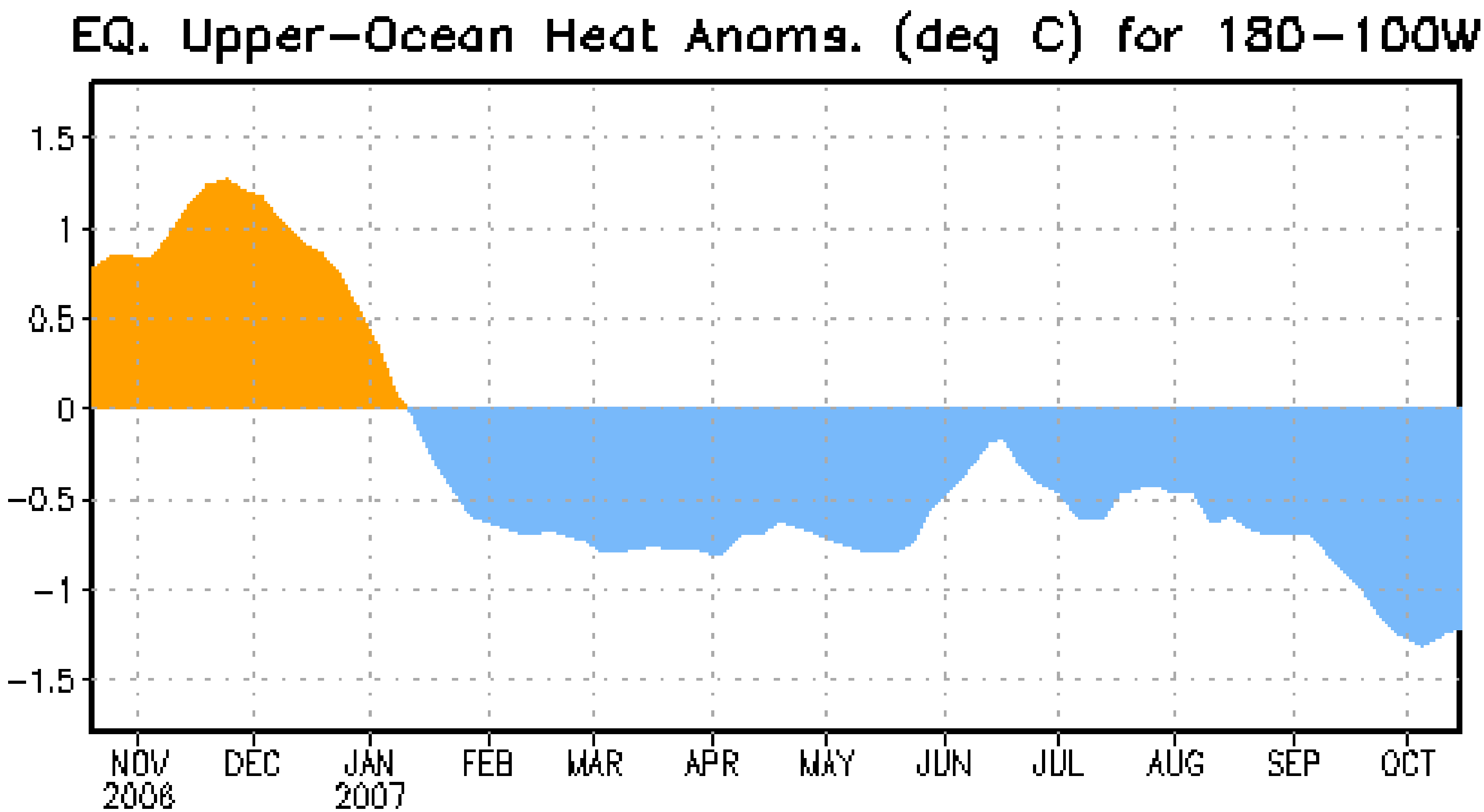
Upper-Ocean Conditions in the Eq. Pacific



- The basin-wide equatorial upper ocean (0-300 m) heat content is greatest prior to and during the early stages of a Pacific warm (El Niño) episode (compare top 2 panels) and least prior to and during the early stages of a cold (La Niña) episode.
- The slope of the oceanic thermocline is least (greatest) during warm (cold) episodes.
- Current values of the upper-ocean heat anomalies (negative) and the thermocline slope index (positive) indicate La Niña.

The monthly thermocline slope index represents the difference in anomalous depth of the 20ºC isotherm between the western Pacific (160ºE-150ºW) and the eastern Pacific (90º-140ºW).

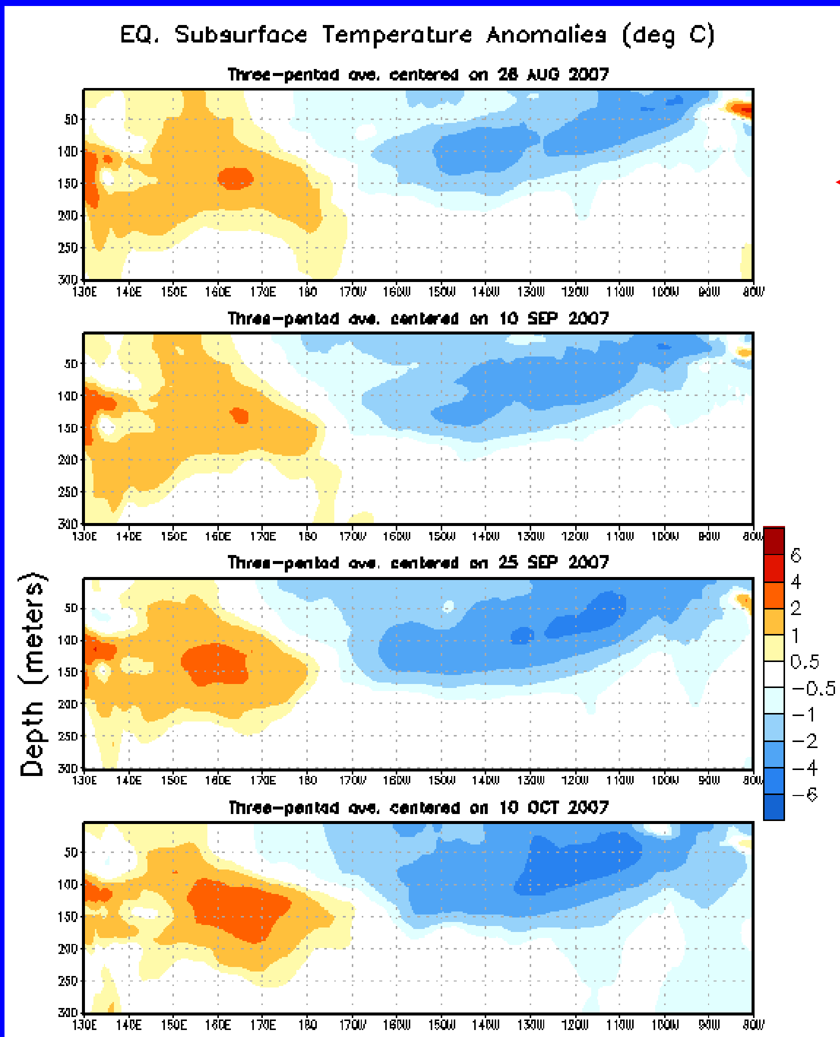
Central & Eastern Pacific Upper-Ocean (0-300 m) Weekly Heat Content Anomalies



Since January 2007, the upper ocean heat content has been below average across the eastern half of the equatorial Pacific Ocean. Intraseasonal fluctuations in heat content during May- August 2007 are related to the MJO. Below average heat content is favorable for the continued development of La Niña.

Sub-Surface Temperature Departures (°C) in the Equatorial Pacific

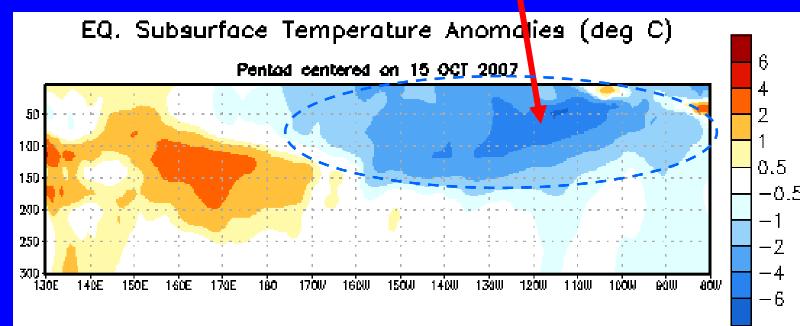
Time ↓



Longitude

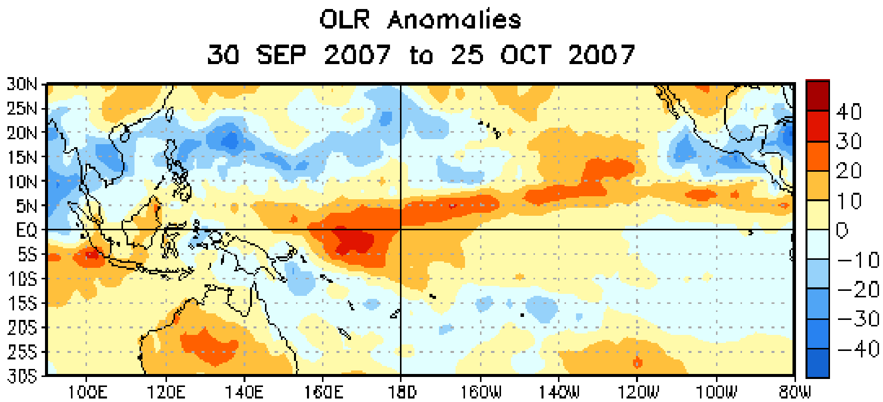
- During late August – mid October 2007 sub-surface temperature anomalies became increasingly negative across the eastern half of the equatorial Pacific Ocean, while positive anomalies remained confined to the western Pacific.

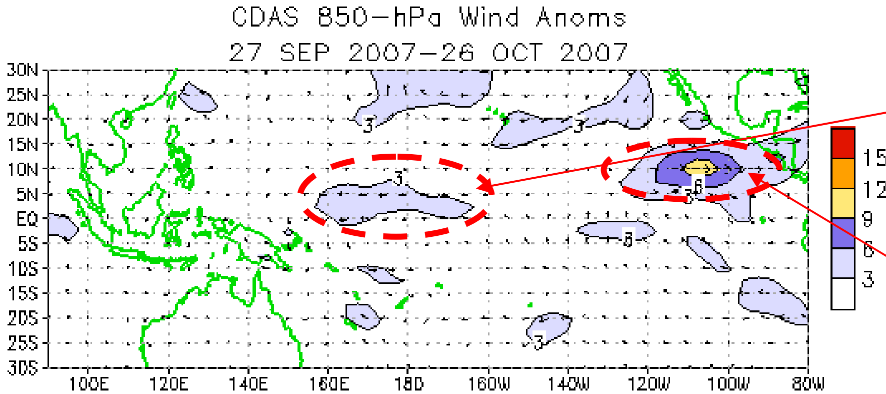
- The most recent period (below) shows negative temperature anomalies between the surface and 150 m depth across the central and eastern equatorial Pacific Ocean, with the largest departures (-4°C to -6°C) between 135° and 100°W.

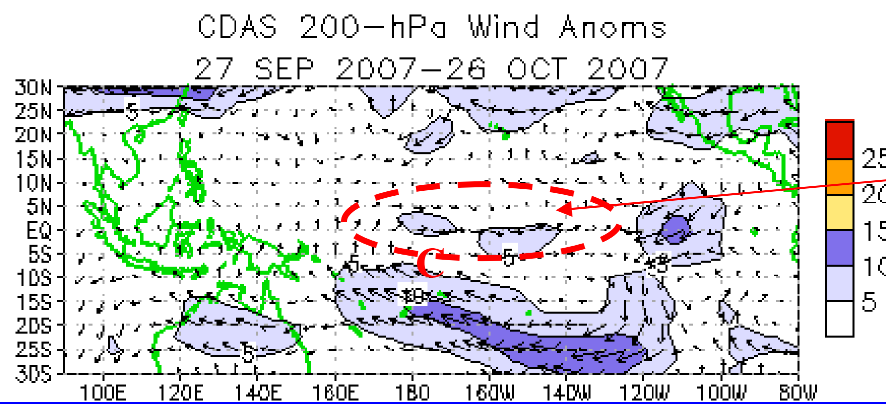


Most recent pentad analysis

Tropical OLR and Wind Anomalies During the Last 30 Days







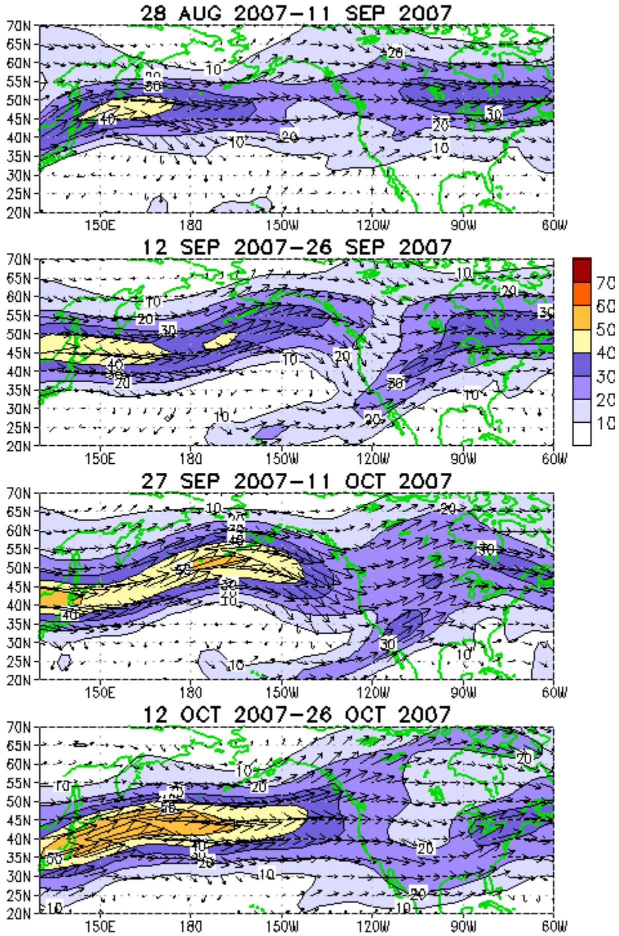
Positive OLR anomalies (suppressed convection and precipitation, red shading) were observed across the tropical Pacific, west of the Date Line and also between the equator and 10°N east of the Date Line. Negative OLR anomalies were present over the Philippines, Southeast Asia, and to the southeast of Papua New Guinea.

Weak low-level (850-hPa) easterly wind anomalies were evident in the central equatorial Pacific. Anomalous low-level westerlies were present in the eastern Pacific just north of the equator.

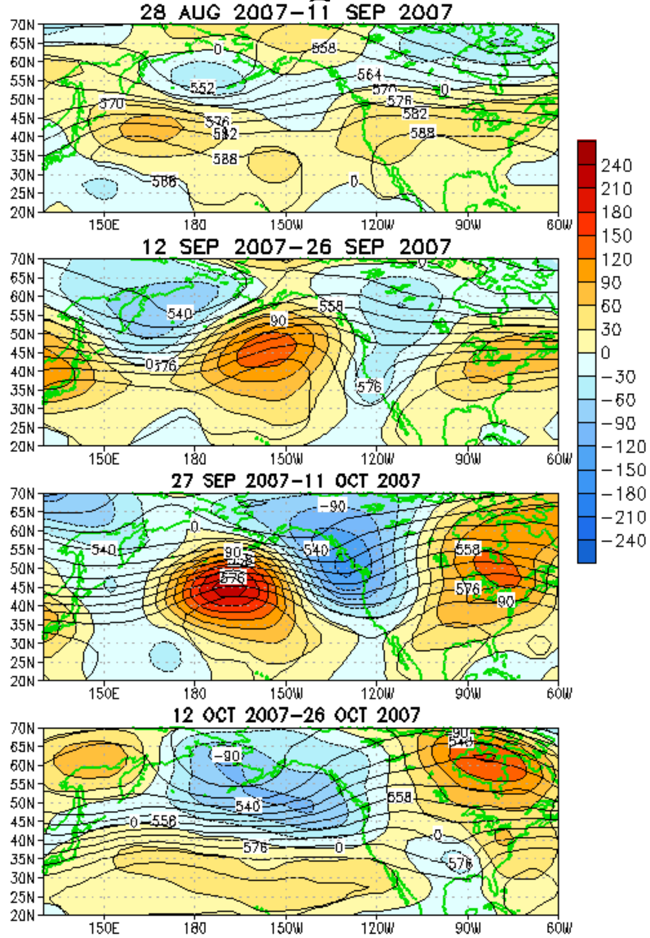
Over the central Pacific, the combination of upper-level (200-hPa) westerly wind anomalies at the equator and cyclonic anomalies in the Southern Hemisphere subtropics, reflect La Niña.

Atmospheric Circulation over the North Pacific & North America During the Last 60 Days

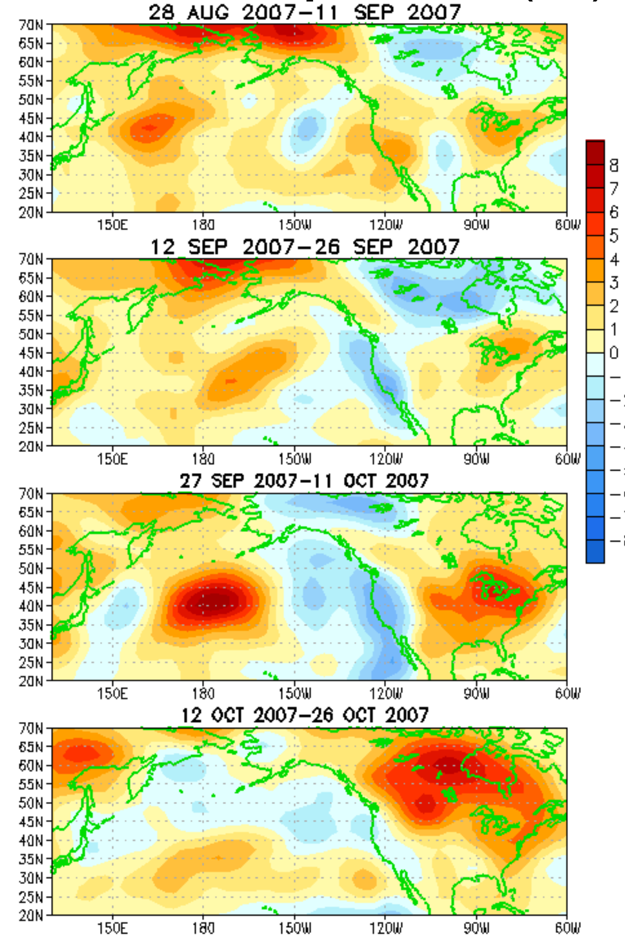
200-hPa Wind



500-hPa Height & Anoms.



925-hPa Temp. Anoms. (°C)

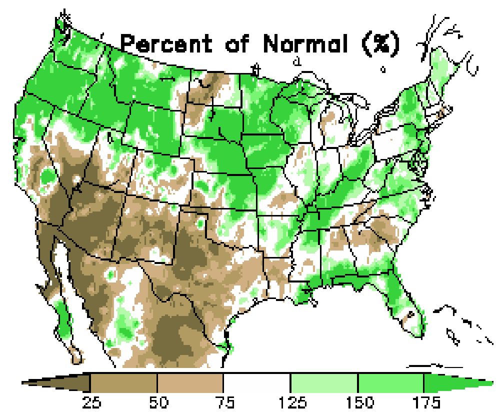


In late August and early September, above-average heights and temperatures dominated much of the contiguous United States. During late September a strong ridge developed over the Gulf of Alaska, followed by a trough over the western North America and a ridge in the East. This wave pattern amplified and slightly retrograded in early October, bringing below-average temperatures to Alaska and the U.S. west coast and above-average temperatures to central and eastern North America. During late October a more zonal flow over the eastern Pacific Ocean and continued above-average heights across eastern Canada brought a return of above average temperatures to much of North America.

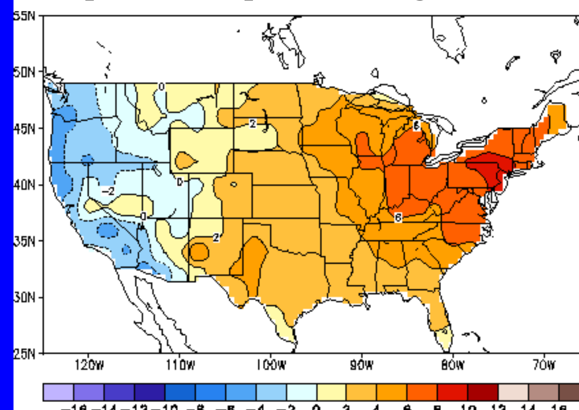
U.S. Temperature and Precipitation Departures During the Last 30 and 90 Days

Last 30 Days

30-day (ending 28 Oct 2007) % of average precipitation

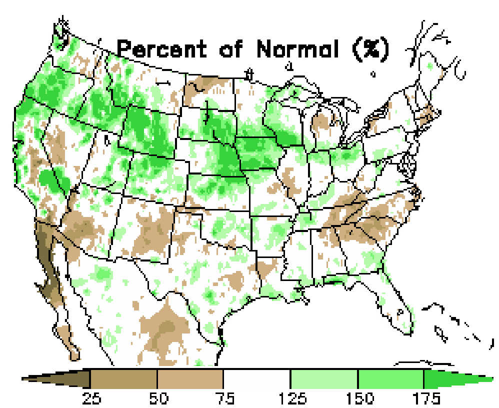


30-day (ending 26 Oct 2007) temperature departures (degree C)

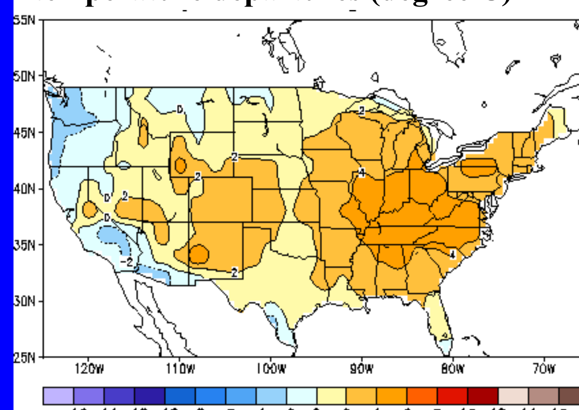


Last 90 Days

90-day (ending 28 Oct 2007) % of average precipitation



90-day (ending 26 Oct 2007) temperature departures (degree C)

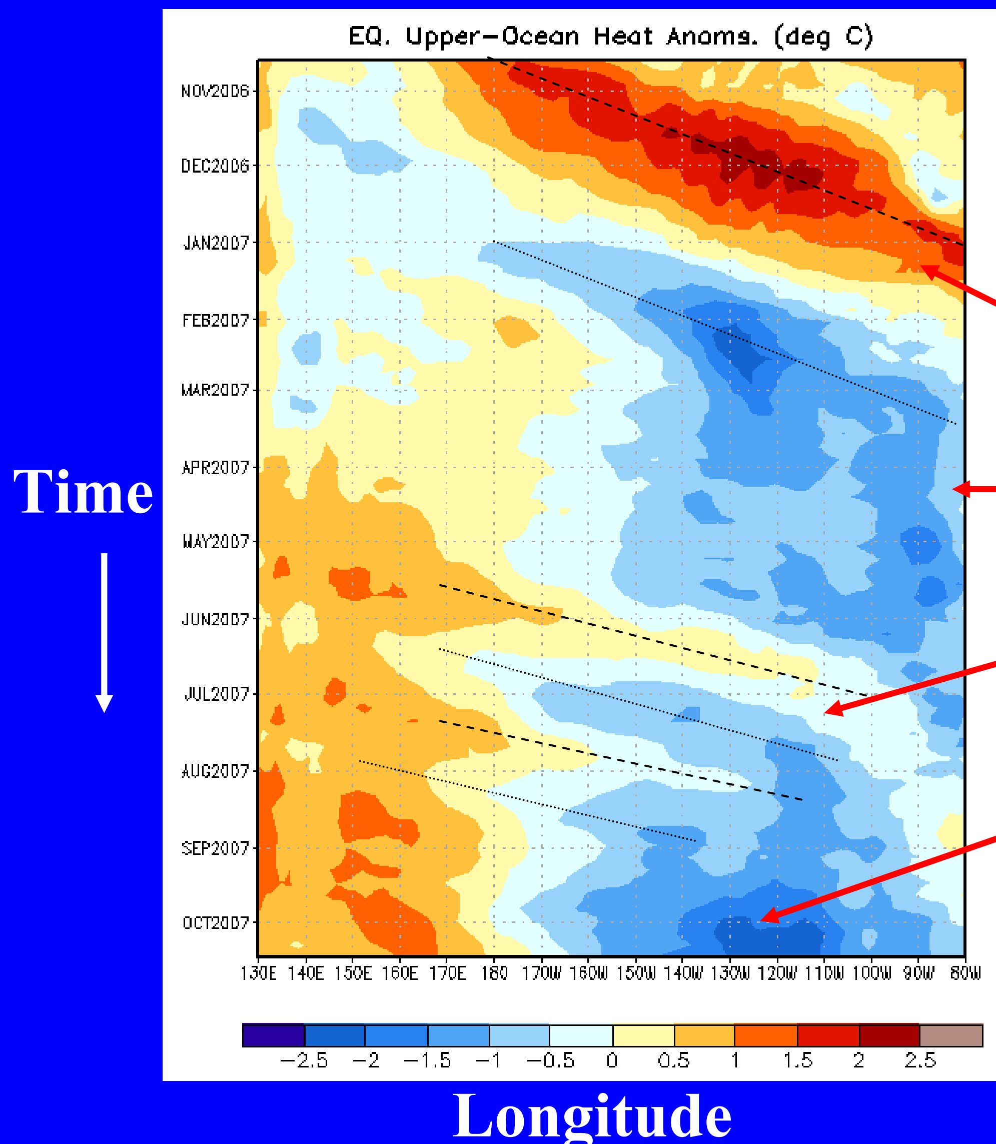


Intraseasonal Variability

- Intraseasonal variability in the atmosphere (wind and pressure), which is often related to the Madden-Julian Oscillation (MJO), can significantly impact surface and subsurface conditions across the Pacific Ocean.

- Related to this activity
  - significant weakening of the low-level easterly winds usually initiates an eastward-propagating oceanic Kelvin wave.
  - Several Kelvin waves have occurred during the last year (see next slide).

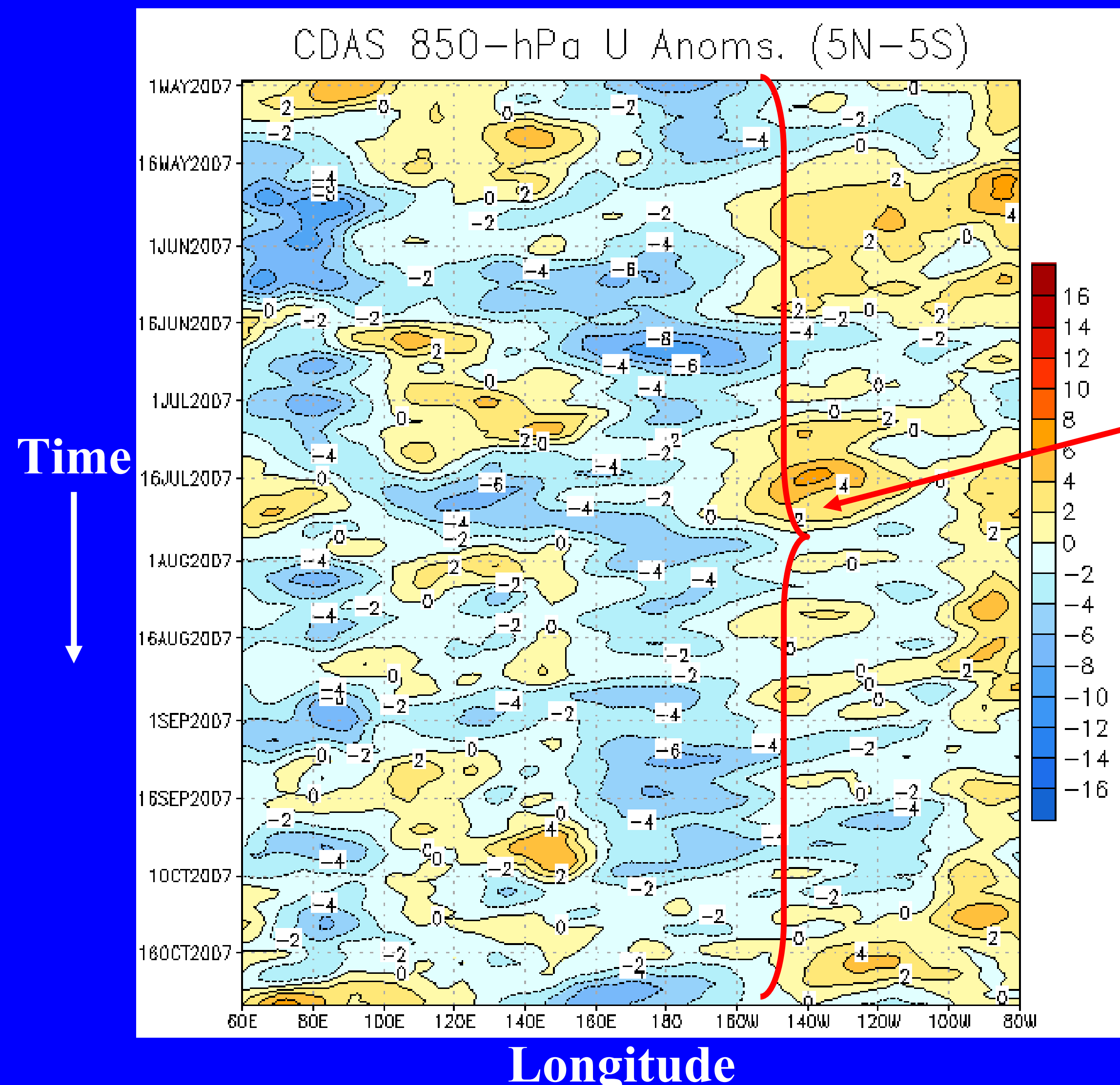
Weekly Heat Content Evolution in the Equatorial Pacific



- El Niño conditions and anomalously high heat content (red) were present during the latter part of 2006.
- Month-to-month variability in heat content during September 2006 – January 2007 is due to Kelvin wave activity.
- During February-May 2007, the heat content was anomalously low (blue) in the eastern equatorial Pacific.
- During May-August 2007, the subsurface temperature anomalies were affected by weak Kelvin wave activity.
- In recent weeks the increasing strength of the negative heat content anomalies reflects La Niña.

- Oceanic Kelvin waves have alternating warm and cold phases. The warm_phase is indicated by dashed lines and the cold phase is indicated by dotted lines. Down-welling and warming occur in the leading portion of a Kelvin wave, and up-welling and cooling occur in the trailing portion.

Low-level (850-hPa) Zonal (east-west) Wind Anomalies (m s^{-1})

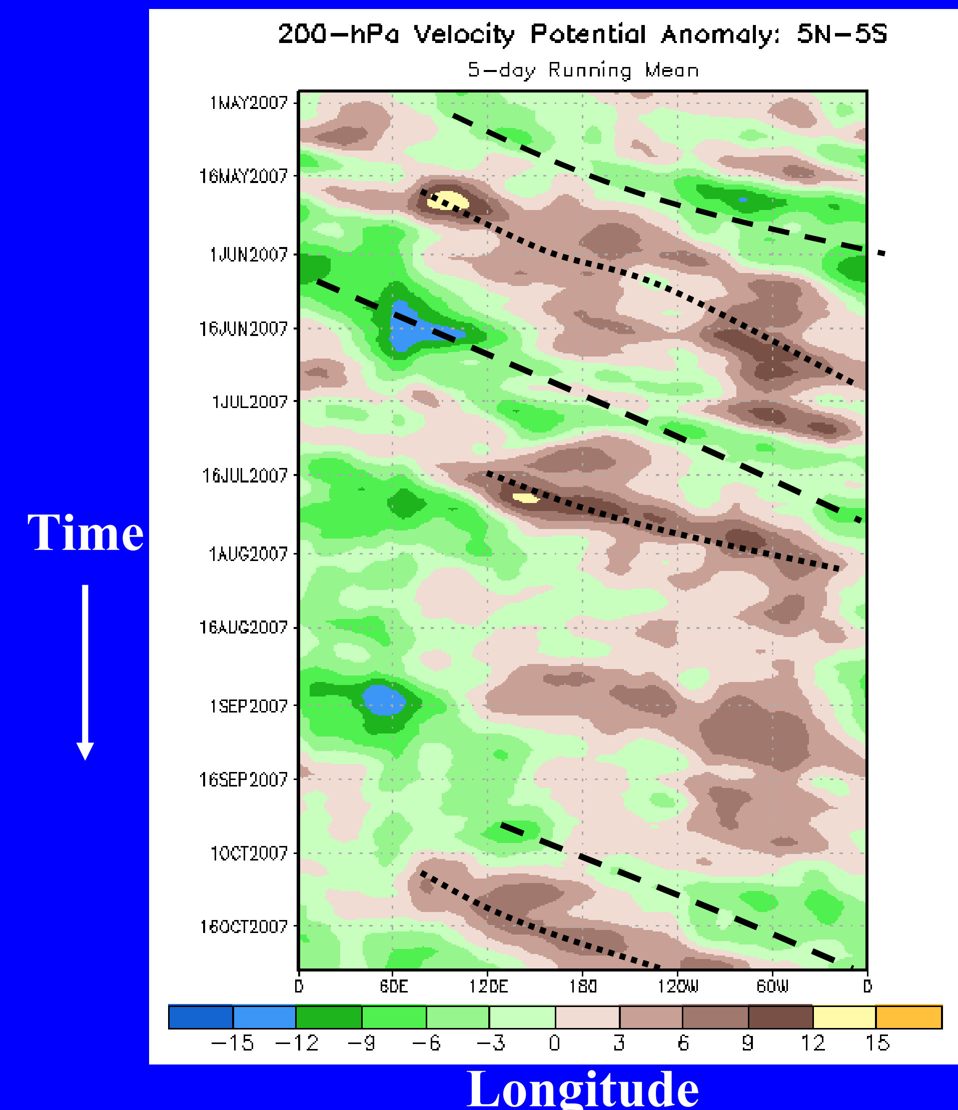


Westerly wind anomalies (orange/red shading).

Easterly wind anomalies (blue shading).

Low-level (850-hPa) easterly wind anomalies have persisted since January 2007 over the equatorial Pacific in areas between 160ºE and 150ºW.

200-hPa Velocity Potential Anomalies (5°N-5°S)



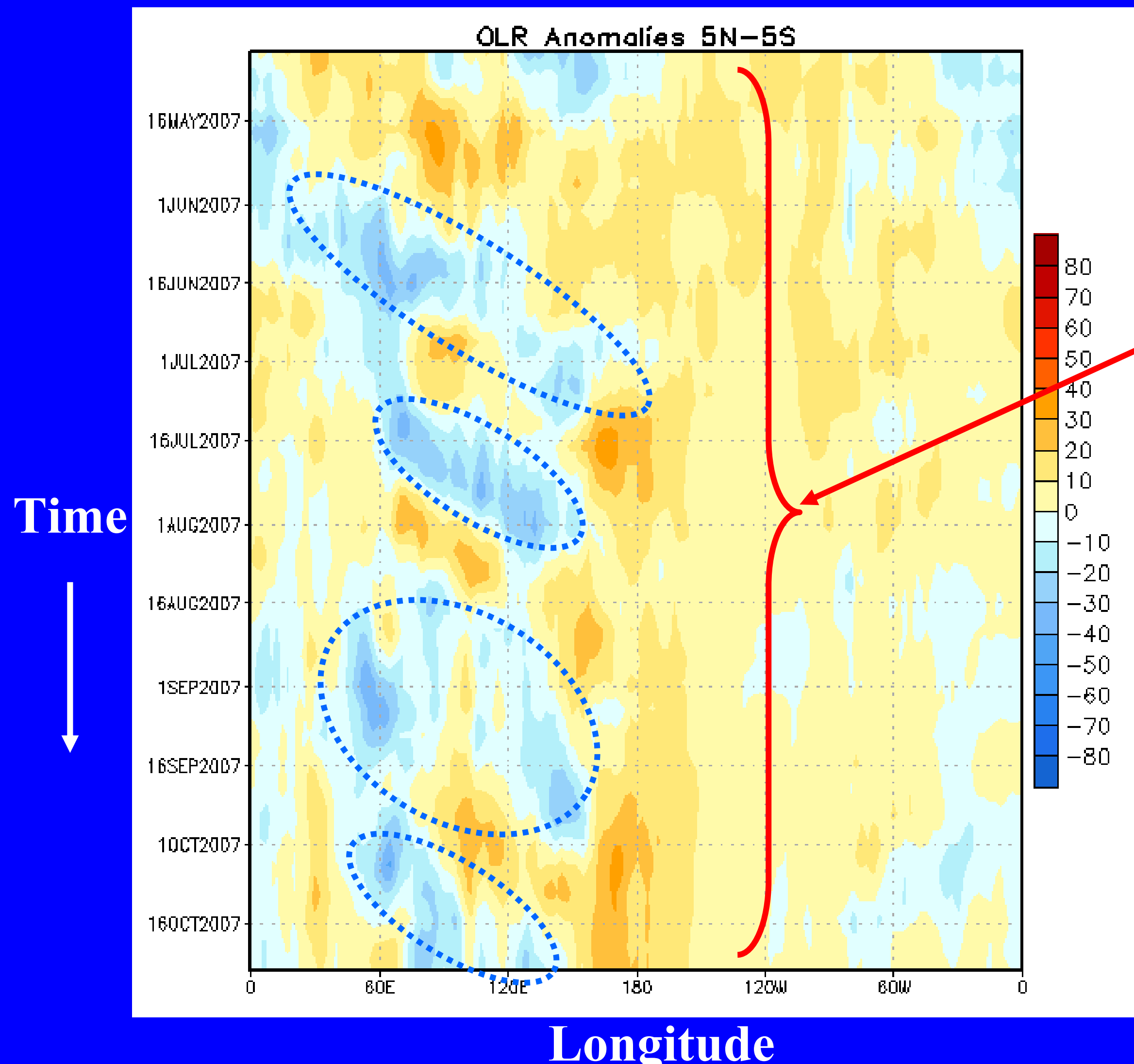
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation.

Negative anomalies (green shading) indicate favorable conditions for precipitation.

Weak-to-moderate MJO activity was observed during May - July, followed by no MJO activity during August and September.

Recently, MJO activity has increased.

Outgoing Longwave Radiation (OLR) Anomalies



Drier-than-average conditions (orange/red shading)

Wetter-than-average conditions (blue shading)

Since February 2007, convection has been suppressed across the eastern half of the equatorial Pacific Ocean.

Convection has occasionally been enhanced over the western equatorial Pacific and central Indian Ocean.

Oceanic Niño Index (ONI)

- **The ONI is based on SST departures from average in the Niño 3.4 region, and is a principal measure for monitoring, assessing, and predicting ENSO.**
- **Defined as the three-month running-mean SST departures in the Niño 3.4 region. Departures are based on a set of improved homogeneous historical SST analyses (Extended Reconstructed SST – ERSST.v2). The SST reconstruction methodology is described in Smith and Reynolds, 2003, *J. Climate*, 16, 1495-1510.**
- **Used to place current events into a historical perspective**
- **NOAA's operational definitions of El Niño and La Niña are keyed to the ONI index.**

NOAA Operational Definitions for El Niño and La Niña

El Niño: characterized by a *positive* ONI greater than or equal to +0.5°C.

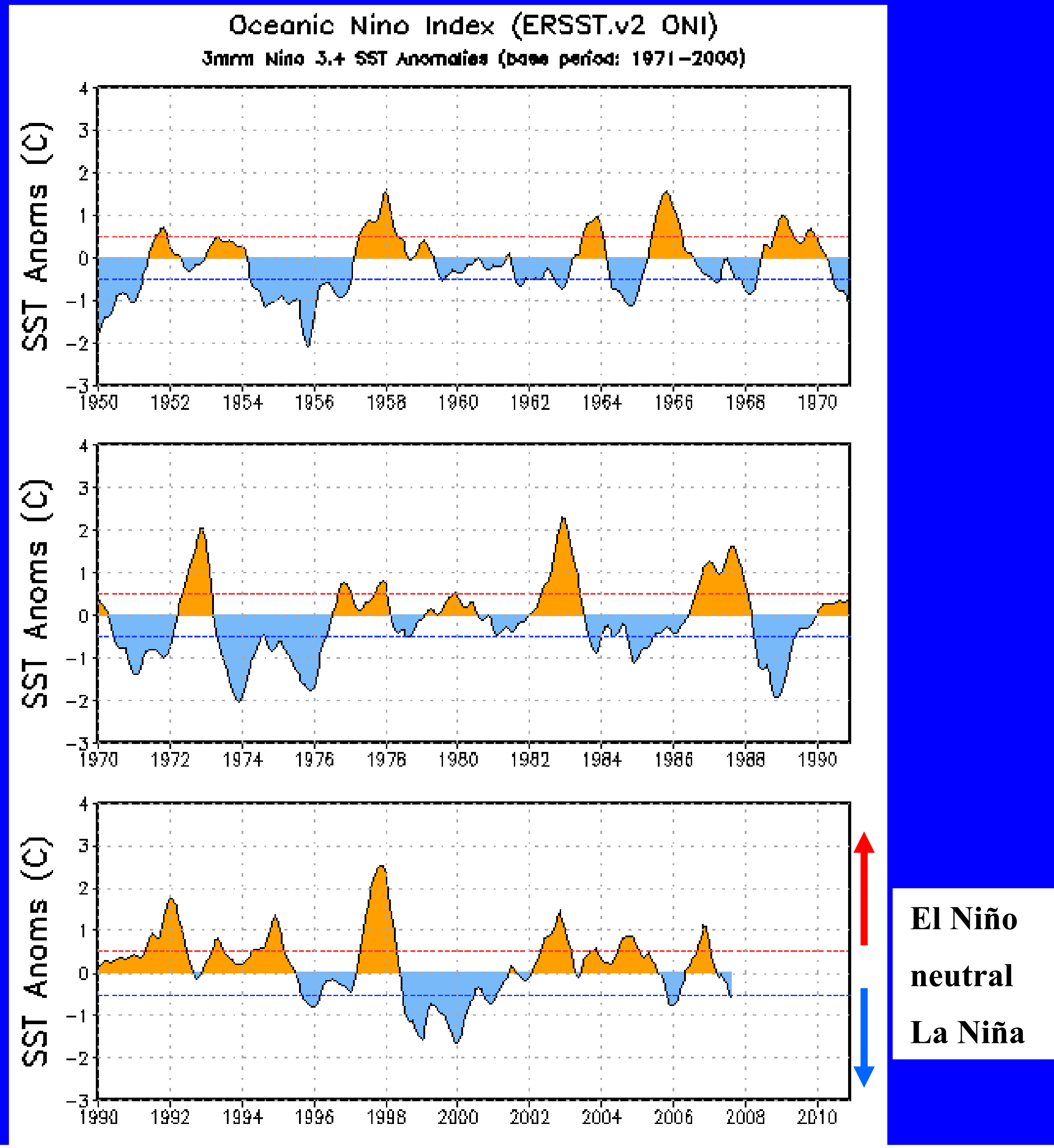
La Niña: characterized by a *negative* ONI less than or equal to -0.5°C.

By historical standards, to be classified as a full-fledged El Niño or La Niña episode, these thresholds must be exceeded for a period of at least 5 consecutive overlapping 3-month seasons.

CPC considers El Niño or La Niña conditions to occur when the monthly Niño3.4 SST departures meet or exceed +/- 0.5°C along with consistent atmospheric features.

ONI (°C): Evolution since 1950

The most recent ONI value (July – September 2007) is -0.6°C.



Historical El Niño and La Niña Episodes

Based on the ONI computed using ERSST.v2

El Niño	Highest ONI Value	La Nina	Lowest ONI Value
JAS 1951 - NDJ 1951/52	0.7	ASO 1949 – FMA 1951	-1.8
MAM 1957 – MJJ 1958	1.6	MAM 1954 – DJF 1956/57	-2.1
JJA 1963 – DJF 1963/64	1.0	ASO 1961 – MAM 1962	-0.6
MJJ 1965 – MAM 1966	1.6	MAM 1964 – JFM 1965	-1.1
OND 1968 – AMJ 1969	1.0	SON 1967 – MAM 1968	-0.9
ASO 1969 – DJF 1969/70	0.7	JJA 1970 – DJF 1971/72	-1.4
AMJ 1972 – FMA 1973	2.1	AMJ 1973 – JJA 1974	-2.0
ASO 1976 – JFM 1977	0.8	ASO 1974 – AMJ 1976	-1.8
ASO 1977 - DJF 1977/78	0.8	ASO 1983 – DJF 1983/84	-0.9
AMJ 1982 – MJJ 1983	2.3	SON 1984 – MJJ 1985	-1.1
JAS 1986 – JFM 1988	1.6	AMJ 1988 – AMJ 1989	-1.9
AMJ 1991 – MJJ 1992	1.8	ASO 1995 – FMA 1996	-0.8
FMA 1993 – JJA 1993	0.8	JJA 1998 – MJJ 2000	-1.6
MAM 1994 – FMA 1995	1.3	SON 2000 – JFM 2001	-0.7
AMJ 1997 – MAM 1998	2.5		
AMJ 2002 – FMA 2003	1.5		
JJA 2004 – JFM 2005	0.9		
ASO 2006 - DJF 2006/07	1.1		

Historical Pacific warm (red) and cold (blue) episodes based on a threshold of +/- 0.5 °C for the Oceanic Nino Index (ONI) [3 month running mean of ERSST.v2 SST anomalies in the Nino 3.4 region (5N-5S, 120-170W)], calculated with respect to the 1971-2000 base period. For historical purposes El Niño and La Niña episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1950	-1.8	-1.5	-1.4	-1.4	-1.4	-1.2	-0.9	-0.8	-0.8	-0.8	-0.9	-1.0
1951	-1.0	-0.8	-0.6	-0.4	-0.2	0.1	0.4	0.5	0.6	0.7	0.7	0.6
1952	0.3	0.1	0.1	0.1	0.0	-0.2	-0.3	-0.3	-0.1	-0.2	-0.2	-0.1
1953	0.1	0.3	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3
1954	0.3	0.2	-0.1	-0.5	-0.7	-0.7	-0.8	-1.0	-1.1	-1.1	-1.0	-1.0
1955	-1.0	-0.9	-0.9	-1.0	-1.1	-1.0	-1.0	-1.0	-1.5	-1.8	-2.1	-1.7
1956	-1.2	-0.8	-0.7	-0.6	-0.6	-0.6	-0.7	-0.8	-0.9	-0.9	-0.9	-0.8
1957	-0.5	-0.1	0.2	0.6	0.7	0.8	0.9	0.9	0.8	0.9	1.2	1.5
1958	1.6	1.5	1.1	0.7	0.5	0.5	0.4	0.1	0.0	0.0	0.1	0.3
1959	0.4	0.4	0.3	0.2	0.0	-0.3	-0.4	-0.5	-0.4	-0.4	-0.3	-0.3
1960	-0.3	-0.3	-0.3	-0.2	-0.1	-0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.2
1961	-0.2	-0.2	-0.2	-0.1	0.1	0.1	0.0	-0.3	-0.6	-0.6	-0.5	-0.5
1962	-0.5	-0.5	-0.5	-0.5	-0.4	-0.3	-0.2	-0.3	-0.4	-0.6	-0.7	-0.7
1963	-0.6	-0.3	0.0	0.1	0.1	0.3	0.6	0.8	0.8	0.9	1.0	1.0
1964	0.8	0.4	-0.1	-0.5	-0.7	-0.7	-0.8	-0.9	-1.0	-1.1	-1.1	-1.0
1965	-0.8	-0.5	-0.3	0.0	0.2	0.6	1.0	1.2	1.4	1.5	1.6	1.5
1966	1.2	1.1	0.8	0.5	0.2	0.1	0.1	0.0	-0.2	-0.3	-0.3	-0.4
1967	-0.4	-0.5	-0.6	-0.5	-0.3	0.0	0.0	-0.2	-0.4	-0.5	-0.5	-0.6
1968	-0.7	-0.9	-0.8	-0.8	-0.4	0.0	0.3	0.3	0.2	0.4	0.6	0.9
1969	1.0	1.0	0.9	0.7	0.6	0.4	0.4	0.4	0.6	0.7	0.7	0.6
1970	0.5	0.3	0.2	0.1	-0.1	-0.4	-0.6	-0.8	-0.8	-0.8	-0.9	-1.2
1971	-1.4	-1.4	-1.2	-1.0	-0.8	-0.8	-0.8	-0.8	-0.9	-0.9	-1.0	-0.9
1972	-0.7	-0.3	0.0	0.3	0.5	0.8	1.1	1.3	1.5	1.8	2.0	2.1
1973	1.8	1.2	0.5	-0.1	-0.5	-0.8	-1.1	-1.3	-1.4	-1.7	-1.9	-2.0
1974	-1.8	-1.6	-1.2	-1.1	-0.9	-0.7	-0.5	-0.4	-0.5	-0.7	-0.8	-0.7
1975	-0.6	-0.6	-0.7	-0.8	-1.0	-1.1	-1.3	-1.4	-1.6	-1.6	-1.7	-1.8

Historical Pacific warm (red) and cold (blue) episodes based on a threshold of +/- 0.5 ^oC for the Oceanic Nino Index (ONI) [3 month running mean of ERSST.v2 SST anomalies in the Nino 3.4 region (5N-5S, 120-170W)], calculated with respect to the 1971-2000 base period. For historical purposes El Niño and La Niña episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1976	**-1.6**	**-1.2**	**-0.9**	**-0.7**	**-0.5**	-0.2	0.1	0.3	**0.5**	**0.7**	**0.8**	**0.8**
1977	**0.6**	**0.5**	0.2	0.1	0.2	0.3	0.3	0.4	**0.5**	**0.7**	**0.8**	**0.8**
1978	**0.7**	0.4	0.0	-0.3	-0.4	-0.3	-0.4	-0.5	-0.5	-0.4	-0.2	-0.1
1979	-0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.2	0.3	0.4	0.5	0.5
1980	0.5	0.3	0.2	0.2	0.3	0.3	0.2	0.0	-0.1	0.0	0.0	-0.1
1981	-0.3	-0.4	-0.4	-0.3	-0.3	-0.3	-0.4	-0.3	-0.2	-0.1	-0.1	-0.1
1982	0.0	0.1	0.2	0.4	**0.6**	**0.7**	**0.8**	**1.0**	**1.5**	**1.9**	**2.2**	**2.3**
1983	**2.3**	**2.0**	**1.6**	**1.2**	**1.0**	**0.6**	0.2	-0.2	**-0.5**	**-0.8**	**-0.9**	**-0.8**
1984	**-0.5**	-0.3	-0.2	-0.4	-0.5	-0.5	-0.3	-0.2	-0.3	**-0.6**	**-1.0**	**-1.1**
1985	**-1.0**	**-0.8**	**-0.8**	**-0.8**	**-0.7**	**-0.5**	-0.4	-0.4	-0.4	-0.3	-0.2	-0.3
1986	-0.4	-0.4	-0.3	-0.2	-0.1	0.0	0.2	**0.5**	**0.7**	**0.9**	**1.1**	**1.2**
1987	**1.3**	**1.2**	**1.1**	**1.0**	**1.0**	**1.2**	**1.5**	**1.6**	**1.6**	**1.5**	**1.3**	**1.1**
1988	**0.8**	**0.5**	0.1	-0.3	**-0.8**	**-1.2**	**-1.2**	**-1.1**	**-1.3**	**-1.6**	**-1.9**	**-1.9**
1989	**-1.7**	**-1.5**	**-1.1**	**-0.9**	**-0.6**	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1
1990	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4
1991	0.5	0.4	0.4	0.4	**0.6**	**0.8**	**0.9**	**0.9**	**0.8**	**1.0**	**1.4**	**1.7**
1992	**1.8**	**1.7**	**1.6**	**1.4**	**1.1**	**0.8**	0.4	0.2	-0.1	-0.1	0.0	0.1
1993	0.3	0.4	**0.6**	**0.8**	**0.8**	**0.7**	**0.5**	0.4	0.4	0.3	0.2	0.2
1994	0.2	0.3	0.4	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**	**0.7**	**0.9**	**1.2**	**1.3**
1995	**1.2**	**0.9**	**0.7**	0.4	0.2	0.1	0.0	-0.3	**-0.5**	**-0.6**	**-0.7**	**-0.8**
1996	**-0.8**	**-0.7**	**-0.5**	-0.3	-0.2	-0.2	-0.1	-0.2	-0.2	-0.2	-0.3	-0.4
1997	-0.4	-0.3	0.0	0.4	**0.9**	**1.4**	**1.7**	**2.0**	**2.3**	**2.4**	**2.5**	**2.5**
1998	**2.4**	**2.0**	**1.4**	**1.1**	0.4	-0.1	**-0.8**	**-1.0**	**-1.1**	**-1.1**	**-1.3**	**-1.5**
1999	**-1.6**	**-1.2**	**-0.9**	**-0.7**	**-0.8**	**-0.8**	**-0.9**	**-0.9**	**-1.0**	**-1.2**	**-1.4**	**-1.6**
2000	**-1.6**	**-1.5**	**-1.1**	**-0.9**	**-0.7**	**-0.6**	-0.4	-0.3	-0.4	**-0.5**	**-0.7**	**-0.7**
2001	**-0.7**	**-0.5**	-0.4	-0.2	-0.1	0.1	0.2	0.1	0.0	-0.1	-0.2	-0.2

Historical Pacific warm (red) and cold (blue) episodes based on a threshold of +/- 0.5 ºC for the Oceanic Nino Index (ONI) [3 month running mean of ERSST.v2 SST anomalies in the Nino 3.4 region (5N-5S, 120-170W)], calculated with respect to the 1971-2000 base period. For historical purposes El Niño and La Niña episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2002	-0.1	0.1	0.3	0.4	**0.7**	**0.8**	**0.9**	**0.9**	**1.1**	**1.3**	**1.5**	**1.3**
2003	**1.1**	**0.8**	**0.6**	0.1	-0.1	0.0	0.3	0.4	0.5	0.5	0.6	0.5
2004	0.4	0.2	0.2	0.2	0.3	0.4	**0.7**	**0.8**	**0.9**	**0.9**	**0.9**	**0.8**
2005	**0.6**	**0.5**	0.3	0.4	0.5	0.3	0.2	0.0	0.0	-0.2	-0.4	-0.7
2006	-0.8	-0.7	-0.4	-0.2	0.0	0.1	0.3	0.4	**0.7**	**0.9**	**1.1**	**1.1**
2007	**0.8**	0.3	0.1	-0.1	0.0	-0.1	-0.2	**-0.6**				
2008												
2009												
2010												
2011												
2012												
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2026												
2027												

Pacific Niño 3.4 SST Outlook

Most ENSO models predict that La Niña (cooler than -0.5°C in the Niño 3.4 region) will persist through early 2008. Nearly all of the dynamical and statistical models predict a weak-to-moderate La Niña during the next several months.

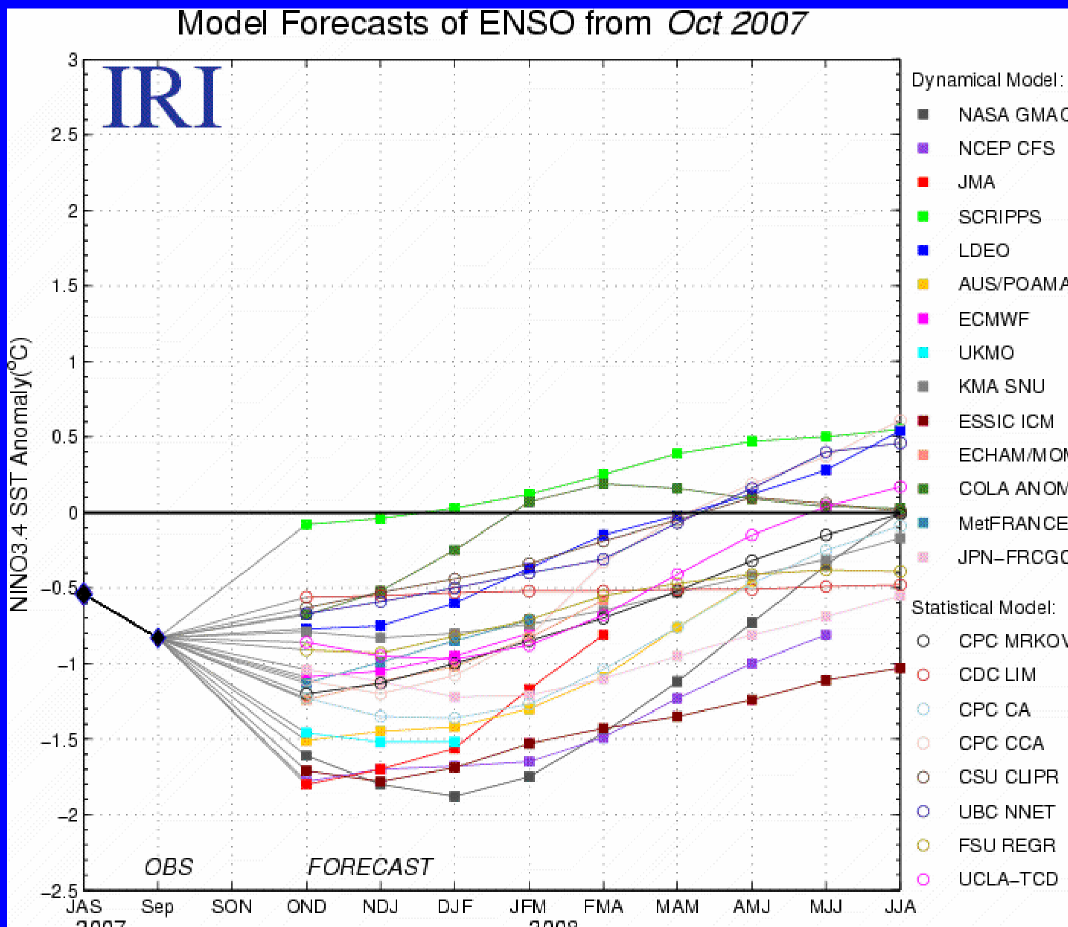
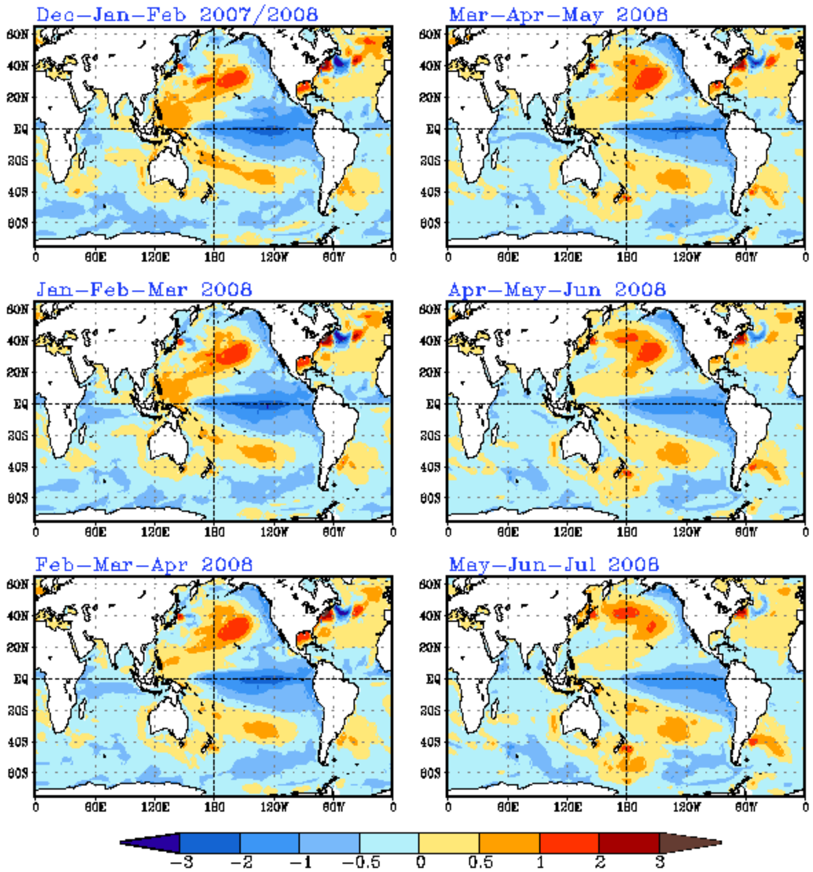
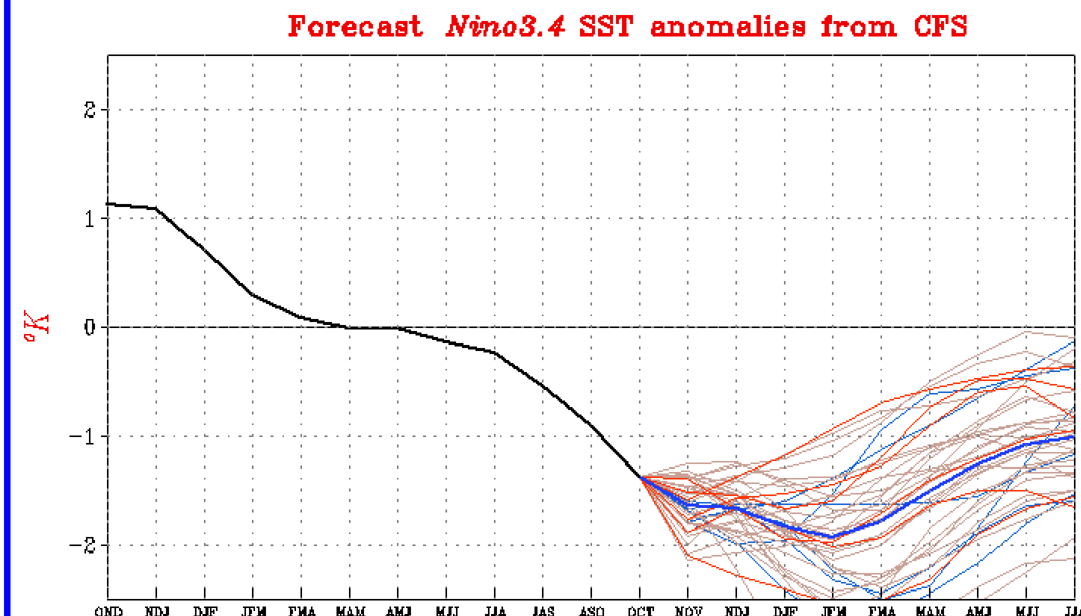


Figure provided by the International Research Institute (IRI) for Climate and Society (updated 16 October 2007).

SST Outlook: NCEP CFS Forecast Issued 29 October 2007

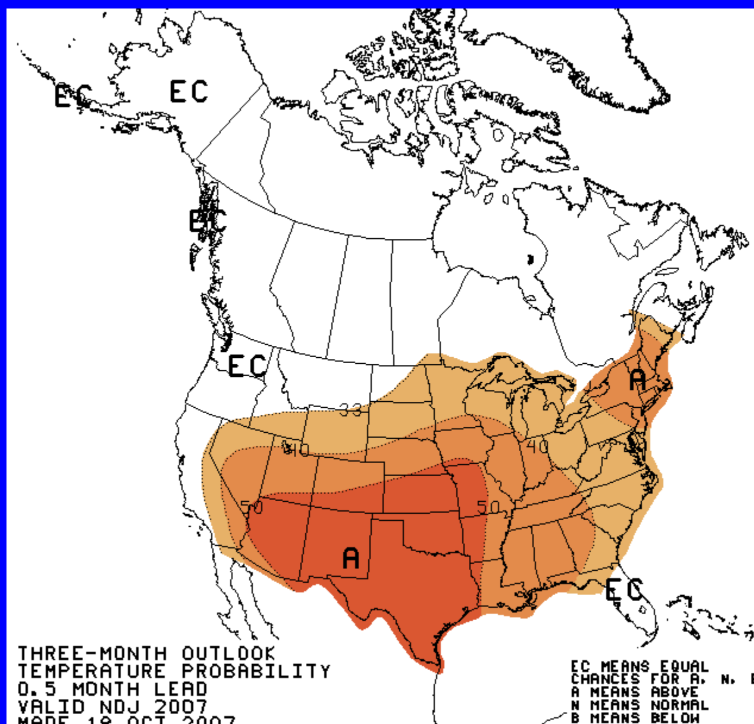


The CFS ensemble mean (heavy blue line) predicts La Niña will strengthen during the next few months.

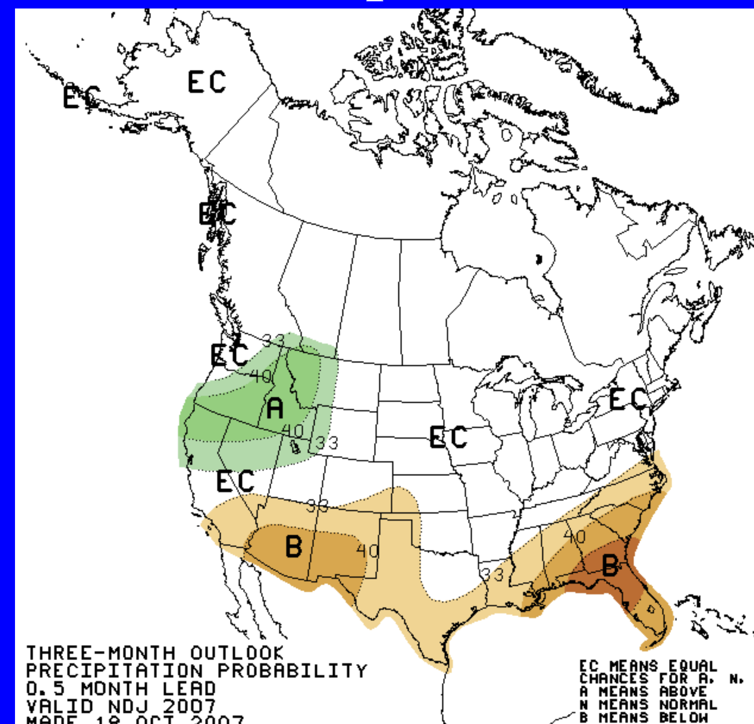


U. S. Seasonal Outlooks
November 2007- January 2008

Temperature



Precipitation

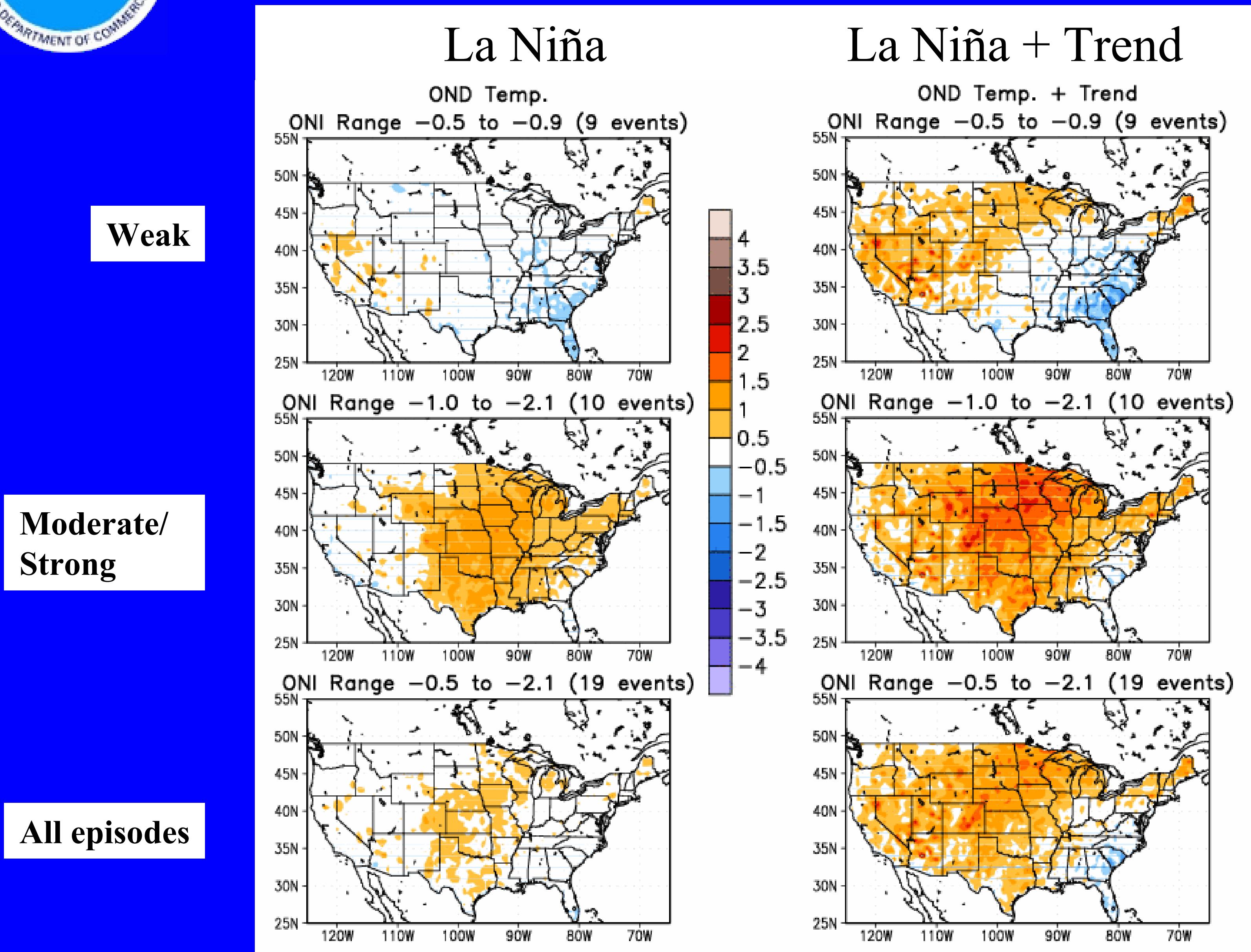


These seasonal outlooks combine typical La Niña impacts, along with long-term trends and soil-moisture effects.

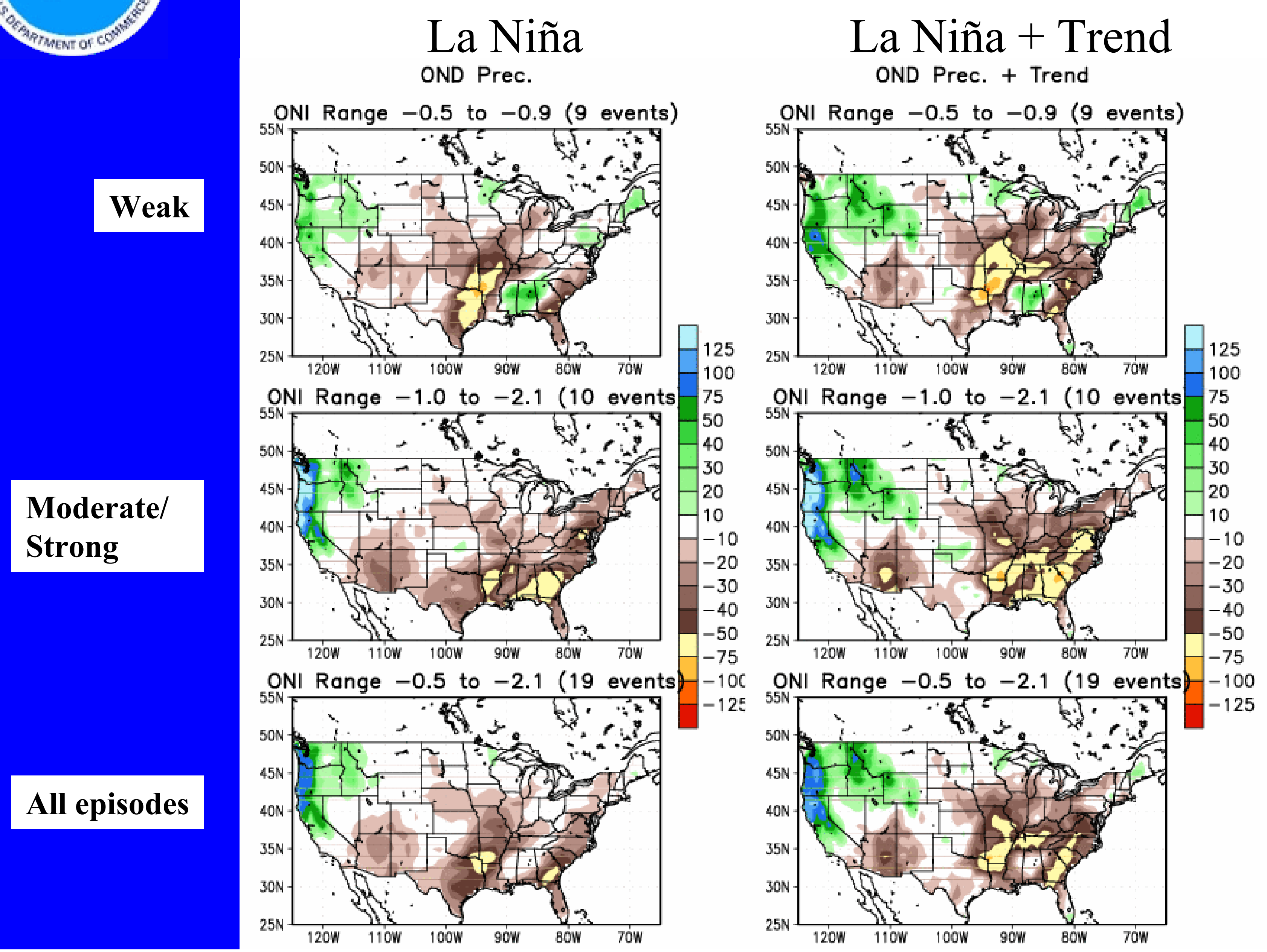
Summary

- La Niña is present across the tropical Pacific.
- Negative SST anomalies extend along the equator from the Date Line eastward to the South American coast.
- Recent equatorial Pacific SST trends and model forecasts indicate La Niña will continue through early 2008.

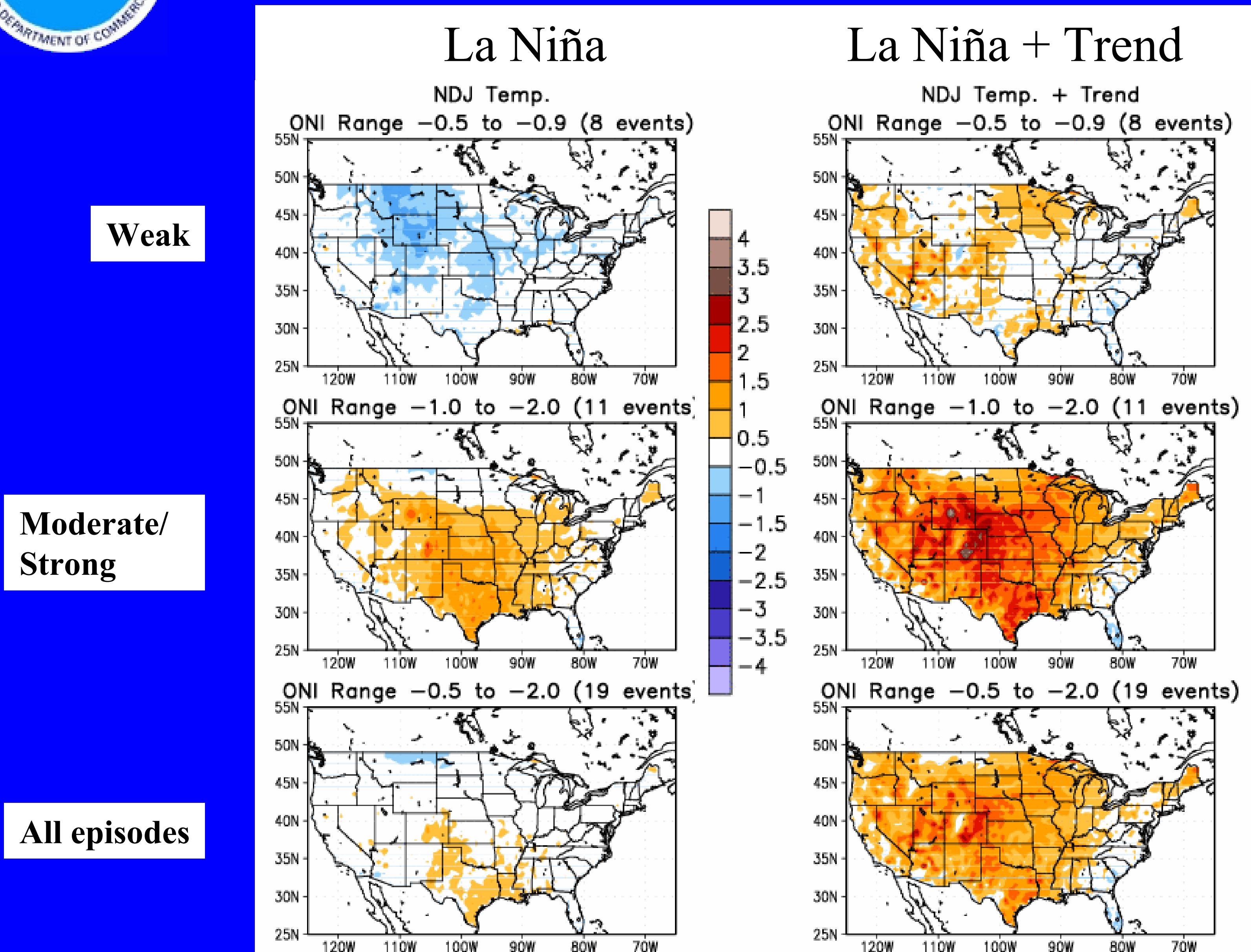
Temperature Departures (°C) for Ranges of the ONI during October-December



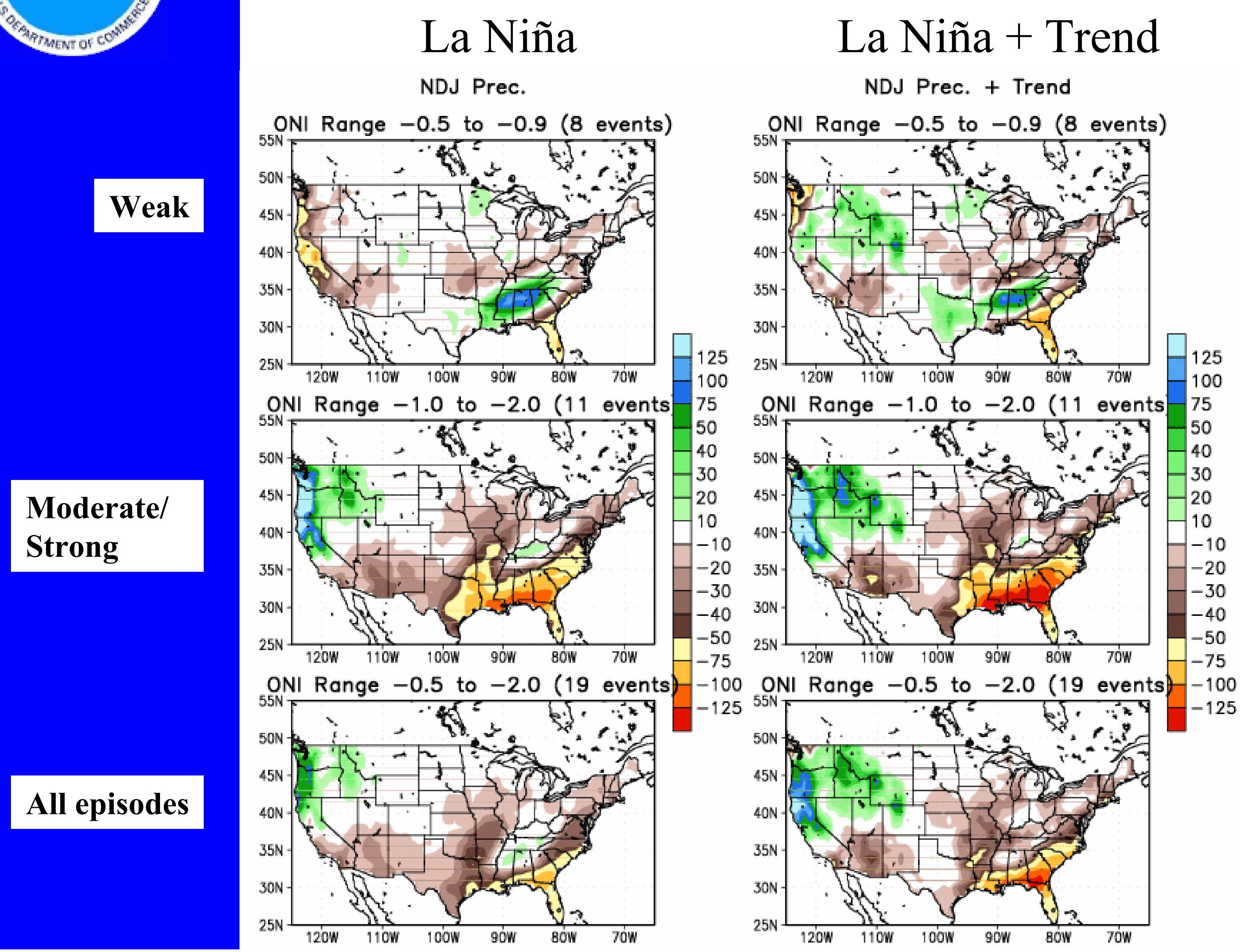
Precipitation Departures (mm) for Ranges of the ONI during October-December



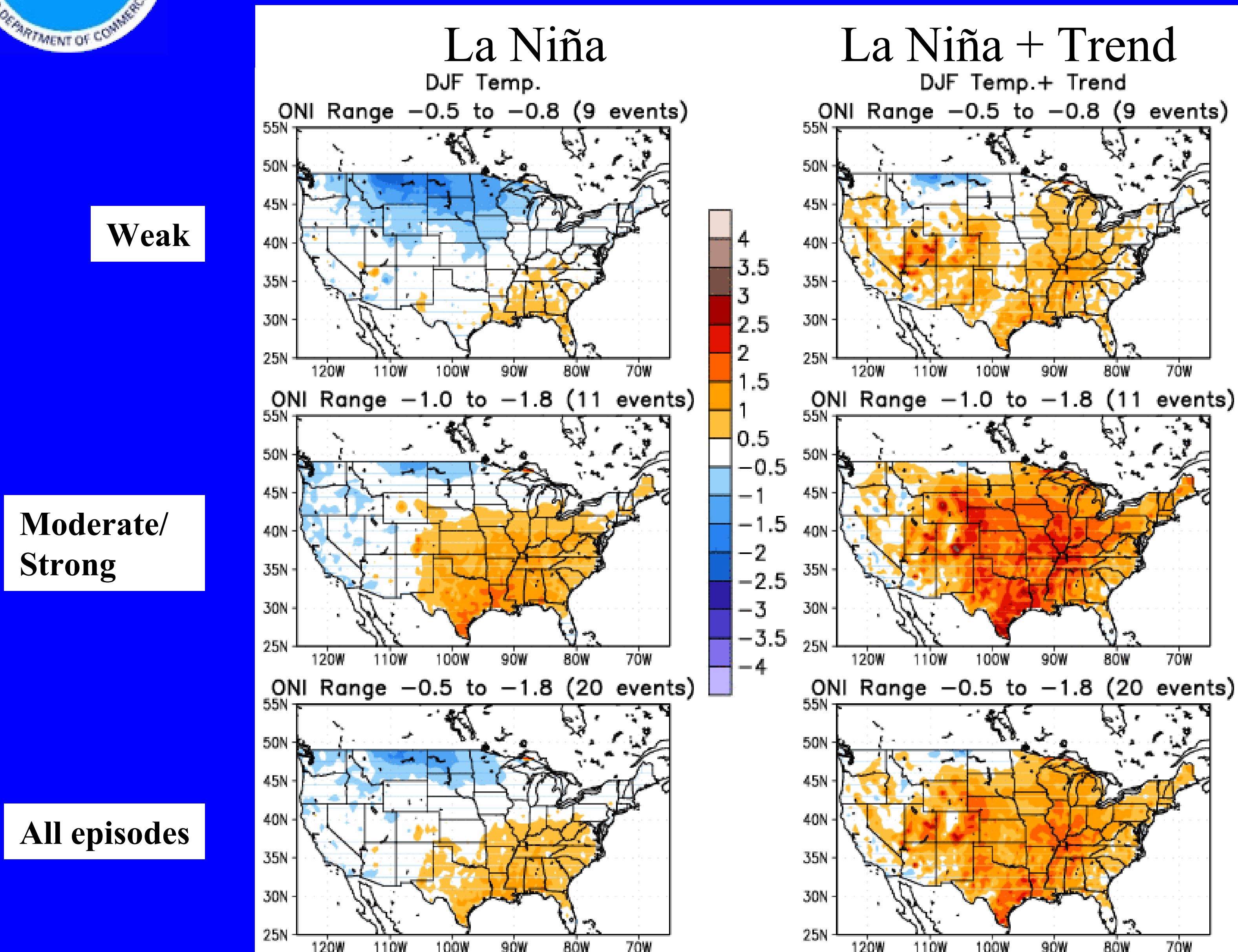
Temperature Departures (ºC) for Ranges of the ONI during November-January



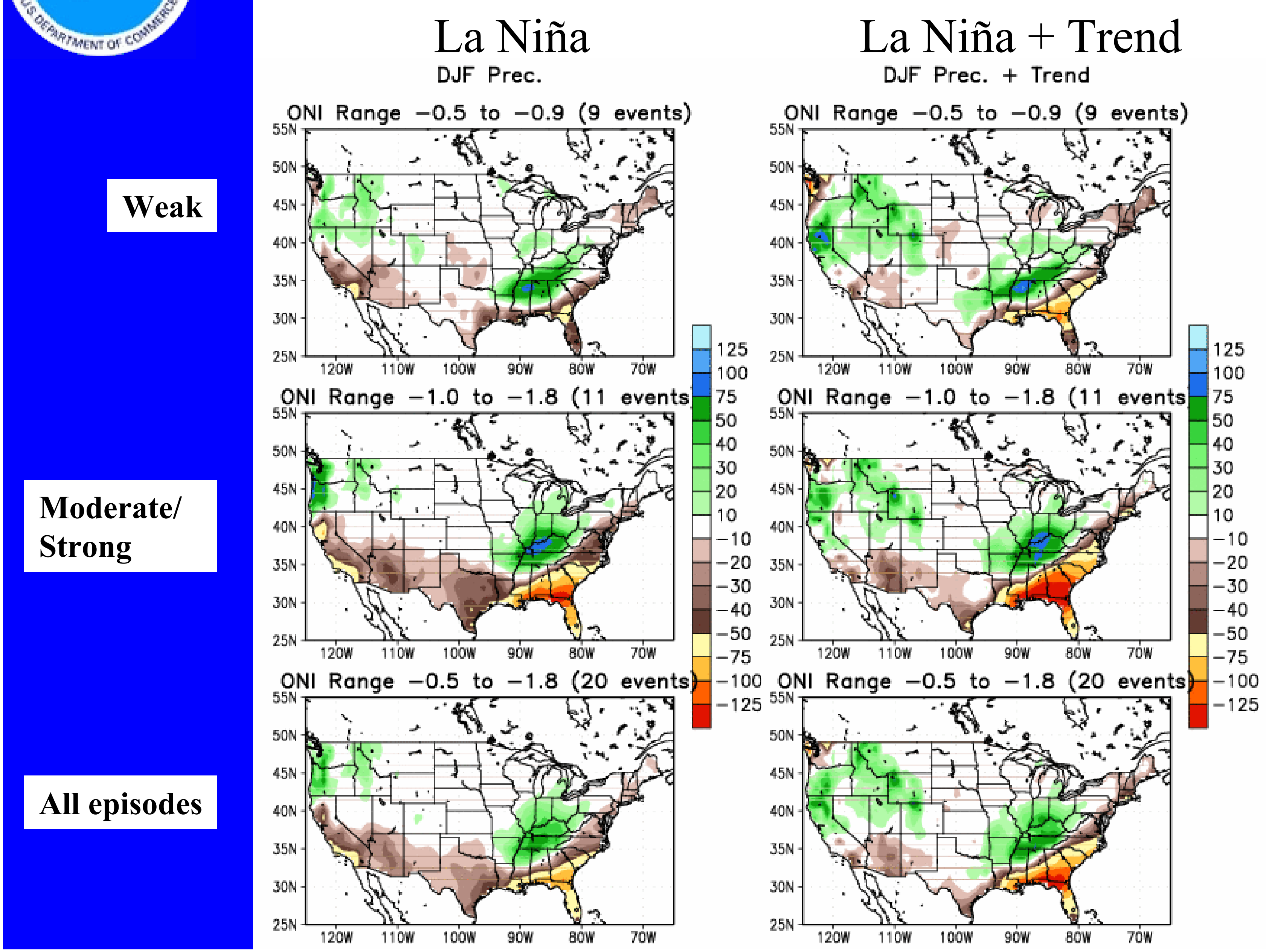
Precipitation Departures (mm) for Ranges of the ONI during November-January



Temperature Departures (ºC) for Ranges of the ONI during December-February



Precipitation Departures (mm) for Ranges of the ONI during December-February



APPENDIX C

GAEPD LETTER

12 OCTOBER 2007

Georgia Department of Natural Resources
2 Martin Luther King Jr., Drive, Suite 1152 East Tower, Atlanta, Georgia 30334
Noel Holcomb, Commissioner
Carol A. Couch, Ph.D., Director
Environmental Protection Division
(404) 656-4713

October 12, 2007

Col. Byron Jorns
Commander and District Engineer
Department of the Army
Mobile District, Corps of Engineers
190 Saint Joseph Street
Mobile, Alabama 36602-3630

Re: Request for Immediate Alteration of IOP Releases

Dear Colonel Jorns:

Since I last wrote to you on September 14, 2007 concerning the status of the federal reservoirs within the Apalachicola-Chattahoochee-Flint (ACF) River Basin, conditions have deteriorated. Reservoir storage is falling to levels not seen in decades, and the climatic forecasts through next winter suggest that the drought will worsen. The Corps' own computer modeling shows that under these conditions, if the Corps continues to operate under the existing Interim Operations Plan (IOP), there is serious risk that the reservoirs will be drained of all conservation storage. If that occurs, there will be severe water shortages for millions of Georgians, and the flow in the Chattahoochee and Apalachicola Rivers will fall dramatically below current levels, harming the biological species that depend on those flows. The Corps must take action now to avert this catastrophe.

Below I provide information concerning 2007 climatic and hydrologic conditions and review the projections of conditions through next February if the Corps continues to operate according the existing IOP. These data lay bare the conclusion that the IOP must be adjusted immediately pending discussions over longer-term modifications. Accordingly, I propose specific short-term adjustments of the IOP and provide the computer modeling showing the relief that this adjustment may provide.

THE DROUGHT OF 2007

Taken together, climatic and hydrologic conditions show that this is the worst drought of record. The ACF Basin in Georgia mainly falls within Climatic Divisions Two, Four, and Seven, with small portions of it in Climatic Divisions 1, 3, 5, and 8. Figure 1 illustrates how precipitation within these Climatic Divisions during March through August of this year compares with the commonly recognized prior droughts of record. For the six month period of March through August, a time when Georgia normally receives the majority of its precipitation, cumulative rainfall deficit in Climatic Divisions Two, which include the northern portion of the ACF Basin was the worst in the past half century, far eclipsing the droughts of 2000, 1988, and 1986. Over the same months, cumulative rainfall deficit within Climatic Division Four, which includes the upper Flint River Basin and the middle reaches of the Chattahoochee River, has matched the levels of the year 2000 as the lowest in the past half century. Rainfall within Climatic Zone Seven, which includes the lower reaches of the Chattahoochee River and the Flint River, was only slightly higher than in the drought of 1986 and was worse than in 2000 and 1988.

We do not yet have final rainfall data for the month of September throughout the basin, but we know it was very dry. The United States Geological Survey recently released a fact sheet stating that "the 2007 drought in Georgia worsened during September, bringing many of the State's rivers and streams to their lowest levels ever recorded for the month." This fact sheet is available at the USGS web site, at http://ga.water.usgs.gov/drought/drought_sept2007.pdf.

Low precipitation levels have resulted in extremely low stream flows across the ACF Basin (Figures 2 through 5 showing the lowest average flow in the period May through August) and record low basin inflow (total amount of flow entering the entire ACF system). Figure 6 compares basin inflow for the years 2007 and 2000. The year 2000 saw the lowest basin inflows on record as of that time for the May to September period. Our calculations indicate that the May through September cumulative flow in 2007 is 15% to 20% lower than in 2000.

Conditions are not projected to improve any time soon. Several weeks ago, the Southeast Climatologist Consortium forecasted that La Nina conditions were developing. This means that we should expect a drier and warmer cool season (October 2007 through March 2008). We did not experience a La Nina following or during the most severe drought years in the past. This means that it is very likely that we will see the drought worsen in the next few months and may well experience further record-breaking conditions in 2008.

ACF RESERVOIRS AT SERIOUS RISK OF DEPLETION

The 2007 drought has taken a serious toll on the federal reservoirs. To make matters worse, the Corps has been operating under the IOP this year. The IOP has required the Corps to release essentially all of the basin inflow entering the system and exhaust large quantities of storage to maintain a minimum flow of 5,000 cfs at Chattahoochee, Florida. The Corps spent a great deal of storage controlling rampdowns after rainfall events, and has released a significant quantity of water in excess of even what the IOP requires.

The current basin inflow to the ACF system is around 2,000 cfs, which means that the Corps has to use 3,000 cfs-day (or 6,000 acre-feet) of system storage to meet the flow requirement of 5,000 cfs. If basin inflow does not improve significantly in the near future, this level of augmentation will deplete the system storage in a matter of 117 days.

As of October 11, 2007, the composite storage of the entire ACF system (the sum of remaining conservation storage from Lanier, West Point, and Walter F. George) is down to 702,907 acre-feet, or 42.9% of the system capacity. (See Figure 7.) By comparison, system storage was at 1.39 million acre-feet on May 1, 2007. By our calculations, the Corps has used more than 600,000 acre-feet of storage to support flow at Chattahoochee, Florida over the past 5 months.

As of October 11, 2007, the elevation at Lake Lanier, the largest storage reservoir and the primary source of drinking water for over four million of people in Georgia, is down to 1057.9 feet. This is more than thirteen feet below its normal pool level and is 2.7 feet lower than the elevation when I last wrote you on September 14 of this year. West Point Lake elevation is at 622.2 feet. This is approximately thirteen feet below its normal pool level, and only two feet away from the bottom of its conservation pool. Elevation at Lake Walter F. George is at 185.2 feet, which is only a foot away from its inactive storage.

GEORGIA'S CONSERVATION MEASURES

Georgia takes seriously its obligation to conserve water under these drought conditions. In response to these exceptional drought conditions, on September 28, 2007, I took the unprecedented step of imposing the highest level of restrictions on water use in our state's history. Since imposing these restrictions, we have already seen a dramatic 15% drop in water use in the Atlanta metro area alone. Alarmed by the dire reality that the water sources they rely on are being drained and that they may not be refilled anytime soon, many communities and industries have gone beyond the state ban on outdoor watering by limiting other water uses and implementing even more rigorous conservation measures.

No specific restrictions on agricultural water use are currently in effect for the remainder of this year and the first two months of 2008, in part because agricultural consumption during the October-February timeframe is minimal. If drought conditions persist as projected, however, it is likely that prior to March 2008 I will declare a drought under the Flint River Drought Protection Act and trigger the agricultural demand reduction measures under that statute.

As we continue to monitor the drought and our water supplies, we will consider the additional, emergency measures that are legally available to the State and local governments and determine any that need to be taken. Reducing and managing consumptive demands is a major focus of our drought response and emergency planning.

MODELING AND PROJECTION OF THE ACF RESERVOIRS

We have continued to update our computer models of the potential impact of the IOP going forward, particularly over the next several months. During an ACF Basin drought conference call with stakeholders several weeks ago, the Corps of Engineers announced that it in light of the record-low rainfall and inflows, it had modeled the effect of the IOP over the next three months assuming the hydrological scenarios: that basin inflow for each day will be at the (a) 2% non-exceedence level (that is, basin inflow will be within the lowest 2% in history), (b) 5% non-exceedence level, and (c) 10% non-exceedence level. On October 4, 2007, the Corps provided us with those computer models. These models, the outputs of which are shown in the attached Figures 8 through 11, paint a very grim picture. Assuming that basin inflow will be at the 10% level, Lake Lanier would fall to the extreme level of below 1048 feet by the end of this year (and 1044 feet by the end of February 2008, as shown in Figures 8 and 16). Both West Point Lake and Lake Walter F. George would hover around the bottom of their conservation pools from late November through at least the first two months of 2008 (Figures 9, 10, 17, and 18). If one assumes that basin inflow will be at the 5% or 2% levels, the results will, of course, be even worse. Lake Lanier would fall as low as 1039 feet by the end of this year and would empty before the end of January 2008 (Figure 12). West Point and Walter F. George would be empty beginning in November and would remain empty through next February (Figures 13 and 14). Of course, the serious effects of draining the lakes would be felt throughout 2008 and perhaps for years to come.

The effects of draining the federal reservoirs to these levels would be felt throughout the ACF Basin. Water supply intakes in Lake Lanier begin to be exposed as the Lake falls to the lower

1050's. At a level of 1039 feet, nearly all water supply intakes would be exposed, and at 1035 feet the lake is effectively empty and unable to provide for any water supply or flow augmentation. Water supply intakes at West Point Lake would be in jeopardy at the projected lake levels. At the bottom of the Basin, the flow in the Apalachicola River would plummet below the 5,000 cfs flow that the Corps has expended so much storage to maintain. Using the Corps' model, we see that at the 5% and 2% basin inflow levels, the flow in the Apalachicola River at the Chattahoochee gage falls to well below 1,000 cfs (Figure 11). As under any of these scenarios the lakes will begin next year extremely low and not have an appreciable opportunity to refill, it is reasonable to expect that the flow in the Apalachicola River would fall even lower in 2008.

NECESSARY SHORT-TERM MODIFICATIONS TO THE IOP

The foregoing illustrates that if the Corps continues to expend massive quantities of reservoir storage to provide a flow of 5,000 cfs, and not to store a substantial amount of the basin inflows, it will risk creating widespread water supply shortages affecting millions of people within Georgia and a steep drop in the flows available to meet the needs of endangered species in the Apalachicola River. Informed by this data, the Corps clearly has no choice but to alter its ACF reservoir operations immediately.

It is apparent that the Corps must cease immediately augmenting basin inflows for the production of any specific minimum flow in the Apalachicola River. While basin inflows are below 5,000 cfs, the Corps should only make releases from Jim Woodruff Dam equivalent to basin inflow. When rainfall events produce a basin inflow in excess of 5,000 cfs, the Corps should release no more than 5,000 cfs. The flow in the Apalachicola River has been at the 5,000 cfs level essentially all summer and early fall. Temporary pulses of more than 5,000 cfs in reaction to rainfall events will provide no benefit to the endangered species that the Corps is seeking to protect. The Corps should eliminate any rampdown restrictions. While flows are within the range of 5,000 cfs or less, the reduction in flows will roughly follow natural drops and will not be severe. Moreover, rampdown restrictions have the perverse effect of causing reservoir storage to fall after rainfall events, as the amount of storage used during the rampdown often exceeds the amount of any storage gained during the rainfall event.

The modeling of these adjustments to the IOP indicates that they will significantly benefit the federal reservoirs and help prevent a more precipitous drop in the flow in the Apalachicola River. Figures 12 through 15 compare the projected results of these modified reservoir operations against the IOP assuming that basin inflow at the 2% non-exceedence level, and Figures 16 through 19 make the same comparison at the 10% non-exceedence level.

Assuming basin inflows at the 2% level, these modifications to the IOP would keep Lake Lanier approximately ten feet higher at the end of this year and through February 2008, and would prevent West Point Lake and Walter F. George from emptying this year. The modeling suggests that modifications to reservoir balancing would be needed under this scenario to prevent West Point and Walter F. George from reaching the bottom in 2008. Under these assumptions, after an initial drop, the flow in the Apalachicola River would be more stable than under the IOP, and the minimum flow in the Apalachicola River would be more than 1,000 cfs higher than the minimum flow that would be experienced under the IOP. Thus, there are benefits throughout the basin.

Assuming the more optimistic scenario that basin inflow at the 10% level, Lake Lanier would be approximately seven feet higher as of the end of the year if the IOP is modified and would be more than ten feet higher at the end of February 2008. As with the 2% basin inflow scenario, the proposed modifications would save West Point Lake and Lake Walter F. George from emptying this year, just barely, and would produce more significant benefits to those lakes in January and February of 2008. At the 10% basin inflow level, the flow in the Apalachicola River would be near the 5,000 cfs level most of the time as basin inflow would be at or above 5,000 cfs for much of that time. Under this scenario, the significant benefits to reservoir storage outweigh the reduction in flow in the Apalachicola River.

DISCUSSIONS ON LONGER-TERM MODIFICATIONS SHOULD BEGIN NOW

The above changes are proposed as immediate and short-term, to avoid exhaustion of reservoir storage over the next four and a half months. These, of course, are not the only or final modifications that will be needed to the IOP. The experience of this year demonstrates that significant long-term, year-round adjustments to the IOP are needed. If the Corps does not make changes to the rules that will apply during the next Gulf sturgeon spawning period (March-May) and the remainder of next year, we may well end up in the same spot next year, or even worse. The above changes will, however, address the emergency situation and give the Corps an opportunity to undertake discussions with the Fish and Wildlife Service and the affected States on the longer-term changes that are needed. Georgia commits to be fully engaged in such discussions and encourages the Corps to include Florida and Alabama in considering longer-term modifications.

REQUEST FOR RESPONSE

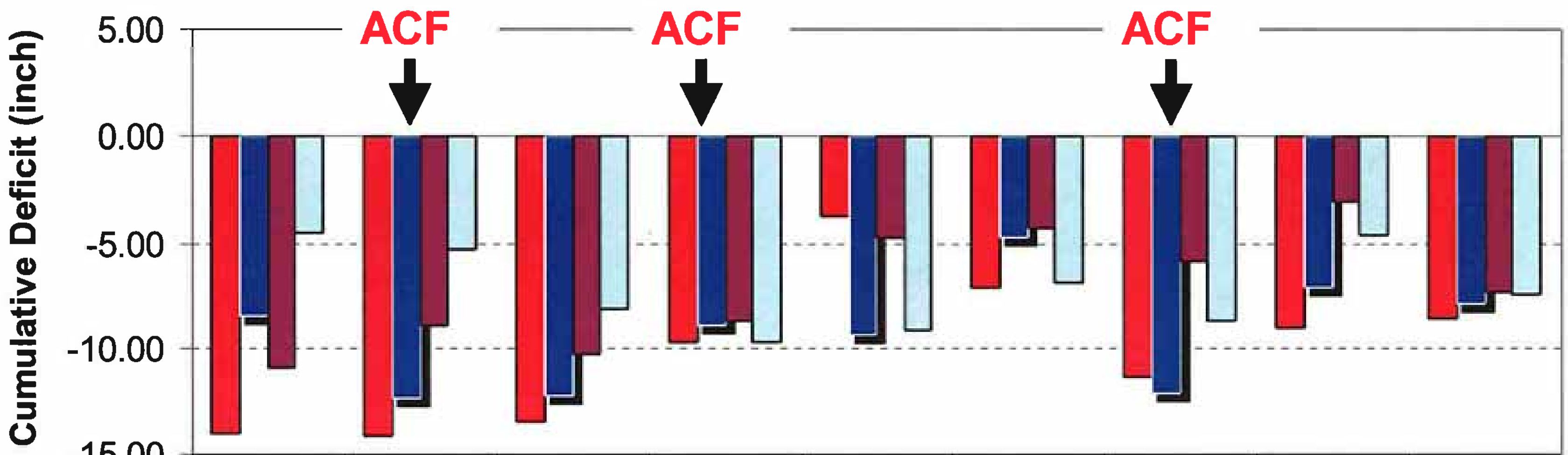
In light of the exigent circumstances, I need your prompt response to this request for specific alteration of the reservoir operating rules under the IOP. Given that time is of the essence, please inform me in writing no later than October 17, 2007 as to whether you intend to make these changes so that Georgia can assess its options.

Sincerely,

Carol A. Couch

cc: Brigadier General Joseph Schroedel, South Atlantic Division, U.S. Army Corps of Engineers
Governor Sonny Perdue
Ms. Joanne Brandt, Corps of Engineers Inland Environmental Team
Mr. Onis Trey Glenn, Alabama Department of Environmental Management
Mr. Michael Sole, Secretary, Florida Dept. of Environmental Protection

Cumulative Mar-Aug Precipitation Deficits (2007, 1986, 1988 and 2000) in Georgia Climatic Divisions



	1	2	3	4	5	6	7	8	9
2007	-13.98	-14.13	-13.39	-9.59	-3.73	-7.08	-11.29	-9.00	-8.47
1986	-8.35	-12.26	-12.15	-8.84	-9.32	-4.77	-12.06	-7.05	-7.86
1988	-10.83	-8.82	-10.18	-8.64	-4.71	-4.22	-5.79	-3.09	-7.24
2000	-4.49	-5.31	-8.05	-9.60	-9.03	-6.81	-8.58	-4.61	-7.41

Climatic Division

Fig. 1 Six-month precipitation deficits in Georgia Climatic Divisions as compared to those of previous severe drought years

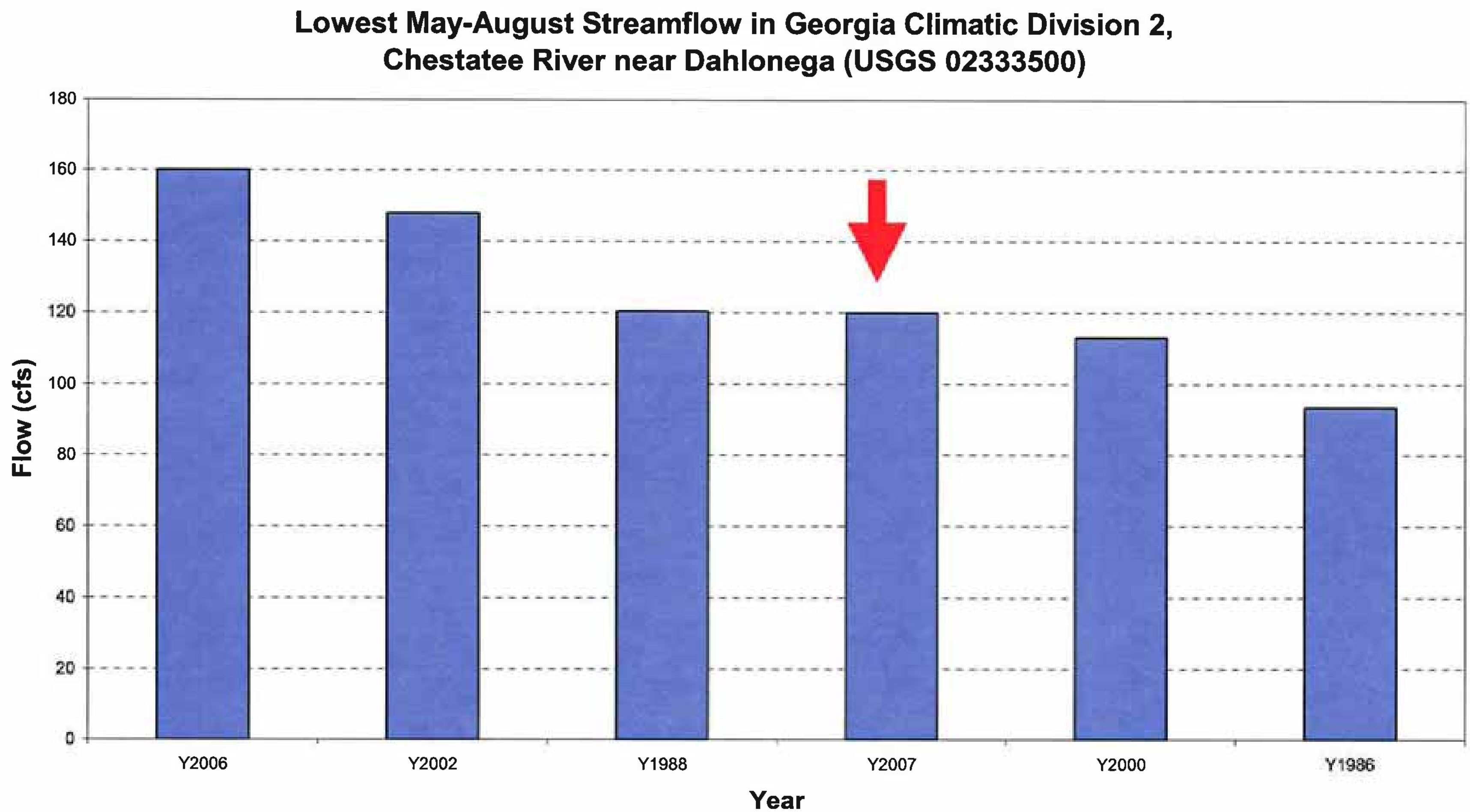


Fig. 2 Low stream flow at Chestatee River in 2007 as compared to those in previous severe drought years

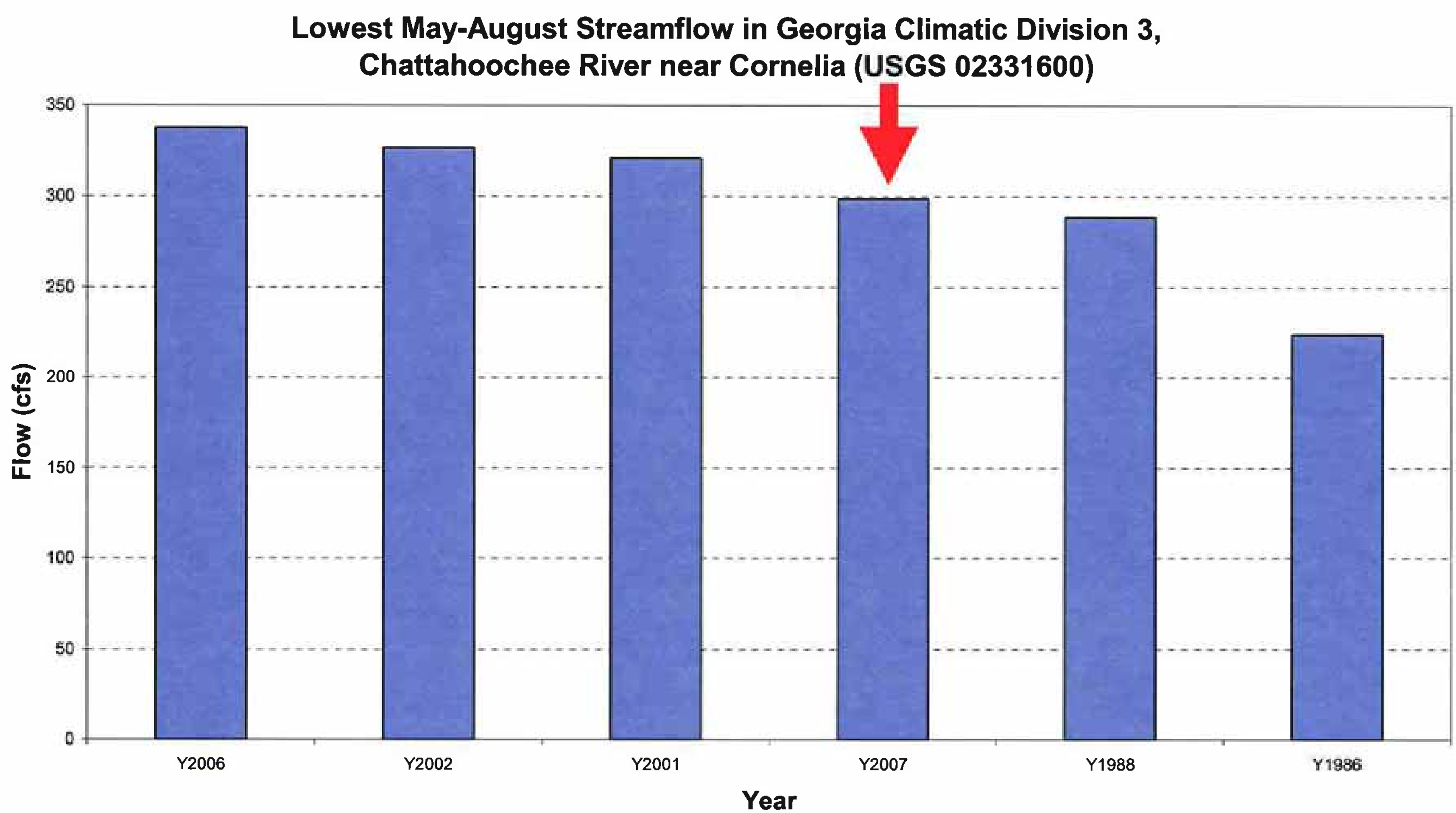


Fig. 3 Low stream flow at Chattahoochee River in 2007 as compared to those in previous severe drought years

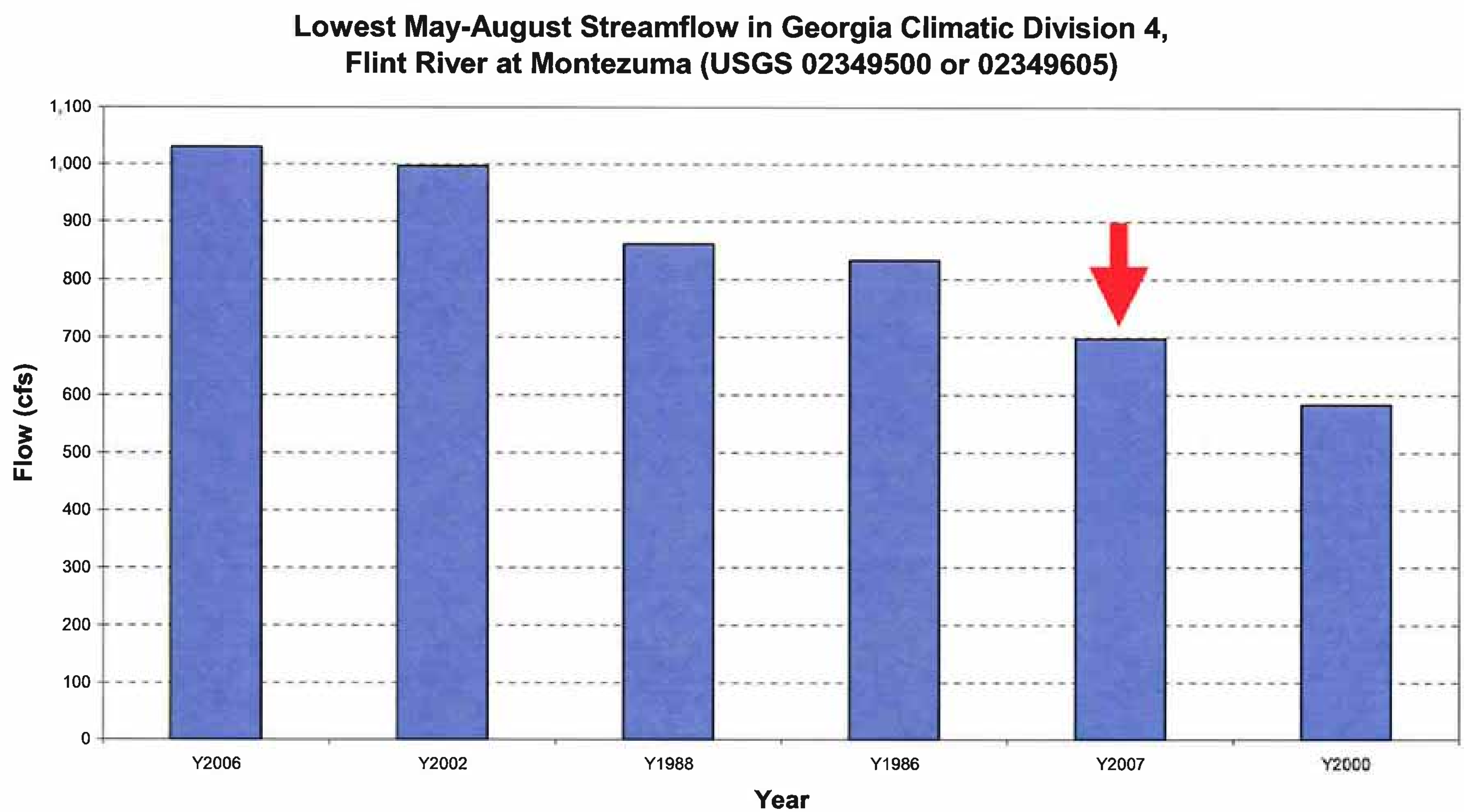


Fig. 4 Low stream flow at Flint River in 2007 as compared to those in previous severe drought years

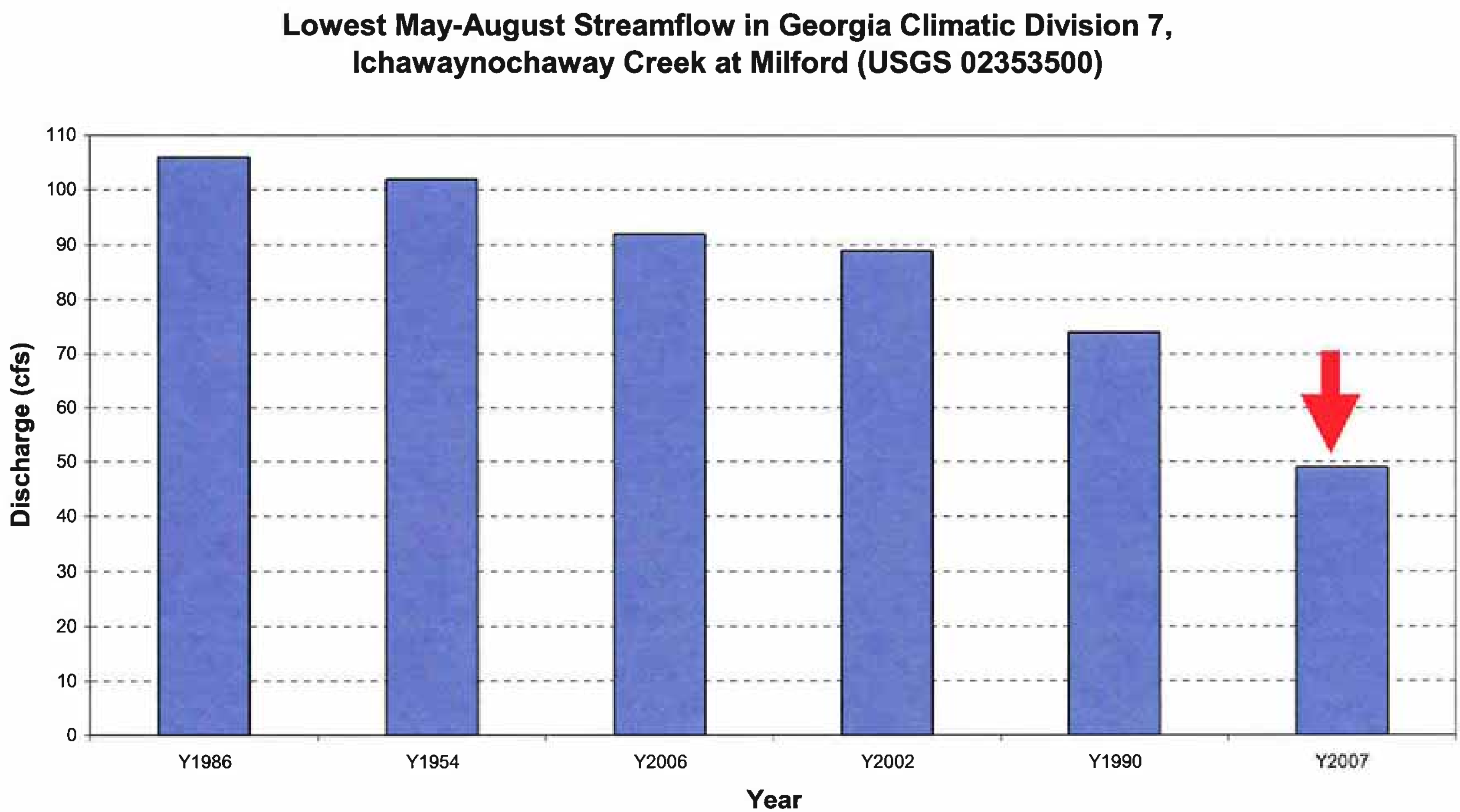


Fig. 5 Low stream flow at Ichawaynochaway Creek in 2007 as compared to those in previous severe drought years

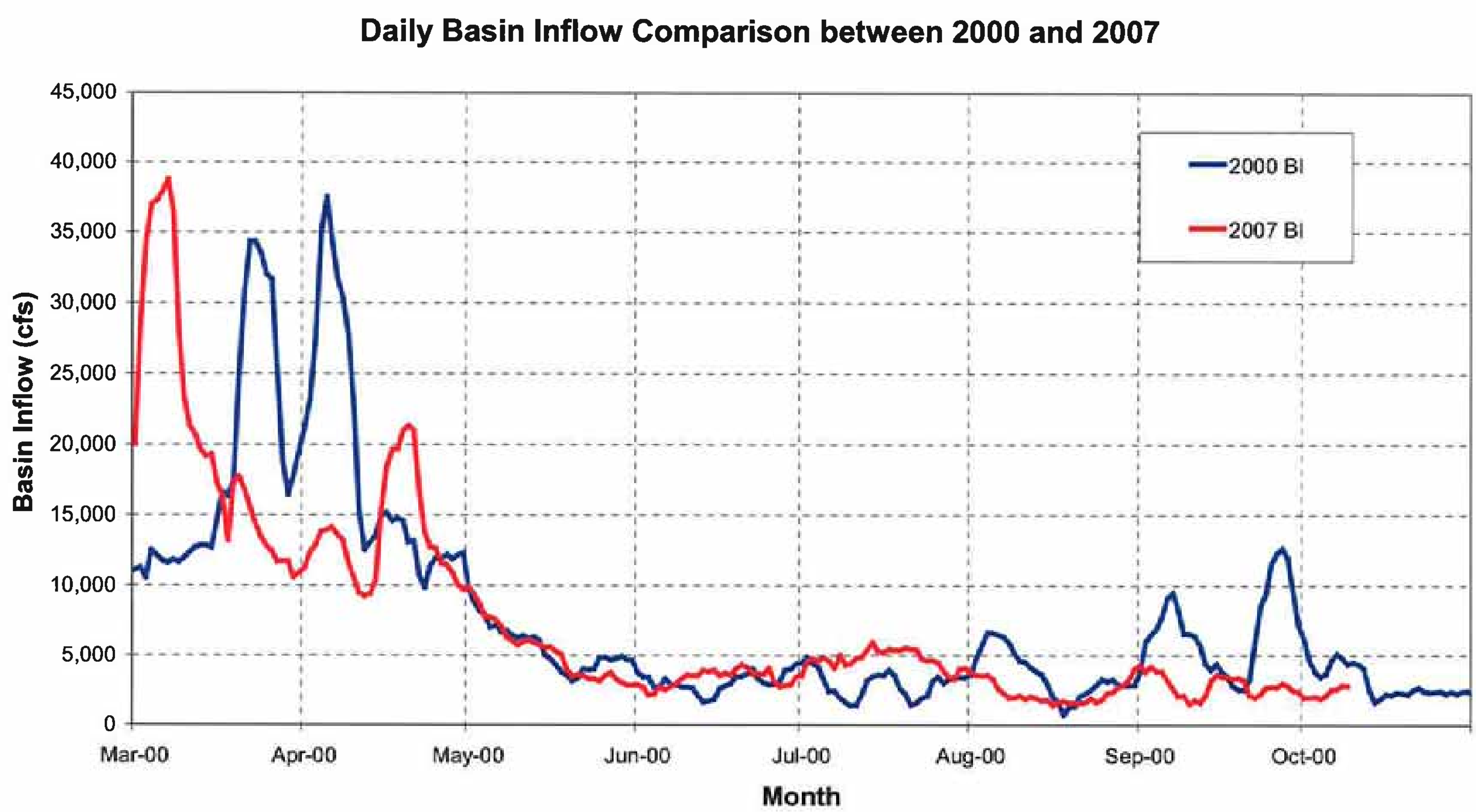


Fig. 6 Basin Inflow of 2007 compared to that of 2000

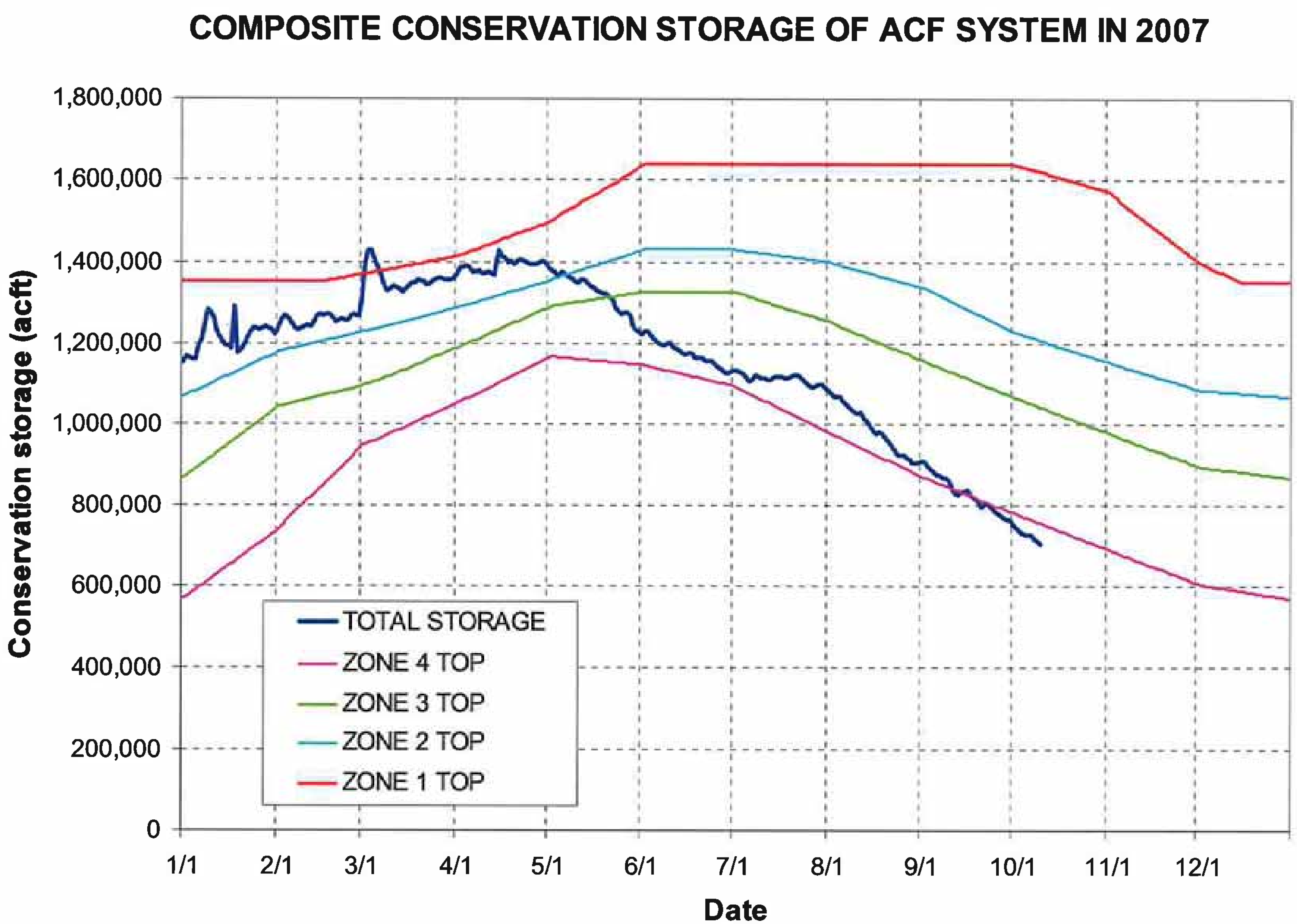


Fig. 7 Composite system storage in the ACF Basin in 2007

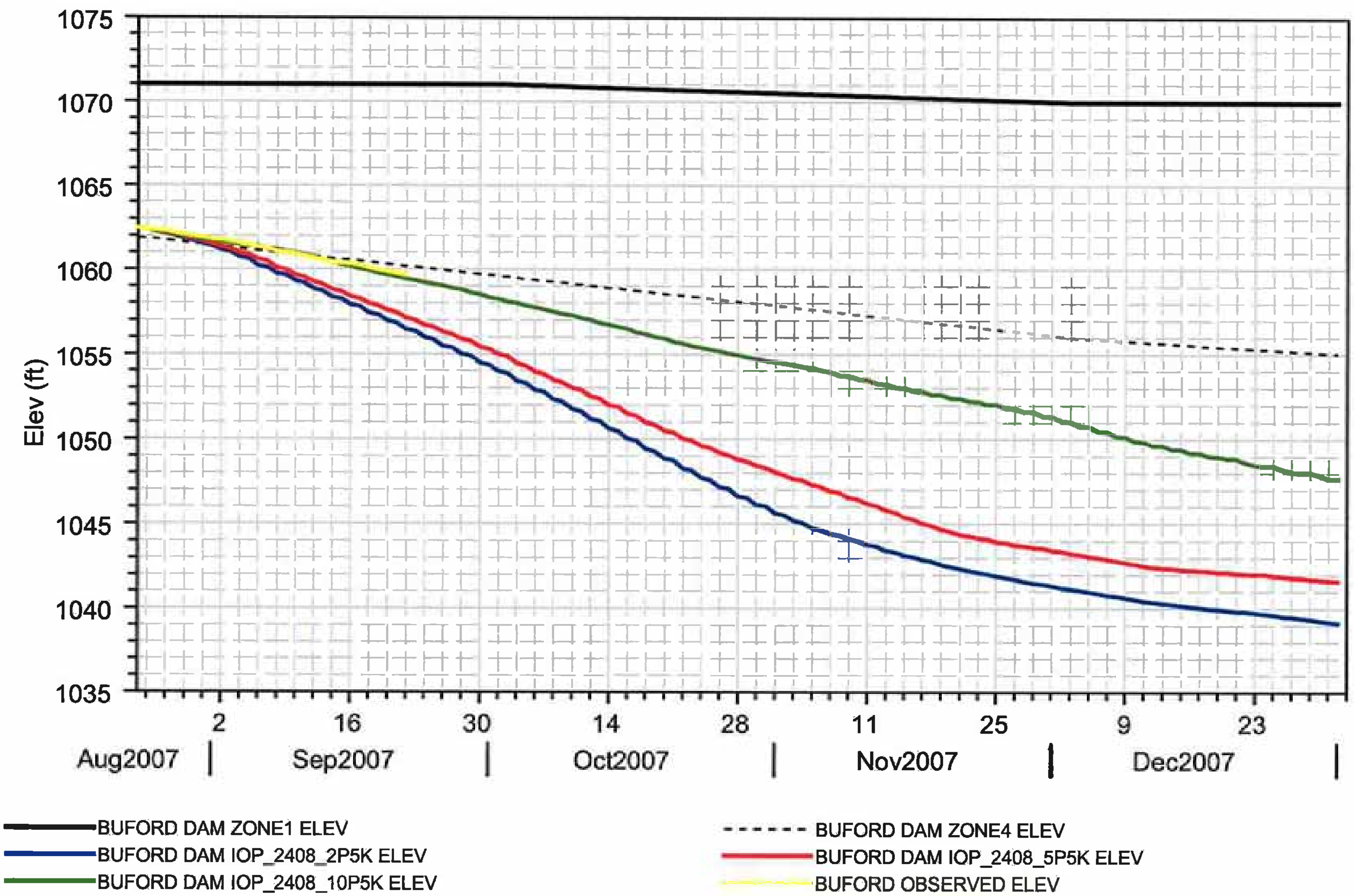


Fig. 8 Year 2007 Lanier elevation projected by the Corps of Engineers

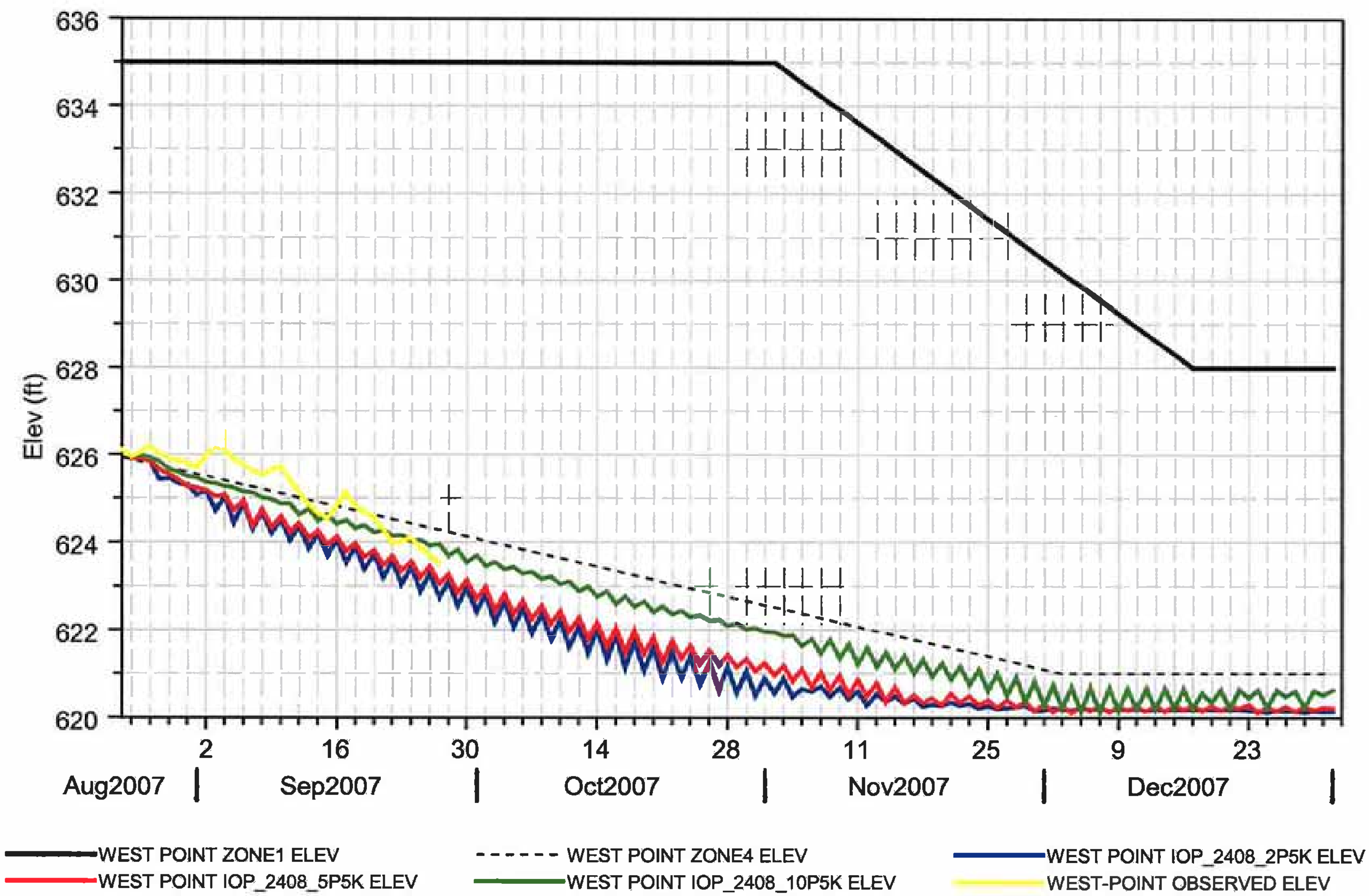


Fig. 9 Year 2007 West Point elevation projected by Corps of Engineers

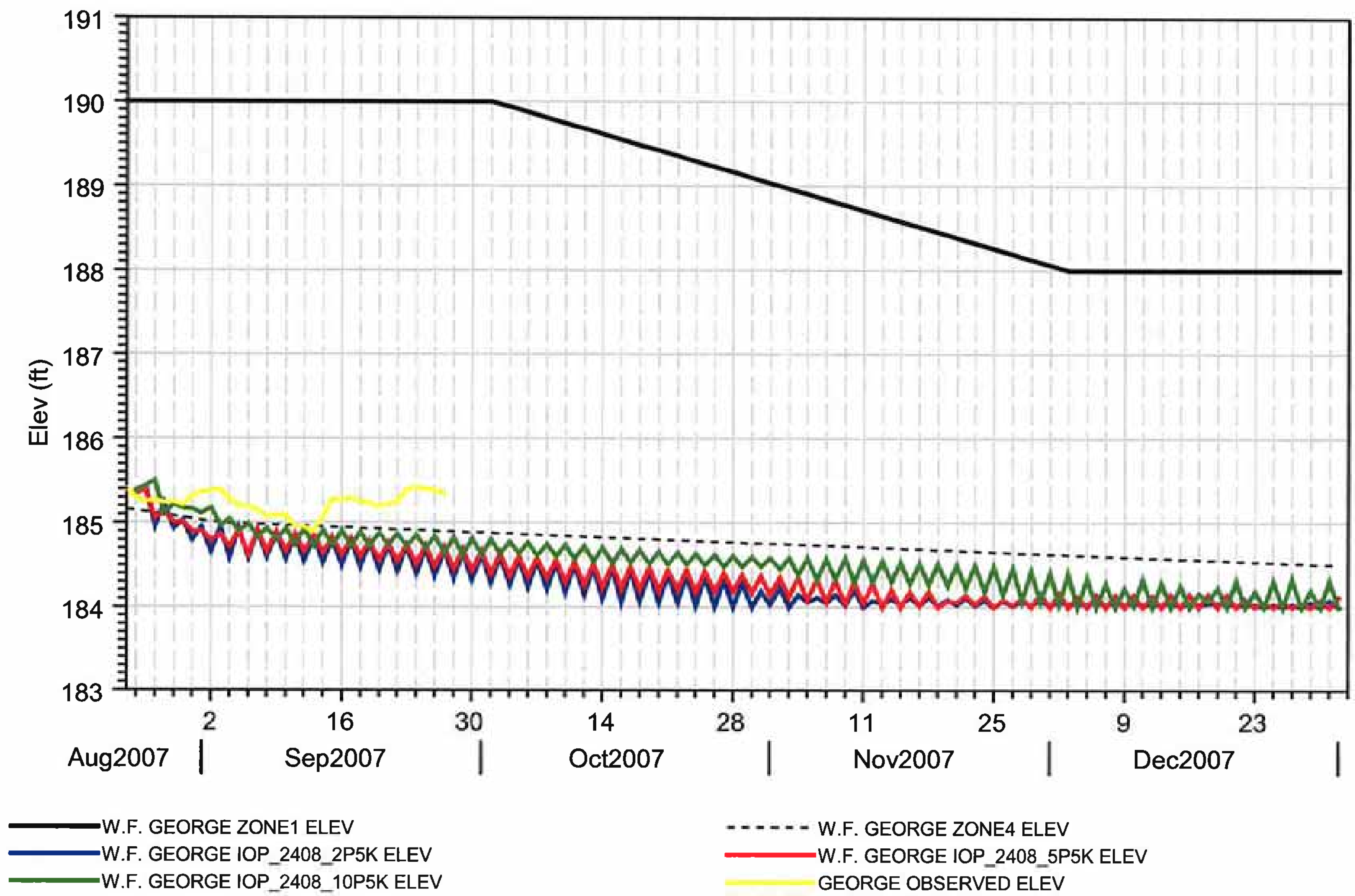


Fig. 10 Year 2007 Walter F. George elevation projected by Corps of Engineers

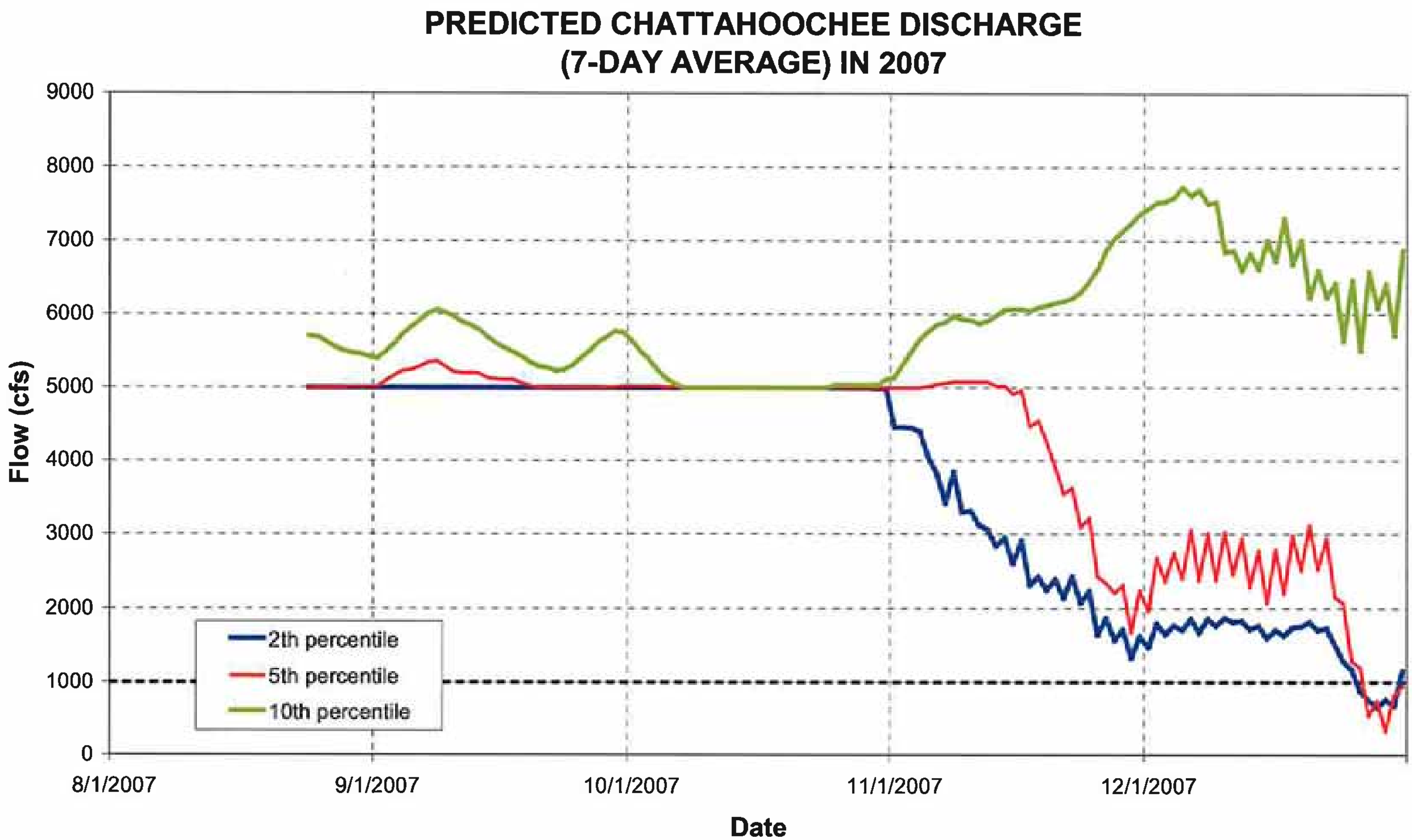


Fig. 11 Year 2007 flow at Chattahoochee, Florida projected by Corps of Engineers' model

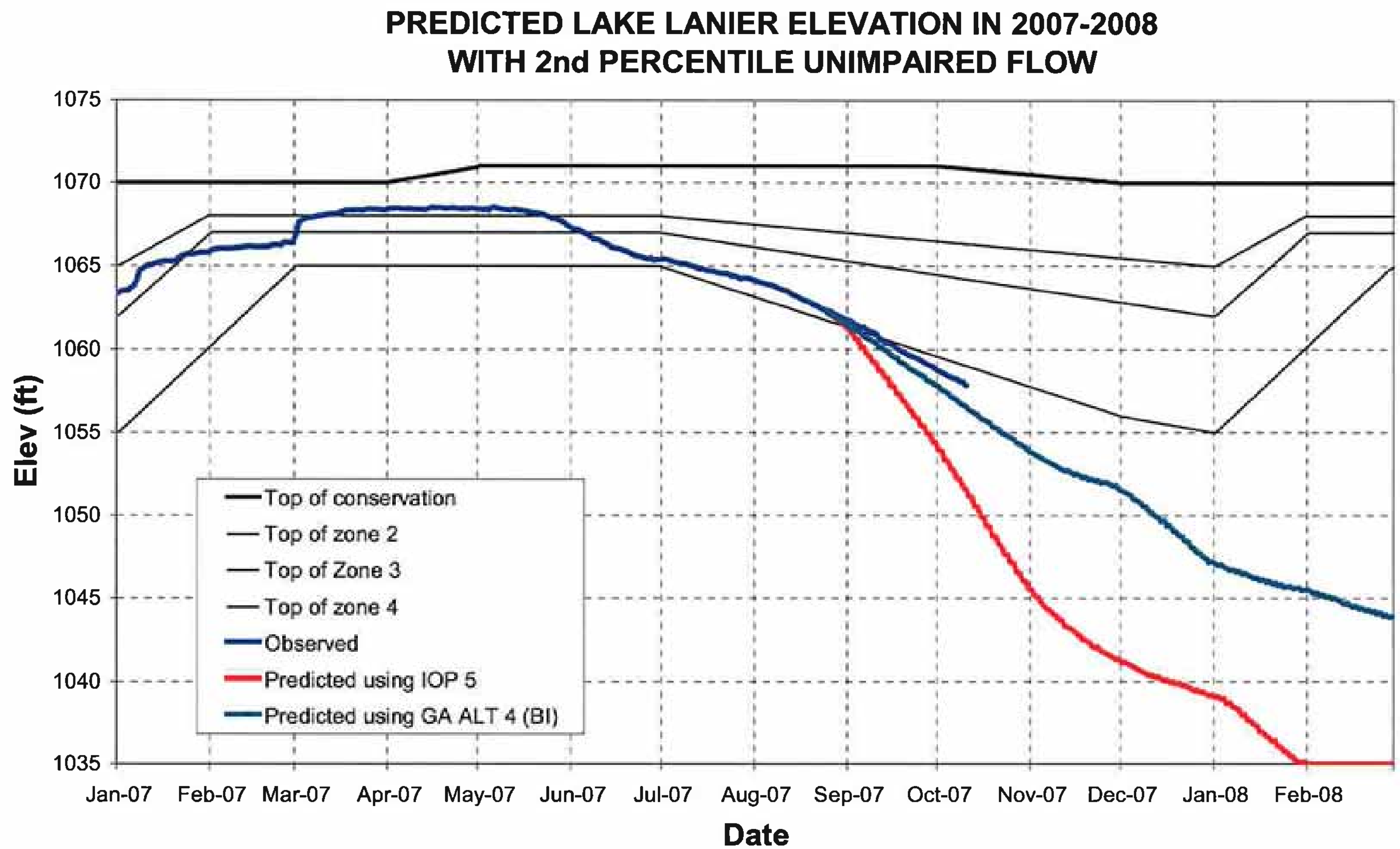


Fig. 12 Effects of emergency measures proposed by Georgia on Lanier elevation (using Corps model and 2 percentile hydrology)

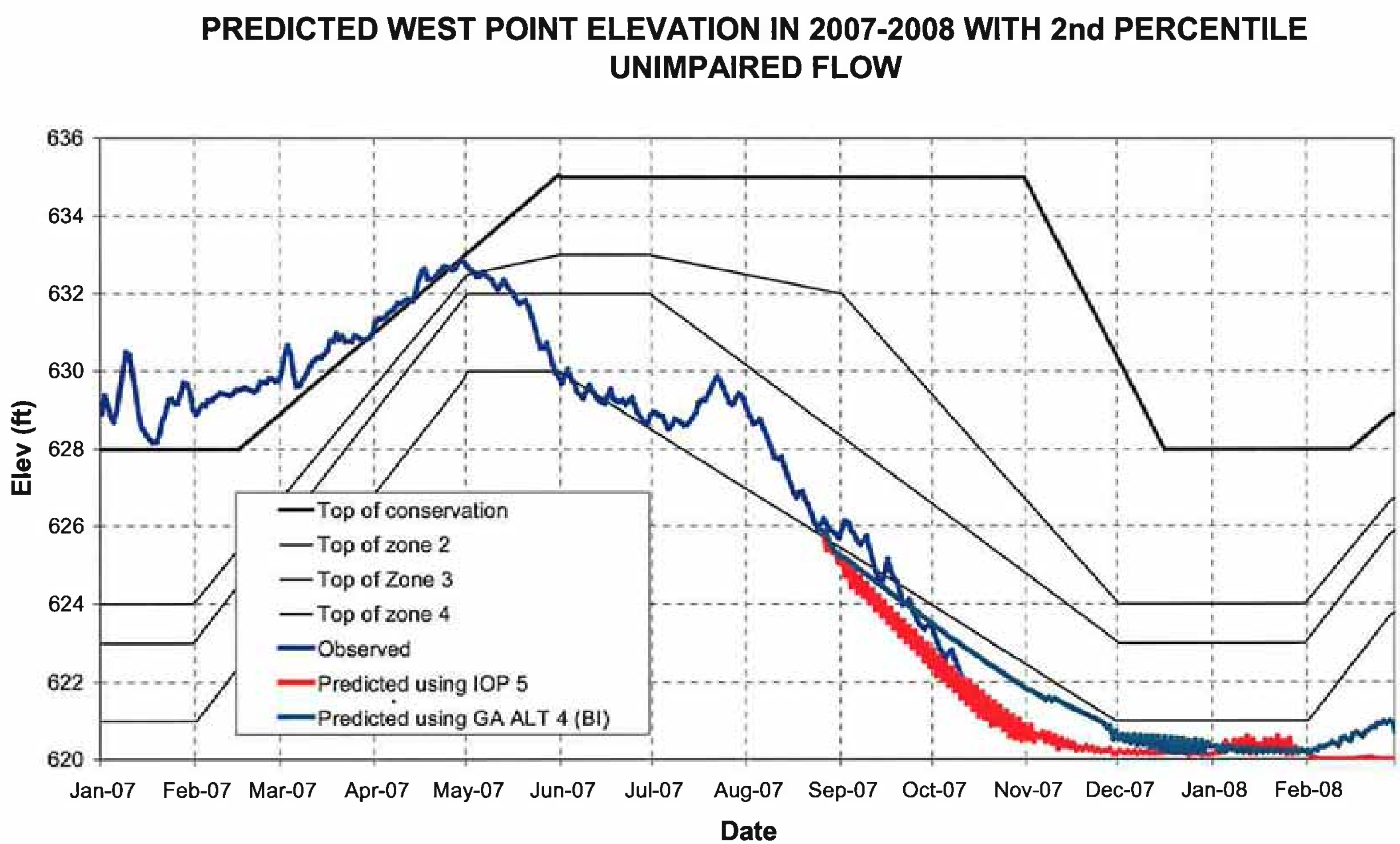


Fig. 13 Effects of emergency measures proposed by Georgia on West Point elevation (using Corps model and 2 percentile hydrology)

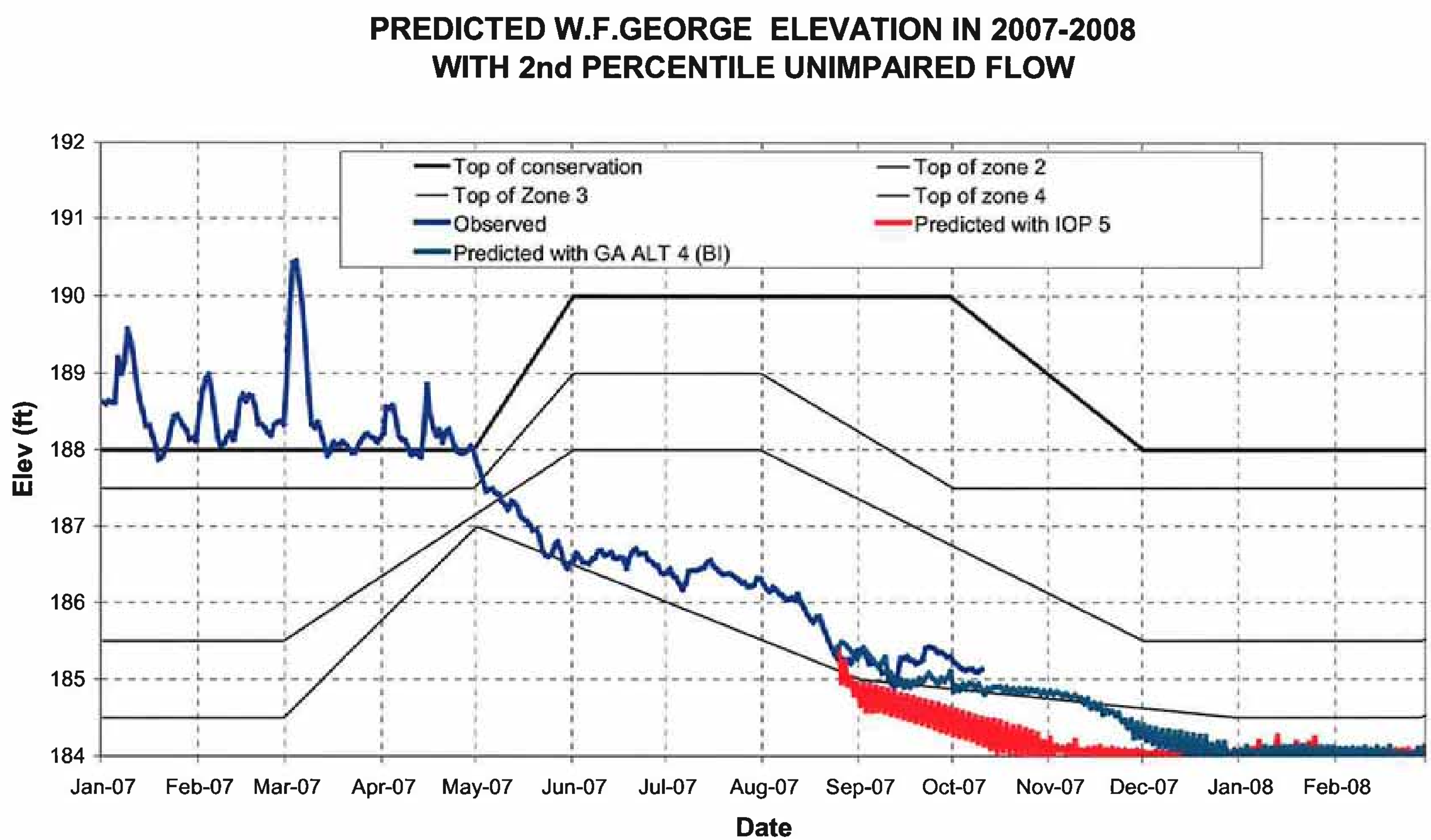


Fig. 14 Effects of emergency measures proposed by Georgia on W.F. George elevation (using Corps model and 2 percentile hydrology)

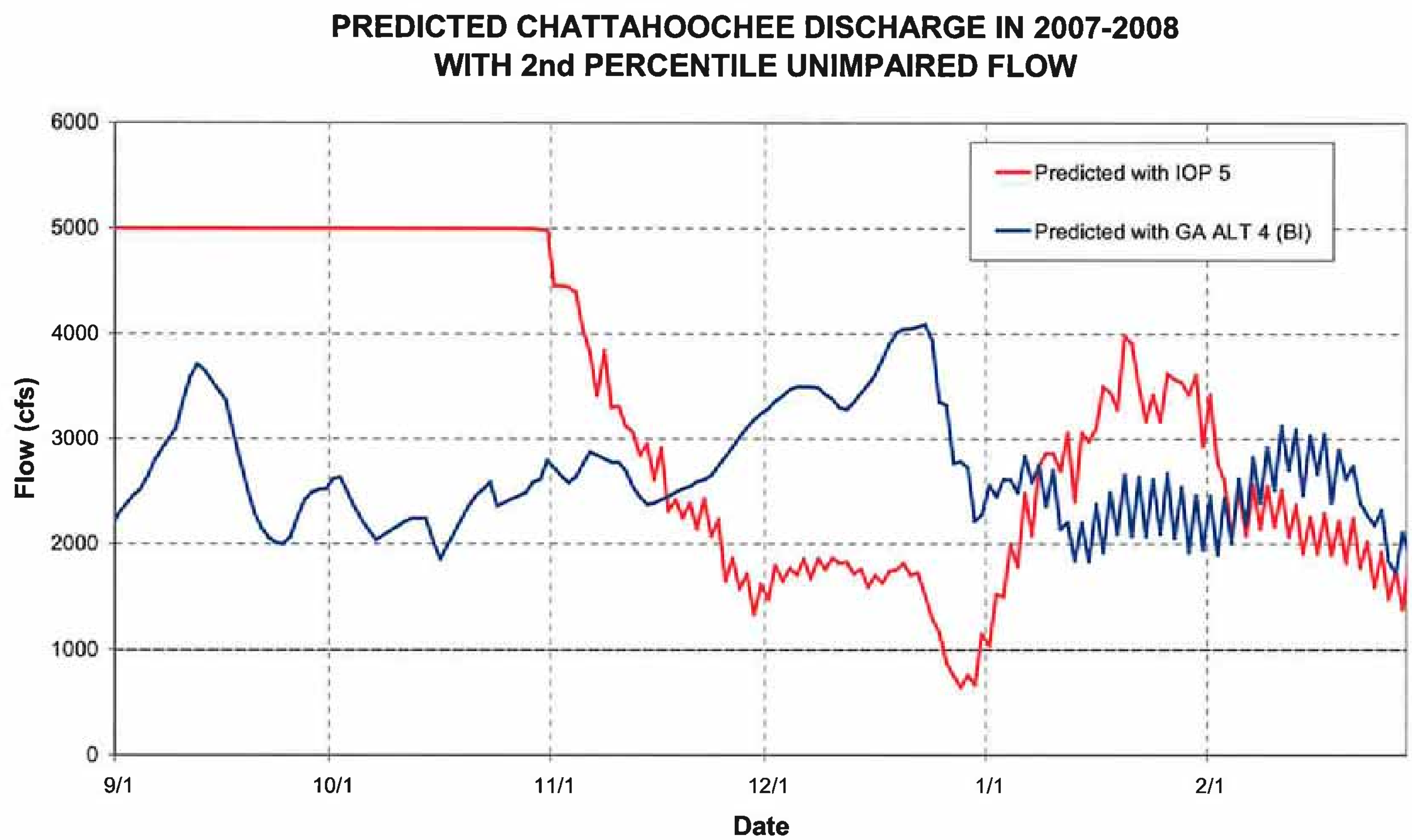


Fig. 15 Flow at Chattahoochee, Florida under the proposed changes to the IOP (Corps' 2 percentile hydrology)

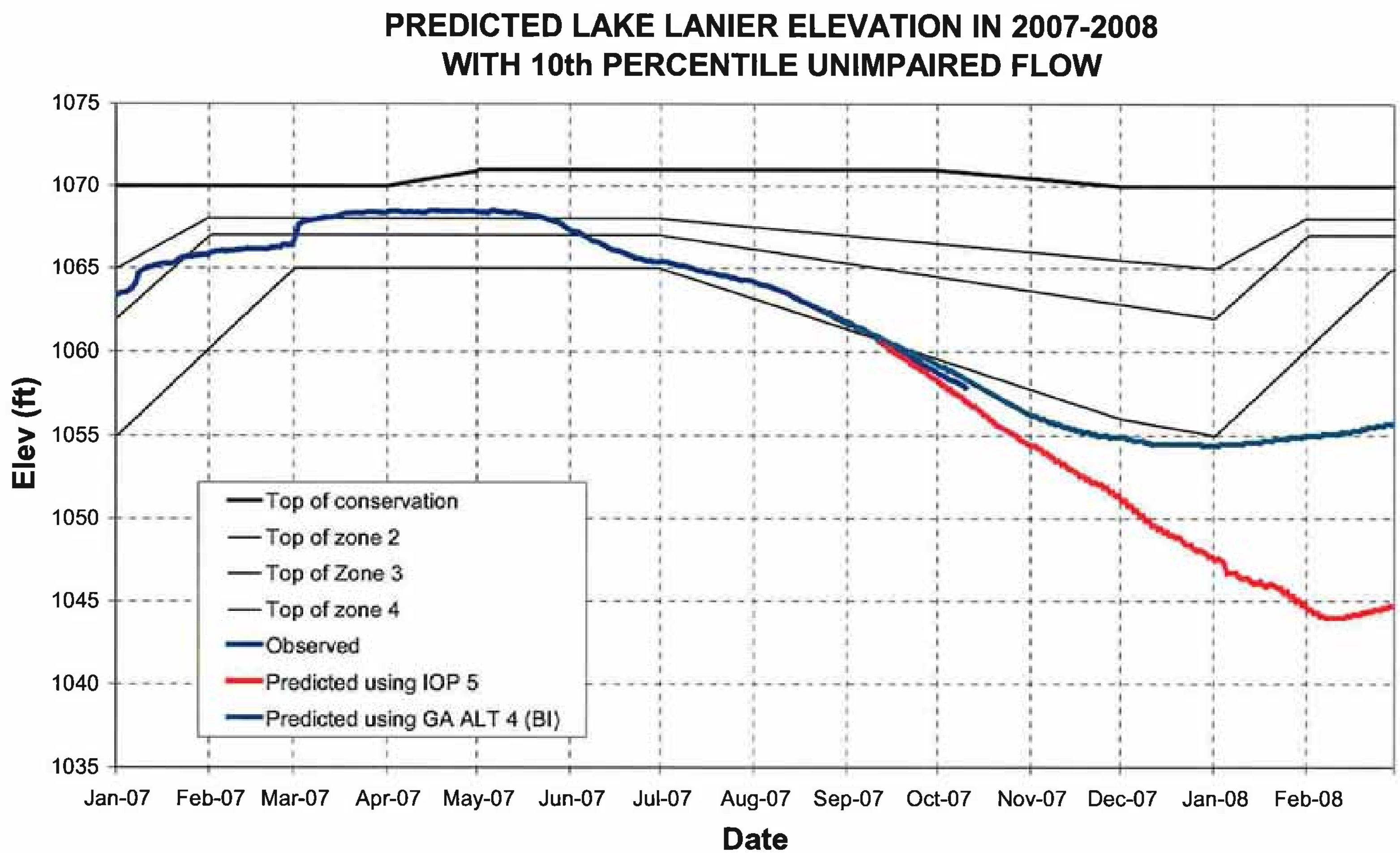


Fig. 16 Effects of emergency measures proposed by Georgia on Lanier elevation (using Corps model and 10 percentile hydrology)

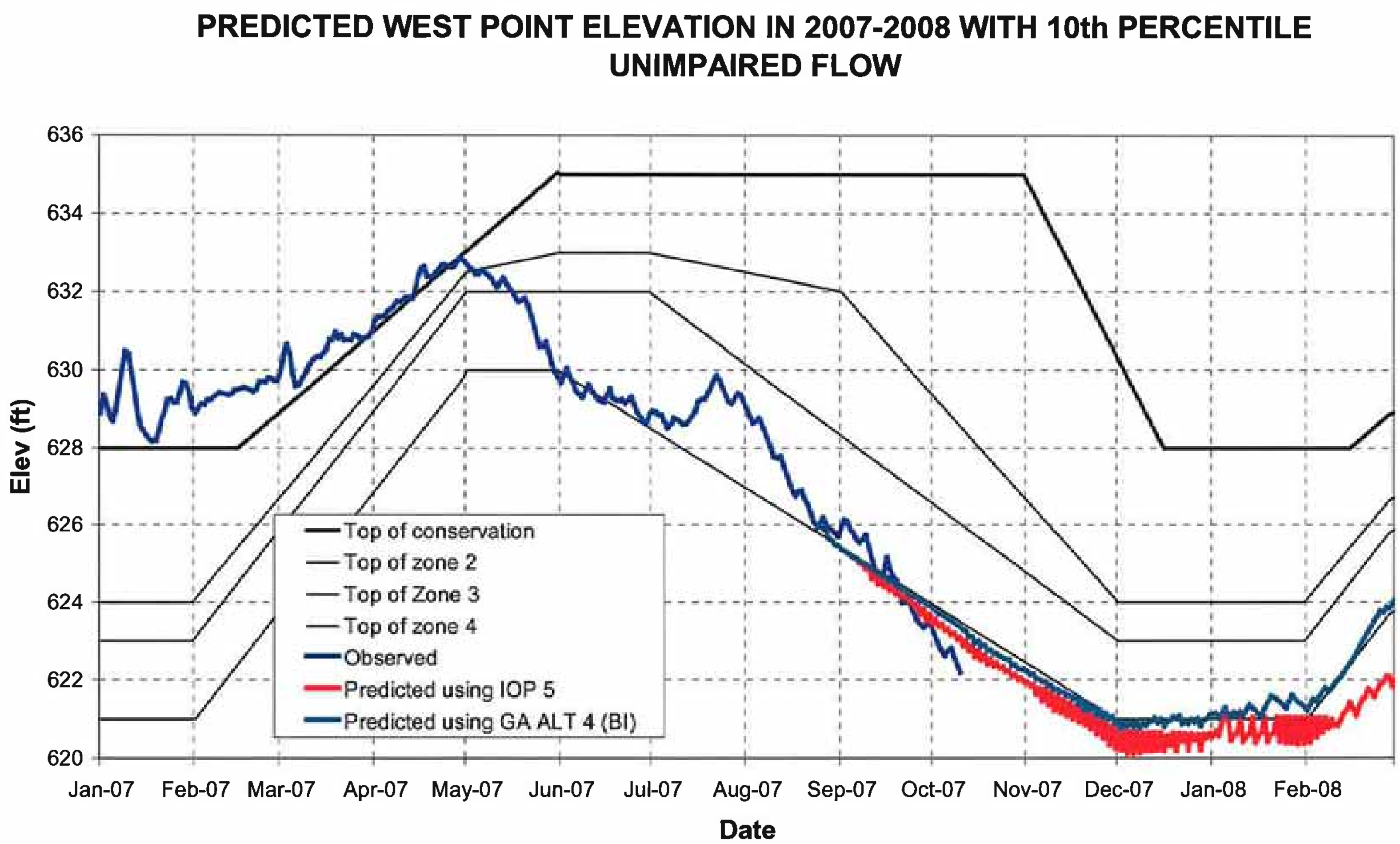


Fig. 17 Effects of emergency measures proposed by Georgia on West Point elevation (using Corps model and 10 percentile hydrology)

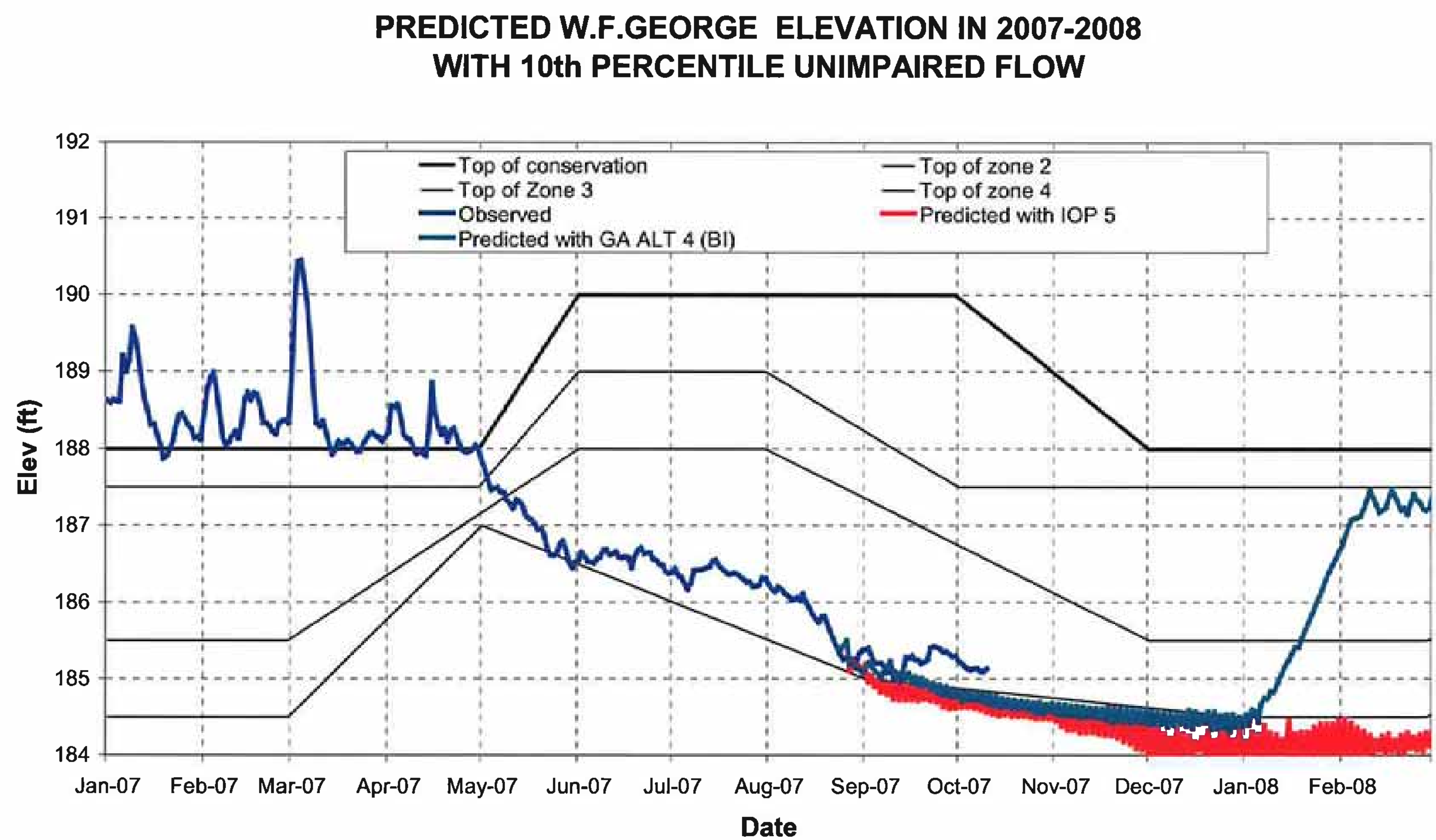


Fig. 18 Effects of emergency measures proposed by Georgia on W.F. George elevation (using Corps model and 10 percentile hydrology)

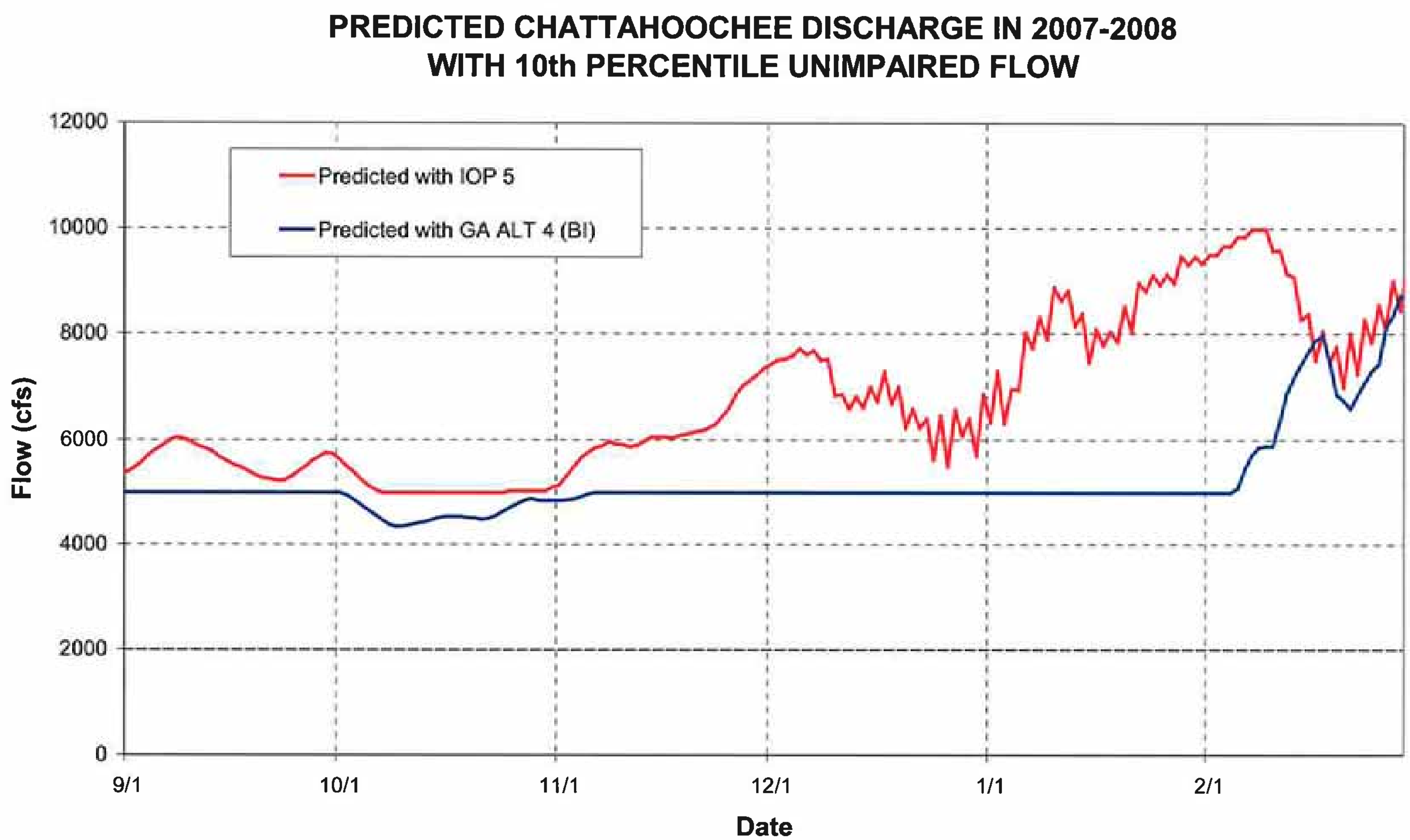


Fig. 19 Flow at Chattahoochee, Florida under the proposed changes to the IOP (Corps' 10 percentile hydrology)

APPENDIX D

GAEPD MOTION FOR PRELIMINARY INJUNCTION

19 OCTOBER 2007

UNITED STATES DISTRICT COURT
MIDDLE DISTRICT OF FLORIDA
JACKSONVILLE DIVISION

IN RE TRI-STATE WATER RIGHTS LITIGATION	Civil Action File No. 3:07-MD-1-PAM *State of Georgia v. United States Army Corps of Engineers*, No. 3:07-CV-251 (*Georgia II*)

MOTION OF THE STATE OF GEORGIA FOR PRELIMINARY INJUNCTION AND MEMORANDUM OF LAW IN SUPPORT THEREOF

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I. INTRODUCTION AND SUMMARY

The State of Georgia is suffering a drought of historic proportions and is facing potentially dire and irreparable consequences if the United States Army Corps of Engineers does not immediately stop depleting the reservoir storage that remains in the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The Corps' current reservoir operations in the ACF Basin are dictated by what is called the "IOP,"[1] developed by the Corps in 2006. As the Corps will acknowledge, in developing the IOP, the Corps never anticipated a drought of this severity or of this duration. If the Corps continues to make the releases dictated by the IOP, the Corps' own projections show a substantial risk that the federal storage reservoirs in the ACF Basin--Lake Lanier, West Point Lake, and Lake Walter F. George--could be drained of all conservation storage and that, as a result, the flow in the Chattahoochee River and Apalachicola River could drop severely. If this occurs,

---

[1] "Interim Operations at Jim Woodruff Dam and Release to the Apalachicola River In Support of Listed Mussels and Gulf Sturgeon," as modified ("IOP"). Although its title implies that it applies only to releases from Jim Woodruff Lock and Dam ("JWLD") on the Georgia – Florida border, the IOP in fact dictates the releases that the Corps must make from all of the federal reservoirs in the ACF Basin.

there will be serious water shortages for people living in Georgia and deaths of federally-protected species in the Apalachicola River in Florida.

The State of Georgia must emphasize that the risk that the system will be drained of all or nearly all conservation storage is not speculative and it is not remote. In fact, the projections upon which this Motion is based come directly from the Corps. Climatologists from the Corps, climatologists contributing to the U.S. Drought Monitor, and Georgia's climatologist concur that the ACF Basin currently is experiencing the most severe category of drought (called an "exceptional" drought) and that conditions will remain drier than normal through the winter of 2008. The State of Georgia is unaware of any climatological forecast that is more optimistic. Among the range of hydrological scenarios that the Corps is using in it projections, even the most optimistic shows a steady decline in the federal reservoirs that, even if it does not deplete all system storage this year, will place the reservoirs at even greater risk of emptying next year.

Because these conditions threaten irreparable harm, and because the State of Georgia has exhausted every other means of obtaining relief, the State hereby moves for a preliminary injunction ordering the Corps to operate as follows:

> (1) While Adjusted Basin Inflow is below 5,000 cubic feet per second (cfs), the Corps shall release no more water from JWLD than is necessary to maintain a flow,

> as measured at the Chattahoochee gage on the Apalachicola River, equal to Adjusted Basin Inflow;
>
> (2) When Adjusted Basin Inflow exceeds 5,000 cfs, the Corps shall release no more water than necessary to maintain a flow, as measured at the Chattahoochee gage on the Apalachicola River, of 5,000 cfs;
>
> (3) The Corps shall not deviate from the foregoing flow requirements because of any "rampdown" restrictions.
>
> "Adjusted Basin Inflow" is defined as the amount of water that would flow by Woodruff Dam during a given time period if all of the Corps' reservoirs maintained a constant water surface elevation during that period, plus Georgia's municipal and industrial consumptive demands from the Chattahoochee River and Lake Lanier (which are deemed for purposes of this order to be 457 cfs during October, 369 cfs during November, 352 cfs during December, 302 cfs during January, and 345 cfs during February).

These emergency changes to the IOP would remain in effect until the earlier of: (a) March 1, 2008; (b) a decision on the merits of *Georgia II*, which is scheduled to be resolved in Phase I of this litigation; or (c) further order of this Court, with the understanding that motions for modification of this relief may be appropriate in the event that conditions improve and the threat of depletion of reservoir system conservation storage is materially reduced.

As explained fully below, this Motion meets all of the requirements for preliminary injunctive relief. First, there is a substantial likelihood that Georgia will succeed on the merits of its claim that the IOP is arbitrary and capricious because the Corps, in developing the IOP, failed to anticipate a drought of this magnitude or build into the IOP failsafe provisions for unanticipated conditions. Second, the harm if the motion is not granted clearly is irreparable in every respect: The damage caused by the Corps' failure to anticipate this drought will be irreparable by the time this case comes up for trial in the ordinary course.

With respect to the balance of the harms and the public interest, the choice is clear. There is a possibility that the Corps' projections are overly pessimistic and that the relief sought by this injunction will turn out to have been unnecessary to avert a severe crisis in the next several months. If this Court should grant this motion and conditions do improve, however, the Court will have the power and ability to order further adjustments or relief as the conditions warrant - and the requested relief expressly contemplates this possibility. On the other hand, if this Court should deny this motion and the Corps' projections turn out to be correct, then it will be too late, the water will be gone. Under these circumstances, clearly, the law, the equities, and common sense compel the same conclusion that this motion must be granted.

The relief sought in this motion will not be sufficient to cure all of the fatal defects in the IOP. This motion is directed at the Corps' operations in the upcoming several months - until March 2008, when a different set of rules for the

Gulf sturgeon spawning season applies. Even if this relief is granted, it is highly likely that unless the Corps voluntarily alters the IOP's releases for the Gull sturgeon spawn, additional preliminary injunctive relief will be necessary to address the fatal flaws in that portion of the flow regime. As set forth in the *Georgia II* complaint, the IOP requires massive releases in the Gulf sturgeon spawning season that far surpass the ability of the system or the needs of the species. In fact, the over-releases during these months earlier in 2007 prevented the reservoirs from refilling and have, in part, contributed to the need to seek the relief sought in this motion. If this motion is granted, there will be a relative improvement in reservoir storage at the beginning of March, when the higher flows are required, but likely not nearly enough to afford the over-releases required by the IOP. Rather than bringing a motion for relief from the rules governing the March through May time frame, however, the State of Georgia has filed this motion focusing on the threat posed by the flow requirement of 5,000 cfs that is in effect from now through February, 2008.

II. FACTS

A. The ACF River Basin

1. Chattahoochee, Flint, and Apalachicola Rivers

The Chattahoochee River originates in northeastern Georgia and flows through Atlanta to the southwest until it turns south and forms, at its western bank, the border between Georgia and Alabama. The river flows for a distance of 434 miles across Georgia before joining the Flint River at Lake Seminole at the Florida border. Upon crossing into Florida, the river becomes the Apalachicola River. The Apalachicola River flows for approximately 106 miles from the dam to the Gulf of Mexico at Apalachicola Bay. The flow of the Chattahoochee River is regulated by a series of reservoirs that the Corps operates. There are no federal storage reservoirs on the Flint River, thus, the Corps of Engineers has no role in determining the flow in the Flint River.

2. Lake Lanier

Lake Lanier is near the headwaters of the Chattahoochee River in northeast Georgia, north of Atlanta. Only 6% of the drainage area of the ACF Basin flows into Lake Lanier. Yet, Lake Lanier provides the majority of storage capacity (64%) among the federal reservoirs within the ACF Basin. As the chief hydrologist for the Corps' mobile district has stated:

> Because it is so difficult to refill Lake Lanier due to its small drainage area, coupled with the fact that storage in Lanier represents such a large and important part of the overall ACF system, particular care should be given in insuring that adequate storage remains in Lake Lanier to insure that all project purposes can be met, particularly during multi-year drought periods.

Affidavit of Dr. Doug Otto, case no 90-1331, (N.D. Ala.), Doc. 502, Exhibit 1, at ¶ 36.

The conservation storage pool (storage pool available to meet project purposes such as water supply, hydropower, and recreation) of Lake Lanier is between elevations 1,071 feet and 1,035 feet above mean sea level. When the conservation storage pool is full, the total quantity of water stored is approximately 1,087,600 acre-feet. At an elevation of 1,056.53 feet (the elevation as of the morning of October 19, 2007), less than 54% of the conservation storage pool remains. At an elevation of 1,050 feet, 35.6% of the conservation pool would remain; at 1,048 feet, 30.3% would remain; at 1,039, 8.6% would remain.

The Cities of Gainesville, Buford, Cumming, the Town of Flowery Branch, and Gwinnett and Forsyth County withdraw water directly from Lake Lanier to meet their municipal and industrial water supply needs. *See* Exhibit 1 at ¶ 26. In addition, the City of Atlanta, Fulton County, Cobb County-Marietta Water Authority, and other local government utilities depend upon releases from Lake

Lanier to provide a flow in the Chattahoochee River for municipal and industrial withdrawals. *Id.* Georgia EPD estimates that approximately 2.85 million people in the Atlanta area depend upon Lake Lanier and the upper Chattahoochee River to meet their water supply needs. *Id.* The City of Gainesville relies on the waste assimilative capacity of Lake Lanier in making its returns of treated effluent to the Lake, and the City of Atlanta, Counties of Cobb and Gwinnett, and other local governments in the metropolitan area rely on the Corps to maintain a flow of 750 cfs in the Chattahoochee River to maintain the waste assimilative capacity of the River. *Id.*

In addition, recreational use Lake Lanier also supports a multi-billion dollar economy. Lake levels have a direct impact on recreation and the recreational economy of the lake. According to the Corps, recreation at Lake Lanier begins to suffer (i.e., some boat launching ramps unusable, most beaches unusable, navigation hazards begin to surface) when the reservoir falls to an elevation of 1,066 feet. Major impacts to concession and recreational areas are observed at an elevation of 1,063 feet. Many docks and ramps are inaccessible, and there are major impediments to navigation, at 1,060 feet.

3. West Point Lake

Another Corps storage reservoir, West Point Lake, is located on the Chattahoochee River approximately 155 miles southwest of Lake Lanier. West Point Lake holds up to 306,100 acre-feet of storage within its conservation storage pool. The top of conservation storage at West Point Lake is 635 feet, and the bottom of the conservation pool is at 620 feet.

The City of LaGrange withdraws water from West Point Lake for municipal and industrial needs. Two of the locations at which LaGrange withdraws water are exposed at the current lake elevation. *Id.* at ¶ 28. The City of West Point relies on withdrawals immediately downstream of West Point Dam. Further downstream, the City of Columbus withdraws water from the Chattahoochee River and relies on the waste assimilative capacity of the Chattahoochee River to meet the needs of approximately 225,000 people. West Point Lake also supports a significant recreational economy. *Id.*

4. Lake Walter F. George (a.k.a., Lake Eufala)

The third Corps storage reservoir on the Chattahoochee, Lake Walter F. George (a.k.a. Lake Eufaula) is located approximately 80 miles downstream from West Point Dam. Lake Walter F. George holds up to 244,400 acre-feet of storage within its conservation storage pool. The top of conservation storage at Walter F.

George is 190 feet, and the bottom of the conservation pool is at 184 feet. Among other things, releases from Lake Walter F. George provide flow in the Chattahoochee River for cooling water at Plant Farley, a nuclear power plant operated by Southern Nuclear Company near Columbia, Alabama.

5. Jim Woodruff Dam/Lake Seminole

Lake Seminole is the southernmost Corps reservoir within the ACF River Basin. JWLD, which discharges into the Apalachicola River at the Georgia-Florida border, has essentially no storage, operates as a run-of-river project, and relies on the storage reservoirs upstream to support its releases, particularly during dry times.

B. The IOP

On March 7, 2006, the Corps introduced a new operating regime for the federal reservoirs in the ACF Basin, the IOP. *See Georgia II* Administrative Record GAII 002499-002526. The announcement of the IOP coincided with the Corps' commencement of formal consultation with the Fish and Wildlife Service concerning the effect of the Corps' ACF reservoir operations on two species of federally-protected freshwater mussels living in the Apalachicola River (the endangered fat threeridge mussel and the threatened purple bankclimber) and threatened Gulf sturgeon, a species of fish that spawns and spends its early life in the Apalachicola River. The March 7, 2006 Corps letter to the Service that initiated formal consultation stated or at least implied that the subject matter of the consultation was the Corps' existing (pre-IOP) operations, and that the Corps was putting the IOP in place only as a protective measure pending completion of the consultation. *Id.* In later correspondence, however, the Corps revealed instead that the subject matter of the consultation was the IOP, and that, for all practical purposes, the IOP was the Corps' new operating regime, at least unless and until modified by the Corps in consultation with the Service. *See Georgia II* Administrative Record GA II 003996-003998.

The IOP establishes rules for releases from JWLD for the stated purpose of providing an appropriate flow regime for the Gulf sturgeon and two species of mussels. There is one set of rules that applies during the months when the Gulf sturgeon commonly spawns in the Apalachicola River (March to May) and another set of rules that applies for the remainder of rest of the year (June through February). The releases that the Corps is required to make from JWLD depend upon the amount of "basin inflow" – a defined term that is roughly equivalent to the amount of water that is coming into the ACF Reservoirs. In addition, the IOP prescribes certain "down ramping rates," which prohibit the Corps from reducing the river stage more than a certain amount per day, even if the naturally-occurring Basin Inflows dropped more precipitously.[2]

The Corps developed and began implementing the IOP before seeking input from the State of Georgia (or, to our knowledge, Alabama or Florida) as to the potential impact of the IOP on the federal reservoirs, streamflows, users of water, and environmental and biological needs throughout the ACF Basin. As will be shown in greater detail below, the Corps in particular failed to model the impact of the IOP during a multi-year drought or a drought similar to the one the ACF Basin now is experiencing.

The Service issued its Biological Opinion and Conference Report on the U.S. Army Corps of Engineers, Mobile District, Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River ("Biological Opinion") on September 5, 2006. *See Georgia II* Administrative Record GAII 005291-005468. In the Biological Opinion, the Service concluded that the Corps'

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[2] On June 12, 2006 the Corps proposed several modifications to the IOP as a result of "lessons learned" by the Corps during the first several months of operation under the IOP. *See Georgia II* Administrative Record GAII 003996-004011. The proposed modifications included a change in the method for computing basin inflows to manage releases under the IOP from the use of the 3-day average to the use of a 7-day average; tying computations of basin inflows and releases to the Chattahoochee gage; clarifying how releases for gradual ramping rate are captured in the volumetric computation of release to meet he volumetric computations of basin inflows; and changes to hydropower generation operation at Jim Woodruff powerhouse.

operations pursuant to the IOP would not appreciably affect the survival and recovery of the federally-protected species that were the subject of the Biological Opinion nor appreciably affect the ability of their critical habitats to serve the essential functions of such habitats. *See Georgia II* Administrative Record GAII 005439-005441. The Biological Opinion stated that the IOP could cause the "take" of the fat threeridge and purple bankclimber mussels within the meaning of the Endangered Species Act if the Corps' decision to store water in the ACF Reservoirs (rather than to release it downstream) allowed these mussels to be exposed. *See Georgia II* Administrative Record GAII 005442-005444.

Based upon its conclusion that the IOP might cause a "take" of federally-protected mussels in low flow conditions,[3] the Service, pursuant to Section 7(b)(4)(C) of the Endangered Species Act, issued "reasonable and prudent measures" that the Corps must follow to obtain protection against liability for the death of individual mussels. In a letter dated February 16, 2007 to the United States Fish and Wildlife Service, the Corps announced that it had modeled and was proposing a modification to the IOP in response to one of the reasonable and

[3] Though not germane to this motion, the State of Georgia, in the *Florida* case, is challenging the Service's conclusion that the minimum flows prescribed by the IOP (assuming they could be maintained without fail) would cause a "take" of federally-protected mussels.

prudent measures. *See Georgia II* Administrative Record GAII 008522-008523. The Corps refers to this modification as "Concept 5."[4]

The IOP, as modified through Concept 5, specifies two sets of rules, one for March through May[5] and the other for June through February. For June through February, the following applies:

> (a) when Basin Inflows are greater than or equal to 23,000 cfs, the Corps would release no less than 16,000 cfs from Woodruff; (b) when Basin Inflows are between 10,000 cfs and 23,000 cfs, the Corps would release between 70% of Basin Inflows, but not less than 10,000 cfs; and (c) when Basin Inflows are less than 10,000 cfs, the Corps would release 100% of Basin Inflows, but not

[4] In the February 16, 2007 letter, the Corps stated that under Concept 5, the Corps would "provide for a higher desired minimum flow of 6,500 for normal to wet years," would lower the minimum flow to 5,000 cfs when composite storage in the ACF Reservoirs falls to the top of Zone 3, and that the Corps would lower "the storage/flow thresholds during the March-May spawning period to 35,800 cfs and 18,000 cfs, respectively."

[5] The IOP calls for higher flows in March through May, during the Gulf sturgeon spawning period:

> During the months of March through May: (a) when Basin Inflows are greater than or equal to 35,800 cubic feet per second (cfs), the Corps would release no less than 25,000 cfs from Woodruff; (b) when Basin Inflows are between 18,000 cfs and 35,800 cfs, the Corps would release between 70% of Basin Inflows, but not less than 18,000 cfs; and (c) when Basin Inflows are less than 18,000 cfs, the Corps would release 100% of Basin inflows, but not less than either 6,500 when the composite storage of the ACF Basin is in Zones 1 and 2, or 5,000 cfs when composite storage falls below the top of Zone 3.

> less than either 6,500 when the composite storage of the ACF Basin is in Zones 1 and 2, or 5,000 cfs when composite storage falls below the top of Zone 3.

The IOP also limits, year around, the rate at which the Corps can "ramp-down" releases as Basin Inflow fall. The ramp-down rates result in further depletion of reservoir storage.

C. Flaws in the IOP

There are at least three critical, and related, flaws in the June to February rules of IOP that have given rise to the rapid drop in reservoir storage last year and this year. First, in designing the IOP, the Corps did not consider the effect that it would have during a drought of the severity that we are now experiencing. The Corps' analysis that preceded its implementation of the IOP evaluated the IOP against historical conditions, with the worst drought being the drought of 2000-2001. As explained further below, over the past several months, the drought of 2007 has been worse than any prior single-year drought. Given that the ACF Basin has experienced droughts with increasing frequency and severity over the past 26 years (1981, 1988, 1998-2001 and now 2006-2007), it could not be unexpected or considered even unlikely that the Basin would see a new record drought developing in the near future. The Corps brushed aside this flaw, however, relying on computer modeling that did not project droughts of the severity that we are now experiencing. The Administrative Record in this case establishes with convincing clarity that the Corps developed the IOP without considering extreme drought conditions and, had the Corps anticipated conditions such as those we are now experiencing, the Corps would never had adopted the IOP in its present form.

Second, the Corps established a number of flow thresholds and an absolute flow floor for the Apalachicola River without biological justification. Most relevant for purposes of this motion, the Corps imposed an arbitrary and absolute floor of 5,000 cfs. The 5,000 cfs originated in Corps operating procedures as the flow believed to be necessary to satisfy the cooling water needs of a relatively small power plant on the Apalachicola River in Florida. *See* Affidavit of Dr. Doug Otto, case no. 90-1331, (N.D. Ala.), Doc. 502, Exhibit 1, at 7716. Neither the Corps nor the Fish and Wildlife Service has ever, neither before the IOP was developed or after, established that maintaining a flow of 5,000 cfs is necessary to the survival of any federally-protected species. The Biological Opinion concluded that the 5,000 cfs floor was sufficient, but this in no way leads to the conclusion that without it there will be jeopardy to the continued existence or recovery of any species. Nevertheless, the IOP in its current form maintains 5,000 cfs as an absolute minimum, never to be breached.

This leads into the third flaw, which is the fact that the 5,000 cfs floor is imposed without respect to weather conditions and without respect to the amount of reservoir storage remaining. This "hard floor" has no fail-safe mechanism. No matter how dismal the climatic forecast, and no matter how empty the reservoirs, the IOP requires the Corps to continue releasing enough water from JWLD to maintain the 5,000 cfs flow rate in the Apalachicola River.

Georgia is suffering from the real effects of these flaws this year and stands to suffer worse before the year is out. Of even greater concern, however, is that, multiplied over extended or successive droughts, the IOP's flaws will cause even greater harm.

D. Georgia's Challenges to the IOP

Within several weeks after the Corps adopted the IOP in 2006, drought conditions had developed in Georgia, and Georgia began voicing its criticism of this and other flaws in the IOP. The Administrative Record and the record of this litigation show that, on many occasions since March 2006, the State of Georgia has provided detailed written explanations and analyses of its concerns that the IOP, under conditions similar to the worst drought of record (2000-2001) would rapidly and significantly deplete ACF Basin conservation storage. *See Georgia II* Administrative Record GAII 003301-003310, GAII 003522-003523, GAII

003901-003903, GAII 003904-003912, GAII 007570-007575, GAII 007745.01-007745.23; Affidavit of Dr. Wei Zeng, Case no. 06-1473, (N.D. Ga.) Doc. 3, Exhibit A.

When the Corps failed to alter the IOP notwithstanding the problems with it that Georgia had illustrated, Georgia filed the *Georgia II* action on June 20, 2006, seeking judicial review of the IOP, and alleging that the IOP was arbitrary and capricious because, *inter alia,* the Corps failed to consider the possibility of an extended severe drought. Litigation over the IOP quickly shifted to the *Alabama* litigation after Georgia filed its suit. Climatic and hydrological conditions during the summer of 2006 never reached the severity seen this year, and the three States and the Corps were even able to reach a short-term agreement over modification of the IOP during from June 30, 2006 to July 24, 2006. *See* N.D. Al. 90-1331, Doc. 490, Ex. A. The winter of 2006 saw a return to more normal rainfall. Because of the combination of the IOP and the drought, however, Lake Lanier did not refill during the winter of 2006-07 and began the year at a lower level (1063.3) than has been experienced at the beginning of any year since the multi-year drought of 1998-2002 drought, making it more susceptible to significant drawdown as the drought of 2007 developed.

E. <u>Conditions Worsen</u>

Drought conditions returned in 2007. Taken together, climatic and hydrologic conditions show that the drought of 2007 is the worst of record, particularly in the northern part of the State. For the six month period of March through August, a time when Georgia normally receives the majority of its precipitation, rainfall in the northern portion of the ACF Basin was the lowest on record, far eclipsing the droughts of 2000, 1988, and 1986. *See* Exhibit 1 at ¶ 7 and at Attachment A, Figure 2. Over the same months, rainfall within the Flint River Basin and the middle reach of the Chattahoochee River, has matched the levels of the year 2000 as the lowest on record. *Id.* at ¶ 8 and at Attachment A, Figures 3 and 4. Rainfall within the lower reach of the Chattahoochee River was only slightly higher than in the drought of 1986 and was worse than in 2000 and 1988. *Id.* at ¶ 9 and at Attachment A, Figure 5.

Final rainfall data for the month of September throughout the basin is not yet available, but we know that drought conditions have worsened. The United States Geological Survey recently released a fact sheet stating that "the 2007 drought in Georgia worsened during September, bringing many of the State's rivers and streams to their lowest levels ever recorded for the month."[6] Moreover, the current map of the U.S. Drought Monitor shows the northern third of Georgia to be experiencing "Exceptional" drought, the most severe category. *See* http://drought.unl.edu/dm/monitor.html.

Low precipitation levels have resulted in record low basin inflow, which is the total amount of flow entering the entire ACF system. The year 2000 saw the lowest basin inflow on record as of that time for the May to September period. Georgia's calculations indicate that the May through September cumulative flow in 2007 is 15% to 20% lower than in 2000, the previous all-time low. See Exhibit 1 at ¶ 11 and Attachment A, Figure 6.

Conditions are not projected to improve any time soon. The Southeast Climatologist Consortium forecasted "La Nina" conditions causing a drier and warmer cool season (October 2007 through March 2008). *See* Exhibit A at ¶ 12. The U.S. Drought Monitor's forecast concurs with this assessment, predicting abnormally dry conditions to remain through May 2008.[7] This means that it is

[6] This fact sheet is available at the USGS web site, at http://ga.water.usgs.gov/drought/drought_sept2007.pdf.

[7] *See* http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/page4.gif

very likely that we will see the drought worsen in the next few months and may well experience further record-breaking conditions in 2008.

The 2007 drought has taken a serious toll on the federal reservoirs. To make matters worse, the Corps has been operating under the IOP this year. The IOP has required the Corps to release essentially all of the basin inflow entering the system and exhaust large quantities of storage to maintain a minimum flow of 5,000 cfs at Chattahoochee, Florida. The Corps spends a great deal of storage controlling rampdowns after rainfall events and has release a significant quantity of water in excess of even what the IOP requires. *See Georgia II* Administrative Record GAII009957-009960. Dry conditions in the fall of 2006 prevented the Corps from replenishing a "significant credit due to down ramping" that had accumulated in 2006. *Id.* Even though the Corps tried to make up for those over-releases in the spring of 2007, they were only able to recover "a portion of the storage previously used for down ramping." *Id.* In addition, the Corps' efforts to balance over-releases do not include over-releases "for other project purposes, such as hydropower generation, flood control, or to maintain head limits." *Id.*

The current basin inflow to the ACF system as of October 11, 2007, was around 2,000 cfs, which means that the Corps had to use 3,000 cfs-day (or 6,000 acre-feet) of system storage to meet the flow requirement of 5,000 cfs at the

Chattahoochee gage. See Exhibit 1 at Attachment A, p. 2. If basin inflow does not improve significantly in the near future, according to the Corps, this level of augmentation would deplete system conservation storage in 100 days.

As of October 11, 2007, the composite storage of the entire ACF system (the sum of remaining conservation storage from Lanier, West Point, and Walter F. George) was down to 702,907 acre-feet, or 42.9% of the system capacity. By comparison, system storage was at 1.39 million acre-feet on May 1, 2007. *See* Exhibit 1 at Attachment A, p. 2. By Georgia's calculations, as of October 11, 2007, the Corps had used more than 600,000 acre-feet of storage to augment flow at Chattahoochee, Florida over the past 5 months. *Id.*

As of 6 a.m. on October 19, the elevation at Lake Lanier, the largest storage reservoir and the source of drinking water for approximately 2.85 million people, was down to 1056.5 feet.[8] This is more than fourteen feet below its normal pool level and is approximately four feet lower than the elevation a month ago. West Point Lake elevation is at 621.9 feet. This is more than thirteen feet below its normal pool level, and less than two feet away from the bottom of its conservation pool. At this elevation, only approximately 9% of conservation storage in the lake

[8] *See* Corps' Mobile District water management website, http://water.sam.usace.army.mil/acfframe.htm.

remains. The elevation at Lake Walter F. George as of the same date, was at 185 feet, which is only a foot away from the bottom of its conservation pool. At that elevation, only 17.5% of conservation storage remains.

The State of Georgia has been in active daily discussions with the officials at all levels of the Corps and the U.S. Fish and Wildlife Service in an effort to secure meaningful relief. On October 12, 2007, Georgia EDP Director Carol A. Couch wrote Col. Byron Jorns, the Commander and District Engineer of the Corps, Mobile District, explaining Georgia's concerns and requesting, formally, the relief that Georgia seeks in this Motion. Dr. Couch's letter is attached hereto as Attachment A to Exhibit 1. In his October 17, 2007 response, Col. Jorns stated:

> Due to the severe nature and predicted duration of the continuing drought conditions, we have initiated discussions with the USFWS to address concerns that remaining storage within the ACF system may be depleted before drought conditions abate. This potential depletion could result in the inability to operate the projects in a way that fulfills all the authorized purposes, to comply with the provisions of the ESA, and to assure that operational decision making minimizes the adverse effect on other water uses and needs within the basin during this time of drought Our discussions are exploring possible interim drought contingency options that may provide some temporary modifications to the IOP and could allow some additional water to be stored to place the reservoirs in a better position to meet minimum needs if the drought conditions continue into 2008 as predicted. We are reviewing the additional information you have provided, as well as information we are developing on the potential impacts to listed species, to assist in our evaluation of possible options.

See Exhibit 1, at Attachment B. Though Col. Jorns' letter is helpful to the extent that it recognizes that the Corps has the flexibility to make temporary modifications to the IOP, the letter falls short of making any commitment and gives no time-table for the implementation of any changes.

F. Georgia's Conservation Measures

Georgia takes seriously its obligation to conserve water. In response to these exceptional drought conditions, on September 28, 2007, Georgia EPD took the unprecedented step of imposing the highest level of restrictions on water use in our state's history. Since imposing these restrictions, we have already seen a dramatic 15% drop in water use in the Atlanta metro area alone. *See* Exhibit 1 at ¶ 14. Alarmed by the reality that the water sources they rely on are being drained, many communities and industries have gone beyond the state ban on outdoor watering by limiting other water uses and implementing even more rigorous conservation measures. *Id.*

As to agriculture, the season of heaviest water consumption is the earlier in the year. If drought conditions persist as projected, the Director of Georgia EPD has determined that it is likely that in 2008, she will declare a drought under the Flint River Drought Protection Act, which is codified at O.C.G.A. § 12-5-540 through 12-5-550. *Id.* at ¶ 15. Under that Act, in order to invoke the Act in any given year, the EPD Director must declare a drought prior to March 1 of the given year. The Act triggers the authority of the EPD Director to determine the agricultural acreage that should not be irrigated to maintain acceptable streamflows in the Flint River and conduct an "irrigation reduction auction" to limit irrigation. *See* O.C.G.A. § 12-5-546.

G. Current Projections of the Impact on Reservoir Levels

On or about October 4, 2007, the Corps provided Georgia, Alabama, Florida, and interested stakeholders with the computer models that it is using to project the ACF Basin elevations that will result from the IOP for the remainder of this year. As the ACF Basin is in a drought worse than any experienced previously, the Corps' simulation does not assume that the amount of water flowing into the basin will be as in the past. Instead, it assumes multiple scenarios as to inflows. One scenario is that inflows for each individual day will be within the lower 2% for that day over the historical record. A second scenario assumes that inflow for each day will be in the lower 5% of the historical record. A third assumes that inflow for each day will be in the lower 10% of the historical record.

These Corps models paint a very grim picture. Assuming that inflow will be at the 10% level, Lake Lanier would fall to the extreme level of below 1,048 feet by the end of this year, and if the drought continues its present severity throughout

2008, Lake Lanier would fall to 1044 feet by the end of February 2008, and at least 1,035 feet, the bottom of conservation storage (or lower) by the end of 2008. *See* Exhibit 1 at Attachment A, Figure 16, and Attachment C, Figure 1. Both West Point Lake and Lake Walter F. George would hover around the bottom of their conservation pools from late November through all of 2008. *Id.* If one assumes that inflow will be at the 5% or 2% levels, the results will, of course, be even worse. Lake Lanier would fall as low as 1,039 feet by the end of this year and would fall to the bottom of conservation storage (1,035 feet) before the end of January 2008. *See* Exhibit 1 at Attachment A, Figure 12. West Point and Walter F. George would reach the bottom of their conservation storage pools beginning in November and would remain empty through next February. *Id.* at Figures 13, 14. Even if one assumes, more optimistically, that inflow conditions in 2008 will improve to year 2000 levels, the current IOP rules will cause Lake Lanier to fall to between 1,044 and 1,038 feet by the end of 2008. *See* Exhibit 1 at Attachment C, Figure 5. The Corps' own modeling results show that when all conservation storage is depleted (at 1,035), the 5,000 cfs flow in the Apalachicola River would not be maintained and would fall well below 1,000 cfs. *See* Exhibit A, Attachment A, Figure 11.

It could (and undoubtedly will) be argued that the 2% and even the 5% inflow assumptions are overly pessimistic because they assume so little rain. It must be remembered, however, that inflows for March through August this year, particularly in the northern part of the basin where Lake Lanier is located, were substantially (15-20%) below the levels seen in the previous drought of record, the drought is believed to have worsened during September, and dry conditions are forecasted for the winter. Therefore, something worse than even the worst conditions experienced historically, over the next few months, should be assumed. Moreover, even if the inflow conditions are somewhat pessimistic, that does not mean that the modeled results are overly pessimistic. In fact, some key assumptions of the model are overly optimistic as compared with actual Corps operations. For example:

(1) The models do not take into account the effect of the IOP's rampdown limitations, which cause the Corps to draw from storage to limit river fall rates following rainfall events. Those rampdown restrictions can cause rainfall events to deplete, rather than enhance storage, particularly where the rainfall occurs below one or more of the federal reservoirs.

(2)The model assumes that the Corps will release precisely 5,000 cfs, not the more than 5,130 cfs that the Corps actually releases as a minimum because of physical limitations of Jim Woodruff Dam, or other over-releases that the Corps makes due to operational imprecision.[9] Though this 130 cfs difference appears insignificant, the average net consumption within the State of Georgia for municipal and industrial water supply out of the ACF Basin for the month of October will be approximately 450 cfs.

At present, actual inflows currently appear to be tracking at between the 5% and 10% levels. The drawdown of Lake Lanier has followed the 10% scenario over the past couple of weeks, but West Point has dropped more precipitously than under the 10% scenario, necessitating an increase in the releases that will be needed from Lake Lanier to maintain the 5,000 cfs flow in the Apalachicola River.

H. <u>Impact of Low Reservoir Levels and Flows</u>

The effects of draining the federal reservoirs to these levels would severe and would be felt throughout the ACF Basin.

Operating the ACF River Basin under the IOP is causing a steady and dangerous depletion of system storage. The depletion of system storage during the dry months of 2006, and the releases prescribed by the IOP during the Gulf sturgeon spawning season, prevented Lake Lanier from refilling in 2007 and made

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[9] *See* http://waterdata.usgs.gov/nwis/uv/?site_no=02358000&PARAmeter_cd=00060,00065; Vaughn e-mail, *Georgia II* Administrative Record GAII 010324.

it more susceptible to significant drawdown this year. Even with the granting of the relief sought in this motion, Lake Lanier will start 2008 at a dangerously low level, and again be overtaxed during the 2008 sturgeon season.

As noted above, applying the Corps 10% hydrology, which the system is currently tracking, Lake Lanier would fall to 1052 feet by the end of December 2007, to 1,044 by February 2008, and to 1,035 feet by the end of 2008, while West Point Lake and Lake Walter F. George will remain around the bottom of their conservation pools. *See* Exhibit 1 at Attachment C, Figure 1. Even if conditions in 2008 improve to only as bad as in 2000, Lake Lanier will fall to between 1,044 and 1,038. *Id.* at Figure 5. Moreover, conditions will continue to fall with the return of the wetter season in March, 2008, because the IOP's rules for the Gulf sturgeon spawn will not allow the lakes to keep pace with the demands.

In addition, a number of local governments have water supply intakes within the Lake Lanier conservation pool that would be exposed. The shared intake for Forsyth County and the City of Cumming withdraws at levels of 1,053 feet and 1,048 feet. *See* Exhibit 1 at ¶ 27. The State's best information at this point is that as the lake falls below 1,053, Forsyth and Cumming will lose approximately one-third of their pumping capacity. *Id.* The other third will be lost at an elevation below 1,048 feet. The City of Buford, with intakes at 1,062, 1,052, 1,042, and

1,032 feet will experience serious water supply problems if Lake Lanier falls to 1,035 feet. *Id.*

The City of LaGrange will also incur substantial hardship as West Point Lake continues to drop. The city operates with intakes at levels 628, 623, 618, and 600 feet. Current lake elevations are at 621.88 (midnight on October 19), which leaves the top two intakes out of the water. There is an older intake at 582, but it apparently has never been used and is probably not functional. In addition, the low lake levels have increased blue-green algae outbreaks, which causes significant increases in treatment costs and other water supply problems. Also at West Point Lake, virtually all shoreline related recreation and most surface use has been eliminated. Damage to marinas and residential docks and boats is extensive. Marinas, almost all boat ramps, campgrounds, beaches and other facilities are no longer accessible or usable. *Id.* at ¶ 28.

Moreover, as the reservoir falls lower in the conservation pool, the quality of the water decreases and the cost of treating the water so that it is suitable for domestic use increases significantly. *Id.*

At the elevations experienced this summer and fall at Lake Lanier, West Point Lake, and Lake Walter F. George, Georgia already has suffered a major economic impact. It is highly unlikely that Lake Lanier will refill or even return to above recreational impact levels next summer based upon the Corps projections through the end of this year, and that, if the drought continues into next year, Georgia once again will see greatly reduced revenue associated with recreation at these lakes.

III. REQUESTED RELIEF

Georgia prays for an Order of this Court stating as follows:

> The Corps shall alter the Interim Operations Plan so as to operate in accordance with the following:
>
> (1) While Adjusted Basin Inflow is below 5,000 cubic feet per second (cfs), the Corps shall release no more water from JWLD than is necessary to maintain a flow, as measured at the Chattahoochee gage on the Apalachicola River, equal to Adjusted Basin Inflow;
>
> (2) When Adjusted Basin Inflow exceeds 5,000 cfs, the Corps shall release no more water than necessary to maintain a flow, as measured at the Chattahoochee gage on the Apalachicola River, of 5,000 cfs;
>
> (3) The Corps shall not deviate from the foregoing flow requirements because of any "rampdown" restrictions.

These emergency changes to the IOP shall remain in effect until the earlier of:

> (1) March 1, 2008; or
>
> (2) A decision on the merits of *Georgia II*, which is scheduled to be resolved in Phase I of this litigation; or
>
> (3) Further order of the Court.

> Modification of this relief is appropriate in the event that climatic and hydrological conditions within the ACF Basin improve in a manner that materially reduces the threat of serious and irreparable depletion of reservoir system conservation storage.
>
> For the purposes of this preliminary injunction, "Adjusted Basin Inflow" is defined as the amount of water that would flow by Woodruff Dam during a given time period if all of the Corps' reservoirs maintained a constant water surface elevation during that period, plus Georgia's municipal and industrial consumptive demands from the Chattahoochee River-Lake Lanier System (which are deemed for purposes of this motion to be 457 cfs during October, 369 cfs during November, 352 cfs during December, 302 cfs during January, and 345 cfs during February).

The benefits of granting the requested relief include the following (all using the Corps' basin inflow projections):

- Assuming the most dire conditions, that inflow is at or below the 2% level for the rest of 2007 and through 2008, Lake Lanier will be approximately 6 feet higher (1,047 versus 1,039 feet) as of the end of 2007, and will retain at least some conservation storage until June 2008. *See* Exhibit 1 at Attachment C, Figure 1. The models project West Point Lake and Lake Walter F. George to reach the bottom of conservation storage, but at least there would be some conservation storage remaining in the system to meet emergency needs. *Id.* at Figures 2, 3. The flow in the Apalachicola River at

Chattahoochee, Florida would not drop below 2,000 cfs, whereas if the IOP continues unabated, the flow will drop below 2,000 cfs for more than a month and will reach a low of under 1,000 cfs. *See* Exhibit 1 at Attachment A, Figure 15.

- If inflow is in the lower 2% for the remainder of 2007 and improves to 2000 hydrologic conditions in 2008, Lake Lanier will remain approximately eight feet higher throughout 2008 than the elevation that will result if the IOP is not modified. *See* Exhibit 1 at Attachment C, Figure 5.
- If inflow is in the lower 10% for the rest of 2007 and 2008, Lake Lanier would be approximately seven feet higher (1,054 versus 1,047 feet) as of the end of this year and would retain at least some conservation storage through most of 2008 to support Georgia's needs and provide at least some flow support at Chattahoochee, Florida. *See* Exhibit 1 at Attachment C, Figure 1. West Point and Walter F. George would remain slightly higher than under the IOP in 2008. *Id.* at Figures 2, 3.
- If inflow is in the lower 10% for the remainder of 2007 and improves to 2000 conditions in 2008, Lake Lanier will be approximately 10 feet higher as of the end of 2008. *Id.* at Figure 5. West Point and Walter F. George

would remain slightly higher than under the IOP for much of 2008. *Id.* at Figures 6, 7.

IV. ARGUMENT AND CITATION OF AUTHORITY

A. Legal Standard

The purpose of a preliminary injunction is "to protect a party from irreparable harm and to preserve the court's power to render a meaningful decision after a trial on the merits." *Alabama v. United States Army Corps of Engineers*, 424 F.3d 1117, 1127 (11th Cir. 2005). The traditional standard for issuing injunctive relief in the Eleventh Circuit requires that the moving party show: (1) a substantial likelihood of success on the merits; (2) that irreparable injury will be suffered if relief is not granted; (3) that the threatened injury outweighs the harm the relief would inflict on the non-movant; and (4) that entry of relief would serve the public interest. *Id.,* at 1128.[10]

[10] Some might characterize this motion as seeking a mandatory injunction and, as such, is governed by those cases holding that a higher standard must be met. But this is largely semantics: the State could move the Court for an order directing the Corps to *stop* operating the reservoirs in accordance with the IOP – a request for relief that would be unquestionably prohibitory but also would require the Court to enter far more coercive relief. Even under a higher standard, however, Georgia has met its burden.

B. <u>Likelihood of Success on the Merits</u>

"A substantial likelihood of success on the merits requires a showing of only *likely* or probable, rather than certain success." *Schiavo v. Schiavo*, 358 F. Supp. 2d 1161, 1163 (M.D. Fla. 2005). When the balance of the equities weighs in favor of issuing injunctive relief "the Plaintiff need only show a substantial case on the merits." *Id.* (internal quotation omitted).

In its *Georgia II* Amended Complaint (Case 3:07-md-00001-PAM-HTS, Doc. No. 15), the State of Georgia seeks judicial review of the IOP. Georgia alleges that the IOP should be set aside because it requires substantially higher releases from the federal reservoirs in the ACF Basin than have occurred in the past or that are "necessary or prudent" for the preservation of the endangered species. ¶ 8. Georgia further alleges that the IOP "was adopted without considering all relevant factors and without following the procedures prescribed for adoption of water control plans under applicable regulations." *Id.*

In the *Georgia II* complaint, and in statements to the Corps both before and after the filing of the *Georgia II* litigation, the State of Georgia has consistently maintained that the IOP was flawed because the Corps in formulating the IOP did not take into consideration the possibility of a sustained severe drought. *E.g., Amended Complaint,* ¶ 49. The evidence in the Administrative Record establishes without question that the Corps in fact did not anticipate a drought as severe as the one of 2007. As discussed above, none of the computer modeling that the Corps performed in connection with the development of the IOP showed reservoir levels or river flows as low as the system is now experiencing. If the Corps had considered more seriously the data and hydrologic modeling presented to the Corps by the State of Georgia and the ARC, it would have taken the possibility of a severe drought into consideration and adjusted the IOP's flow rules accordingly.

Under the APA, agency action is arbitrary and capricious if the agency "entirely failed to consider an important aspect of the problem." *Motor Vehicle Mfg. Assoc. v. State Farm Auto Ins. Co.,* 463 U.S. 29, 43 (1983). Though the recent weather has provided early proof of the severity of the Corps' error, the mistake was made when the IOP was formulated.

The Corps implemented the IOP under the assumption that the region would never experience a drought worse than what had been recorded in the past fifty years. Statisticians can prove that such an assumption is likely to be proven false in several years. Indeed, with the previous worst drought occurring in 2000 and 2001, and the second worst drought occurring in the 1980's, the Corps' guiding assumption in developing the IOP was that, contrary to the experience of the past twenty years, the ACF River Basin was about to enjoy a long period without a new record drought.

In addition, the Corps also failed to build into the IOP a "fail-safe" mechanism that would suspend the flow augmentation rules in the event that an exceptional or sustained drought threatened the ability of the system to meet basic needs. Taken at face value, the IOP requires the Corps to release 5,000 cfs -- a number that has never been justified from a biological perspective -- into the Apalachicola River even after the reservoirs have been emptied of all their storage. This is, of course, a physical impossibility. Yet, the Corps has in fact acknowledged that if these weather conditions persist, there will come a day when it simply runs out of water and can meet no flow requirement. But, until then, the Corps fully intends to release 5,000 cfs even though a lower release would clearly be more responsible for all the species, human and endangered, relying upon ACF River Basin.

There is, therefore, a substantial likelihood that the State of Georgia will prevail on its claim that the Corps' adoption of the IOP was "arbitrary and capricious" and should be set aside.

C. Irreparable Harm

There can be no dispute that the harm that the State of Georgia will endure if this motion is not granted is in every sense "irreparable." The harm will be irreparable -- in the sense that the granting of the motion is necessary to preserve the issue for trial -- because the failure to grant the motion during this extreme drought will in effect deny Georgia the relief it seeks on the merits -- which is relief from the IOP when the ACF Basin is experiencing an extreme drought. *See United States v. State of Alabama*, 791 F.2d 1450, 1459 (11th Cir. 1986) ("The purpose of a preliminary injunction is to prevent irreparable injury so as to preserve the court's ability to render a meaningful decision on the merits.") The harm will be irreparable -- in the sense that the losses sustained cannot be recovered in the future -- because, obviously, there is no way to put the water lost back into the system. Finally, the harm will be irreparable in the economic sense in that there will be no way to calculate the actual losses sustained by the State and its citizens who rely so heavily on the system. *See Phillips v. Crown Central Petroleum Corp.*, 602 F.2d 616, 630 (4th Cir. 1979) ("A future injury of uncertain date and incalculable harm is irreparable harm, and protection from such an injury is a legitimate end of injunctive relief."); *Danielson v. Local 275, Laborers International Union of North America*, 479 F.2d 1033, 1037 (2d Cir. 1973)

("Irreparable injury is suffered where monetary damages are difficult to ascertain or are inadequate.").

D. **Balance of Harms and the Public Interest**

Given the nature of the interests involved in this case, the considerations of the balance of harms and the public interest collapse: granting the motion is in the public interest because the benefits of granting the motion far outweigh its costs.

The benefit of granting the motion is that it will materially reduce the risk of a catastrophic loss of total system storage. *See* Part III, *supra*.

On the other side of the equation, granting the motion will unfortunately result in flows in the Apalachicola below 5,000 cfs. This harm is outweighed by the benefits for the following reasons.

First, except when the Adjusted Basin Inflows are over 5,000 cfs, the relief sought in this motion is simply to eliminate the augmentation of flows to the Apalachicola, not to reduce those flows to a level substantially below what would be occurring if there were no reservoirs. Second, there is little or no biological or environmental "magic" associated with the 5,000 cfs figure. The 5,000 cfs figure came from the Corps, not from the Fish and Wildlife Service. In fact, the Corps' stated purpose for the original 5,000 cfs flow in its water control plan was to assure "an adequate water supply for downstream industrial use." Affidavit of Dr. Doug

Otto, Case No. 90-1331 (N.D. Ala.), Doc. 502, Exhibit 1, at 7116. In the Biological Opinion, the Service did *not* conclude that 5,000 cfs was necessary for the survival of any endangered species. Instead, the Service took the 5,000 cfs figure from the Corps – and the reason the Corps had given for flows of 5,000 cfs was to sustain Florida's *industrial* use downstream – and concluded that flows of 5,000 cfs would not run afoul of the Endangered Species Act. *See* Declaration of Gail Carmody, Case No. 90-1331 (N.D. Ala.) Doc. 494, Exhibit 1, at p. 10.

The State of Georgia is not arguing that reduced flows in the Apalachicola will not cause some harm. But there is no evidence that it will cause a violation of the Endangered Species Act. Moreover, if the Corps' own projections are correct, keeping the flows at the artificial 5,000 cfs level will not be possible in any event if this severe drought conditions persists. If the motion is not granted, there is a significant risk that the Corps will empty the reservoirs and be physically unable to meet the 5,000 cfs flow requirement or the water supply needs up and down the ACF Basin. If there were enough water, of course flows of 5,000 cfs or greater would be beneficial. But that is not the choice. The choice is instead between emptying all the reservoirs now to meet the 5,000 cfs level for 100 days – the "eat, drink, and be merry" option – or saving what little storage is left to be able to survive this persistent and severe drought.

This motion is necessarily based upon projected rainfall and resulting hydrologic conditions. Those conditions may improve to an extent that the relief sought in this motion is no longer necessary to protect the system. If that occurs, the State of Georgia agrees that the issue should be revisited and the relief revised to the extent necessary. If the relief sought in this motion is not granted, however, and the projections prove accurate, the water storage necessary to survive a sustained drought will have already been lost. The balance of harms, and the public interest, clearly support the granting of this motion.

Georgia has conferred with the other parties regarding this motion. The Atlanta Regional Commission, Lake Lanier Association, and Gwinnett County support the motion, and Southeastern Federal Power Customers conditionally support this Motion. The City of Columbus, which is not yet a party but will become one if the Judicial Panel on Multidistrict Litigation transfers Columbus' suit against the Corps to this Court, also supports this Motion. The Federal Defendants, Florida, and Alabama, oppose the motion. All parties wish to be heard with regard to the Motion.

V. CONCLUSION

For the foregoing reasons, Georgia's Motion for Preliminary Injunction should be granted.

Respectfully submitted this 19th day of October, 2007.

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CERTIFICATE OF SERVICE

This is to certify that on this 19th day of October 2007, a true and correct copy of the foregoing MOTION OF THE STATE OF GEORGIA FOR PRELIMINARY INJUNCTION AND MEMORANDUM OF LAW IN SUPPORT was filed with the Clerk of the Court using the CM/ECF system, and was served upon counsel of record by all parties to this proceeding by electronic notification or by depositing copies thereof in United States Mail, postage prepaid, properly addressed to:

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UNITED STATES DISTRICT COURT
MIDDLE DISTRICT OF FLORIDA
JACKSONVILLE DIVISION

IN RE TRI-STATE WATER RIGHTS LITIGATION	Civil Action File No. 3:07-MD-1-PAM *State of Georgia v. United States Army Corps of Engineers*, No. 3:07-CV-251 (*Georgia II*)

DECLARATION OF CAROL A. COUCH, Ph.D.

I, CAROL A. COUCH, Ph.D., declare and state as follows:

1. I am over 21 years of age and am under no legal disability. I make this declaration of my own personal knowledge based upon information known to or made available to me in the execution of my professional responsibilities.

2. I am the Director of the Environmental Protection Division of the Georgia Department of Natural Resources (Georgia EPD).

3. As Director I am responsible for administering or enforcing 26 state statutes and 4 federally delegated authorities that are, in total, comprehensive of the protection of Georgia's air, land and water resources. I am responsible for administering Georgia's permitting programs for ground and surface water withdrawals, drinking water supply and quality, ambient surface water quality,

storm water, and dam safety. My office directs and coordinates Georgia's water conservation and drought management activities. I am chairperson of the Georgia Water Council which oversees the development of statewide water resource planning and policies.

4. I hold a Bachelor of Science Degree from the Georgia Institute of Technology, a Master of Science Degree in Biology from the University of South Carolina, and a Ph.D. in Ecology from the University of Georgia. I have sixteen years of experience in the conduct and management of water resources research and environmental protection. From 1992 to 1997 I was the lead biologist for the United States Geological Survey water quality study of the Apalachicola-Chattahoochee-Flint (ACF) river basin.

5. On October 12, 2007, I authored a letter to Colonel Byron Jorns, Commander of the Corps of Engineers' Mobile District, regarding climatic and hydrologic conditions in the ACF Basin, and Georgia's concerns about the Corps' continued operations under the Interim Operations Plan (IOP). That letter compiles information that I obtained from members of my staff, in particular Dr. Wei Zeng, specializing in the areas of basin hydrological assessment and modeling. The letter references and discusses computer simulations of the effect of the IOP and certain emergency modifications to the IOP through March 1, 2008.

A true and correct copy of that October 12, 2007 letter is attached to this Declaration as Attachment A. A copy of Colonel Jorns' response is attached hereto as Attachment B.

6. I requested that my staff perform further computer simulations of the IOP and emergency modifications that Georgia is now proposing, extend those simulations through the end of 2008. An October 19, 2007 memorandum from Feng Jiang of my staff providing that analysis also is attached to this Declaration as Attachment C.

7. For the six month period of March through August, 2007, a time when Georgia normally receives the majority of its precipitation, rainfall in the northern portion of the ACF Basin was the lowest on record, far eclipsing the droughts of 2000, 1988, and 1986.

8. Over the same six month period, rainfall within Climatic Division Four, which includes the Flint River Basin and the middle reach of the Chattahoochee River, has matched the levels of the year 2000 as the lowest on record.

9. Rainfall within Climatic Zone Seven, which includes the lower reach of the Chattahoochee River, was only slightly higher than in the drought of 1986 and was worse than in 2000 and 1988.

10. Final rainfall data for the month of September throughout the basin has not yet been made available, but current indications are that it was very dry. The United States Geological Survey recently released a fact sheet stating that "the 2007 drought in Georgia worsened during September, bringing many of the State's rivers and streams to their lowest levels ever recorded for the month." This fact sheet is available at the USGS web site, http://ga.water.usgs.gov/drought/drought_sept2007.pdf.

11. Low precipitation levels have resulted in record low basin inflow (total amount of flow entering the entire ACF system). The year 2000 saw the lowest basin inflows on record as of that time for the May to September period. Calculations made by Georgia EPD indicate that the May through September cumulative flow in 2007 is 15% to 20% lower than in 2000.

12. Conditions are not projected to improve any time soon. In September, the Southeast Climate Consortium forecasted that La Nina conditions were developing. This information is available on the Consortium's website at http://www.agclimate.org/Development/apps/agClimate/controller/perl/agClimate.pl/agClimate.pl?function=climforecast/current.html&location=local&type=html&primary=2&major=1&sub=1. This means that the southeast region should expect a drier and warmer cool season (October 2007 through March 2008).

13. Among my responsibilities are administering state statutes and rules governing water conservation and drought management. Georgia has an active and aggressive commitment to water conservation. Georgia mandates and enforces year-round, statewide limitations on outdoor water use that apply regardless of drought status. Additional restrictions on outdoor water use are implemented as described in the Georgia Drought Management Plan. The Drought Plan was adopted by the Georgia Board of Natural Resources in March 2003 and includes both pre-drought mitigation, conservation strategies and drought response strategies.

14. In response to these exceptional drought conditions, on September 28, 2007, Georgia EPD took the unprecedented step of imposing the highest level of restrictions on water use in our state's history. Since imposing these restrictions, we have already seen a dramatic 15% drop in water use in the Atlanta metro area alone. Alarmed by the reality that the water sources they rely on are being drained, many communities and industries have gone beyond the state ban on outdoor watering by limiting other water uses and implementing even more rigorous conservation measures.

15. No specific restrictions on agricultural water use are currently in effect for the remainder of this year and the first two months of 2008, in part

because agricultural consumption during the October-February timeframe is minimal. If drought conditions persist as projected, I have determined that it is likely that in 2008, I will declare a drought under the Flint River Drought Protection Act, which is codified at O.C.G.A. § 12-5-540 through 12-5-550.

16. As we continue to monitor the drought and our water supplies, we will consider the additional, emergency measures that are legally available to the State and local governments and determine any that need to be taken.

17. Under Georgia statute I am responsible for enforcing compliance with the Water Conservation Program adopted by the Metropolitan North Georgia Water Planning District (MNGWPD). The MNGWPD is comprised of sixteen counties in the metropolitan region of Atlanta and serves a population of greater than 4 million. Water conservation measures adopted and aggressively practiced in the MNGWDP include conservation pricing, rain sensor shut-off switches on irrigation systems, sub-unit water metering, leak detection programs, residential and commercial water audits, and public awareness and education programs.

18. The 2007 drought has taken a serious toll on the federal reservoirs located in Georgia. To make matters worse, the Corps has been operating under the IOP this year. The IOP has required the Corps to release essentially all of the

basin inflow entering the system and exhaust large quantities of storage to maintain a minimum flow of 5,000 cfs at Chattahoochee, Florida.

19. The Corps spent a great deal of storage controlling rampdowns after rainfall events and has released a significant quantity of water in excess of even what the IOP requires.

20. The current basin inflow to the ACF system is around 2,000 cfs. The Corps has been releasing an average of approximately 2,600 cfs-day of system storage to meet the flow requirement of 5,000 cfs. If basin inflow does not improve significantly in the near future, this level of augmentation will deplete the system storage in a matter of 100 days.

21. By calculations made by Georgia EPD, as of October 11, 2007, the Corps had used more than 600,000 acre-feet of storage to support flow at Chattahoochee, Florida over the prior 5 months.

22. During an ACF Basin drought conference call with stakeholders several weeks ago, the Corps of Engineers announced that in light of the record-low rainfall and inflows, it had modeled the effect of the IOP over the next three months assuming the hydrological scenarios: that basin inflow for each day will be at the (a) 2% non-exceedence level (that is, basin inflow will be within the lowest 2% in history), (b) 5% non-exceedence level, and (c) 10% non-level.

23. On October 4, 2007, the Corps provided the State of Georgia with those computer models. The Corps modeling of the 10% hydrology indicates that Lake Lanier would fall to 1052 feet by the end of December 2007 and to 1044 by February 2008, while West Point Lake and Lake Walter F. George will remain around the bottom of their conservation pools.

24. If one assumes that basin inflow will be at the 5% or 2% levels, the results will be even worse. Lake Lanier would fall as low as 1039 feet by the end of this year and would empty before the end of January 2008. West Point and Walter F. George would be empty beginning in November and would remain empty through next February. In addition, the Corps' own modeling results show that when all conservation storage is depleted, the 5,000 cfs flow in the Apalachicola River would not be maintained and would fall well below 1,000 cfs.

25. The models do not take into account the effect of the IOP's rampdown limitations, which cause the Corps to draw from storage to limit river fall rates following rainfall events. Those rampdown restrictions can cause rainfall events to deplete, rather than enhance storage, particularly where the rainfall occurs below one or more of the federal reservoirs.

26. The Cities of Gainesville, Buford, Cumming, the Town of Flowery Branch, and Gwinnett and Forsyth County withdraw water directly from Lake

Lanier to meet their municipal and industrial water supply needs. In addition, the City of Atlanta, Fulton County, Cobb County-Marietta Water Authority, and other local government utilities depend upon releases from Lake Lanier to provide a flow in the Chattahoochee River to allow them to withdraw water for municipal and industrial needs. Georgia EPD estimates that approximately 2.85 million people in the Atlanta area depend upon Lake Lanier and the upper Chattahoochee River to meet their water supply needs. The City of Gainesville relies on the waste assimilative capacity of Lake Lanier in making its returns of treated effluent to the Lake, and the City of Atlanta, Counties of Cobb and Gwinnett, and other local governments in the metropolitan area rely on the Corps to maintain a flow of 750 cfs in the Chattahoochee River to maintain the waste assimilative capacity of the River.

27. According to the best information made available to me, the water shared supply intake for Forsyth County and the City of Cumming withdraws at levels of 1053 feet and 1048 feet. As the lake falls below 1053, Forsyth and Cumming lose approximately one-third of their pumping capacity. The other two-thirds will be lost at an elevation below 1048 feet. The City of Buford has intakes at 1062, 1052, 1042, and 1032 feet and would experience serious hydrological problems with their intake at an elevation of 1035 feet.

28. The City of LaGrange will also incur substantial hardship as West Point Lake continues to drop. The city operates with intakes at levels 628, 623, 618, and 600 feet. Current lake elevations are at 621.88 (midnight on October 19), which leaves the top two intakes out of the water. There is an older intake at 582, but to the best of our knowledge it has never been used and is probably not functional. In addition, the low lake levels have increased blue-green algae outbreaks, which causes significant increases in treatment costs and other water supply problems. Also at West Point Lake, virtually all shoreline related recreation and most surface use has been eliminated. Damage to marinas and residential docks and boats is extensive. Marinas, almost all boat ramps, campgrounds, beaches and other facilities are no longer accessible or usable. I understand that studies performed at the direction of the City of LaGrange estimate a current economic impact of $243 million as a result of the current low lake levels.

I certify under penalty of perjury that the foregoing is true and correct.

Executed on October 19, 2007.

Carol A. Couch

Carol A. Couch, Ph.D.

Georgia Department of Natural Resources
2 Martin Luther King Jr., Drive, Suite 1152 East Tower, Atlanta, Georgia 30334
Noel Holcomb, Commissioner
Carol A. Couch, Ph.D., Director
Environmental Protection Division
(404) 656-4713

October 12, 2007

Col. Byron Jorns
Commander and District Engineer
Department of the Army
Mobile District, Corps of Engineers
190 Saint Joseph Street
Mobile, Alabama 36602-3630

Re: Request for Immediate Alteration of IOP Releases

Dear Colonel Jorns:

Since I last wrote to you on September 14, 2007 concerning the status of the federal reservoirs within the Apalachicola-Chattahoochee-Flint (ACF) River Basin, conditions have deteriorated. Reservoir storage is falling to levels not seen in decades, and the climatic forecasts through next winter suggest that the drought will worsen. The Corps' own computer modeling shows that under these conditions, if the Corps continues to operate under the existing Interim Operations Plan (IOP), there is serious risk that the reservoirs will be drained of all conservation storage. If that occurs, there will be severe water shortages for millions of Georgians, and the flow in the Chattahoochee and Apalachicola Rivers will fall dramatically below current levels, harming the biological species that depend on those flows. The Corps must take action now to avert this catastrophe.

Below I provide information concerning 2007 climatic and hydrologic conditions and review the projections of conditions through next February if the Corps continues to operate according the existing IOP. These data lay bare the conclusion that the IOP must be adjusted immediately pending discussions over longer-term modifications. Accordingly, I propose specific short-term adjustments of the IOP and provide the computer modeling showing the relief that this adjustment may provide.

THE DROUGHT OF 2007

Taken together, climatic and hydrologic conditions show that this is the worst drought of record. The ACF Basin in Georgia mainly falls within Climatic Divisions Two, Four, and Seven, with small portions of it in Climatic Divisions 1, 3, 5, and 8. Figure 1 illustrates how precipitation within these Climatic Divisions during March through August of this year compares with the commonly recognized prior droughts of record. For the six month period of March through August, a time when Georgia normally receives the majority of its precipitation, cumulative rainfall deficit in Climatic Divisions Two, which include the northern portion of the ACF Basin was the worst in the past half century, far eclipsing the droughts of 2000, 1988, and 1986. Over the same months, cumulative rainfall deficit within Climatic Division Four, which includes the upper Flint River Basin and the middle reaches of the Chattahoochee River, has matched the

Attachment A

levels of the year 2000 as the lowest in the past half century. Rainfall within Climatic Zone Seven, which includes the lower reaches of the Chattahoochee River and the Flint River, was only slightly higher than in the drought of 1986 and was worse than in 2000 and 1988.

We do not yet have final rainfall data for the month of September throughout the basin, but we know it was very dry. The United States Geological Survey recently released a fact sheet stating that "the 2007 drought in Georgia worsened during September, bringing many of the State's rivers and streams to their lowest levels ever recorded for the month." This fact sheet is available at the USGS web site, at http://ga.water.usgs.gov/drought/drought_sept2007.pdf.

Low precipitation levels have resulted in extremely low stream flows across the ACF Basin (Figures 2 through 5 showing the lowest average flow in the period May through August) and record low basin inflow (total amount of flow entering the entire ACF system). Figure 6 compares basin inflow for the years 2007 and 2000. The year 2000 saw the lowest basin inflows on record as of that time for the May to September period. Our calculations indicate that the May through September cumulative flow in 2007 is 15% to 20% lower than in 2000.

Conditions are not projected to improve any time soon. Several weeks ago, the Southeast Climatologist Consortium forecasted that La Nina conditions were developing. This means that we should expect a drier and warmer cool season (October 2007 through March 2008). We did not experience a La Nina following or during the most severe drought years in the past. This means that it is very likely that we will see the drought worsen in the next few months and may well experience further record-breaking conditions in 2008.

ACF RESERVOIRS AT SERIOUS RISK OF DEPLETION

The 2007 drought has taken a serious toll on the federal reservoirs. To make matters worse, the Corps has been operating under the IOP this year. The IOP has required the Corps to release essentially all of the basin inflow entering the system and exhaust large quantities of storage to maintain a minimum flow of 5,000 cfs at Chattahoochee, Florida. The Corps spent a great deal of storage controlling rampdowns after rainfall events, and has released a significant quantity of water in excess of even what the IOP requires.

The current basin inflow to the ACF system is around 2,000 cfs, which means that the Corps has to use 3,000 cfs-day (or 6,000 acre-feet) of system storage to meet the flow requirement of 5,000 cfs. If basin inflow does not improve significantly in the near future, this level of augmentation will deplete the system storage in a matter of 117 days.

As of October 11, 2007, the composite storage of the entire ACF system (the sum of remaining conservation storage from Lanier, West Point, and Walter F. George) is down to 702,907 acre-feet, or 42.9% of the system capacity. (See Figure 7.) By comparison, system storage was at 1.39 million acre-feet on May 1, 2007. By our calculations, the Corps has used more than 600,000 acre-feet of storage to support flow at Chattahoochee, Florida over the past 5 months.

As of October 11, 2007, the elevation at Lake Lanier, the largest storage reservoir and the primary source of drinking water for over four million of people in Georgia, is down to 1057.9 feet. This is more than thirteen feet below its normal pool level and is 2.7 feet lower than the elevation when I last wrote you on September 14 of this year. West Point Lake elevation is at 622.2 feet. This is approximately thirteen feet below its normal pool level, and only two feet

Attachment A

away from the bottom of its conservation pool. Elevation at Lake Walter F. George is at 185.2 feet, which is only a foot away from its inactive storage.

GEORGIA'S CONSERVATION MEASURES

Georgia takes seriously its obligation to conserve water under these drought conditions. In response to these exceptional drought conditions, on September 28, 2007, I took the unprecedented step of imposing the highest level of restrictions on water use in our state's history. Since imposing these restrictions, we have already seen a dramatic 15% drop in water use in the Atlanta metro area alone. Alarmed by the dire reality that the water sources they rely on are being drained and that they may not be refilled anytime soon, many communities and industries have gone beyond the state ban on outdoor watering by limiting other water uses and implementing even more rigorous conservation measures.

No specific restrictions on agricultural water use are currently in effect for the remainder of this year and the first two months of 2008, in part because agricultural consumption during the October-February timeframe is minimal. If drought conditions persist as projected, however, it is likely that prior to March 2008 I will declare a drought under the Flint River Drought Protection Act and trigger the agricultural demand reduction measures under that statute.

As we continue to monitor the drought and our water supplies, we will consider the additional, emergency measures that are legally available to the State and local governments and determine any that need to be taken. Reducing and managing consumptive demands is a major focus of our drought response and emergency planning.

MODELING AND PROJECTION OF THE ACF RESERVOIRS

We have continued to update our computer models of the potential impact of the IOP going forward, particularly over the next several months. During an ACF Basin drought conference call with stakeholders several weeks ago, the Corps of Engineers announced that it in light of the record-low rainfall and inflows, it had modeled the effect of the IOP over the next three months assuming the hydrological scenarios: that basin inflow for each day will be at the (a) 2% non-exceedence level (that is, basin inflow will be within the lowest 2% in history), (b) 5% non-exceedence level, and (c) 10% non-exceedence level. On October 4, 2007, the Corps provided us with those computer models. These models, the outputs of which are shown in the attached Figures 8 through 11, paint a very grim picture. Assuming that basin inflow will be at the 10% level, Lake Lanier would fall to the extreme level of below 1048 feet by the end of this year (and 1044 feet by the end of February 2008, as shown in Figures 8 and 16). Both West Point Lake and Lake Walter F. George would hover around the bottom of their conservation pools from late November through at least the first two months of 2008 (Figures 9, 10, 17, and 18). If one assumes that basin inflow will be at the 5% or 2% levels, the results will, of course, be even worse. Lake Lanier would fall as low as 1039 feet by the end of this year and would empty before the end of January 2008 (Figure 12). West Point and Walter F. George would be empty beginning in November and would remain empty through next February (Figures 13 and 14). Of course, the serious effects of draining the lakes would be felt throughout 2008 and perhaps for years to come.

The effects of draining the federal reservoirs to these levels would be felt throughout the ACF Basin. Water supply intakes in Lake Lanier begin to be exposed as the Lake falls to the lower

Attachment A

1050's. At a level of 1039 feet, nearly all water supply intakes would be exposed, and at 1035 feet the lake is effectively empty and unable to provide for any water supply or flow augmentation. Water supply intakes at West Point Lake would be in jeopardy at the projected lake levels. At the bottom of the Basin, the flow in the Apalachicola River would plummet below the 5,000 cfs flow that the Corps has expended so much storage to maintain. Using the Corps' model, we see that at the 5% and 2% basin inflow levels, the flow in the Apalachicola River at the Chattahoochee gage falls to well below 1,000 cfs (Figure 11). As under any of these scenarios the lakes will begin next year extremely low and not have an appreciable opportunity to refill, it is reasonable to expect that the flow in the Apalachicola River would fall even lower in 2008.

NECESSARY SHORT-TERM MODIFICATIONS TO THE IOP

The foregoing illustrates that if the Corps continues to expend massive quantities of reservoir storage to provide a flow of 5,000 cfs, and not to store a substantial amount of the basin inflows, it will risk creating widespread water supply shortages affecting millions of people within Georgia and a steep drop in the flows available to meet the needs of endangered species in the Apalachicola River. Informed by this data, the Corps clearly has no choice but to alter its ACF reservoir operations immediately.

It is apparent that the Corps must cease immediately augmenting basin inflows for the production of any specific minimum flow in the Apalachicola River. While basin inflows are below 5,000 cfs, the Corps should only make releases from Jim Woodruff Dam equivalent to basin inflow. When rainfall events produce a basin inflow in excess of 5,000 cfs, the Corps should release no more than 5,000 cfs. The flow in the Apalachicola River has been at the 5,000 cfs level essentially all summer and early fall. Temporary pulses of more than 5,000 cfs in reaction to rainfall events will provide no benefit to the endangered species that the Corps is seeking to protect. The Corps should eliminate any rampdown restrictions. While flows are within the range of 5,000 cfs or less, the reduction in flows will roughly follow natural drops and will not be severe. Moreover, rampdown restrictions have the perverse effect of causing reservoir storage to fall after rainfall events, as the amount of storage used during the rampdown often exceeds the amount of any storage gained during the rainfall event.

The modeling of these adjustments to the IOP indicates that they will significantly benefit the federal reservoirs and help prevent a more precipitous drop in the flow in the Apalachicola River. Figures 12 through 15 compare the projected results of these modified reservoir operations against the IOP assuming that basin inflow at the 2% non-exceedence level, and Figures 16 through 19 make the same comparison at the 10% non-exceedence level.

Assuming basin inflows at the 2% level, these modifications to the IOP would keep Lake Lanier approximately ten feet higher at the end of this year and through February 2008, and would prevent West Point Lake and Walter F. George from emptying this year. The modeling suggests that modifications to reservoir balancing would be needed under this scenario to prevent West Point and Walter F. George from reaching the bottom in 2008. Under these assumptions, after an initial drop, the flow in the Apalachicola River would be more stable than under the IOP, and the minimum flow in the Apalachicola River would be more than 1,000 cfs higher than the minimum flow that would be experienced under the IOP. Thus, there are benefits throughout the basin.

Attachment A

Assuming the more optimistic scenario that basin inflow at the 10% level, Lake Lanier would be approximately seven feet higher as of the end of the year if the IOP is modified and would be more than ten feet higher at the end of February 2008. As with the 2% basin inflow scenario, the proposed modifications would save West Point Lake and Lake Walter F. George from emptying this year, just barely, and would produce more significant benefits to those lakes in January and February of 2008. At the 10% basin inflow level, the flow in the Apalachicola River would be near the 5,000 cfs level most of the time as basin inflow would be at or above 5,000 cfs for much of that time. Under this scenario, the significant benefits to reservoir storage outweigh the reduction in flow in the Apalachicola River.

DISCUSSIONS ON LONGER-TERM MODIFICATIONS SHOULD BEGIN NOW

The above changes are proposed as immediate and short-term, to avoid exhaustion of reservoir storage over the next four and a half months. These, of course, are not the only or final modifications that will be needed to the IOP. The experience of this year demonstrates that significant long-term, year-round adjustments to the IOP are needed. If the Corps does not make changes to the rules that will apply during the next Gulf sturgeon spawning period (March-May) and the remainder of next year, we may well end up in the same spot next year, or even worse. The above changes will, however, address the emergency situation and give the Corps an opportunity to undertake discussions with the Fish and Wildlife Service and the affected States on the longer-term changes that are needed. Georgia commits to be fully engaged in such discussions and encourages the Corps to include Florida and Alabama in considering longer-term modifications.

REQUEST FOR RESPONSE

In light of the exigent circumstances, I need your prompt response to this request for specific alteration of the reservoir operating rules under the IOP. Given that time is of the essence, please inform me in writing no later than October 17, 2007 as to whether you intend to make these changes so that Georgia can assess its options.

Sincerely,

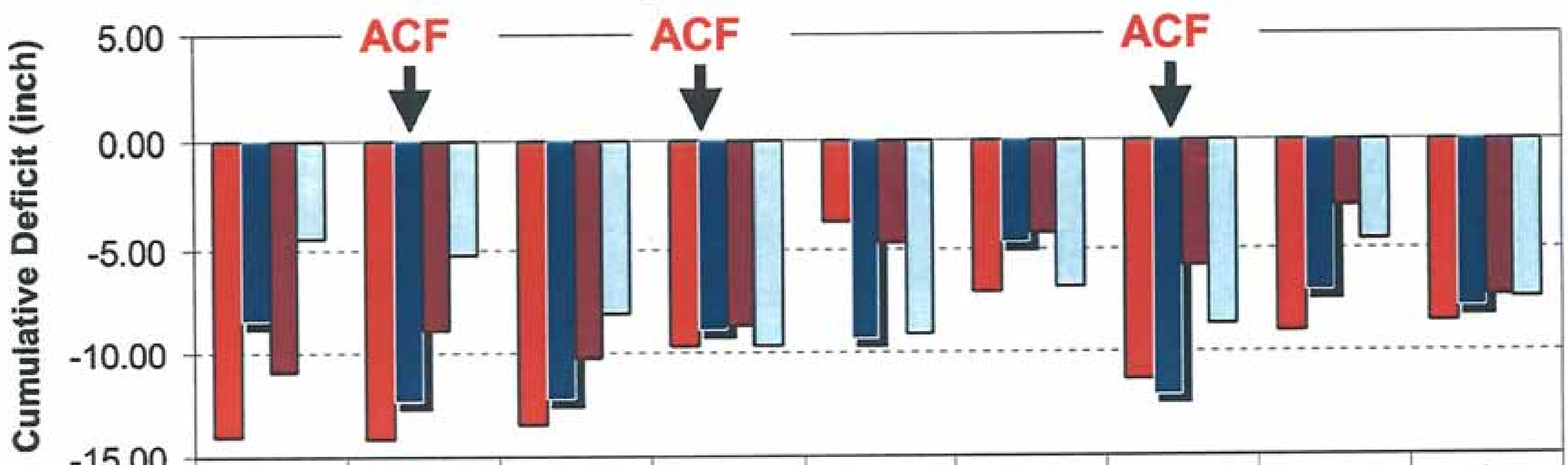
Carol A. Couch

Carol A. Couch

cc: Brigadier General Joseph Schroedel, South Atlantic Division, U.S. Army Corps of Engineers
Governor Sonny Perdue
Ms. Joanne Brandt, Corps of Engineers Inland Environmental Team
Mr. Onis Trey Glenn, Alabama Department of Environmental Management
Mr. Michael Sole, Secretary, Florida Dept. of Environmental Protection

Attachment A

Cumulative Mar-Aug Precipitation Deficits (2007, 1986, 1988 and 2000) in Georgia Climatic Divisions



	1	2	3	4	5	6	7	8	9
2007	-13.98	-14.13	-13.39	-9.59	-3.73	-7.08	-11.29	-9.00	-8.47
1986	-8.35	-12.26	-12.15	-8.84	-9.32	-4.77	-12.06	-7.05	-7.86
1988	-10.83	-8.82	-10.18	-8.64	-4.71	-4.22	-5.79	-3.09	-7.24
2000	-4.49	-5.31	-8.05	-9.60	-9.03	-6.81	-8.58	-4.61	-7.41

Climatic Division

Fig. 1 Six-month precipitation deficits in Georgia Climatic Divisions as compared to those of previous severe drought years

Attachment A

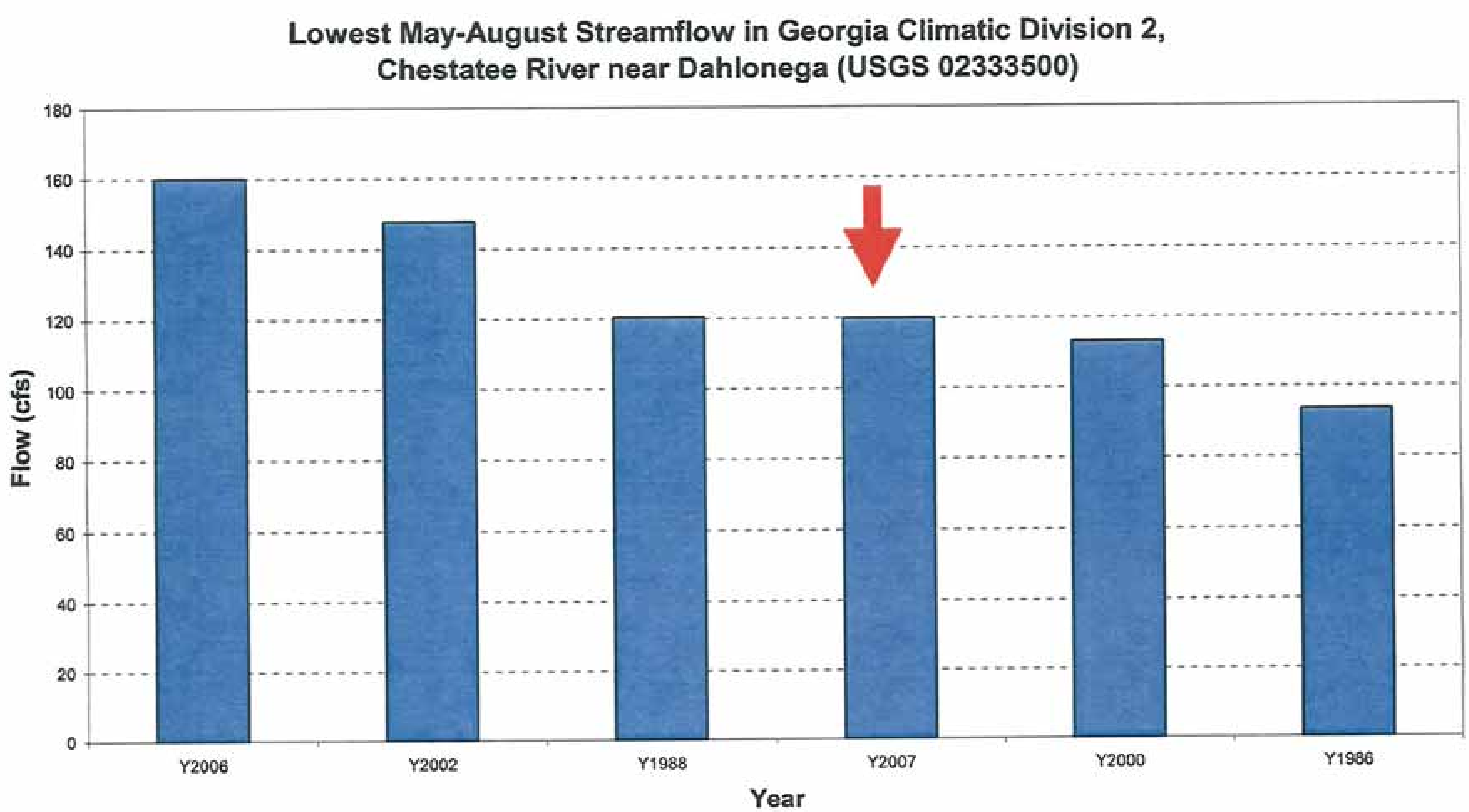


Fig. 2 Low stream flow at Chestatee River in 2007 as compared to those in previous severe drought years

Attachment A

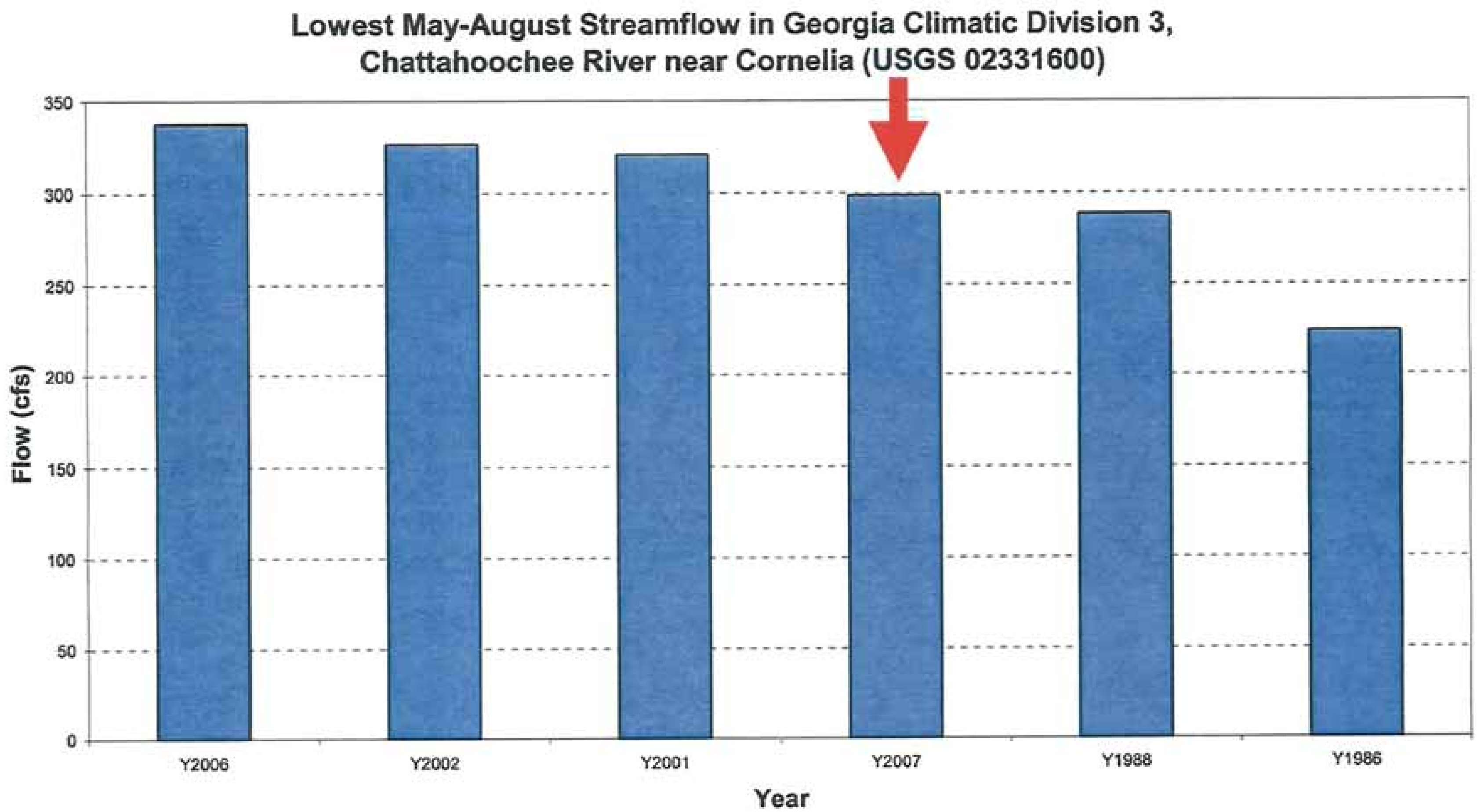


Fig. 3 Low stream flow at Chattahoochee River in 2007 as compared to those in previous severe drought years

Attachment A

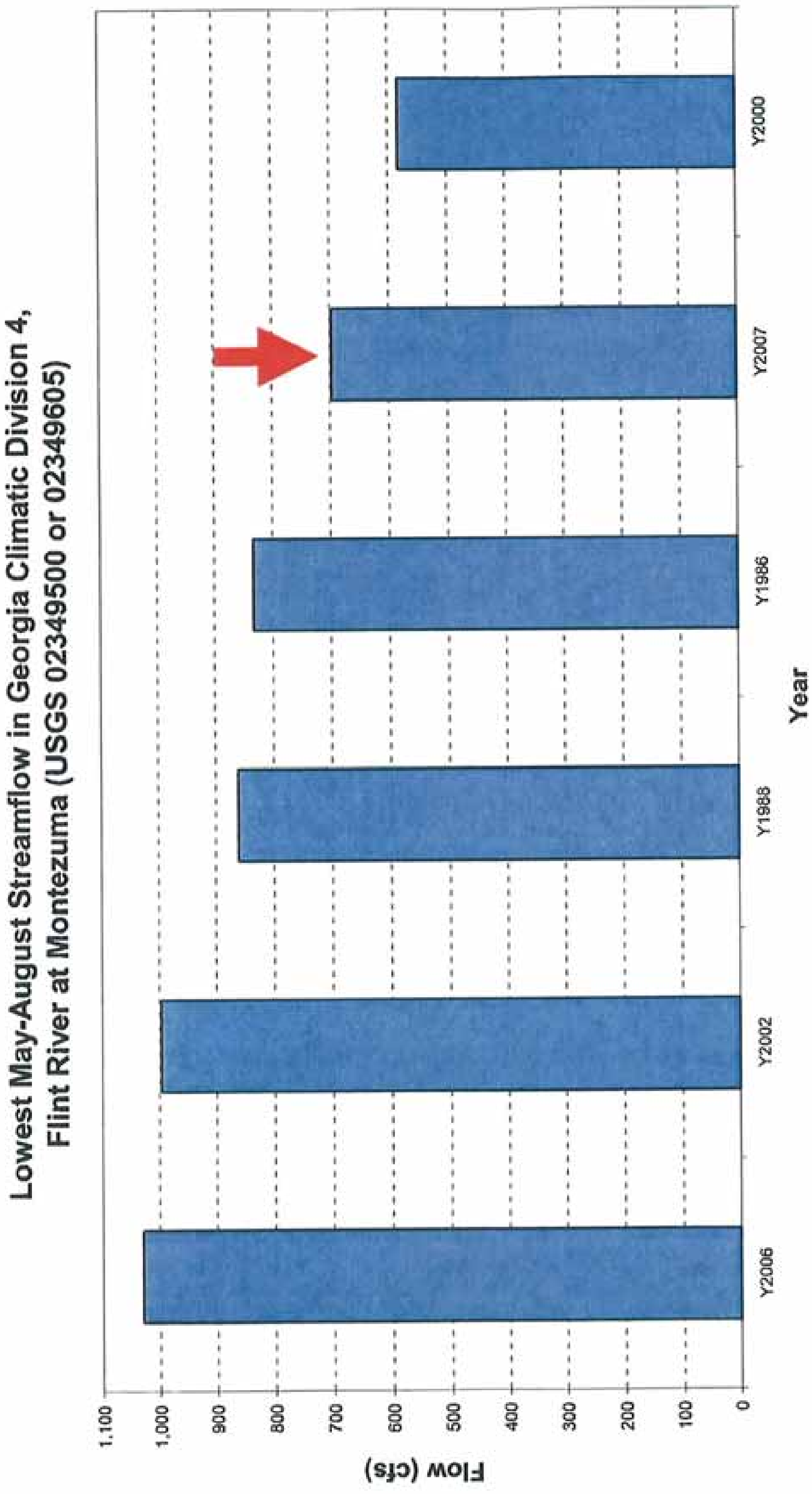


Fig. 4 Low stream flow at Flint River in 2007 as compared to those in previous severe drought years

Attachment A

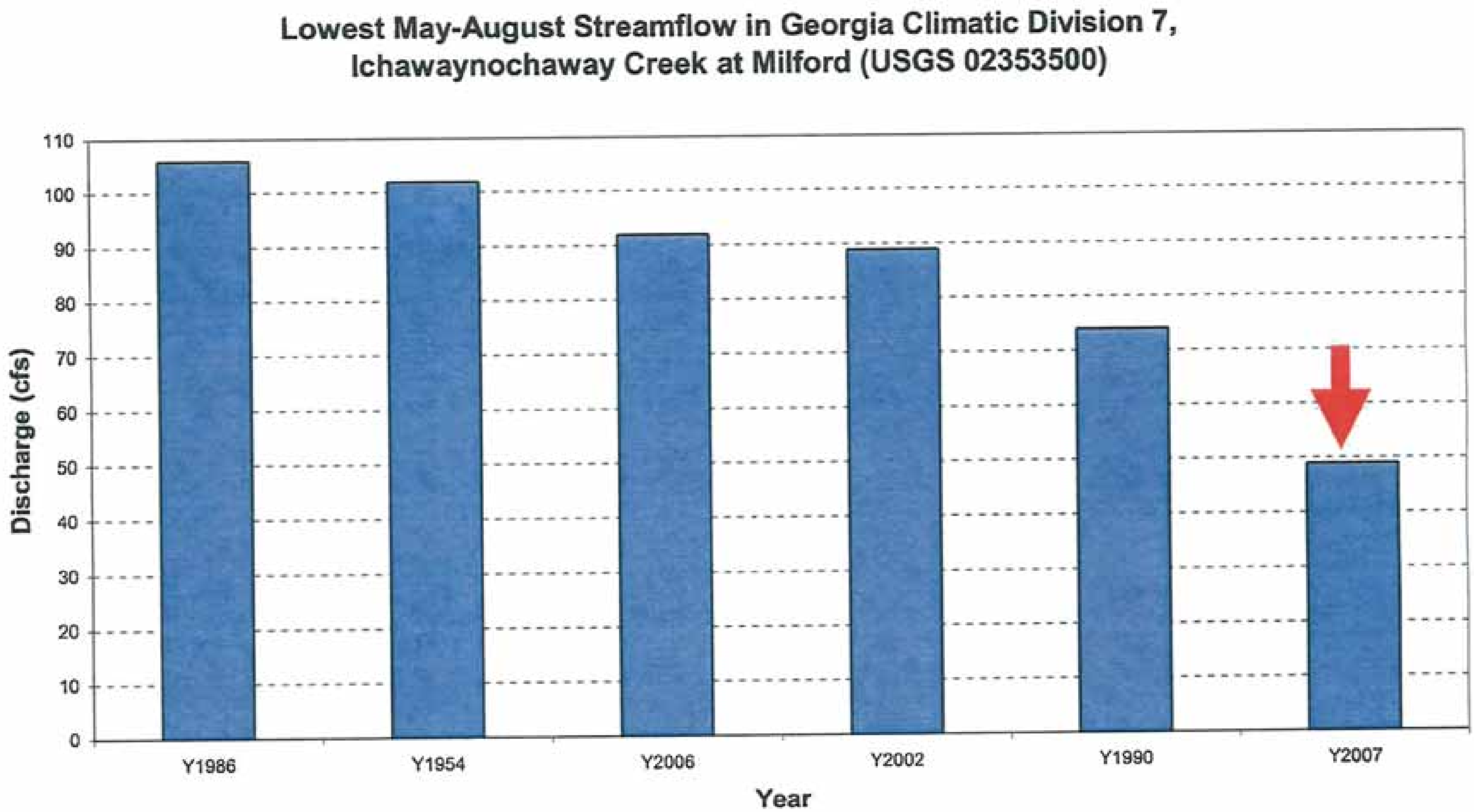


Fig. 5 Low stream flow at Ichawaynochaway Creek in 2007 as compared to those in previous severe drought years

Attachment A

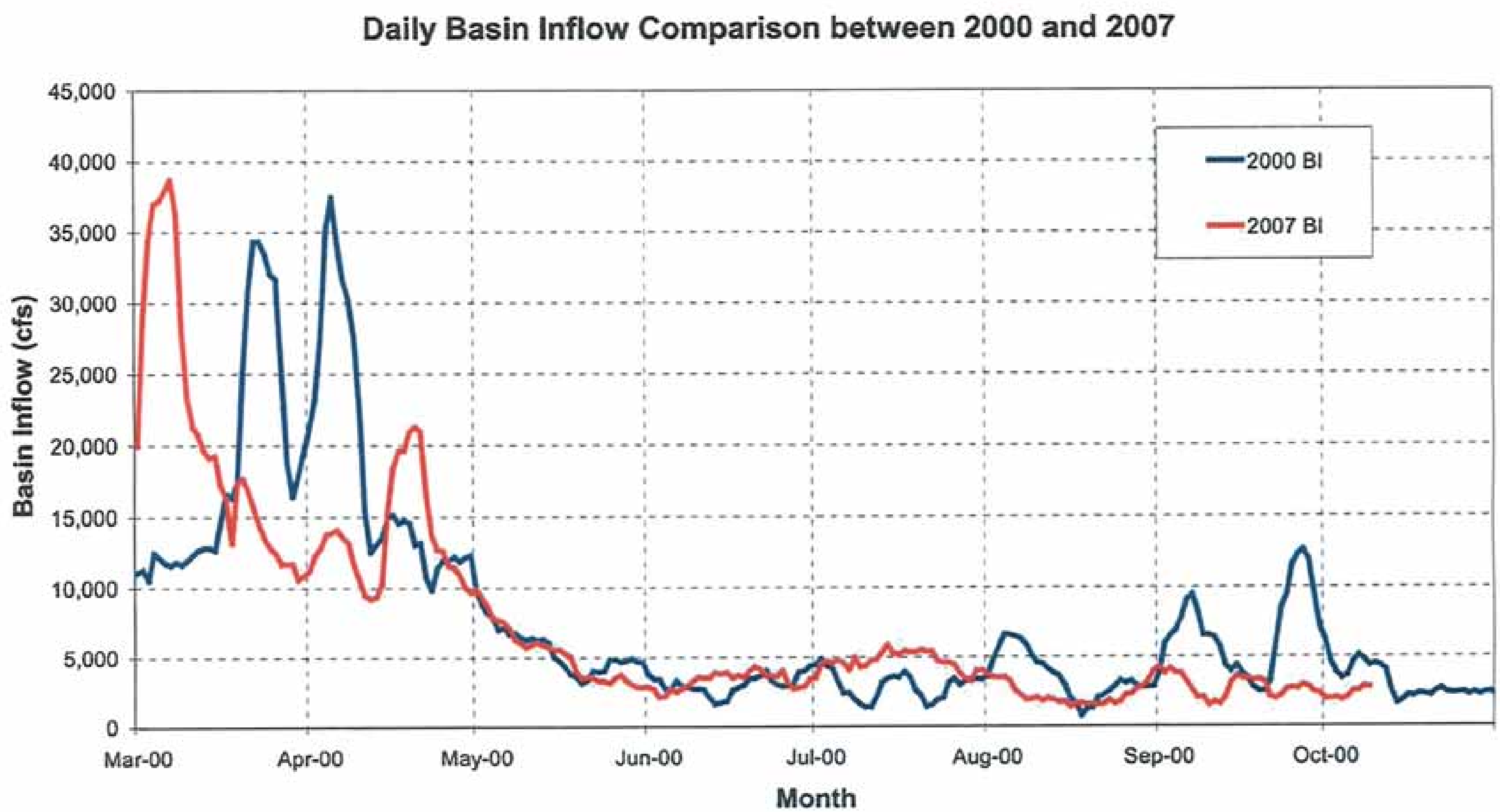


Fig. 6 Basin Inflow of 2007 compared to that of 2000

Attachment A

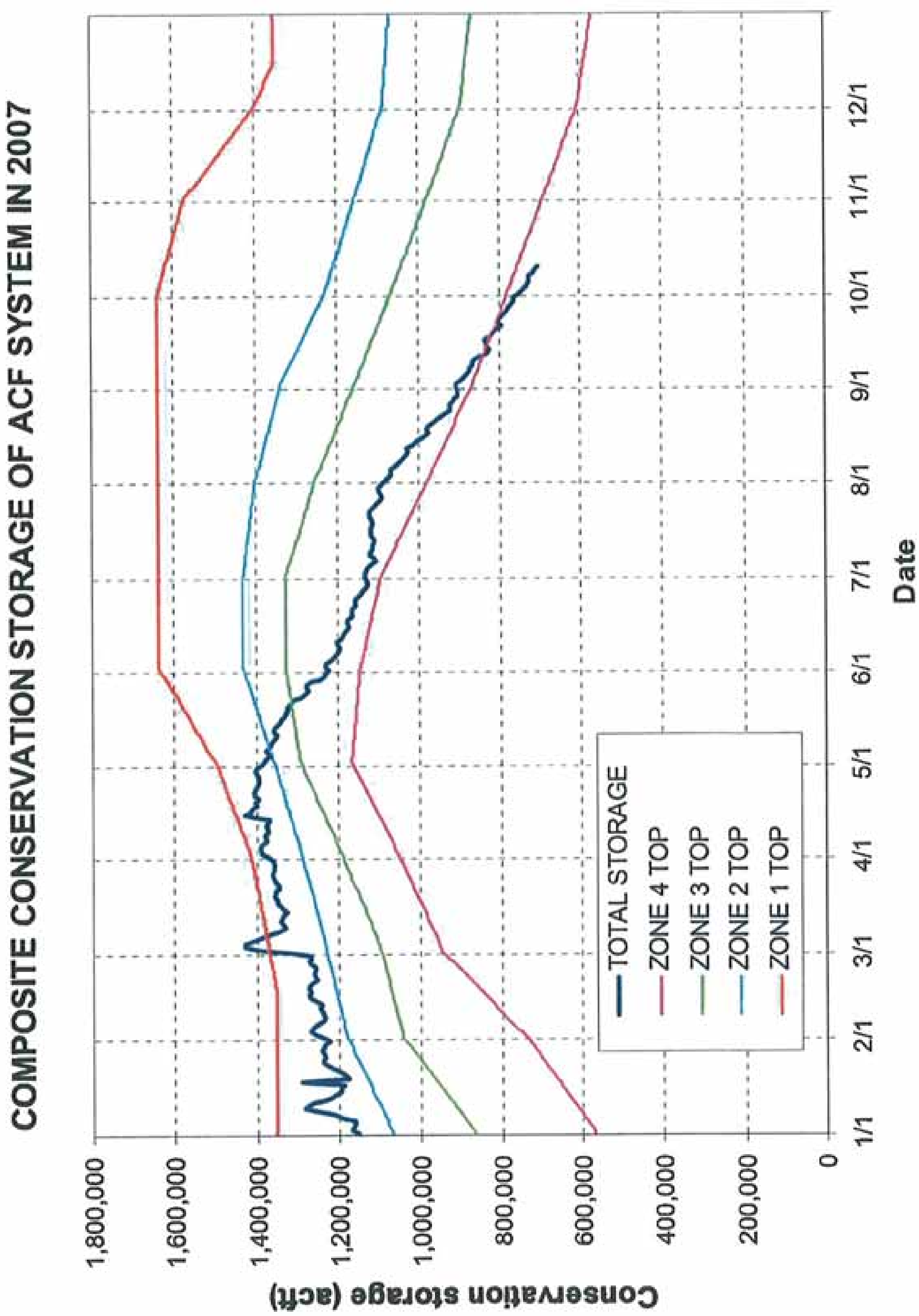


Fig. 7 Composite system storage in the ACF Basin in 2007

Attachment A

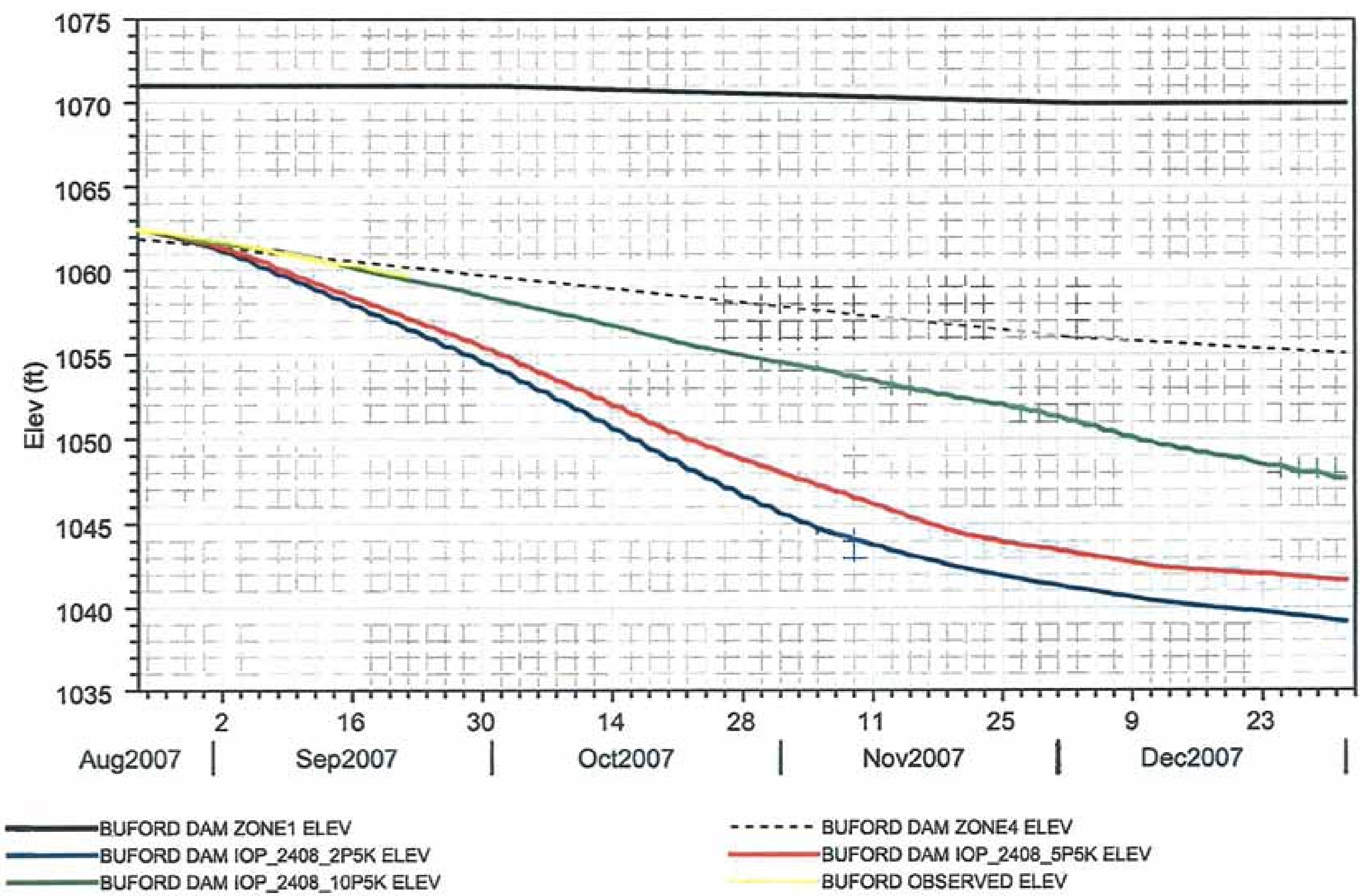


Fig. 8 Year 2007 Lanier elevation projected by the Corps of Engineers

Attachment A

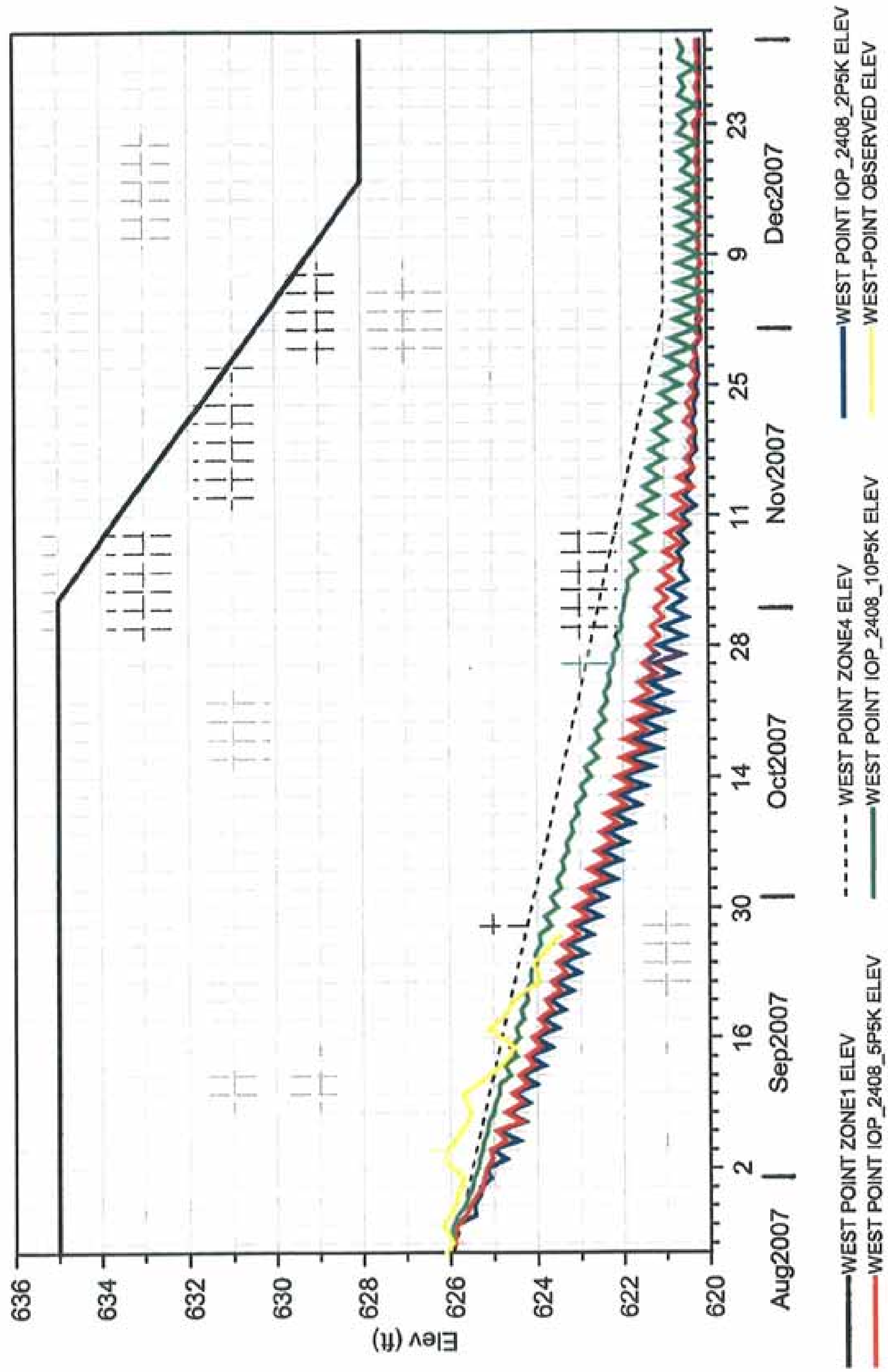


Fig. 9 Year 2007 West Point elevation projected by Corps of Engineers

Attachment A

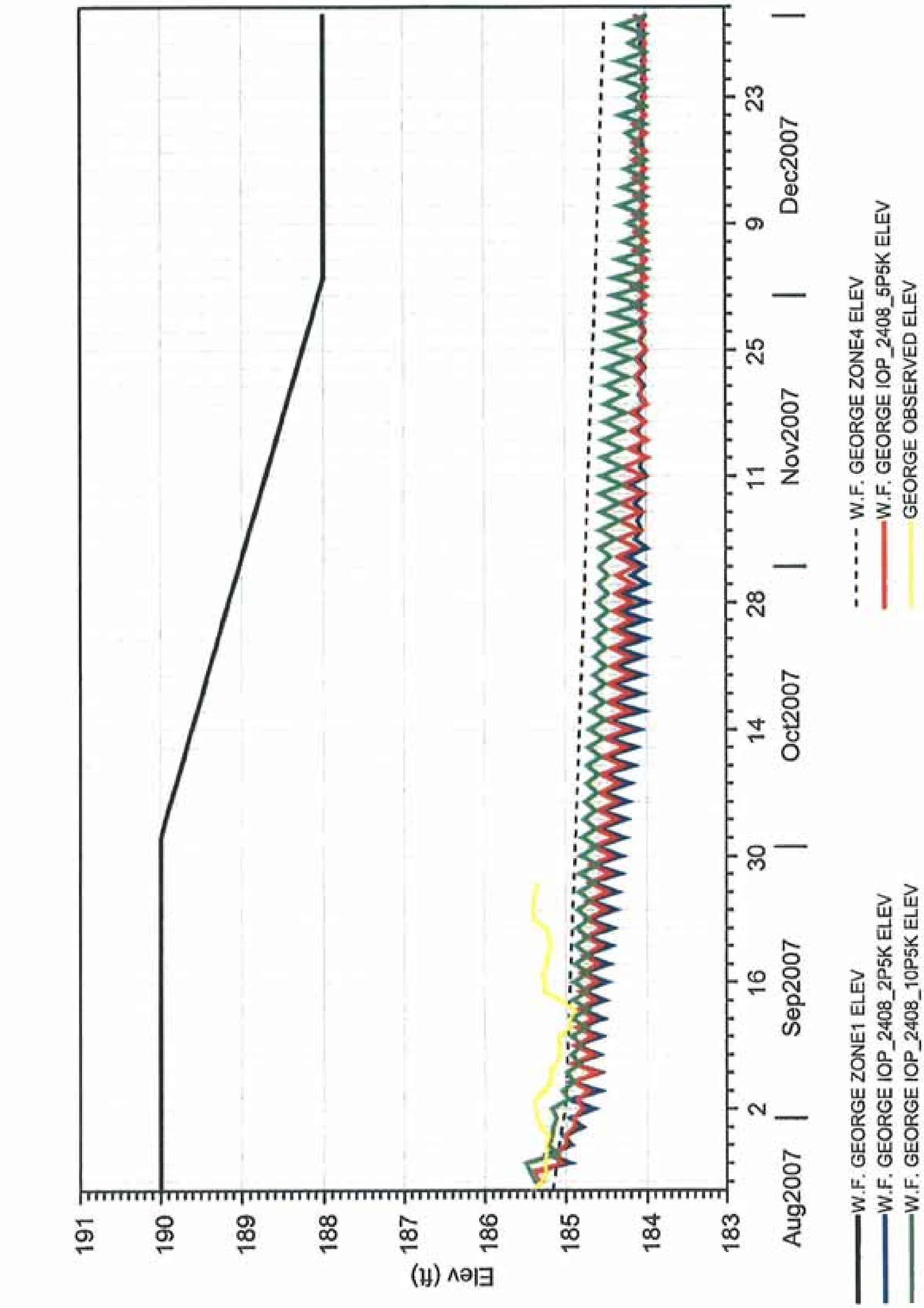


Fig. 10 Year 2007 Walter F. George elevation projected by Corps of Engineers

Attachment 1A

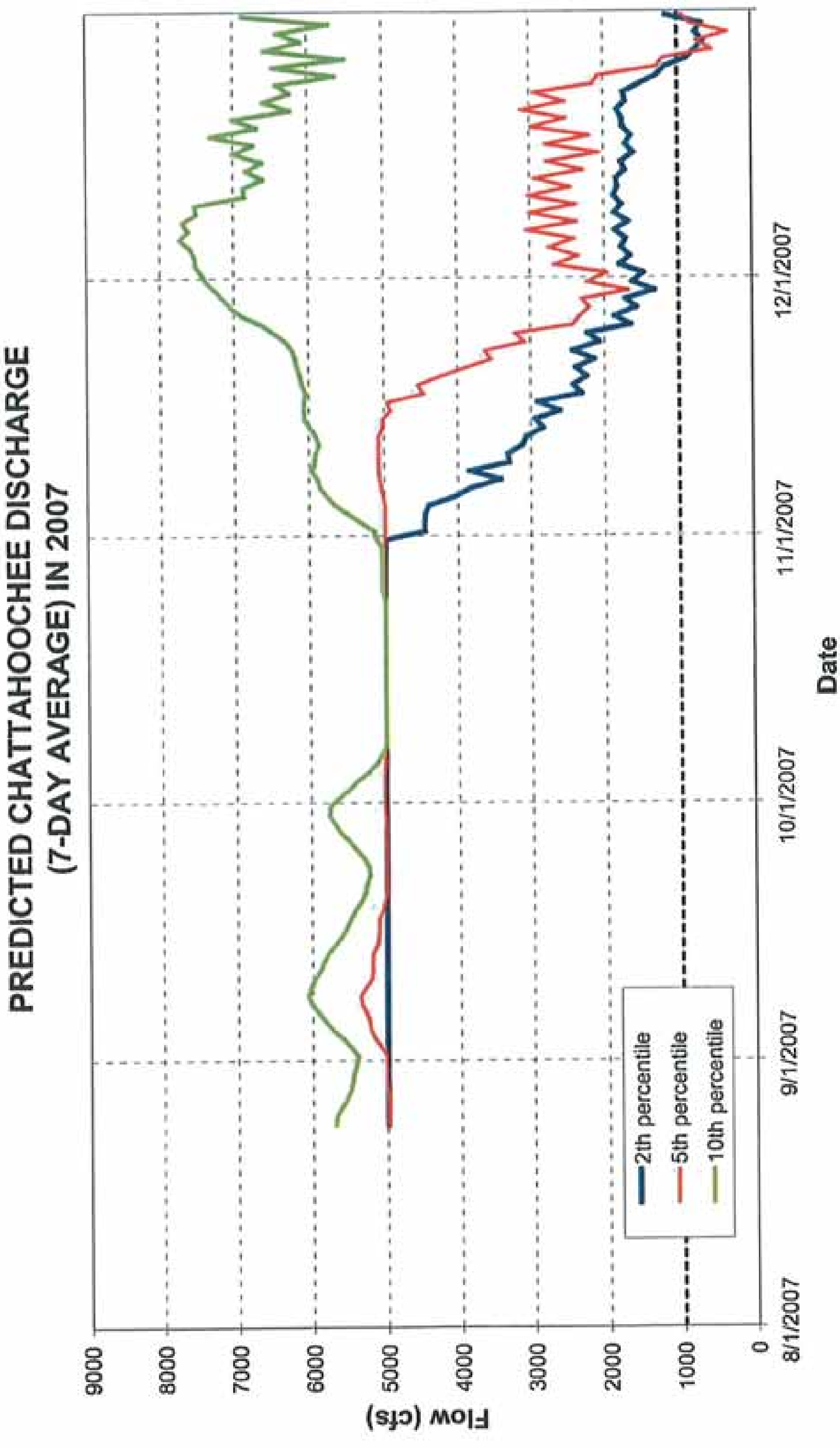


Fig. 11 Year 2007 flow at Chattahoochee, Florida projected by Corps of Engineers' model

Attachment A

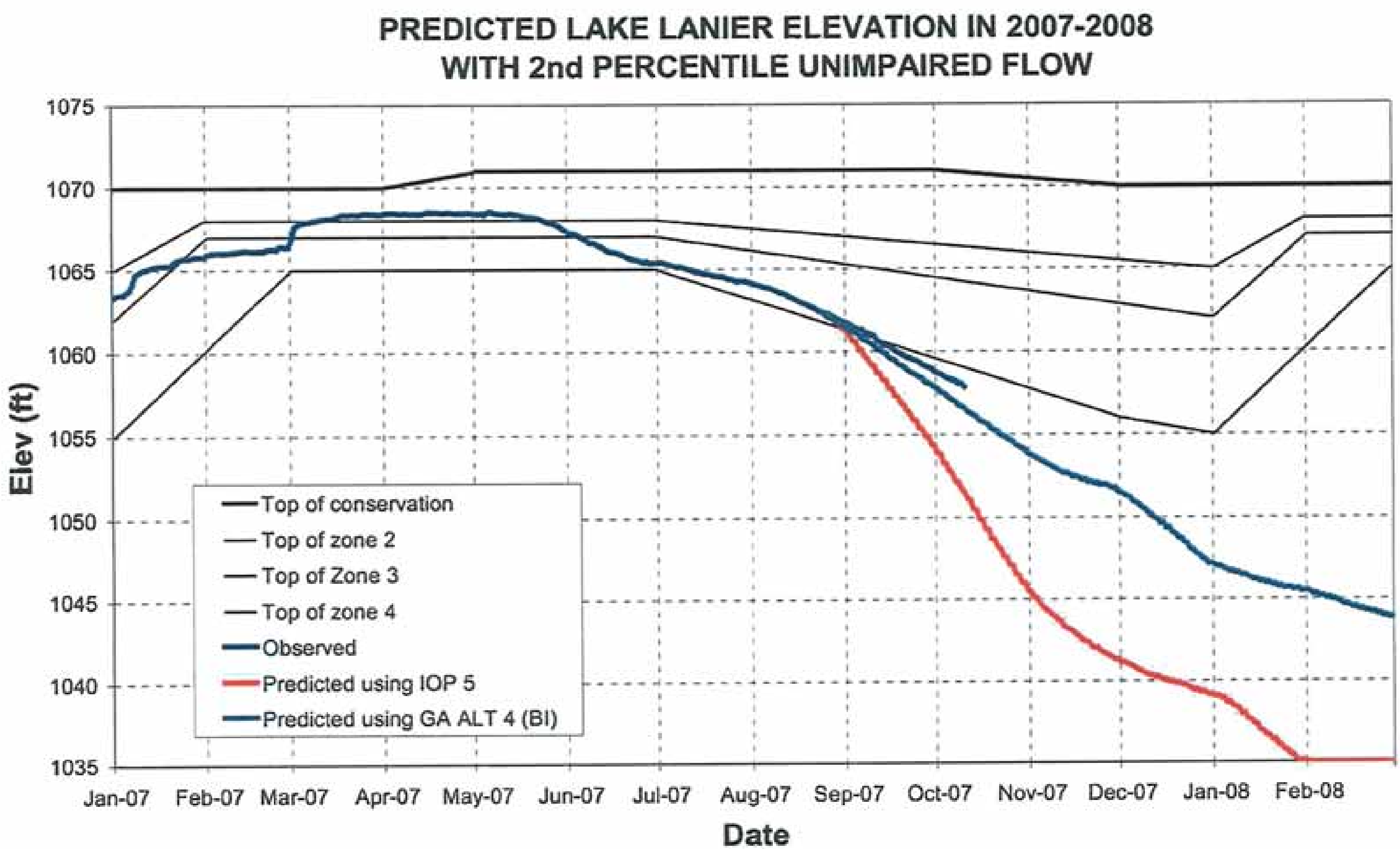


Fig. 12 Effects of emergency measures proposed by Georgia on Lanier elevation (using Corps model and 2 percentile hydrology)

Attachment A

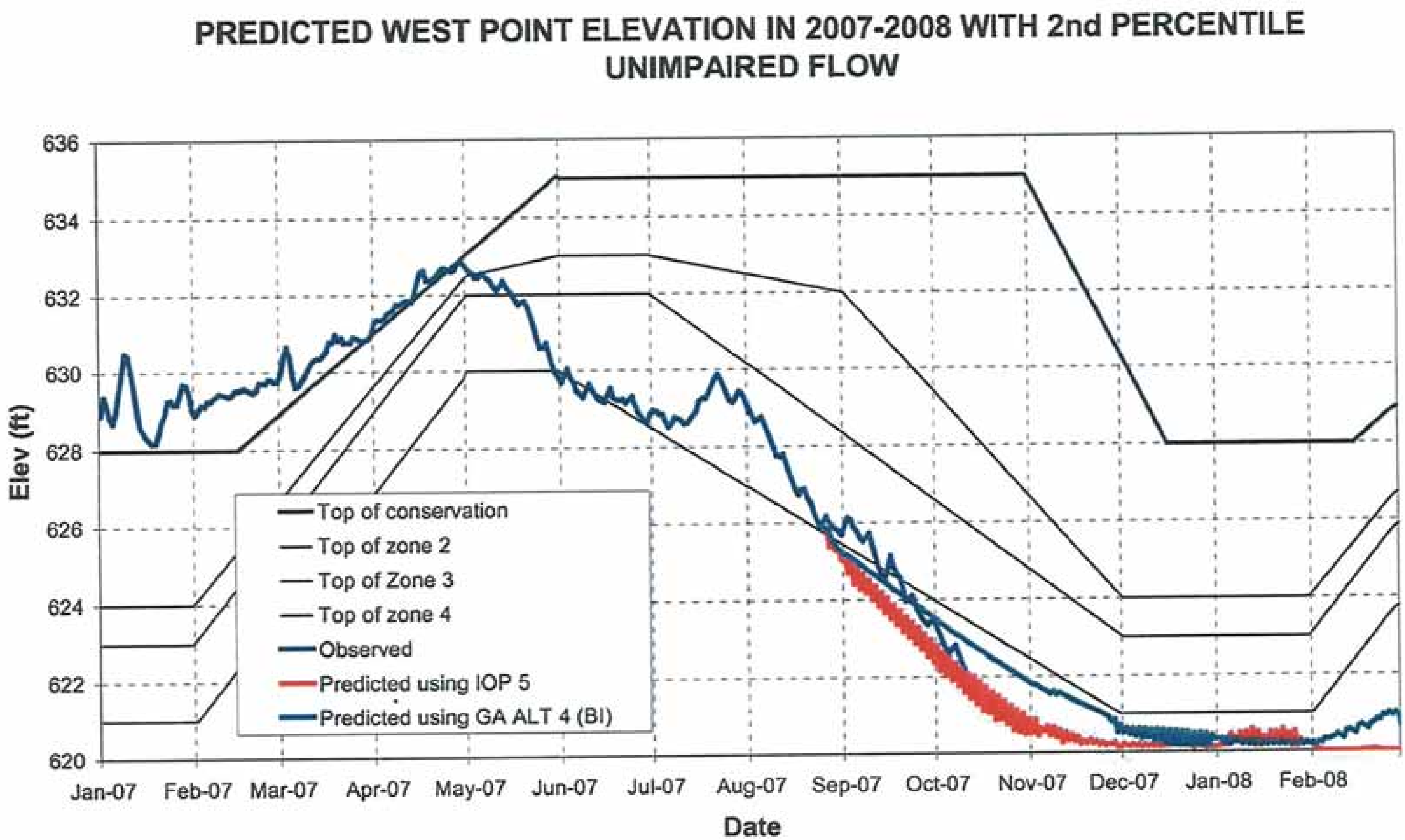


Fig. 13 Effects of emergency measures proposed by Georgia on West Point elevation (using Corps model and 2 percentile hydrology)

Attachment A

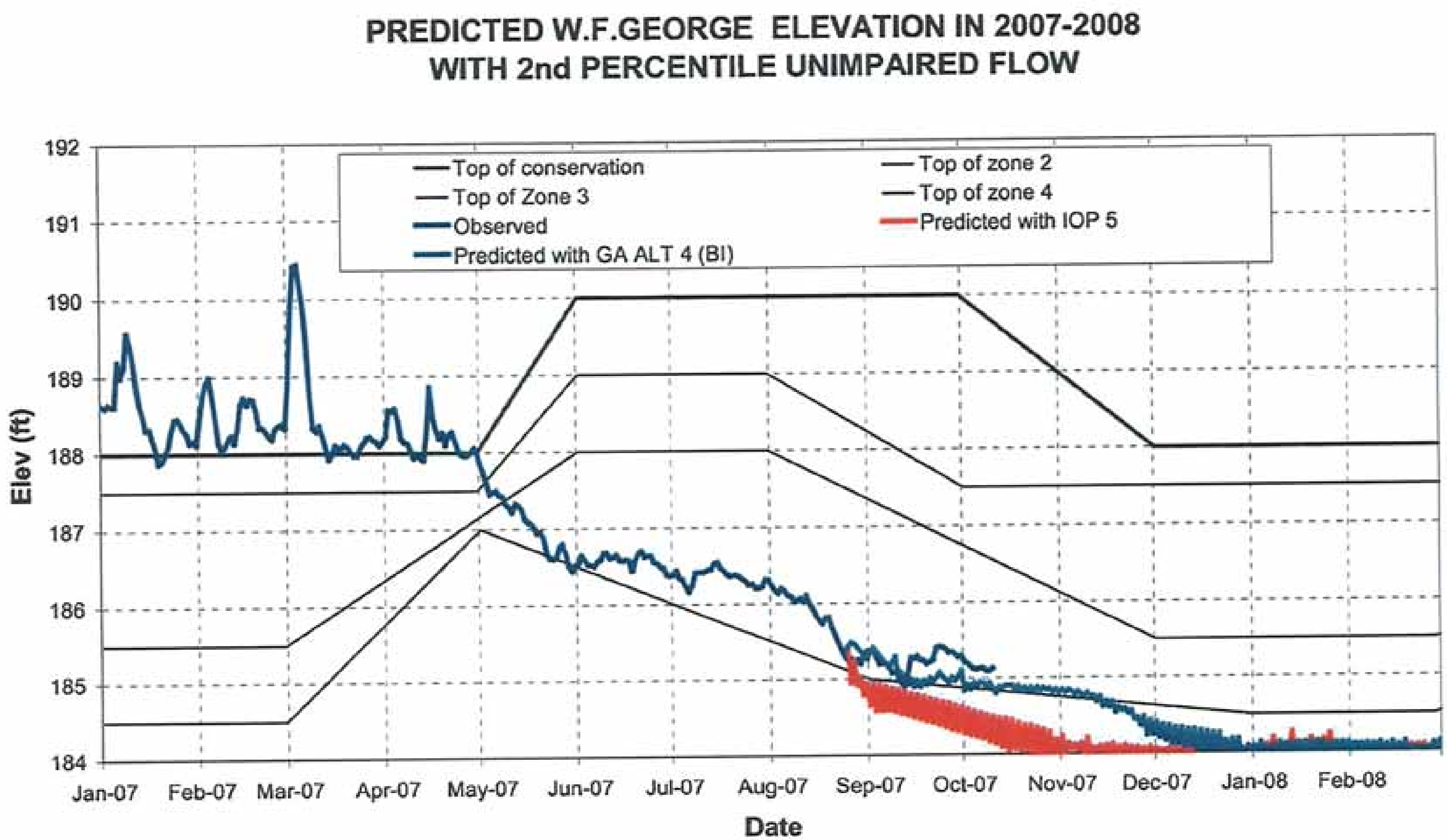


Fig. 14 Effects of emergency measures proposed by Georgia on W.F. George elevation (using Corps model and 2 percentile hydrology)

Attachment A

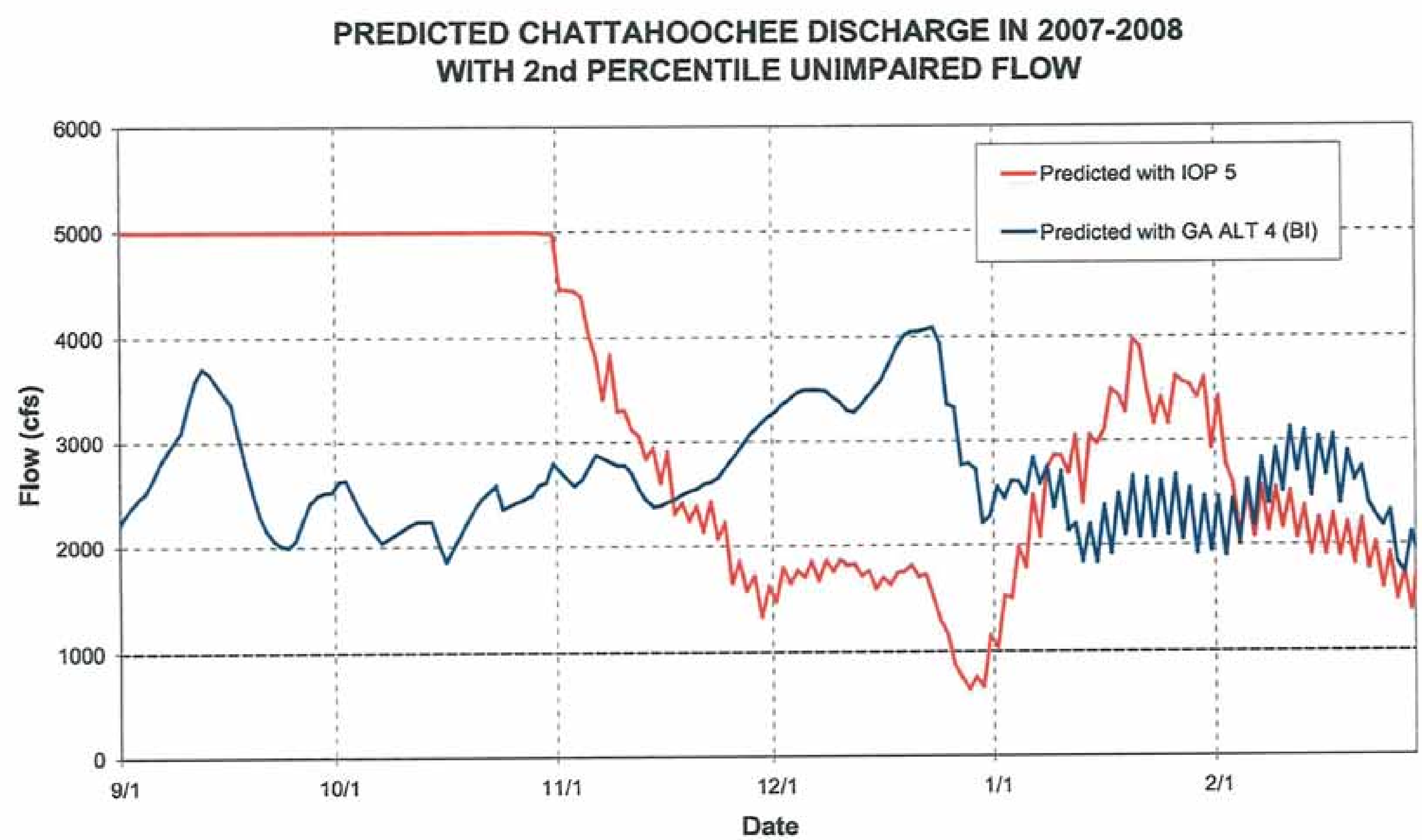


Fig. 15 Flow at Chattahoochee, Florida under the proposed changes to the IOP (Corps' 2 percentile hydrology)

Attachment A

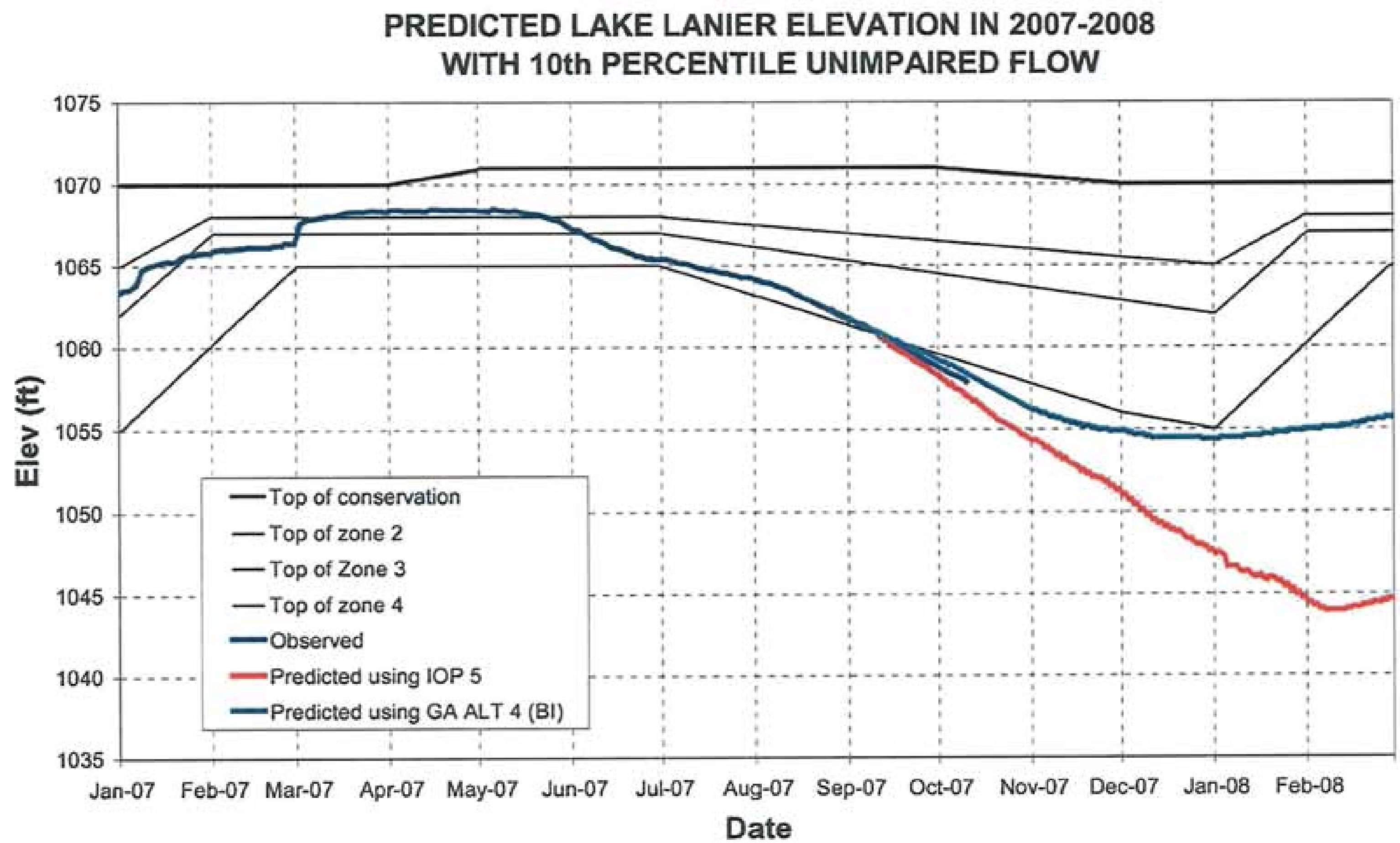


Fig. 16 Effects of emergency measures proposed by Georgia on Lanier elevation (using Corps model and 10 percentile hydrology)

Attachment A

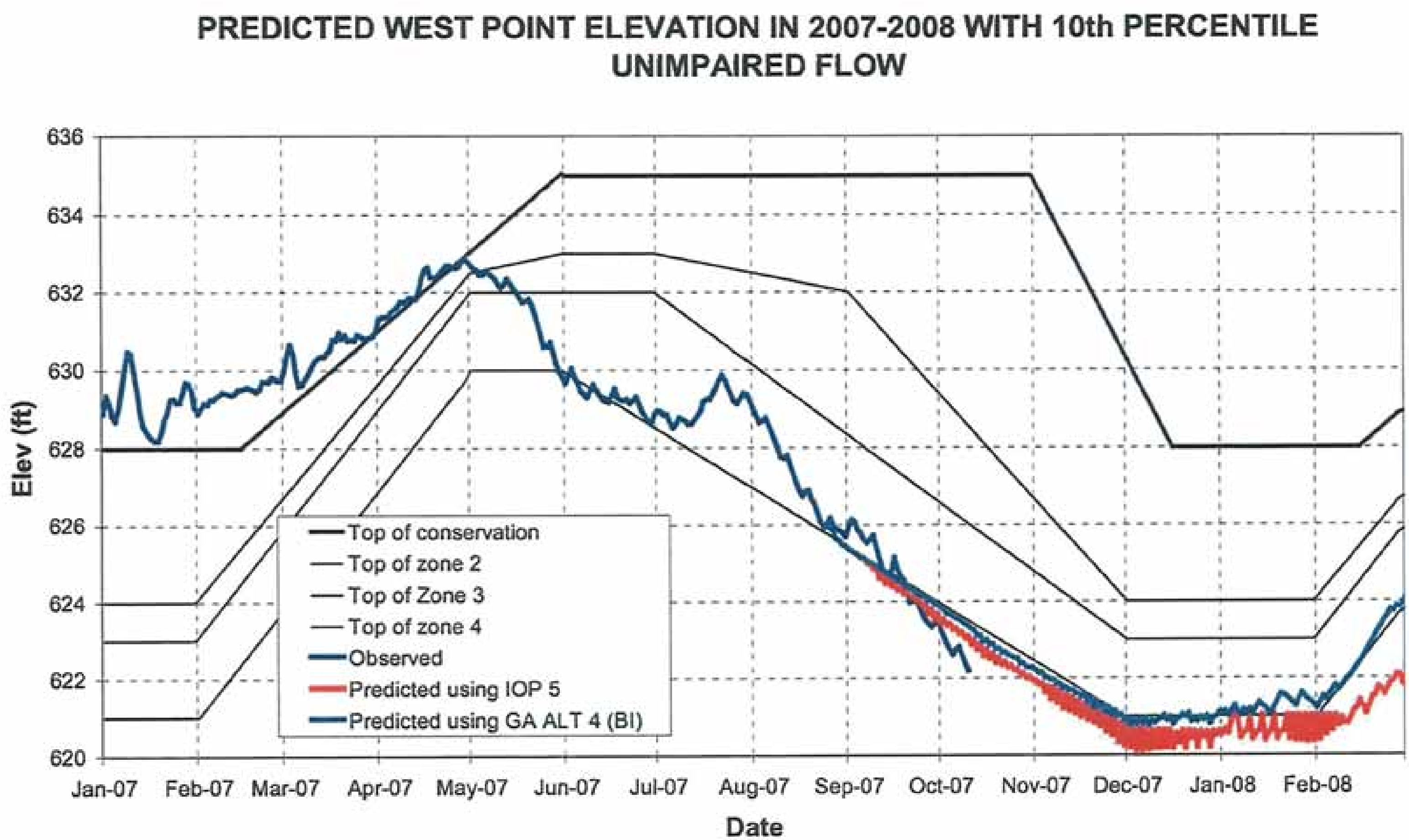


Fig. 17 Effects of emergency measures proposed by Georgia on West Point elevation (using Corps model and 10 percentile hydrology)

Attachment A

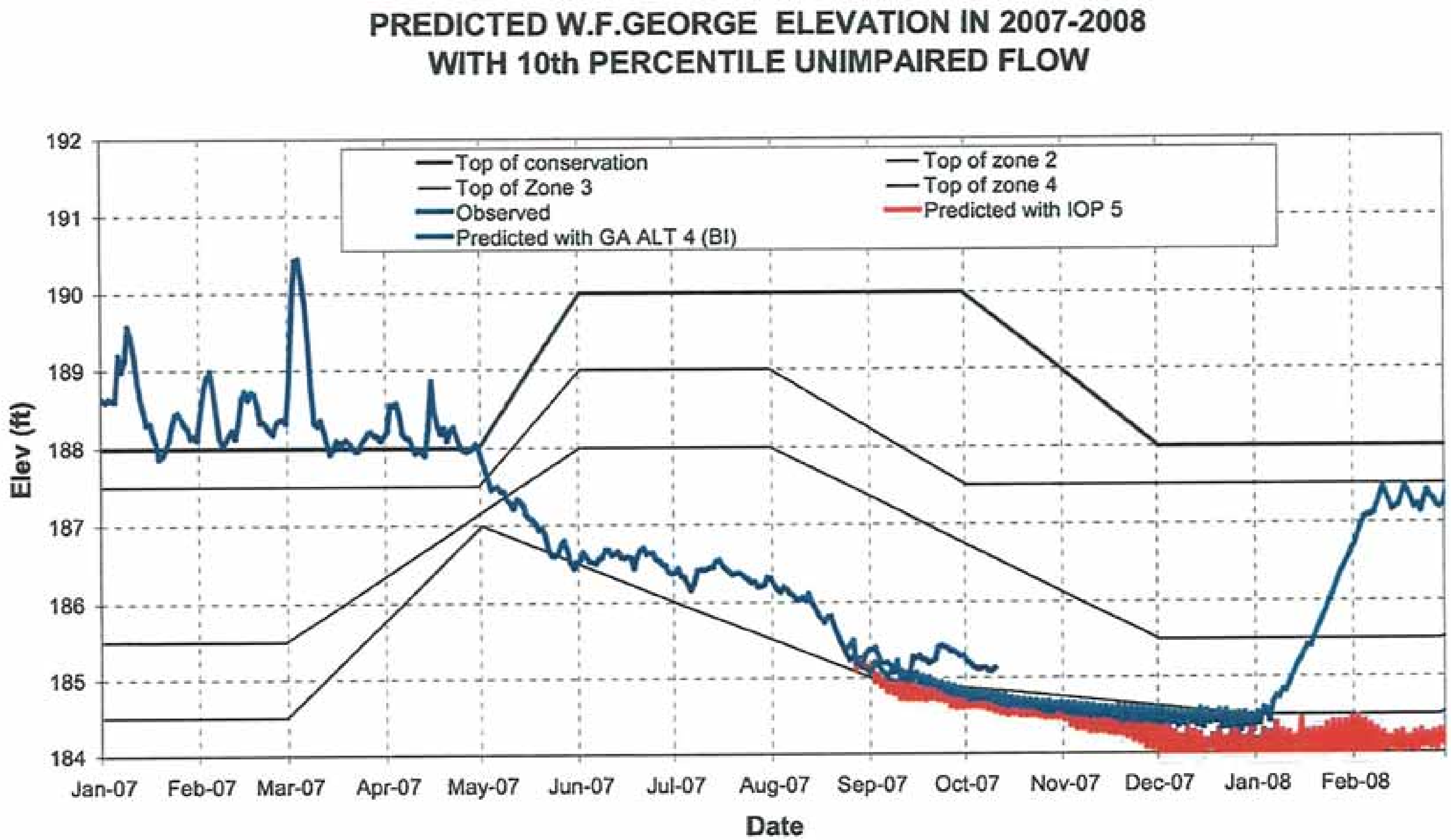


Fig. 18 Effects of emergency measures proposed by Georgia on W.F. George elevation (using Corps model and 10 percentile hydrology)

Attachment A

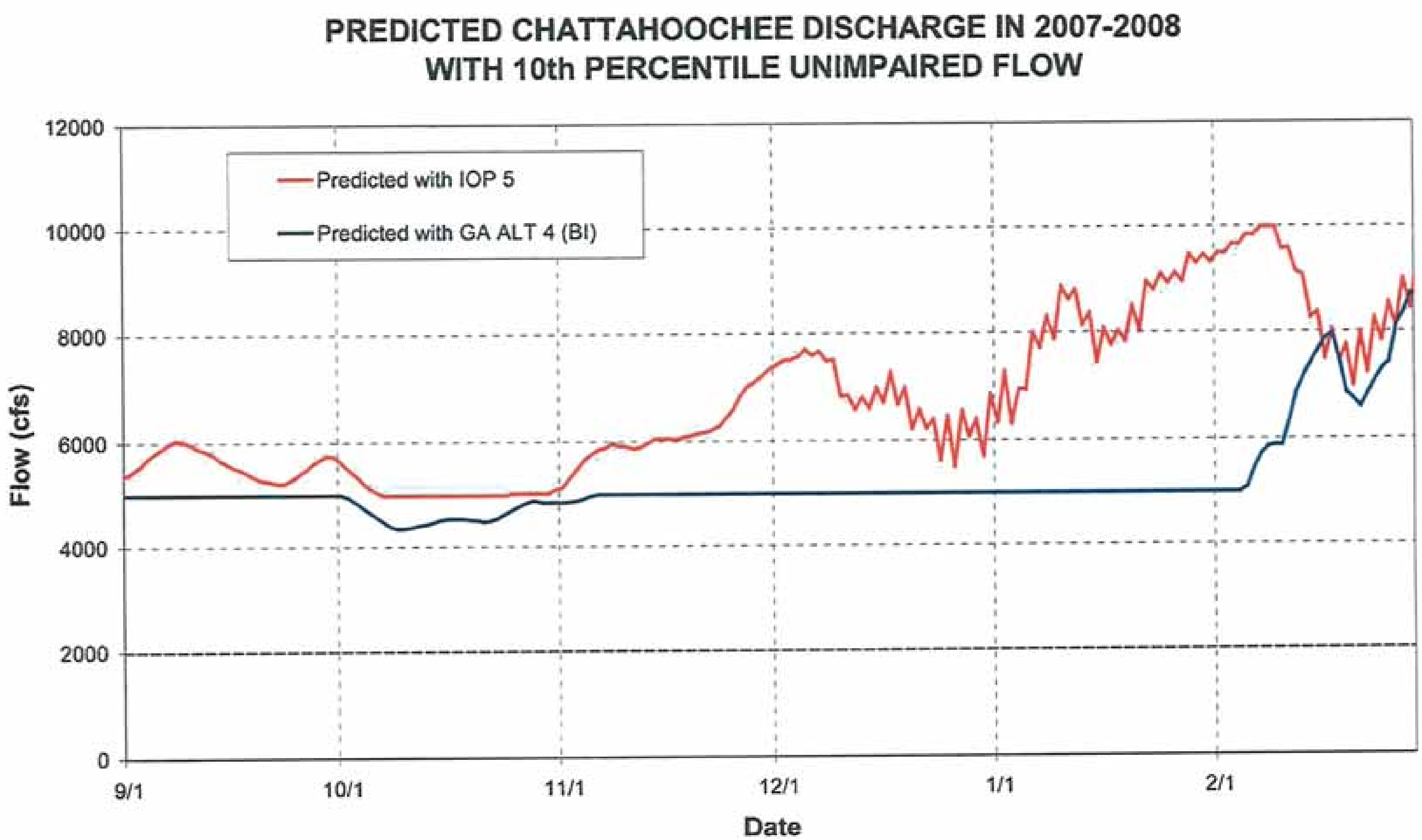


Fig. 19 Flow at Chattahoochee, Florida under the proposed changes to the IOP (Corps' 10 percentile hydrology)

Attachment A

From: Holland, Robert G SAD [mailto:Robert.G.Holland@sad01.usace.army.mil]
Sent: Wednesday, October 17, 2007 4:29 PM
To: Holland, Robert G SAD
Subject: Reply to State of Georgia Letter to Corps of Engineers on Releases from Lake Lanier

Inland Environment Team
Planning and Environmental Division

Carol A. Couch, PhD, Director
Environmental Protection Division
Georgia Department of Natural Resources
2 Martin Luther King Jr. Drive
Suite 1152 East Tower,
Atlanta, Georgia 30334

Dear Dr. Couch:

Thank you for your letter dated October 12, 2007 relating your concerns regarding the status of the Federal reservoirs in the Apalachicola, Chattahoochee, and Flint Rivers (ACF) Basin as we continue to experience severe and record drought conditions within the basin. We also have been tracking the progress and impacts of the drought conditions and have been relaying the current and projected pool elevations and current and projected rates of release of water from the reservoirs and forecasted impacts to stakeholders within the basin during recent ACF Basin Drought Summit teleconferences to assist in planning for drought contingency actions by all parties. As noted in our last teleconferences, drought conditions are predicted to continue at least for the next several months, and our planning will need to address the contingencies of a multiple year drought.

We are currently operating in accordance with the terms of the Interim Operations Plan (IOP), as developed in formal consultation with the U.S. Fish and Wildlife Service (USFWS) pursuant to Section 7 of the Endangered Species Act (ESA), and consistent with the requirements of our current water control plan. Section 7 consultation was required to determine whether our operations at Jim Woodruff Dam would cause adverse effects to federally listed species, including the threatened Gulf sturgeon, the endangered Fat threeridge mussel, and the threatened Purple bankclimber. The Biological Opinion issued by USFWS on September 5, 2006, concluded that the IOP would not result in jeopardy of the listed species, nor adversely modify or destroy critical habitat for these species; and included an Incidental Take Statement (ITS), Reasonable and Prudent Measures (RPMs), and mandatory terms and conditions to minimize harm. Operations must be conducted in accordance with the approved IOP, the RPMs and mandatory terms and conditions in order to maintain compliance with the ESA. Additional consultation would be required to modify the IOP or any of the terms and conditions of the Biological Opinion.

The current IOP terms were approved in follow-on consultation with the USFWS on February 28, 2007. Provisions of the IOP include:

- Required minimum flow of 5,000 cfs, consistent with current water control plan requirement, and a desired minimum flow of 6,500 cfs when hydrological and/or climatological conditions allow;
- Flow/release schedules based on a proportion of basin inflow specific for the sturgeon spring spawning period (March through May); and other portions of the year (June through February); with thresholds based on flow needs of sturgeon, listed mussels, or host fish for mussels;
- Ramping down restrictions to minimize isolation or exposure of sturgeon, mussels, and host fish for mussels.

Attachment B

Due to the severe nature and predicted duration of the continuing drought conditions, we have initiated discussions with the USFWS to address concerns that remaining storage within the ACF system may be depleted before drought conditions abate. This potential depletion could result in the inability to operate the projects in a way that fulfills all the authorized purposes, to comply with the provisions of the ESA, and to assure that operational decision making minimizes the adverse effect on other water uses and needs within the basin during this time of drought Our discussions are exploring possible interim drought contingency options that may provide some temporary modifications to the IOP and could allow some additional water to be stored to place the reservoirs in a better position to meet minimum needs if the drought conditions continue into 2008 as predicted. We are reviewing the additional information you have provided, as well as information we are developing on the potential impacts to listed species, to assist in our evaluation of possible options.

We appreciate the efforts that Georgia and the water users within the State of Georgia have taken and are planning to take in meeting the challenges of reduced water resources in the basin as a consequence of these severe drought conditions. I hope you and the other States and stakeholders will continue to share information that can assist us in planning and managing for this drought. We will keep all parties informed of our plans and anticipated water management actions on the regularly scheduled drought teleconference calls.

If you have any additional information, or questions regarding our operations, please feel free to contact me.

Sincerely,

Byron G. Jorns
Colonel, Corps of Engineers
District Commander

Copy furnished:

Michael Soles, Florida Department of Environmental Protection, Tallahassee, FL
Trey Glenn, Alabama Department of Environmental Management, Montgomery, AL
Gail Carmody, U.S. Fish and Wildlife Service, Panama City, FL

Attachment B

Memorandum
To: Carol Couch
From: Feng Jiang
Date: Oct 19, 2007
Re: ACF Basin Modeling Results

The purpose of this memorandum is to summarize technical analysis of effects of IOP 5 and Georgia Alternative 4 operation in ACF basin.

Settings

This summary contains two sets of results. For the first set, we used the 2%, 5%, and 10% non-exceedence level basin inflow through Aug 24, 2007 to the end of 2008. We simulated two operations: one is IOP 5, the other is Georgia Alternative 4, in which the flow target in Jim Woodruff is set to 5000 cfs if the basin inflow is over 5000 cfs, and equal to basin inflow if it is below 5000 cfs. For the second set of results, we used 2%, 5% and 10% non-exceedence basin inflow in the rest of 2007 and 2000 hydrology in 2008.

Results

For this analysis, we focus on the elevation of Lake Lanier, West Point, and W.F. George, and the flow at Chattahoochee River. The first set of results (Figures 1 to 4) show the consequences of IOP 5 operation. For Lake Lanier (Figure 1), it will be drained at the beginning of Feb 2008 under 2% non-exceedence hydrology. Even under 10% non-exceedence hydrology, it will be drained on Sep 23, 2008, which means no water supply will be supported by Lanier. If Georgia Alternative 4 is adopted, even under 2% non-exceedence hydrology, the Lake can last to June 16, 2008. For West Point (Figure 2), if we continue IOP 5 operation, the Lake will go below the bottom of conservation pool with 2% and 5% non-exceedence hydrology. If Georgia Alternative 4 is adopted, the Lake will be drained for only a short period during October to November 2008. For W.F. George (Figure 3), the picture is also grim. With the IOP 5 operation, the Lake will be drained on May 18, 2008 under 2% non-exceedence hydrology, on June 13, 2008 under 5% non-exceedence hydrology, and June 20, 2008 under 10% non-exceedence hydrology. If Georgia Alternative 4 is adopted, the lake will be drained for a short period during Oct to Nov 2008.

The flows at Chattahoochee (Figure 4) also shows the effects of IOP 5. With IOP 5 operation, even under 10% non-exceedence hydrology, the 5000 cfs target will be violated as early as Dec 2007. Under the 2% and 5% non-exceedance hydrology, the flow will be below 5000 cfs at the end of Oct or middle of Nov 2007. On the contrary, if we adopt Georgia Alternative 4, we can release more water on the spawning season in 2008, which will be very beneficial to the mussels and other organisms downstream.

The second sets of results (Figure 5 to 8) also show the same pattern. Under 2% hydrology in 2007 and 2000 hydrology in 2008, Lake Lanier (Figure 5) will reach 1039 ft at the end of 2008, which is only 4 ft above the bottom of conservation pool. If Georgia

Attachment C

Alternative 4 is adopted, the level will rise to 1049 ft, 10 ft higher than with IOP 5 operation. Under the 10% hydrology and 2000 hydrology in 2008, we also see 10 ft advantage over IOP 5 operation. The elevation of West Point (Figure 6) and W.F. George (Figure 7) also clearly show the benefits of Georgia Alternative 4 compared with IOP 5. For the flows in Chattahoochee River (Figure 8), we also see more steady flow with Georgia Alternative 4 than with IOP 5.

Attachment C

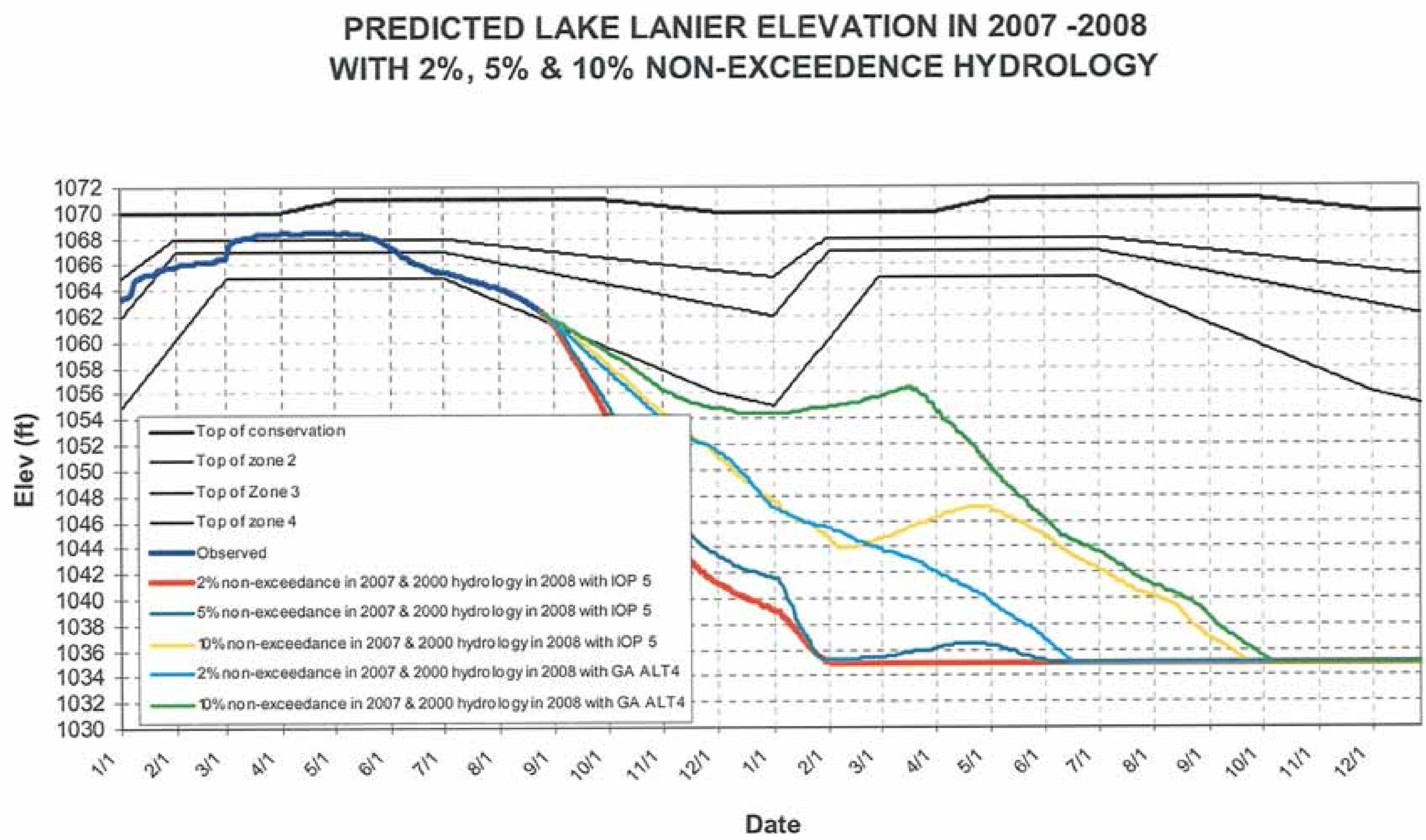


Figure 1. Predicted Lake Lanier elevation in 2007-2008 with 2%, 5%, and 10% non-exceedence hydrology

Attachment C

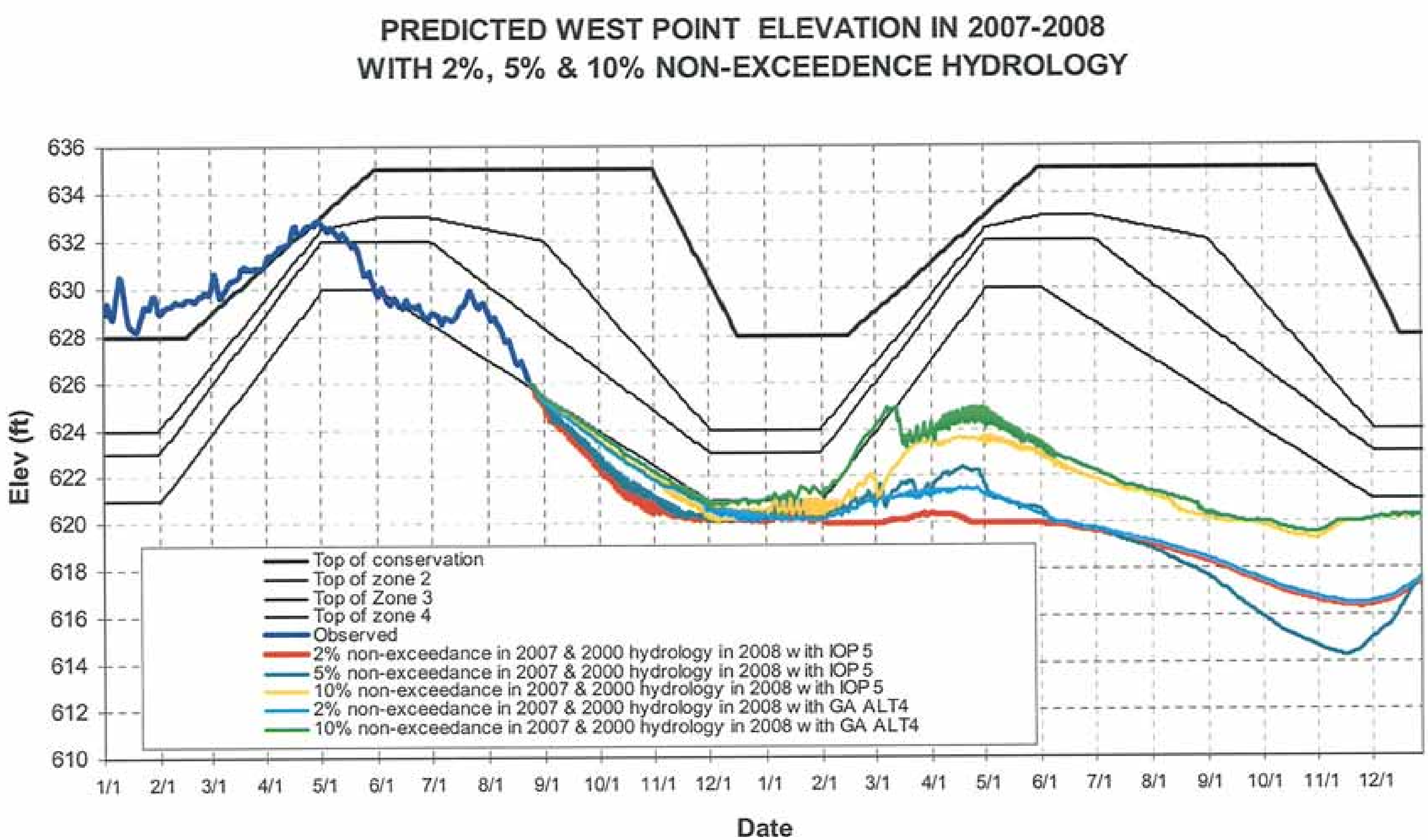


Figure 2. Predicted West Point elevation in 2007-2008 with 2%, 5%, and 10% non-exceedence hydrology

Attachment C

PREDICTED W.F.GEORGE ELEVATION IN 2007-2008
WITH 2%,5%& 10% NON-EXCEEDANCE HYDROLOGY

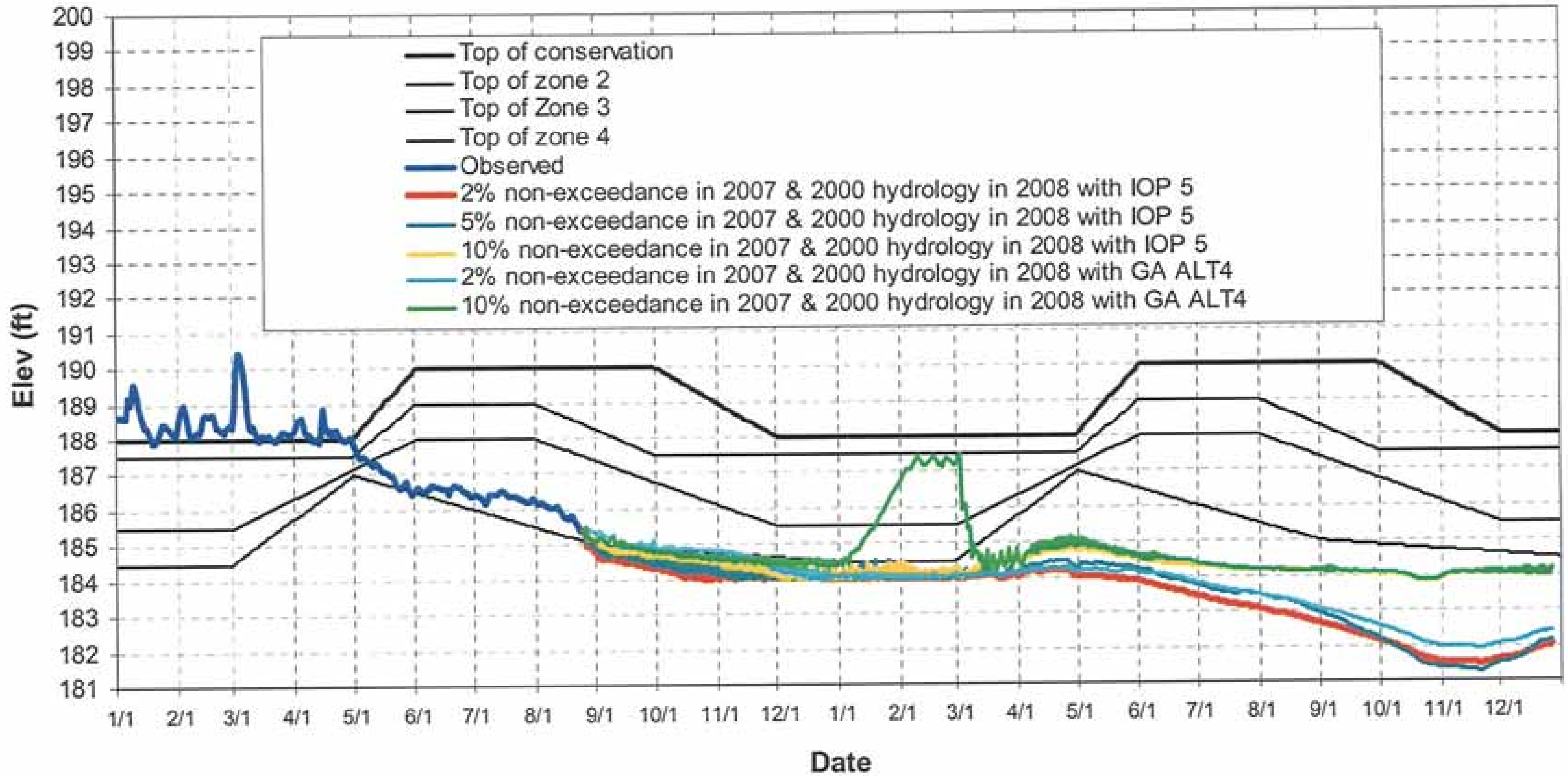


Figure 3. Predicted W.F. George elevation in 2007-2008 with 2%, 5%, and 10% non-exceedence hydrology

Attachment C

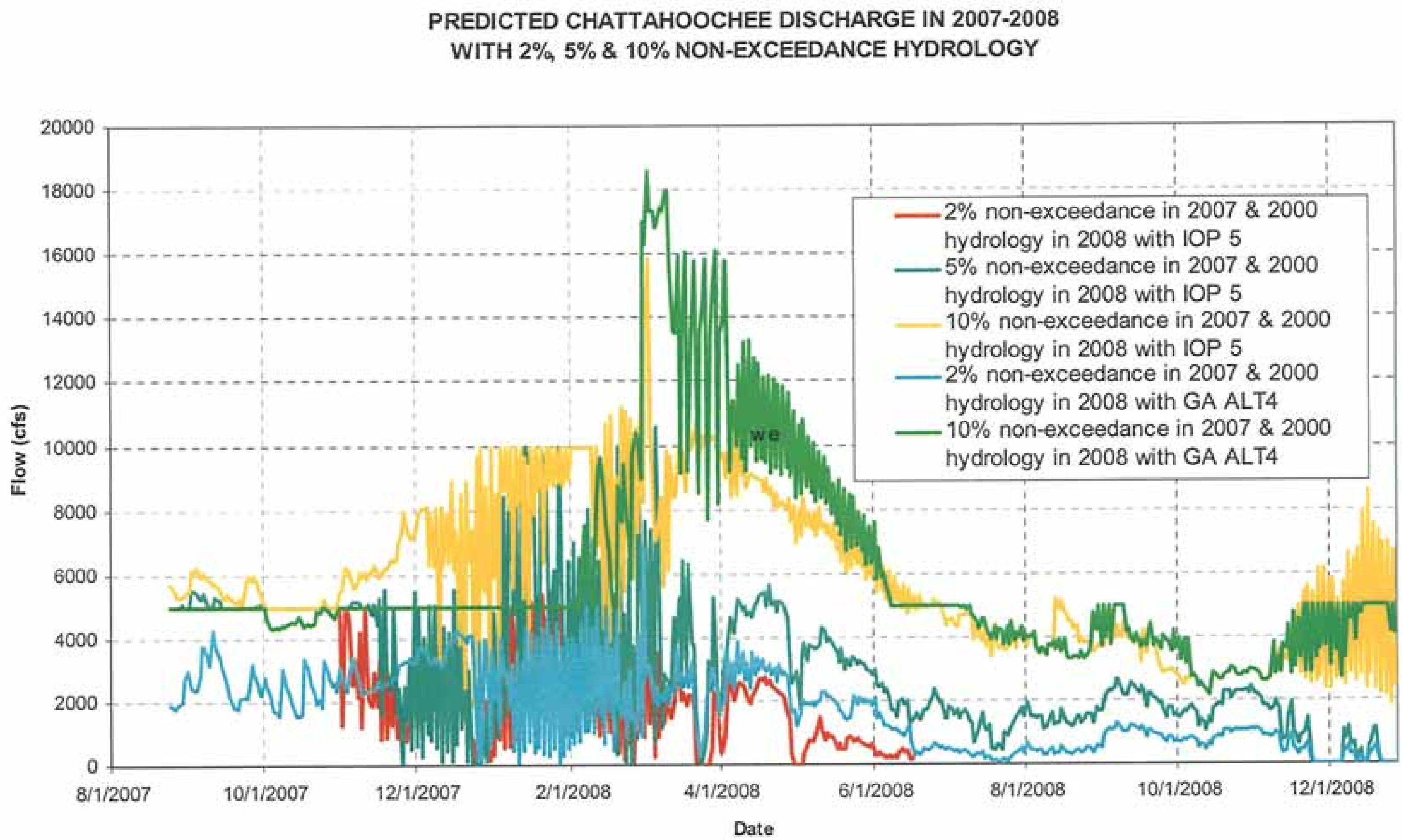


Figure 4. Predicted Chattahoochee discharge in 2007-2008 with 2%, 5%, and 10% non-exceedence hydrology

Attachment C

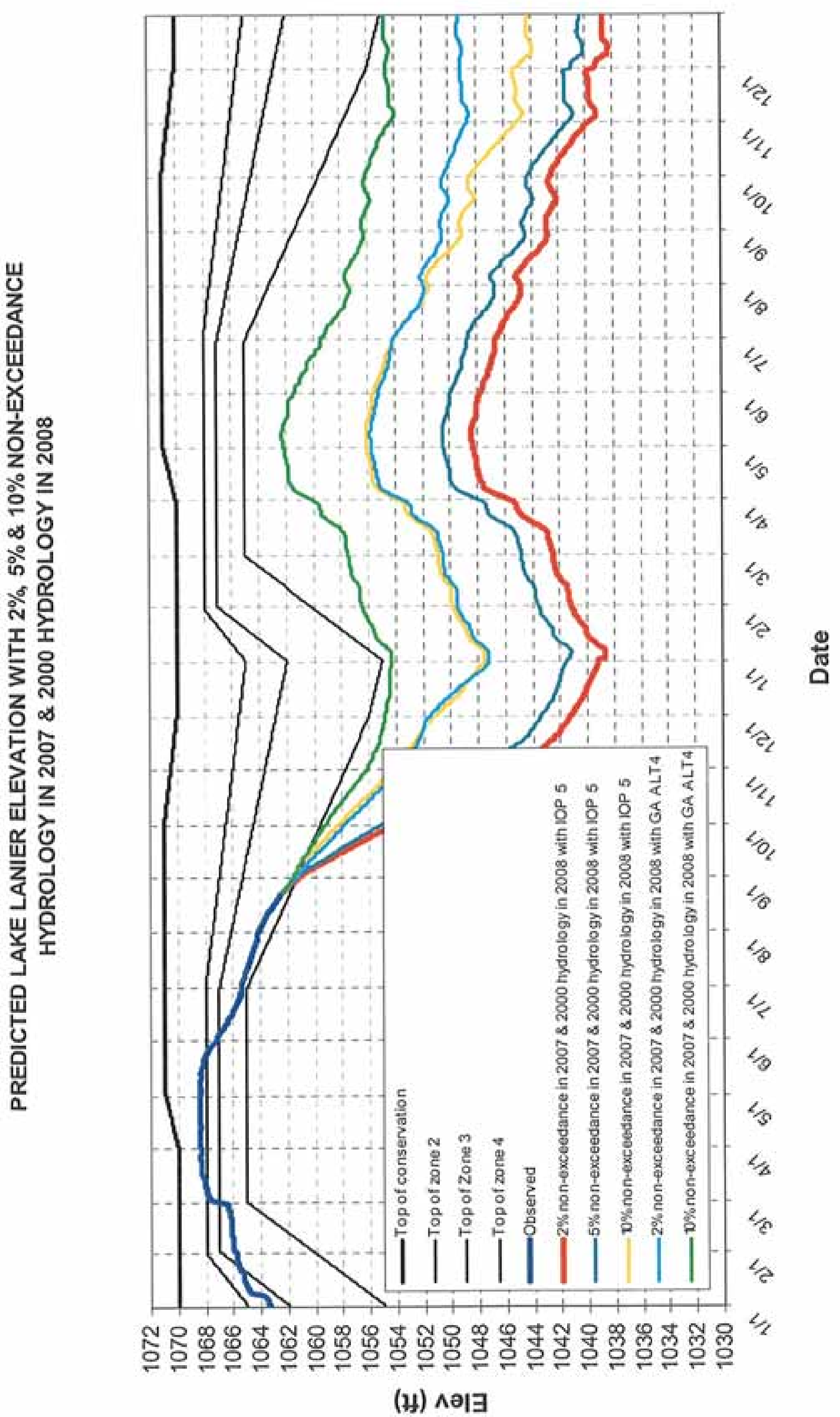


Figure 5. Predicted Lake Lanier elevation with 2%, 5%, and 10% non-exceedence hydrology in 2007 and 2000 hydrology in 2008

Attachment C

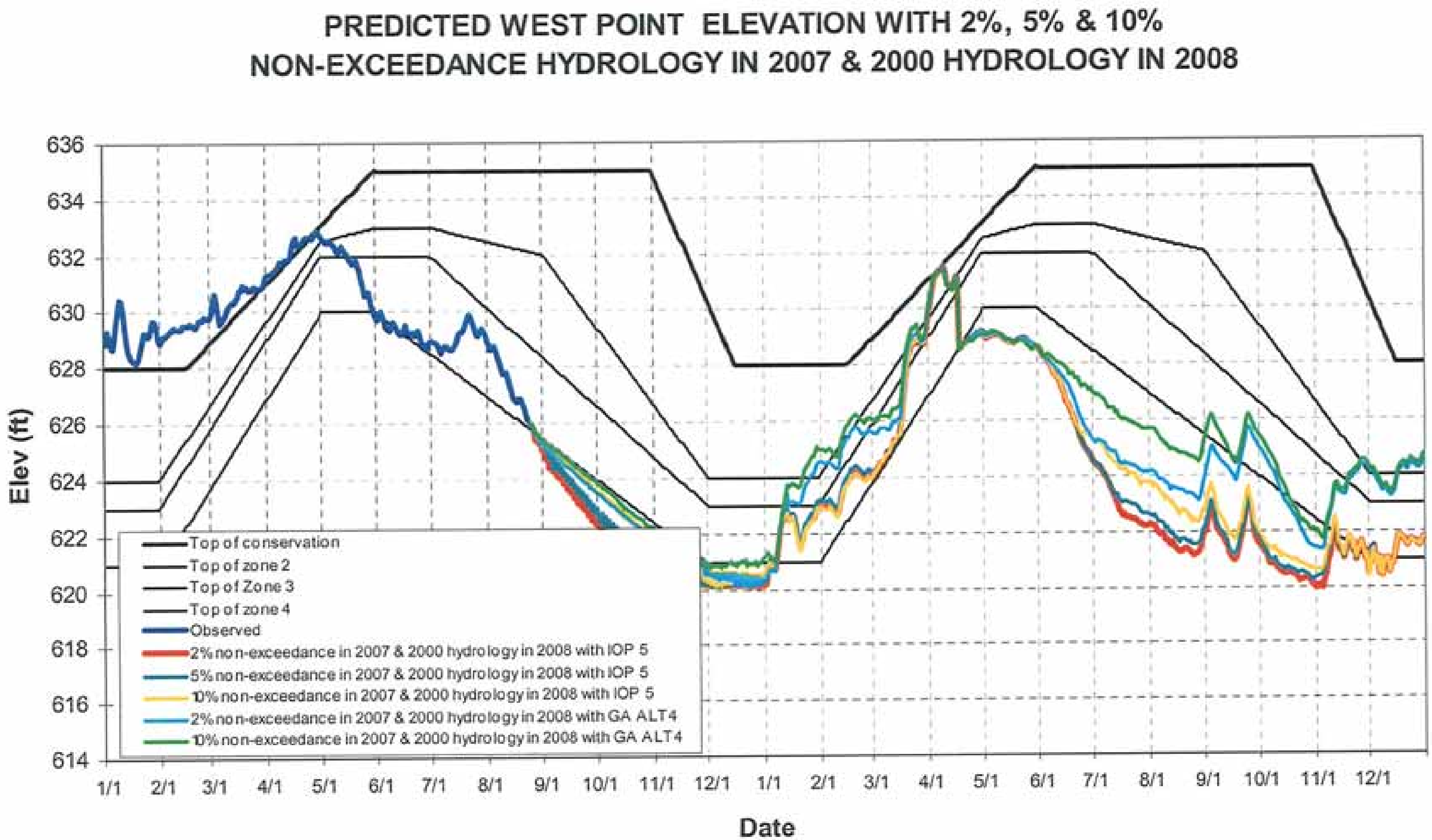


Figure 6. Predicted West Point elevation with 2%, 5%, and 10% non-exceedence hydrology in 2007 and 2000 hydrology in 2008

Attachment C

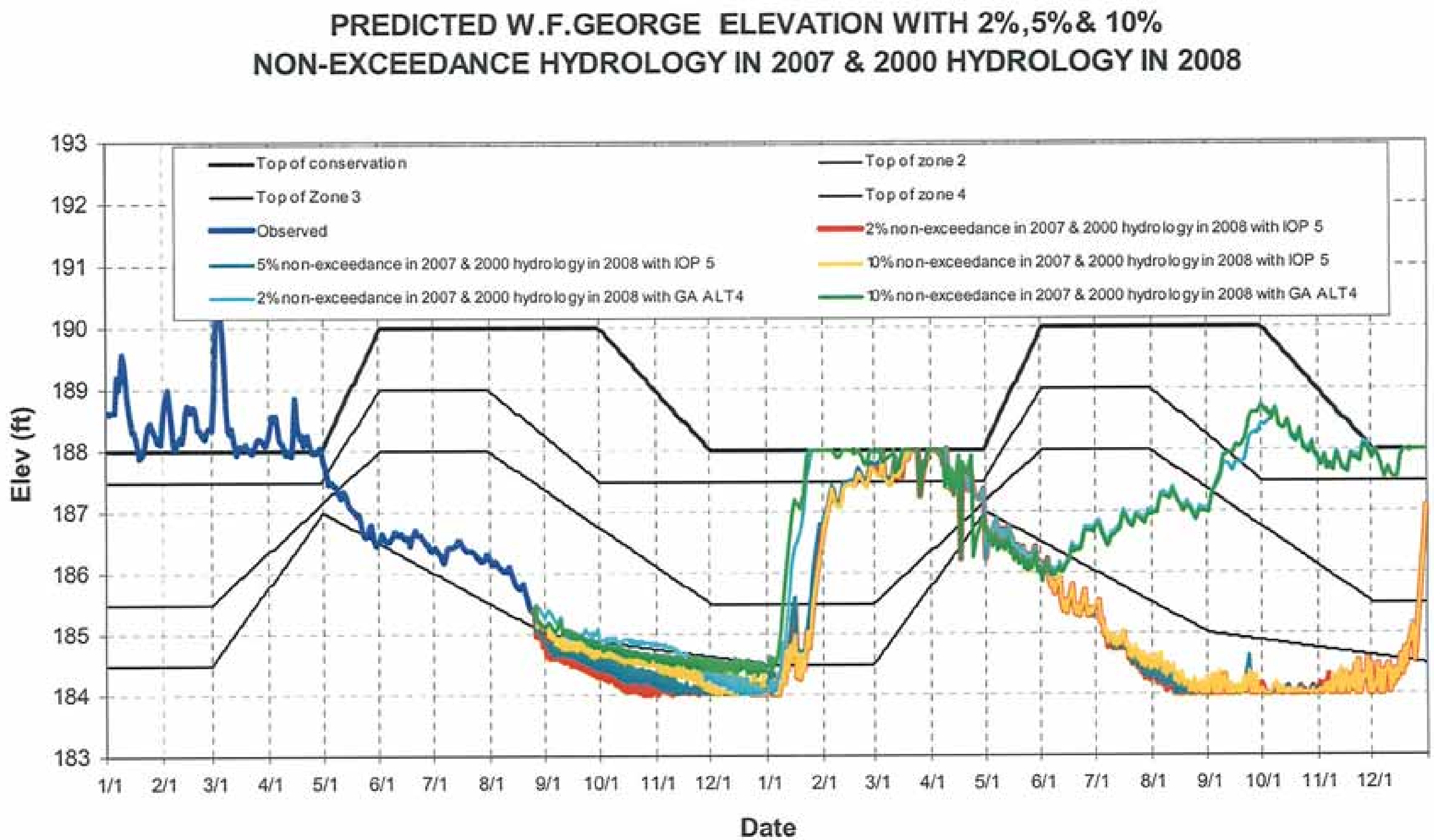


Figure 7. Predicted W.F. George elevation with 2%, 5%, and 10% non-exceedence hydrology in 2007 and 2000 hydrology in 2008

Attachment C

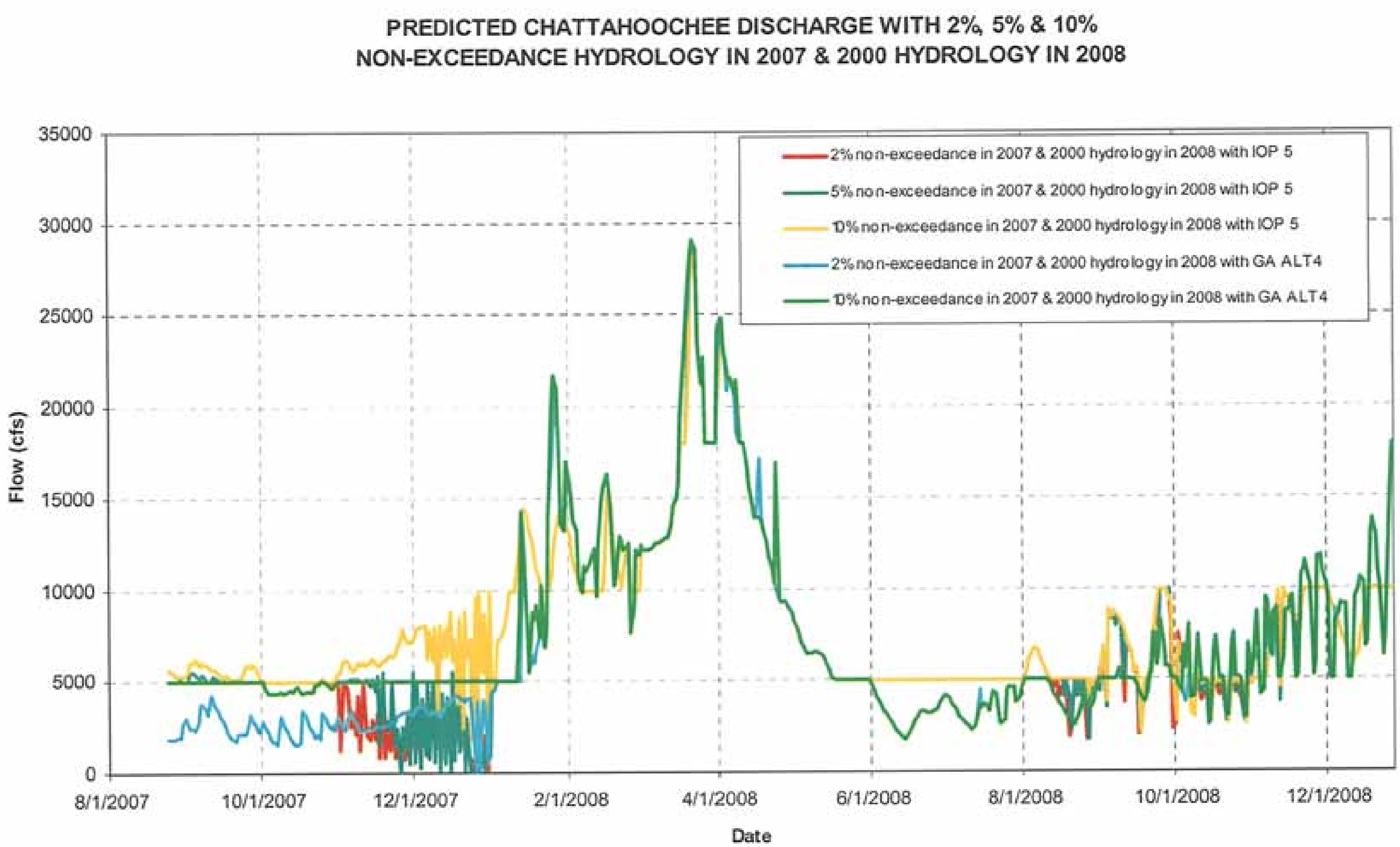


Figure 8. Predicted Chattahoochee discharge with 2%, 5%, and 10% non-exceedence hydrology in 2007 and 2000 hydrology in 2008

Attachment C

APPENDIX E

ARC LETTER

25 OCTOBER 2007

Atlanta Regional Commission 40 Courtland Street, NE Atlanta, Georgia 30303

October 25, 2007

Col. Byron Jorns
Commander and District Engineer
Department of the Army
Mobile District, Corps of Engineers
109 Saint Joseph Street
Mobile Alabama 36602-3630

Re: Request for Immediate Alterations to Interim Operations Plan Releases

Dear Colonel Jorns:

I am writing on behalf of the North Georgia Water Supply Providers—the Atlanta Regional Commission, the City of Atlanta, Fulton County, Cobb County-Marietta Water Authority, DeKalb County, Gwinnett County and the City of Gainesville—to request that the Corps grant relief from its Interim Operations Plan (IOP) and alter its operation of the federal reservoirs within the Apalachicola-Chattahoochee-Flint (ACF) river basin.

The system is in crisis. As described in the State of Georgia's October 12, 2007 Request for Immediate Relief, we are in a drought of record proportions. Given these extreme drought conditions, prudent resource management by the Corps and all other stakeholders is essential to maintaining the integrity of the ACF system.

In addition to our continuing conservation and resource management efforts, our north Georgia communities are continuing to rise to the challenge to respond to this crisis. A total ban on outdoor water use has already been imposed and is being observed. In addition, the Governor has asked for an even greater reduction in water use—requiring all permit holders in the 61-county affected region to reduce water withdrawals to a level 10% lower than last year's base demand. We cannot conserve our way out of this crisis, however. No amount of conservation can overcome the effect of current operations under the IOP, which must be altered immediately for our efforts to make any difference. Simply put, time and water are running out.

Furthermore, although we understand that the "bottom of conservation pool" is not necessarily the bottom of the reservoir, the potential use of dead storage raises numerous environmental concerns and would present an unacceptable risk to public health and safety. Therefore we urge you to adopt a recovery plan for the system that does not rely on the use of dead storage in Lake Lanier or any of the reservoirs. The focus, instead, should be on the adoption of a new plan to restore the system.

We propose a three-part Reservoir Recovery Plan to be implemented immediately. The recovery should proceed in three phases: (1) adopt the Emergency Operations Plan described below to stabilize the system; (2) immediately after the emergency plan has been adopted, initiate a process to develop and implement a new *sustainable* Interim Operations Plan to remain in effect until the water control plan can be updated; (3) formulate a new long-term Water Control Plan to reflect current conditions in the basin and to address risks associated with system failure.

Based on our projections, which assume inflow conditions consistent with the worst drought on record (2000-2001), the Emergency Operations Plan that we propose provides an excellent chance for System Storage to recover to Zone 2 by June 1, 2008. We believe these gains can be achieved without any significant adverse effect to endangered species, flood control, or other purposes. Further, we would like to emphasize that the Emergency Operations Plan should remain in effect only until the reservoirs are restored and/or a new sustainable IOP can be adopted.

Finally, we understand that the Corps will need to initiate an emergency consultation with the U.S. Fish & Wildlife Service before altering its current operations. We urge you to begin that process immediately.

FORECASTING METHODS

Assumptions about future hydrology play an important role in the evaluation of emergency response measures. As a rule, the relative benefit of the measures we propose will increase as hydrologic conditions improve. Even if hydrologic conditions are much worse than anything we have experienced in the historical record, however, the measures we propose will provide a substantial benefit relative to the IOP.

Projections Based on 2000-2001 Hydrology

We have used two methods for projecting inflow in preparing this plan. The first method is to assume that inflows over the next several months will be equivalent to the inflows received on these dates during prior years. Because current conditions appear consistent with the period of 2000-2001—the worst drought on record—it is reasonable to use that period for this projection.

Furthermore, forecasts based on past hydrology do *not* represent the worst-case scenario. A drought worse than the worst drought on record could pull the lakes down even further than forecasts based on historical hydrology would suggest. Therefore, to show what could happen if conditions become worse than we experienced in 2000-2001, we have modeled each proposal using inflow from the same period reduced by 15%.

Figures 1 and 2 use these projections to show the need for immediate relief from the IOP. The solid-line projections are based on a repeat of conditions experienced during the 2000-2001 drought. Figure 1 shows the results for Lake Lanier; Figure 2 for system storage. Figure 1 shows that the IOP could pull Lake Lanier down to 1050' by the end of 2008. This is a dangerously low level of storage. If the current drought is truly the worst drought on record, however, Lake Lanier could be hit much harder. A reduction in inflows of just 20% below 2000-2001 levels would empty Lake Lanier by November 2008.

Figure 1. Projected Lake Lanier Levels For Next Two Years Under Corps IOP Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 & 20 Percent

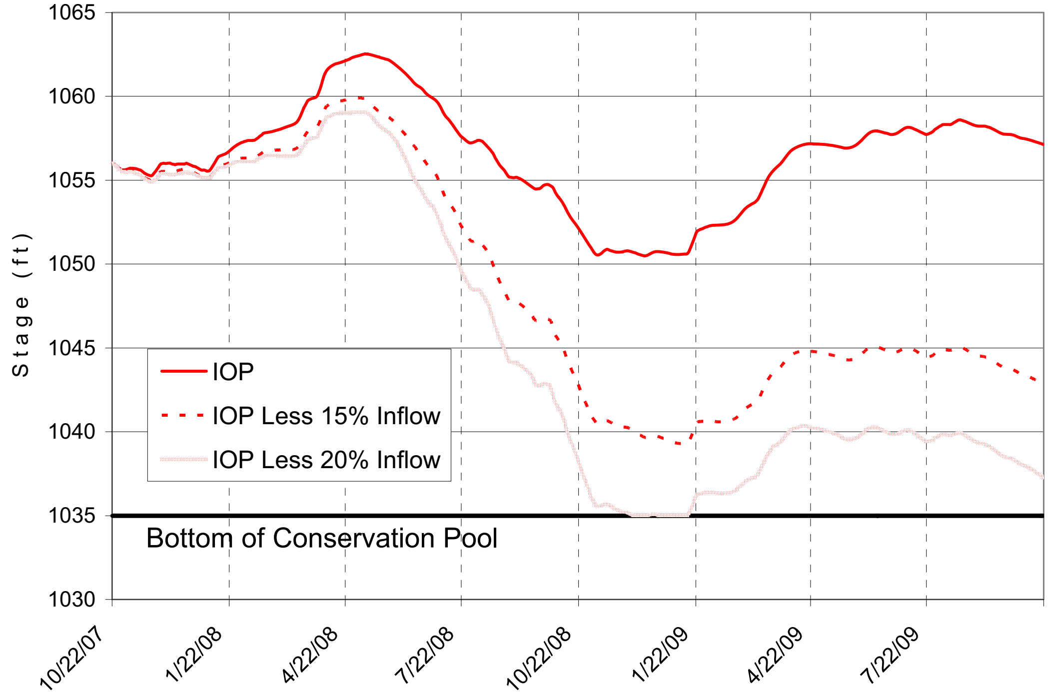
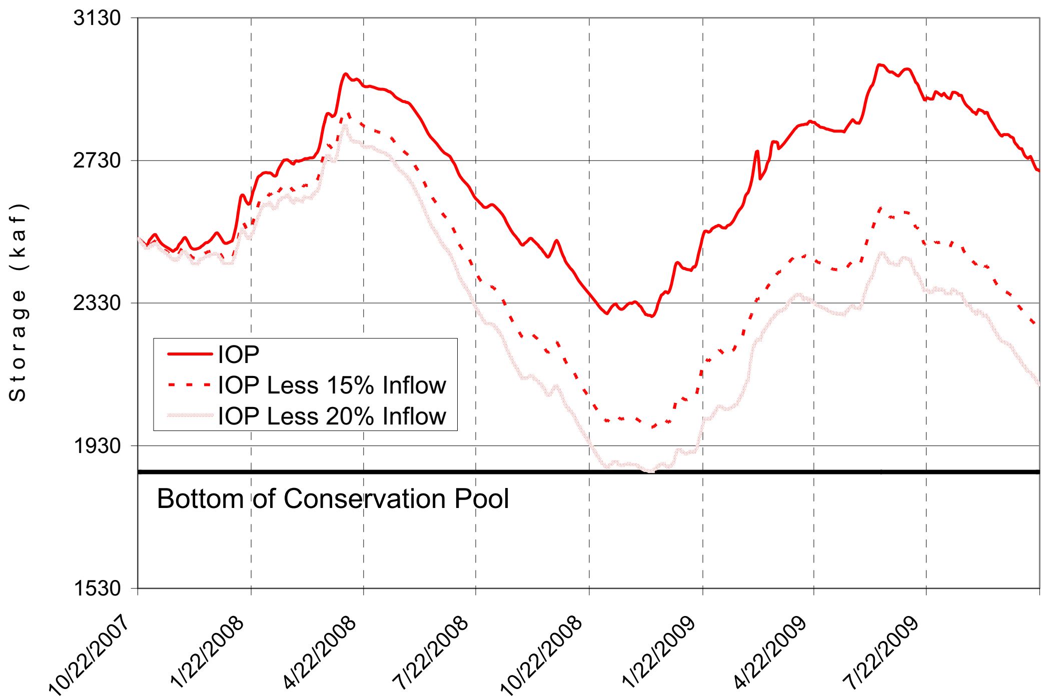


Figure 2. Projected System Storage For Next Two Years Under Corps IOP Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 & 20 Percent



Projections Based on Statistical Inflow Forecasts

Statistical forecasting methods are also available. One method developed by Robert Hirsch of the USGS makes use of the statistical correlation between current and future conditions: if inflows have been low, they tend to stay low, and vice versa. Forecasts based on this method converge with the forecasts that would be made using historical hydrology after about 4 months. This convergence occurs because there is little correlation in the statistical record between flows four months apart. This method is fully documented in the Water Supply Providers' January 10, 2007 submittal.

Projections based on the Hirsch method show that there is a significant probability that Lake Lanier will run out of water by September 2008. Given the magnitude of the consequences if the system does run out of water, this level of risk is unacceptable. Projections based on the Hirsch method also confirm that measures included in the Emergency Operations Plan significantly increase the probability of a full recovery of the ACF system.

Although we have not presented the results of our analysis using the Hirsch method here, we urge the Corps to familiarize itself with this and other forecasting techniques that can be used to improve management of water resources within the ACF Basin. We have automated the process of using the Hirsch method to generate conditional streamflow forecasts and would be pleased to make our tools available to you upon request.

RESERVOIR RECOVERY PLAN

Whichever method is used to forecast inflows, the need for action is clear. The IOP must be suspended or modified immediately to stabilize lake levels and to allow the reservoirs to refill. Lake Lanier simply cannot be allowed to run out of water.

The Reservoir Recovery Plan we propose is divided into three phases. First, the requirements of the IOP must be waived temporarily to reduce reservoir discharges and to allow the reservoirs to refill. We propose an Emergency Operations Plan to guide operations while the IOP requirements are waived. The Emergency Operations Plan is designed to stabilize the system without causing unnecessary harm to the environment or endangered species. After the immediate crisis is stabilized, the next phase should be the adoption of a new, sustainable IOP. Finally the IOP should be replaced by a new Water Control Plan that reflects current conditions within the basin.

1. PHASE 1: Emergency Operations Plan

The IOP requirements that require unsustainable discharges and prevent refill should be waived immediately as part of a one-time-only response to the current crisis. These requirements should then be reviewed in connection with the adoption of a new *sustainable* Interim Operations Plan to be adopted before June 1, 2008.

Specific elements of the Emergency Operation Plan are described in Parts 1.1 and 1.2 below. Figure 3 and Figure 4 show the benefits that can be achieved by implementing these measures under two different hydrological assumptions: the solid lines in these plots project reservoir levels under the IOP under hydrological conditions that mirror the 2000-2001 drought; the dotted lines project reservoir levels if inflow conditions over the next two years are 15% *lower* than the 2000-2001 drought. In either case the Emergency Operations Plan will substantially improve conditions. It should be clearly noted, however, that the Emergency Operations Plan should not be expected to provide a full recovery.

Figure 3. Comparison of Projected Lake Lanier Levels Under IOP and Emergency Operations Plan Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 Percent

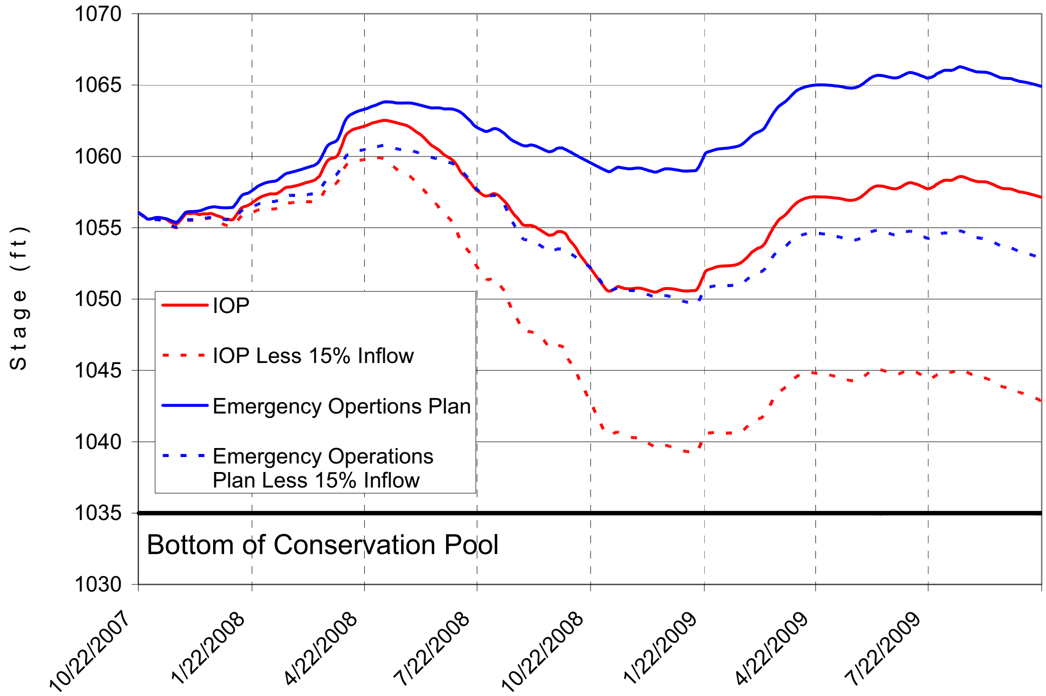
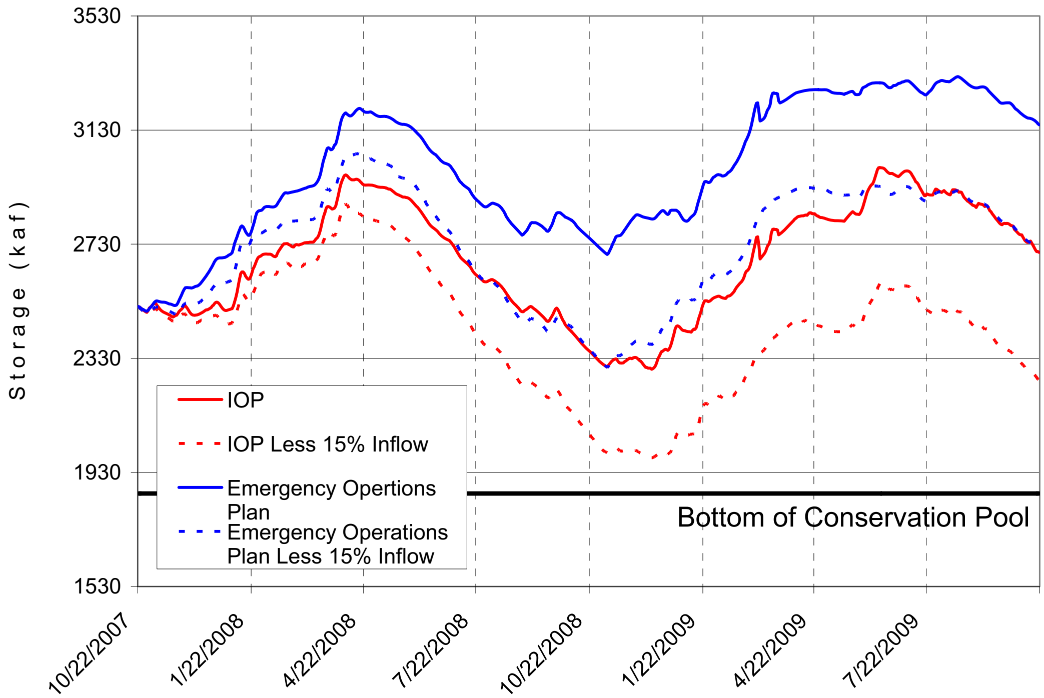


Figure 4. Comparison of Projected System Storage Under IOP and Emergency Operations Plan Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 Percent



1.1 Reduce the Discharge from Lake Lanier and Other Reservoirs

In the short term two steps should be taken to reduce the discharge from Lake Lanier. The first is to modify the minimum flow requirement at the Chattahoochee gage and the second is to modify the ramping requirements.

1.1(a) Modify the 5,000 cfs Minimum Flow Requirement

The 5,000 cfs minimum flow at the Chattahoochee gage should be reduced because it is not sustainable over the long term. The Corps and FWS have both acknowledged that this minimum flow was originally set for industrial purposes and not because it is the minimum flow required by the mussels. Therefore we urge the Corps to work with FWS to determine the minimum flow that is actually required to sustain the mussels.

Given the timing of the current crisis, however, we do not believe that reducing the minimum flow should be the highest priority in the Emergency Operations Plan. Although it would clearly be disastrous to use reservoir storage to support minimum flows through the winter and spring, projections based on past hydrological cycles suggest it is very unlikely that reservoir storage will be required to augment stream flows to meet the 5,000 cfs minimum flow past the end of November. If these projections hold for the upcoming year—and that is an important caveat, which we address below—it follows that it may already be too late to grant meaningful relief *this year* from the 5,000 cfs minimum flow. It is far more important to waive the requirements of the IOP that would otherwise prevent the reservoirs from refilling this winter and spring.

Although we do not believe the minimum flow should be the highest priority for the upcoming months, the requirement clearly should be reviewed and revised before June 1 next year, when the minimum flow is likely to become an important issue again.

1.1(b) Modify Ramp-Down Requirements

The other IOP requirement that must be waived to reduce the discharge from the reservoirs is the ramp-down requirement, which has already been suspended (with approval of FWS) from now until March 1, 2008. The Emergency Operations Plan proposes a slight modification to these new ramping requirements.

The original ramp-down restrictions required the Corps to release large amounts of water from storage to "smooth out" the natural variations in stream flow that occur when it rains. Instead of storing water associated with rainfall events, as it could and should, the Corps was instead required under the IOP to let it go—because it is required to release 100% of Basin Inflow at the critical times—and the Corps was also required to release substantial water from storage to provide a gradual ramp-down from the higher levels resulting from these rainfall events.

FWS has already recognized that ramp-down requirements can be suspended on an interim basis because there likely would be no adverse effect on endangered species. The flow of the Apalachicola River at the Chattahoochee gage has been at or around 5,000 cfs at all times since May 2007. Therefore mussels at risk of stranding have already been stranded. Stranding should not present any significant risk in the next several months unless stream flows are allowed to rise significantly above 5,000 cfs.

Based on the recent actions of the Corps and FWS, both agencies now appear to agree that ramp-down requirements should not be imposed to reduce the rate of fall of the river after a natural rainfall event. Ramping requirements should only be used to transition between man-made alterations of the flow regime, such as between spawning and non-spawning flows or between navigation releases and normal operations.

As we understand it, the new ramping regime approved by FWS is designed to accommodate these concerns. FWS has approved the use of the "Basin Inflow fall rate" rather than the IOP maximum fall rate schedule. We believe this concept adequately captures the principle that reservoir storage should not be used to moderate natural variations in the flow of the river. We do have one concern, however, which is that it might be necessary at times to ramp-down even when Basin Inflow is rising or remaining steady. Therefore we suggest that the maximum flow rate should be the *maximum* of (1) the Basin Inflow fall rate; or (2) the maximum fall rate schedule. This is how we have modeled the ramping requirement for purposes of the models used to prepare the graphs and figures included in this presentation.

1.2 Refill the Reservoirs

Given the timing of the current crisis within the hydrological cycle—as we are currently in the driest month of the year but are beginning to transition into the typically wetter winter months—the highest priority in the Emergency Operations Plan should be an immediate, temporary waiver of the IOP to allow the reservoirs to refill during the winter and spring. We also recommend an immediate, temporary waiver of rule curves for West Point Lake and Lake Walter F. George to maximize storage capacity in the lower basin *for this winter only*.

1.2(a) 5,000 cfs / 11,000 cfs Storage Rule

To allow the reservoirs to refill, the IOP should be temporarily waived and replaced with the following schedule, which is illustrated graphically in Figure 5.

1.2(a)(i)Storage Rules

During the non-spawning season:

- When Basin Inflow is greater than 5,000 cfs, all flows in excess of those required to meet the 2000 cfs minimum flow target at Farley Nuclear Plant should be stored in the Chattahoochee reservoirs to the extent possible.

- When Basin Inflow is less than 5,000 cfs, (or whatever alternative minimum flow FWS determines to be appropriate) storage should be released from the Chattahoochee reservoirs to meet the minimum flow.

During the spawning season:

- When Basin Inflow is greater than 11,000 cfs, all flows in excess of those required to meet the 2000 cfs minimum flow target at Farley Nuclear Plant should be stored in the Chattahoochee reservoirs to the extent possible.

- When Basin Inflow is between 5,000 cfs and 11,000 cfs, Woodruff Outflow should equal Basin Inflow.

- When Basin Inflow is less than 5,000 cfs, (or whatever alternative minimum flow FWS determines to be appropriate) storage should be released from the Chattahoochee reservoirs to meet the minimum flow.

1.2(a)(ii) Potential alterations based on system status:

- This refill plan should remain in effect at least until the system recovers or until a new *sustainable* Interim Operations Plan can be adopted.

- If System Storage is still in Zone 4 on February 1, the spawning flow for 2008 should be eliminated and further emergency measures should be evaluated immediately.

Regarding the caveat for extreme emergencies, additional emergency measures will absolutely have to be taken if system storage is still in Zone 4 on February 1. Our models indicate that this will only occur if the current drought becomes much worse than anything we have experienced in the historical record. In that event the probability of a total system collapse will be very high. If this occurs the spawning flow for 2008 would have to be eliminated. When faced with a choice between a total system collapse and a one-year interruption in spawning flows, a one-year interruption in spawning would be a reasonable and prudent alternative.

Figure 5. Graphical Illustration of 5,000/11,000 cfs Storage Rule

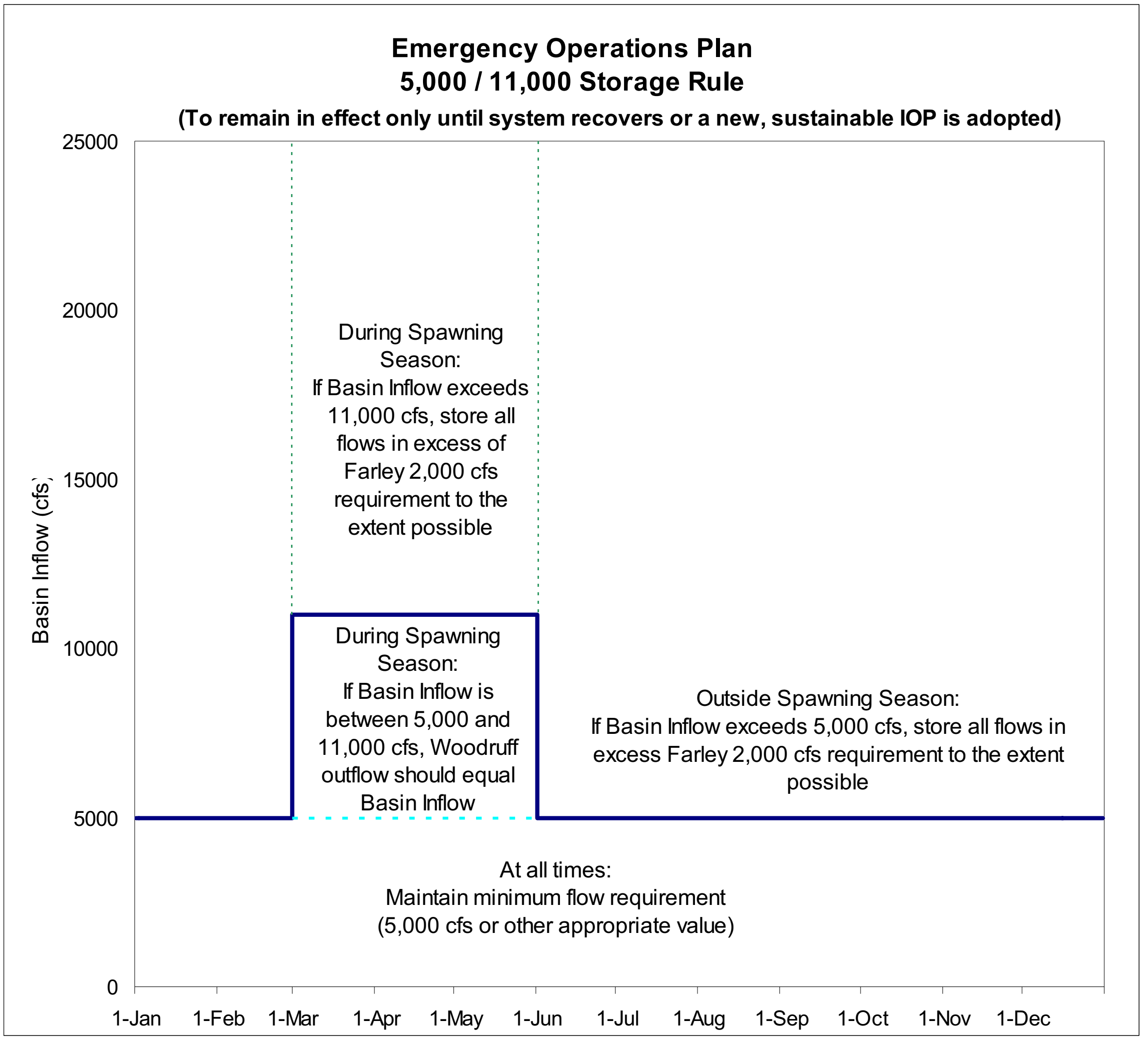


Figure 6, Figure 7, and Figure 8 show the effect of the Emergency Operations Plan on Lake Lanier levels, System Storage and Woodruff Outflow respectively.

Figure 6. Projected Lake Lanier Levels Under 5,000/11,000 cfs Storage Rule Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 Percent

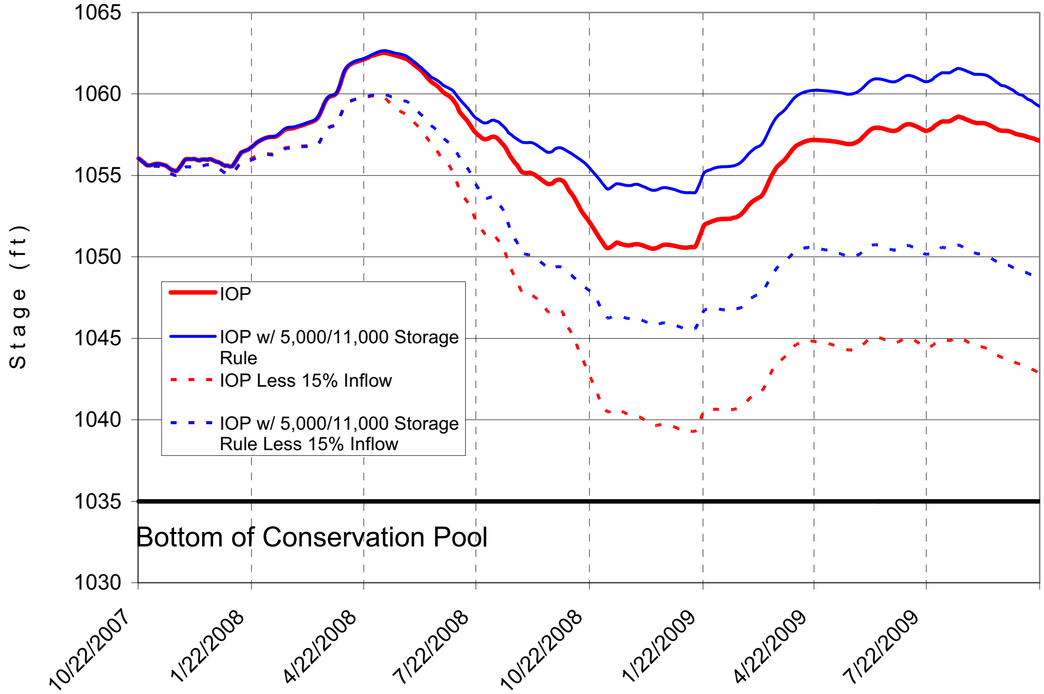


Figure 7. Projected System Storage Under 5,000/11,000 cfs Storage Rule Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 Percent

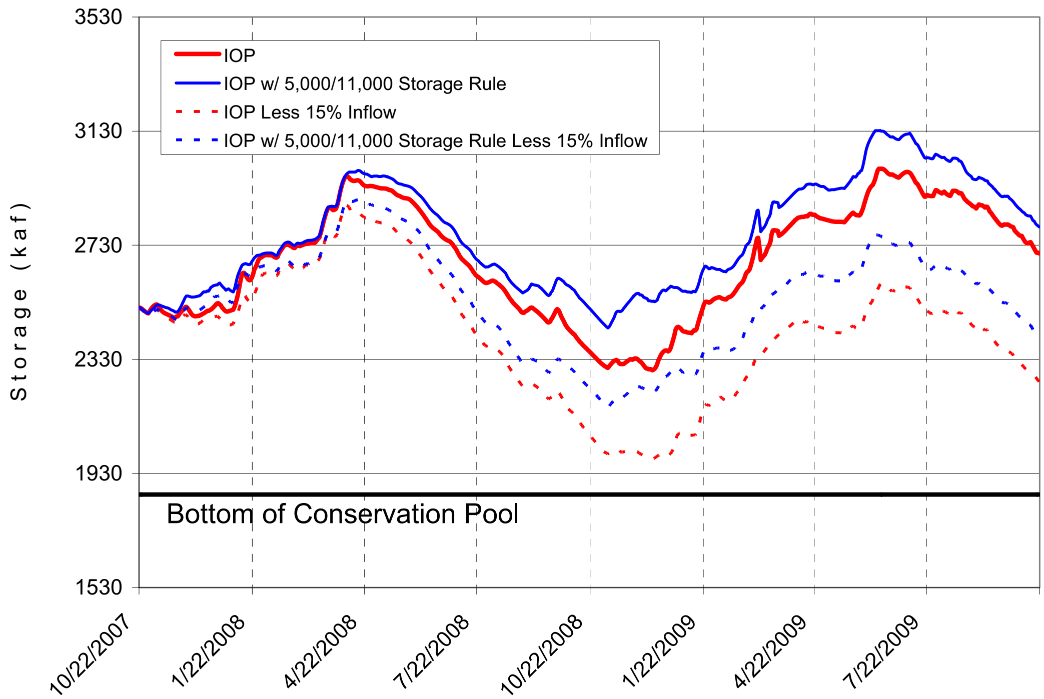
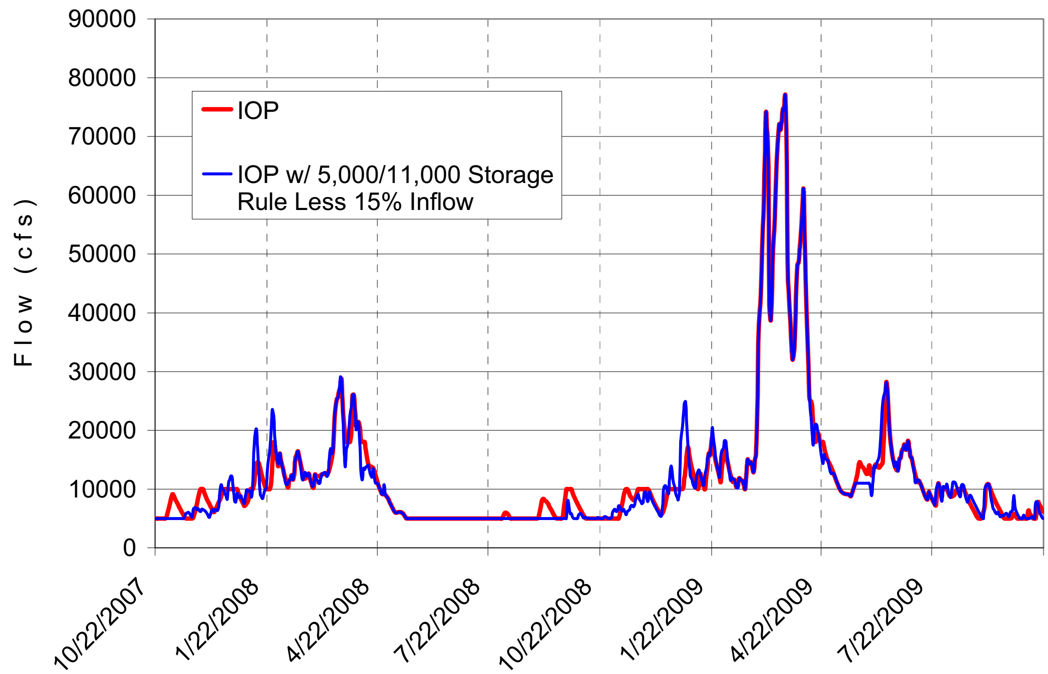
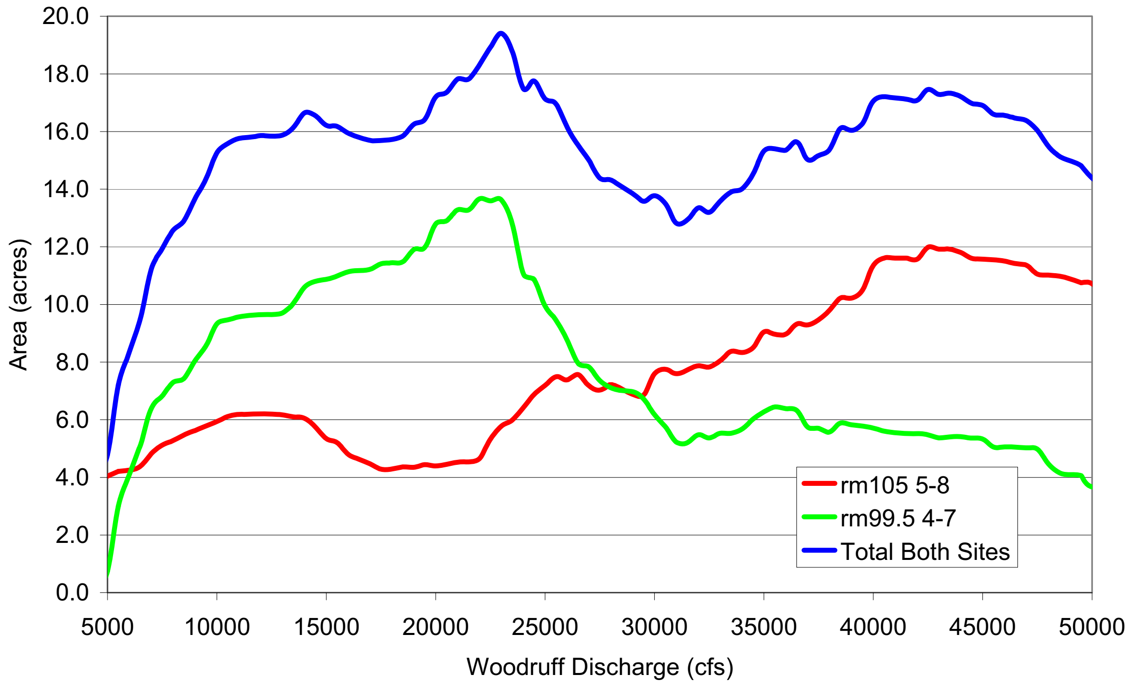


Figure 8. Projected Woodruff Releases Under 5,000/11,000 cfs Storage Rule Using 2000-2001 Inflow Conditions



The provisions of the Emergency Operations Plan for spawning flows should be acceptable to FWS based on data provided in the Biological Opinion about the physical characteristics of the known spawning sites. The Biological Opinion uses the availability of spawning habitat under various flow regimes as a surrogate for spawning success. Habitat is considered to be available if it is inundated to a depth between 8.5 feet and 17.8 feet. FWS has collected data on the amount of habitat that is available at any given flow, which is a function of the shape of the river bottom at the known spawning sites. This data is summarized in Figure 4.3.1.C of the Biological Opinion, which is reproduced as Figure 9 below. The habitat availability curve plateaus after about 10,000 cfs. The curve for RM 105—by far the most important spawning site—shows that flows in the range of 18,000 cfs (the threshold value in the IOP) produce *less* spawning habitat than flows between 10,000 cfs and 14,000 cfs.

Figure 9. Area of hard substrate inundated to depths of 8.5 to 17.8 feet at the two known Gulf Sturgeon spawning sites on the Apalachicola River. [Biological Opinion Figure 3.6.1.4.C]



As shown above, the available data show that the 18,000 cfs "no storage" threshold should be modified to allow flows in excess of 11,000 cfs to be stored. By this measure, storing flows between 14,000 cfs and 20,000 would actually *benefit* sturgeon; storing flows in excess of 11,000 cfs would do no harm. Figure 10 and Figure 11 prove this point by comparing available habitat for 2008 and 2009 under the IOP and under the Emergency Operations Plan. Figure 12 and Figure 13 make the same comparisons for RM 105, the most important spawning site. There is no significant difference.

Given current conditions and the best available data, this relief should be granted.

Figure 10. Comparison of Projected Available Spawning Habitat (Both Sites) in 2008 Under IOP and Emergency Operations Plan, Using 2000-2001 Inflow Conditions and Data From Biological Opinion

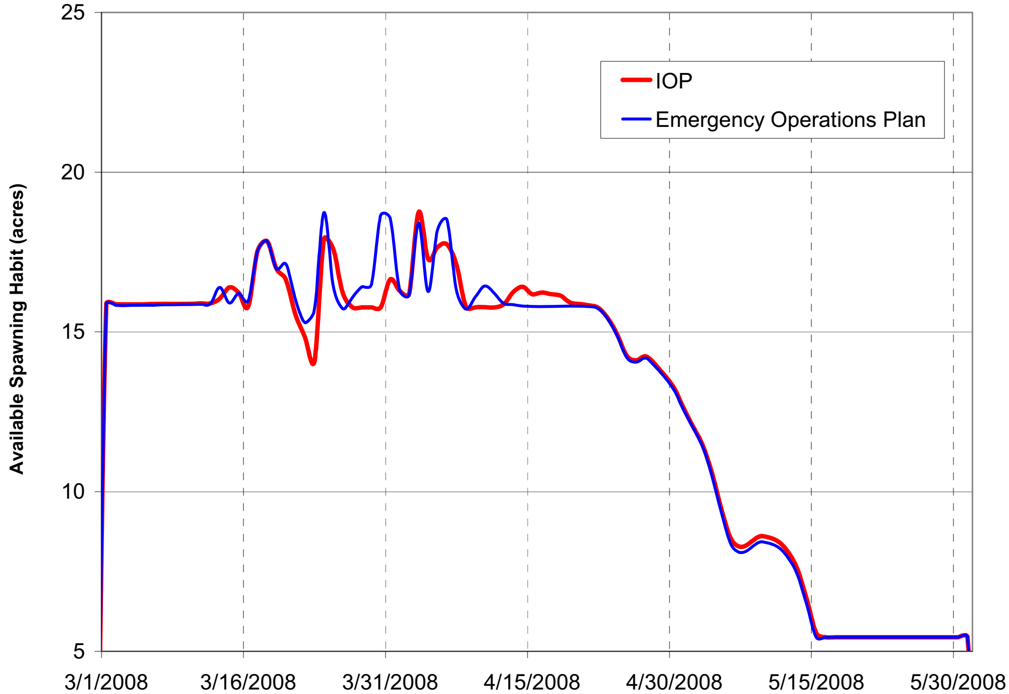


Figure 11. Comparison of Projected Available Spawning Habitat (Both Sites) in 2009 Under IOP and Emergency Operations Plan, Using 2000-2001 Inflow Conditions and Data From Biological Opinion

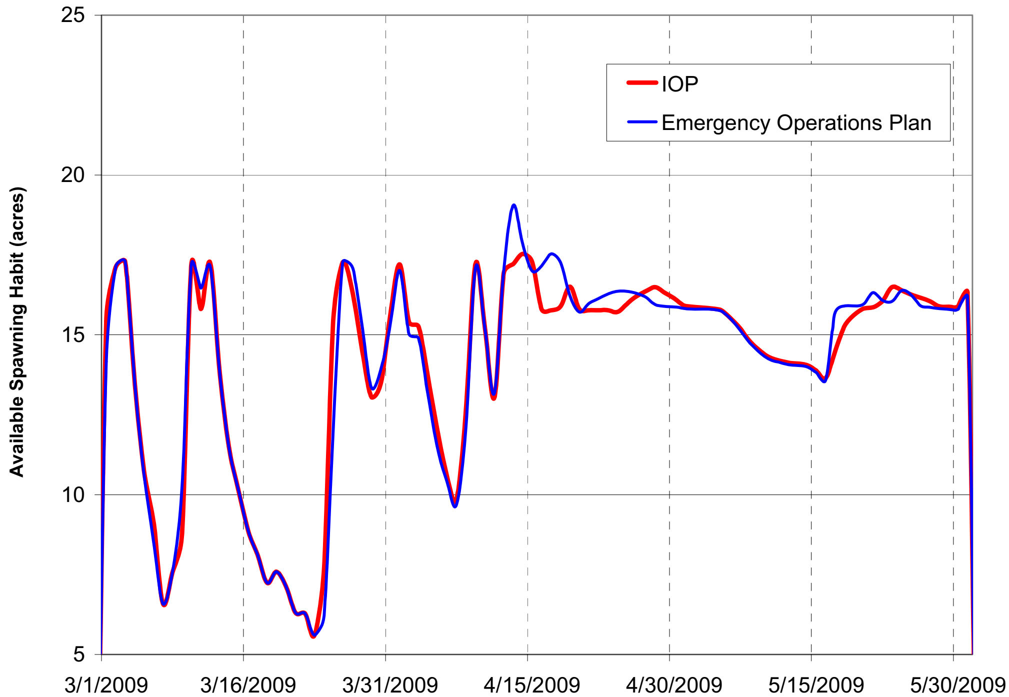


Figure 12. Comparison of Projected Available Spawning Habitat at River Mile 105 in 2008 Under IOP and Emergency Operations Plan, Using 2000-2001 Inflow Conditions and Data From Biological Opinion

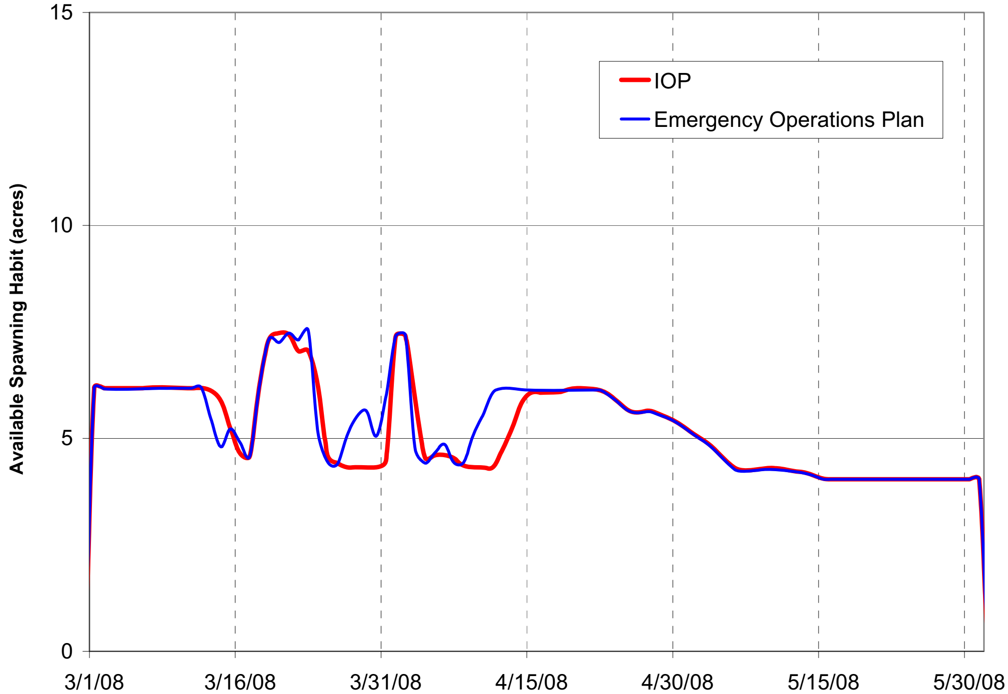
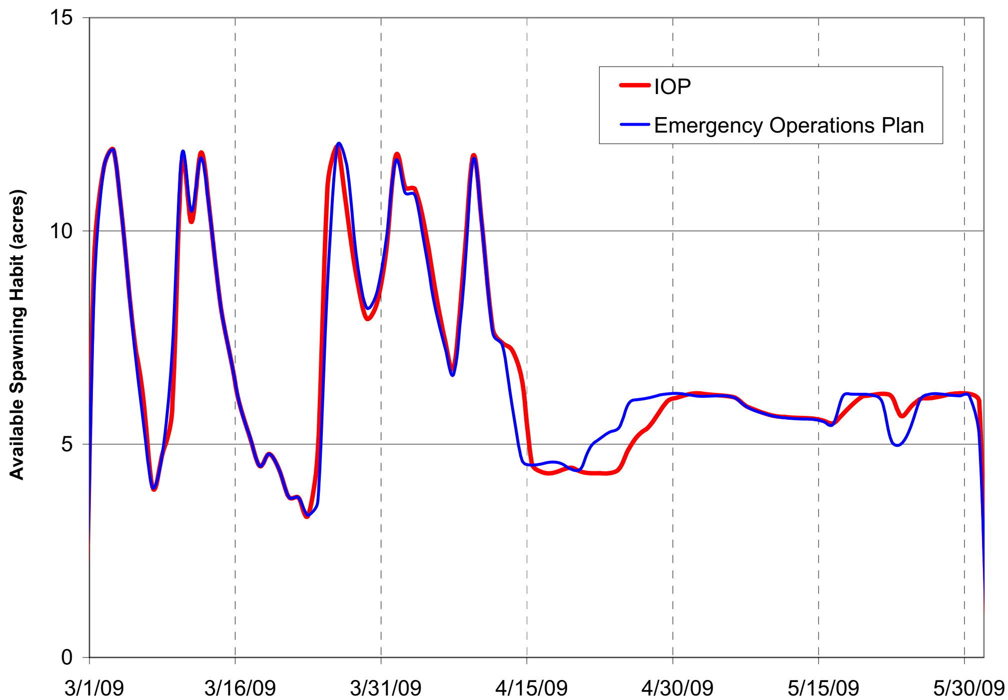


Figure 13. Comparison of Projected Available Spawning Habitat at River Mile 105 in 2009 Under IOP and Emergency Operations Plan, Using 2000-2001 Inflow Conditions and Data From Biological Opinion



1.2(b) Temporary waiver of the seasonal drawdown at West Point and Walter F. George (for 2007-2008 only)

In addition, the provision of the Water Control Plan requiring a seasonal drawdown at West Point and Walter F. George should be temporarily waived as part of the emergency response to the current crisis. A temporary waiver of the drawdown will substantially increase system storage in the lower basin at little or no cost to the environment. This measure will create needed flexibility to manage the current crisis. Figure 14, Figure 15 and Figure 16 show the effect on the IOP of eliminating the seasonal drawdown at these two reservoirs.

Figure 14. Projected Lake Lanier Levels Under IOP With No Seasonal Drawdown at West Point or Walter F. George Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 Percent

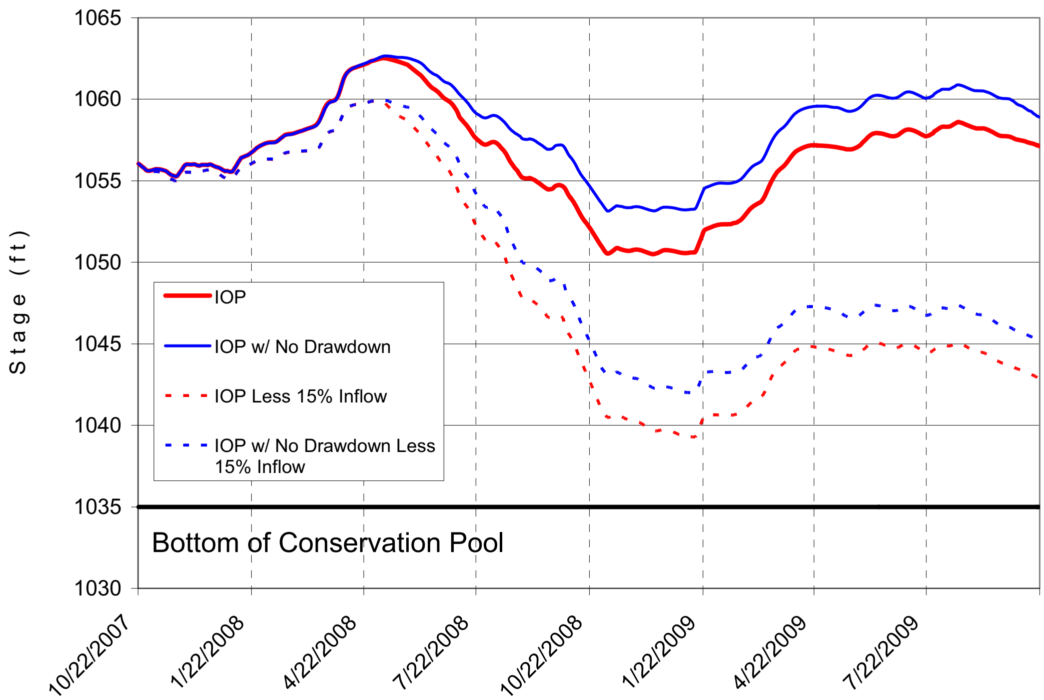


Figure 15. Projected System Storage Under IOP With No Seasonal Drawdown at West Point or Walter F. George Using 2000-2001 Inflow Conditions and 2000-2001 Inflow Conditions Reduced by 15 Percent

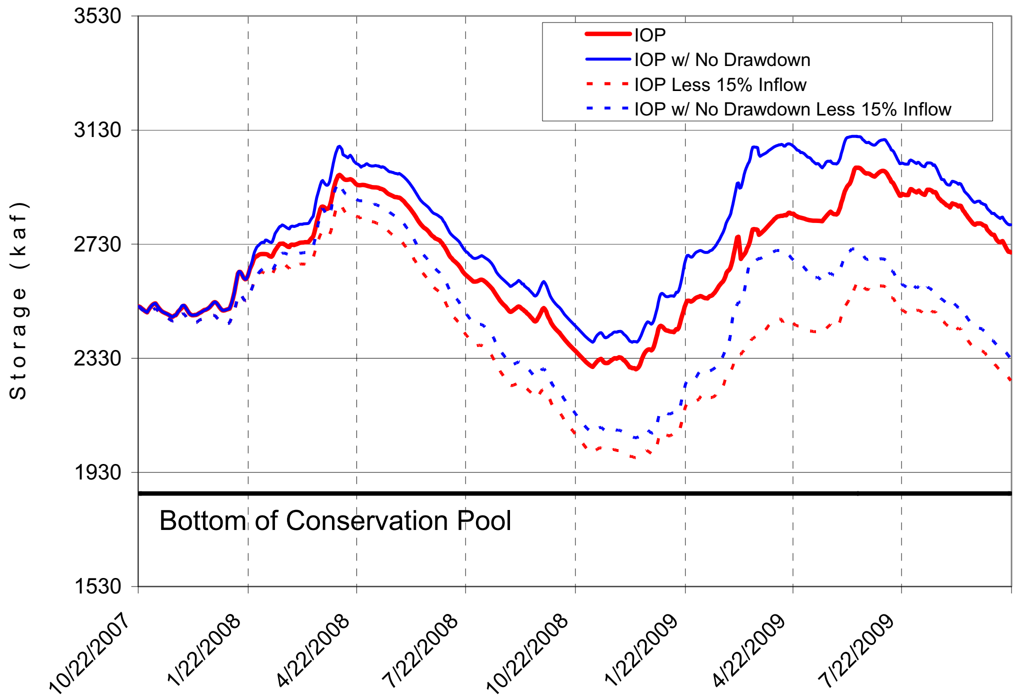
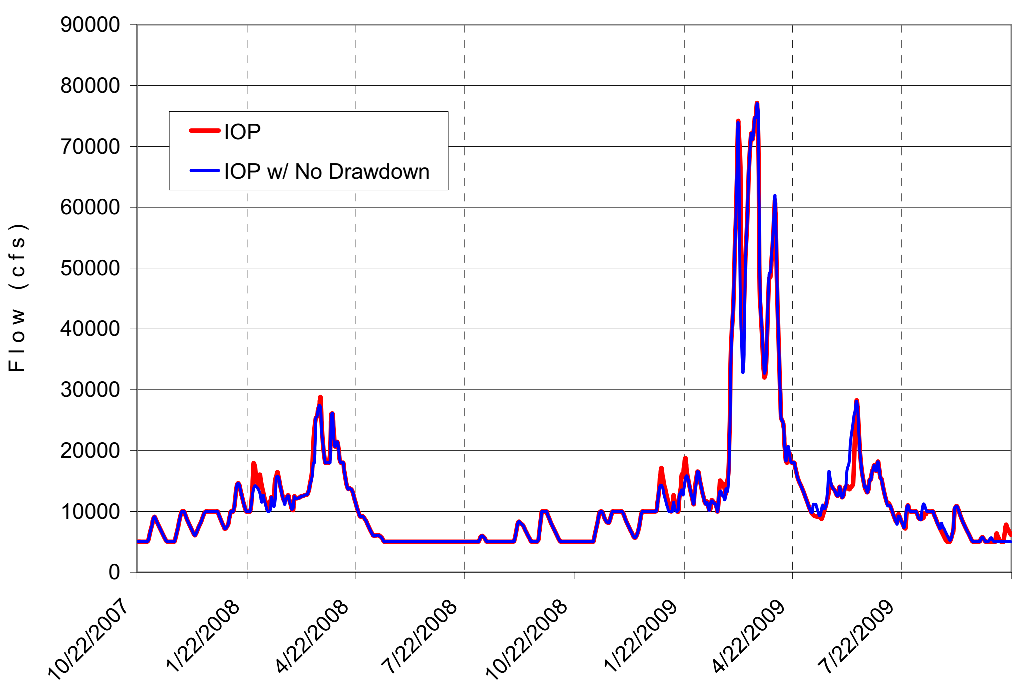


Figure 16. Projected Woodruff Outflows Under IOP With No Seasonal Drawdown at West Point or Walter F. George, Using 2000-2001 Inflow Conditions

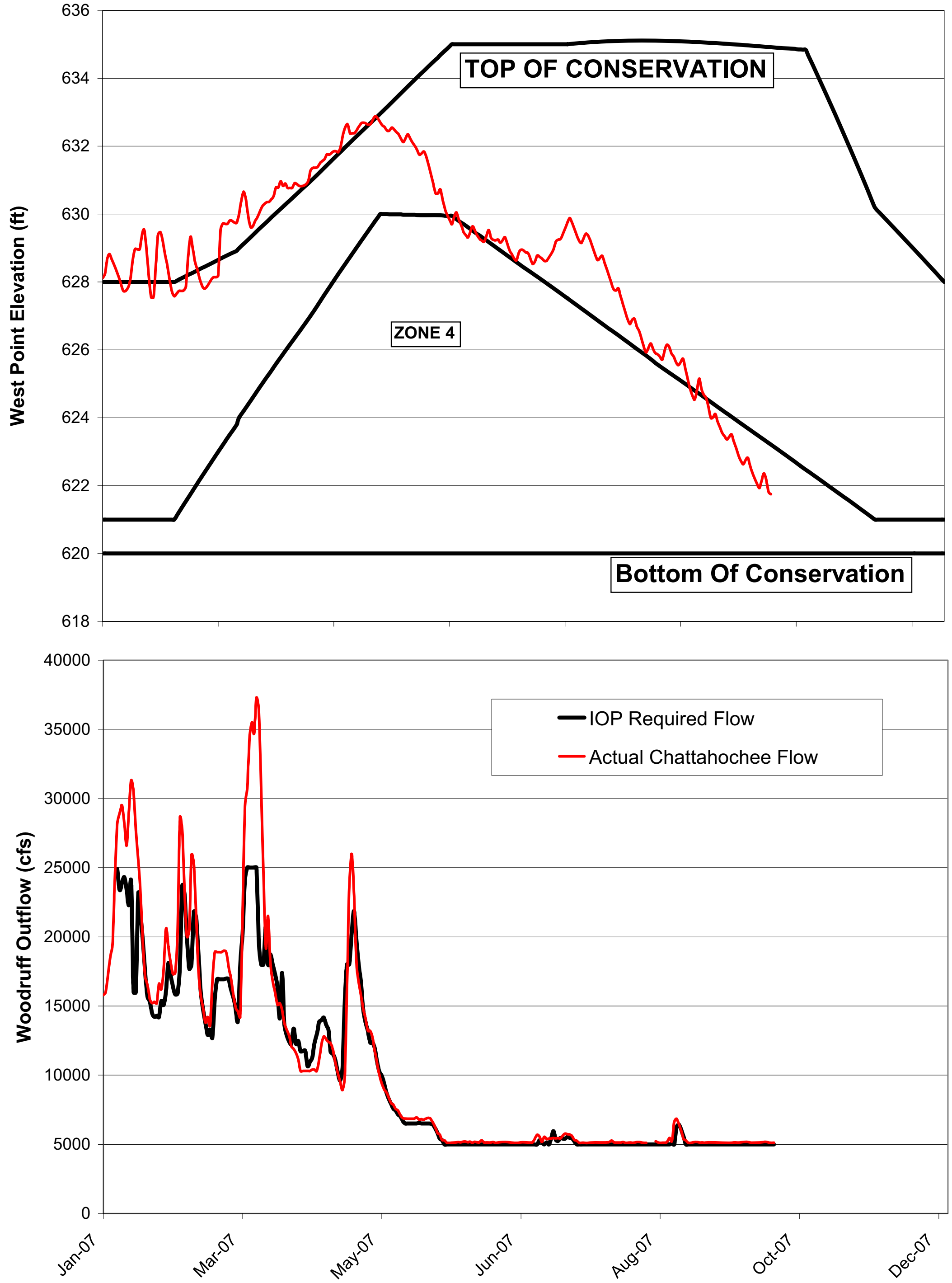


The Corps is legally authorized to reduce or eliminate the seasonal drawdown as long as this can be done without compromising the flood control function. Given present conditions, where the drought risk is much higher than the flood risk, an emergency exception to the water control plan should be granted to keep the winter pool level at 635'. This change would contribute substantially to the system's ability to refill.

Figure 17 shows how the "Water Control Action Zones" for West Point operated in the spring of 2007 to require the release of large quantities of water in excess of the IOP requirements—water that is desperately needed today. The first graph in Figure 17 shows lake elevations in West Point as compared to the rule curve and the second graph shows flows at the Chattahoochee gage as compared to the IOP requirements. During the period from January to May 2007, a volume of water was released from West Point substantially larger than the *IOP* requirements; this excess could have been safely stored in West Point Lake.

Later, when the rule curve at West Point was raised, the Corps was forbidden by the IOP from using basin inflow to fill West Point to the summer pool level. The Corps was therefore forced to release large amounts of water from Lake Lanier to balance the two reservoirs. These mistakes cannot be repeated in 2008 if the system is to have any chance of recovering.

Figure 17. West Point Levels and Woodruff Outflow Under IOP in 2007



2. Phase 2: ***Sustainable*** Interim Operations Plan

We request a temporary waiver of the IOP in accordance with the plan described above to allow the system to recover and to restore public confidence. The Emergency Operations Plan should remain in place at least until the system has recovered or until a new, sustainable IOP has been adopted.

Immediately after a plan has been put in place to get through the current crisis, the Corps should begin work on a new, sustainable Interim Operations Plan. We cannot wait until the water control planning process is completed.

To avoid a repeat of past mistakes, we request that the Corps consult with the Water Supply Providers and other stakeholders before adopting the new IOP. We further suggest that the clear need to adopt a new IOP prior to the adoption of the new water control plan should create opportunities for the Corps to experiment with new types of operations, perhaps on a pilot basis.

On January 10, 2007, the Water Supply Providers proposed an operating plan that we have called the "Maximum Sustainable Release Rule." The basic principle of this plan is to provide the maximum flow in the Apalachicola River that can be sustained while still allowing the ACF reservoirs to refill each year by June 1. Although the rule includes other provisions as a type of "failsafe" to protect the environment and public health and safety, these provisions would only be triggered in the most extreme conditions.

Our modeling of the Maximum Sustainable Release Rule shows it does a much better job for the environment—and for the endangered species in particular—without compromising the security of water supply. Figure 18, Figure 19 and Figure 20 show the effect of the Maximum Sustainable Release Rule on Lake Lanier, System Storage and Woodruff Outflows, respectively, for 2008 using hydrology based on 2000-2001 conditions.

Figure 18. Comparison of Projected Lake Lanier Levels Under IOP and Maximum Sustainable Release Rule Under 2000-2001 Inflow Conditions and 2000-2001

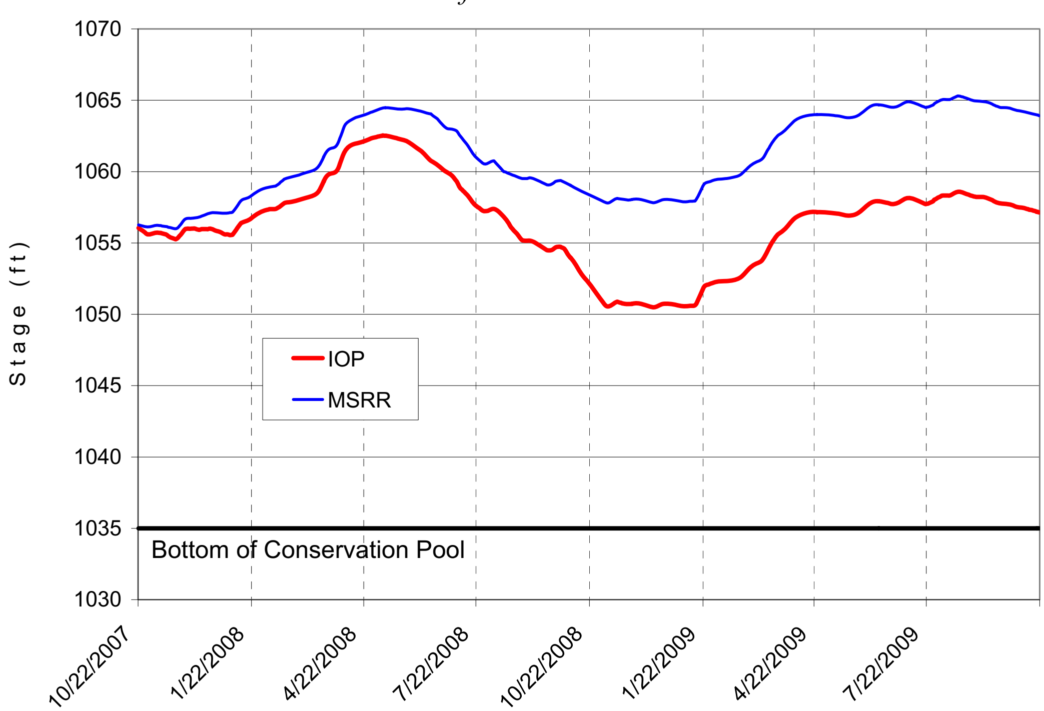


Figure 19. Comparison of Projected System Storage Under IOP and Maximum Sustainable Release Rule Under 2000-2001 Inflow Conditions and 2000-2001

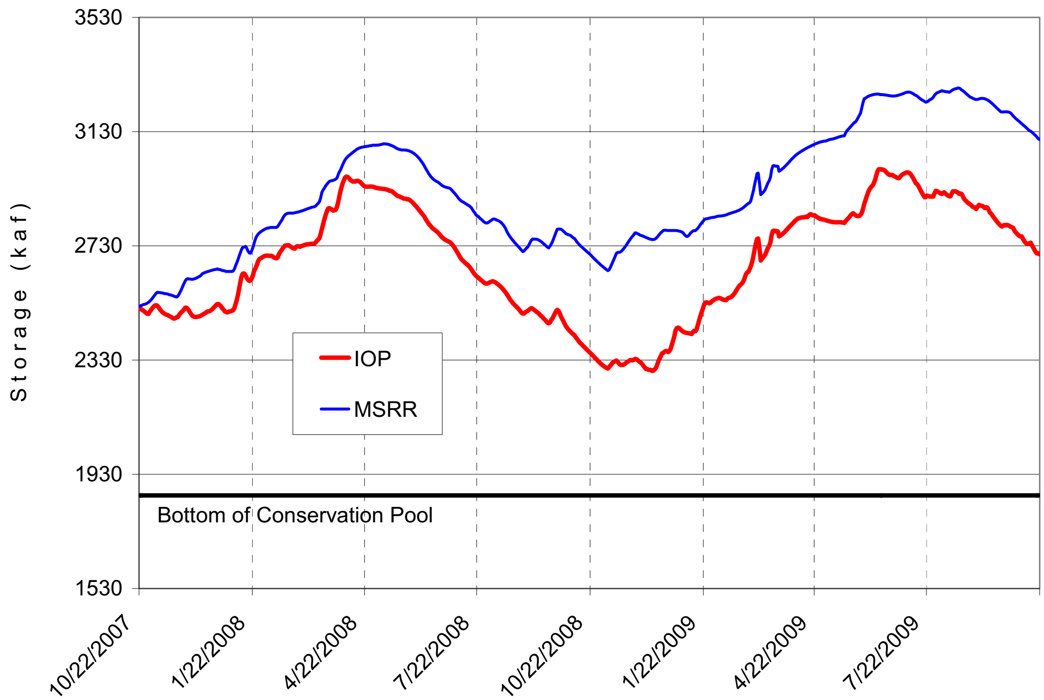
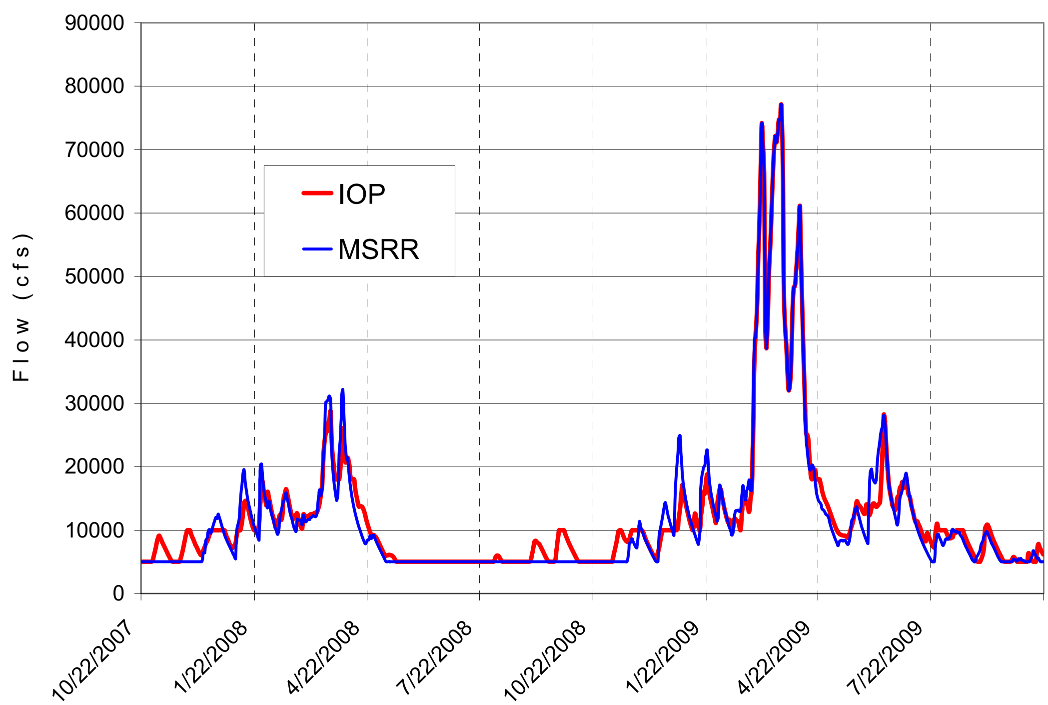


Figure 20. Comparison of Projected Woodruff Outflows Under IOP and Maximum Sustainable Release Rule Under 2000-2001 Inflow Conditions and 2000-2001



We encourage the Corps to consider this and any other reasonable measures to avoid a recurrence of the problems experienced this year.

Phase 3: A New Water Control Plan

Finally, it is long past time for the Corps to prepare new water control plans for the ACF Basin. New plans absolutely must be prepared to reflect current and future conditions in the basin. New plans must prepared not only to avoid a repeat of the current crisis but also to maximize benefits of the federal reservoirs for all users, including the environment. We can do a much better job of managing this resource and we all have a duty to do so.

CONCLUSION

In conclusion, the current IOP is unsustainable and should be altered. Reasonable options exist to stabilize the system without causing unnecessary or significant impacts to endangered species. We request that you implement the Emergency Operations Plan detailed above to address the present crisis and to move expeditiously to adopt the full Reservoir Recovery Plan. We would welcome the opportunity to comment further and stand ready to assist in any way that we can.

Sincerely,

Charles Krautler

Charles Krautler
Director

cc: Gail Carmody
Sandy Tucker
Sam Olens

APPENDIX F

CORPS RPM4 AND RPM5 SUBMITTAL

30 AUGUST 2007

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

August 30, 2007

REPLY TO
ATTENTION OF:

Inland Environment Team
Planning and Environmental Division

Ms. Gail Carmody
Field Supervisor
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405-3721

Dear Ms. Carmody:

On September 5, 2006 the U.S. Fish and Wildlife Service (USFWS) issued a Biological Opinion (BO) and Conference Report for the Jim Woodruff Dam Interim Operations Plan (IOP), pursuant to Section 7 of the Endangered Species Act (ESA). This letter transmits our sediment transport and channel stability evaluation and listed mussel monitoring plan in accordance with Reasonable and Prudent Measure No. 4 (RPM4) and Reasonable and Prudent Measure No. 5 (RPM5) of the BO. RPM4 is intended to improve our understanding of the channel morphology and the dynamic nature of the Apalachicola River as it relates to potential for impacts to listed mussel habitat. RPM5 includes a requirement to evaluate ways to minimize take of listed mussels by studying the distribution and abundance of the listed mussels in the action area. The specific terms and conditions for the two RPMs are included in Enclosure 1.

The BO specifies March 30, 2007 as the date for completion of both the RPM4 and RPM5 actions. By letter dated March 30, 2007 (Enclosure 2), your office agreed to extend the completion date to August 30, 2007 and requested a work schedule for completing the two RPMs. In addition, you requested that we initiate mussel sampling this summer as part of and in support of the mussel monitoring plan. In our letter dated May 11, 2007 (Enclosure 3) we provided the requested information and agreed to initiate a mussel sampling effort this summer. The following describes our actions with regards to RPM4 and RPM5.

Reasonable and Prudent Measure No. 4

RPM4 requires an evaluation of the sediment dynamics and channel morphology trends on the Apalachicola River in order to improve our understanding of dynamic conditions and monitor the zone at which take may occur, and to identify possible alternatives to minimize effects to listed mussels in vulnerable locations. The Terms and Conditions of the BO specify that Mobile District and USFWS will consult with experts, jointly identified by both agencies, to assist in identifying the current status of sediment transport and channel stability in the Apalachicola River as it relates to the distribution of listed mussels and their vulnerability to low-flow conditions. The goals of the evaluation are to identify: 1) feasible water and/or habitat management actions that would minimize listed mussel mortality; 2) current patterns and trends in morphological changes; and, 3) additional information needed, if any, to predict morphological changes that may affect the listed mussels. This evaluation is to be based on available information and tools and best professional judgment.

As a result of previous discussions at our October 2006 and March 2007 semi-annual meetings, we mutually identified three specialists with specific river sediment transport and morphology expertise (Mr. Kirk Vincent, geomorphologist from Department of Interior; Dr. David Biedenharn, sediment transport specialist formerly from the U.S. Army Corps of Engineers Engineering Research Development Center (ERDC), and Dr. Michael Harvey, geomorphologist from the private sector). Additionally, Dr. Andrew Miller, a malacologist formerly from ERDC, with extensive experience regarding freshwater mussels in the Apalachicola River and other large river systems was also identified for participation in this effort. On April 9, 2007, Mobile District and USFWS conducted a teleconference with the potential specialists to determine their availability and willingness to assist in this effort, and to outline the evaluation goals and expectations. Mr. Vincent indicated that he would not be available to participate, but that he could provide comment and review as time allowed. A copy of this letter will be provided to Mr. Vincent for review. All the other specialists were available for the evaluation and their services were procured by Mobile District. Following the teleconference, specific background information was provided to the river specialists to familiarize them with the Apalachicola River and the data available.

We held an initial meeting with Mr. Jerry Ziewitz of your staff and the river and mussel specialists in June 2007, which included a two-day reconnaissance field visit to the Apalachicola River. The field trip consisted of a visual inspection of the entire river from the dam down to the mouth and included numerous stops to more closely investigate sediment sources, potential mussel habitat, and known mortality sites from 2006. During the trip Dr. Miller and Mr. Ziewitz described mussel life history and habitat requirements to the river specialists, and led tours of sites known to provide relatively high, moderate, and low mussel densities. A considerable amount of time was spent discussing the "preferred habitat" at various scales (macro, meso, micro, as well as temporal). A follow-on workshop was held in August 2007, and the individual river specialists shared with both our agencies their observations regarding changes in the river sedimentation and morphology, and opinions regarding any patterns or trends in these processes. Dr. Miller and additional mussel experts from ERDC (Mr. Mark Farr and Mr. Mark Antwine), also provided insight into mussel habitat requirement and mussel responses to predicted or observed riverine sediment or morphological changes. The Memorandum for Record (MFR) for this workshop is provided in Enclosure 4.

Based on review of existing information, the reconnaissance field trip, presentations and discussions at the August workshop, and the summary of findings reports prepared by the river specialists and malacologist, we believe the current version of the IOP adequately meets the intended goal of minimizing or avoiding adverse impacts or providing support to listed species occurring in the Apalachicola River. As documented in the BO, the flow regime in the Apalachicola River has not been changed significantly between the pre- and post- dam periods. The river appears to be in a relatively stable dynamic equilibrium. The morphology of the river could have been impacted over time by land use changes, upstream impoundments and consumptive use of water, and tectonic movement, as well as channel alterations, meander cutoffs, and channel dredging and snagging operations. Obvious channel degradation impacts are noted below Jim Woodruff Lock and Dam immediately after construction. However, these impacts appear to be reduced through time. Data from the Blountstown and Wewahitchka gages downstream of the dam indicate that there was a small change in low flow water surface elevations at those sites in response to Jim Woodruff construction, but the changes appear to have stabilized. Field observations and data analysis by the river specialists suggests that the river is not continuing to degrade and that it may have attained a state of relative equilibrium. This is consistent with the findings of Light et al. (2006) who concluded that channel conditions had been relatively stable for the past ten year period (1995-2004). Although a large portion of the middle river (River Mile (RM) 78 to RM 35) is very sinuous and actively meandering, maximum erosion rates on the outside of the bends in this reach are low compared to other large alluvial rivers and appear to be part of the natural down-valley meander migration which is common to most meandering streams. This does not appear to be the result of continuing post-dam system-wide adjustment such as degradation, aggradation, or channel widening. It appears unlikely that erosion rates will increase over time unless there are significant changes of the flow regime or reduction in sediment supply. Additional studies that further investigate the river widening phenomenon reported by the USGS based on comparative treeline analysis and sediment budget for the river could provide additional insight into whether or not the river has achieved a somewhat dynamic equilibrium. These studies might include development of a one-dimensional sediment continuity model for the river. Perhaps more importantly, additional studies could also be conducted to better understand the spatial and temporal relationships between the meander dynamics of the river and the formation and maintenance of high quality mussel habitat. A two-dimensional hydrodynamic model could be developed for specific sites. A recommendation for this type of study has been incorporated (Phase III) into the proposed mussel monitoring plan described below.

Reasonable and Prudent Measure No. 5

RPM5 requires monitoring of the level of take associated with the IOP and an evaluation of ways to minimize take by studying the distribution and abundance of the listed mussels in the action area. Information from the monitoring of mussel distribution and degree of vulnerability over time will be used to prepare biological assessments for future consultations related to water management operations. The goals of the mussel monitoring plan are to 1) periodically estimate total abundance of listed mussels in the action area; and 2) determine the fraction of the population that is located in habitats that are vulnerable to low-flow impacts. Mobile District collaborated with Dr. Miller and mussel specialists at ERDC in the development of a long-term mussel monitoring plan. As mutually agreed in our March 1, 2007 semi-annual meeting, we integrated the efforts for development of this plan with the observations and evaluations presented by the above sediment/morphology river specialists. Therefore, the mussel specialists were included in the river field inspection and follow-on workshop. Your letter extending the due date for development of the mussel monitoring plan also requested that additional mussel sampling of the distribution of mussels in potentially vulnerable areas be conducted this spring or summer, and that information from the mussel sampling effort be used to assist in developing a more comprehensive monitoring plan.

On May 31, 2007, representatives from your office, the Corps, Florida Fish and Wildlife Conservation Commission (FWCC), and Dr. Drew Miller conducted a field investigation to develop a survey methodology that would support improving our understanding of *Amblema neislerii* densities in areas potentially vulnerable to stranding during low flow conditions similar to those experienced in the summer of 2006. The field trip included inspections of areas of known mussel populations, areas where mussel stranding occurred in 2006, and previously unknown areas that supported the following identified mussel habitat conditions: moderately depositional, low to moderate slope towards thalweg (10 – 20 degrees), silty-sand substrate, and relatively new willow growth. All the areas visited that supported this habitat characteristic were observed to also support *A. neislerii.* During the trip it was agreed that the sampling data to be collected should support an estimate of the density of *A. neislerii* at the sites and that the methods should be repeatable at different flows and locations.

The mussel sampling survey took place on July 7-11, 2007 and focused on habitats occurring between RM 40 and RM 50 on the main channel of the Apalachicola River. The USFWS identified 25 study areas along the river which either supported, or appeared likely to support *A. neislerii.* Ten sites were randomly selected by the USFWS for detailed quantitative study and additional qualitative studies were conducted at the remaining sites. The purpose of the study was to collect information on density and relative species abundance of *A. neislerii* at sites that appeared to provide appropriate water depth, velocity, and substratum. In addition, the study was done to provide information that would be used to prepare a long-term mussel monitoring plan for the river. A detailed description of the sampling methodology, results, and proposed monitoring plan are provided in Enclosure 5. Based upon qualitative sampling, *A. neislerii* were found at 23 of the 25 areas between RM 40 and RM 50. *A. neislerii* were observed at all 10 of the sites where detailed studies occurred and this species comprised nearly 37 percent of the total mussel fauna. Furthermore, approximately 30 percent of the quadrats (n=180) had at least one individual *A. neislerii* present. There was also evidence of strong recent recruitment.

The results of this and previous surveys suggest that high density, recruiting populations of *A. neislerii* exist in the Apalachicola River and probably always have. Although a few specimens can generally be found in most any aquatic habitat, this species reaches its greatest numerical abundance in habitats with similar meso- and micro-scale hydraulic characteristics. On the Apalachicola River these characteristics include flow separation zones (eddies) at higher flows. These eddy zones result in moderately depositional sites generally occurring on the inside of river bends immediately downstream of point bars. These areas further concentrate fine-grained sediments, organic matter, and if present, glochidia larvae of the mussels. The locations of these types of habitat are likely to change through time and space as the river bends migrate laterally and downriver through the floodplain.

Because of recent low water in 2006, mussel mortality was observed at the mouths of sloughs and in associated swales along the margins of the main channel. Based on the analysis provided by the river specialists and the investigations of these areas during 2007 it appears that most of these "vulnerable" sites are becoming terrestrial habitat due to natural river meandering processes such as erosion and sedimentation. Although mussel habitat is lost during this process, new habitat is generally being created simultaneously, resulting in no net loss of habitat. Mussel mortality has likely always occurred due to this phenomenon and it appears that this species is adapted quite well to recovering from these events as they occur in the Apalachicola River. These mussels represent a dynamic population in a dynamic system and it is important to manage for the whole population and not just individuals. We acknowledge that isolated areas of mortality can and do occur, but based on the channel morphology evaluation and mussel density data it appears that these may not be adverse to the population as a whole. However, additional surveys and studies are needed to more confidently understand the effects of these mortality events on the overall mussel populations. Additional information on channel sedimentation and river morphological changes can also assist in determining whether these trends are increasing or decreasing from historical patterns.

A three-phase monitoring plan has been developed in accordance with the requirements of RPM5 based on the results of mussel surveys and the sediment dynamics and channel morphology evaluations. The purpose of the monitoring plan is to provide a reliable estimate of the total abundance of listed mussels in the action area and determine the fraction of the population that is located in habitats that are vulnerable to low flow. Although numerous mussel studies have been conducted on the Apalachicola River by various groups, this proposed monitoring plan would be the first comprehensive study designed to document overall numbers of federally-protected species (within specified confidence limits); and intensively study biotic and physical processes at selected locations. The three proposed study phases include: 1) Describe the location and areal extent of mussel habitats that are particularly vulnerable to low flow and/or channel migration; 2) Estimate the total abundance of federally-protected mussels in the action area utilizing a stratified random sampling technique, and 3) Investigate the relationship between mussel abundance and distribution to geomorphic processes at specific sites in the Apalachicola River. The purpose of the first phase will be to determine if the surface area of vulnerable habitats represents a substantial portion of aquatic habitats that support *A. neislerii*. This information can then be combined with the data collected during the second phase in order to estimate the portion of the population located in vulnerable habitats. The purpose of the second phase is to provide an overall estimate of the total number and distribution of federally-protected mussels in the action area. This study will also demonstrate which meso- and micro-scale habitats support the highest abundances of listed mussels and might therefore warrant additional protection. The purpose of the final phase is to more thoroughly understand biotic and physical processes at three or more high-quality mussel beds in the Apalachicola River. This study will be used to understand the effects of dynamic riverine processes (sedimentation, benthic scour, channel migration) on the long-term survival of mussel populations. All of these studies will ultimately assist planners in determining feasible water and/or habitat actions that minimize listed mussel mortality. A general description of the three phases of this plan is also provided in Enclosure 5. Upon approval of the general plan and the availability of funds, a detailed study plan for these three phases would be developed in late 2007- early 2008 that will specify the number and location of study sites and number of samples to be collected at each site (based on desired precision). The final plan would be coordinated with the USFWS and FWCC to maximize the conservation value of our collective efforts, and avoid unnecessary duplication of effort where possible. The first and second phase studies would begin in 2008 dependent on availability of funds.

The enclosed MFR of the workshop, associated summary of finding documents and presentations, and the mussel survey report and proposed mussel monitoring plan are submitted pursuant to the requirements of Section 7 of the ESA and in accordance with the terms and conditions of the BO. We believe that this sediment dynamics and channel morphology evaluation meets the requirements of RPM4 by: 1) demonstrating that the current IOP minimizes listed mussel mortality to the extent practicable and that additional water and/or habitat management actions are not required at this time based on our current knowledge; 2) describing the current patterns and trends in morphological changes; and, 3) identifying additional studies that could be conducted in order to predict how and to what degree morphological changes affect listed mussels in the action area. We believe the mussel survey report and proposed mussel monitoring plan meet the requirements of RPM5 by providing a feasible plan to monitor listed mussels in the action area and specifically provide a reliable estimate of total abundance of listed mussels and the fraction of the population that occurs in habitats vulnerable to low-flow impacts. Your approval of the general mussel monitoring plan described is hereby requested. As you are aware, the BO recognizes that certain studies and other outreach programs in the RPMs and conservation measures are subject to the availability of funds from the Congress. We will continue to exercise our best efforts to secure funds for these activities. We look forward to discussing these studies and possible implementation schedules with you at the upcoming semi-annual meeting.

A significant amount of time and resources was dedicated by both of our agencies to conduct the sediment dynamics and channel morphology evaluation and to develop the mussel monitoring plan. We especially appreciate the efforts of Mr. Ziewitz, Ms. Karen Herrington, and Ms. Sandra Pursifull to assist our biologists and mussel specialists during development and execution of this summer's mussel sampling effort. I am forwarding a copy of this letter to the following, Mr. Mike Harvey, Mr. David Biedenharn, Mr. Drew Miller, Mr. Jerry Ziewitz, Mr. Kirk Vincent, Mr. Barry Payne and Mr. Mark Farr.

If you have any further questions or comments regarding our operations under the Jim Woodruff Dam IOP and our efforts to minimize or avoid impacts to the listed species on the Apalachicola River, please feel free to contact Ms. Joanne Brandt, (251) 690-3260, Email: joanne.u.brandt@sam.usace.army.mil; or Mr. Brian Zettle, (251) 690-2115, Email: brian.a.zettle@sam.usace.army.mil.

Sincerely,

Curtis M. Flakes
Chief, Planning and Environmental
Division

Enclosures

7.3 REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take of fat threeridge and purple bankclimber on the Apalachicola River.

RPM1. Adaptive management. Identify ways to minimize harm as new information is collected.

Rationale. Additional information will be collected about the listed species and their habitats 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 Corps' water management operations are effective or could be improved.

RPM2. Adjust June to February Lower Threshold to 10,000 cfs. Replace the proposed 8,000 cfs threshold in the IOP with a threshold of 10,000 cfs.

Rationale. Mussels may be in vulnerable areas where take may occur when flows are less than 10,000 cfs. Not increasing reservoir storage when basin inflow is 10,000 cfs or less from June to February will avoid and minimize the potential for take in the zone of 8,000 to 10,000 cfs.

RPM3. Drought provisions. Develop modifications to the IOP that provide a higher minimum flow to the Apalachicola River when reservoir storage and hydrologic conditions permit.

Rationale. Take of listed species due to the IOP may occur when the Corps is using a portion of basin inflow to increase ACF reservoir storage. The Corps can minimize mussel mortality due to low-flow conditions by supporting a higher minimum flow when total reservoir storage and/or hydrologic conditions permit. As proposed, the IOP uses reservoir storage to support a 5,000 cfs minimum flow. The available data indicates that higher minimum flows are supportable during normal and wet hydrologic periods, and during dry periods when the reservoirs are relatively full. Conversely, during extended drier than normal conditions, it may be prudent to store more water than allowed under the IOP during certain times of the year to insure minimum water availability later. Possible components and triggers of the drought plan could be, but are not limited to: Corps reservoir action zones, cumulative reservoir storage remaining, total basin inflows, indictors of fish spawn, climatic condition indices, and flow levels at gages downstream of the Chattahoochee gage, such as the gage at Wewahitchka.

RPM4. Sediment dynamics and channel morphology evaluation. Improve our understanding of the channel morphology and the dynamic nature of the Apalachicola River.

Rationale. The dynamic conditions of the Apalachicola need to be evaluated to monitor the zone at which take may occur and to identify alternatives to minimize effects to listed mussels in vulnerable locations. Both sediment transport and channel morphology need to be considered to provide a basis for predicting changes in morphology that may affect the relative vulnerability of mussels to take due to the IOP. The amount of mussel habitat and thus IOP-related take depends on channel morphology. This evaluation will inform alternatives that may be considered under RPM1 and RPM3.

RPM5. Monitoring. Monitor the level of take associated with the IOP and evaluate ways to minimize take by studying the distribution and abundance of the listed mussels in the action area.

Rationale. Take needs to be monitored monthly to insure that the level of take identified in the biological opinion is not exceeded. As natural conditions change, the populations of the species need to be assessed and the amount of take evaluated relative to any new information. Since this is an interim plan and there will be additional consultations on the overall operations of the ACF project for flood control, water supply contracts, hydropower, and navigation, the monitoring information is needed to prepare the biological assessments for these future consultations.

7.4 TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are mandatory. Studies and other outreach programs in the RPMs and conservation measures are subject to the availability of funds by Congress. The Corps 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 Corps will reinitate consultation with USFWS.

7.4.1 Adaptive management (RPM1)

a. The Corps shall organize semi-annual meetings with the Service to review implementation of the IOP and new data, identify information needs, scope methods to address those needs, including, but not limited to, evaluations and monitoring specified in this Incidental Take Statement, review results, formulate actions that minimize take of listed species, and monitor the effectiveness of those actions.

b. The Corps shall assume responsibility for the studies and actions that both agencies agree are reasonable and necessary to minimize take resulting from the Corps' water management actions.

c. The Corps shall evaluate refinements to predictive tools.

d. The Corps shall provide an annual report to the Service on or before January 31 each year documenting compliance with the terms and conditions of this Incidental Take Statement during the previous federal fiscal year, any conservation measures implemented for listed species in the action area; and recommendations for actions in the coming year to minimize take of listed species.

7.4.2 Adjust June to February Lower Threshold to 10,000 cfs. (RPM2)

a. The Corps shall immediately release the 7-day moving average basin inflow, but not less than 5,000 cfs, when the 7-day moving average basin inflow is less than 10,000 cfs for the months of June to February, and shall incorporate this revision into the IOP table of minimum discharges.

7.4.3 Drought provisions (RPM3).

a. The Corps, with Service concurrence, shall initiate by January 30, 2007, IOP drought provisions that identify the reservoir, climatic, hydrologic, and/or listed species conditions that would allow supporting a higher minimum flow in the Apalachicola River, and that identify recommended water management measures to be implemented when conditions reach the identified drought trigger point(s).

b. If modifications to the IOP parameters for the months of March through May are adopted as part of the drought provisions, the Corps shall assess potential affects to Gulf sturgeon spawning and floodplain inundation. The Corps shall provide the models and a biological assessment of the effects of the drought provisions on listed species at least 135 days in advance of implementing the drought provisions in order to reinitiate this consultation relative to any proposed changes in the IOP.

7.4.4 Sediment dynamics and channel morphology evaluation (RPM4).

a. In coordination with the Service, and other experts jointly identified, the Corps shall evaluate before March 30, 2007, the current status of sediment transport and channel stability in the Apalachicola River as it relates to the distribution of listed mussels and their vulnerability to low-flow conditions. The goals of the evaluation are to identify: 1) feasible water and/or habitat management actions that would minimize listed mussel mortality; 2) current patterns and trends in morphological changes; and 3) additional information needed, if any, to predict morphological changes that may affect the listed mussels. This evaluation shall be based on available information and tools and best professional judgement.

7.4.5 Monitoring (RPM5).

a. The Corps shall monitor the number of days that releases from Woodruff Dam (daily average discharge at the Chattahoochee gage) are less than the daily basin inflow when daily basin inflow is less than 10,000 cfs but greater or equal to 8,000 cfs. If the total number of days of releases in this range in a calendar year is projected to exceed the total number of days of daily basin inflow in this range by more than 39, the Corps shall reinitiate consultation immediately.

b. In coordination with the Service, the Corps shall develop on or before March 30, 2007, a feasible plan to monitor listed mussels in the action area. The goals are to:
1) periodically estimate total abundance of listed mussels in the action area; and
2) determine the fraction of the population that is located in habitats that are vulnerable to low-flow impacts.

c. The Corps shall implement the studies outlined above as soon as is practicable.

d. The Corps shall include monitoring results in the annual report provided to the Service under Condition 1.c.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. The Service believes that the action will result in no more than 39 days per year when project operations reduce basin inflow when it is in the range of 8,000-10,000 cfs. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring the reinitiation of consultation and review of the reasonable and prudent measures provided. The Corps must immediately provide an explanation of the causes of the taking, and review with the Service the need for possible modification of the reasonable and prudent measures.

8 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 an action agency 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 Service recommends that the Mobile District of the U.S. Army Corps of Engineers:

1. Identify watershed-planning opportunities that would assist in identifying alternatives to reduce overall depletions in the ACF basin, particularly the Flint River, thereby increasing baseline flow to the Apalachicola River.

2. 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.

3. Consider alternatives that would increase flexibility in the management of reservoir storage including the feasibility of flood control alternatives (e.g. moving structures from the floodplain, land acquisition) and providing for recreational access at a variety of pool elevations.

4. Provide additional data and hydrodynamic models that would assist in determining areas of bed stability that should be surveyed for listed mussels.

5. Implement freshwater mussel recovery actions including developing habitat suitability indices, conducting a population assessment of the listed mussels of the Apalachicola River, restoring reaches to provide stable habitat, and validating aging techniques for these species.

6. Use the models developed for the Tri-State Comprehensive Study to determine if changes in flow compared to pre-Lanier flows are significant relative to Gulf sturgeon juvenile growth and if changes in the operation of the reservoirs will benefit Gulf sturgeon recovery.

7. Implement Gulf sturgeon recovery actions such as studies of Gulf sturgeon ecology in Apalachicola Bay and possible effects of reduced basin inflow on the ability of the bay to support sturgeon and providing for fish passage at Jim Woodruff Dam.

8. Establish a clearinghouse for biological and water resource information about the ACF system and make such information readily available in several key locations in the basin.

9. Participate in stakeholder discussions to develop a long-term biological monitoring program for the ACF system and support, as feasible, implementation of a long-term program.

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 Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Field Office
1601 Balboa Avenue
Panama City, FL 32405-3721

IN REPLY REFER TO:

Tel: (850) 769-0552
Fax: (850) 763-2177

March 30, 2007

Curtis Flakes
Inland Environment Team
Planning Environmental Division
Mobile District, Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

Dear Mr. Flakes:

Your letter dated January 31, 2007, which transmitted the "Jim Woodruff Dam Interim Operations (IOP) Plan Biological Opinion (BO) Annual Report" for 2006, requested delaying the completion date for actions required under reasonable and prudent measures 4 and 5 (RPM4 and RPM5) of our September 5, 2006, BO. RPM4 calls for evaluating the current status of sediment transport and channel stability in the Apalachicola River as it relates to the distribution of listed mussels and their vulnerability to low-flow conditions. RPM5 calls for, among other things, developing a plan to monitor listed mussels in the area affected by the IOP. The BO specifies March 30, 2007, as the date for completion of both the RPM4 and RPM5 actions. The BO also includes a provision that the conduct of studies in the RPMs are subject to the availability of funds by Congress; that the Corps will exercise its best efforts to secure funding. You have informed the Fish and Wildlife Service (Service) that the Corps has been operating this entire fiscal year under Continuing Resolution Authority (CRA), which has limited your ability to initiate new work and contracts and delayed the ability of the Corps to initiate these actions. However, you state that you anticipate receiving sufficient funds in the next few weeks to initiate and complete the efforts related to the RPM4 and RPM5 activities this fiscal year. Therefore, your letter requests extending the completion date to August 30, 2007. This letter is our response to your request.

The purpose of an RPM is to minimize the impacts of incidental take. As we explained in the BO, we believe that take of listed mussels associated with the IOP is most likely limited to certain areas of channel instability. The overlapping purpose of RPM4 and RPM5 is to compile information about the threat of continuing channel instability to listed mussel populations that may lead to additional ways to minimize take. This information would be available to assist in developing possible future adaptive modifications to the IOP in accordance with the terms and conditions of RPM1, Adaptive Management. When we completed the BO last fall, the date March 30, 2007, was our agencies' mutual best estimate of a feasible completion date for evaluating channel stability with existing information and for developing a mussels monitoring plan, assuming funds to initiate these efforts would be immediately available. Failing to complete these actions by March 30 does not alter the conclusions of the BO or our estimate of incidental take associated with the IOP. We acknowledge that an RPM cannot require actions inconsistent with an agency's authority and that the CRA has constrained your spending authority. Nevertheless, last year's unusual exposure of mussel beds in the vicinity of Wewahitchka was a clear sign of habitat conditions in transition. RPM4 and RPM5 are intended to assist us in understanding and dealing with these changing conditions. Therefore, we believe the Corps should demonstrate progress on meeting the terms of RPM4 and RPM5 as soon as practicable.

We agree to delay the completion date under RPM4 and RMP5 to August 30, 2007, as you have requested; however, we ask that you coordinate with us on a work schedule that could accelerate the completion of these tasks. Please include in this schedule the steps that you have already taken and can take in the next 30 days to ensure that the scientists you have selected for this work hit the ground running. If you have not already done so, please compile all appropriate information to give to them as soon as possible and organize conference calls to begin the detailed work scoping process in advance of any meetings or site visits. We are available to assist with prioritizing such information and to participate in calls with your scientists.

We had expected to begin implementing a comprehensive mussels monitoring plan in the spring of 2007, and now recognize that is not possible based on funding constraints. However, we ask you to consider providing for some mussel sampling surveys in the scope of work for developing the mussels monitoring plan. Should basin inflow levels fall below 10,000 cfs this summer, it will be useful to know the potential risk of exposure to listed mussels located in vulnerable microhabitats, and this information could be used to assist in developing a more comprehensive monitoring plan.

We note that the BO states that "[i]n the event the necessary funding is not obtained to accomplish the RPM activities by the dates established, the Corps will reinitiate consultation with USFWS." As discussed above, our review of your proposal to extend these deadlines indicates that this extension does not alter the conclusions of the BO or increase the estimate of incidental take associated with the operations described in the IOP. As such, this exchange of letters fulfills the Corps' obligation to reinitiate consultation, and a new formal consultation is not required.

Please contact Jerry Ziewitz at extension 223 for coordinating with us on a schedule for completing the channel stability evaluation and the mussels monitoring plan. We look forward to working with you on these actions.

Sincerely yours,

Gail A. Carmody

Gail A. Carmody
Field Supervisor

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

May 11, 2007

REPLY TO
ATTENTION OF

Inland Environment Team
Planning and Environmental Division

Ms. Gail Carmody
Field Supervisor
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405-3721

Dear Ms. Carmody:

Your letter dated March 30, 2007 extended the due date until August 30, 2007 for implementation of certain activities required by the Biological Opinion (BO) issued by the U.S. Fish and Wildlife Service (USFWS) for the Jim Woodruff Dam Interim Operation Plan; in particular those activities required under reasonable and prudent measure (RPM) 4 and RPM5. The extension was requested due to a delay in receiving fiscal year 2007 funds in U.S. Army Corps of Engineers (Corps), Mobile District, which are necessary to allow the award of the contractual agreements to perform the necessary work. Sufficient funding has now been received by Mobile District to allow us to proceed with the required activities. By this letter, I want to inform you of progress made to date toward implementation of the required RPM4 and RPM5 activities and our schedule for complying with remaining requirements of these RPMs.

RPM4 requires an evaluation of the sediment dynamics and channel morphology trends on the Apalachicola River in order to improve our understanding of dynamic conditions and monitor the zone at which take may occur, and to identify possible alternatives to minimize effects to listed mussels in vulnerable locations. The terms and conditions of the BO specify that Mobile District and USFWS will consult with experts, jointly identified by both agencies, to assist in identifying the current status of sediment transport and channel stability in the Apalachicola River as it relates to the distribution of listed mussels and their vulnerability to low-flow conditions. The goals of the evaluation are to identify: 1) feasible water and/or habitat management actions that would minimize listed mussel mortality; 2) current patterns and trends in morphological changes; and 3) additional information needed, if any, to predict morphological changes that may affect the listed mussels. This evaluation is to be based on available information and tools and best professional judgment. As a result of previous discussions at our October 2006 and March 2007 semi-annual meetings, we have identified three possible specialists with specific river sediment transport and morphology expertise (one river geomorphologist from Department of Interior (DOI), one sediment transport specialist formerly from the U.S. Army Corps of Engineers Research Development Center (ERDC), and one renowned geomorphologist from the private sector). On April 9, Mobile District and USFWS conducted a teleconference with the potential specialists to determine their availability and willingness to assist in this effort, and to outline the evaluation goals and expectations. Following the teleconference, specific background information was provided to the river specialists to familiarize them with the Apalachicola River. We are currently drafting a scope of work for award of a task order to fund efforts by two of the specialists. It is our understanding that USFWS will fund participation of the DOI specialist. We anticipate holding an initial meeting with the river specialists this June, to include a field visit to the Apalachicola River, with mussel specialists to assist in identifying mussel requirements and potentially vulnerable areas. A follow-on workshop is planned for July, at which time the individual river specialists will share with both our agencies their observations regarding changes in the river sedimentation and morphology, and opinions regarding any patterns or trends in these processes. The Corps will prepare a report, in coordination with the USFWS, summarizing our conclusions and recommendations. This summary report is scheduled to be completed by the end of August 2007.

RPM5 requires monitoring of the level of take associated with the IOP and the evaluation of ways to minimize take by studying the distribution and abundance of the listed mussels in the action area. Information from the monitoring of mussel distribution and degree of vulnerability over time will be used to prepare biological assessments for future consultations related to water management operations. The goals of the mussel monitoring plan are to 1) periodically estimate total abundance of listed mussels in the action area; and 2) determine the fraction of the population that is located in habitats that are vulnerable to low-flow impacts. Mobile District has initiated discussions with mussel specialists in our ERDC to assist in development of a long-term mussel monitoring plan. As discussed in our March 1, 2007 semi-annual meeting, we intend to integrate the efforts for development of this plan with the observations and evaluations presented by the above sediment/morphology river specialists. Therefore, the mussel specialists will be included in the river specialists field inspection and follow-on workshop. Your letter extending the due date for development of the mussel monitoring plan requested that additional mussel sampling of the distribution of mussels in potentially vulnerable areas be conducted this spring or summer, and that information be used to assist in developing a more comprehensive monitoring plan. We have incorporated the requested sampling into a draft Scope of Work which was coordinated with Mr. Jerry Ziewitz of your staff and approved in mid-April. We intend to initiate the mussel sampling field work before the end of May and plan to submit a long-term mussel monitoring plan in August 2007.

We believe the above accomplishments and schedule of activities demonstrates that we are working toward implementation of the required activities under RPM4 and RPM5 as expeditiously as practicable, given the funding constraints we have experienced this fiscal year. We plan to continue to work closely with your staff as we develop the additional information that will assist in improving our water management operations and minimizing impact to the listed species.

If you have any additional questions or comments regarding our scope of effort or schedule of activities, please feel free to contact Ms. Joanne Brandt, Senior Environmental Specialist, Inland Environment Team, (251) 690-3260, or email at joanne.u.brandt@sam.usace.army.mil.

Sincerely,

Curtis M. Flakes
Chief, Planning and Environmental
Division

CESAM-PD-EI 27 August 2007

MEMORANDUM FOR RECORD

SUBJECT: Jim Woodruff Interim Operations Plan Biological Opinion –
RPM 4 and 5 Workshop

1. Representatives of the US Army Corps of Engineers, Mobile District (CESAM) met with Jerry Ziewitz of the US Fish and Wildlife Service (USFWS), Panama City Field Office, and specialists in the fields of fluvial geomorphology, riverine hydraulics, and malacology on 14-15 August 2007, to participate in a two-day sediment dynamics and channel morphology workshop. This workshop was a follow-up to a previous two day field reconnaissance inspection by the river specialist and malacologist to the Apalachicola River on 19-20 June 2007, to familiarize the participants with the river process and mussel habitat features. The purpose of the workshop was for the various experts to present the findings of their individual analyses of river sediment and geomorphological trends with respect to mussel habitat requirements; discuss the individual findings with the attendees of the workshop; and present their recommendations regarding the issues identified in Reasonable and Prudent Measures (RPM)4 and RPM5 of the Biological Opinion (BO), issued by USFWS on 5 September 2006. The following representatives participated in the workshop.

Jerry Ziewitz, USFWS	850-769-0552, Ext. 223
Joanne Brandt, CESAM-PD-EI	251-690-3260
Brian Zettle, CESAM-PD-EI	251-690-2115
Mike Eubanks, CESAM-PD-EI	251-694-3861
Doug Otto, CESAM-EN-H	251-690-2718
Cheryl Hrabovsky, CESAM-EN-HW	251-694-4018
Bill Stubblefield, CESAM-EN-HH	251-690-3116
Mark Farr, ERDC-EL-MS	601-634-3049
Mark Antwine, ERDC-EL-MS	601-634-3224
Dr. Andrew Miller, Ecological Applications	850-878-7653
Dr. David Biedenharn, Biedenharn Group	601-636-3492
Dr. Michael Harvey, Mussetter Engineering, Inc.	970-224-4612, Ext. 103

2. The participants provided a brief introduction of themselves and then Mr. Zettle discussed the workshop agenda and provided a review of the workshop goals, the Jim Woodruff Dam Interim Operations Plan Section 7 consultation, and the requirements of the RPM's. The following summarizes the RPM4 and RPM5 issues addressed during the workshop:

RPM4. Sediment dynamics and channel morphology evaluation. Improve our understanding of the channel morphology and the dynamic nature of the Apalachicola River.

Rationale. The dynamic conditions of the Apalachicola need to be evaluated to monitor the zone at which take may occur and to identify alternatives to minimize effects to listed mussels in vulnerable locations. Both sediment transport and channel morphology need to be considered to provide a basis for predicting changes in morphology that may affect the relative vulnerability of mussels to take due to the IOP. The amount of mussel habitat and thus IOP-related take depends on channel morphology. This evaluation will inform alternatives that may be considered under RPM1 and RPM3.

a. In coordination with the Service, and other experts jointly identified, the Corps shall evaluate before March 30, 2007, (**extended to August 30, 2007**) the current status of sediment transport and channel stability in the Apalachicola River as it relates to the distribution of listed mussels and their vulnerability to low-flow conditions. The goals of the evaluation are to identify: 1) feasible water and/or habitat management actions that would minimize listed mussel mortality; 2) current patterns and trends in morphological changes; and 3) additional information needed, if any, to predict morphological changes that may affect the listed mussels. This evaluation shall be based on available information and tools and best professional judgment.

RPM5. Monitoring. Monitor the level of take associated with the IOP and evaluate ways to minimize take by studying the distribution and abundance of the listed mussels in the action area.

Rationale. Take needs to be monitored monthly to insure that the level of take identified in the biological opinion is not exceeded. As natural conditions change, the populations of the species need to be assessed and the amount of take evaluated relative to any new information. Since this is an interim plan and there will be additional consultations on the overall operations of the ACF project for flood control, water supply contracts, hydropower, and navigation, the monitoring information is needed to prepare the biological assessments for these future consultations.

b. In coordination with the Service, the Corps shall develop on or before March 30, 2007, (**extended to August 30, 2007**) a feasible plan to monitor listed mussels in the action area. The goals are to: 1) periodically estimate total abundance of listed mussels in the action area; and 2) determine the fraction of the population that is located in habitats that are vulnerable to low-flow impacts.

3. Dr. Biedenharn (riverine hydraulic engineer) provided a presentation outlining his observations and recommendations regarding a) current patterns and trends in morphological changes; b) possibly feasible water and/or habitat management actions that might minimize listed mussel mortality; and c) additional information needed, if any, to identify trends and/or predict future morphological changes that may affect listed mussels. Dr. Biedenharn's evaluation was based on the reconnaissance field trip conducted on the river in June and his review of the existing data provided by the Corps. Dr. Biedenharn's evaluation is provided in the Summary of Findings report he drafted (see enclosure). However, a brief summary of his observations and resultant discussions is provided below. For the purpose of discussion, the river was divided into three reaches similar to those adopted by USGS in their reports regarding river level decline and floodplain connectivity: Reach 1 (Upper reach) extends from the dam at RM 106 down to RM 78; Reach 2 (Middle reach) extends from RM 78 to RM 35; Reach 3 (Lower reach) extends from RM 35 to the mouth of the Apalachicola River.

- The flow regime has not changed significantly since the upstream dams were constructed. This is somewhat atypical since reservoirs generally reduce downstream flood flows and increase low flows. If the dam does not alter the flow regime significantly, then the effects of bed material retention may be more pronounced (i.e., bed degradation and channel widening).
- It appears that the primary impact of the construction of the upstream dams is trapping bed material sized sediments. However, it is unknown how much sediment is moving through the dam. The upper reach of the river provides evidence that a sediment deficit is occurring, but we don't know how large the deficit is. Bed degradation of 4-5 ft has occurred throughout the reach, but appears to have stabilized now. This reach is relatively straight with little sediment storage and appears to be locally controlled both vertically and laterally by limestone outcrops (natural toe protection). A sediment budget could be calculated for the river in order to assess the magnitude of the sediment deficit.
- It's interesting to note that the river slope remains fairly constant between the three reaches. The middle reach is a much more active meandering channel with a high sinuosity. Coincidentally, this reach has the largest erosion rates of the three. However, based on visual observations and cursory data review, this erosion appears to be part of the natural down-valley meander migration which is common to most meandering streams, and does not appear to be the result of some post dam system-wide adjustments such as degradation, aggradation, or channel widening.
- The middle reach has also degraded approximately 1-2 feet, but there is considerable sediment storage in this reach as evidenced by the large point bars. It appears that most of the dam induced channel degradation is limited to Reach 1.
- The processes responsible for the apparent increase in the percent of flow (25% to 34%) diverted at the Chipola Cutoff warrants further study. Dr. Harvey noted that a paper written by Odom in 1966 stated that approximately 35% of the flow was diverted down the Chipola Cutoff at that time. This flow of relatively "clean" water down the Chipola River may be contributing to sediment aggradation and past dredging efforts in the Apalachicola River between the cutoff and RM 35.
- Comparison of the USGS calculated 1941 and 2004 channel widths (based on treeline) indicate that channel widening is occurring throughout the river down to RM 20, and is especially prevalent in portions of the middle reach. Further analysis is needed to determine if these width increases are real, and if so, what the factors responsible for them are. It was also noted by Mrs. Brandt that some of the areas demonstrating the greatest increase in width appear to be associated with anthropomorphic impacts such as meander cutoffs or other navigation activities. Dr. Harvey noted that the relatively low erosion rates observed on the river do not support the theory of rapid widening. Perhaps some of the widening is a long-term result of snagging and removal of woody debris dams that were prevalent in the past.
- The lower reach is less sinuous and has been less impacted by bed degradation. Bed degradation in this reach is likely attributable to local meander cutoffs.
- It appears there is a correlation between good mussel habitat and the highly sinuous reach in the middle river. However, we must recognize that scale (macro, meso, micro, temporal, spatial) plays an important role in interpreting the impacts of river processes on mussels and their habitat. Mr. Farr noted that mussels represent a dynamic population in

a dynamic system and we must manage for the whole population and not just individuals. Isolated areas of mortality can and does occur, but may not be adverse to the population as a whole.

- Preferred mussel habitat appears to occur in the lower energy environments associated with the flow separation zones (eddies) in the transition between meander bends. However, the size and location of the eddy zones change with flow and through time as the meanders migrate though the floodplain. Eddies, and consequently mussel habitat, are constantly being destroyed and created through the natural process of meander migration. Based on the erosion rates and the movement of the bank lines, it appears that there is no net change in the amount of suitable mussel habitat over time.
- The mussel mortality sites at RM 44.3 and RM 43.6 appear to be the result of the natural migration of the channel and not some systematic channel changes. A discussion of whether or not the rate of change in the spatial extent of these habitats has been altered by water management decisions followed. The similarities in the pre- and post-dam construction period flow regimes suggest that this is not likely the case, but additional studies need to be conducted to verify.
- The mussel stranding in Swift Slough appears to be the result of deposition of sands from the river. It appears that a sand bar has moved to the entrance of Swift Slough and may be the source of the sediment. However, a more detailed analysis of this area is needed to establish the exact processes responsible for this situation.
- Dr. Biedenharn made the following recommendations regarding additional study efforts:
    - Perform eco-geomorphic assessment of the system to fully develop how the system has responded in the past and where it is today with emphasis on the connection between the morphology and mussel habitat;
    - Build a relatively simple 1D sediment continuity model (possibly SIAM) of the river. This would provide the big picture assessment of the entire river system below Jim Woodruff dam with respect to sediment continuity, channel stability, impacts of flow diversions, etc.; and
    - Build a 2D hydrodynamic model for selected reaches. This model could be used to link detailed hydrodynamic processes to the mussel assemblages.

4. Dr. Harvey (Geomorphologist) followed Dr. Biedenharn with a presentation sharing many of the same conclusions. A brief summary of further explanations or differences in opinion is provided below. A detailed description of Dr. Harvey's evaluation is available in the Summary of Findings report he drafted (see enclosure). Dr. Harvey utilized slightly different reach delineation as Dr. Biedenharn. Reach 1 (Upper reach) extends from the dam down to RM 78; Reach 2 (Middle reach) extends from RM 78 to RM 42; Reach 3 (Non-tidal Lower reach) extends from RM 42 to RM 20.

- In the upper reach, the bed has degraded about by about 5 feet near the dam and by about 2 feet at Blountstown and the bed material has coarsened, both of which are river responses that are consistent with upstream dam construction.
- It is unclear, based on field observations and the uncertainty associated with measuring treeline width of the main channel, if river widening reported by USGS has actually occurred in this reach (and others) or to the extent which has been reported. Analysis of the comparative bank lines does not indicate much lateral adjustment of the channel in

this reach. This is likely due to the presence of numerous limestone outcrops throughout the upper reach.

- Very little sediment storage occurs within this reach, except between RM 77.2 and RM 78.8 where annual dredging occurred in the past. The observed bed degradation and the limited amount of sediment stored in the numerous dike fields in the reach indicate that the reach was supply limited following construction of the dam.
- The middle reach of the river is very sinuous and the banks are composed of a mixture of cohesive and non-cohesive sediments that exhibit widespread erosion on the outside of bends. The very high sinuosity of the river in the middle reach appears to be the result of the river responding to active tectonics. The axis of the northeast –southwest trending Gulf Trough geologic structure crosses the Apalachicola River near the confluence with the Chipola River at about RM 27. The steeper valley floor (0.00018) on the down-dip side of the trough between about RM 78 and RM 35 requires the river sinuosity to be higher (1.92) to balance the river slope (0.000094) and thus the sediment continuity.
- The bed has degraded approximately 1 to 2 feet within the reach, but there is no evidence that the bed material has coarsened.
- The degree of channel widening reported by USGS for this reach was also questioned. Field observations indicate that bank erosion is limited to the outside of bends as expected for sand bed rivers. Comparative bank lines (1941, 1963, 1993, 1999, 2002) clearly indicate that the bends within the middle reach are migrating laterally and down-valley as a result of cutbank erosion and point bar deposition. The USACE previously reported that erosion rates were highest where the radii of curvature of the bends were smaller, and accordingly, the highest erosion rates were located in the most sinuous portion of the river (between RM 40 and RM 60). The findings of the USACE study are totally consistent with the literature on erosion rates on meandering rivers. Further analysis including the addition of the channel widths to the USACE radii of curvature and erosion rate data for the studied bends permits the Apalachicola River data to be compared with data from other rivers. The maximum erosion rates are associated with radius of curvature to channel width ratios (R/W) of between 1.5 and 2.5, which is consistent with the literature. Dr. Harvey noted that these maximum erosion rates (about 10 ft/yr) are consistent with those calculated for the Alabama River, but are very low in comparison with those reported for other large alluvial rivers. Erosion rates in this range do not suggest that bank erosion on the middle reaches of the Apalachicola River is in response to an upstream sediment deficit. Bank erosion appears to be consistent with what is to be expected for sand bed meandering rivers.
- The upper portion of the lower reach (RM 42 – RM35) is very sinuous and the banks exhibit widespread erosion on the outside bends leading to active channel migration. As stated previously this appears to be the result of the river responding to active tectonics. This high sinuosity could also be due to the diversion of about 35% of the flow (and very little of the bed material load) into the Chipola Cutoff (RM 41.5). This diversion effectively increases the sediment supply to the upper portion of the lower reach which in turn accelerates the meander processes. Below RM 35 the sinuosity is much lower and there is little evidence of channel migration.
- Stage data at the Sumatra gauge do not indicate that the bed of the river has degraded or the channel has widened in the post-dam period and there is no evidence that the bed material has coarsened.

- There is concern regarding the USGS reports that significant widening has occurred in throughout the Apalachicola River. Given the uncertainty associated with these measurements (Smith and Vincent, 2004) and the extensive presence of dredge material disposal sites, especially within the reach between RM 35 and RM 42 that limit vegetation recovery, it is unclear whether the river has actually widened in this reach in the post-dam period. Field observations do not indicate that both channel banks are eroding along the reach, rather the bank erosion is limited to the outside of bends, which is to be expected.
- Fat threeridge mussel habitat appears to be associated with eddy deposits (downstream end of bends, backwater bars, dike fields). Qualitative sampling data for the fat threeridge mussel in the Apalachicola River appear to support the hypothesis that the fat threeridge habitat is formed and maintained by meander processes. These types of habitat are ephemeral and change with time and space. Rates of change are a function of the frequency and magnitude of flood events. Distributary channels (e.g. Swift Slough) which can support mussels are also ephemeral features and are expected to become disconnected or fill in with sediment as the channel migrates through the floodplain. However, these active meander processes are likely to create new channels as the older distributary channels are eliminated. Dr. Harvey noted that based on the qualitative sampling data from the dike field at RM 47.4, it appears that suitable habitat can be created if amount of habitat available is deemed a limiting factor.
- The mortality occurring at sites located along the mainstem of the river and Swift Slough in 2006 appear to be related to deposition of sandy bed material and can be explained by the dynamics of the river.
- Dr. Harvey noted that the erosion rates within the highly sinuous reach are low in comparison to other alluvial rivers and are unlikely to increase over time under the current operations of the system. Bends with low radii of curvature (RM 62, RM 50, RM 43, RM 40, and RM 38) could cutoff in the not too distant future (dependent on hydrology). This would result in reduced sinuosity and increased hydraulic slope.
- Available data do not indicate that the river is continuing to degrade, and in fact the uniformity of the average channel slopes in all three reaches (0.000093 – 0.000095) suggests that the river may have attained a measure of equilibrium. This hypothesis should be further tested by development of a sediment budget for the river.
- Additional studies are needed to speculate on future trends in channel width as there is some uncertainty in the comparative channel width measurements utilized to date. If the channel is indeed widening, then the river processes or anthropomorphic means responsible need to be determined.
- Dr. Harvey made the following recommendations regarding additional study efforts:
    - Conduct an in-depth quantitative geomorphic assessment of the river between the dam and RM 20;
    - Develop a one-dimensional sediment continuity analysis using the SIAM computer code;
    - Develop two-dimensional hydrodynamic models of selected listed mussel habitat sites located: 1) downstream of a bend, 2) in association with a backwater-induced bar complex, and 3) in the upper reach of a distributary channel; and
    - In conjunction with the mussel experts use the results of the above to develop a biological process-physical response model that can be used to predict the

impacts of water management operations at Jim Woodruff Dam on fat threeridge mussel habitat.

5. Dr. Miller concluded the first day of the workshop with a presentation on the sampling efforts he conducted this summer and a recommendations for long-term studies.

- Dr. Miller provided a brief review of fresh water mussels and the fat threeridge in particular. He followed this with a discussion on the methodology and results of this summer's sampling.
- Based on the May 2007 reconnaissance field trip conducted by representatives of the Mobile District, USFWS, and FWCC, personnel of the USFWS identified 25 study areas between RM 40 and 50 along the Apalachicola River which either supported, or appeared likely to support *A. neislerii*. Detailed field studies were conducted at the 10 randomly selected sites and partial (qualitative) studies were conducted at most remaining sites (23 total). In addition, one new site (DS01) was added at a disposal area of interest at the downstream extent of the reach. The 25 sites chosen by USFWS had one or more of the following characteristics: 1) stable, gently sloping banks primarily vegetated with newly established black willow, 2) dense and species-rich mussel assemblages, 3) firm substratum consisting of silty sand, or 4) signs of recent mussel mortality from low water in 2006 and 2007. Virtually every one of these areas was along a moderately depositional reach that was immediately downriver of a point bar.
- *A. neislerii* was found at 23 of the 25 areas between NM 40 and 50. This species comprised nearly 37% of the mussel fauna and at least one individual was present in approximately 30% of the 180 quadrats sampled. Dr. Miller noted that it is unusual to have an endangered species dominate the mussel assemblage.
- Total mean density of *A. neislerii* ranged from 0.2 to 12.7/m^2. The maximum number of *A. neislerii* in a single quadrat at site DM14 was 13 individuals, corresponding to a density of 52/m^2. At the 10 sites surveyed, total mean density (all species) ranged from 2.4 to 28.9 individuals/m^2. Compared with other medium-sized to large rivers, total mussel density in the Apalachicola River is moderate to low.
- Qualitative and quantitative data were used to predict density of *A. neislerii* from CPUE ($Y = 0.28X – 0.77$; $R^2 = 0.59$) for sites where only CPUE data were obtained. If only a 1-m strip (to a water depth of approximately 50 cm) of live *A. neislerii* existed along the shore at each location surveyed between NM 40 and 50, then the total population size at all 25 sites would be estimated at 19,000 individuals. It is likely that this strip is wider than 1 meter and extends into deeper water. Therefore, the total population of *A. neislerii* at these 25 locations probably exceeds 19,000 individuals. In addition, this figure does not include other sites both in and outside the study reach that also support *A. neislerii*.
- There was evidence of strong recent *A. neislerii* recruitment at the sample sites. *Amblema neislerii* is most abundant close to shore and becomes less common moving offshore.
- Dr. Miller agreed that the 2006 mortalities observed during low water conditions appear to be the product of natural river processes. He also noted that Swift Slough supported substantial mussel populations prior to 2006. It is unclear exactly how many *A. neislerii* were in Swift Slough prior to the low water. Regardless, it is difficult to imagine that a 1-mile segment of ephemeral off channel habitat contributed substantially to *A. neislerii* populations in the river (since this species is more prolific in main stem large river

channels). This species is abundant and shows good evidence of recent recruitment at many sites, regardless of the recent low water. There is no reason to believe that a 3,000 m slough could be of much value for a species that is remarkably abundant in moderately depositional habitats that are common in the main stem of the river.

- In the Apalachicola River, like all rivers, mussel distribution is influenced by fish behavior, flow pattern, and velocity. If currents are too erosional, juvenile mussels cannot settle, and if they do, survival is poor. If immature mussels are dropped in reaches with excessive sedimentation, they can be buried and killed. Juveniles almost certainly are more susceptible than adults to sediment accretion and scour. Mussel collections and observations tend to be made mostly in summer and fall at low water. Yet recruitment, which affects adult distribution, usually occurs in periods of higher flow in the spring. The physical effects of water velocity, when integrated over many years, define water depth, sediment characteristics, bank slope and the nature of the riparian community. Regardless, unionid abundance and distribution in rivers is dependent upon flow characteristics at large and small scales. Long-term monitoring should be conducted, including sediment and velocity modeling, in order to provide a better understanding of the distribution and abundance of *A. neislerii* in the Apalachicola River.
- Dr. Miller recommended the following types of long-term study:
    - Knowledge of riverine geomorphic processes is needed to understand effects of reduced flow on the density and distribution of important mussel resources. Three sites that support dense and species rich mussel assemblages would be selected for intensive long-term study and sediment and hydrodynamic models could be used to identify site specific habitat conditions relative to the mussel distribution. The models could also be used to demonstrate how biologically important parameters change in response to various flows and river processes.
    - Conduct stratified random sampling across the various types of mussel habitat in the river in order to estimate mussel population distribution and abundance.

6. The second day (half day) of the workshop consisted of open discussion of the previous day presentations. Specific discussions included:

- Large sample sizes are sometimes required to reach acceptable confidence margins for population estimates.
- Current data suggests that *Amblema* population in Apalachicola River is relatively robust.
- A stratified random design is appropriate for estimating mussel abundance in the river.
- The stratified random design could be accomplished by 1) mapping potential mussel habitat areas (eddies etc.); 2) sorting the habitat by specific type; 3) randomly sampling subgroups from each habitat type; and 4) apply density estimates from samples to amount of habitat available for each type.
- Additional studies could include looking at habitat change over time and mussel response, as well as, using 2D models that measure velocity, vector, and bed sheer stress to understand site specific mussel “hot spots”.
- Mark Antwine mentioned that recent satellite imagery could be purchased and utilized to determine the amount of vulnerable habitat compared to relatively stable habitat. This would help verify the theory that the 2006 mortality sites represent only a small portion of the suitable mussel habitat.

- Jerry Ziewitz suggested that we should coordinate our mussel sampling strategy with Florida's plan in order to avoid duplication of effort and perhaps be able to produce more refined population estimates. He will facilitate these discussions.
- Dr. Harvey and Dr. Biedenharn agreed to edit their Summary of Findings reports and provide final copies the following week.
- Dr. Miller agreed to edit and incorporate the sediment sampling data and new study recommendations into his long-term monitoring proposal and provide a draft copy the following week.

BRIAN ZETTLE
Biologist
Inland Environment Team

Encl
Agenda
Presentations
Reports

Jim Woodruff Dam Water Management Operations
Section 7 Consultation
RPM4 - Sediment Dynamics and Channel Morphology Evaluation
5 Rivers - Alabama's Delta Resource Center
Spanish Fort, Alabama
14-15 August 2007
9:00 a.m.

Workshop Objectives:

- Provide written and oral Summary of Findings documenting geomorphology/sediment transport specialist's individual assessments of the stability of the river, shoaling trends, sediment transport characteristics, and possible reasons for anomalous features (e.g.; shoaling on the outside of some bends) as they relate to the distribution of listed mussels and their vulnerability to low-flow conditions.

- Provide assessment of:
  1) current patterns and trends in morphological changes;
  2) feasible water and/or habitat management actions that might minimize listed mussel mortality; and
  3) additional information needed, if any, to identify trends and/or predict future morphological changes that may affect listed mussels.

- Provide opportunity for mussel specialist and geomorphology/sediment transport specialists to interact with the Corps, USFWS, and each other regarding questions specific to their field of knowledge.

- Provide an opportunity for clarification and understanding of the Summary of Findings.

- Provide an opportunity for the USFWS to evaluate and draw independent conclusions regarding the Summary of Findings as well as verify that the study efforts meet the intent of RPM4.

August 14

Brian Zettle	**Welcome, Introductions, Opening Comments**
Brian Zettle	**Review Workshop Goals, Agenda, and Ground Rules**
Brian Zettle/Jerry Ziewitz	**Section 7 Consultation / RPM4**
Dr. David Biedenharn	**Summary of Findings, Questions and Answers**
Dr. Michael Harvey	**Summary of Findings, Questions and Answers**
Dr. Andrew Miller	**Summary of 2007 Mussel Study, Questions and Answers**

August 15

ALL	**Open Discussion On All Presentations And How They May Relate To Recommendations For Future Actions; and Elements To Be Included In The Final Report Of Findings To USFWS**

[This workshop is scheduled for 2 days. Discussions will be open-ended, but the intention is to cover all material by the end of the second day. There will be a lunch break and two other brief breaks scheduled during each day.]

Directions: 5 Rivers is located across from Meaher State Park on the Mobile Bay Causeway (US Highway 90/98) in Spanish Fort, about five miles from downtown Mobile.

FROM PENSACOLA:
I10 West, take Exit 35 (Daphne-Fairhope)
Cross by the overlook on Hwy 98, go to top of hill to red light
Go straight across, and merge into Hwy 90/98, also called Battleship Parkway
Cross over Blakeley River
Turn right onto 5 Rivers Blvd, directly across from Maeher State Park.
Follow the road and signs into the property.

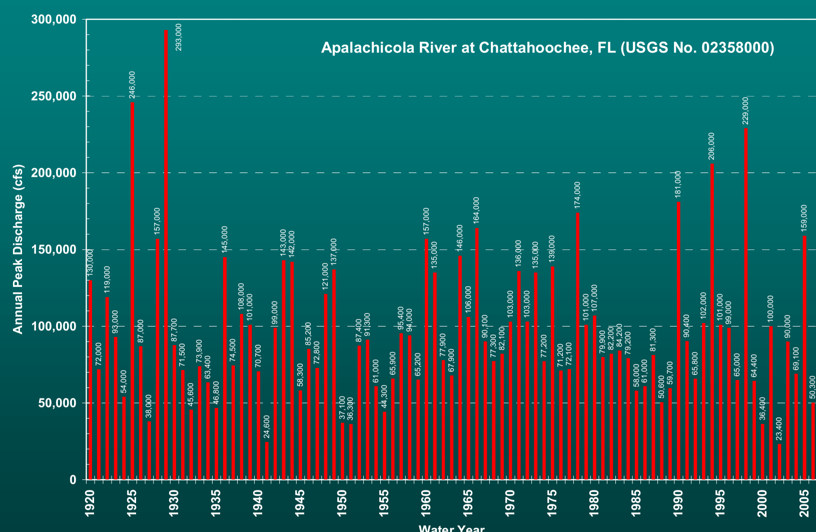
FROM MOBILE/MISSISSIPPI
I10 East through the George Wallace Tunnel.
Take the immediate exit after the Tunnel, Exit 27 onto Battleship Parkway (US 90E).
Go past the Blue Gill Restaurant and turn left onto Five Rivers Blvd, which is directly across the road from Meaher State Park.
Follow the road and signs into the property.


Cursory Geomorphologic Evaluation of the Apalachicola River

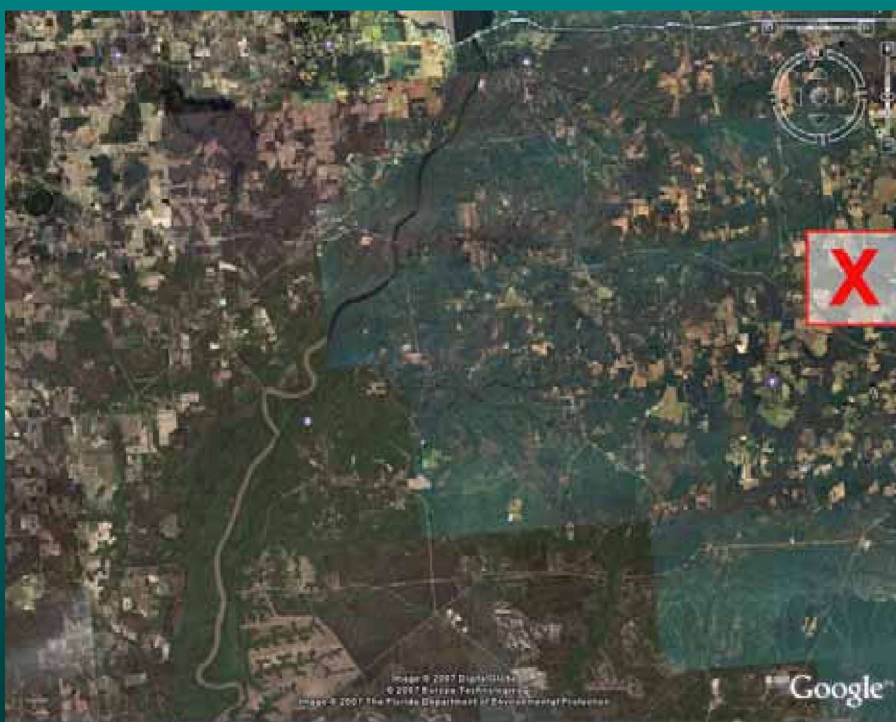
David S. Biedenharn


Observations

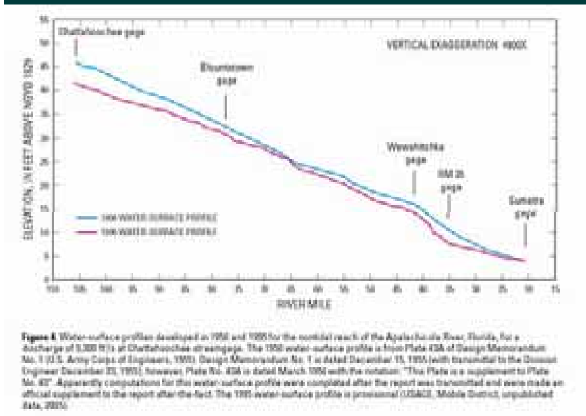
- The flow regime (based on pre-and post-dam flow duration curves) downstream of Jim Woodruff Dam has not been changed significantly between the pre- and post-dam periods.
- The primary impact of Jim Woodruff Dam on the downstream channel appears to be the trapping of bed material sized sediments.
- The amount of bed material that is transported through Jim Woodruff Dam is not known.
- Other alterations impacting the Apalachicola River include localized meander cutoffs, distributary flows, channel training structures, maintenance dredging, and the cessation of maintenance dredging in the 2000 timeframe.



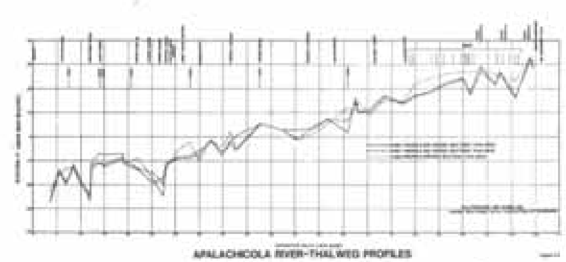
Observations



- The degradational response due to the dam appears to extend downstream to about RM 77 near Blountstown. About 4 to 5 feet of lowering has occurred in this reach.
- Reach 1 (Dam to RM 78) is a relatively straight reach with little sediment stored in the channel, and is controlled in places by local geologic outcrops of limestone.
- The streambanks in Reach 1 are predominately composed of cohesive material and bank erosion and channel widening is minimal.
- The dike fields in Reach 1 do not contain significant amounts of sediment.



Observations



- The river in Reach 2 (RM 78 to RM 35) downstream of Blountstown is a much more active meandering channel with a high sinuosity (sinuosity =1.9).
- Low water gage records and water surface profiles indicate that the channel between Blountstown and RM 20 has experienced about 1 to 2 feet of lowering. However, comparative thalweg plots between 1960 and the early 1980s indicate that the channel has experienced localized areas of scour and fill.
- Reach 2 has the largest erosion rates on the river. This erosion appears to be part of the natural down-valley meander migration which is common to most meandering streams, and does not appear to be the result of some system-wide adjustments such as degradation, aggradation, or channel widening.

Observations

- The channel between the Chipola Cutoff and RM 35 has been one of the most frequently dredged areas on the river. It appears that little sediment is diverted into the Chipola Cutoff, which might be a partial explanation for the frequent dredging just downstream.
- The processes responsible for the apparent increase in the percent of flow (25% to 34%) diverted at the Chipola Cutoff warrants further study.
- There is considerable sediment storage in Reach 2 as evidenced by the large point bars.
- The effects of the cessation of dredging in the 2000 timeframe on the morphology of the channel warrants further study
- Comparison of the 1941 and 2004 channel widths indicated that channel widening throughout the river down to RM 20. Further analysis is needed to determine if these width increases are real, and if so, what are the factors responsible for them.

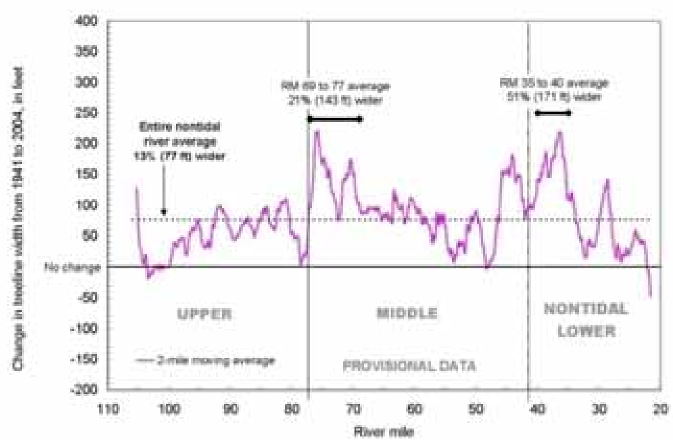


Figure 2. Change in treeline width of main channel of nontidal reach of Apalachicola River, Florida, from 1941 to 2004. Widths were measured at approximately 2,800 points at 164-foot intervals along channel centerline in aerial photographs. Data shows a 2-mile (64-point) moving average. River miles represent those depicted on the most recent USGS quadrangle maps available in 2005.

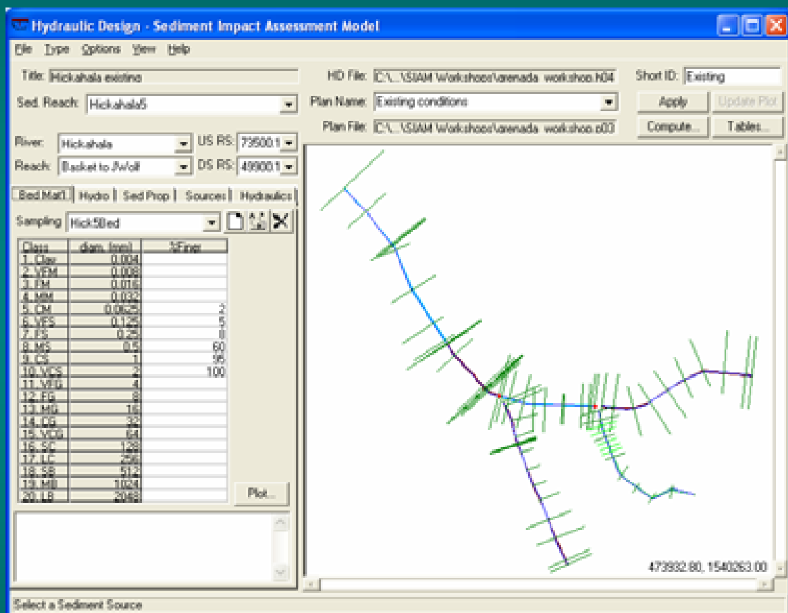
Observations

- The river downstream of the River Styx (RM 35) has a lower sinuosity (1.3) and less bank erosion.
- Local meander cutoffs downstream of the River Styx may be responsible for some of the bed lowering in this area.
- Preferred mussel habitat appears to occur in the lower energy environments associated with the flow separation zones (eddies) in the transition between meander bends
- The size and location of the eddie zones change with flow and through time as the meanders migrate though the floodplain

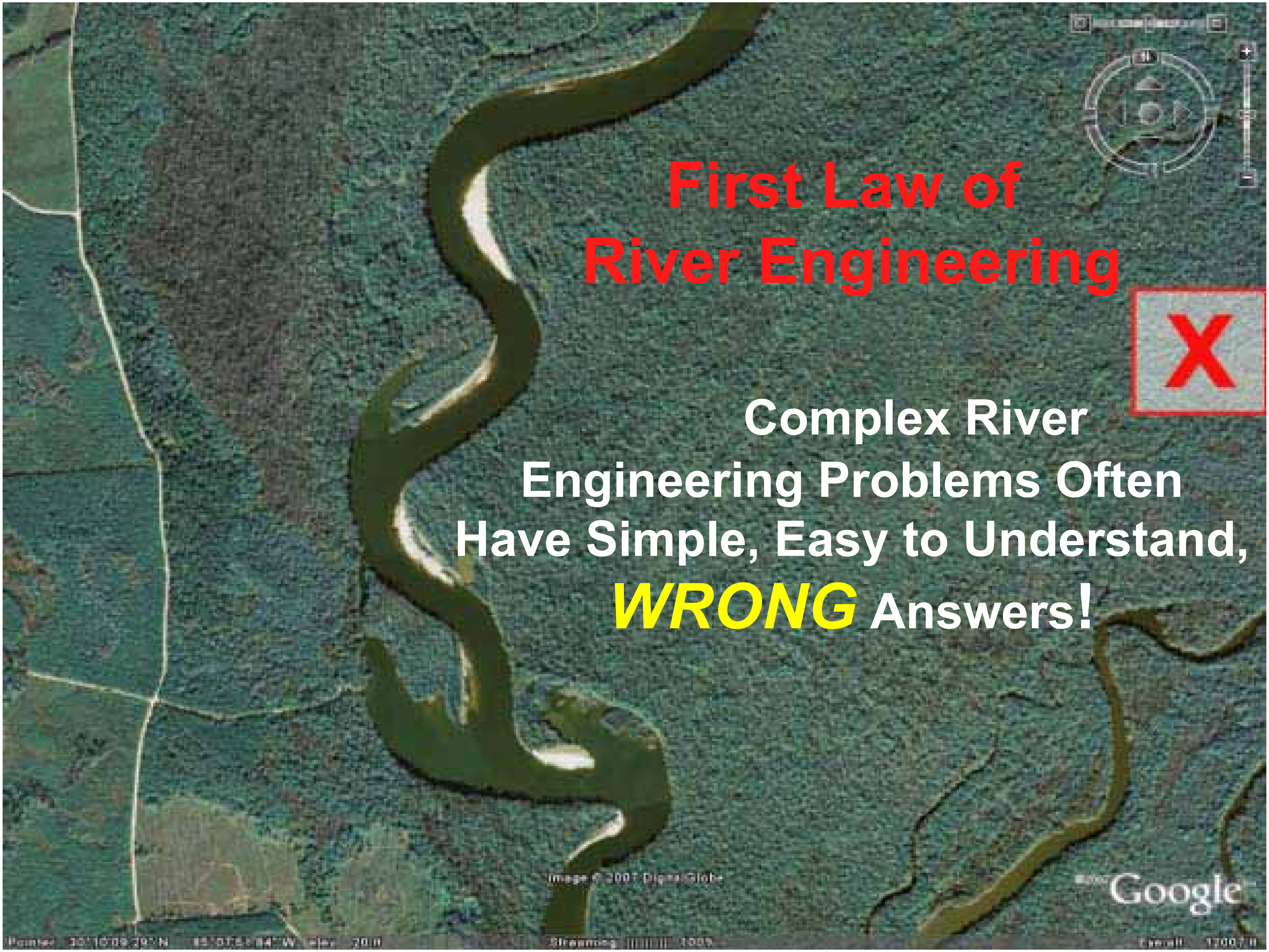
Observations

- Reach 2 contains some of the highest mussels counts on the river
- Eddies, and consequently mussel habitat, are constantly being destroyed and created through the natural process of meander migration
- The mussel mortality sites at RM 44.3 and RM 43.6 appear to be the result of the natural migration of the channel and not some systematic channel changes.
- The mussel stranding in Swift Slough appears to be the result of deposition of sands from the river. It appears that a sand bar has moved to the entrance to the Swift Slough and may be the source of the sediment. However, a more detailed analysis of this area is needed to establish the exact processes responsible for this situation.

Recommendations



- Eco-geomorphic assessment of the system to fully develop how the system has responded in the past and where it is today with emphasis on the connection between the morphology and mussel habitat.
- Relatively simple 1D sediment continuity model (possibly SIAM) of the river. This would provide the big picture assessment of the entire river system below Jim Woodruff dam with respect to sediment continuity, channel stability, impacts of flow diversions, etc.
- 2D hydrodynamic model for selected reaches. Once again the key would be linking these detailed hydrodynamic processes to the mussel assemblages


First Law of
River Engineering
X
Complex River
Engineering Problems Often
Have Simple, Easy to Understand,
WRONG Answers!
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Google

SUMMARY OF FINDINGS: APALACHICOLA RIVER

Mike Harvey
Mussetter Engineering, Inc.

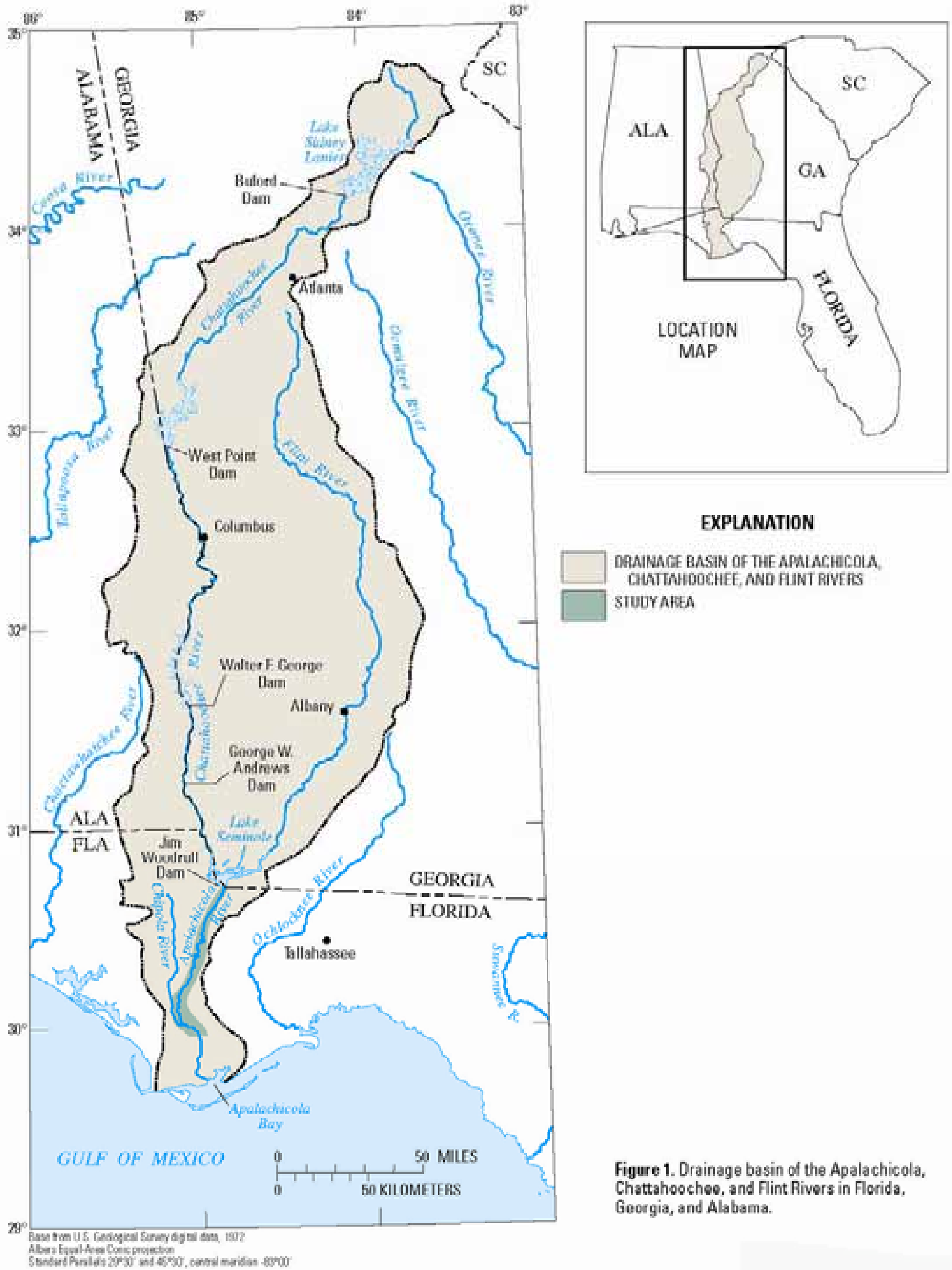

Figure 1. Drainage basin of the Apalachicola, Chattahoochee, and Flint Rivers in Florida, Georgia, and Alabama.

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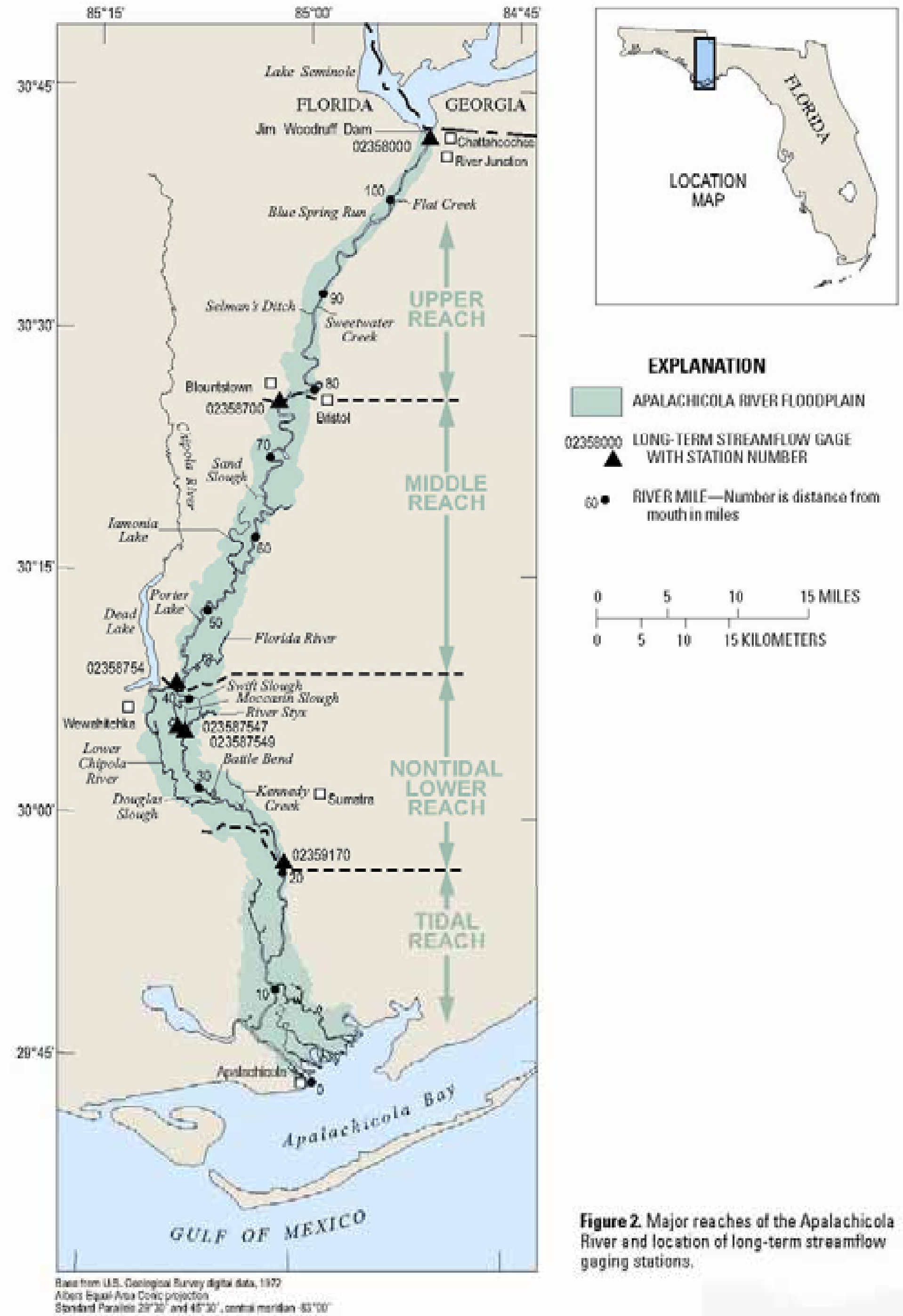

Figure 2. Major reaches of the Apalachicola River and location of long-term streamflow gaging stations.

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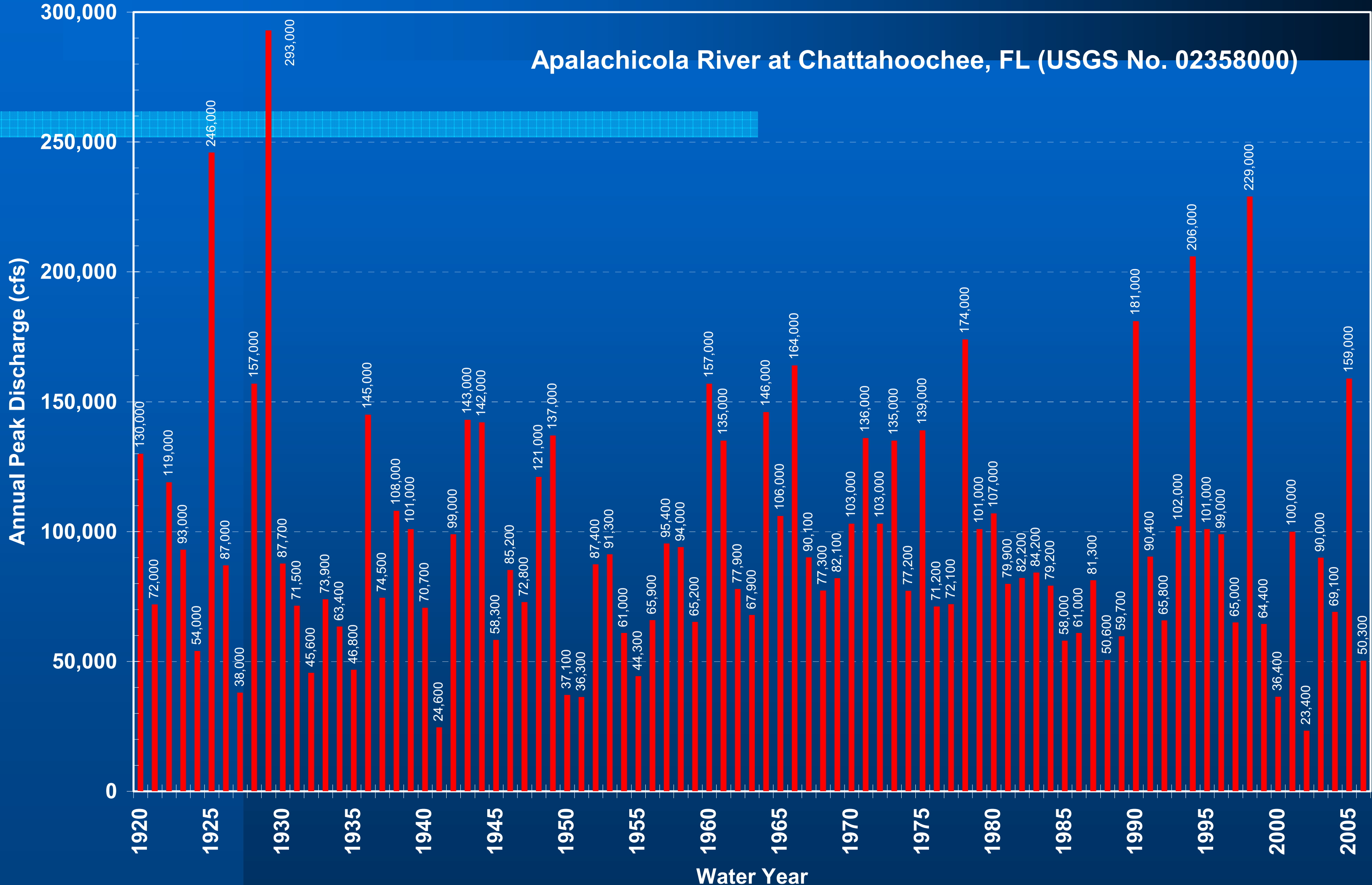

Apalachicola River at Chattahoochee, FL (USGS No. 02358000)
Annual Peak Discharge (cfs)
300,000
250,000
200,000
150,000
100,000
50,000
0
Water Year
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
130,000
72,000
119,000
93,000
54,000
246,000
87,000
38,000
157,000
293,000
87,700
71,500
45,600
73,900
63,400
46,800
145,000
74,500
108,000
101,000
70,700
24,600
99,000
143,000
142,000
58,300
85,200
72,800
121,000
137,000
37,100
36,300
87,400
91,300
61,000
44,300
65,900
95,400
94,000
65,200
157,000
135,000
77,900
67,900
146,000
106,000
164,000
90,100
77,300
82,100
103,000
136,000
103,000
135,000
77,200
139,000
71,200
72,100
174,000
101,000
107,000
79,900
82,200
84,200
79,200
58,000
61,000
81,300
50,600
59,700
181,000
90,400
65,800
102,000
206,000
101,000
99,000
65,000
229,000
64,400
36,400
100,000
23,400
90,000
69,100
159,000
50,300

MEI


ALABAMA
GEORGIA
FLORIDA
GULF OF MEXICO
CHATTAHOOCHEE ANTICLINE
GULF TROUGH
APALACHICOLA EMBAYMENT
SOUTHEAST GEORGIA EMBAYMENT
NASSAU NOSE
JACKSONVILLE BASIN
ST. JOHNS PLATFORM
SANFORD HIGH
BREVARD PLATFORM
OCALA PLATFORM
OSCEOLA LOW
OKEECHOBEE BASIN
N
0 50 100 150 MILES
0 80 160 240 KILOMETERS
SCALE
31°
29°
27°
25°
88°
86°
84°
82°
80°

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Reach	Sv	Sc	P
Upper RM 106-78	0.00012	0.000094	1.3
Middle RM 78 - 35	0.00018	0.000093	1.9
Lower RM 35 - 6	0.00012	0.000095	1.3

MEI

Jim Woodruff Dam


Tributary sediment supply


Low sediment storage in dikes


Limestone outcrop


Cohesive banks


Alum Bluff Fm.


Alum Bluff Fm. sands


Bluff sediment supply

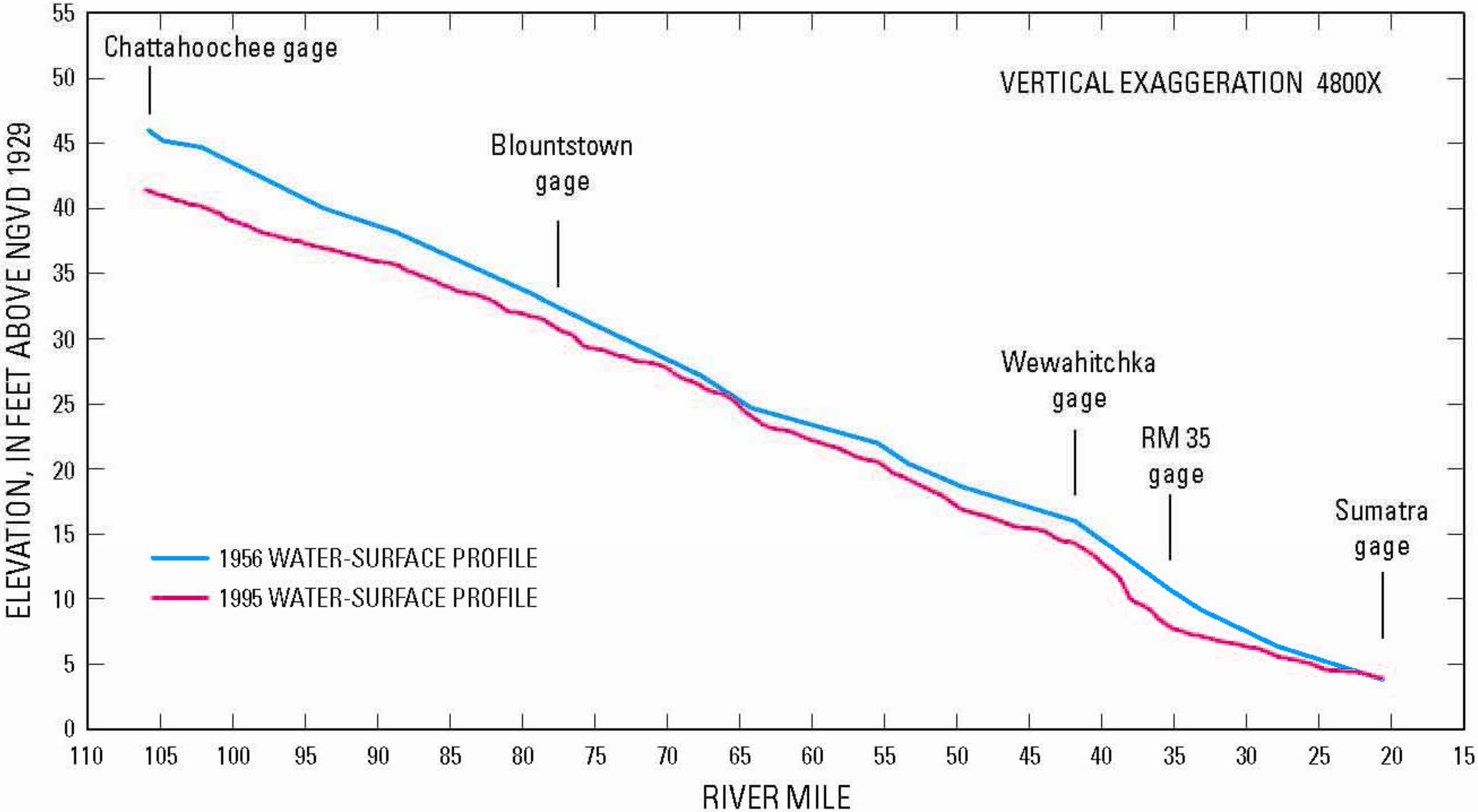

Figure 4. Water-surface profiles developed in 1956 and 1995 for the nontidal reach of the Apalachicola River, Florida, for a discharge of 9,300 ft^3/s at Chattahoochee streamgage. The 1956 water-surface profile is from Plate 43A of Design Memorandum No. 1 (U.S. Army Corps of Engineers, 1955). Design Memorandum No. 1 is dated December 15, 1955 (with transmittal to the Division Engineer December 23, 1955); however, Plate No. 43A is dated March 1956 with the notation: "This Plate is a supplement to Plate No. 43". Apparently computations for this water-surface profile were completed after the report was transmitted and were made an official supplement to the report after-the-fact. The 1995 water-surface profile is provisional (USACE, Mobile District, unpublished data, 2005).

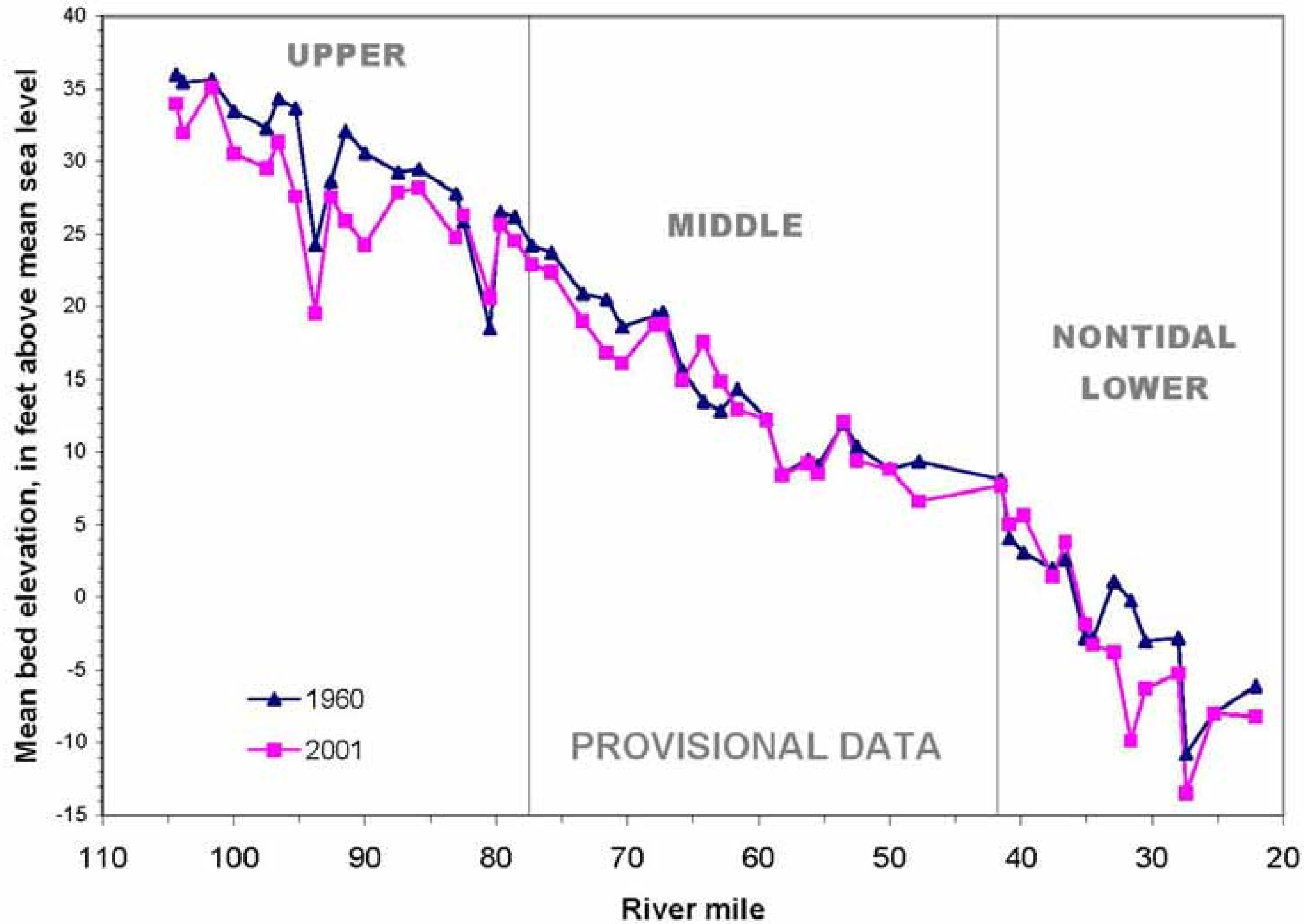

Figure 4. Mean bed elevation of low-flow channel of the nontidal Apalachicola River, Florida, in 1960 and 2001. Data was derived from U.S. Army Corps of Engineers cross-sections surveys. At each cross-section, the water-surface elevation at a lagged discharge of 10,000 cubic feet per second at the Apalachicola River gage at Chattahoochee, Florida, was used to calculate mean bed elevation. River miles represent those depicted on the most recent USGS quadrangle maps available in 2005.

MEI

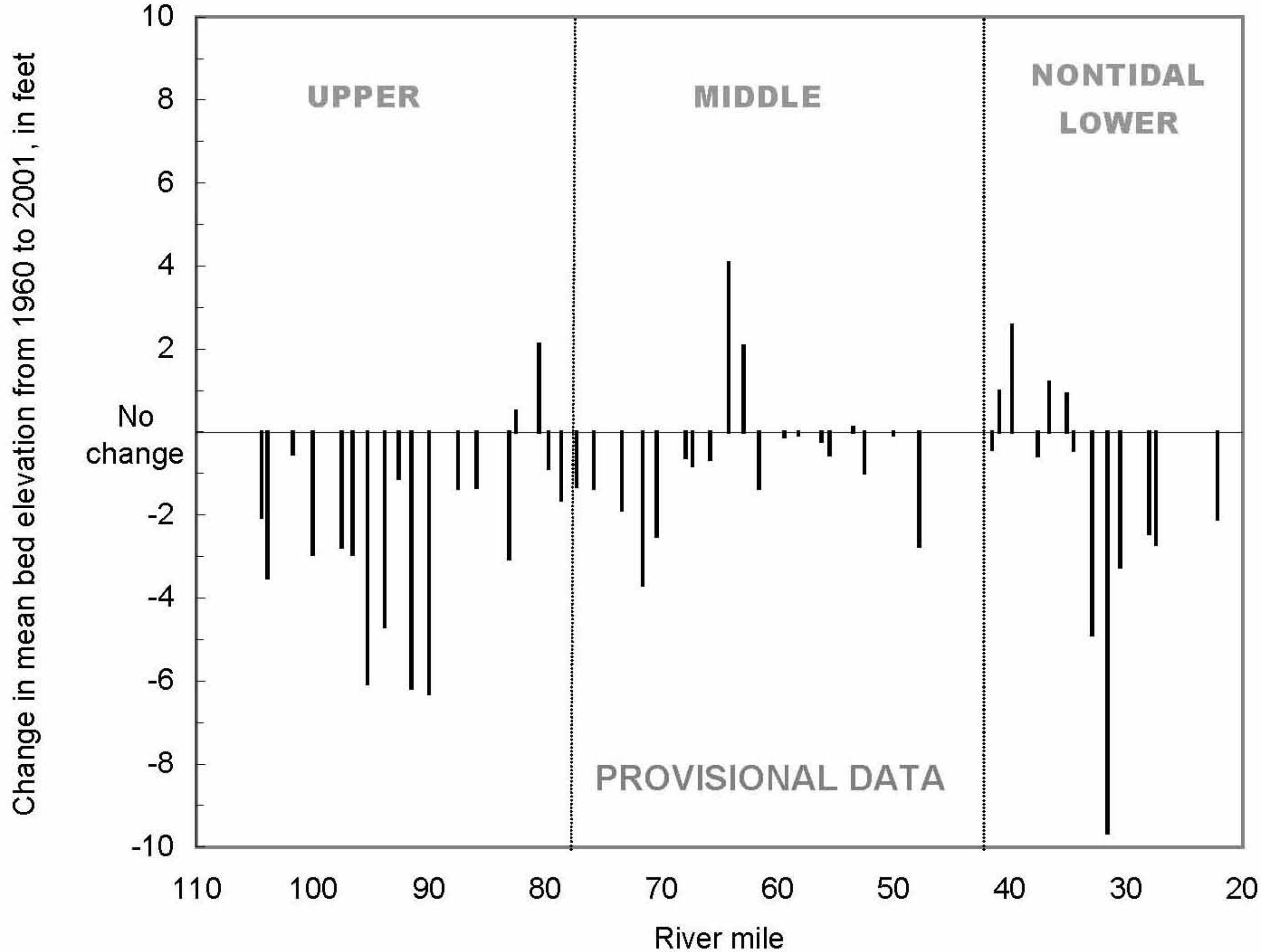

Figure 5.--Change in mean bed elevation of low-flow channel of the non-tidal Apalachicola River, Florida, from 1960 to 2001. Data was derived from U.S. Army Corps of Engineers cross-sections surveys. At each cross-section, the water-surface elevation at a lagged flow of 10,000 cubic feet per second at the Apalachicola River gage at Chattahoochee, Florida, was used to calculate mean bed elevation. River miles represent those depicted on the most recent USGS quadrangle maps available in 2005.

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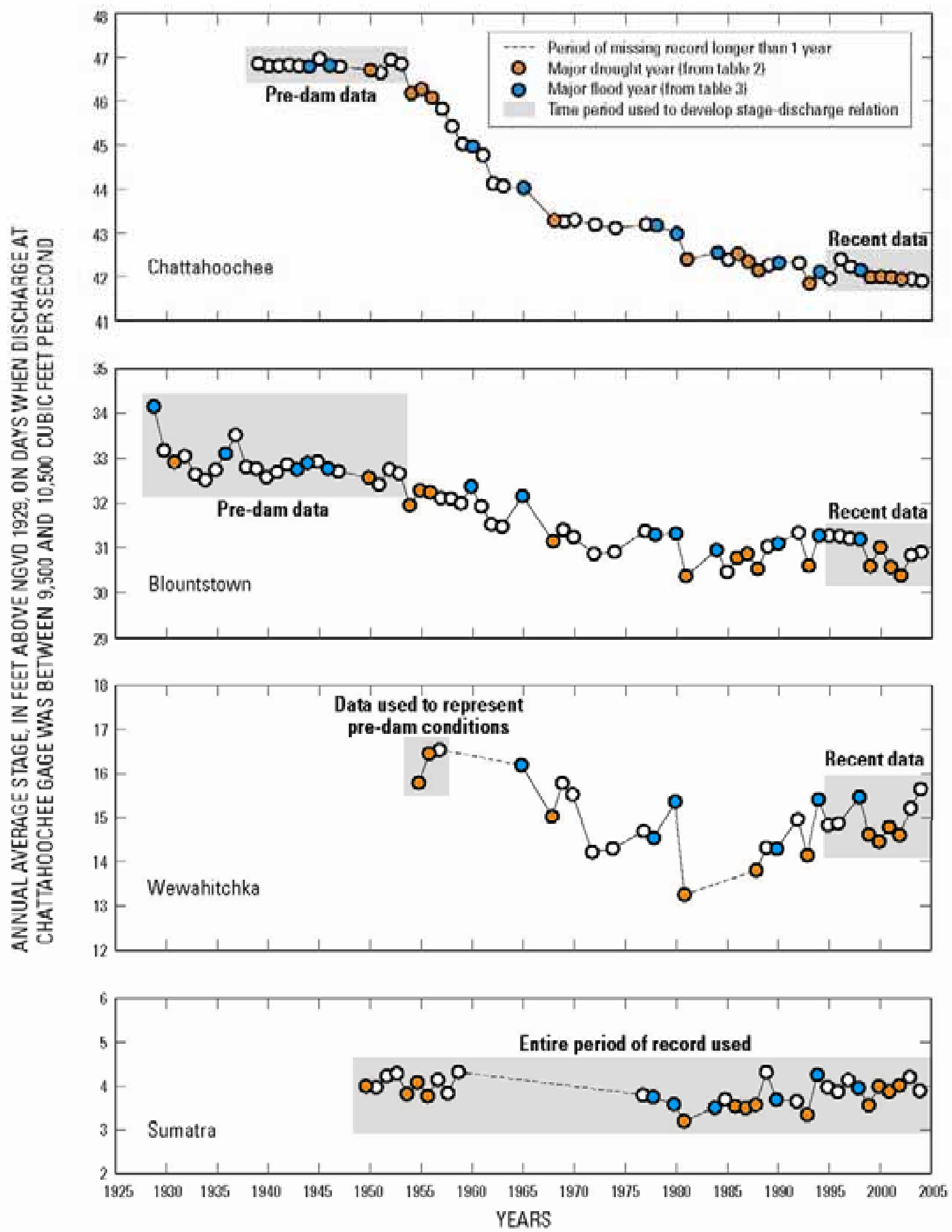

Period of missing record longer than 1 year
Major drought year (from table 2)
Major flood year (from table 3)
Time period used to develop stage-discharge relation
Chattahoochee
Pre-dam data
Recent data
Blountstown
Pre-dam data
Recent data
Wewahitchka
Data used to represent pre-dam conditions
Recent data
Sumatra
Entire period of record used
ANNUAL AVERAGE STAGE, IN FEET ABOVE NGVD 1929, ON DAYS WHEN DISCHARGE AT CHATTAHOOCHEE GAGE WAS BETWEEN 9,500 AND 10,500 CUBIC FEET PER SECOND
YEARS

MEI

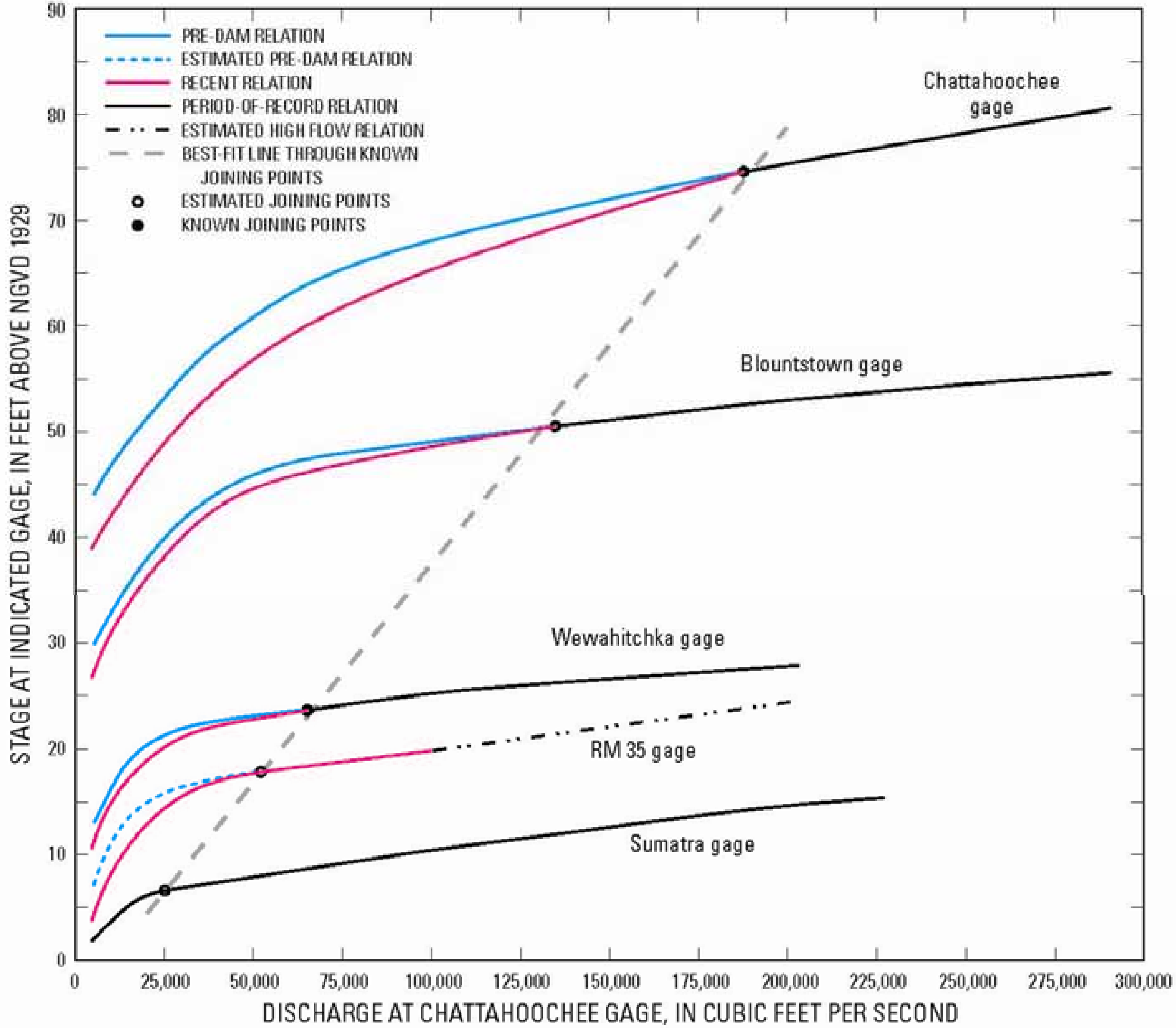


Figure 6. Stage at five streamgages on the Apalachicola River in relation to discharge at Chattahoochee, Florida, with known and estimated joining points for pre-dam and recent relations. Relations at streamgages downstream from Chattahoochee were developed using lag times as defined in glossary. An estimated joining point was needed for Sumatra, even though there is only one curve at that site, so that interpolated pre-dam and recent relations could be developed between RM 35 and Sumatra.

MEI

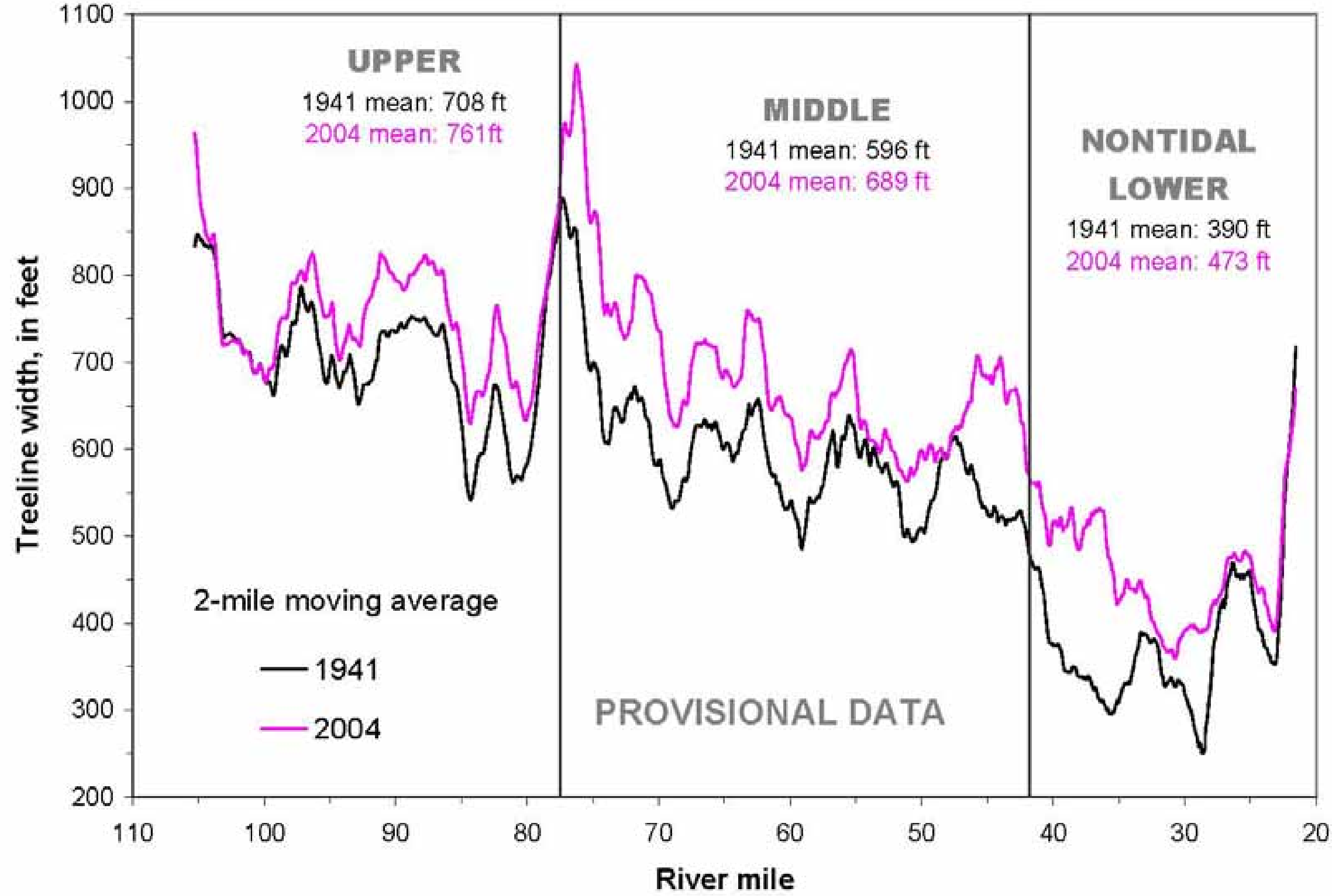


Figure 1. Treeline width of main channel of nontidal reach of Apalachicola River, Florida, in 1941 and 2004. Widths were measured at approximately 2,800 points at 164-foot intervals along the channel centerline in aerial photographs. Data shows a 2-mile (64-point) moving average. River miles represent those depicted on the most recent USGS quadrangle maps available in 2005.

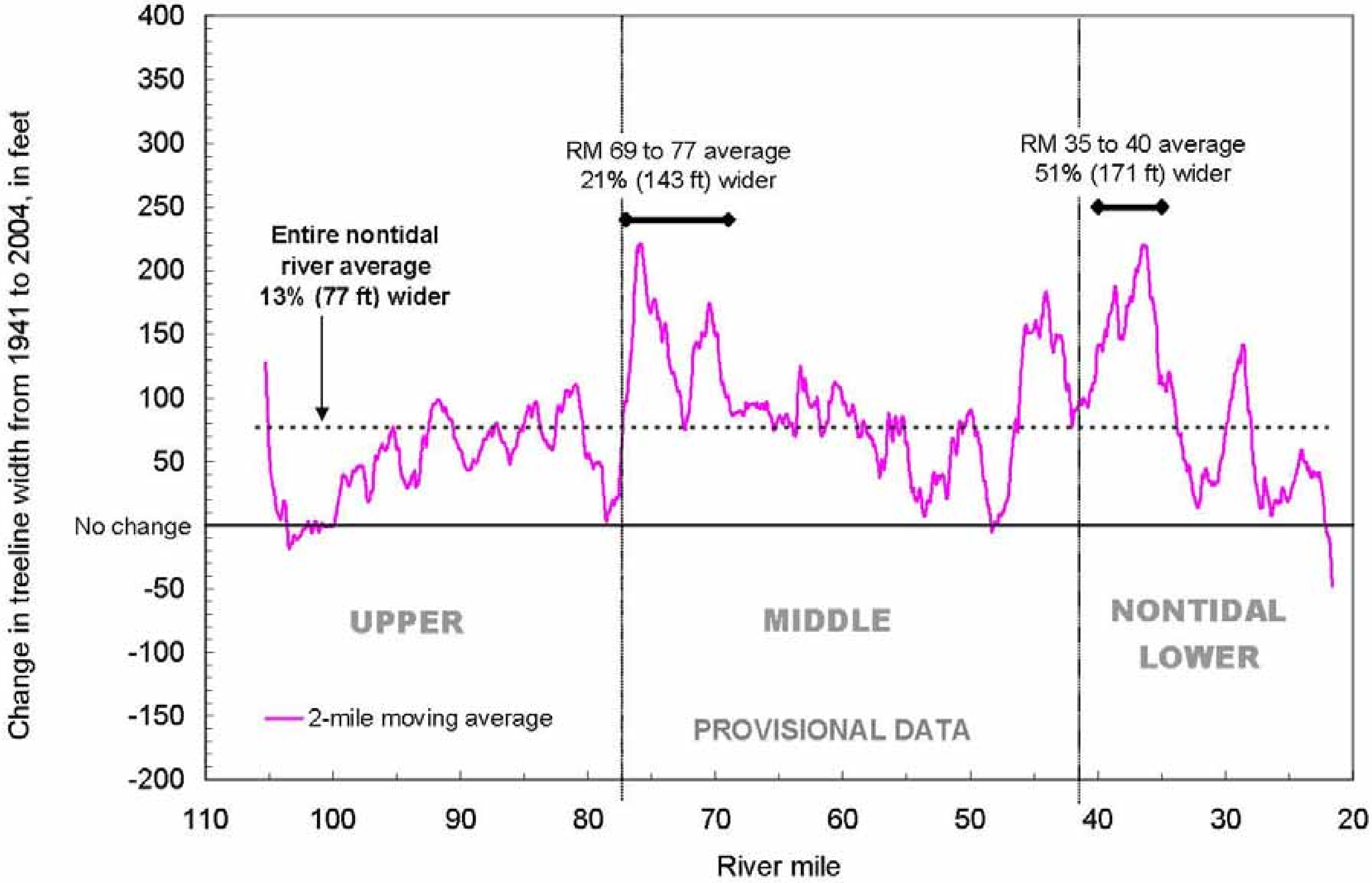


Figure 2. Change in treeline width of main channel of nontidal reach of Apalachicola River, Florida, from 1941 to 2004. Widths were measured at approximately 2,800 points at 164-foot intervals along channel centerline in aerial photographs. Data shows a 2-mile (64-point) moving average. River miles represent those depicted on the most recent USGS quadrangle maps available in 2005.

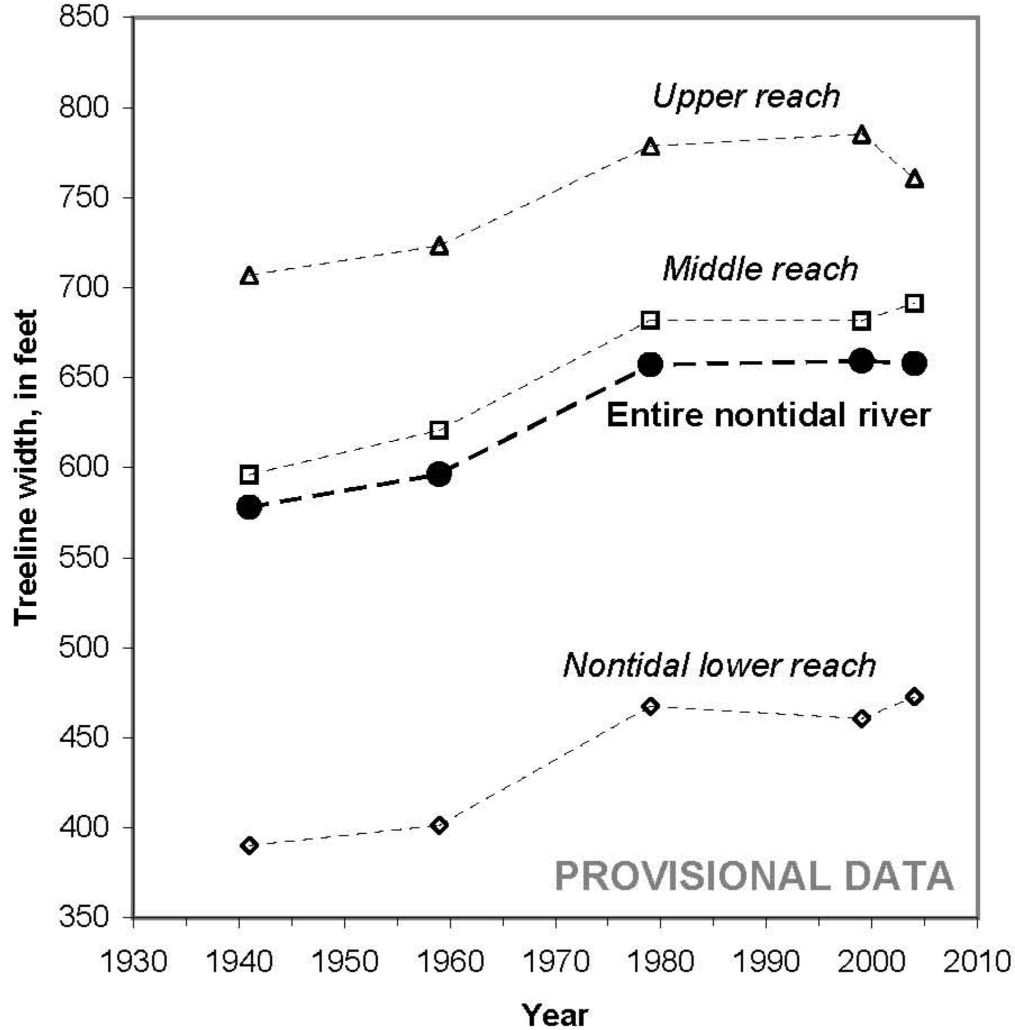
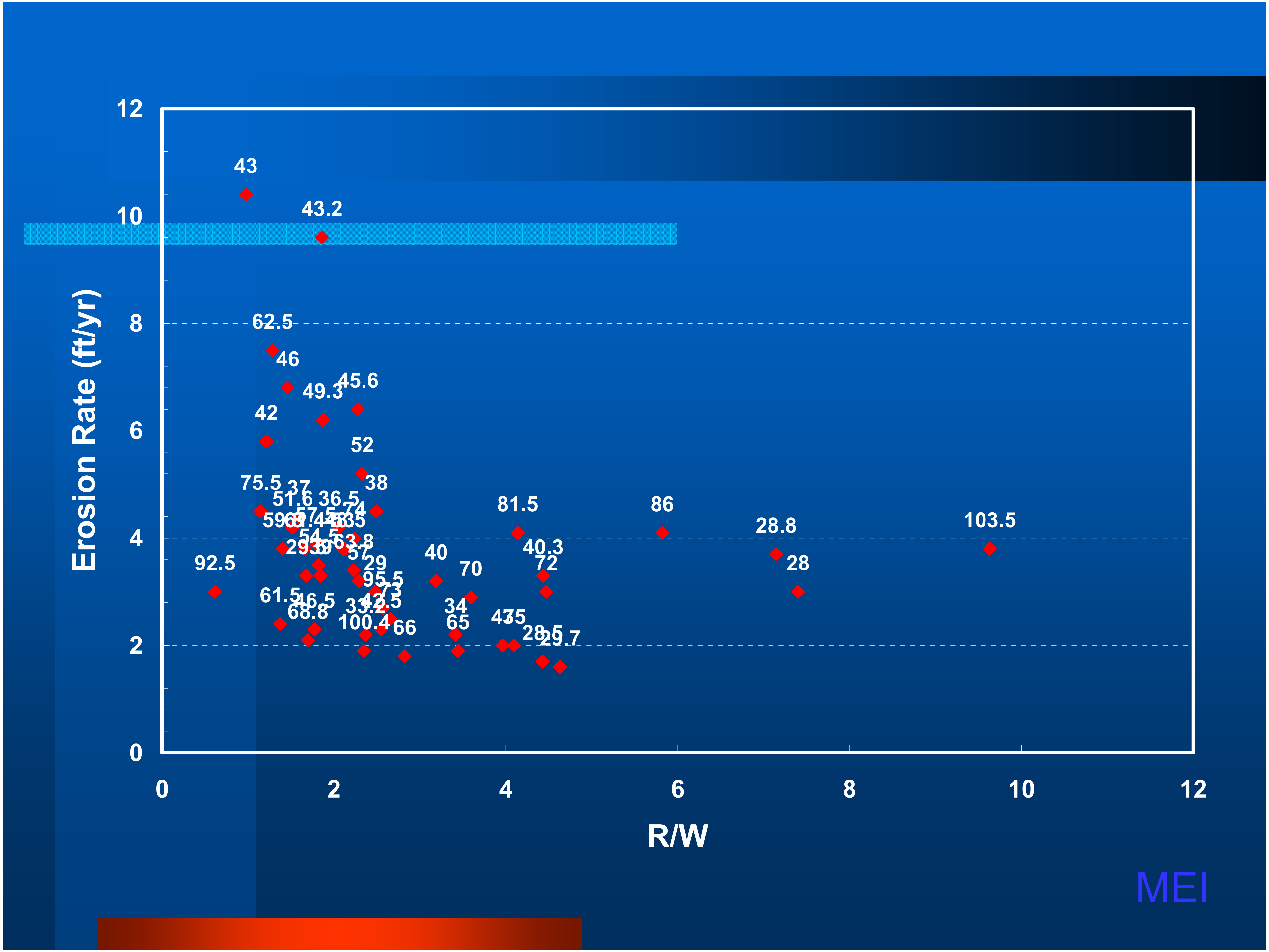
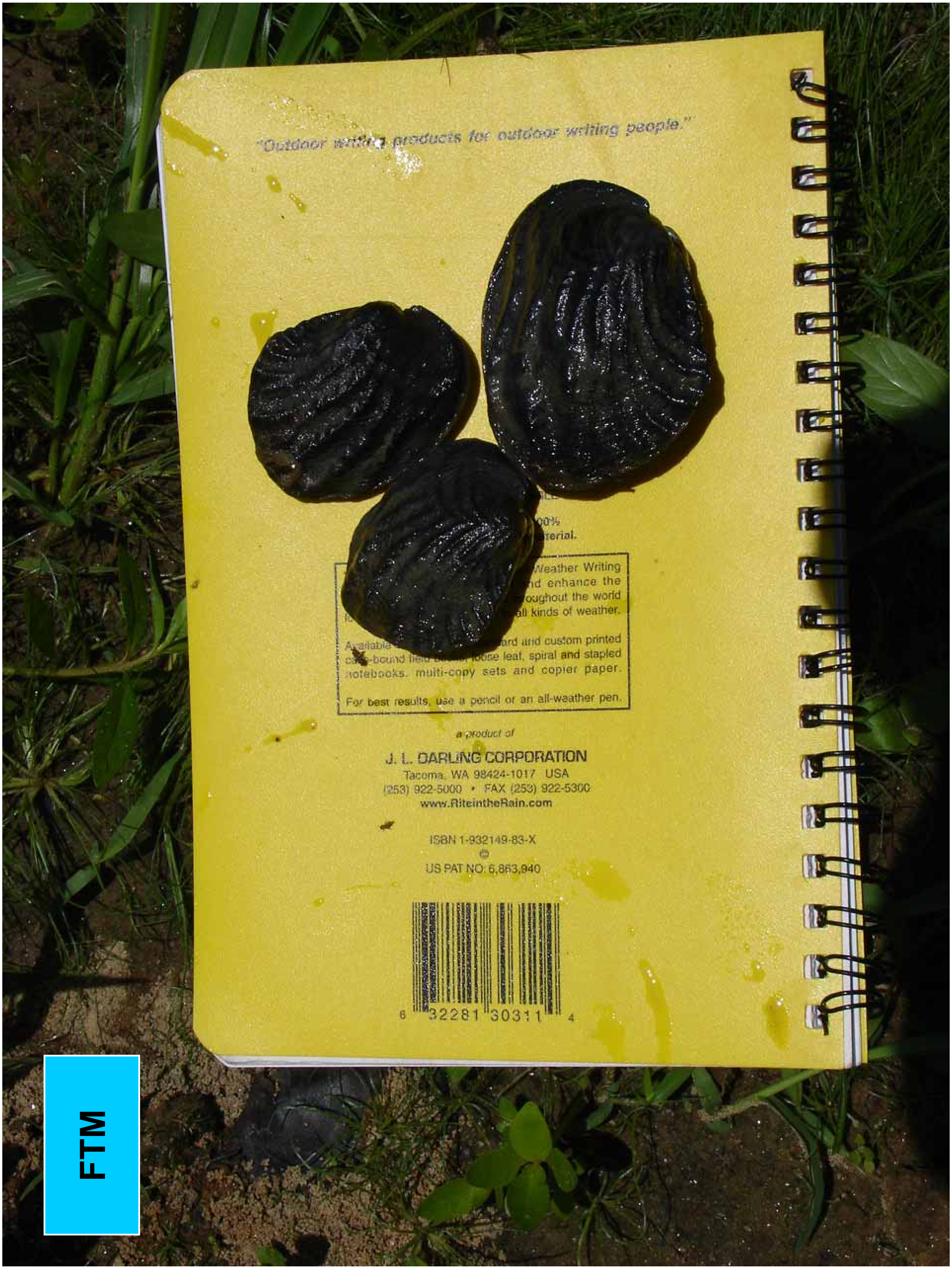


Figure 3.--Mean treeline width of main channel of nontidal reach of Apalachicola River, Florida, in relation to time. Measurements were made on aerial photographs along the river centerline at approximately 2,800 points equally spaced at 164-foot intervals.

MEI


Erosion Rate (ft/yr)
R/W
MEI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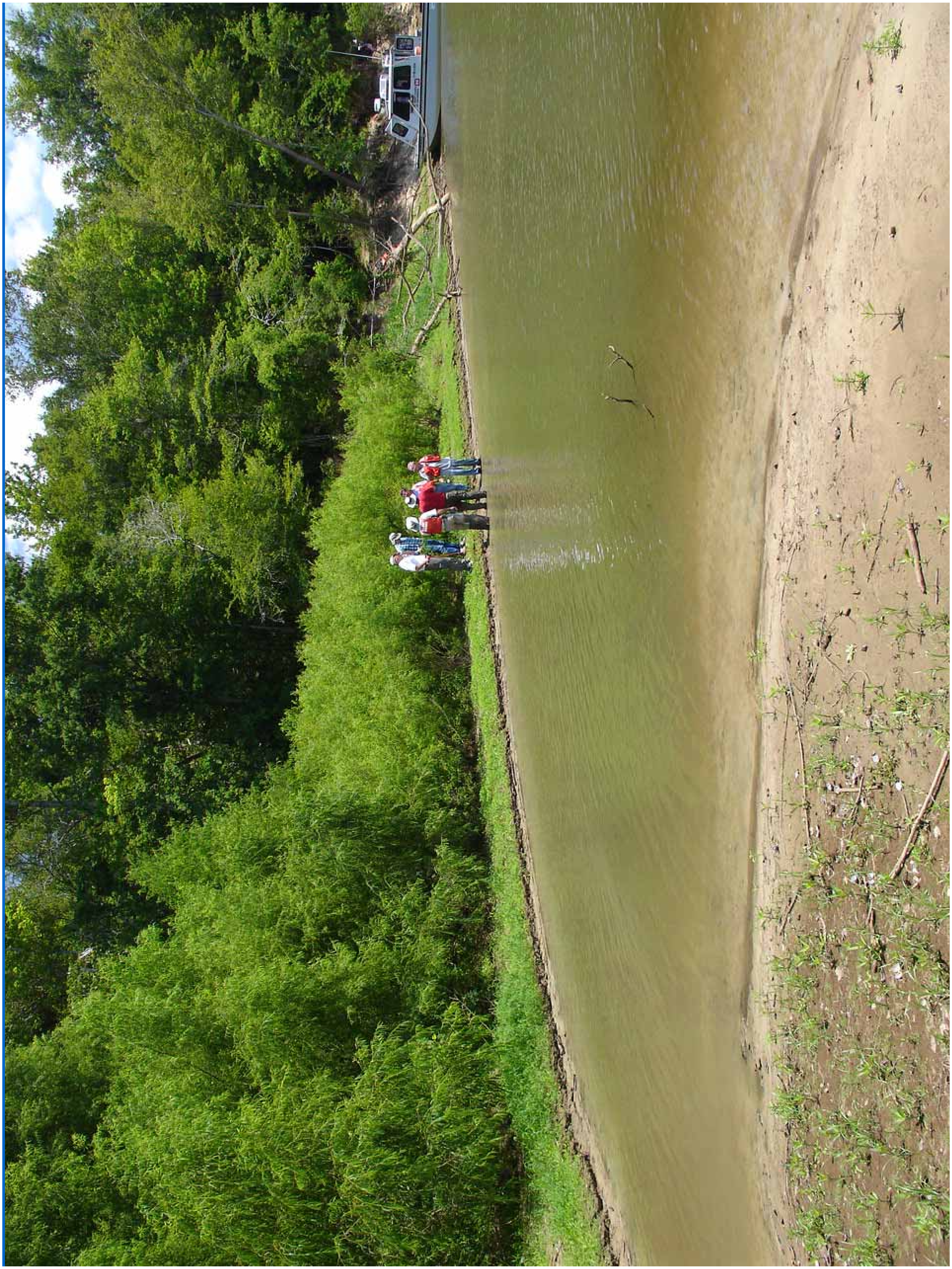
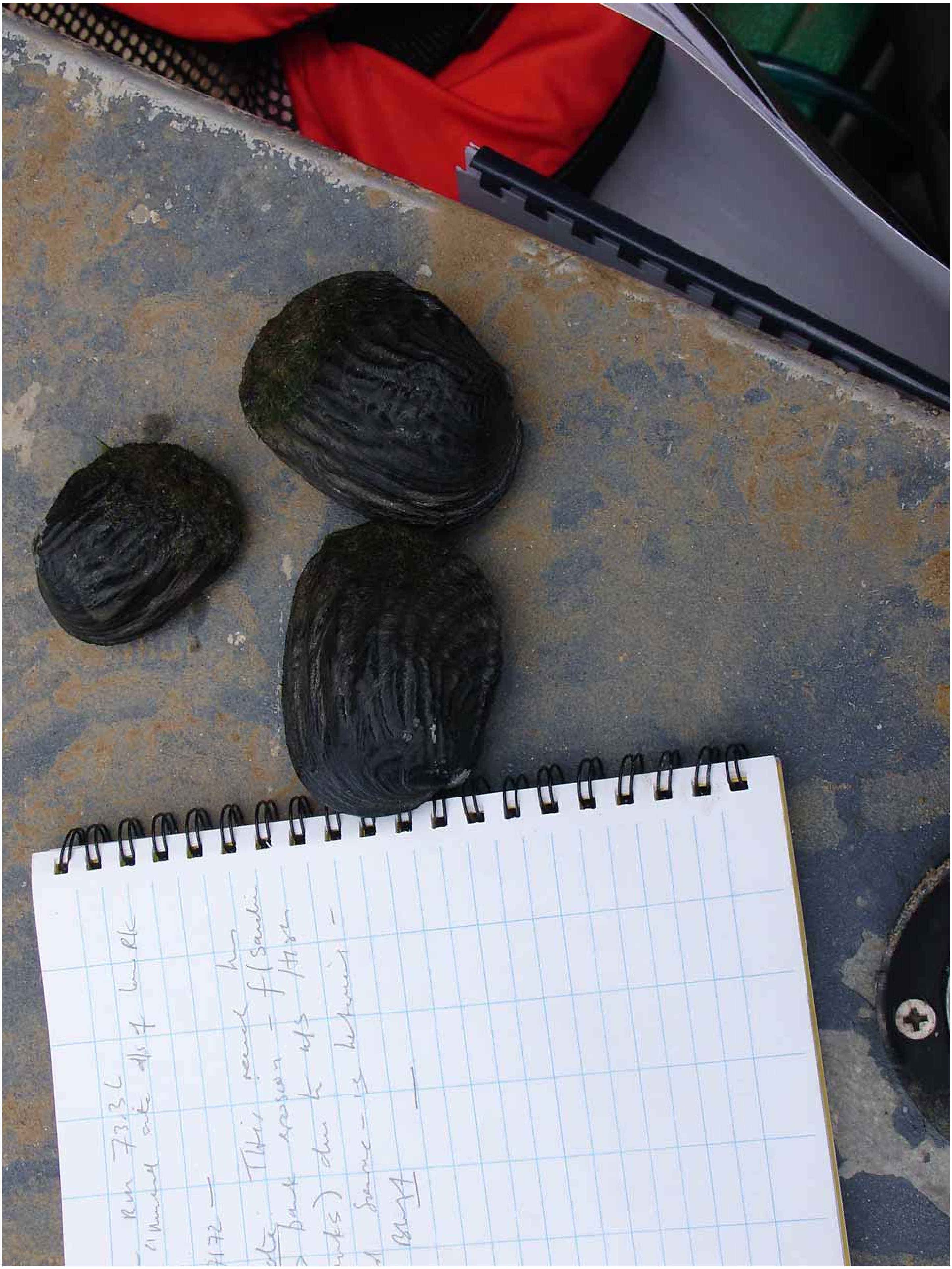
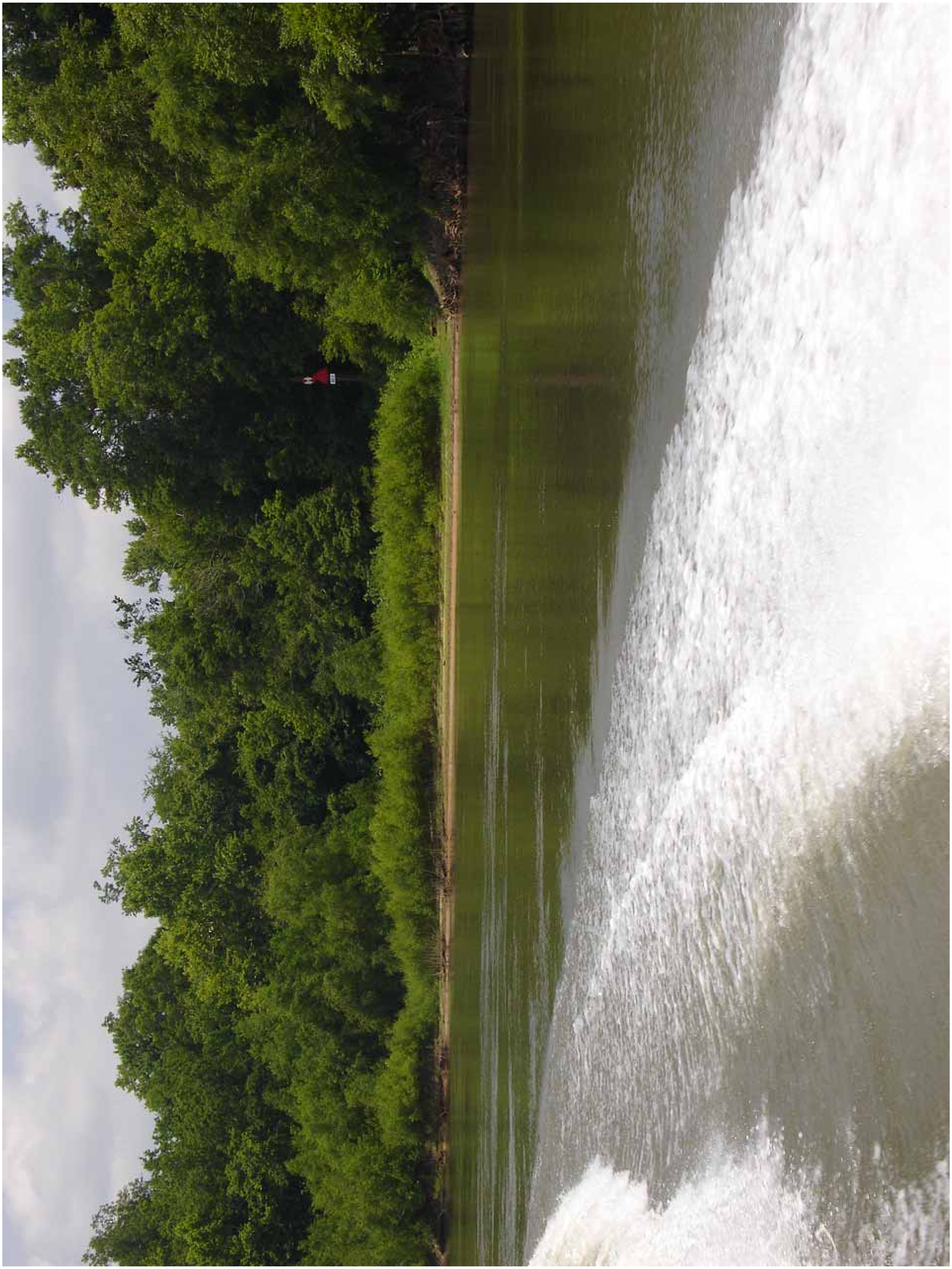


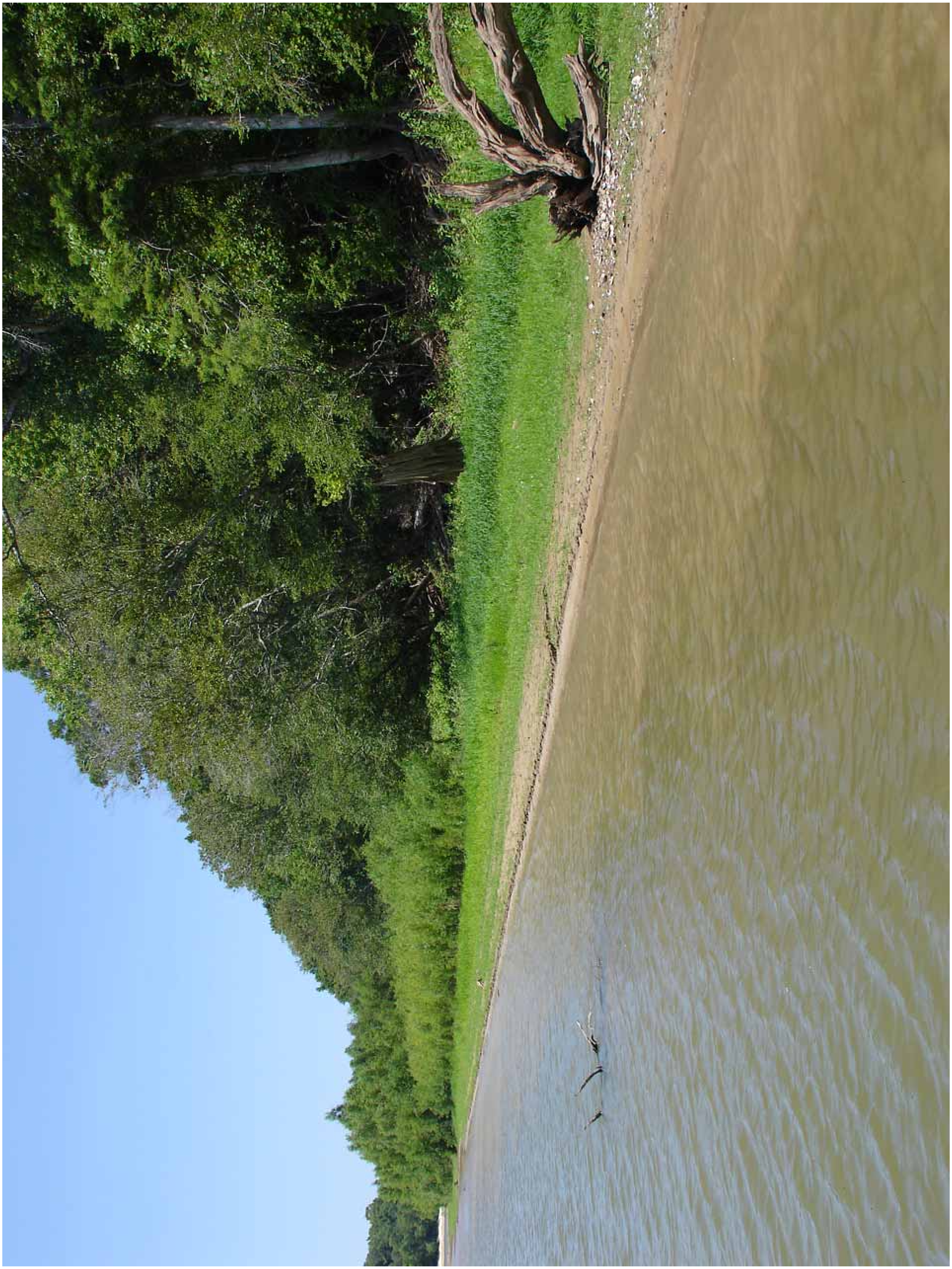



Equiloxic Creek




RM47.2R


RM 44L




Kentucky Ldg.


Swift Slough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CONCLUSIONS - 1

- JW Dam and upstream dams have reduced sediment supply to AR, but have not changed hydrology significantly.
- AR has degraded: 5 ft us – 2 ft ds
- Not clear if AR has widened
- Bed slope is uniform through the reaches (0.000093-95)
- Very high sinuosity from RM 78 – RM 35 probably due to active tectonics

CONCLUSIONS - 2

- Maximum erosion rates (~ 10 ft/yr) are low in comparison to other rivers
- FTM habitat is associated with eddy deposits; ds end of bends, backwater bars, dikes.
- FTM habitat is ephemeral and changes with time and space.
- Rates of change are a function of the frequency and magnitude of flood events.
- Distributary channels (e.g. Swift Slough) are also ephemeral features.

IDENTIFIED ISSUES

- **Is the AR widening and what are the processes**
- **Has the AR attained a level of equilibrium or will instability move ds.**
- **Quantification of the relationships between meander dynamics and FTM habitat**
- **How much eddy habitat is available in the meandering reach (RM 78 – RM 35).**

RECOMMENDATIONS

- **Thorough integrated geomorphic evaluation**
- **Development of a sediment mass balance with SIAM**
- **2-D models of different habitat types**
- **Develop process-response model for prediction of impacts of water ops. on FTM habitat.**


NO
SWIMMING
ALLIGATORS
FREQUENT
THIS AREA !
BE SAFE
SAVE YOUR LIFE

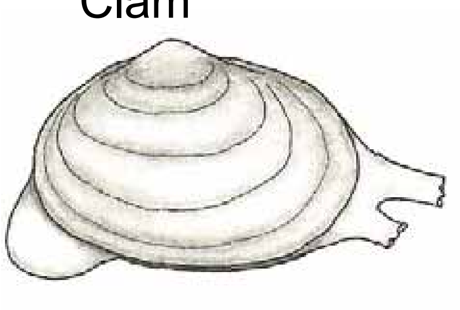
MEI

Density and distribution of *Amblema neislerii*, Apalachicola River, Florida

- Mussel biology and ecology
- Sampling for mussels
- Background on *A. neislerii*
- Abundance & distribution (2007 Survey)
- Mussel monitoring plan

Unionidae: Freshwater Mussels

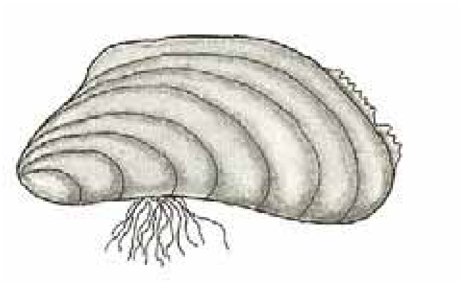
‘Clam’



Burrows, no byssal threads

Asian clam, *Corbicula fluminea*

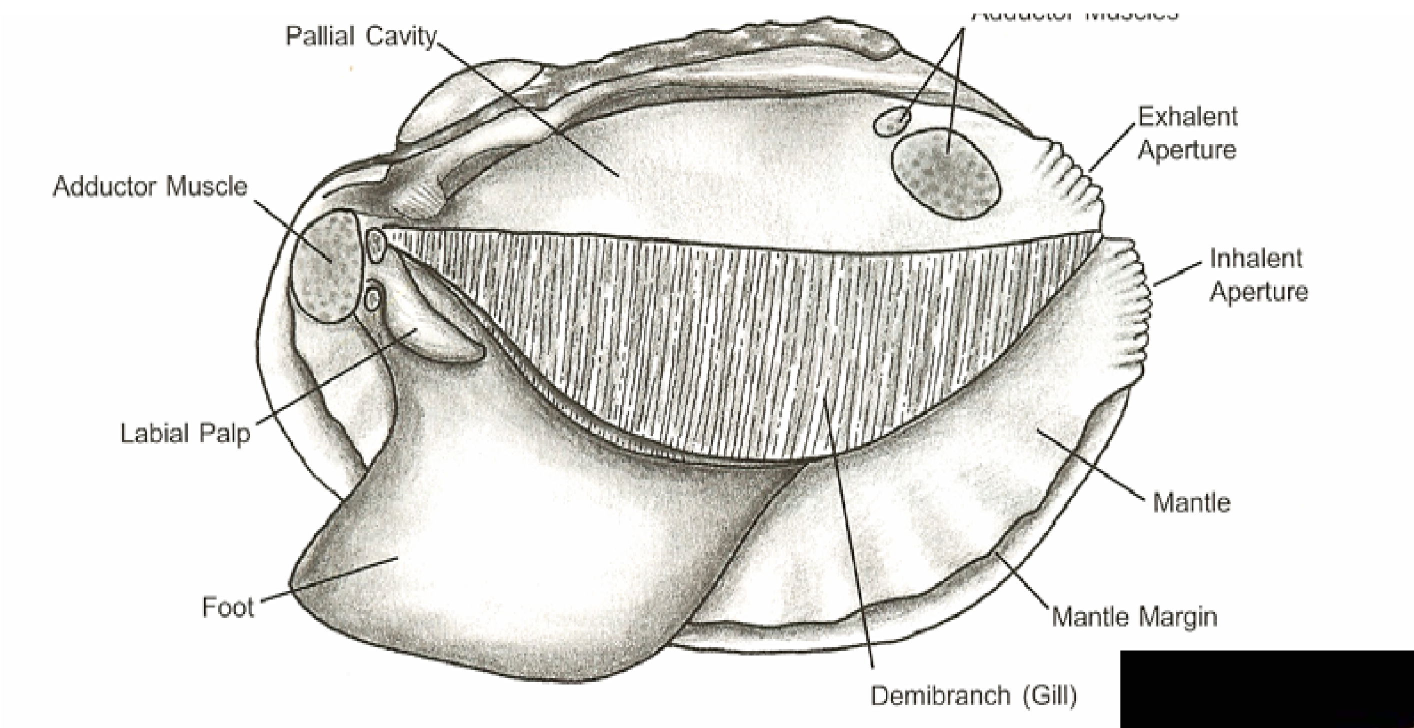
‘Mussel’

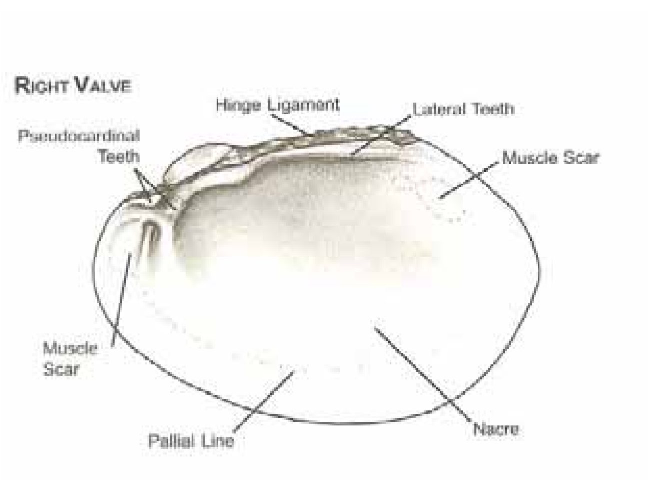


Attached, one or More byssal threads

***Amblema neislerii*, the fat Threeridge mussel (Endangered)**

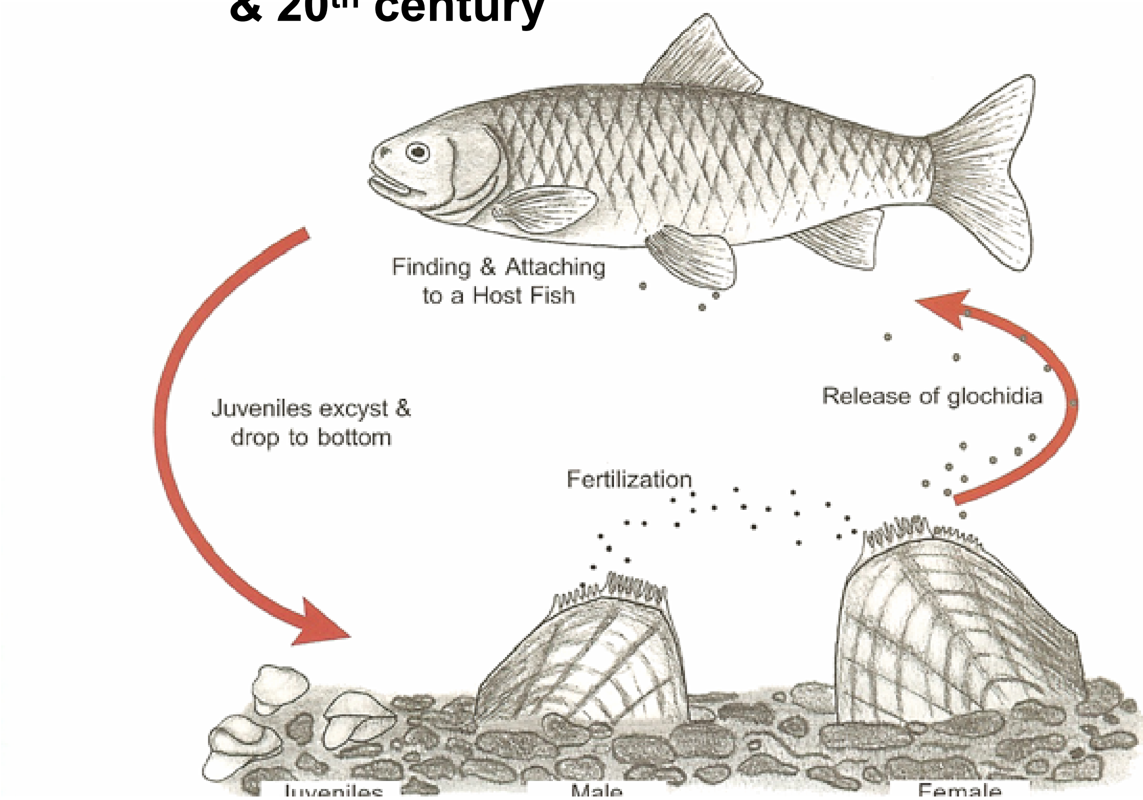
Unionidae: Freshwater Mussels





Unionidae: Freshwater Mussels

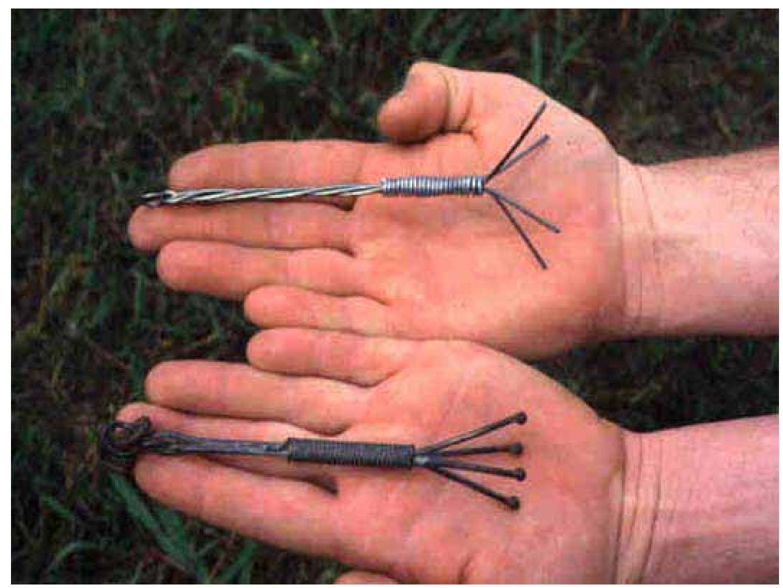
- Need for specific fish host
- Requirement for moderately depositional area
- Chance that juveniles can be dropped in unsuitable habitat
- Mussel beds can be self-sustaining
- Large rivers support diverse, dense assemblages
- Permanent water & stable substratum are important
- Tolerant of short periods of desiccation, poor water quality
- Mussels were affected by large-scale habitat changes in 19th & 20th century



Swift Slough

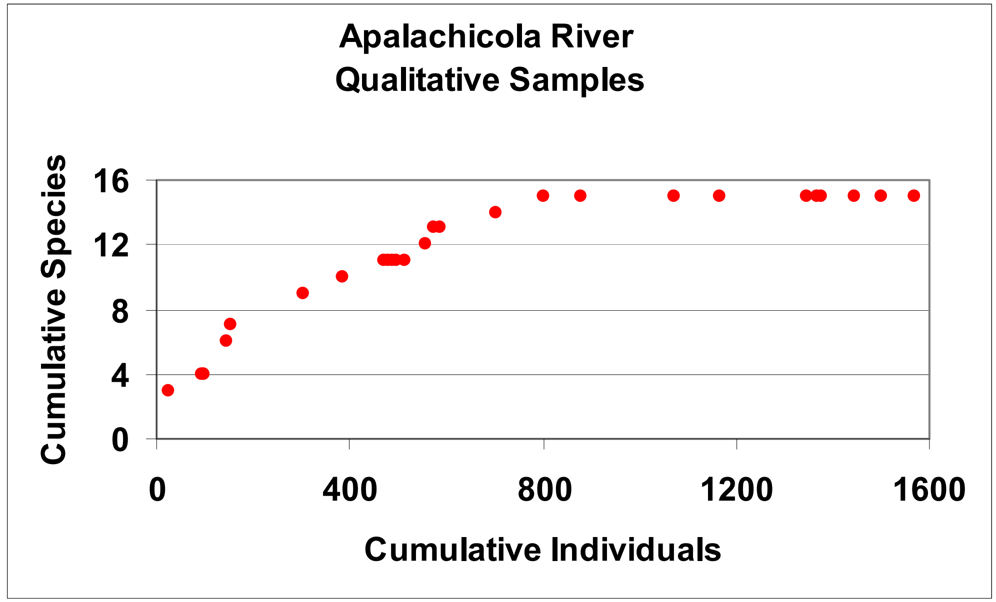
Mussel Sampling Methods

- Prior to 1980s – hand collecting or commercial brail
- After 1980s virtually everyone used divers equipped with scuba or surface supplied air

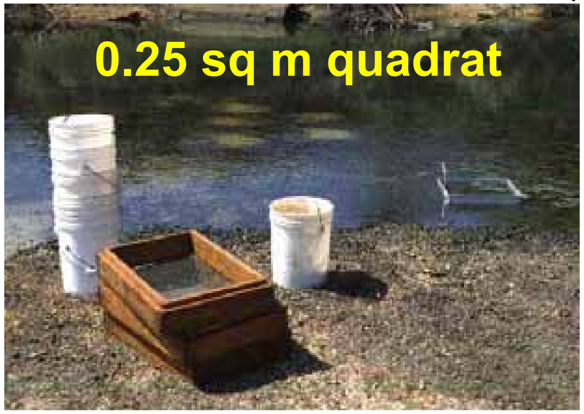


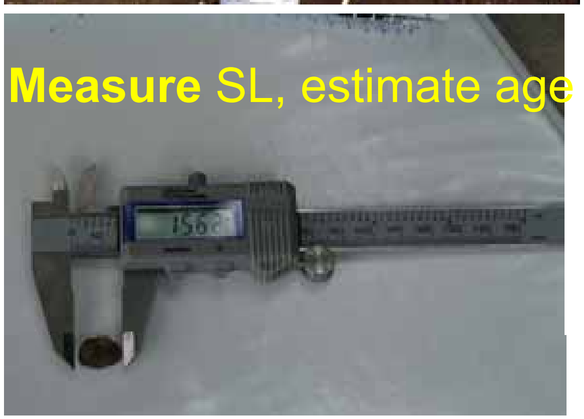
Sampling Strategies

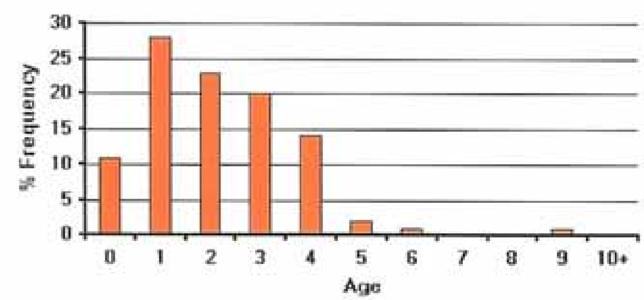
- Reconnaissance
- Qualitative – timed search
  - Species list, relative species abundance
  - Catch per unit effort (CPUE)
  - <u>Spatially extensive</u>
- Quantitative - 0.25 m^2 samples, sieve & pick
  - Density
  - Size demography
  - <u>Spatially intensive</u>



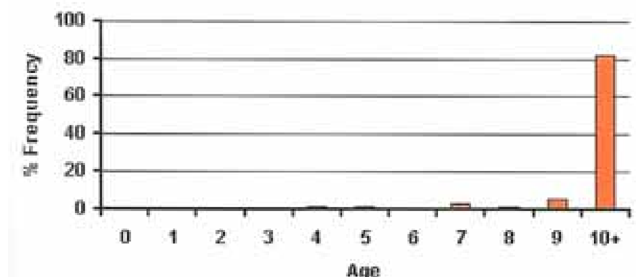
Quantitative Sampling



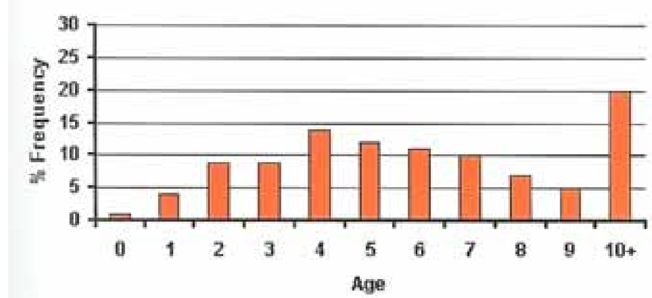




Juveniles



Adults



Even distribution

Amblema neislerii in the Apalachicola River

- "Rare" – Hyning (1925)
- "Rare…but locally abundant" (Clench & Turner 1956)
- *A. neislerii* found at one site (Heard 1975)
- 32 live A. neislerii at 7 sites (Brim Box & Williams 2000)

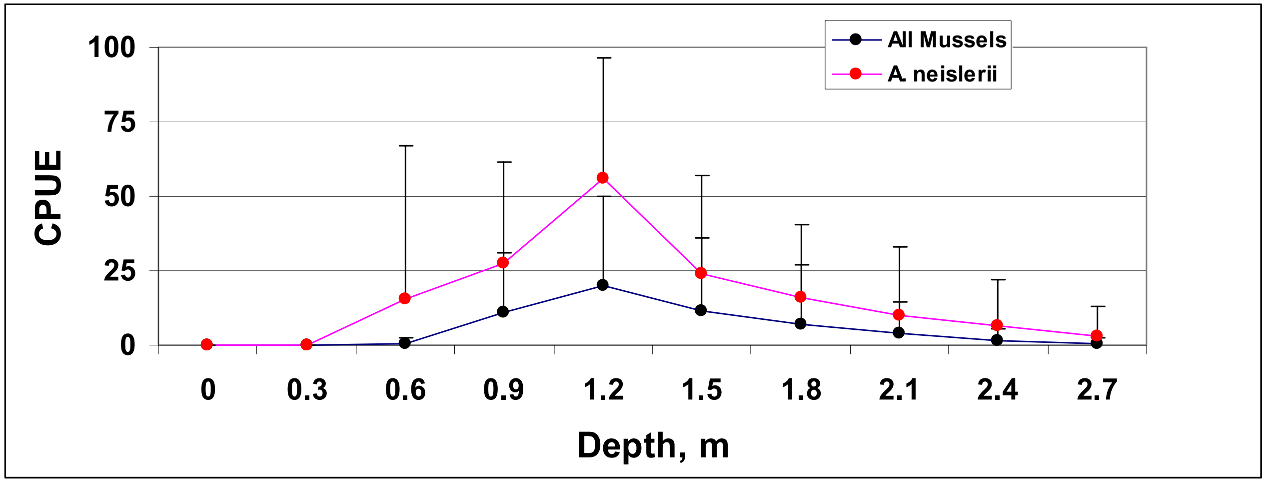
Mussels in the Apalachicola River have been misunderstood and misrepresented……

Previous Studies

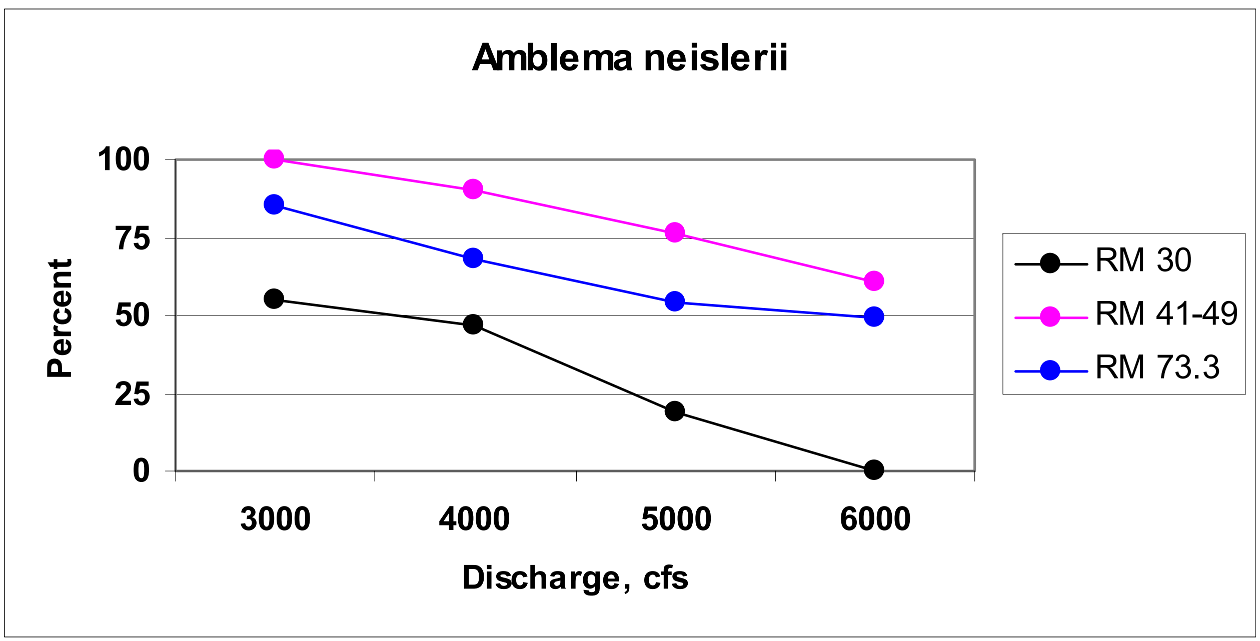
- **Phase I – Dredging impacts**
  - 96 sites likely affected by dredging
  - Timed searches above & below disposal areas
  - Studies conducted 96, 97, 99, 01, 02
- **Phase II – Low water impacts**
  - 11 sites where A. neislerii was abundant
  - Transects from shallow to deep water
  - CPUE for *A. neislerii* versus water depth
  - Studies conducted in 2003

Much data on mussels in the river…..
but how much understanding and wisdom?

Predicting Low Water Impacts-2003 Study



Depth vs. distribution

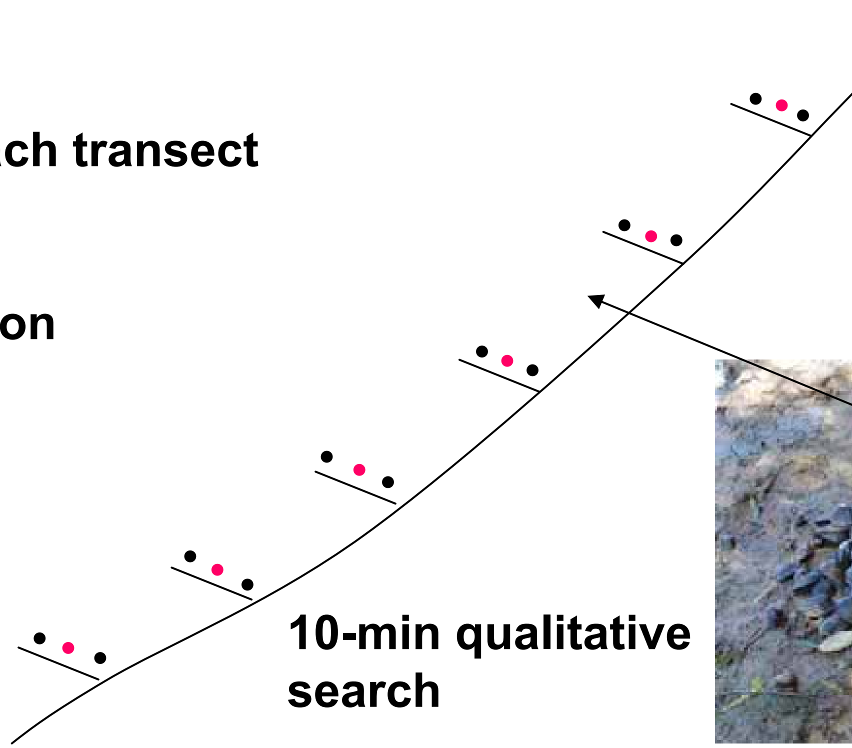


Percent exposed at low water

Based on decisions at a multi-agency meeting, USFWS chose ~25 sites between NM 40 & 50

Ten were randomly chosen for detailed studies

Depth & Distance at each transect
- ~ 1 m deep
- Shoreline
- Beginning of vegetation



Three 0.25 m^2 Quadrats/transect

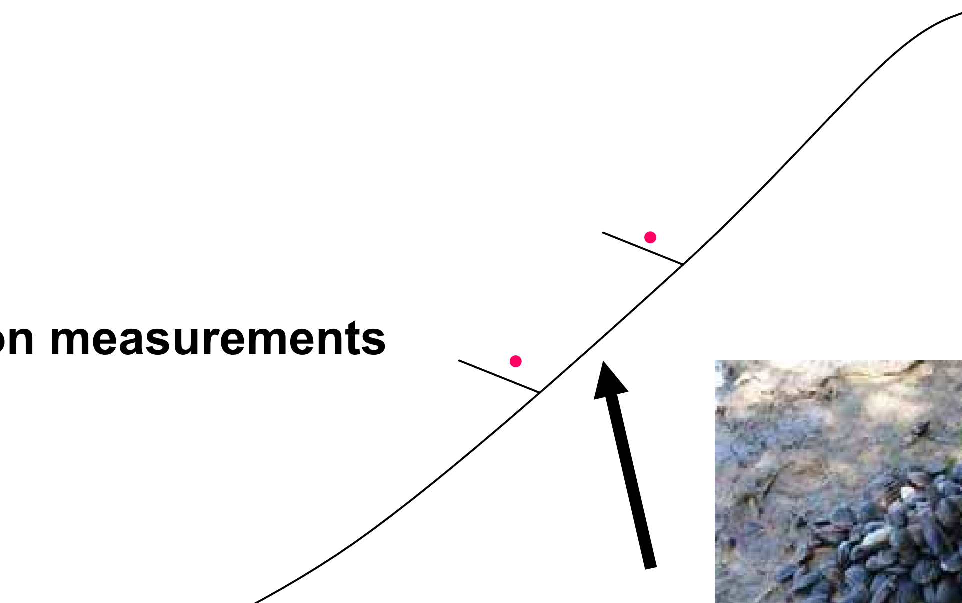
18 quadrats/site

10-min qualitative search

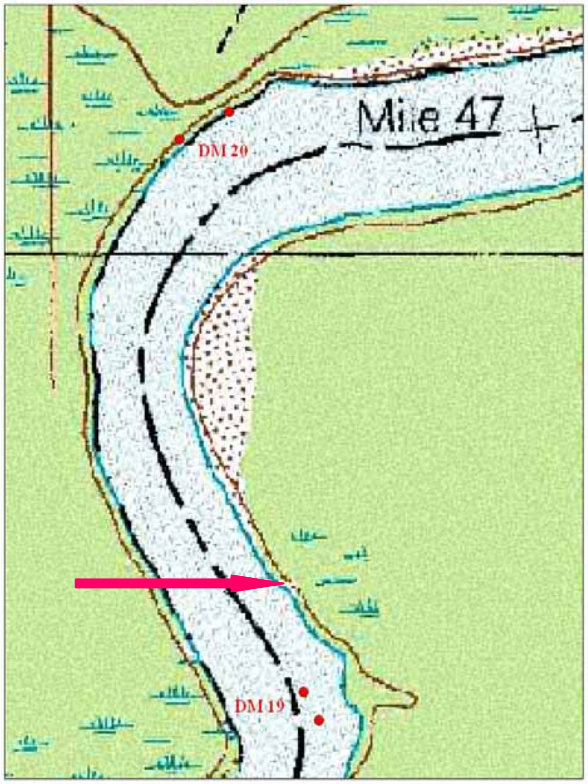
Sediment samples •
- Moisture content (60°C)
- Organic content (550°C
- Grain size distribution

Reduced studies were conducted
At the remaining 15 sites

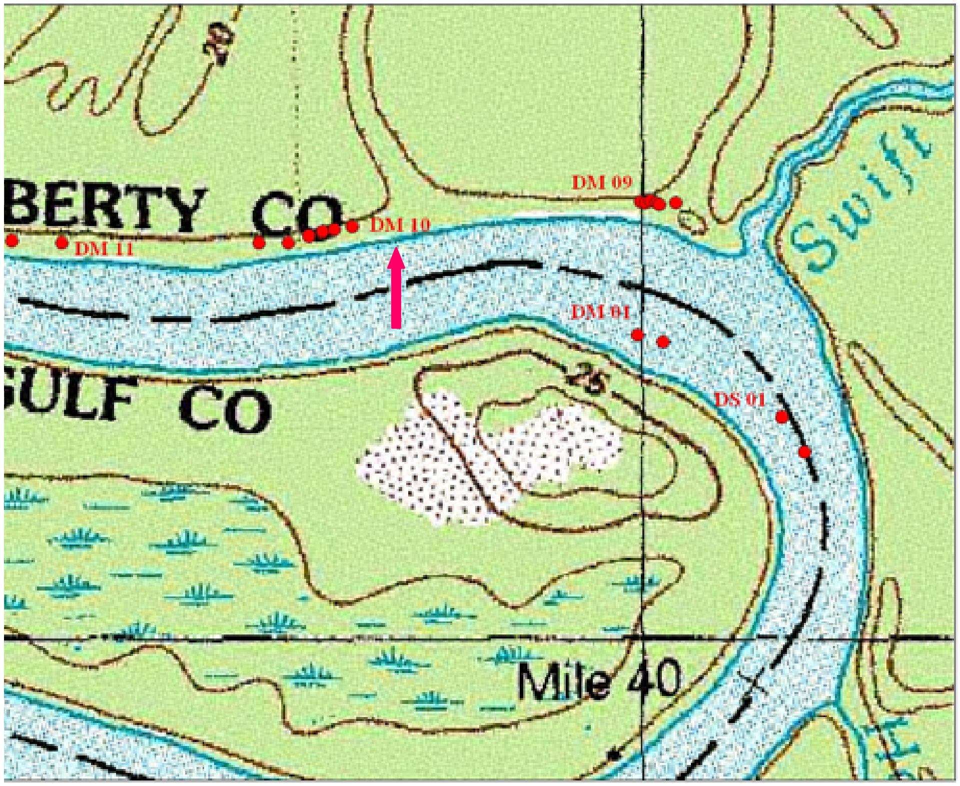
Sediment samples
Distance and elevation measurements
Along two transects



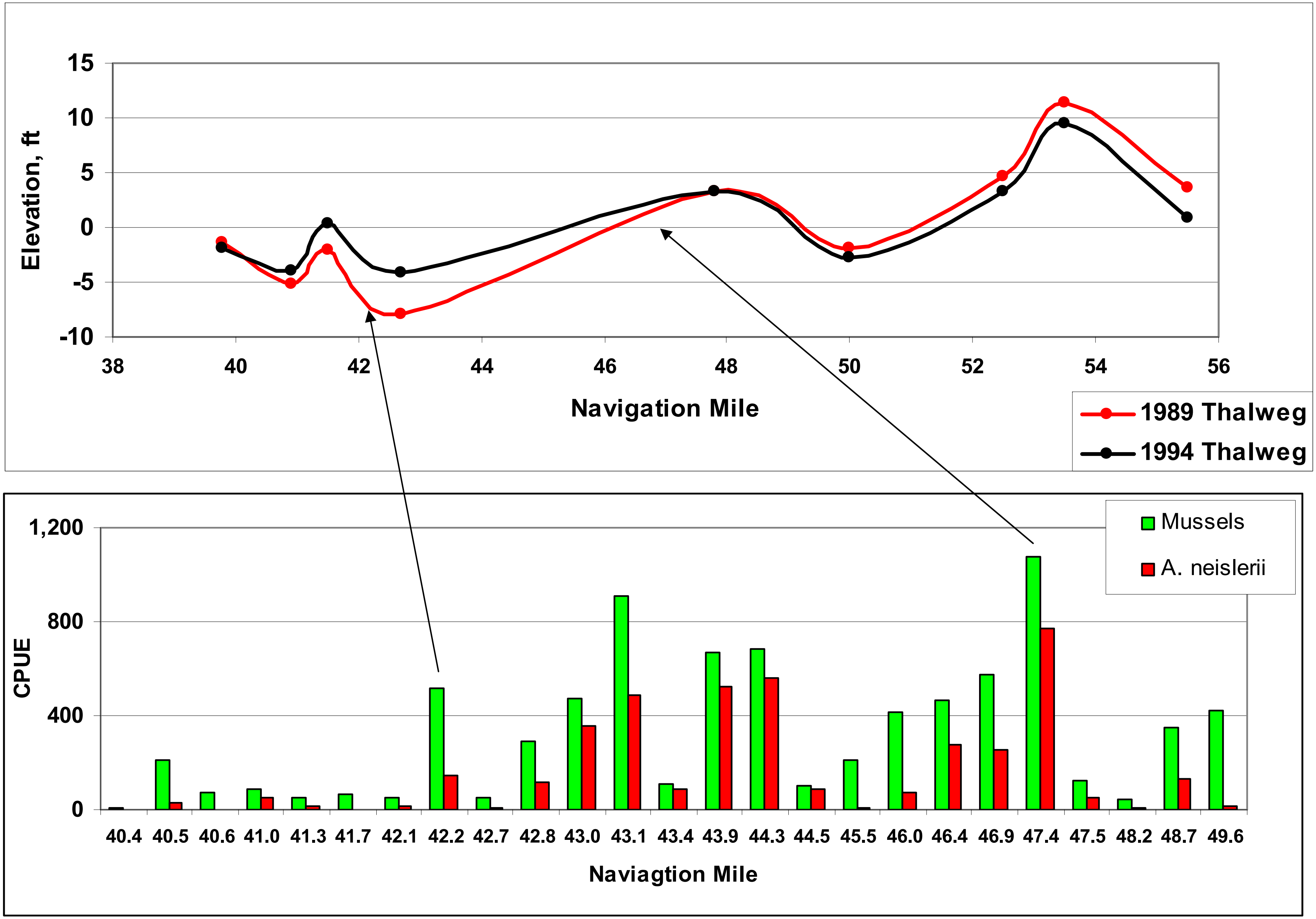
10-min qualitative search



DM19
NM 46.4
CPUE
A. neislerii – 276
All Mussels - 462

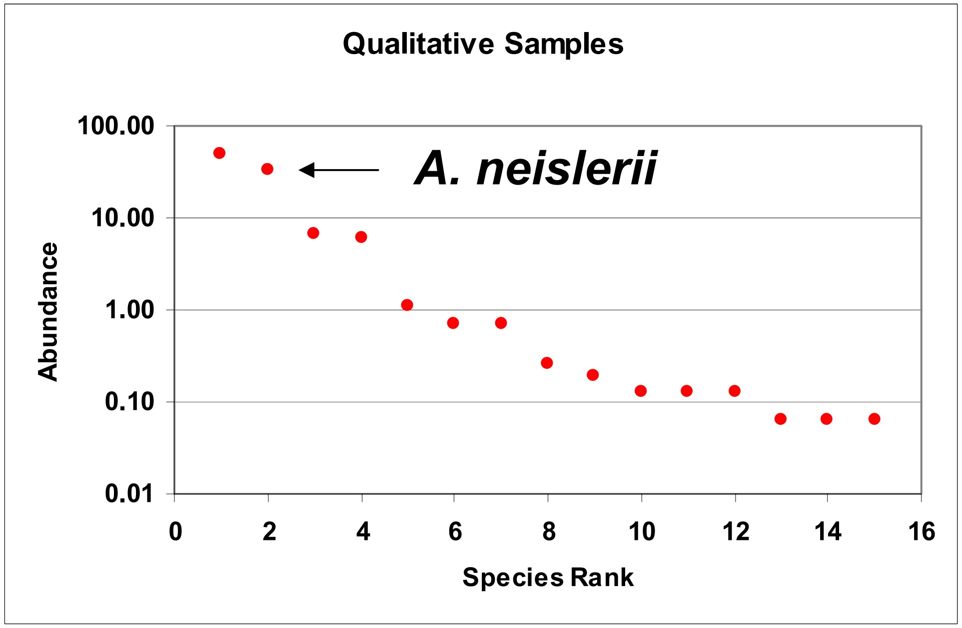


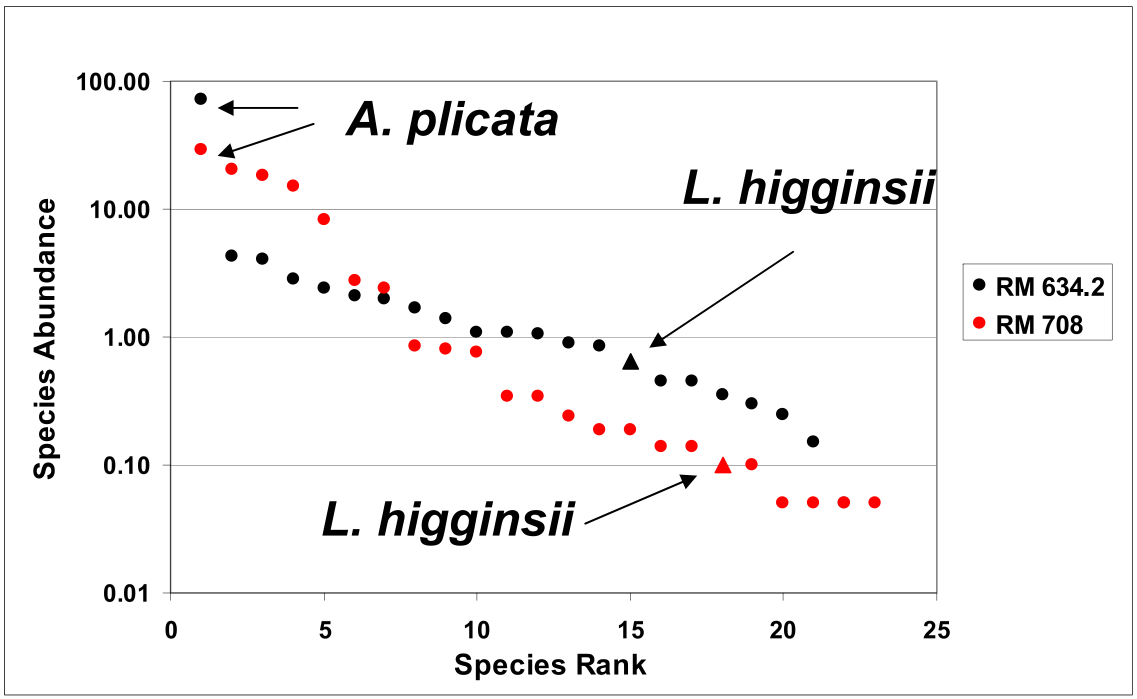
DM 10
NM 40.6, LDB
CPUE
***A. neislerii* – 3**
All mussels - 72



Elevation, ft
15
10
5
0
-5
-10
38
40
42
44
46
48
50
52
54
56
Navigation Mile
1989 Thalweg
1994 Thalweg
CPUE
1,200
800
400
0
Mussels
A. neislerii
40.4
40.5
40.6
41.0
41.3
41.7
42.1
42.2
42.7
42.8
43.0
43.1
43.4
43.9
44.3
44.5
45.5
46.0
46.4
46.9
47.4
47.5
48.2
48.7
49.6
Naviagtion Mile

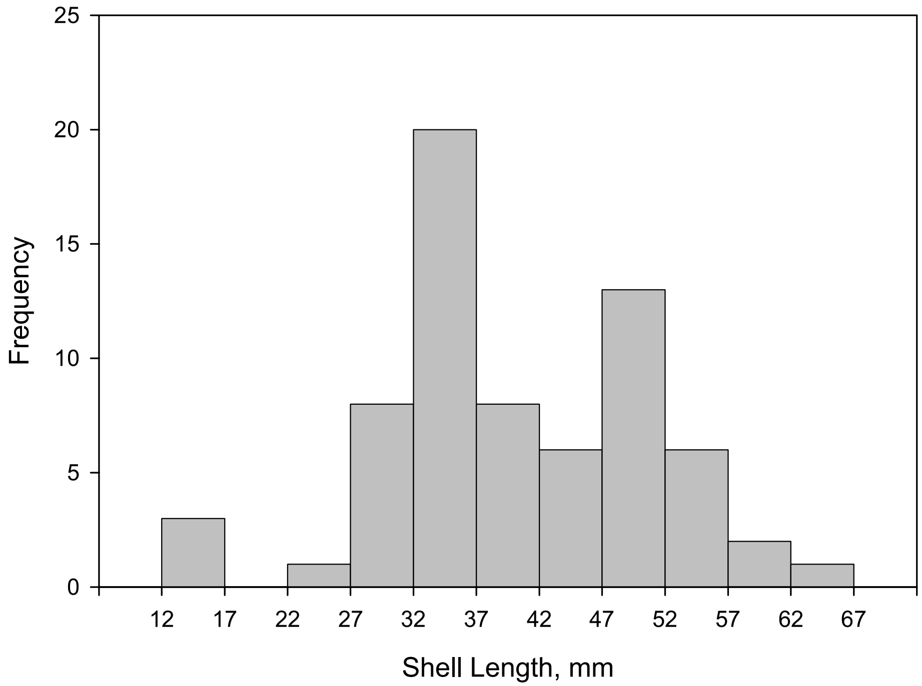
Relative Species Abundance



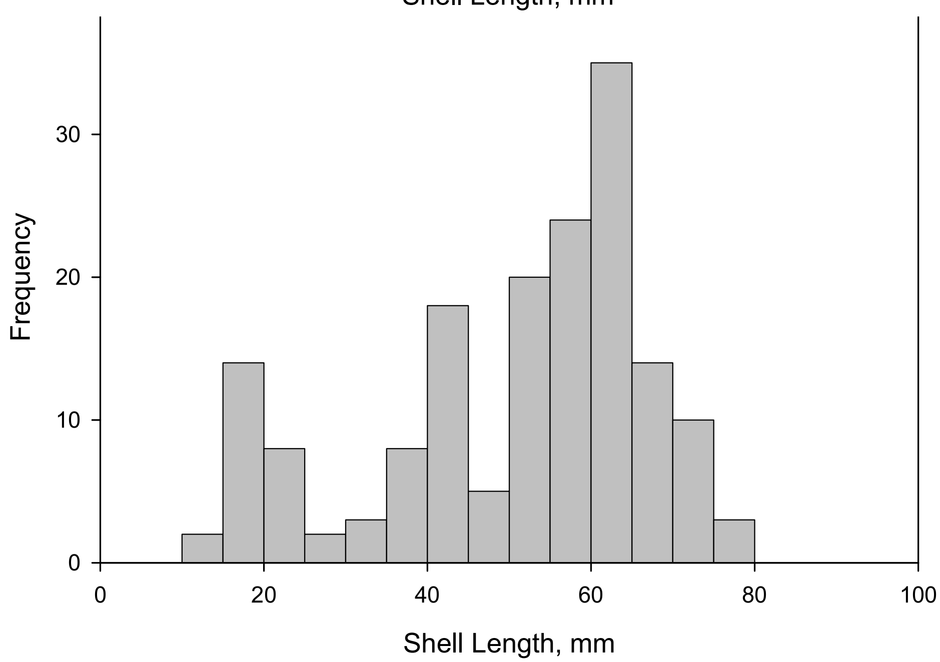


RM 635 near Prairie du Chien, WI

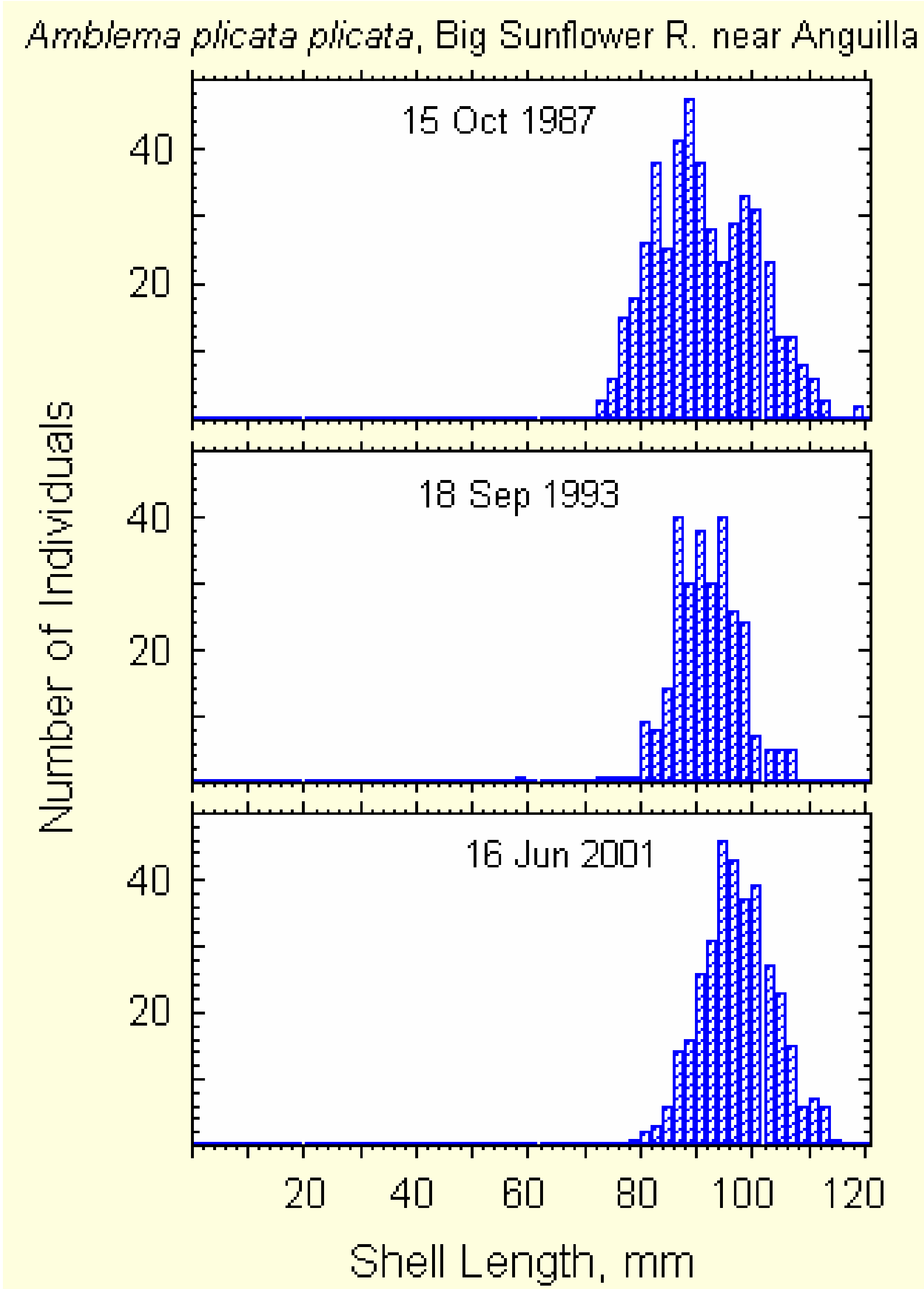
Amblema neislerii, Evidence of Recent Recruitment



Mouth of Chipola Cutoff,
NM 41.6, 1999

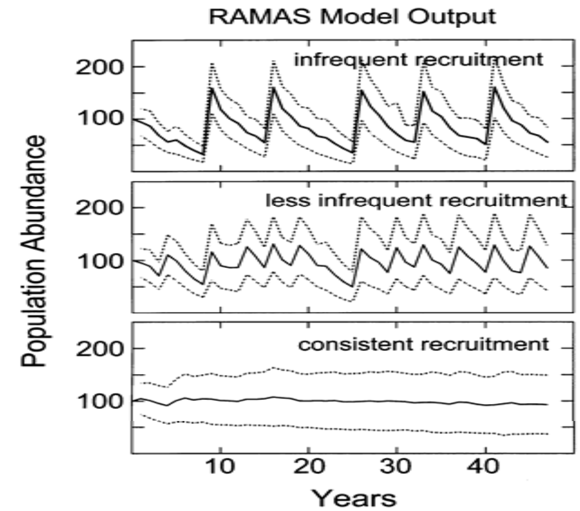


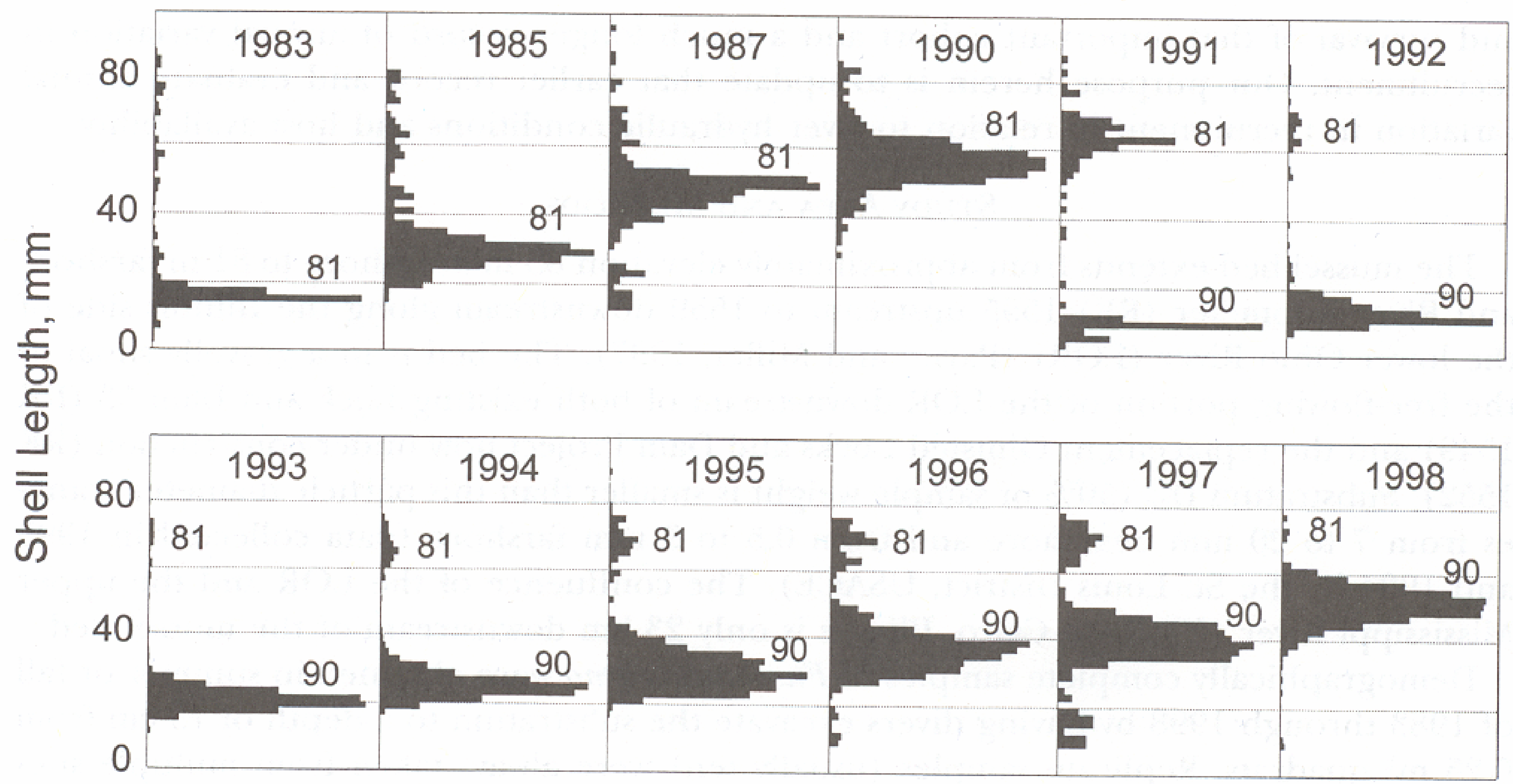
10 Sites between NM 40 & 50
2007



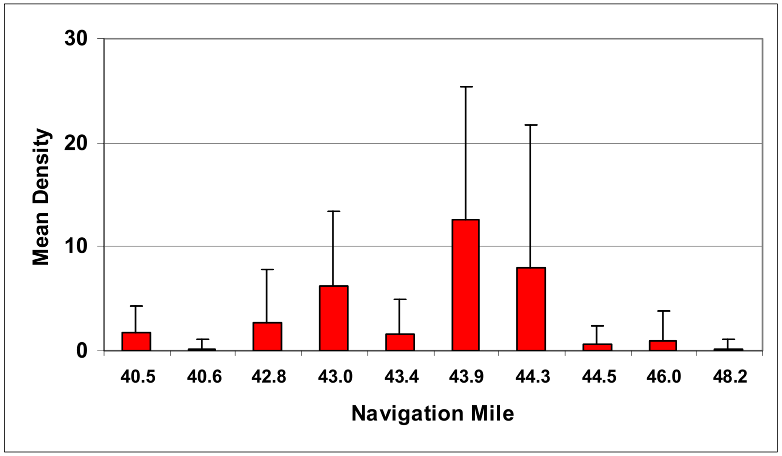
We have never found much evidence of recent mussel recruitment in the Big Sunflower River

Fusconaia ebena, Lower Ohio River, KY

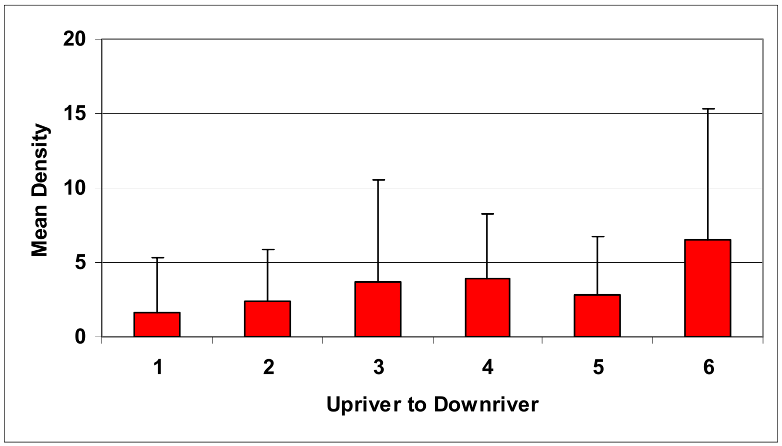




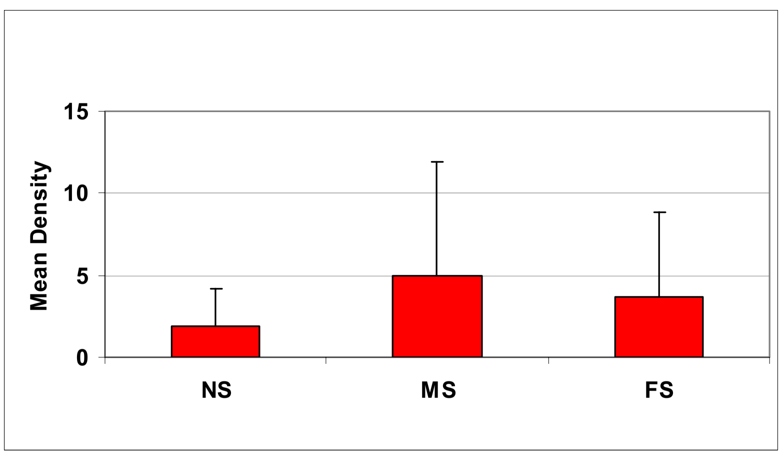
Total Mussel Density



By river mile

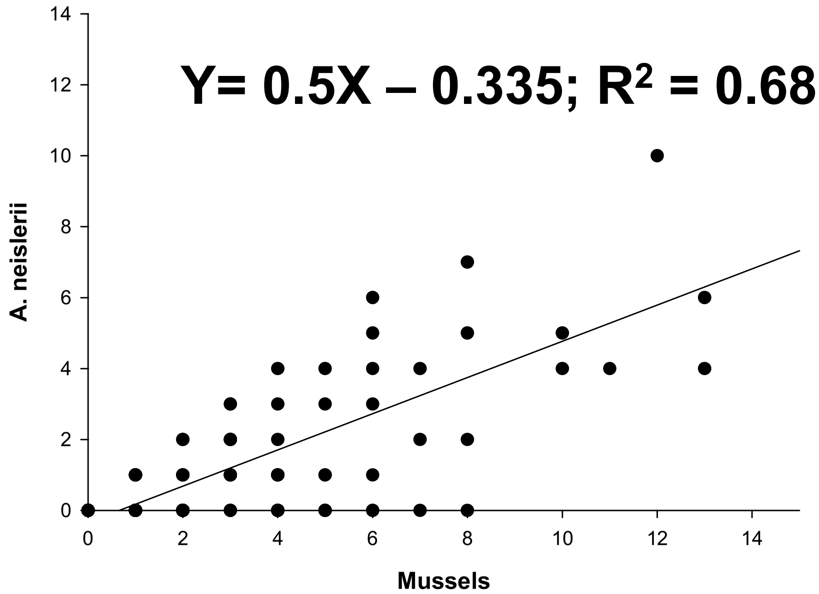


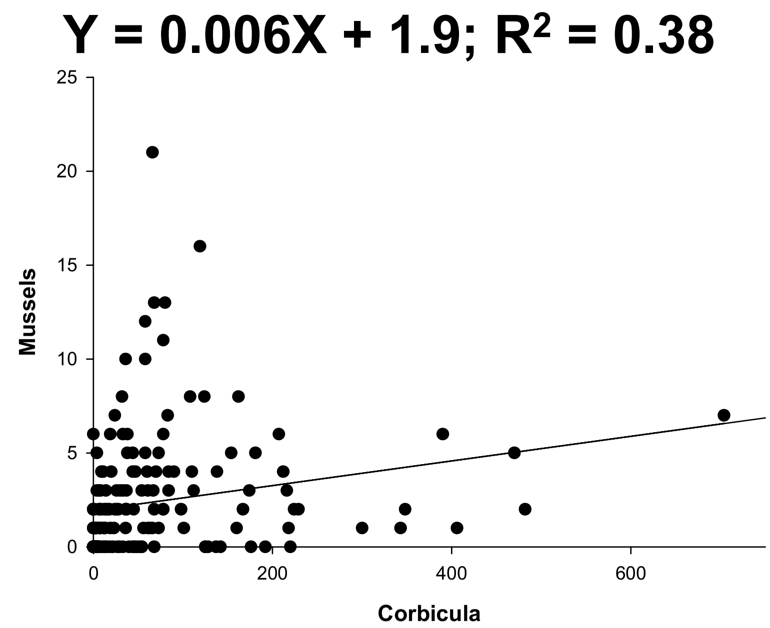
Within site variation – up to downriver

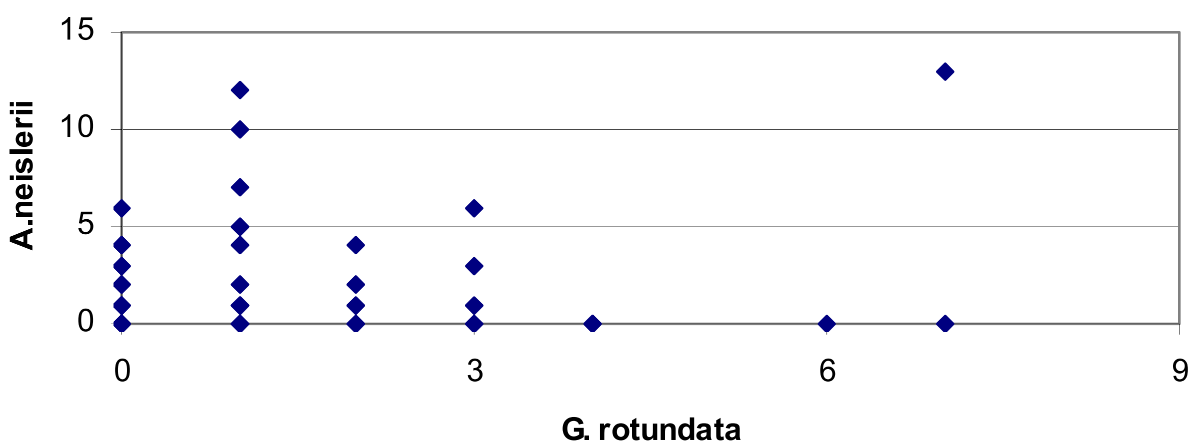


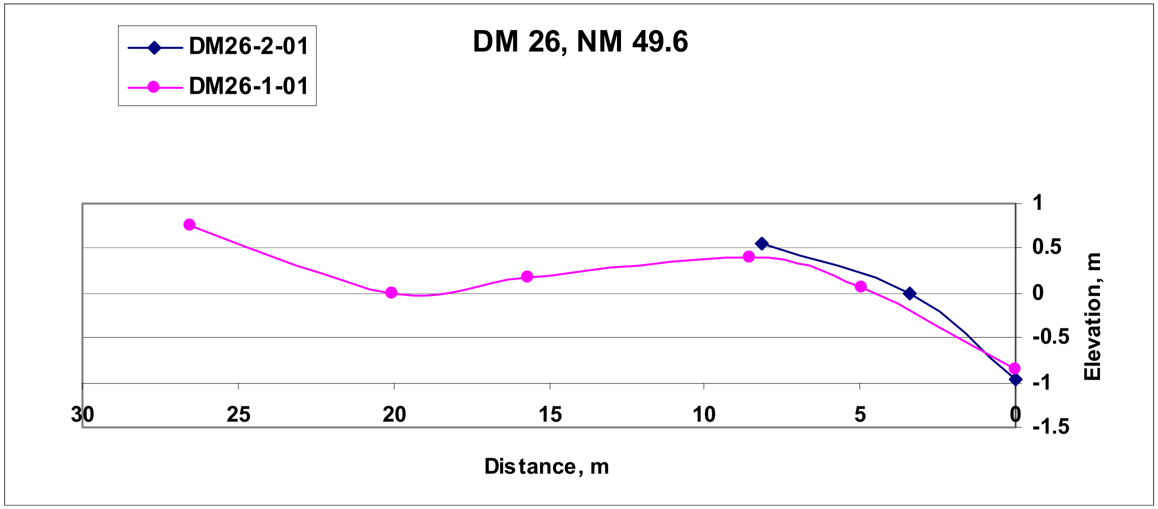
Within site variation – near to farshore

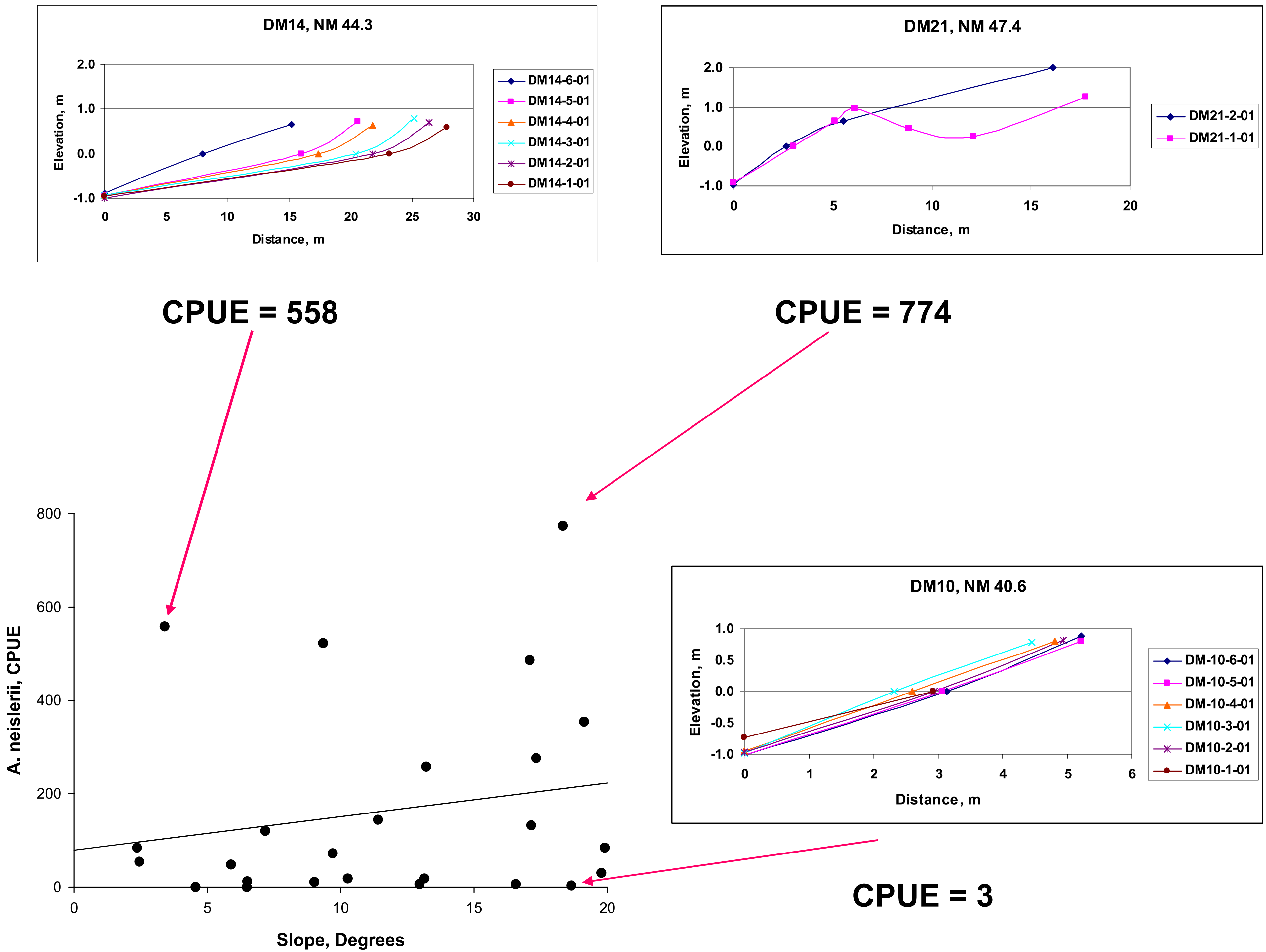
Year	River	State	Density
1998	Upper Mississippi	IA	333.2
1993	**Big Sunflower, Lock & Dam**	**MS**	**235.0**
1990	Lower Tennessee	KY	128.0
1997	Lower Ohio	IL	40.4
1993	Upper Ohio	WV	13.4
1993	**Big Sunflower, RM 71.4**	**MS**	**8.0**
2001	Upper Mississippi	IA	4.2
1992	Green	KY	3.3
1993	**Big Sunflower, RM 68.4**	**MS**	**1.3**


Y= 0.5X – 0.335; R2 = 0.68
A. neislerii
Mussels
0
2
4
6
8
10
12
14


Y = 0.006X + 1.9; R2 = 0.38
Mussels
Corbicula
0
5
10
15
20
25
200
400
600


A.neislerii
G. rotundata
0
5
10
15
3
6
9


DM 26, NM 49.6
DM26-2-01
DM26-1-01
Elevation, m
1
0.5
0
-0.5
-1
-1.5
30
25
20
15
10
5
0
Distance, m


DM14, NM 44.3
Elevation, m
Distance, m
DM14-6-01
DM14-5-01
DM14-4-01
DM14-3-01
DM14-2-01
DM14-1-01
DM21, NM 47.4
Elevation, m
Distance, m
DM21-2-01
DM21-1-01
CPUE = 558
CPUE = 774
DM10, NM 40.6
Elevation, m
Distance, m
DM-10-6-01
DM-10-5-01
DM-10-4-01
DM10-3-01
DM10-2-01
DM10-1-01
A. neislerii, CPUE
Slope, Degrees
CPUE = 3

Amblema neislerii in the Apalachicola River

- *A. neislerii* is much more common in Apalachicola River than previously thought
- Most abundant in moderately depositional areas
- Ample evidence of recent recruitment
- Considerable mortality in 2006 and 2007; however, dense populations still survive—Sedimentation and low water are natural phenomena
- Swift Slough should not be considered a source or sink for *A. neislerii* – A moot point since there are no mussels in Swift Slough

Major Findings

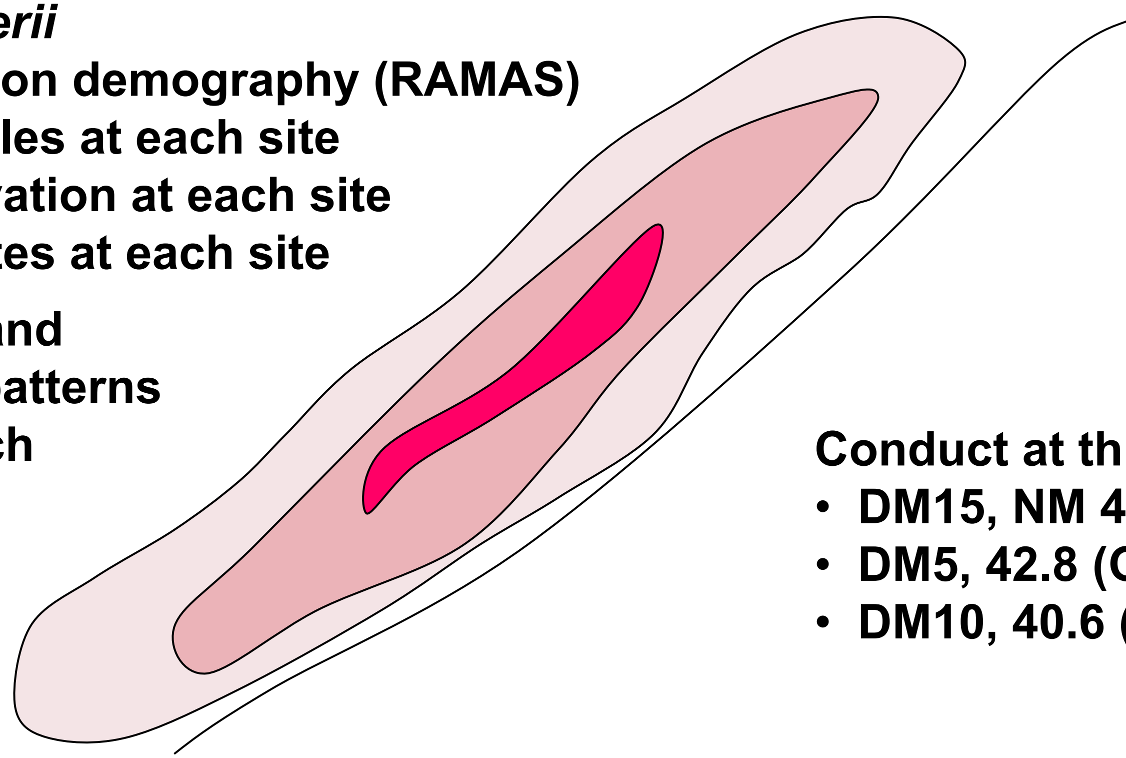
- **Swift Slough**
  - **Maximum CPUE: 228**
  - **Density: 0.0 – 4.4/m^2**
  - **19.8% abundance**
- **Apalachicola River, NM 40 - 50**
  - **CPUE: 0.0 -774**
  - **Density: 0.2 – 12.7/m^2**
  - **37 % abundance**

I – Detailed monitoring at <u>three</u> locations

Relate sedimentation and velocity patterns at a Site to A. neislerii distribution and abundance

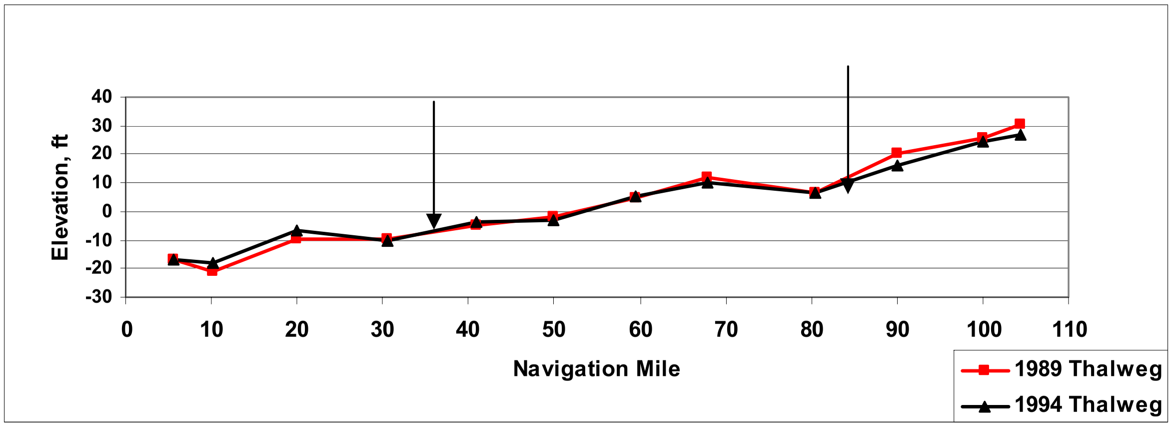
- **Reconnaissance to map bed**
- **Identify 6 – 10 permanent sites**
- **~ 10 quantitative samples/site**
- **30 min search/site**
- **Measure & mark demographically complete set of *A. neislerii***
- **Model population demography (RAMAS)**
  Sediment samples at each site
- **Depth and elevation at each site**
- **GPS Coordinates at each site**

Model velocity and sedimentation patterns in this river reach

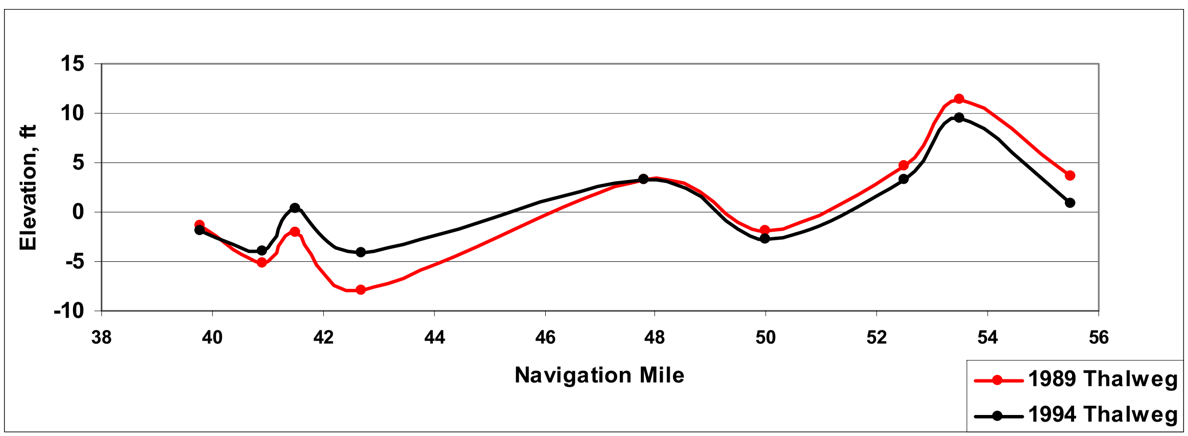


Conduct at three locations
- **DM15, NM 43.9 (Very good)**
- **DM5, 42.8 (Good)**
- **DM10, 40.6 (Poor**

II – Assess effects of scale by biotic and modeling physical studies in selected river reaches



Also—
Good quality mussel aggregations at NM 30 & 73.3



Understand importance of large and small scale physical effects on density & distribution of mussels…..

Summary of Findings

Cursory Geomorphologic Evaluation of the Apalachicola River in Support of the Jim Woodruff Dam Interim Operations Plan

David S. Biedenharn, Ph.D, PE
Biedenharn Group, LLC
August 14, 2007

1. Purpose of Study

A final Biological Opinion (BO) for the Jim Woodruff Dam Interim Operations Plan (IOP) was issued by the U.S. Fish and Wildlife Service (USFWS), Panama City Field Office on 5 September 2006. The BO included five reasonable and prudent measures (RPMs) for further limiting the amount of incidental take associated with water management operations at Jim Woodruff Dam. This current study was undertaken under RPM4, sediment dynamics and channel morphology evaluation. RPM4 was intended to improve the understanding of the channel morphology and the dynamic nature of the Apalachicola River. The objectives of the current study was to provide a cursory fluvial geomorphologic evaluation of the Apalachicola River below Jim Woodruff Dam for the purposes of providing professional opinions regarding trends (especially trends that could impact listed mussels) and potential remedial actions to reduce impacts to mussels. The effort consisted of a two day field trip (June 2007) along the Apalachicola River followed by a limited analysis based on the field observations and review of existing studies and data.

2. Background

The Apalachicola River reflects an integration of natural river processes coupled with various anthropogenic factors. Sorting out the relative contribution of the factors is often a challenge in complex river systems such as the Apalachicola River. A complete listing of alterations to the Apalachicola River is not provided here, but some of the more recent activities are discussed. The modern navigation project began with the construction of the Jim Woodruff Dam (RM) 107) in 1957. Between 1957 and 1971, the U.S. Army Corps of Engineers constructed numerous training structures, and several channel cutoffs. Additional cutoffs were constructed in the 1960's and rock removal in the upper river channel was completed in the 1980's. After about 1971, the major operations on the river consisted of maintenance dredging to maintain the navigation channel. Dredge material is generally placed within-banks in depositional areas such as on point bars. Dredging was stopped in the 2000 timeframe.

Channel degradation is the typical response downstream of a dam due to the retention of bed material sized sediment. However, the channel response to dam construction is highly variable and is a function of both the sediment retention and the altered outflows from the dam. Typically, reservoirs reduce downstream flood flows and increase low flows. The magnitude of these changes is site specific and depends on the manner of operation of the dam. Reduced flood peaks and reduced bed material loads may have somewhat of a compensating effect on downstream morphology. If the reduction in flood peaks is large, then the amount of degradation due to the retention of bed material may be lessened. Conversely, if the dam does not alter the flow regime significantly, then the effects of the bed material retention may be more pronounced.

3. Channel Characteristics

In a detailed geomorphic study, the river system is typically divided into a series of geomorphically similar reaches based on changes in slope, tributary location, geologic outcrops, sediment sources, planform changes, etc. For this cursory geomorphic study, the river was only divided into three broad areas. Reach 1 extends from the dam to about RM 78 near Blountstown. Reach 2 extends from RM 78 to RM 35 near the confluence with the Styx River. Reach 3 extends from RM 35 to RM 0. A brief discussion of these reaches follows.

Reach 1. Reach 1 is a fairly straight reach with an average sinuosity of about 1.3. The limestone outcrops of the Chatahoochee Formation occur frequently in this reach and were observed on the boat trip as far downstream as about RM 92. In fact, rock outcrops between RM 95 and 101.8 were removed in the 1960s and 1980s to provide more satisfactory navigation depths (Odom, 1966; Joanne Brandt pers. Comm.). The reach is also bounded by the Alum Bluffs and the Citronelle Formation. Based on the June 2007 field investigation, there does not appear to be a significant amount of sediment stored within the channel boundaries in this reach, which may reflect the impacts of the dam. Near the lower end of the reach the river encounters the Alum Bluffs at two locations (RM 84.5 and 81). These are very high (greater than 30 feet) bluffs consisting of a mix of sands and cohesive materials. These two locations represent the first major sand source observed downstream of the dam.

Valley slope was measured for all three reaches from topo maps. The sinuosity was calculated as the length of the reach measured along the channel divided by the straight line length of the reach. The channel slope was calculated by dividing the valley slope by the sinuosity. The results are shown in Table 1. As shown in Table 1, Reach 1 is fairly straight with a sinuosity of about 1.3 and a valley slope and channel slope of about 0.00012 and 0.000093, respectively.

Table 1. Valley slope, channel slope and sinuosity for the three reaches of the Apalachicola River.

REACH	Valley Slope	Channel Slope	Sinuosity
Reach 1 (RM 106 – 78)	0.00012	0.000093	1.3
Reach 2 (RM 78 – 35)	0.00018	0.000094	1.9
Reach 3 (RM 35 – 0)	0.00012	0.000095	1.3

A comparison of the pre and post dam flow duration curves indicates that there has not been a significant impact on the flow regime downstream of the dam. Since the hydrology is not significantly impacted by the dam, the primary impact of the dam would be the trapping of bed material. Following the construction of Jim Woodruff Dam in 1957, the channel immediately downstream began to degrade. It is possible that the amount of degradation immediately downstream of the dam may have been limited by the limestone outcrops in this area. Based on low water gage records from Light et al, (2006), stages at the Chattahoochee gage had dropped about 3.6 feet by the mid 1960s (Figure 1). Stages then stabilized until about 1980 when another foot of lowering occurred. According to Mobile District personnel, there was a series of rock removal in the early to mid 1980's that may be responsible for this additional lowering. Since that time, stages have remained fairly stable with maybe a very slight downward trend. At the downstream end of the reach near Blountstown, the gage records indicate that that low water stages had dropped about 1.9 feet by about 1970. Since the early 1970s, the low water stage levels have remained fairly constant. A comparative thalweg plot from Lidstone and Anderson (1989) also indicates about 3 to 4 feet of lowering in this reach between 1960 and the early 1980s (Figure 2). The plot of mean bed elevation of the low flow channel for 1961 and 2001 also illustrates the bed lowering in this reach (Figure 3).

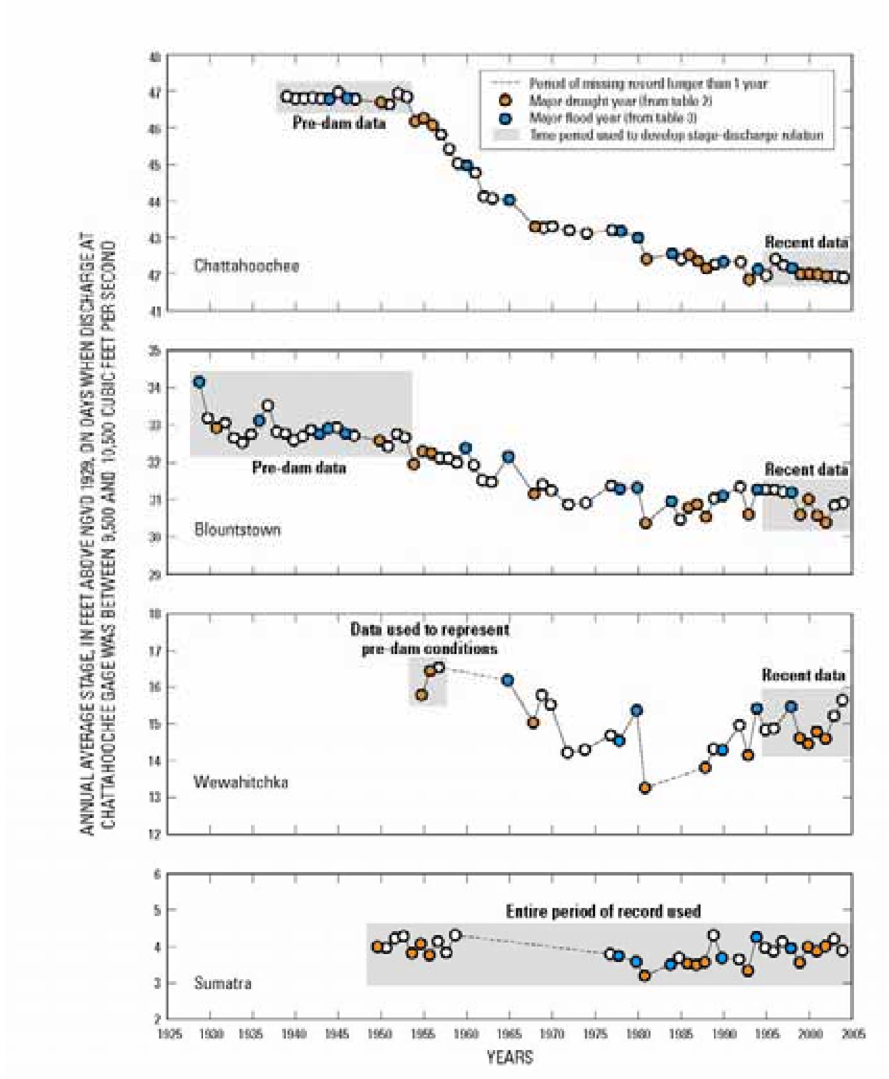


Figure 1. Gage changes at low water along the Apalachicola River downstream of Jim Woodruff Dam (from Light et al, 2006).

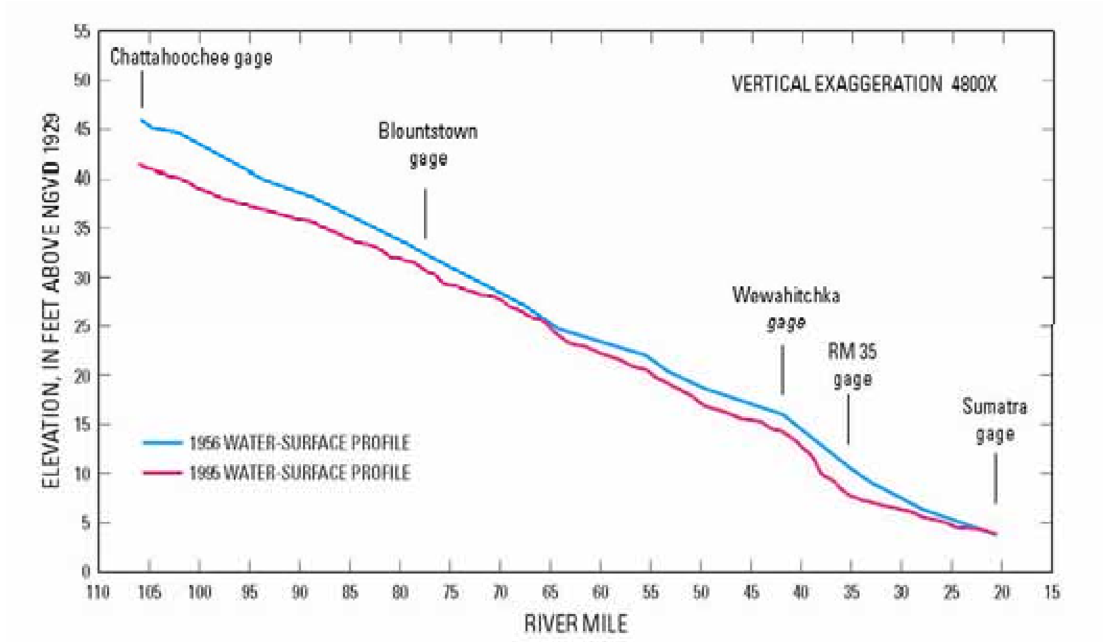


Figure 2. Water surface profiles along the Apalachicola River for the 1956 and 1995 time periods (from Light et al, 2006).

The streambanks in this reach are composed primarily of cohesive materials and bank erosion appears to be minimal throughout most of this reach based on the June 2007 field trip. A cursory examination of the bankline overlays for the periods 1941, 1963, 1993, 1999, and 2002 seems to confirm that there has not been any significant systematic channel widening throughout this reach. One factor that may contribute to the bank stability, particularly in the upper portions of this reach is the present of limestone. In many locations the limestone was observed to extend several feet up the banks, thus, providing protection of the bank toe. In contrast to these observations of stability, is the comparison of channel widths between 1941 and 2004 that was provided by the Mobile District. These data were developed from a USGS GIS system and were based on treeline measurements. According to these measurements, the channel in this reach has widened from an average of about 708 feet in 1941 to about 761 feet in 2004, or about 7%.

Reach 2. The character of the stream changes dramatically in Reach 2. Below Blountstown, the channel becomes much more sinuous with an average sinuosity of about 1.9 (Table 1). The streambanks in this reach are typically a mix of sands and cohesive materials, and active bank erosion was observed throughout this reach along the outside of the meander bends. Erosion of these streambanks is a source of sediment for the river system. The point bars in this reach are much larger than in the reach upstream. The exception to this is the sub-reach between about RM 70 and 64, where the point bars do not appear to be as large as upstream or downstream. These lower point bars may reflect the lower sinuosity, longer radius bends, more cohesive bank material, and reduced sediment supply in this reach. At about RM 64 the channel encounters a high bluff which is a significant sediment source. The reach downstream of this bluff is one of the most sinuous in the river. This high sinuosity may reflect the steeper valley slope (0.00018) in this reach. The average channel slope is about 0.000094 which is almost identical to the slopes in Reaches 1 and 3 (Table 1).

Comparison of water surface profiles between 1956 and 1995 (Figure 2) suggest that there has been some minor lowering down to about RM 20. The gage at Wewahitchka indicates that the low water stages may have dropped by about 2 feet by the mid 1970s, but have since rebounded about a foot or more. The comparison of thalweg plots for 1960, 1981, and 1984 (Lidstone and Anderson 1989) shows localized areas of scour and fill but no systematic lowering (Figure 3). The mean bed elevation comparison between 1961 and 2001 indicates that there may have been some slight lowering in the upper part of this reach, but overall, it appears that the reach has experienced localized areas of scour and fill (Figure 4). Thus, it appears that most of the dam induced degradation may have been limited to Reach 1.

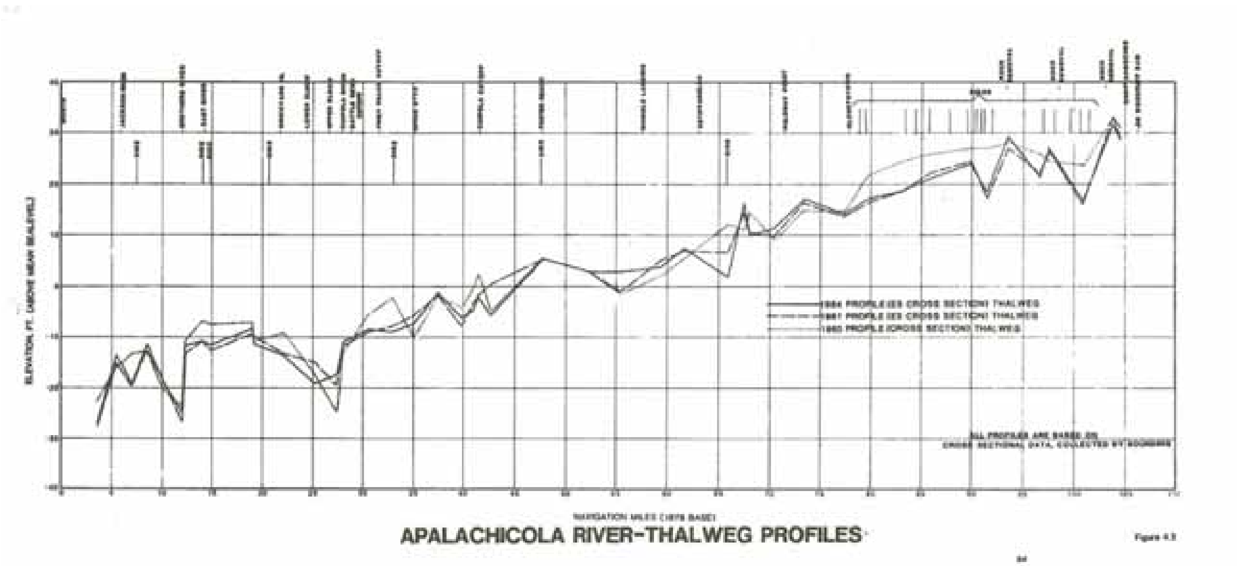


Figure 3. Thalweg comparisons for 1960, 1981 and 1984 (from Lidestone and Anderson (1989)

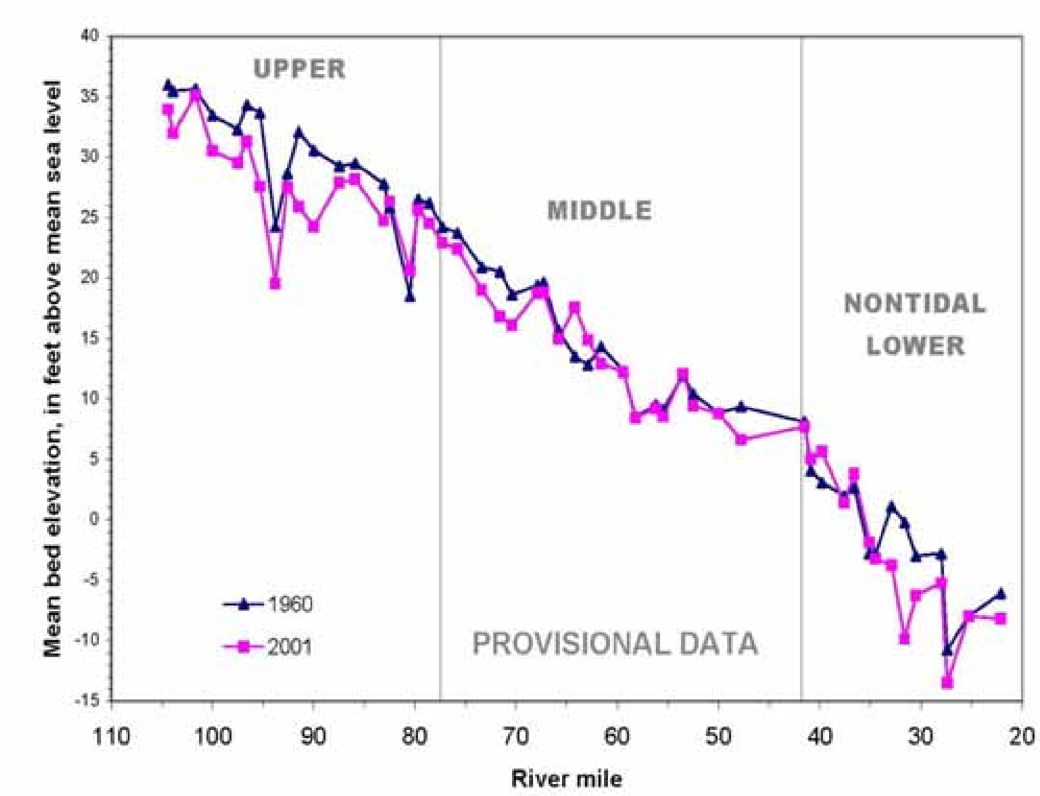


Figure 4. Mean bed elevation for low flows (USGS data provided by U.S. Army Corps of Engineers, Mobile District.

The Chipola Cutoff occurs in this reach at about RM 41.6. According to Mobile District records, the percent of flow entering the Chipola Cutoff has increased from about 25% to 34% over the past 20 years or so. The explanation for this increasing diversion percentage is not clear at this time. A cursory examination of aerial photography suggest that there is very little sediment in the Chipola channel, which would suggest that there is very little sediment being diverted into this system. This lack of sediment being diverted coupled with a 34% reduction in discharge may partially explain why the reach between the Chipola Cutoff and RM 35 has been one of the most frequently dredged areas on the river.

A plot of erosion rate versus the radius of curvature to width ratio (R/W) was developed and examined. The relationship between erosion rate and R/W was similar to most other meandering rivers. However, the erosion rates were quite low, generally less than about 4 feet per year, which is low compared to many large river systems. For instances, average erosion rates on the Red River in Louisiana and Arkansas range from about 25 ft/year to over 150 ft/year (Biedenharn et al, 1989). As expected the maximum erosion rates (between about 6 and 10 feet per year) occurred in the meander bends where the R/W was between about 1 and 3. The maximum erosion rate bends were all located in Reach 2. The field investigation confirmed that this is a very active reach with bank erosion being observed at most all meander bends. This erosion appears to be part of the natural down-valley meander migration which is common to most meandering streams, and does not appear to be the result of some system-wide adjustments such as degradation, aggradation, or channel widening. However, the comparison of the 1941 and 2004 channel widths in this reach indicate that the channel is much wider today than prior to the dam (Figure 4). In fact, the reach between RM 69 and 77 was reported to have increased on average by 143 feet, or 21%. The reach between RM 35 and 40 apparently increased about 171 feet, or a 51% increase. These are significant width increases when one considers that this reach has experienced only minimal bed lowering (less than 2 feet) and that the hydrology has not been significantly altered. Consequently, these width increases should be investigated in more detail to determine if these increases are real, and if so, what are the driving factors responsible for them.

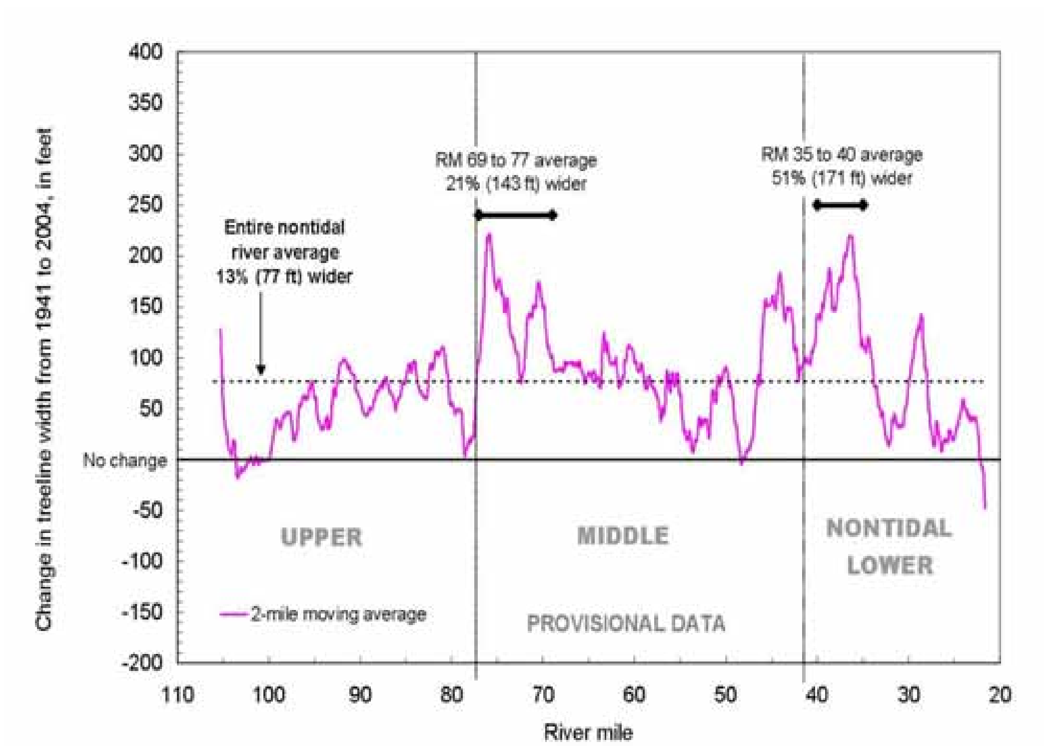


Figure 4. Changes in treeline width of main channel of the non-tidal portion of the Apalachicola River.

Based on data from Dr. Drew Miller, the highest mussel counts occur in the reach between about RM 43 (Florida River confluence) and 47.5. The highest mortality sites from 2006 also occur in this reach at RM 44, and 43.6, and in Swift Slough at RM 40.2.

Reach 3. Although Reach 3 encompasses the entire river below RM 35, the study focused primarily on the non-tidal zone down to about RM 20. The channel morphology changes dramatically downstream of the Styx River confluence (RM 35). The valley slope flattens to about 0.00012, and the channel becomes much less sinuous (sinuosity about 1.3). The channel slope through this reach is about 0.000095 (Table 1). The field investigation indicated that there was much less bank instability in this reach than in Reach 2.

The comparison of water surface profiles between 1956 and 1995 (Figure 2) indicate that there may have been a couple of feet of bed lowering in this reach. The mean bed elevation comparison (Figure 4) also shows that there was some local bed lowering between about RM 28 and 34, with localized scour and fill occurring throughout the other parts of the reach. The comparative thalweg plots from Lidstone and Anderson (Figure 3) also showed similar patterns. The exact cause of this localized lowering between RM 28 and 34 is not known, but it may be in response to some of the local meander cutoffs that were constructed in this reach.

The lowest known mussel site is in this reach at about RM 21.5 in the vicinity of the Brickyard Island.

4. Mussel Habitat.

A significant component of the June field investigation was the opportunity to learn about the preferred habitat of the Fat Three Ridge Mussel. It appears that the preferred habitat is in the lower energy environments such as occur in the flow separation zones (eddies) at the upstream and downstream transitions between meander bends. During the boat trip there was considerable discussion about the recent loss of some of these habitat areas and the stranding of mussels. A characteristic of meandering rivers such as the Apalachicola River is that they are continually changing in space and time. The size and location of the eddie zones change with flow and through time as the meanders migrate though the floodplain. This dynamic behavior is illustrated by examining the bankline overlays from 1941, 1963, 1993, 1999, and 2002. It is important to remember is that as the river meanders through the system, eddies may be destroyed at one location, but are being created at another. Consequently, the mussel habitat areas are constantly being destroyed and created and will vary with space and time. The question is whether there is a net increase or decrease in mussel habitat or is it in some sort of dynamic equilibrium. A more detailed analysis would be needed to answer this question.

The mortality site at RM 44.3 is a good example of mussel habitat being impacted by the natural processes in the river. At this location, an area that provided good habitat a year or so ago became depositional this past year, stranding many mussels. One explanation for this might be that the channel is experiencing some sort of systematic change in its morphology. However, upon closer examination, it became clear that this situation occurred as part of the natural meandering process of the river as the channel migrates downvalley. The mortality site at RM 43.6 also appears to be a result of the natural meander process.

Another area of concern was the mussel strandings in Swift Slough. Swift Slough is a distributary stream that diverts off the river at RM 40.2. According to Jerry Ziewitz (personal communication), Swift Slough was a perennial stream that was disconnected for the first time in July 2006. During the field investigation we were able to walk several hundred yards down Swift Slough. The channel is currently clogged with sand. The depth of sand in the channel was determined, by probing, to be over 4 feet in depth. It appears that during high flows there is a considerably amount of sediment that is delivered from the Apalachicola River into Swift Slough. A sand bar located near the entrance to Swift Slough may be a source of the sand that is entering the slough. The location of this bar may have been further upstream a few years ago, and may have only recently moved into the Swift Slough entrance location as this meander bend migrates down-valley. It is also possible that prior to about 2000, this bar may have been routinely removed by maintenance dredging (Terry Jangular, personal communication). At this time, there is insufficient information to develop a complete understanding of these processes. A more detailed investigation of this site is warranted.

5. Conclusions.

A summary of conclusions based on the cursory geomorphologic study is presented. The conclusions are divided into morphological and biological categories.

Morphology

1) The flow regime (based on pre-and post-dam flow duration curves) downstream of Jim Woodruff Dam has not been changed significantly between the pre- and post-dam periods.
2) The primary impact of Jim Woodruff Dam on the downstream channel appears to be the trapping of bed material sized sediments.
3) The amount of bed material that is transported through Jim Woodruff Dam is not known.
4) Other alterations impacting the Apalachicola River include localized meander cutoffs, distributary flows, channel training structures, maintenance dredging, and the cessation of maintenance dredging in the 2000 timeframe.
5) The degradational response due to the dam appears to extend downstream to about RM 77 near Blountstown. About 4 to 5 feet of lowering has occurred in this reach. Some of this lowering (perhaps one foot) may have been the result of rock removal from the bed in the early 1980's.
6) Reach 1 (Dam to RM 78) is a relatively straight reach with little sediment stored in the channel, and is controlled in places by local geologic outcrops of limestone.
7) The streambanks in Reach 1 are predominately composed of cohesive material and bank erosion and channel widening is minimal.
8) The dike fields in Reach 1 do not contain significant amounts of sediment.
9) The river in Reach 2 (RM 78 to RM 35) downstream of Blountstown is a much more active meandering channel with a high sinuosity (sinuosity =1.9).

10) Low water gage records and water surface profiles indicate that the channel between Blountstown and RM 20 has experienced about 1 to 2 feet of lowering. However, comparative thalweg plots between 1960 and the early 1980s indicate that the channel has experienced localized areas of scour and fill.
11) There is considerable sediment storage in Reach 2 as evidenced by the large point bars.
12) Reach 2 has the largest erosion rates on the river. This erosion appears to be part of the natural down-valley meander migration which is common to most meandering streams, and does not appear to be the result of some system-wide adjustments such as degradation, aggradation, or channel widening.
13) The channel between the Chipola Cutoff and RM 35 has been one of the most frequently dredged areas on the river. It appears that little sediment is diverted into the Chipola Cutoff, which might be a partial explanation for the frequent dredging just downstream.
14) The processes responsible for the apparent increase in the percent of flow (25% to 34%) diverted at the Chipola Cutoff warrants further study.
15) The effects of the cessation of dredging in the 2000 timeframe on the morphology of the channel warrants further study
16) Comparison of the 1941 and 2004 channel widths by USGS indicated that channel widening throughout the river down to RM 20. Further analysis is needed to determine if these width increases are real, and if so, what are the factors responsible for them.
17) The river downstream of the River Styx (RM 35) has a lower sinuosity (1.3) and less bank erosion.
18) Local meander cutoffs downstream of the River Styx may be responsible for some of the bed lowering in this area.

Biological Impacts

1) Preferred mussel habitat appears to occur in the lower energy environments associated with the flow separation zones (eddies) in the transition between meander bends
2) The size and location of the eddie zones change with flow and through time as the meanders migrate though the floodplain
3) Reach 2 contains some of the highest mussels counts on the river
4) Eddies, and consequently mussel habitat, are constantly being destroyed and created through the natural process of meander migration
5) The mussel mortality sites at RM 44.3 and RM 43.6 appear to be the result of the natural migration of the channel and not some systematic channel changes.

6) The mussel stranding in Swift Slough appears to be the result of deposition of sands from the river. It appears that a sand bar has moved to the entrance to the Swift Slough and may be the source of the sediment. However, a more detailed analysis of this area is needed to establish the exact processes responsible for this situation.

6. Recommendations

The conclusions from this cursory geomorphic study should be considered as preliminary due to the limited nature of the study. Although this cursory investigation did provide considerable insight into many of the morphologic processes occurring on the Apalachicola River, there are still many issues that need to be explored in further detail. A key example is the lack of understanding about exactly what processes are responsible for the apparent width increases that have occurred along the river. In order to develop a better understanding of the system, I would recommend a more detailed study be conducted. I could envisage some sort of a three tiered approach. The first tier would be an eco-geomorphic assessment of the system to fully develop how the system has responded in the past and where it is today with emphasis on the connection between the morphology and mussel habitat. I think this would go a long way towards developing a clearer understanding of these complex processes. The next tier would be relatively simple 1D sediment continuity model of the river. This would provide the big picture assessment of the entire river system below Jim Woodruff dam with respect to sediment continuity, channel stability, impacts of flow diversions, etc. I think the SIAM (Sediment Impact Analysis Methods) model might be a good candidate model for this. The third tier might be a 2D hydrodynamic model for selected reaches. Once again the key would be linking these detailed hydrodynamic processes to the mussel assemblages.

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Cursory Fluvial Geomorphic Evaluation of the Apalachicola River in Support of the Jim Woodruff Dam Interim Operations Plan: Summary of Findings

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1. INTRODUCTION

A final Biological Opinion (BO) for the Jim Woodruff Dam Interim Operations Plan (IOP) was issued by the U.S. Fish and Wildlife Service (USFWS) on September 5, 2006. The BO included five reasonable and prudent measures (RPM) for further limiting the amount of incidental take associated with water management operations at Jim Woodruff Dam at the head of the Apalachicola River. RPM4 of the BO, that is the subject of this memorandum, required an evaluation of the sediment dynamics and channel morphology trends in the Apalachicola River in order to improve the understanding of the dynamic channel conditions and how listed mussels (fat threeridge, *Amblema neislerii*; purple bankclimber, *Elliptoidus sloatianus*; Chipola slabshell, *Elipto chipolaensis*) are affected by the IOP. The goals of the evaluation were to:

1. Identify feasible water and/or habitat management actions that would minimize listed mussel mortality

2. Identify current patterns and trends in morphological changes, and

3. Identify additional information needed, if any, to predict morphological changes that may affect the listed mussels.

This evaluation, that was conducted for the Mobile District, U.S. Army Corps of Engineers (Corps), was based on available information, a 2-day boat-based inspection of the river from Jim Woodruff Dam at River Mile (RM) 106.5 to the mouth of the river at the City of Apalachicola (June 19 and 20, 2007) at RM 0 and best professional judgment. The 2-day field inspection was conducted in the company of mussel experts (Mr. Jerry Ziewitz, USFWS, Dr. Drew Miller, Ecological Applications, Inc. and Mr. Brian Zettle, Corps) and engineers from the Corps with extensive knowledge and experience of Corps operations on the river (Mr. Bill Stubblefield, P.E. and Mr. Terry Jangula, P.E.). The field inspection was focused on the non-tidal reach of the river that extended from the dam (RM 106.5) to RM 20 at the Sumatra gage (**Figure 1**).

Documents that were provided by the Corps and that were reviewed for this evaluation included:

- Apalachicola-Chattahoochee-Flint (ACF)1996 Annual Maintenance 5-year Report, Main Report, Mobile District, Corps of Engineers.

- ACF 1996 Annual Maintenance 5-Year Report Appendix, Mobile District, Corps of Engineers.

- ACF 2001 Annual Maintenance 5-Year Report, Mobile District, Corps of Engineers.

- ACF Navigation Maintenance Plan V1, Mobile District, Corps of Engineers.

- ACF Navigation Maintenance Plan V2, Mobile District, Corps of Engineers.

- ACF JWD IOP Biological Opinion Final Corrected prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, September 5, 2006.

- USGS: (Darst and Light, 2007) Drying of Floodplain Forests Associated with Water-Level Decline in the Apalachicola River, Florida – Interim Results, 2006, Open File Report 2007-1019.

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- USGS: Excerpts from an anonymous and un-dated document on Apalachicola River Channel Widening 2006.

- USGS: Smith and Vincent, 2004. Understanding the Physical Processes of the Apalachicola River and Floodplain: Preliminary Comments and Suggested Additional Analyses, February 3, 2004.

Additionally, the Corps provided ArcView files of banklines from 1941, 1963, 1993, 1999 and 2002 as well as other files that identified dredge material disposal sites, and the locations of recent mussel surveys.

Other documents reviewed for this evaluation included the literature on downstream effects of dams on alluvial rivers (Williams and Wolman, 1984; Ligon et al., 1995), the effects of active tectonics on alluvial rivers (Schumm et al., 2000) and the geology of Florida (Florida Geological Survey).

1.1. Background

The Apalachicola River formed by the confluence of the Chattahoochee and Flint Rivers (drainage area of about 17,600 mi^2) (**Figure 2**) has been modified anthropogenically since the 1800's (Light et al., 2006). Jim Woodruff Dam (Lake Seminole) at RM 106.5 was constructed between 1950 and 1954 and filled by 1957 (Odom, 1966). It is operated as a run-of-the river structure, and its primary influence on the downstream river is to limit the downstream sediment supply. Upstream from Jim Woodruff Dam are a further 15 mainstem dams on the Chattahoochee (13) and Flint (2) Rivers that also cause a reduction in the bed material sediment supply to the Apalachicola River. Hydrologic analysis of the streamflows at the Chattahoochee gage (1929-2004) indicate that the average annual discharge appears to be relatively unchanged in the post-dam period, but minimum flows have decreased and the seasonal distribution of flows have changed with higher fall and winter flows and lower spring and summer flows (Light et al., 2006). Hydrologic changes have not been attributed to the operation of Jim Woodruff Dam, and since 2000 a minimum flow of 5,000 cfs has been maintained by reservoir releases (Light et al., 2006). The average annual discharge at the Chattahoochee gage is 21,900 cfs, and the median flow is 15,900 cfs. Review of the peak flow record at the gage indicates that 7 of the 10 largest flows in the period of record (1920-2006) have occurred in the post-dam period (**Figure 3**).

Various navigation improvement projects have been implemented on the Apalachicola River since the 1800's, including construction of the Congressionally Authorized 9-foot by 100-foot navigation channel in 1953. Attempts to maintain the navigation channel by dredging alone were unsuccessful (Odom, 1966), and river training dikes were installed between 1963 and 1970 mainly upstream of RM 78 (USACE, 1968). Dredge material disposal was initially out-of-channel, but subsequently in-channel disposal was utilized. The last time there was significant dredging of the river was in 1999, and no dredging has been conducted since 2001 (Terry Jangula, Corps, personal communication). As part of the dredging operations snagging of woody debris from the channel was also conducted. Meander cutoffs were implemented for navigation purposes at RM 35.5, RM 36.5, RM 31.5 and RM 29 (Battle Bend) and RM 71.5 (Lower Poloway). Limestone outcrop in the bed of the river at RM 99.5 and RM 101.8 was removed in the 1950's to provide more satisfactory navigation depths (Odom, 1966), and it was again removed in the upper river reaches in the 1980s to improve navigation depths (Joanne Brandt, Corps, personal communication).

2. EXISTING CONDITIONS

In general terms, the Apalachicola River is a low gradient (S=0.00009), alluvial, meandering river with an average sinuosity of 1.44 in the non-tidal reach (Light et al., 2006). The river is located within the Gulf Coast Plain Physiographic province. From Chattahoochee to Blountstown (Upper Reach) the river forms the boundary between the rolling topography of the Tallahassee Hills on the east, and the Mariana Lowlands to the west and the width of the meanderbelt is somewhat constrained by the bounding hills (Figure 1). From Blountstown to the Gulf the river flows through the Coastal Lowlands, and has a much wider meanderbelt.

The non-tidal reach of the Apalachicola River (RM 106 to RM 20) has previously been subdivided into 3 subreaches (Light et al., 2006) and these subreach designations are utilized in this report (Figure 1):

1. Upper Reach (RM 106 – RM 78) (Jim Woodruff Dam to Blountstown)
2. Middle Reach (RM 78 –RM 42) (Blountstown to Chipola Cutoff/ Wewahitchka gage)
3. Lower Reach (RM 42 – RM 20 (Chipola Cutoff/Wewahitchka gage to Sumatra gage)

2.1. Upper Reach

The Upper Reach extends from Jim Woodruff Dam (RM 106) to Blountstown (RM 78), a distance of 28 river miles. The valley floor slope in the reach is 0.00012, the channel slope is 0.000093 and the sinuosity is 1.3. In general terms, the river in this subreach is relatively straight, the banks are composed of cohesive, relatively erosion resistant materials, and the bed materials are composed of coarse sands, gravels and limestone outcrop (Chattahoochee Fm). Historically, the bed material in the reach was composed of poorly graded fine to medium sand ranging in size from 0.3 to 0.7 mm (Odom, 1966). As a result of dam construction, and possibly the effects of dredging and installation of the dikes, the river bed has degraded by about 5 feet near the dam and by about 2 feet at Blountstown (Light et al., 2006) (**Figure 4**), and the bed material has coarsened, both of which are river responses that are consistent with dam emplacement (Williams and Wolman, 1984: Ligon et al., 1995). It is conceivable that the amount of bed degradation would have been greater if the limestone outcrop was not present in the bed of the river at a number of locations through the subreach, and this could have led to accelerated mass bank failure of the relatively cohesive bank materials. USGS measurements of tree-line width of the main channel from aerial photography in 1941 and 2004 suggest that the mean width of the channel in this subreach has increased from 708 to 761 feet (53 feet), an increase of about 7.5 percent (**Figure 5**). Given the uncertainty associated with these measurements (Smith and Vincent, 2004) and the extensive presence of dredge material disposal sites within the reach that limit vegetation recovery, it is unclear whether the river has actually widened in this reach in the post-dam period. Field observations do not indicate that both channel banks are eroding along the reach, rather the bank erosion is currently limited to the outside of bends, which is to be expected. Comparative bank lines (1941, 1963, 1993, 1999, 2002) do not indicate much lateral adjustment of the channel in the reach.

Very little sediment appears to be stored within the subreach, except in the reach between RM 77.2 and RM 78.8, where annual dredging has been required downstream of two eroding bluffs located at RM 81 and RM 84 (Terry Jangula, personal communication). The bluffs are composed of the relatively erodible sandy Alum Bluff Group sediments that are overlain by unconsolidated to partly consolidated sands of the Citronelle Fm. Sediment supply to the reach downstream of the dam is limited to delivery by the tributaries that drain the Tallahassee Hills, local bank erosion and erosion of the bluffs. The observed bed degradation and the limited amount of sediment stored in the numerous dike fields in the reach indicate that the reach in general was supply limited following construction of the Jim Woodruff Dam.

2.2. Middle Reach

The Middle Reach extends from Blountstown (RM 78) to the Chipola Cutoff/ Wewahitchka gage area (RM 42), a distance of 36 river miles. The valley floor slope in the reach is 0.00018, the channel slope is 0.000094 and the sinuosity is 1.92. The river in this subreach is very sinuous and the banks are composed of a mixture of cohesive and noncohesive sediments that exhibit widespread erosion on the outside of the bends. The very high sinuosity of the river in the reach between RM 78 and RM 35 may well be the result of the river responding to active tectonics (Schumm et al., 2000). The axis of the northeast-southwest trending Gulf Trough geologic structure crosses the Apalachicola River near the confluence with the Chipola River at about RM 27 (**Figure 6**). The steeper valley floor (0.00018) on the down-dip side of the trough between about RM 78 and RM 35 requires the river sinuosity to be higher (1.92) to balance the river slope (0.000094) and thus the sediment continuity. Historically, the bed material in the reach was composed of relatively uniform sands that averaged 0.4 mm in size (Odom, 1966). As a result of dam construction, and possibly the effects of dredging the river bed has degraded by between 1 and 2 feet within the reach (Light et al., 2006), but there is no evidence that the bed material has coarsened. Sediment sources within the reach are primarily the eroding banks, many of which are composed of sands.

USGS measurements of tree-line width of the main channel from aerial photography in 1941 and 2004 indicate that the mean width of the channel in this subreach has increased from 596 to 689 feet (93 feet), an increase of about 16 percent (Figure 5). Given the uncertainty associated with these measurements (Smith and Vincent, 2004) and the extensive presence of dredge material disposal sites within the reach that limit vegetation recovery, it is unclear whether the river has actually widened in this reach in the post-dam period. Field observations do not indicate that both channel banks are currently eroding along the reach, rather the bank erosion is limited to the outside of bends, which is to be expected. Although channel widening could be a response to the upstream dams, in sand bed rivers the most likely response to the reduced sediment supply is bed degradation and not channel widening (Buchanan, 1985). Clearly, about 2 feet of bed degradation has occurred within the reach, but an increase in bank height of this magnitude (about 6 percent) is highly unlikely to cause bank stability thresholds to be exceeded and initiation of channel widening (Schumm et al., 1984; Harvey and Watson, 1986; Watson et al., 1988). However, the location of greatest channel widening (RM 78) is in an area where dredging has been required on an annual basis, and this aggradation could be the cause of localized channel widening. Additionally, the apparent widening in the reach between RM 43 and RM 46 (the “Hook and Bay” reach) is clearly due to the presence of unfilled portions of the laterally migrated 1941 channel. The lack of in-filling of the former channel locations could be due to a reduced upstream sediment supply in the post-dam period.

Comparative bank lines (1941, 1963, 1993, 1999, 2002) clearly indicate that the bends within the Middle subreach are migrating laterally as well as down-valley as a result of cutbank erosion and point bar deposition (Knighton, 1984). Analysis of bank erosion rates at banks opposite dredge disposal sites and without dredge disposal sites by the USACE did not indicate that the disposal sites were responsible for accelerated bank erosion rates. The analysis showed that the erosion rates were highest where the radii of curvature of the bends were smaller, and that the highest erosion rates were located in the reach between RM 40 and RM 60, which is the most sinuous portion of the river. The findings of the USACE study are totally consistent with the literature on erosion rates on meandering rivers (Nanson and Hickin, 1986; Harvey, 1989). Addition of the channel widths to the USACE radii of curvature and erosion rate data for the studied bends permits the Apalachicola River data to be compared with data from other rivers. The maximum erosion rates are associated with radius of curvature to channel width ratios (R/W) of between 1.5 and 2.5 (**Figure 7**), which is consistent with the trends reported in the geomorphic literature (Nanson and Hickin, 1986; Harvey, 1989). The maximum erosion rates (about 10 ft/yr) are consistent with those of the Alabama River (Harvey and Schumm, 1994), but are very low in comparison with those reported for other large alluvial rivers. The highest normalized erosion rates (erosion rate divided by channel width) on the Apalachicola River (**Figure 8**) are an order of magnitude lower than those reported for the Canadian rivers (0.14;

Nanson and Hickin, 1986) and the Sacramento River (0.26; Harvey, 1989). This does not suggest that the measured bank erosion on the Apalachicola River is in response to an upstream sediment deficit.

2.3. Lower Reach

The Lower reach extends from the Chipola Cutoff/ Wewahitchka gage area (RM 42) to the Sumatra gage at RM 20, a distance of 22 river miles (Figure 1). The valley floor slope in the upper portion of the subreach reach is 0.00018, the channel slope is 0.000086 and the sinuosity is 2.1. The upper portion of this subreach of the river (RM 42- RM 35) is very sinuous and the banks are composed of a mixture of cohesive and noncohesive sediments that exhibit widespread erosion on the outside of the bends that leads to active channel migration. As stated previously, this may well be the result of the river responding to active tectonics (Schumm et al., 2000). The high sinuosity in this part of the subreach could also be due to diversion of about 35 percent of the flow but not very much of the bed-material load into the Chipola Cutoff at RM 41.5 (Odom, 1966) which effectively increases the sediment supply to the subreach, which in turn accelerates the meander processes (Anthony and Harvey, 1991). Between RM 35 and RM 20 the sinuosity is much lower (1.27) and there is little evidence of channel migration. The lower valley floor slope (0.00012) on the up-slope side of the Gulf Trough syncline (downstream of the axis) is consistent with the presence of an active geologic structure (Figure 6). Comparative mean bed elevation data (1960 and 2001) suggest that the bed of the channel may have degraded between RM 29 and RM 35, possibly as a result of the cutting off of two bends in the reach. Stage data at the Sumatra gage do not indicate that the bed of the river has degraded or the channel has widened in the post-dam period (Figure 4; Light et al., 2006). Historically, the bed material in the reach was composed of relatively uniform sands that averaged 0.4 mm in size (Odom, 1966). Sediment sources within the reach are primarily the eroding banks, many of which are composed of sands as well as erosion and reworking of dredge material disposal sites (e.g., Sand Mountain).

USGS measurements of tree-line width of the main channel from aerial photography in 1941 and 2004 indicate that the mean width of the channel in this subreach has increased from 390 to 473 feet (83 feet), an increase of about 21 percent (Figure 5). Given the uncertainty associated with these measurements (Smith and Vincent, 2004) and the extensive presence of dredge material disposal sites, especially within the reach between RM 35 and RM 42 that limit vegetation recovery, it is unclear whether the river has actually widened in this reach in the post-dam period. Field observations do not indicate that both channel banks are eroding along the reach, rather the bank erosion is limited to the outside of bends, which is to be expected. However, channel cutoffs could be responsible for localized channel widening especially in the vicinity of Sand Mountain.

3. TRENDS

There is little doubt that the non-tidal reach of the Apalachicola River has responded to the construction of the upstream dams and the consequent reduction, or possibly elimination, of the bed material supply from upstream by degrading and possibly widening. Light et al. (2006) concluded that channel conditions in the last decade (1995-2004) had been relatively stable.

In the Upper Reach, the channel has degraded, but further degradation potential is limited by the presence of the limestone outcrop and coarser bed materials, as well as local sediment sources downstream of RM 84. The presence of relatively cohesive materials in the banks and the reinforcement of the toes of many of the banks with limestone or other geologically more erosion resistant materials limits the potential for bank erosion, lateral migration and channel widening. Additionally, the presence of extensive dike fields in the reach further limits the potential for lateral channel adjustment. Given the uncertainty in the comparative channel width data, it is not possible to speculate on future trends in channel width.

In the very sinuous Middle Reach, the riverbed has degraded by about 2 foot, but that amount of degradation is very unlikely to be sufficient to cause widespread instability of the channel and general channel widening. The channel is actively migrating as a result of cutbank erosion and point bar accretion, and as a result the hydraulic characteristics and resulting erosional and depositional components of the bends continue to change in time and space. Erosion rates within the highly sinuous reach are low in comparison to other large alluvial rivers, and are unlikely to increase over time. A number of bends have low radii of curvature (RM 62, RM 50, RM 43), and it is conceivable that in the not too distant future these bends could cutoff leading to reduced sinuosity and increased hydraulic slope. In fact, it appears that the cutoff process has already commenced at the bend centered on about RM 50. Given the uncertainty in the comparative channel width data, it is not possible to speculate on future trends in channel width.

The highly sinuous upper portion of the Lower Reach (RM 42 to RM 35) appears to be net aggradational, possibly as a result of diversion of about 35 percent of the flow of the Apalachicola River into the Chipola cutoff without a commensurate proportion of the bed material load. Between RM 35 and RM 29 the bed has degraded most probably as a result of the bend cutoffs, but further degradation is unlikely given the accelerated sediment supply to the river in the vicinity of RM 35. The channel in the sinuous upper portion of the reach is actively meandering and is likely to continue to do so. The low radii of curvature of the bends between RM 40 and RM 38 suggest that natural cutoffs could occur in the future, which would lead to a reduction in channel sinuosity and an increase in hydraulic slope. Given the uncertainty in the comparative channel width data, it is not possible to speculate on future trends in channel width.

4. MUSSEL HABITAT

During the course of the boat inspection of the non-tidal reach of the Apalachicola River, a number of locations where fat threeridge mussels (FTM) were present were identified by the mussel experts and these sites were inspected. Sites inspected that had FTM present included RM 73.2L (downstream end of a point bar) (**Figure 9**), RM 51.8L (downstream end of a point bar & mouth of Equiloxic Creek) (**Figure 10**), RM 48L (downstream of a sharp bend caused by erosion-resistant bank materials) (**Figure 11**), RM 47.2R (dike field) (**Figure 12**) and RM 43.1L (backwater-induced bank-attached bar) (**Figure 13**). While these sites have different macro-scale physical characteristics, they all have common meso- and micro-scale hydraulic characteristics (Harvey et al., 1993). All of the sites are located in flow separation zones (eddies) at higher flows than were present in the river (about 5,000 cfs) at the time of the field inspection. Within the eddy zones finer sediments (fine to medium sand and some silts and clays) are deposited against the bankline and appear to create conditions that provide suitable FTM habitat. In general, the flow separation zones occur on the inside of the bends downstream of the point bar apexes, and therefore, the FTM habitat appears to be related to meander bend dynamics. Consequently, the location of the preferred habitat is likely to change through time and space as the bends migrate laterally and down-valley. This is in contrast to the situation where eddy deposits are formed in fixed locations within canyons (Schmidt and

Rubin, 1995; Cenderelli and Cluer, 1998). Where the local sinuosity is very high and there are a number of very low radii of curvature bends present that cause upstream backwater, mid-channel and bank-attached bars are formed in the upstream limbs of the bend because of the very high energy losses through the bends (Bagnold, 1960; Harvey, 1989). Such conditions are present for example from RM 43 to RM 46. The eddy deposits associated with the backwater-induced bars also appear to create suitable habitat for the FTM.

Qualitative sampling data for the FTM in the Apalachicola River were provided by the Corps and Dr. Miller, and these data appear to support the hypothesis that the FTM habitat is formed and maintained by meander processes (**Table 1**). Within the limits of the ability to identify the FTM sampling sites on the 2002 aerial photography, it appears that the preferred habitat for the FTM is located downstream of the bend apexes within bank-attached eddy deposits and in eddy deposits associated with backwater-bars that have formed in the upstream limbs of the bends. It is of interest to note that the highest number of FTM were collected in the eddy deposits in a dike field at RM 47.4R, which does suggest that if the amount of available habitat is a limiting factor for the FTM it could be created.

Table 1. Locations of FTM habitat (Source of data Dr. D. Miller).

Location (RM)	CPUE/hr	Site Description
49.6R	18	d/s end of bend
48.7R	132	crossing
48.2L	6	d/s end of bend
47.5L	54	d/s end of bend
47.4R	774	dike field
46.9R	258	d/s end of bend
46.4L	276	d/s end of bend
46.0R	72	backwater bar
45.5L	11	d/s end of bend
44.5R	84	d/s end of bend
44.3L	558	d/s end of bend
43.9R	522	point bar near apex
43.4R	84	backwater bar
43.1L	486	backwater bar
43.0L	354	backwater bar
42.7L	120	d/s end of bend
42.2L	144	d/s end of bend
42.1R	12	point bar apex
41.3L	18	d/s end of bend
41.0L	48	d/s end of bend
40.6L	3	d/s end of bend
40.5L	30	d/s end of bend
40.4	0	backwater bar

FTM mortality observed in 2006 following the high sustained flows of 2005 (peak flow of 159,000 cfs at the Chattahoochee gage) is a matter of concern for the Corps and the USFWS. Three sites were inspected where FTM mortality had occurred following the 2005 high flows. These included RM 44L (**Figure 14**) and RM 43.6R (**Figure 15**) on the Apalachicola River and

Swift Slough (RM 40.2L) (**Figure 16**). Mortality of the FTM at each of the sites appears to be related to deposition of sandy bed material, and can be explained by the dynamics of the river. It is axiomatic that most changes in a meandering river occur during periods of high flow, since these are the conditions that cause sediment transport, bank erosion and sediment deposition. At RM 44L, the FTM mortality occurred in an eddy deposit on the downstream end of the bend centered at RM 44.5. Field observations of the conditions at the site (age and size of the willows) indicate that the eddy deposit has moved downstream through time in response to the shift of the bend caused by erosion of the opposing bank (**Figure 17**). Thus, at this site, suitable FTM habitat prior to the 2005 high flows is no longer present at the same location, and FTM present at the site appear to have been killed by excessive sedimentation that is expected as the bendway moves across and downvalley. However, the downstream shift of the eddy appears to be creating suitable FTM habitat downstream of that identified prior to 2005 which indicates that FTM habitat at a given location is likely to be ephemeral, but that new habitat is formed as the bends adjust.

At RM 43.6R, FTM mortality was associated with growth of a bank-attached bar on the outside of the bend. An extremely low radius of curvature bend is located downstream of this site at RM 43. During the high and long duration flows of 2005, the downstream bend created backwater conditions that induced further sedimentation on the bank-attached bar, which was probably responsible for the deaths of the FTM that were present at the site prior to 2005 when the site provided suitable habitat. Whether new suitable FTM habitat will be created in this general location is difficult to predict without a better knowledge of the hydraulic characteristics of the river at a range of higher flows. It is quite possible that the bank-attached bar has a limited lifespan as suitable habitat for FTM.

In the upper reaches of Swift Slough, which is a distributary channel for the Apalachicola River at about RM 40.2L, there is little doubt that relatively recent flows have introduced sandy bed material into the upper reaches of the slough and dead FTM were observed in the channel (**Figure 18**). Prior to 2005, there appears to have been a population of FTM in the upper reaches of Swift Slough, but the large numbers of mussels observed in the channel following the 2005 high flows were probably transported into the slough (Jerry Ziewitz, USFWS, personal communication). During the 2005 high and long duration flows it is quite likely that the cumulative energy losses created by the low radius of curvature bends between RM 38 and RM 40 created sufficient backwater to cause in-channel sedimentation at about RM 40. Additionally, the loss of about 35 percent of the flow without a commensurate amount of the sediment into the Chipola Cutoff was probably also responsible for in-channel sedimentation upstream of RM 40. Annual dredging of the reach between the cutoff and RM 40 was required historically to permit navigation (Terry Jangula, Corps, personal communication), and dredging has not been conducted since 2001, which could have led to a build up of bed material in the reach prior to and subsequent to the 2005 event. The hydraulics of the river at the mouth of Swift Slough are not known with certainty, but it is likely that during the high flows of 2005, sediment deposition was occurring while the bankfull flow was exceeded (about 50,000 cfs) and the overbank areas were submerged. During the recessional flows, it is quite possible that the bed material deposited in the river at the mouth of Swift Slough was re-entrained by flows entering Swift Slough which is a steep distributary with fairly high velocities (Light et al., 1998). Hydraulic modeling of the river and slough will be required to verify or reject this hypothesis. If the hypothesis is correct, it again points to the ephemeral nature of FTM habitat, which will change in response to changes in the meander planform and dynamics of the river.

5. CONCLUSIONS

Based on the review of the information, data and documents provided by the Corps, other information derived from the scientific literature, as well as the field inspection of the non-tidal reach of the Apalachicola River between Jim Woodruff Dam (RM 106.5) and the Sumatra gage (RM 20) the following are concluded:

1. Construction of Jim Woodruff Dam as well as the other federal and non-federal dams on the Chattahoochee and Flint Rivers has significantly reduced the bed material sediment load to the Apalachicola River, but the hydrology of the Apalachicola River has not changed significantly in the post-dam period.

2. The Apalachicola River has responded to the reduced bed material sediment supply from upstream by degrading. In the Upper Reach (RM 106.5 to RM 78) the degradation has ranged from about 5 feet in the upstream part of the reach to about 2 feet in the downstream part of the reach. Further degradation is likely to be prevented by the presence of limestone outcrop and possibly by coarser bed material. About 2 feet of degradation has occurred in the Middle Reach (RM 78 to RM 42). Between RM 35 and RM 29 in the Lower Reach degradation has occurred in response to bend cutoffs. Available data do not indicate that the river is continuing to degrade, and in fact the uniformity of the average channel slopes in all three reaches (0.000093 – 0.000095) suggests that the river may have attained a measure of equilibrium.

3. Because of the limitations of the data, and the extensive presence of un-vegetated dredge disposal sites along the river, it is very unclear whether the Apalachicola River in general has widened in response to the upstream dams. Clearly, local widening has occurred at specific locations where dredging and channel cutoffs have occurred.

4. Between RM 78 and RM 35 the Apalachicola River is a very sinuous (1.92) and actively meandering river which may be due to the presence of a tectonically-active trough (Gulf Trough) whose axis crosses the river just downstream of the mouth of the Chipola River. Maximum erosion rates on the outside of the bends are similar to those measured on the Alabama River, but are very low compared to other large alluvial rivers.

5. FTM habitat in the Apalachicola River appears to be associated with eddy deposits that are located on the inside of bends downstream of the point bar apexes, around bank-attached and mid-channel bars that are located in backwatered reaches upstream of low radii of curvature bends, and in dike fields.

6. FTM habitat is essentially ephemeral and changes location through time as the bends themselves adjust by lateral and downstream migration. Because of the limited mobility of FTM, sites that may have provided suitable habitat prior to a morphogenetically significant event such as the 2005 high flows may end up being unsuitable following the event which leads to mortality. The duration of site suitability for FTM is most probably related to the frequency and magnitude of high flow events. However, as existing habitat is lost as a result of meandering processes, new habitat is also created.

7. Over a longer period of time the hydraulic connections and sediment transport relations between the mainstem river and distributary channels such as Swift Slough will change

in response to changes in the planform and hydraulics of the mainstem. Ultimately, individual distributary channels are ephemeral features, but active meander processes are likely to create new channels as older channels are eliminated.

6. RECOMENDATIONS

This cursory geomorphological investigation of the non-tidal reach of the Apalachicola River has identified a number of issues that require resolution if the dynamics of the river and FTM habitat are to be more fully understood and predictable. Identified issues include:

1. Whether the river has in fact widened in response to the upstream dams, and if so what are the driving processes and mechanisms.

2. Whether the river has fully adjusted to the presence of the upstream dams or if further channel degradation will occur through time in the Middle and Lower Reaches. In other words, will the degradation that was experienced in the Upper Reach move downstream through time, or is the sediment supply within the reaches sufficient to maintain the channel bed at its current elevation.

3. Quantification of the spatial and temporal relationships between the meander dynamics of the river and the formation and maintenance of FTM habitat.

4. Assessment of the amount of habitat that is available for the FTM in the meandering reaches of the Apalachicola and whether the lack of habitat is a limiting factor for the species.

To address the identified issues it is recommended that the following be conducted:

1. An in-depth quantitative geomorphic assessment of the river between the dam and RM 20.

2. Development of a one-dimensional sediment-continuity analysis using the SIAM computer code.

3. Development of two-dimensional hydrodynamic models of selected FTM habitat sites located: (1) downstream of a bend, (2) in association with a backwater-induced bar complex, and (3) in the upper reach of a distributary channel.

4. In conjunction with the mussel experts use the results of the above to develop a physical process-biological response model that can be used to predict the impacts of water management operations at Jim Woodruff Dam on FTM habitat.

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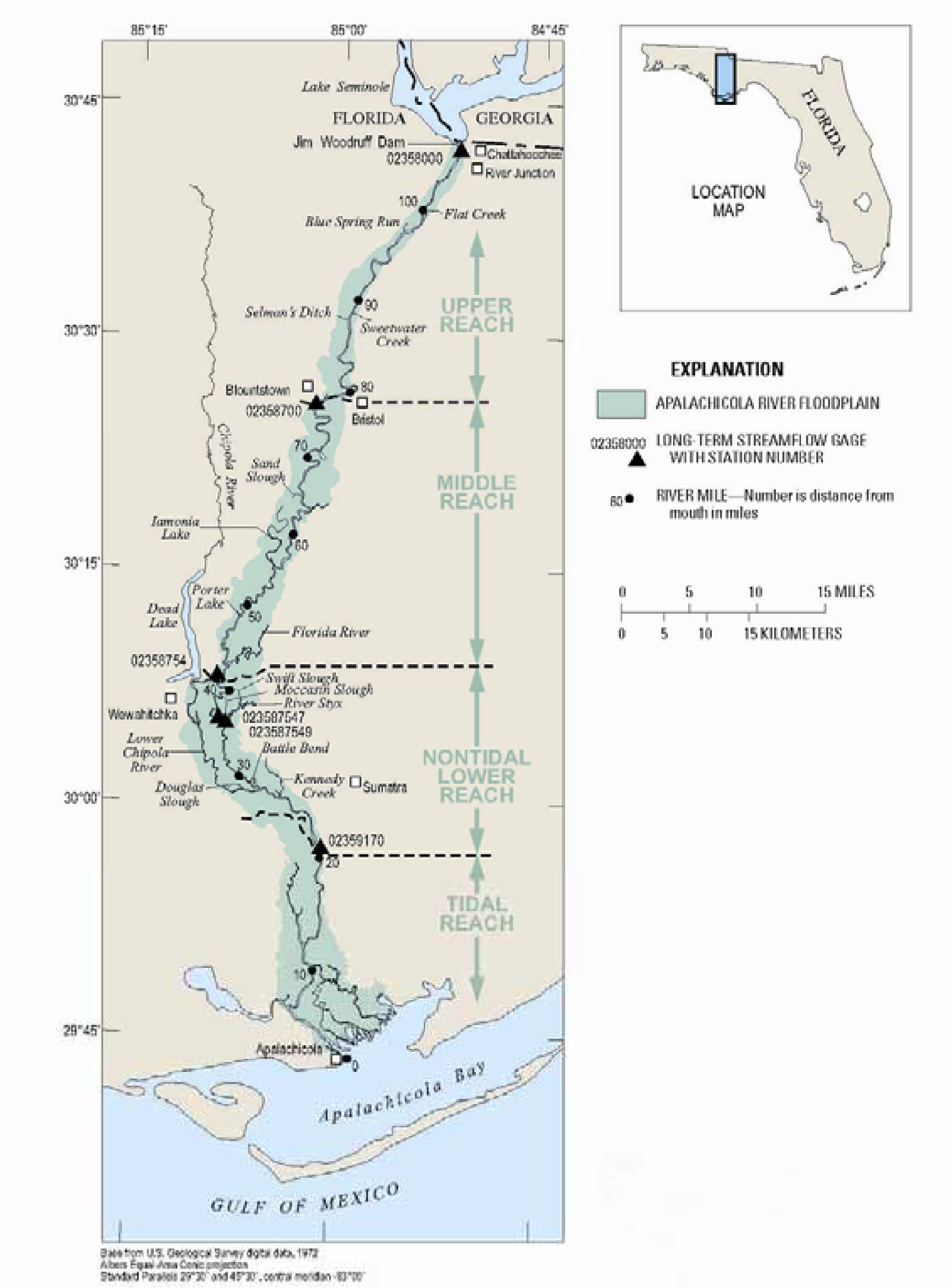

Figure 1. Major reaches of the Apalachicola River and location of long-term streamflow gaging stations (Light et al., 2006).

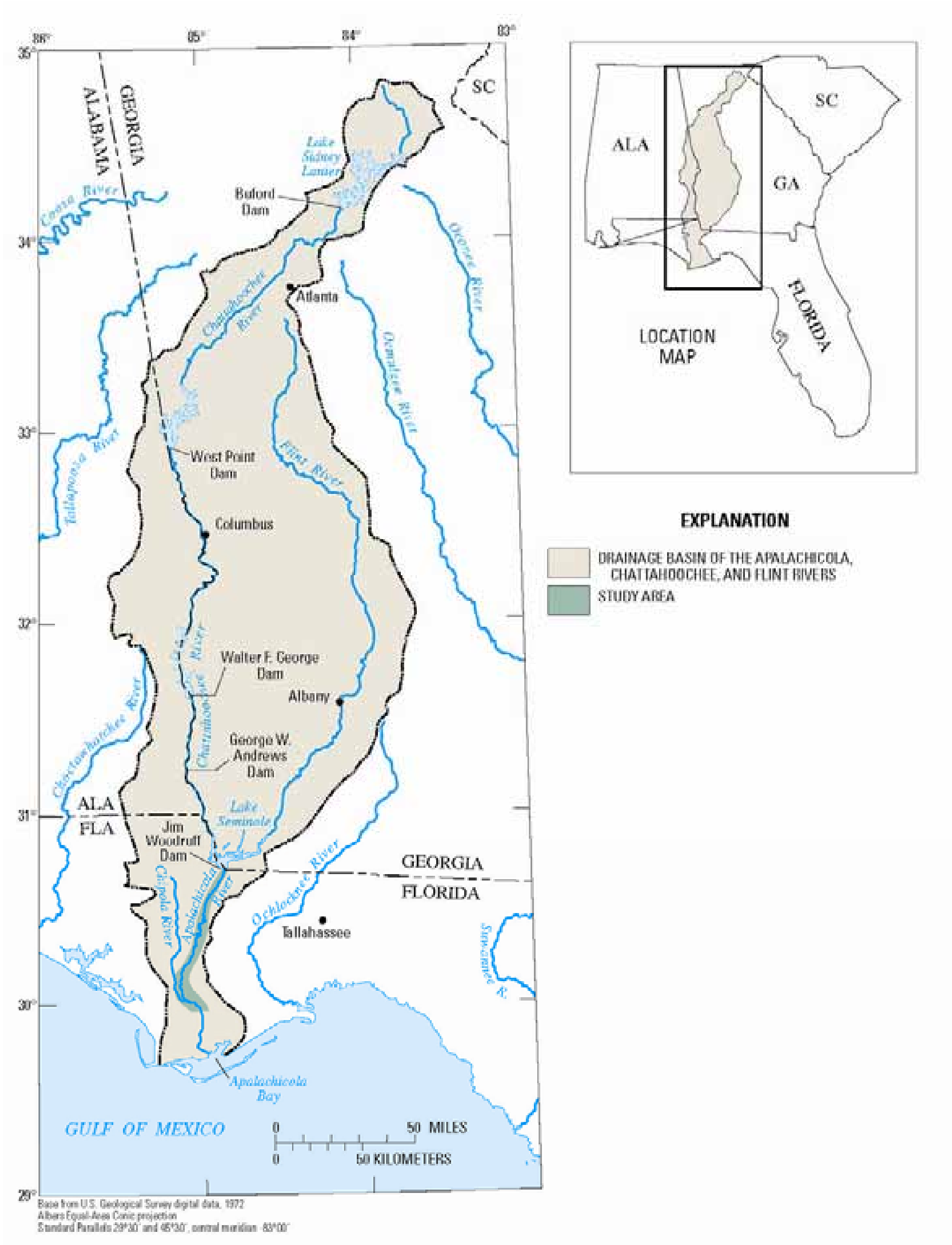

Figure 2. Drainage basin of the Apalachicola, Chattahoochee, and Flint Rivers in Florida, Georgia, and Alabama (Light et al., 2006).

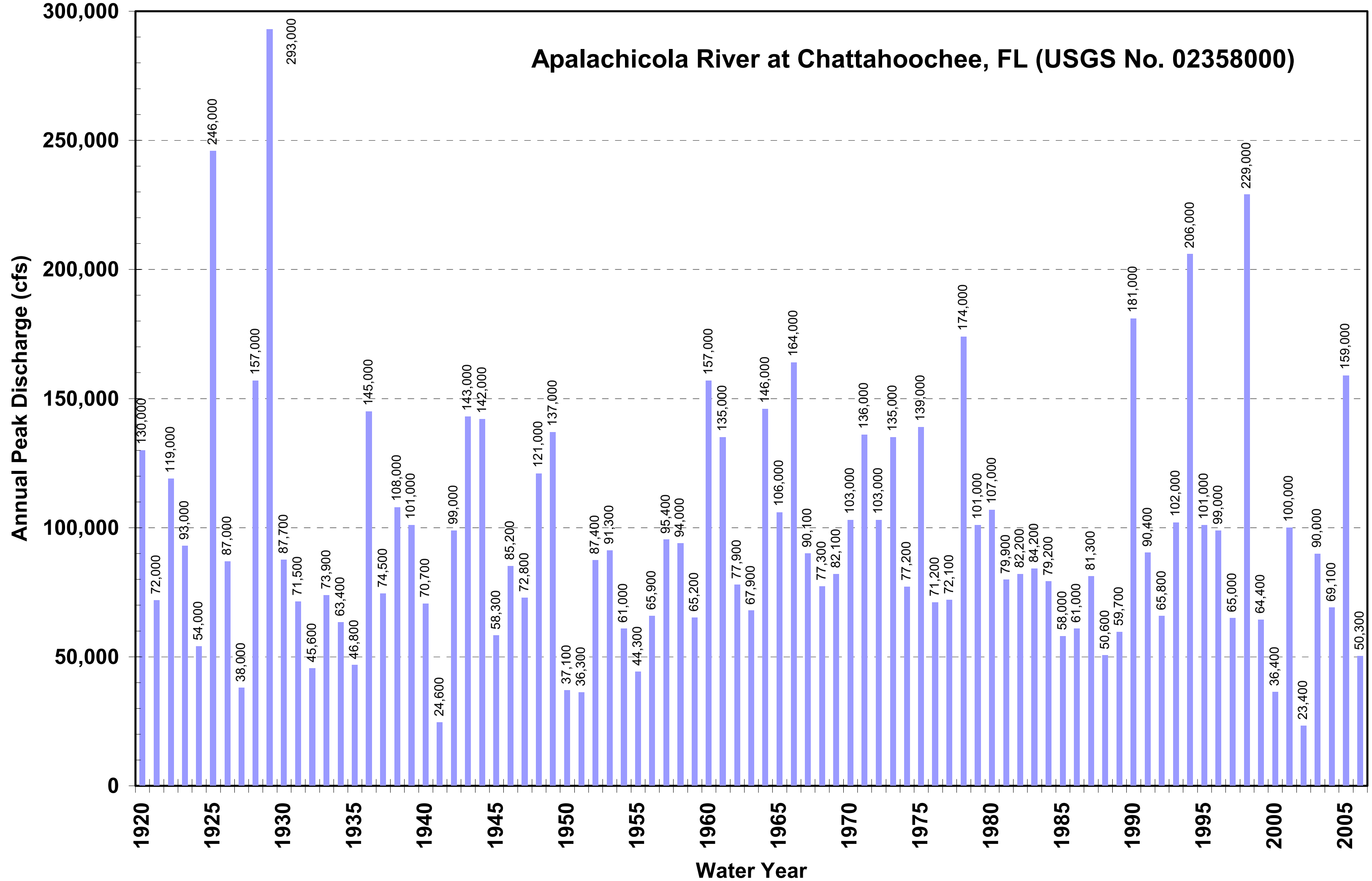

Figure 3. Annual peak flow record (1920-2006) for the Apalachicola River at Chattahoochee, Florida.

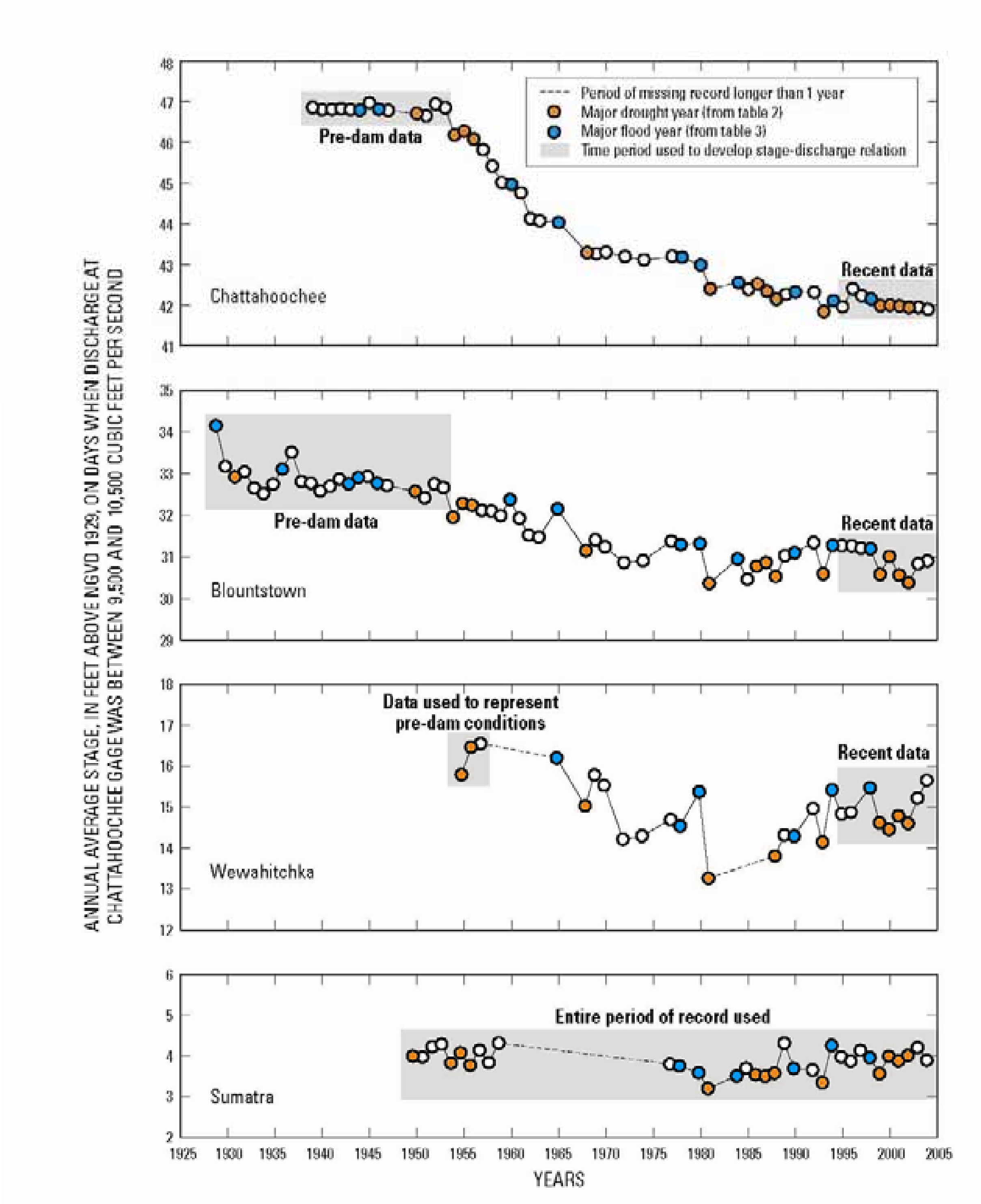

Figure 4. Average annual stages for the four gages on the Apalachicola River for flows at the Chattahoochee gage between 9,500 and 10,500 cfs (Flint et al., 2006).

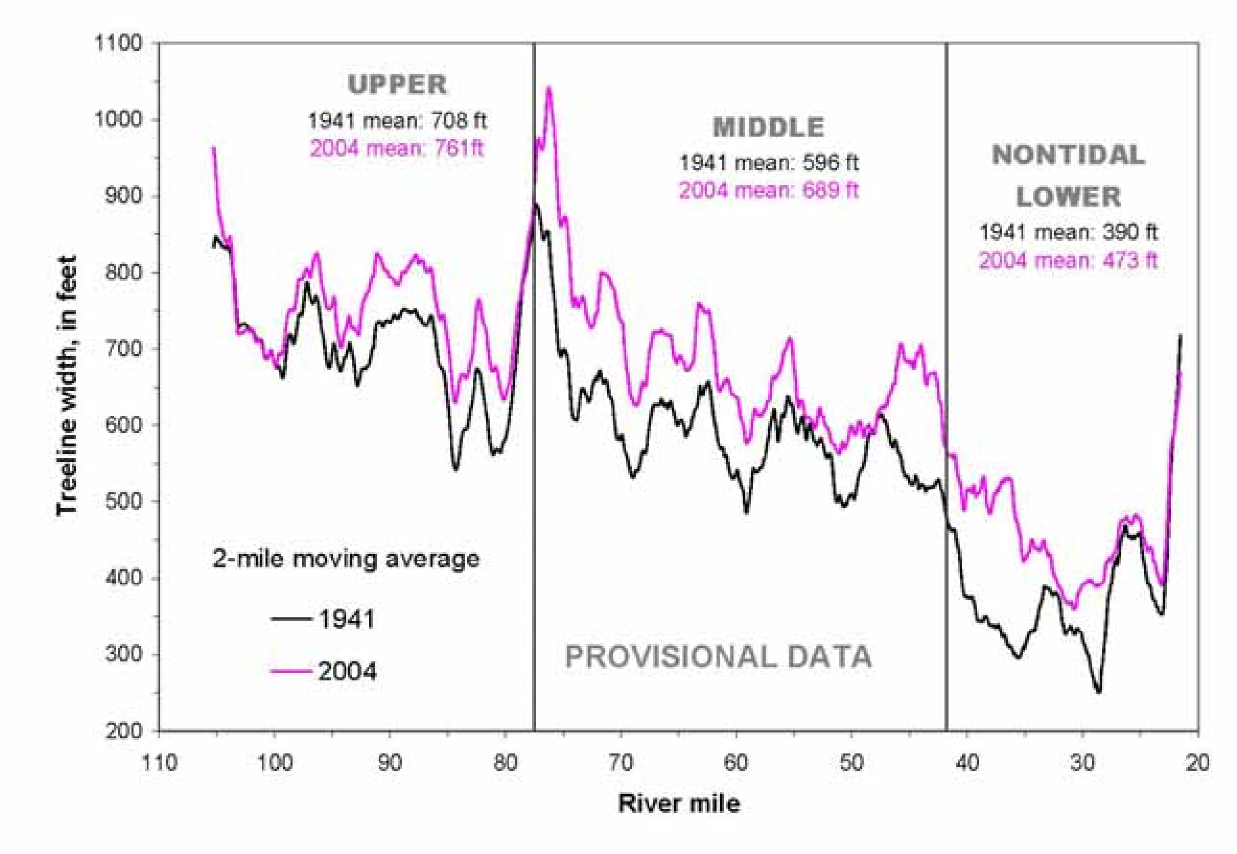

Figure 5. Tree-line width of main channel of nontidal reach of Apalachicola River, Florida, in 1941 and 2004. Widths were measured at approximately 2,800 points at 164-foot intervals along the channel centerline in aerial photographs. Data show a 2-mile (64-point moving average. River miles represent those depicted on the most recent USGS quadrangle maps available in 2005 (undated USGS data provided by Mobile District COE).

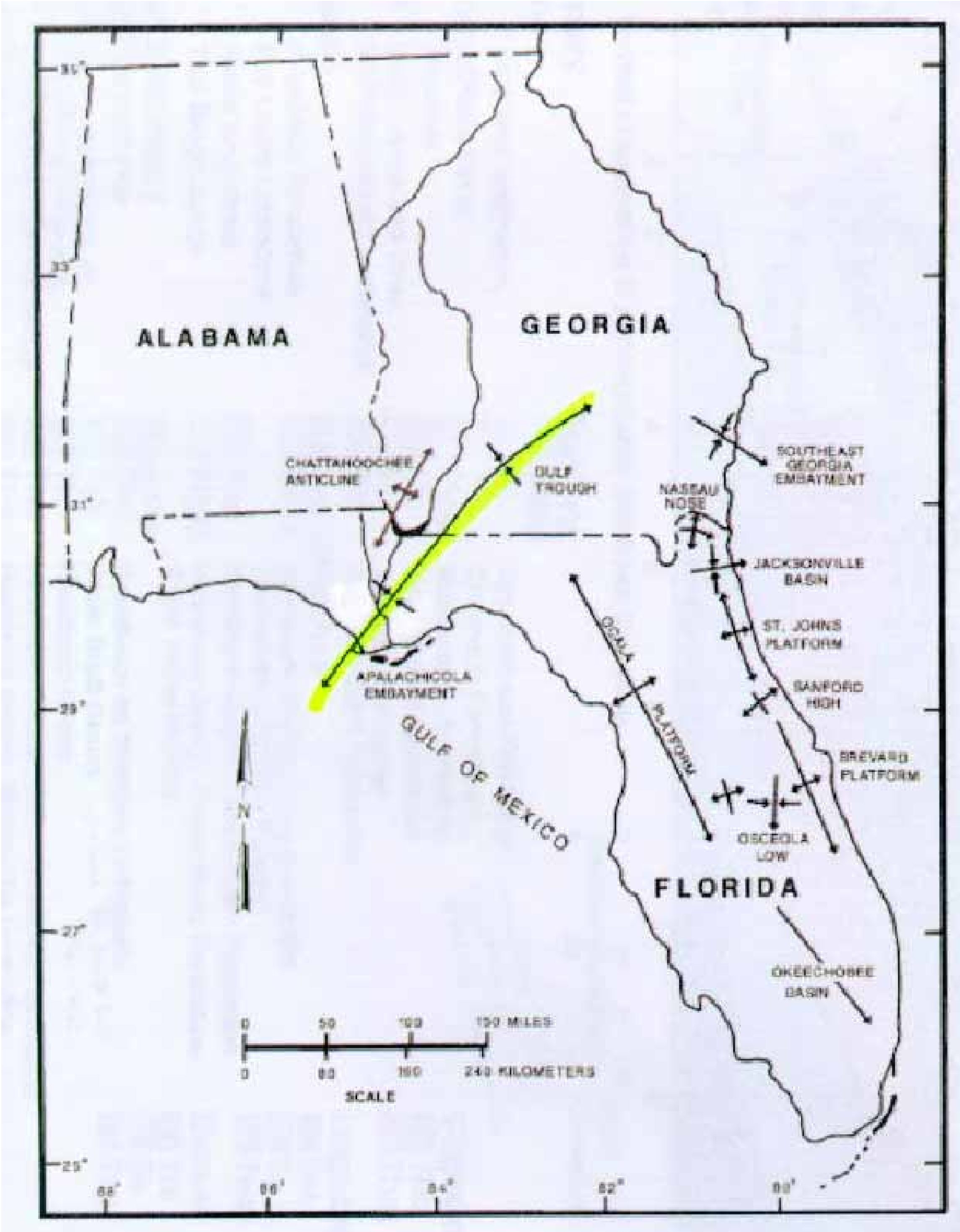

Figure 6. Map showing the location of geologic structures in the State of Florida. Highlighted is the Gulf Trough syncline that crosses the Apalachicola River.

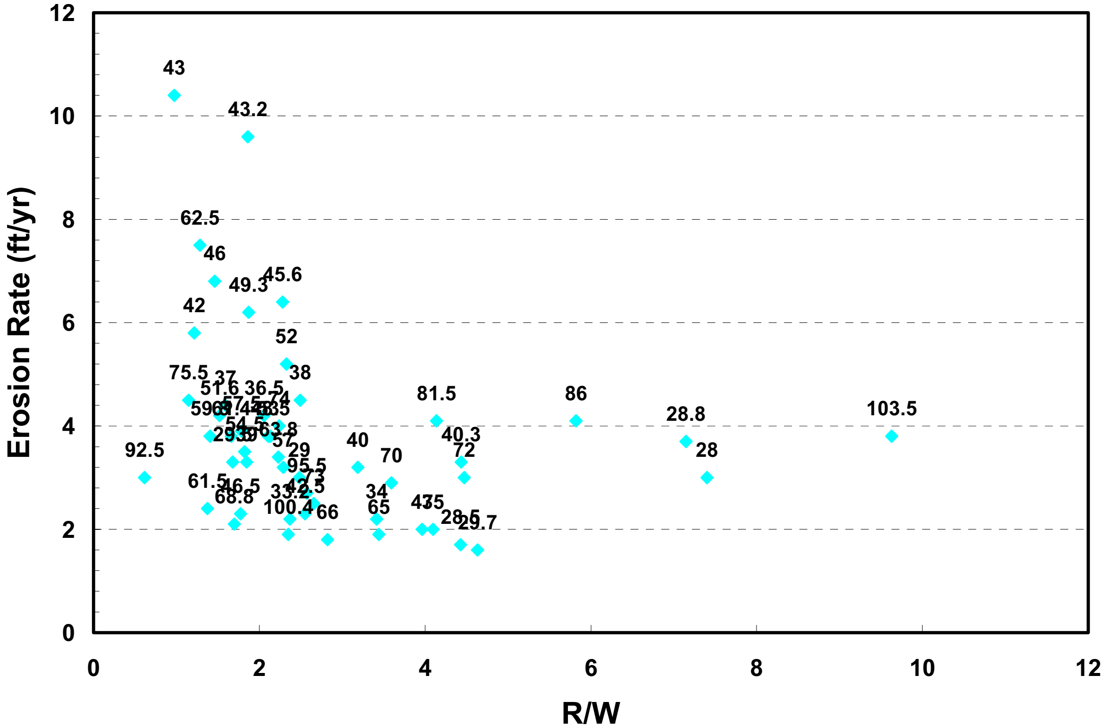

Figure 7. Erosion rates plotted against the radius of curvature to channel width ratio for bends in the Apalachicola River. Numbers shown on the figure are river miles (source of erosion rate and radius of curvature data is USACE).

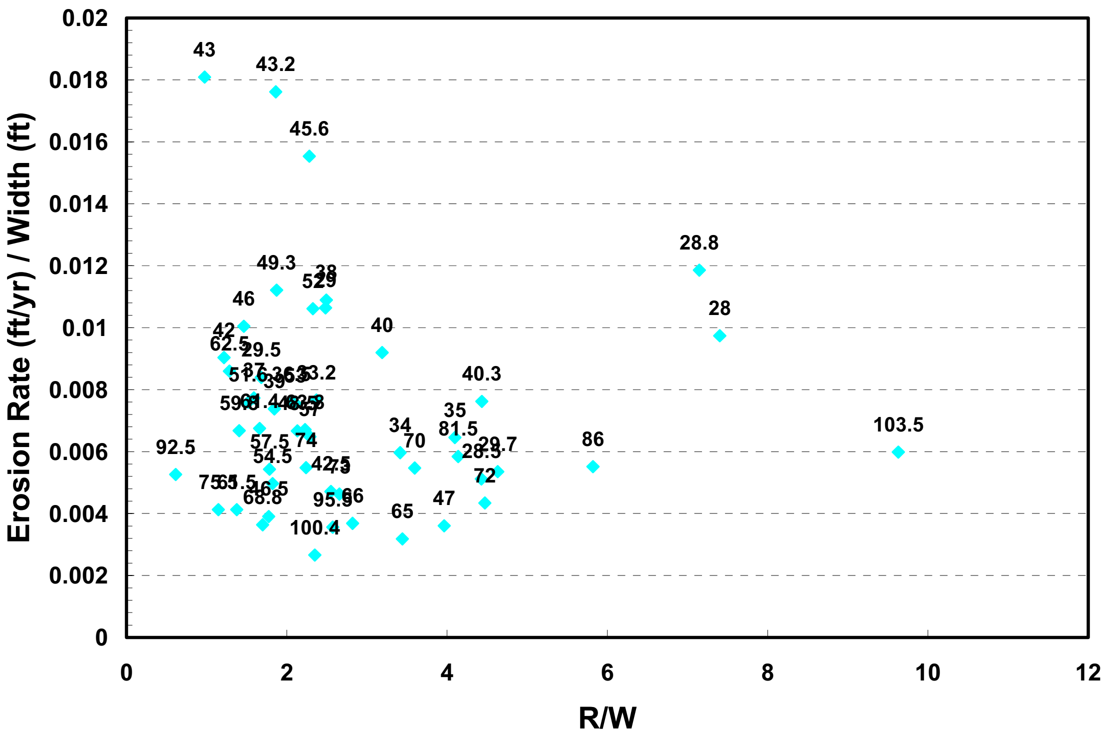

Figure 8. Normalized erosion rates plotted against the radius of curvature to channel width ratio for bends in the Apalachicola River. Numbers shown on the figure are river miles (source of erosion rate and radius of curvature data is USACE).

Figure 9. Upstream view of FTM habitat at RM 73.2L.

Figure 10. Upstream view of FTM habitat at RM 51.8L.

Figure 11. Upstream view of FTM habitat (upstream of house boat) at RM 48L.

Figure 12. View of sediment deposition and FTM habitat in the dike field at RM 47.2R.

Figure 13. FTM habitat associated with a backwater-induced bar at RM 43.1L.

Figure 14. Upstream view of FTM mortality site at RM 44L.

Figure 15. Upstream view of FTM mortality site at RM 43.6R (Kentucky Landing).

Figure 16. Upstream view of the mouth of Swift Slough with the Apalachicola in the background. Note the sand deposits in the bed of the slough.

Figure 17. Downstream view of willow succession at RM 44L.

Figure 18. Downstream view of sand waves on the bed of Swift Slough.

Brian,

Your memo is a very thorough and accurate summary of last week's discussions. I have no suggested edits; however, I will summarize my impressions regarding those ecological issues discussed at the workshop as they affect BO coordination.

1) I am a little concerned because we focused most of our discussions on issues affecting only *Amblema neislerii*, although RPM5 poses the same 2 questions for all 3 species. If RPM5 is to be fully addressed, there must be substantial consideration of population size and effect of low-water events for all three listed species.

2) As with most Coastal Plain streams, the middle section of the Apalachicola River is highly dynamic. Native organisms, at both individual and population levels, typically are well-adapted to dynamic flow and channel migration. Mortality associated with life in this dynamic environment affects all such populations and should not be perceived as particularly unusual or threatening to *A. neislerii*.

3) The mussel populations in the Apalachicola typify those in such dynamic environments. The population depends on many patches of suitable habitat (e.g., eddy habitats) to persist even if portions of the population suffer high mortality from major physical changes at one or a few locations. Habitat suitability probably improves in some locations and declines in others during any particularly forceful hydrologic event. For populations to persist over a long period, habitat losses must be balanced by habitat gains at some biologically significant temporal scale (i.e., "dynamic equilibrium"). Dr. Harvey referred to distributary dynamics as well as the implications of stranding during low water in precisely this sense.

   Aerial photos indicated that the geomorphic phenomenon associated with stranding events has occurred many times in the past. Therefore it is reasonable to assume that stranding events are natural and probably not detrimental to the longterm survival of mussel populations in the Apalachicola.

   Both geomorphic experts were skeptical of the idea that the river is widening. If a detrimental widening process has been occurring since 1940, it is not likely that so many mussels would remain in the middle reach.

4) It seems that the Apalachicola "stranding" or "vulnerable habitat" or "other concern" issues were used to infer that "take" is occurring, thereby requiring actions by the Corps. However, it could be (should be) argued that mortality, stress, harassment, etc…resulting from natural phenomena does not constitute "take." Mortality due to stranding is no different from any other natural selective force on a population. The RPM states that you must estimate population size and estimate effect of stranding on populations. However, the question that most directly addresses to what degree the Corps should be held responsible should be:

Have actions of the Corps caused natural hydrogeomorphological events to occur at an accelerated or altered rate so that mussel mortality occurs in an unnatural manner?

"Take" is really only justified if the above question is answered in the affirmative.

RPM5, as currently written, seems to concede such and requires **monthly** monitoring of "take." It implies that the Corps is responsible for "take," that "take" might be detectable each month, and therefore intense mussel monitoring studies must be conducted. However, preliminary results and discussions at the workshop support the argument that "take" does not occur (i.e., is the result of natural processes, not Corps actions).

I appreciate the opportunity to attend the workshop. Section 7 coordination is difficult enough without pending litigation. We have been assisting the St. Paul and Rock Island Districts with Biological Opinion actions for *Lampsilis higginsii* (Higgin's eye pearly mussel) for several years and are about to initiate a risk-informed decision analysis project to help them design a conservation management plan for another Endangered species, *Quadrula fragosa* (winged mapleleaf).

Please feel free to contact us if you want to discuss such issues in the future. Take care, and good luck with the Apalachicola project.

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Factors Determining Abundance and Distribution of the Endangered Fat Threeridge mussel, *Amblema neislerii*, in the Apalachicola River, Florida

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Abstract

In the Apalachicola River, Florida, aggregated assemblages of native mussels (family: Unionidae) were dominated by the endangered fat threeridge (*Amblema neislerii*) and occurred mainly in moderately depositional, nearshore areas immediately downriver of point bars. In June 2007, *A. neislerii* was present at 23 of 25 areas surveyed between Navigation Miles 40 and 50. Catch per unit effort for all mussels at the 25 sites ranged from 0 to 1,080 (average = 312), and CPUE for *A. neislerii* ranged from 0.0 to 774 (average = 162). Mean *A. neislerii* density ranged from 0.2 to 12.7 individuals/m^2 (average = 3.7, standard deviation = 3.7) and total unionid density ranged from 2.4 to 36.0 (average = 11.9, standard deviation = 11.2). Total shell length for A. neislerii ranged from 11.7 to 76.4 mm, and there was evidence of strong recruitment with cohorts centered at 17.5 and 42.5 mm. Extremely low discharge, less than 6,000 cubic feet per second on the Chattahoochee gage in 2006 and 2007 resulted in considerable mussel mortality in shallow portions of the river and its distributaries during 2006. Never-the-less, most of the riverine assemblage of mussels had sufficient water. The past two years of low water killed virtually all bivalves in Swift Slough.

Despite concerns about its rarity, *A. neislerii* populations are moderately dense and include recent recruits throughout much of the Apalachicola River. This species is found in reaches of the Chipola River, although it is uncommon or absent in most connecting tributaries and sloughs. Until recent low water, it was collected in Swift Slough. A long-term monitoring plan, which focuses on intensive collecting at a few representative areas, coupled with sediment and water velocity modeling, will provide additional understanding of physical factors that affect abundance and distribution of *A. neislerii* in the Apalachicola River.

Introduction

Background. The Apalachicola River, formed by the confluence of the Flint and Chattahoochee Rivers, originates at Navigation Mile (NM) 106.3, just south of Lake Seminole in the tailwater of Jim Woodruff Lock and Dam. This is the largest river in Florida, with a mean annual discharge of 690 m^3/sec (Light et al. 1998). The Apalachicola-Chattahoochee-Flint (ACF) basin, in Georgia and northeastern Florida, drains approximately 210,448 hectares. The river enters the Apalachicola Bay at Apalachicola, Florida.

The river provides habitat for an endemic freshwater mussel (family: Unionidae) the fat threeridge, *Amblema neislerii* (Lea, 1858), which was listed as endangered on 15 April 1998 (Federal Register Volume 63, Number 50, pages 12664-12687). A review of the literature reveals that its abundance and distribution in the Apalachicola River has not been well understood or adequately portrayed. Part of the problem has been the difficulty of sampling mussels in medium-sized to large rivers. It was not until the 1980s, and in some cases later, that biologists routinely used power boats and divers to conduct both intensive and extensive searches for mussels. The following is a brief summary of pertinent literature on *A. neislerii* (also see Butler et al. 2003).

The first published reference to *A. neislerii* in the ACF basin was by Hyning (1925) who described it as 'rare,' after receiving an unreported number of *A. neislerii* from the Chipola River from a fisherman. Several years later, van der Schalie (1940) reported that *A. neislerii* was not found in tributaries but was at two sites in the Chipola River where it constituted 1.49 % of the unionid fauna. Clench and Turner (1956) reported that *A. neislerii* was rare in the watershed, although when present it could be locally abundant. They considered it to be extinct in the upper Flint River where it had not been taken since the latter part of the previous century and they found some specimens in the lower Flint, Apalachicola, and Chipola Rivers. They stated that *Crenodonta* (=*Amblema*) *neislerii* was 'amazingly abundant' in a natural impoundment in the lower Chipola River (referred to as Dead Lake) and suggested that 10-15 could be found in “every square meter” along a 200-meter reach.

In a survey conducted for the Office of Endangered Species, Heard (1975) collected mussels at 150 sites in the Gulf and Southeastern States; four sites were in the Apalachicola and three were in the Chipola River. He collected live *A. neislerii* only in the lower Chipola River (Dead Lake). He did not collect live *A. neislerii* in the Apalachicola River although he did find shells at one site. He did not provide specific information on his methods or location of sites.

Richardson and Yokley (1996) collected mussels in the Apalachicola River using quantitative methods (six 0.25-m^2 quadrats and total substratum removal) at each of three sites where adult *A. neislerii* or *Elliptoideus sloatianus* (threatened) had been found by previous investigators. *Amblema neislerii* was found at one site (NM 21.8) where it constituted 25% of the assemblage. Three live organisms were smaller than 50 mm total shell length. They concluded that appropriate search methods would likely yield additional evidence of recent recruitment for *A. neislerii*.

During 1991-92, Brim Box and Williams (2000) surveyed 324 sites in the ACF basin. They identified 33 species from a collection of 5,757 live individuals and 2,988 shells. Most sites were in the Chattahoochee and Flint Rivers upriver of Jim Woodruff Lock and Dam. *Amblema neislerii* was found at 11 sites in the watershed and 32 live specimens were taken at seven sites in the Apalachicola River.

The US Army Engineers District, Mobile (SAM), funded the first comprehensive mussel surveys of the Apalachicola River in association with maintenance activities for the Federal Navigation Project. In 1996, 1997, 1999, 2001, 2002, and 2003 approximately 100 sites were examined by divers and waders (Miller (1998), Payne and Miller (2002), Miller and Payne (2005a, b)). The surveyed sites were typically associated with potential dredged material disposal sites, slough locations, and other main channel areas within the Apalachicola and Chipola rivers. Over 4,500 live mussels were collected and 19 species were identified. Fat threeridge were detected at 22 locations and several of the locations included signs of recruitment. The fat threeridge was particularly abundant at the Chipola River cutoff (river mile 41.6), where a “dense band” of mussels was located. More than 60% of the mussels observed at this site were fat threeridge. At this same location 10% of the fat threeridge were less than 30 mm in total shell length, representing recent recruitment. The results of these surveys indicated that at moderately depositional areas, *A. neislerii* dominated and constituted approximately 36% of the mussel fauna. It should be noted that the purpose of studies conducted every year except 2003 were conducted mainly to assess impacts of maintenance dredging. Therefore, approximately half of the sites were located in erosional zones immediately upriver of point bars where mussels would not likely be found. Studies conducted in 2003 were designed specifically to investigate depth-distribution of *A. neislerii* at areas where *A. neislerii* was known to be abundant. The highest density assemblages were in water 1.2 m deep, and *A. neislerii* was collected to depth of 2.7 m.

In 2005 the Florida Department of Environmental Protection funded a mussel survey of the Apalachicola and Chipola Rivers and associated sloughs, side channels, and tributaries (EnviroScience 2006a). They used divers and waders and surveyed in a manner similar from that of the present survey. At seven sites in the Apalachicola River (between NM 106-70, 70-40, and 40-21), EnviroScience (2006a) reported that mean CPUE (per hour) for *A. neislerii* was 7.2 and mean CPUE for all mussels combined was 45.6. Habitat conditions at the riverine sites that they studied were similar to those sampled during the present survey. Although the majority of the sloughs either did not have mussels or supported very low densities, large numbers of *A. neislerii* were found in Swift Slough, a distributary of the Apalachicola River.

Recent low rainfall in the southeast has caused conditions in the Apalachicola River to be less than optimal for aquatic life. Since 1999 (with the exception of 2003 and 2005), average monthly minimum discharge at Jim Woodruff Dam for part of the year was less than 10,000 cubic feet per second (cfs). The Mobile District is required to maintain a minimum river flow of 5,000 cfs at Jim Woodruff Dam by releasing water from upstream reservoirs, including Lake Seminole, as specified in the 1989 draft water control plan. The Jim Woodruff Dam Interim Operations Plan, developed as part of Section 7 Consultation with the USFWS, would allow for a minimum flow (6,500 cfs) when conditions permitted. This additional flow would benefit aquatic biota in Swift Slough.

Purpose and Scope. The purpose of this paper is to describe the results of a mussel survey conducted on 7-11 July 2007 at 25 locations between NM 40 and 50 on the Apalachicola River. Survey design was based on discussions with representatives of the Mobile District, US Fish and Wildlife Service (USFWS), and the Florida Game and Freshwater Fish Commission (FWCC). No divers were used; all collecting was done by wading. The purpose was to collect information on density and relative species abundance of *A. neislerii* at sites that appeared to provide appropriate water depth, velocity, and substratum. In addition, the study was done to provide information that would be used to prepare a long-term mussel monitoring plan (see Appendix A). Information from the monitoring plan, in conjunction with results from a fluvial geomorphologic evaluation, will be used to obtain a more comprehensive understanding of reduced water level and project impacts (presence of Jim Woodruff Lake, operation of the lock and dam and maintenance dredging) on *A. neislerii*.

Study Area and Methods

Study Locations. Based on a reconnaissance field trip conducted by representatives of the Mobile District, USFWS, and FWCC, personnel of the USFWS identified 25 study areas between NM 40 and 50 along the Apalachicola River which either supported, or appeared likely to support *A. neislerii*. The USFWS randomly selected 10 sites for detailed study (Table 1, Figure 1, see also Table B1 and Figures B1-B4 in Appendix B). Detailed field studies were conducted at the 10 sites and partial studies were conducted at most remaining sites (23). In addition, one new site (DS01) was added at a disposal area of interest. This site was added because of a desire to obtain sediment and elevation data at a disposal area with little or no value to mussels. The 25 sites chosen by USFWS had one or more of the following characteristics: 1) stable, gently sloping banks primarily vegetated with newly established black willow, 2) dense and species-rich mussel assemblages, 3) firm substratum consisting of silty sand, and 4) signs of recent mussel mortality from low water in 2006 and 2007. Virtually every one of these areas was along a moderately depositional reach that was immediately downriver of a point bar. Eddies, which are swirling and reverse currents in rivers, are created when water flows past upstream obstacles such as point bars. These eddies create favorable conditions for mussel assemblages since they encourage deposition of fine particulate matter and glochidia larvae.

An elevation profile of the Apalachicola River reveals that the upper 25 miles has the steepest gradient (Figure 2a). There are three 10-mile reaches where slope is either nearly flat or slightly negative and water can pool: NM 70-80, NM 40-50 (Figure 2b), and NM 20 to 30. Although mussels are affected by local conditions of depth, water velocity, and substratum, larger-scale effects (i.e., river gradient) can influence local characteristics and therefore mussel distribution and abundance (e.g., Gangloff and Feminella 2007). The influence of large and small-scale physical effects on abundance and distribution of freshwater mussels could be further evaluated through the proposed mussel monitoring plan (Appendix A). It is likely that both effects are important, and further study would help define the relative importance of each. Those sampling for mussels could inadvertently bias their observations toward local effects, when in fact mussel distribution and abundance are largely being influenced by larger scale conditions, such as river gradient.

Based on 78 years of record, mean discharge on the Apalachicola River at Chattahoochee, FL, immediately downriver of Jim Woodruff Lock and Dam (USGS 02358000) was 15,700 cfs**.** Maximum daily discharge was 15,700 cfs and minimum discharge was 4,560 cfs (http://waterdata.usgs.gov/usa/nwis).

Methods

Detailed Studies. At the 10 areas where detailed studies were conducted, six evenly spaced transects were established perpendicular to shore. Mussels were collected with a 0.25 m^2 quadrat at three sites along each transect moving from near- to farshore. All sediment, shells, and live bivalves were excavated to a sediment depth of 15-25 cm from the quadrat and sieved through a screen (minimum mesh size equaled 6.4 mm). Live mussels and the Asian clam *Corbicula fluminea* were identified and counted. All live *A. neislerii* were measured, and the majority were marked and replaced in the substratum at known waypoints by USFWS personnel. A total of 18 quantitative samples were obtained at each site; therefore, 180 quantitative samples were taken. After processing, all live mussels and *C. fluminea* were returned to the river unharmed.

A 10- or 20-min timed search for mussels was conducted between two transect lines. All live mussels encountered by touch were placed in a mesh bag and taken to shore for identification and counting. *Corbicula fluminea* were not counted. After processing, all live mussels and Asian clams were returned to the river unharmed.

A theodolite was used to obtain distance and elevation data along each transect. Three readings were taken: one at a depth of approximately 1 m, one at the shoreline, and one part way up the river bank. Additional points were taken if there were abrupt elevation changes. At several locations transects were extended to include mouths of adjacent swales. Elevation data for four study areas are displayed in Figure 3.

A sediment sample was taken at the midshore location along each transect. Samples were returned to the laboratory for analysis of moisture (dried to 65^{o}C), and organic content (dried to 550^{o}C). A subsample was wet sieved for grain size distribution.

Additional Studies. At the remaining 15 areas only two transect lines were established perpendicular to shore. Sediment samples were collected, and elevation and distance measures were obtained along each transect. In addition, mussels were collected qualitatively for 10 minutes in the area bounded by transects. No quantitative samples for mussels were collected and none of the *A. neislerii* was marked.

Results and Discussion

Background on freshwater mussels

Although freshwater mussels can be found in virtually every type of lotic and lentic habitat in North America, they reach their greatest abundance and species richness in medium-sized to large rivers in the central and southeastern United States. Several features of their anatomy and life history makes them particularly successful in higher ordered rivers: 1) Their immature forms are dispersed to new habitats on the gills and fins of specific species of fish, 2) They are long-lived—30 or more years in many species; 3) As filter feeders they can separate organic from non-nutritious inorganic matter and expel the latter before it is taken into the stomach, and 4) they can withstand brief periods of desiccation and poor water quality. Large rivers, with species-rich fish assemblages, abundance of particulate organic matter, permanent supply of good quality water, and comparatively stable water levels, provide the best habitats for these long-lived, relatively immobile invertebrates (see Vannote et al. 1980). Sustained mussel populations are much less likely in ephemeral habitats such as small sloughs and tributaries, waterbodies lacking a species-rich fish assemblage, or at areas with excessive sediment accretion or erosion.

Freshwater dreisssenid and marine mussels attach to substratum with a bundle of byssal threads. Conversely, juvenile freshwater unionid mussels temporarily anchor with a single thread. After the thread is absorbed, the mussel buries into the sediments. Mussels move by extending their pseudopod (false foot), swelling the distal end to lock it into the substratum, and then contracting it to pull them through the sediment. Such movement is most efficient in silty sand or loose gravel.

Freshwater mussels can live for long periods on the surface of the substratum, or buried beneath several centimeters (cm) of sediments. However, typically they are found with only their anterior two thirds buried. In this position their incurrent and excurrent siphons, used to take in water and expel wastes, protrude into the water.

Usually mussels are found on shoals or gravel bars in large rivers where it is not uncommon to find 20 to 30 species and overall density approaching100 individuals/m^2 or more. Depending on availability of sediments, these shoals or bars can exist in cobble, gravel, or mixtures of sands and silts. Such shoals can be self-sustaining; shells become incorporated into the substratum and then attract invertebrates and fish carrying immature mussels. Because mussels rely on fish hosts for dispersal, juveniles can be deposited almost anywhere, even in unsuitable habitat. Regardless, the greatest survival will be in areas without excessive erosion or sedimentation. Finding a few live mussels in unsuitable habitat simply illustrates their ability to reach and then survive in these areas. Although mussels are most commonly collected in low-velocity water near shore, intensive searching by a diver will almost always yield a few specimens in the thalweg, fissures in bedrock, or partially buried in firm clay. The least suitable mussel habitat is unconsolidated gravel, sand, or silt that is vulnerable to dispersal during high discharge. More background information on freshwater mussels can be found in Fuller (1974), Russell-Hunter (1979), Cummings and Mayer (1992), Williams et al. (1993), and Strayer et al. (2004).

In the study area there are four major aquatic habitats: 1) the thalweg, 2) erosional zones adjacent to clay banks on the outside of bends, 3) sandy areas adjacent to point bars on the inside of bends, and 4) moderately depositional silty-sand substratum in straight reaches or downriver of point bars. Small- to medium-sized sloughs, which enter the river at various points, are another potential habitat for native mussels although most are either ephemeral or too small for unionids. Some larger sloughs, notably Swift Slough, have supported mussels during wet periods; however, the contribution of sloughs to overall mussel populations is minimal compared with the abundant high-quality riverine habitat. The value of Swift Slough for native mussels will be discussed later.

Mussel distribution and abundance in the study reach. Typically, habitat suitable for *A. neislerii* was appropriate for all mussel species (Figure 4a); although this relationship did not hold at every site (Figure 4b). For example, *A. neislerii* populations were poor at DM09, DM22, and DM26, although total mussel populations were judged to be 'good'

(Table 2). Regardless, since it was a major component of the mussel fauna, A. *neislerii* abundance was positively related to the total abundance. Based upon qualitative sampling, *A. neislerii* was found at 23 of the 25 areas between NM 40 and 50.

Amblema neislerii was taken at all 10 areas surveyed using quantitative methods (Table 3). This species comprised nearly 37% of the mussel fauna and approximately 30% of the quadrats had at least one individual present. It is unusual to have an endangered species dominate the mussel assemblage. For example, the endangered *Lampsilis higginsii* comprises approximately 0.5% of the mussel fauna in the upper Mississippi River (Miller and Payne 2007, and references cited therein) and the Endangered *Plethobasus cooperianus* comprises approximately 0.1% of the mussel fauna at a dense and species-rich site in the lower Ohio River (Miller et al. 1986, Payne and Miller 2000).

Density of dominant bivalves in the Apalachicola River. Total mean density of *A. neislerii* ranged from 0.2 to 12.7/m^2 (Table 4). The maximum number of *A. neislerii* in a single quadrat at site DM14 was 13 individuals, corresponding to a density of 52/m^2. At the 10 sites surveyed, total mean density (all species) ranged from 2.4 to 28.9 individuals/m^2. Compared with other medium-sized to large rivers, total mussel density in the Apalachicola River is moderate to low. It is not unusual to find total densities of 50 to 100 individuals/m^2 at sites in the upper Mississippi River (Miller and Payne 2007), and lower Ohio River (Payne and Miller 1989). At a single site in the Sunflower River, MS, average mussel density at one site was greater than 200 individuals/m^2 (Miller and Payne 2004).

A summary of the mean density of *A. neislerii* in each area, as well as density trends from up- to downriver and from near to farshore, appears in Figure 5a. Although there are substantial density differences among the 10 study areas, there are only minor density differences moving up- to downriver (Figure 5b) or near-to-farshore within sites (Figure 5c).

Total mean density of the *C. fluminea* greatly exceeded that of native species at most areas and was greater than 1,000 individuals/m^2 at one location. There was no strong negative or positive relationship between numbers of *C. fluminea* and total number of mussels (Figure 6). The widespread concern that Asian clams exclude native mussels is not well-supported by data (Miller and Payne 1994).

Estimating population size of *A. neislerii* in the study area. Qualitative and quantitative data were used to predict density of *A. neislerii* from CPUE ($Y = 0.28X - 0.77$; $R^2 = 0.59$) for sites where only CPUE data were obtained (Table 5). If only a 1-m strip (to a water depth of approximately 50 cm) of live *A. neislerii* existed along the shore at each location surveyed between NM 40 and 50, then the total population size at all 25 sites would be 19,000 individuals. (Because of extremely high standard deviations (Table 4) the 95% confidence interval will exceed mean values in most cases. Therefore, there could be considerable error (either positive or negative) for predictions using these data). It is likely that this strip is wider than 1 meter and extends into deeper water. Results of a study conducted in 2003 indicated that while maximum densities were at 1.2 m, *A. neislerii* could be found up to 2.7 m deep (Figure 7). This is an additional 1.5 m of depth beyond that which was sampled during the present survey. Therefore, the total population of *A. neislerii* at these 25 locations probably exceeds 19,000 individuals. In addition, this figure does not include other sites both in and outside the study reach that also support *A. neislerii*.

Recruitment. There was evidence of strong recent *A. neislerii* recruitment (Figure 8). Of the 166 *A. neislerii* collected, total shell length ranged from 11.7 to 76.4 mm (mean = 50.6 mm). Cohorts of small mussels were centered at 17.5 and 42.5 mm. Furthermore, at least one individual with a shell length less than 20 mm was noted at 7 of the 10 sites. Additional sampling to increase the number of individuals collected would likely yield evidence of recent recruitment at all sites. Based on sampling conducted in 2007, as well as 1996, 1997, 1999, 2001, 2002, and 2003, *A. neislerii* regularly recruits in the river.

Elevation Profiles. There was no significant relationship between steepness of bank slope and CPUE of *A. neislerii* (Figure 9). Elevation profiles were relatively similar among sites whether they had poor, good, or very good mussel assemblages (Figure 3).

Relationship between sediment characteristics and mussel distribution. The relationship between CPUE for *A neislerii* and total mussels versus size of sediment particle appears in Figure 10a (% sediments < 0.075 mm in diameter), and 10b (% sediments >= 2 mm in diameter). Grain size distribution data indicate that mussels become slightly more abundant as the percentage of smaller-sized particles increases (Figure 10a). Conversely, mussels are most abundant when the percentage of larger-sized particles, >= 2.0 mm, is the least.

The relationship between CPUE for *A neislerii* and total mussels versus sediment characteristics appears in Figure 11a (% moisture content), and 11b (% organic content). These figures illustrate that there was a tendency for mussels to be most abundant in sediments with slightly higher moisture and organic content. Both sets of relationships further illustrate that mussels tend to be slightly more abundant in moderately depositional areas, for example in eddies located immediately downriver of point bars. Sediments in theses moderately depositional areas would be of slightly higher organic and moisture content and smaller diameter than sediments in erosional areas where these species tend to be less dense.

Effects of low water on mussels in the mainstem Apalachicola River. Low water in the Apalachicola River in 2006 and 2007 caused shallow, nearshore areas along many reaches to be exposed to the atmosphere. Observations by resource personnel indicated that many mussels were killed by either exposure, predation, elevated temperatures, or reduced dissolved oxygen. While mussels have the ability to move, many were trapped and did not reach deeper water. Regardless, most thick-shelled mussel species have the ability to withstand limited exposure and survive low water. If sediments are moist and ambient temperatures stay low because of shading or groundwater input, some can stay alive for weeks or longer.

Because of recent low water, considerable mussel mortality was observed at the mouths of sloughs and in associated swales along the margins of the main channel. It is unlikely that an uncommon event, such as high river discharge or wind, transported mussels into these areas. By 2007, the swale habitat at DM 14 and DM 21 was covered with grass, willows, and other terrestrial plants; the presence of partially buried shells indicated that this habitat had supported permanent mussel assemblages. Sloughs that enter the river where an eddy is present will be affected by the increased sedimentation caused by current reversal and swirling water. Such sedimentation is a natural river process, most observable at low water.

The value of Swift Slough for freshwater mussels. Swift Slough is a distributary that exits the Apalachicola River along the left descending bank at NM 40.3. It flows east and south, and then joins the Styx River, which enters the Apalachicola River at NM 35.4. Swift Slough disconnects from the Apalachicola River at 5,100 cfs on the Chattahoochee gage (Light 2006); therefore, at extreme low water most of the slough is dry except for pools of trapped water. If discharge in the Apalachicola River is high, Swift Slough carries considerable flow. High discharge can mobilize sand, silt, and freshwater mussels at the slough entrance and distribute them throughout the channel. Although *A. neislerii* and other mussels were found at several sites immediately upriver of the entrance to Swift Slough, these were low-density assemblages (Table 2).

EnviroScience (2006a) reported that in Swift Slough *A. neislerii* comprised 19.8% of the unionid fauna. Average CPUE (per hour) was 16.8 (maximum = 228) and average mussel density (all species) was 5.35/m^2. These data can be compared with results obtained during the present study. At virtually all sites between NM 40 and 50, *A. neislerii* dominated the assemblage and typically comprised nearly 37% of the native mussel fauna. Catch per unit effort for all mussels at the 25 sites ranged from 0 to 1,080 (average = 312), and CPUE for *A. neislerii* ranged from 0.0 to 774 (average = 162). Mean *A. neislerii* density ranged from 0.2 to 12.7 individuals/m^2 (average = 3.7, standard deviation = 3.7) and total unionid density ranged from 2.4 to 36.0 (average = 11.9, standard deviation = 11.2). The highest number of *A. neislerii* in a single 0.25m^2 quadrat was 13, corresponding to a density of 52 individuals/m^2. Catch per unit effort at 25 sites ranged from 0 to 774 for *A. neislerii* and from 9 to 1,080 for total mussels.

In a later study, EnviroScience (2006b) divided the upper mile of Swift Slough into thirty-five 50-by-9-m reaches and randomly chose six for quantitative sampling. Two could not be effectively sampled because of poor substratum so they were sampled semi-quantitatively. Mean density of *A. neislerii* in the four reaches was estimated to be 4.4, 0.9, 1.4 and 0.0 individuals/m^2. The total number of *A. neislerii* in each reach was estimated to be 1,983, 431, 644, and 90 (the latter value was based on a conservative estimate of density at 90% confidence based on non-detection of species). The mean (787) was multiplied by 23, the number of reaches in which the density estimates applied (two of the six reaches were inappropriate for sampling). The total population size was estimated to be 18,101 (10,626 – 33,879 individuals). An additional 1,809 *A. neislerii* were estimated to be in the remaining 12 reaches. Values include live and fresh dead mussels, but not 'weathered dead' (EnviroScience (2006b)).

These high numbers surprised some resource personnel since it had been assumed that *A. neislerii* was nearly extirpated from the basin (see literature review above). Some resource personnel expressed the belief that Swift Slough was a major and significant source of *A. neislerii* in the Apalachicola River.

Since the slough was essentially dry in the summer and fall of 2006 and the spring and summer of 2007 it is not possible to make additional population estimates; however, results of the previous survey should be viewed with some caution (as the authors recommend). First, very small amounts of benthic habitat were actually examined. Only 2.5% of each of the four reaches, and only 0.3% (45 of 15,750 m^2) of the 1-mile section was sampled. This is significant because low density zones could have been missed since such a low percentage of the habitat was searched. Second, this was not a stratified design in which the number of samples collected was proportional to habitat types. It is unclear if the set of 45 samples were representative of conditions in that reach, or if the six reaches characterized the 1-mile segment. If non-representative areas were searched, then it would be incorrect to extrapolate these data to the entire reach of the slough. Finally, the number of samples required to estimate density with a specified confidence was not determined. Because of high variance-to-mean ratio, the number of quantitative samples needed to estimate density of desired precision and specified chance of being incorrect can be extremely high (see Green 1979). For example, results of studies in the upper Mississippi River by the Wisconsin Department of Natural Resources (2004) indicated that the number of 0.25 m^2 quadrats needed to reliably estimate density of *L. higginsii* can exceed several thousand. It is likely that too few samples were obtained in each reach of Swift Slough to estimate mean density with suitable precision or confidence. Of course the same criticism of course can be made for the sample design for this survey.

As a result of low rainfall during 2006 and 2007, discharge in the Apalachicola River declined and its connection with Swift Slough was severed. Investigations in 2006 and 2007 revealed that large quantities of coarse sand, to a depth of 30 cm or more, had been carried into the slough channel. The sand probably originated at the entrance to Swift Slough and the Apalachicola River. It buried most of the mussels that were censused in 2005 and 2006 by EnviroScience, Inc. Several visits to Swift Slough in early 2007 revealed only a few shells in the channel, although there were some live and dead mussels in shallow pools.

Observations made during low water in 2006 and 2007 caused some to hypothesize that large numbers of adult mussels, including *A. neislerii*, were carried into Swift Slough from the Apalachicola River during periods of high discharge. Any mussels transported down the channel probably originated at the very head of the slough, not in the Apalachicola River. There are no known high-density *A. neislerii* populations immediately upriver of Swift Slough. Catch per unit effort for *A. neislerii* at seven locations between NM 40.3 and 42.2 (closest sites to the mouth of the slough) were all less than 50 (Table 2). The next dense *A. neislerii* assemblage (CPUE = 354) was at NM 43.0, 2.7 miles upriver. It is unlikely that mussels from these populations were carried by high water down the Apalachicola River and then into Swift Slough. It is not unreasonable to assume that mussels colonize Swift Slough like they do all waterbodies; from host fish. It is of course possible that some mussels in the upper reach of the slough are mobilized during high water and dispersed downstream in the slough. Some mussels could survive this translocation, although it is likely that many would be buried in sediments.

The report by EnviroScience (2006a) illustrates the low value of sloughs for native mussels; only Swift Slough supported substantial populations prior to the drought. It is unclear exactly how many *A. neislerii* were in Swift Slough prior to the low water. Regardless, it is difficult to imagine that a 1-mile segment of ephemeral habitat contributed substantially to *A. neislerii* populations in the river. This species is abundant and shows good evidence of recent recruitment at many sites, regardless of the recent low water. There is no reason to believe that a 3,000 m slough could be of much value for a species that is remarkably abundant in moderately depositional habitats that are common in the main stem of the river.

Discussion

As illustrated by results of this and previous surveys high density, recruiting populations of *A. neislerii* exist in the Apalachicola River and probably always have. Although intensive searching nearly always yield a few specimens even in poor habitat, this species reaches its greatest numerical abundance in moderately depositional sites immediately downriver of point bars in the middle reach of the river. As described above, eddies typically develop in these areas, which could further concentrate fine-grained sediments, organic matter, and if present, glochidia larvae. If earlier workers had access to powerboats and divers and conducted intensive and extensive surveys at appropriate locations, they would have also concluded that *A. neislerii* was common-to-abundant. An alternative hypothesis is unlikely. It is difficult to believe that *A. neislerii* was previously uncommon in the Apalachicola River and that it has become more abundant during the last 30 years. Although Swift Slough has supported moderately dense populations, typically sloughs and tributaries do not provide long-term mussel habitat.

Amblema neislerii is most abundant close to shore and becomes less common moving offshore (Miller and Payne 2005b, EnviroScience 2006a). The pooled reaches between NM 80 and 70, 50 and 40, and 30 and 20 likely relate to hydrodynamic conditions that can affect mussel distribution (Benda et al. 2004). In the present study, high-density assemblages were found in the pooled section upriver of the constriction at NM 41.5 (see Figure 2b). Previous studies have identified high-density assemblages at NM 73.3 and NM 30, also pooled reaches (Miller and Payne 2005a). This relationship could be investigated during subsequent monitoring and modeling (see Appendix A). An examination of the hydrodynamic forces that operate at various scales throughout the entire river would provide a better understanding of the *A. neislerii* distribution and density.

In the Apalachicola River, like all rivers, mussel distribution is influenced by fish behavior, flow pattern, and velocity. If currents are too erosional, juvenile mussels cannot settle, and if they do, survival is poor. If immature mussels are dropped in reaches with excessive sedimentation, they can be buried and killed. Juveniles almost certainly are more susceptible than adults to sediment accretion and scour. Mussel collections and observations tend to be made mostly in summer and fall at low water. Yet recruitment, which affects adult distribution, usually occurs in periods of higher flow in the spring. The physical effects of water velocity, when integrated over many years, define water depth, sediment characteristics, bank slope and the nature of the riparian community. Regardless, unionid abundance and distribution in rivers is dependent upon flow characteristics at large and small scales (Strayer et al. 2004). The proposed long-term monitoring plan, which will include sediment and velocity modeling, will provide a better understanding of the distribution and abundance of *A. neislerii* in the Apalachicola River (See Appendix A).

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Table 1. Summary information on study areas in the Apalachicola River, 7-11 June 2007. See also Figure 1 and Figures B1 – B4, and Table B1, Appendix B. (Reach length measurements were provided by USFWS).

NM	Bank	Location	Bank	Waypoints	Survey Type	Length, m
40.3	RDB	DSDM01	RDB	143-144	Partial	No data
40.4	RDB	DM01	RDB	141-142	Partial	64.2
40.5	LDB	DM'09	LDB	134-139	Detailed	40.6
40.6	LDB	DM10	LDB	128-133	Detailed	78.4
41.0	LDB	DM11	LDB	186-187	Partial	85.2
41.3	LDB	DM12	LDB	168-169	Partial	192.3
41.7	LDB	DM13	LDB	166-167	Partial	68.5
42.1	RDB	DM'03	RDB	164-165	Partial	41.9
42.2	LDB	DM'02	LDB	162-163	Partial	238.5
42.7	LDB	DM'04	LDB	152-153	Partial	40.9
42.8	RDB	DM'05	RDB	145-151	Detailed	127.0
43.0	LDB	DM'06	LDB	156-161	Detailed	90.9
43.1	LDB	DM'07	LDB	154-155	Partial	67.4
43.4	RDB	DM'08	RDB	180-185	Detailed	144.2
43.9	RDB	DM15	RDB	201-206	Detailed	212.6
44.3	LDB	DM14	LDB	188-193	Detailed	77.0
44.5	RDB	DM16	RDB	170-175	Detailed	87.8
45.5	LDB	DM17	LDB	176-177	Partial	169.2
46.0	RDB	DM18	RDB	222-227	Detailed	66.5
46.4	LDB	DM19	LDB	196-197	Partial	159.5
46.9	RDB	DM20	RDB	207-208	Partial	No data
47.4	RDB	DM21	RDB	209-210	Partial	277.5
47.5	LDB	DM22	LDB	214-215	Partial	217.3
48.2	LDB	DM23	LDB	216-221	Detailed	107.9
48.7	RDB	DM24	RDB	228-229	Partial	101.0
49.6	RDB	DM26	RDB	230-231	Partial	309.9

Table 2. Results of qualitative sampling (10- or 20-min timed searches) for mussels at 25 areas between NM 40 and 50, Apalachicola River, 7-11 June 2007. Value judgments were based on frequency distribution of the data (also see Figure 4b).					
		A. neislerii		Total Mussels	
NM	Location	CPUE, hr	Value	CPUE, hr	Value
40.4	DM01	0	Poor	9	Poor
40.5	DM09	30	Poor	210	Good
40.6	DM10	3	Poor	72	Poor
41.0	DM11	48	Poor	84	Poor
41.3	DM12	18	Poor	48	Poor
41.7	DM13	0	Poor	66	Poor
42.1	DM03	12	Poor	54	Poor
42.2	DM02	144	Good	516	Very good
42.7	DM04	6	Poor	48	Poor
42.8	DM05	120	Good	294	Good
43.0	DM06	354	Very good	474	Good
43.1	DM07	486	Very good	906	Very good
43.4	DM08	84	Good	108	Good
43.9	DM15	522	Very good	671	Very good
44.3	DM14	558	Very good	684	Very good
44.5	DM16	84	Good	102	Good
45.5	DM17	11	Poor	215	Good
46.0	DM18	72	Good	414	Good
46.4	DM19	276	Very good	462	Good
46.9	DM20	258	Good	576	Very good
47.4	DM21	774	Very good	1,080	Very good
47.5	DM22	54	Poor	126	Good
48.2	DM23	6	Poor	42	Poor
48.7	DM24	132	Good	348	Good
49.6	DM26	18	Poor	420	Good

Table 3. Results of quantitative (0.25m^2 quadrat) samples at 10 areas in the Apalachicola River, Florida, 7-11 June 2007.

Species	Abundance	Percent Abundance	Occurrence	Percent Occurrence
A. neislerii	157	36.85	56	31.11
G. rotundata	95	22.30	45	25.00
L. teres	79	18.54	54	30.00
E. complanta	68	15.96	44	24.44
Q. infucta	7	1.64	4	2.22
V. villosa	7	1.64	5	2.78
T. paulus	5	1.17	4	2.22
E. icterina	4	0.94	4	2.22
E. crassidens	2	0.47	2	1.11
M. nervosa	1	0.23	1	0.56
P. grandis	1	0.23	1	0.56
Total Mussels	426			
Number of areas	10			
Transects / location	6			
Quadrats / transect	3			
Total number of quadrats	180			

Table 4. Mean density and standard deviation (Stdev) at 10 areas in the Apalachicola River, 7-11 June 2007.							
Area	**NM**	**Total Mussels**		***C. fluminea***		***A. neislerii***	
		Mean	**Stdev**	**Mean**	**Stdev**	**Mean**	**Stdev**
DM05	42.8	6.0	8.5	31.3	38.9	2.7	5.1
DM06	43.0	9.6	7.0	33.6	25.0	6.2	7.2
DM08	43.4	3.6	5.3	344.4	389.7	1.6	3.4
DM09	40.5	12.4	7.6	1,008.4	738.9	1.8	2.5
DM10	40.6	2.4	3.9	255.8	223.6	0.2	0.9
DM14	44.3	14.9	19.5	324.2	176.4	8.0	13.7
DM15	43.9	28.9	19.0	312.4	240.2	12.7	12.6
DM16	44.5	2.4	4.8	13.6	12.3	0.7	1.8
DM18	46.0	12.0	8.6	215.3	117.0	0.9	3.0
DM23	48.2	2.4	2.8	16.7	22.6	0.2	0.9

Table 5. Estimated population sizes based on regression analysis of 25 areas between NM 40 and 50, Apalachicola River, 7-11 June 2007.

	A. neislerii			Estimated
Site	**CPUE/hr**	**Predicted Density**	**Length, m**	**Density Width = 1 m**
DM01	0.0	0.8	64.2	0
DM02	144.0	4.8	238.5	1,145
DM03	12.0	1.1	41.9	46
DM04	6.0	0.9	40.9	38
DM05	120.0	4.1	127.0	524
DM06	354.0	10.7	90.9	971
DM07	486.0	14.4	67.4	970
DM08	84.0	3.1	144.2	450
DM09	30.0	1.6	40.6	65
DM10	3.0	0.9	78.4	67
DM11	48.0	2.1	85.2	180
DM12	18.0	1.3	192.3	245
DM13	0.0	0.8	68.5	0
DM14	558.0	16.4	77.0	1,262
DM15	522.4	15.4	212.6	3,273
DM16	84.0	3.1	87.8	274
DM17	10.7	1.1	169.2	181
DM18	72.0	2.8	66.5	185
DM19	276.0	8.5	159.5	1,356
DM20	258.0	8.0	0	0
DM21	774.0	22.4	277.5	6,228
DM22	54.0	2.3	217.3	496
DM23	6.0	0.9	107.9	101
DM24	132.0	4.5	101.0	451
DM26	18.0	1.3	309.9	395
Total			3,066	18,906

Figure 1. Areas surveyed for mussels in the Apalachicola River, NM 40 – NM 50, 7-11 June 2007. For more details, see Table B1 and Figures B1 – B4, Appendix B.

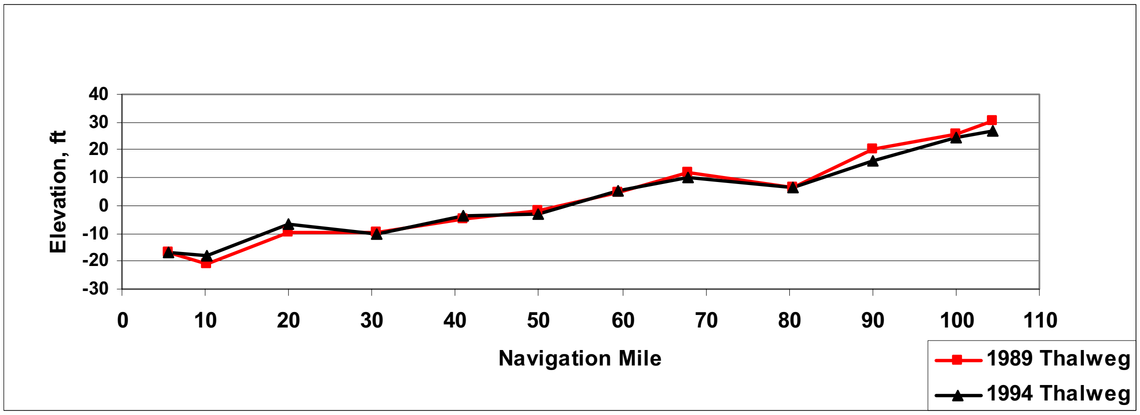

Figure 2a. Elevation profile of the Apalachicola River.

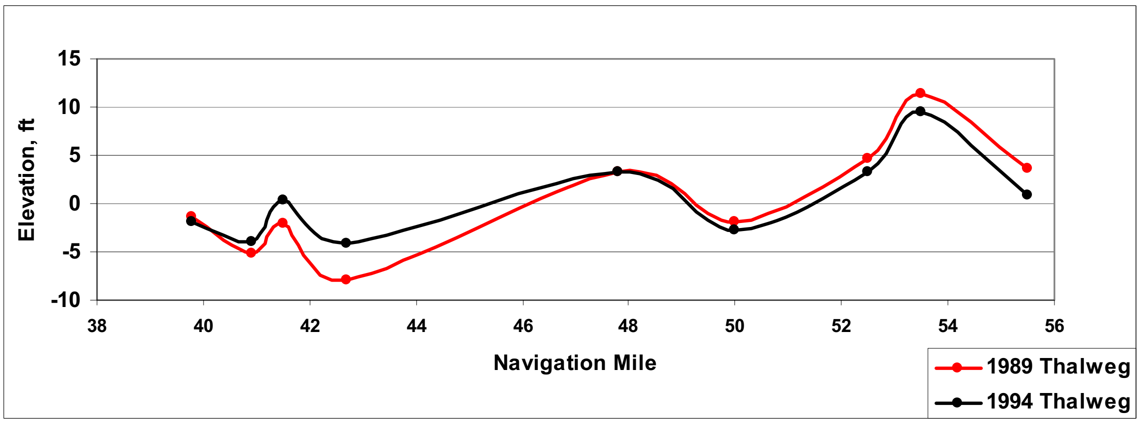

Figure 2b. Elevation profile of the study area, Apalachicola River.

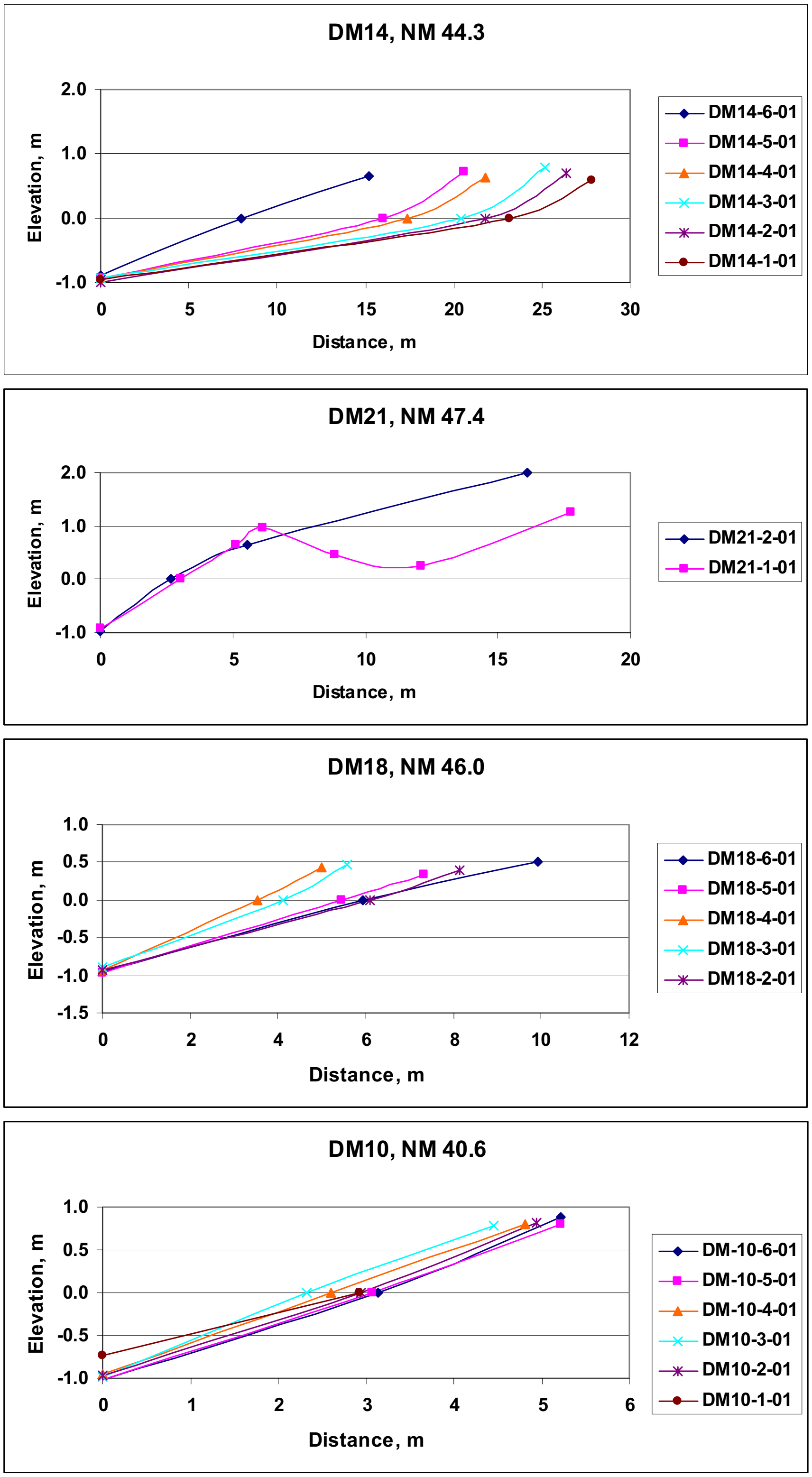

Figure 3. Elevation profiles at DM14 and DM21 (very good habitat), DM18 (good habitat), and DM10 (poor habitat) for *A. neislerii.*

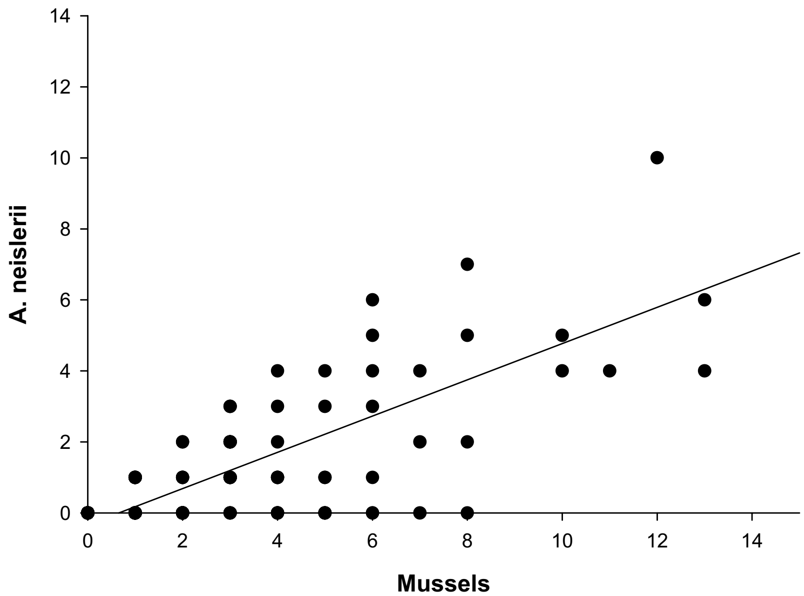

Figure 4a. Relation between total number of mussels and total number of *A. neislerii* (Y= 0.5X – 0.335; R^2 = 0.68).

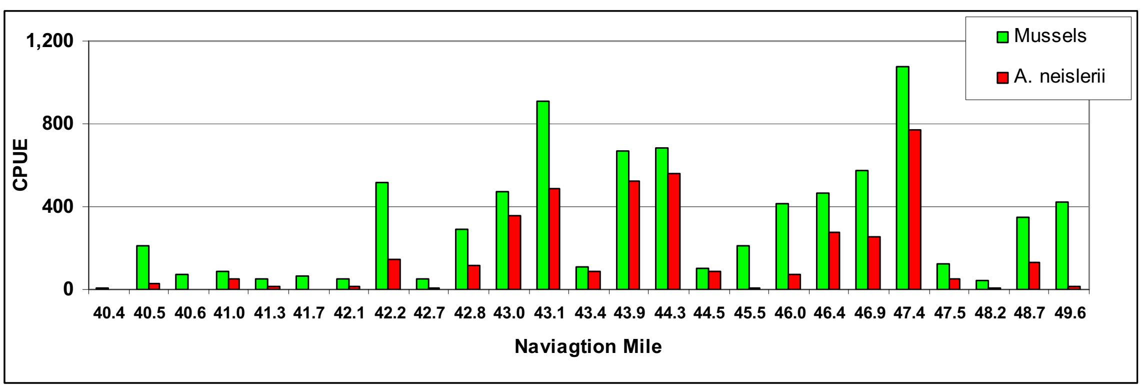

Figure 4b. Catch per unit effort for *A. neislerii* and all mussels at 25 areas, Apalachicola River, 7-11 June 2007.

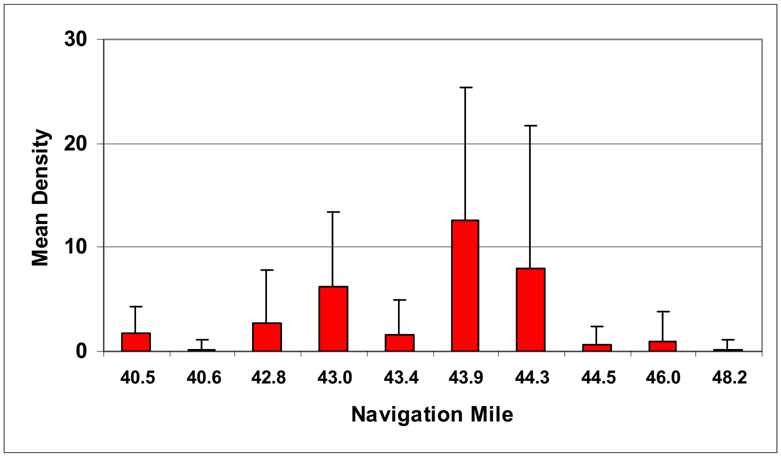

Figure 5a. Mean density of *A. neislerii* at 10 sites in Apalachicola River, 7-11 June 2007.

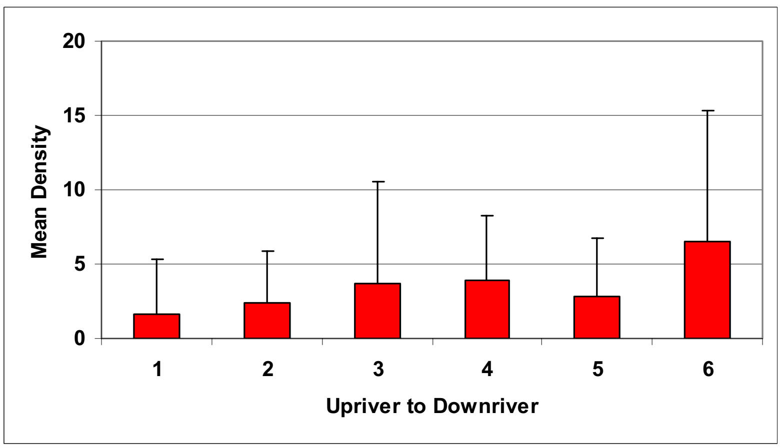

Figure 5b. Pooled within site variation in up-to-downriver density of *A. neislerii,* Apalachicola River, 7-11 June 2007.

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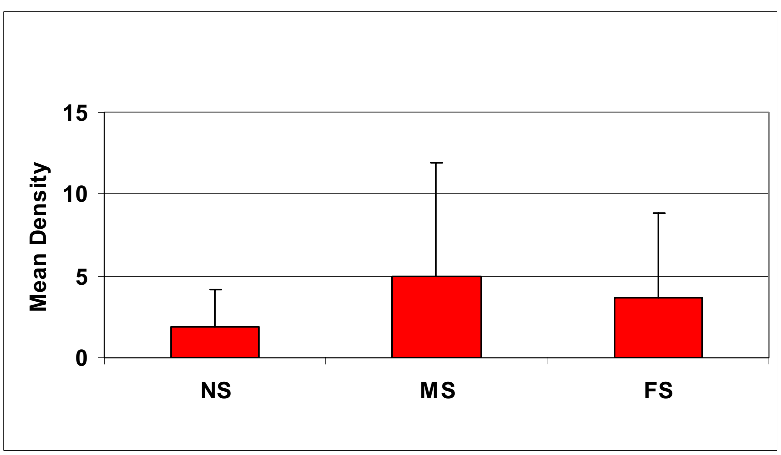

Figure 5c. Pooled within site variation in nearer-to-farshore density of *A. neislerii,* Apalachicola River, 7-11 June 2007.

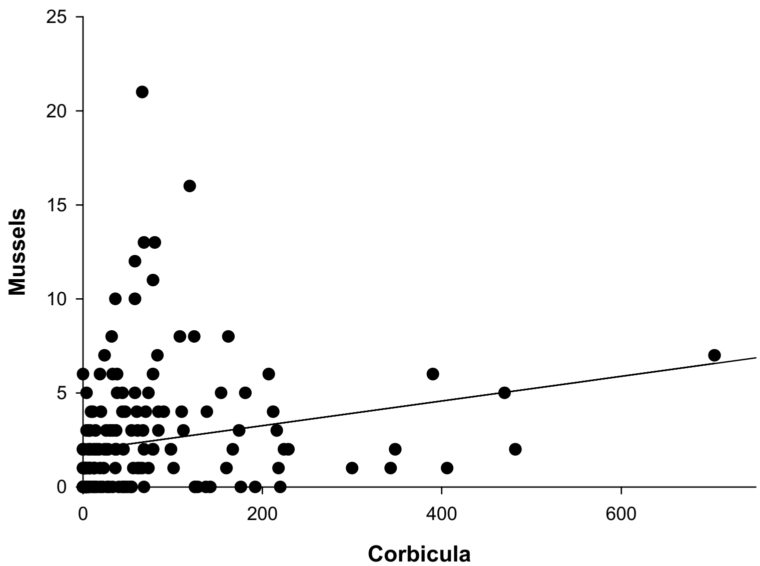

Figure 6. Relation between total number of *C. fluminea* and total number of mussels, Apalachicola River, Florida, 7-11 June 2007 (Y = 0.006X + 1.9; R^2 = 0.38).

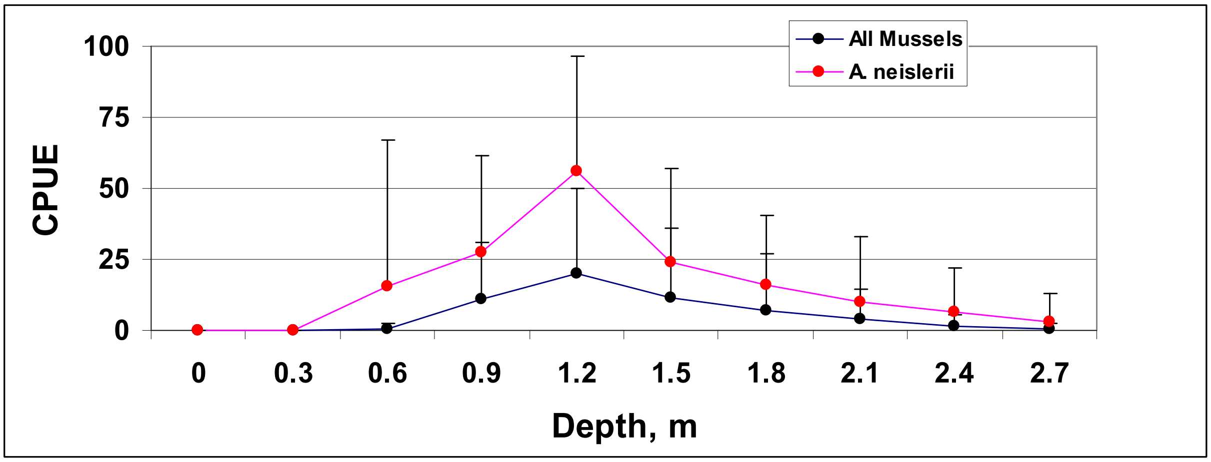

Figure 7. Relationship between abundance of all mussels and *A. neislerii* at multiple locations in the Apalachicola River, FL, 2003. During the survey period gage height and discharge at Blountstown (NM 78) was 3.63 ft, 9,420 cfs (18 Nov 03), 4.17 ft, 10,300 cfs (19 Nov 03), and 4.94 ft 11,500 cfs (20 Nov 03). (Taken from Miller and Payne 2005a).

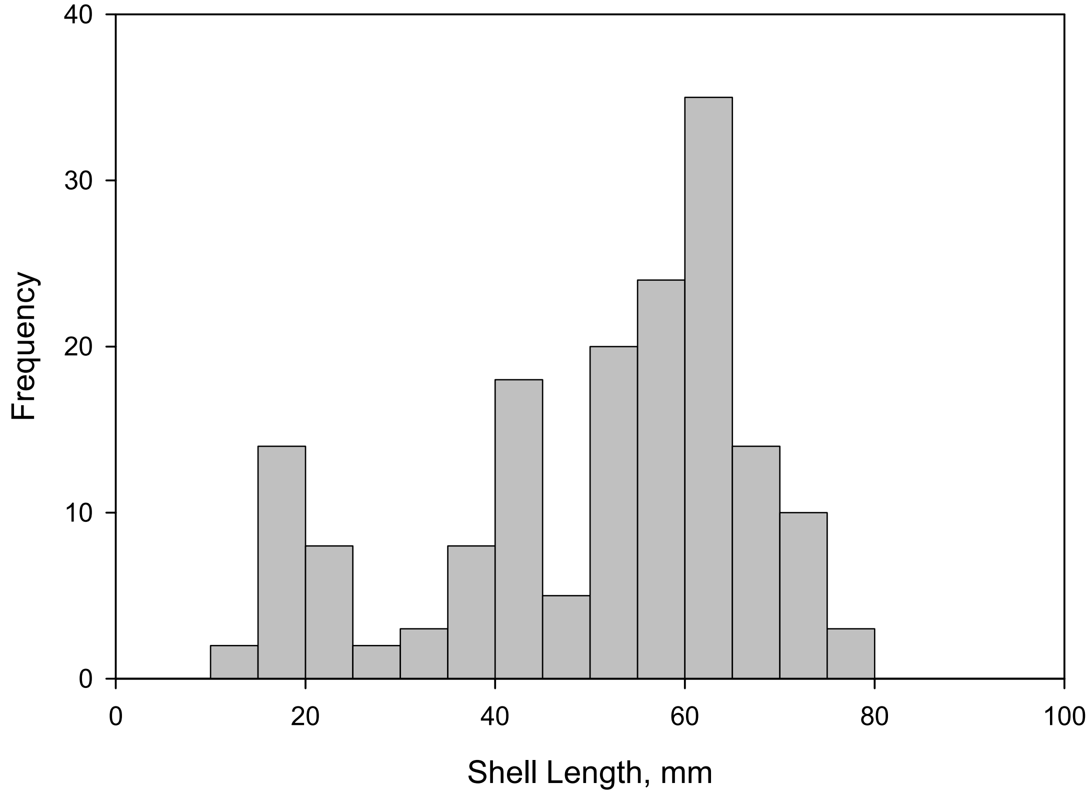

Figure 8. Length-frequency histogram for *A. neislerii,* Apalachicola River, FL, 5-7 June 2007.

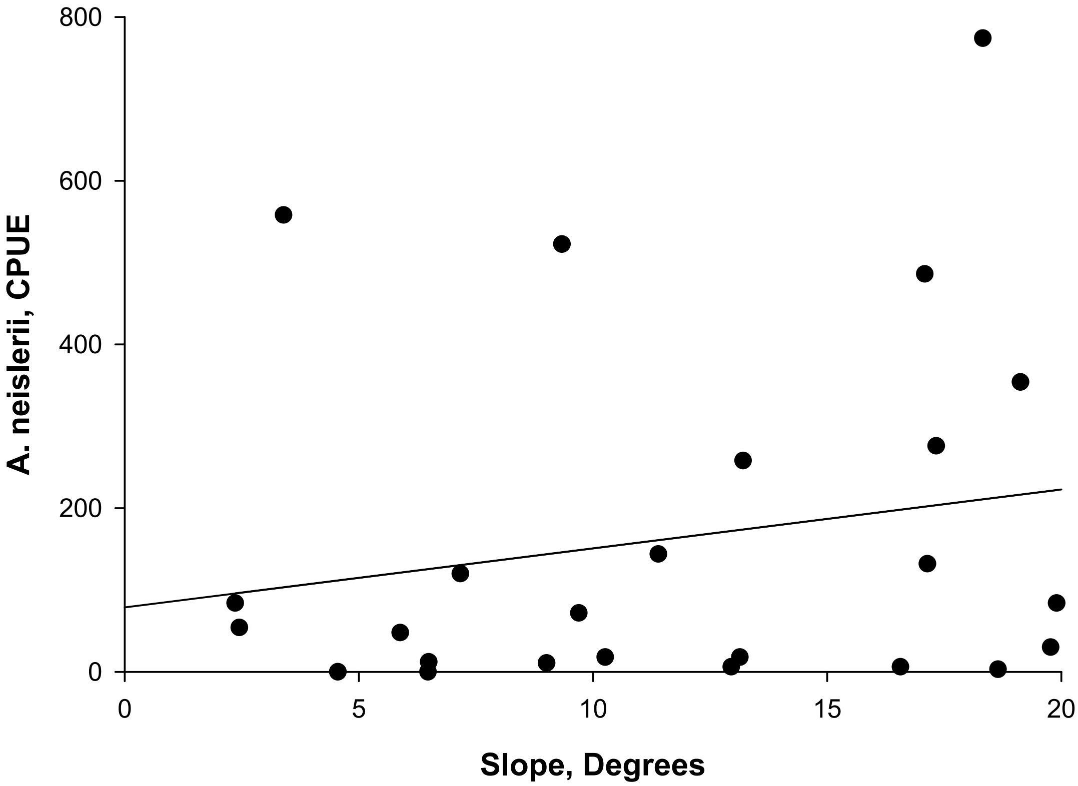

Figure 9. Relationship between bank slope and CPUE for *A. neislerii,* Apalachicola River, FL, 7-11 June 2007 (Y = 7.19X + 78.9; R^2 = 0.038).

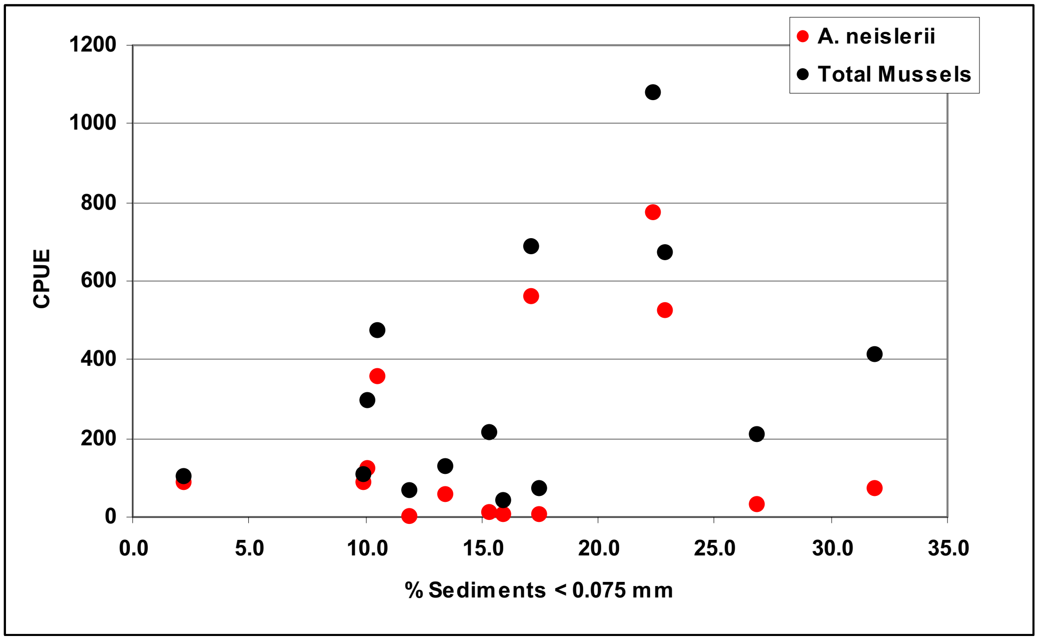

Figure 10a. CPUE for *A. neislerii* and total mussels versus percentage of particles < 0.075 mm.

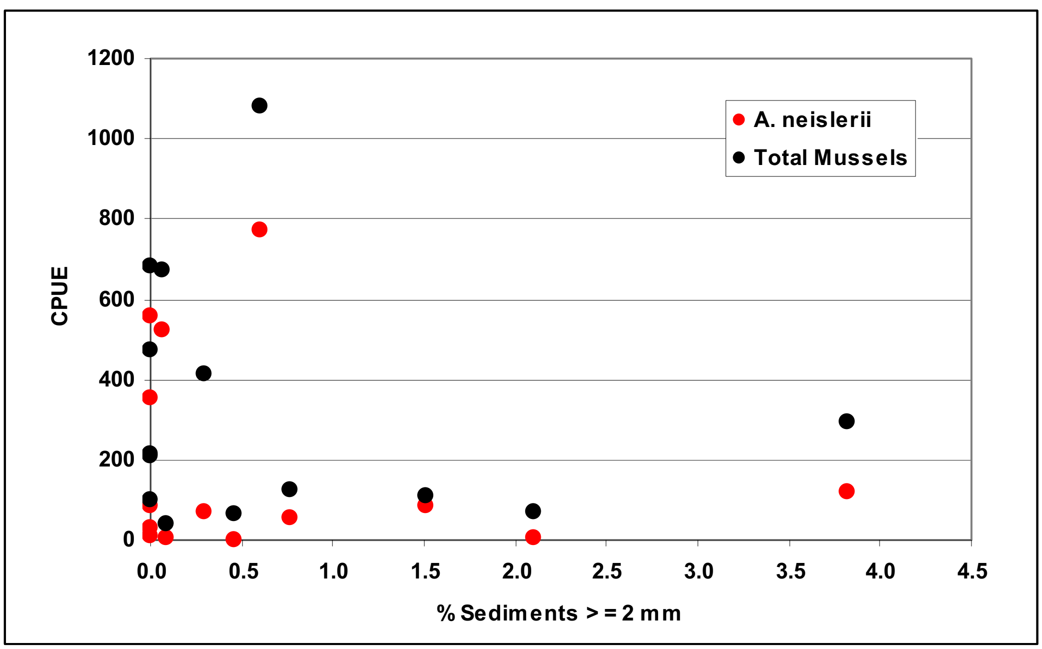

Figure 10b. CPUE for *A. neislerii* and total mussels versus percentage of particles >= 2 mm in diameter.

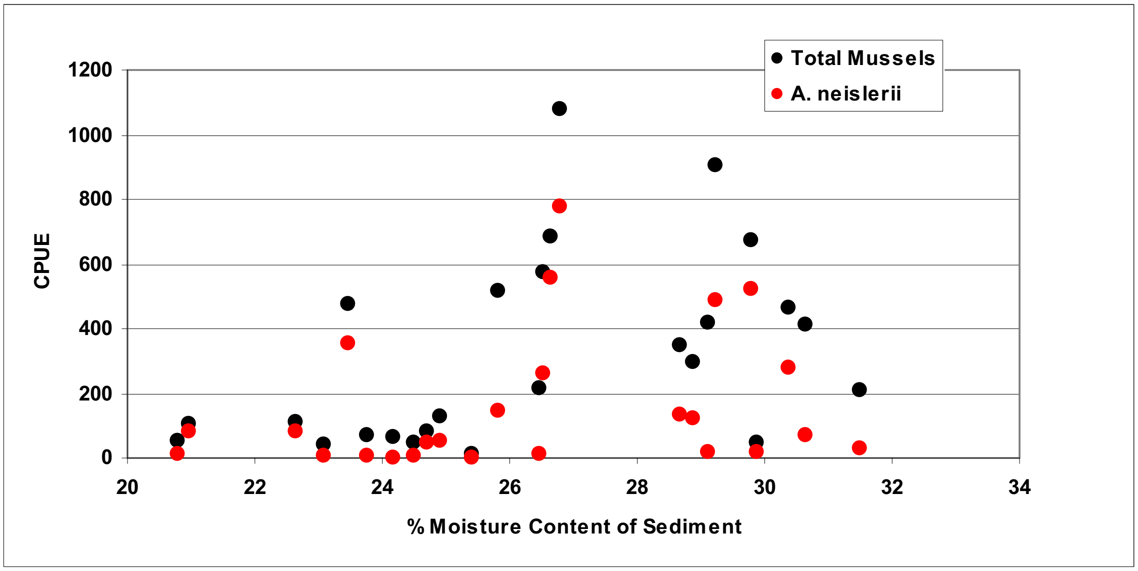

Figure 11a. CPUE for total mussels and *A. neislerii* versus percentage moisture content of sediments.

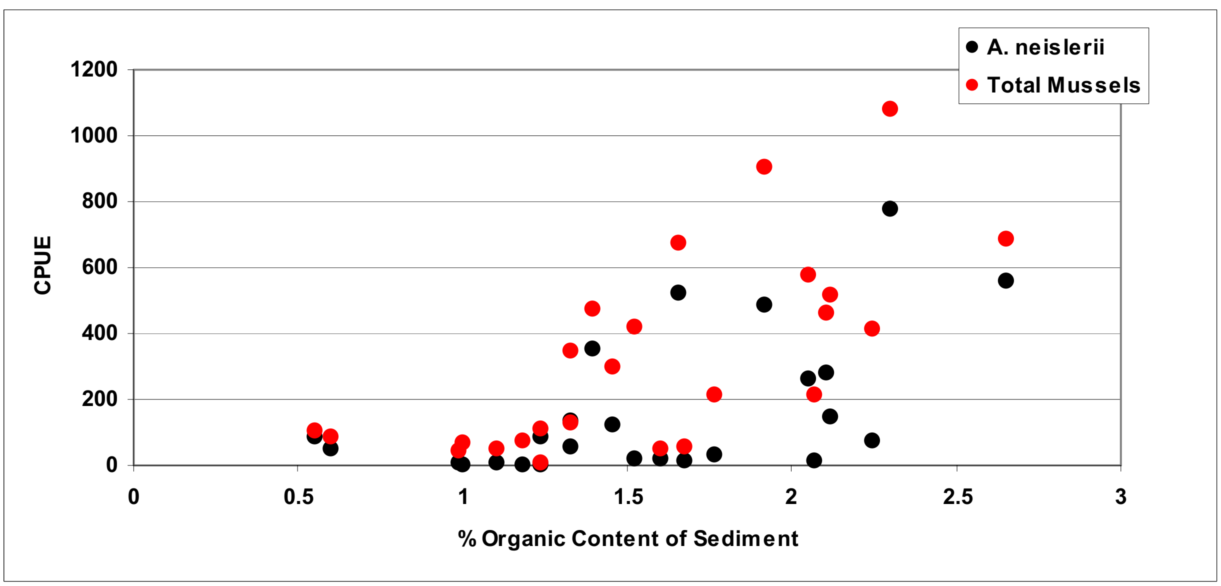

Figure 11b. CPUE for total mussels and *A. neislerii* versus percent organic content of sediments.

Technical Appendices

Appendix A. A Three-Phased Mussel Monitoring Program for the Apalachicola and Chipola Rivers, Florida

Appendix B. List of Waypoints

Appendix C. Maps of the Project Area

Appendix A

A Three-Phased Mussel Monitoring Program
for the Apalachicola and Chipola Rivers, Florida

Background. A meeting was held on 14 - 15 August 2007 with personnel of the Panama City Office of the US Fish and Wildlife Service (USFWS), US Army Engineer District, Mobile, US Army Engineer Research and Development Center (ERDC), as well as Dr. Mike Harvey (Mussetter Engineering, Inc.), Dr. David Biedenharn (Biedenharn Group, LLC), and Dr. Andrew Miller (Ecological Applications). The purpose was to discuss a strategy to address Reasonable and Prudent Measures (RPMs), recommended by the USFWS in their Biological Opinion (BO) for the Mobile District water management operations at Jim Woodruff Dam and associated releases to the Apalachicola River. The intent of an Interim Operations Plan (IOP) is to minimize impacts to and provide support for the federally-protected Gulf sturgeon and mussel species (specifically, *Amblema neislerii*, *Elliptoideus sloatinanus*, and *Elliptio chipolaensis*) in the Apalachicola and Chipola rivers, FL. The two RPMs of concern, taken from the BO, are:

RPM4 – Sediment dynamics and channel morphology evaluation. The goals are to identify 1) feasible water and/or habitat management actions that would minimize listed mussel mortality; 2) current patterns and trends in (river) morphological changes; and 3) additional information needed, if any, to predict morphological changes that could affect federally-protected mussels.

RPM5. Monitoring – Monitor the level of take associated with the IOP and evaluate ways to minimize take by studying the distribution and abundance of federally-protected mussels in the action area. The goals are to 1) periodically estimate total abundance of federally-protected mussels in the action area; 2) determine the fraction of the population that is located in habitats that are vulnerable to low-flow impacts.

Long-Term Mussel Monitoring. At the meeting it was decided that a three phased, long-term monitoring study would be required to meet these RPMs. Although many mussel studies have been conducted on the Apalachicola River by the USACE, state of Florida, and USFWS, this proposed monitoring plan would be the first comprehensive study designed to 1) document overall numbers of federally-protected species (within specified confidence limits); and, 2) intensively study biotic and physical processes at selected locations.

The three study phases are: 1) Describe the location and aerial extent of mussel habitats that are particularly vulnerable to low flow; 2) Estimate the total abundance of federally-protected mussels in the Apalachicola and Chipola Rivers, Florida, and 3) Relate mussel abundance and distribution to geomorphic processes at specific sites in the Apalachicola River. The purpose of the first phase will be to determine if the surface area of vulnerable habitats are a substantial proportion of aquatic habitats that support *A. neislerii*. The purpose of the second phase is to provide an overall estimate of the total number of federally-protected mussels in the Apalachicola and Chipola rivers. This information will assist planners determine the best strategies for protecting these organisms during low water. The purpose of the final phase is to more thoroughly understand biotic and physical processes at three or more high-quality mussel beds in the Apalachicola River. This will be used to understand the effects of dynamic riverine processes (sedimentation, benthic scour, channel migration) on the long-term survival of mussel populations. This final phase will explore relationships reported in related studies by Benda et al. (2004), Graf and Qu (2004), Morales et al. (2006), and Gangloff and Feminella (2007).

The following is a brief description of the three phases of this plan. A detailed study plan for these three phases will be developed in 2007-08 that will specify number and location of study sites and number of samples to be collected. The final plan will be sent to the biologists and planners in the USFWS and State of Florida for their comment and possible cooperation. Studies will begin in 2008. All study efforts are dependent upon the availability of funds by Congress.

Phase I: Describe Location and Aerial Extent of Mussel Habitats that are Particularly Vulnerable to Low Water

Background. In 2005 - 2007 resource personnel identified sites along the Apalachicola River where large numbers of native mussels had been killed by aerial exposure due to low water caused by reduced rainfall. Most sites were in low areas (swales) immediately adjacent to the main channel. Evidently, when water level dropped, resident mussels were trapped and died. Water levels also declined in the main channel, however it is believed that those mussels were able to move into deeper water and survive. Resource personnel felt that these swales were particularly vulnerable to low water. They also felt that the USACE might be able to develop management strategies that could alleviate this problem.

Purpose: The purpose is to locate vulnerable areas along the Apalachicola River, measure their surface area, and estimate the nature and extent of native mortality in each. Work will be accomplished by the completion of the following tasks:

Task 1: Identify vulnerable habitats. Recent aerial photography taken during low water will be analyzed to determine the location and approximate size of vulnerable habitats. Each area will be visited, and an assessment of mussel mortality will be made by counting and measuring total shell length of each individual in 6 randomly placed 0.25 m^2 quadrats. (It must be recognized that density estimates under these conditions could not be representative due to 1) losses due to predation, 2) counting shells that were carried in by high water, and 3) losses due to organisms that were transported away by high water.

Task 2: Estimate the relative percentage of vulnerable habitats. The total area of vulnerable mussel habitat along the river will be estimated. This value will then be compared with the total amount (linear extent) of existing mussel habitat based on surveys conducted in 2007, as well as 1996, 1997, 1999, 2001, 2002, and 2003 by personnel from ERDC as well as other studies conducted by EnviroScience, the USFWS, the USGS, and others.

The overall purpose of Phase I will be to identify habitats vulnerable to low water and to determine if reported mortality in these areas is substantial and likely to jeopardize federally-protected mussels. This phase of the work will provide information needed for RPM5.

Phase II: Estimate the Total Abundance of Federally-Protected Mussels in the Apalachicola and Chipola Rivers, Florida

Background. Low water in the Apalachicola River in 2005 - 2007 caused considerable mortality of *A. neislerii*, and likely two other species of federally protected mussels, *E. sloatianus*, and *E. chipolaensis*. Regardless, since the total number of these federally-protected species is not known, it is difficult to determine if mortality due to low water will have a substantial negative effect on survival of the population. For example, if stranded *A. neislerii* comprised a very small percentage of the total, then such mortality would have little effect on population survival. Conversely, if a substantial percentage of the population died as a result of low flow, then *A. neislerii* could be in jeopardy.

Purpose: The purpose is to estimate the population size of three federally-protected mussel species (*A. neislerii*, *E. sloatianus*, and *E. chipolaensis*) in the Apalachicola and Chipola rivers, Florida (action area). This information will be used to determine if observed mortality, due to recent strandings, is likely to have a substantial negative affect. This will be accomplished by completion of the following tasks:

Task 1: Identify mussel habitat types. Topographic maps and recent aerial photographs will be analyzed to identify and delineate the various types of aquatic habitats along the Apalachicola and Chipola rivers. Results of previously conducted mussel surveys by the ERDC, EnviroScience, USFWS, and others will also be consulted. It is likely that the following habitat types exist: 1) low-velocity, moderately depositional areas (eddies) downriver of point bars, 2) straight reaches with bank slope less than 45 degrees, 3) sharp bends with steep bank slopes, 4) sandy areas associated with point bars, 5) dike fields and other man made features, 6) tributaries, sloughs, backwaters, and distributaries; and, 7) the main channel or thalweg.

The purpose of this task is to identify all mussel habitats in both rivers. Since every river mile cannot be surveyed, representative habitats will be studied in some detail, and then results will be extrapolated to similar habitats in the project area.

Task 2: Develop a preliminary study plan. Based on constraints of time and budget, needs of resource personnel and the USACE, a preliminary study plan will be developed. The plan will describe the number of each habitat type (straight reaches, eddies downriver of point bars, etc.) that support mussels in the project area. In addition, the approximate number of sample areas within each habitat type will be estimated. This will be developed based upon a description of stratified random sampling in Strayer and Smith (2003), and the number of samples required to achieve a desired precision (Green 1979). For example, a desired precision could be +/- 10% or +/- 20% of the true mean. Results of previous studies by ERDC, EnviroScience, and others will be used for this task. Based on our understanding of conditions in the project area, it is likely that 3-5 habitat types could be chosen for study, and that 5-7 similar areas could be chosen in each habitat type. Therefore, from 15 to 35 areas in the Apalachicola and Chipola River could be identified for detailed study. In addition, it is likely that 2-4 different density strata (see Strayer and Smith 2003) exist in each habitat type. Between 50 and100 replicate ($0.25m^2$ quadrat) samples could be taken from each study area; as many as 3,500 individual samples could be required in all. Final values would depend on the desired precision, based on needs of resource personnel and availability of funds.

It could be decided that sampling every year in each area is not required. A sampling plan that includes sampling each area every second, third or fifth year could be acceptable. In this scenario, a subset of different areas could be surveyed each year. This would spread the costs and time required more evenly over the length of the project. A temporal sampling plan will be developed as part of this task.

Finally, a quality assurance/ quality control (QA/QC) protocol will be developed to assess completeness of the sampling plan. Results of detailed sampling will be used to determine if the number of samples actually collected will achieve the desired confidence level. In addition, a protocol will be established to analyze a subset of the sites that were not chosen for detailed study. This will be done to test the effectiveness of the site-selection process.

It is important to note that the purpose is not to conduct a general survey of a great number of sites, but to carefully select representative sites. Results from these representative sites will be extrapolated to the remainder of the project area.

Task 4: Conduct sampling. A brief reconnaissance of each study area will be conducted to identify and delineate the various strata within each habitat type. These strata could be delineated based on either biotic or physical conditions (Strayer and Smith 2003). A dive crew equipped with surface supplied air and communications equipment will collect mussels in deep water and a shore crew will collect in shallow water. It is anticipated that collecting and observations will take place along a set of transects (shallow to deep water) evenly placed along each study area. Divers will collect mussels along transects by touch while describing bottom conditions to the surface crew.

Based on results of the reconnaissance, a preliminary map of the strata defined by either physical or biotic conditions will be prepared. A global positioning system (GPS) will be used to mark coordinates and a pneumofathometer or fathometer will be used to measure depth. Sediment samples to assess moisture content, organic content, and grain-size distribution will also be obtained from each stratum.

Variance to mean ratios from previous sampling on the river will be used to estimate the total number of samples required in each strata to assess density within certain confidence limits (Green 1979). If necessary, a pilot study will be conducted to collect this information. Density will be characterized within each stratum with replicated, $0.25m^2$ total substratum samples. Collectors will excavate each quadrat to a depth of 10 – 20 cm and all substratum, to include shells and live mussels, will be taken to shore and sieved through a nested screen series (minimum mesh size approximately 6.4 mm). Live mussels will be identified, total shell length measured, then returned to the river unharmed. Quantitative sampling will provide density estimates by stratum and an unbiased assessment of size demography for common to abundant species.

After the quantitative sampling is completed, qualitative (timed searches) will be conducted within each stratum at each study area. The purpose is to obtain an estimate of Catch per Unit Effort (CPUE) and a more complete species list than can be obtained through the quantitative sampling.

Based on results of this task, a map of each area will be made that describes local conditions of habitat and mussel density. The estimated density in each stratum will be multiplied by the total area of habitat to obtain an estimate of the total number of mussels present (Strayer and Smith 2003). Results from all strata in each study area will be extrapolated to areas that have not been sampled. Ultimately, a reliable estimate (within desired confidence limits) of the total population density of the three species of interest in the project area will be obtained.

In summary, this phase of study will obtain the following:

1. A reliable estimate (within specified confidence limits) of the total population size of three federally-protected species (*A. neislerii*, *E. sloatianus*, and *E. chipolaensis)* in the project area. This information will be used to determine if low water in the project area is likely to negatively affect threatened species of mussels.

2. An assessment of mussel distribution, habitat preference, relative species abundance, species richness and diversity, total mean density, density of major taxa, and size demography of major taxa by stratum within each habitat type. This phase will provide information required for RPM5.

Phase III: Relate Mussel Abundance and Distribution to Geomorphic Processes in the Apalachicola River

Background. Dense and diverse mussel assemblages are usually found in moderately depositional zones in medium-sized rivers that are not negatively affected by erosion during high discharge or sediment deposition during low flow. Often these areas are found downriver of point bars or along straight reaches where flow is moderate. Since mussels can live 30 or more years, habitat must be suitable during high and low discharge.

One and two-dimensional models can be used to better understand geomorphic processes in flowing water systems. Knowledge of these geomorphic processes is important in understanding density and distribution of riverine mussel populations. For example, Sediment Impact Analysis Methods (SIAM) provides a framework for combining morphological, hydrologic, and hydraulic information that can be used to assess sediment movement through a watershed. In addition, hydrological transport models can be used to simulate river flow under various discharge conditions and ultimately can be used to estimate water quality parameters.

Purpose. The purpose is to apply sediment and hydrodynamic models to reaches of the Apalachicola River that support dense and species rich mussel assemblages. Knowledge of riverine geomorphic processes is needed to understand effects of reduced flow on the density and distribution of important mussel resources.

Task 1: Choose sites for detailed study. Based on results of the Phase I and Phase II of this research, plus requirements for successful application of water velocity and sediment models, three sites for detailed study will be chosen. Sites will be relatively similar with respect to mussel density and species composition, but dissimilar with respect to physical characteristics such as sinuosity, water depth, velocity, etc.

Task 2: Apply hydrodynamic and sedimentation models. The hydrodynamic model will be used to prepare a map of water velocity and direction for each study area. Maps will be prepared for low, moderate, and high discharge.

Task 3: Conduct mussel surveys. Maps developed in Task 2 will be used to identify collection sites. Sites will include the range of physical conditions (low, medium, and high quality) to meet physical requirements for mussels. Based on results of Task 2, Phase II, the number of samples needed to estimate density within specified confidence limits will be determined. Samples will be collected using quantitative methods as in Phase II, and all mussels will be identified, measured, then returned to the river unharmed.

Task 4. Growth Studies. A demographically complete collection (all sizes present) of *A. neislerii* will be obtained, measured, aged, marked, and then replaced in the sediment. Shells from a subset of collected specimens will be sectioned to obtain more reliable estimates of age. Marked specimens will be re-collected each year to assess growth. Data from mark-recapture studies will be used to develop relationships between shell length and ring counts, and to develop population models, for example the RAMAS model described by Akcakaya and Regan (2002) in *Ecological Modeling and Risk Assessment*.

Task 5: Relating physical and biological processes. This phase will provide quantitative data on *A. neislerii* density, population structure and recruitment strength, and relative species abundance with respect to important physical variables (water depth, velocity, and direction), and how these variables affect sediment accretion and erosion.

Studies will be conducted for multiple years to assess large-scale (e.g., river gradient and discharge) as well as small-scale (e.g., local sediment deposition and accretion) effects on *A. neislerii* density, relative species abundance, and recent recruitment. The physical models can be used to simulate geomorphic processes (sedimentation) which were noted during recent low water events.

In summary, Phase III will obtain the following:

1. Tools and techniques for relating information on water velocity, direction of flow, and ultimately shear stress and sedimentation patterns on density, distribution, recent recruitment, and relative abundance of common to abundant mussels including *A. neislerii.*

2. Detailed growth and density information on common to abundant mussel species, including the endangered *A. neislerii*, which can be used for detailed population modeling using software such as RAMAS.

3. Tools and techniques for simulating various geomorphic processes on this river, such as sedimentation and channel movement, on distribution and abundance of common mussels including *A. neislerii*.

Phase III of this monitoring plan will obtain information for RPM4.

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Appendix B. List of Waypoints

Table B1. Location of sites sampled for mussels along the Apalachicola River, Florida, 7-11 June 2007

Location	Bank	NM	Waypoint	Position
DSDM01	RDB	40.3	143	N30 07.125 W85 07.779
			144	N30 07.148 W85 07.795
DM01	RDB	40.4	141	N30 07.201 W85 07.899
			142	N30 07.197 W85 07.880
DM'09	LDB	40.5	135	N30 07.286 W85 07.895
			136	N30 07.285 W85 07.891
			137	N30 07.286 W85 07.888
			138	N30 07.285 W85 07.883
			139	N30 07.284 W85 07.881
			134	N30 07.285 W85 07.869
DM10	LDB	40.6	128	N30 07.263 W85 08.173
			129	N30 07.263 W85 08.151
			130	N30 07.267 W85 08.137
			131	N30 07.270 W85 08.126
			132	N30 07.271 W85 08.118
			133	N30 07.272 W85 08.105
DM11	LDB	41.0	186	N30 07.267 W85 08.353
			187	N30 07.266 W85 08.317
DM12	LDB	41.3	169	N30 07.407 W85 08.655
			168	N30 07.385 W85 08.647
DM13	LDB	41.7	167	N30 07.801 W85 08.597
			166	N30 07.790 W85 08.611
DM'03	RDB	42.1	165	N30 08.008 W85 08.296
			164	N30 07.985 W85 08.304
DM'02	LDB	42.2	162	N30 08.032 W85 08.207
			163	N30 08.004 W85 08.201
DM'04	LDB	42.7	153	N30 08.412 W85 08.168
			152	N30 08.406 W85 08.189
DM'05	RDB	42.8	145	N30 08.437 W85 08.042
			146	N30 08.447 W85 08.061
			147	N30 08.460 W85 08.092
			148	N30 08.468 W85 08.090
			149	N30 08.476 W85 08.099
			151	N30 08.482 W85 08.114
DM'06	LDB	43.0	161	N30 08.568 W85 07.816
			160	N30 08.560 W85 07.808
			159	N30 08.554 W85 07.803
			158	N30 08.547 W85 07.797
			157	N30 08.539 W85 07.793
			156	N30 08.531 W85 07.789
DM'07	LDB	43.1	155	N30 08.614 W85 07.902
			154	N30 08.608 W85 07.886
DM'08	RDB	43.4	180	N30 08.853 W85 08.350

			181	N30 08.847 W85 08.354
			182	N30 08.841 W85 08.357
			183	N30 08.834 W85 08.362
			184	N30 08.818 W85 08.371
			185	N30 08.798 W85 08.381
DM15	RDB	43.9	201	N30 09.104 W85 08.159
			202	N30 09.079 W85 08.170
			203	N30 09.048 W85 08.185
			204	N30 09.036 W85 08.194
			205	N30 09.018 W85 08.207
			206	N30 08.995 W85 08.225
DM14	LDB	44.3	188	N30 09.199 W85 08.056
			189	N30 09.191 W85 08.055
			190	N30 09.182 W85 08.055
			191	N30 09.175 W85 08.055
			192	N30 09.161 W85 08.055
			193	N30 09.148 W85 08.054
DM16	RDB	44.5	170	N30 09.444 W85 08.032
			171	N30 09.439 W85 08.041
			172	N30 09.436 W85 08.049
			173	N30 09.429 W85 08.058
			174	N30 09.423 W85 08.069
			175	N30 09.417 W85 08.077
DM17	LDB	45.5	176	N30 09.934 W85 08.206
			177	N30 09.911 W85 08.184
DM18	RDB	46.0	222	N30 10.284 W85 08.306
			223	N30 10.277 W85 08.323
			224	N30 10.281 W85 08.338
			225	N30 10.276 W85 08.348
			226	N30 10.270 W85 08.358
			227	N30 10.267 W85 08.367
DM19	LDB	46.4	196	N30 10.498 W85 08.060
			197	N30 10.478 W85 08.048
DM20	RDB	46.9	207	N30 10.898 W85 08.113
			208	N30 10.880 W85 08.154
DM21	RDB	47.4	209	N30 11.160 W85 07.553
			210	N30 11.135 W85 07.566
DM22	LDB	47.5	214	N30 11.413 W85 07.403
			215	N30 11.396 W85 07.408
DM23	LDB	48.2	216	N30 11.777 W85 07.229
			217	N30 11.772 W85 07.238
			218	N30 11.767 W85 07.246
			219	N30 11.749 W85 07.270
			220	N30 11.749 W85 07.272
			221	N30 11.735 W85 07.285
DM24	RDB	48.7	228	N30 12.200 W85 06.999
			229	N30 12.173 W85 06.979
DM26	RDB	49.6	230	N30 12.689 W85 07.019

			231	N30 12.693 W85 07.060

Appendix C: Detailed Maps of the Project Area

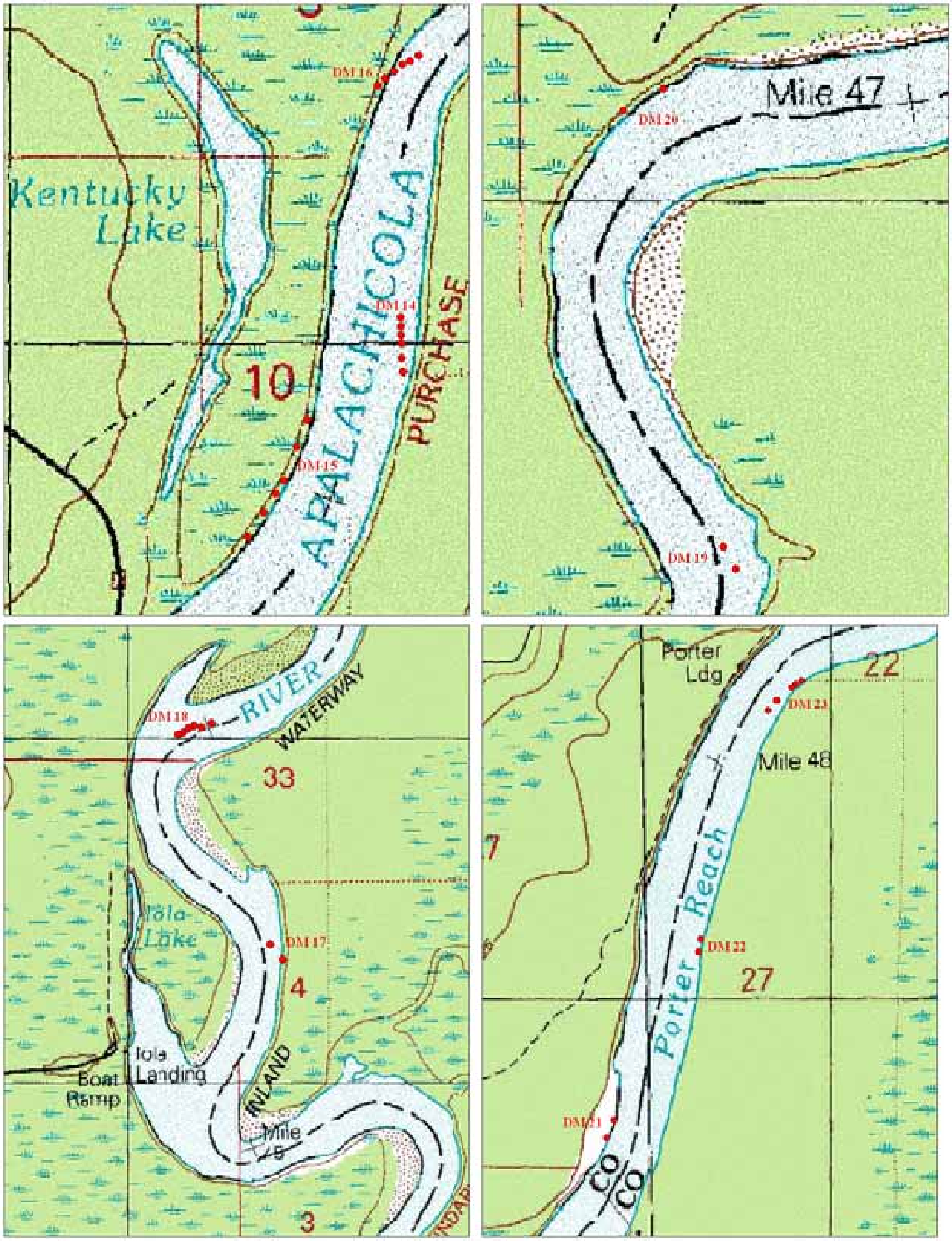

Figure C1. DM15, DM14, and DM16 (top left); DM19 and DM20 (top right), DM17 and DM18 (bottom left), and DM21, DM22, and DM23 (bottom right).

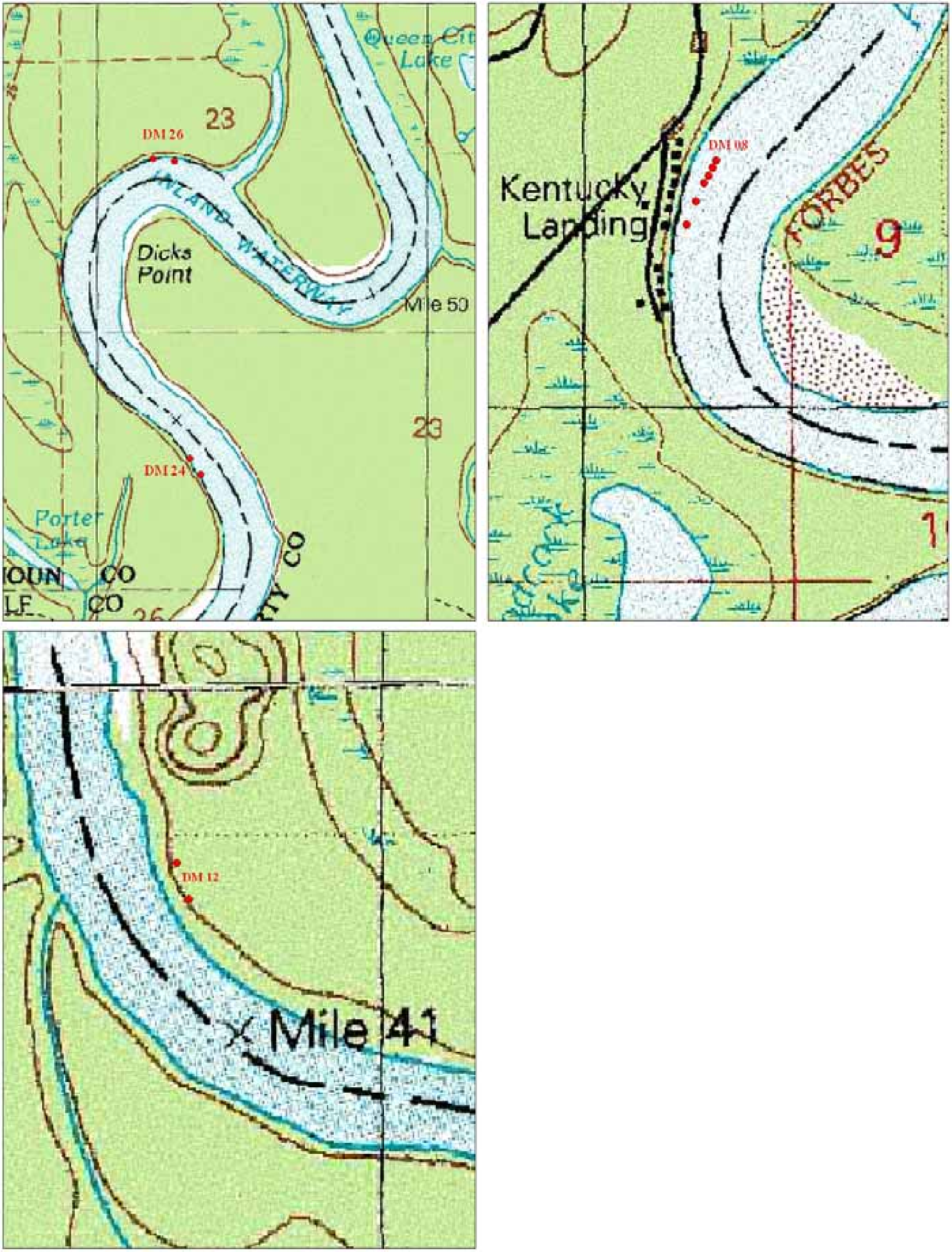

Figure C2. DM24 and DM26 (top left), DM08 (top right), and DM12 (bottom left)

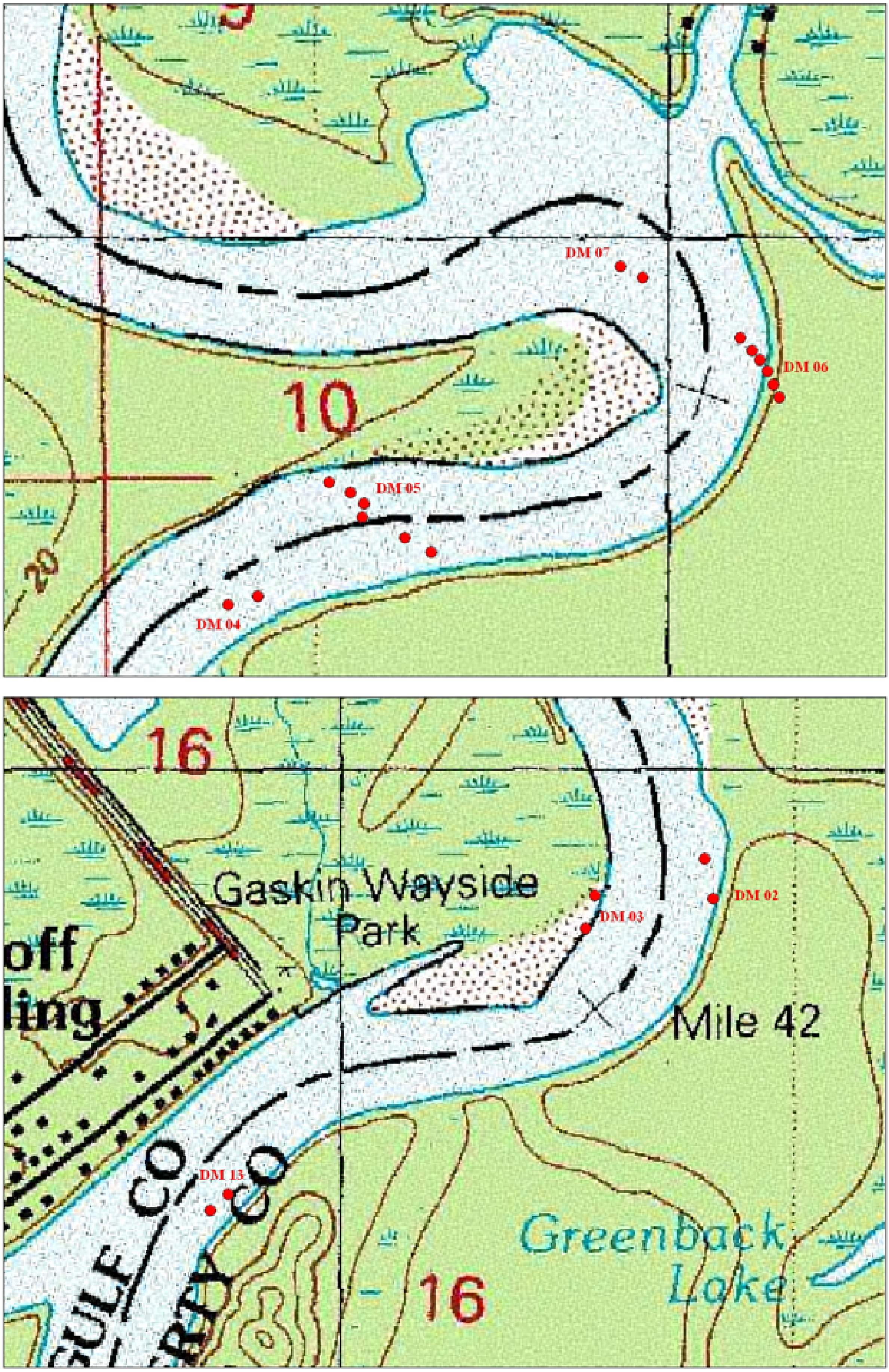

Figure C3. DM04, DM05, DM06 and DM07 (top), and DM13, DM03, and DM02 (bottom)

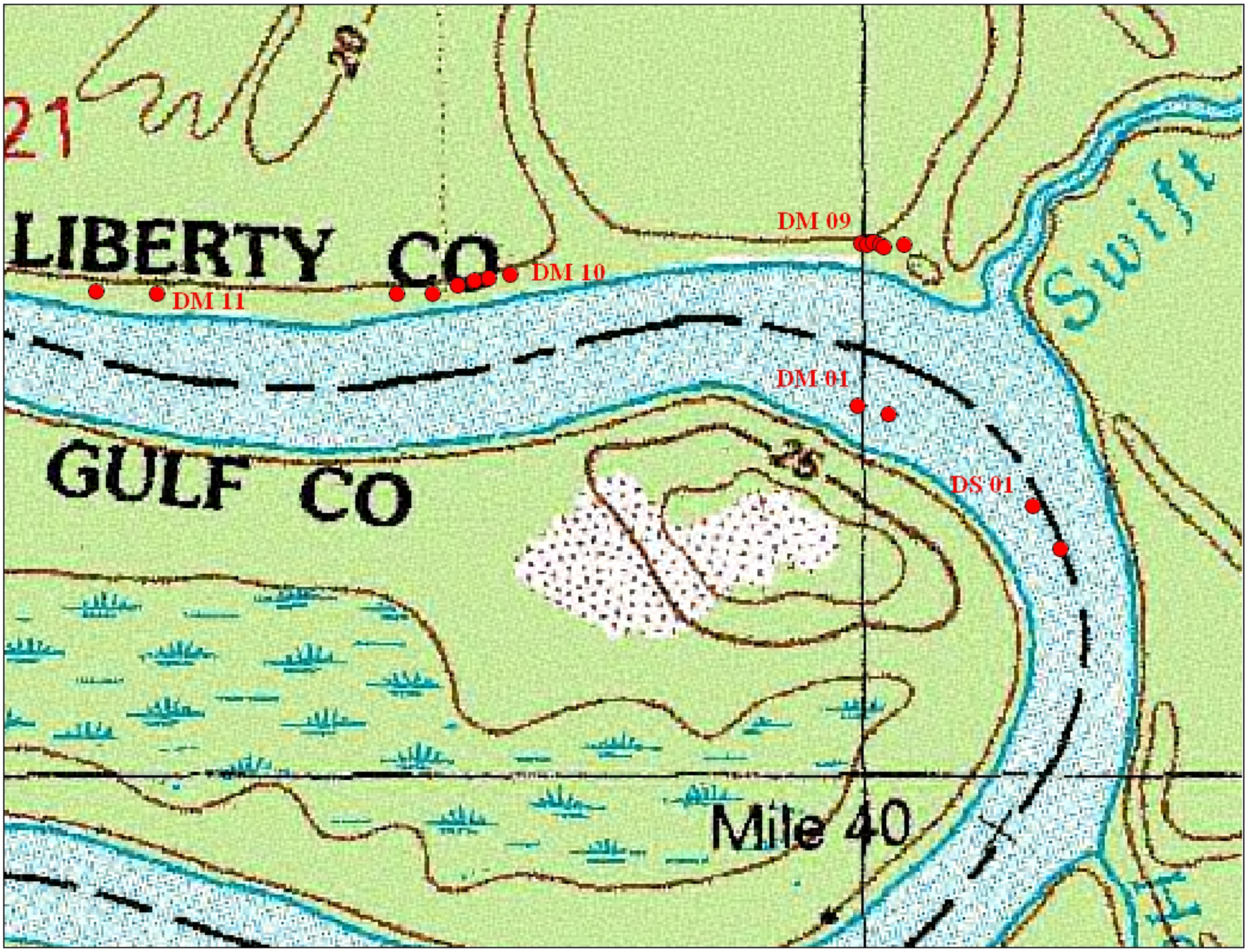

Figure C4. DS01, DM01, DM09, DM10, and DM11.

APPENDIX G

EFFECTS OF LOW FLOW ON *AMBLEMA NEISLERII* IN THE APALACHICOLA RIVER, FLORIDA

15 OCTOBER 2007

Effects of Low Flow on *Amblema neislerii* in the Apalachicola River, Florida

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15 October 2007

Effects of Low Flow on *Amblema neislerii* in the Apalachicola River, Florida

Introduction

Background. The Apalachicola River, formed by the confluence of the Flint and Chattahoochee Rivers, originates at Navigation Mile (NM) 106.3, just south of Lake Seminole in the tailwater of Jim Woodruff Lock and Dam. The river provides habitat for an endemic freshwater mussel species (family: Unionidae), the fat threeridge, *Amblema neislerii* (Lea, 1858), which was listed as endangered on 15 April 1998 (Federal Register Volume 63, Number 50, pages 12664-12687). Recent low rainfall in the southeast has caused conditions in the river to be less than optimal for aquatic life. Since 1999, with the exception of 2003 and 2005, average monthly minimum discharge at Jim Woodruff Dam for part of the year was less than 10,000 cubic feet per second (cfs). As specified in the 1989 draft Apalachicola, Chattahoochee, Flint Basin (ACF) water control plan, the Mobile District is required to maintain a minimum river flow of 5,000 cfs at Jim Woodruff Dam. More recently**,** the Jim Woodruff Dam Interim Operations Plan (IOP), developed as part of Section 7 Consultation with the USFWS, allows for a desired minimum flow of 6,500 cfs when conditions permit. When basin inflows are less than 5,000 cfs (or less than the desired 6,500 cfs under certain conditions specified in the IOP), storage from the upstream reservoirs is used to augment flows below Jim Woodruff Dam.

Because of extremely low water in 2007, plus the likelihood that water levels will remain low in 2008, the Mobile District is concerned that upstream storage used to augment flows could become depleted and the resulting discharges to the Apalachicola River could drop below 5,000 cfs. This lower discharge could negatively affect freshwater mussels, including *A. neislerii*. In the event all conservation storage is depleted, a precipitous drop in flows on the Apalachicola River could result, with flows essentially limited to inflows on the Flint basin (which has been estimated at 2,000 cfs or less in late summer and early fall of 2007). A controlled higher discharge below 5,000 cfs could potentially mitigate the amount of storage necessary for flow augmentation, prolong the length of time augmentation flows can be provided, and avoid a catastrophic loss of all conservation storage in the upstream reservoirs.

Purpose and Scope

The purpose of this report is to analyze the depth-distribution of *A. neislerii* in the Apalachicola River and to discuss the possible effects of discharge less than 5,000 cfs on this species. Data for this evaluation was taken from two studies: 1) a low flow mussel distribution study conducted in 2003 (Miller and Payne 2005), and 2) a similar survey conducted in the early summer of 2007 (Miller and Payne 2007).

Study Areas

2003 Studies. Mussels were collected at 11 sites in 2003 (Table 1). With the exception of the two sites in Chipola Cutoff, all others were at designated dredged material disposal areas rather than at optimal habitat locations.

2007 Studies. Study areas for the 2007 survey were chosen by personnel of the US Fish and Wildlife Service (USFWS). They identified 25 study areas between NM 40 and 50 which either supported, or appeared likely to support *A. neislerii*, based on suspected optimal habitat and potential vulnerability to low flow. The 25 sites had one or more of the following characteristics: 1) stable, gently sloping banks primarily vegetated with newly established black willow, 2) dense and species-rich mussel assemblages, 3) firm substratum consisting of silty sand, and/or 4) signs of recent mussel mortality from low water in 2006 and 2007. Most areas were along a moderately depositional reach immediately downriver of a point bar.

Methods

2003 Studies. Mussels were collected using a 6-person dive crew equipped with surface supplied air and communication equipment on 18-20 November 2003. During the survey period, gage height and discharge at Blountstown (NM 78) was 3.63 ft, 9,420 cfs (18 Nov 03), 4.17 ft, 10,300 cfs (19 Nov 03), and 4.94 ft 11,500 cfs (20 Nov 03). All underwater collecting was done tactilely since visibility was poor. Divers were equipped with a pneumofathometer to record water depth and were tethered to the boat with a 100-m line. Transects were laid perpendicular to shore, running from shallow (2 ft) to deep water (9 ft). Two divers collected mussels for 15 min at each 1-ft depth increment along the transect. This qualitative sampling protocol provided data and information on Catch per Unit Effort (CPUE), and percent species abundance at each 1-ft depth increment.

2007 Studies. In 2007 mussels were collected by hand while wading and no divers were used; therefore, the maximum water depth searched was 3 ft. Quantitative and qualitative methods were used at 10 of the 25 areas, and only qualitative methods were used at the remaining areas. Quantitative sampling included placing six evenly spaced transects perpendicular to shore. Mussels were collected with a 0.25 m^2 quadrat at three sites along each transect moving from near- to farshore (1, 2, and 3 ft depths). All sediment, shells, and live bivalves were excavated to a depth of 15-25 cm (6 to 10 inches) from the quadrat and sieved through a screen (minimum mesh size equaled 6.4 mm, 0.25 inch). Live mussels and the Asian clam *Corbicula fluminea* were identified and counted. A total of 18 quantitative samples were obtained at each site; therefore, 180 quantitative samples were taken. In addition to the quantitative samples, a 10 to 20-min timed search was conducted between two transect lines in the center of the area.

At each of the remaining 15 areas, only a single 10-15 min timed search was conducted and no quantitative samples were taken. After processing, all mussels were returned to the river unharmed. See Miller and Payne (2005), and Miller and Payne (2007) for more information on methods and sample areas.

Essentially the same sampling strategy was used in 2003 and 2007. Since mussels were collected at 1-ft depth increments, results (density or relative abundance) could be expressed in terms of water depth or elevation. At each collecting site, water elevation data were converted to discharge by Mobile District personnel based on recent ratings data provided by the U.S. Geological Survey. This procedure enabled us to estimate the number of mussels that could be exposed to the atmosphere if water level and discharge declined. Mussels exposed to the atmosphere during low flow will not necessarily be killed; an unknown number will likely move into deeper water. In addition, some exposed mussels could survive for days or weeks if they are shaded and partially buried in moist sediment. However, mussels exposed or located in extremely shallow water would likely experience more stress due to low water quality and high temperature and would be more susceptible to predation and mortality.

Results

Comparison of 2003 and 2007 studies. During the 2003 survey, total discharge (ranging between 9,420 cfs and 11,500 cfs) was considerably higher than in 2007 when discharge was approximately 5,000 cfs. Therefore, during the latter survey, all of the sites sampled in 2003 were exposed to the atmosphere. In addition, sites surveyed in 2007 would have been at lower elevations than those sampled during 2003.

In the 2003 survey, the maximum recorded density (2.0 individuals / m^2) was at NM 41.5, at a depth of 4 ft, which corresponded to a discharge of 6,400 cfs (Figure 1, taken from data discussed in Miller and Payne 2005). In the 2007 survey, the maximum recorded density (22.7 individuals / m^2) was at NM 43.9, at a depth of 2 ft, which corresponded to a discharge of 3,150 cfs (Figure 2). Not only were density values greater in 2007, but mussels were collected at much lower elevations than they were in 2003. It must be emphasized that these samples were obtained in the same river reach but not the same locations or type of habitat (disposal areas in 2003 versus more optimal habitat conditions in 2007). The site located at NM 43.9 could always have supported a higher mussel density than the site at NM 41.5.

Depth distribution analysis based on qualitative sampling in 2007. Qualitative data collected from the 15 sites where partial studies were conducted were converted to density and plotted for three depth elevations: 1, 2, and 3 ft, which corresponded to discharge values of 4,150, 3,200, and 2,250 cfs, respectively. (This was done using a regression equation developed from data collected using both quantitative and qualitative methods; see Miller and Payne 2007 for more details). Figures 3 and 4 present density and percent abundance values summarized for all sites. Cumulative densities include all mussels collected along the transect moving from shallow to deep water. Percentages include the proportion of mussels at each depth increment calculated from density values. The cumulative percent value represents accumulated density moving from shallow to deep water. For example, at a discharge of 2,250 cfs all mussels (a cumulative density greater than 4 individuals/m^2, 100% of the assemblage) could be exposed to the atmosphere. (For these and all remaining figures, cumulative density and percent values for 0.5 ft depth increments are displayed; our field collections were only obtained at 1.0-ft increments). As stated above, some of these mussels could move to deeper water and some could be taken by predators. Abundance values for a representative low and a high-density site (NM 42.2 and 47.4) are depicted in Figures 5 and 6.

Predicted density versus discharge for all sites sampled using qualitative methods, with the exception of DM01 and DM12 (where no *A. neislerii* were found) are displayed in Appendix A.

Depth distribution analysis based on quantitative sampling in 2007. Quantitative data collected along transects in 2007 were summarized for all sites (Figure 7). Figure 8 includes percent abundance and cumulative percent abundance data based on all quantitative samples. Mean density for all sites studied in 2007 was greater than the highest density site sampled in 2003 (compare Figure 7 with Figure 1). Density, cumulative density, percent abundance, and cumulative percentage were plotted for a representative low-density site (Figures 9 and 10), and a representative high-density site (Figures 11 and 12).

Mean density versus discharge for all sites sampled using quantitative methods are displayed in Appendix B.

Summary and Conclusions

Concern over negative effects of discharge less than 5,000 cfs in the Apalachicola River due to low rainfall triggered the need to more fully investigate the depth-distribution of *A. neislerii,* a federally protected species. Results of qualitative (timed collections using search by feel methods) and quantitative sampling (total excavation of 0.25 m^2 quadrats) conducted in 2003 and 2007 were used to examine possible effects of extremely low discharge. Depth distribution data were collected in 2003 and 2007 by collecting mussels at known water depths along transects perpendicular to shore running from shallow to deep water. Field-collected water elevation data were converted to discharge values by Mobile District personnel. The objective of both surveys was to develop an understanding of the impacts of extreme low water on *A. neislerii* assemblages.

Results of both surveys illustrate that *A. neislerii* (and most other mussel species in this river) inhabit a fairly narrow band along the shore in reaches with suitable water velocity and substrate. In 2003 the maximum *A. neislerii* abundance was found at a depth of 4 ft; no live mussels were collected in water deeper than 9 ft. In 2007 all collecting was done without divers; therefore, it is not possible to know abundance and distribution of mussels in water deeper than 3 ft. Regardless, comparing results of both surveys suggest that mussels moved into deeper water in response to reduced discharge. In the latter survey, mussels were abundant at elevations corresponding to 3,150 cfs; depths that did not support live mussels in 2003 (compare Figures 1 and 2).

Amblema neislerii density was higher in 2007 than in 2003 in the same river reach. The maximum density in 2003 was 2.0 individuals/m^2, recorded at NM 41.5, at a depth of 4 ft. In 2007 the maximum recorded density was 22.7 individuals / m^2, recorded at NM 43.9 at a depth of 2 ft. Since none of the sites studied in 2003 were re-surveyed in 2007, a direct comparison between study years cannot be done. However, it is possible that the higher densities recorded in 2007 could have been the result of a large number of mussels moving to lower elevations because of reduced water. It is also possible that the areas surveyed in 2007 were better habitat than those studied in 2003 and therefore supported more mussels.

Results of the 2007 survey indicated that a 1-ft loss in water level, below a discharge of 5,150 cfs, to an equivalent flow of approximately 4,150, could expose less than 25% of the *A. neislerii*. A 2-ft decline in water level, corresponding to a discharge of 3,200 cfs, could expose approximately 75% of the mussels (see Figure 8, 10, and 12). Obviously a 2-ft decline in water level could result in more than twice the mortality if water only dropped by 1 ft. As stated above, all exposed mussels would not necessarily be killed by a 1-ft reduction in water level; some could move into deeper water and survive. Regardless, it is uncertain if habitat conditions in the deeper water areas would provide suitable habitat under higher flow conditions due to potential differing geomorphic conditions.

Results from the 2003 and 2007 studies indicated that mussels are able to avoid atmospheric exposure and occupy habitat with suitable depth, velocity, and substratum. As long as water levels remain low, mussels are likely to do well at these previously unoccupied sites. Regardless, if in the future water discharge and velocity increase, these mussels could be vulnerable to sheer stress far in excess of what they can tolerate. These mussels could be eroded out of the substratum and displaced downriver. It is possible that some individuals could be carried to suitable areas and survive, although others could be deposited in the main channel and be killed.

Because divers were not used in the 2007 survey, it is not possible to determine if additional mussels are present at depths greater than 3 ft. Based on 2003 data, the highest mussel densities could be in water 4 ft deep. Therefore, our 2007 survey could have underestimated the number of mussels present.

Using results of 2003 and 2007, the total number of mussels in a river reach exposed to the atmosphere for incremental lower flow conditions could be estimated. However, it would not be advisable to make these estimates without more rigorous sampling (greater replication) over greater areas using divers.

Results of this analysis suggest the need for additional mussel studies in the Apalachicola River. Primarily, there is a need to collect deeper than 3 ft under flow conditions similar to those during the 2007 survey. In addition, there is a need for at least three other studies: 1) Describe the location and aerial extent of mussel habitats that are particularly vulnerable to low flow; 2) Estimate the total abundance of federally-protected mussels by depth distribution using a more rigorous sampling design (more subsites at each area and more replication within each subsite), and 3) Relate mussel abundance and distribution to geomorphic processes at specific sites. Data and information obtained from these studies would assist in assessing the impacts of extreme low flow on *A. neislerii* in the Apalachicola River.

Literature Cited

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, Florida US Army Engineer Research and Development Center, Vicksburg, MS.

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. Report submitted to the US Army Engineer District Mobile, 2007

Table 1. Location of samples sites searched for *A. neislerii*, November 2003. Surveys were conducted immediately downriver of 5 Disposal Areas (DA), along the shore, near the mouth of Douglas Slough, and at 2 sites near the entry of the Chipola Cutoff off the Apalachicola River. This table originally appeared in Miller and Payne (2005).						
WP	**Date**	**Time**	**Longitude**	**Latitude**	**Notes**	**NM**
145	18-Nov-03	2:54:00 PM	85.11685	30.02453	Near mouth of Douglas Slough	30.0
150	19-Nov-03	9:24:00 AM	85.11959	30.1978	DA 65A	48.4
152	19-Nov-03	10:28:00 AM	85.11996	30.1978	DA 65A	48.4
153	19-Nov-03	11:32:00 AM	85.11645	30.20457	DA 66A	49.0
154	19-Nov-03	12:58:00 PM	85.09632	30.22057	DA 70	53.4*
155	19-Nov-03	2:15:00 PM	85.13486	30.18173	DA 63	46.8
156	19-Nov-03	3:42:00 PM	85.147	30.12915	Near entry into the Chipola Cutoff	41.5
157	19-Nov-03	5:09:00 PM	85.14982	30.13413	500 m inside the Chipola Cutoff	41.5
158	20-Nov-03	7:55:00 AM	85.02044	30.39815	DA 107A	73.3
159	20-Nov-03	8:59:00 AM	85.02091	30.39801	DA 107A	73.3
160	20-Nov-03	9:45:00 AM	85.02015	30.39808	DA 107A	73.3
*Note - Although mussels were found at NM 53.4, no *A. neislerii* were collected at this location						

Table 2. Summary information on study areas in the Apalachicola River, 7-11 June 2007. See also Figure 1 and Figures B1 – B4, and Table B1, Appendix B. (Reach length measurements were provided by USFWS). This table originally appeared in Miller and Payne (2007).

NM	Bank	Location	Bank	Waypoints	Survey Type	Length, m
40.3	RDB	DSDM01	RDB	143-144	Partial	No data
40.4	RDB	DM01	RDB	141-142	Partial	64.2
40.5	LDB	DM'09	LDB	134-139	Detailed	40.6
40.6	LDB	DM10	LDB	128-133	Detailed	78.4
41.0	LDB	DM11	LDB	186-187	Partial	85.2
41.3	LDB	DM12	LDB	168-169	Partial	192.3
41.7	LDB	DM13	LDB	166-167	Partial	68.5
42.1	RDB	DM'03	RDB	164-165	Partial	41.9
42.2	LDB	DM'02	LDB	162-163	Partial	238.5
42.7	LDB	DM'04	LDB	152-153	Partial	40.9
42.8	RDB	DM'05	RDB	145-151	Detailed	127.0
43.0	LDB	DM'06	LDB	156-161	Detailed	90.9
43.1	LDB	DM'07	LDB	154-155	Partial	67.4
43.4	RDB	DM'08	RDB	180-185	Detailed	144.2
43.9	RDB	DM15	RDB	201-206	Detailed	212.6
44.3	LDB	DM14	LDB	188-193	Detailed	77.0
44.5	RDB	DM16	RDB	170-175	Detailed	87.8
45.5	LDB	DM17	LDB	176-177	Partial	169.2
46.0	RDB	DM18	RDB	222-227	Detailed	66.5
46.4	LDB	DM19	LDB	196-197	Partial	159.5
46.9	RDB	DM20	RDB	207-208	Partial	No data
47.4	RDB	DM21	RDB	209-210	Partial	277.5
47.5	LDB	DM22	LDB	214-215	Partial	217.3
48.2	LDB	DM23	LDB	216-221	Detailed	107.9
48.7	RDB	DM24	RDB	228-229	Partial	101.0
49.6	RDB	DM26	RDB	230-231	Partial	309.9

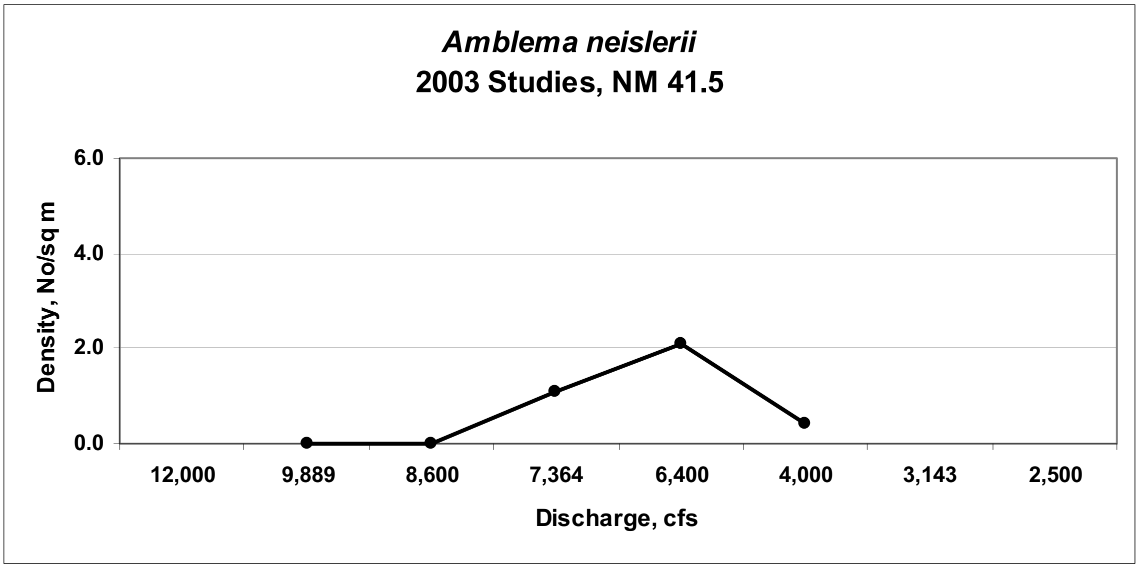


Figure 1. Depth distribution of *Amblema neislerii*, NM 41.5, Apalachicola River, Florida, 2003. Data were obtained by divers using qualitative methods, and then converted to density values. 12,000 cfs corresponds to the approximate edge of the water, 9,889 cfs is at approximately 1 ft deep, etc. This figure is based on data collected in 2003 and discussed in Miller and Payne 2005.

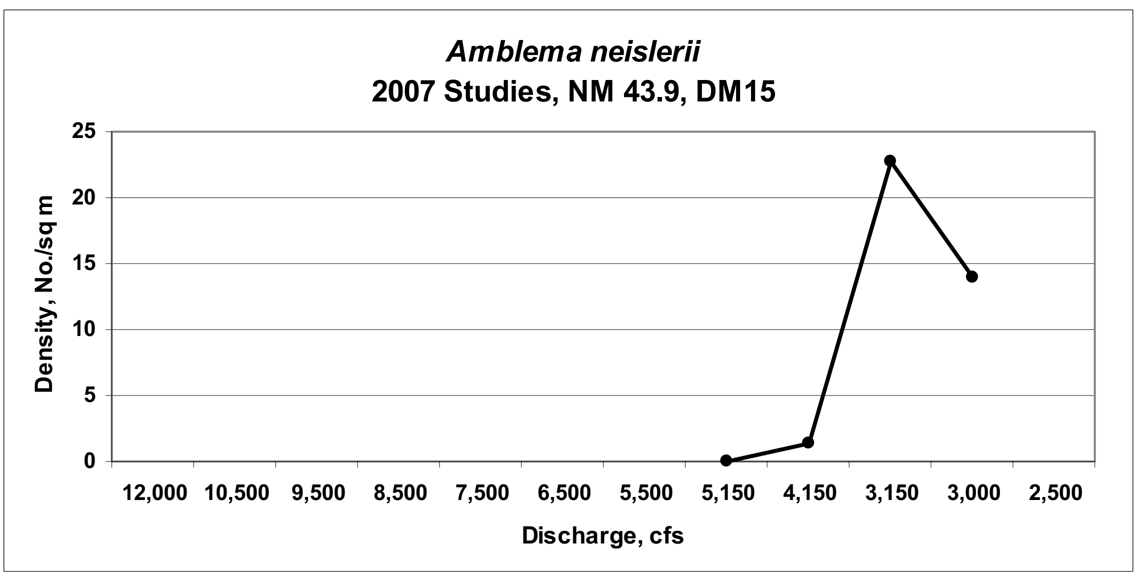


Figure 2. Depth distribution of *Amblema neislerii*, NM 43.9, DM15, Apalachicola River, Florida, 2007. Mussels were using quantitative methods by waders. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

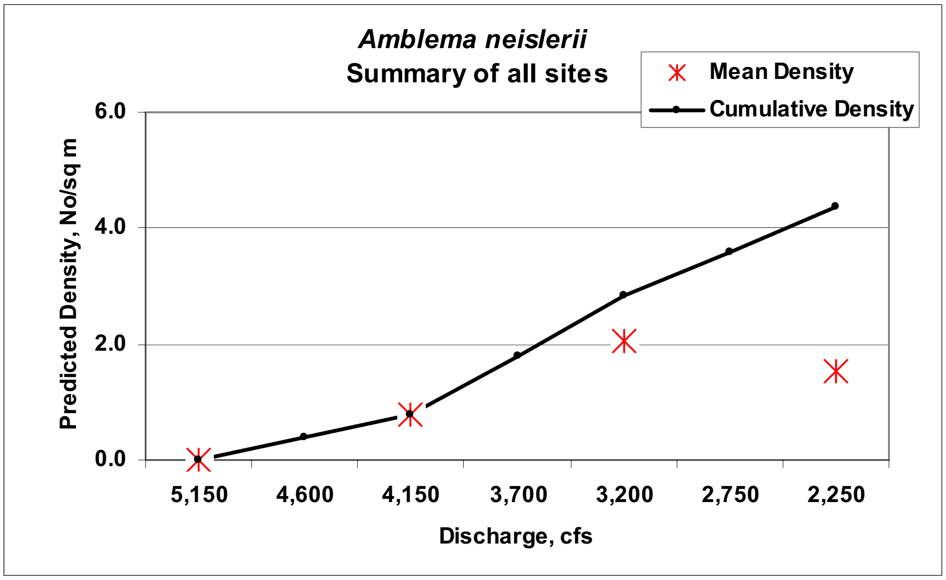


Figure 3. Overall mean density and cumulative density of *Amblema neislerii* for sites along the Apalachicola River, Florida, 2007, sampled using qualitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. Density values were estimated from the relationship between CPUE and quantitative (0.25 m^2) sampling at nearby sites.

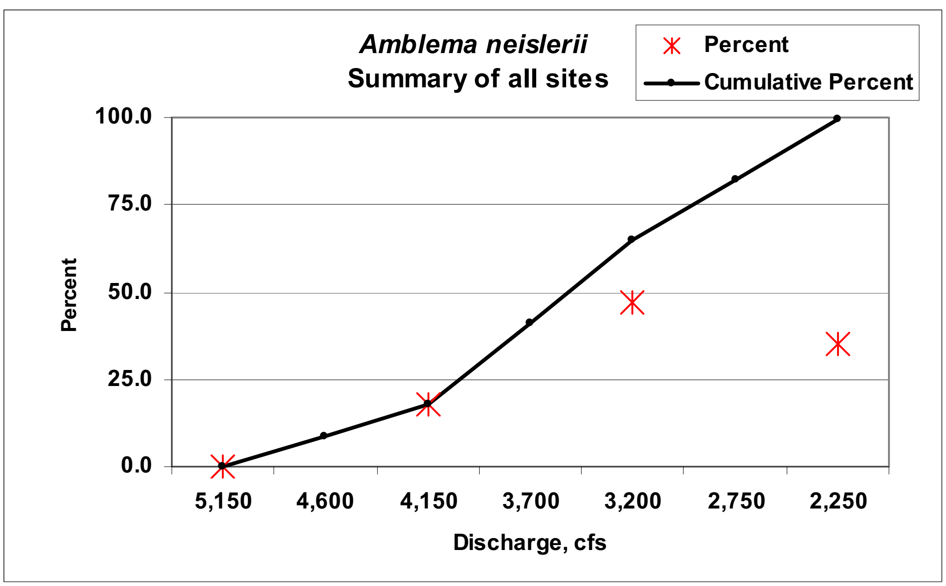


Figure 4. Overall mean percent and cumulative percent (based on qualitative samples) of *Amblema neislerii* at sites along the Apalachicola River, Florida, 2007, sampled using qualitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

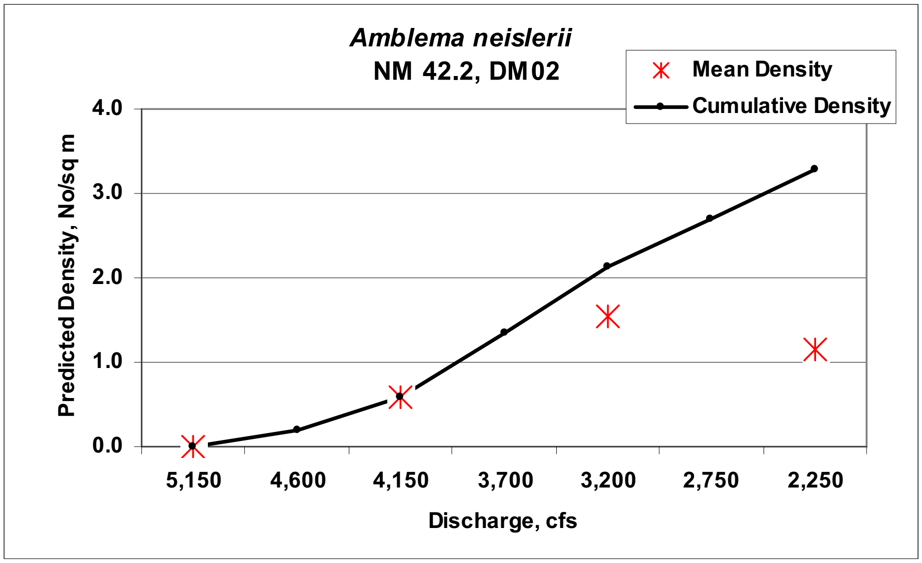


Figure 5. Overall mean density and cumulative density of *Amblema neislerii* for a low density site at NM 42.2, DM02, Apalachicola River, Florida, 2007, sampled using qualitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. Density values were estimated from the relationship between CPUE and quantitative (0.25 m^2) sampling at nearby sites.

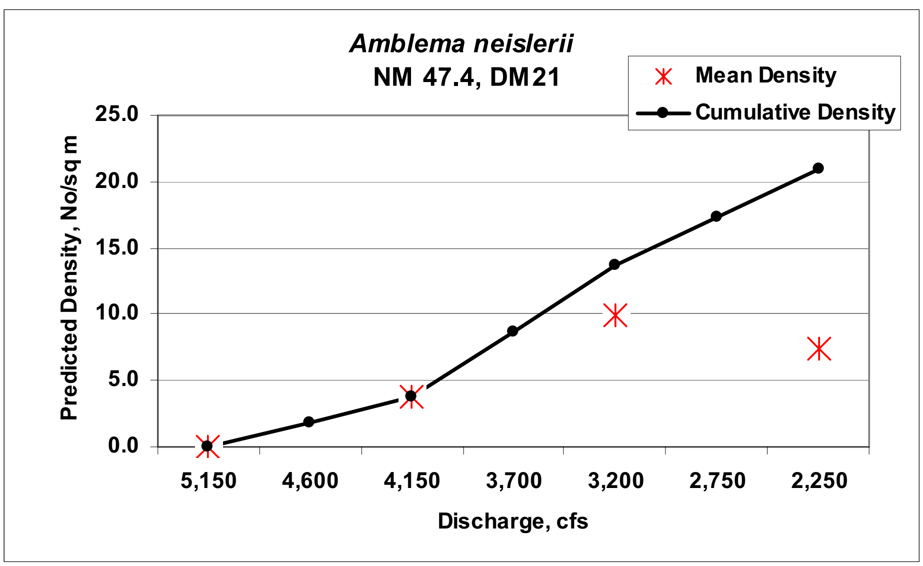


Figure 6. Overall mean percent and cumulative percent (based on qualitative samples) of *Amblema neislerii* for a high density site at NM 47.4, DM21 along the Apalachicola River, Florida, 2007, sampled using qualitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

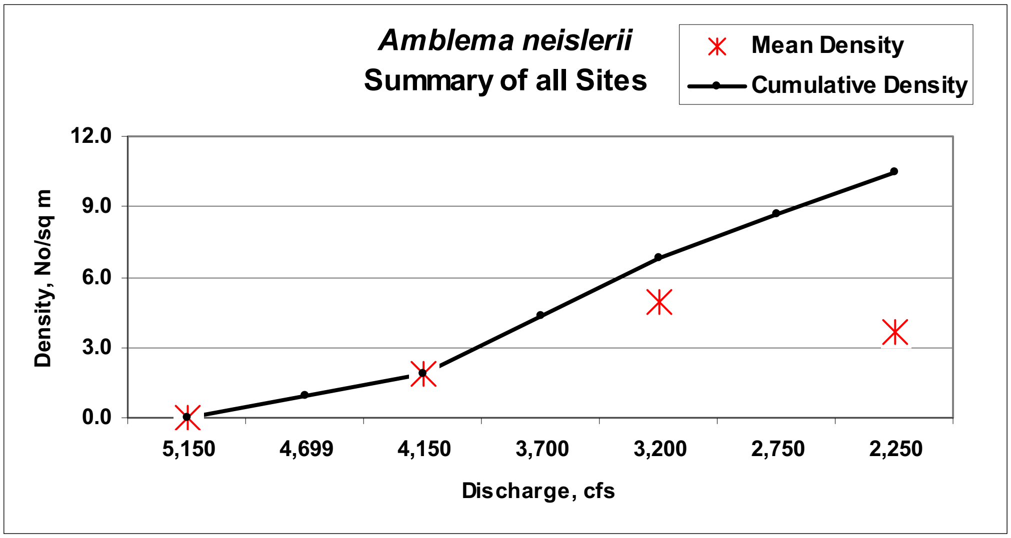


Figure 7. Overall mean density and cumulative density of *Amblema neislerii* for 10 sites along the Apalachicola River, Florida, 2007, sampled using quantitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. Density values were estimated from the relationship between CPUE and quantitative (0.25 m^2) sampling at nearby sites.

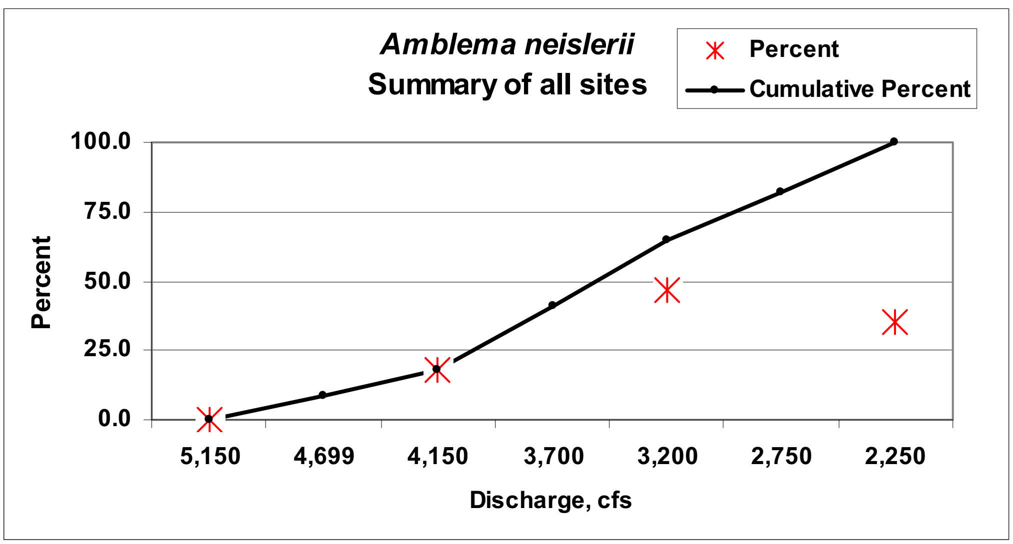


Figure 8. Overall mean percent and cumulative percent (based on quantitative samples) of *Amblema neislerii* at 10 sites along the Apalachicola River, Florida, 2007. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

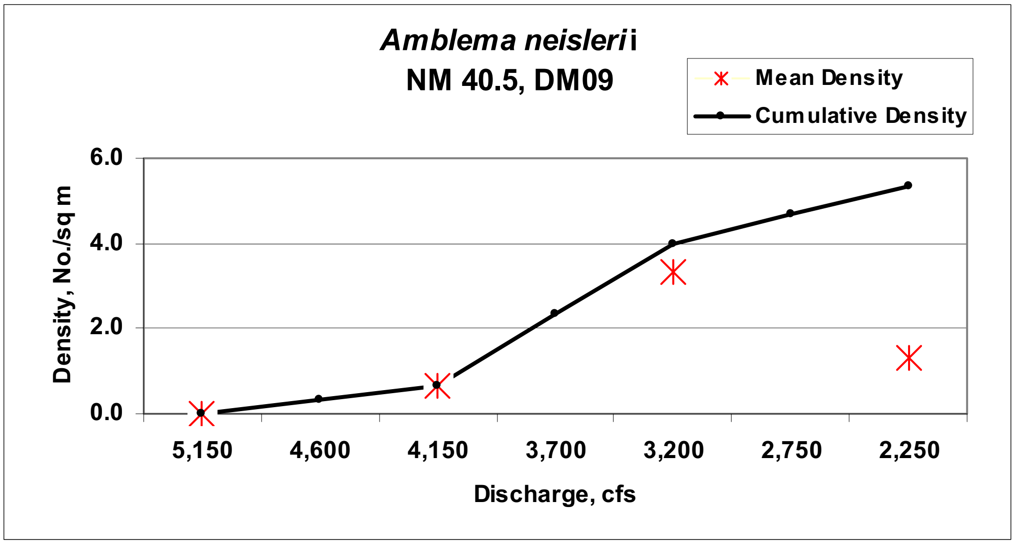


Figure 9. Overall mean density and cumulative density of *Amblema neislerii* for a low density site at NM 40.5, DM09, Apalachicola River, Florida, 2007, sampled using quantitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. .

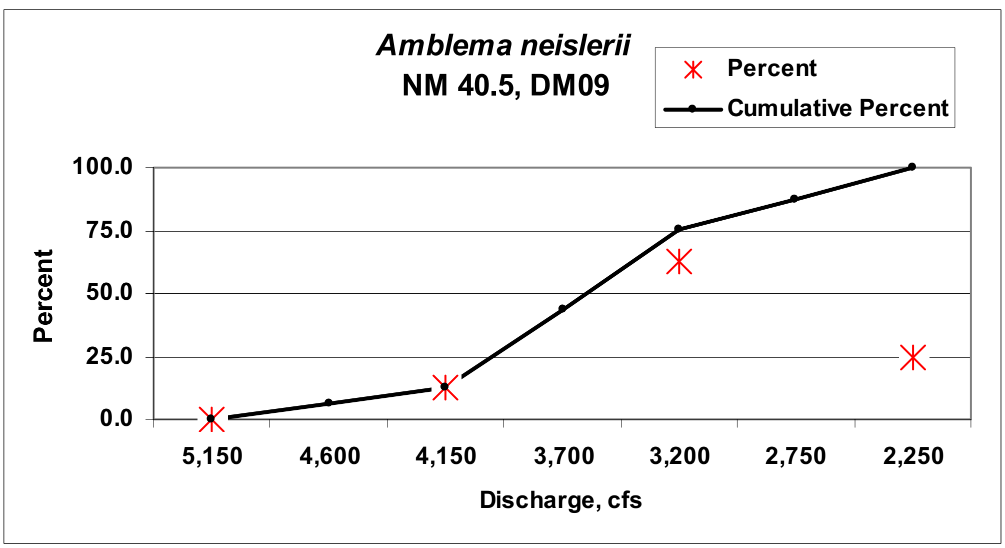


Figure 10. Overall mean percent and cumulative percent of *Amblema neislerii* for a low density site at NM 40.5, DM09, Apalachicola River, Florida, 2007, sampled using quantitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively

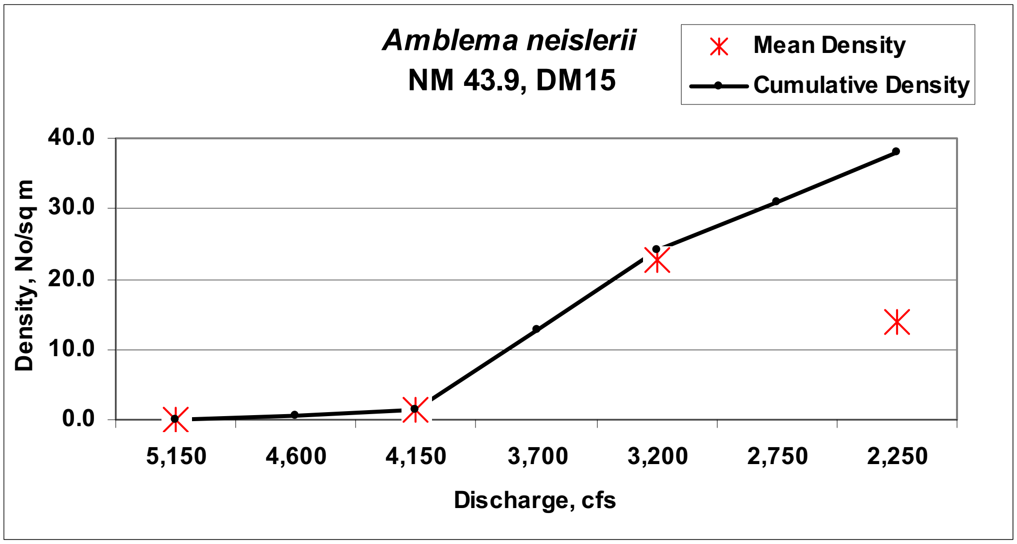


Figure 11. Overall mean density and cumulative density of *Amblema neislerii* for a high density site at NM 43.9, DM15, Apalachicola River, Florida, 2007, sampled using quantitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. .

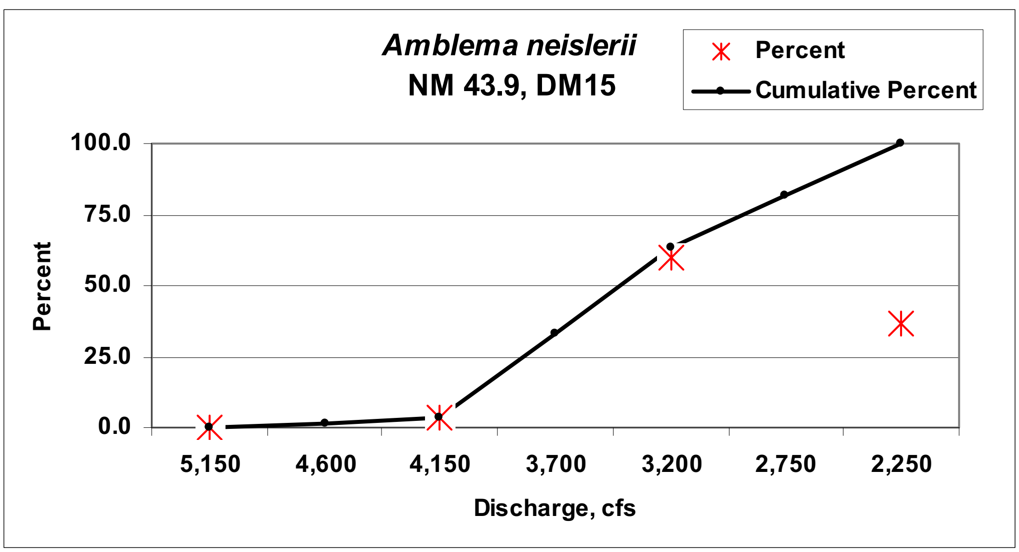


Figure 12. Overall mean percent and cumulative percent of *Amblema neislerii* for a high density site at NM 43.9, DM15, Apalachicola River, Florida, 2007, sampled using quantitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

Appendix A

Effects of low discharge on density of *A. neislerii*, Apalachicola River, Florida, 2007, based on qualitative sampling

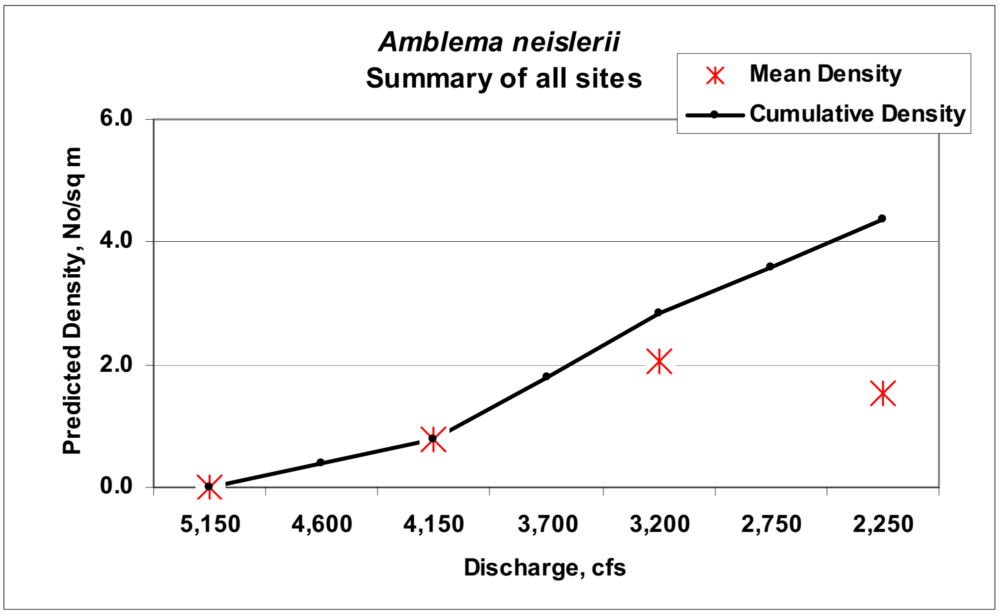


Figure A1

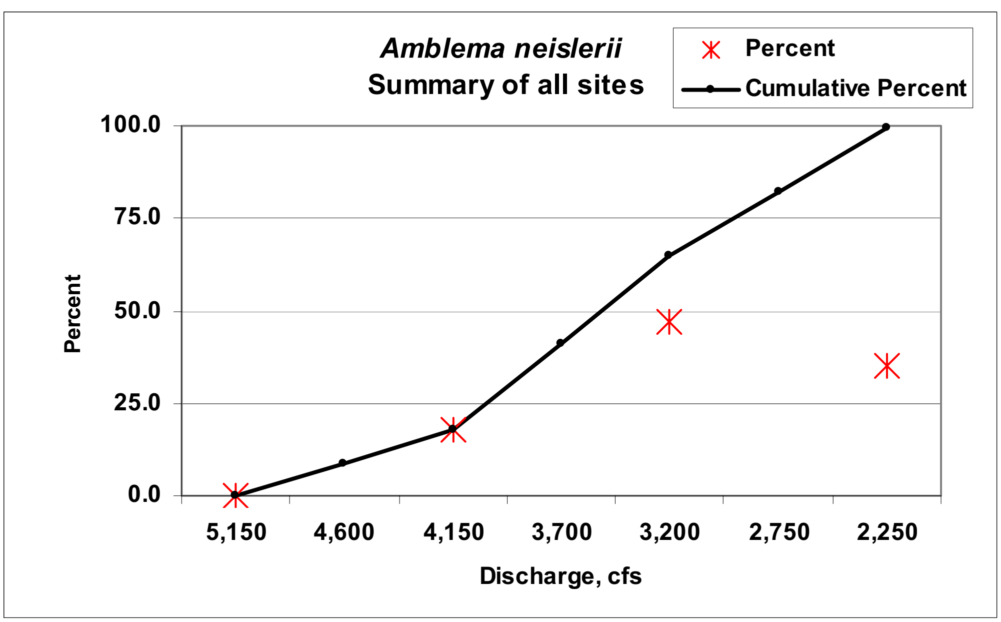


Figure A2

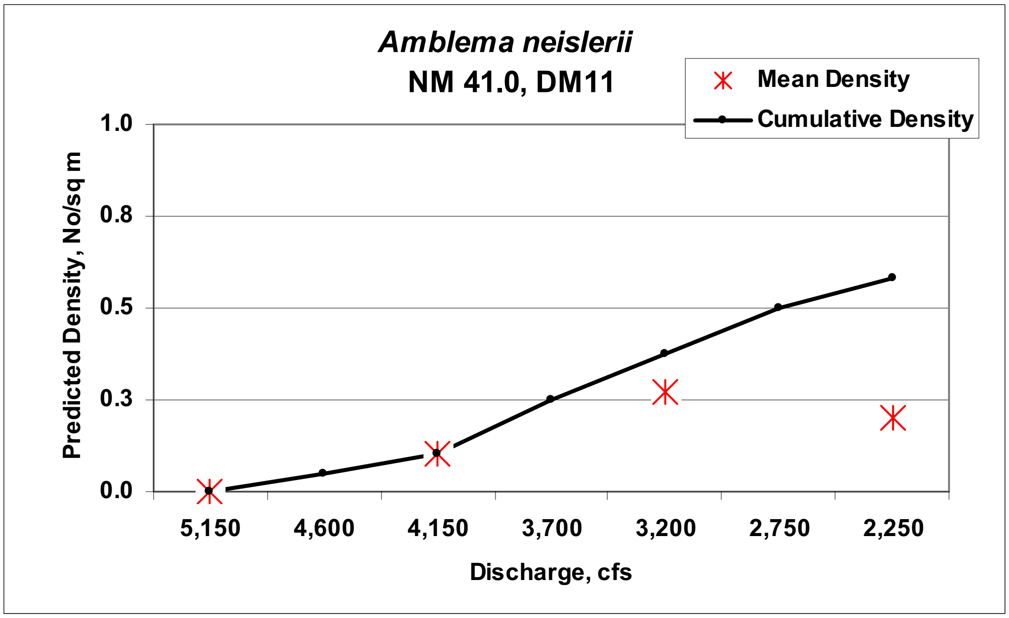


Figure A3

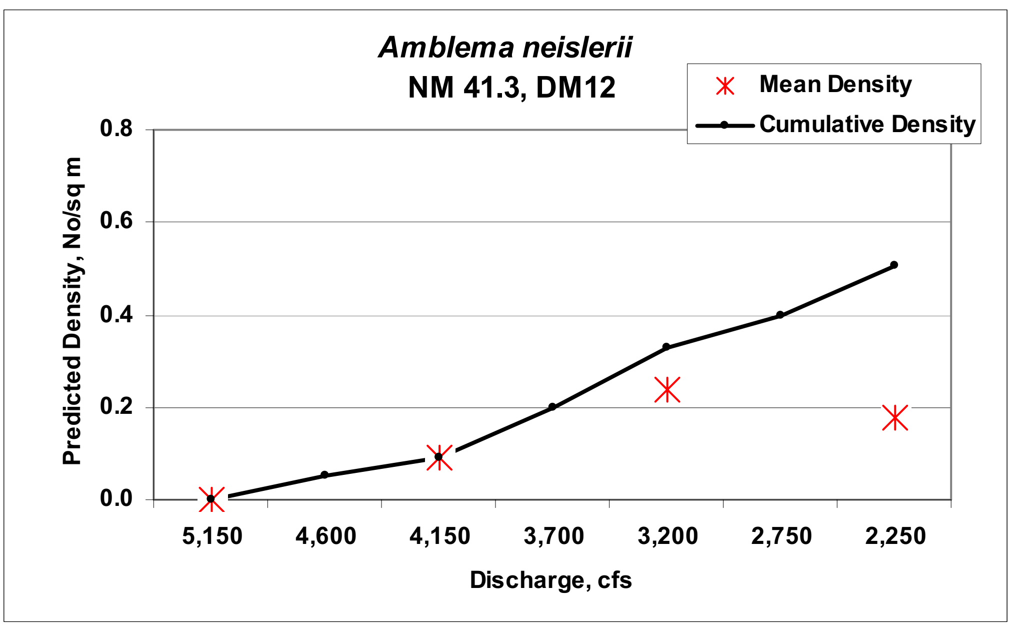


Figure A4

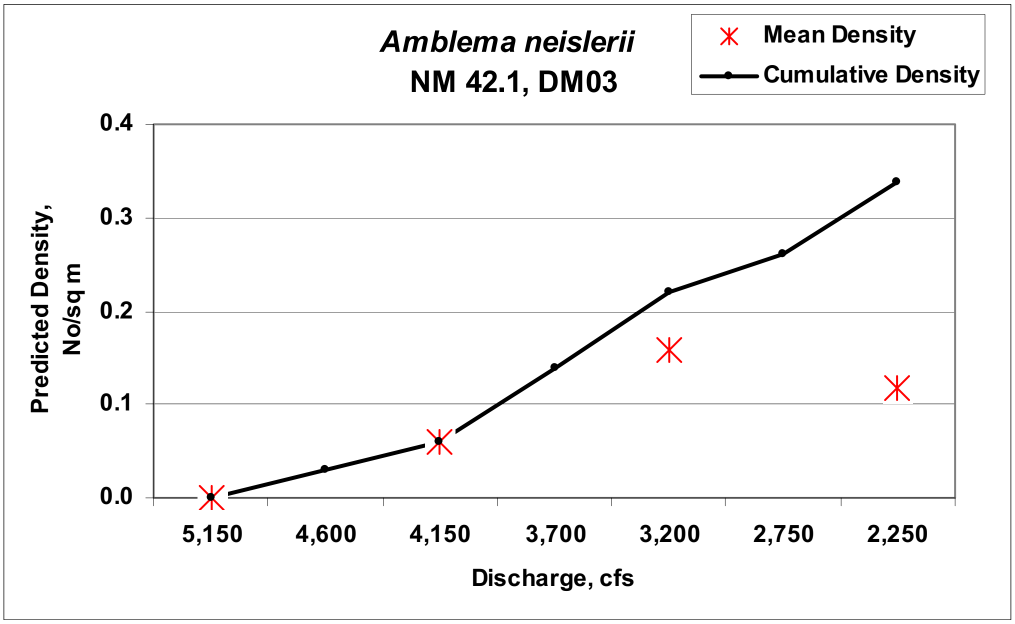


Figure A5

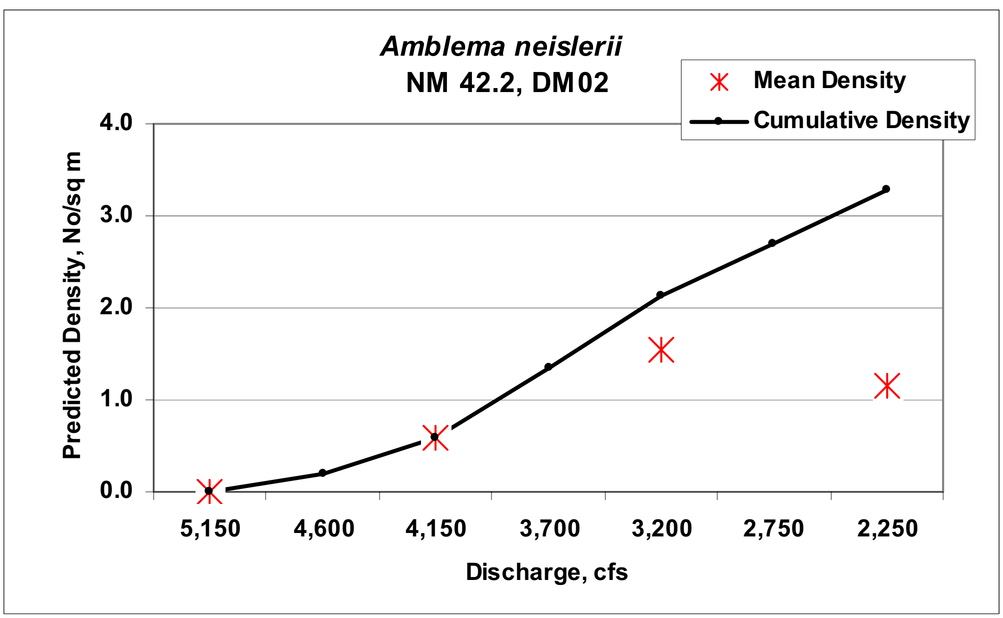


Figure A6

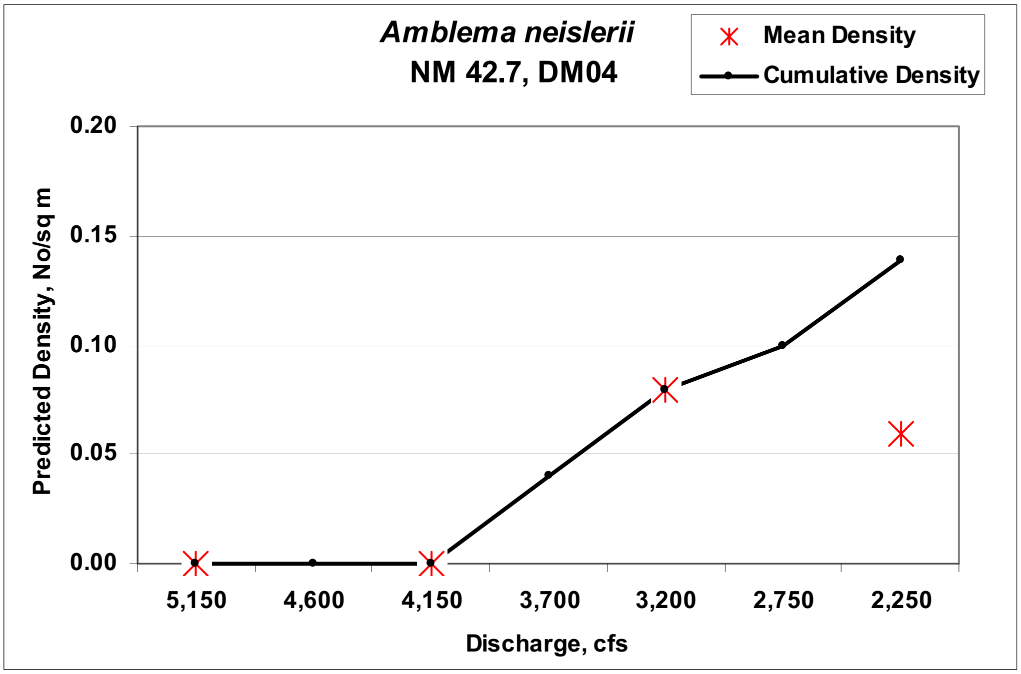


Figure A7

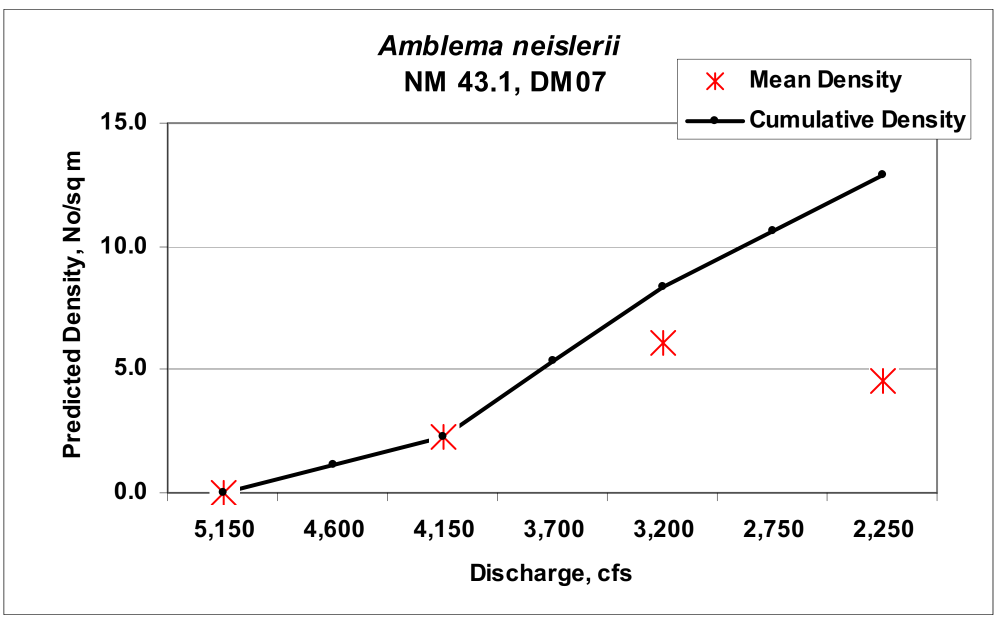


Figure A8

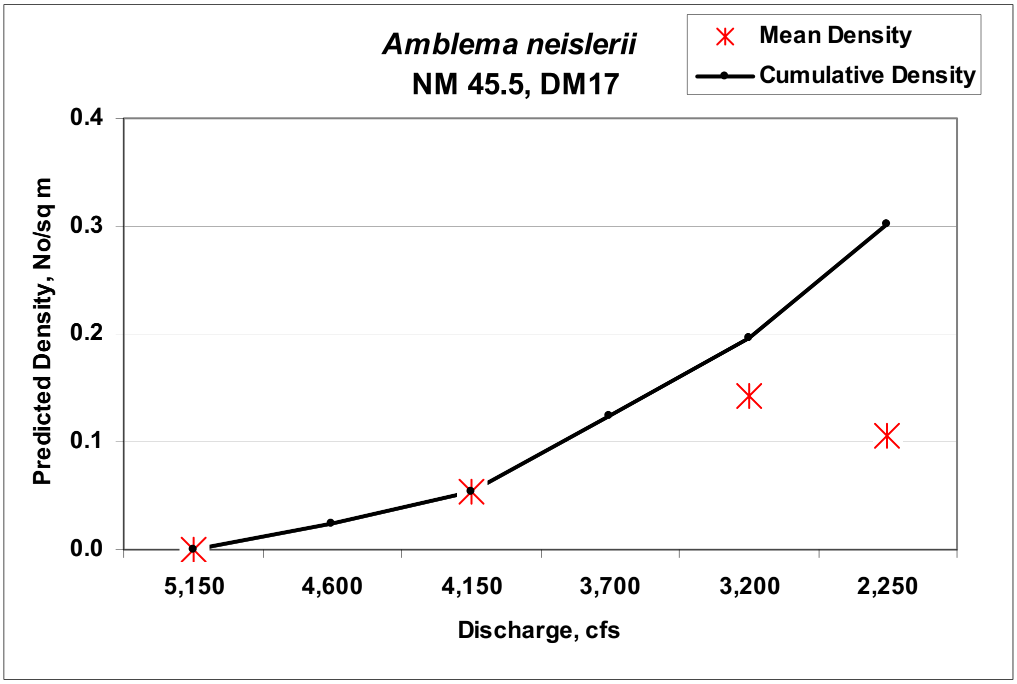


Figure A9

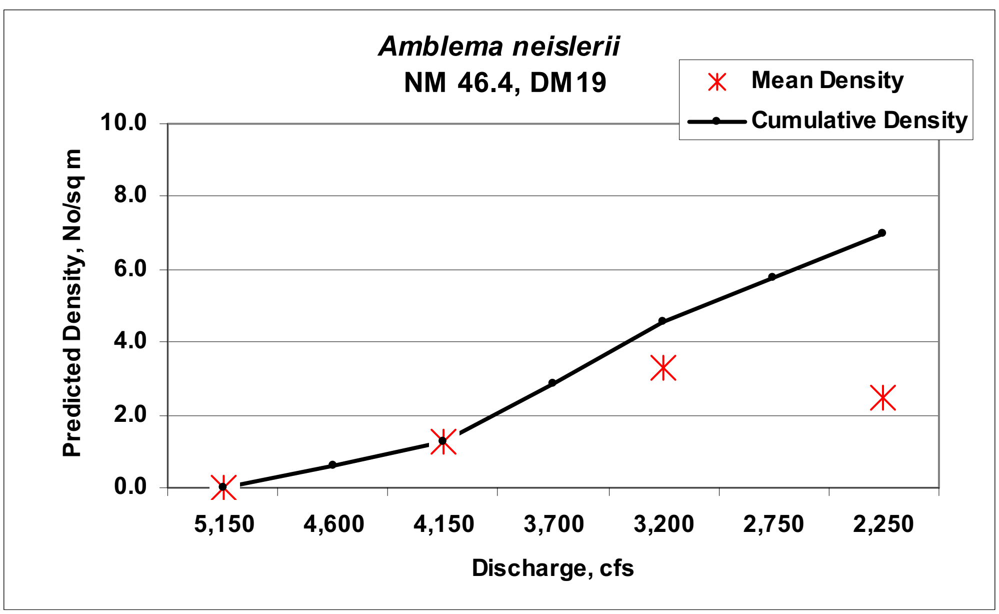


Figure A10

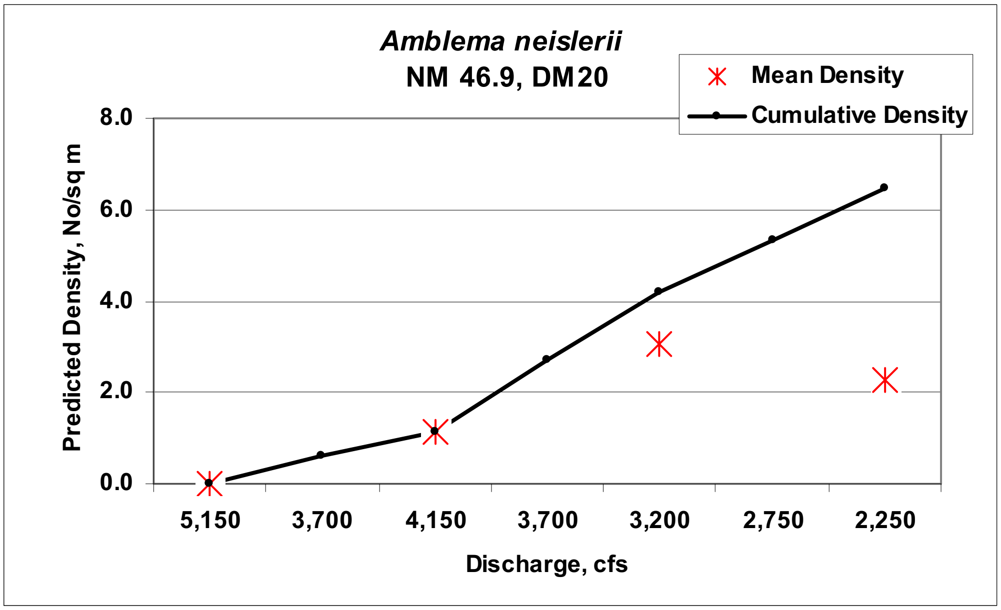


Figure A11

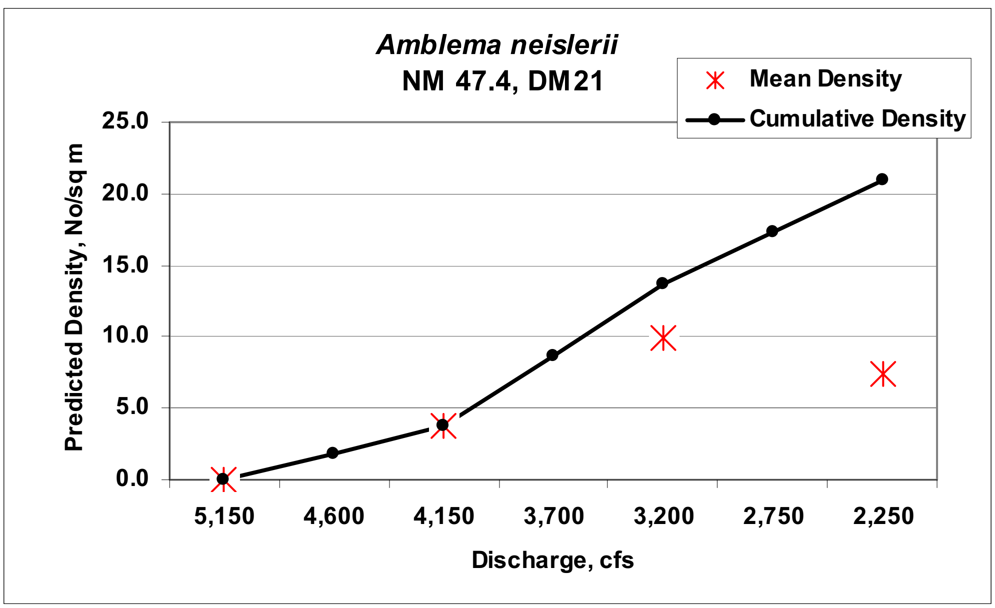


Figure A12

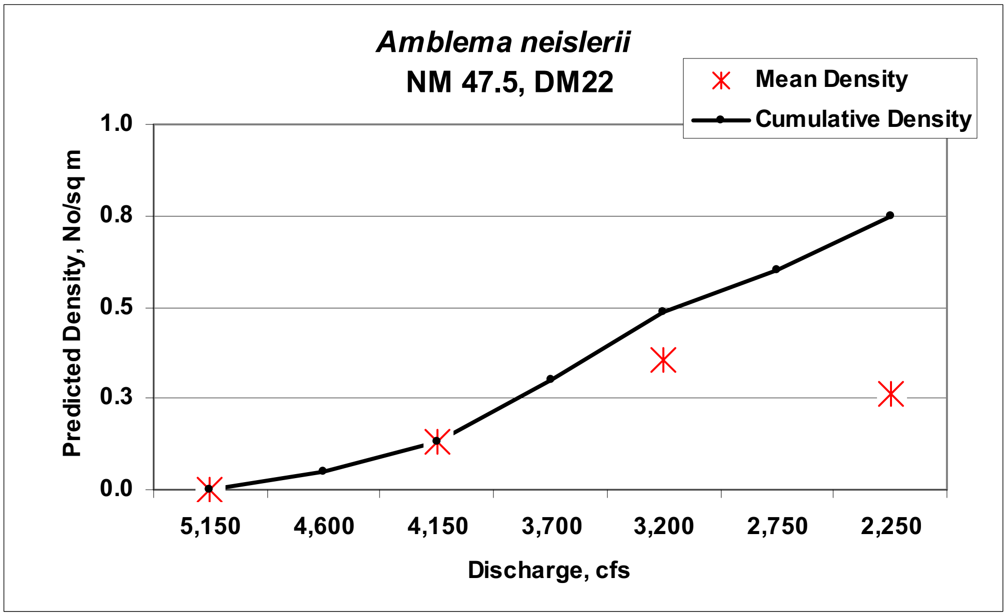


Figure A13

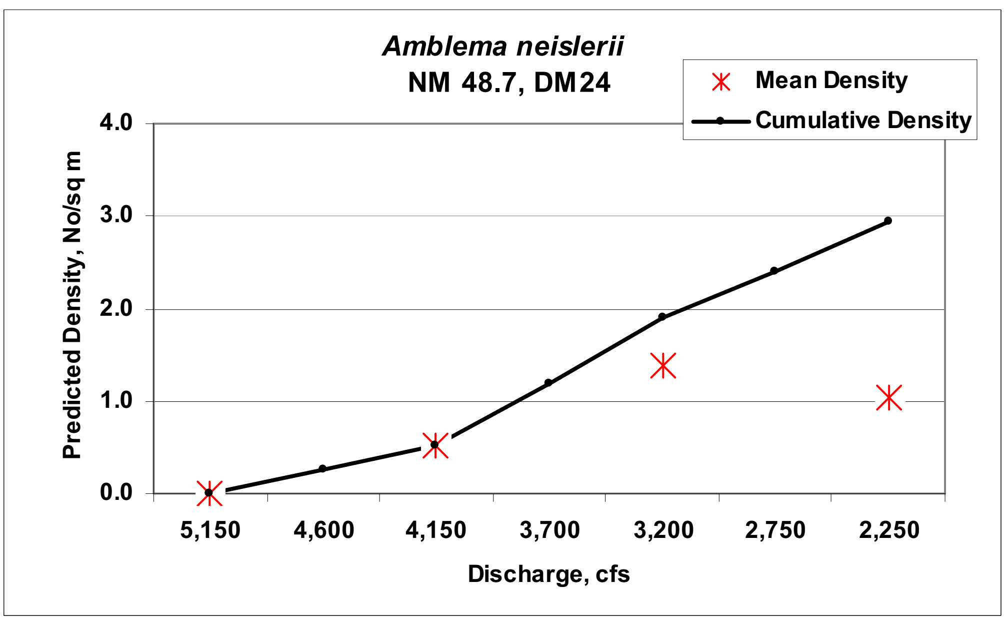


Figure A14

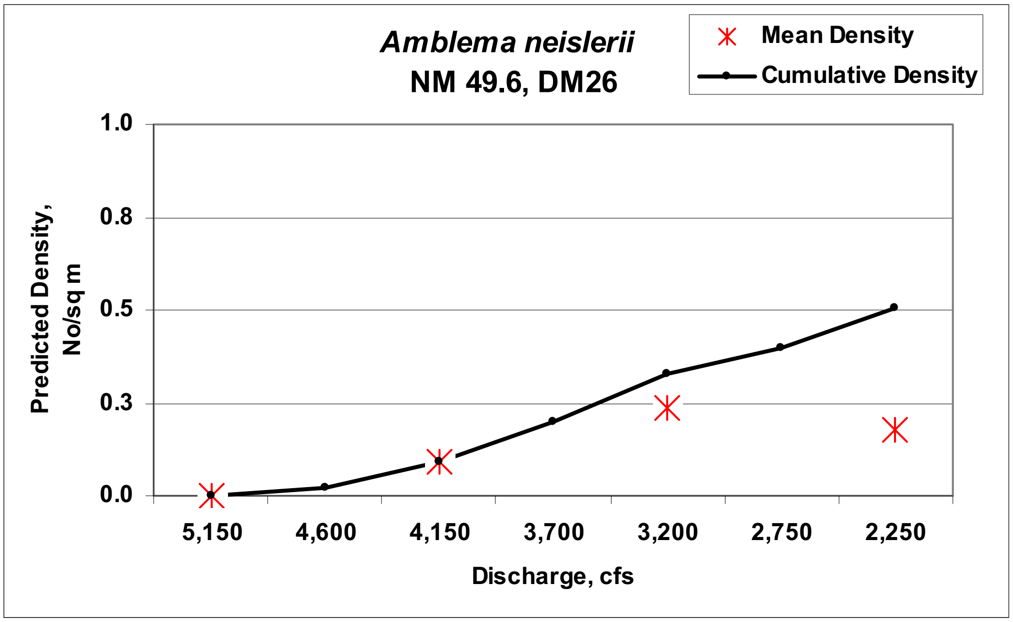

Amblema neislerii
NM 49.6, DM26
Mean Density
Cumulative Density
1.0
0.8
0.5
0.3
0.0
Predicted Density, No/sq m
5,150
4,600
4,150
3,700
3,200
2,750
2,250
Discharge, cfs

Figure A15

Appendix B

Effects of low discharge on density and percent abundance of *A. neislerii*, Apalachicola River, Florida, 2007, based on quantitative sampling

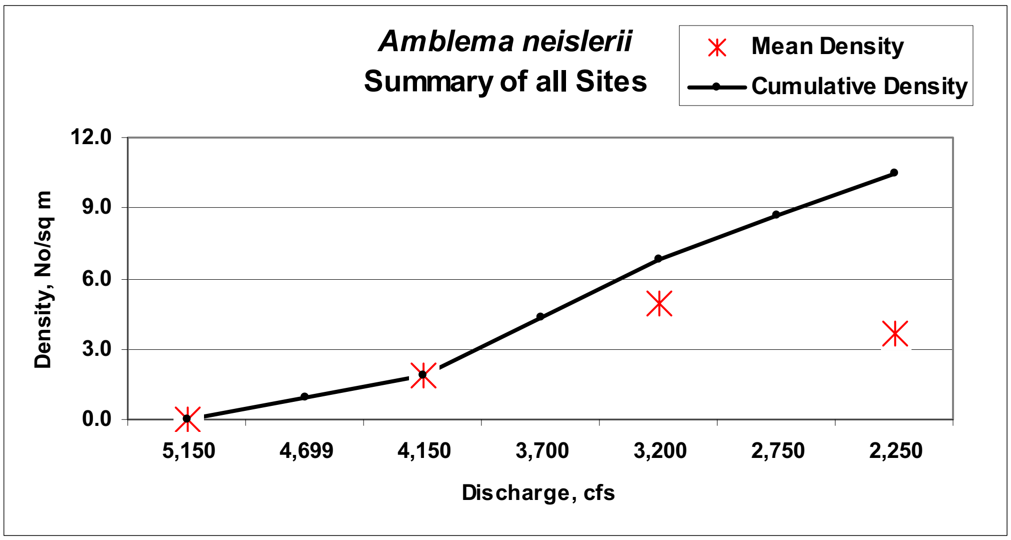


Figure B1

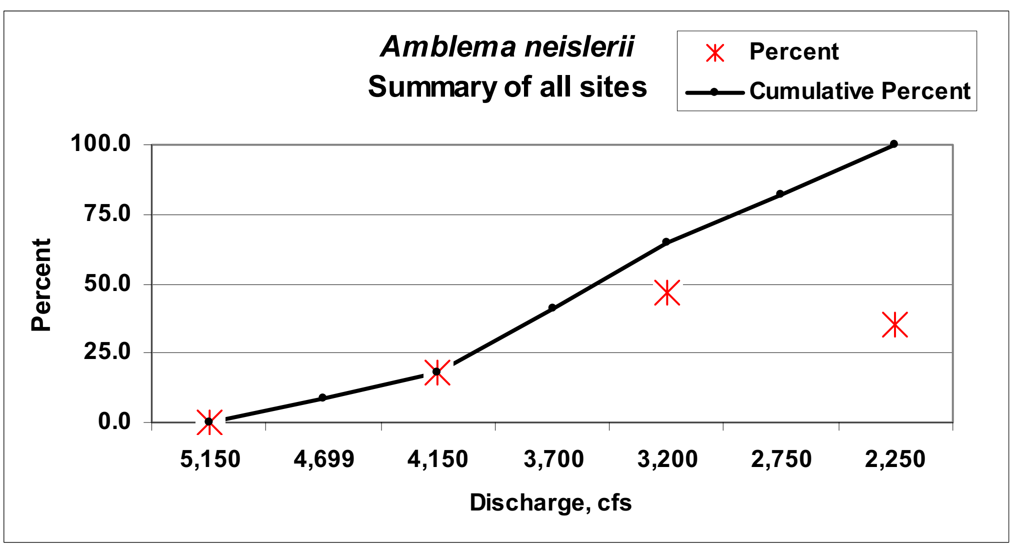
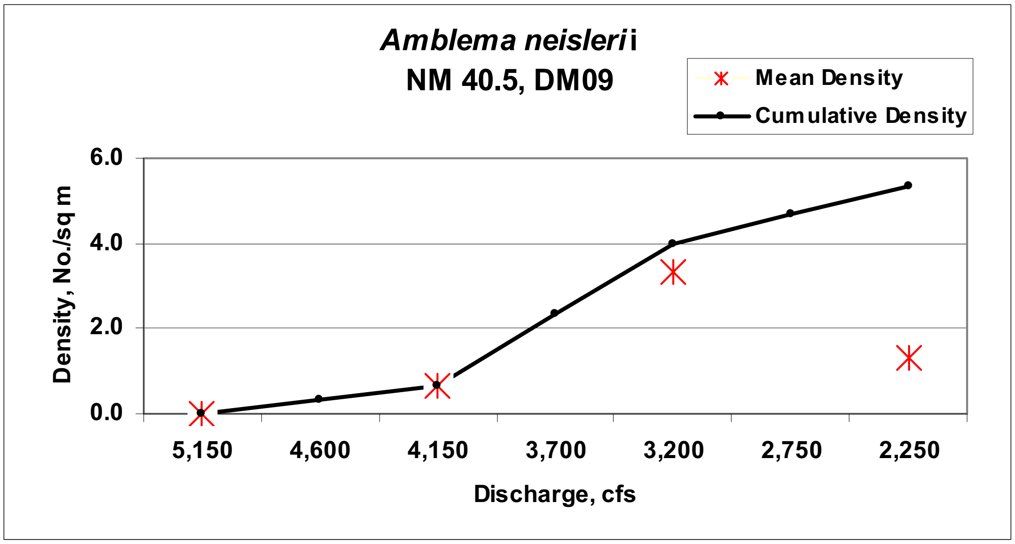


Figure B2



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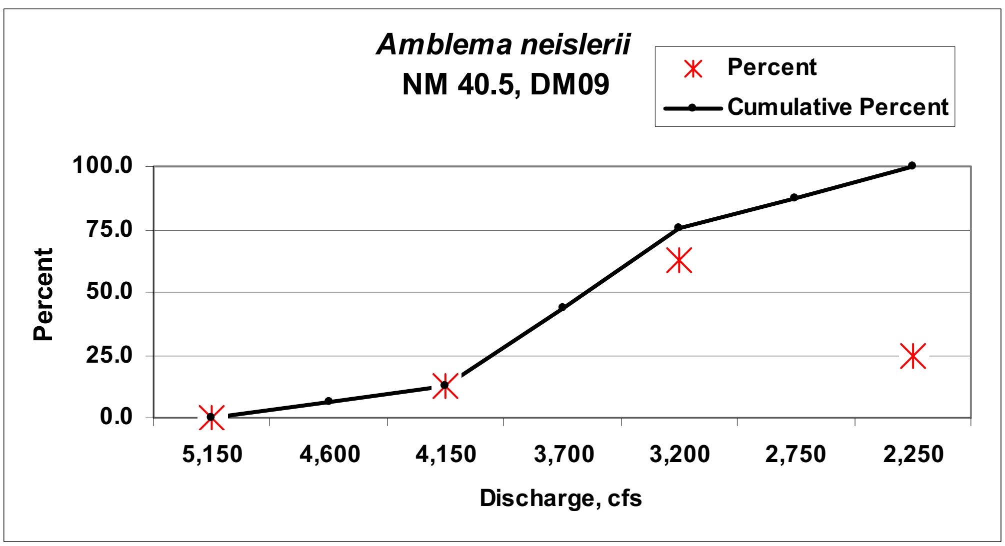

Figure B4

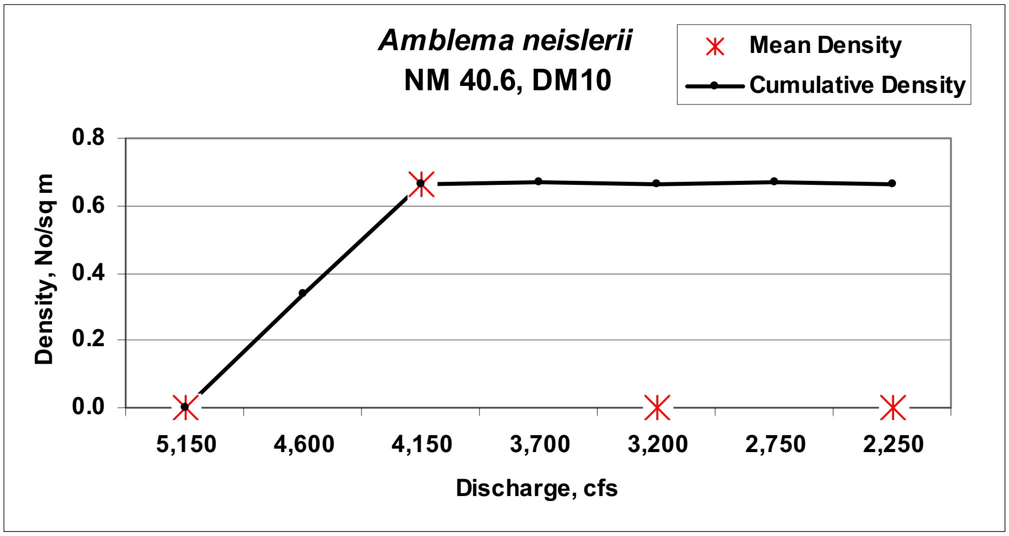

Figure B5

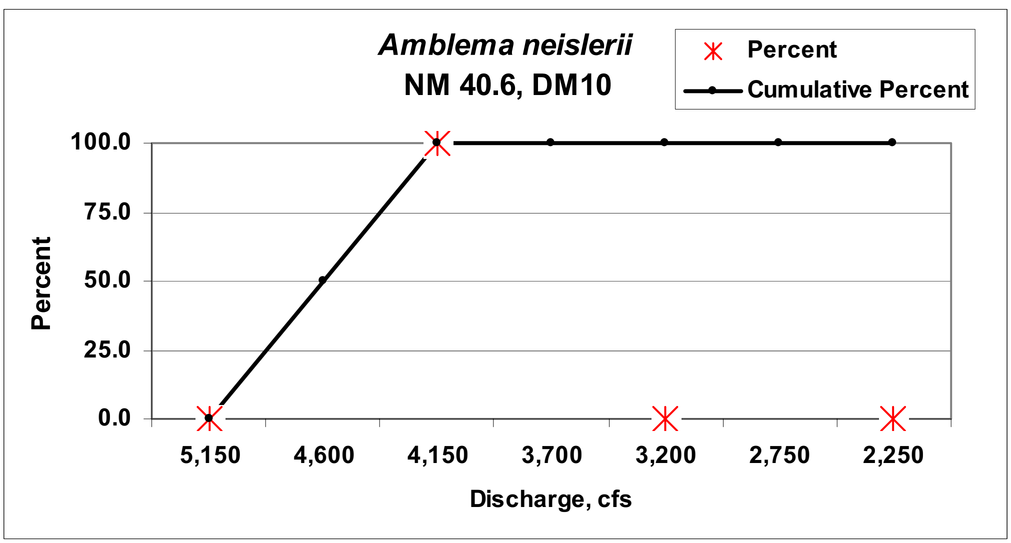

Figure B6

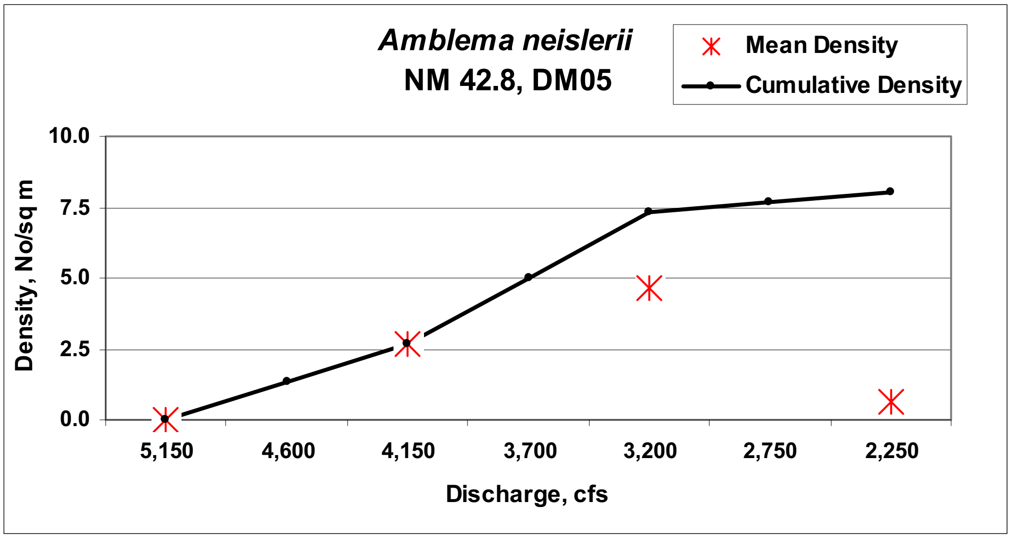

Figure B7

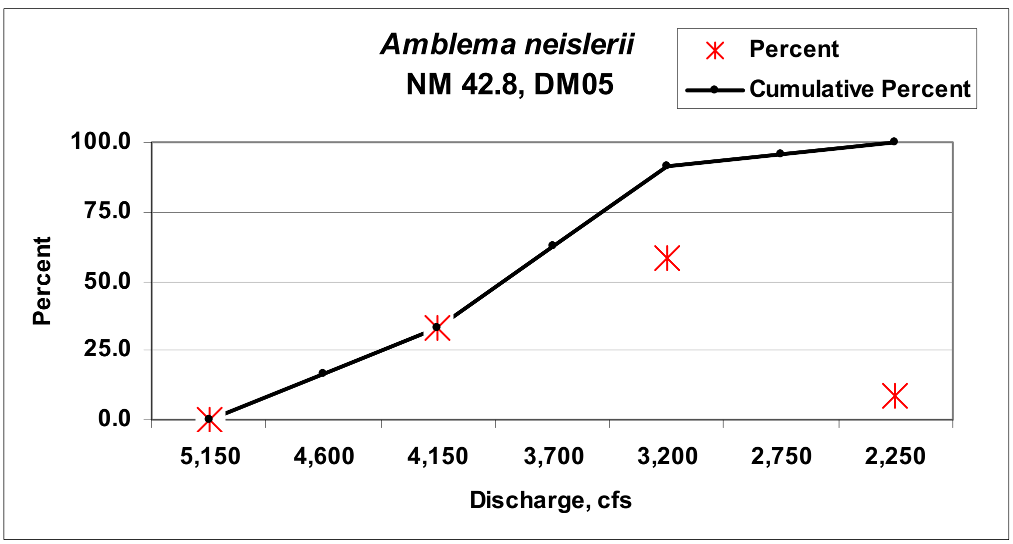

Figure B8

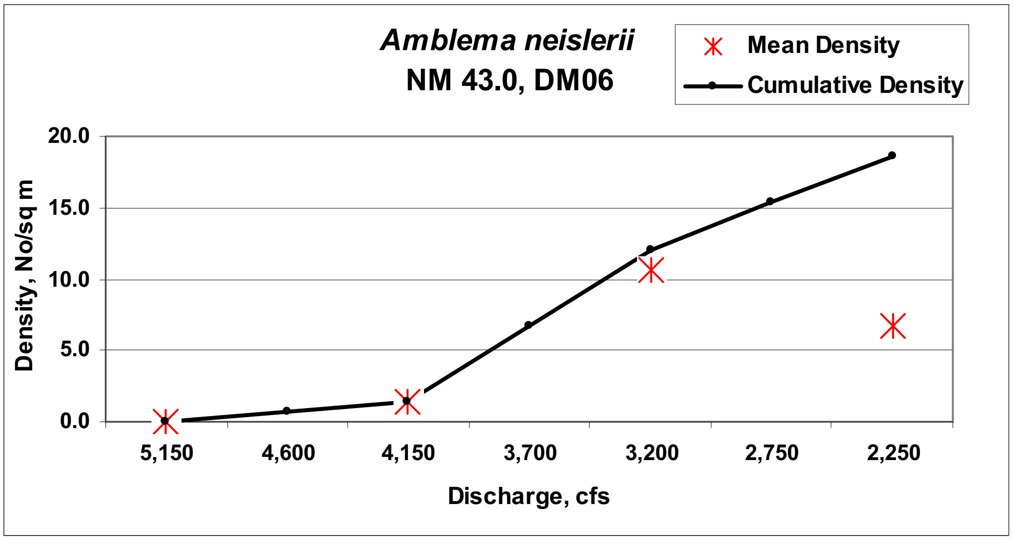

Figure B9

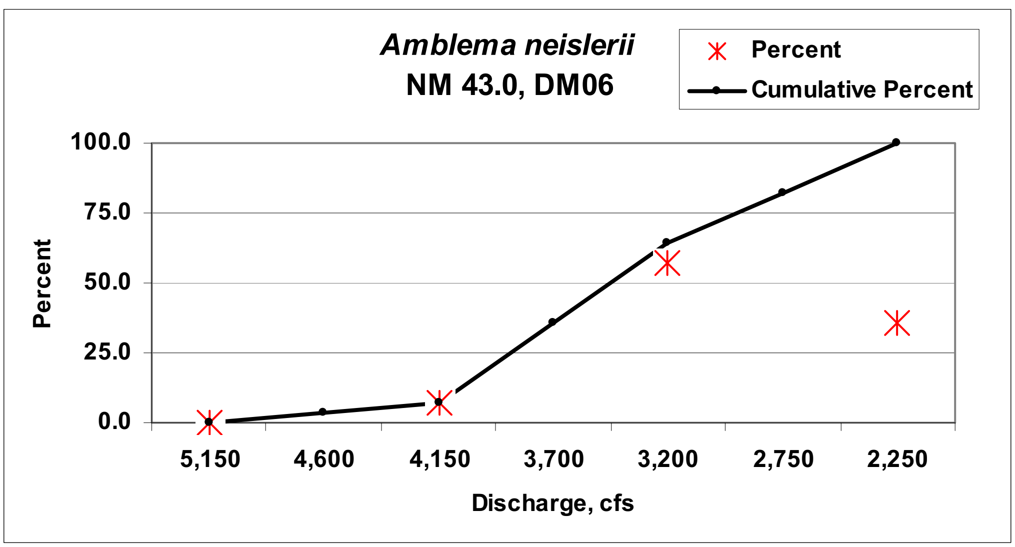

Figure B10

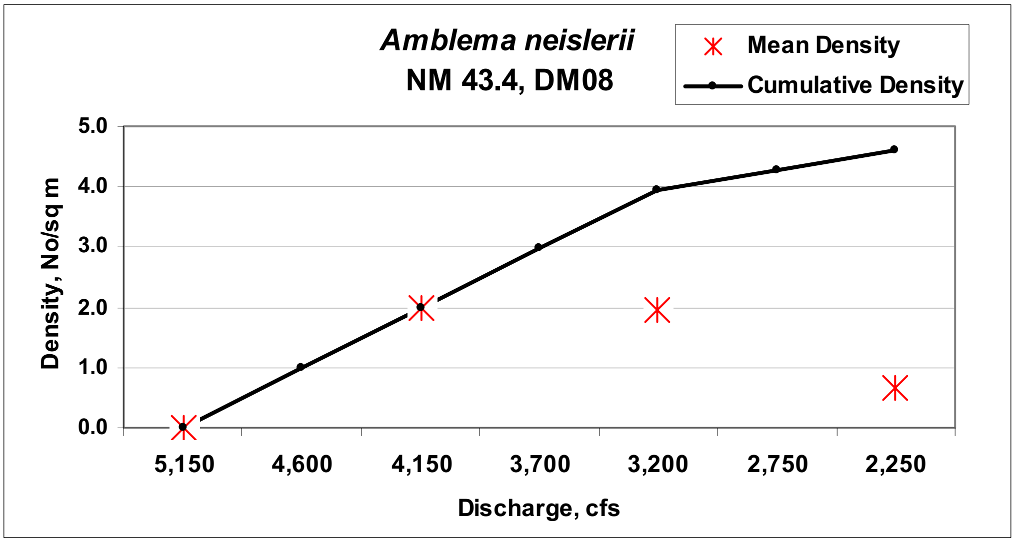

Figure B11

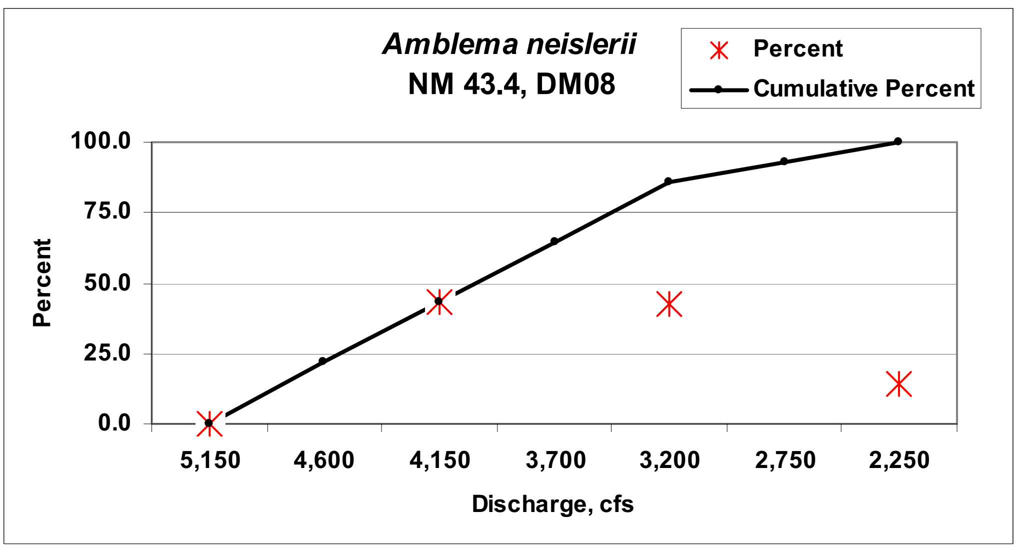

Figure B12

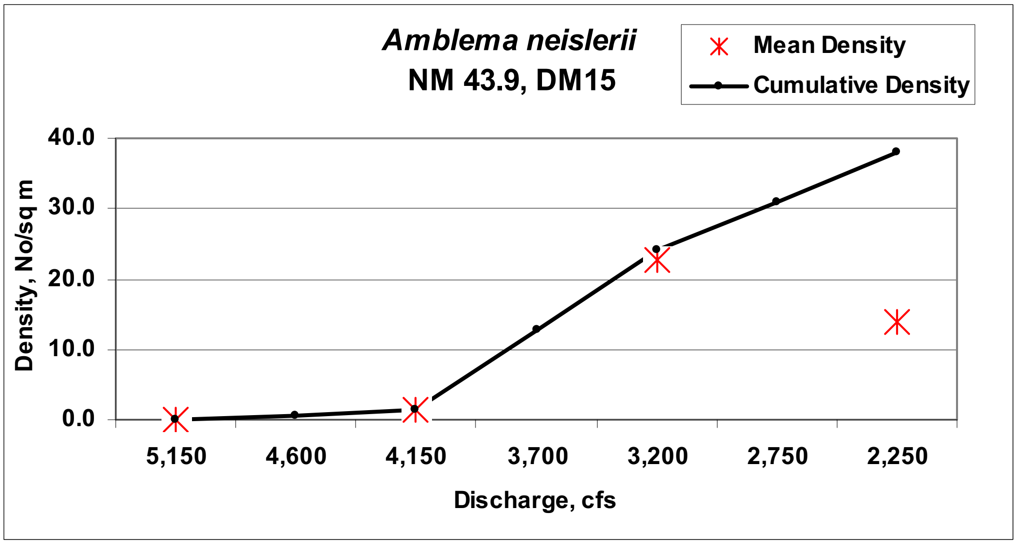

Figure B13

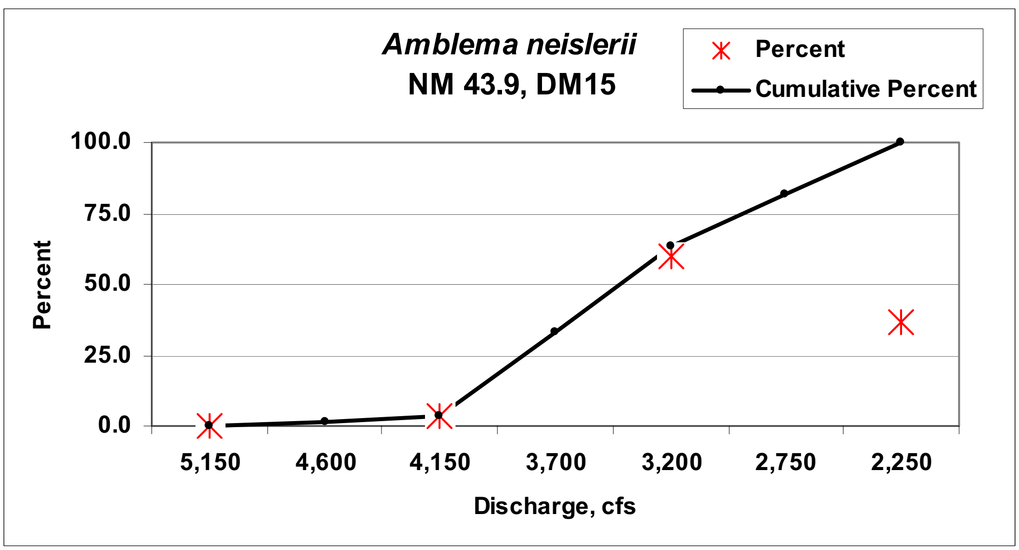

Figure B14

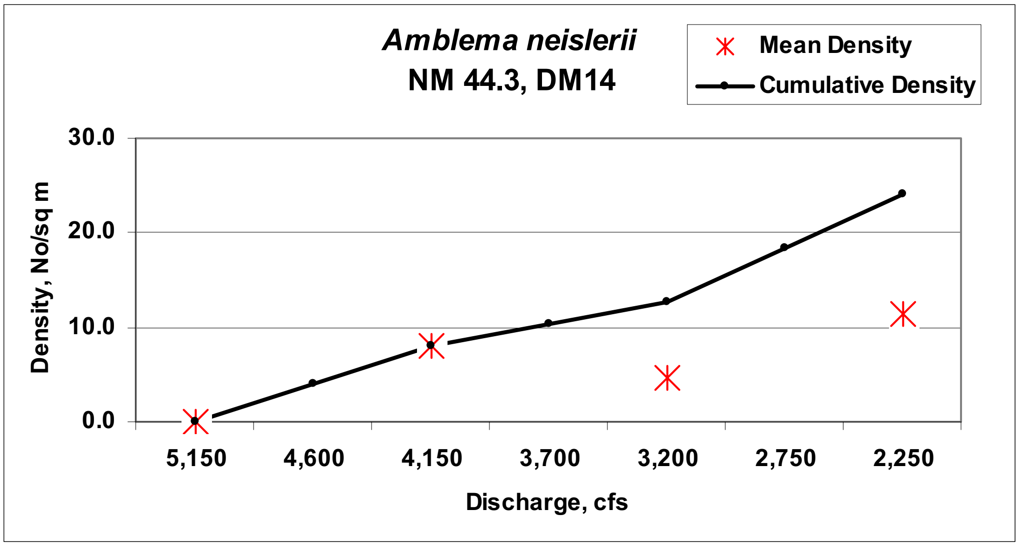

Figure B15

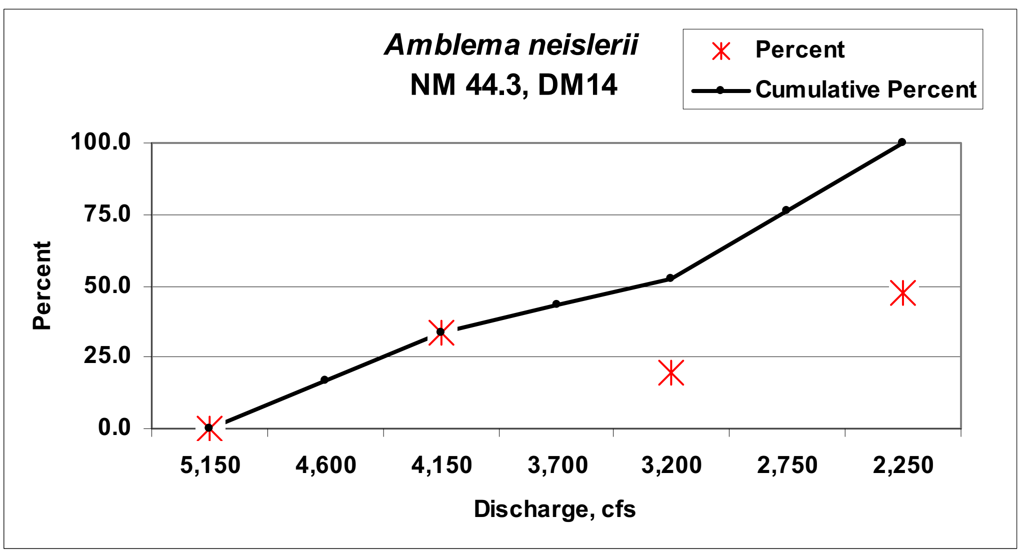

Figure B16

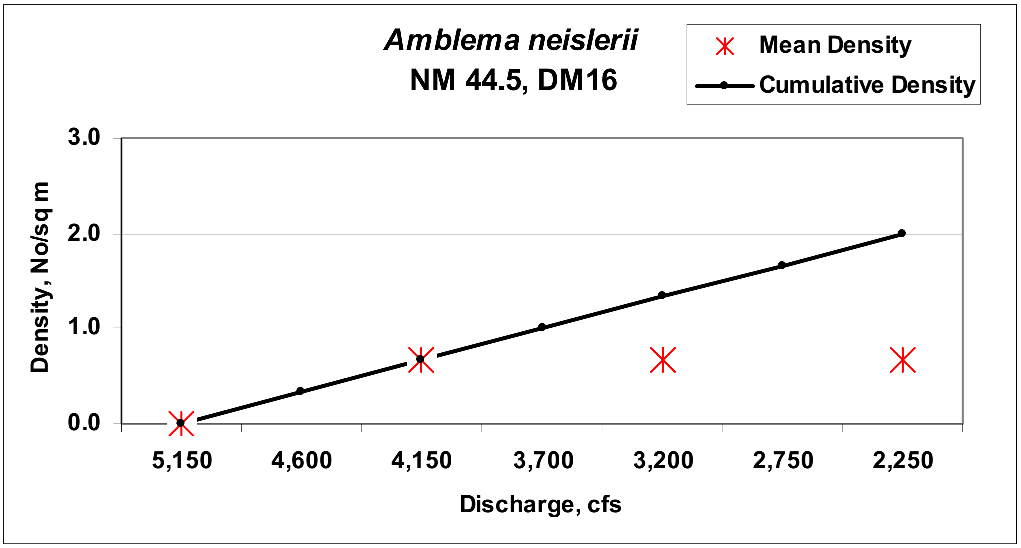

Figure B17

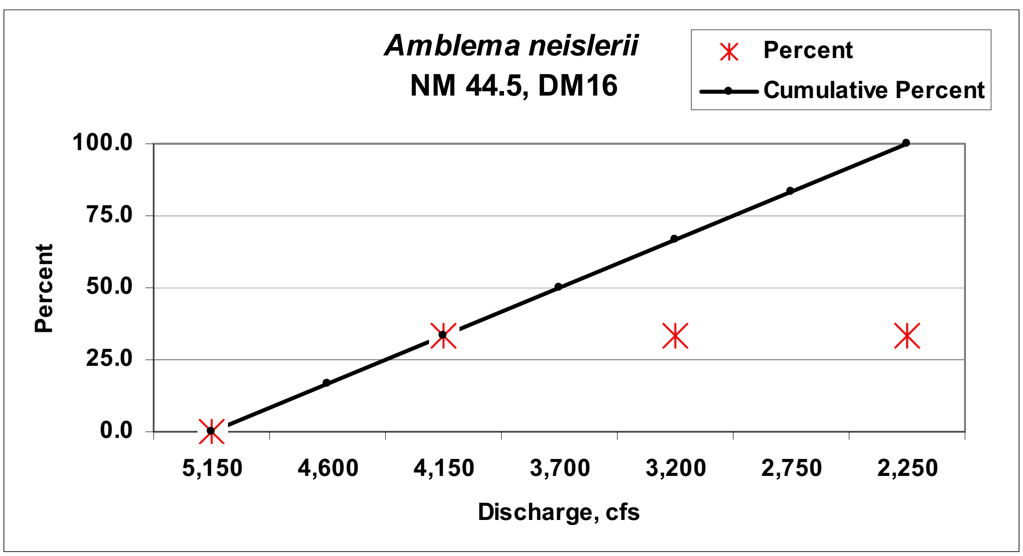

Figure B18

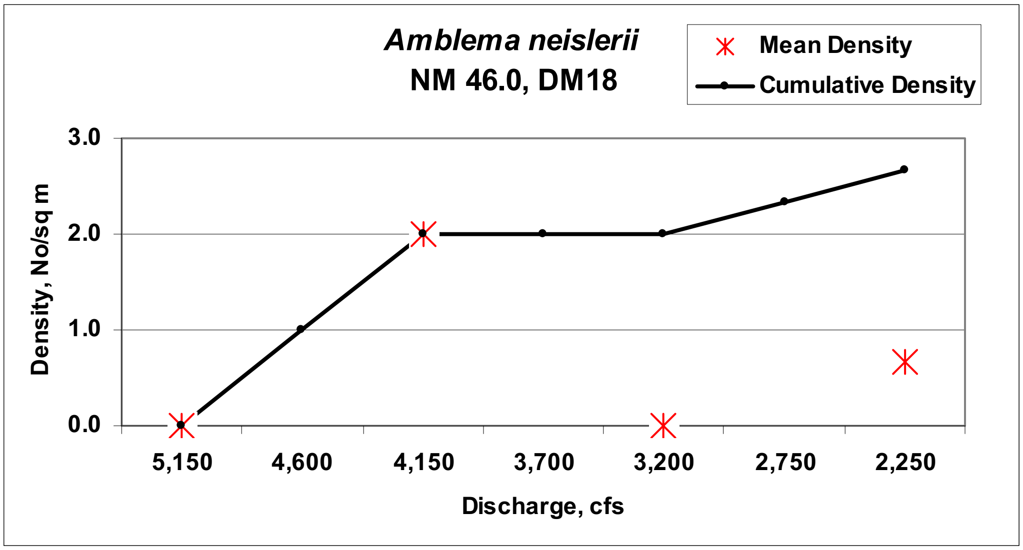

Figure B19

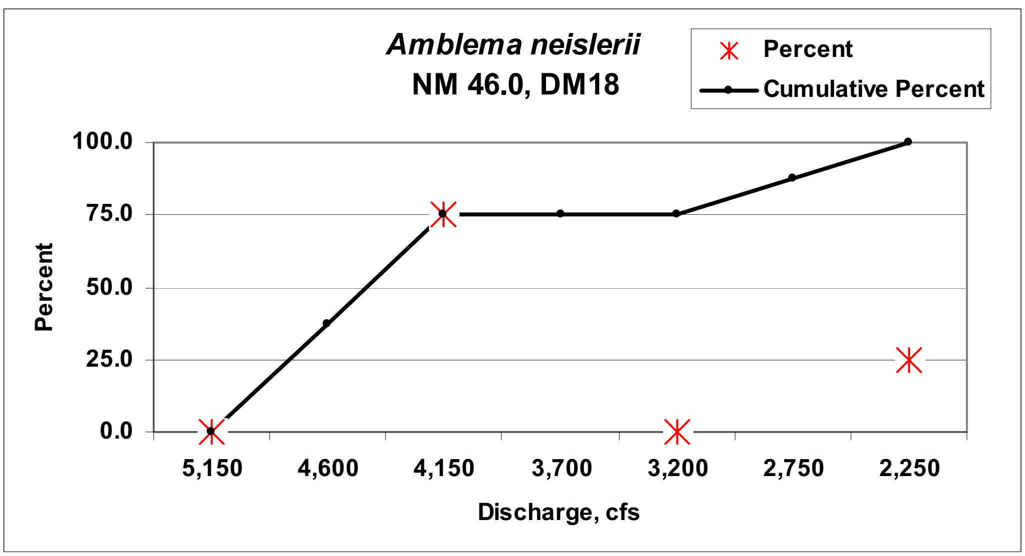

Figure B20

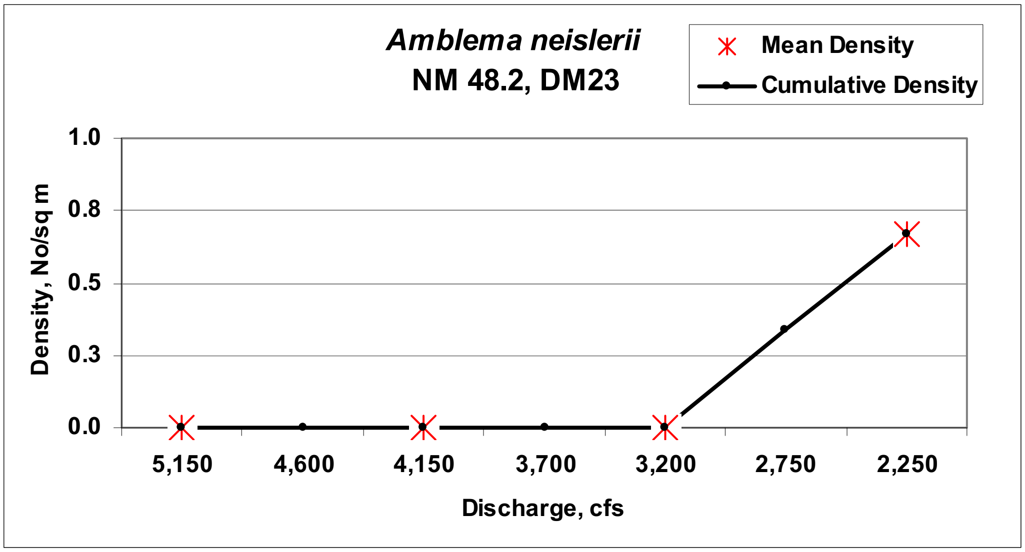

Figure B21

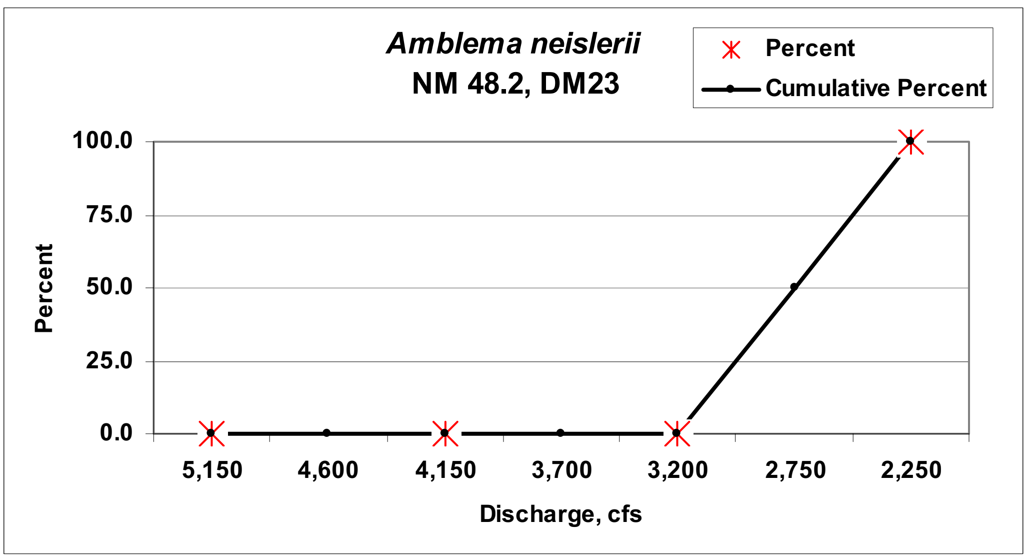

Figure B22