No. 142, Original

In The
Supreme Court of the United States

STATE OF FLORIDA,

Plaintiff,

v.

STATE OF GEORGIA,

Defendant.

GEORGIA'S OPPOSITION TO FLORIDA'S MOTION *IN LIMINE* REGARDING "LOST WATER" IN FLORIDA

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INTRODUCTION

Florida's motion attempts to exclude from this trial evidence that a significant amount of Apalachicola River water is being lost entirely within Florida's borders for reasons having nothing to do with Georgia. This loss is occurring on the order of 4,000 cubic feet per second ("cfs") annually—or roughly *5 to 10 times* the maximum amount of water Florida believes it could gain by imposing its proposed draconian caps on Georgia's water use. Essentially, Florida wants to keep the Supreme Court from understanding that Florida loses *thousands* of cfs within its own borders for reasons it cannot explain, while at the same time asking the Court to impose crushing restrictions on Georgia to restore a fraction of that amount. In a case built on principles of equity, there is no basis to keep this evidence from the Court's consideration, least of all through the ill-fitting vehicle of a motion to exclude expert testimony under *Daubert* or through appeals to "judicial economy."

Indeed, there is no basis for excluding the hydrology work by Georgia's experts that shows a significant flow decline within Florida. Georgia's experts—Dr. Philip Bedient and Dr. Sorab Panday—evaluated the federal government's official flow records for the Apalachicola River Basin and found that Florida's contribution to flows in the Apalachicola River has shrunk from an average of approximately 5,000-6,000 cfs in the 1980s and 1990s to approximately 1,000-2,000 cfs in recent years. Florida describes this as "lost water," which is somewhat of a misnomer. The "loss" refers to a decline in the total amount of rainfall that becomes streamflow in Florida's portion of the ACF Basin. Although there is still a net positive contribution on average, that contribution has declined over the long-term by approximately 4,000 cfs. Georgia's experts have reached these opinions by reviewing, analyzing, and summarizing federal flow records using a traditional, widely accepted method in the field of hydrology.

Florida's motion conveniently ignores that *its own experts* acknowledge flow declines within Florida based on the same methods used by Georgia's experts. Florida's hydrology expert, Dr. George Hornberger, identified a loss and concluded that it is attributable to "natural climate variations" resulting from "the dry period in the last roughly 15 years."[1] This admission is notable not only because it validates Georgia's experts' analyses of the stream gage data, but also because of the significance of his admission that flows in the ACF Basin have been reduced by the three severe, multi-year droughts since 1999—not Georgia's water use. Nonetheless, while Florida's experts opine that the flow declines *below* the state line are attributable to "natural climate variations," they insist that any flow declines *above* the state line are attributable solely to Georgia's water use. Florida cannot have it both ways. Similarly, Florida cannot complain of declining flows in the Apalachicola River and lay the blame entirely on factors above the state line while trying to prevent the Court from hearing any evidence of what is actually occurring below the state line.

[1] Hornberger Dep. Tr. 573:3-8, August 4, 2016 ("Q: And do you see where you say in the caption to Figure 11 the trend is driven by low recorded flows in the past 15 years? A: The slight trend downward is because of the dry period in the last roughly 15 years."); Defensive Expert Report of Dr. George M. Hornberger, at 18-19 (May 20, 2016) ("Hornberger Defensive Rep't") (Attachment 1).

Aside from the obvious contradiction in Florida's positions, the crux of Florida's motion is that the Court should not hear any evidence about the undisputed flow decline in the Apalachicola River because Georgia's experts do not offer opinions regarding the *cause* of those declines. None of Florida's cited authorities are on point, however, because Georgia's experts are not purporting to offer opinions as to the cause of the observed flow change over time, nor do their opinions depend upon identifying any particular cause of the flow decline. As a result, the lack of a "causal analysis" cannot possibly undermine their opinions. There is nothing unreliable or "unscientific" about conducting hydrologic analysis of stream gage data and describing hydrologic changes in the Apalachicola River. The methodologies employed by Dr. Bedient and Dr. Panday are standard and accepted by hydrologists, and are regularly employed by experts in their fields—including by Florida's own experts in this case. This is a classic example of a party seeking to exclude expert testimony not based on any flaw in the expert's methodology, but instead based on the *results* of that expert's analysis.

More fundamentally, whatever the cause, the fact is that these losses are occurring and are critical to understanding Florida's allegations regarding the hydrology of the ACF Basin. Florida is the party that must explain how it can justify calling for severe and costly reductions in Georgia's water use above the state line while substantial losses are occurring below the state line. This Court should refuse Florida's invitation to preclude Georgia from offering testimony on the fundamental issue of declining streamflows in the Apalachicola River solely within Florida.

ARGUMENT

I. GEORGIA AND FLORIDA'S EXPERTS USED THE SAME METHODS AND BOTH CONCLUDED THAT FLORIDA'S CONTRIBUTION TO APALACHICOLA RIVER FLOWS HAS DECLINED OVER TIME

Florida claims that Apalachicola River flows have been declining as a result of Georgia's upstream water use. *See* Compl. ¶¶ 54, 57, 59. Dr. Bedient and Dr. Panday, Georgia's hydrology experts, independently evaluated stream gage records maintained by the United States Geological Survey ("USGS") from measurement stations on the Apalachicola River in Florida. Both experts found that over time, Florida's own contribution of flows to the Apalachicola River has *decreased*, while Georgia's proportional contribution of flows to the Apalachicola River has *increased*. This analysis is methodologically sound and essentially confirmed as valid by Florida's own experts, who conducted similar analyses based on the same methods.

A. Georgia's Experts Used Well-Accepted Methods To Analyze Flow Reductions In Florida

Dr. Philip Bedient is an expert in hydrology and hydrologic modeling. He has over 40 years of experience in surface water hydrology, floodplain analysis, stream gage data analysis, and hydrologic modeling of large-scale watersheds in the Southern and Southeastern United States, including in Florida, Texas, and Louisiana. He is currently the Herman Brown Professor of Engineering at Rice University in Houston, and has authored multiple textbooks, including *Hydrology and Floodplain Analysis* (5th ed., 2012).

As part of his work in this case, Dr. Bedient reviewed recorded flow data from the USGS stream gages at Chattahoochee, Florida and Sumatra, Florida. The Chattahoochee gage is the northern-most gage on the Apalachicola River (just below the state line) and the Sumatra gage is the southern-most gage on the river (just above the Apalachicola Bay). The flows at the Chattahoochee gage reflect inflow to the Apalachicola River (*i.e.*, resulting from releases from the Woodruff Dam), and the flows at the Sumatra gage are comprised of flows at the Chattahoochee gage as well as any flows that are added or subtracted as the Apalachicola River flows through Florida.

The calculation of positive or negative flow contribution by subtracting upstream flow from downstream flow is a standard method of analysis that is regularly employed by experts in the field. USGS scientists studying the ACF Basin use this very method and have explained that "[s]treamflow loss or gain over a reach was calculated by subtracting upstream flow measurements from corresponding downstream flow measurements over a stream segment that defines the reach."[2] Even Florida's experts endorse this method of analysis. Dr. David Langseth, Florida's groundwater expert, explained that "when the upstream flow measurement is greater than the downstream flow measurement the difference indicates" a loss of water from the river.[3]

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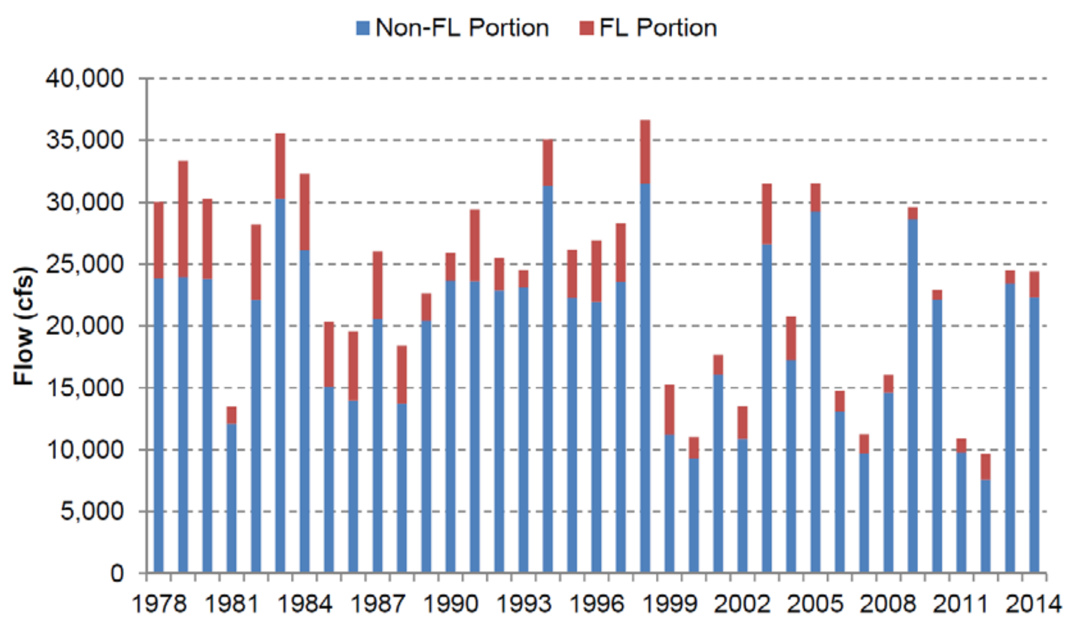
2 Debbie W. Gordon et al., *Hydrologic and Water-Quality Conditions in the Lower Apalachicola–Chattahoochee–Flint and Parts of the Aucilla–Suwannee–Ochlockonee River Basins in Georgia and Adjacent Parts of Florida and Alabama During Drought Conditions, July 2011*, USGS Scientific Investigations Report 2012-5179, at 8, *available at* http://pubs.usgs.gov/sir/2012/5179/pdf/sir2012-5179.pdf.

3 Expert Report of Dr. David E. Langseth, at D-22 (Feb. 29, 2016)(Attachment 2).

Based on this well-accepted methodology, Dr. Bedient found that over the last four decades, the flow contributed to the Apalachicola River solely within Florida (referred to as "incremental flow") has declined over time.[4] The losses here refer to decreases in the amount of surface runoff contributed within Florida to Apalachicola River flow. Dr. Bedient found that for the same amount of rainfall over the Florida portion of the ACF Basin, less water is entering the streams as runoff. From 1978-1998, Florida's contribution of flows to the Apalachicola River generally averaged about 5,000 to 6,000 cfs per year. After 1999, however, Florida's contribution declined to roughly 1,000 to 2,000 cfs per year. The total streamflow in the Apalachicola River for 1978-2014, broken up into Florida and "non-Florida" portions, can be seen in the below figure, which is reproduced from Dr. Bedient's expert report.[5]

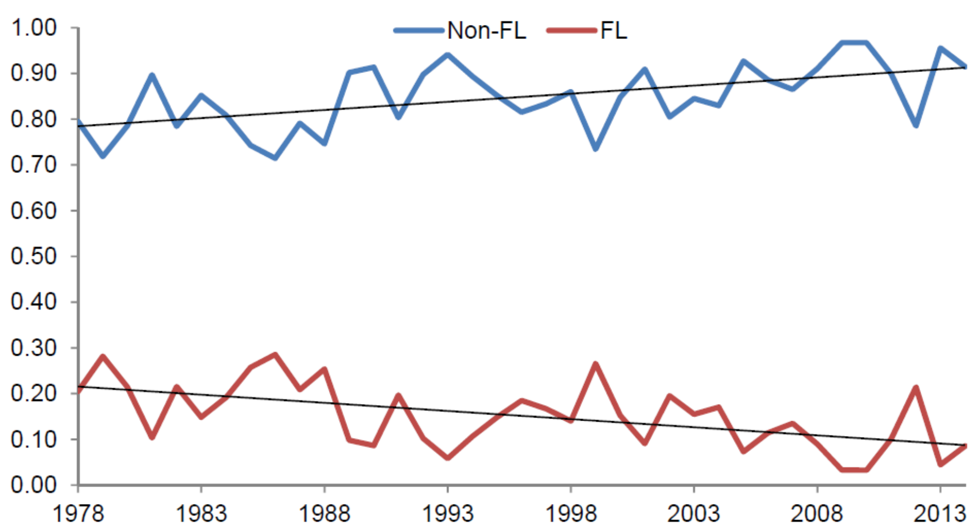


[4] *See* Defensive Expert Report of Dr. Philip B. Bedient, at 76-79 (May 20, 2016) (hereafter "Bedient Defensive Rep't")(Attachment 3).

[5] *See id.* at 77 (fig. 51).

The blue bar represents the "non-Florida" portion of the flow, *i.e.*, the total amount of water entering the Apalachicola River from above the state line as recorded at the Chattahoochee gage. The red bar represents the "Florida" portion of the flow, *i.e.*, the incremental amount added in Florida between the Chattahoochee and Sumatra gages. As shown in the figure, the Florida contribution (red) has been shrinking since 1978, and particularly since 1998, for a long-term average decline of approximately 4,000 cfs.

Florida's contributions have not only declined as a matter of absolute flows; they have also declined in terms of percentage of overall flows. As reflected in the below figure,[6] Florida's share of flows has fallen from approximately 20% in 1978 to approximately 10% in 2014. Georgia's share has actually increased from approximately 80% to approximately 90% over that same time period.



[6] This figure is also reproduced from Dr. Bedient's Defensive Expert Report. *See id.* at 78 (fig. 53).

Contrary to Florida's suggestions, Dr. Bedient has not opined that water has mysteriously vanished. He has opined that Florida has been contributing less water in the form of surface water runoff to the river system over time—both in absolute terms and relative to contributions from Georgia. The "loss" represents this decline over time. It also bears noting that the long-term decline of 4,000 cfs is well within the natural variability of the amount of runoff being contributed to the river. For instance, as the first figure shows, Florida's contribution in 1980 was relatively high (over 5,000 cfs), but in 1981, Florida's contribution was relatively low (around 1,000 cfs). This reflects a difference of approximately 4,000 cfs over a one-year period. The long-term decline indicates that low-contribution years are simply occurring more frequently now than high-contribution years. Even though there is significant natural variability from year to year, on average, there is no question that the data shows that Florida's contribution is consistently declining over the decades.

Dr. Sorab Panday is Georgia's expert in groundwater hydrology and modeling, with decades of experience in the hydrology and groundwater industry. Dr. Panday has developed expertise in analysis of groundwater and surface water hydrology, including water budget analyses. Clients who have relied on his experience include federal agencies such as the EPA, the U.S. Army Corps of Engineers, and various state agencies in Florida such as the Northwest Florida Water Management District. Like Dr. Bedient, Dr. Panday evaluated the flow differences between the Chattahoochee and Sumatra gages and came to a similar conclusion: Florida's average incremental flow contribution to the Apalachicola River has plummeted from 5,254 cfs (pre-1992) to 2,614 cfs (post-1992)—a change of 2,640 cfs.[7] Thus, Dr. Panday found that since 1992, Florida's contributions to the Apalachicola River and Bay are about half what they were pre-1992.

Dr. Panday then went further and performed a "water budget analysis" for the entire Apalachicola River Basin between the Chattahoochee and Sumatra gages. Because this analysis looks at the River Basin instead of just the River, the results are slightly different, though they also showed a losing trend over time. The water budget analysis consists of all inflows and outflows to this Basin area. Water budget analyses are a generally accepted method for analyzing watersheds. The USGS explains: "Water budgets provide a means for evaluating availability and sustainability of a water supply. A water budget simply states that the rate of change in water stored in an area, such as a watershed, is balanced by the rate at which water flows into and out of the area."[8] The USGS has also found that comparing how water budgets change over time is a valid method of analysis: "Observed changes in water budgets of an area over time can be used to assess the effects of climate variability and human activities on water resources."[9]

Dr. Panday's water budget evaluated the flow inputs to the Apalachicola River Basin from Georgia and from the Chipola River, as well as the contribution of

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7 Expert Report of Dr. Sorab Panday, at fig.3-6 (May 20, 2016) (hereafter, "Panday Rep't") (Attachment 4).

8 Richard W. Healey et al., *Water Budgets: Foundations for Effective Water-Resources and Environmental Management*, USGS Circular 1308, at 1 (2007), *available at* http://pubs.usgs.gov/circ/2007/1308/pdf/C1308_508.pdf.

9 *Id.*

precipitation over the Basin area between the Chattahoochee and Sumatra gages. He then compared those values to the output at the Sumatra gage. Based on his water budget analysis, Dr. Panday observed that before 1992, Florida was *contributing* an annual average amount of 727 cfs to the Basin; since 1992, however, the annual average Basin *losses* are 1,276 cfs.[10] This means that Florida has contributed over 2,000 cfs *less* runoff to Apalachicola River flows since 1992, and that that change cannot be wholly explained by changes in precipitation. Dr. Panday's analyses confirm that Florida's contribution of flows—both directly to the Apalachicola River as well as within the Apalachicola River Basin—has declined in recent years.

The observed flow declines in the Apalachicola River represent a significantly greater amount of water than what Florida is seeking in this litigation. Taking at face value the analysis of Florida's economist, Florida hopes that cutbacks in Georgia's water use in the Flint River Basin would generate a maximum of 1,000 to 2,000 cfs increases in streamflow in the Flint River during peak summer months. Because this is a peak monthly value, the annual average increase in streamflows under Dr. Sunding's calculation would be 438 to 877 cfs.[11] The long-term incremental flow loss of 4,000 cfs, which represents an annual average value, is roughly *5 to 10 times* larger than the maximum annual streamflows Florida claims could be generated by imposing severe restrictions on Georgia's water use.

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10 Supplemental Memo of Dr. Sorab Panday, at 8 (July 26, 2016) (Attachment 5).

11 Expert Report of Dr. David Sunding, at 53 (Feb. 29, 2016) (Attachment 6); Defensive Expert Report of Dr. David Sunding, at 4 (May 20, 2016) (Attachment 7); Expert Report of Dr. George M. Hornberger, at 93 (Feb. 29, 2016) (hereafter "Hornberger Rep't") (Attachment 8).

B. Florida's Experts Agree That Flow Declines Are Occurring Solely Within Florida

Although Florida neglects to mention this fact in its motion, its own experts have made findings similar to those of Georgia's experts. Dr. Hornberger and Dr. Langseth evaluated the flow differences between the Chattahoochee and Sumatra gages and found—just like Georgia's experts—that Florida's contributions to the Apalachicola River have declined over time. In his second expert report, Dr. Hornberger found "differences" in measured flows between the USGS gages at Chattahoochee and Sumatra that "show a decrease with time."[12] Dr. Hornberger also used the same method to calculate incremental flow between Chattahoochee and Sumatra for his first expert report (without questioning either the validity of the methodology or the quality of flow data at the Sumatra gage).[13] Dr. Langseth similarly agreed that the incremental flow loss between the Chattahoochee and Sumatra gages reflects a decline in the amount of water being contributed to the Apalachicola River in Florida: at his deposition, Dr. Langseth agreed that a difference in flow between the Chattahoochee and Sumatra gages reflects "less water" between upstream and downstream points on the river.[14]

Florida's experts used the very same methods employed by Dr. Bedient and Dr. Panday to analyze changes in flows over time. After employing these well-

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[12] Hornberger Defensive Rep't, at 18. ("The flow differences for adjusted flows at the Sumatra and Chattahoochee gages show a decrease with time . . . .")

[13] Hornberger Rep't, at 90.

[14] Dr. Langseth was asked: "[D]o you agree that if a downstream gage shows less flow than an upstream gage, water is somehow lost from the river between those two gages?" and he answered, "From a pure numbers perspective, if the numbers— the downstream numbers is less than the other, clearly there's less water." Langseth Dep. Tr. 912:13-913:2, July 21, 2016.

accepted methods, Florida's experts came to the same conclusion: the USGS gages show declining incremental flows in the Apalachicola River, and these losses have increased over time.

II. GEORGIA'S EXPERTS ARE NOT OFFERING OPINIONS REGARDING THE CAUSE OF THE INCREMENTAL FLOW DECLINE, NOR MUST THEY OFFER SUCH OPINIONS

Florida claims that Georgia's opinions regarding incremental flow loss are unreliable and should be excluded as "conjecture and speculation" because Drs. Bedient and Dr. Panday have not performed a "causal analysis" regarding the underlying cause of the flow decline in the Apalachicola River. *See* Mot., at 1-2, 8-9. Florida cites to multiple authorities involving cases where an expert has opined on causation and the courts have excluded that opinion because the expert's causal analysis was lacking, or because the expert failed to investigate other possible causes.[15] But all of these cases are distinguishable because they involve experts who offered opinions regarding causation. The absence of a "causal analysis" cannot possibly undermine Dr. Bedient and Dr. Panday's opinions because they are not purporting to offer any opinions about what caused the incremental flow loss, nor do their opinions depend upon identifying any particular cause. Instead, Georgia's experts have conducted an analysis of hydrologic data from official federal government stream gage records using well-established methods in their field, and

[15] *See Viterbo v. Dow Chem. Co.*, 826 F.2d 420, 422-24 (5th Cir. 1987) (expert claimed Tordon 10K caused plaintiff's symptoms); *Huerta v. BioScrip Pharmacy Servs., Inc.*, 429 F. App'x 768 (10th Cir. 2011) (experts opined that subpotent levels of anti-rejection drug caused kidney transplant recipient's rejection of her transplanted kidney); *Rodrigues v. Baxter Healthcare Corp.*, 567 F. App'x 359 (6th Cir. 2014) (expert claimed that contaminated drug caused injury); Davidov v. Lousiville Ladder Grp., LLC, 169 F. App'x 661 (2d Cir. 2006) (expert claimed injuries caused by defective ladder).

have concluded that there is a loss of water occurring in the Apalachicola River within Florida's borders, and that those reductions cannot possibly be related to Georgia's water use above the state line.

The fact that Dr. Bedient and Dr. Panday limit their opinions to the *fact* of incremental flow loss and do not opine on the *cause* of the loss does not render their opinions unreliable. Federal Rule of Evidence 702 simply requires that expert testimony "help the trier of fact to understand the evidence," be "based on sufficient facts or data," be "the product of reliable principles and methods," and that the "expert has reliably applied the principles and methods to the facts of the case." Fed. R. Evid. 702. Under Rule 702, it is well established that expert testimony is admissible in order to provide expert analysis of "complicated, voluminous, or . . . scientific or technical data" such that the expert's testimony "would assist the trier of fact in understanding" the issues. *See In re DePuy Orthopaedics, Inc. Pinnacle Hip Implant Prods. Liab. Litig.*, No. 3:11-MD-2244-K, 2014 WL 3557345, at *7 (N.D. Tex. July 18, 2014). That is what Georgia's hydrology experts have done here. The existence of significant flow declines in Florida is unquestionably of significance to evaluating Florida's claims that Georgia is causing reductions in flows in the Apalachicola River, and the technical analyses by Dr. Bedient and Dr. Panday are clearly relevant and helpful to the Court's understanding of those claims by Florida.

Florida's motion is premised on a fundamental misunderstanding of the standards for admissibility of expert testimony and an unjustifiably narrow reading of Rule 702 and the caselaw—one that many of its own experts would fail to satisfy.

For instance, in stark contrast to Dr. Bedient and Dr. Panday, Florida's experts on ecological harm *are* offering opinions on causation, but admittedly have failed to perform any causal analysis to support those opinions:

- Dr. Allan, Florida's expert on river ecology, presents causal opinions in his report: "Many of the harms described in this section are primarily caused by Georgia's consumption."[16] But Dr. Allan has admitted that he has not performed any causal analysis: "I do not in my report make any estimate of Georgia's role or any causal factor."[17]

- Dr. Jenkins, Florida's expert in bay ecology, also presents causal opinions, including: "Reduced flows caused by Georgia's consumptive water uses have harmed the ecosystem of the Bay."[18] During his deposition, however, he admitted: "Q: But you yourself have not done any causal analysis to determine whether or not it is Georgia's consumptive use that has impacted those freshwater flows? A. I have not."[19]

Florida likewise cannot argue that there is "too great an analytical gap between the data and the opinion proffered," Mot. at 2 (citation omitted), because Georgia's experts have made *no inferential leap* at all. Florida similarly strains to argue that Georgia's experts "fail[] to apply the scientific method," *id.* at 9, and that Georgia's "expert's methodologies are unexplained," *id.* at 8 (citation omitted), because they have not identified the cause of the flow decline.[20] None of these arguments has any merit, because Georgia's experts are not offering any opinions

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16 Expert Report of Dr. J. David Allan, at 81 (Feb. 29, 2016) (emphasis omitted) (Attachment 9).

17 Allan Dep. Tr. 19:8-10, June 2, 2016.

18 Expert Report of Dr. Kenneth Jenkins, at 9-15 (Feb. 29, 2016) (emphasis omitted) (Attachment 10).

19 Jenkins Dep. Tr. 80:18-22, May 24, 2016.

20 Florida also claims that "[n]either Dr. Bedient nor Dr. Panday addresses the possibility that an anomaly in gage records at the Sumatra Gage during high-flow periods might account for water loss." Mot. at 7. That is not the case. Dr. Bedient's memorandum dated July 26, 2016 contains 19 pages of analysis describing why Dr. Hornberger's analysis is flawed and why the USGS gage records at Sumatra are reliable and show similar variability as those at Chattahoochee, the latter of which Florida takes no issue with. Dr. Panday's July 26, 2016 memorandum contains 12 pages of analysis explaining why Dr. Hornberger's analysis of the Sumatra gage is unreliable.

regarding causation. Dr. Bedient and Dr. Panday are offering analyses and opinions regarding the existence of objective, observable hydrologic changes in the Apalachicola River; their opinions focus on the *existence* of the phenomenon, not the *cause* of the phenomenon.

To the extent Florida has offered any opinion about the cause of the declining contributions in flow on its side of the border, its explanation supports Georgia's arguments throughout this case that any observed flow declines in the Basin are not the result of Georgia's water use, but are the result of natural hydrologic changes. After observing a decline in incremental flow, Dr. Hornberger has concluded that the flow "differences" and decline in the Apalachicola River were the result of "natural climate variations" because "the late 1970s featured wetter years and very recent years included more dry and drought years."[21] As a result of these dry years in the recent period, Dr. Hornberger reasons, Florida's flow contribution in the Apalachicola River have declined. This is exactly what Georgia's experts have been saying is the primary cause of recently observed flow declines at the state line, not Georgia's water use.

Florida's last-ditch effort to prevent this Court from hearing relevant facts is an appeal to "judicial economy" because the "probative value" of the testimony would be "outweighed by the judicial resources it would consume." Mot. at 10. This argument rings hollow. At the outset, a full and fair examination of all relevant facts is critical for any equitable apportionment cases. *See Colorado v. New Mexico*,

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21 Hornberger Defensive Rep't, at 18-19.

459 U.S. 176, 183 (1982) (equitable apportionment "is a flexible doctrine which calls for the 'exercise of an informed judgment on a consideration of many factors' to secure a 'just and equitable' allocation." (quoting *Nebraska v. Wyoming*, 325 U.S. 589, 618 (1945))); *Colorado v. Kansas*, 320 U.S. 383, 393–94 (1943) ("And in determining whether one state is using, or threatening to use, more than its equitable share of the benefits of a stream, all the factors which create equities in favor of one state or the other must be weighed . . . ."). More critically, Florida has called for drastic and costly restrictions to be imposed on Georgia's consumption of water within Georgia's borders. Florida complains of declining flows in the Apalachicola River, but at the same time both sides' experts have found that flow declines are occurring solely within the Florida portion of the ACF Basin, and everyone agrees that those losses have *nothing to do with Georgia's water use*. This evidence indicates a key inequity in Florida's claims against Georgia. Principles of "judicial economy" do not justify preventing this evidence from coming to light in an equitable apportionment action of this significance.

CONCLUSION

Florida's motion is focused exclusively on Georgia's refusal to identify the *cause* of the incremental flow decline, when the real issue is that *there is a flow decline in the first place*. Georgia must be able to present evidence at the upcoming trial that water is being lost entirely within the Apalachicola River, and that that water loss—on the order of 5 to 10 times what Florida is seeking as a remedy—is contributing to the declines in flow in the Apalachicola River and Bay and has nothing to do with Georgia's water use.

For the reasons outlined above, Georgia respectfully requests that Florida's Motion *in Limine* to Preclude Expert Testimony by Dr. Philip Bedient and Dr. Sorab Panday on "Lost Water" be denied.

Date: September 30, 2016

Respectfully submitted,

/s/ *Craig S. Primis*

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September 30, 2016

ATTACHMENTS

Georgia has attached the documents below to its opposition to Florida's motion *in limine* regarding "Lost Water" in Florida. Pursuant to Case Management Rule 3.2, Georgia has not attached copies of the depositions cited in its opposition brief, but can provide them upon request.

Attachment 1	Excerpts from Defensive Expert Report of Dr. George M. Hornberger (May 20, 2016)
Attachment 2	Excerpts from Expert Report of Dr. David E. Langseth (Feb. 29, 2016)
Attachment 3	Excerpts from Defensive Expert Report of Dr. Philip B. Bedient (May 20, 2016)
Attachment 4	Excerpts from Expert Report of Dr. Sorab Panday (May 20, 2016)
Attachment 5	Supplemental Memo of Dr. Sorab Panday (July 26, 2016)
Attachment 6	Excerpts from Expert Report of Dr. David Sunding (Feb. 29, 2016)
Attachment 7	Excerpts from Defensive Expert Report of Dr. David Sunding (May 20, 2016)
Attachment 8	Excerpts from Expert Report of Dr. George M. Hornberger (Feb. 29, 2016)
Attachment 9	Excerpts from Expert Report of Dr. J. David Allan (Feb. 29, 2016)
Attachment 10	Excerpts from Expert Report of Dr. Kenneth Jenkins (Feb. 29, 2016)

ATTACHMENT 1

Measurement of Water Discharge in the Apalachicola River Between the Gages at Chattahoochee and at Sumatra, Florida

Defensive Expert Report in the matter of *Florida v. Georgia*, No. 142 Orig.

Prepared by:

____

Dr. George M. Hornberger

Prepared for
Florida Department of Environmental Protection

May 20, 2016

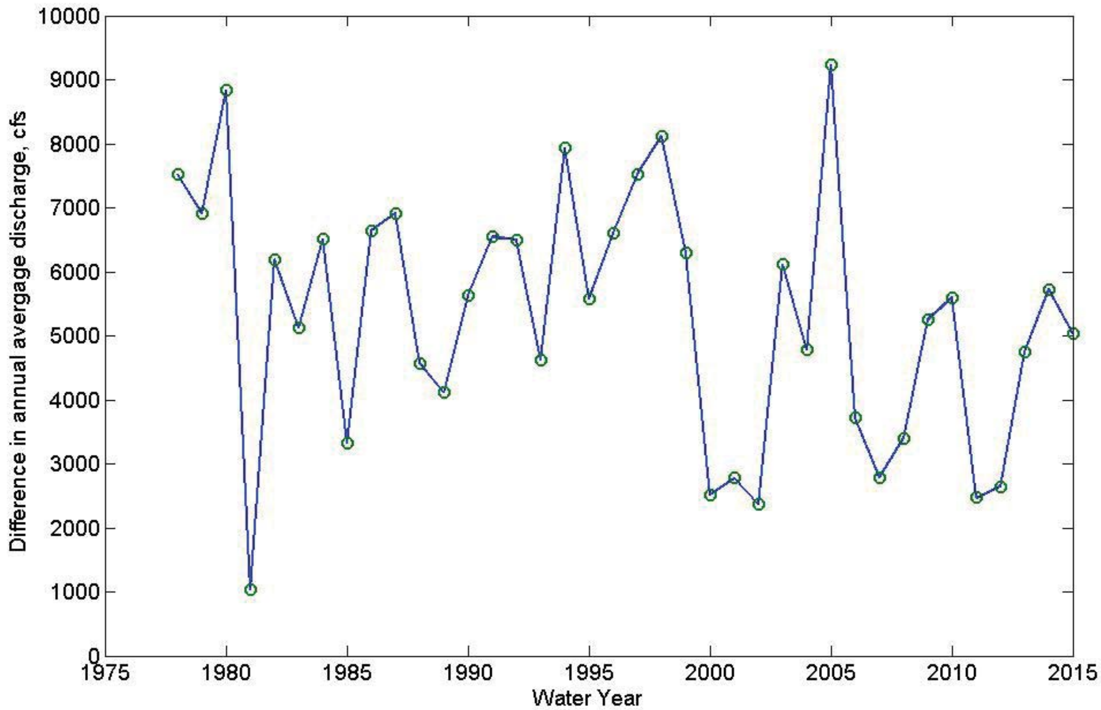

Figure 11. The flow differences for adjusted flows at the Sumatra and Chattahoochee gages show a decrease with time, but one that is much less than for uncorrected reported data. The "trend" is driven by the low recorded flows in the past 15 years.

Second, in gaining reaches of rivers (flow increasing in the downstream direction), differences in flow between two gages will be related to discharge itself. That is, the amount of water gained in a reach is larger for high-flow years than for low-flow years. This makes sense in that during wet years there is more water to feed the reach than there is in dry years. This can be seen clearly for the reach of the Apalachicola River between the Chattahoochee and Sumatra gages; the flow differences using adjusted flows at Sumatra are well correlated with the adjusted discharge at Sumatra (Figure 12).

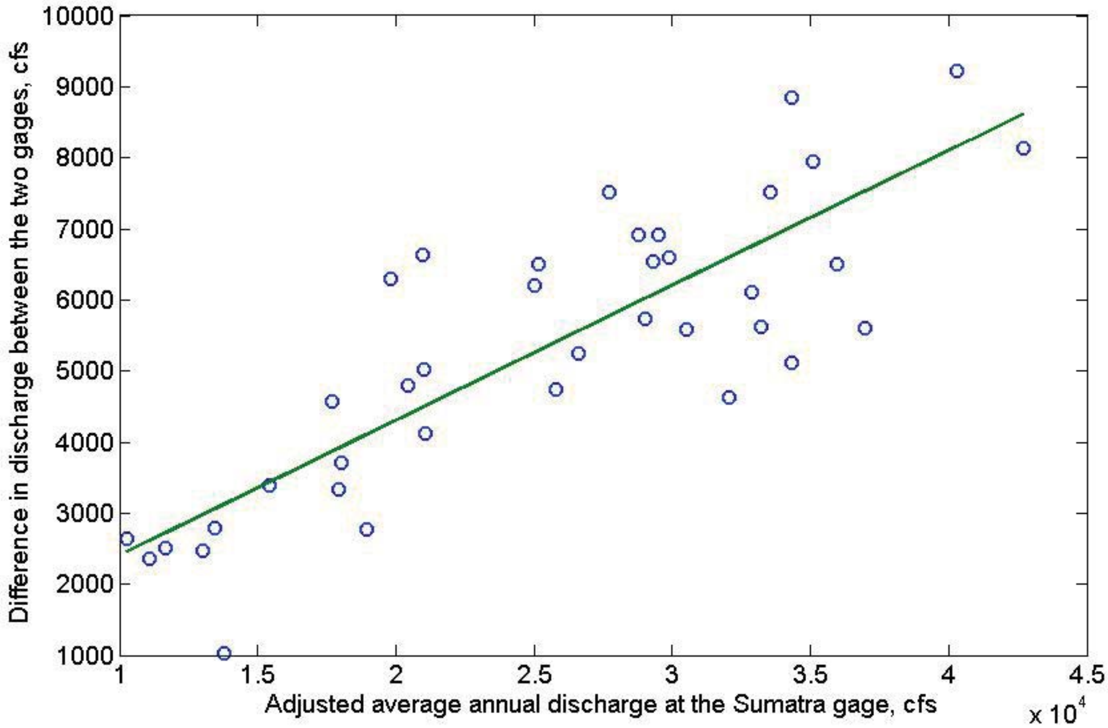

Figure 12. The difference between the adjusted flow at Sumatra and the flow at Chattahoochee is correlated with the adjusted flow at Sumatra.

Part of the apparent decline in differences in average annual discharge in the Apalachicola River between the Chattahoochee and Sumatra gages is simply due to natural climate variations over this limited period that Georgia selected in Figure 1 (1978 – 2014) (annual Sumatra gage discharge data is available from USGS from 1978 to the present). For the most part, the late 1970s featured wetter years and very recent years included more dry and drought years. The record of precipitation for the basin over the past century shows no consistent trend, just climate variability with wet periods and dry periods sporadically interspersed (Lettenmaier Expert Report, Feb. 29, 2016; Lettenmaier Expert Report, May 20, 2016).

The way to take into account the dependence of the flow difference on flow itself is to look at how observed variations are predicted using the flow dependence in Figure 12; this calculation shows that much of the observed variability is due to flow dependence (Figure 13, top panel). The question of whether there is a remaining unexplained trend is reduced to looking at residuals between the observed flow difference and that predicted by the trend in the relative proportion of wet and dry years across the record. There is no trend in these residuals (Figure 13, bottom panel). That is, there is no indication that water has been "lost" between the Chattahoochee and Sumatra gages (Figure 13). Rather, there is an expected greater flow difference in wet years than in dry years that accounts for the underlying data.

ATTACHMENT 2

Expert Report on Groundwater Conditions in the Apalachicola-Chattahoochee-Flint River Basin for the Supreme Court of the United States of America, in the Case of Florida *v*. Georgia, No. 142 Orig.

Prepared by

David E. Langseth, Sc.D., P.E., D. WRE

Prepared for
Florida Department of Environmental Protection

February 29, 2016

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Under normal recharge conditions, a simulated pumping rate of 287 billion gallons per year for 10 years resulted in a nearly 30% reduction in aquifer discharge to streams, which in turn reduced streamflow throughout the Dougherty Plain area (Hayes *et al*., 1983, p. 86). The average head declined 4 ft.

Water budget findings from this study included the following:

- On an average annual basis, approximately 4,310 cfs infiltrates into the semiconfining layer over the Upper Floridan aquifer. Of that water, approximately 3,390 cfs recharges to the Upper Floridan aquifer. The difference, 920 cfs, is lost to evapotranspiration or discharges to streams. During September through November, the recharge rate is about 2,160 cfs (Hayes *et al*., 1983, p. 51).
- On an annual average basis, based on hydrograph separation methods, approximately 4,000 cfs of groundwater discharges to streams in the Dougherty Plain. Average groundwater discharge in September through November was about 2,300 cfs and the average February through April groundwater discharge was about 7,400 cfs (Hayes *et al*., 1983, pp. 34, 51).
- Recharge is spatially variable, ranging from about 0.15-3.5 cfs/mi^2 (Hayes *et al*., 1983, p. 51).
- The average annual pumping rate was estimated to be about 350 cfs, about 9% of the groundwater discharging to streams.

This modeling effort was later extended in geographic scope by Maslia and Hayes (1988) under the USGS Regional Aquifer-System Analysis (RASA) program.

D.1.2 Dougherty Plain Models Based on the USGS MODFE Simulation Code

A series of models for the Upper Floridan aquifer in the Dougherty Plain based on the USGS modular finite element (MODFE) groundwater simulation code (http://water.usgs.gov/software/MODFE/) have been developed and documented in the following publications:

- Torak *et al*. (1993) developed a model for a portion of the Dougherty Plain around Albany;
- Torak *et al*. (1996) developed a model for the entire Dougherty Plain;
- Torak and McDowell (1996) extended the applications of the model developed by Torak *et al*. (1996);
- HydroGeoLogic, Inc. (1988) adapted and applied the Torak *et al*. (1996) model; and
- Jones and Torak (2006) substantially revised and updates the Torak *et al*. (1996) model.

(Torak *et al*., 1993, p. 35) evaluated the water resources potential and surface water-groundwater interactions within their study area and performed sensitivity analyses to determine the hydrologic factors that produced the most change in computed water levels in the Upper Floridan aquifer. This study served as a starting point for the subsequent model development for the entire Dougherty Plain area described below.

D.1.2.1 Torak *et al*. (1996)

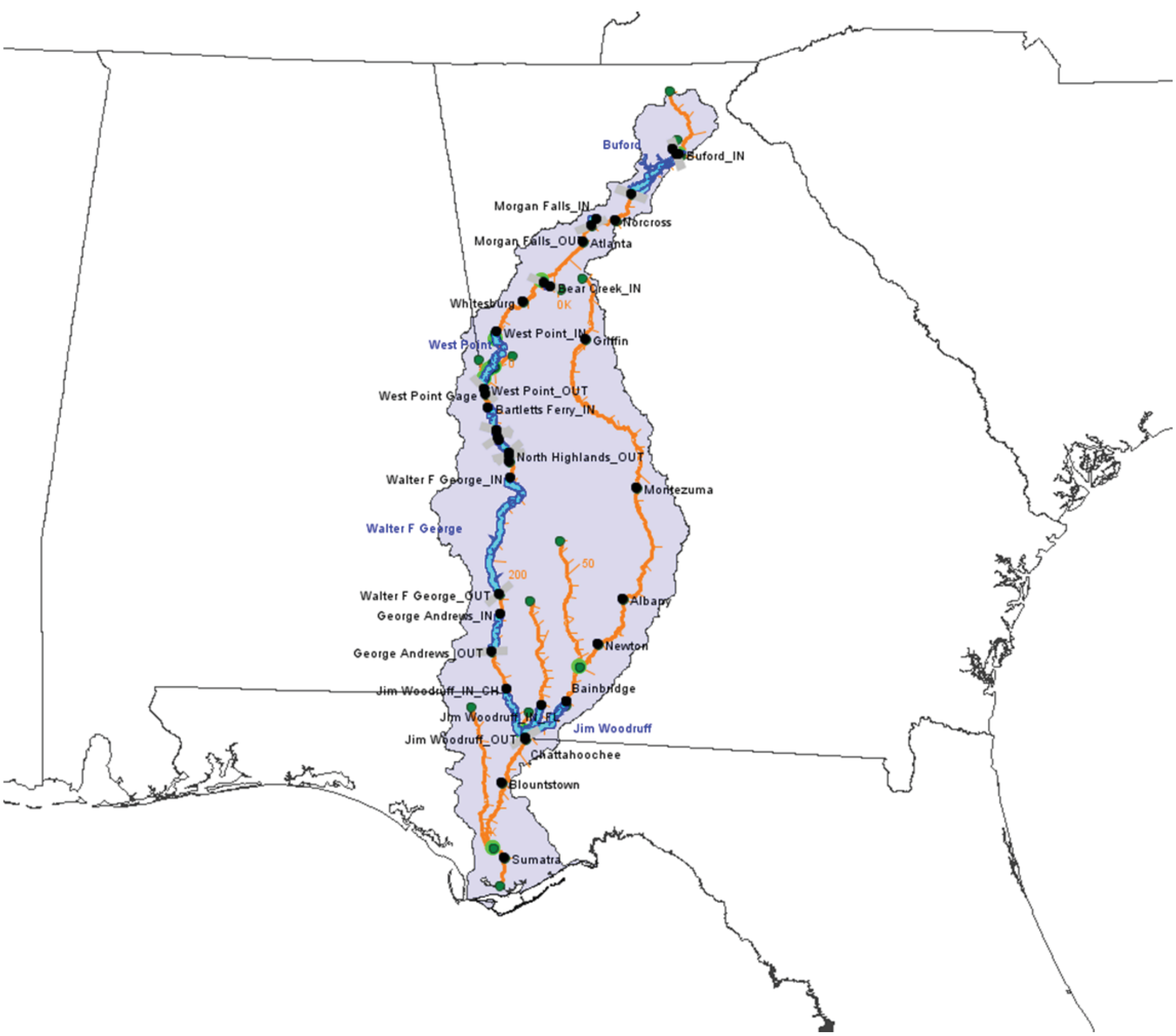
As part of a US Army Corps of Engineers (US ACE) study to develop a water management plan for the Apalachicola-Chattahoochee-Flint (ACF) Basin, Torak *et al*. (1996) developed a finite element model of

ATTACHMENT 3

State of Florida v. State of Georgia

No. 142 Original

Defensive Expert Report of
Philip B. Bedient, Ph.D., P.E.



May 20, 2016

Therefore, the more recent reduction of streamflow entering the Apalachicola Bay from the Apalachicola River is primarily due to the reduced rainfall over this same period, where a number of years of low rainfall resulted in low flows recorded at the Sumatra Gage. Again, the amount of Georgia's consumptive use played an even lesser role in affecting the amount of water that entered the Bay as compared to what was crossing the state line, since more water enters into the river below the state line as it flows through Florida on its way to Apalachicola Bay.

C. Florida's Contribution to Flows into Apalachicola Bay Has Decreased in Recent Years

As part of my streamflow and rainfall analysis, I also considered the portion of the ACF Basin below the state line that contributes to flows into the Apalachicola Bay. As shown in Table 7 below, a drainage area of about 2,000 mi^2, or 10% of the ACF Basin lies between the state line and the Sumatra Gage in Florida (an additional 400 mi^2 of area drain into this ACF Basin between the Sumatra Gage and Apalachicola Bay).

Table 7. Non-Florida and Florida Portions of the Drainage Area for the ACF Basin at Sumatra, Florida

	Drainage Area (mi^2)	Percent (%) of ACF Basin
Non-Florida Portion	17,200	90%
Florida Portion	2,000	10%
Total	**19,200**	**100%**

To understand the specific portion of flows that Florida contributes to the total flows within the ACF Basin, the difference between flows along the Apalachicola River at the Chattahoochee Gage and the Sumatra Gage were analyzed (see Figure 12 for location of these gages). The flows reported at the Chattahoochee Gage for the Apalachicola River equate to the flows from both the Chattahoochee and Flint Rivers and resulting releases from the Jim Woodruff Dam; whereas flows seen at the Sumatra Gage equate to these flows as well as flows being added or subtracted as the Apalachicola River flows through Florida. By subtracting the flows at the Chattahoochee Gage from the flows at the Sumatra Gage this incremental flow contribution from Florida to the streamflow in the Apalachicola River and ultimately into the Apalachicola Bay can be determined.

The contributions of the gaged flows from the non-Florida and Florida portions of the ACF Basin, as shown in Figure 51, show that the Florida portion of the ACF Basin had a fairly consistent contribution of roughly 5,000 cfs from 1978 to 1998. After 1998, however, the average contribution of the Florida portion of flows to the ACF Basin generally declined to roughly 1,000 to 2,000 cfs, much lower than in earlier years.

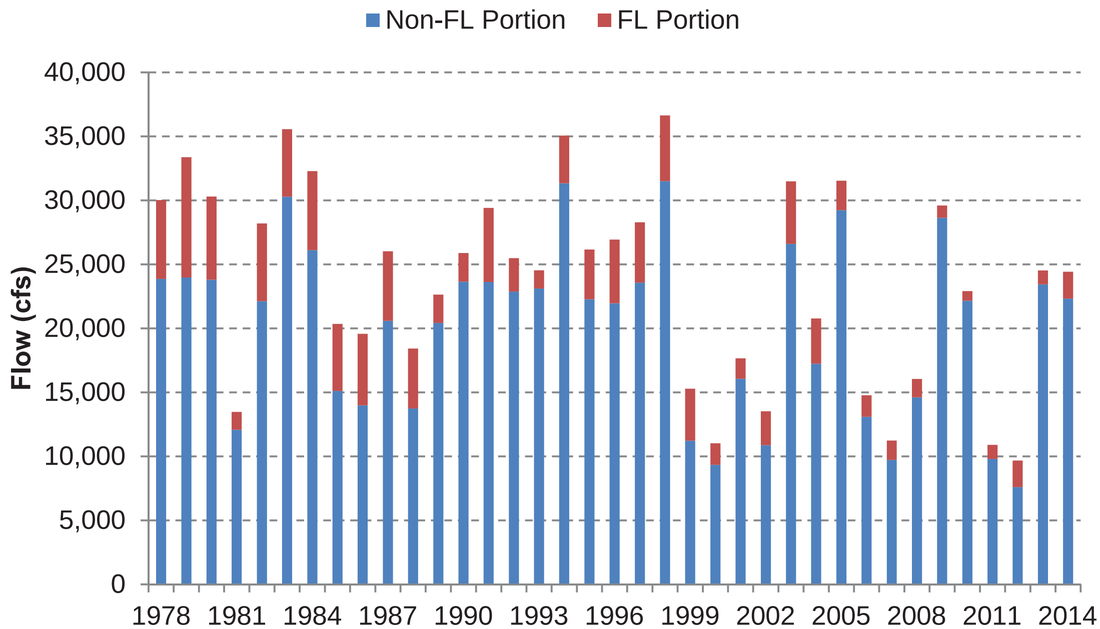


Figure 51. Average Annual Flow Contributions of Non-Florida and Florida Portions of ACF Basin at Gage Near Sumatra, Florida (1978-2014) (Source: USGS)

Next, an analysis was done of how Florida's portion of flows (annual mean and decadal mean) compared to rainfall occurring over the Florida portion of the ACF Basin from 1978 to 2014, as shown in Figure 52, to determine if this trend of reduced contributions of flow from Florida was correlated with reduced rainfall. The decadal mean flows as shown in this figure indicate a consistent decline in flow from almost 6,000 cfs for 1979-1988 to under 2,000 cfs for 2006-2013, while the corresponding rainfall does not show such a consistent decline, but rather follows the pattern previously seen for the entire ACF Basin. The declining trend in the percentage of the streamflow being contributed by the Florida portion of the ACF Basin, as seen in Figure 53, differs from the trend in percentage of streamflow being contributed from the non-Florida portion of the ACF Basin seen in previous figures. Likewise, the strong relationship between rainfall and streamflow that has been seen at the state line does not appear in the data shown for the Florida portion of the ACF Basin. This suggests that there is some other reduction in streamflow occurring in the Apalachicola River entirely within Florida that is not directly attributable to rainfall or to the flows crossing the state line.

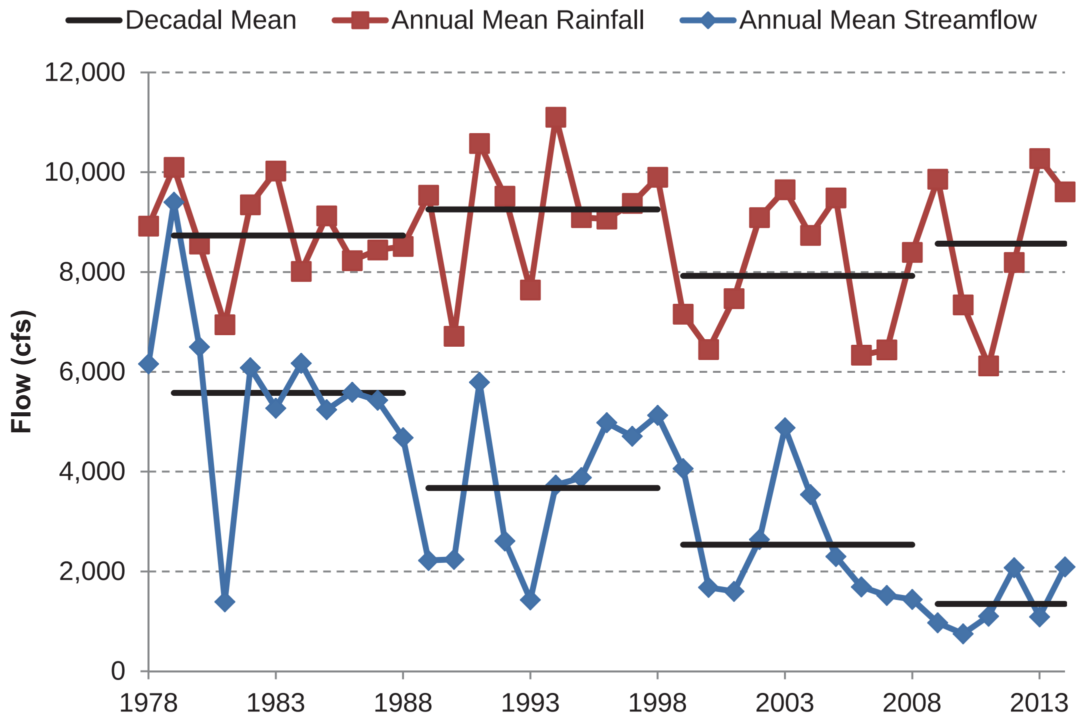


Figure 52. Average Annual Flow and Rainfall for Florida Portion of ACF Basin (1978-2014) (Source: NOAA; USGS)

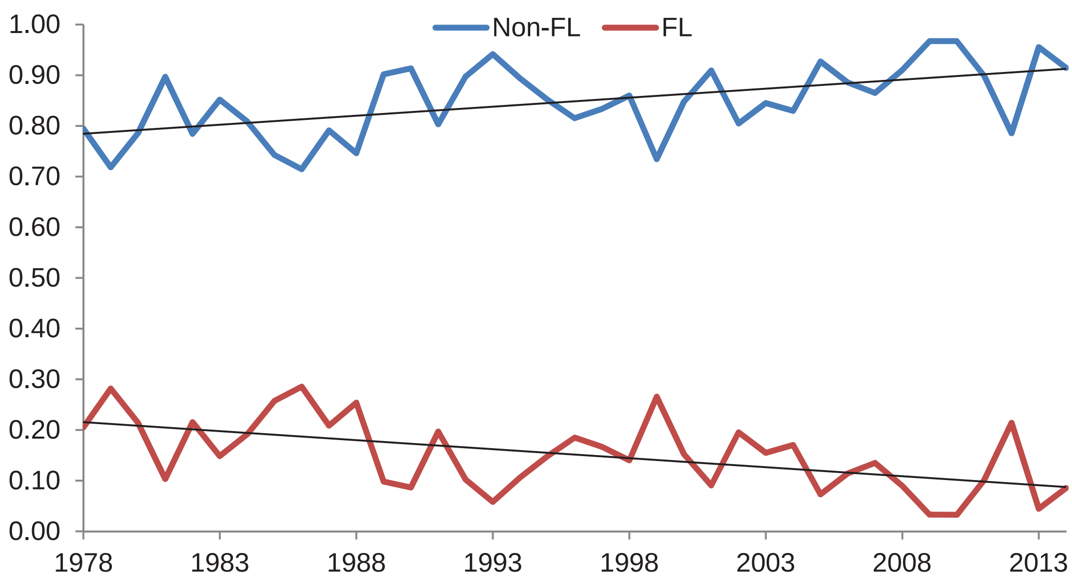


Figure 53. Percentage of Flow Contribution from Non-Florida and Florida Portions of ACF Basin (1978-2014) (Source: NOAA; USGS)

By analyzing the ratio of flow-to-rainfall for Florida's portion of the ACF Basin, as shown in Figure 54, it is observed that the percentage of rainfall that becomes streamflow in the Florida portion of the ACF Basin has also been consistently dropping.

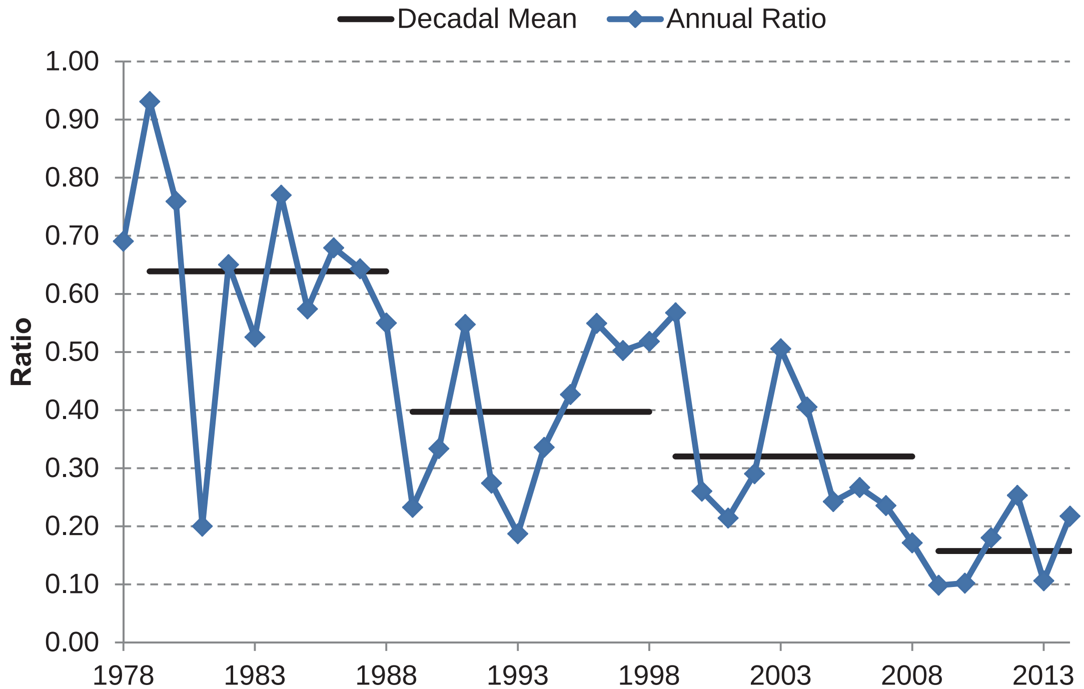


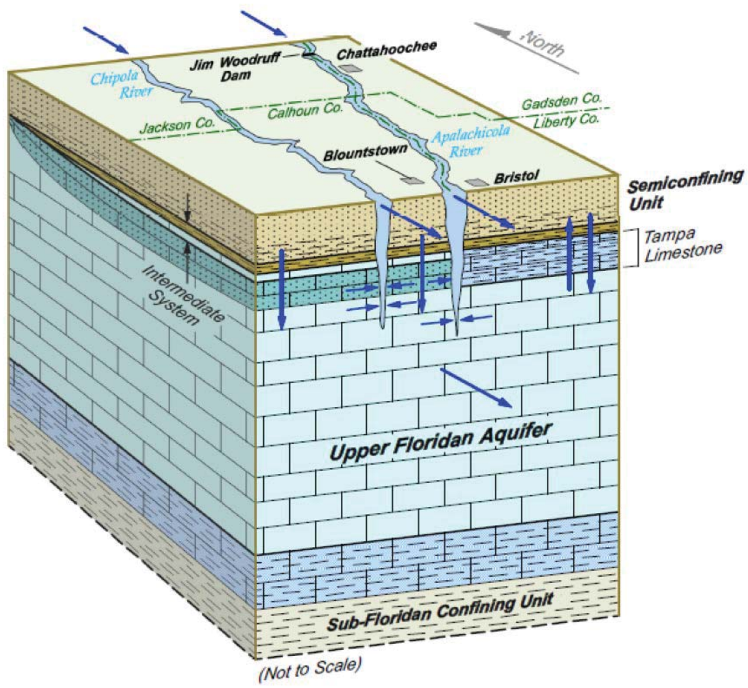
Figure 54. Ratio of Flow vs. Rainfall for Florida Portion of ACF Basin (1978-2014) (Source: NOAA; USGS)

It is not clear why Florida's portion of flow into the ACF Basin has continued to consistently drop even when rainfall has been generally constant, but it is clear that Florida's relative contribution to flow in the ACF Basin has been decreasing. In other words, for the same relative amount of rainfall, the amount of streamflow being contributed from the Florida portion of the ACF Basin and entering into the Apalachicola River and Bay has been decreasing.

ATTACHMENT 4

EXPERT REPORT OF SORAB PANDAY, PH.D.

State of Florida v. State of Georgia
Case No. 142 Original



Issued: 20 May 2016

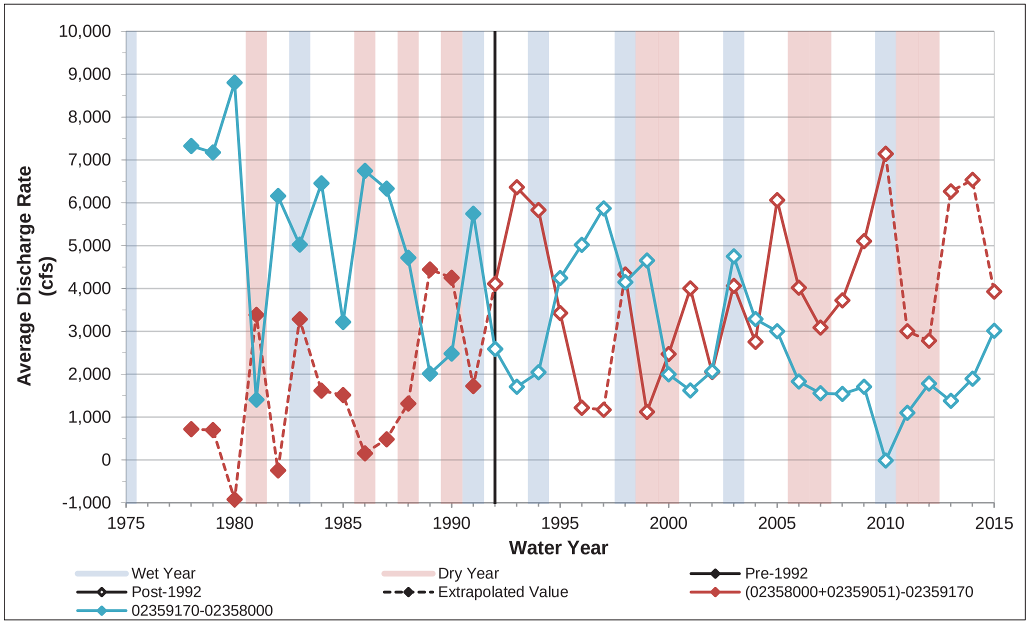
Prepared for: The State of Georgia

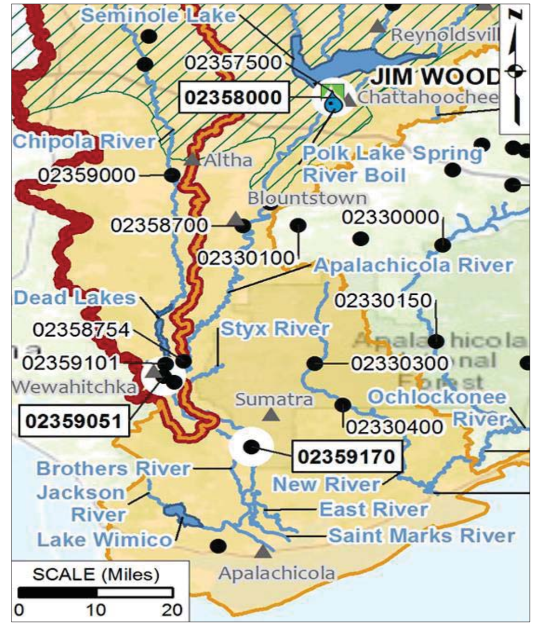
GSI Environmental Inc.

12801 Worldgate Drive, Suite 500, Herndon, Virginia 20170 tel. 713.522.6300

FIGURE 3-6
STREAMFLOW BUDGET OF THE APALACHICOLA RIVER (USGS STATION ID 02359170)

Expert Report of Sorab Panday, Ph.D.
State of Florida v. State of Georgia
Case No. 142 Original





Summary Statistics

USGS Station ID	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Average Discharge Rate (cfs)												
(02358000 + 02359051) -02359170	-927	1,117	535	2,773	1,411	3,961	2,892	5,283	4,443	7,139	1,599	3,938
02359170-02358000	1,402	-15	3,591	1,683	5,950	2,019	6,670	3,499	8,801	5,868	5,254	2,614

Notes:
1. * = Streamflow data for USGS Station ID 02359051 for water years 1975 through 1991, 1996 through 1998, and 2010 through 2015 were extrapolated from the relationship between streamflow at USGS Station IDs 02359000 and 02359051. The relationship between these stations is identified by the equation y = (2.9172*x) + 2436, where y is the streamflow at USGS Station ID 02359051 and x is the streamflow at USGS Station ID 02359000. The R-squared (r^2) value for this relationship is 0.9037.
2. Extrapolated streamflow data are shown as a dashed lines where approximated from flow at Station No. 02359000.

ATTACHMENT 5

GSI ENVIRONMENTAL

MEMORANDUM

TO: File

FROM: Sorab Panday

RE: **Review of Dr. David Langseth's Memo to Dr. George Hornberger on 28 June 2016 titled "Dr. Panday Water Budget Evaluations"**

The 28 June 2016 memorandum by Dr. David Langseth to Dr. George Hornberger analyzes my water budget evaluations of the Apalachicola River and of the Apalachicola River Basin. Dr. Langseth claims that I have made fundamental errors that include:

i) Double counting of flow in the Apalachicola River that was diverted into the Chipola River Cutoff;
ii) Incorrect definition of watershed area causing substantial over-estimation of water contributed by precipitation;
iii) Failure to account for natural evapotranspiration leading to further over-estimation of the effective amount of water contributed by precipitation; and
iv) Use of uncorrected flows reported at the Sumatra Gage (USGS Station ID 02359170), which apparently under-estimates the true flow rates in later years.

I address each of these issues below.

Double Counting of Flow in the Apalachicola River that was Diverted into the Chipola River Cutoff

I have performed the following water budget analyses to evaluate the flow contributions to the Apalachicola Bay from Florida:

i) Apalachicola River in Florida; and
ii) Entire watershed that represents the Apalachicola River Basin.

My first analysis evaluates the water budget of the Apalachicola River between the Chattahoochee Gage (USGS Station ID 02358000) and the Sumatra Gage. I evaluate this in two ways. The first was to simply evaluate the difference between outflow of the Apalachicola River at the Sumatra Gage and inflow at the Chattahoochee Gage; the difference between those two gages shows the net inflow that occurs to the Apalachicola River in Florida be it from baseflow or from other rivers. ***This evaluation does not use any data from the Cockran Landing Gage (USGS Station ID 02359051); and therefore, the question of double counting that Dr. Langseth asserts does not arise.*** Results of the first analysis (shown as the blue curve in Figure C-7 of my Expert Report) indicate that outflow from the Apalachicola River at the Sumatra Gage was larger than inflow to the River at the Chattahoochee Gage by an average of 5,254 cfs pre-1992, which declined to an average of 2,614 cfs post-1992. The important part of this analysis is the change over time — the net inflow to the Apalachicola River between Chattahoochee and Sumatra Gages within Florida has reduced by 2,640 cfs when comparing average pre- and post-1992 conditions.

The second evaluation further refined the Apalachicola River water budget to separately include inflow from the Chipola River in order to determine if contributions from the Chipola River could account for the changes over time. For this analysis, inflow to the Apalachicola River is the sum of the Chattahoochee and Cockran Landing Gages, and outflow of the Apalachicola River is evaluated at the Sumatra Gage. This analysis finds a pre-1992 average loss of 1,599 cfs, which increased to a post-1992 average loss of 3,938 cfs for the Apalachicola River; representing an increase in average loss for the Apalachicola River of 2,339 cfs between average pre- and post-1992 conditions.

The Cockran Landing Gage (USGS Station ID 02359051) that I used for this analysis is downstream of the Chipola River Cutoff, so water diverted from the Apalachicola River at the cutoff is included in the reported flows at the Cockran Landing Gage. However, the impact of the flow contribution from the Apalachicola River at the Cockran Gage is small in comparison to flow in the Apalachicola River and out to the Apalachicola Bay. A comparison of the losses in the Apalachicola River between pre- and post-1992 conditions for the first and second aforementioned evaluations indicates a small difference (2,640 cfs versus 2,339 cfs). Thus, the change in pre- and post-1992 reduction of flow is observed with or without the input from the Apalachicola River at the Cockran Landing Gage. Also, if I followed Dr. Langseth's suggestion and removed 4,200 cfs from the water budget analysis, the ultimate conclusion is still the same: the difference in contribution of flow in the Apalachicola River within Florida still decreases on average by 2,339 cfs from pre- to post-1992 conditions. The contribution of flow from the Apalachicola at the Cockran Landing Gage does not change that computation.

Incorrect Definition of Watershed Area Causing Substantial Over-Estimation of Water Contributed by Precipitation

As mentioned above, I have also performed a water budget analysis for the entire watershed that represents the Apalachicola River Basin. This is different from the water budget analysis for the Apalachicola River itself and reflects the water budget for the entire watershed area, as noted in Figure C-10 of my Expert Report. In general, one can take ***any*** area and do a water budget analysis on it. Basically, IN minus OUT from that area equals zero if there are no storage changes over the long term average. Figure C-10 is simply a statement of that; and the losses defined within this analysis would then also include flows to the Apalachicola Bay from all areas downstream of the Sumatra Gage, as well as evapotranspiration, groundwater or other losses in that area. Therefore, it is not an incorrect analysis.

However, for comparative purposes, I have also reconstructed my water budget analysis to only include the area upstream of the Sumatra Gage. Furthermore, to avoid considering the flow of the Apalachicola River at the Cockran Landing Gage, I have used data from the gage further upstream on the Chipola River (USGS Station ID 02359000 identified as Chipola River near Altha, FL). Note that the Chipola River is a gaining stream so using data from the upstream Gage 02359000 is a conservative estimate, as there will be additional flow downstream in the Chipola River than indicated by this gage. As shown in the attached Figure 1, there is still a loss of flow in the Apalachicola River Basin and this loss is increasing with time showing an average difference of 2,003 cfs (36 in/yr) between pre-1992 and post-1992 average conditions. Nothing in Dr. Langseth's memo explains why there is this loss of flow over time in the Apalachicola River within Florida.

Failure to Account for Natural Evapotranspiration Leading to Further Over-Estimation of the Effective Amount of Water Contributed by Precipitation

The statement that my analysis ignores evapotranspiration (ET) is not true. I do not try to separate out the ET from other losses in the Apalachicola River Basin but that does not mean that my analysis ignores it. The loss terms in my water budget analyses includes evapotranspiration among other losses (both natural and human caused) that may be occurring in the Apalachicola River Basin. I am not trying to attribute the loss to any particular reason, only pointing out that there are losses occurring in the Apalachicola River Basin in Florida and that as per an analysis of the data, those losses are increasing through time.

A related item in Dr. Langseth's memo (see p. 2) indicates that my use of a single rain gage to estimate precipitation for a watershed of nearly 800 square miles was incorrect. Points to note in this regard include:

1) It is common to use a single gage to represent large areas when data is not available.
2) Precipitation is only about 13% of the input as compared to net inflow to the domain for the Apalachicola River Basin water budget analysis. Thus, even if there is a 10% error in the precipitation values, it would reflect as an approximately 1% error in the total water budget of the basin. The intent of the water budget analysis of the Apalachicola River Basin was to understand the magnitudes of the various components and how they change through time. That was achieved here without expending vast amounts of effort in fine-tuning water budget terms that are otherwise relatively small.

Use of Uncorrected Flows Reported at the Sumatra Gage (USGS Station ID 02359170), which Apparently Under-Estimates the True Flow Rates in Later Years

Dr. Langseth suggests that the flows reported by the USGS at the Sumatra gage may not be correct. He relies on a May 2016 "Defensive Expert Report" submitted by Dr. Hornberger, which discusses reasons why Dr. Hornberger feels that Sumatra Gage flow rates reported by the USGS are unreliable and why they should be corrected as per his methodology. Thus, I address Dr. Hornberger's "Defensive Expert Report" here.

<u>Summary of Dr. Hornberger's May 20, 2016 "Defensive Expert Report"</u>

In his summary statement, Dr. Hornberger makes two claims about the Sumatra Gage. The first being that it *"is located on a portion of the river with a broad floodplain and because **physical conditions and measurement techniques changed over time** (emphasis added), the discharge records for high flows at Sumatra are not consistent over the period of record." (Hornberger, May 2016, p. 4)* The second being that *"the difference in discharge between a downstream and an upstream gage is related to the amount of flow in the river. Flow differences between two points are a function of the flow itself, with flow differences in general being higher at high flows and lower at low flows." (Hornberger, May 2016, p. 4)* Dr. Hornberger further claims that the physical conditions have changed over time and that the measurement techniques have changed over time. Then, he performs his analysis of flows in the Apalachicola River and states that this analysis does not show a trend. Finally, he summarizes with the following items on pages 4-5 of his "Defensive Expert Report":

i) Consumptive use in the Florida portion of the ACF basin is much too small to explain the flow decline;

ii) The record of discharge at the Sumatra gage is inconsistent across years because of difficulties with measurements during high flow times, due to the topography surrounding the Sumatra gage and a change in the discharge measurement technique since 2001;

iii) The reported annual average discharge values do not accurately show real trends without accounting for wet or dry years because the amount of water gained in a reach is larger for high-flow years than for low-flow years; and

iv) Significantly dry years in the latter part of the record are simply part of natural variations in flow, but are not accounted for by Georgia in its assertion of trend.

GSI ENVIRONMENTAL

Further Considerations to Dr. Hornberger's Evaluations

In this section, I address the issues, statements, and items raised by Dr. Hornberger.

1) ***Consumptive use in the Florida portion of the ACF basin is much too small to explain the flow decline:*** I have not attributed the flow decline to consumptive use nor have I quantified or evaluated the possible causes. I have not claimed that the water was diverted unnoticed or that large amounts of water were being withdrawn for irrigation. I have simply examined and presented the data. Causes could be plenty, including changes in physical conditions (as referred to by Dr. Hornberger), that may include sedimentation causing larger bank overflow (and subsequent losses to ET and groundwater) along the length of the river, or changes in land use within the Apalachicola River Basin (from native vegetation to pine plantations, for instance) causing less groundwater recharge and higher ET through time. Evaluation and quantification of such factors would require considerable amounts of data (of sedimentation and erosion dynamics along the river, for instance) which are not available to me.
2) ***The reported annual average discharge values do not accurately show real trends without accounting for wet or dry years because the amount of water gained in a reach is larger for high-flow years than for low-flow years:*** There are two points to consider. First, the U.S. Army Corp of Engineers (USACE) controls storage along the river system to provide for minimum flows during dry periods, among other needs of the ACF River Basin. Second, the trends during wet and dry years have been occurring throughout the period of investigation; therefore, whatever bias was introduced has been introduced throughout the period of record over which I have identified the declining trend.
3) ***Significantly dry years in the latter part of the record are simply part of natural variations in flow, but are not accounted for by Georgia in its assertion of trends:*** This same theme is repeated later on p. 16 of Dr. Hornberger's "Defensive Expert Report" that *"…the latter years in the period that Georgia examined (see Figure 1) happen to be drier than the earlier years…"* I have not asserted the reason for the trend, as I note earlier, only presented it. Significantly dry years in the latter part of the record may well be the reason for the trends that I note in the data. It is also the assertion that I have been making for the cause of lower flows into Florida from Georgia in recent years.
4) ***The difference in discharge between a downstream and an upstream gage is related to the amount of flow in the river. Flow differences between two points are a function of the flow itself, with flow differences in general being higher at high flows and lower at low flows:*** The flow difference between two gages is simply an indication of the gain or loss in flow between those two points in the river (through contributions from baseflow or losses to the aquifer, if there are no other inputs or outputs between those gages). For the Apalachicola River system, I would expect the differences to be higher during wetter periods due to higher baseflow (and, not just due to higher flow in the river). This is not however a statement that can be generally applicable to flow in rivers. For instance, a river that is lined would have no baseflow and would show no difference in flow between an upstream and a downstream gage, regardless of whether the flow itself was low or high.

   In my analysis of the data, I have noted that reported flows indicate a consistent decrease through time during both the dry lower-flow periods and the wet higher-flow periods of the more recent years.

5) ***The Sumatra Gage discharge record is inconsistent and that there was a change in the discharge measurement technique since 2001.*** The declines in observed flow rates of the Apalachicola River between the Chattahoochee and Sumatra Gages are noted even before 2001 and did not occur only after 2001 when the discharge measurement technique was changed. I will further address the Sumatra Gage flow rates below.
6) ***"As the USGS states, 'The key to determining changes in floods and droughts is a stable, long-term network of streamgages, including streamgages on watercourses that are relatively free of confounding human influences such as dams, impoundments, and diversions." (Hornberger, May 2016, p. 9):*** The Apalachicola River reach in Florida is relatively free of dams, impoundments, and diversions. The Chattahoochee and Sumatra Gages have stable, long-term records.
7) ***"The USGS maintains records at such gaging stations and when trend analyses are done using these carefully selected gages, there are no trends for locations throughout Georgia and Florida, except in the northern part of Georgia where trends are <u>positive</u> and for only one location in Florida (not in the ACF) where the trend is negative (USGS 2005, Figure 3b)." (Hornberger, May 2016, p. 9):*** I have not performed this analysis; however, it seems to contradict many claims made by Florida's expert reports that indicate flow to be declining.

<u>Evaluation of Streamflow Data at the Sumatra Gage</u>

Dr. Hornberger performs an evaluation of streamflow data at the Sumatra Gage. He notes that stream discharge measurements are not free from errors and may be difficult to measure under broad, flat floodplain conditions, as near the Sumatra Gage. However, these errors and difficulties exist throughout the period of record and are not just something that occur in the latter part of the data. Thus, this hypothesis alone cannot explain why the Sumatra Gage data shows declining flows.

Dr. Hornberger further notes that discharge is often obtained indirectly by measuring the stage (i.e., flow depth at the gage) and converting these depth measurements to discharge values using a rating curve. A rating curve is a relationship between direct measurements of discharge and the respective stage observed at that time of direct discharge measurement. Also, as further noted by Dr. Hornberger, rating curves can be adjusted periodically as new direct discharge measurements are accumulated. In Figure 4 of his "Defensive Expert Report," he shows the major adjustments made to the Sumatra Gage rating curves at various points in time. Specifically, there were three significant adjustments to the first curve that was evaluated for Water Years (WYs) 1978-1985; adjusted rating curves were used for WYs 1986-1993, WYs 1994-2004, and WYs 2005-2015. The attached Figure 2 reproduces the relationships noted by Dr. Hornberger from the raw stage level data I downloaded from the Water Services Database (http://waterservices.usgs.gov/), maintained by the USGS. However, I needed to use the calendar year (January to December) and not the water year (October to September) to distinguish the four separate rating curves.

Dr. Hornberger also notes that the USGS switched from traditional methods of measuring discharge to an Acoustic Doppler System (Doppler) in 2001 (i.e., that the measurement technique had changed over time). He compares the 1978-1985 rating curve with that of 2005-2015, and attributes the differences to errors in the updated Doppler measurements. However, there were also differences in the 1978-1985, 1986-1993, and 1994-2004 rating curves, all of which were apparently developed before the switch was made to an Acoustic Doppler System in 2001. These differences indicate recalibration using the same measurement technique, and reflect observed physical conditions that have changed over time. These updated curves for WYs 1986-1993 and 1994-2004 were used by the USGS to reflect the updated evolving flow conditions in the river (probably including impacts of the levee breach near the USGS discharge measurement site at M-K Ranch, as discussed on p. 16 of Dr. Hornberger's "Defense Expert Report"). Use of these updated curves, as was done in the flow records provided by the USGS, show the declining trend from 1978-2004, even before the switch to the flow rating curve of 2005-2015, which was obtained after switching the measurement technique. Also, the final rating curve would further account for change in measurement technique. Therefore, I believe that the most reliable data for flow measurements are the flow rates as reported by the USGS because the flow values obtained from the USGS used the most updated and recalibrated estimates of flow for the period of record considering that physical conditions and measurement techniques have changed over time.

Dr. Hornberger then "adjusts" the flow rates reported by the USGS by applying the rating curve for 1978-1985 to the entire period of recorded flow stages. Essentially, his "adjustment" to the USGS flow rates is to only use the oldest rating curve and not evolve the rating curve with changing conditions in the river or account for changes in measurement techniques, as reported by the USGS.

To evaluate Dr. Hornberger's "adjusted" flow rates, I reconstructed the historical flow rates consistent with the process described by Dr. Hornberger. I have applied each of the four rating curves shown on the attached Figure 2 to the USGS-reported stage data to compute flow at the Sumatra Gage, and then used that flow to compute the difference of flow between the Chattahoochee and Sumatra Gages, which is shown on the attached Figure 3. As expected, the differences obtained using USGS reported flow rates (also included on attached Figure 3) were similar to those computed by the 1978-1985 rating curve between 1978 and 1985; and the 2005-2015 rating curve between 2005 and 2015. The differences were larger, however, during the 1986 through 2004 period because the regression lines for the 1986-1993 and 1994-2004 rating curves used in the computation did not match the data as well as for pre 1986 and post 2005. Using rating curves that evolve with physical conditions and measurement techniques is the right approach, and use of an outdated rating curve for the entire period of record is incorrect.

Finally, even if I was to accept that the oldest rating curve provides a correct conversion of stage to flow rate at the Sumatra Gage, and that all updates made by the USGS were incorrect, I still note a declining trend in flow at the Sumatra Gage as compared to the Chattahoochee Gage. As noted on Figure 3, a regression line drawn through the differences in flow rates between the Sumatra and Chattahoochee Gages, using the 1978-1985 rating curve, shows a declining trend. The linear regression line indicates an average flow of 6,444 cfs in 1978 reducing to 4,812 cfs in 2015. Thus, even with Dr. Hornberger's calculations that use the oldest rating curve that he analyzed, there is still a loss of 1,632 cfs in Apalachicola River flow contribution within Florida between pre- and post-1992 conditions.

This loss can be shown also on data produced by Dr. Langseth with his 28 June 2016 Memo. The produced file titled *"Lower_Apalachicola_River_Water_Budget_v4.xlsx"* contains a figure for flow at Sumatra Gage minus flow at Chattahoochee Gage in the worksheet titled *"Sumatra_vs_Chatta."* I have fit a linear regression line through both the "adjusted" and the "unadjusted" figures, as shown in attached Figure 4. Though the descent is less rapid, the "adjusted" curve still shows a decrease of 1,851 cfs between 1978 and 2015 following the linear trendline. The curve labeled as "unadjusted," which uses the USGS-reported values of flux shows a decrease of 4,184 cfs between 1978 and 2015 following the linear trendline.

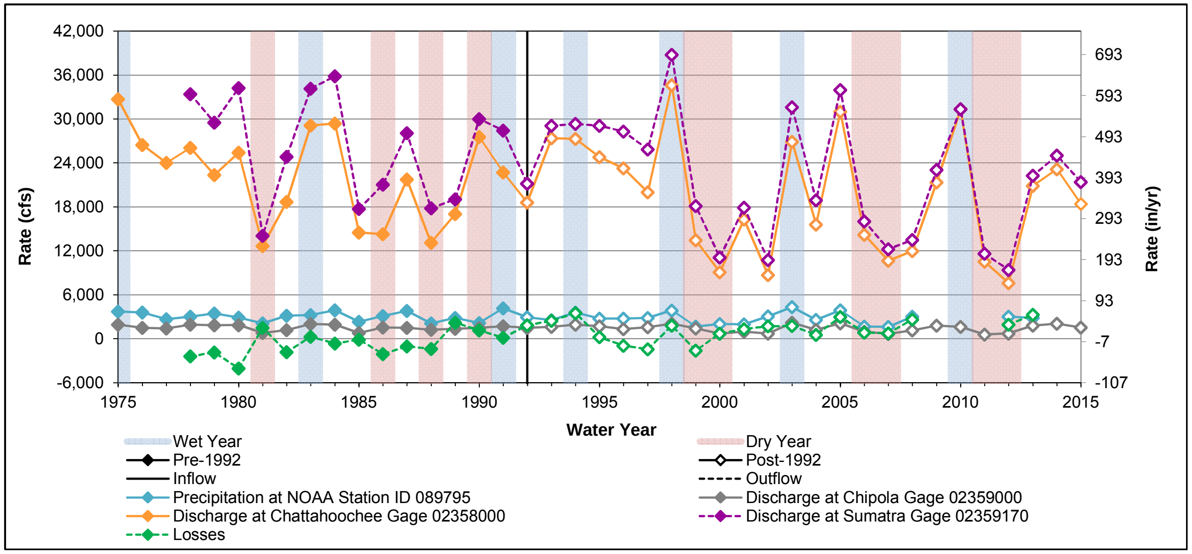
Finally, even if I were to accept that the oldest rating curve provides a correct conversion of stage to flow rate at the Sumatra Gage, and that all updates made by the USGS were incorrect, I still note a declining trend in my water budget analysis of Figure 1 which already rectified the issues with the Cockran Landing Gage and larger watershed area that were raised. As shown in attached Figure 5 for this scenario, the decline in average flow between pre- and post-1992 conditions was 1,744 cfs; wherein a net average gain in the watershed of 1,235 cfs (22 inches) for the pre-1992 period turned into a loss of 509 cfs (9 inches) for average post-1992 conditions.

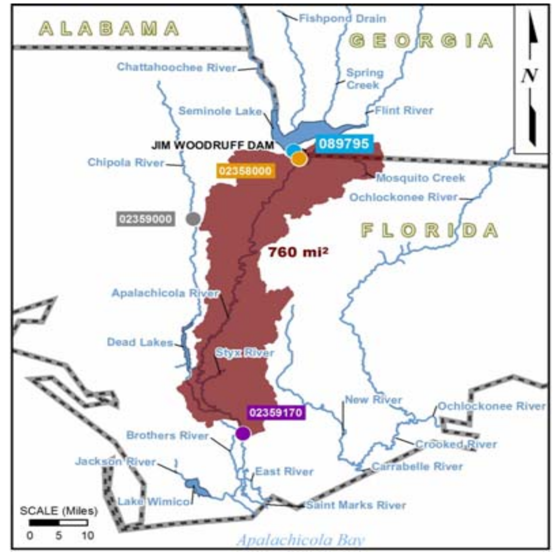
In conclusion, nothing in Dr. Langseth's 28 June 2016 Memo or Dr. Hornberger's report accounts for the observed changes in flows between the Chattahoochee and Sumatra Gages, which ranges from 2,640 cfs to 1,744 cfs between pre-1992 and post-1992 average conditions for all the analyses discussed here – even when assuming the "adjustments" to be valid and using the numbers provided by Dr. Langseth.

GSI ENVIRONMENTAL

FIGURE 1
WATER BUDGET FOR THE APALACHICOLA RIVER BASIN

State of Florida v. State of Georgia
Case No. 142 Original





Summary Statistics

	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Annual Precipitation (NOAA Station ID 089795)												
(cfs)	2,089	1,622	2,654	2,268	3,106	2,838	3,587	3,048	4,143	4,331	3,068	2,789
(in/yr)	37	29	47	41	55	51	64	54	74	77	55	50
Average Discharge Rate (cfs)												
02359000	785	569	1,378	964	1,511	1,513	1,864	1,786	2,011	2,186	1,531	1,411
02358000	12,661	7,605	17,041	13,085	22,697	19,295	26,452	25,340	32,718	34,617	22,231	19,461
02359170	14,063	9,384	19,552	15,406	28,262	21,833	32,566	29,067	35,843	38,763	26,306	22,075
Losses												
(cfs)	-4,045	-1,604	-1,838	624	-830	1,701	218	2,207	2,198	3,495	-727	1,276
(in/yr)	-72	-29	-33	11	-15	30	4	39	39	62	-13	23

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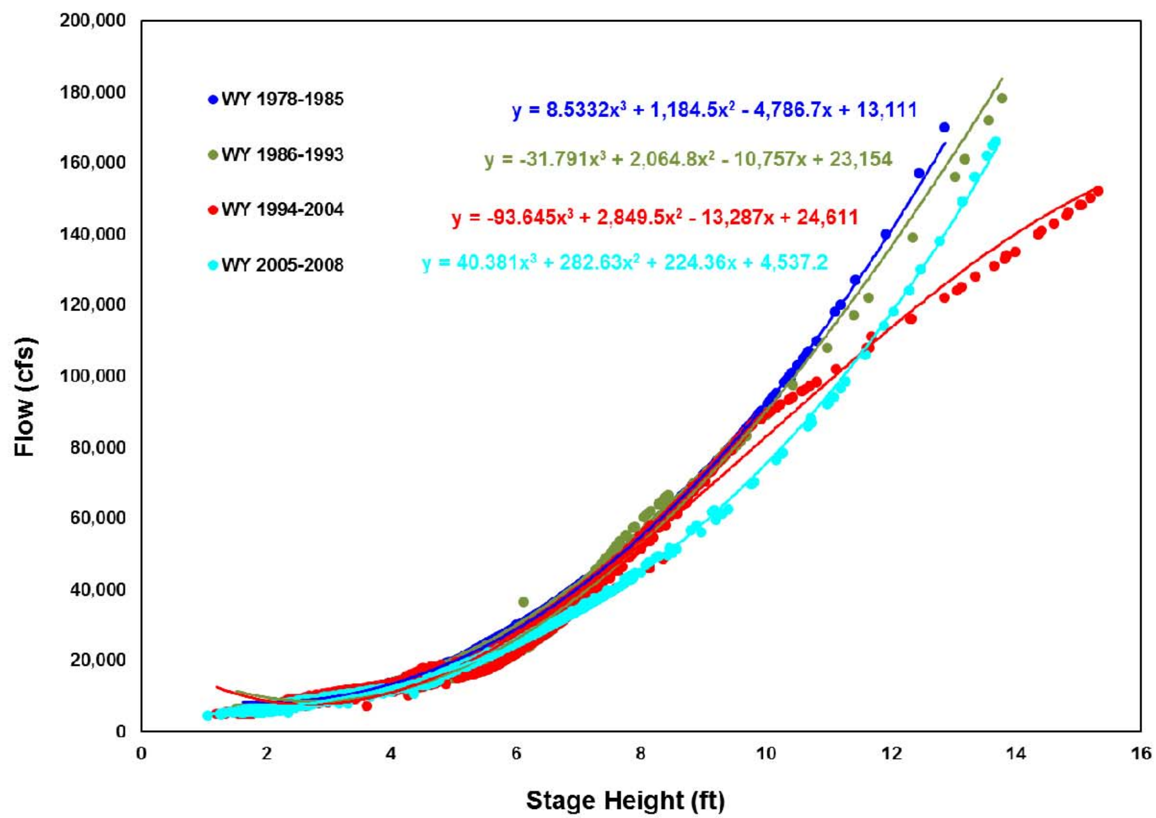
FIGURE 2
USGS REPORTED STAGE HEIGHT V. DISCHARGE RATE

State of Florida v. State of Georgia
Case No. 142 Original



SOURCE: Chart recreated from Hornberger, May 2016, Figure 4.

GSI Job No. 4198
Issued: 26 July 2016

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FIGURE 3
DIFFERENCE IN DISCHARGE RATES BETWEEN SUMATRA AND CHATTAHOOCHEE GAGES

State of Florida v. State of Georgia
Case No. 142 Original

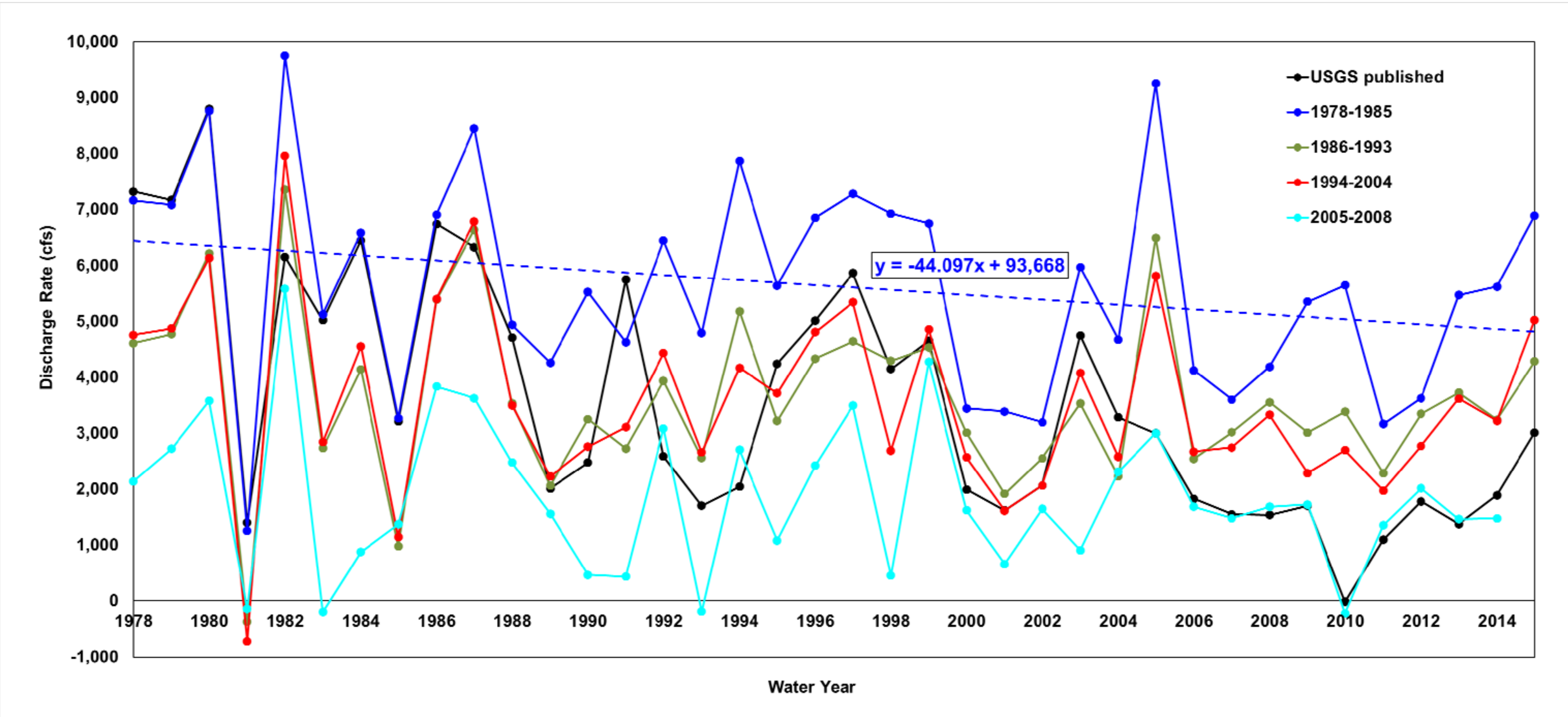

FIGURE 4
STREAMFLOW BUDGET FOR APALACHICOLA RIVER USING DR. LANGSETH'S DATA

State of Florida v. State of Georgia
Case No. 142 Original

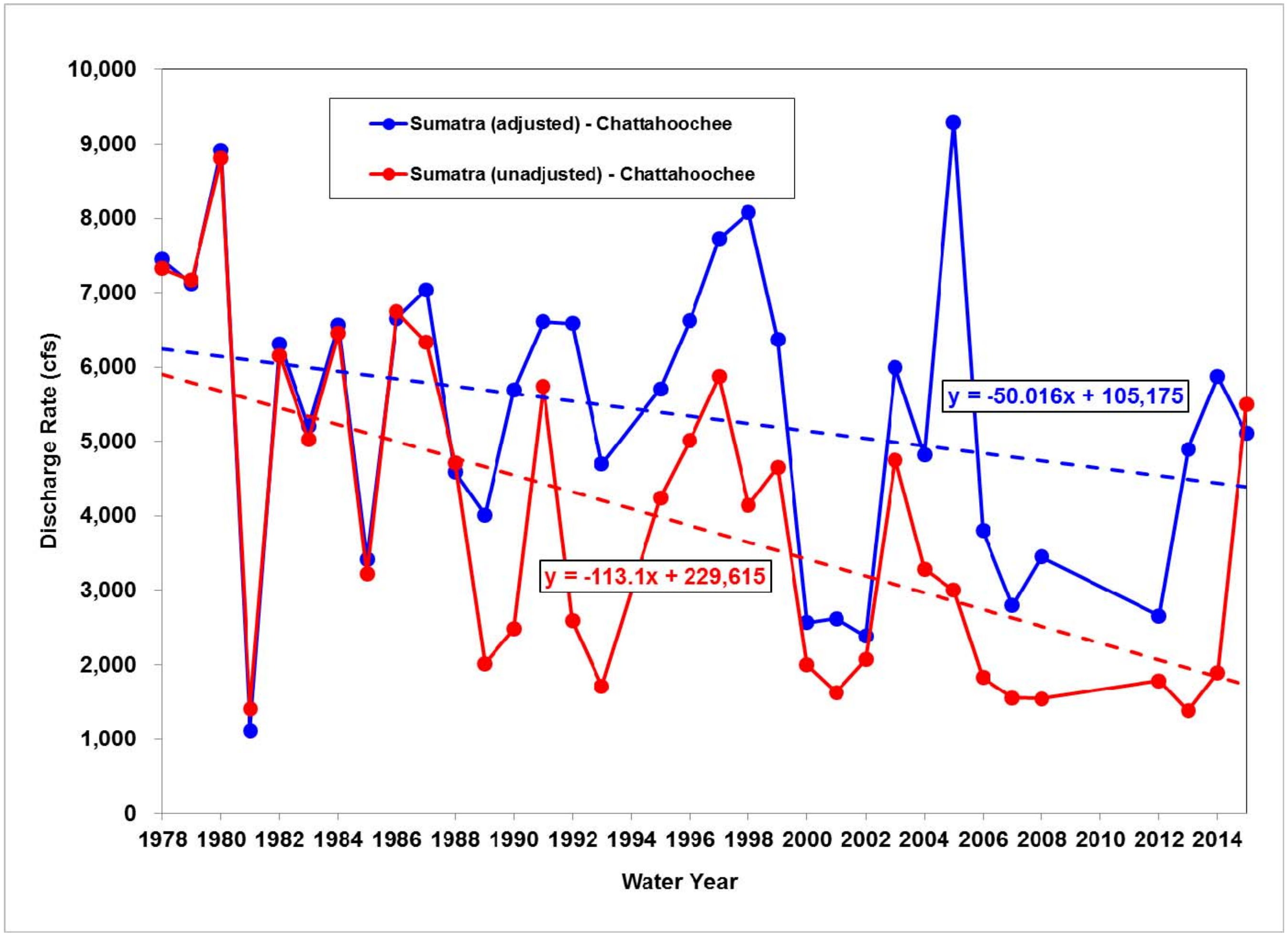

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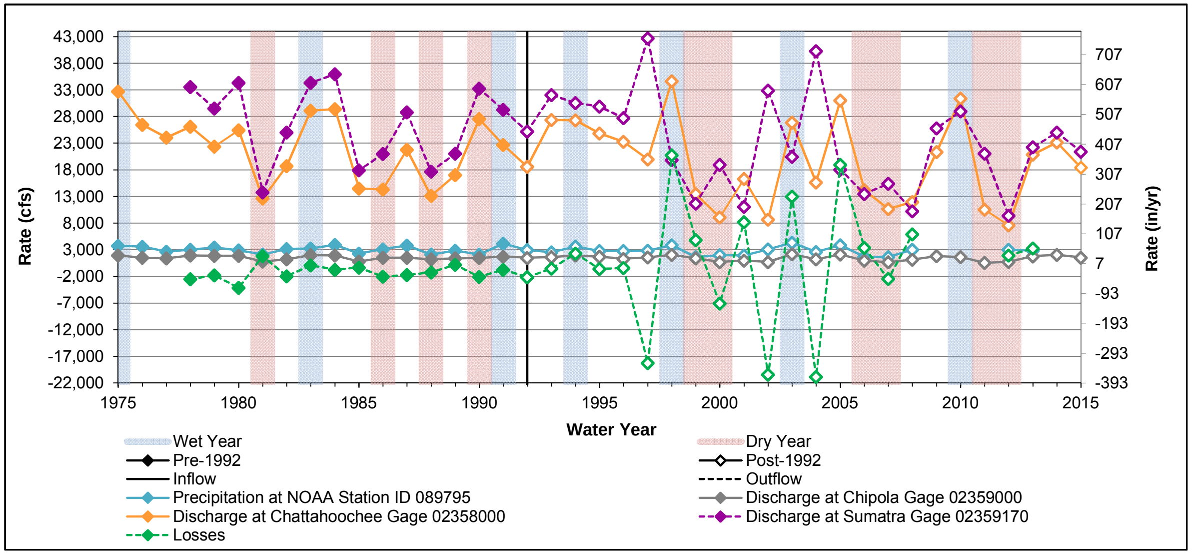
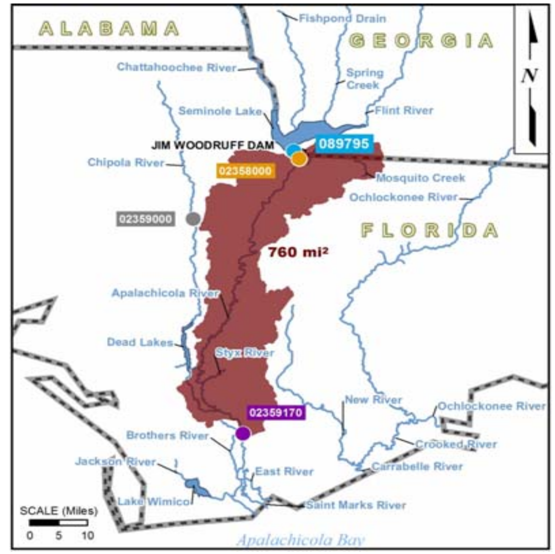
FIGURE 5
WATER BUDGET FOR THE APALACHICOLA RIVER BASIN

State of Florida v. State of Georgia
Case No. 142 Original





Summary Statistics

	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Annual Precipitation (NOAA Station ID 089795)												
(cfs)	2,089	1,622	2,654	2,268	3,106	2,838	3,587	3,048	4,143	4,331	3,068	2,789
(in/yr)	37	29	47	41	55	51	64	54	74	77	55	50
Average Discharge Rate (cfs)												
02359000	785	569	1,378	964	1,511	1,513	1,864	1,786	2,011	2,186	1,531	1,411
02358000	12,661	7,605	17,041	13,085	22,697	19,295	26,452	25,340	32,718	34,617	22,231	19,461
02359170	13,768	9,384	20,982	17,362	29,048	21,833	33,464	29,227	35,952	42,690	26,814	23,090
Losses												
(cfs)	-4,155	-20,867	-2,007	-2,300	-1,501	1,949	-432	5,362	1,788	20,731	-1,235	509
(in/yr)	-74	-373	-36	-41	-27	35	-8	96	32	370	-22	9

ATTACHMENT 6

Report of Dr. David L. Sunding

Economic Impacts of Reducing Water Consumption in the Chattahoochee and Flint River Basins of Georgia

Prepared for the State of Florida, Through Its Department of Environmental Protection and Its Counsel, Latham & Watkins LLP

February 29, 2016

THE Brattle GROUP

Confidential – S. Ct. 142

than water used to irrigate corn and cotton in otherwise similar contexts. Deficit irrigation of cotton also tends to be a more expensive way of conserving water than deficit irrigation of corn. In the 50-percent conservation scenario, which saves a total of 315,000 acre-feet of water in a dry year, irrigation of corn would be mostly eliminated while irrigation of cotton would be reduced by only one third, and peanut irrigation reduced by only one quarter.

78. These estimates aggregate over soil groups and water user categories for simplicity of presentation, but the extent of conservation also varies across user types and soil groups. As expected, cutbacks tend to be more concentrated on coarse soils than fine, and among high water users. Indeed, in some cases, cutbacks in water use among high water users are essentially costless, indicating wasted irrigation.

79. The cutbacks considered above are defined in terms of consumptive use, but the relevant outcome for environmental protection is the reduction in peak streamflow depletions. The relationship between the two metrics is specific to the particular location where conservation measures are implemented. To convert annual consumptive use into streamflows, the spatial pattern of hydrological connectivity of the basin must be taken into account. In all subsequent analyses in this report pertaining to irrigation use in the ACF, I rely on the modeling work described in Dr. Dave Langseth's report, which provides groundwater-streamflow connectivity factors across a grid of individual cells of approximately 250 acres each. The model covers an area that largely overlaps with Subarea4, and I conservatively assume no groundwater streamflow connectivity outside of that model domain. Intuitively, for the deficit irrigation scenarios defined in terms of streamflow depletions presented in Section XII, cutbacks are more concentrated on surface water and in high connectivity groundwater zones.

80. As my analyses rely primarily on annual data, I convert annual water volumes to peak summer streamflows using a conversion factor provided by Appendix D of Dr. George Hornberger's report. Based on his modeling work, I use the groundwater and surface water averaged conversion factor for the month of June, equivalent to 2.28. Annual average streamflow depletions of 1 cfs correspond to 2.28 cfs of peak summer depletions, given the concentration of agricultural water use in the summer months.

ATTACHMENT 7

Report of Dr. David L. Sunding

Opportunities for Water Conservation in the Flint and Chattahoochee River Basins of Georgia

Prepared for the State of Florida, Through Its Department of Environmental Protection and Its Counsel, Latham & Watkins LLP

May 20, 2016

THE Brattle GROUP

conservation measures that were implemented in 2011, outdoor use across the ACF amounted to approximately 163,000 acre-feet of withdrawals. Note that an outdoor watering ban was not called for in 2011, despite the drought's extreme effect on agriculture, because the Metro North Georgia area was relatively less affected.[9]

Table 2: Outdoor Use in the ACF Basin

Year	Outdoor Use (acre-feet)
[1]	[2]
2008	147,510
2009	136,731
2010	154,948
2011	162,792
2012	154,344
2013	119,909

11. Assuming all municipal water is supplied by surface sources, outdoor water use resulted in approximately 513 cfs of peak summer streamflow depletions in 2011.[10] A 50 percent cutback on municipal outdoor use would thus lead to a reduction in streamflow depletions of 256 cfs, and a 75 percent cutback to a reduction of 385 cfs, in a drought year like 2011.

12. Although these outdoor water use cutbacks and resulting streamflow improvements would not entail any monetary costs beyond those needed to maintain compliance, they would be associated with some "quality of life" impacts, as discussed in my February 2016 report. However, other states such as California have opted to implement such restrictions at greater welfare costs than are implied for Atlanta.[11]

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9 Knox, P. "'Quiet' drought is worse in some areas than 2007-2009 drought". Georgia FACES, December 19, 2012. Available at http://apps.caes.uga.edu/gafaces/?public=viewStory&pk_id=4613.

10 163,000 acre-feet of consumptive use is equivalent to an annual streamflow of 225 cfs. Based on the annual to peak monthly conversion factor of 2.28 provided by Dr. David Langseth, the resulting peak summer month streamflow depletion associated with outdoor use is 513 cfs.

11 Buck, S., et al., "The Welfare Consequences of the 2015 California Drought Mandate: Evidence from New Results on Monthly Water Demand," UC Berkeley, 2016.

ATTACHMENT 8

Hydrological Impacts of Georgia's Consumptive Use of Water in the ACF River Basin on the Apalachicola River

Expert Report in the matter of *Florida v. Georgia*, No. 142 Orig.

Prepared by:

____

Dr. George M. Hornberger

Prepared for
Florida Department of Environmental Protection

February 29, 2016

Appendix C Data-Driven Reservoir Models

C.1 Overview of Procedure

Both of the data-driven reservoir models used in my report predict flows that are tied to the observed flow record in the following way:

- Each data-driven reservoir model is run with observed data to create a baseline model prediction of flows.
- Each data-driven reservoir model is then run for a particular scenario where inflows into the model are increased or decreased according to the scenario being evaluated. Changes to inflows associated with agricultural water use and small impoundment incremental evaporation are applied at the Bainbridge node in ResSim, whereas changes to inflows associated with M&I water use and IBTs are applied at the Columbus node. For the Lake Seminole model, all changes to inflows are applied to the Lake Seminole inflow. These adjusted inflows are then used in the reservoir models to predict flows for that scenario.
- The flows in the scenario are then subtracted from the baseline model to calculate the incremental change in model-predicted flow. This incremental change is then added to the observed flows.

Performing the calculations in the above manner creates a modeled flow record that is inherently linked to the observed flows in the basin. Additional details of the two reservoir models I used in my analysis are described below.

C.2 Data-driven ResSim Model

In order to run the data-driven ResSim model, I needed to process observed flow data to convert it to incremental inflows from the surrounding landscape along stream reaches. Incremental flows used as input to the ResSim model were estimated using observed flow data from USGS stream gages and reservoir inflow and outflow data reported by the US ACE. The incremental flow along a stream can be estimated between an upstream and downstream location that both have observed data. For the stream network in ResSim, incremental flows were computed between the following nodes

- Buford Out (USACE) to Norcross (USGS)
- Norcross (USGS) to Atlanta (USGS)
- Atlanta (USGS) to West Point In (USACE)
- West Point Out (USACE) to WF George In (USACE)
- WF George Out (USACE) to Jim Woodruff In (USACE)
- Chattahoochee (USGS) to Sumatra (USGS)

The observed data at Norcross, Atlanta, Chattahoochee, and Sumatra come from USGS stream gages. Observed data at the remaining locations are from the USACE.

The estimation procedure entails routing observed flow from the upstream location to the downstream location and comparing the routed flow to the observed flow downstream. The

Appendix D Methodology for Converting Annual Average Stream Flow Add Backs to Monthly Average Add Backs

In order for the economics analysis to convert its annual average estimates of stream flow add backs to monthly add backs for potential conservation scenarios, a set of scaling factors is needed to translate annual values to monthly values. These monthly values will provide estimates of how much stream flow might be increased during the summer months when flows in the Apalachicola River tend to be low.

To calculate monthly conversion factors, one needs to consider the time lags between when withdrawals occur and when stream flow is affected by those withdrawals. For example, a surface water withdrawal has an immediate effect on stream flow, and hence the time lag is negligible. Conversely, a groundwater withdrawal may not have an immediate effect on stream flow, since the pumping causes a drop in groundwater head that takes time to propagate through the aquifer before being realized as a streamflow depletion. Thus, calculating monthly conversion factors for groundwater withdrawals requires taking these time lags into account.

I calculated monthly conversion factors for surface water withdrawals by dividing monthly withdrawals for a composite drought year (average monthly withdrawals for 2011 and 2012) by the average annual withdrawal for that same composite drought year. This approach is based on no time lags for surface water withdrawals to be realized as depletions, which is reasonable for the monthly timescale of this analysis. The conversion factors calculated in this way are shown in Table 1.

Table D.1 Monthly Conversion Factors for Surface Water Withdrawals

Month	Withdrawal (cfs)	Conversion
Jan	0	0.00
Feb	0	0.00
Mar	551	0.44
Apr	1,363	1.08
May	3,085	2.44
Jun	2,887	2.28
Jul	2,008	1.59
Aug	2,225	1.76
Sep	1,677	1.33
Oct	1,368	1.08
Nov	0	0.00
Dec	0	0.00
Annual Average	1,264	

For the groundwater withdrawal conversion factors, I accounted for time lags by including the results of Dr. Langseth's Expert Report (2016) in the following way:

ATTACHMENT 9

Expert Report of

J. David Allan, Ph.D.

In the matter of *Florida v. Georgia*, No. 142 Orig. in the United States Supreme Court

Prepared for
Florida Department of Environmental Protection

Prepared by

J. David Allan, Ph.D.

Professor Emeritus
School of Natural Resources & Environment
The University of Michigan
Ann Arbor Michigan 48109

February 29, 2016

Harm Summary

Full results from the metrics are shown in Appendix D and summarized in Table 7 below.

Table 7. Years of harm and total duration of harm in days shown in parentheses for tupelo swamps under historical (observed) flows, had there been virtually no Georgia consumption (unimpacted comparison) and under one potential remedy. The unimpacted and remedy comparisons are based on modeled hydrographs as described in the report of Dr. Hornberger. Note that the unimpacted comparison eliminates virtually all Georgia consumption (post-1955), whereas the remedy comparison simply adds a certain percentage of Georgia's consumption to the historical record.

	Historical Comparison			Unimpacted Comparison		Remedy Comparison	
Metric	Early 16 yrs	Recent 16 yrs	Increase in harm	Recent 16 yrs w/o consumption	Decrease in harm	Recent 16 yrs with remedy	Decrease in harm
Tupelo – 10%	1 (43)	10 (421)	9 (378)	4 (131)	6 (290)	8 (392)	2 (29)
Tupelo – 30%	3 (107)	11 (553)	8 (446)	6 (237)	5 (316)	9 (508)	2 (45)
Tupelo – 50%	5 (130)	13 (594)	8 (464)	9 (460)	4 (134)	11 (553)	2 (41)

- Historical comparison: At all thresholds, the floodplain forest in the most recent 16 year period experienced significantly more harm than in the early 16 year period. Harm has increased by 8 to 9 years and by over 400 days.
- Unimpacted comparison: If Georgia had not consumed any water at all, the past 16 years would show a significantly reduced impact. Harm would have decreased by 4 to 6 years and by roughly 100 to 300 days.
- Remedy comparison: Had there been a remedy, harm would have decreased by 2 years and 30 to 45 days.

2.5 Many of the harms described in this section are primarily caused by Georgia's consumption, not channel changes

The broad pattern in all harm results based on my metrics evaluated against historical and modeled flows can be summed up as follows: Increase in harm from the early to most recent 16 years is invariably large. Harm has increased by 4-9 years (out of 16), and duration of harm by up to 698 days. Removing Georgia's consumption (the unimpacted comparison) invariably results in a significant decrease in harm of 1 to 8 years (out of 16) and as much as 800 fewer total days of harm. Although the channel has changed over the years due to both human and natural causes, the present-day ecosystem must live with the modern reality resulting from

ATTACHMENT 10

Prepared for

State of Florida

Department of Environmental Protection

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February 29, 2016

Opinion 3: Adequate freshwater inflows are critical to a healthy Apalachicola Bay ecosystem. Reduced flows caused by Georgia's consumptive water uses have harmed the ecosystem of the Bay through several mechanisms.

Opinion 3A: Low-flows have resulted in increased salinity and standing stocks of phytoplankton, as well as changes in water color and nutrient dynamics. These changes harm habitat quality directly and can also trigger a shift from a highly productive pelagic food web to a less productive and efficient benthic food web (Glibert Expert Report).

Georgia's water withdrawals and subsequent low freshwater flow has resulted in the highest salinities occurring during the late low-flow season (August–October) of low-flow years (Opinion 2B). This is the same time period in which Dr. Glibert's report shows changes in nutrient availability and recycling indicative of a shift from a pelagic to a benthic food web, which is characterized by lower productivity and lower energy efficiency to higher trophic levels, further harming the ecosystem.

The following data also support Dr. Gilbert's opinion that Apalachicola Bay shifts seasonally to a benthic food web during low flow years.

Remote sensing data document physical and biological changes across large geographic areas in Apalachicola Bay during this crucial time period (i.e., the late low-flow season of low-flow years) that are harmful to the ecosystem. Colored dissolved organic matter (CDOM), which is carried downstream into the Bay by the river, is lower throughout most of Apalachicola Bay, especially in East Bay (Figure 3A-1; Appendix 3A). These lower CDOM concentrations contribute an increase in water clarity which, in conjunction with lower nutrient inputs, triggers a shift to a less productive benthic food web (Livingston 1997; Glibert Expert Report).

The habitat of the upper reaches of East Bay during the late low-flow season of low-flow years is further changed by localized increased phytoplankton concentrations, as indicated by elevated concentrations of the photosynthetic pigment chlorophyll *a* (Figure 3A-2).[6] Increased phytoplankton concentrations are the result of reduced flushing in East Bay caused by low freshwater flow. The observed changes in CDOM and chlorophyll *a* concentrations between high-flow and low-flow years reflect measurable changes that are consistent with a

[6] Interactions in this dynamic environment are dependent upon magnitude and timing. Increases in phytoplankton/chlorophyll has a shadowing effect decreasing the amount of light that reaches the bottom and potentially offsetting the increased clarity as a result of lower CDOM. The extent to which light can initiate photosynthesis in submersed aquatic vegetation at the bottom will depend upon an interplay of these two variables (Glibert Expert Report).

shift in primary productivity and nutrient cycling within the Apalachicola Bay system that degrades habitat quality (Glibert Expert Report).

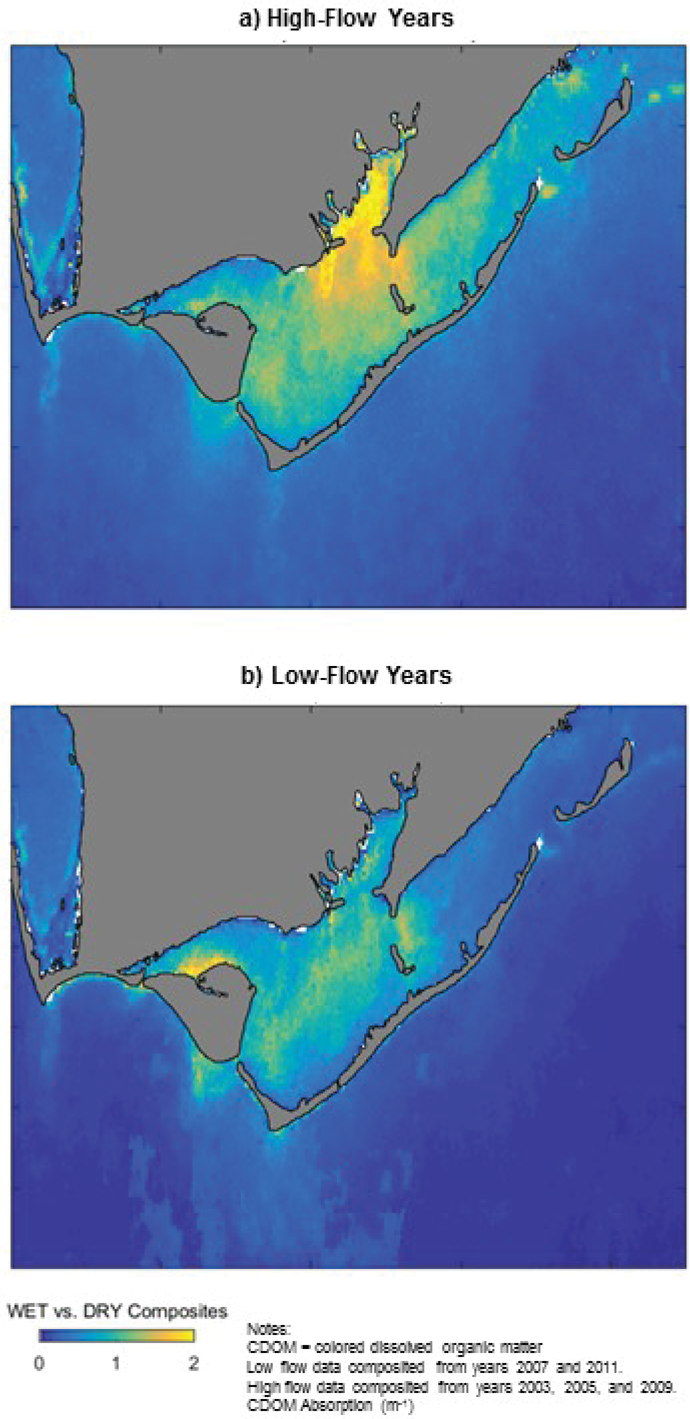

Figure 3A-1. Colored Dissolved Organic Matter in Apalachicola Bay during Late Low-Flow Season (August to October) for Composites of (a) High-Flow Years (2003, 2005, 2009) and (b) Low-Flow Years (2007, 2011)

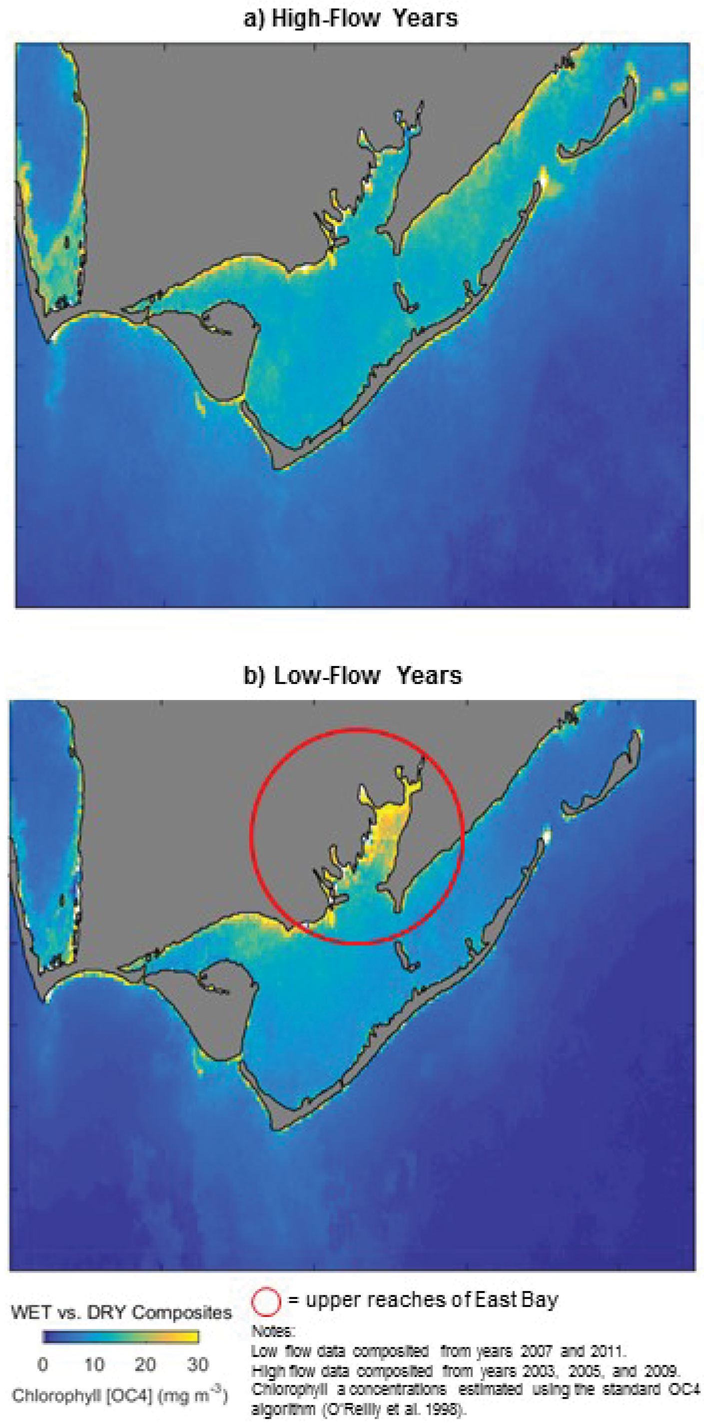

Figure 3A-2. Chlorophyll *a* in Apalachicola Bay during Late Low-Flow Season (August to October) for Composites of (a) High-Flow Years (2003, 2005, 2009) and (b) Low-Flow Years (2007, 2011)

Opinion 3B: The reduced flows from Georgia's increased consumptive water uses in recent years have fundamentally altered the long-term community structure at higher trophic levels throughout the Bay as it becomes less hospitable to freshwater species and more hospitable to marine species.

In the years before Georgia's water withdrawals increased (Hornberger Expert Report; Flewelling Expert Report), the Apalachicola Bay ecosystem was characterized by a mix of fish species adapted to its low salinity conditions. In this period, freshwater and diadromous fish species were commonly observed in the Bay, but as salinity in the Bay has increased, the biological harm to the natural Bay ecosystem has become evident: Fish community composition has changed, shifting away from freshwater fish and diadromous fish toward more brackish and marine species.

The numerically dominant fish species in estuaries such as Apalachicola Bay typically are species that can tolerate the widely varying salinity conditions that occur in estuarine environments. Changes in the abundance of these species due to gradual changes in salinity and nutrient inputs are often difficult to detect, given the high degree of seasonal and annual variability that occurs in estuaries such as Apalachicola Bay and the euryhaline nature of the common species. Yet changes in the community composition of the dominant fish species are observed in Apalachicola Bay between the 1970s (before increases in Georgia consumption) and the 2000s (after consumption increased). These changes are observed across all seasons and within East Bay and the outer Bay indicating widespread shifts in community composition toward a more marine ecosystem (Figure 3B-1; Appendix 3B).

Across all seasons, the differences between 1970s and the 2000s include a marked increase in relative abundance of bay anchovy and a decline in relative abundance of spot throughout the Bay (Figure 3B-1). The 12 most abundant species account for up to 99 percent of all fish present in Apalachicola Bay. The identities of the 12 most abundant species and the relative abundance of those species differ between the 1970s and the 2000s. Four of the 12 most abundant species collected in the 1972–1984 Livingston survey are not among the top 12 in the 2000–2012 ANERR survey (Appendix 3B). Three of these four are species with wide salinity tolerances that are sometimes found in freshwater. The species that replaced them on the list are all marine/brackish species that do not occur in freshwater.

More recent ANERR data show that these trends are continuing. In the 2014–2015 ANERR surveys, bay anchovy accounted for 83 percent of all fish collected compared with 46 percent in 2000–2012, and spot only 1.4 percent as compared to 20 percent in 2000–2012 (Appendix 3B).

Effects of long-term changes in estuarine conditions are more easily observable in rarer components of the fish community. These species often have much narrower ranges of salinity tolerance, and include freshwater-oriented species that can move into the Bay from freshwater tributaries when salinities are relatively low and marine-oriented species that can move in from the ocean when salinities are high.

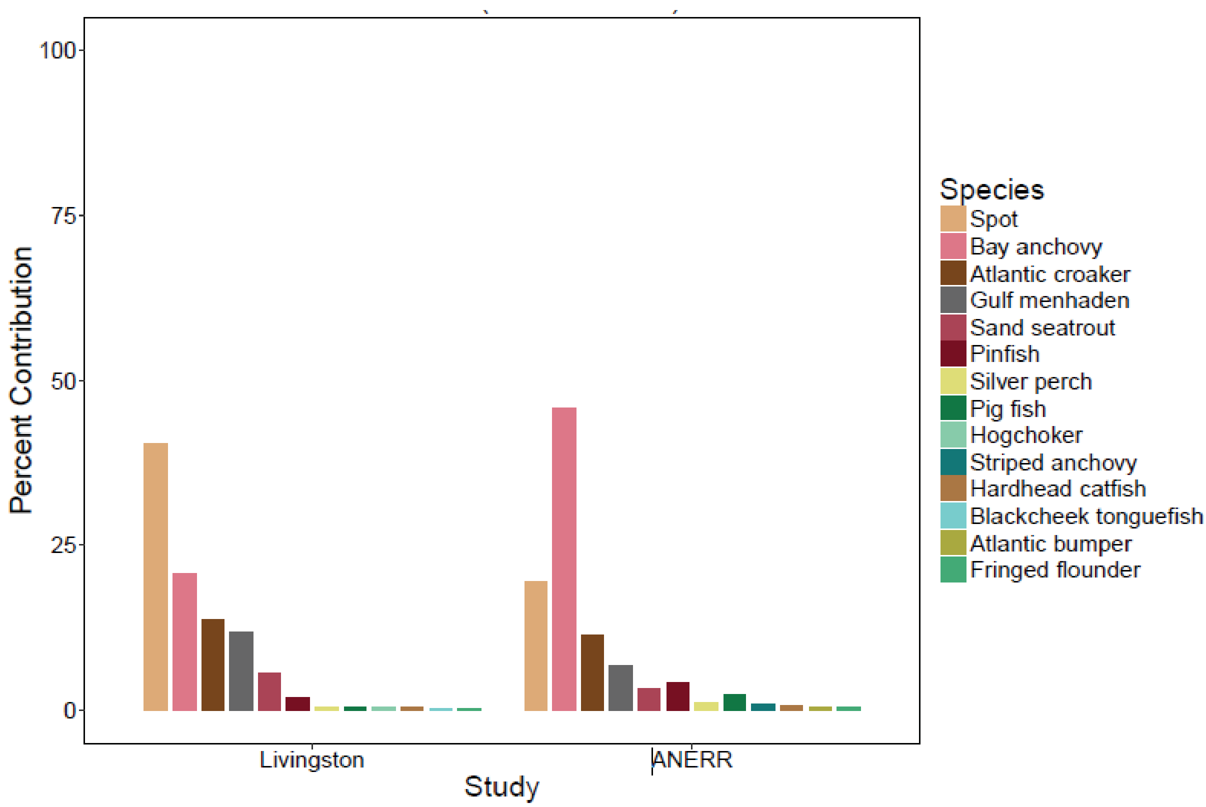

Figure 3B-1. Percent Contribution of Livingston and ANERR Top 12 Most Abundant Species, East Bay and Outer Bay, All Seasons

A comparison of rare species lists compiled from the Livingston (1972–1984) and ANERR (2000–2012) surveys shows that a shift from freshwater-oriented species to marine-oriented species did, in fact, occur between the 1970s and the 2000s. Table 3B-1 presents the salinity preferences of 26 fish species that were collected only in the Livingston survey and 31 species that were collected only in the ANERR survey (Appendix 3B). To minimize the chance that differences in sampling program design between these surveys could have influenced the results, only locations that were sampled in both surveys were included in this analysis.

As shown in Table 3B-1 below, five freshwater-oriented species were unique in the Livingston survey. No freshwater-oriented species were unique to the ANERR survey. In contrast, 28 of the 31 species unique to the ANERR survey were marine-oriented, and the remaining three species tolerate a wide range of salinities.

These results clearly demonstrate that the composition of the fish community in Apalachicola Bay shifted toward marine-oriented species between the 1970s and the 2000s as Georgia's consumptions increased (Fleming Expert Report). Appendix 3B provides a full description of changes in the rare species fish community composition over time.

Table 3B-1. Apalachicola Bay Species Lists—Livingston (1972–1984) and ANERR (2000–2012)

	Livingston	ANERR
Freshwater Oriented		
Diadromous[a]	2	0
Freshwater	1	0
Freshwater/brackish	2	0
Widely Tolerant		
Marine/freshwater/brackish	8	3
Marine Oriented		
Marine/brackish	2	12
Marine	11	16
Total	**26**	**31**

Notes:
[a] Diadromous species are species that either spawn in freshwater and then migrate to the ocean or spawn in the ocean and then migrate to freshwater.

No. 142, Original

In The
Supreme Court of the United States

STATE OF FLORIDA,

Plaintiff,

v.

STATE OF GEORGIA,

Defendant.

Before the Special Master

Hon. Ralph I. Lancaster

CERTIFICATE OF SERVICE

This is to certify that the STATE OF GEORGIA'S OPPOSITION TO FLORIDA'S MOTION IN LIMINE REGARDING "LOST WATER" IN FLORIDA has been served on this 30th day of September, 2016, in the manner specified below:

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