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

FLORIDA'S REPLY MEMORANDUM TO PRECLUDE EXPERT TESTIMONY BY DR. PHILIP BEDIENT AND DR. SORAB PANDAY ON 'LOST WATER'

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INTRODUCTION

In its Opposition, Georgia doubles down on the unsupported position that its experts may inject an unbelievable opinion into this litigation without even attempting to provide any explanation on *how* or *why*—let alone *if*—the phenomenon its experts describe is actually occurring. The Federal Rules of Evidence do not permit Georgia's experts to offer testimony on 'lost water' because their conclusory opinions are untethered to logic or science. Georgia's opinions on 'lost water' reflect an effort to tilt the equities in this litigation by shifting focus away from Georgia's own consumption and onto some unexplained purported phenomenon in Florida. *See* Georgia's Opposition to Florida's Motion in Limine Regarding "Lost Water" (Dkt. 492) ("Opposition or "Opp.") at 1–3. But the attempt fails because, after insisting Georgia is not to blame, its experts do not offer an explanation—let alone a plausible one—as to the actual cause of the supposed 'lost water.'

Florida, on the other hand, will demonstrate at trial that Georgia consumption is causing dramatic flow declines in the ACF, a fundamental fact that Georgia scientists acknowledge:

> Our analysis of climate data does not suggest long-term changes or trends in annual rainfall in southwestern Georgia. While seasonality of rainfall has shifted slightly there is no consistent change in annual total rainfall over the past 60 years. Our analysis of stream flow data show consistent and substantial declines in minimum and seasonal stream flow associated with the development and implementation of agricultural irrigation in the FRDP area of southwestern Georgia. This has resulted in some of the lowest flows on record during recent droughts. There is no climatologic indication that recent droughts were more severe or persistent than those in the past (i.e., 1930's or 1950's). Thus, we conclude that water use is the primary factor causing record low stream flow and other alterations in regional hydrology.

S.W. Golladay, D.W. Hicks, and T.K. Muenz, *Streamflow Changes Associated With Water Use and Climatic Variation in the Lower Flint River Basin, Southwest Georgia* at 4 in Proceedings of the 2007 GEORGIA WATER RESOURCES CONFERENCE (Mar. 27-29, 2007) (emphasis added) (Reply Attachment 11); *see also* Motion In Limine to Preclude Expert Testimony of Dr. Suat Irmak (Dkt. No. 473) at 7 (citing Georgia's 2006 Flint River Basin Plan: "These data provide the clearest evidence that agricultural irrigation compounds the effect of climatic drought on stream flow in the Basin."). In addition to such materials, Florida's expert hydrologists will demonstrate causation at trial: consumption by Georgia, particularly during drought years, is substantially reducing river and streamflow to Florida.

Georgia's Opposition asserts that alleged flow declines in the "Incremental Area" [the Florida portion of the Basin] "have *nothing to do with Georgia's water use*," (Opp. at 16 (emphasis in original)) and Georgia's experts purport to offer supporting ***causation opinions***. For instance, Dr. Panday opines that alleged water losses are "are not caused by any action by Georgia." Panday Report at 3 (Key Finding and Opinion No. 4) (Mot. Attachment 5 to Georgia's Motion in Limine to Preclude Expert Testimony by Dr. Bedient and Dr. Panday on 'Lost Water') (Dkt. 474) ("Motion" or "Mot."). And Dr. Bedient finds that such losses are "not directly attributable to rainfall or to the flows crossing the state line." *Id*. at 77. By their own admission, however, Georgia's experts have conducted ***no causal analysis*** to support their opinions excluding Georgia as a contributing cause or finding that the alleged water losses are real. Mot. at 4–5 (citing deposition testimony by Dr. Bedient acknowledging, "I don't know where, and nor have I done any investigation to determine where that water may be going . . . . I have not done any study or evaluation of that."); *id*. (citing Dr. Panday's admission that he has "not attributed the flow decline to consumptive use" nor has he "quantified or evaluated the possible causes"); *id*. (citing deposition testimony by Dr. Panday reiterating, "I haven't looked at what the possible causes would be. . . . I have not tried to quantify the causes for this flow decline, I have just presented what the data shows me.").

The *Daubert* problem here is simple. An expert cannot simply guess, jump to conclusions, or assume what he seeks to prove. *See, e.g.*, *Gen. Elec. Co. v. Joiner*, 522 U.S. 136, 146 (1997) (neither "Daubert [n]or the Federal Rules of Evidence requires a district court to admit opinion evidence that is connected to existing data only by the *ipse dixit* of the expert" because "[a] court may conclude that there is simply too great an analytical gap between the data and the opinion proffered"); *Nelson v. Tenn. Gas Pipeline Co.*, 243 F.3d 244, 254 (6th Cir. 2001) (affirming the exclusion of expert testimony based on circular reasoning). An expert must use a body of scientific knowledge, and a reasonable investigation of underlying facts, to support an informed opinion. *See, e.g.*, *Presley v. Lakewood Eng'g & Mfg. Co.*, 553 F.3d 638, 646-647 (8th Cir. 2009) ("opinions formulated merely upon general observations of the evidence and general scientific principles [are] unreliable"). Georgia's experts do not satisfy these requirements by proffering causation opinions without supporting causation analysis, and by concluding that the alleged water losses are real based on flawed reasoning. The notion that Georgia's experts may render conclusions without providing any causal basis—simply stating they have "no earthly idea" as to what is causing the purported phenomenon to occur—offends the Federal Rules of Evidence, *Daubert*, and common sense. Thus, the Court should not permit either expert to testify on 'lost water.'

ARGUMENT

A. Georgia's Lost-Water Opinion Should Be Excluded On The Grounds That It Is Based On Circular Reasoning And Inferential Leaps.

Georgia devotes much of its Opposition to defending its experts' methods for calculating flow differences in the Florida portion of the ACF. *See* Opp. at 12. But Florida's motion does not challenge the calculations, and Georgia's focus on arithmetic misses the point. Instead, Florida invokes *Daubert*, *Joiner* and other well-established authorities to exclude the 'lost water' opinion on the grounds that it is based on flawed *reasoning*, lacks analytical support, and is therefore unreliable.

Under Federal Rule of Evidence 702, courts properly inquire not only into the type of material on which an expert relies, but also whether that material actually supports the expert's reasoning. Where an expert's reasoning breaks down—for instance, where "there is simply too great an analytical gap between the data and the opinion proffered"—the court may exclude the expert opinion testimony. *Joiner*, 522 U.S. at 146. Thus, expert opinions based on circular reasoning are unreliable and subject to exclusion. *See, e.g.*, *Nelson*, 243 F.3d at 254 (finding that trial court "judge properly rejected the circular reasoning that the plaintiffs must have been exposed to the PCBs because PCBs were present in the environment and plaintiffs showed symptoms").[1]

Georgia argues the lost-water opinion should stand even though its experts fail to provide ***any causal explanation*** for the fantastic claim that such vast quantities of water simply would disappear—a claim so utterly implausible that Dr. Bedient testified he had "no earthly idea" what could explain the loss. Mot. Attachment 2 at 615:22-616:16. Georgia's expert reports and opinion on 'lost water' are doomed by the analytical gap between their observation of measured-flow differences and conclusion that this observation establishes real and massive water losses. Dr. Bedient and Dr. Panday employ circular logic to conclude that the alleged water losses are real, making an "inferential leap" forbidden by Rule 702, *Daubert* and other applicable

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[1] *See also Mills v. Riggsbee*, No. 12-148-KKC, 2014 WL 1154060 at *5 (E.D. Ky. Mar. 20, 2014) ("This Court cannot permit a witness to offer an 'expert' opinion based on nothing more than circular logic. Accordingly, [expert's] testimony is inadmissible.").

authorities. *See, e.g., C.W. v. Textron, Inc.*, 807 F.3d 827, 836 (7th Cir. 2015) (affirming the exclusion of expert testimony based on "an inferential leap that the district court was rightly unwilling to make.")

Both experts assume that measured-flow differences between the Chattahoochee and Sumatra Gages prove that vast quantities of water in the undeveloped Incremental Area have actually vanished—enough missing water to supply millions of people and irrigate approximately four million acres of farmland. Mot. at 3. The truth of their conclusion regarding water losses is assumed by their premise that the discharge records at the Sumatra Gage accurately represent flow conditions at all times. *See, e.g.*, Opp. 3 ("whatever the cause, the fact is that these losses are occurring"). Because this reasoning is entirely circular, the conclusion should be excluded. *See, e.g.*, *Nelson*, 243 F.3d at 254.

Moreover, the Opposition ignores significant weaknesses in Georgia's premise regarding the accuracy of Sumatra Gage discharge records. While Dr. Bedient and Dr. Panday accept the Sumatra Gage records at face value, Florida's motion presents compelling evidence that Sumatra Gage discharge records are unreliable during certain high-flow periods when the Apalachicola River overflows its banks.[2] *See* Mot. at 6-7 (describing USGS's acknowledgment that the gage is prone to errors during high flows, Dr. Menzie's testimony that the Sumatra Gage produced anomalous flow measurements, and a Georgia hydrologist's conclusion that measured-flow differences in the Incremental Area are "nonsense" and "not meaningful."). Incredibly, and

[2] Stream gages do not measure flow directly. Instead, streamflow or discharge is calculated with a rating curve, which represents a relationship between the river water elevation and flow velocities. Because rivers are subject to continuous change, these manual measurements may introduce errors that can distort streamflow records. The broad floodplain adjacent to the Apalachicola River at the Sumatra Gage presents unique challenges to calculating discharge during high-flow periods when the Apalachicola River overtops its banks and flows through the floodplain. *See* Defensive Expert Report of Dr. Hornberger, at 11-14 (Reply Attachment 13).

tellingly, the Opposition ignores this countervailing evidence. Nor does it address the failure by Georgia's experts to question—let alone explain—the alleged phenomenon.[3] Instead, the Opposition doubles down on the lost-water opinion by reiterating its experts' circular claim that, because measured-flow differences were calculated, those measured differences must correspond with real water losses.

To grant Florida's motion, this Court need not resolve the factual dispute concerning the Sumatra Gage's reliability. But the Court may and should exercise its gatekeeping role by excluding the lost-water opinion on the grounds that it rests on flawed reasoning and no causal explanations.[4]

B. The Opposition Mischaracterizes The Work Of Florida's Experts.

Without any causal analysis of its own, Georgia attempts to rely on the evaluations performed by Florida's expert hydrologists. But Georgia misconstrues and distorts their work to satisfy its own conclusions. For example, Georgia truncates the testimony of Florida expert, Dr. Langseth, by omitting the complete response he provided during his deposition. *See* Opp. at 11

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[3] In Footnote 20 of its Opposition, Georgia claims that Dr. Bedient and Dr. Panday addressed the possibility that anomalous records at the Sumatra Gage during high-flow periods might account for the apparent losses. In the memos Georgia cites, however, Dr. Bedient does not address the substance of Dr. Hornberger's critique of the Sumatra Gage; instead he focuses on data variability at the Sumatra and Chattahoochee Gages. While Dr. Panday discusses the Sumatra Gage, he does not address the rationale underlying Dr. Hornberger's conclusions. Neither expert looks at the physical characteristics of the floodplain around Sumatra and considers how changes in USGS measurement techniques might have led to flawed data.

[4] While the Opposition expressly disclaims the idea that Dr. Bedient or Dr. Panday render any opinion on causation, Georgia ignores the fact that both experts actually opine that Georgia is not the cause of 'lost water' in the Incremental Area. *Compare* Opp. at 12-15 (arguing that neither expert is "offering opinions regarding causation . . . . their opinions focus on the existence of the phenomenon, not the cause of the phenomenon") *with* Panday Report at 3 (identifying as "Key Finding and Opinion" No. 4 that "water lost within Florida is ***not caused by*** any action by Georgia") and Bedient Report at 77 (asserting that the 'lost water' is "not directly attributable to rainfall or to the flows crossing the state line"). Ruling out Georgia as a 'cause' constitutes rendering an opinion on causation --- without having done any causal analysis.

n.14. In suggesting Dr. Langseth agreed with the notion of lost water in the Incremental Area, Georgia chose to excise the highlighted portion of his transcript:

> Q. Now, as a conceptual matter, leaving aside your specific critiques and opinions, do 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?
>
> * * * *
>
> A. From a pure numbers perspective, if the numbers – the downstream number is less than the other, clearly there's less water. Now, whether that has any hydrologic meaning depends on a variety of factors, including whether or not the gages are both accurate.

Langseth Dep. at 912:13-913:2 (July 21, 2016) (Reply Attachment 12). Suggesting that Dr. Langseth found Georgia's incomplete and hypothetical question to have "hydrologic" meaning and by omitting a caveat Dr. Langseth expressly included in his response is misleading.

Georgia also suggests that Dr. George Hornberger—a Distinguished University Professor at Vanderbilt University and member of the National Academy of Engineering—opined that 'natural climate variations' caused loss of water in the Incremental Area. Not true. Dr. Hornberger expressly opined that the *time-period* Georgia selected (1978-2014) contrasted 'wetter,' relatively high-flow years, with more recent 'drier,' relatively low-flow ones. While Georgia ignores this effect, Dr. Hornberger explains it scientifically:

> 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.

Defensive Expert Report of Dr. Hornberger (Reply Attachment 13), at 19. Far from 'admitting' that water is lost in the Incremental Area because of climatic variations (*see* Opp. at 2), Dr. Hornberger simply observed that the timeframe selected by Georgia (1978-2014) compares wet years with dry years and therefore distorts the analysis. Dr. Hornberger relied on Florida expert Dr. Lettenmaier who examined the "record of precipitation for the basin over the past century," and identified "no consistent trend, just climate variability with wet periods and dry periods sporadically interspersed." Defensive Expert Report of Dr. Hornberger, at 19.

Finally, Georgia attempts to excuse its hydrologists' failure to identify the cause of lost water in the Incremental Area by comparing Dr. Bedient and Dr. Panday with two Florida experts (Dr. Allan and Dr. Jenkins). Georgia alleges that Dr. Allan and Dr. Jenkins do not assess causation but nevertheless discuss the impact of consumptive water use. *See* Opp. at 13-14. But Dr. Allan and Dr. Jenkins are ***ecologists, not hydrologists***. ***Both expressly rely on the work of expert hydrologists*** to explain the ecological impacts of increased consumptive use by Georgia. *See* Jenkins Report (Reply Attachment 14) at 5, 13, 23, 29 (citing to findings of Drs. Hornberger and Flewelling); Allan Report at 9 (Reply Attachment 15) at 11, 13, 37, 48, 63, 69, 81, 83-86, 89 (citing analyses by Dr. Hornberger) and 84 (citing to Dr. Lettenmaier's Expert Report). Dr. Bedient and Dr. Panday, on the other hand, are themselves hydrologists who presumably possess the expertise to determine and explain how thousands of gallons of water are supposedly disappearing in the Incremental Area every second. If, as Dr. Bedient conceded at his deposition, he has "no earthly idea" as to how to explain this phenomenon, the Court should not permit either him or Dr. Panday to testify on this issue at trial.

CONCLUSION AND REQUEST FOR RELIEF

Georgia's experts cannot opine that a loss exists unless they first prove the existence of the loss, otherwise they engage in simple speculation. And to prove the existence of a loss necessarily requires causal analysis. Drs. Bedient and Panday admit they have undertaken no causal analysis.

For the reasons stated above and in the Motion, Florida respectfully requests the Court to grant this motion and preclude Drs. Bedient and Panday from offering testimony on "lost water."

Dated: October 7, 2016

Respectfully submitted,

/s/

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ATTACHMENTS TO FLORIDA'S REPLY MEMORANDUM TO PRECLUDE EXPERT TESTIMONY BY DR. PHILIP BEDIENT AND DR. SORAB PANDAY ON 'LOST WATER' AND MEMORANDUM IN SUPPORT THEREOF

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Attachment 11: S.W. Golladay, D.W. Hicks, and T.K. Muenz, "Stream Flow Changes Associated with Water Use and Climatic Variation in the Lower Flint River Basin, Southwest Georgia," Proceedings of the 2007 Georgia Water Resources Conference, dated March 27-29, 2007

Attachment 12: Excerpts from the Deposition Transcript of David Langseth (July 21, 2016)

Attachment 13: Excerpts from the Expert Report of George Hornberger, Ph.D. (May 20, 2016)

Attachment 14: Excerpts from the Expert Report of Kenneth Jenkins, Ph.D. (February 29, 2016)

Attachment 15: Excerpts from the Expert Report of J. David Allan, Ph.D. (February 29, 2016)

ATTACHMENT 11

David Hicks and Stephen Golladay, "Stream Flow Changes Associated with Water Use and Climatic Variation in the Lower Flint River Basin, Southwest Georgia," Proceedings of the 2007 Georgia Water Resources Conference, dated March 27-29, 2007

STREAM FLOW CHANGES ASSOCIATED WITH WATER USE AND CLIMATIC VARIATION IN THE LOWER FLINT RIVER BASIN, SOUTHWEST GEORGIA

S.W. Golladay[1], D.W. Hicks[2], and T.K. Muenz[3]

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REFERENCE: *Proceedings of the 2007 Georgia Water Resources Conference*, held March 27–29, 2007, at the University of Georgia.

Abstract. In the 1970's agricultural water use expanded rapidly in the lower Flint River Basin resulting from the introduction of center pivot irrigation technology. The rapid expansion has raised concerns about impacts on regional stream flows essential to support aquatic fauna. Using long-term stream gage records from the USGS and climate data, we analyzed trends in stream flow in two major sub-watersheds and regional patterns of rainfall from 1940 through 2004. We observed no change in annual rainfall but seasonality changed with winters being slightly wetter. Minimum flows showed substantial declines since the development of irrigation. We attribute altered stream flows to increased regional water demand however; the demand for water is also exacerbated by long-term variations in climate and rainfall distribution.

INTRODUCTION

Human water use affects regional hydrology through consumptive water withdrawals, resulting in reduced streamflow and depressed groundwater levels. In southwestern Georgia, practically all streams originate as groundwater seeps or springs. While stream flow is primarily sustained by precipitation for the much of the year, it is augmented by groundwater discharge, which during the low-flow periods (June-November) can account for a substantial part of the total stream flow. During late summer and fall, when rainfall historically is sparse, the baseflow of many streams in the lower Flint River Basin (FRB) is maintained almost solely by groundwater discharging directly into the streams through springs and seeps in the stream channels, or groundwater discharging from off-channel springs and flowing into the streams.

Between 1970 and 1980, southwestern Georgia saw an enormous increase in the agricultural use of water resources. Irrigated acres increased from 130,000 in 1976, to 261,000 in 1977 (Pollard et. al, 1978). By 1980, irrigated farmland had increased to more than 452,000 acres, and the combined surface water and groundwater annualized use was estimated to be more than 290 million gallons per day (Mgals/day) (Pierce et. al, 1984). By 1999, about 85% of the agricultural lands in the lower FRB were irrigated, mostly by withdrawals from the Upper Floridan aquifer (Litts et. al., 2001). Currently, agricultural irrigation is thought to be about 10 in/yr, or approximately 20% of long-term average annual precipitation of 50 in. (Harrison 2001). The large increases in irrigation drastically changed the pattern of water and land use throughout southwestern Georgia and have raised concerns of sustainability of streams and rivers.

Both surface-water and groundwater withdrawals are permitted by the GA EPD. It is likely that through regulatory oversight, permitted withdrawals may exceed sustainable capacities of the streams and aquifers of the lower FRB, particularly during periodic droughts. The effects of simulated groundwater pumping have been estimated and stream reaches classified based on their sensitivity to water withdrawal (Albertson and Torak, 2002). In addition, long-term declines in flow recession curves have been documented within selected tributaries (Stamey 1996; Torak and McDowell, 1996). It is important to estimate long-term trends in regional stream flow to determine impacts of water use and help determine sustainable stream flows. While some long-term records of stream flow exist, the impacts of water use and changing climate on regional hydrology have not been quantified. The purpose of this study was to examine the long term trends in climate and stream flow in selected streams of the lower FRB.

STUDY AREA

This study was conducted in two watersheds of the lower FRB: Spring Creek and Ichawaynochaway Creek. These streams flow through parts of Stewart, Webster, Randolph, Terrell, Clay, Early, Calhoun, Dougherty, Miller, Baker, Seminole, and Decatur Counties in southwestern Georgia (Figure 1).

METHODS

Long-term trends in rainfall and stream flow were assessed within the lower FRB. Rainfall data were obtained from the National Climate Data Center Drought Series Database (http://lwf.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgr.html#gr, last accessed December 2005). Rainfall data were obtained from Region 7 of southwest Georgia. Monthly rainfall data were obtained for the period 1940 through 2004. Annual total rainfall was determined and compared for the period of 1940 through 1974 (Pre-

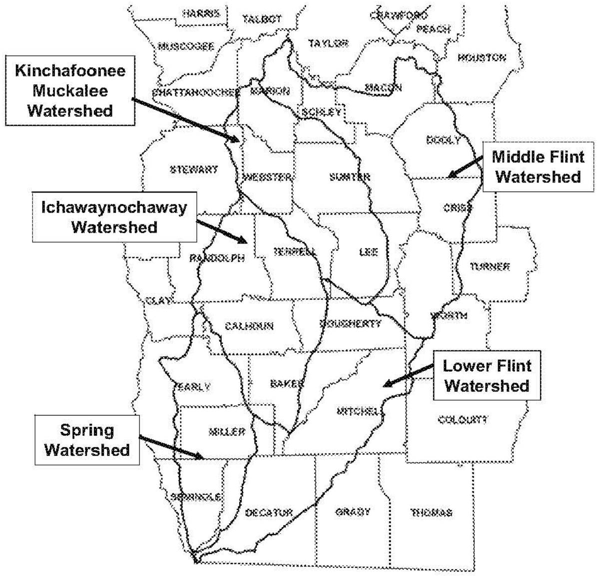

Figure 1. The lower Flint River Basin in southwestern Georgia.

irrigation development) and 1975-2004 (Post-irrigation development). Seasonal rainfall data were calculated from monthly data (winter, Jan-Mar; spring, Apr-Jun; summer, Jul-Sep; and fall, Oct-Dec). Seasonal mean rainfall and ranges were compared for the pre- and post-irrigation development period. In addition, long-term trends in seasonal rainfall were determined using 10-year running averages for the period of record (1940-2004).

Stream flow data were reviewed for 19 continuous monitoring stations that are operated by the U.S. Geological Survey (USGS) in the lower FRB. Of these 19 stations, continuous data adequate to assess long-term trends were only available for two stations: Spring Creek near Iron City (02357000) and Ichawaynochaway Creek at Milford (02353500). Many of the USGS gaging stations within the lower FRB were not in operation prior to the onset of intensive irrigation. Other stations were not usable for the statistical analyses because of back-water conditions, power generation regulation, or intermittent periods of record. Stream flow statistics used in the analyses contained within this paper were developed using the data obtained from the USGS.

REGIONAL HYDROLOGIC ALTERATION

Trends in rainfall

Average annual rainfall for Region 7 of southwestern Georgia is 51.8 inches (1940-2004). Lowest annual rainfall was recorded in 1954 (29.6 inches) and greatest rainfall was recorded in 1964 (77.2 inches). No differences were observed in annual rainfall in the pre- and post-irrigation development periods (Table 1). Slight differences in the seasonal distribution of rainfall were apparent. Winter rainfall tended to be greater in the post-irrigation development period while spring rainfall tended to be lower (Table 1). Summer and fall rainfall were similar across periods. Several long-term trends in rainfall were observed. Winter rainfall generally increased from the late 1950's through the mid 1990's. Spring rainfall generally declined throughout the period of record. Summer rainfall declined from 1950 through the early 1990's; summer rainfall recovered in the late 1990's largely due to the effect of very high rainfall in 1994-95. Fall rainfall did not show a long-term trend. Within the period of record the driest climate period appears to have been in the mid to late 1950's, a period when fall and winter rainfall were substantially below the long-term average.

Trends in stream flow in Ichawaynochaway Creek

Minimum daily stream flow has declined substantially in Ichawaynochaway Creek in the post-irrigation development period (Figure 2). One-day minimum stream flow has declined by 40% from 211 to 128 cubic feet per second (cfs) (Mann-Whitney Rank Sum Test, $p< 0.001$). Seven-day minimum stream flow has declined by about 31% from 219 to 151 cfs (Mann-Whitney Rank Sum Test, $p<0.001$). Thirty-day minimum stream flow has declined about 9% from 239 to 217 cfs (Mann-Whitney Rank Sum Test, $p<0.01$). No changes were observed in 1-day maximum daily stream flow (Mann-Whitney Rank Sum Test, $p=0.76$).

Declines in stream flow are also reflected in percentile flows. For 50- percentile stream flow, post-irrigation development flow equaled or exceeded pre-irrigation development flow for the months of January through March but was lower for late spring and summer. Irrigation season median monthly stream flow also showed a declining trend during May-August. Declines were weakly significant for May ($p=0.066$) and July ($p=0.085$) and highly significant for August ($p=0.002$). There was no significant

Table 1. Annual and seasonal rainfall totals for Region 7 in southwestern Georgia. Values are means and standard deviations.

	Annual (in.)	Winter (in.)	Spring (in.)	Sum mer (in.)	Fall (in.)
Pre-irrigation development (1940-1974)	51.6 (9.4)	14.6 (4.4)	13.2 (3.1)	14.8 (3.0)	9.3 (4.0)
Post-irrigation development (1975-2004)	52.0 (8.7)	15.4 (3.6)	11.7 (3.6)	14.3 (4.7)	10.1 (4.4)

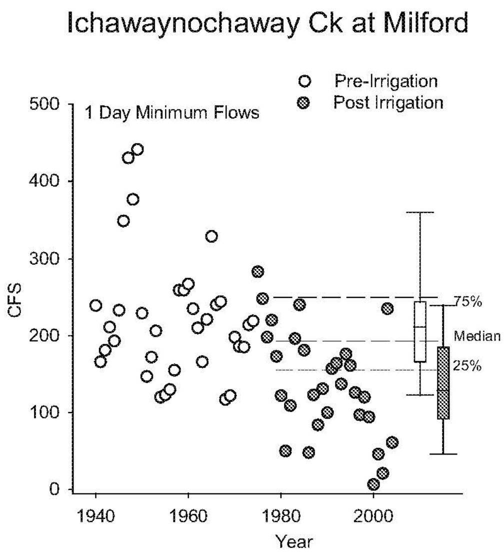

Figure 2. One-day minimum flows in Ichawaynochaway Ck.

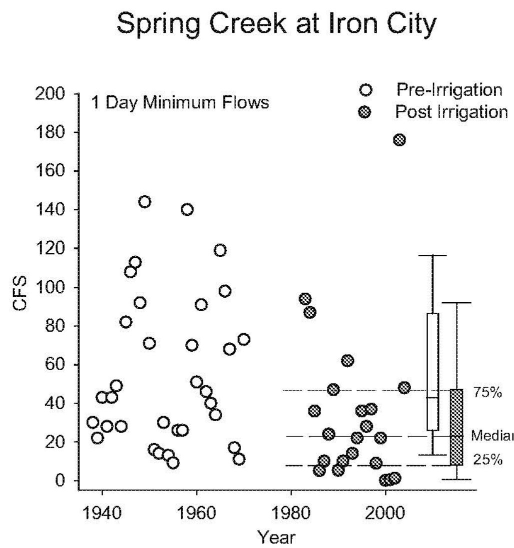

Figure 4. One day minimum flows for Spring Ck.

difference in the pre-irrigation development and post-irrigation development June stream low in Ichawaynochaway Creek.

Trends in stream flow in Spring Creek

Minimum daily stream flow has also declined substantially in Spring Creek in comparisons of the pre- and post-irrigation development periods (Figure 4). One- day minimum daily stream flow has declined by about 46% from 43 to 23 cfs (Mann-Whitney Rank Sum Test, p=0.013). Seven-day minimum stream flow has declined by about 39% from 45 to 27 cfs (Mann-Whitney Rank Sum Test, p=0.016). Thirty-day minimum stream flow declined by about 42% from 58 to 33 cfs (Mann-Whitney Rank Sum Test, p=0.035). One-day maximum daily stream flow increased substantially in Spring Creek from 3,040 cfs in the pre-irrigation development period to 5,665 cfs in the post-irrigation development period (Mann-Whitney Rank Sum Test, p=0.05).

Trends in minimum and maximum stream flow are also reflected in percentile flows. Growing season stream flow tended to be lower for 50% percentiles in the post-irrigation development period (Figure 5). Interestingly, 50% percentiles of winter stream flow tended to be higher, in some cases substantially higher, in the post-irrigation development period. While some of this difference may be attributable to seasonal changes in precipitation, it also suggests that the hydrologic response of the watershed has quickened as landscape development has occurred. This could be explained by greater runoff from fallow fields during the winter or perhaps breaching of riparian buffers by field runoff (Stephen W. Golladay, J.W. Jones Center, personal observation, 2005). Declines in irrigation season mean monthly stream flow has also been observed in May (Mann-Whitney Rank Sum Test, p=0.09) and August (p=0.037). There were no differences between pre- and post-irrigation development stream flow for June and July.

DISCUSSION AND CONCLUSIONS

Annual rainfall in Georgia is influenced by a number of factors. Southwest Georgia generally receives abundant precipitation however, large annual variability occurs and most recording stations report two-fold differences between annual minimum and maximum rainfall during the 20th century (Golden and Hess, 1991). The region is also prone to extreme hydrologic events. Frontal or tropical weather systems circulate humid air from the Gulf of Mexico and can produce heavy rainfall and extended

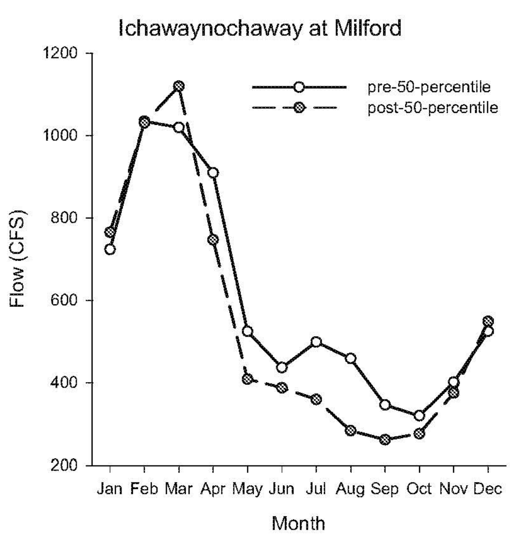

Figure 3. Fifty percentile flows in Ichawaynochaway Creek.

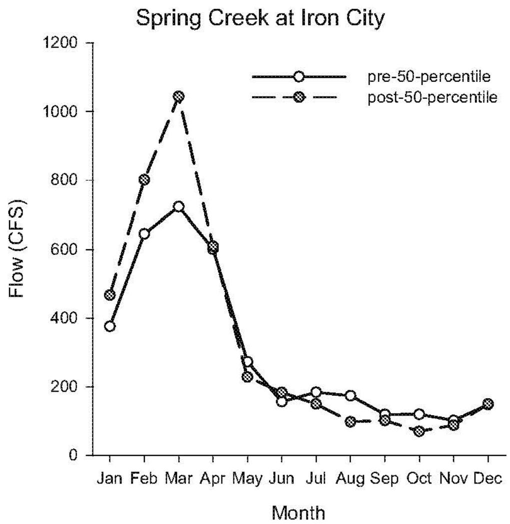

Figure 5. Fifty percentile flows for Spring Ck.

flooding throughout the year (Golden and Hess, 1991). Major floods in the southwest portion of the state occurred in 1925, 1948, 1994, and 1998. Extended droughts result from persistent high-pressure systems, which prevent influx of moisture from the Gulf of Mexico (Golden and Hess, 1991). Extended droughts occurred during the 1930's, 1950's, 1980's, and late 1990's through 2002.

Our analysis of climate data does not suggest long-term changes or trends in annual rainfall in southwestern Georgia. While seasonality of rainfall has shifted slightly there is no consistent change in annual total rainfall over the past 60 years. Our analysis of stream flow data show consistent and substantial declines in minimum and seasonal stream flow associated with the development and implementation of agricultural irrigation in the FRDP area of southwestern Georgia. This has resulted in some of the lowest flows on record during recent droughts. There is no climatologic indication that recent droughts were more severe or persistent than those in the past (i.e., 1930's or 1950's). Thus, we conclude that water use is the primary factor causing record low stream flow and other alterations in regional hydrology.

Record low stream flow raises concerns about the sustainability of stream health in the FRDP area. The region is noted for its diversity of freshwater mussels, stream fishes, and other aquatic life. Substantial declines in mussel diversity and abundance, including several rare and endangered species, were associated with stream drying during the most recent drought (1999-2002) (Golladay et al., 2003). Drying of major springs, a summer refuge for striped bass has caused concerns about the long-term viability of the Flint River population. Declining stream flow also reduces the assimilative capacity for waste discharges, an important ecological service provided by streams and rivers. In the development of water management plans, provisions for the maintenance of stream flows are clearly a critical priority.

LITERATURE CITED

Albertson, P.N., and L.J. Torak, 2002. Simulated effects of ground-water pumpage on stream-aquifer flow in the vicinity of federally protected species of freshwater mussels in the lower Appalachicola-Chattahoochee-Flint River basin (subarea 4), southeastern Alabama, Northwestern Florida, and southwestern Georgia. Water Resources Investigations Report 02-4016, U.S. Geological Survey, Atlanta.

Golladay, S.W., P. Gagnon, M. Kearns, J.M.Battle, and D.W. Hicks, 2004. Response of freshwater mussel assemblages (Bivalvia: Unionidae) to a record drought in the Gulf Coastal Plain of southwestern Georgia. Journal of the North American Benthological Society 23: 494-506.

Golden, H. G., and G.W. Hess, 1991. Georgia: Floods and Droughts. Pages 239-243 *in* National Water Summary 1988-1999. USGS Geological Survey Water-Supply Paper 2375, Doraville.

Harrison, K. M. 2001. Agricultural irrigation trends in Georgia. Pages 114–117 *in* K. J. Hatcher (editor). Proceedings of the 2001 Georgia Water Resources Conference. Institute of Ecology, University of Georgia, Athens, Georgia.

Pierce, R., R. Barber, and H. R.Stiles, 1984, Georgia Irrigation, 1970-80: A decade of growth, U.S. Geological Survey Water-Resources Investigations Report 83-4177, 29 p.

Litts, T., H. Russell, A. Thomas, and R. Welch. 2001. Mapping irrigated lands in the ACF riverbasin. Pages 79–83 *in* K. J. Hatcher (editor). Proceedings of the 2001 Georgia Water Resources Conference. Institute of Ecology, University of Georgia, Athens, Georgia.

Pollard, L.D., R.G. Grantham, and H.E. Blanchard, Jr., 1978, A preliminary appraisal of the impact of agriculture on ground-water availability in southwest Georgia: U.S. Geological Survey Water-Resources Investigations Report 79-7, 21 p.

Stamey, T.C., 1996. Streamflow Characteristics at Selected Sites in Southwestern Georgia, Southeastern Alabama, and Northwestern Florida, Near Lake Seminole. U.S. Geological Survey Open-File Report 95-455, Atlanta.

Torak, Lynn J., and McDowell R. J. 1996, Ground-water resources of the lower ACF river basin in parts of Alabama, Florida, and Georgia—Subarea 4 of the ACF and ACT river basins, U.S. Geological Survey Open-File Report 95-321, 145 p.

ATTACHMENT 12

Excerpts from the Deposition Transcript of David Langseth (July 21, 2016)

IN THE SUPREME COURT OF THE UNITED STATES

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                          )
STATE OF FLORIDA,         )
            Plaintiff     )
                          )
vs.                       )  Case No. 142
                          )
STATE OF GEORGIA,         )
            Defendant     )
                          )
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VOLUME III

THE VIDEOTAPED

DEPOSITION OF DAVID E. LANGSETH

THURSDAY, JULY 21, 2016

9:05 A.M. - 5:47 P.M.

BOSTON, MASSACHUSETTS

REPORTED BY: Sandra A. Deschaine, CSR, RPR, CLR, RSA

Job No. 16738

JULY 21, 2016

9:05 a.m.

Continued videotaped Deposition of David E. Langseth, Volume III, held at Latham & Watkins LLP, 200 Clarendon Street, Boston, Massachusetts, pursuant to Notice, before Sandra A. Deschaine, a Shorthand Reporter, Registered Professional Reporter, Certified Live-Note Reporter, and Notary Public in and for the Commonwealth of Massachusetts.

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I N D E X

(Exhibits continued.)

I N D E X (continued)

THE VIDEOGRAPHER: This is tape Number 1 of the videotaped deposition of David Langseth, Volume III, in the matter of State of Florida versus the State of Georgia, in the 09:05 AM United States Supreme Court of the United States, Case Number 142.

This deposition is being held at Latham & Watkins, 200 Clarendon Street, Boston, Massachusetts, on July 21st, 09:05 AM 2016, at approximately 9:05 a.m.

My name is Gail Ashton from the firm of Transperfect Legal Solutions, and I'm the legal video specialist. The court reporter is Sandy Deschaine in 09:05 AM association with TransPerfect.

Will counsel please introduce themselves.

MS. ALLON: Devora Allon from Kirkland & Ellis for the State of 09:05 AM Georgia.

MR. AVALLONE: Zachary Avallone from Kirkland & Ellis for the State of Georgia.

MR. SINGARELLA: Paul Singarella 09:05 AM

for Florida.

MS. O'CONNOR: Devin O'Connor, Latham & Watkins, State of Florida.

THE VIDEOGRAPHER: Would the court reporter please swear in the witness. 09:05 AM

DAVID E. LANGSETH, Deponent, having first been satisfactorily identified by the production of his Massachusetts driver's license and duly sworn by the Notary Public, was examined and testified as 09:06 AM follows:

EXAMINATION

BY MS. ALLON:

Q. Good morning, Dr. Langseth.

A. Good morning. 09:06 AM

MS. ALLON: Before we start the questioning, I just want to make a brief remark for the record, which is that, obviously, when I arranged and planned my questioning for Dr. Langseth, I did 09:06 AM so on the basis of his initial expert report, which, at the time, we thought would be kind of the universe of his opinions in this case.

We then received a second memo, 09:06 AM

sometimes it's been called a memo, sometimes it's been called a supplement from Florida on your behalf, and I adjusted my planning so that I could plan to cover that today as well, though 09:06 AM obviously we have reserved our rights to move to strike that as inappropriate and untimely.

Last night at about 8:30, we received a third submission on your 09:06 AM behalf; and, obviously, since it came in, you know, 12 hours before we started the deposition, we haven't had the time to really analyze it. And I have no way of knowing how long I might need in 09:07 AM terms of questioning on that new submission.

So I'm going to go you through my questioning today; but, for the record, I just want to make clear, whatever 09:07 AM timing we're at, at the end of the deposition today, I'm reserving the right to take whatever time I need at a later point once we had a chance to reserve -- review that submission, and 09:07 AM

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with respect to the separate analysis he
does, which is reflected in the blue line on
Figure C-7, which only analyzes the
relationship between the Chattachooche Gage
and the Sumatra Gage, do you believe there is 03:01 PM
any issue with double counting with respect
to that analysis?
MR. SINGARELLA: Object to form.
A. That specific analysis -- the
double counting issue, I don't think affects 03:01 PM
that specific blue line analysis on Figure
C6, was it?
Q. Now, as a conceptual matter,
leaving aside your specific critiques and
opinions, do you agree that if a downstream 03:02 PM
gage shows less flow than an upstream gage,
water is somehow lost from the river between
those two gages?
MR. SINGARELLA: Incomplete
hypothetical, vague. 03:02 PM
A. From a pure numbers perspective,
if the numbers -- the downstream numbers is
less than the other, clearly there's less
water. Now, whether that has any hydrologic
meaning depends on a variety of factors, 03:02 PM

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including whether or not the gages are both
accurate.
Q. One of your criticisms of
Dr. Panday is what you call his failure to
use -- well, you criticize his use of the 03:03 PM
USGS flows at Sumatra; right?
A. I do based on -- and I do that
based on Dr. Hornberger's work, evaluating
that gage record.
Q. Do you know how many years the 03:03 PM
USGS has been moderating flows at Sumatra?
A. Off the top of my head, I don't
know the complete period of record.
Q. I'll represent to you there's
almost 40 years of recorded flows. You don't 03:03 PM
believe that the flows reported by the USGS
are accurate?
MR. SINGARELLA: Vague.
A. I've read Dr. Hornberger's, the
evaluation of that and -- issue, and his 03:03 PM
evaluation makes sense to me. In my work, I
drew on that evaluation that he did.
Q. Is it your expert opinion that
Dr. Hornberger's flow curves that he created
for the purpose of this litigation are more 03:04 PM

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accurate than the flows the USGS has reported
for decades with respect to the Sumatra Gage?
MR. SINGARELLA: Object to form.
A. You know, I didn't perform my own
independent analysis of the accuracy at the 03:04 PM
Sumatra Gage. For purposes of my report
here, I took Dr. Hornberger's reconstructed
record there as being a more accurate
representation than the original record as
reported by the USGS. 03:04 PM
Q. When you said you took it, do you
have an opinion that it is, in fact, a more
accurate representation, or are you just
making that assumption for the purposes this
report? 03:04 PM
A. I'm relying on Dr. Hornberger's
analysis for the purpose of bringing that
reconstrcuted record into my evaluation.
Q. Are you offering an opinion, in
this case, that Dr. Hornberger's flow curves 03:04 PM
created for the purpose of this litigation
are more accurate than the flows the USGS has
reported for decades at the Sumatra Gage?
MR. SINGARELLA: Argumentative.
A. I wouldn't say I'm offering my own 03:05 PM

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separate opinion on that. I'm really relying
on Dr. Hornberger's work, and in my
evaluation, I calculated the quantitative
impact of the work that Dr. Hornberger did.
Q. So you just said assuming 03:05 PM
Dr. Hornberger is is right, here the
quantitative impact?
MR. SINGARELLA: Argumentative,
misstates.
A. The way I would say it is that I 03:05 PM
relied on Dr. Hornberger and the work that he
did for the specific alternative record or
reconstructed record of the Sumatra Gage to
use in my analysis to calculate the
quantitative impact of that -- of the 03:05 PM
reconstructed record that he provided.
Q. Did you rely on that work because
that's an assumption you were asked to make,
or because it's your belief that his
reconstructed records are more accurate than 03:06 PM
the USGS records?
A. When I read his analysis, his
analysis made sense to me, but I didn't do my
own complete re-evaluation of it. So I don't
have an independent opinion that's based on 03:06 PM

ATTACHMENT 13

Excerpts from the Expert Report of George Hornberger, Ph.D. (May 20, 2016)

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

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LIST OF FIGURES

ABBREVIATIONS

ACF	Apalachicola-Chattahoochee-Flint River Basin
AGU	American Geophysical Union
cfs	Cubic Feet Per Second
GA EPD	Georgia Environmental Protection Division
USGS	United States Geological Survey
RM	River Mile
NWFWMD	Northwest Florida Water Management District
ADCP	Acoustic Doppler Current Profiler
WY	Water Year
PRMS	Precipitation Runoff Modeling System

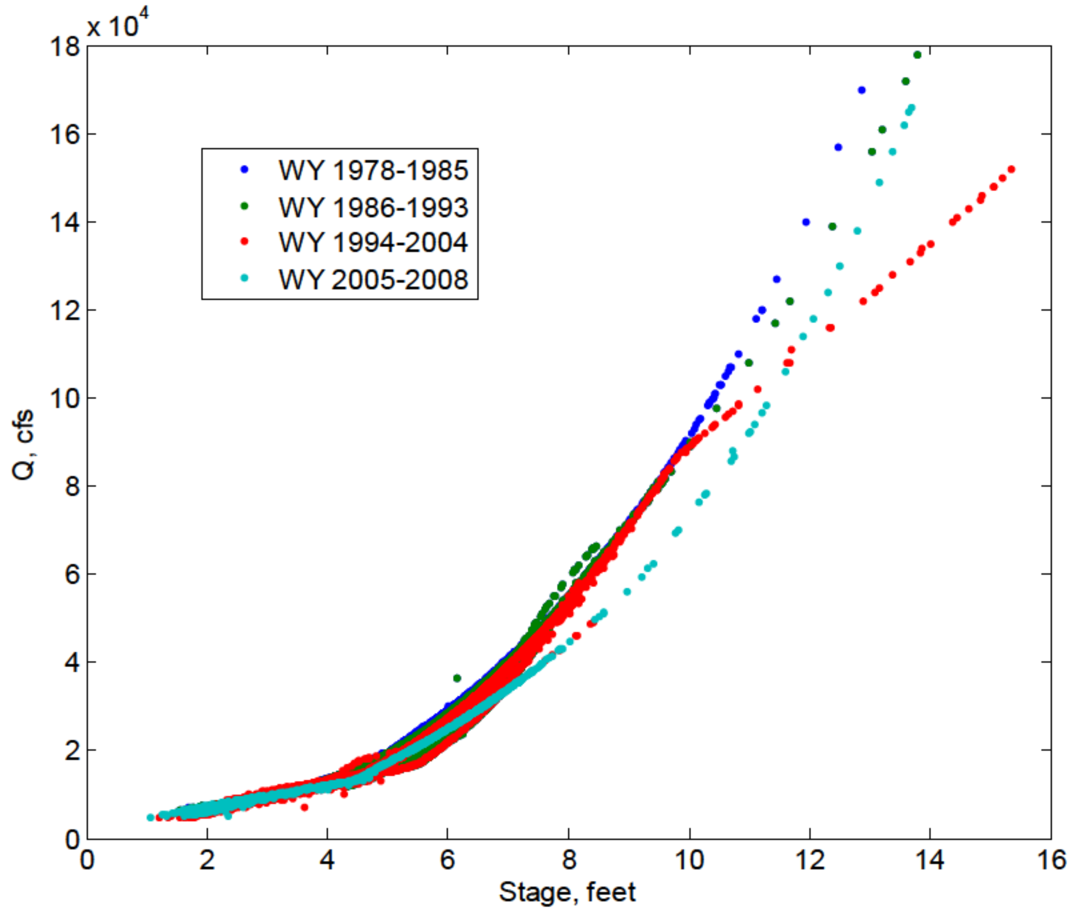

Figure 4. USGS reported values of stage and discharge for the gage on the Apalachicola River near Sumatra. Note that the relationship is consistent below a stage of about 4 feet but highly variable at higher stages.

Measurement of discharge is much more problematic in rivers with broad floodplains and swamps than in areas where the river channel is better defined, such as at the Chattahoochee gage. Figure 5 is a view from the Apalachicola River looking into the swamps and floodplains approximately a mile north of the Sumatra gage. At high flows, the floodplain is inundated with flows from the Apalachicola River that pass through the floodplain and swampy area (and eventually reach the Apalachicola Bay) rather than through the main channel at Sumatra where measurement is most precise. In contrast, Figure 6 shows the well-defined channel near the Chattahoochee gage, where the Apalachicola River flow generally remains within its banks.

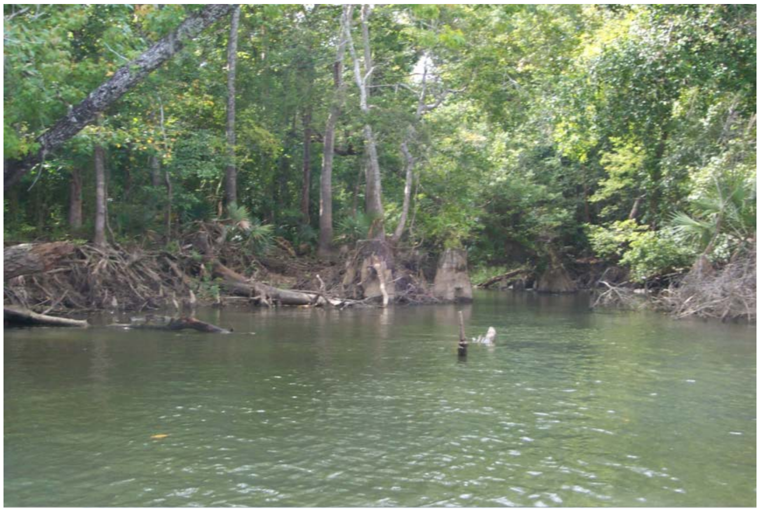

Figure 5. View from Apalachicola River into swamps and floodplain on right descending bank of river at RM 21.3.

Figure 6. Downstream view from Chattahoochee gage (from USGS National Water Information System).[7]

Thus, the topography of the Apalachicola in the reach where the Sumatra gage is located causes the degree of error in discharge measurements there to be much greater than at the gage on the Apalachicola at Chattahoochee. At moderate to high flows the discharge measurements near Sumatra were done along a wide transect across the floodplain in a 1979-1980 USGS study (Figure 7). "Brickyard Cutoff and the Brothers River divide this transect into three areas. [B]etween the Apalachicola River and Brickyard Cutoff on Forbes Island … [is] a large, flat and muddy area of saturated clays … [surrounded by] narrow natural levees. Between Brickyard Cutoff and the Brothers River the land rises to a firm hummock around nearly every tree or group of trees. The land between hummocks is riddled with shallow sloughs having soupy mud bottoms. The flood plain west of the Brothers River is mostly flat with clayey muds. The transect ends at a manmade levee." (Text in quotations abstracted from Leitman *et al.*[8])

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[7] http://waterdata.usgs.gov/fl/nwis/uv/?site_no=02358000&PARAmeter_cd=00065,00060.

[8] Leitman, HM *et al*. 1984. Wetland hydrology and tree distribution of the Apalachicola River flood plain, Florida. U.S. Geological Survey water-supply paper; 2196-A.

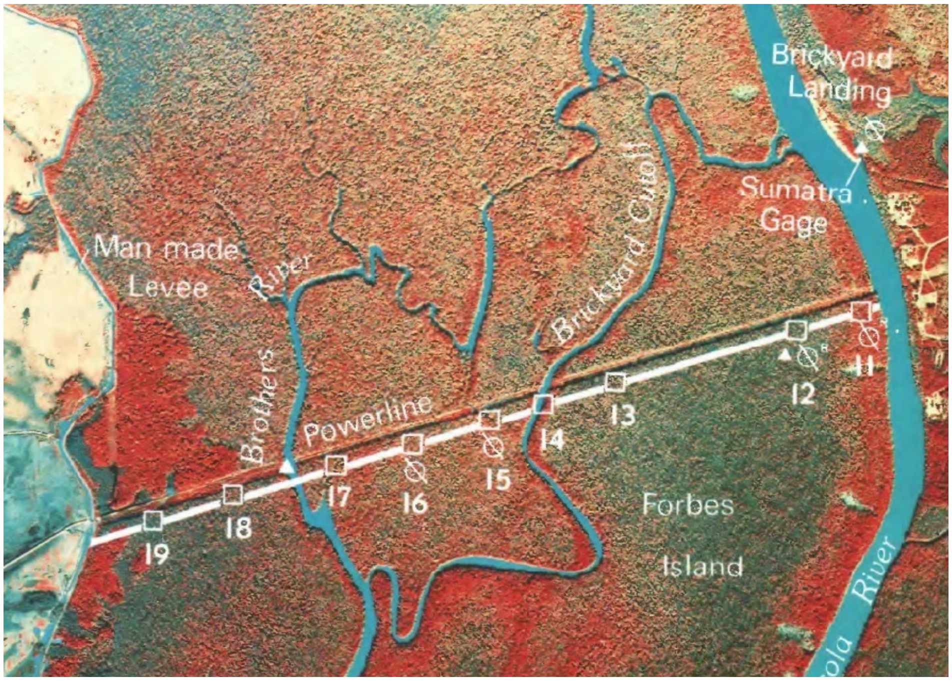

Figure 7. Discharge near Sumatra has been measured in the past along a power line that runs across the river and its floodplain. Source: Leitman *et al.* (1984).

At a stage at or below approximately 4 feet (corresponding flows below about 13,000 cfs) at Sumatra, nearly all river flow is confined to the main channel and two permanently connected floodplain channels, Brickyard Cutoff and Brothers River (Figure 8, top). Discharge can be measured consistently and accurately during these conditions, just as it is at the Chattahoochee gage. Above a stage of about 4 feet, flow starts to be carried through portions of the floodplain. At high stages of 6.9 feet and above, however, the river spreads over the entire broad floodplain (Leitman *et al*., 1984) and precise and consistent measurements are difficult to impossible at this site (Figure 8, bottom). Georgia's graphical representation of reported annual average discharges in Figure 1 does not account for the limitations of high flow measurement in the Apalachicola River at the Sumatra gage.

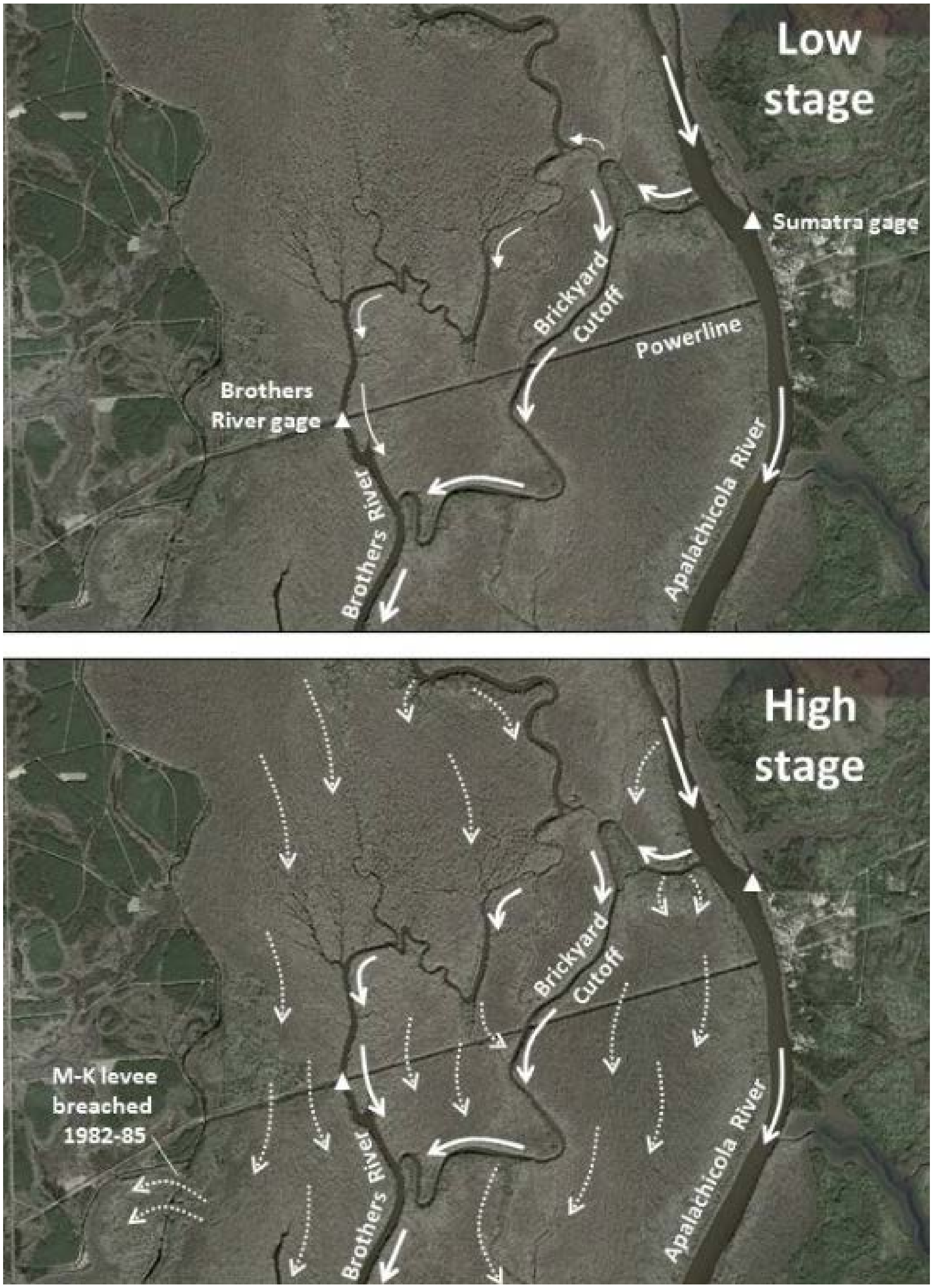

Figure 8. Flow pathways in stream channels and swamp forests across the river floodplain near the Sumatra gage at low stage (3.9 feet or less; top diagram) and high stage (6.9 feet or higher; bottom diagram). Solid arrows represent flow in permanently flowing channels; dashed arrows represent flow in intermittently flowing floodplain sloughs or sheet flow through swamp forests. (Derived from flow and elevation data in Leitman *et al.*, 1984, and topographic data from digital elevation models processed by Northwest Florida Water Management District [NWFWMD] (FL-ACF-04142605.0013; FL-ACF-04142605.0005; FL-ACF-04142605.0006).)

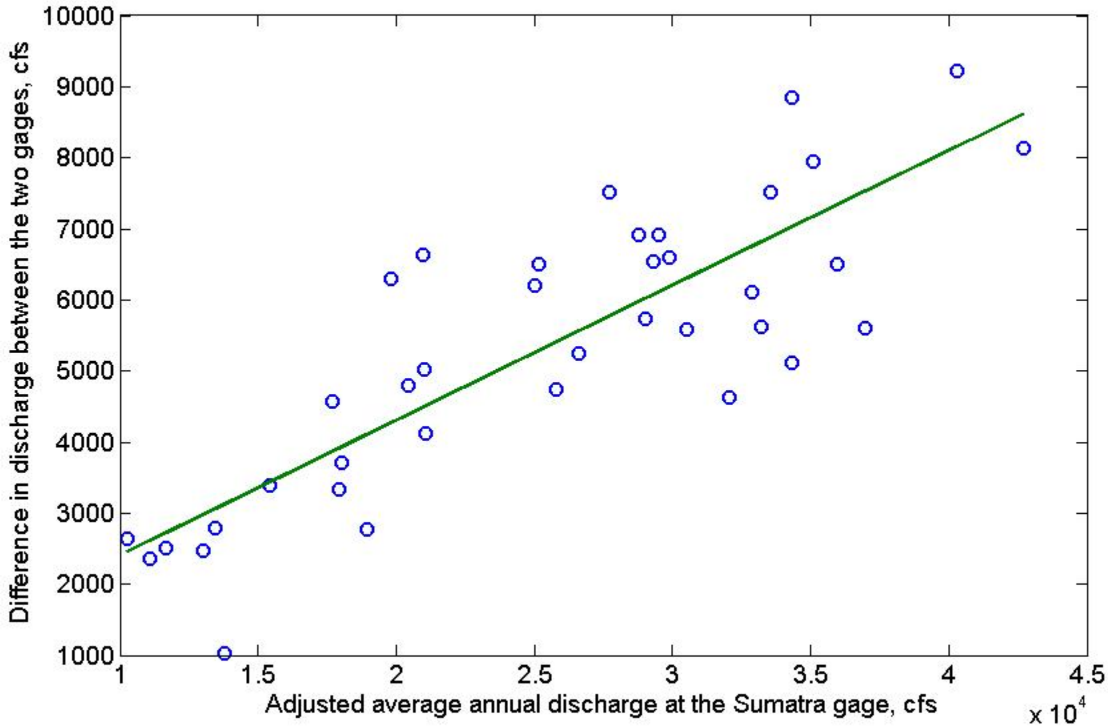

Figure 12. The difference between the adjusted flow at Sumatra and the flow at Chattahoochee is correlated with the adjusted flow at Sumatra.

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 14

Excerpts from the Expert Report of Kenneth Jenkins, Ph.D. (February 29, 2016)

Prepared for
State of Florida
Department of Environmental Protection

Prepared by
Kenneth Jenkins, Ph.D.
Integral Consulting Inc.
115 Sansome Street
Suite 200
San Francisco, CA 94104

February 29, 2016

CONTENTS

Opinion 2: Over the course of decades, more frequent low-flow conditions from the Apalachicola River have caused higher Bay-wide salinities, especially during the late low-flow season of low-flow years.. The confluence of these circumstances has created a "perfect storm" where salinity regimes are high enough to threaten sensitive habitat in the late low-flow season when the ecosystem is most vulnerable and Georgia's water consumption is the greatest.

Opinion 2A: Low-flow periods are more severe, frequent, and of longer duration.

Georgia's consumptive water uses have increased substantially since 1992 and are highest during the low-flow season of low-flow years (Flewelling Expert Report). Dr. Hornberger's analysis concludes that low-flow periods in recent years are more severe in terms of duration and extent due to increased consumptive water uses by Georgia during drought periods. Further, the impacts of Georgia's water withdrawals are most evident during the low-flow season (May–October) in low-flow years (Hornberger Expert Report).[3]

Low-flow periods are defined by Dr. Hornberger as daily flows that fall below 6,000 cubic feet per second (cfs). Analysis of daily flow in the low-flow season for the Apalachicola River at Chattahoochee, Florida, from 1970 to 2015 shows that during the low-flow season, low-flow periods have become more severe, frequent, and of longer duration since 1992.

Opinion 2B: Lower freshwater flow into Apalachicola Bay has resulted in higher salinity in recent years that has harmed habitat quality throughout the Bay including nursery habitat in East Bay.

Livingston (1983) summarized the Bay-wide pattern of near-surface salinity for the first 8 years of this program (reproduced in Figure 2B-1). From 1972 to 1979, average surface salinity in the Bay ranged from 0 to greater than 20 practical salinity units (PSU),[4] with the lowest salinities found near the mouth of the Apalachicola River.

In contrast, hydrodynamic model simulations of Apalachicola Bay from 2007 to 2012 demonstrate that lower flows into Apalachicola Bay have resulted in much higher average surface salinities (Figure 2B-1). These data show that average surface salinities from 2007 to 2012 exceed 20 PSU throughout the outer Bay, whereas in East Bay, salinities have increased from 0–6 PSU in the 1970s to 3 to greater than 10 PSU in recent years.

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[3] Research from Georgia's Department of Natural Resources also demonstrates that water withdrawals affect stream flows and coincide with the dry (low-flow) season; therefore, maximum water withdrawals coincide with the low-flow season and cause especially severe biological impacts (GA00685872).

[4] Prior to 1978, salinity was presented as PPT (parts per thousand). In 1978, PSU (practical salinity units) was adopted. Numeric differences between these two measures is quite small. In this report, I use PSU except when the underlying document uses PPT.

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

Opinion 5C: East Bay is a primary nursery habitat for blue crab populations along Florida's Gulf Coast. Loss of this nursery habitat due to increased water withdrawals has harmed the blue crab population throughout the eastern Gulf of Mexico.

Shallow depths and extremely high bottom productivity explain why the Apalachicola estuary is a primary nursery along the Gulf Coast for blue crabs and white shrimp (Livingston 2008). These species form the basis of highly lucrative fisheries in the broader east Gulf of Mexico region (Livingston 2014). Livingston (2008) found that YOY blue crabs returning from offshore congregate in East Bay and the main river channel during the high-flow season (November–April). A larger accumulation of YOY in East Bay occurs during late summer and fall periods, which correspond with the late low-flow season, which is a time when river flow is at its lowest and salinities in East Bay are highest (Appendix 5C; Opinion 2B).

Abundance of blue crabs in East Bay is also impacted by reduced freshwater flow and resulting high salinities (Figure 5C-1; Appendix 5). The 2002 crash in Georgia's blue crab stock was attributed to drought and increased water use and, as a consequence, high salinities. The crash was further exacerbated by a large toxic algal bloom (Lee and Frischer 2004). Since 2000, crab abundance has been significantly lower in the late-flow season in low-flow years as compared to high-flow years, and this reduced abundance continues until the following summer (early low-flow season of the following year). Lowest crab abundance corresponds with the highest salinities in East Bay (Figure 2B-2, Figure 5C-1). Because this is also the time in which when Georgia's consumptive water uses are greatest, it is also a time in which an increase in freshwater flow can have the greatest impact for improving East Bay habitat and blue crab stock (Hornberger Expert Report).

Opinion 7. Increased consumptive water uses by Georgia have fundamentally changed the structure of the Apalachicola Bay food web and reduced the productivity of key biological and economic resources.

Georgia's water withdrawals have caused increases in the salinity of Apalachicola Bay (Figure 2B-1; Greenblatt Expert Report, Hornberger Expert Report).[9] Because species have different salinity preferences, increases in salinity resulting from lower freshwater flows are more suitable for some species and less suitable for others. Among the species favored by higher salinity are predatory marine snails that enter the Bay during low-flow years and are a major oyster predator (Kimbro Expert Report). Oysters play a major role in the structure and function of the Bay ecosystem, by providing physical habitat structure, water filtration, and food for other species. Oyster predation, in addition to reducing oyster abundance, affects all of the species that are directly or indirectly dependent on oysters. The combined effects of altered salinity regimes and increased oyster predation have caused substantial harm to the structure and function of the Apalachicola Bay food web.

In the past two decades, ecosystem-based modeling has become established as a reliable method by which to examine and evaluate impacts of stressors on marine and estuarine food webs. Ecopath with Ecosim (EwE) is a well-documented and widely accepted food web modeling framework.[10] EwE has recently been used to evaluate the effects of a freshwater diversion on the nekton community in a Louisiana estuary (de Mutsert et al. 2012) and to evaluate potential factors that may affect productivity of valued species including menhaden, red drum, and red snapper in the Gulf of Mexico (Walters et al. 2008). In this case, EwE was used to quantify the effects of salinity and oyster predation on the structure and productivity of the Apalachicola Bay food web. Three stressor scenarios were evaluated:

1. Long-term trends in salinity over the period 1973–2014 were used to predict effects of salinity alone on food-web structure.
2. Long-term trends in predation pressure over this same period were used to predict effects of predation alone on food web-structure.
3. Long-term trends in both salinity and predation pressure were used to predict the combined effects of these two stressors.

Table 7-1 summarizes results of statistically significant trends for each of these three scenarios. The salinity and oyster predation scenarios predict substantially different

[9] And, as Dr. Lettenmaier opines, changes in climate have not played a significant role in the historical shift in flows (and therefore salinity).

[10] The EwE model software was initially developed by the National Oceanic and Atmospheric Administration. EwE has been used extensively by state and federal agencies and academic research institutions working in the Gulf of Mexico (Appendix 7; Okey et al. 2004).

ATTACHMENT 15

Excerpts from the Expert Report of J. David Allan, Ph.D. (February 29, 2016)

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

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February 29, 2016

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Summary of Opinions

In the course of my work, I have developed the following opinions, each of which is presented with a high degree of scientific certainty.

Opinion 1: The organisms, habitats and ecosystems of the Apalachicola River and Floodplain require sufficient flows in terms of quantity, duration and timing to ensure the long-term viability of species (including but certainly not limited to threatened and endangered species), the quality and connectivity of the habitats they depend on, and their functional interactions including food web and nutrient processes. The habitats of the Apalachicola River and Floodplain are vulnerable and highly sensitive to flow conditions, particularly in light of historical alterations in the River which Florida has been trying to mitigate for decades.

Opinion 2: Harm to the organisms, habitats and ecosystems of the Apalachicola River and Floodplain is reliably estimated to have increased over the historical record of declining flows in the Apalachicola River, based on carefully devised biological metrics and hydrologic analyses conducted by Dr. Hornberger. The harmful effects of increased frequency, duration, and magnitude of low flows are most evident in seasons and years of lower than average river flows, and affect multiple biological targets, including the mussel and fish assemblages, Gulf sturgeon and trees of the floodplain forest. These impacts have worsened in the past twenty years notwithstanding the cessation of dredging and other navigation activities in the River.

Opinion 3: Modeled future flows for the Apalachicola River and Floodplain reveal that continued reductions in flow will result in greater harm and likely result in irreversible change to Florida's largest, most intact river and floodplain ecosystem. These changes threaten federally listed species, ecosystem integrity and human benefits afforded by the river and the floodplain as well as the supply of organic matter and nutrients to the Bay.

Opinion 4: Drawing upon evidence from the historical record of demonstrated harm and modeling of future flows under conservation scenarios, it is my opinion that increases in river flow during dry season-dry year events can benefit the Apalachicola River and Floodplain, its federally listed species, ecosystem integrity and services.

Opinion 5: Improved flows will not only aid species in the Apalachicola River, but also aid riverine species (including threatened and endangered mussels) in the Flint River in Georgia, as well as fish populations shared by both states.

focus primarily on the most recent 16-year period and the models are fully described in the report by Dr. Hornberger. I also evaluate a variety of habitats, including microhabitats, that are particularly sensitive to reductions in flow. Together these analyses demonstrate harm to the river and floodplain ecosystems as a direct result of upstream flow depletions. Appendix C shows the methodology of establishing the fifteen harm metrics and Appendix D contains the full results. The results are as follows:

- Mussels: Low flow conditions harm mussel species as declining water levels leave individuals trapped in shallow, isolated pockets or completely dewatered, causing exposure, desiccation and increased vulnerability to predators; and by stagnant water when sloughs become disconnected, resulting in low oxygen and warming water. Our metric for the mussel assemblage shows a substantially increased probability of harm to mussels along shallow, main-channel margins and in sloughs under impacted flow conditions due to upstream depletions for period of analysis.
- Fish: Numerous species of freshwater fish rely on inundated floodplain forests, large sloughs and many smaller sloughs for spawning and nursery habitat. When river flow declines, floodplain sloughs and lakes switch from riverine to backwater conditions, and can be entirely cut off from the main channel. Lack of flow thus reduces the extent of aquatic habitat at all spatial scales, from slough disconnection to reduction of pool depth to exposure of previously submerged micro-habitat elements including woody debris. When side channels experience very low or no flow, dissolved oxygen concentrations decline rapidly, which is especially harmful to fish in floodplain habitats during summer because high temperatures and increased microbial activity further reduce oxygen levels, eventually leading to fish death. The metrics were developed to assess harm to Apalachicola River fishes resulting from altered availability of habitat within inundated forests, large sloughs and smaller sloughs. Loss of access to inundated forest, or getting trapped in cut off side channels, results in a substantially increased probability of harm for all fish-related metrics.
- Sturgeon: The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is a federally listed threatened species and the only known host species for the threatened purple bankclimber mussel. Adults migrate into rivers to spawn in spring, requiring sufficient flows to inundate spawning habitat within the river channel. Juveniles spend up to two years in fresh water, often migrating to estuarine waters but remaining at low salinities. Young-of-year are intolerant of salinities above about 10 parts per thousand (ppt)[1], thereby requiring river flows sufficient to maintain salinities in the optimal range in the lower tidal reaches. Metrics related to impacts on juvenile habitat in the lower distributaries showed a substantially increased probability of harm associated with reduced flows and thus higher bottom salinities.

[1] Sea water is approximately 35 ppt.

cycle of the species affected. Although extreme low flows in one year can cause significant harm, species can rebound if such extreme low flows occur rarely. However, if extreme low flows become more pronounced and more frequent, recovery is impaired and the continued overall health of the ecosystem is in jeopardy. The harm metrics described above exemplify that a trend of increasing, repeated extreme conditions in the Apalachicola River system is causing increased frequency and duration of harm. Beyond the species highlighted in my report, the entire food web and valuable ecosystem services provided by the River ecosystem suffer harm when flows are reduced.

The extent of harm to the Apalachicola River and floodplain ecosystem is expected to increase in the future as a result of increased upstream demands and depletions, if not mitigated now. The statement of Dr. Hornberger provides modeled estimates of harm in the future. Clearly, the evidence strongly supports the expectation that the Apalachicola River and floodplain ecosystem will experience even greater harm in the future as a result of upstream depletions.

Given the already stressed state the Apalachicola River ecosystem is in, it is my opinion that increases in flow will remedy existing harm, prevent future harm, and allow the ecosystem to slowly recover. Additionally, increases in flow in the rivers and streams in Georgia, which have experienced very similar ecological harm, will aid species in Georgia, including some migrating fish populations shared between Georgia and Florida.

For a broad range of features and their associated metrics, harmful flow conditions in the Apalachicola River and its floodplain are occurring more often under the current, impacted flows than occurred in the past and would occur in the absence of upstream depletions. Projecting the extent of harm into the future indicates that harmful conditions will worsen over the coming decades if the flow depletions are not reduced. Even modest amounts of additional flow would benefit the ecosystem, which is expected to improve with the amount of restored flow obtained through an appropriate apportionment.

Opinion 2: Harm to the organisms, habitats and ecosystems of the Apalachicola River and Floodplain is reliably estimated to have increased over the historical record of declining flows in the Apalachicola River, based on carefully devised biological metrics and hydrologic analyses conducted by Dr. Hornberger. The harmful effects of increased frequency, duration, and magnitude of low flows are most evident in seasons and years of lower than average river flows, and affect multiple biological targets, including the mussel and fish assemblages, Gulf sturgeon and trees of the floodplain forest.

The metrics presented in this opinion are specific, evidence-based examples that describe and exemplify harm throughout the River to various important assemblages. All the evidence clearly shows that riverine species are harmed at low flows and would be helped even by modest increases in flows (see opinion 1.5). I selected metrics for each species or assemblage based on observed, documented evidence of harm at various flow thresholds at various locations. None of the locations selected are unusual; the River has a wide variety of habitats, and the various metrics serve as representative examples of how harm occurs throughout the River. For each metric, the main text and Appendix C specify, using strong evidence, why I selected various flow and duration thresholds to characterize significant harm. Metric development is further explained in Appendix C.

Once each metric was defined, I performed various comparisons to understand the harm that has taken place in the River:

- Historical comparison: I compared the most recent 16 years[4] of observed flows with an early 16-year period of observed flows. This comparison shows that the system is much more stressed in modern times.
- Unimpacted comparison: I compared the most recent 16 years of observed flows with a modeled estimate of what flows would have been over this same, recent 16-year period had there been virtually no Georgia consumption.
- Remedy comparison: I compared the most recent 16 years of observed flows with a modeled estimate of what flows would have been had Georgia consumption been reduced to an appropriate level, using the 50%-reduction scenario from the Hornberger report.

[4] We selected the most recent 16 years because this is the period when harm from Georgia's water use has manifested most dramatically. The most recent 16 years also avoids complications associated with artificial flow pulses that occurred previously when water was periodically released from Lake Seminole to aid navigation. For symmetry we then chose an early 16 year period of the historical record that includes a significant drought period to compare the extent of harm captured by our biological metrics in the early and most recent time periods

PWA and Light 2012). However, it is important to note that when flow through sloughs is low, stream banks are exposed and pools are shallow before disconnection, and the bed of streams may dry completely after a prolonged period of disconnection. Additionally, there are many different sloughs which may be connected at other levels than the examples used in this section; thus, mussel mortality occurs both above and below these specific values (Figure 11). Within a slough mortality may vary from micro-habitat to micro-habitat depending on the extent of sun vs. shade, groundwater presence, and ability of individuals to burrow. Accordingly, each mussel-slough metric is based on the conservative expectation that if flows remain below the threshold for **30 continuous days** (or longer) during the warm period between **June 1 and Sept 30**, most mussels will die from a combination of factors including exposure to excessive temperatures, predation and desiccation. While mussels very likely experience harm at fewer than 30 continuous days below this threshold, I selected the longer and more conservative 30-day duration requirement because conditions vary greatly among and within sloughs. (See Appendix C for methodology.)

Harm Summary

Full results from the metrics are shown in Appendix D and summarized in Table 4 below.

Table 4. Years of harm and total duration of harm in days shown in parentheses for mussels 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
Muss-MC-10k	8 (378)	13(1066)	5 (688)	11 (209)	2 (857)	14 (924)	1* (142)
Muss-MC-8k	5 (162)	13 (808)	8 (646)	5 (39)	8 (769)	11 (668)	2 (140)
Muss-Mc-6k	2 (14)	8 (500)	6 (486)	2 (10)	6 (490)	5 (18)	3 (482)
Muss-Slu-Swf	0 (0)	5 (128)	5 (128)	0 (0)	5 (128)	0 (0)	5 (128)
Muss-Slu-Hog	2 (17)	7 (490)	5 (473)	0 (0)	7 (490)	6 (192)	1 (300)

*Numbers in red font are in the opposite direction from expected (in this instance harm increased by one year under the remedy scenario).

recurrences of harm can be even more relevant, as a fish that survives the 5-day window of low DO concentrations, for example by seeking out a deeper pool, will eventually succumb if these conditions are prolonged. For the large slough Kennedy Creek, a **30-day window** with a **12,000 cfs** threshold was used (Figure 20). The longer duration is appropriate because the variety of aquatic habitat in large sloughs is much greater than small sloughs. Therefore, large sloughs may have some areas for fish to seek refuge to survive longer than 5 days. Although oxygen levels in large sloughs could fall to lethal levels in fewer than 30 days, I selected a longer and more conservative exposure duration to allow for waters in sloughs to become stagnant and oxygen depleted.

Harm summary:

Full results from the metrics are shown in Appendix D and summarized in Table 5 below.

Table 5. Years of harm and total duration of harm in days shown in parentheses for fish 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 consumpt -ion	Decrease in harm	Recent 16 yrs with remedy	Decrease in harm
Fish-InunFor60	8 (477)	13 (1148)	5 (671)	11 (892)	2 (256)	13 (1109)	0 (39)
Fish-InunFor120	4 (109)	10 (420)	6 (311)	9 (308)	1 (112)	9 (427)	1 (7)*
Fish-LgSlu-Ken	7 (259)	11 (820)	4 (561)	6 (170)	5 (650)	11 (718)	0 (102)
Fish-SmSlu-Mry	9 (413)	13 (1111)	4 (698)	11 (261)	2 (850)	14 (973)	1 (138)
Fish-SmSlu-Swf	0 (0)	8 (439)	8 (439)	2 (5)	6 (434)	3 (12)	5 (427)

*Numbers in red font are in the opposite direction from expected (in this instance harm increased by 5 days under the remedy scenario) grounds for the vast majority of the 153-day May to September period. This reduction of access to optimal feeding habitat both reduces growth and increases the chance of mortality.

Harm Summary

Full results from the metrics are shown in Appendix D and summarized in Table 6 below.

Table 6. Years of harm and total duration of harm in days shown in parentheses for YOY sturgeon 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
Sturg-YOY60	0 (0)	7 (451)	7 (451)	0 (0)	7 (451)	5 (253)	2 (198)
Sturg-YOY120	0 (0)	4 (88)	4 (88)	0 (0)	4 (88)	2 (20)	2 (68)

- Historical comparison: At both thresholds, YOY sturgeon experienced no harm in the early 16-year period, compared with the most recent 16-year period. Harm has increased by 4 to 7 years and by 88 to 451 days.
- Unimpacted comparison: If there had been no Georgia consumption, sturgeon would not have experienced harm at all under either threshold, thus the difference in harm attributable to Georgia's consumption is 4 to 7 years and by 88 to 452 days, as above
- Remedy comparison: Had there been a remedy, harm would have decreased by 2 years and by 68-198 days.

2.4 The Apalachicola floodplain contains unique tupelo-cypress swamps that are very vulnerable to decreases in flow, and the floodplain forest has already been significantly harmed by flow reductions caused by Georgia

2.4a The Apalachicola floodplain forest, especially its tupelo-cypress swamps, is one of the most intact floodplains in the southeastern United States

The Apalachicola River system is noteworthy for supporting one of the most intact forested floodplains in the southeastern U.S. Three major forest types grow at different elevations (Figure 23), including extensive tupelo-cypress swamps at the lowest and wettest sites, low bottomland hardwoods at intermediate elevations, and high bottomland hardwoods at higher elevations (Darst and Light 2008; FDEP 2013). These three forest types are the product of differences in

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

As described in opinion 1.5, there are many microhabitats in the River that would disappear as flows drop even lower, disproportionately harming species occupying these habitats.

My metrics, described in opinion 2 and Appendix C, can be used to evaluate the difference between a future with one potential remedy (the 50% scenario described in Dr. Hornberger's report) and without a remedy (the future scenario described in the same report). Those models, based on conditions for the past 16 years, provide 16 years of hypothetical hydrographs for these two futures. Using the metrics to compare the two, I am of the opinion that a remedy would significantly mitigate harm in the future.[20]

- Mussels: Under the remedy scenario, mussels in Swift Slough would be expected to experience harm in zero out of 16 future years. However, under expected future conditions with projected declines in flow, those mussels would be expected to experience harm in 6 years (256 days). Mussels in Hog Slough would be expected to experience harm in 6 years (192 days) under remedy conditions compared to 9 years (591) with projected future declines in flow. Mussels that experience harm at 10,000 cfs in the main channel would experience harm in 14 years (924 days) under remedy conditions compared to 14 years (1072 days) with projected future declines in flow. Mussels that experience harm at 8,000 cfs in the main channel would experience harm in 11 years (668 days) under remedy conditions compared to 13 years (901 days) with projected future declines in flow. Mussels that experience harm at 6,000 cfs in the main channel would experience harm in 5 years (18 days) under remedy conditions compared to 8 years (613 days) with projected future declines in flow.
- Fish: For the 60-day threshold, fish would experience harm in 13 years (1109 days) under remedy conditions compared to 14 years (1178 days) with projected future declines in flow. For the 120-day threshold, fish would experience harm in 9 years (427 days) under remedy conditions compared to 10 years (458 days) with projected future declines in flow. Fish in Swift Slough would experience harm in 3 years (12 days) under remedy conditions compared to 9 years (591 days) with projected future declines in flow. Fish in Mary Slough would experience harm 145 more days of harm under the future scenario. Fish in Kennedy Slough would experience 88 more days of harm under the future scenario.
- Sturgeon YOY: For the 60-day threshold, sturgeon YOY would experience harm in 5 years (253 days) under the remedy compared to 7 years (503 days) with projected future declines in flow. For the 120-day threshold, sturgeon YOY would experience harm in 2 years (20 days) under remedy conditions compared to 4 years (112 days) with projected future declines in flow.
- Tupelo Forest: The lowest 10% of Tupelo forest would experience harm in 8 years (391days) under remedy conditions compared to 9 years (407 days) with projected future declines in flow. The lowest 30% of Tupelo forest would experience harm in 9 years (508

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[20] I am using the harm thresholds of current conditions, since those conditions cannot be changed and a remedy is only relevant for the current ecosystem.

days) under remedy conditions compared to 11 years (542 days) with projected future declines in flow. The lowest 50% of Tupelo forest would experience harm in 11 years (553 days) under remedy conditions compared to 13 years (595 days) with projected future declines in flow.

From my understanding, climate change has not been the cause of the historically increased stresses in the ecosystem, and is not expected to significantly impact hydrology in the near- to medium-term (Lettenmaier Report). However, if climate change does cause changes in hydrology in the future, reductions in upstream consumption would be needed even more to avoid significant and likely permanent harm to the ecosystem.

Opinion 4: Drawing upon evidence from the historical record of demonstrated harm and modeling of future flows under conservation scenarios, it is my opinion that increases in river flow during dry season-dry year events can benefit the Apalachicola River and Floodplain, its federally listed species, ecosystem integrity and services.

The metrics I developed for this report are based on specific evidence that supports the flow threshold, duration and timing at which significant harm exists. By specifying the flows at which harm occurs, I am able to use the existing hydrologic record and multiple modeled scenarios of Dr. Hornberger to compare harm in recent years with harm during earlier time periods; as well as under scenarios modeling harm had Georgia's consumption not been present, should Georgia's consumption be reduced, and should Georgia's consumption continue to grow.

The multiple metrics relied upon in this report provide a representative evaluation of harm to the entire ecosystem. Representing the mussel and fish assemblages, young-of-year Gulf sturgeon and the tupelo-cypress swamp forest, these metrics illustrate the harm to the entire ecosystem and its many interdependent species. These metrics also illustrate the longitudinal extent of the river from the middle riverine reach to the upper tidal, and the range of major habitat types from the main-channel margins, flats and backwaters, to the hundreds of loop streams and sloughs of varying size, to the forest of the floodplain which also serves as habitat for reproduction and growth of many fish species.

The evidence presented in supporting the specific flow threshold, duration and timing at which significant harm exists also makes clear that harm is a continuum that begins to exert itself as flows decline to threshold conditions and increases as flow declines below threshold conditions. When harm thresholds are exceed by a greater amount, when duration of harm extends for a longer time, and when harmful events occur sequentially, greater harm to the ecosystem is expected. Much of the evidence used in metric development is compelling as common-sense justification of the harm caused by reduced flows – exposed dead mussels are seen along sloughs that are nearly or completely dry, important habitat elements like woody debris are no longer submerged, only a small fraction of the forest is flooded and accessible to spawning fish, and the forest itself obviously is changing in character. Often, the margin between wetted or exposed habitat and between survival and harm is small, and even modest increases in flow can yield disproportionate benefits to the ecosystem. This is especially true for various microhabitats, described in opinion 1.5. Many of these habitats, which are barely present at extremely low flows, can become viable when flows are increased even by relatively modest amounts. Modest increases in flow would also improve the functioning of the food web as a whole, described in opinion 1.3.

Opinion 5: Improved flows will not only aid species in the Apalachicola River, but also aid riverine species (including threatened and endangered mussels) in the Flint River in Georgia, as well as fish populations shared by both states.

5.1. The Flint River, particularly the Lower Flint River Basin, provides high quality habitat for mussel and fish species, including fish populations shared with Florida, that is sensitive to reduced flows

The Flint and Chattahoochee Rivers are the sources of the Apalachicola, and these rivers also have experienced extreme low flows in recent years, especially the lower Flint where most of the agricultural withdrawals are taking place (Hornberger Expert Report). Thus, an increase in flows reaching the Apalachicola would unquestionably benefit river ecosystems in Georgia. The Flint River Basin (FRB) in particular is of significance because of its extensive high quality habitat and well-documented biological diversity. The Flint River is important habitat for three species of anadromous fishes that historically or currently spawn in its waters, described further below. The Flint River has high physical habitat diversity including shoals, boulder-strewn rapids and varying gradient. The river and tributary streams of the lower FRB historically had a diverse mussel fauna, including at least 14 genera and 29 species, six of which were endemic to the larger Flint River basin although only 22 native bivalve species persist (Brim Box and Williams 2000). Low flows are a particular concern because long-term USGS data sets show that the 7Q10[21] has declined since the 1970s (Rugel et al. 2012), and the region experienced severe droughts in 2000-2002 and 2007-2008. The potential impact of reduced flows in the lower Flint River have stimulated numerous biological studies over the past 1-2 decades, and demonstrated far-reaching effects of low flows on ecosystem condition and the biota.

The Flint River originates just south of Atlanta and flows 565 rkm (351 RM) to where it joins the Chattahoochee at Lake Seminole. Its basin (21,900 km^2, 8,446 mi^2) is entirely within Georgia and includes both the Piedmont and Coastal Plain physiographic provinces. The lower Flint is a free-flowing river of high quality habitat extending for 124 km from the Albany Dam to Lake Seminole. It has a diversity of substrate types, dominated by smooth limestone outcrops and limestone boulders, and increasing predominance of sand/silt/clay as one proceeds downstream. Tributary streams are generally naturally high in fine sand substrates and are low gradient; large

[21] "7Q10" is a measure of the lowest average 7-day flow period in the past 10 years.

portions flow through marshy, slackwater, swampy areas (Gagnon et al. 2006). In contrast to the Flint River which has maintained much of its natural character, numerous dams and urban development in the Atlanta Metropolitan Area have substantially altered the entire length of the Chattahoochee River. Because of the diversity and high quality of habitat within the Flint River and available evidence from numerous biological studies, in the following I focus on the Flint River ecosystem, and how it would benefit from improved flows.

Numerous studies establish that extreme low flows have detrimental effects on water quality, the supply of basal resources and the biota of the aquatic ecosystems of the lower Flint River. Comparison of water quality variables in three tributaries of the lower Flint River basin under drought, dry, wet and flood conditions found that concentrations of particulate and dissolved organic matter, ammonium-N and soluble reactive phosphorus all declined during low-flow and drought periods, which they attributed to streams being largely disconnected from floodplains (Golladay and Battle 2002). However, when flows were sufficient to inundate the floodplain, higher quality particulate organic matter (POM) entered the stream channel, as shown for Ichawaynochaway Creek, a tributary of the lower Flint River (Atkinson et al. 2009).

Measurement of substrate elevation profiles in Ichawaynochaway Creek in conjunction with water elevation-discharge relationships and historic discharge records dating back to the 1930s showed substantial habitat loss today is attributable to current dewatering (McCormick and Baron 2015). Shoals and coarse woody material, two ecologically important stream habitats, were affected, and most shoal habitat that remained wet during extreme droughts in the past now dries under similar climate conditions today.

5.2 Mussels in the lower Flint River, including federally listed ones, are especially affected by low flows

Mussels have been extensively studied in the lower Flint River and found to be negatively affected by low flows (Gagnon et al. 2004, Gagnon et al. 2006, Golladay et al. 2004), which over time have increasingly been exacerbated by Georgia (Hornberger Report)[22]. During the summer of 2000, water levels in the lower Flint River were 1-34% of historic average monthly flows and numerous stretches of perennially flowing streams dried completely or were reduced to intermittent chains of pools. Surveys of the lower Flint River found that unionid mussel mortality ranged from 13 to 93% among sites and was associated with low flows and dissolved oxygen concentrations < 5 mg/L (Gagnon et al. 2004). Low flow conditions and severe drought adversely affected mussel distributions and assemblages, particularly in those occurring in faster-flowing habitat and medium-sized streams. Perennial streams that dried or became intermittent recorded significant declines in mussels (median value 80% decrease) (Golladay et al. 2004). The authors concluded that “prolonged severe drought conditions may drive a diverse mussel community toward greater relative abundance of widespread generalist species, lower relative

[22] Georgia’s own environmental agencies have expressed serious concern over the impacts on mussels from reductions in flow as a result of consumption. *See* Nov. 2014 Presentation at GA00278813.

are of hatchery origin (identifiable by a marker, oxytetracycline), natural reproduction occurs in most if not all years as documented by the presence of unmarked age-0 fish captured in fall sampling (Long et al. 2013). The majority of unmarked age-0 fish were captured in Lake Seminole, suggesting that successful natural reproduction was primarily occurring in the Flint or Chattahoochee rivers. In addition, some unmarked age-0 fish were captured at the two uppermost sites below JWLD, and it is likely that these represent migrants spawned in the Flint River rather than wild fish spawned in the Apalachicola River.

The federally listed threatened Gulf sturgeon is found in coastal rivers from Louisiana to Florida during warmer months, and in the Gulf of Mexico and its estuaries during cooler months. Although historically it occurred in the Flint and Chattahoochee, today within the ACF system it is found only in the Apalachicola River. Efforts to experimentally assess its passage through the JWLD are restricted due to its rarity and threatened status, but 10 males implanted with transmitters recently were released into Lake Seminole on an experimental basis (Marbury and Peterson 2015). Two of the released sturgeon went 68.6 km up the Flint River to historic spawning grounds and the remainder were located in the Flint Arm of Lake Seminole. Six sturgeon successfully passed downstream, apparently during a late April flood event. This preliminary study indicates that if sturgeon could use the full range of spawning areas in the ACF including historically important habitat in the Flint (now heavily impacted by Georgia's water use), the population might increase to levels seen in the Suwannee and Choctawhatchee Rivers.

Conclusions

The Apalachicola River and its floodplain are a national treasure, valuable for their high level of biodiversity, productivity and natural ecological processes. Adequate flow from upstream in Georgia is essential, particularly during droughts, to maintain river-floodplain connectivity and support biological communities throughout the Apalachicola riverine corridor.

The evidence presented in this report strongly documents harm to the Apalachicola River and floodplain ecosystem over recent decades as a result of the diminished flows from Georgia. This evidence rests on two separate analyses: (1) I constructed a series of carefully researched and ecologically meaningful metrics of harm for four important features of the ecosystem (mussel assemblage, fish assemblage, Gulf sturgeon and tupelo-cypress swamps), based on evidence of flow thresholds, duration and seasonal timing at which harmful conditions occur, and (2) Drawing on hydrologic analyses and modeling presented in the Hornberger Report, I showed how harm has increased over the historical record; would be reduced under one potential remedy and would increase under a future of greater water withdrawals. It is important to recognize that the exact metrics selected, while amply justified by known harmful conditions, events and other evidence, are representative of harm that would occur at both higher and lower thresholds. Other species and ecosystem components undoubtedly are likewise harmed by flow depletions, but data are unavailable to quantify all such cases. Thus, the principal conclusion of this extensive treatment of evidence can be stated succinctly as follows:

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 FLORIDA'S REPLY IN SUPPORT OF ITS MOTION *IN LIMINE* TO PRECLUDE EXPERT TESTIMONY BY DR. PHILIP BEDIENT AND DR. SORAB PANDAY ON 'LOST WATER' has been served on this 7th day of October 2016, in the manner specified below:

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