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

STATE OF FLORIDA'S MOTION *IN LIMINE* TO PRECLUDE EXPERT TESTIMONY BY DR. PHILIP BEDIENT AND DR. SORAB PANDAY ON 'LOST WATER' AND MEMORANDUM IN SUPPORT THEREOF

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September 16, 2016

ATTORNEYS FOR THE STATE OF FLORIDA

The State of Florida hereby moves *in limine* pursuant to Federal Rule of Evidence 702 to preclude the State of Georgia's designated hydrologic experts, Dr. Philip Bedient and Dr. Sorab Panday, from offering testimony at trial as to their opinions that Apalachicola River water is lost within the State of Florida, between the Chattahoochee Gage and Sumatra Gage. Dr. Bedient and Dr. Panday's proposed opinions on this topic fail to satisfy the basic standards of Federal Rule 702, *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993), and related case law. The grounds and authority in support of this motion are set forth in the accompanying Memorandum in Support of Florida's Motion *In Limine*, and the attachments thereto.

Dated: September 16, 2016

Respectfully submitted,

/s/ Phillip J. Perry

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INTRODUCTION

In requesting an equitable apportionment of the waters in the Apalachicola-Chattahoochee-Flint River Basin (the "ACF"), the State of Florida alleges that diversion and use of water that occurs upstream in the State of Georgia causes significant downstream harm in Florida. *See* Compl. ¶¶ 5-7, 42-43, and 57-58 (filed Nov. 3, 2014). In response, Georgia contends that myriad other possibilities—but not its own increasing use and consumption of water—are responsible for diminished flows in the Apalachicola River and the associated injuries to Florida. *See* Answer, Third, Fourth, and Fifth Affirmative Defenses (filed Jan. 8, 2015). One of the more novel arguments advanced by Georgia is its theory that since 1992, vast amounts of water—enough to supply millions of people and to irrigate millions of acres of farmland—are "lost" in the Florida portion of the ACF each year. This theory is like many of the other causation possibilities advanced by Georgia: conjecture and speculation offered under the guise of expert testimony but untethered to any scientific analysis.

Two hydrological experts retained by Georgia, Dr. Philip Bedient and Dr. Sorab Panday, evaluate records of stream flow at gages located at opposite ends of the Apalachicola River and conclude the difference between the two reveal that extraordinary water losses have occurred in the Florida portion of the ACF. But nothing connects their conclusion of "water losses" to any scientific or hydrological analysis of causation, nor do these experts offer any explanation as to what has become of this lost water. In fact, Dr. Bedient readily acknowledged he has "no earthly idea" as to what might cause such significant losses of Apalachicola River flow. The unsubstantiated and unreliable conclusion offered by Dr. Bedient and Dr. Panday is apparently designed to support Georgia's argument that harms suffered by Florida as a result of diminished flows in the ACF are attributable to issues occurring within Florida itself—and not Georgia's growing municipal, industrial, and agricultural water demand.

Florida respectfully requests the Court exclude testimony on water losses, and prohibit Dr. Bedient and Dr. Panday from offering an opinion which lacks any methodological support or causal analysis. Making an unsupported inferential leap from review of stream flow gage records to the conclusion that water is lost in the Florida portion of the ACF reflects "too great an analytical gap between the data and the opinion proffered." *Gen. Elec. Co. v. Joiner*, 522 U.S. 136, 146 (1997) (determining trial court properly excluded certain expert testimony).

BACKGROUND

A. Georgia's Experts Theorize That Vast Quantities of Water Are Lost from the Apalachicola River.

The amount of water flowing in the Apalachicola River and throughout the ACF Basin is measured by a national network of stream gages maintained by the United States Geological Survey (the "USGS"). *See, e.g.*, Attachment 1, USGS *Fact Sheet on National Streamflow Information Program* (Mar. 2007). One such gage—the Chattahoochee Gage—is located on the Apalachicola River just below where the Chattahoochee and Flint Rivers converge to form Lake Seminole and the Apalachicola River and just below the Georgia-Florida line. The Chattahoochee Gage is the most upstream gage on Florida's Apalachicola River. Another USGS gage, the Sumatra Gage, is located roughly 80 miles south, about 20 miles above where the Apalachicola River flows into Apalachicola Bay. *See* Appendix 1 (ACF Basin Figure) .

The area between the Chattahoochee and Sumatra Gages (the "Incremental Area") is largely undeveloped. *See* Bedient Dep. 540:9-13 (acknowledging that the Incremental Area is "a natural area") (Attachment 2); Attachment 3, Panday Mem. to File at 5 (July 26, 2016) (the "Panday Memo") ("The Apalachicola River reach in Florida is relatively free of dams, impoundments, and diversions."). Nonetheless, two of Georgia's experts, Dr. Bedient and Dr. Panday, theorize that vast quantities of water are lost along this undeveloped Incremental Area.

Dr. Bedient is a hydrologist and civil engineer at Rice University in Houston, Texas. *See* Attachment 4, Defensive Expert Report of Dr. Bedient at 1 (May 20, 2016) (the "Bedient Report"). He was retained by Georgia to evaluate the amount of streamflow in the ACF Basin, including "Florida's contribution to flows into Apalachicola Bay," with a focus on possible losses in the Incremental Area. *Id*. at 76. Dr. Panday is a groundwater hydrologist and modeler who evaluated how flows in the ACF are impacted by activities outside of Georgia. *See* Attachment 5, Expert Report of Dr. Panday at 3, 5 (May 20, 2016) (the "Panday Report").

Relying on records from the Chattahoochee and Sumatra Gages, Dr. Bedient and Dr. Panday opine that vast physical losses of water occur in Florida from the Apalachicola River. They claim that approximately 1,000-7,000 cfs of water are lost annually from the River since at least 1998. Panday Report at App. C-5; *id*. at Figure C-7; Bedient Report at 76 (alleging post-1998 losses of 3,000 to 4,000 cfs). Both understand the sheer magnitude of this amount:

- Dr. Panday acknowledges that, based on Georgia's consumptive-use estimates, 5,000 cfs would provide enough water both to supply approximately 19 million people ***and*** irrigate approximately four million acres of farmland (600% more than the 693,765 acres that Dr. Panday contends were under irrigation between 2008 and 2011). *See* Panday Dep. 706:21-709:20 (Attachment 6) (discussing Attachment 7, Panday Dep. Ex. 75).
- Dr. Bedient's estimate for the amount of water Georgia consumed in the Georgia portion of the ACF during the severe drought year of 2011 is less than even the lower end of this range. *Id*.; Bedient Dep. 757:21-23.

In addition to opining that average-annual losses have been as high as 7,000 cfs, averaging "over 6,000 cfs in the 2010s," Dr. Panday provides various loss estimates comparing average losses for the pre- and post-1992 time periods, including 2,339 and 2,640 cfs per year.[1] He concludes that

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[1] *See* Attachment 5, Panday Report at App. C-5 (characterizing as a "key finding" Dr. Panday's conclusion that "[t]he flow balance for the Apalachicola River indicates an average loss of 3,938 for post-1992 conditions, which is 2.5 times higher than during the pre-1992 time period (1,599 cfs)" — a difference of 2,339 cfs); Attachment 3, Panday Memo at 1 ("[O]utflow from the

"water lost within Florida is not caused by any action by Georgia," and that "not only are there significant losses along the Apalachicola River reach entirely within Florida, these losses are increasing through time." Attachment 5, Panday Report at 3; *id.* at App. C-5. Dr. Bedient similarly opines that since 1998, Florida's flow contributions have declined by up to 4,000 cfs. Attachment 4, Bedient Report at 76.

B. Dr. Bedient and Dr. Panday Undertook No Analysis and Employed No Methodology That Could Explain the Vast Water Losses They Theorize Have Occurred.

Dr. Bedient cannot support his claim that Florida's Apalachicola River flow contributions have declined significantly since 1998 while rainfall remained constant:

> [I]t's not clear why Florida's – why Florida's portions of flow have continued to consistently drop when rainfall has generally been constant. But it is clear that it has been decreasing based upon this graph [Figure 54 in Bedient Report]. And I have – I mean there are – ***I have actually no earthly idea***. There's a loss of water here, obviously. But I don't know where, and nor have I done any investigation to determine where that water may be going. . . . It [the lost water] has to either be diverted or something going on in groundwater. Those are the only two possibilities, or some huge evaporative loss. And I have not done any study or evaluation of that.

Bedient Dep. 615:23-616:16 (emphasis added). He further stated, "I don't know where it went. I don't know where this has gone." *Id*. at 616:25-617:3.

Dr. Panday was similarly unable to explain the purported water losses, noting that Georgia did not ask him to undertake such an analysis: "I haven't formulated a hypothesis. I did not prejudge something and then try to fit the data, I just looked at the data and I'm just presenting the data." Panday Dep. 253:17-20; *see also id*. at 179:20-180:9 ("I took the data, and I

Apalachicola River at the Sumatra Gage was larger than inflow to the River at the Chattahoochee Gage by an average of 5,254 cfs pre-1992, which declined to an average of 2,614 cfs post-1992," indicating that "net inflow to the Apalachicola River between Chattahoochee and Sumatra Gages within Florida has reduced by 2,640 cfs when comparing average pre- and post-1992 conditions."). *See also* Panday Dep. 212:8-14 ("I stand by the number of 5,254 minus 2,614 . . . [t]hat's 2,640 cfs.").

did a difference between the Sumatra and Chattahoochee gages . . . [to see] how much comes out at Chattahoochee versus how much flows out at the Sumatra gage."); *id*. at 254:13-22 ("it was out of my scope to test why there has been this reduction in flow through time for flow.").

Aside from ruling out declining precipitation,[2] Dr. Panday acknowledged he did not evaluate possible causes:

> ***I have not attributed the flow decline to consumptive use nor have I quantified or evaluated the possible causes***. I have not claimed that the water was diverted unnoticed or that large amounts of water were being withdrawn for irrigation. I have simply examined and presented the data. Causes could be plenty . . . and valuation and quantification of such factors would require considerable amounts of data (of sedimentation and erosion dynamics along the river, for instance) which are not available to me.

Attachment 3, Panday Memo at 4 (emphasis added); *see also* Panday Dep. 178:22-179:18.

When asked whether he evaluated the accuracy of the stream flow gage records, Dr. Panday professed lack of expertise: "My knowledge and expertise is not on how a gage is calibrated or how the gaging is performed. So I wouldn't be able to answer that question." Panday Dep. 267:17-20; *see also id.* at 226:22-25, 229: 21-22, 239:14-18.

Despite having conducted no causal analysis whatsoever, both Dr. Bedient and Dr. Panday concluded that these extraordinary water losses are real: "I just have simply said that there is a loss that has taken place through the decades based on the difference in the two gages and its unexplained." Bedient Dep. 630: 3-6. Yet Dr. Bedient insisted, "I just know that this appears to be a real phenomenon." *Id*. at 617:3-5; *see also* Attachment 4, Bedient Report at 79 ("[I]t is clear that Florida's relative contribution to flow in the ACF Basin has been decreasing."). Dr. Panday similarly opined "that the loss of water between the two gages is a real

[2] Attachment 5, Panday Report at App. C-7 (finding that the "net loss of flow at the Sumatra Gage is even larger" than alleged precipitation declines during the post-1992 period, and thereby concluding that "increasing losses" have actually occurred).

physical loss of water." Panday Dep. 198:16-24, 199:5-7 (testifying that the gages "indicate that there was a loss," "that loss has been increasing in time," and that he has "no reason to believe that it is a loss of water to groundwater or to any of the other possibilities" that he did not investigate).

C. The USGS And Georgia Witnesses Highlight Anomalies with the Sumatra Gage Record—But Neither Dr. Bedient Nor Dr. Panday Address This Issue.

Dr. Bedient and Dr. Panday ignore evidence that others readily have evaluated. The USGS questions the reliability of Sumatra Gage records during high-flow periods:

> [The USGS] team did find a problem with several discharge rating changes made during 1990–2002 when erroneous discharge measurements were made during out-of-bank flood flows. Non-standard methods were used during several high flow measurements that under-reported the flows, which in turn led to inaccurate rating changes.

Attachment 8, Letter from R. Rodriguez, USGS to E. Chelette, Nw. Fla. Water Mgmt. Dist. (July 25, 2016).

The USGS indicated that it was revisiting the relationship between its field data and river-flow estimates for at least the period 1990 to 2002. *See id.* Georgia witnesses also question the reliability of the Sumatra Gage record. For example, Georgia expert Dr. Charles Menzie (ecologist evaluating impacts of freshwater withdrawals) testified that the Sumatra Gage produced anomalous flow measurements:

> I had one of our hydrologists look at the . . . data for Sumatra. And there were, in those data sets, kind of unusual divergences at particular times so that it was apparent . . . the Sumatra Gage wasn't always performing in keeping with what you think would be the operational expectations for that gage."

Menzie Dep. 344:12-19 (Attachment 9); *see also id.* at 343:23-344:9. Another Georgia witness, Dr. Menghong Wen (hydrologist with the Georgia Environmental Protection Division) considered whether a calculation of incremental flow between the Chattahoochee and Sumatra Gages was meaningful:

> [G]age flow measurement error ranges between upstream and downstream gage might make some incremental computation looks like a nonsense. . . For high flows, Sumatra flow can be low than the upstream gage Chattahoochee. Whether it is due to flow loss or the measurement error makes the flow difference fall into insignificant, it gives the fact that incremental flow computation is not meaningful.

Attachment 10.

* * * *

Neither Dr. Bedient nor Dr. Panday addresses the possibility that an anomaly in gage records at the Sumatra Gage during high-flow periods might account for water loss, or whatever differences between the gage records at Sumatra and Chattahoochee could be used to draw any meaningful conclusions; those failures cast significant doubt on the reliability of their conclusion. But more significantly, neither undertakes ***any*** methodological analysis whatsoever to explain how or why tremendous amounts of water could be lost from the Florida portion of the ACF. Without any causal analysis, the opinion on water losses fails under Federal Rule of Evidence 702 and governing case law.

LEGAL STANDARD

Courts consider a number of non-exclusive factors when evaluating the admissibility of expert opinions, including whether the expert's technique or theory can be or has been tested, *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 593-94 (1993), "[w]hether the expert has adequately accounted for obvious alternative explanations," Fed. R. Evid. 702, Advisory Comm. Notes, 2000 Amendments (citing *Claar v. Burlington N. R.R. Co.*, 29 F.3d 499 (9th Cir. 1994), and "[w]hether the expert has unjustifiably extrapolated from an accepted premise to an unfounded conclusion," *id*. (citing *General Electr. Co. v. Joiner*, 522 U.S. 136, 146 (1997) (noting that a court "may conclude that there is simply too great an analytical gap between the data and the opinion proffered")).

Opinion offered as expert testimony that lacks causal analysis, fails to explore alternative explanations, or which is based on suspect data is routinely excluded. *See, e.g.*, *Daubert v. Merrell Dow Pharms., Inc.*, 43 F.3d 1311, 1319, 1321 n.18 (9th Cir. 1995) (excluding, on remand, expert opinion that a drug caused birth defects due to the lack of any "tested or testable theory to explain how, from this limited information, [expert] was able to eliminate all other potential causes"); *ASK Chems., LP v. Computer Packages, Inc.*, 593 F. App'x 506, 510 (6th Cir. 2014) (rejecting expert opinion because the underlying data were out of date and only partially complete, and because the expert's methodology was unexplained); *Amorgianos v. Nat'l R.R. Passenger Corp.*, 303 F.3d 256, 267 (2d Cir. 2002) (precluding expert testimony that failed to account for necessary factors and thus was based on a faulty methodology).

ARGUMENT

A. The Absence of Causal Analysis Renders the Water Loss Opinion Unreliable.

Dr. Bedient and Dr. Panday rely on Sumatra Gage records taken at face value and—without investigating cause—conclude that massive losses of water are occurring in the Florida portion of the ACF. The failure to offer any causal analysis is a hallmark of unreliable expert testimony routinely rejected by federal courts. For example, in *Viterbo v. Dow Chemical Co.*, 826 F.2d 420, 422-24 (5th Cir. 1987), the Fifth Circuit affirmed a decision where, as here, the expert failed to investigate other possible causes. The court held that the expert's "unsupported opinion" "simply lacks the foundation and reliability necessary to support expert testimony" and "does not serve the purposes for which it is offered, that is, objectively to assist the jury in arriving at its verdict." *Id*. at 424. The court explained:

> [Plaintiff's expert] has admitted that [plaintiff's] symptoms could have numerous causes and, without support save [plaintiff's oral history, simply picks the cause that is most advantageous to [plaintiff's] claim. Indeed, [the expert's] testimony is no more than [plaintiff's] testimony dressed up and sanctified as the opinion of an

> expert. Without more than credentials and a subjective opinion, an expert's testimony that 'it is so' is not admissible.

Id. [3]

Dr. Bedient and Dr. Panday similarly offer ***no explanation*** on the cause of water losses in the Florida portion of the ACF; they simply conclude it is occurring. And while the conclusion itself borders on the absurd (rainfall patterns have not changed), the Incremental Area is largely undeveloped, and water does not simply vanish), it is rendered inadmissible under Fed. R. Evid. 702(a) because of the complete failure to provide any causal analysis.

B. Because Dr. Bedient and Dr. Panday Failed to Apply the Scientific Method, Their Opinion on Water Losses Is Unreliable.

Both Dr. Bedient and Dr. Panday failed to follow the scientific method in rendering their opinion on water loss. Dr. Panday admitted he did not follow the basic steps of the scientific method. *See* Panday Dep. 253:17-21 ("I haven't formulated a hypothesis."). Similarly, Dr. Bedient admitted he has "no earthly idea" where the water is going – an admission fairly interpreted as non-scientific. *See* Bedient Dep. 615:22-616:8. Both Dr. Bedient and Dr. Panday hypothesize that massive volumes of water are lost in Florida, but they have not tested this theory. "The courtroom is not the place for scientific guesswork, even of the inspired sort." *Rosen v. Ciba–Geigy Corp.*, 78 F.3d 316, 319 (7th Cir. 1996); *see also Presley v. Lakewood Eng'g & Mfg. Co.*, 553 F.3d 638, 646 (8th Cir. 2009) ("opinions formulated merely upon general

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[3] *See also Huerta v. BioScrip Pharmacy Servs., Inc.*, 429 F. App'x 768, 773,776-77 (10th Cir. 2011) (rejecting expert's diagnosis for failure to consider other obvious possibilities); *Claar v. Burlington N. R.R.*, 29 F.3d 499 (9th Cir. 1994) (failure to investigate some obvious alternative causes renders expert opinion inadmissible); *Rodrigues v. Baxter Healthcare Corp.*, 567 F. App'x 359, 361 (6th Cir. 2014) (affirming exclusion of expert who could "not explain the process" of causation and whose testimony was thus merely "speculative"); *Davidov v. Louisville Ladder Grp., L.L.C.*, 169 F. App'x 661 (2d Cir. 2006) (affirming the exclusion of expert testimony that plaintiff's fall from a ladder was caused by defective ladder because there was simply too great an analytical gap between data and the opinion).

observations of the evidence and general scientific principles [are] unreliable"); *Tamraz v. Lincoln Electr. Co.*, 620 F.3d 665, 676-77 (6th Cir. 2010).

C. Judicial Economy Favors Dismissing the Lost Water Opinions.

Courts also have broad authority to preclude expert testimony whose probative value is outweighed by the judicial resources it would consume, particularly in the context of a lengthy and highly technical trial. *See White v. United States*, 148 F.3d 787, 792 (7th Cir. 1998) (affirming district court's dismissal of evidence during a bench trial for "waste of time"). By simply stating that an extraordinary amount of water is lost in the Florida portion of the ACF—without offering any explanation as to how or why (or if the phenomenon they are describing could even occur in reality)—Dr. Bedient and Dr. Panday offer nothing that would advance resolution of this dispute. Instead, the opinion that large quantities of water are lost in the Florida portion of the ACF would consume valuable trial time and resources without offering probative value.

CONCLUSION AND REQUEST FOR RELIEF

For the reasons stated above, Florida respectfully requests the Court to grant this motion and preclude Dr. Bedient and Dr. Panday from offering an opinion that significant volumes of water are lost in the Florida portion of the ACF, by some undefined phenomenon, at some non-specific location in the 80-mile stretch between the Chattahoochee and Sumatra Gages.

Dated: September 16, 2016

Respectfully submitted,

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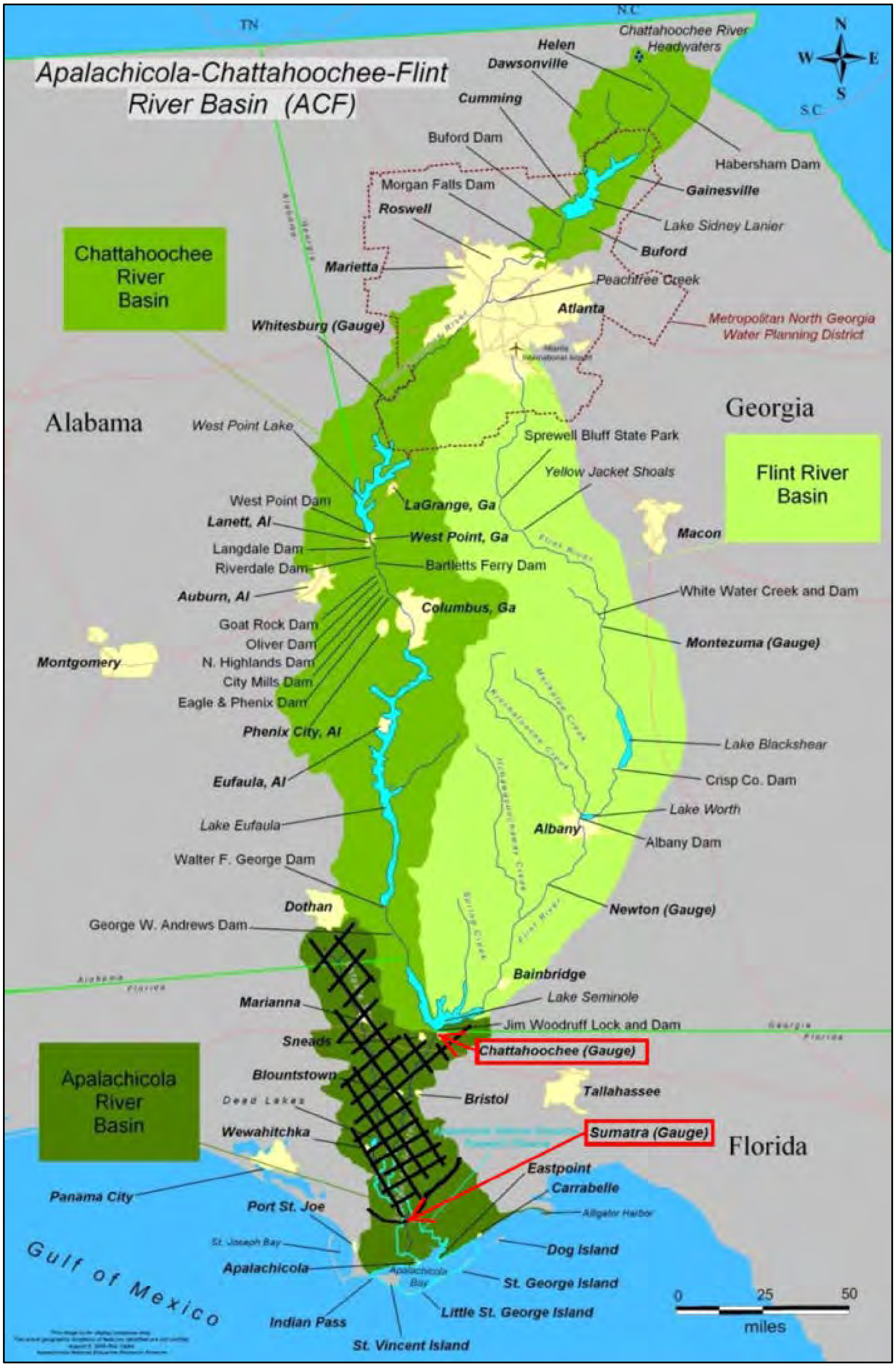
Appendix 1 – ACF Basin Figure

Cross-hatched section, in the lower third of the figure, is the drainage area between the gages on the Apalachicola River between Chattahoochee and Sumatra. Reproduced from the May 20, 2016 Expert Report of Florida Expert, Dr. Hornberger (Figure 2 at 8).



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CERTIFICATE OF SERVICE

This is to certify that the STATE OF FLORIDA'S MOTION *IN LIMINE* TO PRECLUDE EXPERT TESTIMONY BY DR. PHILIP BEDIENT AND DR. SORAB PANDAY ON 'LOST WATER' AND MEMORANDUM IN SUPPORT THEREOF has been served on this 16th day of September 2016, in the manner specified below:

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INDEX OF ATTACHMENTS TO THE STATE OF FLORIDA'S MOTION *IN LIMINE* TO PRECLUDE EXPERT TESTIMONY BY DR. PHILIP BEDIENT AND DR. SORAB PANDAY ON 'LOST WATER'

Attachment 1: USGS Fact Sheet on National Streamflow Information Program (available at http://pubs.usgs.gov/fs/2005/3131/FS2005-3131.pdf (last visited September 16, 2016))

Attachment 2: Excerpts from the Deposition Transcript of Philip Bedient, Ph.D. (June 29-30, 2016)

Attachment 3: Memorandum to File by Sorab Panday, Ph. D. providing a "Review of Dr. David Langseth's Memo to Dr. George Hornberger on 28 June 2016 Titled 'Dr. Panday Water Budget Evaluations'" (July 26, 2016)

Attachment 4: Excerpts from the Defensive Expert Report of Philip Bedient, Ph.D. (May 20, 2016)

Attachment 5: Excerpts from the Expert Report of Sorab Panday, Ph.D. (May 20, 2016)

Attachment 6: Excerpts from the Deposition Transcript of Sorab Panday, Ph.D. (August 1-3, 2016)

Attachment 7: Exhibit 75 from the Deposition of Sorab Panday, Ph.D.: "Population that Could Be Served and Acres that Could Be Irrigated Using Georgia's Reported Values"

Attachment 8: Letter from Rafael Rodriguez on Behalf of the U.S. Geological Survey to Edward Chelette of the Northwest Florida Water Management District Re Sumatra Gage Data (July 25, 2016)

Attachment 9: Excerpts from the Deposition Transcript of Charles Menzie, Ph.D. (July 25, 2016)

Attachment 10: Exhibit 75 from the Deposition of Wei Zeng, Ph.D.: Memorandum by Dr. Menghong Wen to Wei Zeng Titled "Summary of the Historical Flow and Precipitation Analysis for ACF and Part of OSSS"

ATTACHMENT 1

U.S. Geological Survey Streamgaging, from the National Streamflow Information Program (Mar. 2007)

USGS science for a changing world

U.S. Geological Survey Streamgaging

…from the National Streamflow Information Program

This Fact Sheet is one in a series that highlights information or recent research findings from the USGS National Streamflow Information Program (NSIP). The investigations and scientific results reported in this series require a nationally consistent streamgaging network with stable long-term monitoring sites and a rigorous program of data, quality assurance, management, archiving, and synthesis. NSIP produces multipurpose, unbiased surface-water information that is readily accessible to all.

Introduction

The U.S. Geological Survey (USGS) started its first streamgage in 1889 on the Rio Grande River in New Mexico to help determine if there was adequate water for irrigation purposes to encourage new development and western expansion. The USGS currently (2007) operates about 7,400 streamgages nationwide (fig. 1) as part of the National Streamflow Information Program (NSIP). These streamgages provide streamflow information for a wide variety of uses including flood prediction, water management and allocation, engineering design, research, operation of locks and dams, and recreational safety and enjoyment. These streamgages are operated by the USGS, in partnerships with more than 800 Federal, State, Tribal, and local cooperating agencies. In 2007, about 91 percent of these streamgages electronically record and transmit streamflow information to the World Wide Web in near real-time (http://waterdata.usgs.gov/nwis). Most of these streamgages transmit the information by satellite, although telephone and radio telemetry also are used in some streamgages.

The purpose of this report is to describe how the USGS obtains streamflow information. Streamgaging generally involves (1) obtaining a continuous record of stage—the height of the water surface at a location along a stream or river, (2) obtaining periodic measurements of discharge (the quantity of water passing a location along a stream), (3) defining the natural but often changing relation between the stage and discharge, and (4) using the stage-discharge relation developed in step 3 to convert the continuously measured stage into estimates of streamflow or discharge. Each of these four steps is explained in greater detail below.

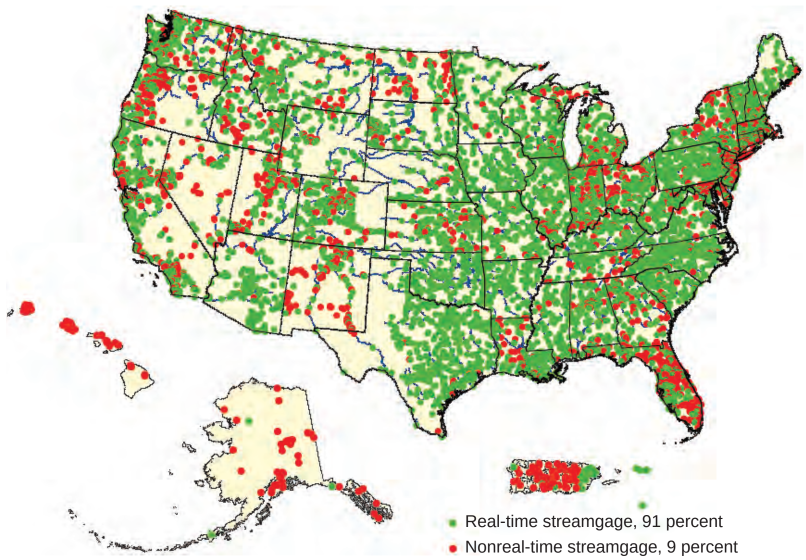


Figure 1. Current (as of 2006) U.S. Geological Survey streamgaging network.

Measuring Stage

Most USGS streamgages measure stage and consist of a structure in which instruments used to measure, store, and transmit the stream-stage information are housed. Stage, sometimes called gage height, can be measured using a variety of methods. One common approach is with a stilling well in the river bank (see fig. 2) or attached to a bridge pier. Water from the river enters and leaves the stilling well through underwater pipes allowing the water surface in the stilling well to be at the same elevation as the water surface in the river. The stage is then measured inside the stilling well using a float or a pressure, optic, or acoustic sensor. The measured stage value is stored in an electronic data recorder on a regular interval, usually every 15 minutes.

At some streamgage sites, a stilling well is not feasible or is not cost effective to install. As an alternative, stage can be determined by measuring the pressure required to maintain a small flow of gas through a tube and bubbled out at a fixed location under water in the stream. The measured pressure is directly related to the height of water over the tube outlet in the stream. As the depth of water above the tube outlet increases, more pressure is required to push the gas bubbles through the tube.

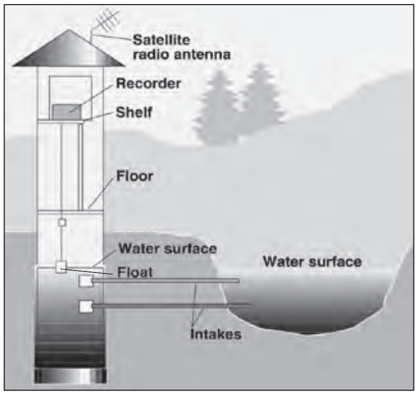


Figure 2. Diagram of a typical USGS streamgage with stilling well.

Streamgages operated by the USGS provide stage measurements that are accurate to the nearest 0.01 foot or 0.2 percent of stage, whichever is greater. Stage at a streamgage must be measured with respect to a constant reference elevation, known as a datum. Sometimes streamgage structures are damaged by floods or can settle over time. To maintain accuracy, and to ensure that stage is being measured above a constant reference elevation, the elevations of streamgage structures, and the associated stage measurement, are routinely surveyed relative to permanent elevation benchmarks near the streamgage.

Although stage is valuable information for some purposes, most users of streamgage data are interested in streamflow or discharge—the amount of water flowing in the stream or river, commonly expressed in cubic feet per second or gallons per day. However, it is not practical for a streamgage to continuously measure discharge. Fortunately, there is a strong relation between river stage and discharge and, as a result, a continuous record of river discharge can be determined from the continuous record of stage. Determining discharge from stage requires defining the stage-discharge relationship by measuring discharge at a wide range of river stages.

The Discharge Measurement

Discharge is the volume of water moving down a stream or river per unit of time, commonly expressed in cubic feet per second or gallons per day. In general, river discharge is computed by multiplying the area of water in a channel cross section by the average velocity of the water in that cross section:

$$discharge = area \times velocity.$$

The USGS uses numerous methods and types of equipment to measure velocity and cross-sectional area, including the following current meter and Acoustic Doppler Current Profiler.

Current Meter

The most common method used by the USGS for measuring discharge is the mechanical current-meter method. In this method, the stream channel cross section is divided into numerous vertical subsections (see fig. 3). In each subsection, the area is obtained by measuring the width and depth of the subsection, and the water velocity is determined using a current meter (fig. 4). The discharge in each subsection is computed by multiplying the subsection area by the measured velocity. The total discharge is then computed by summing the discharge of each subsection.

Numerous types of equipment and methods are used by USGS personnel to make current-meter measurements because of the wide range of stream conditions throughout the United States. Subsection width is generally measured using a cable, steel tape, or similar piece of equipment. Subsection depth is measured using a wading rod, if conditions permit, or by suspending a sounding weight from a calibrated cable and reel system off a bridge, cableway, or boat or through a hole drilled in ice.

The velocity of the streamflow is measured using a current meter. The most common current meter used by the USGS is the Price AA current meter (fig. 4). The Price AA current meter has a wheel of six metal cups that revolve around a vertical axis. An electronic signal is transmitted by the meter on each revolution allowing the revolutions to be counted and timed. Because the rate at which the cups revolve is directly related to the velocity of the water, the timed revolutions are used to determine the water velocity. The Price AA meter is designed to be attached to a wading rod for measuring in shallow waters or to be mounted just above a weight suspended from a cable and reel system for measuring in fast or deep water. In shallow water, the Pygmy Price current meter can be used. It is a two-fifths scale version of the Price AA meter and is designed to be attached to a wading rod. A third mechanical current meter, also a variation of the Price AA current meter, is used for measuring water velocity beneath ice. Its dimensions allow it to fit easily through a small hole in the ice, and it has a polymer rotor wheel that hinders the adherence of ice and slush (see fig. 5).

Acoustic Doppler Current Profiler

In recent years, advances in technology have allowed the USGS to make discharge measurements by use of

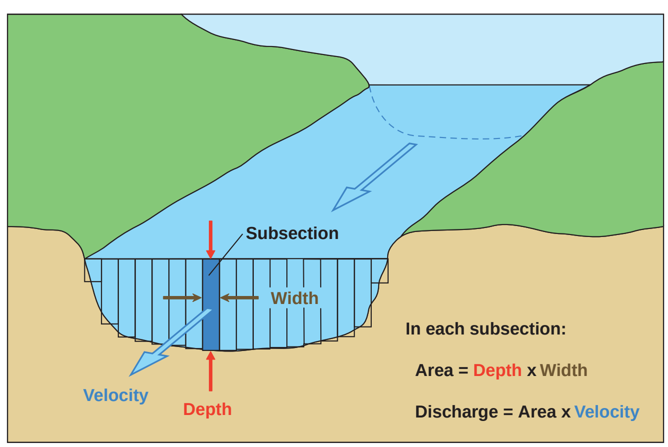


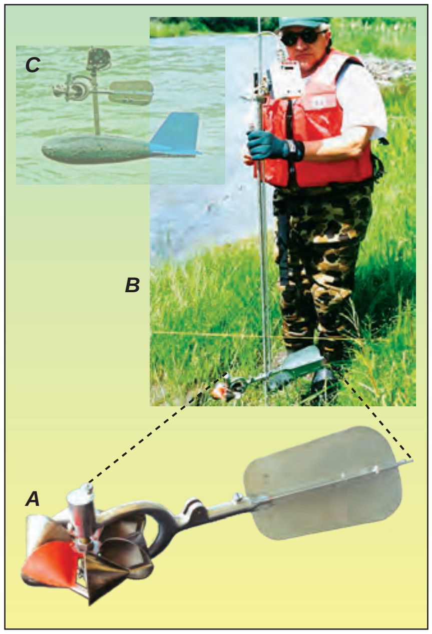
Figure 3. Current-meter discharge measurements are made by determining the discharge in each subsection of a channel cross section and summing the subsection discharges to obtain a total discharge.

an Acoustic Doppler Current Profiler (ADCP). An ADCP uses the principles of the Doppler Effect to measure the velocity of water. The Doppler Effect is the phenomenon we experience when passed by a car or train that is sounding its horn. As the car or train passes, the sound of the horn seems to drop in frequency.

The ADCP uses the Doppler Effect to determine water velocity by sending a sound pulse into the water and measuring the change in frequency of that sound pulse reflected back to the ADCP by sediment or other particulates being transported in the water. The change in frequency, or Doppler Shift, that is measured by the ADCP is translated into water velocity. The sound is transmitted into the water from a transducer to the bottom of the river (see fig. 6) and receives return signals throughout the entire depth. The ADCP also uses acoustics to measure water depth by measuring the travel time of a pulse of sound to reach the river bottom at back to the ADCP.

To make a discharge measurement, the ADCP is mounted onto a boat or into a small watercraft (see fig. 6) with its acoustic beams directed into the water from the water surface. The ADCP is then guided across the surface of the river to obtain measurements of velocity and depth across the channel. The river-bottom tracking capability of the ADCP acoustic beams or a Global Positioning System (GPS) is used to track the progress of the ADCP across the channel and provide channel-width measurements. Using the depth and width measurements for calculating the area and the velocity measurements, the discharge is computed by the ADCP using *discharge = area × velocity*, similar to the conventional current-meter method. Acoustic velocity meters have also been developed for making wading measurements (see fig. 7).

The ADCP has proven to be beneficial to streamgaging in several ways. The use of ADCPs has reduced the time it takes to make a discharge measurement. The ADCP allows discharge measurements to be made in some flooding conditions that were not previously possible. Lastly, the ADCP provides a detailed profile of water velocity and direction for the majority of a cross section instead of just at point locations with a mechanical current meter; this improves the discharge measurement accuracy.



(Photograph courtesy of Michael Nolan, U.S. Geological Survey)

Figure 4. The current-meter method uses equipment such as (*A*) the Price AA current meter; (*B*) the Price AA current meter attached to a wading rod; and (*C*) the Price AA meter suspended above a heavy weight.

(Photograph courtesy of Michael Nolan, U.S. Geological Survey)

Figure 5. To measure velocity beneath ice, a mechanical current meter with a polymer rotor is attached to an ice rod and submerged through a hole drilled in the ice.

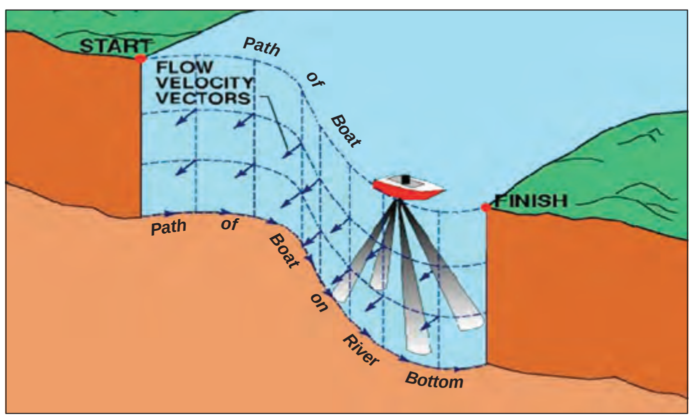


Figure 6. Acoustic Doppler Current Profiler (ADCP) mounted in a small watercraft, is used for measuring the discharge of a river. The ADCP acoustic beams are directed down into the water as it is guided across a river channel.

The Stage-Discharge Relation

Streamgages continuously measure stage, as stated in the “Measuring Stage” section. This continuous record of stage is translated to river discharge by applying the stage-discharge relation (also called rating). Stage-discharge relations are developed for streamgages by physically measuring the flow of the river with a mechanical current meter or ADCP at a wide range of stages; for each measurement of discharge there is a corresponding measurement of stage. The USGS makes discharge measurements at most streamgages every 6 to 8 weeks, ensuring that the range of stage and flows at the streamgage are measured regularly. Special effort is made to measure extremely high and low stages and flows because these measurements occur less frequently. An example of a stage-discharge relation

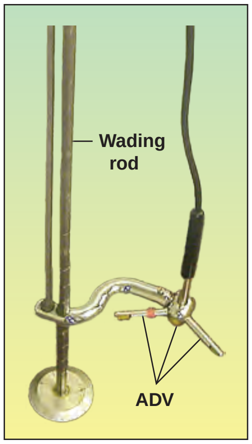


Figure 7. Acoustic Doppler Velocimeter (ADV) mounted on a wading rod.

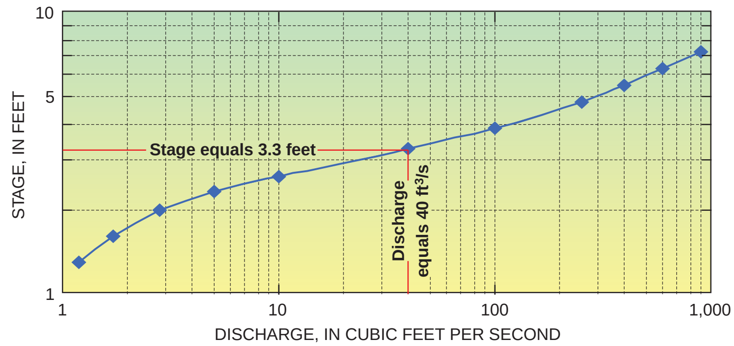


Figure 8. Example of a typical stage-discharge relation; here, the discharge of the river is 40 cubic feet per second (ft^3/s) when the stage is 3.30 feet (ft). The dots on the curve represent concurrent measurement of stage and discharge.

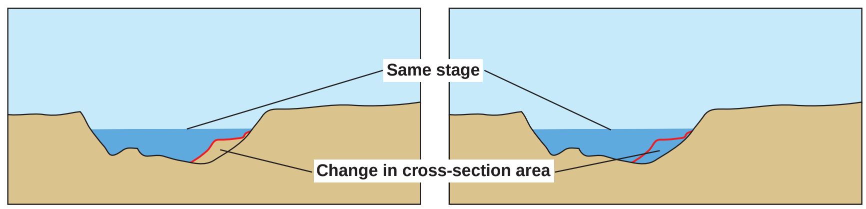


Figure 9. Erosion of part of a channel results in an increased cross-sectional area in the diagram on the right and the potential for conveying a larger quantity of water at the same stage.

is shown in figure 8. The stage-discharge relation depends upon the shape, size, slope, and roughness of the channel at the streamgage and is different for every streamgage.

The development of an accurate stage-discharge relation requires numerous discharge measurements at all ranges of stage and streamflow. In addition, these relations must be continually checked against on-going discharge measurements because stream channels are constantly changing. Changes in stream channels are often caused by erosion or deposition of streambed materials, seasonal vegetation growth, debris, or ice. An example of how erosion in a stream channel increases a cross-sectional area for the water, allowing the river to have a greater discharge with no change in stage, is shown in figure 9. New discharge measurements plotted on an existing stage-discharge relation graph would show this, and the rating could be adjusted to allow the correct discharge to be estimated for the measured stage.

Converting Stage Information to Streamflow Information

Most USGS streamgages transmit stage data by satellite to USGS computers where the stage data are used to estimate streamflow using the developed stage-discharge relation (rating) (see fig. 8). The stage information is routinely reviewed and checked to ensure that the calculated discharge is accurate. In addition, the USGS has quality-control processes in place to ensure the streamflow information being reported across the country has comparable quality and is obtained and analyzed using consistent methods.

Most of the stage and streamflow information produced by the USGS is available in near real time through the National Water Information System (NWIS) World Wide Web site (http://waterdata.usgs.gov/nwis). In addition to real-time streamgage data, the NWIS Web site also provides access to daily discharges and annual maximum discharges for the period of record for all active and discontinued streamgages operated by the USGS.

Summary

Streamgaging involves obtaining a continuous record of stage, making periodic discharge measurements, establishing and maintaining a relation between the stage and discharge, and applying the stage-discharge relation to the stage record to obtain a continuous record of discharge. The USGS has provided the Nation with consistent, reliable streamflow information for over 115 years. USGS streamflow information is critical for supporting water management, hazard management, environmental research, and infrastructure design. For more information on USGS streamgaging, go to the USGS Web site at http://water.usgs.gov. For additional information on the National Streamflow Information Program, go to http://water.usgs.gov/nsip/. For more information on surface-water activities, go to the USGS Office of Surface Water Web site at http://water.usgs.gov/osw/. To see current streamflow conditions nationwide or in your area, go to http://water.usgs.gov/waterwatch.

By Scott A. Olson and J. Michael Norris

For further information, please contact:
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National Streamflow Information Program
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275
mnorris@usgs.gov

ATTACHMENT 2

Excerpts from the Deposition Transcripts of Philip B. Bedient, Ph.D., P.E. (May 4, 2016 and June 29, 2016)

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

VIDEOTAPED DEPOSITION OF

PHILIP B. BEDIENT, Ph.D., P.E.

New York, New York

May 4, 2016

Reported by: BONNIE PRUSZYNSKI, RMR, RPR, CLR

JOB NO. 106213

May 4, 2016
9:03 A.M.

VIDEOTAPED DEPOSITION OF PHILIP B. BEDIENT, Ph.D., P.E., held at the offices of Latham & Watkins, 885 Third Avenue, New York, New York, before Bonnie Pruszynski, a Registered Professional Reporter, Registered Merit Reporter, Certified LiveNote Reporter, and Notary Public of the State of New York.

A P P E A R A N C E S:

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650 Town Center Drive
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BY: PAUL SINGARELLA, ESQ.
BY: GARRETT JANSMA, ESQ.

KIRKLAND & ELLIS
Attorneys for Defendant
601 Lexington Avenue
New York, New York
BY: DEVORA ALLON, ESQ.

Also Present:
John Allen, Deputy Director, Special Assistant Attorney General
Larry Dunbar
Carlos Lopez, Videographer

THE VIDEOGRAPHER: This is the start of tape labeled number one of the videotape deposition of Dr. Philip Bedient in the matter the State of Florida versus the State of Georgia in the matter -- I'm sorry.
This deposition is being held at 885 Third Avenue, New York, New York, on May 4th, 2016, at approximately 9:03 a.m.
My name is Carlos Lopez. I'm the legal video specialist, with TSG Reporting, Inc. The court reporter is Bonnie Pruszynski, in association with TSG Reporting.
Will counsel please introduce yourself for the record.
MR. SINGARELLA: Good morning, Doctor.
Paul Singarella for the State of Florida.
MR. JANSMA: Garrett Jansma on behalf of the State of Florida.
MS. ALLON: Devora Allon from Kirkland & Ellis for the State of

Georgia.
MR. ALLEN: John Allen on behalf of the State of Georgia.
THE VIDEOGRAPHER: Will the court reporter please swear in the witness?
(Witness sworn.)
PHILIP B. BEDIENT, Ph.D., P.E.
called as a witness, having been first duly sworn, was examined and testified as follows:
EXAMINATION
BY MR. SINGARELLA:
Q Good morning, Doctor.
A Good morning.
Q Could you please state and spell your name for the record?
A It's Philip Bedient. P-H-I-L-I-P. B-E-D-I-E-N-T.
Q And where do you live?
A I live in Sugar Land, Texas, which is near Houston.
Q Who is your employer?
A I'm employed at Rice University in Houston.

P. Bedient

Q And are you doing this work through Rice University or as a consultant?

A No. I'm doing this through my company as a consultant.

Q What is the name of your company?

A P.B. Bedient & Associates, Inc.

Q Do you have anybody from P.B. Bedient assisting you in this matter?

A I do.

Q Who would they be?

A There is just one person from the company, and his name is Rik, R-I-K, Hovinga, H-O-V-I-N-G-A.

Q Okay. And I understand you have had your deposition taken many times over the years; is that right?

A I have.

Q So you know the -- how this works. You understand that you are under oath today; correct?

A Yes, I understand that.

Q You understand the importance of giving your best and most accurate testimony; correct?

P. Bedient

A Yes, sir.

Q Any reason that your deposition shouldn't go forward today?

A No.

Q You are of clear mind today?

A Yes.

Q Good, good.

And you understand that if you answer a question, of course, it will be presumed that you understood the question; correct?

A Yes.

Q You are okay with that?

A Yes.

Q By the same token, of course, if you don't understand a question, by all means just let me know, and I would be glad to attempt to clarify it.

A Very good.

Q Okay?

A Sure.

(Bedient Exhibit 1, Initial Expert Report of Philip B. Bedient, Ph.D., P.E., February 29, 2016 marked for

P. Bedient

identification, as of this date.)

Q All right. We have premarked a set of exhibits there.

A Okay.

Q 1 through 10, starting with your expert report on top. I would like you to work with our version of your expert report. It's a clean version, version one.

A Okay.

Q Could you put that in front of you there?

A Sure.

Q And perhaps turn to page 19, sir, table one. I want to ask you about the math in table one.

There is a paragraph just before table one that starts, "In consideration of each of these factors."

Do you see that?

A Yes.

Q And this -- this is your expert report. You are the primary author of this report, I take it?

A Yes, sir.

P. Bedient

Q Okay. Do you see there that the report states that "the Corps developed a complex series of rules"?

Do you see that?

A Yes.

Q And then there is a reference to table one below; right?

A Right.

Q Is table one the set of rules to which you refer in that paragraph?

A Yes, it is.

Q And does table one depict release rules?

A It depicts release rules, yes.

Q And storage rules as well?

A And storage rules as well.

Q And some of them are fairly complicated. Are some of these rules in the form of functions?

MS. ALLON: Object to form.

A They are -- I don't know that I would call it a function, but they are complex rules, and they are a function of time of year, and a function of which zone

PHILIP B. BEDIENT, Ph.D., P.E.

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

DEPOSITION OF PHILIP B. BEDIENT, Ph.D., P.E.

JUNE 29, 2016

9:04 A.M.

Volume 3

Reported by: Michele E. Eddy, RPR, CRR, CLR

JOB NO. 108985

PHILIP B. BEDIENT, Ph.D., P.E.

JUNE 29, 2016
9:04 A.M.

Deposition of PHILIP B. BEDIENT, Ph.D., P.E. held at the offices of Latham & Watkins, LLP, 555 Eleventh Street, Northwest, Suite 1000, Washington, D.C., pursuant to notice, before Michele E. Eddy, a Registered Professional Reporter, Certified Realtime Reporter, and Notary Public of the states of Maryland, Virginia, and the District of Columbia.

PHILIP B. BEDIENT, Ph.D., P.E.

APPEARANCES:

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Costa Mesa, California 92626
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GARRETT JANSMA, ESQUIRE

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BY: DEVORA ALLON, ESQUIRE

Kirkland & Ellis
Attorney for Defendant
655 Fifteenth Street, Northwest
Washington, D.C. 20005
BY: ANDREW PRUITT, ESQUIRE

ALSO PRESENT
Mr. John Allen
Mr. Larry Dunbar
Adolph Green, Videographer

PHILIP B. BEDIENT, Ph.D., P.E.

THE VIDEOGRAPHER: This is the start of tape labeled number 1 for the videotaped deposition of Dr. Philip Bedient in the matter of State of Florida versus State of Georgia in the Supreme Court of the United States, Case Number 142.

This deposition is being held at 555 11th Street, Northwest, Washington, D.C., on June 29th, 2016, at approximately 9:04.

My name is Adolph Green from TSG Reporting, and I am the legal video specialist. The court reporter is Michele Eddy in association with TSG.

Will counsel please identify yourself.

MR. SINGARELLA: Good morning. Paul Singarella for Florida.

MR. JANSMA: Good morning. Garrett Jansma for Florida.

MS. ALLON: Devora Allon, from Kirkland & Ellis, for the State of Georgia.

MR. PRUITT: Andrew Pruitt, Kirkland & Ellis, for the State of Georgia.

PHILIP B. BEDIENT, Ph.D., P.E.

MR. ALLEN: John Allen for the state of Georgia.

THE VIDEOGRAPHER: Will the court reporter please swear in the witness.

\- - -

PHILIP B. BEDIENT, Ph.D., P.E., having been duly sworn, testified as follows:

EXAMINATION

BY MR. SINGARELLA:

Q Good morning, Doctor.
A Good morning.

(Exhibit 51 was marked for identification.)

Q I've placed in front of you what we've marked as Exhibit 51 to your deposition. This is a version of your May 20, 2016, report that we received last Friday from your counsel. Do you recognize this document, sir?
A I do.
Q Did you prepare a redline version of your May 20, 2016, report, sir?
A Yes.
Q Is this it?
A It is.

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PHILIP B. BEDIENT, Ph.D., P.E.
I mean, they -- I don't know about the word "benefit." I know that they look at the Flint and the Chattahoochee River for water supply coming across the state line. I know that. So that, I would agree with. But I don't -- you know, in terms of the benefit, I don't know what -- I've not been asked to evaluate benefits to Florida.
Q I'll tell you, we do think that the baseflows in those two rivers are important to Florida. So you can assume that, that that's the case.
How would a phenomenon that reduces baseflow in the Chattahoochee River, how could that, in and of itself, setting aside the Army Corps of operations, how could that benefit Florida?
MS. ALLON: Object to form.
A Well, unfortunately, you can't set aside the Army Corps operations because it's an intimate, completely, sort of, integral operational system to this whole basin. So if those reservoirs weren't there, then it's a very different response and a different

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PHILIP B. BEDIENT, Ph.D., P.E.
phenomenon. But the fact that the reservoirs are there, they have the RIOP under which they are operating, and the fact that they can augment these low flows has a large effect, as our analysis has shown, at state line flows, in terms of certain drought times of the year, the augmentation elevates those flows up to the 5,000 target. And it's been shown all throughout my report.
Q So let's just assume for a minute that the reservoirs are not there. Would a reduction of baseflow in the Chattahoochee and Flint rivers benefit Florida?
A If I assume that the reservoirs aren't there?
Q Yes.
A Which they are. So we're going to remove the reservoirs now?
Q Please do.
A Okay. So if I remove all the reservoirs and we go back to 1955, then the situation would be that there are differences in flows with urbanization, and I don't disagree that there would be probably some

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PHILIP B. BEDIENT, Ph.D., P.E.
more baseflow, but I have not done that analysis.
Q It would probably be more baseflow where and when?
A I don't know. I have not done the analysis.
Q You're referring to the historic period?
A That's only if -- only if we don't have reservoirs present, completely removed.
Q And if the reservoirs were not present, would the land use phenomenon that you described producing 1,200 cfs, would that phenomenon exacerbate the intensity of drought in the Apalachicola?
A I can't answer that question. I don't know.
Q You don't have an expectation?
A No.
Q So turning to your expert report at page 44.
A Okay.
Okay.
Q Figure 29, panels A, B, and C; are

Page 540

PHILIP B. BEDIENT, Ph.D., P.E.
you with me?
A Sure.
Q Is it your opinion that Metro Atlanta is similar to C, a fully developed watershed area?
A Yes, I think Metro Atlanta could be called fully developed.
Q How about the incremental area between the two gages? Is it your opinion that that part of the watershed is natural as depicted in your figure 29A?
A Yes, it's a natural area. Yes.
Q Let's -- I did do some reading, as Devora anticipated. And I can't say that I'm ready to take the exam, but I did actually buy your book. I am promoting sales.
A I saw the uptick. It came into my in-box.
Q It's required reading at Latham & Watkins now. Thank you very much.
A I'm so sorry.
Q Thank you very much.
A I'm so sorry.
Q Let me give you what we've marked as

PHILIP B. BEDIENT, Ph.D., P.E.

interdependent or independent drought periods?
A No, I have not.
Q So as far as you know, sitting here today, those three drought periods are independent of each other hydrologically, correct?
MS. ALLON: I'll object to form.
A Well, I haven't run the analysis. The data on figure 6 on page 9 do clearly show that there was a rise in rainfall and a rise in streamflow in between. But what I don't know, because this is a fully reservoir operating system, I don't know to what extent reservoirs were all the way filled back up.
Q So I'm just not sure what you're saying here. Just in terms of your knowledge, sitting here today, do you know whether those drought periods are dependent on each other hydrologically?
A I do not.
Q So then, as far as you know, they could be independent of each other.
A They could be. I don't know, yes.
Q What would you have to do to look

PHILIP B. BEDIENT, Ph.D., P.E.

into the possible interdependence of the latter two drought periods on the former, meaning your three drought periods?
A Whatever it is, it would be a complex analysis, I can tell you that.
Q Okay.
A You would have to look carefully at the full operations going on in the system with respect to the reservoirs, how they're being operated, and then compare that to -- I don't even know how one would do this because it is such a complex system.
Q So you're not going to offer an opinion in this case based on hydrology that you have concluded that the second drought period is dependent and impacted by the first drought period, correct?
MS. ALLON: Object to form.
A That's correct.
Q And you're not going to offer an opinion in this case based on hydrology that the third drought period is dependent and impacted by the second drought period, correct?

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MS. ALLON: Object to form.
A That's correct.
Q And you understand I'm referring to your three drought periods?
A Yes, sir, that is correct.
Q So turning back in your report to figure 54 on page 79, please.
A Okay.
Q Now, here you show a declining ratio in the incremental area, do you not?
A Yes.
Q Just in general terms, what can change this relationship over time? I'm not -- I'm just asking you general principles. What are the -- what are the phenomena that can change the relationship between runoff and rainfall over time?
MS. ALLON: Object to form.
Q And I'm talking about years and decades.
A Well, as I say in the statement there, it's not clear why Florida's -- why Florida's portions of flow have continued to consistently drop when rainfall has generally

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been constant. But it is clear that it has been decreasing based upon this graph. And I have -- I mean, there are -- I have actually no earthly idea. There's a loss of water here, obviously. But I don't know where, and nor have I done any investigation to determine where that water may be going.
Q It's interesting that you use the word "earthly" there. I would ask you, where on earth is the water going?
A It has to either be diverted or something going on in groundwater. Those are the only two possibilities, or some huge evaporative loss. And I have not done any study or evaluation of that.
Q No other possibility?
A Not that I know of.
Q If I asked you to assume that there's been no major diversion, that there's been no significant loss to groundwater, and that there's been no major change in evaporation, could you explain figure 54 if I put those constraints on you?
A I can't answer the question. I

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don't know where it went. I don't know where this has gone. I just know that this appears to be a real phenomenon based upon the gages that we have reviewed.
Q And assuming the gages are providing reliable information.
A Assuming that, yes.
Q Yes.
So who, for Georgia, has any information as to what this real phenomenon is, what accounts for it on the earth?
MS. ALLON: Object to form.
A Who from Georgia?
Q Yes.
A You're asking me is there someone in Georgia that knows where this water has gone? Is that what you're asking me?
Q Someone in Georgia or someone working for Georgia on this case.
A No one that I know of. No one.
Q Is it considered a big mystery?
MS. ALLON: One second. Object to form and objection to the extent it calls for attorney-client privileged

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information.
Q Oh, sure, outside of what your counsel may have discussed with you.
A I have -- I just don't know where this water has gone.
Q My question was otherwise. Is it -- to your knowledge, is it considered a big mystery?
MS. ALLON: Same objections.
Q Outside of any mystery that may have been expressed by your counsel.
A It's not -- it's not a -- it's not a mystery that I'm working on. It's not anything that I'm -- I just report the results here, and the results are what they are.
Q Has anybody said this is a really mysterious result?
MS. ALLON: Same objections.
A No, they haven't used that word, "mysterious."
Q Do you think that people believe that this is real?
MS. ALLON: Object to form.
Objection to the extent it calls for

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attorney-client information.
A I don't know about other people. Based upon my analysis, I believe it's real.
Q You think it's real.
A I do.
Q So this is another figure that we blew up. Oh, I have to mark it first. Details, details.
(Exhibit 62 was marked for identification.)
Q So this is a preexisting figure in your electronic production, but to recreate it and create a figure out of it, we had to run the data in two of your columns in your spreadsheet --
A Okay.
Q -- against each other, your two-year average ratio --
A Is what this is.
Q -- information versus year.
Do you recall looking at the two-year average ratio?
A Yes. I'm just getting -- trying to find that again.
Q Yes. I don't think it's actually in

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your report, but if it is --
A I just want to look at the two-year average.
Q Okay.
A And I'm looking for that. I'll find it at some point here.
Q Okay. Okay.
Are you familiar with your ratio expressed as a two-year average for the Georgia portion of the ACF Basin as reflected by the USGS measurements at Chattahoochee?
A Give me just a moment and I'll answer that.
Q Okay.
A (Document review.)
Okay. What's your question?
Q Are you familiar with your ratio, as expressed in a two-year average, for the drainage area above the Chattahoochee gage?
A No, I don't -- I'm not -- that one -- let me just look here, make sure. (Document review.)
I don't think I plotted a two-year average in my report, but I see you have.

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statistical results before?
A I have. I have.
Q How about the Theil that you referred to?
A I've not actually run it myself. I've seen that it's been used. I've reviewed a report from Dr. Lettenmaier. He's used it, I believe.
Q Is that a generally accepted statistical package in your discipline, to your knowledge?
A It is.
Q Theil-Sen, correct?
A Uh-hmm. Yes, sir.
Q Let's turn to -- I just have one more question on this. So I understand what you're saying here on figure 54, do I understand you correctly that you believe that the loss here reflected -- the lowering of the runoff coefficient is real, as depicted in figure 54, but you're not offering an explanation for why it happened, correct?
A That is correct.
Q So it's real but you haven't

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explained it, correct?
A I just have simply said that there is a loss that has taken place through the decades based on the difference in the two gages and it's unexplained.
(Exhibit 63 was marked for identification.)
Q Let's turn to this figure that we marked over the deposition, Exhibit 63, and let me represent to you that we prepared Exhibit 63 by taking a screenshot of the figure from the -- Mr. Keller's spreadsheet that we had up on the screen before lunch, okay?
A Okay.
Q So and you saw that -- you saw this figure up on the screen before lunch, correct?
A Yes, I did.
Q So with regard to Exhibit 63, does this suggest to you that there's a real change in the runoff coefficient?
A Well, I thought before lunch you were going to provide me with the actual spreadsheet. I thought we had that -- I thought you said that. You were going to let

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me look at the spreadsheet upon which this was based.
Q Okay. We would be glad to. So there it is, but we can actually put it right on that computer.
A That would be --
Q I'm glad to do that.
A I figured you could. That would be useful.
Q Let's do that, then.
MR. JANSMA: You should just be able to open it up.
MR. SINGARELLA: And see it?
THE WITNESS: Yeah, I've heard that before.
MR. SINGARELLA: Right. Garrett is pretty reliable, believe me.
MR. JANSMA: Don't put me on the spot here, Paul.
MR. SINGARELLA: This is Garrett Jansma to your right.
THE WITNESS: Good to meet you.
MR. JANSMA: Nice to meet you.
THE WITNESS: Okay. I see it.

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MR. SINGARELLA: It's right there just as Mr. Jansma said. He's a good man.
THE WITNESS: All right.
BY MR. SINGARELLA:
Q Okay. So did you want to navigate around in it?
A Oh, I'm just looking at it here a minute.
Q Now, I know Mr. Keller created this. Have you --
A It's Ms. Kellerman. Ms. Kellerman.
Q Okay. Ms. Kellerman.
A Yes.
Q I thought I read in the transcript that it was a man.
A Frances.
MS. ALLON: That was your assumption.
MR. SINGARELLA: No, no, it's in there. I'm telling you, it's in there. I think it was his joke or something. Ms. Kellerman.
THE WITNESS: It is, yes.
MR. SINGARELLA: Really, that's what

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that?
A Was I looking at these two?
Q Yes.
A I was.
Q What did you note?
A Well, I did note that there was a slight difference in the total consumptive use for 2011 in this table versus the 870 that I plotted and that we discussed earlier. This one is reporting 882, which is pretty close.
Q Yes.
A But it's a little off.
Q What did -- so you went to page 5 of 6 and 6 of 6 --
A Yes.
Q -- and added it up?
A Well, no, it's added up there in the -- it's actually in the table, but you have to hunt for it.
Q So the 2011 average annual is on line 238, and it's 882 cfs, correct?
A I think that's it, yes.
Q You're just saying that that number is a little bit different than the number that

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we saw on your figure 25?
A Yes, sir.
Q Okay.
Did you do any checking between our figure, Exhibit 81, and your numbers, Exhibit 82?
A Oh. Well, I haven't looked at 81 yet.
Q So what we did in Exhibit 81 is -- I owe you an explanation -- is we took your ten drought period years, as we discussed before our last break, and we went into column C, because Exhibit 81 is just for ag streamflow reductions, and we took each of the values -- let me just give you an example -- for July, from each of the ten drought period years, added them up and then divided by 10, and we got a value of 1,089, as you can see in Exhibit 81.
A What does the 1,089 represent?
Q That is the average streamflow reduction from column C of Exhibit 82 for the ten Julys in each of your ten drought period years.

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A Oh, okay. Let me just -- (Document review.)
I'll buy that. It appears to be in the range. It's 1,000 something. I'm assuming that you've done this correctly and that you've computed it correctly.
Q Did you, yourself, prepare any of these annual distributions for your consumptive uses? You had the information in Exhibit 82.
A No, we mostly -- everything that I plotted and worked off of has been, kind of, an annual basis. I mean, I know that -- I know that there are monthly values, but we mostly worked off the annuals.
Q You spent a lot of time in the last few hours explaining to me how the summer values are so important. Do you recall that?
A Yes.
Q Wouldn't that point be the same for the streamflow reductions?
A Well, I think the -- I've got to check the section here in my report to answer that.

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Q Okay.
A (Document review.)
I think these were put into the ResSim model on a monthly basis, and we just simply report and plot mostly on an annual basis just in ease of presenting information. But, clearly, there's a distribution of consumptive use across the year.
Q And is that distribution important to streamflow reductions that occur in the Apalachicola during summers and droughts?
MS. ALLON: Object to form.
A Yes. The distribution of consumptive use throughout the year is incorporated into the model and is part and parcel to the predictions that we make.
Q You understand I'm referring to the streamflow reductions associated with Georgia's consumptive use above the state line, right?
A Yes.
(Exhibit 83 was marked for identification.)
Q So let me give you Exhibit 83. Here in Exhibit 83 we took your Exhibit 82, and we

ATTACHMENT 3

Memo from Sorab Panday Re: Review of Dr. David Langseth's Memo to Dr. George Hornberger on 28 June 2016 titled "Dr. Panday Water Budget Evaluations" (July 26, 2016)

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MEMORANDUM

TO: File

FROM: Sorab Panday

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

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

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

I address each of these issues below.

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

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

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

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

The second evaluation further refined the Apalachicola River water budget to separately include inflow from the Chipola River in order to determine if contributions from the Chipola River could account for the changes over time. For this analysis, inflow to the Apalachicola River is the sum of the Chattahoochee and Cockran Landing Gages, and outflow of the Apalachicola River is

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evaluated at the Sumatra Gage. This analysis finds a pre-1992 average loss of 1,599 cfs, which increased to a post-1992 average loss of 3,938 cfs for the Apalachicola River; representing an increase in average loss for the Apalachicola River of 2,339 cfs between average pre- and post-1992 conditions.

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

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

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

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

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

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

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pointing out that there are losses occurring in the Apalachicola River Basin in Florida and that as per an analysis of the data, those losses are increasing through time.

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

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

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

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

Summary of Dr. Hornberger's May 20, 2016 "Defensive Expert Report"

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

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

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

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

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

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Further Considerations to Dr. Hornberger's Evaluations

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

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

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

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

Evaluation of Streamflow Data at the Sumatra Gage

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

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

Dr. Hornberger also notes that the USGS switched from traditional methods of measuring discharge to an Acoustic Doppler System (Doppler) in 2001 (i.e., that the measurement technique had changed over time). He compares the 1978-1985 rating curve with that of 2005-2015, and attributes the differences to errors in the updated Doppler measurements. However, there were also differences in the 1978-1985, 1986-1993, and 1994-2004 rating curves, all of which were apparently developed before the switch was made to an Acoustic Doppler System in 2001. These differences indicate recalibration using the same measurement technique, and

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reflect observed physical conditions that have changed over time. These updated curves for WYs 1986-1993 and 1994-2004 were used by the USGS to reflect the updated evolving flow conditions in the river (probably including impacts of the levee breach near the USGS discharge measurement site at M-K Ranch, as discussed on p. 16 of Dr. Hornberger's "Defense Expert Report"). Use of these updated curves, as was done in the flow records provided by the USGS, show the declining trend from 1978-2004, even before the switch to the flow rating curve of 2005-2015, which was obtained after switching the measurement technique. Also, the final rating curve would further account for change in measurement technique. Therefore, I believe that the most reliable data for flow measurements are the flow rates as reported by the USGS because the flow values obtained from the USGS used the most updated and recalibrated estimates of flow for the period of record considering that physical conditions and measurement techniques have changed over time.

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

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

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

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

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

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

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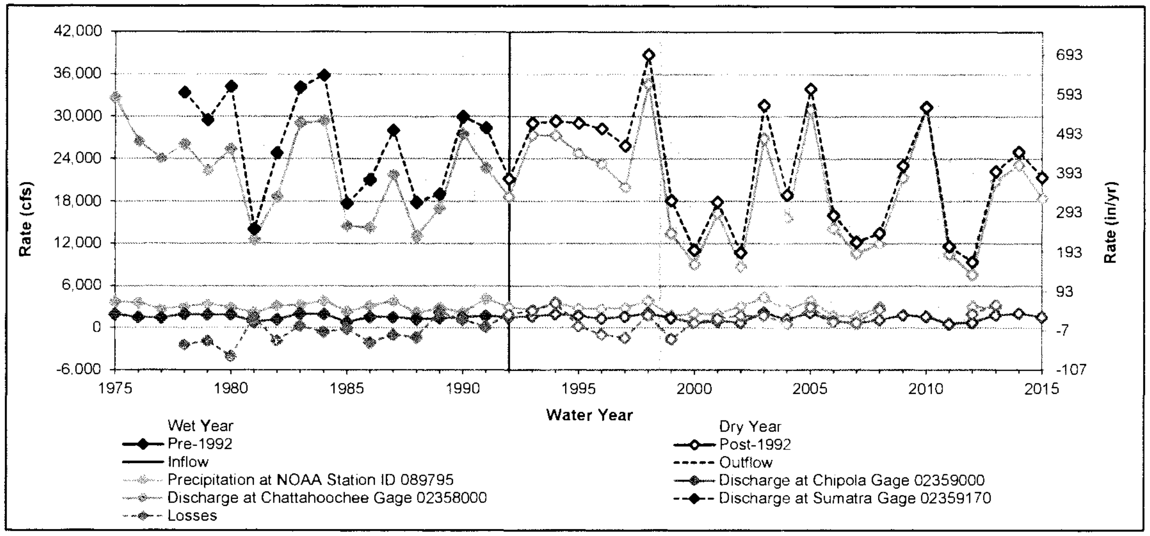
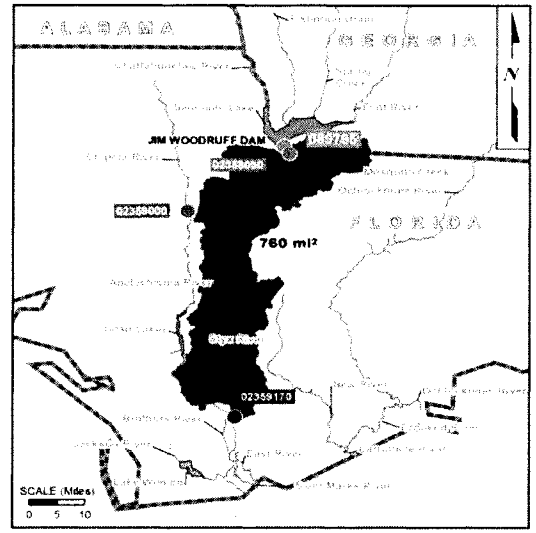
FIGURE 1
WATER BUDGET FOR THE APALACHICOLA RIVER BASIN

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





Summary Statistics

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

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FIGURE 2
USGS REPORTED STAGE HEIGHT V. DISCHARGE RATE

State of Florida v. State of Georgia
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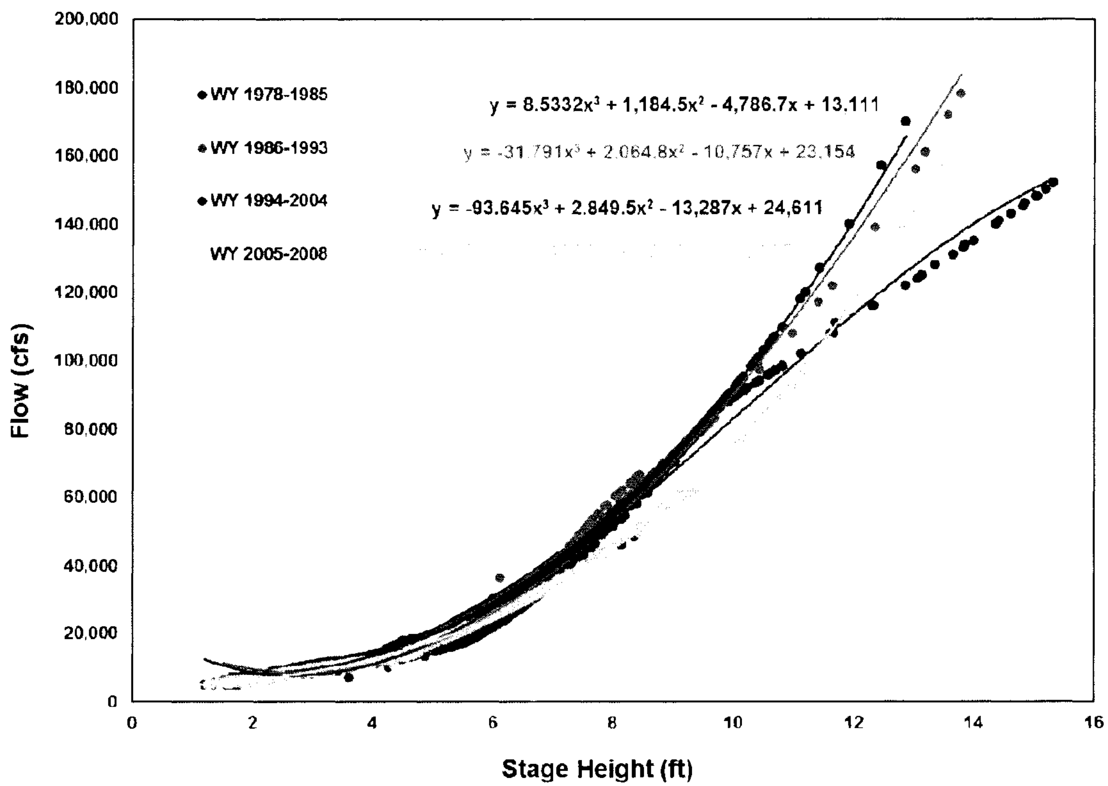

SOURCE: Chart recreated from Hornberger, May 2016, Figure 4.

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FIGURE 3
DIFFERENCE IN DISCHARGE RATES BETWEEN SUMATRA AND CHATTAHOOCHEE GAGES

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

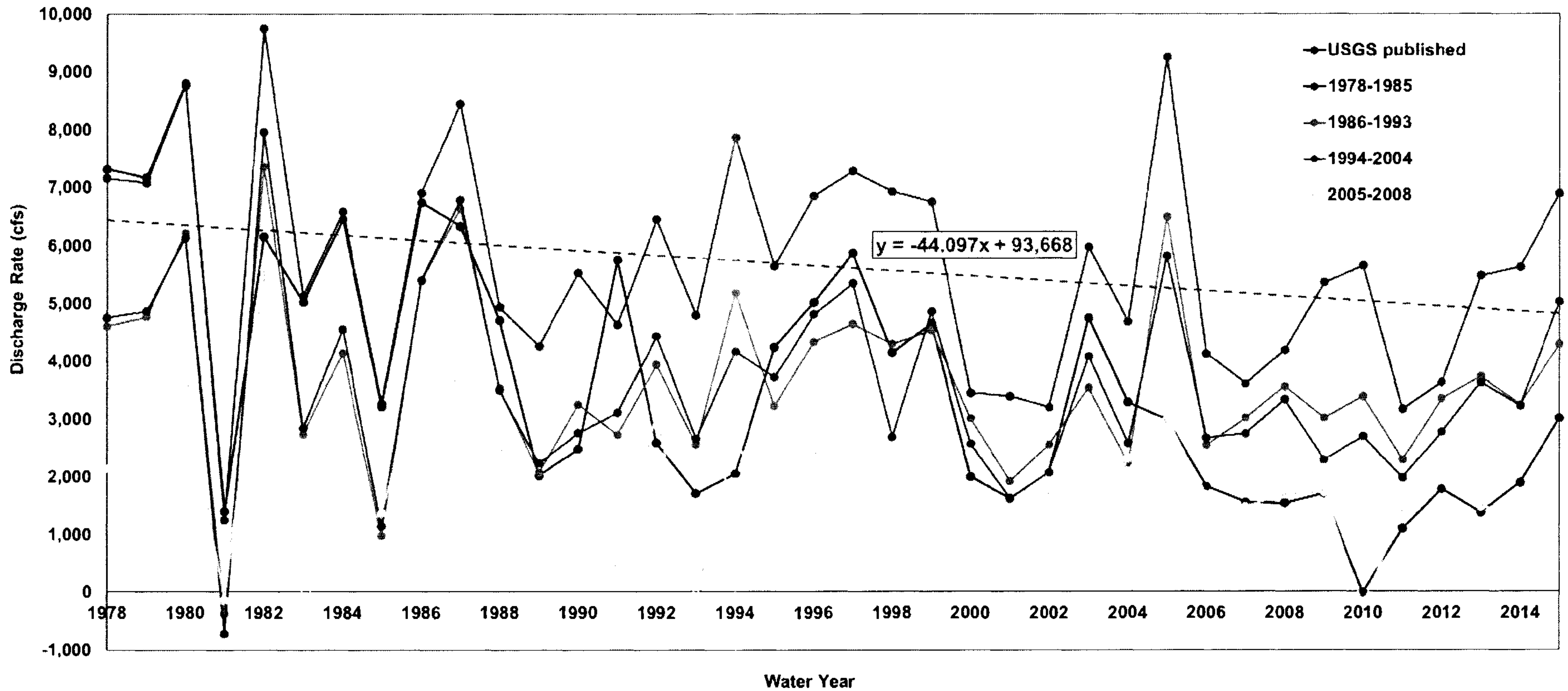

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FIGURE 4
STREAMFLOW BUDGET FOR APALACHICOLA RIVER USING DR. LANGSETH'S DATA

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

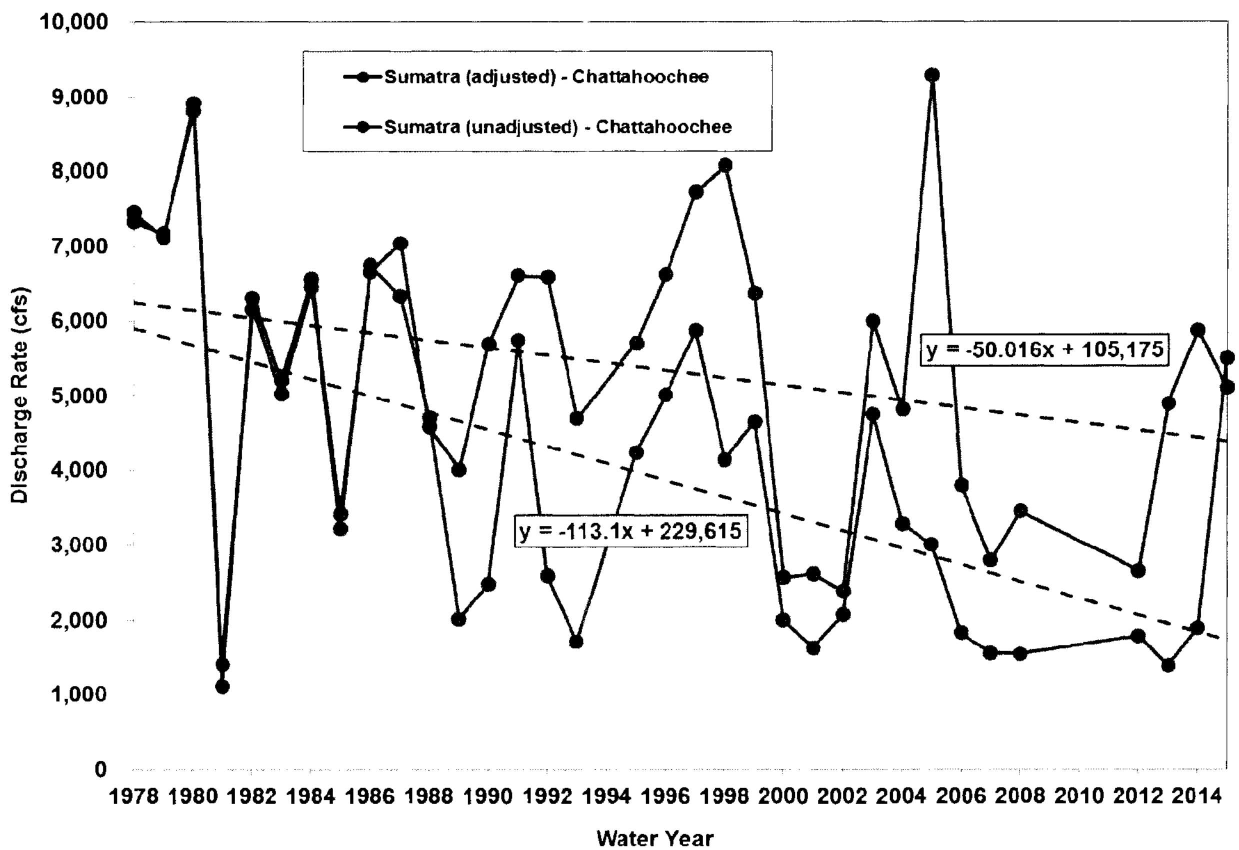

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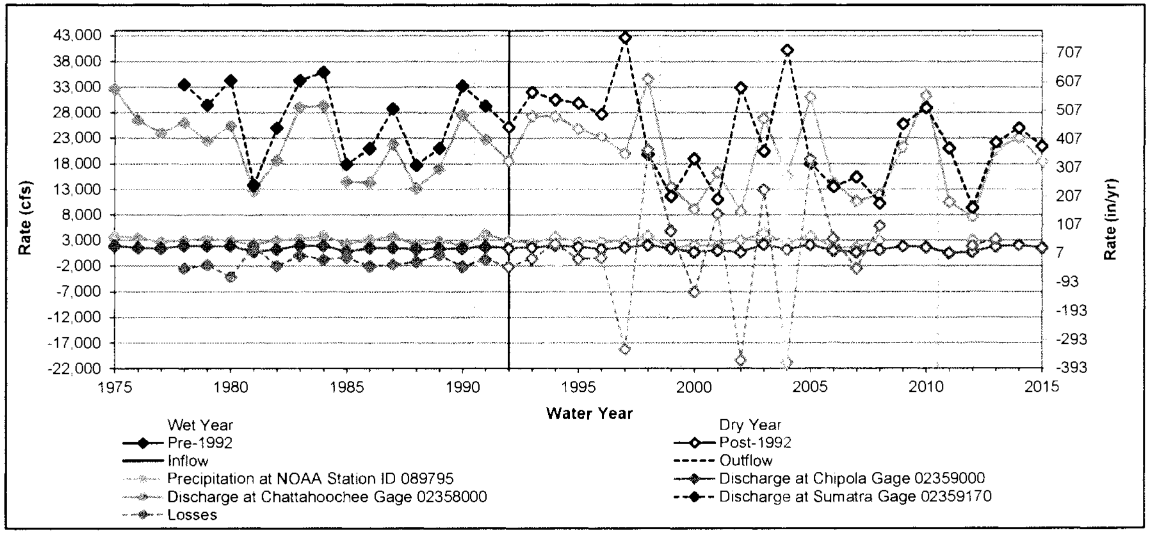
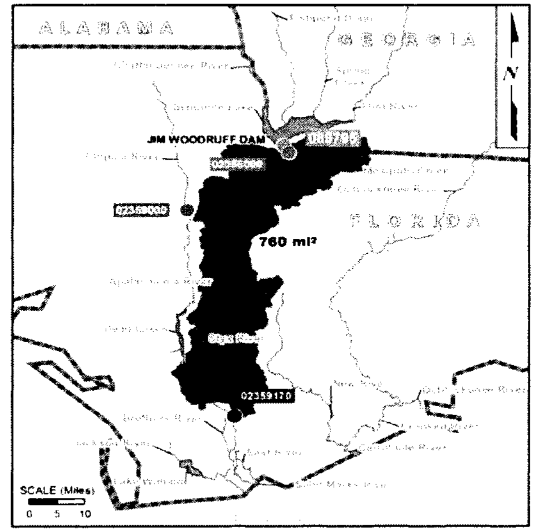
FIGURE 5
WATER BUDGET FOR THE APALACHICOLA RIVER BASIN

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





Summary Statistics

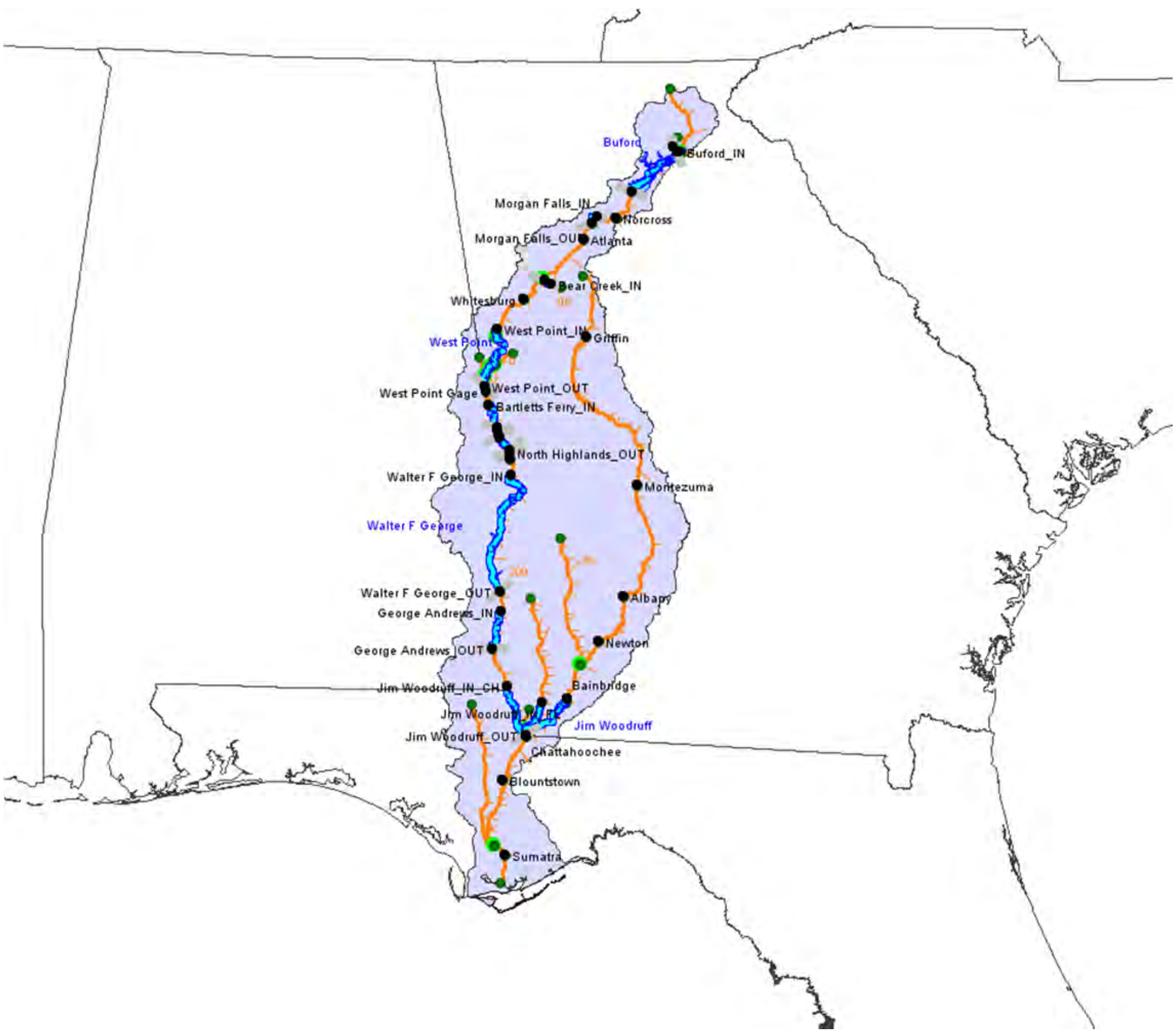
	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Annual Precipitation (NOAA Station ID 089795)												
(cfs)	2,089	1,622	2,654	2,268	3,106	2,838	3,587	3,048	4,143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

ATTACHMENT 4

Excerpts from the Defensive Expert Report of Philip B. Bedient, Ph.D., P.E. (May 20, 2016)

STATE OF FLORIDA V. STATE OF GEORGIA
NO. 142 ORIGINAL

DEFENSIVE EXPERT REPORT OF
PHILIP B. BEDIENT, PH.D., P.E.



May 20, 2016

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

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

Prepared for:
The State of Georgia

By:

P. B. Bedient

<u>May 20, 2016</u>
Date

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I. INTRODUCTION

I am a hydrologist and civil engineer at Rice University in Houston, Texas. I have over 40 years of experience in surface water hydrology, floodplain analysis, and hydrologic modeling of watersheds in the Southern United States. I have been working on both U.S. Army Corps of Engineers ("USACE" or "Corps") and non-federal reservoir projects since the 1970s. I have been working with hydrologic models for most of my career.

On February 29, 2016, I submitted an expert report on behalf of the State of Georgia ("Initial Report") in which I provided an opinion regarding the impact of the USACE's reservoir operations on streamflow in the Apalachicola-Chattahoochee-Flint (ACF) River Basin. In that report, I concluded that any change in the amount or timing of water flowing across the Georgia-Florida state line and entering the Apalachicola River must be coordinated with and executed by the USACE, and that absent a change in the USACE's current reservoir operations, reducing Georgia's consumptive use would result in no or limited additional streamflow at the Georgia-Florida state line, especially during low-flow or drought periods when Florida purports to need it the most.[1]

I have also been asked to provide an expert opinion on the various factors that influence the amount of streamflow in the ACF Basin, including the amount of water that flows across the Georgia-Florida state line into the Apalachicola River and eventually into the Apalachicola Bay. In particular, I was asked to evaluate claims by Florida that Georgia's consumptive water use in the ACF Basin, both historical and projected, has had, or will have an impact on the streamflow at the state line, and to quantify any such impact. I was also asked to evaluate Florida's claims that reducing consumptive uses in Georgia would result in additional flow at the Georgia-Florida state line, and to determine the magnitude of any such increases.

In forming my opinions, I performed extensive analyses of the hydrology and climatology of the ACF Basin, including how the river system responds to rainfall and and corresponding changes in land use that have occurred in the Basin over time as a result of urban development. I also performed a water budget analysis to assess total withdrawals and returns to the system and the impact on streamflow of historical and projected consumptive use of water (for municipal, industrial, and agricultural purposes) in the Georgia and Florida portions of the ACF Basin. The USACE's reservoir operations influence streamflow throughout the ACF Basin and often determine the amount and timing of flows entering the Apalachicola River, and thus my analysis also considers the impact of those reservoir operations. Finally, I have performed hydrologic analyses using a computer model developed by the USACE (HEC-ResSim) to evaluate the effect of increases and reductions in Georgia's consumptive use of water from the ACF Basin on flows at the Georgia-Florida state line.

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1 *See* Initial Expert Report of Philip B. Bedient, Ph.D., P.E. (Feb. 29, 2016).

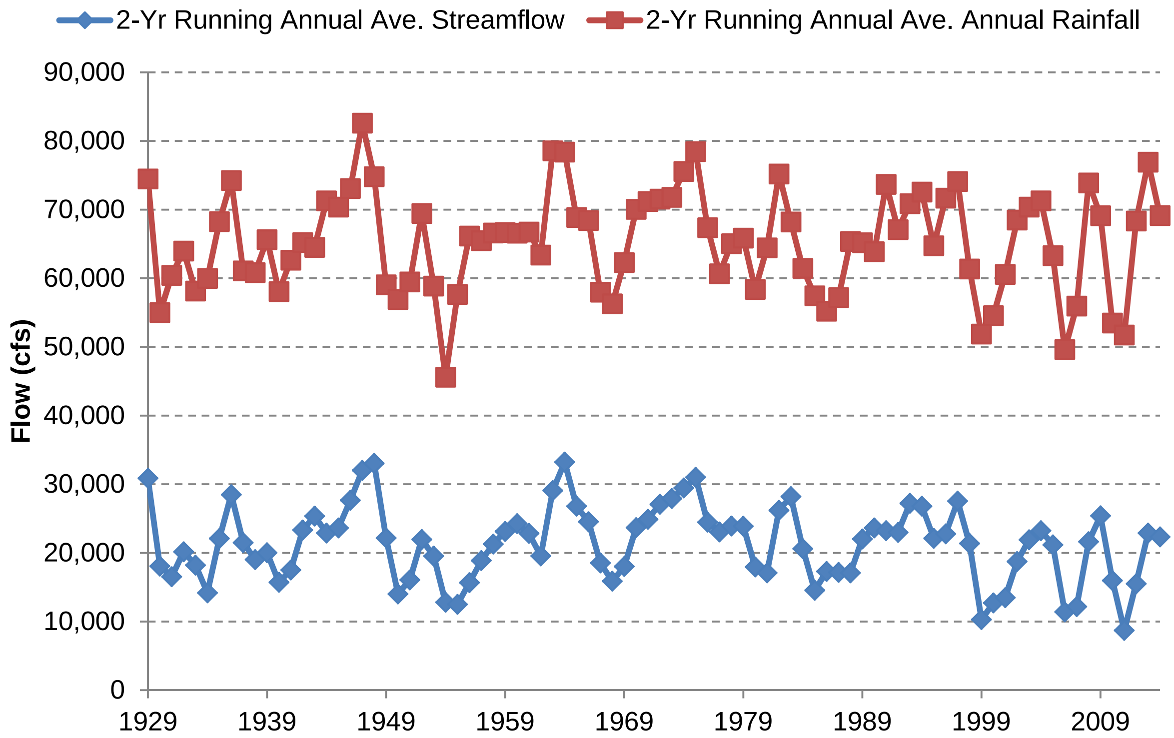


Figure 6. Comparison of 2-yr Running Average Rainfall over ACF Basin to Streamflow at State line for Period 1929-2014 (Source: NOAA and USGS)

- o The lower seasonal flows during these drought periods were being maintained at about 5,000 cfs by the USACE by releasing stored water from its reservoirs in the ACF Basin.

- **Florida's contribution to flows entering the Apalachicola River and eventually entering Apalachicola Bay has been decreasing since 1978, and especially during the most recent drought periods.**

  - o The flow contribution to the Apalachicola River within Florida was about 20% as compared to the 80% flow contribution crossing the state line and entering the headwaters of the river, as of 1978. Since then, Florida's contribution has been decreasing such that in recent years, the flow contribution within Florida has been averaging closer to 10% (see Figure 7).

  - o During the recent drought periods, the flow contribution to the Apalachicola River fell from averaging about 6,000 cfs to as low as 1,000 cfs as an annual average, even during times when rainfall increased over the ACF Basin within Florida.

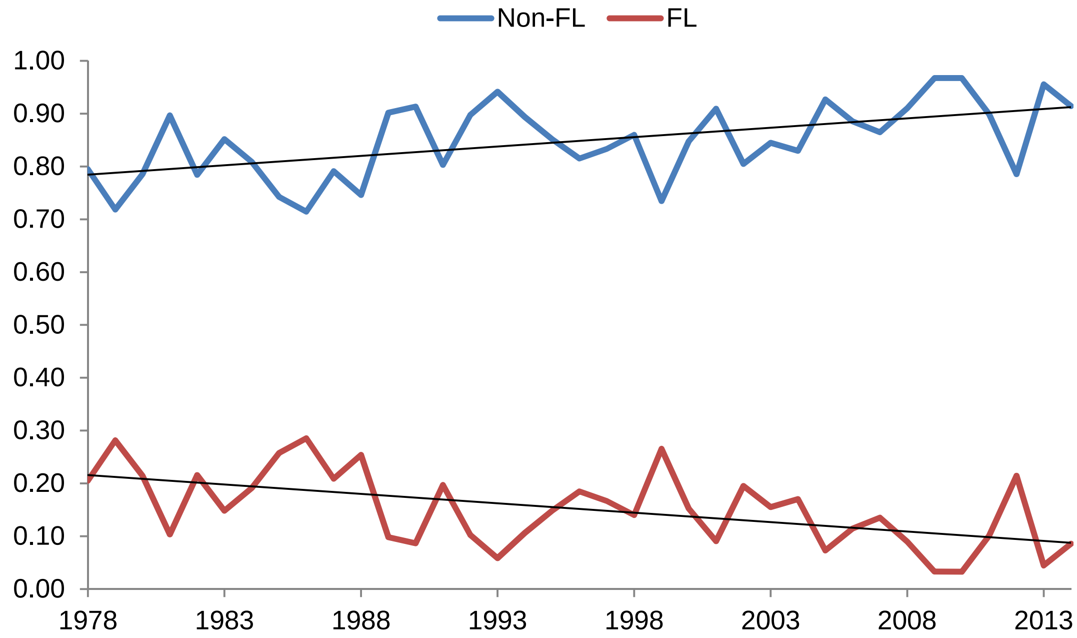


Figure 7. Percentage of Flow Contribution from Non-Florida and Florida Portions of ACF Basin (1978-2014) (Source: NOAA; USGS)

- **Dr. Hornberger's opinion that Georgia's consumptive water use is "the main cause of the streamflow depletions in the Apalachicola River" is based on erroneous estimates of Georgia's consumptive use by Dr. Flewelling, an improper interpretation of climate variability which explains the recent streamflow depletions, and a flawed rainfall-runoff modeling analysis that is biased towards significantly distorting actual flows in the Basin.**

  - Dr. Hornberger relies on the erroneous calculation of Dr. Flewelling for the inflated amount of Georgia's consumptive water use and ignores the relatively small fraction of water actually consumed by Georgia as compared to streamflow in the Basin. Dr. Hornberger also ignores the additional water produced by land use changes in Georgia that crosses the state line and into Florida that more than offsets Georgia's consumptive use.

  - Dr. Hornberger improperly disregards extreme and prolonged low precipitation over the ACF Basin in recent years, which has been the main cause of streamflow depletions at the state line.

  - Dr. Hornberger altered a rainfall-runoff ("PRMS") model specifically for this litigation and used it to "forecast" how much water would have crossed the state line without any consumptive water use in Georgia—based on an 8-year calibration period before the USACE reservoirs existed and during a time when Georgia's consumptive use was minimal. However, this modeling analysis fails to account for all of the inherent errors in the data sets

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

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

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

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

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

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

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

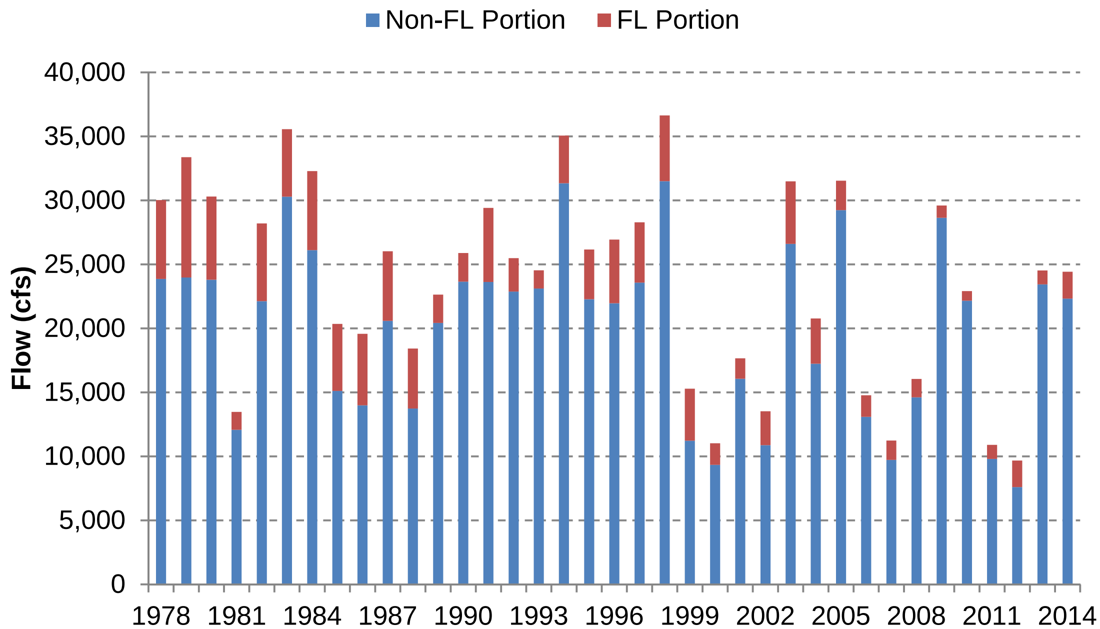


Figure 51. Average Annual Flow Contributions of Non-Florida and Florida Portions of ACF Basin at Gage Near Sumatra, Florida (1978-2014) (Source: USGS)

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

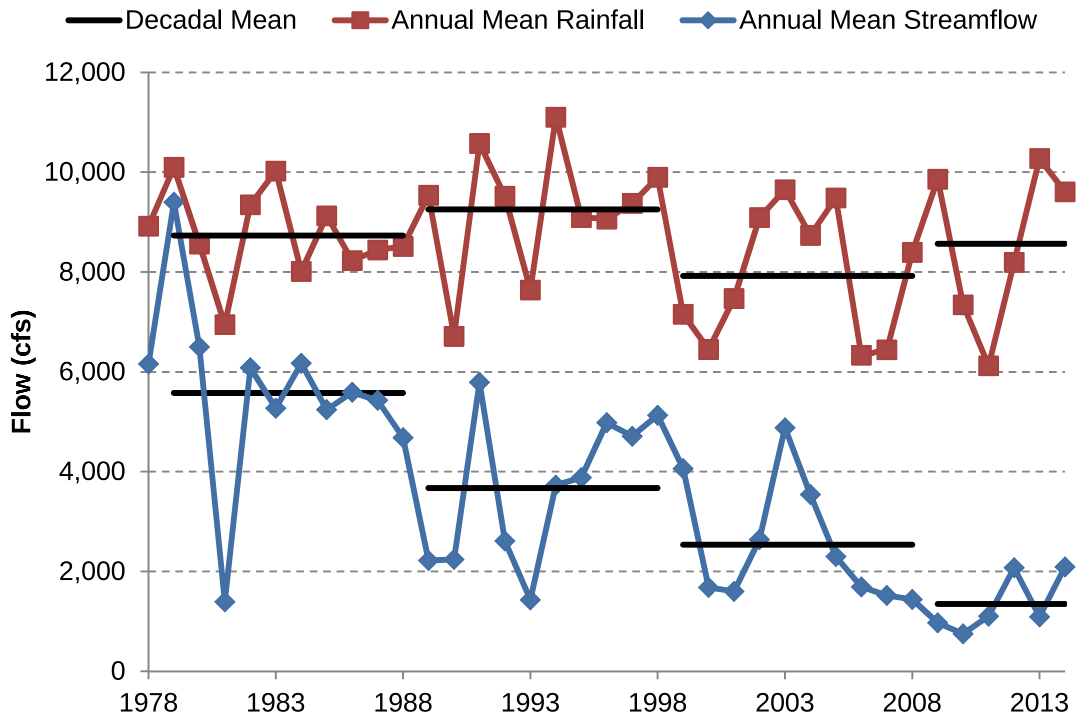


Figure 52. Average Annual Flow and Rainfall for Florida Portion of ACF Basin (1978-2014) (Source: NOAA; USGS)

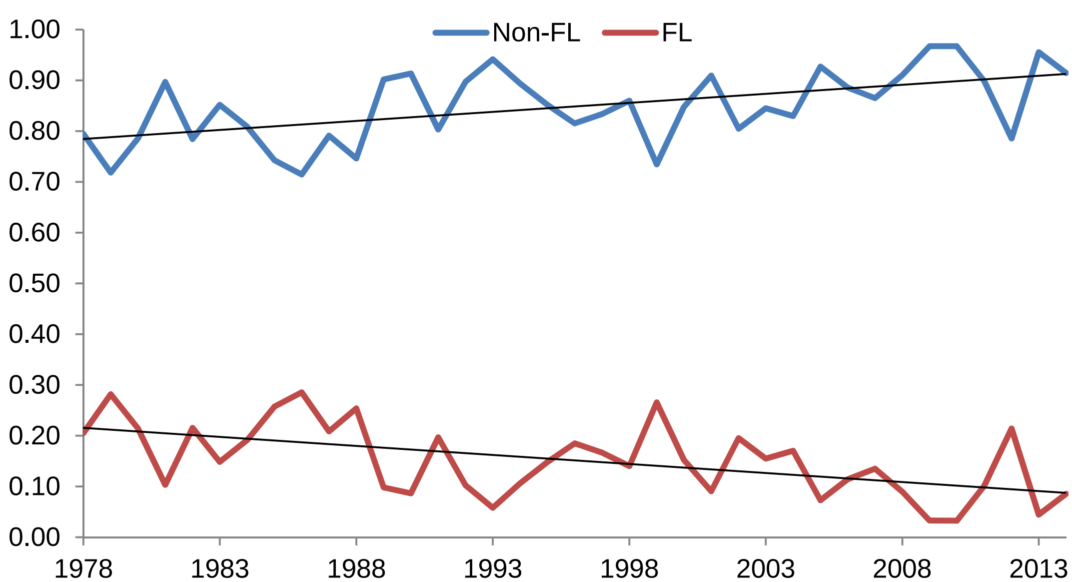


Figure 53. Percentage of Flow Contribution from Non-Florida and Florida Portions of ACF Basin (1978-2014) (Source: NOAA; USGS)

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

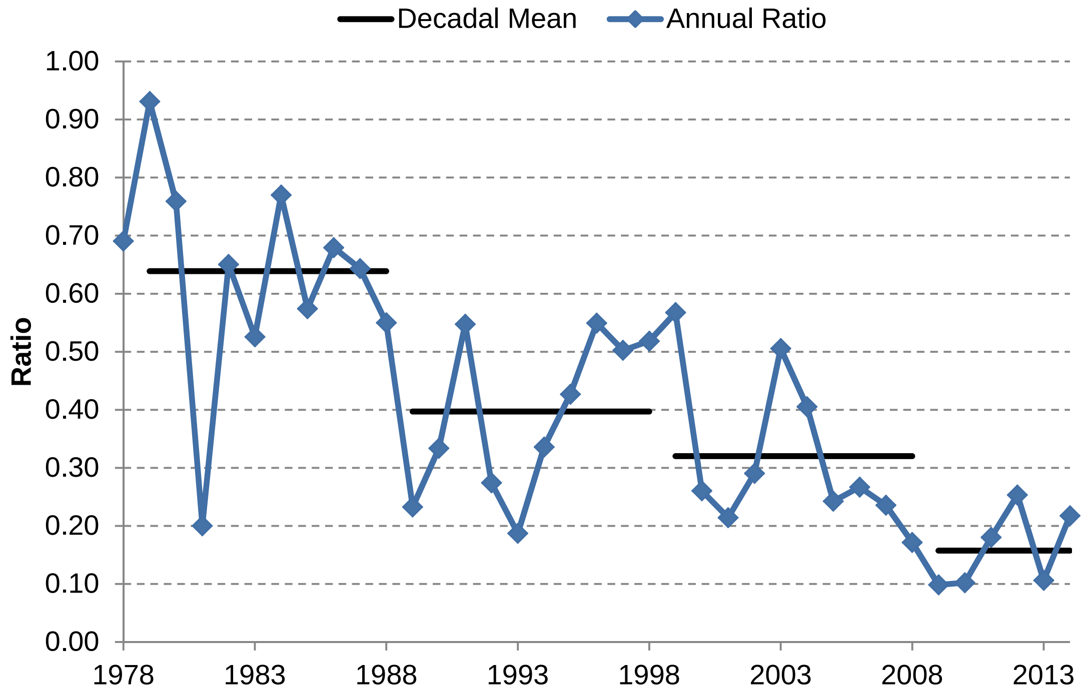


Figure 54. Ratio of Flow vs. Rainfall for Florida Portion of ACF Basin (1978-2014) (Source: NOAA; USGS)

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

iv. Dr. Hornberger Ignores that Declines in Basin Yield Have Been Observed in Rivers Within and Outside the ACF Basin in Florida—Where Georgia Cannot Influence Flows

Basin yield is the ratio of streamflow to rainfall, and varies by time of year, by the amount of rainfall, and by the hydrologic response of the watershed to rainfall. Dr. Hornberger incorrectly concluded that since the average Basin Yield at the state line over selected periods of time has been lower in recent decades in comparison to 1923-1970, this recent decline was attributable to Georgia's consumptive use (see his Table 3). However, he failed to address in his report the amount of low rainfall that occurred during these periods of declining Basin Yield. The rainfall data for the ACF Basin show that the rainfall has been lower in recent years, primarily due to the three major drought periods since 1999. Thus, when these recent years are included in his periods of declining Basin Yield as a greater and greater part of the period, these low rainfalls will be more dominant in the determination of Basin Yield for that particular period. This is especially important for these low rainfall periods since the Basin Yield is reduced greater than the corresponding reduction in rainfall. The USACE recognizes that the amount of rainfall contribution to streamflow varies much more than rainfall (see USACE DEIS pg. 2-9). Yet Dr. Hornberger fails to address this fact and fails to discuss how the recent droughts have been much more frequent than in earlier periods he used.

For example, the USACE noted in its recent DEIS the number of droughts that have plagued the ACF Basin since about 1980. They identify and discuss 5 multi-year droughts during the years 1980-1982, 1985-1989, 1998-2003, 2006-2008 and 2011-2012 (DEIS pgs. 2-8 to 2-9). As one can see, two of these multi-year droughts occurred during the 2003-2013 period Dr. Hornberger selected for demonstrating how Basin Yield has declined during this period as compared to previous periods. Yet one of his previous periods include 1992-2013, when only one more multi-year drought was added as compared to the two multi-year droughts already in the data set from the 2003-2013 period. He then adds another 21 years of additional data for his next period from 1971-2013, during which another two multi-year droughts occurred, but this time they were over a period of 21 years, such that they averaged about 1 multi-year drought per 11-year period. These periods are in sharp contrast to the 1 multi-year drought that occurred in the period 1922-1970 that he uses to establish his baseline Basin Yield value to compare more recent periods against. Such a decline in Basin Yield is expected given the number and frequency of multi-year droughts that have plagued the ACF Basin, having nothing to do with Georgia's consumptive use.

Similar declines in Basin Yield have occurred in the lower portion of the ACF Basin within Florida. Table 9 below shows the dramatic decline in Basin Yield at the Sumatra Gage (on the Apalachicola River just before it enters Apalachicola Bay) for the periods shown that are not related to Georgia's consumptive use.

Table 9. Incremental Flow Decline in Apalachicola River (Between Chattahoochee Gage and Sumatra Gage) in Florida (1978-2013) (Source: USGS)

Historical Period	Basin Yield
1978-2013	0.419
1992-2013	0.309
2003-2013	0.235

Similar declines in Basin Yield can be observed in another river basin in Florida, which is not influenced by Georgia's consumptive use. For example, Table 10 shows the decline in Basin Yield for the Suwanee River in Florida outside of the ACF Basin for the same periods of time that Dr. Hornberger presents in his report that clearly has not been affected by Georgia's consumptive use.

Table 10. Flow Decline in Suwanee River (1928-2013) (Source: USGS (20130311-Florida-Suwanee-White-Springs-Q.xlsx)

Historical Period	Basin Yield
1928-1970	0.194
1971-2013	0.174
1992-2013	0.148
2003-2013	0.152

The tables above show how the Basin Yield decline can occur without any influence from Georgia's consumptive use, contrary to Dr. Hornberger's contention.

v. Dr. Hornberger Mistakenly Concludes that the Recent Shift in the Flow Duration Curve at the Chattahoochee Gage Data Is Due to Georgia's Consumptive Use Rather than a Shift in Rainfall over the ACF Basin

Dr. Hornberger prepared a Flow Duration Curve using the streamflow data recorded at the Chattahoochee gage near the state line based on an earlier period of time (1922-1955) and compared that curve to one based on a more recent period of time (1970-2013). He concludes that since these curves show that the duration of low flows has shifted since this earlier period, these more frequent low flows are a result of Georgia's increased consumptive use since 1970. However, he again fails to account for or analyze whether a shift in rainfall amounts and frequency is the reason for such a shift.

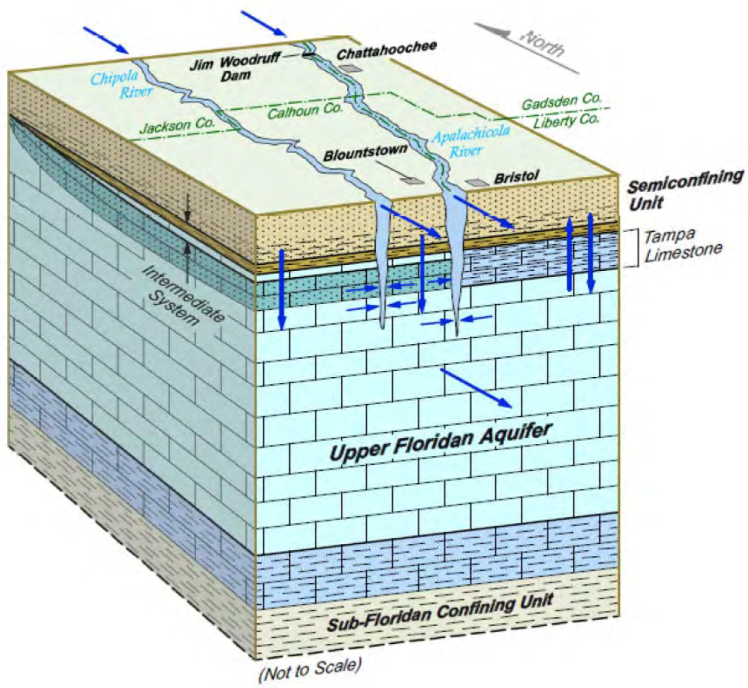
For example, Figures 64 and 65 below show how a change in the flow duration curve at the Chattahoochee Gage is consistent with a corresponding change in the rainfall exceedance curve.

ATTACHMENT 5

Excerpts from the Expert Report of Sorab Panday, Ph.D. (May 20, 2016)

EXPERT REPORT OF SORAB PANDAY, PH.D.

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



Issued: 20 May 2016

Prepared for: The State of Georgia

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EXPERT REPORT OF SORAB PANDAY, PH.D.

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

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GSI Job No. 4198
Issued: 20 May 2016

Sorab Panday, Ph.D.

20 May 2016
Date

Herndon, Virginia U.S.A.
Location

20 May 2016

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FIGURES

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APPENDICES

3) Flows in the Lower ACF River Basin are impacted by activities outside of Georgia.

i) Groundwater pumping outside of Georgia (i.e., in Florida and Alabama) also impacts baseflow in the Lower ACF and Chipola River Basins, which likewise reduces the amount of water flowing into the Apalachicola River and Bay. During extreme drought conditions, baseflow can be reduced up to 83 cfs for the Lower ACF and Chipola River Basins due to groundwater pumping in Florida and Alabama.

4) The Apalachicola River in Florida between Chattahoochee Gage and Sumatra Gage is a losing reach and water lost within Florida is not caused by any action by Georgia.

i) The Apalachicola River from the Chattahoochee Gage to the Sumatra Gage within Florida is a losing reach and those losses are increasing with time.

ii) Groundwater pumping inside the Georgia portion of the Lower ACF River Basin does not affect groundwater/surface water interactions in Florida because Lake Seminole stabilizes water levels in its vicinity. Thus, reductions in baseflow occurring in the Florida portion of the ACF River Basin cannot be explained by aquifer impacts resulting from groundwater pumping in Georgia.

1.4 Summary of Opinions Regarding Florida Expert Reports

I have also reviewed the reports of Florida's experts, including the reports from Dr. David E. Langseth and Dr. David L. Sunding. I have reached the following opinions about their reports:

1) Dr. Langseth's incomplete hydrogeologic analysis leads to incorrect conclusions.

i) There is no evidence that pumping has caused long-term aquifer storage depletion in the ACF River Basin.

ii) Even if Dr. Langseth was correct, water level declines in the Lower ACF River Basin would have minimal impact on flows from Georgia into Florida.

iii) Dr. Langseth's report focuses on local issues that have a small impact on the overall flow from Georgia into Florida.

2) Dr. Langseth's evaluation of prior groundwater studies is flawed.

i) Dr. Langseth's critique that the Jones and Torak (2006) transient model produces "conservative estimates of streamflow depletions related to pumping" is unfounded. Specifically:

a. The model is designed to simulate the interaction between groundwater and surface water, so the model does not need to "represent all streams in the modeled area" when those smaller streams are only fed by runoff and have no (or negligible) groundwater baseflow.

b. Jones and Torak are sophisticated modelers who carefully chose appropriate boundary conditions as they have detailed in their report.

The difference between minimum and maximum monthly flows into the Apalachicola River every year is noted be as low as 10,000 cfs and as high as 75,000 cfs. Thus, streamflow can fluctuate by at least 10,000 cfs (and as much as 75,000 cfs) every year, which occurs as a result of natural climatic conditions and pumping impacts. In my evaluations, I have tried to quantify the contribution of pumping to these fluctuations of streamflow into Florida.

I also analyzed what happens to the water in the Apalachicola River after it enters Florida by comparing the historical flows at the Chattahoochee Gage (USGS Stations ID 02358000) with historical flows at the Sumatra Gage (USGS Stations ID 02359170) located just upstream of the Apalachicola Bay, and by evaluating a water balance for the Apalachicola River Basin. Figure 3-5 shows the annual water budget for the Apalachicola River Basin, located downstream of Woodruff Dam and excludes the Chipola River Basin. A significant amount of water is lost (to withdrawals, evapotranspiration, and groundwater) in the Apalachicola River Basin that lies within Florida. These losses have steadily increased through the years after 1992 and average 11 inches per year (in/yr; 1,425 cfs) higher for post-1992 conditions than before 1992. The resulting loss in freshwater flow to the Apalachicola Bay is significant. The river reach mass balance (i.e., streamflow budget) of the Apalachicola River (Figure 3-6) shows that river outflow, as measured at the Sumatra Gage, is less than the sum of the river inflows, as measured at the Chattahoochee Gage and downstream gage of the Chipola River (USGS Station ID 02359051), indicating that the Apalachicola River in Florida is a losing river reach. More importantly, these losses increased by an average of 2,339 cfs between pre- and post-1992 conditions. Also, the Chipola River reach is noted to have a declining flow trend with average flow being 351 cfs less for the post-1992 time period as compared to pre-1992 average flows (as shown in Figure C-14 in Appendix C of this report). Additional details on the evaluation of streamflow data of the Apalachicola River into Florida and Apalachicola Bay are included in Appendix C of this report.

3.2.2 Aquifers of the Lower ACF and Chipola River Basins

My report will primarily focus on groundwater in the Lower ACF and Chipola River Basins (called Subarea 4; as shown in Figure 3-7)[1] which contain the highly productive limestone of the UFA.

3.2.2.1 The Upper Floridan Aquifer and Intermediate and Surficial Aquifer Systems

The UFA is a highly productive aquifer and supplies most of the water for agriculture in the region. The highly conductive, karstic nature of this limestone aquifer is one key reason why the UFA sufficiently provides for the groundwater pumping needs in the Lower ACF River Basin. Groundwater pumping is significantly less in: i) northern portions of the ACF River Basin, where the UFA is not present, and ii) south of Blountstown, Florida, where the UFA dips below the **Intermediate Aquifer System (IAS)**; and therefore, is not readily accessible for groundwater pumping. Surface water features such as streams and rivers are in contact with the UFA in Subarea 4 until it dips below the IAS south of Blountstown, Florida. The **Surficial Aquifer System (SAS)** overlying the UFA is localized in nature and provides water to the UFA but

[1] Figure 3-7 shows the delineation of the ACF and Chipola River Basins into four subareas of distinct hydrogeologic characteristics for further groundwater analysis. The delineation was identified by as part of the Comprehensive Study in the early 1990s, on the basis of hydrologic and physiographic boundaries (Chapman and Peck, 1997a and 1997b; Mayer, 1996).

During extreme drought conditions, baseflow can be reduced up to 83 cfs for the Lower ACF and Chipola River Basins due to groundwater pumping in Florida and Alabama. As further summarized on Table 5-2,[10] an average (for a normal scenario growing season) of 387 cfs and a maximum of 434 cfs of the net 2011 groundwater pumping-induced reduction of baseflow may be attributed to groundwater pumping within Georgia; whereas, a 62 cfs average and 70 cfs maximum reduction of baseflow may be attributed to groundwater pumping in Florida and Alabama.

For the Chipola River Basin only, irrigation pumping rates were as high as 272 cfs in June for 2011 dry conditions (Figure 5-11), resulting in a baseflow impact of 66 cfs in July and August with a growing season average impact of 62 cfs (Figure 5-12). Actual reductions are probably higher because the MODFLOW transient simulations were noted to underestimate baseflow reductions as compared to the transient MODFE model simulations—the MODFE model results are more accurate for baseflow reduction evaluations because it was specifically designed for that purpose. Also, the peak monthly flow reduction caused by pumping in the Chipola River Basin is about 14% of the peak monthly flow reduction to streams and rivers of the remaining portions of the Lower ACF River Basin for both dry and normal scenarios during the growing season (*Compare* Figures 5-6 and 5-12).

Finally, my evaluation of flow from the Chipola River Basin at downstream USGS Station ID 02359051 (Figure C-14 of Appendix C) indicates that the flow is declining through time with average flow being 351 cfs less for the post-1992 time period as compared to pre-1992 average flows. The minimum annually averaged flow from the Chipola River Basin is 630 cfs lower for the post-1992 time period than pre-1992.

5.4 Apalachicola River in Florida Between Chattahoochee Gage and Sumatra Gage is a Losing Reach and Water Lost Within Florida Is Not Caused By Any Action By Georgia

5.4.1 The Apalachicola River from the Chattahoochee Gage to the Sumatra Gage is a Losing Reach and Those Losses are Increasing with Time

I analyzed the fate of water after it flows from Georgia into Florida by comparing the flows into Florida at the Chattahoochee Gage (USGS Station ID 02358000) with Apalachicola River outflow at the Sumatra Gage (USGS Station ID 02359170), the last USGS gage before the Apalachicola Bay. I further added flow into the Apalachicola River from the Chipola River at USGS Station ID 02359051 to note how the total outflow of the river at the Sumatra Gage compares with the total inflow from the Chipola River and Woodruff Dam. This analysis shows that river outflow at the Sumatra Gage is less than combined river inflows from Woodruff Dam and the Chipola River Basin, indicating a net loss in the Apalachicola River reach (Figure 3-6).[11]

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[10] Table 5-2 shows the baseflow reduction that occurs for the various simulations I have conducted (dry and normal conditions for 1992 and 2011 irrigation pumping), and delineates the impact due to pumping within and outside of Georgia.

[11] The blue line on Figure 3-6 shows the difference between flows into Florida at the Chattahoochee Gage (USGS Station ID 02358000) and Apalachicola River outflow at the Sumatra Gage (USGS Station ID 02359170). The red line shows the net flow loss in the Apalachicola River by adding the inflow from the Chipola River at USGS Station ID 02359051.

Furthermore, there is a steady increase in this net loss, indicating that either the net inflow is increasing or that the net outflow is decreasing. The net loss along the Apalachicola River increases from about 700 cfs in the late 1970s to over 6,000 cfs in the 2010s, changing by over 5,000 cfs.

I also conducted a surface water budget analysis for the Apalachicola River Basin (Figure 3-5). The surface water budget states that inflow is equal to outflow in the surface water system. Inflow to the Apalachicola River Basin occurs due to precipitation, and discharges from Woodruff Dam (USGS Station ID 02358000) and the Chipola River (USGS Station ID 02359051), while outflow occurs from the Sumatra Gage into the Apalachicola Bay, and to other basin losses such as withdrawals, evapotranspiration, or groundwater. This analysis shows that basin losses are increasing through time and are on average 11 inches/year higher during the post-1992 time period than before.

5.4.2 Groundwater Pumping Inside the Georgia Portion of the Lower ACF River Basin Does Not Affect Groundwater/Surface Water Interactions in Florida Because Lake Seminole Stabilizes Water Levels in Its Vicinity

Lake Seminole has a stabilizing effect on groundwater levels in its vicinity. This is because lake water levels are generally maintained, as per USACE operations, at a pool altitude of approximately 77 ft MSL. The lake is in direct contact with the UFA, as noted by a USGS study (Torak et al., 2005); thereby, stabilizing the water levels in the UFA in its vicinity. Drawdown from pumping in Georgia therefore does not extend further downstream of Lake Seminole and Woodruff Dam into Florida. This conclusion is also supported by prior studies (maps of the area indicate water levels of between 70 and 80 feet under Lake Seminole (e.g., Crandall et al., 2013, Figure 2)) and through my own modeling efforts and data analyses, as detailed in Appendices B through E of this report.

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FIGURE 3-5
WATER BUDGET FOR THE APALACHICOLA RIVER BASIN

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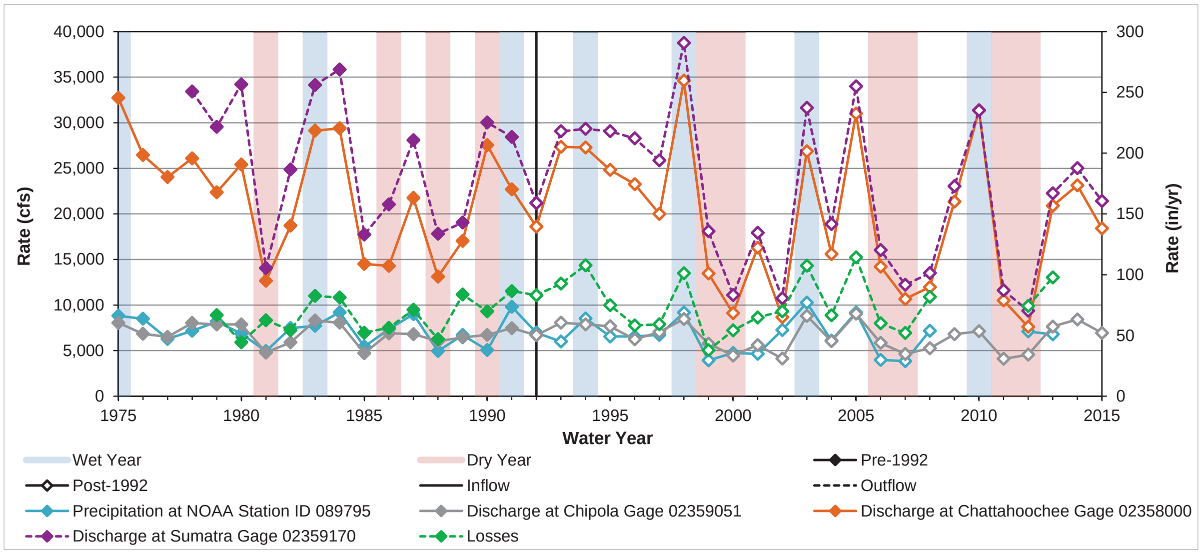

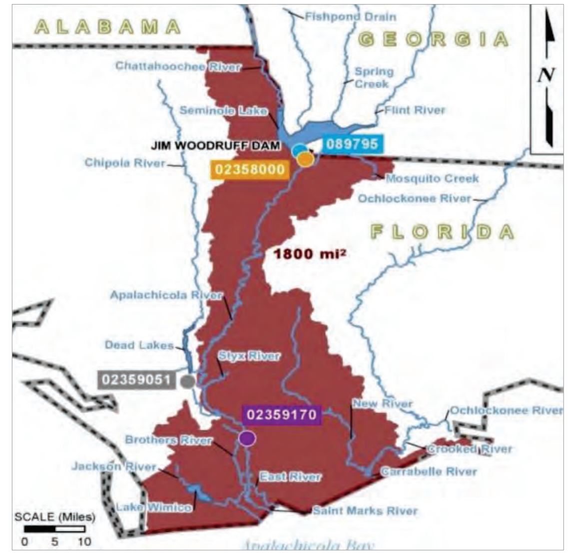

Notes:

1. * = Streamflow data for USGS Station ID 02359051 for water years 1975 through 1991, 1996 through 1998, and 2010 through 2015 were extrapolated from the relationship between streamflow at USGS Station IDs 02359000 and 02359051. The relationship between these stations is identified by the equation y = (2.9172*x) + 2436, where y is the streamflow at USGS Station ID 02359051 and x is the streamflow at USGS Station ID 02359000. The R-squared (r^2) value for this relationship is 0.9037.
2. The primary and secondary y-axes represent the same data in different units.

Summary Statistics

	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Annual Precipitation (NOAA Station ID 089795)												
(cfs)	4,948	3,841	6,285	5,371	7,356	6,722	8,495	7,220	9,813	10,257	7,265	6,604
(in/yr)	37	29	47	41	55	51	64	54	74	77	55	50
Average Discharge Rate (cfs)												
02359051	4,726	4,096	6,456	5,529	6,845	6,749	7,875	7,720	8,302	9,058	6,903	6,552
02358000	12,661	7,605	17,041	13,085	22,697	19,295	26,452	25,340	32,718	34,617	22,231	19,461
02359170	14,063	9,384	19,552	15,406	28,262	21,833	32,566	29,067	35,843	38,763	26,306	22,075
Losses												
(cfs)	5,923	5,040	7,233	7,943	8,890	9,887	10,826	12,697	11,535	15,238	8,801	10,226
(in/yr)	45	38	55	60	67	75	82	96	87	115	66	77

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

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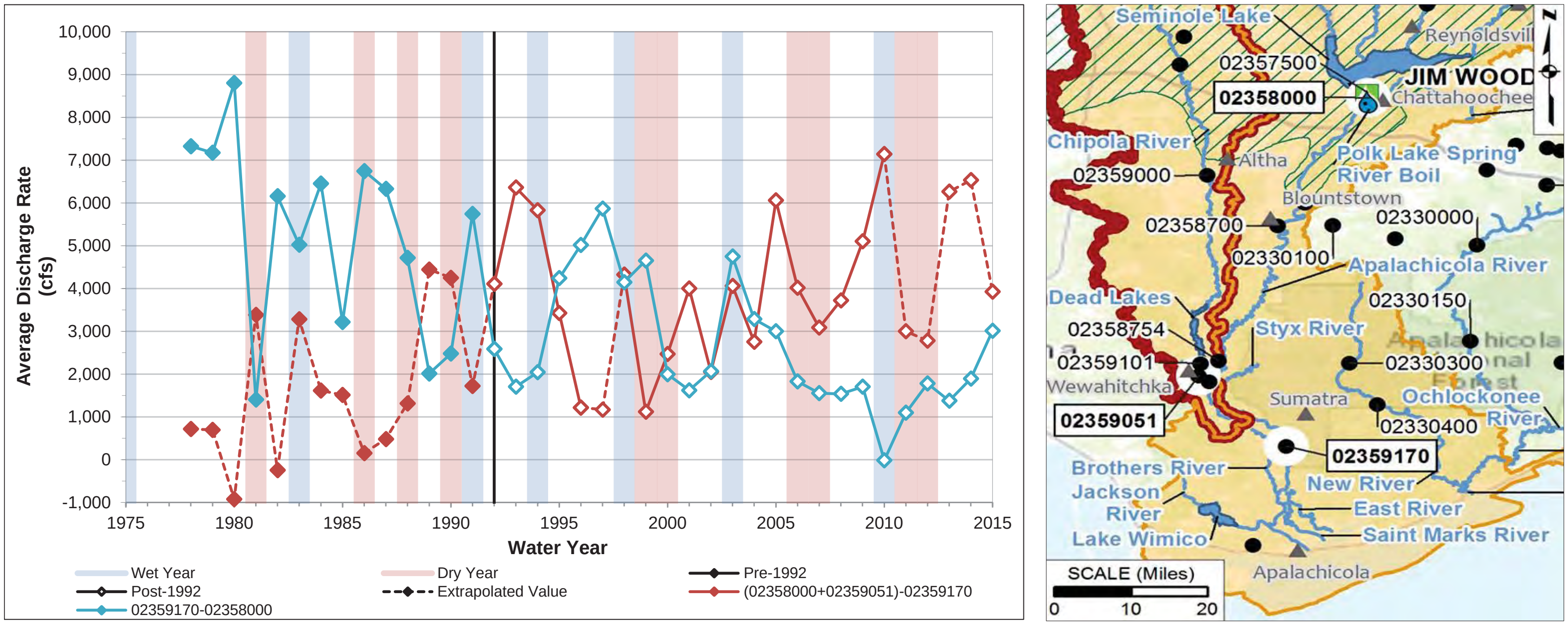
Case No. 142 Original



Summary Statistics

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

Notes:

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

As shown on Figure C-6, average discharge rates in the Apalachicola River slightly increased between Woodruff Dam and the city of Blountstown, Florida. Flow in the river then decreased between the cities of Blountstown and Wewahitchka, especially after 1990, indicating this segment of the Apalachicola River is a losing reach.

C.2.2.3 Water Budget for the Apalachicola River Reach between Woodruff Dam and the Sumatra Gage Upstream of Apalachicola Bay

Figure C-7 shows the flow balance for the entire Apalachicola River below Woodruff Dam by comparing i) the outflow at the Sumatra Gage to the inflow at the Chattahoochee Gage (blue line); and ii) the sum of inflows at the Chattahoochee Gage and the downstream-most gage in the Chipola River (USGS Station ID 02359051)[1] to the outflow at the Sumatra Gage (red line). It is important to note that the second comparison, as shown with the red line, represents a net loss in flow prior to entering the Bay; therefore, positive values represent losses and negative values represent gains.

Points to note on Figure C-7 include the following:

1) The “net inflow minus net outflow” term (red line on the figure) is positive indicating that the net inflow from the Chattahoochee Gage and Chipola River into the Apalachicola River is larger than the net outflow at the Sumatra Gage; therefore, there is a loss of flow in the Apalachicola River occurring entirely within Florida. Furthermore, data from the post-1992 time period indicate a much higher (2.5x) net loss (average of 3,938 cfs) when compared to the pre-1992 time period (average of 1,599 cfs). Thus, the average flow is 2,339 cfs less in the post-1992 time period.
2) There is a steady increase in the “net inflow minus net outflow” terms indicating that either the net inflow is increasing, or that the net outflow is decreasing through the observed time period. This loss along the Apalachicola River increases from about 700 cfs in the late 1970s to over 6,000 cfs in the 2010s, changing by over 5,000 cfs.
3) The decrease in flow difference between the Sumatra and Chattahoochee Gages (blue line on the figure) also reflects this increase in the “net inflow minus net outflow” term, reducing from over 7,000 cfs in the late 1970s to below 2,000 cfs in the 2010s. Thus, Florida’s contribution to flow is steadily reducing over time as compared to inflow at the Chattahoochee Gage.

Key Findings: *The flow balance for the Apalachicola River indicates an average loss of 3,938 cfs for post-1992 conditions, which is 2.5 times higher than during the pre-1992 time period (1,599 cfs). Also, there is a continually decreasing trend in outflow relative to inflow since the pre-1992 time period, which has continued to increase through the post-1992 time period. The difference is over 5,000 cfs between flows in the late 1970s and flows in the 2010s. Thus, not only are there significant losses along the Apalachicola River reach entirely within Florida, these losses are increasing through time.*

[1] The Chipola River Gage (USGS Station ID 02359051) was missing data during both pre- and post-1992 time periods; therefore, streamflow data for USGS Station ID 02359051 for water years 1975 through 1991, 1996 through 1998, and 2010 through 2015 were extrapolated from the relationship between streamflow at USGS Station ID 02359051 and its upstream gage, USGS Station ID 02359000.

C.2.2.4 Flow to Apalachicola Bay from Other Rivers

I examined the influence of sources of water to the Apalachicola Bay other than the Apalachicola River from Woodruff Dam by analyzing streamflow within major supplementary tributaries in or adjacent to the Lower ACF and Chipola River Basins. However, only those tributaries that show an appreciable amount of flow (>5%; as compared to flow in the Apalachicola River) at their furthest downstream station were further evaluated. Therefore, for this evaluation, the following stations and tributaries were considered (Figure C-4): i) USGS Station ID 02359051 on the Chipola River, which discharges directly to the Apalachicola River; ii) USGS Station ID 02330150 on the Ochlockonee River, which discharges directly to the Bay; iii) USGS Station ID 02330400 on the New River, which also discharges directly to the Bay; iv) USGS Station ID 02358000 on the Apalachicola River, just downstream of Woodruff Dam; and v) USGS Station ID 02359170, the farthest downstream station on the Apalachicola River.

Average discharge rates (by water year) at all five stations are shown on Figure C-8. It is noted that flows in the Chipola and Ochlockonee Rivers are considerable as compared to Apalachicola River flow. Also, similar discharges are noted at the upstream and downstream stations in the Apalachicola River during certain periods (especially post-1992) even with contribution from the Chipola River to the Apalachicola River, indicating a net loss of streamflow in the Apalachicola River reach between the Chattahoochee and Sumatra Gages (USGS Station IDs 02358000 and 02359170, respectively).

Figure C-9 shows the relative flows (as percentages) in the rivers as compared to flow into the Bay, as measured by the farthest downstream Apalachicola River streamflow gage (Sumatra Gage; USGS Station ID 02359170). Flow into the Apalachicola River from Woodruff Dam averages 80 to 87% of the River's flow into the Bay, and has an increasing trend with time. Also, all of the post-1992 statistics for percent of flows from Woodruff Dam to the Bay, are higher than pre-1992 statistics.

The Chipola River, a major tributary to the Apalachicola River, contributes approximately 30% of Apalachicola River flow to the Bay. The percentages do not add up to 100% due to gains or losses within the river reaches. The Ochlockonee River contributes an appreciable 9% of Apalachicola River flow to the Bay; whereas, the New River only contributes an average of 1 to 2% of Apalachicola River flow to the Bay.

Key Findings: *Streamflow from other rivers within Florida provides a significant amount of flow to the Bay, as compared to the Apalachicola River. Also, there is a net loss of streamflow in the Apalachicola River reach, which is noted to be increasing with time. This increasing percentage of water reaching the Bay from Woodruff Dam indicates the percent contribution from Florida is decreasing with time.*

C.2.2.5 Apalachicola River Basin Water Budget

Figure C-10 shows the key water budget "inflow and "outflow" terms for the Apalachicola River Basin in Florida, including the following:

1) ***Inflow (by water year):*** i) Annual precipitation rates representative of the entire Apalachicola River Basin (18,000 mi^2) using data from NOAA Station ID 087975 at the Woodruff Dam, and ii) average discharge rates into the Apalachicola River Basin, at the

Chattahoochee and Chipola Gages (USGS Station IDs 02358000 and 02359051, respectively).[2]

2) ***Outflow (by water year):*** i) Average discharge rates at the Sumatra Gage (USGS Station ID 02359170) into the Bay, and ii) estimation of losses (e.g., to withdrawals, evapotranspiration, and groundwater) by a closure of the surface water balance (i.e., inflow minus outflow to the surface water basin is zero).

The groundwater inflow and outflow terms at the lateral basin boundaries are small in comparison; and therefore, are not considered in this analysis. These components are also more steady through time due to the relatively constant water levels at the upstream (77 feet above Mean Sea Level (ft MSL), as maintained in Lake Seminole) and downstream (sea level in the Bay) basin boundaries.

As shown on Figure C-10, precipitation contributes approximately 7,000 cfs to the Apalachicola River Basin, with an average reduction of about 660 cfs in post-1992 conditions. Inflow to the Apalachicola River Basin from Woodruff Dam is more than three times larger averaging approximately 20,000 cfs, with an average reduction of about 2,770 cfs in the post-1992 time period. However, as noted earlier, the ACF River Basin also had significantly reduced precipitation during the post-1992 time period.

Outflow at the Sumatra Gage averages about 22,000 cfs for post-1992 conditions, which is lower than pre-1992 conditions by 4,231 cfs. Basin losses to withdrawals, evapotranspiration, and groundwater average over 70 inches per year (in/yr). These losses have increased by 11 in/yr on average, for the post-1992 time period. This loss amounts to an average loss of 1,425 cfs of water since 1992 that is not going to the Bay. I did not conduct further analyses to segregate this net loss into losses to withdrawals, evapotranspiration, groundwater, or other possible minor losses, as that would have required numerical modeling and associated hydrogeologic details that are not readily available.

Key Findings: *Precipitation over the Apalachicola River Basin generally decreases after 1992, due to the occurrence of more frequent, longer duration, and higher intensity droughts. Declining precipitation over the Chattahoochee and Flint River Basins also contributes to declining flow at the Chattahoochee Gage into Florida, as discussed above in Section C.2.2.1. However, the net loss of flow at the Sumatra Gage is even larger indicating increasing losses within the Apalachicola River Basin through time.*

C.2.2.6 Water Budgets for Other Major River Reaches of the ACF and Chipola River Basins

To evaluate water budgets and baseflow trends across the Lower ACF and Chipola River Basins, I compared inflow and outflow average discharge rates at select stations of interest in other major tributaries. Figures C-11, C-12, C-13, and C-14, respectively, show average discharge rates (by water year) at select upstream and downstream stations in the following four major tributaries: Upper and Middle Chattahoochee River, Spring Creek, Lower Flint River, and Chipola River. The select stations in each tributary, in the order of upstream to downstream, included the following: i) Upper and Middle Chattahoochee River: USGS Station IDs 02334430, 02335000, 02339500, 02341460, 023432415, and 02343801; ii) Spring Creek:

[2] The Chipola River Gage (USGS Station ID 02359051) was missing data during both pre- and post-1992 time periods; therefore, streamflow data for USGS Station ID 02359051 for water years 1975 through 1991, 1996 through 1998, and 2010 through 2015 were extrapolated from the relationship between streamflow at USGS Station ID 02359051 and its upstream gage, USGS Station ID 02359000.

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FIGURE C-7
STREAMFLOW BUDGET OF THE APALACHICOLA RIVER (USGS STATION ID 02359170)

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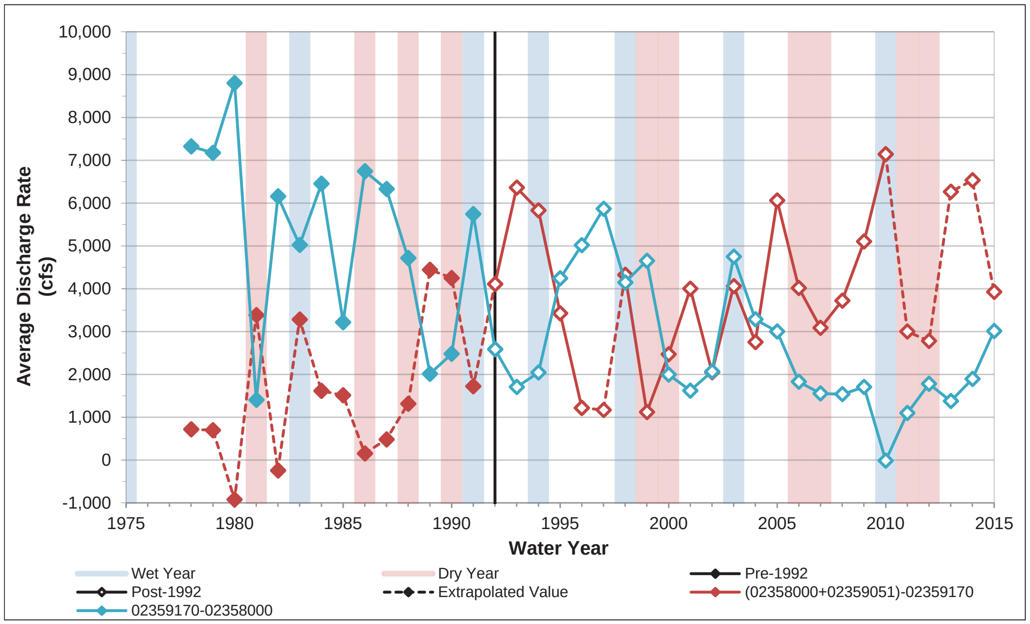

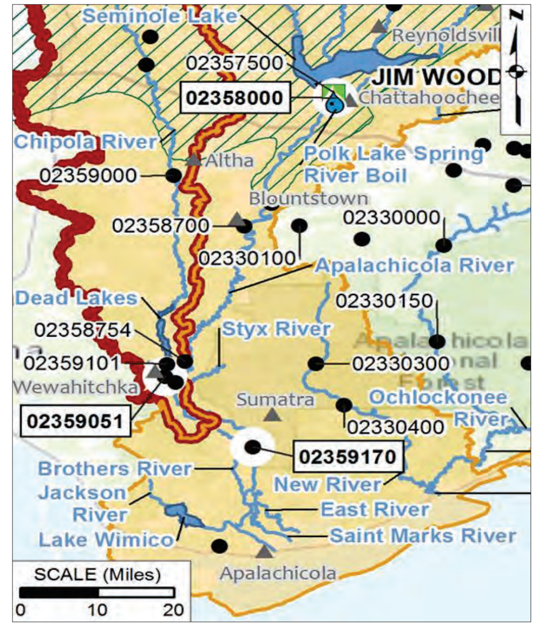

Summary Statistics

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

Notes:

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

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FIGURE C-8
STREAMFLOW IN NEARBY RIVERS COMPARED TO APALACHICOLA RIVER

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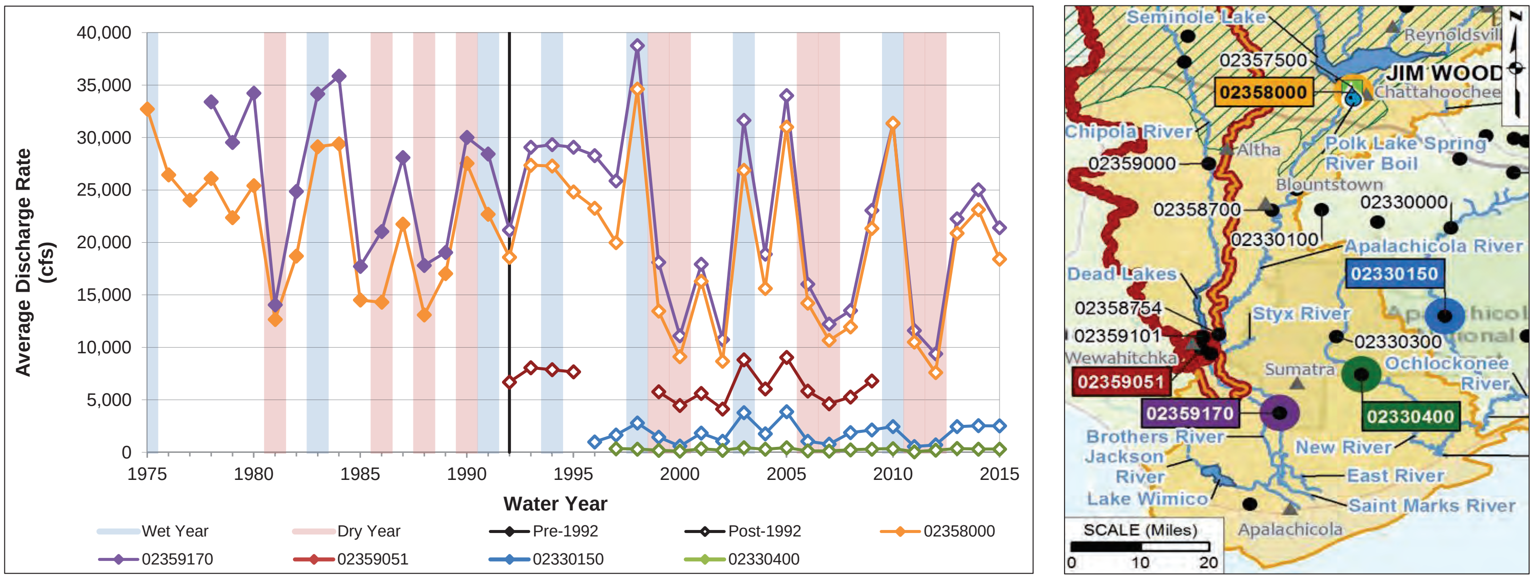

Summary Statistics

USGS Station ID	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Average Discharge Rate (cfs)												
02358000 Upper Apalachicola River	12,661	7,605	17,041	13,085	22,697	19,295	26,452	25,340	32,718	34,617	22,231	19,461
02359170 Lower Apalachicola River	14,063	9,384	19,552	15,406	28,262	21,833	32,566	29,067	35,843	38,763	26,306	22,075
02359051 Lower Chipola River	NA	4,118	NA	5,439	NA	6,039	NA	7,771	NA	9,058	NA	6,448
02330150 Lower Ochlockonee River	NA	554	NA	1,033	NA	1,801	NA	2,473	NA	3,868	NA	1,843
02330400 Lower New River	NA	58	NA	196	NA	304	NA	353	NA	449	NA	270

Note: NA = Data not available for the specified time period.

FIGURE C-9
RELATIVE PERCENT OF STREAMFLOW COMPARED TO APALACHICOLA RIVER (USGS STATION ID 02359170)

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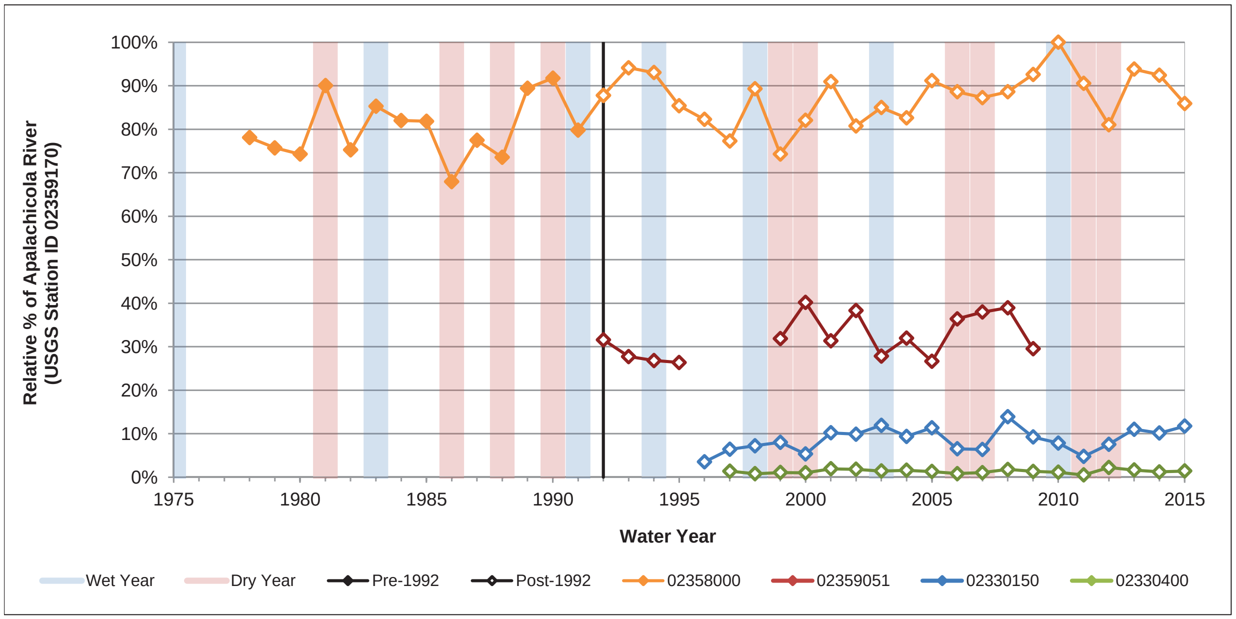
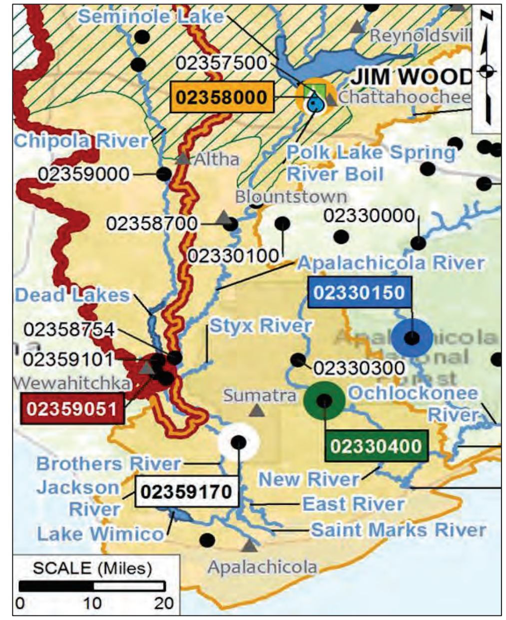
Case No. 142 Original





Summary Statistics

USGS Station ID	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Relative % of Apalachicola River (USGS Station ID 02359170)												
02358000 Upper Apalachicola River	68.0%	74.3%	75.4%	82.5%	78.9%	88.2%	84.5%	91.5%	91.7%	100.0%	80.2%	87.4%
02359051 Lower Chipola River	NA	26.4%	NA	27.8%	NA	31.6%	NA	37.2%	NA	40.2%	NA	32.2%
02330150 Lower Ochlockonee River	NA	3.5%	NA	6.5%	NA	8.6%	NA	10.4%	NA	13.9%	NA	8.6%
02330400 Lower New River	NA	0.5%	NA	1.1%	NA	1.3%	NA	1.6%	NA	2.2%	NA	1.3%

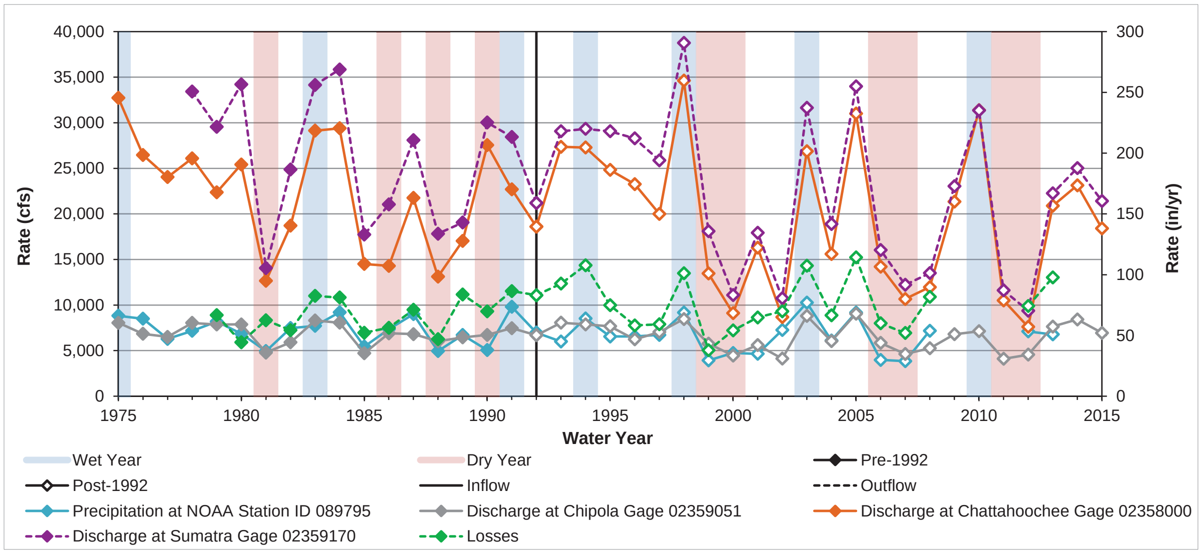
Note: NA = Data not available for the specified time period.

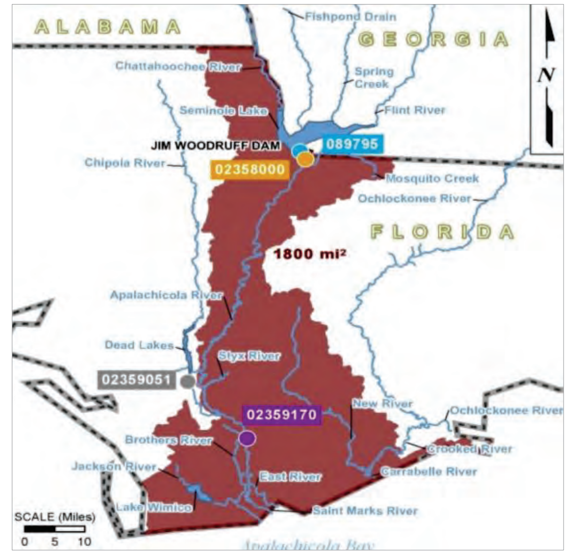
GSI Job No. 4198
Issued: 20 May 2016

GSI ENVIRONMENTAL

FIGURE C-10
WATER BUDGET FOR THE APALACHICOLA RIVER BASIN

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





Notes:
1. * = Streamflow data for USGS Station ID 02359051 for water years 1975 through 1991, 1996 through 1998, and 2010 through 2015 were extrapolated from the relationship between streamflow at USGS Station IDs 02359000 and 02359051. The relationship between these stations is identified by the equation y = (2.9172*x) + 2436, where y is the streamflow at USGS Station ID 02359051 and x is the streamflow at USGS Station ID 02359000. The R-squared (r^2) value for this relationship is 0.9037.
2. The primary and secondary y-axes represent the same data in different units.

Summary Statistics

	Minimum		25th Percentile		Median		75th Percentile		Maximum		Average	
	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992	Pre-1992	Post-1992
Annual Precipitation (NOAA Station ID 089795)												
(cfs)	4,948	3,841	6,285	5,371	7,356	6,722	8,495	7,220	9,813	10,257	7,265	6,604
(in/yr)	37	29	47	41	55	51	64	54	74	77	55	50
Average Discharge Rate (cfs)												
02359051	4,726	4,096	6,456	5,529	6,845	6,749	7,875	7,720	8,302	9,058	6,903	6,552
02358000	12,661	7,605	17,041	13,085	22,697	19,295	26,452	25,340	32,718	34,617	22,231	19,461
02359170	14,063	9,384	19,552	15,406	28,262	21,833	32,566	29,067	35,843	38,763	26,306	22,075
Losses												
(cfs)	5,923	5,040	7,233	7,943	8,890	9,887	10,826	12,697	11,535	15,238	8,801	10,226
(in/yr)	45	38	55	60	67	75	82	96	87	115	66	77

ATTACHMENT 6

Excerpts from the Deposition Transcript of Sorab Panday (Aug. 1 and 3, 2016)

S. Panday

No. 142, Original

IN THE SUPREME COURT

OF THE UNITED STATES

STATE OF FLORIDA,

Plaintiff,

vs.

STATE OF GEORGIA,

Defendant.

Before the Special Master

Hon. Ralph I. Lancaster

VIDEOTAPED DEPOSITION OF SORAB PANDAY

New York, New York

Monday, August 1, 2016

Reported by:

THOMAS A. FERNICOLA, RPR

JOB NO. 108991

S. Panday

Monday, August 1, 2016
9:00 a.m.

VIDEOTAPED DEPOSITION of SORAB PANDAY, held at The Law Offices of Latham & Watkins, LLP, 885 Third Avenue, New York, New York, before Thomas A. Fernicola, a Registered Professional Reporter and Notary Public of the State of New York.

S. Panday

A P P E A R A N C E S:

LATHAM & WATKINS
Attorneys for the Plaintiff
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BY: PAUL SINGARELLA, ESQ.
BY: GARRETT JANSMA, ESQ.

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Attorneys for the Defendant
655 Fifteenth Street, Northwest
Washington, D.C. 20005
BY: ZACHARY AVALLONE, ESQ.
601 Lexington Avenue
New York, New York 10022
BY: DEVORA ALLON, ESQ.

ALSO PRESENT:
Christian Bidonde, Legal Video Specialist.

S. Panday

THE VIDEOGRAPHER: This is the start of media labeled No. 1 of the videotaped deposition of Dr. Sorab Panday, in the matter of State of Florida versus State of Georgia, in the Supreme Court of the United States, Original Action No. 142.

This deposition is being held at 885 Third Avenue, New York, New York, at the Offices of Latham & Watkins, on August 1, 2016.

My name is Christian Bidonde. I am the legal video specialist with TSG Reporting.

The court reporter is Tom Fernicola in association with TSG Reporting.

Will counsel please introduce yourself.

MR. SINGARELLA: Good morning. Paul Singarella for Florida.

MR. JANSMA: Good morning. Garrett Jansma of Latham & Watkins on behalf of the State of Florida.

MR. AVALLONE: Zachary Avallone from Kirkland & Ellis, on behalf of Georgia.

S. Panday

MS. ALLON: Devora Allon, Kirkland Ellis, for the State of Georgia.

THE VIDEOGRAPHER: Will the court reporter please swear in the witness.

S O R A B P A N D A Y,
called as a witness, having been duly sworn by a Notary Public, was examined and testified as follows:

BY THE REPORTER:

Q Please state your full name and address for the record.
A Sorab Panday. The address is 626 Grant Street, Suite C, Herndon, Virginia 20170.

EXAMINATION

BY MR. SINGARELLA:

Q Good morning, Doctor.
A Good morning.
Q How are you today?
A Good. Thank you.
Q Any reason your deposition should not proceed today?
A No.
Q Have you had your deposition taken

S. Panday

before?

A I have done a deposition before, but not for this case.

Q How many times have you had your deposition taken?

A I have had my deposition taken three times.

Q When was the most recent time?

A It must have been seven, eight years ago.

Let me correct that. It must be like five years ago, I would say.

Q Were you deposed in the capacity of a scientist?

A That is correct.

Q Were you working as an expert in a case?

A That is correct.

Q What was the name of the case?

A I don't recall the name of the case itself.

Q What part of the country was it in?

A It was in Michigan.

Q Who was your client?

S. Panday

A My client was BP.

Q What was the nature of your work in that matter for BP?

A I was evaluating the quantity of petroleum that had passed their property line.

Q Prior to your work on that case, when had you previously been deposed?

A It was, I believe, over ten years ago.

Q What part of the country was that matter in?

A That was in Santa Monica.

Q Who was your client?

A I don't recall.

Q What was the nature of your work in that case?

A For that case, all I was doing was establishing that a code that had been -- that a code that had been used was appropriate to use.

Q Do you recall being deposed prior to the Santa Monica matter?

A No, I haven't.

Q Just those two?

S. Panday

A Just those two, yes.

Q So you understand you're here testifying on behalf of Georgia today, and you understand that if I ask you -- I'm here on behalf of Florida. If I ask you a question and you give me an answer, I'm going to presume that you understood the question; is that fair?

A That is fair.

Q And if you don't understand a question, please let me know however you choose to do that, you know, "Counsel, I don't understand the question," or, "I can't answer that," however you choose to do it. I want to make sure we get a clear record and that you understand the questions.

Is that fair?

A Yes, that's fair.

Q Are you of clear mind today and able to proceed and give your best and most accurate testimony?

A Yes.

Q Okay. Great.

Are you basically familiar with the

S. Panday

rules of a deposition?

A Yes.

(Panday's Exhibit 1, Expert report and appendices, was marked for identification.)

BY MR. SINGARELLA:

Q So we have marked, for the record, Exhibit 1 to your deposition.

Do you have that in front of you?

A Yes, I do.

Q What we did is we took your expert report and appendices, and we combined them into a single exhibit, which we've marked as Exhibit 1.

We did two things to just ease our communication and to make the deposition go along. One was just to put in actual tabs A through H.

Do you see that?

A Yes, I do.

Q And the other thing that we did, because there's a lot of material here, it's actually 455 pages starting from the cover, is in the lower right-hand corner of every page

S. Panday

Q Could you read that sentence and the next sentence into the record, please?

A "I have not attributed the flow decline to consumptive use, nor have I quantified or evaluated the possible causes."

Q Could you read the next sentence, too?

A Sure.

"I have not claimed that the water was diverted unnoticed or that large amounts of water will be withdrawn for irrigation."

Q And this is -- this reflects -- the two sentences that you just read, that reflects the status of your work as of July 26; right?

A That reflects a response for Dr. Hornberger, who claims that the possible causes were diverted unnoticed or large amounts of water were being withdrawn for irrigation. That's all that reflects.

Q Now, in the first sentence that you read, what do you mean by "quantified"?

A I have not quantified or evaluated the possible causes. So I have not tried to

S. Panday

say how much is because of what cause, and I don't even know what the various causes are. So I haven't tried to break up that number into its subcomponents of what those causes could be.

Q And in that first sentence you read, what do you mean by "evaluated"?

A By "evaluated," I mean, that I haven't looked at what the possible causes would be. All I have done was reflect what the data has shown me.

Q And in that first sentence, what do you mean by "I have not attributed"?

A What I mean is the same thing, that I have not tried to quantify the causes for this flow decline, I have just presented what the data shows me.

Q As-is, right, the data?

A The data that was presented, I took the data, and I did a difference between the Sumatra and Chattahoochee gages, but otherwise -- and that is what I'm talking about, is how much is the difference between the flow at Sumatra versus the flow at

S. Panday

Chattahoochee.

Besides that, I have not changed anything from the data that was given to me.

Q And by a "difference," you mean you subtracted one value from the other?

A Right. I was seeing how much comes out at Chattahoochee versus how much flows out at the Sumatra gage.

Q And in that same paragraph here on page 4, you go on to say -- you start talking about possible causes, and you indicate that those could be plenty; correct?

A Yes, there could be other causes.

Q When you refer to "possible causes identified by Dr. Hornberger," you refer to "physical conditions."

Do you see that?

A Can you read specifically what you're referring to?

Q "Changes in physical conditions as referred to by Dr. Hornberger."

Do you see that part of your sentence?

A Right, I see that sentence.

S. Panday

Q Could you turn to the next exhibit, which is Dr. Hornberger's May 20 report?

We've marked it as Exhibit 20.

(Panday's Exhibit 20, Dr. Hornberger's report, was marked for identification.)

BY MR. SINGARELLA:

Q Could you show me in Dr. Hornberger's report where he refers to changes in physical conditions that might constitute a possible cause for this difference between the gage records?

A I'll have to search. If I can electronically search, I should be able to find it a lot easier.

Q Okay. Do you have it on your own computer?

A I don't have my computer here with me.

Q Okay.

We'll try to get an opportunity for you to do that, sir.

In the meantime -- oh, sir, would you mind if Mr. Jansma approached to pull it

S. Panday
Q So let's turn to page 3 of your expert report.
A Yes, I'm there.
Q And here on page 3, No. 4 -- page 3, point No. 4 --
A Yes, I see that.
Q -- you refer to that -- that reach between the Chattahoochee gage and the Sumatra gage as a "losing reach"; correct?
A On this page, I refer to the Apalachicola River from Chattahoochee gage to the Sumatra gage within Florida as a losing reach, that is correct, and that the losses are increasing with time.
Q And does that opinion reflect a belief that the loss of water between the two gages is a real physical loss of water?
MR. AVALLONE: Objection to form.
A The measured flows at the Sumatra gage when compared with the measured flows at the Chattahoochee gage indicate that there was a loss, and that that loss has been increasing in time.
Q Do you believe that loss is real,

S. Panday
that there's truly a physical loss of water from Point A to Point B?
MR. AVALLONE: Objection to form.
A I have no reason not to believe that it is a loss of water to groundwater or to any of the other possibilities.
Q So let's talk about the magnitude of the loss for a few minutes. Okay?
A Sure.
Q Let's turn to page 26 of your report.
A Yes, I'm there.
Q So the carryover paragraph, or maybe -- in any event, the top of page 26 talks about the steady increase in this net loss.
Do you see that?
A Yes, I see that.
Q And then you quantify it in the next sentence. You say:
"The net loss along the Apalachicola River increases from about 700 cfs in the late 1970s to over 6,000 cfs in the 2010's changing by over 53,000 cfs."

S. Panday
Do you see that?
A Yes, I see that statement.
Q So the difference that you're describing there is actually 5,300 cfs; correct?
A That is correct, that 5,000 cfs refers to the loss from the late '70s to 2010's.
Q And this is obviously a number from your May 20 report.
Put that in some context for me, if you could, sir, in the sense of what does that mean over the period of record that you're assessing here?
MR. AVALLONE: Objection to form.
A That means that the loss has increased through time since the late '70s to the 2010's.
Q So let's just use a hypothetical. Let's just say that you've got 10,000 cfs at the Chattahoochee gage, and 15,000 cfs at the Sumatra gage back in the late '70s.
Okay?
A Okay.

S. Panday
Q Are you saying that by the 2010's, what would have shown up at the Sumatra gage would have been 15,000 less 5,300?
MR. AVALLONE: If you need someone to keep notes and make calculations, I can get that for you as well.
MR. SINGARELLA: That would be fine.
A Sorry, can you just repeat that question?
I didn't know where the 53,000 or 15,000 came from. I just lost track of that.
Q Oh, sure.
I'm trying to get a sense as to -- can you give me an example in your own words as to how this would look on the ground using a flow at the Chattahoochee gage back then and today, just to illustrate it?
A I do not understand the question.
When you say, "using a flow," I'm not sure what you mean.
Q I'll try to be more straightforward. I'm sorry. With all this technical stuff, it's hard to ask straightforward questions sometimes.

S. Panday

water budget. So when we just look at the river, it is a different water budget from the water budget that we're evaluating when we do that for the basin.

Q Okay.

I'm sorry, sir, where is your -- well, let me just ask you, because I don't have a page reference for this, but does the value 10,226 cfs mean anything to you?

MR. AVALLONE: Objection.

Q Do you know where that value comes from in your water budget analysis?

Is it on page 64?

A That is correct, on page 64 of 455, I see the number 10,226 under losses for the entire basin, and that is for post-'92 conditions for average.

Q Oh, I see. And the difference would be 1,022 -- strike that.

The difference would be 10,226 less 8,801; correct?

A Between three and post-'92 conditions, the difference between 10,226 minus 8,801.

S. Panday

Q And that's your 1,425; correct?

A And that I believe is 1,425.

Q Then you also, both in your July 26 memo and here on page Florida 65, Figure 3-6, you mention the value of 2,339 cfs, and I want to ask you a question about that.

Let's start with Figure 3-6, on Florida page 65.

A That's right. I'm there.

Q Do I understand that your number of 2,339 is the difference between 3,938 and 1,599?

A I could do the calculation, but it looks like that's what it is, yes.

Q You came out in your July 26 memo, and you're standing behind that value, right, the 2,339?

MR. AVALLONE: Objection to form.

A I am standing behind the value of 5,254 minus 2,614, which is on the next line, and we can work that out.

It's 2,000 something, very similar.

The previous value, what had happened there was that I did use that line,

S. Panday

the Chipola River gage, and that Chipola River gage has partially double counted flow coming from the Apalachicola River because there's the Chipola cutoff, which brings in flow from the Apalachicola to the Chipola River, and that gage was downstream of this cutoff.

There were gages upstream of the cutoff, but they didn't have enough data and -- so I stand by the number of 5,254 minus 2,614, because that does not include the Chipola River.

Q What is that difference, sir?

A That's 2,640 cfs.

Q Okay.

MR. AVALLONE: Paul, did you want the napkin as an exhibit?

MR. SINGARELLA: No.

MR. AVALLONE: Just checking.

MR. SINGARELLA: It will not be spoilage if that napkin disappears or if Dr. Panday needs to use it for something else.

(A Discussion was Held off the Record.)

S. Panday

MR. SINGARELLA: Can we take a break here for a bit?

THE WITNESS: Sure.

MR. SINGARELLA: Thanks.

THE VIDEOGRAPHER: The time is 3:40 p.m. Media 4. Off the record.

(Recess taken from 3:40 p.m. to 3:53 p.m.)

THE VIDEOGRAPHER: The time is 3:53 p.m. This begins Media 4.

On the record.

BY MR. SINGARELLA:

Q Doctor, could you turn to Dr. Bedient's report, Exhibit 19, page 76?

A Yes, I'm there.

Q He's got a section called, "Section C, Florida's contribution to flows into Apalachicola Bay has decreased in recent years."

Do you see that?

A I see that, yes.

Q And it goes on for a couple of pages and it ends on page 79.

Do you see that?

S. Panday

out, you know, what could you do with the 5,000 cfs if it were -- the 5,000 cfs in your May 20 report -- strike that. We don't need to go there right now. Thank you, Doctor.

Let's keep out your same memo here, Exhibit 5.

A Yes, I have it.

Q Now, Exhibit 5, it indicates your awareness that the USGS rating curve for Sumatra had been updated three times over the period of record; correct?

A From that first rating curve that we evaluate, there are three more revisions to the rating curve, as I see it, and that's also been represented by Dr. Hornberger.

Q And principally, on that basis, on page 6 of 7 of your July 26 memo, you write that you believe that the most reliable data for flow measurements are the flow rates as reported by the USGS; is that correct?

A I do believe that the flow measurements reported by the USGS are the most updated and recalibrated estimates of flow for that time period.

S. Panday

Q And then, in the two paragraphs down, the one that begins, "To evaluate Dr. Hornberger's adjusted," do you see that?

A Yes, I see that.

Q The very last sentence of that paragraph indicates that you believe that the preexisting rating curves available from the Sumatra gage and relying upon them was the right approach.

Do you see that?

A I say that "Using rating curves that evolve with physical conditions and measurement techniques is the right approach."

Q Did you conduct an independent analysis of the Sumatra record?

MR. AVALLONE: Objection to form.

A In what context are you asking that, please?

Q In the context of this case, did you independently analyze the USGS Sumatra record?

MR. AVALLONE: Objection to form.

A The USGS Sumatra record I have analyzed in terms of what I present in this memorandum.

S. Panday

And what I have analyzed, therefore, is -- first of all, that I've looked at the three -- the four different rating curves, which Dr. Hornberger displayed, and I get the same four different rating curves.

Then I evaluated what the flow would be had we used only the original first rating curve, which is for 1978 through 1985, as Dr. Hornberger had done, and how that flow changes through time at the Sumatra gage.

And I have analyzed then the streamflow budget for the Apalachicola River itself, and this was directly from Dr. Langseth's report, and I just took his curves and I added trend lines to that.

So those have been my analysis.

Q Did you identify any unusual divergences in the Sumatra gage record?

MR. SINGARELLA: I apologize for that.

THE WITNESS: Can we go on?

MR. SINGARELLA: Christian, are we okay?

Q Okay.

S. Panday

A Can you repeat the question, please?

Q I surely can. I'm sorry, sir.

Can you identify any unusual divergences in the Sumatra gage record?

MR. AVALLONE: Objection to form.

A Not that I know of.

When you mean "unusual divergences," I'm not sure what you are referring to, but I thought that the gaged data was reasonable.

Q Did you notice any things about the Sumatra flow records that raised questions?

MR. AVALLONE: Objection to form.

A No, I did not notice anything. There were no questions raised. Nothing flagged me.

Q Did you notice any instances in which the reported records for the Sumatra gage materially misreported flow at Sumatra?

MR. AVALLONE: Objection to form.

A Nothing in the flow record struck to me that things were misreported.

Q Did you notice any sudden jumps in flows where over a period of time the flow record would jump back and forth --

S. Panday

Q Yes. I didn't mean to cause any confusion there. I apologize.
So Exhibit 21 is a report dated May 20 from Dennis Lettenmaier entitled, "Apalachicola-Chattahoochee-Flint Basin Hydroclimate Analysis."
Do you see that?
A This exhibit is titled, "Apalachicola-Chattahoochee-Flint Basin Hydroclimate Analysis, Defensive Report, Incremental Flow Analysis between Chattahoochee and Sumatra Gages," yes.
Q Have you reviewed Exhibit 21?
A I may have seen figures like this somewhere else, but I don't recall having reviewed this document.
Q Are you aware that Dr. Lettenmaier looked at the incremental flow between the two gages and concluded that there was no plausible hydroclimatic explanation for the differences?
MR. AVALLONE: Objection. Foundation.
A I'm not aware of.

S. Panday

I looked at Dr. Hornberger's criticism of my data, but that's because I looked at Dr. Langseth's criticism of my evaluation, so that led me to Dr. Hornberger.
So these are the two that I have evaluated.
Q Okay. Thanks.
Do you know Dr. Charlie Menzie?
A No, I don't.
Q Do you know he's working on this case for Georgia?
A I've heard the name, but I don't know what he does.
Q So I take it you don't know that his team made an independent check of the Sumatra gage record?
MR. AVALLONE: Objection to form.
A No, I don't know that.
(Panday's Exhibit 22, a few pages from Dr. Menzie's deposition, was marked for identification.)
BY MR. SINGARELLA:
Q I'm finally up to 22, and it's -- Exhibit 22 is a few pages from Dr. Menzie's

S. Panday

deposition, which occurred in Washington, D.C., starting a week ago today.
We've created an exhibit from that transcript simply where he was answering some questions I had from him about the Sumatra gage.
And at the bottom of page -- transcript page 2, the second page of the exhibit, at the bottom of the page he indicated that his team recognized that there were -- that there may have been some operational issues from time to time with the Sumatra gage.
Do you see that?
A It says:
"We recognize that there were -- that there may have been some operational issues from time to time with the Sumatra gage."
Q Until I just showed you this, you were unaware that he believes he had identified such operational issues; correct?
A I wasn't aware of that, that he had done this analysis.

S. Panday

MR. AVALLONE: Objection to form.
Q Can you turn to transcript page 7, which should be the next page of the exhibit, and you can see in his big answer there on page 7 he refers to these operational aspects again, and at the bottom of the page I asked him: "What analysis have you made to support any such explanation?"
Do you see that?
A Yes, I do.
Q And on the next page, page 8 of the transcript, he provides his answer to my question.
Do you see that?
A I see that, yes.
Q And he says, I had one of our hydrologists look at the data for Sumatra and there were, in those datasets, kind of unusual divergences at particular times so that it wasn't -- so that it was apparent I wasn't -- the Sumatra gage wasn't always performing in keeping with what you would think -- what you think would be the operational expectations for the gage -- for that gage.

S. Panday

I didn't paraphrase that very well, but you're reading along with me; correct?

A I'm reading along with you, yes.

Q And you see that he's testifying that there were unusual divergences at particular times in the Sumatra gage record; correct?

A He says over here that there were divergences at particular times.

Q And until I just showed you this transcript, you didn't know he had identified such divergences; correct?

A I did not know he had even done this analysis.

Q So if you look at the next page, I asked him about uncertainty, because he raised it.

At the bottom of the page, my last question to him was: "When you say, 'uncertainty around those gage measurements,' what do you mean?"

Do you see my question?

A I see your question there, which says: "When you say, 'uncertainty around those gage measurements,' what do you mean?"

S. Panday

Q And then he answers:

"If you look at the record over long periods of time, there are things about the flow records that raise questions. Why is this diverging in such a way over this period of time relative to some previous period of time?"

Do you see that?

A I see that, yes. But I don't know what he's talking about, what he's referring to here.

Q Have you identified any specific questions that you have with regard to the functioning of the Sumatra gage itself?

MR. AVALLONE: Objection to form.

A No, I have not.

I think that the USGS data that was supplied, there can be uncertainties, first, that it was accurate. If there are uncertainties, the uncertainties existed throughout time. It's not that uncertainties grew now but they weren't there previously.

Q How do you know that?

S. Panday

A Because the uncertainty is there in computation, which he talks about. It's there before as well as after. It's the same river. It's the same gage. It's the same situation that has been measured.

Q Constant with time?

A It's not constant with time. The physical conditions change with time. The measurement methodology changed with time and, therefore, the flow ratings changed with time.

(Panday's Exhibit 23, email, dated June 4, 2016, was marked for identification.)

BY MR. SINGARELLA:

Q Did you receive any copies of emails from the USGS regarding the Sumatra gage?

A On Friday, I saw some communication from the USGS regarding the Sumatra gage.

Q Was it a letter?

A I don't recall what it was.

Q Do you know as of June 8 of this year someone from the USGS indicated that computerized discharges below 12,000 cfs at the Sumatra gage should be considered poor?

S. Panday

MR. AVALLONE: Objection. Foundation.

A I don't recall that.

If you show me something, I would be able to look at it.

Q Here you go.

So we've marked Exhibit 23 to your deposition, which is an email from Ronald Knapp of the USGS dated June 4, 2016, to Dennis Lettenmaier, an expert for Florida.

Do you see that, sir?

A Yes, I see that this is an email from Ronald Knapp at the USGS to Dennis Lettenmaier.

Q Have you seen this email before?

A No, I have not seen this email before.

Q Do you know the USGS rating system of good, fair, and poor with regard to gaging stations?

A I have seen that, yes.

Q Have you -- in your discipline, have you relied upon USGS gage data where the USGS itself says that the record is poor, at least

S. Panday

his book?

We've put a red rectangle around the second half of the paragraph where he describes what he calls the "scientific method."

Do you see that, sir?

A Could you point me to where he talks about the scientific method?

Q Do you see the red box?

A Yes.

Q Right there with the beginning of the sentence, "These shortcuts should be familiar to most."

Are you with me?

A I'm reading that sentence, yes.

Q Okay. Yes, you can read what's inside the red box, please.

A Is someone's phone buzzing.

Q Not mine.

MR. SINGARELLA: Would you like to take a break, sir?

(A Discussion was Held off the Record.)

A Yes, I read that statement in the

S. Panday

red box.

Q Do you see his reference to "identifiable phenomenon"?

A It says, "We first isolate analytically the identifiable phenomenon of limited scope."

Q Right.

And is that what you did here, sir, in terms of identifying the difference between the Chattahoochee and Sumatra gages?

MR. AVALLONE: Objection to form. Foundation.

A I do not know the context of this whole document, and the previous statement talks about solving complex equations that don't have solutions, and that is why things are simplified.

So I don't know what context you are referring to when you say, "Isolate analytically and identify phenomenon of limited scope."

Q Okay.

S. Panday

(Panday's Exhibit 27, printout from Britannica Online Encyclopedia, was marked for identification.)

BY MR. SINGARELLA:

Q Exhibit 27 is also from Encyclopedia Britannica, as was Exhibit 25. It's a description of the scientific method, and then an illustration for a schematic of it.

Do you see that, sir?

A I see Exhibit 27 has a schematic and a little writeup to the side.

Q With regard to your observations about this Sumatra gage, where are we in the scientific method from your perspective with regard to that?

MR. AVALLONE: Objection to form. Foundation. It assumes facts not in evidence.

A We are at the report findings stage. I have reported my findings of the data, which I analyzed between the Sumatra and Chattahoochee gages.

Q What hypothesis testing have you done?

S. Panday

A The context of this page is different. This context of this page is doing experiments and formulating hypothesis.

What I have done is I've taken data from the Sumatra gage, I've taken data from the Chattahoochee gage, and just subtracted the two. And I'm presenting the results of my findings.

Q Did you go from the upper left-hand box directly to report findings?

MR. AVALLONE: Objection to form.

A I read this exhibit and, like I said, it refers to something else. It refers to formulating of hypothesis. It refers to experiments to verify those hypotheses.

I haven't formulated a hypothesis. I did not prejudge something and then try to fit the data, I just looked at the data and I'm just presenting the data.

That's what I've done.

Q When you say you have not formed a hypothesis, what do you mean?

A I did not form a hypothesis saying that flow at the Sumatra gage is less or more

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S. Panday
than flow at the Chattahoochee gage and that it increased or decreased through time, and then do experiments to figure out whether that hypothesis is correct. That's what I mean.
This isn't an experiment in that sense where you create a hypothesis, do an experiment to validate your hypothesis. What I did is an analysis of the data, which has been presented, and in analyzing my data, I evaluated that the flow has been decreasing through time.
Q Have you tested possible causes for the difference in a manner that's consistent with Exhibit 27?
MR. AVALLONE: Objection to form. And foundation.
A I have presented the data, and I was not -- it was out of my scope to test why there has been this reduction in flow through time for flow -- the difference between the Chattahoochee and Sumatra gages.
Q So you did the upper left-hand corner box; right? You collected information, you made observations, and asked questions;

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S. Panday
correct?
MR. AVALLONE: Objection to form. Mischaracterizes the document and prior testimony.
A I haven't been looking at this document and following this document because it's not appropriate for my analysis.
What analysis I have done was essentially to look at what is the difference in flow between gages. And I did that not just for this gage, but I have done that in my report for other gages as well, just to figure out what would be that baseflow or what is the increment of flow between those two gages. And in that whole analysis for all the gages I have done, this was one more of those analysis.
Q And in your prior answer when you referred to "this document," you mean Exhibit 27; correct?
A That is correct. I have not been -- I did not have Exhibit 27 in front of me, and that Exhibit 27 is not appropriate for what I was evaluating here, which was just the

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S. Panday
difference in flow between gages so I can see whether there's a flow gain or a flow reduction between those two gages.
Q So if you turn back to Dr. Hornberger's report that you looked at, which was marked today as Exhibit 20.
A Yes, I have it in front of me.
Q And I think he's saying, at the end of that first paragraph on page 4, that the evaluation undertaken by Georgia is not a strict application of the scientific method.
Do you see that?
He says:
"A claim that water is lost without any indication of why the change might have occurred represents a fundamentally unscientific approach"?
A He says here in his last sentence that:
"A claim that water is lost without any indication of why the change might have occurred represents a fundamentally unscientific approach that essentially negates conservation of mass inasmuch as no divergence

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S. Panday
of groundwater withdrawals in this stretch of the Apalachicola River could support such a hypothesis."
That's what this sentence says.
Q And do you disagree with that sentence?
MR. AVALLONE: Objection to the form of the question.
A I do disagree with that sentence, yes.
Q And on what basis?
A I have not negated conservation of mass, is the first thing. I have not hypothesized on divergence of groundwater withdrawals in this stretch of the Apalachicola River and that -- so that it could support such a hypothesis. This hypothesis was his.
Q You have not yourself developed a hypothesis to explain the difference between the two gages that you report; correct?
A As I mentioned earlier, there are possibilities, and we did go over those possibilities, as to why there could be that

S. Panday
baseflow reductions in the ACF River Basin, and that is what I have done.
Q Would you agree simply from a scientific perspective that a separate model for the Apalachicola River itself would allow testing of a complex hypothesis that might explain the difference between the two gages?
MR. AVALLONE: Objection to form.
A Scientific modeling would be required to determine what happens hydrologically between the Chattahoochee and Sumatras.
Q And is that because of the complexity of the problem?
MR. AVALLONE: Objection to form.
A That is because of the complexity of the problem, which includes natural changes, which includes several other factors, and I'm not trying to delineate or even quantify or even hypothesize as to what those factors are within Florida.
Q Do you see the last two sentences that you read, the entry from Encyclopedia Britannica draws a distinction between complex

S. Panday
hypotheses, on the one hand, and simple hypotheses on the other hand?
MR. AVALLONE: Objection to form. The document speaks for itself.
A These last two sentences say that scientists strive to develop simple hypotheses since they are easier to test relative to hypotheses which would have many variables, which would, therefore, probably require scientific models.
Q Would the hypothesis that the USGS is experiencing difficulty measuring the actual streamflow at the Sumatra gage be a relatively simple hypothesis to explore?
MR. AVALLONE: Objection to form.
A My knowledge and expertise is not on how a gage is calibrated or how the gaging is performed. So I wouldn't be able to answer that question.
Q Okay.
I want to get into your groundwater modeling in a little more detail now.
And first, I'd like to present to you just a brief table that we prepared to

S. Panday
summarize the different simulations that you ran, and I want you to help me make sure that we understand what you did correctly.
(Panday's Exhibit 31, a table, was marked for identification.)
BY MR. SINGARELLA:
Q Do I understand that you had three simulation years, 1992, 2011, and 2013?
A For my transient modeling analysis, I simulated 1992 conditions, 2011 conditions, 2013 conditions, as well as no pumping conditions.
Q Do I understand that you had two simulation hydrologies, one normal and one dry?
A In my simulations with MODFE, I had used a normal hydrology and a dry hydrology.
Q Do I understand that you picked a warm-up period for each?
A For each of those hydrologies, I followed the methodology that Jones and Torak applied, which uses a warm-up period.
Q And you elected to use October 1999, as the warm-up period for the normal

S. Panday
hydrology; correct?
A I believe I used October 1999, as the starting steady-state simulation, and after that, there was a six-month warm-up period from that to start the simulation from March through February for every year that I analyzed.
Q Did you force the hydrology during the warm-up period for normal with October 1999, for each of the six months?
MR. AVALLONE: Objection to form.
A I do not recall exactly how the hydrology was during those six months warm-up period, but I followed exactly what Jones and Torak had done for their warm-up period.
Q Did Jones and Torak use October 1999, as a warm-up period?
MR. AVALLONE: Objection to form.
A Jones and Torak uses October 1999, as the steady-state condition to stop their model, but I don't recall what they used in the six-month warm-up period.
Q How about February 2011, did Jones and Torak use February 2011, as a warm-up

No. 142, Original

IN THE SUPREME COURT

OF THE UNITED STATES

STATE OF FLORIDA,

Plaintiff,

vs.

STATE OF GEORGIA,

Defendant.

Before the Special Master

Hon. Ralph I. Lancaster

CONTINUED VIDEOTAPED DEPOSITION OF

SORAB PANDAY

New York, New York

Wednesday, August 3, 2016

Reported by:

THOMAS A. FERNICOLA, RPR

JOB NO. 108993

Wednesday, August 3, 2016
1:00 p.m.

CONTINUED VIDEOTAPED DEPOSITION of SORAB PANDAY, held at The Law Offices of Latham & Watkins LLP, 885 Third Avenue, New York, New York, before Thomas A. Fernicola, a Registered Professional Reporter and Notary Public of the State of New York.

A P P E A R A N C E S:

LATHAM & WATKINS
Attorneys for the Plaintiff
650 Town Center Drive
Costa Mesa, California 92626
BY: PAUL SINGARELLA, ESQ.
BY: GARRETT JANSMA, ESQ.

KIRKLAND & ELLIS
Attorneys for the Defendant
655 Fifteenth Street, Northwest
Washington, DC 20005
BY: ZACHARY AVALLONE, ESQ.

ALSO PRESENT:
CHRISTIAN BIDONDE, Legal Video Specialist.
DAVID LANGSETH.

S. Panday
(Panday's Exhibit 65, Document, was marked for identification.)
THE VIDEOGRAPHER: The time is 1:10 p.m., August 3, 2016. This begins media 1.
On the record.
BY MR. SINGARELLA:
Q Good afternoon, Doctor.
A Good afternoon.
Q I'd like to start with what came over to us earlier this week from your counsel, which is called revised Figure 5. And we've had marked it as Exhibit 65.
Do you have that in front of you?
A I do.
Q And revised Figure 5 replaces Figure 5 from Exhibit 5; correct?
A Yes, that is correct.
Q And the Figure 5 in Exhibit 5 replaces Figure 3-5 in your original --
A No, it does not replace Figure 3-5. It's separate, aside from that.
Q Does it replace anything in Exhibit 1?

S. Panday
A No, it does not replace anything in Exhibit 1.
Q Is the subject of Figure 5, both revised and in Exhibit 5, the same subject matter as Figure 3-5 in your original report?
A The subject of Figure 3-5 in my original report was a water budget analysis for the entire upper Apalachicola River Basin.
The subject of the revised Figure 5 of Exhibit 65 is a water budget for the Apalachicola River Basin only up to the Sumatra gage, as well as the revised Figure 5 is created using Dr. Hornberger's interpretation of flow at the Sumatra gage, which I actually don't agree with.
But in despite the fact that I decided that to review -- to revise this figure to see how the numbers would look if I were to accept Dr. Hornberger's adjustments to the Chattahoochee gage -- to the Sumatra gage, sorry.
Q Do you agree that Figure 3-5 in your report Exhibit 1, Figure 5 in Exhibit 5, and revised Figure 5, which we've just marked as

S. Panday

same instruction.

A I do not know that.

Q Do you know whether Georgia EPD ever had any concerns about your work in this case?

MR. AVALLONE: Same objections. And, Dr. Panday, the same instruction.

A And I do not know that.

Q Okay.

MR. SINGARELLA: We have to change the tape. Let's take a quick break.

THE VIDEOGRAPHER: The time is 4:03 p.m. This is the end of video 2. Off the record.

(Recess taken from 4:03 p.m. to 4:12 p.m.)

THE VIDEOGRAPHER: The time is 4:12 p.m. This begins media 3. On the record.

BY MR. SINGARELLA:

Q In Exhibit 75, sir, did you note anything irregular with our preparation of Exhibit 75 other than your point about the mixing and matching?

MR. AVALLONE: Objection to form.

S. Panday

A I'm just seeing the exhibit today so I haven't had a chance to review it in detail.

Q By all means, take another look at it, please.

A Just glancing at it, it looks like a table where you have a column which shows water use, and then two other columns associated with that indicating population supplied and irrigated acres.

And the rows you have are the first row showing the water use of Dr. Bedient with population and irrigated acreages as obtained from my expert report with other two rows that uses a scaling of the population irrigated acres and of the water use.

Q And you appreciate that if Dr. Bedient is right, that Georgia's consumption of water in the Georgia portion of the ACF basin creates a streamflow depletion of 882, then according to your numbers and his, that would be enough water for 3.352 million people and about 700,000 acres of irrigation without throw; right?

MR. AVALLONE: Objection to form.

S. Panday

A If Dr. Bedient's value of 882 cfs were appropriate, then my estimation of the population supplied in my expert report as is obtained from a literature review, as well as my estimation of the irrigated acres as in my revised Table C-8 that would be supplied, then that would be the consumptive use as defined by Dr. Bedient.

Q And if the number of 2,640, your number, if that's really happening in the Apalachicola, and if that water could be put to use to the same proportions as water is being put to use in Georgia, it would be enough water to support 10 million people and to irrigate 2.1 million acres of farmland; right?

A These numbers are for the ACF River Basin. This population is for Georgia and these irrigated acreages are for Georgia.

So if Georgia's population was to increase to 10 million people, and if Georgia's irrigated acreages were to increase to 2 million acreages with the pumping being at the same locations only scaled up, then

S. Panday

according to this table if we were to accept that this is Dr. Bedient's values, if I were to accept Dr. Bedient's values, which I have not checked before, then the scaling of 2,640 cfs for that population in Georgia and that irrigated acreage in Georgia would be appropriate.

Q And similarly for the scaling to the 5,000, correct, your number of 5,000?

A And similarly to a scaling of 5,000 cfs, if the population in Georgia were to increase by up to 19 -- 19 million people --

Q It's late in the day.

A -- and irrigated acreages were to increase to around 3.9 million acres, then the consumptive water use as per Dr. Bedient's calculation would be 25,000 cfs according to scaling of the first row in Exhibit 75.

Q Okay, thank you.

There are a few other documents associated with your 1998 report, and I want to share them with you and see if you recognize any of them.

ATTACHMENT 7

Population that Could Be Served and Acres that Cound Be Irrigated Using Georgia's Reported Values (Panday Dep. Ex. 75, Aug. 3, 2016)

Population that Could Be Served and Acres that Could Be Irrigated Using Georgia's Reported Values

Water	**Population supplied**	**Irrigated acres**
882 cfs[i]	3,352,000 people[ii]	693,756 acres[iii]
2,640 cfs	10,033,197 people[iv]	2,076,549 acres[v]
5,000 cfs	19,002,268 people[vi]	3,932,857 acres[vii]

---

[i] As reported in Georgia's files produced in support of Dr. Bedient's May 20, 2016 expert report, total annual average streamflow depletions caused by water use in the Georgia portion of the ACF basin in 2011: 310 cfs (M&I) + 572 cfs (ag) = 882 cfs (total). See 20160223-ACF-GA-total-consumptive-monthly.xlsx. Florida believes there is more than 882 cfs consumed, but uses Georgia's values for the purposes of this table.

[ii] As reported in page B-1 in Dr. Panday's May 20, 2016 report, in 2010, the population of the Georgia portion of the ACF basin was 3.352 million people.

[iii] As reported in Dr. Panday's Revised Table C-8, in 2008-2011 the total irrigated acres in the Georgia portion of the ACF basin were 693,756 acres (which Dr. Panday testified does not include throw).

[iv] = 2640/882 * 3,352,000.

[v] = 2640/882 * 693,756.

[vi] = 5,000/882 * 3,352,000.

[vii] = 5,000/882 * 693,756.

ATTACHMENT 8

Letter from Rafael Rodriguez, Caribbean-Florida Water Science Center, Department of the Interior, U.S. Geological Survey, to Edward Chelette, Northwest Florida Water Management District (July 25, 2016)

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Caribbean-Florida Water Science Center
4446 Pet Lane, Suite 108
Lutz, Florida 33559-6302
Tel. (813)498-5000
Fax (813) 498-5002

July 25, 2016

Edward Chelette, Program Manager
Northwest Florida Water Management District
81 Water Management Drive
Havana, FL 32333

Dear Mr. Chelette:

Recent inquires prompted the U.S. Geological Survey (USGS) to evaluate the hydrologic record for the Apalachicola River at Sumatra gage (02359170). This letter explains the issues found with the record, and the correction plan going forward.

Larry Bohman (USGS Water Science Field Team), Darrell Lambeth (Caribbean Florida Water Science Center (CFWSC) Data Chief - Orlando), and Ron Knapp (CFWSC Field Office Chief - Tallahassee) reviewed the period of record data for the Sumatra gage following several data inquiries, that called into question anomalies in reach-gain flows between Apalachicola at Chattahoochee (02358000) and Sumatra. The team determined that there was no levee breach nor was flow bypassing the measurement section as first feared. However, the team did find a problem with several discharge rating changes made during 1990 – 2002 when erroneous discharge measurements were made during out-of-bank flood flows. Non-standard methods were used during several high flow measurements that under-reported the flows, which in turn led to inaccurate rating changes.

The USGS will develop a new rating at Sumatra based on the most reliable measurements and re-compute (revise) discharge for all overbank events from 1990-present. Preliminary tests indicate significant improvement in the reach gains when compared to previous periods, where the team felt the rating was reliable. Since the Sumatra gage is also tidally influenced, index-velocity equipment was installed two years ago, and a revised rating is being developed.

In addition, the team looked at the Chattahoochee gage and determined that a loop rating (using new methods recently released by the USGS Office of Surface Water) exists at this site. The historic records at the site look reasonable since the rating does not appear to be biased towards rising or falling measurements. No revisions will be made to the record. In the future, a complex rating approach will be considered at this site to ensure the instantaneous value discharges are within the acceptable margin of error.

Sincerely,

Rafael W. Rodriguez

Rafael Rodriguez, Director
Caribbean-Florida Water Science Center

cc:	Marjorie S. Davenport	Deputy Regional Director, Southeast Region, USGS
	Jacklyn Gould	Acting Regional Director, Southeast Region, USGS
	William Guertal	Deputy Associate Director for Water Mission Area, USGS
	Richard Kane	Associate Center Director, CFWSC, USGS
	James Hawthorn, Jr.	Chief, Water Management Section, USACE

ATTACHMENT 9

Excerpts from the Deposition Transcript of Charles A. Menzie, Ph.D. (July 25-26, 2016)

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

VIDEOTAPED DEPOSITION OF CHARLES A. MENZIE, Ph.D.

JULY 25, 2016

9:03 A.M.

Reported by: Michele E. Eddy, RPR, CRR, CLR

JOB NO. 108987

July 25, 2016
9:03 A.M.

Deposition of CHARLES A. MENZIE, Ph.D., held at the offices of Latham & Watkins, 555 Eleventh Street, Northwest, Suite 1000, Washington, D.C., pursuant to notice, before Michele E. Eddy, a Registered Professional Reporter, Certified Realtime Reporter, and Notary Public of the states of Maryland, Virginia, and the District of Columbia.

APPEARANCES:

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655 Fifteenth Street, Northwest
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EMILY MERKI, ESQUIRE

ALSO PRESENT:
Patricia Glibert, Ph.D.
Krishna Sharma, Videographer

CHARLES A. MENZIE, Ph.D.
(Exhibit 1, Exhibit 2, and Exhibit 3 were marked for identification.)

THE VIDEOGRAPHER: Good morning. This is the start of media number 1 of the videotaped deposition of Dr. Charles Menzie, taken in the matter of State of Florida versus the State of Georgia. This case is filed in the Supreme Court of the United States, Case Number 142.

This deposition is being held at 555 11th Street, Northwest, Washington, D.C., on July 25, 2016, and the time on the video monitor is 9:01. My name is Krishna Sharma, and the court reporter today is Ms. Michele Eddy. Both of us represent the TSG Reporting, Inc.

Will counsel please identify yourselves for the record, and after that our court reporter will swear in the witness and we can begin.

MR. SINGARELLA: Good morning, Dr. Menzie. Paul Singarella on behalf of Florida. And I have with me today my colleagues, Jamie Wine and Claudia O'Brien,

CHARLES A. MENZIE, Ph.D.

both from Latham, and I think you may know Dr. Patricia Glibert, who is sitting in today. Welcome.

MS. DeSANTIS: Karen McCartan DeSantis, representing the State of Georgia.

MS. MERKI: Emily Merki, representing the State of Georgia.

- - -

CHARLES A. MENZIE, Ph.D.,

having been duly sworn, testified as follows:

EXAMINATION BY COUNSEL FOR PLAINTIFF

BY MR. SINGARELLA:

Q Good morning, Dr. Menzie. When was the last time you had your deposition taken?

A I would say probably last -- either last spring of 2015 or the previous year.

Q In what matter was that?

A It concerned a stream in West Virginia known as Leatherbrook, and it was an action in which plaintiffs brought a suit against a coal company.

Q Who did you represent in that matter?

A I represented the coal company, Fola.

CHARLES A. MENZIE, Ph.D.

Q How do you spell that?

A F-O-L-A.

Q Over the years, about how many times have you had your deposition taken?

A You know, I estimated roughly 15 times.

Q So is it fair to say that you are familiar with the rules and procedures of a deposition?

A Yes, I am.

Q I won't spend too much time belaboring that. I'll just ask a few questions. Are you able to give clear and accurate testimony today?

A I am.

Q You understand that if you answer a question, I'm going to assume that you understood the question. Is that fair?

A That's fair.

Q Now, your report in this case covers a broad range of topics. You understand that, correct?

A Yes, I do.

Q So as I move from topic to topic,

CHARLES A. MENZIE, Ph.D.

I'll try to do my best to mark the topical transitions, but if you have any questions about, okay, what are you asking me now, please, please do ask those questions of me, okay?

A Okay.

Q Is there any reason we should not proceed today with your deposition?

A No. We should. We should proceed.

Q And you understand that you're under oath?

A I am.

Q We've marked here Exhibits 1, 2, and 3 in front of you. Can you please confirm for me that Exhibit 1 is the main report, your expert report in this case?

A Exhibit 1 is my main report without the appendices.

Q And what we did in Exhibit 2 is we put together a bound volume of your appendices, and we took the liberty of adding an index, which is the first page of Exhibit 2. Do you see that, sir?

A I do.

CHARLES A. MENZIE, Ph.D.

Q Can you confirm that Exhibit 2 appears to be a true and exact copy of your Appendices A through G in this matter?

A It appears to be a copy of it.

Q Last week on July 22nd, we received errata and corrections to your report. We've marked that as Exhibit 3 to your deposition, a cover letter from your counsel, and a series of charts in a memo. Do you see that, sir?

A I do.

Q Does that look like a true and exact copy of your errata and corrections to your report, Exhibits 1 and 2?

A Yes, it does.

Q Now, the first thing I want to ask you about -- thank you, Karen. We're getting our wiring right here. We're good, okay.

The first thing I want to ask you about is the materials upon which you are relying in this matter. Okay? As I read through Exhibits 1, 2, and 3, I noticed a couple hundred footnotes in Exhibit 1. You understand that, right?

A Yes.

CHARLES A. MENZIE, Ph.D.

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

CONTINUED VIDEOTAPED DEPOSITION OF

CHARLES A. MENZIE, Ph.D.

Volume 2

JULY 26, 2016

9:05 A.M.

Reported by: Michele E. Eddy, RPR, CRR, CLR

JOB NO. 108989

CHARLES A. MENZIE, Ph.D.

July 26, 2016
9:05 A.M.

Continued Videotaped Deposition of CHARLES A. MENZIE, Ph.D., held at the offices of Latham & Watkins LLP, 555 11th Street, Northwest, Suite 1000, Washington, D.C., pursuant to notice, before Michele E. Eddy, a Registered Professional Reporter, Certified Realtime Reporter, and Notary Public of the states of Maryland, Virginia, and the District of Columbia.

CHARLES A. MENZIE, Ph.D.

APPEARANCES:

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BY: STACEY VANBELLEGHEM, ESQUIRE

CHARLES A. MENZIE, Ph.D.

ATTENDANCE, Continued

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BY: KAREN DeSANTIS, ESQUIRE
ZACHARY AVALLONE, ESQUIRE

ALSO PRESENT:
Patricia Glibert, Ph.D.
Krishna Sharma, Videographer

CHARLES A. MENZIE, Ph.D.

THE VIDEOGRAPHER: Good morning. This is the start of the continuation of the videotaped deposition of Dr. Charles Menzie in the matter of the State of Florida versus the State of Georgia.

The date today is July 26th, 2016, and the time on the video monitor is 9:05. I am Krishna Sharma, the legal video specialist. The court reporter today is Michele Eddy. Both of us represent TSG Reporting, Inc.

Since the attorneys for both parties have introduced themselves for the record and the witness is already under oath, Counsel, you may proceed.

\- - -

CHARLES A. MENZIE, Ph.D., having been previously duly sworn, testified as follows:

CONTINUED EXAMINATION

BY MR. SINGARELLA:

Q Good morning, Doctor.
A Good morning.
Q Same rules as yesterday. You

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A Right.

Q In that case, you indicated that the relationship would be slightly different, correct?

A That's correct.

Q Do you have a sense as to how large the underreporting would need to be before the relationship that you developed would be materially different?

MS. DeSANTIS: Objection, form.

A I don't -- I mean, the quality assurance check I made was to run it both ways, with Chattahoochee and with Sumatra, and didn't find a difference between them in the outcome.

Q Now, are you aware that Dr. Bedient and Dr. Panday hold to the proposition that over the last several decades, the increase in flow between Chattahoochee and Sumatra has not been as substantial as it was historically?

MS. DeSANTIS: Objection, form.

A I have a general awareness of that.

Q Tell me what you understand them to be saying.

A I haven't read specifically what

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they're saying, but I understand sort of the phenomenon. I don't know what they're saying about it.

Q Tell me what phenomenon you're referring to.

A The phenomenon I'm referring to is that over time there appears to be, I would say, a shift in the relative flows measured at Sumatra and Chattahoochee or even Blountstown that suggest they're not in, let's say, parallel. There's sort of a divergence.

Q When you say "they" are not --

A The flows.

Q The flows. The flows at those locations, Chattahoochee and Sumatra?

A Yes. They're not in parallel over long periods of time.

Q Have you studied that phenomenon?

A I looked into it some, yes.

Q And what -- what analysis of that have you made?

A I wanted to understand why that might be, and the sense I get is that it could be some combination of operational aspects at the

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Sumatra gage over some period of time, over a period of time, but also possibly the pattern of flow from the river into the adjacent floodplains and how the floodplains might actually influence the flow regime at different flows. So I think there was some uncertainty around that, but there's some explanations for it.

Q What analysis have you made to support any such explanation?

A I had one of our hydrologists look at the -- you know, the data for Sumatra. And there were, in those data sets, kind of unusual divergences at particular times so that it was apparent that I wasn't -- the Sumatra gage wasn't always performing in keeping with what you would think would be the operational expectations for that gage. So there was a little bit of that in the data set.

And then in the general conceptual way, I had a discussion with Pravi about expectations in this kind of system where if a large amount of the river flow measured at Chattahoochee spreads into the floodplain, you

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have a kind of a dampening effect of flows returning to the river as river flows change. So you could have a -- under some conditions a more direct relationship between the two gages and other conditions kind of what would appear to be a bit of a divergence from that. So that's it. I mean, that's all conceptually. So I recognize that those kind of variations could exist.

Q When you referred to the hydrologist that looked at data for Sumatra, who -- which hydrologist?

A That would be Pravi Shrestha.

Q And did Pravi produce a work product for you on this matter?

A No, he just basically reported to me, kind of discussed it with me.

Q So do you have any written analysis of the difference in flow over several decades between the Chattahoochee and Sumatra gages?

A I don't know.

Q You do not?

A I don't.

Q I take it, then, that you're not

ATTACHMENT 10

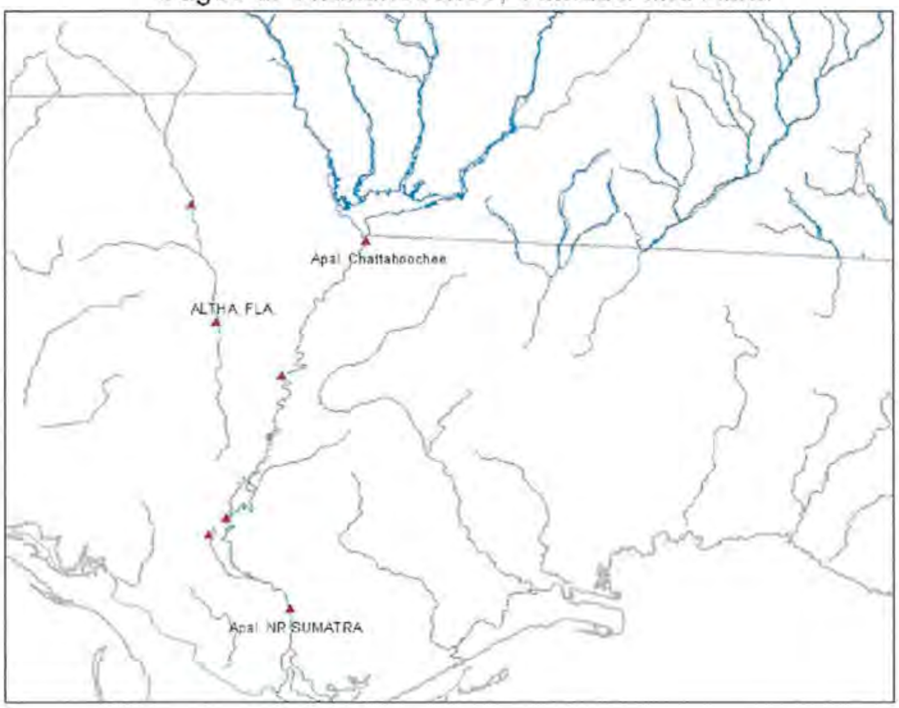
Summary of the Historical Flow and Precipitation Analysis for ACF and Part of OSSS (Zeng Dep. Ex. 75, Feb. 18, 2016)

Summary of the Historical Flow and Precipitation Analysis for ACF and Part of OSSS

Both ACF and OSSS are bordering to Florida.

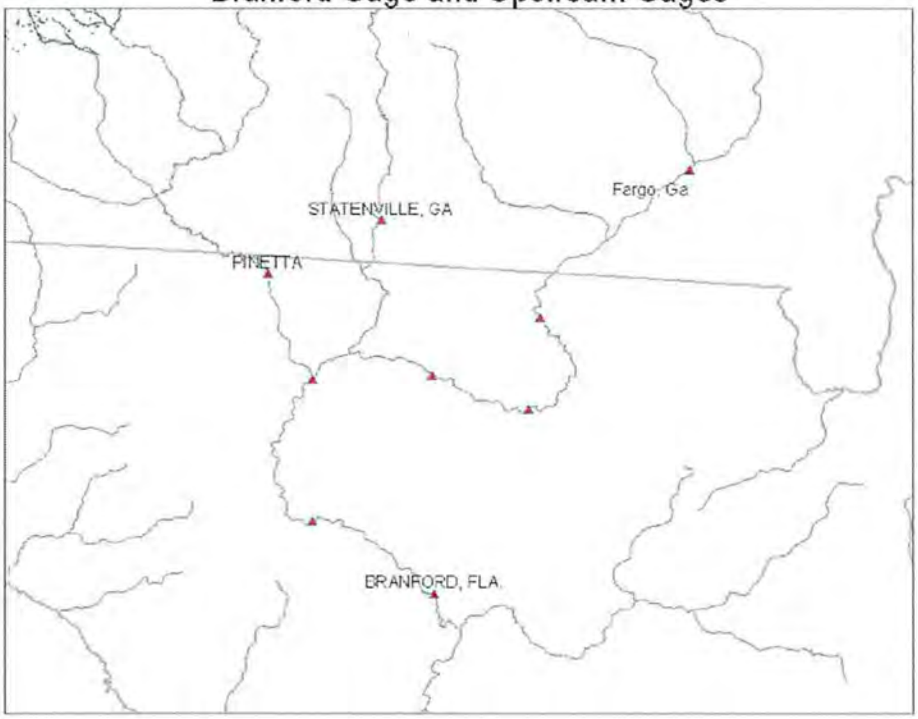
For ACF, Chattahoochee River originates from State of Georgia and then flow across border of states of Georgia and Alabama. Flint River flow through Georgia. Both rivers converges to Apalachicola River at Lake Seminole with a drainage area of 17,200 square miles at the river gage of Chattahoochee, FL of apalachicola River. Downstream from Chattahoochee Gage to Sumatra Gage, it flows across state of Florida and there is an additional 2,000 square mile drainage area (see figure). Among this additional 2,000 square miles, Chipola River at Altha (drainage area: 781 sq. miles) is part of it.

Gages at Chattahoochee, Sumatra and Altha



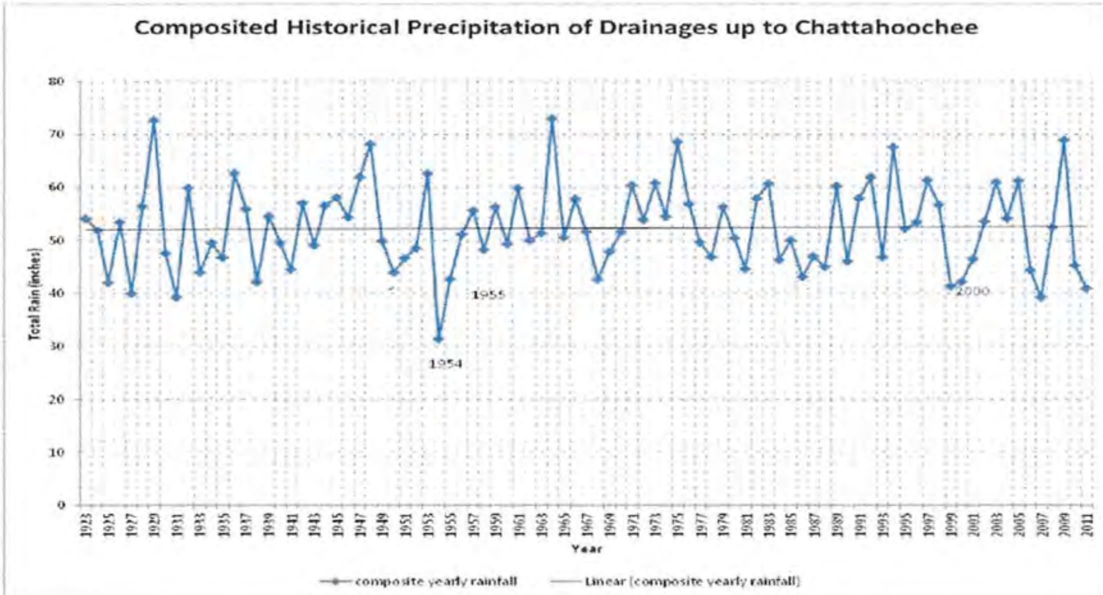
For OSSS, Suwannee River flows across Florida. For the river gage of Branford, FL, it collects a drainage of 7880 square miles. Its upstream river gages includes Pinetta,FL of Whithlacoochee River (drainage area: 2120 sq. miles), Statenville, GA (drainage area: 1400 sq. miles) of Alapaha River, and Fargo, GA (drainage area: 1130 sq. miles) of Suwannee River. These upstream gages collected most runoff from Georgia (see map). Therefore, for the incremental flow between Brankford and these upstream gages, major contributors are runoff from Florida with an additional drainage area of 3140 square miles.

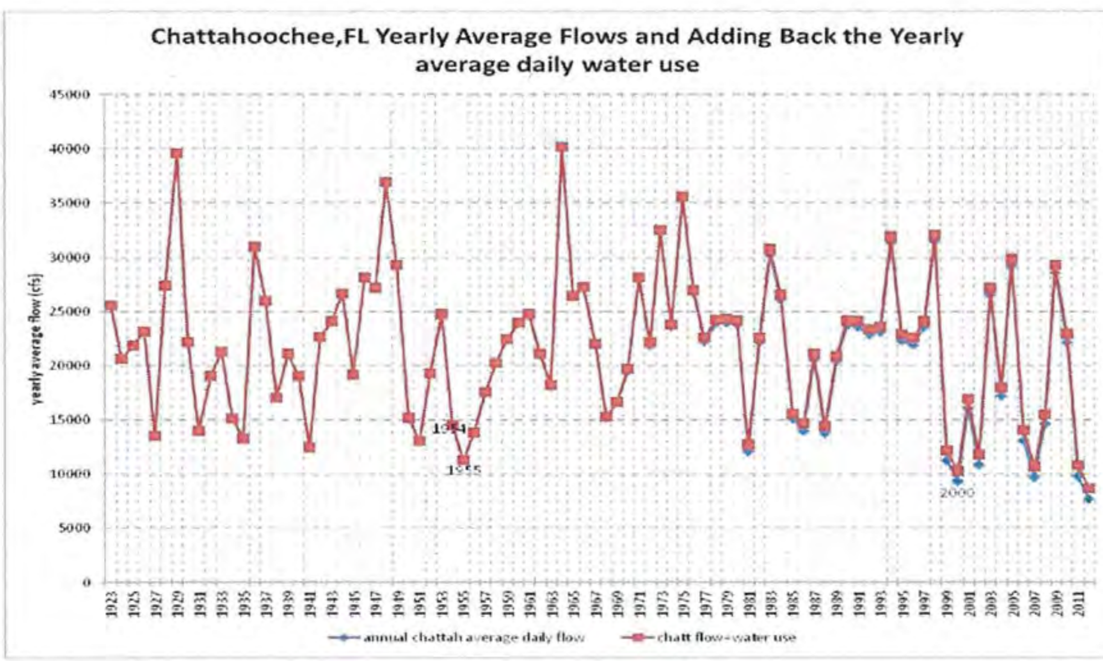
Branford Gage and Upstream Gages



Chattahoochee Gage Flow

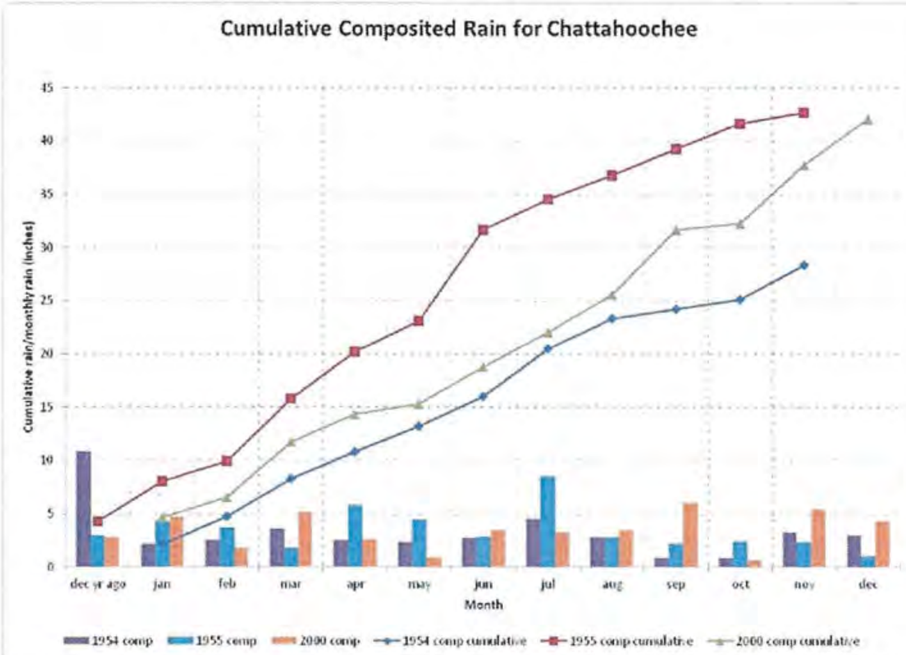
For the Chattahoochee gage, it corresponds to the GA climate regions 2, 4, 7 and Alabama climate regions 5 and 7. Therefore, the gage flow at Chattahoochee, FL is the runoff corresponding to the precipitation of these climate regions. A composited precipitation historical curve has been developed based on the areas of the the Chattahooche Gage drainage proportions of these climate regions. This curve is to be compared to the gage flows of the years.

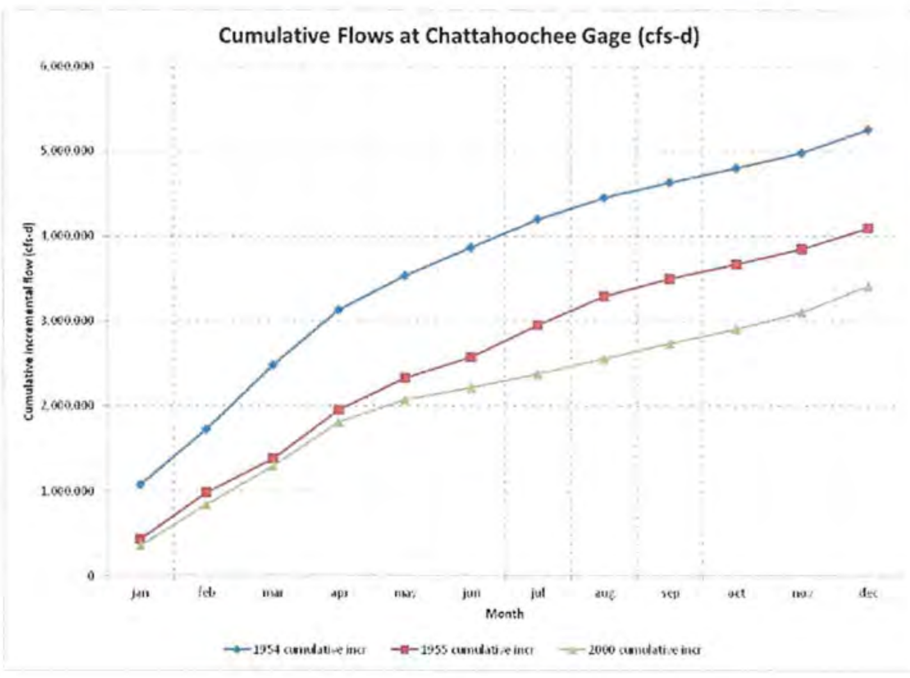




Through comparison, one can see that corresponding to the low annual cumulative precipitations, Chattahoochee Gage's corresponding yearly average daily flow shows also low trend such as 1954, 1955 and 2000. However, the extreme low annual average low flow of 1955 is not the same as cumulative low annual precipitation. Instead, the extreme low precipitation occurred in the 1954 which is prior to 1955. Therefore, it seems that not only the yearly total rain matters but the procedure of the precipitations also does. (Also, Chattahoochee Gage flows includes adding-back-non/ adding-back water use.)

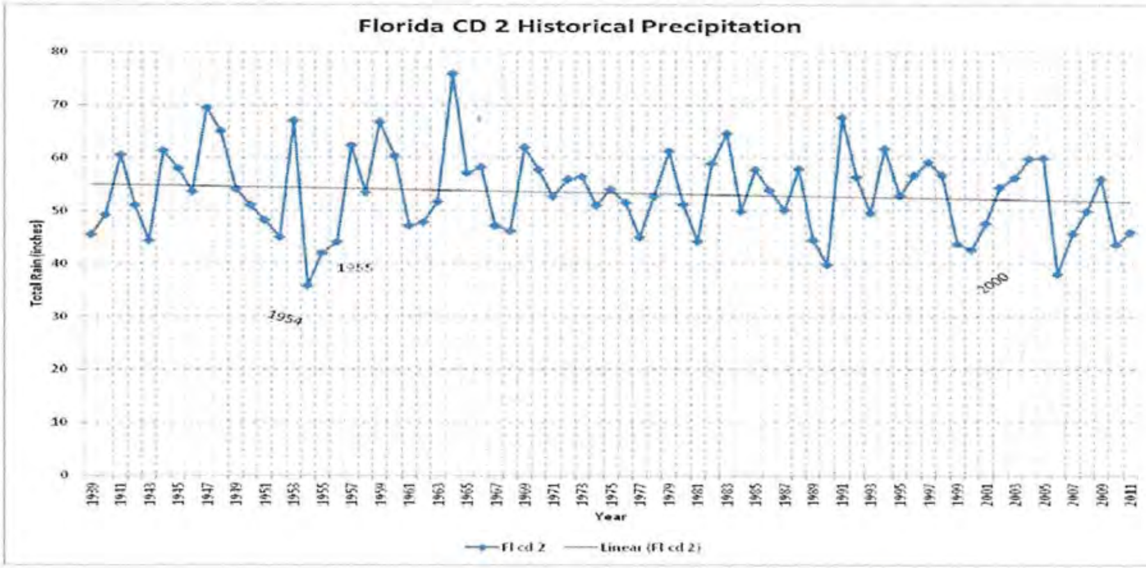
The following figures shows the monthly cumulative rains of the years 1954, 1955, and 2000 to compare with monthly cumulative flows at Chattahoochee Gage. One thing is also important, the previous December played an important role for 1954's cumulative flow not that low.

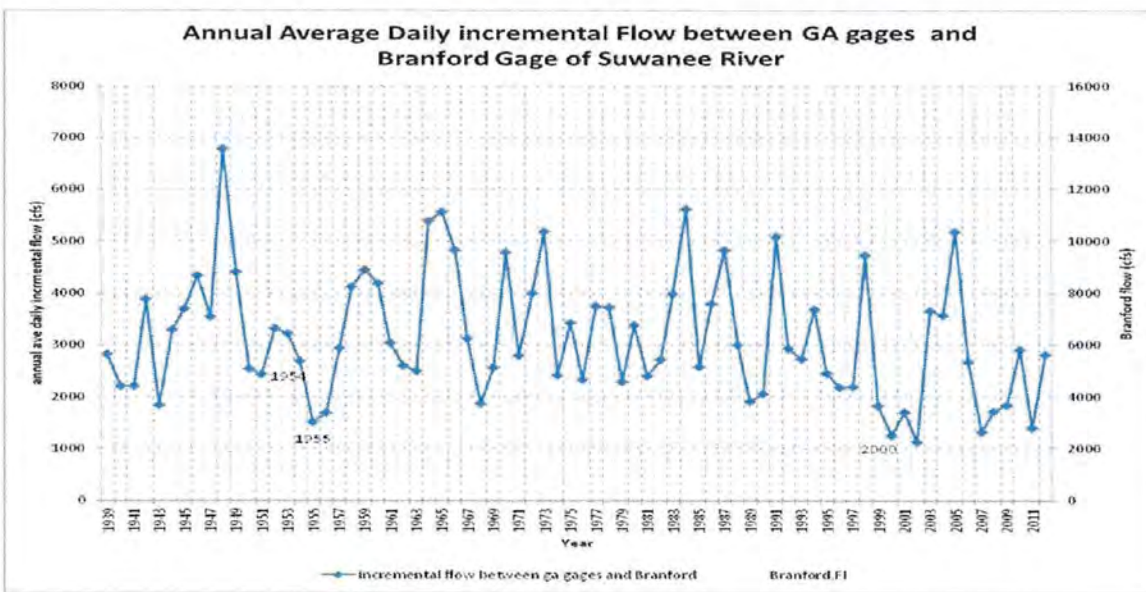




Branford Gage Flow

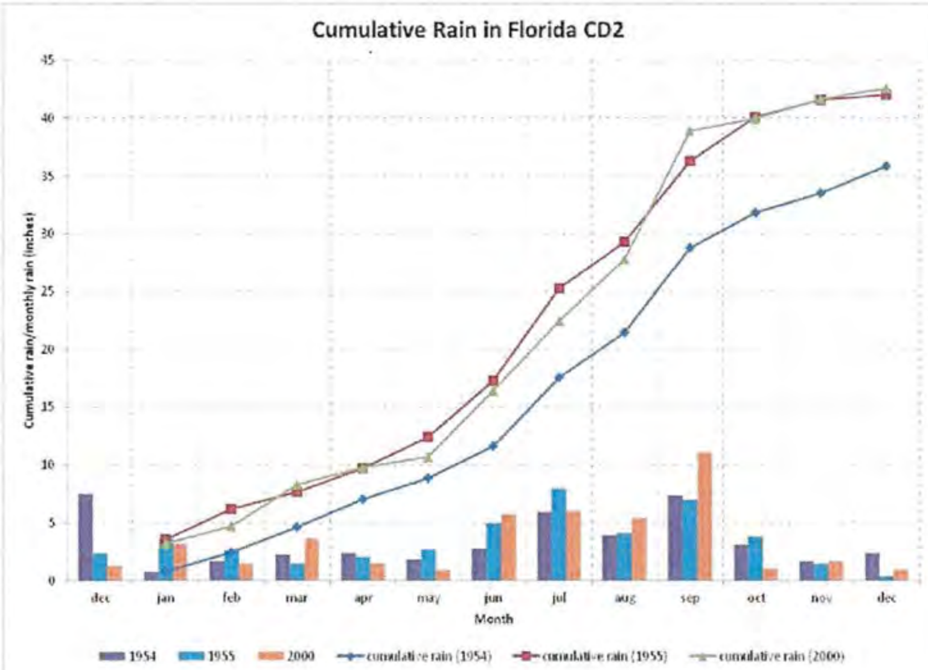
For Suwannee River at Branford Gage, its precipitation should be mainly from Florida climate region 2 for its incremental flow contributor between the gage and its upstream gages of Pinetta, Statenville, and Fargo. A historical precipitation curve is drawn to compare with incremental flows between Gage Branford and its upstream gages.

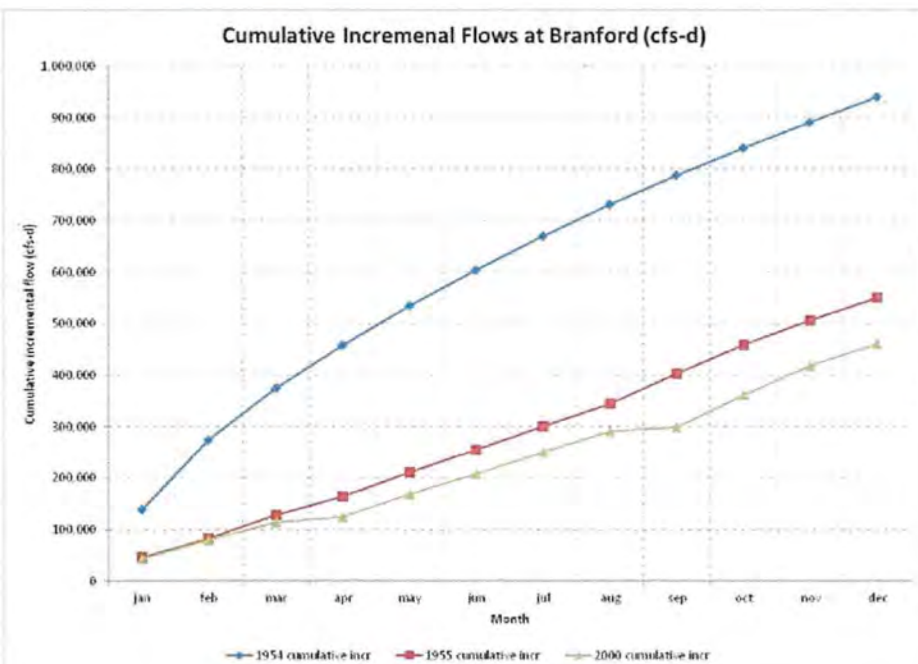




The trend is the same as what observed in comparison between precipitation and annual average flow at Chattahoochee. For the low precipitation, there are corresponding low annual average daily low flows but the extreme low flow was not occurred in lowest year. Look at years of 1954, 1955, and 2000.

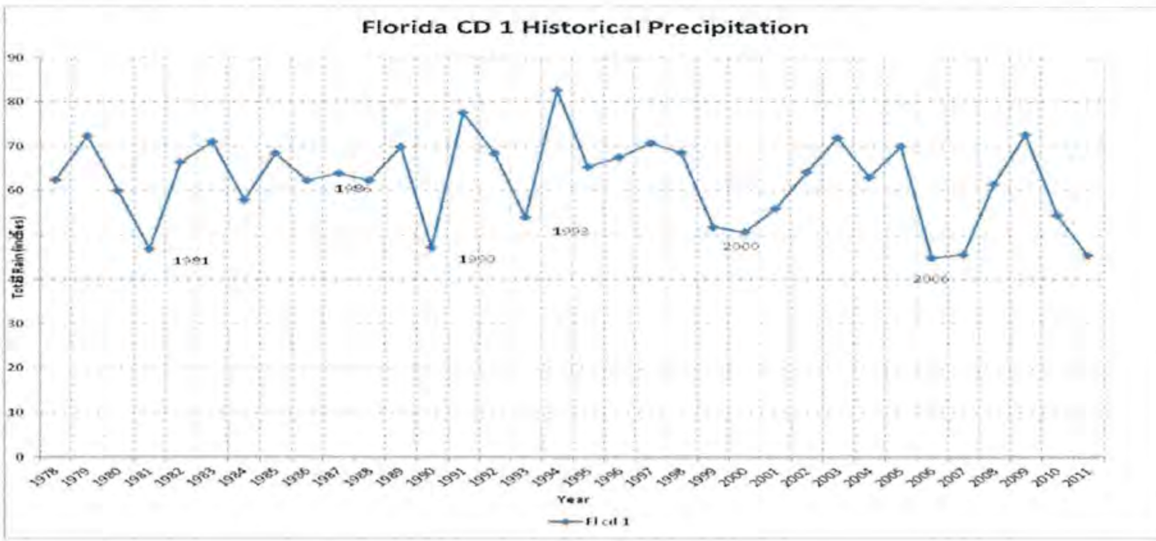
The same monthly cumulative rains of the years 1954, 1955, and 2000 are drawn to compare with monthly cumulative incremental flows at the Branford Gage. One thing is also important, the previous December played an important role for 1954's cumulative flow not that low. Also, 2005 and 2009 precipitation in Florida CD 2 are different from what observed in what controlled Chattahoochee Gage, i.e., 2005 cumulative rain is high but not high for 2009.

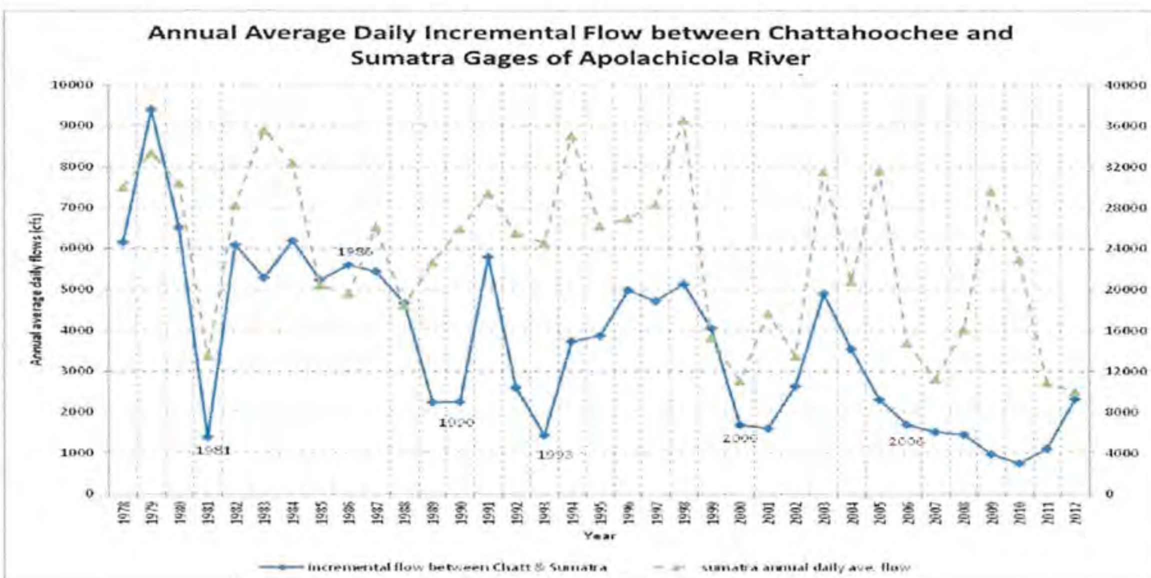




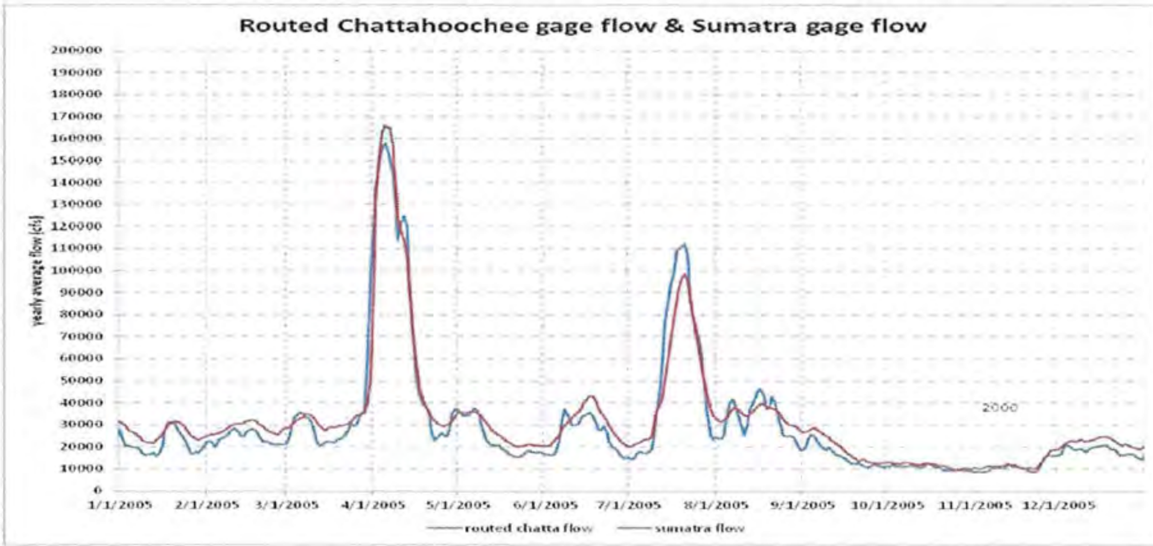
Sumatra Incremental Flow

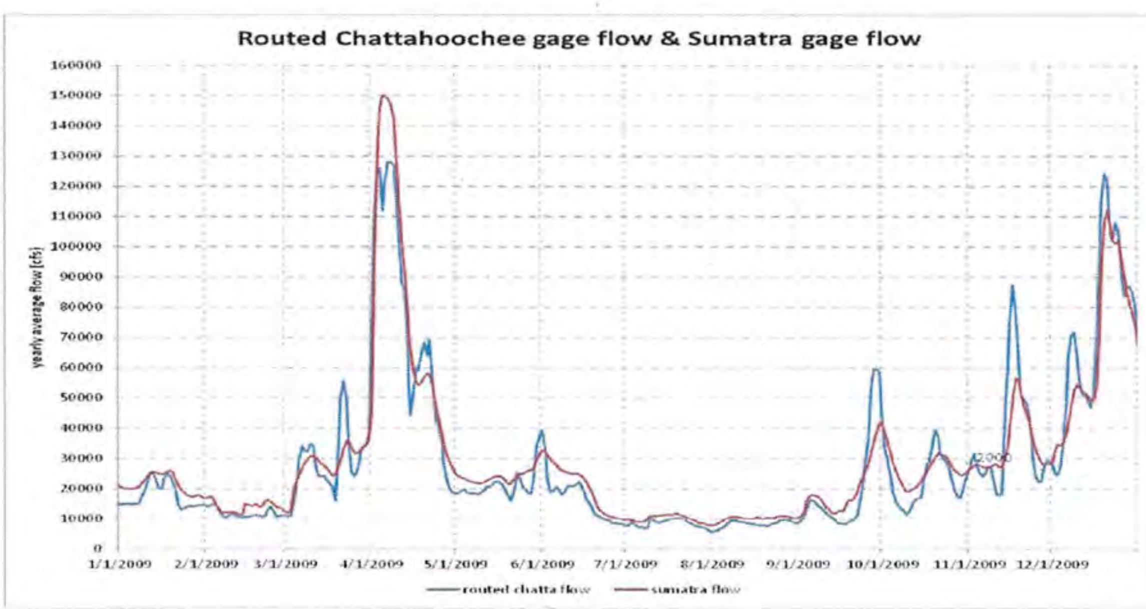
Theoretically, Sumatra's incremental flow can also be computed as those what has done for gage Branford. However, since the gage's drainage is only increased by 10% of the upstream gage Chattahoochee, FL, gage flow measurement error ranges between upstream and downstream gage might make some incremental flow computation looks like a nonsense. Also, Sumatra Gage flow records started late in 1977 so the comparable years are much shorter than the previous mentioned two gage flow/incremental flows. For the incremental flow at Sumatra, dominant contributor is Florida Climate region 1.



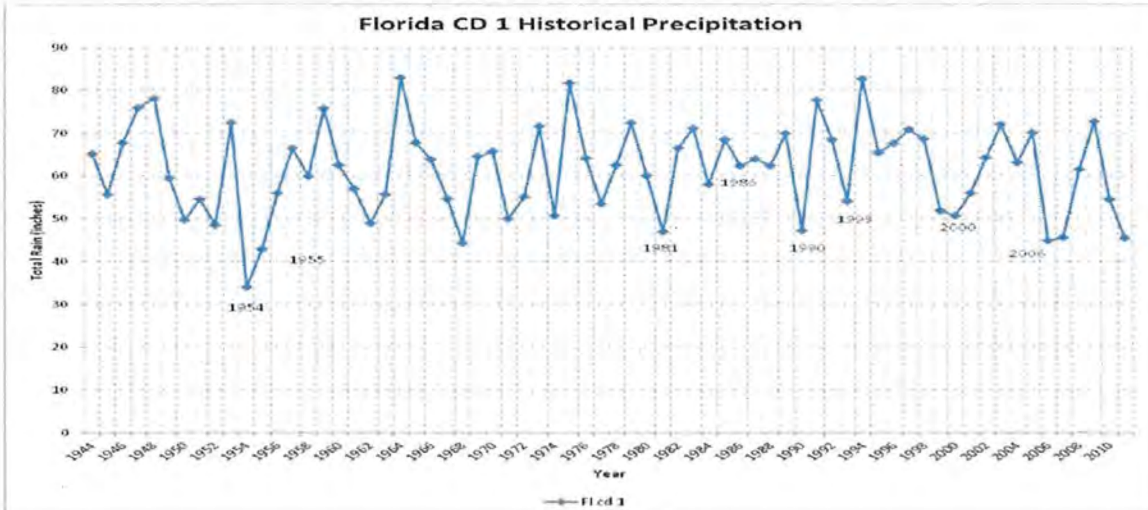


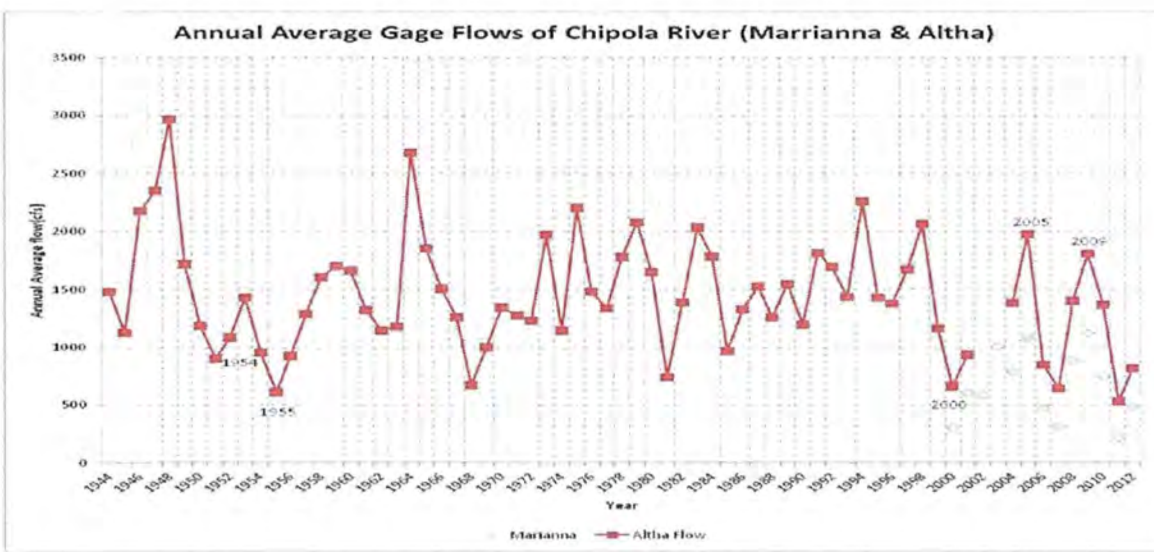
In the above two figures, high rain years like 2005 and 2009 did not have corresponding Sumatra incremental flows of the same years. For the Sumatra Gage, the incremental flows are a little above 2000 cfs and 1000 cfs in 2005 and 2009, respectively. The following figures shows the Chattahoochee Gage flows and Sumatra flows of 2005 and 2009 even considered routing effects. It seems for high flows, Sumatra flow can be low than the upstream gage Chattahoochee. Whether it is due to flow loss or the measurement error makes the flow difference fall into insignificant, it gives the fact that incremental flow computation is not meaningful.

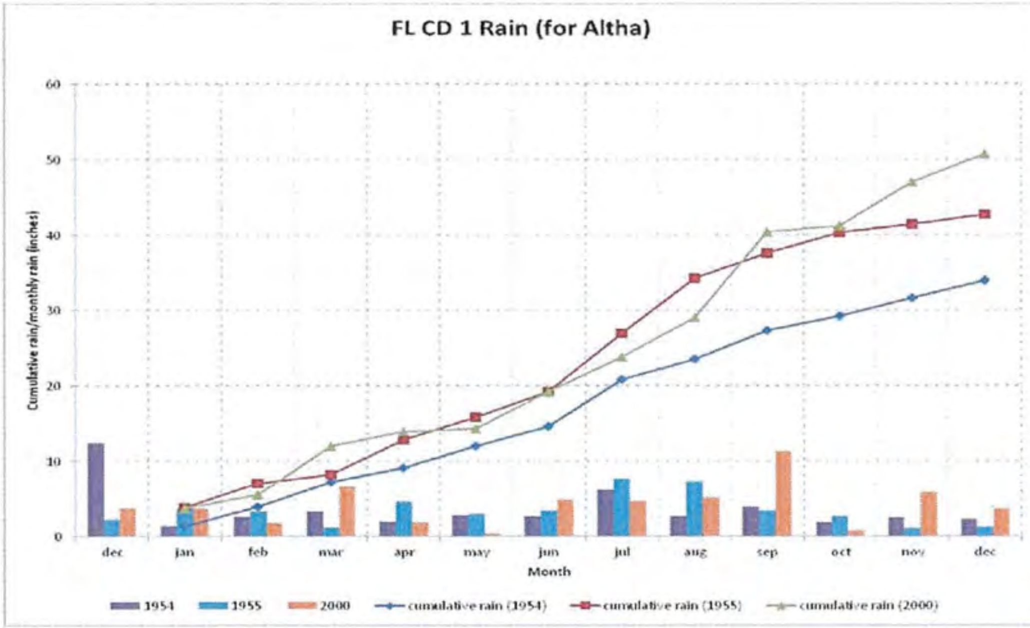


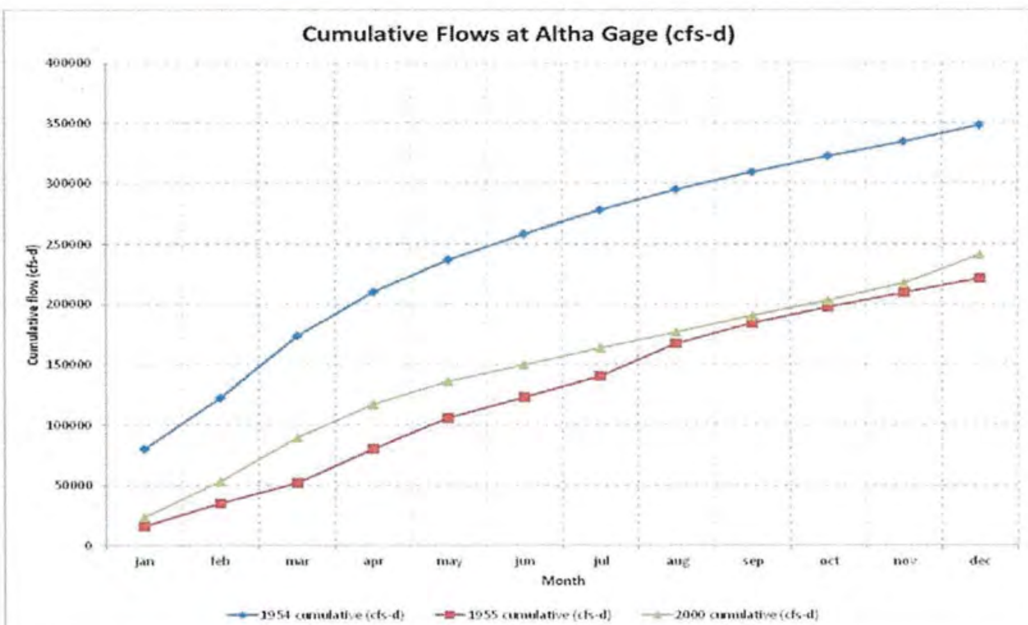


We can also check another gage, Altha of Chipola River, which involved gage Sumatra. As aforementioned, Chipola River is a tributary contributes to between Sumatra Gage. Altha Gage (with 781 sq. miles drainage)corresponding to Florida Climate region 1 precipitation well and the annual average flows are close to 2000 cfs in either 2005 and 2009 (see the following figures). These annual flows should be added to Sumatra as tributary contributions. Also, Altha Gage flows corresponding to Florida CD 1 precipitation trend well as what shows between Composited Precipitation curve vs. Chattahoochee Gage Flow. The 1954 extreme low cumulative rain of Florida CD 1 did not produce the lowest annual average flow at Altha. Instead, better cumulative rain of 1955 produce the lowest annual average flow at Altha. Reasons are the same as what shows at Chattahoochee Gage or Branford, high December 1953 rain.






FL CD 1 Rain (for Altha)
Cumulative rain/monthly rain (inches)
Month
dec
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
1954
1955
2000
cumulative rain (1954)
cumulative rain (1955)
cumulative rain (2000)


Cumulative Flows at Altha Gage (cfs-d)
Cumulative flow (cfs-d)
Month
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
1954 cumulative (cfs-d)
1955 cumulative (cfs-d)
2000 cumulative (cfs-d)