No. 142, Original

In The

Supreme Court of the United States

STATE OF FLORIDA,

Plaintiff,

v.

STATE OF GEORGIA,

Defendant.

CHAMBERS OF THE SPECIAL MASTER

REPORT OF THE SPECIAL MASTER
DECEMBER 11, 2019

PAUL J. KELLY, JR.
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GLOSSARY OF TERMS AND ABBREVIATIONS

ACF	Apalachicola-Chattahoochee-Flint
ACF Basin or Basin	Apalachicola-Chattahoochee-Flint Basin
Army Corps, Corps, or USACE	United States Army Corps of Engineers
Bay	Apalachicola Bay
cfs	cubic feet per second
CPUE	catch per unit effort
EPD	Environmental Protection Division
FoF	Proposed Findings of Fact and Conclusions of Law
FRDPA	Flint River Drought Protection Act
GWRI	Georgia Water Resources Institute
M&I	Municipal and Industrial
Master Manual or Manual	Master Water Control Manual
NESPAL	National Environmentally Sound Production Agriculture Laboratory
NOAA	National Oceanic and Atmospheric Administration
PFD	Pre-Filed Direct Testimony
ppt	parts per thousand
PRMS	Precipitation Runoff Modeling System
RIOP	Revised Interim Operating Plan
River	Apalachicola River
UIFs	Unimpaired Flows
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity Model

I. Introduction

This original jurisdiction proceeding—in which Florida seeks a decree apportioning the waters of the Apalachicola, Chattahoochee, and Flint River Basins (ACF Basin)—comes before me on remand from the Supreme Court. *See Florida v. Georgia*, 138 S. Ct. 2502, 2518 (2018); Order Appointing Judge Paul J. Kelly, Jr. as Special Master, ___ S. Ct. ___, 2018 WL 3765202 (Aug. 9, 2018), *amended* 139 S. Ct. 57 (Sept. 25, 2018) (mem.). Before I was appointed Special Master, a previous Special Master—Ralph Lancaster, Jr.—conducted pre-trial proceedings, oversaw a multi-week trial, and ultimately recommended that the Supreme Court deny Florida's request for relief. The Supreme Court concluded that Special Master Lancaster applied the incorrect legal standard and remanded with instructions to make further factual findings. *Florida*, 138 S. Ct. at 2508. I was then appointed Special Master.

Before I describe how the case has progressed since I was appointed Special Master, I briefly recount the history of the dispute concerning the ACF Basin, which is described more fully in the previous Report of the Special Master, 2017 WL 656655 (Feb. 14, 2017) (hereinafter Lancaster Rep.), and this Court's decision in *Florida*. One can trace the origins of the dispute between Florida and Georgia to 1990 when Alabama sued to enjoin the United States Army Corps of Engineers (the "Army Corps" or "Corps") from reallocating storage in the Basin for water supply to municipal and industrial use in Georgia. Lancaster Rep., 2017 WL 656655, at *10–11. However, that lawsuit was put on hold, and Alabama, Georgia, Florida, and the Army Corps agreed to seek a resolution through negotiation after conducting a comprehensive study of water resources in the ACF Basin. *Id.* In 1997, the States and the federal government entered into the Apalachicola-Chattahoochee-Flint River Basin Compact, Pub. L. No. 105-104, 111 Stat. 2219 (1997). *Id.* at *11. The Compact defined a procedure through which the parties could negotiate a water allocation formula "equitably apportioning the surface waters of the ACF." *Id.* at *11–12 (quoting the Compact). The negotiations were unsuccessful, and the Compact expired in August 2003. *Id.* at *12.

After the Compact expired, litigation continued, and several lawsuits were consolidated and transferred to the United States District Court for the Middle District of Florida. *Id.* at *13. On appeal, the United States Court of Appeals for the Eleventh Circuit held, inter alia, that the Army Corps has authority under the Rivers and Harbors Act to allocate storage in Lake Lanier for water supply in the Atlanta metropolitan area. *In re MDL-1824 Tri-State Water Rights Litig.*, 644 F.3d 1160, 1191–92 (11th Cir. 2011). The Army Corps then began updating its water control manual in the Basin, and Florida subsequently sought leave to file this original jurisdiction suit to equitably apportion the waters of the Basin. Lancaster Rep., 2017 WL 656655, at *13. The Supreme Court granted Florida leave to file and appointed Special Master Lancaster. *Id.* at *16. After holding a trial from October 31, 2016 to December 1, 2016, Special Master Lancaster recommended that the Court deny Florida's request for relief on the narrow ground that "Florida has not proven by clear and convincing evidence that its injury can be redressed by an order equitably apportioning the waters of the Basin." *Id.* at *3, *21.

The Supreme Court held, however, that Special Master Lancaster applied too strict a redressability standard. *Florida*, 138 S. Ct. at 2516. In light of that holding, the Court remanded with instructions to make findings concerning the following questions on remand: (1) whether Florida suffered harm caused by decreased water flow into the Apalachicola River; (2) whether Florida showed that Georgia's use of the Flint River is inequitable; (3) whether that potentially inequitable use harmed Florida; (4) whether an equity-based cap on Georgia's use of Flint River waters would materially increase streamflow in the Apalachicola River given the Corps' operational rules or reasonable modifications that could be made to those rules; and (5) whether such additional streamflow in the Apalachicola River may significantly redress the economic and ecological harm that Florida has suffered. *Id.* at 2518, 2525–27. The Court also made clear that Florida must show that "the benefits of the [apportionment] substantially outweigh the harm that might result." *Id.* at 2527 (alteration in original) (quoting *Colorado v. New Mexico* (*Colorado I*), 459 U.S. 176, 187 (1982)).

These questions are of course motivated by the rules governing equitable apportionment. The Court's previous equitable apportionment decisions control the legal approach I take, and I pay particular attention to the Court's recent explanation in remanding this case. First, "[g]iven the laws of the States, both Florida and Georgia possess an equal right to make a *reasonable use* of the waters of the stream." *Id.* at 2513 (internal quotations omitted) (quoting Lancaster Rep., 2017 WL 656655, at *26). Second, I recognize that the Court seeks to reconcile the States' interests in the River without "quibbling over formulas" and that the Court will not decline to fashion a decree simply because the future may be uncertain. *Id.* at 2513–14 (quoting *New Jersey v. New York*, 283 U.S. 336, 343 (1931)). Third, the complaining state must demonstrate by clear and convincing evidence "that it has suffered a threatened invasion of rights that is of serious magnitude." *Id.* at 2514 (internal quotations omitted) (quoting *Washington v. Oregon*, 297 U.S. 517, 524 (1936)). Thus, the complaining state must show "some real and substantial injury or damage." *Idaho ex rel. Evans v. Oregon* (*Idaho II*), 462 U.S. 1017, 1027 (1983). Moreover, the state must demonstrate that it has "suffered a wrong through the action of the other State . . . which is susceptible of judicial enforcement." *Florida*, 138 S. Ct. at 2514 (quoting *Massachusetts v. Missouri*, 308 U.S. 1, 15 (1939)). Last, if I find that Florida has shown real and substantial injury or damage, then I will make detailed factual findings with which to weigh all relevant factors and decide whether (and in what form) to fashion an equitable decree. *Id.* at 2515. In weighing these factors, I must determine whether "the benefits of the [apportionment] substantially outweigh the harm that might result." *Id.* at 2527 (alteration in original) (quoting *Colorado I*, 459 U.S. at 187).

Soon after being appointed Special Master, I asked the parties whether the existing record would be sufficient to decide each issue identified by the Supreme Court. *See* Case Mgmt. Order No. 23 (Aug. 23, 2018) (Dkt. No. 639).[1] On October 2, 2018, the parties filed a Joint Memorandum addressing my questions, and they agreed that I could decide many issues based on the existing record. *See* Jt. Mem. of Fla. & Ga. at 9–18. Florida, however, asked for additional discovery and an evidentiary hearing relating to the fourth and fifth questions that the Supreme Court raised for remand. *Id.* at 12, 18–21. Namely, Florida sought to add additional evidence on (1) the effects of the Army Corps' new operational manual, (2) reasonable modifications that could be made to the manual, (3) increased agricultural irrigation since trial, and (4) the difficulties with recovery in the Apalachicola Bay since trial. *Id.* at 21–22. After careful consideration, I denied Florida's request for additional evidentiary hearings because the record developed at trial was extensive (there was no restriction on what could have been tendered),[2] because further evidentiary proceedings would only further delay resolving this protracted dispute, and because the United States explained that the question

[1] The docket for this case can be found on the United States Court of Appeals for the Tenth Circuit's website: https://www.ca10.uscourts.gov/special-master-142.

[2] *See* Lancaster Rep., 2017 WL 656655, at *21–22 (explaining that the parties entered 1,800 pages of pre-filed testimony, enough exhibits to fill 60 volumes when printed, and 32 witnesses appeared at trial to deliver live testimony over the course of 17 days).

whether reasonable modifications could be made to the Army Corps' current Master Manual would be better left until after the other issues in the case were resolved. *See* Case Mgmt. Order No. 25 at 5–6 (Nov. 6, 2018) (Dkt. No. 645).

I therefore asked Florida and Georgia to file, by January 31, 2019, simultaneous proposed findings and conclusions and supplemental briefs addressing seven questions of interest on remand. *See id.* at 4–5.[3] I allowed the parties to file response briefs by February 28, 2019. *Id.* Florida and Georgia timely filed their briefs. Florida later requested that I hold oral argument, and I granted the request. Fla. Mot. for Oral Arg. (Mar. 12, 2019) (Dkt. No. 659); Order on State of Fla.'s Mot. for Oral Arg. (July, 29, 2019) (Dkt. No. 662).

Based on the record developed at trial,[4] the parties' remand briefing, and the oral arguments held on November 7, 2019, I have strived to make "extensive," "specific," and "detailed" factual findings to reach a conclusion on the issues identified by the Supreme Court

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[3] The seven questions were derived from the questions the Supreme Court asked to be resolved on remand. In addition to the questions the Court identified, the questions included whether the costs of a cap would be justified by its expected benefits, *see Florida*, 138 S. Ct. at 2527, and whether conservation measures in Georgia already produce some additional streamflow. Case Mgmt. Order No. 25 at 4.

[4] I proceed as Special Master Lancaster did, and I do not consider the testimony of witnesses who provided pre-filed direct testimony but did not appear at trial. *See* Lancaster Rep., 2017 WL 656655, at *22.

in this Report. *See Florida*, 138 S. Ct. at 2515.[5] Although the Supreme Court's and my questions were limited to the Flint River, Florida continues to argue that Georgia's use of the Chattahoochee River (which primarily serves the Atlanta Metropolitan area) is also inequitable. *See* Fla. Opening Post-Remand Supp. Br. at 7–10, 15–18 (Fla. Br.). Because the Supreme Court's list of questions for remand was not exclusive, *see Florida*, 138 S. Ct. at 2527, I also evaluate Florida's arguments concerning the Chattahoochee River.

Given my factual findings, I recommend denying Florida's request for a decree because it has not proved the elements necessary to obtain relief. Florida has pointed to harm in the oyster fishery collapse, but I do not find that Georgia caused that harm by clear and convincing evidence. Next, although Georgia's use of the Flint and Chattahoochee Rivers has increased since the 1970s, Georgia's use is not unreasonable or inequitable. Last, I have determined that the benefits of an apportionment would not substantially outweigh the harm that might result. This is especially true given that the Army Corps' reservoir operations on the Chattahoochee River would prevent most streamflow increases from reaching Florida during the times when more streamflow is needed to alleviate Florida's alleged harms.

[5] *Cf.* Fed. R. Civ. P. 52(a) (findings and conclusions may appear in an opinion or memorandum of decision).

II. Florida's Alleged Injuries

Florida alleges that lower flows in the Apalachicola River (the "River") have harmed the ecosystems in both the River and the Apalachicola Bay (the "Bay"). Florida highlights the collapse of the Bay's oyster fishery, but Florida has not proved that the harm to the oysters resulted from "the action of [Georgia]." *Florida*, 138 S. Ct. at 2514. The harms Florida points to in the River only have an attenuated connection to Georgia's consumptive use or they are not concrete, and Florida has thus failed to show a "threatened invasion of rights . . . of serious magnitude" in the river by clear and convincing evidence. *Id.* (quoting *Washington*, 297 U.S. at 524). I explain these findings in more detail in the following two sections.

Before I analyze the evidence of harm to the Bay and the River, I note that Florida has not provided any evidence of harm during years with normal or more than normal rainfall. Georgia highlighted this fact on remand. Ga. Supp. Br. at 4 (Ga. Br.); Ga. FoF ¶¶ 1–2. Florida has not argued otherwise, and from my own review of the record, I do not find clear and convincing evidence of harm during periods with average rainfall.

A. Harms to the Bay During Dry Years

As Special Master Lancaster noted, Florida "points to real harm." Lancaster Rep., 2017 WL 656655, at *31 (finding that oyster mortality in late 2012 left "many previously-productive oyster reefs virtually empty").[6] Consequently, between September 2012 and February 2013, "commercial harvest revenues declined by 43% and commercially marketed pounds of oyster meat declined by 58%." Kimbro PFD[7] ¶ 33. Georgia does not contest that the oyster fishery suffered significant harm; rather, it argues that the collapse resulted from Florida's mismanagement, and insofar as low flows caused the collapse, those low flows were predominantly caused by drought, not Georgia's consumptive use. Ga. Br. at 4–9. I agree and conclude that Florida has not shown by clear and convincing evidence that the harms in the Bay resulted from Georgia's consumption.

Florida claims the following regarding the oyster collapse. As a consequence of the persistent low flows in the Apalachicola River, freshwater flows were inadequate to dilute the seawater in the Bay and to provide nutrients needed at the base of the food chain. In addition to these direct nutrient and salinity effects, increased salinity allowed saltwater predators to flourish, and those predators greatly reduced the oyster population. Fla. Br. at 10–13; Fla. FoF ¶¶ 12–15. In

[6] For the reasons explained in the Supreme Court's decision, I do not treat Special Master Lancaster's previous statements on harms to Florida as final findings of fact. *See Florida*, 138 S. Ct. at 2518 (listing factual issues where Special Master Lancaster "assumed" the answer); *see also* Order on Fla.'s Presentation Materials at Oral Arg. at 2 (Nov. 5, 2019) (Dkt. No. 667).

[7] If the record contains both a pre-filed direct testimony and an updated pre-filed direct testimony from a particular witness, then "PFD" refers to the updated pre-filed direct testimony.

evaluating this claim, I summarize Florida's evidence on the matter, then I review Georgia's evidence indicating that Florida mismanaged the oyster resource.

I first begin with the evidence on low flows causing nutrient depletions in the Bay. Florida's expert on nutrients and the food chain, Dr. Glibert, testified that nutrient changes resulting from low flows can alter the composition of the microorganisms that compose the base of the food chain. Glibert PFD ¶¶ 35–47. These changes can make it harder for oysters and other animals that consume these microorganisms to feed. *Id.* ¶¶ 17, 35–36, 68–70. Low flows can also lower dissolved oxygen levels in the Bay, which may also harm oysters. *Id.* ¶¶ 50–57.

While Dr. Glibert's testimony relies on ecological principles to describe how the entire Bay ecosystem could be harmed by low flows, such harm does not appear to be borne out by the data. Dr. Glibert did not analyze whether fish at the higher levels of the food chain were indeed harmed by the nutrient effects she described, and in fact testified it was outside her scope of work to examine individual fish species. 7 Trial Tr. 1849:2–1850:5 (Glibert). She did not analyze minimum flows needed, did not analyze what caused the lowest flows, and did not consider harvesting practices. *Id.* 1824:7–12; 1841:12–1842:13; 1888:6–10 (Glibert). Dr. Menzie, Georgia's environmental risk assessment expert, found instead that no fish species in the Bay suffered any declines in population. Menzie PFD ¶¶ 122–26; *id.* at 123 demo.26. Finally, Dr. Glibert has not offered persuasive evidence that the food chain effects she described caused the oyster collapse, *see* Glibert PFD

¶¶ 92–93, and other Florida experts did not reach that conclusion, *see* Berrigan PFD ¶ 3; White PFD ¶ 164. I do not find that nutrient differences resulting from low flows caused the oyster collapse.

Next, turning to the effects of salinity, I find that the increases in salinity caused by low flows were a factor that could have contributed to the oyster collapse. Florida introduced testimony from several experts showing that higher salinities caused by low flows resulted in increased predation by species that prefer saltier water, reduced recruitment of young oysters, and ultimately a loss of oyster biomass.

Beginning with Florida's experts, Dr. Kimbro repeated seven experiments in the Bay between 2013 and 2016, long after the collapse. Kimbro PFD ¶ 78 (discussing experiments conducted after collapse). Dr. Kimbro controlled for salinity and predation, and his results showed a "clear and causal relationship between increasing water salinity and increasing predation on oysters." Kimbro PFD ¶¶ 63–78. In 2013, Dr. Kimbro compared predatory pressures between Apalachicola Bay and the nearby Ochlockonee Bay to assess whether drought was the cause of low flows. *See id.* ¶¶ 91–96. However, at the time his report was submitted, Dr. Kimbro did not control for important differences between the two bays and the drainage basins feeding their respective inflow and did not analyze any shelling restoration data. 6 Trial Tr. 1523:6–11 (Kimbro); *see also* Kimbro PFD ¶¶ 91–96. Given these limitations, I find the results of the comparison between the two bays unreliable.

Ultimately, Dr. Kimbro reached the following conclusions. Increases in salinities led to an increase in oyster predation pressure. *Id.* ¶ 101. This increase in salinity was not caused by regional drought. *Id.* Oyster abundance would have decreased as a result of drought, but the collapse would not have occurred without Georgia's consumption. *Id.*

Next, Florida's Dr. White used the data from Dr. Kimbro's experiment and other data sources to model the biomass of oysters and how that biomass would change with respect to salinity. White PFD ¶¶ 13–14, 148 fig.12. He found that a decrease in salinity resulting from a reduction of Georgia's consumptive use would have increased biomass by a small amount, and he thus concluded that Georgia's consumption impacted oyster biomass. *See id.* ¶ 153 ("the model still demonstrates that Georgia's freshwater withdrawals exacerbated the natural low-salinity conditions in Apalachicola Bay, contributing to the oyster fishery collapse in Apalachicola Bay, and the situation would have been improved if Georgia had removed less water.").

In addition to Florida's expert testimony, an Apalachicola oysterman, Tommy Ward, also testified about the increased predation he observed on the oyster reefs that he leased. Mr. Ward's reefs were not open to public harvesting, yet the oysters on his leases also suffered a population decline in 2012. Ward PFD ¶ 32. However, because Mr. Ward's direct observations were limited to only the reefs that he leases, and because he did not directly measure the salinity at his leases, I place little weight on his testimony in determining what caused oyster populations to decline. *See id.* ¶ 33.

In addition to Mr. Ward's testimony, Florida also attempts to confirm its witnesses' testimony with several other pieces of evidence. It relies on a scientific paper published in 2015 and admitted into evidence that concluded:

> Although a detailed assessment of the dependent and independent data was not able to identify a specific proximal cause (Pine et al. 2015), it is considered likely that a sequence of events occurred whereby: (1) low river flow led to increased salinity in Apalachicola Bay for a multiyear period; (2) which likely led to increases in oyster parasites, predators, or unknown pathogens; (3) causing elevated mortality, particularly among juvenile oysters; (4) which led to recruitment failure, potentially exacerbated by shell removal from fishing or environmental events; and then (5) population collapse of adult oysters.

JX-167[8] at 6.[9] Florida also points to the decision of the National Oceanic and Atmospheric Administration

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[8] This Report cites to Florida and Georgia's joint appendix, Florida's appendix, and Georgia's appendix as "JX-__," "FX-__," and "GX-__" respectively. *See* Lancaster Rep., 2017 WL 656655, at *4 n.2. Florida's demonstratives are noted as "FX-D__" and Georgia's demonstratives are noted as "GX-D__."

[9] Drs. Havens and Pine are among the authors of this paper. *See id.* at 1. I note this because Georgia cites work they performed and statements from their depositions where they could not reach a conclusion on the relationship between flows and oyster population. *See* Ga. Br. at 8.

(NOAA) to declare a fisheries disaster in the Apalachicola Bay. Fla. Br. at 11; *see also* FX-412 at NOAA-3818. I do not find either piece of evidence particularly persuasive. The quoted passage only weakly supports Florida's position; the authors never affirmatively claim that low flows caused by Georgia caused the collapse. *See* JX-167 at 6. And the NOAA evidence is not persuasive because NOAA had to decide whether to grant relief quickly based in part on socioeconomic considerations, 17 Trial Tr. 4423:19–4424:24 (Lipcius), and NOAA did not have the benefit of evidence gathered through an adversarial process as I have before me now.

Given the aforementioned evidence, I conclude that low flows played some role in the oyster population decline of 2012. Nevertheless, for the reasons below, I conclude that Florida's management was a more significant cause of the decline. Further, to the extent that low flows caused the decline, drought was a more significant cause of the low flows than Georgia's consumption.

Georgia highlights evidence that Florida's oystermen overharvested the oyster resource in the period leading up to and after the oyster collapse. After the Deepwater Horizon oil spill, Florida oystermen and fishery managers feared that contamination due to the spill would wipe out the oyster fishery, which resulted in a "use it or lose it attitude." JX-77 at FL-ACF-3386197. Consequently, Florida lifted various harvesting restrictions in the Bay,[10] and the oyster harvests in 2011 and 2012 were significantly higher than any previous harvests since 1986, when Florida began collecting data consistently. Lipcius PFD ¶¶ 153, 116. In 2011, 2.81 million pounds were harvested, and 2012 saw an even greater harvest of 3.03 million pounds. 6 Trial Tr. 1391:17–1392:10 (Sutton). For reference, the total harvest only ever exceeded 2.5 million pounds in three other years between 1986 and 2012. *See* Lipcius PFD at 18 demo.6. Not only was the total harvest especially large, but many of the oysters harvested were smaller than the size that could be harvested legally. *Id.* ¶¶ 163–64; 4 Trial Tr. 835:17–21; 1023:6–17 (Berrigan). Both mature and juvenile oyster populations declined simultaneously, which is indicative of fishing pressure as the cause. Lipcius PFD ¶¶ 106–11.

In addition to showing that harvests reached levels not seen for years, Dr. Lipcius also demonstrated that the most heavily harvested reefs suffered the worst declines. Lipcius PFD ¶¶ 40–45; *id.* at 12–13 demos.3 & 4; *see also* 4 Trial Tr. 822:4–20 (Berrigan). Florida argues that Dr. Lipcius did not consider the effects of salinity on the reefs he compared. White PFD ¶ 114, 32 fig.5. I disagree, and I find Dr. Lipcius's comparison compelling. Dr. Lipcius explained how the bars he examined spanned the ranges of salinity observed in the Bay. Lipcius PFD ¶ 48(a). Furthermore, as Dr. Lipcius notes, Hotel Bar (which was not heavily harvested) experienced one of the largest increases in

[10] *See* 3 Trial Tr. 768:3–769:5 (Berrigan) (describing the management changes that allowed additional harvesting).

salinity, yet the oyster population after the collapse was greater there than before the collapse. *Id.* ¶ 48(b).[11]

Other evidence also supports Georgia's position that overharvesting and a lack of re-shelling were significant causes of the collapse. Re-shelling, also known as reef restoration, is critical to maintaining a healthy oyster fishery because oyster larvae need to attach to a firm surface to develop from larvae during the months they reproduce. Lipcius PFD ¶¶ 21–23. The larvae spend about two weeks floating freely and then settle on a mass of stones, shells, and grit that composes an oyster bed. White PFD ¶ 62. Oyster shells are the preferred substrate. Lipcius PFD ¶ 22.

The evidence reflects that excessive harvesting leads to substrate removal, and if not re-shelled, would lead to the collapse of the oyster bar. *Id.* at ¶¶ 26, 134–135. The evidence reflected, and I find, that is what occurred. Indeed, Florida's then-Governor Scott attributed the collapse in part to overharvesting, *id.* at ¶¶ 163–76, and only 35 acres were re-shelled in 2012 and 16 acres in 2013, 17 Trial Tr. 4391:8–11 (Lipcius). According to the Oyster Situation Report, GX-568 at 5, and acknowledged by Florida's Dr. White, 200 acres per year should have been re-shelled, but Florida only re-shelled 180 acres during the entire ten years preceding the collapse. 7 Trial Tr. 1691:18–1692:17 (White). It is

[11] Dr. Lipcius acknowledged at trial that there was evidence of increased predation in the Bay. 17 Trial Tr. 4414:8–14 (Lipcius). But based on my review of the evidence, predation was not a substantial factor causing the oyster population decline as described here and below.

apparent that inadequate re-shelling contributed to the oyster population decline, unconnected with any consumptive use by Georgia.

Florida responds to the re-shelling statistics by pointing out that the average re-shelling quantity from 2010 to 2014 was not below the historical average. Kimbro PFD at 50 fig.18; *see also* White PFD at 16 fig.2. However, as Dr. Lipcius explains, any re-shelling after the collapse is irrelevant to the question of causality. Lipcius PFD ¶¶ 144–46. Moreover, excluding the post-collapse data clearly shows insufficient re-shelling prior to the collapse. *Id.* ¶ 147; *see also* White PFD at 16 fig.2. Additionally, Dr. White explained how shell material typically remains after snail predation because the snails eat the oyster meat but leave the shell behind. 7 Trial Tr. 1696:14–1697:5 (White).[12] Scientists use the presence of this shell material as a proxy for predation, and dead oyster shells in the Apalachicola Bay would be expected to remain for 4 to 10 years. Lipcius PFD ¶ 69. But Dr. Lipcius's analysis of official Florida data and data gathered by Dr. Kimbro shows a lower density of oyster boxes than would be expected if there had been a large predation event. *Id.* ¶¶ 70–78. Moreover, Dr. Lipcius pointed out that Dr. Kimbro's survey data reveals a much smaller number of oyster predators than would be expected if the collapse had resulted from a large-scale predation event. *Id.* ¶¶ 79–82.

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[12] These remaining shells are typically referred to as a "gapers" or "boxes." *Id.* at 1696:20–24.

Florida's experts respond to Georgia's overharvesting evidence in two ways. First, they claim that Georgia should not rely on data compiled by Florida like total catch, number of trips, and the increased number of harvesting licenses granted, to evaluate the harvesting pressure placed on the oyster resource. Kimbro PFD ¶ 103(c)–(f); White PFD ¶¶ 94–102. These types of data are "fishery-dependent" because they are tied to measures other than direct, systematic measurements of the oyster resource. White PFD ¶¶ 94–95. For instance, total catch will depend on both the total oyster resource and on harvesting effort. *See id.* ¶ 99. Consequently, they suggest fishery-independent data that is not tied to the fishery is more reliable for assessing the health of a population facing fishing pressure. *Id.* ¶ 96. Nevertheless, I cannot ignore available data, and I consider it along with all other evidence.

I still find Dr. Lipcius's analysis using landings[13] and trips data informative. For starters, the total landings data tells me that more oysters were harvested than had been since 1986. Lipcius PFD ¶ 56, 18 demo.6. Florida's Dr. White found that these larger landings did not represent a larger harvest *rate*. White PFD ¶¶ 161–62. But given the concerns about the oil spill, I find that the more likely reason that landings increased was an increase in harvesting rate. This is supported by Dr. Lipcius's observation that exploitation rates increased prior to the collapse. *See* Lipcius PFD ¶¶ 120–23. Moreover, catch per unit effort (CPUE)

[13] "Landings" means a species being fished and taken out of the water to the dock to be sold or consumed. Lipcius PFD ¶ 52.

began to decline sharply in 2009 and further declined into 2014. *See id.* ¶¶ 117–18. Lower fishing efficiency is a sign of overfishing and shows that the fishing rate was likely higher preceding the collapse. *Id.*

As for the trips data, Dr. Kimbro argues that the extra trips were a symptom of the collapse, not the cause. Kimbro PFD ¶ 103(j)–(l) (arguing that as the higher salinities depleted oyster stocks, oystermen had to devote more effort to gathering the same catch). Even if that were the case, the harvesting rate would have been increasing as the oyster stocks were depleted. *See* Lipcius PFD at 35 demo.11 (showing oyster harvest remained elevated through 2012).

Florida's witnesses also contend that the collapse would have occurred even in the absence of harvesting pressure. *See* Kimbro PFD ¶ 101; 4 Trial Tr. 1011:17–1012:4 (Berrigan). But Mr. Berrigan's testimony that harvesting would be especially damaging when the oyster resource is already stressed belies this assertion. 4 Trial Tr. 831:18–23 (Berrigan). Moreover, I cannot reconcile Florida's assertion with Dr. Lipcius's analysis showing that the most heavily harvested oyster bars suffered the worst oyster population declines and with Dr. Lipcius's analysis finding little evidence of a large predation event. *See* Lipcius PFD ¶¶ 40–45, 70–82; *id.* at 12–13 demos.3 & 4.

Next, even if low flows and associated increased salinity caused the oyster crash, Georgia argues that the low flows were the result of drought, not its consumption. Ga. Br. at 8–9. I find this argument persuasive.

Importantly, Florida's own modeling shows that cutting 50% of Georgia's agricultural consumption would only have decreased salinities by one to two parts per thousand (ppt) in only very limited areas of the Bay in 2012. Greenblatt PFD ¶ 27, 37 fig.3-16; *see* Ga. FoF ¶ 18. This shows that drought was a much bigger factor in causing salinity increases than Georgia's consumption. More importantly, Dr. White found that the impacts on oyster biomass of such salinity decreases would also be small (just over 1%). *See* White PFD at 50–51 figs.14 & 15. These very modest increased biomass measures are not surprising given that the optimal salinity range for oysters is between 12 and 25 ppt. Kimbro PFD ¶¶ 27, 31. Given that, Dr. Kimbro's snail predation experiments found only a small increase in predation from a small salinity increase of one to two ppt. *See id.* at 27 fig.10(B); *see also* FX-797 App. 2 at 38 (showing that only reductions by 20 ppt resulted in a "clear negative trend" in predation); Ga. FoF ¶ 17. In the face of persuasive evidence that Florida's mismanagement led to the collapse, these very modest modeling results fall short of showing by clear and convincing evidence that Georgia caused the oyster decline.

Florida nevertheless contends that drought could not have caused the collapse and relies on a historical comparison of climate and flows to argue that the only factor that changed from past droughts compared with the drought preceding the collapse was Georgia's consumption. Fla. Br. at 10–11. I am not convinced. The climatic conditions in years immediately preceding the collapse were different (on both an annual basis and intra-annual basis). *See infra* at pp. 38–40. Moreover, Florida's observational argument ignores the fact that harvesting pressure was especially high while ignoring the lower rates of re-shelling that occurred in the Bay. Offering comparisons with previous years without any control for other possible factors contributing to the collapse cannot satisfy the clear and convincing standard required at this stage.

Florida also introduced evidence concerning broader harms in the Bay resulting from the changes in nutrient composition that low flows can cause. *See* Fla. FoF ¶ 15. I do not find that these harms constitute a substantial invasion of rights, however, because Florida has not shown a "threatened invasion of rights . . . of serious magnitude" to other species by clear and convincing evidence. *Florida*, 138 S. Ct. at 2514 (quoting *Washington*, 297 U.S. at 524). To the extent that Dr. Glibert's evidence on nutrient effects and the food chain might indicate future harm, evidence on the possibility of such harms arising in the future is insufficient for Florida to establish a basis for relief. *See Florida*, 138 S. Ct. at 2514 ("A State 'will not be granted [relief] against something merely feared as liable to occur at some indefinite time in the future.'" (alteration in original) (quoting *Connecticut v. Massachusetts*, 282 U.S. 660, 674 (1931))).

Florida has not shown by clear and convincing evidence that the oyster collapse was caused by Georgia rather than another cause (like mismanagement of the resource or drought), and Florida has not shown any other harms to the Bay.

B. Harms to the River During Dry Years

As Special Master Lancaster observed, the Apalachicola River and its associated floodplain provide habitat that supports the highest species density of amphibians and reptiles in North America. Lancaster Rep., 2017 WL 656655, at *8. The River and floodplain are home to 142 freshwater and estuarine fish species (including the threatened Gulf sturgeon) and host 26 species of freshwater mussels while supporting one of the largest stands of Ogeechee Tupelo and other swamp trees in the country. *Id.*; Fla. Br. at 5–6.

Florida argues that the species and habitats of the Apalachicola River and floodplain have been harmed by low flows when habitats are not inundated at the right times or are not inundated for long enough. *See* Fla. Br. at 13–14; Fla. FoF ¶ 16; Fla. Resp. Br. at 10–12. Georgia responds in two main ways, arguing that Florida has not shown evidence of real harm resulting from low flows and that any of the concrete harms that Florida identified were not caused by Georgia's actions. *See* Ga. Br. at 4–6; Ga. FoF ¶¶ 3–10; Ga. Resp. Br. at 2–3. I agree with Georgia and find a complete lack of evidence of any harm caused by Georgia to the ecosystems of the River and floodplain.

I do not find evidence of harm to the animal species in the River and floodplain ecosystems caused by

Georgia. First, Florida has not shown any population-level harms to animals in the River and floodplain that were caused by Georgia. Although Florida identifies an isolated die-off of the fat threeridge mussel in Swift Slough, the United States Fish and Wildlife Service (USFWS) estimates that the fat threeridge population (between approximately 6.01 million and 18.65 million) is "stable or improving," and, in suitable habitat, is "common to abundant." JX-168 at 113, 124. Similarly, the Gulf sturgeon population in the Apalachicola River and Bay is described as "roughly stable or slightly increasing," and Florida's Dr. Allan presented no evidence of any changes to the populations of mussels, fish, birds, reptiles, amphibians, or mammals in the ACF Basin. *Id.* at 63; 2 Trial Tr. 389:17–390:3, 392:9–17, 395:2–10, 396:11–14 (Allan); 3 Trial Tr. 547:1–548:1 (Allan).

Without evidence of any animal population declines, Florida relies on Dr. Allan's testimony on "metrics of harm." Dr. Allan attempts to attribute ecosystem harm to Georgia's consumption based on the flow regimes that certain organisms theoretically need for reproduction or survival. *See* Allan PFD ¶¶ 33–36, 38–61. I do not find this testimony credible. First, Dr. Allan did not conduct any studies to determine whether the species he considered were increasing, decreasing, or stable, 2 Trial Tr. 389:17–390:3, 390:14–18, 392:9–17, 395:2–10, 396:11–14 (Allan), and he therefore could not confirm that his harm metrics showed actual harm. He also did not study the effect of sediment deposition resulting in sloughs being cut off. *Id.* at 431:24–432:24.

I also agree with Georgia that the harms identified by Florida were not caused by Georgia. The construction of the Jim Woodruff Dam, coupled with the dredging of the channel by the Corps, deepened the channel, which lowered the natural water level and thereby disconnected many sloughs. Kondolf PFD ¶ 17; 1 Trial Tr. 123:2-20 (Hoehn); 3 Trial Tr. 554:13–18 (Allan); *see also* GX-248 at 13–18, 43; GX-72; GX-88 at 4, 13, 28–29. Indeed, Swift Slough used to connect at 4,500 cubic feet per second (cfs), but now connects at 5,600 cfs because of changes to the channel. GX-123 at 63; GX-1272 at 9 tbl.1. Dredge material was also pumped onto the floodplain forest, 10 Trial Tr. 2585:5–7 (Kondolf); GX-248 at 33–34, and clogged tributaries, cutting them off from the main river, 10 Trial Tr. 2574:11–24, 2588:13–18 (Kondolf). *See* Ga. FoF ¶ 8.

Georgia's ecological expert, Dr. Charles Menzie, explained that the United States Geological Survey (USGS) has found that channel deepening caused the changes in the floodplain forest. Menzie PFD ¶¶ 173, 176, 186; *id.* at 97 demo.45; *see also* GX-88 at 1, 48–49. Florida's own evidence on changes to floodplain tree species partially confirms this conclusion. Dr. Allan shows several types of floodplain forest trees that experienced population declines from 1976 to 2004. Allan PFD at 44 fig.22. But this timing is inconsistent with when Florida argues that streamflow declines have been greatest. *See id.* at 27 fig.16 (consecutive days with flows below 6,000 cfs increased since the late 1990s).

Although my finding that Florida has not suffered any harm from Georgia's consumption would typically end my analysis, the Court has emphasized the need for a special master to make a full range of factual findings. *See Florida*, 138 S. Ct. at 2515. I therefore turn to the next question in this case, whether Georgia's use of water from the ACF Basin is inequitable.

III. Whether Georgia's Use of ACF Waters Is Inequitable

The Supreme Court has asked me to determine "[t]o what extent does Georgia take too much water from the Flint River." *Florida*, 138 S. Ct. at 2527.[14] I conclude that Georgia does not take too much water from its portion of the ACF Basin including from the Flint River. I reach this conclusion after considering Georgia's consumptive use as compared with the flows passing to Florida, Georgia's conservation efforts, and Georgia's uses of the water.

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[14] I also analyze whether Georgia has taken too much water from the Chattahoochee River because the Court did not make any findings on this question, the Court did not expressly limit my inquiry to the five questions on remand, and because Florida continues to press its arguments that Georgia's consumption in the entire Georgia portion of the ACF Basin is inequitable. *Florida*, 138 S. Ct. at 2527; *see* Fla. Br. at 7–10, 15–18.

A. Georgia's Consumptive Use

To determine whether Georgia uses an inequitable amount of ACF waters, I first estimate how much water Georgia uses based on the evidence in the record. The parties' estimates vary dramatically.[15] Florida argues that Georgia depletes ACF Basin streamflow by about 4,000 cfs on average in summer months of recent dry and drought years. Fla. Br. at 17; *see id.* at 10 (arguing that Georgia's consumption is the only explanation for estimated streamflow depletions of 3,900 cfs).

Georgia, however, says it consumes much less. Georgia argues that its highest *ever* Flint River consumption in one month was only 1,407 cfs (in July 2012), Ga. Br. at 11, and it presented evidence that its highest *ever* monthly consumption in the entire ACF Basin has never exceeded 2,000 cfs. *See, e.g.*, Zeng PFD ¶¶ 5, 23, 7 demo.3 (showing a peak consumption just over 1,800 cfs).

On an annual basis, Georgia contends that it uses only 282 cfs from the Flint River in normal years and 425 cfs in dry years. Ga. Br. at 10; Ga. FoF ¶ 20. The table below summarizes Georgia's position on its consumption over various time periods, depending on whether it is a dry or drought year. The bottom line: even using Georgia's highest consumption estimate, Georgia argues that it uses less than half of what Florida says it does.

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[15] The parties do, however, agree that Georgia consumes more water during drought years. *See* Ga. Br. at 10; Fla. Br. at 8.

Table 1: Georgia's Estimates of its Water Consumption.

	Flint Basin		Georgia ACF	
	Normal year	*Dry year*	*Normal year*	*Dry year*
Avg. Annual Consumption (cfs)[16]	282	425	540	757
Peak Consumption (cfs)[17]	~850	1,407	~1,300	1,884
Avg. May – Sept. Consumption[18]	425	804	886	1,375

As one might expect given such differing estimates, Georgia and Florida use different approaches to arrive at them. I summarize these approaches, and I then explain why I find Georgia's estimates of its consumptive use to be more reliable.

1. Florida's Approach to Estimating Consumptive Use

Florida's experts used a variety of techniques to estimate consumptive use, but they relied most heavily on rainfall runoff models and comparisons of

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[16] Ga. FoF ¶ 20 (425 cfs); *id.* (282 cfs); *id.* ¶ 19 (757 cfs); *id.* (540 cfs).

[17] Ga. Br. at 11 (1,407 cfs); *see* Zeng PFD at 7, demo.3 (850 cfs); Ga. FoF ¶ 23 (1,884 cfs); *see* Zeng PFD at 7, demo.3 (about 1,300 cfs consumed at peak in 2009).

[18] Ga. Br. at 11 (804 cfs); *id.* at 10 (425 cfs); *see* GX-940 (1,375 cfs is my own calculation averaging May – September consumption in dry years since 2000); *see id.* (886 cfs is my calculation by averaging May – September consumption in non-dry years since 2000).

basin-yield measures. *See* Fla. Br. at 17. Rainfall runoff models predict what streamflow should be, given a set of climate inputs. Lettenmaier PFD ¶ 17. One can then compare predicted flows (based on a calibration to a period before human consumptive uses) with measured flows for a specified period, and the difference between the two provides an estimate of streamflow impact caused by human activity within the basin of interest. *See* Hornberger PFD ¶¶ 83, 86–87; 8 Trial Tr. 2006:8–2007:1 (Hornberger).

These models must approximate the amount of evapotranspiration,[19] groundwater absorption, and many other factors within a basin, otherwise they would omit a significant source of rainfall that is not converted to streamflow. *See* Hornberger PFD ¶ 84, 42 fig.9; *see also* 8 Trial Tr. 2060:3–15 (Hornberger). Evapotranspiration depends on a number of climate factors, including temperature, but solar radiation is the primary driver. 10 Trial Tr. 2432:5–14, 2433:8–14 (Lettenmaier). Because data on solar radiation is not widely available, Florida's experts used the difference between the daily maximum and minimum temperatures within the Basin to approximate solar radiation. *Id.* at 2433:14–2434:9. This approach relies on the fact that daily temperature fluctuations depend closely on the amount of cloud cover, and cloud cover, in turn, blocks solar radiation. *Id.* at 2433:20–2434:5.

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[19] Evapotranspiration is the sum of water lost through evaporation (i.e., water lost directly from soil or open water) and transpiration (i.e., evaporation of water from plants). Hornberger PFD ¶ 19.

Florida experts used two rainfall runoff models. Dr. Hornberger used the Precipitation Runoff Modeling System (PRMS), and Dr. Lettenmaier used both the PRMS and the Variable Infiltration Capacity model (VIC). Hornberger PFD ¶¶ 27, 84; *see* Lettenmaier PFD at 23 fig.11.

Dr. Hornberger calibrated the PRMS model to match measured river flows for the period before 1955 to establish a baseline of streamflow without human consumption. Hornberger PFD ¶ 86. He then purported to model how much streamflow would be expected, based on climate data, in subsequent years. *Id.* ¶ 87. His results showed streamflow reductions of 3,000 to 4,000 cfs on average over June to September in low-flow years during the 2000 to 2012 period and peak depletions of 5,500 cfs. *Id.* ¶ 85, 46 tbl.8.[20] He conceded that his model contains inherent errors, 8 Trial Tr. 2009:4–2013:9 (Hornberger), which have been identified as between 2,000 and 6,000 cfs, Bedient PFD ¶¶ 226–27.

Dr. Lettenmaier calculated the difference between his models' predicted flows and actual flows and concluded that streamflow reductions caused by human activity are now about 3,800 cfs on annual average. Lettenmaier PFD ¶¶ 39–40. He also conceded that his modeling contained errors of up to 10,000 cfs. 10 Trial Tr. 2402:23–2403:15 (Lettenmaier); *see also* Bedient PFD ¶¶ 237–40.

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[20] These results account for evaporative losses from reservoirs operated by the Army Corps. *Id.* ¶ 93.

In addition to using rainfall runoff models, Dr. Hornberger also compared basin yields[21] from before and after 1970, when Georgia began irrigating. *See* Hornberger PFD ¶¶ 63–65; *id.* at 27–28 tbls.4 & 5. Comparing basin yields rests on the same theory underlying the use of rainfall runoff models, but the approach does not control for other factors that may affect streamflow like evapotranspiration. *See* Hornberger PFD ¶ 63, 42 fig.9; Bedient PFD ¶¶ 204, 226–27. Dr. Hornberger found that average basin yields between 2003 and 2013 have been lower than before 1970 and represent a 3,900 cfs deficit on an annual basis. Hornberger PFD at 27 tbl.4.

Dr. Hornberger also relied on another hydrologist's analysis to estimate that Georgia consumes more than 4,500 cfs during peak months. *See* Hornberger PFD ¶¶ 11, 75–76. The individual Dr. Hornberger relied upon did not testify, was not cross-examined, and his testimony was not admitted into evidence. Dr. Hornberger, who did not do an independent study, 8 Trial Tr. 2013:25–2015:14 (Hornberger), determined that agricultural consumption approaches 4,000 cfs during summer months of recent droughts and that municipal and industrial (M&I) use has consistently exceeded 600 cfs in the same periods. Hornberger PFD ¶¶ 77, 80.

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[21] "Basin yield is the ratio of runoff (or streamflow) to rainfall for any particular time period . . . one can think of it as the fraction of rainfall that becomes streamflow." Hornberger PFD ¶ 63.

2. Georgia's Approach to Estimating Consumptive Use

Whereas Florida's approach to estimating Georgia's consumptive use might be described as "top-down," Georgia's approach would best be described as "bottom-up." *See* Hornberger PFD ¶ 71. To calculate agricultural consumptive use, Georgia first aggregated all the acres under irrigation within the Georgia portion of the ACF, but it excluded acres irrigated from aquifers that do not impact streamflow. Zeng PFD ¶¶ 49–52, 58, 60–61.[22] The data for this acreage came from Georgia's Wetted Acreage Database, which is kept in the regular course by Georgia's Environmental Protection Division (EPD). *Id.* ¶ 52.

Next, Georgia calculated how much water farmers apply to their fields on average (this is called "irrigation depth"). *Id.* ¶ 46. Georgia's method for calculating such depths has varied over time, but its most recent was the Agricultural Metering Program, which involved looking at a sample of irrigation meters covering 60% of irrigated acres in the ACF Basin. *Id.* ¶ 55. These meters collected data on the quantity of water withdrawn on an annual basis, and the meters are associated with acreage values. *Id.* In addition to the annual meters, 70 to 90 systems in the Lower Flint River

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[22] Whether aquifer withdrawals affect streamflow depends on the connectivity of the aquifer with the stream. *See* Zeng PFD ¶ 61. Georgia introduced credible evidence at trial that only the Upper Floridan Aquifer connects with streams, except where other aquifers are exposed at the surface. *Id.* ¶¶ 31, 73–81; *see* Zeng PFD at 1 n.1, ¶ 61.

Basin are read at monthly intervals and have been since 2012. *Id.* The monthly measurements allowed Georgia to extrapolate a monthly pattern across the whole Basin. *Id.*

Georgia then calculated its total agricultural withdrawals by multiplying total irrigated acreage by basin-wide irrigation depths. *Id.* ¶¶ 58–59; 13 Trial. Tr. 3306:7–20 (Zeng). Georgia's data sources for total acreage under irrigation varied depending on the time period. *See* Zeng PFD ¶ 58. For the period from 2004 to 2014, Georgia used its Wetted Acreage Database. *Id.* For years before that, Georgia relied on data collected by both Georgia EPD and the University of Georgia, and statewide trends of irrigated acreage developed using county surveys. *Id.*

The source of the data used for the irrigation depths also varied depending on the time period in question. Georgia used the withdrawal amounts from the Agricultural Metering Program to determine irrigation depths for years 2008 and after, and this data included irrigation depths by month for the period after 2012. *Id.* ¶ 59; 13 Trial Tr. 3306:10–14 (Zeng). For the period from 2002 to 2007, irrigation depths came from the University of Georgia's Agricultural Water Pumping Study, which also provided monthly depth measures. Zeng PFD ¶ 59. For periods before 2002, Georgia assumed the same irrigation depths from the Agricultural Water Pumping Study, based on whether the year was a dry or wet year. *Id.*

As mentioned above, groundwater withdrawals do not have a one-to-one impact on streamflow. *See* Panday PFD ¶ 16.[23] Thus, to arrive at an estimate of streamflow depletions caused by agriculture, Georgia used the Jones-Torak model to determine the quantity of streamflow depletions caused by groundwater irrigation pumping. Zeng PFD ¶ 61. Georgia's Wetted Acreage Database contains data on the source of irrigation (surface or aquifer), so Georgia could separate out the impact on streamflow from surface water and groundwater withdrawals. *Id.* ¶ 58.

With these calculations complete, Georgia then estimated its agricultural consumptive use by adding the surface water withdrawals to the streamflow impacts of groundwater withdrawals. Zeng PFD ¶ 63; *see id.* at 23–24 demos.9 & 10.

To calculate its municipal and industrial consumptive use, Georgia used direct measurements from about 300 withdrawing facilities and about 1,000 discharge facilities that are collected and saved in Georgia's Consumptive Use Database in the ordinary course of business. Zeng PFD ¶¶ 25–27, 30. To calculate M&I consumptive use, Georgia subtracts returns (i.e., discharge from water treatment facilities back to the river system) from withdrawals, and the difference

[23] Georgia only applied this analysis to agricultural withdrawals from groundwater sources. *See* Zeng PFD ¶¶ 60–61. Withdrawals directly from surface waters were assumed to have a one-to-one impact on streamflow. *Id.* ¶ 61.

represents consumptive use. *Id.* ¶¶ 31, 34; 13 Trial Tr. 3305:11–3306:6 (Zeng).

Once Georgia calculated its agricultural and M&I consumptive use, it added the two and calculated total consumptive use in the Georgia ACF. *See* Zeng PFD ¶¶ 18–23; *id.* at 6–7 demos.1–3.

3. Georgia's Approach Is More Reliable

Georgia's estimates of its consumptive use are more reliable for several reasons. First, Georgia uses reliable methods to calculate its consumption. Second, I am reluctant to rely on any of the modeling performed by Florida's experts because of significant uncertainties inherent to their analysis and accordingly, their credibility. Third, Florida's attacks on Georgia's methods have not persuaded me that Florida used a more reliable approach.

As described above, Georgia used an accounting approach to calculate its consumptive use. For the most recent years in the agricultural consumption dataset, Georgia relied on direct measurements from its Agricultural Metering Program to calculate average irrigation depths. Zeng PFD ¶ 55; 13 Trial Tr. 3306:10–14 (Zeng). Though the Agricultural Metering Program did not measure watering depths on all acres, Georgia still gathers data from a majority of irrigated acres. *Id.* This represents a reasonably large sample size for reaching a robust estimate, and there was no evidence that the Agricultural Metering Program is systematically biased toward collecting data from acres irrigated to a shallower depth.

Georgia's M&I use calculations are also dependable. Georgia collects and stores its data in the regular course. Zeng PFD ¶ 25. Further, because each withdrawal facility is counted in the Consumptive Use Database, 13 Trial Tr. 3305:11–3306:6 (Zeng), it does not require any extrapolating from a sample of meters to estimate total use.

By contrast, Florida's rainfall runoff models contain significant uncertainties. Dr. Lettenmaier acknowledged that his estimates from rainfall runoff modeling contained an uncertainty range of 1,295 cfs or 34% of his estimated 3,800 cfs streamflow reduction. *See* 10 Trial Tr. 2393:14–24 (Lettenmaier). I also note that Dr. Lettenmaier did not present these uncertainty bounds in direct testimony; rather, the uncertainty associated with his models only came out on cross-examination. *See* Lettenmaier PFD ¶¶ 39–43; 10 Trial Tr. 2393:14–24 (Lettenmaier). Likewise, Dr. Hornberger's model sometimes varied from actual flows by as much as 20,000 cfs during the period in which the model was supposed to be calibrated to match. 8 Trial Tr. 2011:1–18 (Hornberger). These differences persisted into the post-calibration period. *Id.* at 2011:23–2012:1. Last, the models were calibrated using time periods from before the federal reservoirs were constructed on the Chattahoochee River. Hornberger PFD ¶¶ 27, 86 (calibrated to "pre-1955 period"); *see* JX-124 at 2-24 tbl.2.1-3 (showing that all USACE federal dams but the Jim Woodruff dam were completed after 1955). Although

Dr. Hornberger appears to have accounted for evaporation from them, 8 Trial Tr. 2071:22–23 (Hornberger), the effect of reservoirs is complex, and I am not willing to draw conclusions on changes in annual flows by comparing pre-reservoir and post-reservoir periods.

I am also hesitant to rely on Florida's estimates of consumptive use derived from rainfall runoff modeling because the model results Florida's experts provided are somewhat inconsistent. Dr. Hornberger presented rainfall runoff modeling results that suggested total streamflow reductions of 3,000 to 4,000 cfs on average over June to September in low-flow years during the 2000 to 2012 period and peak-month depletions as high as 5,500 cfs. Hornberger PFD ¶ 85, 46 tbl.8. Dr. Lettenmaier estimated a 3,800 cfs streamflow reduction on an average annual basis occurring in 2016. Lettenmaier PFD ¶ 40. Although those absolute numbers are relatively close, they estimate measures that differ in two significant respects. First, consumptive use increases in the summer months compared to an annual average. *See* Sunding PFD ¶ 48 ("agricultural water use is highly seasonal"). Second, consumptive use also increases in dry years relative to normal years. Fla. Br. at 8–9. Dr. Lettenmaier did not provide a satisfactory explanation for this difference when confronted with it on cross-examination. *See* 10 Trial Tr. 2390:22–2393:8 (Lettenmaier).

Although the basin-yield analysis appears to confirm some rainfall runoff modeling, Hornberger PFD at 27 tbl.4, the confirmatory value of a basin-yield analysis appears marginal. I do not see what the analysis adds in terms of precision that rainfall runoff modeling cannot capture because the latter controls for more variables. *See id.* at 42 fig.9 (illustrating some variables).

Further, I place little weight on Dr. Hornberger's testimony and find a lack of credibility. Dr. Hornberger presented an unreliable model (the "Lake Seminole Model").[24] He also failed to report several basin yields that did not support his conclusion in a demonstrative, *see* 8 Trial Tr. 2000:16–2002:5 (Hornberger), and did not report some of his ResSim modeling results that confirmed Georgia's theory until forced to during cross-examination, *id.* at 1931:15–1936:10 (Hornberger).

4. Florida's Arguments Are Not Persuasive

In an attempt to discredit Georgia's consumptive use estimates, Florida raises several arguments. Florida first critiques the Unimpaired Flows (UIFs) data

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[24] Dr. Hornberger developed the Lake Seminole Model for this case to "replicate[ ] the Army Corps' actual operations as closely as possible." *Id.* ¶ 121. The model was unreliable for several reasons. First, whereas the Army Corps' model simulates all five Chattahoochee reservoirs and dams, the Lake Seminole Model only simulated Lake Seminole and the Jim Woodruff Dam. 8 Trial Tr. 1944:18–1945:5 (Hornberger). Next, the Lake Seminole Model did not score as well on goodness-of-fit tests as another of Dr. Hornberger's models and thus undercut his rationale for choosing it. *Id.* at 1956:20–1957:4, 1959:10–19 (Hornberger). And significantly, the Lake Seminole Model predicted outcomes that would be physically impossible (Hornberger). *Id.* at 1961:5–24, 1962:11–1963:6 (Hornberger).

used by the Army Corps, not Georgia's water use data. 13 Trial Tr. 3316:10–3317:2 (Zeng). The UIFs are used by the Army Corps for planning purposes, and they represent what flows in the Basin would be absent human influence. Zeng PFD ¶ 74. The Army Corps develops its estimates of the UIFs using data provided by Georgia EPD. *Id.* ¶¶ 73, 75. Florida highlights a report (FX-534) by the Georgia Water Resources Institute (GWRI) that raises concerns about the UIFs dataset to attack Georgia's consumptive use estimates by proxy. Florida argues that if the UIFs are faulty, then the data underlying them (Georgia's estimates) must also be faulty. Fla. Br. at 16–17; Fla. Resp. Br. at 7–8.

Florida highlights two specific sources of possible error in the UIFs that the GWRI had highlighted: irrigation requirements and farm pond evaporation. *See* Fla. Br. at 16. The GWRI concluded that irrigation requirements might be 70% higher than the UIFs contemplated because the UIFs only used two demand scenarios ("dry" and "normal"), but this binary approach might miss significant variation compared to a simulation model of crop needs. FX-534 at 10. Because Georgia's most recent estimates of its water consumption use direct measurements from irrigation meters, I do not find this critique persuasive. *See* Zeng PFD ¶ 55; 13 Trial Tr. 3305:23–3307:5 (Zeng). Moreover, to the extent that any errors exist, Dr. Zeng described them as "minor." 13 Trial Tr. 3317:10–23 (Zeng).

Nor do I find Florida's farm pond critique persuasive. Florida cites the GWRI report for the proposition that farm pond evaporation depletes streamflow by up to 1,200 cfs. Fla. Br. at 16; *see also* FX-534 at 191–92. But the GWRI report only supports that proposition weakly. *See* FX-534 at 191–92. The report explains that 1,200 cfs is an upper bound, but the annual net loss is estimated at only 225 cfs. *Id.* Moreover, as Georgia argues, farm ponds actually store water for use later during dry times; in that way, they might actually augment rather than deplete streamflow. Ga. Resp. Br. at 8–9.[25]

Second, Florida also contends that the bottom-up accounting method Georgia used is only as good as it is comprehensive and that Georgia undercounted irrigated acres. Fla. Resp. Br. at 6 nn.5–6; *see* Hornberger PFD ¶ 71.[26] Florida argues that Georgia's use of 582,000 acres irrigated from sources with an impact on streamflow is too low and cites other higher estimates without saying which should be adopted. *See* Fla. Resp. Br. at 6. Because Dr. Hornberger concluded that 825,000 acres were under irrigation in 2014, I take Florida's position to be that approximately 825,000 irrigated acres in the Georgia ACF impact streamflow. Hornberger PFD ¶ 77; *see also* Fla. FoF ¶ 18; FX-D-24 (Zeng). The difference between the acres that Dr. Zeng used and Dr. Hornberger used appears to turn in part on whether "throw acres" were included in the

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[25] Respecting other issues in this case, Florida has made similar arguments on uses of storage to augment summer flows. *See* Fla. Br. at 24 (proposing that Georgia construct a new reservoir as a water conservation measure); Fla. Post-Trial Br. at 24 n.3.

[26] Florida also argues that Georgia does not consider farm pond evaporation. Fla. Resp. Br. at 7. The preceding discussion explains why I find this critique unpersuasive.

analysis. *See* 13 Trial Tr. 3223:4–12, 3224:11–3225:8 (Zeng); FX-D-24 (Zeng).[27] Given Dr. Zeng's explanation for not including the throw acres in his assessment of total acres, the acreage value Georgia used does not lead to an overestimate of consumption. Dr. Zeng explained that Georgia calculated irrigation depths by dividing directly-measured irrigation volumes by the acreage irrigated. Zeng PFD ¶ 59. Including throw acres would have increased the total irrigated acreage in the calculation, but the irrigation depth would be proportionally smaller. 13 Trial Tr. 3225:10–3226:15 (Zeng).[28] Accordingly, Florida's approach does not convince me that Dr. Zeng's estimate of 723,127 total irrigated acres as of 2014, Zeng PFD at 18 demo.7, in the Georgia ACF is underinclusive.

Third, Florida relies on an analysis performed by Dr. Sunding to attack Georgia's acreage estimates. *See* Fla. Resp. Br. at 6. Dr. Sunding compared the NESPAL database[29] with the Wetted Acreage Database, and he

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[27] As described by Dr. Zeng on cross-examination, throw acres refer to acres that are irrigated by an end gun on a center-pivot irrigation system. The end gun "throw[s] water out beyond the range of the irrigation equipment so that a bigger area can be irrigated." 13 Trial Tr. 3222:15–3223:3 (Zeng); *see also* Masters PFD at 11 demo.2.

[28] As a matter of arithmetic, Dr. Zeng's explanation relies on the assumption that unmetered acreage in the Georgia ACF has the same relative proportion of throw acres to hardware acres as the acreage measured by the Agricultural Metering Program. I have seen no evidence suggesting otherwise.

[29] The National Environmentally Sound Production Agriculture Laboratory (NESPAL) database was developed as part of a

found that some fields included in NESPAL were not mapped in the Wetted Acreage Database. Sunding PFD ¶ 29. But Dr. Sunding provided no estimate of how much acreage was actually omitted. *See id.* In any case, the Wetted Acreage Database updated the NESPAL database, so to the extent they conflict, the Wetted Acreage Database more likely reflects current irrigation practices. Masters PFD ¶¶ 26, 29–30. The 2016 Wetted Acreage Database started with the 2010 NESPAL data but contains more current information that is the product of extensive mapping efforts and thousands of hours of work. *Id.* at 29–30. Some fields were removed because they no longer (or never were) being irrigated or are irrigated by groundwater from other nonconnected sources. Zeng ¶ 50. One hundred percent of acreage in the ACF Basin was mapped. 14 Trial Tr. 3699:11–14 (Masters). One hundred percent of acreage in the lower Flint Basin was field verified. *Id.* 3701:14–19 (Masters). As part of each field verification, the Water Policy Center team went to each irrigation location, located the source of water, identified the type of source (i.e., which aquifer or surface), captured information about the exact acreage under irrigation from a particular source, gathered information on the type of irrigation system, and located each flow meter and took readings. *Id.* at 3699:24–3701:13 (Masters).[30]

state and regional planning process in 2008 and 2009. Zeng PFD ¶ 49.

[30] Relatedly, Dr. Sunding compared the Wetted Acreage Database with Georgia EPD permit records and suggests that up to 90,000 irrigated acres in the Georgia ACF were irrigated in excess

Fourth, Florida argues that Georgia's impact factor for groundwater pumping was too low because it did not consider long-term impacts. Fla. Resp. Br. at 7. But Dr. Hornberger's testimony provided almost no scientific support for using a long-term impact factor, *see* Hornberger PFD ¶ 99, and this evidence was rebutted by the only groundwater expert to testify at trial. *See* Panday PFD ¶¶ 98–100.

Finally, Florida pursues a more indirect attack on Georgia's consumption estimates by highlighting the increased frequency of low flow days compared with flow records from before Georgia began irrigating. Fla. Br. at 17–18.[31] There is no doubt that days with flows below 6,000 cfs have occurred much more frequently in recent years, but the parties dispute their cause. Florida suggests that Georgia's consumptive use has

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of individual permit terms. Sunding ¶¶ 40, 46–47. Because Dr. Sunding used the Wetted Acreage Database for this analysis, his suggestion does not call into question Georgia's consumption estimates. Rather, I understand his argument to be that even using Georgia's estimates of its irrigated acreage, a portion of those acres are irrigated in excess of permit terms and is therefore inequitable. As described below, because I find no harm to Florida caused by Georgia, I do not find this consumption to be unreasonable.

[31] Additionally, Florida emphasizes statements from Georgia's officials made in the 1990s. *See* Fla. Br. at 21–22, 24–25. Given the wealth of data on consumptive use in the Georgia ACF Basin that the parties have provided, I give these statements little weight. *See Colorado v. New Mexico (Colorado II)*, 467 U.S. 310, 320 (1984) (requiring "hard facts" in equitable apportionment cases); *see also* 3 Trial Tr. 702:24–705:15 (Reheis) (describing the limited data on water consumption available to Georgia in the late 1990s).

caused them, but Georgia suggests with evidentiary support that repeated multi-year droughts and a shift in intra-annual rainfall patterns has caused them. Bedient PFD ¶¶ 4, 124–29; 13 Trial Tr. 3352:11–3353:24 (Zeng).

Florida points to two droughts (1931 and 1954–1955) from the Basin's hydrologic record to argue that previous droughts have not resulted in the same low flows that have occurred in more recent drought years. Fla. Br. at 11; *see* Hornberger PFD ¶¶ 50–53. These droughts, however, are distinguishable. None of the reservoirs operated by the Army Corps were in existence, and as described above, I discount such comparisons because the reservoirs lose water to evaporation, 8 Trial Tr. 1995:21–25 (Hornberger), and regulate releases along the Chattahoochee River. Further, Georgia convincingly distinguishes the 1931 and 1954–1955 droughts from more recent droughts like the 2011–2012 drought. Unlike the 1931 drought, the 2011–2012 drought was a multi-year drought spanning two years, and unlike the 1954–1955 drought, 2011 was not preceded by a wet winter, which ameliorated the 1954 flow rates. Bedient PFD ¶¶ 205–08.

Florida also relies on Dr. Lettenmaier's analysis to rebut Georgia's claim that changes in precipitation patterns have caused lower flows. *See* Fla. Br. at 18. Dr. Lettenmaier analyzed rainfall and other climate patterns[32] from the historic record and concluded that

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[32] Dr. Lettenmaier used gridded data for his analysis. Lettenmaier PFD ¶ 13. Gridded rainfall data does not rely exclusively on one rain gauge; rather, measurements from individual

there has not been a statistically significant trend in either monthly or annual precipitation amounts in the Basin. *See* Lettenmaier PFD ¶¶ 24–25, 30. I do not find Dr. Lettenmaier's approach persuasive. Dr. Lettenmaier argues that there is no long-term trend in precipitation in the Basin. *Id.* ¶¶ 24–25, 14 fig.6. But he reaches this conclusion looking at data from 1895 to 2015, *see id.* at 14 fig.6, although the post-1970 period is the one of most interest. When Georgia confronted him on cross-examination with plots showing decreasing average precipitation after 1970 in Dr. Lettenmaier's own data, he dismissed them as not statistically significant. 10 Trial Tr. 2408:21–2409:19 (Lettenmaier). He explained that he could not reject the trend "as having occurred due to chance." *Id.* at 2409:1–2 (Lettenmaier). My inquiry, however, is not whether the decrease was caused by chance or a trend, but whether there was indeed a decrease that may have lowered streamflow. From the slopes Dr. Lettenmaier calculated, *see* FX-793 at 33, I find that there was such a decrease in annual rainfall amounts.

Dr. Lettenmaier also compared monthly precipitation patterns from before 1970 and after 1980. *See* Lettenmaier PFD ¶ 30. His comparison shows that the months of April through August (with June as a minor

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rain gauges are used to interpolate a weighted-estimate of rainfall across a gridded geographic area. *Id.* ¶¶ 13–14. This method makes gridded rainfall data more robust against sampling errors that might occur when a localized thunderstorm moves over one rain gauge but not the whole Basin. *Id.* Thus, where Dr. Lettenmaier has provided it, I use his rainfall data to draw conclusions on any trends.

exception) were drier in the post-1980 period. *Id.* at 17 fig.8. Nevertheless, he dismisses these differences as not statistically significant. *Id.* Again, however, I want to assess whether a decrease in rainfall might be causing lower streamflow in the recent years with particularly low streamflow, not whether any change in rainfall lies within the expected natural range of variability. As to my inquiry, a shift of precipitation from the hotter and drier times of year to wetter times can reduce streamflow during dry months. Zeng PFD ¶¶ 145–46.

For these reasons, I find that Georgia's estimates of its consumptive use are more reliable than Florida's. I therefore use Georgia's estimates in analyzing whether Georgia's consumptive use is equitable and in my analysis of the other questions on remand.

B. Equity of Georgia's Consumption

Having established that Georgia's estimates of its own consumptive use are more reliable, I now determine whether that use is equitable, considering total state-line flows and relative shares of population and output in the Basin, Georgia's uses for the water, and Georgia's conservation practices.

1. Water Consumption, Economic Activity, and Environmental Resources in the Basin

Georgia consumes a relatively small portion of state-line flows during most periods. The Georgia portion of the ACF Basin contains 92% of the population, 96% of employment, and contributes more than 99% of the gross regional product of the whole ACF Basin. Mayer PFD ¶¶ 27–28; Stavins PFD ¶ 33. The Georgia ACF produces 129 times the gross regional product and contains more than five times the land area of Florida in the Basin. Stavins PFD at 16, 18 demos.7 & 8. Although the comparison between the populations, economic output, and consumption may be helpful, I recognize that "wasteful or inefficient uses will not be protected." *Colorado I*, 459 U.S. at 184. Moreover, if such comparisons were dispositive, then equitable apportionment analysis would be reduced to a rigid rule whereby the larger state always wins. This would clearly run counter to the flexibility and attention to all relevant factors that equitable apportionment demands. *See Florida*, 138 S. Ct. at 2515.

In non-drought years, Georgia's annual average consumption represents only 2.4% of state-line flow (22,812 cfs). Ga. FoF ¶ 19. In dry years, Georgia's 757 cfs annual average consumption represents 6.1% of annual average state-line flow (12,424 cfs). *Id.* From May to September of dry years, Georgia's seasonal average consumption of 1,375 cfs is 17.4% of state-line flows (7,892 cfs). Ga. FoF ¶ 21; *see supra* tbl.1. Looking only at Georgia's Flint River consumption from May to September in dry years, it consumes 10.2% of state-line flow. Ga. FoF ¶ 21. During the worst droughts when flows are lower and when Georgia consumes its calculated one-month peak (more than 1,800 cfs from the Basin and 1,407 cfs from the Flint River), Georgia's total ACF consumption is 35% of state-line flows (5,000 cfs), and its Flint River consumption is 28%. 13 Trial Tr. 3370:18–3371:4 (Zeng); Ga. Br. at 14 (admitting all-time peak Flint River consumption of 1,407 cfs). Thus, relative to its population and economic output, Georgia consumes a relatively small share of the ACF waters.

The abundance of environmental resources and any negative effects that a water use may have on them also represent an important factor in determining whether a water use is equitable. *See Nebraska v. Wyoming*, 515 U.S. 1, 11–12 (1995); *New Jersey*, 283 U.S. at 345. Florida's Apalachicola River and Bay both are home to a rich variety of ecosystems and species. *See* Lancaster Rep., 2017 WL 656655, at *8–10. Nevertheless, because I have not found any harm to the species or habitats in these areas caused by Georgia's consumption, these environmental resources do not weigh heavily in my determination whether Georgia's consumption is equitable.

2. Georgia's Conservation Practices

Beginning with M&I consumption, Georgia has made significant progress in conserving water in ACF Georgia. To name a few measures, Metro Atlanta (1) requires the use of conservation pricing, (2) has a water loss auditing and leak-detection program, (3) mandates that all new multifamily buildings have "sub-meters" for each unit, (4) has replaced more than 110,000 inefficient toilets since 2008, and (5) runs campaigns to educate people on conservation and efficient water use. Mayer PFD ¶¶ 55–56. Georgia has also implemented state-wide conservation measures. *Id.* ¶¶ 58–67. These conservation measures appear to have been quite effective. Georgia's ACF M&I consumption has not increased from 1994 to 2013, despite population growth from 3.3 million to more than 4.9 million people. Mayer PFD ¶¶ 7, 30–32. Moreover, from 2000 to 2013, consumptive use in the Georgia ACF declined from 212.6 to 93.9 million gallons per day, and per-capita consumption in the Metro Water District decreased from 155 to 98 gallons per day. *Id.* ¶¶ 36, 44. Last, it appears that the Metro Atlanta region has its own self-interested reasons for conservation. *See* Mayer PFD ¶¶ 23–24.

Florida argues that Georgia should implement other M&I use conservation measures that it had contemplated but not pursued. Fla. Br. at 24 (arguing that Georgia should have built the Glades reservoir and should have implemented a lawn watering ban in 2011–2012); Fla. FoF ¶ 22. But the measures that Florida would have Georgia pursue are very costly. The Glades reservoir would cost $803 million to construct, and Georgia concluded that its conservation measures rendered the project unnecessarily expensive. JX-40 at 82; Turner PFD ¶ 55. Banning all outdoor water would have also had significant costs, and Georgia's Water Stewardship Act already prohibits outdoor watering from 10 a.m. to 4 p.m. Mayer PFD ¶¶ 130–31; Turner PFD ¶ 74.

Georgia has also taken steps to conserve water in the agricultural sector. In this matter, I respectfully disagree with Special Master Lancaster's characterization that Georgia believes its agricultural use should not be subjected to limits. *See* Lancaster Rep., 2017 WL 656655, at *34. I agree, however, with Special Master Lancaster's assessment that the Flint River Drought Protection Act's auction mechanism has been ineffective because it has not been employed in recent droughts of 2006–2007 and 2011–2012. *Id.* at *33–34; *see* Couch PFD ¶ 31. But I also have found the explanations given by former Georgia EPD directors Carol Couch and Judson Turner persuasive. *See id.* ¶¶ 31–33; Turner PFD ¶¶ 85–95.

Based on USGS studies on the impact of groundwater withdrawals on streamflow, Georgia categorized areas into three different zones as part of the 2006 Flint River Basin Regional Water Development and Conservation Plan. Couch PFD ¶ 22. Georgia then placed more rigorous permitting requirements on the zones that were more closely connected to groundwater aquifers. *Id.* These three zones were titled "Capacity Use Areas," "Restricted Use Areas," and "Conservation Use Areas." Cowie PFD ¶ 13, 5 demo.1. Georgia then placed permit conditions on new permits in Conservation and Restricted Use Areas that withdrew water from the Floridan aquifer or from any surface water. JX-21 at 34. After March 1, 2006, new permittees in these areas were required to

> 1) have end-gun shut off switches installed to prevent irrigation of non-cropped areas by center pivot systems, 2) be maintained to prevent and repair leaks, 3) have pump-safety

> shutdown systems installed on center-pivot systems that will stop water delivery in the event of an irrigation system malfunction; 4) have rain-gage shut-off switches for traveler, solid set, or drip irrigation systems.

Id.

Then, in 2012, Georgia issued a permit moratorium on new agricultural withdrawal permit applications and applications to increase permit pump capacity or irrigated acreage from Floridan aquifer and surface water sources in parts of the Flint River Basin. Turner PFD ¶¶ 96–97; *see* JX-73. As of trial, the moratorium was still in effect. Turner PFD ¶ 97.

In 2014, Georgia amended the Flint River Drought Protection Act (FRDPA) to require all center-pivot irrigation systems to achieve 80% efficiency by January 1, 2020 in a large portion of the Flint River Basin. *Id.* ¶ 110; JX-105 at 4–5. Under the amendments, other types of irrigation systems may only need to reach a 60% efficiency, but these systems compose a small percentage of irrigation systems in the Flint Basin (8.4%). Cowie PFD ¶ 58; *see* Masters PFD at 21 demo.6 (dividing the number of acres irrigated by traveler systems in 2015 by the total number of acres irrigated in 2015). Whether it came about as a result of the efficiency requirements or otherwise, field surveys revealed that in 2015 approximately 90% of center-pivot systems (covering 93% of center-pivot acreage) in the Lower Flint River Basin used the two most efficient types of sprinklers. Masters PFD ¶¶ 61–62, 67–68.

Florida introduced evidence to suggest that these conservation measures have been ineffective. This evidence suggests that the moratorium was illusive because Georgia still granted permits on backlogged applications filed before the moratorium took effect. 12 Trial Tr. 3089:12–3090:14 (Turner). And only a handful of new permits are subject to the efficiency requirements imposed on new permits in the Conservation and Restricted Use Areas, while grandfathered permits even in sensitive areas have no withdrawal limits or requirements to use specific efficiency technologies. 12 Trial Tr. 3110:2–19 (Turner); 17 Trial Tr. 4447:2–4448:7 (Stavins).

Florida has not shown that Georgia's agricultural water use is inequitable based on this evidence. First, the efficiency standards under the 2014 amendments to the FRDPA may apply to all center-pivot irrigators, including the grandfathered permits. JX-105 at 4–5. Next, although Florida's evidence that grandfathered permits face no withdrawal limits certainly shows that irrigators do not face a direct limit on how much they pump, Georgia has shown that other factors limit how much irrigators withdraw. *See* Stavins PFD ¶ 63 (noting cost of irrigation equipment and pumping); 14 Trial. Tr. 3696:9–3697:7 (Masters) (describing cost of irrigation and noting that it can be harmful to irrigate too much). Indeed, as discussed below, it appears that the majority of farmers actually water less than the productive maximum. Sunding PFD at 25 figs.3 & 4 (graphs showing that many farms underwater).

3. Georgia Uses Water for Important Purposes

I begin my analysis of the value derived from M&I consumption in the Georgia ACF by observing that "[d]rinking and other domestic purposes are the highest uses of water." *Connecticut*, 282 U.S. at 673. Additionally, Georgia introduced evidence showing the benefits that M&I consumption generates in ACF Georgia. Stavins PFD ¶¶ 12–17, 7 demo.1.

As for agriculture, irrigation in the Georgia ACF Basin provides substantial benefits, and these benefits are greater in drought years. Agriculture in the Flint River Basin produces approximately $4.7 billion in annual revenues. Stavins PFD ¶ 31. Irrigation helps farmers mitigate the effects of dry weather. *Id.* ¶ 22. For example, without irrigation, expected yields during dry years would be 51% lower for peanuts, 78% lower for cotton, and 93% lower for corn. *Id.* ¶ 23. Analysis from Florida's expert witness Dr. Sunding shows that a majority of farms' incremental irrigation applied to crops goes toward productive uses. *See* Sunding at 25 figs.3 & 4 (graphs showing that many farms underwater); 11 Trial Tr. 2822:23–2825:12 (Sunding).

4. Georgia's Consumption Is Reasonable

Beginning with M&I consumption, I conclude that Georgia's consumption has been reasonable. Georgia has taken concrete steps to increase efficiency and conserve in this area, and the effectiveness of those steps has been borne out by reductions in per-capita use. On top of that, M&I consumption generates benefits for 4.9 million people's "domestic purposes" in the Georgia ACF. *Connecticut*, 282 U.S. at 673. Finally, Florida has not pointed to any compelling evidence of waste or inefficiency in Georgia's M&I consumption.[33] I therefore conclude that Georgia ACF consumptive water use in the M&I sector is reasonable.

Whether Georgia's agricultural consumption during droughts is equitable is a closer question. On the one hand, I find that Georgia's use of irrigation in agriculture provides great value (especially during drought), and Georgia has implemented a number of agricultural efficiency measures. On the other hand, when severe droughts hit the region, Georgia's agricultural consumption only increases, and Georgia has not effectively curbed this use. Thus, in July 2012, when the Corps-operated Chattahoochee reservoirs were in drought operations and Georgia's agricultural consumption peaked, agricultural consumption reached 28% of state-line flows. *See* GX-960.

The question, then, is to what extent the two States should share the burdens of drought. Enter the doctrine of reasonable use and the Supreme Court's

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[33] For example, Florida's arguments about inter-basin transfers ignore the realities of the water system. Inter-basin transfers occur when a municipal water system withdraws water from one basin, but the water is then conveyed by gravity to a treatment plant lying in a different basin. Mayer PFD ¶ 103. Mr. Mayer explained that Metro Atlanta is situated on a ridgeline and straddles six separate river basins. *Id.* These ridgelines are not always obvious and can bisect individual counties and water service areas. *Id.*

equitable apportionment precedents. Both Florida and Georgia possess "an equal right to make a *reasonable use* of the waters of the stream," and "[w]asteful or inefficient uses will not be protected." *Florida*, 138 S. Ct. at 2513 (emphasis in original) (quoting Lancaster Rep., 2017 WL 656655, at *26; *Colorado I*, 459 U.S. at 184). In *Tyler v. Wilkinson*, a case *Florida* cites as setting forth the principle of reasonable use, *see Florida*, 138 S. Ct. at 2513, Justice Story explained that "the true test" of reasonable use is whether it injures other users. 24 F. Cas. 472, 474 (C.C.D.R.I. 1827) (No. 14,312). Given that test, I conclude that Georgia's use is not unreasonable because Florida has not shown that the oyster collapse was caused by Georgia's consumptive use.[34]

IV. Army Corps Operations

The Court held that the previous Special Master applied too strict a standard when he required Florida to prove at the outset that its injuries would be redressable by a decree limiting Georgia's consumption. *Florida*, 138 S. Ct. at 2516. In reaching that holding, however, the Court did not make final factual findings on "how much extra water there will be, when, and how much Florida would benefit," *id.* at 2525, and it remanded with instructions to answer the question "[t]o what extent (under the Corps' revised Master Manual

[34] Georgia also presented evidence at trial that Florida's contribution to Apalachicola streamflow has fallen over time. Bedient PFD ¶¶ 130–41. I make no finding on this factual issue because I find Georgia's use to be reasonable.

or under reasonable modifications that could be made to that Manual) would additional water resulting from a cap on Georgia's water consumption result in additional streamflow in the Apalachicola River?" *Id.* at 2527.[35] The Supreme Court also did not question Special Master Lancaster's explanation of how the Army Corps operates its system of five Chattahoochee reservoirs and dams to maintain storage and the rules it follows to do so. *See* Lancaster Rep., 2017 WL 656655, at *36–46. I therefore incorporate by reference Special Master Lancaster's explanation.

In answer to the Supreme Court's question, I conclude that very little streamflow generated by a potential decree would pass through to Florida at the times it claims to need additional streamflow under existing operational rules.[36] In reaching this conclusion I have paid particular attention to the possibility that increased flows will allow the Corps to postpone the onset of drought operations or hasten the return to normal operations.

The Army Corps' releases are dictated by its Master Manual,[37] and an evaluation of that manual's rules

[35] Given the laws of mechanics, all the increased streamflow generated by a decree and not lost to evaporation would eventually have to flow through to Florida. But my inquiry is whether a decree would result in increased streamflow at the times when it would remedy Florida's alleged harms.

[36] Because Florida has not otherwise proved its case, I do not answer the question whether the Corps would update its rules.

[37] Although the current manual subsumed the Revised Interim Operating Plan (RIOP), which was the subject of the 2016 trial, I did not admit more evidence on the effects of the new

and historical releases shows that increased flows in the Apalachicola River during low-flow periods would only be "rare and unpredictable." Bedient PFD ¶ 58. Under the Master Manual rules, additional flows generated on the Flint River would not be passed through to the Apalachicola River when basin inflow is below 5,000 cfs or when the Corps enters drought operations as a result of composite reservoir storage falling into Zone 3. *Id.* ¶¶ 36, 48; *see also* Br. for United States as Amicus Curiae at 11, *Florida*, 138 S. Ct. 2502 (2018) (No. 142, Original). At least one of these two conditions has occurred very frequently during summers of recent dry years. In 2012, drought operations were in effect and basin inflow frequently fell below 5,000 cfs. Bedient ¶ 28, 23 demo.10; Zeng PFD at 37 demo.17. During the summers of 2007 and 2011 (the first years of recent multi-year droughts) basin inflow was frequently less than 5,000 cfs. *Id.* ¶ 28, 14 demo.5, 27 demo.13; Zeng PFD at 35 demo.15.

Consequently, if 2007 basin inflow were repeated and drought operations were not triggered, still only 19 days during the summer and fall months would

manual. The updated manual provides largely the same rules as the RIOP, except it enters drought operations sooner. Drought operations now begin when composite storage falls into Zone 3 rather than Zone 4. Brief for United States as Amicus Curiae at 11, *Florida*, 138 S. Ct. 2502 (2018) (No. 142, Original). This difference does not affect my analysis because I have concluded that flows would continue to Florida during drought only in very limited circumstances that have occurred infrequently over the hydrologic record. The new manual would only make the frequency of those circumstances even more limited.

experience pass-through flows. Bedient PFD ¶¶ 52–53. Dr. Bedient used ResSim[38] to model 2011 conditions and found that state-line flows would increase an average of 177 cfs for all of May to September even if Flint River flows increased by 1,000 cfs during that time. Ga. FoF ¶ 54; GX-911; *see also* Bedient PFD ¶ 86; *id.* at 41 demo.24. Significantly, Dr. Hornberger's own ResSim modeling produced similar results showing only small flow increases resulting from substantial reductions in Georgia's consumption. 8 Trial Tr. 1933:20–1935:6 (Hornberger); *see also* Bedient PFD ¶¶ 177–80.

Florida argues that it would benefit from a decree without changing the Corps' current operational rules because the beginning of drought operations can lag behind the onset of dry periods. Fla. Br. at 29. For example, the Army Corps did not enter drought operations in 2007 and in 2011—the first years of recent multi-year droughts. *Id.* Florida urges that any additional streamflow generated in Georgia would pass through immediately during those dry times when drought operations have not begun. *Id.* But Florida does not acknowledge that this would only be the case

[38] According to the Army Corps, ResSim is "the standard for [Corps] reservoir operations modeling," and is the "tool most capable of faithfully representing" reservoir operations. JX-124 at 4-3. The ResSim model was developed by the Army Corps and accounts for reservoir storage levels, the Corps' operating rules, and hydrologic conditions. Bedient PFD ¶¶ 62–63; *see also* Lancaster Rep., 2017 WL 656655, at *66–68 (finding ResSim model to be "a valid tool for evaluating the impact of increased streamflow from the imposition of a consumption cap as compared to a historical record"). I therefore place significant weight modeling done using ResSim for comparison purposes.

if basin inflow during such dry periods exceeds 5,000 cfs. *See id.* As described in the preceding paragraphs, however, basin inflow exceeded 5,000 cfs only occasionally during summer and fall months of recent dry years.

Florida notes that the Master Manual rules only require a minimum release and argues that the Corps has discretion to release more. Fla. Br. at 28. I agree that the Master Manual only provides a minimum flow requirement. *See* Shanahan PFD at 17 tbl.2 (showing the Corps must make releases greater than or equal to 5,000 cfs). But a review of past releases into the Apalachicola River during dry periods shows that the Corps rarely released more than the 5,000 cfs (plus a cushion to maintain a margin of error) provided for by the then-controlling RIOP. *See* Bedient PFD at 14 demos.5 & 6. Florida highlights limited occasions in the recent record when flows were above 5,000 cfs either during drought operations or when basin inflow was below 5,000 cfs. *See* Shanahan PFD ¶ 57. But Georgia explained (and I find) that those increased releases were in response to localized precipitation events and were made as required by the Corps' own rules. Bedient PFD ¶ 28; Zeng PFD ¶ 102. Moreover, Dr. Shanahan used the wrong data to analyze what the Corps intended to release because the Corps uses provisional data to assess how much it releases in real time. Bedient PFD ¶ 161; Zeng PFD ¶ 94. I therefore find that the Corps has not exercised discretion to release significantly more water than the minimums required by its operational rules. Rather, the Corps targets 5,000 cfs of releases during drought operations, Bedient ¶ 27, and it augments streamflow as required to achieve 5,000 cfs of streamflow when total basin inflow is below 5,000 cfs.

Of course, as Florida emphasizes, augmenting basin inflow during dry summers in the first year of drought like those of 2007 and 2011 depletes reservoir storage. Fla. Br. at 29. Florida therefore argues that reducing the amount that the Army Corps must augment streamflow during periods when basin inflow is less than 5,000 cfs could delay the onset of drought operations and reduce their duration. *Id.* (arguing that a 2,000 cfs remedy would have provided more than enough extra storage in one month to avoid entering drought operations in May of 2012). The first problem with this theory is that Florida's example uses a 2,000 cfs remedy, but such a remedy is impossible considering that Georgia consumes less than 2,000 cfs even during peak months of dry years. *See supra* Table 1. Further, Florida's argument is not supported by any modeling of actual reservoir operations to confirm its argument. By contrast, Georgia's modeling, which accounted for reservoir storage levels and the Corps' operational rules, contradicts Florida's theory and shows that drought operations would not be delayed in all dry years that Georgia simulated. Ga. FoF ¶¶ 60–62. Last, because the Corps now enters drought operations when composite storage enters Zone 3 (instead of Zone 4), drought operations would not be avoided in the future under the same hydrologic conditions even if I accept every other aspect of Florida's example. *See*

GX-924 (showing that by May 1, 2012, composite storage had already dropped well into Zone 3).

Even in the scenario where future hydrologic conditions are such that the Corps could delay entering Zone 3 (rather than Zone 4) by releasing less from storage, such occasions would be rare and may not delay drought operations at all. As Georgia notes, the Corps decides whether to enter drought operations on the first of each month. JX-124 Part 2 7-21, 7-12; *id.* at App. A, pp. 7-11 n.c, 7-23; Brief for United States as Amicus Curiae at 11. Consequently, Georgia notes that delaying entry into Zone 3 by one day in the middle of a month would not change when drought operations actually begin because the change occurs within a month. Ga. Br. at 27. And according to Georgia's reservoir modeling (which Florida does not directly challenge),[39] a 30% reduction in consumption from the Flint River in a year matching 2011 conditions would only delay composite storage dropping into Zone 3 by one day in the middle of May. Ga. FoF ¶ 61. But that change would not have had any effect on when the

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[39] That is not to say that Florida did not attempt to rely on some modeling to evaluate the effect of reservoir operations at trial. Drs. Hornberger and Shanahan did some reservoir modeling, but it was not useful. Dr. Shanahan's statistical correlation analysis used data from both dry and wet years, including years from before the RIOP went into effect. Shanahan PFD ¶ 37–41; *id.* at 22 fig.3; *see also* Bedient PFD ¶¶ 148–49, 65 demo.42 (critiquing the model). Dr. Hornberger's model, the "Lake Seminole Model," was oversimplified and produced clearly erroneous outputs. *See* 8 Trial Tr. 1956:20–1957:4, 1959:10–19, 1961:5–24, 1962:11–1963:6 (Hornberger). Florida does not rely on either expert's modeling on remand.

Corps would begin drought operations because the Corps would still wait until the beginning of the next month to enter drought operations.[40] *See id.*

I do not reach the question whether the Corps could make reasonable modifications to its Master Manual so that flows would pass through to Florida during drought. The Supreme Court noted that the Corps would "work to accommodate any determinations or obligations the Court sets forth *if a final decree equitably apportioning the Basin's waters proves justified in this case*." *Florida*, 138 S. Ct. at 2526 (emphasis added). The United States maintained this position on remand. *See* United States' Statement of Continued Participation at 3–6 (Oct. 10, 2018) (Dkt. No. 643). I agree with this sensible approach. Because Florida has proved neither that Georgia's consumption is inequitable nor that the benefits of a decree would substantially outweigh the potential harms, *infra* Section V, I do not decide whether reasonable modifications could be made to the Corps' Manual.[41]

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[40] The Court also noted that increasing storage could delay the onset of extreme drought operations. *Florida*, 138 S. Ct. at 2522. Florida has not pressed this argument on remand separately from its argument on delaying the onset of drought operations, and I therefore do not consider it.

[41] This case does not turn on my decision not to reach this question because I assume without deciding that the Corps could modify its reservoir operations to pass any additional flows to Florida when I evaluate the benefits of a decree.

V. Whether the Benefits of a Decree Would Substantially Outweigh the Harm that Might Result

Because very little of the additional streamflow generated by a decree would result in increased Apalachicola flows at the times when Florida needs them, I find that Florida would receive no appreciable benefit from a decree. For Florida to be entitled to an equitable apportionment, it must be "shown that 'the benefits of the [apportionment] substantially outweigh the harm that might result.'" *Florida*, 138 S. Ct. at 2527 (alteration in original) (quoting *Colorado I*, 459 U.S. at 187). Consequently, I conclude that Florida is not entitled to a decree equitably apportioning the waters of the Flint and Chattahoochee Rivers.

Recognizing, however, that the Supreme Court "benefit[s] from detailed factual findings," *Florida*, 138 S. Ct. at 2515, I also evaluate the cost-benefit balancing question while assuming without deciding that all extra streamflow generated by a decree would immediately pass through to the Apalachicola River. Under that assumption, I again determine that Florida should not be entitled to a decree because the likely benefits do not "substantially outweigh the harm that might result." *Florida*, 138 S. Ct. at 2527 (quoting *Colorado I*, 459 U.S. at 187).

The parties disagree about which evidentiary standard applies to this inquiry. Whereas Georgia would have Florida make the showing by clear and convincing evidence, Ga. Resp. Br. at 13 n.2, Florida would have me apply a less exacting standard. Fla. Br. at 4 n.1; Fla. Resp. Br. at 3–4 & n.1.[42]

Although *Colorado I* and *Colorado II* applied the clear-and-convincing standard given the circumstances in that dispute, Florida now distinguishes those cases. Florida argues that it is seeking to prevent rather than make diversions, Fla. Br. at 4 n.1, and previously observed that both Colorado and New Mexico use the rule of prior appropriation to determine water rights. Fla. Post-Trial Br. at 15–16. Because the *Colorado* decisions may not control this case, I turn to the Supreme Court's recent statements in *Florida* for guidance. In my view, the Court did not address whether a heightened standard should apply in these circumstances. *See Florida*, 138 S. Ct. at 2527 ("We repeat, however, that Florida will be entitled to a decree only if it is shown that 'the benefits of the [apportionment] substantially outweigh the harm that might result.'" (quoting *Colorado I*, 459 U.S. at 187)). Given this silence and the Court's emphasis on the importance of "flexibility," "approximation," and "reasonable estimates," and on the understanding that "answers need not be 'mathematically precise or based on definite present and future conditions,'" *id.* at 2527 (quoting *Idaho II*, 462 U.S. at 1026), 2514–15, I am hesitant to apply a heightened burden to the equitable balancing question.

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[42] Given its default use in civil cases, I assume that Florida would have me apply a preponderance of the evidence standard, *see Colorado II*, 467 U.S. at 316, meaning whether the fact is more probable than not. *See* 29 Am. Jur. 2d *Evidence* § 170 (2019).

In any event, I do not need to reach a conclusion on this question in making a recommendation because I do not find by a preponderance that the benefits of an apportionment would substantially outweigh the harm that might result. If anything, it appears that the potential harms to Georgia would substantially outweigh the benefits to Florida.

Before analyzing the individual measures that Florida has proposed, I set the stage by describing my general approach to this inquiry. First, in balancing costs and benefits, I am only concerned with the marginal or incremental effects of proposed conservation and efficiency measures.[43] Identifying these incremental effects requires establishing a baseline against which to measure them. Florida would have me set a baseline where Georgia has already adopted reasonable conservation measures, and then I should only consider the costs of further measures that remain. Fla. Br. at 33–34. For support, Florida cites *Colorado I*, where the Court explained, "[I]t is entirely appropriate to consider the extent to which reasonable conservation measures . . . might offset the proposed . . . diversion." 459 U.S. at 186. Florida argues that doing otherwise would reward Georgia for not taking voluntary conservation measures because it could later count prevention of waste as a cost. Fla. Br. at 34.

I am not persuaded, and I conclude that the proper baseline against which to measure the costs and

[43] Florida and Georgia's economic experts both recommend this approach. *See* Sunding PFD ¶ 105; Stavins PFD ¶¶ 36–37.

benefits of proposed conservation measures is the status quo. After the portion of *Colorado I* that Florida cites, the Court then elaborated that "whether existing users could offset the diversion by reasonable conservation measures to prevent waste" is an important consideration in determining whether the benefits would substantially outweigh potential harms. 459 U.S. at 187–88. This shows that consideration of reasonable conservation measures is part of the cost-benefit inquiry, which makes perfect sense because cost is certainly a necessary factor in determining whether a proposed measure is reasonable. *Cf. Michigan v. EPA*, 135 S. Ct. 2699, 2705–06 (2015) (considering cost as a necessary step in determining whether a regulation is "appropriate"). Setting the baseline at the status quo allows me to account for all the incremental costs and benefits that Florida's proposed conservation measures would produce.

I understand completely, however, that "[n]o State can use its lax administration to establish its claim to water," *Colorado II*, 467 U.S. at 321, and that "wasteful or inefficient uses will not be protected," *Colorado I*, 459 U.S. at 184. But starting at the status quo would not do so. Using the circumstances in *Colorado II* as an example, if Colorado had shown that New Mexico could have eliminated some inefficient water uses, then New Mexico would not be rewarded for having had those practices because the cost-benefit balancing would necessarily consider those low-cost improvements. *See id.* at 181–82; *Colorado II*, 467 U.S. at 321.

Relatedly, many of Florida's estimates of costs to Georgia are set to zero because Florida argues that the conservation measures produce no fiscal cost to Georgia. *See* Fla. Br. at 33–34. I see no support in the case law for this approach. Indeed, Florida urges me to weigh all the possible benefits, not just the fiscal benefits. *See* Fla. Br. at 30–33. To make an apples-to-apples comparison with those benefits, I consider all costs. *See* Ga. Resp. Br. at 17.

To evaluate the benefits, I need to decide how much streamflow a potential decree would produce. Given my finding that Georgia's consumptive use has never exceeded 2,000 cfs, it would be impossible to require a 2,000 cfs remedy as Dr. Sunding proposed. Instead, I evaluate the expected streamflow benefits and costs generated by each of Dr. Sunding's proposals, *see* Sunding PFD at 44–45 tbls.4, 5 & 6, individually while recognizing reasonable approximations may be necessary. I find that the maximum streamflow increase would be less than 1,000 cfs and would therefore be less than the scenarios modeled by Florida's experts when they evaluated the effects of a decree.[44]

[44] It is not entirely clear what exact streamflow increase Florida's experts used to estimate the effects of a remedy, but it appears to be around 1,000 cfs. *See, e.g.*, Greenblatt PFD ¶ 24; White PFD ¶ 152. Dr. Allan's testimony suggests the streamflow estimates came from Dr. Hornberger's expert report. *See* Allan PFD ¶¶ 71–73 (citing Dr. Hornberger's expert rep. (FX-785 at 82–83, 87) in which conservation scenarios increase streamflow in 2011 and 2012 by about 1,000 cfs during May through October).

A. Florida's Proposals and Their Costs

In the following subsections I evaluate each of the measures that Dr. Sunding suggested Georgia could employ to reduce its consumptive use in the ACF Basin. I assess the reliability of the evidence that Dr. Sunding used to support the likely costs and benefits associated with each suggestion, and I also determine whether the suggestion would be feasible. If the suggested measure is both adequately supported and feasible, then I estimate the likely streamflow increases and costs associated with the measure. I then provide a summary of the likely costs and streamflow benefits associated with those suggestions in Table 2, *infra*.

1. Municipal Leak Abatement

Dr. Sunding, ignoring the fact that Georgia has implemented many, if not all of the conservation measures subsequent to Florida's use of 2007 numbers, *see* Mayer PFD ¶ 37, suggests that Georgia could generate 42 cfs of additional streamflow on an annual basis at no cost by undertaking a leak abatement program. Sunding PFD ¶¶ 42–44. I find that testimony not credible. The cost if adopted would be at least $260 million to implement. Mayer PFD ¶ 100 (citing JX-040 at 61, 65). Because Georgia has already made great progress in this area, and because it would be so expensive to implement, I do not consider this proposed efficiency measure.

2. Eliminate Inter-Basin Transfers

Dr. Sunding recommended that Georgia could eliminate inter-basin transfers to increase streamflow by 66 cfs. Sunding PFD ¶ 45. I find this recommendation not credible because inter-basin transfers result from the normal construction of water and wastewater systems. *See* Mayer PFD ¶¶ 103–04. To eliminate inter-basin transfers would require the construction of totally new wastewater infrastructure at a cost in "the hundreds of millions and more likely billions" of dollars to implement, which is "neither realistic nor reasonable." *Id.* ¶¶ 101–11; 14 Trial Tr. 3545:8–15 (Mayer).

3. Reduce Outdoor M&I Watering During Drought

Dr. Sunding's suggestion that reducing outdoor water consumption by 50% in drought years could generate 207 cfs at a cost of $0 per year, *see* Sunding PFD ¶¶ 72–79; *id.* at 44–45 tbls.4, 5 & 6, is simply not believable. Dr. Sunding analyzed withdrawals of all customer categories within a utility, not the individual level or residential level, and his analysis therefore fails to distinguish outdoor watering use from other seasonal uses. Mayer PFD ¶¶ 117–21. At any rate, Georgia has already adopted measures to reduce M&I water use during drought. During the 2007–2009 drought Georgia banned virtually all M&I outdoor water use in 61 counties. Mayer PFD ¶¶ 68–70. The evidence also reflects that withdrawals and consumption did *not* increase between 1994 and 2013 despite a population increase of 50% during the same period. *Id.* ¶¶ 7, 32. Moreover, daily per capita water use in the Metro Water District has declined by 36.7% since 2000. *Id.* ¶ 44, 17 fig.7. I therefore reject this proposed conservation measure.

4. Stop Irrigating Unpermitted Acreage

Dr. Sunding compared Georgia EPD's permitted acreage database with the Wetted Acreage Database, and he concluded that Georgia ACF farmers irrigate 90,000 acres more than their permits allow. Sunding PFD ¶¶ 46–47. Dr. Sunding calculated that eliminating irrigation on those acres in peak summer months during non-drought years would increase streamflow by 76 to 91 cfs and would increase streamflow by 125 to 151 cfs in a drought year. *Id.* ¶ 47. The range in Dr. Sunding's estimates contemplates that the ratio of groundwater pumping to streamflow depletions is between 0.43 and 0.6. *Id.* ¶ 48. Georgia argues that 0.6 is too large and depends on modeling results from an outdated model. Ga. Br. at 17; *see also* Panday ¶ 88. I agree, and I therefore evaluate all of Dr. Sunding's modeling using the 0.43 impact factor,[45] meaning I select the lower range of his estimates. Taking Georgia's databases at face value, I therefore find that eliminating irrigation on these purported unpermitted acres would increase streamflow in peak summer months by

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[45] Georgia argues that the impact factor should be 0.4, but I use Dr. Sunding's 0.43 as a conservative estimate.

about 125 cfs during dry years and 76 cfs during normal years.

Dr. Sunding's remedy scenarios use a cost of $0 for this measure, Sunding PFD at 44–45 tbls.4, 5 & 6, and I adopt that because Georgia law already requires irrigation to cease on acres irrigated in excess of permit terms.

5. Stop Irrigating When Marginal Yield Approaches Zero

Dr. Sunding's proposal to measure and compare irrigation depths and his conclusion that the total amount of water applied would generate no additional yield, *see id.* ¶¶ 49–51; *id.* at 25 figs.3 & 4, is not supported by the evidence.

For row crops, Dr. Sunding's estimate on differences between "modeled" irrigation requirements and irrigation depths is based upon misinformation and lack of investigation. *See* Masters PFD ¶¶ 46–49. Dr. Sunding also contradicts his "overwatering" analysis by presenting evidence that many farmers, rather than overwatering, actually underwater their crops. Sunding PFD at 25, figs.3 & 4; 11 Trial Tr. 2824:16–2825:1 (Sunding); 17 Trial Tr. 4526:16–4527:8 (Stavins).

For his pecan recommendation, Dr. Sunding relied upon one study of a single orchard conducted outside the ACF basin, and he never spoke with the author and did not confirm the analysis. Stavins PFD ¶ 74–76; 11 Trial Tr. 2831:15–24 (Sunding). Georgia calculates the cost, if adopted, for just pecans would cost $39 million per dry year. Stavins PFD ¶ 76.

Because I cannot conclude that the costs would be zero for row crops, this measure merges with Dr. Sunding's suggestion that farmers reduce irrigation depths during drought to a level below the productive maximum (what he calls deficit irrigation).

6. Irrigation Efficiency Improvements

Dr. Sunding's recommendations on irrigation efficiency, that half of center-pivot systems in the Flint River Basin could improve their irrigation efficiency to 80% and another half could be improved to 90%, Sunding PFD ¶ 56, ignores that a great number of center-pivot systems in the Flint River Basin are already achieving efficiencies in that range. Stavins PFD ¶¶ 69–70; *see* Masters PFD ¶¶ 66–68, 24 demo.11. Adjusting for this difference results in a streamflow increase of no more than 35 cfs, at a cost of nearly $4 million per year. Stavins PFD ¶ 70; Sunding PFD ¶ 56.[46]

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[46] Dr. Sunding also contends that farmers could install variable rate irrigation systems and employ intelligent irrigation scheduling to reduce their demand. Sunding PFD ¶ 57. But Dr. Sunding does not predict a streamflow increase or a cost for such proposals, and I therefore do not consider them.

7. Permanent Buyback of Irrigation Permits

Despite Dr. Sunding's suggestion that Georgia could also buy back irrigation permits, I find that it would be impracticable and would eliminate irrigation, not just the option to irrigate. *See* Stavins PFD ¶ 103. Additionally, Dr. Sunding only relied on a sample of 27 land transactions, did not consider the investment in irrigation equipment and groundwater wells, and did not take into account the value of lost crop productivity. *Id.* at ¶¶ 104–10; *see* Ga. Supp. Resp. Br. at 16 n.3. Dr. Sunding conducted his analysis using a ratio of $4 million (annual cost for the benefit of increased water flow) to $86 million (one-time cost to buy back the permits). *See* Sunding PFD ¶ 66. The buyback is estimated to cost Georgia an additional $809 million in lost crop yields, *id.* at ¶ 110, 47 demo.17, and would increase peak summer streamflow by 128 to 157 cfs in a normal year and 211 to 259 cfs during a drought year, *Sunding* PFD ¶ 66. Using Dr. Sunding's ratio but considering the $809 million in lost crop yield, the true annualized cost for the increased streamflow is $37.6 million.

8. Reduce Irrigation Depths During Drought

Dr. Sunding proposes that Flint River Basin farmers could reduce irrigation during drought years by employing "deficit irrigation." *Id.* ¶¶ 80–85. Under this proposal, Georgia could set a cap on irrigation depths based on the maximum amount of water a crop can use productively, or Georgia could limit total pumping volumes and users could trade permits to achieve reductions at lowest cost. *Id.* ¶¶ 83–85.

I find that the first approach is not feasible. *See* Stavins PFD ¶¶ 46–51, 60. A cap-and-trade proposal would not work because water users do not have a transferable right to water. *Id.* ¶ 48. It is further complicated because it would require a regulator to establish coefficients to inflate or discount one farmer's use compared to others. *Id.* ¶ 50.

As for the proposal that Georgia limit irrigation depths without trading, the cost to Georgia would be significant, while the supposed increase in streamflow would be small. Dr. Sunding estimates that different levels of deficit irrigation could increase peak summer streamflow during dry years by 430, 181, and 103 cfs for $20.7, $5.5, and $4.6 million, respectively. Sunding PFD at 44–45 tbls.4, 5 & 6. Converting those costs to costs per dry year only scales them up by a factor of three. *See* 11 Trial Tr. 2788:6–16 (Sunding) (acknowledging converting from an annualized cost to a per-drought-year cost requires multiplying by three); FX-801 at 15 n.29 (Sunding Expert Report). The costs are thus $62.1, $16.5, and $13.8 million per dry year.

9. Attendant Reductions in Farm Pond Evaporation

Dr. Sunding contends that reducing irrigation volumes would in turn reduce evaporation from farm ponds in proportion to the reductions in irrigation.

Sunding PFD ¶¶ 68–70. He contends, without support, that this is a reasonable assumption. *Id.* ¶ 70. I am unwilling to rely upon this unsupported assumption, especially when farm ponds may augment rather than deplete summer flows, and I find no farm pond evaporation benefits.

10. Switching High-Value Crop Irrigation to Deeper Aquifers

Due to a lack of meaningful evidence concerning feasibility and cost estimates, I find this proposal to be without merit. *See* Stavins PFD ¶ 73.

In summary, Table 2 shows my findings on the costs required and streamflow impacts produced by Dr. Sunding's feasible and adequately supported proposals. If the measure was not feasible or not adequately supported, then it is not included in the table. The table shows that it would cost a total of $55.3 to $103.6 million per dry year to augment streamflow by 474 to 801 cfs during peak summer months of dry years. Because Florida requests a remedy of between 1,000 and 2,000 cfs, the high end of the estimate ($103.6 million) best reflects the likely costs that a remedy would impose on Georgia.

Table 2: Summary of Streamflow Incremental Benefits and Their Associated Costs.

Proposal	Peak Summer Streamflow Incremental Benefits (cfs)		Incremental Cost (in millions of dollars)	
	Normal year	*Dry year*	*Normal year*	*Dry year*
Stop Irrigating Unpermitted Acres	76	125	0	0
Efficiency measures	35	35	4	4
Permanent Permit Buyback (minimum)	128	211	37.6	37.6
Deficit Irrigation				
Deficit Irrigation (aggressive)	--	430	--	62.1
Deficit Irrigation (less aggressive)	--	181	--	16.5
Deficit Irrigation (least aggressive)	--	103	--	13.8
Total	**239**	**474** to **801**	**41.5**	**55.3** to **103.6**

B. Benefits of a Decree

I find that an extra 1,000 cfs of Apalachicola flows during low flow periods would not significantly benefit Florida.[47] Florida argues that a remedy would increase

[47] I note that this is more than the 801 cfs that I have found could be generated by Dr. Sunding's feasible and adequately supported proposals.

freshwater inflow, which would reduce salinity and thereby reduce predation by predators that prefer more saline environments. Fla. Br. at 32. Florida's evidence does not support that conclusion. Dr. Greenblatt, Florida's own expert on salinity modeling, found that Dr. Hornberger's 2012 remedy scenario would have decreased salinity by less than one ppt in almost all portions of the Bay, except for a portion of East Bay. Greenblatt PFD at 37 fig. 3-16; 7 Trial Tr. 1775:7–1776:7 (Greenblatt). Florida also contends that a one ppt change is comparatively large given that some portions of the Bay have salinities between zero and five ppt. Fla. Br. at 32.[48] But Florida's own experts on oysters concluded that optimum salinity for oysters is about 15 ppt, White PFD ¶ 64; *see also* Kimbro PFD ¶¶ 27–28, and that oyster predators cannot survive in low salinity conditions. Kimbro PFD ¶¶ 27–28. Florida also cites a USFWS study for the proposition that "the 1 ppt salinity change would materially improve the survival rates of oysters and juvenile sturgeon." Fla. Br. at 32 (citing JX-122 at 34). The study, however, says nothing about materially improving survival rates; it simply discusses salinity thresholds for oysters. *See* JX-122 at 34.

Next, one of Florida's oyster experts, Dr. White, modeled what would happen to oyster biomass if

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[48] Florida also argues that a reduction in flows that would only cause a one ppt increase in salinities is not insignificant because it caused the collapse in the first place. *Id.* But I have already concluded that Florida could not prove that Georgia's consumption caused the collapse. *See supra* Section II.A.

Georgia were to completely eliminate its consumption or if a remedy were imposed on Georgia. White PFD ¶¶ 146, 151–53.[49] Dr. White's results show only a modest increase in oyster biomass resulting from a complete cessation of consumption in Georgia and a very modest increase resulting from a remedy of 1,000 cfs. In 2012, oyster biomass at Cat Point and Dry Bar would have only been greater by about 10% and 7%, respectively, if Georgia had consumed no water at all. *Id.* at 47–48 figs.12 & 13. In the scenario where Georgia reduces consumption by 1,000 cfs, oyster biomass would have only increased by just over 1% at Cat Point and almost 1.4% at Dry Bar. *Id.* at 50–51 figs.14 & 15.

Florida speculates that the benefits would be greater than Dr. White suggests because other parts of the Bay, closer to the mouth of the River, would help repopulate bars further from the mouth. Fla. Resp. Br. at 15. However, Florida has not established that bars closer to the River's mouth were significantly harmed by the collapse. Dr. Lipcius, a Georgia oyster expert, explained how oyster bars that are closer to the River were not significantly harmed. Lipcius PFD ¶¶ 41–44, 12–13 demos.3 & 4.[50] Moreover, as noted above, Florida

[49] Dr. White does not explain in his direct testimony exactly what amount of increased streamflow he modeled, but he explains that he used Dr. Greenblatt's salinity modeling results. *Id.* ¶ 146. Dr. Greenblatt, in turn, used Dr. Hornberger's "very conservative 'remedy' " scenario. Greenblatt PFD ¶ 24. Dr. White's result thus appears to be based on approximately a 1,000 cfs remedy. *See* Dr. Hornberger's Feb. 29, 2016 Expert Rep. (FX-785 at 82–83, 87).

[50] Dr. Lipcius attributes the differences in the survival rates to harvesting pressure, not lower salinities. *Id.* ¶¶ 45–49.

did not model the likely biomass increase that the bars near the River's mouth would experience.

Turning to the ecosystems in the River, because I have not found any harm to the River and floodplain ecosystems, there are no harms for increased flows to remedy and the benefit to these ecosystems is zero. And even if I were to accept that Dr. Allan's harm metrics show evidence of real harm, which I do not, his metrics show only small benefits to many of the ecosystems he analyzed. *See* 3 Trial Tr. 542:11–544:10 (Allan).

C. Balancing Costs and Benefits

Weighing the benefits of a potential decree against its costs to determine whether "the benefits . . . substantially outweigh the harm that might result," *Florida*, 138 S. Ct. at 2527 (quoting *Colorado I*, 459 U.S. at 187), I conclude that the benefits of a decree would not substantially outweigh the harms or costs that might result. I reach this conclusion for two reasons. First, Florida's own evidence on benefits does not convince me that the benefits would be substantial. As noted above, Florida's modeling only showed small benefits to the amount of oyster biomass that would result from a decree, and Florida has not shown that the oysters would benefit substantially more than its modeling indicates. And the evidence on benefits to the River shows similarly small, if any, incremental increases.

Second, I have concluded from Dr. Stavins' and Dr. Sunding's testimony that the cost of a decree to reach nearly 801 cfs during summers of dry years would be over $100 million per dry year.[51] *See infra* tbl.2. I am able to compare the fishing industry's revenues with these costs. The Apalachicola fishing industry generates only $11.7 million in revenue per year, Stavins PFD ¶ 31, and the oyster fishery only generated about $6.6 million per year before the oyster collapse. Lee Gordon, *Where Have All The Oysters Gone?*, Tallahassee Magazine, Jan. 3, 2013, https://www.tallahasseemagazine.com/where-have-all-the-oysters-gone/; *see* Ga. FoF ¶ 93. Notably, these are total revenues, and do not represent the incremental benefit from increased streamflow. Dr. Stavins calculated that the incremental revenues would be only $760,000 for the fisheries in the Apalachicola Bay, generating only $190,000 in profits (which Dr. Stavins maintains is the proper measure of economic benefit). Stavins PFD ¶¶ 126–27.

Setting such economic considerations aside, Florida has also noted that the Apalachicola oyster fishery has a "distinctive culture" that may be lost if the fishery does not recover. Fla. Br. at 6. However sympathetic I may be to such concerns, Florida must still show that the benefits of a decree would substantially outweigh the harms, but Florida has not shown that there would be any benefit to that cultural resource

[51] With respect to Dr. Sunding's suggestion that Georgia irrigators should not irrigate more acreage than their permits allow, I have found that the cost would be zero. Nevertheless, I do not recommend fashioning a decree to better enforce permit terms because I have found that Florida has not shown clear and convincing evidence of harm caused by Georgia.

given Dr. White's quite modest modeling results on oyster biomass. And because the benefits to oysters would be so modest, the value of preserving the oyster resource for its own sake would also be very minor in comparison to the significant costs imposed on Georgia.

Even considering the claimed incremental benefits to ecosystems in the River resulting from a decree in addition to the benefits in the Bay, I cannot conclude that the total benefits would substantially outweigh the costs because Dr. Allan's harm metrics demonstrate small positive changes. *See* 3 Trial Tr. 542:11–544:10. Florida notes that "[a]pproximation and reasonable estimates may" be required in making my findings and to protect the equitable rights of a state, Fla. Resp. Br. at 16 (quoting *Florida*, 138 S. Ct. at 2527), but even viewing its evidence through that lens, a reasonable estimate shows that Florida should not prevail on this question because the evidence does not show that the benefits of a decree would substantially outweigh the potential harms.

VI. Conclusion

I do not recommend that the Supreme Court grant Florida's request for a decree equitably apportioning the waters of the ACF Basin because the evidence has not shown harm to Florida caused by Georgia; the evidence has shown that Georgia's water use is reasonable; and the evidence has not shown that the benefits of apportionment would substantially outweigh the potential harms.

Respectfully submitted,

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