SUPREME COURT OF THE UNITED STATES
No. 142, Original

STATE OF FLORIDA, )
Plaintiff, )
V. ) VOLUME X
STATE OF GEORGIA )
Defendants. )

TRANSCRIPT OF PROCEEDINGS

The above-entitled matter came on for HEARING before SPECIAL MASTER RALPH I. LANCASTER, held in the U. S. Bankruptcy Court, at 537 Congress Street, Portland, Maine, on November 16, 2016, commencing at 8:50 a.m., before Claudette G. Mason, RMR, CRR, a Notary Public in and for the State of Maine.

APPEARANCES:

For the State of Florida: PHILIP J. PERRY, ESQ.
JAMIE L. WINE, ESQ.
ABID R. QURESHI, ESQ.
DEVIN M. O'CONNOR, ESQ.
GARRETT L. JANSMA, ESQ.

For the State of Georgia: CRAIG S. PRIMIS, ESQ.
DEVORA W. ALLON, ESQ.
BRITNEY A. LEWIS, ESQ.
ANDREW PRUITT, ESQ.
ZACHARY A. AVALLONE, ESQ.

Also Present: JOSHUA D. DUNLAP, ESQ.





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THE CLERK: Please raise your right hand.

Do you solemnly swear that the testimony you shall give in the cause now in hearing shall be the truth, the whole truth, and nothing but the truth, so help you God?

THE WITNESS: I do.

THE CLERK: Please be seated.

Pull yourself right up to the microphone and please state your name and spell your last name.

THE WITNESS: Yes. Dennis Patrick Lettenmaier, D E -- Dennis with two N's, Patrick Lettenmaier, L E T T E N M A I E R.

MS. WINE: Your Honor, the State of Florida has called to the stand Dr. Dennis Lettenmaier. Dr. Lettenmaier is here, hopefully, to answer some of the questions you have been asking the last few witnesses. He is a hydroclimatologist who has analyzed whether various climate factors such as precipitation, temperature, and drought have impacted the flows on the Apalachicola River.





Your Honor, may I approach to provide the witness with his testimony?

SPECIAL MASTER LANCASTER: Yes.

THE WITNESS: Thank you.

DIRECT EXAMINATION

BY MS. WINE:

Q. Good morning, Dr. Lettenmaier.

A. **Good morning.**

Q. I have provided you with your prefiled direct testimony. Do you recognize that document?

A. **Yes, I do.**

Q. And, sir, do you accept that here as your testimony in this proceeding?

A. **I do.**

Q. Thank you.

MS. ALLON: Good morning, your Honor.

SPECIAL MASTER LANCASTER: Good morning, counselor.

MS. ALLON: I have some witness binders. May I hand them out?

SPECIAL MASTER LANCASTER: Pardon?

MS. ALLON: Some witness binders. May I hand them up?

SPECIAL MASTER LANCASTER: Sure.

CROSS-EXAMINATION
BY MS. ALLON:
Q. Good morning, Dr. Lettenmaier.
A. **Good morning.**
Q. Your testimony is that there has been a downward trend in streamflow in Apalachicola River in Florida from 1970 to 2014. Is that right?
A. **That's correct.**
Q. And even though you say you have identified a downward trend from 1970 to 2014, you agree that streamflow went up and down during those 45 years from 1970 to 2014; isn't that right?
A. **I don't quite understand the question because I don't know the time scale. Up and down from year to year?**
Q. Yes. You agree there was variability in streamflow from year to year in the years between 1970 and 2014; is that right?
A. **I do agree.**
Q. But you're not offering an opinion as to how much variability there has been in streamflow from year to year as between 1970 and 2014; isn't that right?
A. **I'm not sure that's quite correct. But, you know, if you're asking whether we have analyzed**





**and provided you with numbers on a coefficient of variation and so on, no, I haven't printed them out in the report. But it's fairly obvious that there is variability from year to year. And in fact the variability from year to year is accounted for in trend analysis --**
Q. My question was --
A. **-- so it is calculated. It is buried in that calculation.**
Q. My question was a bit more narrow than that.
A. **Okay.**
Q. I didn't ask whether it was involved in some calculation you did. My question was whether you, as an expert for the State of Florida, are offering an opinion as to how much streamflow went up or down between any given year between 1970 and 2014?
A. **I guess I'm a little confused by the question. The U.S. Geological Survey records have that. We have provided that in plots and so on. So at that level, certainly, we have provided that information. I don't have to offer an opinion, at least with respect to the Chattahoochee Gage, which is the primary one that we used, as to the variability. That's a USGS measurement.**





Q. So you haven't offered that opinion in this case; is that right?
A. **Okay. I'm not an attorney, so I don't quite understand the meaning of the word opinion. I'm trying to get this down to a level where I can understand what I have or have not stated.**
**Have I offered a particular number? No. But as I said before, it's buried in the calculation of the trends. So, certainly, we consider variability.**
Q. Dr. Lettenmaier, why don't we just turn to your direct testimony. And I want to look at page 1 of that testimony.
A. **Sure.**
Q. Do you see in paragraph 2 where you say, a summary of my opinions is as follows?
A. **Correct.**
Q. Okay. So just so we're clear, when I ask you if you have offered a certain opinion, it's those opinions that I'm referring to; and it's that meaning of the word opinion as you used it in your testimony that I, too, am using --
A. **So --**
Q. -- so we can have a common language.
A. **Fine. So if we do a search for variability or**





**variance, I'm not sure you will find it in section 2.**
Q. Now, you're also not offering any opinion as to how much streamflow went up or down within any single year from 1970 to 2014; isn't that right?
A. **Well, we're at exactly the same point. All of that, there are many plots. Those are USGS observations. We used those. And that information is accounted for in various of our calculations. Have I provided a -- the variance of this record is no, because I can pull up the USGS website; and it's printed there.**
Q. You haven't offered an opinion on whether or how much streamflow went up or down within any single year from 1970 to 2014; is that correct?
A. **Within the very limited language that you are using that is a correct statement.**
Q. Now, the long-term trend that you do identify with respect to streamflow tells us what happened from point A in 1970 to point B in 2014. Isn't that correct?
A. **Not exactly, because the way you state that implies that you only used the first observation in 1970 and the last one, and you draw a line between it. That's not the way it's done. You**

**use all the data.**
**So taken as a whole, I can go through the set of procedures, if you would like, as to how exactly you do that. But it includes all the data, not the beginning and the end point only.**
Q. Thank you, Dr. Lettenmaier, for that explanation.
The beginning of your trend line is 2014 -- is 1970; is that right?
A. **In the one particular calculation, yes. We have actually looked at this over many different time periods.**
Q. The end of your trend line is 2014; is that correct?
A. **I believe that's correct.**
Q. All right. Let's take a look at that analysis. I want to turn to your direct testimony at page 21. And I want you to look specifically at figure 9.
A. **I have that. Thank you. I have the figure, yes.**
Q. Now, figure 9 in your direct testimony shows the annual average amount of flow on the Apalachicola River as measured at the Chattahoochee Gage for each year from the 1920's to 2014; is that right?
A. **That's correct.**
Q. And the black line in your figure 9 shows the





trend you identified from 1970 to 2014. Is that right?
A. **The solid line, that's correct.**
Q. That's called a linear trend; isn't that right?
A. **That is correct at a higher level.**
Q. And it's a mathematically-generated line, meaning you pick a time period; and whatever program you're using generates a trend line for that time period. Isn't that right?
A. **Certainly. I mean, I can tell you exactly how it's done; but it's not a very complicated program to calculate that.**
Q. Am I correct that is a mathematically-generated line and that you --
A. **That's correct.**
(Discussion off the record.)
BY MS. ALLON:
Q. Dr. Lettenmaier, am I correct that the trend line that you have on figure 9 is a mathematically-generated line, meaning you picked a time period, and the program you were using generated the trend line?
A. **That's correct.**
Q. Now, I would like to look at a couple of other trends that you don't discuss in your testimony.





So I would like to turn to demonstrative No. 1. There is a tab in your binder that says Demonstratives, and it is the first slide behind that tab.
A. **I don't see demonstrative 1.**
**Demos?**
Q. Demos will get you to the same place.
A. **Hmm.**
**So it's way at the end here?**
Q. Yes.
A. **Okay.**
Q. And do you see a slide that has a 1 in the bottom right-hand corner?
A. **Yes.**
Q. And all we have done on slide 1 is we replotted the same data that we were looking at in figure 9, and we regenerated your trend line. Do you see that?
A. **I see that.**
Q. Okay. I would like to turn to slide 3. Now, in slide 3 we're, again, looking at the same streamflow data that you have been looking at, but we simply added a dotted green trend line from 1950 to 1998. Do you see that?
A. **I see that.**





Q. Now, the streamflow data that you relied on for your analysis shows an increasing trend in streamflow from 1950 to 1998; isn't that correct?
A. **I would have to give you that you correctly plotted it, but there is a major problem with that analysis. It's completely flawed.**
Q. You don't report an increasing trend in streamflow from 1950 to 1998; do you?
A. **No. And there is a very good reason why not.**
Q. Now, you say there was consumptive use by Georgia occurring in the ACF Basin over this entire time period from 1950 to 1998; isn't that correct?
A. **I'll need you to quote me chapter and verse where I say that.**
Q. Sure.
A. **Because it depends on the amount.**
Q. Let's go back to your direct testimony.
A. **Okay.**
Q. And if you go to page 2, paragraph 2e at the very bottom of the page, do you see where you say, between 1950 and 2015 Georgia's water use has reduced streamflow on the Apalachicola River. Do you see that?
A. **That is correct.**
Q. Okay. And is it your testimony that starting in

1950 and through 1998 at least, which is the period I have been asking about, there was consumptive use by Georgia occurring in the ACF Basin?
A. **The answer to that is some, but a very minor amount until about 1970.**
Q. You don't offer the opinion that Georgia's consumptive water use caused an increase in streamflows from 1950 to 1998; do you?
A. **I do not.**
Q. Let's look at some other trends in your dataset that you didn't identify. I would like to turn to slide 4 in the demonstratives.
And, again, this is the same data that we have been looking at from your streamflow analysis; but we added a couple more trend lines. Let's look at the part of the record that's colored in blue. That's 1950 to 1980. Do you see that?
A. **I see it.**
Q. That's a 30-year period?
A. **If you're subtracting correctly, yes.**
Q. The data shows an increasing trend in streamflow for 1950 to 1980; isn't that right?
A. **It does not show a statistically significant**





**increase. You have no statistical significance on any of these lines. So what you're doing is completely specious and, in fact, it's a violation of anybody's first statistics course.**
Q. Dr. Lettenmaier, I appreciate that you have testimony you would like to give; and you will get the opportunity to do that with your counsel. But I'm going to ask you to try to answer my question.
A. **Simply pointing out your analysis is specious.**
Q. My question was your data shows an increasing trend in streamflow for 1950 to 1980; is that right?
A. **No.**
Q. You don't agree that there is a trend line that has been generated that shows an increasing trend from 1950 to 1980?
A. **Without seeing whether it's statistically significant or not, if there is no statistical significance, there is no trend.**
Q. Well, actually, I can vouch for you that all of the trends we have identified we ran Theil-Sen; and they are all statistically significant. So we can dispense with that problem.
A. **Actually, we can't. There is another major**





**problem.**
Q. Dr. Lettenmaier, I'm just asking you to answer my question.
A. **I'll answer your questions, but your analysis is specious.**
Q. Do you agree -- do you see on slide 4 that there is an increasing trend in streamflow for 1950 to 1980?
A. **A reported increasing trend.**
Q. And you say that there was consumptive use by Georgia occurring in the ACF Basin from 1950 to 1980; isn't that right?
A. **Some.**
Q. You don't offer the opinion that Georgia's consumptive use was responsible for the increase in streamflow from 1950 to 1980; do you?
A. **I do not.**
Q. Let's look at the part of the record that's colored in green. That's the period of 1980 to 1998. Do you see that?
A. **I see that.**
Q. The data shows an increasing trend in streamflow for 1980 to 1998. Do you see that?
A. **Excuse me. I need to look at this for a minute.**
**Well, we're back to the exact same statement.**





**And, in fact, your statement that that's statistically significant is almost certainly incorrect.**
Q. Dr. Lettenmaier, I didn't ask anything about statistical significance.
A. **But there is no trend if there's no statistical significance, so I'm not going to give you that there is a trend there.**
Q. Dr. Lettenmaier, do you see that we mathematically generated a trend line in the same way that you mathematically generated trend lines in your testimony?
A. **You have represented that. I have no idea whether you did it the same way we did it or not.**
Q. Do you see that the trend line from 1980 to 1998 shows an increasing trend?
A. **I do not see that because it's not statistically significant as near as I can tell.**
Q. You can't see that the trend line is leaning upward? You don't see that on slide 4?
A. **I see an R-squared .11. That's a tiny R-squared.**
Q. Dr. Lettenmaier, with all due --
A. **It's not statistically significant.**
Q. Again, I understand that you have used with respect to statistical significance --

A. **It's not used. Excuse me. I have training in --**
Q. Dr. Lettenmaier --
A. **I have not used. This is not how I feel. This is an analysis, and it's been done incorrectly.**
Q. Dr. Lettenmaier, could you try to answer my question.
A. **Happily.**
Q. My question was not about statistical significance. My question was do you see that there is a trend line from 1980 to 1998 on this demonstrative that shows an increasing trend in streamflows?
A. **I think you just gave me that there is no statistical significance, so the answer is no.**
Q. You're not offering the opinion that Georgia's consumptive use was responsible for the increase in streamflows from 1980 to 1998; are you?
A. **I'm not offering an opinion about Georgia's consumptive use; but as nearly as I can tell, there is no trend.**
Q. Let's look at the period of record colored in purple. That's the period of 2002 to 2010. Do you see that?
A. **I see an R-squared of .05. There is no trend.**
Q. Dr. Lettenmaier, my question was do you see the





purple on the demonstrative?
A. **I see a purple line.**
Q. Can you try to answer my question.
A. **If they're properly posed, yes.**
Q. Dr. Lettenmaier, for the period of time from 2002 to 2010, the trend shows an increasing trend in streamflows in the ACF Basin. Do you see that?
A. **Almost certainly there is no trend.**
Q. You don't see a trend line with an upward slope on the slide?
A. **I see a line. There is no statistical significance. There is no trend.**
Q. Dr. Lettenmaier, do you see a trend line with an upward slope on this slide?
A. **I see a line.**
Q. Let's look at the part of the record colored in red. That's the part of the record from 1946 to 1956. Do you see that?
A. **I see that.**
Q. Now, there is a very sharp decline in streamflow over this period. Right?
A. **That's -- well, decline, correct. The lower dots are -- the dots later in the period are lower than dots earlier in the period.**
Q. And you said before that you didn't think there





was significant consumptive use by Georgia occurring before 1970.
A. **That's correct.**
Q. So I assume you're not offering the opinion that consumptive use in Georgia was responsible for this sharp decline in streamflows from 1946 to 1956; are you?
A. **No, I'm not.**
Q. Let's talk about your analysis of what you call residuals. Your residuals analysis is an analysis of the difference between modeled streamflow and observed streamflow; is that right?
A. **That's correct.**
Q. And what you did is you took a rainfall runoff model, and you predicted flows under natural conditions for the period after 1950; is that right?
A. **That's correct. Actually, two models and several different implementations of one of them.**
Q. And then you compared those modeled derived flows with observed flows. Right?
A. **Actually, we take the difference. I'm not sure what context compared implies.**
Q. And you determined the difference between modeled





flows and observed flows, and that difference is what you call the residual; is that right?
A. **That's correct.**
Q. And you say the residual between modeled flows and observed flows represents Georgia's water use; is that right?
A. **Well, I have to go back; and you can point me to what exactly is said in the testimony. But it's the combined effect of everything that's acting on that basin that's not climate.**
Q. And you say the residual between modeled and observed streamflow has increased by about 3800 cfs; is that right?
A. **That's correct.**
Q. And in your direct testimony and the testimony we just looked at on page 2, paragraph 2e, you say, between 1950 and 2015 Georgia's water use has reduced streamflow on the Apalachicola River by at least 3800 cfs on an annual average basis. Do you see that?
A. **That's correct. Yes. At least that has particular meaning.**
Q. In other words, over the entire period of record, the difference between what your models predict for streamflow and what the observed streamflow

is averages about 3800 cfs; is that right?
A. **No, that's not a correct interpretation. The correct interpretation is there is a wedge, which essentially is the gap that opens up over time between the model and the observed. And the value of that ramp that's opened up over the period from 1950 to present is, at the end, 3800.**
Q. You call the 3800 cfs an average depletion; don't you?
A. **You would have to go point me to the language in the testimony. If you say it's coming out of the testimony, yes. But the interpretation of that is at the end of the record.**
**So it's an average, but it's an average at the end of the record, not an average over time over the whole record. It's important to understand that.**
Q. And 3800 cfs is an annual average; is that right?
A. **That is correct.**
Q. You understand that the impact of streamflow changes throughout the year. Right?
A. **Of course.**
Q. Okay. Because consumptive use changes throughout the year. Right?
A. **Of course. And we analyzed that.**





Q. Typically there are larger or peak impact values during the summertime; is that right?
A. **That's correct. We analyze summertime as well.**
Q. You understand that annual average numbers are typically lower than peak summer values?
A. **That would mostly be correct, yes.**
Q. And are you aware that Dr. Hornberger, another expert for Florida, came up with what he calls a conversion factor that tells you how much annual impacts translate to in terms of peak summer impacts?
A. **I haven't read Professor Hornberger's testimony; so, no, I'm not aware of that particular number.**
Q. Do you have any reason to doubt that Dr. Hornberger's conversion factor of 4.28 for converting annual average streamflow reduction to peak summer streamflow reduction is accurate?
A. **Well, we're getting -- if Professor Hornbergerer has it in his testimony, it's almost certainly accurate; but I suspect you're misrepresenting what was done there.**
**And I can explain, if you like, what was done and how our 3800 relates to the numbers that he calculated, because I am well aware of that.**
Q. What I would like to do is convert your 3800 cfs





annual number to a peak streamflow depletion number.
MS. ALLON: And, your Honor, I think there might be a bit of math; so if I may, can I hand a calculator up to the witness?
SPECIAL MASTER LANCASTER: Sure.
BY MS. ALLON:
Q. Now, using Dr. Hornberger's 2.28 conversion formula, if we multiply your 3800 by 2.28, we get 8,664 cfs. Is that right?
A. **Obviously you have done the calculation correctly. It sounds about right.**
Q. Now, using Dr. Hornberger's conversion factor means your 3800 cfs annual average reduction translates to a peak summer streamflow reduction of 8,664 cfs. Isn't that right?
A. **You have represented you did the calculation correctly. That's the multiple of the two numbers, yes.**
Q. Dr. Lettenmaier, are you aware that Dr. Hornberger is offering opinions in this case quantifying the amount of Georgia's historic consumptive use?
A. **Again, I have not read Professor Hornberger's testimony.**





Q. But you have no reason to think his calculations of Georgia's consumptive water use are inaccurate; do you?
A. **I do not.**
Q. Okay. Let's take a look at Dr. Hornberger's consumptive use estimates. And I would like to turn to Dr. Hornberger's direct, which is in the binder you have in front of you. And I would like to turn to page 37 and look at figure 7.
A. **This is Hornberger direct?**
Q. Yes.
A. **Okay.**
Q. Now, in figure 7, Dr. Hornberger calculated total monthly consumptive water use in the Georgia ACF Basin. Do you see that?
A. **I see that.**
Q. Okay. Now, Dr. Hornberger didn't find any monthly consumptive use numbers higher than 5,000 cfs. Isn't that right?
A. **There is no number higher than 5,000 cfs in that plot.**
**I can tell you that I have not read any of this testimony, so I can't offer you any details. But, no, there is no number higher than 5,000 cfs.**

Q. The 8,664 cfs that we just calculated is 3664 cfs higher than Florida's consumptive use expert's numbers. Is that right?
**A. You're going at a representation, again, of Professor Hornberger's testimony, which I haven't read. So I can only tell you that the difference between the number which you multiplied out and 5,000 is the number you just quoted.**
Q. Let's talk about the amount of uncertainty or error in your estimate of 3800 cfs average annual reductions. You agree that there's a range of uncertainty on your 3800 number. Don't you?
**A. Yes. And in fact we quote it.**
Q. And the range of uncertainty on your number is 1295 cfs. Isn't that right?
**A. I thought it was 1292; but if you say 1295, that's correct.**
Q. That's around 34 percent of the 3800; is that right?
**A. That's correct.**
Q. So your 3800 cfs estimate of Georgia's consumptive use could be 34 percent higher or 34 percent lower; isn't that right?
**A. That is correct.**
Q. You don't actually know where it is within that





range?
**A. That's the whole nature of an uncertainty analysis. No, we don't know.**
Q. And, again, since we're talking in annual values, I would like to translate the upper and lower bound estimates of your uncertainty into peak summer levels. Using, again, Dr. Hornberger's conversion factor of 2.28, do you agree that 2505 cfs, which is the lower bound of your uncertainty, translates to roughly 5,711 cfs of peak summer streamflow depletions?
**A. If you multiplied the numbers correctly, yes; that sounds about right.**
Q. Well, you have a calculator, Dr. Lettenmaier; and you should feel free --
**A. This is not a calculator I'm familiar with, but I'll take your number as correct.**
Q. And going to the upper bound of your uncertainty analysis, using Dr. Hornberger's conversion factor, 5,095 cfs translates to roughly 11,617 cfs of peak summer streamflow depletions; is that right?
**A. That sounds correct.**
Q. Now, 11,617 cfs is over 100 percent higher than Dr. Hornberger's highest estimate of consumptive





use ever. Isn't that right?
**A. I can't speak to that because I don't know what the uncertainty bounds are in his numbers.**
Q. Well, if you look --
**A. I haven't read his testimony, so I don't know exactly how he did it.**
Q. If you look at figure 7 --
**A. Yes?**
Q. -- and you testified the highest value he reported was 5,000, you would agree with me that 11,617 cfs is over 100 percent higher than 5,000 cfs?
**A. Well, the correct way to do it is to go fit a line through those numbers and then go put uncertainty bounds around the slope, which is exactly what we have done. I don't know if he's done that.**
**And, again, you're asking me on the fly on testimony I haven't seen before.**
Q. I --
**A. So just simply saying the biggest number there, because I don't know where the numbers came from. There's a lot of different ways of estimating these. There are conservative numbers. There's top down. There is bottom-up estimates. And**





**you're putting a testimony in front of me that I have never seen before, so I don't know how he calculated them; and I don't know if these are his conservative numbers or not.**
Q. Dr. Lettenmaier, I asked you a very simple question.
**A. Please repeat the question.**
Q. My question was do you agree that 11,617 cfs is over 100 percent higher than 5000 cfs?
**A. That is correct.**
Q. You didn't report the uncertainty around your residual in any of your expert reports; did you?
**A. Incorrect. We did. In fact, you just quoted it.**
**I'm a little surprised that you're saying we didn't do it. We gave you the 1292 --**
Q. Yes, you gave us --
**A. -- and said where it came from.**
Q. Dr. Lettenmaier, do you recall giving a deposition in this matter?
**A. I do.**
Q. And there was a court reporter there?
**A. There was.**
Q. And you were under oath. Right?
**A. I was.**
Q. And Mr. Pruitt asked you questions, and you gave

answers. Right?
A. **I did.**
Q. And you told the truth?
A. **I did.**
MS. ALLON: Your Honor, may I hand up a copy of the witness's deposition transcript?
BY MS. ALLON:
Q. Dr. Lettenmaier, if you turn to page 195 of your deposition testimony.
A. **Okay.**
Q. And do you see on line 22 the question was -- well, let me start with line 17 where you were asked about the uncertainty range on your number being 1295. Your answer was, that is a confidence bound about the 3800, yes.
And then you were asked, where is that in your report?
Your answer, it's not in the report. And then you go on to say, but what is in there is the Theil slope and the least-squares estimator, so you can go derive those. And then you walk through a mathematical equation.
Were you asked that question, and did you give that answer?
A. **Well, if you read line 17 when you say, 3800 cfs**





**plus or minus 1295 cfs, is that the range of uncertainty of your number?**
**Answer. That is a confidence bound of about 3800, yes.**
**So I'm not quite sure how you're getting off trying to say there was no uncertainty bounds. I gave it there on line 21.**
Q. Dr. Lettenmaier, my question was did you report your uncertainty bounds in your expert reports?
We're now looking at your deposition transcript.
A. **I cannot tell you whether it's in the expert report, but I can tell you that it is on line 18 of the deposition.**
Q. For your residuals analysis, you looked at five different model-derived datasets; is that right?
A. **That is correct.**
Q. And the average residual on all five gave you your 3800 cfs number; is that right?
A. **That's correct.**
Q. Let's turn to your analysis from your February 29 report. It's FX-793 in the binders, and it's on page 38.
A. **Okay.**
Q. Now, figure 5.1.8-1 shows annual average runoff





for the five model-derived datasets; is that right?
A. **That is correct.**
Q. And you used the term runoff synonymously with streamflow; is that right?
A. **Yes. I think we pointed that out somewhere in there.**
Q. Now, those are the colored lines. Right?
A. **Yes.**
Q. And they are the model-predicted streamflow values for the Chattahoochee Gage for the past century. Right?
A. **Yes. Not quite last century for some of them, but yes.**
Q. The colored lines are the streamflows that your models produced; is that right?
A. **That's correct.**
Q. And the black line shows the observed streamflow at the Chattahoochee Gage for the entire period of record for that gage; is that correct?
A. **That is correct.**
Q. It's the actual records of flow at the gage?
A. **That is correct.**
Q. And the difference between the average of the colored lines and the black line is how you got





your 3800 cfs residual; is that right?
A. **Yes. With the proviso that I think there actually is an offset in there, so you're really better to go look at the subsequent figure.**
Q. And the difference between the average of the colored lines and the black lines, that residual difference is what you attribute to Georgia's consumptive use; is that right?
A. **That is correct.**
Q. Let's look at the period before 1950 when you agree there was no significant consumptive use by Georgia. Your modeled runoff, the colored lines, before 1950 do not match the observed streamflow at that time. Right?
A. **There is an offset; and I think we went through that in the deposition, the reason for that.**
Q. Dr. Lettenmaier, all I asked was do you agree that for the period before 1950, your modeled lines do not match your observed lines?
A. **They're generally a little high.**
Q. The colored lines are all above the black line; isn't that right?
A. **Well, it's not quite true that all of them are. There is an offset, and I think some of that is applied.**

Q. In the pre-1950 period, your models are all overpredicting flows compared to the observed data. Isn't that right?
A. **They are a little bit, yes.**
Q. And that's before any consumptive use by Georgia; isn't that right?
A. **That's correct.**
Q. I want to talk about the magnitude of overprediction that's inherent in your models.
A. **Uh-huh.**
Q. And I would like to turn to slide 5 in the demonstratives. And slide 5 is the same figure that we were just looking at. All we did was we added two red circles to help orient the Court to two specific time periods.
I want to look at the red circle on the left, which corresponds to about 1940. Do you see that?
A. **Yes, I do.**
Q. Okay. Now, the black line, the USGS line, is around 250 or 275 millimeters; is that right?
A. **That's correct.**
Q. And the highest runoff value that your model predicted is around 400 millimeters; is that right?





A. **The highest -- well, that's not correct, first off. I'm not -- could you restate?**
Q. The highest runoff value your models predicted in 1940 is around 500 millimeters?
A. **Yes. I think you said 400 before. But 500, yes.**
Q. Your models are overpredicting flows in 1940 by as much as 200 or 250 millimeters; isn't that right?
A. **That's correct.**
Q. 200 millimeters is about 10,000 cfs; isn't that right?
A. **If you have done the conversion correctly, I'll take that.**
**It's also irrelevant. And there is a long discussion that we had with Mr. Pruitt about that.**
Q. Let's talk about the lack of agreement among your models. You agree that all of your models are producing different results. Right?
A. **Well, they produce different results; but they also go up and down about the same. And they go up and down with the observations. I think you can conclude that.**
Q. There is a spread among your models; isn't there?
A. **There is.**
Q. And the spread can be determined by comparing the





highest prediction to the lowest prediction at any given point. Right?
A. **Certainly that's one way of doing it.**
Q. And one difference we just looked at was 200 millimeters, which we said was 10,000 cfs. So you would agree that there is a lack of agreement or a spread among your models on the order of 10,000 cfs. Is that right?
A. **I think that's the maximum. There actually -- if you look at the orange line, it's down at, what, 300 versus your 250 or something. It's pretty close.**
**I don't know which one -- orange is PRMS actually, which matches more closely. And there's reasons for that.**
Q. You would agree that there is a spread among your models by as much as 10,000 cfs; is that right?
A. **So I need a clarification because I don't understand your -- please define your -- you're acting as if they're my models that I developed and applied. That's not the case for all the lines plotted, so I think you need to be a little more precise.**
Q. You would agree that there is a lack of agreement or spread among the models that you depict in





this figure and your report and that you rely on as the basis for your opinions on the order of 10,000 cfs. Wouldn't you?
A. **I wouldn't agree on the order of 10,000 cfs. That's for one model that you had picked out of there. But there is a spread amongst the models, quite certainly.**
Q. Dr. Lettenmaier, let's talk about precipitation. You agree that over the long term and holding all else constant, declines in precipitation caused declines in streamflow. Isn't that right?
A. **Yes.**
Q. And as a part of your work in this case, you evaluated long-term trends in precipitation over the ACF Basin. Right?
A. **We did.**
Q. You were looking at whether over the long term climate datasets showed a decrease or increase in precipitation. Isn't that right?
A. **That was part of my charge, yes.**
Q. All right. And I want to take a look at your analysis. And I put it in one place on slide 6 in the demonstratives.
A. **Well, if you could blow that up. I can't read that to be perfectly honest.**

**Could you give me reference to a paper copy so I can read it?**

Q. Well, you can look in your report. It's FX-793 at page 31.

A. **Hold on.**

**FX-793, page 31, I don't think so. It's not --**

Q. I'm sorry. Could you turn to 32 and 33. Do you see your analysis there?

A. **Just a minute.**

**I'm sorry, which pages?**

Q. The next page, 32.

A. **Okay. I have got it.**

Q. Okay. And this shows your analysis of long-term trends in precipitation since 1970; is that right?

A. **That is correct.**

Q. And if you want to know what we did, we just took the one that's at annual; and we reproduced it in slide 6.

A. **Okay. So you're representing that's exactly the left-hand column?**

Q. Copied from your direct -- from your report.

A. **Great. Thank you.**

Q. Now, the figures on the left in demonstrative 6





show the six climate datasets that you looked at; is that right?

A. **For 1970 on, correct.**

Q. And for each dataset, you looked at whether there was a statistically significant trend up or down since 1970. Right?

A. **We did.**

Q. You looked at two different ways of estimating statistical trends for slope. Correct?

A. **Correct.**

Q. The Theil-Sen slope estimator and the least-squares linear regression slope or LS slope; is that right?

A. **That's correct.**

Q. And you can see that we produced the results of those two analyses on the right-hand side. Do you see that?

A. **Yes, I do.**

Q. Now, Dr. Lettenmaier, all of your datasets that you considered showed declining trends in precipitation since 1970. Isn't that right?

A. **That is incorrect.**

Q. It's your testimony that the trend lines that are reflected in slide 6 and that come from your expert report do not slow declining trends for





precipitation for these six datasets?

A. **They do not. They show no statistically significant trends for any of them.**

Q. I didn't ask about statistical significance.

A. **You can't interpret a trend without statistical significance. It's meaningless.**

Q. Well, Dr. Lettenmaier, precipitation doesn't have to decrease by a statistically significant amount in order to generate a statistically significant decrease in streamflow; does it?

A. **That statement is partially correct, not for the reasons you think.**

Q. Dr. Lettenmaier, I'm not asking about statistical significance; and I would like you to try to answer my question.

A. **I cannot answer your questions without a statistical context. It's meaningless. If one year has higher precipitation than the other, and we have two years, does that constitute a trend?**

**So how about three, four, five?**

**Without a statistical context, it's meaningless. You're just playing with numbers.**

Q. Your testimony for this Court is that you are unable to look at the datasets in your report and tell me if you see a trend regardless of whether





it is statistically significant or not; is that your testimony?

A. **That is not my testimony. My testimony is that I am able to look at the results and tell you that there is no statistically significant trend in any of those plots that you have put up on the screen.**

Q. And I appreciate your testimony. That wasn't my question.

A. **Thank you.**

Q. My question, again, is not about statistical significance. My question is do you see a downward trend in these datasets?

A. **Okay. You're asking me to make judgments which are totally against standard practice in my field. Standard practice in my field is that there is no meaning to trends without statistical significance. So I can't answer your question. You have gone outside the bounds of standard practice.**

Q. Okay. You can't answer my question of whether you can see a downward trend in the six datasets that you identified? That's your testimony for this Court?

A. **My testimony for this Court would be anything you**

**see there cannot be rejected as having occurred due to chance. That's what statistical significance is all about. We cannot say that those lines that are plotted there that appear to go in one direction, that that's not due to chance. And, in fact, that's the reason we go shade the different slopes. The shading range of the difference slopes gives you an idea of uncertainty.**

Q. Dr. Lettenmaier, I'm going to try this one last time. I'm not asking about what you think caused the trends. I'm not asking about whether or not they're statistically significant. I'm asking whether you are able to answer the question of whether these datasets show a declining trend line?

A. **And I cannot answer that question within the confines of standard practice in my field. Sorry.**

Q. Now, you did an analysis of intra-annual precipitation patterns; is that right?

A. **We did.**

Q. That means you looked at how rainfall has changed within the year over time?

A. **Or has not changed, as the case may be.**





Q. You looked at how rainfall has changed within the year over the time; isn't that right?

A. **Actually, we concluded that it is not.**

Q. You wanted to know whether more recently rainfall has fallen at different times of the year compared to when it used to. Isn't that right?

A. **That is correct.**

Q. The idea being that even if the total amount of rainfall doesn't change, the amount of streamflow being generated can change based on when that rain falls within the year; is that right?

A. **We made no hypothesis as to the second part of that. We limited the first part of your statement having to do with whether or not there had been changes within the year. We did not address the question if there had been changes, what the effects on streamflow would be, in part because there are no statistically significant changes intra-seasonal with one minor exception, which is pretty much irrelevant to this case.**

Q. For this analysis you compared the period before 1970 with the period after 1980; is that right?

A. **That's correct.**

Q. And you looked at whether more or less rain fell in each of the 12 months in the earlier period





compared to the later period; isn't that right?

A. **That's correct.**

Q. Are you aware that Georgia EPD's hydrology unit performed a similar analysis just a few years ago?

A. **That's precisely the reason we performed our analysis, and that's the reason for the somewhat unusual choice of periods which aren't consistent, by the way, with the other periods we have used.**

Q. Let's take a look at what Georgia EPD found. I would like you to turn to the Zeng direct. It's in your binder. And I want to turn to page 52.

A. **Okay.**

Q. And if you look at Zeng demonstrative 20, the blue line shows cumulative monthly precipitation for 1895 to 1974; isn't that right?

A. **Well, I'm not sure what's right about that plot, first off, because I cannot find anywhere in his description what he means by 95th percentile. So perhaps you could explain that.**

Q. Do you understand that there is a legend next to the blue line, and it says 1895 to 1974?

A. **I understand that part. I understand a heading that says 95th percentile monthly precipitation**





**CD7. I understand every part of that except 95th percentile. And I need to have that explained because there is no explanation in this document that I was able to find.**

Q. And do you understand that the red line there is a legend that says 1975 to 2013?

A. **I see that there's a line that's labeled that way, yes.**

Q. And do you understand that if the blue line is higher than the red line, that means rainfall was higher in the earlier period for those months than in the later period?

A. **So we're back to the same thing. There is no statistical significance, as near as I can tell. And they don't say anything about statistical significance, so it's a meaningless plot.**

Q. Dr. Lettenmaier, with all due respect, my question does not go to your views on whether this analysis is meaningless.

A. **Excuse me. It's not views. It's standard practice in the field. I'm sure there's standard practice in the field of law as well that you would not be willing to go outside.**

MS. ALLON: Your Honor, could I ask you to instruct the witness to answer my

question?
SPECIAL MASTER LANCASTER: Please try and answer.
THE WITNESS: I'll do my best, your Honor.
BY MS. ALLON:
Q. Dr. Lettenmaier, if the blue line is higher than the red line, that means rainfall was higher in the earlier period for those months than in the later period?
A. **The blue line is higher than the red line. The rest of it is your interpretation, which I can't endorse.**
Q. For the month of June, Georgia EPD found less rainfall in CD4 in the 1975 to 2013 period compared to the 1895 to '74 period; is that right?
A. **I think you may mean July.**
Q. I'm going to get to July. But for right now my question is about June.
A. **Okay. Perhaps you could repeat the question for me.**
Q. For the month of June, Georgia EPD found less rainfall in CD4 in the 1975 to 2013 period compared to the 1895 to 1974 period?





A. **The red line is below the blue line, yes.**
Q. By nearly 1/2 inch. Right?
A. **If you're reading off the label correctly, that would seem to be the case.**
Q. For the month of July, Georgia EPD found less rainfall in CD4 in the 1975 to 2013 period compared to the 1895 to 1974 period; is that right?
A. **That seems to be correct.**
Q. By more than 1 full inch. Correct?
A. **If you're reading the labels correctly.**
Q. For the month of August, Georgia EPD found less rainfall in CD4 in the 1975 to 2013 period compared to the 1895 to 1974 period; isn't that right?
A. **By a tiny amount apparently.**
Q. In January, February, and March Georgia EPD found more rainfall in the 1975 to 2013 period as compared to the earlier period; isn't that right?
A. **For where?**
Q. CD4.
A. **Okay. Your statement is only correct for CD4. It's not correct for CD7.**
Q. In October, November, and December Georgia EPD also found more rainfall in CD4 for 1975 to 2013





as compared to the earlier period. Isn't that right?
A. **Yes.**
Q. This data shows a decline in precipitation in the drier months of recent decades compared to prior decades; isn't that right?
A. **Could you clarify for me where CD7 and CD4 are? I don't quite know.**
Q. Dr. Lettenmaier, can you answer my question?
A. **I don't recall your question.**
Q. This data shows an increase in precipitation in the wetter months in recent decades compared to prior decades?
A. **Statistically not significant, yes.**
Q. You aren't offering the opinion that natural changes in precipitation have anything to do with Georgia's consumptive use; are you?
A. **We have made the statement that there are no statistically significant trends in precipitation over either period you have looked at over the entire ACF Basin.**
**I don't understand where CD4 and CD7 are. I assume they're climate divisions. I, frankly, don't think they're even within entirely the ACF Basin.**





Q. I'm going to ask my question again because you haven't answered it. My question was you aren't offering the opinion in this case that natural changes in precipitation have anything to do with Georgia's consumptive use? Are you?
A. **I'm not sure if we have a double negative. Could you take a negative out of there and make a positive statement?**
**I can't understand the statement.**
Q. Are you offering the opinion in this case that natural changes in precipitation have anything to do with Georgia's consumptive use?
A. **No.**
Q. Let's look at the results of your precipitation analysis. I would like to turn to your direct at page 17.
A. **Okay.**
Q. Okay. Figure 8 on page 17 shows the results of your analysis of intra-annual precipitation patterns; is that right?
A. **Over the areas indicated, which I might point out are within the ACF Basin above the two gages.**
Q. And your opinion, based on this analysis, is that changes in annual rainfall patterns cannot explain the decreased flows in the Apalachicola

River during summer months; is that right?
A. **This analysis is about seasonal, not annual.**
**Maybe you want to restate.**
Q. I'm reading actually directly from your testimony on the same page.
A. **Okay. Where are you -- point me to the lines, please.**
Q. Page 17, paragraph 30. I found that changes in annual rainfall patterns cannot explain --
A. **Okay.**
Q. -- the decreased flows --
A. **Okay.**
Q. -- in the Apalachicola River during summer months.
A. **Okay.**
Q. Is that your testimony?
A. **Thank you. I mean, the annual rainfall patterns -- the patterns is the key part, which really means seasonal. It doesn't mean annual flows. Annual precipitation -- although that hasn't changed either. So the statement is correct.**
Q. Now, you looked at precipitation over three different drainage areas in the ACF Basin. Right?





A. **That's correct.**
Q. There's the Chattahoochee, which you call the Georgia ACF; the Sumatra, which you call the entire ACF; and incremental, which is the Florida ACF. Is that right?
A. **That's correct.**
Q. Okay. Now, the blue line shows average rainfall in the period before 1970; is that right?
A. **That's correct.**
Q. And the red line shows average rainfall in the period after 1980; is that right?
A. **That's correct.**
Q. And when you compare the two, you can see whether for each month less or more rain has fallen in the period after 1980 as compared to the period before 1970; is that right?
A. **We also analyzed statistical significance. And if you look down there on the legend, it explains that if it's the black bar, it's statistically significant. Otherwise, it's not.**
Q. I'm going to ask my question again because you didn't answer it.
By comparing the red line and the blue line you can see whether for each month less or more rain has fallen in the period after 1980 as





compared to the period before 1970; is that right?
A. **That is correct.**
Q. If the blue line is higher in a particular month, that means there was more rain in that month before 1970 as compared to after 1980; is that right?
A. **That's correct.**
Q. And if the red line is higher in a particular month, that means there was less rain in that month before 1970 compared to after 1980; is that right?
A. **Correct. Once again, you're making the fatal statistical error of saying nothing about significance.**
Q. Let's look at April. For April, all three results show the blue line is higher than the red line; is that right?
A. **I'm not sure I can agree to that. But my eyes aren't quite good enough to go see that.**
**April -- it seems to be the case, yes.**
Q. For May, all three areas show the blue line is higher than the red line; is that right?
A. **And you see light gray for all those; that's correct.**





Q. For July, all three areas show the blue line is higher than the red line; is that right?
A. **In light gray, yes.**
Q. For August, all three results show that the blue line is higher than the red line; is that right?
A. **Let's go back for a minute. Did you put July in there or did you conveniently omit it?**
Q. Dr. Lettenmaier, my question was for August all three results --
A. **Okay. I need to --**
Q. -- show --
A. **I need the previous question. Was July one of the questions?**
**I'm losing track of your questions.**
Q. I would like you to answer my question first. My question was for August do you agree that all three results show that the blue line is higher than the red line?
A. **That's correct.**
Q. Okay. And I asked you about July, but we can go back and ask about it again. For July, all three results show that the blue line is higher than the red line; isn't that right?
A. **I don't think that's correct for the incremental area, but I would have to go into my -- I'm just**

**looking at the gray bars; and I see that the directionality has changed for -- oh, that's June. Excuse me.**

**For July -- yes, for July they all go in the same direction. For June there is a reversal.**

Q. Now, I want to calculate the cumulative decline in precipitation shown by your own graphs for April, May, July, and August. So I would like to turn to slide 7 in the demonstratives.

A. **So which figure in my testimony?**

**This is figure 8? This is the same figure?**

Q. This is the same figure we have been looking at.

A. **Okay.**

Q. Now, if you look at slide 7, the decline in precipitation for April was greater than 15 millimeters in all three datasets. Isn't that right?

A. **The gray bar appears to be. And, again, it is shaded gray, not black. So there is no statistical significance.**

**And you moved that in such a way I can't see it.**

**It appears to be below 15 for -- what, you're asking about April?**

**I lost track of your question. You're asking**





**April?**

Q. Looking at your figure 8, the decline for April was greater than 15 millimeters in August in all three areas you looked at --

A. **Yes.**

Q. -- is that right?

A. **Correct.**

Q. 15 millimeters converted to inches is about 0.591 inches; is that right?

A. **Well, I mean, divide by 25.4. It's about .6, yes.**

Q. All right. So we have called it .6 up there, as you can see.

A. **I'll give you that.**

Q. For May the decline in all three datasets was around also around 15 millimeters; is that right?

A. **Around, yes.**

Q. So we'll call that 0.6 inches as well.

For July the decline was actually greater than 15 millimeters in all three datasets; isn't that right?

A. **So apparently we're ignoring June?**

**For July you're correct. Looks like June -- if you go April, May, skip to July, skip to August, and you're trying to draw some**





**conclusion.**

Q. So that's also --

A. **Why is June not in there?**

Q. So that's also about negative 0.6 inches; is that right?

A. **No. June is actually increasing.**

Q. For July, the decline was also greater than 15 millimeters in all three datasets; isn't that right?

A. **You know, I'll give you -- you're correct. You calculated that correctly.**

**I don't understand why June isn't there.**

Q. And the decline --

A. **Which cancels July.**

Q. And a decline of 15 millimeters is equal to a decline of about 0.6 inches; is that right?

A. **That's the conversion for millimeters to inches, yes.**

Q. Now, for August there was a little less of a decline. It was about 10 millimeters in all three datasets; isn't that right?

A. **Appears to be the case.**

Q. And 10 millimeters would be about 0.4 inches. Right?

A. **10 over 25.4 is about .4; you're correct.**





Q. Now, if we add these four numbers up, the cumulative decline for these four months would be about 2.2 inches; is that right?

A. **Yes. Of course, you conveniently left June out; but yes. If you put June in, it's less than that.**

Q. Now, you can convert inches to -- inches of precipitation to cfs. Right?

A. **If I run it through a model, I can. I'm not sure exactly how you're going to do that.**

Q. All right. Well, I think we can actually do the math. Let's turn to slide 8.

The first thing we need to do is convert inches of precipitation into feet. So if we take 2.2 inches and divide by 12 inches per foot, we get 0.18333 feet of precipitation. Right?

A. **I can save you the time with all the conversion factors. I mean, I don't understand exactly where you're going with this because you somehow -- cubic feet per second ordinarily is used for streamflow. So there's the implication, which I'm sure you know is incorrect, that precipitation -- the 2.2 inches of precipitation is the same as 2.2 inches of streamflow, which**

**it's not.**
Q. Dr. Lettenmaier, do you agree that 2.2 inches of precipitation translates to 0.18333 feet of precipitation?
A. **I'm sorry. Your .183 looks like you divided it correctly.**
Q. The next step is to convert feet of precipitation into a volume of rain over the entire basin. You're aware that the area of the Chattahoochee and Flint River Basins is about 17,200 square miles. Right?
A. **Yeah. That's correct.**
**I can't tell what you're doing. I mean, no first-year engineering student would go pass on this because you haven't indicated the units correctly; and I can't tell exactly what you're doing here.**
**But, you know, I can stipulate that you have done this correctly. It seems like it could be about right. I have no way of telling what you put up on the screen whether or not you have made an error or not.**
Q. Well, that's why I have given you a calculator --
A. **No, I'm not going to do that.**
Q. -- to check my calculations --





A. **No, sorry.**
Q. -- so you can let the Court know if you think it's accurate.
A. **No, I'm not doing it on the fly.**
Q. If we convert -- if we multiply 0.1833 feet of precipitation by the total area of the Chattahoochee and Flint River Basin, which we have said is 17,200 square miles --
A. **Okay. Since you're doing the calculations here, put it in acre-feet per year for me, please; and I'll convert it to cfs.**
Q. Dr. Lettenmaier --
A. **And then I --**
(Discussion off the record.)
SPECIAL MASTER LANCASTER: Doctor, would you please wait until she's finished.
THE WITNESS: Certainly.
SPECIAL MASTER LANCASTER: And then if you can, answer her question. Your counsel will have an opportunity when she's finished to let you say what you want to say. But if she's asking you an arithmetical question and you can multiply it, using the calculator or otherwise, you can say yes or no.
THE WITNESS: Yes, your Honor.





BY MS. ALLON:
Q. Dr. Lettenmaier, if we multiply 0.18333 feet by 17,200 square miles, we get 3,153 cumulative square mile-feet of precipitation for the entire Georgia portion of the ACF Basin; isn't that right?
A. **That's correct.**
**In your next step you're representing that it's about 2.01 million acre-feet, and I'll give you that.**
Q. Now, there are 640 acres per square mile; isn't that right?
A. **That's correct.**
Q. So 300 -- 3,153 cumulative square mile-feet equals about 2,018,097 acre-feet; isn't that right?
A. **I think so.**
Q. Now, since we're interested in how declines in streamflow can be converted into cfs, we need to convert a volume to a rate. There are 1.983 acre-feet in each cfs day; isn't that right?
A. **Well, 1 cfs is 724 acre-feet per year; so if you take your 2 million and divide by 724, you should get it in cfs. If that turns out to be 8274, you have done it correctly.**





Q. Dr. Lettenmaier, are you aware that there are 1.983 acre-feet in each cfs day?
A. **No, I'm not. I don't do the conversion that way. I do the conversion the way I indicated. But I think if you take 724 and divide it by 365, you're probably going to get your 1.983 number.**
Q. You don't know how to do the conversion between acre-feet and cfs days?
A. **I know exactly how to do it. You take your 2.01 million and divide it by 724. I just told you that.**
Q. Dr. Lettenmaier, are you aware that there are 1.983 acre-feet in each cfs day?
A. **It appears that that's correct.**
**You have very peculiar units here.**
Q. So 2,018,097 acre-feet converts to 1,017,699 cfs days; is that right?
A. **You just divided 2.01 million by 1.983. That appears to be about right.**
Q. And to get a rate, all we need to do is divide cfs days by the number of days. Right?
A. **That's one way of doing it, yes.**
Q. In this case we have been looking at four months, April, May, July, and August. They have a total of 123 days. So if we divide 1,017,699 by 123,

we get 8,274 cfs. Isn't that right?
A. **As the unit conversion goes, yes. But that has nothing to do with streamflow.**
Q. You didn't do any analysis to calculate how much less streamflow there would be in the ACF Basin if 8,274 less cfs of rainfall fell each day during April, May, July, and August; did you?
A. **No. But I can give you a bounding estimate.**
MS. ALLON: I have nothing else.
Thank you, your Honor.
SPECIAL MASTER LANCASTER: Thank you.
Ms. Wine?
REDIRECT EXAMINATION
BY MS. WINE:
Q. Good morning again, Dr. Lettenmaier.
A. **Good morning.**
Q. I just want to back up a little bit to make sure that everybody has the big picture regarding your experience and your testimony here today.
So I introduced you earlier as a hydroclimatologist. Could you please explain what a hydroclimatologist is.
A. **Sure. So the hydro part generally refers to hydrologist. And my technical training is in hydrology, which is basically saying how water**





**gets in the rivers. The climate part has to do with the interaction between climate and hydrology. So, hence, hydroclimatology.**
Q. And the interaction of climate and hydrology, does that mean that you look at climate factors in whether or not they are impacting a hydrological system?
A. **That's correct.**
Q. And how long have you been working in this field?
A. **Well, my Ph.D. was 1975. The hydroclimatology part started in the '80's. So back about 30 years.**
Q. And what work have you done over the course of your career generally, apart from this case, to look at the impact of climate factors on hydrological systems?
A. **Oh, I would lose track of the number of individual studies; but of the 300 or so papers I have written, at least 50 deal with that topic or various systems in the U.S., including the ACF as well as globally.**
Q. And I just want to be clear about what your opinions are in this case. In this case, you have concluded that climate factors such as precipitation and temperature are not the cause





of the decrease in streamflow in the Apalachicola River; is that correct?
A. **That's correct.**
Q. And you have further formed the opinion that seasonal changes and drought are not the cause of the decreases in streamflow in the Apalachicola River; is that correct?
A. **That's correct.**
Q. Okay. Now, I would like to walk through the methods that you used to arrive at those opinions. First, what climate factors did you consider in your analysis?
A. **So the climate variables that we considered were actually of two types. The ones that are directly measured, and that's precipitation and temperature; and then certain other variables that affect hydrology, such as solar radiation, humidity and so on, which are derived from the observed variables.**
Q. So, first of all, let's take the observed variables, precipitation and temperature. Why are those two variables that you looked at?
A. **Well, so precipitation is the proximate cause or driver of streamflow. I mean, everybody at a very high level understands that if it rains**





**more, there is more runoff or streamflow than if it rains less. Precipitation is measured at a number of gages across the U.S. which are archived by NOAA, some 12,000 of them.**
**The other proximate factor that controls runoff in streamflow is what's called evapotranspiration, which is basically just the water that's returned to the atmosphere via plants, evaporation off the bare soil, and so on. That's somewhat more complicated because it in turn depends on a number of factors, one of which is temperature but also, and more importantly, solar radiation, and so on. And, hence, those factors we derive.**
**So we're looking at precipitation, which gets measured directly, and the other factors that influence evapotranspiration. And effectively runoff is the balance or difference between those two, precipitation minus evaporation. Precipitation minus evaporation in the long term is runoff.**
Q. Okay. And I just want to make one thing clear. When you talk about the proximate cause or the primary drivers of streamflow, you're talking about among the climate factors that could impact

streamflow?
A. **Exactly. Exactly. This is for all other factors, like what humans have done to the watershed surface and so on, being held constant.**
Q. Okay. So you looked at precipitation. And then for evapotranspiration, is temperature relevant to that analysis?
A. **Temperature is relevant; but what most people think is that temperature controls evapotranspiration. In fact, the primary driver is solar radiation, which is not dependent on temperature. And there's other terms in there. It gets a little bit complicated. But solar radiation is the big one. It's actually related to the daily temperature range, which is the daily maximum temperature minus the minimum temperature. And we did look at that because those -- there are observations for maximum and minimum temperature.**
Q. So if I understand you correctly, it's not the absolute temperature on a day that impacts evapotranspiration primarily; it's this temperature range --
A. **Yes.**
Q. -- during the day that you just described?





A. **That's correct. And the reason is is that on a clear day, you tend to have cooler nights and warmer days than you do on a cloudy day. You have more solar radiation on a clear day than on a cloudy day; hence, we can index.**
**The reason that we have to do that is that there are not good long-term measurements of solar radiation at nearly as many stages as there are for temperature, say.**
Q. Okay. And so you're able to derive that variable from the temperature readings?
A. **Exactly.**
Q. Okay. Now, to analyze these various climate variables, did you look at historic data?
A. **Yes, we did.**
Q. And where did that historic data come from?
A. **So the data are archived by NOAA. And in particular, it's the National Climatic Data Center in Asheville North Carolina. They're collected mostly by cooperative observers; and then there are some other manned weather stations, mostly at airports and so on. But the archive is maintained by NOAA.**
Q. Okay. And when you speak about cooperative observers, are those just people who are manning





those stations and reporting their readings?
A. **Exactly.**
Q. Okay. Now, over what period of time did the data you analyzed span?
A. **So there are some slightly different variables. The longest dataset goes back to 1895. Most of them go back to 1920 or so. And then they go to current, which for this purpose it was either 2014 or '15. I don't remember which.**
Q. Okay. Now, there was a lot of focus in the questioning this morning about your analysis of the data from 1970 to the present, which I think for this purpose is basically around 2014 --
A. **I think it's 2014.**
Q. -- where that ends.
Did you just look at that time period, or did you consider the data going back all the way to the early 1900's?
A. **No. We considered the entire period, which is basically a century. And then we considered 1970 on separately.**
Q. And why did you consider these two periods? Why did you look both at the entire century as well as a subset looking from 1970 to the present?
A. **Sure. Basically, it's following convention in**





**the climate literature where people have looked at trends over about a century. And the reason for going back a century is further back than that, the number of stations drops off very rapidly. So that's about the longest period for which you can get pretty good data over the entire U.S. and the Southeast in particular.**
**1970 on, there's two reasons. One is from the standpoint of this particular project, Georgia's water use ramped up very rapidly. And there was discussion about 1950. There's a little bit from 1950 to about 1970, and then it starts going up pretty quickly. And we saw opposing counsel put forward one of Professor Hornberger's plots to that effect.**
**The other reason is that post-1970 or so is the period for which greenhouse gases have begun to ramp up pretty rapidly globally. So a number of other papers have looked at this -- this particular period.**
**So we looked at the two of them.**
**I think the one thing I do want to inject here is that opposing counsel has attempted to chop up records into little pieces and see -- well, don't you see a trend here? Don't you see**

**a trend there?**

**The whole concept of statistical significance goes out the window when you deviate from a prior decision as to what period to look at and go on essentially what amounts to a fishing expedition where you look and say, oh, it looks like it's going here. Let's fit a line here or let's fit a line there.**

**In a first course of statistics they tell you you can't do that.**

Q. Now, were you also aware that in Dr. Bedient's testimony, who is one of Georgia's experts, he suggests that in looking -- in doing your analysis, you should ignore 1999 to the present. Do you agree that that's the way you should do your analysis?

A. **No. Absolutely not. I mean, basically he's throwing out the signal. Because in the Southeast and the ACF in particular, irrigation, which is the primary consumptive use of water, is applied essentially to augment natural rainfall.**

**So I come from the West where if you don't irrigate things in the summer, nothing grows. And, in fact, if you look from year to year the amount of water you use for irrigation, it's very**





**similar. If the crop type doesn't change, the amount of irrigation water you need doesn't change.**

**In the ACF Basin, what they're doing is using irrigation to augment precipitation in the summertime. So in the drier years, they use more water than they do. So contrary to the West, there is a lot of variation. So the highest water use, of course, is in the years where there is the lowest precipitation. That's when we have the problems where we're seeing the low flow issues.**

**And he wants to throw those years out. So I can't possibly agree with that.**

Q. Now, for both of the time periods you looked at, the beginning of the century to the present and then 1970 to the present, you also analyzed each of those time periods three different ways. You looked at it on an annual basis, and then you looked at it on two different seasonal bases; is that correct?

A. **That is correct.**

Q. And can you explain what those seasonal bases are --

A. **Sure.**





Q. -- and why you looked at it that way?

A. **Sure. So one of them is the growing season, which is May, June, July, August, September. I think there's five months in there. So that lines up with peak water use. The other is a low flow season, which is August, September, October, if I remember correctly. We were asked to consider that period by -- by Florida's ecology experts.**

Q. And what is your understanding as to why you were asked to consider those periods?

A. **Well, my understanding was at a very high level, because it's not my part of the project. But there are two dominant issues. One is issues having to do with the ecology and the things that grow and live in the river which are sensitive to low flows. So this is the low flow time of the year in the river. The other one has to do with the Apalachicola Bay and salinity issues there. And low inflows means freshwater -- low freshwater input, which affects the salinity.**

**So I think those are the two dominant reasons that they wanted that summer period --**

Q. So --

A. **-- late summer period.**





Q. -- not only for the low flow period --

A. **For the low flow.**

Q. -- but for the growing season, the reason to look at the growing season is that due to the issue you just referenced earlier about irrigation increasing?

A. **Exactly. That's the core of the irrigation season.**

Q. Now, I would like to spend a couple minutes looking a little bit more deeply at your rainfall data analysis. Now, rainfall and precipitation are the same thing?

A. **Used interchangeably. The difference is in parts of the world where there is snow, which is not here, precipitation includes snow. But precipitation and rainfall for our purposes are the same.**

Q. And what did your analysis of the rainfall data show?

A. **We find no statistically significant trends for any of the datasets, if I recall correctly, over the entire period or the post-1970 period.**

Q. And so for both of those periods, going back to the turn of the century or the early 1900's to the present or for 1970 to the present, and also

breaking it down into annual or the two sub-seasonal periods you looked at, you found no statistically significant correlation?
A. **Yes. There -- trend. There is no statistically significant trends in any of those periods for any of the datasets.**
Q. Okay. And you mentioned that the rainfall data that you looked at came from NOAA. In your prefiled direct testimony, you talk about gridded datasets. Are these the gridded datasets?
A. **Yes. All the datasets are gridded.**
Q. And could you just explain to us what you mean by gridded datasets?
A. **Sure. So what is commonly done in the hydroclimatic field these days is rather than attempting to use individual stations, you take the stations; and you put them on a grid mesh. And there's a couple of different grid meshes. You use the one that's -- most common, I think, in our analysis is 1/16 degree latitude-longitude. That's about 3 miles north-south by 2-1/2 miles east-west, something like that.**
**So if you imagine putting a wire mesh over the top of your map of the ACF and then each**





**place where the wires cross, we estimate what the precipitation is at that point by interpolating from nearby stations, so each of their seven different precipitation datasets. They used somewhat different decisions as to how to do that, but they all weight different precipitation stations.**
**One -- one thing that's fairly interesting is that if you go look at the different precipitation datasets, you see, at least on an annual level for the whole ACF, they're really quite similar.**
Q. And are gridded datasets commonly used by hydroclimatologists?
A. **They're pretty much the standard in the field.**
Q. And is it your understanding that the -- Georgia's experts did not use these gridded datasets in their analyses?
A. **From what I have seen, no.**
Q. Okay. Now, there was also a discussion of your rainfall analysis and the fact that you looked at whether there was an intra-annual shift in rainfall. Do you recall that from this morning?
A. **Yes. Opposing counsel went into that in some detail.**





Q. Okay. That's looking to see whether there's been a shift in rainfall from, for example, summer months into a later time of the year?
A. **That's correct.**
Q. And what did your analysis show?
A. **We found that aside from an apparent shift in most of the datasets in November, which probably doesn't have too much effect on runoff generation -- and that's actually an increase -- there's been no statistically significant changes in the seasonality.**
Q. And you will recall that Georgia's counsel showed you figure 8 from your testimony, which we can pull up. It's also slide or demo 7 in their book.
A. **Yes.**
Q. And she was picking out a few different months where she was showing that there were some differences, albeit you said they were not statistically significant. I just want to clarify. Did anything that she walked you through with your figure 8 change your view that there's been no statistically significant intra-annual shift in rainfall?
A. **No. We stated that. We have done the analysis.**





**There is no statistically significant change in any of those months other than November. And it appears that even that doesn't pertain to the incremental area which is -- it's labeled increment on the right of that panel.**
Q. Maybe in a little bit more plain English, for some of us can you explain why that one shift you see in November isn't relevant to your analysis about whether there's an overall intra-annual shift?
A. **Well, there's a couple things. One is that it may be a statistical artifact. So these statistical tests are all applied with a 5 percent significance level or 95 percent confidence. So since there's 12 different months, when you take .05 times 12, you would expect, just due to chance, something between 1/2 and 1 would reject by chance. So it may well just be that.**
**From a physical context, it indicates a little more precipitation in the winter months, which should increase rather than decrease streamflow.**
Q. Okay. So, if anything, that shift that you see in November, if anything, that would result in an

increase in streamflow rather than a decrease in streamflow?

A. **Exactly.**

Q. Okay. Now, they also showed you a chart from Mr. -- I don't know if I'm pronouncing this correctly, but Mr. Zeng's testimony, which is in the binder that you still have in front of you that counsel gave you. It's page 52 of his --

A. **Yes, I have it.**

Q. -- prefiled direct testimony.

A. **I have it.**

Q. And, again, I just want to confirm or just ask you; is there anything about this analysis that they showed you that changes your conclusion regarding whether there's been a significant intra-annual shift that has meaning in this case?

A. **No. As near as I can tell, this is completely flawed on two different levels. One is I was never able to get an explanation from opposing counsel of what 95th percentile means, nor does there appear to be any explanation in this particular prefiled direct.**

**I take it to mean that it is the largest or the upper 95th percentile of all of the precipitation events. But that would mean that**





**it's 5 percent of the total years in those increments, which are only about four or five years, in which case they're comparing four years, four values from one set with three in the other.**

**In any case, we tested statistical significance ourselves; there is no statistical significance.**

**The other thing is Climate Division 7 and 4 -- first off, climate divisions are antiquated -- that that is a way of breaking up the country that used to be used by NCDC for some historical reason, which is a NOAA agency. For historical reasons, they still produce these datasets. But if you look at where the climate conditions are, they aren't even entirely within the ACF Basin.**

**So it's not at all clear. From a statistical standpoint the analysis is flawed. And it's for locations the relevance of which the ACF is not at all clear.**

Q. Okay. Thank you.

Now, through your rainfall analysis, did you analyze whether the recent droughts in the ACF Basin are more severe than the historic droughts





in the basin as Georgia's experts contend?

A. **Yes, we did.**

Q. And what did you find?

A. **We found that the recent droughts are by no means exceptional. There are a number of years which had low -- lower precipitation, and much lower in the case of 1954. We also have looked at work done in the paleoclimatology field; and there is a paper -- I think Peterson is the primary author -- in environmental research letters where they state that the instrumental period of record -- and they very specifically state for the ACF Basin -- is particularly benign or wet relative to the last 350 years.**

MS. WINE: Your Honor, if I may approach, I would like to hand out a demonstrative.

SPECIAL MASTER LANCASTER: Sure.

BY MS. WINE:

Q. Sir, we have handed out a demonstrative that I will represent at least the bottom portion of it with the colored lines going up is directly from Dr. Bedient, Georgia's expert -- is from his materials that he produced along with his prefiled direct testimony. And then you have





added some precipitation data to this.

I was wondering, sir, if you could explain to the Court what you're showing here and what the relevance is to your analysis.

And if it would be helpful, we have a pointer; and you could get up. I'm not sure what's easier for you, sir.

Would you like a pointer?

A. **Sure.**

MS. WINE: Is that okay, your Honor, if he comes around and uses a pointer with the big screen?

THE WITNESS: Okay?

A. **Do I need a mike or -- so the reporter can hear me?**

Q. I think you just need to talk really loudly.

A. **Okay. So what we have here is the annual precipitation. And this is from one of the seven datasets we looked at. In particular it's the one that NOAA itself produces.**

**This is 40 inches per year is the red line. And you will see 40 inches per year, the drought years in 2000 and -- what is that, about '8, '9, or so goes slightly below that. It's barely touched by these years, so there's three years in**

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**here that -- you have got another one here. And I won't attempt from memory to say which in particular they are.**

**This is 1954; I can tell you that. And in the '30's, we have got three years clustered in here. So by no means of the imagination are these recent years in any way unprecedented.**

**Plotted down here is Professor Bedient's plot of the number of days in each year where the flow was below. And the blue lines, which are the highest bumps, is 6,000 cfs. It turns out the other ones are just smaller amounts.**

**What you see is, is if you go along here for these earlier droughts back in the '20's and '30's -- and this is all at Chattahoochee Gage -- there were 40, 50, about 60 in 1954, the drought of record, days on which the flow was below 6,000 cfs. That has just shot up during the recent drought until now where we have 180 days, even higher than that, we're up to 250 days, over half of the year where the flows are below 6,000.**

**There is simply no way that you can explain that by the fact that the precipitation was here about 10 inches below the long-term average. Something is going on here that is not related to**



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**the precipitation variability.**

Q. Thank you. Now, sir, I would like to talk in a little bit more detail about your analysis of temperature and evapotranspiration. So for your temperature analysis, is it correct that you used the same seven gridded datasets that you did for the precipitation analysis?

A. **Yes, we did.**

Q. And I think you already said earlier that to the extent there was any trend in temperature and evapotranspiration, it was one that would actually suggest an increase in streamflow and not a decrease in streamflow; is that right?

A. **Well, you have to be a little careful in the interpretation because, as I said, solar radiation is the primary driver of evapotranspiration. So if you look at the different datasets, most of them show -- essentially all of them show either downward trends or no trend in temperature when you take the entire 100 years.**

**Okay. That perhaps is a little deceptive; but it follows what we know about climate in the -- across the U.S. and the Southeast in particular in that there was a warming period**



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**through the '30's. Then the temperatures dropped through about the '60's or so, and then they started sort of coming back up a bit.**

**So if you take the whole period over the ACF, you actually get downtrends.**

**If you look at post-1970 where the regional trend has come up a bit, some of the datasets -- and it's about a quarter to a third -- show statistical significance. The others don't show anything.**

**Now, from the standpoint of solar radiation, it's this temperature range that is more important. One of the datasets shows a decrease in the temperature range post-1970. And the reason is that the minimum temperatures are going up more rapidly than the maximum, so the range narrows. That implies less solar radiation.**

**That's only in one of the datasets. Most of them -- in which case you get reduced evapotranspiration, which would imply more runoff. Most of the datasets say no statistical significance, which implies neutral with respect to runoff.**

Q. Thank you.

SPECIAL MASTER LANCASTER: Excuse me,



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counsel. How much longer do you think you'll be?

MS. WINE: I probably have about 10 minutes. Would you like to take a break now?

SPECIAL MASTER LANCASTER: I think we should.

MS. WINE: Okay. That would be great.

(Time Noted: 10:28 a.m.)

(Recess Called)

(Time Noted: 10:40 a.m.)

BY MS. WINE:

Q. Dr. Lettenmaier, before the break we were talking about your temperature analysis. And I just want to ask you a question about a term you used in your prefiled direct testimony. The term is warming hole. Do you recall using that term?

A. **Yes, I do.**

Q. And what does that term mean?

A. **So this is a term that's been used by a number -- in a number of other studies far predating my work on this case. And it simply refers to the fact that over the southeastern U.S. there has been less or actually no warming than over the rest of the country. And I think somebody actually thought the term doughnut hole maybe was**

**better.**

**But if you go look at -- there is a figure, I think in my report -- and I don't remember if it's in prefiled direct -- where it shows an absence of statistically significant changes in temperature over an area of the Southeast, which actually pushes sort of west of the Great Plains and up into sort of the corn belt.**

**And the Southeast is almost the southeast quadrant of the U.S.**

Q. So the warming hole or the doughnut hole is actually a hole in the southeastern part of the country where we're not seeing the warming trends that we might be seeing elsewhere?

A. **Exactly. And, again, I'm from the West; and very substantial warming has been observed. We have actually written on that about the effect on the snow pack. So in the Southeast it's much more muted, if present at all.**

Q. And what is the relevance of this warming hole to your conclusions here in this case?

A. **Well, it's simply consistent with our finding that there's not been much going on with temperature.**

Q. In the area of the ACF Basin?





A. **In the area of the ACF.**

Q. Okay. Now, sir, you were asked a number of questions this morning regarding your residual analysis; is that correct?

A. **That's correct.**

Q. And am I correct that your residual analysis was looking at rainfall runoff, and it was looking at the difference between modeled streamflow, so what you would expect streamflow to be, versus observed streamflow, what the streamflow actually was. Is that what your residual analysis was looking at?

MS. ALLON: Your Honor, these are all leading questions.

These are all leading questions, your Honor.

MS. WINE: I'm just trying to summarize from this morning.

BY MS. WINE:

Q. But let me just ask you; can you please explain what your residual analysis looked at in terms of streamflow.

A. **Sure. So let me put it in a slightly different way than I was able to earlier on. You can view the residuals analysis as being analogous to a**





**treatment control experiment where the model is actually the control relative to climate, because nothing -- the climate is the same in the model as it is in the observations. And then the observations are actually the treatment. Anything that man has done other than climate that would affect the streamflow are recorded in the observations.**

**So by looking at the difference, we can go see what man's effect on that basin has been.**

Q. And so in your modeling work for the climate variables, you used the same variables that we actually see -- saw in actuality; is that correct?

A. **That's correct. It's the gridded data.**

Q. Okay.

A. **The gridded data essentially.**

Q. And what model did you use in order to do this rainfall --

A. **So --**

Q. -- analysis -- rainfall runoff analysis?

A. **So there's two models. One, we looked at Dr. Hornberger's results from PRMS. We simply were provided with his output. We did nothing else with that.**





**The variable infiltration capacity, or VIC model, which was developed by my group when I was at University of Washington and Princeton University some 20-plus years ago, is used in four of the datasets. It's a slightly different form.**

**So there were a total of five different datasets from which we were able to calculate residuals. Four of them based on VIC, one of them based on PRMS.**

Q. And this VIC model that you used, as you just said, it was developed a long time ago not for purposes of this litigation?

A. **That's correct.**

Q. Okay. And were -- there were some questions this morning about whether the results of your rainfall runoff modeling and Dr. Hornberger's rainfall runoff modeling analysis were consistent. In your view were they consistent?

A. **If you look on an annual basis -- and whichever figure it is; and we may want to go pull it up -- but the panels that show on an annual basis PRMS residuals and they show VIC residuals for something called the Livneh dataset -- it happens the Livneh datasets were used as the inputs to**

**the Hornbergerer PRMS analysis, so the inputs are the same. Those residuals on an annual basis look surprisingly similar given that they spent considerable effort implementing the model.**

**I think you need the panel that's got -- that's got all the model results, the 7 by 3 panel -- no, not that one. It's going to be the next one. It's going to be two figures on from there.**

**They look very similar on an annual basis, which suggests that the VIC model, despite the fact that it wasn't calibrated specifically for this study, gives about the same residuals on an annual basis. And I emphasize the "on an annual basis".**

Q. And, sir, you, I believe, have your prefiled direct testimony. It's actually -- actually, let's look at your report, which is FX-793, which is what counsel showed you.

A. **Yes.**

Q. So she had showed you page 38, which is what Mr. Walton just put up on the screen. Could you let us know what you were just referring to in your answer.

A. **Sure. I'm sorry. Prefiled direct -- do we have**





**different page numbers here?**

Q. Yes. They're at the top right.

A. **I guess I better use the one out of the leaflet.**

Q. Sorry. I'm in your report, I'm sorry, FX-793.

A. **Okay. FX-793.**

**Okay. And page number?**

Q. 38 is what she was showing you.

A. **Yes. She was showing 38, but I was referring to 40.**

Q. Page 40?

A. **I believe. Isn't that the residuals?**

**No. It is 42, actually.**

Q. Okay. Just let us know what this is showing and what -- the consistency between your analysis --

A. **Yes.**

Q. -- and Dr. Hornberger's.

A. **If we look at the left panel, lower left, which is panel M, okay, that is PRMS. If you look at panel D, which is Livneh and VIC, those patterns are really quite similar on an annual basis. That was my point. On an annual basis, when using the same coordinates, the VIC model and PRMS are pretty similar.**

Q. Okay. And now, sir, if you could turn back to page 38, which is the page that Georgia's counsel





showed you during cross.

A. **Yes.**

Q. And do you recall this chart at the bottom of the page?

A. **Yes.**

Q. She focused you in, I believe, on 1940 and drew a rough circle around where 1940 is and asked if looking at the lines on this chart of 1940, if that changed your analysis in any way. Does it, sir?

A. **No. I mean, she pointed out, which is correct, that the VIC model results -- she didn't quite point it out this way, but tend to be higher, give numbers that are higher.**

**If you look at the orange line, which is actually PRMS, it's much closer to the black than the -- than the VIC one. Not terribly surprising since a lot of effort was put into calibrating the PRMS model, whereas, the VIC model came with basically off-the-shelf parameters.**

**The important point is that the variations from year to year and the long-term trend in the residuals are very similar. In fact, PRMS gave, I believe it was 3925; and the average across all of them was 3800. So the models are giving about the same estimate in the residuals.**





**The reason is is that if there's a bit of offset, which could be removed via very laborious process of calibration in the VIC model, all that does is reduces an offset. And the slope or the trend line which gives you the 3800 is going to come out being about the same.**

Q. All right, sir. I would like to put up one other table. And this is going to be table 1 from Dr. Hornberger's prefiled direct.

A. **Sure.**

Q. Page 20.

MS. WINE: And, Mr. Walton, if you could, would you put that up on the screen.

A. **Which one in my folder -- oh, Hornberger direct.**

**And which page number?**

Q. It's page 20, table 1, in Dr. Hornberger's prefiled direct.

MS. WINE: Mr. Walton, do you have that?

A. **Okay. I have it.**

Q. Let's just wait a moment so we can get it pulled up on the screen.

MS. WINE: Jon -- Mr. Walton, will you just blow that up, that table?

BY MS. WINE:

Q. Now, Dr. Lettenmaier, this is a table that comes

from Dr. Hornberger's prefiled direct testimony. Is this a table that you're familiar with?
A. **Yes, I am.**
Q. And, sir, could you explain what is being depicted in this table.
And, again, if you need to use the pointer, if the Judge is okay with that, you can come around.
A. **Sure. I think that would be best.**
MS. WINE: Is that okay, your Honor?
SPECIAL MASTER LANCASTER: As long as he keeps his voice up.
MS. WINE: Okay.
BY MS. WINE:
Q. Please speak loudly, Dr. Lettenmaier.
A. **Okay. Usually that's not a problem, but -- people are usually telling me to quiet down.**
**I think it's easiest to look at the lowest part of the table, first, all of which is for annual. And what this is showing are two droughts, 1954 and 1955, way back in the record, and 2011-2012, more recently. And what you see, annual precipitation, 1954, 30.8. That was the drought of record in terms of precipitation; about 40 for the subsequent year, which also, if**





**you remember the previous plot, is right down near that orange line. We look at the annual streamflow, 14,000 in 1954. And then the second year where you would expect it to be affected by the very dry year, it was still 11,000, okay. These are the two combined years that I believe are the driest of record.**
**Now, if you look at 2011-2012, with higher precipitation, below normal by about 8 inches or so in both cases, and you look at the -- and you look at the streamflow, you find 9796 the first year, 7599 the second. They're way lower even though the precipitation was higher.**
**The upper lines or entries here are basically the same thing except they compare summer, defined as the four-month period June through September, precipitation, '54-'55, 2011-2012. And it shows basically the same thing.**
**I mean, if you look at the first year, 1954, a little -- close to 9,000 cfs in the summer flow. And the second year following the exceptionally dry 1954 is 9500.**
**Now, look at 2011. It's only about 60 percent of the same amount given -- even given that the precipitation was higher. And if you**





**look at the following year, which is only 3.3 inches below the long-term -- I'm sorry. I may not have that quite right. But it's only slightly below the long-term mean. It's got about the same. Way lower flows for the same low precipitation.**
**So what Georgia's experts have tried to argue is that, well, this is all about just dry periods. Dry periods, low streamflow. Of course, that's true. Low precipitation, low streamflow. But how much is the question?**
**And what's happened is the signal has been greatly amplified during these dry periods. This is just another way of looking at the previous visual which showed the number of years below a threshold. Same signal. These recent droughts have a way bigger streamflow response, meaning low streamflow response, than the ones earlier on record.**
Q. And, sir, what does that way bigger response tell you about whether or not it's climate variables such as rainfall and temperature that are impacting the lower streamflows that we're seeing?
A. **We have already established that there's nothing**





**exceptional about these recent droughts. So something has to be amplifying the signal. And, you know, Georgia has made an argument about land cover change, other kinds of land cover change, for instance, urban. We don't dispute that urbanization increases streamflow. But that actually makes the problem better. The problem would be even worse if there weren't an urban contribution. So it doesn't explain it.**
**The only thing that's leftover realistically -- you could argue reservoirs; and you could very quickly figure out that the reservoirs would have to be huge compared to what they are to hold back the water and keep it out of the stream. The only other thing is Georgia's consumptive use.**
Q. Thank you, sir.
RECROSS-EXAMINATION
BY MS. ALLON:
Q. Dr. Lettenmaier, I would like to turn to page 2 of your direct testimony.
A. **Yes, I have it.**
Q. And in paragraph 2e at the bottom of the page --
A. **Yes?**
Q. -- you testify that between 1950 and 2015

Georgia's water use has reduced streamflow on the Apalachicola River. Do you see that?
A. **I see that.**
Q. Now, let's turn to Dr. Hornberger's analysis of consumptive use in his direct testimony at page 37, figure 7.
A. **Yes.**
Q. And if you look at Dr. Hornberger's analysis of consumptive use, he does not show any meaningful change in Georgia's consumptive use as between pre-and-post 1950; does he?
A. **I'm totally confused by your statement. The graph is labeled consumptive use, and it's going up very substantially post-1970. I'm not sure -- I don't understand.**
Q. If you look at 1950, which is the year --
A. **Yes?**
Q. -- that you say Georgia's water use began reducing streamflow on Apalachicola River, my question is do you see that Dr. Hornberger identifies any shift in Georgia's consumptive use beginning in 1950?
A. **Well, beginning -- there's a huge increase in the consumptive water use I see in that figure. I'm not quite sure where you're going.**





Q. My question was looking at 1950 --
A. **Yes?**
Q. -- does 1950 show any change in consumptive use as between 1949 and 1950, 1950 and 1951; any years around those periods do you see a change in consumptive use in Dr. Hornberger's figure 7?
A. **That's not what you asked earlier.**
**Around 1950 and the decade before that and after that it's fairly constant at a very low level.**
Q. And let's turn to page 3 of Dr. Hornberger's written direct.
A. **Page which, 3?**
Q. Yes. And I want to call your attention specifically to paragraph (e) where he says Georgia consumption of ACF water has escalated significantly. Do you see that he says since about 1970?
A. **That's correct.**
Q. Okay. And do you see in the following sentence he says, irrigation in the Georgia portion of the ACF was not prevalent prior to 1970. Do you see that?
A. **I see that.**
Q. Are you aware that you are the only Florida





expert who claims there has been an impact from Georgia's consumptive use before 1970?
A. **I haven't claimed that.**
Q. Dr. Hornberger, you said before -- Dr. Lettenmaier, you said before that you hadn't reviewed Dr. Hornberger's direct testimony. Do you recall that?
A. **That's correct.**
Q. And you didn't know what his estimate of Georgia's consumptive use was; is that correct?
A. **That's correct.**
Q. And --
A. **I know -- excuse me. I know in general terms. I don't know what he put in his testimony.**
Q. You weren't able to say whether your peak estimate of streamflow decline is even within 5,000 cfs of Dr. Hornberger's estimate; is that right?
A. **Your -- that's what I said here?**
**I don't think so.**
Q. Are you able to tell the Court whether your peak estimate of streamflow decline is within 5,000 cfs of Dr. Hornberger's estimate?
A. **I don't know what Dr. Hornberger's estimate is. Is that the previous figure?**





**I would need to look back at it.**

MS. ALLON: I have nothing further, your Honor.

MS. WINE: I have nothing further.

SPECIAL MASTER LANCASTER: Doctor, excuse me.

THE WITNESS: Oh, sure.

SPECIAL MASTER LANCASTER: You will forgive me for not looking directly at you; but I have chided others about speaking into the microphone, so I'm going to have to be speaking into the microphone rather than addressing you.

What do you mean by statistical significance?

I'm a layman.

THE WITNESS: Sure, okay. So the concept of statistical significance is simply to be able to establish with some probability that a result is not just due to random chance. Okay?

So to give you an example, you give me a coin which may or may not be biased. Maybe it's a weighted coin; maybe it's a fair one. I flip it 100 times. I get 60 heads. Now, is that coin biased or not?

What statistical significance would say is that, look, the expected result for a fair coin would be 50 heads or 50 tails plus or minus some interval. I can't do it in my head, but it may or may not include 60. If it doesn't include 60, we say that's a statistically significant result. The coin is biased.

That's all this business is about in the trend analysis is if we see something that looks like it's going up, is that just due -- or down, is that just due to chance or can we say, no, it's outside the range of what we could reasonably expect due to chance. And there is a lot of mathematics behind it, but that's all it boils down to.

SPECIAL MASTER LANCASTER: And if I understood your testimony correctly, you have concluded, based upon your modeling and statistical significance, that Georgia's consumptive water use rather than long-term changes in climate variables have caused significant declines in the flow in the basin?





THE WITNESS: That is correct.

SPECIAL MASTER LANCASTER: Now, am I not correct that precipitation, evaporation, seasonality, and other considerations could also influence the result that you come to?

THE WITNESS: That's correct. But we have ruled those factors out, changes in those factors, in the basis of our statistical analysis.

SPECIAL MASTER LANCASTER: How do you measure solar radiation?

THE WITNESS: So solar radiation, if you measure it, is measured with something called a pyranometer, which is the way to directly measure solar radiation. There is a very limited number of stations across the U.S. that have high-quality records. There's something like 10 of them actually, and they only go back about 20 years or so. So we have to use methods -- and these are widely established; and we have done written papers analyzing them -- where they estimate the solar radiation based on the daily temperature range. That's why I went into the discussion of daily temperature range.





There are parameterizations that are established in the literature.

I am pretty sure I referenced a paper where we evaluated these in my report.

SPECIAL MASTER LANCASTER: Help me, if you will. I have lived in Maine all my life. It's mid-November, and it was 54 degrees when I came in this morning. And the prediction is that it's going to be in the high 50's, maybe even 60's before the week is out. Is that an aberration or is it statistically significant?

THE WITNESS: So the problem we have -- and there's a lot written about this in the climate literature; but looking at individual events and saying, okay, we'll give you that on this day, 54 degrees, maybe it's the highest of record, second highest of record or something, okay. So you expect, as you collect a record, it's gone 100 years, now 101, 102 years, each year by chance some number of records are set. It doesn't mean that there's climate change.

However, superimposed we have the climate change effect also. That's clearly





going on. And trying to go separate out the two is very difficult.

There are different ways that this has been done. Lots of discussion and dispute in the literature about it. Happily for this case, we don't really have that case because -- that situation because, as I showed, there is nothing unprecedented about these recent droughts in the ACF Basin.

The short answer is I can't tell you whether or not the 54 degrees or whatever is a manifestation of climate change or not.

SPECIAL MASTER LANCASTER: Finally, you referenced the Sumatra Gage.

THE WITNESS: Yes.

SPECIAL MASTER LANCASTER: Did you consider the dams and the reservoirs that are on this river -- on this stretch?

THE WITNESS: Yes.

Well, there's two things, okay. So our modeling does not represent the reservoirs directly. That was the job of another expert. Dr. Hornberger in particular has spoken to that model and so on. We don't deal directly with that. But we can show that in terms of these long-term trends downward in the extreme low flows, just on a very basic level that reservoirs could not cause them. On an annual basis, you -- you would have to say, if you argue, look, this is because of reservoirs that these flows are going down in the recent past. Okay. So what would you have to do to make that happen?

You have a big reservoir, and you're holding back a certain amount of water. And you have been holding it back since 1950 or, as opposed counsel prefers, 1970. And you keep holding the water back so that you get to this 3800 trend. You can work out the size of the reservoir has to be about 50 times larger than the combined total of all the existing reservoirs.

It can't possibly be reservoir storage.

SPECIAL MASTER LANCASTER: Further cross?

MS. ALLON: No, your Honor.

SPECIAL MASTER LANCASTER: Further direct?

MS. WINE: No thank you.





SPECIAL MASTER LANCASTER: Thank you, doctor.

MR. QURESHI: Good morning, your Honor.

SPECIAL MASTER LANCASTER: Good morning.

MR. QURESHI: Florida would like to call Dr. Peter Shanahan.

SPECIAL MASTER LANCASTER: I'm sorry. I didn't get the name.

MR. QURESHI: Florida would like to call Dr. Peter Shanahan.

SPECIAL MASTER LANCASTER: Thank you.

THE CLERK: Please raise your right hand.

Do you solemnly swear that the testimony you shall give in the cause now in hearing shall be the truth, the whole truth, and nothing but the truth, so help you God?

THE WITNESS: I do.

THE CLERK: Please be seated.

Pull yourself right up to the microphone and please state your name and spell your last name.

THE WITNESS: Okay. My name is Peter Shanahan. That's spelled S H A N A H A N.

MR. QURESHI: Your Honor, Dr. Shanahan





is a hydrologist and an environmental engineer. He's also a retired senior lecturer at the Massachusetts Institute of Technology.

Before I begin, I would like to make a comment about his direct testimony.

SPECIAL MASTER LANCASTER: Sure.

MR. QURESHI: Yesterday, Dr. Shanahan discovered some computational errors and a labeling issue with one of his tables. He corrected that, and we provided a copy promptly to our colleagues from Georgia. I'm certain they will challenge that characterization of the issues in his direct testimony, but it does not change his opinions. It does not change his conclusions in any way.

And what we have done for the convenience of everyone is to provide copies of what was provided to Georgia yesterday. And that is the updated direct testimony as well as a red line showing exactly what those changes are.

SPECIAL MASTER LANCASTER: Thank you, counsel.





DIRECT EXAMINATION

BY MR. QURESHI:

**Q.** Dr. Shanahan, do you recognize this as the testimony you prepared for this matter?

**A.** **Yes.**

**Q.** Okay. Do you adopt it in its entirety?

**A.** **Yes, I do.**

**Q.** Thank you.

MS. ALLON: Your Honor, may I hand up some binders for the witness?

SPECIAL MASTER LANCASTER: Pardon me?

MS. ALLON: May I hand up some binders for the witness?

SPECIAL MASTER LANCASTER: You certainly may.

CROSS-EXAMINATION

BY MS. ALLON:

**Q.** Good morning, Dr. Shanahan.

**A.** **Good morning.**

**Q.** You have been offered by Florida as an expert on Army Corps reservoir operations. Isn't that right?

**A.** **That sounds about right, yes.**

**Q.** And Army Corps owns and operates the five federal reservoirs in the ACF Basin; isn't that right?

A. **That's correct.**
Q. And your testimony discusses the Army Corps operation of those reservoirs. Right?
A. **Among other things, yes.**
Q. You're aware that Florida retained another expert, James Barton, on Army Corps reservoir operations; aren't you?
A. **Yes, I understand that they did.**
Q. And are you aware that Mr. Barton actually worked for the Army Corps for nearly 30 years?
A. **I was aware he worked for the Army Corps for a long time, yes.**
Q. And are you aware that Mr. Barton actually managed reservoir and dam operations for the Army Corps?
A. **I'm -- I'm not sure of his exact job; but I knew it was something of that sort in any case.**
Q. And you don't have any reason to think that the description he put in his expert report is in any way inaccurate. Right?
A. **That's correct.**
Q. And are you aware that Mr. Barton has been involved with planning and making decisions about how to actually operate reservoirs?
A. **Not off the top of my head, but that does not**





**surprise me. I can accept that.**
Q. Are you aware that when Mr. Barton worked for the Army Corps, he actually decided how much water to release and what level to hold the reservoirs to?
A. **I'm -- I don't know his job function to that specificity.**
Q. Dr. Shanahan, you don't have 30 years experience working for the Army Corps operations. Do you?
A. **I have -- I have not been an employee of the Army Corps. I have worked for them, but certainly not continuously for 30 years.**
Q. You have never been employed by the Army Corps. Right?
A. **I have never been an employee. I have worked on a number of projects completed for the Army Corps of Engineers and have written computer models of operating systems, for example, for the Army Corps of Engineers.**
Q. You don't have any experience managing reservoirs anywhere; do you?
A. **No. That would not be the -- that would not be the kind of work that I do. I tend to do more analysis and modeling work.**
Q. Before this case, you had never testified as an expert on reservoir operations; had you?





A. **No. My prior work did not involve testimony.**
Q. So you would agree that Mr. Barton has more experience with real world reservoir operations than you do?
A. **I suppose he does, yes.**
Q. And you would agree that Mr. Barton has more direct experience working with Army Corps reservoir and dam operations than you do?
A. **I suppose he does. I mean, we have different kinds of experience. But for that particular type of work, I assume he does.**
Q. Now, let's talk specifically about the Corps models. You offer opinions about ResSim, the Corps' computer model for simulating reservoir operations. Right?
A. **I do, yes.**
Q. And are you aware that Mr. Barton has actual firsthand experience using ResSim for reservoir operations?
A. **I'm not aware of that.**
Q. You didn't have any experience with ResSim before this case; did you?
A. **Not ResSim per se. As I said, I have actually written models of that sort; so I have experience with other very similar models.**





Q. And even in the context of your work on this matter, you had never actually run ResSim yourself. Right?
A. **No. We had other folks who were doing the day-to-day runs.**
Q. Now, Florida isn't calling Mr. Barton to testify in this case; but we had the opportunity to depose him. So I would like to ask you about some of his opinions on Army Corps reservoir operations in the ACF Basin. Are you aware that Mr. Barton testified that ResSim is widely used because the model is very dependable?
A. **I don't recall that specific testimony.**
Q. Are you aware that Mr. Barton testified that ResSim is widely used because the model is reliable?
A. **Again, I don't recall that specific testimony. Can you point me to a document or --**
Q. Okay. Well, we can take a look at Mr. Barton's deposition transcript in a moment. But you disagree with Mr. Barton, Florida's expert on Army Corps operations, that ResSim is reliable; don't you?
A. **Certainly I -- I disagreed with his opinions regarding the applicability of ResSim. Whether I**

**specifically said reliable, I don't recall.**
Q. Okay. Well, your testimony is that ResSim does not reliably reflect Corps operations; isn't it?
A. **That's correct. In certain of the Corps operations, the Corps' discretion is not reliably reflected.**
Q. Are you aware that Mr. Barton also testified that there is no other model he is aware of that better represents reservoir operation in the ACF Basin than the Corps ResSim model?
A. **I recall you asking me a question during the deposition of that sort. So I do recall that, and I recall I disagreed with that.**
Q. Are you aware that Mr. Barton was asked about the remedy Florida is seeking in this case?
A. **I don't recall that.**
Q. Let's take a look at Mr. Barton's transcript. It's in the binder in front of you. And I want to turn to page 204. And do you see at line 6, Mr. Barton was asked, do you agree with me that there's no way of guaranteeing how much flow enters the Apalachicola River at any given time without some involvement by the Army Corps?
And Mr. Barton answered, well, I think because the Corps operates the Woodruff Dam and





that's what releases water into Florida, there would probably need to be some involvement of the Corps.
Do you see that?
A. **I do.**
Q. And if we turn to page 205, line 14, do you see that Mr. Barton was asked, so if you want -- if you need a predictable flow at a predictable time, you have to have the Army Corps deliver that flow. Right?
And Mr. Barton answered, I don't see how else you would do that -- you would do it.
Do you see that?
A. **Yes.**
Q. Let's talk about another Florida representative, Steve Leitman. Are you aware that Mr. Leitman was Florida's chief hydrologic modeler during the ACF Compact negotiations?
A. **No, I was not.**
Q. Are you aware that Mr. Leitman worked for the Northwest Florida Water Management District for 12 years?
A. **I think I have seen that he worked for them. I don't know how long.**
Q. Okay. You actually cite to Mr. Leitman's





analysis in your own direct testimony as support for one of your pieces of analysis. Right?
A. **I believe I cite one of his published works, yes.**
Q. And you described Mr. Leitman in your direct testimony as a long-time observer of the ACF Basin; is that right?
A. **That's correct.**
Q. Let's look at some of Mr. Leitman's testimony. If you turn to Mr. Leitman's deposition transcript in your binder, I would like to call your attention to page 207. And specifically, if you look at line 21, you can see Mr. Leitman was asked, so under those conditions in extreme low flow events -- oh, I'm sorry.
So under the current RIOP, even if Georgia decreases its consumptive uses of water, the benefit of increased flows will not reach the Apalachicola River without a change in the operations of the Army Corps of Engineers? And Mr. Leitman answered yes.
Do you see that?
A. **I do. I disagree with that, but I do see that.**
Q. Now, let's turn to page 214 of Mr. Leitman's deposition transcript. And if you look at line 4, Mr. Leitman was asked, so under those





conditions, in extreme low flow events, even if irrigation in the Flint River Basin was reduced, the resulting increased flow would result in the same flows into the river because the Army Corps would be releasing less water from the upstream reservoirs. Right?
And Mr. Leitman answered yes.
Do you see that?
A. **I do.**
**May I have a minute to just look at the preceding text and understand the context?**
Q. Sure. And I'll tell you my next question is just going to be you disagree with Mr. Leitman, Florida's chief modeler, on this point as well. Right?
A. **May I read the context?**
Q. Sure.
A. **I would disagree with that, but he seems to be talking about a very specific example and a very specific case here, looking at the text before that.**
Q. My question is just whether you agree or disagree with the testimony I read to you from Mr. Leitman's transcript on page 214, lines 4 through 11.

**A. Again, let me look at the context.**
**Well, the answer appears to be -- appears to be correct within the specifics of the example he gives on the preceding page. I would not agree with that as a general characterization, however.**
Q. All right. Thank you.
Dr. Shanahan, your opinion is that the Army Corps uses its discretion to release more water into Florida than is required by the 5,000 cfs minimum flow under the RIOP; isn't that right?
**A. Well, recognizing that 5,000 cfs is just one part of the year and one particular set of conditions. But my -- my opinion is based on reviewing the data records and so forth that the Corps routinely releases more than the minimum.**
Q. Your opinion is that the Corps deliberately releases more than the minimum; isn't that right?
**A. Yes.**
Q. Your opinion is that the Corps consistently and routinely releases more than the minimum; isn't that right?
**A. Yes. That's what my evaluation of the historical data indicated.**
Q. Dr. Shanahan, in your direct testimony and in the two expert reports you have submitted in this





matter, you don't cite to any statement from the Corps itself saying that they use their discretion to release more than the minimum. Do you?
**A. I -- I know there is a document where the Corps discusses releases more than the minimum and their intent to do so. But I can't recall if that is cited in those -- in the reports or the testimony.**
Q. You never spoke to anyone at the Army Corps who told you they use their discretion to release more than the minimum; did you?
**A. Not in those words. However, I have had a discussion with the operator at Jim Woodruff Dam; and at that point they were releasing more than the minimum.**
Q. Did the operator at Jim Woodruff Dam tell you that the Corps uses its discretion to release more than the minimum?
**A. As I said, he did not use the term discretion; but obviously if they're releasing more than the minimum, they're using their discretion. And, you know, in their discussions of the RIOP, they make very specific reference to their discretionary releases.**





Q. Now, your opinion is that the Corps has what you call significant incentive to use discretion to make releases in excess of the minimum based on the need to protect threatened and endangered species downstream; isn't that right?
**A. Yes. Among other things, yes.**
Q. Dr. Shanahan, in your direct testimony and in your two expert reports in this matter, you don't cite to any statement from the Corps itself saying that they release more than the minimum because of an incentive to protect downstream fish and wildlife; do you?
**A. No, I don't believe I do.**
Q. And you never spoke to anyone at the Army Corps who told you they were incentivized to release more than the minimum based on the need to protect downstream fish and wildlife. Right?
**A. No. That was an inference I reached by reading the biological opinion prepared by U.S. Fish and Wildlife Service.**
Q. You can't point to a single statement by the Army Corps where they say they are incentivized to release more than the minimum to protect downstream fish and wildlife; can you?
**A. No. I don't believe I have seen that -- that**





**specific statement in the document.**
Q. Now, you say that the Corps often releases significantly more water than the minimum. Right?
**A. That's correct.**
Q. And when we're talking about times that the 5,000 cfs minimum is in place, your opinion is that these releases in excess of the 5,000 minimum show that the Corps uses its discretion to deliberately release more than required to protect downstream fish and wildlife. Right?
**A. That they deliberately released more than the minimum to protect downstream fish and wildlife, among other possible purposes.**
Q. Your support for this opinion is your analysis of the recorded flow values at the Chattahoochee Gage. Right?
**A. That's correct.**
Q. And you say that the recorded releases show that the Corps routinely released flows well above 5,000 cfs when the 5,000 cfs was in place. Right?
**A. Correct.**
Q. Now, you don't quantify the number of days with releases above 5,000 cfs in your testimony; but

you did it in your expert report. So let's take a look at FX-811, which is your May 20 expert report. And I would like to turn to page 21 and look at figure 3.

Figure 3 shows your analysis of days in 2008 with flows into Florida that were above 5,000 cfs. Is that correct?

A. **Yes.**

Q. And --

A. **Pardon me. Could you give me the question again.**

Q. Sure. Figure 3 -- and I'm specifically looking at the bottom panel -- shows your analysis of days in 2008 when flows into Florida were above 5,000 cfs. Right?

A. **Yes. But with the -- the caveat that this is during the days when the total basin inflow was less than 5,000 cfs.**

Q. Right. So it's days when you say the RIOP called for a 5,000 minimum release?

A. **This is among the days when the RIOP calls for a minimum 5,000 cfs. There are others as well.**

Q. And the bottom panel shows the total number of days during 2008 when measured flows at the Chattahoochee Gage were above 5,000 cfs. Right?

A. **Yes.**





Q. And you separate out the number of days where flow is above 5,000 cfs by magnitude of discharge. Right?

A. **Correct.**

Q. In 2008 you observed only five days of flow above 6,000 cfs out of a total of 74 days. Right?

A. **Yes. There are five there going between, well, 6,000 and 9,000 cfs.**

Q. And -- and only two days above 8,000 cfs out of a total of 74 days. Right?

A. **Correct.**

Q. Most of the days above 5,000 cfs are between 5,000 and 6,000 cfs. Right?

A. **That's correct.**

Q. And the flow interval with the highest number of days is somewhere between 5,000 and 5200. Right?

A. **Could you give me the question again, please?**

Q. Sure. The flow interval with the highest number of days is somewhere between 5,000 and 5200 cfs?

A. **So -- so you're asking about that 12-day spike, if you like?**

Q. Yes.

A. **That would be -- that would be correct.**

Q. Let's look at the same analysis you did for 2012, if you turn to page 24 and we look at figure 6.





Now, for 2012 there's only one day when flow is above 7,000 cfs. Right?

A. **Correct.**

Q. Out of a total of 181 total days?

A. **That's correct.**

Q. Most of the days above 5,000 cfs are between 5,000 and 6,000 cfs. Right?

A. **That's correct.**

Q. And you would agree that the most common is somewhere right between 5300 and 5350 cfs. Right?

A. **You said 5300 and 53-five?**

Q. Yes. 5350.

A. **Yes. That -- that spike is in that interval.**

Q. Now, your opinion is that these days that we just looked at show a deliberate use of discretion by the Army Corps to make releases in excess of the required minimum to support fish and wildlife; isn't that right?

A. **Yes. And as I said, among other things. They balanced the authorized project purposes as well.**

Q. Is it your opinion that releases in excess of the minimum are made for any purpose other than to support downstream fish and wildlife?

A. **Oh, yes. There are other purposes as well.**





Q. Now, you agree there are reasons the Corps may make releases in excess of the minimum that have nothing to do with exercising their discretion to protect downstream fish and wildlife. Right?

A. **I'm sorry. Could you give me that again?**

Q. Sure. You agree there are reasons the Corps may make releases in excess of the minimum that have nothing to do with exercising their discretion to protect fish and wildlife?

A. **Well, that one is kind of tricky because any releases that they make that increase the flow downstream benefit fish and wildlife as well. So they may make releases for other reasons as well, but any releases that increase the flow will also benefit fish and wildlife.**

Q. You haven't done any analysis to determine whether any of the days of flow in excess of 5,000 cfs that we just looked at are the result of these other circumstances that have nothing to do with a deliberate exercise of discretion by the Army Corps. Right?

A. **No. That's not correct.**

Q. Well, let's go through a few examples. You agree that as a practical reality, it's difficult for the Corps to be able to make a precise release of

5,000 cfs at Woodruff Dam when that minimum flow target is in effect; don't you?
A. **Yes. As I understand it, they have -- you know, they have controls on how much goes through the turbine; and those are not necessarily precise.**
Q. So some portion of the releases you identified, the ones we just looked at as being in excess of 5,000 cfs, at least some of those days may be a result of this inherent imprecision and not a deliberate exercise of the Corps to protect downstream fish and wildlife; isn't that right?
A. **Well, I -- the Corps understands the degree of imprecision, I believe. They recognize that it exists. And so I believe they account for that in their releases. And as I said, you know, it -- that would benefit fish and wildlife -- that conservatism in their operations would benefit fish and wildlife.**
**You know, it's not necessarily being done specifically and only for protection of fish and wildlife; but it's certainly being done and the Corps would understand the benefit to fish and wildlife of being conservative and releasing additional water.**
**When you actually look at the record, they**





**released a very considerable sum of additional water even over 2012, for example, that we were just looking at.**
Q. Dr. Shanahan, I'm going to try to ask you to answer my question because my question was very narrow; and you didn't answer it.
My question was do you agree that some portion of the releases we just looked at where you quantified days with releases in excess of 5,000 cfs, at least some of those days the excess release may have been a result of the inherent difficulty with making a precise release of 5,000 cfs at Woodruff Dam?
A. **Some maybe, but recognize that that's a -- that's a small increment. That uncertainty is a small increment; so it would not particularly affect, you know, the majority of these bars that you see in the chart.**
Q. But you haven't done any analysis to be able to tell the Court which portion of those days or how much of those excess releases we just looked at were caused by the practical difficulty of achieving an exact 5,000 cfs release?
A. **Well, I would say -- I would say I have. In fact, you asked me about this during my**





**deposition. And I indicated that the Corps has a -- in some of the reports have indicated that they released 5,050 cfs to basically account for this uncertainty. So if you look at this chart, the error bars are in 50 cfs intervals, so you might affect that very first interval. But it's only -- the difference is 50 cfs; so it's not going to appreciably alter the chart that you see there.**
Q. Your testimony is on each of the days you identified as having flows in excess of 5,000 cfs, 50 of those cfs may have been caused by the practical difficulty of achieving a precise release?
A. **That's -- that's what I gathered from what the Corps has published. It's --**
Q. You also agree that the Corps makes releases in excess of 5,000 as a margin of safety so as not to go close to or below the minimum. Right?
A. **Yes. That's what we were just discussing, the 50 cfs is that margin of safety.**
Q. Let's turn to JX-124.
MS. ALLON: And, your Honor, this is the very large exhibit that we looked at before and that I have excerpted.





BY MS. ALLON:
Q. If you look at tab 1, you can see that this is the DEIS. Dr. Shanahan, do you see that?
A. **Yes, sir. A very slimmed-down version.**
Q. And you're familiar with Army Corps' DEIS. Right?
A. **Yes.**
Q. Let's turn to tab 9. And do you see behind tab 9 where it says table 2.1-6?
A. **Yes, I do.**
Q. You're familiar with the RIOP's maximum fall rate rules. Right?
A. **Yes.**
Q. The fall rate rules are part of the RIOP just like the 5,000 minimum cfs is. Right?
A. **Yes.**
Q. And the fall rate schedule in table 2.1-6 limits how fast flow can come down from a previous day's high. Right?
A. **I don't think that's exactly right.**
Q. Well, it says when the Corps comes down from higher flow, sometimes they have to come down slowly. Right?
A. **Well, yes. I mean, too abrupt a change in flow would be harmful to the downstream biological**

**populations. But I believe this is based on -- I believe it's based on daily averages; and I don't know that you have given me enough to double-check that here.**

**So it's not the previous day's high, which is what you asked. It's based on -- I believe it's based on the daily average number. So it's not quite what you asked in your question.**

Q. Table 2.1-6 says that the Corps can only go down so many feet of river height per day. Right?

A. **That's correct.**

Q. So if the Corps enters a time where the 5,000 cfs minimum is in effect, it might not immediately be able to drop its releases to 5,000 cfs because of the maximum fall rate rules. Right?

A. **That could happen.**

Q. And the consequence of this is that you would have more days above 5,000 cfs while the Corps drops down in accordance with the maximum fall rate. Right?

A. **Yes. That -- that could be possible.**

Q. You haven't done any analysis to determine whether any of the days you identified as having had releases in excess of 5,000 cfs were a result of the maximum fall rate schedule of the RIOP.





Right?

A. **No, that's not correct. I have -- Dr. Bedient, I believe -- either Dr. Zeng or Dr. Bedient, maybe both of them, made claims regarding the maximum fall rate. And so I have done a detailed review of those. And what I have found actually is that they seem to exercise discretion even during the fall rate. They will keep a lower fall rate than they're required to, so they will let the water go down even more gradually. So there is discretion in their application of the fall rate as well.**

**But I guess the other point I would make is when you look at those -- for example, the graphs that I have in my report of what the flow looks like over time, the fall rate only comes into play when the flow rate changes. And the Corps tends to keep the flow at a pretty even level.**

**And, for example, in those bar charts where you saw flows clustered around a certain, you know, level, that's reflecting the fact that the Corps keeps the water level at a pretty constant rate. And there's good reason for that. I mean, up and down would be problematic downstream for the wildlife, the fish, and the biological**





**population. So they tend to keep a pretty steady rate. So the fall rate doesn't come into play very much at all.**

Q. Dr. Shanahan, do you recall giving a deposition in this case?

A. **I do.**

Q. And there was a court reporter. Right?

A. **Yes.**

Q. And you were under oath?

A. **Yes.**

Q. And you did tell the truth. Right?

A. **Yes.**

MS. ALLON: Your Honor, may I hand up a copy of the witness's deposition transcript?

BY MS. ALLON:

Q. Dr. Shanahan, could you please turn to page 315 of your deposition transcript. And at line 23, I asked you, for any of these analyses reflected in figures 3 through 8, did you consider whether any of the days where releases were in excess of 5,000 cfs were a result of the maximum fall rate schedule under the RIOP?

Answer. No.

Were you asked that question, and did you give that answer?





A. **Yes. But as I said in my prior answer today, I have subsequently done an analysis to look at some specific claims made by Dr. Zeng and Dr. Bedient. So I have done work now since then to look at their very specific claims about maximum fall rate and tested -- basically tested their claims.**

**And Dr. Zeng has a place in his testimony where he points to certain actual files and says, if you look at these, you will see it supports that the -- the notion that the maximum fall rate -- excuse me -- no, excuse me. No, that -- that's not about the maximum fall rate; that was about the maximum head limit.**

**But elsewhere he or -- he or Dr. Bedient made claims about the maximum fall rate. And I evaluated those specific claims and found that they didn't hold up.**

Q. So this new analysis that you're describing you did after you received the written direct testimony from Dr. Zeng and Dr. Bedient; is that your testimony?

A. **Yes. They had some new -- some new things to evaluate in there; so I took a look at those.**

Q. Now, one category of special operations that can

affect the amount of water released from Woodruff Dam are what the Army Corps calls unplanned deviations. Right?
A. **I don't remember that specific term, but certainly something like that, yes.**
Q. All right. Let's turn to the DEIS to tab 7b in JX-124.
And do you see there the section heading Special Operations and Releases?
A. **I do.**
Q. Okay. And if you go to the second paragraph, about halfway down, do you see where it says, the need for unplanned deviations might be caused by unforeseen conditions? Do you see that?
A. **Yes.**
Q. Okay. And as one example, the Corps says in the next sentence, special releases have also been used in response to unplanned situations, including to help free grounded barges in the navigation channel downstream of Jim Woodruff Lock and Dam. Right?
A. **Yes.**
Q. Now, if the Corps had to make a special release to help free a grounded barge, it would need to release more water than it otherwise would have.





Right?
A. **Yes.**
Q. That unplanned deviation would have the effect of increasing the discharge at the Chattahoochee Gage over and above 5,000 cfs. Isn't that correct?
A. **Yes. Temporarily.**
Q. You haven't done any analysis to determine whether any of the days of flow in excess of 5,000 cfs that we just looked at were at least in part caused by these sorts of unplanned deviations. Did you?
A. **There really is no way to do that. There is no record that would show those. But --**
Q. So how --
A. **-- they would look different.**
**I haven't seen anything that would seem to indicate that they had done that. But, of course, they would look different than the kinds of normal releases that you see. But I haven't -- I haven't done an analysis; and I don't know that one would even really be possible.**
Q. A flash rainfall event that caused thousands of cfs to enter Lake Seminole in a very short amount





of time could cause flows over and above the 5,000 minimum; isn't that right?
A. **What do you mean by a flash rainfall event?**
Q. If there was a rainfall event that caused thousands of cfs to enter Lake Seminole in a very short amount of time, do you agree that might cause flows over and above the 5,000 minimum?
A. **Well, let's set aside flash, if we can. You know the Flint River Basin and the Chattahoochee Basin are large basins. So the notion that you would have a very, you know, rapid increase and a very rapid decrease doesn't happen. Those basins are too large to see that kind of a response.**
**For example, it takes about nine days for the water to travel from the headwater of the Flint River down to Jim Woodruff Dam. So the notion that you could have a flash event is incorrect. But you could certainly have rainstorms in the basin which will increase the inflow to Lake Seminole to over 5,000 cfs.**
Q. And under those circumstances, the Corps would -- might make releases in excess of 5,000 cfs even when the minimum was in place?
A. **Well, in fact, they would have to. The -- Lake Seminole is what's known as a run-of-the-river**





**reservoir. It doesn't have appreciable storage capacity. And as the name implies -- it's actually a term of art in hydrology -- the river basically runs right through it.**
**So if you have an increase of flow of about 5,000, if the flow into that reservoir increases to above 5,000, you will have that flow coming through, perhaps not immediately, but it will come through within a matter of days. So it really doesn't have anything to do with Corps operations. They just have to do that. There is no place to put the water, and it has to go through.**
Q. You haven't done any analysis to consider whether any of the days you identify as having had releases in excess of 5,000 cfs were a result of these types of rainfall events; have you?
A. **Again, it's a similar situation to what we just discussed. There are some specific events identified and claims made in, I believe it's Dr. Bedient's prefiled direct testimony. So I have evaluated those events, the ones that he pointed out specifically as rainstorms that caused the flow to increase or not. And so I have looked at those.**

Q. Okay. That wasn't my question. My question was if we look at your figures where you point a number of days out of the year where you say the Corps deliberately made releases in excess of 5,000 cfs, can you tell the Court which of those days were a result of rainfall events rather than a deliberate exercise of discretion by the Corps to make releases in excess of the minimum?

A. **Oh, this is something we, again, discussed in my deposition. Those graphs only show days in which the flow into -- the basin inflow, which is the entirety -- basically it's the rain -- the rainwater flow that's coming into the entire system, is less than 5,000 cfs. And the Corps computes that on a running basis. And so the events that I show in those charts are only occasions when that basin inflow is less than 5,000 cfs.**

**So you're asking me did I count the events where the inflow was greater than 5,000 cfs? Well, those events are not in that chart.**

Q. I'm asking you whether you considered rainfall events, whether or not they brought basin inflow above 5,000. Do you have a way to tell the Court which, if any, of the days you identify as having





had releases in excess of 5,000 cfs may have been due at least in part to a rainfall event?

A. **The -- very, very few.**

Q. Do you have a way -- have you done the analysis to be able to quantify that number for the Court?

A. **Yes, I have. And, again, this is work that was done in response to some specific claims that appear in the prefiled testimony of Dr. Zeng or Dr. Bedient, I'm not sure which. And the way this would come into play is the maximum head rule. So you would have flow come into the reservoir. It would raise the elevation of the reservoir. And that would then trigger what's known as the maximum head rule.**

**If the water gets too high in Lake Seminole, it can actually pose a danger to the stability of the dam. So they have to watch that quite closely. So if you have a rainstorm, flow comes in, it raises the water level, then you would make a release basically to protect the dam.**

**And so I looked at the historical record for those kinds of events and found that they're -- you know, they're very, very rare.**

Q. Well, Dr. Shanahan, since we haven't had the benefit of seeing this new analysis, could you





tell the Court how many days you identified in 2008 and 2012 where an excess release was made above 5,000 cfs as a result of rainfall events?

A. **I -- I don't believe I did that analysis for 2008. I did the analysis -- it was either 2011 or 2012. So I'm not 100 percent sure as I sit here.**

**If those were the two years that Dr. Zeng and Dr. Bedient focused on, whichever year it was, it was one day.**

Q. Looking back at FX-11 at your analysis on page 24 --

A. **I'm sorry?**

Q. Page 24 of FX-11, back to your frequency analysis.

A. **So -- I don't have something labeled FX-11. Which one --**

Q. FX-811.

A. **811. Oh, okay. I'm sorry.**

Q. Are you on page 24?

A. **Yes.**

Q. Now, you're not saying that all of the instances you have identified here where the Corps releases more than 5,000 cfs are a deliberate exercise of discretion by the Corps; are you?





A. **No.**

Q. And you're not saying that all of these instances where you have identified that the Corps releases more than 5,000 cfs are explained by the Corps being incentivized to release more than 5,000 based on the need to protect threatened and endangered species. Right?

A. **Certainly not exclusively.**

Q. And you haven't quantified for any given day whether all of the excess release is a result of Corps discretion as opposed to something else. Right?

A. **Well, I would have to say I have on any given day. Certainly there are days where I have, you know, looked at the universe of possibilities; and the only one that was left was that they exercised discretion to release more.**

Q. Let's turn to page 304 of your transcript. And on page 304, line 12, I asked you, now, in the instances you identified where you attribute releases in excess of 5,000, when the 5,000 minimum is in place, to the Corps incentive to release more based on the need to protect threatened and endangered species, is it your opinion that the entire release in excess of

5,000 is a result of that Corps incentive?

And you answered, I can't -- I haven't really formulated an opinion on that. I haven't diced it that finely.

Did I ask that question, and did you give that answer?

A. **Yes. But that's a different question than you just asked. You asked on any given day.**

Q. You didn't do any work to quantify which releases are a result of the incentive that you attribute to the Corps and which are not. Correct?

A. **That -- that's correct. I have not isolated out that particular incentive on a day-by-day basis. I have looked at it as a more general matter and indicated that there is that incentive for them to do that. I have not attributed particular instances in the record to that. I looked at the record in a more general way.**

MS. ALLON: Your Honor, I'm about to move into another section. I would be happy to break now or happy to keep on going, whatever the Court's preference is.

SPECIAL MASTER LANCASTER: I'm happy to break now.

(Time Noted: 12:03 p.m.)





(Recess Called)

(Time Noted: 12:56 p.m.)

SPECIAL MASTER LANCASTER: Counsel?

BY MS. ALLON:

Q. Dr. Shanahan, your opinion is that increases in Flint River flows will lead to increases in releases from Jim Woodruff Dam into the Apalachicola River in Florida. Isn't that right?

A. **That's correct.**

Q. You say that flows on the Flint are well correlated with releases from Jim Woodruff; is that right?

A. **Yes. They are.**

Q. Let's take a look at the actual data. I would like to turn to the tab -- the demonstrative tab in your binder; and I would like to go to slide 2. It's all the way at the end.

A. **Oh, okay.**

Q. And do you see the slide that has a 2 in the bottom right-hand corner?

A. **Yes.**

Q. Now, this demonstrative shows Flint flows for 2012; that's the orange line. And then we also plotted the state line flows into Florida for the same time period; that's the blue line. And we





used the Chattahoochee Gage data that you relied on in your analysis.

Now, if you look at the yellow circle on the left, you can see this in June, flows from the Flint River dropped below 2,000 cfs. Do you see that?

A. **In -- in June you said?**

Q. Yes.

A. **Yes.**

Q. There is no corresponding decrease in releases into Florida; is there?

A. **Well, there is certainly not a one-to-one decrease. But the flows do, in fact, decrease a little bit.**

Q. Do you see in mid-June there's a spike in Flint flows. Do you see that?

A. **I do, yes.**

Q. There is no corresponding increase in flows into Florida; is there?

A. **Well, in fact, if you look at the area that -- well, the area under that curve -- under that orange curve would represent a line of water. So, for example, there is a low, as you pointed out, in June. And then it comes up, and then it gets back down to about the same level. So if**





**you were to draw a line up from that -- you know, if you had a starting point and ending point, there is a certain amount of flow that's above that line. And there is a volume associated with that.**

**And I actually computed those volumes after seeing this exhibit in Dr. Bedient's prefiled testimony. And what you actually find is that if you then look at how much the flow out of Jim Woodruff, the blue line, how much that's above 5,000 cfs, in fact, that volume does get discharged over the next while.**

**So it's not a one-to-one correspondence where the flows from the Flint River come up and the discharge from the Jim Woodruff Dam immediately comes up. Again, they're trying to keep that flow fairly steady. But when you look at the volume of water that comes in, the amount of water that comes in, that amount of water does come out; it's just not coming out immediately. It's being lagged a few days.**

Q. Dr. Shanahan, I'm going to ask my question again because I don't think you answered it. In mid-June there is a spike in flows from the Flint River. There is no corresponding increase in

mid-June in releases into Florida; is there?
A. **Well, as I said, there is -- there is a -- there is not a corresponding spike; but there is a corresponding increase. The volume is basically discharged from the dam, you know, over the next while.**
Q. Dr. Shanahan, I'm just comparing the orange line and the blue line. The orange line comes up in mid-June, and the blue line stays relatively constant. Do you see that?
A. **I do, yes.**
Q. Now, in October, the yellow circle on the right, there is a small spike at the beginning of the month; and you actually see a small spike in state line flows. But then towards the middle of October do you see that Flint flows again drop below 2,000 cfs?
A. **Yes.**
Q. Okay. And then in early November, do you see there is a spike in Flint flows?
A. **Yes.**
Q. Okay. In early November where there is a spike in Flint River flows, there's no corresponding increase in early November in releases into Florida; is there?





A. **Well, again, this is the same situation that you don't see the same kind of a spike; but you do, in fact, see flow that is being released that's roughly equal to the volume under that spike.**
Q. Dr. Shanahan, in early November do you see a corresponding increase in releases into Florida at the same time that there is an increase in Flint River flows?
A. **Well, not at the same time, but there is a corresponding increase.**
Q. Dr. Shanahan, you say that ResSim, the Army Corps reservoir model, does not reliably reflect Army Corps operations; is that right?
A. **That's correct.**
Q. You're aware that the Army Corps itself regularly uses ResSim; isn't that right?
A. **What I understand -- I'm pausing on the word regularly. I understand they use it for planning purposes, and so they have from time to time used it to analyze proposed changes in the operating plan. So, for example, they used ResSim as a part of the analysis for the proposed new Water Control Manual. And they will use it in those kinds of planning exercises. I don't believe that they use it regularly in the sense that they**





**use it, say, for day-to-day operations.**
**In fact, I don't believe they can because the input data for the ResSim model only go through 2011. So I don't believe they can use it contemporaneously. They don't have input data for it.**
Q. Dr. Shanahan, you would agree that the Army Corps knows more about its operations than you do. Right?
A. **I would expect they do, yes.**
Q. And you would agree that the Army Corps knows more about ResSim than you do?
A. **Certainly certain people within the Army Corps would know more, yes.**
Q. Let's take a look at what the Corps itself has said about ResSim.
I would like to turn to slide 1 in the demonstratives. And this is a download from the Army Corps website. Do you see in the second sentence the Army Corps has said that the software, referring to ResSim, simulates reservoir operations. And then it says for a number of reasons, and the last one is for real-time decision support. Do you see that?
A. **I do.**





Q. Okay. And do you see in the bottom sentence, the last sentence, the Corps has said that ResSim is a decision support tool that meets the needs of modelers performing reservoir project studies as well as meeting the needs of reservoir regulators during real-time events.
Do you see that?
A. **Yes. But I would just qualify this to say that this is a description of the software package, the computer code that constitutes the ResSim model.**
Q. Doctor --
A. **It has to be programmed to be used for a particular system. I have not seen anything that says the Corps of Engineers is using ResSim in the ACF Basin for other than planning purposes. I have not seen anything that indicates they're using it for real-time events. And what I have seen indicated is they seem to use other tools.**
Q. Dr. Shanahan, let's refer to the DEIS, JX-124. And I would like to turn to tab 11. And do you see the bottom paragraph that starts with USACE? Do you see that?
A. **Yes.**
Q. USACE is shorthand for the Army Corps. Right?

A. **Yes, U.S. Army Corps of Engineers.**
Q. And if you look about halfway down, do you see where it says -- the last word in the sentence, USACE selected? Do you see that?
It's right after --
A. **Yes.**
Q. Okay. And the Corps has said that it selected ResSim as the tool most capable of faithfully representing District water management practices. Do you see that?
A. **I do; but then they -- you know, on line 35 they also point out that -- they say, ResSim falls under the category of engineering models used in planning studies.**
Q. Dr. Shanahan, do you see that the Corps said, at the culmination of a three-year model development and verification process, it selected ResSim as the tool most capable of faithfully representing District water management practices. Do you see that?
A. **I do. But I think we have to be careful in understanding the context in which they are describing this. And they're describing it in the planning process that I just described. They use this to evaluate possible alternative**





**operating plans. And it's -- they're really asking different questions than, for example, Dr. Bedient was asking when he used ResSim.**
Q. You don't disagree that in what you call the planning process, the Corps has said that ResSim is the tool most capable of faithfully representing District water management practices; do you?
A. **No. I think it's a -- it is a good tool. It is a good tool that's available for that planning type of analysis. But that does not mean that the kind of purpose for which Dr. Bedient put it is appropriate.**
**I -- you know, I don't want that to be misconstrued. ResSim is like any model. Any model entails certain approximations, certain assumptions. You basically have to tailor your model to what you want to do with it.**
**And they are using ResSim for a particular purpose. They're using it for -- at a planning level studies with a simulated, long history and evaluate kind of overall differences. But it is not appropriate, for example, to answer the question that I was looking at is what happens at low flow? What happens at 5,000 -- you know,**





**when the rule says 5,000 cfs and the Corps of Engineers is discharging more? It's not an appropriate tool to look at that question.**
Q. But as we have said before, you agree the Corps knows more about its own model than you do. Right?
A. **Well, I -- I assume they do. But they have not -- I haven't heard their opinion of how Dr. Bedient used it. And I don't -- I don't -- they have not used it in the same way he has to answer the kind of specific questions that he has.**
MS. ALLON: Your Honor, I have nothing further.
Thank you.
THE WITNESS: Excuse me.
REDIRECT EXAMINATION
BY MR. QURESHI:
Q. Good afternoon, Dr. Shanahan.
A. **Good afternoon.**
Q. You had some questions there at the end about ResSim and modeling, and we'll certainly get to those. But I would like to start by understanding what tools you used in your analysis, sir.





A. **I actually used comparatively simple tools. The primary tool that I used was the Microsoft Excel spreadsheet program. And what I did was I obtained the actual records that are published by the U.S. Geological Survey as far as flows in the river. And the Corps has really an astoundingly complete record of the inflows and outflows and reservoir elevations for the entire history of when these projects have been in place.**
**So I used those actual historical records and then basically did bookkeeping. I looked at where the inflows were coming into the system and were -- you know, what happened to those and how they came out of the system. So it was really a bookkeeping operation done on Microsoft Excel.**
Q. Okay. And over what time horizon did you evaluate these historical records, sir?
A. **It varied a little bit. The Geological Survey records date back to the late 1920's. And for certain comparisons, I used that entire record. But primarily I used -- I looked more specifically at the period from 1980 to the present, which is a period over which the operating rules are more or less similar to what they are today, as far as I know. And I**

particularly focused on the driest years and the -- the June through September, the growing season, as far as the results I looked at.

So I did spreadsheet calculations and so forth day by day through the entire period. But then as far as the results I looked at and presented in my report, I really looked at those low flow years and low flow times during those years.

Q. And why in particular did you focus on the growing season, as you described it?

A. **Well, the growing season is important. And Dr. Lettenmaier kind of got to this where he talked about the fact that demands here are highest. The irrigation demands for agriculture are highest during that time of year. And they actually tend to be higher still during the driest years. And as well, that's when the potential impacts on biological populations in the river and the bay are the greatest.**

**And, for example, the -- the biological opinions that the U.S. Fish and Wildlife Service has put out on the ACF point out that those times of low flow are when the stresses on the biological populations are the greatest. And**





**that's really a truism in water quality generally. I mean, we know that low flow periods are the periods of water quality stress and biological stress.**

Q. And, Dr. Shanahan, why do you conclude that additional basin inflow will make its way into Florida's Apalachicola River?

A. **Well, probably the best way to show that would be by reference to -- I think it's figure 1 in my prefiled testimony.**

Q. Okay.

MR. QURESHI: And that is on page 3 of the binder that was handed out. The very first tab contains Dr. Shanahan's prefiled direct testimony.

BY MR. QURESHI:

Q. And with the Special Master's permission, Dr. Shanahan, perhaps you can show us what about the map informs your conclusions.

SPECIAL MASTER LANCASTER: Just keep your voice up.

THE WITNESS: Okay. Thank you.

A. **So this map, which appears in my prefiled testimony, is a map of the ACF Basin upstream of Lake Seminole and Jim Woodruff Dam. First of**





**all, just one kind of general aspect of this. Of course, this is going more or less from north to south. The highest land is in the north.**

**And so you're really looking at a system where we have water going downhill. And it's really a hydraulic certainty that there may be some losses of water due to evaporation and so forth; but water that goes into this basin at -- falls on the land surface, goes into streams and rivers, eventually gets into the larger rivers. That river is going south. It's going to Florida. There is really no place else for it to go. It's not going to disappear someplace. All the water is going to Florida eventually. It's not a question of if; it's a question of when. And that's a hydrologic certainty.**

**I have subdivided this part of the watershed into three different areas, which I call area A, which is in pink; area B, which is in blue; and area C, which is in yellow. And those are set apart based on the location of the Corps of Engineer projects. And in particular, four of the Corps of Engineer projects are important here.**

**Area C is the area that's upstream of Buford**





**Dam and Lake Lanier, the major storage reservoir. Area B includes West Point Lake and West Point Dam. And then it's the area that's upstream of W. F. George Dam and reservoir. So that's area B.**

**And then finally area C is the area that's upstream of Jim Woodruff Dam.**

**So let's talk about these specific areas just briefly. Area C, as you can see here, is only 7 percent of the land area in the basin in Georgia. However, it drains into Lake Lanier, which contains 65 percent of the storage capacity of the entire system. So you have got a relatively small area going into a large storage bucket, if you like. And as it turns out, if you look at the annual average flow that comes into Lake Lanier, it's about enough -- it's about equal to the conservation storage capacity within the lake. So the conservation storage is really the usable storage; it's the water that can be used. And so you really have enough water coming in here to fill that bucket once a year.**

**In contrast, area B is a good deal larger; and it has two storage reservoirs. These three reservoirs are the only reservoirs that have storage or appreciable storage. So 35 percent --**

**the remaining 35 percent of the storage is in these two reservoirs. And they drain a much larger area. And so the amount of water that's going into those reservoirs in an average year is much greater.**

**So West Point, there is enough water that goes in to fill and empty its bucket, if you like, seven times a year. W. F. George, it's over 10 times a year. So that contrasts with one time a year up here.**

**The other thing that's different here is Buford -- Lake Lanier lies just upstream of the Atlanta metropolitan area. So it's really got a very large -- the largest municipal and industrial demand in the basin, very large and insistent demand for water immediately downstream. In contrast, there really aren't anywhere near the kind of large demands in area B. So you have a situation where you have got relatively -- you know, comparatively plentiful water compared to the storage available and not anywhere near the same kind of demand on those reservoirs.**

**And for that reason, the Corps is able to basically dispense that water more freely. And**





**they discuss how in their documents the fact that they draw on those reservoirs really much more quickly than they would draw on the upper reservoir because it has so much more storage available.**

**Now, finally there is area A; and that's in pink here. This is 62 percent of the basin in Georgia, so the majority of the land area. And this is what is known as an unregulated basin. There is a reservoir down here, Lake Seminole. But it has very, very little storage within it. It's -- as I said earlier, it's what I call a run-of-the-river reservoir. The river basically runs right through it. So this whole area here has really no storage capacity. The water that's generated in that -- you know, from that area goes down to Lake Seminole; and it basically has to run through.**

**There is no capability to hold it back in that basin. So that water, you know -- if any extra water is generated within this area, that has to go to Florida. There is not a way to hold that water back and prevent it from going to Florida. And it will go to Florida relatively quickly because there is such -- there is no**





**storage in that downstream reservoir.**

**Q.** Thank you, Dr. Shanahan.

Dr. Shanahan, when you were discussing the water that is in the basin and making its way into Florida, were you excepting from your answer the water that's consumed in the Georgia portion of the basin?

**A. I didn't -- accepting or excepting?**

**Q.** Excluding. The water that's consumed in Georgia won't make it to Florida?

**A. That's right. Consumptive use basically is water that disappears and would not make it to Florida.**

**Q.** Okay. Sir, having understood your description of the system geography, can you explain how your review of the historical record is consistent with the explanation you just provided?

**A. Well, yes. As I said, I looked at really the -- you know, how the system has actually been operated in the past. And in hydrology, we very typically do that and look at that as an indication of how things will go in the future.**

**And so I looked at the Corps operations, and what you find is that West Point and W. F. George basically pass water during the dry time of year. So during the summer and the fall, they do not**





**increase their storage, at least not on a month-to-month or seasonal basis. They basically let whatever water that comes in, passes through those reservoirs. And in addition, they release some of their storage. And so that's quite consistent with this architecture.**

**And then as well, the water that comes out of area A, as I said, simply as a matter of hydrology has to go to Florida.**

**Q.** Dr. Shanahan, during your cross-examination you were asked questions about Corps discretion and whether or not the Corps would actually release more than 5,000 cfs into the Apalachicola River. Based on your understanding of Corps operations and the historical record, why might have the Corps released more than 5,000 cfs in the past?

**A. Well, certainly the -- when you look at what the Army Corps has written about their system operations, they talk about the fact that it's -- it's something of a balancing act, that they have multiple authorized purposes; and they're attempting to meet those purposes. So the Corps has a number of reasons why they would want to release water.**

**For example, one of the authorized purposes**

**is hydropower. We talk about how valuable the hydropower is to this region, how it reduces electricity costs. And the nature of the hydropower is really a -- is really beneficial. And so they have those incentives.**

**But then as well, I discussed this -- I have discussed the fact that there are sensitive species in the downstream waters, in the waters in Florida, and that the Corps has been through a lengthy process of consultation and interaction with the U.S. Fish and Wildlife Service. And so they do have an incentive to enhance those biological populations -- to enhance conditions for those. And, in fact, the U.S. Fish and Wildlife Service has found that there are impacts even below 10,000 cfs. So they have incentive to try and release, you know, more water than 5,000 cfs.**

Q. Sir, counsel for Georgia challenged you to locate statements from the Corps in which it discusses its discretion and its incentives. And I know we have JX-124 in our cross-examination binders, but as counsel pointed out, that only contains excerpts and not all of the excerpts.

MR. QURESHI: So with the Court's





permission, I would like to hand out additional pages from 124.

BY MR. QURESHI:

Q. In particular, Dr. Shanahan, I would like to direct you to page 6-35 of JX-124. And I would ask you to review lines 9 through 16.

After you have had an opportunity to do so, please explain how this discussion is consistent with your understanding of how the Corps operates.

**A. Yes. This language is really some very specific language as to how the Corps interprets how much water they have to release from the projects. And they distinguish what they call mandatory minimum flow requirements and then nonmandatory flow targets and goals.**

**And so there are certain absolute minimum flow requirements. The -- for example, the -- there is a requirement to release a certain amount of water from Buford Dam up at -- up at Lake Lanier in order to preserve the water quality in the reach of the Chattahoochee River downstream of Atlanta where a lot of wastewater from the Atlanta treatment plants come in. They need that water to basically assimilate the**





**wastewater. So there's a requirement in the Corps' mind, and they define a number of those.**

**But then they also have what they call nonmandatory flow targets. One example, for example, downstream -- just upstream of Lake Seminole on the Chattahoochee River there is a nuclear power plant, Farley nuclear power plant. And if the flow in the river drops below 2,000 cfs in the Chattahoochee River at that downstream location, Farley runs into some difficulties in withdrawing, circulating water for their cooling down their nuclear power plant from the river. And so, you know, the Corps, for example, says that they consider that -- I forget what -- I think the language they use is they give that serious consideration. They don't want the water to drop down to a level that would be problematic for the Farley nuclear power plant. So that's not a requirement per se; but that's a judgment the Corps makes. And they use their discretion to -- to meet that requirement.**

Q. Similarly, Dr. Shanahan, you refer to the biological opinion and information in that document that might support your belief that the Corps would release more than 5,000 cfs and, in





fact, has. I would like to show that document now. It's JX-168.

**A. Okay.**

Q. Dr. Shanahan, I'll refer you to pages 43 and 44 and ask you to read the paragraph on low flows to yourself and then explain how this is consistent with your belief that additional water into the system will be released into Florida, particularly during drought years.

**A. Okay. Just one correction. I think you identified this as JX-168. But --**

Q. I'm sorry. It's JX-72.

**A. That's right, yes. That's what I have anyway.**

Q. Thank you. It's on page 43, sir.

**A. Yes. I'm -- could you just repeat your question?**

Q. Sure. Could you explain how this discussion is consistent with your understanding that additional basin inflow will make its way into Florida, particularly during drought years?

**A. Okay. This is a good discussion of the fact that -- as they say here, extreme low flows are likely among the most stressful natural events faced by riverine biota. And they go on to explain why it is so stressful and basically why it is so important to have higher flows. And**

**they say, you know, given the physical and biological harshness of extreme low flow conditions, decreasing the magnitude, increasing the duration, or increasing the intra-annual frequency of low flow events is likely to cause detrimental effects on native riverine biota.**

**So they make quite clear that low flow is bad. More frequent low flow is bad. Longer period of low flow is bad. So they obviously have stressed in this document the importance of maintaining higher flows.**

Q. Thank you. Dr. Shanahan, are you familiar with the work that Georgia's expert, Dr. Bedient, has performed in this matter suggesting that the Corps will always release 5,000 as a target into the Apalachicola?

A. **Yes, I am.**

Q. Okay. And have you had an opportunity to review some of the demonstrative exhibits that Dr. Bedient prepared?

A. **Yes.**

MR. QURESHI: Your Honor, I would like to show him one of those.

BY MR. QURESHI:

Q. This is Bedient demo 5 in the left-hand corner.





And, Dr. Shanahan, I would like for you to explain to us what analysis you performed on this particular exhibit?

A. **As I recall, Dr. Bedient used demo 5 and demo 6 to try and make the point that the flow was basically 5,000 cfs coming from Woodruff Dam during low flow periods in 2001 and 2012. And certainly, when you look at his exhibit and given the scale that is used for the vertical axis on that exhibit, it looks like the flow is right about 5,000 cfs.**

**And so I looked at this and -- looked at it more carefully and specifically the graph on the lower right on both pages. I blew up that low flow period. And as you can see, my axis on the first page goes from 4700 to 5500. So I'm really looking at just a period of when the flow was around 5,000 cfs. And as you can see, the flow is consistently greater than 5,000 cfs. On the first page it's shown as around 5100 and at times much greater. Similarly, on the next page, it's shown as around 51 to 5200, and at other times much greater.**

**I guess one caution with this is, as you see, the -- at the top of this it says Source**





**Provisional Data in GX-143. So GX-143 is a database that Georgia EPD had put forward that they say they maintain. It's -- it's not a published database. It's -- what they say it is is the provisional data that the U.S. Geological Survey collected.**

**So the USGS will make measurements. They will come out with an initial estimate of what flow is. But then they will go through quality assurance procedures and so forth and update that. So the record that's published on the internet that hydrologists use is, for the most part, data that has a little A after the number, which means accepted. Sometimes there's a little E, which means estimated. And it's only the most recent data that gets a P, which is provisional.**

**Well, this record is something that they have indicated is the provisional data. The provisional data aren't -- you know, stay on the internet for a very short while and then disappear. So there is not a complete record of provisional data to compare this with.**

**But I have found excerpts of the USGS provisional data, and these numbers are not the**





**same. So even though it's portrayed as the U.S. Geological Survey provisional data, it is not, at least for the instances when I found the data.**

**The database also that was provided is somewhat curious. I mean, it has gaps in it. It's kind of piecemeal. It's in two different pieces. But I guess the other thing that's really quite curious is Dr. Bedient indicates that he used that database. However, we have received the Microsoft Excel files that Dr. Bedient, you know, has his data in. And when we compared those data with the data that are in GX-143, which is what he contends is the source of his data, there are differences there as well.**

**So to be honest, I don't quite know what this database is. It's not an official published database. And I think the problems that I have found points out why people don't use those kinds of databases. They use the official databases that are published by the U.S. Geological Survey. They're available to everyone. Anyone can go and check your work by looking at the official database.**

**I don't quite know what this database is that they're using.**

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Q. And the exhibit that I provided you, Dr. Shanahan, is it your testimony that the graphs that you prepared were relying on the provisional data that Dr. Bedient and Georgia provided to Florida in this case?
A. **Yes. I -- well, as I said, I'm not quite sure what Dr. Bedient plotted out is necessarily what's in GX-143. But -- because they're -- again, these two provisional databases seem to be different.**
**But I used GX-143 to plot these data up so that it would be comparable with the numbers that Dr. Bedient used here. If I actually used the U.S. Geological Survey accepted data, the flows are, in fact, a good deal greater.**
Q. And the first page of what I handed you, I guess if you call it Shanahan demo 1, I think you said this was 2001. Did you mean it was 2011 to 2012?
A. **Oh, did I say 2001?**
**I'm sorry. Yes. 2011-2012.**
Q. Thank you.
A. **Sorry.**
Q. And in your prefiled direct, again, in the first tab of your cross-examination binder, you have a table on page 4. Can you explain to us what that



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table represents.
I'm sorry. A table on page 32, table 4.
A. **Yes. Page 32?**
Q. Yes, sir.
A. **This is another way to look at the flow that is being discharged from Jim Woodruff Dam. And so what was done here is we used the -- again, the actual U.S. Geological Survey accepted record and compared the flows at the Chattahoochee Gage, which is immediately downstream of Jim Woodruff Dam. You can actually stand under there and see the gage location. It's right there.**
**And so we took the flow in the river and subtracted from that what was the minimum flow specified under the RIOP during that time period. And so the RIOP specified that for the entire time period shown in this table, that the flow should be greater than or equal to 5,000 cfs. So we subtracted 5,000 cfs from the daily observed flows, added those up over the course of each of these months, and determined how much -- how much cumulative water was discharged each month because of that excess above 5,000. And that's the difference in cfs days in the third column. And then in the fourth column we converted that**



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**into a daily average.**
**So it's how many -- how many cfs, what the flow -- the equivalent flow would be so that you can see, you know, at -- say at the bottom of the third column, 1.1 million cfs days -- and let me make sure I get my conversion correct here. The conversion between acre-feet and cfs days is a factor of two. And so the acre-feet would be about twice that, so it's about 2.2 million acre-feet.**
**So kind of for comparison, the storage capacity of the ACF system is 1.6 million acre-feet. So you're looking at a very substantial amount of water that's being released in excess of the 5,000 cfs minimum.**
Q. Okay. Dr. Shanahan, who else shares your view that additional basin inflow will make its way into Florida's Apalachicola River?
A. **Well, certainly one thing that I cite in my report is an amicus brief that the U. S. Government has filed in this action. And they discuss a contention that Georgia made in some other legal filing that any -- any extra flow, any flow or any extra water generated by conservation in the Flint River Basin would be**



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**offset by extra storage upstream. That's Georgia's contention.**
**The Government said, you know, Georgia gives the Flint River short shrift. In essence they're saying we wouldn't necessarily do that. I think they called it unwarranted speculation that they would store that water rather than pass it through. And, again, my review of the historical records show that they have tended to pass it through.**
**The other thing I would -- I would cite is Dr. Aris Georgakakos at Georgia Tech who did work for the ACF Stakeholders Group did a number of model runs and -- did a large number of model runs, in fact, and did a lot of simulations. And one of the things he looked at is what would be the effects of extra conservation in the basin in terms of how much water got down to Florida. And he basically concluded that whatever water was conserved would get to Florida, and the amounts were basically equal.**
**And this goes back to that thing I said about the hydrologic certainty. The fact that, you know, flow is going to go downstream. Extra water is going to get to Florida. There is no**

**place else for it to go. And certain -- and, sure enough, his model results show the same thing.**

Q. Thank you, Dr. Shanahan. One -- I believe this is the final document I would like to run through with you. With Georgia's counsel you looked at an excerpt of a document that was apparently downloaded from the Army Corps of Engineers website regarding ResSim. I would like to review with you some information from the ResSim users manual, if I might.

In particular, Dr. Shanahan, I would like to direct you to pages 11-19 and 11-42 of JX-46, if you could explain how your analysis of ResSim is consistent with the discussion in the user manual.

A. **Certainly. Well, as I have mentioned, I have written computer programs similar to the kind of computer -- to do the same kind of thing that ResSim does.**

**And one of the things about computer programs is they're actually quite stupid. They do exactly what you tell them to do. And this points out one of the potential stupidities in ResSim.**





**And so it -- if you think about the RIOP table, the RIOP table says the Corps of Engineers must release greater than or equal to 5,000 cfs. ResSim cannot -- it's not really programmable to do that greater than. It can't -- you can't program the kind of discretion that the Corps uses to make that decision. And so what ResSim does is it fixes that discharge -- and this is the number I talked about earlier of 5050. So no matter what's going on, when this particular rule is in place, only 5,000 -- the Corps will discharge only 5050 cfs when, in fact, my review of the records and so forth shows that the Corps, you know, uses its discretion and discharges more pretty much all of the time.**

**Now, this points out really what I was talking about earlier as far as the flaw in ResSim. So Dr. Bedient has done an analysis with ResSim; and he has reached a conclusion that, oh, the Corps will never discharge, you know, more than the RIOP minimums. Well, of course not. ResSim is programmed to only discharge the RIOP minimums. There is no possibility of having any other finding.**

**So in essence the program has that answer**





**already in it because of the way these rules work and because of this caution sign in their own manual.**

Q. Thank you, Dr. Shanahan. Finally, there were some questions about deposition testimony from Mr. Barton. You're aware, sir, that Mr. Barton is not a hydrologist?

A. **I didn't know that, but I'll accept that.**

Q. And Mr. Barton has never worked in the ACF system?

A. **I think I did know that, yes.**

Q. Okay. And I believe counsel for Georgia characterized Mr. Steve Leitman as the chief modeler for Florida. You're aware that he's an adjunct professor at Florida State University?

A. **I think I have seen that, yes.**

Q. Okay. And that he's currently pursuing a degree in hydrology from a university in South Africa. Did you know that?

A. **No, I didn't know that.**

Q. Okay.

MR. QURESHI: Nothing further, your Honor.

Thank you.

SPECIAL MASTER LANCASTER: Recross?





MS. ALLON: Yes, your Honor.

RECROSS-EXAMINATION

BY MS. ALLON:

Q. Dr. Shanahan, the 5,000 cfs minimum release that's set forth in the RIOP was established through Army Corps consultation with the U.S. Fish and Wildlife Service. Right?

A. **Yes. I believe that's correct.**

Q. And, in fact, the Corps and U.S. Fish and Wildlife consulted on numerous occasions before the minimum release was set; isn't that right?

A. **I believe so, yes.**

Q. And the U.S. Fish and Wildlife published their analysis and determination with respect to the RIOP on the biological opinion that you testified about on redirect; isn't that correct?

A. **That's correct. Although they also pointed out in that same document they recommended that conservation be considered for the basin to provide more water.**

Q. Okay. And, Dr. Shanahan, you had the opportunity to give your testimony. I'm going to ask you to try to answer my question.

Let's turn to page 143 of the document your counsel walked you through, the U.S. Fish and

Wildlife 2012 biological opinion. Do you have
that in front of you?
A. **Yes. 143?**
Q. Yes. The bottom of page 143, the heading that
says Determinations.
A. **Yes.**
Q. And do you see where it says it is the Service's
biological opinion that the proposed action will
not jeopardize the continuing existence of the
fat threeridge, purple bankclimber, and Chipola
slabshell and will not destroy or adversely
modify designated critical habitat for the fat
threeridge, purple bankclimber, and Chipola
slabshell. Do you see that?
A. **Yes.**
Q. And you're aware that most recently, in 2016, the
U.S. Fish and Wildlife also published a
biological opinion where it signed off on 5,000
cfs minimum release. Are you aware of that?
A. **Yes. I don't believe -- yes. I don't -- I
haven't reviewed that in detail; but I don't
believe they have changed that.**
Q. Now, on redirect you talked about basin inflow
and how basin inflow correlates with releases at
Jim Woodruff. So I would like to take a look at





your analysis. And we can actually turn in your
witness binder to slide 3 in the demonstratives.
And slide 3 is actually reproduced figure 6
from your testimony. All we did was we added the
yellow circles. And I want to focus -- did you
find it, doctor?
A. **Yes.**
Q. Okay. And I want to focus on the pink line
that's called basin inflow because that's what
you testified about just before.
And I want to compare basin inflow with the
blue line, which is what you observed, the
observed releases into Florida.
Now, the first circle shows basin inflow in
excess of 7500 cfs in the middle of June 2012.
Do you see that?
A. **Yes.**
Q. And at the same time observed releases into
Florida were just above 5,000 cfs. Do you see
that?
A. **Yes. I'm hesitating on just above. I think they
are about 5600 perhaps.**
Q. In the middle of June 2012 when basin inflow was
in excess of that 7500 cfs, releases into Florida
were around 5500 cfs. Do you see that?





A. **Sorry. Could you say that again.**
Q. I was just using your terminology of 5,000
instead of just above 5,000. But I can repeat
the question.
A. **Okay. Yes. I just got lost a little bit.**
Q. In mid-June when basin inflow was in excess of
7500 cfs, your figure 6 shows that observed flows
into Florida were right around 5500 cfs. Is that
right?
A. **That's correct. Yes.**
Q. And in mid-November of 2012, if you look at the
next yellow circle, basin inflow, the red line,
was around 3500 to 4,000 cfs. Do you see that?
A. **Yes.**
Q. And observed flows at the Chattahoochee Gage
symbolizing releases into Florida were just above
5,000 cfs. Do you see that?
A. **Yes. I think they may be about 5400 then.**
Q. Throughout November of 2012, basin inflow goes up
and down. Do you see that?
A. **Yes.**
Q. But at the same time flows into Florida stay
constant, right above 5,000 cfs. Do you see
that?
A. **Yes. And I said that they use Lake Seminole to**





**kind of smooth out the ups and downs. But the
water is going through.
I talked about the volume calculations I did
earlier. So the water is going through. It's
just not going through at the same kind of up and
down pattern.**
Q. Dr. Shanahan, I'm asking you to focus on November
of 2012. Do you agree with me that throughout
November of 2012 releases into Florida stayed
constant?
A. **Yes. But they stayed constant at an amount about
5,000 cfs. That was more or less equal to the --
when you add it up, it was more or less equal to
the extra volume that came in in that event in
early November that is circled. So the water got
through. It just got through on a somewhat
different schedule.**
MS. ALLON: Nothing further.
Thank you, your Honor.
SPECIAL MASTER LANCASTER: Further
questions?
MR. QURESHI: I have no further
questions, your Honor.
I failed to introduce my colleague,
Garrett Jansma, who is assisting me today.

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SPECIAL MASTER LANCASTER: Welcome.
MR. JANSMA: Thank you, your Honor.
SPECIAL MASTER LANCASTER: Doctor, bear with me for a minute.
THE WITNESS: Certainly.
SPECIAL MASTER LANCASTER: You mentioned the ACF Stakeholders in your testimony.
THE WITNESS: Yes.
SPECIAL MASTER LANCASTER: Are you familiar with their published Sustainable Water Management Plan?
THE WITNESS: It's been awhile; but, yes, I have seen it. Yes.
SPECIAL MASTER LANCASTER: I'm going to violate one of my own rules and read a paragraph to you. This is on page 2. It says, ACF worked closely with state and federal agencies to compile the best available water withdrawals and returns data in the ACF Basin and used this in modeling current and possible future conditions. ACFS also documented needs and concerns for different stakeholder groups in geographic areas of the basin and incorporated those concerns in the plan by developing



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performance metrics like appendix A which were used in the modeling to assess water management alternatives.
Is that a process you're familiar with?
THE WITNESS: In general, yes.
SPECIAL MASTER LANCASTER: And recognizing the fact that, as you said, models are what you put into them and how you design them, are you familiar at all with the model that the ACF Stakeholders came up with?
THE WITNESS: Yes. Well, the work was done by Georgia Tech and actually another MIT grad; we were in grad school together at the same time. And he used two -- this is Aris Georgakakos. He used two models. He used a model of his own creation, and then he also used ResSim.
SPECIAL MASTER LANCASTER: And my question was are you familiar with the plan?
THE WITNESS: Oh, with the plan. I'm sorry. I thought you asked if I was familiar with the models.
I guess probably the right answer is I was; but I have gotten rusty. It's been awhile since I have looked at it.



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SPECIAL MASTER LANCASTER: Trust me; I know the feeling.
Is Woodruff Dam a run-of-the-river project?
THE WITNESS: Yes, it is.
SPECIAL MASTER LANCASTER: Under all conditions?
THE WITNESS: Yes. They have -- the water level can vary really only about a foot. And so you don't really have, you know, the capability there to, say, hold extra water that comes in in any appreciable amount.
I mean, you can raise the level a little bit; but it's not like a, you know, Lake Lanier where there is a deep reservoir in which water can be stored. Woodruff just doesn't have that capacity.
SPECIAL MASTER LANCASTER: Bear with me, because I'm probably not going to state this very well. But in extreme low flow events even if irrigation in the Flint River Basin was reduced, the resulting increased flow would or would not result in the same flows into the river because the Army Corps would



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be releasing less water from the upstream reservoirs?
THE WITNESS: Well, you know, I don't -- my review of the historical record really doesn't show that to have been what has transpired in the past. And so certainly they had some extreme droughts in 2011-2012; and, yet, they continued to release water. You know, they drained down, if you like, W. F. George and West Point. So they continued to release water. But even when they were done, they still had a considerable amount of storage left in the system.
So -- and everything I have reviewed says that they -- well, first of all, it's really not a question of if; it's a question of when. The water is going to get to Florida. There is no place else for it to go. And the question is how long would you store it? How long would you delay it in storage?
And my review of the record says, really, not very long.
SPECIAL MASTER LANCASTER: But if we're actually using less water in the lower basin,

it would move water upstream; wouldn't it?
I know it sounds strange, but wouldn't water be flowing uphill?
THE WITNESS: Well, the -- if they were using less water, it might allow them to hold more water upstream and let less go downstream, yes.
SPECIAL MASTER LANCASTER: Counsel?
MS. ALLON: Nothing, your Honor. Thank you.
SPECIAL MASTER LANCASTER: Counsel?
MR. QURESHI: Nothing further, your Honor.
SPECIAL MASTER LANCASTER: You're finished.
THE WITNESS: Thank you.
SPECIAL MASTER LANCASTER: Thank you.
MR. PRIMIS: Your Honor, we're shifting teams so we're going to need to shuffle some paper and people.
THE CLERK: Please raise your right hand.
Do you solemnly swear that the testimony you shall give in the cause now in hearing shall be the truth, the whole truth, and





nothing but the truth, so help you God?
THE WITNESS: I do.
THE CLERK: Please be seated.
Pull yourself right up to the microphone and please state your name and spell your last name.
THE WITNESS: My full name is George Mathias Kondolf. So George, as you would expect, Mathias, M A T H I A S, Kondolf, K O N D O L F.
MR. QURESHI: Your Honor, we would like to introduce Dr. Kondolf. He's a specialist who studies rivers, and he's a professor of environmental planning at University of California, Berkeley.
And with your permission, I would like to hand him his prefiled direct.
SPECIAL MASTER LANCASTER: Please.
DIRECT EXAMINATION
BY MR. QURESHI:
**Q.** Dr. Kondolf, do you recognize the document I provided to you as the testimony you prepared for this litigation?
**A.** **Yes. I do.**
**Q.** And do you adopt it in its entirety?





**A.** **Yes.**
**Q.** Thank you.
MR. PRIMIS: Your Honor, may I approach with some binders of documents --
SPECIAL MASTER LANCASTER: Please.
MR. PRIMIS: -- as is our custom?
SPECIAL MASTER LANCASTER: I would be disappointed if you didn't.
MR. PRIMIS: Your Honor, before I begin, I want to just recognize two individuals on our team who have been in court and have not been thanked yet for their work; and I would like to introduce them. I believe you know Matthew Smith, who is our senior trial technology specialist and keeps things moving for us; and also Ken Dyche is another member of our team who helps prepare all these demonstratives. And I just wanted to acknowledge them on the record.
With that, I'm ready to proceed.
CROSS-EXAMINATION
BY MR. PRIMIS:
**Q.** Good afternoon, Dr. Kondolf.
**A.** **Good afternoon.**
MR. PRIMIS: Your Honor, I'm going to





introduce a new scientific vocabulary term now; and so I'm going to take it slow with the doctor.
BY MR. PRIMIS:
**Q.** You are a fluvial geomorphologist. Correct?
**A.** **That's correct.**
**Q.** And would you agree that fluvial geomorphology is the study of river channels, floodplains, and the processes that shape and change them over time?
**A.** **Yes. That's a good description.**
**Q.** And essentially you analyze rivers, the riverbed, and the banks and the floodplains. Correct?
**A.** **Yes. And the flows and transport of sediment and processes like that as well.**
**Q.** Thank you. Now, you have written in the past that the Apalachicola River ecosystem has been severely degraded through a long history of navigational dredging by the U.S. Army Corps of Engineers' impoundment of water by upstream reservoirs and consumptive use of water upstream. Isn't that true?
**A.** **Sounds familiar. Can you direct me to where that quote is from?**
**Q.** Certainly. It's from your American Riverkeepers report, which we have in tab 4.

**A. Okay.**
Q. And we're going to come back to that. I just want to know is that something you have said in the past?
**A. It's always good to check and confirm that.**
Q. Please do. GX-248, tab 4.
**A. Okay.**
Q. Page 1.
**A. Okay. Yes. Thank you. You have read that correctly.**
Q. That's in the first paragraph -- I'm sorry, the first sentence of the second paragraph. Correct?
**A. That's right.**
Q. Okay. We're going to come back to that report, Dr. Kondolf. Right now, I want to walk through your analysis of the various portions of the Apalachicola River that you address in your direct testimony. Okay, sir?
Now, on page 4 of your written direct you have a map of the entire Apalachicola River. Correct?
**A. Yes. That's correct.**
Q. Okay. And just to make things easy, because I'm going to refer to that a lot, we have included a demonstrative which is essentially just a much





larger picture of that river right from your testimony. It's behind the demonstrative tab in the back. And it's the first picture. And I have also put it on the screen so we can all follow along.
Now, as we look at the map, Dr. Kondolf, you have divided it into different sections. Correct?
**A. That's correct. This map shows the different sections which I adopted from the U.S. Geological Survey categories.**
Q. Okay.
**A. Their divisions.**
Q. And you have little numbers as you go along the river. Do you see on the screen I'm pointing at 100; is that right?
**A. That's right.**
Q. And just to -- to level-set what that means is that's the number of miles from Apalachicola Bay that you're at in the river. Correct?
**A. That's correct.**
Q. Now, you have what you call here the upper riverine or the upper reach; is that right?
**A. That's right.**
Q. And that extends from about river mile 106, which





is right at the Jim Woodruff Dam at the state line, and that goes down to about river mile 80. Correct?
**A. That's about right. Yes.**
Q. Okay. And then you have a middle reach which extends from about river mile 80 down to river mile 42. Correct?
**A. I forget exactly if it's 40 or 42. But somewhere around there.**
Q. Down around Wewahitchka?
**A. That's right.**
Q. And that's the middle reach. Correct?
**A. That's right.**
Q. And then you have the lower riverine reach or the lower reach, which goes from about 42 to 20. Correct?
**A. Right. To approximately 20, right.**
Q. And then everything south of 20, which is where that Sumatra Gage is that's been mentioned in court previously, that's called the tidal region. Correct?
**A. Right. The river itself is classified as tidal. The floodplain is not tidal down to about river mile 12.**
Q. So let's start with the upper reach of the





Apalachicola River. It's the portion that's right beneath Jim Woodruff Dam and, as you say, goes doing to about mile 80. Okay?
And I want to start, if you could turn to tab 3 in your book, tab 3 has a GX-72 behind it. And this is a document that we looked at on the first day of trial with Mr. Ted Hoehn. Have you seen this document before?
**A. No, I haven't.**
Q. You haven't. Now, Mr. Hoehn created this presentation called Apalachicola River Damage. Do you see that?
**A. Yes.**
Q. And the picture on the front page of this document, that's Jim Woodruff Dam. Correct?
Do you recognize that?
**A. I assume it is. I -- I don't know the dam. I assume it is the dam.**
Q. Okay. And you can see water coming through the dam and some people watching. Correct?
**A. Uh-huh.**
Q. Now -- do you agree?
**A. Yes.**
Q. Okay. Now, this dam sits right at the Florida-Georgia border. Correct?

A. **That's correct.**
Q. And it signifies where the Apalachicola River begins. True?
A. **That's right. Technically the river began where the Chattahoochee and Flint came together a little bit upstream, which is now under the reservoir. But for all intents and purposes the river begins here now.**
Q. Okay. We won't quarrel -- the river begins pretty darned close to the dam in that picture?
A. **That's correct. Absolutely.**
Q. Okay. So before the water comes into Florida from Georgia it has to go through this dam. Right?
A. **That's correct.**
Q. Now, it was the Army Corps of Engineers that built Woodruff Dam. True?
A. **Yes. The Army Corps of Engineers built Woodruff Dam.**
Q. Okay. Now, let's go two pages back in this same document, GX-72. And the slide there is titled Damage in Upper River. Correct?
A. **That's right.**
Q. And as a fluvial geomorphologist, that's something that you would study. Correct?





A. **Damage to -- in the upper river?**
Q. Yes. Correct.
A. **Well, it refers here to down-cutting of the channel; and that's certainly the kind of thing that I study, yes.**
Q. Okay. Let's start on that. You -- you say in paragraph 17 of your testimony that Woodruff Dam caused incision of the Apalachicola River channel bed immediately downstream from the dam. Is that right?
A. **That's correct.**
Q. And incision is another name for down-cutting, which is what Mr. Hoehn put in his presentation here. Correct?
A. **That's right.**
Q. And just to use some laymen's terms, if you have incision or down-cutting of the riverbed, that means that the dam had the effect of lowering the riverbed. Correct?
A. **Well, the way this happens is that the dam traps sediment. And the river has a natural sediment load. And because the dam does not reduce flood flows, you still have the same energy of the water coming out of the dam. And without the sediment, then there's excess energy; and the bed**





**tends to erode. And that's why the -- the bed erodes and drops down. So that's what gives you the down-cutting or incision.**
Q. Okay. Thank you for that, Dr. Kondolf. And I just want to be clear on this point though that the area immediately beneath the dam, because of the process you just described, erodes; and the riverbed gets lower. Correct?
A. **Yes. That happened after the dam was constructed. Typically with dams, the response occurs pretty much right after the dam is built, and it's most intense immediately downstream of the dam. Over time the riverbed usually equilibrates.**
Q. Okay. Dr. Kondolf, you agree with Mr. Hoehn that the down-cutting of the channel or the lowering of that riverbed underneath Jim Woodruff Dam was about 5 feet. Correct?
A. **Yes. I think the maximum was about 5 feet. That's correct.**
Q. And that 5-foot reduction in the level of the riverbed goes for the first 20 miles of the Apalachicola River. Correct?
A. **It -- it decreases as you go downstream.**
**Also just a minor point, but just to clarify,**





**the reduction is actually in the water surface that is measured, that 5-feet reduction. It's measured in the water surface. The bed, I'm sure, has gone down as well; but the bed itself is a -- has a lot more variation. So we usually refer to the water surface.**
Q. That's a good clarification. I want to make sure I have got this straight. The riverbed can actually reduce by more than 5 feet in places and less than 5 feet in other places; but what you're looking at, when we say a reduction in 5 feet, that means the river level goes down 5 feet in the river. Correct?
The water level goes down 5 feet?
A. **It would -- we would refer to a water level decline of 5 feet, yes. And as I was also starting to say, as you go downstream from the dam, the amount of incision decreases. So it's 5 feet directly below the dam. It gets less as you go downstream. It disappears entirely by river mile 65.**
Q. Okay. That's an important point. There is effect of down-cutting and a reduced river level all the way from the dam down to river mile 65. That's what you just said; correct?

**A. Yes. As of the -- the data from 1995 would indicate that there was an effect down to there. You know, there may have been some recovery since then; but that would be -- yes.**
Q. That's your understanding?
**A. Yes.**
Q. Now, when the river level goes down, the river -- there is a decline in the river level of 5 feet, that means that for the same amount of water coming through the dam, the whole river is going to be 5 feet lower. Correct?
**A. I believe I understand what you're saying that for the same flow of water from upstream, that with a 5-foot drop in the river stage, that, yes, the river is 5 feet lower for the same flow.**
Q. And that also means that if you want to get the river to the level that it used to be at before this dam was constructed, you need to add a substantial amount of water in order to get that river level back up. Correct?
**A. Depends on what your objective is. You could also take some action within the riverbed to try to raise it. That's been done in some places, too, so --**
Q. Okay.





**A. You could add sediment to bring it back up. There are other ways that that could be done.**
Q. I'm not trying to quibble with you. Whether you raise the bottom up 5 feet or you add 5 more feet of water, you have got to take a significant action to get the river levels to where they used to be before that dam was built. Correct?
**A. Yes. If your objective is to get the river levels back to where they were pre-dam, yes.**
Q. And you also understand that Florida has not made any attempt to put back in sufficient sedimentation in the first 20 miles of the Apalachicola River to get that river back up by 5 feet. Correct? That hasn't happened?
**A. No. It's -- I mean, to do that is a major undertaking and would be a significant project. But, no, I'm not aware that that's been done.**
Q. Now, Mr. Hoehn mentions a loss of hydrologic connectivity. Do you see that?
**A. Yes.**
Q. And you agree that down-cutting that channel by 5 feet did, in fact, result in a loss of hydrologic connective in the upper part of the river. Right?
**A. I -- that's a fairly vague term there. You can**





**have longitudinal connectivity, lateral connectivity, vertical connectivity. So I'm not sure exactly what he was referring to there. But it may have been connection with the side channels and sloughs. That would be a factor certainly.**
Q. Dr. Kondolf, again, I'm really not trying to quibble with you. When the river stage goes down 5 feet, it doesn't flood as often. Correct?
**A. That's right.**
Q. And there is less connection between those floodplains and the river. Correct?
**A. Right.**
Q. Now, you would agree that 5 feet of down-cutting is quite large; wouldn't you?
**A. Depends on the context, but -- but it's certainly not trivial.**
Q. Okay. Well, let's make the context really clear. In the context of the Apalachicola River, which is the subject of this trial, you would agree that down-cutting of 5 feet is quite large. Wouldn't you?
**A. It's -- yes. I suppose it's large.**
Q. And you would also agree that the riverbed degradation caused by Woodruff Dam has had a very





big effect in the upper reach of the Apalachicola River. Wouldn't you agree with that?
**A. In the -- in the immediate upper reach of the river, yes; it's certainly had an effect.**
Q. It's had a very big effect in your view; hasn't it?
**A. Feel free to use whatever qualifiers you want; but, you know, compared to what, I guess that's the -- that's the thing. So --**
Q. Why don't we --
**A. These things are always --**
Q. Why don't we pull out your deposition and see what you said.
**A. Okay.**
Q. Dr. Kondolf, would you turn to page 102, line 16 of your deposition through 103, line 16.
MR. PRIMIS: And I would ask Mr. Smith to play clips 12 and 13.
(Whereupon the video was played.)
BY MR. PRIMIS:
Q. Dr. Kondolf, were you asked that question; and did you give that answer?
**A. Yes.**
Q. Now, I would like to move away from the dam and its effect on the channel; and I want to talk

about dredging. Okay?
You would agree that there was dredging throughout the river in the upper, middle, and lower reaches. Correct?
A. **Yes. There was dredging throughout those reaches, yes.**
Q. Now, going back to Mr. Hoehn's presentation at GX-72 -- that's tab 3 -- I would like to turn to slide 4 in there, which is called Destruction of Channel and Riparian Areas. Let me know when you get there.
A. **Okay. I'm there.**
Q. Now, Mr. Hoehn lists three examples of destruction of the channel and riparian areas here. Do you see that?
A. **Yes.**
Q. And he lists channelization is first, dredging and sand disposal is second, and increased erosion is third. Correct?
A. **That's right.**
Q. Now, in your work, you have also found that dredging and sand disposal caused destruction of channel areas and riparian areas; correct?
A. **Are you talking about my work elsewhere or specifically on Apalachicola?**





Q. You can assume for purposes of today, I'm only interested in the Apalachicola River.
A. **Yes, that's correct.**
Q. The answer to my question is yes?
A. **Yes.**
Q. And dredging is when the Army Corps actually goes to the river and digs up the riverbed. Correct?
A. **Yes. That's right.**
**So I forget exactly what your prior question was; but, yes, in many reaches of the river there has been impacts from this. And dredging is removal of sand and other sediments from the riverbed.**
**In this case it's navigational dredging, so it's designed to create a deep channel for ships to pass.**
MR. PRIMIS: Mr. Smith, could you blow up the picture that we have here on slide 4 of Mr. Hoehn's presentation.
BY MR. PRIMIS:
Q. And, Dr. Kondolf, you would agree that this is a picture of what dredging looks like. Correct?
A. **Yes. I -- I don't know specifically where that's from; but that does appear to be a dredge, yes.**
Q. And dredging involves taking heavy machinery,





like a backhoe or a crane, out to the river and digging it up. Right?
A. **That's right.**
Q. And it can also go out with that same heavy equipment and stick down a pump and pump out sand off of the bottom onto the riverbank. Correct?
A. **Yeah. It's slightly different equipment, but -- a suction dredge, but yes.**
Q. And this picture -- I take it you don't know for sure whether this is the Army Corps digging up a stretch of the Apalachicola River?
A. **I -- I don't recognize the picture. But -- so I can't say one way or the other.**
Q. Okay. And just to be clear, in all of your work in this case studying the Apalachicola River and Army Corps activities there, you never looked at Mr. Hoehn's presentation on this?
A. **Not this -- no.**
Q. Now, the piles of sand that we have got in the picture there, do you see those big mounds of sand?
A. **Yes.**
Q. Those were dug up and dumped there by the Army Corps. Right?
That's how it works?





A. **If this is an Army Corps dredge working in the Apalachicola River, I would presume that those piles were put there by that dredge.**
Q. And --
A. **But, again, I don't know this particular place and time.**
Q. These types of sand piles on the side of a river are called dredge spoils. Right?
A. **Yes. That would be correct. If they're -- if they are the sediment that was pulled out by the dredge, that would be called dredge spoils.**
Q. Okay. Now, let's go to page 7 of Mr. Hoehn's presentation. I'm not sure the pages are numbered, but this is called Damage to the Middle and Lower River. Are you there?
A. **Yes.**
Q. Okay. First, I want to start off by looking at these pictures. And I will tell you that Mr. Hoehn has already testified that these were pictures taken from the Apalachicola River.
And I think you have similar pictures in your own report, too, so you might even recognize these.
Like in the last slide we looked at, the pictures here on page 7 show dredge spoils that

were scooped off the bottom of the river and dumped on the side by the Army Corps. Right?
**A. Excuse me. What was your question?**
Q. My question is simply that this picture here on slide 7 --
**A. Yes?**
Q. -- where you have a huge mound of sand on the side of the river, again that would have been scooped off of the bottom of the river by the Corps and placed on the side of the river by the federal government. Right?
**A. Right. If that's -- if that is as indicated by Ted Hoehn, that's the picture on the Apalachicola River that -- and that's the Army Corps dredge, yes. And that would probably be Sand Mountain that we're looking at there, in fact.**
Q. You're familiar with Sand Mountain?
**A. Yes.**
Q. Okay. We'll come back to Sand Mountain.
The bottom picture shows what happens when a floodplain gets disconnected from the river by dredge spoils. Correct?
**A. Well, the -- the bottom picture -- again, I don't know where that is; and I don't have the whole context, but it -- it might be the inlet to a**





**slough which -- and I don't know what Mr. Hoehn testified about; so what the picture was -- you know, since he took the picture, presumably he would know.**
**But I see sand there. Whether it -- it doesn't actually appear that it's completely blocking the slough, although maybe it's raising the level of connection. But, again, I don't have the context for that photo. I didn't take the photo, and I haven't seen it before.**
Q. Okay. Apart from the picture, you understand that when the Army Corps digs up the sand and puts it on the side, it can disconnect the floodplain. Right?
**A. So when you say digs it up and puts it on the side, can you be more specific what exactly you're referring to there?**
**In different places where the Army Corps has disposed of sand, some of those would disconnect the floodplain; some probably would not.**
Q. Okay. Sometimes -- that's my only question. Sometimes it can disconnect the floodplain when sand is placed there. Correct?
**A. Yes.**
Q. And sometimes, as you just said, the Corps can





dump sand at the base of a slough, which is a little stream off the river, and can block that as well. Right?
**A. Yes. And that would be the main way that it would disconnect the floodplain by -- if sand were either directly deposited at a slough mouth or if it were deposited nearby and carried to the slough mouth by flows.**
Q. Okay. Let's go --
MR. PRIMIS: Let's take the picture down.
BY MR. PRIMIS:
Q. And you agree, don't you, that there's been down-cutting in the middle reach of this river as well?
**A. Yes. There's been historical down-cutting.**
Q. So down-cutting is not limited to the upper reach; it's in the middle reach, too. Correct?
**A. There has been historical down-cutting in the middle reach.**
Q. And there's been historical down-cutting in the lower reach, too?
**A. Yes, parts of the lower reach.**
Q. Now, Mr. Hoehn says in his presentation that there's 25 miles of riverbank converted to sand





due to Army Corps dredging. You would agree with the rough order of magnitude of that number. Correct?
**A. I don't know what that -- I -- I can't speak to that number. I would -- I would ask, I guess, what was the date of this presentation? Do you know?**
Q. Mr. -- Dr. Kondolf, do you know how many miles of riverbank were converted to sand as a result of Army Corps dredging?
**A. No, I don't. And I'm not -- well, it looks like this may be a slideshow taken while the dredging was still going on.**
**And you have to bear in mind that the major dredging stopped in 1999. And the last dredging at all was 2001. So -- so the river looks quite different today. And so that's why I can't really speak to some of these things. They're not -- they're not the way the river looked today when I have been out.**
Q. You can't speak to it because as an expert in the case you never looked at this document, and you never talked to Ted Hoehn about this document. Right?
**A. Right. I haven't seen this document of Ted**

**Hoehn's; and I haven't discussed it with him, no.**

Q. And you don't know when it was created either. Right?

A. **No. That might -- that might bear a little bit on some of what we're talking about here.**

Q. Okay. Now, Dr. Kondolf, like Mr. Hoehn, you also personally have documented destruction caused by -- caused by the Army Corps to the Apalachicola River. Correct?

A. **Yes. I have seen some things.**

MR. PRIMIS: Your Honor, I'm at a natural breaking point. I actually went ahead and asked my first question, but I can break here if the court reporter would like a break.

SPECIAL MASTER LANCASTER: Yes.

MR. PRIMIS: I'm seeing a positive nod, so let's take a break.

(Time Noted: 2:30 p.m.)

(Recess Called)

(Time Noted: 2:45 p.m.)

BY MR. PRIMIS:

Q. Dr. Kondolf, can I ask you to refer to tab 4 of the book we gave you, and take a look at GX-248.

A. **Yes.**





Q. GX-248 is a report that you created for a group called American Rivers. Correct?

A. **That's correct.**

Q. You published it in June of 2009?

A. **That's correct.**

Q. And it's called Restoration Prospects for the Apalachicola River. Correct?

A. **That's correct.**

Q. This report documents the impacts from Army Corps activities on the river. Correct?

A. **The main purpose of the report is to look ahead at restoration opportunities; but as part of the introduction or setting the stage, I can discuss impacts from the Army Corps dredging, yes.**

Q. Dr. Kondolf, you also mentioned that low river flows had an impact on the river, too, in this report. Correct?

A. **That's correct.**

Q. Can you turn to page 22 of the report.

A. **Yes.**

Q. And can you look at the last sentence of page 22.

And read that to yourself, and then I'll have some questions for you.

A. **The sentence that goes from page 22 and continues onto page 23?**





Q. Yes, sir.

Have you had a chance to read that?

A. **Yes. Yes, I have.**

Q. All right. Now, I'm going to come back to what you said about how the Army Corps impacted the river. And for now, I'm just going to focus on this concept of low flows. You wrote that low flows can probably be attributed to less precipitation in recent decades. Correct?

A. **Yes, I did write that.**

Q. And you also wrote that lower flows could be caused by diversions from upstream rivers. Correct?

A. **That's right.**

Q. And you also had mentioned evaporation from numerous reservoirs in the basin as a potential cause for lower flows. Right?

A. **That's right.**

Q. But, ultimately, the issue of low flow was beyond the scope of the study in this report. Correct?

A. **Yes. So I mentioned those as factors and that they would contribute to the decimation of the floodplain. And the last sentence was that while overall a problem of equal or greater threat to the long-term health of the floodplain, the issue**





**of low flows from upstream is beyond the scope of this report.**

Q. And that was true; the issue of low flow was beyond the scope of this particular report. Correct?

A. **I mentioned the issue and the factor in this report because it was obviously important. But I didn't conduct an independent analysis of that.**

Q. And, again, as potential causes of low flows, you identified a number of different things including less precipitation, upstream use, and evaporation from reservoirs. True?

A. **Yes. This was without doing any analysis to sort those out. But just identifying potential factors, yes.**

Q. Let's turn now to page 13 of your report. And I want to focus on the last paragraph of page 13. And in particular, about two-thirds of the way down there is a sentence that starts, the Corps initiated navigational dredging. Do you see that?

A. **Yes.**

Q. And could you read those few sentences. And I will ask you some questions about them.

Are you ready, sir?

A. **Yes.**
Q. You referenced earlier in your testimony that the Corps dug a 9-by-100 foot navigation channel in the river. Correct?
A. **That's right.**
Q. And here you describe that as large-scale, intensive channel dredging. Right?
A. **That's correct.**
Q. The Corps then, after it finished digging out that channel, would carry out maintenance dredging. And that went up to through 2000. Right?
A. **Right. In here I say through 2004, but that was really just the last year that they had the permit. The dredging on any large scale, the last year was 1999. They didn't do any in 2000; and they did some in 2001, but were -- I think the barge ran aground.**
**Yes, so they did an initial dredging that -- essentially that creates a hole in the riverbed. And then the river begins to fill that in with sediment. So you have to go back and continue doing it because there's natural recovery of the riverbed that would happen unless you continued to dredge.**





Q. So they dredged the channel. It starts to fill in, and then they dredged it again?
A. **That's correct.**
Q. And you said that the last permit to dredge expired in 2004. Right?
A. **That's right.**
Q. Now, just to be clear, that's a permit issued by the State of Florida. Correct?
A. **That's correct.**
Q. And prior to 2004 the State of Florida continuously authorized the Corps to dredge in the Apalachicola River through these permits. True?
A. **Well, the -- the dredging began before any environmental legislation and before any permits were, you know, required or possible. The -- as of the -- 1970 was the environmental legislation. Then the Corps had to get permits from the State of Florida. I guess there was some legal question whether they really needed to; but -- and beginning with those first permits, the State did raise a lot of issues about environmental impacts and began putting requirements on the Corps and eventually -- eventually did not renew their permit.**





Q. If I heard your testimony correctly, from the 1970's until 2004 Florida granted permits to the Army Corps to conduct dredging. Maybe subject to restrictions, but Florida granted those permits. Correct?
A. **Correct. Subject to restrictions and requirements for mitigation projects and things like that, but yes.**
Q. Now, until the '70's the Corps would dispose of this sand that got dredged both on the floodplain and on channel banks. Correct?
A. **That's right.**
Q. And this dredged material was virtually all sand. Right?
A. **Yes. Mostly all sand, yes.**
Q. And when the Corps pumped that sand onto the floodplain, it would be near the river channel bank or directly in sloughs. Isn't that right?
A. **Some -- some was deposited on the river channel banks. In some cases in a large deposit area, some cases smaller piles. And there was some that was put actually in sloughs and some that was put along the riverbank near sloughs.**
Q. Now, Dr. Kondolf, you included an aerial picture that you took of one of these dredge spoil piles,





it looks like. Correct?
A. **Yes. These are --**
Q. Hang on.
A. **Sorry.**
Q. Let's just get to there. It's on page 16 of your report. And it's figure 4. And do you -- are you there?
A. **Yes.**
Q. Okay. Now, that picture is one you took in April of 2008. Right?
A. **That's correct.**
Q. On the right-hand side there's a big pile of sand. And that one is Sand Mountain. Correct?
A. **That's right.**
Q. And just -- maybe this might be a term the Court is not familiar with. Everyone down in Apalachicola knows about Sand Mountain. Right?
Correct?
A. **Yes.**
Q. It's famous?
A. **Locally famous.**
Q. Yes. And then across the river on the left-hand side of your picture is something called Site 39. Right?
A. **That's right.**

Q. And that big mound of sand there at Site 39, where that currently is, that used to be trees and forest. Right?
A. **I assume, yes.**
Q. And the Army Corps dredged, put the sand there, and killed everything that lived under it. True?
A. **Yes. I presume that to be the case.**
Q. Now, I want to show you another picture of Sand Mountain. If you go to the tab marked demonstratives in your book and go to the slide marked No. 2. Are you there?
A. **Yes.**
Q. And you're familiar with Google Earth; isn't that right?
A. **Yes.**
Q. It shows aerial pictures of the Earth. Correct?
A. **Yes.**
Q. And, in fact, you have used photographs like this in your own work. Correct?
A. **That's correct.**
Q. Now, you have flown over Sand Mountain. Right?
A. **That's correct.**
Q. And this picture we have here as demonstrative 2 shows Sand Mountain on the left-hand side. Correct?





A. **That's right.**
Q. And that is what it looks like from the sky. Correct?
A. **Yes. That's -- that appears to be Sand Mountain, yes.**
Q. And, again, across the river you have got Site 39, which is that very long pile of sand surrounded by trees. Right?
A. **That's right.**
Q. Now, Dr. Kondolf, I'm not sure if you're familiar with this technology; but Google Earth actually allows you to take a video from the sky. And I have asked my team to create a video of this area of Sand Mountain and Site 39. I'm going to play it now, and I'm going to ask you some questions as we go.

MR. PRIMIS: Mr. Smith, can you play that.

(Whereupon the video was played.)

BY MR. PRIMIS:
Q. Do you recognize this as the Apalachicola River, sir?
A. **Yes, it appears to be so.**
Q. And we're zooming in on Sand Mountain on the left and Site 39 on the right. Correct?





And that is what Sand Mountain looks like from the river. Correct?
A. **Well, yes. From that vantage point of the Google Earth, yes.**
Q. And have you seen Sand Mountain from the river, sir?
A. **Yes.**
Q. And you agree that is roughly what it looks like. Correct?
A. **Yeah. Obviously the perspective from the river is a little different, but I have no reason to doubt that that's Sand Mountain.**
Q. Now, Sand Mountain is really high. Isn't it?
A. **Yeah. It's pretty high.**
Q. It's, like, three or four stories tall?
A. **I forget how tall it is, but -- yeah, 20 or 30 feet, something like that.**
Q. Okay. And let me show you one other video. This is one that we pulled from the internet from the Florida State University website, which is a 30-second video that shows people on Sand Mountain. And it gives you some perspective for the size of it. And I want to ask you if it's consistent with your experience.

(Whereupon the video was played.)





BY MR. PRIMIS:
Q. Do you recognize that as people climbing Sand Mountain?
A. **It certainly looks like it could be.**
Q. Looks like it's tiring getting up there.

Any reason to doubt that we just showed a video depiction of a very tall structure that is made of sand that is identified as Sand Mountain?
A. **Again, it looks consistent with my experience. I can't personally vouch for that video, but I don't see anything inconsistent there from my experience in the field.**
Q. Now, Dr. Kondolf, you would agree with me, wouldn't you, that Sand Mountain today is very actively delivering a lot of sand to the Apalachicola River channel. Correct?
A. **Yes. When the flows impinge on the bank, sand is eroded and goes into transport.**
Q. And you would also agree that Sand Mountain is currently an unstable site where some sort of stabilization remediation might be a good idea. Correct?
A. **Yes.**
Q. And to date, that stabilization remediation has not occurred at Sand Mountain. Correct?

A. **I'm not sure if -- I think the Corps or the State has done some stabilization in the past. But -- but there's -- when you go there today, it doesn't appear to be stabilized. So --**

Q. Can you move the microphone a little closer to your mouth? It's a little hard to hear.

A. **Yes.**

Q. And I just want to make sure I heard you right. You're not aware of any current stabilization or remediation efforts on Sand Mountain. Correct?

A. **No.**

Q. Okay. Now, I want to talk about the extent and scope of this dredging that the Army Corps did in the Apalachicola River. You have figures in your expert report that you didn't include in your written direct testimony. Isn't that right?

A. **I'm sure I did. The expert report was a lot longer, so I think there were figures there that I didn't put in the direct testimony.**

Q. There were charts and tables that were attached to your expert report that aren't in the official direct testimony. Right?

A. **That sounds right.**

Q. Okay. Let's take a look at some of those. I want to start with tab 5 which Florida has marked





as FX-796. And that's your expert report. And I would like to have you flip all the way to the back. You have some charts that are labeled figures A through some later letter. And in particular, I want to get you to figure C. And I'll give you a minute because the pages aren't numbered.

A. **Okay.**

Q. Are you there?

A. **That's right.**

Q. Let me wait for the Court.

SPECIAL MASTER LANCASTER: Sorry. I'm not following. Where you are?

MR. PRIMIS: It's figure C. It's all the way at the back, there's a series of alphabetical charts.

SPECIAL MASTER LANCASTER: Okay.

MR. PRIMIS: Okay. And it's also on the screen if you want to just confirm we're looking at the same thing.

BY MR. PRIMIS:

Q. Now, this chart at figure C in your expert report, that shows dredging over time in the Apalachicola River. Correct?

A. **That's correct.**





Q. And this chart comes from a report drafted by Helen Light. Correct?

A. **That's correct.**

Q. Now, Ms. Light has been mentioned in various points throughout this trial. Other witnesses have commented on her work. You would agree that Ms. Light is an authority on the issues of water level decline due to channel change in the Apalachicola River. Correct?

A. **Yes.**

Q. This chart, figure C, shows that 96 percent of the dredging in Apalachicola happened between 1956 and 1999. Correct?

A. **That's correct.**

Q. And in '56 the Corps dredged over 2.5 million cubic yards of sand out of the river. Correct?

A. **That's right.**

Q. And in 1998, which is much more recent, the Corps dredged over a million cubic yards of sand out of river. Right?

A. **It looks like that, yes.**

Q. Now, I had trouble understanding how much volume a million cubic yards is. So I asked my trusted colleague, Mr. Avallone, if he could find something to put it in perspective. And what he





came up with, figure 3 -- I'm sorry, tab 3 in the book. And I'm going to ask you to put your finger -- maybe it's not tab 3.

It's demonstrative 3. And put a pen on something in the charts because I'm going to come back to this.

So in demonstrative 3 we have a dump truck that I'm told can hold 20 cubic yards of dirt. Do you have any reason to disagree that that's approximately what 20 cubic yards of dredged material would look like?

A. **Seems about right, yes.**

Q. Seems fair?

A. **Yes. Dump trucks vary in size, but I presume that's a 20-cubic-yard dump truck.**

Q. That's a 20.

So sticking with that dump truck analogy, in 1998 the Army Corps dredged enough sand out of the river to fill 50,000 of those 20-cubic yard dump trucks; didn't they?

A. **Well, you have done the math; but I'm sure it's a lot.**

Q. A million divided by 20 is 50,000.

Now, I want to look at the next chart from your expert report which, as a reminder, is tab 5. And we're going to look at figure D. It's all the way to the back, maybe five or six pages from the back.

MR. PRIMIS: Everyone there, figure D?

BY MR. PRIMIS:

**Q.** Okay. So figure D also comes from Helen Light's 2005 article. Correct?

**A. Yes, that's right.**

**Q.** Now, this -- this chart doesn't appear in your direct testimony. Right?

**A. I would have to go back and look; but if you say it's not there, I'll take your word for it.**

**Q.** Okay. It's not there.

**A. Okay.**

**Q.** So, sir, what the purpose of this figure D is is to show the spatial distribution of all that dredging we were just looking at on the prior page. Right?

**A. That's correct.**

**Q.** And what this shows is you have got the river mile markers along the bottom, and the spikes show you how much dredging occurred at that particular river mile. Right?

**A. That's right.**

**Q.** And it tracks it for two different time periods.





The blue is from 1957 to 1979. And the red is from 1980 to 2001. Correct?

**A. That's right.**

**Q.** So, for instance, if we want to focus on the 1980 to 2001 period and I want to zero in on mile -- river mile 40, it looks like there was about 140,000 cubic yards of dredging done around river mile 40. Right?

**A. That's right. This is a 2-mile moving average, so -- but that's about right. Yes.**

**Q.** And that would have been in the more recent period of 1980 to 2001. Right?

**A. That's right.**

**Q.** And so, again, to put it into something we can understand, that's about 7,000 of those dump trucks dredged in that 21-year period around river mile 40. Right?

**A. That sounds about right.**

**Q.** Now, one thing that we did -- I'm sorry. We're moving back and forth.

I would just ask you to put a pen or a sticky note on this chart, figure D, because we'll come back to it. But we made a demonstrative at the back of the binder that turns this figure D sideways and compares it to the river so you can





see where on the river physically that dredging happened. It's slide 5 in my demonstrative tab.

Do you see that, Dr. Kondolf?

**A. Yes.**

**Q.** And so what we did was we took your figure D, which you got from Helen Light, turned it sideways and scaled it so that it lines up with the river miles from the back. Are you with me?

**A. I am.**

**Q.** So let's walk through the upper reach first. And remember, that's, like, the first 20 miles here up at the top.

There was a large amount of dredge in the upper river from 1957 to 1975. Correct?

**A. That's right.**

**Q.** And that dredging actually continued after 1980 as well, although to a somewhat lesser degree. Right?

**A. That's correct.**

**Q.** And in particular, just around mile 90 there was -- that's where the most significant dredging was in the upper reach. Right?

**A. Looks like --**

**Q.** Might have been down closer to 80?

**A. 87 or something like that, looks like.**





**Q.** Okay. And another area of intense dredging was right around Blountstown. Right?

**A. That's right.**

**Q.** And that's the one I was just talking about right around river mile 80 at the border between the upper and the middle reach?

**A. That's right. A little below mile 80, right.**

**Q.** And near Blountstown there was 100,000 cubic yards dredged in the first period as well as again in the second period. Right?

**A. That looks about correct, yes.**

**Q.** Now, on the whole map, the area where there was the most intense dredging was down around river mile 40. Right?

**A. Yes. That's correct.**

**Q.** There's a big red spike there indicating significant dredging in the 1980 to 2001 period. Right?

**A. That's right.**

**Q.** Now, Dr. Kondolf, have you heard -- I didn't see you in the courtroom; but earlier in the trial there was quite a bit of discussion about a place called Swift Slough. Do you understand that that's been the subject of some testimony in the case?

**A. I'm aware of that, yes.**
Q. And Swift Slough is a small offshoot from the mainstem of the river. Right?
**A. Swift Slough is a -- it's a slough. It's a loop stream. So it comes off of the Apalachicola River, it flows through the floodplain, it actually joins with some other sloughs, and ultimately flows back into the river downstream.**
Q. You understand that when Dr. Allan testified and gave his written direct, that he said that Swift Slough was a representative slough when you're looking at things like mussel habitat. Are you aware of that?
**A. Yes.**
Q. And we're going to come back to Swift Slough. I'm going to have some questions for you. But the one thing I just want to point out is you agree that Swift Slough is located right around this river mile 40 where you had the most intensive dredging by the Army Corps on the Apalachicola River. Correct?
**A. That's where Swift Slough is located. That's right.**
Q. Now, there's another slough that Dr. Allan mentioned and used for one of his metrics. Are





you familiar with these metrics that Dr. Allan did?
**A. Yes.**
Q. And he also used a mussel metric for a place called Hog Slough. Are you aware of that?
**A. I recall that, yes.**
Q. And Hog Slough is also at this river mile 40 area where all that dredging took place. Right?
**A. I have forgotten exactly where Hog Slough is located, but I think it's around that area.**
Q. All right. So what I want to do now is go back to your American Rivers report, which is tab 4. And I refer you to page 17. And what I want to do now is I want to focus on some Corps activities other than building the dam and the dredging.
Now, on page 17 I would like you to read the first few sentences to yourself of the paragraph starting under natural conditions. It's the second paragraph on that page.
**A. Okay.**
Q. Now, you say that under natural conditions, which I take you to mean before dredging and down-cutting?
**A. Yes. So before modifications to the channel like**





**dredging and the dam, yes.**
Q. Okay. So under natural conditions before it was modified by the Corps, you said that the channel capacity of the river was limited. Right?
**A. Yes. The channel was smaller, and so it would go over-bank more frequently.**
Q. That's what I wanted to ask you. When the river capacity is smaller, you have more frequent flooding of the floodplains because the river can't physically hold the water. Right?
**A. That's right.**
Q. And from the perspective of the floodplains and sloughs having limited channel capacity, it was a good thing. Right?
**A. Yes. So it's -- it's two things. It's the capacity of the channel and then how much water is coming down the river. So if the amount of water is reduced, that also reduces the frequency of a connection to the sloughs.**
Q. Under natural conditions if you keep the water at a constant level, you would have more flooding than when it -- later when it was dredged. Right?
**A. Can you say that again?**
Q. Sure. Under natural conditions, the point of





what you're saying here is that the river couldn't hold the same amount of water; and so it would flood over. But after it got dredged and changed, it was -- had more capacity; and you didn't get as much flooding. Right?
**A. Right. For the same amount of water.**
Q. Exactly.
**A. And you also have to factor in if the amount of water from upstream has been reduced, that would certainly compound the problem.**
Q. Okay. So let me ask a cleaner question then. For the same amount of water, the river in its natural state flooded more than in its dredged state. Correct?
**A. That's true for the parts of the river that were affected by dredging. So -- and to the extent that the river has not recovered from that dredging.**
Q. Now, Dr. Kondolf, you go on to say that numerous changes in channel conditions contributed to less frequent inundation of the floodplain and for shorter periods of time. Correct?
**A. That's right.**
Q. And you list a number of physical changes to the river in the next sentence. Correct?

A. **That's right.**
Q. Okay. I want to talk about a few of those. The first one you identify is straightening of the river. Correct?
A. **Yes.**
Q. And what you mean by straightening of the river is when we saw all those bends in the river, the Corps would actually cut off those bends in places and make the river straight. Correct?
A. **Yes. There were a number of places in this area affected where the Corps would -- well, there were a limited number of these, but they were important. They cut off meander bends, and then there were some in which they did what they call bend easings, which was sort of a partial bend cutoff.**
Q. Now, Dr. Kondolf, we -- I wanted to illustrate what it looked like for the Court, so we went back to Google Maps. And can you turn to the demonstrative tab -- and it's No. 6.
And we included a red arrow. It's a little hard to see with the lighting. It might be easier to see on the computer screen. But you have an area there called Battle Bend which we pointed out in the red arrow. Do you see that?





A. **Yes.**
Q. And what the Corps did at Battle Bend --
MR. PRIMIS: You can take that away.
BY MR. PRIMIS:
Q. -- it wanted the river to be straight there, so it cut off Battle Bend so the water would stay in the Apalachicola River. Right?
A. **The Apalachicola River formerly flowed through Battle Bend, this big meander. And in order to straighten the river, make it easier for barges and so on, the Corps cut a new channel so that the river now flows through a shorter channel; and Battle Bend itself has been abandoned. That's what we call an oxbow now.**
Q. Now, you would agree that -- and you call those meander bends; is that right?
A. **Yes.**
Q. And that's because the water would meander through the bend and then get linked back up with the river?
A. **Well, that's just a standard term in geomorphology for a big river bend of this kind.**
Q. You would agree that the Army Corps cutting off this meander bend reduced the river's hydraulic complexity. Right?





A. **Yes --**
Q. And --
A. **-- it would.**
**Sorry. Yes, it would.**
Q. And you also agree that cutting off meander bends and straightening the river like this would reduce the Apalachicola River's habitat diversity. Correct?
A. **Yes. By -- by having less connection with the -- with this longer, more complex channel, it would reduce that diversity.**
Q. And that's due to activities by the Army Corps in straightening the river. Correct?
A. **That's true. All these navigational activities, navigational dredging, these other activities, were undertaken to benefit navigation to the upstream states. I think that's important to recognize. That's very clear in all the documents that that's the reason for this.**
Q. Is the answer to my --
A. **To allow large ships to go up there, large barges.**
Q. Is the answer to my question, yes, the dredging to straighten this river and blocking off meander bends was done by the Army Corps of Engineers.





Correct?
A. **That's correct.**
Q. Now, Dr. Kondolf, I want to leave straightening; and I want to talk about sloughs. Okay?
A. **Okay.**
Q. Now, flipping back again to your American Rivers paper at tab 4, I would like to go to page 18 at this time.
Do you see on page 18 of tab 4, which is GX-248, there is a section called Cutting Off and Filling Sloughs?
A. **Yes.**
Q. Okay. Could you take a moment and read that paragraph to yourself, and then I will ask you some questions about it.
A. **Okay.**
Q. Okay. Dr. Kondolf, you, again, reference here something called natural conditions. Do you see that?
A. **Yes.**
Q. And that's before the manmade changes to the river. Right?
A. **That's correct.**
Q. And you make the point that the flow in the river, when it would go over the banks, was

frequently accommodated in streams next to the river called sloughs. Right?
A. **Right. These side channels, sloughs, that would carry a lot of those flows, yes.**
Q. And what you're saying here in this American Rivers report is that the Corps actively pumped dredged sands into these sloughs to discourage water from going into the sloughs. Right?
A. **In some of them, yes, they did that.**
Q. And you mentioned this in your direct testimony in this case as well. Right?
A. **Yes.**
MR. PRIMIS: And for the record, I'll just note that it's in paragraph 18.
BY MR. PRIMIS:
Q. Now, the other thing the Corps did with this dredged sand and the sloughs was sometimes it would deposit it just upstream of a slough. And then as water came down the river, it would carry that sand into the mouth of the slough. Right?
A. **That's right.**
Q. And that would have the effect of blocking off that slough when that occurred. Right?
A. **Yes. It could. It would at least raise the level at which it would take to get the water in**





**there. Right.**
Q. You talked about the same thing, again, in your direct testimony. Right?
A. **I think so. Yes.**
Q. And that's in paragraph 18.
Now, the U.S. Army Corps directly and indirectly disconnected sloughs from the main channel. Correct?
A. **Yes. And so this was during the -- during the period of dredging and other activities for -- for improving navigation. And as I say in my last sentence, there has been recovery of a lot of these sloughs since the dredging stopped.**
Q. Not all of them. Correct?
A. **We don't actually have good enough information to know all. But there certainly -- I still see some sand deposits in these; but I think -- based on my interviews with local fishermen, the -- they can get into these sloughs when they couldn't before. So -- so there's been a lot of recovery and improvement in terms of these connections. But, you know, what I describe here, those are the impacts that the Corps did in the '50's, '60's, '70's, '80's, and the '90's.**
Q. And to the extent these sloughs are now being





connected because of natural recovery, that's a good thing. Right?
A. **Yes.**
Q. And that's happening even with the current flow regime set by the Army Corps of Engineers, correct, all this recovery?
A. **Their -- recovery is going on; but the recovery is limited. If you don't have adequate flow regime, that still limits how much water can get into sloughs. It limits how much habitat you can connect.**
Q. You just said a lot of sloughs were connected. Right?
A. **That's right. Far more than before.**
Q. Now, when the sloughs were disconnected by all this sand and blockage, that reduced hydraulic complexity in the sloughs. Right?
A. **By blocking the sloughs -- by having -- by blocking the sloughs, it certainly reduces hydraulic complexity in the river system overall. The -- whether you would say it reduces hydraulic complexity in the slough itself is probably just a matter of whether you have water in the slough or not. If you have water in the slough, it's still complex.**





Q. Dr. Kondolf, let's turn to your direct testimony, which is in tab 2. And in particular, I want to focus on page 20 and 21 where you address the slough we have talked about earlier in the trial, Swift Slough. And in particular, I'm focused on paragraph 47 for now.
A. **Okay.**
Q. Do you see the second sentence starts, one such location is Swift Slough?
A. **Yes.**
Q. And this is where you confirm that Swift Slough is near river mile 40, which is where all that dredging occurred. Right?
A. **It's one of the areas of intense dredging, yes.**
Q. And then in the next paragraph, 48, you confirm what we just said, which is that Swift Slough is in an area with significant historical dredging. Right?
A. **That is correct.**
Q. Now, when the -- sticking with paragraph 48, you would agree that the sand that the Corps put into circulation that settled in the mouth of Swift Slough, that raised its bed elevation. Correct?
A. **Yes, it raised the elevation of the bed of Swift Slough.**

Q. And that's in the second sentence of paragraph 48?
A. **Yes.**
Q. And it also had the effect of raising the level at the mouth of Swift Slough. Correct?
You're aware of that?
A. **The bed elevation at the mouth of Swift Slough.**
Q. Yes.
A. **Yes.**
Q. You agree with that?
A. **I'm -- I'm not sure where exactly the sand deposits are in Swift Slough. They might not be directly right at the mouth.**
**And the mouth is kind of a difficult term. I like to use inlet because the water is flowing into Swift Slough.**
**I think on Swift Slough the main deposits may be farther -- farther away from the river. But -- but certainly the effect is similar, to reduce the connection.**
Q. You understand -- and I take it you're not disputing that in order to connect Swift Slough, it takes more water now than it did in, say, 2000. Correct?
A. **I forget the sequence, but there's -- the level**





**has gone up and down over time. And it seems to have stabilized. From 2006 to about 2013 it seemed to be about the same.**
Q. And you understand that it increased from 2000 to 2006. You know that; right?
A. **I know that that exists. I would need to consult the data to remind myself exactly what. But there certainly has been fluctuations.**
Q. All right. Now, let's take a look at a map of Swift Slough. And I have got that in the demonstrative tab at No. 7. And I'll put it on the screen as well.
Do you see the little stream that comes off the river in the top right?
I'm sorry. You're not there yet.
A. **Okay.**
Q. Are you there, Dr. Kondolf?
A. **Yes.**
Q. So we took this from Google Maps. And you would agree that the stream that comes off the Apalachicola River in the top right marked by the arrow is Swift Slough. Right?
A. **It appears to be; correct. There is no river mile markers here, but the shape of the river looks about right.**





Q. Well, if you can see where my pointer is, do you see it says Swift Slough actually in the river -- in the stream?
A. **Okay.**
Q. Do you see that?
A. **So if it's labeled by Google, it has to be right.**
Q. We can all agree on that. Correct?
So then what we then did was we wanted to take a look at Swift Slough in an aerial photography. I'm just using this to show everyone where it is, but in the next demonstrative we actually used Google Earth and got a picture of Swift Slough and, once again, marked it with a red arrow. Is that consistent with your understanding of where Swift Slough meets the Apalachicola River?
I actually included the prior map so you would be able to locate the two as looking the same.
A. **Yes. Again, it looks certainly plausible. Looks like the right form of the river and so on. So I -- I don't have any reason to think you would switch photos or anything like that.**
Q. I will represent I'm not pulling a fast one on you.





A. **Okay.**
Q. This is a photograph of the prior slide. Okay, sir?
A. **Okay.**
Q. So what we did was we zoomed in a bit, because Google will let you do that.
And if we can go to the next demonstrative, do you see the red arrow? That is Swift Slough. It's just a closer picture. Right?
A. **Yes.**
Q. And do you see there's a sand formation right at the mouth of Swift Slough?
A. **Yes.**
Q. And you understand that's the type of thing that can require more water to connect that slough. Right?
A. **Yeah. I guess it depends on how the sand deposit is configured, but along -- right there I see that it seems like there's a channel behind it which might provide connection. But sort of the classic case would be a pile of sand of -- a little farther in across the channel.**
Q. Okay.
A. **But -- but I agree; I do see that deposit of sand at the mouth.**

Q. We're going to zoom in one more time from Google Earth, and we'll go to the next demonstrative.
And do you see this is -- what's the word you wanted to call it, the inlet?
A. **Yes. The inlet to the slough.**
Q. All right. So the red arrow shows the inlet to Swift Slough. And what you have there is a little sandbar. Correct?
A. **That's correct.**
Q. And that is the type of thing that can require more water to connect Swift Slough. Right?
A. **Well, what I see here wouldn't necessarily because you see that water can flow around the back of that and get into Swift Slough. As I say, I think the -- I think the real blockage in Swift Slough is a little farther away from the river.**
Q. Okay, sir.
A. **The one that would really control. But --**
Q. But you agree there is blockage of Swift Slough due to sand and aggradation. Correct?
A. **Yes. I -- that's my understanding from -- I haven't been back up to the blockage; but that's my understanding that there is -- that there is one there.**





Q. Now, Dr. Kondolf, I want to switch now to river widening. That's another thing the Army Corps did through its dredging program. Correct?
A. **The Army Corps, as far as I know, did not attempt directly to widen the river. In fact, they would not have wanted the river to widen. But that was a consequence of some of the dredging and disturbance that they did.**
Q. Thank you for clarifying that.
You would agree with me that one effect of all the work the Army Corps did on this river was to widen it in places. Correct?
A. **That was a consequence of their activities.**
Q. Now, can you turn to page 20 of your direct testimony, which is behind tab 2.
A. **Okay. Page 20?**
Q. Yes. And in -- I'm sorry. I'm in the wrong place. Page 8, paragraph 20.
Now, in the fourth sentence there you say that the Corps' dredging program was intended to create a deeper, wider channel to allow barges. Do you see that?
A. **The fourth line, yes.**
Q. Yes. Now, a minute ago you said widening was just a consequence; but here you say it was one





of the intentions of the Corps. Correct?
A. **Okay. Let me clarify, I guess, your -- in this context, I'm referring to a navigational channel. So that would be the channel that the Corps actually excavated. And they wanted a 9-foot deep 100-foot wide navigational channel.**
Q. So if I hear you right, we have two types of widening, one that was intentional, the river navigation channel; and then you have the consequence of other dredging which had the effect of widening the channel in other places. Correct?
A. **Well, it's different. The -- by digging this deep hole in mostly a sand bed, the walls would tend to collapse; and you would get erosion out to the margins. There are other things they did that would tend to erode the banks. And that would cause the channel as a whole to widen.**
**So what we would -- the kind of channel we were looking at on this Google Maps imagery, the channel I referred to here, I should have included the word navigational channel because that's what they were trying to create, a large enough navigational channel for these barges. Mostly they were going after the depth, but they**





**also wanted a certain width.**
Q. Dr. Kondolf, let's go back to your expert report in tab 5. And I want to look at the extent of the widening of the channel.
In particular, it's figure F, which is all the way at the back of your expert report.
A. **Okay.**
Q. You're there?
A. **Yes.**
Q. Now, the purpose of this chart is to show the distance between the tree line on each side of the river at each river mile marker. Correct?
And in particular, the change in the tree line over time. Right?
A. **That's -- that's right. The changes in the tree line width from 1941 to 2004.**
Q. And what this shows is that from 1941 to 2004, that in the upper reach the river has widened by 14 percent or 82 feet. Correct?
A. **This figure comes from a report by Helen Light and others in 2005. And the way this is labeled is that the entire nontidal river averaged 14 percent wider in 2004 than it did in 1941.**
Q. That's actually a good clarification. Thank you for that.

But it does actually specify widening in certain areas, like river mile 68.9 to 77.3 increased by 23 percent or 154 feet in width. Correct?
A. **That's correct. And I point out this was through 2004. And in the research that I'm now undertaking for the Florida Wildlife Commission to develop restoration strategies, we have been -- we have started to measure the changes since 2004. And we are seeing narrowing of the river since then as a -- I think a consequence of the lack of dredging in the recovery of the channel.**
Q. Dr. Kondolf, you attached figure F to your expert report. Correct?
A. **That's correct.**
Q. And that figure shows that in river mile 35 to 46, the river widened by 40 percent or 165 feet. Isn't that correct?
A. **That's correct.**
Q. Now, if the river is wider and deeper, the water -- same amount of water going through it is going to stay in there longer than in its natural condition. Correct?
A. **The river's capacity to hold water is greater,**





**yes.**
Q. And, therefore, in that condition you will have less inundation of the floodplain for the same amount of water. Correct?
A. **That's correct.**
Q. Now, you looked at the net effect of all of these structural changes on the river level. Right?
A. **Can you repeat that?**
Q. Well, let's just go to figure A in your expert report. It's a few pages earlier.
Figure A is another chart from Helen Light. Correct?
A. **That's correct.**
Q. And this one shows the difference in the water surface profile, 1956 versus 1995. Correct?
A. **That's correct.**
Q. The blue line shows what the water elevation was by river mile in 1956. Right?
A. **That's right.**
Q. And the pink line shows what it was by river mile in 1995. Right?
A. **In 1995 while the dredging was still going on. It was about 20 years ago.**
Q. And the difference between those lines shows how many more feet of water would be required in the





Apalachicola to inundate the floodplains at that point in time when this chart was created. Correct?
A. **That -- for the time period indicated, 1995, yes.**
Q. And dredging continued for four years. Correct?
A. **So it shows the difference in the river stage, the level of the water surface for -- these are two flows. It's not indicated here, but they are two flows of about the same discharge. And so that would indicate the water level lowering that occurred over that 50 years up to the mid-1990's during the -- while the dredging was still going on.**
**Once the dredging stops, as we have already talked about, the river tends to fill the -- fill those holes back in; and the bed tends to come back up. So --**
Q. That's depicted here in Ms. Light's chart; the same amount of water in 1995 rose to a lower level than it did in 1956. Correct?
A. **That's correct.**
Q. Now, let's go to one of Helen Light's reports. It's in your book at tab 6. It's GX-88. In particular, I want to look at page 5, figure 3. Are you there?





A. **I'm here. Yes.**
Q. Okay. Now, we looked at this table, this chart, with Dr. Allan earlier in the trial; so I'm not going to go into great detail, but I did have a few questions for you about it. Do you agree with Ms. Light that the factors that she identifies in the downward pointing arrows are, in fact, potential causes of long-term water level decline. Correct?
A. **Let me just take a moment to review.**
**Yes. So she's identified a number of factors that would lead to long-term water level decline in this.**
Q. And you agree that in the Apalachicola, each of the factors that Ms. Light has identified have, in fact, contributed to long-term water level decline in this river. Correct?
A. **Well, we should clarify that. Not all the river has experienced water level decline from navigational dredging activities. The lower 23 miles has not. And so when -- when we look at these various factors on this chart, for the lower 23 miles of the river, which is especially important because it has the Ogeechee tupelo and the swamp tupelo forest, water level decline**

**there is entirely attributable to the arrow on the right, which is reduction in amount of flow from upstream. For -- that part of the -- that channel -- the channel there has not changed there in the lower 23 miles. Upsteam of that then we would be seeing a combination of these factors playing out.**

**And the other thing that's not on her chart here is the -- is the recovery, that once you stop dredging, the river starts filling in those holes and starts -- the bed starts to recover. And then there, of course, is recovery of the sloughs as well.**

Q. Dr. Kondolf, that was a long answer. And I'm not sure it quite got at my question, but I'll be more precise for you. From river mile 23 and up all the way to the Woodruff Dam, that 80 miles, you would agree that each of the factors that Helen Light identifies here in her paper contributed to long-term water level decline in the Apalachicola River. Correct?

A. **Well, thank you for restating that because I realize this -- the arrow on the left mentions large dams decreasing sediment supplied to the river. That effect is really only in the upper**





**part of the Apalachicola River. But these other -- on that left arrow, the one above that, increased bank erosion from larger or more frequent peak floods, engineering work, or other anthropogenic activity, I guess that includes navigational dredging. She's also including the more frequent floods in there, that that would cause channel widening.**

**Then under increasing velocity, she has channel straightening, which would be the meander cutoffs that we talked about, debris removal, decreasing the bed roughness. And then she lists the reductions in flows from upstream and -- and possible change in precipitation.**

**So, yes, I think, as I mentioned, the large dams don't apply -- apply only to the upper part. For the lower 23 miles, the first two arrows don't apply. It's only the one on the right, reduced flow from upsteam. But with those caveats, yes.**

Q. Dr. Kondolf, can you turn to page 12 of your expert report, which is tab 5. In particular I want to focus your attention on the chart marked A.

I'm sorry, I didn't -- excuse me one minute.





Okay. Dr. Kondolf, page 12 of your expert report behind tab 5. And what you're showing here in chart A, again, is the difference between the water surface level at two points in time. Correct?

A. **That's right. Two points in time for a roughly similar flow.**

Q. And you would agree that for river miles 30 to 38, water levels were substantially lower because of channel erosion. Correct?

A. **At the time of this 1995 water surface profile, again, 20 years ago while the dredging was still going on, yes, it was significantly lower. We have a lot of evidence that that part of the riverbed has -- has aggraded. It's built up. People run their boats aground through there all the time now. It's definitely shoaling in that reach.**

Q. Now, your chart here that you include in your expert report ended at river mile 42. Correct?

A. **Yes.**

Q. But you understand that channel change continued upstream from 42. Right?

A. **Right. And as shown here in this chart, from river mile 23 downstream you don't see any**





**channel change. That's also shown in that chart.**

Q. Dr. Kondolf, I understand you're eager to talk about river mile 23 and south; and we'll get there. But I'm focusing now on river mile 23 and north. And you would agree with me, sir, that for the river upstream of river mile 23, you have concluded that the change in water surface elevation is due to changes in channel geomorphology. Correct?

A. **For the river upstream of river mile 23, changes in the channel form or the channel geomorphology are one factor affecting water level changes.**

Q. And, in fact, sir, in your direct testimony on page 14 you say expressly that for the river upstream of river mile 23, you conclude that the change in water surface elevation is due to the changes in channel geomorphology. That's your testimony. Correct?

A. **Can you direct me to that again?**

Q. It's page 14 of your direct testimony, last sentence of paragraph 35. That is your sworn testimony; correct, sir?

A. **Yes. That does not include -- it would also be, as I have said in many other places -- maybe I didn't mention it here; but I said in many other**

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**places, for the river upstream of river mile 23, there would be changes in water surface elevation, reductions in water surface elevations from less flow coming from upstream as well. That was illustrated in Helen Light's diagram just now. So that's another factor. But certainly the changes in channel geomorphology are one of the factors and upsteam of river mile 23, yes.**

Q. Dr. Kondolf, just simply yes or no. Is it still your sworn testimony that for the river upstream of river mile 23 you conclude that the change in water surface elevation is due to the changes in channel geomorphology as set out in paragraph 35 of your written direct testimony?

A. **That's correct. However, there is another factor which is if flows are reduced from upstream, that also would reduce the water surface elevation. I neglected to include it in the sentence, but there are many other places in my writings where I have pointed that out. So I don't think that's a -- I'm sorry if I wasn't complete in this sentence.**

Q. Now, Dr. Kondolf, we're sticking with your written direct testimony now. And I want to go



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to paragraph 36, which is on the next page. In particular I want to focus five lines down on the sentence starting therefore, I conclude.

A. **Okay.**

Q. Do you see that?

A. **Yes.**

Q. Now, here you're saying that you concluded that geomorphic changes, these dredging and dam building activities and river straightening and the like, did not affect river elevation south of river mile 23. Correct?

A. **That's correct. That's evident from the plot on figure 3.**

Q. And you talk about upper, middle, and lower tidal reaches; but really, what you're talking about is the total of 20 miles of this river. Correct?

A. **23 miles going from the lower nontidal down through the tidal. And that -- that includes the very important tupelo forest -- swamp tupelo forest.**

Q. So 23 miles?

A. **That's right.**

Q. Now, Helen Light talks about the water levels in this tidal reach. So we have got to go back to tab 6, and in particular page 7. And we're going



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to look at the bottom of the first column. There is a sentence all the way at the bottom that starts, in reality. Can you turn to that?

A. **Yes, I see it.**

Q. Can you take a moment and read that, and then I'm going to ask you some questions about it.

A. **Okay.**

Q. Dr. Kondolf, you would agree with Ms. Light that the lower 20 miles of the Apalachicola River are called the tidal reach because the tides influence the water levels at least up to the Sumatra Gage. Correct?

A. **This report was published in 2006. Since then, there's been some research that helps to clarify the tidal/nontidal boundary in this reach. And I can summarize that very briefly.**

**So by Anderson and Lockaby there is a paper in 2011 and 2012. And in it they had water level recorders in the -- in the forest and in the river. And so they would show that in the river channel itself, you get tidal action. But a little higher where you're on the forest, that is not affected by tides down to river mile 12. So the forest all the way down to river mile 12 is influenced by the river. It's -- the hydrology**



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**is controlled by the river. However, when you're down in the channel itself, then you have tidal action that goes farther upstream.**

Q. So you would agree from the bay up to river mile 12, tides have an influence on water levels. Correct?

A. **That's correct.**

Q. And so now we're talking about the space between river mile 20 and river mile 12. Right?

A. **Right. So that's --**

Q. That's the area where you say there is no effect from tides or human activity. Correct?

A. **I'm not sure where you got that.**

Q. Okay, sir.

A. **I'm saying that the research indicates that in that reach from river mile 12 to about river mile 20 -- 20.6 is where the gage is located -- that in the river channel itself you still have a tidal signal. But the floodplain forest is at a higher elevation, so it's not affected by those tides.**

**It is affected by flows in the river. So the forest there is controlled by flows in the river rather than tidal exchange.**

Q. From river mile 12 to 20. Correct?

A. **Yes.**
Q. Now, sir, I want to shift years --
A. **And upstream of 20 as well it's controlled by the river.**
Q. Sir, I want to shift gears and talk about Florida's requested remedy in this case. Okay?
You have not analyzed what effect an additional 1500 cfs of flow at certain times would have on the level of the river. Correct?
A. **No, I haven't; but if you look at something like slough connectivity, it's very clear that even a modest increase in flow would connect more sloughs. So, for example, from 5,000 to 7,000 cfs there are 37 sloughs that connect to the river at that -- in that area. So if you increase the flow from five to 7,000, you would be reconnecting another 37 sloughs.**
Q. Dr. Kondolf, it's late in the day; and I think you know the answers to these questions. I want to move through this.
Can you pull out your deposition transcript, please, sir, and turn to page 108, lines 12 through 21.
MR. PRIMIS: And, Mr. Smith, could you play clip 18.





(Whereupon the video was played.)
BY MR. PRIMIS:
Q. Were you asked that question, and did you give that answer?
A. **Yes. And that's consistent with what I -- I was just quoting data from the USGS report from 1998 in which they categorized all the sloughs. There were over 300 sloughs in Apalachicola River. And the -- and they -- they have the range at which they are connected, at least at the time of that field work in the 1990's.**
Q. Dr. Kondolf, my question is were you asked that question at your deposition; and did you give that answer under oath?
A. **Yes, I did.**
Q. Now, Dr. Kondolf, you're not offering any expert opinion in this case that an additional 1500 cfs would raise the river by any particular number of inches or feet at any point on the river. Correct?
A. **No. I am not offering that expert opinion.**
Q. You have not attempted to quantify the ecological benefit that would accrue from any given increase in flow. Correct?
A. **That was done by Dr. Allan and Dr. Hornberger and**





**a combination of their modeling and biological analysis.**
Q. So the answer to my question is, no, you haven't done that work?
A. **That was not part of my responsibility.**
Q. And you have not analyzed the impact on the ecology that would occur from an additional 1,000 cfs. Right?
A. **No. But, again, we can simply look at the U.S. Geological Survey report from 1998; and we can get a report of the slough connection, which would have a lot of ecological benefit obviously.**
Q. Dr. Kondolf, can you refer to page 142, line 7 of your deposition. And to speed things along, I'll just read it for you.
You were asked, do you have an opinion -- line 11. Do you have an opinion with respect to how much benefit to the ecology of this stretch of the Apalachicola there would be from a 4-inch change in water level?
And you said you haven't analyzed that specifically. And it was referencing a thousand cfs.
Were you asked that question, and did you give that answer?





A. **Yes. I -- I was asked that question; and I gave that answer. And I think it's consistent with what I'm saying now.**
Q. And you're not offering any expert opinion in this case on what amount of water would be needed during dry periods or drought. Correct?
A. **That seems like an open-ended question. What amount of water would be needed for what purpose?**
Q. Can you turn to page 111, line 9 of your deposition, sir.
MR. PRIMIS: Mr. Smith can you play clip 21 and 22.
(Whereupon the video was played.)
BY MR. PRIMIS:
Q. Were you asked those questions; and did you give those answers, sir?
A. **Yes.**
Q. Now, Dr. Kondolf, we're almost done. I want to go back to your American Rivers report in tab 4. And turn to page 43, please, and the section marked conclusions. Do you see the first sentence there --
A. **Yes.**
Q. -- on page 43?
You agree, sir, that the navigational

dredging by the Corps has had severe impacts on the hydrologic and ecological functions of the Apalachicola River ecosystem. Correct?
A. **Yes.**
Q. And it's because of activities by the Army Corps that overflows of water onto the floodplain and through sloughs occur less frequently and for shorter periods of time. Correct?
A. **Sorry. I was reading here. Can you say that again?**
Q. Yes. I just wanted to ask you that part of the reason that the dredging by the Corps has had severe impacts on the hydrologic and ecological functions of the Apalachicola River ecosystem is that overflows of water onto the floodplain and through sloughs occur less frequently and for shorter periods of time. Correct?
A. **Yes. Those overflows on the floodplain and flows through the sloughs occur less frequently now for two reasons. In the part of the river that was affected by navigational dredging, where those effects are still evident, that would cause -- require a higher flow to inundate the sloughs and the floodplain. And reduced flows from upstream also cause less frequent and less prolonged**





**connection of the sloughs and inundation on the floodplain.**
Q. And, Dr. Kondolf, you would agree that the Apalachicola River ecosystem has been severely degraded through a long history of navigational dredging by the U.S. Geological Survey. Correct?
A. **Again, not the entire river, but parts of the river that were affected upstream of river mile 23, yes.**
**And I think it's also important to point out that the river is recovering. There is a really substantial recovery of the river.**
**So the Corps impacts were severe, but rivers have a capacity to self-heal. And that's evident on the Apalachicola that things are getting better.**
Q. Thank you, Dr. Kondolf.
SPECIAL MASTER LANCASTER: Counsel, let me ask you if you think we would be finished by 4:30?
MR. QURESHI: I don't think so, your Honor.
SPECIAL MASTER LANCASTER: I hate to do this to you, but I think we'll recess now.
MR. QURESHI: Thank you.





SPECIAL MASTER LANCASTER: Thank you.
(Time Noted: 4:03 p.m.)
(Proceeding adjourned to Thursday, November 17, 2016, at 9:00 a.m.)
(End of day)
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CERTIFICATE

I, Claudette G. Mason, a Notary Public in and for the State of Maine, hereby certify that the foregoing pages are a correct transcript of my stenographic notes of the Proceedings.

I further certify that I am a disinterested person in the event or outcome of the above-named cause of action.

IN WITNESS WHEREOF, I subscribe my hand this 9th day of December, 2016.

/s/ Claudette G. Mason
Claudette G. Mason, RMR, CRR
Court Reporter

My Commission Expires
June 9, 2019.

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