In the Matter Of:

STATE OF MISSISSIPPI vs

STATE OF TENNESSEE

143, Original

PROCEEDING

May 21, 2019

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IN THE SUPREME COURT OF THE UNITED STATES

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STATE OF MISSISSIPPI,

Plaintiff,

v. No. 143, Original

STATE OF TENNESSEE, CITY OF MEMPHIS, TENNESSEE, AND MEMPHIS LIGHT, GAS & WATER DIVISION,

Defendants.

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May 21st, 2019

9:00 a.m.

ON BILL OF COMPLAINT

Before:

HON. EUGENE SILER,

Special Master

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EXAMINATION

EXHIBITS ADMITTED

THE CLERK: The United States Supreme Court, Special Master Eugene Siler presiding. All who have business before this honorable court, draw near.

THE COURT: When we left off yesterday we had the issue of whether the present witness, Dr. Spruill, should go ahead and testify sort of as a rebuttal witness to the witness, Mr. Waldron. And I think what we'll do, we won't require him to do that because that's not in the ordinary way that you try cases. And although we're not bound by the rules, we generally follow those.

So he can testify that way if he wants to or if counsel wants him to, but he's not required to. And then if Dr. Waldron takes the stand, it will be up to Mississippi to decide whether they want to call the witness in rebuttal.

I do not anticipate that we would allow it out of order since that's generally not procedure in the courts.

So with that, you may proceed for Mississippi.

MR. ELLINGBURG: Thank you, Your Honor. One thing. We have someone coming over on the way with the copies of this, but they were circulated yesterday, and I just wanted to show you these figures. Oh, here it is. Thank you.

MR. BRANSON: You're saying these are the ones that you're going through one by one to authenticate?

MR. ELLINGBURG: That's just for the authenticity of them.

MR. BRANSON: Thank you.

MS. ROBERTS: And you'll be using these again with this witness?

MR. ELLINGBURG: Yes.

THE REPORTER: I can't hear you, Counsel.

(Off-the-record discussion.)

MR. ELLINGBURG: Can you hear me now?

Dr. Spruill, will you take the stand?

DIRECT EXAMINATION

BY MR. ELLINGBURG:

Q Dr. Spruill, do you have a copy of the figures from your report we identified yesterday?

A Yes.

Q Thank you.

MR. ELLINGBURG: Your Honor, may we proceed?

THE COURT: Yes. Go ahead.

MR. ELLINGBURG: Thank you.

BY MR. ELLINGBURG:

Q Dr. Spruill, yesterday afternoon we marked a set of plaintiff's exhibits, and I'm going to walk through them briefly now for purposes of a few clarifications. And so what I'd like you to do is to look at P191, which is the first figure in front of you.

And I don't think we need to go into any detail with it except I'd like to ask you if you know where that came from.

Where did that figure come from?
A It's a figure from Alley, et al., in 1999, somewhat modified.
Q Okay. And the Alley report is J2.
And this basically shows the top area, the undefined off to the right?
A That's correct.
Q We don't need to discuss it any further, I don't think. Okay.
Now, the next figure is also one that we discussed at some length yesterday at P192.
And this is taken from Heath; is that correct?
A No.
Q No?
A I think it's found on the -- on a website.
Q Okay.
A The State of Minnesota.
Q Thank you.
But you discussed this figure yesterday, so we won't. It's P192. And this is the one that titled "Confined versus Unconfined Aquifers and Artesian Wells"?
A Yes.
Q Figure -- the next figure, it's P193, is the aerial view. It says, "Physiographic Provinces of the Mississippi Embayment."

And was that taken from USGS documents?
A It was.
Q And basically what does it show? What does physiographic mean?
A It shows the different subdivisions of the Mississippi Embayment, such as the West Gulf Coastal Plain, the Mississippi Alluvial Plain, et cetera.
Q Thank you.
And what is the Mississippi Alluvial Plain? Is that the area of the Mississippi Delta primarily?
A Primarily.
Q Thank you.
Now, the next slide or the next figure is P194. And that is the chart we looked at for some time yesterday, right?
A Yes.
Q And it --
A No. No. I don't believe we looked at this chart yesterday other than during this time when you -- we looked at a modification, a different version of this chart.
Q Okay. Now, this one is limited to West Tennessee and Northern Mississippi?
A Correct.
Q And these are all figures that came out of your June -- out of your report issued in 2017; is that correct?
A That's correct.

Q Okay. And so -- and this one, it clearly shows a division you were pointing out on the larger chart, I believe, between West Tennessee and North Mississippi under those two columns; is that correct?

A That's correct.

Q And you go into some detail.

And that came from -- is that Alt 2016?

A Yes.

Q And that is Joint -- Joint Exhibit 39.

Exhibit 195, which came from your report, what is this showing different than what we talked about yesterday?

A We talked about a lot of --

MR. D. BEARMAN: Excuse me, Your Honor. I'm sorry to interrupt.

Mr. Ellingburg, you identified that previous exhibit as Joint Exhibit 39, and I believe it is Plaintiff's Exhibit 194.

MR. ELLINGBURG: That comes -- the point is Joint Exhibit 39 is the source of that document, as I believe shown on the document.

MR. D. BEARMAN: I'm sorry. I just want to make sure because ours is listed --

MR. ELLINGBURG: Okay. I'll make this clear.

THE COURT: Okay. Clear it up. Thank you.

MR. ELLINGBURG: P194 states on its face that it is

from Haugh 2016, Table 1. That -- and I stand to be corrected, but I believe, looking at it -- I know it's a joint exhibit, and I believe it's J39, is the document from which this chart was obtained.

BY MR. ELLINGBURG:

Q Moving on back to Exhibit 1 --

MR. ELLINGBURG: And the same was true of P194. In each of these cases, the reference that I'm making is to -- the source is joint exhibits where they are that provided the original document from --

THE COURT: I'm sorry?

MR. ELLINGBURG: When I refer to a joint exhibit, what I'm pointing out is that the particular figure was taken from that joint exhibit, not that it is entire joint exhibit.

THE COURT: Okay. You may proceed.

MR. ELLINGBURG: Is that clear? Okay.

BY MR. ELLINGBURG:

Q If you would, look at Figure 1 of 9 -- or P195.

Do you see it, Dr. Spruill?

A Yes, sir.

Q All right. P195 is not in a joint exhibit, but it states on its face that it's from Grubb 1998.

What is Grubb 1998?

A It's a publication that I utilized.

Q Is it a book or a --

A It's a publication, if I remember correctly.
Q Okay. Thank you.
Do you know who the source -- what the source of it was?
A I do not recall.
Q Thank you.
Tell me what it shows.
A It shows that the surface distribution of the regional aquifers and confining units in the Mississippi Embayment and the larger Gulf Coastal Plain, and so as far as distribution, it means what you would see at the surface if you walked around the surface and looked at the composition and nature of materials.
Q Okay. And the Gulf Coastal Plain is -- the Mississippi Embayment is within the Gulf Coastal Plain; is that correct?
A That's my opinion.
Q Okay. Well, is that what the geology shows?
A Yeah. That's what the geologists say.
Q Okay. Now, Figure 198 is the figure we talked about at some length yesterday. We're not going to talk about it again. But I just want to point out for the record that it is -- has been taken from Joint Exhibit 36, which is a Parks 2008 USGS report. And I believe the arrows are probably added off of that particular version.
P199 was -- it says that it's -- the figure in your

report said it was modified and taken from Arthur and Taylor, 1998, which is a USGS report; is that correct?

A Correct.

Q So how was it modified? With the arrows?

A I drew two flow lines on this figure.

Q Okay. So what was the purpose of drawing the two flow lines?

A Flow lines are drawn at right angles to lines that equal total hydraulic head, and flow lines would be an indication, based on this head distribution, of flow direction.

Q Okay. And that -- is this -- I think it says, "Predevelopment Groundwater Equipotential Map."

What does that mean?

A It means that prior to any significant pumping, this -- these authors, Arthur and Taylor -- so it's confusing; the author is Arthur and Taylor -- depict their equipotential surface using a series of contour lines, each of which is a line of equal total hydraulic head.

Q Okay. You discussed that some yesterday. Did you modify this in any way other than adding the arrows showing where the groundwater would flow with these -- within their map?

A No.

Q So the only thing you did was add the arrows?

A That is correct.

Q Okay. And what does this show with regard to groundwater

flow before development in Mississippi?
A It shows that in -- where I drew the arrow down in the State of Mississippi, that there is a westward -- I suppose slightly north of a westward flow direction, and in Tennessee there is a more northwestern flow direction as it -- based on these lines of total hydraulic head.
Q Okay. Thank you.
P200 is another map from that same source, is it not?
A That is correct.
Q Okay. And have you changed anything about this map other than drawing those arrows on it?
A I did not.
Q And what does -- this shows -- it says it's "Postdevelopment Groundwater Equipotential Map and Flow Patterns in Middle Claiborne Aquifer" from Plate 7 or from Arthur and Taylor, 1998.
THE REPORTER: From?
MR. ELLINGBURG: And I will try to speak up. I'm bad about doing that. My wife tells me all the time.
BY MR. ELLINGBURG:
Q So did you change anything about this map other than adding the arrows?
A No.
Q What did this map show? Why was it in your report?
A This map is -- was produced by the authors, Arthur and

Taylor, to depict the configuration of the equipotential surface in this area based on data, I assume, from prior to 1998, which is the published data, publish date. And it shows the impact of groundwater withdrawals on the equipotential surface.

Q In Tennessee?

A In Tennessee and Mississippi. Well, it shows the -- it shows the impact of groundwater withdrawals generally.

Q Okay. Which has changed the flow pattern predevelopment?

A That is correct.

Q From an essentially western, maybe a little north, to north, right, in Mississippi?

A The flow path previously indicated in the predevelopment map is shifted more towards the cone of depression as shown by some closed contours, roughly in the position of the City of Memphis, and it shows a deviation of groundwater flow direction more towards the northwest in northern Mississippi and more westward, with a slight -- slight southwestward bend at the end of the flow line, up in Tennessee.

Q That was a little confusing to me.

A Okay.

Q The P1 -- let's see. P199 is their predevelopment natural flow; is that correct?

A Yes.

Q That's 199. 200 is postdevelopment, after there is

pumping?
A Correct.
Q Does P200 show the impact of pumping in Tennessee on the natural flow direction?
A Yes.
Q Okay. And those arrows are indicated to -- that you added are put on there to show that change in the natural flow direction; is that correct?
A They're -- they're on there to show the direction of flow based on those lines of equitotal hydraulic head.
Q After pumping starts?
A Absolutely. After the onset of pumping, but not beyond 1998, which was the obvious publication date.
Q Thank you.
Okay. P201 is the next one I have. And this is just a general unconfined groundwater example, is it not?
A Yes, it is.
Q And it says you took it from Graniman? Is Graniman [phonetic] a book or a publication?
A I don't recall whether Graniman is a small book or a publication or -- sorry, or a reference paper.
Q But it's published hydrogeological information?
A Yes. Absolutely.
Q Now, we covered P202 in some detail yesterday. We don't need to talk about it again at any length.

But what I'd like to ask you, it says it's a -- it's modified from Winter, et al., 1998. Now, Winter, 1998, is Joint Exhibit 79, which is a USGS publication.

Was taken from Winter?

A Yes.

Q And when it says "modified," was that modified by you or was it --

A I'm not sure about that, but I did modify it. So there could have been modifications on the figure that I looked at, and I further modified it by adding a couple of small arrows.

Q All right. And where do they appear?

A Those small arrows appear between the -- the water table and the land surface in the unsaturated zone.

Q And how did you draw those small arrows? Was it based on those equipotential lines?

A No. It was based on the concept that I think is poorly understood, and that is that when you look up at the top of this diagram and see groundwater recharge areas -- area, it leads people to believe that recharge only occurs in the groundwater recharge areas and not in the discharge area, that is, across the land surface and down to the water table.

So I emphasized that, when it rains, it doesn't just rain in the recharge area and water doesn't just make it down into the aquifer in the recharge area.

Q Okay. So -- but all you added to this figure was the

arrows?
A That's what I recall.
Q Thank you.
A Yep.
Q If you would, look at P204.
And this is taken from Criner and Parks, 1976; is that correct?
A Correct.
Q And that is Joint Exhibit 24.
Did you modify this in any way?
A I don't believe that I did, no.
Q Okay. This is the chart, to your knowledge, that came out of Criner and Parks?
A To the best of my knowledge, yes.
Q Thank you.
I'd like to look at P205, Figure 3.
A Yes.
Q It says, Criner and Parks, 1976 Equipotential Map --
A Correct.
Q -- for Confined Portions of the Middle Claiborne Aquifer, right?
A Correct.
Q And you added, "Also known as SMS or Memphis Aquifer," and then, paren, "in 1886."
That's going to be predevelopment; is that correct?

A Yes.
Q Now, you used SMS in this report to refer to Sparta and Memphis Sand, right?
A Yes.
Q Okay. Are the Sparta and the Memphis Sands -- strike that.
Yesterday you said those were different from aquifers. Why would you refer to them as SMS here?
MR. BRANSON: Objection, Your Honor. He's testifying for the witness.
MR. ELLINGBURG: I didn't. I'm just asking him.
THE COURT: Go ahead. You may ask.
BY MR. ELLINGBURG:
Q Did you testify yesterday that the Sparta Sand and the Memphis Sand were separate aquifers?
A The Sparta Sand and the Memphis Sand are separate formations, and my opinion is that the Sparta Aquifer and the Memphis Aquifer are different aquifers.
Q Thank you.
And are they part of the same hydrogeological unit?
A Yes.
Q Is that why you referred to them this way?
A Yes.
Q Thank you.
Next figure is 206. And it says on its face that it is from pre-2000- -- 1972.

And it shows an equipotential map for confined portions of the Middle Claiborne Aquifer, again, same nomenclature, in 1886. This is part of J -- Joint Exhibit 67.

Now, why did you use this figure?

A I was looking for different reports that indicated the configuration of the equipotential surface in this region, but I was also interested in finding reports that showed how different aquifers exist in different parts of the system. And I believe this diagram shows both equipotential lines and as an indication of how aquifers exist in different parts of the region.

Q Okay. Now, this is a 1972. Does this show the transitions we were discussing yesterday?

A It shows the approximate zone of transition.

Q And does it show outcrop areas for the two aquifers in Tennessee and Mississippi?

A Yes.

Q And how are those shown?

A It's shown by this darkest pattern, which would occur on the east side of the Mississippi Embayment in Tennessee and Mississippi but, again, on the west side of the Mississippi Embayment.

Q Okay. So this shows the east side and the west side?

A Yes.

Q So on the east side, the dark pattern is the area that's

outcropped or unconfined; is that correct?
A Correct.
Q And the rest of it would be confined?
A That's correct.
Q Okay. And that would be the dark line within the diagram? There's a dark line --
A Dark pattern.
Q Dark pattern?
A Yes.
Q Thank you.
Now, Exhibit P207, it says -- it explains that it is taken from two different USGS reports; is that correct?
A Yes.
Q Okay. And could you tell me what you're showing in these two USGS reports?
A The one at the top was produced by Criner and Parks in 1976, and the one at the bottom was produced by Reed in 1972.
Q And you've blown up the Reed portion at the Mississippi-Tennessee border; is that correct?
A Yes.
Q So what do these two -- what were you illustrating with these two in your report?
A Once again, I was very interested in how groundwater flows in the Memphis Aquifer and the Sparta Aquifer, and the way you determine that is to find maps that show contours of total

hydraulic head, and then you can begin to understand the directions of groundwater flow and hydraulic gradients.

Q Is the bottom figure predevelopment?

A Yes.

Q Okay. Is that a blowup -- that's a blowup of the -- I think the figure we just looked at, right, at the border?

A That's correct.

Q Okay. And the top figure, is that one of those while there's pumping going on?

A No.

Q There is no --

A I can't say there was none, but I think this is an equipotential surface map for the year 1886.

Q Okay. So they're both predevelopment, and the Mississippi state line is at the very bottom of the top figure; is that correct?

A Yes, it is. It's hard to see, but it's at the 35th -- more or less at the 35th parallel.

Q Or latitude?

A Latitude.

THE COURT: I don't understand what you're telling me.

THE WITNESS: 35th degree latitude, more or less. I apologize.

BY MR. ELLINGBURG:

Q And the last of these figures is P208.

And this is a -- this is, again, a general educational slide we discussed yesterday?

A Yes.

Q Okay. And it was taken by a guy by the name of Tarbuck and Lutgens. And so who are they?

A They are the authors of -- the only textbook I've ever considered using for the last 15 years for teaching fundamental concepts of geology to the graduates.

Q Okay. Thank you.

MR. ELLINGBURG: Excuse me, Your Honor.

BY MR. ELLINGBURG:

Q Dr. Spruill?

A Yes, sir.

Q I'm handing you a document titled "Appendix A," list of references.

Can you identify this as the appendix to your original report?

A Yes, I can.

Q Okay. So would you tell me, what is this list?

A This is a list of publications of different types, including books, such as each book or series of books, like Groundwater Reaches of the US and other publications that I have relied on since my involvement in this -- in this process.

Q Yesterday you testified that part of your basis for the pre- and postdevelopment flow were the Brahana reports; is that

correct?
A Correct.
Q And are those listed on your list of references?
A Yes.
Q So yesterday when we were talking about USGS reports that you'd utilized and relied on, does this list reflect those?
A Yes, it does.
Q And I think -- are there any other USGS reports that are not on this list? I mean, it says at the top it's not -- or you say at the top -- comprehensive.
A I would just say generally that I'm a voracious reader, and I'm sure that I've read lots of reports that may not show up on this list.
MR. ELLINGBURG: Okay. Can we mark this for identification, the appendix?
THE COURT: Any objection on that?
MR. BRANSON: Is this the same version in his expert report?
MR. ELLINGBURG: It's exactly the one taken from his expert report.
MR. D. BEARMAN: No objection.
THE COURT: Okay. That would be fine.
MR. ELLINGBURG: I'd like to mark this for identification as Exhibit P197.
THE COURT: All right.

MR. ELLINGBURG: No, that's not right. I'd like to mark this for identification as Exhibit P209.

THE COURT: That's fine.

(Exhibit No. P209 was marked for identification.)

MR. ELLINGBURG: And yesterday we circulated the drawing made on the white board. I'd like to mark it as P210.

THE COURT: All right.

MR. BRANSON: No objection.

MR. D. BEARMAN: No objection, Your Honor.

(Exhibit No. P210 was marked for identification.)

BY MR. ELLINGBURG:

Q Before we look at this, I wanted to get them circulated so everyone would have them. I'd like to ask a few questions, Dr. Spruill.

A Yes.

Q Before you look at those, I'd like to ask a few questions.

Yesterday you talked some about the impact -- you talked a lot about the impact of pumping and the conditions and some about well field design. I'd like to turn briefly to the issue of well field management.

In terms of cones of depression that are created by pumping the wells, now, is it -- is it possible to avoid impacts -- the area influenced by cones of depression of pumping a well?

A Can you repeat that question?

Q Yes. Is it possible to control -- we talked about calculating the reach of a cone of depression yesterday.
A Yes.
Q Is it possible to limit the reach of cones of depression when you're developing groundwater in the Memphis Sand or some other aquifer?
A It's possible to limit the cone of depression in both of the dimensions that I've talked about yesterday, and that is, it's possible to limit the size of the cone of depression as area of extent, which we always referred to in terms of arsetero [phonetic], the theoretical limit of the cone of depression, as its radius.

But it's also possible to limit the depth of the cone of depression, which is the drawdown associated with the withdrawal centers in the wells and adjacent to the wells.
Q Okay. So first let's talk about the -- what I'll call the geographic extent.

How do you limit the geographic extent of pumping the same amount of groundwater in a particular aquifer on the Memphis Sand?
A The geographic extent of the cone of depression is a function of the hydraulic properties, transmissivity, storage coefficient, and time.
Q Okay.
A So it's important to remember that. The pumping rate does

not affect the limit of the cone of depression.

If you want to limit the geographic extent of the cone of depression as you have described it, you can limit the amount of time of pumping primarily. So that the cone of depression, after a year of continuous pumping, is appreciably larger than the cone of depression after a few days or weeks of pumping at the same rate.

Q I think that was shown on one of your slides yesterday --

A That's true.

Q -- that had the logarithmic scale.

A I used the example of pumping around 6,000 gallons a minute versus 14,000 gallons a minute, if I remember correctly, at Lichterman, as calculated early on for the Lichterman -- the Lichterman study done by the USGS.

Q Have you ever designed a well field that was intended to limit the reach of the cone of depression through cycle -- through limiting the time of pumping?

A Often, yes.

Q So how is that done?

A So I try to calculate the -- I don't try. I calculate the theoretical limit of the cone of depression by understanding the hydraulic properties of the aquifer within the well field. So I very systematically determine the hydraulic properties of the aquifer.

Armed with transmissivity and storage coefficient of

the aquifer, can calculate the cone of depression theoretical limit for any time of continuous pumping.

And the way I like to limit the cone of depression is by having multiple wells that pump on alternating schedules with significant rest periods between the pumping cycles so that the cone of depression expands outward during a pumping cycle but recovers during the rest period.

Q I think the theoretical limit is based on continuous pumping. Is that correct?

A The theoretical limit is based on continuous pumping of any duration.

Q Okay.

A So you can -- the theoretical limit of the cone of depression is a function of time.

Q So that was -- that was the 90,000 feet or so, 100,000 feet we talked about yesterday?

A That was the example I gave for an aquifer of certain hydraulic properties pumped for a year.

Q Okay. So if you pump it -- so explain -- again, these wells, more than one well, are they right next to each other?

A Are you asking for a specific example of how I would do it?

Q Yes.

A Okay. Let's see. One of the examples I would give would be a well field that I designed for the City of Washington, North Carolina, that involved water supply for a town of about

10- to 12,000 people. I designed eight total wells, each well spaced a mile apart.

I designed a pumping schedule where, in this sequence of eight wells spread over many, many miles, I designed a pumping schedule so that four of those wells would pump for 12 to 16 hours to meet a supply, including storage.

And the wells would be turned off. The cone of depression would essentially recover. And after a period of rest, I'd pump the alternate sequence. So I'm not even pumping the same wells maybe once every 48 hours or 36 hours.

So pump -- pump half my wells for a while, shut them off, let the system rest. Let the -- let the cone of depression lessen to essentially what it was before pumping, and then pump the other schedule of wells.

Q And was that well field designed for any specific application in that case in terms of what the geology was and the --

MR. L. BEARMAN: May I interrupt just a second?

MR. ELLINGBURG: I'm leading. I'll stop. I'll withdraw the question.

MR. L. BEARMAN: If I stood up every time he's leading, Your Honor, I would be in better shape probably than I am now.

I want to be sure that we are maintaining in the record our continuing objection to this area and other areas

that have been attempted to introduce as being beyond the scope of the issue that Your Honor has set out so that I don't have to jump up every time.

THE COURT: Okay. You can have a continuous objection on that. I'll overrule it.

You may proceed.

MR. L. BEARMAN: And as long as I'm up and he suggested it, I object to all the leading.

THE COURT: Okay. All right.

MR. ELLINGBURG: There hasn't been that much. Just that question.

MR. L. BEARMAN: And the testifying, if I may add that to my motion.

THE COURT: I understand. The Court will disregard any testimony by counsel anyway.

MR. ELLINGBURG: Thank you.

BY MR. ELLINGBURG:

Q That was an example of how the limitation -- was that just an example of how the cone of depression can be accomplished?

A That was an example of how I designed a well field to limit the cone of depression because of overwhelming concerns about saltwater intrusion if the cone of depression was too large and sustained.

Q Thank you.

Is there any way you use the existence of multiple

aquifer units to limit the reach of a cone of depression from groundwater pumping?

A One of the ways to limit the cone of depression is to use multiple units within an aquifer or multiple aquifers to limit the size of the cone of depression.

Q And how is that done?

A Well, I'm sure it's done differently in different states. We don't allow, in North Carolina, the construction of a single well that taps multiple aquifers, so it would require different wells tapping different aquifers. And the wells can be real close together or tapping different zones within the same aquifer.

But, again, depending on the transmissivity, storage coefficient, and pumping time, each of those wells would be a certain radius of the cone of influence.

Q Thank you.

Yesterday towards the end you referred to a USGS report by the name Moore. Do you remember that?

A Yes.

Q Have I placed that report in front of you? Was it at the top of the stack? That's not it.

A Did you say on the top of the stack?

Q No.

A Oh.

Q Okay. If you would look at J50 -- Joint Exhibit 58.

A I found it now.
Q Is this the Moore report you were referring to yesterday?
A Yes.
Q And how did you use this in the analysis that you gave yesterday in terms of your opinion about pumping in Tennessee?
A Moore offers a lot of information about the geology and hydrology of the Claiborne group in Western Tennessee and giving, I think, a pretty detailed analysis of the hydrology conditions in the Memphis Sand in Western Tennessee.
Q When you say "pretty detailed information," what kind of information are we talking about?
A He gives information on the size of the outcrop area, the geological formations that exist in the region, the occurrence and movement of groundwater. He gave information about hydraulic properties of the Memphis Sand and what he called the unnamed sand in that region.
Q What is the unnamed sand?
A The unnamed sand is a sand of different age; I interpreted it to be above the Memphis Sand in this region. And at the time he did the work, I suppose, is what I interpret, that there was no formal name assigned to it, so he called it the unnamed sand unit.
Q Well, without regard to whether he -- it was named, did he provide you hydraulic properties for the unnamed sand and the Memphis Sand in that report?

A Yes.
Q And is there extensive discussion in this report of Shelby County, Tennessee?
A Yes.
Q Thank you.
And did you actually utilize in allowing this report in forming your opinions?
A Yes.
Q Thank you.
I'd like you to look at Joint Exhibit 22.
A I'm sorry. While I've learned a lot about the legal process sitting here, but I have trouble following by number. What is --
Q It has an exhibit sticker on the lower right-hand corner on the far part of this report.
A Is it in this report?
Q Let me see. It's not Moore. No. I've changed to another report. Let me see your stack.
A Okay.
Q There should be one more report here. There you go.
Now, do you see that number?
A I do.
Q Okay. Each of these reports has a number.
A Okay.
Q Thank you.

Have you seen Joint Exhibit 22 before and used this as part of formulating your opinions?
A Yes.
Q And how did you use this report?
A In the same way. I used this report to gain information about the groundwater system in the area around Memphis, Tennessee.
Q And by "information," what kind of information do you mean?
A I'm mainly -- I'm very interested in the hydraulic properties of aquifers and flow directions within aquifers, and so I've used it because I was interested in finding values of transmissivity and storativity for the Memphis Sand Aquifer.
Q And did you allow that in formulating your opinions that you described -- that you gave yesterday?
A Yes.
Q And I have one more report, which is Joint Exhibit 59.
A Okay.
Q Have you -- you testified yesterday, I believe, about this Lichterman report; is that correct?
A Yes.
Q Okay. And was that testimony based on information you obtained from J59?
A Yes.
Q Now, I believe you gave an opinion yesterday, but you'll have to let me know, about the availability of groundwater in

West Tennessee, north of Memphis, that was subject to being developed; is that correct?

A Yes.

Q And what information, if any, did you use from any of those reports to -- as a foundation for that opinion?

A Well, I used the -- both of the two reports that we've just been talking about.

Q Which ones? We listed three.

A J59, which is the predicted hydraulic effects of pumping from the Lichterman well field. And then Moore's report, which is J58 predominantly, but I've always used J22.

Q The Moore is J22?

A No.

Q No? That's -- Moore is J50 -- let's see, is 58, right? So Moore is J58?

A It is.

Q So you're saying you used Moore?

A I used Moore.

Q For what?

A For developing an understanding of the geology and the hydrology of the Memphis and unnamed aquifer in Western Tennessee.

Q Okay. Now, I'm going to return to the -- I'm going to show you some figures and maps that were part of the Moore report, and I'm going to ask you one at a time what they showed you or

told you about the geology and hydrology of West Tennessee.
A Okay.
Q The first one -- the first one is page 51 of J58, which is the Moore report. And I'd like to ask you to explain what this shows because it's difficult to understand otherwise.
MR. ELLINGBURG: Your Honor, it's in that stack I gave you. But I apologize. I believe it's in the bottom of that stack.
THE COURT: Okay.
BY MR. ELLINGBURG:
Q Do you have it in front of you?
A I believe I do, yep.
Q Okay. If you would, explain what is shown by page 51 of J58, Exhibit J58.
A I didn't hear the last part.
Q If you would, explain what is shown by page -- on page 51 of Exhibit J58.
A Okay. The best way to understand what's going on here is to look at the map in the lower right-hand corner of this diagram, and that map is of Western Tennessee.
And on that map are a series of black lines running generally north-south and east to west. Those are lines of section. They would have letters at the end, which are so small that I'm having trouble seeing them, but maybe things like A and A prime on the right and so forth.

Those are lines of section, and they indicate where a geologist or hydrologist would develop a picture of what goes on in the subsurface, called a geological cross-section, of that line of section.

And so the one, two -- three figures above it are geological profiles of what you would see in the subsurface in this area of Tennessee along those profiles.

Q So is this done with well information?

A This is done with well information and geophysical logging.

Q So these are -- these are based on actual wells that were drilled to determine the geology in this area?

A That's correct.

Q Or that show the geology?

A That is correct.

Q Okay. Now, if you would, look at page 52, the next page of J58.

What is shown on this?

A Could I verify that you asked me about J58, page 52 of 58?

Q Yes, which is Plate 2 from the Moore report.

A Right.

Q First tell us what was shown in the upper left-hand corner where you have the map of West Tennessee.

A These are really poor copies, so I'm having trouble reading them, but if you'll just give me a second, I can focus on it.

Q Okay.

A So I got it now. And the lighting is not really great right here.

Oh, the upper left-hand diagram is a map of Western Tennessee showing several things. It's showing, in the dark stipple pattern on the right, the outcrop area of the 500-Foot Sand, which was an early designation for the Memphis Sand. And it shows an interesting concept that we haven't talked about called isopach. Isopach.

An isopach map is a map of equal thickness of a geological formation. And so by drilling through the geological formation, geologists can determine the thickness of a formation, in this case, the 500-Foot Sand.

By knowing the thickness in a large number of areas, a geologist can produce a map that contours the values of thickness in an area, and so those light sort of -- those lines between the outcrop area and the Mississippi that are curvilinear --

Q Mississippi River?

A -- the Mississippi River, are lines of equal thickness.

Q Thank you. That's helpful.

A Okay.

Q Now, looking to the right, we have something that I believe is referred to as a fence diagram; is that correct?

A Uh-huh. Yes.

Q And so what -- just generally, first of all, what is this

showing?
A It shows, for all these different orientations -- and probably all of those orientations are also shown on the index map in the upper left -- it shows in the subsurface the varying lithologies, the different types of materials that you have in the subsurface.
Q Okay. And so what are the dark portions?
A The dark portions that are sort of discontinuous across the area are mapped by this geologist as clay, layers of clay.
Q So they have layers of clay and layers of sand and silt shown in the map, based on the explanation to the left of the fence diagram; is that correct?
A On this fence diagram, the lithologies in the 500-Foot Sand are clay, silt, and sand.
Q Okay. Is that a simple geologic formation?
A It's a complex geological formation both vertically and laterally, in my opinion.
Q Thank you.
If you would, look at page -- the next page, 53 of J -- of Exhibit -- Joint Exhibit J58. This is a map of West Tennessee, and I just want you to explain generally what we're looking at.
A This is a structure contour map at the base of the 500-Foot Sand, and so a structure contour map is not like an isopach map. An isopach map is a thickness map. A structure map shows

the elevation of the specified boundary between geologic units. In this case, these contours tell you the elevation relative to sea level of the base of the 500-foot thick -- 500-Foot Sand in Western Tennessee.

Q And what is the dark gray area?

A The dark gray area, once again, is the outcrop area.

Q So that's where the water would be coming in within the state of Tennessee?

A That's correct.

Q Into the 500-foot Memphis Sand?

A The preponderance of water to go to the aquifer there.

Q Thank you.

Now let's move to the next one, which is page 54 of Joint Exhibit 58.

A Yes.

Q And this appears to be essentially the same map, but is it showing the top or sort of the bottom or something else?

A Yes, this is a structure contour map showing the configuration or elevation of the top of the 500-Foot Sand in Western Tennessee.

Q Thank you. Thank you.

Now let's move to Joint Exhibit 58, page 55.

And here we have another map. What's shown in this map?

A For the same general area, for the same exact area, it

shows a contour map of the potentiometric surface of the 500-Foot Sand.

Q And is this predevelopment, or is it at the time of this report, do you know?

A The report indicates that these data would be based on data from January of 1960.

Q Thank you.

So in north of Memphis -- there's a line -- a dotted line on here. It's hard to read. I think it says, "Line of area influenced by pumpage at Memphis"; is that correct, that little dotted line across there with some words above it? We could have obviously used a bigger slide on this.

A I'm just going to have to rely on you. I can see some of these words, but I'm sorry, I can't see the rest.

Q Well, it says what it says.

A It says what it says.

Q North of that water line, is there groundwater available for development according to Moore's study?

A Yes.

Q How much?

A The report indicates that the aquifer is thick and transmissive in this area.

Q Above the dotted line?

A Above the dotted line.

Q Thank you.

Now, thick would be thickness and transmissive meaning what?

A Thickness is the distance from the bottom to the top of the sand unit, and transmissivity is of a permeability of the unit times the thickness of the unit.

Q Okay. Then if you would, look at the next document, which is page 56 of Joint Exhibit 58. And if you could, tell us what this shows.

A This is a map of the surface, the potentiometric surface, of what he calls the unnamed sand unit in Western Tennessee based on data from about 1960, January.

Q And north of that area, which was indicated as the dotted line on page 55, the page before this, is there any apparent influence once you go into Tipton County of any consequence, or is there any presence of sand in that area?

A I'm sorry. Could you repeat that?

Q I'm sorry. I confused it, a bad question. I apologize.

The question is, what does this show about the unnamed sand?

A It shows the -- at that time what they would call a potentiometric surface, the piezometric surface, so same concept. And so for this sand layer that he calls the unnamed sand, he's showing values for total hydraulic head that range from 360 feet or so to 200-and-some feet, which would indicate a westward flow pattern in this unnamed sand layer.

Q Water moving from the outcrop to the -- towards the Mississippi River?
A Yes.
Q To the west.
A Yes.
Q I'm going to show you page 57 of Joint Exhibit 58.
Would you look at page 57 of Joint Exhibit 58?
A Yes.
Q Okay. What does this show?
A It shows the -- the author's mapping, again, of coefficients of transmissibility, which is an old term equivalent to transmissivity today. They're synonymous. So this is a map showing the variation of transmissivity in the 500-Foot Sand.
Q Okay. And did you use this in any way in forming your opinion with regard to the availability of water in West Tennessee, North Memphis?
A Yes.
Q How?
A Well, the values for transmissivity of the sand unit in this area are -- are similar to, and in many cases, the same as the value of transmissivity for some parts of the well field, as indicated in other reports that I've read.
Q When you say "the well" --
A The well fields.

Q In Memphis?
A In the Memphis area.
Q Okay.
A For example, in the Lichterman study, the author routinely used a value of 200,000 units for transmissivity at the Lichterman well field, and so I see transmissivities in the vicinity of 300,000 and 250,000 well north of the City of Memphis, beyond Tipton County even.
Q Thank you.
And how does that influence your opinion, that the water was available north of Memphis?
A Well, the aquifer is transmissive there. It has a significant transmissivity of several hundred thousand units. It is similar in transmissivity to the geological formation at Lichterman where it's possible, and was predicted even in the 19- -- mid-1960s, that the aquifer there could produce 20 million gallons of water per day.
Q Thank you.
I'm going to show you, this is the last page of J58 -- 58. And this is a little different map of that same section of West Tennessee.
And just briefly, would you tell me what that's showing?
A This shows -- are we talking about 58 of 58?
Q Yes, sir.

A This is from the US Geological Survey, which shows what are called down-dip changes in the chemical quality of water in 500-Foot Sand in Western Tennessee.
Q So what does it tell you about the quality of the water in terms of its chemical composition north of Memphis?
A Very difficult to read these individual little boxes, but if you read them in detail, you would determine that the water quality is -- is what I would say high, high water quality, good water quality.
Q From the standpoint of a hydrogeologist developing water, this is good water?
A Yes, this would be good water. I'm not saying it wouldn't require some treatment, but it's good water.
THE WITNESS: Your Honor, may I stand up?
THE COURT: Sure.
THE WITNESS: Can I stand up?
THE COURT: Sure. Do you want a recess?
THE WITNESS: I'm good. Water.
THE COURT: Do you need some water?
THE WITNESS: Yes, sir.
THE COURT: Okay.
BY MR. ELLINGBURG:
Q Dr. Spruill, would you like a brief recess?
A I'm good to go if you want to finish.
Q Thank you.

The next series of illustrations or maps are all taken from Joint Exhibit 22. And I'm going to ask you to summarize essentially what each of them shows --

A Okay.

Q -- if you could. And we'll start with page 63 of 69. As I said, this is from Joint Exhibit 22.

A I found page 63 of 69.

Q Yes, sir.

A Okay.

Q And what is -- this is from Joint Exhibit 22 -- 22, plate 1, and this 22 is the exhibit hydrology and aquifer systems in the Memphis area of Tennessee, to give you context. So this is not all of Tennessee. It's the Memphis area in the report prepared by the USGS.

A Yes.

Q Have you had a chance to look at it?

A Yes.

Q Can you tell us what this report is showing -- what this diagram is showing?

A This is another composite diagram that shows in the lower right-hand corner a map, and so this figure is a combination of maps and cross-sections. The lower right-hand figure is a map of Southwestern Tennessee. I think it's mostly Shelby County.

And within Shelby County on the map are shown some lines that are lines of section, and you have to visualize that

along those lines you can lift up the earth and look at it from the side, and you would see the two diagrams above for A to A prime and B to B prime.

Q Thank you.

A Okay.

Q Now, the next slide of J -- again, J22, page 64. And it's a structure map showing configuration at the top of the 500-Foot Sand in the Memphis area.

So does this show the same type of information we talked about earlier geologically for the entire West Tennessee but only in the Memphis area on the top?

A That's correct.

Q That's the top of the Memphis Sand?

A The top of the 500-Foot Sand, which I interpret to be the Memphis Sand.

Q Thank you. Okay.

And then the next one, J20 -- Exhibit Joint -- Exhibit 22, page 65.

And is that the bottom?

A That is the bottom of the 500-Foot Sand contoured --

Q Okay.

A -- in terms of elevation.

Q Okay. And then the next one, J22, page 66, tell us what this is showing.

A This is a map of the same area showing the configuration of

the piezometric, which I interpret to be the potentiometric, surface of the 500-Foot Sand based on data up to 1960 of the Memphis area.

Q So this would be in 1960?

A That is correct.

Q Thank you.

Now, the next exhibit is page 67 from J22.

A Yes.

Q Is this showing something different?

A Yes, it is.

Q What is this showing?

A So this map is showing a decline of water level in the 500-Foot Sand based on data from 1950 to 1960.

And so I would -- my understanding of this figure is that if you look at the amount of decline in the water level in the Memphis Sand during the time period 1950 to 1960 and you plot it based on the location where those data were collected and you contour it. And so it shows the amount of water level decline during a specific time frame, and that time frame is 1950 to 1960.

Q So how do pages 66 and 67 differ in terms of what they're intended to show between Plate 4 and Plate 5 from J22?

A Okay. So page 66, first, is the configuration of the potentiometric surface. So it shows the height to which water would rise in nonpumping wells that tap this aquifer.

Q In 1960?
A In 1960. So it's a map of the equipotential surface showing the depression of the potentiometric surface in Southwestern Tennessee near Memphis.
Q Thank you.
And then the next one?
A The next one simply says, okay, during a specific time period, 1950 to 1960, how much did the water level in the aquifer -- that's the pressure in the aquifer -- decline during the period -- ten-year period 1950 to 1960.
Q Okay. And how does water level decline relate to anything that -- hydrologically?
A One would assume --
Q Don't assume.
A I would interpret that the water level declined because of its position relative to the cone of depression shown on page 66, that water level decline is related to the withdrawal of water from wells in the Memphis well fields.
Q Thank you.
And from the standpoint of groundwater development, is the water level -- is the drop or decline in the water level related in any way to a cone of depression?
A Yes.
Q Is it related in any way to total available drawdown?
A Yes. The decline in water level in an artesian or confined

aquifer system reduces the total available drawdown.
Q Thank you.
So next is page 57.
A Was that a question? I'm sorry.
Q No. I'm talking to myself.
Do these figures in 1960 relate in any way to the groundwater flow in Mississippi as it existed in 1960 compared to predevelopment?
A Can you please repeat that question?
Q Yes. We looked at predevelopment flow earlier, right?
A Yes.
Q Looking in the 1960 in this report by Moore, do you see any changes in predevelopment flow across the state line, which is towards the bottom of these maps, in the State of Mississippi?
A Well, page 67, which is the map showing the decline of the water level in the 500-Foot Sand for 1950 to 1960, indicates that a 5-foot decline of the water level in the 500-Foot Sand in DeSoto County, which is south of Tennessee and Mississippi or -- so the inference, water levels of 4, 3, 2, 1 feet would have occurred in the same county.
But that doesn't show flow direction. That shows the amount of reduction in total available drawdown.
Figure -- sorry. Page 68 of 69 shows the potentiometric surface for the 500-Foot Sand in August 1960. And based on contours that I see on this map, flow, almost due

south of the City of Memphis, would be from south to north.
Q North, northwest?
A From south to north in the area right above the word "piezometric" on this figure.
Q Okay. Thank you.
So having reviewed these materials, just in summary, do you have an opinion of whether pumping in Tennessee had changed the natural groundwater flow direction in Northwest Mississippi?
A Based on these figures?
Q Based on -- no, based on everything you've looked at.
A Yes.
Q And what is that?
A Exactly that, that generation of a large cone of depression associated with 100-plus million gallons of water withdrawal per day in the Memphis Sand has produced fundamental changes in flow patterns in Northern Mississippi.
Q And based on all of your work, have you developed an opinion as to whether that change in flow patterns in Mississippi caused by the cone of depression has reduced the amount of available water for production within the State of Mississippi?
A My opinion is that the total available drawdown in Northern Mississippi has been impacted and reduced by groundwater withdrawals from north of the Mississippi-Tennessee line.

Q Now, we talked about total available drawdown, but just for simplicity, has the amount of water available for production been reduced within that area of total available drawdown, in your opinion?
A Yes.
MR. ELLINGBURG: Okay. I'll tender the witness.
THE COURT: Are you through with your witness on direct? Are you through with your witness on direct?
MR. ELLINGBURG: Yes. I'm sorry. I said I'll tender the witness, but I didn't say it loud enough. I am bad about that.
THE COURT: I just wanted to make sure. We'll take a recess, and then you may proceed with your cross-examination.
(A recess was taken.)
THE CLERK: All rise. This Honorable Court will be back in session.
THE COURT: You can begin your cross-examination.
MR. BRANSON: Your Honor, with your permission, before we start, could we get the display switched over to our computer?

CROSS-EXAMINATION

BY MR. BRANSON:
Q Good morning, Dr. Spruill.
A Good morning.
Q We've met before, but let me reintroduce myself. I'm Josh

Branson. I represent the State of Tennessee, and I'm going to ask you a few questions now. Okay?
A Okay.
Q You testified yesterday that the Middle Claiborne Aquifer is a very important aquifer in the Mississippi Embayment, correct?
A I did.
Q And you also stated, in response to Mr. Ellingburg, that hydrogeologists have classified the Middle Claiborne Aquifer as a hydrogeologic unit, correct?
A Yes.
Q The Middle Claiborne Aquifer, as we saw yesterday, is housed within the Mississippi Embayment, correct?
A Yes.
Q And as we also saw in your slides yesterday, the Mississippi Embayment is physically present in portions of eight states, correct?
A Yes.
Q And those eight states, just so we're on the same page, are Tennessee, Mississippi, Arkansas, Illinois, Louisiana, Missouri, Alabama, and Kentucky, correct?
A Yes.
Q The Middle Claiborne Aquifer is laterally extensive within the Mississippi Embayment, correct?
A The Middle Claiborne Aquifer Unit, yes.

Q And so that means that the Middle Claiborne Aquifer physically extends beneath the same eight states that we just mentioned, correct?
A The Middle Claiborne Aquifer Unit extends beneath parts of eight states.
Q And those are the same eight states that we just discussed, correct?
A Yes.
Q You've heard the term "transboundary aquifer" before, haven't you, Dr. Spruill?
A I've heard it.
Q And you understand that term to mean an aquifer that physically underlies national or international state boundaries, correct?
A Certainly I understand what the definition of a transboundary aquifer is, but I've not seen a definition of a transboundary aquifer, so if you have one, I'd be glad to look at it.
Q You testified at your deposition that you understood a transboundary aquifer to mean an aquifer that underlies national or international state boundaries, didn't you?
A I believe I did.
Q Okay. So you have heard the term before, and you do --
A I've heard the term before.
Q And you understand it means what I just said it means,

correct?
A I believe it indicates that the physical aquifer underlies those states.
Q And so applying the definition of transboundary aquifer that we just discussed, you would agree that the Middle Claiborne Aquifer is a transboundary aquifer, correct?
A If a transboundary aquifer is classified as one that -- whose criteria is based on its presence under eight states, then, yes.
Q And that is the criteria that you understand the term "transboundary aquifer" to mean, correct?
A Yes.
MR. ELLINGBURG: I'm going to object. He's already testified he didn't know what the definition of that was.
THE COURT: I'll overrule it.
You may answer the question.
BY MR. BRANSON:
Q Dr. Spruill, let me clarify. The understanding of a transboundary is physically extending beneath political boundaries, that is the understanding of transboundary aquifer that you have, correct?
A If that's the definition of transboundary aquifer, then I understand. It's not my -- I didn't define it that way.
Q But you do understand it to mean that, and you've heard the term before, correct?

A I've heard the term before.
Q And you understand it to mean what I said it means, correct?
A I understand, according to that definition, it means it underlies one or more states.
Q Dr. Spruill, the USGS has also described the Middle Claiborne Aquifer as physically extending between the same eight states that I mentioned earlier, correct?
A The Middle Claiborne Aquifer Unit, yes.
Q Okay. Let's go to one of your slides from yesterday. Let's do slide -- this was your slide 23, which you showed yesterday.
MR. BRANSON: Judge Siler, for the record, this is from Joint Exhibit 36 at PDF page 26.
BY MR. BRANSON:
Q And I'd like to highlight the legend on this USGS figure that you mentioned yesterday, Dr. Spruill.
A Okay.
Q You see the highlighted part? It says the "Middle Claiborne Aquifer" on here, correct?
A Yes.
Q It does not say the "Middle Claiborne Aquifer Unit"; it says the "Middle Claiborne Aquifer," doesn't it?
A Well, if it's a USGS figure, it's stipulated that -- my opinion is that it is -- it means that it's the Middle

Claiborne Aquifer Unit.
Q But the words that the USGS actually used on this map which you showed yesterday says "Middle Claiborne Aquifer," correct?
A Yes.
Q And in this figure it is depicting what the USGS has called the Middle Claiborne Aquifer as extending beneath the same eight states that we discussed, correct?
A Yes.
Q Dr. Spruill, you testified yesterday about a facies change that occurs in the Middle Claiborne Aquifer near the Mississippi-Tennessee border, correct?
A Yes.
Q And as you testified, facies change is caused by the lower Claiborne Confining Unit which pinches out in the Middle Claiborne Aquifer, correct?
A No.
Q Well, let's -- I'd like to go to your --
MR. BRANSON: Your Honor, may I walk over to his drawing from yesterday?
THE COURT: Sure.
MR. BRANSON: Thanks. I think it might be easier. I just want to make sure that we're on the same page.
BY MR. BRANSON:
Q This is the Lower Claiborne Confining Unit that I'm pointing to, the blue thing sticking out in the middle from the

right of your diagram, correct?
A It's the Lower Claiborne Confining Unit.
Q Okay. That's what I just said, correct?
A Yes.
Q So -- and the facies change, as you called -- you labeled it a transition zone in green at the top of your diagram?
A Yes.
Q But you labeled it because it's caused by this Lower Claiborne Confining Unit that you've drawn here, correct?
A Yes.
Q Okay. So just so we're on the same page, the facies change is caused by that Lower Claiborne Confining Unit that you've drawn on this figure, correct?
A And the -- yes. And I objected to the way you stated it earlier because the Lower Claiborne Aquifer also disappears at the transition zone.
Q So let's talk about that, Dr. Spruill. I want to make very clear, first of all, you testified that the Middle Claiborne Aquifer on this diagram extends from the very right-hand side above the Lower Claiborne Confining Unit covering this area, moving north into Tennessee, past the facies change, and then down and encompassing everything in Tennessee, correct?
A I did.
Q That's all called the Middle Claiborne Aquifer, MCA abbreviated on your drawing, right?

A Unit.
Q You didn't even write "unit" on here, just MCA.
A Okay.
Q The Lower Claiborne Aquifer here is the part below the Lower Claiborne Confining Unit, correct?
A Correct.
Q You've drawn a vertical red line at the northern edge of the Lower Claiborne Aquifer on here.
Do you see that?
A Uh-huh.
Q You're not suggesting, are you, that there's any sort of barrier to flow that would prevent water from flowing naturally from the Lower Claiborne Aquifer into what you've called the Middle Claiborne Aquifer, are you?
A No. That vertical line I drew as a part of a box around both the Lower Claiborne Confining Unit and the Lower Claiborne Aquifer when I said that these things undergo a facies change and do not exist north of the transition zone.
Q Just so my question is clear, you're not implying that there's any barrier to water flowing naturally from the Lower Claiborne Aquifer to what you termed the Middle Claiborne Aquifer, correct?
A There's no physical barrier there. It's a facies change, in my opinion.
Q And the facies change means that the sediment in the

composition changes as you move past that facies change, correct?
A As you move through that facies change, not past it.
Q As you move through the facies change?
A Okay. I'm sorry.
Q But there's no physical barrier to flow that prevents water from flowing naturally from one to the other, correct?
A No.
Q Now, I want to put up slide 22. Actually, before -- I'm sorry, before we do that, Dr. Spruill, I just want to clarify. You agree that what you've called the Lower Claiborne Confining Unit and the Lower Claiborne Aquifer are all housed within the same major hydrostratigraphic unit that I've been calling the Middle Claiborne Aquifer?
A No.
Q You don't agree with that?
A No.
Q Dr. Spruill, do you remember when I took your deposition in September of 2017?
A Vividly.
MR. BRANSON: Your Honor, may I approach the witness?
THE COURT: Yes, you may.
BY MR. BRANSON:
Q I'm going to hand you a copy of your deposition.
MR. BRANSON: Judge Siler, would you like one or --

THE COURT: No.

BY MR. BRANSON:

Q Dr. Spruill, you were under oath when you sat for this deposition, correct?

A Yes.

Q You knew that you had an obligation to tell the truth, correct?

A Yes.

Q I'd like you to turn in your transcript to page 19, line 19. And I'm going to read your answer from there to the bottom of the page.

"A good example would be" --

A Wait, wait, wait. Sorry.

Q Yep. Sure. Page 19, line 19. I'm going to read. This is you talking. "A good example would be the hydrogeological units that you refer to as the Middle Claiborne Aquifer. It actually has a Lower Claiborne Confining Unit and Lower Claiborne Aquifer all within the same major hydrostratigraphic unit."

Do you see that?

A Yes.

Q That was your testimony, correct?

A Yes.

Q So it is accurate to say that the Lower Claiborne Confining Unit and the Lower Claiborne Aquifer are within the same major

hydrostratigraphic unit, correct, Dr. Spruill?
A Regardless of what this says, the major hydrostratigraphic unit can be the embayment system of hydrostratigraphic units. This Lower Claiborne Aquifer and Lower Claiborne Confining Bed is shown on every reasonable geological cross-section as existing below the Middle Claiborne Aquifer, and so my interpretation is that both of those units, the Lower Claiborne Aquifer and the lower Claiborne Confining Layer, exist below the Middle Claiborne Aquifer in Mississippi.
Q Okay. And, Dr. Spruill, that's not what you said in the part of the deposition I just read, correct?
MR. ELLINGBURG: I'm going to have to object. Counsel has started from the third paragraph of Dr. Spruill's answer in the deposition. He's ignored the context.
THE COURT: You'll have a chance to redirect, Counsel.
MR. ELLINGBURG: Thank you.
THE COURT: You may proceed with a question.
BY MR. BRANSON:
Q Dr. Spruill, I just asked you a yes-or-no question.
A Ask it again, please.
Q You testified -- I read your testimony accurately at your deposition, correct?
A You read what's written there, yes.
Q And you were under oath when you gave that answer, correct?
A I was under oath.

Q Dr. Spruill, I'd now like to put up slide 5.

And you just said a moment ago when I was asking you about your deposition that you think every representation you've seen of this system depicts the Lower Claiborne Aquifer as a -- as somehow separate from the Middle Claiborne. Did I understand you correctly?

A That's correct.

Q This is your slide that you put up yesterday, slide 22 from Arthur and Taylor. You called these two geologists or these scientists yesterday well-respected, correct?

A Yes.

Q They don't depict the Lower Claiborne Aquifer on here as separate from the Middle Claiborne, do they, Dr. Spruill?

A Yes, they do.

Q Where do they say "Lower Claiborne Aquifer" on this diagram?

A Lower Claiborne/Upper Wilcox Aquifer is here (indicating) and here (indicating). That's a change in chemistry, not a change in lithology. That's a change in water chemistry.

Q Dr. Spruill, that's -- can we highlight the Middle Claiborne Aquifer on here?

Have I highlighted what Arthur and Taylor have depicted as the Middle Claiborne Aquifer accurately?

A No.

Q According to Arthur and Taylor map I have, correct?

A Okay. So here is the Lower Claiborne Confining Unit.
Q Yeah. Let's highlight that in pink if we could.
I've highlighted that accurately, correct?
A Yes. This is the lower Claiborne/Upper Wilcox Aquifer, and that is not a change in stratigraphy. That's a change from freshwater to saltwater at that location. And so that aquifer extends all the way over to here, in my opinion.
Q But that's not how Arthur and Taylor have labeled this map, is it?
A It is in my opinion.
Q On what basis, Dr. Spruill, are you saying that Arthur and Taylor labeled this map as having the Lower Claiborne Aquifer extending beneath the facies change? They have a solid black line --
A On the same basis -- can you take away the pink, please, and the yellow? Thank you.
The Middle Claiborne Aquifer right here undergoes a change in composition. The Lower Claiborne Confining Unit extends all the way over to there (indicating). But it does not undergo a change in chemistry from freshwater to saltwater.
This is a boundary right here between the Lower Claiborne Confining Unit -- sorry, the Lower Claiborne/Upper Wilcox Aquifer, it goes to fresher water there and ends there. And on every geological map that's produced by the US Geological Survey, the Lower Claiborne Aquifer ends here

(indicating).
Q What you just said -- I understand what you're saying, Dr. Spruill, but what you just said is not depicted on this map that we're looking at?
A It is to me.
Q But nothing that you just said is physically drawn on this map, correct?
A Well, look, the word "Middle Claiborne Aquifer" doesn't extend all the way up into this area. The word "Upper Claiborne Aquifer" doesn't extend over it. It's written one time.

The Lower Claiborne/Upper Wilcox Aquifer extends all the way over to here. And if you look at any maps depicting its thickness and aerial extent, it ends here. And then just look on the big geological cross-sections that you have always in these figures, and it shows a Lower Claiborne Aquifer and an Upper Claiborne Aquifer beneath the Middle Claiborne Aquifer system.
Q To be clear, Dr. Spruill, this is just a very simple question. There's no vertical line on this map that we're looking at that depicts the separation between the Lower Claiborne Aquifer and the Middle Claiborne Aquifer as you just described it?
A It's a facies change.
Q There's no vertical line on this map that depicts that

change, correct?
A Correct.
Q Let's -- let's now go to another slide. I want to do Brahana.
MR. BRANSON: For the record, Judge Siler, this is from Joint Exhibit 15, which is the Brahana and Broshears paper.
BY MR. BRANSON:
Q Dr. Spruill, you've reviewed the Brahana and Broshears paper before, have you not, correct?
A Correct.
Q And I want to point us to Figure 3 and zoom it in. Could we highlight the Memphis Sand and equivalents?
Do you see that, Dr. Spruill?
A I see that you've called it yellow, but I don't agree.
Q Can we highlight in the confining unit on the left? What I've highlighted in pink, that is the Brahana and Broshears' depiction of the Lower Claiborne Confining Unit, correct?
A It -- yes.
Q And on this map again, there's no -- do you see the area of the Memphis Sand and equivalents that extends beneath the confining unit that I just highlighted?
A Yeah. Well, I don't agree with that.
Q Okay. Well, according to Brahana and Broshears, they don't label any part of this map Lower Claiborne Aquifer, do they?

A Well, where's the Lower Claiborne Aquifer, then?
Q I guess I should ask you. Is it depicted on this map?
A Yes.
Q But it's not labeled as such?
A Well, I'm -- I'm sorry, it's not. It should be.
Q So this is a USGS map, correct?
A Yes.
Q And these USGS scientists do not label the Lower Claiborne Aquifer as separate from the Memphis Sand and equivalents, correct?
A I agree that they don't label it. It doesn't mean that it's not there.
Q Understand -- I understand your opinion, Dr. Spruill. I'm just trying to establish that these USGS scientists do not label it the way that you think it should be labeled?
A I agree that they didn't label it properly. It --
Q All right.
A There's a Lower Claiborne Aquifer -- there's a Lower Claiborne Aquifer beneath the Lower Claiborne Confining Unit. This is an important point. Geologists name a confining unit with the words for the aquifer below it, so if that's the Lower Claiborne Confining Unit, then there's a Lower Claiborne Aquifer below it.
Q Okay. That's not shown on this map?
A It's shown on this map. It's not labeled.

Q Okay. Dr. Spruill, let's change gears.

You recall your testimony in response to Mr. Ellingburg about the Memphis Sand and the Sparta Sand?

A Yes.

Q In your expert report in this case, you stated that the terms "Middle Claiborne Aquifer" or "Memphis Aquifer" are considered synonymous with the Sparta-Memphis Sand for purposes of this expert report, correct?

A For purposes of the report.

Q And you also, in your expert report, treated the Sparta Aquifer, quote/unquote, as synonymous with the Memphis Aquifer, quote/unquote, correct?

A I may have generalized that they are a part of an aquifer unit.

Q When you introduced the term in your expert report, you literally said Sparta Aquifer, a/k/a, and you listed Memphis Aquifer and Sparta Aquifer as two names for the same thing, correct?

A Because it's in the literature, yes.

Q And you also used the phrase "Sparta Memphis Sand Aquifer" in your expert report, correct?

A Because it's in the literature.

Q And you agree that the terms "Memphis Sand" and "Sparta Sand" are often used interchangeably, correct?

A I see it in the literature. Doesn't mean I agree with it.

Q I'm not asking if you agree with it, Dr. Spruill. I'm just asking if you often see the terms used interchangeably. And you do, correct?
A Yes.
Q And you also agree that what you called the Sparta Sand in Mississippi and the Memphis Sand in Tennessee are part of a single geological formation, correct?
A Say that again.
Q You -- you also agree that what you call the Sparta Sand in Mississippi and the Memphis Sand in Tennessee are part of a single geological formation, correct?
A No.
Q You don't agree with that?
A No.
Q You think that they're separate geological formations?
A Yes.
Q Dr. Spruill, could you turn to your deposition? And I want you to turn to page 9 --
A Okay.
Q -- line 4. And this is you answering my question.
"They are part of a single geological formation. The Sparta Sand is not the same unit as the Memphis Sand in terms of its thickness and its aerial distribution."
A I'm sorry. I don't know where you are yet. I haven't found it.

Q I'm on line 9.
A You're faster than I am.
Q I'm on page 9, line 4. Page 9, line 4.
And I had just been asking you questions about the Sparta Sand and the Memphis Sand. And you answer: "They are part of a single geological formation. The Sparta Sand is not the same unit as the Memphis Sand in terms of its thickness and its aerial distribution. There are some differences. They are part of the same hydrostratigraphic unit." Correct?
A They're part of the same hydrostratigraphic unit, but they're not the same geological formation.
Q You said the words, "They are part of the same geological formation." I'm quoting you, aren't I, Dr. Spruill?
A On the previous page, I indicate to you that the Memphis Sand and the Sparta Sand are often used interchangeably, but there are regional differences in the two. In terms of what I called hydrostratigraphic interpretations, they are more or less equivalent. And so they are part of the same hydrostratigraphic unit, but they are -- they're not the same geological formation.
Q Okay. So you just -- you misspoke at your deposition?
MR. ELLINGBURG: I'm going to object. He's just ignoring the very last sentence. It says, "They are" --
THE COURT: You'll get a chance to ask it later.
MR. ELLINGBURG: Yes, sir.

BY MR. BRANSON:

Q Dr. Spruill, I'm going to stop where you just stopped reading when you said they are more or less equivalent. I asked you --

A I stopped reading. Tell me the page again. I'm so sorry.

Q Page 8. You went back to page 8.

And just to give context, I'll start at line 14. And I'm just going to read this whole thing because it seems necessary.

I'm going to say question: "Do you understand the names Memphis Sand and Sparta Sand, as used at various times in this case, are both referring to the same aquifer?

"Answer: I think the Memphis Sand and Sparta Sand are often used interchangeably, but there are regional differences in the two. In terms of what I would call hydrostratigraphic interpretations, they are more or less equivalent.

"Question: When you say 'more or less equivalent,' just to make sure we're on the same page, you understand that they are part of a single geological formation, correct?

"Answer: They are part of a single geological formation."

And you keep going and you say, "The Sparta Sand is not the same unit as the Memphis Sand in terms of its thickness and aerial distribution. There are some differences. They are part of the same hydrostratigraphic unit."

Dr. Spruill, you did say very clearly that they are part of a single geological formation, correct?

A I think you picked one sentence out of all this and convoluted it. The Sparta Sand is not the same unit as the Memphis Sand in terms of its thickness and, I say, aerial distribution, and that's a definition of a formation.

So if I made this statement they are part of a single geological formation, they are relative. You can trace them laterally from one to the other, but it's not the same unit. They're not the same geological unit. They're part -- and I keep emphasizing this. They're part of the same hydrostratigraphic unit, but they're not geologically the same formation.

Q So you -- you agree with the part of your deposition where you say they are part of the same hydrostratigraphic unit, correct?

A Yeah, because I say it repeatedly.

Q But you're saying you don't agree with your words where you said, in response to a direct question about a geological formation, your first sentence was, "They are part of a single geological formation," you don't agree with that?

A I don't agree with that statement.

Q So now that we're at the hearing today, leaving the deposition aside, I just want to make sure I understood your testimony yesterday correctly.

You said that both the Sparta and the Memphis are part of the hydrogeologic unit called the Middle Claiborne Aquifer. I was quoting your testimony yesterday. That's accurate?

A The Sparta Aquifer and the Memphis Aquifer.

Q Yes. The Sparta Aquifer and the Memphis Aquifer are part of the hydrogeologic unit called the Middle Claiborne Aquifer, correct?

A Part of the Middle Claiborne Aquifer hydrogeologic unit, yes.

Q And I counted yesterday -- I just kind of went through the transcript. You said the phrase "Middle Claiborne Aquifer" without any "unit" qualifier over ten times yesterday.

Does that sound accurate?

A I didn't count it.

Q But you do recall saying it, right?

A I recall saying it, you know, okay.

Q Okay. Dr. Spruill, there is no physical barrier in the Middle Claiborne Aquifer along the Mississippi-Tennessee boundary that impedes groundwater from flowing across the state border, is there?

A That impedes? Do you mean stops?

Q Well, I'll ask you stops.

A There's no boundary that stops the movement of water across the boundary.

Q And there's no physical barrier at all that extends

directly along the Mississippi-Tennessee boundary that would impede groundwater from flowing across the state border, is there?

A I mentioned before that a reduction in permeability and grain size and clay content and so forth can impede. Impede, to me, means something other than stop. So there are lateral changes in aquifer materials that can impede the flow of water, and many of them occur at or near the state boundary, interestingly enough.

Q But there's no physical barrier directly along the Mississippi-Tennessee boundary that would block water from flowing across that boundary, is there?

A Do you mean a physical boundary like a man-made wall or -- I don't get what you mean, "physical barrier"?

I don't know of any physical barriers in the subsurface directly beneath the Tennessee state line except a transition in composition roughly in that area from coarser sand grains and less clay to finer sand grains and more clay to the side. That's the only changes that I could relate to a barrier.

Q And none of those changes block water from flowing across the border, correct?

A No.

Q And you agree that there was no such barrier in predevelopment times either, correct?

A Correct.
Q Now, Dr. Spruill, you have opined that pumping out of the Middle Claiborne on the Tennessee side of the state boundary has affected groundwater flow on the Mississippi side of the aquifer, correct?
A Correct.
Q And that's true even though the MLGW wells doing the pumping are all physically on Tennessee's side of the state boundary, correct?
A They are on Tennessee's side of the state boundary.
Q None of those wells physically cross the state boundary into Mississippi, do they?
A No.
Q And as far as you know, there is no MLGW well screen that physically touches Mississippi territory, correct?
A Correct.
Q Now, you also agree that pumping on the Mississippi side of the Middle Claiborne Aquifer can affect groundwater flow on the Tennessee side of that aquifer, correct?
A Yes.
Q Beyond the Middle Claiborne, the Mississippi Embayment, which you've talked about, also houses the Wilcox Aquifer system and the Shallow Alluvial Aquifer system?
A And others.
Q And others.

And, generally speaking, you would agree that the Middle Claiborne Aquifer is hydrologically connected to those other aquifers, correct?

A The different aquifers are classified in my mind and categorized as mostly leaky, confined aquifers, and so there is exchange of groundwater from one aquifer to another, and especially in discharge areas.

Q So the answer is yes, you do agree that groundwater in the Middle Claiborne Aquifer is hydrologically connected to the groundwater in the other aquifers in the Mississippi Embayment System, correct?

A Well, I've always had trouble with the term "hydrologically connected."

I'll say again that the aquifers are leaky. They have leaky confining beds. So hydrogeologists call them leaky aquifers. And we define the confining beds as leaky confining beds. So it allows interchange of water between aquifers. And that's what we mean by hydrologically connected, water can flow from one aquifer to another, albeit at a slow rate.

Q And there are also places where, in your terminology, the aquifers are hydraulically connected, correct?

A I don't know the difference between those two, hydraulically connected and hydrologically connected.

Q So when you said in your deposition that there are places where the offers in the Mississippi Embayment are hydraulically

connected, you understand that to be referring to the exchange of water that you just mentioned, correct?

A Yes, I do.

Q And so using that definition, you also understand that groundwater in the Middle Claiborne Aquifer is hydrologically connected to surface waters in the area, correct?

A Would you ask that again?

Q I said, Would you also agree, using that same definition we just asked -- we just talked about, that groundwater in the Middle Claiborne is hydrologically connected to some surface waters in the area?

A The water in the Middle Claiborne Aquifer and the outcrop areas clearly interchanges and interacts with surface water where it flows, as I showed yesterday, from areas of recharged areas of discharge.

But once water enters the deep parts of the groundwater system in the confined aquifer system, water can interchange -- can discharge to streams, but it discharges to streams by the slow migration upward in discharge areas across a series of confining beds, aquifers, other confining beds, and so forth.

And so I think it's confusing to say that the aquifer and the water in the aquifer is hydrologically connected to the river -- to a river system without understanding that we're talking about thousands of years of travel time as water moves

from this deep aquifer to the river.

I say that the water in the Middle Claiborne Aquifer is hydrologically connected to the confining bed above it. And the confining bed above it is hydraulically connected to the aquifer above it and, ultimately, there's discharge to surface water.

Q So you agree taking -- you know, taking as correct for the time being your description of the slow travel time, you do agree there can be a long-term exchange of water between the Middle Claiborne Aquifer and surface waters in the area, correct?

A Long term, yes.

Q And you also agree, just to be more specific, that there could be a long-term exchange of water between the Middle Claiborne Aquifer and the Mississippi River, correct?

A Long term, yes.

Q So under natural conditions in the Middle Claiborne Aquifer, Dr. Spruill, every molecule of groundwater in that aquifer was moving to some extent, correct?

A Yeah. What flashed through my mind immediately is this idea that there are special places in the groundwater system where theoretically the water is not moving. But what we're talking about here is a regional scale systems in which water is moving from recharge areas to discharge areas and it's continually moving.

Q Just to make sure that the record is clear, under natural conditions in the Middle Claiborne Aquifer, every molecule of groundwater in that aquifer, under natural conditions, was moving to some extent, correct?
A With an absolutely odd occurrence where a few molecules of water might not be moving, the answer is yes.
Q And you agree, Dr. Spruill, that under predevelopment conditions, at least some of the groundwater in the Middle Claiborne Aquifer flowed naturally from Mississippi into Tennessee, correct?
A Yes.
Q I want to now put up a slide, slide 9.
MR. BRANSON: And, Judge Siler, for the record, this is Defense Exhibit 112. I'm happy to give you a paper copy if that would be easier.
THE COURT: I don't need it. Thank you.
BY MR. BRANSON:
Q Dr. Spruill, this figure was generated by David Wiley, one of Mississippi's experts in this case, correct?
A Yes.
Q And you included this figure in your expert report, correct?
A Yes.
Q And this is depicting predevelopment conditions in the Middle Claiborne Aquifer near the Mississippi-Tennessee border,

correct?
A Yes.
Q And you see the yellow triangle on here just south of the state line towards the center right of the diagram?
A Yes.
Q And it's labeled "Area of Limited Natural Flow from Mississippi to Tennessee (Interstate Flow)."
A Yeah.
Q Do you see that?
A I do.
Q Water in Mississippi within this yellow triangle would have flowed naturally from Mississippi into Tennessee under natural predevelopment conditions, correct?
A A molecule of water entering the groundwater system at this location would flow, according to this flow line, over this distance of 6 miles in hundreds of years in the direction of Mississippi -- I'm sorry, Tennessee.
Q And it would have crossed the state boundary into Tennessee, correct?
A Ultimately.
Q And you see two flow lines showing an example of that on this chart are drawn in green, correct? Do you see that, two green arrows?
A There's a glare on it from where I'm sitting. Oh, yeah, sure.

MR. BRANSON: Judge Siler, can you see the colors okay?

THE COURT: Yes.

BY MR. BRANSON:

Q Okay. So those two green arrows are demonstrating an example of that interstate flow under predevelopment conditions that we just talked about, correct?

A Yes.

Q And Mr. Wiley, if you can see in the legend -- and if we could zoom in on the bottom of the legend -- he has labeled those green lines "interstate flow."

Do you see that?

A I do.

Q Now I want to talk about the -- well, I guess, first of all, I should also ask, many of the flow paths drawn on this figure also extend into Arkansas, correct?

A Yes.

Q Now I want to focus on the blue shading, the other eight areas on here shaded in blue which Mr. Wiley has labeled "Intrastate Flow."

So you see the rest of those areas?

A Yes.

Q At least some of the water flowing along these so-called intrastate flow paths would have left Mississippi and flown into Arkansas under to natural conditions, correct?

A According to these lines, yes.
Q And you're also fond of saying, I think you said yesterday, that what goes down, must come up, correct?
A Yes.
Q And so that means that eventually, over a long enough time horizon, all of the groundwater in the Middle Claiborne beneath Mississippi is going to leave the system, correct?
A Given enough time.
Q Given enough time, the answer is yes?
A The answer is yes.
Q Now, Dr. Spruill, you think that Mr. Wiley generated this map by importing the model developed by Brahana and Broshears, correct?
A That's my understanding.
Q And Brahana and Broshears were the authors of that diagram of the Middle Claiborne that you thought mislabeled the absence of the Lower Claiborne Aquifer, right?
A Right.
Q You personally did not rerun Brahana's model to check this map, did you?
A No.
Q You didn't run any model yourself in preparing your opinions in this case, did you?
A No.
Q You did not go back and compare this figure generated by

Mr. Wiley to the results published by Brahana, did you?
A I would have looked at maps in the Brahana and Broshears output and compared it with what Dave Wiley produced.
Q Dr. Spruill, let me try that again.
You did not look specifically at this map and compare it to a similar map in the Brahana model, did you?
A I recall that I did.
Q Okay. Dr. Spruill, I'd like you to turn to your deposition, and this is going to be page 141.
And I want to start at --
A Let me get there.
Q Yeah. Sure.
And I want to start at line 21. And we're discussing Figure 17. That was just the number for this figure in your expert report. You renumbered it?
A Uhm-uhm.
Q So I'm going to say, "Did you go back and compare the Figure 17 generated by LBG, which is Mr. Wiley's firm, to the results published by Brahana?
"Answer: I don't believe I looked specifically at this map and compared it to a similar map in the Brahana model, nor do I know whether or not LBG improved the Brahana model with any data input. I don't know."
That was your answer, correct?
A Yes.

Q That was accurate testimony, correct?
A Yes.
Q So you did not go back and compare this figure that we're looking at on the screen, Defense Exhibit 112, to the results published by Brahana, did you?
A I guess at the time of my deposition, I did not. But I obviously have done it. So in my mind, I'm not sure when I looked at the Brahana and Broshears map and the LBG one. I stated in my deposition that I don't believe I looked at it.
Q Okay. So you're now saying that you think you did look at it; you don't know when, if it was before or after your deposition?
A I don't.
Q And what did you -- did you notice that there are differences here between Mr. Wiley's map and the Brahana map?
A Sure.
Q What differences did you notice?
A I don't recall them, but if you'd show me the differences -- you'd show me the other map. I've looked at thousands of maps. If you ask me to recall specific differences between two maps, I can't do that.
Q And, Dr. Spruill, you don't know what, if any, actual control data was used to draw any of these contours on this map, do you?
A No.

Q Do you know whether it was generated by a model or by some other means?
A This was generated by a model.
Q This figure?
A This figure by LBG, by Dave Wiley, was produced by model output, I believe.
Q So if Mr. Wiley gets in here and testifies later today that these contours on his figure were not generated by a groundwater model, you're saying he's going to be wrong?
A No.
Q So you don't know one way or the other, do you, how he generated this map?
A I don't know with certainty whether this 1886 estimated potentiometric surface map for predevelopment conditions was generated by his model or generated by some other aspect of his system of developing the data.
Q So if he comes in here later today and testifies that this was not generated by a model, you don't have any basis to disagree with that, do you?
A I don't, no.
Q Dr. Spruill, when you first came to this case, you had never defined an interstate aquifer before, had you?
A No.
Q You did not come to your work on this case with any definition of an interstate aquifer in mind, did you?

A I had thought about it in the past, but I didn't come with any definition in my mind.
Q And your initial charge in this case was not to offer any opinion about whether water in the Middle Claiborne Aquifer is interstate or intrastate, was it?
A That's correct.
Q And, in fact, when you submitted your first expert report in this case, you hadn't found any criteria that you thought could be used to make a determination about whether groundwater in the Middle Claiborne Aquifer was interstate or not, correct?
A Correct.
Q So when you were developing your opinions in this case, Dr. Spruill, you didn't think you could answer the interstate versus intrastate question by considering, for example, the hydrological and geological connections between the groundwater in Tennessee and the groundwater in Mississippi, correct?
A I would have considered that as part of development as a criteria.
Q But you didn't -- you just testified you didn't have any criteria in your mind about how you thought you could decide the intrastate versus interstate question?
A Well, that doesn't mean I wouldn't develop criteria if I began to think about the subject.
Q And I'm not asking what you may have later developed. I'm asking what you did when you came to this case and offered your

expert report.

MR. ELLINGBURG: Your Honor, I'm going to object because our position is, and has been, that whether it is an interstate aquifer and, separately, whether the water in it is inter- -- an interstate natural resource is a determination to be made by the Court. There is no fixed definition. I think that's a conclusion of law.

THE COURT: Well, it will be. He can ask him the question, and the Court will not be bound by it.

You may ask him the question.

BY MR. BRANSON:

Q So, again, I'm just asking, you didn't consider the principle in answering -- when you came to your expert report in this case, you didn't have a definition of interstate aquifer in mind that you thought you could answer by considering the hydrological and geological connections between the water in the two states, correct?

A I wouldn't -- I wouldn't develop any concept of intrastate and interstate based on the hydrologic connection between the aquifers in two states, as a single criteria, would be something that would be part of the -- part of the concept of developing.

Q In developing your opinion in this case, your opening expert report, you didn't consider the principle, did you, that if a body of water is such that the removal of water within a

state's borders can have a direct effect on the availability of water in another state, the resource is likely interstate in nature?

A I didn't understand the question. I'm sorry.

Q So the principle I'm asking you about is if a body of water is such that the removal of water within a state's borders can have a direct effect on the availability of water in another state -- that's the principle -- if that's true, then the resource is likely interstate in nature?

A Well, that's the definition of an interstate resource that you're proposing?

Q I'm just asking you, did you consider that definition when you were coming up with your expert reports in this case?

A That could be part of criteria that someone could develop when they thought about a definition of interstate resource.

Q Dr. Spruill, I'm not asking you if that could potentially be a criteria. I'm asking did you, Dr. Spruill, consider that principle when you were drafting your expert reports in this case, yes or no?

A I certainly thought about the flow of water from one state to another.

Q But do you agree with the principle that if body of water is such that the removal of water within a state's borders can have a direct effect on the availability of water in another state, then, if that's true, the resource is likely interstate

in nature?
A That's not the definition of an interstate resource.
Q It's not?
A No. I don't know what the definition of an interstate resource is.
Q But you think that's not an accurate definition of interstate resource?
A It may be part of the definition of an interstate resource.
THE COURT: We have an objection.
THE WITNESS: I'm sorry, Your Honor.
THE COURT: Are you objecting?
MR. ELLINGBURG: Yes. I object to his effort to force him to give an agreement with a definition he proposes that he's already said that he hasn't developed or have and doesn't propose to develop because he's a groundwater hydrogeologist, not a lawyer.
THE COURT: Well, I think he kind of beat the around enough. The witness obviously doesn't have an opinion about whether it's interstate or not, so we can go on to another topic.
MR. BRANSON: Okay. I'll move on.
BY MR. BRANSON:
Q Dr. Spruill, you didn't know that the principle I just read that I was trying to get you to answer, you didn't know that that was a quote from Judge Siler's August 2016 opinion, did

you?
A No.
Q And you didn't know that because, in preparing your expert reports in this case, you didn't review Judge Siler's opinion, did you?
A I don't recall.
Q You don't recall whether you reviewed it or not?
A I don't recall whether I reviewed at this time legal opinions. I just don't recall.
Q Okay. Dr. Spruill, I'd like you to turn in your deposition, page 28, line 1. I put this one up on the screen so you can see it a little bit clearer.
"Question: Did you review Special Master Siler's 2016 memorandum in preparing your report in this matter?
"Answer: I really did not see it.
"Do you consider Judge Siler's opinion relevant to your opinion that you have offered in this case?
"Answer: I really don't know what is in that particular document. That's not something I looked at."
A Okay. I stated that.
Q And that testimony was truthful, correct?
A Yes.
Q So you did not review Judge Siler's opinion before developing your expert reports in this case?
A I don't believe I did, according to this.

Q And when I -- at your deposition you also testified that, when you finally scanned Judge Siler's opinion after you prepared your opinions, you thought it was, quote, so filled with legal jargon, unquote, that you couldn't understand it, correct?
A Yes, I said that.
Q So, Dr. Spruill, I just want to be --
THE COURT: I have an understanding about you saying that. Go ahead.
THE WITNESS: Thank you.
BY MR. BRANSON:
Q Dr. Spruill, I just want to make sure the record is clear. You did not offer any opinion in response to Mr. Ellingburg's questioning about whether the groundwater at issue in this case is interstate in nature, did you?
A Yesterday?
Q Yesterday or this morning.
A No.
Q Nor did you offer any opinion about whether the groundwater at issue is intrastate in nature, did you?
A Not yesterday or this morning, no.
Q And you're not offering an opinion on those principles for purposes of this evidentiary hearing, are you?
A No.
Q Dr. Spruill, I'd like to turn now to Defendant's Exhibit

129. This is tab 9. I'm sorry. PowerPoint slide 10. And I'm going to put it up on the screen.

MR. BRANSON: We also have paper copies, Judge Siler, if you'd like them, but I'm assuming this is okay.

BY MR. BRANSON:

Q Dr. Spruill, this was a figure that you prepared and included in your opening expert report in this case, correct?

A Yes. Yes.

Q And this is a hypothetical aquifer that you're depicting, correct?

A Right.

Q And let's zoom in on it.

MR. ELLINGBURG: Your Honor, I'm going to enter an objection for the record at this point in that we did not cover this in direct and also that it is, by definition in his report, a hypothetical and doesn't really have any direct relation to this case.

THE COURT: I'll overrule. You may ask questions about this.

MR. BRANSON: Okay.

BY MR. BRANSON:

Q And just to be clear, Dr. Spruill, you chose to include this in your opening expert report in this case, correct?

A I did.

Q Okay. So I just want to lay some principles. You -- I

showed this to you at your deposition, and you underlined "interstate aquifer" at top?

A Uh-huh.

Q And just to make sure we're on the same page, the gray area that's kind of unevenly shaded in, that's the extent of the hypothetical aquifer, correct?

A That's correct.

Q And you used the word "interstate aquifer" in this figure because the aquifer exists beneath both of these states, correct?

A That's correct.

Q In applying that very same definition of interstate aquifer to this case, the Middle Claiborne Aquifer would be an interstate aquifer because it physically exists beneath multiple states, correct?

A Yes.

Q You also used the words "interstate flow" on this figure, correct?

A Right.

Q And you used the words "interstate flow" because the water in this case 1 aquifer is flowing across state boundaries, correct?

A Right.

Q And that's true even though the groundwater depicted by these blue flow lines would be moving very slowly, as

groundwater inherently does, correct?
A Yeah. That was -- a whole conclusion that I reached with respect to this concept is that what's important here is not whether the aquifer underlies major states, large numbers of states, but you have to focus on the flow. It's the water at issue here, not the aquifer.

If you remove the water from an aquifer, you don't have an aquifer. You have a formation. And so all of this illustration and the next one that I drew, if I remember correctly, all had, in my mind, to do with groundwater as -- which I call that intrastate, flowing within the state for a really, really long period of time. Even those flow lines for a molecule of water near the word "State A" would require, in a typical confined aquifer, thousands of years to make it to state B. So it's part of the groundwater system in the state.

Even in this case, I focused on water, groundwater, as the inter- -- as the resource, not the aquifer.
Q But you underlined at the top and you acknowledge that this is an interstate aquifer, correct?
A Yes.
Q And then when you drew those flow lines, I just want to be very clear, you've characterized that as interstate flow even though the water is moving very slowly and will take a long time to flow across the boundary, correct?
A My intent there was to say water will flow from one state

to the other in the groundwater system in this scenario, this hypothetical scenario.

Q And that's why you label it "interstate flow," correct?

A From one state to another.

Q And, Dr. Spruill, because of that interstate flow within an interstate aquifer, you have opined that the groundwater in this case 1 aquifer, case 1 hypothetical, is a shared natural resource under natural conditions analogous to an interstate river, correct?

A I'm sorry. You were quoting from my report or --

Q I am quoting from your report. I'm just reading from your report.

MR. ELLINGBURG: I'm going to object. I'm not looking at the report, but did he offer a specific opinion? Did he say, "It's my opinion"? I object to the "opined." I believe he was trying to give him more brevity.

THE COURT: I'll overrule your objection. The witness can say whether he opined it or not.

THE WITNESS: Well, could I not see what you're talking about?

THE COURT: Yes, you may see that.

MR. BRANSON: I've got it right here.

Judge Siler, you don't need a copy, right?

THE COURT: No.

BY MR. BRANSON:
Q So, Dr. Spruill, I was reading a direct quote from page 32. And you see the bullet entitled "Case 1"?
A Yes.
MR. ELLINGBURG: Your Honor, could I just have a continuing objection to this line of questions?
THE COURT: All right. You may have that. It's overruled.
MR. ELLINGBURG: Thank you.
BY MR. BRANSON:
Q And, Dr. Spruill, I just want to read the very last sentence on this page that spills over to page 33.
You write, "In this case, case 1, the groundwater accumulates within and flows through both states under natural conditions. Thus, the groundwater is a shared natural resource under natural conditions analogous to an interstate river."
You did say that, correct?
A I said that.
Q Thank you, Dr. Spruill. You can put that away.
I'd like to now --
A Well, I would like to -- I would like to comment, however, that you only showed one of my hypothetical cases, not the other. And my other hypothetical case, which in my mind was more relevant to the situation that I was evaluating at the time, was my case 2 that showed flow within the states. And I

opined that the groundwater accumulation of flows from millennia through one state under natural conditions to its discharge area located within that state, therefore, the groundwater, is that state's natural resource under natural conditions and the groundwater is analogous to water in an intrastate river. And so -- so it was more than the one hypothetical case in my report that you pointed out.

Q Well, we're about to get to that, Dr. Spruill. I just wanted to make sure the record is clear on this case 1.

And just to make clear, you agree that the case 1 involves an interstate aquifer, correct?

A An interstate aquifer in that the aquifer underlies multiple states.

Q And that's the sense of the term "interstate aquifer" in which you used the terms in your report, correct?

A In the simple case, yes.

Q And it also has interstate flow, correct?

A Yes.

Q And you characterized that flow as interstate even though the water is flowing very slowly, taking a long time to get across the border, correct?

A Yes.

Q And, thus, because of that, you stated in your opening expert report that you considered the groundwater in this case 1 to be a shared natural resource under natural conditions

analogous to an interstate river, correct?
A I made that statement.
Q Okay. Now let's do case 2. This is the next slide.
This was the other hypothetical that you just invoked, correct, Dr. Spruill?
A Yes.
Q And, again, this is -- the gray shaded area, that's the extent of this case 2 hypothetical aquifer, correct?
A Yep. Right.
Q And you used the term "interstate aquifer" at the top in the same sense as you did with case 1, to depict that the aquifer underlies both states, correct?
A Yes.
Q And, again, just so the record is clear, if we were to adopt that same definition of the term interstate aquifer in this case and apply it to the Middle Claiborne, the Middle Claiborne Aquifer would be an interstate aquifer, correct?
A Because it underlies multiple states?
Q Yes. The same way you've used that term on this chart.
A Yes.
Q And the squiggly dark blue line in the middle, do you see that?
A Yes.
Q You're depicting a river?
A A hypothetical river.

Q This is all hypothetical. I understand that.

And from a geological perspective, you would consider the surface water flow in this river you depicted to be interstate flow, correct?

A In the river?

Q In the river, that's what I said.

A Yes.

Q And you also agree that over a long time horizon, again, in this depiction of a hypothetical aquifer, the groundwater is going to migrate into the river and then eventually flow in the interstate river out of both of these states, correct?

A In the -- the way I depicted these flow directions, the implication is that water would flow from interstate within the aquifer system; reside for a very, very long time period within the aquifer system; and, according to this diagram, would ultimately discharge upward across other layers to the hypothetical river that's shown in the middle of the diagram.

Q And then once it's in the river, it will flow out of both states, correct?

A Yes.

Q So the answer to my question is yes, over a long enough time horizon, the groundwater in this aquifer in both states will migrate up to the river and leave both of these states, correct?

A Over really long periods of time.

Q Over really long periods of time, the answer is yes?
A Measured in thousands of years, yes.
Q Dr. Spruill, I now want to change gears here, and I want to discuss your testimony about MLGW's pumping. Okay?
A Okay.
Q Given current water demand in DeSoto County, water purveyors in Mississippi are currently able to meet demand for water from Mississippi's side from the Middle Claiborne Aquifer, correct?
A As far as I know, they are.
Q You also have no direct evidence of any degradation in water quality in well fields in Mississippi, do you?
A I do not.
Q And, in fact, you have not opined that MLGW is withdrawing groundwater at a rate greater than the recharge rates in the Middle Claiborne, have you?
A No.
Q Nor have you provided us with any calculations of any reduction in the total available drawdown in the Middle Claiborne Aquifer, have you?
A I haven't done specific calculations. I've tried to generalize, based on drawdown maps that I've seen, how much reduction in total available drawdown has occurred.
Q But you have not provided us with any calculations, have you?

A No.
Q You testified yesterday and this morning, I think, that you thought Tennessee could move its wells north away from the border to lessen the cone of depression along the state line, correct?
A Did you say "could"?
Q Yeah, could?
A Yeah, could.
Q But you acknowledge that moving MLGW's wells away from the border would not be a cheap fix, correct?
A I certainly understand that.
Q You have not calculated how much it might cost, have you?
A No.
Q In fact, you have not offered any opinion in this case about the economic cost of any of the factors that you discussed relating to well field planning for MLGW's wells, have you?
A No.
Q And you don't actually know, Dr. Spruill, whether relocating MLGW wells to the north would eliminate the cone of depression, do you?
A I have not said it will eliminate the cone of depression. I've said it would relocate the cone of depression further away from the Tennessee-Mississippi border. I've never said that it would eliminate the cone of depression.

Q So depending on where Tennessee were to move the wells, it might just move the cone of depression and extend it into Arkansas, correct?
A It might if it wasn't designed properly with elimination of that problem in mind.
Q Dr. Spruill, I want to put up slide 12. This is Plaintiff's Exhibit 157 that you read off of at some length yesterday.
A Right.
Q Do you remember this?
A Yes, sir.
Q This was not in either of your expert reports, was it, Dr. Spruill?
A No.
Q This was an exhibit to Mr. Wiley's deposition, correct?
A Correct.
Q That's Mississippi's other expert, correct?
A Correct.
Q It was prepared by Mr. Wiley, not by you, correct?
A That's correct.
Q And you didn't mention this chart at your deposition, did you?
A I don't think so.
Q You weren't involved in the creation of this chart, were you?

A No.
Q You don't have any independent knowledge of the numbers on this chart other than what you're seeing in the table Mr. Wiley put together, correct?
A That's correct.
Q So when -- when Mr. Ellingburg was asking you questions about this yesterday, all you were doing was reading numbers off of a chart that Mr. Wiley had given you, correct?
A That's correct.
Q Okay. I want to now go to slide 13. This is tab 25. I'm going to put this up on the screen, and I'm going to hand it to you in a moment, Dr. Spruill. I have a paper copy for you.
A Oh.
Q Dr. Spruill, have you reviewed this memo before?
A I don't remember seeing it.
Q This is a memo by David Wiley, Mississippi's other expert in this case, correct?
A Yes.
Q And so when you were opining yesterday about the possibility of Tennessee moving its wells north away from the border, you weren't aware of this memo, were you?
A No.
Q I want to focus on the second sentence of this first paragraph. I'm going to read it. "This modeling exercise began by moving the southernmost MLGW well fields (Davis,

Palmer, and Lichterman) located in the Memphis area up to the northern part of Shelby County. This new configuration showed very little change in the cone of depression."

I read that accurately, correct?

A You read it accurately.

Q And Davis, Palmer, and Lichterman, those were the three MLGW well fields that were closest to the state line that you talked about yesterday, correct?

A Yes.

Q And Mr. Wiley is stating here that he ran a model to test what would happen if you moved those wells that are close to the border up to northern Shelby County, and he concluded that there would be very little change in the cone of depression in Mississippi, correct?

MR. ELLINGBURG: I'm going to object to him characterizing a document he hasn't even fully identified, which is a May 25, 2007, memo by Dave Wiley. And I believe it contains more content, but I'll cover it on redirect.

THE COURT: I'll overrule that. He can say if he agrees with it or doesn't agree with it or what his position is.

BY MR. BRANSON:

Q Do you need me to ask that again?

A Yes.

Q It's been awhile.

So Mr. Wiley is stating here that he ran a model to test what would happen if you moved those three wells that are close to the Mississippi-Tennessee boundary to the northern part of Shelby County, and he concluded that there would be very little change in the cone of depression in Mississippi, correct?

A That's what it says.

Q And you never reviewed this before, so you have no basis to disagree with that conclusion, right?

A No. No.

Q So you're not offering Judge Siler any opinion that MLGW could materially reduce the cone of depression in Mississippi by moving its wells into northern Shelby County?

MR. ELLINGBURG: I object to that question based on his effort to compare it to the 2007 memo.

THE COURT: Overruled. He may answer the question.

THE WITNESS: I'd like to take a second to read this document.

Okay. So I'm just going to focus on the sentence here that says, "Based on these exercises, it became obvious that, in order to minimize or eliminate the cone of depression in Mississippi, most of the MLGW well fields would need to be moved a significant distance to the north outside of Shelby County, essentially requiring the design and construction of hundreds of new wells and many miles of pipelines. The cost

would be enormous."

He didn't say that it couldn't be done. He certainly said it would cost a lot of money.

BY MR. BRANSON:

Q So I want to be clear what I was asking you, Dr. Spruill. The specific question that I just asked you was whether MLGW could move its wells into northern Shelby County and materially reduce the cone of depression in Mississippi. And the answer to that, you have no basis to disagree with this memo's conclusion that the answer to that is no, correct?

A This memo doesn't say what you're saying. This memo says that it became obvious that in order to minimize or eliminate the cone of depression in Mississippi, you'd have to move the wells to the north. It's a -- it's not what you're saying, in my mind.

Q Okay. I want to stop -- I want to continue reading right where you just stopped. You said you have to "move the wells to the north outside of Shelby County, essentially requiring the design and construction of hundreds of new wells and many miles of pipeline."

A Most of the well fields. He didn't say "all." He said "most of the well fields."

Q Do you have any basis to disagree with this conclusion?

A Which conclusion?

Q Let's start with -- let's start with the one --

A So let me just say, first, focus on the sentence, "This new configuration showed very little change in the cone of depression in Mississippi." So there was a change, albeit small.

So that's -- is that -- is that the conclusion you're talking about?

Q That is one of the conclusions, I want to make sure that you're not offering any opinion that you would disagree with that conclusion, correct?

A I haven't seen the data that he used to reach this conclusion.

Q So the answer is no, you have no basis to disagree with that conclusion, do you?

A I have no basis to agree or disagree with it.

Q Okay. Now let's do the next sentence that you highlighted.

You have no basis to disagree with Mr. Wiley's conclusion that moving MLGW's well fields north outside of Shelby County would require the design and construction of hundreds of new wells and many miles of pipeline? You don't have any basis to disagree with that, do you?

A Once again, you only read part of the sentence. It became obvious that, in order to minimize or eliminate the cone of depression in Mississippi, most of the wells are going to be moved north, and I agree with that.

Q And you don't -- and you agree that, if MLGW were to do

what you just said, it would require the design and construction of hundreds of new wells and many miles of pipeline?

A Absolutely.

Q And you agree that the cost would be enormous, correct?

A Yes.

Q Now, this morning you cited at some length Moore in 1965 as the basis for your analysis of the supposed availability of groundwater north of Memphis, correct?

A Correct.

Q This memo done by Mr. Wiley, that was some 40 years after the Moore report on which you relied, correct?

A Correct.

Q And you did not cite Moore in 1965 in either of your expert reports, did you?

A I did not.

Q It's not on your references list, is it?

A No.

Q Now, you agreed this morning, in response to a leading question from Mr. Ellingburg, that you relied on Moore 1965 in formulating your opinions, right?

A In formulating my opinions?

Q That's what you --

A My opinions or opinions?

Q In formulating your opinions, you said you relied on Moore

1965, correct?
A Correct.
Q When I asked you, Dr. Spruill, at your deposition whether there were any other significant sources that you relied on other than the ones listed in your expert reports, you said no, correct?
A Correct.
Q And you did not mention Moore in 1965 at your deposition, did you?
A I did not, but I also indicated that this is not a comprehensive -- comprehensive list of resources and documents.
Q And I asked you specifically about that statement that you just read and asked you whether there were any other significant sources that you relied on other than the ones that were on that list, and you said no, correct?
A It's not in my references.
Q Yeah. And your answer to that question was no, just to be clear, correct?
A My answer to the question is it in my reference list?
Q No.
A Okay. Sorry.
Q The question in the deposition was, looking at the reference list, reading the sentence that you just read to me, and asking you whether there were any other significant sources on which you relied other than the ones in your reference list,

and the answer was no, correct?
A I'd like to see the deposition, but I assume that I said no to that question. There weren't any other significant sources, but I have relied on the Moore report through time.
Q So are you saying you started relying on Moore after your deposition?
A Probably during that time and then after my deposition, yeah.
MR. BRANSON: Your Honor, I'd like to reserve our right to move to strike on that basis later.
THE COURT: All right.
MR. ELLINGBURG: And I'll object to the form of the question, the inclusion of him lying at that point.
THE COURT: Objection overruled. You may reserve his right to ask to strike later.
BY MR. BRANSON:
Q And, Dr. Spruill, you have not offered any opinion in this case about the cost associated with the cone of depression in the Middle Claiborne Aquifer, have you?
A The cone of depression doesn't have a cost. I don't know what you mean. Would you ask me again?
Q Yeah. Have you estimated the cost associated with the impact of the cone of depression --
A Oh.
Q -- that you testified about, and the answer is no?

A No.
Q Correct? The answer is no?
A Correct answer.
Q Okay. Dr. Spruill, I want to apply some of the same concepts that you've talked about this morning to wells in Mississippi.

In preparing your opinion in this case, you did not determine whether or not Mississippi is pumping from, let's say, Southaven well field in DeSoto County was consistent with your principles of good well design, did you?
A No.
Q And at your deposition, you didn't know how many wells there were in Mississippi pumping within one mile of the Tennessee-Mississippi border, did you?
A No.
Q And, Dr. Spruill, you testified yesterday about well interference, correct?
A Yes.
Q Mississippi's wells on its side of the border are also generating well interference, correct?
A Correct.
Q And if I were to tell you that one well field in Southaven, Mississippi, right on the border wells that are an average of 383 feet apart, would you have any basis to disagree with that?
A No.

Q And you would acknowledge that those wells are much closer together than the wells that you testified about on -- in Tennessee yesterday, correct?
A They are.
Q And when preparing your opinions in this case, then, you did not set out to assess whether Mississippi's wells that are pumping out of the Middle Claiborne Aquifer are consistent with your principles of good well design, did you?
A No.
Q Dr. Spruill, I think we've covered this earlier, but you do not have a good understanding of the Federal Doctrine of Equitable Apportionment, do you?
A No.
Q And are you aware that the purpose of this hearing was to determine whether equitable apportionment should apply to Middle Claiborne?
MR. ELLINGBURG: I'll object to that. That's not what --
THE COURT: Objection sustained on that. It's a legal question.
BY MR. BRANSON:
Q Let me ask it this way, Dr. Spruill. You've not offered any opinions, in your view, about whether equitable apportionment would be a good way of regulating wells in the Middle Claiborne Aquifer, correct?

A No.
Q Correct?
A No.
MR. BRANSON: So, Your Honor, it's five to noon. I'm about to transition into a new subject. I'm happy to keep going, or I thought if you wanted to break now, that would be fine. I defer to you.
THE COURT: We'll go on for another 15, 20 minutes, something like that. Then we'll take a break.
BY MR. BRANSON:
Q Dr. Spruill, you've testified that, under predevelopment conditions, you think water within the Middle Claiborne Aquifer in Mississippi was generally flowing in a westerly direction, correct?
A Yes.
Q But you yourself have not run any models to verify that, have you?
A That's correct.
Q You testified yesterday, I believe, that if you want to determine the direction of groundwater flow, you generally need at least three wells measuring water elevations, correct?
A Well, that would give you the direction of groundwater flow with a degree of certainty in the triangle between those three wells.
Q So if you want to draw -- if you want to kind of create

a -- one contour line, you generally are going to need three wells to triangulate the measurement, correct?
A You can get more than one contour line and three wells to triangulate.
Q But you would agree that generally you need at least three in order to start getting an accurate assessment of the groundwater flow?
A Unless you fortuitously drilled two wells at the same head. Then you could at least determine a lot of equal -- pressure, but you couldn't determine direction of groundwater flow.
Q And I believe you also said yesterday that if you want to determine groundwater flow with any reasonable degree of accuracy, you need a fairly large number of monitoring wells. Did I hear you correctly?
A Yes.
Q Now, Dr. Spruill, you testified this morning in response to Mr. Ellingburg's question about the predevelopment map of the Middle Claiborne Aquifer created by Criner and Parks, 1976, correct?
A Correct.
Q I'm going to put this up on the screen. For the record, everybody, this is Plaintiff's Exhibit 205 as Mr. Ellingburg handed it up today.
And this was a map that you briefly discussed with Mr. Ellingburg, correct?

A Yes.
Q And you opined in your expert report that this Criner and Parks map employed data from reliable sources and provides a reasonably sound basis for estimating the predevelopment surface, correct?
A Yes.
Q When you were evaluating the documentation for this Criner and Parks figure, you didn't look at anything beyond the Criner and Parks report itself, correct?
A You mean did I evaluate the actual data used in -- no.
Q Yeah. The answer is no, you did not evaluate the actual data that Criner and Parks used, correct?
A Correct.
Q And so you opined in your expert report, Dr. Spruill, that you thought this map was reasonably sound even though you did not go and look at the scientists' underlying data, correct?
A Correct.
Q Now, Dr. Spruill, I want to put up on the screen here, I want to circle and label the four control points that Criner and Parks used.
Do you see how I've put red circles around the four things that they've denoted as an observation well on here?
A Yes.
Q Do you have any reason to disagree with the identification of the control wells that Criner and Parks used?

A No. All of those -- all of those wells, in my opinion, would be in the confined portions of the groundwater system.
Q Dr. Spruill, all I asked you was do you have any reason to disagree with the labeling that I put to the four wells on Criner and Parks' report.
A No.
Q I'm sorry. What did you say?
A No.
Q So let's go to slide 24. I'm going to darken in the state boundary here just so we can all see it.
You see how I put a black line around the Tennessee-Mississippi border?
A Right.
Q Criner and Parks do not have any control data at all on Mississippi's side of the border, do they?
A They do not.
Q Now, you've previously testified when I asked you about this that it was important to you that Criner and Parks only used observation wells that were away from the center of pumping, correct?
A There was no center of pumping at this time.
Q Do you even know when the measurements were taken from these four control wells?
A Well, it's depicting the potentiometric surface of the Memphis Sand in 1886, and so I assume that there were some

measurements taken prior to -- prior to pumping because I don't see a cone of depression here.

Q You assume that, but you don't know that, correct?

A I don't know that, correct.

Q You didn't go and look at the actual data Criner and Parks actually used to determine when they might have taken these measurements?

A I don't know if there's a model or a location or not. I don't recall.

Q So if I were to tell you that some of these control points took measurements 40, 50, 60 years after predevelopment, you'd have no basis to disagree with that, correct?

A I don't know when they were -- when these measurements took place.

Q Okay. So I want to ask my previous question again.

You previously opined that it was important to you that Criner and Parks used only observation wells that were away from the estimated center of pumping, correct?

A If you want to determine the predevelopment potentiometric surface, by definition, there is no substantial development. That's the definition of predevelopment.

Q So let me focus on the observation wells part of the question. It was important to you, I think you said, that Criner and Parks only used observation wells, correct?

A Correct.

Q And I want to focus on control point SHO-124. Do you see that?
A Yes.
Q That's an inspection shaft to an underground tunnel, correct, Dr. Spruill?
A I don't know.
Q It's not an observation tunnel, is it?
A I don't know.
Q So you said it was important to you that Criner and Parks used only observation wells, you said that even though you have no idea if that thing that we've marked in downtown Memphis is actually an observation well?
A I don't know if it's an observation well or not.
Q So when you said that it was important to me that Criner and Parks used observation wells, you don't know if they actually used those, do you?
A I don't know whether it's an observation well or not. But it's important, if you understand how groundwater flows, to use observation well data. That is reliable.
Q So if I were to establish to you that this is an inspection shaft to an underground tunnel and not an observation well, then you would think this map is not reliable?
A I would want to look at the criteria that this highly qualified geologist working for the US Geological Survey looked at to determine that this gives a reliable measure of

equipotential surfaces or values at that location.
Q And you'd want to look at that, but that's not something you've looked at for this case --
A No.
Q -- correct?
Let's focus on SHU-2.
A Okay.
Q Have you checked to see whether that's actually an observation well?
A No.
Q If I were to tell you that that well has an 80-foot screen length, would you have any basis to disagree with that?
A I wouldn't -- I wouldn't know what the screen length is just sitting here.
Q And if a well has an 80-foot screen length, it's a production well, right?
A No.
Q So you think that there could be an observation well with an 80-foot screen length?
A In a confined aquifer, yes.
Q But do you know SHU-2 is actually an observation well?
A No.
Q So if I were to tell you it's a production well, you'd have no basis to disagree with that?
A Well, is it a production well that had a pump in it? You

can have a production well that has a pump in it and take a water level measurement as long as the pump is not running and it's an observation well.

Q And you have no idea whether the pump was running in that --

A I don't. I don't. I don't, no.

Q And, Dr. Spruill, I want to look at this map. I want to focus on the contours right along the black line, the state line.

Do you see that?

A Yes.

Q I want to focus on the 220, 230, 240, and 250. And I've tried to zoom in. I was counting the lines starting from the left.

Do you see me?

A Yes.

Q Do you see how those lines go south of Memphis; they're coming in at a northeast-to-southwest orientation?

A Yes.

Q And you see how, as they approach the state boundary, they curve and become vertical?

Do you see that?

A Yes.

Q You don't see any control data on this figure that would justify that north-south bend in the contours, do you?

A No. But these challenges don't live in a vacuum. I mean, they're looking at things other than just this particular area. So I can't say whether they had any information to the south, either just general understanding, other reports and so forth, to make this transition that you see from northeast to more northerly across the border.

Q So what you just said, Dr. Spruill, you have no idea if Criner and Parks actually had any other information that they used to justify this bend, do you?

A No.

Q And so without any actual control data that you as a scientist have evaluated that would justify that bend in the contours, you can't opine one way or the other on whether those contours at the state line are accurate, can you?

A No. All I can say is that those -- those contour lines deflect more to the north-south from the northeast beginning at about the state border to the south.

Q They do that, and I'm not -- I agree with you that they do that.

I'm asking you, without any actual data you've looked at, you can't opine on whether those contours are accurate, can you?

A No, I can't. I mean, those are contour lines drawn by very competent US Geological Survey individuals. And this report, because I know a lot about the survey, has gone through

rigorous review. And, to me, there must be evidence that this report is done using standard geological practices that meet the rigorous demands of the US Geological Survey. And that's all I can say about that.

Q So you assume it must have gone through that process, but you don't know, do you?

A No. I certainly hope it's gone through that process.

Q And without knowing what the data is that may or may not justify these contour lines all along the state border, you as a scientist, you can't opine on their accuracy, can you?

A No.

Q Okay. Dr. Spruill, let's go on, and I want to focus now on slide 16. This is -- for the record, everybody, this is Plaintiff's Exhibit 206. And this is from Reed in 1972. I'm going to blow this up. There you go.

This is a figure that you have provided in your expert report. I didn't take your version, but this is the underlying document, correct, Dr. Spruill?

A Correct.

Q In preparing your reports, you did not take any steps to go back and look at any underlying control data that Reed may have used to generate this map, did you?

A No.

Q So you don't even know whether Reed had a single control well justifying any of these contours, do you?

A I don't know how many wells he may have had to generate this -- this map.
Q So could -- you don't know if he had any wells, do you?
A I don't know how many he had.
Q Could have been zero; could have been five?
A I don't know.
Q Certainly there's nothing on this map that would give any indication that Reed has met the Dr. Spruill test of needing at least three control wells to draw the contour line or determine flow direction, correct?
A Well, my interpretation is that these potentiometric surface maps predevelopment that were drawn by scientists in the 20th Century have to be based on something other than measurements in that a large number of wells because they didn't exist in predevelopment times. So geologists relied on basic geologic knowledge of how aquifers work and so forth to draw lines of equitotal hydraulic head on maps in the absence -- in the absence of actual monitoring well data.
Q So -- but what you just said, I just want to be clear, you're speculating; you have no idea how Reed drew this map, do you?
A I don't know what his control points were, if any.
Q Let's do another one. I don't think I have a slide for this one, but I want to focus on Arthur and Taylor, Plate 5, which was P199. Mr. Ellingburg handled it to you this morning,

I believe. I can give you another copy if that would be useful, Dr. Spruill.

A Sure.

Q What was it? I'll hand you another copy just so we're not lost.

MR. BRANSON: Judge Siler, since I don't have a slide for this one, do you want a paper copy to --

THE COURT: I don't need one.

MR. BRANSON: You don't need one?

THE COURT: No.

BY MR. BRANSON:

Q So this was another USGS estimated predevelopment map that you've cited, correct, Dr. Spruill?

A Uh-huh. Yes.

Q When you offered your expert reports, you didn't have any understanding of the control data Arthur and Taylor used to generate these contours, did you?

A No.

Q There's no discussion of Arthur and Taylor's control data in either of your expert reports, is there?

A No.

Q So, for example, you don't know whether Arthur and Taylor relied on any observation wells, do you?

A I do not.

Q You certainly don't know the construction details of any

wells that Arthur and Taylor might have had, do you?
A I do not.
Q You don't know what time period Arthur and Taylor's measurements might have been taken from, do you?
A Well, if it's predevelopment, I would assume it's 18 -- the concept is what does it look like in the 1800s.
Q Dr. Spruill, I'm not asking what you're assuming. I'm asking what you actually know from studying this paper. And the answer is you don't know, correct?
A I don't know what?
Q You don't know what time period Arthur and Taylor took any measurements they might have had from?
A No. I don't think Arthur and Taylor took any time measurements during the 1800s.
Q So we have no idea -- as you're sitting there on the witness stand right now, you have no idea when Arthur and Taylor's measurements may or may not have been taken?
A I don't know whether others took measurements that Arthur and Taylor used. I don't -- I don't know.
Q And because you don't know that, again, you can't opine on the accuracy of these contour lines, can you?
A What I can opine on is that these are lines drawn on a map by the US Geological Survey. It's their best estimate of the predevelopment configuration of the equipotential surface.
Q Do you know whether this map estimating the predevelopment

surface was the purpose of Arthur and Taylor's article?
A I don't remember what the stated purpose of this was. Predevelopment maps are often used as the basis for calibrating a model, for example.
Q You have no idea whether Arthur and Taylor calibrated any model using this Plate 5, do you?
A I don't remember.
Q And so, again, I'll ask you, without having any knowledge of the data used to generate this chart, you, Dr. Spruill, as a scientist, cannot opine on the validity of these contours, can you?
A No. I have to take them at face value.
MR. BRANSON: Judge Siler, I'm at another changing-gears spot. I'm happy to keep going.
THE COURT: I will declare a recess until 1:30.
(A lunch break was taken.)
THE CLERK: All rise. The Court is back in session. United States Supreme Court Special Master Eugene Siler, Jr., presiding. You may be seated.
MR. BRANSON: Your Honor, I am happy to rest and pass the witness.
THE COURT: Okay. Let me bring up one thing, that's just a matter of our plans. If we have to go next week, are we in agreement that we would go on Tuesday and we'd finish on Tuesday if we go on Tuesday?

MR. BRANSON: That's certainly our position, Your Honor.

THE COURT: Okay.

MR. ELLINGBURG: Mississippi agrees.

THE COURT: Okay. Agree?

MR. L. BEARMAN: Yes.

THE COURT: Can we do it in one more day after this week?

MR. BRANSON: I certainly think so.

MR. ELLINGBURG: I think that's probable.

THE COURT: The problem, I think, is Mr. Frederick.

MR. FREDERICK: Your Honor, our instructions from the State of Tennessee are to finish the hearing when we finish the hearing. And we have a strong preference to finish on Tuesday. We would ask our colleagues from Mississippi to proceed efficiently so that we can do that. We have endeavored to present our case, and we will, efficiently. We'd like to finish on Tuesday, and if we can't, we'd like to finish on Wednesday.

THE COURT: I've set aside that time for myself, but I wanted to make sure it's agreeable with everybody and we can work it in. If we finish before then, fine.

MR. L. BEARMAN: I was going to say, Your Honor, my strong preference is to finish this Friday, but --

THE COURT: Well, I would, too, if we could, but --

MR. L. BEARMAN: I thought I better be on record --
THE COURT: Okay.
MR. L. BEARMAN: -- with that.
THE COURT: You've got a trip planned by your wife? Is that the idea?
MR. L. BEARMAN: No, sir. No, sir.
THE COURT: Okay. I won't ask. You may cross-examine the witness.

CROSS-EXAMINATION

BY MR. L. BEARMAN:

Q Thank you. Dr. Spruill, my name is Leo Bearman, and I represent the City of Memphis and the Memphis Light, Gas & Water Division.

I'm going to ask you just a few questions. If you don't understand one, want it repeated or clarified, all you have to do is ask me.

Do you understand that?

A Yes, sir.

Q Can you hear me?

A Yes, sir.

MR. L. BEARMAN: Your Honor, I'm kind of confounded by these microphones. Can Your Honor hear me?

THE COURT: Yes, I can.

BY MR. L. BEARMAN:

Q Dr. Spruill, you were in the courtroom when we opened this

case, were you not?
A Yes, I was.
Q Okay. And you remember in opening statements the attorneys, and I'm just going to talk about me, but we all -- or I talked and Mr. Frederick talked about the factors involved in proving what we understood the Court had delineated as the appropriate issue in the case.
And then before we started doing that, I talked a little bit about nomenclature as what these aquifers are called. Let me see if you agree with me, if you will.
Do you agree that in Tennessee the names Memphis Sand or Memphis Aquifer are synonymous with the Middle Claiborne Aquifer; in Mississippi, the upper part of the Middle Claiborne Aquifer is called the Sparta Sand? Do you agree with that?
A Yes.
Q Good. That comes right out of your report.
A Good.
Q Do you recognize it?
A Well, I -- yes.
Q All right. Now, what I want to talk about are the factors that at least we felt were significant in determining whether or not this aquifer in question, the Middle Claiborne, was and is an interstate resource, the aquifer and the water in it.
One -- the first factor that we talked about, that I talked about, was that the Middle Claiborne lies between eight

different states.

You agree with that?

A The Middle Claiborne Aquifer Unit lies --

Q Beneath eight different states.

A I agree.

Q Okay. I'm going to -- you're going to agree on everything. I'm just confident.

The second factor that I suggested was that pumping groundwater in one state, that is, Tennessee, affects groundwater flow across the state line into Mississippi.

You agree with that, don't you?

A I'm not going to just agree with that. I'm going to want to know what you mean by "affects."

Q By what, sir?

A Affects groundwater flow.

Q All right. Well, let me read you your deposition answer.

You understand the importance of a deposition, don't you, sir?

A Yes, sir, I do.

Q Have you ever given one before this one?

A Yes.

Q Hundreds of times?

A Not hundreds.

Q Dozens of times?

A Perhaps.

Q All right. You understand the significance is that the attorneys who are asking questions want specific and truthful answers, correct?
A Correct.
Q Okay. Do you understand you're under oath and that you have the opportunity, as I just gave you, that if you don't understand a question or you want it repeated or clarified, all you have to do is ask?
A I understand.
Q Okay. One of the questions asked apropos of this pumping was, "I believe you have opined," says the questioner, "that groundwater pumping out of the Middle Claiborne on the Tennessee side of the state boundary has affected groundwater flow on the Mississippi side, correct?"
Your answer was --
MR. ELLINGBURG: Excuse me. Could you direct me so I'll know --
MR. L. BEARMAN: Certainly. Page 38. I apologize.
MR. ELLINGBURG: -- and can refer to it.
BY MR. L. BEARMAN:
Q Do you want to look at it, sir?
A I do.
Q Okay. This doesn't have a line number, so it's right in the middle of the page. That was your opportunity -- do you want to take a look at it?

A Where are you on this page?
Q Right in the middle. "I believe you have opined" --
A Okay.
Q -- "that groundwater pumping out of the Middle Claiborne on the Tennessee side of the state boundary has affected groundwater flow on the Mississippi side, correct?"

And you didn't say, "It depends on what you mean by affected."

All you said -- just a minute, sir. I'm going to ask, and then you can respond if you want to.

You said, "Yes."

Is that the correct answer?

A Yes.
Q Okay. Now, the next question -- and you agree with that?
A I thought you were going to give me an opportunity to speak.
Q All right, sir. If you -- if His Honor feels that this could be responsive, it's up to His Honor. I don't give opportunities. I'm not authorized to give opportunities.

THE COURT: You can explain it if you have an explanation.

THE WITNESS: You started off this discussion by saying that -- and you gave me this impression that that question wasn't relative to a -- the specific case of water pumping in Mississippi affecting water levels in Tennessee and

vice versa. What I heard in the opening statement was that this might be some part of a criteria for a definition. And so when you said -- when you asked your question, I related it to the general, not the specific case here.

BY MR. L. BEARMAN:

Q Dr. Spruill, you're telling me that a question that says "I believe you have opined" --

A No. I'm talking about the previous statement.

Q Listen to my question, please, sir.

My question was, "I believe you have opined that groundwater pumping out of the Middle Claiborne on the Tennessee side of the state boundary has affected groundwater flow on the Mississippi side, correct?"

A Yes.

Q And you said, "Yes."

All I want to know is, did you answer that question truthfully?

A Yes.

Q Okay. Fine.

Let's go to -- and let's go to the next question or next factor.

The next factor that I want to ask is, would you also agree -- are you with me, sir?

A Yes, I'm listening.

Q "Would you also agree that groundwater in the Middle

Claiborne is hydrologically connected to some surface waters in the area?"

And your answer was --

MR. ELLINGBURG: Could you give us a page reference?

MR. L. BEARMAN: Page 40.

MR. ELLINGBURG: That helps.

BY MR. L. BEARMAN:

Q Your answer was, sir?

A I'm looking. You're ahead of me.

Q Right in the middle. Don't get ahead of me. Stay with me, if you will.

MR. ELLINGBURG: He's entitled to look at his testimony.

MR. L. BEARMAN: I understand that. I just want to get the answer first, if you will.

THE WITNESS: The answer was, "In the unconfined portions of the system, I think they are hydraulically connected, and some recharge takes place there. I also think they are hydraulically connected through the system," through the system.

BY MR. L. BEARMAN:

Q "Throughout the system," sir.

A "Throughout the system, even in the confined portions of the groundwater system."

Q All right. So that's your answer, is it not? That is,

would you agree that groundwater in the Middle Claiborne is hydrologically connected to some surface waters in the area?

Your answer was basically I agree. In the unconfined portions of the system, you think they are hydrologically connected and some recharge takes place there.

Then you said, "I also think that they are hydrologically connected throughout the system even in the confined portions of the groundwater system."

And that's an accurate statement by you, is it not?

A Yes, it is.

Q And you agree with the statement you made; it's an accurate statement?

A I'm agreeing that I wrote this statement.

Q All right, sir. Now, the next point I want to make, which was the fourth point, was that it's -- hang on, if you will, please.

MR. L. BEARMAN: I'm sorry, Your Honor. It's hard for me to read with these glasses, but I'm going to get there.

THE COURT: That's fine. Take your time.

BY MR. L. BEARMAN:

Q You'll also agree with the fourth factor, would you not, that it's absolutely clear that a small amount -- a small amount of water, but some amount of water, crosses the border from Mississippi to Tennessee in predevelopment, that is, prepumping, times? You acknowledge that, right?

A Yes.
Q In fact, you said that specifically. So we're in agreement on those four points.
Now, the next point I want to ask is, these are two that I added gratuitously, and that is that there is no -- you would agree, would you not, sir, that there is no physical barrier at all that extends along the Mississippi-Tennessee boundary that would impede groundwater from flowing across the border? You agree to that, don't you?
A I'm sure that I would agree to the concept of a physical boundary like a wall or something like that, but I've stated so today that impede can mean the slowing of water in that general area by facies change, for example.
Q And that, sir, is what you pointed out, was it, to the questioner when he asked this crucial question?
A I don't remember, so I'm sure you'll point me to it.
Q Well, I will point you to it. Take a look at page 37, the last line, and page 38 at the top.
A Uh-huh.
Q Your answer was not, It depends on this and it depends on that. Your answer was, sir, "I agree," correct?
I can't hear you.
A Sir?
Q I said your answer was not, Well, it depends on this or it depends on that.

MR. ELLINGBURG: Your Honor, I want to interpose an objection. This is not a proper way to impeach when you read part of a question.

THE WITNESS: Exactly. So --

THE COURT: All right. Read him the full question and he can answer whether he said that.

BY MR. L. BEARMAN:

Q We'll talk about complexity in a minute. The question is -- I want to make sure the record is clear. "You initially said in response to my question that there was no significant physical barrier, I think, along the Mississippi state boundary. I want to make clear that there is no physical boundary -- barrier at all that exists -- that extends directly along the Mississippi-Tennessee boundary that would impede groundwater from flowing across the border, right," says the questioner.

And your answer was, "I agree," correct?

A Correct. But that's all misleading and -- and it is out of context.

Q And so being an experienced deposition giver, sir, dozens of times and knowing that you were in the room giving a deposition under oath for the purpose of determining exactly what your position was as an expert, you said to the questioner, Wait a minute now, that's out of context; that's -- you have -- you have not been ingenuous?

You didn't do any of that? All you said was I agree.
A Sir, that's one question that dealt with the issue of physical barriers. I stated on page 38 -- 37 that there are lateral and vertical changes in the Claiborne Aquifer System that caused significant variations in the rate of groundwater movement, which is incredibly slow, and the direction of water movement at both the lateral and vertical sense.

So while there are no physical barriers that would prevent the movement of water downgradient in response to decreasing total hydraulic head in this aquifer system, there is amazing complexity.

Q And so you said, in response to Mr. Branson's question, Look, you've got to think about -- I've got to think about all those complexities and facies and everything else?

All you said was, sir, being an experienced deposition giver, you said, "I agree." And you still do agree to that, do you not?

And look at the next question before you answer that. The next question was, "There was no barrier in predevelopment times, right?" I'm sorry, "either."

And you said, "I agree."

A I had already made my position clear on this, and that is that I was thinking about some sort -- source -- some sort of subsurface geological barrier that exists. And my point was there is no such subsurface geological barrier, like a wall and

so forth, but there are mechanisms that impede the movement of water in that particular location, and that's the significant facies change that occurs there.

Q And you explained all that in the answer where you say "I agree"?

A I explained it in the verbiage that I read before that.

Q I see. And you referred to your previous answer when you said "I agree"? You didn't, did you?

A We're talking about two different things. We're talking about a physical barrier that you want to impose on me, and I'm talking about a lateral change in composition of the material, sir.

Q Did you give -- let's try it this way. Did you say in the deposition, sir, "I agree"?

A Well, yes.

Q Thank you.

Now, here's the next question. Under natural conditions in the Middle Claiborne Aquifer, every molecule of groundwater in that aquifer, under natural conditions, was moving to some extent, correct?

A Yes.

Q And that's exactly what you said, and you agree to that?

A Yes.

Q Okay. Fine.

Now, a couple of more points, sir, on a transboundary

aquifer, okay? If you're hurting, I'll stop.
A I'm fine. I just need to stand for a second.
Q Okay. You gave the deposition -- the definition, sir, did you not, on what a transboundary aquifer is when you were questioned?
A I remember talking about it, but I don't remember the specifics, though.
Q All right. Take a look at page 76.
A Okay.
Q Are you with me?
A I am.
Q Mr. Branson said, "Question: You've heard the term 'transboundary' aquifer before?

Your answer was, was it not, if I'm reading it correctly, "It is not a term I use, but I have heard it," correct?
A Correct.
Q Then he said, What do you understand, sir? And my -- "What do you understand it to mean?"

In other words, Mr. Branson's not asking a definition that he created. He is asking your definition. And you said, "An aquifer that underlies national or international state boundaries."
A That's my statement.
Q Okay. And then he said, "When you say 'underlies,' you're

talking about physically underlies the geographical extent of the aquifer?"

All right. The next question that I want to ask is, "On the Middle Claiborne," which was the next question asked, "is the Middle Claiborne," said Mr. Branson, "a transboundary aquifer?"

Now, by "transboundary," you defined it as an aquifer that underlies national or international state boundaries.

A national state boundary would certainly be the boundary between Tennessee and Mississippi, right?

A Yes.

Q Okay. And then he says, "Is the Middle Claiborne a transboundary aquifer? That's the aquifer we're talking about."

And you said, "The Middle Claiborne underlies multiple states in this region."

That's correct, isn't it?

A Yes, that's what I said.

Q Sir?

A That's what I said.

Q My question was not what you said. That's correct, isn't it?

A The Middle Claiborne, I said then and I'll say now, underlies multiple states.

Q Thank you.

And then the question was, "It does meet your understanding of what a transboundary aquifer is?"

And your answer was, "If a transboundary aquifer is simply one that is defined as a physical aquifer system underlying multiple states, then the Middle Claiborne fits the definition of a transboundary aquifer."

You agree with that, right?

A I made that statement.

Q Okay. Well, you wouldn't have made a statement under oath if you didn't agree with it, would you, sir?

A Well, I'm saying in that statement that a trans- -- if a transboundary aquifer has no other characteristics than it simply occurs beneath multiple states, then it's a transboundary aquifer because it meets that single criteria.

Q All right. And the Middle Claiborne is one such?

A It underlies multiple states.

Q And the Middle Claiborne, therefore, is one such aquifer?

MR. ELLINGBURG: Objection to form. He's answered the question.

MR. L. BEARMAN: I can't get an answer, if the Court please.

THE COURT: Overruled. He can answer it again.

THE WITNESS: The question is?

BY MR. L. BEARMAN:

Q And the Middle Claiborne Aquifer is one such transboundary

aquifer, as you defined it?
A I'll repeat my statement. If a transboundary aquifer is simply one that is defined as an aquifer system that underlies multiple states, if that's the definition, then the Middle Claiborne fits the definition of a transboundary aquifer.
Q Thank you, sir.
Now, finally -- finally, you agree, do you not, that the Memphis-Sparta Aquifer would be a major water-producing aquifer system in the Memphis -- I'm sorry, in the Mississippi-Tennessee border region because the citizens of Tennessee rely on that for a public water source, right?
A Yes.
Q But you not only said yes, sir, you said, "as do citizens of Mississippi and other areas," correct?
A Yes. Citizens in Mississippi and other areas do rely on parts of the Middle Claiborne Aquifer Hydrologic Unit.
Q And then the question was, "Including Arkansas?"
And your answer was?
A "Yes."
MR. ELLINGBURG: Excuse me. Could you please help me again catch up with where you are?
MR. L. BEARMAN: 245.
MR. ELLINGBURG: I see. You jumped from page 70-something to 245.
MR. L. BEARMAN: One second, Your Honor.

I'm sorry. I apologize. Thank you.

THE COURT: Does Mississippi have any redirect?

MR. ELLINGBURG: Yes, Your Honor.

REDIRECT-EXAMINATION

BY MR. ELLINGBURG:

Q We should be finished soon, Dr. Spruill.

A Oh, good. If we finish on Friday, I vote for Bearman for president. Off the record.

MR. L. BEARMAN: Your Honor, if nominated, I will not accept, and if elected, I will not serve.

THE COURT: There you go.

THE WITNESS: That's good.

BY MR. ELLINGBURG:

Q That encourages me.

Dr. Spruill --

A Yes.

Q -- you were -- I'm going back to Mr. Branson's examination, and I'm going to hit a few points.

You were asked a lot of questions going back to this whole question about whether the Middle -- the Memphis Sand Aquifer and the Sparta Aquifer are, in fact, distinct aquifers within a larger system; is that correct?

A That's correct.

Q Okay. Now, to put that in some context, the -- would you pull up slide 21?

So he showed you this figure, right? Mr. Branson, now, are we there now? Now, this is --

MR. BRANSON: Objection. I did not show this slide to him so --

MR. ELLINGBURG: No, you didn't, but it addresses your issue. And the issue is what we're talking about.

BY MR. ELLINGBURG:

Q So my question is, we looked at that earlier. Is that a table from the MERAS report prepared by the US Geological Survey, I believe in 2009?

A Yes, it is.

Q Does that report show that there are separate aquifers within the larger hydrogeological units?

MR. BRANSON: Objection. Leading.

MR. ELLINGBURG: No, it's a question.

THE COURT: Okay. Just ask him what it shows there.

BY MR. ELLINGBURG:

Q Okay. What does that show with regard to aquifers?

A This diagram shows a lot of information about geologic units, but with -- specifically with respect to aquifers, it shows that within the Mississippi Embayment region, there are multiple aquifers that are referred to as aquifer units that are hydrogeologic units.

Q And what does it show with regard to what appears in Tennessee and what appears in Mississippi.

A In Tennessee, it shows several different aquifer units and confining units in both Tennessee and Mississippi.

Are you asking specifically with respect to --

Q Is there a difference in the aquifers found in the two states?

A Yes.

Q What is it?

A There are lots of different examples of different formations that make up the same aquifer -- make up the same aquifer unit. For example, in Tennessee, there's a formation called the Flower Island. Similarly, there is an undifferentiated one because they've not been able to describe it yet. And I can't begin to pronounce that word, but I'll take a stab at it. I won't take a stab at it; I'll spell it. H-A-T-C-H-E-T-I-G-B-E formation.

Q In Mississippi?

A In Alabama. And I pointed out that the similar formations are undifferentiated, not been able to subdivide them yet into the State of Mississippi. And other examples certainly exist throughout the system called the Mississippi Embayment Hydrologic System.

Q Does this show a Lower Claiborne Aquifer?

A Yes.

Q And where does it show it?

A It shows it on -- in the column labeled "Hydrogeologic

Units, Lower Claiborne Aquifer."
Q And do you see that in Tennessee?
A My opinion is that you definitely do not see that in Tennessee.
Q Thank you.
Now, if you would, go to the next slide. That is -- would be 26, I think.
A Yes.
Q Now, this is the slide we looked at earlier.
Can you blow up the text up in the left-hand corner?
Can you read that? I thought we could blow it up.
A Yes.
Q What does it say?
A It says, "The approximate" -- are you talking about the explanation?
Q Yes, sir.
A The approximate area of outcrop of the Sparta Sand or Memphis Aquifer outcrop, areas covered by quaternary deposits in places, that's the first pattern, which would be indicative of this pattern.
And then it says, for the next pattern which is shown there, and it's shown as this linear feature paralleling just south of the Tennessee-Mississippi border. And the verbiage associated with it says, "To the best of my ability, approximate zone of transition where Cane River formation or

equivalents change facies from clay to sand. Zone marks southern limit of Memphis Aquifer."

Q Okay. Now, would you point to where the southern limit of the Memphis Aquifer is?

A The southern limit of the Memphis Aquifer is this facies change, which, remember, is a change in the subsurface of materials from one composition to materials of another composition.

Q Thank you. One moment.

Now, have you seen any USGS documentation that would deject that there is not a separate Sparta or Lower Claiborne Confining Unit in the State of Mississippi?

MR. BRANSON: Objection. Leading.

THE COURT: Overruled. You may answer the question.

THE WITNESS: The -- the literature is quite clear that there is a Lower Claiborne Aquifer and a Lower Claiborne Confining Layer in the State of Mississippi that covers a large area.

BY MR. ELLINGBURG:

Q Does it appear in Tennessee?

A No.

Q Thank you.

Now, I don't have it, but you may recall that counsel for Tennessee put up a slide where they had circled in red and put some large letters and said these are the observation wells

with regard to the Criner and Parks report.

Do you recall that?

A Yes, I do.

Q And you were asked a lot of questions about whether you had verified the accuracy of everything in Criner and Parks.

Do you recall that?

A Yes.

Q Is it uncommon for any expert to rely on published scientific information provided by the United States Geological Survey?

A My opinion of the US Geological Survey is high. I hold them in phenomenally high regard. I understand the complexity of their process of data evaluation, report writing, and review, and I simply trust what I see from that organization more than any other organization that exists to do this kind of work, not just in this country but in the world.

Q Thank you.

Now I'm going to show you something. You were shown one -- a blowup of one slide out of the Criner and Parks report. And I'm going to hand you a copy of that report, which is Exhibit J24.

Do you have it already?

A I think so.

Q Do you have a copy of it?

A I'm looking. Just a second. Is it a specific figure from

it?
Q No, just the report itself.
A I have J22, J59, J58.
Q You don't have J24 in front of you? Okay. That's fine.
A I do not.
MR. ELLINGBURG: May I approach the witness, Your Honor?
THE COURT: Yes, you may.
MR. ELLINGBURG: Thank you.
BY MR. ELLINGBURG:
Q I'm going to hand you a copy of J24, and I'd like you just to take a moment and look at it and tell me if there is any basis, other than those four observation wells, in this report for the conclusions reached by Criner and Parks, including past studies, if there are any.
MR. BRANSON: Your Honor, it just looks like Mr. Ellingburg is handing him a marked-up copy that has sticky notes.
THE COURT: You can come over here and look at it if you want to.
MR. ELLINGBURG: It isn't marked. I will direct you to page 10.
THE COURT: Let him look at it.
MR. BRANSON: Well, I have an absolutely clean version of Criner and Parks.

MR. ELLINGBURG: So do I.
MR. BRANSON: So there's no markings on there?
MR. ELLINGBURG: No, sir. That wouldn't be right to do that.
MR. BRANSON: Okay.
THE COURT: Okay. You may ask the question.
BY MR. ELLINGBURG:
Q I'm going to ask you to read the paragraph on page 10 that starts with "This report reviews."
A "This report reviews the historic changes of water levels in the Memphis area with emphasis on the period after 1960. It also presents information on pumpage from the Memphis Sand since 1886 and from the Fort Pillow Sand since 1924, and it discusses the relationship between pumping rate and water level decline to 1975. The report is intended to provide basic data and interpretive information for use by water managers, planners, and other persons interested in the groundwater resource and to update prior publications discussing the water level changes in the Memphis area."
Q Thank you.
It says "update prior publications." And does it identify any specifically?
A "General aspects of the aquifer systems in the Memphis area are described or discussed in reports by Schneider and Cushing -- that's with a C -- 1948; Criner and Armstrong, 1958,

Criner, Son, and Nyman, 1964; and Bell and Nyman, 1968, "and other reports which contain pertinent information about pumping rates and water levels where the principal aquifers are included in the selected references."

Q And I'm going to just ask you to look at page 32 and 33 and tell me if that's a list of selected references referred to by the author of that report -- of the authors of that report that are supporting and providing information for their conclusions?

A Yes.

Q Okay. Thank you.

Now I'm going to ask another question or two, and then I'm going to move on.

Now, is it uncommon for the USGS to build on their past studies in a specific area rather than just starting all over again?

A It would not be uncommon. It would be -- in my opinion, it would be expected of their behavior.

Q Is it a fact that, based on the published reports, the USGS has been collecting water data from the Memphis Sand, the 500-Foot Sand, since the early 1900s?

MR. BRANSON: Objection. Leading, Your Honor.

THE COURT: Well, overruled. You may answer the question.

THE WITNESS: Yes. I've seen even in that list of selected references data that support their involvement for a

long period of time.
BY MR. ELLINGBURG:
Q And just to make the point, and I believe the text of this report refers to earlier, but could you tell me what the citation is with regard to Wells in 1931?
A The specific reference is Wells, F.G. The publish date would be 1931, "A Preliminary Report on the Artesian Water Supply of Memphis, Tennessee." It's a US Geological Survey water supply paper, 638-A, 34 pages in length.
Q Thank you.

Now, do you know whether Criner and Parks' work was later rejected by any other USGS groundwater hydrologists studying the groundwater system in the Memphis area?
A I've seen no evidence to support that statement.
Q Now, do you know if it's been subsequently cited by other USGS official reports?
A Yes.

MR. ELLINGBURG: Josh, I have a few marked here. Do you have one I could just show him and give back to you?
BY MR. ELLINGBURG:
Q Dr. Spruill, I'm going to show you a report that's been marked as Joint Exhibit 10, which is titled "Digital Groundwater Model of the Memphis Sand and Equivalent Units, Tennessee, Arkansas, and Mississippi."

I believe we've referred to that before, but I only

want to ask you one question about this one. Okay?
A Okay.
Q Would you please turn to page 26?
A Is that J26 or their page 26?
Q It's J10, page 26 of 80.
A I see it now. I understand. I found that page.
Q Okay. Thank you.
Would you just read for us the final paragraph on that page?
A You're talking about page 26 of 80?
Q Yes, sir, where it starts with "Transient conditions."
A That paragraph reads, "Transient conditions associated with pumping are thought to have dominated the system since 1886 when the first wells were drilled and pumped. From 1886 to 1975, pumpage at Memphis has gone down to the original potentiometric surface by as much as 150 feet and the major pumping center and reversed the original gradient which was to the west (Criner and Parks, 1976). Flow that moved through the area towards natural discharge points to the south and west before 1886 is now diverted and captured by pumpage at Memphis."
Q So at least at this point in time, the Criner and Parks paper you were cross-examined on still is being accepted. That's 1981, right?
A Correct.

MR. BRANSON: Objection. Leading.
THE COURT: Overruled. Don't lead your witness.
MR. ELLINGBURG: Thank you.
BY MR. ELLINGBURG:
Q One more on this. Dr. Spruill, I'm going to hand you Exhibit J15. And I believe this has also been discussed during your testimony, but I'd just like to ask you one question about it.
A Do you want this back?
Q Or a couple of questions, actually. One is not true.
First, what is the date of this report?
A The year 2001.
Q So this was published in 2001; is that correct?
A That's correct.
Q Now, if you would, look over to page 10 of 64 of J15.
A I found page 10 of 64.
Q Okay. Do you see an area that starts "Previous investigations"?
A Yes.
Q Now, do you see the -- and I'm not asking you to read it all, but do you see a list of prior USGS investigations in this area that this report is building on?
A Yes.
Q Okay. And among that list of reports, do you see Criner and Parks?

A I see Criner and Parks, 1976, and Parks and others -- and other authors combined. But I see Criner and Parks in 1976 listed.

Q Thank you.

So is that the procedure that was -- is generally followed by United States Geological Survey now for decades?

A That would be my understanding of how they work, having studied with a USGS hydrogeologist.

Q Do they have any particular high standards of what they will allow to be published based on the work they do?

A Again, I have phenomenal confidence in them, and I believe they have -- their standards are the highest caliber imaginable.

Q Thank you.

And if you would, turn to page 61 of 64 of that report, if I'm looking at the right one.

Have you found it?

A Yes, I have.

Q Now, in the lower right-hand corner, it starts off with "Selected references."

Do you see that?

A Yes, I do.

Q And could you tell us, just so we can understand, what the US Geological Survey uses as support for their papers and their publications? Essentially, how many pages do we have of

reports?
A So on page 61, roughly a fourth of a page of references, a full page on 62, a full page on 63, and 80 percent of a page on 64.
Q And we're talking about two columns, right?
A We're talking about two columns on three of the four pages.
Q Thank you.
Now, you've been asked a fair number of questions about this physical boundary that exists or does not exist or, for that matter, any impediment at all at the Mississippi-Tennessee border. And I believe that you have clearly testified that some water moves across the border, right?
A That some water --
Q Some water is moving across the border?
A I have.
Q Molecules, we talked about molecules this morning.
A Yes.
Q Okay. There is -- but you've said there are differences in the geology within that area of the facies change from north in Memphis; is that correct?
A Correct.
Q Okay. Why are those differences important, briefly?
A Okay. The importance of those differences are, or the importance is, that a change from more permeable material to

lower permeable material, facilitated by a reduction in grain size from north to south and an increase in clay content in the aquifer system from north to south, results in a reduced capacity of the groundwater system to transmit water. It slows it down.

And so, to me, that's a form of a barrier. But I felt like there was some discussion about things like this. The geologists know how to put in a physical barrier. We can call them grout barriers. I wanted to make sure we weren't talking about that. There's no sort of man-made barrier there. There's a transition in aquifer materials to the south.

Q Thank you.

Now, what determines the natural direction and flow of groundwater within a specific area where there is no pumping? So on a high level, what determines that?

A The composition of the materials will help to determine the rate of flow, and the inclination of the aquifer system and the configuration of layers above and below it relative to the recharge area control, in large part, the direction and gradients of the groundwater flow.

Q Is what you have determined in your studies with regard to the composition of the earth beneath the surface in the Middle Claiborne -- I mean, in the confined Sparta Sand in Mississippi and the Memphis Sand in a little bit of Mississippi, is that consistent with the direction of groundwater flow that you have

seen in the USGS reports?
A Yes.
MR. BRANSON: Objection. Leading.
THE COURT: Well, overruled. You may answer.
BY MR. ELLINGBURG:
Q Now, the fact there's no hydrological barrier there means it's possible to pump water out of Mississippi by reducing the pressure significantly within those two formations, isn't it?
MR. BRANSON: Objection. Again, I'm sorry, Your Honor, but he's leading.
THE COURT: Don't lead your witness.
MR. ELLINGBURG: Thank you, Your Honor. I was just trying to hurry us along to make everybody happy.
THE COURT: I understand.
THE WITNESS: Especially me.
BY MR. ELLINGBURG:
Q Especially you.
Would it be possible to pump water out of Mississippi into Tennessee if there were a complete physical barrier, like a Great Wall of China, below the ground?
A Not as long as it was intact.
Q Okay. So this hydrogeologic connection they're talking about, how does that relate to making it possible for someone in Tennessee to pump water across the state line or vice versa?
A In spite of the fact that the -- in my opinion, the

aquifers are different because they have different characteristics, there is a transition zone there in the composition of the materials; hence, a change in the permeability of the materials, so there's not a preclusion of water. There's a change in the ability of that aquifer zone in that part of the world to transmit water.

Q Thank you.

So it makes it possible to pump it into Tennessee from Mississippi?

A It certainly does.

Q Thank you.

Now, you've made this comment several times, so I'm only going to ask it once, and you just give a short answer.

Assuming a molecule of water, which was the reference used by Mr. Branson, enters into the confined portion of the Sparta Sand in Mississippi, or even that little bit of the Memphis Sand in Mississippi, how long would it take that particle of water to follow its natural flow path and ultimately be discharged?

A I've stated already that groundwater velocities are in the order of a few inches per day, and so given the particular flow path that you're talking about through the aquifer and then upward across any confining layers along the axis of the Mississippi Embayment, it could take literally thousands of years for that water molecule to complete that travel path.

Q Now, each of those individual molecules wouldn't follow exactly the same path, would it?
A Similar, but not exactly the same paths.
Q And why is that?
A That's because the groundwater system is complex, and there are lots of fine-grain particles there that are incredibly small. They all can't follow the same flow path. They have to diverge and go downgrade in the direction of the decreasing total hydraulic head.
Q Now, Mr. Branson used the phrase in one of his questions, and I want to make sure that phrase isn't taken out of context.
Is the groundwater within the State of Mississippi that is at issue in this case in the confined aquifer, is it a body of water?
A I think that's a terrible way to describe the groundwater system. A body of water gives the connotation of a lake, a pond, a river, and so it's not a body of water. It's an amount of water stored in the pore spaces of the naturally-occurring sedimentary materials that make up that part of the system.
Q Does that water residing under pressure in the confined aquifer have any role in what's going on at the surface? I mean, does it -- is it part of the earth?
A It's absolutely a fundamental part of the earth. I'm not sure what you're asking me. I'm sorry.
Q Well, okay. So you mentioned earlier that, if you take all

the water out of it, what do you have?
A If you take the water out of an aquifer, you have a formation, a geological formation, not an aquifer, because an aquifer is a group of some sort of material that can transmit usable quantities of water. So an aquifer is a two-part thing. Take the water away, you no longer have an aquifer; you have a formation, a geological formation.
Q Thank you.
And the -- the water is what we're talking about in terms of hydrogeology in this case, is it not?
A The water is a resource, from my perspective, because it's what we consume. It's what you can use an aquifer for is the water. A 500-foot-deep layer of sand that has no water in it doesn't -- is not much of a resource unless you can drill and mine at those depths. The resource is the water in the aquifer.
Q Now, your testimony has been directed to the science -- or has your testimony been directed to the science of geology and hydrology?
A Yes.
Q Do you consider yourself qualified to give any legal opinions?
A No.
MR. ELLINGBURG: That's it. We thank you. We have completed with this witness.

THE COURT: Okay. Any recross?

MR. BRANSON: Just very briefly, Your Honor, if I may.

RECROSS-EXAMINATION

BY MR. BRANSON:

Q Dr. Spruill, whenever you're ready.

A I'm ready.

Q Okay. Do you recall when Mr. Ellingburg just asked you about what you have termed the Lower Claiborne Aquifer, correct?

A The Lower Claiborne Aquifer.

Q You recall that testimony, correct?

A Yes. Yes.

Q MLGW does not have any well screens that are touching the Lower Claiborne Aquifer, as you framed it, correct?

A It doesn't exist in that part of the world.

Q So the answer is no?

A The answer is no.

Q MLGW is pumping, for purposes of this case, out of the Middle Claiborne Aquifer, correct?

A Yes.

Q And there's no barrier, again, that's going to block water from flowing from what you've termed the Lower Claiborne Aquifer into what you've termed the Middle Claiborne Aquifer, correct?

A There's no barrier that will prevent it from flowing.

Q And the same -- the converse is true as well. There's no barrier that would prevent flow naturally from going from the Middle Claiborne Aquifer into what you've termed the Lower Claiborne Aquifer, correct?
A There's nothing that prevents it from flowing.
Q Either direction, from the Middle Claiborne Aquifer to the Lower Claiborne Aquifer or vice versa?
A Correct.
Q Dr. Spruill, I'd like to put plaintiff's slide 26, our slide 16, back up. And let's blow it up, and let's look at the Reed in 1972 map.

Do you see that, Dr. Spruill? And do you recall your testimony about it?
A Yes.
Q Now, I want to focus on what you called the facies change, which is that gray horizontal line. If we can zoom in a little bit. It's south of the state border.

Do you see that?
A Yes.
Q On this chart, that facies transition zone, as Reed has depicted it, is entirely south of the Mississippi-Tennessee state line, correct?
A That's what's shown on this diagram.
Q And, Dr. Spruill, when you drew the transition zone earlier in your chart over here, you also drew the transition zone as

south of the Tennessee-Mississippi border, correct?
A Yeah. I sketched it that way and indicated that it's based on this general concept of a facies change in the subsurface, which is not a sharp line but, rather, a transition from one material to the other so that this is not a sharp boundary.
Q It's not a sharp boundary, but that's why you created the transition zone on your chart, the two green diagonal lines at the top, to depict that zone of transition, correct?
A Yes.
Q And that zone of transition, as you drew it on your own chart, is entirely south of the Tennessee-Mississippi state border, correct?
A On this particular figure.
Q And on the chart that you drew in this courtroom?
A Well, I have it slightly south of the Mississippi-Tennessee border.
Q So the answer is yes, the way you drew it, the transition zone, in its entirety, is south of the border?
A The way I drew it.
Q So according to Reed, which we have on the screen here, I believe you testified, in your view, at least in this evidentiary hearing today, that the portion of this Middle Claiborne Aquifer that's north of the facies change, you've called that the Memphis Aquifer, correct?
A Yes.

Q And even if you accept for a second that the Memphis aquifer is separate from the Sparta, according to Reed's figure, the Memphis Aquifer also crosses state lines, correct?
A According to this diagram, yes. In other more recent work -- I believe it's more recent work -- detailed -- more detailed maps of the thickness of the Sparta and Memphis show the line essentially at the border, sometimes crossing the border. So I just try to emphasize that.

This is something that's occurring in the subsurface that is a transition zone over some distance, and geologists just see it as what it is, like facies change from one material to another that occurs over some reasonable horizontal distance.
Q And according to Reed, that transition zone occurs south of the border, correct?
A According to Reed, that's where it occurs.
Q And Reed worked for the USGS, correct?
A Yes.
Q And you have opined at some length that you trust what the USGS does, correct?
A That doesn't mean that interpretations can't change and become refined, but I trust the USGS at the time.
Q But you acknowledge, for example, that the interpretation the USGS might have had in 1976 might change over time as newer data become available, correct?

A It can change subtly. It changed subtly, especially in this area, according to the data I've seen.
Q And you have not seen any data, Dr. Spruill, that would suggest there's a hard facies change line between the Mississippi-Tennessee boundary?
A That's not what a facies line is, sir.
Q Correct. So you have not seen any at the state boundary, correct?
A Yes.
Q Mr. Ellingburg had you read a series of reports on page 10 of that article, Schneider and Cushing; Criner and Armstrong; and Criner, Son & Nyman, and Bell and Nyman.
Do you remember reading that?
A I do.
Q You hadn't reviewed any of those articles for the purpose of evaluating Criner and Parks' predevelopment map, have you?
A I don't recall doing that.
Q You didn't mention any of those papers at your deposition, did you?
A I don't think so.
Q You didn't cite them in your expert reports, did you?
A No.
Q On page 10 of that article that Mr. Ellingburg had you read, Criner and Parks don't say anything about predevelopment groundwater flows, do they?

A I don't remember.
Q Well, you can refresh your memory if you'd like.
A Someone will have to give me the article.
Q Here you go. I've got a fresh copy for you, Dr. Spruill.
A So can you repeat the question?
Q Sure. On page 10, which Mr. Ellingburg had you read a laundry list of citations, that page does not discuss the specific predevelopment potentiometric surface that we have put up on the screen today?
MR. ELLINGBURG: Objection to form. Objection to I don't understand what he means by "put up on the screen."
MR. BRANSON: That's what I've put on the screen right now.
THE COURT: If the witness doesn't know, he can say so. If he does, he may answer.
BY MR. BRANSON:
Q Do you remember discussing this map, Dr. Spruill?
A I do, yes.
Q This is the predevelopment equipotential surface?
A Yes.
Q Do you have any idea whether any of those citations Mr. Ellingburg had you read in court say anything about this specific figure?
A I wouldn't -- I would have to really dig into it to answer a question like that.

Q And you have not dug into it, correct?
A What?
Q And you have not dug into it, correct?
A I didn't say that. I would just have to dig into it to refresh my memory of what data he used to generate this report, this particular figure. So hold on while --
I don't see any reference to use of a previous report to generate the figure that you're showing by Criner and Parks, 1976.
Q So of all of the citations Mr. Ellingburg asked you to read, you have no idea whether anything in there supports the figure that I put on the screen, do you?
A Well, none of this work is done in a vacuum. All of these that USGS geologists rely on knowledge gained in previous reports to help them do the things they're doing now. So it's not like they've walked out there and they didn't know anything and they didn't focus on any reports that were in the past.
But to answer your question, I don't know if he used specific reports done in the past to generate this figure.
Q And, conversely, you also don't know whether anything in any of those reports you cited say anything about the predevelopment equipotential surface of this region that we have on the screen, do you?
A No.
Q Dr. Spruill, you also discussed a Joint Exhibit 10 in

response to Mr. Ellingburg just now. This was the Brahana paper entitled "Digital Groundwater Model of the Memphis Sand and Equivalent Units."

Do you recall that testimony?

A Yes. Yes.

Q This was not on your reference list in either of your expert reports either, was it?

A Brahana?

Q This specific Brahana paper that he had you read, Joint Exhibit 10.

A Could I see it, please?

Q Yeah. Unfortunately, this is my only copy because I --

A I'll give it back.

Q I'm sure you've got it in there.

A No, I think they took it back.

Q That's fine. Take a look.

You can keep that, Dr. Spruill. I procured myself another one.

This wasn't in your reference list in your expert reports, was it?

A I don't think so.

Q So you didn't review this in connection with evaluating Criner and Parks' predevelopment map, did you?

A No.

Q So what you were doing earlier on redirect, you were just

reading aloud from a document that Mr. Ellingburg placed in front of you, correct?
A I was answering Mr. Ellingburg's question.
Q Dr. Spruill, you never worked at the USGS before, have you?
A No.
Q I also want to now focus on Joint Exhibit 15. That's the other Brahana paper, the 2001 paper that Mr. Ellingburg placed in front of you on redirect.
Do you recall that testimony?
A I'm sorry. Which paper now?
Q Joint Exhibit 15, the Brahana and Brashears 2001 -- you got it?
A Uh-huh. Okay.
Q Do you know, Dr. Spruill, what Brahana and Brashears say about the reliability of Criner and Parks' predevelopment equipotential map in this paper?
A I do not.
Q Okay. That's -- that's my only question on that.
A Okay.
MR. BRANSON: I think that's it, Your Honor. I appreciate it.
THE COURT: We'll take a short recess before we go on. We'll take a recess.
(A recess was taken.)
THE CLERK: All rise. The Court will be back in

session. You may be seated.

THE COURT: All right. Who is our witness?

MR. McMULLAN: Yes. The State of Mississippi calls Dave Wiley.

THE COURT: Okay. Everybody finished with Dr. Spruill?

MR. ELLINGBURG: Yes, Your Honor.

MR. BRANSON: Yes, Your Honor.

MR. D. BEARMAN: Yes. I'm sorry, Your Honor.

MR. McMULLAN: May it please the Court. Your Honor, my name is David McMullan. I've not yet spoken, I believe, in court today. I wanted to introduce myself.

THE COURT: Okay. Glad to have you?

MR. McMULLAN: Thank you.

DAVID WILEY,

having been first duly sworn, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. McMULLAN:

Q Mr. Wiley, can you hear me okay?

A Yes, I can.

Q Okay. If you cannot at some point, please tell me. We're all here to hear your very important testimony, so it's clearly important that we hear what you have to say. So take it slow, take it easy, and make sure that what you say can be heard in

the courtroom.

Mr. Wiley, what's your full legal name, sir?

A David Allen Wiley.

Q What do you go by?

A Dave most of the time.

Q And if I may, I may address you as Dave at times, and I don't mean any disrespect to the Court, but I may refer to you as Dave.

Mr. Wiley, tell me where you're from.

A I live in Denton, Florida, which is near St. Petersburg, Florida.

Q And tell me, are you married?

A Yes.

Q And I understand you have another passion in your life that may involve cycling; is that correct?

A Yes, I did, until about seven or eight months ago.

Q And are you okay to make it through and sit and deliver your testimony today in spite of that injury?

A Yes.

Q If at any point in time you become uncomfortable and you need to take a rest or stand up, will you please let us know. I'm sure the Court will allow that. Okay?

A Okay.

Q Mr. Wiley, tell us, where do you work?

A I work for WSP USA.

Q That's a mouthful. What is WSP USA?
A It's an international engineering consulting firm.
Q Tell me the types of work that the firm handles.
A The firm handles a variety of work, from -- anywhere from transportation consulting, design and consulting, to water and environmental consulting.
Q Yes, sir. What is your title with the company?
A I am the Tampa area manager for the water and environment group.
Q All right. And how long have you been with WSP?
A It's a little more than a year and a half. WSP acquired my old firm, Leggette Brashears & Graham, in August of 2017.
Q All right. Tell us about Leggette Brashears. What was Leggette Brashears?
A Leggette, Brashears & Graham was a groundwater consulting firm that had been in existence since about 1944 that specialized in groundwater consulting, and I've been working with that firm since 1985.
Q Okay. 1985. Were you with Leggette Brashears when you first started working on this case in 2006? Is that right?
A Yes.
Q Okay. And were you a partner at Leggette Brashears?
A Yes, I was.
Q Did you manage others at Leggette Brashears --
A I'm sorry?

Q -- did you manage other personnel at Leggette Brashears?
A Yes.
Q As part of your work?
A Yes.
Q And your title, again, was what at Leggette Brashears?
A Well, I was a principal in charge.
Q Okay.
A Senior vice president, like being an owner.
Q And as far as your area of expertise while you were with Leggette & Brashears, what is that area or what are those areas?
A Groundwater consulting.
Q Okay. Are you a registered professional geologist?
A Yes, I am, in the state of Florida and several other states.
Q Are you licensed or -- licensed as a professional geologist in Tennessee?
A No. Oh, I'm sorry. Yes.
Q Okay. I know you have an aversion to associating with Tennessee at the moment, but let's just go with it.

Nevertheless, tell me a little bit about -- we've heard some discussion in court, and I know you were present for some of the testimony and the opening statements.

We've heard a lot about hydrogeology. I'd like for you to remind the Court what your view of what that discipline

is. What is hydrogeology?
A It's the -- it's the -- with respect to the discipline of geology and the science of geology, hydrogeology specializes in the study of groundwater within geologic systems.
Q And when you say "within geologic systems," are you including in that definition of hydrogeology both groundwater and surface water?
A Yes.
Q Okay. And tell me about or, more accurately, tell all of us about your duties presently at WSP as a hydrogeologist?
A Well, my first duty, I'm managing the staff in the Tampa area in the water and environmental division, but my responsibilities are to get work and do work.
Q Okay. Who do you get work from and do work for?
A With respect to our water resources work --
Q Yes, sir.
A -- many of the clients are municipalities, water agencies. And there's quite a bit of private industry.

The environmental work, mostly private industry, but also with municipalities.

Q Okay. That's who you get the work from or you seek to get work from.

What kind of work do you do for those entities, in a little more specific -- a little more detail?
A For example, with respect to municipality water utility

departments, we help them develop, permit, design, manage their well fields or groundwater systems in their well fields.

Q Would that include -- do you do any advising of those entities with respect to how they operate water systems?

A Yes.

Q Do you do any work with respect to advising those entities in terms of analyzing prospective or planned groundwater withdrawal systems?

A Yes.

Q In more layman's terms, do you talk to your clients about where to put their wells?

A Some of the clients, yes, they ask us to help them with the well field, well location, and design.

Q Yes, sir. And I believe you've got in front of you -- I don't want to test your memory too much unnecessarily.

MR. McMULLAN: We have had a submission, Your Honor, a joint submission of the credentials, including Mr. Wiley's, as docket 73, I believe. 78 or 73.

BY MR. McMULLAN:

Q But you've got a copy. You've got that in front of you if you need to reference that, but I want to talk to you a little bit about some of the particular projects you've been doing or have done over the course of your career.

So take me back. So how long have you been actually doing the work you just described of advising clients about

where to put well systems, how to operate them, and analyze those issues? How long has that been?

THE COURT: Is there any objection to the credentials of this witness?

MR. D. BEARMAN: No, Your Honor.

MR. McMULLAN: Your Honor, I'd be happy to tender the witness.

MR. D. BEARMAN: I'm sorry. Your Honor, subject to our -- we have motions.

You're asking about the CV?

THE COURT: Yes.

MR. D. BEARMAN: Not the CV, but we have our pending motions, so we reserve.

THE COURT: Okay. You may proceed.

MR. McMULLAN: Thank you, Your Honor.

BY MR. McMULLAN:

Q Let's talk a little bit more about some of the specific projects, some examples, if you would, of where you have worked with clients to develop well fields in, I understand, Florida or other places. Tell us about where you worked.

A Mostly in Florida.

Q What other states besides -- you mentioned Tennessee. You're registered in Tennessee as a licensed geologist. Have you done work in the area of groundwater well field planning in states besides Florida?

A I worked quite a few years back, it was in the -- I think it was early '90s -- late '80s, early '90s. Assisted the State of Mississippi with the state water plan.

Q All right. And in your career, would you say that the balance of your work in the area of hydrogeology has been more towards the groundwater issues or surface-water issues?

A Groundwater issues.

Q Can you -- and we're not going to belabor the point, but a lot of us have heard about the differences between groundwater and surface water.

Is it your view that there's some fundamental differences between issues that are to be analyzed with respect to groundwater and surface water?

A It's completely different.

Q How so?

A Surface water, you can see it. It's -- it's exposed. It's in -- it's contained and it doesn't have to flow through a rock system like groundwater does. So for groundwater, you need to understand the hydrogeologic character of the formations that the water is moving through.

Q And groundwater?

A Yes.

Q What characteristics would you ascribe to the analysis of groundwater issues? Is it complex?

A Oh, very complex.

Q Is it more difficult, in some means, to measure what's happening with groundwater versus surface water?
A Well, they both have their complications. But there are certain tools we use to develop an understanding of hydrogeologic system or aquifer system, such as putting in test wells, monitor wells, performing some pumping tests to measure the character of the aquifer system --
Q Yes, sir.
A -- in the confined units.
Q And the term "flow" has been used in the courtroom in this case a number of times. Could you please describe for the Court and for all of us what you mean by "flow" in the context of groundwater versus surface water, generally?
A Well, groundwater moves very slow. Surface water moves at a speed of miles per day. Whereas, groundwater is inches per day.
Q Yes, sir. Thank you.

And I believe you made reference to working with clients with regard to groundwater withdrawal systems.

Did you use that phrase? Or maybe I'm thinking about it. Is that a phrase you've heard before, "groundwater withdrawal systems"?
A Yes.
Q What's a lay term for that?
A The well field.

Q Okay. And so you worked with well fields. And are well fields the principal vehicle which you've worked with in terms of how water is removed from -- groundwater is removed from aquifers?
A Yes.
Q And your experience with -- in the area of hydrogeology and working with public entities, do all public entities rely on surface water?
A No.
Q Do all public entities rely on groundwater?
A No.
Q Let me back up a little bit, and just from -- and you can do this from memory, but you're welcome to refer back to your CV if you need to.
Tell us about where you attended college.
A University of South Florida in Tampa, Florida.
Q Okay. And what program did you take, and what degree did you obtain there?
A Bachelor's degree in geology.
Q And what year did you obtain that?
A 1980.
Q Did you have any coursework in hydrogeology during the course of your time in college?
A Yes.
Q Okay. What types of courses did you have?

A I took the basic hydrology course that they teach as part of the curriculum for geology there.
Q All right. Mr. Wiley, are you a member of any professional organizations?
A Yes. American Institute of Professional Geologists, AWWA.
Q What is AWWA?
A American Water Works Association.
Q Thank you.

A lot of folks hate acronyms, and I do too, so thanks for explaining that.

Before you worked at Leggette Brashears -- well, let me make sure I take this in more logical order.

When you finished your degree at the University of South Florida, where did you go to work?
A I went to work at the Southwest Florida Water Management District, which is in the Tampa Bay area.
Q That's a mouthful. I will not use an acronym, but may I refer to them as Southwest for purposes of my question?
A Yes.
Q Thank you.

Tell us about what kind of work that you do at Southwest.
A I worked in the regulatory department, and my work included evaluating water-use permit applications for groundwater withdrawals.

Q Okay. I think I skipped over something. What is Southwest?
A Southwest Florida Water Management District is a state regulatory agency that manages and regulates the use of water, whether it's groundwater or surface water. And it's an arm of the Department of Environmental Protection.
Q Okay.
A Who is the -- sort of the umbrella agency in the state.
Q Is there a federal agency that does that type of regulatory work in Florida that's corollary to Southwest?
A No.
Q Okay. The state handles that?
A Right.
Q Adopts its own laws and regulations, would that be correct?
A That's correct.
Q And that's how it carried out that function; is that correct? Using the laws of Florida and regulations of Florida, that's what your agency carried out?
A Yes.
Q How many regional agencies are there in Florida?
A Five.
Q And you're one of five. Which one of the five are you with?
A Southwest Florida Water Management District, which it does have an acronym and they call themselves SWFWMD. The mud

doesn't relate, but --

Q Okay. Great. I'm going to skip that acronym for sure.

All right. And tell us about exactly -- well, not exactly. Give us some examples of what your duties were and how you carried them out at Southwest?

A Well, as I mentioned a few minutes ago, I evaluated water-use permit applications for groundwater withdrawals, and many of those that I worked on were municipal -- municipal supply applications for city and county well fields.

Q All right. And when you worked with Southwest, were you involved in any way with testing with regard to groundwater control?

A Yes. I was involved with testing design. In some instances we would require the permit applicant to provide supporting information for their permit application, and if it was -- especially if it was a new facility. And back in those days -- that was '80 to '85 -- Florida was growing vastly. And there was a lot of new development, so a lot of new groundwater supplies were being developed.

So we were requiring those folks to go out and collect data by putting in test wells. Then we would require them to prepare a test plan. We'd review it and approve it and sometimes help participate.

Q Were you involved in the performance of testing while you were with Southwest?

A Not directly but indirectly through observation of the applicants doing their testing.
Q So you would analyze the results of the testing to determine whether it was sufficient?
A Yes.
Q Were you involved in the analysis of the testing to see if it was rigorous?
A Well, if it met the requirements that we were -- that were included in the approved test plan.
Q And you're welcome to refer back to your CV, but I would like for you to give us just a couple of examples, if you don't mind, of some typical types of projects that you handled while with Southwest. Or you can do it from memory if you'd like.
A Well, the City of St. Petersburg has -- had three well fields that I had to evaluate their -- the permit renewals and modifications for those permits. And it actually -- they were -- they were looking to re-manage the well fields. And there were some politics going on. A new agency was being invented called the West Coast Regional Water Supply Authority, and they were going to take over those well fields. So I was in the middle of evaluating their permits and amongst -- while this transfer was going on, so that was an interesting -- interesting angle there.

There were -- many of the permits I was renewing at that time were renewals and modifications.

Q Okay.
A But once -- once I left the district, then I got into doing the work -- you know, doing more of the design work myself.
Q Okay. Let me take you forward in time a bit and ask you just for maybe one or two examples of projects that you handled while with Leggette Brashears that involved groundwater.
A Okay. Probably one of the more interesting ones recently was City of Tarpon Springs, which is along the Gulf Coast of Florida, north of Clearwater, St. Pete.

They were looking to develop a new groundwater supply. Historically, they had been buying water from a regional water supply. The prices were going up, and they decided they were going to develop their own supply. They obtained fund -- state funding that helped them do that or they would not have been able to do it.

But they developed a brackish groundwater supply, and I was a project manager at Leggette Brashears & Graham that designed, permitted, tested that project. And it actually -- the permit received objections, and it had to go to an administrative hearing before a state hearing officer in the state. I won't get into what the objections were because it's -- it's really not relevant to anything.
Q Okay. Let me ask you, if I may, while you're on that topic, have you testified in relation to groundwater issues as an expert in any of your prior employment with Leggette

Brashears or Southwest?
A Yes. I testified once while I was with the Southwest Water Management District in a hearing that involved the renewal of a major well field by the regional water supply authority, and at the same time a private property owner that was actually adjacent to that well field that owned a big ranch wanted to develop his own well field and sell the water to the same people that were buying the water from the regional authority well field.

So it went to a hearing, and I was evaluating the permit for the regional well field that was being -- being renewed, so I testified regarding the renewal of that particular permit.
Q With respect to your work in the area of evaluating water-use permits, did that evaluation include development or consideration of safe yields?
A The water management district had a set of rule criteria that every water supplier had to meet, and as we evaluated permits, we would follow those rule criteria to see if their pumpage -- we'd run groundwater models to see if their pumpage would -- and the effects of that pumpage would meet the rule criteria.
Q And I used the term "safe yield." Perhaps you should tell us if that has any particular meaning in your work.
A Safe yield?

Q Yes, sir.
A It -- yes, it does. It has -- it could have several meanings.
Q What was the meaning it was given in terms of the criteria that you mentioned you applied in evaluating the permitting of water?
A To either minimize or not impact items that were addressed in the rule criteria, such as effects on other water users -- I should say unacceptable effects on other water users; unacceptable effects on wetland systems.

The Tampa Bay area, especially to the north, is characterized dramatically with wetlands and lakes, and so the -- and the groundwater system is fairly leaky from the surface, so we had to evaluate effects on wetlands and lakes to ensure that groundwater withdrawals were not exceeding the requirements there. So that -- that's where you -- that's where I would relate safe yield there.
Q Yes, sir. Did you also have occasion, in your work with those -- with Southwest and with Leggette Brashears, to evaluate safe yield with respect to impacts of aquifers?
A As a matter of fact, I mentioned earlier the City of St. Petersburg well fields. I had -- when I was with Leggette Broshears & Graham, I performed a safe yield analysis of one of their well fields. And, again, it was based on regulatory criteria from the Southwest Water Management District to

determine what that safe yield from the well field would be.
Q Did the evaluation in those instances include evaluations of how much was going to be pumped from the aquifer?
A Yes.
Q Other than what you've described, I think you mentioned in your CV that you'd done some work for other areas. Did you mention Parkland Springs already?
A Yes.
Q And Upper Floridan Aquifer. Have you done any work with the Upper Floridan Aquifer?
A Pretty much all of the work in Florida deals with the Upper Floridan.
Q So permitting and consideration and the analysis you're talking about had to do with aquifers; they all related to the Upper Floridian?
A Upper Floridan.
Q Upper Floridan. Excuse me.

In your work in your time with Leggette Brashears and with Southwest and now with WSP, have you had occasion to analyze the issues relating to groundwater flow?
A Yes.
Q One time? Many times?
A Pretty much everything we do deals with groundwater flow.
Q Okay. And in -- among the examples on your CV, are there any examples that come to mind in which you analyzed flow?

A Well, pretty much every permit I've worked on, every municipal water supply system that has a well field, we've had to do groundwater flow modeling to assess impacts to make sure that we meet rule criteria with the Southwest Water Management District.

Q While you were at Leggette, did you do any work in other aquifers outside of Florida? For instance, in North Carolina.

A Yes. Long-term project in coastal North Carolina. It's a very large phosphate mining operation, and they -- the mining operation is -- it's a dry mining operation where large draglines are used to get the ore body out of the earth, which is -- I forget the exact depth to the ore body. But there's a confined aquifer below that ore body, and it's under -- it's under pressure, so for the mine to be able to safely dry mine, they have to de-pressurize the aquifer in the area where they're digging.

And we've been helping them since -- well, my former boss at Leggette Brashears & Graham was working there in the '60s, and I inherited that when I came to Leggette, Brashears & Graham, and we were still helping them design and de-pressurizing wells, design and locate those wells so they can adequately pressurize the aquifer. And we do that through use of groundwater models.

Q That was going to be my next question.

In your work in analyzing groundwater flow, you work

with models. Is there more than one type of model that you work with? Or can you give us an example of what you're talking about or an explanation of what you're talking about? When you say modeling, what do you mean?

A Groundwater flow modeling, for the most part, on all these water resource projects. And groundwater model, it's a -- it's a tool that hydrogeologists and engineers use. It's a computer tool with -- made up of mathematical calculations to simulate a groundwater system. And it's used -- we developed these models to use to help assess what -- what the groundwater system is doing, what's happening to it based on stresses that are placed on the system.

MR. McMULLAN: Your Honor, if it hasn't already been admitted, I'd like Mr. Wiley's updated CV to be admitted into evidence as part of Docket Number 73. Any objection to that?

MR. D. BEARMAN: No objection, Your Honor.

THE COURT: All right. No objection. It may be entered in.

MR. McMULLAN: Thank you, Your Honor.

MR. BRANSON: Based upon the testimony so far and based upon the CV, I'd like to tender Dave Wiley as an expert in the area of geology and hydrogeology.

MR. D. BEARMAN: Your Honor, we reserved our objections in the form of our motions.

THE COURT: All right.

MR. HILL: Yes, we have the same objections.

THE COURT: I will overrule it for this time but without prejudice for it to be raised later. So you may testify as an expert, but you still preserve your objection. We'll take it up later, if necessary.

MR. D. BEARMAN: Thank you, Your Honor.

THE COURT: You may proceed.

MR. McMULLAN: Thank you, Your Honor.

BY MR. McMULLAN:

Q Dave -- let me refer to you as Mr. Wiley. I'll be a little more formal.

Tell us about how you became involved in this case, now, from I understand, 13 years ago?

A Yeah. I believe it was 2006, I was asked to look into this issue with respect to the groundwater conditions in the DeSoto County, Mississippi, area.

Q Who asked you to look into the conditions in the DeSoto County, Mississippi area, the best you recall?

A The State of Mississippi.

Q Thank you.

Before that point in time, did you have any personal involvement in any of the issues that have been discussed in this litigation or that you've been asked to give opinions about?

A No.

Q Okay. And is that correct? I'm assuming I'm correct, but I believe that you or your firm were retained in 2006. Does that sound about right?
A I think it was about that time. I don't know the exact date, but it was 2006. It had to have been 2006 because our first report was 2007.
Q Yes, sir. And you can put this in lay terminology and not necessarily in hydrogeological terms.
But can you tell us what Mississippi asked you to do when they retained you and asked you to look at these issues?
A We were asked to evaluate the groundwater conditions in the northwest Mississippi area/DeSoto County area with respect to pumpage coming from Memphis.
Q Were you asked to do anything else when you were initially retained?
A Yeah. We were asked if we could determine how much water that was being captured from Mississippi by pumping in the Memphis area.
Q Have you, in the course of your investigation, referred to the concept of diversion at any point in time?
A Yes.
Q And, if you would, could you explain what diversion means?
A It would be the capture of water from DeSoto County, Mississippi, and inducement of it to move into the Memphis area as a result of groundwater pumpage.

Q Was that the result of any particular condition? Was it a natural situation or was it unnatural?
A Well, of the -- the diversion would be caused by pumping, so that's not a natural situation.
Q Were you asked to -- excuse me. Were you asked to estimate how much water had been diverted?
A Yes.
Q Do you recall approximately what period of time that you were initially asked to calculate the amount of diverted water from Mississippi?
A Yes. 1965 originally through 2006. And then eventually through 2016.
Q And since you've been involved in this case -- and I understand you've been involved since 2006. And over the course of the 13 years, I understand that you've had more than one round, if I can use that term, of work that you've done in the case; is that correct?
A We've -- we've prepared three different reports.
Q So let me ask you this. In each instance where you prepared reports, were you able to complete the assignments that you had been given by the State of Mississippi?
A Yes.
Q All right. Let me talk to you about, first, the first round, for lack of a better term, the first initial work that you did in 2007.

And I think you mentioned that the assignment was to evaluate the effects on the groundwater conditions in Mississippi, particularly in DeSoto County, as a result of groundwater pumpage by MLGW; is that correct?

A Yes.

Q Okay. Tell us -- and we'll get more into detail in a few minutes, but can you give us a 30,000-foot explanation as to the steps that you took to evaluate that question put to you by Mississippi?

A Yes. I guess the first thing would be that we would review existing available reports on the hydrogeology and groundwater conditions in the DeSoto County, Memphis area.

Q Let me stop you there and ask you this. Is that standard procedure for hydrogeologists to examine literature of studies by prior hydrogeologists?

A Yes.

Q Okay. Can you just give us one or two examples of the types or categories of existing literature that you turned to to begin to investigate this issue? Is there a category --

A Well, we -- the United States Geological Survey would be always the first place we go.

Q Is the USGS -- and I may use an acronym, if I may. I'm going to break my own rule.

Is the USGS, pardon me, considered authoritative as a source of information by hydrogeologists?

A Yes.
Q What is the second thing that you did in the course of your initial analysis?
A We -- we performed a flownet analysis.
Q Let me stop you there and ask you to explain what that is. Is that a type of groundwater modeling?
A It's a -- it's an analytical model that hydrogeologists did -- it's a methodology hydrogeologists use to calculate flow through a given geographic area.
Q And before I move to the next step, is that also a common methodology, or is that something you had to invent?
A No. That's -- that's -- it's one of the first things you learn in hydrology class.
Q Is there another step that you took in your analysis initially?
A Groundwater flow modeling. Computer groundwater.
Q And I apologize, Madam Court Reporter. I'm going to do my best not to speak over the witness.

And, likewise, let me finish my question. You may know exactly what I'm going to ask you but let me finish it for a clearer record.

A All right.
Q Thank you.

Okay. So we talked about computer groundwater modeling. Was there another step that you took in your initial

analysis?
A Yeah. Groundwater budget analysis to help us to determine what the diversion amounts were that we were talking about a little while ago.
Q How is that different from modeling, if at all?
A Well, groundwater budget is a part of the modeling.
Q Is that a way to say that you calculated totals?
A I'm sorry. I didn't hear.
Q Is a water budget analysis the way you calculated the totals of the diversion?
A Yes.
Q All right. Let's go back to the first step that you took. I want to ask you, you mentioned that you had looked for authoritative existing literature on the subject matter.
Did you find specific subject matter literature about the issues in the area around Memphis already in the literature?
A Yes.
Q Was that USGS material?
A Yes, it was.
Q Do you recall seeing any other reports from the existing literature about the MLGW pumping in the area of Memphis other than from the USGS?
A Yeah, there were the State of Tennessee and the University of Memphis.

Q Okay. Any particular entity within the University of Memphis that was involved?
A Groundwater Institute.
Q Okay. Is that where Dr. Waldron works?
A He did back in 2007. I --
Q He's not that old.
A I assume he's still there.
Q All right. And did you find any information in the literature where there had been any sponsorship by any of the other parties in the case?
A Well, there were quite a few USGS reports that were cosponsored by MLGW.
Q Memphis Light, Gas & Water, the defendant in this case?
A Yes.
Q In what period of time did you find that there were sponsorship studies of the groundwater conditions in Mississippi as a result of the Memphis area pumping that were sponsored by MLGW?
A I don't know if I can recall exactly those kind of dates, but we had -- we reviewed reports back from the '60s. As early as the '60s, 1960s.
Q Okay. And did the range, the chronological range of the literature that you looked at in 2007, did it stop in the 1960s? Did it decide to stop looking at the issues and stop publishing about it?

A No.
Q How far into the future did you find that the literature continued?
A Well, the -- one of the primary, excuse me, reports that we -- we relied on in our analysis was the report by the USGS in 2001 by Brahana and Brashears.
Q Is that the same -- I believe you've been in the courtroom while there's been pretty extensive testimony about different reports from Brahana. Is that the Brahana we're talking about?
A Yes.
Q We'll get back to that in a few minutes.

Do you recall any papers from the 1960s area -- era, excuse me, from the USGS that were authored by anyone named Gerald K. Moore?
A Yes.
Q And do you recall what, if anything, was significant about the Moore study that you looked at, if you recall?
A Well, we were -- one of our tasks was to determine how much water was being diverted from Mississippi to Tennessee, and Moore had -- in his report in 1965, he had indicated that there was approximately 25 million gallons a day that was estimated to flow from the south of Memphis into Memphis, into their groundwater system. And that date, I think, he -- he related that to the year 1960, I believe.
Q Okay. Did that article have any other information that you

considered to be particularly interesting in your initial analysis?

A Well, there was obviously information in there regarding the impacts or the drawdown effect occurring from the Memphis area and the surrounding area.

Q What do you mean by "surrounding area"?

A Well, the Memphis area down into Northern Mississippi.

Q All right. So that article had some -- expressed some concern about the development --

MR. D. BEARMAN: Objection. Leading.

THE COURT: No leading.

MR. McMULLAN: I'll rephrase, Your Honor. Thank you.

BY MR. McMULLAN:

Q Did that article have any statements that related to any impacts in Mississippi?

A Yes. As I mentioned, he identified 25 million gallons a day of flow in the groundwater system from the south into the Memphis area.

MR. McMULLAN: Your Honor, I've got an exhibit I'd like to show the witness. I can share with counsel, if I may, please.

THE COURT: All right.

MR. McMULLAN: Your Honor, I'll be turning to electronic copies after a couple of these exhibits, so it will make it a little bit quicker.

Your Honor, may I approach?

THE COURT: Sure.

MR. McMULLAN: And this is a copy of several exhibits that I'll be using.

BY MR. McMULLAN:

Q Mr. Wiley, I'm going to hand you what's been marked as J58, a Joint Exhibit. I don't need you to read the entirety of that large document, but could you identify Exhibit J58 for us, please?

A "Geology and Hydrology of the Claiborne Group in Western Tennessee, Geological Survey, Water Supply Paper 1869-F."

Q Is that the -- is that the Moore report you've been talking about?

A Yes.

Q All right. Can you tell me -- and you may be able to do this from memory. If you can, I don't want to belabor this, but is there any mention of the existence of a cone of depression in that report?

A I believe there is.

Q We'll talk more about that in a bit.

How about other reports that you considered in your analysis -- initial analysis of the existing literature about the issues in North Mississippi arising out of Memphis's pumping? Do you recall any other names of any other authors?

A Well, I mentioned Brahana and Broshears. There was also

Arthur and Taylor.

MR. McMULLAN: All right. Your Honor, may I approach the witness and show him J10, which is Brahana?

THE COURT: Yes, you may.

BY MR. McMULLAN:

Q There you go.

Mr. Wiley, what is that document?

A "Digital Groundwater Model of the Memphis Sand and Equivalent Units, Tennessee, Arkansas, Mississippi," by J.V. Brahana.

Q And did you consider that report to be significant in your initial analysis?

A Yes.

Q And do you recall why you gave it some significance in your initial analysis?

A It -- it was identifying the impacts in the Memphis area.

Q All right. And I've got one more paper copy. I'm going to make the walk one more time. J3.

A By the way, David, this is --

Q Yes, sir.

A -- this is not the 2001 Brahana report.

Q What year did that come from?

A 1981.

Q All right. And I think I handed you J3. Is that right?

A Yes.

Q And what is J3?
A "Definition of the Geohydrologic Framework and Preliminary Simulation of Groundwater Flow in the Mississippi Embayment Aquifer System, Gulf Coastal Plain, United States," by J. Kerry Arthur and R. E. Taylor, United States Geological Survey, Water Resources Investigations Report 86-4364.
Q Okay. And how was that report significant in your initial analysis of the existing literature on the issues of the groundwater pumping by Memphis and the effects in Mississippi?
A It was an overall assessment within the Mississippi Embayment that included the Memphis area, which was the area we were interested in for this project.
Q Let me ask you that right there. You said these studies were on the area in northeast Mississippi and Memphis; is that correct, all these studies we're talking about?
A Yes.
Q Were they -- these studies were not studies -- let me rephrase.

Were these studies of the entirety of the Mississippi Embayment?
A No.
Q All right. And with respect to the existence of a cone of depression emanating from Memphis and affecting groundwater in Mississippi, were these studies consistent or were they at odds with one another about the existence of such a cone of

depression?
A No. They all identified that there were -- there was a cone of depression in the Memphis and surrounding area.
Q Was there any indication in the literature review that you did of any experts in the area of hydrogeology doubting the existence of such cone of depression existing from the Memphis pumping extending into Mississippi?
A No.
Q All right. Let's talk a little bit about the second step. We've covered generally in your first assignment your first step, which was looking at the existing literature. You've done that.

The second step, you remind us again what you did in your second step? Did you do your own work, or did you do something different?
A The flownet analysis, we performed our own and compared our results with others that had done similar analysis.
Q And I think I've asked you, but I want to return to it. Is the flownet analysis a standard methodology used by hydrogeologists to calculate the amount of groundwater that flows through a defined geographic area?
A Yep. That's what I said a few minutes ago.
Q You said it better too.

And why did you use the flownet analysis?
A To help determine the amount of water that was flowing from

Mississippi to the Memphis area as a result of pumpage in the Memphis area, primarily from MLGW.

Q All right. In performing your flownet analyses, did you have to utilize any existing materials to begin that process? How do you do that?

A Well, yeah, the standard process, you utilize potentiometric surface maps. So we were able to obtain a number of potentiometric maps from the United States Geological Survey, and those maps were based on existing measured groundwater level data.

And then you take those maps and you construct flow -- flownets on those maps by drawing flow lines perpendicular to the potentiometric surface lines that are on the map.

Q Okay.

A Your downward flow is always perpendicular to potentiometric surface. So we drew the flow lines on the map and in the direction of Memphis and the well fields up there. And then there's -- you use Darcy's law, a primary law in hydrology, to calculate flow through these -- this flownet.

Q Let me stop you and ask you this. I'm not going to ask you to explain Darcy's law, but is Darcy's law standard methodology for calculation of these flownets?

A It's a standard calculation for flow in the underground.

Q And the potentiometric maps that you utilized from the USGS, did you just pick one year, or did you pick a bunch of

years?
A We picked a few years. I believe there was about six years we were able to get at that time.
Q Do you recall generally the spacing or the span of the years in which you examined those, generally?
A I think we were 1980. And a couple of them were in the '80s, a couple in the '90s, and then the early 2000s.
MR. McMULLAN: Okay. Dawn, would you put up slide Number 25, please.
MR. D. BEARMAN: Excuse me, Your Honor. I'm sorry. I'm sorry to interrupt. Our screen is not working, so I just want to make -- because that's the only way we can see.
MR. McMULLAN: What do you want to do?
THE COURT: Is it working now?
MR. D. BEARMAN: Not yet, Your Honor. I'm sorry.
THE COURT: We'll take a short recess while you do that.
(A recess was taken.)
THE CLERK: All rise. The court will be back in session. You may be seated.
THE COURT: I've been advised that you're willing to go ahead, but we still don't have any contact here.
MR. D. BEARMAN: That's correct, Your Honor. We have paper copies, and we're happy to push forward.
THE COURT: Okay. We're going to see if we can find

an IT specialist. I'm not too familiar with the facilities, but we'll try and help you out.

MR. D. BEARMAN: Thank you.

MR. McMULLAN: May I proceed?

THE COURT: Yes.

BY MR. McMULLAN:

Q Mr. Wiley, I want to double back around and ask you about a document before you. I asked you some questions about the various studies, existing studies in the literature that you examined in your initial analysis of the issue of the effects of MLGW pumping on Mississippi. I asked you about a Brahana study, and I want to ask you perhaps if you looked at this study. This has been previously marked as J15.

MR. McMULLAN: May I approach, Your Honor?

THE COURT: Yes.

MR. McMULLAN: You have copies. I don't have extra copies.

BY MR. McMULLAN:

Q Mr. Wiley, have you had a chance to look at that document?

A Yes.

Q What is that document?

A "Prepared in Cooperation with City of Memphis, Memphis Light, Gas & Water Division and the Tennessee Department of" Environmental -- "Environment Conservation, Division of Water Supply, Hydrogeology and Groundwater Flow in the Memphis and

Fort Pillow Aquifers in the Memphis Area, Tennessee, Water Resources Investigation Report 89-4131."

Q Who's the author?

A Brahana and Broshears.

Q And I think you may have mentioned Brahana and Broshears. Is that the one you were talking about?

A Yes.

Q Okay. And I believe the other one you mentioned, the other Brahana, was an earlier study, the other exhibit you've got in front of you that's an earlier study by Brahana?

A Yeah, it -- J10 is dated 1981. J16 is dated 2001.

Q The 1981 study, was it also part of your initial literature which you reviewed?

A Yes.

MR. McMULLAN: I'd like to move to have admitted into evidence each of those exhibits. That's J58, J15, J10, and J3.

THE COURT: Any objection to those?

MR. HILL: No, Your Honor. These have all been admitted conditionally subject to our outstanding relevance objection.

THE COURT: They're admitted. Thank you.

MR. McMULLAN: I'm sorry. I didn't know that we had an agreement. I apologize.

THE COURT: Yes. Thank you. I thought we did.

MR. McMULLAN: Yes, sir. I'm defaulting in my

mechanics, and so I thank you.

THE COURT: You're doing fine. Thank you, sir.

BY MR. McMULLAN:

Q Let's go back to the slides. We may --

MR. McMULLAN: And, David, this is P170. David Bearman, this is P170.

BY MR. McMULLAN:

Q Mr. Wiley -- if you could go to slide 25, Dawn.

Mr. Wiley, can you see that on the monitor?

A Yes.

Q All right. And what are we looking at in Exhibit Number P170? Is that a USGS potentiometric surface map we've been talking about, or is it something different?

A It's a USGS potentiometric surface map for 2000 in the Greater Memphis -- or the area there.

Q Okay. This is one -- is this one of the USGS -- is this one of the USGS potentiometric surface maps that you used to perform your flownet analysis in your second step in your initial work?

A Yes.

Q Okay. And if you would, could you explain to us what this shows generally and explain how you reached a conclusion about what it shows?

A Well, it shows the potentiometric surface elevations in 2000, and it -- what it shows is a cone of depression in the

Memphis area. You see the little bulls-eyes here and there. Those are cones of depression, individual cones of depression. Then you see a larger cone of depression outside of the Shelby County, Tennessee, area.

Q Let me stop you there and ask you a couple of questions about the little bulls-eyes.

Do you see the little bulls-eyes you just mentioned?

A Yes.

Q There's one that's pretty close to Davis. What is that?

A Well, that is a small cone of depression that would be related to the Davis well field.

Q Okay. And similarly, I guess I see Allen and Lichterman. Are those also well fields?

A Those are MLGW well fields.

Q And you said that these individual bulls-eyes -- what is the significance of the individual little bulls-eyes? How do they have any relationship, if any, to the overall cones of depression?

A Well, all of these well fields have their own cone of depression, but when you mix them all together, you have a large regional cone of depression.

Q Okay. And does the cone of depression, as depicted on P170, indicate whether the cone of depression extends into DeSoto County, Mississippi?

A Yes, it does.

Q And tell us -- and I don't want to make this too complicated, but I want to make it clear in the record how you used this map in your flownet analysis. Take us through what you did when you got the map, and each of these maps. What is the next step in your methodology to complete the flownet analysis?

A The groundwater gradient goes from higher potentiometric surface elevation to lower potentiometric surface elevation, and on this map, as you sort of move from east to west, the potentiometric surface levels decrease until you get around the well fields.

In order to -- groundwater flow is always perpendicular to -- or at 90 degrees with potentiometric surface elevations. So what we do to determine -- to make a flownet, we draw lines perpendicular to these black potentiometric surface lines everywhere.

From -- and our interest was starting them in DeSoto County, starting those lines in DeSoto County, and following -- and drawing them until they reach into Shelby County at the well field areas.

And you draw a number of those flow lines across there until you have a net, so to speak, and then you calculate the amount of flow based on Darcy's law to get -- to get from DeSoto County into the well fields at Shelby County.

Q Okay. Let me stop you and ask you a couple of questions

about that process.

And what we're looking at on P170, this is something you prepared at Leggette Brashears, or is this a USGS document?

A This map was prepared by the United States Geological Survey, the potentiometric surface contours were.

Q Your reference to USGS, is that a source?

A Yes.

Q But it's got a name on the bottom, Leggette, Brashears & Graham, so this shows it was prepared by your firm, right?

A Right.

Q So is it correct that you took a USGS map and you utilized that and it became what we're seeing in P170?

A Yes.

Q And I -- make sure I'm clear on this also. We've got lines. The lines that you mentioned that you draw in perpendicular to the potentiometric surface lines, they're not on this one yet?

A No.

Q All right. And I think you said earlier that flownet analysis was done to calculate the amount of groundwater flowing from Mississippi into Tennessee and that you used a number of different potentiometric maps for a number of different years. Is that correct?

A That's correct.

Q And do you recall, what are the years generally that you

looked at besides -- and what year is this? This is a 2000, I believe, right?

A Yes.

Q Do you remember what other years you looked at?

A There were several in the '80s, several in the '90s, 2000, and I think 2005.

Q Okay. We'll come back around to this in a few minutes in a little more detail. But let me ask you generally, your analysis of the flownet that was based on these different potentiometric surface maps, what did you conclude, if anything, about flow of groundwater from Mississippi into Tennessee?

A We calculated about an average of 33 to 43 million gallons a day from those flownets going from DeSoto County into Shelby County.

Q And for what period of time are you talking about that these maps and the resulting flownets --

MR. D. BEARMAN: Your Honor, can we -- we want to renew our objection with respect to relevance. Your Honor asked us to address whether this is an interstate resource, and now we're talking about amounts diverted, which we assert is not relevant to the issue and the factors that Your Honor identified.

MR. McMULLAN: If I may respond. Your Honor, all of this testimony and the documents which we intend to introduce

go to the characteristics of the water that's at issue in the aquifer, and so it's relevant to the issue of whether the water was interstate in nature or was, in fact, mobilized unnaturally to become interstate. And that's critically important to the core issues in this case, so it's -- it's of the most highest relevance that I can imagine.

THE COURT: What do you want to say about the state?

MR. HILL: Your Honor, we join in the continuing objection. We think that pumpage and diversion are not relevant to the core characteristics of the aquifer that would make it an interstate resource or not.

Also note that we think we're prejudiced because we closely followed Your Honor's discovery order and did not take discovery on this subject.

MR. McMULLAN: May I respond to that last point? We engaged in extensive pretrial, and there's no surprise in any of this, so there's no prejudice.

THE COURT: I'm going to overrule the objection subject to it be stricken later on.

MR. D. BEARMAN: Thank you, Your Honor.

THE COURT: Your objection has been preserved.

You may proceed.

MR. McMULLAN: Thank you, Your Honor.

BY MR. McMULLAN:

Q Let's get back to where we were talking a moment ago before

the objection. Let me restate the question or reask the question to make sure I'm clear about this.

I think you indicated that there was some calculation that you'd derived about the amount of groundwater that was diverted from Mississippi into Tennessee; is that right?

A That's right.

Q And what was the range again?

A I believe it was approximately 33 to 43 million gallons a day for those years that we looked at. I don't recall the amount for each year, but I know that was the range.

Q And the range that you just mentioned was the output of the model of the flownet analysis that you conducted?

A Yes.

Q Okay. And I think you said earlier that you had considered in the literature, among the literature that you looked at, were sources that included one from 1965 by Moore.

Do you recall that? We talked about that.

A Yes.

Q Do you recall -- I believe you may have mentioned there was some figures -- or were there any figures mentioned about the estimated amounts of groundwater that was being diverted from Mississippi into Tennessee by Moore in 1965?

A Yes. I mentioned earlier that he reported 25 million gallons a day.

Q And how does that figure compare to the range that you

established with your flownet?
A Well, his number was generated in 19- -- of 1960 information. There wasn't as much pumping as there was later.
Q Okay.
A So it's -- it does -- his number sounds reasonable with respect to the numbers we calculated. It was just earlier on when there was less pumping occurring.
Q Okay. I want to go back to the Brahana and Broshears model or -- the Brahana and Broshears study that you have before you, I believe the 2000.

Do you have that?

A 2001.
Q 2001. Excuse me.

Can you take a look at that again and tell us what the significance was in that report with respect to any information concerning groundwater flow that was modeled in that study?
A Well, this -- this study was a -- Brahana and Broshears developed a groundwater flow model to simulate the hydrologic system around the Memphis and surrounding area.
Q How did the methodology that was employed by Brahana and Broshears compare to the methodology that you utilized in your flownet analysis?
A Well, he used a numerical groundwater flow model. Whereas, this flownet was not a numerical model.
Q Which -- which would be more sophisticated?

A The numerical groundwater flow model.
Q And why was the Brahana model and Broshears model significant to you when you considered the results of your study, if it was significant?
A Well, it addressed, again, as I said, the groundwater conditions in and around the Memphis area, that it showed that there was a cone of depression extending down into DeSoto County, and it was a calibrated groundwater flow model to 1980 conditions.
Q Okay. To 1980. So did the range consider the groundwater flow level conditions from predevelopment?
A Yes.
Q And generally, what do you mean when you say "predevelopment conditions"?
A Conditions where there's no pumping going on, where there was no pumping in the aquifer.
Q Okay. And in the Brahana model that you're talking about, there's some discussion about predevelopment conditions; is that correct?
A Yes. There's a -- a map presented, a predevelopment map, an estimated predevelopment map by -- that originated from Criner.
Q Okay. Dawn, would you put up slide Number 11, which is P168.
Okay. Is that what we're talking about?

A This -- yeah, the source of this map was from Criner. We -- we utilized Criner's map and modified it slightly to extend the potentiometric surface contours further down into DeSoto County.

Q Okay. And any other modifications of Criner's work other than what you've just described?

A No.

Q Tell us what we're looking at here in lay terms.

A This is our potentiometric surface map that we utilized from Criner as a starting point. It -- we've also drawn flow lines on there that are perpendicular to the potentiometric surface contours. Those are the blue and green lines.

And then we have a yellow triangle on there. It says, "Area of limited natural flow from Mississippi to Tennessee." And at this time, the blue lines were labeled intrastate flow because that water stayed in -- for example, up in the -- the blue lines at the top were flow lines that stayed in the State of Tennessee, and then the flow lines in the bottom stayed in Mississippi, and then there were green lines that went from Mississippi into Tennessee.

Q Okay. And I don't think we have any indication on here -- when you say "flow," we don't have any indication on this particular potentiometric or flow to indicate what the flow rate is, but just generally, when you say "flow," what are you talking about with respect to this particular --

A We're just showing the direction of flow.
Q Okay. What -- and, again, for the benefit of the Court, what's the rate of flow generally in this area predevelopment?
A Inches per day.
Q All right. And I believe -- let's go back to the steps that you were taking in your initial assessment. And when you decided to do the modeling, the computer modeling, is that the next step that you did in your analysis initially?
A Yes.
Q Did you -- did you just pick a model randomly, or did you select a model, or what did you do?
A Well, we reviewed this -- the Brahana model from this 2001 report. There were several other models that were -- that were provided to us. I forget the first names, but there was an Outlaw model, a Kenley model. We reviewed those -- those three models and selected the Brahana model to use as our tool for evaluating the groundwater conditions in this area.
Q Why did you choose to utilize the Brahana and Broshears model?
A It was set up to better represent the groundwater system that we were -- exists there. It was calibrated to 1980 conditions. It was a good calibration.
Q Let me stop you there and interrupt you, if you don't mind. I'd like to ask you to explain what you mean by "calibration."
A When you develop a groundwater flow model, you set up a

model grid for the area in question. And this grid has cells where you assign off for characteristics to the cells to represent the hydraulic system in both aquifers and confining layers.

Once you get the model set up, then you try to match water levels that the model calculates with actual observed measured water levels in the field. The process for calibrating typically includes adjusting aquifer characteristics in the model until you get your best match.

And then once the model is calibrated, you use the model to simulate and evaluate hydraulic conditions, groundwater conditions.

Q And you did all those things?

A No.

Q Not at this point?

A No. We -- we utilized Brahana's calibrated model.

Q Got it. And does that model have a name?

A Oh, the -- it's MODFLOW --

Q Okay. And what's MODFLOW?

A -- if that's what you're asking. I think it's --

Q Well, I was asking, you know, what -- if it had a particular name or is it just Brahana.

What's MODFLOW?

A MODFLOW is a model developed by McDonald Harbaugh of the USGS. It's the -- sort of the bible of groundwater flow models

that's been used for decades now.
Q And with respect to calibration, was MODFLOW suitable or not suitable?
A Suitable.
Q And you said "suitable." Why was that?
A I'm sorry?
Q Why was it suitable? Why was it well calibrated?
A The model was specific for the area we were evaluating, so that was a big plus for us. And it had a very good calibration to the year 1980 when -- that 1980 stresses on the groundwater system were pretty high, so it had a good calibration there, so that's why we elected to use this model to further evaluate more recent conditions.
Q Okay. And with respect to your use of the model, what did you do to use the model in terms of how -- what period of time did you evaluate, for instance?
A Well, we were asked to look at -- from 1965 through -- originally through 2006 and then 2016.
Q Okay. Let me ask you about that. So you did the initial work in 2007, and there was some subsequent work; is that right?
A Yes.
Q Okay. In 2017, I think you mentioned?
A 2014, then 2017.
Q Did you just rerun the model in 2017, or did you do

anything to change the dynamics of the run?
A The only thing we did to the model was change pumpage as time went on.
Q What do you mean, "change pumpage"? You changed the data?
A We put -- in 2006 we ran the model with what we had through 2006 with respect to pumpage. Then we updated it through 2014 with new pumpage that occurred between the two periods. And then we updated it again after 2014 through 2016, actually. We updated it -- the report was 2014. The pumpage update was 2013 through 2016.
Q Okay.
A For the 2017 report.
Q Thank you. Thank you for that.

Dawn, would you put up slide Number 11. This is P168.

Mr. Wiley, we'd like to take a look at what's been marked as P168, and it's illustrated here on Figure 11, or slide 11.

Can you tell us what we're looking at here?
A That's the same slide we just went over.
Q Okay. I'll move on then. Thank you. I can move on.

Slide 12. All right. What are we looking at here, P172?
A This is a 1980 potentiometric surface map developed from the groundwater model.
Q All right.

A So it shows potentiometric surface contours based on the Brahana model, 1980.
Q All right. And the methodology that you utilized to create this slide, is it the same methodology you've already described?
A Yes. We -- we've just -- we ran the Brahana model to make sure that what we were using matched what he -- he had produced, and it did.
Q Does this slide indicate or illustrate the cone of depression that is -- that results from MLGW pumping?
A Yeah. This is a potentiometric surface map, but you can see there's a cone of depression occurring as a result of the somewhat oval contours.
Q And does this indicate any effect on the groundwater located in Mississippi at this point in time?
A Yes. There's a -- there's definitely an effect to Northern Mississippi.
Q And the effect that you observed in your rendition here, how did it compare to the effects that had been described in the existing literature that you reviewed in your initial literature review?
A This is pretty -- this is similar to what every -- every other author had been describing.
Q I'm going to go back to this issue of calibration. You mentioned that the model was calibrated in 1980; is that

correct?
A Yeah.
Q And what did you do with the model to use it for evaluating groundwater conditions?
You've already covered this, though. You've already explained everything on that.
A We updated it to more recent conditions by adding pumpage as the years went on.
Q Okay. So you took it through 1980, and then subsequently you did additional runs?
A Through 2006 and then through 2012 and then through 2016.
Q All right. Let me go back to the big picture on the different four steps that you did initially in your 2007 work.
I believe you mentioned that fourth step was developing a groundwater budget. Is that right?
A (Nods head.)
Q And remind us, to keep our place here -- it's not easy -- what a groundwater budget is?
A It's the -- it's the inflows and outflows and change in storage in the groundwater system. And the groundwater model develops a groundwater budget when you run the model.
Q How does it do that?
A And then what we do -- what we do, we take the groundwater budget. It's cell-by-cell flows from the groundwater budget, the model. Then we plug them into another USGS program that

calculates the net groundwater budget in an area, and you can assign -- actually, this program allows to you assign numbers to -- you can assign a whole county in one of these zone budgets, and it will calculate the net budget for that particular county. And that's how we determine the diversion maps.

Q All right. Carrying out your water budget analysis again, what did you conclude?

A We concluded that the pumping in the Memphis area, primarily MLGW, was creating a large cone of depression, altering the natural groundwater flow direction in Mississippi and diverting groundwater from Mississippi into the Memphis area.

Q Did you reach a conclusion as to what the disposition of that water that was diverted would have been in the absence of the cone of depression?

A The vast majority of the Mississippi water would have stayed within the State of Mississippi, you know, if it wasn't induced towards Memphis.

Q When you say stayed in the State of Mississippi, for what period of time would it have stayed in the State of Mississippi under natural conditions?

A Well, moving at an inch per day, it would be thousands of years before it reached the Mississippi River.

Q Okay. And did you reach any conclusions in your initial

study as to what percentage of water the Memphis area was drawing from Mississippi?

A Well, in our initial -- as I mentioned from the flownet analysis, it was 33 to 43 percent. Moore had estimated 25 million gallons a day in 1960. We also, through research, found that -- I forget his name, David Fetterman from the University of Tennessee, had estimated in his report 20 to 40 million gallons a day of water being pumped in the Memphis area, it was coming from Mississippi.

Arthur-Taylor, in their study, they estimated 30 percent of the water being pumped in the Memphis area was coming from Mississippi. And.

Mr. Gentry, who used to work for the Groundwater Institute, he even estimated 25 to 33 percent of the water being pumped in the Memphis area was coming from Mississippi.

Q In that initial analysis, did -- that analysis about what was being pumped in the Memphis area, was it an aggregate including MLGW and other sources of pumping, or was it just MLGW?

A Yeah. I believe those numbers I just gave you were all relative to all pumpers, not just MLGW.

Q And we'll come back to this, but in subsequent analysis, did you attempt to separate out what was being pumped by MLGW from the other sources of pumping?

A Yes.

Q Did you complete that analysis?
A Yes.
Q We'll come back to that. Let me ask you a few more questions about the cone of depression.
Have you seen cones of depression in your work in other areas of the country?
A Yes.
Q What is a cone of depression?
A It's drawdown from a pumping well on or from a well field that is in the shape of a funnel where the withdrawal point is in the middle.
Q Okay. Dawn, would you put up slide Number 8, please. It's P161.
Okay. Mr. Wiley, can you see that slide?
A Yes.
Q All right. Did you create this slide?
A Yes.
Q Did you create this slide in the course of your analysis?
A Yes.
Q All right. Tell us what we're looking at.
A These are just examples of what a cone of depression is. Unfortunately, not in 3D but 2D.
The upper -- the upper portion of the figure shows two wells. Both -- each well is pumping and each well has its own unique cone of depression. And the significance of that is

that these cones of depressions do not overlap from those two wells.

Q Okay. And the bottom part of the slide indicates something different, obviously?

A Well, the bottom slide -- part of the slide shows many more wells close together, and their cones of depressions are overlapping.

Q Okay. And which of these depictions, the cones not overlapping or the overlapping cones, would be generally more representative of well fields in the Memphis pumping area -- MLGW pumping, rather?

A Well, the -- there's ten well fields, with approximately 170 wells, and a large cone of depression has been created that covers all of Shelby County and down into most of DeSoto County. So what we have there is one large cone of depression that's created by many smaller cones of depression.

Q All right. And, Dawn, would you put up slide Number 9, please. That's P162.

Mr. Wiley, do you see that?

A Yes.

Q What are we looking at there?

A It's a cone of depression in the Shelby County/DeSoto County area. It shows -- it's vertically exaggerated to get the point across, but it shows -- those -- those black holes, so to speak, are approximate locations of MLGW well fields. So

those are individual cones of depression within a more regional cone of depression that has the outer blue shape.

Q Does a cone of depression exist if pumping exceeds recharge rate? How does a cone of depression happen?

A As I mentioned, the well -- a well draws down the potentiometric surface and is -- does -- it brings in recharge from around the cone of depression, but the cone of depression is created because more water is coming out of the well than can be recharged at the same time.

Q Okay. That kind of depression that we're looking at or that representation of the kind of depression, does it still exist today, as far as you know?

A Yes.

Q Okay. Dawn, let's put up slide Number 7, please. That's P160.

Mr. Wiley, do you see that on your screen?

A Yes.

Q Okay. Tell us what we're looking at in that depiction, please.

A The yellow shaded area is the drawdown area from -- oh, this is from a 2016 model run. The model run -- and it's a 2016 output from the model. The yellow shaded area is actually the 20-foot drawdown contour from that model run, and it represents the cone of depression area out to the 20-foot drawdown contour.

The orange circles are the MLGW well fields, and the size of the circle represents how much water, approximately, is coming from that well field.

Q Okay. And let's take a look at a couple of -- a few of those well fields.

You see the one that's marked as Davis?

A Yes.

Q Can you give me, just approximately, how far from the border between Tennessee and Mississippi that appears to be located?

A Without -- according to the scale here, it's less than a mile.

Q How about Palmer, which is in the center there, close to the line?

A I'm sorry. Davis is probably -- probably a mile -- the scale is so -- it's hard to tell, but near a mile. Palmer is definitely -- it looks like it's less than a mile.

Q And Lichterman, likewise?

A Lichterman, it looks like it's at least two miles, two and a half miles.

Q Okay. And in your analysis, did you consider how many wells MLGW was operating during the period of analysis?

A We considered the total well field pumpage from each well field. The number of the wells really wasn't -- wasn't at issue.

Q All right. And so this cone of depression discussion we're having about 160 and the drawdown, how did it compare to what you found in your literature review of the existing sources of information that we talked about earlier that you did in your first step?

A Again, this is consistent with the -- the studies that had been going on in Western Tennessee regarding the aquifer there around the Memphis area.

Q And in your analysis of the literature and in your own analysis of doing your own modeling, did you reach any conclusions about whether the cone of depression that extends into Mississippi has gotten larger, stayed the same, or gotten smaller over the course of the period of study that you've conducted?

A The cone of depression, I believe it stabilized. If anything, it's stabilized, maybe even gotten a little smaller.

Q Do you have an opinion about why it might have gotten any smaller?

A Yes. MLGW has been pumping less.

Q Okay. And correspondingly, if they pump more, would your expectation be, based upon your analysis, the cone of depression would increase?

MR. D. BEARMAN: Objection. Leading.

THE COURT: Objection sustained.

BY MR. McMULLAN:

Q Do you have an opinion about whether that kind of depression would be affected by any increase in pumping?

A Yes, it would.

Q Mr. Wiley, we've been talking a little bit about an area of study, and I think that on this slide you talk about project area on P160. That's Figure 7. I think you referenced project area in some of your documents.

Why did you study this area and not all eight states that were in the embayment?

A Because this was the area we were asked to evaluate groundwater conditions in.

Q All right. I want to ask you to take a look -- Dawn, if you would, would you put up slide 22, which is P165.

All right. What does this depict?

A It's a simple cross-section, actually a cube, that actually shows the setup of the Brahana model by the hydrogeologic domain and structure with a surficial system, which is represented in the yellow upper confining bed and the gold-ish brown. It says "Sparta Sand Aquifer" in blue and then "Flower Island Confining Bed" below that in gold, gold-ish brown, and then "Fort Pillow Aquifer" below that, and that's the -- that's the structure of the Brahana model.

It also shows -- over to the east side, there's an outcrop area of the aquifer, of the Sparta Sand Aquifer, where

rainfall comes in, provides recharge, and flows into the aquifer.

Q Okay. Just for clarification and make sure we're all clear on this, when you show the arrows here in this depiction in the Sparta Sand Aquifer, you're showing just a direction of movement of the water naturally; is that right?

A Yes.

Q Any indication of what the flow rate is on this depiction?

A No.

Q And, again, what is that flow rate generally under natural conditions?

A An inch or so a year. I mean per day.

Q An inch or so today -- inch or so today -- per day?

A Or per day.

Q I can't even say it. All right.

And we've been talking a bit, or I may have used the phrase a couple of times, "natural conditions." And let me ask you, what do you understand "natural conditions" to mean?

A Well, that we -- I've used it and others have used it as predevelopment conditions before pumping.

Q And in your analysis, did you -- what did you consider to be the predevelopment period of time?

A What was reported by the USGS as 1886.

Q Okay. So in your review of the literature, would it be fair to say or is it accurate to say that this aquifer area,

this area of study, has been examined for decades and decades?
A Oh, yeah. Because we know -- well, one of the first reports we talked about was 1960.
Q Right.
A But there's been older reports.
Q Let's go to slide Number 11, Dawn. This is P168.
Mr. Wiley, can you see that slide?
A Yes.
Q And we talked a little bit about this already, but what is this?
A Again, it's our representation of the potentiometric surface predevelopment in the Shelby-DeSoto County, and it shows the flow paths in both states, and it shows some flow paths that go from Mississippi into Tennessee.
Q Okay. Let me ask you about the yellow triangle that you've got on this depiction.
"Area of limited natural flow from Mississippi to Tennessee," what did you intend to communicate by putting that on there? What is that?
A Well, based on the potentiometric surface contours, when you draw a flow path in that area, as shown in green, that's the direction the groundwater will flow. So we wanted to show that there's an area where groundwater in Mississippi does flow into Tennessee.
Q Compared to the remainder of this depiction, what -- strike

that.

Let me ask you this. On the yellow area, from the right side of that yellow triangle to the Mississippi border, what would be the travel time for that?

A I'm sorry. Could you ask that again, David?

Q Sure. From the yellow triangle, I'm wondering if you could give us your opinion about the time it would take for water that's located on the right side of the triangle to cross the entirety of the yellow triangle to reach the border under natural conditions or predevelopment conditions.

A I haven't calculated that. But, I mean, if I had a calculator, I could. But it's --

Q Let me ask it this way. Would the rate of flow in the predevelopment condition in that area of yellow be generally the same as the rate of flow outside of the yellow triangle?

A It would still be inches per day.

Q All right. In your report and the slides we've been looking at so far today, there have been a number of depictions of the kind of depression that reach from Memphis into Mississippi. Do any of the maps show a cone of depression that cover the entire embayment, the Mississippi Embayment?

A Are you asking if there's one big cone of depression?

Q Right.

A Not -- no, I have not seen that.

Q We've talked a little bit about flow rates today so far.

There's also a phrase that's been used at times, perhaps in the courtroom.

Are you familiar with the a term called "residence time"?

A Yes.

Q What does that mean?

A How long the water resides where it's located.

Q All right. And in the context of this case, we've been talking about flow and how that compares between the flow in aquifers versus surface water. And, again, just to make sure we're all very clear here, the flow we're talking about in the aquifer is -- how does it compare to the surface water?

A Extremely slow moving compared to surface water. I think I mentioned more than five times, inches per day in groundwater, and rivers are typically feet per second.

Q Dawn, let's take a look at -- if you'll pull up slide Number 17. This is P184.

Mr. Wiley, can you see that slide?

A Yes.

Q What are we looking at here?

A This is a map showing particle tracking analysis, specifically across DeSoto County and beyond to the Mississippi River.

The red -- the red line -- it's hard to see, but the state line is right just below the top of the upper red line or

lines, the state line between Tennessee and Mississippi. The DeSoto County line is where the red lines all start. And the blue lines running sort of north-south, northwest-southeast, those are predevelopment potentiometric surface lines. And this -- this base map was generated from the USGS MERAS model.

Q Let me stop you. Let me unpack a little bit of what you've said. It's a lot.

First of all, what is a particle tracking model?

A It measures the flow in time for a particle to move a given distance.

Q Okay. And did you perform this analysis?

A Yes.

Q When did you do this? I'll help you out. This says August of 2017.

A So it was in 2017.

Q Okay.

A August or before.

Q Why did you do this analysis?

A We were interested in finding how long it took a particle of water to move from the DeSoto County line, the east side, across the remainder of the state. And we were also interested in the direction of flow.

Q How long -- how long the water would move across this area under what conditions?

A Under predevelopment conditions.

Q Okay. Excuse me. Let's take a look at your particle tracking analysis insert on the left-hand side.

Do you see that?

A Yes.

Q Tell us what you reached as far as conclusions that are reported there.

A Well, these particles, they all -- they travel differently, so they reach their final destination at different times. So we had the minimum travel time to get from the DeSoto County line across the state was 3,877 years, the maximum was 22,189 years, and the average was 7,542 years.

Q Would that be the same thing as residence time?

A Residence time in Mississippi, yes, for those water particles.

Q Is particle tracking analysis standard methodology or something that you invented?

A No, I didn't invent it.

Q Is it a standard analysis?

A It's a standard -- standard analysis, yes. It's used quite a bit in the contamination assessment industry.

Q Why is that?

A To -- to try to track how long it takes some -- some chemical in the water to move from point A to point B to make sure it's not causing a problem.

Q And you mentioned that this was a MERAS model.

A Yes. The Mississippi Embayment Regional Aquifer Simulation model.
Q And how did you choose the MERAS model?
A Actually, we got it from MLGW.
Q Something they use?
A Yes. I don't know if we got it from MLGW, but you got it for us from somebody on that side.
Q All right. Let's go back. I think we may have already seen slide Number 7, but it's P160. Let's make sure we're clear about this.

Does this depict the area of diversion that you're talking about with respect to water removed from Mississippi by pumping by MLGW?
A Well, it -- it doesn't depict the area of diversion. It depicts the drawdown area or part of the cone of depression.
Q Okay. And can you explain to the court the drawdown area and whether that's the same thing as the cone of depression or what the difference may be?
A This drawdown area is a planar view of where the cone of depression occurs.
Q So essentially, they're one and the same or not?
A I would say yes, this is -- this is a planar view of the cone of depression.
Q What are you saying? What view?
A Map view, planar view.

Q And in your experience as a hydrogeologist planning well fields, is drawdown good, bad, neutral?
A Cone of depression, good -- typically it always occurs when you pump a well because you're drawing down faster than recharge occurs. So it's -- depending on how big it is and what it's impacting as to whether it's good, bad, or otherwise.
Q Are cones of depression avoidable?
A No.
Q Can they be mitigated?
A Yes.
Q What are the means by which they can be mitigated?
A Well, let me -- let me back up on that. The cone of depression in itself can't -- can only be mitigated if you put water back in it. So --
Q How do you do that?
A You'd have to put water back in it, and that's not a normal thing to do.
Q Would the cone of depression we've been talking about today continue to exist if MLGW stopped pumping their pumping station?
A Yes.
Q Why would it continue?
A Oh, did you say would it continue or stop?
Q Yes.
A If they stopped pumping?

Q Yes, sir.
A No, it wouldn't. The cone of depression would shrink and maybe even go away. If there's no pumping at all, it would go away.
Q I want to talk to you a little bit about your analysis and whether you reached any conclusions, and I think you mentioned you had, but tell me if I'm right.
Did you reach any conclusions about the amounts -- total amount of groundwater that was diverted or captured by MLGW through its pumping in Northeast Mississippi, as depicted in the cone of depression?
A Yes.
Q Let's look at slide 26. That's P171. That's not the right one. Let's look at 172, slide 12. No, that's not right either. Hang on a second. The Court's indulgence.
All right. Let's start with this. P157, which is -- is that Figure Number 2, I believe.
Mr. Wiley, there's a lot of information on this, this slide. Tell me what we're looking at here.
A This is a table with historical Memphis Light, Gas & Water pumpage from 1965 through 2016.
Q How was this information obtained?
A Most of it was from MLGW records, and I believe some was from the State of Tennessee.
Q All right. And let's take a look and see, over the course

of a period of time -- I think you've testified earlier that there had been some changes in the total amount of pumping over the course of a period of time from 1965 through 2016. Is that correct or is that --

A Yeah. The pumpage is -- it increased, and then it decreased in later years.

Q Okay. Let's take a look at a couple of the columns that -- let's focus on the well fields that we've been discussing that are closest to Mississippi.

Do you recall those, the Palmer and Davis and Lichterman? Take a look with me on this depiction.

Let's talk about Lichterman first. Can you tell us the trend with regard to pumping in Lichterman, let's say from 2000- -- well, all the way through? Has the trend increased over time, stabilized? What do you see there?

A Well, it started out at 4,240,000 gallons a day. And then it increased 13 million, 14 million, 16. Stayed around that for a while. And then in '78, it got into the low 20s. It looks like mid-'80s, mid- to late '80s, it went up and then went down into the low 20s again, staying in the low 20s. Then in 2001 it dropped below the low 20s.

Q Okay. Well, I follow all that. Let me ask you about totals. At the very bottom, let's look at the 2016 figures.

Out of the various well fields that are on this graph, that are on this list, Lichterman, how does it compare to the

others in that bottom column, that bottom number?
A Lichterman, for example, in 2016, pumps more than any -- pumped more than any of the other of the well field except for Shaw.
Q Let's see. What was the number for Davis in 2016?
A Davis was 14,980,000.
Q Okay. Let's go back to talk a little bit more about what you did in the groundwater budget analysis.
Did you come up with a total amount of water that was diverted from Mississippi into Memphis due to the MLGW pumping?
A Yes.
Q And how did you go about doing that? Let's remind the Court about the methodology involved in the groundwater budget analysis.
A We ran the model, took the cell-by-cell flows, put them into zone budget analysis, and calculated net budget out of DeSoto County into Shelby County.
And I think -- and I think in 2016 the average was about -- in the 2017 report, the historical average we calculated in '65 through 2016 was about 21.7 MGD, if I remember right.
Q Okay. Did you do a groundwater budget analysis in your initial work in 2007?
A Yes.
Q Did you do a groundwater budget analysis in your subsequent

update in 2017?
A Yes.
Q And let's take a look at slide Number 33, Dawn. This is P181.
All right. Mr. Wiley, what are we looking at here?
A Just as it says, "Volume of Groundwater Contributed to Shelby County, Tennessee, from DeSoto County, 1965 through 2016."
Q Okay. Let's start on the left-hand side in from that first data point. About how much are we talking about there for a starting point?
A It looks like about 13 million gallons a day.
Q And then I guess it climbs up, and it peaks out, it looks like, in about 1988. Is that correct?
A That looks about right.
Q And presently for 2016, what did we end up with on your graph?
A We're back down, it looks like, about maybe 14 million gallons a day.
Q So this would be the amounts that you calculated as being contributed to Shelby County from Mississippi due to MLGW pumpage from that period?
A That's right. That's right.
THE COURT: I think we'll stop now for the evening and recess. So we'll resume tomorrow at 9:00 o'clock. We'll

recess now.

(Proceeding concluded at 5:00 p.m.)

REPORTER CERTIFICATE

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COUNTY OF DAVIDSON

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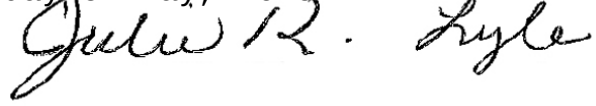

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