In the Matter Of:

STATE OF MISSISSIPPI vs

STATE OF TENNESSEE, ET AL

PROCEEDINGS

May 24, 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 24th, 2019

9:00 a.m.

ON BILL OF COMPLAINT

Before:

HON. EUGENE SILER,

Special Master

APPEARANCES

BARRETT LAW GROUP, P.A.
Attorneys for Plaintiff
BY: DAVID M. MCMULLAN, JR.

DANIEL COKER HORTON & BELL, P.A.
Attorneys for Plaintiff
BY: C. MICHAEL ELLINGBURG
LARRY D. MOFFETT

NEAL & HARWELL
Attorneys for Plaintiff
BY: CHARLES BARRETT

A P P E A R A N C E S (continued)

KELLOGG, HANSEN, TODD, FIGEL & FREDERICK
Attorneys for Defendant State of Tennessee
BY: DAVID C. FREDERICK
JOSHUA D. BRANSON
T. DIETRICH HILL
GRACE W. KNOFCZYNSKI

HERBERT H. SLATTERY III
Attorney General for Defendant State of Tennessee
BY: BARRY TURNER

BAKER, DONELSON, BEARMAN, CALDWELL & BERKOWITZ
Attorneys for Defendants City of Memphis, Tennessee and Memphis Light, Gas & Water Division
BY: LEO M. BEARMAN
DAVID L. BEARMAN
KRISTINE L. ROBERTS

BRUCE A. McMULLEN
Attorney for Defendants City of Memphis

EXAMINATION

EXHIBITS ADMITTED

TRANSCRIPT OF PROCEEDINGS

THE CLERK: All rise. This Honorable Court is called to order, the Supreme Court Special Master Eugene Siler presiding.

You may be seated.

THE COURT: You may proceed with your questioning.

MS. ROBERTS: Good morning, Your Honor. Before I begin or continue my direct examination of Dr. Langseth, there were two housekeeping matters that the parties wanted to address, if Your Honor will allow us.

THE COURT: Okay. Sure.

MS. ROBERTS: Your Honor, the first issue we wanted to address is that prior to this evidentiary hearing, we submitted designations of deposition testimony, and we wanted to state for the record that that is part of the record, the deposition designations and the objections to those portions of designated testimony.

MR. ELLINGBURG: Okay. Mississippi agrees.

THE COURT: Okay. That's fine, then.

MS. ROBERTS: Your Honor, the other issue that we wanted to address is that, as I proceed with Dr. Langseth's direct examination, I will not be offering individually each defendants' exhibit into evidence because of the fact that the parties previously, you know, conditionally submitted all of the evidence into the record, so there's not a need to, with

each new exhibit, ask that it be offered.

THE COURT: Okay. Do you agree with that?

MR. ELLINGBURG: Mississippi also agrees with that.

MR. BRANSON: Your Honor, just to be clear, Tennessee was operating under the same principles when we put on our witnesses.

THE COURT: Well, that's the way I thought it was so --

MS. ROBERTS: I just wanted to make that clear for the record.

DIRECT EXAMINATION (CONT.)

BY MS. ROBERTS:

Q Good morning, Dr. Langseth.

A Good morning.

Q What question were you asked to address or evaluate in this case?

A Well, I was given a copy of Special Master Memorandum of Decision from August 2016 and asked to read this and address the questions that the special master identified for the hearing that -- this hearing that we're in now.

Q And what is your understanding of that question or those questions?

A Well, I'm thinking in particular of the summary page. There was a lot of legal material in the middle that I read but I didn't fully understand, but when we get to the summary page,

the special master provided a very clear statement that he was interested in whether the aquifer was or was not an interstate resource, and then he listed some particular types of evidence that he thought would be useful for making that determination. And so I identified the issues that I addressed in my report based on the -- my understanding of that memorandum.

Q And you said "the aquifer." What is your understanding of the aquifer at issue?

A Well, the aquifer has gone by different names but is most commonly Middle Claiborne Aquifer.

Q I want to make sure that we're on the same page regarding terminology. You used the term "Middle Claiborne Aquifer," and you've heard a number of different terms during these proceedings. You use a different term in your report. Can you explain why?

A Yes, I actually did. In my report I used the name the Memphis-Sparta Sand Aquifer, abbreviated MSSA. And I used that because it's a concatenation of the more commonly known local names for what the -- for the overall Middle Claiborne Aquifer.

And I'd also used that term in my report for the district court action, so to provide some continuity between my work, I continued with that same name.

Q Are these different names for the aquifer at issue used in the scientific literature?

A Yes, they are.

Q Can you elaborate on that, please?
A Well, as explorations are done of the subsurface, names are developed based on, frequently, locations that -- where the explorations are done or other things that seem meaningful to the geologists that are doing the exploration at the time. So you've got this collection of historical names that develop. And then you've also got the broader hydrogeologic unit names that get applied by the USGS as they're later doing more integrated studies.

The Middle Claiborne is one of those sort of broader integrative names where both Memphis Sand and Sparta and other names that we've heard during this hearing, along with the local names that get applied by various investigators for particular reasons during their particular investigations.
Q Do those different names refer to the same aquifer?
A They do.
Q For purposes of your testimony today, if I simply used the term "aquifer," is it -- do you understand that I'm referring to the Middle Claiborne Aquifer or the Memphis Sand-Sparta Aquifer?
A Yes.
Q Dr. Langseth, can you explain to the special master, what is your opinion on the question whether the aquifer at issue here is an interstate resource?
A In my opinion, the aquifer is clearly an interstate

resource, in particular interstate between Mississippi and Tennessee, but also interstate between other states.

Q When we talk about an aquifer, does the aquifer include the groundwater in it?

A Yes. That's -- inherent in the -- when you say the word "aquifer," it includes the water. You can't say the word "aquifer" without including the water. It's the water in the formation, the combination of the two.

Q Dr. Langseth, did you prepare an expert report in this case?

A Yes, I did.

Q Mr. Taylor, could you please bring up Exhibits D191 and D192. And, Dr. Langseth, these are in the binder in front of you at tabs D191 and 192.

Is this your report, your initial expert report, and the supporting figures?

A Yes, it is.

Your Honor, it was issued in two volumes, the first volume being the text and the second volume being the tables and figures.

Q When was this prepared?

A It was -- well, it was issued on June 27th, 2017, and it was prepared in the months preceding that date.

Q How did you go about preparing this report? Tell us what work you did.

A Well, my customary practice for doing this type of work is to first do a literature review and then identify the evaluations that are appropriate to answer the questions that I need to address on this particular topic.

And so, Your Honor, in this case, I first reviewed the literature that I'd already collected and reviewed for the district court action, refreshed myself on that.

Then I identified any additional literature that I could find that had been released since my prior work. And then I evaluated what I thought were the best ways to address the questions that you outlined in your memorandum, the types of evidence you wanted to see. And in doing that, I identified both literature that was relevant and did some modeling studies. So I identified the model that I thought was the most relevant and did some studies with that model.

Q What scientific literature did you review?

A Well, there's quite a wide variety. I would say most of it is prepared by the USGS or in conjunction with the USGS, but there is other scientific literature also, as identified in my report.

Q How did the scientific literature help you answer the question you were asked to address in this case?

A Well, Your Honor, as you review the scientific literature, it consistently, going back over 100 years, probably 130 years, identifies this aquifer as being continuous underneath the

state line, underneath the Mississippi-Tennessee state line, under the Tennessee-Kentucky state line, and other state lines. So the literature really provides a direct and clear answer, in my view, to the question at hand here.

Q Is the literature to which you're referring reflected in your report?

A Yes, it is.

Q Mr. Taylor, could you please bring up -- I guess it's PDF page 16 of the report.

MR. ELLINGBURG: What page did you --

MS. ROBERTS: It's page 10 of his report, page 16 of the PDF.

MR. ELLINGBURG: Thank you.

BY MS. ROBERTS:

Q Dr. Langseth, I'm showing you a page from your report. Let's take a look at the first sentence in the section that starts with 2.3.

Can you read that sentence for the record?

A Yes. It's "Historical and recent scientific literature characterize the MSSA as an interstate aquifer."

Q Did the references that follow the statement support that proposition, in your opinion?

A Yes, they do.

Q Let's take a look at a couple of examples. The first one listed here is Safford.

Can you tell us about that record?

A Yes. Your Honor, this was one of the very first reports -- it's actually the first report that I could find that was evaluating the Memphis water supply.

By 1890 Memphis had just started using wells. They switched from surface water, which had real bacteriological problems, to well water, and this Safford report was one of the early assessments, or the earliest that I could find.

And in there, in this report, they recognized, and you can see in the second line there, that the MSSA, or the Middle Claiborne, extended south into Mississippi and north into Kentucky. So even 130 years ago this aquifer was recognized as an interstate aquifer.

Q Mr. Taylor, if you could go to the next page. Let's take another example, the Stevenson report.

Dr. Langseth, what is this report?

A This was a report that was about water supplies in Mississippi. And it was conducted by the USGS in cooperation with the State of Mississippi.

And in this report, they go county by county through the state. And I've got a quote in here about -- that's from the discussion of the water supplies available in DeSoto County, Mississippi, and that quote is in the last two lines of this highlighted section where it says -- and this is talking about DeSoto County now. It's -- well, first it says --

Stevenson discussed the water supply in Memphis, and then with respect to DeSoto County, he said "similar abundant supplies of water could undoubtedly be developed at comparable depths from the southward extension of the same water-bearing beds."

So this was a report done, in conjunction with the State of Mississippi, by the USGS that 90 years ago recognized the interstate character of the aquifer that we're talking about.

Q Dr. Langseth, in your review of the scientific literature regarding the aquifer, have you found any support for the proposition that the aquifer is not continuous across the Mississippi-Tennessee state line?

A I have not.

Q You indicated that you also made use of a model in your work in this case. Can you tell us about that, please?

A Yes. In order to do my own supporting evaluations, I thought a numerical model would be appropriate, and so I selected a model that has been developed by the USGS under what's called the Mississippi Embayment Regional Aquifer Study. We've heard the term MERAS, M-E-R-A-S, so that's the name of the study.

And as part of the study, they developed a numerical model, and I call it the MERAS model and others call it the same thing. So I used that model to do some evaluations.

Q So the record is clear, who created the MERAS model?

A This was a very large effort by the US Geological Survey. Quite a few people participated. Dr. Brian Clark was the lead developer of the model.

Q What does the MERAS model involve?

A Oh, the MERAS model is a comprehensive model for the entire Mississippi Embayment Aquifer System, so it's -- which is a multi- -- you've heard -- Your Honor, you've heard the description already. It's a multilayered system with aquifers and aquitards in it, and it has an extent over eight states. So the MERAS model is a numerical model, a computer model, of that entire aquifer system.

Q How did the USGS MERAS model help answer the question you were asked to address?

A The primary way which I used the MERAS model is to evaluate flow patterns in the vicinity of the Mississippi-Tennessee border in the aquifer under predevelopment conditions, prior to pumping.

Q Is using a USGS mathematical model to evaluate an aquifer something that is regularly or customarily done in the field of hydrology?

A It's very common, yes.

Q Did anyone assist you with your work in this case, Dr. Langseth?

A Yes. Various Gradient staff worked under my direction.

Q And how did they assist you?

A The primary way is that one person, John Kondziolka, assisted me by actually sort of pressing the keys on the keyboard, if you will, to run the model. He was actually a former student of mine that we hired into Gradient, and I knew of his modeling capabilities from when he was my student.
Q Was the work that he did, was that under your direction?
A Yes, it was all under my direction.
Q Have any of your opinions in your report changed since you've issued the report?
A No, they have not.
Q Are the resources you relied on and reviewed listed in your report?
A Yes, they are.
Q Have you prepared any other reports in this matter?
A I have prepared a rebuttal report also.
Q Mr. Taylor, could you please bring up Exhibit D193? And, Dr. Langseth, this is also in your binder of materials.
Is this your rebuttal report?
A Yes, it is.
Q When was this prepared?
A Well, it was prepared during the month after my initial report, and you can see the release date of July 28, 2017, on the cover page.
Q Did anyone assist you in the preparation of this report?
A Gradient staff again assisted, primarily John Kondziolka.

Q Have any of your opinions in this rebuttal report changed?
A No, they have not.
Q Are the resources you reviewed and relied upon listed in the rebuttal report?
A Yes, they are.
Q Dr. Langseth, you were present in the courtroom for Steve Larson's testimony; is that right?
A Yes.
Q You heard him give an overview of basic principles of hydrogeology?
A Yes, I did.
Q Do you agree with that testimony?
A Yes, I do.
Q And in that case, we don't want to retread that same ground, so I want to go ahead to look at some of the figures in your report. Can you please bring up Exhibit D12, Mr. Taylor.
Dr. Langseth, is this a figure from your expert report?
A Yes, it is.
Q And what is it?
A This is a map prepared by the USGS of what they call the principal aquifers of the United States.
Q And what is a principal aquifer?
A Principal aquifer is identified as a regionally important aquifer that is either currently providing significant water

supplies or the potential to be used to provide significant water supply.

Q What does this figure show about the principal aquifers in the United States?

A Well, it shows a few things. One is that they're distributed throughout the United States. It shows that there's many of them, and it shows that many of them underlie state lines and are, hence, interstate aquifers.

Q Why did you include this map of principal aquifers in your expert report?

A There was really a couple of reasons. One is just to provide context for aquifers, major aquifers, on a US scale, and then also to provide -- to show where the Mississippi Embayment aquifer exists within these larger aquifer systems.

Q Can you show Special Master Siler where the Mississippi Embayment appears on the map of principal aquifers?

THE WITNESS: Your Honor, may I approach the big screen?

THE COURT: Yes.

THE WITNESS: If we look down here in kind of the -- you know, the Southeast US, there's this yellow color, which is a larger system called the Gulf Coast Aquifer System, and then this brown outline right here (indicating) is specifically the outline of the Mississippi Embayment Regional Aquifer System. It's the aquifer system that was the subject of the MERAS

study, and it's the aquifer system that the MERAS model simulates.

BY MS. ROBERTS:

Q What's the relationship between the aquifer at issue in this case and the Mississippi Embayment Aquifer System?

A Well, the aquifer at issue in this case is one of the aquifers within this Mississippi Embayment Aquifer System that's outlined in the brown outline.

And I should mention, the brown outline I added on top of this map. The underlying map is copied exactly from the USGS website. The brown outline I added, but I added it from the USGS work under the MERAS study. It's their -- it's still a USGS line. It just doesn't appear on this map if you just look on the USGS website.

Q Let's take a look at the aquifer at issue. Mr. Taylor, can you please bring up Exhibit D13?

Dr. Langseth, what is this figure?

A Well, this is effectively, Your Honor, a close-up of the area of the Mississippi Embayment Aquifer System. And if we look at this map -- well, first off, just a little orientation. Tennessee, Mississippi, Arkansas, you can see the states I labeled here. And the brown line here that I'm pointing to, that's the same brown line as was on the other map. It's just at a smaller scale.

And then the light blue line and the blue shaded area

is the area of the Middle Claiborne Aquifer, or what I call the MSSA. So it's one of the aquifers within the Mississippi Embayment. And you can see it; it's almost as large as the whole Mississippi Embayment but not quite. There are areas where it doesn't go to the edge.

Q And so we're clear, where is Memphis on this map?

A Oh, yes. Well, here we have Tennessee. Memphis is down here in the southwest corner of Tennessee, just north of DeSoto County, Mississippi, which is up here in the north part of Mississippi.

Q Where is the Mississippi River?

A The Mississippi River is this squiggly dark line that runs kind of down through the center of the Mississippi Embayment Aquifer System.

Q Can you point to the states that overlie the aquifer at issue?

A Yes. There's eight. Starting from the north, it catches just a little bit of Illinois and then Kentucky and Missouri, down into Tennessee, Arkansas, Mississippi. Extends a little bit into Alabama and then over here into northern Louisiana.

Q Dr. Langseth, why did you include this exhibit in your expert report?

A Well, this shows the accepted delineation by the USGS of the Middle Claiborne Aquifer System. So it's really a direct demonstration that this is, in fact, an interstate aquifer.

Q Let's go ahead and look at the aquifer in cross-section. Mr. Taylor, if you could bring up Exhibit D15, please.

And this is one that we've seen before in this case. Dr. Langseth, can you take us through what we're looking at here?

A Yes. Your Honor, I know you've seen this cross-section a few times before, but if you'll allow me to kind of explain it in my own words.

THE COURT: Sure.

THE WITNESS: Just, first, my own description of what a cross-section is. I think you've heard already, it's like you slice a knife into the ground and peel away a piece of it. You've undoubtedly seen real-life cross-sections as you've driven around on like interstate highways. In mountainous areas, you go through an area with these steep rock walls on either side of the highway, then you're observing a real cross-section there where the people who built the road have actually made that knife cut into the ground and peeled it away.

And sometimes you can see different layers in the formation and so on when you go through there, so that's a real cross-section.

Here, a cross-section like this is a depiction based on information we've learned from borings into the ground where the material had been characterized. And, of course, a

cross-section at this scale is very generalized.

But this one is a cut -- imagine a cut in the earth kind of parallel to the Mississippi River, just a little bit on the Kentucky-Tennessee-Mississippi side of that line and -- of the Mississippi River, and then you peel it away, and we're standing in either Kentucky, Tennessee, or Mississippi, looking into Missouri, Arkansas, or Louisiana in this particular section.

BY MS. ROBERTS:

Q And what is the source of this figure in your expert report?

A Oh, this comes from the work of Arthur and Taylor, which you've heard a lot about before. And Arthur and Taylor did really the first comprehensive study of that Gulf Coast, that whole Gulf Coast Aquifer System, that we saw in yellow on that bigger map. And, of course, part of what they did, they did this cross-section.

Q Where are Mississippi and Tennessee on this figure?

A Your Honor, I don't know if you can read these. It might be good to focus in on it a little bit. Here is the Mississippi-Tennessee state line, right here (indicating). And then I don't know if we need to blow it up, but further north you can see the Tennessee-Kentucky state line.

Q Where is the aquifer at issue?

A The aquifer at issue here is labeled the Middle Claiborne

Aquifer, and we can see it extending underneath the Mississippi-Tennessee state line.

Q What does this figure have to do with your opinion in this case?

A Well, this is really very basic to my opinion because it shows that the aquifer is an interstate aquifer. It's quite -- very much a foundation of my opinion.

Q Let's talk about your opinion in this case. I know you briefly mentioned what your conclusion is, but can you state again, what is your opinion on the question of whether the aquifer at issue, including the groundwater in it, is an interstate resource?

A In my opinion, it clearly is an interstate resource, over a broad area, but in particular, over the area between Mississippi and Tennessee.

Q Can you state for the Court, what are the primary bases of your opinion?

A The primary basis for my opinion is the simple delineation or the extent of the area over which the aquifer exists. It exists over an area above which there are state lines, and that simple fact makes it an interstate aquifer.

Now, I also looked at other lines of evidence that helped demonstrate the continuity of the aquifer underneath those state lines, in particular, the predevelopment flow patterns, to look to see whether or not there's evidence of

flow across the state line, which, you know, helps demonstrate the continuity of the aquifer underneath the state line, under the Mississippi-Tennessee state line.

And I also looked to see whether or not the impacts of pumping across the state line, because that's another strong piece of evidence that the delineation such as we see in this cross-section is indeed a correct delineation.

And then the final thing I looked at was some of the details of the interactions between the aquifer and interstate surface waters.

Q Mr. Taylor, could you please bring up the demonstrative that we prepared showing this opinion and the bases for that opinion?

Does this accurately state your opinion in this matter and a summary of the main bases for that opinion?

A Yes, it does.

Q Are these bases for your opinion reflected in your expert report?

A Yes. This is really very consistent with my report.

Q For purposes of your analysis in this case, how do you define an interstate aquifer?

A My definition is really quite simple. If you have an aquifer that -- where a state line overlies that aquifer, that is an interstate aquifer. Or another way to say it is if the aquifer extends underneath the aquifer of the state line, then

that is an interstate aquifer.
Q What is your definition based on?
A It's based on a couple of things. One is the common language meaning of the word "interstate." I think actually in my report I list a particular dictionary definition of interstate, and it's based on the scientific meaning of the word "aquifer," and it's also based on how I've used the term myself in other work and how I've seen it used in the literature.
Q How have you used it in other work?
A Well, for example, one -- I mentioned my work with the Advisory Committee on Water Information, the ACWI. And one of the things that we did in that project was to -- or let me back up a minute. I was on the subcommittee for groundwater under ACWI, and one of the things we did is we developed a national groundwater monitoring network. And as part of that, we used the term "interstate aquifer," and we discussed interstate aquifers in that work. So that's a report that I was a coauthor of.
Q Have you seen the term "interstate aquifer" in the scientific or technical literature?
A Yes, I have.
Q And how does it -- the scientific or technical literature use the term "interstate aquifer"?
A It uses it the same way that I've just defined it.

Q Does the scientific or technical literature use any other terms other than "interstate" for aquifers that cross state boundaries?

A Yes. A commonly used other term, Your Honor, is transboundary. That's a more general term to refer to an aquifer that extends underneath some kind of boundary, whether it's an international boundary, a state boundary, or county boundary. But when a transboundary aquifer is transboundary for a state line, then it's the same thing as an interstate aquifer.

Q I'd like to go through each one of these bases for your opinion one at a time.

The first one is that "The aquifer extends beneath portions of Mississippi, Tennessee, and six other states."

How did you make this determination?

A Well, with regard to the -- the broad basis, the total of the eight states, I really relied on the delineations that had been prepared by the USGS. We saw one of the delineations earlier for the -- based on the MERAS model, we looked at a figure.

But as regard to the delineation between Mississippi and Tennessee, I also looked in detail at some of the -- some of the boring logs and some of the work that's been done in that vicinity.

Q Are you referring to Exhibit D13?

And, Mr. Taylor, please bring that back up.

A Yes. When I said the aquifer extending underneath eight states, it's really this well-accepted delineation created by the USGS under the MERAS study that I relied on for the extending under eight states, though I will say it's very consistent with earlier work, such as the work by Arthur and Taylor, which also had it extending under eight states. So it's not a new discovery under the MERAS study.

Q Given that aquifers are underground, how is the lateral extent or delineation of an aquifer determined?

A Well, what we do is we put -- drill holes in the ground and we characterize the material. We characterize the material in a few different ways. Sometimes physically -- Your Honor, you've already heard other experts testify about grain size. Like, you know, sand, clay, silt, you're familiar with those terms based on grain size.

And then there's also electronic methods that are used because it's -- if you're drilling a hole that's 2,000 feet deep, it's really onerous to go in and collect samples and test them of the physical characteristics all the way down that 2,000-foot-deep hole. So there are various what are called geophysical methods that characterize the material.

And then that's information at one location. But when you get similar information at several locations, then you can connect the dots and figure out what's underground that way.

It's called correlation oftentimes, that connecting-the-dots process.

Q What is your understanding of whether such work has been done, drilling in to make holes and bore logs in the aquifers that exist in this area?

A A lot of that work has been done. And, in fact, it's under -- Arthur and Taylor did quite a bit of that sort of study. They relied on other work that had been done.

And then for the MERAS study, they did a major reevaluation, bringing in lots more boring logs than had previously been evaluated to further refine the delineation to create the figure that we see on the screen right now.

Q I think it might be helpful to look at an example. Mr. Taylor, can you please bring up the demonstrative of the boring log.

Dr. Langseth, are you familiar with this demonstrative?

A Yes, I am.

Q Can you explain, where does this come from?

THE WITNESS: Your Honor, can I just be free to go up to the screen when I --

THE COURT: You may.

THE WITNESS: I didn't know if I needed to ask every time or not.

THE COURT: You may.

THE WITNESS: So there's two basic things on this diagram, and we'll go over each of them in detail in a minute. But I just want to orient you to the overall diagram.

One is we have here a cross-section where different formations have been identified and that have been identified as extending between particular borehole locations. And we can see the borehole locations labeled along the top. And then we'll come back to that for more detail.

And then there's a location map over here that shows where these boreholes are located. And this is a fairly common and consistently used overall structure for these kinds of displays. And it might be useful to take a look at the location map here for a moment in detail.

BY MS. ROBERTS::

Q Before we look at that, Dr. Langseth, where does this come from? What's the source of this?

A Oh, this is from the USGS study conducted by Moore and Brown in 1969. And this is actually an interesting study. Just a little side bite, this is the study in which the name Memphis Sand was coined. They -- I mentioned earlier that these various historical names come during the studies of the aquifers. Previously what's now called the Memphis Sand used to be just called the 500-Foot Sand. That was a driller's term because it was typically found 500 feet below the ground surface in the Memphis area.

Well, in this study, which was a very, very deep test hole up by Fort Pillow, Tennessee, up in, I think it was, Lauderdale County, they coined the name. They said, Well, from now on we're going to propose calling this deeper section of the Middle Claiborne in the Memphis area, we want to call it the Memphis Sand.

And in this same report, that's actually when they named the Fort Pillow Sand. I think you've heard the Fort Pillow Sand discussed as a deeper aquifer. You may remember hearing the terms Flour Island Confining Unit and Old Breast-Works Confining Unit. Those were also named in this report as Old Breast -- Fort Pillow was where they did the hole, so they named that deep aquifer the Fort Pillow. Old Breast-Works was some of the fortifications around the fort, so they used that as the name for one of the confining layers. And then Flour Island was an island in the river near where they did the study.

So that's an example of how some of these names come about. They do the study and they pick names based on things near the area. In fact, Sparta comes from Sparta, Louisiana, where that formation was first discovered.

Q Dr. Langseth, you were starting to look at that map on the right side of the screen.

A Oh, yes.

Q Tell us, what does this show?

A Well, first off, just to orient, Shelby County is down here in the lower left-hand corner of this diagram. So we have Tennessee. And then Mississippi is labeled. I guess the authors assumed we know that this is Tennessee.

And then there's dots on this map that show the locations of the various test holes. And each one has a label on it, like SH:U-12. Actually, we heard yesterday Dr. Waldron talking about this labeling system where the SH, for example, stands for Shelby County, and then the section that we'll see goes through these four borehole locations.

Q So the line connecting those dots, what is that line?

A Well, the line connecting these dots is just to help your eye follow these dots. I'm not sure why they didn't put a line down to SH:U-12, but the line just indicates that those are the dots that will form the basis of the section that's on the rest of the bigger diagram.

Q Let's go back to that bigger diagram. What is the area highlighted in blue?

A Well, before I explain the highlighted in blue, let me just explain a little bit where this comes from.

In each of these borings, based on the -- in this case, mostly the geophysical studies, the geologists or whoever is interpreting this, identifies layers that have common characteristics. For example, they might find a layer that's largely sandy and then a layer that's got a lot of clay and

then a layer that maybe is a mix of sand and silt. And they get different signals from the geophysical studies.

And then -- so they identify that in each hole. Then they look at this hole and this hole, and they see -- ah, we see about the same thing here as we see here, and it looks pretty similar to what we see here and pretty similar to what we see over here. And based on that, they connect the dots between those holes and then provide a name.

So in this case, it's -- there's two labels for names, so this -- what's shaded in blue is one of those formations that is -- they've been able to connect the dots between the boreholes and say this is a consistent formation between these boreholes and given it a name.

In this case, as I mentioned, this particular study was the first one to call this the Memphis Sand. We can see the -- I don't know if you can actually read it, but there's the 500-Foot Sand labeled over here, which was the historical driller's name, just because that way the drillers knew that they -- when they got down about 500 feet, they should start watching for this nice sandy aquifer unit.

Q Have boring logs like this been direct-drilled elsewhere in the aquifer in Southwest Tennessee and Northwest Mississippi?

A Yes. Throughout that area and also really throughout the whole Mississippi Embayment.

Q And has that work helped you identify the geographic extent

of the Middle Claiborne Aquifer?
A Very -- very much so. In the MERAS study, it actually expanded to, I think it was, around 2,600 boring logs and developed essentially a network of these kind of diagrams in order to identify the extent of the aquifer we're looking at, plus the extent of the whole Mississippi Embayment Aquifer System.
Q I want to go back just for a moment to Exhibit D15 and focus, again, on that region near the border of Tennessee and Mississippi.

Can you just explain for us, what happens at the border of Tennessee and Mississippi?
A Well, at the border of Tennessee and Mississippi, not much happens. The aquifer just continues right on underneath the border. So, I mean, obviously other things happen at the border, but in terms of the aquifer we're talking about, nothing really happens.
Q Is there anything in the ground that impedes the flow of water in the aquifer across the border of Mississippi and Tennessee?
A No, there's not.
Q Are there any barriers in the aquifer that align with the Mississippi-Tennessee state line?
A No, there are not.
Q There's an area in white on the Mississippi side of the

Tennessee-Mississippi state border.

Do you see where I'm referring to?

A Right about this area right in here (indicating).

Your Honor, do you see where the cursor is?

THE COURT: Yes.

BY MS. ROBERTS:

Q What is that area?

A Well, this is an area that's -- we've heard the term facies change. It's commonly called a facies change. And facies is just a geologist term for the character of the material.

And what this is is that, as we look at this aquifer, as you go far enough south, there are areas where there's a lower permeability unit that can be identified as being areal extensive.

As we go further north, it pinches out. It doesn't disappear, but it's not areal extensive; it's discontinuous so that south of somewhere -- and notice there's a jagged line at the end of this facies change, meaning it's not an exact location; it's not an abrupt change, but if you go sufficiently far south of that, then it provides some restriction to vertical water movement.

And if you go north of that, even though there are remnants of the same low conductivity materials that continue all the way up through certainly at least middle of Tennessee, as far as I've looked at boring logs, they're not continuous

enough to restrict the vertical -- vertical flow of water and so they're not considered to be present in a meaningful way with regard to the aquifer.

Now, I should also mention that the location of where this pinches out changes as you move east-west. This is a pretty accurate description of roughly where it pinches out at the location of this section. But if you move east or west, it changes. The location where it really pinches out would move north in some places, move south in some places. So it's not an exact consistent location, nor is it a solid vertical wall like it's portrayed in this very generalized cross-section.

Q Does this facies change impact your opinion at all in this case?

A No, it does not.

Q Why not?

A Well, I've taken account of the presence of this facies change in my evaluation of the aquifer and the continuity of the aquifer underneath the Mississippi-Tennessee state line and other state lines, and it really has no impact on the continuity of the aquifer underneath those state lines.

Q Dr. Langseth, how do the USGS and other scientific publications describe the aquifer's geographic extent?

A The -- it's consistently described as underlying eight states and having the outline that we described. Now, historically, it wasn't -- you know, you go back 130 years, as

I showed earlier, it was understood to extend between Kentucky, Tennessee, and Mississippi.

At that time it wasn't known that it extended under eight states, but over the years, as we've gathered more information, it's become consistently and well accepted -- consistently described as and well accepted that it underlies that eight-state area we saw in the prior figure.

Q In your research and analysis, have you found any scientific support for the proposition that the aquifer does not extend across state lines, including Mississippi and Tennessee?

A I have not.

Q Going back to the demonstrative listing your opinions, if you don't mind, Mr. Taylor, the second basis for your opinion is that "Before pumping began, groundwater in the aquifer naturally flowed from Mississippi into Tennessee (and across other state lines)."

As a threshold matter, how do you know that the groundwater in the aquifer is flowing or moving?

A Well, there's really two ways. First off, groundwater is always flowing. That's just inherent in the nature of groundwater.

But then specifically, we can look at potentiometric head data, and where there are variations in potentiometric head, we know that the water is moving from the higher head to

the lower head. That's just a basic law of how groundwater moves.

Q In this case, how did you reach the determination that groundwater in the aquifer naturally flowed from Mississippi into Tennessee and across other state lines?

A Well, I used two approaches. One is I reviewed the literature to see what other people had concluded about that matter, largely from studies of potentiometric head data, that is, water level -- studies of water level data. And then I also looked at modeling studies that addressed that issue. And then I conducted my own evaluations using the MERAS model.

Q Let's start with the publications you looked at with regard to water level data.

Can you tell Judge Siler what you found in the scientific literature regarding water level data in the aquifer under predevelopment, or prepumping, conditions?

A Well, Your Honor, I found two studies that addressed this question. Both of these studies have been actually discussed extensively in the courtroom, the Criner and Parks study, where we have seen the map several times, and then the study by Dr. Waldron and Larson. And, of course, we've heard the testimony about that study yesterday. Those are the two studies that I've put in my report.

There's a third study we've heard a little bit about by Reed in 1972. I didn't include that in my report because he

did not indicate anything about where his -- what his data source was.

Q Let's start with the Criner and Parks evaluation you mentioned.

Mr. Taylor, could you please bring up Exhibit D17?

What is the source of this figure?

A This figure, Your Honor, comes from this Criner and Parks 1976 study that you've heard about several times before. It's a reproduction of Figure 4 from that 1976 study by Criner and Parks, and then I've added some lines on top of it.

Q And, for the record, who are Criner and Parks?

A They were hydrogeologists working for the USGS.

Q Where is the Mississippi-Tennessee border on this figure?

A It's kind of faint, so it might be good to highlight it. It's down here near the bottom. You can see the words "Tennessee" and "Mississippi." They're a little bit faint.

And then over to the right you can see Shelby County, DeSoto County. And I should probably say where the Mississippi River is. That's kind of faint too. It's over on the left-hand side. It kind of curves up here on the west side -- west side of Memphis, Memphis, of course, being down here in the southwest corner of Tennessee.

Q You mentioned potentiometric head data. How is that reflected on this map?

A Okay. Your Honor, you've heard the concept of contour

lines already were the lines of equal potentiometric head. So this drawing has such lines, and they're labeled in feet above mean sea level.

For example, you can see the label 260, and then the curving line that goes north and south of the label 260, and then there are other lines for going higher, 270, 280, 290, and going lower, 250, 240, 230. So --

Q You mentioned that the blue lines are yours. Why did you draw those lines on the map?

A I drew the blue lines to indicate the general directions of groundwater flow that are indicated by these contour lines. And I used the principles that, Your Honor, you've heard before, basic principles of groundwater flow, that the water goes from higher head to lower head and flows at approximately perpendicular to the contour lines.

Q What does this indicate about predevelopment flow in the area of the Mississippi-Tennessee border?

A It indicates that there is flow across the border. I drew -- a couple of the lines I drew show flow across the Mississippi-Tennessee state border in this aquifer.

Q How does that relate to your opinions in this case?

A Well, this is supporting information that -- that there's no impediment to flow across the border. We've got the delineation that shows the aquifer continues across the border, and where you've got flow across the border, that supports the

accuracy of that delineation.

Q Now let's look at the Waldron and Larson analysis you mentioned. Mr. Taylor, could you please bring up Exhibit D18?

What is the source of this figure, Dr. Langseth?

A Well, this is copied directly from the study that we heard quite a bit of testimony about yesterday from Dr. Waldron. It's a copy of his Figure 4 or their Figure 4 from that study.

Q Why don't you zoom in on the map so it's a little larger.

Can you please identify, where is the Mississippi-Tennessee border on this figure?

A Yes. It's -- it's down here, right in this area where -- well, maybe first the Mississippi River, that squiggly line running up through the left, and then right about through the middle third of the way up where the cursor is, that's the border.

It changes from red to brown because the red is the outline of Shelby County, and then the brown is the state line between the other counties. And then, of course, DeSoto County here south of the border, Shelby County here in the Memphis area north of the border.

Q And as you mentioned, we've heard extensive testimony about this yesterday, but what is your understanding of what Dr. Waldron and Larson did?

A Well, they did really the same type of study that Criner and Parks did, although more exhaustive. They looked for

historical information about water levels, they plotted up those water levels, drew contour lines, based on the water levels that they plotted up, and then this particular map ends with having drawn the contour lines.

But it's quite easy to see that if you go from -- well, higher values, 104 out here to 73 in here, the water is flowing from those higher values to the lower values across the state line from Mississippi into Tennessee in the aquifer.

Q What is the direction of natural groundwater flow based on the fracture contours shown on this map?

A Oh, it would be -- it would be from Mississippi in this -- well, first off, let's look at this 104 contour. If we start a flow line anywhere along this 104 contour, it's going to head up north across the border until we get down near kind of the end of the 104 contour. Then it might head over into Arkansas rather than going into Tennessee. But the -- most of the water, as we look along here, along the 104 line, is going to be heading up and catching at least some portion of Tennessee.

Q What does this tell us about the predevelopment flow in the area of the Mississippi and Tennessee state border?

A Well, once again, it shows us flow across the border, which is confirming the delineation, the characterization of the aquifer as continuing underneath the Memphis -- Mississippi-Tennessee state border.

Q So we've looked at two different maps, the Criner and Parks

map and the Waldron and Larson map. What do these maps tell you about predevelopment flow?

A They basically show that there is flow across the border in this -- in this region. And from my perspective, I looked at this as a literature review, confirming that people who have studied the data found that there is, in fact, flow across the border.

And I should mention the Reed study, which we're not showing here, shows the same thing.

Q In your research, are you aware of any USGS or other scientific analysis of predevelopment flow from the aquifer along the Mississippi-Tennessee border that does not show some water moving naturally, that is, predevelopment, from Mississippi into Tennessee?

A No, I'm not.

Q You testified that you also did some modeling work in this case. Can you please tell Judge Siler about your modeling work?

A Yes. Your Honor, what I did is -- you know, you asked in your memorandum of decision for information about flow patterns in the vicinity of the border, so I obtained this model, the MERAS model, from the USGS, and then I did a variety of different applications of that model to illustrate various flow patterns across the border.

Q You said you obtained the model from the USGS. How did you

obtain it?
A Oh, I contacted the lead developer, Dr. Brian Clark, and got it from him. I'd actually had some prior contact with him when I was supervising graduate student research on this aquifer in Arkansas.
Q What is your understanding of how the USGS MERAS model was developed?
A Oh, this was a big study. It started back in 2006, and it initially included a massive review of boring logs. They reviewed something like 2,600 boring logs to further refine the -- both the vertical and horizontal delineation of the various geologic and aquifer units underground.
And then they also did a major study of pumping rates. And they did a lot of work to develop this model that is very highly districized for such a large model, both vertically and horizontally. And it includes what I'm going to call physically based representations of how water moves in this system. So it was quite a large multiyear effort to develop this model.
Q You mentioned the bore log work. Did that have any impact on your decision to use this model?
A Well, yes, because it's really -- it's the most comprehensive review of boring logs in the Mississippi Embayment area that I'm aware of.
Q What did do you, if anything, to confirm the reliability of

the MERAS model?

A Well, there's really two aspects to that, Your Honor. One is I was following the development of the model right from the beginning. I was aware of the work in 2006, aware that they were beginning the work, and they produced various interim reports that I've been reading and evaluating.

And I also went to a conference where they presented some of their interim results. I also made a presentation at that same conference. And then -- so I've been tracking the development of it, knowing how they did it.

And then within the model reports, it's common to provide both statistics of how well the model performs and then also discuss limitations of the model. And so I've looked at those evaluations of those statistics, and it really performs quite well and has just the normal limitations that you expect a numerical model of this type to have.

Q So, Dr. Langseth, you testified as to why you used this model. Can you explain to Judge Siler how you used this model for your work in the case?

A Okay. First off, I didn't modify it. I just -- I took it as it was. And I used it for predevelopment conditions, which is with no pumping, because I wanted to evaluate natural flow patterns across the border or in the border region with this model.

And, generically, the way I did this is to use a

technique that's called particle tracking. It's an unfortunate misnomer. It's really a mathematical way to track the pathway of water through a three-dimensional system, three dimensional versus two dimensional.

When we look at these flow arrows like the ones we just looked at on the Criner and Parks data and other flow arrows we've seen, those are two-dimensional approximations. And they're useful, but they don't tell the whole story.

With the MERAS model, which is a fully three-dimensional model, and this particle tracking method -- I'm going to use that name even though it's a bit of a misnomer -- you can follow the fully three-dimensional flow paths of the water.

Q What was the results of your analysis of the natural flow patterns in the Middle Claiborne Aquifer?

A Well, there are really two things I looked at. I did look at the broad flow patterns in the overall aquifer and saw that there were many areas where flow went across state borders. And then I looked in detail at the Mississippi-Tennessee border and saw that -- evaluated some of the flow patterns as they crossed the border in this aquifer -- or, I should say, evaluated the flow patterns in the border region. Because not all the water crosses the border naturally, but I evaluated the flow patterns in this aquifer in the region of the Mississippi-Tennessee border, a lot of water -- or there's a

lot of locations for which water does flow across the border, and I illustrate that with the results of the model.

Q And you're referring to natural or predevelopment conditions?

A All of this is natural, predevelopment conditions, with no influence of pumping.

Q Before we look more closely at your use of the USGS model and analysis of predevelopment flow, I want to ask, are there any other USGS models of the aquifer of which you are aware?

A There's two primary other models, and they've all been mentioned in this hearing so far. One is a model of the northern part of the Mississippi Embayment that was developed by Brahana and Broshears, commonly called the Brahana model. That's the model that Mr. Wiley used and that Dr. Spruill relied upon in terms of Mr. Wiley's use of that model.

And then there was the model developed by Arthur and Taylor, the same authors, USGS hydrogeologists who developed that cross-section that we've come back to so many times.

Q I want to ask you a few questions about each of those models. Who are Brahana and Broshears?

A Well, they at the time were hydrogeologists working for the USGS.

Q And how were you aware of the Brahana and Broshears model?

A Well, I first became aware of that, Your Honor, back when I was working on the district court action. And for some of the

evaluations I did in that action, modeling studies were appropriate, and at the time the Brahana and Broshears model was the best available model for the general, you know, greater Memphis area, if you will.

Q And what is your understanding of what the Brahana and Broshears model shows as to predevelopment and natural flow of the Mississippi-Tennessee state border?

A Oh, it shows flow across the Mississippi-Tennessee border in this aquifer. If you run the Brahana and Broshears model for predevelopment conditions, that is, no pumping, and it produces contour lines that show that you've got flow across the Mississippi-Tennessee border in this aquifer.

Q You also mentioned the Arthur and Taylor model. Tell us about that model.

A Well, that's a model for the entire Mississippi Embayment System, similar to the MERAS model, although it's not as highly districized. That is, it's fewer layers; the block sizes are bigger. But it was developed for the entire Mississippi Embayment, and it also shows predevelopment flow across the border.

Q Across the border from Mississippi to Tennessee?

A Yes. It shows predevelopment flow in this aquifer across the border from Mississippi to Tennessee.

Q Are you aware of any computer mathematical models of the aquifer that do not show water moving from Mississippi into

Tennessee under predevelopment or natural conditions?
A No. Every modeling effort that I'm aware of, which is the three that we're talking about, shows flow in the aquifer across the Mississippi-Tennessee border. Mostly from Mississippi into Tennessee, but there's actually also some areas further west where sometimes flow from Tennessee into Mississippi is shown. So it goes both ways.
Q Are you aware of any computer models or mathematical models of the aquifer that represent the aquifer as something other than a continuous aquifer across the Tennessee-Mississippi state line?
A No. All three of these efforts show this aquifer as a continuous aquifer going right underneath the state line, the Mississippi-Tennessee state line.
Q I'd like to look at some of your work on predevelopment flow with the USGS MERAS model. Mr. Taylor, could you please bring up Exhibit D26?
Dr. Langseth, can you identify this figure, please?
A Yes. This is a figure from my report. And this is -- I mentioned earlier that I looked at the broad regional patterns of flow from the MERAS model. This is a potentiometric head map created from the MERAS model for the Middle Claiborne Aquifer over the entire region of the Middle Claiborne Aquifer.
Q Because it's fairly small print, for me at least, let's zoom in on the caption.

Could you read that, please?
A Yes. "USGS MERAS Model, Predevelopment, MSSA, Potentiometric Surface with Generalized Flow Directions."
Q All right. Going back to the overall exhibit, Dr. Langseth, can you explain what is shown on Exhibit D26?
A Yes. There's -- well, there's several pieces to it. First off, in the brown we can see the overall outline of the Mississippi Embayment System, the same outline we've seen earlier. And then in the blue, these blue lines are lines of equal potentiometric head.

The contour lines, like we've seen before, these lines were generated by the MERAS model, and these are contour lines for the Middle Claiborne Aquifer. And the numbers on them are in feet above mean sea level. So each one tells the potentiometric head or water level, in other words, in feet above mean sea level.
Q Where is Memphis on this figure?
A Oh, yeah. Well, let's -- we've got the Mississippi River, the squiggly line, running up through the middle. We see the State of Mississippi. North of that, the State of Tennessee. And then Memphis is, of course, right down here in the southwest corner of Tennessee, with DeSoto County, Mississippi, being just south of the border in Mississippi.
Q And you mentioned that -- the blue lines, are those lines that you drew, or those are lines that are drawn by the model?

A Well, the way this is done is that the model computes values of potentiometric head, or water level, in each of the 1-mile-square grids over this entire -- some -- the area of the blue lines is some probably 70,000 square miles or so, so there's a value of potentiometric head computed in each square mile. And then a computer program is used to draw the contour lines, though the methods that the computer program uses are essentially the same as the ones that we heard Mr. Larson testify about in his little diagram of how contour lines are drawn.

Q And what are the black arrows on this figure?

A The black arrows are arrows that I added to show the generalized flow directions, and they follow just the same kind of principles we've talked about before in that they go from areas of higher head to lower head, and they are approximately perpendicular to the contour lines.

Q And what do they represent?

A Well, they just represent general flow directions starting at various locations. I just picked a sample of locations to illustrate the broad regional flow patterns over the entire aquifer.

Q Mr. Taylor, could you enlarge the inset?

Dr. Langseth, can you take us through what we're looking at here?

A Well, this is just an inset that is focusing on the area

that we've been discussing most, that is, the area of Southwest Tennessee. We can see here, you know, Memphis here in the southwest corner of Tennessee and Mississippi with DeSoto County being here, or the northwest county in Mississippi.

So it's the same contour lines as were on the other map but just looking more closely at this area of Shelby County and DeSoto County.

Q What does this show about flow direction in the Tennessee-Mississippi border area under predevelopment conditions?

A Well, it shows a couple of things. One is that there's kind of a curvilinear flow path, which comes up in all of the models. It's something that's characteristic of this northern portion of the Middle Claiborne Aquifer. And these flow paths, many of them start in Mississippi, go through Tennessee, and then into other states. The one that I happened to draw starts in Mississippi, goes into Tennessee, and then into Arkansas.

But you could start in other places where they might start in Mississippi, go up into Tennessee, and then come back down into Mississippi.

Q Dr. Langseth, how does this impact your opinion in this case that the aquifer is an interstate resource?

A Well, it's a demonstration of flow across the border that is unaffected by the state line, flow in the aquifer, flow in the Middle Claiborne Aquifer, across the Mississippi state line

and other state lines that is unaffected by the presence of that state line. And so that demonstrates the interstate character of the aquifer.

Q Thank you.

Dr. Langseth, I want to look at some of your particle tracking work that you mentioned earlier.

Mr. Taylor, can you please bring up Exhibit D27?

Dr. Langseth, is this a figure from your report?

A Yes, it is.

Q Can you please read the caption?

And, Mr. Taylor, if you could enlarge it for us.

A "Predevelopment MSSA Flow Pathways for Water in the Northern 4 miles of Mississippi."

Q What does that mean?

A Well, what I did is I looked at the northern 4 miles of Mississippi. Your Honor, I remember in your memorandum of decision you were interested in flow patterns in the vicinity of the border, so I looked on this diagram at flow patterns for water where the initiation of the flow pathway is in the northern 4 miles along the Mississippi border in the aquifer.

Q And why did you select those -- the northern 4 miles?

A Oh, simply to illustrate flow patterns near and in the vicinity of the Mississippi-Tennessee border in this aquifer.

Q Can you orient us as to what we're looking at here?

A Yeah. Just in terms of where we're at, the

Tennessee-Mississippi state line is this horizontal dark line. Mississippi, of course, here. Shelby County, southwest corner of Tennessee, DeSoto County here, northwest corner of Mississippi, and, as usual, the Mississippi River, although it's the state line, the former course of the Mississippi River, this black squiggly line running down through roughly the middle of the map, with then, of course, Arkansas on the west.

Q Can you explain how you created this figure?

A Yes. Well, first off, this is all, again, from the MERAS model, then using an additional program called mod-PATH, which does the particle tracking. So mod-PATH just takes the output from the MERAS model and then tracks the water flow paths using standard mathematics for how groundwater moves.

And so what I did is that, in the northern 4 miles of the Mississippi border for the entire extent of the Middle Claiborne Aquifer -- so we see the blue outline, the little stepped outline, along the eastern side, that is the border of the Middle Claiborne Aquifer, the aquifer we're dealing with.

So everywhere along the northern 4 miles of the State of Mississippi, I started a particle and then allowed the program to move those particles through the groundwater system. And these lines, these blue lines, show their pathways through the aquifer, through the Middle Claiborne Aquifer.

And we're looking at it in two dimensions. In three

dimensions these particles also move up and down. So the program accounts for the full three-dimensional movement, but we're looking just down in plan view, so we're seeing the motion as it would be mapped if you were looking on a map.

Q I want to make sure the record is clear on this. You indicated that you selected the starting points for each of these lines. Did you have any influence on where the lines went?

A No. I selected the starting points, but then the output of the MERAS model determines where they go from there.

Q And what are the thick black arrows?

A Oh, I added thick black arrows to show generalized flow directions, because these thin little blue lines, there's a lot of them, and it's a little bit harder to track sometimes the individual lines.

And the thin blue lines also don't have arrows on them to show which direction they're going. So I added the black lines with arrows just to indicate the generalized flow patterns of movement.

Q Why did you include this figure in your expert report?

A Well, it was part of the evidence, I understood, that was requested in the memorandum of decision to look at flow patterns, in particular predevelopment flow patterns in the vicinity of the aquifer in the Mississippi-Tennessee state border.

Q And how does this analysis impact your overall opinion that the aquifer is interstate?
A Well, it confirms that the flow in the aquifer continues unimpeded, underneath the state, under the Mississippi-Tennessee state line as though that state line weren't there. The state line basically had no effect on these flow patterns.
Q Mr. Taylor, can you please bring up Exhibit D51?
Dr. Langseth, is this a figure from your rebuttal report?
A Yes, it is.
Q Can you explain how you created this figure?
A Well, the fundamental way that I created it is the same as in the other one. I took the output of the MERAS model and then I started -- and I'm using this term "particle." It's just a starting location for tracking the flow of water. But I started -- I have many more starting locations than I did in the prior figure. The locations in the prior figure are also included in here, these blue lines, but I also have several other colors of lines that show other starting locations for particles and then for flow paths.
And I also incorporated the famous, perhaps legendary, yellow triangle of Mr. Wiley's on this map.
Q Tell us about some of those other colors of flow lines.
A Well, they're just different locations for starting points.

For example, I mentioned the blue lines are the ones from the northern 4 miles of Mississippi. It turns out there's some interaction between the Fort Pillow Aquifer and the Middle Claiborne Aquifer, so I also released particles in the Fort Pillow and some of them in Mississippi, and some of them go up into the Middle Claiborne in Mississippi and then cross the line. Some of them cross the line in the Fort Pillow and then go up into the Middle Claiborne.

So that's another sort of category of flow paths that are shown on here.

Q You mentioned that you included the yellow triangle. Where exactly did you get that triangle from?

A I got that from Figure 9 of Mr. Wiley's initial report in this matter.

Q Mr. Taylor, could you please bring up Figure 9, which I believe is P168? And let's look at them side by side.

How does the yellow triangle, as Mr. Wiley depicted it, compare to your yellow triangle on your map?

A Well, I did my best to copy it exactly, to take the -- as best I could, to take the exact dimensions and location of Mr. Wiley's yellow triangle and superimpose it on top of the map that I drew.

Q Do you agree with Mr. Wiley that there is natural or predevelopment interstate flow in the area of the yellow triangle?

A Well, yes, I do. I certainly agree that there is predevelopment flow across the border in the area of the yellow triangle. I just think that the -- there's also predevelopment natural flow across the border in other areas. And I actually -- as I understand Mr. Wiley's testimony, he thinks the yellow triangle might be a little bit too small also.

Q What is the significance between the difference -- between Plaintiff's Exhibit 168 and Defendants' Exhibit 51?

A Well, in a way, there's two issues. One is that the representation in Mr. Wiley's report of what he calls the limited area of natural flow is simply way too small, that the area of natural flow across the border is much larger than represented by that yellow triangle. So that's one area of significance.

But in another way, it doesn't matter. Mr. Wiley's shows that there's natural flow across the border. My analysis shows there's natural flow across the border. In both cases, that demonstrates the interstate natural predevelopment flow across the border from Mississippi into Tennessee. So from that sense, there's no significant difference with regard to arriving at my opinion.

Q Let's go back to the demonstrative listing your opinions. Mr. Taylor, if you could please put that up on the screen.

The third basis listed here for your opinion is that "Pumping groundwater from the aquifer in both Tennessee and

Mississippi impacts the groundwater in the other state."

How did you reach that conclusion?

A Your Honor, what I did for this is really similar for what I did for the other work in that I did a literature review based on measured analysis of measured data, that is, measured water level data, to see what could be inferred from that information.

And then I also looked at modeling studies and what the modeling studies say about the impacts of pumping.

Q Is it possible to tell if pumping from an aquifer in one state is having an impact in that same aquifer across a state border?

A Well, this gets to a term we've heard a lot, the cone of depression. That is the -- Your Honor, remember, the cone of depression is the area around a well in which the potentiometric head, or water level, is -- has been caused to be lowered by the action of that well.

So everywhere where that lowering takes place is the cone of depression. And also, everywhere where that lowering takes place is an area where there is impact from that pumping.

So if you look at cones of depression from pumping, if they cross state lines, that's an indication -- that's, I should say, a direct demonstration that the impact of that pumping crosses the state line.

Q We've heard testimony about cones of depression in the

Memphis, Shelby County, DeSoto County area. What, if anything, does the existence of cones of depression in the Memphis, Shelby County, DeSoto area tell you about the interstate character of the aquifer?

A Well, the fact that these cones of depression cross the state line in both directions is an indication of the continuity of the aquifer underneath the Mississippi-Tennessee state line, which is confirmation of the interstate character of the aquifer.

Q You mentioned that one of the things you looked at was literature that measured water level data. Let's start from an exhibit from your report on that, Exhibit D30, please.

Is this a map that you created, Dr. Langseth?

A No, this is a map that was created by the USGS. It was a fairly comprehensive study of water levels done in 2007, run by Mr. Tony Schrader of the USGS. And it was really done under the MERAS study, the overall MERAS study.

Q Could you help us get oriented as to what we're looking at here?

A Yeah. Well, we're looking here at the whole eight-state region of the -- what I call here the Memphis-Sparta Sand Aquifer, but you could also call it the Middle Claiborne Aquifer. So, as before, you know, it extends up into Illinois and Kentucky, Missouri, Tennessee, Mississippi, Arkansas, Louisiana, Alabama, the same -- actually, they don't have the

water level contours done in Alabama here, so this shows water levels in seven of the eight states for the aquifer.

Q Can you identify any cones of depression in the aquifer on this map that reach or cross into state lines?

A I can. And first I should mention that Mr. Schrader was kind enough to shade in areas that he identified as cones of depression, and the way he identified those is if you've got a contour line that closes back on itself, that is, creates something of a circular region, that's an indication you've got a cone of depression.

Now, the actual cones of depression for that pumping are certainly larger than the outermost closed contour, but within the closed contours, you've definitely got a cone of depression from the aggregate pumping within that pumping center. And Mr. Schrader shaded those in gray. You can see -- it's a little bit faint, but you can see several areas of gray shaded on this map. And that's where the author of the study, Mr. Schrader, identified cones of depression. And there's at least three of them that touch or cross state lines.

Q Could you take us through each one of those?

A Well, if we start down here in Southern Mississippi, about by the Arkansas-Louisiana state line, just a little -- just on the east side of the Mississippi River -- maybe we could enlarge that area. A little bit hard to see, but here we've got the -- you know, this dark black line running down through

here, that's the state line, and we can see this shaded closed contour here.

And you notice it's not a perfect circle. This is a reflection of a variety of wells, several wells, in this area. If it were an individual well, it would more likely be closer to a circle, but it's sort of a pumping region.

And we can see that this collective cone of depression from all that pumping reaches and just barely crosses that state border into Louisiana. And, like I said, the actual cone of depression almost certainly extends further.

Q You mentioned there were two others?

A Yes. If we go back out, Southern Arkansas, Union County, major pumping center down here. I'm not sure if we -- does that show -- oh, it is shaded. It's awfully faint, Your Honor. But we can see this area where I'm pointing, we can see the flow arrows going into this pumping center. This one, again, touches and just barely crosses into the state of Louisiana from Arkansas.

And then the third one is up in the Shelby County area. Up here (indicating). We'll enlarge that one. And, once again, it's faint on this map, but you can see the difference between the light color and the dark color.

Well, first off, Mississippi River, state line here (indicating) between Tennessee and Mississippi. Shelby County is up here where this cone of depression is indicated.

Now, I should mention that -- and I said this for down in Mississippi too. This set of contours is the collective impact of all the pumping in the area, actually including the pumping in Mississippi in DeSoto County. But where there's a closed contour, then that indicates a regional cone of depression around a major pumping center, and certainly Shelby County is a major pumping center.

And we can see that this cone of depression crosses the state line here of Mississippi and Tennessee, crosses into Mississippi. And over here, on the west, we can see it crosses into Crittenden County, Arkansas. So it crosses into two other states, both Arkansas and Mississippi.

Q What do these cones of depression that reach or cross state lines tell you, if anything, about whether the aquifer is interstate?

A When you've got a cone of depression from pumping that crosses a state line, it's confirmation that that aquifer in which the cone of depression is developed itself crosses the state line. So what we see in particular for our question here, the cone of depression in -- that's represented in the Shelby County area crosses the state line into Mississippi, indicating the continuity of the aquifer between Tennessee and Mississippi.

Q Dr. Langseth, now let's look at some of the results produced by different mathematical models of the aquifer.

Mr. Taylor, could you please bring up Exhibit D31?

Dr. Langseth, do you recognize this figure?

A I do.

Q What is it?

A This is a figure that I put in my report. It was produced by Arthur and Taylor.

Q What does this figure show?

A Okay. This figure shows drawdowns, which is a little different than what we've been looking at before. The other maps we've been looking at show directly potentiometric head. This map shows the change in potentiometric head caused by pumping. So it's actually a more direct way to look at the cones of depression.

And, Your Honor, what I mean by potentiometric head, let's say the water level is up here. And I'll just call it 100 before pumping. Then you turn on the pump and it drops down to 90. Well, that 10-foot drop would be the drawdown caused by the pumping.

And this figure, these contour lines show lines of equal drawdown caused by pumping. So it's not the total potentiometric head. It's directly reflecting the impact of pumping, the change in the water level caused by pumping.

Q Now, this is not modeling work that you did; is that right?

A No. This is modeling work done by Arthur and Taylor.

Q Let's, again, get oriented so we know what we're looking

at. Can you identify, where is the City of Memphis and the Mississippi River?

A Yes. Well, I'm here -- well, the State of Tennessee is up here, and Mississippi. So the state line between Tennessee and Mississippi is on here. Memphis down here in the southwest corner of Tennessee and, of course, DeSoto County in Northwest Mississippi.

Q What does this figure have to do with your opinion in this case?

A Well, this figure, as I mentioned, this shows more directly the impact of pumping crossing state lines and being unaffected by those state lines, which is a direct indication of the continuity of the aquifer underneath those state lines.

And we see that in several -- several locations -- well, there's several spots where the effects of pumping are seen directly to cross state line, like I say, with no impact to the state line.

Q Can you give us a few examples?

A Yes. Let's start -- let's go to Union -- southern Arkansas, Union County again. This down here, yeah, that's a good -- in this one, we're looking at just the water levels. The cone of depression as it appeared there barely crossed the state line, but once we're looking at the direct impact of pumping, we can see much more substantial indication of crossing the state line.

And one of the things I want you to notice is that the shape of this contour just doesn't -- is not affected by the state line. There's no indication of any impact of the state line, which indicates the continuity of the aquifer underneath the state line.

And then there's another one, another pumping center, around Stuttgart, which is really a big pumping center. And we can see -- well, if we could enlarge that a little bit, if we can catch a little bit more to the southeast on that enlargement. We can see here this pumping center, which is a complex pumping center, so it creates some shapes that aren't quite as circular. We see the impact of this pumping center crossing over from the State of Arkansas into the State of -- the State of Mississippi. And, again, a direct impact, a direct indication of the continuity of the aquifer underneath the Arkansas-Mississippi state line.

And then the third area is if we go up to Memphis. So here, just to orient, we see the label. Memphis is actually on the -- to the west of where Memphis really is. Memphis is actually over here on the east side of the Mississippi River, which is this -- as usual, the dark squiggly line running kind of through the center.

This dark line here that I'm pointing to, Your Honor, is the Mississippi-Tennessee state line. And we see the representation of the impact of pumping. This would be 1987

impact of pumping. So pumping rates were higher back in '87 than they are now. But we see the -- these lines as the total impact of pumping and -- in both Shelby County and DeSoto County. So this reflects DeSoto County pumping also, but in '87 DeSoto County pumping was quite a bit lower than it is now. Shelby County pumping was higher than it is now. But, nonetheless, we see the impacts of pumping crossing the state lines as though the state lines simply weren't there.

So, once again, this shows the continuity of the aquifer underneath the state lines, the Mississippi-Tennessee state line in particular, but also the Tennessee-Arkansas state line, as though the state lines simply weren't there.

Q Dr. Langseth --

THE COURT: I think we'll take a short recess.

MS. ROBERTS: Thank you, Your Honor.

THE COURT: We'll have a ten-minute recess.

(A recess was taken.)

THE CLERK: All rise. This Honorable Court is called back to order. You may be seated.

THE COURT: You may proceed.

MS. ROBERTS: Thank you, Your Honor.

Is your microphone on?

THE WITNESS: I think so. Sound check? Is it working?

Can you hear me all right, Your Honor?

THE COURT: Yes.

THE WITNESS: Okay.

BY MS. ROBERTS:

Q Dr. Langseth, in your rebuttal report, you discuss an example provided by Dr. Spruill in his report about pumping in the City of Southaven in Mississippi. Can you explain that example for Judge Siler?

A Yes. Well, this is a part of rebuttal. I noticed that in Dr. Spruill's initial report, he discussed a municipal well in the City of Southaven, and he described how the cone of depression of that well extended out, I believe it was some 17 miles, and since the City of Southaven only extends about 6 miles south into Mississippi, that's a direct indication of pumping in Mississippi, the effects of pumping in Mississippi in the aquifer extending across the Mississippi-Tennessee border into Tennessee. So it's just a -- it's evidence that the effects of pumping go both directions across the border.

And this was documented in Dr. Spruill's report.

Q I'd like to go back to the demonstrative listing your opinions.

The fourth basis you have listed for your opinion in this case is that "In the Tennessee-Mississippi border region, groundwater in the aquifer is hydrologically connected to interstate surface water."

How did you reach this conclusion, Dr. Langseth?

A Well, really through two ways. One is the very broad patterns of flow in the aquifer where, Your Honor, you've heard before about the big-picture patterns where eventually the water moves up into the Mississippi River, so that provides one type of direct connection. And we also know that at the northern end of the Mississippi Embayment where the Middle Claiborne outcrops the Mississippi River is in direct connection.

But I also looked, using my model -- not my model, the MERAS model and my use of the model, to look at the details of those interactions between a local smaller interstate river, the Wolf River, and the aquifer.

Q Mr. Taylor, could you please bring up Exhibit D20?

Is this the analysis that you're referring to, Dr. Langseth?

A Yes, it is.

Q Can you explain, what does Exhibit D20 show?

A Okay. Well, this is, once again, one of those particle tracking figures which is prepared using the MERAS model and the companion mod-PATH model. And it shows the pathways in the aquifer of water that was either in the Wolf River and left the Wolf River, down into the aquifer and came back up into the Wolf River, or was otherwise connected between the aquifer and the Wolf River.

Q Can you orient us on the map again?

A Yes. That was sort of a general outline. So if we look, we see the state line here between Mississippi and Tennessee, the horizontal line with, of course, Shelby County in the southwest corner of Mississippi, DeSoto County here in the northwest -- Shelby County in the southwest part of Tennessee, DeSoto County in the northwest part of Mississippi.

And then let's focus on the Wolf River. We can see the Wolf River rises here in Benton County, flows then north -- west for a little ways, then northward across the Mississippi-Tennessee state line, then flows in Tennessee, eventually emptying into the Mississippi River.

Q So if I understand your testimony, the Wolf River originates in Mississippi, flows across the border into Tennessee, and discharges into the Mississippi River?

A Yeah. So the Wolf River itself is clearly an interstate river starting in Mississippi, flowing -- and it flows into Tennessee.

Q What do the orange lines represent?

A The orange lines represent particle tracks. And in the middle, there's a -- the interactions between the river and the aquifer are represented in certain of the model cells, and so I started a particle or a path line in each of the model cells that represents the Wolf River and then tracked the movement of that water through the aquifer.

And we can see -- I added generalized flow direction

areas as before, and we can see that water crosses the state line. Water associated with the Wolf River and associated with that interconnection with the aquifer crosses the state line -- the Mississippi-Tennessee state line in a variety of ways.

Q How, if at all, does this analysis impact your opinion that the aquifer is interstate?

A It just shows one more hydrologic connection across state lines as it relates to interstate rivers and the aquifer.

Q Dr. Langseth, you can sit down.

There were a couple of opinions that were expressed by Steven Larson that I wanted to ask you about.

Do you recall his testimony that water that enters the aquifer, the Middle Claiborne Aquifer in Mississippi, will eventually leave Mississippi?

A Yes, I recall that.

Q Do you agree with that testimony?

A Oh, absolutely.

Q Do you agree that that's true both under predevelopment conditions and today?

A Yes.

Q Okay. Dr. Langseth, Steven Larson also testified that the USGS treats the aquifer as a regional resource.

Do you recall that testimony?

A Yes, I do.

Q Do you agree with that testimony?

A Yes, I do.
Q Dr. Langseth, do you recall hearing testimony from Dr. Spruill about a report by someone named Moore?
A Yes, I do.
Q Let's bring up the Moore report that was referenced. Mr. Taylor, could we please see Joint Exhibit 58?
Dr. Langseth, can you please read the title of this report?
A So "Geology and Hydrology of the Claiborne Group in Western Tennessee."
Q Let's go to the next page, please.
Can you see where the author is listed?
A Yes, it's Gerald Moore.
Q Did you review this report as part of your work in this case?
A Yes. I reviewed it in the district court action and then reviewed it in this case.
Q What is this report about?
A Well, this is a study to provide a better characterization of the Claiborne Group, as it was known at the time, in Western Tennessee. And that's kind of apparent from the title.
But it was really an outgrowth of some interests starting in the '40s to develop better characterization of the aquifer from which Memphis was drawing its water. And there was a series of studies over the next several years that

were -- that were motivated by that, designed to provide further characterization, further analysis of the Memphis-area water supply.

Q I'd like to start with plate 1 of this report. I believe you've got it marked as J58A.

All right. There's a lot here. Can you explain what it is that we're looking at?

A Okay. First of all, Your Honor, this is -- remember, I just -- we looked at a figure that was something like this before from that Moore and Brown 1969 paper. This follows that same general structure where there are some cross-sections shown on this figure. And then there's a little map down on the lower right-hand corner that shows where those cross-sections are and which borings are used to define those cross-sections.

Q So let's start with that little map. Maybe we can enlarge it.

What does this show us?

A Okay. Well, first, just orienting, this shows only Western Tennessee in terms of the specific outline, but the dashed line at the bottom is the Tennessee-Mississippi border. So Mississippi is here south of that line, and then, as before, we see dots that indicate the specific borings that are used in this -- in this figure.

Each one has a label on it, and then there are letter

designations at the end of the dots that are connected by lines. So, for example, we see A, A prime; B down here starting in Mississippi, extending on this line, going all the way up to B prime in Kentucky. So -- then there's a C, C prime line up here. So each one of these labeled lines defines one of the cross-sections that are on the rest of the figure that we'll come back to.

Q I want to focus on the BB line and in particular -- if we could go back to that a moment.

A Yeah, that would be the middle cross-section.

Q So the BB line and that point --

A Yeah. So this starts in Mississippi, moves up into Shelby County, through Shelby County, and then continues on up through Western Tennessee.

Q And what is Withers 1?

A Oh, that's just the name of a boring in Mississippi down here at the beginning of this section line.

Q Let's go back now to that full plate, and I want to select the middle portion.

Dr. Langseth, can you explain what this figure shows?

A Well, the basic structure of this figure, Your Honor, is like the one we saw before where we can see the ground surface indicated at the top, and then along the ground surface line, we see each of the wells labeled.

And we also see the section line label. Over by the

left-hand side of the figure, you see the letter B, and underneath the letter B, you see Withers 1. Well, that's the same Withers 1 well we saw in Mississippi on the location map.

And then it continues on heading north up to B prime, showing, at each boring, the interpretation of what was found underground at that boring. And then where you can see commonalities, then they draw the lines between the different borings and say, okay, we see -- we see this formation in this boring; we see it in the next boring. We're going to draw a line between the two and say that that formation continues between those two borings. That's basically how the underground exploration is done.

Q Can you explain what's happening at the Mississippi-Tennessee border?

A Yes. It might be good if maybe we could blow up maybe the third or so of this -- so we see here, we're at B, Withers, and in Mississippi. We see here on the upper portion of the diagram the Mississippi-Tennessee state line indicated up here at the top.

So we've got our B location at Withers, and if you look down, the first labeled formation is called the Sparta Sand. And this formation labeled the Sparta Sand continues right across the border from Mississippi into Tennessee.

It eventually is later called the 500-Foot Sand over here, but the key issue is that the formation, as identified

from the boring logs, continues right across the state line.

And this is -- this is our aquifer. The Sparta Sand and the 500-Foot Sand, you know, this overall area, is our aquifer. But certainly this upper portion identified as the Sparta continues right underneath the Mississippi-Tennessee state line.

Q I want to go back to the text. Mr. Taylor, could you please go to page 57 of 58 and enlarge the bottom paragraph?

Dr. Langseth, do you recall Mr. Ellingburg's reading of the second sentence of this paragraph during his opening statement?

A Yes, I do. You're talking about the sentence that begins "Future development"?

Q Yes.

A Yes, I recall that during Mr. Ellingburg's opening statement.

Q He omitted from this paragraph the sentence before that. Could you read it, please.

A Yes. The first sentence is, "Thus, groundwater supplies in both the 500-Foot Sand and the unnamed sand unit will be adequate for the predicted rate of municipal growth and economic development for many years to come."

Q Have you reviewed the entire Moore report, Dr. Langseth?

A Yes, I have.

Q What was his conclusion?

A Well, my conclusion or Mr. Moore's conclusion?
Q Mr. Moore's conclusion.
A Well, what Mr. Moore did, he did a few things. He looked at the stratigraphy -- we saw that earlier -- to further define the stratigraphy. But one of the other things he did was he looked at the potential for the aquifer to supply increasing amounts of water.

So he looked at substantial increases, up to like 2- and 300 million gallons per day, which is substantially more than is being pumped now, and he determined that he thought the aquifer would be adequate to supply those larger amounts of water.
Q Do you recall Dr. Spruill's testimony that this Moore report concluded that pumping in Memphis was, quote/unquote, problematic?
A I recall that testimony, yes.
Q Do you agree with Dr. Spruill's testimony?
A Well, I don't think he characterized the Moore report properly. Mr. Moore does not call this problematic. He says what he says in that -- what's that blue border, blue shaded line, sentence.
Q And he never stated that this was problematic?
A He did not.
Q Dr. Langseth, do you recall that we heard testimony about one of these old reports, a 1964 report by Criner and a couple

of other authors?
A Yes.
Q Let's bring up the report that was referenced. Mr. Taylor, can we please see J22?
Can you please read the title of this report, Dr. Langseth?
A It's "Hydrology of Aquifer Systems in the Memphis Area, Tennessee."
Q Let's go to the next page, and then one more after that.
Who was the author of this report?
A Three men, Criner, Sun, and Nyman.
Q Did you review this report as part of your work in this case?
A I did, and also reviewed it as part of the district court action.
Q What is this report about?
A Well, this is another one of these series of reports that was happening at this time to provide further information, further characterization of the aquifer being used for water supply in the Memphis area.
Q Let's go to plate 1 of this report that we've got marked as J22A.
Dr. Langseth, what are we looking at here?
A Okay. Well, this is another one of these figures of the same styling that has some cross-sections up above and then a

location map down in the lower right-hand corner.
Q Let's start with the location map.
Do any of the boreholes reflected there extend into Mississippi?
A Well, yes. Before I just -- yeah, the answer to that is yes. But let's just get oriented here. We've got the Tennessee-Mississippi border down here along the border. And, fortunately, on this one, it actually labels Tennessee and Mississippi.
And, once again, the dots show the various boring locations, and then the connected lines show where the cross-sections are done. And looking at cross-section labeled A to A prime, that one starts in Mississippi at a boring labeled "Walls," which I think is labeled Four Walls, Mississippi, and then continues across the border into Tennessee, and specifically into Shelby County.
Q All right. Let's go back to the full plate, and I want to select the top part.
Can you please explain what this shows?
A Yes. So this --
THE WITNESS: Your Honor, can you see this clearly enough now?
THE COURT: Yes, I can. I have one closer to me.
THE WITNESS: Okay. Okay. So we -- once again, we see the individual borings. We see at A, the Walls boring, and

then there's several other borings labeled here.

We see up on the top Mississippi-Tennessee state line. It says Mississippi-Shelby County, but of course we know Shelby County is in Tennessee.

There's a boring here right along the border that is kind of shallow, but we have these deeper borings, the one in Mississippi and then the one further up into Shelby County.

And, once again, the analyst, generally a geologist who is evaluating these, has identified zones that they consider to be comparable material, has connected the lines between the borings in which that material is found. And we can see what was then called the 500-Foot Sand. The Memphis Sand name had not yet been introduced at the time that this work was done. And we can see what's called the 500-Foot Sand continuing right underneath the Mississippi-Shelby County line.

And what's called the 500-Foot Sand is, of course, our Middle Claiborne Aquifer as we know it today.

Q How does this impact your opinion in this case?

A Well, it shows fundamental geological data indicating the continuity of this aquifer underneath the Mississippi-Tennessee state line, and that indicates the interstate character of the aquifer.

Q Okay. Dr. Langseth, we previously introduced your rebuttal report.

Mr. Taylor, could you please bring it up, Exhibit

D193?

Dr. Langseth, I wanted to ask you just a few questions about it. Can you tell the Court what you did to prepare this rebuttal report?

A Well, I -- I read the reports prepared by Dr. Spruill and Mr. Wiley and identified areas of disagreement, although I also identified some areas of agreement. And then I wrote this report to document some of the -- some of those key areas.

So I'd have to say I didn't address everything that they said because I thought much of what was said was not relevant to the specific question at hand.

Q As to what you identified as relevant, can you provide any examples of areas of agreement with your work?

A Well, yes. There were really quite a few, and I've got an extensive section in my rebuttal report on this. They -- both Dr. Spruill and Mr. Wiley, in their rebuttal reports or in their reports, not -- because I hadn't seen their rebuttal reports yet -- in their original reports, they agreed that the aquifer extends underneath the Mississippi-Tennessee state line and also other state lines.

They agreed that there was predevelopment flow across the border, both of them. They both agreed that there was -- that the impacts of pumping went across state lines in both directions, from Mississippi to Tennessee and Mississippi to Tennessee.

And they both acknowledged either -- I can't remember if they acknowledged in their reports, but they certainly did in their testimony here, that there are interactions between the aquifer and interstate river, or hydrologic connections between the aquifer and interstate rivers.

So from a technical basis, Dr. Spruill and Mr. Wiley really support the bases for my opinion.

Q Have you heard any testimony from Mr. Wiley at this hearing that is inconsistent with the four bases for your opinion as to the interstate nature of the aquifer and the water in it that you've testified about today?

A I have not.

Q What about Dr. Spruill? In listening to his testimony regarding the aquifer at issue, did you hear anything that is inconsistent with the bases of your opinion that the aquifer is interstate that you've testified about today?

A He made some claims with regard to names of aquifers, but his fundamental technical analysis of this aquifer is consistent with my opinion.

MS. ROBERTS: Thank you.

Your Honor, before I pass the witness, I would like to mark the demonstrative exhibit that was the bore log as Defendant's Exhibit 201.

THE COURT: Any objection?

MR. ELLINGBURG: Which one do you want to --

(Exhibit No. D201 was marked for identification.)

MS. ROBERTS: It was a demonstrative, so it was at the back of your binder.

MR. ELLINGBURG: Okay. No objection, Your Honor.

THE COURT: All right. That would be fine.

MS. ROBERTS: Thank you, Your Honor. I pass the witness.

THE COURT: Are you finished? Does the State of Tennessee wish to question this witness?

MR. FREDERICK: We have no questions for this witness.

THE COURT: You may proceed, State of Mississippi.

MR. ELLINGBURG: Thank you, Your Honor.

CROSS-EXAMINATION

BY MR. ELLINGBURG:

Q Good morning.

A Good morning.

Q I had a little difficulty following a lot of that because it seemed like you were weaving in and out between space and time in terms of the area being discussed and also in terms of when these various slides or exhibits were shown, and so I'm going to try to start off with a few concepts. Okay?

Is it your testimony that before any development, there was some movement across the area that now makes up the Mississippi-Tennessee border of groundwater within the entire Mississippi Embayment System?

A I did not provide any testimony about the entire Mississippi Embayment with regard to that question.

And I would also say that when you said the area of the Mississippi-Tennessee state line, everything that I did testify about with regard to movement across the state line was for the line itself, not an area of the line.

Q Well, I asked the question wrong, which may happen a little bit, and I appreciate corrections.

Your testimony is that what is now presented on a map as the area -- or as the state line of Mississippi-Tennessee, before there was ever any pumping, there was some movement back and forth across that border of groundwater; is that correct?

A My testimony was about movement of that groundwater before there was any pumping in the Middle Claiborne Aquifer. My testimony was specifically about the Middle Claiborne Aquifer, the aquifer at issue in this hearing.

Q Okay. And the Middle Claiborne Aquifer that you're talking about covers all but one of the states in the Mississippi Embayment; is that correct?

A Which -- you'll have to be specific about which state you think is missing for me to answer that question.

Q I think you said that it didn't show -- it didn't include any real water in Alabama. Is that correct?

A What I said was, in the 2008 publication by the USGS where they did a set of water level measurements that was extensive

throughout the rest of the Mississippi -- rest of the Middle Claiborne Aquifer, which they called the Sparta-Memphis Aquifer, they did not show any data in Alabama.

Q They did not show what?

A Data in Alabama.

Q Okay. So you're not saying that the aquifer doesn't extend into Alabama?

A That's correct. I'm not saying that, but I am saying in that particular study of measured water-level data, they did not show any data in Alabama.

Let me clarify that. They didn't show any contour lines in Alabama. I haven't looked at it closely enough to know if they had some data and simply chose not to show the contours.

Q Thank you.

Now, this is your Figure 2.2.1a in your report, is it not?

A It appears to be.

Q Now, what is all of the yellow on this map?

A The yellow -- you know, it's the legend over on the side.

Q Well, what does it represent?

A Generally the Atlantic Coastal Plain. It's a little bit hard to read, but it's the Coastal Lowlands Aquifer System, and then there's a lot of text here. But it's basically a set of coastal aquifers along the Gulf and Atlantic coast.

Q Now, under your definition, the water in the coastal -- the Gulf Coastal Aquifer is all interconnected; is that correct?
A Under what definition?
Q Your definition that it crosses state lines and it's called -- it all contains aquifer formations that are interconnected? Aren't those formations all in some way hydrologically connected? Either they are or they're not? You can explain, but are they or are they not?
A If you're talking about that entire system shaded in yellow, there's two things I would say. One is that I have not studied that entire system, but I would be surprised if there were direct hydrologic connection -- what I would call direct hydrologic connections through all of them.
Q Let's get some terminology straight before we get too far.
Are all of the hydrological connections that you have been talking about in your direct testimony direct hydrological connections?
A I would characterize them that way, yes.
Q Okay. So you characterize a connection from the bottom of the Middle Claiborne Aquifer that then has to flow up through multiple confining layers to ultimately come to a surface or discharge point near the surface, your testimony is those are all direct hydrological connections?
A That -- that is a reasonable way to characterize those because it's continuous flow of water between one area and

another. There's no evaporation involved. It hasn't evaporated, gone into the atmosphere, and rained somewhere else. It's not an ephemeral connection through the broader hydrologic cycle.

Q So in your testimony, the only thing that falls into the category of a direct hydrological connection would be something that went from the surface to the atmosphere? Is that what you just described?

A No. No. Let's just get a definition in place. There's no standard definition of "direct hydrological connection."

The way I'm using the term, it means that the connection is mediated through water flowing through whatever system we're talking about, and it's not mediated by evaporation of that water going up into the clouds and raining somewhere. Because if you look at that, the entire hydrologic cycle, all the water in the world is interconnected. And that's true in a very ephemeral sense, but it's not very useful.

You know, there's a wonderful line from a Mary Oliver poem. It's something like, "In water that is forever leaving and forever returning, we find the eternal."

So it's -- the hydrologic cycle is that way, but I don't consider that a direct connection.

Q Okay. But you do consider all connections that take place in the earth between hydrogeological units, whether they are

through confining units or whether they are direct in terms of being part of the same formation, and you consider all those to be direct hydrological connections?

A That's a definition that I just made for purposes of my answering your questions today.

Q Right. But that's your personal definition today?

A That's a definition I just made to give me the ability to answer questions -- you're asking me about direct hydrologic connections, and I'm telling you about the definition that I've used today when I broadly used the term "direct hydrologic connection."

Q Okay. Looking at your map, are there direct hydrological connections between the Sparta Sand in Mississippi and the Sparta Sand in Texas?

A I have not studied the area in Texas enough to be able to answer that question.

Q Well, you are aware, aren't you, that one of the joint exhibits issued in this case, there is -- there are, I believe, two studies that specifically study the entire western portion of the Gulf Coastal Plain and specifically what they have identified as a Sparta Sand component created during a specific geological time?

You know that, don't you?

MR. FREDERICK: Objection, Your Honor. Texas is not a defendant in this case.

THE COURT: Well, that's true. He can say it's not very relevant, but you may answer the question.

THE WITNESS: Could you please point me to a specific study you're talking about?

BY MR. ELLINGBURG:

Q Sure. Will you pull up J69?

In your earlier testimony, you specifically carved out of this map the area of the Mississippi Embayment; is that correct?

A That's correct.

Q Now, the Mississippi Embayment is just one of the aquifer systems within the Gulf Coastal Plain, isn't it?

A That's a generally correct characterization.

Q Is it generally correct or is it true? Is the Mississippi Embayment just one of the aquifer systems that lies within the Gulf Coastal Plain?

A If you add the words "aquifer system" after the words "Mississippi Embayment," that would be a true statement.

Q I did say aquifer system, didn't I?

A No, you didn't. You said, Is the Mississippi Embayment one of the aquifer systems in the Gulf Coastal Plain? But if -- the Mississippi Embayment Aquifer System is one of the aquifer systems that's represented in that broad yellow band. That's the general coastal -- general set of Coastal Plain aquifer systems.

Q So there are multiple aquifer systems within the Gulf Coastal Plain Aquifer System; is that correct?
A I think that's a correct statement.
Q Okay. And they are all, to some extent, hydrologically connected, aren't they, directly, according to your definition?
A I don't think so.
Q You don't?
A No.
Q Okay. So what do you base that on?
A Well, I base it, in part, on my knowledge of how the Mississippi Embayment Aquifer System has been defined and awareness of a substantial confining zone that's represented by this white area here between the Mississippi Embayment area and the coastal system south of that.
Q Okay. So you said the connections to the Mississippi Embayment and the coastal system south of that don't exist. There's no hydrological connection of any kind between those two -- those systems; is that correct?
MS. ROBERTS: Objection, Your Honor. He's constantly misstating his testimony. I'm trying to be patient and respectful, but time and time again, he's putting words into my -- our witness's mouth.
MR. ELLINGBURG: Okay. And I'm leading, but I'll try to be a little less leading with a witness that I can lead.
THE COURT: All right. You may do that.

MR. ELLINGBURG: Thank you.

BY MR. ELLINGBURG:

Q Have you ever seen any USGS report that identified the Sparta Sand as a specific hydrogeologic unit that was formed during a particular time of the formation of the Mississippi Embayment?

A I have seen several reports that identify the general geologic era during which the Sparta Sand and its related formations were laid down.

Q Okay.

A But that's discussed in numerous reports.

Q Can you find -- I'm going to hand you a copy. I said J68. It's essentially 69. That's my problem.

Take a moment to look at that.

MR. D. BEARMAN: Mike, what number is that?

MR. ELLINGBURG: It is J69.

MR. FREDERICK: Counsel, we had an agreement that both sides would provide paper copies of what they intended to use in the courtroom for ease and efficiency.

MR. ELLINGBURG: We certainly said that for direct examination, but I don't know if we've done that --

THE COURT: Hold on. We'll call a short ten-minute recess and come back.

MR. ELLINGBURG: Okay.

(A recess was taken.)

THE CLERK: All rise. The Court will be called back to order.

You may be seated.

THE COURT: Have we resolved the dispute about what we need?

MR. ELLINGBURG: I believe we have for the moment, and we'll try to --

THE COURT: Okay. You may proceed.

BY MR. ELLINGBURG:

Q Dr. Langseth, do you have Exhibit J69 in front of you?

A Yes, I do.

Q Now, that was one of the joint exhibits by the parties. Is that one of the things that you looked at in preparing to testify?

A I don't recall that I relied on this in my report. If I cited it, I don't specifically recall it off the top of my head.

Q Okay. Well, I'm going to ask a few things about it.

Now, this is a United States Geological Survey, Professional Paper 1410-B; is that correct?

A That's correct.

Q And it was published in 1996; is that correct?

A Yes. That's the date given on page 3 of 153 of this document.

Q And the title of it is "Hydrology of the Southeastern

Coastal Plain Aquifer System in Mississippi, Alabama, Georgia, and South Carolina."

A I think you read that correctly.

Q And does that show up -- can you put the map back up?

Okay. Is this area that's covered by this study reflected on your map?

A The area covered by this study -- I mean, the map is the whole United States.

Q Right.

A So this is a study in the United States, so of course it's on the map.

Q Well, no. My point is, does it appear -- in what you identified as the Coastal Plain on your map and in your report, is this study a study that covers that area?

A Let me see if I can reframe this and answer what I think your question is.

The portion of the -- this study is about a portion of the overall Coastal Plain aquifer system, and the portion of the overall Coastal Plain aquifer system that is covered by this report is indeed identified on this map of -- that is not my map. It is the USGS of principal aquifers in the US.

Q Right. So the USGS study that is part of the regional studies that the USGS has conducted in this case covers Mississippi, Alabama, Georgia, part of Florida, and South Carolina, correct?

A That is the geographic scope of this specific study, this J69 that you put in front of me.
Q Thank you. If you would turn to page B7.
A B?
Q B.
A B as in "boy," 7?
Q The pages are numbered with a B. It's also joint exhibit page 17 of 153.
A I see. I was looking at the bottom of the page. You're talking about the original report page numbers?
Q Yes.
A Yes. Okay.
Q Have you got the page?
A I do.
Q Now, do you see where it says, "definition of hydrological framework"?
A I see that.
Q Now, and I'm just going to read it, and I just want to ask you if this is the same definition you're using in your testimony.

"The regional hydrogeologic system, or aquifer system, can be described as a body of strata having a wide areal distribution and containing an extensive set of aquifers in confining units. The aquifers are hydrologically connected in varying degrees and in areal extent and can be regionally

treated as a single-flow system." Is that correct?
A I think you read that correctly.
Q Is that what you have done in this case with regard to the Mississippi Embayment?
A The focus of my work was not on the overall Mississippi Embayment. The focus of my work was the aquifer for this work, which is the Middle Claiborne.
Q I'm going to learn.
A So I'm not -- so the basic answer is no.
Q Okay. So --
A But that's not -- when I say no, that's not saying I have a quibble with this definition for the purposes of the study that's in front of me.
Q No. It's the lawyer is asking bad questions, so I'll restate it.

With regard to the Mississippi Embayment Aquifer System and the Claiborne -- the Middle Claiborne Aquifer hydrological unit, are you following this same scope in terms of how you have testified to its interstate connection?
A I'd say the fundamental answer to that is no. But, again, that does not mean I disagree with what the USGS has said here in the context of the study that is in front of me.
Q Okay. When you were talking about the same aquifer, the phrase you use a lot, that exists within the MERAS study area, are you clarifying it as the same aquifer because it has this

type of hydrological connections that are described in Exhibit J69?

A If you're talking about the -- the text that you just read, I certainly did not use that entire description. I used really a different evaluation method.

Q Okay. So how is yours different than what the USGS does in a regional aquifer study? How is your definition different?

A My definition has to do with the areal extent of an aquifer. And we're talking about in this matter -- my understanding is that this hearing is focusing on an aquifer, not an aquifer system.

And so I was looking at the lateral extent of an aquifer and whether or not the lateral extent of that aquifer goes underneath state lines and, in particular, the Mississippi-Tennessee state line since this matter is between the states of Mississippi and Tennessee. And of course Memphis, City of Memphis, and MLGW.

Q My apologies.

As you use the phrase "aquifer system" -- or as you use the phrase "aquifer," does that include multiple separate aquifer hydrogeologic units within the Middle Claiborne formation?

A First, I would note that the word "aquifer" isn't a phrase. I would call it a word, not a phrase.

Q Excuse me.

A The word -- you called aquifer a phrase. I think of it as a word.
Q Okay.
A So when I use the word -- so I'm going to translate your question into saying when I use the word "aquifer," can it include multiple hydrogeologic units. Is that what you're saying?
Q What is the answer to your question?
A The answer is that there can be multiple historical names or alternate names that are going to apply to different sections of the aquifer for various reasons, but I'm looking at it as continuity of material that is recognized as aquifer.
Q As a single aquifer?
A Recognized as -- an aquifer is -- we went over that definition earlier. It's a formation, saturated formation, from which you can extract usable quantities of water. And if you've got that characteristic, an aquifer that continues underneath the state line, that's what I'm calling an interstate aquifer. That's my basic test that I was using.
Q I understand that. But is that the way the US Geological Survey has defined what it is doing in its regional aquifer studies, such as the MERAS study, which you've testified to extensively, is that the USGS description of what they've done?
A The MERAS study is a study of a regional aquifer system, just like this study is a study of a regional aquifer system.

The MERAS study included multiple aquifers, various confining units, and that was a study of the aquifer system.

Within the study of the aquifer system, there's also information about the specific aquifer in question.

Q So is it your testimony there are no changes anywhere within what you have defined as the Middle Clairborne-Sparta system in the underlying geology?

A Hardly. That's a ridiculous statement the way you phrased that question.

Q I mean --

A I have never testified anything close to what you just said.

Q Okay. No, but you did testify that if there are connections of the type you described, they are direct hydrological connections, according to your definition, right?

Do you agree with your definition of the direct hydrological conditions?

A I told you I developed that definition to try to answer questions that you were asking me.

Q Okay. So let's use your definition again. Look at this report, J69.

Are there direct hydrological connections between the Sparta Sand in Mississippi and Alabama, Georgia, and South Carolina under your description, under your definition?

A Okay. Direct connections between the Sparta -- could I get

that question repeated?
Q Yes. Are there direct hydrologic connections between the Sparta Sand in Mississippi and the state -- the formations, the aquifer formations, within Alabama, Georgia, South Carolina, and part of Florida?
A To the best of my knowledge, the formation that is called the Sparta Sand in Mississippi that I have been dealing with crops out, that is, it comes to near the surface, mostly in Mississippi, extends a little bit into Alabama. So it simply does not extend into Georgia. I think you mentioned -- I can't remember all the list of states you mentioned, but it sounded like you were moving east along the Eastern Seaboard, and to my knowledge, that same formation that is identified as an aquifer formation and locally called the Sparta Sand in Mississippi and some other places, does not extend into Georgia, Florida, and South Carolina.
Q Okay. Does it extend into Louisiana?
A The name actually came from Louisiana. It was named after Sparta, Louisiana, where it was first identified.
Q Does it extend into Texas?
A I don't know if a similar formation may be identified in Texas, but as part of the aquifer that's -- the aquifer that is in the Middle Claiborne Aquifer system -- excuse me, the Mississippi -- strike that. I got mixed up between my aquifers and aquifer system.

As the aquifer that's part of the Mississippi Embayment Aquifer System, I don't believe it extends into Texas.

Q Okay. And you're talking about the Mississippi Embayment that is carved out of the Gulf Coastal Plain, right, for study purposes?

A Well, I wouldn't -- you used the word "carved out." All of these issues depend on the scale of which you're looking at something.

The USGS, on the map that we had before, has identified this broad, big system of aquifers along the Coastal Plain as having some degree of similarity and characteristics that caused them to identify them as a group of aquifer systems.

The Mississippi Embayment Aquifer System is an identifiable subsystem, if you will, as part of that that exists as this layered set of formations that's been discussed a lot in the testimony in this hearing within this plunging syncline that starts up around Illinois and continues down into the states that have been discussed so many times.

And then the southern boundary of it is really defined by the edge of the freshwater. It's about 10,000 -- southern boundary of the study area is defined by where the water becomes too saline to be usable as fresh water.

Q The southern boundary of the study area that's covered by

the MERAS study is the boundary where it becomes saline water and is not freshwater; is that correct? That's what you just said, isn't it?

A That's -- they picked a value of -- I think it was 10,000 parts per million total dissolved solids, is that boundary.

Q But that is not the end of the hydrological connections within that system, is it?

You've talked a lot about hydrological connections. I'm trying to get an understanding of what you're talking about. Because the -- the southern part at the bottom of the MERAS study area, the hydrologic connection to the saline water, is on the end.

A You do know I was starting to answer your question and you interrupted me.

Q I didn't mean to, and I apologize. Counsel from Tennessee scared me.

A The water continues to the south. There's some flow in that system that goes south -- there's some component of flow that continues south in those aquifer units and heads -- heads towards the Gulf. And so there is -- I call it hydrologic continuity across that southern border, but it was small enough that the authors of the MERAS study determined that that was a sufficient definition of -- that was an appropriate definition of their study area, southern boundary of the study area.

Q Thank you. Now I'm going to try to make sure I get this

right, though.

Go back to B7, on page B7.

A Yeah, I'm still there.

Q Okay. You are? All right.

It says, "A regional hydrogeological system or aquifer system can be described as a body of strata having wide areal distribution and containing an extensive set of aquifers and confining units." Is that correct?

A You read that correctly.

Q Thank you.

Would you agree with that statement?

A I think that's a reasonable definition for a regional -- for what they said. You could use either the term "regional hydrogeologic system" or "aquifer system." For example, you could apply that definition to the Mississippi Embayment Regional Aquifer System.

Q Right. Because it has a body of strata which would include the Sparta Sand in Mississippi and the Memphis Sand north of the transition zone, right?

A Well, you're using names that are, you know, applied local names. I just want to be clear that when you use those names, I recognize them as local names, but I don't recognize them as different aquifers. So I'm happy for you to use those names as long as, in using those different names, I'm not creating the implication that I view them as separate aquifers.

Q Do you agree that the United States Geological Survey has identified them as separate aquifer hydrogeologic units?
A No.
Q You do not? So your testimony is USGS makes no differentiation between the two, between the Sparta Sand in Mississippi and the Memphis Sand in Tennessee?
A With regard to their characterizations as a hydrogeologic unit, and specifically as an aquifer, I believe the USGS considers them to be a continuous aquifer unit underneath the state line.
Q A single continuous line?
A A continuous aquifer underneath the state line.
Q Okay. I'll agree with you they're hydrologically connected, but can you tell us if there are any differences between the Sparta Sand in Mississippi south of the transition zone and the Memphis Sand in Tennessee? Are there any differences?
A There are differences everywhere. We're talking about natural systems. Everywhere you go, there's differences from one point to the next.

But the issue here is whether there's enough commonality to characterize the material as aquifer and recognize the continuity of that -- these formations as an aquifer underneath the state line. But of course there are differences. There are many, many, many differences.

Q That's the issue within your definition of aquifer? That's not a USGS definition, is it?
A I would argue that the USGS would agree with it. I don't -- I'm not aware that they've ever written it down.
Q Can you -- have you looked to see if they've ever written it down?
A I've looked, and I haven't been able to find where the USGS has written down a definition that says "interstate aquifer" equals the following.
Q Okay. You've never found anything in the USGS literature that directly supports your definition of interstate aquifer, have you?
A I disagree with that.
Q Okay. So I'm saying a direct statement by the USGS that this constitutes an interstate aquifer?
A I have seen the term used in USGS reports where it is clear that it's used in a manner consistent with my definition.
Q Okay.
A And it's also been used in a report that was -- where one of the lead authors was the head USGS groundwater scientist where it was used consistent with my definition.
Q And who was that?
A I'm talking about the report that was published by the -- by the subcommittee on groundwater, which I'm a member -- subcommittee on groundwater of the Advisory Committee on Water

Information, and the lead federal chair of that subcommittee is William Cunningham of the USGS.

Q Is that marked among your references?

A I don't think so.

Q Has it been published as an official USGS document?

A It's been published as an official Advisory Committee on Water Information document.

Q It's an Advisory Committee on Water Information internal publication?

A Well, when you call it "internal," it's internal to the United States Federal Government, I guess.

Q Does the United States Geological Survey have standards --

A But it's publicly available. I'm sorry. I interrupted your question. Excuse me.

Q Does the United States Geological Survey have standards that they use that they apply before they will publish something as an official report?

A So now you're back to -- you're not in ACWI publications anymore?

Q I've been at the USGS the whole time. I'm trying to find out how you can testify that the USGS has used your definition that you are using in this case.

A Mr. Ellingburg, I believe you're very much twisting the discussion we've just had.

Q I'm twisting it.

A Because you were asking me about any reports published. I specifically was discussing a report that was published under the aegis of the Advisory Committee on Water Information by the subcommittee on groundwater. We were specifically talking about that. You knew it was not a USGS report, and somehow now you're saying, Oh, I was talking about USGS reports all the time. You know that you weren't.

Q I'm just trying to find out if you can tell us -- if you can testify that the USGS has adopted your definition in this case anywhere.

A I told you earlier, and I'll say it again, I'm not aware that the USGS, as an organization, has ever published or written down a definition of interstate aquifer. But I can say that it's been used in USGS reports in a manner that's consistent with my definition.

Q The phrase has been used, is that correct, in USGS reports?

A The phrase "interstate aquifer."

Q It's been used in titles to USGS reports. Have they ever said this report addresses an interstate aquifer in the text of it and explained what they meant by that?

A They -- I have not found anyplace where they explained what they meant by that, but using my expertise, combined with my discussions with people who work for the USGS, as I said, including their lead groundwater scientist, other groundwater scientists around the country, such as state geologists, they

use the term consistent with my definition.

THE COURT: We'll take a lunch break at this point. We'll break until 1:15.

MR. D. BEARMAN: Your Honor, I was only going to ask if Your Honor would consider a break for an hour so we can again try to maximize our time.

MR. ELLINGBURG: We're fine with that.

THE COURT: I need to go ahead with this for the lunch break, but we will take longer sessions this afternoon.

MR. D. BEARMAN: So --

THE COURT: We will break now until 1:15.

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

(A lunch recess was taken.)

THE CLERK: All rise. This Honorable Court is called back to order. Special Master Eugene Siler presiding.

You may be seated.

THE COURT: All right. You may proceed.

MR. ELLINGBURG: Thank you, Your Honor.

THE WITNESS: Mr. Ellingburg, before you proceed, can I clarify two items from this morning's testimony? Would you allow me to do that?

BY MR. ELLINGBURG:

Q Sure.

A One is you asked me if the report that we were talking about that was produced by the Advisory Committee on Water

Information was an internal report, and I said it was internal to the federal government. That was correct but not complete.

It's an official publication of the federal government, and it's not classified, which means it is a publicly available document, so that's a more complete answer to your question.

Q Have you included that in your reference materials?

A No, I don't believe -- I have not.

Q Do you have it with you?

A No.

So the other clarification I wanted to make is at one point you asked me about whether or not I'd seen a definition of interstate aquifer, and since at some point there was some uncertainty about whether you were focusing just on USGS documents or not, I wanted to say that I gave the answer in the context of just USGS. I said the answer was no in the context of just USGS because I have seen definitions in other documents.

Q Okay. Thank you.

A So I just wanted to clarify that for the record.

Q Thank you. I appreciate that.

Can you give us, as you sit here today, a reference to the other publicly available documents you're talking about?

A Well, you can search. It's the Nationwide Groundwater Monitoring Network, and it -- and a search -- or National

Groundwater Monitoring Network, and a search on that, I think, should lead to the document.

Q It contains your definition?

A No. It uses the term "interstate" in a manner that's consistent with my definition. There are other documents that contain the definition consistent -- that are consistent with my definition but are not USGS documents.

Q I appreciate that.

A Nor are they ACWI documents. They're simply other sources in other documents.

Q I appreciate that.

But just to make sure I'm clear, the report that you have now referenced that I can find in the groundwater modeling part of the USGS document, you referred to going to the -- not groundwater modeling -- groundwater monitoring?

A Monitoring is correct.

Q If I search for that, I can find the committee report that you talked about?

A I believe you -- I believe you can. I mean, I haven't done that search for a while, but I believe that would lead you there.

Q But you're not saying that that is the same as your definition; you're saying it's something else that supports your definition?

A I'm saying that, as a member of the committee and a

coauthor of the document, the word was used -- the term "interstate aquifer" was used in a manner that was consistent with my definition. That's what I'm saying.

Q Okay. Well, let's talk about -- do you have your report before you in the notebook, the one you testified about on direct, which is your initial report?

A Yes, I do.

Q Okay. Could you turn, please, to page 21 of 80? As far as the big numbers at the bottom, it's actually, I think, 15 of your report.

A Yes, I'm here.

Q Thank you.

The first paragraph starts off and it says, "Based on the use of the term 'interstate aquifer' in scientific literature." Now, that's not the complete sentence. I'm going to get there. But did I read that correctly?

A So far.

Q Thank you.

And you actually give a citation with regard to supporting that statement, do you not?

A I do.

Q And that is a publication by Bittinger and Jones; is that correct?

A That's correct.

Q Thank you.

MR. ELLINGBURG: Your Honor, this is a --

BY MR. ELLINGBURG:

Q I've handed you a copy, it looks like an article dated April 1972, from the Water Resources Bulletin. And it has a short article "Interstate and International Aquifers" by Bittinger and Jones.

Is this what you were referring to in your footnote?

A Yes, this is the article.

Q And is this the primary basis that you've cited in your reports for your use of the phrase "interstate aquifer"?

A Well, in terms of an example of scientific literature, it's the example that I cited.

Q Okay. This is the scientific literature being cited in support of that statement?

A This is an example of scientific literature in which the term "interstate aquifer" is used in a manner consistent with my definition.

MR. ELLINGBURG: Okay. I'd like to mark this as Exhibit -- Plaintiff's Number 213 for the record.

THE COURT: All right. Any objection to this?

MS. ROBERTS: No objection, Your Honor.

MR. FREDERICK: No objection, Your Honor.

THE COURT: That would be fine.

(Exhibit No. P213 was marked for identification.)

BY MR. ELLINGBURG:
Q Within the body of the report itself, does it actually define what constitutes an interstate aquifer, or is that primarily in the title?
A They don't have a statement that says an interstate aquifer equals X in this. They have the title and then the first paragraph where they describe what they're talking about.
Q Thank you.
Now, going on in that sentence, in addition to Bittinger and Jones, as an example given here as your reference to the scientific literature, you say "and the common meaning of the word 'interstate'"; is that correct?
A You read that correctly.
Q And for that, you cite the American Heritage College Dictionary; is that correct?
A That's correct.
Q So at least as to this introduction to what your definition of an interstate aquifer, at this point it is an interstate aquifer citing Bittinger and Jones as your scientific source and the American Heritage College Dictionary as an additional source; is that correct?
A Well, I'm citing Bittinger and Jones for the whole phrase "interstate aquifer," and I'm citing the dictionary just to confirm the common language meaning of "interstate."
Q Those are your two sources at this point in your opinion?

A Those are the two sources that I cited here.
Q Right. So then you go on, and that complete sentence, "If some portion of an aquifer is beneath one state and another portion is beneath another state, that aquifer is an interstate aquifer."
Did I read that correctly?
A I believe you did.
Q So those are your two components, the geographic extent of the aquifer and whether it is transected by two states; is that correct?
A Well, transected by a state line on opposite sides of which are two different states.
Q You said that so much better than I did. Thank you very much.
So we have a map that shows the subsurface location that's been identified as an aquifer, as you define it. And if there's a state border within it, it's an interstate aquifer; is that correct?
A That is my definition, yes.
Q And that's your opinion in this case, right? That is your opinion on the issue, is that this -- the Mississippi-Tennessee border intersects the Middle Claiborne, as you have defined it, Aquifer, and that makes it an interstate aquifer; is that correct?
A What we just talked about is the primary criteria by which

I make my judgment as to whether or not it refers to an interstate aquifer, and the Middle Claiborne Aquifer meets this definition.

Q And I believe you said in your deposition that that was really all you needed to reach that opinion?

A That is correct. Everything else I've done is supporting information.

Q Thank you. I understand that.

I've put back the map titled "Principal Aquifers of the United States" that we talked about a little bit earlier.

Now, this is part of your report, is it not?

A This figure appeared in my report, yes.

Q Yes. And I believe that you state in your report that the Mississippi Embayment, as you have defined it and using the USGS MERAS model, is a component of the Gulf Coastal or the Coastal Plain. Is that correct?

A I don't recall saying that in my report, but it's clear from this figure and the other figure, where I drew the outline of the Mississippi Embayment Aquifer System, that the Mississippi Embayment Aquifer System is contained within the larger coastal plain aquifer system.

Q Thank you. That's what I was trying to establish earlier today.

The Coastal Plain aquifer system is the yellow area on this map; is that correct?

A That's correct. I just don't recall whether I had a discussion of one of those lines in my report or not.
Q Would you turn to page 7 of your report, page 13 of 80 in your report?
A Okay. I'm there.
Q I'm going to look at the first sentence in Section 2.2.
Have you found that?
A I see it, yes.
Q Now, would you read that first sentence to me?
A "The MSSA is one of several aquifers in the Mississippi Embayment Aquifer System, a large hydrogeological system underlying parts of several states, including Alabama, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee."
Q Thank you.
Now, the MSSA here is the aquifer, as you described it and we discussed earlier, that extends in Tennessee and Mississippi; is that correct?
A I did provide testimony on that, yes.
Q Now, you say it's one of several aquifers in the Mississippi Embayment Aquifer System.
Are there others? Are there other aquifers in the Mississippi Embayment Aquifer System?
A Yes, there are.
Q Are any of them hydrologically connected to the MSSA, as

you have described it, using your definition of hydrological connection and direct hydrological connection?
A Yes, some of them are.
Q Have you included those within your opinion?
A They're not part of my opinion with regard to the Middle Claiborne or what I call the MSSA in this report.
Q Why not?
A I didn't view the characteristics of the other aquifers as being directly relevant in determining whether or not the Middle Claiborne was an interstate aquifer.
Q Is what the USGS has identified as the Sparta Sand aquifer found in all of the states listed in your first paragraph?
A The aquifer formation that happens to be called the Sparta in some states is found within all of the listed states.
Q Now, you looked at the chart yesterday that was associated with the MERAS report.
Do you recall that?
A I do recall, although it would be good if you were specific about which chart you're talking about.
Q Well, I'm talking -- actually, "chart" is the wrong word. You looked at Table 1, I believe, of the MERAS report, which shows the geologic units and the hydrogeologic units. Do you recall that? And the monolayers.
A Yeah. The table you're talking about, just to be sure we're talking about the same thing, I think appears in my

report on D192, page 6 of 60. Just to be sure that we're talking about the same thing.

Q Okay. We are.

In terms of the aquifer formations that have been identified by the USGS survey, does the -- actually, it's Table 2.2.1 in your report, and it says it's from Clark, et al., in 2011, which is -- this is the Mississippi Embayment Regional Aquifer Study; is that correct?

A That's one of the reports that was published in the Mississippi Embayment Regional Aquifer Study.

Q Right. And this one shows where the Sparta Sand is found and where the Memphis Sand is found; is that correct?

A In looking at a chart like this, you have to realize what this is. This is a summary chart that helps someone understand the different naming conventions that have been used in different areas and to provide some general correlation between those local naming conventions and the broader hydrogeologic units that the USGS has identified.

So when you say the Sparta Sand, for example, that's not a separate formation from the Memphis Sand. It is a formation that correlates with the upper portion of what's called the Memphis Sand.

Q Well, that's a nice clarification. It correlates with the top layer of the Memphis Sand; is that correct?

A Correlates in the same -- I'm using the word "correlates"

in the sense that geologists use it in that you can trace it as being continuous with.

Q But the Memphis Sand is much thicker, is it not?

A The name "Memphis Sand" was coined to -- as a, if you will, shorthand way of describing an area where the sandy formations that are generally vertically hydraulically connected don't have as much of a confining layer -- consistent confining layer in the middle of them, if you will, than other areas where there is a stronger confining layer.

So it's like -- it's a label. It's a nice label to be used for those areas where the -- the generally sandy material, without a broad regional confining layer, although there certainly are confining units, is thicker.

Q Has the USGS studied what's been referred to as the transition zone or the facies changes that exist between the Sparta Sand formation and the Memphis Sand formation?

A You know, it's been studied for years, including the most recent comprehensive study being the one presented as part of the MERAS model.

Q My only question is, so that's been an area that's been studied, facies change in the transition zone?

A Oddly speaking, the stratigraphy in this whole area, the Memphis area, the Mississippi Embayment area, has been studied as part of that broad study. It certainly includes study of the stratigraphy in the area that's been called this transition

zone.
Q Do you know if the conditions, environmental earth conditions, at the time of the formation of the Sparta Sand, were in fact a specific type of delta at what was the mouth of the Mississippi River at the time?
A I have read the descriptions of the various conditions at times when different layers were deposited, but I can't sit here and remember them off the top of my head.
Q Well, the only question I have here is, would the deposits be the same in what -- I think it's called a fluidial delta?
A Fluvial delta.
Q Fluvial delta. Thank you.
Are those deposits the same as they are in other areas during the history of the earth? Are fluidal deltas --
A Fluvial.
Q -- yeah, fluvial deltas particularly complex?
A Materials that are deposited under different conditions are normally different. These are environmental processes that have a lot of variability. But despite differences, they can -- many similar materials can be identified as aquifer materials. I'm focused on aquifer materials.
Q I know. But I'm struggling, and I'm going to struggle for just one more time to see if I can ask a question which is sufficiently clear for you to give me a direct answer. Okay? Is that all right with you?

A I'm going to try.
Q Okay. As a scientist, is it, in fact, true that when you look back in geological time and you find areas -- and I know you're not a geologist, but you find areas where there was a -- how did you say it?
A Fluvial.
Q -- fluvial delta, are those deposits complex for any particular reason?
A They're not more complex than anything else underground. Most underground formations have complexities to them.
Q Thank you.
So your testimony is that the deposits formed during a fluidial delta, if I didn't --
A Fluvial delta.
Q -- fluvial delta -- thank you -- time period are no more complex than the sedimentary materials deposited in the Memphis Sand area at this time?
A You did not ask me about comparison between any two particular types of deposits. You asked me if they had complexities, and I said they do. As all natural deposits do.
Q Okay. So all sedimentary deposits are complex?
A Pretty much everything underground has some degree of complexity, but it's complexity we can figure out in determining whether or not they're aquifers or not.
Q Well, does the complexity of the particular sediments

deposited in a local area have any impact on the ability to recover water? Just yes or no.

A Okay. I'm interpreting your question is you're asking me about very local conditions now, as if you put a well in a particular location in an area and you're trying to target a deposit that, let's say, is a fluvial delta.

Increased complexity in terms of finer grain or coarser grain materials can affect the local conditions and the ability to achieve a certain yield out of a given well in a given location. So once you're talking about, okay, do I put the well here or put the well here, detailed local complexities can certainly influence that.

Q And other than sand grain size, what about the presence of more clay?

A Well, that's grain size in general. You know, sand grains aren't the only ones that have grain size. Clay also has grain size. So grain size absolutely affects that.

Q Okay. So local water production capability will depend on the underlying geology to a large extent; is that correct?

A There's variabilities of that all over the place. Like if you looked at the history of development of the MLGW well fields, they don't get a good well every time they drill. Sometimes they find materials that are too fine grind and move over 100 feet and try again and then get a good well there. So, yes, there are definitely local variations of that type of

thing.
Q Thank you.
And one of the things that is fundamental how much water can be withdrawn and the impacts of stress in the system is the thickness of the particular formation out of which you're pumping water, isn't it? Isn't transmissivity a function of permeability and thickness?
A Okay. When you're talking about transmissivity, the theoretical construct is indeed permeability times thickness.
However, it's rare that you have sufficiently consistent permeability and thickness for that to apply precisely. Transmissivity is really a measure of how effectively a given formation can deliver water to a particular well or a particular well as it's screened under a given head gradient.
So you're generally correct. I'm just saying it's not quite as precise as saying you just multiply thickness times permeability, though that is the theoretical construct that we use to mathematically characterize transmissivity.
Q These subsurface formations are more complex than that; they're not typically homogeneous and isotropic, right?
A Absolutely. Using the MLGW well fields, frequently most of the wells are developed in the upper portion because that has coarser sands. You get down near the deeper portions and the sands get finer and, in fact, you run into clay layers of

various sizes.

So there are variations that need to be taken into account when you're actually developing a particular well or well field.

Q Thank you.

The document -- I'm going to show you a document, just to kind of close off the discussion of the area, which has been marked J66. He's going to put it up on the screen. All I'm going to do is ask him to identify it.

Have you studied this document as part of developing your opinions in this case?

A I have definitely looked at this document before. I don't recall specifically to the extent to which I relied upon it.

Q I'll ask you again if Sparta Sand extended as far west as Texas?

A There may very well be a material occult of the Sparta Sand in Texas. I did not -- for my -- for purposes of this work, I did not extend my investigations into Texas.

Q But from the standpoint of the US Geological Survey, the Sparta Sand in Texas is hydrologically connected, under your definitions, to the Sparta Sand in Mississippi, isn't it?

A I don't know that.

Q You don't know that. You don't have an opinion one way or the other?

A As regards to anything in Texas, that's correct. I have

not developed an opinion on that.
Q Thank you.
Let's put up that second one. Now, this is a map you put up earlier, and you testified that you drew the outline of the area that was covered by the MERAS model on this map. Is that correct?
A Well, what I testified is I took the brown outline of the Mississippi Embayment Aquifer System from the MERAS model and transferred it onto this map of principal aquifers of the US.
Q Thank you.
And you're not testifying, are you, that that is the full extent of the Mississippi Embayment Aquifer System, are you? I mean, this is an area you picked out to study, right?
A This is -- this is definitely the area of the Mississippi Embayment Regional Aquifer Study.
Q For which they prepared a model?
A They did prepare a model for this area, yes.
Q But you're not testifying that that dark area is the full extent of the Mississippi Embayment aquifer System, are you, that area that you've outlined that they studied?
A Well, that's a good question. I would have to go back and check the definition. That's definitely the area of the study. As to whether some area outside of that -- well, we already talked about the southern boundary is the -- is the -- really defined by the salinity of the water.

Q In this study?
A Yeah. As to whether some portion of the western boundary, particularly towards Texas, might be defined by something other than the end of the identified geological formations, that's something I would have to refresh myself on. But I do know that around the upper portion, if I could go point --
Q Sure.
A As we look at sort of this portion of the Mississippi Embayment Aquifer System, that, I know, is defined by where the unit's outcrop essentially end and come to the surface. What I'm realizing I'm not 100 percent certain about is the definition of this portion of the study area. I'd have to refresh myself on that.
Q Thank you.

But under your definition, all of the groundwater found within the Middle Claiborne Aquifer, as you define it within that entire study area, is interstate groundwater; is that correct?
A All of it is contained within an interstate aquifer.
Q But I'm just saying, your opinion is that all of the groundwater that can be found with that entire Mississippi Embayment study area is interstate water that is shared by all of the states over which that formation resides; is that correct?
A The entire aquifer is a shared resource, and any state can

drill down into that resource and extract water from it.
Q So if it were possible, a well could be drilled in northwest Louisiana, and if they were technologically able to recover water from Mississippi, that would be a resource they were entitled to recover; is that correct?
A Well, you're asking me about entitlement now. I'm providing technical scientific evaluation. "Entitlement" sounds to me more like a legal judgment, which I'm not here to make.
Q Well, okay. Is it your testimony as a scientist that you're telling the Court that all of the groundwater in any of these states within that area, if it's technologically possible, is a resource available to every other state in that area?
A Well, okay. You're -- I mean, this is a confusing question. Are you asking -- so if you've got a well in a given state --
Q Anywhere.
A Okay. You put a well in a given state and you're asking me, if they pump hard enough, will the water come from another state?
Q If they, under current technology or future technology, have the ability to recover water from all of the states in the Mississippi Embayment, is that a shared resource they're entitled -- that they have a right to, a claim to?

A Okay. You've moved into rights and claims again now. I'm not here to testify about rights and claims. That really very much sounds like you're asking me to issue a legal opinion, and I'm not going to talk about rights and claims.

I'm saying that the -- you have -- everyone has the ability, the technical ability, to drill down, straight down in their state and access water in this interstate aquifer.

Q Is it your testimony that all that water is shared -- a shared interstate resource for all of the states within that area?

A When you say "for all the states," it's an interstate resource available to all the states. In every state you can drill down and you can get water from that interstate aquifer.

Q Okay. So to the extent they can get it, it's a shared resource; is that correct? Well, let me back up.

A Well, I'm not sure what --

Q I'll stop.

A I've described my opinion several times.

Q I'll stop.

A I'm not sure what you're trying to get at.

Q I'm trying to get at what it really means when you say it's a shared natural resource among all the states within the Mississippi Embayment. I was just trying to get an idea if there's any limitation on that statement.

Do you place any limitation on your opinion that the

water within the aquifer, as you have defined it, is a shared resource in that entire area? Have you placed any limitation on that?

A Not in the sense that I describe, where, in any state you can drill down, you can pump that water, and if you pump hard enough, it's going to have effects in other states.

Q And so the ability to pump it is one of the things that you have said makes it interstate?

A No. The ability to pump it makes it an aquifer. The interstate is the part where the aquifer underlies state boundaries.

Q Yeah. But you did testify that one of the things that supported your broad definition was that it could be pumped from one state to the other, right? In your opinion, that supports your position that it's an interstate resource, right? Did you or did you not --

A The fact that -- the fact that it impacts the pumping across state lines supports the delineation of the aquifer going across state lines.

Q Thank you.

Now, you described pumps, and appreciated it, in your report.

Would you go look at page 7 of your report, page 13 of 80?

A I'm sorry. Tell me the page again. I was just getting

there.
Q Page 7 of your report. It's 13 of 80 of D191.
A 7 of --
Q It's your page 7 --
A My page 7.
Q -- in your report. It's also page 13.
A 13. I've got it now. I'm sorry. Yeah.
Q Do you see up there where you have bullet points talking about how pumps work?
A Yes, up near the top of the page.
Q Thank you.
Now, the -- the part that I'm interested in is you say, "The pump impellers which are placed below the water level in the well casing and push groundwater from the aquifer toward the surface" -- did I read that right?
A Yes.
Q Okay. Now, you're talking about turbine pumps, right?
A That would be the technology that I'm referring to here, yes.
Q Impellers generally means turbine pumps, correct?
A Yeah, that's correct.
Q Turbine pumps can pump a great deal more water than the traditional pumps, can't they?
A Well, I'm not sure what you necessarily mean by "traditional pumps." But turbine pumps were indeed a great

advance in pumping that allowed higher capacity wells than previously available with the older methods.

Q When did they come into use, to your knowledge?

A Say that again.

Q When did they come into use, to your knowledge, turbine pumps?

A I don't remember. Sometime post-World War II. Maybe in the '50s or '60s, but I don't really remember exactly when that technology came into common use.

Q They made it possible to pump a lot more water out of the system; is that correct?

A Turbine pumps, as I said, were a big advance in pumping technology that allowed higher capacity wells than were really previously available.

Q And that pumping load is the pressure point that it pulls water not only up the well bore but from around the well toward the well within the confined formation, doesn't it? That's your cone of depression?

A Well, I describe it here, and it's not the pressure that lowers the head in the well. And it does that by pumping water out of the well, and then under natural laws, the water -- because the head in the well has been lowered, the well is exposed to the aquifer through the screen, that creates a head gradient, which moves water in the aquifer towards the well.

Q So -- but you're not saying the pumping is a natural -- is

a natural -- or is a natural law, are you? I know it's an application.

A Well, the impellers operate according to natural law. You know, they've been constructed -- they're a manufactured item, but all pumps, mechanical pumps, whether you're pumping out groundwater or surface water, are machinery.

Q Okay. Man, they're created by man, right?

A Yes, but natural laws are used to design them.

Q Natural laws are used for our cars too, aren't they?

A For our cars, yes. Many things.

Q And all the technology in this courtroom and everything else?

A Our microphones and everything else.

Q So you can't get much away from the natural law, can you?

A It's hard.

Q Okay. Thank you.

Now, you defined in your report the phrase "predevelopment"; is that correct?

A I believe I did somewhere, but I couldn't tell you exactly where.

Q You can look at page 5 of your report or page 11 of 80.

A Oh, yes, there it is.

Q And it says, "Time prior to human influence on the aquifer. Most commonly time before pumping began."

Did I read that right?

A Yes.
Q And it -- your paragraph also says that it's generally considered before 1980. And that would be throughout the United States; is that correct?
A Oh, boy, I don't think so.
Q Well, you said --
A 1980.
Q No, 1870. Thank you.
A The 1870 number is for the entire Mississippi Embayment Aquifer System.
Q Okay. And then 1886 is the Memphis area?
A Right. That's the first pumping that I'm aware of in the Memphis area.
Q So before those dates, all of the groundwater found in the Mississippi Embayment Middle Claiborne Aquifer system -- aquifer, as you defined it, would be under natural conditions?
A I would describe it that way, yes.
Q And I believe you've already described it, that pumping changes -- pumping stresses aquifers, does it not? Isn't that a term used regularly by the USGS?
A Well, not just by the USGS, but hydrologists in general, when you think about the variety of different types of stresses that can be put on a hydrological system, and pumping is one of them.
Q But pumping is the primary one that is used to withdraw

additional groundwater, is it not?
A I would say it's the primary one, yes.
Q Thanks.
Now, this is one of the slides that was used under direct testimony. And I believe the slightly shaded blue area is the area that you were indicating that is covered by your opinion. Is that correct?
A Yeah, the blue shaded area is the area that I'm saying is an interstate aquifer and the aquifer in question in this matter.
Q Thank you. Let's go to the next one.
MS. ROBERTS: Could you speak a little louder, please.
MR. ELLINGBURG: Yes, I will. I'm sorry.
BY MR. ELLINGBURG:
Q I put D18 before you. You testified about this on direct.
This is Dr. Waldron's predevelopment map; is that correct?
A This is a map from the article prepared by Drs. Waldron and Larson.
Q And have you relied on that map? Yes or no.
A As part of my literature review to determine what other scientists have said about what can be inferred about data or what can be inferred from data about whether there's flow across the state line, I relied on it in that sense. I have not independently verified it.

Q Sure. Do you know if the USGS has documented this predevelopment flow and changed the predevelopment flow, as reported in this area, in the reports all the way through MERAS?

A Well, I wasn't aware that the USGS had actually reported predevelopment flow, but I'm also not aware of any adoption of this work by the USGS.

Q Has the USGS modeled predevelopment flow in the Brahana and Broshears groundwater model and in the MERAS groundwater model?

A In the Brahana and Broshears report, they did not report predevelopment flow that I recall. Now, if they did and you can show me, then I'll stand corrected.

And the same with the MERAS model. I'm not -- I'm not recalling that in the various MERAS studies that they reported any predevelopment flow rates.

Q What about Arthur and Taylor?

A Arthur and Taylor had some water budgets in them. I don't recall that any of them were specifically for predevelopment flow across the Mississippi-Tennessee state line.

Q What about Criner and Parks?

A Criner and Parks, I don't recall if they actually reported a flow rate across the state line.

Q No, I didn't say a flow rate.

A Oh. What did you ask me?

Q Are there any potentiometric surface maps that have been

generated by the USGS that cross the Mississippi-Tennessee state line that you have studied?
A Is that the question that I've been answering? Because I was answering a different question, if that's what you --
Q I'm sure it was my question. But I'm asking --
A I was answering a question -- I thought you asked me whether the studies had reported flow rates across the Mississippi-Tennessee state line.
Q No, I was asking about predevelopment.
A So all of that series of answers I just gave were related to whether or not those studies reported flow rates across the state line.
Q Well, then I'll withdraw that if that's what the question was.
A Yeah, that's the question I was answering.
Q That's fine. This is tough stuff for me, so I'm --
A Okay.
Q -- I'm easy to be misunderstood.
Did the USGS report any predevelopment subsurface potentiometric map -- or did they provide any subsurface predevelopment potentiometric maps that they had created with models?
A Let's just go through the three primary models that I talked about.
Q Okay.

A The Arthur and Taylor work, they did present a predevelopment head map. In fact, that was one of the slides in my direct testimony.
Q Right.
A The Brahana and Broshears report did not present a predevelopment contour map developed with their model. They only presented the work of Criner and Parks, unfortunately, not totally accurately presented, but they included that map. But that was not generated by the model.
And then for the MERAS work, you know, I'm not -- there's several different reports, and I don't remember whether in their reporting they presented a predevelopment potentiometric head map. I created one in the model, but I don't remember whether one was presented in the various MERAS study reports.
Q So the ones we've looked at that are in your report, you created it?
A The Arthur -- I mentioned that Arthur and Taylor, in their study, they -- they created and published a predevelopment potentiometric head flow map -- or not flow map -- predevelopment potentiometric head contour map, and that was one of the maps that was in my direct. They also did a -- no, that was pumping. I'm sorry.
For predevelopment, they did present the one that was in my direct. Brahana and Broshears did not present, in their

2001 report, a model-generated predevelopment potentiometric head map.

And I can't remember whether the MERAS study published a predevelopment potentiometric contour map in their reports or not.

Q Okay. With that clarification, have you seen the predevelopment map that is shown in D18 in any USGS publication?

A I'm not aware of seeing it.

Q Okay. You relied on it, right?

A I relied on it in the way I described, as part of my literature review to see what people who had studied predevelopment data, what kind of conclusions they arrived at.

Q But you did say, I think, that you didn't do anything to confirm its accuracy. Is that correct?

A That's correct. And the same is true for the Criner and Parks work. I did not independently verify their work either.

Q You haven't made any effort to confirm the accuracy of any of the predevelopment flow maps you've looked at; is that correct?

A I'm talking about the predevelopment flow maps developed from data, the Criner and Parks map and the Waldron and Larson map. I have not done independent verification of any one of those.

Q Thank you. Let's go to the next one.

Now, you testified about this particular slide on direct; is that accurate?

A I don't think so.

MS. ROBERTS: I'm going to object. This was not part of his direct examination.

BY MR. ELLINGBURG:

Q Okay. I'm showing you Defendant's Exhibit D19. Is this a -- a particle tracking map that you created using the MERAS model and another program?

MS. ROBERTS: Again, Your Honor, I'm going to object. This was not part of his direct examination.

THE COURT: Well, that may be. I'm going to let him ask the question, though. Overruled.

THE WITNESS: The answer is, I believe so. I'm just double-checking.

MS. ROBERTS: Yeah, if you could give him -- this is not -- he does not have every defendants' exhibit in front of him.

MR. ELLINGBURG: I know, but it's part of his report, I believe; it's part of your rebuttal report.

MS. ROBERTS: So direct him to where it is so he can find it, please.

THE COURT: You can ask him if it was part of his report. If it was testified and introduced by some other witness, he probably doesn't even need to answer unless he --

MR. ELLINGBURG: Also, he testified to a number of particle tracking maps.

THE COURT: If he knows about it, he can testify about it.

MS. ROBERTS: Can we make sure he has the right --

MR. ELLINGBURG: This is an exhibit -- this is in your rebuttal report, and I believe it's in Exhibit --

THE WITNESS: I don't think so.

MS. ROBERTS: I don't think so.

THE WITNESS: I think it's in my original report.

BY MR. ELLINGBURG:

Q It is?

A It appears to be. The colors are a little different but, you know, colors sometimes appear different in different --

THE COURT: You may answer it if you know about it, or if you prepared it, you may do that.

THE WITNESS: Yes, I did prepare it. It was part of my report, part of my original report.

BY MR. ELLINGBURG:

Q Thank you.

Now, is this also a particle tracking map where you identified the line from which the particles would be tracked using the information -- using a different computer program and the MERAS model?

A Yes, with one clarification. I identified the location of

the initiation of the tracks that are shown on here.
Q Yes. That's what I meant to say.
A Yes, I thought that was.
Q And you -- what was the program you said you used to perform the particle tracking?
A Mod-PATH. That's M-O-D-P-A-T-H, is the name of that program.
Q Thank you.
In this particular case, the southernmost line you originated, it looks like right at the Coldwater River; is that correct?
A Well, let's look at the caption on this figure.
Q Yes.
A It says, "Predevelopment MSSA Flow Pathways for Water that Recharged the MSSA in Mississippi from the Outcrop Area North of the Coldwater River."
Q Okay. So it's a little bit north of the Coldwater River, according to the map?
A Well, it's starting from the model cells immediately north of the Coldwater River that are also in the outcrop area.
Q Thank you.
Does that same model that you ran provide you with travel time?
A You can estimate travel time or compute travel times from that model.

Q So when you put that location in for the particle tracking, if you had done what you have to do with the computer program, it would have not only generated these -- these lines that underlie your arrows, it would have also generated travel time of those particles, would it not?
A It generates the information at least from which you can compute travel time. That can be computed.
Q I mean, generally, it's information you ask, right, or does it generate travel time automatically?
A You know, I don't remember if it automatically generates travel time or if it generates information from which travel time can be computed.
Q In any event, you chose not to report travel time in your -- in your particle tracking maps; is that correct?
A That's correct.
Q And why did you decide travel time shouldn't be reported?
A Well, let's go back to my definition of an interstate aquifer. It's an aquifer that exists on both sides of a state line. And then this kind of -- so that has nothing about travel time in that definition.

And then in the memorandum of decision from the special master, he was interested in flow patterns in the vicinity of the border, so I'm showing flow patterns.
Q Okay.
A I was not -- there was nothing in developing my opinion or

in what I interpreted from the special master's memorandum where time of travel was significant.

Q Is travel time something that you use as a hydrogeologist in any of your work?

A Yes, it is.

Q And how do you use it?

A It depends on the question being asked.

Q Okay. If someone drops gasoline on the ground and the question is where that gasoline might end up and how far it might pollute the water, do you use travel time?

A Well, for the two questions you just asked, no. But sometimes the question also is when will it arrive at a particular area of concern, and in that question, then I would compute travel time.

Q Right. So in this case, you could easily have obtained the information necessary to tell us how long it would have taken the water beneath your point on the map that you selected to reach the Mississippi-Tennessee border, right?

A I could have, yes.

Q You just didn't think it was important for the Court to know?

A I didn't think it was an important part of my opinion.

Q Thank you.

Now, you are a hydrogeologist, so you have some idea of how fast water flows within the particular type of formation

that you chose here, which is an outcrop area of the aquifer; is that correct?

A I have general knowledge of the range of groundwater flow rates.

Q And how far south of the border is that particle that's most south in this particular case, the one that starts at the Coldwater River? And it looks like it's consistent with your 4 miles.

A When you say my 4 miles, what do you mean?

Q I think in your direct testimony you pointed out that some of the particles were approximately 4 miles from the border.

A Well, this looks a little further than 4 miles to me. Just using this marker as a scale, I would say it might be closer to 10 miles, but it's a little bit -- I'm not doing anything very accurate here using the end of this magic marker as a scale.

Q That's fine with me.

Okay. How long -- assuming the fastest travel time through this particular aquifer material, how long would it take it from the time it left that point that you described at the Coldwater River until it hit -- an estimate, within a thousand years or so, 100 years or so, before it intersected the Mississippi-Tennessee border? How long would it take?

A I don't know off the top of my head what the fastest travel time is. And I would need a pen and paper or a calculator to do that calculation anyway, even if I -- even if I knew what

the -- what the number of the fastest travel time you mentioned was.

Q And you don't know the number?

A I don't know, off the top of my head, what the fastest travel time is. That's something that would have to be computed.

Q Does the model contain the kind of information -- well, it obviously does because the model would calculate it, right?

A In order to determine the fastest travel time, you would have to compute lots and lots and lots of travel times and figure out which one -- or not travel time; velocities, fastest velocity -- you would have to compute lots and lots of velocities and figure out where it was the fastest. So that would be a significant undertaking.

Q Okay.

A And I'm not aware that anyone has done that.

Q Or you would have to collect the data from the model?

A I'm talking about using the model. What I described is you'd have to do those calculations for lots of places and figure out where it's moving the fastest. That would be a massive task.

Q Okay.

A And I don't think anyone has done that. I haven't done it, and I've not heard that anyone else has done it either.

Q Thank you.

Within your opinion, is it your opinion that you've reached a point that you've identified within a year to the Mississippi border? From north of the Coldwater River to the Mississippi border, could that particle travel in a year that distance?

A Well, that would be highly unlikely to travel that 10 miles or so in a year. In fact, I don't think that would happen.

Q Okay. What about 10 years?

A Probably not.

Q What about 50?

A Let's see. 50 years, I said it's about 10 miles, so that would be, what, half -- I'm not very good at doing arithmetic in my head sitting here on the stand.

How many miles in a year would that be? That would be two-tenths of a mile in a year, is it? No, that's not right.

Q You're the mathematician.

MR. BRANSON: Your Honor, I thought yesterday we decided we weren't going to ask witnesses to multiply numbers. That's just a waste of time.

MR. ELLINGBURG: Okay.

THE COURT: If you can do that, even I can't guess.

MR. ELLINGBURG: Okay. I'll move off.

BY MR. ELLINGBURG:

Q In any event, what you're showing here is water that leaves Marshall County, Mississippi; is that correct? In the first

line, the southernmost line?
A Many of these locations start in Marshall County.
Q In this particular map, do any of them start in DeSoto County?
A I don't believe so, because I'm not aware that there's -- there may be -- some reports may show a little bit of outcrop in DeSoto County, but as I understood the outcrop areas in the MERAS model, they were not included in DeSoto County -- there weren't any outcrop areas in DeSoto County.
Q Primarily in Marshall County east, right?
A Yes. That's where these particle locations were started. That's what it says in the caption, in the outcrop area.
Q What was the reason for selecting the outcrop area, as distinguished from the confined aquifer?
A The specific purpose of this map is to show pathways for precipitation that falls in Mississippi, infiltrates into the outcrop areas north of the Coldwater River. So that's really what we're looking at here, the outcrop areas where precipitation can enter the aquifer directly. So you've got rain that falls on the aquifer. Some of it infiltrates down -- excuse me. Precipitation falls on the ground surface. Some of it infiltrates down into the aquifer and in the outcrop areas, and then this -- these tracks show the pathway that that water follows for the outcrop areas north of the Coldwater River, as described in the caption of the figure.

Q Thank you. Let's go to the next slide.

Is this another particle tracking map that you created?

A It appears to be. Just let me double-check here.

Q And, again, the lines are lines you drew within the mass of particles that are shown on this map, correct?

A This is a figure from my report, and the dark black lines with arrows on them are lines that I drew to indicate generalized directions. The underlying narrow blue lines are -- were generated through the MERAS model combined with the mod-PATH model.

Q Is there any reason you didn't start these particles further to the west when you drew -- or not -- strike that.

Is there any reason you didn't draw your line reflecting the particle flow further to the west?

A Let me be sure I --

MS. ROBERTS: I'm not sure what line you're talking about.

BY MR. ELLINGBURG:

Q That's the only line.

A Are you talking about this -- well, there's this line and this line. So are you talking about this line further west or this line further to the west?

Q Well, I believe, if you moved the one that's on the east, further west, you're going to get a different line to the west,

are you not?
A Well --
Q If -- looking at the particle tracks on here -- I'm just looking at them -- if you had originated your dark line further to the west but still within your particle tracking, then that path you have drawn there would be further to the south, wouldn't it? That arc would move further to the south?
A I'm not following you. I will say --
THE COURT: Go up there and use the pointer, Mr. Ellingburg, and show him what you're talking about.
MR. ELLINGBURG: I'll do it. Thank you very much, Your Honor. I didn't know if I should do that.
THE WITNESS: Do you want to use this?
MR. ELLINGBURG: I certainly do.
BY MR. ELLINGBURG:
Q If you follow this particle right here and follow it, you would get a little lower line across here, wouldn't you? It may even touch Tennessee, which is a little lower, isn't it?
A Well, it's hard to follow the individual lines, but there certainly are lines within that vicinity that do not go into Tennessee, yeah.
Q So if the particle started here, then you would have ended up with a different arc; you wouldn't necessarily have gone to Tennessee; is that correct?
A It's generally correct that, wherever you start from,

there's a slightly different pathway.
Q And even in this, most of the particles here are within the State of Mississippi, aren't they?
A You asked me about most. I never tried to --
THE COURT: Keep your voices up, both of you, please.
BY MR. ELLINGBURG:
Q I'm taking it that these lines represent particles. Is that correct?
A Each line represents the travel path for one initial location.
Q Thank you.
So on this map, most of these -- most of this water, most of these particles, are primarily in Mississippi, aren't they?
A I have not done a count to allow me to say most.
Q So you can't look at this and look at this and tell that most of it's down here (indicating)?
A That -- if you're asking me about whether most of the tracks on this particular diagram do not enter Tennessee, I can't -- I can't tell you that looking at this.
Q Good enough.
A There's no question that some don't.
Q Just a few of them may not make it into Tennessee?
A I'm not going to characterize how many because I've never tried to count, but there's no question that some do not.

Q Thank you. That's good enough.

MR. L. BEARMAN: Your Honor, I wonder if we could persuade --

MR. ELLINGBURG: I'm getting close to stopping.

MR. L. BEARMAN: Good. I vote for that. But can we persuade Mr. Ellingburg to let the witness at least finish his sentence before he leaps back to the podium and says good.

MR. ELLINGBURG: Well, Mr. Ellingburg --

THE COURT: That's a good point, yes.

MR. ELLINGBURG: I apologize. I didn't mean to press you too much.

THE COURT: Okay.

MR. L. BEARMAN: Thank you, sir.

THE COURT: Yes, as long as you finish your question and then let the witness answer.

MR. ELLINGBURG: Thank you.

I don't believe we need to ask any additional questions at this point.

THE COURT: Will there be any other --

MR. FREDERICK: Tennessee has no questions.

THE COURT: All right. Do you have some?

MS. ROBERTS: Your Honor, I have no redirect.

THE COURT: You may step down. We'll take a short recess for ten minutes, and then we'll come back in and proceed.

(A recess was taken.)

THE CLERK: All rise. This Honorable Court is called back to order.

You may be seated.

THE COURT: Okay. Now do we have any further evidence here on behalf of Tennessee or Memphis?

MS. ROBERTS: Your Honor, the City of Memphis and Memphis Light, Gas & Water Division rests.

THE COURT: Tennessee has already rested?

MR. FREDERICK: Yes.

THE COURT: Now, is there any rebuttal testimony?

MR. ELLINGBURG: Your Honor, the State of Mississippi has no rebuttal testimony.

THE COURT: You what?

MR. ELLINGBURG: No rebuttal testimony.

THE COURT: With that, that completes our hearing, I suppose. I think before we had talked about allowing you to -- before I think we had had an agreement that you may file post-trial motions. Do recall about it, or what do you want to do?

MR. FREDERICK: Your Honor, this is David Frederick for the State. Under the original post-trial briefing schedule, we have 90 days to file a brief as of today, close of hearing.

MR. ELLINGBURG: Yes.

THE COURT: Okay.

MR. FREDERICK: That was established at a time when the hearing was going to be in January. The State is prepared to offer to do a shorter briefing schedule if that facilitates the work of the Court in light of your staffing situation, and we would be prepared to file briefs within 45 or 60 days, which would put the opening briefs in July. I can give the precise dates.

I have not consulted with Mississippi about that, but I wanted to offer to you, on behalf of the State of Tennessee, to do that because we appreciate that we're getting to that time when staff changes occur.

THE COURT: Okay. But what, Mississippi?

MR. ELLINGBURG: Your Honor, we would prefer to just stay with the original agreement and the original order, which would give us 90 days from today.

THE COURT: 90 days from today?

MR. ELLINGBURG: Yes, sir.

THE COURT: And, well, we'll just do it that way, then, if that's the way it was originally.

MR. FREDERICK: Your Honor, that would put the briefs due on August the 22nd, which is 90 days from today.

THE COURT: Yes.

MR. FREDERICK: And then, under the schedule set by Your Honor, there would be joint briefs -- or I should say

simultaneously briefs, post-trial briefs, filed on that day. 30 days later, there would be reply submissions from the parties.

THE COURT: Okay. Are you agreeable to that?

MR. ELLINGBURG: Yes, Your Honor.

THE COURT: And how about for Memphis?

MR. FREDERICK: And we would have briefs those days. We would also have proposed findings of fact for Your Honor.

THE COURT: Okay.

MR. D. BEARMAN: That is the understanding of the City and MLGW also, Your Honor, 90 days and then -- for briefs and proposed finding of fact and then 30 days for rebuttal.

THE COURT: All right. That's fine. If everybody is agreeable to that, that's the way we'll do it.

I don't know how soon you can get transcripts of this. Are you aware? I don't know.

MR. FREDERICK: We have a marvelous reporter, Your Honor.

THE COURT: Well, you can talk to the reporter about that.

MR. FREDERICK: Okay. And, Your Honor, just --

THE COURT: Because you'll need that, I'm sure.

MR. FREDERICK: Just so the record is clear, I think there are page limits in the post-trial briefs that the opening briefs are limited to 40 pages and the responsive briefs are

limited to 30 pages. But just to confirm that the order that we were operating under for the January hearing would still apply.

THE COURT: That's still applicable, unless we change it. And if it's not changed, that's the way we'll proceed.

MR. D. BEARMAN: Your Honor?

THE COURT: Yes.

MR. D. BEARMAN: Would you like the parties to provide the Court with the transcript, or does your -- does the Court have one? I just want to make sure that you have what you need.

THE COURT: When you order, we will have an order also. We'll have our -- we'll pay for our own transcript.

MR. FREDERICK: And, Your Honor, I've noted that there are a few corrections to be made, from what I've seen from today's transcripts. We'll get those to the reporter as promptly as possible so we can get a final certified copy.

THE COURT: Okay. Mississippi can do the same.

MR. ELLINGBURG: Yes, Your Honor.

MR. L. BEARMAN: That's it.

MR. D. BEARMAN: Thank you for your time, Your Honor, and to our court reporters.

THE COURT: I'm glad we got it all the way so then we don't have to come back. As much as I like Nashville, I'll don't have to come again for a while.

Okay. Anything else? I commend the attorneys for their work here. And we expedited quite a bit of it, but you have to put on the testimony in the record.

And what do we do about -- we've got some exhibits in the bankruptcy chambers. Do we take those, or are they copies of what we already have?

MR. D. BEARMAN: Your Honor, the boxes prior to the -- this hearing, we brought from Memphis copies of the joint exhibits and the defendants' exhibits, and we understand that Your Honor already has copies back home.

THE COURT: That's correct.

MR. D. BEARMAN: And if it is easier, we are more than happy to take those boxes. Whatever Your Honor has not used, we can get those back so that you don't have to take them. If you'd rather take them, that's fine, too.

THE COURT: Okay. I don't see any reason to take them if they're duplicates of what I already have.

MR. D. BEARMAN: They absolutely are.

MR. ELLINGBURG: The ones marked during the hearing will be the exception.

THE COURT: The what?

MR. ELLINGBURG: There are exhibits that were marked during the hearing that you would need to take.

MR. FREDERICK: May I propose, Counsel, that we also get those exhibits that were admitted in court during the

hearing, vet them amongst each other, and then have a set sent to the judge, to chambers, so that there's no confusion to the things that were just handed up to the dias.

MR. ELLINGBURG: Yes, we can do that.

THE COURT: Good idea.

Is there anything else that we need to take up at this time?

MR. ELLINGBURG: No, Your Honor.

MR. D. BEARMAN: No, Your Honor.

THE COURT: Now, we'll be in touch with you if we find a problem that we can't handle. I'll let all you know. And if you have any subsequent problems, we can all have a conference call, if necessary.

MR. FREDERICK: Your Honor, in light of -- I think that we agreed also to do closing arguments after the post-trial briefs were filed.

THE COURT: Yes.

MR. FREDERICK: And under the schedule we have, we would do the opening briefs the third week of August, the reply briefs the third week of September. If you could let us know what your availability is for a closing argument promptly thereafter so that we could get it reserved in our calendars and plan accordingly, we would be grateful for that.

THE COURT: Okay. We will take that down and let you know. If I'm not going to be around or if you have problems,

we can be kind of flexible.

Do you want the closing arguments in person?

MR. ELLINGBURG: Yes, Your Honor.

MR. FREDERICK: Yes, Your Honor.

MR. D. BEARMAN: Yes.

THE COURT: All right. We'll do that.

If there's nothing else, we'll recess court.

MR. FREDERICK: Thank you, Your Honor.

MR. ELLINGBURG: Thank you, Your Honor.

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

MR. BRANSON: Thank you, Your Honor.

(Hearing concluded at 2:51 p.m.)

REPORTER CERTIFICATE

STATE OF TENNESSEE

COUNTY OF DAVIDSON

I, JULIE K. LYLE, RPR, RMR, CRR, Licensed Court Reporter, in and for the State of Tennessee, hereby certify that I reported the foregoing transcript by machine shorthand to the best of my skills and abilities, and thereafter the same was reduced to typewritten form by me.

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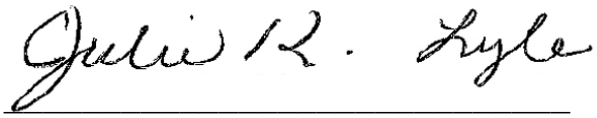

Julie K. Lyle, RPR/RMR/CRR
REGISTERED PROFESSIONAL REPORTER
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