In the Matter Of: STATE OF MISSISSIPPI vs STATE OF TENNESSEE, ET AL 143, Original PROCEEDINGS May 23, 2019 ALPHA REPORTING Corporation 1st in Reporting, 1st in Service, 1st in Technology We Bridge the State and Cover the Nation! www.alphareporting.com 800-556-8974

IN THE SUPREME COURT OF THE 1 UNITED STATES 2 -----x 3 STATE OF MISSISSIPPI, 4 Plaintiff, 5 No. 143, Original v. STATE OF TENNESSEE, CITY OF б MEMPHIS, TENNESSEE, AND MEMPHIS LIGHT, GAS & WATER 7 DIVISION, 8 Defendants. 9 -----x 10 11 May 23, 2019 12 8:59 a.m. 13 14 ON BILL OF COMPLAINT 15 Before: 16 HON. EUGENE SILER, 17 Special Master. 18 APPEARANCES 19 BARRETT LAW GROUP, P.A. Attorneys for Plaintiff 20 BY: DAVID M. MCMULLAN, JR. 21 DANIEL COKER HORTON & BELL, P.A. Attorneys for Plaintiff 22 BY: C. MICHAEL ELLINGBURG LARRY D. MOFFETT 23 NEAL & HARWELL 24 Attorneys for Plaintiff BY: CHARLES BARRETT 25

722 A P P E A R A N C E S (continued) 1 2 JIM HOOD Attorney General for the State of Mississippi 3 BY: DONALD L. KILGORE 4 KELLOGG, HANSEN, TODD, FIGEL & FREDERICK Attorneys for Defendant State of Tennessee 5 BY: DAVID C. FREDERICK JOSHUA D. BRANSON T. DIETRICH HILL 6 GRACE W. KNOFCZYNSKI 7 HERBERT H. SLATTERY III Attorney General for Defendant State of Tennessee 8 BY: BARRY TURNER 9 BAKER, DONELSON, BEARMAN, CALDWELL & BERKOWITZ 10 Attorneys for Defendants City of Memphis, Tennessee and Memphis Light, Gas & Water Division 11 BY: LEO M. BEARMAN DAVID L. BEARMAN 12 KRISTINE L. ROBERTS 13 BRUCE A. McMULLEN Attorney for Defendants City of Memphis 14 15 16 17 18 19 20 21 22 23 24 25

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724 Larson - cross (Case called) 1 THE COURT: We have some questions for Mr. Larson? 2 MR. ELLINGBURG: Yes, your Honor. 3 4 THE COURT: All right. Resume. 5 6 STEVEN LARSON, resumed. CROSS EXAMINATION (continued) 7 BY MR. ELLINGBURG: 8 9 I've been told by everybody around me that I need to talk 0. 10 louder. So I'm going to make an effort this morning to talk 11 louder and talk at a pace which is reasonable. Hopefully it 12 won't be as disruptive as the blasting next door. 13 I believe yesterday you testified that the Lower 14 Claiborne Aquifer hydrologic unit is part of the Middle 15 Claiborne hydrologic unit; is that correct? 16 A. Yeah, they're a group sort of together. One would be kind 17 of, in my view, sort of a subunit of the other. Q. Well, but I'm asking specifically, you testified that's all 18 19 the Middle Claiborne; it includes the Lower Claiborne 20 hydrogeologic unit as defined by the USGS. Is that correct? 21 At least as it was characterized in that table, yeah. Α. 2.2 Okay. Are you familiar with the nomenclature the USGS uses Ο. 23 when it names hydrogeologic aquifer and confining units? 24 A. Yes, generally. 25 Q. Now -- generally?

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1	Larson - cross A. Yeah, I mean, I've read through documents that describe it.
2	Q. Okay. How does the USGS distinguish between
3	hydrogeological units within its reports on a scientific basis?
4	A. The principal basis for distinguishing these units is on
5	the basis of permeability. That is to say that the more
6	permeable units are characterized as aquifers, and the less
7	permeable units would be characterized as confining units.
8	Q. Okay. So in the USGS scientific nomenclature, would the
9	hydrogeologic unit above an aquifer hydrogeologic unit be the
10	hydrogeologic confining of the confining hydrogeologic unit?
11	Is that the way they do it?
12	A. Not exactly.
13	Q. Okay. So the USGS doesn't when it maps things for its
14	scientific purposes in complex data, it doesn't show confining
15	hydrogeologic units big word as resting above what it
16	defines as a separate aquifer hydrogeologic unit? You're
17	saying they don't do it that way?
18	A. Well, no. What they're trying to do is identify, based
19	primarily on permeability characteristics, where the aquifers
20	are and where the confining units are. It may be that in some
21	cases that an aquifer might overlie another aquifer, for
22	example.
23	Q. Okay. But if they characterize them as separate and
24	distinct, is that shown in the USGS scientific reports?
25	A. I think they try to define these units so that they can

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1	Larson - cross create a framework for understanding how the groundwater flow
2	is going to occur and how one area is going to interact with
3	another area.
4	Q. I'm sorry. My question is intended to be simple. Is the
5	USGS, when it moves from the geology to the hydrogeology you
6	know what I'm talking about? When it puts the geology let's
7	put this table up. Let's put up Spruill 21. It's not a table;
8	it's there you go.
9	Now, has the USGS distinguished on this table, which
10	has been testified to in some detail by many, did they
11	distinguish between geological units and hydrogeological units?
12	A. Yes. They defined the hydrogeological units in the
13	let's call it the right-hand column of this diagram, and then
14	they show in the left-hand column how those units correlate
15	with geological various geological names and units that have
16	been defined in other reports and documents.
17	Q. Right. And the USGS does that consistently, don't they?
18	They use the same nomenclature, so that you can tell what
19	you're looking at from one report to another?
20	A. Well, I think they're doing it to try to be sure people
21	understand that the way they're defining the hydrogeologic
22	units, people can see what geologic names or formations they
23	might correlate with from other reports.
24	Q. Now, looking at this report, it was your testimony
25	yesterday that the Meridian Sand member in Mississippi, and the

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1	Larson - cross Zilpha Clay and the Winona Clay and the Tallahatta Formation
2	and the Sparta Sand, are all part of what the USGS defines as
3	the Memphis or the Middle Claiborne hydrogeologic unit; is
4	that correct?
5	A. They correlate with certain portions of Middle Claiborne
б	hydrogeologic unit.
7	Q. No, but you have equated yesterday, you've included the
8	Lower Claiborne Aquifer hydrogeologic unit within your
9	definition of the Middle Claiborne hydrogeological unit, did
10	you not?
11	A. I don't know that I equated them directly. I think what
12	the point was that within the groundwater system, those they
13	identified areas within that Middle Claiborne Aquifer
14	hydrogeologic unit where the conditions have changed to a more
15	fine-grain condition, and identified a confining unit; and then
16	they have given a name to the areas under that as the Lower
17	Claiborne Aquifer.
18	Q. I believe counsel actually put up a slide, and he
19	highlighted the entire area on this chart of the Memphis Sand
20	within Tennessee, and then extended it across into the
21	Mississippi. And you said that was all the Middle Claiborne
22	hydrogeologic unit, did you not?
23	A. On that chart, yes.
24	Q. Okay. Now, in fact, the USGS consistently recognizes the
25	Lower Claiborne Aquifer and confining unit as a separate

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1	Larson - cross hydrogeological unit, does it not?
2	A. In the more recent work by Clark & Hart in 2009, they've
3	distinguished a unit that occurs below the Lower Claiborne
4	Confining Unit as an aquifer unit for the purposes of
5	assembling their model.
6	Q. Is that the first time that was done, to your knowledge?
7	A. I'm not sure if it was the first time or not.
8	Q. But you just you referred to "more recent." Do you have
9	any idea as to whether the USGS has been doing that for years?
10	A. Well, as you go back in time, the names of the different
11	units or the different formations change, and depending on
12	where you are, as illustrated on this table.
13	MR. ELLINGBURG: Let's look at it. Would you pull up
14	Spruill 19, please, Slide 19.
15	Q. Now, this is not exactly what you looked at, because this
16	comes from Arthur & Taylor in 1990, and it's blown up so that
17	it does not show as much of the of what's below the Lower
18	Claiborne Confining Unit, which is the Wilcox; is that correct?
19	A. Yes.
20	Q. Now, when you look at that map, which is a section in
21	Mississippi, do you see a connection shown in that map, a
22	hydrologic connection shown directly in that map without any
23	interference between what the paper the USGS refers to as the
24	Lower Claiborne Aquifer?
25	A. You don't in this vertical profile.

	Largon - cross
1	Q. Okay. And that's so you're suggesting that in
2	Mississippi, this isn't what it looks like?
3	A. No, that's not what I'm suggesting. I'm suggesting this is
4	a vertical profile.
5	Q. Okay. But I'm just now asking about within the state of
б	Mississippi, does this represent what the USGS actually
7	reports, as distinguished from included in the Lower Claiborne
8	Aquifer within the Middle Claiborne hydrogeologic unit as an
9	aquifer which is different from what you said yesterday,
10	isn't it?
11	A. No. This represents a cross-sectional profile, and then
12	when you look at the longitudinal profile, going north and
13	south, you can see how the different units are interconnected.
14	Q. Okay. Does the Lower Claiborne confining hydrogeological
15	unit and the Lower Claiborne Aquifer hydrogeological unit, as
16	shown in this particular illustration, does it exist in
17	Tennessee?
18	A. Does it exist in Tennessee?
19	Q. If we looked at that same type of east/west contour
20	subsurface, would we see the same thing in Tennessee?
21	A. No. My understanding is that the transition zone tends to
22	be south of the Mississippi/Tennessee border, where this kind
23	of characterization would be appropriate.
24	Q. No, because in Tennessee there is no Lower Claiborne
25	Confining Unit, hydrological unit, and no Lower Claiborne

	Larson - cross
1	Aquifer Unit, is there?
2	A. My understanding is that it does not extend into Tennessee.
3	Q. Okay. And it disappears in that transition zone; is that
4	correct?
5	A. That's where they try to delineate the unit.
6	Q. But do you agree that as distinguished from your testimony
7	yesterday, that within Mississippi, the USGS does not include
8	the Lower Claiborne Confining Unit or aquifer unit as
9	hydrological units within the Middle Claiborne Aquifer? Do you
10	agree with that?
11	A. They distinguish these for purposes of assembling their
12	model as individual units.
13	Q. Was my question wrong? I mean, do they or do they not
14	distinguish between the Lower Claiborne Aquifer and confining
15	hydrologic unit in Mississippi and the Middle Claiborne Aquifer
16	and confining units in Tennessee? Does the USGS distinguish
17	between them or does it not?
18	A. It distinguishes the extent of those units.
19	Q. In Mississippi?
20	A. And in other areas.
21	Q. Okay. In Mississippi, Louisiana, right?
22	A. Arkansas.
23	Q. Arkansas. But not in Tennessee?
24	A. It does not extend that those particular distinguished
25	units do not extend in Tennessee.

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1	Larson - cross Q. They fade out at the facies; is that	101
2	A. Yes, generally that's where they are.	
3	Q. "Pinch out" is the word they use, right?	
4	A. I don't remember that particular word, but it would be a	
5	facies change.	
6	Q. So in all the study you've done, you've never seen them	
7	referred to as "pinching out," in the facies change?	
8	A. I don't remember that name. I know what it refers to,	
9	but	
10	Q. Okay. You didn't pay that much attention to it?	
11	A. Well, I did what I paid attention to was the how th	ıe
12	different hydrogeologic units are arranged relative to one	
13	another, and how that would impact groundwater flow or the	
14	impacts of pumping in terms of propagating from one place to	
15	another.	
16	Q. Okay. So you looked at it on a large scale, with regard	to
17	these hydrogeologic connections, or these what is it	
18	hydra is that what it is? Hydrogeologic connections? Is	
19	that right? Is that the word?	
20	A. Hydrogeologic or hydraulic interconnections.	
21	Q. Okay. So you looked at it on a large scale for that,	
22	right?	
23	A. Yeah, and then on a regional scale of these investigation	s.
24	Q. Okay. So "regional scale" meaning the Mississippi	
25	Embayment?	

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1	Larson - cross A. Well, I think there's obviously mapping and evaluating the
2	curve throughout the Mississippi Embayment; it's not over the
3	whole Mississippi Embayment that a particular characteristic
4	applies. They've tried to map out the variations from one
5	place to another.
6	Q. But you have testified that the groundwater at issue is
7	within the entire Mississippi Embayment, have you not?
8	A. I testified that there's an aquifer that extends over most
9	of the Mississippi Embayment that contains groundwater.
10	Q. Okay. So that's when you talk about your definition in
11	this case as the aquifer, as an interstate resource, you're
12	talking about the entire Mississippi Embayment, right?
13	A. No, I'm talking about the aquifer, which includes the water
14	contained within the aquifer.
15	Q. In the entire Mississippi Embayment?
16	A. Within the regional area.
17	Q. "Regional area" being the eight states and 90,000 square
18	miles, or whatever, of the Mississippi Embayment, right?
19	A. Yes. That's the extent that it encompasses.
20	Q. That's what your testimony addresses?
21	A. Well, my testimony of that demonstrates, in part, the
22	interstate nature of the water resource.
23	Q. Okay. Now, talk of transitions here a little bit.
24	Now, I believe you testified yesterday, based on an
25	Arthur & Taylor slide, that the transition zone started about

	Larson - cross
1	ten miles south of the Tennessee border: Is that correct?
2	A. I don't recall if that's what I said. It looks like it was
3	south of the border.
4	Q. Okay. But didn't counsel ask you to estimate the
5	difference of transition zone or the distance of the
6	transition zone by showing you an Arthur & Taylor map that had
7	a hatched mark across it?
8	MR. FREDERICK: Objection, your Honor. I think that
9	mischaracterizes the testimony.
10	THE COURT: Overruled.
11	You may answer, if you can.
12	A. I don't remember if he asked me to estimate a distance, but
13	it was south of the border.
14	Q. Okay. You don't have any recollection of how far you said
15	it was?
16	A. I don't.
17	Q. Okay. But did you make that estimate based on that
18	Arthur & Taylor map?
19	A. I considered that Arthur & Taylor map, and then I also
20	considered other maps as well.
21	Q. Okay. Thank you.
22	Now, I'm going to show you well, first I'm going to
23	show you Slide 22 from Mr. Spruill. Did you use that yesterday
24	in discussing the transition zones?
25	A. Yes, I did.

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1	Larson - cross Q. Now, a couple of things about this slide. First, does this
2	slide show a Lower Claiborne Confining Unit?
3	A. Yes, it does.
4	Q. As a hydrogeologic unit?
5	A. Yes.
6	Q. And the words are a little hard to read, but do you see
7	where it says "Lower Claiborne/Upper Wilcox Aquifer" below that
8	Lower Claiborne hydrogeologic confining unit?
9	A. Yes, I see that.
10	Q. Okay. So that would extend up, and the area beneath that
11	would be that Lower Claiborne Aquifer unit, would it not, that
12	area in blue?
13	A. It extends up into that area, yes.
14	Q. Okay. Until the facies change, right?
15	A. Well, you can't really discern that from this diagram, but
16	in the more recent characterizations, it's it's extended up
17	into that area.
18	Q. Okay. Well, let's talk about the more recent some of
19	the more recent information, because I think you said yesterday
20	that as the USGS gains more data, they tweak and modify their
21	reports on that data; is that correct?
22	A. They can, yes.
23	Q. Okay. Would you please show Spruill Slide 23.
24	Now, you've seen this slide before, haven't you?
25	A. Yes, I have.

	Larson - cross
1	Q. Now, is this from the what we referred to as MERAS
2	report from the United States Geological Survey?
3	A. That's my recollection, yes.
4	Q. Yes. And this is a map created based on the data of the
5	United States Geological Survey had at the time the map was
6	created, which would be around 2009, 2011; is that correct?
7	A. Yes, that's my understanding.
8	Q. Where does this map show the transition zone?
9	A. It shows it on the map with the sort of wide gray line that
10	goes from west to east across near the Tennessee/Mississippi
11	border.
12	Q. It actually shows that gray line on the
13	Mississippi/Tennessee border, doesn't it?
14	A. In portions, yes.
15	Q. Okay. And then just slightly below. So it's not ten
16	miles, is it?
17	A. Not as shown on here.
18	Q. So you think this is less reliable than Arthur & Taylor in
19	1998, or more reliable?
20	A. Well, they're defining their hydrogeologic units here for
21	the purposes of the modeling, and this is where they've placed
22	it. I think, when you look at other maps within these
23	documents, you can see that sort of correlation between how
24	it's characterized in Arthur & Taylor and how it's
25	characterized here.

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1	Larson - cross Q. They're in similar somewhat similar, but this particular
2	map which is the most recent map we have from the USGS,
3	isn't it?
4	A. It is among those, yes.
5	Q. Okay. It shows that transition zone right on the
6	Mississippi/Tennessee border, and not ten miles south; is that
7	true?
8	A. It shows the edge of the unit they've defined to be in that
9	area.
10	Q. Okay.
11	A. Other maps show the amounts of sand within that unit, and
12	that extends further to the south and is more consistent with
13	what you see in the Arthur & Taylor report.
14	Q. Okay. Let's look at that.
15	MR. ELLINGBURG: Would you please put Spruill Slide 24
16	up.
17	Q. Now, can you tell the Court what this slide shows.
18	A. This slide depicts the thickness of the Lower Claiborne
19	Confining Unit, in feet, over the area that they delineated as
20	the Lower Claiborne Confining Unit.
21	Q. Now, you were talking about the sand thickness. How far
22	does this sand thickness, with the Lower Claiborne confining
23	hydrogeologic unit, extend into Tennessee?
24	A. Well, first of all, I wasn't talking about sand thickness;
25	I was talking about sand content.

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1	Larson - cross Q. Okay. I stand corrected. I thought this said thickness of
2	Lower Claiborne Confining Unit.
3	A. This map does, yes.
4	Q. My question is, how far does it show it extending to the
5	north?
6	A. It extends to the boundary of what they defined as the
7	Lower Claiborne Confining Unit, in the red outline.
8	Q. In the light red outline within the dark outline of the
9	Mississippi Embayment?
10	A. Yes.
11	Q. So that's consistent with what we've just looked at in
12	terms of where the transition zone considers, which is right on
13	the Mississippi/Tennessee border; is that correct?
14	A. That line corresponds with the gray line that we saw on the
15	other diagram.
16	Q. All right. And this is the most recent data we have,
17	right?
18	A. Yes.
19	Q. Okay.
20	A. As far as I know, yes.
21	Q. Now, this is the confining unit, which would sit on top of
22	the actual Lower Claiborne Aquifer hydrogeologic unit as
23	defined by the USGS; is that correct?
24	A. Yes, that's the way they've defined it.
25	Q. Okay. Let's look at the next slide.

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1	Larson - cross Could you tell the Court what we're looking at now?
2	A. This is a map of the thickness of what they have defined as
3	the Lower Claiborne Aquifer hydrogeologic unit.
4	Q. Okay. And how far does it extend into Tennessee?
5	A. It it goes up to the border between Mississippi and
6	Tennessee.
7	Q. You don't see any significant amount of that separate
8	hydrogeological unit as reported by the USGS in Tennessee, do
9	you?
10	A. No, not the way they've mapped it out here.
11	Q. But yesterday you included that in the Middle Claiborne
12	Aquifer hydrogeologic unit, did you not?
13	A. I did, because when you juxtapose these against one
14	another, you can see how they're interconnected.
15	Q. Okay. But from the standpoint from the scientific
16	standpoint, as reported by the United States Geological Survey,
17	without any interpretation on your part, they are separate and
18	distinct aquifer hydrogeologic units, are they not?
19	A. They've defined these as hydrogeologic units and mapped
20	them accordingly.
21	Q. Was the answer to my question yes?
22	A. Well, they've outlined these for the purposes of looking at
23	groundwater flow and construction of their model.
24	Q. I'm having difficulty understanding how my question is not
25	clear. Has the USGS, based on the scientific data it has

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1	collected and analyzed for the purposes of creating this model,
2	recognized that the Lower Claiborne Aquifer hydrogeologic unit
3	is separate and distinct as a hydrogeologic unit in North
4	Mississippi and extending into Arkansas and Louisiana?
5	A. Yes, they've mapped it out in that fashion.
6	Q. And you disagree; it's not separate and distinct, in your
7	opinion?
8	A. Well, I hesitate with the word "separate," because you have
9	to look at how they're interconnected hydrogeologically.
10	Q. Right. By the way, how thick is that sand shown in this
11	unit in North Mississippi?
12	A. It's mostly in the range of the 100 to 200 foot.
13	Q. Thank you.
14	MR. ELLINGBURG: Can we back up two slides. This one.
15	Q. How thick is the sand shown across the border from
16	transition zone in the State of Tennessee, according to this
17	map?
18	A. It's in the range of zero to 200 feet.
19	Q. Okay. So you're saying the Tennessee
20	A. Oh, I'm sorry.
21	Q. In Tennessee.
22	A. Well, there are varying ranges between it actually spans
23	the whole range, from very thinner on the east to thicker on
24	the west, up to 1,100 feet.
25	Q. Okay. Immediately north of the border, in the Memphis
25	Q. Okay. Immediately north of the border, in the Memphis

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1	Larson - cross area, and extending up through West Tennessee, does it show a
2	sand of 601 to 800 feet thick?
3	A. Yes, it shows a thickness of that range.
4	Q. And do you see any of that in Mississippi?
5	A. No. The thickness as you go south goes into the area of
6	zero to 200 feet.
7	Q. Thank you.
8	Now, right there, in the Memphis area, that white
9	area, what does that reflect?
10	A. The whitish area represents thicknesses between 800 and
11	1,100 feet.
12	Q. And do you see any of that south of the transition zone in
13	Mississippi?
14	A. Not of the white. It looks like there's some areas maybe
15	in the 200 to 400, but not in the white.
16	Q. Thank you. And most of it's in the 100 to 200 Mississippi;
17	is that right?
18	A. Well, as you extend further south, it gets thicker, in the
19	200 to 400 range.
20	Q. Okay. Is it your testimony because you were asked
21	yesterday about this cone of depression created around Jackson,
22	Mississippi. Is it your testimony that the cone of depression
23	created around Jackson, Mississippi is withdrawing groundwater
24	from Tennessee?
25	A. It's not my testimony, no.

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1	Larson - cross Q. Okay. Well, is it withdrawing groundwater from Tennessee,
2	in Jackson?
3	A. I don't think it would have impact on groundwater flow in
4	Tennessee.
5	Q. That's because there is a limit to the area from which
6	wells can withdraw groundwater; is that a fact?
7	A. There are limits to cones of depression, yes.
8	Q. Okay. Now, do you know who Mr. Kelvin was?
9	A. I'm sorry?
10	Q. Scientifically, do you know who Mr. Kelvin was?
11	A. Kelvin?
12	Q. Yes.
13	A. Are you talking about the Kelvin temperature scale?
14	Q. That's part of what he did, right?
15	A. That's what I understand.
16	Q. Do you recall that he suggested that from a scientific
17	standpoint, you have to rely on data; that you have to have
18	something that will can be reduced to a scientific method
19	of by a scientific method to something which is clearly
20	understandable, repeatable?
21	A. I'm I'm not aware of that, but
22	Q. Okay. Is that a fact? I mean, when you look at what
23	you're doing, as a scientist, don't you have to have something
24	which you can quantify?
25	MR. FREDERICK: Objection. There was nothing about

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1	Larson - cross Kelvin in the direct.
2	THE COURT: Well, objection sustained.
3	Q. Okay. I'm not asking you about Kelvin; I'm asking you
4	about you.
5	A. What was the question again, please?
6	Q. The question is, do scientists, when they're giving
7	opinions based on science, utilize established procedures and
8	methods and quantify the basis for their opinions?
9	A. They in some cases will make quantifications, yes.
10	Q. Okay. If there are material differences in what you're
11	looking at in the groundwater, the larger groundwater system,
12	don't you need to quantify the local conditions to
13	appropriately use the information?
14	A. I don't think you need to quantify it for every conclusion
15	you're going to reach, if that's your question.
16	Q. Okay. Let's do it this way: Yesterday you made a
17	significant point about all the groundwater in the world being
18	part of being part of the hydrological larger
19	hydrological cycle, right?
20	MR. FREDERICK: Objection, your Honor. He didn't talk
21	about water everywhere in the world.
22	MR. ELLINGBURG: Okay, I'll
23	THE COURT: Objection sustained.
24	MR. ELLINGBURG: Sustained. I'll restate it.
25	

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1	Larson - cross BY MR. ELLINGBURG:	
2	Q. Did you say that all of the groundwater found in the	
3	Mississippi Embayment is part of the hydrological site?	
4	A. I didn't say that. I said that when I described the	
5	hydrogeological site, I was describing the general circulatio	n
6	of water in various environments.	
7	Q. Right. But you've said that in hydrogeology, all that	
8	water is constantly moving, right?	
9	A. The groundwater is moving, yes.	
10	Q. Yeah. In some direction, at some point in time?	
11	A. Yeah, generally moving from places of recharge to places	of
12	discharge.	
13	Q. Now, once it's discharged into the river or into a an	
14	unconfined aquifer, then as part of a hydrological cycle, it	
15	goes into the atmosphere oftentimes, does it not?	
16	A. Some of it can, yes.	
17	Q. I mean, that was one of the issues in your case out in	
18	Montana, wasn't it, was whether that water actually was	
19	returned or was it that it went into plants?	
20	A. One of the issues was whether evapotranspiration can affe	ct
21	the amounts of water in the stream.	
22	Q. So when you talk about this constantly moving, you're	
23	really talking about water evaporating and going into the sky	<i>`</i> ,
24	from clouds raining down on the ground, and then either by	
25	surface flow or groundwater flow or evaporation, ultimately	

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1	ending up on some back in that same cycle, at the beginning,
2	right?
3	A. As a general concept, yes.
4	Q. Okay. Now, as a general concept because I know you
5	didn't do any calculations or any analysis of the groundwater
6	in this Mississippi/Tennessee area as it related to direction
7	of flow, either a personal analysis of the volume of water or
8	anything that related specifically to this case in the Memphis
9	area; you didn't do any actual studying, analysis, scientific
10	investigation, did you? You, personally?
11	A. Well, I reviewed the reports that describe the various
12	investigations to familiarize myself with what those
13	investigations have found.
14	Q. But what you didn't do was you didn't, yourself, reach any
15	conclusions about how long groundwater would reside within the
16	State of Mississippi once it came into the confined aquifer in
17	the State of Mississippi, before it left Mississippi, did you?
18	A. I didn't attempt to make any estimates of residence time,
19	say, going from the recharge areas to the place of discharge.
20	Q. Because you didn't think it was important?
21	A. Well, I said I didn't think it was important to answering
22	the question that I was tasked to answer.
23	Q. You didn't think it was important to the question that you
24	created; is that right?
25	A. No. I didn't think it was important to the question that

	/45
1	Larson - cross the master posed, that I was trying to focus on.
2	Q. Well, the question the way you posed it, though, was you
3	cannot separate the geology from the water within the earth
4	within that geology; is that correct?
5	A. No. The question was whether or not the aquifer
6	constituted an interstate water resource.
7	Q. Okay. And so what scientific literature did you use to
8	determine whether anyone had classified it scientifically as an
9	interstate water resource?
10	A. I looked through the documents that described the nature
11	and extent of the resource.
12	Q. Okay. My question, though, is very narrow; it's about what
13	scientists do.
14	What did you do? Did you find any scientific report
15	by the United States Geological Survey that said, everything in
16	the Middle Claiborne Aquifer hydrogeologic unit and the
17	separate Lower Claiborne Aquifer hydrogeologic unit, and all
18	eight states, is an interstate water resource? Did you find
19	anything like that?
20	A. I didn't find a specific statement like that. I found
21	references to the regional nature of the aquifer and to how it
22	transcends state boundaries and political boundaries.
23	Q. But the travel time in which it transcended boundaries or
24	the travel time within particular states, none of that was
25	anything that you felt it was important to look at as a

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1	Larson - cross scientist?
2	A. It wasn't important for me to quantify that for purposes of
3	concluding whether it was an interstate water resource or not.
4	Q. Was it important for you to estimate? I mean, did it make
5	any difference to you whether that water that entered the
6	outcrop in Mississippi would take 25, 30,000 years to get to
7	Arkansas? Did that make any difference to you?
8	A. The exact time it would take did not, because groundwater
9	is leaving Mississippi even as we speak. And it's a the
10	fact that the groundwater is moving and the fact that state
11	boundaries don't interrupt that movement, that I believe was a
12	factor in determining whether or not it's an interstate water
13	resource.
14	Q. Your testimony is pretty much all broad generalizations.
15	So can you make a broad generalization, as an experienced
16	hydrogeologist, based on the things that you have read, as to
17	what the residence time would be of water entering at the
18	outcrop in Mississippi that would follow a flow path in
19	Mississippi, of how long it would stay in Mississippi?
20	A. Groundwater typically moves at relatively slow rates, so it
21	would be a very long time.
22	Q. What is a relatively slow rate?
23	A. Say tens of feet per year to hundreds of feet per year.
24	Q. Okay. So have you determined, by looking at the specific
25	hydrogeological conditions in the state of Mississippi, that it

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Larson - cross would move hundreds of feet in a year under natural conditions?
A. No, that's just my general expectation. I think I've seen
some references here and there to those kinds of rates.
Q. Well, you were sitting in the courtroom when Dr. Spruill
and Mr. Wiley testified that the predevelopment rate, before
pumping, would be about an inch or two a day. Is that
consistent do you have anything to refute that?
A. Well, the pumping I didn't understand.
Q. No, I'm sorry. Before pumping, predevelopment, did you
hear testimony that groundwater entering Mississippi would be
moving from the outcrops would move at a rate of an inch
or two a day? Did you hear that?
A. I heard that the rates actually, the velocity of the
flow were on the order of inches per day, according to them.
Q. Thank you. I appreciate you correcting me technically just
any time you can, because I want this to be clear.
And that "velocity" is a scientific term, as
distinguished from what I said, right?
A. Yes, it is.
Q. Okay. Do you have any basis for disagreeing with their
opinions and statements that that groundwater naturally flowed
or at a velocity of approximately one to two inches a day in
Mississippi from the entry at the outcrop into the confined
area?
A. The range of numbers that I've seen go from, say, tens of

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1	Larson – cross feet per year to, say, hundreds of feet per year, so
2	Q. In in predevelopment?
3	A. Yes. But at least in the at the lower end, inches per
4	day would be similar to that.
5	Q. Do you have any idea where those velocities change within
6	DeSoto County, Mississippi, under natural conditions?
7	A. Well, the velocities will change from place to place as the
8	water moves through that area.
9	Q. Right. Right. What I'm saying, though, is you have this
10	big range, you know, and you confirm what was the upper end
11	of your velocity?
12	A. Hundreds of feet per year.
13	Q. Okay.
14	A. A few hundred feet per year.
15	Q. Okay. And do you have any idea how that would be
16	distributed between the lower range, across DeSoto County,
17	Mississippi, from east to west? Do you have any information
18	that you've developed that would address that issue?
19	A. The only thing I I've read, if I recall correctly, was
20	the density higher on the eastern sides, and as the water moves
21	in toward the center of the basin and groundwater is discharged
22	from the aquifer, it tends to be lower.
23	Q. Okay. Now, your definition of an interstate aquifer or
24	an interstate natural resource, right, or an interstate
25	resource that's what you've defined, interstate resource?

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1	Larson - cross A. Interstate water resource.
2	Q. Interstate water resource. Okay.
3	Would you substitute the phrase "interstate aquifer"?
4	I mean, does your definition address, in all of its aspects, a
5	scientific basis for stating it's an interstate aquifer?
6	A. Yes. The Middle Claiborne Aquifer, it's my opinion it's an
7	interstate water resource.
8	Q. Well, I asked you that you said that, but I'm talking
9	about the water in the aquifer. Is it your opinion, from a
10	hydrological standpoint, that the groundwater contained in the
11	aquifer systems in North Mississippi is all interstate water?
12	A. My opinion notes that the aquifer, which includes the
13	geologic materials and the water, is an interstate water
14	resource.
15	Q. Okay. And again, you don't separate the geology from the
16	water, water from the geology?
17	A. No. I'm in my view, the aquifer includes both the water
18	and the materials.
19	Q. And from that standpoint, even though the groundwater in
20	the aquifer that you're describing may be flowing at an inch or
21	two a day, and may stay within one state for 25,000 years,
22	makes that water the same as river water; is that correct?
23	A. No, that's not correct.
24	Q. That's not correct? Why not?
25	A. Because it's groundwater.

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1	Larson - cross Q. Okay. And groundwater is much more complex than river
2	water?
3	A. Well, groundwater and aquifers have their own level of
4	complexity, and rivers have their levels of complexity as well.
5	Q. Has the is the language used in your definition about
6	which you testified this is an interstate water that the
7	Mississippi Embayment, entire Embayment, is an interstate water
8	resource, is that language used anywhere by the USGS
9	specifically?
10	MR. FREDERICK: Asked and answered, your Honor.
11	THE COURT: Overruled.
12	You may answer it again, but don't go back to it.
13	MR. ELLINGBURG: Yes, sir.
14	A. As I've testified, I'm not aware of a specific place where
15	those exact words are used. I think, if you look at the
16	documents and their characterizations, they recognize the
17	regional nature and how that transcends state boundaries.
18	Q. Okay. So your opinion is based on your inference from
19	those documents?
20	A. Well, it's based on my knowledge and experience as a
21	groundwater hydrologist as to what they're referring to and
22	what their characterization characterizations indicate.
23	Q. To you?
24	A. To me, yes.
25	Q. Right. And so you are testifying to your inference from

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ι	USGS documents, is that to state your exact opinion in this
	case; is that correct?
Z	A. That's my conclusion from reading how they characterized
:	it.
Ģ	Q. Okay. Have you discussed this with anybody at the USGS?
Z	A. Yes, I have.
Ģ	Q. Okay. Are they testifying or present in this case?
Z	A. Not that I'm aware of.
Ģ	Q. Okay. Thank you.
	Now, do you know how many regional groundwater systems
1	have been identified in the United States?
	A. Not off the top of my head. There's areas scattered
1	throughout the United States where these regional studies were
1	undertaken. I think that's what you're referring to.
Ģ	Q. Yes. Have you looked at all of those regional areas to
c	decide that they were because under your definition, they
7	would all be interstate they would all be what was your
1	phrase? "Interstate resources"?
Z	A. "Interstate water resources"; is that what you're referring
1	to?
Ģ	Q. Yes. Is that what you're saying, that all every region
:	in the United States that has been defined by the USGS, all the
	states that are covered by that region, the water beneath the
	ground is necessarily an interstate resource; is that your
	opinion?
0	opinion?

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1	Larson - cross A. I didn't give that opinion.
2	Q. Well, if they have if they underlie if a
3	hydrogeologic group underlies multiple states, and there are as
4	yet undefined in this testimony similarities in the aquifer
5	hydrogeologic groups, then by your definition, all that water
6	would be an interstate natural resource within those states; is
7	that correct?
8	A. If the hydrogeologic units spanned more than one state, and
9	they had characteristics that were continuous within those
10	regions, and if there were no barriers to water movement across
11	political boundaries or no barriers to the ability of pumping
12	in one area to affect the conditions in another area, then I
13	would consider them interstate water resources.
14	Q. Okay. Now, you said "if the characteristics." Now, what
15	do you mean by "characteristics"?
16	A. The physical characteristics of the materials; for example,
17	sands and clays and silts and so on. And the physical
18	properties of those materials, such as permeability,
19	transmissivity, and storage properties.
20	Q. Now, we've already we've already testified about this,
21	but those physical properties varied significantly within even
22	North Mississippi and West Tennessee, don't they?
23	A. They varied from place to place.
24	Q. But, I mean, we've just looked at it this morning. They
25	vary significantly from North Mississippi to West Tennessee,

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1	Larson - cross don't they?
2	A. There are differences between those areas, yes.
3	Q. But you don't think it's significant?
4	A. Well, they're the nature of them, in my view, are not
5	significant to the determination of whether they're
6	hydraulically interconnected.
7	Q. Okay. So the actual hydrogeologic characteristics under
8	which the water exists in the ground in multiple states is not
9	relevant to your determination of what constitutes an
10	interstate natural resource; is that correct?
11	A. No, that's not correct.
12	Q. Well, I thought you said that if they had sand and clay and
13	similar material and covered multiple states, that's good
14	enough, right?
15	A. No. I said if the hydrogeologic units extended underneath
16	multiple states, and there was a continuity to these
17	characteristics, and there were no barriers along state
18	boundaries that would prevent movement from one place to
19	another or prevent the effects of pumping, for example, to lead
20	properly from one place to another, I would consider an
21	interstate water resource.
22	Q. Okay. Could you please provide me with the scientific
23	definition of "continuity"?
24	A. Continuity means there there's a continuum of the
25	existence of the materials and the nature of those materials

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1	Larson - cross from one place to another.
2	Q. Okay. So there can be a if it's do you know how a
3	particular unit is defined as a sand or a clay?
4	A. They use the grain size of the materials to try to identify
5	that.
6	Q. I'm saying if you look at a geological map, which would
7	also correlate with hydrogeologic units, what does it take for
8	something to be classified as a sand?
9	A. It has to be a coarser grain type of material within the
10	sand ranges.
11	Q. Does it have to be all sand?
12	A. No, it does not have to be all sand.
13	Q. How much sand has to be there for it to be classified as a
14	sand on the map?
15	A. Well, they classified the amounts of sand on the maps, so
16	that doesn't have to be any particular amount. They can
17	characterize the range in the amounts of sand to help
18	characterize the nature of the materials.
19	Q. Let's be a little bit more scientific about your continuity
20	thing here. If there's predominantly sand in a formation, then
21	it will be classified generally as sand; is that correct?
22	A. I would assume so, yes.
23	Q. So that's predominantly.
24	Now, that doesn't mean that it's not littered with
25	other materials that are much less permeable, does it?

	Larson - cross
1	A. It does not mean that it does not contain other materials
2	that may be less permeable.
3	Q. And I think you know, I don't know if you testified to
4	it, but within sand, there's a broad range of materials with
5	different permeabilities, is there not?
6	A. There can be variations in permeability among sands, yes.
7	Q. Okay. And then the in terms of transmissivity, which I
8	raised yesterday, one of the elements of transmissivity is the
9	thickness of the material, is it not?
10	A. Yes, it is.
11	Q. But that's just one, right?
12	A. That's one, right.
13	Q. And then also the specific composition of the material in
14	that area and how much sand, how much clay, how much silt, all
15	those things, those affect the transmissivity and the
16	permeability, don't they?
17	A. They can, depending on how people might calculate it, based
18	on the permeability and the thickness.
19	Q. Yeah. That's all based on local conditions and local
20	information you collect when you drill wells, isn't it?
21	A. That's certainly part of it, yes.
22	Q. You haven't done any of that? You haven't done any
23	particular analysis of this region at issue in this case, have
24	you?
25	A. I haven't done any personal well drilling, if that's what

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	Larson - cross
1	you're referring to.
2	Q. Well, you haven't even looked at all of the information
3	that's available on the variations and the subsurface
4	conditions, have you?
5	A. I can't say that I've looked at all the information. I've
6	certainly looked at the information that's contained in the
7	reports that I reviewed.
8	Q. Have you studied the information that's available within
9	this particular region?
10	A. I have studied some, yes.
11	Q. No, have you studied the information necessary to be able
12	to say that if you drop in the Mississippi from Tennessee, that
13	you're going to find the consistent hydrogeologic
14	characteristics that you find north of the border?
15	A. I haven't I haven't gone from well log to well log to
16	figure out how those variations occur. I've relied on the
17	characterizations that I find in these reports.
18	Q. Okay. You relied on the characterizations that you then
19	collectively used to infer your opinion, right? You take
20	put those characterizations, you've looked at all of them, and
21	then you inferred this specific opinion which you're giving in
22	this case?
23	A. I looked at that information to understand whether or not
24	there was sufficient information for me to draw that
25	conclusion.

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1	Larson - cross Q. Okay. In your opinion?
2	A. In my opinion.
3	Q. Because you didn't use a static scientific method?
4	A. I think I clearly used the scientific method, in that I'm
5	reviewing scientific investigations that characterize these
6	materials.
7	Q. Okay. Now, using your hydrological connection approach, is
8	it possible for a single molecule of water to move from the
9	ocean to the sky and move back to the ocean in a very short
10	period of time?
11	A. I guess it's possible.
12	Q. Well, I mean, does that happen?
13	A. I suspect so.
14	Q. You don't know?
15	A. No, I suspect you get evaporation. Some of it becomes
16	rainfall and goes right back down again.
17	Q. Is there any part under your definition, is there any
18	water in the entire water cycle that is not hydrologically
19	connected?
20	A. Well, it's all part of a hydrologic system and a hydrologic
21	cycle. So in that sense, there is, I guess, a connection.
22	Q. Is there a distinction between direct hydrological
23	connection and indirect hydrological connection?
24	A. I think there is somewhat of a distinction there, yes.
25	Q. Is that distinction anything ever used in groundwater?

	Largon - grogg
1	A. I suspect so, yes.
2	Q. You say you suspect so. Is it or is it not?
3	A. Yes, I think so.
4	Q. Okay. Now let's talk about the hydrological connection
5	between the Sparta Sand in Mississippi, the Lower Claiborne
6	Aquifer hydrologic unit in Mississippi, and the Mississippi
7	River. Okay?
8	Is that a direct hydrological connection?
9	A. No. I recall that an indirect connection via
10	interconnections to overlying hydrogeologic units and
11	ultimately to the Mississippi River.
12	Q. Okay. So that water actually, to get to the Mississippi
13	River, not only has to travel across the state in Mississippi,
14	but it also has to push its way up through those confining
15	units that are above it before it can get into the river,
16	doesn't it?
17	A. Through the groundwater, yes. It would have to take that
18	pathway.
19	Q. Okay.
20	A. Or I guess it could take an alternate pathway to get to the
21	river, when you say if it if it discharged into a tributary
22	that then led into the Mississippi River.
23	Q. Sure. But it's going to have to push its way up out of
24	that confined aquifer through those confining hydrogeologic
25	units of whatever characteristic they are locally until

1	Larson - cross until it gets to the surface, right?
2	A. Except for the tributaries where the outcrop area is at the
3	surface, or where the streams may be connected at the surface.
4	Q. Right. But that's all unconfined groundwater flow
5	primarily, isn't it, where the streams are and the tributaries
6	are? That's either surface flow or unconfined groundwater
7	water flow before it enters into the confining confined
8	aquifer; is that accurate?
9	A. It would be in the areas where the aquifer is unconfined.
10	Q. That's what I'm okay.
11	Can you quantify in any way the degree of hydraulic
12	connection between the aquifer and its overlying confining
13	unit?
14	A. You can make quantifications of that, yes.
15	Q. I asked if you had.
16	A. Can you
17	Q. Can you do it? Have you done it?
18	A. I haven't tried to go in there and make my own
19	calculations, but I have reviewed calculations and evaluations
20	by the USGS that have done that.
21	Q. Okay. Yesterday you defined the term called leakance; is
22	that correct?
23	A. Yes.
24	Q. So what is leakance?
25	A. Leakance is a term that reflects the vertical conductivity

	Largon grogg
1	and thickness of typically confining units. And it references
2	the ease with which water can move vertically, typically, from
3	one place to another.
4	Q. Can that concept be used to determine the degree of
5	interconnection between separate aquifer hydrogeologic units
6	that are separated by a hydro a confining bed hydrogeologic
7	unit or confining unit?
8	A. It would characterize the degree of vertical connection
9	between overlying and underlying hydrogeologic units.
10	Q. Have you determined the leakance for any confining bed in
11	the Mississippi Embayment to give your testimony in this case
12	that all this water is an interstate natural resource?
13	A. Have I personally determined
14	Q. Have you looked at the document have you studied the
15	documentation? Have you made a determination of the leakance
16	throughout the Mississippi Embayment?
17	A. I haven't gone everywhere, but I've looked at the
18	reports for example, the Brahana & Broshears report and
19	I've looked at the MERAS report in terms of their
20	characterizations of these vertical connections.
21	Q. Okay. But you haven't made an effort to determine how that
22	would how that would impact, if at all, your opinion?
23	A. Well, the thing that I observed is that these
24	characterizations are not zero. They don't say that they're
25	zero leakance, say, between one place and another. And that

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1	Larson - cross indicates that there is a connection and that they're part of a
2	hydrogeologic system.
3	Q. But you haven't looked at those connections throughout the
4	Mississippi Embayment?
5	A. Only in terms of what I've observed in the reports that I
6	reviewed.
7	Q. Okay. Well, what did you observe with regard to the
8	leakance in Kentucky?
9	A. I don't recall specifically, but those characterizations
10	are in the report.
11	Q. But you didn't really look at that; they're in the report,
12	but you didn't look at it, did you?
13	A. Well, I read the reports, so in that sense I've looked at
14	it, but
15	Q. That
16	A. And I understood what the ramifications of that would be
17	with respect to the conclusions that I was drawing.
18	Q. What about Louisiana? Did you look at that, look at them
19	in that area, the leakance?
20	A. In reviewing the reports, I looked at those
21	characteristics.
22	Q. And so looking at those characteristics, you decided that
23	all of this was sufficiently the same material in these systems
24	to classify all in one interstate natural resource; is that
25	correct?

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1	Larson - cross A. No, it's not correct.
2	Q. You didn't take that into account; is that correct?
3	A. No, that's not correct.
4	Q. Okay. So tell me how you took it into account.
5	A. That when you look at the nature of those
6	characterizations, they illustrate that while there are lower
7	permeability environments in these confining beds, and although
8	permeabilities tend to be lower than the aquifers, that they
9	are nonetheless interconnected.
10	Q. And to some unspecified degree; is that what you're saying?
11	They're interconnected to some unspecified, undefined degree?
12	A. No, they're defined by the estimates that are contained in
13	the reports.
14	Q. Did you did you actually have you got anything that
15	you created that would show how you came to your continuity
16	conclusion, any specific data that you that you can point us
17	to right now?
18	A. Yes. I looked on the maps and the various reports to
19	understand how they were distributed and interconnected.
20	Q. Did you so you're saying they're all sufficiently
21	uniform; you didn't have to worry about looking at the details?
22	A. No. That's not I didn't say that they were uniform. I
23	said that they
24	Q. Were continuous?
25	A. They demonstrated continuity. Among other things, they

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1	Larson - cross demonstrated continuity.
2	Q. Okay. Are you saying that the flow throughout this area is
3	continuous within a can you define a range? I need to know
4	what "continuity" means. Tell me how you scientifically define
5	continuity.
6	And I don't want to just hear that there's sand. What
7	are the hydrogeological aspects which you say are so common,
8	and are uninterrupted, because when you say "continuity,"
9	you're suggesting they're uninterrupted. What are the
10	scientific hydrogeological characteristics that are
11	uninterrupted in the entire Mississippi Embayment within what
12	you have classified as the Middle Claiborne Aquifer?
13	A. Those characteristics would include transmissive
14	characteristics. They would include storage characteristics.
15	They would include the continuity of potentiometric elevations
16	within this area that would illustrate that there is a
17	continuity to groundwater flow within the Mississippi or
18	within the Middle Claiborne Aquifer.
19	Q. In the entire Mississippi Embayment?
20	A. Well, throughout the area where the aquifer had been
21	defined.
22	Q. Let's break that down just a little bit. Are you saying
23	the transmissivity is the same, or within a small range,
24	throughout the entire Mississippi Embayment?
25	A. No, I'm not saying that.

		Largon groad 764
1	Q.	Why not?
2	A.	Because it's not.
3	Q.	Well, doesn't that have something to do with continuity?
4	A.	No.
5	Q.	You just included in continuity transmissivity, didn't you?
6	A.	I said that there would be continuity to transmissivity
7	cha	racteristics from one place to another.
8	Q.	Now, what does that mean?
9	A.	That means that you will have some ability to transmit
10	wat	er from place to place throughout this area.
11	Q.	Some ability?
12	A.	Yes.
13	Q.	What does that mean?
14	A.	It means that the water can move throughout this area from
15	one	place to another.
16	Q.	It's possible for water to move from one place to another?
17	A.	The water does move from one place to another throughout
18	thi	s area.
19	Q.	Does the water moving into the recharge in North Tennessee,
20	fro	m Northwest Tennessee, within the Mississippi Embayment,
21	nat	urally find its way to Mississippi, ever? The
22	gro	undwater we have all these maps. We know where the
23	out	crop areas are.
24		You know where the outcrop in West Tennessee is, don't
25	you	?

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1	Larson - cross A. Outcrop area is in West Tennessee.
2	Q. I mean, have you looked at the outcrop areas and the
3	formations in West Tennessee to the Mississippi River?
4	A. Yes, I have.
5	Q. Okay. Does the water that is being coming in to the
6	outcrop area to recharge the groundwater in Tennessee, in the
7	northern part of the central part of West Tennessee, from south
8	to east, does that water naturally flow to the state of
9	Mississippi?
10	A. The further you go north, the water would flow over toward
11	Arkansas.
12	Q. Okay. Can Mississippi capture that groundwater in
13	Northwest Tennessee by pumping?
14	A. Are you talking about areas
15	Q. I'm saying that if Mississippi puts wells in along the
16	Mississippi/Tennessee border, can it capture water, as far as
17	that water is shown in thick formations, in Northwest Tennessee
18	on that map?
19	A. No. The pumping will be limited in terms of its effect.
20	It will spread out, and it will capture water enough to satisfy
21	the pumping, but it will have a limited effect.
22	Q. Okay. And you don't really know what the effect is,
23	because we don't know the specific hydrogeologic
24	characteristics the specific characteristics in those areas,
25	do we, that entire area? We can't just point at a place on

	/00
1	Larson - cross that map and say it's the same, can we?
2	A. Say what's the same? I'm sorry?
3	Q. You can't even look at this map and tell me what the
4	transmissivity is, all by looking at this map in the presence
5	of water and those geologic formations, can you?
6	A. You can't just look at this map in isolation, no. This is
7	a map of thickness.
8	Q. Right. And thickness is one factor, right?
9	A. That's correct.
10	Q. And so that varies all the way through the formation; the
11	thickness, the composition specific composition, all the
12	characteristics that determine groundwater, availability, and
13	natural flow, and actual responsible pumping are localized,
14	aren't they?
15	(Reporter clarification)
16	Q. I know things vary from place to place. Actually, this
17	place right here, right now, is different than outside the
18	building, okay? The conditions here vary.
19	But my question to you is, what can be recovered from
20	the groundwater system at any point in the Mississippi
21	Embayment, and in the Middle Claiborne hydrogeological unit in
22	the Mississippi Embayment, will depend upon the geology at the
23	point where someone is attempting to recover the water, will it
24	not?
25	MR. FREDERICK: Your Honor, I don't understand the

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question. I'm not sure how the witness could possibly
understand that question.
THE COURT: If he understands it, he can answer it.
I'm not sure I understand it either.
A. I'm not sure what you mean by "possible to recover the
water." If you're saying well, I don't understand that.
Q. Okay. I'll ask you something different. I'm going to go
up there, and I'm going to drop a well in that thick sand in
Northwest Tennessee. Can you tell me right now how much water
can be recovered from it?
A. No, I cannot.
Q. Okay. If I give you some generalized information, and
there are no wells in that area, can you tell me how much water
I can recover without other wells?
MR. FREDERICK: Objection, your Honor. There's no
specific evidence that counsel is referring to. If he has some
specific evidence that the witness could respond to, we're
happy to hear what that testimony would be.
MR. ELLINGBURG: Well, I mean, I'll back up.
THE COURT: All right.
BY MR. ELLINGBURG:
Q. Let me ask you didn't you testify just a little bit ago
that you had studied the formations and the hydrogeologic units
identified by the USGS in West Tennessee?
A. I have, yes.

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1	Larson - cross Q. You studied that, right?
2	A. I have.
3	Q. Okay. So tell me: Can you tell me, if we look at a point
4	on the map in West Tennessee where there are no existing wells,
5	just by looking at the available hydrogeologic data, whether
6	I'm going to be able to drop a well in my quarter-section of
7	the land and commercially pump groundwater at a reasonable
8	rate, pricing? Can you do that, without any well in that
9	direction?
10	A. Well, I can based on my knowledge that I've gleaned from
11	looking at this, I would conclude that you can put a well
12	virtually anywhere in there and get that well to produce water.
13	As to specifically how much you can produce or how it would
14	affect things would depend on the circumstances.
15	Q. It doesn't even so you could just drop it anywhere at
16	any depth, you're saying, and produce water?
17	A. Yes, because it's characterized as an aquifer.
18	Q. Okay. So if you dropped it to a depth that ended in a
19	screen, in a clay lens, would it produce water?
20	A. You could probably produce some water, but it would be less
21	than certainly less than you could produce from the aquifer.
22	Q. Is that something that you've done, you recommended to
23	people they drop wells in the clay lenses to produce water?
24	A. Have I done that?
25	Q. Have you ever done that?

1	Larson - cross
- 2	0 You're speculating right?
2	
3	A. You were the one that suggested that the well could be
4	constructed into a clay lens, not me.
5	Q. Well, how do you know if there's a clay layer there without
6	doing some test wells, if there's not any wells in that area?
7	A. Because it in looking at how the aquifer has been mapped
8	out, and the thicknesses of it, it indicates that the aquifer
9	is capable of producing water throughout that area.
10	Q. Okay. Well, let me try to get you on to the end.
11	You discussed total available drawdown yesterday,
12	right?
13	A. You asked me some questions about it.
14	Q. Okay. And you purported to answer them; is that correct?
15	A. I answered.
16	Q. Okay. So if you would, just define for me total available
17	drawdown.
18	A. Well, I'm not sure it has a specific definition, but a
19	definition that I'm aware of are the amount or the
20	difference between, say, the potentiometric elevation and the
21	elevation of the top of the aquifer in question.
22	Q. You can't define you can't give a scientific definition
23	of total available drawdown?
24	A. Well, it could have varying meanings from depending on
25	the circumstances, it could mean that, or it could mean the

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1	Larson - cross available water column above a pump, for example.
2	Q. Okay. So that's not a phrase that's typically used in
3	evaluating wells and in developing wells; total available
4	drawdown is not something that has some common meaning in that
5	area of expertise; is that correct?
6	A. It has different meanings, depending on how it's been
7	defined.
8	Q. Okay. Now, how do you define it? I want you to give me an
9	accepted definition that would be accepted by other scientists
10	and other experts in groundwater hydrology.
11	A. I can think of a couple. One is
12	Q. The one you use. I want the one you use.
13	A. The point I'm making is that there isn't a single
14	definition, because it depends on the circumstance.
15	Q. So you don't ever use that definition?
16	A. No, that's not I I use that definition, depending on
17	the circumstance.
18	Q. What are the circumstances?
19	A. Well, I can give you two: One is the difference between
20	the potentiometric elevation of the groundwater and the
21	elevation of the top of an aquifer.
22	Another one is the difference between potentiometric
23	elevation and the location of a pumping tank.
24	Q. Okay. So let's take a hypothetical confined aquifer. Say
25	the thickness of 100 feet, okay, and you poke a hole in the

1 ground, and you get some information about it. Now 2 you and you decide to start pumping. How would 3 the total available drawdown in that well?	you define erence the top of
2 you and you decide to start pumping. How would 3 the total available drawdown in that well?	you define erence the top of
3 the total available drawdown in that well?	erence the top of
	erence the top of
4 A. Well, one of the definitions would be the diffe	the top of
5 between the potentiometric elevation observed and t	batla ana
6 top of the elevation and the top of the aquifer. T	mat's one.
7 Q. Okay. So let's say that the groundwater, when	you poked a
8 hole in the ground before you put a pump in it, ris	ses to
9 100 feet above the top of the aquifer. What is the	e total
10 available drawdown in that well?	
11 A. Under the definition of that you just said, that	at would be
12 100 feet.	
13 Q. Okay. Now, when I start pumping, is the total	available
14 drawdown going to reduce in the area of the well?	Will it be
15 lowered in the area of the well?	
16 A. The total available drawdown is the difference	between the
17 static water level and the top of the aquifer. Whe	en you pump,
18 the water level in the well will decline.	
19 Q. Okay. And within the area of the cone of depre	ession, will
20 the available water decline? Because when you poke	e a hole in
21 the ground, will it rise to its predevelopment or p	prepumped
22 condition?	
23 Let me stop. Okay.	
24 So when you put your well in, that well, t	to 100 feet
25 of available drawdown, and you start pumping at a s	specific

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1	Larson - cross rate, will it create a cone of depression?
2	A. Yes, it will.
3	Q. Within the area of that cone of depression, will total
4	available drawdown be reduced if you put another well within
5	the cone?
6	A. Yes. The total available drawdown under that definition
7	will be lower, and reduced by the amount of drawdown created by
8	the pumping.
9	Q. So if I'm on my land, I put a drop a well let's say I
10	own a half an acre, and I drop a well, and I start pumping, my
11	cone of depression is going to go outside of my land, right,
12	more than likely?
13	A. Well, I can't tell from that description
14	Q. Okay.
15	A how far it's going to be.
16	Q. Okay. If I drop a well in my acre, and I start pumping
17	1,000 gallons a minute, is it likely under any set of
18	circumstances that I'm not putting a cone of depression out far
19	beyond my boundaries of my land? I am, for
20	A. You're saying the boundary is one acre?
21	Q. One acre, yes.
22	A. I suspect it would be larger than one acre.
23	Q. Okay. Now, if we go over to my neighbor's one acre, and he
24	decides he wants to pump 1,000 gallons a minute, because that
25	was my maximum total available drawdown, can he do it?

Γ

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1	Larson - cross A. Can he pump water?
2	Q. Can he pump 1,000 gallons a minute?
3	A. I can't tell, from the hypothetical that you've given me,
4	whether he can or he can't.
5	Q. Okay. So you're assuming that you can't tell, because
6	you're assuming that I can have a cone of depression limited to
7	my acre?
8	A. No. That's not why.
9	Q. Okay. If I establish a cone of depression that extends out
10	a mile, can my neighbor pump the same amount of water that I'm
11	now pumping within that cone of depression I've created?
12	A. It's possible that he can, yes.
13	Q. Okay. Is that something you see all the time?
14	A. What do you mean, "see all the time"?
15	Q. Let me put this in specific context. What does it mean
16	that there is a reduction in total available drawdown inside of
17	a cone of depression?
18	A. It means that the distance from the potentiometric
19	elevation to the top of the aquifer has been reduced.
20	Q. So there's less total available drawdown?
21	A. So there's less total available drawdown under that
22	definition.
23	Q. Okay. So and under your definition, my neighbor, who's
24	trying to pump from the same aquifer that I am, within that
25	cone of depression, cannot produce as much water as I am; is

1	Larson - cross 774
2	A. You can't determine that from the facts that you've given
3	me.
4	Q. Okay. Has their total available drawdown been reduced?
5	A. Yes, the total available drawdown would have been less at
6	that location, yes, if there was drawdown from your pumping.
7	Q. So if mine was 1,000 gallons a minute, and it went to the
8	top of the aquifer, and that was my total available drawdown,
9	would they have 1,000 gallons a minute if they dropped a well
10	near the same location?
11	A. Only if you had exactly the same transmissivity at his
12	location versus your location.
13	Q. Okay. So if we had exactly the same transmissivity, and
14	there are
15	A. And, and you're pumping lower potentiometric level to the
16	top of the aquifer at that rate.
17	Q. And they could they could pump the same amount with
18	inside the cone of depression I've created; is that what you're
19	saying?
20	A. Well, I said that was possible. You didn't give me enough
21	information to determine whether they could or they couldn't.
22	Q. Okay. Within the cone of depression created by Memphis,
23	did they have reductions in total available drawdown that
24	impact their own wells and their own wellfields?
25	A. In terms of total available drawdown to the top of the

	Larson - cross
1	aquifer, yes, it would be reduced.
2	Q. They do. And as it extends into Mississippi, has it
3	reduced the amount of water that someone in Mississippi can
4	produce from a well in that same formation when they drill a
5	second well, because they have less total available drawdown
6	than they would have had absent the Memphis pumping?
7	A. Total available drawdown would be reduced by whatever the
8	amount of drawdown was in the cone of depression.
9	Q. And that's the amount of water you can actually get out of
10	a well, right?
11	A. No. That reflects the available drawdown you have
12	Q. You're right. You're right. But it reflects it. So there
13	is less available water to be pumped with inside the cone of
14	depression; is that correct?
15	A. No. It just means that you have less available drawdown to
16	work with in your well.
17	Q. Okay.
18	THE COURT: I think we'll stop for a short recess.
19	We'll have a ten-minute recess.
20	(Recess)
21	THE COURT: All right. You may continue with your
22	examination.
23	MR. ELLINGBURG: Thank you, your Honor. I only have a
24	few more questions, I hope.
25	MR. FREDERICK: We join your hope, counsel.

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1	Larson - cross MR. ELLINGBURG: I would think you would.
2	BY MR. ELLINGBURG:
3	Q. Based upon the work you've done, how far does the cone of
4	depression created by the MLGW pumping in Tennessee extend in
5	the State of Mississippi?
6	A. I haven't tried to evaluate that. I can just see from the
7	maps that they're the overlapping cones of depression are
8	shown to extend into Mississippi, but I never tried to figure
9	out how far.
10	Q. Have you made any effort to determine what the depth of the
11	cone of depression is in Mississippi from the pumping by the
12	MLGW wells?
13	A. I've seen maps that would indicate the combined cones of
14	depression associated with not just MLGW, but whatever other
15	wells are there, would indicate declines of 40, 50 feet;
16	somewhere in that neighborhood.
17	Q. Have you obtained enough specific information to actually
18	predict what the additional cost of pumping would be in
19	Mississippi, to any reasonable degree, as a result of the cone
20	of depression being created by the wells pumping in Tennessee?
21	A. I haven't tried to make a specific estimate of it, no.
22	Q. Without that, you testified yesterday that it really
23	wouldn't cost much more money to place those wells in
24	Mississippi compared to what counsel introduced as a demand for
25	Mississippi. But what is the basis for that? I mean, how

777 Larson - cross do you know how much it would cost to Mississippi, or it does 1 2 cost to Mississippi? Do you have any basis for an opinion on 3 that? 4 Only my experience and judgment about the amounts of energy Α. 5 used to lift water. 6 Q. Anything else? 7 A. No. Q. Okay. Thank you. 8 9 Do you still have the transcript from the Montana vs. 10 Wyoming case up there? 11 A. I do, yes. 12 MR. ELLINGBURG: May I approach the witness, your 13 Honor? 14 THE COURT: Yes, you may. 15 MR. ELLINGBURG: I would like to mark the transcript 16 from the Montana vs. Wyoming case, original action 137, as an 17 exhibit for identification in this hearing, so that when it's reflected in the record, it will be possible to look at the 18 19 transcript. 20 THE COURT: All right. Yes? 21 MR. FREDERICK: Your Honor, are you talking about the 2.2 transcript or the Special Master's interim report which you 23 referred to yesterday, Counsel? 2.4 MR. ELLINGBURG: I apologize. MR. FREDERICK: It's not a transcript. 25

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1	Larson - cross MR. ELLINGBURG: I appreciate the correction. I would
2	like to mark the second interim report of the Special Master in
3	the original action of the Supreme Court, Number 137, dated
4	December 29, 2014, as an exhibit for identification.
5	MR. FREDERICK: We have no objection.
6	THE COURT: Okay. You may do that.
7	MR. FREDERICK: Counsel, did you give it a number?
8	MR. ELLINGBURG: I didn't. I just asked if we can
9	give it a number, but I'll have what is our last Plaintiff's
10	Exhibit? 209?
11	THE COURT: Okay.
12	MR. ELLINGBURG: Please mark the report as Plaintiff's
13	Exhibit 210.
14	(Plaintiff's Exhibit 211, was marked for
15	identification.)
16	MR. FREDERICK: Your Honor, I think it should be
17	just so the record is clear, we believe that they put the
18	photograph of Dr. Spruill's hand-drawn figure as Plaintiff's
19	Exhibit 210, and that this one should be named Number 211. So
20	if the record could reflect that this is Plaintiff's
21	Exhibit 211, I think it will be clearer as we go forward.
22	MR. ELLINGBURG: I appreciate the help.
23	MR. FREDERICK: You're welcome.
24	THE COURT: All right. Thank you for that.
25	MR. ELLINGBURG: Yes. At this time, your Honor,

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1	Larson - redirect Mississippi moves to strike the testimony of this witness, to
2	the to the extent certainly that it covers areas that were
3	not covered before this trial, and in this report, the
4	deposition, and also move to strike the opinion in its entirety
5	as lacking any scientific foundation.
6	Thank you.
7	THE COURT: All right. That motion is denied.
8	All right. Are you finished with your examination?
9	Are you finished with your examination?
10	MR. ELLINGBURG: Yes, your Honor, I'm finished with
11	cross-examination of this witness at this time.
12	THE COURT: Okay.
13	Redirect?
14	MR. FREDERICK: Thank you, your Honor.
15	And thank you, Mr. Larson.
16	REDIRECT EXAMINATION
17	BY MR. FREDERICK:
18	Q. Do you recall testifying about the fact that the Middle
19	Claiborne Aquifer was subdivided into multiple units for
20	purposes of the Clark & Hart model?
21	A. Yes, I do.
22	Q. I'm showing you Table 1 from Clark & Hart. This is
23	Exhibit J18. Can you identify where these model layers were
24	referenced?
25	A. Model layers are referenced on the right-hand side of the

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1	table in the most right-hand column.
2	Q. And they're given numbers?
3	A. And they're given numbers, correct.
4	Q. Can you give us the numbers for the Middle Claiborne
5	Aquifer, please.
6	A. They run from 5 through 10. 5, 6, 7, 8, 9, 10.
7	Q. Why do they subdivide the units for modeling purposes?
8	A. To help be able to calculate in one sense vertical
9	gradients within particular aquifer units, and to help define
10	subunits as the conditions vary from one place to another.
11	Q. And I believe that you testified that in some layers they
12	mapped the Middle Claiborne Aquifer as stopping at the facies
13	change, which they place near the Mississippi/Tennessee border.
14	A. They map the extent of the Lower Claiborne Confining Unit
15	and the Lower Claiborne Aquifer as extending up into that area.
16	Q. Did the hydrological unit abruptly stop at the facies
17	change?
18	A. No. The hydrologic unit, the boundary was drawn, and then
19	the characterization of the unit was displayed on other maps
20	that they had.
21	Q. Okay. I'd like to ask you to look at Figure 14H from that
22	same publication. And we've got it up on the screen.
23	What does this figure show?
24	A. This figure shows the extent of the sand percentage for
25	Layer 8, which is one portion of the Middle Claiborne Aquifer

-	Larson - redirect 781
T	hydrogeologic unit.
2	Q. Okay. And did you look at this exhibit or this figure in
3	formulating your conclusions about the interstate nature of the
4	Middle Claiborne Aquifer?
5	A. Yes, I did.
6	Q. Did you also look at Figure 14K, which I've got up on the
7	slide?
8	A. Yes, I did.
9	Q. And what does that show?
10	A. This shows the percentage of sand in what they delineated
11	as the Lower Claiborne Confining Unit, also Layer 8 in the
12	hydrogeologic model.
13	Q. So both pictures show Layer 8?
14	A. They do.
15	Q. Okay. And Clark & Hart just depicted them on separate
16	maps; is that right?
17	A. Yes, they did.
18	Q. Now, I'd like to show you all of Layer 8, as Clark & Hart
19	depicted it, by superimposing the two maps together. What does
20	this does this accurately superimpose the two maps of
21	Layer 8 into one an image?
22	A. Yes, I believe it does.
23	MR. FREDERICK: Now, I'd like to ask that this figure
24	be entered into the record as defendant's Exhibit 200, your
25	Honor.

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1	THE COURT: All right. Any objection?
2	MR. ELLINGBURG: No objection.
3	THE COURT: All right.
4	(Defendant's Exhibit 200 received in evidence)
5	BY MR. FREDERICK:
6	Q. Is there a sharp change in the sand composition just south
7	of the Mississippi/Tennessee border?
8	A. No. The superimposition of the maps shows that the
9	there's a high sand content that extends from north of the
10	Tennessee/Mississippi border for some distance into
11	Mississippi.
12	Q. Now, approximately how far south of the border does the
13	80 to 100 percent sand content extend?
14	A. It looks like to be on the order of 25 or 30 miles.
15	Q. Okay. Does the Clark & Hart report discuss the Lower
16	Claiborne Aquifer?
17	A. Yes, it does.
18	Q. I'd like to ask you to look at your binder, Exhibit J18,
19	page 11 of 70. We don't have a slide for this, unfortunately,
20	so I just ask you to go to page 11 of 70.
21	Counsel sure. It's Exhibit J18. And I will ask
22	you to look at the very bottom of the second right-hand column,
23	if you would, please.
24	Under the topic "Hydrogeologic Units," Mr. Larson,
25	could I ask you to read the last sentence of that paragraph,

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1	Larson - redirect please.
2	A. "As noted in Hart and others (2008), the Lower Claiborne
3	Confining Unit and the Lower Claiborne Aquifer undergo a facies
4	transition and merge into the Middle Claiborne Aquifer in the
5	northern part of the model area (Figure 1.)"
6	Q. Did this statement inform your conclusion that the Lower
7	Claiborne Aquifer is part of the Middle Claiborne Aquifer?
8	A. Yes, that's what it would indicate to me.
9	Q. Now, let's look at Table 1 from Clark & Hart.
10	Now, we talked about the words "Middle Claiborne" and
11	"Lower Claiborne." Can you identify where they are in this
12	table, please.
13	A. If you look in the "Hydrogeologic Units" column, there's a
14	"Middle Claiborne" within the Middle Claiborne Aquifer,
15	there is a reference to the Lower Claiborne Confining Unit and
16	the Lower Claiborne Aquifer.
17	Q. And in what column are they designated by the US Geological
18	Survey?
19	A. In the "Hydrogeologic Units" column.
20	Q. Okay. Now, using Plate 2 from Arthur & Taylor this is
21	Exhibit J4 we've seen this figure before, have we not?
22	A. Yes.
23	Q. Could you point out the area of the Middle Claiborne
24	Aquifer that Mississippi has referred to as the Lower Claiborne
25	Aquifer?

	/04
1	Larson - redirect A. It would be the area underneath the Lower Claiborne
2	Confining Unit, extending beneath that unit from south to
3	north, up to the area of the transition.
4	Q. Have any other names been given to that area?
5	A. I think it's also referred to as the Meridian Sand in some
6	places.
7	Q. Does the USGS sometimes refer to this section as the Lower
8	Claiborne Aquifer instead of the Middle Claiborne Aquifer?
9	A. Can you ask that question again?
10	Q. Sure. Does the USGS sometimes refer to that section as the
11	Lower Claiborne Aquifer instead of the Middle Claiborne
12	Aquifer?
13	A. Yes.
14	Q. Okay. Do you know why the USGS sometimes refers to that
15	section by a different name?
16	A. Well, my conclusion would be they're trying to identify
17	areas where the aquifer characteristics would be overlain by
18	materials that will be more consistent with a confining unit
19	characteristic, that being the Lower Claiborne Confining Unit.
20	Q. And why would USGS need to distinguish between those two
21	different areas?
22	A. Well, in trying to be descriptive of how groundwater can
23	flow, they would want to be able to depict how water could flow
24	laterally between the Lower Claiborne Aquifer and further to
25	the north, and how it might move vertically between the Lower

	785
1	Larson - redirect Claiborne Aquifer and the aquifer above the Lower Claiborne
2	Confining Unit.
3	Q. So if I refer to the bottom layer, marked as the Lower
4	Claiborne, as the bottom of the fork, would you agree with me
5	in characterizing it that way
6	A. Yes.
7	Q as a tine of a fork?
8	And if I refer to the where it's marked as the
9	Middle Claiborne as the handle of the fork?
10	A. Yes.
11	Q. Now, is the bottom part of the fork, what Mississippi has
12	called the Lower Claiborne Aquifer, hydrologically connected to
13	the handle of the fork, marked here as the Middle Claiborne
14	Aquifer?
15	A. Yes, it is.
16	Q. Now, why are you saying it's hydrologically connected?
17	A. Because when you look at the nature of the transmissive
18	characteristics and permeability, there's a continuity between
19	the area to the north and as it moves underneath the Lower
20	Claiborne Confining Unit to the south.
21	Q. Okay. Do the hydrogeological properties of the sand
22	deposits of the Middle Claiborne Aquifer change as one moves
23	south of the facies change?
24	A. Well, they will vary from place to place throughout that
25	area.

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1	Larson - redirect Q. Does that change affect the ability of water to flow in the
2	bottom prong of that fork, what's been denominated the Lower
3	Claiborne Aquifer?
4	A. Well, the water can still move from one place to another
5	within from the bottom prong into the handle, for example.
6	Q. And is that directional is it only in one does the
7	water flow in only one direction, or can it flow in opposite
8	directions, depending on conditions?
9	A. Depending on conditions, it can go either way.
10	Q. Okay. Now, I'd like to ask you about your testimony in the
11	Montana v. Wyoming and North Dakota case. Do you recall
12	testifying on cross-examination about that testimony?
13	A. Yes, I do.
14	Q. And that was an original action in the Supreme Court of the
15	United States?
16	A. Yes.
17	Q. Can you briefly describe what the dispute was about in that
18	case?
19	A. Well, the principal dispute was about water storage and
20	reservoir operations within Wyoming and how those water uses in
21	Wyoming change after I think it was 1950. And so that was
22	the principal component of that.
23	Q. And on whose side were you an expert in that case?
24	A. On the Montana side.
25	Q. And was Montana the plaintiff in that case?

1	Larson - redirect 787
2	Q. What injury was Montana claiming that Wyoming had caused
3	it?
4	A. They were claiming that water that they should be entitled
5	to more water was being used in Wyoming than they were
6	entitled to, and that that water should have come down to
7	Montana.
8	Q. Okay. And that's because the water flows north in that
9	particular part of the country?
10	A. Yes. In the Tongue River, the water flows to the north.
11	Q. Okay. So the downstream state is actually Montana, even
12	though it is north of Wyoming?
13	A. That's correct.
14	Q. Okay. What were you asked to investigate in the Montana
15	case?
16	A. I was asked to make estimates of the potential impact of
17	coalbed methane water development on stream flows in the Tongue
18	River.
19	Q. So your role was to predict future effects on stream flow,
20	based on coalbed methane development?
21	A. Yes, historical some historical and future effects.
22	Q. How did you go about determining the effects of coalbed
23	methane development on stream bed flow?
24	A. I reviewed the information and found that the BLM had
25	constructed a groundwater model to look at coalbed methane,

	788 Larson - redirect
1	water development or water production. And so I examined that
2	model and decided that I think that would provide the best tool
3	that I could add at that time to make an estimate of what the
4	impacts might be.
5	Q. So the record is clear, what does "BLM" stand for?
6	A. The Bureau of Land Management.
7	Q. And do you know in what executive department the Bureau of
8	Land Management resides?
9	A. I believe it's in the Department of Interior.
10	Q. Is that the same department that the US Geological Survey
11	exists?
12	A. Yes, it is.
13	Q. So the BLM is a sister agent of the USGS?
14	A. Yes. Agencies.
15	Q. Now, when you say you looked at a model developed by the
16	federal agency, BLM, why did you use that model?
17	A. Well, I felt that the they had done a lot of work to
18	compile the model and put it together, and to test the model
19	and so on, and that would be the best tool that I could use,
20	given the task that I was assigned at the time.
21	Q. What conclusions did you draw in your testimony there?
22	A. I concluded that there were some small impacts that the
23	model predicted on stream flows within the Tongue River
24	Q. Do you recall
25	A based on the model and calculations.

	789
1	Larson - redirect Q. I'm sorry to interrupt you.
2	Do you recall how you tried to measure those effects?
3	A. Well, the the effects were very small, and there really
4	wasn't an ability, given the variations in stream flow and
5	whatnot, to actually measure those effects.
6	Q. So was one of the difficulties that you encountered the
7	lack of calibration in the Tongue River base flows?
8	A. Yes.
9	Q. And was that lack of calibration a function of the Bureau
10	of Land Management model that you used?
11	A. Yes.
12	Q. Given your assignment, was there anything you could have
13	done to substitute for that lack of data?
14	A. No. I mean, historically, the time period was passed, and
15	you can't really go back and recreate information.
16	Q. Did the Special Master rule that you were unqualified as an
17	expert, or simply that the data you worked with was
18	insufficient to prove Montana's case?
19	MR. ELLINGBURG: I'm going to object to the form of
20	that question and counsel's characterization. I believe the
21	Special Master's report is very specific.
22	THE COURT: The Court can read that without him
23	answering the question. Overruled.
24	A. Could you repeat that?
25	Q. Sure. Did the Special Master rule that you were

	790
1	Larson - redirect unqualified as an expert, or simply that the data that you
2	worked with was insufficient to prove Montana's case?
3	A. My understanding is he did not conclude that I was not
4	qualified as an expert, but that the model calculations were
5	insufficiently reliable to rely on for his purposes, judging
6	the case.
7	Q. And what is your opinion of that decision by the Special
8	Master?
9	A. Well, I recognize that there was uncertainty in the
10	modeling, or in those calculations, that the calculations were
11	rather small. It didn't surprise me that someone might find
12	that those calculations to be insufficiently reliable, so I
13	was not I was not surprised.
14	Q. How does the technical complexity of your assignment in the
15	Montana case compare to the technical complexity of your
16	assignment in this case?
17	A. It was much more complex in the Montana case.
18	Q. Thank you.
19	MR. FREDERICK: No further questions, your Honor.
20	THE COURT: All right.
21	Do you have any further questions?
22	MR. ELLINGBURG: A few only.
23	THE COURT: Okay.
24	MR. ELLINGBURG: Can we have the Slide J18, USGS
25	MERAS. Could I have that table just now the Table 1? It is

	79'
1	Larson - recross from J18, and it's page 15 of 17.
2	MS. KNOFCZYNSKI: Page what?
3	MR. ELLINGBURG: 15 of 17.
4	MR. BRANSON: This table?
5	RECROSS EXAMINATION
6	BY MR. ELLINGBURG:
7	Q. Is this the table that you were just looking at a few
8	moments ago, on redirect?
9	A. Yes, it is.
10	Q. I may be confused, but is the Lower Claiborne Aquifer
11	hydrogeologic unit assigned a model layer that's all by itself?
12	A. It's Layer 10. It's not all by itself, because Layer 10
13	would include portions of the Middle Claiborne Aquifer as well
14	as the Lower Claiborne Aquifer.
15	Q. Okay. But it does have that particular layer has a
16	separate model designation with regard to its hydrogeological
17	characteristics, right?
18	A. That portion of the Middle Claiborne Aquifer unit and the
19	Lower Claiborne is represented by Layer 10 in the model.
20	Q. Right. But it doesn't the rest of the Middle Claiborne
21	is actually represented by Layers 5 to 7 and 8 and 9; is that
22	correct? I mean, this is not all one layer. I was a little
23	confused when I heard your testimony.
24	A. The Middle Claiborne Aquifer is represented by Layers 5
25	through 10.
	792
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1	Larson - recross Q. That's your opinion?
2	A. No, that's what they did in the model.
3	Q. Okay. The Middle Claiborne hydrogeologic unit is
4	represented by Layers 5 through 10?
5	A. Yes.
6	Q. In some areas. But 10 has been separated out for some
7	reason; is that correct? Layer 10?
8	A. In areas where they distinguish the Lower Claiborne Aquifer
9	unit, that's also part of Layer 10.
10	Q. Okay. And where they had got the Lower Claiborne confining
11	hydrogeological unit, that's Layers 8 and 9; is that correct?
12	A. That's correct. Or that's part of it, obviously. There's
13	part of the Middle Claiborne Aquifer that are also Layers 8 and
14	9.
15	Q. Right.
16	A. But within Layers 8 and 9, I should say.
17	Q. Did you talk to any legal counsel for any of the defendants
18	in the day yesterday, until this testimony this morning?
19	A. No, I did not.
20	Q. Okay. So you received no help on the slides or no
21	you didn't provide any assistance with any of these slides you
22	were going to testify to in any way?
23	A. No, I did not.
24	Q. Now, the model shows different layers. I believe you were
25	shown a slide that has been combined by counsel, 14H and 14K;

	793
1	Larson - recross is that correct?
2	A. That sounds right, yes.
3	Q. Do you have that
4	MR. FREDERICK: We gave you a copy of it.
5	MR. ELLINGBURG: Okay. I can't put it up on the
6	screen.
7	MR. FREDERICK: Would you like us to do that for you,
8	counsel?
9	MR. ELLINGBURG: It would be very kind of you.
10	BY MR. ELLINGBURG:
11	Q. Exactly what is shown by this particular combined exhibit
12	prepared by defense counsel?
13	A. Exactly what's shown? It's showing a juxtaposition of the
14	components of Layer 8, one of them being the area to the south,
15	which has been distinguished in the modeling framework as the
16	Lower Claiborne Confining Unit, and the area to the north,
17	which is a portion of the Middle Claiborne Aquifer.
18	Q. All right. Is there a line drawn on this figure near the
19	Mississippi border it's a little difficult to see, but it's
20	kind of a somewhat affected by the combination. But do you
21	see that line that runs from actually from Arkansas all the
22	way across, above and below?
23	A. Yes, I do.
24	Q. Okay. That's would that be essentially where the
25	transition zone is shown in these studies?

	Larson - recross
1	A. Yes, I believe so.
2	Q. Okay. Now, the fact that there is to the far to the
3	right-hand side, in Mississippi, an equivalent sand thickness,
4	does that mean that the groundwater behavior in that area is
5	the same as the groundwater behavior north, in Tennessee, below
6	the transition zone?
7	A. Well, this figure doesn't show sand thickness; it shows
8	sand percentage.
9	Q. Okay. Sand percentage. Does that tell you anything about
10	the actual transmissivity within that area, below
11	A. Not
12	Q below the transition zone?
13	A. Not in and of itself, no.
14	Q. Thank you.
15	Now back between microphones the Montana case,
16	your work all related to the parties' compliance with an
17	existing interstate compact, did it not?
18	A. Yes, it did.
19	Q. And so you weren't making decisions about what was or was
20	not interstate in nature, were you?
21	A. I was not making decisions about what the different states
22	were entitled to, if that's what your question is.
23	Q. Right. And just to put it in perspective, were you
24	sponsored, as an expert, information on behalf of your client
25	as to how much groundwater was involved and how that water

795 Larson - recross contributed or didn't contribute to the flow of the river, 1 2 right? A. No, that's not quite right. 3 O. You didn't --4 5 MR. FREDERICK: Can I object to the use of the word 6 "sponsor." 7 MR. ELLINGBURG: Okay. MR. FREDERICK: He's an independent expert in the 8 9 case. BY MR. ELLINGBURG: 10 11 Q. Okay, let me ask you this -- I apologize. 12 Did you give an expert opinion with regard to the 13 amount of water based on a much more detailed scientific study 14 in that case? 15 I gave an opinion about the effects or -- both some Α. 16 historical and potential future effects of the development of 17 water associated with coalbed methane development in Montana on stream flows in the Tongue River. 18 Q. Right. So that was an expert opinion based on your 19 20 independent scientific investigation on the use of the model; 21 is that correct? 2.2 A. Yes, I based it on using the BLM model. 23 Okay. And that -- those results that you testified to as Ο. 24 an expert were rejected by the Court; is that correct? 25 A. The Court found that they were not sufficiently reliable

796 1 for him to use them, yes. 2 0. That's all I wanted to know. Thank you. 3 MR. FREDERICK: Your Honor, if there are no further questions, we would ask that Mr. Larson be permitted to step 4 5 down so that Tennessee can call its next witness. THE COURT: All right. Are you finished with your 6 7 recross? 8 MR. ELLINGBURG: Yes, your Honor. 9 THE COURT: Okay. You may do that. 10 MR. FREDERICK: Thank you. 11 (Witness excused) 12 MR. BRANSON: Your Honor, Tennessee calls Dr. Brian 13 Waldron as its next witness. THE COURT: Okay. 14 15 BRIAN WALDRON, 16 called as a witness by the Defendant State of Tennessee, 17 having been duly sworn, testified as follows: 18 MR. BRANSON: Thank you, your Honor. We're just getting our binders distributed. 19 20 THE COURT: Okay. 21 DIRECT EXAMINATION BY MR. BRANSON: 2.2 23 Q. Good morning, Dr. Waldron. 24 A. Good morning. 25 Q. Could you state your full name for the record.

			797
1	Α.	Brian Anthony Waldron.	151
2	Q.	Are you currently employed?	
3	Α.	Yes, I am.	
4	Q.	Where?	
5	Α.	At the University of Memphis.	
б	Q.	What's your title there?	
7	Α.	I am an associate professor in the department of civil	
8	eng	ineering, and I also direct the Center for Applied Earth	
9	Sci	ence and Engineering Research, or what we call CAESER.	
10	Q.	How long have you been at the University of Memphis?	
11	Α.	About 20 years.	
12	Q.	When did you become a professor there?	
13	Α.	I started my tenure track in 2007 and received tenure in	
14	Aug	ust of 1999 I'm sorry, 2010. Went back in time.	
15	Q.	Do you teach courses at the university, Dr. Waldron?	
16	Α.	I do.	
17	Q.	What courses do you teach?	
18	Α.	Undergraduate and graduate courses. Graduate level in	
19	con	taminant transport, groundwater hydraulics, groundwater	
20	qua	lity control, others.	
21	Q.	What do you cover in groundwater hydraulics?	
22	Α.	What I cover in my particular class is the construct of	
23	wat	er moving through porous media, the development of Darcy'	S
24	Equ	ation. We look at flow to wells and the types of gett	ing
25	aqu	ifer characterization from that.	

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1	Q. Do you teach groundwater modeling in any of your courses at
2	the University of Memphis?
3	A. I do.
4	Q. In what course do you teach that?
5	A. Typically, groundwater quality control.
6	Q. How long have you been teaching groundwater modeling at the
7	university?
8	A. Little over ten years.
9	Q. Dr. Waldron, can you briefly describe your educational
10	background for the Court.
11	A. Yes. I received my undergraduate in civil engineering at
12	Memphis State University. That's now called the University of
13	Memphis; it changed names. And that was in 1992.
14	Then I received my master's in civil engineering at
15	the University of Memphis. And that was in 1994.
16	And then I went to Colorado State University and
17	received my doctorate in civil engineering, also specializing
18	in groundwater, in 1999.
19	Q. You mentioned earlier, Dr. Waldron, the Center for Applied
20	Earth Sciences in Engineering Research, or CAESER. Can you
21	describe what your responsibilities are there.
22	A. They're twofold. One is to conduct research, and the other
23	is to do some director-type operations.
24	In conducting research, I conduct numerical modeling
25	of groundwater and contaminant transport. I've done that for

	700
1	the Middle Claiborne Aquifer and other aquifers.
2	I also do subsurface mapping of geologic formations.
3	And that particular area, it's my area of Memphis; it's the
4	confining clay above the Middle Claiborne Aquifer, but I've
5	also done it elsewhere.
6	And I also do water sampling and age dating of the
7	groundwater, primarily of the Middle Claiborne Aquifer. And I
8	also do recharge work to the Middle Claiborne Aquifer, and
9	that's east of Shelby County, where I am.
10	And I also do water level measurements and water
11	water level maps. That's of the Middle Claiborne Aquifer and
12	the shallow aquifer.
13	And then we also do education outreach. So in
14	education outreach, we really focus on talking to kids about
15	the water and how to conserve it, and then we also talk to
16	elected officials.
17	As the director, it's my job to go and bring in
18	research dollars to the university. And then those dollars pay
19	for students, graduate students, to get their degrees, or
20	undergraduate students to engage themselves in research.
21	Q. While you've been at the university, Dr. Waldron, have you
22	personally published any research studies?
23	A. I have, 20 yes. Yeah. A number of them.
24	Q. How many have you published?
25	A. I've published about roughly 22.

1	800 0. Of those 22, how many of the studies you've published have
2	concerned groundwater hydrology?
- 3	A 16 of them
4	0. Now, you've mentioned the Middle Claiborne Aquifer in your
-	testimony already, and you've been sitting in court this week
6	hearing about that aguifer. How did you first become familiar
7	with the Middle Claiborne Aguifer in particular?
8	A. I was a lot younger than I was now. It was when I was an
9	undergrad student. The Groundwater Institute had just started
10	at Memphis State, and I was hired on as an employee. So what I
11	did was I was a digitizer, so I digitized all the
12	potentiometric maps and thickness maps that were in the USGS
13	publications into GIS.
14	(Reporter clarification)
15	A. And then the graduate students would use those in their
16	research.
17	Q. Have you continued to study the Middle Claiborne Aquifer in
18	future years, after you were an undergraduate?
19	A. Yes, I did.
20	Q. And for how long have you been studying the Middle
21	Claiborne Aquifer?
22	A. About well, more than 20 years.
23	Q. So Dr. Waldron, of the time that you spend on an everyday
24	basis as a groundwater hydrologist, can you just tell me
25	roughly what percentage you devote to the Middle Claiborne

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1	Aquifer in particular?
2	A. Roughly about 50 to 60 percent.
3	Q. And just in your professional life, Dr. Waldron, can you
4	give Judge Siler just a rough estimate of how many hours you've
5	spent studying the Middle Claiborne Aquifer?
6	A. About 20,000 hours.
7	Q. Now, in the course of your professional work on this
8	aquifer, Dr. Waldron, do you keep up with the academic
9	literature on it?
10	A. As much as I can, yes.
11	Q. And what about USGS studies on this aquifer? Do you keep
12	up with those as well?
13	A. As much as I can.
14	Q. Now, Dr. Waldron, you've been retained by the State of
15	Tennessee as an expert witness, correct?
16	A. Yes, sir.
17	Q. Are you being compensated for your work?
18	A. Yes, I am.
19	Q. What's your rate?
20	A. \$275 an hour.
21	Q. How does that compensation arrangement work?
22	A. Well, I'm an employee at the university, so what happens is
23	that the university has a contract with the State of Tennessee
24	Attorney General's Office. So I'm not a party to the contract.
25	So the university will ask me what time I spend, which

802 I give to them; then they get the money from the AG's Office. 1 2 If I want to get paid, I have to do paperwork, internal, and get approval. So that gets submitted, and then if it's 3 4 approved, I get paid for my normal salary structure. 5 Is your compensation contingent in any way on the substance 0. of your opinions? 6 7 A. No, it's not. Is it contingent in any way on the outcome of this case? 8 0. 9 A. No, it's not. MR. BRANSON: Judge Siler, Tennessee offers 10 Dr. Waldron as an expert in the field of groundwater hydrology. 11 MR. MOFFETT: No objection, your Honor. 12 13 THE COURT: He is found to be an expert. 14 BY MR. BRANSON: Q. Dr. Waldron, did you produce any expert reports in the 15 16 course of your work on this case? 17 A. Yes, I did. 18 Q. When you set out to create those expert reports, how did you determine the question that you were trying to answer? 19 I read Judge Siler's opinion. 20 Α. 21 And at a high level, what did you base your opinions on 0. 2.2 that you expressed in your expert reports? 23 Α. They're based on my training and expertise, primarily that 24 on the Middle Claiborne Aquifer and in the publications that I 25 read in my report.

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	Floceculitys - May 23, 2019
1	803 O Dr Waldron I'd like you to turn in your opening report in
2	vour binder it should be D194 if you can find it
2	You found it?
2	A Found it
4 5	A. Found IC.
5 6	Q. IS DI94 an accurace copy of the opening expert report that
0	you prepared in this case?
7	A. Yes, It IS.
8	Q. Does that report accurately state your opinions with
9	respect to the question that you understood the Special Master
10	to have posed?
11	A. Yes, it does.
12	Q. I'd like you to turn, Dr. Waldron, to paragraph 51 in your
13	opening expert report. Just let me know when you're there.
14	A. I'm there.
15	Q. Do you see, in the last clause of paragraph 51, there are
16	two numbers, 221,000 cubic meters per day and 186,000 cubic
17	meters per day? Do you see that?
18	A. I do.
19	Q. Is there anything you'd like to correct about that?
20	A. Yes. The numbers are transposed. The 221 cubic meters per
21	day is for
22	(Reporter interruption)
23	A. The numbers are transposed. The 221 cubic meters per day
24	is for 1886, and the 186,000 cubic meters per day is for 2008.
25	Q. And Dr. Waldron, just to be clear, when you just said

		Proceedings - May 23, 2019
1	"222	804 1," you meant 221,000 right?
2	Α.	221,000, ves.
3	0.	And the transposition you just referred to, that was a typo
4	in v	your report?
5	A.	Yes, sir.
6	0.	Besides that, is there anything else in this opening expert
7	repo	ort that you no longer agree with?
8	Α.	No.
9	Q.	Dr. Waldron, I'd now like you to turn to D195.
10		Is this the first rebuttal report that you prepared in
11	this	s case?
12	Α.	Yes, sir, it is.
13	Q.	And does this accurately state your opinions about the two
14	oper	ning expert reports submitted by Dr. Spruill and Mr. Wiley?
15	Α.	Yes, it does.
16	Q.	Is there anything in this Exhibit 195 that you no longer
17	agre	ee with?
18	Α.	No.
19	Q.	Finally, let's turn to Exhibit D196 in the binder.
20		Is this a copy of the surrebuttal expert report that
21	you	submitted in this case?
22	Α.	Yes, it is.
23	Q.	Does this accurately state your opinions in response to
24	Dr.	Spruill's rebuttal report?
25	Α.	Yes, it does.

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1	Q. Is there anything in this document that you no longer agree
2	with?
3	A. No.
4	Q. Dr. Waldron, have you ever testified as an expert witness
5	before?
6	A. No.
7	Q. So let's turn now to the some hydrogeology. You've
8	heard a lot about the Mississippi Embayment this week. Are you
9	familiar with what that is?
10	A. Yes, sir.
11	Q. Very briefly, what is that?
12	A. The Mississippi Embayment is a south-plunging trough or
13	geologic formation that underlies portions of eight states.
14	It's filled with Cretaceous and younger sediments that can be
15	broken out into hydrogeologic units like aquifers and confining
16	units.
17	Q. What is an aquifer, in your view?
18	A. An aquifer is a water-saturated formation that is able to
19	store and transmit water for its intended use.
20	Q. What about a confining layer: What is that?
21	A. A confining layer is a laterally extensive geologic
22	formation that in our area is composed comprised mostly of
23	clay, but also can contain silt and fine sands. And it
24	restricts the vertical movement of water between aquifers.
25	Q. We've heard from other witnesses this week that the Middle

	806
1	Claiborne Aquifer is one of the aquifers within the Mississippi
2	Embayment. I take it you agree with that?
3	A. Yes, I do.
4	Q. Let's turn now to an exhibit. And there we go. Putting
5	up on the screen, I put up, for the record, Joint Exhibit 18.
6	We've discussed this article quite a lot this week.
7	Do you recognize this, Dr. Waldron?
8	A. Yes, I do.
9	Q. Very briefly, could you identify it for the record.
10	A. Yes. It's a USGS publication by Clark & Hart, 2009, MERAS.
11	Q. I'd like to turn to Figure 14G in that article, which is on
12	page 37 of the exhibit.
13	What is this depicting, to you?
14	A. This is depicting four things. The first point is this
15	outer boundary, it's kind of brownish, and that's the extent of
16	the Mississippi Embayment.
17	Then you go you see that black boundary, and that's
18	filled with brownish colors. That black boundary represents
19	the lateral extent of the Middle Claiborne Aquifer.
20	And then the next piece are the brown gradations, and
21	that represents percentages of sand within the Middle Claiborne
22	Aquifer. And this is for Layer 7.
23	And then the fourth thing are the black dots. And
24	those are control points that they use to obtain from logs
25	those sand percentages.

	807
1	Q. Now, on the first two things you said, is the lateral
2	extent of the Mississippi Embayment the same as the lateral
3	extent of the Middle Claiborne Aquifer on this chart?
4	A. No, it's not.
5	Q. Why is there a difference?
б	A. Well, one, physically, the Middle Claiborne Aquifer does
7	not extend to the outer extent of the Mississippi Embayment.
8	But there are other aquifer systems below it, and as they come
9	up to the surface, they will fill in that white gap between the
10	Middle Claiborne and the Mississippi Embayment.
11	Q. You also mentioned the brown shading depicting sand
12	percentages. In your opinion, what's the significance of those
13	varying percentages?
14	A. It shows the heterogeneity of the Middle Claiborne Aquifer.
15	Q. And according to this map, Dr. Waldron, how many states
16	does the Middle Claiborne Aquifer underlie?
17	A. The Middle Claiborne Aquifer underlies eight states.
18	Q. And for the record, could you just identify those eight
19	states, according to this map?
20	A. Yes. Illinois, Missouri, Kentucky, Tennessee, Arkansas,
21	Alabama, Mississippi, and Louisiana.
22	Q. And in your expert opinion, is this map consistent with the
23	scientific consensus on the geographic extent of the Middle
24	Claiborne Aquifer?
25	A. Yes, it is.

1	808
T	Q. Let's turn now to another document that, for the record, is
2	Joint Exhibit 76.
3	Dr. Waldron, do you recognize this document?
4	A. Yes, sir, I do.
5	Q. Could you identify it for us?
6	A. I can. This is a report that myself and many other authors
7	wrote in 2011 for the Environmental Protection Agency. It's
8	called MERGWS, which is the Mississippi Embayment Regional
9	Groundwater Study.
10	Q. At a high level, what was this study attempting to
11	accomplish?
12	A. This study was a phase one of four. At a high level, it
13	was meant to be a compilation of existing information about a
14	subregion of the Middle Claiborne Aquifer, and to address the
15	issue at a high level of the disparity that existed at the
16	time, things like geology and chemistry, water chemistry.
17	Because at the state boundaries, it ended; that type of
18	information didn't cross over. So it was trying to address
19	that regionality function of it.
20	Q. And you mentioned phase one of four. Did the other phases,
21	phase two through four, did those ever happen?
22	A. No, they did not. The study was appropriated through EPA,
23	and then there was authorization language in WRDA to do the
24	remaining three. It's still in WRDA, but it's not been
25	appropriated.

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1	809 O. What was your personal role in this study, Dr. Waldron?
2	A. I was the primary investigator.
- 3	0 As a primary investigator, what did you actually do?
4	A I really tried to gather together the troops that worked on
5	this effort and that included faculty from the University of
5	Momphia It included faculty from the University of
0	Memphis. It included faculty from the oniversity of
/	MISSISSIPPI, and it included faculty from Arkansas State
8	University in the conduction of the research of the various
9	aspects.
LO	And then also we for pieces of this, we contracted
L1	with the US Geological Survey for their assistance as well.
L2	Q. As the primary investigator, does that mean that everything
L3	in this lengthy report reflects your own personal opinion?
L4	A. No, sir, it does not.
L5	Q. Let's go to page five of this exhibit, and I'm going to put
LG	it on the screen.
L7	This is the forward. Are you familiar with this
L8	forward to the study?
L9	A. Yes, sir, I am.
20	Q. And the author here is David G. Jewett. Do you know who
21	that is?
22	A. He's the acting director of the Groundwater and Ecosystems
23	Restoration Division.
24	Q. Let's focus on the bottom paragraph of this forward, and I
25	have expanded it on the screen.

	810
1	Does this paragraph of the forward accurately describe
2	your understanding of the purpose of this EPA-funded study?
3	A. Yes, sir, it does.
4	Q. I want to highlight a few things on here in yellow. And I
5	want to address first the first thing I've highlighted.
б	Do you agree, Dr. Waldron, that this study was
7	designed to address the problem created by disparate methods
8	and uncoordinated timing of hydrologic and geologic data
9	collection across state lines?
10	A. Yes, I do.
11	Q. And why did you consider that to be an important problem to
12	solve?
13	A. Because back at this time, each state, even within the
14	USGS, had their own offices in each state, and each state had
15	like TDEC or MDEQ and the one in Arkansas, they were dealing
16	with data in their own state.
17	And what happens what was happening was everyone
18	would collect their data, but we got to the state line and
19	stopped. And therefore you see this disparity between the
20	information that had crossed the state lines. So knowing that
21	this system was a regional system, we needed to address that
22	disparity so we could really look at it on a regional scale.
23	Q. Dr. Waldron, in your expert opinion, did you think it was
24	appropriate to look at a regional system using data that was
25	collected in the constraints of political boundaries?

1	811 No
Ţ	
2	Q. I want to now focus on the second part that I highlighted.
3	And did you also consider it important, when you and others
4	were working on this study, to improve the understanding of the
5	groundwater resources in this aquifer system without the
6	constraints of political boundaries?
7	A. Yes, we did.
8	Q. And why did you consider that to be important?
9	A. Well, it started out earlier with this thing called MATRAS,
10	and the idea was we needed to get rid of these political
11	boundaries to understand what was going on about a system of
12	aquifers that were regional in scale.
13	So, you know, groundwater knows no political
14	boundaries. So we didn't need to know the political
15	boundaries.
16	Q. And you used the acronym "MATRAS" in your answer. I
17	just could you explain what that is, so the record is clear?
18	A. MATRAS is the Mississippi, Arkansas, Tennessee Regional
19	Aquifer Study. It was a collection of faculty from University
20	of Memphis, and it was each of the state agencies, like
21	MDEQ, TDEC I don't remember what Arkansas is called and
22	then the USGS offices in each state, and then Shelby County,
23	and then the Corps of Engineers.
24	So we're all getting together to try to look at the
25	system holistically.

	812
1	Q. Let's go to Figure 3 in this study, and it's on page 32 of
2	the exhibit. I'm going to expand Figure 3 on the screen here.
3	Dr. Waldron, at a high level, what is this figure
4	depicting?
5	A. This figure is depicting a it's a cross-section through
6	a number of hydrogeologic layers within the Mississippi
7	Embayment.
8	Q. Where was this cross-section taken?
9	A. It was it's actually on a Figure 2, that's before this
10	figure.
11	Q. I'll put that up on the screen and expand it.
12	Using this Figure 2, Dr. Waldron, could you help
13	orient us about where the cross-section was taken in Figure 3?
14	A. Yes. There's a you'll see the little black box that
15	says Memphis Area, and there's a dotted line that says
16	Northwest-Southeast. That's where that cross-section was
17	taken.
18	Q. Now that we're oriented, let's go back to Figure 3.
19	And, you know, I'd like to ask you see a lot of
20	layers here stacked on top of each other, like a cake. In your
21	opinion, are these layers hydrologically connected to each
22	other?
23	A. Yes, sir.
24	Q. What does it mean, in your expert opinion, for two layers
25	of an aquifer system to be hydrologically connected?

	Q12
1	A. There's an exchange of water between them.
2	Q. What is the function of the various confining units that we
3	see on this cross-section?
4	A. I'm sorry, could you say that again?
5	Q. Yeah. What is the function of the confining units that we
6	see on this cross-section?
7	A. They are laterally extensive, and they restrict the
8	movement of water between the aquifers.
9	Q. They restrict the movement of water
10	A. The vertical movement; I'm sorry.
11	Q. They restrict the vertical movement of water. Do the
12	confining layers restrict the lateral flow of water in this
13	aquifer system?
14	A. No, sir, they do not.
15	Q. Dr. Waldron, let's now talk about these layers, and I want
16	to start at the top. I've highlighted the very top layer in
17	blue on the screen.
18	Can you explain to Judge Siler what I've highlighted?
19	A. Yes. This is an unconfined portion of the aquifer system
20	on the Arkansas side, which is the left side. That's
21	Mississippi River alluvium. It was deposited by the
22	Mississippi River, so it's comprised of a lot of mainly with
23	sand and gravel.
24	And then on the Tennessee side, that's unsaturated
25	I'm sorry, unconfined portion of the shallow aquifer, and that

	814
1	is comprised primarily of sand and gravel as well.
2	You can get water in and out of that. One way to get
3	water in is through rainfall. So there's no confining layer
4	above any of them, so they go in. You can get water for those
5	for surface water bodies, like lakes and rivers, and then there
6	can be movement of water from the lower units into that.
7	Water can leave those systems, one, through pumping.
8	They could leak into surface water systems, like rivers and
9	lakes. And then there could be downward leakage of water from
10	those units into the lower units.
11	Q. Let's go to the next unit down, that I've highlighted in
12	pink now. What is this, Dr. Waldron?
13	A. This is a confining unit. It it confines the top of the
14	Middle Claiborne Aquifer.
15	Q. Let's go to the next unit down, that I've highlighted in
16	blue. And this is labeled "Memphis Aquifer (Memphis Sand and
17	Equivalents)."
18	What is this layer that I've highlighted?
19	A. This is the Middle Claiborne Aquifer.
20	Q. So if it's the Middle Claiborne Aquifer, why does it say
21	"Memphis Aquifer" on this chart?
22	A. Well, there's different naming conventions, which I know
23	we've talked a lot about here. In my area, in Shelby County,
24	when we talk about the geology, we call it the Memphis. If we
25	talk about the water side of it, we call it the Middle Aquifer.

1	815 If I was giving a public talk in Mississippi, down in
2	Mississippi, I would call it Sparta, because it's what they
3	call it.
4	Then that's where the equivalents come in, because
5	when these units cross state lines, the names may change, just
б	by how people have named them.
7	Q. Do these various naming conventions, that we spent so much
8	time talking about this week, affect any of your opinions that
9	you're going to give in this case?
10	A. No, sir, they do not.
11	Q. Why don't the naming conventions matter, in your view?
12	A. Because they're just various names given to pieces or
13	subunits of the Middle Claiborne Aquifer, and the Middle
14	Claiborne Aquifer crosses multiple state boundaries.
15	Q. Now, you anticipated my next question, Dr. Waldron.
16	A. Sorry.
17	Q. Judging from this map, does the Middle Claiborne Aquifer
18	cross state lines?
19	A. Yes, sir, it does.
20	Q. Which ones I'm sorry.
21	Which ones does it cross?
22	A. If you go northwest to southeast, it's Arkansas, Tennessee,
23	and Mississippi.
24	Q. Now, are those the only state boundaries that the Middle
25	Claiborne Aquifer crosses?

1	816
Ţ	A. NO. IL CLOSSES MOLE.
2	Q. Why are those other ones depicted here?
3	A. Well, again, back to Figure 2, I believe that cross-section
4	is only across a certain section of the Mississippi Embayment.
5	Depending upon where that cross-section is taken, you'll see
б	the other states come into play.
7	Q. Now, we've heard a lot this week about confined and
8	unconfined parts of the aquifer. Do you agree that the Middle
9	Claiborne has both confined and unconfined parts?
10	A. Yes, I do.
11	Q. And can you identify the unconfined part of the Middle
12	Claiborne Aquifer on this map?
13	A. Well, it just showed up, is what I recall it. It's the
14	yellow outlined area. So on the Tennessee/Mississippi side,
15	that is where the blue kind of reexposes itself to the surface.
16	Q. So where I put those vertical blue lines, is that roughly
17	describing the area of this aquifer that you would call
18	unconfined?
19	A. Yes.
20	Q. And just so the record is clear, what is your understanding
21	of an unconfined aquifer?
22	A. An unconfined aquifer is when you put a well into that
23	aquifer, the static water level will rise up in that well to
24	the water table. It's not in
25	Q. What about a confined so the part of the aquifer on the

	817
1	left of this diagram what is a confined part of an aquifer?
2	A. So a confined part is when you put a well into the aquifer,
3	that static water level will rise up to be above the base of
4	that upper confining layer, so it's under pressure.
5	Q. Dr. Waldron, is there any geologic barrier inhibiting the
6	flow of water between the confined and the unconfined parts of
7	the Middle Claiborne Aquifer?
8	A. No, sir, there's not.
9	Q. Is there any such hydrological barrier that would impede
10	water in that way?
11	A. No, sir, there's not.
12	Q. Do you consider the confined and the unconfined parts of
13	the Middle Claiborne Aquifer to be part of the same
14	hydrogeologic unit?
15	A. Yes, I do.
16	Q. Why do you say that?
17	A. Because you start with the Middle Claiborne Aquifer, and
18	confinement and unconfinement is just a condition of the system
19	itself.
20	Q. Let's very briefly finish the rest of the layers on this
21	cross-section. I have now highlighted in pink the next layer
22	down. Can you identify what I've highlighted?
23	A. Yes, sir. This is a confining unit that forms the base of
24	the Middle Claiborne Aquifer and the top of the Fort Pillow
25	Aquifer. In my area, that's called the Flour Island.

	818
1	Q. I want to now highlight the Fort Pillow Aquifer in blue.
2	Can you describe to Judge Siler what that is?
3	A. This is a lower aquifer. It's comprised mainly of sand,
4	and it is below the as you can see, the Middle Claiborne
5	Aquifer.
6	Q. And does the Fort Pillow Aquifer cross state lines,
7	according to this map?
8	A. It does.
9	Q. Which states does it cross?
10	A. Arkansas and Tennessee and Mississippi.
11	Q. Let's move down to the next layer on this cross-section,
12	which I've highlighted in pink. What is this?
13	A. This is a substantial confining unit. It's comprised
14	mostly of clay, and forms the base of the Fort Pillow and the
15	top of the McNairy aquifer.
16	Q. Finally I want to talk about the McNairy Aquifer, which
17	you've mentioned, and I've highlighted it in blue.
18	Can you describe to Judge Siler what that aquifer is.
19	A. Yes. It's a deeper aquifer system within the Mississippi
20	Embayment. And it in certain places it's saline, it's so
21	deep. But on here, on the outcrop areas, or further north,
22	you're probably going to start seeing it have fresh water.
23	Q. Does the McNairy Aquifer that I've highlighted cross state
24	lines on this chart?
25	A. Yes, sir, it does.

1	Q. Which ones does it cross?
2	A. Arkansas, Tennessee, and Mississippi.
3	Q. Dr. Waldron, I'd now like to turn to another exhibit which
4	we've heard a lot about this week, Joint Exhibit 4.
5	Do you recognize this document?
6	A. Yes, I do.
7	Q. What is it?
8	A. This is a USGS publication. It's by Arthur & Taylor, in
9	1998, and it's of the RASA study, the Regional Aquifer System
10	Analysis.
11	Q. And I'm going to ask you to turn to Plate 2, which I'm
12	going to highlight on the screen. And I know we've looked at
13	this an awful lot, including today, so I'm just going to ask
14	you some very brief questions about it.
15	A. Okay.
16	Q. Do you recognize this Plate 2?
17	A. Yes, sir, I do.
18	Q. And what is this?
19	A. This is a cross-section showing the various hydrogeologic
20	layers within the Mississippi Embayment.
21	Q. And where was this cross-section taken?
22	A. Well, this is a north/south cross-section, and it's in
23	in Plate 1.
24	Q. All right. Let's turn to Plate 1, and I'm going to expand
25	it on the screen here.

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1	Can you use this plate to help orient Judge Siler
2	about where our cross-section in Plate 2 was taken?
3	A. Yes, sir. On this you'll see "A," down at the bottom, and
4	that's at the Mississippi/Louisiana state line. So that's
5	going to be on the left of our cross-section.
б	And then if you follow it up to the north, into
7	Kentucky, you'll see an A prime, and that's going to be the
8	right side of our cross-section.
9	Q. So as we move to the right on our cross-section, we're
10	going to be heading north to northeast; is that right?
11	A. Yes.
12	Q. Okay. Let's go back to the cross-section, and I'm going to
13	put it back up on the screen here.
14	Dr. Waldron, is the Middle Claiborne Aquifer depicted
15	on this figure?
16	A. Yes, it is.
17	Q. I'm going to try and highlight it in yellow. And I know
18	everyone has seen this before.
19	Do you think that I've accurately highlighted the
20	Middle Claiborne Aquifer?
21	A. Yes, sir.
22	Q. Does the Middle Claiborne Aquifer cross state boundaries on
23	this diagram?
24	A. Yes, sir.
25	Q. Which ones does it cross, according to this particular

	821
1	cross-section?
2	A. Mississippi, Tennessee, and Kentucky.
3	Q. Now, did you hear Mr. Larson testify earlier about how the
4	Middle Claiborne Aquifer forms a type of a fork shape on this
5	cross-section, with the handle on the right and the prongs
6	sticking out to the left?
7	A. Yes, I did.
8	Q. Do you consider that entire fork shape to be part of the
9	Middle Claiborne Aquifer?
10	A. Yes, I do.
11	Q. Now I'd like to highlight in pink the Lower Claiborne
12	Confining Unit, which we've heard so much about this week.
13	Have I accurately highlighted that confining unit in
14	pink?
15	A. Yes, sir, you have.
16	Q. Can you explain what you understand the Lower Claiborne
17	Confining Unit to be?
18	A. Yes. It's a confining unit, and to the as you move to
19	the south, it is a marine clay. And it becomes more
20	substantive. It's much broader when you get into Southern
21	Mississippi and Southern Alabama and Louisiana. But as you go
22	north, you'll see that little squiggly, I guess you could call
23	it, where it terminates within the middle of the Middle
24	Claiborne Aquifer. We've been terming that in the case here as
25	a facies change. And that's where it transitions from a marine

1	clay to a sand.
2	Q. And roughly how far south, in your opinion, does the facies
3	change occur south of the Mississippi/Tennessee border?
4	A. Based on different USGS publications, they show it between
5	six and ten miles.
6	Q. And let's focus, Dr. Waldron, on the area above the Lower
7	Claiborne Confining Unit. So this is the on the left part
8	of the fork, this is the top prong. Do you see that?
9	A. Yes, I do.
10	Q. Is there a common name that you've heard used to describe
11	this portion of the Middle Claiborne Aquifer?
12	A. Yes. In Mississippi, we call that the Sparta.
13	Q. Do you consider what you just termed the Sparta to be part
14	of the same aquifer as the Middle Claiborne Aquifer?
15	A. Yes, sir, I do.
16	Q. Do you consider them part of the same hydrogeological unit?
17	A. Yes, I do.
18	Q. And why is that?
19	A. Because there's no impeding barrier between the at the
20	facies change between what you see on the right versus what you
21	see on the left, to reach stop flow between those two
22	sections.
23	Q. So if I were to take water that was in what we could call
24	the Sparta, which is the top prong of the fork
25	A. Right.

	823
1	Q is there any barrier that would prevent that water from
2	flowing naturally north into the part of the Middle Claiborne
3	Aquifer in Tennessee?
4	A. No.
5	Q. Okay. Let's now talk about the bottom prong of the fork,
6	which is beneath the Lower Claiborne Confining Unit. Do you
7	see that?
8	A. Yes, sir, I do.
9	Q. And I know we've again talked an awful lot about this this
10	week. Can you identify what that prong of the fork is?
11	A. That is a part of the Middle Claiborne Aquifer. It's given
12	a different name in Mississippi; they'll call it the Meridian
13	Sand. But it's part of the Middle Claiborne Aquifer.
14	Q. And we've have you heard the term "Lower Claiborne
15	Aquifer" used this week?
16	A. Yes, sir, I have.
17	Q. Have you also heard that term as one name for this bottom
18	prong of the fork?
19	A. Yes, sir, I have.
20	Q. Do you consider the Meridian Sand or the Lower Claiborne
21	Aquifer to be part of the same hydrogeological unit as the
22	Middle Claiborne Aquifer?
23	A. Yes, sir, I do.
24	Q. Why is that?
25	A. Well, just like at the top, if you go to where the little

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1	squiggly is on the pink, where the facies change is, there's no
2	barrier that's going to keep flow from going north or south at
3	that location. They're connected.
4	Q. So, Dr. Waldron, if we were to focus just on what
5	Mississippi has called the Lower Claiborne Aquifer this week,
б	is there anything stopping water from flowing naturally either
7	from the Lower Claiborne Aquifer to Tennessee, or vice versa?
8	A. No, sir, there's not.
9	Q. Stepping back a bit, Dr. Waldron, how do you determine, as
10	a scientist, the lateral extent of a given aquifer?
11	A. Well, a geologist will drill a borehole. And from the
12	material that they pull from the borehole, they will use that
13	information in order to describe or correlate you know,
14	maybe by deposition, maybe by sedimentation, maybe by grain
15	size, maybe by fossil record or some other type of biological
16	flora this correlation of geologic units. That's my
17	understanding of it.
18	Q. And applying those principles to the Middle Claiborne
19	Aquifer, how many states do you believe fall within the Middle
20	Claiborne Aquifer's lateral extent?
21	A. It underlies portions of eight states.
22	Q. Now, Dr. Waldron, are you saying that the Middle Claiborne
23	Aquifer is identical in every part of it underneath those eight
24	states?
25	A. No, I'm not.

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Q. What sorts of variations might there be as you move from
one part of the aquifer to another?
A. Well, a lot of it's been discussed here, but I'll
reiterate: You'll have differences in thickness. You'll have
differences in hydraulic conductivity. You will have
variations in storage. And you will even have variations in
porosity.
Q. Do those variations affect your conclusion that the Middle
Claiborne Aquifer is an eight-state hydrogeological unit?
A. No, it does not.
Q. Why do those variations, that we've heard so very much
about this week, not affect your conclusion?
A. Because for geologic units, heterogeneity is not uncommon.
It's more the norm than the rarity.
Q. So if you were, as a hydrogeologist, looking at a regional
aquifer like the Middle Claiborne Aquifer, would you expect
there to be the type of heterogeneity that we've discussed in
this hearing this week?
A. Yes, sir, I would.
Q. Do any of the hydrological variations that we've discussed
in the hearing this week in the Middle Claiborne Aquifer align
with political boundaries?
A. No, sir.
Q. Do state boundaries have any effect on the hydrological
properties of the Middle Claiborne Aquifer?

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1	A. No, sir, they do not.
2	Q. Is there any physical barrier in the Middle Claiborne
3	Aquifer, Dr. Waldron, that would inhibit the flow of water
4	between the part of the aquifer in Mississippi and the part of
5	the aquifer in Tennessee?
б	A. No.
7	Q. Is there any such hydrological barrier?
8	A. No, sir, there's not.
9	Q. Dr. Waldron, did you hear Mr. Larson explain yesterday and
10	today that pumping on Tennessee's side of the border in the
11	Middle Claiborne Aquifer can affect groundwater flow on
12	Mississippi's side of that same aquifer?
13	A. Yes, I did.
14	Q. Did you agree with him on that?
15	A. Yes, I do.
16	Q. What about the converse: Do you agree with Mr. Larson that
17	pumping on Mississippi's side of the Middle Claiborne Aquifer
18	can affect groundwater flow on Tennessee's side of that same
19	aquifer?
20	A. Yes.
21	Q. Now, Dr. Waldron, let's change gears a bit. Have you held
22	an opinion in this case about whether the Middle Claiborne
23	Aquifer is an interstate aquifer?
24	A. Yes, I have.
25	Q. What is that opinion?

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1	A. My opinion is that the Middle Claiborne Aquifer is an
2	interstate aquifer.
3	Q. Why do you say that?
4	A. Because as an aquifer, its geology crosses state lines, and
5	the water within it naturally moves across those state lines.
6	Q. Now, Dr. Waldron, is the term "interstate" a word that you
7	often hear hydrologists use to describe aquifers?
8	A. No, it's not.
9	Q. In your experience as a hydrologist, is there another word
10	that you've relied on in coming up with your opinions on this
11	case?
12	A. I've heard more so the term "transboundary."
13	Q. And in your experience as a trained hydrologist, what is a
14	transboundary aquifer?
15	A. Very simply, it is an aquifer or aquifer systems that cross
16	a political boundary.
17	Q. And under the ordinary hydrological definition of a
18	transboundary aquifer, do you consider the Middle Claiborne
19	Aquifer to be transboundary with respect to the state border
20	between Mississippi and Tennessee?
21	MR. MOFFETT: Your Honor, I object to that. Leading,
22	and also I don't believe that was phrased as a hydrogeological
23	definition. So I believe he's misstated what Dr. Waldron said
24	about transboundary aquifers.
25	THE COURT: Well, objection overruled. He may answer
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1	the question.
2	Q. Dr. Waldron, if I may clarify, in your understanding, is
3	the term "transboundary aquifer" a hydrological principle that
4	you're familiar with?
5	A. Yes, it is.
б	Q. Is it a hydrogeological principle as well?
7	A. Yes, it is.
8	Q. In applying that principle to Middle Claiborne Aquifer,
9	would you consider the Middle Claiborne Aquifer to be
10	transboundary with respect to the Mississippi and Tennessee
11	state line?
12	A. Yes, sir, I do.
13	Q. Now, does it matter to you, Dr. Waldron, for purposes of
14	whether the Middle Claiborne Aquifer is interstate or not, how
15	much water is flowing across the state line?
16	A. No, sir, it does not.
17	Q. Why does that not matter to you?
18	A. Because if you go and stand at the state line, right then
19	and there, water is moving across. It's just the fact that it
20	actually moves across state line makes it an interstate
21	aquifer.
22	Q. Dr. Waldron, have you tried, for purposes of your opinion,
23	to separate out any particular groundwater molecule within the
24	Middle Claiborne Aquifer to determine whether that particular
25	piece of groundwater is interstate or not?

1	A. No. No, I do not.
2	Q. And why did you not try and do that in offering your
3	opinions in this case?
4	A. Well, in my world, I don't deal with the molecules. I know
5	we've mentioned that word here, but as groundwater scientists,
б	we don't look at molecules. That's because at the molecular
7	level, it's not observable, and you can't you can't map it.
8	So what we as scientists do is we scale up. We go
9	from the molecular scale and move it up to the particle scale,
10	which is the microscopic scale. So then you've got a water
11	particle.
12	Well, so you could look at groundwater flow at the
13	particle scale; but if you wanted to do that, you have to use
14	fluid dynamics. And in order to do that, you have to know how
15	the water is moving between the sand grains. Well, that means
16	you have to map every sand grain and every opening.
17	We're not going to do that, so we scale up. So then
18	we scale up to the MATRAS scale, where we look at a block of
19	porous media. And it's the law of averages. That's what we
20	do. That's how Darcy's Law is driven. Darcy's Law is driven
21	on a law of averages, and therefore we look at groundwater that
22	way.
23	Q. So, Dr. Waldron, in evaluating the question that you
24	understand Judge Siler to have posed for this hearing, as a
25	hydrogeological matter, what unit have you focused on?

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1	A. I had focused on the Middle Claiborne.
2	Q. Why do you believe that that is the unit that we should be
3	focused on, rather than any particular piece of water?
4	A. Well, because that's what was in Judge Siler's opinion.
5	Q. But leaving aside Judge Siler's opinion for a second, just
6	as a hydrological matter, why, as a scientist, have you thought
7	that it's most appropriate to focus on the entire aquifer as
8	opposed to any one particular piece of water?
9	A. Well, because you treat it all as one just one giant
10	unit. You don't partition out a piece of the aquifer and say,
11	"I'm going to look at you in isolation."
12	And that's because if you went and zoomed in to a
13	piece of water, the aquifer is acting against that water. So
14	it daisy-chains out. Water's acting against that; water's
15	acting against that. Pretty soon you're at the regional scale.
16	This is a daisy-chain reaction, so you look at the
17	system as a whole.
18	Q. Dr. Waldron, you've also heard quite a lot from Mississippi
19	this week about the rate of speed with which groundwater flows
20	in the Middle Claiborne Aquifer. Have you heard all that
21	testimony?
22	A. Yes, sir, I have.
23	Q. Do you consider the rate of speed of groundwater flow
24	relevant to your opinion that this is an interstate aquifer?
25	A. No.

1	831 Q. And why do you not consider the rate of speed relevant to
2	your opinion?
3	A. Because the rate of speed is slow. It's slow everywhere in
4	the groundwater system where we are. And you treat that, you
5	treat it as a constant not a constant, but you treat it
6	as it's very similar, and it's so slow, you could move to,
7	again, the state line; groundwater is moving slowly across the
8	state line. And at the exact same time, water is slowly moving
9	in from the outcrop area. And it's just moving everywhere it's
10	moving, but it's all slow.
11	So, yeah.
12	Q. Are you familiar, Dr. Waldron, with the concept of
13	residence time that you've heard discussed this week?
14	A. Yes, sir.
15	Q. And does that have any bearing on your opinion that the
16	Middle Claiborne Aquifer is an interstate aquifer?
17	A. No, sir.
18	Q. And why does residence time not have any bearing on your
19	opinion?
20	A. Because at any point in time, water is moving across the
21	political boundaries, so it's irrelevant.
22	Q. Dr. Waldron, I'd like to change gears a bit now and ask
23	you, do you agree with the statement that's been made in court
24	this week that pumping in the Memphis area out of the Middle
25	Claiborne Aquifer began in 1886?

	022
1	A. Yes, sir, I did.
2	Q. So when I use the term "predevelopment" in my questions,
3	will you understand me to be referring to the time period
4	before 1886?
5	A. Yes, sir, I will.
6	Q. Have you ever studied predevelopment groundwater flow in
7	the Middle Claiborne Aquifer?
8	A. Yes, sir, I have.
9	Q. Have you published your findings anywhere?
10	A. Yes, I have.
11	Q. Dr. Waldron, I'd like to turn in your binder to Defense
12	Exhibit 174. And I put the cover page up on the screen for
13	ease of reference.
14	Is this the study that you were just referencing?
15	A. Yes, sir, it is.
16	Q. When was this published?
17	A. February of 2015.
18	Q. And where was this published?
19	A. The Journal of American Water Resources Association.
20	Q. Is that a peer-reviewed journal, Dr. Waldron?
21	A. Yes, it is.
22	Q. Did your article go through the peer-review process before
23	it was published?
24	A. Yes, it did.
25	Q. At a very high level, Dr. Waldron, what was the purpose of

	Q22
1	this article that you published?
2	A. One purpose, and that was to develop predevelopment
3	condition of the Middle Claiborne Aquifer in the Tri-State Area
4	of Tennessee, Mississippi, and Arkansas.
5	Q. How did you first come up with the idea to try and create a
б	predevelopment map of the Middle Claiborne Aquifer in the
7	region you just described?
8	A. Well, one, I work in the area, so it's a very interesting
9	topic to me, so I have a passion for it. And I was reading
10	some USGS publications, and they would reference you know,
11	publications reference publications, so they referenced an
12	older one. So I'm like, "Oh, that's kind of cool."
13	So I went and read that one. I read those. And then
14	they would reference older publications, and pretty soon I was
15	drilling down for these older publications as I read them, and
16	eventually come across these three very old USGS publications,
17	1903 or '4, or 1906, that right around 1886, which is
18	predevelopment, by the USGS. So
19	Q. And when did you kind of have that realization, that you
20	found these old USGS publications that you thought would enable
21	you to create a predevelopment map of the aquifer?
22	A. It was around late 2006, early 2007.
23	Q. And so when you had this realization, Dr. Waldron, did you
24	have any idea in your mind about what you wanted the results to
25	look like?

1	834 A. No. Uh-uh.
2	Q. Did you have any expectation about what the ultimate
3	contour lines you would draw might show?
4	A. No, I did not.
5	Q. Who funded this particular study that's in Defendant's
б	Exhibit 174?
7	A. The University of Memphis.
8	Q. Did you receive any funding for this study from MLGW?
9	A. No, I did not.
10	Q. Did you receive any funding from the University of Memphis?
11	I'm sorry
12	A. Yes.
13	Q. That was a bad question, Dr. Waldron. Did you receive any
14	funding from the City of Memphis, is what I meant to ask.
15	A. No, I did not.
16	Q. Did anyone at MLGW or Memphis give you any input into your
17	research as you were conducting it?
18	A. No, sir, they did not.
19	Q. What about Tennessee: Did any lawyers for the State of
20	Tennessee give you any input into this research as you were
21	conducting it?
22	A. No, sir.
23	Q. I'd like to turn to Figure 4 of this article, which is on
24	page 17 of the exhibit. I'm going to highlight it on the
25	screen here and blow it up.

1	835 For the record, for this demonstrative, the only thing
2	I've changed is I've darkened in the Mississippi/Tennessee
3	state boundary in black.
4	Do you see that, Dr. Waldron?
5	A. Yes, I do.
б	Q. Other than that change, is this Figure 4 that I've put up
7	on the screen, is that the predevelopment water level map that
8	you generated as a result of your research?
9	A. Yes, sir, it is.
10	MR. BRANSON: Judge Siler, I have about 30 to
11	40 minutes of questions on this that I'm about to transition
12	into. I notice that it's noon, so I wanted to ask how you'd
13	like to proceed.
14	THE COURT: Well, we'll call it a recess noon
15	recess. We'll have court be in recess until 1:15.
16	MR. BRANSON: Thank you, Judge Siler.
17	(Luncheon adjournment.)
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Proceedings - May 23, 2019 836 1 AFTERNOON SESSION 2 1:20 P.M. THE COURT: 3 All right. You may proceed. 4 MR. BRANSON: Thank you, Judge Siler. BY MR. BRANSON: 5 6 0. Welcome back, Dr. Waldron. 7 Α. Thank you very much. Can we get the slide back up on the screen, please. 8 0. 9 Dr. Waldron, before the break, do you recall that we 10 were discussing Figure 4 from your 2015 research paper? 11 A. Yes, I do. 12 Q. And just so the record is clear, again, this is D174 at 13 exhibit page 17. 14 Dr. Waldron, I want to talk about what this map shows. But before we do that, I want to walk Judge Siler through how 15 16 you made it. So let's start at the beginning. 17 When you're -- generally speaking, when you're trying 18 to draw a predevelopment water map like this, what types of data do you need to get? 19 20 A. Well, first you need depth of water. And then you need 21 ground surface elevations. Once you have that, you need to 2.2 actually locate the point, and then you need to make sure it's 23 in the correct aquifer. 24 Q. When you say "the point," Dr. Waldron, just so we know what 25 we're talking about as we move forward, where are the points on

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1	this map that we have up on the screen?
2	A. The points are the red dots.
3	Q. So let's take the things that you said, and let's take them
4	in order. First you said "depth to water." Can you explain to
5	Judge Siler what that is in layman's terms?
б	A. Yes. It's the measurement from ground surface or a
7	measurement point on the well down to where you get to the
8	water elevation.
9	Q. So how did you get the depth to water measurements that you
10	used to create this predevelopment map of the Middle Claiborne?
11	A. Well, as I mentioned before, there's really old USGS
12	documents, back into the early 1900s, 1904 or '6, somewhere in
13	there. And these documents listed hundreds of wells and their
14	water levels, and it was within those USGS publications that I
15	extracted out depth of waters.
16	Q. I'd like to identify those for the record. Could you turn,
17	Dr. Waldron, in your binder to Joint Exhibit 21, J21.
18	A. Yes.
19	Q. Have you found it?
20	A. Yes, sir.
21	Q. Can you identify that document for the record.
22	A. Yes, sir. It's a USGS publication. It's called the
23	Underground Water Resources of Mississippi. It's by
24	Criner & Johnson, and was published in 1906.
25	Q. Was this one of the three USGS publications that you relied

1	on to get your depth to water measurements from?	838
2	A. Yes, it is.	
3	Q. Dr. Waldron, could you turn to Joint Exhibit 30 in your	
4	binder.	
5	Are you there?	
6	A. Yes, sir.	
7	Q. And could you identify that document for the record.	
8	A. This is a USGS publication. It's the hydrology of the	
9	Eastern United States. And it's by Fuller, and it was	
10	published in 1904.	
11	Q. And was this also one of the three USGS publications you	
12	used to get your depth to water measurements from?	
13	A. Yes, it is.	
14	Q. Finally, Dr. Waldron, could you turn to Joint Exhibit 31.	
15	I think it's in your other binder.	
16	A. Yes, sir. I see it.	
17	Q. And could you identify that document for the record.	
18	A. This is another USGS publication. It's the "Underground	
19	waters of Tennessee and Kentucky west of Tennessee River and	of
20	an adjacent area in Illinois." It's by Glenn, and was	
21	published in 1906.	
22	Q. And was this the third of the three old USGS publications	
23	that you mentioned you used to get your depth to water	
24	measurements from?	
25	A. Yes, sir.	

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1	Q. How many total depth to water measurements did you glean
2	from those three USGS reports that we just identified?
3	A. About 77 of them.
4	Q. And how many of those 77 readings that you got did you end
5	up investigating any further?
6	A. Just 31 of them.
7	Q. So what happened to the other 46?
8	A. They were outside the area of interest. They were
9	extending further up into Tennessee or Arkansas or Mississippi,
10	outside of the area of interest that I was looking at.
11	Q. And what time periods were the depth to water readings that
12	you used taken from?
13	A. Well, they started in predevelopment, so that was 1886.
14	And they went so far as 1906.
15	Q. So, Dr. Waldron, you have your 31 depth to water readings
16	that you decided you wanted to use to build this predevelopment
17	map, and I believe one of the other things you mentioned was
18	figuring out their location. So how did you go about doing
19	that?
20	A. Well, that was a pretty long process. I had to get
21	their in the books, they'll list it by state and then county
22	and then city. And then there's some other information
23	sometimes provided, and I would use that information to try to
24	better locate where these wells were located.
25	Q. And how many counties were these 31 wells that you were

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1	investigated located in?
2	A. Nine of them.
3	Q. So how did you go about figuring out where these wells were
4	located in those nine different counties?
5	A. That took a while. I had to go visit each county, the
б	county seats, in order to do that.
7	Q. So you personally went to the county seat for these various
8	counties that these wells were in?
9	A. Each one, or the library, or the engineering departments,
10	or the utility department.
11	Q. And what did you do in those counties to help figure out
12	where these very old wells had been located?
13	A. Well, so it kind of varies, based on you know, which
14	where you are. When you look at these publications, they will
15	list, you know, the state; then they'll list the county; then
16	they'll list the city. And then they'll list information like
17	depth; the depth of the well, depth of the water, maybe ground
18	surface elevation.
19	But there's also tables. And those tables will list
20	information about the owner. They'll list information about
21	the use of the well, the use of the water, how they got it out,
22	maybe its quality; things like that.
23	And what I would do is I would, let's say, go to
24	Fayette County, and I'd have pieces of information from this
25	book, and it may list a person's name. So I would go to the

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1	county seat, and I would pull up the census record or at the
2	library, sometimes they had really old maps, like 1850s and
3	'70s. And on those maps, they would draw the properties. And
4	they would write the people's names on them. So I'd try to
5	find the person's name on the property, and I would be like
6	"Ah, that's where you are."
7	Other times that didn't exist, so I had to use the
8	census. And back then there was a 1900 census and a 1910
9	census. And in those it would list the person, so I'd find
10	I'd correlate the name in the census to what's in the USGS
11	publication, and I would look up the address.
12	And sometimes, as I said, in the USGS publication,
13	they would give you what it was used for, like lumber. So
14	maybe the owner may look like "Oh, they worked at the
15	lumber," and that matched up, so I would locate it that way.
16	Other times they were rail stops. So I would get
17	these really old railroad maps, and they would go through these
18	towns, and then I would be able to find old maps of the county
19	where they showed the original town, and you could see a
20	railroad spur come off. You know, back then there was steam
21	locomotives, so that's where they needed water. So I would put
22	it right there on that spur.
23	Other times, like in Arkansas, there was a there's
24	a well, so on the map. There's on the left-hand side,
25	there's actually a point that's not shown, it's a for a

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1	city. And that I went to the utility and asked about the
2	well, and they said, well they believed it was in the old
3	building, the building was really there, they didn't know where
4	it was. But walking down the hall they had a blueprint of the
5	old structure, the old building.
6	So I took a picture of it and went out, found the old
7	building, worked my way down to the basement, where it showed
8	on the blueprint where it was, and sure enough, there's the
9	room, and there's a big concrete pad and you know, concrete
10	hole.
11	So I that, to me, was a well. And at least it was
12	what was on the figure. And, you know, like Number 2, down on
13	the southeast corner of the map
14	Q. Southwest?
15	A. Southwest corner of the map. That's Helena. So the
16	engineering department that place still existed. So I went
17	to the engineering firm; they told me where that was.
18	Downtown Memphis, that was where the first well was.
19	So when we all say 1886, that's where it happened. That was
20	R.C. Graves. And he owned an ice company, the Bohlen-Huse Ice
21	Company. And he decided to drill a well. And he drilled one
22	and hit the Memphis or we call it the Memphis Aquifer; in
23	this case, it's the Middle Claiborne.
24	The water was under so much pressure it flowed to the
25	surface, and on the ground for days. And Memphis has changed a

	843
1	lot since then, from what I have now to what it was then. So I
2	actually found that one on an old Sanborn map, the old fire
3	insurance maps that exist. Sure enough, found the Bohlen-Huse
4	Ice Company, and then had the rooms, and then it had the well
5	room, and then it had the well. So I was able to pinpoint it
6	that way.
7	There was another one in Shelby County called Kirby.
8	And in fact there was actually a road in Memphis called Kirby,
9	and I have friends that live off of it. And I went and visited
10	the farm. So Mrs. Kirby answered the phone or the door, and
11	she walked me to the field and pointed to the well. It's not
12	used anymore, but she pointed to it.
13	You know, it was stories like that, I guess, you know,
14	Number 13, in Fayette County, I had an idea where it was, just
15	between two points, which means you have two choices. I didn't
16	really know where it could be, so I was talking to some folks
17	in town, and when I was walking out of the store, the
18	convenience store, this lady, older lady was sitting on the
19	bench. She goes, "Hey, I overheard you. My mom, she was
20	friends with this girl, and that girl's mom owned that
21	mercantile store."
22	I'm like, "Oh, my gosh." I'm like, "Where is it?"
23	So she told me. And I had two choices, and sure
24	enough, went out there and that was the one on the circle.
25	It's a concentric circle issue.

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1	So it was a it was a long process of going to each
2	one of these and trying to find them, but it was it was
3	enjoyable.
4	Q. Dr. Waldron, how long did this process of manually going
5	out to all of these locations and investigating where the well
б	was, how long did that take you?
7	A. It was probably about a year.
8	Q. And can you estimate for Judge Siler how many hours you put
9	into this?
10	A. Into this thing, the whole thing, probably about
11	2,000 hours.
12	Q. And using this process of going out to these county seats,
13	you estimated the location of the 31 depth to water readings
14	that you'd taken?
15	A. Yes, I did.
16	Q. Okay. So you've got your depth of water readings from the
17	USGS; you've got your estimated locations. What's the next
18	thing that you do?
19	A. Well, I need all the water levels are kind of apples to
20	oranges; they're just up with water. So depending upon what
21	elevation you're at, you know, you've got a different
22	elevation. So to put them all in the same playing field, I had
23	to get ground surface elevations. And that is what we use for
24	mean sea level.
25	Q. And how did you go about estimating the ground surface

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1	elevation at the 31 points that you were using?
2	A. Well, when I when I was locating the points, I had a
3	feel for how accurate that was going to be. You know, I went
4	into Arkansas, and I found actual rooms where the well was
5	oops, sorry where the room was; that was pretty accurate.
6	Other times I wasn't quite sure, so I would draw a
7	circle around the town it was smaller then, but around the
8	town. So that kind of gave me a radius of confidence.
9	So when I went to get elevations, I got them different
10	ways. The first, most accurate, was surveying. So I found the
11	well in Arkansas. So I went to the post office, and they have
12	a benchmark sitting out on one of the steps, and that's a
13	survey benchmark. And I ran a transit from there to the
14	building and down to where the well was in the basement.
15	Q. And Dr. Waldron, you did this personally; you personally
16	set up the equipment to survey the ground surface?
17	A. Yeah. Yes. Uh-uh, yes.
18	Q. What else did you do?
19	A. Well, I did that also, too. Then huh? Oh.
20	Q. Keep going.
21	A. Sorry.
22	At number 29, which was downtown Memphis, Memphis had
23	changed a lot. We had a lot of bayous in Memphis, so we the
24	City put them in brick tunnels and paved over them, so the land
25	surface was changing in downtown Memphis, as there was some

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1	fill going on, so I knew I couldn't use current elevations.
2	So I obtained a quadrangle from the US Army Corps of
3	Engineers. It was 1935, and that was as far back as I could
4	get on elevations. I believe that that map was probably
5	probably created after the historic floods on the Mississippi
б	River of 1927 and 1933. And that had five-foot quadrangles,
7	which is very good, so that's what I used for that one.
8	The other type of elevation was LIDAR, which is like
9	nowadays, using lasers from airplanes to get. And granted,
10	that's elevations now, so we're looking at Shelby County in the
11	red.
12	And the places that are there are haven't changed.
13	Like Number 25 is fire house that's down in Collierville. And
14	I went of course I live real close; I'm in Shelby County.
15	So I drove to Collierville, and there was a firehouse, and it
16	was right in the town square, and it's still there. So I was
17	pretty good with those elevations.
18	So everything else, all the other points remember I
19	had that little radius of comfort of accuracy about these
20	points?
21	Q. Right.
22	A. What I did is I got the USGS National Elevation Dataset.
23	And those are ten-meter cells of that elevation all across the
24	United States. And what I did is I took that that buffer of
25	what I felt was accuracy, the spatial accuracy, and took all

	9/7
1	the elevations in that buffer. I didn't just pick one right
2	where the well is; I took all of them.
3	Sometimes there would be 200 elevations; sometimes it
4	was over 2,000 elevations. And I would average them together,
5	and I would use the average, but I kept the standard deviation,
6	which is that spread of the values about that average.
7	And that's the various ways I got elevations.
8	Q. So we have three things. We've got depth of water; we've
9	got your estimated location; and now you've got the ground
10	surface elevation. How do you get from those three things to a
11	map like this?
12	A. Well, before you plot it, you've got to make sure you're in
13	the right aquifer. So I had to do that check first.
14	Q. And what describe for Judge Siler why might you not have
15	been in the right aquifer with these depth of water readings?
16	What other aquifers might have been implicated?
17	A. Well, either the ones above or below it. I mean, you can
18	be in the shallow aquifer in Shelby County, the one that
19	blue one that was up above, on that cross-section; or you could
20	go too deep, and you could be in the Fort Pillow Aquifer.
21	Q. So how did you check to make sure that your water level
22	readings that you calculated were actually taken from the
23	Middle Claiborne Aquifer?
24	A. Well, there was a little bit of a process, too. CAESER has
25	probably the biggest geologic database in the area.

1	Q. Can you remind Judge Siler what CAESER is again?
2	A. That's the research center that I direct at the University
3	of Memphis. The Center it's a long name: Center for
4	Applied Earth Science and Engineering Research.
5	Q. So what did you do at CAESER to help check for whether you
6	were in the right aquifer?
7	A. Well, using that database, we have a lot of geophysical
8	logs. Those are probably the better of the types of logs. And
9	then we have geologist logs, and that's primarily well,
10	that's everywhere. Those came from the Phillips Coal Company.
11	And they drilled tens of thousands of boreholes all across the
12	Embayment, and those have the geologist's logs and geophysical.
13	And then all the drillers' logs.
14	In the USGS publications, there were instances where
15	they would describe what geology they would go through. And
16	then there were some ancillary factors, like the quality of
17	water. One even said like Number 4, in Mississippi, it said
18	that it that the water maxed out of the Memphis water.
19	And then also the it would be a high a lot of
20	flow rate in certain circumstances. That's indicative of the
21	Memphis Aquifer Middle Claiborne Aquifer.
22	Q. And so did this process lead you to eliminate any of your
23	31 water level measurements from your data set?
24	A. I did. I removed four of them.
25	Q. So if my math is correct, that left you with 27, right?

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2	Q. So you've got your 27 water levels that now have been
3	adjusted to mean sea level. What did you do with them to get
4	them on this map?
5	A. What I did is I plotted those points using GIS, the mapping
б	software, to place them on a map.
7	Q. And that's those little red dots that we see on this map?
8	A. Yes, sir, it is.
9	Q. And so with each one, I see a number above the dot, and
10	then a number in parentheses above that. Can you explain to
11	Judge Siler what that means for each dot.
12	A. Yes, sir. The number above, in the parentheses, that's the
13	number I gave to the well.
14	Q. That's just your your reference number, your
15	A. Yeah. It goes 1 to 27, so I wasn't real creative.
16	And then the number that's below that is the water
17	elevation in meters, mean sea level.
18	Q. So you plotted those all on this map, and then of course
19	the other thing I see are these blue lines. What are those?
20	A. Those are the contour lines, what we've been calling here
21	in the case "equipotential lines."
22	Q. How did you draw those?
23	A. Well, these I drew by hand.
24	Q. And why did you decide to draw them by hand, Dr. Waldron?
25	A. Well, because I'm mapping water levels in the Middle

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1	Claiborne Aquifer, and, you know, we mentioned two conditions
2	of the aquifer. One was it was confined and unconfined. And
3	the unconfined is that little brown piece on the right, that
4	hatched not hatched, but kind of shaded-in area; that's
5	where it's unconfined.
6	And water levels move differently in the unconfined
7	than they do confined, so I needed to draw them by hand in
8	order to honor that type of movement.
9	Q. Is there more than one scientifically accepted way of
10	drawing contour lines like this?
11	A. Yes. Yes, there are.
12	Q. What was another way, other than hand contouring?
13	A. You can use computer methods to do that.
14	Q. And when you were dealing with an aquifer that is partly
15	unconfined, would you consider it more common in the field of
16	groundwater hydrology to draw contours by hand, or using a
17	computer?
18	A. I would draw them by hand.
19	Q. Okay. Now we know how you drew these contour lines. Can
20	you explain to Judge Siler what that blue number by each blue
21	contour line means.
22	A. Yes. That's the water elevation in meters and mean sea
23	level. And for that line, that is the head, the water level
24	along that path.
25	Q. And now that we've got the contours, what do these contours

	851
1	tell you about predevelopment groundwater flow in the Middle
2	Claiborne Aquifer?
3	A. That the flow is naturally from Mississippi into Tennessee,
4	following a southeast-to-northwest direction.
5	Q. And I know we've heard this before, but can you just give
6	us a refresher on how groundwater flows in connection to an
7	equipotential line like we had on this map?
8	A. Yes. The groundwater will flow perpendicular to those
9	contours.
10	Q. So I'm going to add some green arrows to this map.
11	Do the green arrows that I've put on the screen
12	provide a rough approximation of how groundwater was flowing in
13	this area of the Middle Claiborne Aquifer under predevelopment
14	conditions?
15	A. Yes, it would yes.
16	Q. And as part of your paper, Dr. Waldron, did you compare the
17	predevelopment groundwater flow from Mississippi into Tennessee
18	that you've calculated as compared to more recent
19	postdevelopment estimates of the same thing?
20	A. Yes, I did.
21	Q. Where did you get your postdevelopment groundwater flow
22	figures from?
23	A. I used a USGS publication by Schrader, 2008.
24	Q. For the record, that is Joint Exhibit 71.
25	Why did you choose Schrader in 2008 for purposes of

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1	your comparison?
2	A. Different reasons. One, it was the latest water levels at
3	the time. And two, Schrader actually his water levels
4	crossed state lines; that was that issue that we had on the EPA
5	project that was recognized there was this disparity in
6	state lines. But his actually crossed the state lines, so that
7	was good.
8	And also he mapped contours or water levels in the
9	unconfined portion.
10	Q. So I'm going to go now to Figure 5 from your 2015 paper,
11	which again is D174. I'm going to blow up the figure on the
12	screen.
13	Is this the figure that contains the contours that
14	you've borrowed from Schrader in 2008?
15	A. Yes, it does.
16	Q. Why do these contours look different from the ones that you
17	drew for predevelopment in Figure 4?
18	A. Well, one, this is 2008, so pumping's been going on for
19	over 120 years. So it's it has shifted the contours
20	accordingly. You know.
21	Q. And what do the flow paths look like, according to these
22	contour lines that you've borrowed from Schrader in
23	postdevelopment?
24	A. This shows that the groundwater moves from Mississippi into
25	Tennessee in a southeast/northwest direction.

1	853 Q. Again, I'm going to add some green arrows to this figure.
2	Do those arrows provide a rough approximation of what
3	groundwater flow would look like according to the Schrader
4	contours?
5	A. Yes, sir.
6	Q. Now, Dr. Waldron, when you compared your estimated
7	predevelopment flow across the border to the postdevelopment
8	cross-border flow estimated by Schrader, what did you find?
9	A. I found that on average, the volume of water during
10	predevelopment, going from Mississippi into Tennessee, was
11	higher than it was in 2008.
12	Q. So you're saying did I understand you correctly that you
13	found that the volume of water flowing from Mississippi into
14	Tennessee has declined since predevelopment?
15	A. Based upon that average, yes.
16	Q. And but we all know, we've talked about it at length,
17	that MLGW is pumping out of the Middle Claiborne Aquifer. So
18	how does your comparison make any sense?
19	A. Well, I guess different reasons. One, you know, with the
20	natural flow of water from Mississippi into Tennessee being
21	from southeast to northwest, since that time, Mississippi has
22	put in wells in their municipalities right along the border.
23	So by doing so, they've put in their wells, they're
24	intercepting that flow that would have naturally gone into
25	Tennessee. So that's taking some of that.

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T	But, you know, MLGW the wells in Shelpy County, not
2	just MLGW, still need their water. So they're going to pull it
3	from somewhere else. So they're going to pull it from the
4	east, in Fayette County; they're going to pull it from Tipton
5	County, to the north; they're going to pull it's going to
6	pull water from Arkansas, to the west.
7	So that's part of it. Another part is leakage from
8	the shallow groundwater system above, down to the Middle
9	Claiborne. Back in 1886, when R.C. Graves put in that first
10	well, it was under so much pressure remember, I said it shot
11	up to the ground surface and flowed across the ground.
12	So the water was being was pushing up through these
13	units. Well, since over the last 120 years, that water
14	level has dropped. So the gradient has flipped. Now
15	shallow the shallow groundwater system is moving water
16	downward into the Middle Claiborne.
17	And it will go through the clay, but, you know, it's
18	like art class; you go real slow with your clay. However, the
19	USGS, and us at CAESER, have identified naturally occurring
20	breaches in that protective clay layer over the Middle
21	Claiborne Aquifer, and that's allowing water to infiltrate more
22	quickly through that clay layer. And that's providing
23	additional sources of water to the wells in Shelby County.
24	Q. Dr. Waldron, I'm going to put your predevelopment map back
25	up on the screen now.

	YAA YAA
1	Did you do an error analysis on your results?
2	A. Yes, I did.
3	Q. And what sort of error analysis did you perform?
4	A. Well, I looked at the spatial error: Did I get the point
5	in the right spot? And then also the elevation error.
6	Q. What was the purpose of doing those error analyses?
7	A. Well, you know, data has inherent error in it. And how
8	even the process I had, of course, has inherent error in it.
9	So I wanted to account for the error, the plus and minus of
10	that error, to know if that shifted the results at all.
11	Q. What did you find when you did the analysis?
12	A. The flow was still naturally occurring from Mississippi to
13	Tennessee, in a southeast/northwest direction.
14	Q. Were you surprised, when you ran the analysis, to find out
15	that the error in either direction didn't really change the
16	trajectory of the groundwater flow?
17	A. I didn't know what to expect when I did it, actually. I
18	just I didn't know what was going to happen.
19	Q. Did you have now that you've performed the error
20	analysis, does it make sense to you as to why the results
21	didn't change?
22	A. It does. I mean, especially from the spatial side, knowing
23	where the point is. This is when you look at this, it's
24	like very regional. So, you know, moving a point 1,000 feet on
25	something as large of a space as this is not going to impact

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856 it. 1 2 The bigger impact really was coming from the elevation 3 difference. And I wouldn't say it changed the results, but it 4 certainly had higher error numbers. 5 On the elevation, you know, what I did to get the errors, I used the worst possible. So remember when I 6 7 mentioned like LIDAR in that red -- in Shelby County, which is like lasers, things were great; I didn't have any information 8 on the accuracy of that. So that was an issue. 9 Elsewhere, where I had elevations from the USGS 10 11 elevation data set, it has inherent error of 2.4 meters, which 12 is about eight feet, something like that. So I could be off by eight feet, plus or minus. 13 So what I did is I took that error and applied it to 14 all the LIDAR points in Shelby County. Just said, "I don't 15 16 know what your error is, but I'm going to just make you the 17 worst of that." 18 Then, where I had the elevations from the -- from USGS, I took the worst. It was either the error of -- the 19 20 standard error from the elevation map, 2.4 meters, or I went back to that standard deviation. And if the standard deviation 21 2.2 was much bigger than that, I used that. 23 So I tried to use the worst possible error to create 24 the biggest probable shift in what could have been happening. Q. Did any of those assumed worst-case errors affect the 25

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| 1  | overall trajectory of the groundwater flow that you estimated   |
| 2  | in a material way?                                              |
| 3  | A. No, sir, it did not.                                         |
| 4  | Q. Now, Dr. Waldron, does your predevelopment flow analysis     |
| 5  | that's in Defendant's Exhibit 174 support your opinion that the |
| 6  | Middle Claiborne Aquifer is an interstate aquifer?              |
| 7  | A. Yes, it does.                                                |
| 8  | Q. And how so?                                                  |
| 9  | A. Because it shows that the water is moving across the         |
| 10 | political boundary.                                             |
| 11 | Q. Based on your analysis, would you agree with the claim that  |
| 12 | only a very small amount of water was flowing naturally from    |
| 13 | Mississippi into Tennessee under natural conditions?            |
| 14 | A. No, sir. Based upon the averages that I calculated, it was   |
| 15 | more substantial.                                               |
| 16 | Q. Dr. Waldron, are you aware of any other studies in the       |
| 17 | literature that have also mapped predevelopment water levels in |
| 18 | the Middle Claiborne Aquifer?                                   |
| 19 | A. Yes, I have.                                                 |
| 20 | Q. And ultimately, in terms of your opinion that the Middle     |
| 21 | Claiborne Aquifer is an interstate aquifer, does it matter to   |
| 22 | you which one of those studies is ultimately adopted for        |
| 23 | purposes of this hearing?                                       |
| 24 | A. No, it does not.                                             |
| 25 | Q. And why does it not matter to your ultimate opinion?         |

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| 1  | A. Well, from the basic definition that the water is moving    |
| 2  | across the political boundary, all the maps show it.           |
| 3  | Q. Are you aware of any study of the Middle Claiborne Aquifer  |
| 4  | that has ever shown zero predevelopment flow from Mississippi  |
| 5  | into Tennessee?                                                |
| 6  | A. No, sir.                                                    |
| 7  | Q. All right. Let's put back up on the screen now I'm          |
| 8  | going to go to Joint Exhibit 24. This is the much discussed    |
| 9  | Criner & Parks 1976 article.                                   |
| 10 | Dr. Waldron, do you recognize this article?                    |
| 11 | A. Yes, I do.                                                  |
| 12 | Q. Did you review this while you were working on your 2015     |
| 13 | paper?                                                         |
| 14 | A. Yes, I did.                                                 |
| 15 | Q. Let's turn to Figure 4 of this article, which for the       |
| 16 | record is on page 23 of the exhibit. The only change I've made |
| 17 | to it is I've darkened, in black, towards the bottom, the      |
| 18 | horizontal Mississippi/Tennessee state line. Do you see that?  |
| 19 | A. Yes, I do.                                                  |
| 20 | Q. Otherwise, is this an accurate representation of            |
| 21 | Criner & Parks's Figure 4?                                     |
| 22 | A. Yes, it is.                                                 |
| 23 | Q. Dr. Waldron, do you believe that this figure is as accurate |
| 24 | as the one that you produced in your 2015 paper?               |
| 25 | A. No, I do not.                                               |
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| 1  | Q. And what are your critiques of this paper or of this         |
| 2  | particular figure, I should say?                                |
| 3  | A. Of this figure, Criner & Parks, they had four observation    |
| 4  | points they used. And that's pretty sparse for developing a     |
| 5  | map, especially when they're all kind of close together. And    |
| 6  | that the data for those points were about 40 to 70 years        |
| 7  | post predevelopment.                                            |
| 8  | Q. So I want to start with the first one, the sparseness of     |
| 9  | the control data. Can you explain to Judge Siler why, as a      |
| 10 | groundwater hydrologist, you want more than four control points |
| 11 | to draw a contour map this big?                                 |
| 12 | A. Well, the more points you have, the more contours you hope   |
| 13 | that you would be able to draw, and that you would hope or try  |
| 14 | to have your points encompass where you're drawing your         |
| 15 | contours. You want to really try to avoid extrapolating too     |
| 16 | far away from your control.                                     |
| 17 | Q. And Dr. Waldron, I'm going to label the four control points  |
| 18 | that Criner & Parks had depicted.                               |
| 19 | Have I accurately labeled this map?                             |
| 20 | A. Yes, sir, you have.                                          |
| 21 | Q. Can you explain to Judge Siler what those funny-looking      |
| 22 | letters and numbers are that I put up on the screen?            |
| 23 | A. Yes. The "SH" stands these are USGS designations. So         |
| 24 | the "SH" is Shelby County. "FA" is Fayette County. And then     |
| 25 | the letter is the grid system that the USGS used, so U and W    |
|    |                                                                 |

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| 1  | 860<br>are just grid numbers letters, sorry.                    |
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| 2  | And then the number is the number that they gave that           |
| 3  | well.                                                           |
| 4  | Q. Do Criner & Parks have any control points in Mississippi     |
| 5  | that they used to draw these contours?                          |
| 6  | A. No, they do not.                                             |
| 7  | Q. And in your opinion, what does that do to your assessment    |
| 8  | of the accuracy of this map?                                    |
| 9  | A. It's not as reliable.                                        |
| 10 | Q. Dr. Waldron, I now want to focus you on the contour bend     |
| 11 | towards the south of this map that I discussed with Dr. Spruill |
| 12 | on cross-examination. Do you see the contours that how they     |
| 13 | bend to become more vertical as they approach the state         |
| 14 | boundary?                                                       |
| 15 | A. Yes, I do.                                                   |
| 16 | Q. In your opinion as a groundwater hydrologist, is there any   |
| 17 | data on this map that justifies the bend, the vertical bend in  |
| 18 | those contours?                                                 |
| 19 | A. No. Your contours should be governed by the control points   |
| 20 | that you have. There's no control points in that area to        |
| 21 | say why all of a sudden it takes a kick to the south.           |
| 22 | Q. So let's take the kick to the south, as you just put it,     |
| 23 | and let's assume that that's accurate for one moment. How       |
| 24 | would you draw your predevelopment flow directions based on     |
| 25 | Criner & Parks's kick-to-the-south contours?                    |

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| 1  | A. It would be east to west.                                   |
| 2  | Q. And so do you understand that to be the basis for why       |
| 3  | Mississippi's experts have said that the groundwater generally |
| 4  | flowed in a westerly direction or along the Mississippi and    |
| 5  | Tennessee border?                                              |
| 6  | MR. MOFFETT: I object to that. He's asking what our            |
| 7  | experts might have thought or done. Improper.                  |
| 8  | MR. BRANSON: Your Honor, I didn't ask that.                    |
| 9  | THE COURT: Okay.                                               |
| 10 | MR. BRANSON: I asked what did he understand the                |
| 11 | reason to be.                                                  |
| 12 | THE COURT: You may ask that question.                          |
| 13 | BY MR. BRANSON:                                                |
| 14 | Q. So again, I'm not we're not going to try and mind-read      |
| 15 | Dr. Spruill or Mr. Wiley. I'm just asking you, listening to    |
| 16 | their testimony, is that what you understood the reason to be  |
| 17 | for the westerly direction, allegedly, of groundwater flow     |
| 18 | under predevelopment conditions?                               |
| 19 | MR. MOFFETT: Your Honor, I also want to I've been              |
| 20 | very patient with the questions, and these have been leading.  |
| 21 | And I've tried to be very patient, but I'm going to object. I  |
| 22 | just want the record to I need a continuing objection, at      |
| 23 | least on these questions. But for this moment, I'm objecting   |
| 24 | to this particular question based on leading.                  |
| 25 | THE COURT: Okay. Don't lead your witness. Although             |
|    |                                                                |

|    | 862                                                            |
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| 1  | I understand sometimes it saves time.                          |
| 2  | BY MR. BRANSON:                                                |
| 3  | Q. Dr. Waldron, did you understand my last question?           |
| 4  | A. Yes.                                                        |
| 5  | Q. Can you answer the question as I asked it?                  |
| б  | A. Yes, and yes.                                               |
| 7  | Q. Okay. So Dr. Waldron, let's remove, then, the bend in the   |
| 8  | contour that we just talked about, and let's assume that       |
| 9  | Criner & Parks had not bent the contours to be vertical along  |
| 10 | the state line. If they hadn't done that, what would the       |
| 11 | direction of groundwater flow have been, as you would estimate |
| 12 | it?                                                            |
| 13 | A. It would turn more toward a southeast-to-northwest          |
| 14 | direction.                                                     |
| 15 | Q. And if it was going northwest, would it that natural        |
| 16 | trajectory cross the state line?                               |
| 17 | A. Yes, sir, it would.                                         |
| 18 | Q. Now, Dr. Waldron, are all four of these points that I put   |
| 19 | up on the screen, are those all actually wells?                |
| 20 | A. No, they're not.                                            |
| 21 | Q. What is an example of one that's not a well?                |
| 22 | A. The one downtown Memphis, SHO-124, is not a well. It's      |
| 23 | actually a tunnel to an underground tunnel that goes into      |
| 24 | like a 40-foot cistern pool that where the water collects,     |
| 25 | and then the City would pull water into that pool and pump it  |
|    |                                                                |

|    | 863                                                           |
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| 1  | to the City.                                                  |
| 2  | Q. How do you know that it's a tunnel to a tunnel?            |
| 3  | A. Well, one, it's mentioned in Criner & Parks, and it's      |
| 4  | rementioned in a little more detail in Brahana & Broshears.   |
| 5  | Q. And would you consider a tunnel to a tunnel to a 40-foot   |
| 6  | cistern to be an observation well?                            |
| 7  | A. No, I do not.                                              |
| 8  | Q. What about SHU-2, the well in northern Shelby County? Do   |
| 9  | you have an understanding of whether that is an observation   |
| 10 | well or not?                                                  |
| 11 | A. It's not. It's owned by Mr. Irvin, and it's not a he       |
| 12 | doesn't have an observation well. I don't think he's a        |
| 13 | groundwater-avid person, so                                   |
| 14 | Q. Have you evaluated the screen length associated with the   |
| 15 | SHU-2 well?                                                   |
| 16 | A. Yes, sir, I have.                                          |
| 17 | Q. Do Criner & Parks say anything about the screen lengths in |
| 18 | their paper?                                                  |
| 19 | A. No, sir, they don't.                                       |
| 20 | Q. So how did you figure it out?                              |
| 21 | A. Well, like I mentioned, CAESER has a lot of information    |
| 22 | about the wells in the area. And based upon what we have from |
| 23 | the USGS and from MLGW, we have a lot of those records. So I  |
| 24 | went into those records and just looked it up, and it's an    |
| 25 | 80-feet screen.                                               |
|    |                                                               |
|    | 864                                                             |
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| 1  | Q. As a and what does an 80-foot screen length suggest to       |
| 2  | you about the type of well?                                     |
| 3  | A. Well, it's very likely, as I mentioned, a production well,   |
| 4  | because other wells in the area are also 80 to 100 feet. And    |
| 5  | that's typical of a production well.                            |
| 6  | Q. Dr. Waldron, as a groundwater hydrologist, do you consider   |
| 7  | it best practice to draw contours based on an inspection tunnel |
| 8  | to a 40-foot cistern?                                           |
| 9  | A. It's not the best.                                           |
| 10 | Q. And why do you say it's not the best?                        |
| 11 | A. Well, one, the point's unreliable, from that standpoint;     |
| 12 | but 0-124, the value the water level at that time was           |
| 13 | 40 years postproduction. It was actually projected back in      |
| 14 | time as a linear trend. It wasn't a measurement back in         |
| 15 | none of these measurements are back in the time frame that I    |
| 16 | did mine. Mine was 1886 to 1906; this is 1927 to 1970s, or      |
| 17 | something like that.                                            |
| 18 | Q. And can you just explain to Judge Siler I know you think     |
| 19 | it's obvious, but why would you not think that it's best        |
| 20 | practice to create a predevelopment map based on water level    |
| 21 | measurements that are taken so far in the future?               |
| 22 | A. Well, if you want to make a predevelopment map, you get the  |
| 23 | points at the time of redevelopment. You wouldn't get points    |
| 24 | so far into the future and then try to guess what happened back |
| 25 | seven years before. So                                          |
|    |                                                                 |

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| Q. Dr. Waldron, when reading the Criner & Parks article, did   |
| you have an understanding of the purpose of that article?      |
| A. Yes.                                                        |
| Q. And what was the purpose of the article, as you read it?    |
| A. The emphasis of the article was focusing on 1960 to 1975.   |
| Q. And in terms of that main purpose of the Criner & Parks     |
| article, do you generally agree that Criner & Parks did        |
| scientifically valid work?                                     |
| A. Yes.                                                        |
| Q. Now, Dr. Waldron, have you studied the sources that         |
| Criner & Parks cite in their paper?                            |
| A. Many of them.                                               |
| Q. And do any of the ones that you've read support the         |
| specific way that Criner & Parks had drawn their contours on   |
| this predevelopment map in particular?                         |
| A. Not that I saw, no.                                         |
| Q. Dr. Waldron, let's now turn on to turn to the next          |
| article you mentioned, Brahana & Broshears in 2001.            |
| For the record, this is Joint Exhibit 15.                      |
| Do you recognize this article, Dr. Waldron?                    |
| A. Yes, I do.                                                  |
| Q. Have you reviewed it before?                                |
| A. Yes, sir.                                                   |
| Q. Let's turn to Figure 16, which for the record is on page 38 |
| of the exhibit. And I have also darkened in the state line in  |
|                                                                |

|    | 866                                                             |
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| 1  | black, horizontally, again.                                     |
| 2  | Do you recognize this Figure 16?                                |
| 3  | A. Yes, I do.                                                   |
| 4  | Q. What is this?                                                |
| 5  | A. This is a recreation of Criner & Parks's predevelopment      |
| 6  | condition of the Middle Claiborne Aquifer in 1886.              |
| 7  | Q. And do Brahana & Broshears say how they came up with this    |
| 8  | map?                                                            |
| 9  | A. Yes. They reference it down at the bottom right-hand         |
| 10 | corner, that it came from Criner & Parks's Figure 2 that we     |
| 11 | just looked at.                                                 |
| 12 | Q. Did Brahana & Broshears make any changes to the              |
| 13 | Criner & Parks figure that we just looked at?                   |
| 14 | A. Yes, they did.                                               |
| 15 | Q. What changes did they make?                                  |
| 16 | A. Well, Parks with USGS, he continued doing some more          |
| 17 | work, and he extended the outcrop region of the Middle          |
| 18 | Claiborne Aquifer, which is on the right, big squiggly lines,   |
| 19 | took more along Shelby County, up toward the north.             |
| 20 | By doing that, they wiped out a 290 contour. And on             |
| 21 | this figure, they added a fifth control point that's not really |
| 22 | there.                                                          |
| 23 | Q. And where is the fifth control point?                        |
| 24 | A. It's right at near the state line, between contours 260      |
| 25 | and 270.                                                        |
|    |                                                                 |

|    | 867                                                            |
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| 1  | Q. I'm going to put a red box around it.                       |
| 2  | Have I accurately identified what you're talking               |
| 3  | about?                                                         |
| 4  | A. Yes, you yes, you have.                                     |
| 5  | Q. Why do you say that's not a real control point?             |
| б  | A. Well, so Brahana & Broshears got their map from Criner &    |
| 7  | Parks. So then you go back to Criner & Parks, and they show    |
| 8  | all the data points that they use. And you can look in the     |
| 9  | table and in the figures that Criner & Parks have, and you can |
| 10 | see that it's not that there's nothing there. It's a           |
| 11 | smudge.                                                        |
| 12 | Q. It's a smudge. Okay.                                        |
| 13 | Let me put both of the two articles side by side on            |
| 14 | the screen. I have Criner & Parks Figure 4, and I have         |
| 15 | Brahana & Broshears Figure 16. And I have drawn a red box      |
| 16 | around the smudge, as you put it.                              |
| 17 | A. Yes.                                                        |
| 18 | Q. Do you have any understanding of why Brahana & Broshears    |
| 19 | would have taken that smudge and labeled it as a control point |
| 20 | on their predevelopment map?                                   |
| 21 | A. It was a mistake. And in Brahana & Broshears, in the        |
| 22 | actual text, they say that there's only four control points.   |
| 23 | So it was just an accident or something.                       |
| 24 | Q. Now, do Brahana & Broshears say for what purpose they're    |
| 25 | including a predevelopment figure in their articles?           |

|    | 868                                                             |
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| 1  | A. Yes. Brahana & Broshears wanted to look at how water         |
| 2  | levels had changed in the Middle Claiborne Aquifer since        |
| 3  | predevelopment.                                                 |
| 4  | Q. And did they discuss any models in the course of their       |
| 5  | article?                                                        |
| 6  | A. They did. They used they developed a numerical model in      |
| 7  | order to simulate the water level changes in the Middle         |
| 8  | Claiborne Aquifer into the I think the 1985ish time frame.      |
| 9  | Q. From reading the article, was your opinion that              |
| 10 | Brahana & Broshears were focused in particular on accurately    |
| 11 | estimating the predevelopment surface?                          |
| 12 | A. No. They were more interested in what had been the changes   |
| 13 | in the Middle Claiborne Aquifer as pumping had gotten stronger  |
| 14 | since post 1960.                                                |
| 15 | Q. So other than the change in the outcrop area and the smudge  |
| 16 | that we've talked about, did Brahana & Broshears make any other |
| 17 | changes to the Criner & Parks predevelopment figures?           |
| 18 | A. No.                                                          |
| 19 | Q. So overall, then, do you have an opinion about whether the   |
| 20 | Brahana & Broshears figure is as accurate as the predevelopment |
| 21 | map that you put together in your 2015 paper?                   |
| 22 | A. It's not as accurate, no.                                    |
| 23 | Q. Have Brahana & Broshears done anything, in your view, to     |
| 24 | fix the problems that you identified with the Criner & Parks    |
| 25 | map that you discussed earlier?                                 |
|    |                                                                 |

| 1      | 869 No                                                          |
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| -<br>2 | 0 Dr Waldron let's now so to Defendant's Exhibit 112 I          |
| 2      | y. Dr. wardroh, rec 5 now 90 to berendant 5 Exhibit 112. I      |
| 2      | put it up on the screen. This is the famous yerrow triangle     |
| 4      | map, at least the original version, before the enlarged yellow  |
| 5      | triangle we saw yesterday.                                      |
| 6      | And I'd like you to just explain to Judge Siler, have           |
| 7      | you reviewed this figure before?                                |
| 8      | A. Yes, I have.                                                 |
| 9      | Q. Have you evaluated this figure in the course of preparing    |
| 10     | your opinions in this case?                                     |
| 11     | A. Yes, I have.                                                 |
| 12     | Q. Where does Mr. Wiley say in his report that he got his data  |
| 13     | from to draw these contours?                                    |
| 14     | A. Brahana Brahana & Broshears report.                          |
| 15     | Q. The same one that we just looked at?                         |
| 16     | A. Yes, sir.                                                    |
| 17     | Q. And to remind Judge Siler, where did Brahana & Broshears     |
| 18     | get their contours from?                                        |
| 19     | A. Criner & Parks.                                              |
| 20     | Q. So have you reached an opinion about the scientific          |
| 21     | validity of the contours that are drawn on this yellow triangle |
| 22     | map?                                                            |
| 23     | A. They're not as accurate as what I produced in my             |
| 24     | publication.                                                    |
| 25     | Q. And why is that?                                             |
|        |                                                                 |

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| 1  | A. Well, because they didn't Mr. Wiley didn't add any extra    |
| 2  | control to fix the issues that were inherent with Criner &     |
| 3  | Parks. And then there was this extension of predevelopment     |
| 4  | flow lines from what Criner & Parks had, southward and deeper  |
| 5  | into Mississippi, seemingly to the past the southern           |
| 6  | boundary of DeSoto County.                                     |
| 7  | Q. From reading Mr. Wiley's report, did you discern any        |
| 8  | control data that would have justified extending the contours  |
| 9  | that far south into Mississippi?                               |
| 10 | A. Not from what I've read, no.                                |
| 11 | Q. And once you get to the very southern end of this map,      |
| 12 | where the contours are moving in a slightly southeasterly      |
| 13 | direction, at that point, what is the nearest control point    |
| 14 | that Criner & Parks had?                                       |
| 15 | A. So you mean from the very southern end?                     |
| 16 | Q. Yeah, I'm talking about the contours at the southern end of |
| 17 | this map.                                                      |
| 18 | A. So from there up to the downtown Memphis, which was         |
| 19 | SH-0124. It's about 30 miles.                                  |
| 20 | Q. And if we were to look only at actual wells, as opposed to  |
| 21 | a 40-foot cistern, what's the closest well that Criner & Parks |
| 22 | would have had to these contours that are going into           |
| 23 | Mississippi at the bottom?                                     |
| 24 | A. Well, the next one in line going north would be, from       |
| 25 | Criner & Parks, would be Arlington. And that's almost to the   |
|    |                                                                |

|    | 971                                                             |
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| 1  | north of Shelby County.                                         |
| 2  | Q. And can you just estimate for Judge Siler, you know, how     |
| 3  | many miles are we talking about, rough estimate?                |
| 4  | A. I'm going to estimate about 40 miles.                        |
| 5  | Q. And as a groundwater hydrologist drawing contour lines, do   |
| 6  | you consider it to be scientifically valid to draw contour      |
| 7  | lines that are, you know, 30 to 40 miles away from your nearest |
| 8  | control?                                                        |
| 9  | A. No.                                                          |
| 10 | Q. Dr. Waldron, I'd now like to go to Joint Exhibit 4, which    |
| 11 | is Arthur & Taylor 1998. And I want to focus on Plate 5. I'm    |
| 12 | going to expand it on the screen.                               |
| 13 | Do you recognize this document?                                 |
| 14 | A. Yes, I do.                                                   |
| 15 | Q. What is this?                                                |
| 16 | A. This is a USGS publication, Arthur & Taylor, and this is     |
| 17 | the predevelopment map of the Middle Claiborne Aquifer.         |
| 18 | Q. And what from reading Arthur & Taylor's table, what did      |
| 19 | you discern about the purpose of the publication that this      |
| 20 | figure appears in?                                              |
| 21 | A. They were interested in knowing how water usage had changed  |
| 22 | over the Mississippi Embayment since the period of              |
| 23 | predevelopment up into the 1980s, I think, going all the way to |
| 24 | 1987.                                                           |
| 25 | Q. From reading the paper, did it appear to you to be to        |
|    |                                                                 |

| 1  | 872<br>have been Arthur & Taylor's focus to develop an accurate |
|----|-----------------------------------------------------------------|
| 2  | predevelopment map?                                             |
| 3  | A. No. It was not their sole sole focus, no.                    |
| 4  | Q. And how do Arthur & Taylor say they came up with these       |
| 5  | contour lines that appear on this figure?                       |
| 6  | A. Well, what they did is they took this model, and they        |
| 7  | didn't turn on any pumping, so they didn't activate anything.   |
| 8  | And what they did, they allowed recharge to be applied to the   |
| 9  | system, and then rivers. And just based off the physics of      |
| 10 | discharge to recharge, or recharge to discharge, that's how     |
| 11 | they developed their predevelopment map.                        |
| 12 | Q. Could you tell from reading their paper whether              |
| 13 | Arthur & Taylor used any actual observed water level data to    |
| 14 | generate these contour lines?                                   |
| 15 | A. No, they didn't. That was not in this figure, no.            |
| 16 | Q. And in your opinion, Dr. Waldron, what's a better way to     |
| 17 | develop predevelopment contour lines? Observe data, or use a    |
| 18 | computer model?                                                 |
| 19 | A. Observe data.                                                |
| 20 | Q. And why is that?                                             |
| 21 | A. Well, I mean, the contours come from physical measurement.   |
| 22 | So just like on my map, you produce the red dots. Once you      |
| 23 | have red dots and you feel, you know, confident as you can      |
| 24 | about those, then you draw your contours in between the red     |
| 25 | dots.                                                           |

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| 1  | So, you know, having the actual real data, that's               |
| 2  | something that's measurable, and you're in the field taking a   |
| 3  | measurement. So                                                 |
| 4  | Q. Let's focus on the area right along the                      |
| 5  | Mississippi/Tennessee boundary in the Arthur & Taylor Plate 5.  |
| 6  | Do you see those contours, Dr. Waldron?                         |
| 7  | A. Yes, I do.                                                   |
| 8  | Q. Do you think that these contours that Arthur & Taylor have   |
| 9  | drawn along the boundary are as accurate as the ones that you   |
| 10 | drew in your 2015 predevelopment map?                           |
| 11 | A. I don't think so, no.                                        |
| 12 | Q. Dr. Waldron, let's now go to Defendant's Exhibit 194. This   |
| 13 | is a figure from your opening expert report.                    |
| 14 | Could you describe to Judge Siler what this is.                 |
| 15 | And I'm sorry, for the record, this is Figure 12 at             |
| 16 | page 27 of the exhibit.                                         |
| 17 | A. Yes. This is depicting the predevelopment conditions as      |
| 18 | they would have been extracted from the USGS Brian Clark MERAS  |
| 19 | model.                                                          |
| 20 | Q. How did you generate this figure yourself?                   |
| 21 | A. What I did is Clark & Hart didn't have a figure for          |
| 22 | predevelopment. So I called Brian Clark in Arkansas and asked   |
| 23 | him for the model, and got it, and ran that. And ran and        |
| 24 | off that very first stress period, very first time step, I felt |
| 25 | it was predevelopment. So I extracted that out and put it in    |
|    |                                                                 |

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| 1  | GIS and mapped it, and that's the contours that you see here,   |
| 2  | which are similar to the other information.                     |
| 3  | Q. Have you drawn these red arrows on this map?                 |
| 4  | A. I did.                                                       |
| 5  | Q. Why did you draw those?                                      |
| 6  | A. I wanted to show that based upon Clark & Hart's              |
| 7  | predevelopment contours, that water naturally flowed across     |
| 8  | political boundaries. It if you look at the arrows from         |
| 9  | right to left, it goes from Mississippi into Tennessee,         |
| 10 | Tennessee into Mississippi, Mississippi into Arkansas, Arkansas |
| 11 | into Mississippi. So                                            |
| 12 | Q. And in your opinion, is this map that you generated through  |
| 13 | the MERAS model as accurate as the map that you put as Figure 4 |
| 14 | in your 2015 academic paper?                                    |
| 15 | A. I don't think so, no.                                        |
| 16 | Q. Let's do one more, Dr. Waldron, and that is Reed in 1972.    |
| 17 | This, for the record, is Joint Exhibit 67.                      |
| 18 | Have you reviewed this document before, Dr. Waldron?            |
| 19 | A. Yes, I have.                                                 |
| 20 | Q. Let's zoom in on Figure 2. What is this?                     |
| 21 | A. This is depicting the predevelopment conditions of the       |
| 22 | Middle Claiborne Aquifer.                                       |
| 23 | Q. Do you have an opinion about the accuracy of this map, at    |
| 24 | least as it pertains to the Mississippi/Tennessee boundary?     |
| 25 | A. I don't think that it portrays it as accurate as what I had  |
|    |                                                                 |

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| 1  | in my publication.                                              |
| 2  | Q. Why do you say that?                                         |
| 3  | A. Well, for the same reason that, one, the contour is going    |
| 4  | in the wrong direction; but two, there's no control provided on |
| 5  | the figure that justifies helps me to justify the position      |
| 6  | and orientation of those contours.                              |
| 7  | Q. How does Reed say that he came up with these contours?       |
| 8  | A. He doesn't. I tried to look at it. Reed lists like four      |
| 9  | references in his publication. And I went through those, and    |
| 10 | just like I had done before for when I found, you know, my      |
| 11 | stuff, for my paper, I would drill down probably about two,     |
| 12 | three generations of references, looking for potential data     |
| 13 | that Reed may have used to create this surface. And I couldn't  |
| 14 | find anything.                                                  |
| 15 | Q. And so as a scientist, what's your reaction to a water       |
| 16 | level map like this, when there you can't tell how the          |
| 17 | contour lines are drawn?                                        |
| 18 | A. I don't trust it as much as I would with one with control    |
| 19 | points.                                                         |
| 20 | Q. Dr. Waldron, we've looked at a lot of maps today. I think    |
| 21 | there have been about six in total. Do all of them, in your     |
| 22 | view, support your ultimate opinion that this is an interstate  |
| 23 | resource?                                                       |
| 24 | A. Yes, they do.                                                |
| 25 | Q. Why is that?                                                 |

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| 1  | A. Because no matter which map you look at, each one shows      |
| 2  | some water moving across the political boundary.                |
| 3  | Q. And just if you could summarize, what's the main             |
| 4  | difference, in your view, between the map that you drew in      |
| 5  | Figure 4 of your 2015 paper and the other maps that we looked   |
| 6  | at?                                                             |
| 7  | A. I would say the biggest difference is that with my paper,    |
| 8  | its sole purpose was to build a predevelopment map. With all    |
| 9  | these other publications, it was something done toward other    |
| 10 | efforts, and looking at future water in the 1940s, '60s, '80s.  |
| 11 | Q. Thank you, Dr. Waldron. Now I'd like to turn to your         |
| 12 | surrebuttal report, which was D196.                             |
| 13 | Do you remember that report?                                    |
| 14 | A. I do.                                                        |
| 15 | Q. And in that report, did you respond to any criticisms that   |
| 16 | had been made of your predevelopment map?                       |
| 17 | A. Yes, sir, I did.                                             |
| 18 | Q. And leaving aside for a minute the individual merits of the  |
| 19 | criticisms that Mississippi offered in its expert reports, how  |
| 20 | did you interpret those individual errors in light of the error |
| 21 | analysis that you did?                                          |
| 22 | A. For the most part, those, you know, fell within any error    |
| 23 | that I was dealing with in my report. So they were you          |
| 24 | know, the error that I had in my report was so large in some    |
| 25 | places it just superseded any smaller errors that were          |
|    |                                                                 |

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| 1  | presented in the in the surrebuttal.                            |
| 2  | Q. And so if you even accepted the merits of the criticisms     |
| 3  | that were expressed in some of the other expert reports, in     |
| 4  | your opinion, would any of them materially change the direction |
| 5  | of predevelopment groundwater flow?                             |
| б  | A. No, they would not.                                          |
| 7  | Q. Now, Dr. Waldron, do you recall that one criticism you       |
| 8  | responded to in your surrebuttal report was the claim that you  |
| 9  | improperly drew contours through the unconfined part of the     |
| 10 | Middle Claiborne Aquifer?                                       |
| 11 | A. Yes.                                                         |
| 12 | Q. And how would you respond to that criticism?                 |
| 13 | A. Well, it's if you it's okay to draw contours within          |
| 14 | the unconfined section, as long as you're aware of what should  |
| 15 | be happening.                                                   |
| 16 | Q. In your opinion, is it common for scientists creating a      |
| 17 | water level map of the Middle Claiborne Aquifer to draw         |
| 18 | contours in the unconfined part of the aquifer?                 |
| 19 | A. Yes.                                                         |
| 20 | Q. Have you reviewed other examples in which other scientists   |
| 21 | have done that?                                                 |
| 22 | A. Yes, I have.                                                 |
| 23 | Q. Let's walk through a few, and I'd like to turn to a figure   |
| 24 | in your surrebuttal report. This is D196 at page 12, Figure 3.  |
| 25 | And I'm going to ask you just to explain to Judge               |
|    |                                                                 |

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| 1  | Siler what this figure is.                                     |
| 2  | A. This is a figure from Reed, 1972. And what it's showing is  |
| 3  | the gray area is the outcrop of the unconfined portion of the  |
| 4  | Middle Claiborne Aquifer. And there's different color boxes.   |
| 5  | Q. Zoom in on those, Dr. Waldron, to make it easier.           |
| 6  | A. Okay. So there's a red box, and in the red box you can see  |
| 7  | that in that gray area, there's a 400 and a 340 contour drawn  |
| 8  | in the confined portion of the Middle Claiborne. You can       |
| 9  | follow that up in the blue box, see that there's a 360.        |
| 10 | And depending upon how anyone wants to see it, if it's         |
| 11 | yellow or green, there is a much bigger box, and that          |
| 12 | represents so Reed was 1972. And, you know, the USGS, as       |
| 13 | they collect data and improve upon what they've had in the     |
| 14 | past, and that yellow polygon represents where the USGS now    |
| 15 | draws the or defines the unconfined portion of the Middle      |
| 16 | Claiborne Aquifer.                                             |
| 17 | So in that particular case, some of those contours in          |
| 18 | Reed would fall in the unconfined portion of the Middle        |
| 19 | Claiborne.                                                     |
| 20 | Q. Let's do another one. I want to turn to Joint Exhibit 58.   |
| 21 | Do you recognize this document?                                |
| 22 | A. I do.                                                       |
| 23 | Q. Is this the Moore 1965 paper that we heard about earlier in |
| 24 | the week?                                                      |
| 25 | A. Yes.                                                        |
|    |                                                                |

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| 1  | Q. I want to go to Plate 5, on page 55 of the exhibit.          |
| 2  | Can you describe briefly what this is?                          |
| 3  | A. Yes. This is the piezometric surface of the Middle           |
| 4  | Claiborne Aquifer in West Tennessee for the winter of 1960.     |
| 5  | Q. And I'm going to zoom in here, and I'm going to add a red    |
| б  | shape around a part of this.                                    |
| 7  | What am I highlighting on this screen?                          |
| 8  | A. You're highlighting the section of the Middle Claiborne      |
| 9  | Aquifer that's unconfined.                                      |
| 10 | Q. Why are we talking about this? What point do you want to     |
| 11 | make with this figure?                                          |
| 12 | A. Well, this this illustrates the fact that other              |
| 13 | scientists, your USGS, is drawing water level contours in an    |
| 14 | unconfined section of the Middle Claiborne Aquifer, in addition |
| 15 | to outside the red box, the left, the confined portions of the  |
| 16 | aquifer.                                                        |
| 17 | Q. Can you tell from this figure whether Moore relied on any    |
| 18 | control points that were in the unconfined part of the aquifer? |
| 19 | A. Yes. Moore actually in this case puts control points on      |
| 20 | the map.                                                        |
| 21 | Q. And I'm going to highlight or circle in red two of them.     |
| 22 | Have I accurately circled two of said control points?           |
| 23 | A. Yes, you did. And there's little black dots, and then the    |
| 24 | number beside it is the water level in feet, mean sea level.    |
| 25 | Q. Let's now do another figure from your surrebuttal report.    |

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| 1  | This is Defendant's Exhibit 196, at page 15.                  |
| 2  | Can you describe to Judge Siler what we're seeing             |
| 3  | here.                                                         |
| 4  | A. Yes. This is, I believe, Parks & Carmichael. And they      |
| 5  | mapped water levels in West Tennessee in the Middle Claiborne |
| 6  | Aquifer. And this is for the fall of 1983.                    |
| 7  | The darkened line area to the right, that's the               |
| 8  | unconfined section of the Middle Claiborne Aquifer. And they  |
| 9  | show that there are or they map water level contours and      |
| 10 | control, both in the unconfined and confined section of the   |
| 11 | Middle Claiborne Aquifer.                                     |
| 12 | Q. And for what purpose are we showing this diagram?          |
| 13 | A. This is the USGS scientist drawing water levels in the     |
| 14 | unconfined and confined sections of the Middle Claiborne      |
| 15 | Aquifer.                                                      |
| 16 | Q. Let's go to Joint Exhibit 71. This is the Schrader 2008    |
| 17 | article that we've discussed in this hearing.                 |
| 18 | Do you recognize this document, Dr. Waldron?                  |
| 19 | A. Yes, I do.                                                 |
| 20 | Q. I'm going to zoom in on part of it. Can you explain to     |
| 21 | Judge Siler why we're showing this part of Schrader 2008?     |
| 22 | A. Yes. It shows that the USGS mapped water levels in the     |
| 23 | unconfined portion of the Middle Claiborne Aquifer, which is  |
| 24 | that gray area, and then they also mapped it in the confined  |
| 25 | area as well.                                                 |

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| 1  | Q. Finally, Dr. Waldron we've only got one more of these; I     |
| 2  | promise. It's Joint Exhibit 52.                                 |
| 3  | Can you identify this article for the record?                   |
| 4  | A. Yes. This is a section of the groundwater analysis by        |
| 5  | Lloyd & Lyke in 1995. It's a USGS publication.                  |
| 6  | Q. I'd like to turn to page 31 of this exhibit and zoom in on   |
| 7  | figure 137.                                                     |
| 8  | What does this show?                                            |
| 9  | A. This is showing the mapping of water levels. This time       |
| 10 | we're not talking about the Middle Claiborne; this is actually  |
| 11 | just an aquifer that's actually below the Middle Claiborne, the |
| 12 | Wilcox. And it shows that even for that particular aquifer,     |
| 13 | they are mapping water levels in the unconfined section of that |
| 14 | aquifer.                                                        |
| 15 | Q. Thank you, Dr. Waldron.                                      |
| 16 | We saw in earlier testimony in the week that in                 |
| 17 | unconfined systems, groundwater might not always move           |
| 18 | horizontally. Were you in the courtroom for that?               |
| 19 | A. Yes, sir.                                                    |
| 20 | Q. And would you agree with Mississippi's suggestion that       |
| 21 | there may be some vertical component to flow in unconfined      |
| 22 | aquifers?                                                       |
| 23 | A. I do.                                                        |
| 24 | Q. Do you think that that phenomenon undermines the accuracy    |
| 25 | of your results as published in your 2015 paper?                |
|    |                                                                 |

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| 1  | A. No.                                                         |
| 2  | Q. Why not?                                                    |
| 3  | A. Well, because you can use the Dupuit Assumption in order to |
| 4  | define where that equipotential line is vertical. And where    |
| 5  | that equipotential line is vertical, then the head does not    |
| 6  | have vertical movement, and therefore it's the appropriate     |
| 7  | head, no matter where you are, up or down.                     |
| 8  | Q. Can you help our court reporter out with "Dupuit"?          |
| 9  | A. D-U-P-U-I-T.                                                |
| 10 | Q. And what is the Dupuit Assumption that you just invoked?    |
| 11 | A. The Dupuit Assumption is that if you are one and a half to  |
| 12 | two times away from a discharge point, times the saturated     |
| 13 | thickness, that you can assume that you'd have a a vertical    |
| 14 | equipotential line.                                            |
| 15 | Q. And is that sometimes called the Dupuit-Forchheimer         |
| 16 | Assumption?                                                    |
| 17 | A. Yes. And do not ask me to spell "Forchheimer."              |
| 18 | Q. I won't.                                                    |
| 19 | How do the prevailing groundwater flow models                  |
| 20 | available in your field deal with the Dupuit Assumption?       |
| 21 | A. They the Dupuit Assumption is inherent in the concept of    |
| 22 | finite different grid cell.                                    |
| 23 | Q. And in English, what does that mean for groundwater models? |
| 24 | A. Sorry. That well, I was about to throw in an equation.      |
| 25 | It is that the groundwater L level can be assumed to           |
|    |                                                                |

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| 1  | 883 be more horizontal than vertical. And in MODFLOW, which is the |
|----|--------------------------------------------------------------------|
| 2  | USGS model which was used in just about everything here, uses a    |
| 3  | finite different grid cell, a cube. And that cube puts a dot       |
| 4  | in the center of that cell, and that what that means is that       |
| 5  | up or down within that cell, that head is going to be the same.    |
| б  | Q. And when the Dupuit Assumption is valid, is using water         |
| 7  | level measurements, in your opinion, is it well accepted to use    |
| 8  | those measurements from an unconfined area of an aquifer?          |
| 9  | A. Yes.                                                            |
| 10 | Q. Now, did you do any calculations in this case to verify         |
| 11 | whether the Dupuit Assumption was valid for your treatment of      |
| 12 | the unconfined aquifer?                                            |
| 13 | A. I did. I considered the streams in the area and looked at       |
| 14 | my points. And the range is one and a half to two times            |
| 15 | saturated thickness. So I took the worst again and did two         |
| 16 | times saturated thickness, and I'm beyond that distance. So        |
| 17 | being beyond that distance, I was able to assume that my           |
| 18 | equipotential lines were vertical.                                 |
| 19 | Q. If you assume that if your equipotential lines are              |
| 20 | vertical, in your opinion, do you have to use only observation     |
| 21 | wells with short screen lengths to get an accurate water level     |
| 22 | reading?                                                           |
| 23 | A. No, because it has to be the same along that vertical           |
| 24 | distance.                                                          |
| 25 | Q. Now, I want to put up on the screen, Dr. Waldron, a diagram     |
|    |                                                                    |

884 1 that Dr. Spruill discussed earlier this week. This is Plaintiff's Exhibit 202, for the record. 2 3 Do you recall seeing this diagram before? Yes. 4 Α. 5 What are your reactions to it? 0. It's a good academic figure. What it does is it shows you 6 Α. 7 the compilation of what would happen in the unconfined section of an aquifer system where you have at C, which is on the 8 9 right-hand side, you have this re -- well, recharge is 10 occurring across the whole thing, but this recharge aspect to 11 the system, and then that moves down to where you have B, where 12 it's moving horizontal. And then you have your discharge at 13 point A, where the groundwater goes up to the discharge point. And do you think that -- you see that Dr. Spruill's labeled 14 0. 15 a Y-axis with -- the words "Arbitrary Scale." Do you see that? 16 Α. I do. In your opinion, how does this figure compare to the 17 0. 18 reality of the Middle Claiborne Aquifer? 19 Well, those aspects that are shown on the figure exist in Α. 20 the Middle Claiborne Aquifer. But again, from an academic 21 figure, this is trying to illustrate everything that could 2.2 happen that you would witness in the unconfined section. So 23 you've really got to expand it out. 24 So the way that this would more so look is that C is 25 going to be, you know, like against this wall; A is going to be

| 1      | 885<br>aqainst that wall, and B is going to be in between. This kind                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2      | of shows that point B is few and far between in current, but                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 2      | it's actually not in these types of aquifer systems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Л      | And in the actual actua |
| т<br>Г | y. And in the actual aquiter system that we re dealing with,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| c      | the control that you estually used?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| o<br>E | the control that you actually used?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| ./     | A. Based upon the formula, it would be at B.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 8      | Q. Dr. Waldron, in your surrebuttal report, do you recall also                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 9      | responding to the criticism that your you might not have had                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 10     | enough information about all the wells that you used to draw                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 11     | your control points?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 12     | A. Yes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 13     | Q. For example, did you always know for sure all of the                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 14     | construction information about every well you used?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 15     | A. No, I did not.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 16     | Q. Did you always know, for example, whether the wells you                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 17     | used had been properly routed back in the early 1900s?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 18     | A. No, sir, I did not.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 19     | Q. So if if someone were to criticize you and claim that                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 20     | the lack of information about those things made your map                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 21     | unreliable, what would you say in response?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 22     | A. Well, I mean, I had that's all I had that's the only                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 23     | data I had at the time from USGS. There wasn't that                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 24     | information didn't exist in my publication. Or in the                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 25     | publications of the USGS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

|    | 888                                                             |
|----|-----------------------------------------------------------------|
| 1  | Q. After reading the water level measurements that you took     |
| 2  | from the USGS, were you confident enough in the measurements to |
| 3  | use them?                                                       |
| 4  | A. Yes.                                                         |
| 5  | Q. And why was that?                                            |
| 6  | A. Well, you know, these three publications, they were          |
| 7  | produced by the USGS. And the purpose of those publications     |
| 8  | was to develop these water levels. I mean, you look back at     |
| 9  | some of the tables, and there's hundreds of them listed.        |
| 10 | So, you know, they were as USGS, as they do, they               |
| 11 | were collecting these data and publishing it. So I have no      |
| 12 | reason to discount the USGS.                                    |
| 13 | Q. Dr. Waldron, are you aware of any study in existence that    |
| 14 | maps predevelopment conditions in the Middle Claiborne, using   |
| 15 | control points that are only taken from wells from which we     |
| 16 | have complete construction information?                         |
| 17 | A. No, I do not know.                                           |
| 18 | Q. Let's take Criner & Parks as an example. I'm going to put    |
| 19 | it back up on the screen again. This is Joint Exhibit 24, at    |
| 20 | page 23.                                                        |
| 21 | Do Criner & Parks give any information about the                |
| 22 | construction records of the three wells and a cistern that they |
| 23 | use?                                                            |
| 24 | A. No. I mean, they mention the O-124 being a brick-lined       |
| 25 | tunnel, because that's about it. But no not on the others,      |
|    |                                                                 |

|    | 887                                                             |
|----|-----------------------------------------------------------------|
| 1  | no.                                                             |
| 2  | Q. Do they give any indication about whether their wells were   |
| 3  | properly routed?                                                |
| 4  | A. No, they do not specify that.                                |
| 5  | Q. Do they specify the height of their well casings?            |
| 6  | A. No, they do not specify that.                                |
| 7  | Q. Do they give any indication in their article about screen    |
| 8  | lengths of the wells that they used?                            |
| 9  | A. No, they do not.                                             |
| 10 | Q. Do they give any indication of how they determine the        |
| 11 | ground surface elevation for any of their control points?       |
| 12 | A. No, they do not discuss it.                                  |
| 13 | Q. What about Mr. Wiley? I'm going to put the yellow triangle   |
| 14 | map, as we're calling it, back up on the screen. Does he        |
| 15 | provide any information about any construction history of any   |
| 16 | wells he may or may not have used to generate this map?         |
| 17 | A. No.                                                          |
| 18 | Q. What about the other predevelopment maps we've looked at,    |
| 19 | Reed, and Arthur & Taylor? Is there any such information about  |
| 20 | construction history of wells in any of those publications that |
| 21 | you're aware of?                                                |
| 22 | A. Not that I've seen, no.                                      |
| 23 | Q. So Dr. Waldron, in your opinion, if we were going to limit   |
| 24 | ourselves to wells for which you had complete construction      |
| 25 | information, including things like routing, would you consider  |

|    | 888                                                            |
|----|----------------------------------------------------------------|
| 1  | it feasible to draw an accurate predevelopment map of Middle   |
| 2  | Claiborne?                                                     |
| 3  | A. You're going to be pretty hard pressed to do it.            |
| 4  | Q. Dr. Waldron, I want to go back now to your Figure 4, and    |
| 5  | we're almost done.                                             |
| б  | You said that you used 27 control points, I think, to          |
| 7  | draw this map. Did I hear you correctly?                       |
| 8  | A. Yes, sir.                                                   |
| 9  | Q. So I've counted pretty carefully; I actually only see 26 up |
| 10 | there. Did I miscount?                                         |
| 11 | A. No, no you didn't miscount.                                 |
| 12 | Q. So what am I missing? Where is the 27th one?                |
| 13 | A. It was used; it's just not on the figure. It's off to the   |
| 14 | left, in the county next to St. Francis, I believe.            |
| 15 | Q. So why didn't you include that 27th control point on this   |
| 16 | figure?                                                        |
| 17 | A. I was focusing in on the contours.                          |
| 18 | Q. So it was outside the geographic extent of your map?        |
| 19 | A. Yes.                                                        |
| 20 | Q. Even though you didn't include it on the map, did you       |
| 21 | account for that 27th control point when you were drawing your |
| 22 | contours?                                                      |
| 23 | A. Yes.                                                        |
| 24 | Q. And just for the record, can you identify what the missing  |
| 25 | control point is?                                              |

|    | 88                                                             | Q |
|----|----------------------------------------------------------------|---|
| 1  | A. Forrest City.                                               | 3 |
| 2  | Q. Forrest City, Arkansas?                                     |   |
| 3  | A. Yeah, Arkansas.                                             |   |
| 4  | Q. Let's go to the next diagram here. And this is Defendant's  |   |
| 5  | Exhibit 196, your surrebuttal report, at page 21 of the        |   |
| б  | exhibit.                                                       |   |
| 7  | What are we seeing here?                                       |   |
| 8  | A. This is a plot in GIS of the control points and the         |   |
| 9  | contours as they were as I drew them.                          |   |
| 10 | Q. And was this the this was the a depiction of the            |   |
| 11 | process you used to generate your contours that appeared in    |   |
| 12 | your 2015 paper?                                               |   |
| 13 | A. It reflects that kind of process, yes.                      |   |
| 14 | Q. And do we see the Forrest City control point on here?       |   |
| 15 | A. Yes. It's there. It's off to the left. It says yep,         |   |
| 16 | there she is. Or he.                                           |   |
| 17 | Q. And so what does this diagram tell us about your use of the | : |
| 18 | Forrest City control point?                                    |   |
| 19 | A. I used it.                                                  |   |
| 20 | Q. Dr. Waldron, I don't see on this map for this GIS output    |   |
| 21 | the Mississippi/Tennessee state boundary. Am I missing it      |   |
| 22 | somewhere?                                                     |   |
| 23 | A. No. No, it's not on there.                                  |   |
| 24 | Q. And why is that not on this figure?                         |   |
| 25 | A. Well, I mean, groundwater knows no political bounds, so     |   |
|    |                                                                |   |

#### Proceedings - May 23, 2019

890 Waldron - cross why -- I didn't put them on there for that reason. 1 Q. Thank you, Dr. Waldron. 2 3 MR. BRANSON: I'll pass the witness. THE COURT: All right. We'll take a short recess at 4 5 this time. Ten minutes. 6 (Recess) THE COURT: All right. Have you finished with your 7 direct examination with this witness? 8 9 MR. BRANSON: Yes, your Honor, we passed the witness. 10 THE COURT: Okay. 11 MR. MOFFETT: Your Honor, good afternoon. Larry 12 Moffett on behalf of the State of Mississippi. May it please 13 the Court. 14 CROSS EXAMINATION BY MR. MOFFETT: 15 16 Q. Dr. Waldron, we've met before. My name is Larry Moffett. 17 I'm here on behalf of the State of Mississippi. I've got a few questions for you. I don't think we'll be real long, but I 18 19 want to make sure we cover anything in a reasonably prompt 20 manner, and at the same time cover the things we need to cover. 21 Now, if I ask you a question that you do not 2.2 understand, would you please ask me to rephrase it or repeat 23 it, please? 24 A. Yes, sir. 25 Q. Okay. Thank you.

|    | 891                                                                    |
|----|------------------------------------------------------------------------|
| 1  | Waldron - cross<br>Dr. Waldron, you, as you said, were employed by the |
| 2  | University of Memphis, right?                                          |
| 3  | A. Yes, sir.                                                           |
| 4  | Q. And you have been working for quite a while at what used to         |
| 5  | be called the Groundwater Institute, correct?                          |
| 6  | A. Yes, sir.                                                           |
| 7  | Q. And a lot of times we refer to that as GWI?                         |
| 8  | A. Yes, sir.                                                           |
| 9  | Q. Now we refer to it by another acronym?                              |
| 10 | A. CAESER.                                                             |
| 11 | Q. CAESER?                                                             |
| 12 | A. More like the Roman leader, not the salad.                          |
| 13 | Q. I got you. I never can spell it right.                              |
| 14 | But I'm just going to refer to CAESER instead of the                   |
| 15 | full name.                                                             |
| 16 | A. Yes, sir.                                                           |
| 17 | Q. And when you were talking about the work you do at the              |
| 18 | university, you said one of the things you do is bring in              |
| 19 | research for the university, correct?                                  |
| 20 | A. Yes, sir, I do.                                                     |
| 21 | Q. Now, research for the university includes doing work for            |
| 22 | MLGW, correct?                                                         |
| 23 | A. Yes, sir, it does.                                                  |
| 24 | Q. And you certainly don't want to take away any take any              |
| 25 | positions publicly that would be adverse to one of your largest        |
|    |                                                                        |

|    | 8                                                              | 392 |
|----|----------------------------------------------------------------|-----|
| 1  | Waldron - cross<br>beneficiaries benefactors, would you?       |     |
| 2  | A. I could you repeat the question?                            |     |
| 3  | Q. MLGW is one of CAESER's largest benefactors, correct?       |     |
| 4  | A. Right now it is, yes.                                       |     |
| 5  | Q. Okay. And you certainly don't want to take any positions    |     |
| 6  | publicly that would be adverse to MLGW's interests, would you? | ?   |
| 7  | A. No.                                                         |     |
| 8  | Q. Now, your résumé, your CV, is attached to well, it's        |     |
| 9  | been marked as Exhibit D155. And I notice that back on         |     |
| 10 | page four of that CV there are a list of grants and contracts. | •   |
| 11 | A. Yes, sir.                                                   |     |
| 12 | Q. I see, just for example, you received in 2019, \$250,000    |     |
| 13 | from MLGW, correct?                                            |     |
| 14 | A. Yes, sir.                                                   |     |
| 15 | Q. And you've got \$1 million from MLGW in 2018 for an aquitar | ٢d  |
| 16 | study?                                                         |     |
| 17 | A. Yes, sir, we did.                                           |     |
| 18 | Q. And in 2018, from MLGW, you received \$436,000 for some     |     |
| 19 | mapping?                                                       |     |
| 20 | A. Yes.                                                        |     |
| 21 | MR. BRANSON: Objection, your Honor. He's using just            | 2   |
| 22 | the pronoun "you," and I want to make clear we're not talking  |     |
| 23 | about Dr. Waldron personally.                                  |     |
| 24 | BY MR. MOFFETT:                                                |     |
| 25 | Q. I would hope you didn't get it.                             |     |

|    | 893                                                                         |
|----|-----------------------------------------------------------------------------|
| 1  | Waldron - cross<br>A. No, CAESER did. University actually the University of |
| 2  | Memphis did.                                                                |
| 3  | Q. We'll clarify. University of Memphis?                                    |
| 4  | A. Yes, sir.                                                                |
| 5  | Q. Yes. And that's what I meant by "you," and I think you and               |
| 6  | I understood that, you personally.                                          |
| 7  | So continuing on, CAESER in 2018 received \$250,000                         |
| 8  | from MLGW, correct?                                                         |
| 9  | A. Correct.                                                                 |
| 10 | Q. And in 2017, \$412,000 from MLGW for some mapping?                       |
| 11 | A. Yes, sir.                                                                |
| 12 | Q. And in 2017, it looks like \$250,000 from MLGW?                          |
| 13 | A. Yes, sir.                                                                |
| 14 | Q. To 412,000 from MLGW in 2016?                                            |
| 15 | A. Yes, sir.                                                                |
| 16 | Q. \$250,000 from MLGW in 2016?                                             |
| 17 | A. Yes, sir.                                                                |
| 18 | Q. And 2015, about the time we filed, I guess, this instant                 |
| 19 | proceeding, you received you, CAESER, received about                        |
| 20 | \$250,000 from MLGW, correct?                                               |
| 21 | A. Yes, sir.                                                                |
| 22 | Q. And there are some others. I won't go through all of                     |
| 23 | those; they're listed on there. But historically, MLGW has in               |
| 24 | fact been a large contributor to the operations of CAESER, or               |
| 25 | formerly GWI, correct?                                                      |

|    | 894                                                          |
|----|--------------------------------------------------------------|
| 1  | Waldron - cross<br>A. Yes, sir.                              |
| 2  | Q. And as I understand, just for historical purposes and     |
| 3  | contexts, Groundwater Institute was formed back in around    |
| 4  | what, 1992 or so?                                            |
| 5  | A. 1992, yes, sir.                                           |
| б  | Q. Okay. And that was really a collaborative effort between  |
| 7  | University of Memphis and MLGW, correct?                     |
| 8  | A. Yes, sir.                                                 |
| 9  | Q. And GWI was formed to address concerns about groundwater, |
| 10 | correct?                                                     |
| 11 | A. Yes.                                                      |
| 12 | Q. And while you were with GWI well, I don't know what you   |
| 13 | were doing at the specific time, but you worked with Randy   |
| 14 | Gentry in the '90s at GWI, right?                            |
| 15 | A. In 1999 and then in 2000ish.                              |
| 16 | Q. And some of the things that GWI does for MLGW is develop  |
| 17 | wellhead protection plans, correct?                          |
| 18 | A. Yes, sir.                                                 |
| 19 | Q. And by the way, those are maps that delineate zones of    |
| 20 | influence around production wells?                           |
| 21 | A. Yes, it is, and it includes the mapping of potential      |
| 22 | contaminant sources within those zones, and has an education |
| 23 | outreach component, yes, sir.                                |
| 24 | Q. And GWI now CAESER, I guess performs some modeling,       |
| 25 | mapping of Memphis Sands aquifer for MLGW?                   |

| 895                                                                          |
|------------------------------------------------------------------------------|
| Waldron - cross<br>A. Yes. One of our projects was doing some modeling, most |
| recently.                                                                    |
| Q. Now, I don't I saw some reference to GWI assisting MLGW                   |
| with the potential placement of a wellfield. Was that the                    |
| was it called Charlie Pickle?                                                |
| A. Yes, or the Pickle plant.                                                 |
| Q. That's a great name, the Pickle plant.                                    |
| A. He was a good guy, but he had a funny last name.                          |
| Q. He did.                                                                   |
| And whatever happened to that? Is that                                       |
| A. You know, it hasn't been I don't know where it is within                  |
| MLGW, but we did perform a plausible wellhead protection plan                |
| around that.                                                                 |
| Q. Now, I read something in the paper about a recent contract                |
| that's been awarded by the City of Memphis about something to                |
| CAESER about a \$5 million contract. Is that correct? Has                    |
| CAESER received a recent contract from Memphis?                              |
| A. More correct would be that the City of Memphis, with MLGW,                |
| went to raise these dollars through the City Council, but the                |
| contract is not from the City of Memphis; it's from Memphis                  |
| Light, Gas & Water.                                                          |
| Q. Go ahead. Excuse me, Brian I mean Dr. Waldron.                            |
| A. Whatever.                                                                 |
| Q. I may slip through "Brian"                                                |
| A. That's okay.                                                              |
|                                                                              |

|    | 896                                                             |
|----|-----------------------------------------------------------------|
| 1  | Waldron - cross<br>Q it's no sign of disrespect.                |
| 2  | A. No, sir. That's fine.                                        |
| 3  | Could you repeat the part that you wanted to know?              |
| 4  | Q. Well, let's break it down. First of all, yes, there is a     |
| 5  | contract recently entered with Memphis related by CAESER,       |
| 6  | correct?                                                        |
| 7  | Or who's the contract with, let's start it?                     |
| 8  | A. The contract is between Memphis Light, Gas & Water and the   |
| 9  | University of Memphis, being done through CAESER.               |
| 10 | Q. All right. What is the scope of the contract, or the         |
| 11 | project the contract addresses?                                 |
| 12 | A. The scope of the contract is addressing specifically the     |
| 13 | what we call the aquitard, which is the upper confining unit to |
| 14 | the Middle Claiborne Aquifer. And it's looking at the presence  |
| 15 | of naturally occurring breaches within the aquitard and the     |
| 16 | movement of water between the shallow groundwater system        |
| 17 | through those breaches into Middle Claiborne Aquifer.           |
| 18 | Q. Is the concern potential contamination being drawn as an     |
| 19 | aquifer? Is that part of the concern?                           |
| 20 | A. That is drawing some concern, yes, sir.                      |
| 21 | Q. And are you going to be one of the folks working on that?    |
| 22 | A. I am working on that, yes, sir.                              |
| 23 | Q. Now, when did you become an expert for the State of          |
| 24 | Tennessee?                                                      |
| 25 | A. 2017.                                                        |
|    |                                                                 |

|    | 897                                                                              |
|----|----------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>Q. Now, when you became an expert for Tennessee, you knew the |
| 2  | positions that Tennessee and MLGW were advocating in this case,                  |
| 3  | correct?                                                                         |
| 4  | A. Yes, sir.                                                                     |
| 5  | Q. And when you formulated the definition we're going to talk                    |
| 6  | about here shortly, about interstate resource, you knew what                     |
| 7  | kind of definition and opinion would be a good one for                           |
| 8  | Tennessee and MLGW's defense of this case, and what kind of                      |
| 9  | definition would not be so good for them. Would you agree with                   |
| 10 | that?                                                                            |
| 11 | A. No. I I developed my definition independent of how I                          |
| 12 | felt people would feel.                                                          |
| 13 | Q. All right. But you didn't, at the time, even think about                      |
| 14 | what might be good for their defense and what might be not so                    |
| 15 | good for the defense? Are you telling us under oath that that                    |
| 16 | didn't enter your mind at all?                                                   |
| 17 | A. Oh, sure, it entered my mind.                                                 |
| 18 | Q. Now, let's look at the definition of "interstate resource."                   |
| 19 | A. Yes, sir.                                                                     |
| 20 | Q. And I looked at your report, and some of the things I had                     |
| 21 | to say ask you about would be based on your report; some of                      |
| 22 | them will be based on your testimony. But in your report, you                    |
| 23 | stated it this way, that you had been asked to give your                         |
| 24 | opinions on whether the groundwater in the Middle Claiborne                      |
| 25 | Aquifer Middle Claiborne is an interstate resource, right?                       |
|    |                                                                                  |

|    | 898                                                           |
|----|---------------------------------------------------------------|
| 1  | Waldron - cross<br>A. Yes, sir.                               |
| 2  | MR. BRANSON: Your Honor, I'd ask, if we're going to           |
| 3  | read from the report, that we provide the witness with a copy |
| 4  | and a cite.                                                   |
| 5  | Q. Dr. Waldron, you have a copy in front of you; it's in the  |
| 6  | notebook.                                                     |
| 7  | MR. BRANSON: Mr. Moffett, I just ask we clarify which         |
| 8  | report we're talking about. Page cite, things like that.      |
| 9  | MR. MOFFETT: I apologize.                                     |
| 10 | MR. BRANSON: Your Honor, I'd also just note                   |
| 11 | Dr. Waldron's screen appears to be flashing black and white.  |
| 12 | I'm concerned it might be distracting him.                    |
| 13 | I don't know if it is, Dr. Waldron.                           |
| 14 | A. No, I was about to break into disco, but I'm doing okay.   |
| 15 | I don't know where it is.                                     |
| 16 | Q. Dr. Waldron, if you would, I'm not sure which exhibit      |
| 17 | number it is, but it's your initial report, dated June 30,    |
| 18 | 2017.                                                         |
| 19 | A. I have it.                                                 |
| 20 | Q. Okay. And would you please turn to page 2.                 |
| 21 | A. Yes.                                                       |
| 22 | Q. At the top, would you read what's provided there in        |
| 23 | paragraph five.                                               |
| 24 | A. I'm not in the right spot. Page two is a table of          |
| 25 | contents, for me.                                             |
|    |                                                               |

|    | 899                                                          |
|----|--------------------------------------------------------------|
| 1  | Waldron - cross<br>Q. Well, it's okay.                       |
| 2  | A. Oh, you mean page two.                                    |
| 3  | Q. Two, page two.                                            |
| 4  | A. I was looking at page two on the thingamabob. Okay.       |
| 5  | Number five?                                                 |
| 6  | Q. Yes, sir.                                                 |
| 7  | A. Okay. Got it.                                             |
| 8  | "The central question that I have been asked to give         |
| 9  | my opinion on is whether the groundwater in the Middle       |
| 10 | Claiborne Aquifer is an interstate resource."                |
| 11 | Q. So you agree that was your assignment?                    |
| 12 | A. Yes, sir.                                                 |
| 13 | Q. And what is your definition of an interstate resource?    |
| 14 | A. It is an aquifer, and that constitutes the geology of the |
| 15 | water that crosses a political boundary.                     |
| 16 | Q. That's it?                                                |
| 17 | A. That's it. Water flows across the boundary. That's it.    |
| 18 | Q. That's one thing, so it's also it's both geographic       |
| 19 | in the sense that the aquifer underlies multiple states, and |
| 20 | there's some hydraulic there's some water that goes across   |
| 21 | state lines; those two things?                               |
| 22 | A. Yes, sir.                                                 |
| 23 | Q. Okay. And based upon that, you believe that the Middle    |
| 24 | Claiborne Aquifer, as you've described it, is an interstate  |
| 25 | resource, correct?                                           |
|    | 900                                                             |
|----|-----------------------------------------------------------------|
| 1  | Waldron - cross<br>A. Yes, sir.                                 |
| 2  | Q. All right. Now, isn't it true that when you were carrying    |
| 3  | out your assignment, to reach a definition that you present     |
| 4  | here today, that you simply read the Court's order and inferred |
| 5  | a definition of "interstate resource"?                          |
| 6  | A. I did read Judge Siler's opinion, and based upon what he     |
| 7  | had stated, based upon my understanding of what I would         |
| 8  | constitute an interstate resource, I came to my conclusion of   |
| 9  | what that would be, yes, sir.                                   |
| 10 | Q. So just to be clear, you didn't go out and look in some      |
| 11 | body of scientific literature for the definition of "interstate |
| 12 | resource"; you didn't do that?                                  |
| 13 | A. I had done some research on my paper where I had looked at   |
| 14 | transboundary or water systems, and the European Union has      |
| 15 | looked into that. And at the time I didn't see a definition.    |
| 16 | They actually have one.                                         |
| 17 | But no, it was just the fact of what I stated.                  |
| 18 | Q. Well, let's be clear: Did you or did you not go to           |
| 19 | scientific publications and attempt to find a definition of the |
| 20 | phrase "interstate resource"?                                   |
| 21 | A. I don't recall if I did.                                     |
| 22 | Q. And you said that you looked did a little looking, and       |
| 23 | you found something about transboundary, correct?               |
| 24 | A. That's the more common term that I'm used to, yes, sir.      |
| 25 | Q. Does the word "transboundary" appear anywhere in your        |
|    |                                                                 |

|    | 901                                                                          |
|----|------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>the reports, the written reports you've submitted in this |
| 2  | proceeding?                                                                  |
| 3  | A. I do not know.                                                            |
| 4  | Q. Do you know of any occasion during your deposition where                  |
| 5  | you used the word "transboundary"?                                           |
| 6  | A. I do not recall.                                                          |
| 7  | Q. Now, you mentioned, when you were talking about interstate                |
| 8  | resource, in the science of hydrogeology, that political                     |
| 9  | boundaries don't affect hydrogeology of groundwater, correct?                |
| 10 | A. Correct.                                                                  |
| 11 | Q. Yet it is your testimony that "transboundary" is a                        |
| 12 | hydrology term?                                                              |
| 13 | A. I only know it as a term that is used by others to describe               |
| 14 | an aquifer system that crosses political boundaries.                         |
| 15 | Q. It's descriptive; it's a descriptive word. It's not a                     |
| 16 | hydrology term?                                                              |
| 17 | A. I don't know if it is or is not. I                                        |
| 18 | Q. But hydrologists don't use that word in their discipline,                 |
| 19 | do they?                                                                     |
| 20 | A. Well, you know, I know that the way that "transboundary"                  |
| 21 | has been used in other by others, it does describe the                       |
| 22 | hydrology as crossing the same the political boundary.                       |
| 23 | Q. So do boundaries matter or not?                                           |
| 24 | A. The boundaries matter that the geology in the water crosses               |
| 25 | it, yes.                                                                     |

|    | 902                                                                  |
|----|----------------------------------------------------------------------|
| 1  | Waldron - cross<br>Q. But the political boundaries do not affect the |
| 2  | hydrogeology, right?                                                 |
| 3  | A. In the way of the governing of imposing some change in            |
| 4  | its flow or character of the geology, no.                            |
| 5  | Q. Now go ahead.                                                     |
| б  | A. Oh, no, I'm here.                                                 |
| 7  | Q. All right. Did you ever in your review of documents for           |
| 8  | this case, or any other occasion, find a USGS publication that       |
| 9  | provides a definition of the phrase "interstate resource"?           |
| 10 | A. No, sir, I did not.                                               |
| 11 | Q. Did you ever find, in those materials that you've reviewed        |
| 12 | for this case or other purposes, a definition of the phrase          |
| 13 | "interstate aquifer"?                                                |
| 14 | A. No, sir, I have not.                                              |
| 15 | Q. Now, Dr. Waldron                                                  |
| 16 | A. Yes, sir.                                                         |
| 17 | Q let's now take a look at your opinions, or rather the              |
| 18 | basis for your opinions, I assume.                                   |
| 19 | One of those bases is that this and if you've got                    |
| 20 | your report there, it's on page two, paragraph well,                 |
| 21 | actually the heading of "Opinion 1." Do you see that?                |
| 22 | A. Yes, sir.                                                         |
| 23 | Q. All right. And correct me if I'm reading it wrong, but it         |
| 24 | says that this is your Opinion 1 on page two, your initial           |
| 25 | report, that, quote, "The Middle Claiborne Aquifer extends           |
|    |                                                                      |

|    | 903                                                                       |
|----|---------------------------------------------------------------------------|
| 1  | Waldron - cross<br>continuously underneath Tennessee and Mississippi, and |
| 2  | groundwater in the aquifer is not and has never been confined             |
| 3  | to the borders of Mississippi or any other state."                        |
| 4  | Did I read that correctly?                                                |
| 5  | A. Yes, sir, you did.                                                     |
| 6  | Q. Dr. Waldron, you've been studying the Middle Claiborne for             |
| 7  | a long time, haven't you?                                                 |
| 8  | A. Yes, sir, I have.                                                      |
| 9  | Q. Long, long time; since the '90s, early '90s, I guess?                  |
| 10 | A. Yes, sir.                                                              |
| 11 | Q. And I think you said you wrote your master's thesis on the             |
| 12 | Middle Claiborne or Memphis Aquifer?                                      |
| 13 | A. My master's thesis was on a proposed landfill in the                   |
| 14 | Galloway section in the Middle Claiborne Aquifer, yes, sir.               |
| 15 | Q. Now, I got to say I may be in the minority, but I think                |
| 16 | there's been a lot of confusion in this case about terminology.           |
| 17 | And I'm going to try one of the things I want to do is see                |
| 18 | if we can find some common ground on some things.                         |
| 19 | A. Okay.                                                                  |
| 20 | Q. And let me see if we can get on the same page.                         |
| 21 | Now, do you agree with me that an aquifer system, the                     |
| 22 | phrase "aquifer system," is a term used to refer to a regional            |
| 23 | collection of hydrogeologic units?                                        |
| 24 | A. Yes, sir.                                                              |
| 25 | Q. An example of that would be would be what? Let me state                |
|    |                                                                           |

|    | 904                                                                         |
|----|-----------------------------------------------------------------------------|
| 1  | Waldron – cross<br>it the Mississippi Embayment Regional Aquifer System, is |
| 2  | that is that a description of an aquifer system?                            |
| 3  | A. Yes, sir.                                                                |
| 4  | Q. Okay. Now, let's take that down a step. What is a                        |
| 5  | hydrogeologic unit?                                                         |
| 6  | A. That is a finer description of a particular aquifer or                   |
| 7  | confining unit within that aquifer system.                                  |
| 8  | Q. Now, hydrogeologic units can either be a confining unit or               |
| 9  | an aquifer unit, correct?                                                   |
| 10 | A. Yes, sir.                                                                |
| 11 | Q. And a hydrogeologic aquifer unit can include one or more                 |
| 12 | aquifers, correct?                                                          |
| 13 | A. Yes.                                                                     |
| 14 | Q. Okay. And a hydrogeologic confining unit can contain one                 |
| 15 | or more confining layers, correct?                                          |
| 16 | A. Yes.                                                                     |
| 17 | Q. We're doing good so far.                                                 |
| 18 | A. Okay.                                                                    |
| 19 | Q. Now                                                                      |
| 20 | A. Someone is.                                                              |
| 21 | Q. Your testimony has been referring to the Middle Claiborne                |
| 22 | Aquifer, correct?                                                           |
| 23 | A. Yes, sir.                                                                |
| 24 | Q. But when you use that phrase, you are referring to a single              |
| 25 | hydrogeologic unit, correct?                                                |
|    |                                                                             |

Г

|    | 905                                                            |  |  |
|----|----------------------------------------------------------------|--|--|
| 1  | Waldron - cross<br>A. Correct.                                 |  |  |
| 2  | Q. You're not referring to a single aquifer, but a single      |  |  |
| 3  | hydrogeologic unit, correct?                                   |  |  |
| 4  | A. Correct.                                                    |  |  |
| 5  | Q. Now, we agree that a hydrogeological aquifer unit can       |  |  |
| 6  | contain more than one aquifer, correct?                        |  |  |
| 7  | A. Correct.                                                    |  |  |
| 8  | Q. What aquifers are included in the Middle Claiborne Aquifer  |  |  |
| 9  | unit?                                                          |  |  |
| 10 | A. In the Middle Claiborne Aquifer, they're given different    |  |  |
| 11 | names in different areas. So as you look at that hydrogeologic |  |  |
| 12 | unit, the different aquifer names that could exist are the     |  |  |
| 13 | Memphis Sand, the Sparta Aquifer, the Meridian West Sand, the  |  |  |
| 14 | Lower Claiborne Aquifer. Yes.                                  |  |  |
| 15 | Q. And is it your testimony do you agree that the Memphis      |  |  |
| 16 | Aquifer itself has been recognized as a separate aquifer?      |  |  |
| 17 | A. From                                                        |  |  |
| 18 | MR. BRANSON: Object to the form, your Honor.                   |  |  |
| 19 | Separate from what?                                            |  |  |
| 20 | THE COURT: Well                                                |  |  |
| 21 | MR. MOFFETT: As its own.                                       |  |  |
| 22 | THE COURT: Overruled. You may answer the question.             |  |  |
| 23 | BY MR. MOFFETT:                                                |  |  |
| 24 | Q. It is an aquifer?                                           |  |  |
| 25 | A. The Memphis Aquifer is a name given to the Middle Claiborne |  |  |

|    | 906                                                                           |
|----|-------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>Aquifer as one of the aquifers within the Middle Claiborne |
| 2  | Aquifer.                                                                      |
| 3  | Q. That's what I'm trying to get clarified, okay?                             |
| 4  | A. All right.                                                                 |
| 5  | Q. So the Memphis Aquifer is one of the aquifers that is                      |
| 6  | included in the Middle Claiborne Aquifer unit?                                |
| 7  | A. It's one of the names given of the aquifer that we call in                 |
| 8  | Tennessee, global regionally, you would call it the Middle                    |
| 9  | Claiborne Aquifer.                                                            |
| 10 | Q. All right. Let me look at your report on page two,                         |
| 11 | paragraph                                                                     |
| 12 | A. Okay.                                                                      |
| 13 | Q. First sentence, it says "There is a scientific consensus                   |
| 14 | that the 'Memphis Aquifer' and the 'Sparta Aquifer' are parts                 |
| 15 | of one aquifer, a single hydrological unit referred to as the                 |
| 16 | Middle Claiborne Aquifer."                                                    |
| 17 | Did I read that correctly?                                                    |
| 18 | A. You read that correctly, yes, sir.                                         |
| 19 | Q. So again, the reason we're talking here, when we use the                   |
| 20 | term the "Middle Claiborne Aquifer Unit," we're talking about                 |
| 21 | the hydrogeologic unit, correct?                                              |
| 22 | A. Correct.                                                                   |
| 23 | Q. So this case concerns two separate aquifers that are                       |
| 24 | located at least two separate aquifers that are located                       |
| 25 | within that single hydrogeologic unit; do you agree with that?                |
|    |                                                                               |

|    |                                                                | 907                                                                      |
|----|----------------------------------------------------------------|--------------------------------------------------------------------------|
| 1  | A.                                                             | Waldron - cross<br>No, I thought we were looking at the Middle Claiborne |
| 2  | Aqui                                                           | ifer, the Middle Claiborne Aquifer.                                      |
| 3  | Q.                                                             | Right.                                                                   |
| 4  | A.                                                             | Hydrogeologic unit.                                                      |
| 5  | Q.                                                             | And is it your testimony under oath that there is no                     |
| 6  | difference between the Memphis Aquifer and the Sparta Aquifer? |                                                                          |
| 7  | A.                                                             | Just a naming convention.                                                |
| 8  | Q.                                                             | It's just a name change that you go from Tennessee, it's                 |
| 9  | Memr                                                           | phis Aquifer, and when you cross the state border it's the               |
| 10 | Spar                                                           | rta Aquifer; is that what you're saying?                                 |
| 11 | A.                                                             | Yes, sir.                                                                |
| 12 | Q.                                                             | Well, we were making progress up until                                   |
| 13 | A.                                                             | Hmm?                                                                     |
| 14 | Q.                                                             | We were making some progress until just a few minutes ago.               |
| 15 | A.                                                             | I think we're going to be going round and round on this                  |
| 16 | one.                                                           |                                                                          |
| 17 | Q.                                                             | We're not going to fight?                                                |
| 18 | Α.                                                             | I'm sure we're not.                                                      |
| 19 | Q.                                                             | At the risk of making everybody scream, I've got a chart up              |
| 20 | here                                                           | e back, go back. Okay.                                                   |
| 21 |                                                                | All right. This is one of these MERAS charts, and                        |
| 22 | ther                                                           | re's a bunch of versions floating around, I know. But                    |
| 23 | look                                                           | king at this chart, Dr. Waldron, would you please do you                 |
| 24 | see                                                            | the column "Hydrogeologic Units" on the right-hand side?                 |
| 25 | Α.                                                             | Yes, sir, I do.                                                          |

| 908                                                                         |
|-----------------------------------------------------------------------------|
| Waldron - cross<br>Q. All right. And would you identify each of the aquifer |
| units that are listed in that hydrogeologic chart. Just the                 |
| aquifer units.                                                              |
| A. The only thing in the chart are the geologic names. The                  |
| aquifer units are not named; just the hydrogeologic units. You              |
| mean name those?                                                            |
| Q. Just the hydrogeologic units.                                            |
| A. Oh, like all of them?                                                    |
| Q. Yeah, just want to make sure. So I can look at them for                  |
| you.                                                                        |
| The Mississippi River Valley Alluvial Aquifer is one.                       |
| The Upper Claiborne Aquifer unit is another. The Middle                     |
| Claiborne Aquifer quantity is listed. The Lower Claiborne                   |
| Aquifer is listed. There's a listing in the middle, Wilcox                  |
| Aquifer unit. And there's a listing at the Lower Wilcox                     |
| Aquifer unit. Correct?                                                      |
| A. Yes, sir, correct.                                                       |
| Q. So within the Mississippi Embayment Regional Aquifer                     |
| System, that's an identification of those hydrogeologic units               |
| that are aquifer units, correct?                                            |
| A. Yes, sir.                                                                |
| Q. All right. Then you also have confined units listed. We                  |
| see there Vicksburg-Jackson Confining Unit, and then we have                |
| the Middle Claiborne Aquifer Confining Unit. We have a Lower                |
| Claiborne Confining Unit. And down at the very bottom, there's              |
|                                                                             |

| 909                                                             | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Waldron - cross<br>a Midway Confining Unit, correct?            | -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| A. Yes, sir.                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Q. So those are the hydrogeologic units that are confining      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| units within the Mississippi Embayment Aquifer System, correct? |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A. For what's listed here, yes, sir.                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Q. Yes, sir. That's all.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A. Sorry.                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Q. All right. Now, Dr. Waldron, I'm also not going to belabor   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| this, but it may be a relative term, but the I see here         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| there is again a Sparta Sand listed under Mississippi,          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Kentucky, and Louisiana, Southern Arkansas, right? There's a    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| geologic unit?                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A. Yes.                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Q. Geology. And then the Memphis Sand is in Tennessee,          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Missouri, and Northeastern Arkansas, correct?                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A. That's what's shown in the figure, yes.                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Q. Okay. There's been a lot of talk about a so-called facies    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| change, where the geology changes in the vicinity of the        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Tennessee/Mississippi border. Is it it's your opinion, is       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| it not, that this facies change marks the southern boundary of  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| the Memphis Aquifer?                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A. No. Because the Middle Claiborne you said "Memphis           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Aquifer"?                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Q. Yes.                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| A. No, because the Memphis Aquifer is part of the Middle        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|                                                                 | <pre>901<br/>Waldron - cross<br/>a Midway Confining Unit, correct?<br/>A. Yes, sir.<br/>Q. So those are the hydrogeologic units that are confining<br/>units within the Mississippi Embayment Aquifer System, correct?<br/>A. For what's listed here, yes, sir.<br/>Q. Yes, sir. That's all.<br/>A. Sorry.<br/>Q. All right. Now, Dr. Waldron, I'm also not going to belabor<br/>this, but it may be a relative term, but the I see here<br/>there is again a Sparta Sand listed under Mississippi,<br/>Kentucky, and Louisiana, Southern Arkansas, right? There's a<br/>geologic unit?<br/>A. Yes.<br/>Q. Geology. And then the Memphis Sand is in Tennessee,<br/>Missouri, and Northeastern Arkansas, correct?<br/>A. That's what's shown in the figure, yes.<br/>Q. Okay. There's been a lot of talk about a so-called facies<br/>change, where the geology changes in the vicinity of the<br/>Tennessee/Mississippi border. Is it it's your opinion, is<br/>it not, that this facies change marks the southern boundary of<br/>the Memphis Aquifer?<br/>A. No. Because the Middle Claiborne you said "Memphis<br/>Aquifer"?<br/>Q. Yes.<br/>A. No, because the Memphis Aquifer is part of the Middle</pre> |

|    | Waldron - gross                                                 |
|----|-----------------------------------------------------------------|
| 1  | Claiborne, and the Middle Claiborne includes the Sparta and the |
| 2  | Meridian, and therefore extends into Mississippi.               |
| 3  | Q. Okay. The Memphis Sand extends into Mississippi, but then    |
| 4  | known as the Sparta; is that what you're saying?                |
| 5  | A. Correct. Well, the Memphis Sand is a large body, so the      |
| 6  | Memphis like when you cross that line, you have the Memphis     |
| 7  | Aquifer and then the Sparta. It's just a naming convention.     |
| 8  | Q. Okay.                                                        |
| 9  | A. So it comes one body of sand. Then, as you move further      |
| 10 | south in Mississippi, you will call it at the top, the Sparta   |
| 11 | Aquifer, and then down below, you'll call it the Lower          |
| 12 | Claiborne.                                                      |
| 13 | Q. Okay. By the way, on the chart here, under "Mississippi,"    |
| 14 | just going down from youngest to oldest, I suppose, you've got  |
| 15 | the Sparta Sand and the Zilpha Clay, Winona Sand, and the       |
| 16 | Tallahatta Formation, and Meridian Sand, correct?               |
| 17 | A. Yes, sir.                                                    |
| 18 | Q. Is it your testimony that the Winona Sand is the same        |
| 19 | aquifer as the Sparta Sand?                                     |
| 20 | A. The Zilpha the Winona Sand is a sand unit within the         |
| 21 | Zilpha Clay, and that facies or that unit actually              |
| 22 | penetrates into the middle of the Middle Claiborne Aquifer and  |
| 23 | subprops or terminates.                                         |
| 24 | Q. So it is the same aquifer as Sparta Sand?                    |
| 25 | A. You mean as an aquifer itself? The Winona Sand actually      |

|    | 911                                                                             |
|----|---------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>does, from what I've seen from USGS publications, breaks out |
| 2  | from Zilpha Clay and exposes itself as sand. So in that                         |
| 3  | particular case, it acts as 100 geologic units as part of the                   |
| 4  | Middle Claiborne Aquifer.                                                       |
| 5  | And if you want to daisy-chain it, then that's                                  |
| 6  | Q. Well, I'm just trying to understand. So even if the Sparta                   |
| 7  | Sand is separated from the Winona Sand by the Zilpha Clay, and                  |
| 8  | the Winona Sand is separated from the Meridian Sand member by                   |
| 9  | the Tallahatta Formation, the Meridian Sand, the Winona Sand,                   |
| 10 | and the Sparta Sand are the same aquifer; that's your                           |
| 11 | testimony?                                                                      |
| 12 | A. They are all part of the Middle Claiborne Aquifer.                           |
| 13 | Q. Hydrogeologic unit?                                                          |
| 14 | A. Yes.                                                                         |
| 15 | Q. I'm asking if your testimony is that they are separate                       |
| 16 | aquifers from each other. Is the Sparta Aquifer separate from                   |
| 17 | the Winona?                                                                     |
| 18 | A. So if you were that's where I always get confused                            |
| 19 | between the naming convention and the unit itself. So if I was                  |
| 20 | to model it, I would put a as they do with MERAS, I would                       |
| 21 | put a layer of grid cells on the Sparta. I'd do a layer of                      |
| 22 | grid cells for the Zilpha Clay section area, and a layer of                     |
| 23 | cells for the Meridian Sand member, because of the property                     |
| 24 | change.                                                                         |
| 25 | Q. So it's your testimony that the Memphis Aquifer stops at                     |
|    |                                                                                 |

|    | 912                                                                              |
|----|----------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>the Tennessee/Mississippi line, and then we've got the Sparta |
| 2  | Aquifer? Again, I'm just trying to make sure.                                    |
| 3  | A. I think we've we've done this one before.                                     |
| 4  | Q. All right.                                                                    |
| 5  | A. It's the Middle Claiborne Aquifer.                                            |
| 6  | Q. All right. All right.                                                         |
| 7  | I'm going to show a slide here that's from your                                  |
| 8  | report, I believe. Do you recognize this?                                        |
| 9  | A. Ooh. Yes.                                                                     |
| 10 | Q. Is this what is this?                                                         |
| 11 | A. This is Figure 1. It's showing the geography of the area.                     |
| 12 | MR. BRANSON: Just for the record, could we identify                              |
| 13 | what exhibit and what page we're on, so that the rest of us                      |
| 14 | THE COURT: It should be identified, whatever that is.                            |
| 15 | MR. MOFFETT: D174. I apologize, your Honor, for the                              |
| 16 | delay on that. This is at D174, page 4 of 21.                                    |
| 17 | Q. Dr. Waldron, this is a figure in your predevelopment flow                     |
| 18 | article, correct?                                                                |
| 19 | A. Yes, sir, it is.                                                              |
| 20 | Q. And Figure Number 1, correct?                                                 |
| 21 | A. Yes, sir.                                                                     |
| 22 | Q. All right. Read the description of Figure 1.                                  |
| 23 | A. "Map of the Memphis area and surrounding region, showing                      |
| 24 | the estimated outcrop zone for the Memphis Aquifer from                          |
| 25 | Brahana & Broshears 2001. Transition is approximate southern                     |

|    | 913                                                                             |
|----|---------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>extent of Memphis Aquifer in Northern Mississippi, where the |
| 2  | regional Middle Claiborne is divided into three or more                         |
| 3  | distinct aquifers separated by regional confining units." With                  |
| 4  | a citation.                                                                     |
| 5  | Q. So in this report, or this publication, which you prepared                   |
| 6  | before you formulated your opinions in this case, you recognize                 |
| 7  | that the Memphis Aquifer was a separate and distinct aquifer                    |
| 8  | that terminated at the southern basin and transition zone,                      |
| 9  | correct?                                                                        |
| 10 | A. Yes.                                                                         |
| 11 | Q. Okay. And then the transition zone you've got there, about                   |
| 12 | how far south would you just estimate that transition zone is                   |
| 13 | there from the Tennessee/Mississippi border?                                    |
| 14 | A. About tennish miles.                                                         |
| 15 | Q. Tennish. Okay.                                                               |
| 16 | So based on what you said here, the Memphis Aquifer                             |
| 17 | didn't change to the Sparta Sand at the state line; it                          |
| 18 | changed or there was a change that occurred at the                              |
| 19 | transition zone. This wasn't just a name change, was it,                        |
| 20 | Dr. Waldron?                                                                    |
| 21 | A. According to this, this is the way it's stated here is                       |
| 22 | that the Memphis Aquifer would be given the name below the                      |
| 23 | Mississippi state line.                                                         |
| 24 | Q. Well                                                                         |
| 25 | A. A name.                                                                      |
|    |                                                                                 |

|    | 914                                                                        |
|----|----------------------------------------------------------------------------|
| 1  | Waldron - cross<br>Q. Read the second sentence. "Transition is approximate |
| 2  | southern extent of Memphis Aquifer in Northern Mississippi."               |
| 3  | Did I read that correct?                                                   |
| 4  | A. Correct.                                                                |
| 5  | Q. Now, you say there and you also say, "Where the regional                |
| 6  | Middle Claiborne is divided into three or more distinct                    |
| 7  | aquifers" distinct aquifers "separated by regional                         |
| 8  | confining units."                                                          |
| 9  | Did I read that correctly?                                                 |
| 10 | A. Yes, sir, you read it correctly.                                        |
| 11 | Q. All right. Please identify for us what you are referring                |
| 12 | to when you referred to three these three or more distinct                 |
| 13 | aquifers. What are those?                                                  |
| 14 | A. I remember one being the Sparta, and I remember the other               |
| 15 | being the Lower Claiborne, and I would assume the third is the             |
| 16 | Memphis.                                                                   |
| 17 | Q. Did you say "Memphis"?                                                  |
| 18 | A. Memphis.                                                                |
| 19 | Q. Do you mean Meridian?                                                   |
| 20 | A. For the Meridian, is the well, the Meridian is the                      |
| 21 | lower the Meridian is the Lower Claiborne Aquifer.                         |
| 22 | Q. Right. Dr. Waldron, I'm not going to go through them, but               |
| 23 | I think you've been in the courtroom while the others were                 |
| 24 | testifying, but if you look at the MERAS maps, I think it's in             |
| 25 | 2009, they show that transition zone right at that border,                 |
|    |                                                                            |

|    | 915                                                                              |
|----|----------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>correct, the Tennessee/Mississippi border, the facies change? |
| 2  | A. It's not I don't think it's called the transition in                          |
| 3  | that. They're calling it the                                                     |
| 4  | Q. "Facies change"?                                                              |
| 5  | A northern extent.                                                               |
| 6  | Q. "Facies change," maybe?                                                       |
| 7  | A. I believe it's called the northern extent of that                             |
| 8  | particular unit, the Lower Claiborne.                                            |
| 9  | Q. Okay. Let's look at hold on just a second.                                    |
| 10 | All right. Let's look at Slide 5, please. Okay.                                  |
| 11 | This is a map from J36, page 26 of 41.                                           |
| 12 | Do you see that they've got a darkened line there                                |
| 13 | that's called "facies transition"?                                               |
| 14 | A. Okay, yes.                                                                    |
| 15 | Q. So they've bumped that facies up north now, right?                            |
| 16 | A. I see that on the figure, yes.                                                |
| 17 | Q. Okay.                                                                         |
| 18 | MR. MOFFETT: By the way, Don, if you would go back to                            |
| 19 | Slide 4.                                                                         |
| 20 | Q. I've heard the Middle Claiborne or rather the when we                         |
| 21 | look at these charts, I think at least it seems to me that                       |
| 22 | from a layman's standpoint, I like charts; but charts are                        |
| 23 | generalizations, right? Typically, right? And when we see                        |
| 24 | this these big pictures, these layer cakes, I've heard the                       |
| 25 | phrase "layer cake"; you remember that                                           |
|    |                                                                                  |

|    | 916<br>Waldron - cross                                         |
|----|----------------------------------------------------------------|
| 1  | A. Yes.                                                        |
| 2  | Q description being used?                                      |
| 3  | But really, what's underneath the subsurface is really         |
| 4  | pretty messy, isn't it?                                        |
| 5  | A. Depends on how you describe it.                             |
| 6  | Q. Well, I just put a chart up here. This is from J76,         |
| 7  | page 36 of 192. And I think this is from your MERGWS study?    |
| 8  | A. It is.                                                      |
| 9  | MR. MOFFETT: And Don, if you could blow that up just           |
| 10 | a little bit.                                                  |
| 11 | Q. The point I guess I wanted you to confirm here, do you see  |
| 12 | here this on the right is the Cenozoic stratigraphic units in  |
| 13 | Mississippi. And you put this in or you and your cohorts       |
| 14 | put this in the MERGWS study, right?                           |
| 15 | A. Correct.                                                    |
| 16 | Q. And so as we go down here                                   |
| 17 | MR. MOFFETT: Don, just scroll down just a little bit,          |
| 18 | if you would let's go to the EF stop. That's good.             |
| 19 | Q. So when you look at these charts, you can have groups or    |
| 20 | members, but within any geologic formation you can have        |
| 21 | submembers, right?                                             |
| 22 | A. Correct.                                                    |
| 23 | Q. And so as we go down through here, you'll see who the       |
| 24 | formation has got a bunch of submembers, and then you go down, |
| 25 | Vicksburg Group has got a bunch of submembers; Jackson Group's |
|    |                                                                |

|    | 91                                                           | 7 |
|----|--------------------------------------------------------------|---|
| 1  | Waldron - cross<br>got a                                     |   |
| 2  | A. I'm not well, I hear the words, but I'm not following     |   |
| 3  | where you are.                                               |   |
| 4  | Q. I apologize. I hauled off got put my foot on the          |   |
| 5  | accelerator a little bit.                                    |   |
| 6  | The point is that underneath the surface of the earth,       | , |
| 7  | they're not just groups of there's not just these big        |   |
| 8  | formations. You bore down into more detail, correct?         |   |
| 9  | A. What happens is that you do have these very large groups, |   |
| 10 | and based upon the depositional environment made out of      |   |
| 11 | existence, you form the various sublayers that could just be |   |
| 12 | comprised of different levels of sand; they would be given   |   |
| 13 | different names.                                             |   |
| 14 | But it does not mean that you that you necessarily           |   |
| 15 | have to separate them into individual layers. You can treat  |   |
| 16 | them as a single hydrogeologic unit.                         |   |
| 17 | Q. I understand.                                             |   |
| 18 | A. Okay.                                                     |   |
| 19 | Q. I guess the point I'm trying to make is that the down     |   |
| 20 | under the earth is not some layer cake of just these large   |   |
| 21 | layers of formation; it's messy. As I said, it's messy down  |   |
| 22 | there. There's a lot of                                      |   |
| 23 | A. I mean, all systems are geologic systems are              |   |
| 24 | heterogeneous. And the fact that you know, we recognize      |   |
| 25 | that. So as we go down through the earth, and we develop     |   |
|    |                                                              |   |

|    | 918                                                                                |
|----|------------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>these, as you call them, layer cakes, in order to make a better |
| 2  | understanding of them and how these units act as one singular                      |
| 3  | unit, how the water may be moved within it granted, they                           |
| 4  | have heterogeneity that they still act as a singular unit.                         |
| 5  | So, yes, I mean, we'll give it a singular name in                                  |
| 6  | order to simplify the actual layer cake picture that we that                       |
| 7  | we use in order to define these units.                                             |
| 8  | Q. But there is some reason for creating submembers within                         |
| 9  | those                                                                              |
| 10 | A. Geologists like to do it.                                                       |
| 11 | MR. MOFFETT: Now, Don if you would, go back to the                                 |
| 12 | chart. The other one. There you go.                                                |
| 13 | Q. Dr. Waldron, we talked about the Sparta, the Memphis.                           |
| 14 | We're not going to get back to that conversation about what                        |
| 15 | you know, whether it's one or two or whatever. But the Sparta                      |
| 16 | Sand, as a geologic formation, would you agree, is thinner than                    |
| 17 | the Memphis Sand geologic formation, correct?                                      |
| 18 | A. So as you                                                                       |
| 19 | Q. Not as excuse me, Dr. Waldron, and I interrupted, and                           |
| 20 | that's rude; but just to clarify, I'm talking about the                            |
| 21 | thickness of the formation. Let me clarify that.                                   |
| 22 | In terms of its thickness, the Sparta Sand is not as                               |
| 23 | thick as the Memphis Sand?                                                         |
| 24 | A. So it depends on who is labeling the aquifer. So if you're                      |
| 25 | in where you are at that boundary, but if you want to go                           |
|    |                                                                                    |

Γ

|    | 919                                                                             |
|----|---------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>into southern the southern part of Mississippi and be on top |
| 2  | of the Zilpha Clay, then the Sparta Aquifer is is thinner;                      |
| 3  | then you would compare past the facies change, which would be                   |
| 4  | the different people give it different names; Sparta or the                     |
| 5  | Memphis Aquifer, or in this case the Middle Claiborne Aquifer.                  |
| 6  | Q. Okay. Let's look at it in terms of at that point that                        |
| 7  | you had said where the southernmost extent of the Memphis Sand,                 |
| 8  | that's the southern boundary of the Memphis Sand at that                        |
| 9  | transition. South of that point, would you agree that the                       |
| 10 | Sparta Sand formation is not as thick as the Memphis Sand that                  |
| 11 | exists north of that transition?                                                |
| 12 | A. As you have described it, yes.                                               |
| 13 | Q. And again, let's stick with just those two, as I've                          |
| 14 | described. How do those compare in terms of thickness, in                       |
| 15 | terms of some numbers? Can you give me some numbers?                            |
| 16 | A. Well, I would be speculating some.                                           |
| 17 | Q. Don't speculate. But you know a lot about this stuff,                        |
| 18 | based upon your study, you say; so do you have some approximate                 |
| 19 | comparison you can provide for us?                                              |
| 20 | A. I would it's at least half.                                                  |
| 21 | Q. Okay. Now, are there any changes in the sand composition                     |
| 22 | as you move from the Memphis Aquifer south to the Sparta?                       |
| 23 | A. There are changes in the sand composition throughout the                     |
| 24 | entire system, wherever you are.                                                |
| 25 | Q. Okay.                                                                        |

|    | 920                                                             |
|----|-----------------------------------------------------------------|
| 1  | Waldron - cross<br>A. So yes.                                   |
| 2  | Q. Okay. All right. How would you compare the composition of    |
| 3  | the sand in the Memphis Sand north of the transition with the   |
| 4  | sand composition of the Sparta Sand south of the transition?    |
| 5  | A. I don't know.                                                |
| 6  | Q. Okay. Well, in terms of strike that.                         |
| 7  | Dr. Waldron, what is transmissivity?                            |
| 8  | A. Transmissivity is the hydraulic conductivity of a unit       |
| 9  | times its thickness. For a confined aquifer, it's the           |
| 10 | thickness of the Unit B. For a confined aquifer, it's the       |
| 11 | head H.                                                         |
| 12 | Q. Okay. We're not going to use H when they have letters, but   |
| 13 | how about this: Is it the permeability times thickness, is      |
| 14 | that a layman's                                                 |
| 15 | A. Thickness of a saturated section, yes.                       |
| 16 | Q. All right. Now, based on differences in thickness alone,     |
| 17 | would you agree with me that the Memphis Sand transmissivity is |
| 18 | significantly greater than the Sparta Sand's transmissivity?    |
| 19 | A. Yes.                                                         |
| 20 | Q. Now, I want to talk a little bit about the water. I know     |
| 21 | it's here. And we can talk about it in terms of the Middle      |
| 22 | Claiborne hydrogeologic unit, okay? We'll talk about it that    |
| 23 | way. That's what I'm talking about right now. Would you agree   |
| 24 | with me that the water in the Middle Claiborne Aquifer unit is  |
| 25 | not I know this is obvious but it's not one large               |

|    | 921                                                            |
|----|----------------------------------------------------------------|
| 1  | Waldron - cross<br>indivisible object, correct?                |
| 2  | A. It's not one what?                                          |
| 3  | Q. One large object?                                           |
| 4  | A. What isn't one large object?                                |
| 5  | Q. All the water; it's just not a single thing. It's           |
| 6  | comprised of untold numbers of molecules of water, correct?    |
| 7  | A. I don't understand the question. You're saying water is     |
| 8  | comprised of itself?                                           |
| 9  | Q. No. When we talk about water, when you say the water in     |
| 10 | the Middle Claiborne collectively, actually, the water is just |
| 11 | untold numbers of individual separate molecules located at     |
| 12 | different places throughout the aquifer, correct?              |
| 13 | A. The water that exists in the Middle Claiborne Aquifer       |
| 14 | exists with throughout the Middle Claiborne Aquifer.           |
| 15 | Q. But it's made up of individual molecules?                   |
| 16 | A. We're all made up of molecules, sure.                       |
| 17 | Q. The molecules of water can separate from each other.        |
| 18 | They're not                                                    |
| 19 | A. If they do, then they're not water.                         |
| 20 | Q. The molecules, not the atoms.                               |
| 21 | A. Oh.                                                         |
| 22 | Q. I'm talking about molecules of water. As they flow through  |
| 23 | that                                                           |
| 24 | A. Are you saying that the water is separating from itself?    |
| 25 | Q. No. I'm not, Dr. Waldron. All I'm saying is that when       |
|    |                                                                |

|    | 922                                                                         |
|----|-----------------------------------------------------------------------------|
| 1  | Waldron - cross<br>water falls on that outcrop and comes into that aquifer, |
| 2  | that all that water is not going to the same place.                         |
| 3  | A. That, I agree with.                                                      |
| 4  | Q. That's good. We're making progress.                                      |
| 5  | So and the aquifer is not like a big bathtub of                             |
| 6  | water, or an inground lake. It's not an underground lake,                   |
| 7  | right?                                                                      |
| 8  | A. It is not an underground lake, no.                                       |
| 9  | Q. And each molecule of water that is included within the big               |
| 10 | descriptor, "water," is located within the pore spaces of                   |
| 11 | unconsolidated sedimentary material, correct?                               |
| 12 | A. The Middle Claiborne Aquifer is comprised of the porous                  |
| 13 | material and the water, and the water resides within the                    |
| 14 | interstitial pore space of the matrix, yes.                                 |
| 15 | Q. I'm not trying to make you separate out the water from the               |
| 16 | aquifer. All I'm saying, in terms of water, that these                      |
| 17 | molecules of water are located within the pore spaces of                    |
| 18 | sediment?                                                                   |
| 19 | A. Yes. Yes.                                                                |
| 20 | Q. And the water in the Middle Claiborne Aquifer system is                  |
| 21 | going to come into the aquifer from many different places,                  |
| 22 | correct?                                                                    |
| 23 | A. Correct.                                                                 |
| 24 | Q. And these molecules of water are going to take many                      |
| 25 | different paths through that aquifer, correct?                              |
|    |                                                                             |

|    | 923<br>Waldron - cross                                         |
|----|----------------------------------------------------------------|
| 1  | A. Correct.                                                    |
| 2  | Q. And there could be some general flow patterns, but they all |
| 3  | have their own path, correct?                                  |
| 4  | A. Well                                                        |
| 5  | MR. BRANSON: Objection. What is "they"?                        |
| 6  | MR. MOFFETT: Okay. I'll rephrase.                              |
| 7  | THE COURT: Yes. Rephrase.                                      |
| 8  | Q. The point is that these molecules of water, as they come    |
| 9  | into the confined portions of the aquifer, they're each going  |
| 10 | to have to make their way through those pore spaces, correct?  |
| 11 | A. I don't really look at it that way. I look at it from I     |
| 12 | don't really look at molecules. I look at just the general     |
| 13 | movement of water through the porous media.                    |
| 14 | Q. Okay.                                                       |
| 15 | A. So I just look at it that water is going to move through    |
| 16 | the pore space in a particular direction.                      |
| 17 | Q. Okay.                                                       |
| 18 | A. I I don't look at individual molecules.                     |
| 19 | Q. Okay. That's fair. But the water is not all the same        |
| 20 | the water is obviously not all at the same depth, correct?     |
| 21 | A. Correct.                                                    |
| 22 | Q. And they the water has many different fates; would you      |
| 23 | agree that?                                                    |
| 24 | MR. BRANSON: Objection. I don't understand what                |
| 25 | "fates" means.                                                 |
|    |                                                                |

|    | 924                                                                 |
|----|---------------------------------------------------------------------|
| 1  | Waldron - cross<br>THE COURT: All right. Overruled. You may ask the |
| 2  | question.                                                           |
| 3  | Q. They don't always they don't go to the same place when           |
| 4  | they when they travel?                                              |
| 5  | A. What's "they"?                                                   |
| 6  | Q. The water, the molecules of water that constitute the water      |
| 7  | in                                                                  |
| 8  | A. I don't deal with molecules, but if we talk about the            |
| 9  | water, the water will go in different locations, yes.               |
| 10 | Q. All right. Now, is the quality I think you might have            |
| 11 | covered this earlier, but the there are some fairly                 |
| 12 | significant differences throughout the Middle Claiborne Aquifer     |
| 13 | system in terms of water quality, correct?                          |
| 14 | A. I didn't cover it, but there are differences in water            |
| 15 | quality within the Middle Claiborne Aquifer.                        |
| 16 | Q. Right. Could you generally describe as many patterns of          |
| 17 | that as you can describe?                                           |
| 18 | A. I don't know the random.                                         |
| 19 | Q. I mean, are there areas in the Middle Claiborne Aquifer          |
| 20 | hydrologic unit that are known to be of less quality than           |
| 21 | others?                                                             |
| 22 | A. I'm sure somewhere in the aquifer there's going to be a          |
| 23 | difference.                                                         |
| 24 | Q. You can't provide any information on that?                       |
| 25 | A. Well, like I said it's random. So you asked for a pattern.       |
|    |                                                                     |

|    | 925                                                                              |
|----|----------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>And there's not like a trend or big block over here and a big |
| 2  | block over there.                                                                |
| 3  | Q. Okay. So it could be every all over the place?                                |
| 4  | A. The water quality can vary wherever.                                          |
| 5  | Q. Okay. Dr. Waldron, you've been studying the Memphis Sand a                    |
| 6  | long time, and I think you said since the 1990s. You would                       |
| 7  | agree that the Middle Claiborne Aquifer unit is extremely                        |
| 8  | complex, correct?                                                                |
| 9  | A. It has its heterogeneities.                                                   |
| 10 | Q. As you testified earlier, there are variations in                             |
| 11 | thickness, transmissivity, and water quality, etc., throughout                   |
| 12 | the Middle Claiborne?                                                            |
| 13 | A. I testified that there were variations in the thickness and                   |
| 14 | the hydraulic conductivity, and the storage, and in the                          |
| 15 | porosity.                                                                        |
| 16 | Q. And are there differences in the depths at which you can                      |
| 17 | find sand that is capable of producing water into a well?                        |
| 18 | A. Say that again?                                                               |
| 19 | Q. Are there differences in depths as if you were to drill                       |
| 20 | a hole, a water well, right here in the middle of this                           |
| 21 | courtroom, and sink a water well, and find water, that doesn't                   |
| 22 | mean in the Middle Claiborne you can move 100 feet and be                        |
| 23 | assured of finding water there, correct?                                         |
| 24 | A. In the Middle Claiborne Aquifer?                                              |
| 25 | Q. Yes.                                                                          |

|    | Waldron - cross                                                 |
|----|-----------------------------------------------------------------|
| 1  | A. Like anywhere, or                                            |
| 2  | Q. All I'm saying, things change as you go to different         |
| 3  | locations within the Middle Claiborne in terms of the formation |
| 4  | and the thickness of the sand, presence of clay layers, that    |
| 5  | kind of thing?                                                  |
| 6  | A. Well, I mean, there are recognized regional changes. I       |
| 7  | don't think there's any scientific publication that has         |
| 8  | pigeonholed the Middle Claiborne Aquifer to understand every    |
| 9  | possible variation that exists on those matters that I          |
| 10 | mentioned that give you that fine of a scale. We have to        |
| 11 | generalize what is going on in this regional system.            |
| 12 | Q. That's merely all I'm trying to say is we know a lot of      |
| 13 | general things, but there's a lot more specificity that could   |
| 14 | be learned about the Middle Claiborne Aquifer unit, correct?    |
| 15 | A. Yes.                                                         |
| 16 | Q. Okay. Now, let's talk about just briefly about cones of      |
| 17 | depression. Now, you agree with me, don't you, that a majority  |
| 18 | of the groundwater pumped in Shelby County and from the Memphis |
| 19 | Sand is pumped by MLGW, correct?                                |
| 20 | A. I agree with that.                                           |
| 21 | Q. And would you agree with me that the pumping in Shelby       |
| 22 | County is creating a cone of depression that extends into       |
| 23 | DeSoto County, Mississippi?                                     |
| 24 | A. I agree with that.                                           |
| 25 | Q. And would you agree with me that the cone of depression      |
|    |                                                                 |

|    | 927                                                                         |
|----|-----------------------------------------------------------------------------|
| 1  | Waldron - cross<br>causes water to be diverted to to be diverted toward the |
| 2  | center of a cone?                                                           |
| 3  | A. Can you go back to the question prior? Is that all right?                |
| 4  | Q. Yeah. Sure.                                                              |
| 5  | A. Sure. Can you ask the question again?                                    |
| 6  | Q. Let me get an answer I believe I                                         |
| 7  | A. I just wanted clarification. Did you say that MLGW caused                |
| 8  | cone of depression, or just pumping?                                        |
| 9  | Q. I well, let's move on.                                                   |
| 10 | A. Oh, I can't do that?                                                     |
| 11 | Q. If you feel like it needs to be clarified, counsel can do                |
| 12 | that for you.                                                               |
| 13 | A. Sorry. So what's your question, the new one?                             |
| 14 | Q. Well, the new one, I guess, would be the cone of depression              |
| 15 | that has been created by the Shelby County pumping causes water             |
| 16 | to be diverted toward the center of the cone, correct?                      |
| 17 | A. No. There's one cone in the western part of Shelby County,               |
| 18 | and then there are other cones as well. And it's not just the               |
| 19 | Shelby County pumping; there's pumping by Mississippi along the             |
| 20 | border, so it's also forcing that gradient into the northwest               |
| 21 | direction. As that water moves past those wellfields, it's                  |
| 22 | still already in the gradient, and it's still moving toward the             |
| 23 | cone in Shelby County.                                                      |
| 24 | So it's a much broader cause and effect. It's not                           |
| 25 | just one singular                                                           |
|    |                                                                             |

|    | 928                                                             |
|----|-----------------------------------------------------------------|
| 1  | Waldron - cross<br>Q. Okay.                                     |
| 2  | A thing.                                                        |
| 3  | Q. But the cone of depression caused by Shelby County pumping,  |
| 4  | you would agree, has caused water underlying DeSoto County in   |
| 5  | the Middle Claiborne to flow into Tennessee for capture by MLGW |
| 6  | and other pumpers. That's just happening, correct?              |
| 7  | A. Correct. There is pumping that is occurring in Shelby        |
| 8  | County that has pulled some water that across the state line    |
| 9  | that but there is also that natural movement of water from      |
| 10 | Mississippi and Tennessee. So that has to be kind of            |
| 11 | considered as well, that you have that natural movement in that |
| 12 | direction anyways.                                              |
| 13 | Q. Well, we'll talk about that later. But                       |
| 14 | A. Okay.                                                        |
| 15 | Q. Regardless of what direction the water is flowing, whether   |
| 16 | it's moving from east to the west or whether it's moving from   |
| 17 | the southeast to the northwest, water that is located in        |
| 18 | Mississippi is being pulled into Tennessee by MLGW pumping,     |
| 19 | correct?                                                        |
| 20 | A. It's being pulled into Shelby County by various pumpers,     |
| 21 | not just MLGW.                                                  |
| 22 | Q. But including MLGW?                                          |
| 23 | A. But including MLGW, yes, sir.                                |
| 24 | Q. Now, would you agree with me that strike that.               |
| 25 | Dr. Waldron, when your deposition was given in 2007             |
|    |                                                                 |

|    | 929                                                             |
|----|-----------------------------------------------------------------|
| 1  | and certainly you'll have a opportunity to correct me if I've   |
| 2  | stated this wrong; I'm just trying to get some things clarified |
| 3  | here and talk about a couple things.                            |
| 4  | You'd said previously that you first learned of the             |
| 5  | existence of the cone of depression extending from Memphis into |
| 6  | DeSoto County in 1999, when you were looking at some            |
| 7  | potentiometric maps, correct?                                   |
| 8  | A. I don't recall.                                              |
| 9  | MR. BRANSON: Your Honor, if we're going to be citing            |
| 10 | a 2007 deposition, I'd ask we have a transcript and page cites  |
| 11 | and the like.                                                   |
| 12 | MR. MOFFETT: Well, we can turn this on page 113.                |
| 13 | I've got the deposition. I was just trying to move things       |
| 14 | along.                                                          |
| 15 | Q. When did you first learn of the existence of the cone of     |
| 16 | depression extending from Memphis into DeSoto County?           |
| 17 | A. I don't recall.                                              |
| 18 | Q. Okay.                                                        |
| 19 | THE COURT: He can look at the previous transcript.              |
| 20 | MR. MOFFETT: Yes, sir.                                          |
| 21 | THE COURT: If it's available.                                   |
| 22 | MR. MOFFETT: Yes, sir.                                          |
| 23 | Your Honor, do you want one?                                    |
| 24 | THE COURT: We'll take a short recess while he's                 |
| 25 | looking at the deposition. We'll take a ten-minute recess.      |

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|    | 930                                                             |
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| 1  | Waldron - cross<br>(Recess)                                     |
| 2  | THE COURT: You may continue with your questions.                |
| 3  | MR. MOFFETT: Thank you, your Honor.                             |
| 4  | BY MR. MOFFETT:                                                 |
| 5  | Q. Dr. Waldron, I handed you a copy of your deposition from     |
| 6  | 2007, and I'm going to be asking about some testimony that      |
| 7  | appears on page 113. And there, beginning at line 11, this      |
| 8  | question was asked: "Do you recall when you first learned of    |
| 9  | the existence of the cone of depression extending into DeSoto   |
| 10 | County, Mississippi?"                                           |
| 11 | "A Since 1999, just looking at potentiometric maps and          |
| 12 | recalling their shape."                                         |
| 13 | Does that refresh your recollection?                            |
| 14 | A. Well, no, it does not refresh my recollection. But in        |
| 15 | reading it, yes, I think it was at that time because I just     |
| 16 | started back in 1999, being away, and I had revisited maps and  |
| 17 | recognized the cone of depression.                              |
| 18 | Q. And Dr. Waldron, feel free to I'm going to ask you just      |
| 19 | a few follow-up questions that were addressed here on pages 113 |
| 20 | and 114. I just if you don't recall, and you certainly can      |
| 21 | read your testimony there, but based upon this testimony, it    |
| 22 | seems that the maps you were looking at were Criner & Parks,    |
| 23 | correct?                                                        |
| 24 | A. Correct.                                                     |
| 25 | Q. And the maps included 1960, 1970, and 1975, and then the     |
|    |                                                                 |

|    | Waldron - cross                                                 |
|----|-----------------------------------------------------------------|
| 1  | Criner & Parks maps from the '80s, correct?                     |
| 2  | A. Correct.                                                     |
| 3  | Q. Then it also says that Kingsbury had produced a map for the  |
| 4  | USGS in 1995 that showed the same thing, correct?               |
| 5  | A. Correct.                                                     |
| 6  | Q. Now, Dr. Waldron, Jamie Outlaw was a graduate student at     |
| 7  | the Groundwater Institute at Memphis State, correct? Do you     |
| 8  | recall Jamie                                                    |
| 9  | A. Yes, I recall him. I did not know he was a master's          |
| 10 | student.                                                        |
| 11 | Q. And Memphis is now the University of Memphis?                |
| 12 | A. Yes, it is.                                                  |
| 13 | Q. And you testified and if you want to, refer to page 181      |
| 14 | to 182 of your 2007 deposition.                                 |
| 15 | But would you agree that Jamie Outlaw had reported              |
| 16 | that had prepared a model that showed that much of the water    |
| 17 | entering the Shelby County originated to the southeast in       |
| 18 | DeSoto County, correct?                                         |
| 19 | A. So what was your question again? Sorry.                      |
| 20 | Q. Well, Dr. Waldron, just look at page 182. You were shown     |
| 21 | page first of all, let's stop just a minute.                    |
| 22 | Dr. Waldron, I've handed you a document that's been             |
| 23 | marked as Plaintiff's Exhibit P51 in this case, and it's styled |
| 24 | "A groundwater flow analysis of the Memphis Sand Aquifer in the |
| 25 | Memphis, Tennessee, area. James Eddie Outlaw Jr., 1994."        |
|    |                                                                 |

|    | g                                                              | 32 |
|----|----------------------------------------------------------------|----|
| 1  | Waldron - cross<br>Are you familiar with that document?        |    |
| 2  | A. I have seen it before, yes.                                 |    |
| 3  | Q. All right. And it will speak for itself, but do you recal   | 1  |
| 4  | that GWI used Jamie Outlaw's model to prepare wellhead         |    |
| 5  | protection plans for MLGW?                                     |    |
| 6  | A. I do recall that, yes.                                      |    |
| 7  | Q. And the Jamie Outlaw model is reflected in this document I  |    |
| 8  | hand you, P51; this is what we're talking about, correct?      |    |
| 9  | A. I'm assuming they're one and the same.                      |    |
| 10 | Q. You don't have any reason to think there's a different one  | ؛, |
| 11 | do you?                                                        |    |
| 12 | A. I do not have any reason to think there's a different one,  |    |
| 13 | no.                                                            |    |
| 14 | Q. Dr. Waldron, isn't it true that at some point, Randy Gentr  | У  |
| 15 | asked you to help him look at the amount of water that might b | юe |
| 16 | coming from Mississippi into Tennessee?                        |    |
| 17 | A. Yes, he did.                                                |    |
| 18 | Q. And you all used a flowdown analysis to get an estimate of  |    |
| 19 | the amount?                                                    |    |
| 20 | A. As best we could. We had a plot of a potentiometric         |    |
| 21 | surface, and then we drew flow lines perpendicular to the      |    |
| 22 | contours and used Darcy's Law to estimate what that flow may   |    |
| 23 | be, if I recall correctly.                                     |    |
| 24 | Q. And the results of your analysis was I guess the result     |    |
| 25 | was that y'all concluded that without quantifying the amount,  |    |
|    |                                                                |    |

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|    | 933                                                                               |
|----|-----------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>you concluded that there was in fact water flowing from DeSoto |
| 2  | County into Memphis as a result of pumping?                                       |
| 3  | A. I believe that we mapped that there was flow going across                      |
| 4  | the Mississippi/Tennessee state line.                                             |
| 5  | Q. Into                                                                           |
| 6  | A. Into the Middle Claiborne Aquifer.                                             |
| 7  | Q. From Mississippi into Tennessee?                                               |
| 8  | A. Yes, from Mississippi into Tennessee.                                          |
| 9  | Q. Dr. Waldron, you recall that in 2003, MLGW asked GWI to                        |
| 10 | look at an alternative water supply source for Memphis?                           |
| 11 | A. No, I don't.                                                                   |
| 12 | Q. You don't?                                                                     |
| 13 | If you would perhaps I've misstated that, but if                                  |
| 14 | you would turn to page 93.                                                        |
| 15 | A. In the same thing?                                                             |
| 16 | Q. Yes, sir, of that deposition transcript.                                       |
| 17 | A. Okay. I'm there.                                                               |
| 18 | Q. So look at line 7 on page 93.                                                  |
| 19 | A. What now?                                                                      |
| 20 | Q. I'm sorry. What?                                                               |
| 21 | A. What?                                                                          |
| 22 | Q. Let's start on line 9.                                                         |
| 23 | A. 9?                                                                             |
| 24 | Q. Part of the question on page 93. It says, "Has GWI ever                        |
| 25 | been asked to look at alternative water supply sources for the                    |
|    |                                                                                   |

|    | Valdren gregg                                                  |
|----|----------------------------------------------------------------|
| 1  | City of Memphis other than the Memphis Sands aquifer?"         |
| 2  | And your response was "Yes."                                   |
| 3  | A. Okay. Yeah, that was a you didn't misspeak; I got           |
| 4  | confused when it was alternative source. That was a            |
| 5  | reinjection of water, from what I remember. It wasn't a it     |
| 6  | was taking water, treating it, putting it back into the system |
| 7  | that you would pull right back out. So you already pulled it   |
| 8  | out. You already pumped it back. You treated it, put it back   |
| 9  | if. And then you pump it back out when you need it, and        |
| 10 | there's less treatment costs.                                  |
| 11 | That was that particular topic, that was of that               |
| 12 | nature.                                                        |
| 13 | Q. Dr. Waldron, I think you testified earlier that the pumping |
| 14 | of groundwater from the Middle Claiborne Aquifer unit in       |
| 15 | Tennessee can have effects on the hydrologic conditions        |
| 16 | existing in Middle Claiborne in Mississippi, correct?          |
| 17 | A. Near that boundary, yes.                                    |
| 18 | Q. Okay. And does pumping from the Middle Claiborne in one     |
| 19 | state always impact another state?                             |
| 20 | A. No, it does not. If you are near the boundary, then it      |
| 21 | will. If you are far from them, because Middle Claiborne is so |
| 22 | regionally extensive, you could be further south in the        |
| 23 | Mississippi, or further north, and not have that impact.       |
| 24 | Q. Dr. Waldron, before a water operator installs and begins    |
| 25 | pumping water from a water well, can a calculation be done to  |

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|    | Waldren grogg                                                   |
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| 1  | predict the extent and depth of the cone of depression that     |
| 2  | would be caused by that pumping?                                |
| 3  | A. Could you repeat the question one more time?                 |
| 4  | Q. Before a water well is turned on for operation, can the      |
| 5  | operator of that well make a prediction, do a calculation and   |
| 6  | make a prediction, some reasonable prediction, that pumping     |
| 7  | areal extent and the depth of the cone of depression that would |
| 8  | be created by that well pumping?                                |
| 9  | A. You said before they start drilling?                         |
| 10 | Q. Yeah.                                                        |
| 11 | A. So it's you'd have to be based on a number of parameters     |
| 12 | that you would have to assume for that particular location.     |
| 13 | Based upon the number of parameters, you could put it into an   |
| 14 | analytical model and determine what that drawdown could be.     |
| 15 | Q. Yes. So you may have to apply some information you have on   |
| 16 | hand, which you can do an estimate at least, correct?           |
| 17 | A. It's if you wherever you want to put the well, you           |
| 18 | have that information nearby, then you could. If you don't,     |
| 19 | then you're going to need to test drill a test well and get     |
| 20 | that information.                                               |
| 21 | Q. Okay. Are there steps that can be taken as part of           |
| 22 | wellfield design to reduce the areal extent or depth of a       |
| 23 | well's cone of depression?                                      |
| 24 | A. I don't really deal with wellfield design, so                |
| 25 | Q. Okay. So you don't know anything about well spacing, and     |
|    |                                                                 |

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|    | 936                                                            |
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| 1  | Waldron - cross<br>issues such as that?                        |
| 2  | A. I do understand the concept of well spacing, yes, sir.      |
| 3  | Q. And what is that concept?                                   |
| 4  | A. In are you talking about with regard to drawdown?           |
| 5  | Q. Yes.                                                        |
| 6  | A. That well spacing, if you are your wells are far apart,     |
| 7  | they'll each create their own cone of depression. As when      |
| 8  | wells come closer together, those cones of depression will     |
| 9  | cross each other, and you'll see that affect drawdown.         |
| 10 | Q. Are there steps in and if you don't know, just say so.      |
| 11 | But are there steps that can be taken as part of the well      |
| 12 | operations which will help manage, so to speak, the areal      |
| 13 | extent or depth of a cone of depression?                       |
| 14 | MR. BRANSON: Your Honor, just for the record, I'd              |
| 15 | like to renote our relevance objection to this and preserve it |
| 16 | for the record as applied to this witness. And this is beyond  |
| 17 | the scope of the interstate aquifer                            |
| 18 | THE COURT: I understand it is. I'll approve him to             |
| 19 | ask the question.                                              |
| 20 | A. Okay. Ask it again.                                         |
| 21 | Q. I don't think so.                                           |
| 22 | A. She can read it back.                                       |
| 23 | Q. I barely made it through the first time.                    |
| 24 | Okay. Are there steps that can be taken as part of             |
| 25 | wellfield operations which can help manage or mitigate the     |
|    |                                                                |

|    | 937                                                             |
|----|-----------------------------------------------------------------|
| 1  | Waldron - cross<br>potential effects of a cone of depression?   |
| 2  | A. I'm sure there are steps that can be taken to do that. I     |
| 3  | think there was a variety of parameters that you'd have to look |
| 4  | at.                                                             |
| 5  | Q. Have you heard about the concept of pumping time, turning a  |
| 6  | well on for 12 hours and turning it off for 12 hours? Are you   |
| 7  | familiar with that?                                             |
| 8  | A. I'm not familiar with the term, but I understand the         |
| 9  | concept of turning a well on and off.                           |
| 10 | Q. Okay. And so as you turn the well on, the cone of            |
| 11 | depression is created; and it's created, correct? And then as   |
| 12 | you turn it, the pump the well off, that cone of depression     |
| 13 | shrinks, contracts, disappears?                                 |
| 14 | A. Correct. I don't know if it necessary it will expand         |
| 15 | and turn off, it will start to contract. If you turn it back    |
| 16 | on, it's going to sorry about that.                             |
| 17 | It will catch itself and keep going.                            |
| 18 | Q. Okay. But that's the idea. You pump for 12 hours, the        |
| 19 | cone goes out, turn it off, cone comes back in, pump 12 hours,  |
| 20 | cone comes out like that. Correct?                              |
| 21 | A. To a degree, in a rough sense.                               |
| 22 | Q. Okay. And Dr. Waldron, you studied Middle Claiborne a lot,   |
| 23 | the Middle Claiborne Aquifer unit. And there is, would you      |
| 24 | agree, a significant amount of high-quality groundwater in the  |
| 25 | Middle Claiborne Aquifer unit in West Tennessee north of        |
|    |                                                                 |

|    | 938                                                            |
|----|----------------------------------------------------------------|
| 1  | Waldron - cross<br>Memphis, correct?                           |
| 2  | A. I can't speak for all of West Tennessee.                    |
| 3  | Q. How about part of it? Is there some good high-quality       |
| 4  | water in the Memphis Sand to the north of Tennessee north of   |
| 5  | Memphis?                                                       |
| 6  | A. I think that what we have what we mentioned before, that    |
| 7  | in the Middle Claiborne Aquifer, there's a variation of the    |
| 8  | chemistry that can occur. So there are places where you will   |
| 9  | have high quality, yes; and there will be places where you     |
| 10 | don't have that high of a quality. So                          |
| 11 | Q. But you could go up there and find the good stuff, I guess, |
| 12 | if you wanted to, right?                                       |
| 13 | A. Yeah, I guess you could like see where it's good already,   |
| 14 | and hope that it's going to be the same. But there's no        |
| 15 | guarantee that it would be.                                    |
| 16 | Q. Okay. Dr. Waldron, I want to talk a little while about      |
| 17 | predevelopment flow. And you presented extensive testimony     |
| 18 | today about your conclusions that you reached on that. I want  |
| 19 | to understand, when that process started, about and you may    |
| 20 | have said this earlier, and I apologize if I missed it; but    |
| 21 | when did you begin investigating the predevelopment flow issue |
| 22 | which resulted in your preparation of this article that you    |
| 23 | discussed today?                                               |
| 24 | A. It pretty much began around the in the 2006, early 2007.    |
| 25 | Q. When you began the study or before you began the study,     |
|    |                                                                |

|    | Waldron - grogg                                                                 |
|----|---------------------------------------------------------------------------------|
| 1  | wardfon - cross<br>were you aware of the fact that the State of Mississippi had |
| 2  | sued MLGW?                                                                      |
| 3  | A. Yes, I was.                                                                  |
| 4  | Q. And isn't it true that before you began your study, you                      |
| 5  | were retained by MLGW as a nontestifying consultant?                            |
| 6  | A. I don't recall.                                                              |
| 7  | Q. When you began your study that resulted in the publication                   |
| 8  | of this article, did you have an understanding of the claims                    |
| 9  | that were being made by Mississippi against MLGW in that                        |
| 10 | litigation?                                                                     |
| 11 | A. I don't recall the exact claims, but I was obviously aware                   |
| 12 | of the lawsuit between the State of Mississippi and MLGW and                    |
| 13 | the City of Memphis. So I know the parameters, too, have been                   |
| 14 | required to provide a lot of documentation to it.                               |
| 15 | MR. MOFFETT: Your Honor, may I speak with my                                    |
| 16 | THE COURT: Yes.                                                                 |
| 17 | MR. MOFFETT: Thank you, your Honor.                                             |
| 18 | BY MR. MOFFETT:                                                                 |
| 19 | Q. Dr. Waldron, I believe you also may not recall, we don't                     |
| 20 | have to go into details but when you gave your deposition in                    |
| 21 | 2007, you I believe you said that the study was underway at                     |
| 22 | that time. You hadn't finished it.                                              |
| 23 | A. Correct.                                                                     |
| 24 | Q. I think we heard some testimony about who was helping you                    |
| 25 | with that, gathered some information. Who all helped you                        |
|    |                                                                                 |

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|    | 940                                                                      |
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| 1  | Waldron - cross<br>collect the data that you've talked about here today? |
| 2  | A. My mom. Hey, great. Supreme Court. That's fantastic.                  |
| 3  | Q. I'm sure she's a wonderful lady.                                      |
| 4  | A. Thank you. Yes. Sure she is.                                          |
| 5  | Q. She helped you?                                                       |
| 6  | A. She helped me some, yes, sir.                                         |
| 7  | Q. So when you were talking about all this work you did, some            |
| 8  | of that all that work wasn't done by just you?                           |
| 9  | A. The majority of it. My mom went with me to the Kirby farm;            |
| 10 | she knew where they lived. And she also liked genealogy, so              |
| 11 | only when I went to the Memphis library, she knew her friend             |
| 12 | was in charge of the historic documents section. So she knew             |
| 13 | who that was, so she helped me get into that.                            |
| 14 | So yes, she                                                              |
| 15 | Q. It's okay. I'm just trying to understand.                             |
| 16 | So was there anybody else that helped you with the                       |
| 17 | project?                                                                 |
| 18 | A. No. Uh-uh.                                                            |
| 19 | Q. Okay. All right.                                                      |
| 20 | A. No, sir.                                                              |
| 21 | Q. So when you when did you reach your conclusions that are              |
| 22 | reflected in the article that has been discussed today?                  |
| 23 | A. I don't recall.                                                       |
| 24 | Q. Do you recall when you submitted the article to the                   |
| 25 | American Water Association for publication?                              |
|    |                                                                          |

|    | 941                                                               |
|----|-------------------------------------------------------------------|
| 1  | Waldron - cross<br>Well, let me help you out. That was a terrible |
| 2  | question.                                                         |
| 3  | So D174, if you want to pull that up. It should be in             |
| 4  | your notebook. D174.                                              |
| 5  | A. This notebook?                                                 |
| 6  | Q. Yes. It's your predevelopment groundwater article.             |
| 7  | A. Okay.                                                          |
| 8  | Q. Okay. See down there in the footnote, it says it looks         |
| 9  | like it was received January 24, 2013. Right?                     |
| 10 | A. 2013, yeah, is that yeah.                                      |
| 11 | Q. I'm just trying to pin down when you might have wrapped up     |
| 12 | the project in I realize you might have polished it up a          |
| 13 | little bit before you submitted it, but I'm trying to get an      |
| 14 | understanding of when you first reached the                       |
| 15 | A. I don't recall.                                                |
| 16 | Q. Okay. Dr. Waldron, what are the differences in flow            |
| 17 | direction in a confined aquifer versus an unconfined aquifer?     |
| 18 | A. The groundwater flow direction in a confined aquifer system    |
| 19 | is more smooth, and it moves in the direction of lower            |
| 20 | pressure; whereas in the confined system, it still moves in the   |
| 21 | direction of lower pressure, but moves toward discharge points.   |
| 22 | Q. Now, you say on page four of your article, you said, "In       |
| 23 | the unconfined regions" I apologize; I'll give you time to        |
| 24 | get there.                                                        |
| 25 | A. All right.                                                     |

|    | 942                                                                |
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| 1  | Waldron - cross<br>Q. On the left-hand side, first full paragraph: |
| 2  | "In the unconfined regions of the Memphis Aquifer,                 |
| 3  | groundwater gradients are expected to be toward the river          |
| 4  | systems similar to what is observed in a shallow aquifers          |
| 5  | aquifer beneath Shelby County."                                    |
| 6  | Did I read that correctly?                                         |
| 7  | A. Yes, sir. You read it correctly.                                |
| 8  | Q. Now, see there, in support of that, you cite Graham &           |
| 9  | Parks, 1986, and then Honduro in 2007?                             |
| 10 | A. Yes, sir.                                                       |
| 11 | Q. Now, does topography affect the flow direction of               |
| 12 | groundwater that is in the unconfined portion of the Middle        |
| 13 | Claiborne?                                                         |
| 14 | A. The water level in an unconfined portion of the the             |
| 15 | water level in the unconfined portion of the aquifer will          |
| 16 | typically follow the topography. So where the topography is        |
| 17 | high, the water level will be high; where the topography is        |
| 18 | low, the water level will be low.                                  |
| 19 | Q. Are those such conditions present in the confined aquifer?      |
| 20 | A. No, they are not.                                               |
| 21 | Q. Dr. Waldron, has your predevelopment flow article and the       |
| 22 | conclusions in there, have those been used by the USGS?            |
| 23 | A. I don't know if the USGS has used them or not.                  |
| 24 | Q. And counsel went through the Criner & Parks, the                |
| 25 | Brahana & Broshears, MERAS, Reed; and basically your opinion on    |

|    | 943                                                                            |
|----|--------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>that is that you in your opinion, they all got it wrong and |
| 2  | you're right. Correct?                                                         |
| 3  | A. My opinion is that I had data that was more approximate of                  |
| 4  | the predevelopment condition, and therefore my map shows what                  |
| 5  | the predevelopment condition was, versus in their map, based                   |
| 6  | upon how they produced their data, it differs definitely from                  |
| 7  | what mine is.                                                                  |
| 8  | Q. Right. And you say your map is correct and their maps are                   |
| 9  | incorrect?                                                                     |
| 10 | A. I would say that my map is more correct and their map is                    |
| 11 | less correct, yes. Not correct.                                                |
| 12 | Q. Is there any credence that can be given at all to the                       |
| 13 | Criner & Parks, Brahana & Broshears, MERAS, and Reed maps?                     |
| 14 | A. Any credence?                                                               |
| 15 | Q. Yes. Are you just saying all this all these maps are                        |
| 16 | just junk?                                                                     |
| 17 | A. Well, they had their maps, except for Criner & Parks;                       |
| 18 | theirs was just for Shelby County. The others were more                        |
| 19 | regional. And in the regional sense, they do show that basic                   |
| 20 | trend movement of on a regional scale, from toward the                         |
| 21 | syncline of the Mississippi Embayment, and then it turns                       |
| 22 | southerly areal toward the goal. That's the typical movement                   |
| 23 | of groundwater.                                                                |
| 24 | So they do illustrate that. But at a higher scale on                           |
| 25 | my particular figure, at that location, my depiction of the                    |

|    | 944                                                            |
|----|----------------------------------------------------------------|
| 1  | Waldron - cross<br>predevelopment is more accurate.            |
| 2  | Q. That's your opinion, correct?                               |
| 3  | A. Yes, sir, that is my opinion.                               |
| 4  | Q. And USGS has been citing and relying on those papers for    |
| 5  | years and years, haven't they?                                 |
| 6  | A. To my knowledge, they have cited those papers in subsequent |
| 7  | publications, yes, sir.                                        |
| 8  | Q. And how many times has USGS cited your predevelopment flow  |
| 9  | map?                                                           |
| 10 | A. I am I don't know what they have cited.                     |
| 11 | Q. So to your knowledge                                        |
| 12 | A. Or                                                          |
| 13 | Q. To your knowledge, they've never cited?                     |
| 14 | A. You tell me. I don't know.                                  |
| 15 | MR. MOFFETT: Pull up Slide 8. Can you blow that up.            |
| 16 | Expand it out a little bit so Dr. Waldron can see what we're   |
| 17 | looking at here. This is he needs to see more of the page.     |
| 18 | Need to see what figure's on there.                            |
| 19 | Q. Dr. Waldron, do you recognize this as Figure 13 from your   |
| 20 | predevelopment map predevelopment groundwater article?         |
| 21 | A. Figure 13 is in what document?                              |
| 22 | Q. Exhibit D194, which is your publication.                    |
| 23 | A. Oh, that publication.                                       |
| 24 | MR. BRANSON: Your Honor, 194 is Dr. Larson's expert            |
| 25 | report. I think that might be what's taking                    |
|    |                                                                |

|    | 945                                                            |
|----|----------------------------------------------------------------|
| 1  | Waldron - cross<br>MR. MOFFETT: From the wrong place.          |
| 2  | THE COURT: Do we have what this document is?                   |
| 3  | MR. MOFFETT: Yes, sir.                                         |
| 4  | BY MR. MOFFETT:                                                |
| 5  | Q. Let me ask you this: This is Dr. Waldron, if you would      |
| 6  | turn to your if you have D174 in front of you.                 |
| 7  | A. 174?                                                        |
| 8  | Q. D174. That is your                                          |
| 9  | A. Got it.                                                     |
| 10 | Q. And if you would turn, please, to page 17 of that document. |
| 11 | D174.                                                          |
| 12 | A. I am there.                                                 |
| 13 | Q. Okay. Is there a map on there?                              |
| 14 | A. Yes, there is.                                              |
| 15 | Q. And just in terms of the substance of it, is the map on     |
| 16 | page 17 of D174 the same map that now appears on the screen?   |
| 17 | A. Yes, sir, it is.                                            |
| 18 | Q. Okay. Dr. Waldron, Mr. Branson covered this; I just want    |
| 19 | to make sure I understand. So how many wells were used to      |
| 20 | prepare this map?                                              |
| 21 | A. I had 27 control points.                                    |
| 22 | Q. And how many of those 27 wells were in the unconfined       |
| 23 | portion of the Middle Claiborne Aquifer units?                 |
| 24 | A. I would have to count them, but hang on.                    |
| 25 | Q. It may be easier if you count the confined, but             |
|    |                                                                |

Γ

|    |                                                               | 946 |
|----|---------------------------------------------------------------|-----|
| 1  | Waldron - cross<br>A. 14ish, 15ish.                           |     |
| 2  | Q. All right. Well, let's do it this way: Would you           |     |
| 3  | excluding the wells north of Shelby County and Fayette County | ,   |
| 4  | how many well points do you have in the confined portion of t | he  |
| 5  | Memphis Aquifer?                                              |     |
| 6  | A. I'm sorry. I missed the first part. From where to where    | ?   |
| 7  | Q. Let me ask you this a different way: How many locations    | do  |
| 8  | you have in Shelby County that are in the confined portion of |     |
| 9  | the Middle Claiborne Aquifer unit?                            |     |
| 10 | A. From what I can tell on the map it's just kind of smal     | l,  |
| 11 | but one, two, three, four about four.                         |     |
| 12 | Q. Okay. And                                                  |     |
| 13 | A. You said "Shelby County," right?                           |     |
| 14 | Q. Yes, sir.                                                  |     |
| 15 | A. Yes.                                                       |     |
| 16 | Q. Yes, sir.                                                  |     |
| 17 | And you had how many wells do you have in                     |     |
| 18 | Mississippi, in the confined portion of the Middle Claiborne  |     |
| 19 | Aquifer unit?                                                 |     |
| 20 | A. In the Middle Claiborne? Looks like two of them.           |     |
| 21 | Q. And                                                        |     |
| 22 | A. Because you get below that transition, but I can't rememb  | er  |
| 23 | where the depth is of Number 5. So in DeSoto County, one.     |     |
| 24 | Q. And then there's two in Marshall County, in the in the     | :   |
| 25 | unconfined, correct?                                          |     |

|    | 947                                                                             |
|----|---------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>A. One is in the unconfined. I cannot recall what happens on |
| 2  | Number 5, because I only drew the yeah. Yeah, that would be                     |
| 3  | it.                                                                             |
| 4  | Q. Okay. But just to be clear, let's look let's think                           |
| 5  | about these wells in Mississippi. To be clear, those wells do                   |
| 6  | not exist any longer, right? They did not exist at the time                     |
| 7  | you did your study, correct?                                                    |
| 8  | A. Correct. They did not exist.                                                 |
| 9  | Q. So you had to estimate the location of locations of                          |
| 10 | those wells?                                                                    |
| 11 | A. As best I could, yes, sir.                                                   |
| 12 | Q. Now, if you would look up at the map, in Fayette County                      |
| 13 | there, why didn't you what is a flow line?                                      |
| 14 | A. Flow line is a groundwater flow perpendicular to the the                     |
| 15 | equipotential line.                                                             |
| 16 | Q. And up there in Fayette County let me ask this question:                     |
| 17 | Why didn't you put flow lines on this map?                                      |
| 18 | A. That was not something I considered doing.                                   |
| 19 | Q. If you did put flow lines on this map in Fayette County,                     |
| 20 | let's look down there at Well 87 or rather 12. 12.                              |
| 21 | A. Yes, sir.                                                                    |
| 22 | Q. What would be the flow directions out around that well?                      |
| 23 | A. From the contour, it is going to be toward the river and                     |
| 24 | then toward the west.                                                           |
| 25 | Q. Okay. But so below the river, the flow line's going to                       |

|    | Waldron - cross                                                |
|----|----------------------------------------------------------------|
| 1  | head to the north, correct?                                    |
| 2  | A. They're going to head to the northwest.                     |
| 3  | Q. Okay. And then just above Location 12, the flow line moves  |
| 4  | to the south, correct?                                         |
| 5  | A. To the southwest.                                           |
| 6  | Q. Okay. And then if you go up north of Fayette County,        |
| 7  | there's a little it looks like a dip there, where you have     |
| 8  | Locations 8 and 16. What would the flow lines look like there, |
| 9  | if you drew them?                                              |
| 10 | A. They're going to be toward the Hatchie River, or a          |
| 11 | tributary of the Hatchie River. It would be at 8, there        |
| 12 | would be west, toward the river. And then when you curve that  |
| 13 | around on the other the coming around towards 16 and           |
| 14 | going up, it will be east toward that tributary.               |
| 15 | Q. All right. Dr. Waldron, I want to make sure I understand.   |
| 16 | So at Location 8, the flow line just above there, maybe that's |
| 17 | what you're trying to get at. Just that fun line that looks    |
| 18 | like this little U right there, which                          |
| 19 | A. Where 91 is?                                                |
| 20 | Q. Yes. Yes. Yes.                                              |
| 21 | Well, what are the flow directions in between that and         |
| 22 | the middle of that U?                                          |
| 23 | A. That's what I just said.                                    |
| 24 | Q. Okay. So you've got in those areas we've looked at,         |
| 25 | some flow is going north, some is going east, some is going    |
|    |                                                                |

|    | 949                                                                       |
|----|---------------------------------------------------------------------------|
| 1  | Waldron - cross<br>west, some is going south in that Fayette County those |
| 2  | Fayette County points we looked at?                                       |
| 3  | A. Yeah, they're going different directions, yes, sir.                    |
| 4  | MR. FREDERICK: Your Honor, while we're waiting, we                        |
| 5  | were wondering if you might consider extending the trial day              |
| 6  | today until 5:30, so that we could maximize our chances of                |
| 7  | finishing the hearing by tomorrow.                                        |
| 8  | THE COURT: We can. Yes.                                                   |
| 9  | MR. FREDERICK: Thank you.                                                 |
| 10 | THE COURT: Okay.                                                          |
| 11 | BY MR. MOFFETT:                                                           |
| 12 | Q. Dr. Waldron, you see on there, just south of DeSoto County,            |
| 13 | there's a county called Tate County. Do you see that?                     |
| 14 | A. Yes, sir, I do.                                                        |
| 15 | Q. Now, is it your opinion that water located in the pore                 |
| 16 | spaces of sand in the Middle Claiborne underlying Tate County,            |
| 17 | that water is interstate water?                                           |
| 18 | A. Yes, I do.                                                             |
| 19 | Q. Even if that water has been located in that area and has               |
| 20 | been located within Mississippi for thousands and thousands of            |
| 21 | years, and might be located in Mississippi for another thousand           |
| 22 | years, you it's your opinion that that water is an                        |
| 23 | interstate resource?                                                      |
| 24 | A. Yes. The concept is that, as has been throughout the core              |
| 25 | period, is that the Middle Claiborne Aquifer is reasonably                |
|    |                                                                           |

|    | 950                                                                              |
|----|----------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>extensive, and therefore it crosses the state lines, and that |
| 2  | the water in that aquifer, irregardless of time, rest of the                     |
| 3  | time spent in the system, is not a factor because water is                       |
| 4  | moving across the state lines. As somebody said earlier, right                   |
| 5  | now, at this very second, water is moving across this                            |
| 6  | interstate system.                                                               |
| 7  | Q. Okay. What about water that is located in Shelby County,                      |
| 8  | Tennessee? Are you saying that the water in Shelby County,                       |
| 9  | Tennessee, is a shared resource, interstate resource available                   |
| 10 | for taking by Mississippi through pumping?                                       |
| 11 | A. I believe that the Middle Claiborne Aquifer, being a                          |
| 12 | regional extent that it is, is a shared resource by all the                      |
| 13 | states, and by different uses as well.                                           |
| 14 | Q. Dr. Waldron, I've handed you a document, Tennessee statute,                   |
| 15 | Tennessee Code Section 68-221-702. And I'll read it. It says,                    |
| 16 | quote: "Recognizing that the waters of the State are property                    |
| 17 | of the State and are held in public trust for the benefit of                     |
| 18 | its citizens, it is declared that the people of the State are                    |
| 19 | beneficiaries of this trust and have a right to both an                          |
| 20 | adequate quantity and quality of drinking water."                                |
| 21 | Did you, in reaching your conclusion that the water in                           |
| 22 | Shelby County is a shared interstate resource, take this                         |
| 23 | statute into consideration?                                                      |
| 24 | A. No. I did not know that this existed.                                         |
| 25 | Q. Dr. Waldron, I know there's been a good bit of activity up                    |
|    |                                                                                  |

|    | Valduar gragg                                                   |
|----|-----------------------------------------------------------------|
| 1  | in the Shelby County area over the TVA's plan I guess former    |
| 2  | plan to pump water from the Memphis Aquifer. Are you            |
| 3  | familiar with that?                                             |
| 4  | A. I am familiar with that situation, yes, sir.                 |
| 5  | Q. Just we're not going to get into the details of it, but      |
| 6  | just for the Court, would you just give a brief general         |
| 7  | overview of what that issue is?                                 |
| 8  | A. The issue that has been raised in the papers, and from what  |
| 9  | the public have said, and other officials, is that the          |
| 10 | Tennessee Valley Authority had placed production wells into the |
| 11 | Middle Claiborne Aquifer for the intended use of steam for      |
| 12 | their new cycle plant, and that there was disagreement, I guess |
| 13 | you could say, by people of the use of the water for that       |
| 14 | purpose. And there was some expressed concern regarding the     |
| 15 | potential of local contamination to the Middle Claiborne        |
| 16 | Aquifer at that site.                                           |
| 17 | Q. Are you aware of the fact that the State of Tennessee sued   |
| 18 | the Tennessee Valley Authority in Chancery Court for the State  |
| 19 | of Tennessee, Davidson County? Are you aware of that?           |
| 20 | MR. BRANSON: Your Honor, there's been no foundation             |
| 21 | laid for that. I don't think that's true. I'd object to the     |
| 22 | question.                                                       |
| 23 | THE COURT: That objection is sustained. You may                 |
| 24 | place it in the record later if you wish to.                    |
| 25 | MR. MOFFETT: Your Honor, I'll lay a basis for it,               |
|    |                                                                 |

|    | 952                                                             |
|----|-----------------------------------------------------------------|
| 1  | Waldron - cross<br>then.                                        |
| 2  | BY MR. MOFFETT:                                                 |
| 3  | Q. Dr. Waldron, you're not familiar with this document at all?  |
| 4  | A. No, sir.                                                     |
| 5  | MR. MOFFETT: Okay. Just I will just mark it for                 |
| 6  | identification, your Honor. But what I'd like to do is just     |
| 7  | again, just to note for the record, this is a notice of removal |
| 8  | that was filed by the Tennessee Valley Authority, and attached  |
| 9  | to that notice of removal is a verified complaint filed by the  |
| 10 | State of Tennessee against Tennessee Valley Authority. And in   |
| 11 | paragraph 13 of that verified complaint that was filed by the   |
| 12 | Attorney General of the State of Tennessee, the State of        |
| 13 | Tennessee said, "The General Assembly has declared that the     |
| 14 | waters of Tennessee are the property of the State and are held  |
| 15 | in public trust for the use of the people. Tennessee Code,      |
| 16 | annotated section 69-3-102A."                                   |
| 17 | I'd like to have that marked. For purposes of the               |
| 18 | question, I wish to see if he was aware of this and if he took  |
| 19 | that into consideration in forming his opinion.                 |
| 20 | THE COURT: Well, if he says he doesn't know anything            |
| 21 | about it                                                        |
| 22 | MR. MOFFETT: That's what I I just need to have it               |
| 23 | marked. That's the point.                                       |
| 24 | THE COURT: Okay.                                                |
| 25 | MR. MOFFETT: Your Honor, we'll have this marked as              |
|    |                                                                 |

952

| 953<br>Waldron - cross                                        |
|---------------------------------------------------------------|
| THE COURT: Okay                                               |
| MP PRANSON: No objection                                      |
| MR. BRANSON: NO ODJECTION.                                    |
| THE COURT: That will be filed.                                |
| (Plaintiff's Exhibit P212, was marked for                     |
| identification.)                                              |
| BY MR. MOFFETT:                                               |
| Q. Now, Dr. Waldron I've seen where folks up in Memphis       |
| sometimes refer to the Memphis Sand or the Memphis Aquifer as |
| "our aquifer." Have you heard it called that?                 |
| A. I don't recall.                                            |
| Q. Okay. And that phrase isn't known to you at all, "our      |
| aquifer"?                                                     |
| A. Doesn't ring a bell.                                       |
| Q. Now, you understand, do you not, Dr. Waldron, the position |
| of Tennessee and MLGW in this case is that if Mississippi has |
| concerns about or has been damaged by MLGW's plan, then       |
| Mississippi's sole judicial remedy is an equitable            |
| apportionment of the Middle Claiborne Aquifer; do you         |
| understand that?                                              |
| MR. BRANSON: Objection.                                       |
| MR. D. BEARMAN: Your Honor                                    |
| MR. BRANSON: He's not a legal expert. He's not here           |
| to talk about legal remedies.                                 |
| MR. D. BEARMAN: For either party, your Honor.                 |
|                                                               |

|    | 954                                                             |
|----|-----------------------------------------------------------------|
| 1  | Waldron - cross<br>THE COURT: Objection sustained.              |
| 2  | BY MR. MOFFETT:                                                 |
| 3  | Q. Dr. Waldron, in your view, the fact that in your opinion     |
| 4  | that the Middle Claiborne Aquifer is a shared interstate        |
| 5  | resource, do you understand that to mean that Mississippi can   |
| 6  | install wells just south of the Tennessee border and pump as it |
| 7  | may please and capture water from Shelby County?                |
| 8  | A. My opinion on the matter is that we need to follow along     |
| 9  | with what started with MATRAS back in 2003, where we all got    |
| 10 | together I won't say as one happy family, but we were we        |
| 11 | all got together, the scientists, the different agencies, the   |
| 12 | USGS, the Corps of Engineers, and we all got together, and we   |
| 13 | said, "What are we going to do to look at the system? Because   |
| 14 | it is regional, what are we going to do to keep it sustainable  |
| 15 | for all the various uses and all the various people in these    |
| 16 | states to make it a viable resource?"                           |
| 17 | That's my that would be my my opinion.                          |
| 18 | Q. That's your personal preference, I suspect. But in terms     |
| 19 | of what Mississippi could do, based upon your opinion that this |
| 20 | water is an interstate natural resource, Mississippi could      |
| 21 | install, under your view of what this constitutes could install |
| 22 | 100 wells just ten miles or ten feet south of the Tennessee     |
| 23 | border and pump if it wants to, and Tennessee's only judicial   |
| 24 | remedy would be equitable apportionment. Do you understand      |
| 25 | that?                                                           |
|    |                                                                 |

954

|    | 955                                                                   |
|----|-----------------------------------------------------------------------|
| 1  | Waldron - cross<br>MR. BRANSON: Your Honor, same objection as before. |
| 2  | He's not here to talk about judicial remedies.                        |
| 3  | THE COURT: Objection sustained. You may argue that                    |
| 4  | later.                                                                |
| 5  | BY MR. MOFFETT:                                                       |
| 6  | Q. Dr. Waldron, we're going to talk about residence time in           |
| 7  | just a little while. Now, you agree, and you clarified on your        |
| 8  | direct testimony that you your opinion, or rather in                  |
| 9  | formulating that opinion, you do not did not take residence           |
| 10 | time into consideration, correct?                                     |
| 11 | A. Correct. I did not take residence time into consideration          |
| 12 | in the formulation of the of the interstate aquifer                   |
| 13 | Middle Claiborne Aquifer.                                             |
| 14 | Q. So in your view, even if water were to remain in the Middle        |
| 15 | Claiborne in Mississippi under natural conditions for tens of         |
| 16 | thousands of years, the water would be interstate groundwater         |
| 17 | and not intrastate groundwater?                                       |
| 18 | A. No matter how long the groundwater is in the ground, if it         |
| 19 | is crossing a political boundary, it is an interstate border          |
| 20 | system.                                                               |
| 21 | Q. Okay. Let's break that down, because that's what I want to         |
| 22 | talk about, molecules.                                                |
| 23 | A. Oh, okay. Go ahead.                                                |
| 24 | Q. Because there is water hey, molecules of water that will           |
| 25 | stay in the State of Mississippi's water tens of thousands of         |
|    |                                                                       |

|    | 956                                                            |
|----|----------------------------------------------------------------|
| 1  | years, correct?                                                |
| 2  | A. Certainly.                                                  |
| 3  | Q. All right. So I'm talking about that discrete molecule of   |
| 4  | water. It's your position that that molecule of water, even if |
| 5  | it's in the State of Mississippi for thousands of years, is    |
| 6  | interstate groundwater, that molecule of water?                |
| 7  | A. If there is water that is 10,000 years old and that did     |
| 8  | exist within the State of Mississippi, because that water is   |
| 9  | part of the Middle Claiborne Aquifer, that water is interstate |
| 10 | water, yes, sir.                                               |
| 11 | Q. Okay. Now, in terms of the your decision to not take        |
| 12 | residence to have any consideration, did you reach that        |
| 13 | decision to not consider residence time based upon any type of |
| 14 | publication, scientific or otherwise?                          |
| 15 | A. No. It was not no.                                          |
| 16 | Q. You simply decided yourself that it was not relevant?       |
| 17 | A. It's in my opinion intuitive that you have this aquifer     |
| 18 | system and it crosses political boundaries, and the water is   |
| 19 | moving across it; hence, interstate.                           |
| 20 | Q. Assuming average flow velocity under natural conditions of  |
| 21 | one inch per day, would you agree that it would take about 175 |
| 22 | years for water, groundwater, in the Middle Claiborne Aquifer  |
| 23 | to travel one mile?                                            |
| 24 | A. I have to run the calculation.                              |
| 25 | Q. Okay. So the one inch a day can travel 365 inches in one    |

|    | 957                                                            |
|----|----------------------------------------------------------------|
| 1  | Waldron – cross<br>year, right? So about 30 feet a year?       |
| 2  | A. Well, are you is your one inch per day Darcy velocity or    |
| 3  | the regular groundwater velocity?                              |
| 4  | Q. I'm talking about flow, negative flow of velocity, that     |
| 5  | A. Go ahead. I'm sorry.                                        |
| 6  | Q. Yeah. And you can just assume my calculations are correct   |
| 7  | if you want, just                                              |
| 8  | A. Based upon a flow velocity, and then some distance or time, |
| 9  | you'll get some distance out of that.                          |
| 10 | Q. Well, if it's moving at an average of an inch a day, it     |
| 11 | would take it would move 30 feet in a year, approximately?     |
| 12 | A. Okay.                                                       |
| 13 | Q. Okay? And so you can subject to check, it would take        |
| 14 | about 175 years for that molecule of water to travel one mile, |
| 15 | okay?                                                          |
| 16 | A. Okay.                                                       |
| 17 | Q. Now, pumping of course accelerates the flow rate as it      |
| 18 | moves into the moves toward the well, right?                   |
| 19 | A. Yes, sir, it does.                                          |
| 20 | Q. Now, let's pull up Slide 9.                                 |
| 21 | So this is these are some flow lines you put in                |
| 22 | here to show what you believe is the flow direction of         |
| 23 | groundwater in the Middle Claiborne as depicted here, correct? |
| 24 | A. They're rough approximations, yes.                          |
| 25 | Q. So let's pick the southern most flow line. There's no       |
|    |                                                                |

|    | 958                                                                        |
|----|----------------------------------------------------------------------------|
| 1  | Waldron - cross<br>scale on here. But you have an approximation of see the |
| 2  | southern most flow line, you do see, see that there would be               |
| 3  | some water that enters Mississippi and flows northwest over                |
| 4  | that track that you've shown there, right?                                 |
| 5  | A. The one the southern one?                                               |
| 6  | Q. Yes, sir.                                                               |
| 7  | A. Yes, sir.                                                               |
| 8  | Q. Okay. Can you give me an estimate of about how many miles               |
| 9  | it would that flow line is there that you have drawn in                    |
| 10 | green there?                                                               |
| 11 | A. An estimate?                                                            |
| 12 | Q. Yes.                                                                    |
| 13 | A. Thirty maybe?                                                           |
| 14 | Q. Okay. And what you're depicting there is groundwater that               |
| 15 | entered the outcrop in DeSoto County, Mississippi, flowed in a             |
| 16 | northwesterly direction, and eventually exited the state of                |
| 17 | Mississippi, correct?                                                      |
| 18 | A. Yes, sir.                                                               |
| 19 | Q. Okay. So based upon that flow path, for a molecule of                   |
| 20 | water entering the outcrop, how long would it take again, an               |
| 21 | estimate for that water to exit Mississippi if the flow                    |
| 22 | velocity is one inch a day?                                                |
| 23 | A. I'd love to have a calculator. I'm not that fast with that              |
| 24 | kind of stuff.                                                             |
| 25 | Q. Let's do these we agree it saves 176 miles in a year.                   |
|    |                                                                            |

|    | 959                                                                                |
|----|------------------------------------------------------------------------------------|
| 1  | Waldron - cross<br>If it takes 176 miles to go one mile, so to go ten miles you're |
| 2  | talking about 1,760 miles                                                          |
| 3  | A. 176 miles to go one mile?                                                       |
| 4  | Q. If it takes 176 years for that molecule of water to flow                        |
| 5  | one mile                                                                           |
| 6  | A. Then 30 times that.                                                             |
| 7  | Q. Yeah, you don't have to do that math; I'll break it down                        |
| 8  | for you.                                                                           |
| 9  | A. That's easier, but convert from inches to feet to miles.                        |
| 10 | Q. We'll do tens.                                                                  |
| 11 | A. Excellent.                                                                      |
| 12 | Q. So let's say that flow line were only ten miles long. It                        |
| 13 | would take how long? 1,000                                                         |
| 14 | A. 30 what                                                                         |
| 15 | Q. No, ten times 176: 1,760 years to go ten miles?                                 |
| 16 | MR. BRANSON: If all we're doing is just multiplying                                |
| 17 | numbers, we'll stipulate to the math out of court. I don't                         |
| 18 | think we need to ask the witness to multiply numbers on the                        |
| 19 | stand.                                                                             |
| 20 | THE COURT: You may put that in your argument later.                                |
| 21 | That's fine.                                                                       |
| 22 | MR. L. BEARMAN: Your Honor, I also suggest that what                               |
| 23 | we're hearing is argument, rather in the alleged form of                           |
| 24 | questions, and I I've heard your Honor's ruling, and I                             |
| 25 | understand it, on relevance; but I think this goes beyond the                      |

|    | 960 Julie - 1960                                               |
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| 1  | pale.                                                          |
| 2  | THE COURT: I think you're right. There's no sense in           |
| 3  | arguing with this witness. You can do it by math later, show   |
| 4  | it in your briefs and argument whether you're                  |
| 5  | MR. MOFFETT: Okay, your Honor.                                 |
| 6  | BY MR. MOFFETT:                                                |
| 7  | Q. But let me make sure, Dr. Waldron, we were going to do one  |
| 8  | thing. We can have some disagreements about the flow           |
| 9  | direction, but you would agree, would you not, that there is   |
| 10 | some groundwater in the Middle Claiborne in DeSoto County that |
| 11 | has been within DeSoto County under natural conditions for     |
| 12 | thousands of years?                                            |
| 13 | A. Yes, sir, I do.                                             |
| 14 | Q. Okay. And would you agree that there is some groundwater    |
| 15 | that enters the outcrops in Mississippi, enters the confined   |
| 16 | portions of the Middle Claiborne in Mississippi, and never     |
| 17 | enters Tennessee under natural conditions; there is some water |
| 18 | like that?                                                     |
| 19 | A. Yes, sir, I do agree with that.                             |
| 20 | MR. MOFFETT: If I may have just a moment.                      |
| 21 | That's all I have, your Honor.                                 |
| 22 | THE COURT: Do you have any further questions of this           |
| 23 | witness?                                                       |
| 24 | MR. BRANSON: Your Honor, I have. My guess is between           |
| 25 | five and ten minutes of redirect, with your permission.        |

|    | 961                                                                     |
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| 1  | Waldron - redirect<br>THE COURT: Okay. I didn't ask Memphis whether you |
| 2  | all want to question the witness separately.                            |
| 3  | MR. L. BEARMAN: No, sir.                                                |
| 4  | THE COURT: Okay. All right. You may proceed.                            |
| 5  | MR. BRANSON: Thank you, Judge Siler.                                    |
| 6  | REDIRECT EXAMINATION                                                    |
| 7  | BY MR. BRANSON:                                                         |
| 8  | Q. Dr. Waldron, how are you doing?                                      |
| 9  | A. I'm doing okay.                                                      |
| 10 | Q. Do you recall Mr. Moffett's questions about the funding              |
| 11 | that CAESER receives from MLGW?                                         |
| 12 | A. Yes, sir, I do.                                                      |
| 13 | Q. Outside of the context of depositions or formal litigation           |
| 14 | process, has anybody at MLGW ever discussed your 2015 paper or          |
| 15 | Defendant's Exhibit 174 with you?                                       |
| 16 | A. No.                                                                  |
| 17 | Q. Do you remember when you first submitted your 2015 research          |
| 18 | paper into the peer-review process at the Journal of the                |
| 19 | American Water Resources Association?                                   |
| 20 | A. Yes. It was 2013, January.                                           |
| 21 | Q. And at that time, in 2013, were you aware of any litigation          |
| 22 | that was still pending between MLGW and Mississippi at that             |
| 23 | time?                                                                   |
| 24 | A. No, I was not aware of any litigation.                               |
| 25 | Q. Were you aware of any litigation still pending at that time          |

|    | Waldron - redirect                                             |
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| 1  | between Tennessee and Mississippi concerning the Middle        |
| 2  | Claiborne Aquifer?                                             |
| 3  | A. No, I wasn't aware. I actually thought I couldn't publish   |
| 4  | when it was 2007, because I didn't understand the system, so I |
| 5  | thought that I couldn't at all. And it wasn't until it came    |
| б  | down from the Supreme Court that it was dismissed without      |
| 7  | prejudice that I felt that I could complete the study and      |
| 8  | actually publish it.                                           |
| 9  | Q. And so when you felt you could publish it, it was because   |
| 10 | you thought that the litigation that Mr. Moffett referred to   |
| 11 | was over?                                                      |
| 12 | A. Yeah. I mean, I thought I wasn't allowed to say anything.   |
| 13 | Q. Dr. Waldron, in your experience, when MLGW funds a          |
| 14 | scientific project that you do, what type of expectations had  |
| 15 | they conveyed to you for how you should comport yourself as a  |
| 16 | scientist?                                                     |
| 17 | A. To be professional and unbiased and ethical.                |
| 18 | Q. And given your experience with MLGW, what type of reaction  |
| 19 | would you expect them to have if they found out that you had   |
| 20 | slanted some scientific project you were doing to achieve some |
| 21 | political objective?                                           |
| 22 | A. I would lose my credibility and probably never get a        |
| 23 | project again.                                                 |
| 24 | Q. Now, do you recall Mr. Moffett's question and I'm just      |
| 25 | going to paraphrase about whether you would ever be willing    |
|    |                                                                |

|    | 963                                                                                |
|----|------------------------------------------------------------------------------------|
| 1  | Waldron - redirect<br>to, you know, say something publicly that might be averse to |
| 2  | MLGW? Do you remember that question?                                               |
| 3  | A. Yes, I do.                                                                      |
| 4  | Q. I just want to make sure the record is clear. Would you be                      |
| 5  | willing, as a scientist, to perhaps sometimes take a public                        |
| 6  | position that might be adverse to MLGW?                                            |
| 7  | A. Yes. I may have not heard well, I guess I should have                           |
| 8  | said that, but yes, I would not do that. Sorry.                                    |
| 9  | Q. I don't understand. I'm not sure                                                |
| 10 | A. Can you say it one more time?                                                   |
| 11 | Q. Would you be willing, Dr. Waldron, on occasion to take a                        |
| 12 | public position that might be adverse to MLGW?                                     |
| 13 | A. Yes.                                                                            |
| 14 | Q. And is adversity to MLGW something that you generally let                       |
| 15 | guide you when you're doing your scientific work?                                  |
| 16 | A. Adversity? No.                                                                  |
| 17 | Q. Now, Dr. Waldron, we've talked a lot about naming                               |
| 18 | conventions of these various things in the Mississippi                             |
| 19 | Embayment this week. Do you remember that?                                         |
| 20 | A. Oh, I remember.                                                                 |
| 21 | Q. Do you recall your testimony in response to Mr. Moffett                         |
| 22 | about the, quote/unquote, "three or more distinct aquifers"                        |
| 23 | line in the caption to Figure 1 of your 2015 paper?                                |
| 24 | A. Yes, sir, I do.                                                                 |
| 25 | Q. In what sense were you using the word "aquifer" when you                        |

|    | 964                                                            |
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| 1  | Waldron - redirect<br>said that?                               |
| 2  | A. It was a subunit to the Middle Claiborne Aquifer, subunits. |
| 3  | Q. And so for purposes of your opinion in this case, do you    |
| 4  | think it matters whether we call this whole thing the Middle   |
| 5  | Claiborne Aquifer unit or whether we say that one part is the  |
| 6  | Sparta and one part is the Memphis?                            |
| 7  | A. No, we've been going over that so much, and you know,       |
| 8  | there's so much confusion with the naming conventions. But     |
| 9  | when you look at it from the Middle Claiborne Aquifer          |
| 10 | hydrologic system as one system, and it doesn't doesn't        |
| 11 | matter that it's given different names.                        |
| 12 | Q. Thank you, Dr. Waldron.                                     |
| 13 | MR. BRANSON: I'll pass the witness.                            |
| 14 | THE COURT: Okay. Any further questions?                        |
| 15 | MR. MOFFETT: No, your Honor. Thank you.                        |
| 16 | THE COURT: You can step down.                                  |
| 17 | (Witness excused)                                              |
| 18 | MR. FREDERICK: Your Honor, the state rests. And MLGW           |
| 19 | has a witness, and we'd like to get his credentials on and get |
| 20 | that ball rolling, if that's okay, in our remaining time this  |
| 21 | afternoon. It won't take but a few minutes to get his          |
| 22 | testimony started.                                             |
| 23 | THE COURT: Okay. I said you could have to 5:30,                |
| 24 | so                                                             |
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|    | 965                                                            |
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| 1  | Langseth - direct<br>DAVID E. LANGSETH,                        |
| 2  | called as a witness by the Defendant City of Memphis,          |
| 3  | Tennessee, and Memphis Light, Gas & Water Division,            |
| 4  | having been duly sworn, testified as follows:                  |
| 5  | MS. ROBERTS: Your Honor, I'm Kristine Roberts, on              |
| 6  | behalf of the City of Memphis, Tennessee, and Memphis Light,   |
| 7  | Gas & Water Division. We call Dr. David Langseth to the stand. |
| 8  | THE COURT: All right.                                          |
| 9  | DIRECT EXAMINATION                                             |
| 10 | BY MS. ROBERTS:                                                |
| 11 | Q. Will you please state your full name for the record?        |
| 12 | A. David Eugene Langseth.                                      |
| 13 | Q. Dr. Langseth, are you here to testify to your opinions in   |
| 14 | this case?                                                     |
| 15 | A. Yes, I am.                                                  |
| 16 | Q. Before getting to your opinions, I would like to ask you    |
| 17 | briefly about your background.                                 |
| 18 | MS. ROBERTS: Mr. Taylor, are you ready to proceed?             |
| 19 | MR. TAYLOR: Almost.                                            |
| 20 | MS. ROBERTS: When you're ready, will you please bring          |
| 21 | up Exhibit D1.                                                 |
| 22 | And, your Honor, we provided a notebook to everyone.           |
| 23 | You could either follow along in the exhibit binder they're    |
| 24 | noted by the exhibit number and we'll also put them on the     |
| 25 | screen.                                                        |

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|    | A30                                                            |
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| 1  | Langseth - direct<br>THE COURT: All right.                     |
| 2  | BY MS. ROBERTS:                                                |
| 3  | Q. While Mr. Taylor is getting set up, would you please        |
| 4  | explain, where did you obtain your university degrees?         |
| 5  | A. I obtained my bachelor's degree in civil engineering and    |
| 6  | mathematics at the University of Minnesota.                    |
| 7  | Q. And what year was that?                                     |
| 8  | A. I received both degrees in 1977.                            |
| 9  | Q. Did you complete any undergraduate course work relating to  |
| 10 | the study of groundwater resources?                            |
| 11 | A. Yes, I did.                                                 |
| 12 | Q. Would you please tell Judge Siler about your undergraduate  |
| 13 | work relating to groundwater.                                  |
| 14 | A. Yes, your Honor, there are two courses. One was a general   |
| 15 | water resources course, included groundwater as part of it.    |
| 16 | The other was a series of courses in what was called           |
| 17 | geotechnical engineering, that included a very heavy component |
| 18 | of the flow of water through granular materials, which is      |
| 19 | effectively groundwater flow.                                  |
| 20 | Q. Did your undergraduate studies include any work in          |
| 21 | mathematical or computer modeling of groundwater?              |
| 22 | A. Well, it certainly did in mathematical modeling, because    |
| 23 | that's how we understand groundwater flow. It's really all     |
| 24 | mathematics of groundwater flow.                               |
| 25 | With regard to computer modeling, computer methods             |
|    |                                                                |

|    | 967                                                                                |
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| 1  | Langseth - direct<br>were quite new at the time, and so they got touched upon. But |
| 2  | that wasn't really covered very much, especially at the                            |
| 3  | undergraduate level.                                                               |
| 4  | Q. Would you please explain, what is mathematical or computer                      |
| 5  | modeling?                                                                          |
| 6  | A. Well, first off, mathematical modeling is basically how we                      |
| 7  | characterize groundwater flow. Like the word "Darcy's Law" had                     |
| 8  | been mentioned, your Honor; you've heard that. That's an                           |
| 9  | equation that describes water movement in the subsurface of                        |
| 10 | granular materials. And there are other equations, the                             |
| 11 | continuity equation, that we use, and that's how we understand                     |
| 12 | and how we characterize groundwater movement. So that's                            |
| 13 | mathematical modeling.                                                             |
| 14 | Now, when you're talking about computer modeling, and                              |
| 15 | we look at large natural systems, they're too complicated to                       |
| 16 | solve those equations by hand. So we can use computers,                            |
| 17 | through methods commonly called numerical methods, to break                        |
| 18 | down a large area into small pieces. And we use the same                           |
| 19 | mathematics, and use it over those small pieces, doing hundreds                    |
| 20 | of thousands in some cases millions of calculations in                             |
| 21 | order to solve those same fundamental equations over a large                       |
| 22 | area. And that's what we call numerical or computer modeling.                      |
| 23 | Q. Were you employed while you were an undergraduate student                       |
| 24 | at the University of Minnesota?                                                    |
| 25 | A. Yes, I was. I essentially worked all the way through to                         |

| 968                                                             |
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| Langseth - direct<br>pay my way through school.                 |
| Q. Where were you employed?                                     |
| A. A hydrologic engineering firm called Barr Engineering.       |
| Q. What type of work did you do at Barr Engineering?            |
| A. A large part of my work was hydrologic monitoring; for       |
| example, measuring water levels in wells, as that is            |
| groundwater monitoring levels. I also did surface water         |
| monitoring. I installed groundwater monitoring wells; for       |
| example, I think it was in 1971, when I installed my first      |
| groundwater monitoring well, working for Barr Engineering.      |
| I also did water quality studies. I did land                    |
| surveying and construction resident engineering work, where I   |
| was for example, I was the resident engineer for                |
| reconstruction of the dam in Northern Wisconsin. But the bulk   |
| of my work through the years was this hydrologic monitoring,    |
| going around and measuring water levels and groundwater         |
| monitoring wells and measuring lake levels in lakes and also in |
| rivers.                                                         |
| Q. Do you have any postgraduate degrees?                        |
| A. Yes. I got my master's and doctorate from the                |
| Massachusetts Institute of Technology, known as MIT for short.  |
| Q. Did your postgraduate work at MIT include any coursework in  |
| hydrogeology or related to groundwater?                         |
| A. Yes. It did. I took two courses in hydrology, both of        |
| which address groundwater as part of that coursework. And I     |
|                                                                 |

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|    | 909                                                                               |
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| 1  | Langseth - direct<br>also took a course that is focused in groundwater hydrology. |
| 2  | And then I took another well, those were the ones that were                       |
| 3  | really on hydrology and groundwater.                                              |
| 4  | Q. Did any of your postgraduate work at MIT relate to computer                    |
| 5  | or mathematical modeling?                                                         |
| 6  | A. Yes, I took on that area, I took a course that was                             |
| 7  | focused on numerical methods for solving environmental                            |
| 8  | problems, which included of course groundwater, solving                           |
| 9  | equations of groundwater flow.                                                    |
| 10 | In fact, I remember having to write finite difference                             |
| 11 | and finite element code, you know, using computer code to solve                   |
| 12 | the equations and groundwater flow in that course.                                |
| 13 | Q. Since you graduated from MIT, what has been your area of                       |
| 14 | professional focus or expertise?                                                  |
| 15 | A. I've done a lot of different things, but the core focus has                    |
| 16 | really continued to be groundwater and surface water hydrology                    |
| 17 | and hydraulics.                                                                   |
| 18 | Now, I've also done environmental quality work. I've                              |
| 19 | done environmental transport and chemicals in the environment.                    |
| 20 | I've dealt with hazardous waste site remediation, risk                            |
| 21 | assessments, health risk assessments, environmental management,                   |
| 22 | environmental impact studies, but my personal expertise running                   |
| 23 | through all of this has really been the groundwater and surface                   |
| 24 | water hydrology and hydraulics has been my core expertise.                        |
| 25 | Q. Can you explain those two terms you just used, "hydrology"                     |
|    |                                                                                   |

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|    | 970                                                            |
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| 1  | Langseth - direct<br>and "hydraulics"?                         |
| 2  | A. Oh, sure. Hydrology is kind of the overall movement of      |
| 3  | water movement and occurrence of water in an; environment.     |
| 4  | Your Honor, you heard Mr. Larson review the hydrologic         |
| 5  | cycle; that's really hydrology is the study of that            |
| 6  | hydrologic cycle and hydraulics is when you get into the       |
| 7  | detailed physics of, you know, the equations of just how water |
| 8  | moves through the environment, how fast it might move, how     |
| 9  | much how much might be flowing. That would be more of the      |
| 10 | hydraulics end of it.                                          |
| 11 | Q. Can you give us an overview of your work as it has related  |
| 12 | to groundwater hydrology and hydraulics, starting with your    |
| 13 | first job after MIT.                                           |
| 14 | A. Sure. Your Honor, I worked for a company called Metcalf &   |
| 15 | Eddy initially, after MIT, and there I started doing mostly    |
| 16 | surface water work, but it soon became clear that they needed  |
| 17 | greater groundwater expertise, and they actually asked me to   |
| 18 | develop the company's groundwater modeling expertise. So I got |
| 19 | the models set up, used them on several projects and actually  |
| 20 | even modified them and did some, you know, coding, writing     |
| 21 | computer code, to make the models better for the purposes we   |
| 22 | needed them for at the at Metcalf & Eddy.                      |
| 23 | Q. What was your next job after you left that company?         |
| 24 | A. Your Honor, I next went to a company called                 |
| 25 | Arthur D. Little.                                              |
|    |                                                                |

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| 1  | Langseth - direct<br>Q. And what did you do there?              |
| 2  | A. Well, I once again, I did a wide variety of work, but        |
| 3  | thinking about my groundwater work, I did a fair bit of         |
| 4  | groundwater modeling in addition to other groundwater-type      |
| 5  | projects.                                                       |
| 6  | A few that come to mind, that I think would illustrate          |
| 7  | the kind of work I did, there was one where we were looking at  |
| 8  | a refinery in Montreal Island, and there was concern that the   |
| 9  | benzene in the groundwater there was getting into the           |
| 10 | St. Lawrence River. And so developed a numerical model of the   |
| 11 | groundwater flow on this quite large refinery site, and then    |
| 12 | estimated the groundwater flow into the St. Lawrence River, and |
| 13 | then also estimated how much benzene was going into the river   |
| 14 | with the groundwater.                                           |
| 15 | And then there was another project in Kingston,                 |
| 16 | New Hampshire, where we developed a groundwater model again, a  |
| 17 | numerical model for the purpose of designing a wellfield to     |
| 18 | and extract a set of wells in order to pump contaminated        |
| 19 | groundwater out of the ground so it could be treated.           |
| 20 | And then at one point the Easton Christensen Company,           |
| 21 | which was an oilfield drilling company, and they developed a    |
| 22 | method for horizontal drilling in the oilfields. They wanted    |
| 23 | to bring that into the water business. And so they came to me,  |
| 24 | and I developed models to assess how those horizontal wells     |
| 25 | would perform when they were used to pump water instead of oil. |
|    |                                                                 |
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|    | 972                                                                    |  |  |  |
|----|------------------------------------------------------------------------|--|--|--|
| 1  | Langseth - direct<br>That was part of and I did some of the pioneering |  |  |  |
| 2  | work to assess how those horizontal wells would behave. And            |  |  |  |
| 3  | then also when the Army hired us to do a major pump test               |  |  |  |
| 4  | horizontal wells had never been used to assess aquifer                 |  |  |  |
| 5  | properties.                                                            |  |  |  |
| 6  | Your Honor, you've heard about transmissivity and                      |  |  |  |
| 7  | permeability; we learn about those things through predominantly        |  |  |  |
| 8  | something that are called pump tests, which are normally done          |  |  |  |
| 9  | with vertical wells; but the Army wanted to try doing it with          |  |  |  |
| 10 | horizontal wells.                                                      |  |  |  |
| 11 | So I developed a method to to estimate the                             |  |  |  |
| 12 | transmissivity and permeability and storage properties of the          |  |  |  |
| 13 | aquifer using a pump test with horizontal wells, and then that         |  |  |  |
| 14 | work subsequently formed the basis of a peer-reviewed paper            |  |  |  |
| 15 | about those methods.                                                   |  |  |  |
| 16 | Then the final thing I'll mention is a project that I                  |  |  |  |
| 17 | did for the State of Mississippi, where I developed a numerical        |  |  |  |
| 18 | model of the Middle Claiborne Aquifer in Southern Mississippi          |  |  |  |
| 19 | down near Hattiesburg. It was actually centered around the             |  |  |  |
| 20 | Richton salt dome, and that was related to a proposal at the           |  |  |  |
| 21 | time to dispose of or store high levels nuclear waste in that          |  |  |  |
| 22 | Richton salt dome. But those are some examples of my                   |  |  |  |
| 23 | groundwater work at Arthur D. Little.                                  |  |  |  |
| 24 | Q. How long did you work at that company?                              |  |  |  |
| 25 | A. That was twelve years.                                              |  |  |  |
|    |                                                                        |  |  |  |

# Alpha Reporting Corporation

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|----|-----------------------------------------------------------------|
| 1  | Q. What was your next job after you left that company?          |
| 2  | A. I then went to a company called Exponent.                    |
| 3  | Q. Can you tell the Court about your work at Exponent related   |
| 4  | to groundwater hydrology?                                       |
| 5  | A. Yeah. I continued to do a number of projects that have       |
| 6  | been involved on water hydrology, though I did less of the      |
| 7  | numerical modeling while I was there, but it was still more the |
| 8  | Darcy's Law kind of calculations that I would do related to     |
| 9  | projects where I was dealing with groundwater issues.           |
| 10 | Q. And what did you do after you left Exponent?                 |
| 11 | A. Well, that was kind of interesting. I was sitting at my      |
| 12 | desk one day at Exponent, I got a call wondering if I wanted to |
| 13 | apply for a faculty position at Northeastern University. And    |
| 14 | I it's not something I'd thought about before, but I decided    |
| 15 | to do it, and I applied, and I got the job. So then I joined    |
| 16 | the faculty at Northeastern University in the civil engineering |
| 17 | department or civil and environmental engineering, I think      |
| 18 | it was called.                                                  |
| 19 | Q. What did you teach at Northeastern?                          |
| 20 | A. At Northeastern, your Honor, I taught the graduate level     |
| 21 | groundwater hydrology and groundwater quality courses, and      |
| 22 | graduate level surface water hydrology and water quality        |
| 23 | courses. I also taught undergraduate hydraulic engineering,     |
| 24 | and I taught a graduate-level course in general environmental   |
| 25 | management.                                                     |
|    |                                                                 |

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|    | 974                                                                    |  |  |  |  |
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| 1  | Langseth - direct<br>Q. What were your research areas at Northeastern? |  |  |  |  |
| 2  | A. The primary research area for the first couple of years was         |  |  |  |  |
| 3  | a detailed study of groundwater surface water interactions.            |  |  |  |  |
| 4  | You may remember a chart that I think Dr. Spruill put up,              |  |  |  |  |
| 5  | looking at nested piezometers and getting evaluating those             |  |  |  |  |
| 6  | curve flow lines near rivers. So it was a detailed study of            |  |  |  |  |
| 7  | those kind of flow patterns near a near a stream.                      |  |  |  |  |
| 8  | Q. Where did you work after you left Northeastern University?          |  |  |  |  |
| 9  | A. I then joined Gradient, where I work now.                           |  |  |  |  |
| 10 | Q. What is Gradient?                                                   |  |  |  |  |
| 11 | A. We are a science environmental and risk sciences consulting         |  |  |  |  |
| 12 | firm.                                                                  |  |  |  |  |
| 13 | Q. What is your job position there?                                    |  |  |  |  |
| 14 | A. I'm a principal.                                                    |  |  |  |  |
| 15 | Q. What types of projects do you work on at Gradient?                  |  |  |  |  |
| 16 | A. Well, over the I guess it's 15 or 16 years I've been                |  |  |  |  |
| 17 | there, it's been quite a variety of projects, but many of them         |  |  |  |  |
| 18 | have involved groundwater and surface water hydrology, and then        |  |  |  |  |
| 19 | also the contaminant fate transport issues.                            |  |  |  |  |
| 20 | Q. Do you belong to any professional associations or                   |  |  |  |  |
| 21 | organizations?                                                         |  |  |  |  |
| 22 | A. Yes, there's two primary ones I belong to. One is the               |  |  |  |  |
| 23 | American Society of Civil Engineers, and in particular I belong        |  |  |  |  |
| 24 | to a subgroup called the Environmental Water Resources                 |  |  |  |  |
| 25 | Institute. That's the group that within the civil engineering          |  |  |  |  |
|    |                                                                        |  |  |  |  |

|    | 975                                                                        |
|----|----------------------------------------------------------------------------|
| 1  | Langseth - direct<br>organization that focuses on water resources matters. |
| 2  | And then I also belong to the National Groundwater                         |
| 3  | Association.                                                               |
| 4  | Q. What do you do as a member of the National Groundwater                  |
| 5  | Association?                                                               |
| 6  | A. Well, a few things. One is I attend their conferences.                  |
| 7  | But my key sort of activity within the organization is that                |
| 8  | I've been their representative on a body called the advisory               |
| 9  | Federal Advisory Committee on Water Information, and that's a              |
| 10 | federal advisory committee that advises all of the different               |
| 11 | federal agencies that deal with water information, such as US              |
| 12 | Geological Survey, the Bureau of Reclamation, the Forest                   |
| 13 | Service, NOAA, EPA.                                                        |
| 14 | So we provide sort of advice regarding water water                         |
| 15 | information, including things like groundwater levels. And                 |
| 16 | then in particular I'm a member of what's called the                       |
| 17 | Subcommittee on Groundwater that's been established under the              |
| 18 | overall Advisory Committee on Water Information.                           |
| 19 | Q. Have you ever served as an expert or given expert testimony             |
| 20 | in any cases involving groundwater?                                        |
| 21 | A. Yes, I have.                                                            |
| 22 | Q. About how many times?                                                   |
| 23 | A. I counted, and it's somewhere in the neighborhood of                    |
| 24 | 20 times.                                                                  |
| 25 | Q. Can you give Judge Siler some examples?                                 |

|    | 976                                                                                 |
|----|-------------------------------------------------------------------------------------|
| 1  | Langseth - direct<br>A. Well, one very recent example is I testified on a matter in |
| 2  | Long Island, where as part of my work that we developed quite a                     |
| 3  | large complex groundwater model, like a 12- or 13-layer-deep                        |
| 4  | model, six to eight miles in length and about three miles wide.                     |
| 5  | And very complex representation of the hydrology in that area.                      |
| 6  | Q. Other than this case, have you ever served as a groundwater                      |
| 7  | expert in an interstate dispute pending before the United                           |
| 8  | States Supreme Court?                                                               |
| 9  | A. Yes, I have.                                                                     |
| 10 | Q. And when was that?                                                               |
| 11 | A. That was, your Honor, for original action number 142, which                      |
| 12 | was Florida against Georgia. And I worked on behalf of Florida                      |
| 13 | in that matter.                                                                     |
| 14 | Q. Dr. Langseth, what work did you do in Florida vs. Georgia?                       |
| 15 | A. I had two roles, your Honor, in that. I was the overall                          |
| 16 | lead for the hydrology team for Florida, and then my personal                       |
| 17 | role and in the hydrology team, we did some very                                    |
| 18 | sophisticated surface water modeling of the flows in that river                     |
| 19 | system. And then we also evaluated the impacts of pumping                           |
| 20 | groundwater on the flows in those interstate rivers.                                |
| 21 | And that was my personal role that I provided                                       |
| 22 | testimony on, was the evaluation of the impacts of pumping on                       |
| 23 | stream flow; that is, when you pump water, you reduce the                           |
| 24 | amount of water that's in the stream. And I did the detailed                        |
| 25 | evaluation and testimony on that on that matter.                                    |
|    |                                                                                     |

|    | 977                                                                           |
|----|-------------------------------------------------------------------------------|
| 1  | Langseth - direct<br>Q. Dr. Langseth, have you previously served as an expert |
| 2  | witness regarding the aquifer issue in this case?                             |
| 3  | A. Yes, I have.                                                               |
| 4  | Q. And when was that?                                                         |
| 5  | A. That was back around two thousand in the period 2006 to                    |
| 6  | maybe 2008, in an action in District Court. Again, Mississippi                |
| 7  | suing City of Memphis and MLGW, I think. The State of                         |
| 8  | Tennessee was not involved at that time.                                      |
| 9  | Q. How did you go about analyzing the aquifer at issue in the                 |
| 10 | District Court litigation?                                                    |
| 11 | MR. ELLINGBURG: Could I I'm going to object to the                            |
| 12 | testimony about the District Court litigation, to the extent it               |
| 13 | exceeds the scope of what he has defined as his role in this                  |
| 14 | case in his reports and his deposition testimony.                             |
| 15 | MS. ROBERTS: Your Honor, I'm simply asking him what                           |
| 16 | work did he do in that case.                                                  |
| 17 | THE COURT: Sure. You may. I'll overrule the                                   |
| 18 | objection.                                                                    |
| 19 | A. I'm sorry, what's the current question, then?                              |
| 20 | Q. What work did you do regarding the aquifer at issue in that                |
| 21 | earlier case?                                                                 |
| 22 | A. Oh. Well, I started, as I always do, with a literature                     |
| 23 | review of the aquifer; and then, based on the questions that                  |
| 24 | needed to be answered for that particular for that                            |
| 25 | particular matter, then I did various evaluations, some just                  |
|    |                                                                               |

|    | 978                                                                                  |
|----|--------------------------------------------------------------------------------------|
| 1  | Langseth - direct<br>based on the literature, and then I also used a numerical model |
| 2  | to answer certain other questions that needed to be addressed                        |
| 3  | in that matter.                                                                      |
| 4  | Q. Are you being compensated for your work in this case?                             |
| 5  | A. Well, Gradient is being compensated, and I'm an employee of                       |
| 6  | Gradient.                                                                            |
| 7  | Q. Are you aware of the rate at which Gradient is being billed                       |
| 8  | for your services?                                                                   |
| 9  | A. I believe Gradient bills for my time at \$355 an hour.                            |
| 10 | Q. Is your compensation or the compensation paid to Gradient                         |
| 11 | in any way related to your opinions or the outcome of this                           |
| 12 | matter?                                                                              |
| 13 | A. No, it's not.                                                                     |
| 14 | MS. ROBERTS: Your Honor, we tender Dr. Langseth as an                                |
| 15 | expert in the field of groundwater technology.                                       |
| 16 | MR. ELLINGBURG: No objection.                                                        |
| 17 | THE COURT: So qualified. He may testify as an expert                                 |
| 18 | in that field.                                                                       |
| 19 | MS. ROBERTS: Your Honor, I'm noting that it's                                        |
| 20 | almost 5:30. This probably would be a good stopping point for                        |
| 21 | the day.                                                                             |
| 22 | MR. FREDERICK: Your Honor                                                            |
| 23 | THE COURT: You may step down, then.                                                  |
| 24 | (Witness stood down)                                                                 |
| 25 | MR. FREDERICK: Thank you, your Honor.                                                |
|    |                                                                                      |

|    | 979                                                                   |  |  |  |  |
|----|-----------------------------------------------------------------------|--|--|--|--|
| 1  | Langseth - direct<br>I'd like to propose that the current time clock, |  |  |  |  |
| 2  | Mississippi has used 14 hours and 58 minutes and the defendants       |  |  |  |  |
| 3  | have used 9 hours and 35 minutes. And I'd like to make a              |  |  |  |  |
| 4  | modest proposal, if I could: That we start tomorrow at                |  |  |  |  |
| 5  | 8:30 a.m.; that each side has three and a half hours of trial         |  |  |  |  |
| 6  | time, and that we commit to stop and end the hearing tomorrow         |  |  |  |  |
| 7  | afternoon.                                                            |  |  |  |  |
| 8  | THE COURT: I'll have to see what the parties want to                  |  |  |  |  |
| 9  | say about it.                                                         |  |  |  |  |
| 10 | MR. L. BEARMAN: Your Honor, we agree, if the Court                    |  |  |  |  |
| 11 | please.                                                               |  |  |  |  |
| 12 | THE COURT: Sir?                                                       |  |  |  |  |
| 13 | MR. L. BEARMAN: I said we agree with the proposal and                 |  |  |  |  |
| 14 | strongly urge it.                                                     |  |  |  |  |
| 15 | MR. ELLINGBURG: Mississippi objects to that, because                  |  |  |  |  |
| 16 | at the present time, we don't really know exactly what's going        |  |  |  |  |
| 17 | to be said on what we covered on cross. That doesn't mean             |  |  |  |  |
| 18 | we'll using the remaining available time if we don't need to,         |  |  |  |  |
| 19 | but there was a lot of negotiation that went into limiting this       |  |  |  |  |
| 20 | hearing to 20 hours each.                                             |  |  |  |  |
| 21 | THE COURT: Okay. I'll overrule the suggestion.                        |  |  |  |  |
| 22 | We'll start at 9:00 tomorrow, and we'll go the best we                |  |  |  |  |
| 23 | can. And if we have to, we'll be back Tuesday.                        |  |  |  |  |
| 24 | I have something I'm supposed to do, too. That's what                 |  |  |  |  |
| 25 | we originally started in our schedule, and we'll do it if we          |  |  |  |  |
|    |                                                                       |  |  |  |  |

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|    | 980                                                                             |
|----|---------------------------------------------------------------------------------|
| 1  | Langseth - direct<br>get through tomorrow by 5:00, we'll do it. And if it takes |
| 2  | another 20 minutes, we'll stay 20, but we won't stay another                    |
| 3  | several hours.                                                                  |
| 4  | So I understand the problems that you have. It's just                           |
| 5  | the way it goes.                                                                |
| 6  | MR. FREDERICK: Thank you for your consideration, your                           |
| 7  | Honor.                                                                          |
| 8  | THE COURT: Anything else for me to take up?                                     |
| 9  | This Court will be in recess until 9:00 tomorrow                                |
| 10 | morning.                                                                        |
| 11 | (Adjourned to Friday, May 24, 2019, at 9:00 a.m.)                               |
| 12 |                                                                                 |
| 13 |                                                                                 |
| 14 |                                                                                 |
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| 25 |                                                                                 |
|    |                                                                                 |

STATE OF TENNESSEE: 1 COURT REPORTER'S CERTIFICATE 2 3 I, PATRICIA A. NILSEN, Licensed Reporter for the State of Tennessee, CERTIFY: 4 1. The foregoing deposition was taken before me at the time and place stated in the foregoing 5 styled cause with the appearances as noted; 2. Being a Court Reporter, I then 6 reported the deposition in Stenotype to the best of my skill and ability, and the foregoing pages contain a full, true and 7 correct transcript of my said Stenotype notes then and there taken; 3. I am not in the employ of and am 8 not related to any of the parties or their counsel, and I have 9 no interest in the matter involved. 10 WITNESS MY SIGNATURE, this, WITNESS MY Si the\_\_\_\_\_ day of \_\_\_\_\_\_, 2019. 11 Part A. Nila 12 13 14 PATRICIA A. NILSEN, RMR, CRR, CRC TN Licensed Court Reporter 15 LCR Number: 717 Expiration: 6/30/2020 16 17 18 19 20 21 2.2 23 24 25

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