STATE OF NEW MEXICO

ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT

OIL CONSERVATION COMMISSION

IN THE MATTER OF THE HEARING CALLED BY THE OIL CONSERVATION COMMISSION FOR THE PURPOSE OF CONSIDERING:

APPLICATION OF THE NEW MEXICO OIL CONSERVATION DIVISION FOR REPEAL OF EXISTING RULE 50 CONCERNING PITS AND BELOW GRADE TANKS AND ADOPTION OF A NEW RULE GOVERNING PITS, BELOW GRADE TANKS, CLOSED LOOP SYSTEMS AND OTHER ALTERNATIVE METHODS TO THE FOREGOING, AND AMENDING OTHER RULES TO MAKE CONFORMING CHANGES; STATEWIDE

CASE NO. 14,015

ORIGINAL

REPORTER'S TRANSCRIPT OF PROCEEDINGS

COMMISSION HEARING

BEFORE: MARK E. FESMIRE, CHAIRMAN
JAMI BAILEY, COMMISSIONER
WILLIAM OLSON, COMMISSIONER

RECEIVED
2008 FEB 8 PM 3 07

Volume XIV - December 3rd, 2007

Santa Fe, New Mexico

This matter came on for hearing before the Oil Conservation Commission, MARK E. FESMIRE, Chairman, on Monday, December 3rd, 2007, at the New Mexico Energy, Minerals and Natural Resources Department, 1220 South Saint Francis Drive, Room 102, Santa Fe, New Mexico, Steven T. Brenner, Certified Court Reporter No. 7 for the State of New Mexico.

* * *

C U M U L A T I V E   I N D E X

Monday, October 22nd, 2007 (Volume I)
Commission Hearing
CASE NO. 14,015

* * *

Monday, November 5th, 2007 (Volume II)
Commission Hearing
CASE NO. 14,015

(Continued...)

PUBLIC COMMENTS (Continued):

DIVISION WITNESSES (Resumed):

(Continued...)

* * *

Tuesday, November 6th, 2007 (Volume III)
Commission Hearing
CASE NO. 14,015

(Continued...)

DIVISION WITNESSES (Continued):

* * *

Wednesday, November 7th, 2007 (Volume IV)
Commission Hearing
CASE NO. 14,015

DIVISION WITNESSES (Continued):

(Continued...)

DIVISION WITNESSES (Continued):

* * *

(Continued...)

Thursday, November 8th, 2007 (Volume V)
Commission Hearing
CASE NO. 14,015

* * *

Friday, November 9th, 2007 (Volume VI)
Commission Hearing
CASE NO. 14,015

(Continued...)

PUBLIC COMMENTS:

OPENING STATEMENT:

INDUSTRY WITNESSES:

PUBLIC COMMENTS:

(Continued...)

INDUSTRY WITNESSES (Resumed):

* * *

Tuesday, November 13th, 2007 (Volume VII)
Commission Hearing
CASE NO. 14,015

(Continued...)

PUBLIC COMMENTS:

OGAP WITNESSES (Resumed):

DIVISION WITNESSES (Continued):

(Continued...)

PUBLIC COMMENTS:

* * *

(Continued...)

Wednesday, November 14th, 2007 (Volume VIII)
Commission Hearing
CASE NO. 14,015

(Continued...)

PUBLIC COMMENTS (Continued):

NMCCAW WITNESS (Continued):

PUBLIC COMMENTS:

* * *

(Continued...)

Thursday, November 15th, 2007 (Volume IX)
Commission Hearing
CASE NO. 14,015

* * *

(Continued...)

Friday, November 16th, 2007 (Volume X)
Commission Hearing
CASE NO. 14,015

* * *

(Continued...)

Monday, November 26th, 2007 (Volume XI)
Commission Hearing
CASE NO. 14,015

* * *

(Continued...)

Tuesday, November 27th, 2007 (Volume XII)
Commission Hearing
CASE NO. 14,015

(Continued...)

IPANM WITNESSES (Continued):

* * *

Friday, November 30th, 2007 (Volume XIII)
Commission Hearing
CASE NO. 14,015

IPANM WITNESSES (Continued):

PUBLIC COMMENTS:

(Continued...)

PUBLIC COMMENTS (Continued):

IPANM WITNESSES (Continued):

* * *

Monday, December 3rd, 2007 (Volume XIV)
Commission Hearing
CASE NO. 14,015

(Continued...)

PUBLIC COMMENTS:

* * *

E X H I B I T S

Applicant's	Identified	Admitted
Exhibit 1	163	163
Exhibit 2	163	163
Exhibit 3	2736	-
Exhibit 4	(58)	205
Exhibit 5	(61)	205
Exhibit 6	(94)	205
Exhibit 7	-	-
Exhibit 8	421	-
Exhibit 9	(373)	399
Exhibit 10	(383)	399
Exhibit 10A	(385)	399
Exhibit 11	(176)	205
Exhibit 12	178	205
Exhibit 13	427	511, 527
Exhibit 13A	430	-
Exhibit 13B	430, 432, 832	834
Exhibit 13C	(345), 433	511
Exhibit 14	428, 449, 511	-
Exhibit 15	449	511
Exhibit 16	457, 459	511
Exhibit 17	450, 458, 484	511
Exhibit 18	484	511
Exhibit 19	676	764
Exhibit 20	677, 764	764
Exhibit 21	679	764
Exhibit 22	-	1159
Exhibit 23	842	1159
Exhibit 24	844, 846, 1109, 1156	1159
Exhibit 25	846, 1157	1159
Exhibit 26	1158	1159

(Continued...)

E X H I B I T S (Continued)

* * *

(Continued...)

E X H I B I T S (Continued)

OGAP	Identified	Admitted
Exhibit 1	1417	1417
Exhibit 2	1489	1490
Exhibit 3	1418, 1420	1486
Exhibit 4	-	-
Exhibit 5	1491	1607
Exhibit 6	1491	1607
Exhibit 7	1491	1607
Exhibit 8	1491	1607
Exhibit 9	1492	1607
Exhibit 10	1492	1607
Exhibit 11	1492	1607
Exhibit 12	-	1607

* * *

NMCCAW	Identified	Admitted
Exhibit 1	1757	1861
Exhibit 2	1758	1861
Exhibit 4	1861	1861

* * *

IPANM	Identified	Admitted
Exhibit 1	-	-
Exhibit 2	-	-
Exhibit 3	-	-
Exhibit 4	3074	3176
Exhibit 5	3121	3176
Exhibit 6	(3065)	-
Exhibit 7	(3065)	-
Exhibit 8	3161	3176
Exhibit 9	3164, 3168	3176

(Continued...)

E X H I B I T S (Continued)

IPANM (Continued)	Identified	Admitted
Exhibit 10	3170	3176
Exhibit 11	-	-
Exhibit 12	-	-
Exhibit 13	2749	2951
Exhibit 14	-	-
Exhibit 15	-	-
Exhibit 16	-	-
Exhibit 17	-	-
Exhibit 18	-	-
Exhibit 19	-	-
Exhibit 20	-	-
Exhibit 21	-	-
Exhibit 22	2961	3012
Exhibit 23	-	-
Exhibit 24	-	-
Exhibit 25	-	-
Exhibit 26	-	-
Exhibit 27	-	-
Exhibit 28	-	-
Exhibit 29	-	-
Exhibit 30	-	-
Exhibit 31	-	-
Exhibit 32	3330	3361
Exhibit 33	-	-
Exhibit 34	-	-
Exhibit 35	-	-
Exhibit 36	-	-
Exhibit 37	23	-

* * *

Additional submissions by the Division, not offered or admitted:

	Identified
OCD's Requested Changes to 9/21/07 proposal, 11/7/07	558
e-mail from David Brooks to Kelly O'Donnell, 10/22/07	559

* * *

A P P E A R A N C E S

FOR THE COMMISSION:

CHERYL BADA
Assistant General Counsel
Energy, Minerals and Natural Resources Department
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

FOR THE DIVISION:

DAVID K. BROOKS, JR.
Assistant General Counsel
Energy, Minerals and Natural Resources Department
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

FOR NEW MEXICO OIL AND GAS ASSOCIATION; CONOCOPHILLIPS COMPANY; DUGAN PRODUCTION CORPORATION; and ENERGEN RESOURCES CORPORATION; and an INDUSTRY COMMITTEE comprised of BP America Production Company, Inc.; Benson-Montin-Greer Drilling Corporation; Boling Enterprises, Ltd.; Burlington Resources Oil and Gas Company; Chesapeake Energy Corporation; Chevron USA, Inc.; ConocoPhillips Company; Devon Production Company; Dugan Production Corporation; Energen Resources Corporation; Marathon Oil Company; Marbob Energy Corporation; Merrion Oil & Gas Corporation; Occidental Permian, which includes OXY USA, Inc., and OXY USA WTP Limited Partnership; Samson Resources Company; J.D. Simmons, Inc.; Williams Production Company, LLC; XTO Energy, Inc.; and Yates Petroleum Corporation:

HOLLAND & HART, L.L.P., and CAMPBELL & CARR
110 N. Guadalupe, Suite 1
P.O. Box 2208
Santa Fe, New Mexico 87504-2208
By: WILLIAM F. CARR

(Continued...)

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

FOR INDEPENDENT PETROLEUM ASSOCIATION OF NEW MEXICO:

KARIN V. FOSTER
Independent Petroleum Association of New Mexico
Director of Governmental Affairs
17 Misty Mesa Ct.
Placitas, NM 87043

FOR NEW MEXICO INDUSTRY COMMITTEE
and YATES PETROLEUM CORPORATION:

JORDEN, BISCHOFF & HISER, P.L.C.
7272 E. Indian School Rd., Suite 360
Scottsdale, AZ 85251
By: ERIC L. HISER

FOR CONTROLLED RECOVERY, INC.:

HUFFAKER & MOFFETT, L.L.C.
155 Grant
Santa Fe, New Mexico 87501
P.O. Box 1868
Santa Fe, New Mexico 87504-1868
By: MICHAEL J. MOFFETT

FOR NEW MEXICO OIL AND GAS ACCOUNTABILITY PROJECT:

New Mexico Environmental Law Center
1405 Luisa Street, Suite 5
Santa Fe, New Mexico 87505
BY: ERIC JANTZ

* * *

ALSO PRESENT:

JOHN BARTLIT, PhD
DONALD A. NEEPER, Phd
New Mexico Citizens for Clean Air and Water

* * *

WHEREUPON, the following proceedings were had at 9:03 a.m.:

CHAIRMAN FESMIRE: Okay, let's go back on the record.

Let the record reflect that it's 9:00 a.m. on Monday, December 3rd, 2007. This is a continuation of Case Number 14,015.

Let the record also reflect that Commissioners Bailey, Olson and Fesmire are all present, we therefore have a quorum.

I believe we were in the process of cross-examining Mr. John Byrom; is that correct?

MS. FOSTER: Yes, Mr. Chairman, that's correct.

CHAIRMAN FESMIRE: And I believe it was my turn, wasn't it?

MS. FOSTER: I believe it was Mr. Brooks's turn.

CHAIRMAN FESMIRE: Oh, that's -- Okay.

Mr. Byrom, would you re-take the stand, please, and please remember that you've been previously sworn in this case?

THE WITNESS: Yes, I have.

CHAIRMAN FESMIRE: Mr. Carr --

MR. CARR: Yes.

CHAIRMAN FESMIRE: -- your witnesses, are they here today?

MR. CARR: Dr. Buchanan is here. He has to testify tomorrow in Utah, but he is here and ready whenever we get to him.

CHAIRMAN FESMIRE: Is there any problem with continuing with Mr. Byrom, or should we --

MR. HISER: It depends how long you think Mr. Byrom is going to take, but he's ready to go whenever, so it's what the pleasure of the Commission is.

CHAIRMAN FESMIRE: Okay. Well, I think we'll continue with Mr. Byrom with the understanding that we've got to go until we finish Dr. Buchanan.

Doctor, what time should --

MR. BROOKS: Oh, I recall where we were. Ed just reminded me. Dr. Neeper had been -- Mr. Byrom had been tendered to Dr. Neeper, and Dr. Neeper said he would take about 20 minutes, so you decided to postpone it till this morning.

CHAIRMAN FESMIRE: Okay.

MR. BROOKS: I would imagine ours will take about the same length of time.

CHAIRMAN FESMIRE: And how long?

COMMISSIONER BAILEY: Just one question.

CHAIRMAN FESMIRE: One question.

Do you have some questions of this witness?

COMMISSIONER OLSON: Yeah, just a couple, not --

you know.

CHAIRMAN FESMIRE: If we were to take a couple-hour -- delay Dr. Buchanan by a couple hours, would that allow us to finish with him today?

MR. HISER: The direct testimony of Dr. Buchanan I estimate is less than two hours, so that may -- But how long cross would be, I have no idea.

CHAIRMAN FESMIRE: Okay. Well, it sounds like we can go ahead and finish with Mr. Byrom and then start with Dr. Buchanan.

Dr. Neeper, are you prepared to question this witness?

DR. NEEPER: Yes, I have some questions.

JOHN BYROM (Continued),

the witness herein, having been previously duly sworn upon his oath, was examined and testified as follows:

CROSS-EXAMINATION

BY DR. NEEPER:

Q. Good morning, Mr. Byrom.

A. Good morning, Dr. Neeper.

Q. Do I understand correctly that your cost estimates that are shown on your graphs are based on the assumption that the new rule -- or that the operator would be using a closed-loop; is that correct?

A. That's correct, that was the analysis that I used from Mr. Small's differential -- the differential price between closed-loop and the existing methodology.

Q. In the northwest, can you give us a guess as to what fraction of the ground -- the area would have a depth to groundwater of less than 50 feet? That is, would actually -- where a closed-loop would actually be required according to the proposed rule?

A. Well, I think there's quite a lot of area that has a groundwater depth greater than 50 feet, and I think, you know, just looking at the current area that's the restricted -- what is -- what am I thinking? But it's the area that -- under current rules that is outside of the -- basically the river drainages.

Q. Yes.

A. I would think that that would be easily over 50 feet.

However, the other provisions in the rule, in particular the 200 feet to a dry watercourse, I think would pose significant restrictions for us on siting pits up in the northwest, just because of all the arroyos and the drainages within drainages, and the definition of what you call a dry watercourse.

Q. So it's the dry watercourse that is making you feel that closed-loop would be used in many instances, or most of the instances?

A. Yeah, in many instances I think so. And you know, as I said before, Mr. Small's testimony assumed no problems when you're digging up your pit and excavation and it was according to the rule.

If you find 250 milligrams per kilogram, then you would have to start a spill remediation site, and I don't know, you know, how much that would be a problem also, on top of the base AFE costs that we used for digging and -- for burying in place, which is the -- or excuse me, the deep-trench burial.

Q. I want to revisit a potential clarification in the wording you just gave. When you said if one found in excess of 250 milligrams per kilogram under a pit it would trigger a remediation, did you mean it would trigger further investigation of determining whether or not there was a release?

A. Well, I think that if you find the 250, if I remember the writing of the rule, you basically have to report that there was a release. Then from that point, then you have to delineate the spill, and then from that point then go to the OCD and they will tell you what you need to do.

Q. Very good. Yes, I understood spill delineation.

Do I remember correctly that you estimated costs imposed by the rule or required by the rule to be something like $35,000 for a fairly ordinary northwest pit? And I recognize there are different sizes of --

A. Oh, on the -- under the existing methods that we use for construction and burial in place? Is that what you're saying?

Q. No, I was getting at impact of the rule. I had made a note --

A. Oh.

Q. -- that you had said an impact of the rule was 35K, and I'm not sure that I made a correct note.

A. Oh, I'm sorry. No, if I said that I -- I was mistaken. I think my additional cost due to the new rule -- on my table you can see the first white column, kind of in the middle of the page is, I used $160,000 for the deeper wells and then $127,000 for a Mesaverde, which runs around 5500, and then the Pictured Cliffs I used $85,000 differential costs.

Q. And if one were not within the required setback, shall we say, from a dry watercourse, would those costs be considerably less? Would it be anything -- would anything -- costs required by the rule be beyond simply dig, haul and disposal costs at the landfill? Would there be other costs involved?

A. At that point, if you were to just basically build a conventional pit and then the closure, assuming that -- well, that you could have a pit based on the restrictions in the rule -- so that would mean that you're away from groundwater, away from dwellings, away from watercourses, away from what somebody could potentially define as a playa -- then you could actually do the burial in place -- Well, I'm sorry, then you would have to -- then you could actually dig and haul and actually use a pit.

And those numbers would be less, to the tune of -- according to Mr. Small, it would be about 70 percent of the costs, if I just recall off the top of my head of what we're looking at here.

And I think it's important to keep in mind that as I was speaking -- the graphs show that a fairly large percentage, depending on what kind of wells that you're looking at, whether it's 20 or 30 percent or 70 percent, 70 or 80 percent, are in the marginal category. So even a -- even the dig-and-haul option would still entail a significant amount of additional investment to drill that well, in my opinion would put that well in jeopardy as to whether it would be drilled or not.

So these are still not trivial numbers.

Q. In the concept of economic, which I appreciate from your graphs, do you assume -- when you draw that line that distinguishes economic wells from uneconomic wells, do you assume that when a well that is -- reaches that threshold, it's turning a profit, or is that just at a break-even point?

A. What those lines are is, if you were to somehow be able to drill the well, get it on production, see what the -- the kind of production that you're going to have, and then you'd be able to estimate the future revenue with a lot less risk, then what that line was doing is -- I used a 15-percent return on investment threshold, so if you were to -- so based on my price forecast, based on the production forecast and based on the return on investment threshold, that line is -- anything above that would be giving a greater than a 15-percent return on investment, anything lower is 15 -- would be less.

So once again the point is that that is a general area to where your threshold is between what I would call economic wells and wells that are uneconomic, or marginal wells.

Once again, the wells that came in way below 15 percent, obviously the operator didn't expect them to be making that low a production, but that -- you know, many of the wells just don't come in where we had hoped.

So that well is not necessarily -- somebody didn't say, Well, that -- this well is going to be terrible, let's go ahead and drill it anyway. They figure that it was going to be at least a marginal well when they drilled it, when they spudded it.

Q. So in these terms, if I were an operator and I had a well that was giving me only a 10-percent return, it would fall just below the line that you drew?

A. Right, and I think that's a case where -- the case of the return on investment that you're looking for takes into account the inherent risk of your investment.

Obviously -- you know, I think T-bills are going for something in the 4.5-, 5-percent range right now, and that's hopefully risk free, given the status of our nation. And then you can get on up into the very high return on investments if you're investing in, you know, some startup company or something like that.

So the 15 percent is a general number that I use to -- that I feel is a good number to use related to the typical risk versus return that you see in the oil and gas industry.

So it's possible that there are some wells that an operator may drill with a 10-percent return on investment if they feel that the other risk factors are low enough that that works, and there's other wells that you'd be wanting more of a 20-percent return on investment, or higher.

Certainly, if you're drilling a wildcat well I think you'd be wanting to see something higher than that because odds are, you're going to get a dry hole.

Q. I understand that.

Pages 11 through 14 of your exhibit show the count of wells that, by this criterion, you would judge as uneconomic. And you also show the increase in the count that might be caused by the rule, by the upper line.

A. Okay, I'm sorry, let me --

Q. Try -- page 14 is one example.

A. Which is page 13 on that, or is it page 15?

Q. I just happen to have page --

A. It's okay --

Q. -- 14 --

A. -- would that be the -- yeah, we're on the same graph. The Dakota-Mesaverde commingle one?

Q. Yes. You have several -- several charts --

A. Right.

Q. -- on pages 11 through 14.

A. This particular one being labeled Dakota-Mesaverde commingle.

Q. Right. Page 14, by the way I would count it, would show something like 17 percent of the wells are below the line, being uneconomic.

A. Yes.

Q. And the red dashed line increases the amount of uneconomic wells by about 6.5 percent or so. In other words, it goes from 17 to 22 or 23 percent, becoming uneconomical.

A. I think your numbers are fairly close, without having a calculator.

Q. These are hip-pocket numbers, and we could do that for each one of the curves.

A. Right.

Q. So this is a correct interpretation of your graph?

A. That's correct.

Q. Would it be -- when I looked at all four of these graphs, this fraction that becomes uneconomic differs, depending on which type of well it is?

A. That's correct. It's mainly -- it just comes down to the reserves that you get versus the expense that you spend to get to those reserves.

Q. But for a broad average of costs, then, would it be correct to interpret that, if a requirement for closed loop were imposed, as you imply it might effectively be, would the decrease in rational drilling -- a driller could kind of do these numbers ahead of time -- would the decrease in drilling be something like about 10 percent? That's --

A. No, actually --

Q. -- this graph.

A. -- I don't think that that's the way you should interpret these graphs. Once again, I'm not saying that the operator can necessarily draw this graph ahead of time before they have an estimate of what kind of well they're going to get, and the purpose of these graphs is to show the relative percentage in each of these categories of the number of wells that I would consider that would probably be marginal when the operator decided to go ahead and drill them.

So in this case I think, as you indicated, it's something like 17 percent of these wells would be in the marginal categories. So 15 to 20 percent would be in that range.

So my point is here that while it looks like a small little incremental increase, or a 6-percent difference, as you're saying, I think that what in effect this shows is that 15 to 20 percent of these wells actually may not be drilled if you pile on that much more cost up front, that the operator knows with certainty that they're going to need to be spending, versus the type of risk -- versus the type of reserves that they're hoping to get.

So my point is with these graphs, is to show that 15 to 20 percent of these wells may not get drilled at all with this kind of increase in costs up front.

As I mentioned before, this increase in costs occurs up front with certainty when you drill the well. It's not something that you can put off until you find out what kind of reserves you're going to get.

Q. And can you compare that 15- to 20-percent threat which you see with the -- both within-the-year fluctuation and the year-to-year fluctuation of the drilling activity, maybe as measured by the rig count?

A. Well, I think this is just one particular formation. I think we've showed other formations could be much more significantly affected. So overall, I think I've estimated something like 30 percent of a threat -- that 30 percent of the wells could be threatened by this rule to not be drilled.

So year-to-year, you know, this year, I think -- in 2004 there was over 700 wells drilled. I think we're down more in the 600 range. So 30 percent of 600 would be about 180 wells that would be under threat of not being drilled because of this impact on their marginal status.

Q. And can you compare that to the fluctuation, say, over the last three years, that occurred without -- without this rule?

A. Without the rule? Yeah, with the -- I think what we saw in the 2002 -- and this is off the top of my head, but we did see a ramp-up with the revenues coming up with companies because of the increased price.

As I mentioned, I think, in 2002, we had point of gas prices being around $2 per MMBTU and oil prices around $20 or less. But when prices started to come up, drilling accelerated with that. And so in 2004 -- well, back then I think we were under 600 wells -- and that's kind of a guess on my part, but we are up pretty high.

But since then -- in 2005 I think we had strong drilling, 2006, but then it's dropped off. And I think that that's a case where we have seen the continual increase in costs and services going up without any corresponding increased cost in gas prices. And we've seen a similar effect, I think, with that kind of the cost versus price bringing the return on investment back down.

So in effect, we've kind of seen partially a similar phenomenon of the drilling dropping as a reaction to that return on investment. The profitability of the well is coming down, and so the drilling is dropping.

So I think this would just compound that, and in going forward I think we would expect to see even more of that.

Q. I simply want to interpret that in terms of the fluctuation that we've seen that you mention is due to all the various market forces.

A. Correct.

Q. So the -- your version of the expected impact of the rule would be something comparable to, or perhaps even a little less than, what's been experienced in fluctuation due to market forces?

A. I don't know if it would be less than, but -- I don't know if necessarily comparable, but yeah, you do see adjustments to drilling activity based on the profitability of the wells. When prices went up there for a while and there was the -- really, the expense of services hadn't gone up, there was a lot of money coming into the industry chasing that higher return on investment. And that advantage has gone away, and so you're just not seeing as much drilling happening.

Q. But you're speaking almost strictly related to gas here; is that right?

A. Yes, well, I think oil in the past had followed along also. But I think in the southeast, as we heard from testimony last Friday, those drilling counts are going down despite the high oil prices. Once again, I think you're seeing costs or risks going up greater than the revenue is going, so your rate of return versus risk is getting out of balance, so there's less drilling.

DR. NEEPER: No further questions.

CHAIRMAN FESMIRE: Mr. Brooks, have you completed your examination of this witness?

MR. BROOKS: No, I have not.

CHAIRMAN FESMIRE: Okay, why don't you go ahead and do that?

CROSS-EXAMINATION

BY MR. BROOKS:

Q. Good morning, Mr. Byrom.

A. Good morning, Mr. Brooks.

Q. Well, my cross-examination is going to be shorter than it would have been if I had done it on Friday, because I've forgotten a lot of what you said --

(Laughter)

Q. -- the opportunity to address those things.

My first question, though, is very simple. You didn't do your own estimate of incremental cost, did you?

A. My own numbers, no, I did not.

Q. You relied on Mr. Small?

A. Mr. Small -- mainly I relied on him for specific numbers. But as far as just generally cross-checking the validity of the numbers that he used, I used discussions with our own engineer on what he thought we might be looking at, as well as previous testimony from other experts that have testified in here, which -- they indicated their costs were significantly higher than what Mr. Small was using.

Q. Okay. Well, I'm not going to go back over and question you about the other evidence that's come in that I questioned Mr. Small about, because I've been over that with a couple of witnesses. Just bottom-line.

If Mr. Small's numbers were high, then that would mean that your conclusion -- if his -- if his incremental cost numbers were higher than what actually proves to be the case, that would mean that you would be -- that would mean that your number of how many wells -- how many wells will not be drilled because of this rule would also be high, correct?

A. Yeah, if it turns out that the actual drilling -- incremental drilling cost increase is less than what I'm expecting, then obviously one would think that there would be less of an impact on those marginal wells --

Q. Right.

A. -- and some of the better marginal wells would go ahead and be drilled, and others would still be impacted. So it -- obviously it does matter what the incremental costs are.

And like I said, I feel like Mr. Small's numbers are very reasonable.

Q. Okay. And you're not saying that there won't be any gas wells drilled in the San Juan Basin if this rule is adopted?

A. No, I think there's still going to be -- there's still going to be wells drilled in the San Juan Basin. I think this graph shows that there still is a lot of wells that are being able -- that would be able to be drilled, but would be well above the threshold that an operator would be looking at.

You know, it certainly is going to -- could have an impact on a number of wells, and I think that one of the things to keep in mind is that, as I've shown, these wells look good now, but in the future we're continually depleting the reservoir pressure, depleting the reserves, so all of our wells are going to be under threat of becoming marginal as you're drilling more and more wells in a maturing gas field.

And one thing, I think another point to make is, even some of these wells that may look good on this graph, there's a lot of wells that are being infill drilled.

And another effect that we're seeing is depletion of offsetting wells, and that's something that we've seen in large fields that Simmons owns a small interest in that are operated by big operators, as well as our own fields, is some of these infill wells, and ours specifically in the Mesaverde, we saw our offset wells that had been drilled in the '80s be affected by the production of the new well that was drilled in early 2000, or in the late '90s and early 2000 when we drilled them.

So that is something that's not showing up on these graphs, because this just looks at the new well. It doesn't look at the offsetting depletion of the existing wells.

Q. Yeah, and I wasn't going to ask you that right now, but since you're raised the issue I'll go ahead and ask that question.

Some of the production that would -- some of the gas that would be produced by the wells that will not be drilled will actually be produced by wells that already exist or that will be drilled, correct?

A. Yeah, some of it would be.

Q. Not all of it, but some of it?

A. Some of it would be --

Q. And --

A. -- depending on the length of time. And of course that's in a -- drilling in an existing reservoir, that is the issue that you look at is, the reserves that you're getting sooner because of a well that you drilled, versus -- and more reserves because of that time, versus not drilling the well and waiting a longer period of time to get lesser reserves.

You have to look at the whole picture to decide, is it going to be economic to drill that new well?

Q. And incremental production may or may not be beneficial to the -- accelerated production, I'll say what

I -- what I -- accelerated production, now you understand what I mean by accelerated production?

A. Well, accelerated, just to make sure, that means you drill a new well in a field that's surrounded by other wells, and by drilling that new well you get those reserves out faster than you would if you waited for the other wells to deplete it.

Q. Right, exactly.

A. And I would say that still, you're probably also going to be getting -- you're going to get incremental reserves also, over and above accelerated reserves. You're going to get some gas that you probably wouldn't get otherwise.

Q. Right. But some part of what you're going to get is going to be accelerated as opposed to incremental production, right?

A. In a lot of cases. As I just mentioned, and what we were seeing in some of this infill drilling that's going on in the San Juan, that can happen, that you would be getting accelerated --

Q. And you haven't made any estimate of how much is -- of how much is which, accelerated versus incremental?

A. Not that I have off the top of my head. I think we've looked at some of that, but --

Q. Now in addition to the fact that there are going to be wells drilled, there are going to continue to be marginal wells drilled, are there not?

A. Yeah, whatever the marginal plan is at that point in time based on the risk versus return.

Q. And there will --

A. Somebody's always going to decide to go ahead and drill that iffy well.

Q. And there will continue to be uneconomic wells drilled, because people won't know that they're drilling them when they drill them, correct?

A. That's right, that shows -- that is a risky business, and hence the returns that we look for.

Q. So this curve -- if you trace this curve at any point in time, whatever happens, you're always going to see some wells that are good producers out there, and some wells that are not?

A. Yes, you're always going to do that. And I think that's -- that's a point that -- to maintain the viability of -- particularly the mature fields that we have in New Mexico, both in the Permian and the San Juan, I think that we're going to need to keep in mind our need to husband these resources and not put any additional costs on the drilling or add additional risks to the drilling that we don't absolutely need to. So I think it is important.

Q. You -- did you -- did I understand you to say in response to Dr. Neeper's question that you were estimating 30 percent fewer wells would be drilled in the San Juan Basin?

A. That was a -- that's my approximate estimate. I'm estimating that there's a potential for 30 percent, based on this analysis.

Q. And is there any mathematical derivation of that 30 percent from what you've given us here on your graphs, or is that just where you've eyeballed the graphs --

A. I've eyeballed the graphs.

Q. -- and come to a conclusion?

A. Yes, I feel my eyeballing, given the range that I'm looking at -- I'm just trying to see if I can find the right graph to point to. It may be 25 percent, it may be 35 percent. Okay, I think I'll go use this graph.

But if you look in the range of all the wells that were drilled in 2004, looking at my graph labeled number 10, which would be Exhibit 9, I guess, and pick a line that's in the 100,000 or 80,000 threshold, and draw it over, you'll come to something in the -- somewhere around 300,000 out of the -- excuse me, 300 out of the 700-and-something wells which would be greater than 30 percent.

But keeping in mind, some of those wells will fall lower than that, would need less reserves to be economic, some of them would be -- would need more.

As I mentioned before, a lot of the wells drilled in the San Juan Basin in 2004 were coal wells, so since they tend to have inclining production, they will need less first year production to get the same reserves.

So that's where I came up with my 30 percent.

Q. And there are a lot of wells that produce from multiple zones in the San Juan, are there not?

A. Yeah, there's -- there's quite a number.

Q. And as Dr. Neeper pointed out by reference to page 14, those wells have a higher production --

A. Yes, they do.

Q. -- they look more favorable on this kind of graph?

A. Well, they have more production but they also cost more. So once again, those wells, if you look at the Mesaverde-Dakota graph, which is --

Q. Yeah.

A. -- my slide 11, Exhibit 13 [*sic*], I suppose, that threshold of first year's production was over 100,000, just because those wells cost significantly more, because you're completing the multiple formations with multiple fracs, multiple completions.

Q. Still, you have a whole lot higher -- a whole lot more wells showing that meet your cutoff criterion here on your graph --

A. On --

Q. -- than you do on some of the others?

A. On that one in particular, the Dakota-Mesaverde wells do have -- there's more reserves at this point in time.

As I mentioned, those are wells that being drilled more in the center of the Basin where you have the good Dakota and good Mesaverde reservoirs overlapping one another --

Q. Okay --

A. -- so that's not Basinwide by any means.

Q. The well -- What you're saying, basically, is that -- and this is fairly intuitive, I should think -- that with higher costs your -- would be -- well operators are going to be more picky about what they choose to drill?

A. Well, yeah, I think they're always picky. I think it just moves the picky threshold.

Q. They're going to look for greater estimated recovery from a well to offset the higher cost?

A. That's correct. I came up with -- like a typical Mesaverde well, you're going to need an extra year's production to get that additional cost.

Or, my table -- back to my table. Sorry for flipping through here, but my table on page 15, Exhibit -- I guess it would be 14 [*sic*] -- shows the difference for a

Mesaverde well from -- going to basically 434,000 to 489,000 MCF in reserves. So you're right.

Q. Okay. Of course, sometimes like we said, they're going to be wrong? Sometimes they're not going to get a good well, even though they think they are?

A. Right. And I think, you know, sometimes, you know, based on your estimate, you'll see some that come in better than what you had hoped --

Q. Right --

A. -- to --

Q. -- but given the science of the industry, overall there's going to be a tendency for them to be right, correct?

A. I wish that were true.

(Laughter)

A. I need to talk to my engineer about that.

You know, overall, I think that's one advantage of the San Juan Basin, and that's why I think our return on investment threshold is lower, is because we've got so many wells.

And I know 15 percent seems high, but in this kind of a risk business, because we have so many wells, you have a better idea of the kind of reserves that you're drilling for than you would in other cases.

Q. You have a lot of well control?

A. You have well control. Now we just drilled some Gallup-Dakota wells, and there was well control. But the Gallup formation is not necessarily a blanket-type reservoir, there's definitely boundaries. And so we are kind of extending that boundary.

So even though there's lots of wells around there, we're not -- you know, we weren't sure what we were going to get. So I guess -- That's what I'm talking about is, the risk is lower because of the well control.

Q. Well, to the extent that the science is right, then the wells that will be drilled despite the increased cost would be the better wells, right?

A. Yes, that's correct.

Q. Which means that the amount of production -- the decline in production will be less than the decline in number of wells?

A. Yeah, that's an interesting observation. I think you're right, that it's going to cull out the lower producing wells, and the better producing wells would still get drilled.

Q. And that's on top of the fact that some of the production you get from the additional wells will not be incremental but will be merely accelerated production, so that in the long run it's going to be even more true that the decline in production is going to be less than the decline in number of wells drilled, correct?

A. I don't think that the accelerated production issue would be necessarily much of a factor, because your -- the better wells are having the same effect, I think. Sometimes the really good wells will affect offsetting wells.

Q. Yes, but looking at in the long run, the wells that aren't drilled, to the extent that they only produce gas that would have been produced from the existing wells -- in the long run, they're not going to add anything to production?

A. Well, if you consider the long run to be a thousand years, you might be right. But I don't think that that incremental production is zero that you're getting from infill wells --

Q. Well, I said to the extent --

A. -- accelerated --

Q. -- that it's represented by accelerat- --

A. Well, okay, to the extent, whatever percentage that might be, then you would eventually get that gas out. But once again, you know, that's a time-value-of-money issue.

Q. But the time value of money is only a valid observation, is it not, if the price remains stable? If the price goes up, that changes the odds quite a bit, doesn't it?

A. No, I think time value of money is valid all the time, and the -- predicting the future of gas prices is part of the risk in the business.

So no, I don't think that gas pricing negates time value of money. It depends on what the gas pricing is.

Q. Well, let me modify what I said. The money that you get farther out is a lot more valuable than -- well, I think I've made my point. I'm going to move on to something -- I'm going to make one other point in that regard and then go on to something else.

Regardless of the time value of money -- and it does have to be applied with price in mind, does it not? You have to take account of price -- you have to have some kind of price estimate to make a meaningful computation?

A. Yes, definitely. You have to have a price estimate in order to predict your estimated future cash flow.

Q. For instance, if you had owned a large ranch in west Texas that had a lot of oil in it, and it was discovered back in the 1930s and you had found a way to produce all the oil while it was at 90 cents a barrel, you might not have made a good deal?

A. That's true, yeah, that's true. I think that's

-- But when you say might not have made a good deal to that owner, that may have made them quite wealthy, and that money that they made, then, was invested, maybe they turned around and invested in the offsetting oilfield and they're doing even better.

Q. Okay. But taking that analysis a step further, unless we have some major breakthroughs in energy development, there's going to be a continuing need for the gas reserves, right?

A. I certainly hope so.

Q. And if the price were to go up significantly, then many of these wells that would be rendered marginal by an increase in cost would again become advantageous to drill, would they not?

A. That is true. If prices go up, then it expands the envelope of the wells that are -- that then become economic. So -- and I think that's something that is important. I don't think that we can automatically assume, you know, that pricing is going to be going up.

One of the things that we're seeing right now is, there's a lot of gas constrained in Wyoming due to pipeline constraints. And because of that, when they get their pipeline on there's going to be a pretty good flush of gas coming out of Wyoming, which could have a negative effect on San Juan Basin gas and even Permian Basin gas.

The other thing that we're expecting in the not-too-distant future is, the Thunder Horse platform in the Gulf of Mexico, owned by BP, is supposed to be coming on line. It's going to be producing a BCF of gas a day, which is one-quarter of what the San Juan Basin produces.

And then farther out, we're seeing LNG terminals being built that will be coming on line, and they are going to have a kind of a capping mechanism on the upper end.

So I don't know that we can necessarily assume that natural gas prices will continue to decline like they have in recent years since 2002.

Q. All of which does not negate the proposition that if, as and when the price of gas moves higher, wells that may be uneconomic at the present time will then become economic?

A. Definitely, and I think you're right, the higher the price -- once again, one of the things that we've seen, though, is, from 2002 till now, I think we had a certain amount of costs that were built into our calculations and the corresponding revenue, very low gas prices.

And now when we have significantly higher gas prices, we've got significantly higher costs, which are drilled not -- driven not only by services but also through hardware because of the changing market, because of the Chinese demand for steel and even cement and commodities like that.

We are not necessarily seeing more wells become economic because the costs have come up, to a large extent, with the revenue.

So it depends not only -- If you were to say, yes, costs are going to stay flat and I'm going to significantly increase my gas prices, then that would expand the number of wells that are no longer marginal and that would be drilled.

Q. Isn't that what happens in every boom, though? The revenues go up and then the costs go up and pinch the revenue to some degree?

A. I haven't been around for enough booms to be able to know that. I suspect you may be right, I don't --

Q. Okay.

A. -- it seems like -- yeah.

Q. Well, I've got just a couple of other questions for you.

One is just about your graphs, about the pages that were -- that were added Friday, where you look at results of particular companies. And you have -- on each of those graphs you have a bold line at 100,000 M -- MCF --

A. Or MM -- yes, MM -- MCF --

Q. MMCF --

A. -- I'm sorry, it's MCF --

Q. -- or is it 100,000 MCF?

A. You were right, it's MCF, I'm sorry.

Q. It's 100 MMCF, right?

A. Yes, it would be 100 million.

Q. And you're not telling us that that's some kind of cutoff that each of those companies has, are you?

A. No, I am saying that generally I know that each of the companies has a cutoff, and it's going to be --

Q. Right.

A. -- in a range somewhere there. I think -- I hope I made it clear up front that the 100,000 is not to be the cutoff number.

Q. Right.

A. It's supposed to be a reference for folks to be able to view and see, Okay, well there's 100,000. If I go lower then there's going to be less wells affected; and higher, more wells affected.

Q. But on the composite graphs back on pages 10 through 14, you have drawn what you believe to be an actual computed cutoff, right?

A. Yes, those are actual computed cutoffs based on the estimated cost to drill that particular well for that particular formation.

Q. So the solid lines on pages 17 through 20 don't mean the same thing as the solid line on pages 10 through

14?

A. Well, they have a similar meaning in that that's an area of concern, but it's not from an exact calculation.

Q. Actually, you don't know what various companies' cutoffs are, would you?

A. I don't know what their exact numbers are. For instance, if you look at graph number 19 with XTO --

Q. Yeah.

A. -- that shows their total wells. But once again, as I've showed before, that economic cutoff line varies based on the formation. So depending on what their mix of production -- or their mix of the wells that they're drilling to, that will move that line up or down.

Q. And the data they use to run their economics would ordinarily be something that companies would keep confidential, would it not?

A. Yes, it is. But I think -- nonetheless, I think that I'm still going to be in the ballpark for most any kind of company, once again looking at future gas price estimates and a reasonable return on investment versus risk.

Q. Okay, let me back up. I had a couple of follow-up questions from what I was talking about, about the decrease in production being less than the increase in number of wells.

If you were concerned about the effect that the -- if you were concerned about the impact that something is going to have on state revenues, you wouldn't be looking at the number of wells, you'd be looking at the decrease in production, right?

A. Well, that will have an effect as far as production taxes. If we have a reduction of 30 percent of drilling, I don't think that we'll have a reduction of 30 percent of production taxes --

Q. Right.

A. -- because I think you're right.

Q. Exactly.

A. On the other hand, though, I think the 30 percent of drilling will have a corresponding reduction of -- similar reduction in jobs that relate to drilling those wells. And so then you're going to have a reduction of, you know, the various sales tax or employment taxes, property taxes on homes that they own and that kind of thing that we would -- that the State would also need to consider as impacting.

Q. And if that -- down the road, the price goes up and these wells become economic again, that would actually -- that would conceivably tend to prolong the life of the San Juan Basin as a producing reservoir, if we produced it slower rather than faster, would it not?

A. I don't think that by increasing costs you're going to lengthen the time of the Basin. I think if you want to lengthen the time of the Basin it would be better to lower costs. Over time, that will make more of your wells economic.

I think even now there's still additional reserves out there that are not presently economic. But if we manage to hold costs down and allow technology to come along and help us out, we may be able to get to some of those reserves that are on the fringe, such as -- you know, I think Mr. Mullins talked about a project that he's working on that is hopefully currently now economic.

But there's a lot of areas as you start getting out beyond the normal range of the San Juan Basin that there still could be tremendous gas reserves out there if we can get to them economically.

Q. But like what we said about the presently marginal wells, they'll still be there if the price goes up and the economics improves, right?

A. If -- Yeah, if the price goes up and the economics improve, that's absolutely true. And part of making those economics improve is to keep the costs down too.

Q. Okay. Well, I'm just going to ask you one more question, and then I'll let you go.

If there's a 30-percent reduction in drilling, as you predict, then a computation of the increase in truck traffic resulting from the waste-hauling requirements of this rule, which assumed no increase in drilling, would be flawed correct?

A. I'm sorry, I didn't quite catch that.

Q. If there is a 30-percent decrease in drilling --

A. Right.

Q. -- as you have predicted, then analysis of the increase in truck traffic that would be caused by this rule, because of its waste-hauling provisions, which assumed that the present level of drilling would continue into the indefinite future, would be flawed, would it --

A. Well, I think that you would -- assuming that you did see a reduction of 30 percent in drilling, then you would need to make the increase in truck traffic proportional to the wells that actually get drilled.

Q. Yeah, and wouldn't that increase in truck traffic be somewhat offset also by the decrease in truck traffic, which is servicing those wells that wouldn't be drilled? In other words, waste-hauling is not the only truck traffic for a well?

A. That's correct --

Q. So if there's a 30-percent -- even if you didn't change the waste-hauling rules at all, if there's a 30-

percent decrease in drilling there'd be some decrease in truck traffic?

A. I don't know -- Now are you saying that there would be a decrease in truck traffic if you were to decrease drilling by 30 percent?

Q. Right, other things equal, nothing else changed, and you drilled 30 percent fewer wells, there'd be less truck traffic in the oilfield, correct?

A. Okay, so assuming that the new rule didn't go into place, you just reduced drilling by 30 percent?

Q. Right.

A. Yes, if the new rule did not -- if you had -- if the existing rule continued and the continued existing situation, then you would -- if you reduced drilling by 30 percent, one would assume you would drop truck traffic by 30 percent.

Q. So the estimate that truck traffic will be increased from the waste-hauling caused by all of the exist- -- by -- the estimate that truck traffic will be increased by the waste-hauling that would be generated from drilling the number of wells now being drilled is flawed in two respects: It overestimates the amount of truck traffic that will be gener- -- that will occur from waste-hauling, right? If you assume that the current number of wells will be drilled.

A. Yeah, I -- Well, once again, obviously, if you drill less wells than the model predicts, then you will have less truck traffic for hauling waste.

Q. And it fails to account for the fact that less wells will account for less truck traffic for other purposes?

A. That's -- well, and I think if you have -- yeah, if you have less wells that you're drilling, then not only will you not be hauling waste from those wells, you will be also not hauling the normal operational truck traffic.

MR. BROOKS: Thank you, pass the witness.

CHAIRMAN FESMIRE: I believe all the attorneys have had a chance to question this witness; is that correct?

Commissioner Bailey?

EXAMINATION

BY COMMISSIONER BAILEY:

Q. Just one question --

A. Yes, ma'am.

Q. -- to follow up on Commissioner Olson's comments regarding the lack of information on the impacts of properly closed drilling pits.

Would IPANM be willing to join a joint group to sample downgradient -- or to do a true monitoring around properly closed drilling pits?

A. Well, you know, as president I don't know that I can give a definitive answer. That's more of a board decision. So it's not a legal answer.

But certainly as far as the intent, I think IPANM would very much be interested in working in a collaborative way in research on the effect of existing pits, what may those be doing, as well as for continuing the research on properly handling of the cuttings, you know, what is the best way to dig them -- or bury them on place or haul them away? Anything related to that, I think -- I would think IPANM would be very interested in participating in that.

COMMISSIONER BAILEY: That's all I have.

CHAIRMAN FESMIRE: Commissioner Olson?

COMMISSIONER OLSON: Yes, thanks. Just a couple questions.

EXAMINATION

BY COMMISSIONER OLSON:

Q. Mr. Byrom, I guess I just was -- want to see if I understand some things that -- coming about through your working with the task force, the pit task force that was coming up.

I guess there was agreement in the task force that we needed to have higher protections in shallow groundwater areas. Is that correct? I thought I heard you say that. I want to make sure I understand --

A. Well, that -- yes, that was one of the consensus items, was the 50 feet to groundwater. It specifically was the 50 feet to groundwater for the closed-loop.

Q. And that we shouldn't have burial of drilling pits in those areas, then? Is that -- Was that the consensus?

A. Yes, that was the consensus.

Q. And then I guess to me some of that seemed to relate back to the vulnerable groundwater areas that have existed for a long time up in the San Juan Basin. Those areas were mapped out by the Division a long time ago. And wouldn't you expect that in most of those areas the groundwater is going to be probably 50 feet or less in a lot of that vulnerable groundwater area?

A. I would expect -- Yeah, I think I would expect a significant part of that vulnerable area to have shallower than -- or 50 feet or so. I think there's some areas -- I can't remember what the definition of the vulnerable area was, though. It seemed like it was 100 feet or something like that.

So it's possible that there's some -- still areas in the current, quote, vulnerable area, unquote, that you could be greater than 50 feet to groundwater. But I think generally that would be the case.

Q. And that's probably more likely up some of the tributaries, then, in the San Juan and Animas, La Plata, where you've got, you know, the alluvial kind of ephemeral systems that come into the river systems?

A. I think so. I think, once again, that vulnerable extends up some -- like you say, some of the drainages like -- I know Largo Wash would be one of them that doesn't have flowing water, but you would expect groundwater to be closer in those areas.

Q. Those have relatively shallow water, in Largo Wash, for example, and Gallegos Wash, some of the larger washes?

A. I believe so.

Q. So it sounds like the -- the 50- -- at least for the San Juan Basin, the 50-foot criteria is largely going to be consistent with the current vulnerable areas, allowing greater protection for those areas that are already defined under rule?

A. I think there is a big difference in the proposed rule versus the existing one. The current one said anything in the vulnerable area, you had to line the pit --

Q. Right.

A. -- and -- whereas in the proposed rule it's going to say you can't have a pit at all. And in my opinion, even though I agree to the 50 feet, I think particularly in the northwest, unless you're drilling with brine, I think even in that range you could still have a pit and not have the threat to groundwater that I would be concerned about.

However, I think in the interest of -- what do I want to say? -- trying to be cooperative and have a spirit of working forward, that was one of the things that the industry representatives agreed, was that the 50 feet to groundwater would be the limit for having a pit. So that's what we did.

Now, I would say that even if you didn't have a pit, allowing on-site burial of the cuttings after you finish your closed- -- your closed-loop operation, should e something that should definitely be considered, because in that case you would be close to groundwater but you would be not having the pit with the head of water on it that may be a concern. So you're eliminating that through the use of the closed-loop drilling and then still be able to use -- bury the cuttings on site.

I think that's a practice that's going on by -- that they're dealing up in Colorado, just for instance.

Q. Well, I guess I wonder if we're not going to allow use of a drilling pit if it's within 50 feet of water, why would we want to allow burial then?

A. Well, once again I think -- you know, the concern is, if you have the drilling pit, that you could have a leak in the liner, and then that head, that continuous head there of two weeks or three weeks or -- well, it's going to be longer than that. Depending on the length of time to drill the well and then when they remove the water, that would -- that could potentially drive any contaminants quicker down to the groundwater.

But I think if we were able to remove the fluids in those cases, I still think that digging -- or burying the contaminants or the cuttings on site, in that case you wouldn't have the fluid drive, and I don't think that we would have the concern with groundwater contamination like you potentially could with a pit with 10 feet of head in it.

Q. I guess it just seems to me that that's kind of conflicting, then. You were saying it's a shallow groundwater area, and so it should have higher protection, but than we'd allow burial of wastes in shallow groundwater areas, so it just doesn't seem to make sense to me.

A. I guess I don't think it's conflicting. And it's -- once again, I don't know that I'm saying if it's two feet that you'd do it, but I think if you were closer to 50 feet in that case, I think once again, depending on what's buried, I think you have a case where you can clearly, at least -- maybe it would take further study, or maybe we've got enough information now that would show that the rate of travel and the concentrations that you could potentially get would be within acceptable limits.

Q. And you were mentioning, I guess, a little while ago -- I don't know if it was under questioning, I think maybe from Dr. Neeper, and you were concerned about the 200-foot setback requirement to a drainage.

Those drain- -- Largely, those drainages now are defined by the vulnerable areas that exist up in the San Juan Basin, aren't they? Isn't that correct?

A. I wish. If that was the case, I would be much less concerned.

What I'm concerned about is the language that is in the rule just says watercourse. And even under testimony from Mr. Jones, he indicated that it had to have a defined bank. But I think I've seen defined banks on watercourses that I could hop across, and that really -- that does bring concern.

And particularly, we've had some direct cases with our company permitting some locations, trying to find locations up in the northwest where, because of that interpretation -- the existing rule says you can't have a pit in there. Well, we had a heck of a time trying to find a place to put a pit because of literally a little -- you know, a wash that's as wide as that -- two feet across, that they were saying, Well, that's a watercourse, you can't have a pit there.

So we did -- we were able to move the pit and get it out of there.

But if you're going to define -- without a clear definition of a significant watercourse, especially up in the northwest -- when I say especially, I don't know enough about the southeast topography, enough.

And then the other thing is a playa. Once again, if you've got a little depression there that there's a little salt buildup on the surface, there's not much plant growth there that's the size of, you know, 15 feet across, somebody could say that's a playa. Well, you have to be 200 feet away from that.

And the thing that I'm so concerned about is, recently we've drilled some wells that we had a heck of a time finding a surface location for them, and it had nothing to do with this rule. It had everything to do with the archaeology surface examination, and also the threatened and endangered survey, and also the fact that these happened to be on Navajo-allotted -- and I think that the local representatives had some kind of sacred areas that they were wanting to avoid.

So in this 160-acre block we found one location that nobody said you couldn't drill a well there.

But I'd like to -- in those locations there's washes close, certainly within 200 feet. And when I say wash, I'm talking about clearly a place that carries water when it rains hard. And that would eliminate that spot.

So basically I did a case where I couldn't drill a well on a whole 160-acre lease. And that's my concern, is, we keep blocking off areas and -- from various requirements for various agencies. And it would be all right if the -- everybody piled on top of one another, but they're covering different parts of the leasehold.

And that's why it concerns me, that 200 feet to a watercourse and playa lake, really concerns me about that.

Q. Well, I guess I'm thinking about the existing vulnerable areas now as they're mapped. If you go up a lot of the -- and they were mapped based upon the, you know, named drainages on that -- you know, those are larger --

A. Uh-huh, yes.

Q. -- larger systems. They're the tributaries. But they were based on that 50-foot criteria from the -- 50 foot above the elevation of the drainage itself.

A. Okay, so was it 50 -- maybe -- you're filling in a blank that I didn't know before was 50 feet, was that number that I was looking for, 50 feet --

Q. Yeah, for the ephemeral systems --

A. Okay.

Q. -- it was 50 feet.

A. Okay.

Q. But if you look at those maps, that can be -- 50 vertical feet from that drainage can be quite an extensive --

A. -- area.

Q. -- area to either side of those drainage systems. So it seems to me that the -- Well, let me say this, I guess.

Isn't most of the areas in the San Juan Basin where it's less than 50 feet to water in those ephemeral drainages, isn't that usually relatively close to the channel itself, because those are recharge areas for the alluvial aquifer? So the shallow groundwater areas are usually relatively close to the drainage channels, aren't they?

A. I would assume, but I'm speaking out of my expertise. I know that when we had some wells down close to Largo Wash, that we found groundwater fairly close.

But as far as how far up, I do know that -- for instance Largo Wash, as you get away from the wash you're climbing pretty quickly, even though you're not getting to the, quote, canyon edges until you go out -- the canyon across Largo Wash just upstream of the San Juan Basin, I don't know if it's a half mile or a mile across, or a half mile across maybe.

So I think you -- I think there would be cases within the canyon edge that you'd be getting above that 50 feet to groundwater potentially, but I don't know that I could say that for sure. I haven't drilled, you know, to find water depths that I know of.

Q. Because I'm just thinking, it seems to me if this is actually going to shrink the existing vulnerable areas, if it's only allowing the shallow groundwater areas of less than 50 feet and then a 200-foot setback criteria, because right now those things -- like you said, I think a lot of times they're half a mile or, you know, a mile across, covering the way those drainages are now mapped.

So it seems to me like this would effectively reduce what's considered vulnerable areas in the San Juan Basin. Have I got that wrong or -- ?

A. Well, I think it's going to -- I think the area where you couldn't have a pit would be -- could potentially be smaller, the way you're describing it, than the current vulnerable areas. But right now, once again, currently within the vulnerable area you can have a pit, it just has to be lined, so --

Q. Right.

A. -- I think I would -- you know, with the 50 feet to groundwater where you can't have a pit, and then outside of that you have to have a lined pit, obviously the protection that would be under that scenario would be increased, not decreased.

Q. Well, I was thinking along the lines if they just use the vulnerable areas as an example and said, Okay, you don't have -- you can't have a pit, you have to use a closed-loop system in the vulnerable area, that would have even more effect than the rule as proposed by the Division, wouldn't it?

A. Yes, it would. I think I wouldn't -- I would hope that the Commission wouldn't go there. That was beyond the consensus of the task force. Obviously the Commission doesn't have to follow the task force necessarily, but the -- going beyond that, extending the not pits all the way to the -- through the vulnerable area, I think, would be -- have even more effect or potential effect.

If you were to get rid of that 200 feet to a watercourse -- now the 200 feet to a watercourse probably covers all the vulnerable area anyway, and then some, and then plus a lot of area up -- well out of the vulnerable area, if you do not define a watercourse as a significant waterway.

Q. So the problem is just the definition if what you're seeing is the definition of the watercourse, so --

A. Yeah, it definitely concerns me. If you want to call a watercourse Blanco Wash, I can see that. But if a watercourse, once again, is something that, you know, I can hop across, they're everywhere.

Q. So it sounds like you don't really have a problem, though, with the systems that were defined through the vulnerable area, which was major named washes, that if you had a 200-foot criteria and 50-foot depth to groundwater criteria for those major named washes, you don't really have a problem with that. You're more worried about these ancillary systems that don't have names; is that what I understand?

A. Yeah, I don't know if I don't necessarily have a problem. As I said, I think the consensus agreement in the task force was done in a spirit of cooperation, and I think that there may be some cases where maybe you don't have a pit, but you dig on -- you bury on site, or maybe further research could show further advances that we could do and still be protecting the groundwater.

But generally, the way to go on the watercourses would, as you were saying, go to something that's more definitive and far less subjective than what we've seen in the past. And actually my company's experienced of the subjective determination of a watercourse by an inspector who's looking at the plain language of the rule and interpreting it as a reasonable person could. So it -- it would be definitely better if we had something much more definitive.

Q. Well, I guess, just from what I'm hearing, it sounds to me like the Division has made some concession to not at least use the existing vulnerable areas as no-pit areas, say, for drilling pits; they've essentially made some concession, it sounds like, to industry in that respect, to allow a smaller vulnerable area than currently exists in a lot of the major named washes.

A. Well, if you call the proposed rule a concession. But yeah, there -- they didn't just adopt the vulnerable area.

But I still think that the lined pits gives ample protection to within that vulnerable area, in my opinion.

So I don't know. Maybe they considered it a concession.

Q. Right. But there's at least a concession from industry that, okay, it wouldn't -- it would be acceptable or be okay with closed-loop drilling systems in the 50-foot criteria?

A. Well, that was the consensus on the -- from the task force --

Q. From the task force.

A. -- based on the spirit of cooperation. And like I said, I think the industry gave on, well, pretty much every point. So I think --

Q. Okay. And then just the -- you were touching on the below-grade tank issues. I guess industry doesn't have a problem with the idea of permitting below-grade tanks, do they? Just general --

A. No.

Q. -- permitting, the actual physical permitting of them?

A. And I think that was part of the -- that was part of the STRONGER recommendation through the OI- -- OG- dang it --

CHAIRMAN FESMIRE: IOGCC?

THE WITNESS: IOGCC. Thank you, Mr. Chairman. -- that they recommended tracking where they were and making sure that they were dealt with and that kind of thing, and so there's -- I'm sure that -- I have heard no objection from industry of -- having to do with the permitting of them, so that the OCD knows where they are and the condition and status of them.

Q. (By Commissioner Olson) Because right now they're not permitted under the current Rule 50.

A. I suppose that's true. I don't know that every operator is treating it that way. But according to the letter of the law, that is technically not defined presently as a below-grade tank, so it wouldn't even fall under Rule 50.

Q. Right, that's my reading of it as well. Thank you.

And so the major issue that comes up is the fact that you're looking at having to come back and retrofit existing tanks with some kind of secondary containment and leak detection?

A. Yeah, I think industry made a tremendous effort to address concerns. I think we have a very good system out there in place now with mostly steel tanks that are sitting on the surface of the ground, even though that surface is in a cellar.

So I think the risk to the environment is very low, and allowing industry time to go back over time and put that deflection shield under that, just to allay the fear that you could ponentially [*sic*] end up with a leak right in the middle of the tank that somehow wouldn't come up to the surface and not be detectable, that would be addressed.

But to require industry to go back and then put secondary containment on all those tanks, I don't think -- I think is unreasonable and not a productive use of the operator's dollar to get the benefit that the State would hope to get in protecting groundwater.

I think treating a partially buried tank is something that needs to be -- have secondary containment.

That's one thing.

But the tank that's on the surface of the ground, I don't think that we should be requiring industry to go back and spend money again to do that.

Q. But it sounds like you were just saying that it would be okay -- industry would be okay with the idea of potentially coming back and installing, as you were saying before, some kind of impermeable membrane or something underneath those tanks, just to ensure that the bottoms aren't leaking if it's -- there's -- or installing some type of mechanism to show that the -- you know, if you get bottom leaks, they come out the sides. Is that what you're saying?

A. Well, that was a consensus item, as I understood it, in the task force, that industry would be required -- anything new and over time, to put those -- what I'm calling a deflection layer, something that would deflect a leak out to where it would be readily visible by an operator.

Q. Well, are you saying that industry would be acceptable with retrofitting the existing tanks to meet that same standard?

A. Well, I think retrofitting is a -- once again, I don't think there's a risk out there, a significant risk at all out there at present, so I think that industry should be given the opportunity to do any new installation, and then any time that they go into an existing tank they've got to retrofit that tank.

Q. So essentially just letting the current system go, just -- the new systems would come on line with a different standard?

A. Yes.

Q. Okay. And then you were -- you were mentioning the problems with, I guess, the double-bottom tanks and moisture causing accelerating corrosion.

Isn't there that same problem, though, with a steel tank that's just sitting in a cellar like that? Because that's going to -- the cellar is going to collect some water itself, and wouldn't moisture most likely keep concentrated under the tank more than in surrounding soils?

A. You know, it would -- I haven't done any research on that, it would be more just based on general experience and background as a mechanical engineer.

When you don't put that impermeable barrier, you are at least allowing for the vapors to dry out when it warms up and dries out, and so you're allowing the vapors to -- and the liquids to basically vacate the space, rather than creating a confined area. And usually I think the operators are setting those tanks on some gravel or setting them up on I-beams where it does allow the area underneath the tank to breathe, so...

Q. Uh-huh.

A. And I would think that when we do the deflection liner, you'd still want to have some area, breathable, permeable mechanism that actually supports the tank up above that liner.

Q. So it can somehow breathe --

A. Yes --

Q. -- underneath there?

A. -- yes.

Q. Because I seem to recall there had been some that were done up in the San Juan Basin before, when they put down essentially in those cellars an impermeable barrier and then some kind of a gravel pad on top of it, or something --

A. Yeah --

Q. -- like that.

A. -- I think I've seen those. I don't think our company has done that. I think Simmons has done the cellar, in the cases that we've done it, more sitting on the -- kind of the gravel.

Q. Without the impermeable liner?

A. Yeah, I don't think that we put --

Q. Okay.

A. -- impermeable liners.

Q. Okay. I guess, then, what is the estimated life of the tanks anyways, the steel tanks?

A. That's a good question. I think that those tanks probably have been out there -- well, I mean, would -- not have been, but you can see steel tanks out there in the field for 20 or 30 years.

Q. And then I want to make sure I understand some of what you're testifying about. You were referring at some points to in-place burial, and that's not the same as deep-trench burial, that's --

A. No, no, I would hope that -- the deep-trench burial is certainly more expensive, you're having to dig a trench, you're having to line that trench, bury it. And I would hope that we would come up with a better way to manage on-site burial than having to dig a second pit, basically. So there's -- that's definitely not my preferred way for on-site burial.

Q. So you're referring to an in-place burial pretty much as the taco system?

A. Yes. I did think of another one that we could do is, if we were to cover it over and then spill some oil on top and light the oil on it and basically fry it, it would be --

(Laughter)

CHAIRMAN FESMIRE: -- the chalupa system?

THE WITNESS: -- or chimichanga burial, would be a third alternative.

CHAIRMAN FESMIRE: Let the record reflect that the witness was being facetious.

THE WITNESS: With no disrespect to the Commission.

Q. (By Commissioner Olson) And then I guess clarifying again something that -- from your work with the task force. So you're saying that the 100-mile radius that is in the Division's proposal now wasn't discussed at the task force, that came as a later edition to --

A. That's correct --

Q. -- the proposals?

A. -- it was -- you know, it was not discussed in the task force hearings at all, nor was it in the draft that was sent out by the OCD with the consensus items in it. I didn't see that 100-mile until it came out as a proposed -- the actual official proposed draft to go into the hearings.

Q. Well, I guess maybe I'll ask you, because I've asked the Division witnesses a number of times. What do you understand as the rationale for the 100-mile radius?

A. There is no rationale. I'm sure there is rationale from their standpoint.

I don't know what -- the only rationale would be, is if you just don't want things left on site you would make that 100-mile rule, because I think it does cover a significant part of the producing basins, is that 100-mile rule.

So the only thing that would be left out is things that are on the far fringes or, you know, truly and completely new developing basins such as around Albuquerque or the soon-to-be burgeoning Santa Fe Basin. Ha-ha. Ha-ha. Ha.

(Laughter)

Q. I guess -- and have you -- has your company hauled much waste to the existing facilities up in the San Juan Basin?

A. Yeah, we have hauled some waste to the landfills -- I mean, excuse me, the landfarms. I think some of our flowback sand we've hauled to landfarms. And then we do haul things to the landfill such as, you know, the plastics, but other things that are incidental to the drilling operation, the trash, is going to the landfill.

I don't know if we've hauled -- I don't -- to my knowledge, I don't think that we've hauled any soils to the landfill.

Q. Or drilling mud?

A. No, that's correct.

Q. I guess, and do you have any knowledge, I guess, of the potential lifetime of those facilities that are existing now, how that's going to be affected by the --

A. No, I don't. I've heard other people speaking, but I don't know how that would be affected.

Q. Okay. And I think just one last set of questions.

I think I heard Dr. Neeper asking about how many wells you were expecting in the 50-foot-depth-to-groundwater area. But I guess I was thinking that a lot of that is going to correspond with the existing vulnerable areas, and I -- how many wells are there that -- you know, that -- I thought there had been some industry estimates in the past that there was, I don't know, 6000 wells or something like that in the vulnerable groundwater areas? Does that sound about right, or --

A. That seems like a reasonable number. I don't know that I've ever seen that calculation. I think there's 20,000 producing wells in the Basin, in the San Juan Basin. So just conceptually it seems like 6000 would be a reasonable number.

Q. Roughly around one third of those, okay.

A. Yeah, and without having ever seen a number, an actual analysis, that would just be my guess. But it seems like a reasonable number.

Q. So probably as a worst case, then, the 50-foot-depth-to-water criteria is -- would affect maybe -- just based on that alone, would affect maybe about one-third of the -- roughly, the wells in the Basin?

A. I would --

Q. One-third of the area that's been drilled --

A. Based on the number that you said, assuming that that's correct, then that would seem to be correct from that perspective.

I've heard other -- it seems like I've heard in this testimony -- maybe it was from Mr. von Gonten, saying that a large part of the San Juan Basin had depth to groundwater of 60 feet, which was very surprising to me. So if that's the case, that would obviously have substantially more effect. But I would be very surprised to see -- out of the vulnerable areas, that groundwater would be anywhere close to that.

Q. And those vulnerable areas would be essentially a smaller portion of the overall San Juan Basin than --

A. That's correct, it's more around the major drainage areas of the San Juan Basin. As you say, the major named drainages.

Q. And then that comes back to your concern of how you just -- I guess for the current rules, how do you define watercourse?

A. Yes, it's a major concern.

COMMISSIONER OLSON: Okay, I think that's all I have.

EXAMINATION

BY CHAIRMAN FESMIRE:

Q. Okay. Mr. Byrom, starting with page 17, you've got the history for Burlington, you've got a history for Energen, you've got a history for XTO, and one for Dugan. You don't have one for D.J. Simmons.

A. That's correct. We have -- We actually didn't drill any wells in 2004, although I say -- I think we drilled one, and it's one that I've been trying to forget. It was a deep well, we spent a lot of money, and I think the reason it didn't even show up on my list -- I was kind of looking for it -- but it was because it didn't make production for the first year, notable or -- I can't remember, but for some reason it wasn't even good enough to show up on my chart.

So if D.J. Simmons would have had -- the chart of D.J. Simmons would have had one little blip with the 100,000 thing, and you would have had to have a magnifying glass to see the production from it, so...

Q. Okay. And starting on page 11, you cover the Dakota formation, the Mesaverde --

A. Yes.

Q. -- the PC --

A. Right.
Q. -- and then the Dakota-Mesaverde commingle, but you don't have the Fruitland Coal.
A. That's correct. And I mentioned that earlier. That was a case where I didn't feel comfortable at the time putting that graph in. I was still doing my analysis. It took a lot of man-hours on the computer, pulling the data out. And so the graph on the -- I don't have one on the Fruitland Coal.
I think the threshold for the Fruitland Coal would be lower in the -- somewhere in the 50,000, because once again, they're not going to need -- they don't have an initial decline like the Mesaverde-Dakota, the tight sands, so they're going to need less first-year's production because -- to make their revenue, because they -- actually increasing revenue and then dropping off.
So those wells, just guessing, I would expect the coal wells to be --
Q. Well, we don't want you to guess.
A. Well, okay.
Q. If you're not comfortable with it --
A. I don't think that they're -- I don't -- I think that -- Well, it would be a guess, because some of the better coal wells are very expensive, because they're doing the cavitation on them. So that's where I did some

calculations, and I came up with that 50,000 as an estimate.

The other thing is, they have higher operating costs because the better wells do have to dewater a fair amount too. So you've got disposal costs related to that, where a Mesaverde well you're not moving nearly the water.

Q. Okay. Can we go back one exhibit to page 13?

A. Yes, sir.

Q. Okay. The point I'm trying to make here is that this business -- the analysis you've done is a post-drilling analysis, right?

A. That's correct.

Q. Sometimes called a post-mortem, although --

A. Yes, post-mortem --

Q. -- that analogy.

And basically this industry, when they're trying to decide whether or not to drill wells in the future, they're dealing with expectations, right?

A. That's correct.

Q. And in, for instance, this example, if they had had perfect knowledge, they wouldn't have drilled these eight wells, correct?

A. Exactly.

Q. But as long as the area under this part of the curve exceeds the area under this part of the curve, the expectation is that it will provide an economic return, right?

A. Are you saying if I were to drill all 11 wells?

Q. No, we're looking at a forward-looking analysis now.

A. Right.

Q. And the assumption is that you can take this -- this post-mortem, and if the area under this part of the curve exceeds the area under this part of the curve, the expectation is that those wells will be economical and they will be drilled, correct?

A. Well, I think that would be assuming that all of those wells that you drilled were in the same field and were subject to the same reservoir and cost analysis.

Q. Were subject to your post-mortem analysis?

A. Yes, and that would be assuming that wells 10 and 11, as good as they were, actually were drilled in the same areas that the other, lower-producing wells were, so --

Q. But you wouldn't have put them on here if they weren't comparable, right?

A. Well, no, because they were all out of the San Juan Basin. So if I was -- because when you're looking at wells going forward, you're not -- you don't look at all the San Juan Basin wells and say, Well, this is the reserves I got from all the San Juan Basin wells, so this well I'm going to drill up just outside of Farmington, New Mexico, I'm just going to take the average of all those wells. With the --

Q. But for whatever group you're doing the analysis on -- and I was making the assumption that you were doing this analysis on the Pictured Cliff wells.

A. No, that -- well, this was the Pictured Cliffs wells, but once again, if you were to drill a well, then you would be looking at the wells that are immediately surrounding, say the surrounding nine-section block, and look at those wells and say, Okay, well, based on those wells I'm expecting my reservoir to be similar and contiguous across that area, so based on the production from those wells and the depreciation or the depletion of the reservoir pressures, this is what I'm going to expect.

And so that sets your --

Q. And that's what your geologist and engineer --

A. That what -- that sets your deal.

Now this graph is looking at the whole San Juan Basin, so trying to apply -- this Pictured Cliffs graph -- trying to apply wells 9 and 10 or 10 and 11 as part of your average going forward I think could be erroneous, because those wells could have been in much more productive areas and would clearly not be marginal, therefore, as I'm saying, probably wouldn't be affected by the implementation of this rule.

Q. But everybody who, for instance, participated in the decision to drill number 4 --

A. Yes.

Q. -- assumed that it would be up here, right?

A. They assumed that it would be at least meeting their economic threshold. So it would have been up -- yes, up -- when you say "here", up into the thirty-five --

Q. Up above --

A. -- thousand, the blue line.

Q. Up above the blue line?

A. Yes.

Q. Okay. So because you have to drill these wells to get these wells, the expectation is, as an old geologist used to tell me, If you want to catch a disease you've got to get exposed. So you've got to drill these wells to get these wells, correct?

A. That's -- once again, this is the whole San Juan Basin. I think you're in that if -- in order to get the better wells, you've got to drill lesser wells. But on -- that would be more on a large-volume drilling program.

If you're in a case where -- and once again, even a large-volume drilling program is going to be specific to the geology surrounding your prospect, which may be nine square sections; it's not going to be the whole San Juan

Basin.

So the -- in the case where you're drilling a few wells on there, then you're actually having to look at the offsetting production. And as I said, you're going to assume that you're going to average somewhere in that offsetting production.

And so you're hoping that some -- you're probably going to figure, Well, yeah, if I drill five wells in this area, some are going to be below my line, or I'm going to have unexpected costs, which will drive my economics down. And then hopefully some will be above the line to offset that. So --

Q. And in fact, everybody who made the decisions to drill 1 through 8 --

A. Yes.

Q. -- decided that they had a pretty good probability of getting the expected return, and that expected return can be defined as essentially the average of the returns, right?

A. Yes. And I think the same decision is made even on the single well. Nobody drills a single well expecting, Well, this well is going to be below our threshold, but we'll drill it anyway, because it's going to be averaged out.

I think every well they drill, they're assuming, based on -- I mean, they're estimating, based on their analysis, that it's going to meet that threshold.

Q. Okay. So the premise that I started out with, this area under the blue line --

A. The wells 1 through 8 --

Q. Right.

A. -- in the Pictured Cliffs.

Q. -- has to equal this area above the blue line, correct? Or greater?

A. Once again, that would only be true if you were looking at a specific reservoir area. And this graph, once again, is of the whole Pictured Cliffs formation, and so there are definitely --

Q. And I'll grant you that --

A. Yeah.

Q. -- the universe of your -- of your analysis --

A. Right.

Q. -- the area that exceeds your expectations, has to be greater than or equal to the area that does not meet your expectations, right?

A. That's correct, but this graph shows the whole San Juan Basin, so wells 9, 10 and 11 may very well be in an area that has offsetting wells that all produce up in that area. It may be that well 10 was a disappointment to them and -- even as good as it was, just because the surrounding wells were so good.

So I don't -- I think it's important to remember that on these graphs this is Basinwide, not what I would call a pool- or a projectwide evaluation.

So the wells that are well above the line most probably were in areas where the reservoir is well above what it would take to make the wells economic, and so they really don't enter into this equation as being affected by this rule, because they are so much better than --

Q. Okay.

A. -- the economic threshold.

Q. And that's an important point. These wells up here --

A. Yes.

Q. -- didn't need any difference in this -- in these two lines?

A. That's correct. Those wells up there, even if the rule had been implemented and that incremental cost had gone, if their analysis was anywhere close to what they did get, they still would have gone and drilled the well.

Q. Okay. Now this line, if I understood you correctly, is based on a rate of return of about 15 percent?

A. Yes, sir, that's correct.

Q. And there are no incidents that peak between the two lines, right?

A. Not on this graph, that's right.

Q. Okay. And we'll go to the other graphs where there are in a minute. So how is this going to -- how is using this analysis to make a future decision going to be affected by the difference between this line and this line?

A. Well once again, I didn't use these graphs to show, well, if we were to somehow know the production of all these wells before we drilled them, then we would know which wells would be affected by this rule and which wouldn't.

What I'm using this analysis for is looking over our shoulder at wells drilled in 2004 to determine a rough percentage of which wells that we're drilling in the San Juan Basin are what I call marginal wells, versus wells that are clearly not marginal wells.

And so the difference between the blue line and the red dashed line is not significant from the standpoint of the -- you know, which wells on my graph that they would affect.

The difference there is to show mainly that the wells 1 through 8 on this graph are wells that there's a good chance that the operator thought those were marginal wells when they were drilled to begin with, and so any significant increase in drilling costs when you go to drill those wells would affect that decision and potentially cause the operator not to drill those wells.

Q. But he was expecting -- you're telling us that he was expecting to lose money on these eight wells, and they were drilled in spite of the expectation --

A. No.

Q. -- that he would lose money?

A. No, I'm --

Q. So is he not making money on these wells?

A. Not now, he's not making those money -- money. He may still make money, but it's not going to be at the rate of return --

Q. Okay, so --

A. -- that he had hoped for.

Q. -- at these wells, especially up here, he may not be making 16 percent or -- was it 15 percent you used?

A. Fifteen percent was the number that I --

Q. Okay, he may not be --

A. -- the threshold I used.

Q. -- making 15 percent, he may be making 14 percent, he may be making, oh, 10 or 11 percent like the --

A. Or 5, or --

Q. -- example Mr. Foutz showed us?

A. -- or 5 or 4 or something. Yeah, down there at that range it's hard to guess. It could be pretty low.

Q. But the way that he establishes that hurdle rate, he intends to make that just about every time -- every time he puts the bit in the ground, doesn't he?

A. Well, that's -- you're absolutely right, he intends to make that hurdle rate every time he puts the bit in the ground, which goes to the fact that if you add these costs that I've been referring to, that hurdle rate is raised significantly. As I mentioned on the Mesaverde well, it's a whole 'nother year's worth of production.

So if you don't think that you're going to be making that added reserves, as I pointed out -- let's see -- in my table, it's a -- it's a 16-percent jump in reserves in order to still make your threshold amount.

So if you are basically at the cusp of drill/no drill and you have that additional drilling cost, then you are -- your reserves -- you're no longer at your 15 percent, you're down in the 11 percent or whatever, and your -- you've got to make a decision on your capital, what's my cost of capital?, where am I going to spend my money?, or am I going to get the funding, based on my bank lending rate and my owner's expected return on investment as to whether I can afford to drill that 11-percent-return-on-investment well.

So this rule takes a 15-percent well and turns it into an 11 or 10 or whatever the number is --

Q. Okay --
A. -- and that puts that well under the danger of not being drilled -- or whatever -- danger's the right word.
Q. -- and let's go back to the Pictured Cliffs example that you had up.
A. Yes.
Q. I believe that was page 13.
A. Yes, sir.
Q. The point I'm trying to make is that using your analysis and the assumptions that you included in your analysis, there is no example that peaks between those two lines, to those -- between those two lines.
So there's no difference in the expectation -- Given this very limited set of data, there's --
A. That's --
Q. -- no difference in the expectations in any position here, right?
A. Once again, if we were able to drill the wells and then see what they were going to produce and then decide whether or not to pay for them, then that would be correct. And if we could manage that, then I would go for the pit rule, as I said before.
Q. Okay. Well, let's go back to page 12. Now here, we have some number -- it looks like, oh, somewhere around

31 to maybe 36 --

A. That's correct, 37, something in that range.

Q. Right. Five out of the 79 wells, the expectation is going to be a decrease, I mean is going to fall below your cutoff line, right?

A. Right. But I think that's a misinterpretation of this graph, once again. This is a mechanism that I've used in order to give -- in order to estimate the number of wells that are drilled in that particular category, in this case --

Q. Okay, so --

A. -- the Mesaverde wells.

Q. -- so what you've got here is a post-mortem tool used to define future expectations, isn't it?

A. Yup, and that's what -- that's --

Q. Okay, so --

A. -- what we use --

Q. -- the future expectation is that five, maybe six, out of the 79 wells will not be drilled, right?

A. No --

Q. They --

A. -- no.

Q. -- but you don't expect to do these? No?

A. No, Mr. Chairman, I -- I don't -- I -- that's -- that's not the way that I am presenting these graphs.

What this is, once again, is to show an approximation of the number of wells or the percentage of wells that are drilled in each category that would be -- could be -- would have been potentially marginal wells when the operator decided to drill them.

So once again in this case, we're showing approximately 30 of those 70 wells as marginal wells. So once again, those are the wells that -- 30 percent of those wells, or in this case somewhere around 30 or 33 wells, so I guess it would be more like 40 percent --

Q. But I'm --

A. -- would be --

Q. -- but I'm saying, Mr. Byrom --

A. Uh-huh.

Q. -- the difference in expectations is -- if you were to use this to forecast future expectations and make your drilling decisions on that, at this point you would assume that 30 wells are not going to be economic, but you've got to drill them anyhow, right?

A. No.

Q. You don't have to drill those wells --

A. No.

Q. -- to get these wells?

A. No, once again I think -- the operator that drilled well number 1 was not assuming that their production was going to be 5000. The operator that drilled number 1 was probably assuming that their first year's production was going to be more on the 75,000, giving them the rate of return. However, the well was less than what they had hoped --

Q. Absolutely, and I think --

A. -- so --

Q. -- I think we're talking about the same thing here.

What I'm saying is that if you use this graph to determine your future expectations of what each well is going to produce, that the change in your expectation is going to be from 30, what amounts to economic failures, to 36 economic failures. So you're going to decide not to drill some percentage of those six wells, right?

A. No, I don't think so. I still -- I disagree with the way that you're interpreting it, Mr. Chairman. I think that once again, this graph is an estimate of the relative percentage of wells that are drilled in those categories that would be marginal wells.

So once again, if they're in a marginal range -- and some of them are going to be above margin, you know, maybe not in the margin, some of them will be a little bit lower, but whatever threshold that operator has is going to be falling somewhere in that category. And clearly what this graph shows is that there's a significant portion of the Mesaverde wells that fall in that marginal range. And so a significant increase in drilling costs, that this rule would bring on, would put those wells in jeopardy of not being drilled.

Q. Okay, but those wells are in jeopardy of not being drilled under the current economic conditions, aren't they?

A. Yeah, they certainly are. I think --

Q. So the change in the number of wells in danger of not being drilled goes from 30 out of 79 to 36 out of 79, right?

A. No, Mr. Chairman. Once again, those wells -- As you said earlier, those wells were in danger of not being drilled, and that's correct, because once again they are already marginally economic.

So if you add the additional costs onto those -- that percentage of wells, you would be looking at the potential of the operator making the decision to not drill the well, to either withhold funds, not try to pursue additional funds for that drilling program, or spend those funds on other projects that give them the better return on investment.

Q. Okay. Mr. Byrom, let's talk about the components of this line. We've said that it's a 15-percent rate of return, right?

A. Yes, sir.

Q. What if the Commission were to decide that, oh, any kind of waste rules were ridiculous, that you could just bury everything on site, and we'll lower your costs by some significant amount, wouldn't we?

A. Well, it depends on -- right now our baseline is that we are leaving the cuttings on site.

Q. Okay. What if we said you didn't have to reclaim it, you could just bury it and walk off? Would that lower your costs any?

A. I suppose there's a scenario that if we could just pour it, not have to worry about reclamation of any type, we could lower the costs.

Q. I've got a new toy, I like to use it.

A. All right.

Q. We would lower that blue line somewhere below where it's at now?

A. That's correct.

Q. That would make more wells economic, right?

A. Theoretically, yes.

Q. So why don't we do that?

A. Why don't you do that?

Q. Yes.

A. The -- Why don't you just allow us to not reclaim --

Q. Sure.

A. -- the surface?

Q. That would accomplish the -- you know, a --

A. That's right, you would --

Q. -- that would stimulate the --

A. -- you could --

Q. -- drilling of wells.

A. -- you could -- as I said earlier, reducing costs would definitely increase the range of wells that would be economic, and I think I'm all for that.

However, I recognize that there's a cost-benefit analysis that the Commission has to do, based on the economic benefit to the people of the State of New Mexico, versus the potential environmental and thus economic costs, in the long run, to the citizens of New Mexico.

And so that's an evaluation that the Commission and the regulators and the Legislature all collectively have to make, based on being representatives of the people of New Mexico.

Q. Okay.

A. So that is -- you know, I think it's important to judiciously look at the added costs that we are putting on wells as time goes on, and even look at reducing costs through added technology, further study, and -- but I'm not saying that we should sacrifice the environment, just so that we can drill every possible well that we could ever drill.

Q. Okay. I think we agree on that.

A. Yeah, I think we do too, Mr. Chairman. I agree.

Q. The difference here, does that take into account the value of the intangible drilling costs credit to the driller?

A. Yes, I think once again, the 15-percent threshold that I'm using is a reasonable number based on the expected risks of that project versus the -- versus return. So I think 15 percent is a very reasonable number to be using --

Q. Okay --

A. -- for those cases.

Q. -- and do you realize there are other operators -- for instance, Synergy, who uses 29 percent?

A. Well, I think -- once again, I think the numbers -- and of course I can't speak for Mr. Mullins, but that -- as he mentioned, that is a project that is more on the fringes of the San Juan Basin. And so -- and it is not, to my understanding it is not an infill project. It is going into a more untested reservoir. And so the inherent risk of that project is probably going to be significantly higher than more the typical infill program at lower risk that would be more related to 15 percent.

So it's -- his 24 percent could be more appropriate, given the risk of his project.

Q. And you may not know -- well, I'll bet you do know the answer to this. What is D.J. Simmons' DD&A rate, annual DD&A rate, do you know?

A. Depletion, depreciation and amortization, the -- I don't know that I know it off the top of my head. Depletion is based on production, which also is based on what your basis in the wells. So depending on what you either paid to buy those wells if you purchased them, or whatever you paid to drill those wells, if you drilled them, then based on the production versus what you estimate the lifetime production of each individual well. Then you deplete that off against your taxes, and this is all against taxes.

And then you also have a depreciation rate that you use against that.

And then the amortization is another part, but having to do with more the physical assets of the company.

Q. I was looking for a BOE equivalent, but you don't have that off the top of your head?

A. Barrels of oil equivalent?

Q. Yeah, per barrel.

A. Oh, the annual BOE depletion rate?

Q. Yeah, if you've got it like that.

A. I still don't know that off the -- I mean, it's obviously a number that we look at, but off the top of my head I -- I don't know what it is.

Q. Okay. And again, the difference between those two lines is based on the previous witness's $160,000 incremental cost, right?

A. In the Mesaverde well, I think it's less. It's $127,000, because a Mesaverde well is not as deep as a typical Dakota well. So I reduced his number, just extrapolated with that, so...

Q. Okay. I'm going to switch subjects on you, switch gears on you a little bit.

You seemed to imply that most of the green language in the -- in the draft of the -- of the rule was concessions by industry that you wouldn't have given if you'd known that they would be prevented from burying the waste on site.

Is the fact that the proposed rule would prohibit most of the site burial negate the technical reason for the concessions? *Does* the fact?

A. I'm sorry, say that again, Mr. Chairman.

Q. That happens to be the one I have written out.

You seemed to imply that most of the green language was concessions by industry that you would not have given if you'd known that they would be prevented from burying waste on site.

Does the fact that the proposed rule would prohibit most of the site burial negate the technical reason for the concessions in the first place?

A. I'm -- Well, I guess the first part is, the green language was consensus language, we did all agree. I think once again, in the minds of my industry compatriots, without speaking for them, just my impression is that -- I mean, I think even the whole task force at one point was working toward this matrix deal that I said, based on what's in the pit, based on closeness to groundwater, other threats, then you would deal with the cuttings in different ways, one of them being just the burial on site.

So now, ask the second part of your question again? I'm sorry, I'm --

Q. Does the fact that things didn't turn out the way that you thought they would --

A. Yes.

Q. -- does that negate the value of the technical concessions that the industry made?

A. Well, I think that industry did concede on a lot of items that aren't necessarily backed up by actual scientific fact. It was more just general concern.

And I think if we are going to make the -- go to the extreme, in my mind, of a lot of closed-loop and then pretty much everything else having to be dig-and-buried, I think that we need to have more information through scientific study to confirm the suspicions or dispel the suspicions before we move to that strict of a restriction on what we can do with the cuttings.

So that's where I am coming from, is those consensus items, I think, from industry were based more on, yes, there's a concern about groundwater contamination as expressed by the environmental representatives and by the state, and so we should be doing -- we would agree to concede that, okay, if we're closer to 50 feet to groundwater, no pits.

There was a lot of problems that were shown to the task force, having to do -- at least discussion with, as you saw, torn pit liners and that matter. And I think that was something that the task force agreed on and that industry agrees on, and I definitely agree, that we need to have better construction and better operation of the pits to alleviate those concerns that were brought out, having to do with making sure that we get proper slopeage, making sure that we prepare the ground underneath the liner correctly, making sure that the liner is installed with adequate slack so that we don't get tearing and ripping.

And I have even spoken to other members of IPANM on the board about implementing a proactive education campaign to bring in operators and installers, to make sure that we get the pits properly installed and properly operated.

And that was another thing, was making sure that you didn't damage the liner through the water hose dumping in and gashing the liner, or also monitoring the liquid level, you know, realizing that a drilling pit liquid level will fluctuate during drilling program. But I maintain that the company man or the operator will know what's going on and if he's having, you know, liquid loss and he's pulling out of the pit, he knows when he's pulling out of the pit, and he knows when he's going back in. So it will change, but basically he'll still be able to monitor that on a daily basis.

And then the once-a-week monitoring after the rig moves off by the lease operator that would be coming out to the site and checking that liquid level once a week, that way I think that we would be catching any -- you know, if we were to be having leakage out of the pit we would be catching that.

So those were the kind of things that I felt that we were making good progress on, to alleviate the concerns of groundwater contamination from the current operations.

Q. Now you mentioned that drilling has dropped off due to the cost, right?

A. I think we've seen costs go up, we've seen -- we also have not seen prices in the San Juan Basin go up, although we've seen -- you know, oil prices have been going up quite a bit, so...

Q. But most of the production in the San Juan Basin is gas, let's face it.

A. Yes. Yeah, and I guess I was talking about the southeast part of the state. The -- Certainly they are seeing quite a bit higher prices than they have in the past for oil.

Q. I want to make a self-serving point here.

A. Yes.

Q. That's not my fault, is it?

A. No. In fact, I'd be willing to give you credit for that if you --

(Laughter)

A. -- wanted to take it.

Q. In the economics that you've got and that is inherent in these graphs, starting on page 12, did you escalate the price of gas at all? This goes back to a point that Mr. Brooks was making.

A. Yes, I did. I started off -- the first year was $5.75, and then the second year, then on, I went to a flat $6.00, just from that point on.

Q. Okay. And did you escalate the operating costs?

A. No, I did not, I just left that flat.
Q. And -- well, that's just the opposite of what Mr. Foutz did?
A. Well, he felt that costs would be going up. I felt that costs could be going up, but once again I felt that that was accurate for what my analysis was.
Q. Okay. And when you run your analyses, your decision analyses for D.J. Simmons, do you use a particular program?
A. Actually, I use an Excel spreadsheet. We also have an in-house program that we use as part of a Geographics package. But for my analysis I used an Excel spreadsheet, and I had both systems compare one another, so that's what I use.
Q. Okay. And your decision analysis includes the same gas price scenario, right?
A. Yes. Now let me ask -- let me make sure. When you say my decision analysis --
Q. The economics you'd run to decide whether or not to drill a certain well.
A. Yeah, would I use that same gas pricing that I'm using for this? Yeah, that would be in that same range.
Q. And you understand that some of the components that were found in this sampling during the task force, they were not natural components but were introduced during

the drilling operations, right?
A. You know, I don't know exactly which components. I know that there were some components that are coming from the mud additives, some components are coming from the producing formation, and then some components are just coming from the general cuttings as you're digging down to the producing formations.
Q. What about corrosion products in the drill stream?
A. That's true too, there would be anti- -- or corrosion inhibitors.
Q. And corrosion products too, right?
A. Oh, products of corrosion?
Q. Yes.
A. Yeah, I would suppose there would be some products of corrosion --
Q. So --
A. -- from -- You're about products of corrosion from the drilling -- from the --
Q. From the pipe.
A. -- the drill pipe and the casing if -- well, I guess it would be -- I guess you could have casing on shallower parts of the hole while you're drilling deeper.
Q. Okay.
A. I suppose there could be some corrosion from

that, although I'm speaking a little bit out of my expertise in that range.

Q. Okay. You said you'd hauled some stuff to the landfills. Which landfills did you use?

A. I think the only landfill that I'm aware of that we're hauling to in the San Juan Basin is the county landfill, and I think that was -- that would be things like plastic and the general trash and that type of thing.

Q. Okay. We were talking about the definition of watercourse. How would you change the definition of watercourse? How could it be addressed?

A. Well, I think -- I think one possibility is Commissioner Olson's suggestion of restricting it to major named watercourses, but I'm not sure -- I don't know where that limits the naming, because I haven't really looked at the other names. I don't know how far the names get down. If this is Billy's Wash and this is Jimmy's Wash, that would concern me, because -- So I don't know where that threshold is. But that seems like more of a reasonable case.

The other alternative too is to -- as I had proposed, was to move that distance from 200 feet down to 20 feet. Now if you're talking about Largo Wash, then I could see giving more than 20 feet. But if we're talking about little washes, then I think 20 feet is ample, if not too much.

So I guess I'm kind of giving you two different scenarios. Either restrict the naming or the -- limit what the watercourses are, or greatly reduce the setbacks for those.

Q. Okay. Due to the constraints of time I'm probably not going to ask you anything on the tanks.

A. Darn it.

Q. Commissioner Olson asked a lot. One of the things that we're going to ask at the end is for a -- proposed statutory changes. And the thing I would want you to encourage your attorneys to include is proposed statutory changes in the definition of below-grade tanks.

A. Okay.

Q. But I'm not going to -- I'm not going to ask you any questions on that. It will be made part of the record there at the end.

COMMISSIONER BAILEY: Regulatory or statutory?

COMMISSIONER OLSON: Regulatory?

CHAIRMAN FESMIRE: Regulatory, I'm sorry.

COMMISSIONER OLSON: Thank you.

CHAIRMAN FESMIRE: Freudian slip.

Ms. Foster, are you going to have redirect --

COMMISSIONER OLSON: Could I just follow up on the costs a little bit?

CHAIRMAN FESMIRE: Sure.

FURTHER EXAMINATION

BY COMMISSIONER OLSON:

Q. Has your company had to do any groundwater cleanups in the San Juan Basin?

A. No -- well, not on -- I don't think we've had to do groundwater cleanups, but when we -- we also did close some of those unlined production pits. I don't think they reached groundwater, but we had to do some excavation. It was quite a while ago, it was closer to when I was first starting, but we did do some of that remediation from the unlined production pits.

Q. And I think I'd asked Mr. Small this. With -- you know, the cost of groundwater remediation could -- usually in the ranges of hundreds of thousands of dollars up to millions of dollars. Would you --

A. I --

Q. -- disagree with that?

A. That would only be from what I've heard other people speak to, but I've certainly heard those numbers referred to in that kind of a project.

Q. And so there is a cost benefit that needs to be looked at in terms of preventing contamination as well, just due to the costs of remediation; isn't that correct?

A. Yes, and I am all for preventing that scenario.

I think -- I think that there -- I think that there are ways that we can do that, especially given time to do research that would be effective without necessarily having to go closed-loop to --

Q. Well, that --

A. -- but I agree, I agree that you don't want to be contaminating groundwater, and especially -- aside from affecting society, the actual cost to the company could be very significant if that happens.

COMMISSIONER OLSON: Okay, that's all.

CHAIRMAN FESMIRE: Ms. Foster, are you going to have a long redirect of this witness?

MS. FOSTER: I think I have about five questions.

CHAIRMAN FESMIRE: Okay. Would it offend you if we went ahead and took a break, came back and then proceeded with Dr. Buchanan, and then brought your witness back after Dr. Buchanan?

MS. FOSTER: I believe my witness has been here for the whole hearing, and he hasn't told me he's leaving, so that should not be a problem.

CHAIRMAN FESMIRE: Okay, so why don't we do that. We'll go ahead and take a break, and we'll reconvene at 11:20, and we'll start with Dr. Buchanan at 11:20.

(Thereupon, a recess was taken at 11:10 a.m.)

(The following proceedings had at 11:20 a.m.)

CHAIRMAN FESMIRE: Let's go back on the record.

The record should reflect that this is a continuation of Case Number 14,015, that all three Commissioners are present, there is a quorum present.

And at this time we're going to break with the cross-examination of the IPANM witness to go to the -- Dr. Buchanan, who's a witness for the industry committee.

Mr. Hiser, I'm assuming that you're going to be doing the examination of Dr. Buchanan?

MR. HISER: That is correct, Mr. Chairman.

CHAIRMAN FESMIRE: Are you ready to proceed?

MR. HISER: I am in fact ready to proceed.

CHAIRMAN FESMIRE: Then let's proceed.

MR. HISER: Mr. Chairman, if we could have the witness sworn, please.

CHAIRMAN FESMIRE: Dr. Buchanan, would you please stand.

(Thereupon, the witness was sworn.)

BRUCE A. BUCHANAN, PhD,

the witness herein, after having been first duly sworn upon his oath, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. HISER:

Q. Dr. Buchanan, could you please state your name for the record?

A. Bruce A. Buchanan.

Q. And could you give us an overview of your educational background, please?

A. Sure. I graduated with a bachelor's degree in 1966 from the University of Utah in botany, continued on and finished a master's at the University of Utah in 1969 in plant ecology, and then went to Montana State University and completed a PhD in 1971.

I was 27 years old, I was hired at New Mexico State University as a professor in forest soils, and I spent from 1971 to 1991 at New Mexico State and actually retired in 1991 from the university and then started my own business.

While I was at the university I taught classes. I was awarded the outstanding FFA teacher in the State of New Mexico, the outstanding teacher in the College of Agriculture, I was given the Burlington Northern Teaching Award for outstanding professor in agriculture, and then the Don Roush Award for outstanding professor at New Mexico State University.

I taught courses in introductory soils, forest soils, soils and land use, soil morphology, soil genesis, soil classification.

My work in research was primarily around ponderosa pine reforestation. I did a great deal of work on water use, water redistribution in the ponderosa pine zone. And towards the latter part of my years at research I was almost exclusively doing work in mine land reclamation. I had started that work in the '70s, had done some through the '80s and then right up to 1990. My last graduate students that I had were working in mine land reclamation.

I'll address the purpose of that a little later, but 1991 I retired. And I had been doing consulting for various companies, different agencies and started doing consulting in the mining industry and moved to Farmington, New Mexico, and still reside there, and I've worked for mining companies for oil and gas, for copper mining, molybdenum mining, primarily coal mining. I have worked in areas of soil erosion, reclamation and have published in those areas and then published in the areas of salt migration.

Salt migration became a major issue in the mining industry in the late '70s and through the '80s, and I did research in those fields of looking at salt migration and trying to resolve whether salts, in fact, were migrating.

Then more recently my work has been in designing reclamation for the mining industry and recently doing a lot of what I started with some 40 years ago, was doing soil surveys, and I've done surveys in most of the western states, a lot in New Mexico. Just recently finished a 12,000-acre survey in Arizona and a 5000-acre survey in New Mexico.

So I get out in the field, I still work, I still get out, I still put a hard hat on hard-toed shoes and sample soils. And I plan on doing this for a while, I guess.

Q. And Dr. Buchanan, about how many years of professional experience do you have now dealing with the soils and soil-reclamation issues of New Mexico?

A. Since 1972, so 35 years.

Q. And do you have any particular accreditations or certifications that are relevant to this area? For example, I see CPSS on --

A. Yeah, that's certified professional soil scientist, it's a certification that's awarded through the American Society of Agronomy. I've been a certified professional soil scientist for most of my career, starting at New Mexico State.

Q. Do you have any other accreditations that are relevant to this area?

A. No.

Q. Okay. Now are you familiar with the industry committee Exhibit Number 4, which is your résumé --

A. Yes

Q. -- curriculum vitae?

A. Yes.

Q. Does that accurately reflect your work experience in this area?

A. Yes.

Q. Okay.

A. I guess I would add one thing. For a period I served on the technical committee for the American Society of Mine Reclamation and a few years ago was the past president of the -- It's a national society, American Society of Mine Reclamation, acronym is ASMR -- served as a president for that society.

MR. HISER: Mr. Chairman, we would move the admission of Plaintiff's Exhibit Number 4, which is Dr. Buchanan's résumé and curriculum vitae.

CHAIRMAN FESMIRE: Is there any objection to Exhibit Number 4 being made part of the record?

MR. BROOKS: No objection, Mr. Chairman.

MR. JANTZ: No objection, Mr. Chairman.

CHAIRMAN FESMIRE: Seeing no objection, Exhibit Number 4 will be admitted.

MR. HISER: Mr. Chairman, we'd also move that Dr. Buchanan be qualified as an expert in the areas of environmental soil science, soil physics and reclamation.

CHAIRMAN FESMIRE: We couldn't have done that at the same time?

MR. HISER: No, I like to do it twice.

(Laughter)

CHAIRMAN FESMIRE: Any objection?

MR. BROOKS: No objection, Mr. Chairman.

MR. JANTZ: No objection.

CHAIRMAN FESMIRE: Noting no objection, Dr. Buchanan will be admitted as the expert in -- soil physics?

MR. HISER: Soil physics, soil sciences generally and reclamation.

Thank you, Mr. Chairman.

Q. (By Mr. Hiser) Dr. Buchanan, have you been here for the testimony of a number of the experts throughout this proceeding --

A. I have.

Q. -- and all that?

And so you've seen generally how we've proceeded in sort of a narrative formation --

A. Right.

Q. -- formulation?

A. Right.

Q. What I'd like you to do is, have you prepared a presentation to talk about issues of salt migration and reclamation with drilling pits for the Commission?

A. I did.

Q. And is this here, the Exhibit 5, an example of that presentation?

A. Yes, it is.

Q. Would you like to please proceed through that?

A. Yes. Let's go to the first slide. The -- I state an objective. In giving this presentation, the objective is to demonstrate that salts do not migrate or accumulate at the soil surface when drilling pits are properly closed and re-vegetated.

The next slide.

My thesis is that, based on research and practical experience from the fields of soil chemistry, soil physics and reclamation, that these areas will be discussed to support the position that upward salt migration to the surface of closed drilling pits does not occur when the site is properly reclaimed.

Let's get into this if we will and go to the next slide, and I want to talk about some basic things here. We've talked about them before. I know you are going to become nearly certified soil scientists before this is over, you've heard this before.

But we talk about two conditions in the soil. One when the soil is saturated, and that's when every pore in that soil is filled with water, it's saturated with water. When that water moves in those conditions, it's called saturated flow. That doesn't happen very often in soils, but it's a condition that has been described and we call it saturated flow.

The more common situation, if we go to the next slide, is unsaturated flow. This is when water is moved through the profile, and it's been typically moved by gravity, and there is some pore space. There's water in the soil and there's some pore space.

In an introductory soils class we would describe the soil as the mineral part, the sand and the silt and the clays, occupying about half of the volume. About half of the volume would be pore space, and maybe about -- I'm sorry, the other half is pore space. Of that pore space, about half would be water. And this is described as a typical soil in an introductory soils class. I don't pretend to say that that's how it always is, but it just gives us a place to start from.

And that's called -- when that water is moving in the soil it's called unsaturated flow. And in fact, water moves in an unsaturated condition.

The void -- and you want to think of this in a three-dimensional form -- that void has a very high relative humidity. We assume it to be pretty close to 100 percent. That's vapor.

As water is taken out of that soil, either by plants or evaporation, then these voids become larger and the vapor exists in that soil.

We know soils to be wet, we know soils to be dry. And most of the time soils are not saturated, they're unsaturated, and most of the time there are voids and those pores are filled with vapor.

And that's all I'm really trying to show here, is just start out with some basic understanding of what happens in the soil.

Let's go to the next slide.

Q. Well, before we go to the next slide, though, we're looking here at the saturated and the unsaturated flow. In terms of contaminant movement, and particularly for salts or chloride, does that occur in the liquid phase or the water phase, or does that occur in the gas phase?

A. It would be limited to the water phase.

Q. And so does the void then serve in part as a barrier to the movement of the contaminant?

A. Yes, it is a barrier, it does not transport those products.

Q. And so that's why when we were talking earlier that salt doesn't tend to move in the vapor phase, that's part of the reason why?

A. That's right.

Q. Thank you.

A. Let's go to the next slide.

We all pretty much know this. We all know that it rains and it rains on soils, and if you go out there during the rain you get muddy. I don't mean to make this too simple, but I want it to be understood that somehow we get water on the soil. Most of the time in the situations we're talking about here, we're talking about rainfall.

Rainfall falls to the surface, and it approaches a saturated condition. A soil physicist will -- most soil physicists won't agree that it's ever saturated. For all purposes it seems to be saturated, and for our purposes here we can just say, well, it's close to saturation.

Think of that as a plug of water, and that water is at the surface -- and we've all seen that situation -- and then that water wants to move down. And the reason that it wants to move down is simply because of gravity. And that's what it will do.

So underneath that plug of water, or that front, is an unsaturated condition, of course, and now this water is going to infiltrate into the soil.

Let's go to the next slide and let some of that water infiltrate.

Again, it's not completely saturated. It moves down as a wetting front, and whatever products are soluble that are in that water will move with that water.

Behind that front, the soil will be under unsaturated conditions, and of course in front of that front it will be unsaturated.

Now let's give it some more time and go to the next slide.

What I'm trying to depict here is, two things are happening. Water is moving down, and the water is distributing itself through the profile. So this quasi-saturated zone is becoming less water, and the soil behind it is being wetted, but it's under unsaturated conditions.

Let's go to the last one, and finally the front runs, if you will, out of water. There's -- the soil has been wetted sufficiently that there's no longer a front, and gravity can't pull that water any deeper. And that soil is said to be moistened and has unsaturated water in it.

Now if we can, let's go to the next slide --

Q. Let's -- before we go to the --

A. I'm sorry.

Q. -- next slide. Now when you have the flow here, for example, in this second block, and we can see that the saturated flow is passed down or what you're calling quasi-saturated flow is passed down, this is going to be wetter than it was before the wetting front went through?

A. That's correct.
Q. And so the reason that you're showing the blue area as becoming less is because some of that liquid has been left behind, or what's happening there?
A. It's being left behind.
Q. And is that a result of matric potential, which we've heard discussed in this hearing?
A. That's correct, as we've discussed matric potential that's what's controlling the reduction of that saturated flow, and it's holding that water to the soil particles.
Q. And when we have an area of quasi-saturated flow, the matric potential within this area would be -- would that be considered a high or a low matric potential?
A. Well, when we talk about it, it's considered very low. It's a negative number, but we often talk about it as low potential. This is the potential that this water is near-saturated, it's near zero -- I guess that doesn't mean anything.
It just means that it's -- that water is held very loosely and is easily extracted by plants, so it's said to have a low potential, and it -- as it moves down and that water becomes more tightly held, it is held at higher and higher and higher potentials, until it's held at such a high potential that even plants -- some plants can't

get the water off of the soil.

Q. And that would also be true, then, in the sense of gravity as well, that where the matric potential is low, gravity is going to have a proportionately greater effect --

A. Under these --

Q. -- in terms of moving the volume of water?

A. Under these low potentials, gravity is able to pull that water down, and at some point even gravity can't move that water.

Q. Why don't you move on to your next slide?

A. So what I've tried to depict here is that we start out with a wetted area in the profile, and below that is a dry area, and that potential is such that it will go -- the water will move from the wet area to the dry area. In this case, gravity is having a great influence on that.

Let's go to the next slide.

So gravity has pulled that water down, it's left a moist soil behind, and the soil is dry in front. And there's some capillarity, of course, on that wetting front that that water is being pulled by capillarity. But the major force for the moment is gravity.

The next slide.

Now we've moved the water down deeper into the profile. It's moist behind. We've given this enough time that there's been some drying at the surface. And as we know, if we've been out in a rainstorm and the soil gets wet, a couple days later we go out and we drive around, and in New Mexico it might even make dust.

But the point is that the soils are dry -- can be dry at the surface, and then moist deeper, and there will be more water deeper in the profile than what might be at the surface.

I think there might be one more slide.

And now the wetting front has stopped, the soils are a little drier on the surface and for various reasons, and I'll talk about that in a minute, and then the soil is moist deeper in the profile.

If we can, let's go to the next.

And what I want to depict here is getting this water out of this profile. There are two main ways water is removed from a soil out to the top. One is by evaporation, and the other is by transpiration by a plant.

So I've tried to depict a plant here, that its roots are in the soil, the water moves to the roots, moves up through the plant, and the water is removed from the soil.

As the plant has an ability to take water from -- water that's the easiest to get, and then as water becomes less and less available, then it will start to take water from deeper parts of the profile.

These are all things that we pretty much know, and it just depicts that the surface generally dries out before the subsoil dries out. We know that's how it works.

So let's put some time on this and go to the next slide and start moving that water out.

And then what will happen in the next slide is, we've dried that profile.

Q. Now --

A. That water that's being moved is moved through that plant and moves out as a vapor. It's water moved into the plant, and it's transported up through the leaves and transpired.

To a great extent, the water that has evaporated has evaporated as a vapor as well.

Go ahead.

Q. Dr. Buchanan, now on this drawing you've shown the roots extending some distance down from the plan surface. What's the typical root structure for desert vegetation?

A. The -- a typical is -- The roots will go where the water is, and in grasses, which are genetically controlled, actually, will be in the upper 50 to 60 centimeters of the profile. That's the upper 20 to 24 inches of the profile.

Most studies show that -- in the arid southwest, that the roots are confined, 75 to 90 percent of the roots will be confined in the upper 12 inches, and the remaining will be limited to the upper 24 inches, the small percentage of roots.

Q. Okay.

A. Those are grasses. Grasses have, only in exceptions, deeper roots.

Shrubs, on the other hand, are a little different. They will basically root much deeper in a profile, and our experience has been that most of the desert shrubs that we study -- there's a couple exceptions, and I'll bring those out, but they're deep-rooted, they'll get down five or six feet.

I did some extensive studies with four-wing saltbrush, and we found that it would root about six feet. And about 90-plus percent of the roots were in the upper six feet of the profile.

Creosote in the southern part of the state is more lateral roots and more on the surface.

Mesquite, which grows alongside of it, can be extremely deep-rooted.

So to summarize that, grasses are generally confined to the upper part of the profile, roots of shrubs are commonly deeper in the soil profile.

Let's go to the next.

What I want to depict here is a soil that is representing -- a soil that has formed in six inches of precipitation, it's a desert soil.

And there's a couple things I want to share here about this photograph, and that is, when soils form, they get modified, they weather. The surface weathers differently than the subsoil, and there's a place deeper in the profile that virtually doesn't weather. And as soil scientists, we try to describe that.

We describe the surface as an A horizon. It doesn't mean anything other than it's just a letter. But this is where organic matter has accumulated. And it's common, even in desert soils, that there will be some organic matter accumulated.

This is a horizon -- and I know this doesn't mean anything to anybody, but it's a horizon of eluviation. It starts with an "e". This is where materials have eluviated or have transported out of that horizon. That's very common, that typifies an A horizon, typifies most all soils.

The B horizon is a horizon of illuviation. This is a horizon of accumulation. These are where the clays accumulate. This is where they become more colorful, this is where iron predominantly oxidizes.

Deeper in the profile -- and I've depicted here what's called a BK horizon, the K stands for calcium carbonate -- these are rather insoluble salts, calcium carbonate is. And it forms in the soil, it is transported to the soil surface in some cases by wind, and it becomes somewhat solubilized and it moves down through the profile. A goodly amount of calcium carbonate is thought to have formed in the soil. It represents thousands and thousands of years of soil formation.

It's not uncommon that they date calcium carbonate layers, and they will be in the vicinity of in the millions -- excuse me, in a million years old. But it's very common that they're thousands of years old. This is an integration of that climate over hundreds and hundreds or thousands of years.

Below the carbonate it's most common that there will be soluble salts, and that's depicted by a measurement of electrical conductivity that's shown on the right.

Electrical conductivity is just a way that we try to express salt in a soil. We take a soil, put water in it, extract the water, or put a probe inside the soil, and somehow we measure how electricity will conduct through the soil. So if it has a lot of salt, it conducts more. If it has less, it doesn't conduct so much.

So what we see here is values of like .6 and .58.

This is actual data for this soil profile. Numbers less than 1, very low salt content -- very low soluble salt content, I shouldn't say salt, just soluble salts. These soluble salts have been removed. They don't exist in the upper part of that profile.

In the carbonate layer, the electrical conductivity is -- I think it's 1.39, and it's a little higher, there's a little more soluble salt. But there's even more soluble salt below the carbonate layer, and I think the number is 3.5. And that's common, that's what we see, that's what we expect, and that's common.

Q. So, Dr. Buchanan, to help the Commission, just because we have ECs and all sorts of things, if we were to convert this back to a milligrams per kilogram, an EC in the .58 to .6 would be approximately what total salts?

A. If -- the number we commonly use is to multiply that number by 600 or 640.

But it's easy, if you want, multiply those numbers by 600. So let's take .6 and multiply it by 600, and I usually use a calculator, but I think it's 360. And that would say that there's 360 parts per million salt.

Q. And by salt, you mean a combination --

A. All of the soluble salts. And it's the soluble salts, it's not just sodium or potassium or calcium or magnesium, it's all of those salts that are soluble.

Q. And so the EC of .6 is approximately 360. Then when we get to an EC of 1.39, which is a little more than double that, what would you expect that --

A. So a little more than double -- a little more than 360 doubled, somewhere around 720. So it's probably around 800 parts per million.

And then the next one is pretty close to 4, times 6 is about 2400 parts per million.

Just for reference, 10,000 parts per million is one-percent salt. The ocean is about three-percent salt, about 30,000 parts per million. So we're not anywhere near the ocean. That's obvious if you live in New Mexico. We have a lot of beach, we just don't have a lot of ocean.

Q. And --

A. But the salts there are what would be considered low.

Q. And Dr. Buchanan, did you say that this would be fairly typical of a soil -- not necessarily the numbers, but this horizon strati- -- stratification --

A. Yeah, this -- that's one of the things I'm trying to depict here, is that this is representative of arid, semi-arid type soils, that the upper part is leached and the lower part has accumulated products.

Q. About how many of these soil profiles have you looked at?

A. Well, I'm not embarrassed to say this at all. I counted up here a few years ago, and I had described somewhere around 6000 soil profiles, and I had sampled well over 1000 soil profiles in my career. And that was about maybe seven or eight years ago.

And I thought maybe I was done, and a dear friend of mine said -- I was running a business and spending a lot of time behind the desk, and he says, Bucky, you've seen your last soil profile. And you know what? I haven't. I think I've probably in the last couple years seen again over another 1000 soil profiles that I've mapped and described.

So I'm somewhere over 6000 profiles that I've looked at, and mostly in New Mexico, various parts of New Mexico, throughout most of the state. I think I've been in every county in New Mexico.

I tease sometimes. I know you don't want a lot of levity here, but I used to fly in a helicopter a lot, looking at soils, and I think I've thrown up in every county in New Mexico.

(Laughter)

THE WITNESS: I have mapped in --

(Laughter)

THE WITNESS: I'm sorry, what?

CHAIRMAN FESMIRE: No, nothing.

THE WITNESS: Oh. Well, I -- you know, I don't want to be too serious, but I -- I have mapped in Arizona and Montana and Colorado, I've mapped in Utah, I've described soils in all of those states, I've sampled soils in all of those states.

I've seen soils -- This won't mean anything to you. There are 12 orders of soil. There's aridosols, these are the arid soils. There's genosols, these are the poorly developed soils. There's spodosols in the forests, alfisols in the forests, mollisols in Iowa, Kansas. There are 12 of those. I think I've seen every order. I've seen soils from Hawaii to Maine and Florida to Washington and I've been in those states and looked at soils.

So most of my life has been in the arid-type soils, and what I'm trying to depict here is an integration of what an arid, semi-arid soil is like. It's weathered, it has salts, they move in -- deep into the soil profile. They are often accumulated with calcium carbonate.

As we move across the country, or even in New Mexico, for that matter, if we get into a little wetter zone those carbonates will be deeper. This represents a profile in a six-inch precip zone. That's about as dry as New Mexico gets. I think that some of the driest precipitation we have in New Mexico is six inches.

Q. (By Mr. Hiser) And so if we were to have, say, 12 inches or 16 inches, where would these soil profiles -- where would the distances break down instead?

A. It would be deeper. The carbonates here are depicted at about, I think, 10 inches or something in that vicinity, above 12 inches. There's been some studies done to try to predict where carbonates will be, given different -- and it's not easily done, but in general we can easily say that if we were to double that precipitation, those carbonates would be definitely deeper under the profile. And the soluble salts typically are below the carbonates, and they would be below those carbonates.

Let's move on and --

Q. Now here you have a series of studies that you're going to present, and you had testified, I think, earlier when you were talking about your educational background, that there was a concern in the coal mining industry about salts and whether they might move. Why don't you tell us a little bit about that concern and how that relates to the studies that we're about to see?

A. In the mid-seventies what really precipitated this was a SMCRA law. There was a law in the United States that coal mining, surface mining, had to reclaim these areas, we had to reclaim the mining sites.

And there were some pretty strict rules that hadn't been enforced before, or didn't exist before, really, and the -- one of those was that topsoil wasn't saved, topsoil was just discarded in part of the mining.

Topsoil is now being saved, and let me just -- you probably all know about mining, coal mining. You dig a hole, you take out the coal, put the spoil back in the hole, and put the topsoil back on top.

This spoil material are marine deposits for the most part. They can be very salty. They can have electrical conductivities well above 18. They are typically in the range of 4 to 12. They can have salt -- sodium concentrations, as depicted by a sodium absorption ratio, of well over -- 13 is kind of a guideline in agriculture. They can be up in the 30s and the 40s.

Q. So --

A. A great concern -- I'm sorry.

Q. -- a very high sol -- high-sodium environment?

A. Very high soluble salts, high sodium.

Q. Was there a concern by the conservation community and the larger community that these salts might come back up into that cover that was being placed --

A. Yeah, that's --

Q. -- back over the --

A. That was the concern, we put the topsoil, that these salts will migrate from this spoil material, and so a whole host of studies were done, almost in every western state. Started in North Dakota, South Dakota, studies -- extensive studies were done in Montana, Wyoming. I did some studies in New Mexico, to try to uncover, in fact, will these salts migrate?

Q. And it's your opinion that those studies are going to be very similar to the situation of looking at salts in the pit perhaps coming back up through a cover that we have placed over a pit?

A. Yeah, I do, I think the analogue is there, and it's material that -- they're marine-type deposits, they're mined and re-deposited and covered, and they weather and the salts are released.

Q. Why don't you take us through a number of the studies that were conducted as part of that investigation?

A. Okay, let's start with one that was done by Stutz and Buchanan. Howard Stutz and I did a study in '87 where we went to sites that were vegetated -- they had to have vegetation, they had to be at least 12 years old, and these sites didn't have cover soil put on them. So this is just raw spoil out on the surface. The vegetation is alkali sacaton for the most part, a salt grass, and then a four-wing saltbrush, a saltbush.

Here's what we found, that the spoils weather and the salts migrate down. And they migrated about 10 to 30 inches, and that the concentration of the salt in the upper

10 inches was substantially reduced from values somewhere in the vicinities of 10 to 12 down to 3 or 4.

We actually found sodium to accumulate at about 30 inches. We specifically measured for sodium, and we found the sodium to accumulate at a lower depth than the profile.

It's interesting how this stuff weathered and how it was able to support vegetation. It's not the way to reclaim, it's not what we would do today, but it was a study to see if in fact salts would move down and if there was a change in this material.

So I bring this out initially as one of the early studies that was done to just look at, what would happen if you didn't put any cover soil in a mined area? And we were mostly interested in the root distribution of the four-wing saltbrush, and we did quite a bit of -- and that's why I know quite a bit about four-wing saltbrush roots, is, we excavated a goodly number of these sites and looked at root distribution.

We found, just out of interest, four-wing saltbrush to grow in electrical conductivities as high as 16 and SARs as high as 60, and those are very high numbers. And the four-wing was doing fine.

Okay, let's move to the next study, let's put some topsoil on top of this.

This is some studies that were done in '84 by Barth and Martin out of Wyoming, Montana and North Dakota. Their study covered a five-year span. They put 60 inches of cover soil over the spoil material, and what they found was that the salts did not come to the surface, but the salts did migrate.

And that is going to be a reoccurring thing that I'm going to say in the next few studies, that the salts did migrate from the spoil, up three to six inches from the interface, into the cover soil. So it does happen. With five years of study, that's where they found the salts to be.

Let's go to another study in Montana. This is done by Doug Dollhopf. Doug has spent most of his life -- he's a soil physicist from Montana state. Doug and I were actually graduate students together. And Doug and I have talked about these studies and his involvement, my involvement.

He did a study over an 11-year period, and he sampled every year for 11 years. He actually took 20 different sampling periods over a 20-year period. It's virtually about two samples a year, kind of a spring and fall type thing.

They put 27 inches of cover soil over the spoil, and here's what he found, that the salts did not accumulate at the surface over 11 years. In fact, the upper 18 inches of that 27 -- he took samples from zero to 9, 9 to 18, 18 to 27. So you've got to think of how he did his sampling.

He in no instance found in the cover soil, in the upper 18 inches, any accumulation of salt. That's what we were all finding -- these people doing these studies, that's what they were all finding, that there was not salt accumulating at the surface.

But he found, and what other people were finding, is that there was salt migrating from the spoil and migrating up into the horizon sampled right above that spoil, and for him it was nine inches.

It essentially levels out right away, and there -- and I've got some slides I'll show later, but it shows what that did over an 11-year period, and it just basically stayed flat at the zero to 9, 9 to 18, and...

Q. Now, when you're saying that, are you talking temporally, so that when Mr. Dollhopf -- or Professor Dollhopf went out and did that, that he saw the migration occurred fairly early on and then stopped --

A. Right.

Q. -- at the same level?

A. Yeah, that's what happened, was, he took a few years and then the salt came to an equilibrium, migrated, and then it just stayed at that level.

One of the things he found was what Howard and I found, was that the spoil weathers, and as it weathers it produces more salt. That's what happens when those minerals weather, it produces more salt.

But the salt concentrations really didn't change in the soil. The salt concentrations changed in the spoil. And what he found and what I found is that those salts eventually migrate down, and there's still some salts in those -- on the cover soil.

Let's go to another study.

This was a very specific study for the State of New Mexico. Mining and Minerals requested the mine to look at this migration, and this study was done over a long period of time, but this represents what happened after four years.

And at the end of four years, the issue was no longer an issue. It was just not a problem. And so the study, although designed to go longer, was discontinued, because after four years with 24 inches of cover soil, what we found was that the salts weren't accumulating at the surface, and they did migrate -- we sampled in two-inch increments from the interface to the surface, and then two-inch increments below the interface, down a foot, and tried to address what was happening with the sodium migration.

And here's what we found, that in some instances some of the plots had two inches of migration, some had four inches of migration, none had any more than that, and that the upper 20 inches, if you will, of the cover soil had no accumulation of salt.

I've visited those plots here in the last year. They're vegetated. They're vegetated with saltgra- -- or with alkali sacaton, Indian rice grass, galletta -- those are just grasses -- and four-wing saltbrush and winterfat. Winterfat is a shrub, four-wing saltbrush is a shrub.

It's effective, it works, they're doing well, and there's no appearance of salt at the surface.

And although we haven't sampled that, other studies that we've done where we have, we don't find any salt at the surface.

Let's go to something -- Let's see, I'm sorry, there's one more study, and then we'll go to something else.

This is some studies that were done in the northern Great Plains over a 16-year period by Bailey. He had two treatments, 28 and 43 inches of cover soil, and he found the same thing we were finding in New Mexico, Wyoming, Montana.

Salts did not accumulate at the surface, and his sampling showed a migration of about six inches into that 28-inch profile or the 43-inch profile.

The dominant studies that have been done -- I know of no instance -- I know of no one -- I had a graduate student here that I served on his committee, recently completed his master's. He looked at some long-term studies. Same identical thing that I've just depicted to you, that salts do not accumulate at the surface from these spoiled materials. They do migrate a bit from the interface. And then there's no mechanism for them to rise any further.

Let's go to a situation that maybe more represents the oil and gas industry.

This is a study done by a graduate student, McFarland, finished his PhD at Texas. He reported his dissertation in 1992, and this is what he reported. I've kind of summarized -- he did an extensive amount of work at several different sites, but here's what he found.

They took drilling fluids, drilling pit material, from a site, transported it to a study site, went to a Reagan silt-loam, and I say that because I'm familiar with Reagan. I've mapped Reagan. Reagan -- Soils have names. We commonly map a soil over in San Juan County called Shiprock, and there's another one called Shepherd, another one called Rosito and Gilco and Glenton. We just come up with names for soils so that we can talk about them.

And so Reagan is a soil, it's a silt-loam.

That's what he did his study in. He dug a pit, put the pit fluids in the pit and then covered it with 12 inches of this material, 36 inches of this material, and then a hundred and -- I'm sorry for going back and forth on metric, but it's 150 centimeters of soil, and I think it's a little over six feet of -- So he had six feet, three feet and one foot.

Here's what he found.

After a -- Well, let me just give the summary and then I'll show you some data.

Salts did not accumulate at the surface, and the salts did migrate, and they migrated up six to 12 inches.

Let's look at this more specifically, if we can go to the next slide.

This is a site that the called the Mertz site, it's just a place. And look at those drilling fluids. That's an EC of 169. I've got to tell you, I've never sampled anything like that. 169.

You multiply that by 600, and that will give you approximately the parts per million. That's about 10-percent salt. That's a lot of salt.

Look at the sodium. It's 1913. That's over -- almost 2000. It's in millimoles per liter of sodium, and 2000 millimoles of chloride. This is some pretty salty stuff, more so than anything I've ever seen.

He put, remember, 12 inches, three feet and six feet. I've just depicted here the three foot, and I've got some slides later that will show what happened with the one and the three and the six, but when I put this together months ago I just depicted the 36. So let's walk through this.

Let's start with the drilling fluids, they're in the gray. And there's an interface, and those fluids are 12 inches thick. And one month after he constructed the site, he took samples.

There seems to be a slight elevation of electrical conductivity in the zero to 6, and then you've got .4, .5, .5, .6, and the Reagan silt-loam is in that vicinity, so there wasn't much happening after six inches.

And then there's measurements, if you want to look at them, of the sodium migration and the chloride migration.

Let's go to 20 months. After 20 months of study, the fluids -- he didn't measure, we'll just assume they're pretty close to the same. That's a lot of salt there. In the zero-to-6-inch the electrical conductivity raised, so the soluble salts moved into that 6-inch layer. But 6 to 12 and 12 to 24 and 30, 36, virtually no change. And that is pretty well represented both in sodium and in the chloride.

Okay, let's go to another site. This is the Weatherby site. Similar kind of conditions, a little different drilling pit material. The EC is now 180, a little less sodium, about the same on the chlorides.

One month, some salt -- soluble salt has migrated into the zero to 6.

Let's go to 20 months.

At 20 months it appears as though there's definitely salt in the zero to 6, and it appears from 6 to 12, the salt has migrated. But after that, there really isn't much change.

Q. And just --

A. The -- I'm sorry, the sodium, of course, has accumulated at that interface in the soil, and the chlorides have accumulated at that interface.

Q. And although I'm sure it's clear to everybody here in the room and on the Commission, these numbers that he's giving here for the zero to 6 would be sort of a composite value for that range; is that correct?

A. Right, he had several -- several stud- -- several sites, and these are means of those sites.

Q. Okay.

A. So does salt migrate? Yeah.

Does it migrate into the soil, cover soil? Yeah.

Does it migrate very far? I don't think it migrates very far. It can migrate a few inches in some studies and more in other studies.

This particular site is about 500 millimeters of precipitation. That's about 50 centimeters, that's about 20 inches. That's a little wetter than here, or what I would depict in the San Juan Basin. But 20 inches.

That water is moving down -- there's a water accumulating there at that drilling pit fluid material, and I would propose that those salts have accum- -- have redistributed themselves, much like I would describe for mining pit materials, by diffusion. That's how those salts got moved.

And the net movement of water is down. And as long as it rains, and as long a there's gravity and water continues to move down, it will show us that water moves those salts down. And where we have a pit fluid or a spoil material there's a brief hangup of that water, is how I would describe it, enough time for diffusion of salts. And then it rains again, and some of those salts are -- continue to be leached.

What's going t happen in 50 or 75 years? Probably not a lot, probably not a lot of difference. I think what you see today is pretty much what you're going to see in the future.

Based on -- If you will, please, go back to that soil that I showed that represented an arid soil.

Thousands of years of calcium carbonate accumulation, thousands of years, if you will, accumulation of salts. Where are they? The carbonates are deeper in the profile, the soluble salts are below the carbonates. That's where they wind up.

I think that's the analogue to what we'll see in the future at these sites.

I think I've got some closing slides, and if we could do that --

Q. Well, before we go there, I'd just like to focus on the science for what you believe is happening, for a couple of minutes, so that we're all on the same page.

Now you believe that from the spoil material -- in this case drilling fluids -- what we're seeing upward is the movement of salt, and you said you believe that was by diffusion?

A. Uh-huh.

Q. And so that diffusion is occurring --

A. I'm sorry, yes.

Q. So that diffusion is occurring, then, as the salts are moving up how? How does the salt move? Because salt requires water to move, does it not?

A. It does. This profile is wetted. Let's go back to the original slides that I had shown how water was moving down.

This water moved down, we've got a 20-inch precip zone. In 20 months the water's moved down to this drilling fluid. That profile was moist. It's unsaturated. It's critical that we don't discuss this as a saturated soil. It's not saturated, it's unsaturated.

There are films of water on those particles. Those films of water are -- you have a tremendous, tremendous potential here. You have an electrical conductivity, you have a salt concentration of these drilling fluids that's 10-percent salt. And what's on the other side of that interface? Virtually nothing, virtually no salt.

So what that salt wants to do is to move from the fluids to satisfy that concentration gradient, and so this -- think of the water as being attached to these particles, and the salt is diffusing through that water on those faces, on those interfaces, up some distance into that profile.

Q. Okay. Now Dennis, if you'll flip back, and I think it may be helpful, to the -- one of the very first slides where we showed the difference between saturated and unsaturated conditions. That one there. Okay?

So if we look at that -- which has now disappeared.

CHAIRMAN FESMIRE: Hang on.

THE WITNESS: Yeah.

Q. (By Mr. Hiser) So we would have our soils that are sitting here, and so the salt is actually having to diffuse through this and then through this very thin area here in order to move up; is that correct?

A. That's correct.

Q. Is that going to be a very fast process?

A. That's a very slow process.

Q. And what's going to happen when a wetting front or rain comes down and hits this area here and suddenly we may look more like this so that we may not fully saturate the soil?

A. It may not be fully saturated, but now there's more water. And now that water is going to move by gravity, and as it moves down it takes the products that are soluble in the water and moves those products down.

Q. So that would have the effect of flushing a lot of what we've seen in the salt that may have diffused up, back down --

A. Yeah.

Q. -- would it not?

A. That's exactly what happens, is, we get flushing. It's ever so critical in agriculture. That's how we irrigate the Mohawk in Yuma, Arizona. We depend on the fact that those salts -- they may move, but they can be flushed down, and we can accumulate salts at depth. And that's why the well at Mohawk is so successful.

Q. Okay. Now you had a couple of conclusions that you wanted to reach?

A. Yeah. Yeah, let's go to the end of the presentation here and go to lunch. Oh, did I say that?

(Laughter)

Q. Just stating what everybody's thinking.

A. In conclusion, this is what I would -- my conclusion is that salts migrate upward. I said a maximum of 6 to 12 inches from spoil or drilling materials, somewhat affected by the salt concentration, it's affected by the amount of precipitation. There's a lot of factors into that.

But for the most part, my studies, studies that I've read, most of the work that's in the west demonstrates that those salts are limited to the 12 inches above the interface.

Salts do not migrate or accumulate at the soil surface when drilling pits are properly reclaimed. And let's go into that, let's go into the next slide and talk about that.

This matter of reclamation, what I'd recommend is that these drilling materials be stabilized, meaning that one way to stabilize would be to put soil in with the drilling materials. It tends to dry them out, it dilutes the salts, and would allow that equipment can be put over the top of it so that additional soil can be put on.

The standard in mining has been about four feet of cover material, suitable cover material for root growth. If we put about four feet, we capture most all of the plants that can be grown at that site, most of the shrubs, most of the grasses.

Now keep in mind that these are plants that have high tolerance of salts that grow naturally at these sites, much higher than agriculture. And so they're going to grow into these drilling fluids. I've seen it. I mean, I've dug holes in this material, and plants have rooted into these materials. They root into the spoil, they certainly do that.

But the standard in the industry has been to put four feet. With four feet, that protects the material below, protects the plants, and we should be able to get sustainable reclamation.

So apply four feet.

Sufficient to prevent salt migration to the surface. The salts are only going to migrate up a few inches, 10, 12 inches. Three and a half feet of soil that won't have salt in it.

2. Sufficient to establish a sustainable native vegetation. And I believe with four feet that statement can be supported.

And third, sufficient to maintain a community similar to conditions prior to oil and gas operations, that before this operation this native site had a certain amount of vegetation on it, had certain kinds of native species on it, and that by putting this cover on those kinds of vegetation can be re-established. And for the most part you will hear me say that I am a supporter of the use of native vegetation that's local to the area. The genetics are not much different.

Genetics is really important here. We pooh-pooh it a lot, we -- you know, it's just seed is seed and plants are plants and soil is soil. Sometimes we say soil is dirt, but you won't hear me say that.

No, it's not that way. Plants are not just plants. Plants have specific genetic materials that are adapted to certain areas. Plants that are adapted to northern New Mexico do well in northern New Mexico. They don't do so well in Montana. Montana plants don't do so well in New Mexico. So I'm not a big supporter of using grasses from Montana to plant in New Mexico, or vice-versa.

These soils are reclaimable, we know that. We've won awards, State of New Mexico has won an award, the best of the best. A mine in northern New Mexico, San Juan Mine, was submitted as one of the best examples of reclamation in the United States. It won for the State of New Mexico, it was compared to other states. There were five sites, five areas that were recommended as being outstanding reclamation in the United States. New Mexico won the best of the best. It was the best in this country. We know how to do reclamation.

We've still got a lot to learn, you know, I'm not saying we know everything about reclamation. We know a lot about reclamation.

And we know that genetics is important. We know that native plants are important. We know that having soil that is suitable to support those plants is important.

You don't want to hear me get off on reclamation. You know, I'll go off --

COMMISSIONER BAILEY: Oh, yes, I do.

THE WITNESS: -- all afternoon.

THE WITNESS: You do?

(Laughter)

THE WITNESS: Well, you ask some -- you ask some specific questions, and I'll try to answer them.

But I love reclamation, I've spent my whole life in it, and I am delighted in the fact that New Mexico represents the best of the best.

So what I'm saying here is that these sites, these oil and gas sites, they can be reclaimed if we put sufficient soil, we use the right kind of plants.

And this fear, this concern -- which is a concern that was in mining 20 years ago, 15 years ago -- will that salt migrate to the surface? Yes, yes, it'll migrate to the surface. And because of that, we have to bury those spoils deeper and deeper, and...

So studies were initiated. There's a lot of studies that were initiated, they were studied in almost every state.

And the dominance -- and I know of no exception to this -- the salts don't migrate to the surface. They do migrate, they move up a little bit. I personally have seen it, I've personally sampled it, I've done those studies.

The analogue to nature, when I look at some 6000 soils cross the western states, the carbonates move down to some depth, the soluble salts move deeper than that. The mechanisms are there for the salts to move down. The mechanisms are not there for the salts to migrate to the surface, and I submit that they don't.

Q. (By Mr. Hiser) Which brings me, I guess, to just a couple of concluding questions, and then we can break for lunch, if the Commission is so willing.

In your mind is this an emerging area of science, or is this a well-understood area now?

A. I think it's quite well understood now.

Q. And so based on that experience, it's your professional opinion that the salt would not move up more than, say, six to 12 inches; is that correct?

A. Correct.

Q. And how many years have you been working in this area?

A. Thirty-five years, I guess.

Q. And when you've been working for those thirty-five years, have you looked at all different ages of spoil material or drilling-fluid materials

A. I've -- Yes, I have looked at different ages.

Q. And so you've seen those have been very fresh, versus those which have been disposed of for a while?

A. Correct.

Q. In all that experience, have you ever seen the salt migrate to the surface?

A. I have not.

Q. Do you believe that that would be a basis for -- that concern would be a basis for, particularly, handling pits in a particular way? That's a vague --

A. Yeah --

Q. -- question, I know.

A. -- yeah.

Q. Okay. But you don't believe that we need to be -- that if we reclaim the pits in the way that's laid out in the proposed rule, which is with four foot of surface cover, that that's not an issue that you believe we need to be concerned about?

A. I don't believe it's an issue.

Q. With that, then, Dr. Buchanan, does Exhibit Number 5 from the industry committee reflect these slides that you've just gone through?

A. This is number 5?

MR. HISER: May I approach the witness?

CHAIRMAN FESMIRE: You may, sir.

THE WITNESS: Oh, oh, yes.

Q. (By Mr. Hiser) And does -- behind that is industry Exhibit 6, which is a report that you prepared; is that correct?

A. That's correct.

Q. And that report contains more details and the supporting references for the material that you've testified today?

A. It does.

Q. And you prepared that report?

A. Yes, I did.

MR. HISER: Mr. Chairman, we would move the entry of Exhibit Number 5 and Exhibit Number 6.

CHAIRMAN FESMIRE: Is there any objection to Exhibits 5 or 6?

MS. FOSTER: No objection.

MR. BROOKS: No objection, Mr. Chairman.

MR. JANTZ: No objection.

CHAIRMAN FESMIRE: Exhibits 5 and 6 will be admitted to the record.

MR. HISER: Mr. Chairman, we've also prepared rebuttal materials, but this might be an appropriate place -- I'm sure everybody would love to break for lunch, and we can come back and then go through those materials.

CHAIRMAN FESMIRE: Okay. Is there anybody here who would like to make a statement on the record before we break for lunch?

Okay, with that, we will break for lunch for an hour and fifteen minutes and return at a quarter to 2:00 and reconvene at that time.

Thank you all.

(Thereupon, noon recess was taken at 12:30 p.m.)

(The following proceedings had at 1:50 p.m.)

CHAIRMAN FESMIRE: Let's go back on the record.

Let the record reflect that this is again a continuation of Case Number 14,015, that all three Commissioners are present, that it is approximately 10 minutes till two o'clock on Monday, November 3rd --

COMMISSIONER BAILEY: December.

CHAIRMAN FESMIRE: Huh?

COMMISSIONER BAILEY: December 3rd.

CHAIRMAN FESMIRE: December 3rd. God, have we been here a month already?

(Laughter)

MR. BROOKS: Almost.

CHAIRMAN FESMIRE: Monday, December 3rd.

And I believe that we were going to proceed -- go directly from his direct testimony to Dr. Buchanan's rebuttal. Is that --

MR. HISER: If that pleases the Commission.

CHAIRMAN FESMIRE: I think we've agreed to do that.

Why don't you just go ahead, Mr. Hiser?

MR. HISER: Thank you, Mr. Chairman.

<u>BRUCE A. BUCHANAN, PhD</u>,

the witness herein, having been previously duly sworn upon his oath, was examined and testified as follows:

DIRECT EXAMINATION (Rebuttal)

BY MR. HISER:

Q. (By Mr. Hiser) Dr. Buchanan, have you prepared a number of slides in rebuttal of some of the testimony that we heard earlier?

A. I have.

Q. And these slides are going to be primarily addressing some of the testimony that was introduced by Dr. Neeper; is that correct?

A. Correct.

Q. Okay. The first slide is one that's called Assessing the effect of salinity and sodium adsorption ratio on infiltration rate.

What does the -- First of all, where did the slide come from, and what does it tell us?

A. This is a paper that was published by Hanson, and there's been a number of researchers, soil physicists, that have studied this situation of the relationship of electrical conductivity to SAR.

What this is saying, what the research is demonstrating is, we have to kind of go back in time.

In the '50s, a handbook was produced by the soil salinity lab, and some guidelines were given and said that SAR values above 13 are limiting to agriculture, and so soils that have SARs 13 and above will be called sodic soils. And the soils that have electrical conductivities of 4 and greater will be called saline soils. And that was just by convention.

And for the longest time people thought that an SAR of 13 was damaging.

What we've come to find out through work with the soil salinity lab and researchers, that SAR doesn't work alone by itself. You can't really do anything with SAR all by itself. It has to be in combination with the electrical conductivity.

And it has to do with the way clays distribute themselves in a soil. And if they are aggregated, or what -- we sometimes use the term flocculated -- then they act as an aggregate and water moves through the soil.

If they become dispersed, then these clays will seal the soil, and water doesn't move through the soil very easily.

We thought it had to do with SAR. It has to do with the EC/SAR, so it's -- Let me try to explain the graph relative to what I just said.

Let's start on the bottom of that chart and look at an electrical conductivity of 1, and then go up on the left-hand side and find an SAR value of 5. So if the SAR is 5, well below 13, and the electrical conductivity is 1, you're kind of on the border of where there's no effect on infiltration, where there might be slight to moderate effect.

If that EC were to drop to .2 -- I know that's not on the chart, but if it were to drop to .2, it's likely with an SAR of 5 that that soil could become dispersed.

However, if for some way we were able to raise the electrical conductivity by putting saltwater on that soil and get electrical conductivity of 2.5, 10 times greater, then these soils will stay flocculated or aggregated.

Let's just do one more, and then -- Let's take an EC of 4. Let's -- off to the right, go up to the top of the page, about where it intersects that first line.

So here's an SAR of 25, 25, well above a 13, and yet that soil with an EC of 4 and an SAR of 25 stays flocculated, stays aggregated.

But if that EC were to drop to 2, that same SAR of 25, then that soil has a very high risk of becoming dispersed, and water infiltration would be compromised.

Q. Now Dr. Buchanan, just a couple of things on this. At the bottom here we see this measurement that we haven't seen before, which looks like decisiemens per meter.

A. Correct.

Q. Is that effectively the same as --

A. -- millimhos --

Q. -- millimhos per centimeter?

A. That's millimhos per centimeter.

Q. Millimhos, thank you, millimhos per centimeter.

A. The decisiemens per meter is an international units, and millimhos per centimeter is one we use here in the United States.

Q. And so you could read that --

A. -- either way.

Q. -- either way, it means the same --

A. -- same -- same -- the decimal is in the same place.

Q. Now if you recollect the testimony of Dr. Neeper, he said that it was the sodicity of loam that caused the impact on the soils; is that correct?

A. Yeah, the sodicity -- and to help you here, we'll just go back to teaching at New Mexico State. Sodicity is a word that has the beginning of sodium in it, s-o-d-i- -- sodium, s-o-d-i-u-m. So sodic soils are those soils that are high in sodium.

Saline soils are soils that are spelled s-a-l-i-n-e. Think of that as being salt, just soluble salt. So when we talk about a saline soil, we're talking about a soil that is high in soluble salts, whereas if we're talking about a soil that is high sodicity, it has a high SAR value.

We know that soils, in California, for example, have SAR values of 125. And they're very effective in growing vegetation, because we have to maintain -- or they have to maintain the electrical conductivity as a very high number. So they irrigate with fairly salty soils.

So sodicity alone does not tell the story. It has to be in combination with the salinity or the soluble salts.

So we can have very aggregated soils at very high SARs, as long as the soluble salt content is high. Lower that soluble salt content, and then these soils start unraveling or become dispersed.

Q. Now, if we were to take a look at this chart and try to apply it to the top of the pit, where we're trying to do the soil reclamation, what impact is this chart going to have if we're taking the soils that were there beforehand and we're just sort of putting them back, and then we're going to contour them back to the ground surface?

A. Well, what you're asking and how I'd address that is that, if we take these soils that were there before and we put them back, we want to maintain a soil structure. That's important. And one way of maintaining that soil structure is to keep this salinity/sodicity balanced so that we're on the far right of that chart.

If we have soils that are high in SAR, and that's all you know, it's really not a problem as long as the EC is high.

If that soil winds up at the surface, and it were to be -- have rainwater on it, that rainwater has extremely low electrical conductivities. You run a risk of that soil becoming dispersed and causing a slaking, and then water -- it's difficult for water to move into that soil, because the aggregation has been lost.

Q. Now if that soil had been present beforehand, would we expect to have seen that condition before we even put the pit in place?

A. That's typical, what -- if that soil was there before, that's the way it looks and it has had that experience of -- Maybe it's just simpler if I just said, yeah, that's what it looked like before, and that's -- They're easily identifiable, they're -- if it has this problem, it had it before, and it can be remediated. It's remediated all the time in agriculture. We do it all the time in agriculture.

Q. And so from a reclamation perspective, if you were to have this occur because your native soil condition was that before you put it in, what step would take --

A. One step --

Q. -- -establishing --

A. -- one step is, you try to aggregate the soil. Anything you can do to aggregate that soil. One is to add calcium sulfate. Get that sodium, that SAR down. Get that sodium out of -- off of those -- it's been adsorbed to the soil particles. You want to replace that sodium, replace it with something that's soluble. Gyp is a good example, or gypsum, calcium sulfate.

And then that lowers the SAR. We're for the moment not doing anything with the EC, so we're coming down the left side of that chart and hopefully intersecting somewhere where the electrical conductivity and the SAR is balanced and we can re-aggregate that soil. It's done with gyp.

It's occasionally done with organic products. There are area- -- there are studies that have been done. Jerry Schumann up in Wyoming has done quite a bit of work on that subject, and has been successful in aggregating soils with organic products.

Q. Now it's possible, Dr. Buchanan, that Dr. Neeper was also concerned, given his presentation about salt migrating upwards from the underlying pit contents, if we put our fresh soil in and then suddenly we have sodium migrate up, and that that might cause a problem. Would, in your professional opinion, that cause a problem if we had some sodium migrate up into that upper soil? What would happen?

A. Well, as the sodium migrates up, we would expect the SAR value to raise. In an extreme condition, if you raise the SAR high enough and the electrical conductivity stays low, we would wind up in a dispersed situation.

But the -- As long as that water can move in that soil, as long as water can go into that soil, it will flush that sodium back down, and that problem is alleviated.

Q. So that you would not expect to see that as a problem in a typical --

A. I don't expect -- that's right, I -- there's -- because of rainfall and water moving with gravity, as we discussed in a simple way, that water moves down and flushes those salts back down.

Q. And is there also a contribution of natural rock weathering that may affect this as well?

A. Natural rock?

Q. In other words, will salts come out of --

A. Oh.

Q. -- materials that are in the soil as well, over time?

A. Yeah. Yeah, what happens is, the predominant cation in a soil is calcium. That's kind of a quiz question in introductory soils, and you trip up a lot of graduate students, what's the most common cation? And calcium is one of the most common cations in the soil.

As soils weather, that calcium weathers out. And it's kind of a natural system of the calcium replaces the sodium, the sodium is more soluble, tends to move down, the calcium replaces it, and soils kind of naturally aggregate.

It's kind of a neat thing that got invented.

In time, or in wetter zones, if we were to go to, oh, a 60-inch precip zone, you know, let's go to Tennessee, for example, that calcium is gone, those salts are down 50, 60 feet. That salt is just long since gone. Those soils are weathered down 10, 12, 15 feet. That's a very high-precip zone, high humidity, the extreme weather.

Let's go one more extreme, Hawaii. Those soils weather out so fast, they weather so much and so much is removed, they're infertile, they virtually will not grow vegetation.

And you go, I've been to Hawaii, I saw vegetation growing there. Well, yeah, you did. But those soils are so weathered agriculturally that the clays are even washed out, the calcium is long since gone. They're very difficult soils to grow agricultural crops on, and so they have to be supplemented.

Those are the extremes of weathering. We don't ever see those kinds of conditions in New Mexico. And maybe I just got off on something there, I -- just to stay in New Mexico.

The products as they weather will -- if they're less soluble they tend to stay in the profile, if they're more soluble they tend to move out of the profile.

Q. And so over time as more of the calcium came out and the sodium moved down, you tend to see the SAR come down in those areas -- those layers of the soil horizon?

A. That's what happens. If you can replace that sodium -- I know you know this. The SAR is a ratio of sodium to calcium and magnesium and -- you know, don't worry about -- just think of sodium on top of the line and some calcium and magnesium underneath the line. And we add them up and divide by two, take the square root and divide, and you get a number over here. All you need to know is, you just get a number over there. It's a ratio.

If I can lower that numerator, if I can get that sodium out of the system -- and in fact, if I can even add some calcium and magnesium and make that denominator a bigger number, I can drop that SAR like a brick and I can reduce that number considerably.

As the SAR goes down, the sodicity goes down, and you have a better chance at low electrical conductivities of keeping those soils aggregated.

Q. And then natural processes such as frosh heave, would they tend to restore soil structure?

A. That's -- yeah, we haven't talked much about that, but soils weather. And one of the weathering phenomenons that go on in soil is a phenomenon of frost-heaving. And ice -- water gets in the soil, it freezes.

And no one believes this, you know, we didn't when we were in high school, but it works. Ice floats. So it expands, and -- that ice expands in the soil, it pushes on that soil. And it's kind of a fun thing to demonstrate, I'd jump up and do it for you, but it just wants to go, and it just pushes, and then you've got Dennis here, he's wet, he's frozen, and he's pushing and I'm pushing, and the next thing you know something's going to give. And it can't go down, can't go down. Can't go sideways. And up it goes, and we call it frost-heaving. And it's an interesting phenomenon in creating soil formation.

Q. And so sort of the bottom line on this chart is, do you believe that the concern that Dr. Neeper had that the salt that may -- and the sodium that may be in the pit would constitute a potential threat to the re-vegetation of the surface is one that we really need to be concerned about?

A. I don't believe so.

Q. Okay. Let's then move on to the next concern that Dr. Neeper had, which was what he called either chloride or salt poisoning for the vegetation, and it may also have been more reflective of osmotic pressure and starving the plants of water. And you have a slide or two that addresses this?

A. Yeah, I do. This is a chart that was produced by Montana State University, and it shows at the top of the page some crops, and then a level at which productivity could be affected, of electrical conductivity. And there you see decisiemens per meter, and then it says or millimhos per centimeter, and the upper limits of plant survival.

So maybe the one that's the most sensitive on that list is corn. At 4, its productivity is going to be affected. The upper limit is 6. You start getting above electrical conductivities of greater than 6, you're not going to grow a lot of corn.

Then it goes down into some forages, and then on wet sites these are types of grasses that grow in wetter areas, and then the next category is forages that grow on drier soils, and then there's a list of native soils.

If we can, without looking at those numbers too much, let's go to the next page, and what I've done is highlighted some of the plants that grow in New Mexico and are used in -- they're natives that grow in New Mexico, they're natives that are used in reclamation.

Let's start with slender wheatgrass. That's, you know, the top. It has an initial -- affected at levels of 10, its limit is 20. That's -- Now if you remember, and you -- I shouldn't expect you to remember this. There will be a quiz at the end of this, I guess. That was a joke, that was a joke.

The electrical conductivities of 4 --

CHAIRMAN FESMIRE: Just for the record, Doctor --

THE WITNESS: Yes?

CHAIRMAN FESMIRE: -- one of the Commissioners said, Yeah, but you're the one that's going to get quizzed.

(Laughter)

THE WITNESS: That's probably right. That's probably right.

The electrical conductivities of 4 were designated as being limiting to most agricultural crops. And for the most part that's pretty much true.

But for native plants, plants that grow wildly, they're extremely tolerant to salts. And slender wheatgrass is an example. Look at Nuttall's alkali grass. It wasn't called alkali grass for nothing. That stuff will handle electrical conductivities of 30.

One that we use a lot is second from the bottom, that western wheatgrass, and then just above there is alkali -- second from the top, alkali sacaton. Those are really bread-and-butter-type species that are used in reclamation. The alkali sacaton, I've done some greenhouse studies with it and those numbers are very much right on line. That's what I found in some greenhouse work. 14 starts to be limiting, 26 is the upper limit. Western wheat, very commonly used, upper limit 16.

So --

Q. (By Mr. Hiser) So these are -- The ones that you've highlighted here would be species that you would expect to see on the New Mexico landscape, and which would be easily able to handle this -- the saline conditions that are typical New Mexico --

A. Yeah, A, handle the saline conditions. And B, these are species that are used in -- commonly used in reclamation.

Q. Would you be able to successfully reclaim a pit using these species?

A. Sure. These species are adapted to mostly the northern part of the state, some of them would do well in the southern part of the state, and then there's some similar grasses. It's inland saltgrass. It's not on this list, but it's much like Nuttall's saltgrass, and it does well in the southern part of the state. So these could be used to reclaim.

Q. And these species tend to be palatable for livestock or --

A. And they -- Western wheatgrass is very palatable, alkali sacaton very palatable. Yeah, most all of these are -- the slender, the tall, those are all palatable species.

Q. Now one of the concerns that Dr. Neeper has expressed is, well, what happens if we have enterprising root --

A. If we have what?

Q. If we have the enterprising root --

A. Oh.

Q. -- from either one of our shrubs or our grass, and it goes and say it penetrates the liner that's over the pit contents. When it hits those highly -- or the more saline pit contents, what's going to be the impact on the plant? Is it probably going to die, or what will happen to it?

A. My experience is -- comes in part from the mining industry where you have spoil materials that have a wide range of characteristics, very salty. And the plants will come down, the roots will start to explore -- I guess enterprising roots that will explore these materials.

When they're limited -- when they hit something that they can't handle, they are enterprising and they will seek other places. That represents generally a small portion of the profile, and they will move sideways or they'll do something to find a place to grow.

Don't get misled -- and I've probably misled people into believing this, and I don't believe it, and I certainly don't want to mislead you that plants have brains and that they think and they know what's going on. There's nothing like that.

They have the ability, they explore places, they hit something that will stop that root hair -- and this root is not the size of a pencil when it's moving through the soil, this thing is a tiny little root that is the root tip that's growing out there. This thing is so small you can hardly see it. And it's -- it -- Bam, it hits something and it doesn't like it, and that's the end of that root.

That happens every day, and every root. Yeah, the plant's going to die, but if it can find some other place to get water and nutrients, that's what it'll do, it just goes.

I've got some -- I have experience where -- in mining where the materials below are extremely acid. First off, let me just say that plants can handle some very extreme acid conditions. We think of agricultural soils being pH of 7, pH of 6.5. Lodgepole pine, for example, will handle pH's of 2.3, 3.0. Douglas fir actually handles some fairly high acidities.

But if a plant cannot handle this acidity -- let's make it extreme, let's make it a pH of 1. It's a layer in the mine materials, or if it were drilling materials, and this root comes down and it hits that acid and it's 1.0, it's over. That's it, it's done. It cannot penetrate that. And that's the end of that root exploration. That root now will have to explore other areas. And in fact, that's what it does.

In the Gallup area, I can't tell you why, but there's some mines down there, and they're extremely acid materials. They put about 12 to 18 inches of cover soil over those acid materials, supports vegetation. How does it do it? Vegetation goes down, hits those acid materials, and it is done. There are no roots in that acid material.

But there's an extensive root system in the upper 18 inches of that profile. And it's enough profile and enough water-holding capacity that that vegetation is able to sustain itself, and it has for, oh, 15, 20 years that I know of.

Q. And so it would be your professional opinion, to bring this back to drilling pits, that the four foot of cover that's been recommended would be more than adequate to establish grasses or shrubs or whatever?

A. Yes, yes.

Q. Okay. Now did you -- I think you did one additional chart and that just shows some common shrubs; is that correct?

A. Correct. One of the things that is critical and important to reclamation is the establishment of a shrub community. There's just a whole host of reasons why I say that, but let's just leave it to be said that shrubs are important in reclamation.

There's quite a variety of shrubs out there that can be used, and they're called saltbushes. And again, they're not called saltbushes because they don't like salt.

Let's start with mat sage saltbrush up at the top. It can handle electrical conductivities greater than 16. That's a commonly used bush for reclamation.

Mound saltbush, castle valley, sickle saltbush, these are all up -- well above 4, up in the teens.

The one that I think most of us here know -- some of us know it as chamisa, you might have called it that sometime in your life, but it's four-wing saltbush. That shrub I have found growing at the mine in electrical conductivities in excess of 16, as high as 18. Some people found it as higher than that.

We did a study one time with four-wing saltbrush. We took pure water, pure good old drinking water, and we couldn't get it to germinate very well. We put one-percent salt solution, germinated well. We put three-percent, ocean water, we germinated four-wing saltbush in ocean water, three percent salt, 300,000 parts per million. That thing is pretty salt tolerant.

Four-wing, I don't know where its limits are. I haven't found them really. It seems to grow everywhere. It has an extreme tolerance for low water content. It has a propensity to root to wherever it has to, to get itself to grow.

Shadscale, which is right above it, is a sister to -- or brother, whichever way you want to call it -- to four-wing saltbrush. One is *canescens*, and the other one is *confertifolia*. And those two characters just about grow everywhere in New Mexico. They have a tremendous ability to handle salt and have a tremendous ability to handle drought, droughty conditions. They're both grazeable, palatable, and they are grazed in fact. The genetics on them are extremely complicated, and we've done a lot of work in the genetics of the four-wing, not so much with the shadscale.

Sagebrush, everybody knows sagebrush. Under some extreme conditions it's able to handle some extreme salt conditions. It actually likes salty soils.

Rabbit brush is actually, in my mind, a little more tolerant of salt than even sagebrush.

And then winterfat, which you may not know, but it's an extremely palatable shrub that's used in reclamation extensively, is extremely tolerant of salt. We hardly ever see its limits. We never see it limited by salt, we rarely ever see it limited by water. It's -- the problem with -- well, we don't need to get into -- the problem with winterfat is, it's just a real bugger sometimes to get it to germinate. But once we get it up and going, it does well.

Anyway, the point of all this is -- and I know I've belabored the point -- is that there are shrubs out there that are extremely salt-tolerant, and they are not limited by most of the salinities that we deal with in reclamation, either in the oil and gas industry or in the mining industry.

Q. And now just to answer a question that may come up about this slide, there are a number of columns here, and in fact those columns are just meant to reflect the reference from which you drew this information; is that correct?

A. Yes, yes.

Q. Okay.

A. The references are Hodgkinson, he works at a plant -- used to work at a plant materials center; Stutz and I have worked together; I'm the Buchanan guy; and Danny and I were roommates in college, Uresk. Danny is the director of Rocky Mountain Forest Range and Experimental Station out of South Dakota, Rapid City, South Dakota.

Q. But these are all part of the extension network, basically?

A. Yeah, right. Yeah.

Q. Why don't we flip to the next slide now?

A. What I've tried to depict here is the McFarland study. Since I put the original paper together, I found that McFarland had published another paper, and he had published his work after 40 months. Remember earlier today, I talked about his work on his PhD dissertation, one month, eight months and 20 months, and then this is after -- I'm sorry, I said 40. 44 months.

So let's walk through this. This is the Mertz site. Same drilling fluids, EC of 169 that I reported earlier.

All right, let's start on the left-hand side and let's start with 30 centimeters of cover. That's 12 inches. McFarland took samples from zero to 15 centimeters and 15 to 30 in that cover. Let's just concentrate on that for the moment.

After one month, the electrical conductivity was 2, at zero to 15. And then let's move to the right, that kind of greenish color, olive, 9.54. And then after 20 months 4.39, and then after 44 months 24.2.

Let's look at the electrical conductivities at the layer above that, .51, .53, .54 and .90. And McFarland reported that there was no statistical difference in those electrical conductivities in the upper -- that 15 to 30 centimeters above the -- or the upper six inches.

Q. Okay.

A. Okay, digest that for a moment, and let's just talk about it.

Salt migrate into the cover soil? Yes.

Did it migrate after 20 months? Yes.

Was the electrical conductivity 169? Think of the gradient that must exist between those drilling fluids and then that cover soil. That's an extreme soil.

Will salts continue to migrate? Probably.

Will they migrate into the upper six inches? No. It isn't likely that it won't. My answer is, no, it will not.

This is a 50-millimeter -- 50-centimeter, 20-inch precip zone. This site is getting water, rainwater. That water and gravity move through that profile and keep continually flushing that surface and will continue doing that.

Those salts, there's no mechanism -- there is no mechanism for those salts to accumulate at that surface, as long as we have gravity on this planet, and as long as it rains at that site. When it quits raining, then those salts will migrate to the surface. But as long as it'll rain, there is going to be a pulse of water put to that profile.

And that upper six inches -- and that's been my experience where I've put -- we've put 12 inches of topsoil over spoil material at -- in the mining industry. Now they do that sometimes. But that upper part of that profile, that upper six inches, is going to remain salt-free. It will not accumulate at that surface.

Let's go to the 90 centimeters. 90 centimeters is 36 inches of soil. Now you've seen part of this. Let's go to the bottom and let's work our way across. Let's start with 1.84. The electrical conductivity after one month, 1.84. Then it goes to 3.14, then 8.13, then 14.5.

In the six inches above that, after 44 months, there was salt migration into that are, 6.8. So it took -- the first 20 months didn't show an effect. After 44 months there started to be salt moving in.

What happened above that? His samples after 44 months in the upper part of that profile are relatively the same as they were before, and that salt did not migrate into that zone.

What will happen in time? Who knows what will happen in time, but there will be some salt migration. You've got electrical conductivity, you have such a tremendous gradient between 169 and that subsoil -- or that cover soil. That gradient is wanting to push that salt up. So that salt wants to go up.

But what's happening at the other side? The water is coming into this profile and moving that salt back down. So there's this battle between salt coming up and salt coming down -- and salt coming down due to the water movement.

Let's go to the 150 centimeters of cover.

Again, similar to what happened at the other, 1.63, then 3.45, then 9.17, and then 21. In the 44-month, in that 15- to 30-centimeter, it jumped to 14.8. So the salts migrated up into that upper six inches. You've heard that today. You see it in the mining industry.

And then there's -- appears to be some salt movement into that 30- to 60-centimeter zone.

The upper part of that profile -- now keep in mind, that profile goes all the way to that title, 150 centimeters of cover; he just didn't sample it. So there's some six feet of material over this drilling pit material, and those materials, those soluble salts, have migrated up, in this case, 12 inches and possibly a few more inches.

Q. And it's -- in this case, once again, are these showing the sample intervals, and so --

A. Yes.

Q. -- he sampled in sort of six-inch intervals until he got to 30 and 60, and then he did a 12-inch?

A. Yeah, he went six inches, six inches, then for some reason he went 12 inches, and then he went six, and then he went six again.

And then -- I guess based on his experience, they just didn't sample the -- above 150 centimeter -- or -- well, I'm sorry --

Q. -- 75 --

A. -- they didn't sample above 36 inches to the surface, thinking that there was no change. If there wasn't any change below, there wasn't going to be any change there.

So this water from this natural precipitation is driving those salts down.

Q. And so we --

A. Well --

Q. -- in, for example, the 44-month under the 150 centimeters of cover, we don't know where the salt is within that 12-inch interval that may be causing it to go to 2.7?

A. That's right. We know it's -- He just took that composite, 12 inches, and that salt could be -- and most likely is in the lower part of that profile. If he had cut that at six inches, probably would have seen it in that six inches, and the one above it, I would suspect, would have been more like the soil above it.

Q. Now based on --

A. Keep in mind -- I'm sorry, keep in mind that this material is this -- Remember, I said the Reagan silt-loam.

These are fairly silty soils, these are clay contents in the vicinity of about -- he doesn't say, but I'm just -- my familiarity with the Reagan silt-loam is a little -- around 30-percent clay, about 60- -- 55-, 60-percent silt, and probably 10- or 15-percent sand in these soils. And the sand that's in here is very fine.

Q. So it's a very -- relatively tight soil?

A. Yeah, it's a heavy-textured soil, right. It's not a clay soil, it's a silt-loam. It's a silt-loam, silty clay-loam, in those -- That's what the Reagan is.

Q. Now, if you take the work that was done by McFarland and you add to that what we know from the greater longitudinal study done by Dollhopf, what conclusions can you draw from that?

A. This -- from the Dollhopf work, after a few years, the salts in the cover soil didn't change. They -- There was an elevation and the -- nine inches above the contact zone, the interface, and then it stayed pretty much the same for 11 years.

The upper 18 inches of that cover soil on the Dollhopf study never had salts accumulated any time during those 11 years.

The conclusion that I would draw, that that gradient is extreme for me between 169 and what it is in that cover soil, so there'll be some salts wanting to satisfy that gradient. And so you have that gradient trying to be satisfied, and over time those salts will -- that level of salts above that drilling fluids will increase in the cover soil, and then in time it will level out.

And at the same time, don't forget, you have 20 inches of precipitation coming down onto these soils and driving those salts back down. And that's why the upper part of this profile will remain relatively salt-free.

Q. And if we were to make this a coarser-textured soil, what do you think would happen?

A. The salts wouldn't migrate up as high -- if -- When we say a coarser texture, we're talking about a soil that's more sandy, less clay. The capillarity wouldn't rise as high. The infiltration would be greater. You put 20 inches on a sandy loam, now you really have a battle going on because you can't get the salt to migrate up as high because the capillarity is not there. Now you've got this water moving down and infiltrating deeper. And given all things, I suspect the salt would be deeper -- the salt would not migrate as high up in that soil.

Q. Now you said that you've worked pretty extensively throughout the State of New Mexico; is that correct?

A. Correct.

Q. And in terms of the general soil characteristics where drilling activities are going on, do they tend to be more in the sandy-loamy area, or more towards the heavy clays?

A. New Mexico is an interesting place, it wasn't called the land of enchantment for nothing. And I've said that a few times today, and I don't mean to make a big issue of it, but it is the land of enchantment.

From a soils perspective it has a tremendous variety of soil types, because we have a tremendous range of elevations in this state.

But one of the things that's unique about it is, it tends -- the soils tend to be more sandy throughout the state. If you look at San Juan County, the heavy-textured soils are confined to the river drainages. And they're still, even at that, not very high clay content, 35-, 40-percent clay.

I only know of a couple places in all of the San Juan Basin where there is -- ever I've found 60-percent clay. In my experience throughout the State of New Mexico, I only know a few places that are truly the exception where there's ever been 60-percent clay. I've spent 20 years in southern New Mexico.

Other than playas where clays have been able to have been transported in, the Isaac Lake playa, just out on the Jornada experimental station, just out of Las Cruces, has 60 percent clay. It's the highest clay I've ever seen actually in New Mexico. I've been over on the eastern part of the state, and the playas there don't seem to have as high a clay content for some reason.

Clay is a product, it's a product of weathering. It's an aluminum silicate, it's either double-layered or single-layered, and it's a one-to-one lattice or a two-to-one lattice. It's either in the smectites or it's in the kaolinites or the illites. There's a variety of kinds of clays, but they're either two-to-ones or one-to-ones. They are products of weathering.

We just don't weather those clays out in this state. We're not Texas. Texas has much more weathering, has high clay contents. They can grow rice in clay soils in Texas. It's very similar to India, for example. We don't grow rice in this state. We don't have playas enough, we don't have clays enough.

Clays represent a very small percentage -- when I say clays, I'm talking soils that have in excess of 40 percent clay. If you -- if we talk about soils having in excess of 60 percent, I virtually know of no place in New Mexico where I've ever seen clay contents higher than 60 percent. I've seen them 60 percent, but I haven't seen them higher than that.

Clays are not common in this state.

The common are those soils that are in the loams, and we're -- mostly soils that are derived out of alluvia. And that means a lot. We are not a loess state. If we go to Iowa, Kansas, Nebraska, Illinois, Indiana, those are loess-deposited soils. Those are silts, those are the breadbasket of America. That's where agriculture was so effective because of the effectiveness of those soils. They're very fine-textured. They're not clay, they're just fine-textured.

We're not that, we're not a loess state. We're an alluvial state. Most of the materials have been transported in this state, and those transported materials aren't highly weathered to the point where clays have formed. This is not Kansas, this is New Mexico.

So we don't have but in the loams, the sandy clay loams, the sandy loams. San Juan County is predominantly in the sandy loams and sands. We have lots of dunes, for example, or soils derived from aeolian -- not loess, but aeolian, sand dunes. That's -- aeolian is a word for soils that have been moved by the wind.

So what Eric is asking me is that -- what kind of soil textures do we expect in New Mexico?

My experience is that throughout the state -- in the southern part of the state we get more into the siltytextured soils, sandy-textured in the western, south, northwestern, mostly sandy soils. Over in Roy County -- or near Roy, Colfax County, and places like that, they're mostly loams, and occasionally of course clay loams, 30, 35 percent clay.

The clays are either in the playas in this state or in river floodplain drainages.

Q. And under the proposed siting regulations would we be locating a pit in those locations?

A. That's my understanding, is that they're limited to -- when they locate sites in the floodplains, they're limited as to how they do that.

Q. And so if we are excavating the soils and we're not in a place with clayey soil to begin with, then you'd anticipate that we wouldn't have clayey soils when we put them back?

A. Sure, if we excavate an area that doesn't have clay to begin with you're certainly not going to create it. So you wind up with what you excavated. And for -- the predominance in San Juan County, for example, would be mostly sandy loam to loam and sandy clay-loam textures. 25, 30 -- well, 25, 20 percent clays. Southern part of the state, just a little bit higher.

Q. In terms of the longitudinal study, I think your last slide has to do with the Dollhopf study one more time --

A. Correct.

Q. -- and this is a graphical presentation of his results. And there's a split on this chart, is there not, between the cover soil and the actual mine spoil?

A. Correct.

Q. Where is that split?

A. The upper three graphs, zero to 23, 23 to 46, and 46 to 70, those are representative of the cover soil.

Below that, 70 to 92, 92 to 115, and 115 to 161 are representations of the spoil. Okay?

Let's walk through this a little. Let's start at the very top. This is what Doug found.

With 20 measurements over 11 years, the salt concentration did not statistically change from the beginning of the study to the end of the study, and that's what that graph is trying to depict. There was no salt accumulated in the upper nine inches, the upper 23 centimeters of this soil.

In the next nine inches, 23 to 46 centimeters, this is the 18- to 27- -- I'm sorry, 9- to 18-inch layer, he found the same thing. There was no statistical change in those salt levels.

In the next layer, this is the -- nine inches above the spoil, initially there was some increase, and it seemed to kind of level out in the mid-years. And then there's a bump, kind of, and it seems to correspond with a bump in the spoil. So what happened?

Here's my interpretation, and I agree with Doug on this that after about six, seven years, or whatever time that is, '84, there was enough weathering of the spoil that now you're starting to release some of those elements that are in the spoil, it's weathering out. And the electrical conductivity would have raised some. That gradient would have changed. And that change in gradient would have moved some of that salt up into that nine inches of contact with that interface, and that's why you see a slight increase.

But for all intents and purposes after that, the spoil didn't change. And for all intents and purposes after that, statistically the cover soil didn't change.

Q. And so once again, this tends to do what, in your opinion, in terms of the likelihood of salt migration in the soil profiles?

A. That the salt migration is limited to that interface, and that salt migration is controlled by gradients, and one of the strong gradients that's going on here is, this is in about a 12-inch precip zone and there's enough water that it just keeps driving that upper 18 inches of -- not allowing those salts to migrate into that upper 18 inches. That's limited to the bottom nine inches.

The reality for me would be that I suspect most of those salts are in the upper four or five inches at that interface. It's just the way Doug sampled that was in that nine inches.

I apologize, I call him Doug like -- Doug and I were graduate students together at Montana State. Dr. Dollhopf.

The -- notice the spoil weathering in time, but those aren't particularly strong gradients, not particularly a great amount of weathering. I have found more weathering than that in New Mexico in the spoil that released.

But what happened -- and I think this is what's happening here -- if we could look at this and, in my case, that the salts actually -- that an amount of that salt migrates down, and there's bulges down below. Doug didn't really show that.

Q. Okay. Now you were here for Dr. Neeper's testimony; is that correct?

A. I was.

Q. And in that testimony do you remember Dr. Neeper presenting a model that he ran using some computer code that came from, I guess, freeware available from the Los Alamos National Lab?

A. I do.

Q. And in that he purported to show in the tight soils salt moving upward, did he not?
A. Correct.
Q. Do you remember that model?
A. I do.
Q. Do you have any comments on that model?
A. Well, one comment would be that the model depicts what happens in a very clayey soil. Those are not common, for one thing.

But what it shows is that in very clayey soils the capillaries are small. You expect higher capillary rise in a clay soil than you would in a sandy soil, for example. That's pretty well accepted. Capillarity is greater in a small capillary than it is in a large capillary.

The -- One of the things I'm concerned about is, that whole model addressed the soils below 20 inches from the surface. If you remember, the upper 20 inches wasn't addressed in salt migration, and I think some of what I've showed -- have shown today, is that in this upper 20 inches or this upper part of the profile at least, there's a driving force of water bringing those -- either bringing salts down or not letting the salts migrate.

In essence, Dr. Neeper's model showed that salts will migrate up. Guess what? He's right, they do. I agree with that.

But how far will they migrate up? Largely has to do with the capillarity, has largely to do with the thickness of that soil, the amount of rainfall. There's a lot of different things going on. And what I'm suggesting is that the model, as I understand it, is unsaturated flow.

And one of the things that we know happens in New Mexico, and it's -- it's hard to document, it's hard to know what happens, we're not out there when it does this rainstorm, but we often get a rainstorm here that's an intensity of two inches per hour, we'll say. Just rains cats and dogs.

Remember very early today when I was trying to depict what happens with a pulse of water. It rains cats and dogs, we get this high amount of water on the soil, we have a soil that has a pretty decent infiltration, the water moves into that soil, and that pulse of water starts moving down. That's a fact, that -- there's no messing around, that's what happens. That water starts moving down. Gravity is pulling that water down.

Anything that's in that water is going to move by conductivity. It's conducting itself down, it's unsaturated flow.

Those pulses can be substantial, they can be significant. And maybe -- I'm just going to talk about something that's theoretical. For a period of time -- and just for argument we'll just say maybe a year, there hasn't been many pulses of water, there hasn't been a lot of rainstorms.

One time at Navajo Mine we recorded three-quarters of an inch in 18 consecutive months, three-quarters of an inch over an 18-month period. Now it didn't rain very much that year. Vegetation was hurting, it was a low precipitation, not much was going on in those soils.

I suspect if there was ever a time -- and the reality is, salts can't migrate under those conditions because the water content is so low. But there wasn't really much flux going on in that soil. But once it rained, once it started raining, it just started moving all of that material down. And the vegetation responded and started coming back, and we get back to our normal six inches per year of precipitation.

Those pulses -- that's so common to the southwest, those pulses bring -- that water brings those soluble products down. That's how I would explain why the soluble salts are below the carbonates in most of the soils in New Mexico, why the carbonates are where they are, and why above those carbonates we distinctly find very low soluble salts in that upper part of that profile.

Q. And so your critique, then, would be that Dr.

Neeper's model, which sort of just introduced soil moisture at a certain level and then followed what happened, isn't really capturing that dynamic of a wetting-front pulse that may come down and --

A. Yeah, that's my -- that's my take, is that I don't think it captured the -- these pulses. And I don't think that the -- I mean, the fact that salts will migrate up, he showed that and that's right, that's what everybody else has been able to show.

As to how high it will go, it really has an accounting to how much it rains and -- But I'll continue to say that it doesn't represent what happens in that upper 20 inches, and that upper 20 inches is an issue with me today, that that stays relatively salt-free.

Q. Now Dr. Buchanan, you said that you had experienced most soil types. Does that include true clay soils as well? No so much here in New Mexico, but elsewhere?

A. True clay in that it's almost entirely clay?

Q. Uh-huh.

A. It doesn't happen in the world. About the highest clay content I've ever seen is in Hawaii, and it was 80 percent.

Q. And in those high-clay soils, under the theory that Dr. Neeper has presented, if there was salt would you expect that salt then to have percolated all the way up to the top of the -- of the clay?

A. No. You got that nod, I guess, didn't you? I'm sorry, I was nodding, and I should have said something.

No, I don't expect -- and where I've seen even clay soils in New Mexico and -- where the clay contents are relatively elevated, it turns out I can't think of ever an instance where I've seen salt migrate to the surface in a normal well-grained clay soil.

I mapped soils in Arizona in a similar precip zone. These soils had as high a clay contents that I've mapped in a long, long time. There was about 45 percent -- consistently across those soils were about 45 percent clay. We took samples, we had to -- we had to develop a criteria for the suitability of growing Christmas trees on these soils, and cottonwoods. So they needed to know the SAR and the electrical conductivity and nutrients and things, besides just knowing what the soils were.

In some 12,000 acres of that area, and as clayey as those soils were, there was not one instance where that -- any -- the salts were -- and there were carbonates in those soils, by the way, and the salts were below the carbonates, much like I've told you earlier, and there were no soils in those carbonates. Those soils were relatively free of low-soluble salts. Soluble salt contents, electrical conductivities of less than 1.

In the carbonate layer, somewhat elevated, 2 or 3, and below the carbonate layer a little more elevated, 5 or 6.

Q. So based on your practical experience, then, even clay soils, they tend to resemble the general processes that you --

A. They generally -- yeah, the -- generally, you know, if you generalize, yeah, generally. The capillarity is a little different.

Q. So in summary, then, based on even after having seen Dr. Neeper's presentation and the model that he's presented, has that changed your conclusion in any way that a four-foot recommendation for a cover soil would be protective for a successful re-vegetation for pit reclamation?

A. No, it doesn't. I still abide by the thesis that four feet of cover is sufficient and that the upper part of that profile remains salt free, and that those salts from the pit contents will not migrate to the surface.

Q. Okay, now --

A. They'll migrate up, but not to -- certainly not to the surface.

Q. Now Dr. Buchanan, on these slides that we've just gone through, which for grouping purposes I'll call 5A, did you prepare these yourself?

A. I did.

Q. And did you prepare them from generally recognized sources?

A. Yeah. Yes, I did.

MR. HISER: Mr. Chairman, we would move the admission of these as Exhibit 5A.

CHAIRMAN FESMIRE: Is there any objection to -- I guess we'll call it Rebuttal Exhibit 5A?

MR. HISER: Yeah, Rebuttal Exhibit 5A.

CHAIRMAN FESMIRE: -- Rebuttal Exhibit 5A?

MS. FOSTER: No objection.

MR. BROOKS: No objection, Mr. Chairman.

MR. JANTZ: No objection.

CHAIRMAN FESMIRE: Okay, seeing no objection, Rebuttal Exhibit 5A will be admitted to the record.

MR. HISER: Mr. Chairman, that concludes our direct and our rebuttal testimony from Dr. Buchanan.

CHAIRMAN FESMIRE: Okay. Ms. Foster, do you have any questions of this witness?

MS. FOSTER: I do not, thank you, sir.

CHAIRMAN FESMIRE: Okay. Since Dr. Neeper's probably going to be the most time-consuming, Mr. Jantz, do you have any questions?

MR. JANTZ: Well, Mr. Chairman, if I could make a suggestion. Since New Mexico Citizens and OGAP's positions are very closely aligned, it may be more efficient to have Mr. Neeper go first, and then I can do mop-up of any as necessary.

CHAIRMAN FESMIRE: Okay. Mr. Brooks, do you anticipate a lot of questions of this witness?

MR. BROOKS: No, I don't, and I would also suggest that Dr. Neeper go ahead of us, because I think it'll be a very short question.

CHAIRMAN FESMIRE: The phrase piggy-back comes to mind.

Dr. Neeper, would you like to -- would you be ready to question this witness?

DR. NEEPER: I have a few questions, other people having deferred to watching me walk into the lions' den first.

CROSS-EXAMINATION

BY DR. NEEPER:

Q. Good afternoon, Dr. Buchanan.

A. Good afternoon.

Q. I have some questions. I'll start first with your rebuttal testimony, just because that's freshest in my mind, and also because I'm really puzzling over just what it is you're rebutting.

If we can start with the first slide, which is on

the screen, this -- am I understanding it correctly? -- shows the effect on the soil, not on plants, of sodium-adsorption ratio as a function of the quality of the irrigation water?
A. It does.
Q. Are you aware of any oilfields or gas fields in New Mexico that are irrigated?
A. I'm not.
Q. So irrigation water isn't a question here, it's rainwater in New Mexico; is that right?
A. That's right.
Q. And rainwater would have an EC probably of less than .5; would that be correct?
A. That would be correct.
Q. So almost universally, then, on this plot a sodium adsorption ratio certainly greater than 5 would be in the range of what we call severe reduction of infiltration; would that be correct?
A. If that were the case, that's right.
Q. In other words, if you're dealing with rainwater, you're into that severe reduction area as soon as you have a significant SAR?
A. That's right.
Q. Thank you.
A subsequent slide, I think down two from this,

showed tolerant forages with a yellow highlight. Now you have discussed both the forages and the brushy plants in terms of remediation of damaged lands, which is your business, I understand?

A. That is correct, your -- that's correct.

Q. Your main -- I have to state it as a question, but that is the context for the question.

So you would regard, then, these plants that you have outlined in yellow as forages that are suitable for remediation purposes?

A. That's correct.

Q. Are you aware that the Roswell BLM district requires re-seeding the sideoats grama, Lehman's lovegrass or Boer lovegrass, which do not appear on your list?

A. No, they don't appear on the list.

Q. And would the lovegrass be classified as one of these highly salt-tolerant plants, or would it be very low in its salt tolerance?

A. Which lovegrass is it?

Q. I'm not a plant pathologist. They list two, Lehman's lovegrass, or Boer lovegrass. I can give you the Latin names, but I may not be able to pronounce them.

A. Lehman's -- Lehman lovegrass is used extensively in Arizona. It's a non-native, it's an introduced specie, and I tried to concentrate on natives. But Lehman lovegrass does quite well in the re-vegetation of tailing material in copper mines in Arizona, and quite often those materials can be elevated salts.

So although I don't know the limits of Lehman lovegrass, I know that it does well on relatively high-salt-content tailing material in Arizona.

What was the other one?

Q. There's a Boer lovegrass.

A. I'm not familiar with that.

Q. And the sideoats grama.

A. Sideoats grama is in this family of gramas, blue grama, black grama, sideoats. They -- although they're not on that list, they are in this family of highly salt-tolerant grasses. We see the grama grasses growing and are used all the time in the mining industry, and although they weren't on this Montana list, I know them to be salt-tolerant.

Q. Salt tolerant in the sense -- can you give them, say, an EC value for the threshold of damage?

A. Something above 8.

Q. Something above 8. So you find them suitable for use in this case?

A. Correct.

Q. You have listed on the next slide salt-tolerant shrubs and stated these can be used in germination.

A. Used in what?

Q. Excuse me, in reclamation.

I am understanding, then, is it correct, that they will be -- will grow well, even if the total depth of soil that they could use would be three feet or less?

A. I'm wondering what I said -- I'm wondering what I said that led you to make that statement.

Q. Well, I can restate the question --

A. Yeah, why don't you restate the question?

Q. -- more clearly.

You have said that it would be recommended to use four feet of cover soil, and that it certainly could be possible to get a significant salt movement, perhaps, into the first foot but not above that.

So in my mind I was treating as a hypothetical case that the top three feet might not be salt-impacted --

A. Correct.

Q. -- or strongly salt-impacted?

A. Right.

Q. And you have also said that when plant roots get into a very highly salty situation they will simply just not go further, they will -- the plant will look elsewhere for its water.

So I was saying, is then, say, three feet of relatively unimpacted soil sufficient for the brushy-type plants, shrub-type plants?

A. Not only is three feet sufficient, there's -- I didn't bring this out, but there's numerous, numerous examples of the four-wing saltbrush growing directly in the spoil, there's no cover soil. Rabbit brush grows directly in the spoil, there's no cover soil.

Those two species, shadscale included -- those species are so salt-tolerant that they're not limited by the spoil material. So your idea that -- will they grow in the upper three feet? Yes. Will they grow in the next foot? Yes. Will they grow in the spoil? Yes.

And they -- if these materials, whether they're drilling fluids or whether they're spoil materials, have electrical conductivities less than something in the vicinity of 16 -- 16, more or less, is about 1 percent, about 10,000 parts per -- or, I'm sorry, I lost the number. 1-percent salt solutions -- or 1-percent in the salt, these plants are not limited. So they'll grow in soil, they'll grow in three feet of soil, and they'll grow where there's no soil --

Q. You have said --

A. -- no cover soil.

Q. -- clearly they will grow in the spoil. But what is your chloride concentration in the spoil?

A. I don't have those numbers at my fingertips, Dr.

Neeper, as to what --

Q. One of the examples you cited started with an EC not of 16 or 30, but 160 in the pit-type -- in the simulated --

A. That's in -- that was a case in Texas, correct.

Q. Yes. Would that not also be the case in New Mexico where saltwater is used for drilling?

A. Could be.

Q. Would the roots of piñon and juniper naturally penetrate or be established at the depths of a pit?

A. What would be the electrical conductivity?

Q. Well, the electrical conductivity, I would guess, in the pit material, and from what you've shown here, would -- far exceeds the 30s and be more like in 100.

A. So are you ask- -- is the question, would something like piñon and juniper grow in material that had electrical conductivities of excess of 100?

Q. I'll rephrase the question. Would the natural root depth of piñon and juniper, piñon or juniper, take it into the pit region? Would piñon and juniper --

A. Dr. Neeper --

Q. -- naturally want to establish roots in --

A. -- you don't need to go any further. You're going to have to put some depths and parameters on this. We're not going to talk in generalities, so --

Q. Very good, the top of the pit is at four feet, the bottom of the pit is at 10 feet. If I were digging in a native situation, would I likely find piñon roots or juniper roots at depths of between 4 and 10 feet?

A. It's possible.

Q. So would piñon and juniper be so salt-tolerant that they could, then, grow with their roots going through a closed pit that would have a very high salt content, something that would --

A. What's a very high salt content?

Q. Very high ECs, much greater than 30.

A. Not likely.

Q. In the slide that shows different colors -- I think it's the next slide, thank you -- these diagrams show the progression of electrical conductivity upward, given a situation in which there was about 20 inches of rain per year. Do I understand you correctly there?

A. You do.

Q. And you have said that what goes on at least in the top of this soil is that water infiltrates, the saturated flow goes for some short distance, gradually peters out and is returned by plants or evaporation to the surface. And that action washes any salt that got up there back down.

So there is -- do I understand it correctly? --

essentially a contest of salt trying to go up, but it keeps getting washed down as long as there ever is rainfall?

A. That's somewhat descriptive of what goes on, yes.

Q. All right. Would that in any be at variance with anything you found in my testimony?

A. I don't believe -- I think the variance would be -- I don't believe your testimony addressed the upper part of that profile.

Q. Very well. But you maintain that if there is rainfall, then the salts should get washed down?

A. Correct.

Q. At least away from the top foot or two of surface land?

A. Or more --

Q. Or more.

A. -- for -- right.

Q. Can you explain, then, why I found high salts at the surface, and then below, in a pit that had been closed -- at a pit site that had been closed 31 years ago, what's going on that that salt couldn't get washed back down?

A. You understand, I didn't visit the site, right?

Q. I understand --

A. -- you're giving me --

Q. -- my description --

A. -- a sketch of --

Q. -- photographs --

A. -- what's -- of what the situation is. So what you're asking me is, Can you explain why there would be salts at the surface?

And so I guess I would beg the Commission's indulgence that I'm going to say some things to explain, as best I can, with as little information as I have, but one possibility is --

CHAIRMAN FESMIRE: Doctor, you're allowed to give your opinion. I mean --

THE WITNESS: Okay.

CHAIRMAN FESMIRE: -- you can --

Q. (By Dr. Neeper) And I can supply a photograph, if that's --

A. I don't think a photograph is going to help.

You said 31 years ago. Thirty-one years ago, it's entirely possible that the materials weren't even buried, that the materials that were resulting from the drilling operation were left at the surface. That's a possibility. And if that was the case, then those materials would be at the surface.

And you want to make an issue of this SAR/EC that it has to do with rainwater.

Once that rainwater comes into that soil, that concentration of that rainwater changes. You're of a mind to think that what happens is only with rainwater. That rainwater comes down, it is incorporated into the soil, and the salinity could change dramatically within millimeters.

A possibility is that that surface was compacted in the process of the closure of that pit. Compaction is an enemy to reclamation. Compaction can change the whole infiltration-permeability phenomenon that goes on in soils.

If that soil were compacted, if the water -- the conditions were such that that surface was dispersed -- the clays, I'm sorry, the clays were dispersed, early on, you now have a situation where water is not really able to get into the soil, and for some time it's not going to be able to get into the soil. It's compacted, to add insult to injury here, and entirely possible that the salts that were at the surface and didn't migrate to the surface, they started out at the surface.

My experience has been that when those conditions persist, quite often water will not infiltrate, there's no mechanism to flush those salts down, and we create a situation that we sometimes call a playa or a sealed-off area. It happens in nature. It's not common, but it happens in nature.

And my explanation, Dr. Neeper, in a sentence would be, the salts were probably there to begin with, they were probably compacted, the clays are probably dispersed, and I highly doubt that those salts got there from migrating up. I think they probably started there.

Q. I would hypothetically agree, they might have started there. The thrust of the question was why they hadn't washed downward?

A. Because the water isn't infiltrating into those soils because they're sealed, is a possibility. Between the dispersion and compaction, those are possibilities.

Q. You have stated in the written materials and also in your testimony that you felt diffusion was the dominant mechanism for moving the salts.

A. What I stated was that diffusion accounts for the movement of salt from an interface where a salt content is high and where it migrates upward.

Dr. Neeper, I don't want you to mislead me or the Commission, that I would say that salts primarily move by diffusion. Anytime salts are moving down with water, it's largely due to convection.

Q. And the same would be true potentially upward, but do I understand it correctly, they get washed back down? They may diffuse upward or --

A. Yeah, they --

Q. -- they could be advected upward, but only temporarily, because if rain comes they will get pushed back down --

A. Correct.

Q. -- in your understanding?

I'll move on, then, to your direct testimony.

You have made it very clear that you do not expect salts to migrate upward. Would the migration occur, however, in the absence of plants? If for any reason a site did not become re-vegetated, or vegetation not survive, would the migration -- upward migration --

A. I'm sorry, Doctor Neeper, your statement started out, you said, You've made it clear, Dr. Buchanan, that salts will not migrate upward.

Q. I'll correct that.

A. Please.

Q. I'll restate the question. In the absence of vegetation --

CHAIRMAN FESMIRE: Who needs attorneys?

(Laughter)

THE WITNESS: What?

CHAIRMAN FESMIRE: Nothing. Coaching here.

DR. NEEPER: I don't have a coach.

Q. (By Dr. Neeper) In the absence of vegetation, would the salts tend to migrate upward?

A. Yeah.

Q. So vegetation is the real key to keeping the site safe for the indefinite future; is that correct?

A. Whoa, you just opened up a big can of worms. What you said was, Does vegetation maintain the site? Is that -- is that about what you're trying to say? What are you trying --

Q. I'll try to say the question again, because --

A. Yeah, why don't you?

Q. -- it's not a trick question.

A. Because this is -- this is one load question.

Q. Yeah. What I'm -- I will state first hypothetically what I understand by making a statement, but it's to give you a context, and that is that the plants naturally recycle much of the moisture that would arrive in the soil. Without the plants, the moisture can penetrate farther. Would it be reasonable --

A. That -- let's stop -- let's stop there.

Q. All right.

A. Don't go any further.

Q. Don't go farther.

A. What Dr. Neeper just said is correct. If you don't say any more, what you just said is correct, that if you take plants off of a site, plants are largely responsible for the removal of water out of a soil profile.

Okay, now let's go on.

Q. If for any reason, let us hypothesize, we fail to re-vegetate a site, or the vegetation on the site failed for some reason, then in the future would that give any cause for buried salts to come toward the surface? Would that increase the upward gradient?

A. Okay, that's -- that's where we're getting ourselves into trouble here.

You said for any reason that vegetation doesn't grow there. Well, it isn't for any reason, it is for some reason. And one of the some reasons is because water is not getting into that profile. If water is not getting into that profile and the vegetation is not growing, then you don't have water to accommodate this whole process of salt cedar moving up or down.

Okay. Do you see what's happening here is, we're creating a situation that we really don't want to create? We don't want to create a situation, do we, Dr. Neeper, that has no vegetation? We want vegetation out there.

So you're saying, Dr. Buchanan, if there's no vegetation, what's going to happen?

This is going to unravel, that's what's going to happen. This site now doesn't have sustainable vegetation, and we're in deep trouble, and this site is going to experience erosion, it's going to experience things that we can't hardly even imagine, that water may go in, water may not go in. And you're asking me some specific thing that will happen in this whole host of conditions that you and I both agree we don't want to see happen.

So let me answer your question this way.

If for some reason there is no vegetation, and if for some reason water were to get into the soil profile, I contend, as long as water can come into that profile, regardless of the vegetation, water can move down, that water will keep those salts moving down.

And there may be some migration at the interface, but even without the vegetation -- and don't mislead us here that now I've got water coming into a site and I don't have vegetation. You know, we're trying to set these parameters. That my contention is, as long as you can move water through that profile, those salts will move from the upper part of that profile.

Did that even come close?

Q. That's what I wanted to know, it was like a yes or no --

(Laughter)

Q. -- and you said yes.

(Laughter)

A. It will --

Q. Well, moving it down, it will not accent upward movement, even if the vegetation is reduced.

A. All right --

Q. It's a situation we really --

A. -- I'll try --
Q. -- we don't want --
A. -- to get -- I'll try to get more yes and no in the future.
Q. Well, it's not required that you answer yes or no. We agree it's a situation we don't want. I just happen to have been on some sites that we didn't want.
A. That's right. Glad we agreed.
Q. In any of your reclamation experience, including the measurements shown here, do you have experience with the salt concentrations that we find in drilling pits, normally chloride, say, of 100,000 milligrams per kilogram of dry soil or more?
A. Chlorides of 100,000?
Q. Yes, sir.
A. No.
Q. Thank you.
What would be -- You have mentioned acidity and that some plants could live with acidity. What would be the impact of highly alkaline soil of, let us say for example, pH of 11?
A. What would be the impact?
Q. Yeah --
A. In general --
Q. -- on the plants? Can plants survive -- I'll

just tell you, I don't know the answer, I'm asking the question --

A. Okay --

Q. -- I don't --

A. -- right.

Q. -- know the answer.

A. Well, in general most plants don't handle pH's of 11. There are exceptions. None come to mind right now, but there are plants that tolerate extreme alkalinity, as there are plants that tolerate extreme acidity.

But Dr. Neeper, I can't think of an example in my experience where I've seen plants grow much above 9.5. I've seen them at 9.5, but that's about as -- that's about the extent. And you have to have an extreme condition to get those kinds of pH's. Those -- those are -- to get that high of a pH. That's not common. So that would -- to me, would be the very extreme of soils.

Q. Are you aware that the pH's in the pits that were sampled were often in the range of 9.5 to 11?

A. No.

Q. Many of the examples you showed were for roughly four to 11 years of measurement, and in some of those there appeared to be some increase. If you go to the very last slide of the rebuttal section -- Can you still get there?

MR. NEWMAN: He said he was done.

DR. NEEPER: Well, I thought I was.

THE WITNESS: Might be in a different file.

DR. NEEPER: Sorry.

MR. NEWMAN: Which one?

THE WITNESS: Keep going down, further down. No, it's one more, couple more. Yeah, right there.

Q. (By Dr. Neeper) That one. If I were to look at the bottom three curves in that, I would say very roughly they're all increasing. You might --

A. You understand that's spoil, don't you?

Q. Yes --

A. Okay.

Q. -- I understand it's spoil. But they're indicating movement.

And then we see also the third from the top sort of increasing, and this is on an 11-year basis.

Do I really have an assurance that if I carry that out for 100 years I'm not going to continue to see those curves climb?

A. Dr. Neeper, Dr. Dollhopf stated that in the last few years in that lower profile that you're talking about of the cover soil, there was no statistical difference, there was no change.

You said there appears to be an increase.

There appears to be an increase, but

statistically there is not an increase. Okay? So let's establish that.

So you're making a statement that there appears to be an increase, and would that increase continue? First off, there wasn't an increase, there's no statistical increase.

Would I expect that to increase? No, I wouldn't. Until those gradients -- once those gradients are somewhat satisfied, then there's no reason to -- for the salts to migrate, the gradient is established.

So the -- You're back to this mechanism. And I guess I would refer -- and I think this is an interesting question, and I think Dr. Neeper's on a line that should be pursued and that is, What happens in the future?

And Dr. Neeper, the way I'd address this is, let's not forget what happens in nature, let's not forget what happens in natural soils, that over hundreds of years, if not thousands of years of weathering, the salts do not come to the surface. Even in natrargids that are highly sodium-affected soils, those surfaces are relatively free of soluble salts. The mechanism is for the salts to move down. That's why -- that happens because it rains.

So your question is, do I expect that to continue to increase? First off, it's not increasing. And secondly, no, I do not expect it to change substantially over time. That's my answer.

Q. I'll revisit that, just to be clear that I understand you. On the third line down, the last four points jiggle up and down, and you're saying -- that's the area where you're saying there's not a statistical increase there?

A. Correct.

Q. Thank you.

You did just say that you thought looking at the long-term future was a good idea. Would you recommend that at least some of the pits be monitored if burial goes ahead for the next 20 years or some period of time?

A. Dr. Neeper, you're asking a businessman that has a consulting service that does that very thing, and you're asking me --

(Laughter)

A. -- would I be interested in that? Oh, yeah, I'd be interested in that.

(Laughter)

CHAIRMAN FESMIRE: That's kind of like asking lawyers to set the schedule for the hearing.

(Laughter)

THE WITNESS: Dr. Neeper, even if I were completely retired and I wasn't -- I would recommend that, I think that's a reasonable request.

DR. NEEPER: No further questions.

CHAIRMAN FESMIRE: Mr. Brooks, do you have any questions of this witness?

MR. BROOKS: Could we take a break first?

(Laughter)

MR. BROOKS: Give me a chance to confer with my client and see if he has questions he wants me to ask.

CHAIRMAN FESMIRE: Okay, why don't we take a little over a 10-minute break and reconvene at 20 minutes to 4:00?

(Thereupon, a recess was taken at 3:27 p.m.)

(The following proceedings had at 3:47 p.m.)

CHAIRMAN FESMIRE: Let's go back on the record.

Let the record reflect that this is Case Number 14,015, that all three Commissioners are present, that prior to the break we were to begin Mr. Brooks' cross-examination of Dr. Buchanan.

Mr. Brooks, are you ready to proceed?

MR. BROOKS: Yes, and I'm going to be very brief, Mr. Chairman. I mean it this time.

CHAIRMAN FESMIRE: Heard that before, Mr. Brooks.

CROSS-EXAMINATION

BY MR. BROOKS:

Q. The thrust of your testimony -- Well, good afternoon, Dr. Buchanan.

A. Good afternoon.

Q. Let's see -- I have to say that even though I'm going to be very brief.

As I understand the thrust of your testimony is that salts in buried waste will not move up -- will not move up beyond the first 12 to 18 inches above the top of the waste?

A. Something like that, that's right.

Q. Have any of your studies involved situations where the waste was buried in a lined pit which was lined at the bottom and around the sides but was not lined -- I'm talking about being lined with an impermeable liner that -- a membrane liner, as opposed to a soil liner -- which was lined on the bottom and around the sides, but without a membrane liner over the top?

A. No.

Q. Very good. Now the salts that don't move up, as the wetting front comes down are they going to tend to move down with the rain?

A. Would you repeat that?

Q. Well, the precipitation -- you know, you had this model of the precipitation where the wetting front moved down, you had the wet zone, and then the next slide it was further down, the next slide it was further down.

Are the salts from the waste material, if there's not a liner below it, are they going to tend to move down?

Yeah, you've got the slide up on there.

A. If I understand what you're asking me, you're asking me will I testify as to the movement of salt below a drilling mud and what will happen below that drilling mud --

Q. Yeah, in the --

A. -- in an unlined pit?

Q. -- absence of a liner or --

A. In an unlined pit, is that what you're asking me?

Q. In effect, yes.

A. And what is -- Is the question, Will the salts move down?

Q. Will they tend to move down?

A. They will tend to move down.

MR. BROOKS: I believe that's all the questions I'm going to ask you, Mr. -- Dr. Buchanan. Pass the witness.

CHAIRMAN FESMIRE: Mr. Jantz?

MR. JANTZ: I have a few questions, Mr. Chairman.

CROSS-EXAMINATION

BY MR. JANTZ:

Q. Good afternoon, Dr. Buchanan.

A. Good afternoon.

Q. My name is Eric Jantz. I represent the Oil and

Gas Accountability Project. I actually have a very few questions myself.

When you analyzed the chloride -- the way chloride moves through soils, did you analyze any other pollutants besides chlorides?

A. I don't want the Commission to be misled here. Mr. Jantz asked me as I monitored chlorides. I have monitored electrical conductivity most of my career, which are soluble salts. I've -- can't think of many instances where I've ever isolated out the movement of chloride.

So your question is, as I've monitored chloride.

I haven't monitored chloride, I've mostly monitored soluble salts --

Q. Okay.

A. -- and that's a collection of salts that are soluble in water.

And then you said, have I monitored any other pollutants? Yes.

Q. And what pollutants were those?

A. Selenium.

Q. Selenium. Did you -- have you presented any of those results here?

A. No.

Q. Okay. I had a question about Rebuttal Exhibit 5A slide 5, which was just up on the screen -- or, I'm sorry, the previous one. That one, yes, thank you.

When you were initially talking about this on rebuttal, it sounded like, to me -- and please correct me if I misunderstood this -- that the increase, the little bump there in 1984 --

A. Which graph?

Q. This is the third from the bottom.

A. Correct.

Q. -- that you talked about that being -- representing weathering of the mine spoils; is that right?

A. Could be.

Q. Could be, that was your --

A. It could be -- it could be an explanation for that bump.

Q. That was your postulate?

A. That's right.

Q. Okay. Would weathering continue throughout the life of the mine spoils?

A. Yeah.

Q. Okay.

A. Yeah.

Q. And finally, your reclamation assumes -- reclamation via re-vegetation with native -- native plants or salt-resistant plants, or salt-tolerant plants, I should say --

A. Right.

Q. -- that assumes no subsequent disturbance, or little subsequent surface disturbance; is that right?

A. I'm not actually sure what you mean by subsequent disturbance, but it's -- not revisited? Is that what you're suggesting? I mean, disturbance could be visited by animals, the pocket gophers, prairie dogs --

Q. Sure.

A. -- those kinds of things, but --

Q. In terms of -- Well, for example, you don't want -- you don't -- you're assuming that it won't be revisited by an activity that would cause compaction; is that right?

A. That's -- Yeah, in general, in reclamation, once it's reclaimed and successfully reclaimed, you often don't expect that to be revisited by something that would substantially cause compaction, that's --

Q. Okay --

A. -- right.

Q. -- and would you also not expect a revisitation by significant surface disturbance like digging, for example -- and not pocket gophers -- for example, with a backhoe?

A. Other than -- I'm sorry for laughing. I -- and I need to explain to the committee. I've gone back and dug up some of these pits, and it's pretty substantial. I've done it with a trackhoe and a backhoe, and it makes a mess out of things.

But in answer -- I think what you're trying to ask, and in answer to your question, no, I would not expect much disturbance after reclamation by humans digging.

MR. JANTZ: Okay, thank you. That's all I have.

CHAIRMAN FESMIRE: Commissioner Bailey?

EXAMINATION

BY COMMISSIONER BAILEY:

Q. While we're here, let's look at this one.

The fourth graph down, there's a bump between F84 and F85 or -6, which shows that -- that's about four feet, right? 70 to 92 centimeters?

A. Seventy centimeters is going to be 27 inches, more or less, and then another 20 centimeters is going to be less than 10 inches. So 27 to about 36 inches, I guess.

Q. Okay --

A. If somebody's got a --

Q. -- so let's call it about three feet then.

A. Okay, let's call it three feet.

Q. And that bump is due to spoil weathering --

A. Correct.

Q. -- from downward percolation of rainwaters?

A. Correct.

Q. Then that infiltration rate which shows up in less than nine years is much greater than the 2.5 millimeters per year that Dr. Stephens talks about?

A. Correct, because we're in the upper -- if you will -- I was going to use a word -- Let me use the word, and then let me define it. We're in the upper solum. We're in the upper part of the soil profile and it's called the s-o-l-u-m. And it's that portion of the profile that is biologically active where water is moving in and plants are growing, and that's much more dynamic. And water goes in and plants take it out and sun evaporates it. We're in that upper three or four feet of that soil profile that's very biologically dynamic.

Q. Can we assume that there's some kind of vegetation on the surface?

A. Of this site?

Q. Of this site, within nine years of --

A. Yes --

Q. -- building it?

A. -- there was vegetation after the second year on this site.

Q. So within nine years we have three feet of percolation, rather than an infiltration rate of only 2.5 millimeters?

A. Yes, the infiltration here would be much higher than two and -- 2.5 millimeters per year.

Q. Okay, let's go to the previous slide. Where is the Mertz study area?

A. Where is this --

Q. Where is this located?

A. Somewhere in Texas.

Q. Somewhere in Texas.

A. I think the student was at Texas A&M, and I think the study was done closer to the Louisiana border.

Q. So what is the annual rainfall?

A. About -- it varies -- he gives the precipitation for the two years of the study, he did his dissertation. The average was around 500 millimeters, 50 -- that's 50 centimeters, about 20 inches.

Q. About twice what it is in some parts of the San Juan Basin?

A. About twice.

Q. Okay.

A. That's right.

Q. So there didn't need to be any irrigation connected with this, this was all --

A. Yeah, it did pretty well on its own.

Q. Okay, which brings up the fact of irrigation as a factor. The mine reclamation that you're familiar with up in the San Juan Basin, does that vegetation start with irrigation, and is there irrigation used to maintain a vegetative cover until bond release?

A. No -- well, yes and no. At Navajo Mine they initiate the reclamation with irrigation, and they irrigate the first year and sometimes the second year, and then they don't ever irrigate again. The bond release is in the first -- after 10 years, and so you're not -- they don't irrigate in -- to sustain that vegetation.

At San Juan Mine they irrigate, and they irrigate typically now one year. There are instances where they've irrigated two years, but there's really no incident where they've ever irrigated more than that.

At La Plata Mine where there's 12 inches of precipitation -- and I guess for the sake of the committee, the -- the precipitation at Navajo Mine is around 6 to 7 inches, at San Juan Mine it's 7 to 9 inches, and at Navajo Mine it's -- I mean, at La Plata Mine it is 12 inches, and they do not irrigate and have never irrigated there.

Q. But for those smaller rainfall amounts, they have to irrigate in order to get the vegetation to at least sprout and develop that first year or two?

A. That's what -- that's what they're trying to get it to do, is to get a jumpstart on the early establishment, that's right.

Q. How high is the EC for that irrigation water? Is it Cretaceous water or --

A. No, it's taken -- that water is taken out of the San Juan River and in some instances directly stored just as San Juan River water -- in other words, it's not concentrated -- and then that water is directly applied.

And I don't -- I can tell you that it has a fairly high salt content, but I don't know the salt content for the San Juan River and for those waters that they're irrigating with, but they're somewhat elevated.

Q. Okay, which helps with the SAR potential problems?

A. It does.

Q. You've spoken of the term mine spoil, you've written of the term mine spoil. Would it be helpful for you to explain to the group here what mine spoil actually is?

A. It would be. I'm sorry for hesitating, I was about to go to the board over there. If I do that --

Q. Old habits.

A. -- we'll be here all afternoon.

The mining that's done in the Four Corners region, in Wyoming, Colorado, Montana, we call it strip-mining. If you've never been around a strip mine, this is so foreign. If you've been around one, it's very elementary.

They make a first cut. The outcrop may be at the surface -- "the outcrop" meaning the coal has come to the surface. That's of -- really of no value. The coal needs to be buried about 20 or 40 feet before it's of any value.

They remove that first cut of material that is sitting on top of the coal, and it's taken off, and that's called the box cut. And that material is laid out on the surface, and now there's a hole.

They remove the coal.

This material is sitting -- the box-cut material is sitting there -- now keep in mind, this box-cut material is highly weathered, compared to what's going to happen in the future.

And now we're going to proceed in this direction and create a deeper hole because the coal is laid on a strike, and this material over the coal now is going to be moved over and put in that previous hole. And that's called spoil.

Originally, everything was spoil. They just went out and draglined everything from the coal to the surface.

In more recent years, they remove the cover -- they remove the soil. We call it topsoil or cover soil. It's stockpiled somewhere, and now the dragline starts from that level and goes down to the coal, fills the hole, coal is removed, move over, and the process continues. And it looks like a bunch of -- if you're in an airplane or fly over, it looks like a bunch of furrow. And these furrows are anywhere from 50 to 75 feet high, and it's called spoil.

It's that overburden, it's that material that sits over the top of the coal. And in New Mexico that coal is in seams. And there might be five or six feet of coal, or 12 feet of coal or -- fortunately, it might be 20 feet of coal.

And so you take the spoil, get the coal, take the inner seam and spoil that, get the coal, take the inner seam, spoil that, and then take the next layer of coal.

Those materials are largely ocean -- shallow-sea deposits. They're marine shales, siltstones and claystones and sandstones. They're a mixed bag of tricks. They have high salts in some instances and low salts in others. But it's the overburden, and once it's in place it's overburden, and once it's moved it's called spoil. And then this topsoil that we stored previously is placed back on top, and now it's been reclaimed.

Is that helpful?

Q. Yes, but it's telling me that it's the same material as can be found in a pit once the -- a drilling pit area, a deep-trench area, when the topsoil is removed, because they're all cretaceous materials. Mine spoil means the coal is removed.

A. That's more or less right, Commissioner Bailey, that the -- for the economics of coal mining in New Mexico, about 180 to 200 feet of those marine shales are removed. They're of the Fruitland formation, so if in the drilling...

Now the depth here isn't such an issue, because the coal out at the mine is 180 feet below the surface. In Farmington, New Mexico, it's 4000 feet below the surface. So that coal is dipping. So that coal is intermingled with the Fruitland and Kirtland formations.

If in this process of drilling you drill through the Fruitland formation, that formation is very similar -- very similar, to the Fruitland formation out at the mine.

Q. And so the issues you've talked about for mine reclamation are very appropriate for drilling pit reclamation in the northwest?

A. I'd agree with that.

Q. Okay. You've talked about the visible layer of calcium carbonate that's in the soil layer.

A. Yes.

Q. The sodium or chlorides would not be visible as any kind of layer except as an impact on the vegetation; is that right?

A. Sodium chloride is difficult to see in the soil, sodium chloride. Sodium sulfate is very easy to see, sodium -- calcium sulfate is very easy to see, calcium carbonate is very easy to see. The chlorides are somewhat unique in that, in that the minerals are not easily seen, and -- I'm sorry for going off on that. Why don't -- I'll just say, you're right, the chlorides are difficult to see.

Q. A previous rule that we put together for landfills and landfarms, for the re-vegetation, talked about establishment of a vegetative cover equal to 70 percent of the native perennial vegetative cover, consisting of at least three native plant species, including at least one grass, but not including noxious weeds, and maintenance of that cover through two successive growing seasons.

Is that a reasonable requirement for closure of different scenarios that have been discussed for this proposed rule?

A. It's reasonable. There are other industries that are more strict than that. There might be some less strict. But 70 percent is reasonable, and the idea of incorporating natives is -- I'm very supportive of that. And I'm supportive of -- that there's not weeds, or noxious weeds supported on that, to fill in that vegetation. So...

Q. Is 70 percent reasonable within two consecutive growing seasons?

A. Oh, yeah, that's relative- -- should be relatively easily obtained. If you're not obtaining that, then this site is not effectively reclaimed or will sustain -- it's not likely it will sustain itself.

Now that's two years consecutive after some period of time, right?

Q. After six months of closure or release of the drilling rig --

A. Oh.

Q. -- so it would be immediately upon --

A. Oh.

Q. -- closure of that location?

A. No, that's not reasonable. My experience in reclamation is, you have to have a lot of patience, and that -- I've seen sites that have been released after 12 or 15 years, they're effectively sustainable vegetation that look like the moon after two years. And it took a while for that vegetation to become established.

There are sites and there are areas that the precipitation is low enough that -- you keep pushing this, I'm going to go over to that board, but let me -- let me do it this way.

We've done some studies on the precipitation and the San Juan Basin, and it's not too dissimilar -- I've done some work in the -- southern New Mexico. But let me address, just for the sake of argument here, that in a 10-year period there are three years, on the average over the last 75 years, where the precipitation is in three years higher than the normal precipitation.

Now we don't want to address normal precipitation because nobody knows what that is. But if you just take these numbers and average them, we get a line. Three years out of 10 it will be above the line, and seven years out of 10 it will be below the line.

Seven years out of 10 we don't have an average precipitation, and we have difficulty re-vegetating these areas.

If an attempt is made to re-vegetate during one of the dry years, you can expect failure. If you attempt reclamation during one of the wet years, we hope and expect success.

But what I have found is that it doesn't really have anything to do with the annual precipitation. It has everything to do with the seasonal precipitation. That -- our reclamation, even though it's a normal or dry year, if we have high precipitation during a season and we reclaim during that time, we can expect success. We can seed an area, we don't get success, we go through several seasons, if you will, and then mag- -- well, I shouldn't say magically, but explainably, then, the site successfully reclaims itself, and it will be something well after six months after it was reclaimed.

So if it hasn't met -- so what I want to say is, if it hasn't met the reclamation standard after six months or even a year after it's been reclaimed, my comment would be, I think we need to be a little patient. I wouldn't jump to go back and reclaim that right away, because I have too much experience of where it was successful a couple years later once we got into some seasonal precipitation that was enough to start the vegetation.

So my answer was no, I don't think that's reasonable in that sense. I think it's reasonable that that's what we expect down the road. And we get four or five years out -- and I'm not kidding here -- if we haven't got it by four years, then my experience has shown, then you get the seeder back out and you re-seed this site.

Is that helpful?

Q. Very much so.

A. Good.

Q. Would you expect that within the first two years of closure of the pit, that mulching would be helpful?

A. Yes. Generally speaking, and there's very -- very much -- very often there's no exception to this, mulching is a benefit to reclamation.

You have to be careful with it, because you're introducing a foreign product, and that foreign product can introduce weeds and non-natives. But more importantly, it elevates the carbon level in the soil, and now we get a carbon-nitrogen ratio that's out of sequence, and we get a nitrogen drain for the micro-organisms, and mulching can actually keep us from successful reclamation, without supplementing with nitrogen to maintain those carbon-nitrogen ratios.

Q. So mulch is used and fertilizer should also be used?

A. You will hardly ever get me to support fertilizers. The studies generally show that fertilizer, all it does is introduce weeds. But there are amendments that can be used, and there is the exception that when you put a high-cellulose mulch -- straw is a good example -- then you have to supplement it with nitrogen. You just have to do that. And it does run a risk with introducing weeds, but it's the thing to do.

But to just generally out there and fertilize to get greenery is a mistake in my experience.

Q. Your Exhibit 7 [*sic*], page 14, which is your salt-migration statement --

A. Okay.

Q. -- about in the middle of the page it talks about -- it postulates reasons why re-vegetation fails on drilling pits. Number 2 on the list says that plant growth material originally containing a high salt content, and then material being compacted, would be the culprits for lack of re-vegetation, which brings up the issue of compaction, which you've mentioned before.

Under the closed-loop system, where there are tanks spread out, where there is a drying pad, where there are ample opportunities for compaction of the soils, would you say that ripping of the soils is a necessary as recontouring or any other effort being made for re-vegetation, particularly for closed-loop system drilling?

A. Commissioner Bailey, if I had a flag right now I'd raise it and wave it. I am so big on removing compaction that it's not as important, it's the probably most important -- If you talk to any reclamationist in the United States, they will tell you the most important thing is seed bed prep, and that's what I'll say and that's what most people will say, that the preparation of that seed bed is so critical that it almost circumvents every other activity we do in reclamation. And if we don't do that seed bed prep correctly, we often are just setting ourselves up for failure.

I'm for doing whatever it takes, whether it's disking, ripping, shanking, dynamiting -- oh, I'm not -- I'll fish with dynamite, but I don't use dynamite in reclamation.

CHAIRMAN FESMIRE: You realize that the Game and Fish Department is a sister agency?

(Laughter)

THE WITNESS: Oh, yeah.

MR. PRICE: You can get a permit.

THE WITNESS: The -- Yeah, I have a permit to fish with dynamite. No, I do not, I -- you know I'm teasing. I don't know that -- I've never seen anybody use dynamite in reclamation. They do it to plant orange trees in California.

But ripping, shanking, anything we can do to remove that compaction is ever so critical to the success of reclamation.

Q. The next page on this same exhibit, page 15 of Exhibit 7 [*sic*], conclusion number 2 says, The data show that if soluble salts are maintained at or above a threshold electrolyte concentration value for a specific material, the physical condition of the material will be maintained in a flocculated state no matter how high the sodium adsorption ratio.

Are we going back to the clays being flocculated rather than dispersed?

A. Correct.

Q. Okay.

A. That's correct.

Q. I just wasn't sure how to interpret to that sentence.

A. Yeah, that's what we're trying to do, is maintain that flocculated aggregate.

COMMISSIONER BAILEY: That's all I have.

CHAIRMAN FESMIRE: Commissioner Olson?

EXAMINATION

BY COMMISSIONER OLSON:

Q. Yeah, Dr. Buchanan, I guess I'll follow up a little bit on what Commissioner Bailey was talking about in terms of mining applications. I think you made kind of a generic statement that four feet of cover is standard in mining applications, but I guess you're saying now it's just standard in coal-mining applications. Is it standard in other mining applications as well?

A. No. The -- We're doing some research at the Chevron Mining Company in Questa, formerly Molycorp. We'll install a study this year to look at the suitability of one foot of cover and three foot of cover. The requirement is four feet. You can imagine -- it doesn't take anything to imagine -- that cover is money. It takes money to get it there.

If we -- if -- I say we -- if the reclamation -- if the mining company can demonstrate sustainable, successful reclamation and a suitable cover for erosion and sustainability and for moisture release, then they would like to put one foot of cover.

We did a study where we put one foot of cover on the rock pile material on the mine, on the Questa mine, and three feet of cover. And to date there is no significant difference in the success of the vegetation on the one and the three foot of cover. And the soil moisture release is better on the one foot of cover than it is on the three foot of cover. And the idea is that the one foot of cover actually will be a better method of reclamation than the three foot.

So this topsoil depth issue is being studied to death right now. I have several studies that are called wedges, and we have a 10-year -- I guess getting now a 12-year wedge at La Plata Mine, looking at four inches of cover all the way to 30 inches of cover, and to see if -- what differences are and what is sustainable.

When we talk about four feet in the mining industry, they're talking about four feet of suitable root zone material, and that has to meet certain standards. And below that, it doesn't matter.

But that spoil material has to meet certain electrical conductivity and SAR standards, clay standards, saturation percentage standards. And the SAR and EC is used together so that the SAR can be high as long as the electrical conductivity is high. If the SAR is low and the EC is very, very low, it can disperse those soils. And so they're unsuitable as root-zone material.

Then there's a cover put on top of that that acts as the recipient of the soil mois- -- of the rainfall, and that's why this whole issue that we've talked about is topsoil, and then this spoil material below. This spoil material is meeting certain suitability criteria.

In the past, there's been studies done where that spoil was pretty nasty stuff, and the success of the reclamation was questionable, and the sodium-migration issue and all of that.

I'm of the opinion -- and this is not real maybe popular with the Commission, but I can reclaim in -- on Navajo Mine we've seen successful reclamation -- I shouldn't say I -- we've seen successful reclamation consistently with 12 inches of cover soil over spoil that meets the root zone suitability criteria. And this stuff has got electrical conductivities in excess of 8 or 10, SARs in the 30s and 40s, and clay contents of 35 percent. And we've been able to sustain reclamation on those sites. Those plants area adapted to those conditions.

Without the 12 inches, we're sunk, we just can't do it. You put -- Here's the problem. And I guess -- You didn't ask for a lecture here, and I apologize for that, but I think this needs to be addressed. Here's what we have found.

As we put excessive depths of cover soil on sites, we monoculture the site and we lose the diversity. I've seen it time and time and time again. And I'm for diversity.

The Lee Ranch Mine -- maybe I shouldn't have said that. There's a mine in -- don't write that down.

(Laughter)

There's a mine out of Grants that uses --

CHAIRMAN FESMIRE: Doctor, he's got to take everything down.

THE WITNESS: Well, there's a mine outside of Grants, and they use deep applications of topsoil, and they predominantly have a few -- one or two species that become established on those sites, and they're looking at this whole diversity issue and coming to realize that they've got to do something different. You've got to change something. You can't have an Iowa cornfield and expect to have 10 or 12 different species out there. That's just not going to happen. You have to vary something.

And so I'm big on varying landscape or the relief, and I'm big on varying the depth of topsoil.

And if we get too much topsoil, heaven forbid, then we wind up with a monocultured site, and it'll be difficult to establish -- once you get a monoculture, it's very difficult to establish diversity into a monoculture. And that's another whole day's lecture, so don't ask me about that.

It's our notion that we try to maintain diversity, and if you maintain landscape diversity -- and that is how New Mexico won the New Mexico Mine Reclamation Award, because they created diversity in the landscape, and they created diversity in the topsoil.

Q. (By Commissioner Olson) Well, wouldn't we, I guess, most likely have that with a lot of the pit locations? They're relatively small in size. You're looking at something that's 100 by 100 or 200 by 200, so it's --

A. If you look --

Q. -- probably going to look towards diversity as other seeds move in, then, because it's a small area.

A. Yeah, it's small, and they're level for the most part. But there's some -- there might be some differences in the soils or -- because you have a cut side, and then you have a fill side.

So the fill side -- Now I'm not talking about the pit now, I'm talking about the whole pad, that on the fill side you have one kind of soil and on the cut side you have a different kind of soil. Is that diversity? Absolutely. Not so much in landscape, but in soils, and that will create diversity in that vegetation.

Q. I guess I get back to my -- just original point was, when you were talking about mining applications, you kind of implied this was in all mining applications. You're saying -- four feet of cover, I guess, is standard for coal mining applications that we're looking at now, not for hard-rock mining or other types of circumstances.

So where you're looking at the plot that you showed here -- I think somebody referred to it as page 5 or something, where you have materials growing in spoils, you're looking at something that does have materials that do have root-zone potential, not rockpiles or stockpiles at a -- you know, acid-generating capability --

A. Correct.

Q. -- at a hard-rock mine, correct?

A. Correct.

Q. So you wouldn't have that capability.

Same thing for the vegetation that you're mentioning about that was -- would take place in spoils. That's not going to occur in a hard-rock environment?

A. No. Oh, you didn't get that nod, did you? I'm sorry. No.

Q. And I guess I just -- I guess in coming back, again, to Commissioner Bailey's questioning, the vegetation is critical to removing the moisture from the cover and keeping the viability of the cover, correct?

A. Correct.

Q. So I guess along that lines, it would be important for us to have some type of requirements on ensuring that we get good re-vegetation?

A. I agree with that.

Q. I think that's all I have. Oh, actually I have one other one I just saw.

Under your one slide under water flow, I just want to make sure I understood something. You're referring here to this slug flow, and you've -- you've got it for the soil profile. What are you considering the soil profile?

A. That whole depth there.

Q. So is that the top three feet or -- roughly?

A. Yeah, roughly. It's undefined here, because -- you know, it's just a concept, but in New Mexico those carbonate -- it's kind of judged by the carbonates, and the carbonates pretty much stay in the upper three feet of the soil, and that's about the extent that we see these dynamics of the water going in and the plants removing.

There are instances when a shrub community will -- the dynamics are four or five feet. And nonshrub grassland-type situations, the dynamics are probably limited to the upper couple of feet.

Q. Well, I just wanted to make sure we had a distinction. So for soil profile here, you're thinking of -- essentially you're kind of theorizing that you've got mostly kind of slug flow within the top three feet, but not what we're looking at for what Dr. Stephens and other --

A. Oh --

Q. -- witnesses were talking about for the vadose zone, just because -- a lot of times folks talk about soil. I know you look at soil differently than maybe a geologist does, so what's considered soil.

A. Yeah, I -- Don't take me literally, but my experience is pretty much at the end of a shovel, and his is at the end of an augur that's power-driven by a big truck. Once in a while I've had that opportunity to augur down 75 feet in a soil and experience what was going on there. But yeah, most of my work is limited to the upper five or six feet of a soil.

Q. So I just -- just in following along, then, with your model, then, you would kind of theorize, you know, pretty much a slug flow in the top three feet and then moving on to some unsaturated vadose zone flow from there on down?

A. That's correct.

COMMISSIONER OLSON: Okay. Just making sure I understood that.

Thank you.

EXAMINATION

BY CHAIRMAN FESMIRE:

Q. Doctor, can we go to the Mertz study results?

A. Sure. Go down -- quite a ways. There you are.

Q. Keep going to the colored --

A. Oh, let's go to that other --

Q. -- in the rebuttal --

A. We'll have to get into a different file.

Q. There you go.

I don't understand something that's happening here. You've got higher EC's and corresponding higher salt saturations at shallower depths on several of these results. Maybe I missed it when you explained it, but can you tell me what's happening there?

A. In a few -- in a few sentences, what's happening is, the salts are migrating from the drilling material up. For the most part, they're migrating up the upper six inches. And the upper part of the profile, this 20 inches of rainfall is moving down through the profile, and it -- the salt content that we see in the upper part of the profile is a resident salt content, and it's in equilibrium with the amount of rainfall coming in and the amount of weathering that's going on in those soils. So that salt content probably won't change over long, long periods of time.

Q. And I understood that --

A. Oh --

Q. -- I mean --

A. -- okay.

Q. -- you said that about -- enough times that even I understood that.

A. Okay.

Q. But the thing that's got me concerned here is, several places in there that curve is inverted. You know, the source of the salt all comes from the bottom, right?

A. Correct.

Q. And yet you have layers that have higher salt concentrations above layers of lower salt concentrations. So if the water is coming down from the top it is -- you've got some sort of mechanism that is transporting the salt up at a higher rate than transporting the -- than washing the salt down.

A. Can I approach that or help you --

Q. Yeah. Would it be better if you had a pointer?

A. All right. I don't have one.

MR. HISER: May I approach the witness?

CHAIRMAN FESMIRE: You may.

Q. (By Chairman Fesmire) Let's use the 150 millimeter after 44 months on the right, where it goes from 70 down to 60. What's going on there?

A. Oh, that's just natural variation in the soil. There's no difference between .7 and .6, there's no statistical difference. That's just the randomness of the ability to measure electrical conductivity. We can probably take those samples again, and they could be 1/10 different just because we sampled from a different place or -- there's no statistical difference in those numbers.

You shouldn't look at that number, .7, and say, Oh, that's higher than .6. You should look at .7 and .6 as essentially being the same statistical number.

Q. Well, it happens repeatedly throughout your statistical data. So what you're telling me is that that's just statistical scatter, that's --

A. That's what it is --

Q. -- that's not affected --

A. -- that's what it is.

Q. Okay. And he did not sample above the 75-millimeter layer?

A. This layer here he did not sample. He has no data for that.

Q. Okay, and the reason being that -- I heard your statement that he didn't see any changes up there, but I'm concerned because -- you know, because of that -- what you described as a statistical anomaly shows that there is still a tendency for the salt to move up at that point.

A. Commissioner Fesmire, the salts in this 44-month are moving from the drilling fluids to this layer, to this layer, and questionably whether that's statistical scatter, if that's really salt movement, but we'll argue that it is salt movement. But there's no salt migrating to this level or to this .7 level.

Q. Well, and I will, you know, of course not argue with you about the statistical scatter. But in the two-year period on the 150-millimeter cover -- centimeters of cover, from the 20-month to the 44-month, the salt concentration tripled in that middle layer, didn't it?

A. You mean from 144 to --

Q. From .75 to 2.7.

A. Right, it did.

Q. Okay. And, you know -- and then to see the anomaly above that and have that explained as statistical scatter is a little bit of concern to me.

A. Well, let's go back to the one month. On that same 150 centimeters of cover let's start at one month. It's .64 and .82.

Then it goes to -- in the eighth month, .67 to .68. Now I'm going to suggest that those numbers are no different. But is there -- you know, let's argue, is there a trend there? If there's any trend, one went up and one went down.

Then in the next, 20 month, .44 and .53, so the trend looks like maybe there's less salt.

And then it goes to .7. Well, we were there at .64 and .67 previously. And then the one below is .6, which suggests that it may have started at .82 after one month.

Let me emphasize that those are all within the ability to measure the electrical conductivity in the soil. The instrument that we use -- if we can get within a tenth of the actual number --

Q. You mean .1 or -- ?

A. One-tenth -- I mean, the difference between .6 and .7 -- the instrument can't hardly measure it that accurately.

If I had taken a sample, that .82 for example, I'm suggesting that could be anywhere from .7 to .9 and still fall within the range of the instrument. But if I sample from -- Keep in mind now, I went out -- or this McFarland went out, and he collected a sample. We can't -- that's one thing you can't do in soils, you can't go back and replace that. So now I have to sample another place, so I'm going to be 25, 50 centimeters away from where I previously sampled.

If I initially went out there and I start -- I had a high wall and I had two meters of soil and I took a sample here and here and here and here and here and here and here, first off, my instrument is not going to measure it much closer than about a tenth, but now I have these 12 samples that I've collected along this. Those samples are going to have a scatter, and it's -- those numbers are well within that scatter.

When those numbers start doubling and tripling, then I'm suggesting that there are some differences. And your observation of .75 to 2.7, that could be a real change. That's a significant statistical change, and that is accumulated salt in that layer.

Q. Now Commissioner Bailey touched on this. You were talking about the marine deposits above the coal, and you said that they would sink. The question is, are they the -- basically the same kind of deposits that would be above oil and gas deposits?

A. If they're of the Fruit- -- they're of the Fruitland formation, and I would say as long as I'm in the Fruitland formation, then I have some confidence that I will find similar kinds of materials.

If I move to another formation, then it's entirely possible that there might be some differences.

Q. Okay. But I think the point you were making is that these -- you know, the coals are shallow-water deposits or shallow -- my geology just --

COMMISSIONER BAILEY: Cretaceous.

Q. (By Chairman Fesmire) -- but marsh-type deposits, right?

A. They are.

Q. Okay, and the shales and the interbedded deposits are deeper-water deposits as the --

A. They're inland seas, and they can be very shallow.

Q. Okay. And they have a high salinity concentration, right?

A. They often do.

Q. So anybody drilling through those zones, the cuttings and stuff would have a significant salt contamination, or salt content, right?

A. They would.

Q. We talked a lot about the transport mechanism, and I think you said it was diffusion?

A. Correct --

Q. How does --

A. -- yeah.

Q. Okay. How does gravity affect diffusion? Does it have any effect on it at all? I guess the rate of diffusion upgradient would equal the rate of diffusion downgradient. And I'm asking a real question here, I don't know the answer.

A. You are, you're asking a real question, and you're asking a question I probably haven't thought of too often.

Diffusion is a gradient due to, in this case, osmotic concentration. I suspect that osmotic concentration so overwhelms gravity that gravity is virtually not an issue here.

But if I put something in the water -- if I have a glass of water and I put something in the top, yeah, it'll diffuse down. If I put it in the bottom, it will diffuse up. What effect does gravity have on that? You know, I'm not sure I know.

Q. Okay.

A. I think it -- I think it's probably insignificant.

Q. Now given -- Are you familiar with the current rule, Rule 50, or did you get a chance to look at that?

A. I've looked at -- Yeah, I've looked at the rules, and you just have to help me, but -- if you want me to address some specific part of it.

Q. Okay. Specifically, I wanted to know what recommendation you would have to improve the efficiency of reclamation under Rule 50. Can you -- ?

A. Just the reclamation?

Q. Just the reclamation.

A. Does it include ripping, the rule now?

Q. I think it's got a performance standard in it, rather than --

A. I think -- I think that's right. I'm sorry for hesitating, I'm just thinking.

Q. But --

A. What I would -- I guess the bottom line -- you know, and it's been my experience the bottom line is the performance standard, and whatever voodoo you've got to do to get there is okay with me. If you don't get there, then I think you start asking a question, how come we didn't get there together? Well, we didn't get there because we didn't do something right someplace along the line.

So do you as a Commission want to make rules of how to get there? Or do you want to just say, You get there?

And now you're asking me what my opinion about that is. My opinion is, in general, don't make too many rules, but I think you have to have some rules, and I think you can have suggestions. And I think you've got to be careful when you universally say all areas will be whatever -- will be mulched, for example. That's a good example. There are some areas that don't need to be mulched. There are some areas that may not need to be ripped. There are some, absolutely, you don't rip them, you're sunk.

So if you make a rule that all sites will be ripped, well, yeah, that works for a goodly number of the sites. But maybe there are some the industry is going to come back and say, You're crazy, why are you having us rip these sands? These sands are not compacted, there's no reason for ripping them.

So you have to be careful when you universally apply a rule to reclamation, because reclamation -- now you didn't want to hear this, but I'll say it. I think there's a certain amount of art that's associated with reclamation. I think it takes some experience and I think you have to have a bit of a farmer in you, and you have to be somewhat of an agriculturalist, besides just being a soil scientist or a soil physicist or a miner or an oil and gas person. And you have to use good common sense.

And if you're restricted to a performance, you will do what you have to do to get there. And if the performance is there, and if you want to stay in business, my observation is -- you're probably hearing a lot of my philosophy, I guess -- then you'll do the right thing to get there. And if you don't do the right thing, you're not going to get there.

So what's my recommendation? Do the right thing.

Q. Okay. There is one thing that -- I'm having trouble reconciling some of your testimony and Dr. Stephens'.

Dr. Stephens says the salt doesn't go down, and you say it doesn't go up. Where does the salt go?

A. There's these little people that live in caves, and they come out and they mine it.

(Laughter)

A. I don't know where it goes.

The salts -- When we're talking about soluble salts, they're somewhere below the carbonates --

Q. And it's --

A. -- and the carbonates are sequestered at some depth that we can dig to with a backhoe. It's the exception when I dig with a backhoe in New Mexico and I don't experience calcium carbonate somewhere. So those salts are there. Those kinds of salts, the calcium carbonate salts, are there.

The sodium sulfates, the calcium sulfates, the sodium chlorides, they're deeper than that. Where are they? Somewhere below the carbonates.

Q. Now on page 3 of your handout, your rebuttal handout, the species that you list there, most of them aren't native to New Mexico, even the highlighted ones, are they?

A. Yeah, they're native. They're native and they're -- western wheatgrass, for example, is native, and it's native to New Mexico. Alkali sacaton is very much native to New Mexico.

Q. To the oilfields?

A. I'm sorry?

Q. To the oilfields?

A. Yeah, alkali sacaton likes to grow at about 12 inches or less precipitation, and then right above that is galletta, and then right in there is -- and I don't think I had this on there, it's *hilario jamesii*. But it's right in that same family.

The -- Western wheatgrass is a 12- to 18-inch -- it likes that 12- to 18-inch precip zone.

Q. Okay --

A. It doesn't do well at nine inches.

Q. -- so are we talking a differential? I mean a different type of native plant in the northwest than we are down in the southeast?

A. Yeah. Yeah, there's different species down there.

Q. Okay. And there's -- not knowing anything about, you know, plants and revegetation, things like that, are there -- are these going to -- these that we are encouraging, these saline-resistant plants that you're talking about here that we're going to be encouraging to grow when we reclaim these sites, are they the same plants that we would have displaced initially?

A. Yeah. Yes, you want to -- whatever plants are growing in southern New Mexico -- Tobosa grass, for example, is a good example -- you would encourage the re-seeding of Tobosa grass. It's native and it's highly salt tolerant, and it's -- very effectively survives droughty periods.

In northern New Mexico at a 13-inch precip zone, I would recommend western wheatgrass. Nine inches, wasting your money, won't grow, won't establish. Alkali sacaton, any day of the week it'll do well. Galletta is kind of in between. Four-wing saltbrush, crazy plant, doesn't have respect for the United States, it's grow in Canada to Mexico.

Q. Now you said two things that interested me. First, compaction is the enemy to remediation.

A. It is.

Q. That's something we need to remember in any -- in any sort of rule that we promulgate, right?

A. Correct.

Q. And you also talked about very clayey soils. Now one of the things that we've talked about here is the components of the drilling muds, including clays. What will the introduction of drilling muds into these pits do to the testimony and some of the issues that you've raised today?

A. When they're high in clay -- and sometimes high because of, say, bentonite, or just high because of the material that it's drilled through -- if they wind up high in clay, then they'll act much like a clay soil.

Sometimes what's drilled through, some of these marine shales are dominated with sandstones.

Let me repeat that, because that didn't make any sense. I said marine shales are dominated by sand- -- Some of the marine deposits that are drilled through are predominantly sandstone, so they wind up quite sandy materials, and so clay is not a component of that drilling mud.

But when the drilling mud is high in clay, either because of the nature of what it was drilled through or the nature of the bentonites, then that will act like a clay. And it has a low permeability, slow -- water moves very slowly through those soils. They have a high capillarity, so they will attract water, but the water won't move very rapidly.

If in the case there was no liner -- Do you want to go there?

Q. Yes.

A. Okay. If there's a case where these materials exist in a profile and they're a few feet or some feet below the surface, and there's no liner underneath that, that material does not want to give that water up very easily because it's held by these clays, and it's held very tenaciously. But gravity is working on this, and it will try to move that water down.

If that water is particularly of high water content, then it more easily moves. If the water is of a low -- I mean if the soil is of a high water content --

Q. I was a little concerned there.

A. Yeah, I -- yeah, I could see that concern. That was kind of dumb on my part.

If the material has a high water content, then that water is given up more easily. If that material has a low water content, then it's not given up so easily.

We don't want to farm in clays for the most part, you don't really want to farm these materials. So they act like materials that are high in clay, they don't give up water, they don't let water move through very easily, and the condition where they exist -- at the top of this drilling mud, and then there's material on top of that, we have a condition where this has got very small pores, and this might likely have larger pores, particularly if it's like a loam or a sandy loam or even a clay loam. And so the gradient is going to try to be -- to pull that water down.

What I think happens, and maybe what you would like addressed is, asking about these materials, that water moves from the surface down so slowly when it hits this clay that it in a sense kind of accumulates right there, and we get enough unsaturated flow, enough water on those clay -- on those particles, that that salt -- and the gradient now is such that the diffusion of that salt can move up into that interface.

If that wasn't clay, if that was sand, if those drilling muds were predominantly sand, and you put a clay loam over the top of that, I suspect there would be very little salt movement up. It would -- that water would come down, and then it would want to move down, it wouldn't want to hang up, it would want to move down, and you wouldn't be able to establish that wetting front long enough to get any substantial diffusion. That's what I think would happen.

Q. Okay, so I must have missed something. You know, clay -- natural clays in the soil would have a tendency to bring the salt higher above the source, wouldn't it?

A. It would.

Q. So if we had bentonite, say you have a drilling pit that contained saltwater and bentonite, you cover it up. Could that be the source of some of the salt that Dr.

Neeper has found on the surface out there?

A. If you put it at the surface, but --

Q. I mean, wouldn't that clay -- additional clay in the soil have a tendency to help that salt get to the surface?

A. Well, the clay is confined to the -- as you described this and as I understand it, the clay is confined to the drilling --

Q. It's --

A. -- mud --

Q. -- mixed with the salt, yes.

A. -- and what is above that is quite different. So if anything, that clay wants to hold that water, it doesn't want to give it up.

Q. Even as it's closed and you've got a Cat running over it and closing it down?

A. Yeah, the hydraulics here, the capillarity, is largely controlled by the material that's above that, not that material in and of itself.

Q. So unless the clay gets mixed with the cover, it probably wouldn't --

A. All right, now you're starting to get a mechanism. If you can bring that clay to the surface, or if you can bring those materials to the surface somehow, yes, those salts will be strongly attached to those clay particles, and those salts will be held by those particles. And if they're at the surface, yeah, the salts would be at the surface.

Q. So it would depend on the type of closure, whether or not --

A. Yeah. Yeah, yeah, right.

CHAIRMAN FESMIRE: I have no --

THE WITNESS: That was yes, yes, and yes, and --

CHAIRMAN FESMIRE: Commissioner Olson?

FURTHER EXAMINATION

BY COMMISSIONER OLSON:

Q. I just want to follow and make sure -- make sure I understood correctly what you were saying earlier.

So you're saying that the re-vegetation is critical to proper maintenance of the cover, correct?

A. Correct.

Q. But you were worried about it being too prescriptive to tell them exactly how to do it.

But if I understand correctly, you thought the requirement that -- I think that Commissioner Bailey read to you from our Rule 36 for commercial and centralized facilities, where it talks about, you know, establishment of a cover equal to 70 percent of the native perennial materials, I guess, or vegetation, gives enough flexibility, then, to be able to allow them to establish it whatever way they want then?

A. I think that's -- I think that's a correct assessment. I think that's a correct statement, that it does provide the flexibility that -- You've got to have a guideline there somewhere. You just can't say, Well, it ought to look when you get done. Well, now we're going to define "good" for the next few years.

Why don't we just say 70 percent of something, and then that something can be measured, and then we can measure the pad and say, yeah, it's 70 percent, 72 percent. Did it meet it? Yeah.

We --

Q. Well --

A. -- we deal with that all the time. It's 90 percent in mine reclamation, but that's after 10 years, and it has to be with a standard deviation of, you know, 10 percent, and a confidence interval, and -- you don't want to get into the statistics.

But let's make it simple. 70 percent, you know what that is, I know what that is, and you either meet it or you don't meet it. If you meet it, you move on. If you don't meet it, get your seeder back out.

Q. Isn't that why you're not telling them they have to rip it, they have to mulch it, they just have to get to this level?

A. Right.

Q. However they get there is up to them, or however they figure the best way to do it is?

A. Yeah, and then what they do -- what this oil and gas company does, the oil and gas industry does -- These are miners, they're engineers.

Commissioner Fesmire, you said, Well, I'm not a veg person. Well, you are something, and you have expertise in the field. You just don't happen to have it in vegetation. I probably don't know a thing about what -- you know, if you ask me about some engineering question we're in deep trouble. But you ask me about reclamation and vegetation.

So a company would come to specialists, reclamation, and say, We need to meet this standard, how are we going to do it?

This is my best -- that's my best estimate of what to do here, is to do it this way. And I've got my reputation on the line to say -- of years of experience of doing this, this is how we've done it

And that's how this process works, is my take on this.

COMMISSIONER OLSON: Okay, thank you.

CHAIRMAN FESMIRE: Mr. Hiser, do you have any redirect of this witness?

MR. HISER: Very, very little, actually.

CHAIRMAN FESMIRE: Very, very good.

REDIRECT EXAMINATION

BY MR. HISER:

Q. Now Dr. Buchanan, the very first slide in your rebuttal, if you want to go to that, is one that shows the SAR and EC relationship.

A. Correct.

Q. And Dr. Neeper asked you a question about, we don't actually use irrigation water; is that correct?

A. That's correct.

Q. Did you show this more to show the impact of pore water? And if so, could you explain that?

A. That's right, this -- this whole relationship, whether it's irrigation water or any kind of water, it's just when the electrical conductivity in the soil, which is, of course, measured by an instrument that measures the -- we saturate the soil, we extract the satur- -- the water out, and we measure the electrical conductivity in our water.

Q. And so --

A. What we're doing here is saying -- I'm sorry for interrupting, but what we're doing here is, we're saying, when the electrical conductivity is at this level and the SAR is at this level, it will either be stable or it won't be stable. The double layer will either collapse, or the double layer will stay intact. And it has reference to the electrical conductivity of the material.

Q. And this was also, then, with respect to your discussion about what happened when the rainwater hits and infiltrates, and then it absorbs some amount of the salts from the soil; is that correct?

A. That's correct.

Q. There was a discussion also, I believe, by Dr. Neeper about alkalinity. Do you recall that --

A. I do.

Q. -- discussion?

Now if he said that pits might be as high as -- I think he said 11 pH --

A. He did.

Q. -- do you recall a statement along those lines?

Now is it true that as we're looking at the reclamation of pits, as you understand it, that there would be substantial stabilization of these pits?

A. There could be, that's right.

Q. And what would happen if we were to take, say, native soils from around there and mix them with the pit contents to the alkalinity?

A. If the native soils had low alkalinity and you mix it with material that has high alkalinity, it would reduce the alkalinity of the pit materials.

Q. Do native soils in New Mexico tend to have alkalinities in the 11 or 10 range?

A. Not common, I -- I just don't know of many soils that have that high of pH.

Q. And would that same stabilization process also tend to, to some extent, dilute the effect of the bentonite that may be left in the drilling mud that Commissioner Fesmire just asked about?

A. Yeah, that's what happens is, we dilute those products with soil, and those materials are not in as high a concentration as they were before.

Q. Now Mr. Brooks asked you a question about the situation where you would have rain coming in, and then you would have a liner that would be on the sides and the bottom but not on the top. Do you recollect that question?

A. Right.

Q. And is that your understanding of what the industry committee is recommending, or are we recommending a top liner on top of everything?

A. Well, I've heard both, that -- to cut the liner and not put a liner on top, and then I've heard of encapsulating that material by putting the liner. I guess I don't know how to answer what the industry is really in favor of.

Q. Well, Commissioner Fesmire then asked a question about gravity and diffusion, remember that?

A. I do.

Q. Just a few minutes ago? And I think he talked about if you put the salt at either the top or the top, and it would tend to diffuse, all that.

Was the point in our earlier discussion about that that with convective movement, that if the whole water thing moves that's what you were talking about?

A. Right, when gravity is acting, when water is moving, it's still unsaturated, but this is when those products that are soluble in the water are moving by convection, and largely that's happening in -- under gravitational pull.

Q. Okay, and so that would essentially move the salt as well, when the whole water column moves?

A. Correct.

Q. And last, on the Rule 36 language, which we just discussed and which Commissioner Bailey read from that, as she read it she also said that that needed to be achieved, I think, in like two years following closure, and did you have an objection to that tight of a time frame?

A. I do. Sometimes it takes longer than two years to establish that vegetation, and so the two years -- I'm a little reluctant to support that, because I know that sometimes it takes longer than two years. So if you say, well, you have to be there in two years, I know I can get there, I just may not do it in the first two years.

And there are instances, of course, that after two years it looks like the moon, and it's not going to look any different 10 years later. And so I think that's when the industry comes and makes a decision and say, Are we even anywhere near on a line towards success? No, we're not even close, we need to go back.

Q. And you had suggested in your earlier testimony that maybe four years was appropriate?

A. I think four to five years. My experience is, in reclamation, if you haven't made it in that fourth to fifth year -- by that fourth year -- and I have been there, I have been there at four years, and I've been there at four years and I've been facing failure in the face and going, You know what? I just ran out of patience. And get the seeder out, let's do this again. We did something wrong.

And so I'm -- Yeah, I'm more in favor of four years than I am two, because I've seen too many times that at the end of two years it didn't look at all near 70 percent, and two years later it was in excess of 70 percent.

MR. HISER: Okay, that completes my questions.

CHAIRMAN FESMIRE: Are there any other recross questions of this witness on that sub- -- on those subjects?

MR. BROOKS: I have one question.

CHAIRMAN FESMIRE: Mr. Brooks.

RECROSS-EXAMINATION

BY MR. BROOKS:

Q. Talking about this re-vegetation. If I understood Commissioner Bailey's question, which was the inspiration, I might say, for Mr. Hiser's last question -- and I'm not sure that I did, but if I understood it correctly, her hypothetical was based on the rule requiring that a particular level of vegetation be achieved within two years after the rig was released, I believe was the words that I heard.

Is that the way you understood it?

A. Well, I didn't understand it from being released. It was my understanding from two years after the site was completed, but --

Q. But after the closure of the pit?

A. Yeah.

Q. Okay. She was paraphrasing from a rule which related to -- which relates to surface waste management facilities, and at least the 70 percent and so forth were in that rule and are not in the current proposal.

But there is -- as far as the timing, I wanted to read to you the actual language in the current proposal and get your comment on that.

The current proposal says, Upon completion of the closure the operator shall substantially restore the impacted surface area to the condition that existed prior to oil and gas operations by placement of a soil cover and re-vegetation of the site, and maintain the cover established by re-vegetation through two successive growing seasons.

Now, isn't that -- As I interpret that, it's a little bit different from what you were assuming. In other words --

A. I was assuming that that all had to happen in two years.

Q. The two-year -- as I -- if I am right that the two years runs from the time the vegetative cover is established, would that change your comments?

A. I don't think that language is clear enough for you to make that statement, because I wouldn't make that statement that it just says that there's two consecutive years. That could be in the 10th and 11th year, that could be the second and third year. I think that needs to be clarified.

Q. Well what it says is, by re-vegetation and maintain the cover established through two successive years. Doesn't that pretty clearly say that the two successive years, whenever they are, begin after the cover is established, as opposed to being the two years to establish the cover?

Let me withdraw that question.

A. I -- I --

Q. Let me withdraw --

A. I know what you're saying, but I can tell you --

CHAIRMAN FESMIRE: Wait a minute, Doctor, you --

Q. (By Mr. Brooks) I want to withdraw the question, because I'm really not asking --

A. Okay.

Q. -- I'm really not asking you, Dr. Buchanan, to construe the rule.

What I'm going to ask you is this:

If the rule contemplates that you'll first establish the cover and then you'll maintain it for at least two years before the operator is off the hook on the deal, is that an adequate time frame from a regulatory standpoint, in your opinion?

A. Yeah, in my opinion that's fine, that's adequate.

MR. BROOKS: Thank you, that's all I have.

CHAIRMAN FESMIRE: Are there any other recross questions of this witness?

MR. JANTZ: Just -- actually just a quick clarification, Mr. Chairman.

CHAIRMAN FESMIRE: Mr. Jantz?

EXAMINATION

BY MR. JANTZ:

Q. Dr. Buchanan, I just wanted to make sure I'm clear that the Mertz and Weatherby sites, those are the sites that are the subject of your reference number 13, McFarland, M.L., Hartman, Ueckert and Hon; is that right? 1992?

A. Yeah, that's correct.

Q. Okay, is that published anywhere?

A. The dissertation is available on line, and then the publication that followed his work, that included the 44-month, as I recall, is in the *Journal of Environmental Quality*, and that is published.

MR. JANTZ: Thank you.

CHAIRMAN FESMIRE: Commissioner Bailey, do you have a question?

COMMISSIONER BAILEY: Yes.

FURTHER EXAMINATION

BY COMMISSIONER BAILEY:

Q. Would you consider the following language reasonable: Seeding or planting may need to be repeated until vegetative cover is successful to equal 70 percent of the native perennial vegetative cover consisting of at least three native plants, et cetera, et cetera?

And following along BLM's best management plans that are in their gold book to say, When conditions are not favorable for the establishment of vegetation, such as periods of drought, the Division may allow for subsequent re-seedings to be delayed until soil moisture conditions become favorable or may require additional cultural techniques, such as mulching, fertilizing, irrigating, fencing or other practices?

That does incorporate the BLM's best management plans.

A. I think that's very reasonable.

COMMISSIONER BAILEY: Thank you.

CHAIRMAN FESMIRE: Are there any other questions of this witness?

Dr. Buchanan, thank you very much.

THE WITNESS: You're welcome.

CHAIRMAN FESMIRE: At this time we intend to work our way towards adjournment for the evening.

Is there anyone who would like to make a public comment?

Come on forward, Jason. Jason, we have two ways of doing this. You can either make a statement of position, or you can be sworn and raise -- and make a testimony on the record. If you do that, you're subject to cross-examination.

MR. SANDEL: Mr. Chairman, I'd be willing to be subject to cross-examination.

CHAIRMAN FESMIRE: Okay, why don't you come up and take -- and be sworn? Raise your right hand.

(Thereupon, the witness was sworn.)

CHAIRMAN FESMIRE: Why don't you start with your name?

JASON SANDEL,

the witness herein, after having been first duly sworn upon his oath, testified as follows:

DIRECT TESTIMONY

BY MR. SANDEL:

MR. SANDEL: Mr. Chairman, members of the Commission, my name is Jason Sandel, and I am the vice president for health, safety and environment for Aztec Well Servicing and Triple-S Trucking and our affiliated companies in the San Juan Basin, located in Aztec, New Mexico. Okay?

CHAIRMAN FESMIRE: Good enough.

THE WITNESS: Thank you very much, Mr. Chairman and honorable members of the Commission. I do have a prepared statement that I'd like to get through.

My name is Jason Sandel, I'm the vice president of -- for health, safety and the environment, and a shareholder, for the Aztec Group of Companies, which includes Aztec Well Servicing and Triple-S Trucking. I am also an elected representative of the City of Farmington, as I serve as city counselor.

My father, former State Representative Jerry Sandel, sends his best wishes and asked for me to make sure that of these pictures on the wall that there is some red iron somewhere. It doesn't appear so, so we need to send some down, Mr. Chairman.

I believe that one of the greatest challenges before you in this decision-making process is to balance the variety of needs which have been presented to you in these hearings.

I come to you today with the greatest amount of respect in that you have dedicated significant time and effort in hearing from your constituency, including receiving my testimony this afternoon.

To me, as one whom has watched this debate from afar, I have heard the rhetoric elevate -- regarding economics versus protecting our groundwater. It is my hope today to bring forth yet another perspective while also acknowledging in advance that economic impacts will be great, and protecting groundwater is imperative.

While I not -- while I cannot come before this esteemed Commission to argue the science of the proposed rule, as I am not a scientist, I also cannot come before this Commission to argue the economic impact on producers or operators, as I am not that either.

Instead, I am a service contractor. I'm a third generation of a family to offer turnkey service to producers who seem -- who seek to drill for or work over natural gas wells in the Four Corners region of the United States.

Aztec Well Servicing is a San Juan County-based oil and gas drilling and well servicing company that currently employs approximately 450 people.

Triple-S Trucking is an oil and gas fluid hauling and equipment hauling trucking company that currently employs approximately 150 people.

Along with our other affiliated companies, an equipment supply store and equipment rental company and a produced water disposal facility, we imply -- we employ over 700 people in the San Juan Basin of New Mexico. It is from this perspective that I come to you today to offer information that I do not believe has been presented as of yet.

Before I proceed, I want to point out that my title of VP for HSE is my choice. I take great pride in serving my employees and my community in a function which ultimately results in a better way of life. I say this because I don't believe that our industry -- excuse me, I say this because I do believe that our industry has changed, and for this the industry needs to be commended.

For example, Mr. Fesmire is quoted in the *Santa Fe New Mexican* that 4552 incidences of oil spills have been reported to the OCD since 1992.

The reality is that for most of these incidents there is a report that highlights the cleanup that has occurred based on that spill. And the cleanup protects our groundwater. How do I know this? I know because I'm one of those within industry who voluntarily reports these incidents. I want for the material to be cleaned up successfully.

The article implied that Mr. Fesmire believed that the reporting of the spills was a negative. But consider the alternative. The alternative is, 4552 incidents of oil spills gone unreported and thereby not being cleaned up.

In my role as chief officer responsible for HSE within my business, I'm proud that we're reporting and in fact encourage more so every day. But remember, if the statistics are used against us rather than for building partnerships, the only result is to drive reporting underground.

Our company is well known throughout the State of

New Mexico, Colorado and Texas for working to build these proactive partnerships with regulatory agencies. In fact, Aztec well servicing is the first drilling and well servicing contractor in the state to be officially recognized by the New Mexico Environment Department as being awarded the New Mexico Safe Sites Award.

Additionally, I have recently spearheaded the creation of the Four Corners Safety Counsel. The goal of this organization is to work hand in hand with regulators to improve safety and environmental performance on a voluntary basis, rather than through the compliance wing of an agency.

So again, I am a contractor coming before this Commission with testimony regarding the proposed rule as it relates to my small piece of the industry.

From my perspective it is easy to focus on the economic impact arguments which this Commission has so patiently endured. And in large part I echo many of the arguments which have been raised.

To offer some impact from the perspective of my business, I can only depend on the expertise of my customers. Our companies primarily work for -- Our companies primarily work for major corporations, largely because they share our active commitment to safety. In one case a primary customer of mine indicated the immediate impact of the proposed rule to be a 75-percent reduction in drilling activity. Another customer has expressed interest in hiring as many drilling rigs as possible to drill up their New Mexico permits prior to the rule being implemented so they can shut down and move to alternative states after the implementation of the rule.

While I am not an operator and I cannot adequately testify to what their activity levels are going to be, I can only respond to what I have heard through media accounts.

Let there be no question. The economic impact of this is scary to contractors. Likewise, the economic impact should be scary to New Mexicans. No one would have ever believed that with seven-dollar gas there would be 13, or 29.5 percent of drilling rigs, and 27, or 18.5 percent of service units that are not currently working in the Four Corners region. While many experience three-dollar gasoline at the pump and figure all is well, I can tell you that there is significant uncertainty in our market right now, and that has a direct impact on the lives of my 700-plus employees.

Beyond the economics, which so many have brought before you previously, my goal is to bring a contractor's perspective from a health, safety, environmental point of view.

Focusing on safety, just within our trucking company we have driven almost 3 million miles thus far in 2007. On average, each heavy-haul truck has driven 31,000 miles and each water truck has driven nearly 47,000 miles.

The National Institute of Occupational Safety and Health reports that 52 percent of all oil and gas industry deaths are a result of vehicle incidents.

Upon reviewing the rule, as a turnkey contractor we believe that there will be a tremendous additional exposure by way of additional vehicle miles that would come from dumptrucks, supersuckers and forklift or loader transports.

And I want to clarify that it's not automatic that there will be injuries, but the exposure is greater.

In fact, we believe that each of these operations will be required for each move of each of our drilling rigs, and each requires a separate fit-for-purpose type of vehicle. Our equipment, both service and drilling, have moved over 1000 times in 2007 alone.

Assuming that the total miles driven on a move is 100 miles, for the sake of calculation only, thereby increases the risk to my employees by another 20 percent. When vehicle accidents are the leading cause of fatalities, I believe that additional research to the impact on our workers is necessary before we can move forward.

Along the same lines as the additional impact to safety from additional miles driven, there are a number of additional safety impacts which are a by-product of the rule as written. Primarily, these impacts are impossibly to qualify and are largely a result to increased equipment needs on location and the transport thereof. There will be additional dust and visibility impacts, as well as impacts as they relate to the balance between a reduced footprint of locations, including twinning of locations, and increased heavy equipment movement, specifically dumptrucks and front-end loaders on location.

As we think about the safety of the oil and gas industries, we look to vehicle incidents as that which causes the greatest number of fatalities, and our number-one danger is the accidental release or contact with a hydrocarbon. From my perspective as a contractor, this rule as proposed increases my employees' exposure to those two very dangerous items significantly.

From an environmental perspective, I suspect, Mr. Chairman, that in this time that you all have been having hearings that a great number of experts from industry and advocacy groups have come before you to cuss and discuss the science of this rule.

As I said at the beginning of my presentation, I am not a scientist and do not plan on disputing the science of any proposal.

Instead, I would like to bring forth what I view to be a contractor's perspective on the issue of the environmental impacts of the proposed rule.

I am confident that the impact of this rule will require several new pieces of equipment that are currently not part of our rig package or transport services. While I have little scientific knowledge of carbon emissions, I am keenly aware that the federal government is attempting to regulate and control carbon emissions as much as possible throughout the United States.

From our perspective, the additional equipment that can be required in order to be compliant with the proposed rule is significant. We will need a diesel-powered closed-loop pit, a front-end loader to remove the cuttings, a supersucker fluid truck to remove any additional fluid from the closed pit, a heavy-haul vehicle to transport the front-end loader, a dumptruck to haul the cuttings and significant yet unknown quantities of earthmoving equipment to operate a landfill.

Each of these pieces of equipment carry their own carbon footprint, which is an increase to our current activity levels. In addition, each of these pieces of equipment are generally powered by diesel fuel, which production carries its own impact to the environment.

I cannot sit before you today and qualify each piece of equipment and the fuel which runs them and testify to the additional impact each will carry, but I can say that the additional impact, from my perspective, will be great.

The additional environmental impacts that are a result of this additional equipment are many. For each truck or moving piece of equipment there's more dust. During each transport there's additional opportunity for oil and other contaminants to be spilled into navigable waters. Remember the 4500 spills that already been reported? There will be additional environmental impact to ranchers' lands via increased traffic and roads and additional noise impact from locations and the additional motors and trucks.

Other environmental impact, and economic, for that matter, will be felt by the State of New Mexico through additional degradation of our already dilapidated road network. With increased traffic will come the need for additional repairs to our roads. Of course, roads will then increase our state's dependence on oil, therefore defeating our purpose of reducing our needs.

While I'm not an environmental scientist nor expert, those who have asserted that there are no cases of groundwater contamination relating to temporary -- those who are -- have asserted that there are no cases of groundwater contamination relating to temporary reserve pits in the northwest, whether lined or unlined, in addition, those same experts indicate that NMOCD modeling utilizes Dulce, New Mexico, as representative of the precipitation and growing season, soil humidity and other parameters that would be typical of the San Juan Basin, yet there are no producing oil or gas wells located within five miles of Dulce.

Even still, other experts point to the potential of contamination of drinking water in Flora Vista near Farmington as it relates to a nearby dehydrator pit. Nevertheless, isn't it best for us to work together to combat those issues which we know to be a problem, carbon emissions, as opposed to exasperating the issue for one that isn't even proven yet? My belief is that the implementation of this rule makes our carbon footprint greater at a time when we are working diligently to reduce it, and increases other known and accepted environmental impacts of our injury -- industry, in favor of attempting to solve an issue that has yet to be conclusively proven.

As a contractor, as a locally elected official and as a person who cares in general, my goal is the same as that reported by Mr. Fesmire. I want to be sure -- and this is a quote -- I want to make sure we produce oil and gas in a way that doesn't harm the water resources of the state. But I also do not believe that any of us can make that statement or one that is protectionist of the industry in a vacuum.

As a contractor, I have brought to you my concerns that this attempt to protect our water could, and likely will, have even greater impact on employee livelihood, employee safety, the safety of people on the State's roads, carbon emissions, dust and noise and the degradation of our roads, thereby requiring additional production and further dependence upon natural resources.

Chairman Fesmire is also quoted to say that he did not want to hurt the oil and gas industry in any way. And truth be told, I believe him.

I believe that everyone in this room and throughout our state knows and understands the importance of oil and gas production to our state and our communities. But at this juncture we are really prepared -- are we really prepared to create additional environmental impacts to solve that which we're not exactly sure about? As Senator John Arthur Smith said, We can't afford to be wrong.

Lastly, Mr. Chairman, I would be remiss if I did not point out that as a contractor who makes his livelihood providing these types of services to producers, I sit before you today to say that once implemented I will not be able to provide the services that you are calling for. As is often quoted during a boom of the industry, there is not enough equipment to address the demand.

My father always taught me not to bring forth a problem without a solution.

Mr. Chairman, I come today not to shoot arrows or poke holes. As I have stated, I do not have the expertise to bring forth that type of challenge. I only know about the impact from my world of providing services to producers in the State of New Mexico. So my suggestions are simple.

For any rule, I would suggest a phase-in.

In making revisions to any rule, I'd suggest a fit-for-purpose ruling that is specifically designed for the area that it is trying to protect.

Furthermore, I would suggest an economic impact analysis and further environmental impact analyses to evaluate the additional impact of the proposed ruling.

Lastly, yet most importantly, I would heavily study and weigh the safety impact to the lives of our workers. These men and women are out there day and night, out there right now, working hard to deliver oil and gas to satisfy our nation's energy needs, and their safety must be our core value.

Thank you very much, Mr. Chairman and members of the Commission.

CHAIRMAN FESMIRE: Thank you, Mr. Sandel.

Are there any questions of this witness?

MR. CARR: No questions.

MR. BROOKS: No questions.

MR. JANTZ: No questions.

CHAIRMAN FESMIRE: Okay. Mr. Sandel, thank you very much.

MR. SANDEL: Thank you very much, Mr. Chairman.

CHAIRMAN FESMIRE: Tomorrow I guess we will finish up with -- Oh, I'm sorry, Doctor.

DR. NEEPER: Could we have a question for Mr. Sandel?

CHAIRMAN FESMIRE: Do you have a -- oh, I'm sorry --

DR. NEEPER: May I ask a question?

CHAIRMAN FESMIRE: Dr. Bartlit -- Dr. Neeper?

EXAMINATION

BY DR. NEEPER:

Q. What I heard was a concern in part with heavy equipment might be required by closed-loop systems. If the rule did not in any explicit way necessarily require closed-loop systems, would that solve some of your concern?

A. And I'm sorry, your name is -- ?

Q. I'm Don Neeper, I'm sorry, I'm with --

A. Dr. --

Q. -- New Mexico Citizens for Clean Air and Water.

A. Dr. Neeper, yes? My concerns relate beyond just the closed-loop system in that the sucking of the cuttings and the fluid from the existing pit and the reclamation of that pit, there's all kinds of safety concerns of people getting down into the pit and the heavy equipment that's associated with cleaning those out. So it's a broad-based concern with regard to additional equipment that's required, in order to facilitate what's required by the rule.

CHAIRMAN FESMIRE: Now are there any other questions?

MS. FOSTER: Actually, could I ask one question --

CHAIRMAN FESMIRE: Surely.

MS. FOSTER: -- a series of questions?

EXAMINATION

BY MS. FOSTER:

Q. Mr. Sandel, thank you for coming today.

Have you been here for some of the prior testimony from some of the other witnesses?

A. I have not.

Q. Okay. Well, there was some discussion earlier today that if the rule were to be passed, that there would be very likely a reduction in the amount of drilling, something in the area of 30 percent in the San Juan Basin. Have you heard those numbers, or do you --

A. And I'm sorry, your name is -- ?

Q. Karin Foster --

A. Ms. --

Q. -- I'm with the Independent Petroleum Association --

A. Ms. Foster, you know, again, I can't really state from my point of view as a contractor exactly what the impact to each of the operators is going to be. All I can say is what's been reported to me, all the way from newspaper reports of the 75-percent shutdown, and I have seen accounts of a 30-percent shutdown, and I have heard those saying that we're going to shut down completely.

Q. Okay. Well, assuming that there was a shutdown of some percentage, would it still be your position that there would still be increased greenhouse gas emissions, even though there might be a smaller percentage of drilling, if the closed-loop systems were instituted?

A. Would there be additional greenhouse emissions if drilling were to shut down?

Q. Not completely, but a certain percentage. Say -- let's take the 30-percent number --

A. Okay.

Q. -- okay? And what you know of closed-loop drilling systems and the dig-and-haul perspective -- in other words, do you think that the amount of greenhouse gases that would be emitted for having to dig and haul and using closed-loop systems, would that be greater or less than the offset that would result from less drilling?

A. Well, frankly it really depends. I mean, there would be less on the drilling rig, but there would still be the same in the pit operation that was required, as well as the sucking of fluid and other items that were associated with the drilling bit that was going on.

So I would see a reduction that was specific to the drilling rig, but I would see that the other levels would remain in that you would have to continue those same operations in order to be able to comply with the rule.

Q. Okay.

A. Did that answer your question?

Q. Well, I mean, I'm kind of getting at your safety concerns --

A. Sure.

Q. -- with the increased amount of traffic and vehicles on location with the closed-loop system.

A. Whether there's one rig operating or whether there's 13 rigs operating, from my perspective you're adding equipment onto location, you've got twinned locations and often -- "often" -- you've got reduction in location size mandated by the BLM. And all of these things, when you're adding a front-end loader, when you're adding another piece of equipment, contribute to that safety concern that's associated with doing our operation safely.

MS. FOSTER: Okay, thank you.

THE WITNESS: Yes.

MS. FOSTER: I have no further questions.

CHAIRMAN FESMIRE: Thank you, Mr. Sandel.

THE WITNESS: Thank you.

CHAIRMAN FESMIRE: Okay. Making sure, are there any other questions of this witness?

THE WITNESS: I'll stay up here, Mr. Chairman.

CHAIRMAN FESMIRE: Thank you, Mr. Sandel.

THE WITNESS: Thank you, Mr. Chairman.

CHAIRMAN FESMIRE: Okay, at this time, in just a minute, we're going to go ahead and adjourn for the evening.

Tomorrow we've got -- we'll only go until about 4:15, then we'll be off until Thursday morning at nine o'clock.

Starting tomorrow morning at nine o'clock.

Wednesday we've got a hearing where I understand the Legislature wants to talk to me about my budget, so we will do that Thursday morning -- I mean Wednesday morning, and be back here Thursday morning at nine o'clock. Tomorrow afternoon we -- like I said, we do have to leave a little bit early, so we'll shut down about 4:15.

Any questions before we adjourn?

MS. FOSTER: Yes, Mr. Chairman, so is the intention that we would start with Mr. John Byrom for the completion of his testimony tomorrow morning?

CHAIRMAN FESMIRE: That's my intention. Then we go to Dr. Thomas, right?

MR. HISER: Actually, we'll probably have Eric Pease from Daniel B. Stephens and Associates to discuss the report that they prepared --

CHAIRMAN FESMIRE: Okay, and then --

MR. HISER: -- and then Dr. Thomas after that.

CHAIRMAN FESMIRE: -- Dr. Thomas. Okay.

Any questions before we adjourn?

With that, I'll see you all tomorrow morning at nine o'clock.

(Thereupon, evening recess was taken at 5:36 p.m.)

* * *

CERTIFICATE OF REPORTER

STATE OF NEW MEXICO)
) ss.
COUNTY OF SANTA FE)

I, Steven T. Brenner, Certified Court Reporter and Notary Public, HEREBY CERTIFY that the foregoing transcript of proceedings before the Oil Conservation Commission was reported by me; that I transcribed my notes; and that the foregoing is a true and accurate record of the proceedings.

I FURTHER CERTIFY that I am not a relative or employee of any of the parties or attorneys involved in this matter and that I have no personal interest in the final disposition of this matter.

WITNESS MY HAND AND SEAL January 31st, 2008.

STEVEN T. BRENNER
CCR No. 7

My commission expires: October 16th, 2010