STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT
OIL CONSERVATION DIVISION
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO

21 & 22 August 1986

COMMISSION HEARING

VOLUME II

IN THE MATTER OF:

Application of Jerome P. McHugh and Associates for an amendment to the special rules and regulations of the Gavilan-Mancos Oil Pool... CASE 8946

and

Application of Benson-Montin-Greer Drilling Corporation for the amendment to the special rules and regulations of the West Puerto Chiquito-Mancos Pool ... CASE 8950

BEFORE: Richard L. Stamets, Chairman
Ed L. Kelley, Commissioner

TRANSCRIPT OF HEARING

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I N D E X

I N D E X CONT'D

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E X H I B I T S

I N D E X CONT'D

MR. STAMETS: The hearing will come to order.

It's nice to see that there is undiminished interest in this case.

I would encourage everybody to be as brief as possible so that we can conclude this hearing in the two days we have allocated to it this week. I know that may be difficult for some of you but rest assured we are capable of listening very, very fast.

At this point, then, we will resume hearing this case and ask who's next?

MR. KELLAHIN: Mr. Chairman, we'd like to continue with our direct presentation.

At this time we would like to call Mr. Al Greer.

MR. PEARCE: Mr. Chairman, if I might, before we begin that I have one brief preliminary matter which I'd like to discuss, if that's acceptable.

MR. STAMETS: Certainly.

MR. PEARCE: In reviewing the transcript of the last day and a half hearing on this matter, it has come to my attention that, at least my clients are concerned, that we need to have a preliminary statement because of the break to remind the Commission that we've got

two cases under consideration today. We've got two pools under consideration today. We've got two sets of information and my clients are concerned that because of the break, some continuity of organization might be lost and that they feel it's necessary to make clear that we've got two pools and we may have two sets of data.

They asked me to emphasize that.

In addition, after reading that transcript, it occurs to me that although I did not rise and join in a couple of Mr. Padilla's objections at the last hearing, there was a lot of discussion in that record about spacing.

Reading the ad of this case it is clear that what we are talking about is reducing allowables and reducing the gas/oil ratio and I have been asked to emphasize that. I may have been asked to emphasize it to myself as much as anyone else, but we are concerned because of time and because of the amount of information available, that we not get sidetracked into issues which are not before this Commission today and not try to keep clear lines about the applicability of the information that is being presented.

Thank you.

MR. CARR: Since Mr. Pearce has

decided that it is appropriate to make a brief opening statement, with your permission I would like to do the same and I'm going to keep in mind that it's important to keep this hearing moving, but I think what we're here talking about is a reservoir that's in trouble, and when we talk about what is happening in that reservoir, we necessarily must talk about what's going on in that formation and some of the evidence that is presented might be appropriate in a sapcing cased, but what we're presenting and will present today is evidence about what is happening in the Mancos formation and even though you may be able to utilize if we were here talking about a change in spacing, we're going to be talking about imposition of certain restrictions on withdrawals for a period of time and the data that we're going to be presenting is directed toward that and so even though it is true this information might to appropriate in another hearing, we submit to you today that everything we're going to be presenting is directed strictly to the issue that is presented to you for consideration in the applications of Jerome P. McHugh and of Benson-Montin-Greer Drilling Corporation.

There has been a break of two weeks. As you'll recall, two weeks ago Mr. McHugh called witnesses that discussed the geology of the area, the basic land situation of the Gavilan area, and also presented

through Mr. Roe, some engineering testimony which I believe clearly identified that there's a problem in this particular area.

Today we're going to call Mr. Greer. Mr. Greer is going to talk about the formations and the area that are involved in the consolidated cases and we believe we'll show that immediate action should be taken if, in fact, you're to carry out your duty to prevent waste and protect correlative rights.

We're also going to show you why the limitation that we have proposed is the limitation that must be adopted by this Commission, and we're going to show you that you've got to limit the withdrawals from the reservoir as well as limiting the gas/oil ratio if in fact what you are being asked to do is done in a meaningful fashion.

At this time we call Mr. Greer.

MR. STAMETS: While Mr. Greer is coming to the stand, let me ask if there are additional appearances in this case today.

ALBERT R. GREER,

being called as a witness and having been previously sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. CARR:

Q Would you state your full name for the record, please?

A Albert R. Greer.

Q Mr. Greer, where do you reside?

A Farmington, New Mexico.

Q What is your relationship to Benson-Montin-Greer Drilling Corporation?

A I'm an officer and engineer in that corporation.

Q How long have you been an officer and engineer in that corporation?

A About twenty-five or thirty years.

Q What is your present office in Benson-Montin-Greer?

A I'm president.

Q And Benson-Montin-Greer is applicant in Case 8950?

A Yes, sir.

Q What interest does Benson-Montin-Greer Drilling Corporation have in the West Puerto Chiquito Mancos Oil Pool?

A Benson-Montin-Greer is the operator of the Canada Ojitos Unit, which lies within the West Puerto

Chiquito Pool.

Q For how long has Benson-Montin-Greer been the operator of the Canada Ojitos Unit?

A Since about 1963 or 4.

Q Briefly summarize for the Commission your educational background and your work experience.

A Yes, sir. I was graduated from what was then New Mexico School of Mines at Socorro in 1943; Bachelor of Science degree in petroleum engineering.

After a short time in the Navy during World War II I went to work for a subsidiary of El Paso Natural Gas Company in Jal, New Mexico, Western Natural Gas Company.

In a couple of years I went to work for Anderson-Prichard operating out of Hobbs; then for two or three years I was in Oklahoma City as a reservoir engineer for Anderson-Prichard.

Then I spent two or three years in Dallas working for an independent, Leland Fikes, and as an engineer.

Then, since about 1952 I've spent most of my time in the San Juan Basin of New Mexico, working as principally an engineer and involved in the drilling and production of wells in that area.

Q Have you personally been involved with

the Canada Ojitos Unit since its creation?

A Yes, sir, we helped form the unit initially and have continued with it for some twenty-five years.

Q Have you during that time period personally been responsible for the engineering work and development of this unit?

A Yes, sir, we've made some rather intensive engineering studies because of the unusual nature of the formation, and I've been directly involved with that.

Q Mr. Greer, are you familiar with the applications filed in these consolidated cases for Jerome P. McHugh and Benson-Montin-Greer Drilling Corporation?

A Yes, sir.

MR. CARR: At this time, Mr. Stamets, we tender Mr. Greer as an expert witness in the field of petroleum engineering.

MR. STAMETS: Without objection Mr. Greer is considered qualified.

Q Initially, Mr. Greer, would you briefly explain to the Commission why you are here and what your purpose is here in testifying in this matter?

A Yes, sir. Mr. Chairman, I'm here today because one of your oil pools is in trouble. In Rio Arriba County the Gavilan-Mancos Pool, with only about a third of

the wells on a third of the spacing units in the area that appears to be productive, the pool is over-drilled and over-produced.

There are three problems that we see that we will address and identify and set out for you to consider.

One is that if the existing rules continue, the existing competitive operation of the pool, there are going to be a large number of unnecessary wells drilled and this constitutes waste, waste which we hope that the Commission would recognize.

In addition, the high rate of production, the high rate of withdrawal, this high rate of depletion will deny the otherwise recoverable oil that might be realized through a gravity drainage depletion process. This constitutes underground waste.

Then there's a third problem, Mr. Chairman.

The majority of the tracts in the pool are being denied the opportunity to protect their correlative rights. This is a problem that's similar to the one that first occurred, first was recognized as a problem in the oil industry when commercial oil was first discovered over some 100 years ago in the continental United States, and that is that the operators in a pool had a complaint,

they took their complaint to the courts for relief. Their complaint was that their neighbors were taking more than their fair share of oil from a pool. They were pulling oil out from under their land, and I know, Mr. Chairman, that you well know the -- the -- how the judge ruled in that case but for the similarity and the comparison in this case I thinkn it's appropriate to -- to note, and if I recall, about what his decision was, and that was that he concluded that oil in its underground movement was like a wild animal skulking through the underbrush and belonged to whoever could capture it, and thus the law of capture was born, and it persisted for many years.

Then in this century, in a more enlightened era, the states with their laws, the commissions with their regulations, adopted a change in a sense to go from the law of capture to protection of correlative rights, and New Mexico has been a model in the United States for regulation and for -- for moving in what we have considered as the right direction.

But now, Mr. Chairman, there is a blemish; there is a blemish on our record, for in Gavilan today the law of Gavilan is the law of capture, and this requires your attention and we suggest here today how -- how that can be corrected.

Now we feel that there should be no blame

placed on anyone that this has come about. Until this hearing the Commission had no idea of this problem and until about a month ago the majority of the operators in the pool didn't realize there was a problem.

What the operators apparently felt and I believe in good faith felt, was that they had drilled into a bonanza, a world without end, reservoir without end that they could produce at high rates, that would last forever. They weren't deliberately trying to take oil out from under their neighbor's land but regardless of their intentions, that's what was happening.

They should not be blamed for that. The Commission should not be blamed. Now that we know about it we feel that the Commission and the operators should work together to correct this problem.

Now how could it come about? How in this age and with the regulations that we have, how could it come about that we're operating under the law of capture?

Well, it's because of the nature of the formation and I'll try not to be repetitious in my testimony today, but over twenty-five years that we've studied this -- this reservoir, this formation, we have testified before this Commission, we have pointed out how different it is from an ordinary reservoir in which the industry used to develop. In fact the words the geologists ordinarily use to

characterize formation are not the kind of words really that we need to understand this formation, and I'm thinking of words like deceptive, deceptive. We're indebted to Mallon Oil Company for coring a well as late as last December, having the core analyzed, not only analyzed, a petrographic analysis, and the analyst in reporting on this analysis pointed to one of the log characteristics, and Mr. Chairman, we have testified to this Commission many times that logs and cores just cannot show the character of this formation.

Here core analysis made this comparison. One zone showed by the log to have a porosity of 10 percent but the analyst in writing up his report said, this is a deception. This is a deception. The core porosity was one percent. So the log shows 10 percent and the core shows one percent; that's a 1000 percent difference in the pore space. It's a deceptive formation.

Not only deceptive, it's treacherous, and I would go so far as to say that it's insidious, and how can that be? Well, an operator has a well producing 75 to 100 barrels a day; the pressure in the reservoir drops; the gas/oil ratio increases; the well has really had a higher productivity, he didn't realize it and he was pumping the well at pump capacity; now with the lighter column, the additional gas, the well starts to flow through the annulus, so where he was making 75 to 100 barrels a day, now he's

making 2-to-300 and he feels that everything is great, when in truth, the reservoir is on the skids.

MR. LOPEZ: Mr. Chairman, with all due respect I would like to suggest that in the spirit of trying to get through the hearing, that if we're going to listen to all the conclusions that Mr. Greer has drawn, that we get to his evidence and data so that we can have Mr. Greer respond to direct questions.

I want to hear Mr. Greer's story but I think there's a more expeditious way of getting at it.

MR. CARR: Mr. Stamets, one common criticism of a lot of our testimony in the past has been that it's complicated, that it's extremely technical, and that it is difficult to fit within a framework and keep it understandable as we go forward.

Mr. Greer's been qualified as an expert. He can give his conclusions now and he then will go through and give you detailed information and comprehensive data that support the statements he's made and the problem that he's identified.

We'll be happy if Mr. Lopez wants to the other way now to move into particular exhibits, but our intention was to give you an overview of the problem so that as we develop each of the pieces they fit into some

sort of a logical pattern.

MR. STAMETS: If that was an objection, we'll overrule it and permit Mr. Greer to continue.

Q Mr. Greer, you have identified a problem in this area. How does that problem affect your interest in the Canada Ojitos Unit?

A It affects the Canada Ojitos Unit in that if over-drilling is continued in Gavilan, and Gavilan joins Canada Ojitos, then in order to prevent drainage from the unit to the Gavilan area, we have to do something, and we would have to drill at a minimum, the same density, the same number of wells, as -- as in Gavilan, and it's clear from the information we now have that those would be unnecessary wells, and so what we are suggesting, if I might go so far ahead of my testimony to say this, is that if Gavilan be unitized, then we can work out a boundary agreement between Gavilan and Canada Ojitos such that the oil in the boundary area can be shared by the two units without having to drill the unnecessary wells.

For Gavilan to be unitized and be unitized in time to -- to hopefully get the benefit of some gravity drainage, it must be done soon and it must be done before significantly greater amount of depletion takes place, and we'll go into that later as to why that is.

But that's how it affects it.

Now, by reducing the allowables, which are the subject of these applications, it does two things.

The first thing in reducing the allowables is that it addresses the problem of getting the opportunity to protect their correlative rights.

The other thing it does is it slows down the rate of depletion so that an opportunity can be had for Gavilan to be unitized and solve these problems before its too late.

Q Now, Mr. Greer, you have testified in a general sense about the nature of the formation and withdrawal effects, correlative rights, and waste problems. Have you prepared particular exhibits which address these concerns?

A Yes, sir.

Q Would you refer to what has been marked as Benson-Montin-Greer Exhibit Number One, let's take a minute and pass that out, and then I'll ask you first to just identify those documents contained in this exhibit.

Mr. Greer, will you refer to what -- to the document behind reference Tab 1, or A in Exhibit Number One, and identify that, please?

A This is a copy of our application in this case.

Q If you'll now move to Tab B, and first I'll ask you to identify the first exhibit, or first document contained in that portion of the exhibit.

A The first map is a copy of -- out of Exhibit Number Nine, McHugh's Exhibit Number Nine, Section A, in Case 7980, November, 1983, which had to do with the spacing in this area, and we bring this out at this time to show the nature of the boundary problem between Canada Ojitos and Gavilan and why we have the two concurrent applications.

I'd point out first in the upper part of the map that the Boulder Pool had been spaced on 80 acres and drilled on 80 acres.

Under that we see Puerto Chiquito Mancos West was spaced on 640 acres. The density was about one well to four sections, 1 to 2500 acres.

The Puerto Chiquito Mancos East on the east side of the map, spacing 160 acres, density about 160 acres.

On the far west side of the map the Lindrith Gallup-Dakota West was spaced on 160 acres and drilled on about 160 acres.

Then between Lindrith and the new area of Gavilan was Ojito spaced on 40 acres with a drilled density at that time of approximately 160 acres.

So we show that at that time the spacing

ran from 40 acres to 640 acres in the area. It seemed that a reasonable transition from one area to the other would be 320 acres for Gavilan. That was McHugh's application; we supported it at the time. We had special pool rules regarding wells along the boundary because we recognized at that time that the first well drilled in Gavilan had a pressure which appeared that it might have been affected by -- by wells in the Canada Ojitos Unit in the other pool; that there was probably some kind of communication, we didn't know how good it was. There appeared to be a permeability restriction, but two things were -- two points of evidence were very significant at that time.

One was that the discovery well had a productivity of approximately 100 barrels per day. The pressure build-up test run on that well indicated a transmissibility much like what we found in the Canada Ojitos wells but which was much less than what we found to be the reservoir transmissibility.

After six months of production the working -- casing pressure on the well didn't decline at all and so it was clear that the well was producing from a reservoir not like the characteristics shown by the pressure build-up test but that it was in communication with a high capacity fracture system very much like what we found in Canada Ojitos.

Farther to the north in Township 26 North, 2 West, Dugan's Tapacitos 2 Well had a flat decline curve indicating the same characteristics, even though it was a small well, about 40 barrels a day, it was obviously in communication with a high capacity fracture system.

So we anticipated that there would be production all along the west boundary of Canada Ojitos Unit and to have some way of recognizing the problem, trying to have a way to solve the problem, we had special pool rules for Gavilan for wells along the boundary and a year or two later we asked for special pool rules for the West Puerto Chiquito wells to help meet this problem.

We didn't know then how serious it is. We still don't know how serious it is, but we've made attempts to solve what could be a problem, and the problem being that in the Canada Ojitos Unit, for some eighteen years, we've had a pressure maintenance project. We've produced wells at rates which fit the -- our estimate of the gravity drainage potential so that we could get -- realize a maximum recovery from that pool. That requires restricting production to rates below the wells' capacities to produce.

If on the boundary we have to drill too many wells, then that means we have increased the production rate; we have exacerbated the problem of trying to realize gravity drainage potential when that required a low rate of

production. So here was our problem. We had to restrict production to get the maximum recovery. We had to increase production to protect from -- from drainage.

So that's why the special pool rules we had at that time. It's clear now that they're inadequate to solve the problem and so now we have other -- other ways that we must go to solve this problem.

Q Mr. Greer, the pool boundaries as depicted on the first exhibit in Section A of Exhibit One are the pool boundaries as they existed at the time of the pool rule hearing, is that correct?

A Yes, sir, that's correct.

Q Now will you go to the next document contained in this section of Exhibit Number One and identify that, please?

A This shows our -- our estimate of -- of what I have referred to as effective hydrocarbon pore space for the different areas.

Q And if you would, I'd like you to go through the exhibit and indicate what that pore space is, and also, if you could while you're doing that, indicate how those figures are derived.

A All right, sir. First I might point out why -- why it's important to look at this -- this character of the reservoir rock.

There is a tremendous range of recoveries of oil from individual wells from as low as 10 or 20,000 barrels per well to up over 2-million barrels per well, and although there is this wide range of recovery of production from wells, the formation nevertheless over the same area has relatively similar characteristic in terms of hydrocarbon pore space per acre.

Starting at the top of the map with the Boulder Mancos, I've estimated 2500 to 4000 barrels per acre of effective hydrocarbon pore space and I arrived at that from the production decline curves in Boulder, comparing the rate of pressure decline when the pressure was above the bubble point, the rate of pressure decline when it's below the bubble point. By having those two -- two characteristics we can calculate what the oil in place per acre was.

Another way to estimate it would be to -- by recombination of the gas that was produced, the oil that was produced, but in Boulder the gas was not measured so we lack the -- the accuracy that we'd like to have to arrive at it that way.

Going farther south in the orange colored area in the Canada Ojitos Unit, by intereference test we estimated 2000 or 3000 barrels per acre, and this was over, we think represented a fairly large area, several thousand acres covered by the interference test.

Then by comparison of the rate of pressure decline and the -- and estimating, and, of course, this is a problem with the normal estimates of recovery, is how many acres are being drained. But from that calculation we come up with 1500 to 3000 barrels an acre and in Canada Ojitos we are producing primarily one zone, whereas in the Lindrith Gallup-Dakota area to the west all the zones have been opened and the first well or two in Gavilan, it looked like they were planning to open all three zones in Gavilan.

So we've estimated in round numbers that there is no reason to believe that there's any big difference in Gavilan than the other areas in terms of effective hydrocarbon pore space.

Now to determine from effective hydrocarbon pore space recoverable oil, depends on a number of things and we'll get to that as we get into the testimony.

But first we need to see the similarity. They're just quite similar throughout the whole area in terms of what we identify as effective hydrocarbon pore space.

Q Will you now go to your structure map which is behind index Tab C in Exhibit Number One, identify this and then review the information contained on the exhibit?

A Well, this is a structural contour map.

It covers the area of East and West Puerto Chiquito Pools and the Gavilan-Mancos Pool.

Q Does this show the current boundary of the Gavilan?

A The current boundary of Gavilan and West Puerto Chiquito is the heavy north/south line which goes through the upper green circle.

The formation outcrops on the -- as shown on the east side of the map by the dashed lines, dips to the west, initially dips very steeply at rates of 1000, in fact 3000 feet per mile initially, then down to 1000 feet per mile, and as we go farther west, 400 feet a mile and 200 feet per mile.

Then the re-entrant, which we've shaded with question marks in it, is an area where we anticipate or we have postulated that there might be a permeability restriction.

Also on this map we've identified with the green circles the area of high withdrawal, the areas that are causing the problems.

The upper green circled area, the two wells adjoining each other across the boundary are wells that were used in an interference test. We asked the Commission 1st fall to conduct an interference test with the cooperation of the operator of the adjoining well, Mallon

area, or the Canada Ojitos Unit?

A The overall recoveries, if the -- if the production rates continue as they have and drilling continues as it has, of being denied the gravity drainage potential that they might otherwise recover, will reduce their recoveries to something on the order of 200 barrels per acre; whereas the same formation in -- or the same characteristics in Canada Ojitos Unit, we anticipate three or four times that much.

Q This plat also has indicated on it the location of the injection wells for your pressure maintenance project.

A Yes, sir. The injection wells are shown by triangles.

Q Now, Mr. Greer, in preparing for today's hearing have you made comparison of certain characteristics of a fractured reservoir and contrasted those with a sand or matrix reservoir?

A Yes, sir, I have.

Q And are those what is set forth in what -- in the documents behind index Tab D in Exhibit Number One?

A Yes, sir.

Q Would you refer to the first exhibit behind that tab and then identify it and explain what it is?

A The first two gold colored pages show the title of one of the Transactions from which an article and statistics were taken, which is shown on the second gold page, an article by Bulnes and Fitting, which showed a relation between porosity and permeability for sandstone type reservoirs.

And then I have taken that information and gone to the next graph, the graph with the brown and yellow stripes on it. The brown colored area represents approximately the area covered by --

MR. PEARCE: Excuse me. Could the witness speak a little louder? We're having a hard time back here, sir.

A I'll try.

MR. PEARCE: Thank you.

A The brown colored area is the same as the area shown by Bulnes and Fitting, approximately, for the relation of permeability and porosity for a sandstone reservoir.

To make a comparison with the fractured reservoir, I started out with a simple system of parallel fractures running in parallel to the direction of flow, and I calculated the porosity and permeability relation for three different conditions.

The bottom line shows the relation for

one fracture per foot; the middle line for 10 fractures per foot; and the upper line for 100 fractures per foot.

Now this is a simple, exact relation readily calculated. It was first presented to this Commission in Case 3455, November 16th, 1966, Exhibit One, Figure 9. At this time my counselor suggested that although I know the calculations are right and he accepts them as right, it might be helpful to other people to know that someone else has calculated the same thing that I have.

So, if we skip over three or four pages to the white colored sheet titled The Flow of Homogeneous Fluids... we'll find where I -- I arrived at the -- or found the relation of fracture thickness to permeability, and this was by Muskat in the book identified there, page 425.

From that I went to the next sheet and you can see my original notes here where I calculated through the law of parallel flow what the permeability and porosity relation would be.

From that I constructed the graph which we just looked at.

Q Now, Mr. Greer, the red point upon the bottom line in the yellow shaded area, what is that?

A That -- that point is a point that is shown as calculated by Craft and Hawkins, by the two pink sheets which follow the white one that we were just looking

at.

Q What is the blue point?

A And I might point out on the pink colored sheet, the page shown as 283, that in the center paragraph they have calculated the permeability for a fracture with 0.005 of an inch and an almost impermeable matrix. They have a more complicated formula there, of course, because of that. I eliminated that complication by assuming an impermeable matrix.

Then the blue colored sheet is the same kind of a calculation made a few, just a few years ago by another author where he shows a relation for three fractures per foot 0.01 of an inch thick, and in my penciled notations I show there, if you have one fracture per foot instead of three you would have 500 millidarcys instead of 13,000.

So those -- those pink and blue sheets, analyses there are, by happenstance those authors chose the same points that I did on the lower line of the yellow and brown colored graph, and we show this just simply to -- as confirmation of how -- that this is a simple, fixed relation. There's no judgment involved. If you have a fracture system, fractures running parallel to the direct of flow and for these characteristics that's what it is; there's just no question about it.

Now, to -- since we just don't have any

way of determining reservoir pore space and the relation of porosity to permeability from cores and logs, I wanted to have something that would give us some kind of an idea as to relation might be and I made the arbitrary assumption that in a fractured reservoir there's probably fractures running in different directions, not necessarily directions parallel to the line of flow. Mother Nature didn't know where we were going to drill the wells and how they would go.

If that's the case, it's probable that there would be a higher porosity for any given permeability if we had crossways fractures.

And so I have again rather arbitrarily assume the upper line as perhaps might be something representative of what actually happens in the reservoir.

I selected two points, one just above and one just below and then I came up with the graph on the next page, the gray shaded -- has the gray streak across it, and I said this might be the best representative as we could have, representation of porosity and permeability for a fractured reservoir and how it compares with a sandstone reservoir.

And there are two things that are significant here. One is if we take a range of -- as shown on the lower scale -- of 10 to 100 millidarcys permeability, we see that we're looking at porosities from 0.1 to .01 percent

on the gray shaded area.

A sand for a similar permeability runs like from 10 percent to maybe 25 percent.

So we're looking at 10 to 50 times, perhaps, as much reserovir pore space in a sandstone as in a fractured reservoir for the same transmissibility, same permeability.

Now what that means is that an operator goes out and he drills a well in a sand reservoir and he drills another one in a fractured reservoir, they both make 500 barrels a day, the well in the sand reservoir he has every reason to believe that he has a high volume of oil in place, a high potential for recovery of oil, but in the fractured reservoir he probably has only one-tenth as much; not only one-tenth as much in place but if it's produced by solution gas drive there will be probably a third as much oil recovered from the initial oil in place.

So there's a tremendous difference in a fracture reservoir and a sand reservoir in the amount of oil that might be anticipated to be recovered from any particular potential.

Q Now, Mr. Greer, will you go to the next graph and identify that and review it, and could you speak as loud as possible?

(Thereupon a short recess was taken and a microphone obtained for Mr. Greer's use.)

MR. STAMETS: Mr. Greer, why don't you do some testing there and we'll see if everybody can --

MR. GREER: Testing, testing, can you hear me now? Testing.

MR. PEARCE: That's much better.

MR. STAMETS: You may proceed.

Q Mr. Greer, I believe you were testifying from an exhibit in index Tab D in Exhibit Number One. Would you identify the graph you're talking about and explain what it shows?

A Yes, sir. This shows on a different scale the same information we had on the previous yellow and brown colored graph and the information shown as yellow and brown on the previous graph is shown as yellow and brown on this.

Q And this graph is entitled Comparison of Relation of Poroisty to Permeability.

A Yes, sir, and the purpose of this graph

is just to show an extension of the sandstone relation and the fracture relation and the fact that they join at an area somewhere around 50 to 100 percent porosity, and this is something that we would really expect to have. It doesn't make any difference if you call them a matrix porosity or a fracture porosity, once the porosity is 50 to 60 to 100 percent of the pore space we can call them the same thing.

So this seems to me adds a little bit of rationale or reason or credibility to -- to the relation that we came up with before. Certainly one would expect whatever relation you have would have to meet out in the righthand side of the graph as we've shown here.

Q Mr. Greer, would you go to your next graph which shows the relation of oil in place to transmissibility and identify the exhibit and then review what it shows?

A Yes, sir. This yellow colored graph shows for the three lines on this graph compared with the three lines that we have labeled A, B, and C, on the preceding graph, and by -- by taking the relation for, for instance, the A, the A line, if we had 17 feet of formation with the characteristics shown as A, then the bottom line as we have shown on the yellow graph would be the relation of transmissibility to -- to stock tank barrels of oil in place per acre.

By the same token, 50 feet of the B characteristic or 150 feet of the C characteristic would give the same thing.

And then I calculated the same thing for the X and Y lines.

Then we've made a comparison of what we found from our interference tests and information for Boulder, and those points are shown on this yellow graph.

The blue dash mark shows approximately where the information derived from the 1965 interference test would lie.

The pink stripe shows a 1968 interference test and the green circle shows approximately the relation for the Boulder Pool, and so although we have drawn in a sense an arbitrary characteristic or relation for oil in place per acre, it does have some background in what would be the situation for a fracture system in which the fractures are all parallel to the line of flow, and it also by happenstance, perhaps, is about the same thing as we actually found in the field.

So we think there is some -- there is some reason to believe, until somebody comes up with something better, that for this particular area, for this formation, in -- in the West Puerto Chiquito and Gavilan areas, that this is about the best relation we can have, and it's

significant in that we show that the porosity or the pore space varies as the cube root of the ratio of the transmissibility.

If we follow the line, say, from transmissibility of one darcy foot on the upper X line it would be about 2000 barrels an acre. It goes up to about 10,000 an acre for an increase in transmissibility of 100-to-1. So that's a relation that we think is -- has some application in the treatment of these formations in this reservoir in West Puerto Chiquito and Gavilan.

Q And is that relating transmissibility to productivity, is that what you're doing?

A Transmissibility and productivity will have some kind of a relation. The higher the transmissibility, the higher we can anticipate the productivity from wells drilled in that area.

We've found this to be a characteristic that probably covers a substantial part of the reservoir. There's just no way that we can -- can identify one particular small tract and say it has exactly this amount of oil in place per acre and its neighbor is substantially different. Overall and for a fairly large area of the reservoir they would be about the sames and I should point out an example as to how we really can't try to tie exactly a well's productivity to oil in place per acre. An example is that we

drilled one well, produced it natural. We drilled it with air. We found about 60 barrels a day production. We had a downhole fire that melted the drill pipe, drill collars in two; we left about 1000 feet of them in the hole. We produced the well that way for nearly a year and that well, incidentally, was one that by analyzing its production behavior led me to believe that the oil was under-saturated, that we were dealing with a drainage area that was probably several miles in a fairly large reservoir.

So in order to repair the well we went back in, sidetracked the hole, bottomed the well about 100 feet from the initial point (unclear) and it showed absolutely nothing. It was dry.

We fraced the well and managed to get back the initial productivity, but this shows how in this particular reservoir individual tracts close by are substantially different, yet over all in that area the formation is contributing to the production and -- and this is the problem that we come up with.

We drilled a well which would be about 40-acre spacing, we didn't know any better in those days, north of this particular well. Instead of making 50 or 60 barrels a day, it made about 500 barrels a day.

Well, if the allowables were based on just productivities, then one well 40 acres north of the one

we had the trouble with would get ten times as much oil form the reservoir and I know in my own mind that there's no way that there's ten times as much oil under that tract.

Q Mr. Greer, you just stated that using this approach you could see that the formation was contributing production.

What do you mean when you say the formation contributed production in this area?

A Well, we're speaking about the pore space in the reservoir that forms the reservoir. In this instance it's fracture porosity and it's -- it's what forms the pool that the wells draw from.

Q What does this exhibit tell you, if anything, about the oil in place that you encountered in this area?

A Well, it tells me that -- that over fairly large parts of any one of the pools that the oil in place will vary but not significantly; vary -- to use the cube root of the productivity, if you have ten times the productivity in one area as compared to another it doesn't have ten times as much oil, it has maybe twice as much oil.

Q Now, would you generally describe for the Commission the lithology of the reservoir rock in the areas we're talking about?

A Yes, sir. We have a general description

of the lithology under Section E of our Exhibit One and I believe I'd -- perhaps I'd best just read this.

"Although the majority of the industry's oil reservoirs that are fractured are those that comprise a rock with matrix porosity laced with fractures, the operators in the Boulder and Puerto Chiquito Pools have recognized the producing reservoirs to be of fracture porosity only."

And references are made to the -- to the study.

"Performance of wells in the Gavilan Pool are showing the same characteristics. It is clear that the Gavilan also produces from fracture porosity only.

The subject reservoirs are referred to as fracture reservoirs and occur in the Niobrara member of the Mancos shale formation. The lithology of the rock varies from shale to siltstone to sandy layers, and sometimes containing a high percentage of calcium or dolomite."

And we make reference to some papers that have studied that.

"The rock property which is significant n the determination of oil in place is 'effective hydrocarbon porosity'. It is an eluisive physical characteristic impossible to evaluate from currently available core and log data.

Effective hydrocarbon poroisty can be approximated from the statistics of depleted pools given a reasonable estimate of the pool's areal size. As to reservoirs early in their production lives, the only reliable method of estimating effective hydrocarbon pore space is be interference testing. Conventional drawdown and buildup analyses are woefully inadequate for this purpose."

Q Now, Mr. Greer, you have conducted interference tests in the Canada Ojitos Unit, have you not?

A Yes, sir.

Q What results did you obtain by conducting these -- in conducting these tests?

A We found that oil in place per acre to be on the order of 2000 to 2500 barrels per acre for -- for the zone that we were producing, and I might add, in Canada Ojitos we were dealing with one zone and so we had what an engineer might refer to as a nice, neat problem to deal with. We did not have the complication of additional zones to -- to influence the test, and so we were able to tell a very, what I consider very accurately for the kind of information otherwise available, the amount of oil in place per acre, and at the same time we determined the reservoir transmissibility.

The reservoir transmissibility much higher than the individual transmissibilities determined

from buildup tests and drawdown tests on individual wells, simply because these wells are completed in what I call tight fractured blocks and the tight fractured blocks surrounded by high capacity fracture system, and this high capacity fracture system, it appears, contains maybe half of the oil in place.

Q Now, Mr. Greer, would you go to the next page in this exhibit and review for the Commission the results of your work in this area concerning fracture porosity as opposed to the matrix porosity in the subject area?

A Yes, sir. On the green sheet we make a comparison of what we found in this fractured reservoir with typical characteristics or characteristics typical of sand, and for this 2500 barrels per acre -- I've used 2500 here -- that could be contained in a sand with 10 percent porosity of about three feet, or about two feet of producing sand with 15 percent porosity.

So we showed on the bottom schedule a comparison, then, of the transmissibilities that would be anticipated from a typical sand.

If it's sand three feet thick and permeability one millidarcy, the transmissibility would be about 3 millidarcy feet as shown in the fourth column.

If the sand is two feet thick and 15 percent porosity and 10 millidarcy permeability, it would have

transmissibility of 20 millidarcy feet.

Now we did not measure 3 or 20 or 100 millidarcy feet in our interference test. We measured transmissibility in the range of 5 to 10,000 darcy feet. This means to me that there's no way that the reservoir in which we were taking the interference test was a matrix or sand porosity. It just doesn't fit the characteristics of sand reservoir, and this is important when we get to the problem of studying the possibility or the potential of gravity drainage.

It really doesn't have much to do with whether Gavilan is in trouble. It doesn't make any difference whether it's producing from a fracture porosity or a matrix porosity, Gavilan's in trouble.

So from that standpoint it doesnt make any difference, but it does make a difference if we are dealing with sand or fracture reservoir when it comes to gravity drainage.

Q Now, Mr. Greer, at this time I'd like to ask you some questions and direct your attention to the effect of solution gas drive in the Mancos formation in this area.

MR. CARR: May it please the Commission, we have some slides that I think will assist Mr. Greer in presenting this part of the case. We also have

hard copies of this material that we have marked as our Exhibit Number Two and can circulate at this time.

We need to, I think, dim the lights.

Q Mr. Chairman, what we want to show here is a comparison of recoveries from solution gas drive mechanism for a sand reservoir as compared to a fractured reservoir, and the solution gas drive recovery mechanism is dependent on the gas dissolved in the oil that gives it the energy to move and we find it is -- in deeper reservoirs there's more gas involved than oil.

In the Gavilan the pvt data that we have shows about 38 percent shrinkage or 38 percent of the reservoir pore space would be occupied by gas, if there were a way to separate the gas and the oil in reservoir and measure the comparative amounts.

Q Mr. Greer, you were talking from the first slide, or page one of Exhibit Two.

A Yes, sir.

Q Would you now go to the second page, which is an illustration showing relative permeability in a sandstone reservoir?

A Yes, sir, we show on this slide some sand grains surrounded by oil. I show no connate water in this instance to simplify it and this is for the -- we have as-

sumed here 100 percent liquid saturation; pressure, if it's above the bubble point and the well is produced the oil will expand. The pore spaces would still stay filled with oil. You'll have 100 percent liquid saturation until you reach the bubble point. Then at the bubble point as the pressure drops, gas starts to come out of solution and we show that on the next slide.

Q Okay, and that's page three of Exhibit Number Two.

A Yes, sir. And in a sandstone reservoir with good relative permeability characteristics, the gas becomes trapped in the interstices between the sand grains and doesn't move and oil flows around it and as the pressure drops the gas, more gas comes out of solution, the oil shrinks and the oil expands and that takes a little while to get that concept in one's mind, but as the oil is withdrawn from the reservoir by production, the remaining oil tends to expand to take up that space but it can't go all the way and so some gas comes out of solution to help, and we speak even though the oil is expanding, we speak of it shrinking because the space occupied by the oil shrinks and there's just more -- gas space.

As production continues, then, the gas bubbles apparently begin to link together, as shown on the next slide, and at this point the gas then moves much more

rapidly through the pore space. By moving rapidly through the pore space there's more gas produced with each barrel of oil and then the pressure drops faster with each barrel of oil produced than it did before, and as the pressure drops the oil shrinks, the gas space increases, and a vicious cycle is started in which there is a continually increasing ability for the gas to move through the pore space and the pressure to drop.

Q Now these first four pages or slides illustrate a typical cycle for a solution gas drive reservoir, do they not?

A Yes, sir, for a sandstone reservoir.

Q Are you ready to go to the next slide on page number five?

A Here we show the relative permeability characteristics. The three solid lines on the right represent relative permeability characteristics for a fractured reservoir.

The dashed line represents the line that I used in calculating what we might anticipate for a solution gas drive in this area.

The wavy line on the left is -- shows characteristics for a typical sand and we note at the bottom of the graph, if I could point to it, this is 100 percent liquid saturation on the right, 90 percent liquid saturation

about where the gas first starts to appear as a free gas in a sand reservoir.

In a fractured reservoir the gas starts immediately.

Given this relative permeability ratio and the pvt data of the oil, the relative permeability characteristic is characteristic of the reservoir rock, the pvt data is characteristic of oil, given those two things an engineer can calculate the recovery of oil in place by the solution gas drive.

Q Will you now go to page six of Exhibit Two, identify this and review it?

A This is the -- shows the relation which I calculated for -- for solution gas drive for the dashed line relative peremeability characteristics and pvt data for West Puerto Chiquito.

Now Gavilan pvt data, as best we know it, is about the same as West Puerto Chiquito.

On the vertical scale on the left we show the pressure scale and this is the pressure line running down.

The gas/oil ratio scale is on the right and this is the gas/oil ratio curve.

For this reservoir, these characteristics, I come up with about 5-1/2 percent of the oil in place

to be anticipated to be recovered then at about 175 - 150 pounds reservoir pressure.

If the price of oil and such allows continued operations, there could be a little bit more recovered at the lower -- lower pressures.

Q Now, Mr. Greer, are you ready to go to the next slide?

A Yes.

Q Would you identify this, please?

A I've shown schematically here some fractures and here we show by brown the impermeable matrix; green, a thin connate water film and then in the center of the fractures the (unclear) oil.

Q Now go to page number eight, please.

A And here we show what happens when we reach the bubble point in this particular reservoir. There are no -- there are no restrictions to the gas in the fractures. Once the gas comes out of solution and bubbles form, they're going to move right in the direction of wherever the oil is going. There's nothing to impede their progress and so that's why gas/oil ratios start high quicker in a fractured reservoir than they do in a sand reservoir.

Q All right, would you now go to the next slide or page number nine?

A And here we show the high capacity chan-

nel which is going to develop soon after the gas starts to move through the -- through the fracture.

The oil shrinks up against the walls, thickens as the pressure drops, and will be left in such a way that it's impossible to recover it by any enhanced means later on. If -- if a high recovery solution gas drive is intended or attempted to be achieved in the reservoir, you have to do it in the primary stages, or the initial stages. You can't wait to deplete it like you can in sand reservoirs, and go back and then with enhanced methods get the oil you left behind. Once it's left in the fractured reservoir, it's there forever.

Q Will you go to page number ten in Exhibit Number Two, the next slide? What does this show?

A Well, this shows that even in a sand reservoir, depending upon the cementing characteristics of the sand grains, it's possible to have a flow channel somewhat similar to the fractured reservoir, and in a sense this sand would have a poorer relative permeability characteristic.

We don't know if that's what happend in Gallegos Gallup but Gallegos Gallup, according to the study made by the consultants when secondary recovery measures were contemplated some thirty years ago, they came up with a

relative permeability characteristic poorer than what I've selected for a fractured reservoir. Perhaps this is what happened in Gallegos Gallup. We don't know, but that's a possibility.

Q All right, Mr. Greer, would you now go to the next slide, the last page in the Exhibit Number Two and explain that?

A In this graph we anticipated the production histories of two reservoirs that had the same kind of oil but they had different relative permeability characteristics.

The upper curve shows pressure for a sand reservoir extending on out at depletion to about 20 percent of oil in place.

Q That's the curve that has BHP above it, is that right?

A Yes, sir.

Q All right.

A It's corresponding gas/oil ratio follows along this lower line and we know that by the time the gas/oil ratio for this particular reservoir reaches about 3000 cubic feet per barrel (unclear) 2000 - 3000, that more than half of the oil has been produced from this sand reservoir.

By the same token, for the fractured re-

servoirs we show a pressure decline by the red colored area runs from about 4 to 6 percent of the oil in place and the gas/oil ratios run much higher, of course, than in the sand resevoir, and so ultimate recoveries are substantially less then for the fractured reservoirs as compared to the sand reservoirs. Not only is there less oil in place in a fractured reservoir than a sand reservoir, of that oil in place a smaller percent is recovered in a fractured reservoir.

Q Now, Mr. Greer, I'd like you to go back for a minute to page eight and ask if you could briefly describe the effect of gravity segregation on this example.

A Yes, sir. We can see here how in a fractured reservoir it's possible to have gravity drainage and gravity segregation that's going to come about much ore readily than the sand reservoir.

For instance, once those bubbles form, if they have an up-dip direction to go and the pressure gradient from wherever these bubbles are to the producing well is less than the segregation pressure, the difference in densities of the gas and oil, those bubble would rise to the surface, you'll have gravity segregation and variable drainage, an opportunity to recover a high volume of oil.

This is a very powerful force. If those pressure gradients are held low in the reservoir in producing wells, there's just no way to stop those bubbles from

moving to the top and the oil from going to the bottom.

Q Now, Mr. Greer, at this time I'd like to direct your attention back to Exhibit Number One, and that concludes the slide presentation, and direct your attention in Exhibit One to Section F and I'd ask you to first identify the first document behind the index Tab F.

Is this the same graph that was included in Exhibit Two on page number 5?

A Yes, sir.

Q And do you have anything to add to your testimony at this time from this particular exhibit?

A No, only that I guess we would apologize for not having all of these hard copies in this particular exhibit. We presented all of them at the hearing three years ago and in order to save time I thought that we could just skip over the details but upon review, why our counselor suggested that we should not make that -- to try to save time at this point, so that's why we have them in this fashion.

Q Would you identify the next exhibit in this packet?

A It's the same exhibit as the last slide and the last page of our Exhibit Two, Page 11.

Q And this is colored as the slide.

A Colored as the slide, yes.

Q All right. Would you now turn to the information contained behind index Tab G in Exhibit Number One and identify that and then, if you would, explain what this comparison shows?

A This is a comparison of the rates of depletion in West Puerto Chiquito and Gavilan, and the reason we show this is that I have said that Gavilan is being overdrilled and over-produced, and although the Canada Ojitos Unit may not be an ideal comparison of what Gavilan should -- should try to be the same as, the comparison is nevertheless helpful to see the difference in depletion rates that are taking place in the two different pools side by side.

In Line 1 we show anticipated recovery in barrels per acre for the two different pools and I have identified by the asterisk how I arrived at those recovery factors.

Q As to the 300 figure, would you review in detail what is included within that figure?

A Yes, sir. In that 300 barrels per acre we've included approximately 200 barrels an acre of solution gas recovery and then another 100 barrels per acre divided between oil production above the bubble point, a hoped for thing, we're not sure that there was a pressure above the bubble point when Gavilan was first drilled, but many of us think that's a possibility.

And the rest of it is from gravity drainage.

Now, this was what we had hoped for if there had not been too -- too many wells drilled and too high a rate of production unless a change is made in the way the pool is being developed.

So for Gavilan and for future production the 300 barrels per acre is probably high, so we might keep that in mind as we look down through the schedule.

Under Line 2, if we have an allowable production rate of 700 barrels per well per day, that's the same for both areas.

The depletion rate, then, in terms of acres per day, this may be a depletion rate that people have not really thought much about before, but in this instance it's significant, how many acres a day is a well depleting; in Canada Ojitos about one acre a day; in Gavilan, then, at least two acres a day, maybe closer to three.

The well density in West Puerto Chiquito, 2500 barrels per acre, or within the Canada Ojitos Unit, 2500 acres per well, I'm sorry; in Gavilan about 320 acres per well.

Then if we divide this well density in terms of acres per well by the depletion rate in terms of acres per day, we arrive at the number of days that it takes

to deplete that particular well's tract.

In Canada Ojitos it's 2500 days, several years.

In Gavilan it only takes 140 days to pull all the oil out from under the well spacing unit and this doesn't mean that at the end of the 140 days that the well starts pulling oil out from under its neighbors. We've found from the testing that we've done that this begins to take place within if not days, a matter of hours from the time a well goes on production in Gavilan it's beginning to drain its neighbors.

Then if we have an allowable it's depleted at the same rate as Canada Ojitos is depleted. Canada Ojitos is 700 per well; the comparable depletion in rate allowable in Gavilan would be 39 barrels a day.

Q Now are you saying that's the proper allowable?

A No, sir, we're not saying that's the proper allowable. In this instance our applications are asking for 200 barrels per day. But what we're saying is that 200 barrels per day is plenty. It's more than adequate.

Q Do you present subsequent calculations that justify the 200 barrel allowable figure?

A Yes, sir.

Q And on this exhibit the 700 figure in the

second line, we're talking about the state's depth bracket allowable, is that what we're talking about in Line 2, the production rate, that 700 figure?

A Yes, sir, the -- the allowable for Gavilan now is approximately 700 per well and 320-acre spacing, and within the Canada Ojitos Unit wells drilled on the same spacing, it's the same 700 barrels.

Q Now, Mr. Greer, have you participated in recent meetings with operators in the area?

A Yes, sir.

Q And at those meetings what concerns have you discussed concerning possible solutions of the problem in the Gavilan - Puerto Chiquito areas?

A We've talked about, and I believe that all the operators recognize that there's a problem, and they appear to have differences as to -- to how to solve the problem. They appear to be in agreement that allowable should be reduced. They appeared not to be in agreement as to the level at which the well was to be reduced and they've had some -- discussed some arguments against the allowables which McHugh and Benson-Montin-Greer recommended.

The main arguments that they put forth are shown on this first page under Section H.

The first one is a change in allowable during development of a field is an improper regulation

since it adversely impacts industry's plans made at an earlier time.

Another argument put forth is that the allowable change will caue economic hardship.

And another argument is reduction in production rates from current levels, if undertaken, should be proportional to current rates of production.

Q Mr. Greer, do you believe that changing allowables during the development of the field is an improper type of regulatory action?

A No, sir, I don't. We set out our position in that respect under -- on the second page, the pink colored sheet following the yellow colored sheet.

Q In Section H?

A Under Section H.

Q And basically what is that position?

A That position, as we describe it on the second page under Section H is that any rule or regulation of the Conservation Division is subject to change. The Conservation Division is obliged to make changes in any of its rules and regulations whenever information is developed supporting such a change and this information is brought before the Commission in accordance with its rules.

The operators cannot be guaranteed that any given allowable will remain fixed throughout any parti-

cular time or phase of development or depletion in the life of a pool, including an operator's payout period for his development program.

The risk of a change in allowable is just one of the many risks an operator assumes when he drills a well.

Q What about the argument that an allowable change will cause economic hardship on certain operators? What's your response to that?

A We set out our response to that on the blue colored page, the third page under this section.

And we say, as noted in Item 1, Page 2, the owner of a well assumes many risks when he undertakes the drilling of a well and some of those risks are factors affecting economics. Just as the Oil Conservation Division cannot guarantee a fixed allowable, it cannot guarantee the stability of other economic factors, such as fixed price for oil.

Those owners developing West Puerto Chiquito have in the past faced many economic adversities, including tier one category pricing and windfall profits tax for oil.

Initial development conditions in West Puerto Chiquito included a price for oil of $2.05 per barrel at the wellhead when drillins costs approximately $180,000

per well, compared to today's drilling costs of approximately $500,000 per well, this would equate to an oil price of about $6.00 per barrel at the wellhead.

Although current economic conditions are not favorable, they still are not as adverse as those under which the West Puerto Chiquito Pool was initially developed.

Q Mr. Greer, do you agree with the idea that any reduction in the current level of production in this area should be on a proportional basis?

(Thereupon a recess was taken.)

MR. STAMETS: The hearing will come to order.

Q Mr. Greer, when we recessed I had just asked you if you agreed with the idea that any reduction in the current level of production in this area should be on a proportional basis. Will you comment?

A Yes, sir, I feel very strongly that it should not be and --

Q Would you explain why?

A -- we set out on a green sheet, the last sheet under this section, our arguments, and although ordinarily I dont like to read my testimony, I think in this instance I need to read this information set out here.

This argument, implicit in it are two unwarranted assumptions. One is that the existing allowable is a proper allowable and the other is that each well's share is a proper allowable, and the other is that each well's share of the pool's recoverable oil is directly proportional to well productivity.

As to the first reason, and as shown earlier herein, the existing allowable is unreasonably high give the anticipated average recovery from a 320-acre proration unit, absent pressure maintenance and gravity drainage, which refutes this assumption.

As to Item -- the second one, Item B, listed above, that a well's productivity is in direct proportion to the well's share of the pool's recoverable reserves, we note the following:

1. As shown earlier herein, hydrocarbon pore space is greater for those parts of the reservoir which have higher transmissibilities. The proportion, however, is not one to one; rather the hydrocarbon pore space can be expected to vary with transmissibility approximately as the cube root of the ratio of transmissibilities of the two areas.

2. This variation in reservoir pore space throughout the pool can be described only on an area basis, not on an individual well basis.

Extensive testing in West Puerto Chiquito has shown that not only are individual well productivities not representative of area reservoir characteristics, but information derived from pressure buildup tests, although yielding better information than well productivities, still does not show the area's reservoir characteristics.

In this type of a reservoir such information can be determined only through interference testing.

4. As a consequence of the above, it is a practical impossibility to relate well productivities to reervoir volume directly, such that well productivity would be a proper parameter to use in determining well allowables.

We note, for example, that wells in West Puerto Chiquito have indicated productivities up to 10 to 20,000 barrels per well, and a 70 percent reduction thereof, the approximate reduction proposed in Cases 8950 and 8946, could still result in allowables of 3000 to 6000 barrels per day per well, unreasonably high figures.

Q Now, Mr. Greer, would you identify for the Commission the document contained behind index Tab I in Exhibit Number One?

A Yes, sir. This is a recommended proposed special rules and regulations which would apply to the pressure maintenance project in the Canada Ojitos Unit in the event the Commission adopts our recommendation. This would

be a starting point for the Commission drawing up its rules.

Q Now, Mr. Greer, throughout --

MR. PEARCE: I apologize, Mr. Carr, for interrupting your examination of this witness.

We are not here on an application for a pressure maintenance project, are we?

MR. CARR: No, we are not here asking for a limit on that. We're here to restrict production as set forth in the application.

MR. PEARCE: In the -- and the way in which the witness just discussed the source of these special rules and regs, I don't understand. Could you have the witness go through that again?

MR. CARR: Yes.

MR. PEARCE: Thank you.

Q Mr. Greer, would you explain why the proposal is contained in the format it is as the last part of Exhibit One?

A Yes, sir. The regulations and the rules that we're currently living under in our pressure maintenance project sets out the allowable and a gas/oil ratio. For instance, it says the gas/oil ratio is 2000-to-1, so that if the Commission adopts a different gas/oil ratio, then it, perhaps, would just automatically flow through the rule that the pressure maintenance project is under.

But it would seem to me that it's appropriate for the pressure maintenance project special rules to be modified so that they're compatible with what this order will be if it's changed from the condition it's in.

MR. STAMETS: Mr. Greer, these rules would apply only to the West Puerto Chiquito Mancos Pool and the Canada Ojitos Unit.

A Yes, sir, that's all --

MR. STAMETS: They would not apply at all to the Gavilan.

A Well, no, no, sir. We're not talking about pressure maintenance.

Q And that's simply where these figures are contained in the rules under which you operate.

A Yes, sir, if we don't change these special rules, then there would be a conflict between the order which we hope the Commission will enter and the rules that we have to live under for the pressure maintenance project.

Q Now, Mr. Greer, throughout the -- this hearing one of the conflicts which bears on, I think, all the discussions is gravity drainage.

I'd like now to ask you several questions about gravity drainage and its impact on this reservoir, and

would ask you now to refer to what has been marked as Benson-Montin-Greer Exhibit Number Three.

A Exhibit Number Three is in a red cover.

Q It's also in a red cover.

A Also in a red cover.

Q All right, Mr. Greer, would you refer to the first document contained in Exhibit Number Three, which is a portion of a well log, identify this, and review for the Commission what is shows?

A Yes, sir. This shows the three principal producing zones that we've identified as A, B, and C Zones. We recognize them in Canada Ojitos area and West Puerto Chiquito Pool.

It appears to be the same zones are -- are -- exist in Gavilan and with respect to gravity drainage, I have assumed that the different zones are separated.

Now we know that in places where a fault exists that probably all three zones are tied together and there could be gravity flow directly from top to bottom through the section.

To be on the conservative side I've assumed that the reservir is a stratified reservoir. We know that in some instances as far as individual wells are concerned, that the zones are isolated.

So in order to calculate gravity drainage

I've dealt only with the dip of the formation and the assumption that the oil will flow down dip, not down the -- directly down the well, or down the formation from top to bottom.

Q Will you now go to the pink sheets that follows the log section and identify those?

A I show here where I arrived at the method of calculating gravity drainage and, Mr. Chairman, I'd point out again, here where we're dealing with a different kind of a formation and not as typical, namely this fractured formation, that the formulas ordinarily used to calculate gravity drainage are not much help. The problem is, as shown on the second of the pink sheets, where Muskat shows gravity drainage in terms of barrels per day per acre, the third equation on the sheet, it's expressed in terms of permeability and we just don't -- can't measure permeability directly in this formation, nor can we measure pay thickness.

We can from interference testing come up with transmissibility in terms of permeability feet. We can get some kind of an idea from individual well testing, although not much, but there again we're limited to permeability feet, and to convert this to a practical formula that we can use and apply in this area, I took Muskat's formula and changed it as shown, or from that worked to a expression in terms of barrels per day per linear mile along

strike, and this information was first presented to this Commission in Case 3455, in 1969, BMG Exhibit 2.

Q Now you're talking about the blue sheets --

A Yes, sir.

Q -- in this exhibit.

On the second blue sheet we show Muskat's formula at the first of the equations at the top of the page, then how we go through and just by very simple, elementary mathematics convert the relations to one that's useful to us, which gives us, at the bottom we show the different barrels per day per linear mile along strike.

And on the third blue sheet we show what that formula is, and --

Q Has anyone else used this basic approach to calculating gravity drainage rates?

A Generally -- generally no, and in searching through the literature to see if anyone else had developed this same kind of an approach, I found it very difficult to locate it, but I did find one article, which is shown on the yellow colored sheets, published in the AIME Transactions for 1949, and article by Elkins, French, and Glenn, we show the title page of their article on the second of the yellow sheets, and then on the third of the yellow sheets the formula that they arrived at, they determined in

the pool that they were working in that they needed to know a gravity drainage in terms of distance along the strike, the same as I had done for this area, and their formula is shown as the third, third equation on this yellow sheet, and they expressed the density of the oil in terms of pounds per square inch per foot, and Muskat in his work used density in terms really of specific gravity in which water is equal to 1.

So we convert Elkins, French, and Glenn's formula by -- back to specific gravity and when we do, as shown by the penciled notations on the page, and we come up with exactly the same formula that I did by working straight from Muskat's initial work.

Q Mr. Greer, would you go to the graph contained in this exhibit on the green sheet, entitled Gravity Drainage Rates, West Puerto Chiquito --

A Yes, sir.

Q -- and would you review that, please? Are you ready to go to that yet?

A Yes, sir. By using the formula just described to calculate the gravity drainage rate in terms of barrels per day per linear mile along the strike, and I've shown it here for dips running from 800 feet per mile down to 100 feet per mile.

The work which McHugh's witness, Dick El-

lis, mapped that he put on in the early part of this hearing, showed dip approximating 100 feet per mile. We used the bottom line here as the applicable dip for Gavilan, for a good part of Gavilan, and transmissibilities we've seen from the interference testing, although we can't calculate oil in place directly, we can make an estimate of transmissibility by analogy to the tests which we made in Canada Ojitos.

In Canada Ojitos we found that we could pick up an interference effect within 24 hours of observation wells a mile away from the producing well, and we found the same thing in Gavilan.

Now in West Puerto Chiquito we knew that the oil was under-saturated and in Gavilan we don't know that it's under-saturated at the time of the test. But what that means is that if the oil is under-saturated, otherwise the analogy is the same, we can expect the same transmissibility for the reservoir in the Gavilan as was found in Canada Ojitos.

Now if the oil is saturated and not under-saturated, then the transmissibility in Gavilan is higher than what we have shown.

Those transmissibilities run in the range of 5 to 10 darcy feet and those are the last lines on the righthand side of the graph which projected up to 100 feet per mile dip, show gravity drainage rates of 200 to 400 bar-

rels per day per linear mile along the strike, and circling the Gavilan nose we can come up with 8 to 10 miles along the strike and so that means like 2000 to 3-or-4000 barrels per day possible potential gravity drainage rates in the Gavilan.

Now even if we were to cover only a small part of that, that's significant and it's something which we feel the operators should strive for in Gavilan.

Q Mr. Greer, when you make this comparison, does the dip in the West Puerto Chiquito area, is it comparable to what you see in the Gavilan?

A Yes, sir, it is comparable. The -- in some of the discussions we've had with engineers estimating gravity drainage rates, they point out, to where you have those real steep dips in the Canada Ojitos Unit, up to 1000, 2000 feet per mile. But those steep dips in the Canada Ojitos Unit are in the gas cap. They don't have anything to do with the rate of gravity drainage in the main part of the reservoir.

The main part of the reservoir with gravity drainage has dips of 200 to 400 feet per mile and the best gravity drainage area we have is 200 feet per mile, only twice that of Gavilan, so they are comparable. They are quite comparable.

Q Have you prepared a comparison of gravity

drainage rates for a fractured reservoir and also for a matrix sand reservoir?

MR. STAMETS: Could we stop for just a minute?

MR. CARR: Yes.

MR. STAMETS: I'd like to be clear what Mr. Greer is telling me here, based on the last -- on Figure Five, the Gravity Drainage Rates.

Mr. Greer, are you saying that in what is now designated the Gavilan-Mancos Pool, that under -- well, under what you would consider maximum operating conditions or maximum efficient rates of flow, or production from this pool, that from the overall pool we could expect to get 2000 to 4000 barrels a day gravity drainage within the reservoir?

A Yes, sir.

MR. STAMETS: Okay. Now, is this at the production rates which have been proposed by you and Mr. McHugh and if the current production rates continue to prevail, will this 2000 - 4000 barrels a day go away?

A Yes, sir, the 2000 - 4000 a day is dropping every day and the comparison is this: As the gas/oil ratios rise and the -- as you'll recall from our -- our slide presentation, the ability of the gas to move increases rapidly. At the same time that the gas production and gas

moving increases rapidly, the rate of oil movement decreases rapidly, and so once the bubble point is reached and the pressure drops below that, then the rate of movement of the oil through the reservoir drops off fast, and this may not show up in a well, in an individual well; as the gas/oil ratio increases in a flowing well, the column gets lighter and it will even produce better and you think you have a higher productivity for the reservoir. The rate at which the oil moves through the reservoir and the gravity drainage part drops off significantly, and it is so significant that that is one of the reasons for the timing, and why the timing is so critical.

I would estimate that somewhere in the range of six months to twelve months, that that gravity drainage rate will drop from its maximum amount down to almost zero. For all practical purposes it will drop down to where it just would not be feasible to attempt to recover and that's -- that's why the urgency of this order, to give the operators an opportunity to look at the problem, to see if they agree with this, and to do something about it, and if, for instance, and I've taken a simple for instance, but if we can change not 100 percent of the gravity drainage potential but 10 percent of the gravity drainage potential, just one-tenth of what's possible, then that is equivalent to the solution gas drive, because, you see, the gravity

drainage potential is like 55 percent of the oil in place; from the reservoir information that's available we know about that. Solution gas drive is like 5 percent. So if we can get one-tenth of the gravity drainage potential, we can double the reservoir's recovery, and I'm estimating in round numbers from the rate at which the pressure is declining and the other information we had before, the Gavilan is looking at something like 5-milllion barrels in the future. If you double that to 10-million barrels, there's 5-million barrels of additional gravity drainage that can be recovered, can be recovered, say at $10 a barrel is $50,000,000.

If in a year that potential disappears, then we've lost $50,000,000 of future recoverable oil and you convert that to dollars a day and that's like $150,000 a day that we're losing. If it's direct proportion and it probably is, for every day this hearing continues, we're losing another $150,000.

So we're producing maybe 70, $60 or $70,000 worth of oil a day and we're losing twice that. I think that's a reasonable explanation.

I hope that's the answer to your question.

Q Mr. Greer, to follow up on that, if the application of Benson-Montin-Greer and McHugh is granted, something happens and gravity drive, anything doesn't work

as you've done it, who's harmed?

A Oh, there'd be no harm. There'd be no harm. The oil is still there and if it's solution gas drive recovery that everybody is going to look to, why, then nobody would be harmed, it's still there.

Q What's the effect of not granting this application and continuing?

A Well, one of the effects is going to be that we have a very serious problem in continuing our operation in -- in Canada Ojitos Unit.

For twenty-five years we've done our best to recover the maximum amount of oil, utilizing gravity drainage, restricted production rates, and we just don't know that the permeability restriction which we hope is between the two pools will be effective enough to protect us or not, and in addition to the gravity drainage recovery that Gavilan is going to lose, we will lose the gravity drainage recovery that we have every reason to believe and expect that we should be entitled to.

Q And in a nutshell isn't that why you're here?

A That's why we're here.

Q Have you prepared a comparison of gravity drainage rates for fracture porosity reservoirs and also for matrix sand porosity?

A Sure. We've shown that comparison as the last sheet in this exhibit, Exhibit Number Three, and the reason we show this is because there's such a significant difference in attempting to recover oil from a sand reservoir by gravity drainage as compared to a fractured reservoir.

And that's why many sand reservoirs realize only small, small amount of gravity drainage.

Within a fractured reservoir you have high transmissibilities, the ability of oil to move rapidly down dip and there's not much oil in place, so by gravity drainage you can recover all of the oil that's possible to recover in a reasonable length of time, whereas in a sand reservoir that would be impossible.

We make this comparison and I think we just need to go down through every line.

We have two reservoirs with the same transmissibility of 10 darcy feet.

The sand reservoir let's say is 20 feet thick, porosity 20 percent, permeability of 500 millidarcys, and we have the 10 darcy feet transmissibility.

The fracture reservoir we don't know the sand thickness, don't know the porosity, don't know the permeability but by interference test or whatever we know that the oil in place is 3000 barrels.

The comparable oil in place per acre for the sand reservoir is about 31,000 barrels, and the oil in place in a 3 square mile section, say, is one mile along the strike and 3 miles down dip, in a sand reservoir would be 60-million barrels and in a fracture reservoir about 5.8-million barrels.

The solution gas drive recovery percent of oil in place, we'll say it's 20 percent to the sand and about 6 for the fractured reservoir. That gives us a recovery per acre of 6000 barrels for the sand reservoir, 200 for the fractured reservoir. That's solution gas drive recovery.

This recovery then for this 3 square mile section is 11-million barrels for the sand reservoir and about 400,000 barrels for the fractured reservoir.

The gravity drainage recovery, and here I've used 1/2 of a maximum of 55 percent of the oil in place, and I've used that because that's what we think we're realizing in Canada Ojitos, and if it's a good sand reservoir you'll probably get more than 55 percent, but to make them comparable, I've used about 1/2 of 55 percent for both of them.

The barrels per acre recovery under gravity drainage for the sand reservoir is about 8000 barrels, and about 800 for the fractured reservoir.

For the 3 square mile section, 16-million barrels for the sand reservoir, a million and a half for the fractured reservoir.

Gravity drainage rate for both reservoirs, now, is only 200 barrels per day per linear mile along the strike.

Despite all the oil, all the sand, all the volume in the -- in the sand reservoir, its gravity drainage rate is still only the same. I've assumed here that the vertical permeability is zero in order to make the two columns.

Then the number of years that it takes for gravity drainage to reach the equivalent solution gas drive recovery for a sand reservoir is something like 150 years, whereas in a fractured reservoir it's only 5 years.

To obtain the entire gravity drainage recovery it would be like 200 years in the sand reservoir versus about 20 in the fractured reservoir.

So whereas gravity drainage might not be feasible in all sand reservoirs, in a fractured reservoir the characteristics make it entirely possible and a target to shoot at.

Q Mr. Greer, you were present at the first two days of this hearing, were you not?

A Yes, sir.

Q And at that time you heard certain questions asked concerning the impact of your proposal on state revenue.

A Yes, sir.

Q Have you studied that question and prepared certain exhibits which address the overall impact on state revenue of what's being proposed?

A Yes, sir, I have.

Q Are those contained in the booklet with the green cover that's been marked Benson-Montin-Greer Exhibit Four?

A Yes, sir.

Q Would you refer now to the first item in that booklet behind index Tab A, identify that and review the information for the Commission, please?

A Yes, sir. We show under Tab A, we note here that the chairman ahs asked for this information and in order to answer it, to make an informed answer, we checked on what the State's current situation is with respect to earnings and borrowing.

And in Item 1 we show that in the week ending August 15th, that the excess funds on deposit were about 6.1 to 6.25 percent. Approximately $184-million of these kinds of funds were on deposit then.

The longer term interest earnings ran for

CD's about 6.01 percent for a year; for 182 days, 5-75 percent.

$256-million were earning interest at these rates at the time, according to our inquiry.

The cost of money for funds borrowed is that some severance tax bonds were sold in July at the rates indicated there, which was about 6-1/2 percent.

So from the above, then, I've assumed a discount rate of 6-1/2 percent per year to make my analyses, and I noted in this morning's paper that the Fed lowered the discount rate another .5 of a percent and that will soon be reflected in such things as this, and so the 6-1/2 percent that I used may be a little bit high.

Q But this is how you calculated the discount rate.

A Yes.

Q All right, will you go to the next page, please?

A The next page shows posted prices in the Four Corners area by two of the companies, Shell up until the end of 1984 and Giant Refining Company after that.

The price of oil was decontrolled in January, 1981, and since that time we can see how the price has gradually dropped until it reached its precipitous decline here early this year.

I've shown an approximate scale here of the 6-1/2 percent per year escalation, starting from the point at which oil is being sold here in mid-August, and the point of this, Mr. Chairman, is to show what would happen in terms of state revenue if for instance oil that could have been sold today was delayed until later on, say, for instance, it sold two years down the line, it sold for more than about $13.00 a barrel, the State would realize a higher discounted net worth from that oil than if it sold today.

In other words, the State could reduce the allowable, could sell some severance tax bonds for a similar amount, pay interest on those bonds and in two years sell the oil and be ahead financially as compared to producing the oil and getting the income now.

And the question, of course, is what is the price of oil going to do, and I'm sure that everybody in this room studies all the information they can get in that respect, and without exception we find that the analysts have concluded that the price of oil is at the bottom of its cycle now. It's going to have to go back up. It's just a question of when and how fast.

So what this -- what this shows is that for the current earnings or for borrowings for the State, the chances, in my opinion, are very, very good that production can be delayed and produced at a later date and the

State will be ahead by having done that.

Q Would you now go to the next page and explain that graph, please?

A The next graph shows what the current production rate is in terms of barrels per well per day and the purpose of this is to give one more, one more analysis of how the State will not be hurt by reducing the allowables. And we start off by saying, well, current average production rate is approximately 130 barrels a day. In May it dropped down. That was because some of the new wells didn't produce the full month. 130 barrels a day is a pretty good figure for the average production rate in terms of barrels of oil per day.

So I've made the comparison which will show the statistics under Tab B of two wells, and the assumption that I made is that Gavilan would be instantaneously drilled up on 320-acre spacing. We would have current production as fast as the wells would be allowed to produce it, and we'd compare that, then, against restricting the rate not by the amount that we're recommending in this application, but rather severely to about a fourth of what it currently is, and those statistics are set out on Page 1 and they're a little easier to -- to see the comparison on the second white sheet under Tab B, where we show for Example I the initial production rate, 130 barrels a day; for Example

II, about a fourth of that, 37.5 barrels a day.

Production decline rate in percent per year, 72.43 percent for Example I and 5 percent for Example II.

In this decline rate I've used the relation that the ratio of the productivity from one point to the next is equal to e - e raised to the power of the decline rate times ti (sic), e being the base of a natural logarithm.

The producing life, then, for Example I is 5.2 years; Example II, 6 years.

The ultimate recovery for Example I is 64,000; Example II, 71,000 barrels.

The discounted present worth for both examples is 59,000 barrels.

And why I've used more recovery for the well producing at the lower rate is because I have, as shown here, that if the lower rate of production obtained in the field and some gravity drainage results, it is necessary to obtain only one percent potential gravity drainage to realize 10 percent of the solution gas drive.

So I have said that if we increase the solution gas drive recovery by 10 percent, then this well getting some gravity drainage needs to get only one percent, one percent is substantial for gravity drainage to come up

with enough oil that the discounted present worth is the same even if the price of oil stays the same, and the statistics for that are shown in the yellow pages following for a well for 130 barrels a day; on the second of the yellow pages we make a comparison with the continuous discount rate to see whether the engineer making these calculations could have had a big mistake. I come up with about the same thing that he did in the way of discount rate so I feel that the figures are accurate.

On the green colored pages are the statistics for the well starting off with 37-1/2 barrels per day and on the third page we show again the comparison there of the discount, the weighted average discounted at this rate.

Q Mr. Greer, will you go to the graphs that are contained in Section C of Exhibit Number Four and review that for the Commission?

A Under Section C we show these examples, first on the pink sheet plotted on semilog paper.

Q Initially, Mr. Greer, in the caption at the top you've got a figure there and it says Per Year Decline. Would you explain what you mean when you use that term?

A Well, that's the formula I just mentioned. The one I use is the instantaneous rate of decline

where the ratio of productivity varies as the natural logarithm e raised to the power of the decline rate times time.

Q Now would you explain the exhibit?

A We show here graphically the statistics that were shown on the previous pages and of course a semi-log graph is sometimes a bit difficult to -- to realize or get the perspective of the differences in a comparison like this, so we plotted also the same information on the gold colored sheet, in which we used the coordinate scales there.

Here we show that the well reaches an economic limit at 130 barrels per day. If Gavilan was all drilled up, drilled up completely on 320-acre spacing, that's the decline rate that we would see. That's the fastest that you can get the oil out of the ground on average that you can get the oil out of the ground, on average, assuming that the new wells would have the average production of the old wells, which you have some of them making an allowable of 700 barrels a day; some of them are making a lot less.

Then the dashed line shows the restricted rate of production and the fact that you only need 10 percent more ultimate recovery to have the same discounted present worth, even if the price of oil does not change.

Q Now, Mr. --

A So all in all I feel that the State is taking no risk in -- in lost revenue by reducing allowables.

The State particularly has more incentive, it seems to me, to exercise its prerogative regardng conservation.

Q Now, Mr. Greer, you are recommending, as is Mr. McHugh, a production limitation factor that is 400 barrels per day for a 640-acre unit and in McHugh's case, 200 barrels per day for each 320-acre unit.

Could you explain to the Commission how this 200 figure is obtained or developed.

A Yes, sir, I will. But first I think I should point out that the 700 barrel per day allowable in Gavilan now has really no basis, no relation to reservoir characteristics whatsoever. It's based simply on the State's depth and acreage factor and overall it's probably fine for the State's reservoirs overall, but overall the State's reservoirs are normal reservoirs. They're certainly more normal than this reservoir; this is an unusual reservoir and so the allowables which are determined for you might say conventional or the average reservoir really has no application here, and so -- so we look at what factors might be reasonable to use in determining the allowable, and first we go to the statistics of the wells as of now.

Q And you're looking a the first sheet be-

hind Tab D in Exhibit Number Four.

A Yes, I am. Now this sheet shows the total pool production, the production in terms of barrels per -- per well per month, and then we have some more statistics. We'll be looking at all the statistics on graphs in a minute. I'd like to just run through quickly and the second page, the white page, is statistics we have showing again the production rate in terms of barrels per day per well for all the wells in the set of figures on the lefthand side and then we've deducted out wells making more than 300 barrels per day on the righthand side.

Then the next sheet, the pink colored sheet, shows on the righthand side the same information where we've deducted from the pool average wells making less than 25 barrels per day.

Then the next graph, the next -- it's a blue colored sheet under this tab, Tab D, we show here graphically the production from the pool in total barrels per month.

Then the next graph, the second blue colored graph, using all wells, with the barrels per well per day, and this the same graph that we looked at a little earlier, approximately 130 barrels per day, the average production rate for all the wells in the pool.

Then we go to the next graph and we've

deducted out the large wells and we see then that the production for all wells except the large wells is about 80 barrels a day.

Q And that's the green shaded area?

A The green shaded area, and had Gavilan been developed, say, with wells like that, there would not be the problem that we before us today.

The next pink sheet shows by deducting the wells with less than 25 barrels a day, we deduct them, gives us a little perspective of the higher capacity wells, and you can see the jump that happens about the first of the year when more of the higher capacity wells came on stream.

Q All right, Mr. Greer, would you now, using this information, go to Section E of this exhibit?

A Yes, sir, in Section E we show in the first column productivies of sample wells and then in the second column an allowable, which would be -- which I would consider a reasonable allowable for the Gavilan given the Gavilan's characteristics, and for that we use as a base the average production rate of the wells in the pool now, which is 130 barrels per day.

Then we structure the allowable from that point up and down based on the cube root of the ratio of the productivities, which is what we had found earlier is one of the characteristics the formation apparently exhibits.

Now we realize that this would not be a practical formular to adopt explicitly because of difficulty in measuring productivities in the wells. The Commission has always controlled production by an allowable and a gas/oil ratio and I see no reason to change from that now.

But to give an example of just what the variation would be if we would adopt a theoretical formula that the allowable would vary as the ratio of the cube root of the productivities, then we have a second column what that allowable would be. For instance, at 130 barrels a day it's 130, which is our base.

We drop down to 300 barrels a day it would be 172 barrels a down or down to 700 barrels a day it would be like 228.

Compare those figures with what would be the allowable based strictly on productivity, in a sense that's what we have now, 200 barrels a day is more than the majority of the wells can make, and only a few can make 700 barrels a day, and so the net of it is that the allowable now is based strictly on productivity.

The comparison would be like at 200 barrels a day in both instances, the well would be allowed to produce 50 barrels a day more than its theoretical amount.

If you drop down to 500 barrels a day and under our -- this formula the well would be allowed to pro-

duce 4 barrels a day less than what its theoretical amount would be.

But on the other hand by comparison in the last column that the way we're producing now, the allowable we have now, it would receive nearly 300 barrels a day more than it should.

So there's no way to have a perfect formula but at least we can have one that's not as far out in left field.

For a 700 barrel a day rate we would come up with the well should have 228 barrels a day. By the application it would get only 200, so it would be 28 barrels a day less than it really should have and otherwise it's going to get nearly 500 barrels a day more than it's entitled to.

You can carry that on down to 1000 barrels a day or 10,000 barrels a day. There's no reason to stop at 700 barrels a day if allowable can be based on productivity.

At 1000 barrels a day under our formula it would be entitled to 257 barrels a day, 57 barrels a day less than what its theoretical amount should be but by the same token, based directly on productivity it would get 700 barrels a day more than it should, and so on, where under direct proportion the well would get 10,000 a day more allowable than it should.

The basing allowables on productivity we consider is absolutely the only way to determine allowables.

Q Will you now go to the graph which is the next page in Section E?

A This just shows graphically the same information that we looked at that if allowables were based on the cube root of productivity as to what it would be.

Q Okay, go to the next graph. What does that show?

A The yellow colored graph we've shown the difference in the theoretical allowable against the 200 barrels a day which we're proposing. The shaded area at the top of the two lines on the lefthand side show how far the theoretical allowable would be from 200 barrels a day, and for wells with productivities less than 450 barrels a day the stippled area on the bottom shows the difference there.

By comparison if the allowable is 700 barrels a day the area would be much greater and we show that in color on the next graph.

Q Okay, why don't you do that?

A Here in color we compare the amount of excess allowable that a well will receive with a 700 barrel per day maximum allowable, as compared to what we think would be a reasonable allowable if productivities -- or if allowables were based on the cube root of the productivity

if 130 barrels a day is a base.

Q So this is the basis for the 200 figure for the 320-acre unit that you're advancing?

A Yes, sir.

Q Now, Mr. Greer, is it your testimony that production rates must be limited in this area as well as simply gas/oil ratio restrictions --

A Yes, sir.

Q -- ratios being restricted?

A Yes, sir, absolutely. The withdrawal rates, even if there were no free gas, the withdrawal rates are just excessive.

Q Will reducing the gas/oil ratio alone result in an effective relief for the time being for the problem you see out there?

A No, sir.

Q How soon in your opinion must action be taken if the problem is to be avoided?

A It's just a very critical problem and action is neede urgently and just as fast as the Commission can see its way clear to act.

Q If action isn't taken in the immediate future, what consequences do you foresee?

A Well, one of the consequences, of course, is the problem that we've had and we would have in contin-

uing to produce our Canada Ojitos Unit in a manner in which we had hoped to recover the maximum amount of crude oil.

Q Do you believe granting this application and imposing these limitations for ninety days will have any adverse affect on the State of New Mexico?

A No, sir.

Q In your opinion, what is the ultimate solution to the problem that exists in this area?

A The ultimate solution is very clear. Gavilan has to be unitized. Gavilan just must be unitized. That's the only way to avoid the drilling of unnecessary wells. That's the only way that the maximum recovery of oil is going to be realized, and it's the best way to protect correlative rights.

Q In your opinion when we look a the Mancos formation in this area, are we talking about a typical solution gas drive reservoir?

A No, sir, this is one instance in which Mother Nature gave us a choice of -- of the kind of completion mechanism would take place.

It it's produced at a high rate it will be solution gas drive primarily.

If it's produced at intermediate rates there will be solution gas drive plus some gravity drainage and if produced at the lower rates it will be significant

gravity drainage.

Q Sir, I'd like to hand you what has been marked for identification as Benson-Montin-Greer Exhibit Number Five and I'd ask that you identify that, please.

Would you identify that, please?

A Yes, sir. This shows the notices to the affected parties in the area, and the receipts.

Q Is the last document in that exhibit a copy of a letter that was actually sent?

A Yes, and that's the letter that was sent with the notices.

This is the notice.

Q And the return receipts and return letters are attached there, that's the original copy?

A Yes, sir.

Q Mr. Greer, were Benson-Montin-Greer Drilling Corporation Exhibits One through Five either prepared by you or compiled under your direction?

A Yes, sir.

Q Can you testify from your own knowledge as to the accuracy of those exhibits?

A I believe they're accurate.

MR. CARR: At this time, Mr. Stamets, we would offer into evidence Benson-Montin-Greer Exhibits One through Five.

MR. STAMETS: Are there any objections?

The exhibits will be entered.

MR. CARR: That concludes my direct examination of Mr. Greer.

MR. STAMETS: I'd like to ask just one or two questions before we take a break.

CROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Greer, looking at Exhibit Number Four, and we're back the fourth from the last page, comparison of allowables, immediately behind Tab E.

A Yes, sir.

Q Now from your earlier testimony, are you saying that the cube root of ratio of productivity is roughly comparable to how much oil there is under any particular tract?

A The chain of thought, Mr. Chairman, is that the oil under the tract is proportional to the cube root of the transmissibilities of that area and it would be on a rather large area.

Now the productivities of individual wells within that area will be somewhat in proportion overall and on an average with the transmissibility of the for-

mation. But it cannot be determined exactly, just that it's the best comparison that we have.

Q So what you're saying, in essence, is that the -- that the 200 barrels a day comes much more close to representing an allowable that will let everybody produce their share from the individual -- from the reservoir than the 700 barrels a day.

A That's exactly right. It will come very much closer to giving each operator the opportunity to protect his correlative rights.

Q Let me ask a question off the record.

(Thereupon a discussion was had off the record.)

MR. STAMETS: We will recess the hearing until 1:30.

(Thereupon the noon recess was taken.)

MR. STAMETS: The hearing will please come to order.

I assume that there may be a couple of questions of Mr. Greer.

Mr. Lopez?

MR. LOPEZ: Mr. Chairman.

CROSS EXAMINATION

BY MR. LOPEZ:

Q Mr. Greer, I'd like you to refer to your exhibit under Tab C in Exhibit One and I would like to discuss this exhibit with you.

Mr. Greer, I believe a great theme in your testimony this morning was that unless some measures are taken to restrict production immediately, that substantial waste will occur because there will not be the benefit of gravity drainage realized in the Gavilan-Mancos Pool, and in reaching these conclusions you compared the producing characteristics of the Puerto Chiquito Pool and your Canada Ojitos Unit to the Gavilan-Mancos Pool.

I believe you stated that, in this regard, that the angle of dip in the Canada Ojitos Unit where you realize the greatest recovery was approximately 200 feet per mile and that the angle of dip in the Gavilan-Mancos Pool was 100 feet per mile and therefore they compare, the two pools compare favorably.

I assume that the wells which are located in the Canada Ojitos Unit are located along the wester flank of that unit but on the east side of the permeability barrier or at least permeability restriction that you have located on this exhibit in the shaded area with question marks.

A Yes, sir, that's correct.

Q Isn't it true that these wells are at the bottom of the down dip of a dip that goes to the eastern boundary of the unit where you have pressure injection wells?

A I don't believe I understand what you're saying.

Q Well, I'm saying is it your opinion that the oil that you're recovering is drained from the eastern boundaries of the unit where you have pressure injection facilities?

A Yes, sir, to -- to take an example, about the center of the unit, Township 25 North, Range 1 West, Section 13, where we show a well K-13, if you can find that, about halfway between the K-13 and the injection well B-18, located in Section 18 of 25 North, 1 East, was where we felt the initial gas/oil contact was.

The gas cap had what we felt high gas/oil ratio saturation, not a pure gas cap, but the solid oil started at about that 1600 foot contour interval.

Going down dip from there to the west you can see it's approximately 400 feet per mile. Going further to the west you can see it's about 200 feet per mile. That's the area where most of the production has come.

Q Then you'd agree with me, would you not,

that the dip across the unit, Canada Ojitos Unit, is much more severe than any dip we see reflected in the Gavilan-Mancos Pool.

A I believe what I said, that the best area of gravity drainage that we've had in Canada Ojitos was at the 200 foot per mile area, and that would be just east of the well located in Section 10, just west of the area you are presently talking about. You can see the contours there are roughly 100 feet per mile.

By happenstance, the transmissibility in that area, thanks to Mother Nature, was about twice as much as the transmissibility further east, where the dip was 400 feet per mile, so we were fortunate in that the area where it was 400 feet per mile and had the transmissibility, we had roughly the same gravity drainage potential there as we did lower down.

Q Now I note in the Canada -- in the Gavilan-Mancos Pool, in the heart of the pool where most of the wells are drilled, outside the northern end of the pool, that there is no dip whatsoever reflected on this exhibit.

A Oh, I see. Well, I have to apologize for that. As I indicated, by basic map was contoured on 200 feet per mile. I sketched in with the dashed line the 100 foot -- 200 foot contours, they are 200 foot contours. I sketched in with the dashed line a 100 foot contour but in

order to be able to see the Gavilan nose. If I hadn't sketched that in, it wouldn't appear at all, but on this map I didn't see any need, it would be wasting my time to -- to try to contour it closely and accurately when the work had already been done by McHugh.

So to look a the dips we really would need to look at the map which I referred to this morning in discussing that, which Dick Ellis prepared.

I can find it here in a moment if you want to look at it.

It's McHugh's Exhibit Three under Section -- Section C.

Here Dick Ellis has contoured in fine detail the structure as accurately as it can be possibly known at this time. This map, of course, concentrates on the Gavilan structure itself, and you can see there that these are 50-foot contours and there is about two of them per section, which is roughly 100 feet per mile dipping to the west and to the northwest.

Right along the nose it's down to 50 feet per mile and then on the east side of the nose it gets back up to about 100 feet per mile.

Q And I believe you also stated that in your Puerto Chiquito Unit you encountered interference between wells one mile apart within 24 hours.

A Yes, sir.

Q In the Gavilan-Mancos you said you encountered the same experience.

A Yes, sir.

Q Which wells did you encounter this experience in?

A We ran an interference test between the Mallon Howard 1-A in the green circled area on the map that you had earlier referred under Section C in our Exhibit Number One, and the well just east of that, the Canada Ojitos Unit E-6, and some of the pressure data that was recorded during those tests was put on by John Roe in his testimony, and an example of the well approximately a mile away is the effect of the Howard 1-11 when it was shut in about mid-January and within one to two days I measured the pressure change occurred in the pressure recorded in the E-6.

Q Would this suggest to you that your well, then, in Section 6 is actually located in the Gavilan-Mancos Pool rather than the Puerto Chiquito Unit or the Canada Ojitos Unit?

A Mr. Chairman, they're all located in the same common source of supply, the East and West Puerto Chiquito and Gavilan.

Q Then how do you explain the permeability restrictive barrier between the two?

A Well, that's a postulation. I just sincerely hope it's there. We've had some indications that it's there and how effective it is, we don't know. Whether it's in all three zones we don't know, and it's just something I wake up in the night and hope it's there.

Q What indications have you had that indicates that it is there?

A Some small wells to the south, the finger pointing to the southeast to the K-8 Well, which is a rather small well. The finger pointing to the southwest there are some small wells on the Gavilan side.

Coming up to the north there's a small well in Section 31, the K-31.

Moving farther north, we don't know about 30, we'll be treating that well next week or so.

Moving farther north up to Section 8, the J-8 Well appears to be real tight, and moving farther north, the G-32 in Section 32 of 26 North, 1 West, is a rather small well, so we feel there's a permeability restriction through there. Again how effective it is, we just don't know.

Q What can you tell me about that J-6 Well in Section 6?

A The J-6 Well is a -- has lower productivity than the E-6, as we indicated in some of our discussions

in the Engineering Committee.

The E-6 currently produces about 600 barrels a day; the J-6 about 200 barrels per day, so it's not as good a well as the E-6, and it would appear that perhaps it's getting (unclear) from the east, but that's not a certainty. There are wells within the Gavilan Pool where we go from 600 barrels to 200 barrels a day and the pool continues beyond that, so that alone doesn't tell us that we're going to have a restriction.

Q Now, changing the subject, I'd like to ask you whether or not the relationship of permeability to porosity which you described this morning as a cube root relationship and which you used to justify your 200 barrel a day allowable, whether that's no more than an assumption on your part?

A The relation of --

Q I'd like a yes or no, if possible.

MR. CARR: You can explain it. I think his answers are responsive to the questions and I think he should be permitted to answer them. I think the answer will be yes or no but I think he should be permitted to answer (unclear).

MR. STAMETS: We'll allow Mr. Greer to answer this question in his own way and see if it is something we can all live with.

We'll see about any further objection you might have to having yes or no answers.

A The relation of the porosity as a function of the cube root of the transmissibility, is an absolute, simple, engineering fact insofar as a fracture system of parallel fractures and flow in the same direction parallel to the fractures. That is an absolute, simple, fundamental engineering fact; no question about that.

Now, in the reservoir I had assumed , and I grant you that's an assumption, that the porosity would be a little bit higher than indicated there because the fractures are probably not all lined up directly in line with the directional flow and so that's the difference.

To the extent, then, that wells can represent the transmissibility of the formation, then the wells productivity may be indicative of the ratio -- the cube root of the ratio of the productivity then becomes a measure of the pore space in the (unclear).

MR. STAMETS: Did you get an answer to your question?

MR. LOPEZ: I think the answer was yes.

MR. KELLAHIN: I believe the answer was no, Mr. Lopez.

MR. CARR: Mr. Stamets, there

are certain questions which can be answered yes or no. Were you there on Tuesday at 10:30?

There are other questions that you'd never require a witness to answer yes or no because you are looking for an incorrect answer.

Mr. Greer admitted there were assumptions involved and there were facts involved and there were formulas involved that are reliable engineering formulas that are not subject to interpretation, and he was responsive to the question unless the question was, can we take this complicated area and write the whole thing off as an assumption, and if that is what he's being asked to answer yes or no, we object to the question because he cannot give you an honest answer.

MR. STAMETS: Mr. Lopez? Are you satisfied with where we are?

MR. LOPEZ: The answer is on the record and we can discuss it later.

Q I think when you were discussing the Howard No. 1 Well that you stated that the core porosities bore no relationship to the log porosities.

Did you do any -- did you independently do any log analyses of your own to vertify this fact?

A Oh, no, sir, I was just reporting the report of the technician.

Q In your direct testimony I think you also stated that the oil allowable should e 200 barrels a day.

A Yes, sir.

Q As I understand it, you didn't address the gas allowables so does this mean there should be no gas allowable restriction?

A Well, our application asked for the gas/oil ratio limit to be 1000 cubic feet per barrel. While we didn't go into that specifically, I believe, this morning, but that's our application.

Q And was no other independent evidence or data to support that, it is just in your application and you rest on the statement in your application and no other evidence (unclear).

A We're asking that the rate of reservoir depletion be reduced. The existing gas/oil ratio is 2000 to 1, so by reducing the allowable gas/oil ratio limit from 2000 to 1000, we're moving substantially in the right direction to help minimize the depletion rate.

Q And I believe you stated you wanted this limitation for a period of ninety days.

What is going to be your position if the Gavilan-Mancos Pool is not unitized at the end of the ninety days?

A Well, I haven't speculated on that. I

would sincerely hope that that's something that doesn't come about. Surely the operators will realize the situation and will respond. That's -- that's my hope. I haven't planned anything for our unit or West Puerto Chiquito beyond this working toward unitization of Gavilan.

Q Well, isn't it true that if in ninety days that no effort towards unitization are realized that you would want to make these temorary rules permanent, or maybe even just more restrictive allowables?

A Oh, I believe we'd want to think about that and discuss it with the other operators and it's just very impossible to say at this time the progress that will be made in ninety days. At the end of ninety days it may be so close to unitization that we might be ready to go forward with it.

MR. LOPEZ: I have no further questions.

MR. STAMETS: Are there other questions of Mr. Greer?

Mr. Pearce.

MR. PEARCE: Thank you, Mr. Chairman.

CROSS EXAMINATION

BY MR. PEARCE:

Q Mr. Greer, I want to thank you for using a mike (unclear) this morning.

Mr. Greer, if you would, please, sir, in your Exhibit Number One behind Tab C, which contains your structure map.

Do you have that before you, sir?

A Yes, sir, I have.

Q Looking at that, if you would, please, I'd like to refer you to a couple of specific wells. Could you tell me the difference in elevation between McHugh's Mother Lode No. 1 Well and Mesa Grande's No. 1 Gavilan Howard Well?

A Well, I should have brought my magnifying glass, but I believe the Moter Lode appears to be +513 and the Howard -- which one was it?

Q The Gavilan Howard No. 1, and that may be the 1-11, I'm --

A If it's the 1-11, well, I need to refer to --

Q The well I'm looking at, sir, this map shows Mesa Grande Resources Howard No. 1. I apologize.

MR. STAMETS: How about some sections, townships and ranges on this.

A Well, let's see, in Section 23 of 25 North, 2 West.

MR. CARR: That's the Howard No. 1?

MR. PEARCE: The Howard No. 1, yes, sir.

MR. STAMETS: And what about the --

MR. PEARCE: The Mother Lode?

MR. STAMETS: Yes.

MR. PEARCE: That well is in Section 3 of 24, 2.

A Okay, I'm looking at Dick Ellis' structure contour map, if I've got the well, I believe the Mother Lode is +511 and the Howard 1-11 is 438, and the Howard 1-H is 437, both in Section 1.

Q I'm sorry, I was looking at the Howard 1. In looking at your exhibit it appears to be in Section 23.

MR. CARR: Talking about the Mesa Grande Howard No. 1.

Q Mesa Grande Howard No. 1.

A Oh, Mesa Grande, I'm sorry.

I apologize for being so slow. Tell me again the quarter section in Section 23.

Q It appears to be in the northwest quarter section of Section 23, Township 25 North, Range 2 West.

A Okay, I believe that's a +568.

Q What's the difference between those two elevations, please, sir?

MR. STAMETS: For the record Mr. Greer is now utilizing the structure map in McHugh's exhibit rather than the structure map in his own.

MR. PEARCE: Yes, sir, apparently he is.

Those numbers, by the way, on your exhibit, sir, appear to be 513 and 574.

A Oh, I'm pleased that I can get that close to a geologist' interpretation.

Q They probably are, too.

A The difference there is about, looks like 57 feet, going by Dick Ellis' --

Q Okay, and what's the distance between those wells, please, sir?

A They're along the nose of the anticline about, oh, a couple of miles.

Q Approximately two or approximately three?

A Approximately three.

Q Thank you, sir. Mr. Greer, looking --

continuing to look at that exhibit, you indicate the permeability restriction which you answered some questions about, I'm wondering, sir, if you ever conducted a pressure interference test across that permeability restriction?

A No, sir, such a test was suggested by Meridian's engineer, Dick -- or Richard Fraley, and in line with that we're currently trying to work out plans to do that.

Q Mr. Greer, you previously testified about calculating the amount of expected oil in place from the results of interference tests, is that correct, sir?

A Yes, sir.

Q Would you explain to me once again how you did that, please?

A Yes, sir. If one can -- can stabilize a reservoir such that there are no strange pressure transients moving through it, and one has adequate control of the shut in wells and the producing well, and put the producing well to production, then during the transient period in which pressures drop rather rapidly initially and then gradually fall off, during that period of time if the test has been conducted properly and if conditions are such that it can be done, which we found possible in the two tests we ran in Canada Ojitos in 1965 and 1968, then one can calculate, in the instance of our 1965 test, simply by plotting the pres-

sures against time on a semilog plot, one exactly the same relation that you had in the pressure buildup or pressure drawdown in the well, given the proper time period that that's taken.

From that you can calculate the transmissibility, Kh.

Then from the exponential integral solution of the disfusivity equation you can calculate the ratio of permeability to porosity.

So then you have two equations and two unknowns and it's a rather -- by now it's a rather commonly accepted method of calculation. At the time we did it there weren't so many of those -- that kind of test run.

There was a paper written by one of the Amoco engineers that described the process calculated slightly differently but with the same results.

Q Mr. Greer, were you in the hearing on a previous occasion when we met about two weeks ago?

A Yes, sir.

Q And were you here when Mr. McHugh's own geologist concluded that the Gavilan-Mancos Pool is a solution gas drive reservoir?

A Yes, sir.

Q Are decreasing pressures and increasing GOR's predictable and necessary results of production in a

solution gas drive reservoir?

A Yes, sir, might I add that in this particular pool the depletion mechanism is dependent not just on the character of the reservoir itself but how it's produced.

If it is produced at a low rate there'll be substantial gravity drainage in addition to the solution gas drive.

If it's produced at (unclear) there will be no gravity drainage.

So I presume what Mr. Ellis was referring to was that under the current conditions of excessive rate of withdrawal that the depletion mechanism is principally solution gas drive and (unclear).

Q All right, sir, and in your opinion will gravity drainage be as effective a production mechanism in the Gavilan Pool as you believe it is in the West Puerto Chiquito Mancos Pool?

A I don't think quite as effective. It doesn't have to be as effective to be a practical process to try to achieve.

Q All right, sir. Looking back and Mr. Ellis' structure map which we've discussed for some time, a couple of times, am I correct in reading this structure map that the developed area of this pool at this time is on the high part of the pool and the undeveloped area is down dip

from the developed area?

A Yes, sir, that's why there is an opportunity yet to achieve some gravity drainage if it's properly developed from this point forward.

Q And that will require further development in the undeveloped area of the pool.

A Yes, sir.

Q Looking, Mr. Greer, if we may, at I believe it is your Exhibit Number Three, in which you gave your gravity drainage calculations, is that Exhibit Three or am I --

A Yes, sir, that's Exhibit Three.

Q I'm looking at Page 4 of that exhibit. My question is in applying the Muskat formula, as you have modified it, will gravity drainage be eliminated as a production mechanism if production rates are not decreased?

A Yes, sir.

Q What factors in that equation, sir, will be changed to make the Q zero?

A If you look on the next page, Page Five, I believe you will see the formula says that the production rate will be equal to 2580 times Hk and that Hk is the transmissibility is the product of thickness and permeability.

The permeability there is the

permeability to oil and the permeability to oil decreases rapidly as the gas/oil ratio increases and the gas saturation increases in the reservoir.

So that's how -- how it affects the gravity drainage here.

Q Thank you, sir. One moment, please, sir.

If you could explain a little further, Mr. Greer, the last area, when you say that the relative permeability of oil changes, how is that affected in a fractured reservoir?

A Well, as we indicated this morning when we were talking about how when the pressure drops the gas expands and the oil in a sense shrinks and there's a higher volume of free gas in the reservoir, and that restricts the rate of flow of the oil.

Q How does it do that, sir?

A Well, it is very commonly understood in all the engineering treatises on relative permeability that as the gas saturation increases that the oil, permeability to oil decreases. I think it's a pretty common fact.

Q I'm sorry, sir, but if use is made of this transcript in the future I don't think it's going to be by a petroleum engineer.

So I'd like for you to explain to me as simply as you can for a layman that commonly accepted fact.

I don't understand how it works.

A I see. Well, the -- there have been many tests, laboratory tests. There have been many calculations of productivities of wells and you can arrive at it either way or both ways.

As to wells, the productivity of the wells will decrease substantially as the permeability to oil decreases and that's just a physical fact we can measure from time to time. As the oilfield is depleted tests are made on individual wells, the productivity index, and that's the amount of oil that will be produced for a drawdown of 20 pounds, will decrease, and it just happens in all reservoirs.

Q Do you have some indication that that is true of fractured reservoirs as well as matrix or I believe wht you referred to this morning as sand reservoirs?

A Yes, sir.

Well, sir, perhaps I should clear that up. I just realized I overlooked a point and that is if gravity drainage is taking place, then of course the oil and gas segregate and it's in the up dip wells that the productivity drops down, the oil saturation stays high in the low, the wells low on the structure, and so in that instance their productivities stay up.

But that's where gravity drainage is tak-

ing effect and having its influence rather than the solution gas drive.

Q Okay, I did not understand one answer you gave, I think to Mr. Lopez' question, and if you did I'd ask for you to repeat it and if you didn't, I'd like for you to answer it for me, please, sir.

Where is the gas/oil contact at this time as near as you can tell in the Canada Ojitos Unit?

A We put on an exhibit three years ago that showed pretty much how we think the gas/oil contact exists.

I don't have the exhibit now but I can tell you generally that I feel like gas cones down to the producing wells and with the gas/oil contact lying, the main gas/oil contact lying somewhat below the initial contact of 1600 feet, probably between, oh, 1200 and 1600 feet coning down to the individual wells.

Q Thank you, sir. Mr. Greer, short of unitization of the Gavilan-Mancos Pool, how can the present owners of undeveloped acreage protect their correlative rights?

A Well, the first step is production of allowables as we discussed this morning.

Q How does that participate in protecting correlative rights for someone with undeveloped acreage?

A Oh, I misunderstood, I'm sorry.

People with undeveloped acreage, of course, the only way they have to do to protect their correlative rights is to drill their wells under the regulations applying at that time.

MR. PEARCE: One minute, sir. Nothing further at this time. Thank you, Mr. Chairman. Thank you.

MR. STAMETS: Are there other questions of the witness? Mr. Padilla.

CROSS EXAMINATION

BY MR. PADILLA:

Q Mr. Greer, this morning you talked a little bit about the rule of capture and the rule of capture, or you indicated something to the effect that the rule of capture was actually in existence in the Gavilan-Mancos Pool, is that correct?

A Yes, sir, that's correct.

Q In an answer to Mr. Pearce now you just stated that everyone had an opportunity to drill the wells in order to protedt their correlative rights, is that correct?

A I think what I said is in order to protect your correlative rights you had an opportunity to do it, then you had to drill a well. That doesn't mean that

the regulations are such that if you drill a well you cannot protect your correlative rights, so it's not quite the same thing.

Q But there exist spacing regulations presumably to protect correlative rights, is that correct?

A Yes, sir, and what we're saying is that they're not adequate. A man could go out now and drill his well on his tract and he would not be able to get his fair share of the oil because of the high allowable.

Q Mr. Greer, does your application include a spacing change?

A A spacing change, no, sir.

Q Does your application include the restriction of further drilling in the Gavilan-Mancos Pool?

A No, we've not asked that the drilling be restricted. We've asked that the allowables be reduced and we would hope that the operators would voluntarily get together and unitize and minimize the depletion rate.

Q In an emergency situation as you characterize the Gavilan-Mancos Pool as being in right now, wouldn't it be appropriate to expect further drilling in that pool?

A Mr. Chairman, I think that would probably be an appropriate action of the Commission to do that, because an action of the Commission is to reduce the allow-

ables, minimize the depletion rate, and give the operators the opportunity to voluntarily come about a minimum drilling program.

I think it would be highly improper for the Commission to order restriction on the drilling at this time; certainly not until the operators have had an opportunity to produce their share.

Q Well, hasn't your testimony been that there are a lot of wells that are being drilled unnecessarily both for the Gavilan-Mancos Pool and then as a consequence you don't want to drill any unnecessary wells in the West Puerto Chiquito Pool.

A That's right. Unnecessary wells are being drilled and we'd like -- we would hope something could be done to stop that.

Q Now as I understand your testimony, there are no unproductive -- there is no unproductive acreage either in the West Puerto Chiquito Mancos Pool or in the Gavilan Pool. Is that accurate?

A It's pretty difficult to -- to say, Mr. Chairman. An example I gave this morning of a well drilled, produced 60 barrels a day, sidetracked the hole and bottomed it 100 feet away from the initial hole shows no production, one answer to that question would be that that tract was dry, but that's not the case. So --

Q Well, in answer to my question, my question is do I understand you to say that all acreage in both pools is productive, or it is underlain by equal amounts of oil per acre?

A No, sir, I believe I said that I thought there was a difference in the pool in areas, generally, depending upon the transmissibility of the formation.

Within any one of those areas wells can be drilled just like the one I mentioned that show absolutely nothing; move over 100 feet and you show a high productivity on an average; on an average that area generally is productive.

Q But it's not uniformly productive.

A In no way. This is the most non-uniform kind of reservoir that you can imagine.

Q So in your concept of unitization, unproductive acreage would participate equally with productive acreage.

A Oh, no, I'm not suggesting that at all. I would hope that the operators would see the virtue of unitization. They would sit down and work out the problems of unitizing after wells are drilled, and of course that's a -- that is a difficult problem, but hopefully, the operators would see the benefit of unitization and try to work out a method.

I would not suggest any formula at this time for Gavilan. That's just up to the engineers and the geologists as to how they can best work that out.

Now in the Canada Ojitos Unit we have based equities in the third expansion area strictly on acreage, which I think was a fair and proper thing to do.

Q Okay, but this morning you also testified that you did not agree that any proportional allocation based on the productivity of a well to individual owners in the Gavilan Pool, is that correct?

A I'm not sure I understood your question.

Q Well, aren't you against the proportional allocation of reserves in the Gavilan-Mancos Pool?

A I feel certain --

Q Based on productivity of wells?

A Yeah. I feel quite strongly that that the oil in place is not in direct proportion to the productivities of the wells.

Yes, sir, I feel quite strongly about that.

Q Yet in the West Puerto Chiquito you did at one time have a different allocation and not based upon straight acreage.

A In West Puerto Chiquito while we recognized the gas cap as having less value than the -- than the

oil zone, and the net effect, I believe, was approximately one-sixth was assigned to the gas cap.

Q But you recognized that there were factors other than straight acreage which should play a role in that allocation of reserves.

A Oh, certainly.

Q Let me refer you to your Exhibit Number Two, Mr. Greer, and I believe that was the one that you had in slides.

During the lunch hour I've got to tell you that Mr. Nutter thought that you were going to give us a lecture on cholesterol when he saw that.

MR. CARR: I understand why Mr. Nutter would be concerned.

A I appreciate his sense of humor.

Q In looking at Phase III on page 9 of that exhibit, I believe that is the extreme case that you characterize there.

A Yes, sir, this is just a sketch to show the difference between fracture and matrix porosity.

Q Now you also testified that the oil would adhere to the walls of the -- the walls of the fracture and would not break loose.

Does this assume that pressure would be at zero?

A No, sir, as pressure declines and the gas comes out of solution, the viscosity gradually drops in the oil and this is a continuous process from the time the pressure reaches the bubble point until the pressure reaches abandonment pressure of the reservoir.

Q Did this exhibit show approximate time with respect to viscosity?

A It's a function of pressure rather than time. Time will influence it depending on how fast the pressure pulls down and so that's how time would affect it.

Q Well, at what -- at what pressure point would we have the Phase III?

A You say Phase III?

Q Well, yes, the phase that's characterized on that page 9.

A Well, I forget what we had. I believe on page 9, that was the first sketch so that I believe shows 100 percent oil saturation.

Well, I'd better check. Oh, okay, this is after the gas saturation has increased substantially and simply shows schematically how the oil will cling to the sides and not run down the center.

Q Well at what point, at what pressure point would you no longer have any oil production?

A Well, we could go back, Mr. Chairman, to

a lot of the tests that we have on Canada Ojitos wells. We keep daily records of the pressures and the gas volume, and we could draw some curves that would show you how productivity has fallen off with depletions. I have not done that but it could be done for this reservoir, since we have the information.

It just happens as the -- as the gas saturation increases, the productivity of the oil decreases, that there's just less gravity drainage and this can be no other way.

Q In other words, your Exhibit Number Two simply -- simply shows in general terms what could occur in the reservoir.

A Oh, yes, sir, it's just schematic. It doesn't have any statistical exactness to it.

Q It doesn't show when we can no longer produce oil from the reservoir.

A Not that sketch.

Q Mr. Greer, with respect to the permeability barrier, I'd like to hand you a letter that I believe you wrote to three governmental agencies with respect to the expansion. This letter was received by Koch Industries, or Koch Exploration, and I'd like to have you look at the geological and engineering portion of that.

If I may, let me look at this page that I

was --

A Is this the page?

Q Yes, sir, on page 3. Now I don't want to get into an argument with you as to the construction of your own language there, but it doesn't appear to me that it characterizes the situation as bad as you characterized it to Mr. Lopez in answer to Mr. Lopez' question, that you pray every night about that permeability not being there, and I'd like for you to read that, if you would.

A Yes, sir, I will. It's -- this report is entirely consistent with what I was telling you this morning.

On the top of the page -- well, let's see, the K-31 Well, it's west offset shows that the permeability is extremely low in this area and further supports that this is a good location for a boundary separating the reservoirs.

It now appears that wells drilled along this boundary area will probably be of low enough capacity that protective wells within the unit could stop migration of oil from the inner reservoir to the outlying lands. This statement can be true only if the "border area" is wide enough. We now believe this to be the case. I probably should have said hope rather than believe.

Q Well, I believe you used the word "hope" this morning.

A Yes, sir.

Q But it's certainly --

A It's a possibility, yes, sir. It's possible it's there; I still hope it's there.

Q Well, you've -- in your structural map you've actually mapped a permeability barrier there, haven't you?

A Well, I prefer to refer to it as a permeability restriction. I just don't feel I know enough about it to call it definitely a barrier.

Q In the letter you've called it a terrace, have you not?

A I believe so. I think that's probably accurate.

Q What's the -- what's the difference?

A Well, by terrace I meant the dip of the formation levels off and flattens out and I believe when that happens, of course, you re-enter an area where the permeability restriction is postulated.

Q Does that affect gravity drainage, then, in the Gavilan Mancos if indeed there is a -- a dip?

A The indication or the suggestion that I made, in my analysis of gravity drainage in that area, I made a reference to Dick Ellis' structural contour, McHugh's Exhibit Number Three, Section C, in which there is a dip

from the north to the east and hopefully wells located just west of the permeability restriction would be good recovery wells for gravity drainage, but not too many; not too many.

Q Now, the gravity drainage in the West Puerto Chiquito and gravity drainage in the Gavilan-Mancos Pool are entirely different because of the -- the extent of the dip, isn't that --

A Well, as I said before, I feel they're not entirely different. We had a good gravity drainage in Canada Ojitos with 200 feet a mile. There's a lot of Gavilan along the east and west sides of the nose that are 100 feet a mile. Those are generally the same, same rates of dip.

Gavilan is about half as much as Canada Ojitos.

Q Are yours affected by your pressure maintenance project?

A Pressure maintenance definitely helps, yes, sir. I would hope that the Gavilan operators, if they unitize, it would be considered. It's certainly, I'm convinced, a very helpful adjunct.

Q Mr. Greer, your testimony here today is in relation to your own case, isn't that correct?

A I'm sorry, I didn't understand you.

Q Your testimony here today is with respect

to your own case, the Benson-Montin-Greer case.

A Well, of course, it's hard to talk about just our case without discussing how it's tied in with Gavilan, and so that's the reason that we asked that the two cases be heard together. They're just really trying to solve a common problem and if allowables are reduced in Gavilan I think it's appropriate from a good faith standpoint that then Canada Ojitos, West Puerto Chiquito, that we restrict our production the same as Gavilan.

Q Is that a -- does the oil market have anything to do with your desire to restrict allowables, Mr. Greer?

A No, sir.

MR. PADILLA: Just a moment, Mr. Chairman.

I have no further questions, Mr. Chairman.

MR. STAMETS: Are there other questions of this witness?

MR. LYON: Mr. Chairman.

MR. STAMETS: Mr. Lyon, do you have some?

MR. LYON: I'd kind of like to ask a couple of questions, please.

QUESTIONS BY MR. LYON:

Q Mr. Greer, I've been looking through your data to see if there is any estimated porosity in here. Do you have an estimate of porosity?

A The -- the only estimates that we could come up with are based on the oil in place per acre which we calculated for the one zone in Canada Ojitos, and porosity then is just going to depend on how many feet of pay is effective and in round numbers there's about 2500 barrels an acre would equate to about .3 of the porosity times thickness, so that would be like 30 feet of pay and one percent porosity.

I think that's about as good as we can get. It might be 60 feet of pay and a half percent; might even be 1-1/2 percent and 20 feet of pay but it's somewhere in that, in that range and I ran the thing all the way up to 300 feet to see what -- what these figures looked like, but for a practical estimate of the one zone in Canada Ojitos, I'd say we're looking at something like that.

Q And as I understand your testimony, and that of the other witnesses, this porosity that encloses this reservoir is strictly fracture porosity and you're not giving any weight at all to matrix porosity.

A Yes, sir, that's my feeling. I just have not seen any indication of matrix porosity in any of the information available (not clearly understood.)

Q Have you given any consideration to the impact or the effect on the porosity with the reduction of reservoir fluid pressure?

A Yes, sir, we've made some studies of the fractured Mancos reservoirs and my conclusion is that the productivity drops off far more rapidly with the decrease in pressure than can be accounted for by the decrease in relative permeability, and I don't know what the answer is but we suspect, and one of the reasons we entered into the pressure maintenance project was that as the pressure decreases and the fractures squeeze together, there is a geometric effect on reduction in permeability and I just believe that that's a possibility. We measured productivity indices on the wells in the Canada Ojitos Unit prior to the time the pressure reached the bubble point when the reservoir was fully saturated with oil and the productivity indices dropped off with pressure, which in that instance there could be no -- no influence of the relative permeability restriction due to free gas, so it had to be some outside influence that I think can only be explained by the fractures squeezing together.

Q So as the pressure, the reservoir pressure declines, then, it looks probable that the permeability and the ability of the oil to flow to the well will be diminished.

A Yes, sir, I think that's true.

Q Do you think it's likely that some of those fractures will be closed entirely?

A Gosh, I don't know. That's another thing you hope for, you know, when you wake up at night, but I just don't know.

MR. LYON: I believe that's all.

RECROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Greer, the main thrust of your testimony today is about the Gavilan Pool and you've sort of indicated that you're proposing decreases in allowables in the West Puerto Chiquito just as a courtesy.

A Yes, sir, I just believe it would be, well, in a sense unfair when I think that there can be oil migrating across the boundary, not to have the allowables the same on both sides of the boundary. If we ask them to restrict production I just feel it's only proper that we do the same thing.

Q And even though there -- this tight streak that you've indicated with the -- whatever kind of a mark that is, a question mark --

A Yes, sir.

Q -- even though that is in there, there

are wells in the West Puerto Chiquito Pool which lie to the west of that and I presume your opinion is that they're in communication with the Gavilan-Mancos Pool.

A Yes, sir, and of course one of the considerations which we discussed was, well, perhaps that's the only area that we should consider restricting our allowables, but I just can't have enough confidence in that permeability restriction to know that really that's a proper, fair, and equitable thing to do, so we ask that it be the same throughout the pool.

And, of course, another reason was we presumed that it would be difficult for a -- for the Commission to establish different allowables in different parts of the same common source of supply. I've never known a commission to do that so we felt like that was necessary.

MR. STAMETS: Let me ask if there is any party here who is opposed to the Benson-Montin-Greer application to reduce the allowables and the GOR to West Puerto Chiquito Pool?

I see no one standing up and indicating that there is any opposition to that application.

MR. PEARCE: Mr. Chairman, we're not sure what that question means. Mr. Greer has testified that he only wants those rules for his pool if they're adopted for the Gavilan Pool.

If not objecting to those rules in the West Puerto Chiquito means that I've agreed that they're appropriate for the Gavilan, I am clearly opposed to that, and I think Mr. Greer would object to those rules being adopted for the West Puerto Chiquito if our position is correct that they should not be adopted for the Gavilan.

MR. STAMETS: Let me see if I can phrase that to relieve your mind.

Q Let me ask Mr. Greer a question. Mr. Greer, if after this hearing the Commission chose to leave everything in the Gavilan-Mancos Pool as is, would it be your request that your application be dismissed for the West Puerto Chiquito Pool?

A Yes, sir, I feel that the rules need to be the same, Mr. Stamets.

MR. STAMETS: All right, now let me ask the audience, then, that should the Commission after this hearing adopt the rules for the Gavilan-Mancos Pool as proposed, would there be any party who would object to the adoption of Mr. Greer's proposed rules for the West Puerto Chiquito Pool?

Again I see no one --

MR. LOPEZ: Mr. Chairman, the response to that question I think would be no, there'd be no objection. It would be essential that it be done.

MR. STAMETS: Thank you. I would presume that the answer then would be probably the same if the Commission should adopt some variation of what has been proposed so that the -- what we come up with in West Puerto Chiquito would be equivalent.

Say that we gave 300 barrels a day for the Gavilan, it would be 600 for the West Puerto Chiquito, and I presume we have no objection.

That certainly makes order writing a lot simpler to know if there are objections or not.

Okay.

Q Mr. Greer, now you've indicated that the Mancos in this area is basically a single reservoir.

A Well, where it's faulted, and they're tied together, I believe I tried to indicate that it acts a lot like a stratified reservoir, the zones being separated by individual wells.

And so in parts of the pool where the faults tie the three zones together, then they will indeed act as a single reservoir, but otherwise the individual well tests, and it's one of the complicated factors we have in trying to analyze them, the strings where all zones are open will act as a stratified reservoir.

Q In asking this next question, or series

of questions, I'm not asking you if you believe that we ought to change the pool designations out here and create one or more pools out of what are now several pools. I'm just trying to get at what you were telling me.

Do you believe that what is currently designated as the Gavilan-Mancos Pool and the West Puerto Chiquito Pool are the same common source of supply?

A Yes, sir.

Q How about the Boulder Mancos Pool?

A I think Boulder is separate.

Q Okay, and then what about the East Puerto Chiquito?

A The East Puerto Chiquito we have found on the down dip side of East Puerto Chiquito that the zones contain water and we have indications of north/south faults running through that area, and they appear to be sealing faults, and so that pretty well separates East Puerto Chiquito from West Puerto Chiquito.

I believe at one time, I think in 1963, we asked that they all be one pool and then after that time we found this separation and -- and so those are separate.

Q At this time is there sufficient evidence for you to make the -- give the opinion about the Ojito Gallup, or Ojito Gallup-Dakota, is the Mancos portion of that in your opinion part of a common source of supply with Gavi-

lan Puerto Chiquito?

A Mr. Chairman, I have to confess that I have not studied this particularly. I recall that when the hearing was held for spacing for Gavilan that I could see a distinction in the electric log charactertistics between Gavilan and the Lindrith Gallup-Dakota area.

And the characters of the wells at the time were substantially different and I felt that they probably were separated and I've not attempted to do anything since.

Q In both cases before us the gas/oil ratio has been proposed at 1000-to-1. We had testimony at the earlier hearing that at least as to Gavilan the solution gas/oil ratio is 588-to-1.

Why should -- why, if we're convinced by the testimony offered by McHugh and Greer, to adopt 1000-to-1 as a gas/oil ratio as opposed to 588-to-1?

A Well, there are a couple reasons. One is that the reservoir being stratified as it is, we've found that there's some free gas that is produced from some of the zones.

We found the A and B zones in the Canada Ojitos area to be more gassy than the C zone, and that appears to me to be a possibility in Gavilan.

So there is a possibility that a well

could have a gas/oil and this is in the range between 600 and 1000, that really the gas is not coming from the oil, the main bulk of the oil reservoir as I visualize it, and so you might be unfairly penalizing some wells. That's one thing.

Another is just a real practical application of the gas/oil ratio limit when one deals with -- with only the solution ratio, then the allowable becomes so sensitive to just small change in the gas/oil ratio, that just even the errors in calculation and measurement of the gas becomes a factor in determining allowable, and just from a practical standpoint, I would recommend that the 1000-to-1 is a reasonable and a practical limit.

And it's really, Mr. Chairman, not the gas/oil ratio that's causing a problem. The problem is the high oil productivity, that's the problem.

Q Mr. Greer, based on your testimony in this case, even if unitization were never achieved in the Gavilan-Mancos Pool, would reduction of the allowable to 200 barrels of oil per day result in substantial increases in recovery of oil from this reservoir?

A Yes, sir, any reduction in allowable will help. It's hard to quantify it with any reduction. If the pool was drilled up entirely on 320-acre spacing and allowables of 200 barrels a day were permitted, there will be the

very minimum amount of damage occurring.

Q Earlier you talked about a potential value of the oil lost --

A Yes, sir.

Q -- in the Gavilan Pool of $50-million. At $16.00 a barrel that 's about 3-billion barrels of oil. Is that the range of volume you were talking about?

A I believe what I was talking about was 5-million barrels and $10.00 a barrel, $10 or $12.00 a barrel, would be $50 or $60-million, and that would be if 10 percent of the gravity drainage potential was realized; 1/10th of the maximum.

Q With your 200 barrels a day of oil production limitation is it reasonable to assume -- is it your engineering opinion that we would recover that 10 percent additional gravity drainage?

A Not if the pool is drilled up on 320 acres.

Q Even with the 200-barrel restriction.

A Even with the 200 barrel, that's just too much.

Q Do you have an opinion as to how much of that recover?

A Well, I haven't tried to put a figure, but I -- we can take a quick look at our Exhibit Four, our

Exhibit Four, Section C, and here we show if the pool is developed on 320-acre spacing the overall average production rate would be only 130 barrels a day and even at that low rate the pool is essentially depleted in five years and in round numbers, looks like about 75 or 80 percent of it would be produced in two years.

And that rate of depletion would be too high to achieve a substantial gravity drainage.

Q So the 200 barrel oil allowable is not a long term solution to this problem.

A No, sir, it's an interim solution and will help protection of correlative rights and give operators a chance to do something reasonable.

MR. STAMETS: Are there other questions of this witness?

MR. KELLAHIN: Yes, Mr. Chairman.

MR. STAMETS: Mr. Kellahin.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Mr. Greer, in making your analysis of the potential of the Gavilan-Mancos receiving benefit from gravity drainage, have you availed yourself of the information provided in the Dugan Production Corporation exhibits as

well as the Jerome P. McHugh exhibits that were presented at the prior hearing?

A Yes, sir.

Q With specific reference to Mr. Ellis' structure map, the hearing on August 7th was not the first time you saw that structure map, was it, sir?

A No, sir, I'd seen it before that.

Q Mr. Pearce asked you some questions with regard ot the elevations of two wells that followed the general strike of the axis of the nose of the Gavilan-Mancos.

A Yes, sir.

Q It showed a difference of approximately 50 feet, I believe.

A Yes, sir.

Q If we go perpendicular to the axis of the nose, do we then see on the structure map a type of difference in structure that caused you to reach your opinion that the Gavilan-Mancos was a suitable candidate for gravity drainage?

A Yes, sir. I did not take into account or estimate that there would be any gravity drainage along the direction of the question at that time.

Q Your hypothesis about the potential of gravity drainage in the Gavilan-Mancos then was based upon specific data generated by Mr. Roe and Mr. Ellis?

A Yes, sir, I used their -- their information, as well as mine.

Q As a well respected petroleum engineer, Mr. Greer, would you articulate for me why the -- some of the information that the engineers and experts are looking at in the Gavilan-Mancos does not cause you to conclude that they're seeing what is characterized as the typical solution gas drive reservoir?

A I'm sorry, I didn't --

Q Yes, sir. There's been some discussion and questions of you and the other witnesses about characterizing the Gavilan-Mancos as the typical solution gas drive reservoir and you told us in your testimony that you disagreed with that; that you felt that that was now what we were seeing.

I would like you to summarize for me, if you can, sir, the reasons and basis that have caused you to conclude that the Gavilan-Mancos is not a typical solution gas drive reservoir.

A Yes, sir. The, as I thought I'd testified earlier, the Gavilan Pool in which an option is given to the producers as to the producing mechanism, and it depends on how fast the pool is depleted as to whether it will be entirely solution gas drive, primarily gravity drainage, or a combination of the two, and at the current rates of

production, the way that the pool is scheduled to be developed on 320 acres with a high allowable, then there will be a minimum of gravity drainage, and so the process would degrade to primarily a solution gas drive.

Q You have posed for us a temporary solution or stopgap measure on restricting gas/oil ratios and allowables and you have used a combination of the two in which gas/oil ratios are reduced to 1000 cubic feet of gas to one barrel of oil and a production limitation of 200 barrels of oil per day.

Do you have an opinion, sir, as to whether or not you can significantly vary either one of those factors or eliminate one entirely?

A No, sir, I think it's a pretty good -- pretty good combination. To reduce the gas/oil ratio would not significantly help and I think would compound just the practical problem of handling it, and certainly the oil allowable should be any -- a bit higher than 200 barrels.

Q Thank you, sir.

MR. STAMETS: Any other questions of Mr. Greer?

REDIRECT EXAMINATION

BY MR. CARR:

Q Very briefly, Mr. Greer, you were asked

by Mr. Padilla to read from a letter that you'd previously written.

Do you happen to know the date of that letter?

A I believe it was -- seems about a year ago, in March of '85.

Q Since that time has additional information come -- become available to you concerning this area?

A Yes, sir.

Q In your opinion is it safe today to characterize what you called a restriction, is it safe to charactize that as a barrier?

A Yes, sir, I feel like restriction is more proper term than barrier.

MR. STAMETS: Any other questions?

Mr. Padilla.

RECROSS EXAMINATION

BY MR. PADILLA:

Q Mr. Greer, if I understood your testimony this morning you were concerned about the pressure decline and in answer to some of my questions you also -- concerning the Exhibit Number Two, you talked about decline in pressure and I understood you to mean decline in pressure associated

with gas withdrawal. Is that correct?

A Well, the decline in pressure will cause gas to come out of solution and then the gas moves to the wellbore and then pressure drops more rapidly and a vicious cycle is started.

Q If gas is restricted, will that reduce -- will that cause a decreased pressure production?

A Well, restricting the gas/oil ratio and restricting the production simply slows down the rate of depletion so the operators can hopefully get together and devise a better plan for developing this reservoir before it's too late to realize some gravity drainage potential.

That's my feeling.

Q And it's your testimony that there's no correlation between a reduction in GOR and oil takes.

A A reduction in GOR and what?

Q Oil withdrawals from the reservoir.

A Okay, if you lower the gas/oil ratio limit you will lower somewhat the withdrawals, yes, sir, but not significantly and in the sense that one could simply reduce the gas/oil ratio limit and say that's all.

Q In other words, it doesn't make any difference in your opinion, it doesn't make any difference whether the GOR is 588-to-1 or 1000-to-1.

A Well, I tried to describe why I felt that

it was impractical to go below 1000-to-1. It's possible and of course operators could probably live with it, and it's just kind of an impractical thing to do, I think.

Q Well, doesn't that leave more gas in solution at that point if you bring it down to 588?

A Well, if you bring the gas/oil limit down to 588 it would limit the production from the reservoir a little bit more than 1000-to-1, but it -- my opinion is that that would be a bad choice to go that direction rather than down to 200 barrels a day.

Q Then why don't we leave it at 2000-to-1?

A Well, as I've indicated, I think it's proper to reduce the gas/oil ratio. It's just from a practical standpoint of how it's handled and how the gas volumes are calculated and how the Commission calculates the gas/oil ratio limitation, but I think it becomes too sensitive, too sensitive to go down to 588.

Q Well, I'm just a little confused that you seem to be saying it doesn't matter what GOR we have, let's just reduce the oil and trying to make a big point on simply reducing the amount of oil that can be withdrawn from the reservoir and I don't understand the decision as far as GOR is concerned.

A Well, reducing both the allowable and the GOR will reduce the rate of withdrawal from the reservoir.

I think below 1000-to-1 is impractical and at 1000-to-1 it's necessary to come down to 200 barrels a day in order to have a reasonable -- a more reasonable rate of withdrawal.

The main thing coming down to 200 barrels a day, it will give the operators in the pool the opportunity to protect their correlative rights.

Q Well, let me ask you if your correlative rights, if you don't want to drill to protect your well and if you restrict the allowable to 200 barrels per day on oil, you wouldn't have to drill any wells.

A No, sir, that's not the answer at all. If you restrict the allowable to 200 barrels a day, then an operator can go in the pool, drill a well under the current spacing order, and he would have an opportunity to protect his correlative rights.

Currently, with the allowable 700 barrels per day, an operator can go in the pool, drill the well, it wouldn't otherwise be a commercial well, but his correlative rights are not being protected because the big wells are taking too much oil out from under his lands, so that's the concern on that.

Q On an undrilled tract or a drilled tract?

A That's -- we're talking about where an operator goes out and drills a tract, either one already

drilled or where he would go out and drill a new one.

In either instance he's not afforded the opportunity to protect his correlative rights if he doesn't tunnel into a fracture that will give him 700 barrels a day.

Q He has an equal opportunity. It just so happens that he didn't hit the fracture, isn't that --

A Yes, sir, and then you're back to the law of capture in which the allowable is based upon the productivity of the wells and that's not related to oil in place and in my view it's an improper way to set an allowable.

Q Well, in the normal situation, wouldn't you agree, Mr. Greer, if you drill a well and it happens to be a dry well under -- under the current conservation laws, that's just the risk you assume.

A Yes, sir, and I think we all understand that. The problem we have here is we don't have a normal reservoir and it needs special consideration.

Q Well, Mr. Greer, let me ask you, how do you know whether or not you have a dry hole, whether you missed the fracture?

A Well, when you put the well on production you'll find out whether it's a producer or not.

Q Well, I understand that but let's assume the difference between a well that produced 25 barrels a day and one that produces 500 barrels a day. Did the 25-barrel

well miss the fracture?

A Yes, sir. The man has had an opportunity to drill his well. He didn't hit a fracture and he's bound to his productivity and that we understand.

My concern is for wells that come in with productivities of in excess of 200 barrels a day and even at 200 barrels a day the big wells are taking oil out from under their lands.

Q Well, that's an assumption, isn't it?

A Well, it's my best estimate of what the character of the reservoir is like, made up on the work that we've done over the last twenty-five years.

Q As far as the West Puerto Chiquito is concerned.

A Yes, sir, and we feel that West Puerto Chiquito and Gavilan are quite similar.

MR. PADILLA: I don't have anything else.

MR. STAMETS: Any other questions of the witness?

He may be excused.

We'll take about a fifteen minute recess.

(Thereupon a recess was taken.)

MR. KELLAHIN: Mr. Chairman, I would renew my request to admit Jerome P. McHugh Exhibits One and Two, I think they were. They were our affidavits on notice that we submitted at the last hearing.

MR. PEARCE: As far as I know there are no problems with that in terms of accurately representing the ownership and on that basis we do not object to those exhibits being admitted.

MR. STAMETS: Those exhibits will be admitted.

Mr. Lopez, do you have any witnesses?

MR. LOPEZ: I sure do, Mr. Chairman. I'm just wondering if I'm the next appropriate person to address. Meridian is here in support of the issue.

MR. STAMETS: Yes, perhaps we ought to have a show of hands of those who have witnesses today. Other than Meridian, who else is in support of this application?

Okay, I see none. We thank you, Mr. Lopez. We will let Meridian put their testimony on at this time.

MR. COOTER: Mr. Examiner -- Mr. Stamets, I'm sorry, Paul Cooter, appearing on behalf of

I didn't really realize that we would be cast in a position of jumping in or staying out of the pond at this early stage. If those are our two alternatives, we'll jump into the pond, but we would prefer listening to the pros and cons before presenting our case, but if we're logically called on now, we're ready to proceed.

We won't be long.

MR. STAMETS: We'll allow you to go ahead at this time, Mr. Cooter.

RICHARD E. FRALEY,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. COOTER:

Q State your name for the record, please, sir.

A My name is Richard E. Fraley.

Q And by whom are you employed, Mr. Fraley?

A Meridian Oil, Farmington, New Mexico.

Q What's your position with the company?

A I'm a Senior Reservoir Engineer for Meridian.

Q Relate, if you would for the Commission,

your education and professional experience.

A I graduated in 1979 from Colorado School of Mines with a Bachelor of Science degree in geological engineering.

I was that employed by Superior Oil, beginning in 1980 in The Woodlands, Texas, as a production geologist for a period of about nine months.

At that point in time I went to work in Denver, Colorado, for Husky Oil as a production geologist. I worked there for approximately nine months.

In November of 1981 I went back to work for Superior Oil in Denver as a reservoir engineer. When Mobil took Superior over I was a reservoir engineer for Mobil and in February of this year I went to work in Farmington for Meridian as a reservoir engineer.

Q Are you familiar with the Gavilan-Mancos Oil Pool?

A Yes, I am.

Q And the special or the temporary proposals as advanced by the applicants, Mr. McHugh and Mr. Greer?

A Yes, I am.

Q Let me direct your attention, please, to your exhibits.

First, let's look at Exhibit One-A, if

you would, which is a plat, I believe, of the area.

Explain that.

A This is a map done under the direction of Van Gobel (sic), who is a landman with Meridian Oil in Farmington.

This map indicates Meridian's acreage in the area, whether it's 100 percent or partial interest acreage.

To this end I haven't specifically highlighted -- well, I have.

If you look, the wells in red with the red box around them indicate wells that Meridian currently has an interest in and I've enumerated those on Exhibit One, which I'll talk about in a minute.

We currently have an interest in nine wells in the area.

Also, I have colored in Meridian's interest in undeveloped acreage within the Gavilan study area, and that acreage is the acreage that shows up as yellow with no red box around it.

Q All right, let me direct your attention back for just one minute to what was introduced at the prior hearing as the Dugan Exhibit Number One. Were the figures or the interest credited to Meridian Oil Company in that exhibit substantially correct?

A I'd have to look at it. I don't have that exhibit with me.

Q Do you recall that exhibit?

A Yes, I do. It's a list that Dugan has supplied in previous testimony that indicates the wells that Meridian operates. There is no indication on this list as to wells that Meridian may have interest in other than the wells they operate.

Q Meridian's net interest is a greater amount than shown on that but those are just the operated wells.

A That's correct.

Q All right. Let's go from that, if you would, back to Exhibit Number One. The -- at the top of that you list several wells and included are the five wells that are shown on the Dugan Exhibit Number One, are they not?

A Correct.

Q Explain Exhibit Number One, if you would.

A Exhibit One, I'll go through rather quickly, indicates wells in the area that Meridian has an interest in.

Column two, if you go across from those wells, indicates what our working interests and net interests are in those wells.

What I'd like to point out here is the fact that we do have production from wells other than the ones that Meridian operates and the summary indicates there are nine wells total we have an interest in, 4.1 net, if you look at what our working interest is in those wells.

The next column across indicates what the June production was listed on the C-115's and the total production on the bottom indicates 13,154 barrels of oil produced that month, 18,568 MCF of gas produced for the month of June, and again I reiterate that Meridian has 2277.3 acres in this study area, including acreage in eight undeveloped locations, if we look at 320-acre drill sites.

Meridian also has a 4.15 percent working interest in Canada Ojitos.

Therefore we are concerned about what's happening at Gavilan and what's happening at Canada Ojitos.

One thing I'd like to point out, I'm not able to calculate all the company's effect on their net production in this area, and therefore it's directionally correct to look at the opertor's production, but it doesn't really tell the whole story and to say that Meridian is hurt only from production from their wells is incorrect. We're hurt from production in other wells, depending on whatever the allowables are set.

And addressing that point, using some of

the assumptions going down through the page, that have been made in the Gavilan study committees, again Bo = 1.38, solution gas of 588, and Bg of 1.78, the total Gavilan production, if you look at the Gavilan Pool, from 43 wells in June of '86 is indicated and that amounts to, using these numbers for conversion, to 17,163 reservir barrels of oil produced per day for June.

As you can see, with the exception of the Mallon Post Federal 13-6, all of our production as allocated to Meridian for June came from four wells of the nine that we have an interest in and amounted to 1248 reservoir barrels a day production for June.

If you look at what that is as a percentage of the total, our production for June amounted to 7.3 percent of the total reservoir withdrawal for June, 1986.

This next section I indicate what the effect would be on Meridian's production for June --

Q Let me interrupt you right there, if I may, Mr. Fraley, and we'll come back to that in just a minute.

Let me go at this point to your Exhibit Number Two and ask you to explain that.

A Exhibit Two is similar to some that have been submitted already in previous testimony. As I note in the heading, these are wells that Meridian has a working interest

in in the area and pressure points that have been reviewed and approved by the subcommittee, the engineering subcommittee, and again to reflect what is happening in the pressure in wells that Meridian has a specific working interest in.

Also indicated on this plot through time is what the actual reservoir barrel withdrawals were from the wells that are listed on this plot.

As you can see, with the exception of November of 1985 when we were testing our Hill Federal No. 1 Well, there is very little production associated with this pressure decline from wells that Meridian has an interest in. The initial pressure that we had was from the Hawk Federal No. 2 on April 13th, 1984, which indicated a pressure of 1740 pounds and you can see that through time the wells have come on at a lower pressure and have declined substantially with very little production associated.

You could think of these wells basically as observation wells on undeveloped acreage and they are indicating what is happening to the reservoir in terms of pressure drop through time.

This is something we are very concerned about.

Q Let me next direct your attention to Exhibit Number Three. Is that also compiled from information relating to the Meridian oil?

A Yes, it is. This is a static pressure test. It was run from July 26th to July 30th, 1986, in our Hill Federal No. 2Y, which, if you refer back to the map, is located in Section 25, Township 25 North, Range 2 West, and it indicates that during this test there was an average reservoir pressure drop of .8 of a psi a day. Again this is associated with no production.

Q There appears back on Exhibit Two on this Hill Federal No. 2Y Well an increase in pressure from December of '85 when it was -- or January of '86 when it was first placed on production. Can you explain that?

A Again that doesn't indicate the well is on production. It indicates the initial pressure tests that we had in the Hill 2Y, and I checked our records. To the best of my knowledge the only explanation I have for that increase in pressure is the fact that the well had not been fraced at that point in time and probably we're looking at some formation damage.

The well was IPed and tested on January 6th of 1986 and therefore I think that pressure point is probably invalid, but I presented it on this document to indicate that we are looking at all the data.

Q All right, now let's go back to Exhibit Number One, if you would, I interrupted you a little bit ago.

If the only alternatives would be to accept the recommendations that have been made, have you calculated what effect that would have on the wells in which Meridian has an interest?

A Yes, I have.

Q What would be that effect?

A Well, as you review this document, first looking at what total Gavilan Pool withdrawals would decrease to if they had been subject to 200 barrels a day, 1000 GOR in June, I indicate from my calculations that the total pool withdrawal would have been 13,952 barrels -- reservoir barrels per day, which is a decrease of 3211 reservoir barrels a day.

I haven't written it on here, but that's an 18.7 percent decrease in production for June from the total pool.

Withdrawal from Meridian's wells would drop for 1248 barrels a day to 414 barrels a day, which is -- I'm sorry to 834 barrels a day, which is a 414 reservoir barrel per oil -- reservoir barrels of oil per day drop for June.

I'd like to point out that that amounts to a 33.2 percent increase in Meridian's real production from all the wells that they have an interest in in the area.

So as you look at that, we are looking at a substantial cut over and above what the total pool would see as a total decline for June.

Q What is your company's suggestion for the time limitation for any special rules?

A We would request they be for no more than ninety days.

Q What about new wells coming on line between this time on?

A We've indicated to the various operators in the area that we'd like to see a 60-day clean out period for any new wells that are brought on. A lot of the wells increase slightly in their producing rates as they clean up, as the frac jobs are cleaned up through time, and therefore you need to test them for about 60 days to get a true idea of how the well is going to perform.

Q In addition to those recommendations, do you have any other suggestions or clasing statement to make?

A Well, I'd like to indicate that even though, as I stated, we see a disproportionate cut in production from the wells that we have an interest in in the Gavilan area, as I stated here, and as is highlighted in yellow, this in my mind and in Meridian's mind is inconsequential when you compare it to the rapid pressure decline that we see from our shut-in wells, as seen on Exhibit Two,

and this points to the fact that a minimum allowable level should be set to conserve the reservoir pressure until a study can be done, and I'd like to indicate we feel like a study needs to be done as soon as possible, and as quickly as possible, and the study should focus on what the most prudent methods of development and production in the Gavilan Field are.

Also in summary I have a statement here.

It appears to me, and I think most people would agree, that there have been a variety of facts and opinions expressed to date, both in the context of this hearing and the subcommittee meetings, as to what the facts and opinions are concerning the producing mechanisms at the Gavilan area.

Meridian is not precluding unitization and we're not precluding the fact that the final allowable, and I stress the final allowable versus temporary, should be 200 barrels a day or 1000 GOR, but the evidence presented indicates that the reservoir pressures are dropping, the GORS are climbing at rates which in my experience are alarming compared to other reservoirs, and therefore the 200 barrel a day, 1000 GOR proposal should be implemented until such time as a study is completed to determine the most prudent plan of development and operation to produce the reserves in Gavilan, and in addition to prevent waste and to

protect correlative rights.

Personally I don't like to see severe, rapid depletion of a reservoir that may have possible alternatives other than solution gas drive depletions, and I think these things need to be studied.

To this end I think Mr. Greer's testimony and McHugh's facts and opinions must be reviewed, as well as any other facts and opinions, the point being that the study needs to move forward very soon.

To that end we are in support of the 200 barrel a day, 1000 GOR.

Q In your opinion, Mr. Fraley, would a period of ninety days be sufficient for that study if all parties entered into it in a spirit of cooperation?

A Yes.

Q Were Exhibits, the four exhibits, One, One-A, Two, and Three, prepared either by you or under your direction and supervision?

A As I indicated, Exhibit One-A was prepared by Meridian's land department and under the direction of our land people.

MR. COOTER: We offer the four exhibits, Mr. Stamets.

MR. STAMETS: Without objection, the exhibits will be admitted.

MR. COOTER: That concludes my direct examination.

MR. STAMETS: For the record, Mr. Cooter, I presume you were qualifying Mr. Fraley as a geological engineer?

A I'm currently working as a reservoir engineer.

MR. STAMETS: Was your expert testimony offered as a reservoir engineer?

A Yes.

MR. STAMETS: Without objection his qualifications as a reservoir engineer will be accepted.

Are there questions of this witness?

MR. PEARCE: If I may have just a moment, please, Mr. Chairman.

CROSS EXAMINATION

BY MR. PEARCE:

Q Mr. Fraley, just for purposes of clarification, looking at your Exhibit Number One, where you did the calculations of percentage restriction down towards the bottom of the page?

A Yes.

Q I notice that those calculations were

done in terms of reservoir barrels. Do you have the same calculoations in terms of oil production?

A Just straight oil production?

Q Yes.

A You could -- you could look at what a 200 barrel a day limit would do. I haven't presented that there. I have it in rough numbers on some yellow sheets of paper up here, I think, but --

Q Do you recall approximately where those percentage figures about the same as these? Were they higher, lower, one direction or the other?

A In reference to the wells that Meridian has an interest in, is that what you're --

Q Yes, sir.

A -- specifically addressing? Well, I'll go into detail here on the four wells that produce.

The Hill Federal -- the Hawk Federal No. 2, excuse me, averaged 141.5 barrels a day in June and the restriction on the allowable would have been based on a GOR which would have knocked it down to 80 barrels a day.

Q (Unclear) zero?

A Yes.

Q The Hawk Federal No. 3 produced 219.8 barrels a day. It's restriction was based on an allowable restriction; therefore it would have been knocked down to

200 barrels a day.

A Yes, sir.

Q The McHugh Native State -- I'm sorry, the Native Son No. 3 would not be restricted. The production was 68.3 barrels a day. The gas production was 20.8, therefore it would not be subject to either 200 or 1000.

And the McHugh New Horizon No. 1 averaged 8.8 barrels a day and 35 MCF a day and it would have been knocked down to 2.2 and 9; therefore its total production, it would have been GOR restricted but in the overall scheme of things you're not talking about much there.

Q And just looking at that -- okay, roughly, that's about 1030 barrels versus 357 barrels, approximately.

A 357, I don't know. Are we saying total production?

Q Yes.

MR. STAMETS: Are you saying that they currently enjoy 1000 barrels --

MR. PEARCE: 1031.8 barrels, I thought I added the numbers you gave me --

A Okay, and then it goes down to 351.

Q And the numbers would be, I think, 357.3.

A Well, I get 351, so we're in the ballpark.

Q Thank you. I can never figure out how to work that calculation.

MR. STAMETS: What kind of a cut are we looking at there? Is that a 60 percent reduction in allowable? Oil allowable?

A Yeah, and the only well that's severely restricted by the GOR would be the Hawk Federal No. 2.

CROSS EXAMINATION

BY MR. STAMETS:

Q Mr. Fraley, based on these numbers, Mr. Fraley, based on these numbers are we talking about a cut in allowable for Meridian wells of 60 percent, more or less?

A The production cut based on my figures was 33.2 percent (unclear).

Q Okay. How does that compare with the overall allowable reduction?

A The total pool would have seen a decrease of 18.7 percent.

Q So what you've got to say about oil alone is roughly equivalent to reservoir voidage. You're suffering greater than the average.

A Yes, that's correct and we are willing to suffer until we can study and figure out what needs to be done.

MR. PEARCE: Okay, Mr. Fraley, as I understood your closing statement there before the end, do you not yet have an opinion on what the production mechanism in this reservoir is or do you have such an opinion?

A I do have an opinion it's solution gas drive at this point and what I said was that I indicated that there may be alternatives to solution gas drive that need to be studied.

MR. PEARCE: I have nothing further. Thank you, sir.

MR. STAMETS: Are there other questions of this witness? Mr. Padilla.

CROSS EXAMINATION

BY MR. PADILLA:

Q Mr. Fraley, have you participated in the study committee for study previous -- previous to this hearing?

A Yes, I have.

Q During the course of that -- your participate in the study committee, did you make statements to the effect that gas wasn't a problem with regard to the Gavilan-Mancos Pool?

A I may have.

Q Is that your opinion today?

A My opinion is that the withdrawal of both oil and gas are what are affecting this rapid pressure drop that we're seeing here.

Q Which is the greater problem in your opinion?

A The oil, and I've stated that in subcommittee meetings.

I've indicated that I feel the high rate wells hurt the reservoir more than low rate high GOR wells.

Q In your testimony you said you were unable to calculate, make some calculation due to lack of information. Can you elaborate on that?

A Well, I don't have the data available in terms of everyone's working and net interests in the -- all of the wells at Gavilan. I have the information on Meridian's wells. I think it would be prudent for all the operators to calculate what their net pay-in is from any kind of a well's production because it's not strictly based on the wells that they operate.

If I had the data I'd be glad to do the calculations but I don't have any data on any of the wells we don't have an interest in.

MR. PADILLA: No further questions.

MR. STAMETS: Any other questions of this witness?

MR. COOTER: That's all.

MR. STAMETS: If there is nothing further then, he may be excused.

MR. COOTER: That's our case.

MR. STAMETS: Mr. Lopez, is there anyone you would prefer to have go on before you at this point?

KATHLEEN A. MICHAEL,

being called as a witness and being duly sworn upon her oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. LOPEZ:

Q Would you please state your name and where you reside?

A My name is Kathleen A. Michael and I reside in Tulsa, Oklahoma.

Q Ms. Michael, by whom are you employed and in what capacity?

A I'm employed by Mesa Grande Resources as a landman.

Q Would you briefly describe your educa-

tional background and work experience?

A Yes. I graduated in 1972 from North Texas State University with a Bachelor of Science degree in secondary education.

I started working in oil and gas, or as a landman in oil and gas, for Fuel Resources Development Company, a subsidiary of Public Service Company of Colorado, in 1977. I worked there for two years and I specialized in Federal exploratory units there.

In 1979 I went to Northwest Pipeline Corporation and was employed there for four and a half years as a landman. There again I specialized in Federal exploratory units, and also I worked extensively on the Gavilan area from the beginning of the exploration.

Q From the beginning of the exploration program?

A After that I worked for two years as an independent land consultant and now I'm employed by Mesa Grande Resources.

Q And how long have you been employed by Mesa Grande?

A Since January.

Q And you are familiar, then, with the area in question that's being heard by the Commission in these consolidated cases?

A Yes.

MR. LOPEZ: I tender Ms. Michael as an expert landman.

MR. STAMETS: Without objection she will be considered qualified.

Q For the record we have prepared an Exhibit One but it was essentially identical to a McHugh exhibit so we're just going to skip Exhibit One and move directly -- and so we would remove that and we're going to start our exhibits with Exhibit Two.

On that basis I'd like to have you turn your attention to what's been marked Exhibit Two and have you describe what it shows.

A Exhibit Two is a plat of the Gavilan area. It includes a portion of the Canada Ojitos Unit and it shows color coded by owner the leasehold ownership in the Gavilan area, and it's basically to show the location and distribution of acreage within the Gavilan area.

Q Have you described the unit boundary which was shown on (interrupted) --

A Yes, we have. We've located the Canada Ojitos Unit boundary. We've also located the Gavilan Pictured Cliffs Pool, the Gavilan-Mancos Pool, and the Gavilan Greenhorn-Graneros-Dakota Pool, and we've also included two areas, the west half of Section 8 and the east half of Sec

tion 17, which will become included in the Gavilan-Mancos Pool with a hearing that I understand is supposed to be initiated by the State.

MR. LOPEZ: I have no further questions of this witness.

MR. STAMETS: Are there questions --

MR. LOPEZ: Was Exhibit One prepared by you or under your supervision?

A Yes, it was.

MR. LOPEZ: Or Exhibit Two, I mean?

A Exhibit Two, yes, it was.

MR. LOPEZ: I'd offer Mallon-Mesa Grande Exhibit Two.

MR. STAMETS: Without objection Exhibit Two will be admitted.

Are there questions of this witness?

She may be excused.

ALAN P. EMMENDORFER,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. LOPEZ:

Q Would you please state your name and where you reside?

A Yes. My name is Alan P. Emmendorfer. I liove in Broken Arrow, Oklahoma.

Q By whom are you employed and in what capacity?

A I'm employed by Mesa Grande Resources as a geologist.

Q Would you describe your educational background and work experience?

A Yes. I graduated from Southeast Missouri State University in 1977 with a BS in geology.

Then I went to the University of Oklahoma and graduated with a Masters of Science degree in geology in 1979.

I started working for El Paso Exploration Company in 1979, based in Farmington, New Mexico, and my role there was a production development geologist for the San Juan Basin.

I worked there for two months shy of five years and then went to work in my current job with Mesa Grande Resources as a geologist.

Q You are familiar with the Gavilan-Mancos

Pool and are familiar with the cases that are before the Commission today as consolidated cases of McHugh and Benson-Montin-Greer?

A Yes, I am.

MR. LOPEZ: I tender Mr. Emmendorfer as an expert geologist.

MR. STAMETS: Without objection Mr. Emmendorfer is considered qualified.

Q I now refer you to what's been marked Exhibit Three and ask you to identify and explain that.

A Okay. Exhibit Number Three is a structure map of the Gavilan area and I've mapped this on the top of the Niobrara A zone or commonly called the Gallup.

I took the tops from the study committee. We had one day of referring especially to the geology.

The subcommittee got together and commonly in agreement picked the top of the Niobrara A zone with the well that we had with us at that time.

We used those values for most of the wells on this map.

The wells that we did not use, I used the same basis that we did in the study committee and correlated those wells and picked -- used that top as my basis for the structure map.

Q What does this exhibit show?

A It shows -- this is a structure map. It shows two structurally different environments.

We have on the east side of the structure map a deeply dipping monocline. This is evidenced by the structural contour lines and it goes together, this map is contoured on 50-foot intervals.

In the center of the map, which is centered in Township 25 North, 2 West, we see a small domal development commonly referred to as the Gavilan Dome. It is this area that the Gavilan-Mancos oil pool is producing out of.

Separating these two structurally different units, a deeply dipping monocline and a gently dipping dome, we have a well defined trough that's been defined by the drilling of several wells within the Canada Ojitos Unit, so therefore we have off the monocline wells with the formation dipping to the west and on the other side of this trough, on the east side we have the wells dipping towards the east.

Q Who participate on this subcommittee which you referred to in picking your tops for the structure map?

A Well, all the operators were invited to participate in this, send a geological representative. In

fact there were four of us that were initially involved and three that actually did the picking.

The four geologists were myself, John Bircher with Meridian, Kurt Fagrelius with Dugan, and Dick Ellis with McHugh.

At the beginning we discussed our objectives and what we were going to do and in this agreement was Dick Ellis. He said that was fine, he was going to participate in the engineering meeting that was being held concurrently. So John Bircher, Kurt Fagrelius and myself picked the tops.

Q Is there anything else you want to talk about with respect to this exhibit now?

A I may refer to it later but this is all for now.

Q I'd now refer you to what's been marked Exhibit Number Four and ask you to identify and explain that.

Okay, what is it we have here?

A This is a structural cross section that I put together across the area that is represented on the structure map in Exhibit Number Three, and if you will look on the structure map you can see the actual trace of the cross section as it's represented on the structure map.

Q Okay, what does this show?

A Well, there are several things that I would like to point out on this structure, structural cross section.

I think the big picture here is to show the differences in structural dip across the area.

The wells over here are in the west -- the Canada Ojitos Unit on the monocline and as you can see, very steep dips, we've already heard testimony today as to what type of dips those are, what the rates of dip is, but this is a graphic reprsentation of this.

You have very steeply dipping Niobrara rocks with Gallup rocks, and as you come through the trough as indicated on the structure map, you see a leveling out of the -- of the dip. Then as you come onto the Gavilan Dome you see the wells coming back up into a domal configuration and then going off again and the last wells on the structure, structural cross section map is in the Ojito Gallup-Dakota Pool.

The big difference that you see on the structure is the fact that on the monocline you have very steep dips and on the Gavilan Dome it's very gentle and there is some structural relief here but it really is slight compared to the rest of the structure offsetting it.

Q Does it show any stratigraphic variation?

A Yes. I believe it does. Unfortunately I

didn't have (unclear) the Canada Ojitos Unit wells available for our draftsman to put on the cross section so we included a stick diagram based on tops from PI scout cards, but what we have are induction logs and as you can see, the Gallup, this Niobrara is commonly broken down into the Niobrara A, B, and C zones, and likewise within the Gavilan-Mancos interval there is another basin unit called the Sanostee (sic) and then there is shale sections in between.

The Niobrara A and C zones on a cursory analysis look very similar. You can trace the sand or depositional unit across wide areas of the Gavilan area; in fact in a lot of areas of the San Juan Basin this basic interval is the same; however when you look at the induction curve or the SP curve, the gamma ray curve, you start to see some differences from well to well; that indeed it is not exactly homogeneous, it is heterogeneous.

The Gallup or Niobrara was deposited in an offshore environment consisting of sandstones, siltstones, and shales. Due to the depositional nature in any particular area we have more sand or more silt or more shale deposited. This is the nature of deposition and we can see that these ratios between the sands, silts, and the shales, indeed do vary from well to well across the area.

One major difference is we have in the northern part of the Gavilan area and a little bit of the

northern part of the Canada Ojitos Unit, another portion of the Gavilan-Mancos interval some people have called the gray zone and it's well picked up on some wells as a high resistivity area. We don't see that everywhere within the Gavilan-Mancos Pool.

To the west and to the southwest portions of the pool this is absent. That's another thing that we looked at on our geological subcommittee meeting, we identified which wells had this gray zone in it and which wells didn't. We don't know the significance of it from production or not, but we felt we needed to identify that it was present in some wells and in some wells it is not.

Since there are some companies that perforate in that zone we feel that's something that needs to be addressed.

Another thing that I would like to point out on the structure map is that these zones, the gray zone, the A zone, B zone, the C zone and the Sanostee, they're very continuous across the area like I pointed out on a gross basis, although in the Gavilan Dome area operators, different operators have completed wells in the different zones.

Over in the Canada Ojitos Unit I believe on the historical monoclinal production the C zone was the only zone that was open.

Then on the Gavilan-Mancos we have operators that -- some operators perfed in the Sanostee. Some operators perfed in the gray zone, where present, and the A zone, the B zone, and the C zone, and in areas in between.

We feel that there's production occurring all up and down the Gavilan-Mancos interval.

Q And as you just indicated, that you do observe these differences on the logs themselves.

A I think so. Like SP development, which is a gross representation of permeability, porosity and permeability development, some wells show positive SP deflection, negative SP deflection, no SP deflection, within the same A interval across the area, or B interval, whichever interval you happen to look at. Those are -- those are brought out.

Likewise, the gamma ray, which is an indication of relative amounts of sandstones, siltstones or shales, those vary from well to well.

Q And do these logs also indicate the size of the structural differences, as you've already indicated, between the monocline and the Gavilan zones, the stratigraphic differences between the two areas?

A Yes. The -- there are, since we've known that there are differences from well to well, we also see that in the Gavilan or in the monoclinal wells in the Canada

Ojitos Unit, that the induction is so much lower on many of these wells as we see here in the Gavilan Dome area. So there are, at least seem to be differences.

Q Are there any differences in the Pictured Cliffs?

A Yes, there are. I believe in our other exhibit, Exhibit Two, that we have the boundary of the Pictured Cliff, the Gavilan Pictured Cliff Pool listed on there.

We do have production on the Gavilan Dome in the Pictured Cliff interval. It is -- the boundary stops at -- the boundary between the western tier of sections in 25, 1, with the rest of 25 and 1. For whatever reason, and I hope to point this out later, that Pictured Cliff production stops here at this trough area, the general area of this trough, and that there is no Pictured Cliff production on the monocline.

Q How about any differences in the Mesaverde?

A Yes, there are. We do not have production at this time but I have looked at the Mesaverde, have mapped for different parameters there and Point Lookout shows this relationship very good, that there are differences between the Gavilan Dome and the monocline.

Q Okay. I now refer you to what's been

marked Exhibit Number Five and ask you what it is.

Okay, well, first of all, what is this map?

A Okay, this -- this is actually a montage of a stratigraphic cross section and then two maps, one being the structure map from the top of the Point Lookout sandstone, and an Isopach map of the porosity feet as mapped within the -- within the (unclear) Point Lookout.

I must apologize that this map, the work that I did on this was done just about a year ago and there's been a lot of drilling since then but I haven't had a chance to update any new wells that are -- that have come -- been drilled in the area at that time.

Q Okay. What does the Isopach show?

A Okay, what I --

MR. KELLAHIN: Mr. Chairman, I'm going to object, file an objection at this point until there is a relevancy established for this exhibit. It's in the Gavilan-Mesaverde. I don't believe that's under discussion.

A There is no Gavilan-Mesaverde.

MR. KELLAHIN: How does that relate to this case?

MR. LOPEZ: I think if Mr. Kellahin will bear with us, this relationship and purpose will

be amply demonstrated.

MR. STAMETS: We will allow the cross examination to continue and see if the relevance can be demonstrated.

Q Okay, is the Mesaverde productive?

A No, it isn't at this time but that was basically why I developed this map for my boss to let him know that I thought that in the future we would be able to develop the Mesaverde and produce oil and gas, but at this time, you know, with the gas market the way it is, we've chosen not to drill any wells at this time.

What I've attempted to do is map the porosity development which was in the top of the Point Lookout, the massive Point Lookout sandstone, and I had the interval marked off on each of these wells.

What I did was took the gamma ray neutron log and looked at the porosities and calculated the net amount of feet, effective pore feet within that interval and like on the Gavilan Howard No. 1 I found there was 3.35 porosity feet in that interval. Likewise, on the Gavilan No. 1-E I mapped 4.63 porosity feet, and farther on. I said that we hoped that the Mesaverde would be productive. On the stratigraphic cross section that I showed, only two of the wells have mud logs run on them. We saw excellent sample shows and mud logs shows and so we're very hopeful that

we will get something out of the Mesaverde on the Gavilan Dome.

What the -- the most striking element on this map is we see the Point Lookout sandstone and it's been -- in the San Juan Basin there are offshore bars that are well developed, and on the cross section we see the development of a new bar we have more development in and you can see that in the net porosity feet. We jump from 2.3, 1.6,

We've Isopached these values from the well data I had at the time and we see a nice bar development occurring. As you go toward the center of this bar you have higher amounts of porosity being developed.

But the most, the thing that interested me whenever I first mapped this, was that as you approach the edge of the Gavilan Dome end of the trough, and again ths is an old map, but the structure on this map at the Point Lookout does not really show the trough as good as the new data that we have on the top of the Niobrara A, but I did some sort of trough here. Anyway, perpendicular to the development of the bar we saw the permeability of the Point Lookout sand stopping and it kept gettng lower and lower permeability, porosity and permeability, until from the data that I had at the time, we saw that as you did approach the synclinal trough there, at the west edge of the Canada Ojitos Unit, we have an effective permeability barrier, that

the -- porosity and permeability barrier -- that the sandstone, excellent sandstone bar is being developed has been deteriorated since we cannot map it any more.

A lot of -- fortunately a lot of the Canada Ojitos Unit wells did not have -- are older wells and they did have gamma ray neutron log on them, but several of the wells were cored in the Mesaverde and I assume that they are nonproductive, no completions were attempted.

So what I envision is that we do have porosity development within the Mesaverde interval and that as we approach the trough as mapped on the -- between the Gavilan Dome and the monocline, that we see porosity, effective porosity being eliminated.

Q What about any differences in the Dakota formation?

A Well, I don't have a map showing the trends of the sandstones bars in there . All I can say is on Exhibit Number Two we did show the existence of the pool boundary for the Gavilan-Greenhorn-Graneros-Dakota Pool and we have established production. Some of the wells in that pool are complete or producing on their own and some of them are producing commingled with Gavilan-Mancos intervals; however, I'm of the opinion that the Dakota is nonproductive on the mononcline and that -- that indeed there were some wells drilled through the Dakota and tested in that way and

there was no production found.

Again we might postulate that the Gavilan-Mancos, the Gavilan-Dakota Pool seems to stop at the trough. Again the same trough that the Pictured Cliffs, the Mesaverde, and the Dakota seems to stop at, that trough between the Gavilan Dome and the monocline.

Q How about the Pictured Cliffs?

A Pictured Cliffs?

Q Is there any evidence of Pictured Cliffs production on that?

A Monocline?

Q Yeah.

A No, there isn't. Of course the wells were drilled through the Pictured Cliff interval and I believe there were some wells that were drilled just to test the Pictured Cliff and no production at this time in that area.

Q Does Exhibit Two show the Pictured Cliff boundary?

A Yes, it does. I pointed that out, that the pool boundary stops right in the center of that trough as defined in the Gavilan-Mancos interval.

Q Okay. What about any differences between the two areas of the Gallup?

A Well, I feel that there are some differ-

ences in the Gallup or the Niobrara -- Mancos and the Niobrara interval between the Gavilan Dome area and the monocline.

Q And on what basis do you feel this?

A Well, wireline logs and I've already pointed that out on my structural cross section there seems to be differences, and from what I've witnessed in the Gavilan area from the limited core data that we had and from mud log shows and sample shows, we feel that there is matrix porosity developed within the Mancos interval in the Gavilan Dome area.

Q And what do you base this on?

A Again I base this on sample shows and mud logs we see as the well is being drilled. Mud logs have drilling breaks indicative of porosity development. The samples coming over the shale shaker lag back to this interval of drilling breaks. The mud loggers, many, many of the mud logs that I've seen in the area did cuts off of these samples, to me indicating that there is matrix porosity and that it is indeed filed with oil, and that it has some permeability.

I've been out on a well where I watched the samples come over, you know, I was with the mud logger when we looked for mineral fluorescence and we looked for sample cuts and all and we did see this, so I feel that

there are -- is matrix porosity in this area.

I pointed out that we have limited core data and we've pretty well discussed that so far in the hearing.

Mobil has a core down in the southwest portion of the field.

Mallon has a partial core in Section 1 of 25 and 2, and Mallon is now drilling a well in Section 3. We're probably on the second to the last or the last core now. That coring effort is being paid for by the engineering and geological subcommittee meeting and we hope to see evidence, more evidence of matrix porosity.

The evidence I've seen on the core evaluations shows that there is some -- some matrix porosity.

Q Do you think this matrix porosity is high or low as the permeability goes?

A I think that probably the matrix porosity is on the low side and that indeed the permeability is probably low also.

We can look at the core data and as brought out by Mr. Greer this morning on Mallon's well, he didn't see very good relationship between the core porosities and the wireline log porosity measurements.

I would like to point out that I feel that there is probably an error on the CORE Lab handout that

was given to Mallon whenever they paid for the analysis of the core, and when they shared the information with us at the geological and engineering subcommittee meetings.

The main error that I would like to point out is that CORE Lab realized that there was a depth problem between the core and how they had logged it with the wireline logs and I believe they shifted it 16 feet and it says that here in the report; however, I look at it and I think they should have shifted it a little bit more and exactly 6 more feet lower.

What they did was they showed where there was less shale, a shale peak. They matched that against a gamma ray peak showing more shale and they probably based it on a little blip in the caliper. I think if you move that down 6 feet you will actually see that the -- then the shale corrections from the core actually match the gamma ray, and then if you take the corrections and using the wireline log porosity measurements and cross plot those, I think you would find that the wireline logs are in more agreement with the core porosities.

I know Mobil has done that with their core and have told me in conversations that these do, if you do the correct shale corrections, you do get a very close estimate between the core porosity and the wireline log porosities.

Q Do you think the matrix can produce on its own?

A If it was strictly a sandstone, typical sandstone reservoir, no; however, I think that with the aid of fractures it can produce, since the initial development of the San Juan Basin, initial rapid development, I guess, in the fifties is what I'm trying to say, many of the companies realized that the sandstones and siltstones within the Gallup interval contained large amounts of oil. They realized that the porosities were low and permeabilities were low, and so for the most part it was pretty well bypassed.

They did try to mechanically frac the wells and put a fracture into the formation in hopes of draining some of this matrix porosity with the oil in there, and what happens is for awhile you get a real good well and then as you drain farther away from the frac, the manmade frac in the wellbore, and when you do frac a well you only have one -- one fracture going 180 degrees apart from each other from the wellbore, you -- you drain the area close to that fracture.

So what people do is try to find areas that are naturally fractured. You get a double benefit there. You have fracture porosity that's going to have oil in it so you're going to get oil thataway. You're going to

get -- the more fractures that you have in the reservoir, scattered around in these tight sands, the closer any particular area of the tight sand will be to a fracture, and I think that in the Gavilan area, which in most areas are highly fractured, some areas appear to be less fractured than others, that we may only be one foot, two foot away from any fractures, any of the large fractures. We don't know about the microfractures, but if you're never more than a foot away or two foot away from a fracture, being an optimist, I think that these tight sands have a very good chance of giving up some of that oil that's in the matrix into the fractures system and then ultimately out the wellbore down the sales line.

Q And discussing fractures, have you been able to determine whether they're present and how they're oriented in the Gavilan Dome area?

A Yes, we -- determining their presence is fairly easy and that's by looking -- well, actually a lot of times it's being on the rig floor when you drill through it, and you can look at it from mud logs when you see rough drilling indicated. But you can't really tell the orientation of the fractures, and on the last three wells that Mesa Grande drilled we ran a fairly new log called a -- well, there's -- it's called different things by -- depending on which wireline company you have out there logging your well,

but it basically allows you do detect the fractures and determine their orientation within the formation.

Q I'd now refer you to Exhbiits, I think, Six and Seven, and ask you to discuss how -- these exhibits and also explain how to determine fracture orientation.

A When we -- the oriented frac finding tool that we've been running in the area is a -- is another use of the dipmeter tool, which is widely used throughout the industry, and what it measures on four pads that are ninety degrees apart from each other are -- is micro-resistivity, and the computer utilizes the signals from these four pads to see if there are any differences.

First, in Exhibit Number Six I'd like to just show hypothetically how this tool would read or not read fractures in the wellbore if they were encountered.

We have one possibility to where there could be a fracture in the reservoir or in the formation that we don't see it with the tool. That is the one that's running from, if we looked at it at a compass orientation, from northeast to southwest. This fracture would be in the wellbore and none of the four pads would see this.

Q Maybe you should hold it up and point it out, if you would, please.

A That would be this particular fracture right here.

Q And that's the line that doesn't --

A That's the indication of a fracture that would cut the wellbore that the tool would not see because pads 1, 2, 3, and 4 are not sitting on top of the fracture.

Okay, the easiest case is when we use this data to get the orientation of the fractures, would be this fracture here running, basically, in a north/south direction. Pad 1 and pad 3, or it could be pad 2 and pad 4, any of the pads that are 180 degrees apart from each other. If both of these pads read it then they will see an anomaly that pad 2 and pad 4 don't.

Another case would be one where the fracture passes the wellbore, here sits the wellbore, and of course in this case it's pad 1 and pad 4, or it could be any of the two pads that are 90 degrees apart from each other to see that. It takes a little bit more calculation either on the computer or by hand to get the orientation of this fracture and from the last fracture I talked about, but it can be done.

And the last hypothetical case is where the fracture is the one shown on the righthand side of this exhibit, where it passes the wellbore and only one pad reads it. In this case all we can say is that there is a fracture present somewhere in the wellbore. We don't know the orientation; however, if you get a lot of these points where you

only see one pad reading them, you do start to get a pattern and you can then get an idea as to its orientation.

Q Now referring to Exhibit Seven, why don't you explain that one?

A Okay. Exhibit Seven is a composite and what's shown are two of the three wells that we ran the dipmeter to along the frac finding log. The reason I didn't include all three of them was because Welex ran two of the logs; Schlumberger ran one, and what I'm trying to show is the method of how we arrive at orientating the fractures, and they're different, so I just -- I showed the Welex and the Schlumberger.

First I'll direct your attention to a Mesa Grande Well, to Bearcat No. 1. In there we ran a Schlumberger log and it's called the oriented micro-resistivity log, and what you see is each of the four pads are listed on the left in the center of the log and you can see them spiraling up the wellbore.

The pad number 1 is highlighted on the log as opposed to the other four pads, by the dark nature of the curve. It's also listed here on my composite log.

Knowing the -- the computer keeps tract of the orientation of this -- of the tool, and like I said, as you log the well the tools rotate up the hole.

Knowing the orientation of pad 1 you also

know where pad 2 is. It's always 90 degrees away from there. Pad 3 is 180 degrees from pad 1. Pad 4 is 270 degrees going along and around that compass from pad 1.

As we see in the Bearcat No. 1, as you get down in what I've listed as the C zone on this well, you see the tool, the orientation of pad 1 and actually of all the pads, changing. This is because of the normal rotation of the tool as it goes up the hole as you log, the tool will rotate, and you can see that the tool is rotating. Then as you start getting farther up the hole, basically starting at about 6850, the orientation of the pad 1 is no longer normally, it's starting to maintain a constant direction, rotating slowly and as you get higher up, beginning at about 68 -- 6810 on the log, you see that pads -- the tool has stopped rotating and that the pads are maintaining a constant compass direction and then likewise, as you get to about 6730, the tool starts to slowly rotate again, although not fast, normal rotation again, but slow, and then as you get farther up on the log here, the tool is back to its normal rotation.

When you drill in a fractured interval, the fractures cause the hole to shift from a round hole more to an oval or elliptical shape in the direction of the fracture and what happens is if you come to a large fractured interval this tool can no longer rotate freely in that hole.

It's kind of squeezed in and it will go up -- log up the hole in that same elliptical orientation as the hole is due to the fractures that you penetrated.

Okay. I said that, back on Exhibit Six, the computer reads the information coming from all four pads and sees the different anomalies and on the Schlumberger presentation what they do is let's look at pad number 1 and where it shows pad number 1 written here, we see an area that's separated and darkened in. Well, if pad 1 is seeing the average of all the other pads then you have a direct overlay and if pad 1 sees something than the average from the other pads it kicks it out and separates it and that flag, that pad is seeing something different.

If you go and look at pad 3 and if it's seeing something different and pad 1 and pad 3 are seeing the same thing, then we have an indication that there's a fracture in the wellbore and that it is this case here where this fracture here is running north/south and pad 1 and pad 3 are seeing it.

We see this in the interval from about 6735 down to about 6810, where in that interval, as I pointed out earlier, that the tool was not rotating, but was actually probably following the fracture plane and we see here the indications are that pads 2 and pads 4 are seeing the fracture. Pad 1 and pad 3 are not, because of the sep-

aration on the curves as the computer has shown us.

Since we know the orientation of pad 1, the computer keeps track of that for us, we know that pad 2 is 90 degrees from that; pad 4 is 270 degrees away from that, so later I will show how you plot that up and determine the orientation of the fractures.

I would like to now go over to the other composite log. This is Mesa Grande Resources well, the Marauder No. 1.

Welex logged this well and their log is called a 4-arm dip fracture profile.

MR. STAMETS: Mr. Lopez, could I inquire at this point how much more testimony we have from this witness?

MR. LOPEZ: Half an hour max; 20 minutes.

MR. STAMETS: Much as I hate to interrupt, Mr. Kelley does have some obligations to leave and so I believe we're going to break at this point and then we will resume in the morning in Room 337 of the Roundhouse at 8:30.

So we will recess the hearing until that time.

(Thereupon the evening recess was taken at 5:00 o'clock p.m.)

(Thereafter at the hour of 8:30 o'clock a.m. on the 22nd day of August, 1986, the hearing was again called to order in the Committee Room Number 337, New Mexico Capitol Building, Santa Fe, New Mexico, at which time and place the following proceedings were had, to-wit:)

MR. STAMETS: The hearing will please come to order.

When we recessed last night Mr. Emmendorfer was in the middle of his testimony.

You may resume when ready.

ALAN P. EMMENDORFER,

resuming the witness chair and remaining under oath, testified as follows, to-wit:

DIRECT EXAMINATION CONT'D

BY MR. LOPEZ:

Q Well, maybe we both can help each other pick up where we left off.

I think you were describing Exhibit Number Seven, which was the Welex and Schlumberger logs and how these logs help identify fracture orientation as you had

described it in the process of your other exhibits.

So maybe you could pick up where you left off. I think you had completed discussing, as I recall, the Schlumberger log and now we're discussing the Welex log.

A Okay. Well, Mr. Commissioner, if I might, I'd might just review (not clearly understood) what I've said so far in my testimony and what I pointed out was we have very steeply dipping monocline over here to the east in 25 -- centered in 25, 1 West, and we have a slow, gently dipping structural dome here centered in 25, 2, and the structural cross section shows this very well. You have, again you see the very steeply dipping monocline which is where the historical Canada Ojitos Unit production has occurred; the trough that is outlined here on the structure map separating the two structural entities; and then you have again the low dome of the Gavilan Dome with very low structural dips.

Then I pointed that if we look back on Exhibit Number Two, the pool boundary of the Gavilan-Pictured Cliffs Pool, gas pool, the pool boundary ends and production stops right when we get to this trough as outlined on the structure map.

Likewise on the Point Lookout Isopach we saw the development of a good example of development of a

bar, an offshore sand bar, and as you approach that same trough between the two structural features, we see that perpendicular to the bar you have evidence that porosity of this bar decreases rapidly as you approach this trough.

I also pointed out that the Gavilan-Greenhorn-Graneros-Dakota Gas or Oil Pool, we do -- the pool boundary stops at the boundary between Township 25 North, 1 West, and Township 25 North, 2 West, and that we have, we do have Dakota production established over here on the dome and there is no production, there has been drilling through the Dakota but no production on the monocline.

Then I started discussing the ways to detect fractures in the wellbore and their orientations.

If I may, I'll continue then on that.

Yesterday I talked about Schlumberger's log on the Mesa Grande Resources Bearcat No. 1.

We next go to the Mesa Grande Resources Marauder No. 1. The two companies use the same dipmeter tool. Their software packages to analyze it are slightly different.

Welex shows the raw data just as -- well, Welex shows the raw data.

The Schlumberger goes one step farther. It's strictly a software program to give the computer. The computer then reads everything and shows us the orientation

END OF VOLUME II