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

23 August 1989

EXAMINER HEARING

IN THE MATTER OF:

Application of Devon Energy Corporation for a unit agreement, Eddy County, New Mexico, and	CASE 9734
Application of Devon Energy Corporation for waterflood expansion and to amend Division Order No. R-7926, Eddy County, New Mexico.	CASE 9735

BEFORE: David R. Catanach, Examiner

TRANSCRIPT OF HEARING

A P P E A R A N C E S

For the Division:	Robert G. Stovall Attorney at Law Legal Counsel to the Division State Land Office Building Santa Fe, New Mexico
For Devon Energy Corporation:	W. Thomas Kellahin Attorney at Law KELLAHIN, KELLAHIN & AUBREY P. O. Box 2265 Santa Fe, New Mexico 87504

I N D E X

E X H I B I T S

E X H I B I T S Cont'd

MR. CATANACH: Call next Case 9734 at this time.

The application of Devon Energy Corporation for a unit agreement, Eddy County, New Mexico.

Are there appearances in this case?

MR. KELLAHIN: Mr. Examiner, I'm Tom Kellahin of the Santa Fe law firm of Kellahin, Kellahin & Aubrey, appearing on behalf of the applicant.

At this time we'd like to consolidate the unit case, 9734, with the request for waterflood modifications to our project. That's Case 9735.

MR. CATANACH: Okay, at this time we'll call Case 9735 and consolidate the two cases.

Application of Devon Energy Corporation for a waterflood expansion and to amend Division Order No. R-7926, Eddy County, New Mexico.

Are there any other appearances in either one of these cases?

MR. KELLAHIN: I have four witnesses to be sworn.

MR. CATANACH: Will the witnesses please stand to be sworn in?

(Witnesses sworn.)

MR. KELLAHIN: Mr. Examiner, our initial witness is Mr. Curtis McKinney. Mr. McKinney is a petroleum geologist with Devon Energy Corporation. He has organized his exhibit book in the blue binder.

While I have yet to stamp his displays with the exhibit numbers, I will do that after the hearing, we will follow in order of his presentation. Our Exhibit One will correspond to what he has inserted in pocket one of the exhibit book, which, for example, is the current status map.

We will then try to identify for the record each of the displays and then subsequent to the hearing I will -- I will mark them with your exhibit stamp.

CURTIS McKINNEY,

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

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Mr. McKinney, for the record would you please state your name and occupation?

A My name is Curtis McKinney. I'm a petroleum geologist for Devon Energy Corporation.

Q On prior occasions, Mr. McKinney, have you testified as a geologist before the Division?

A No, I have not.

Q Would you take a moment, sir, and describe your educational background?

A I have a BS in geology taken in 1979 and subsequent to that I've been employed by Devon Energy Corporation for approximately 10 years as a petroleum geologist.

Q Pursuant to your employment as a petroleum geologist, have you studied the geologic factors surrounding the Grayburg-Jackson-San Andres Flood that was formerly operated by Texas American Oil Corporation and is now operated by Devon Energy Corporation?

A Yes, I have.

Q And this located in Eddy County, New Mexico?

A Yes.

MR. KELLAHIN: At this time, Mr. Examiner, we tender Mr. McKinney as an expert petroleum geologist.

MR. CATANACH: He is so qualified.

Q Let me ask you, sir, to take what is identified as the current status map. We have labeled that as Devon Exhibit Number One. And before we get into the geologic discussion of what you have studied and what you have concluded, Mr. McKinney, let me have you use this display and help orient the Examiner as to the type of wells involved in the flood, how to identify the outer boundary of the flood, and to show him the location of the outline of cross sections that we're going to be discussing.

A All right. In the center of this exhibit. Section 16, you can see some dashed lines that circumscribe portions of Section 16 and the northeast portion of Section 17. That outlines our leasehold in this area and that's the -- that's the area that we would like to unitize for waterflooding purpose.

Of interest to our waterflood are the yellow circles or the wells that are colored yellow. Those are the Grayburg producers and it's the Grayburg formation that we wish to flood.

There is a pilot injection project underway currently and the injectors for that project are shown as yellow triangles.

Cross sections noted, there's an east-west cross section denoted as A-A', which crosses more or

less through the center of Section 16 in the east-west direction, and cross section B-B', which crosses Section 16, as well, on a north to south direction.

Q When we look in the immediate area offsetting the Devon waterflood project, are there other waterflood projects being conducted by other operators in the Grayburg formation?

A Yes, there are. To the north and northeast, I believe it is Anadarko that has a waterflood underway that they call their Square Lake Waterflood, and to the immediate east and somewhat to the southeast there is an older waterflood, also, in the Grayburg. I don't recall the name of that waterflood but the Grayburg is being flooded offsetting us.

Q In reviewing the geologic data that's available to you, have you been able to formulate an opinion as to whether the outer boundaries of this waterflood project area, the unit, has a logical geologic explanation for inclusion within the project area?

A Yes, I have.

Q And what is that opinion?

A I believe that there's permeability barriers located to the -- in the northwesterly direction and to the -- to a degree, to a lessor degree, to the southerly direction and the individual reservoirs within

the Grayburg formation are uniform across our acreage. That's really the basis for the flood.

Q Can you locate within the unit area from wellbore to wellbore, Grayburg production and have that production on log correlation be continuous throughout the unit area?

A Yes. Yes. It's very easily demonstrated.

Q Geologically, do you find in your opinion that this is a suitable formation in a logical area by which waterflood projects or waterflood injection can occur?

A Oh, yes.

Q Let's talk about the vertical relationship of the various formations in this immediate area and particularly look at the well-to-well correlation of the Grayburg formation and in illustrating that presentation, Mr. McKinney, let me ask you to turn to pocket 4 and let's look at cross section A-A'.

Let me, first of all, before you begin describing Exhibit Four, have you explain to us why you've selected this particular row of Grayburg wells to construct the east/west cross section.

A Well, some of the engineering data pertinent to this project will -- comes from the existing

pilot flood and this cross section goes right through it.

It begins on the north -- excuse me, begins on the west with the Grayburg producer, goes to an injector, then to another Grayburg producer, and then finishes with another Grayburg producer on the far eastern edge of the unit, proposed unit.

Q Is the east/west cross section, A-A', going to be typical of -- of the Grayburg wells in this area?

A Yes.

Q All right, and had you selected other wells to construct the east/west cross section with, you would have had a similar result or a similar depiction of the geology that you see here in Exhibit Four?

A Yes.

Q Let me have you identify and describe for us the major geologic conclusions that you see as an expert when you examine Exhibit Number Four.

A Okay. This is a stratigraphic cross section hung on the top of the Grayburg formations. The formations are labeled on the righthand side of this exhibit.

The individual reservoirs within the Grayburg are also labeled. Our primary zones of interest for flooding are the Loco Hills member, the Metex member,

which I break into an upper, middle and lower units, and the Premier member at the base, and the Grayburg is underlain by the San Andres formation, and what this primarily shows is the horizontal continuity of each of these members of the Grayburg and therefor their suitability to the response to a flooding operation.

Q Is it geologically suitable to use the entire Grayburg formation as shown on this cross section as the flood area rather than try to flood individual or separate members of the Grayburg formation?

A We believe that would be the most economic way to approach the flood on our leasehold. There's -- I can think of no reason to isolate one member or another. Part of the reason for that is this is an old unit and it's difficult to attribute specific primary recovery to any one single member. We have -- we have production attributed to the Grayburg formation as a whole, so it would be difficult to select an individual member as having a great deal more residual oil than another, so we would opt to just flood the entire formation in the porous intervals as are -- which are indicated in the green on this cross section.

Q Let me have you go now to the B-B' cross section, which is the one that runs north/south. We're going to mark that as Devon Exhibit Number Five. Does this

also represent your work product, Mr. McKinney?

A Yes. All these exhibits are my work product.

Q What does this show you?

A It's very similar to A-A', again showing the lateral continuity of the reservoirs in a north/south direction and it ties at Well No. 19, which is your second well from the left on this cross section. It ties the other cross sections so that if a person wanted to compare the two cross sections it would be readily apparent. I believe that we do have lateral continuity within the Grayburg formation in the units that we wish to inject water into.

The other -- well, that's basically --

Q One of the topics we're going to be discussing with the Examiner is to request a surface injection pressure for the injection wells of approximately 1600 psi.

A Yes.

Q Which I understand will be a pressure above the step rate pressures in certain wells and will be in excess of the .2 psi per foot of depth guideline.

My question for you as a geologist is to what extent you have examined the formations immediately above and below the Grayburg formation to satisfy yourself

that those are -- that the Grayburg is adequately sealed so that injection fluids introduced into the Grayburg formation are going to remain confined to that formation.

A Geologically the Queen formation, which immediately overlies the Grayburg, is -- is just a tight, nonporous lime immediately above us, and furthermore, the Grayburg itself, there are some 50 feet of Grayburg above the first zone that we will be injecting into, the Loco Hills, that is equally impermeable.

Beneath us is the San Andres, which the top 70 feet or so before you get to the Lovington porosity zone, is also a tight, impermeable, nonporous lime. So geologically we don't really have any -- we have -- we have good seals above and below.

Of note on this cross section is the injector well, which is your second well from the left. It's fairly small type but it's the Etz State No. 24. There is some engineering testimony which will follow that -- pursuant to mine -- that is of particular interest with this well 24. So all if really want to state about this is please note from this cross section how uniform the zone is and how correlative Well 24 is to the other wells in the cross section, as well as cross section A-A', because the engineering testimony will key off of Well 24, and I -- that's what I really want to demonstrate with this exhibit.

Q Are you satisfied, then, that the Etz State 24 Well is -- is very typical of all the other injector wells that are going to be selected and utilized for injection in the flood area?

A Yes. Yes, I am.

Q Have you attempted to map the structure in the area immediately inclusive of the waterflood project to see what the structure, the geology looks like?

A Yes. Again noting on your cross section, you'll see the Loco Hills member of the Grayburg, that's readily correlated across the area, so it gives us an idea of what the structure is immediately above us. I made a structure map on the top of the Loco Hills porosity zone.

Q All right, Mr. McKinney, let me take just a moment so we can clarify for the record how we're going to identify these exhibits. I propose that we'll take the first structure map, which is the top of the Loco Hills, is it not?

A Yes, that's right.

Q Let's mark that as Two-A and we'll mark the top of the San Andres structure map as Two-B.

Now let me have you direct your attention to the structure map on top of the Loco Hills and identify and describe that structure for us.

A Again the unit is centered on the map in Section 16 and 17 and it's a -- basically shows an anticline plunging in an easterly direction and oriented with the axis due east/west. This is on the axis of the well known Vacuum trend and this is the structure that forms the Grayburg Jackson Field, very old field in that part of the state.

Q Is there a geologic relationship or logic to the shape of the -- of the unit area with regards to the structure?

A Could you repeat that, please?

Q Sure. When you look at the structure map as shown on top of the Loco Hills, is there a geologic explanation to the boundaries and shapes of the surface area included within the unit?

A Well, we certainly can see that the structure drops off to the south, so we would be high to those wells, which would be advantageous to a flood, and it drops off also to the north of our unit, so it's also advantageous; plunging to the east, that's an advantage.

To the -- to the west it would be up dip; however, we are suspicious that to the west the Loco Hills, which is the best developed member of the Grayburg in this area, may be more gas productive and less oil productive and therefor would not be as good a location for

our flood. So we think we're well located on the axis of this structure, down dip of higher gas saturations if there be some. I don't have technical data to demonstrate that. It's mostly derived from initial potentials and such from wells over there. They're certainly not gas well, they're oil wells, but that -- that plays a part in our thinking.

Q Can you reach similar conclusions from an examination of the structure which is drawn on top of the San Andres?

A The San Andres predominantly, in conjunction with that Loco Hills structure, just shows you that these are conformable throughout the Grayburg; that the bottom of the Grayburg, top of the Grayburg are just -- just lay right on top of each other and this a similar anticline trending east/west across our proposed unit.

Q Let's go to your isopach maps.

MR. KELLAHIN: There are three isopach maps in pocket number 3, Mr. Examiner, and I propose to label these with the Loco Hills being Three-A, the middle porosity in the Metex is Three-B, and then the Premier Zone is Three-C.

Q What do you conclude as a geologist, Mr. McKinney, from having made the interpretation, drawn the isopach maps, with regards to the reservoir thicknesses involved in these three -- three mapped intervals?

A The Loco Hills is the best developed in terms of gross thickness, or net thickness. It's present everywhere across our acreage and reached a maximum of approximately 35 -- 34 feet, our proposed unit, and a minimum of perhaps 14 feet. So it's -- it is the best developed of the three porosity zones that we believe most of our -- most of our production will come from if we unitize.

The Middle Metex, which is Three-B, Middle Metex also is present across most of our acreage. It's -- it's thinner. The Middle Metex is the best developed porosity zone within the Metex unit, so we mapped that. The Upper and Lower Metex will be less so, but the Metex will probably contribute least of the three primary objective reservoirs, but it is present across the acreage and does reach development, I believe a maximum of about 16 feet, and in the far northern edge of our unit there is no porosity development.

The last of the packet is the Premier. The Premier is not -- again, not as well developed as the Loco Hills but better developed than the Metex, and on the (unclear) again, it's present across our acreage. Again, data just off our unit to the south indicates that it's -- that it's losing porosity in that direction. We have a maximum thickness of porosity in the Premier, of approximately 13 feet -- 20 feet, excuse me, 20 feet in the far

northwestern corner of Section 20, and a minimum of perhaps 7 feet -- excuse me, 2 feet, I see.

Q Are you satisfied as a geologist that you have sufficient reservoir thickness and reservoir continuity to make this an effective flood?

A Yes, I am.

Q Let's go to what is marked as -- what I will mark as Exhibit Number Six. It's in the pocket marked number 6.

I think, Mr. McKinney, this is a good display to put on the wall. If you'll help me put this one up, we might have you speak from the one on the wall.

First of all, if you'll identify Exhibit Number Six before you begin to describe it.

A We've title this exhibit Comparison of Vertical Confinement Properties Etz State Ballard Grayburg Producing Areas, and we have a location map here, south -- we're in 17 South, 30 East, in Section 16 for our well on this exhibit, which is our Well 24, which I mentioned earlier.

We're comparing it to the Ballard Grayburg unitized area, which is approximately 8 miles distant to the southwest. The well that we have (unclear) is the Ballard GSA Unit No. 23-4.

What we've got on the left side of this

exhibit are the open hole logs from each of these wells. Logs are hung on the top of the Grayburg, so it's a stratigraphic cross section. The primary purpose there is to demonstrate the continuity in zones and then when we speak of the Loco Hills in our area, we are referring to the same Loco Hills zone in the Ballard Unit and the same applies to the remainder of the Grayburg reservoirs, the Upper Metex, Middle Metex, and the Premier.

The primary purpose of this portion of the exhibit is to show the continuity and the similarity of nomenclature.

Q All right, before you go to the second portion, what do you conclude as a geologist when you examine the Anadarko Ballard type well with Devon Etz State 24 type well?

A I believe they're geologically similar and that conclusions that can be reached in our unit or at their unit, it's reasonable to extend those conclusions from one area to the other.

I should add, we are working interest owners in this unit so we are privy to some information down there, as working interest owners.

Q Let me have you describe the other two logs on the display.

A On this side we have basically computed

products from additional sonic logs. In the Anadarko Well it's called a frac pressure, frac type log. The Devon Well is called a frac type (unclear) sonic. They are basically both showing the same thing. What we're trying to show here is the confinement pressure, confinement of the frac gradient that's necessary to frac out of the zone and this is primarily an engineering exhibit and I really don't want to say too much about that. I'm not really qualified.

Q Well, the purpose is you have made a proper correlation of the logs --

A Certainly.

Q -- and stratigraphically have properly hung those logs on an adequate datum point.

A Yes. They are all hung on the same point on top of the Grayburg, stratigraphically hung.

Q And have you as a geologist reviewed the Anadarko Ballard Unit geology presented in the case by which they obtained an increased injection pressure for their project with the geology available to you for your unit area?

A Yes, I have.

Q And for all purposes that are material on that issue, are they sufficiently similar enough to draw conclusions from one to the other?

A Yes, they are.

MR. KELLAHIN: I believe Mr. McKinney has included in his package of exhibits the Etz State 23 type log.

Q Let me simply have you identify that for us, Mr. McKinney.

A On your -- let's slide back to that first exhibit called current status map, I don't know what the exhibit number was on that.

MR. KELLAHIN: I'm going to mark this as Exhibit One-A, Mr. Examiner, which is the type log.

Q Why have you selected this as a type log, Mr. McKinney?

A It's in the center of the unit. We had a good log on it. Some of the wells on this -- on this unit are quite old and we don't have open hole logs, so it was -- I mean it is similar to all the logs in this unit, are very similar geologically. This was a good log and it's in the center of the unit and that was -- well, it's not in the center of this unit, but anyway, -- I'm confusing it with 24 -- it was a good log, a good open hole log, and it's representative in my opinion to identify where that well is. It's at the tail end or the south end of cross section B-B' on the current status map. It's a Grayburg producer, as well.

MR. KELLAHIN: Mr. Examiner, I have for your information made an extra copy of the prior order that was issued on behalf of Texas American Corporation. It applies to this particular flood. This is the order that we're seeking to expand and to modify. It's Order No. R-7926.

That concludes my examination of Mr. McKinney.

We would move at this time the introduction of his Exhibits One through Six and the corresponding counterparts.

MR. CATANACH: Exhibits Number One through Six will be admitted as evidence.

CROSS EXAMINATION

BY MR. CATANACH:

Q Mr. McKinney, what is the unitized interval in this proposed unit?

A It's from the top of the Grayburg to the base of the Grayburg, as shown on those cross sections and also on the type log; approximately 260 feet, I believe, in our area.

MR. CATANACH: That's all I have at this time. The witness may be excused.

STEVEN K. BLAIR,

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

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Mr. Blair, would you please state your name and occupation?

A Steven K. Blair, Senior Reservoir Engineer for Devon Energy Corporation, Oklahoma City.

Q Mr. Blair, have you on previous occasions testified before the Oil Conservation Division?

A No, I have not.

Q Would you describe for us what your educational background is?

A I have a 1974 degree, a Bachelor of Science in Engineering, from the University of Oklahoma.

After school I went to work for Texas Pacific, where I worked as a development engineer in both their Oklahoma City and Midland offices.

Following that I worked for Energy Reserves Group in Oklahoma City and (unclear).

For the past fifteen months I've worked with Devon in the capacity I'm in now.

Q Okay, and that is that capacity now?

A Senior Reservoir Engineer.

Q As a senior reservoir engineer what have you done with regards to this waterflood project on the Etz State Unit?

A I've reviewed the log data and all the available producing data that we've had in addition to the performance of some offset waterfloods and surrounding data where available, and basically completed a field study on the feasibility of secondary recovery operations for the proposed waterflood acreage.

Q Have you completed that study?

A Yes, I have.

Q And did you have, in your opinion, sufficient information available to you from which to reach conclusions that in your opinion are reliable?

A Yes, I did.

Q Let's talk about the economics of the project for a moment. Have you reached an opinion as to whether or not there is going to be additional hydrocarbons recovered that might not otherwise be recovered if the project is not approved?

A Yes. Based on the analogy to the offset fields, which show a secondary to the primary ratio of anywhere from .72 to 1.2 and couple that were reported as 1.5

that I can't verify. All indications are that the acreage in the proposed unit would recover an additional 480,000 barrels of oil under secondary recovery operations, the value of which would be estimated at approximately $7-million at current prices.

MR. KELLAHIN: Mr. Examiner, at this time we tender Mr. Blair as an expert reservoir engineer.

MR. CATANACH: He is so qualified.

Q Mr. Blair, what is the approximate current producing rate of the wells in the unit?

A We're making 40/45 barrels of oil a day.

Q Is that per well or on a unit basis?

A No, that's total, on a unit basis.

Water is ranging anywhere from 350 to 400 barrels a day; gas, 75 to 120 MCF a day; and currently in the four wells that are currently having water injected to them, we're injecting 375 to 425 barrels of water a day.

So, essentially, right now we're injecting at the same volume that we're withdrawing, so at the current pressure limitations on the injection wells, we're unable to really develop any kind of pressure front and, you know, sweep efficiencies to efficiently flood this acreage.

Q Is there a remaining opportunity for further primary wells to be drilled in the unit?

A No, unless at some point gas prices or oil prices would support increased density which would give you some marginal recovery, probably, because of an improvement in sweep efficiency, but at this time at current prices that's not feasible and all of the acreage has got producing wells located on them, so it's basically fully developed under current economic scenarios.

Q What type of injection pattern are you planning to implement or to continue with this unit?

A Basically what TAO implemented was a 5-spot pattern pilot flood with four injection wells around a single producer.

We would propose extending this pattern to cover the entire unit.

At this time we would like to convert two additional wells to injection and based on their performance possibly either convert additional wells on the edges of the unit or possibly reach lease line injection agreements with offset operators at a future date.

Q Can you identify for the examiner the two additional injectors that you propose to add to the project area?

A Yes. It's the No. 22 Well, which is the

southernmost yellow triangle on what's been marked as Exhibit One and the No. 1 Well in the northeast northeast corner of Section 17 on the Collier Federal Lease.

Q Again quantify for me the range of estimated additional recovery that you might expect with the waterflood project.

A Based on my best estimates we should -- we should achieve 480,000 barrels of oil through secondary recovery; an estimated, probably, 15,000 barrels has been recovered to date from the pilot flood. After the pilot flood was initiated, TAO did not filter their water and they had a lot of oil carry over and the injection wells became plugged and unable to take any water and so their flood -- I mean their injection was really not in place for more than 6 or 7 months before it basically got shut down because of their failure to adequately monitor, you know, the contaminants they were putting back in. They were using produced water and they were getting carry over.

Q Are your estimates of additional recovery based or predicated upon receiving from the Division a surface injection pressure of 1600 pounds per injector well?

A Yes, they are. I believe that without the permission to exceed the fracture gradient, as represented in the step rate injection test, that the water in-

jection would be at best marginally better than what we would be withdrawing from the reservoir and therefore we would not have a good pressure front and good sweep efficiencies, and, in essence, would probably derive very little benefit from the water injection.

Q Have you conducted or had studies conducted in your behalf of determine whether or not the injection pressure of the injector wells can be increased up to a surface pressure of 1600 pounds and do so without fracturing the confining formations of the Grayburg?

A Yes, we have.

Q And what did you do to satisfy yourself of that?

A We took the No. 24 Well, which is currently an injector, and we ran a (unclear) log, which is a Schlumberger product. It's using a long spaced sonic and they measure the arrival times of different wave fronts and from that they can develop values for rock properties, rock compressibility, for (unclear) ratio of Young's (not understood) of elasticity.

Based on that, they can predict, based on a differential pressure above the fracture gradient, what will frac under a given pressure. Based on that, the log indicates that there will not be any injection out of zones with pressures up to as high as 600 pounds over the

injection or the fracture gradient, but we feel like we can get adequate water in the ground with 400 pounds over, so that's all --

Q I believe it was 450, was it?

A Well, it was 1600 pounds, 450 --

Q 1600 pounds. It would be 450 over the step rate number as opposed to 600. Let me have you go to Exhibit Number Six and demonstrate for us on the log what you have just described.

A Basically what you have presented on this log is this tract is calculated fracture height based upon properties that are calculated from the sonic log. Upon close examinations there's four different shadings in this tract that show different pressures from -- this tract is from zero to 1000 pounds differential. Each line is 200 pounds differential pressure above frac pressure.

So, basically, the first shading, which I believe is just a small dotted pattern, which is represented, it's hard to see from a distance, but it's represented by a very small area immediately within the fractures is what is predicted to fracture if you exceed the pressure by 200 pounds.

What we have colored in an orange is what is expected to fracture at a 600 pound differential. You can see that based on this the injection is expected to

remain pretty much within the porous zones, extending just a little bit above or a little bit below the zones.

Now, we've further taken this data and correlated it to the well in the Ballard Grayburg Unit, where they ran a similar log that is a Welex product, but basically the same process, it's long spaced sonic and they're calculating the same properties and going through the same exercise. And in this well we have shown what was projected to frac in their well and there again, perforations for both of these logs, on our well are indicated by the little diamond shaped triangles and on the Ballard Grayburg well on inside track here, and you can see in both cases that the predicted frac height stays within the zone. One thing to note, and we were unable because of our San Andres zone being plugged back, to get the log down to the top of the San Andres base, the Premier, and so therefor we were unable to show the perforations that exist in the Premier. But the excellent correlation we have between the upper zones with the zones in the Ballard Grayburg would indicate to me that the same things that they see were once this fracture hit the San Andres it stopped and you can see that because of the three different closeups, the three different pressures that they're looking at here for injection, they all stack and become very close, indicating a very strong barrier at the top of the San Andres.

So I have no qualms in saying that based upon the correlation between the two that I believe that this log clearly shows that at the proposed injection pressures, that all water would stay within the Grayburg formation, and in fact, not go very far out of the porous zones.

Q How confident are you in the reliability of the frac type log?

A I feel confident. The main problem that you have in doing these logs is that when you're going through casing you have to have an extremely good cement job behind casing in order to get the readings, and that is the problem that you run into a lot of times in that the cement isn't good and you can have some false readings.

In our well the -- actually the open hole log was not an open hole log, it was run in a cased hole, as a cased hole sonic and it was run at the time that the well was drilled and as the initial log, and it showed extremely good bonding, extremely good sonic response and we saw the same thing. In fact, the Schlumberger personnel said that they -- that was as good a readings as they had seen from a cased hole sonic log, so they thought the cement was excellent and the log quality was excellent and everything that I see indicates to me that there are no problems with the quality of the log and I feel very confident of that.

Q Is it a reliable method by which to determine the length and propagation of the fractures induced by the pressure that are applied to the well for this test?

A There are numerous examples in Oklahoma where I'm more familiar where they have gone in and predicted what zone they frac, how far, in order to design fracture treatments for some of the deep Anadarko Basin wells, and in work they've done after the frac, and they've gone back in and they've checked these holes, either tagging of the frac and running radioactive tracer a radioactive tracer for injection profiles. They've seen very good agreement between the log and what was actually induced by the fracture treatment.

So, yes, I would say that it is a very reliable method.

Q Can you have a successful flood in your opinion if you're limited to simply the pressure set forth in a step rate test for individual wells?

A I do not believe so because it's going to limit the water to the point that it just will not drag things out too long. We would not be able to -- it's going to take too much money. It ruins the economics of the situation, if it is even possible.

Based on what we're seeing right now

you'd have to drill many, many more injection wells in order to get enough water into the ground and I don't believe the economics would afford that.

Q Can we use the F State 24 Well as a good example of a typical injector well for this unit area?

A Yes. As Curtis testified, all of these wells have very similar characteristics and seem to have behaved in essentially the same manner throughout their lives, and we see such good correlation that I think this is a very typical well.

Q Would it serve any purpose to you as an engineer to have a similar log run on each of the injectors? Is that going to give you a more comfortable basis upon which to make a judgment about the injection pressure?

A No, I personally don't feel like it would benefit. I feel it's very clear from this log that we're not fracing out of zone if we inject at a higher pressure and I wouldn't expect anything different so I really don't think the (not clearly understood) improved.

Q Thank you.

MR. KELLAHIN: That concludes my examination of Mr. Blair, Mr. Catanach.

CROSS EXAMINATION

BY MR. CATANACH:

Q Mr. Blair, let's make sure I understand this process here.

The actually log measures the rock properties in the Grayburg.

A The actual log is a measurement of -- you send out a sonic wave and you'll be getting a response not much like a regular sonic, but what you're looking for is the first arrivals and you're looking for a different wave from than you are under a normal porosity type sonic log.

From the transit time of this wave front they can calculate properties using ratios between particular waves to get the (not understood) ratio and the rock compressibility so that the rock properties are actually calculated using theoretical calculations based on behavior of a sonic wave within the rock properties.

Q Once you have all these properties defined, then they -- how do they calculate what the frac pressure will be?

A Taking those -- the strength of materials was not a good course for me in college -- taking the (not understood) ratio and the Young's modulus and the rock compressibility, they can take those and based on that

determine shear stresses and what will happen when you apply force in a particular direction to the rock, and based on that they've got the equations that they calculate the fracture height and what will propagate through the rock.

Q Uh-huh. Well, when does reservoir pressure come into play?

A The reservoir pressure is -- it is included in the -- let me go back up there -- if you'll note on their well, the frac gradient above the zone shows to be a lesser gradient than the frac gradient through the zone and we believe this to be the effects of reservoir pressure based on the reservoir test that I supplied you and have used that data to calculate. As the pore pressure goes up, the frac gradient goes up so actually you're getting a smaller differential the more you inject because the frac gradient will be up.

Q Well, in a new injection well that is basically properly completed, wouldn't you expect these frac heights to go higher?

A As tight as the Grayburg is, what we've seen even after acidizing the existing wells and from the initial data that we had on the TAO injectors, the process of filling it up near wellbore and getting it repressured is very quick. I mean we did not see a period of repres-

suring. They started injecting and it was -- the pressure went up almost immediately because of the tightness of the rock.

I would not anticipate, you know, really any -- any problem with that because we're going to be limited waterwise to what we're going to put in trying to, you know, get uniform injection rates, and I don't believe that we're -- we're putting enough water in that even if that would be the tendency that it would create -- I guess what I'm saying is initially we're not going to have 1600 pounds on the new wells because we won't need it to put the 200/300 barrels of water a day we want to put into the well, and so I don't foresee that that would be a problem in the reservoir. I guess it could be if you were going to, you know, immediately go to 1600 pounds and put all the water in that it would take but we're not going to do that because we don't want to just flood out one area to the exclusion of the other.

Q You're actually, then, in effect, going to be fracturing the Grayburg. Will these fractures -- how far away from the wellbore will they go?

A I can't answer that exactly. Based on conversations that I've had with -- with some of the stimulation company's personnel, they don't believe that at the rates that we're looking at that they will extend extremely

distance because of the leak off. I would say that a maximum would be 2-or-300 feet, but I don't have anything firm to base that on other than some comments that I've received from some of the stimulation companies that the rates are such that it's just not -- you take a normal frac job and you're talking 10-12 barrels a minute down tubing and we're talking, you know, 10 barrels an hour down tubing and so you're going to have a lot more time for the leak-off and, you know, I would anticipate it would probably just frac near wellbores; maybe within 50 feet of the well-bore.

Q Okay, so you guys are initially going with a rate, not a pressure.

A Yes.

Q Do you have a set rate for these wells?

A What we'd like to see, probably, an injection to withdrawal ratio of somewhere maybe 4-to-1, 5-to-1 at most.

Q Is -- is Devon not operating anything but the Grayburg wells in this unit?

A The other wells are all temporarily abandoned or we are the operator of them. I believe the next witness would be better qualified to answer those questions. There are no nonoperated wells within the boundaries of that unit. Some of those have been TA'd and

plugged. The Queen flood has been abandoned before we took over the properties.

Q What -- what secondary to primary ratio did you use?

A My calculations were based on a .72, which is what was seen in the West Square Lake, which is the Anadarko offset.

The other floods, the Shenandoah Park Cooperative, which is to the southeast, the only real reference I could find to that were in some studies and they said it was higher than the West Square Lake, but how much higher, I don't know.

The Ballard Grayburg I have calculated 1.19. My calculations were based on .72.

Q Uh-huh.

A The uncertainty there as to how much actual Grayburg oil has been recovered to date, because it's been commingled with San Andres at times in the past, and I have recoveries indicated in TAO records as anywhere from 952,000 to a 1,400,000, of which I estimate 23 percent was San Andres, and that was based on some tests done by TAO and some TAO estimates, and it seems to be fairly consistent by the TAO reports, but the records were not very complete when we bought the properties, but, you know, I think that's reasonable based on looking at the recoveries

from the other floods and I'm comfortable with that number.

Q Have you guys actually run some step rate tests out there?

A Yes, we have run step rate tests on all four of the injectors.

Q And what have you found?

A I believe that the frac gradient ranged between -- I can answer that exactly. The frac gradients ranged between 1035 and 1330, the average being probably close to 1150, or so.

Q Okay, and you guys are asking for 1600 for all -- all four -- all six wells.

A Yes.

MR. CATANACH: I believe that's all I have for now. The witness may be excused.

MACK DUCKWORTH,

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

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Mr. Duckworth, would you please state your name and occupation?

A My name is Mack Duckworth and I'm a

petroleum engineer.

Q Mr. Duckworth, have you previously testified before the Division?

A No.

Q Would you describe your educational and work experience as a petroleum engineer?

A I have a BS in petroleum engineering from the University of Texas at Austin.

I went to work for Texaco, Incorporated, out of school; worked for Grace Petroleum, Ribinowitz Oil Company, and for the last nine years have been employed by Devon.

A And what year did you get your degree?

A 1977.

Q Did you prepare the Commission Form C-108 that applies to the various injector wells that you're seeking to add to your project area?

A Yes, I did.

MR. KELLAHIN: We tender Mr. Duckworth as an expert petroleum engineer.

MR. CATANACH: He is so qualified.

Q Let me refer you to Exhibit Number Seven, Mr. Duckworth, and ask you if this represents a complete package of information that you have prepared and

supplied the Division as attachments to the Commission Form C-108?

A Yes, sir, it does.

Q Let's have you turn through that exhibit package until you find the display that shows the various colored circles.

A Texas American Oil Corporation had previously permitted four injection wells and the -- I don't have a colored one, I've got a xeroxed package, I'm sorry.

The green lines are the area of -- a half mile radius area of review of those four original wells.

The red semicircles are the areas outside of that original review area that I reviewed to extend the area.

Q Within the area of review did you make a tabulation of all the wellbore information for those wells that penetrated to or through the Grayburg formation?

A Yes, sir, I did, all the additional wells that were not included in the original exhibits.

Q In examining that information did you find any wells in your opinion as a petroleum engineer have not been properly cemented and cased through the Grayburg formation?

A There is only one well which I could not

confirm that was properly protected and that was the McIntire G Federal No. 1, which is on page 2 of the computer printout of the tabulation.

The problem there is we don't know how much cement was pumped. I could not find any public record or contact anyone who knew how much cement was used and they didn't have any record of measurement of that top of cement.

Q Does the location of that well for which there is missing information, the location of that well in relation to the nearest injector well, give you any reason to be concerned as an engineer that that might be a source by which injector fluid could migrate to the Grayburg formation in that wellbore and out of that formation?

A It is a possibility if the well was not properly cemented but in reviewing the entire area and looking at the exhibits that were originally submitted, all of these wells were protected high enough to where the Grayburg, and in most cases, the Queen, could be produced.

So my educated estimate is that this well would have been properly protected also across the interval that we are concerned about.

Q Would you go back and let's look at the schematic that shows the example by which you propose to complete for injection either the ETZ J-22 or the Collier

Federal 1, either one of those? Which one would you like to look at?

A I have the Collier Federal No. 1 is the first one.

Q Well, it's the first one I have after the cover sheet. Describe for us your method of completion for injection.

A The Queen perfs in this well have been squeezed off. We propose to go down and set a cast iron bridge plug above the San Andres at 2875 and to place a cement cap on top of that.

We will then run a plastic-coated 2-3/8ths inch tubing string with a packer, circulate packer fluid in the annulus, set the packer, and that will be our injection string and procedure.

Q Will there be a method at the surface to measure or gauge the pressure on the annular spacing?

A Yes, sir.

Q Is there any different method by which you will complete for injection on the Etz J-22 Well?

A No, sir.

Q And that's the next schematic shown in the information package?

A Yes.

Q Describe for us the general method of

operation for the injection wells in terms of rates on a daily basis of injection water.

A We anticipate using 200 barrels of water per day as the initial rate, or 1200 barrels of water per day for the entire project into the six injection wells. We have already built the injection plant and installed a filtering system and settling tanks. Our supply water will come from the fresh water supply of the city of Loco Hills and a private firm that's going to furnish water to us. This is good, clean water that is compatible with the formation water.

Each of the wellheads has a filter at the wellhead and will receive secondary filtering.

Q Have you made an examination to determine the location, if any, of any fresh water sources in the immediate area?

A To my knowledge there is no fresh water, are no fresh water sands, in this area. All of the drinking water, even the water for the agricultural business has to be piped in.

Q Have you supplied to the Division -- what other information have you supplied to the Division?

A There are two wells that were plugged and abandoned that are in the new area of review. I submitted downhole diagrams of those two wells. They are

properly plugged and would be adequately protected from any migration of fluids.

I also supplied the request for the 450 psi increase above the step rate test established fracture pressure, which was 1142 for the average of the two wells.

Q Have you had to conduct operations and determine the effectiveness of the waterflood using pressure rates up to the rates allowed for the various step rates?

A Yes, sir, we have and we're having a real problem there.

In the month of August at the allowed pressures we were only able to put 16 barrels of water per day in one injection well; 107 barrels of water per day in the second injection well; zero barrels of water per day in the third injection well; and 148 barrels of water per day on the fourth injection well.

The additional produced water has been placed down of one of the permitted Queen injection wells, using it more or less as a disposal well.

Q Do you have an opinion as an engineer as to whether or not the surface injection rates for the injector wells can be increased up to 1600 pounds without risk of fracturing the confining formations above and below the Grayburg formation?

A Yes, sir, I believe that what we're asking for at the 1600 psi us a safety margin above fracing out of the zones. There are established injectors around us that are injecting at 1700 and 2000 psi.

The Queen flood inside this unit area injected at pressures closer to 1500 psi and they have a lower fracture gradient than the Grayburg, and there were no problems with fracing out of zone or communication to surface at all. So I feel like --

Q There are no light flows on the surface from any of those operations?

A No, sir, and I feel like it has been demonstrated in the area that the higher pressures can be utilized if proper casing and cementing has been put into the injection wells, the injection will be confined within the reservoirs themselves.

MR. KELLAHIN: That concludes my examination of Mr. Duckworth.

We would move the introduction of his Exhibit Number Seven.

MR. CATANACH: Exhibits Number Seven will be admitted as evidence.

CROSS EXAMINATION

BY MR. CATANACH:

Q Mr. Duckworth, did the Queen waterflood pretty much cover the same area?

A Yes, sir, it does. It's the orange -- everything that's orange inside that unit boundary is Queen production.

Q This was operated by whom?

A Texas American.

Q Was this separate from the other -- from R-7926?

A Yes, sir, it was. It was a true Queen individual waterflood.

Q It was.

A And it is totally watered out. There is no recoverable oil left in the Queen.

Q Who operates the flood?

A It is shut in and we're currently plugging all the Queen wells.

Q You are? Are you going to plug all the Queen wells?

A Yes, we are in the process of plugging three of the Queens right now, as of -- work started last Monday. We got one well plugged, we're on our second and should finish it today and begin the third. You have a

representative on location, has been throughout the process.

My recommendation to my bosses is that we plug two additional Queen wells every six months until all the Queen wells are plugged.

Q Are these Queen wells drilled through the Grayburg?

A No, sir, they are Queen wells only. The only two exceptions to that are on the east end of the flood where two of the Grayburg wells we want to use -- still have the Queen open, and that, those two Queen perforation intervals will be cement squeezed off before we utilize those wells as Grayburg producers.

Also, I would like to mention that all the Queen wells that were injectors were tested by the Commission within the last sixty days. The three wells that are being plugged are wells that the Commission did not feel were in good repair so they are the first three we're plugging. The other two wells do meet all of the Commission requirements, or Division requirements.

Q Injection wells.

A Yes.

Q Do you plan on still utilizing those wells to inject?

A Until we get a pressure increase on our

Grayburg injection wells, we're going to have to utilize at least one of the Queen wells to take the produced water.

Q Okay. When you say that to your knowledge there isn't any fresh water sand in the area, did you verify that with anyone, or did you say that --

A We've looked at the logs and I've asked the field representative down there, and we also checked with the people that live in the area and the farmer who is currently leasing this land for grazing. As a matter of fact, he had worked out a deal with TAO to receive fresh water from them out of the system so that he could have water to -- for his cattle.

MR. CATANACH: No further questions of the witness. He may be excused.

CARTER MUIRE,

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

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Mr. Muire, for the record would you please state your name and occupation?

A My name is Carter Muire and I'm a petroleum landman.

Q Mr. Muire, as a petroleum landman for Devon Energy Corporation, would you describe what you have done with regards to the Etz State Unit?

A I have reviewed all of the oil and gas leases, both State and Federal, and prepared a unit agreement and submitted that to the State Land Office and to the Bureau of Land Management for their preliminary approval and we've received the preliminary approval from the BLM and from the State Land Office.

Q Is this a function you typically perform for your company?

A Yes.

Q And how long have you been a petroleum landman, Mr. Muire?

A I've been a petroleum landman for eleven years.

MR. KELLAHIN: We tender Mr. Muire as an expert petroleum landman.

MR. CATANACH; He is so qualified.

Q Let me turn your attention, Mr. Muire, to what is marked Exhibit Number Eight. It's a package of documents. I would ask you to identify the first document in the Exhibit package book Eight. What are we showing there?

A That's the proposed unit agreement.

Q And is this a unit formed that has been approved for use in this type of secondary recovery project by both the state Oil Conservation Division, the Commissioner of Public Lands and the Bureau of Land Management?

A It is.

Q Let's go to the attachments in the end of the unit agreement and have you turn, sir, to Exhibit A to the unit agreement and identify that for us.

A That's a plat of the proposed unit.

Q When we look at the unit, what type of acreage is included in the unit?

A We have Federal acreage, which is located within the north half of the northeast quarter of Section 17 and the northeast of the northeast -- I'm sorry -- southeast northeast of 17, also.

Q That's the acreage that has the cross hatched --

A Right.

Q -- lines on it?

A And the remainder of the acreage is State land under lease.

Q When we go to Exhibit B, what is tabulated here, Mr.Muire?

A We have the leasehold ownership within the unitized interval. Our rights are limited to the base of the San Andres.

We also have the serial number, the number of acres committed, the description of the oil and gas leases and overriding royalty owners and the working interest owners and the participation factor of each tract within the unit interval.

Q Are there any other working interest owners besides Devon Energy Corporation?

A Devon owns all of the working interest within the unitized formation, or proposed unitized formation.

Q Have you received preliminary approval from the Commissioner of Public Lands and the Bureau of Land Management for your unit operations?

A Yes, we have.

Q The final attachment on here, identified as Exhibit C, represents what, Mr. Muire?

A Exhibit C is the exhibit that shows the tract factors and the participation formula that was used to arrive at the specific factor for each tract.

Q Is the method by which participation is calculated, is that the same for the entire unit area?

A It's uniform across the unit.

Q Have you received any objections from any of the parties notified about either the waterflood project or the unit?

A No. sir.

Q Have there been any objections filed?

A No, sir.

MR. KELLAHIN: Mr. Examiner, Exhibit Number Nine represents a notification that we have sent from our office to all of the offsetting parties or anyone within a half mile radius that has operated a well or has a working interest owner (sic) in a well at this depth.

Also included is notification to those owners of the surface for the injector wells, and that's marked as Exhibit Number Nine.

That concludes my examination of Mr. Muire. We would move the introduction of Exhibits Eight and Nine.

MR. CATANACH: Exhibits Eight and Nine will be admitted as evidence and, Mr. Kellahin, did this include the surface owner?

MR. KELLAHIN: Yes, sir, it did.

MR. CATANACH: I don't have any questions. The witness may be excused.

Is there anything further in

this case, Mr. Kellahin?

MR. KELLAHIN: No, sir.

MR. CATANACH: If not, Case 9735 and 9734 will be taken under advisement.

(Hearing concluded.)

C E R T I F I C A T E

I, SALLY W. BOYD, C. S. R. DO HEREBY CERTIFY that the foregoing Transcript of Hearing before the Oil Conservation Division (Commission) was reported by me; that the said transcript is a full, true and correct record of the hearing, prepared by me to the best of my ability.

Sally W. Boyd CSR

I do hereby certify that the foregoing is a complete record of the proceedings in the Examiner hearing of Case No. 9734, 9735 heard by me on August 23 1989.

David R. Catanach, Examiner
Oil Conservation Division