

ALASKA LEGISLATURE SPECIAL COMMITTEE / SUBJECT FILES 86/2

473 SCOM14: JOINT GAS PIPELINE COMM. (FINANCING) 1979-80

1 BY: MR. MILES

2 Thank you.

3 BY: DR. DOSCHER

4 Okay. Again I quote Muscat (ph) "there is practically no
5 major physical factor making secondary recovery," that is
6 water flooding after pressure decline, "advantageous as
7 compared with similar fluid injection before substantial
8 pressure reduction has occurred." The only reason then for
9 delaying injection of water in reservoirs without a natural
10 water influx is economics. But the economics has -- be
11 considered not in a vacuum. It must be estimated with
12 respect to the several interests that will receive the
13 benefits. The economic value to the State and nation of
14 various schemes for operating the Prudhoe Bay field must be
15 developed by the State on its own behalf, and this was
16 basically the thrust of our recommendation. Now, let me say
17 something about water flooding which is not in my report, but
18 appropo of some of the comments that were made yesterday.
19 Fields with natural water invasion, in general, show the
20 highest recovery efficiency of any fields in the world.

21 BY: MR. MILES

22 Well, what's water invasion?

23 BY: DR. DOSCHER

24 Well natural...natural water flood. In other words, the
25 oil reservoir is next to a water aquifer, okay? So

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1 natural water drive.

2 BY: MR. MILES

3 Okay.

4 BY: DR. DOSCHER

5 The East Texas field is probably the greatest example of this.
6 It has a natural slow water influx, production has been
7 managed by the State because of competitive influences since
8 the early 30's and the recovery efficiency there is going to
9 be over 80%. Now, that's a very special field, don't...I'm
10 not trying to tell you that all water floods are going to be
11 80%. But, natural water invasion in a good reservoir gives
12 you these high recoveries. Cores taken from behind the water
13 invaded region in East Texas give oil residuals as low as 4
14 and 5%. The oil is substantially swept out. All along the
15 south...Louisiana and south Texas coast, where we have
16 natural water invasion, we see the same thing. A slow
17 natural water influx is apparently unbeatable. There are
18 some places where you can by restoring gas in very good
19 reservoirs as Exxon has pointed out, yet recoveries that are
20 comfortable. Water flooding, in general, does not require
21 too much piloting as suggested yesterday, in my thinking,
22 because you can't tell very much from a water pilot unless
23 you go in and do it on a fairly large scale or go in and
24 drill an extensive number core holes. The original water
25 pilots, many of which were pioneered by the company I formerly

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1 worked with, were primarily to get some basic knowledge of
2 sweep efficiency in the reservoir and was readily, rapidly
3 concluded that it was not working because when you just water
4 flood a spot in the reservoir, the water goes out all over
5 and it's very difficult to confine. So, that water piloting,
6 since we have learned this, is usually confined to basically
7 determining injectivity and this is a very serious matter.
8 Now, one of the things that also is involved when we talk
9 about water injectivity, putting water into the reservoir,
10 which was not brought out too strongly yesterday, but if you
11 have shales and you say you're going to confine the water to
12 within the shales, this is a tremendous mechanical problem
13 because in the hole, in the subsurface, there will be many
14 intervals between shales, there may be three, there may be
15 five, there may be ten, and if you're going to water out
16 between the shales you've got to make sure to get the water
17 in between each and every set of shales, and this is a man-
18 size problem, a very difficult problem. So, just

19 saying we've got shales and this is going to help water
20 flooding is not an adequate answer. It may help you in
21 keeping the water confined, but first of all you've got to
22 get it in and I say that as offsetting the fact that I say
23 water flooding is good, there are many problems and you can't
24 really tell in advance how good or how bad you're going to
25 turn out. The way you get water in you get the oil out.

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1 I'd like to bring the State's attention to way the Province
2 of Alberta manages its reserves. The Province produced in
3 1977 only a million barrels of crude oil and had a proven
4 reserve of 5.4 billion at the end of that year. The Province
5 is one of the most richest, one of the richest and most
6 solvent political entities in the world. Its oil and gas
7 conservation board maintains its own technical staff which
8 analyzes all new pool discoveries. An operator can be
9 excused from committing a pressure maintenance program only
10 if it is concluded would not recover additional economic
11 reserves. The Province's evaluation of recovery and economics
12 is the initial framework for any discussion on the subject.
13 The Province reports that 3.8 billion barrels of its total
14 reserves have been added by pressure maintenance compared to
15 7.6 realized from natural depletion. The need for this
16 State to have its own appraisal of Prudhoe Bay is obvious
17 and it is very rewarding to see the State going ahead with
18 it. Its unfortunate that the study being undertaken by
19 VanPoolen and Associates is taking somewhat longer than I
20 had originally estimated to this committee. One of the
21 major problems in this study has been the assignment of
22 permeabilities and the positioning of the shale barriers in
23 the model of the reservoir. Both of these parameters are of
24 critical importance in effecting the outcome of the simulation
25 and it is for this reason that VanPoolen and Associates have

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1 done it very methodically, very well to leave as little doubt
2 as possible as to what is the right way of doing it. One of the things,
3 however, about the simulation which should be brought out
4 because I think it may prove to be significant; it may be
5 something, it's not an irrevocable lack, it can be put in
6 later, is that at the moment it does not have a coning
7 model for the wells. And I have agreed with Mr. -- Dr.
8 VanPoolen, it would seem at this time, that there's probably
9 no reason to work it in. The reason for this is that all the
10 simulations of reservoirs -- of well behavior today and all
11 the observations in the field suggest that there is a shale
12 pretty close above the upper perforation of the wells. Under
13 these conditions you're not going to get any coning. But it
14 also means that you're not going to get direct gravity
15 drainage, although as you heard yesterday, the shales are
16 leaky, we don't know exactly yet until there is more
17 experience accumulated, leaky to what, certainly to gas, at
18 the moment, you'd have to say that, but whether they will
19 leak oil at the same rate they leak gas is something that
20 will still have to be determined. So, what we do see and I
21 really am sorry that this hearing has come now, if it came
22 two months later we would be able to say things with a little
23 more definitiveness, but what we are supposedly seeing now,
24 is we are seeing the shales there, we are seeing
25 have to realize there is going to be interference with a

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1 unmitigated gravity drainage. In general, I would have to
2 say this is going to detract from gravity drainage, there's
3 now two ways about that, whether they will be compensating
4 things and I would like you to note that the compensating
5 things that were suggested yesterday would be water flooding,
6 and if you didn't get the gravity drainage we get with water,
7 but that's important, get it with water flooding, and we have
8 to take in to account when will the water flooding be coming
9 on and what will be the effect of the shrinkage of the oil
10 and the gas liberation by the time water flood comes on. In
11 other words, the situation is building for me that water
12 flooding, although a questionable thing two years ago, is
13 more and more looming on the horizon as something that
14 Prudhoe Bay will need and if it needs it, the sooner it gets
15 it the better.

16 BY: MR. PARR

17 Did you by -- instead of water flooding, Dr. Doscher, mean
18 that pressure maintenance by (indisc - simultaneous speech)

19 BY: DR. DOSCHER

20 No, because, no -- the pressure has been going down now, by
21 the time we get around to it, it will be water flooding now.

22 BY: MR. PARR

23 Okay, thank you.

24 BY: DR. DOSCHER

25 We've got another....

BY: MR. PARR

I just wanted to make sure that was deliberately chosen.

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1 BY: MR. MILES

2 That decrease in pressure though is -- is not unusual.

3 BY: DR. DOSCHER

4 Now, let's talk about the decrease in pressure. This is a
5 very -- for me to sit her and say the pressure is going
6 faster or slower is very difficult. I am not -- I don't
7 spend the time to follow the data week by week. I didn't
8 think that was my job. I only recently, incidentally, got
9 permission to view the data, pressure data in the field. Ah..
10 when I asked? it was given, but this only happened a month ago.
11 Now, talking in pressure decline, in terms of absolute
12 numbers, at this point, is a little questionable. You see,
13 I was retained, I believe, to look at the fine points of the
14 reservoir behavior, not to see whether it was qualitatively
15 behaving as predicted, but is there something very, very
16 small here that may be indicating some problems. Now, I
17 think there is something here that's indicating some problems
18 in terms of pressure behavior. First of all, yesterday we
19 saw what the GOR is and it was said to be a little bit above
20 the solution gas ratio, but then it depends upon what you
21 mean by a little bit above. The number I saw on the chart
22 was 900 cubic feet per barrel. This is about 20% greater
23 than the solution gas ratio. This is about 20% greater than
24 that predicted in the Exxon runs, the numerical simulation
25 runs, which were distributed at the hearing in May '77 at

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1 Anchorage. Now is 150 significant? I think it is, particu-
2 larly if the solution gas ratio is 750, an average of 900,
3 although you say, "Well, it's -- it's only 150, its 20%,"
4 but you don't get up to 900 on the predicted Exxon runs or
5 even on VanPoollen runs, I don't think we can use the old
6 VanPoollen model here as any reference because it was a 2-D
7 Model, so I think the reference has to be to the 3-D runs.
8 You don't get up to 900 for four or five years. Now, the
9 pressure decline, the numbers that were quoted yesterday were
10 six hundred and thirty million -- three million barrels in
11 171 psi. That's .28 psi per million barrels. Again, looking
12 at the xerox copies of the Exxon report and there has to be
13 some error there, but still looking at all thirteen runs and
14 taking average figures, it seems that it should be closer to
15 two tenths, a difference of about 50%. Now, I think that's --
16 that's something significant because you're in the early life
17 of the reservoir and you have to look at these fine points.
18 I hope I'm wrong, but I'd stop looking at why this difference
19 is being-- occurring.

20 BY: MR. CHATTERTON

21 Before you get too far away from that Todd, let me explore
22 something with you. This is...ah...normally a 440 foot
23 thick oil column...ah..what's the solution gas-oil ratio --
24 is there any variance in the solution gas-oil ratio between
25 the ...

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1 BY: DR. DOSCHER

2 ...Oh yes, yes...

3 BY: MR. CHATTERTON

4 ...top of the column and the bottom and would you give me
5 those numbers?

6 BY: DR. DOSCHER

7 Oh, it varies from 700 to 900.

8 BY: MR. CHATTERTON

9 Thank you and what was the average GOR that was reported
10 yesterday?

11 BY: DR. DOSCHER

12 900.

13 BY: MR. CHATTERTON

14 An you gave us percentages -- and you gave us some percentage
15 numbers here, what were you comparing?

16 BY: DR. DOSCHER

17 I'm comparing to the 750 average that is used in the simula-
18 tion studies and the projections of the field behavior.

19 BY: MR. CHATTERTON

20 Granted, and my point being this Todd, most of the withdrawals
21 are from the lower section of the oil zone, the lithologic units
22 in the lower section of the oil zone where you have the...

23 BY: DR. DOSCHER

24 ...then I'd expect it to be less than 900.

25 BY: MR. CHATTERTON

You'd have to expect it to be somewhat less.

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1 BY: DR. DOSCHER

2 Less than 900. Particularly since most of the pro-
3 duction, I believe, is from the better, I forget how the
4 intervals are named from the interval that has the least
5 shale, and so..ah..I think we should be seeing something so
6 that it is on the average, but less than 900. In other words
7 it is 900 already. This bothers me, that it should be even
8 at the upper end of the ratio.

9 BY: MR. CHATTERTON

10 Thank you.

11 BY: DR. DOSCHER

12 And the pressure decline also bothers me because it is just
13 that much over what was projected..ah.. I want to know why.
14 Now, we've heard of the wells over on the eastside, those
15 lined out in red, these are -- I mean they're four, six
16 thousand GOR, many -- some, I don't know how many, are shut
17 in and if you shut them in and open, the GOR goes back up.
18 In other words, you don't seem to be able to heal it for long.
19 Ah...now, there -- this is the shaley part of the field, it's
20 at the edge of the field and you can say, "Well, the gas is
21 coming out, it's close to the gas cap, it's channeling under
22 the shale," but you see this may -- if this is real, this
23 may happen a little further down, a year or two from now.
24 In other words, it's the suggestion that something could happen
25 here which has not been anticipated in the model run. Now,

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1 it's -- you know, we're not going to change this overnight.
2 These things are going to happen, but one thing that's
3 suggested to me is that until we understand why this is
4 going to happen, all I can say is that my original conclusion
5 is not to commit the gas until we get a better handle on this
6 is a little strengthened, not to commit to higher production
7 ratios until we get a little better handle on it is somewhat
8 strengthened, because again we're going to have problem with
9 our own model, the State's model, in making adequate rate
10 analyses or analyses of rate, because of the absence of a
11 coning model and insofar as this may be important, we're not
12 prepared at the moment to do it and this is no oversight,
13 this is a question of what it takes to build a coning model
14 and whether it's absolutely necessary to make our checks at
15 this point, noted, in order to start being able to predict. It's a very,
16 very complicated problem. So, there's no faults involved
17 here, it's just the way things are working out. Now, there
18 are a couple of other things then that since I haven't had
19 a chance to talk to you since the...ah...in any great length,
20 until since the hearings were held in Washington and since
21 the transactions of the hearings have come out, there are a
22 couple of things I'd like to bring to your attention. One
23 is we were criticized because our proposal to reinject the
24 gas into the reservoir was said to take a lot of gas, a lot
25 of the natural resource we had. Well, we didn't make a

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1 calculation before because I knew what it was and didn't
2 think it worth mentioning, but at this time I will mention it
3 that in fifteen years based on the VanPoolen models, and
4 again these are -- you know -- they have to be confirmed by
5 the 3-D, we would have to reinject about 15 trillion cubic
6 feet of gas in 15 years if we did not sell it. It would
7 take one and a half trillion cubic feet as fuel to compress
8 this gas and return it to the reservoir. Now, this one and
9 a half trillion is less than 4% of the total and if you're
10 going to produce gas after that time, this difference of
11 4% is just not going to effect the ultimate recovery of gas
12 from the reservoir. So, the matter of wasting energy or
13 using energy in an irrevocable way to
14 return the gas to the reservoir, I don't believe is a valid
15 point. Another point which we were fairly well criticized
16 for and it wasn't something we said should be done, but we
17 posed the question in our report, should consideration be
18 given to using the crude oil line for the two phase flow of
19 gas and oil at that time some fifteen years away when the
20 oil production might have dropped to five hundred thousand
21 barrels and of course continue to do so, we said, should
22 consideration be given. Well, we heard everything that --
23 from -- that this was a mind-boggling idea and then Exxon
24 subsequently did a very professional job, a good job, of
25 showing that with conventional technology this was -- just

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1 not to be considered. But our point is that we have to look
2 for unconventional technology in this time when energy is
3 so important to the nation. We can keep throwing out ideas,
4 could you transmit it as a foam, and then you'd avoid many
5 of the problems that were raised as problems in transmitting
6 two phases, but there'd be problems here. I don't know if
7 you can make a foam. These are things though, that when you
8 start crashing a subject, what can you do to save money, what
9 can you do for a more efficient utilization of the capital
10 and energy resources of the nation, one might come up with
11 some ideas. For example, right now, the pipeline is testing
12 a friction reducing agent. The friction reducing agent was
13 not developed by the pipeline people. It was developed by a
14 small competitor. The times require a tremendous effort in
15 order to save both our energy and our capital. Now, finally
16 just in ending, there is no question that any decision not
17 to sell gas is going to be subject to the most -- well, it's
18 going to be subject to a lot of criticism by many, many
19 different groups of people. We say that this might be the
20 best way of running the reservoir, we also point this out,
21 that the gas in Prudhoe is only 5% of what is available to
22 America today, only 5%. Whereas the crude oil in Prudhoe
23 Bay is one-third of what is presently available to the nation.
24 Now, under those conditions -- which should we conserve more,
25 which should we worry about more. Will rushing that 5%

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AGO 532293

1 to market, substantially change the welfare of the State or
2 of the nation. Will conserving a billion or two billion
3 barrels of oil in Prudhoe Bay substantially aid the nation
4 and the State. These are questions that have to be considered
5 and I trust that with the work that the VanPoolen and Associates
6 are doing and the work you're doing in-house, that you'll
7 reach the right answers.

8 BY: MR. MILES

9 Thank you very much Doctor. We appreciate the presentation.
10 Representative Hayes

11 BY: MR. HAYES

12 Thank you, Chairman Miles. Yesterday I asked the question
13 of Dr. VanPoolen was if he would be able today to respond
14 to any of the points Dr. Doscher might make.

15 I wonder if..ah..it would be appropriate at this time to ask
16 Dr. VanPoolen if he would like to make any rebuttal or any --
17 or did you have that in mind for later?

18 BY: MR. MILES

19 I don't think that would be appropriate at this time Joe --
20 I'd rather have questions directed to Dr. Doscher, we don't
21 want to get into a pingpong match here. If there're questions
22 of Dr. Doscher, fine, if..ah.. Dr. VanPoolen thinks that --
23 you know -- it's appropriate to respond, we'd certainly make that a
24 available opportunity and then we will make it available to
25 Dr. Doscher and whoever the hell else wants to respond.

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AGO 532294

1 BY: MR. Hayes

2 There have been some -- there have been some comments made by
3 Dr. Doscher that are -- you know -- are practically 180 degrees
4 to some of...

5 BY: DR. DOSCHER

6 Oh, I don't think so.

7 BY: MR. MILES

8 Well, let's -- let's ask the direct questions to Dr. Doscher
9 first.

10 BY: MR. CHATTERTON

11 I think so too.

12 BY: MR. MILES

13 Mr. Chatterton.

14 BY: MR. CHATTERTON

15 Thank you Mr. Chairman. Doctor, really the impact of your
16 direct testimony is..ah..and I think it's concurrent with
17 your studies and everything else that you've done, has been
18 directed more against gas sales, the appropriateness of it,
19 is it also -- I read in the newspapers..ah..questions about
20 regardless of whether or not there are gas sales of crude
21 oil recovery up there..ah.. and particularly the matter of
22 rate sensitivity of the ultimate recovery to withdrawal rates..
23 ah..you were talking about a natural water flood, I guess
24 there would be no question but what ultimate recovery would
25 be, or is there a question sensitive to withdrawal rates in

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AGO 532295

1 the case of a natural water flood. In other words, what
2 happens if you..ah..withdraw black oil faster than the
3 influx of the natural aquifer?

4 BY: DR. DOSCHER

5 Oh, you won't sustain the pressure and your recovery will
6 go down.

7 BY: MR. CHATTERTON

8 Okay, so in a reservoir of that type, why definitely -- why..
9 ah..withdrawal is -- recovery is rate sensitive?

10 BY: DR. DOSCHER

11 Absolutely.

12 BY: MR. CHATTERTON

13 Now at Prudhoe Bay -- why -- what I've read and I think you
14 mentioned it also, we have seen no evidence of natural..ah..
15 action that we hear (indisc) aquifer, right?

16 BY: DR. DOSCHER

17 That's right, that's right, oh yes. Sadly, it's (indisc)

18 BY: MR. CHATTERTON

19 In fact, are we not seeing basically..ah..solution gas drive
20 and gas at this point in time anyways, solution gas drive
21 and gas cap expansion as a primary measure.

22 BY: DR. DOSCHER

23 That's right.

24 BY: MR. CHATTERTON

25 How do reservoirs and under that type of a drive..ah..react

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1 to rate sensitivity?

2 BY: DR. DOSCHER

3 Oh, gas cap expansion is notoriously as the prime -- as the
4 prime mechanism which contributes to rate sensitivity
5 because the depletion of oil in the gas cap area is a very
6 rate sensitive phenomena because it depends on the rate at
7 which the oil will drain down the column which has very little
8 to do with what else your doing. So, gas drainage -- oil
9 drainage in a gas column is very rate sensitive.

10 BY: MR. CHATTERTON

11 I'm not sure I understand.

12 BY: DR. DOSCHER

13 Well, you see, up above here you have oil, you start out with
14 oil in top, okay? And your gas is going to come down
15 penetrating that oil zone leaving behind some oil residual
16 saturation, okay? The attainment of the lowest equilibrium
17 saturation of oil is a rate sensitive phenomena.

18 BY: MR. CHATTERTON

19 Due to the ability of it (indisc - simultaneous speech)

20 BY: DR. DOSCHER

21 ...of the oil itself to drain down. It has nothing -- it
22 doesn't care what's going on down below, you see. If you
23 start ripping and taking it out too fast below the gas is
24 going to finger down and leave a lot of oil behind. The
25 drainage of oil in the gas environment is terribly rate sensitiv

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AGO 532297

1 BY: MR. CHATTERTON

2 Alright, I guess, if you're under a gas cap expansion drive
3 where it is coming down uniformly, why then probably you're
4 within in your efficient rate production of black oil. In
5 other words....

6 BY: DR. DOSCHER

7 I bet -- I'm not sure I understand.

8 BY: MR. CHATTERTON

9 Alright, supposing we have, as we have up there now, we have
10 an expanding gas cap and we're withdrawing black oil. Alright,
11 if that expanding gas cap is coming down sort of uniformly,
12 not tonguing, not fingering, so forth and so on, would that
13 be suggestive that we're within the envelope....

14 BY: DR. DOSCHER

15 Well no, we don't know that. This is one of the -- this is
16 explicitly the thing that the State is setting about or has
17 asked the operators to make surveillance of the gas-oil contact
18 to actually measure that. You see, because depending on how
19 the gas-oil contact falls, if you finding it falling faster
20 than you anticipated, it means your leaving more oil behind.

21 BY: MR. CHATTERTON

22 I understand.

23 BY: MR. CHATTERON

24 Okay. So we don't know that this is one of the things that
25 hopefully we will learn and one of -- that is one of the main

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1 things we suggested two years ago that we needed to know
2 before we could commit the gas sales.

3 BY: MR. CHATTERTON

4 Right, and at that point -- and at this point in time we do
5 not have the knowledge or the equipment to say whether....

6 BY: DR. DOSCHER

7 I don't know that, I have not been exposed to the results of
8 that test. I don't know that. I presume this would be..ah..
9 made available at the hearing that was, I believe, was
10 scheduled for June or so, and that is now being deferred to
11 fall.

12 BY: MR. CHATTERTON

13 But perhaps it's premature to cry foul at this point in time
14 (indisc - simultaneous speech)

15 BY: DR. DOSCHER

16 Yea, I -- just as I say, two months from now we could be --
17 you know -- there would be a lot less suggestion and a little
18 more information.

19 BY: MR. CHATTERTON

20 Thank you. Thank you Mr. Chairman.

21 BY: MR. MILES

22 Mr. Rogers.

23 BY: MR. ROGERS

24 Yes, Dr. Doscher, you've talked a lot about ultimate recovery
25 of crude oil and particularly said since we have a greater

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percentage of U.S. domestic oil reserves ⁺¹²ⁿ and gas reserves,
that we should sort of concentrate, I guess, on ultimate
recovery of crude oil, but is the State's interest, do you
think, then on the crude oil recovery on the total hydro-
carbon recovery.

BY: DR. DOSCHER

Oh well, you will not interfere with ultimate gas recovery
no matter what you do. You see, when you finish taking all
the oil out you just open the valve and the gas will come
out. I mean, you'll just blow it, what we'd say would be a
volumetric gas reservoir, which means you just have a can of
filled with gas, open it up and the gas just comes out. So
that's why even using up...

BY: MR. ROGERS

So you think that 1.5 trillion cubic feet loss is negligible.

BY: DR. DOSCHER

Negligible, because you -- you stand to get 75 or 80% of the
gas in the gas cap at that time without any sweat at all.
So, when I say if you improve the recovery of oil then
automatically regardless of time, I mean, taking the time
value out, you're going to get maximized BTU then.

BY: MR. MILES

Doctor, go to the question of shale, I find the more I hear
about shale the less I understand it. It is my understanding
of yesterday that the -- we can't tell right now whether or

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1 not the presence of shale is going to be a serious problem.

2 I understood you say that it will detract -- from the
3 gravity drain.

4 BY: DR. DOSCHER

5 I believe that was said yesterday too. I think if you look
6 back it was said that it would certainly detract from gravity
7 drainage, but then the statement was also made, you can check
8 the minutes, that it would also help -- help you sweep the
9 reservoir with water because you would have boundaries into
10 which the water could be channeled.

11 BY: MR. MILES

12 Okay, so we can't -- we can't necessary say that, I'm sorry
13 I can't discuss these things in the technical level with you,
14 but we can't say that shales are bad for

15 BY: DR. DOSCHER

16 Oh they're bad, they're bad for gravity drainage recovery.

17 BY: MR. MILES

18 Well, okay.

19 BY: DR. DOSCHER

20 Okay? Now, they may be good for water flooding provided you
21 water flood early enough. Okay? If you wait until the
22 oil has shrunk..ah..due to its abnormal -- very high pressure
23 decline -- I'm sure they're not going to wait that -- I mean,
24 so it shrinks that bad. But..ah..if you wait until it
25 shrinks..ah..if you wait until the pressure is released, if

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1 you wait until you get high gas saturation in there, then
2 water flooding will not be as efficient as if you start
3 early.

4 BY: MR. MILES

5 Well I guess, guess what I'm asking is, I understand in the
6 first vanPoolen runs the existence of the shales wasn't
7 a fact that if it was plugged into the computer, they are
8 now being plugged into the computer because they're --
9 they're obviously a very real factor. The question that I
10 want to know is can we say that the presence of these is
11 going to reduce recovery?

12 BY: DR. DOSCHER

13 I would venture the guess that in the absence of water
14 flooding -- in the absence of water flooding it will reduce
15 recovery compared to the absence of water flooding before.
16 Okay?

17 BY: MR. MILES

18 Okay. How about if we go in after five years of production
19 and water flood?

20 BY: DR. DOSCHER

21 Ah..you may get more -- you may get more as compared to not
22 doing a water flood at all. Okay? In other words -- in
23 other words you're going to -- as soon as you say I've got to
24 water flood, you're in a different ball park, but if you go
25 back and compare the situation without water flooding then

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1 the shales, in my mind, have -- will cause a drop in
2 recovery.

3 BY: MR. MILES

4 We in essence have two different ball games.

5 BY: DR. DOSCHER

6 That's right.

7 BY: MR. MILES

8 Thank you. Mr. Chatterton.

9 BY: MR. CHATTERON

10 Anybody else first. Okay, Todd, let's talk about water
11 flooding for a minute. I've had a little experience in
12 producing operations and one thing I always feared was getting
13 increased water cuts in my producing column because it took
14 more energy to lift the column, to get my black oil, and..ah..
15 I guess that's a paranoia with me more -- I hate to..ah..
16 willy nilly -- see, put water into a reservoir. You
17 even spoke of the fact that..ah..of pilot floods and don't
18 you sort of really want to know the geometry and just how
19 things are going before you start...

20 BY: DR. DOSCHER

21 I want to know the relevant injectivity. That's a pretty easy
22 thing, I want to know the compatibility of the water, I can
23 do that on paper in a half hour. Now, breakthrough, see
24 you're talking about early water breakthrough. Now where --
25 how can we get that? Now, let's assume you have a uniform

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1 reservoir, okay? The only time you'll get early breakthrough
2 in a uniform reservoir is if you have a viscous oil, which
3 we do not have at Prudhoe Bay....

4 BY: MR. CHATTERTON

5 Under pressure?

6 BY: DR. DOSCHER

7 mind you, that as the pressure goes down and gas comes
8 out of solution, the viscosity will start going up. Now
9 never going to go very high, but we do change it from something
10 which is delightfully favorable viscosity ratio to something
11 that's not quite favorable, okay? If you wait for pressure
12 to go down. But now, in Prudhoe Bay I would expect water
13 fingering or water channelling to occur only from hetero-
14 geneity in lithology. In other words, a very gross change
15 in permeability between adjacent strata or a foot apart.
16 Ah..this has to be known..ah..it can be if you find that it
17 occurs, it can be avoided to some extent not completely.
18 Ah.. there are all sorts of remedies which we can call on for
19 close in support of..ah..channelling, like channel blocks and
20 silica and even cement. But if it is very bad we cannot
21 stop it. In other words, if you had a gross heterogeneity
22 like a fracture, we cannot stop it, but if we have that, this
23 reservoir is going to suffer even from gas expansion because
24 once the gas sees that it's going to channel through. I
25 hope we don't have it, there is nothing to suggest we have

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1 such gross heterogeneities here.

2 BY: MR. CHATTERTON

3 If I may Mr. Chairman, I can always get a better feel and
4 qualify and quantify things if I work from the extremes.
5 So, I'll ask you this question and it's an extreme question,
6 from day one or year one after production is started and we
7 know nothing more than the oil is coming out of the ground,
8 so to speak, to go willy-nilly blindly for the full scale
9 pressure maintenance by water injectivity, is it conceivable
10 that you might cause irreparable harm to ultimate
11 recovery?

12 BY: DR. DOSCHER

13 Ah..it's conceivable, but I think the level of expertise in
14 the -- among the operators and among the State is such that
15 this probably would not happen. It's a remote possibility,
16 I think, given the expertise that's here.

17 BY: MR. CHATTERTON

18 But, would you share with me that in many things, the assimily
19 of this, you learn to crawl before you walk.

20 BY: DR. DOSCHER

21 Well, yea, except we've been -- you know -- we've been at
22 this business for a long time. Now,-- you know -- we're not
23 going to water flood this within a year anymore, okay? So,
24 and I'm not the one to say we did something, I don't believe
25 in looking back, okay? It happens, it happens, for any reason.

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1 But I do believe in looking forward and if the evidence
2 begins to accumulate, as I think it is, that water flooding
3 seems to be indicative for the -- indicated as a need
4 for the reservoir we'd better start thinking of it very seriously.

5 BY: MR. CHATTERTON

6 For the last question -- which is really, cause I sure want
7 to see how you feel about it. We've talked about pressure
8 maintenance by water injection, we've talked about water
9 flooding, we already know that we haven't maintained pressure
10 because we've lost our material ballast to this point. Can
11 we not over inject once water -- once we start pouring water
12 into the ground, can't we over exceed our withdrawal rates
13 and catch up, build our pressure up.

14 BY: DR. DOSCHER

15 You can catch up but never 100%. Now, again this depends on
16 the particular -- you never get 100%.

17 BY: MR. CHATTERTON

18 Understood (indisc - simultaneous speech)

19 BY: DR. DOSCHER

20 How close you come depends on the particular reservoir and
21 the timing that's involved. As I said, the -- again you
22 use an extreme case, I'm using an extreme case. If you let
23 the pressure go down, you have enough shrinkage and you
24 establish a high gas (indisc) you may start channelling a
25 lot of water to the gas, okay? So, I don't think that we'd

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1 ever go that far here but -- talking about extreme. We'll --
2 we'll catch up a way whether it's 100% I couldn't tell you --
3 I mean, we'll get pretty close. The faster we get there the
4 better it is, if we need it.

5 BY: MR. CHATTERTON

6 Thank you. Thank you Mr. Chairman.

7 BY: MR. MILES

8 Mr. McKinnon.

9 BY: MR. McKINNON

10 A few minutes ago you used the phrase "if water flooding is
11 indicated"....

12 BY: DR. DOSCHER

13 Well, I believe it's indicated already, okay?

14 BY: MR. McKINNON

15 and Dr. vanPoolen believes it's indicated?

16 BY: DR. DOSCHER

17 I think -- well, I'm not going to -- if he says that, that's
18 great.

19 BY: MR. McKINNON

20 He makes that recommendation in his study two years ago.
21 and apparently the companies are applying for permits and I
22 would assume that indicates the company believes
23 water flooding if necessary. The question is when is it
24 necessary?

25 BY: DR. DOSCHER

Well, if it's necessary then at this point, the faster,

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1 because you can't put water in that ground for another three
2 years. Okay? Even if you had the pumps there today probably
3 because the piping and everything and the treating plant and
4 the stabilization system and..ah..at that time we will have
5 produced 25-30% of the reservoir. That's a lot of oil.

6 BY: MR. McKINNON

7 At that time, I assume, we'll have enough production history
8 to be able to tell (indisc - simultaneous speech)

9 BY: DR. DOSCHER

10 you'd know exactly where to go.

11 BY: MR. McKINNON

12 So if everybody agrees that water flooding is necessary, it
13 would seem logical to go ahead and start with facilities
14 that could be constructed at this point.

15 BY: DR. DOSCHER

16 This is up to the Oil and Gas Conservation Commission to
17 study and all I can say is that this is what it seems to me.
18 Their conclusions agree, I -- that's great.

19 BY: MR. McKINNON

20 At what point is it too late to start water flooding?

21 BY: DR. DOSCHER

22 I'd say if you started twenty years from now it's too late,
23 okay? Now where in between I don't know.

24 BY: MR. McKINNON

25 Well, Chat's - Chat's talking about willy-nilly which I

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1 assume means four or five years into production.

2 BY: DR. DOSCHER

3 No, I didn't know...

4 BY: MR. McKINNON

5 You said a year or...

6 BY: MR. CHATTERTON

7 No, no, no I meant we -- blindly just pour water in like a
8 year ago now start pouring water in, is what I was trying to
9 emphasize.

10 BY: MR. McKINNON

11 When is it too late economically for the companies?

12 BY: DR. DOSCHER

13 Well, I couldn't tell you, you'd have to ask them what their
14 rate of return is expected. But I would think -- I mean, I
15 just -- you don't want to wait until you're just producing
16 a -- look it -- if you injected water so late that you're
17 only producing 100,000 barrels a day, I don't think there is
18 anyway, even with zero discount rate, that you could make
19 out with 100,000 barrels of oil a day. In other words, you
20 have to produce it so that you're still getting oil where
21 everything else can carry itself, where you can afford the
22 maintenance in the field and the pipeline burden.

23 BY: MR. McKINNON

24 Water flooding is going to increase ultimate recovery, why
25 wouldn't the companies want to go ahead and do it?

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There is no
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discontinuity is
evident. nk

1 at...ah..I believe, the reservoir -- the formation volumn
2 factor is about 1.4 which means if you took all the gas out,
3 zero pressure, the oil would shrink 40%. Now if the oil
4 shrinks it leaves gas, so when you put the water in, the
5 water sees this very mobile free-flowing gas and it kicks
6 the gas out and leaves the oil behind, okay? That's the
7 most damaging thing that can happen.

8 BY: MR. MCKINNON

9 When you -- when you start putting water in and you've delayed
10 it for a period of time and you start building the pressure
11 back up, how much of that -- or what's the difference,
12 let's say from putting it in year four and year eight?

13 BY: DR. DOSCHER

14 Well, there are sometimes you never catch up with pressure.
15 I mean there are oodles of examples down along the gulf
16 coast where -- you've rather a small reservoirs, where you're
17 just -- where you're taking the oil out so fast you just
18 can't put the water in that fast. I mean, we say you play
19 catch up but this catch up means you're really going to
20 have to whale the water in which makes the problem a little
21 more difficult because the faster you try to put water in,
22 the more problems you have in overall integrity.
23 So, there has to be an optimum time. Certainly you can't do it
24 at zero -- at time zero on terms of a shear economics, you
25 can't wait twenty years in terms of what you can get out

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1 of the reservoir. But, I would say that we are coming close
2 to the time when..ah..any -- my own feeling is any further ,
3 delay is not warranted.

4 BY: MR. MILES

5 Ah.. Mr. Parr is next, I think.

6 BY: MR. PARR

7 Very simple question, Dr. Doscher, for the benefit of us
8 laymen who don't understand all this.

9 In your considered judgment, there should be no gas sold
10 until the water injection system for pressure maintenance
11 is in place and ready to operate.

12 BY: DR. DOSCHER

13 That's right.

14 BY: MR. MILES

15 Mr. Rogers.

16 BY: MR. ROGERS

17 Yea. Going back to this -- I was asking you about ultimate
18 hydrocarbon -- recovery, but there is two ways to measure
19 that, one's in volume and one's in dollars, and given that..ah..
20 there's a time value to the dollars but there may or may not
21 be a time value to the quantity..ah..should we be -- in your
22 opinion, should we be looking at..ah..trying to go for the
23 highest ultimate quantity or the highest dollar return.

24 BY: DR. DOSCHER

25 Well, this is a question that -- you know -- this is a

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1 stateside question. Certainly, I would recommend that you
2 want the maximum return to the State; as a citizen of the
3 United States I'd want you to temper that with some thought
4 of the maximum BTU. Now, I think, considering the increase
5 in crude oil price and gas price, inevitable increase, that
6 you don't have to worry about some delay as losing your
7 investment since it doesn't -- you don't put in much capital.

8 BY: MR. ROGERS

9 Because the State's discount rate, whatever it is, is
10 probably lower than the inflation rate....

11 BY: DR. DOSCHER

12 That's right, that's right. And don't have any question about
13 the price of oil and gas going up. When I two years ago
14 suggested \$20 a barrel, I'm off by a couple of dollars, it's
15 above \$20. And, Mr. Schlessinger, yesterday suggested that
16 \$40 a barrel in uninflated costs in five or six years. Now,
17 the reason for this is simple, it's not because the OPEC is
18 greedy, and they are greedy, and everybody would be, but
19 we're running out of it. See this, this is the fact. We
20 have reached peak production in the world, not now, maybe
21 tomorrow. If you find something in Prudhoe Bay, may delay it
22 a year or two, but basically, the areas we can look and search
23 for oil we are running out of them. We'll need alternates
24 well before you go -- you finish producing at Prudhoe Bay.
25 So, your value of the goods is just going up.

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1 BY: MR. ROGERS
2 For that reason you'd suggest that the State pursue a course
3 of..ah..ultimate hydrocarbon recovery rather than, than..ah..
4 their current guess of what the ultimate dollar recovery is.
5 BY: DR. DOSCHER
6 I would, I would tend to opt in this direction.
7 BY: MR. ROGERS
8 Thank you.
9 BY: MR. MILES
10 I think Mr. Hayes is next.
11 BY: MR. HAYES
12 Dr. Doscher..ah..yesterday Mr. Hamilton and Mr. Green discussed
13 ..ah..water flooding and they were talking about their --
14 their plan to ..ah.. as I understood it to wait until such
15 time as the field produced about 100,000 barrels of water a
16 day as a byproduct and then reinject that. One of the reasons
17 they stated for doing that was because of the compatibility
18 of the residue water with the water that was already in the
19 field. The comment you made a little -- a few minutes ago,
20 talking of -- about how many -- how many years involved
21 accomplishing water injection, you mentioned a treatment
22 plant and pipe and that sort of thing, I inferred from that
23 that you're talking about a different type of water injection,
24 perhaps sea water -- my question is, is that what you're
25 talking about...

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1 BY: DR. DOSCHER

2 Yes.

3 BY: MR. HAYES

4 and the second part of my question is, do you agree with
5 the..ah..plan as outlined by..ah..Mr. Hamilton and Mr. Green
6 as far as the proper way to ..ah.. sort of, ease into the
7 water flooding program?

8 BY: DR. DOSCHER

9 I would..ah..first of all I'd like to say that yesterday they --
10 it was said that eventually you would use sea water, so
11 basically, we are all talking about the same thing eventually.
12 Now, the -- I don't want to -- I'm not going to say I agree
13 or disagree with the Board, I would put it this way, that I
14 would like to -- or there are some folks around who could
15 convey to them..ah..possibly ideas that are at variance with
16 their -- what they suggested here which would speed things
17 up. Now, I for example, believe that you could test compati-
18 bility in a test tube with a chemical analysis in an hour.
19 The data is available. Now, again, this may be just some
20 oversight or of some problem that I'm not aware of, but
21 basically, I think, compatibility is easily determined. Now,
22 the need for 100,000 barrels, I believe, they were thinking
23 that they would see something in the reservoir behavior, in
24 the reservoir behavior and my point is, I really don't think
25 you'd see anything in reservoir behavior unless you had a very --

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1 unless you'd drill a lot of core holes to see where the water
2 had gone. and where it had displaced or had a lot of close-in
3 wells where you could see the response. This is generally
4 difficult to do because when you put water in you have a
5 high pressure right near that well bore and that water just
6 skirts all over, so it's very difficult to control, so from
7 a reservoir standpoint you don't learn too much. I think
8 about the only thing you can learn is injectivity, knowing
9 injectivity, the need for it, you start in a fairly -- well,
10 you start in a big part of the field -- in a part of the
11 field on a fairly good size scale though, not just one or
12 two wells where you think you need it most, then you build
13 from that point. Now, again, I'm not saying I disagree
14 it because I would have to see the logistic and so forth and
15 I would be one for saying, let's get the 100,000 barrels by
16 going into shallow aquifers if we could find those in order
17 to hasten the definition of what the needs are.

18 BY: MR. MILES

19 Doctor, you mentioned the proposed increase to..ah.. a million
20 five barrels a day in your paper, but you don't, but you don't
21 get into it too much, what -- what impact or what effect on
22 ultimate recovery ..ah.. will this -- may this have and
23 this increase in production, how will ..ah..just how will
24 that..ah..how may that effect the ultimate recovery?

25 BY: DR. DOSCHER

Again, I, of course, cannot give you a firm answer but ..ah..

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1 I'm willing to summarize.

2 BY: MR. MILES

3 Well, we're going to have to make a decision on the -- Nobody's
4 firm answer, because (indics) not going to be there.

5 BY: DR. DOSCHER

6 I'm concerned about the fact that in the..ah..one side of the
7 field we have high GOR's that won't go away. I'm concerned
8 that this may spread on us if we start because you recall it
9 was brought out yesterday, very clear, that coning or gas
10 breakout is occasioned by high rates and large pressure draw-
11 downs so that if higher rates are instituted and this
12 condition spreads, we may find more and more of the field is
13 going to high GOR's. So, again, because I don't know different
14 I'd say be a little cautious, we'll let 300,000 barrels mean
15 that much to you or the operators, this is a question that
16 the commission has to decide. If it's going to mean the
17 question of life or death or whether..ah..cash flow is
18 viable or not, you'd tend to nudge it the other way, but as
19 far as the needs of the United States, I think another
20 300,000 barrels isn't going to change our basic conditions
21 and..ah..matter of fact, I feel the sooner we start living
22 without that 300,000 barrels the better off we are because
23 we're not finding a replacement for it.

24 BY: MR. MILES

25 Thank you. Chat.

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1 BY: MR. CHATTERTON

2 Thank you Mr. Chairman, I've got a series of three unrelated
3 questions, if you'd give me the latitude, I'll try and proceed.
4 One, Dr. Doscher, in response to Representative Parr's question
5 you said, in effect, that no gas should be sold until injection
6 tion is in place and ready to operate..ah..and you gave him
7 an answer to the affirmative.

8 BY: DR. DOSCHER

9 That's correct.

10 BY: MR. CHATTERTON

11 I would like to follow up on that question a little bit. Do
12 we know that even with these injection facilities in a position
13 to operate that it still would be wise?

14 BY: DR. DOSCHER

15 Oh -- you're right on. When I said ready to operate, I meant
16 that. ah..we knew we could put the water in because there
17 may be a significant time, even with the water at the well
18 head before the water starts going in a uniform way.
19 Now, I hope that's not going to be long, I hope that the
20 injectivity tests which are being done now will teach us what
21 we need to know so that when that time occurs there won't be
22 a delay, but basically you're right. As a matter of fact,
23 you might even say that you want to wait until the pressure
24 builds up to some point in the reservoir. Again, I have to
25 say we'll have to wait until we see the 3-D studies to ascertain
this.

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AGO 532318

1 BY: MR. CHATTERTON
2 Alright, I'll try to clarify where I was going to get a
3 response to, even then, do we know whether we'll suffer
4 ultimate loss of recovery of black oil by permitting gas sales?
5 BY: DR. DOSCHER
6 Well, I hope the 3-D studies will have informed us.
7 BY: MR. CHATTERTON
8 Yea, I know, I know, I know, but it may show that you might
9 not even want to do it....
10 BY: DR. DOSCHER
11 You're absolutely right.
12 BY: MR. CHATTERON
13 I didn't want a closed answer to....
14 BY: DR. DOSCHER
15 You're absolutely right..ah..I beg -- this goes back to our
16 study, basically, of..ah..not -- but the runs we made with
17 the vanPoolen and Associates model which indicated that
18 water flooding and no gas sales gives you all that much more
19 oil.
20 BY: MR. CHATTERTON
21 Thank you. Okay, and I said next unrelated question, water
22 flooding and I'm using your definition of water flooding,
23 given that that became sort of a field wide technique 3-1/2
24 decades ago, where was water flooding started, it wasn't --
25 first -- what types of reservoirs, weren't they virtually

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1 depleted as far as primary recovery is concerned?
2 BY: DR. DOSCHER
3 No, the first reservoirs were..ah.. not depleted at all, they
4 were leaks in the casing in Pennsylvania in 1890.
5 BY: MR. CHATTERTON
6 Well -- well then -- let's say man -- well it's man made too,
7 on purpose by man....
8 BY: DR. DOSCHER
9 On purpose by man, you're right, that they were depleted....
10 BY: MR. CHATTERON
11 3-1/2 -- okay, they were depleted reservoirs and basically
12 our history has improved the recoveries -- has been our long
13 standing histories, anyway, has been from depleted reser-
14 voirs and now we're boning up on the fact, well, maybe we should
15 have -- we should start early in the game.
16 BY: DR. DOSCHER
17 Again, I could point to say..ah..a couple of the reservoirs
18 in the North Sea -- or you put water in or the operators
19 putting water in very early and in Alberta you'll find
20 several reservoirs where..ah..water goes in just about from
21 day one, but there they have a experience level....
22 BY: MR. CHATTERTON
23 but we don't have too much field history in back of us,
24 when I say too much....
25 BY: DR. DOSCHER
You're right.

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1 BY: MR. CHATTERTON

2 Okay, in those cases. Let me ask you one other question.

3 BY: DR. DOSCHER

4 Except in natural water drive we have....

5 BY: MR. CHATTERON

6 Oh, I understand, right. One other unrelated question, you
7 gave -- you expressed concern with the rate sensitivity between
8 1.2 and 1.5 million barrels a day, and you were alluding to
9 the fact that we had some gas tongueing and/or coning, what-
10 ever. Now, given that that gas coning and so forth and so on,
11 or tongueing occurred -- it occurred with X number of with-
12 drawal points, now -- we now have many more withdrawal points
13 in the reservoir to where possibly even the rate of withdrawal
14 from any single straw is dropping off, doesn't that not sort
15 of mitigate your concern?

16 BY: DR. DOSCHER

17 A little bit..ah..but again, without knowing the exact nature
18 of the coning, if it is coning or tongueing..ah..basically
19 you're right. The more drainage points I have the less will
20 the problems be.

21 BY: MR. CHATTERTON

22 And were gaining...

23 BY: DR. DOSCHER

24 So, I'll just stop and say this....

25 BY: MR. CHATTERTON

....and we're gaining about six or seven drainage points per

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1 month up there.

2 BY: DR. DOSCHER

3 Right, but on pretty big spacing. You see, I don't know at this

4 time whether it's a spacing phenomena or just what because

5 again -- I mean, our control is small again. Okay, and on

6 the east side the thing of concern is we have -- that's where

7 we have the most wells, where we have the most coning.

8 BY: MR. CHATTERTON

9 I guess what I'm saying is, do you agree with me we'd be on

10 very thin ice to -- with this expanding number at the rate of

11 six a month, let's say withdrawal points being drilled in and

12 put on production. Why, we're on thin ice if we pound

13 the table and say you can't go to 1.5 barrels....

14 BY: DR. DOSCHER

15 Oh, there's no question of that, no, no question of that.

16 BY: MR. CHATTERTON

17 Thank you.

18 BY: DR. DOSCHER

19 And as I've said, I had no ice at all, I have only trends

20 that I'm extracting.

21 BY: MR. CHATTETON

22 Yea, alright. Thank you, thank you Mr. Chairman.

23 BY: MR. MILES

24 Mr. Rogers.

25 BY: MR. ROGERS

..Ah..maybe another no ice question ..ah.. follow up on that

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1 and what Chairman Miles said, if we're three years from
2 water flooding..ah..and if you think it may -- that the
3 increase of 300,000 barrels a day up to 1.5 could effect ultimate
4 recovery..ah..what would -- what do you think the
5 effect would be if production were held to a slower rate than
6 the current 1.2, at either 1.0 or 800,000 or something given
7 as that....

8 BY: DR. DOSCHER

9 isn't that what it is? We have no evidence to indicate
10 any serious negative effect. Maybe there will be after he does
11 some more work.

12 BY: MR. ROGERS

13 Is there significant positive effect? Alright
14 (indisc - simultaneous speech)

15 BY: DR. DOSCHER

16 No significant -- we have no evidence to believe that there
17 would be a significant positive effect..ah..at this time.

18 BY: MR. ROGERS

19 Thank you.

20 BY: MR. MILES

21 Mr. Parr

22 BY: MR. PARR

23 Yeah, Mr. Chairman. Ah.. Dr. Doscher, you said in Alberta
24 they -- sometimes they bring the water in on day one, right?
25 Now, have they done that much advance research on those fields

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1 that they are -- they know the reservoir that intimately that
2 know that the water flooding is a desirable thing, at day one
3 that, as we've been told, that there are dangers in water
4 flooding if you don't know -- you may be doing yourself harm
5 rather than good. How do they know that day one bit.

6 BY: DR. DOSCHER

7 I think the dangers have been a little exaggerated. As I
8 walk through with some of the answers with Representative
9 Chatterton..ah..one of the most important dangers was this
10 question of the water channelling through. Well, you
11 more or less learn about the possibility of these channels
12 in your drilling program, whether your drilling mud gets
13 lost. In other words, you know a lot of this by the
14 time you finish drilling the well. You know a lot of this
15 from the viscosity how thick the oil is. So, in general,
16 I'm not -- there are dangers but I don't make as much of
17 them, I thought that with my answers to Mr. Chatterton that
18 came out. I don't make that much of it.

19 BY: MR. PARR

20 Well, to come back into my question, did the people in
21 Alberta, where you're doing this on day one, know their
22 reservoir that intimately before they started that they could
23 do that?

24 BY: DR. DOSCHER

25 Yep, they do that.

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1 BY: MR. PARR

2 Now we don't have anywhere close to that kind of knowledge
3 at Prudhoe Bay.

4 BY: DR. DOSCHER

5 It's pretty close, it's pretty close. In other words, I
6 think there's just a little -- you just need the operators --
7 possibly have to do a little more -- your injectivity test
8 will tell you. The injectivity test will tell you whether
9 there is -- and profile test, where you go in after the
10 injection and see where the water is going. You can learn
11 fairly quickly whether there are some sands that take most
12 of the water and that's the danger. And you can learn that
13 pretty directly.

14 BY: MR. PARR

15 Well, let me ask you the other question on -- why wouldn't
16 we have..ah..done all those tests before we started exploiting
17 the reservoir at all here in Prudhoe Bay. If it is as you
18 say -- make it sound rather simple injectivity test and it
19 doesn't (indisc - simultaneous speech)

20 BY: DR. DOSCHER

21 Alright, at the time of our first -- at the time of our first
22 study, we asked the operators whether these tests were going
23 on and being considered and we were told that, particularly
24 BP that a test like this was being planned and so, I can't
25 tell you more than that. I don't know whether it was executed

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1 or not but certainly as of two years ago there was -- we had
2 definite information and it's recorded in our report to you.
3

4 BY: MR. PARR

5 Well is there anything gained by holding off on injectivity
6 tests? . . .

7 BY: DR. DOSCHER

8 Oh, I would -- I couldn't see that at all.

9 BY: MR. PARR

10 In other words, the most prudent course might be, in a field
11 like this, to have gone in with injectivity tests very early
12 in the game.

13 BY: DR. DOSCHER

14 Yea, well, I think there was made, I think there was some
15 made. I can't tell you all of it because I'm not privy to
16 it, but I believe there were some tests made and yesterday
17 you heard that a test had been made in the aquifer and in the
18 oil column in the tar sand. So, injectivity tests have been
19 made..ah..maybe not as early as I would have suggested, but
20 they have been made and apparently available for the Board's
21 consideration.

22 BY: MR. PARR

23 Thank you.

24 BY: MR. MILES

25 Are there other questions for Dr. Doscher? Doctor, thank you

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1 very much. If there's no more questions -- I hope you'll
2 hang around as long as you can.

3 BY: DR. DOSCHER

4 I'll be here. Okay.

5 BY: MR. MILES

6 We'll take a brief five minute recess and come right back and
7 continue with the hearing.

8 OFF RECORD

9 ON RECORD

10 BY: MR. MILES

11 We have..ah..we have a number of representatives of the
12 industry..ah..who will be testifying next, prior to that
13 just a brief statement to let folks know the status of the world
14 on the second floor right now. The status is Joe, what
15 would you say, limbo

16 BY: MR. HAYES

17 Limbo.

18 BY: MR. MILES

19 We may -- we may be called away, we may not, nobody really
20 knows right now, if we are we'll just have to vacate..ah..
21 if that's the case, we do go adjourn, it's my plan that we
22 come back and finish the..ah..finish taking the testimony
23 from the witnesses and I would hope that the committee would
24 join me back here even though the post adjournment celebrations
25 are always in order. At least through the

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1 witnesses that are out of town witnesses who have been kind
2 enough to come and join us. If we don't adjourn, it's my
3 intention to..ah..probably break at 5:00 and come back at
4 7:00 and hopefully we can..ah..hear from a couple of other
5 people who have indicated they would like to make a statement,
6 ..ah..following that just a general question and answer period,
7 it seems like there's a number of questions that have
8 arisen that people aren't real clear on and maybe give and
9 take between the witnesses might help, if the witnesses can
10 stay. If they can't, I'd certainly understand, I wouldn't
11 want to ..ah.. have anybody miss their plane, but this has
12 really been valuable set of hearings for me. I can't speak
13 for anybody else and I really appreciate everybody's help. Without fur
14 adieu then..ah.. Paul do you want to start introduce your
15 people and their various fields of expertise and go ahead
16 with your presentation in the manner that you choose.

17 BY: MR. NORGAARD

18 I'll do that, if I may, I'll introduce them as I go into
19 what I have prepared before, if that's alright.

20 BY: MR. MILES

21 Okay, can you tell us who we're talking to though first,
22 to start out with?

23 BY: MR. NORGAARD

24 Well, definitely, sure I will. Larry Smedley with Exxon,
25 he'll be talking principally about the reservoir and you're?
Allen Lasky?

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1
2 BY: MR. NORGAARD

3 That shows how well I'm prepared.

4 Brian Davies of Sohio, he's going to be talking about
5 reservoir preformance, Dave Griffiths with ARCO, will be
6 talking about the waterflood plans.

7 BY: MR. MILES

8 Okay, go ahead Paul.

9 BY: MR. NORGAARD

10 Thank you Mr. Chairman. Committee members, I join the Prudhoe
11 Bay Unit Owners in thanking you for the opportunity to discuss
12 the Prudhoe Bay reservoir here this afternoon. I am Paul
13 Norgaard, I'm Vice President with ARCO Oil and Gas Company,
14 a division of Atlantic Richfield Company. I'm responsible
15 for ARCO's activities north of Fairbanks, which includes the
16 Prudhoe Bay Unit. This afternoon I'm here as a management
17 representative for the major owner companies. I believe
18 our prepared testimony, our direct testimony, will be
19 responsive to many of the quetions which I have heard you
20 ask today of the other witnesses. To begin, I would like
21 to summarize some of the activities in which the major
22 owner companies have been engaged since field discovery. As
23 you are aware, the Prudhoe Bay State No. 1, Sag River
24 State, and the Put River No. 1 wells were completed in 1968.
25 Information from these wells, plus seismic data, was

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1 immediately used, and used as input into our mathematical
2 reservoir simulators, and we began our first reservoir
3 simulation studies.

4 (Discussion regarding blinds)

5 Obviously this initial data was incomplete and the results of
6 the studies were simply used as a guide to facility design
7 and to overall general reservoir management. The owner
8 companies initiated a very aggressive data gathering program
9 with the start of development drilling 1969. We obtained
10 basic data from cores, that was mentioned yesterday, these
11 are underground rock samples that are recovered in most
12 incidences from 8500 to 9000 feet deep, brought to the sur-
13 face and analyzed there, from the fluid samples, many of
14 these samples were collected right at reservoir conditions,
15 right at 9000 feet, and finally from the numerous logs which
16 were run (indisc) and all the wells drilled today. In
17 addition, we developed highly sophisticated laboratory tests
18 and interpretive procedures to analyze these tests. Some
19 of them essentially brand new to the industry. The owner
20 companies began immediately to share the bulk of this data
21 to assure the best possible reservoir studies and therefore
22 reservoir management. In addition, the owner companies
23 agreed on the location and sizing of facilities to minimize
24 a surface damage or change to the Prudhoe Bay area. The
25 major interest owners met on several occasions to exchange

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1 and discuss these reservoir studies, the facility studies,
2 and on several occasions met with with the Oil and Gas
3 Conservation Committee and with some legislative committees
4 to share our understanding and our knowledge. I should
5 mention that we continually changed and improved the
6 mathematical reservoir simulators to better reflect the
7 real reservoir, something we always look forward to. As
8 development wells were drilled, the frequency and location
9 of shale was better -- became better known and the rock
10 characteristics, fluid characteristics were better refined.
11 The major owners, in general, were making improvements and
12 in refinements in their reservoir description and in their
13 simulators at least once every year. Prior to the May, 1977
14 unitization hearings, the three major interest owners
15 finalized a series of extensive simulation studies to
16 address the major reservoir management uncertainties and
17 questions. These were offtake rates, gas sales, water
18 injection, and the timing of additional facilities. These
19 results were summarized at the May, 1977 Pool Rules Hearing
20 and are a matter of public record. It should be noted that
21 this operating plan provides for and contains several key
22 elements and I'd like to mention several of them here for
23 the record.

24 BY: MR. MILES

25 Paul, were there -- you said they were summarized in public

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1 record. Were those runs similar to the ones we have in
2 (indisc - cough)

3 BY: MR. NORGAARD

4 Most of the runs that were made prior to the unitization
5 hearings were two dimensional strip models which all three
6 companies participated in running and the results from all
7 three companies were incorporated in the hearings and..ah..
8 presented in the May, '77 hearing.

9 BY: MR. MILES

10 Let me start over. Were those runs similar to the ones
11 vanPoolen did in '77, '76 and '77?

12 BY: MR. NORGAARD

13 They have the basic parameters, we like to believe that we
14 had a little better tool to use because we had more time to
15 develop it.

16 BY: MR. MILES

17 I see, now, those runs are a matter of public record.

18 BY: MR. NORGAARD

19 Ah..the results of the runs are a matter of public record.
20 We have not kept them from anyone intentionally, it's just
21 that with simulation work you get an awful lot of output as
22 I believe, Mr. vanPoolen showed yesterday and it -- most --
23 most times it doesn't warrant getting into if the results
24 look they're consistent and compatible.

25 BY: MR. MILES

I see, but what Mr. vanPoolen provided us are a number of ten

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1 test runs with..ah..aquifer and no gas sales, 1.5, two
2 billion cubic feet, are those how yours are broken down?

3 BY: MR. NORGAARD

4 In general, yes.

5 BY: MR. MILES

6 Okay, and is that information available to us as public
7 record in a form?

8 BY: MR. NORGAARD

9 Yes it is. Certainly, it's in the testimony itself.

10 BY: MR. MILES

11 Oh great. Okay, fine. I haven't got a copy of that, I'd like
12 to see that if you could send it to us.

13 BY: MR. NORGAARD

14 I'm sure we can make sure it gets to you, yes.

15 BY: MR. MILES

16 Thank you.

17 BY: MR. NORGAARD

18 Moving back to the key elements of the Pool Rules. First, an
19 oil production rate of 1.5 million barrels per day which we've
20 heard repeatedly during -- up to this point in time. Second,
21 gas pipeline deliveries of 2 billion standard cubic feet per
22 day when treating and transportation facilities are available.
23 The drilling of wells on 160 acre spacing or denser if
24 necessary. Four, installation of low pressure gathering
25 system and artificial lift when necessary to maintain the

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1 production rate. Fifth, selective injection of produced
2 water into the producing horizons, sadlerochit formations,
3 in areas of low natural depletion when water volumes are
4 significant, and last, supplemental injection of source water
5 when optimum injection locations and volumes can be determined
6 additional recovery predictions verified, and the project's
7 economic viability can be confirmed. One key point made at
8 the hearing and later by the Oil and Gas Conservation
9 Committee was the need for production history to verify the
10 study results and provide a basis to calibrate the reservoir
11 simulation, the simulators themselves. We are now two years
12 into production history and possess some of the needed
13 history. During this two year period, extensive data has
14 been obtained and has been continually analyzed. We have
15 provided summary reports, as well as the basic data itself,
16 to the Oil and Gas Conservation Commission. The owner com-
17 panies have developed three-dimensional fieldwide models to
18 fully utilize this data and have conducted studies to again
19 analyze, refine and improve the quality of our reservoir
20 management plan. This careful analysis demonstrates that
21 the field is performing very well, at least as well as
22 predicted, and slightly better in some regards. Nevertheless,
23 we must continue to gather and analyze additional data to
24 fully optimize this field. The studies for a source water
25 injection system have moved forward in parallel with the

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1 reservoir studies. The pace and detail of these studies
2 has increased during the past two years with good progress
3 in all study areas. Last week, the permit application was
4 filed with the Army Corps of Engineers. We shall discuss
5 these items in considerable detail later in our presentations.
6 Moving now to our presentation. All three major owner com-
7 panies have participated in the studies which we shall be
8 discussing and in the preparation of this hearing. We have
9 broken our discussion into three parts. First, Field
10 Performance, and as I indicated this will be presented
11 by Brian Davies of Sohio. Second, Reservoir Management
12 Studies, this will be presented by Larry Smedley of Exxon.
13 And last, Waterflood Study Progress which will be presented
14 by David Griffiths of ARCO. Since the pieces of our presen-
15 tation are inter-related, we suggest that clarification
16 questions be asked as they arise, but that new type questions,
17 leading questions be held until later since in a high
18 probability much of your questions will be answered as we
19 move forward in our testimony. Certainly, we encourage your
20 questions, we want to answer all of your questions, but we
21 think we can more efficiently answer them if we go through
22 our prepared testimony. But, without a doubt, any clarifica-
23 tion questions, please ask them immediately because that's
24 the right time.

25 BY: MR. MILES

Nobody asks leading questions on our committee except Chat.

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1
2 BY: MR. NORGAARD

3 Last, copies of the text will be made available at the con-
4 clusion of our presentation. And with that, I'll turn it
5 over to Brian Davies who will be talking about the Field
6 Performance as we see it. Brian.

7 BY: MR. DAVIES

8 Mr. Chairman, Members of the House Resources Committee,
9 Ladies and Gentlemen; my name is Brian Davies. I hold a
10 Honors Degree in Natural Sciences from Trinity College,
11 Dublin. I have been employed by British Petroleum and
12 Sohio in petroleum production and exploration activities for
13 16 years in the North Sea, Arabian Gulf, Columbia and
14 Alaska. Since 1971, I have been involved in the development
15 of the Prudhoe Bay Field, first, as District Petroleum
16 Engineer then as Sohio's representative to the Prudhoe Bay
17 Unit Planning Subcommittee in Anchorage. My current position
18 is Supervisor of Production Planning for Sohio and as such I
19 continue to be involved with the development plans for the
20 Prudhoe Bay Field. The purpose of my presentation to you
21 today is to describe production performance of the Prudhoe Bay
22 Field today. I will start with a summary of the field develop-
23 ment since the commencement of production in June of 1977.
24 Next I will briefly discuss the reservoir surveillance methods
25 that the operators are using to monitor the field performance.

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1 I will then discuss the production and pressure behavior,
2 the well performance, and the fluid contact movements in the
3 reservoir. I'd like to say right now that overall the
4 production performance has been good and essentially as
5 predicted. The Prudhoe Bay Field has been on sustained
6 production for just over two years. I apologize for the
7 switching on and off but we'll get through that here. Ah..initial
8 offtake from the field was restricted to about 720 thousand
9 barrels per day, because of the accident at Alyeska Pump
10 Station #8. After the repairs to the Pump Station were
11 completed in March of 1978, the rate of production was in-
12 creased to about 1.16 million barrels per day. Since then,
13 the performance of the pipeline system has been progressively
14 improved so that currently an offtake level of about 1.28
15 million barrels per day is being achieved. In the field,
16 we have maintained sufficient producing potential so as to
17 continuously produce at pipeline capacity rates. Early
18 production from the field was sustained by approximately
19 100 wells in total serving two flow stations in the Eastern
20 Operating Area and two Gathering Centers in the Western
21 Operating Area. By the end of the first three months of
22 production, all facilities were functioning satisfactorily.
23 And also, the flaring of gas ceased except during the
24 commissioning of new facilities and for emergencies caused by
25 minor upsets in the operation of the plant. Of the total of

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1 500 billion standard cubic feet of gas produced since
2 January 1, 1978, over 99.8% has been reinjected into the
3 reservoir or used as fuel. Because, we emphasize that,
4 99.8 has been reinjected into the reservoir or used as fuel.

5 BY: MR. MILES

6 Which -- which percentage of -- which has been..ah.. what
7 percentage has been reinjected, with what percentage has been used
for fuel?

8 BY: MR. DAVIES

9 Approximately as Dr. vanPoolen and the OGCC mentioned, over
10 90% has been reinjected into the reservoir.

11 BY: MR. MILES

12 So, roughly 9.8's used as fuel.

13 BY: MR. DAVIES

14 Yes, roughly. I don't have the breakdown on that, we can get
15 that for you, if you wish. Continuing on with the history
16 of development to date..ah..the third Gathering Center in
17 the Western Operating Area was commissioned in March of
18 1978, and the third Flow Station in the East came on stream
19 in March of this year. These facilities have enabled additional
20 wells to be progressively brought on production and so have
21 permitted offtakes to be distributed more evenly over the
22 field. We currently have nearly 200 wells drilled and
23 connected for production. Thus, over a period of two years
24 this represents a doubling of the number of wells available
25 for production. And we are proceeding with the further

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1 development and the operation of the Prudhoe Bay Field in a
2 manner which is consistent with the plans presented in the
3 May 1977 Pool Rules Hearing before the Oil and Gas Conservation
4 Committee. These plans permit the degree of flexibility that
5 is necessary for good reservoir and production management
6 control. Turning now to the question of reservoir surveillance.
7 In the previous testimony to the Oil and Gas Conservation
8 Committee in May 1977 the Unit owner companies described
9 their plans for reservoir surveillance. The owners recognized
10 that a comprehensive reservoir surveillance program was
11 necessary to provide the data needed to optimize the con-
12 tinued development of the field. The response of the
13 reservoir to production is indispensable in understanding
14 the recovery mechanisms and in checking the accuracy of
15 reservoir descriptions. In addition to frequent well testing
16 the owners proposed an intensive reservoir pressure measure-
17 ment effort, a program designed to monitor changes in gas
18 saturation and an evaluation of techniques to monitor changes
19 in the water saturation of the reservoir. Subsequently,
20 the Alaska Oil and Gas Conservation Committee issued
21 Conservation Order No. 145 which incorporates rigorous
22 surveillance requirements in the Prudhoe Bay Oil Rules. Over the
23 last two years this surveillance program has generated a
24 tremendous volume of field performance data. In our view
25 the level of reservoir surveillance and testing activity which

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1 has been carried out and which is continuing in the Prudhoe
2 Bay Field has rarely been surpassed. This viewgraph summa-
3 rizes this surveillance activity. We have over 450 measure-
4 ments of reservoir pressure and 220 flow meter surveys have
5 been run. These flow meter surveys are used to establish the
6 contribution of the various intervals that are open to
7 production in the well bore. In addition to this, 215 initial
8 baseline and follow-up surveys have been done to monitor the
9 changes in gas saturation in the reservoir. The neutron
10 logging tools which are used in these surveys have proved to
11 be extremely valuable in locating the leading edge of the
12 advancing gas cap and also in monitoring other changes in
13 gas saturation around the well bore. Some 60 surveys have
14 been made to attempt to monitor the changes in the water/oil
15 contact in the reservoir. As was pointed out in the May 1977
16 hearing this is a difficult technical problem. However,
17 the aggressive evaluation program has given us encouraging
18 indications that a technique is available which will yield
19 quantitative estimates of the changes in water saturation
20 caused by any rise in the water/oil contact.

21 BY: MR. MILES

22 Can you give me just a short idea what you do when you
23 do one of these surveys -- what -- what actually happens?

24 BY: MR. DAVIES

25 Ah..well, depends on which..ah..one your dealing with. Lets

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1 for instances look at the gas/oil contact survey. There is
2 a..ah..tool we use, is called a neutron tool and basically,
3 that bombards --you lower the tool down the well bore and the
4 tool bombards the formation of the neutrons and the response
5 of the tool..ah..is dependent among other things, upon the
6 gas saturation that's present in the reservoir at that point.
7 What we do is we run the tool initially to establish a base-
8 line survey and then after some period of production..ah..
9 we'll shut the well in and run the tool again and look for
10 changes from our initial baseline survey. By doing this we
11 have found that -- we have a very good technique for detecting
12 these changes.

13 BY: MR. MILES

14 Thank you.

15 BY: MR. DAVIES

16 Let me now briefly review the production history since June
17 of 1977. This viewgraph shows the buildup in oil production
18 from an initial rate of 720 thousand barrels a day to the level
19 of 1.28 million barrels per day in June 1979. Also shown is
20 the production of gas which is associated with the oil, that's
21 the..ah..red line. As I'm sure you're aware, the ratio of the
22 produced amount of gas to oil at any particular time is
23 referred to as the gas/oil ratio, a term that we've heard a
24 lot about today. At the start of production this gas/oil
25 ratio was approximately 750 standard cubic feet of gas per

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AGO 532341

1 barrel of oil. The ratio has risen somewhat and currently
2 in July of 1979 is approximately 920 standard cubic feet
3 of gas per barrel. This slight increase in the overall
4 gas/oil ratio is primarily due to wells in the Eastern part
5 of the field, particularly in the Flow Station 2 area, that's
6 in the extreme Eastern part of the field. This increase is
7 mainly caused by the localized influx of gas cap gas under
8 the continuous shales in this area. Currently the operators
9 have considerable flexibility in controlling the gas/oil and
10 the oil/water ratios, and they are deliberately producing
11 high gas/oil ratio wells which are located high on the struc-
12 ture and close to the gas cap so that they maximize the
13 recovery of the gas condensate liquids, while excess gas
14 injection capacity is available. Before we leave this
15 viewgraph, I'd like to point out the line, right at the
16 bottom, it's barely distinguishable from the lower-most axis
17 of the graph, represents the water production which has been
18 very low and currently amounts to just under 20,000 barrels
19 per day. The data that's obtained from the reservoir
20 pressure measurement program is, among other analyses, used
21 to draw maps of the pressure decline at various times. This
22 particular viewgraph shows such a map which corresponds to
23 our interpretation of the decline at August 1, 1978. Can
24 anyone -- everyone see that? Each line...

25 BY: MR. MILES

....probably doesn't make a hell of a lot of difference.

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1 BY: MR. DAVIES

2 Your -- you just can't see the detail or....

3 BY: MR. MILES

4 No, I can.

5 BY: MR. DAVIES

6 This particular viewgraph, as I've mentioned, shows the
7 interpretation of the decline to August 1, 1978. Each of
8 these lines connects a point at which we believe the reser-
9 voir pressure is the same. This line, here for instance,
10 is the contour line corresponding to the 100 pounds per square
11 inch decline level. You will note that the area showing the
12 greatest decline occurs in the Flow Station 2 region. This
13 line here represents a decline of 600 psi, at that time.
14 Once again, this is caused by the unusually high incidence
15 of shales which prevent good vertical communication of the
16 producing intervals with the overlying gas cap. And, as I
17 mentioned before, these shales are also the cause of the
18 localized influx of the gas cap gas. We will discuss this
19 matter in some more detail later, and show that the perfor-
20 mance as was predicted. We'd also like to emphasize that
21 this is a relatively small part of the field and that the
22 intervals affected contain less than 6% of the oil in place
23 in the reservoir. To avoid any further increase in the
24 pressure decline in this area, we changed our production off-
25 take distribution and reduced the amount of oil that was

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1 being withdrawn from the Flow Station 2 area. This next map
2 shows the reservoir pressure decline corresponding to
3 August 1, 1979. Due to the reduced
4 production from the Flow Station 2 area, the pressure sink,
5 that's this area here, that pressure sink has stabilized and
6 is now no greater than it was one year ago. You see that
7 this line here is corresponding to 600 pounds of decline,
8 and as I say, that was the decline that we'd saw there one
9 year ago. In fact, in some of the wells, in this area,
10 there has been an increase in the reservoir pressure during
11 the past year. Another factor that I should point out, and
12 this is one that has been referred to in testimony by..ah..
13 the OGCC and by Dr. vanPoolen, is that the pressure measure-
14 ments, that we take, reflect primarily the pressures in the
15 reservoir intervals that are being drained. Where the
16 presence of extensive shales impairs communication with other
17 parts of the oil column, then the measured reservoir pressure
18 will be lower than the average pressure of the total oil
19 column in the reservoir at that location. When we take into
20 account the distribution of the pressure, both in an aerial
21 sense, looking across the whole field, and also in the verti-
22 cal sense taking into account the intervals that are not
23 open to production, then the pressure decline for the oil
24 column is approximately 185 psi, pounds per square inch. And
25 this is actually less than was predicted prior to production

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1 and is certainly no cause for alarm. Let me turn now to
2 the question of well performance. The well capacities
3 average about eleven and one-half thousand barrels per day
4 and these two are in good agreement with our preproduction
5 predictions. It has been suggested that gas coning is causing
6 production problems at Prudhoe Bay. It is a fact that in
7 wells, where there is relatively good communication between --
8 in the vertical section between the producing interval and
9 the overlying gas cap, there is a potential that early gas
10 production will occur.

11 BY: MR. MILES

12 Before we go off that, Brian, did you say that in some
13 areas the pressure's higher?

14
15 Brian, did you say that in some areas in Prudhoe that the
16 pressure was higher than originally?

17 BY: MR. DAVIES

18 No, what I said was, turn back, in a pressure sink area,
19 perhaps we could put the thing back in here, in this pressure
20 sink area one year ago we recognized a significant
21 decline right in the core of the sink, so we reduced the
22 production off-take from that area. Ah..... Well,
23 we look at the map one year later, we see that the pressure
24 -- sink has not increased, there is no decline greater than
25 600 pounds. In some wells in that area, we are actually

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1 seeing an increase that are a bounce back. Let me put it to
2 you -- there are many...
3 BY: MR. MILES
4 so it's not bouncing back over the original pressure, it's
5 bouncing back from the drop of 600?
6 BY: MR. DAVIES:
7 Let's say a year ago we might have measured, for example,
8 550 pounds decline in a particular well and this year we'll
9 be measuring..ah..for example, 450.
10 BY: MR. MILES
11 Did you indicate what percentage of the field -- these are --
12 that's a substantial drop, is that right? 600 pounds
13 pressure?
14 BY: MR. DAVIES
15 That -- that is a substantial drop compared with the rest
16 of the field where we're looking at..ah..well, in that first
17 map, in the order of 200 pounds.
18 BY: MR. MILES
19 Okay, did you say here a percentage of the field that the
20 substantial drop was measured in?
21 BY: MR. DAVIES
22 Yes, I....
23 BY: MR. MILES
24 you say it's 6% or....
25 BY: MR. DAVIES

We have to take into account both the aerial effect again,

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1 and the vertical effect. What I said was that, if we look at
2 the intervals where we measure that pressure, and bear in
3 your mind that these intervals are isolated by shale, then
4 the amount of oil that's effected is 6% of the oil in place.
5 What I'm getting to is that it's not just a matter of the
6 aerial extender which is pressure sink, we also have to look
7 at the limitations in the vertical section, and when we do
8 that, then the amount of oil that we're looking at that is
9 seeing this larger than average, very much larger than
10 average, pressure drop is only 6% of the oil in place.

11 BY: MR. MILES

12 What does that mean for downstream recovery?

13 BY: MR. DAVIES

14 What -- I'm sorry I don't quite see the.....

15 BY: MR. MILES

16 Well, okay, it's a 6% drop in this isolated area...

17 BY: MR. DAVIES

18 no, it's no 6% drop....

19 BY: MR. MILES

20 Well it basic -- okay, it's -- yes, 6% of the oil in place.

21 Is that right?

22 BY: MR. DAVIES

23 The oil affected by this large decline is 6% of the oil in
24 place.

25 BY: MR. MILES

6% of the oil in place, in other words, what you're saying is

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1 that the greater part of the oil is not affected by this
2 very large initial decline. Okay, what does that -- what
3 does that very large initial decline -- how does that affect
4 future recovery?

5 BY: MR. NORGAARD

6 Mr. Chairman, we will be addressing that directly in testi-
7 mony, a little later, if that's alright. We can answer it
8 now if you like.

9 BY: MR. SMEDLEY

10 Ah..this performance, as you'll see later, was predicted
11 almost identically in the projections that -- that we've
12 used to get the recovery figures that we're citing. So, in
13 effect, it doesn't have any. In other words, it was
14 considered, I'll show some comparisons with this same chart
15 ..ah..from the predicted runs.

16 BY: MR. MILES

17 Mr. Chatterton.

18 BY: MR. CHATTERTON

19 I am on the point of clarification -- if your going to
20 touch on this and that, why just say so, and go.

21 Obviously, I'm looking at iso -- pressure lines there, is
22 that correct?

23 BY: MR. DAVIES

24 That's right.

25 BY: MR. CHATTERTON

Okay, and I didn't see the previous slide fast enough to see

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1 how much variance there was over the years time. You might
2 put that up. Okay, fine, Now, let's get back to the other
3 one. And, my question now is basically -- and you, sir, you
4 may be answering it later on, but basically, where the
5 intersection of the trunkation line is at the top of the zone
6 and -- and at the base of the zone in that -- on that plat
7 there. You're out in an area where you don't have a full
8 sand thickness, aren't you?

9 BY: MR. DAVIES

10 Yes...

11 BY: MR. CHATTERTON

12 Right, now, are you also within an area where you have gas
13 cap overlying you completely or does the oil zone go to the
14 top of your zone?

15 BY: MR. SMEDLEY

16 In much of the area there's no gas cap over (indisc)

17 BY: MR. CHATTERTON

18 No, gas cap over it. So it has -- yea -- okay, thanks.

19 BY: MR. MILES

20 Mr. McKinnon.

21 BY: MR. MCKINNON

22 Yea, you said that when you look at it aerially, it -- it may
23 be a large portion of the field, but when you look at it
24 vertically, it doesn't affect -- it only affects 6% of the --
25 And that's because you're drilling between shale layers and the

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1 pressure loss is confined between those shale layers.

2 BY: MR. DAVIES

3 We drill all the way through -- that..ah..if you recall the
4 diagram that..ah..Mr. Hamilton showed you where having
5 drilled the case to well, then you lower a perforator down
6 and zap holes into the (indisc. - simultaneous speech)
7 We just zapped holes in that particular area between the
8 shales.

9 BY: MR. MCKINNON

10 Okay, and what you're saying, it doesn't effect the area
11 above it or below it.

12 BY: MR. DAVIES

13 Because the shales there are quite extensive and there's not
14 ..ah..good workable communication between the producing
15 interval of the -- interval above the shales, then the
16 pressure drop in the interval, direction of measuring in..
17 ah..is not representative of the whole oil column.

18 BY: MR. MCKINNON

19 Will that help when you go up to the next interval or down
20 to the next interval?

21 BY: MR. DAVIES

22 When you -- when you open -- if and when you open up
23 the intervals that are not bounded by the shales, then you'll
24 see the pressure response from those particular parts of the
25 reservoir. You'll see a high pressure.

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1 BY: MR. MCKINNON

2 Let me see if I can get -- if the whole interval were open,
3 you would not see that pressure drop.....

4 BY: MR. DAVIES

5 That's right.

6 BY: MR. MCKINNON

7 because the well would break and record something that
8 approaches very close the highest pressure that it sees or
9 at least a composite of the two. So, if the whole interval
10 were open, that 600 pound pressure sink might look like 200
11 pounds and that's what Brian's dealing with when he says you
12 have to look at both the horizontal and the vertical -- make
13 a -- I guess it's just a straight calculation on what is
14 effected.

15 BY: MR. SMEDLEY

16 We confirmed this with some tests that we..ah..that those
17 zones above those shales are -- you know -- substantially
18 higher pressures or near original pressures and have not
19 drawn down nearly anything like this.

20 BY: MR. NORGAARD

21 Also, it may not be germane but we have taken this area and
22 looked at it in a very microscopic context with simulator
23 models, rather than with the larger models, we have taken a
24 look at it in a very fine context and have been able to match
25 exactly what's happening in the real world with what we

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1 suspect would happen with a simulator, so we can tell very
2 closely what in fact has happened. We've been able to history
3 match. That's the kind of thing we will do and we have done
4 anytime we see an anomaly, we get the best technical expertise
5 we've got available and take a look at it.

6 BY: MR. McKINNON

7 Has this situation shut down some wells?

8 BY: MR. SMEDLEY

9 That was the method of reducing the production -- Brian
10 mentioned that we reduced the production rather than cutting
11 the production back at all the wells, we did shut some of
12 the wells in that were right in that..ah..area, in the highest
13 pressure drawdown area there. Drill size 9 wells, particularly.

14 BY: MR. McKINNON

15 Did..ah..

16 BY: MR. MILES

17 Joe, are you done or.....

18 BY: MR. McKINNON

19 Yeah....

20 BY: MR. DAVIES

21 We were about to get on to coning. As I've mentioned, we've
22 heard quite a bit of discussion on coning and..ah..we'd like
23 to run through this diagram here to just explain what
24 happens. This is a phenomena which occurs -- occurs in the
25 well where there is relatively good communication in the

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1 vertical interval between the producing interval down at the
2 bottom and the overlying gas cap. As oil is produced from the
3 perforated interval of the well, pressure drop is felt at the
4 gas/oil contact so we're producing from these perforated
5 intervals here and we feel a pressure drop opposite the
6 original gas/oil contact. This pressure drop..ah..can
7 result in the contact being locally drawn down around the
8 well bore, and here we see the contact is dipping down around
9 the well bore.

10 BY: MR. MILES

11 So, the gas is actually sinking?

12 BY: MR. DAVIES

13 Yes, the -- what's happening here is that the -- when field
14 pressure drops here..ah..pressure drop due to production
15 here is felt up here and that closes the gas/oil contact
16 so it tilts into -- towards the well bore.

17 BY: MR. MILES

18 So the -- physically, the oil drops down -- the well bores
19 between my fingers -- the oil drops down and that -- that
20 area is -- the gas cap moves down into that area?

21 BY: MR. DAVIES

22 Right. It's sucked in. Like the -- I think the analogy that
23 someone made when you stick a straw in a milkshake, a rather
24 viscous milkshake, and you suck hard on it and you get
25 this sort of coning down around the well, that's exactly

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1 what happens when you drill the wells.

2 BY: MR. CHATTERTON

3 Brian, clarification question. If the mobility, relative

4 permeability, was equal for the oil and the gas, would

5 you expect to see that?

6 BY: MR. MILES

7 Can I pass that one?

8 BY: MR. DAVIES

9 Paul can answer it.

10 BY: MR. SMEDLEY

11 I'll try that one. The..ah..the mobility, the gas being

12 much more mobile, contributes to this problem, the density

13 difference between oil and gas combats this phenomena, in

14 other words, the density difference is trying to keep that

15 contact very sharp so you've got kind of opposing forces --

16 that you really try to balance. (indisc.)

17 BY: MR. CHATTERTON

18 Thank you.

19 BY: MR. DAVIES

20 Okay, so, as one produces, through the perforations, the

21 oil - gas/oil contact starts the coning down until eventually

22 gas is produced through the uppermost part of the perforated

23 interval. This is the fully developed gas core and

24 when -- when you refer to a well coning gas, that's what's

25 happening, you develop the cone so gas is being produced

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1 through the uppermost parts of the perforated interval
2 because the cone is developed all the way down to the
3 top of the producing interval. Now, as we discussed at the
4 May 1977 hearing, we deliberately restricted the interval of
5 the reservoir that is open to production in some -- such
6 wells. Perhaps we can take this (indisc.) By that I mean
7 that we have chosen not to perforate up here, we have
8 restricted our perforations to the lower part of the interval.
9 We have generally maintained a distance of 200 to 260 feet
10 between the top of the interval and the gas cap and this is in
11 order to minimize the potential for this coning effect.
12 In general, the further you stay away from the gas cap, the
13 less the potential from coning gas.

14 BY: MR. MILES

15 What happens if something is -- you screw up and you suck
16 some of that gas cap into the bore.....

17 BY: MR. DAVIES

18 What's that?

19 BY: MR. MILES

20 you suck some of the gas cap up into the oil or does
21 technology prohibit that if your gas cone come to the top
22 holes where you're drawing the oil out, what happens?

23 BY: MR. DAVIES

24 When the gas coning comes down to top holes, then you stop
25 producing gas cap gas.....

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1 BY: MR. MILES

2 It just goes right up in the top.

3 BY: MR. NORGAARD

4 and you just produce the higher amount of gas. That's
5 it. The (indisc.) gets reinjected back into the gas cap.
6 That's what happens and that's the most serious thing that
7 can happen to you.

8 BY: MR. MILES

9 Thank you.

10 BY: MR. SMEDLEY

11 The question was asked here yesterday and I don't think it
12 was fully explained. It is a reversible process and -- you
13 know -- it's not a real serious problem. It's something tha
14 when it happens, you can reverse it.

15 BY: MR. DAVIES

16 As I mentioned, we have, generally, maintained a -- this
17 standoff distance of 200 to 260 feet and we found that this
18 policy has been very successful in preventing gas coning in
19 the highly productive wells completed under the gas cap. In
20 short, we can say that gas coning has not been a significant
21 problem at Prudhoe Bay. One side effect of this practice is
22 that it reduces the production capacity of such wells and
23 thereby increases the number of wells that are required to
24 make a given production rate from the field. We also have
25 similar restrictions placed upon how close to the oil/water conta

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1 we open up for production. And, so by adopting these
2 measures, we are surrendering the short term benefits in the
3 well productivity in exchange for the longer term benefits
4 that will be derived from the more efficient displacement
5 of oil by overlying gas and the underlying water. It's a
6 long sentence but let's punch it home. In essence, we have
7 spent more money, drilling more wells early, in order to
8 ensure better long term reservoir performance.

9 BY: MR. PARR

10 May I ask a question, if you compensate for this by drilling
11 more wells, don't you get the same end result?

12 BY: MR. DAVIES

13 No.

14 BY: MR. PARR

15 You're spending more money to do it, I understand, but in
16 terms of what's coming out of the reservoir, you drill more
17 wells you're getting the same result.

18 BY: MR. DAVIES

19 Well, the answer to that, I think, is that gas coning is..ah..
20 principally a function of the rate from a well and this
21 business of how far you keep away from the gas cap. So, it's
22 -- if you draw a high rate from the well, then you'll have
23 more potential for gas coning. If, however, you increase
24 the number of wells and limit your perforation intervals,
25 you will not have gas coning.

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1 BY: MR. PARR

2 Well, maybe I don't quite understand you but if I under-
3 stood your statement. Ah..because you use this 200 and
4 260 feet distance, you reduce the production and that
5 you compensate for this by drilling more wells. Now..ah..so
6 what is that doing in terms of benefits to the reservoir
7 which is what I understood. It appears to me you're pulling
8 the same amount of oil out of that reservoir in either case,
9 right? If you have ten wells pulling out 10,000, that's
10 100,000, one well putting out 100,000 that's 100,000. So,
11 I mean -- what's -- I don't understand how you're
12 gaining anything here in terms of protecting the reservoir.

13 BY: MR. DAVIES

14 Well (indisc.) -- maybe the slide will help. First,
15 as we developed this cone down here, we started getting a
16 gas producing in the bottom and we're not allowing --
17 we are allowing, I'm sorry, basically, we are accelerating
18 the time in which we see gas entering the well, and so,
19 in this particular area, we are..ah..we're not efficiently,
20 as efficiently..ah..displacing the oil by the gas as if we
21 restrict the production rate. We keep that gas cone high.

22 BY: MR. NORGAARD

23 Let -- let me take a shot at it, if I may. The ideal, the
24 textbook case that I think people are talking about would be
25 if this gas/oil contact moved uniformly all the way across th

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1 reservoir straight down. That's -- that's the textbook case.
2 There are some reservoirs in Canada, as a matter of fact,
3 where -- that are very steep where -- where they really
4 are bringing it down, straight down, and by having more
5 straws than you avoid the little bumps, the little anomalies
6 and that again by textbook case, should be beneficial. I
7 don't think that there is any way that that can be verified
8 or substantiated but in textbook case, it would be desirable
9 to do. Does that help?

10 BY: MR. SMEDLEY

11 If you elected to do what I think you're suggesting, why
12 don't you just go ahead and perforate the whole thing, but
13 have more wells, that's what (indisc. - simultaneous speech)

14 BY: MR. PARR

15 I didn't suggest that, this gentleman said you drilled more
16 wells to compensate for that lower production or.....

17 BY: MR. SMEDLEY

18 lower capacity.

19 BY: MR. PARR

20 Well, alright, lower capacity. The point is -- you know --
21 how is this protecting the reservoir by drilling more wells
22 and if you're getting the same amount of production.....

23 BY: MR. SMEDLEY

24 That's a long term thing. As you look -- you know -- as this
25 reservoir's producted, what's going to happen is that that gas/c

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1 contact, as original, it is going to advance, in fact, it is
2 already moving and we are already monitoring its movement.
3 It will move down, down towards those perforations. If we
4 weren't prudently perforating the wells with the standoff like
5 we are, if you perforated, for instance, up close to where
6 that red line is, as that contact advanced, even without
7 coning, the gas would come right into the well bore and
8 you'd be faced with a mechanical repair which is difficult.
9 ah..not as risky, a lot of time we lose wells when you try
10 to do this..ah..and very expensive. So it's -- that's
11 a part of the reservoir management that you're optimizing.
12 To me there's another point that really hadn't come across
13 strong enough to this, in regards to -- we've talked a lot
14 in the last few days about coning. To our knowledge, there
15 has not been a well at Prudhoe Bay yet that has exhibited
16 this behavior. We have not coned gas into a well at all
17 in Prudhoe Bay. So, we've talked a lot about something
18 that is actually -- there is a potential there, as
19 Brian indicated, we've always anticipated, we've indicated
20 that in the long term we will see this type of behavior up
21 there, but as of now, we have not and it has been because
22 we have perforated the wells in this manner.

23 BY: MR. PARR

24 Thank you.

25 BY: MR. NORGAARD

I hope we answered it close enough.

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1 BY: MR. CHATTERTON

2 Could I intercede as a friend of the court, so to speak, and
3 try to talk to Charlie to get a feel for this? If your seat
4 cushion had 4 vertical spikes on it, it would hurt like hell
5 to sit on it, right? If you put 400 vertical spikes on it, it
6 would not hurt very much. And it's the same analogy as this.

7 (laughter)

8 BY: MR. PARR

9 Perhaps I misunderstood Mr. Davies, but I understood him to
10 be saying or at least implying that this was a conservation
11 technique which would result in better management of the
12 reservoir. I'm not interested in whether it's a good test --
13 economically for the companies or any of those factors. The
14 additional cost benefit ratio for several wells as opposed to
15 one. I understood him to say that this was a technique which
16 was better management of the reservoir and I was thinking in
17 terms of not wasting oil or getting maximum recovery and so
18 forth and therefore I didn't understand how this made any
19 difference. Now if I did misunderstand something, then of
20 course, I've wasted your time.

21 BY: MR. SMEDLEY

22 I think in the context it is -- it's an improvement in
23 reservoir management -- to quantify it would be really
24 impossible. I think it's a textbook thing like we've talked
25 about a number of times before. Directionally, it's got to

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1 be good. You know, how much good is it, I don't think any-
2 body could ever answer that. It's just one of the variables.

3 BY: MR. PARR

4 Thank you.

5 BY: MR. SMEDLEY

6 To get the maximum recovery of oil though, that's what we're
7 after. In this type of mechanism where the gas/oil contact
8 is advancing, you will ultimately need your perforations as
9 low as you can in the reservoir. That's how you maximize
10 recovery.

11 BY: MR. ROGERS

12 So, if I understand it right, coning would decrease recovery
13 because your pressure would drop faster.

14 BY: MR. NORGAARD

15 Not really, because all the gas that you take out goes back
16 into the gas cap so really it has no impact at all on pressure
17 other than the fuel that you would consume to compress the
18 gas to put it back in the ground.

19 BY: MR. ROGERS

20 So there would be some loss and is the reason -- do you think
21 the reason that you had no coning is because you've got more
22 wells producing?

23 BY: MR. SMEDLEY

24 It's because we perforated the wells like this. By perforating
25 the wells like this, we ended up with less initial producing

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1 capacity than had we perforated the pipe all the way. That
2 in turn resulted in more wells. So it's really a combination.
3 The well rates are lower per well because of the perforated
4 policy and also coning has less of a tendency because you've
5 increased the distance from the perforations to the contact -
6 so both facts.

7 BY: MR. ROGERS

8 And whose decision was it to have more wells, was that the
9 producers or the commission?

10 BY: MR. SMEDLEY

11 That was our decision but it was a program prior to produc-
12 tion startup was discussed with the Oil and Gas Conservation
13 Commission and they endorsed it.

14 BY: MR. NORGAARD

15 I think both really had a role to play in that decision.

16 BY: MR. ROGERS

17 How about the eastern wells, ARCO, ones that were shut down,
18 was that your decision or

19 BY: MR. NORGAARD

20 Yes.

21 BY: MR. CHATTERTON

22 Well, before they leave I've got a couple of general questions
23 here, Brian if I may. One, is -- you followed the display
24 of the rather sensational pressure sink and it was very
25 sensational because we didn't have a third dimension to the

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1 drawing and you explained that, but you followed it
2 immediately with coning -- and so, that did not result
3 from coning because you didn't even have any free gas over
4 that area because of the (indisc.--cough), is that correct?

5 BY: MR. DAVIES

6 Ah.. that did not result in coning because in that particular
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1 area we have shales between the perforated intervals and the
2 gas cap, and so in that situation you don't see coning as a
3 result of the shale blocks -- you put a shale in here then
4 the original gas cap does not see the pressure drop caused
5 by production through the perforations. Thus, the cone
6 does not form.

7 BY: MR. MILES

8 The cone doesn't -- doesn't perforate or doesn't go through
9 a shale.

10 BY: MR. DAVIES

11 No, because the shale blocks the transmission of that
12 pressure drop up to the gas cap.

13 BY: MR. MCKINNON

14 What is the phenomena then that results in the lowering of
15 pressure and all the gas come in the

16 BY: MR. DAVIES

17 What the phenomena there is that, we should have a diagram,
18 basically, we have -- let's say the gas/oil contact is here,
19 like this, and you have a well producing down here and as
20 the pressure comes down, the gas tends to underride the
21 shale and come down underneath its (indisc.).

22 BY: MR. SMEDLEY

23 Maybe even more simply, if we -- and we have done this on
24 some wells, had an impermeable shale here and impermeable
25 shale here and chose to perforate in between, which we

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