

ALASKA LEGISLATURE SPECIAL COMMITTEE / SUBJECT FILES 86/2

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1 frequently did, particularly in the Eastern area, not knowing
2 whether this shale would be continuous or not, because you
3 have to watch the pressure area and gas/oil ratio behavior
4 really to decide. Since we perforated right between
5 two continuous shales there's no way that the -- that you
6 can get gas cap pressure support or pressure support from
7 the rest of the oil column, or in your aquifer, if you have
8 an aquifer below, it's isolated. There's no means of pressure
9 support other than just the limited amount of oil that's
10 exposed to the perforation. Then you get rapid
11 pressure drop, and that's what we saw, that's basically the
12 way we are over there in that Eastern area. And we're -- you
13 know -- we're taking steps like where we've proven that the
14 shale is very continuous, it's obvious that we'll have to add a
15 set of perforations on top of it, for instance, to expose it.

16 BY: MR. DAVIES

17 Let me answer the question of the..ah.. the movement of the
18 fluid contacts. As I mentioned previously, the neutron tool
19 has been proven to be a highly effective method for monitor-
20 ing changes in gas saturation in the reservoir. And based
21 upon the results of these surveys, we interpret that the
22 overall movement of the gas/oil contact is of the order of
23 15-20 feet per year, on average. This is certainly very
24 close to what was predicted prior to production, for the
25 oil offtakes we have maintained to date. We have also

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1 observed gradual rises in water/oil ratios in a number of
2 wells over the last two years. When we match the individual
3 well performance with our reservoir models, the results suggest
4 that the heavy oil-tar zone, which is often present just
5 above the oil/water contact, does not present a barrier to
6 water influx. And, this is consistent with our predictions
7 prior to coming on production. To date the monitoring of
8 the oil/water contact with the logging techniques available
9 has indicated very little overall movement of the contact,
10 which is also in agreement with the previous predictions.

11 BY: MR. MCKINNON

12 A while earlier somebody had made the comment that it was
13 primarily a gas cap and dissolved, correct? Your
14 saying that there is no problem with the water..ah..is there
15 any water drive involved at all?

16 BY: MR. DAVIES

17 Well, its early days..ah.. but, to date, we've not seen
18 very much movement of the oil/water contact (indisc)
19 Which is -- you know -- what we kind of..ah..predicted
20 previously.

21 BY: MR. MCKINNON

22 Oh, alright, I confused what you were saying.

23 BY: MR. DAVIES

24 In summary I would just like to emphasize the following
25 points. A very extensive data gather program has been

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1 undertaken during the first two years of production and this
2 data gathering program is continuing, in order to ensure
3 adequate surveillance of reservoir performance at Prudhoe
4 Bay Field. The data that we generated by this program is
5 largely consistent with our pre-production predictions, and
6 there have been remarkably few surprises to date. In over-
7 all terms the field is performing quite well. The next
8 speaker, Mr. Larry Smedley of Exxon will provide some more
9 details of the comparisons between our predicted reservoir
10 behavior and those that we have observed in the field to date.

11 BY: MR. SMEDLEY

12 Mr. Chairman, Members of the Committee, my name, as Brian
13 indicated, is Larry Smedley. I have been employed by Exxon
14 Company, U.S.A. since receiving my engineering degree at the
15 University of Missouri at Rolla in 1966. And I have spend most
16 of the past 13 years involved in various aspects of petro-
17 leum reservoir engineering. I first became involved in
18 Prudhoe Bay reservoir studies in 1970 and I have spent some
19 six years either studying or supervising others' study of
20 this field. My current position is Division Reservoir
21 Engineer for Exxon's Western Production Division. Each of
22 the major owners of Prudhoe Bay carry out comprehensive
23 reservoir management studies independently on an almost con-
24 tinuous basis. These independent analyses, followed by
25 exchange and comparison of results, provide us added insights

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1 to reservoir behavior. While the study results are not
2 identical, they are similar and have let us to the same
3 general conclusions regarding the proper operating plan for
4 Prudhoe Bay. Now, each company presented their independent
5 studies at the Oil and Gas Conservation Committee hearing in
6 May of 1977 and that testimony is a matter of public record.
7 So, in the interest of time, today I will present only the
8 Exxon study results. I may have a little bit of trouble
9 with these view graphs, this first one, you can see they've
10 put a lot of green backing on these things and they're a
11 little bit dark, but I hope you can follow them. The first
12 figure summarizes the areas that I plan to cover. I will
13 briefly review the reservoir description, highlighting the
14 oil zone rock properties and major shale complexes used in
15 our reservoir model studies. The description of the reser-
16 voir is the key to accurate performance predictions, and I
17 will show that the Prudhoe Bay description has not changed
18 much from our pre-production estimates. And next, I will
19 compare the observed pressure and production history to
20 predictions made by our three-dimensional reservoir model.
21 Now, this model was constructed in 1976, prior to production
22 start-up and was mentioned and discussed at the May, '77
23 Pool Rules Hearing. You'll see that when we review this that
24 performance to date in the field has been encouragingly
25 similar to this early model study result. Finally, I will

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1 review the reservoir study results which then led to the
2 Prudhoe Bay operating plan, I'll highlight various develop-
3 ment options that we studied, such as well spacing, arti-
4 ficial lift, waterflooding, and so forth. And, I'll also
5 review sensitivity studies which describe the impact of oil
6 and gas offtakes and the time of water injection on the
7 ultimate oil recovery.

8 BY: MR. MILES

9 Larry, I'm going to ask the same question I asked Paul, are
10 those -- are your 3-D models, that you said - from '76, are
11 those public record?

12 BY: MR. SMEDLEY

13 The 3-D model was discussed at the Pool Rules Hearing, as
14 you will hear later. The results that we used for the
15 sensitivity studies were based on -- well, it's really what
16 we call a three-dimensional cross-section, it's a cross-
17 sectional type model, it's not what you would think of as a
18 full three-dimensional model of the field, I think I can
19 explain this maybe a little bit better in the context of the
20 total testimony. Those model results and the ones I'll
21 present today are a matter of record, of public record, they
22 were included in our testimony at the May '77 hearing, May,
23 1977 hearing.

24 BY: MR. MILES

25 Are they laid out like the ones from -- vanPoolen is the

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1 only thing we have to compare it by and you guys can dazzle
2 us with terminology, are the same -- you know --....

3 BY: MR. SMEDLEY

4 Yes, Mr. Chairman, they are -- we looked at the basic
5 same variations, the same variables..ah..we also presented
6 some results where we varied the reservoir description in
7 areas that you're uncertain as to what the description might
8 be, like shales for instance, and that's one of the things
9 we varied, one of the techniques used in the trade is to
10 analyze the impact with and without those shales. I'll
11 assume it's continuous, I'll assume it's discontinuous --
12 you know -- what's the impact on the operating plan. So, I think,
13 the major addition that we had to the studies that vanPoolen
14 did is we also did show some results that looked at reservoir
15 property sensitivities.

16 BY: MR. MILES

17 Okay, can you send me those?

18 BY: MR. SMEDLEY

19 Yes.

20 BY: MR. MILES

21 Okay.

22 BY: MR. SMEDLEY

23 Okay, this next figure is a well log, and it's going to be
24 equally hard to see I think, but it's got a lot on it that
25 ..ah..we presented it at the hearing, it shows the geologic

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1 zonation of the reservoir, the gamma-ray and sonic log
2 responses that we get from logging through the reservoir, and
3 it shows the location of major, correlatable shale complexes
4 in the Sadlerochit sandstone interval. Also shown, on the
5 right-hand side of the chart, are the average rock properties
6 such as thickness, porosity, horizontal permeability, net
7 sand to gross thickness ratio, and vertical to horizontal
8 permeability ratio. Now I want to emphasize that this same
9 figure, although you could read it a little better than, was
10 presented at the May '77 hearing and is included in the
11 public record of that hearing. And, I've included it here,
12 though it's a rather technical figure, I wanted to include it
13 here really for two reasons. First, the average rock
14 properties, which are shown -- it's hard to read, but
15 for instance the permeability of the various lithologies in
16 the Sadlerochit or the different zones of the Sadlerochit --
17 you know -- range from about 240 millidarcys in the lower
18 most zone up to in excess of 900 millidarcys, almost a
19 darcy (ph) in the most permeable zone. These are properties --
20 while I'm not going to try to explain to you exactly what
21 they mean, they are properties that indicate
22 the Sadlerochit reservoir has very good qualities. These are
23 good qualities relative to other reservoirs, they're not the
24 best, but they're good properties. And it is these favorable
25 properties, rock properties that are shown here, in combination

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1 with the thick oil column and a large overlying gas cap that
2 lead to -- the good natural depletion recovery that we are
3 predicting at Prudhoe Bay. The second, and perhaps more
4 important reason that I have included this figure for you
5 here today, is to point out that the description that we
6 provided the Oil and Gas Conservation Commission over two
7 years ago is still valid. We have obtained enormous quanti-
8 ties of additional information, as Brian described, from
9 drilling, logging, coring, and running pressure buildup tests
10 and so forth, since start-up. The new data confirms these
11 pre-production estimates. Now, several newspaper articles
12 have suggested recently that a "shale problem" has been
13 discovered at Prudhoe Bay, and there's been some discussion
14 of that here at this hearing. The major shale complexes that
15 are identified on this log were mapped and included in our
16 reservoir model studies long before the start of production.
17 We provided the Oil and Gas Conservation Commission maps of
18 these shale complexes in 1976. And at that time, we described
19 a technique that we used to evaluate the impact of the many,
20 minor, non-correlatible shales, and you can see on the log
21 the indentations, the small indentations that are similar in
22 direction to the major shale indentation are minor non-
23 correlatible shales that don't go from well to well, but they
24 do have an impact on vertical permeability, and so we consider
25 their impact on vertical permeability. While continued

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1 drilling and production data has resulted in some revisions
2 to the anticipated extent of the major correlatible shales,
3 the changes that we have seen have been toward less shale
4 continuity rather than more as has been suggested in the
5 newspapers and suggested here today. This next figure is an
6 example of that. The Main Sadlerochit Reservoir productive
7 limit is shown by the dashed line. The shaded area shows the
8 aerial extent of the uppermost correlatible shale within the
9 oil column of the Sadlerochit, based on our pre-production
10 interpretation, the 1976 interpretation. While the cross-
11 hatched area shows the current interpretation of the extent
12 of this shale. In general, you can see that the shale is now
13 believed to be much less continuous over most of the reservoir
14 than we previously thought. The decreased shale continuity
15 should increase the efficiency of the natural recovery process
16 which has been discussed predominantly gravity drainage. You'll
17 notice that both interpretations show that the shale is
18 quite continuous in the extreme eastern portion of the reser-
19 voir where two similar shale complexes have served to isolate
20 portions of the oil column from gas cap pressure support,
21 similar to what we described awhile ago between -- with the
22 perforations between the two shales. Consequently, greater
23 than average pressure declines and increasing gas/oil ratios
24 have been observed in this small area. I want to emphasize
25 that this performance was expected because we have included

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1 the effect of these shales in our model studies for many
2 years. It's through monitoring actual performance and model-
3 ing performance in terms of pressure behavior and gas/oil
4 ratio behavior that we confirm the extent and the continuity
5 of shales such as this. They are mapped -- these shales
6 have primarily been mapped based on well information, you
7 notice the indentations on the log where the shales exist,
8 and through that and through geologic depositional studies,
9 studies of the history of what was going on when the sand
10 was deposited, that and well data is what's used to develop
11 these maps and we confirm them through observing pressure,
12 production history and modeling. The -- okay -- I think we --
13 as Brian mentioned, we have seen greater than average pressure
14 decline and increasing gas/oil ratios in that eastern area.
15 Okay, and I want -- the next figure I want to go to then is
16 a predict -- is the measured -- it should be -- it's similar
17 plot to the one Brian showed and it's going to be hard for
18 you to read, but..ah..you saw a little more closely awhile
19 ago, it's the measured pressure drawdown from original in
20 the reservoir. The lines, again, represent contours of equal
21 pressure drawdown as measured at the producing wells. As
22 Brian pointed out, the pressure drawdown in the producing
23 intervals is somewhat greater than the average drawdown
24 if you considered the entire thickness of the oil column.
25 Overall, we see that the oil rim is demonstrating excellent

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1 gas cap pressure support. As you can see, the pressure
2 drawdown varies from about a 100 psi in areas of low produc-
3 tion to some 600 psi in this eastern segment of the area --
4 reservoir where the shale complexes restrict gas cap pressure
5 support. Okay, turning then to the next view graph, that --
6 that was a picture of ^{pressure} measure performance, the same picture
7 basically that Brian showed earlier. This is the pressure
8 behavior observed in our 1976 model prediction, the three-
9 dimensional model that we talked about. The simulator has
10 predicted both the shape of the pressure contours and the
11 approximate magnitude of the pressure drawdown. And in fact,
12 where Terry has his pencil now, you can see that the pressure
13 drawdown predicted, at this point in time, maximum, was 700
14 psi, so it's slightly greater. We go from 100 to 700 on the
15 predicted as opposed to 100 to 600 on the measured. The
16 inset on the chart compares the predicted April, 1979
17 average reservoir pressure of 4135 psi to the observed value
18 of 4155 psi, indicating very similar, but somewhat better
19 pressure performance than predicted. You can see these
20 pressures, the original pressures, these are pressures
21 referenced to the original gas/oil contact at a substantive
22 depth of 8578 feet and the original pressure was 4335, so
23 it represents a pressure drawdown to date of a little less
24 than 200 psi. Okay, the next figure compares historical
25 production performance to the model prediction and shows the

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1 predicted performance for the next several years. The oil
2 production history is identical because we produced the
3 model at actual field rates. As you are aware, the TAPS
4 pipeline owners have announce recently that pipeline capacity
5 will be increased to about 1.5 million barrels a day by the
6 end of 1979. Actual and predicted gas production rates are
7 also shown on the chart. As Brian pointed out earlier, the
8 operators have considerable latitude in controlling the amount
9 of gas production at Prudhoe Bay. The model has actually
10 predicted slightly higher gas production rates than actual.
11 The field gas production is currently about 1.1 to 1.2 billion
12 cubic feet per day, which is quite close to predictions. As
13 shown, an increasing trend of gas production is expected in
14 the future. Such performance is normal for an oil field like
15 Prudhoe Bay with a large overlying gas cap. As the oil is
16 withdrawn, the gas cap will expand and override along the
17 top of the reservoir and under major continuous shales,
18 resulting in the increase in gas/oil ratio. The lower curve
19 shows water production which is currently quite low, as
20 expected, and is forecast to gradually increase with time.
21 The upper curve is a plot of actual and predicted average
22 reservoir pressure versus time. And as I mentioned earlier,
23 the measured pressure decline agrees quite well with the
24 predicted. The fact that reservoir pressure has declined
25 only about 200 psi to date supports that the expected

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1 efficient natural depletion process of gas cap expansion and
2 gravity drainage is dominating over most of the reservoir.
3 Indeed, if an inefficient, solution gas drive type mechanism
4 were dominant, as some have suggested, the pressure decline to
5 date would be in the order of 400 psi, or about twice the
6 measured value. Okay, with that comparison of the measured
7 and predicted performance as a backdrop, I would like to --
8 turning to the next figure, I'd like to review the results
9 of the studies which were presented at the Oil and Gas
10 Conservation Committee Hearing, and provided the basis for
11 the current operating plan for the Prudhoe Bay Unit. Testi-
12 mony presented at that hearing indicated that ultimate oil
13 recovery from the Main Area Sadlerochit reservoir would be
14 approximately 40% of the original oil-in-place with full
15 development and planned oil and gas offtake rates.

16 BY: MR. MILES

17 What's full development?

18 BY: MR. SMEDLEY

19 Full development means we drill all the wells and install all
20 the planned facilities and it

21 BY: MR. MILES

22 What are planned facilities?

23 BY: MR. SMEDLEY

24 That's what -- I'm going to talk about some of those as I go
25 down this chart. As we pointed out at the hearing, enormous

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1 future investments would be required to achieve that
2 recovery level. The first area that -- that's very difficult
3 to read, that chart, for sure if you could push it down flat
4 maybe. These are the facilities additions, Mr. Chairman,
5 that are inherent in that. Ah -- completing development
6 drilling on 160-acre spacing rather than 320-acre spacing
7 which was basically what was taking place at the time of the
8 hearing, is projected to increase recovery about 4% of the
9 original oil-in-place. The operators have been proceeding
10 with development drilling, as Brian indicated, they have increased the
11 producing well count from about 100 at start-up to about 200
12 today. However, there are some 300 additional wells which
13 will be required for full development. The drilling and
14 equipping of these wells to produce will cost in the order of
15 \$2 to \$3 billion. Studies are underway now to evaluate the
16 proper development limits and well density for the fields.
17 The second potential facility addition shown is a low pres-
18 sure gathering system to allow reduced wellhead producing
19 pressures. The study indicates an additional recovery
20 potential of about 5% of the original oil-in-place. Total
21 cost for such a system field-wide has been estimated at \$1.5
22 to \$2 billion. Now, the first increment of this facility
23 was recently approved by the Unit Owners and equipment has
24 been ordered for installation at Flow Station 2 in the
25 eastern operating area in 1982. Other increments must be analyzed,

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1 designed and justified. The study indicates additional
2 recovery potential of about 5% for an artificial lift system
3 at Prudhoe Bay. Again, the cost is estimated to be in the
4 order of \$1.5 to \$2 billion, and although this system is at
5 a very early stage of planning, we expect to install such a
6 system when needed to maintain production rates. The studies
7 also show a potential of up to 2% additional recovery by
8 injecting the water that is produced with the oil into
9 portions of the Sadlerochit Reservoir which experienced poor
10 natural depletion recovery. Depending on the final design,
11 this system has been estimated to cost in the order of \$1
12 billion. The Unit Owners recently approved funds for the
13 first increment of produced water injection. Equipment for
14 this system has been ordered and we expect the first increment
15 to be operational in the Eastern Operating Area in 1981. The
16 produced water injection system will be expanded as volumes
17 increase and as production performance allows refinement of
18 the waterflood design. Source water injection systems also
19 offer potential to increase ultimate oil recovery. Exxon's
20 studies indicate the additional recovery may be in the order
21 of 4% of original oil-in-place, as shown on this chart. Sohio,
22 on the other hand, has estimated that the additional recovery
23 from source water injection could be as much as 7% of the
24 original oil-in-place, and both of these figures were
25 presented at the hearing and are a matter of public record.

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1 The cost of the source water injection system has been
2 estimated to be in the order of \$1.5 to \$2 billion. Dave
3 Griffiths, the next speaker will describe studies and tests
4 which will cost in excess of \$40 million which the Unit
5 Owners have been engaged in for the past two years to evaluate
6 and design a water injection system. Estimated recovery
7 without these development additions described would be approxi-
8 mately 20% of original oil-in-place. So, the remaining half
9 of forecast recovery depends upon additional facilities and
10 investments which will cost well over \$10 billion, just to
11 develop the main Sadlerochit Reservoir.

12 BY: MR. ROGERS

13 How many barrels do you get per -- per each percent?

14 BY: MR. SMEDLEY

15 Ah...it's about 200 million, in that order.

16 BY: MR. ROGERS

17 Thank you.

18 BY: MR. SMEDLEY

19 This future investment of in excess of \$10 billion compares
20 to less than \$4 billion that's been spent on the field
21 development today. These are enormous future investments
22 which must be justified and facilities designed based on
23 field performance data, detailed studies, and economic
24 factors. As I have indicated, the Unit Owners are already
25 proceeding with several of these projects and others are

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Owners need to decide soon on a major water injection program. As you can see from this chart, water injection is but one of the many development activities that we plan for Prudhoe Bay Units. Indeed, others may have a more significant impact on ultimate oil recovery. We are moving forward in a prudent manner on all of these projects.

BY: MR. MILES

Larry, the last chart caused me a little bit of concern. I thought — when we began...ah...we began this in the late 60's and early 70's, we were assuming a roughly 45 -- 40% recovery, but was it known that this extra investment was going to be needed to get to the 40%? I'm really....

BY: MR. SMEDLEY

Yes it was and it was discussed that each of these things would have to be considered and analyzed independently that that in the context of the overall plan as we envisioned it developing for the unit these measures would be carried out and that recovery would be attained.

BY: MR. NOIRGAARD

Let me change a word. We knew and were planned and prepared for the facilities. You said investment, I don't think at the time we worked this problem we knew what the investment would be. Only time and inflation and a few other things give us the key to

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1 what the investment....
2 BY: MR. MILES
3 there was never a dollar figure put on it?
4 BY: MR. NORGAARD
5 Yes, we had dollar figures but they were terribly, erroneously
6 wrong.
7 BY: MR. MILES
8 Until when?
9 BY: MR. NORGAARD
10 They were low, like everything we did.
11 BY: MR. MILES
12 How much low.
13 BY: MR. NORGAARD
14 I'm sorry I really -- I really can't....
15 BY: MR. MILES
16 You know -- we're talking about roughly, Larry said 10 billion,
17 how much were we talking about then?
18 BY: MR. NORGAARD
19 I would speculate that they were probably half, our estimates
20 were probably half, at that point in time. Well, they've
21 changed....
22 BY: MR. MILES
23 What was that point in time, when was it.
24 BY: MR. NORGAARD
25 Let's say four or five years ago.

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1 BY: MR. ROGERS

2 And revenues were about one-quarter?

3 BY: MR. NORGAARD

4 Things have changed dramatically all the way around.

5 BY: MR. ROGERS

6 You mentioned both on the well spacing and produced water..

7 ah..east -- the east operating -- are you -- do I get from

8 that you're going to be using as additional recovery earlier

9 in the eastern section?

10 BY: MR. SMEDLEY

11 The -- it's planned that the produced water injection will go

12 in early -- one year earlier, as we currently envision it in

13 the eastern section and the west.

14 BY: MR. ROGERS

15 Is there any -- since this May, 1977, are there any new

16 technologies that might push us beyond the..ah..40% recovery?

17 BY: MR. SMEDLEY

18 Not new technologies, I don't think, but....

19 BY: MR. ROGERS

20 Are there new -- ones that have become economic because of

21 the higher value of oil.

22 BY: MR. SMEDLEY

23 No, sir ..ah..you're thinking in terms of like a tertiary

24 recovery process or something like this I assume, and no,

25 there are none currently.

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1 BY: MR. NORGAARD

2 I think the answer to that may be expanded a little bit. I
3 think, that's a continually changing target as people learn
4 more from other areas and also as the economic environ-
5 ment of the world changes, but there's one thing for sure,
6 that Prudhoe was not the place to experiment. It's a high
7 cost area and experimenting should be done in something that's
8 relatively safe and (indisc) so we look very heavily to other
9 similar environments to -- to see what's happening and to
10 (indisc - simultaneous speech)

11 BY: MR. ROGERS

12 Sub-surface environments, what areas of the world are similar?

13 BY: MR. NORGAARD

14 Well, there are a number of reservoirs that are not dissimilar
15 from Prudhoe Bay -- I went for many years, it's probably too
16 late to try anything with it, but there are a number of
17 reservoirs that you can use as, certainly not parallels, but
18 it's something that you could use as a go by. I don't think
19 that there's another Prudhoe Bay in the world, but there's
20 reservoirs with character in (indisc). Larry mentioned that
21 high quality characters in Prudhoe Bay, there's other reser-
22 voirs in the world that same, a similar high quality
23 (indisc)

24 BY: MR. ROGERS

25 Sir, when did you do your first preview runs? When did you

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1 build your model?

2 BY: MR. NORGAARD

3 We built the model in 1976 and ran it in 1976.

4 BY: MR. PARR

5 I realize that every field is unique, I understand that, but
6 isn't there sort of a general rule of thumb around the world
7 that 35 to 40% of your -- 35 to 40% of your reservoir is
8 recoverable? Generally, speaking?

9 BY: MR. SMEDLEY

10 No sir, that's how I -- for an overall average.

11 BY: MR. PARR

12 I - we've been lead to believe that in previous testimony
13 that -- not necessarily this particular set of hearings, but
14 one we've had in the past. Now, I'm just wondering when I
15 see that 20% on there..ah..did the -- your operators -- your
16 Owner companies ever consider any possibility of only getting
17 20% and stopping?

18 BY: MR. SMEDLEY

19 Yes sir. We have since the very early studies, very early,
20 that's -- I mean, since our studies in the early 1970's where
21 we started getting pretty sophisticated with reservoir modeling
22 and interestingly those days have not changed too dramatically
23 even up to now, since that point in time when I've been involved
24 in this type of work on this field..ah.. the plans for
25 development, the types of things you see..ah..facility

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1 additions and so forth have been contemplated. We never
2 really ever expected to stop development when we had only
3 320 acre spacing since the -- that was -- you drill 320 acre
4 wells before you drill 160 acre wells, just like you would
5 drill 160 acre wells before you drill 80 acre wells. So, at
6 some point in time we had those kinds of wells, but it was
7 never envisioned that we would stop.

8 BY: MR. PARR

9 Let me ask my question in another way -- en. The impression
10 you gave in going through this chart is that you're going to
11 start off with 20% recoverable and then at each one of these
12 additional capabilities the Owner companies are going to
13 look at this on say a cost benefits ratio, bases or something
14 of that sort, and decide -- you know -- whether it is economi-
15 cally feasible for the company to do it, and so you might get
16 20, you might decide that only the first 160 acre wells is the
17 one you'll do and stop at 24, or you got down through that one
18 and then you decided it wasn't economically feasible so you
19 might stop at the second item which is 29% and so forth.

20 But, I'm getting -- now, I'm understanding that that never was
21 contemplated and is not now contemplated, is that correct?

22 BY: MR. SMEDLEY

23 It was -- the studies were sophisticated enough that -- it was
24 anticipated that we would be able to go to this type of
25 development. In terms of presenting our estimate of recovery

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1 we pointed out that there are alternate development schemes
2 possible, several of which may go after the same oil. In
3 other words, there are different ways to get there. This is
4 one, I don't like scenario, but that's one scenario for
5 getting to 40% recovery. There are others, perhaps involving
6 closer well spacing, 80 acre spacing, this type of thing, and
7 as we mentioned at the Pool Rules Hearing, based on a wide
8 variety of studies where we have varied the reservoir descrip-
9 tions, would Prudhoe reservoir look like this or will it look
10 like this. We could see that 40% recovery appeared to be
11 reasonably achievable under varying reservoir descriptions, but
12 the way to get there, the best way to get there, was different
13 with different descriptions, and so, we gave the 40% recovery
14 as our best estimate. We left some flexibility in the steps
15 we take to get there and we'll take the optimum steps as we
16 learn more and more about the reservoir.

17 BY: MR. PARR

18 In other words then, it may not really cost the \$10 billion
19 to get that 40%? You might take some other steps which don't
20 cost that much money, is that correct? You got \$10 million,
21 this isn't that short that you told us, but you just said
22 that there are other possible ways to do it.

23 BY: MR. SMEDLEY

24 That's right. It is conceivable, and on the other hand it's
25 also conceivable it may cost way more than \$10 billion.

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1 BY: MR. PARR

2 Let me -- in other words, if you don't use the systems, the
3 steps shown here, if you use other ones that may not even cost
4 you the \$10 billion.

5 BY: MR. NORGAARD

6 Let me offer an comment here if I may, I don't like to inter-
7 ject myself, but I think that as far back as we go in the
8 direct testimony before Conservation Committee, yourselves,
9 federal government and whatnot, the plan for the field has
10 always been to fully develop the field, and when we say fully
11 develop the field, that means doing essentially all of those
12 things, include waterflooding. That has been the plan and
13 it -- you probably -- the May, '77 hearing, we said that we
14 were proceeding along that plan, we just needed some produc-
15 tion history to verifying certain things that we had specu-
16 lated and therefore we have always planned on doing all of
17 this. The exact timing and the exact sequence, that's some-
18 thing we will learn as we go, but the plan has always been to
19 do all of that, we have always looked for 40% recovery and
20 this is just one way of isolating and saying this is what
21 each of these contributes. It's almost an academic exercise
22 in a certainty.

23 BY: MR. PARR

24 Thank you, that's the kind of answer I wanted.

25 BY: MR. MILES

When -- Paul, as long as you're

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1 in this discussion, when do you plan to begin waterflooding?
2 BY: MR. NORGAARD
3 Well, the -- thing you deal with is what does waterflooding
4 mean and when we begin to inject water -- no, when we plan
5 to begin injecting water into the producing formation will be
6 in 1981 and it will be in the Flow Station 2 area, the area
7 where we have seen the greatest pressure, highest continuity
8 in shales, therefore the most obvious and logical place to
9 start waterflooding.

10 BY: MR. MILES
11 That's just a - that's just a little trickle in comparison.
12 I mean, that's just a -- what Dr. vanpoolen said, the
13 goop that comes up, goes back down to 100 thousand barrels
14 (indisc. - simultaneous speech)

15 BY: MR. NORGAARD
16 And it could be when we get there, sir, we will choose to
17 augment that in some fashion. We're looking at that and we'll
18 continue to look at that. When we would be looking at going
19 to a major outside source

20 BY: MR. MILES
21 Yea, that's what I'm

22 BY: MR. NORGAARD
23 the earliest possible would be in '84, and Dave Griffiths
24 will give you a lot of detail on that in just a minute, but
25 the timing that you ask, would be the earliest possible is

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1 '84 and that's certainly our objective, unless something
2 trips us up very badly between now and then.

3 BY: MR. MILES

4 Thank you, that's the objective, but.....

5 BY: MR. NORGAARD

6 There's no way that we see we can get there before '84.

7 BY: MR. MILES

8 What might trip you up?

9 BY: MR. NORGAARD

10 A permit application, just physical constraints, and
11 material delivery times. The -- some very, very strange
12 reservoir interpretations between now and then. We've done a
13 lot of work, but we still have a lot to do, i.e., history
14 matching and carrying forward that..... Those are the three
15 main areas and Dave Griffiths will speak to each of those
16 in some detail.

17 BY: MR. MILES

18 It's costs -- costs are not a main factor.

19 BY: MR. NORGAARD

20 I'd have to say I don't believe right now -- I'd have to
21 look at it again, but I don't believe right now that the
22 cost or who -- how it's financed is material at all. We
23 really are worrying the permit problem -- the design problem
24 and materials and then finally the reservoir analysis problems.
25 And I think in each of those, we are targeting ourselves so that

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1 they coincide, we hope, about a year from now, we'll consider
2 it a year from now, and at that point in time everything will
3 fit and we'll move forward.

4 BY: MR. MILES

5 Thank you very much.

6 BY: MR. NORGAARD

7 But, Dave will elaborate on that point.

8 BY: MR. CHATTERTON

9 Yea, I'd like to go to Larry for a minute, if I can. In your
10 1977 presentation in May, I've always had a little bit of
11 a problem with these two charts because you also testified
12 that that primary recovery while you were anticipating about
13 36% recovery, yet you got 20 down there. I think you were
14 trying to sell well spacing with that one, and you were trying
15 to sell that you were going to recover a lot of oil with the other
16 guy that testified. I've never been able to correlate the --
17 this chart with your other statement, not yours personally,
18 but other statements made by the operators, that the primary
19 recovery is going to be 36%, waterflooding ultimate recovery
20 is going to be 4% -- 40% and of course, obviously, the 4%
21 differential is not any great, horrendous incentive to proceed
22 to that point, but I've never been able to figure where you get the 20.

23 BY: MR. SMEDLEY

24 Okay, let me try it, one more shot at this thing. Ah..the
25 reason for this chart is to show several things that are

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1 reasonably similar decisions that have to be made, that are
2 being made, but in a logical course, to get from where we are
3 right now which is with adequate facilities and wells and so
4 forth, to get about 20% of the oil-in-place out to where we
5 think we will end up and that is with wells and facilities
6 and so forth to get 40% of the oil-in-place. So, it's --
7 really its primary intent is to say it -- waterflooding is
8 one of the decisions we have to make, in terms of money
9 the inference is that we're not willing to make that decision
10 because it's a large capital investment. These other items
11 are equally large capital investments.

12 BY: MR. CHATTERTON

13 How do you get from 20% to the 40%, what else can you do there?

14 BY: MR. KOONZ

15 This is primary recovery here.

16 BY: MR. CHATTERTON

17 I understand, and if you say it's 36% in your testimony
18 (indisc.- simultaneous speech)

19 This one always just confused the hell out of me.

20 BY: MR. NORGAARD

21 I don't -- you're alone in that. I think the main thrust here is
22 that the 20% is not a primary number. The 20% is a primary
23 number under a given set of assumptions and that assumption
24 is that we don't do anything more in Prudhoe Bay.

25 BY: MR. CHATTERTON

....The oil in 1977, I think....

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1 BY: MR. NOORGAARD

2 what, no, if we don't do anything more in Prudhoe Bay,
3 that right now we quit. Matter of fact, that was in 1977
4 that we quit. and that's an unrealistic assumption. We all
5 know that's unrealistic and therefore, this was an attempt
6 to say there are other options or there are several require-
7 ments to get the primary recovery out and this is a listing
8 of them and what we suspect will be recovered with each one
9 of these. Now, there's another point here that those numbers
10 the fours and fives and whatnot, are certainly not rigorous
11 because when you do all of those things they're interrelated
12 and you can't say which barrel of oil was recovered from
13 which one of those phenomena. That is just a guide in how
14 much oil each of these will deliver to the tanks. Now, did
15 that help?

16 BY: MR. CHATTERTON

17 That helps. I think the point that you've made is the impor-
18 tant point, that that 20% was your estimate of the recovery
19 from Prudhoe Bay in May, 1977 if you walked away and did
20 nothing more.

21 BY: MR. NORGAAARD

22 We did no more, put no more money into it.

23 BY: MR. CHATTERTON

24 but with continued development drilling, continued with
25 waterflooding, continued with this and everything as you are,

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1 you could get to 40%, if, with waterflooding. Without water-
2 flooding you would only get the 36% and your testimony, if
3 you correlate it in that fashion fits, but your explanation
4 did not.

5 BY: MR. SMEDLEY

6 The way I would have walked down through that is to say,
7 alright, we were at 20% recovery by drilling the additional
8 wells, get down to 160 acre wells which is some 500 in the
9 field, we will get up to 20+4, 24, if we -- by adding a little
10 pressure gathering system, we get up another five to
11 29. By adding an artificial lift system we add another five
12 we get up to 34, that's the natural depletion recovery with-
13 out produced water returned to the reservoir. If we return the
14 produced water to the reservoir we get another two, that's
15 the 36 (indisc - simultaneous speech)

16 BY: MR. CHATTERTON

17 There you are, okay.

18 BY: MR. MILES

19 I told you Chatterton was the only one who grasped this.

20 BY: MR. MILES

21 But he asks leading answers.

22 BY: DR. DOSCHER

23 Mr. Miles, may I ask one clarifying question? You didn't mean
24 that you'd walk away in 1977, you meant completed at 320
25 acres, didn't you.

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1 BY: MR. SMEDLEY

2 Yes, that would be with some 200 and some odd wells for 320

3 (indisc - simultaneous speech)

4 BY: DR. DOSCHER

5 Fine, it didn't mean that -- it didn't mean to stop cold
6 in 1977.

7 BY: MR. SMEDLEY

8 That's right. It was 320 acre development, if you stopped at
9 320 acre development.

10 BY: MR. ROGERS

11 Since, since a number of these methods are pretty high cost,
12 and you're talking about \$2 billion each on the average and
13 some of them, I don't know which ones, waterflooding apparently
14 is time sensitive, the earlier the better, and I don't know --
15 I don't know about the others. And, is the -- since the
16 recovery comes later on, it's not going to be a early re-
17 covery, obviously, your cost is higher, your internal cost
18 is higher if you do it sooner than if you -- you hold off for
19 a year even though the recovery might be higher if you did
20 it sooner. I guess -- since the State's discount rate is
21 probably lower than the industry, if the State were to offer
22 to participate in the financing would that speed up any of
23 the..ah..any of the secondary recovery techniques.

24 BY: MR. NORGAARD

25 I think the answer to that is basically that we are on a

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1 critical path right now. Ah..with '84 as being the earliest
2 possible start-up to take things in a logical sequence and
3 we would have to look at it closer than what we have right
4 now, but the general answer was no it would not speed it up.

5 BY: MR. ROGERS

6 So, you're saying then that the financial aspects are not
7 the limiting things on..ah..I'd say waterflooding, it would
8 be equipment or materials.

9 BY: MR. NORGAARD

10 That would be the case at this point in time, yes, as we
11 perceive it right now. Come 1980 though, the answer might
12 be a little different, if something strains, if the purely
13 unforeseen happens between now and then. We don't visualize --
14 we don't envision that the plans for water injection, we
15 fully expect to moving forward in 1980.

16 BY: MR. McKINNON

17 Can I ask four questions, if I may. When you do your economic
18 analysis, cost benefit, what discount rate do you use for the
19 industry?

20 BY: MR. NORGAARD

21 That's -- that's really an impossible question to answer in
22 many (indisc.) because first of all there's three companies
23 involved and therefore, there's probably three different
24 considerations, but certainly industry in general, and I
25 believe that they have testified, several of our companies,

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1 have testified a number of times in a number of places, we
2 do look at discount rates, we are looking at discount rates,
3 they're basically industry averages, if you will, which is
4 really not just oil industry but total domestic industry --
5 you know, all industry, automobiles, everything else and that
6 is influenced, of course, by the value of money, what it costs
7 to borrow and so it varies depending on which year you're
8 talking about and I believe, that this particular point in
9 time, it's somewhere 13, 14, 12 somewhere like that, is the
10 kind of numbers that industry is looking at..ah.. in
11 generating good prospects in moving forward. I really don't
12 know what the prime rate is right now, but I think it's over
13 12. It varies, and I don't think that there's a pat answer to
14 that question.

15 BY: MR. MCKINNON

16 Your economic analysis doesn't use an average for the industry,
17 it uses an average -- an average for the oil industry, you
18 use an average for industry in general.

19 BY: MR. NORGAARD

20 Again, I think the economic analysis each company has its
21 own, but in general, for -- they would be reflected.

22 BY: MR. MCKINNON

23 What is your companies....

24 BY: MR. NORGAARD

25 To be very honest, I can't give you answer on that right now

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1 because again it's a changing thing and I really don't know
2 what it is. That isn't the only criteria, that isn't the
3 only parameter that goes into the decision making property
4 and I'm not in a level in our company where I can give you
5 all the answers because I really don't know. But certainly,
6 I'm going to step - take a step further than you questioned,
7 if I may, and it goes into what -- at I and I think, we as
8 oil companies perceive them in Prudhoe Bay field. Ah..several
9 questions have come forward here with respect to the rate of
10 return and the difference the State has versus what industry
11 has in their rate of return criteria and there can be instances
12 and there probably have been and will be instances where that
13 does create differences, different desires, different objec-
14 tives and different opinions. I would be naïve not to say
15 that that is true. I think in the Prudhoe Bay Field, though,
16 we happen to be very fortunate, in that the reservoir is a
17 high quality reservoir. The work -- at least I heard from
18 Dr. vanPoolen and Dr. Doscher also mentioned, the work that
19 we have seen suggests that the decision process and the
20 decision timing that we're going through on this, is not
21 sensitive to these discount factors. It appears as the
22 reservoirs are -- sufficient quality, the decision appears to
23 be, like it will be clear enough so we won't get into differ-
24 ence of opinion or conflict because of the discount rate.
25 Now, I can't guarantee that, but that's certainly what I

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1 heard from Dr. vanPoolen and I believe from Dr. Doscher,
2 and tied to our own studies we're talking about at this
3 point in time. Our plans are to waterflood it as early as --
4 we physically can do that. I think that is consistent with
5 everything I heard and now I can't guarantee that's what is
6 going to happen because a ducks could fall on the road
7 between now and 1984, but that certainly is what we expect.

8 BY: MR. McKINNON

9 At what point -- is...ah..what point does waterflooding
10 become economically unfeasible, in some point it's just not
11 worth doing?

12 BY: MR. NORGAARD

13 You know -- again, I'll answer it. It's a technical question
14 but I'll answer it because I really think it has overtones
15 in it. If you can predict to me what the world is going to
16 be in 1990, I might be able to answer your question. I don't
17 think that there is a point in time when one can say. It's
18 uneconomic to waterflood a reservoir or a facility because
19 it's tied so much to what it's going to cost, in what the value of
20 the product your going to get and therefore, I don't think
21 we can sit here today and..ah..make a realistic prediction.
22 I think we can say though, and I believe it will be said
23 later on, that in the realistic environment waterflooding
24 within any time frame that we could realistically accomplish
25 it or that we would consider, has simply no impact on the

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1 Prudhoe Bay performance and I believe that's what you're
2 looking for in your question. In other words, whether it's
3 in '84, or '86, or '87, it realistically has no impact on
4 Prudhoe Bay on the recovery from the field, that we've been
5 able to see, and if I understand -- I mean, if what's been
6 done in that's true of what other things?

7 By; MR. McKINNON

8 If you start water injection in 1984 it's going to get you an
9 extra billion -- billion barrels.

10 BY: MR. NORGAAR

11 pick a number...

12 BY: MR. McKINNON

13 you start at 1985, it's not going to get you a billion
14 barrels.

15 BY: MR. NORGAARD

16 Well, you've gone outside, I believe, the realistic range

17 BY: MR. McKINNON

18 that's what I'm trying to understand, what the range is.

19 BY: MR. SMEDLEY

20 There were study results presented at the hearing, I know we
21 varied the timing of water injection, as I remember, we're
22 going into these in just a second from..ah..five to nine
23 years, so that would be , like, it'd be in '86. Other
24 companies, I think ARCO presented a study where they delayed
25 the start for like fifteen years. At nine years there is

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1 essentially no -- we got essentially the same benefits from
2 water injection that we got with earlier cases, at fifteen
3 years it was a little less but I don't remember exactly how
4 much less, but it wasn't a great deal less, but it was -- in
5 both cases -- alright, if you wait, one of the things that
6 will happen -- you know -- water injection offers really two
7 benefits as we see it, it's a rate maintenance benefit by --
8 you can maintain the production plateau, whatever that
9 production plateau, 1.5 million barrels a day, we're talking
10 about longer -- it offers some benefits in that regard and
11 also offers some additional recovery benefits, I think we've
12 talked about. If you wait past the point that it -- produc-
13 tion plateau has already dropped off, you've gone in decline
14 portion, then -- and this is the way in previous times,
15 waterfloods were typically implemented. You see a production
16 response, production goes from low to higher..ah..so that's one
17 of the differences that you see with a delayed one is
18 you actually show an increase in production, whereas, if you
19 start before the end of the plateau period it's an extension
20 of the plateau. But the impact on ultimate recovery has been
21 shown to not be very sensitive to timing of the start. Its
22 much more sensitive studies indicate to where the water is
23 injected to getting the most efficiency out of the water you inject.

24 BY: MR. NORGAARD

25 And that -- that is the key point that you're probably going

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1 to get to later, but that is -- you can make a bigger mistake
2 by putting water in the wrong place than you can by waiting
3 too long.

4 BY: MR. SMEDLEY

5 Okay, the next view graph summarizes some of these studies
6 that we've just talked about..ah..these are....

7 BY: MR. MILES

8 Larry can I interject just a second, we had originally planned
9 to break at 5:00, we haven't had any word from the second
10 floor one way or another, so I think what we'll do right now
11 is, I understand a number of people have early evening planes
12 6:30 plans to catch, I think what we'll do is go through
13 until 5:30 and Paul try and finish up with your presentation.
14 Assuming we haven't adjourned by 7:00, we'll come back, any-
15 body who cares to come back, those people from out of town
16 with planes to catch, I don't expect them to come back, I
17 mean you folks have gone above and beyond as has this committee,
18 I think. A number of us are interested in continuing the
19 discussion. To me it's been -- I've learned as much in the
20 last two days as I had in a year, I think, from just
21 the give and take. There are a couple of other people who
22 indicated that they wanted to testify, 7:00 presuming we
23 haven't adjourned..ah..we'll give those folks the opportunity
24 to testify and then again presuming we haven't adjourned, I'd
25 like to just sort of open it up to a general discussion. Ah..

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1 it's a pretty loose way to run an operation, but it -- I
2 think after we adjourn, everyone will be drunk. There won't be
3 too much we can do after that. That's sort of the setup and
4 right now if people have to leave fast at 5:30, I'd certainly
5 like to thank everybody.

6
7 [Discussion re time schedule]

8
9 BY: MR. SMEDLEY

10 This..ah..as I indicated earlier in this hearing, because of
11 the large number of cases that were involved in our sensitivity
12 studies, we ran these cases with our -- with basically a
13 two-dimension -- it's really a three-dimensional model but it
14 can best be classified based on what you've learned in the
15 last couple of days as a cross-sectional model of the
16 reservoir. The field-wide three-dimensional model that we've
17 described and we've shown the history match compared to, was
18 used to verify the cross-sectional runs. But the results
19 we presented at the hearing and that we are presenting here,
20 were run on a cross-sectional model which was proven to be
21 by the three-dimensional model an adequate model for looking
22 at these sensitivities and for predicting the ultimate recovery
23 for Prudhoe Bay. Cases that we looked at with oil offtakes
24
25

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1 ranging from 1.2 to 1.8 million barrels of oil per day showed
2 no significant effect of oil offtake rate on ultimate
3 recovery. These cases that are shown on the chart were run with
4 produced water injection and two billion cubic feet per day of
5 gas pipeline deliveries commencing after five years of pro-
6 duction. The second sensitivities shown investigate the
7 impact of gas pipeline deliveries beginning in 1982, or five
8 years after the start of oil production, compared to delayed
9 deliveries. If we only injected produced water, a 10 year
10 delay in the gas offtake from 1982 to 1992, increase
11 recovery only slightly, from 36.2% to 37.5% of original oil-
12 in-place. Studies show that with appropriate modifications
13 to the reservoir management plan, we can offset this relatively
14 small impact of gas deliveries on oil recovery. One method
15 of offsetting it is with source water injection and it's just
16 shown in the next cases, with source water injection and gas
17 deliveries commencing in 1982, recovery varied for different
18 cases from 39.3 to 40.2% of original oil-in-place, this
19 depended primarily on the level of water injection, this
20 compares to 40% recovery with gas deliveries commencing in
21 1987. So that was comparing '82 versus '87 deliveries. As
22 you're aware, progress has been slow on the proposed gas pipe-
23 line. Consequently, we now believe that 1985 is the earliest
24 likely timing for gas deliveries from Prudhoe Bay. The final
25 results shown on this chart represent the sensitivity of

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1 ultimate oil recovery to various water injection programs.
2 With natural depletion supplemented by produced water injection,
3 a recovery level of about 36% is predicted. This
4 relatively high recovery without source water injection is
5 due to the favorable rock properties that we described earlier
6 from the view graph, which provide for efficient gas cap
7 expansion and gravity drainage over most of the reservoir.
8 The studies show that source water injection commencing in
9 1982 to 1986 with rates varying from 1.7 to 2.5 million
10 barrels per day offer potential to increase recovery to about
11 39% of original oil-in-place, this is the nine year case we
12 were talking about, 1986 starting up. Larger water injection
13 programs that were analyzed commencing in 1982 and 1984
14 resulted in recoveries of about 40%. The studies indicate
15 that ultimate oil recovery is not very sensitive to the
16 timing of injection start-up within reason and within the
17 range as shown. Cases with injection beginning later result
18 in the same recovery if we increase the rate of injection to
19 "catch up" with the earlier injection program. Now, this is
20 because the major benefit of water injection at Prudhoe Bay
21 is improved conformance or sweep efficiency rather than
22 pressure maintenance. Therefore, it's more important to
23 select proper injection locations and volumes than is the
24 timing of injection start-up. Decisions on the proper
25 injection locations in this complex and diverse field will

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1 require substantial performance and testing data as well as
2 detailed studies. As Paul mentioned earlier, there is too
3 much risk of reducing recovery if we were to proceed without
4 sufficient data and we injected water at improper locations
5 so as to impair gravity drainage where it is the most effi-
6 cient recovery process. Indeed, the risk of reducing
7 recovery by improper water injection more than offsets the
8 potentiation risk of deferring the start of injection. With the
9 natural depletion process being very efficient, we believe
10 there is time available to obtain the necessary data and
11 perform the required studies and still be in a position to
12 initiate waterflooding so as to achieve maximum oil recovery
13 benefits. I'll hit briefly the final chart which basically
14 summarizes our conclusions. First, that the Operating Plan
15 studies submitted at the May, 1977 Conservation Commission
16 hearings are still valid. Field performance and testing
17 hasn't significantly changed the outlook that we provided
18 then. Secondly, the oil and gas offtake rates approved by
19 the Oil and Gas Conservation Committee in Conservation Order
20 No. 145 are consistent with achieving maximum economic
21 recovery from the Prudhoe Bay Field. And finally, the
22 ultimate recovery estimates of 40% for oil and 75 to 80% for gas
23 still appear reasonable. However, achieving this recovery will
24 require enormous future investments. These investments must
25 be evaluated and justified individually, considering such

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1 factors as the amount of additional oil to be recovered, the
2 value of the oil , associated operating costs and taxes.
3 Additional production performance and testing data is
4 required before many of these decisions can be finalized. Now,
5 that concludes my prepared testimony and we're aware of your
6 keen interest in waterflooding and what we're doing with
7 regard to studying waterflooding at Prudhoe Bay, so Dave
8 Griffiths of ARCO is now going to give you an update on the
9 progress of our waterflood studies.

10 BY: MR. CHATTERTON

11 Thank you Mr. Chairman. Larry, I appreciate the constraints
12 of time and everything else, but there's one thing that I
13 would like to rap with you on. I realize that you are
14 representing 16 participants here today and that there are
15 16 participants, I presume there's 17 different ideas on
16 everything, as 17th being what you're presenting, the consensus
17 opinion and I appreciate that, but let me follow through a
18 little bit. The thing that has bothered me for a long while
19 is the small -- well, let me put it this way, the expected
20 high natural depletion recoveries of 36% and the small
21 differential between that and full scale of 40% everything.
22 Now, that expected natural depletion, I've been told anyway,
23 was due highly or one of the very major factors and it was
24 gravity drainage. Do we still today, I mean, having watched what's
25 happening, still believe that it's going to be a very overriding

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1 mechanism in the recovery?

2 BY: MR. SMEDLEY

3 Yes sir, we do. And in fact, we have developed some more
4 sophisticated models than the one I described to you today.
5 The impact of the one today was to go back to its earlier
6 developed model. These models, in order to get a very
7 precise match of history, indicate that the shales that we
8 have built in the models are less continuous or the shales
9 are actually less continuous than we built in the models,
10 they indicate that the permeabilities, in order to get a good
11 pressure match, are somewhat higher than was originally
12 anticipated, so the properties as we would analyze them right
13 now today are more favorable for that mechanism than two
14 years ago.

15 BY: MR. CHATTERTON

16 And this, if I may Mr. Chairman, is this in view of the fact
17 that you've showed us a slide today which is the same as you
18 used in '77 that showed the KBKH ratio as being extremely
19 low, you also mentioned that even in '77 you knew about these
20 major shale breaks. Do you still feel you've got an
21 excellent vertical permeability?

22 BY: MR. SMEDLEY

23 That's right. The vertical permeability -- I think we probably
24 concentrated far too much on that small portion of the field
25 over there where the shales are very continuous, gravity

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1 drainage won't be efficient in that area, for sure, where we
2 saw the big pressure sink, but over most all of the field,
3 it's going -- it appears to be very efficient.

4 MR. CHATTERTON

5 Thank you, thank you Mr. Chairman.

6 BY: MR. NORGAARD

7 I think one of the thing is that the..ah.. permeability levels
8 in the reservoirs are very high, so even though you have
9 KBKH that..ah..is less than ideal, you still -- the permea-
10 bility available in the vertical direction is very high.

11 BY: MR. PARR

12 Mr. Smedley, I got into a little thing awhile ago there with
13 you and I thought you sort of made me feel a little better
14 about it, but then your last paragraph, you go back to the
15 statement, comes back to the same point I was raising. You're
16 going to take each one of these things and evaluate it and
17 so forth before you apparently decide to do it. You may not
18 intending to go for 40%. You read the last few
19 lines of your statement you just now read. That's exactly
20 the point that made me raise those questions earlier.
21 You know, I mean is -- are the producers planning to invest
22 this money and shoot for 40% or are they not. The original
23 targets were 40% oil and 75% gas and that was still valid, then
24 you said each one of these additional things have got to be
25 studied and evaluated and I guess costed out, I don't know

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1 what, your own words out of your own statement a few minutes
2 ago which indicates or implies at least, they may not be done,
3 right? And I don't know.

4 BY: MR. SMEDLEY

5 I think both parts of your statement are basically true. We
6 anticipate that they will be done, it is our best estimate
7 that they will be economic. They will be evaluated indepen-
8 dently, they do have to meet our minimum investment criteria,
9 we do not believe that we serve the consumers in -- of the
10 country by making uneconomic investments.

11 BY: MR. PARR

12 What I'm coming back to -- laying down to the sort of bottom
13 line, to use the jargon, there may or may not be an attempt to get out
14 40% if the producers decide that one of these steps you
15 listed is uneconomic, it will probably not be done, therefore
16 those percentages would fall out unless you find some other
17 way to handle it. Is that correct?

18 BY: MR. SMEDLEY

19 All of these are decisions that have to be made, some of them
20 have been made, we indicated we're already proceeding with
21 several of them, we fully anticipate that they will be made
22 based on our best studies today. Those decisions will be made
23 and affirmatively made, but in a grosser sense, I think what
24 you're saying is proper.

25 BY: MR. SHOWALTER

Yea, I would try to answer your question with a question to you

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1 BY: MR. MILES

2 I said no, you're supposed to answer these questions.

3 (indisc. - simultaneous speech)

4 MR. SHOWALTER

5 Do you anticipate that the ferry system schedule in Alaska
6 will be exactly like it is today in 1985 and are you willing
7 to make that decision today or will you examine the budget
8 for the fiscal year '85 when it comes up and decide how
9 much funding you're going to give to the ferry system.

10 I think it's a very similar thing.

11 BY: MR. PARR

12 Well, I don't think so at all, Mr. Showalter. I -- I never
13 expected Exxon or ARCO or BP or anybody else to operate at a
14 loss; nobody would expect me to run my business at a loss.
15 I never -- I never expected that, but the impression was
16 being given to that and that's what I wanted confirmed, either
17 it is or is not, that these things are not firm. They're firm
18 if they're economically feasible for the producer company,
19 is that correct?

20 BY: MR. SMEDLEY

21 That's correct and these other things in that sense are in
22 the same boat as the water injection system. They're all
23 investment decisions.....

24 BY: MR. PARR

25 but now we understand one another. These things are all

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1 contemplated if the producers decide they're economically
2 feasible, they will be done.

3 BY: MR. SMEDLEY

4 We believe, based on our best current estimates, that they
5 will prove economically feasible.

6 BY: MR. PARR

7 I said but that's your -- that's an estimate, there's no
8 guarantee of any of that.

9 BY: MR. SMEDLEY

10 That's right.

11 BY: MR. PARR

12 That's all I wanted to get clear.

13 BY: MR. NORGAARD

14 Let me just say one thing that I think is consistent and
15 compatible with this, until the owner companies have
16 authorized the expenditures for whatever lies in the future,
17 and that could be the next well in Prudhoe Bay, there's
18 nobody that could say it will happen. Once the expenditure
19 has been authorized, we can say it will happen. We can look
20 at the plan and say that is what we think will happen. I
21 think we can go a step further. I think I can say that the
22 decisions will be easy, but I don't think there's anyone who
23 can say until the major companies and a proper vote has been
24 taken that this will be done. It does take the senior manage-
25 ment of our companies to say that it's a proper expenditure before

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7 ON
8 PRUDHOE BAY RESERVOIR MANAGEMENT
9

10 ROOM 118 - CAPITOL BUILDING
11 JUNEAU, ALASKA
12

13 August 6 and 7, 1979
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1 we can make it, but we believe in everything that we've done,
2 and I'm speaking for ARCO right now, that the decisions are
3 easy, they're not tough decisions. Now does that help?

4 BY: MR. PARR

5 I think so, thank you. I think we understand where each other
6 is coming from now and it is all clearer now that this is
7 not -- anything guaranteed at this point.

8 BY: MR. GRIFFITHS

9 Thank you, Mr. Chairman. My testimony will last about 20
10 minutes if I go through it rather hurriedly, so with your
11 permission, I'll take off. If there are any questions why
12 somebody (indisc.)

13 BY: MR. MILES

14 Before you start so you don't get interrupted, if anybody
15 has to take off to catch a plane, I know we said we'd stop
16 at 5:30, it's almost 5:30 now. Anybody besides you, Mr.
17 Griffiths? Okay, let's go.

18 BY: MR. GRIFFITHS

19 Members of the House Resources Committee, ladies and gentlemen,
20 my name is David Griffiths. I received a Bachelor of Science
21 degree in Petroleum Engineering from the University of Texas
22 in 1958, and was employed by Atlantic Richfield as an engineer-
23 ing trainee. Following three years of military service, I
24 rejoined ARCO where I have had a number of reservoir produc-
25 tion engineering assignments. Since moving to Alaska in 1974,
I have been directly associated with North Slope activities.

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1 For the past two years I have been a member of the Prudhoe
2 Bay Unit Planning Subcommittee, which has had the responsi-
3 bility of coordinating the waterflood studies which have
4 been conducted in the Unit. During the next few minutes, I
5 would like to discuss the progress of the waterflood studies
6 that have been underway during the past several years. I
7 will briefly reflect on the work that has been done to date
8 and describe the current status of the waterflood project.
9 Following this, I will outline the future waterflood project
10 plans as they are now envisioned. Between 1969 and 1974,
11 several waterflood feasibility studies were undertaken by
12 ARCO, Exxon and Sohio. The studies led to these conclusions,
13 first a waterflood system for Prudhoe Bay is mechanically
14 feasible; second, the most probable source of water is the
15 Beaufort Sea; and third, field performance history is needed
16 to properly design the system. Work done between 1974 and
17 1976 established eighteen engineering studies that would
18 need to be undertaken prior to completing the conceptual
19 design of a waterflood system. Such studies would include
20 analysis of water source, freeze problems, soils and perma-
21 frost; ice; weather, materials selection, water treatment,
22 and more general project interface studies such as environ-
23 mental and permitting requirements, project planning, and
24 cost estimating. While many of these study areas were common
25 to many waterfloods, some were unique to Prudhoe Bay.

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1 Following the formation of the Unit, owners have maintained
2 an aggressive program to resolve questions regarding the
3 viability of a waterflood. This effort has proceeded on
4 two fronts; one, improving our knowledge of the reservoir
5 and secondly, developing a waterflood design. As has been
6 mentioned, reservoir studies have recognized the potential
7 benefits of returning produced water to the reservoir and of
8 supplementing the produced water with source water for some
9 time. Estimates of additional oil recovery ranged from
10 four to seven percent of the oil-in-place. We recognized
11 that production history would be needed to verify the need,
12 locations, and volumes of waterflood. We identified areas
13 of engineering interpretation, such as fact efficiency,
14 stratification in the reservoir, and injection of well
15 capacity as important factors affecting the expected benefits
16 resulting from waterflooding. In addition, early in the
17 reservoir study period we recognized the effects of geolo-
18 gical factors such as faults, the heavy oil/tar mat, shale
19 continuity on the selection of flood location, volumes and
20 flood performance. As an example, shale continuity is perhaps
21 the most important geological factor affecting choice of
22 recovery mechanism and it's the most discussed here today.
23 The two most efficient recovery mechanisms available, gravity
24 drainage and waterflooding, are each capable of higher than
25 average recoveries in particular areas of the field. Normally,

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1 gravity drainage works better in thick oil columns which have
2 no continuous shale barriers blocking oil movement, while
3 waterflooding works better where the oil column is broken up
4 by continuous shales into several isolated layers. It is
5 vitally important to identify areas where gravity segrega-
6 tion is most effective prior to injecting water. If water
7 is injected into areas where the shales are discontinuous,
8 the waterflood recovery will be poor and the more effective
9 natural recovery mechanism will be eliminated. On the other
10 hand, if the shales are continuous, gravity segregation will
11 be less efficient than waterflooding. However, reservoir
12 studies show that even in these areas the ultimate recovery
13 is effectively unchanged with a minor delay in initiation of
14 waterflooding. Consequently, it is far more important to know
15 where to waterflood than when to waterflood. Since shale
16 continuity is such an important factor, a group composed of....

17 BY: MR. MILES

18 How can they determine -- if that's true, how can they determine
19 for example like we've heard earlier in Alberta, where
20 waterflood prior to a field going into production.

21 BY: MR. SMEDLEY

22 Let me try and take a shot at that. Ah.. frequently, that's
23 done -- you don't have the same situation like the one that
24 I'm most familiar with because it's an Exxon field, is J
25 Field in Florida which other than Prudhoe is the most

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1 significant discovery in recent times. We -- decided to
2 waterflood J very, very early and started water injection
3 essentially at the start of production. It was -- it had
4 no possibility of good efficient natural depletion mechanism.
5 It was..ah..I don't want to get into the technical terms,
6 it's natural recovery would have been very low, nothing like
7 in the order of 30's% like we have at Prudhoe, it would have
8 been like less than 20% and so, there wasn't this option to
9 trade off -- you know -- to -- maybe, the natural
10 mechanism may be more efficient in some areas at least than
11 an induced mechanism.

12 BY: MR. MILES

13 Even -- almost setting the recovery level aside, if it's more
14 important to know where to sink that hole as opposed to when,
15 don't you have to have some kind of a production history,
16 I mean (indisc - simultaneous speech) We keep hearing that
17 everything has to be done based on production history..ah..
18 and this seems to fly in the face of that..ah..so, I guess
19 I don't understand, even if the -- even if your -- you know --
20 the best hopes without waterflooding are only 20%, it seems like,
21 at least from what we've heard, you'd have to know the
22 dynamics of the field prior to -- prior to sinking a water-
23 flood well.

24 BY: MR. SMEDLEY

25 It depends -- its -- every reservoir is so different and so

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1 unique..ah..if it's purely a pressure maintenance thing,
2 if your putting the water in, many times the water is just
3 injected out in the aquifer out in the natural water
4 bearing part of the reservoir, not even within the oil part
5 of the reservoir. Okay? Just purely for pressure main-
6 tenance because the reservoir would not do well if you
7 didn't inject it, like at J. The pressure -- in the first
8 year of production at J, for instance, here we are talking
9 about a 200 psi pressure drop in two years, at J the
10 pressure drop would have been thousands of pounds in this
11 period of time. An order of magnitude difference. So,
12 the need was obvious, the injection -- so the injection
13 was started Ah..and it was done -- the reservoir
14 properties were such that you didn't have this concern of
15 -- you know -- messing up an efficient natural mechanism
16 in some parts of the reservoir by injecting in others.
17 You had -- you had a very poor natural mechanism you
18 couldn't foul it up any worse than it was -- you know.
19 Face it, you aren't going to get hardly anything if you
20 didn't do something.

21 BY: MR. NORGAARD

22 Let me offer a comment on that, too, if I may, Mr. Chairman.
23 I think we can go to a very close Alaska scene, the Trading
24 Bay unit. There is an utter saturated reservoir; it has
25 no gas cap and therefore, you can determine very early that
primary recovery will be low and you can take rock samples and very quickl

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1 in the laboratory analyze it and see what the expectations
2 would be if you waterflooded and you can determine very
3 quickly and very early that you have a natural and logical
4 candidate to waterflood. The waterflood is initiated in
5 Trading Bay unit, I believe, within three years. It was --
6 you know -- as fast as they could physically get equipment.
7 And, in that you just have a single mechanic, just a single
8 mechanism, it's solution gravity -- it's solution to drive
9 system where you just have rapid fluid expansion. Very
10 simple. You can look at it, you can analyze it and you've
11 got, probably 20 other reservoirs that you can hone in on
12 immediately that are similar, and you just need to get
13 some laboratory data of the rock itself and the fluids
14 themselves and you can go. Canadian reservoirs could be
15 that same kind of thing. In Prudhoe you've got a very
16 complex field. You've got several mechanics working
17 simultaneously, you need to determine how they are working,
18 how they're interrelating, how the -- and the locations
19 of the interrelation. So you do need some time to look, I
20 would speculate also that the fields in Canada are generally
21 very small and they have a sister or a cousin that are pretty
22 close by. You know -- there's a lot of oil fields in Canada
23 and there's only one Prudhoe -- you know -- it's very
24 difficult to find a sister or cousin, but there's an awful lot of
25 oil fields in Canada where you could be looking at a sister or cousin
right next door. You know -- just the day you drill it, you can say, gee

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1 that's exsands (ph) -- exsands well that works this way, so
2 we'll do it. I think, I'd turn to Dr. vanPoolen for a
3 probably a better explanation than that.

4 BY: MR. MILES

5 Do you care to comment?

6 BY: DR. DOSCHER

7 The story is if you have a gravity drainage field, so
8 in part, or in the most part, now, if you started injecting
9 water in that gravity drainage, you may ruin the gravity
10 drainage next. So we want to find out where there is no
11 gravity drainage where the shales are and not just the
12 shales from the cores and the logs but also the shales from
13 the production history. That's why we need some production
14 history. It's rather obvious we're going to go, I mean,
15 that the industry will start flooding the eastern part of
16 the field now that we have confirmed that shale breaks
17 are accurate. That's why we have to have history. Where
18 in all the other stages are correct. If you have a small
19 field and no good drive mechanism, you start injecting water
20 and it doesn't matter where you put it in, you're not ruining
21 anything. In this case, you have a chance of ruining a good mechanism
22 by waterflooding so you want to be selective in where you put it.

23 BY: MR. GRIFFITHS

24 Since shale continuity is such an important factor, a group
25 composed of ten geologists from five companies spent thousands

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1 of man hours verifying and updating shale correlations and
2 making predictions as to their continuity between wells and
3 in undrilled areas in the field. This work has indicated
4 that the shales are less continuous than previously predicted,
5 which emphasizes the need to proceed with caution. Further
6 improvement in the shale description will result from
7 continued drilling and history matching the production
8 performance of the field and wells with reservoir models.
9 Also, the vast number of pressure buildups and the inter-
10 ference test data are providing insight into shale continuity
11 and reservoir depletion mechanisms. A reservoir engineering
12 study group from the Unit Owner companies has been working
13 steadily to narrow the uncertainties related to this project.
14 The group has identified seven potential waterflood areas in
15 the field and has undertaken specific reservoir studies in all
16 of the major areas. The key to verifying the benefits to be
17 derived from waterflooding is the analysis of the production
18 and test data that is constantly being collected. Highly
19 sophisticated "state-of-the-art" reservoir models have been
20 developed and we are now comparing the detailed performance
21 history with the model predictions. By next year the owners
22 expect to have the knowledge upon which to base initial
23 waterflood decisions. To enable an early evaluation of the
24 many reservoir and mechanical factors which can affect the
25 success of a large scale waterflood, the Unit Owners have

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1 implemented two pilot water injectivity tests in the Sadlerochit
2 reservoir. One of the tests, located in the Western
3 Operating Area near Gathering Center No. 3, was completed
4 recently and the data that has been obtained is being analyzed.
5 The other test, located in the Eastern Operating Area near
6 Flow Station No. 1, is underway and will soon continue --
7 and will continue for about nine more months. The pilot
8 tests have been designed to evaluate reservoir parameters
9 such as injection pressures and injection capacity in the
10 wells, the efficiency of water in displacing oil in the
11 reservoir, aquifer properties, and the impact of water quality
12 on injectivity. The mechanical factors under investigation
13 include an evaluation of two artificial lift systems, poten-
14 tial corrosion, scaling and freezing problems, and general
15 design parameters. In addition, a valuable benefit from the
16 tests is an opportunity to gain operating experience with a
17 North Slope waterflood. Although very costly, so far about
18 \$33 million, the tests are providing extremely worthwhile
19 data. Soon after unitization, the owners formed a Waterflood
20 Task Force. The Task Force, consisting of sixteen full-time
21 engineers from several owner companies, was charged to accom-
22 plish the design studies previously mentioned and develop a
23 conceptual design for a waterflood project. The normal
24 sequence of events in the design and implementation of a
25 waterflood is first to define the benefits to be derived from

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1 the flood and then specify design parameters, such as flood
2 locations, volumes, pressure, quality, etc., and then design
3 a system to meet these requirements. Because of the time
4 required to fabricate and construct a major facility such as
5 this at Prudhoe Bay, we have carried out the facility design
6 and the reservoir engineering studies concurrently. As a
7 result, the design was developed to accommodate a range of
8 potential flood volumes. As is the case with most projects
9 of this magnitude, a wide range of alternative concepts was
10 developed for practically every facility in the system. In
11 July, 1978, we retained Bechtel Inc., an engineering contrac-
12 tor, to fully evaluate these alternatives. An average of
13 fifty contractor personnel have been employed in the con-
14 ceptual design studies. Early this summer, we developed a
15 conceptual waterflood design which will accommodate the range
16 of potential injection requirements, as I mentioned. The
17 slide before you shows a layout of the waterflood system.
18 The conceptual design envisions the Beaufort Sea as the
19 water source. The seawater would be treated in a facility
20 located near the end of the west dock (indisc). From there
21 the low pressure lines would carry the treated water to two
22 water injection plants, one located in the east area near
23 Flow Station No. 1 and one in the west area near Gathering
24 Center 1. From the plants, high pressure injection
25 water would be transported to appropriate drill sites and

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1 drill pads for injection. Although we still need to resolve
2 several design questions during the next phase of the
3 engineering, which incidentally is already underway, the
4 project is mechanically feasible and environmentally sound.
5 Prudhoe Bay owners recently submitted applications to the
6 Corps of Engineers for major permits required to install
7 waterflood facilities. Supporting these applications is a
8 two-volume document entitled, Prudhoe Bay Unit Waterflood
9 Project Overview, and I have copies of those here.
10 Volume 1 is the engineering overview and it is a pretty
11 complete description of the Prudhoe Bay conceptual design
12 as it stands now. Volume 2 is an environmental overview that s
13 prepared by a consultant, Woodward Clyde, and Mr. Chairman
14 I'd like to leave copies with you for the record.

15 BY: MR. ROGERS

16 May I ask, is that -- are you going to have to file a
17 environmental impact statement in addition - in addition to
18 that for waterflooding plant?

19 BY: MR. GRIFFITHS

20 We expect that an environmental impact statement will probably
21 be required. Ah..the determining agency will be the Corps of
22 Engineers.

23 BY: MR. ROGERS

24 And..ah..are -- do you have any problem with water injection
25 in the winter up there?

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1 BY: MR. GRIFFITHS

2 Some of those 18 studies that I've mentioned were addressed
3 to that very question and we think -- well, we're quite
4 certain that we can operate through the winter months.

5 BY: MR. ROGERS

6 Well, maybe you're going to get into this later, but I under-
7 stand the North Slope Borough has an ordinance that could
8 effect -- it effects a lot of the activities up there, is
9 that going to effect the waterflooding operation do you think?

10 BY: MR. GRIFFITHS

11 We really don't know, that ordinance has not been finalized,
12 to my knowledge.

13 BY: MR. NORGAARD

14 Certainly it is a concern to us. We are working with the
15 borough and..ah..you know -- we intend to work with the
16 borough in every way we can, but that is a very great concern
17 to us that..ah..they -- they are moving forward on "CZM"
18 ordinances and what is written right now would be very
19 difficult to operate and work with, and we're optimistic
20 that we will be able to work with them to come up with some-
21 thing that makes sense, but that's a great concern.

22 BY: MR. ROGERS

23 Am I hearing you say then that the ordinance could prohibit
24 you from waterflooding?

25 BY: MR. NORGAARD

We will have to get the borough's concurrence on what we

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1 propose to do, yes, as well as the Corps of Engineers,
2 as well as the State of Alaska, as well as, I believe, the
3 citizens of Alaska. I'm not sure that there's anybody's
4 approval we don't need.

5 BY: MR. CHATTERTON

6 (Indisc - simultaneous speech) I told you that I would like
7 an opportunity to ask a facetious question, but I guess it's
8 been partially answered, so I'll rephrase it. Have you or
9 do you plan to send a courtesy copy to the North Slope
10 Borough, to the Coastal Zone Management..ah..group, also?

11 BY: MR. NORGAARD

12 We have met with just about all agencies that have any
13 involvement and met with the borough at least twice before
14 submitting the application to them. We've visited with --
15 explained what we were planning on doing and have gotten
16 any suggestions that they have had at that point in time and
17 we certainly would intend to follow to all these agencies
18 with the permits, but it does have to go through the
19 Corps of Engineers and then they become the lead agency and
20 they do their thing. We are continually following and work-
21 ing with all agencies to see if we can't assist them whatever
22 way we can and answer questions that they must have, certainly
23 they will have some questions. Thank you for the question,
24 Mr. Chatterton.

25 BY: MR. CHATTERTON

Thank you, Mr. Chairman. You're welcome.

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1 BY: MR. NORGAARD

2 I was suppose to say that when I got a chance and I forgot.

3 BY: MR. GRIFFITHS

4 As we have pointed out before that the waterflood implemen-
5 tation schedule envisions a 1984 startup and this slide
6 shows the events needed to get to startup in 1984. A major
7 decision will be required on the part of the Unit Owners in
8 mid-1980 in order to achieve a 1984 startup. To meet this
9 objective, we must complete the preliminary engineering
10 design and sufficiently resolve the reservoir uncertainties
11 in order to verify the recovery benefits by that time. Also,
12 I know that you can appreciate our need to have permits in
13 hand prior to any major commitment of funds to the project.
14 If the decision is to proceed with the waterflood, long
15 lead-time equipment orders will be placed and the final
16 design of the system will commence about mid-1980. Fabrica-
17 tion will begin in mid-1981. Sealifts then will occur in
18 1982 and 1983 and construction of the facilities on the North
19 Slope would take place between 1982 and 1984.

20 BY: MR. MILES

21 Excuse me Dave, I guess I'm missing something in the time
22 frame. I thought the water injection, natural water injec-
23 tion was going to begin in '81, that's when you got up to
24 100 thousand barrels of..ah..produced water.

25 BY: MR. GRIFFITHS

That's right.

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1 BY: MR. MILES

2 Well how can -- if you got -- how can you do the engineering
3 in '80

4 BY: MR. GRIFFITHS

5 I'm sorry, I failed to point that out that this is the
6 schedule for the major waterflood, the source waterflood.

7 BY: MR. MILES

8 So those are really two independent operations, completely
9 independent of each other.

10 BY: MR. GRIFFITHS

11 They're independent in that the time frame is different and the
12 source of water is different. Eventually, of course, those
13 two systems will have to be -- will have to come together,
14 not physically, but from a injection sense and become part
15 of one major waterflood system.

16 BY: MR. MILES

17 I see, but the produced water injection, or the source water
18 injection doesn't depend on what happens from the produced
19 water injection, when you pump the 100 thousand barrels back in.

20 BY: MR. SMEDLEY

21 Not at least in the first increment because the basic
22 decisions will have been made for the first part of the source
23 water system before the -- before you'll have that information.

24 BY: MR. NORGAARD

25 I think, we're tied in with what both Dr. vanPoolen and

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1 Doscher indicated was that some of the information we can
2 get through laboratory studies and with the injection
3 programs we currently have, the two programs we have now that
4 one could call the tests or one could call pilot,
5 depending how you felt that day, and we are anticipating
6 getting all the information required, to go ahead and make
7 the decisions in 1980 from those two pieces, so we do not
8 need this source water injection to make the decision in 1980.

9 BY: MR. MILES

10 Well, you -- okay, you don't need the information from the
11 produced water injection to make the source water injection
12 decision in 1980, is that correct?

13 BY: MR. NORGAARD

14 Yes.

15 BY: MR. MILES

16 I see, okay, thank you.

17 BY: MR. ROGERS

18 Could you tell me what you're expecting for a construction
19 work force up north.

20 BY: MR. SMEDLEY

21 Our current estimate is about 1600.

22 BY: MR. ROGERS

23 And a maintenance work force after you've completed construc-
24 tion.

25

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1 BY: MR. SMEDLEY

2 Oh, in the order of 100 people to operate a system depending
3 on how large the system turns out to be.

4 BY: MR. GRIFFITHS

5 I'm sure you will recognize most of the areas constituting
6 the project schedule are inter-related and delay in finali-
7 zing one segment could impact the overall schedule. I would
8 like to briefly discuss each of these major segments and
9 identify those areas that potentially could delay the
10 implementation of the waterflood. The reservoir studies,
11 of course we have discussed at great length, I don't think I
12 need to expand on those, except to say we do have a high
13 degree of confidence that the reservoir studies will develop
14 the necessary design parameters and recovery benefits on
15 time. The major permit applications have recently been
16 submitted, and consequently, it will be several months before
17 a firm assessment of the permit timing can be made. Since
18 the potential exists for considerable slippage in this area,
19 permitting could become a critical factor in achieving a
20 1984 startup. The preliminary engineering design phase is an
21 in-depth review of the system that has been developed in the
22 conceptual design. At the completion of this phase, all
23 major equipment for a system to handle a finite volume of
24 water at specified locations and pressures will be identified.
25 This is a major engineering effort. Final design is the

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1 phase in which equipment and piping layouts, valve and
2 vessel design, control system layouts, and construction
3 drawings are prepared. Again, for a project of this magni-
4 tude, this will be a massive effort involving about 1000
5 owner company and contractor engineering personnel. The
6 long lead items include structural steel, turbine-driven
7 pumps, water treatment equipment, and other specialized
8 items associated with the flood. We have forecasted delivery
9 times based on our previous experience with such equipment
10 and forecasts of market conditions and their availability.
11 Unforeseen changes in availability of these items could
12 cause delayed deliveries and if these deliveries are severe,
13 the delays are severe, it could delay a sealift. In the
14 fabrication stage, the equipment previously mentioned is
15 assembled in modules for sealift to Prudhoe Bay. The
16 principle variables affecting this schedule are material
17 deliveries and manpower availability. The critical factor
18 here is that minor slippage could cause a delay of one year
19 in the sealift. Sealifts are the vital link between the
20 North Slope and the Lower 48. Due to the size of the modules
21 no other transportation system is feasible. The critical
22 factors affecting the success of a sealift are the ice condi-
23 tions in the Beaufort Sea and the ability to unload barges
24 once they arrive at Prudhoe Bay. The ice factor is beyond
25 our control, of course, but we have been able to achieve at

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1 least a partially successful sealift even under the worst
2 conditions experienced during the past five years. Our
3 planning calls for the waterflood equipment to be sealifted
4 at the same time the other major facilities that Larry
5 mentioned, are programmed for the Prudhoe Bay Field. The
6 total forecasted requirements will tax the existing dock
7 facilities, and our ability to achieve that goal would be
8 highly questionable if it were not for the West Dock and
9 causeway. With this facility, we can develop the offloading
10 capacity. The North Slope construction schedule is based on
11 several years of experience. The primary factor that would
12 affect this schedule is an unforeseen lack of construction
13 manpower. The commissioning and startup of the waterflood
14 system will, in some respects, be a unique experience and as
15 such, it could encounter minor delays. By 1984, however, we
16 will have had a produced water injection system in operation
17 for three years which, along with the injectivity tests, will
18 develop valuable operating experience. In general, we feel
19 we have a realistic implementation schedule and are confident
20 it can be achieved. On the other hand, we feel there is
21 very little chance that the schedule can be accelerated.
22 The one area that will have the most impact on the schedule
23 is the timely receipt of the necessary permits. The permit
24 schedule carries the greatest chance of -- for slippage and
25 could easily delay the project a year or more.

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1 BY: MR. ROGERS

2 Yea, what State permits are required?

3 BY: MR. GRIFFITHS

4 There's a..ah..a permit required that you operate from the
5 Oil and Gas Commission, there are permits that are required
6 from the Dept. of Environmental Conservation, there are
7 permits required from..ah.. the land department I don't
8 recall -- Fish and Game (indisc) land use permits..ah.. affecting
9 gravel and what have you and the Fish and Game Department,
10 that's correct.

11 BY: MR. ROGERS

12 Do you think it would be -- would be helpful in this -- in
13 the critical permitting area if the State were to appoint a
14 permit coordinator or some -- some sort -- equivalent to the
15 pipeline coordinator that we've got on board.

16 BY: MR. NORGAARD

17 Are you speaking for just waterflood or total?

18 BY: MR. ROGERS

19 Well, for the waterflood.

20 BY: MR. NORGAARD

21 Well, as you understood there's a lot of other things that
22 are very critical too, besides just the waterflood, we got a
23 lot of other facilities that will be going and they're
24 equally critical, because almost of them require permits of
25 some kind all the way through. Really, our permit dealings

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1 with the State during the X period of time have been --
2 we've been very satisfied. We are, I believe, working very
3 well together. Our greatest concern that we have at this
4 point in time, is the multitude of different -- bodies that we
5 deal with, the North Slope Borough, the Corps of Engineers
6 and the State, and being able to coordinate those things
7 together and seeing that one doesn't have objective A and one
8 doesn't have objective B and they conflict. Who's going to
9 resolve that conflict. That's our biggest concern right now,
10 it isn't so much dealing with the State or dealing with the
11 Corps.

12 BY: MR. ROGERS

13 Do the three governments have any -- any kind of..ah..group
14 -- the same way the operators have a group planning for this--
15 do the three governments...

16 BY: MR. NORGAARD

17 Not at this time, the Corps has indicated a desire and will-
18 ingness to work with the State, so that their systems are
19 compatible in -- would simplify the process. I'm really
20 not familiar enough with the borough's intentions to speak
21 to that. Somebody here may be, I'm not. That's a new phase
22 that we're just getting into -- you know -- and that's going
23 to be one that we'll have to crawl before we can walk, I
24 guess.

25 BY: MR. ROGERS

Could you keep the committee posted on, particularly the

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1 State's efforts and if there are any problems along that.
2 BY: MR. NORGAARD
3 We would love too, thank you.
4 BY: MR. ROGERS
5 On manpower requirements, are there any specialized forms of
6 training required that we might want to -- that the State
7 might want to be pushing in the next couple of years to make
8 sure we had the right kind of manpower available for you.
9 BY: MR. GRIFFITHS
10 No, the craft manpower that will be required to install the
11 waterflood will be the same disciplines that have been avail-
12 able in the past to install the existing facilities and the
13 same people are going to be....
14 BY: MR. ROGERS
15 The same ones are primarily non-residents which is why I was
16 asking the question. Is it primarily plumbers and steamfitters
17 dependent work that would....
18 BY: MR. GRIFFITHS
19 I think it crosses a whole range of crafts and manpower,
20 electricians, plumbers, welders, pipelayers, just about every
21 -- every profession is up there.
22 BY: MR. NORGAARD
23 I don't believe that you'll single anyone out, you see, that's
24 the one you concentrate on.
25 BY: MR. ROGERS
Do you know well enough which ones you're going to need so

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1 we can try to assist at all in making them available.
2 BY: MR. GRIFFITHS
3 Our studies, as far as the waterflood are concerned, have not
4 gone into that detail.
5 BY: MR. NORGAARD
6 Let us worry that a bit because it's a broader question than
7 waterflood question. We do have lots of other facilities
8 going. And, we have looked at what the requirements will be
9 on the slope (indisc.), and we just have to look at that
10 and talk to our construction people.
11 BY: MR. ROGERS
12 'Cause you're going to be going at the same time as some gas-
13 line construction, perhaps it's quite possible that a lot
14 of these things will be going on concurrently and that could
15 create some -- a demand that we couldn't fill with residents
16 unless we knew about it in the next year or so, so we could
17 gear up some training programs.
18 BY: MR. NORGAARD
19 We appreciate the desire.
20 BY: MR. ROGERS
21 If there is any way that you can let us know during the next
22 legislative session, I think it would be rather helpful.
23 BY: MR. NORGAARD
24 We will be happy to work with that .
25

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1 BY: MR. MILES

2 Dave, you indicated a passle full of permits that you have
3 to get from Fish and Game, the Land Use Planning and
4 Environmental Conservation and who knows, did you say in your
5 presentation what the status of those, have those all been
6 applied for, have they been filled out or what -- for the
7 waterflooding project?

8 BY: MR. GRIFFITHS

9 So far we have made applications the Corps of Engineers
10 for about six or seven permits.

11 BY: MR. MILES

12 You haven't done any State applications and permits.

13 BY: MR. GRIFFITHS

14 We have not applied for State permits for the waterflood as
15 yet. That's going to be one of the next steps.

16 BY: MR. MILES

17 Okay, if this is one of the most significant problems and it
18 seems like everybody's been saying, all along, you planned
19 to go into this full scale waterflooding project, why didn't
20 you start sooner?

21 BY: MR. GRIFFITHS

22 Well, in order to submit a permit application we had to have
23 a conceptual design. The Corps of Engineers or
24 whoever will permit a specific system, they won't just permit
25 waterflooding -- you know -- across the board. We had to

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1 develop a conceptual design and document it and also to
2 prepare an environmental overview for that system, prior to
3 submitting permits. Earlier this summer, we did complete
4 that conceptual design and then moved right ahead with the
5 documentation of it and the environmental aspect of it. As
6 soon as those were completed the permits went in and we
7 anticipate the longest lead permit will be from the Corps of Engineers.

8 BY: MR. MILES

9 I see. You couldn't simultaneously apply for all of these,
10 is that right?

11 BY: MR. GRIFFITHS

12 No sir.

13 BY: MR. MILES

14 You got to -- do you have to get something back now from the
15 Corps of Engineers?

16 BY: MR. GRIFFITHS

17 We have to get an okay, our first look at it, yea, it looks
18 like its a hell of a deal.

19 BY: MR. MILES

20 Do they -- say something like that before you can apply to
21 the Dept. of Environmental and Conservation. I just don't
22 know what the -- you know -- what the....

23 BY: MR. GRIFFITHS

24 No, we do not have to get something back fro the Corps of
25 Engineers before we make..ah..subsequent applications.

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1 Matter of fact, we have other applications in the process
2 right now, that have not been submitted but they're being
3 prepared. Ah..the first act from the Corps of Engineers,
4 first official act, will be whether or not the Corps of
5 Engineers declares this a significant federal action.

6 BY: MR. MILES

7 Are they slower than the State is that why you went there
8 first?

9 BY: MR. NORGAARD

10 Dave let me see if I -- let me see if I can answer your
11 question. We obviously, as everybody, there's only so many
12 things you can do at one time and so we take the most
13 critical element first and the most critical element was the
14 permit from the Corps of Engineers and we will go ahead and
15 follow that -- you know -- as quickly as we can get the data
16 together in the form that's desired and required and move
17 forward on the permits. But, we don't see any of the other
18 ones as being the critical length. The one that's in
19 is the critical length. We may have guessed wrong, we don't
20 think we have. We see that as being the most critical and
21 we got that in as fast as we could. Now, we'll take the
22 same data that we had in that application and put it in a
23 different format so it satisfies the other permit requirements.
24 But, we have visited with all the people already, got their
25 input so we know what their concerns and desires and requiremen

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1 are and, therefore, in that context we have got a jump on
2 the game, if you will, and that was it -- we were able then
3 to pick the most critical and move forward on it.

4 MR. CHATTERTON

5 Thank you, Mr. Chairman. Dave, you made sort of an innocuous
6 statement about the westside dock and causeway. I've been
7 told that the Corps of Engineers' permit, and I don't know
8 whether it was issued through the unit or to ARCO, had a
9 requirement that they remove at a certain time, and I've
10 further been told that there are those that are pressuring
11 the Corps to have you meet that requirement. Now, apparently
12 this west dock and causeway is an integral part of your
13 waterflooding, -- have I been told right is the first question
14 and where's that issue stand now?

15 BY: MR. GRIFFITHS

16 I don't know really if
17 somebody is being pressured for us to take the dock out. I
18 think the initial permit did not stipulate we would have to
19 take the dock out, it stipulated we would have to do environ-
20 mental studies which we have done each year to assess the
21 impact of the dock being there and I suppose we would be
22 subject to take -- having to take the dock out if there was an
23 environmental impact shown. So far, there has not been any
24 environmental impact shown.

25 BY: MR. CHATTERTON

As far as you're concerned.

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1 BY: MR. NORGAARD

2 The permit did -- you'd have the stipulation

3 that we could be required to taking the dock out at a point

4 in time. It did not say that we had to, but it has the

5 stipulation that we can be required.

6 BY: MR. CHATTERTON

7 Thank you, thank you, Mr. Chairman.

8 BY: MR. MILES

9 (indisc - simultaneous speech) Mr. Griffiths did you conclude

10 your statement?

11 BY: MR. GRIFFITHS

12 I just have one brief summary, Mr. Chairman.

13 BY: MR. MILES

14 I thought you had concluded. Joe do you want to go now or...

15 BY: MR. McKINNON

16 Well, I'm not sure -- just one question. One of the things

17 you're doing to increase recovery is to double up spacing of

18 wells to..ah..150 acres and that increases it by 4% or 5%.

19 What would increasing it to 80 acres make?

20 BY: MR. SMEDLEY

21 That's as we indicated in the May, '77 testimony. The

22 way you go about developing is you drill and we were then

23 drilling on 320 acres spacing, and we've since been drilling

24 on 160 acres spacing. We will continue to look at that and

25 as we drill and see performance of these wells -- you know --

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1 reservoir, to drill wells on 80 acres spacing, and, if so, we
2 would go to the Oil and Gas Conservation Commission and ask
3 for permission to do so. Right now, the Pool Rules specify
4 160 acre spacing, so we would have to get permission to
5 drill on denser spacing.
6

7 BY: MR. NORGAARD

8 ARCO did testify at the May, '77 hearing that by drilling, and
9 I forget how many 80 acre wells, but there were quite a number,
10 that recovery would be increased by 1%, either 1 or 1.2.
11 Chat could check me out, but it's in that range. The point
12 is that you can increase oil recovery, obviously, by adding
13 wells, but it's a diminishing return to go from 320 to 160
14 got 4%, to go from 160 to 80, in certain areas, got 1%. Ah..
15 so, and I forget who it was yesterday suggested that you could
16 mine the Prudhoe Bay, I guess it was Hoyle, but you could
17 mine Prudhoe Bay and 100%. And that's -- the closer you're
18 making wells, that's the closer you are to mining the
19 reservoir.

20 BY: MR. CHATTERTON

21 May I make a statement for the record that with this dis-
22 cussion that we've had and seeing as how my name was men-
23 tioned, I have a distinct conflict of interest and I'd like
24 that known. (Laughter)

25 BY: MR. MILES

Go ahead, Mr. Griffiths, if you'd like to conclude.

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1 BY: MR. GRIFFITHS

2 In summary, the Prudhoe Bay Owners have proceeded in an
3 aggressive and orderly manner to verify the feasibility of a
4 waterflood in the Sadlerochit Reservoir. This course
5 follows very closely the program outlined in the Unit Owners'
6 presentations before the Oil and Gas Conservation Committee
7 during the hearings in May, 1977. Reservoir studies and
8 design studies have progressed concurrently. Injectivity
9 tests have been designed and implemented, and analysis is
10 progressing with the production data -- production history
11 and test data obtained to date. As a result of many years of
12 reservoir studies and the analysis of field production, we
13 feel we are developing an excellent understanding of the
14 Prudhoe Bay reservoir and its future performance. We intend
15 to continue our extensive efforts to build on this foundation.
16 During the past two years alone, the Prudhoe Bay Unit Owners
17 have invested over 40 million dollars in engineering studies
18 and special tests designed to reduce the risks associated
19 with a source waterflood. The Waterflood Task Force has
20 developed a conceptual design based on a Beaufort Sea water
21 source and the Task Force is proceeding into the next phase
22 of engineering. Permit applications have been submitted to
23 the Corps of Engineers. Permitting could become the critical
24 factor in meeting a 1984 startup of the project. The Unit
25 Owners plan to be in a position to make the decision to

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1 proceed with a source waterflood project by mid-1980 if the
2 permits are in hand and the project is determined to be
3 economically viable. Mr. Chairman, that concludes my testimony.
4 I think Mr. Norgaard has some concluding remarks .

5 BY: MR. PARR

6 I have one question and you probably mentioned this and I
7 missed it. Have your tests indicated that this Beaufort
8 Sea water is suitable for the purpose or is it -- are you
9 going to have to build a conditioning plant of some sort or
10 what?

11 BY: MR. GRIFFITHS

12 Yes, we will have to build a treating plant. Now the
13 Beaufort Sea water, based on the tests that we have run so far
14 and those tests started back in 1976, indicates that the
15 Beaufort Sea is a very good quality water, but still it will
16 require some treatment and heating and that facility is the
17 one that will be located out at the end of the west dock.

18 BY: MR. PARR

19 Thank you.

20 BY: MR. MILES

21 Are there other questions? Mr. Norgaard, would you conclude?

22 BY: MR. NORGAARD

23 It's been long and I'm going to make a very short concluding
24 statement. Maybe, that will be unique for me. First off,
25 I think that Prudhoe is unique in one respect and it's come

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1 out repeatedly and that is the money, technical expertise
2 and manpower that have been dedicated to that field to learn
3 as much as we can and to manage it as properly as we can for
4 all parties concerned. I think it's unique in the annals of
5 oil fields and considering the reservoir we're dealing with,
6 it's appropriate, and I think the oil companies will continue
7 to treat it as such. Secondly, the plan is a sound plan,
8 and we believe it should be followed. We believe we said that
9 very clearly. We see it actually maximizing the amount of
10 oil and gas to be recovered from the Prudhoe Bay Field and
11 I think oil and gas is important. I know Dr. Doscher did not
12 feel that 1.5 trillion feet of gas was significant. That
13 equates to over 200 million barrels of oil, so I guess I
14 feel it is equivalent. And, in my opinion, it definitely is
15 something that will not be seen. When you burn it, you burn
16 it and that's that. Ah..thirdly, the plan, I believe again,
17 is prudent for both the owner companies and the State of Alaska
18 and, in this regard, I believe our interests are essentially
19 identical. And the reason for that is the reservoir is a kind
20 of reservoir where the decisions are not borderline decisions.
21 They are broad, big decisions in the different economics
22 that exist between us, which will always exist between us;
23 it's not a critical element. And, lastly, we have worked
24 with this Oil and Gas Conservation Commission in the past,
25 we certainly intend to work with them fully in the future

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1 and...ah...we expect to share our ideas and thoughts and our
2 information with them as frequently and as openly as
3 they desire and that's the end of my -- and we thank you
4 again for the opportunity to be here today and, hopefully,
5 we've shed some light on what we're doing and what it means
6 to you and to the State of Alaska. Thank you.

7 BY: MR. MILES

8 So, great gentlemen...ah...thank you very, very much -- it's
9 been thoroughly enlightening to me and I think to other
10 members of the Committee. We know you have gone well out
11 of your way to come up here and put your presentation together,
12 and it has been enlightening and most appreciated. Also, I'd
13 like to thank you, Ken, for what you did in organizing the
14 effort. It's most appreciated. It's now 6:15. I think
15 we'll back up our voluntary evening session at 7:15 and give
16 everybody at least the time to have one martini at dinner.

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MEMORANDUM

To: Joint Interim Natural Gas Pipeline
Financing Committee

Date: July 27, 1979

THE ALASKA NATURAL GAS PIPELINE:
CURRENT PROSPECTS FOR FEDERAL
ASSISTANCE

This report is in response to the Committee's request that we examine the issues involved in possible federal financial support for or participation in the Alaska Natural Gas Pipeline project. The specific areas of inquiry suggested by the Committee include:

1. What would be the most likely forms of federal participation?
2. What is the overall likelihood of federal participation?
3. If federal participation occurs, when is it likely to come about?
4. What events must occur in order to make federal participation a reality?
5. What steps could the State of Alaska take in order to convince the federal government that such financial support or participation is necessary?
6. In the event the State chooses to actively solicit federal participation in the project, what areas of the federal government and what methods of approach would be most likely to achieve favorable results?

The remainder of this memorandum discusses these questions. By way of preliminary comment, it should be noted that since the Committee requested the analysis of these points (at its meeting of June 4, 1979), there has been a significant upheaval with

regard to the domestic energy policy situation and with regard to international energy prices. The result of the major OPEC price increase of July 1, President Carter's domestic policy summit at Camp David, and the subsequent attempt by the President to initiate major personnel and policy changes within his Administration, have all combined to make this report somewhat more speculative than might otherwise be the case. Consequently, where these major events have influenced our analysis, we have so noted. We have also added analyses of President Carter's latest energy proposals where appropriate.

Possible Forms of Federal Financial Participation

As evidenced by the President's recent proposals on synthetic fuels, the range of possible federal support for the proposed Northwest Alaska Natural Gas Pipeline is great. The material provided to Congress describing the President's proposal to establish an Energy Security Corporation (to promote synthetic fuels and unconventional natural gas supplies) contained the following financial authorities which would be provided to the Corporation:

1. Direct loans to companies that produce or manufacture synthetic fuels or unconventional natural gas supplies.
2. Loan guarantees for such projects.
3. Authority to guarantee prices of synthetic fuels or unconventional natural gas supplies.
4. Authority to guarantee federal government purchases of such materials.
5. Direct government ownership of a maximum of three synthetic fuels projects.

Specifically excluded, however, is authority to make equity investments, enter into joint ventures, engage in lease or lease-backing arrangements, or make grants.

Based on our conversations with Congressional staff and Executive Branch officials, we believe that provision of loan guarantees for at least a portion of the Alaska Natural Gas project is the most likely alternative in the event the federal government decides that financial assistance for the project is