**ENRON OIL CANADA LTD.**

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DEPARTMENT OF ENERGY AND MINES
DEC 3 1986
PETROLEUM BRANCH

1 December 1986

The Oil and Natural Gas Conservation Board
#555, 330 Graham Avenue
Winnipeg, Manitoba
R3C 4E3

Attention: Mr. Charles S. Kang,
Chairman

Dear Sir:

Re: Additional Information and Amendments to
Waskada Lower Amaranth "A" Pool
Pressure Maintenance Application
Dated: August 13, 1986

Within the following application we will first address the deficiencies as noted in your letter of September 10, 1986 and following this we will discuss the results of the simulation study as contained in the attached report, as well as Enron's proposed amendment.

**Deficiencies**

1. In regards to the injector 15-4, the original text should have read:

   "Enron Oil Canada Ltd. requests permission to inject water into wells' Andex Waskada 12-4-2-25, Andex Waskada 15-4-2-25, Andex Waskada 16-5-2-25 and Andex Waskada 3-4-2-25 coincident with the effective date of the new Unit."

2. The letter from Omega regarding the water supply agreement is attached as complete.

3. The reservoir pressures discussed in the Preliminary Engineering Report (dated July 1986) were not corrected to the pool datum. They are now corrected and included as such in Table 3 in the attached report. The impact was insignificant due to the flat topography of the study area.

4. In regards to the Claridge analytical model; the results were intended as a preliminary look. With any analytical model it lacks some of the discreteness of a 3D simulator which study we have now completed. For additional information please refer to paper number SPE 2930 for the original paper by E.L. Claridge. Also included is a paper by B.A. Slevinsky et al which compare the performance of the Claridge model to simulator results. The program was purchased from D & S Consultants in Calgary; please contact Bruce Slevinsky for further discussion (403-268-6617).

5. With regards to the final deficiency of insufficient information regarding off-patter injection we wish to state the following in support of our position:

   There is no doubt that the advantage of a regular pattern allows for optimum sweep when all things considered are equal. Strict adherence however does not allow for heterogeneities and other producing/injecting considerations which can affect the flood performance. For example:

   i) Although the Lower Amaranth A zone is "blanket" in nature, it does not equate that it is necessarily continuous in all lenses. This fact is demonstrated by various papers discussing infill drilling. One such (attached for your perusal) "Infill Drilling to Increase Reserves - Actual Experience in Nine Fields in Texas, Oklahoma and Illinois; JPT August 1983" shows that pools with 40 acre spacing which were initially thought to have 85% lens continuity actually only had 30% continuity between 40 acre locations and 60% between 10 acre locations after infill drilling down to 10 acre spacing. Thus, injecting into a well that evidenced more stringers increases the probability that all lenses will be swept to some degree. This is a more important consideration in a nine spot with a 3 to 1 producer/injector ratio rather than a 5 spot pattern that has a 1 to 1 ratio. At least with a 5 spot a "partial pattern" would probably exist for any given lens.

   ii) Due to the variance in well productivity, some attention should be devoted to this criteria. The gain in water injection capacity from oil production capacity after converting an oil well to a water injector is far greater than the oil rate gains experienced by an oil well subsequent to pressure maintenance. This point was discussed in the original application but the data which exemplifies the injection capacity gains is repeated below for convenience.

| Location | Initial Oil Rate ($m^3$/day) | Maximum Injection Rate ($m^3$/day) | Average Injection Rate ($m^3$/day) |
|---|---|---|---|
| 15-8-1-26 | 2.8 | 89 | 53 |

As can be seen from the Omega well within the study area, the ratio of injectivity rate to oil rate is very large. Looking at injectors further removed from our project is as follows:

| Location | Initial Oil Rate ($m^3$/day) | Injection Rate ($m^3$/day) |
|---|---|---|
| 15-23-1-26 | 6.5 | 62 |
| 13A-24-1-26 | 1.3 | 72 |
| 15-24-1-26 | 2.1 | 82 |
| 5-25-1-26 | 6.7 | 126 |
| 7-25-1-26 | 9.7 | 106 |
| 13-25-1-26 | 2.0 | 28 |
| 15-25-1-26 | 2.5 | 28 |
| 7-26-1-26 | 2.8 | 57 |

The high capacity gains upon converting to an injector not only substantiates the viability of an inverted nine spot but also allows flexibility in keeping the better producers as oil producers. All other things being equal the preference should be to convert one of two wells having the lower productivity, thus shortening the waterflood life. Depending on the economic limit, the recoverable reserves could be noticeably higher if most of the high rate wells were maintained as producers.

iii) A final consideration in examining injection location possibilities is the potential of injection losses to the Mississippian. Commmunication with the Mississippian is a common problem in the Lower Amaranth A and where it exists it always results in high water cuts in producers and injection losses for the injectors. This loss in injection is more of a concern than one would at first anticipate. We currently operate two waterfloods in Alberta (Highvale Field) that are under injected (due to injection loss) as confirmed by pressure analysis. The complications are as follows:

a) Pressure surveys must be on producers with low water cuts to eliminate the effect of Mississippian pressure communication. Our experience indicates that getting reliable pressure surveys from seven day buildups in a rock that is layered and often tight could be difficult. However, assuming success in obtaining the necessary reservoir pressures it would take a few years (time to fillup) to identify the disparity between actual reservoir pressure and the presumed reservoir pressure. Unfortunately the initial reservoir pressure in the project area is unknown but assumed, which introduces some uncertainty as to further preclude early idenfification of injection losses. Once the loss is identified there remains the task of determining which injectors are transmitting losses and how much. Potential anisotropy and uneven continuity will make the above mentioned task difficult.

b) If over injection is the preferred path, thus ensuring that replacement will be acheived, the risk of channelling is increased (if in fact the injector is over injecting) and again the magnitude of over or under injection will be uncertain until approximately fillup as discussed in a) above.

c) Workovers to shut off the Mississippian water have not been completely successful. Within the project area, location 4-9 is an example of reducing water cuts from 95% to its current 50% value. The question of successfully shutting off the Mississippian in an injector is even more uncertain considering that for producers where low wellbore pressures tend to keep the frac closed, the water production is often only reduced not shut off completely as in location 4-9. Add to this the high bottom hole pressures of an injector and the successful cement squeezes on a producer will not necessarily retain its integrity. The success of the cement squeeze on an injector would be difficult to assess via pressure analysis since the pressure response of the Mississippian would behave most like a high permeability layer within the Lower Amaranth Unit. Also, the production response of the offset producers would not be a reliable indicator as point d) below demonstrates.

d) Another element of concern associated with injection losses is the potential flood losses in the medium and low permeability sands. With restricted vertical communication, the amount of water received by any lens is proportionate to its permeability. Hence with fracture communication to the Mississippian, the lion's share of injection volumes will no doubt go to the high permeability lens and the Mississippian. Since the high permeability layers yield the majority of the production in the early years of a flood this phenomenon as discussed above will not be recognizable, and all will seem to be going well, at least during the initial phase. However as water breakthrough becomes evident, the high capacity layer will yield mostly water and the medium and low capacity layers will not perform as predicted due to lack of water supply and the later stages of the flood will perform very poorly.

e) Finally, the results of further model study as the flood progresses becomes tenuous due to the uncertainty of injection volumes into the Lower Amaranth A zone.

Following the above reasoning, the specific injector locations as preferred by Enron of Canada Ltd., can be addressed in conjunction with a review of the 1986 production data and calculated net pay as displayed below.

INJECTION LOCATION COMPARISON

| Oil Rate ($m^3/d$) | Jan | Feb | Mar | April | May | June | July | Aug | Sept |
|---|---|---|---|---|---|---|---|---|---|
| 3-4 | - | - | - | - | - | - | 3.0 | 1.8 | 1.4 |
| 4-4 | - | 8.2 | 7.8 | - | - | 10.3 | 8.4 | 6.9 | 5.9 |
| 5-4 | 13.4 | 10.4 | 9.6 | - | - | - | - | 10.8 | 8.6 |
| 6-4 | - | 9.9 | 7.3 | - | - | 10.9 | 10.2 | 8.7 | 7.8 |
| 11-4 | - | 3.8 | 2.6 | - | - | 4.1 | 2.6 | 2.2 | 2.0 |
| 12-4 | - | 8.4 | 6.0 | - | - | 10.3 | 8.1 | 4.8 | 4.1 |
| 13-4 | 7.7 | 6.0 | 6.3 | - | - | 6.6 | 3.7 | 3.2 | 2.8 |
| 14-4 | - | 4.8 | 3.6 | - | - | 4.9 | 3.6 | 3.0 | 2.9 |
| 15-4 | 1.4 | 1.4 | 1.4 | - | - | - | - | - | - |
| 9-5 | 16.0 | 14.6 | 10.9 | - | - | - | - | 11.8 | 10.4 |
| 10-5 | 2.1 | 1.3 | 1.4 | - | - | 2.3 | 1.1 | 1.3 | 2.5 |
| 15-5 | 2.1 | 1.7 | 1.4 | - | - | - | - | 2.9 | 1.7 |
| 16-5 | 2.3 | 2.3 | 2.0 | - | - | 4.1 | 2.5 | 2.0 | 1.9 |

| Water Cut (%) | Jan | Feb | Mar | April | May | June | July | Aug | Sept |
|---|---|---|---|---|---|---|---|---|---|
| 3-4 | - | - | - | - | - | - | 16.8 | 6.2 | 9.5 |
| 4-4 | - | 2.8 | 5.7 | - | - | 8.0 | 3.6 | 2.5 | 4.8 |
| 5-4 | 8.5 | 7.4 | 10.7 | - | - | - | - | 8.8 | 10.8 |
| 6-4 | - | 3.1 | 7.8 | - | - | 8.4 | 4.2 | 5.7 | 2.3 |
| 11-4 | - | 2.4 | 3.9 | - | - | 5.9 | 4.4 | 4.6 | 4.5 |
| 12-4 | - | 7.0 | 4.6 | - | - | 9.9 | 9.6 | 13.7 | 5.0 |
| 13-4 | 40.3 | 41.2 | 35.5 | - | - | 49.7 | 51.7 | 52.3 | 55.2 |
| 14-4 | - | 2.4 | 2.6 | - | - | 6.6 | 2.7 | 9.5 | 3.4 |
| 15-4 | 11.1 | 5.9 | 8.5 | - | - | - | - | - | - |
| 9-5 | 8.3 | 5.8 | 5.5 | - | - | - | - | 11.8 | 6.1 |
| 10-5 | N/A | 11.2 | N/A | - | - | 11.2 | 12.6 | 10.0 | 9.6 |
| 15-5 | 22.6 | 17.1 | 24.0 | - | - | - | - | 30.3 | 22.3 |
| 16-5 | 17.9 | 10.6 | 20.0 | - | - | 17.1 | 19.6 | 22.6 | 16.5 |

Calculated net pay taken from Table 1 (attached report) is repeated below.

| Well Location | Total Calculated Net Pay (ft) |
|---|---|
| 3-4-2-25* | 23.8 |
| 4-4-2-25 | 14.8 |
| 5-4-2-25 | 18.7 |
| 6-4-2-25 | 11.9 |
| 11-4-2-25* | 38.1 |
| 12-4-2-25 | 8.6 |
| 13-4-2-25* | 26.6 |
| 14-4-2-25 | 21.4 |
| 15-4-2-25* | 44.8 |
| 9-5-2-25 | 13.2 |
| 10-5-2-25* | 9.0 |
| 15-5-2-25* | 14.9 |
| 16-5-2-25* | 23.5 |

*Wells with core data.

## Choosing Injector Locations

The various quarter sections can be examined with reference to the three criteria discussed above.

| | Net Pay | Potential Productivity Loss | Barrier to Mississippian Communication |
|---|---|---|---|
| NE¼ Section 4 | | | |
| 15-4 | High | Low | Good |
| NW¼ Section 4 | | | |
| 11-4 | High | Low | Excellent |
| 12-4 | Low | Medium | Excellent |
| 13-4 | Medium | Low | Very Poor |
| 14-4 | Medium | Low | Excellent |
| SW¼ Section 4 | | | |
| 3-4 | High | Low | Good |
| 4-4 | Medium | Medium | Excellent |
| 5-4 | Medium | High | Good |
| 6-4 | Low | High | Excellent |
| NE¼ Section 5 | | | |
| 9-5 | Medium | High | Excellent |
| 10-5 | Low | Low | Good |
| 15-5 | Medium | Low | Poor |
| 16-5 | High | Low | Medium |

Although there is only one candidate for NE¼ Section 4, the qualifications are excellent for an injector location; high net pay increases the probability that all lenses will be at least partially swept, the barrier to Mississippian communication is obvious with water cuts less than 10%, and finally the overall oil production capacity of the project is affected very little by converting 15-4 to an injector.

All wells of the SW¼ of Section 4 exhibit good communication barrier status. To avoid high productivity loss would eliminate 5-4 and 6-4 as choice. Considering net pay figures also rules out 6-4 and identifies 3-4 as the best choice. Location 3-4 is also the best choice as identified by the low loss to oil productivity upon converting it to an injector.

The NW¼ of Section 4 immediately looses 13-4 as a potential candidate due to its very poor barrier status; water cuts in excess of 50% are the highest of any potential injector location. To avoid placing an injector next to another injector, ie always having one producer separating two injectors as in an inverted nine spot, requires elimination of 14-4 and possibly 11-4 leaving 12-4. Location 11-4 certainly stacks up as the best injector location of this quarter and could be considered as a viable alternative to 12-4.

The NE¼ of Section 5 is more of a mixed bag. Location 15-5 has the highest water cuts of this quarter which again, being our major concern, disallows this choice. Location 10-5 is next to the 7-5 Omega injector, and also has very low net pay which suggests inadequate flooding of some lenses. Neither of the remaining choices, being 9-5 and 16-5, are excellent choices. The concern of 16-5 is the water cut which although not high averages 18% for 1986. Location 9-5 has excellent "barrier to communication" status but would be next to injector 12-4 and as the best producer within the whole project area would suffer high oil productivity losses. Location 16-5 on the other hand has excellent net pay and would suffer very little in the way of productivity loss. Everything considered, our choice is location 16-5.

### Proposed Amendment to Injector Locations

Because the above injector pattern choice has met with objection from Omega Hydrocarbons Ltd. we have met with Omega and discussed the elements of the pattern and in consideration of the concerns of both parties we have proposed to Omega that amendments (see attached letter dated November 21, 1986) be made as follows:

- Move injector location from 3-4 to 5-4; and
- Move injector location from 12-4 to 11-4

Appropriate schematic changes (injection well diagrams and flowline maps) are included. The model results show that this final injector pattern gives the best recovery of all three waterflood cases. Omega has agreed to waive their objection based on the above (see attached letter dated November 18, 1986).

### Simulation Model Results

The attached 3D black oil simulation study presents details of five thirty-five year forecast cases.

- Project under primary with outside Omega injectors injecting (Case A).
- Project under primary with outside Omega injectors as oil producers (Case B).
- Project under waterflood with Enron initial preferred injector locations (Case A).
- Project under waterflood with standard pattern (Case B).
- Project under waterflood with Enron final injector locations (Case C).

Results are summarized below:

| | Prim A | Prim B | Wtrfld A | Wtrfld B (standard) | Wtrfld C |
|---|---|---|---|---|---|
| Percent recovery @ 10 years | 7.2 | 5.6 | 12.5 | 13.0 | 12.6 |
| Produced oil @ 10 years (MSTB) | 747 | 586 | 1 305 | 1 356 | 1 313 |
| Water injected @ 10 years (MSTB) | 0 | 0 | 2 666 | 2 436 | 3 116 |
| Percent recovery @ 35 years | 11.8 | 8.8 | 24.2 | 26.3 | 26.5 |
| Produced oil @ 35 years (MSTB) | 1 232 | 913 | 2 516 | 2 736 | 2 761 |
| Water injected @ 35 years (MSTB) | 0 | 0 | 8 527 | 7 618 | 9 702 |

Due to the assumptions and restrictions of the model, the above figures do not consider the following items nor their impact on recovery and performance.

- The Mississippian zone is not modelled and thus communication with the wet Mississippian on either producers or injectors is unaccounted for. Case B, the standard pattern, uses two injections wells (15-5 and 13-4) that are obviously in communication with the Mississippian. The negative effect of water injection loss is unaccounted for and the total impact on Case B is unknown.
- The actual injectivity of the injectors is unknown and the assumption of multiplying the injector cell transmissibility by 100X has limited reliability. A higher number would change the performance as all cases are injector restricted due to the pressure constraint thus affecting withdrawal replacement.
- The data available for history match is somewhat scanty due to the newness of the wells and uncertainty over GOR and WOR data. Also, the pressure survey includes mostly AWS results which are not as reliable as the static gradients taken at the same time.

All simulations were run using D&S Consultants "FAST", fully implicit three dimensional black oil simulator.

Yours very truly,

ENRON OIL CANADA LTD.

R.A.W. Smith, P.Eng.
Senior Reservoir Engineer

RAWS:pdc
attach

cc/w: Audax Gas & Oil Ltd., Attention: Mr. P.E. McComb
Chauvco Resources Ltd., Attention: Mr. E.A. Beaman
Consolidated Pipe Lines Company, Attention: Mr. P. Sidey
Highridge Exploration Ltd., Attention: Mr. R.T. Vanderham

OMEGA
HYDROCARBONS LTD.
1300 SUN LIFE PLAZA III
112 - 4th AVENUE S.W.
CALGARY, ALBERTA, CANADA T2P 0H3
TELEPHONE (403) 261-0743

August 8, 1986

Andex Oil Co. Ltd.
1300, 700 - 9th Avenue S.W.
Calgary, Alberta
T2P 3V4

**Attention: R.A. Schultz**

Dear Sirs:

**Re: Purchase of Formation Water**

Omega Hydrocarbons Ltd. (Omega) has equipped the well Omega Waskada 2-18-2-25 as a water source well. Andex Oil Co. Ltd. (Andex) has offered to purchase water produced from the Blairmore Formation underlying the said well (the water) and Omega has agreed to sell the water to Andex under the following terms and conditions:

1. The water will be delivered to Andex via pipeline at a presure of at least 9,000 kilopascals (kPa) to a point located in Legal Subdivision Twelve (12) of Section Nine (9), Township Two (2), Range Twenty-five (25), West of the Principal Meridian (WPM) in the Province of Manitoba (point of delivery).

2. All costs and expenses required and necessary to tie-in Andex's pipeline to Omega's pipeline shall be borne by Andex.

3. Omega will endeavour to deliver to Andex its full requirement of water during each and every month of the term hereof (such amount estimated to be one hundred thirty (130) cubic metres per day); provided, however, it reserves the right to limit or discontinue the delivery of water at any time or from time to time immediately after notice of such intention has been given either verbally or in writing to Andex.

4. Andex will obtain any and all governmental permission and authorization required or necessary to accept water from Omega and use the water for its intended purposes.

5. Andex will be charged and will pay to Omega $1.60 per cubic metre for all water delivered to it by Omega at the point of delivery. Payment for the water delivered hereunder will be on the basis of measuring devises of a type appropriate for its intended use which shall be furnished and installed at the point of delivery by Andex. Invoices will be rendered each month and payment made on or before the 20th day of the month following the month in which the invoice was received.

6. Following the initial period of two (2) years as provided in paragraph 8 hereof, the charge per cubic metre for water delivered hereunder is subject to change from time to time by Omega on Thirty (30) days written notice to Andex of such change, after which period the new charge will be effective and the Agreement modified thereby shall continue to be valid and subsisting until terminated.

7. Control of and risk respecting the water shall pass to Andex at the point of delivery and Andex agrees to indemnify Omega from and against any actions, causes of action, suits, debts, claims and demands of any nature whatsoever arising out of or connected with the acceptance by Andex of the water and hereby release Omega from and against any suits, actions, causes of action, debts, claims and demands whatsoever that Andex might have now or in the future against it arising out of or connected with the acceptance by it of the water.

8. This Agreement shall be for an initial period of two (2) years from the date hereof and thereafter shall remain in force and effect until terminated by either party hereto on sixty (60) days written notice.

9. Omega's address for service hereunder is:

1300, 112 - 4th Avenue S.W.
Calgary, Alberta
T2P OH2

Andex's address for service hereunder is:

1300, 700 - 9th Avenue S.W.
Calgary, Alberta
T2P 3V4

If the foregoing meets with your approval, kindly indicate your acceptance of this Agreement by having the attached copy of this letter executed by Andex in the space provided below and return the same to Omega.

Yours truly,

OMEGA HYDROCARBONS LTD.

G.E. Patey,
Vice President, Production

GEP/sk
Encl.

Accepted this 11 day of August, A.D., 1986.

Andex Oil Co. Ltd.

PETROLEUM SOCIETY OF CIM

PAPER NO. 81-32-21

THIS IS A PREPRINT — SUBJECT TO CORRECTION

# RECOVERY PREDICTIONS AN EXTENSION OF EXISTING CORRELATION TECHNIQUES

CLARIDGE

by
B.A. Slevinsky[1], B.G. Kergan[1], R.P. Delaney
Esso Resources Canada Ltd.
[1] Now with D&S Petroleum Consultants Ltd.



## ABSTRACT

This paper deals with the development of an analytical tool to predict recovery under both waterflood and miscible flood environments. The recovery predictions are based on correlations in the literature derived as a function of mobility ratio. These correlations are applied on a pattern by pattern basis for the entire reservoir. Extensions were developed to handle the impacts on recovery resulting from the stratified multiple layer character of a reservoir in addition to the areal discontinuities.

## INTRODUCTION

Recovery prediction methods for five spot patterns have been extensively analyzed in the literature. In general, they tend to be complex and tedious to apply. E.L. Claridge (1) has developed a correlation to model laboratory miscible flood data which simplifies these calculations. The enhancements proposed in this paper are extensions of the original formulation that deal with predictions of both miscible and waterflood performance while taking into account the geological complexities specific to each reservoir.

The sweepout correlation developed by Claridge is comprised of three components dealing with specific aspects of a flood. He found that breakthrough of the displacing phase is a function of mobility ratio and can be represented by the following:

$$N_{bt} = \frac{0.9}{1.1 + M} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

The second component of the correlation was actually developed by Koval (2), who proposed that for miscible floods the effects of fluid mixing needs to be considered. He postulated that this mixing behaviour resulted in an effective viscosity ratio represented by:

$$K = \left[0.78 + 0.22 \left[\frac{\mu o}{\mu d}\right]^{0.25}\right]^{4} \quad H.....(3)$$

Koval included a term (H) to allow for the ability to account for reservoir hetrogeneities. In practise, it was found by the authors to be more practical to account for this factor by a different approach which will be discussed later in the paper.

Combining these two correlating equations with the laboratory data resulted in the following relationship between breakthrough recovery, effective viscosity ratio, poor volumes of injected fluid and oil recovery:

$$\left[\frac{N_p - N_{bt}}{1 - N_p}\right] = \left[\frac{1.6}{K^{0.61}}\right]\left[\frac{N_i - N_{bt}}{1 - N_{bt}}\right]^{\left[\frac{1.28}{K^{0.26}}\right]} \quad \text{.....(4)}$$

This equation can be rearranged to explicitly solve for cumulative recovery as follows:

$$A = \left[\frac{1.6}{K^{0.61}}\right]\left[\frac{N_i - N_{bt}}{1 - N_{bt}}\right]^{\left[\frac{1.28}{K^{0.26}}\right]} \quad \text{............(5)}$$

$$N_p = N_i \qquad N_i \leqslant N_{bt}$$

$$N_p = \left[\frac{A + N_{bt}}{1 + A}\right] \qquad N_i > N_{bt} \quad \text{............(6)}$$

These equations are capable of determining recovery as a function of both mobility ratio and injected hydrocarbon pore volumes, but apply only to a single layer homogeneous reservoir.

The need exists then to extend this approach to account for the geological complexities of the reservoir specifically in the areas of permeability distribution and reservoir continuity. Also, these equations were developed for a single fluid displacement from initial conditions to final depletion. However, in determining performance under a miscible flood environment, modifications were required to account for a pre-existent secondary waterflood. These modifications are discussed in the next section.

In a complex reservoir situation, two parameters can greatly influence the recovery estimates. These are the permeability distribution and reservoir continuity. The permeability distribution effects are applied by considering the reservoir as being comprised of a number of layers, each with a specific permeability, porosity and thickness characteristic. Each layer is then treated as a distinct reservoir and injections allocated in proportion to the permeability thickness of the layer with respect to that of the total zone open to injection.

The reservoir continuity effect needs to be included to account for the degree to which a zone is connected between the injector and producer. Application of a continuity term to the injected volume, allows its conversion to a hydrocarbon pore volume (HCPV) basis. The permeability thickness weighting technique can then be used to allocate injection on a zonal basis (i.e. a number of layers). should the discontinuities be such that the layers are easily correlatable, then an approach allowing allocation of injection only to those layers which are continuous between both the injector and producer could be used, in lieu of the general zone calculation. This application of reservoir continuity effects is outlined schematically in Figure 1.

The second major extension is to account for the pre-existent secondary waterflood. The approach taken is to superimpose an incremental tertiary production forecast on a base of waterflood forecast as shown schematically in Figure 2.

The incremental tertiary forecast is calculated simply on the basis of the difference between the tertiary and waterflood forecasts starting from initial conditions, and added to the waterflood forecast beginning at the point where the pre-injection stops. This approach, by its nature mandates that there is no influence on the break-through, response time, or incremental recovery because of the waterflood pre-injection. If the waterflood injection volumes have been small (<.3 HCPV) the impact of this assumption is minor. However, if the pre-injection volumes are large, the tertiary response time will be shortened. The acceleration of the tertiary flood response can be explained using a Buckly-Leverett illustration (Figure 3). The waterflood pre-injection moves the average pattern water saturation up the water fractional flow curve (typically S shaped, as shown). Having moved up the curve, the tangent to the fractional flow curve shifts to the left (i.e. the saturation at the front is reduced) and the incremental saturation change behind the front is reduced. This translates to an increase in the speed of response to the tertiary injection. If the fractional flow curve is simply decreased by the pre-injection (for large water injection volumes greater than the break-through volumes), this assumption yields unrealistic acceleration.

## APPLICATION

The basic Claridge method with the extensions developed in this paper have been extensively applied to the Judy Creek Beaverhill Lake "A" Pool in order to estimate both waterflood and $CO_2$ miscible flood recoveries.

For the purposes of analysis and to account for geological variations in the reservoir, the field was divided into fifty four areas which closely approximate existing waterflood patterns. The oil bearing part of the reservoir is comprised of six generally separable zones. Each pattern was analyzed geologically for continuity on a zone basis where each zone was composed of an average of 15 layers, each of which were about 0.6 m thick. Permeability and porosity data were developed for each layer based on an extensive analysis of core and log data. In addition, an analysis of the continuity for each well and for each zone was undertaken in order to ascertain the continuouspore volume to be used in the allocation of injection. The data obtained from the above analyses formed the basis of the reservoir description that was used in combination with the correlations to derive recovery estimates for each pattern. At the same time, an analysis of the productivity decline for each pattern was undertaken as well as a field wide displacement calculation. The general results of these analyses were in agreement to ± 1% of recovery.

In order to use this technique for production forecasting, it was deemed appropriate to compare the Claridge results to those obtained from a black oil simulator. The general method for conducting the simulation is described in a recent CIM paper (3) on "Judy Creek $CO_2$ Performance Predictions". The simulation and correlation calculations were performed using a seven layer one quarter five-spot pattern. The results generally compared favourably, but it was found that the Claridge method predicted a slightly longer time to displacing phase breakthrough equation in order to achieve a match for breakthrough time.

$$N_{bt} = \frac{0.9}{2.6 + M} \qquad \text{.............................(6)}$$

can use Buckley Leaverett curve & get $N_{bt}$ (ie Sw behind flood front @ breakthrough) & set this value $= \frac{0.9}{x+M}$ & solve for $x$.

A comparison of the results obtained is shown in Figure (4).

Future plans are to attempt to develop further correlations between the constant term and the applicable relative permeability curves. Incorporation of material balance terms into the methodology is also an area for enhancements.

CONCLUSION

In conclusion then, some general extensions to a simple and effective analytical method for predicting recoveries have been formulated. Their prime advantages lie in the ease of their application as well as their computational efficiency. The normal simulator approach would have required twenty times as much computer time and would have made it impractical to model each of the fifty-four areas of the field. The reservoir simulation results of both rate and recovery are comparable to the analytical correlation technique. Limitations do exist and the information provided is not as complete as that obtained from a simulator. Also, the need exists to calibrate the analytical tool to the more rigorous reservoir simulation model. The method though shows promise as an effective tool for examination and comparison of individual pattern performance, and screening of enhanced recovery processes.

REFERENCES

(1) Claridge, E.L.: "Prediction of Recovery in Unstable Miscible Flooding", Soc. Pet. Eng. J. (April, 1972) 144.

(2) Kovel, E.J.: "A Method for Prediction the Performance of Unstable Miscible Displacement in Heterogeneous Media", Soc. Pet. Eng. J. (June, 1963) 145.

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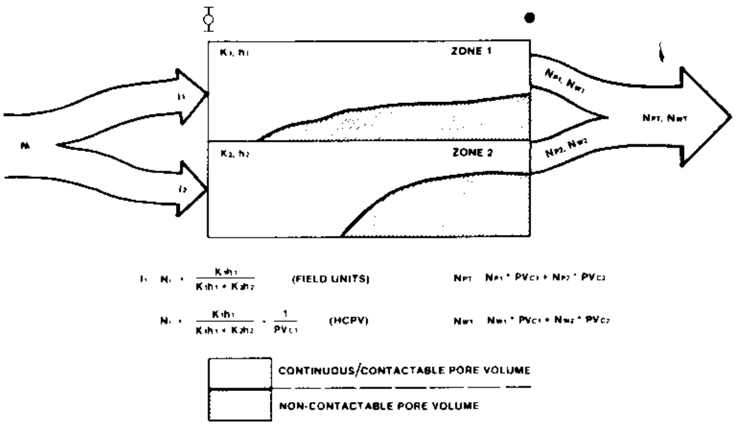


INJECTION ALLOCATION

FIGURE 1

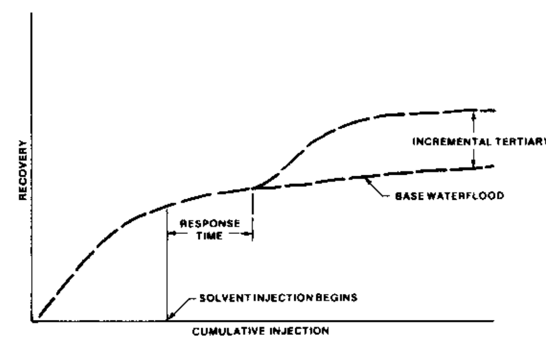


FIGURE 2

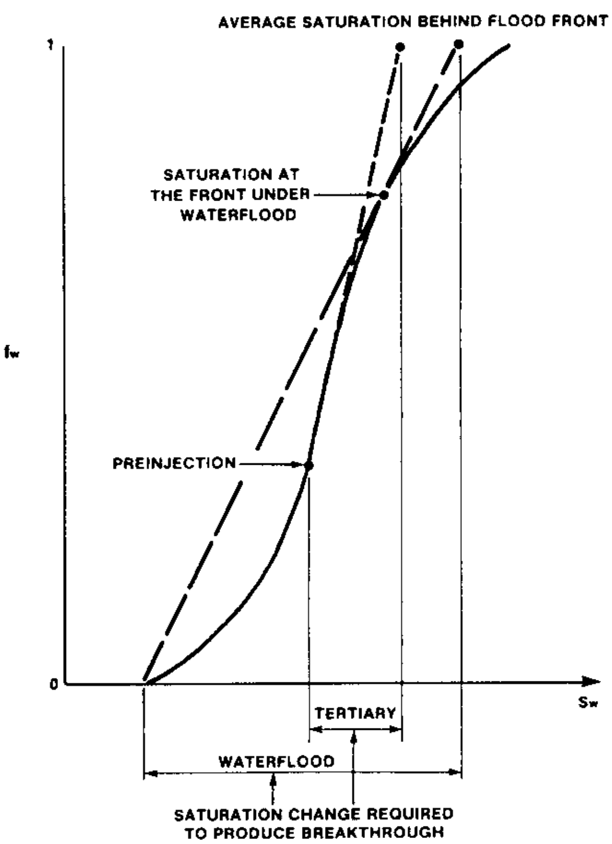


FIGURE 3

**COMPARISON OF CLARIDGE AND SIMULATION**
**7 LAYER WATERFLOOD**

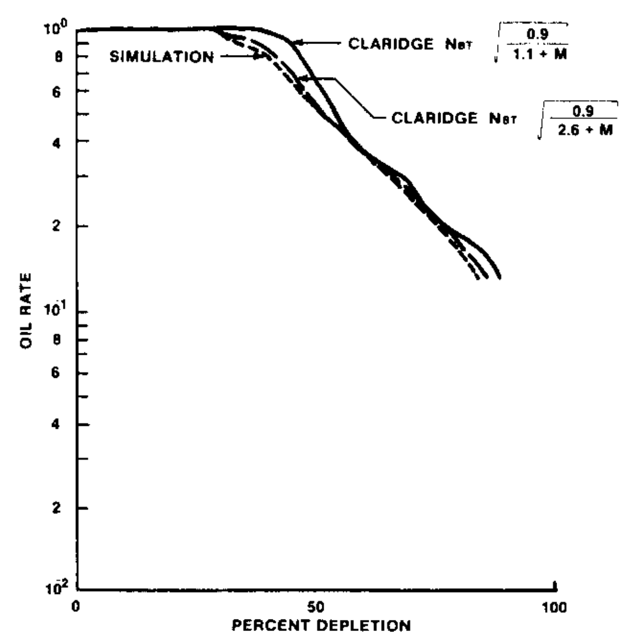


FIGURE 4

# Infill Drilling To Increase Reserves—Actual Experience in Nine Fields in Texas, Oklahoma, and Illinois

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## Summary

Evaluation of reservoir discontinuity has been used by industry to estimate potential oil recovery to be realized from infill drilling. That this method may underestimate the additional recovery potential is shown by continuity evaluation in a west Texas carbonate reservoir, as infill drilling progressed from 40-acre ($162 \times 10^3$-m$^2$) wells to 20-acre ($81 \times 10^3$-m$^2$) wells and eventually to 10-acre ($40.5 \times 10^3$-m$^2$) wells.

Actual production history from infill drilling in nine fields, including carbonate and sandstone reservoirs, shows that additional oil recovery was realized by improving reservoir continuity with increased well density.

## Introduction

One objective of an orderly field-development program is to determine the maximum well spacing that will effectively drain oil and gas reserves. While wide spacing has proved effective in many oilfield applications, there are a growing number of examples where infill drilling, combined with water-injection pattern modifications, has provided substantial additional oil reserves. This paper deals with such fields: Means, Fullerton, Robertson, IAB (Menielle Penn), Howard Glasscock, Dorward, and Sand Hills fields in west Texas, Hewitt field in southern Oklahoma, and Loudon field in Illinois. The paper will quantify the contribution to current production and the additional reserves attributable to this action, using data available through Oct. 1981. Infill drilling has continued in most of these fields. Also revealed by infill drilling is the fact that the west Texas carbonate reservoirs are more stratified, and porous stringers are more discontinuous than revealed by initial studies.

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## Background

The theoretical concepts indicating that infill drilling will increase reservoir continuity and improve waterflood pattern conformance in heterogeneous west Texas carbonate reservoirs were researched and published in the early 1970's by Ghauri,[1] Ghauri *et al.*,[2] Stiles,[3] George,[4] and Driscoll.[5]

Detailed field studies recommending infill-drilling and waterflood-pattern modifications were made for the Means, Fullerton, and Robertson fields by Stiles and George.[3,4] Unpublished studies were made for the other reservoirs prior to infill drilling.

Borrowed from a previous work by George and Stiles,[4] Fig. 1 is a type cross section in the Fullerton Clearfork reservoir that illustrates the concept of "continuity," the percentage of pay in a well that is continuous to another well. The two original Wells A and B are 40-acre ($162 \times 10^3$-m$^2$) locations, and the center well is an infill location 660 ft (201.2 m) from either original well. Note the discontinuous nature of the porosity stringers and that correlation before the infill well was drilled would have been considerably different than it is after the infill well was drilled. The increase in net pay in the infill well, especially in the upper part of the Clearfork formation, illustrates the fact that the more wells that are drilled, the more highly stratified, discontinuous, and complex a given west Texas carbonate reservoir is found to be. This fact leads to a conservative evaluation of the potential increased recovery from an infill well.

## Considerations in Infill Drilling

A progression of continuity improvement was revealed by infill drilling in the Means San Andres field. Fig. 2 is a statistical plot of continuous pay vs. horizontal distance

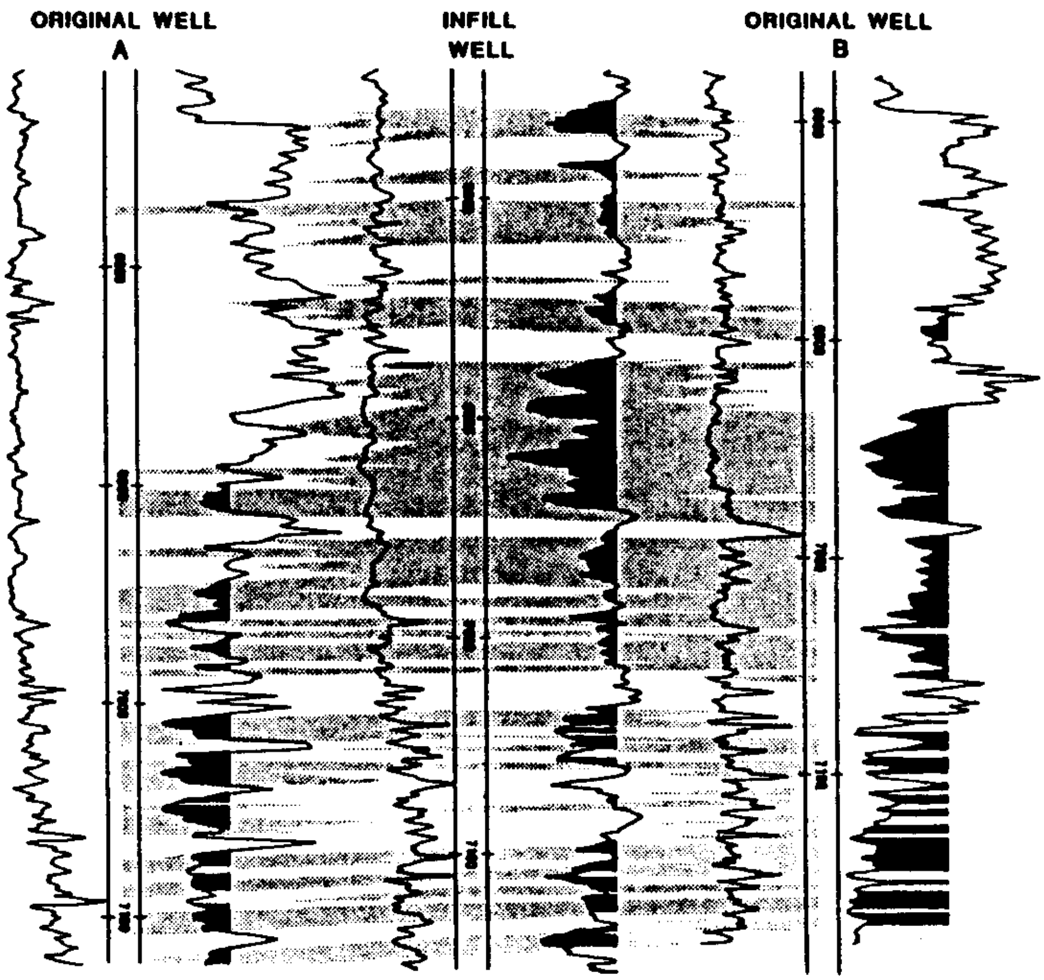


Fig. 1—Type cross section—Fullerton Clearfork reservoir (adapted from Ref. 4).

between wells for an area at Means that has been infill drilled to 10-acre ($40.5\times10^3$-$m^2$) density. This technique was used by Shell Oil Co.[6] and was discussed by Stiles[3] in a previous paper. The top curve, made prior to infill drilling, shows the increase in apparent continuity between wells with increasing well density. Subsequent curves, made after infill drilling, show the pay development to be more discontinuous than would have been predicted. As shown by the upper curve, based on 40-acre ($162\times10^3$-$m^2$) wells alone, an increase in continuity of 3% would be expected as spacing decreased from 20 acres ($81\times10^3 m^2$) to 10 acres ($40.5\times10^3$ $m^2$). The second curve, after 20-acre ($81\times10^3$-$m^2$) wells were drilled, shows that with only 40-acre ($162\times10^3$-$m^2$) and 20-acre ($81\times10^3$-$m^2$) wells, an increase in continuity of 4% would be anticipated as spacing decreased from 20 acres ($81\times10^3$ $m^2$) to 10 acres ($40.5\times10^3$ $m^2$). The analysis including the 10-acre ($40.5\times10^3$-$m^2$) wells, shown by the lower line, indicates an apparent 14% improvement in continuity. The absolute values obtained for this particular area of the field are not necessarily typical of what would be expected throughout the field but do illustrate the concept of progressive increase in continuity with closer well spacing.

The complexity of stringerization is even more obvious after Fig. 3 is examined. This is a cross section

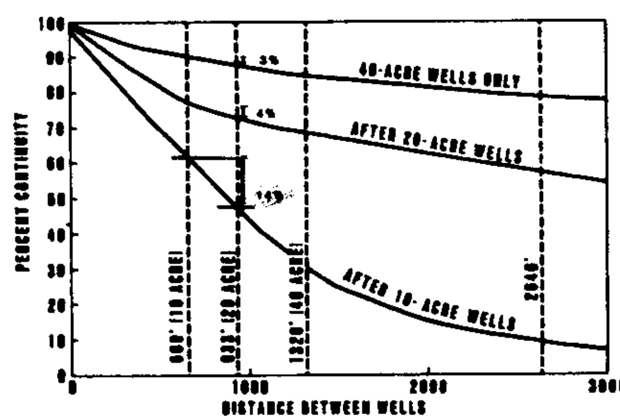


Fig. 2—Continuity progression—Means San Andres Unit.

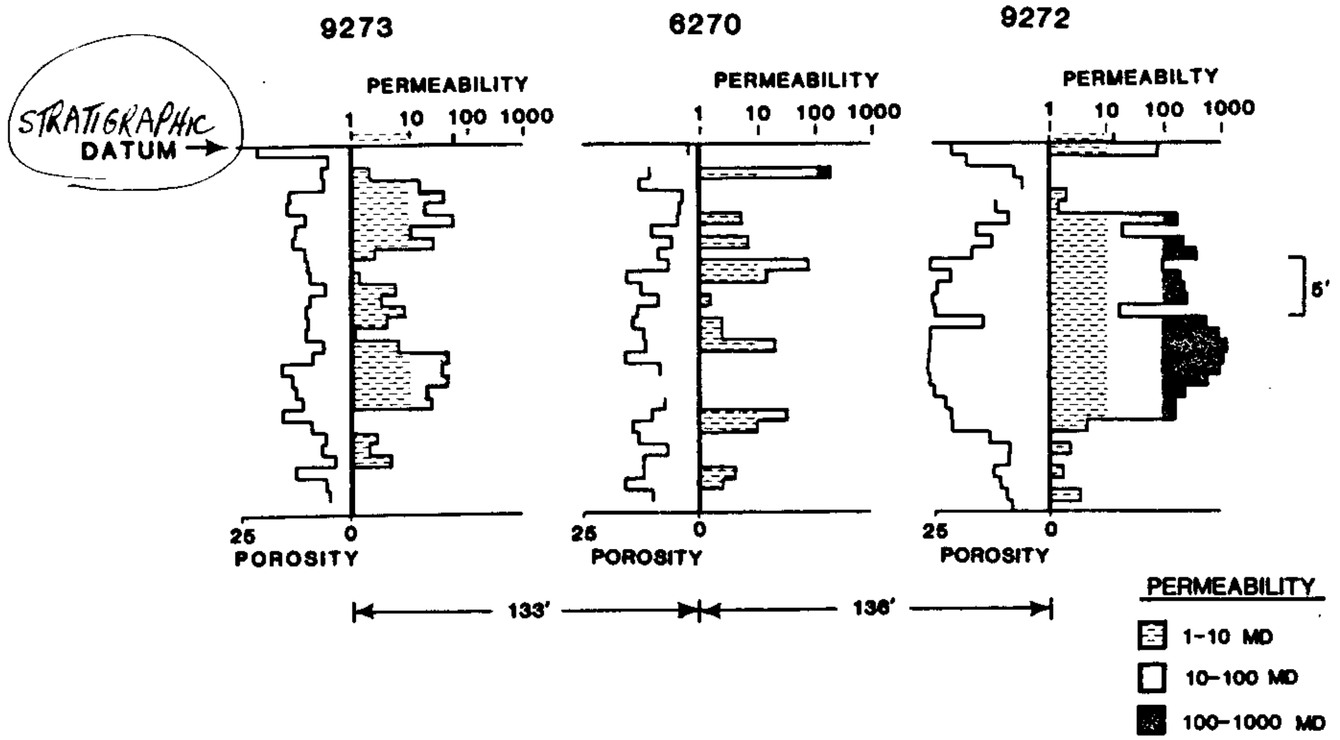


**Fig. 3**—Porosity and permeability variations—Means tertiary pilot.

through three wells in a tertiary pilot in the Means San Andres reservoir. The wells are located approximately 150 ft (45.7 m) apart, and core porosity and permeability have been correlated over the same stratigraphic interval. Porosity is plotted to the left and permeability is plotted on a log scale to the right. The pay intervals are relatively continuous between wells, but the porosity variations are significant in an individual stringer between wells. Permeability variations are even more severe. With injected fluids taking the path of least resistance, this plot serves to illustrate why, even in stringers that are continuous between wells, recovery may be lower than anticipated. ie WITHOUT INFILL WELLS.

In a previous paper,[3] it was stated that a pay interval must meet the following three requirements for waterflooding.

1. It must be continuous and reasonably homogeneous between an injection well and the offset producing wells.
2. It must be injection supported.
3. It must be effectively completed in the offset producing well.

In many west Texas Permian carbonate reservoirs there may be 50 or more individual pay stringers. Only rarely will all the stringers be effectively completed in a specific well. When a pay stringer is not effectively completed in a given well, a partial pattern exists for that stringer, and recovery will be less than for a complete pattern. These considerations were used to evaluate infill drilling and pattern modifications in several fields.

## Infill Drilling Results

Major infill drilling programs were implemented in nine fields in west Texas, Oklahoma, and Illinois. These fields include dolomite, limestone, and sandstone reservoirs with porosities varying from 4 to 21% and with average permeabilities varying from 0.65 to about 184 md. Two of the fields are still on primary production, the other seven are waterflood fields. A detailed discussion of each of these fields follows.

### Means San Andres Unit

One of the first fields studied was the Means San Andres reservoir in Andrews County, TX. Production is from a depth of 4,400 ft (1341 m). The San Andres is over 1,400 ft (427 m) thick, but only the upper 200 to 300 ft (61 to 91 m) is productive at Means. It is predominantly dolomite with minor shale and anhydrite. Average porosity and permeability are 9% and 20 md, respectively. Oil viscosity was 6 cp (6 mPa·s) at initial reservoir conditions. The reservoir was discovered in 1934 and drilled to 40-acre ($162\times10^3$-m$^2$) spacing. Waterflooding began in 1963 with a peripheral pattern, which was expanded to a three-to-one line drive in 1970. Following a detailed reservoir study in 1975, a large-scale infill-drilling and pattern-modification program was begun. By the 1981 study cutoff date, 141 twenty-acre ($81\times10^3$-m$^2$) and 16 ten-acre ($40.5\times10^3$-m$^2$) infill wells had been drilled. During this period the pattern was gradually changed, generally to an 80-acre ($324\times10^3$-m$^2$) inverted nine-spot. ie 3 Prod to 1 injector

Actual production from the 40-acre ($162\times10^3$-m$^2$) wells is shown by the lower line in Fig. 4. Production from the total unit is shown by the upper line. The area between these lines is wellbore oil production from the infill wells. The area between the dashed line and actual 40-acre ($162\times10^3$-m$^2$) well production is interference oil. Increased recovery resulting from infill drilling is that production represented by the area between the dashed line and the total unit production. The infill wells account for 68% of the unit daily production.

Increased recovery is calculated to be 15.4 million bbl ($2.4\times10^6$ $m^3$) oil, or 66% of the total oil produced by the infill wells. The unit was divided into 40-acre ($162\times10^3$-$m^2$) tracts and the original oil in place (OOIP) was calculated volumetrically for each of these tracts.[4] Additional recovery was calculated for each infill well, and as to be expected, the recoveries varied widely. In general, the additional recovery for the 20-acre ($81\times10^3$-$m^2$) infill wells ranged from 5 to 8% OOIP in the 40-acre ($162\times10^3$-$m^2$) tract in which the infill well was drilled.

In a smaller area in the Means field sixteen 10-acre ($40.5\times10^3$-$m^2$) wells were drilled in two pilot areas in 1979 and 1980. Fig. 5 shows the impact of the 10-acre ($40.5\times10^3$-$m^2$) infills on the production in the pilot areas. Decline-curve analysis indicates that additional recovery from the 10-acre ($40.5\times10^3$-$m^2$) infills will be 1.2 million bbl ($1.9\times10^5$ $m^3$) oil, or 67% of the wellbore recovery. Additional recovery from the 10-acre ($40.5\times10^3$-$m^2$) infill wells is estimated to vary from 2 to 5% OOIP in the 40-acre ($162\times10^3$-$m^2$) tract in which the infill well was drilled.

### Fullerton Field

The Fullerton Clearfork Unit, also located in Andrews County, TX, produces from the Permian Clearfork and Wichita formations, which are predominantly dolomite interbedded with limestone, anhydrite, and shale. Production is from an average depth of 7,000 ft (2134 m), and the reservoir averages 10% porosity and 3-md permeability. At initial reservoir conditions, the oil viscosity was 0.75 cp (0.75 mPa·s).

Fullerton was discovered in 1942 and was originally developed on 40-acre ($162\times10^3$-$m^2$) spacing. The Fullerton Clearfork Unit has been under water injection since 1961. The original pattern used in the largest portion of the field, the North dome, was a three-to-one line drive, with the injectors oriented north-south. The original north-south injection rows are shown in Fig. 6. Note the 80 acres ($324\times10^3$ $m^2$) outlined by the dashed line. An 80-acre ($324\times10^3$-$m^2$) tract in this position will be discussed further.

Based on the recommendations of a 1973 study reported by Stiles,[3] a program later called the Phase I Infill Program was initiated. Under this program, the wells shown by the solid dots in Fig. 6 were drilled as infill producers, and half the adjacent row producers were converted to injection wells as shown by the solid triangles. Sixty-one Phase I wells were drilled. At the conclusion of the Phase I drilling in 1976, the average production of the Phase I wells was 88 B/D (14 $m^3$/d) oil with a 46% water cut. Average production for the offset wells was about half, or 46 B/D (7.3 $m^3$/d) oil, with a 68% water cut. The fact that these infill wells performed better than the offsets indicated that additional pay was being opened up, which in turn implied that less than all the pay was being flooded.

An 80-acre ($324\times10^3$-$m^2$) tract, outlined in Fig. 6, has been enlarged and is shown in Fig. 7. The original north-south injection row is to the left and the black dot to the right fixes the location of the 61 Phase I wells. The

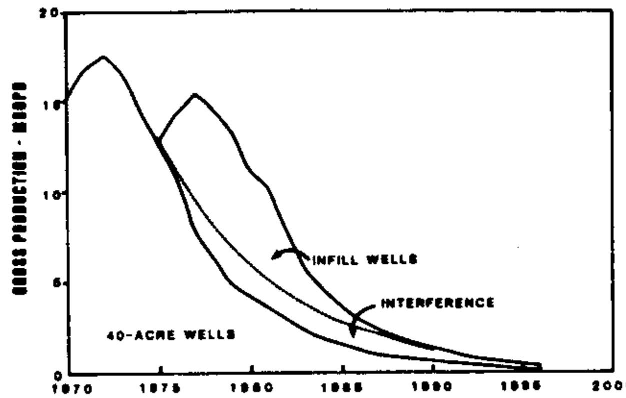


Fig. 4—Production datagraph—Means San Andres Unit.

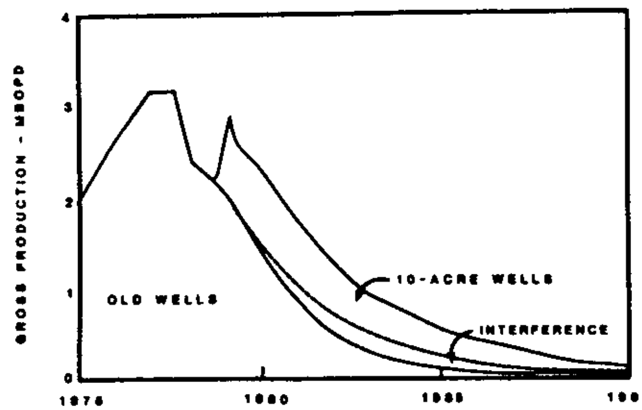


Fig. 5—Production datagraph—10-acre pilot, Means San Andres Unit.

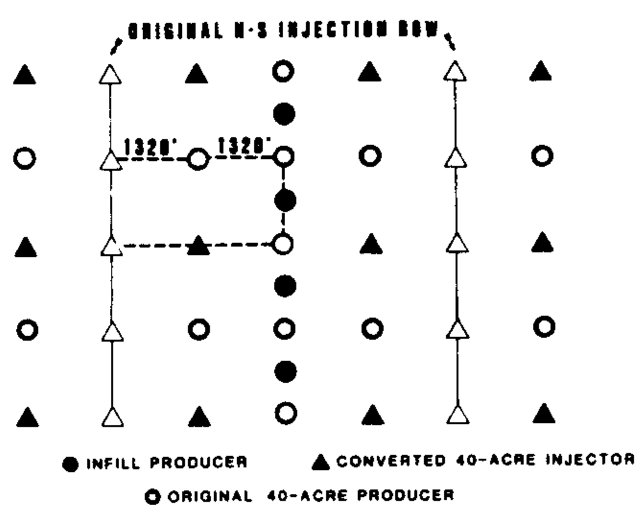


Fig. 6—Phase 1 infill drilling—Fullerton Clearfork Unit.

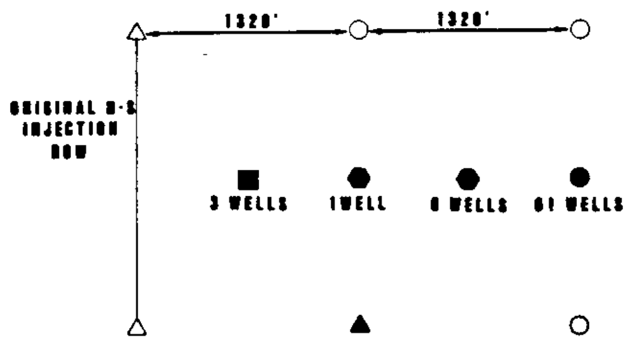


Fig. 7—Pilot infill drilling—Fullerton Clearfork Unit.

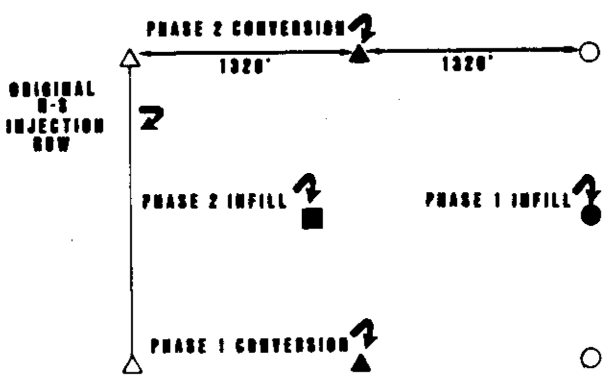


Fig. 8—Phase 2 infill drilling—Fullerton Clearfork Unit.

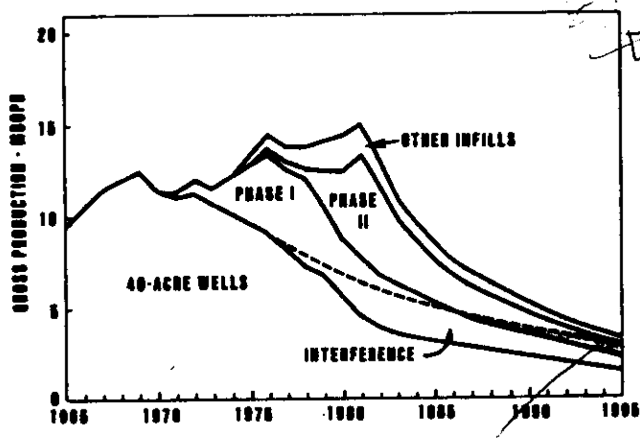


Fig. 9—Production datagraph—Fullerton Clearfork Unit.

solid triangle shows the location of the Phase I injection conversion. Prior to the Phase I program, seven wells had been drilled between 1970 and 1972 in the positions shown by the hexagons. These wells had average initial potentials of 221 B/D (35.1 $m^3$/d) oil, and in July 1976 they were producing an average of 92 B/D (14.6 $m^3$/d) oil and 70% water. Their offset wells were producing an average of 26 B/D (4.1 $m^3$/d) oil. The performance of the Phase I wells and the seven earlier wells suggested that additional recovery might be obtained if wells were drilled anywhere within the pattern. In 1976, three wells were drilled in the position shown by the square. They produced an average of 115 B/D (18.3 $m^3$/d) oil with a 74% water cut. Four of the six direct offsets to these wells had been shut in from 4 to 9 years earlier as uneconomical to produce. One was a producer testing 1 B/D (0.16 $m^3$/d) oil and 500 B/D (79.5 $m^3$/d) water. The sixth was an injector that had been converted in 1975 while producing 38 B/D (6 $m^3$/d) oil.

As a result of these 10 pilot wells, a 151-well Phase II infill drilling program at Fullerton was undertaken. Phase II wells have been drilled in the position shown by the square in Fig. 8. Wells in the position captioned "Phase II Conversion" are being converted to injection as part of the Phase II program. Of the 171 wells in this conversion location, 111 were watered out by 1976. Most others were producing at very low rates. It can be concluded that Phase II wells are mostly additional recovery. The production contribution from these infill drilling programs can be seen in Fig. 9. This datagraph shows the impact of the Phase I, Phase II, and other infill wells. These wells account for 71% of the unit's current production and will result in additional recovery of 24.6 million bbl ($3.9\times10^6$ $m^3$) oil. Fifty-six percent of the wellbore reserves are increased recovery and will average about 97,000 bbl ($15.4\times10^3$ $m^3$) per infill well.

## Robertson Field

The Robertson Clearfork Unit in Gaines County, TX, produces from the Permian Glorieta, Upper Clearfork, and Lower Clearfork formations, at an average depth of 6,500 ft (1981 m). The reservoir is about 1,400 ft (427 m) thick with actual net pay of about 200 to 300 ft (61 to 91 m), broken vertically into as many as 50 to 60 separate porosity stringers in any given well: Fig. 10, a cross section between two 40-acre ($162\times10^3$-$m^2$) wells, better illustrates the extreme stringerization. The reservoir rock is predominantly dolomite with anhydrite and shale. Porosity averages 6.3% and permeability averages 0.65 md. Oil viscosity at reservoir conditions is 1.2 cp (1.2 mPa·s). Beginning in 1942, the area was drilled on 40-acre ($162\times10^3$-$m^2$) locations. In 1969, the unit was formed for waterflooding. From 1976 through 1980, 107 infill wells were drilled on 20-acre ($81\times10^3$-$m^2$) spacing. A 10-acre ($40.5\times10^3$-$m^2$) drilling program has begun with 31 wells completed through Oct. 1981.

The contribution of the 20-acre ($81\times10^3$-$m^2$) and 10-acre ($40.5\times10^3$-$m^2$) wells is shown in Fig. 11. The dashed line represents the expected production from the 40-acre ($162\times10^3$-$m^2$) wells had there been no infills. Infill wells provide 73% of the current production. They are expected to add additional reserves of 10.7 million bbl ($1.7 \times 10^6$ $m^3$). Increased recovery represents 79% of the wellbore reserves and is about 73,000 bbl ($11.6 \times 10^3$ $m^3$) per well.

### IAB Field

The IAB (Menielle Penn) field is located in Coke County, TX. The Menielle Penn reservoir produces from a depth of 5,800 ft (1768 m) and is a coarse skeletal limestone buildup with an average of 7% porosity and 27-md permeability. The oil viscosity at initial reservoir conditions was only 0.2 cp (0.2 mPa·s) at IAB. The reservoir was discovered in 1958 and was drilled initially on 80-acre ($324 \times 10^3$-$m^2$) spacing. Waterflooding began in 1962 with an initial pattern which was essentially a three-to-one line drive. Fig. 12 is the production datagraph showing the impact from a 17-well 40-acre ($162 \times 10^3$-$m^2$) infill drilling program that began in 1978. The dashed line is an extrapolation of what the 80-acre ($324 \times 10^3$-$m^2$) wells would have done if the infill wells had not been drilled. The lower solid line shows the actual and forecasted performance of the old wells. This analysis shows that the infill wells will increase the field's reserves by 1.7 million bbl ($2.7 \times 10^6$ $m^3$). This represents additional recovery of 100,000 bbl ($1.59 \times 10^3$ $m^3$) per well, which is 58% of the wellbore reserves and 4% of OOIP in the affected area.

### Howard-Glasscock Field

The Douthit Unit, located in Howard and Sterling Counties, TX, was formed for waterflooding the Permian Seven Rivers reservoir in the Howard-Glasscock field. The reservoir is approximately 1,400 ft (427 m) deep and is a sandstone with a porosity of 18% and a permeability of 44 md. In this reservoir, the oil viscosity of 9.4 cp (9.4 mPa·s) is relatively high for west Texas reservoirs. Development of the Seven Rivers reservoir in this area began in 1957, and it was originally drilled on 40-acre ($162 \times 10^3$-$m^2$) locations. Waterflooding began in 1968 with a peripheral injection pattern. Ten-acre ($40.5 \times 10^3$-$m^2$) development began in 1976, and, by the 1981 study cutoff date, 52 infill wells had been drilled. The production datagraph, Fig. 13, shows the additional production from the infills along with production from the older wells. The infill wells account for 75% of the current production, and wellbore production is 88% additional recovery. Total additional recovery of 1.0 million bbl ($1.59 \times 10^6$ $m^3$) is expected.

### Dorward Field

The Dorward field is located in Scurry and Garza Counties, TX. Production is commingled from the Permian San Angelo and San Andres formations at average depths of 2,350 and 2,100 ft (716 and 640 m), respectively. The San Angelo formation is mostly dolomite interbedded with shale and sandstone. The San Andres consists of dolomite, anhydrite, and shale. Apparent porosity for the San Angelo and San Andres are 15 and 13.5%, respectively. Actual porosities are probably less because of the presence of gypsum, which causes optimistic measurements of porosities in cores and logs. Average permeability is about 3 md in both reservoirs. In the San Angelo, the oil viscosity is 1.9 cp (1.9 mPa·s) while in the San Andres, it is 3.2 cp (3.2 mPa·s).

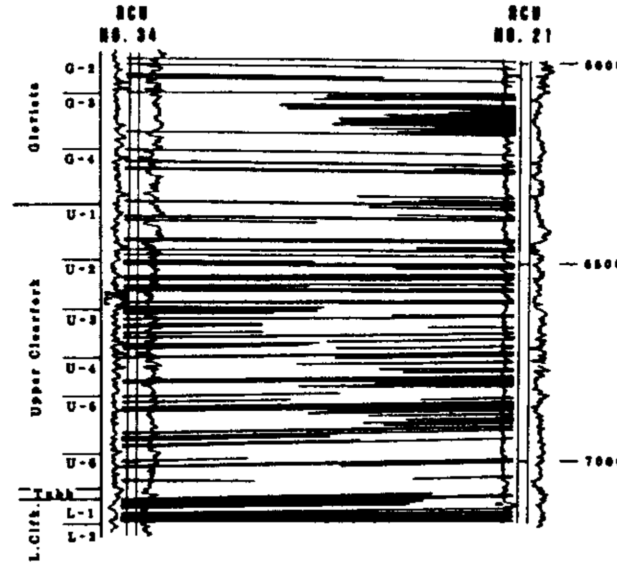


Fig. 10—Cross section—Robertson Clearfork Unit.

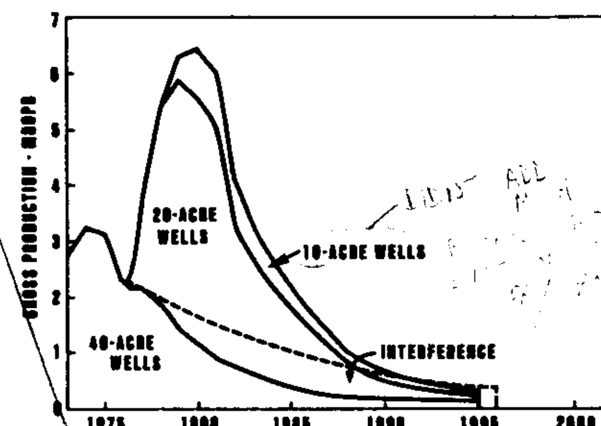


Fig. 11—Production datagraph—Robertson Clearfork Unit.

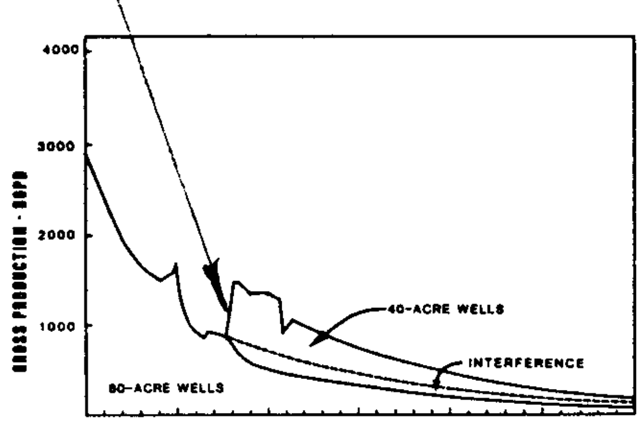


Fig. 12—Production datagraph—IAB (Menielle Penn) field.

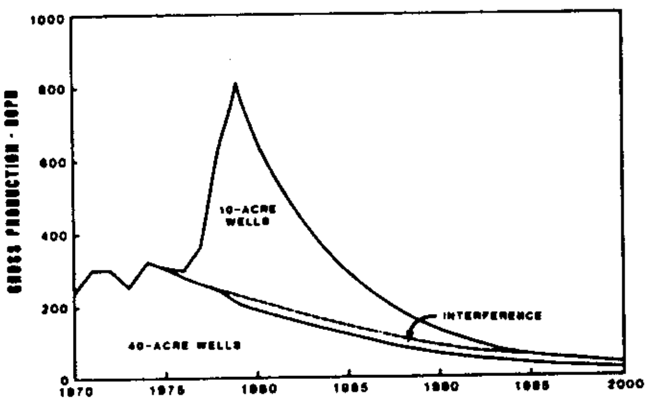


Fig. 13—Production datagraph—Douthit Unit, Howard-Glasscock field.

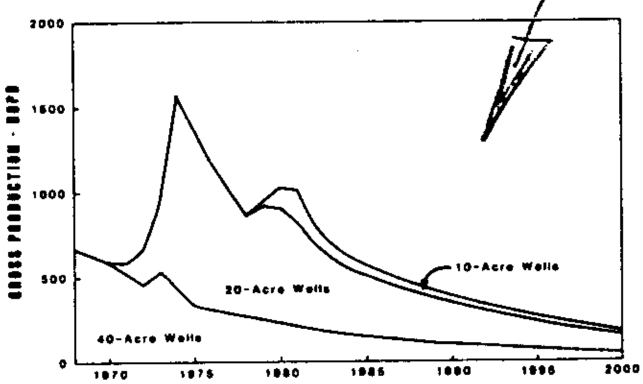


Fig. 14—Production datagraph—Dorward field.

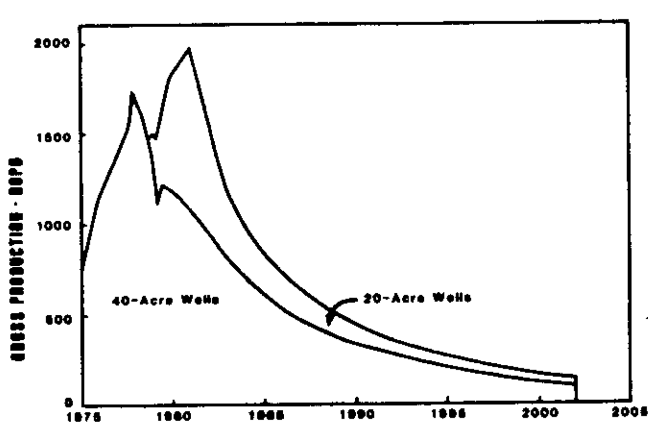


Fig. 15—Production datagraph—Sand Hills area.

The field was discovered in 1950 and drilled on 40-acre ($162\times10^3$-m$^2$) spacing. Although waterflooding began in 1958 in a portion of the field, most of the field has been and is currently producing primary oil by dissolved-gas drive. Peripheral and 80-acre ($324\times10^3$-m$^2$) five-spot patterns were tried. Early water breakthrough, caused by directional permeability and severe stratification, discouraged expansion of waterflooding to other areas.

Infill drilling began in 1971. At that time, 149 wells on 40-acre ($162\times10^3$-m$^2$) spacing had been drilled. An average of 49,400 bbl (7850 m$^3$) oil per well had been accumulated, and production had declined to an average of 4.8 B/D (0.76 m$^3$/d) oil per well for the 107 wells still producing at that time. From 1971 through 1980, there were 123 twenty-acre ($81\times10^3$-m$^2$) infill wells drilled. Ten-acre ($40.5\times10^3$-m$^2$) drilling began in 1979, and 17 wells had been drilled by the end of 1980. Fig. 14 shows the results.

Because production was nearing the economic limit when infill drilling began, essentially all production from the infill wells is considered increased recovery. The infill wells will provide additional recovery of 4.6 million bbl ($7.3\times10^5$ m$^3$) of oil or 33,000 bbl (5244 m$^3$) per well. The field is now being studied for further 10-acre ($40.5\times10^3$-m$^2$) development and to determine if waterflooding is feasible with increased well density.

## Sand Hills

Infill drilling in the Sand Hills area of Crane County, TX has been concentrated in the Sand Hills (Tubb and McKnight) fields. The Tubb reservoir produces from the Permian Lower Clearfork formation at a depth of 4,250 ft (1295 m) and is anhydritic dolomite with a minor amount of limestone. Average porosity and permeability are 4% and 12 md, respectively. Oil viscosity in the Tubb is 1.5 cp (1.5 mPa·s) at initial reservoir conditions. The McKnight reservoir produces from the Permian Lower San Andres at a depth of 3,200 ft (975 m) and is also mostly anhydritic dolomite. In this reservoir, average porosity and permeability are 5% and 1.3 md, respectively. In the McKnight reservoir, the oil viscosity is 1.0 cp (1.0 mPa·s). Gross productive interval is approximately 400 ft (122 m) in the Tubb and 350 ft (107 m) in the McKnight. Both reservoirs are highly stringerized with indications of poor reservoir continuity. They are both productive throughout the area of interest.

The Sand Hills (Tubb) field was discovered in 1931 and was generally developed on 40-acre ($162\times10^3$-m$^2$) spacing. In the area of interest, most of the Tubb 40-acre ($162\times10^3$-m$^2$) drilling was between 1936 and 1941. Development of the McKnight reservoir did not begin until 1955. McKnight development was erratic, depending largely on recompletions from the depleting Tubb reservoir; however, there was some drilling along with the workovers. Most of the 40-acre ($162\times10^3$-m$^2$) McKnight activity was from 1955 to 1965 and later during the 1970's.

A 20-acre ($81\times10^3$-m$^2$) infill program was begun in 1979. By the 1981 cutoff date, 56 infill wells had been drilled, with most of them being dually completed in both reservoirs. As expected, these wells found stringers that were pressure depleted but also found stringers that

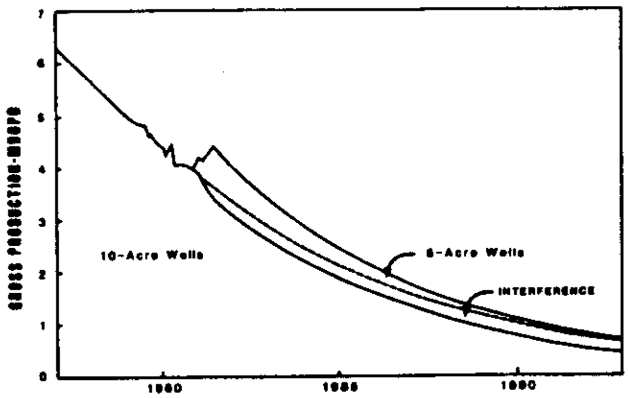


Fig. 16—Production datagraph—Hewitt Unit, Hewitt field (OK).

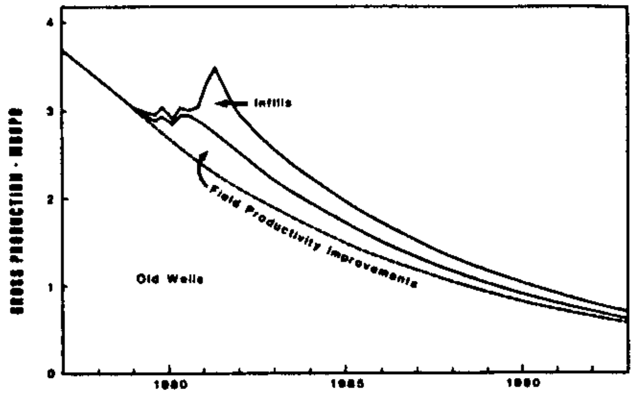


Fig. 17—Production datagraph—Loudon field (IL).

were only partially depleted or had not been penetrated by other wells. Forty-acre ($162 \times 10^3$-m$^2$) development had continued until the time when the 20-acre ($81 \times 10^3$-m$^2$) infill program began. Thus, a substantial amount of total production was flush production from recently drilled wells. Production from the older 40-acre ($162 \times 10^3$-m$^2$) locations, those drilled before 1975, was 5.5 B/D (0.87 m$^3$/d) oil from the McKnight and 5.3 B/D (0.84 m$^3$/d) oil from the Tubb. Remaining reserves from these wells were about 9,000 bbl (1431 m$^3$) per well.

Fig. 15 shows both the performance of the 20-acre ($81 \times 10^3$-m$^2$) infills and offset 40-acre ($162 \times 10^3$-m$^2$) wells, including the recently drilled ones. During 1981, the infills produced 45% of the total production. Performance to date indicates they will ultimately produce 1.6 million bbl ($2.5 \times 10^5$ m$^3$) of additional oil or 28,400 bbl (4516 m$^3$) per well. This recovery compares favorably with the estimated remaining 9,000 bbl (1430 m$^3$) per well from the older 40-acre ($162 \times 10^3$-m$^2$) wells. Because of the extreme lenticularity of these reservoirs and difficulty in obtaining reliable porosity data, good values for OOIP are not available.

### Hewitt Field

The Hewitt field, located in Carter County, OK, was discovered in 1919. Production is from 22 Pennsylvanian Hoxbar and Deese sand intervals, with a gross thickness of over 1,500 ft (457 m). The many sand intervals are separated by shale zones. Average depth to the top of the first pay interval is about 2,000 ft (610 m). The sands have an average porosity of 21% and an average permeability of 184 md. Oil viscosity in this reservoir is 8.7 cp (8.7 mPa·s). In the area of infill drilling, the original spacing was 2.5 acres ($10 \times 10^3$-m$^2$). After the field was unitized for secondary recovery operations, many of the old wells were plugged and the field was redrilled on 10-acre ($40.5 \times 10^3$-m$^2$) spacing. A fieldwide 20-acre ($81 \times 10^3$-m$^2$) five-spot water injection project was begun.[7] Fifteen five-acre ($20 \times 10^3$-m$^2$) infills have been drilled and their impact is shown in Fig. 16. The infills account for 23% of current unit production. Our analysis indicates about 60% of the wellbore reserves will be increased recovery and will total about 400,000 bbl ($6.4 \times 10^4$ m$^3$) from the 15 wells.

The performance of the best well of these infills is a good example of the erratic nature of the porosity development and fluid-flow characteristics of this reservoir. This well potentialed for 414 B/D (65.8 m$^3$/d) oil with a 50% water cut, although one offset was producing 44 B/D (7.0 m$^3$/d) oil with a 96% water cut, and the other was producing only 7 B/D (1.1 m$^3$/d) oil with a 99% water cut. Overall project water cut is 97%. This type of result was obtained in a reservoir that was developed on 2.5-acre ($10 \times 10^3$-m$^2$) spacing with a 20-acre ($81 \times 10^3$-m$^2$) five-spot pattern.

### Loudon Field

The Loudon field, discovered in 1937, is located in Fayette and Effingham Counties, IL, and produces from four Mississippian sandstones, the Weiler, Paint Creek, Bethel, and Aux Vases, at an average depth of 1,500 ft (457 m). Average porosity is 19%, and average permeability is about 100 md. The oil viscosity is 5 cp (5 mPa·s). The northern half of the field was drilled on 20-acre ($81 \times 10^3$-m$^2$) spacing in a sunflower pattern. The southern half of the field was drilled on 10-acre ($40.5 \times 10^3$-m$^2$) spacing. Waterflooding began in the early 1950;s, with the north half of the field on a 70-acre ($283 \times 10^3$-m$^2$) nine-spot pattern and the south half on a 20-acre ($81 \times 10^3$-m$^2$) five-spot pattern. Subsequently, injection wells were drilled in 10-acre ($40.5 \times 10^3$-m$^2$) "dead" spots that are characteristic of the sunflower pattern, thus creating 10-acre ($40.5 \times 10^3$-m$^2$) five-spot patterns. Producing water cut is now 98%.

Beginning in 1979, 50 infill wells have been drilled in the 20-acre ($81 \times 10^3$-m$^2$) development area. These infills were drilled at the intersection of a line between 20-acre ($81 \times 10^3$-m$^2$) producing wells and a line connecting offset injection wells. This is a dead area in the flood pattern, and it was thought that these areas had been inadequately flooded. Initial production ranged from 131 B/D (20.8 m$^3$/d) oil to 3.4 B/D (0.54 m$^3$/d) oil, with the average being 25 B/D (4.0 m$^3$/d) oil. Offsets were producing less than 4 B/D (0.6 m$^3$/d) oil average prior to the drilling of the infill wells. Fig. 17 shows the impact of drilling these 50 infills. At the time of analysis these wells were producing about 600 B/D (95.4 m$^3$/d) oil or 18% of total field production.

Because of their location and the stage of depletion of the field, essentially all production from these wells is considered increased recovery. These infills are expected to increase oil reserves by 970,000 bbl ($1.5 \times 10^5$ $m^3$).

## Conclusions

The conclusions formulated from this infill drilling study are as follows.

1. Infill drilling in nine fields has resulted in per-well-recovery improvements that are attractive under current economic conditions.
2. Increased oil recovery from the drilling of 870 infill wells in 9 fields ranges from 56% to 100% of their wellbore production.
3. Total additional reserves from these wells will be 60.8 million bbl ($9.7 \times 10^6$ $m^3$) oil.
4. Continuity calculations made after infill drilling indicated the pay zones to be more discontinuous than when calculations were made before infill drilling.
5. The experience in these nine fields indicates that the ultimate well density in any given field can be determined only after several years of field performance provide sufficient information on reservoir continuity and recovery efficiencies.

## Acknowledgments

We thank the many persons who made this paper possible by supplying data, preparing graphics, and typing the manuscript.

## References

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7. Ruble, David B.: "Case Study of a Multiple Sand Waterflood, Hewitt Unit, OK," *J. Pet. Tech.* (March 1982) 621-27.

## SI Metric Conversion Factors

| | | | |
|---|---|---|---|
| acre | × 4.046 873 | E+03 | = $m^2$ |
| bbl | × 1.589 873 | E−01 | = $m^3$ |
| ft | × 3.048* | E−01 | = m |

*Conversion factor is exact.

JPT

Original manuscript received in Society of Petroleum Engineers office July 20, 1982. Paper accepted for publication Jan. 26, 1983. Revised manuscript received May 5, 1983. Paper (SPE 11023) first presented at the 1982 SPE Annual Technical Conference and Exhibition held in New Orleans, Sept. 26-29.

21 November 1986

Omega Hydrocarbons Ltd.
1300, 112 - 4 Ave. S.W.
CALGARY, Alta.

Attn: Mr. Richard Brekke

Dear Sir:

In regards to the meeting held with yourself on November 14, 1986 we wish to confirm our position relative to the injector locations. Enron Oil Canada, Ltd. proposes a change in the injection pattern locations from the initial application. The new locations would be; 5-4-2-25 WPM, 11-4-2-25 WPM, 15-4-2-25 WPM and 16-5-2-25 WPM. Considering the similar recoveries from our previous two forecasts i.e. the initial Enron Pattern (injectors 3-4, 12-4, 15-4 and 16-5) and the standard pattern, we feel that the new injector locations will not reduce the ultimate recoveries and to confirm this we will run the model for verification. We anticipate that these changes will significantly reduce the negative impact on the offset lands. If Omega is agreeable to this arrangement and therefore willing to waive the previous objection please indicate in writing.

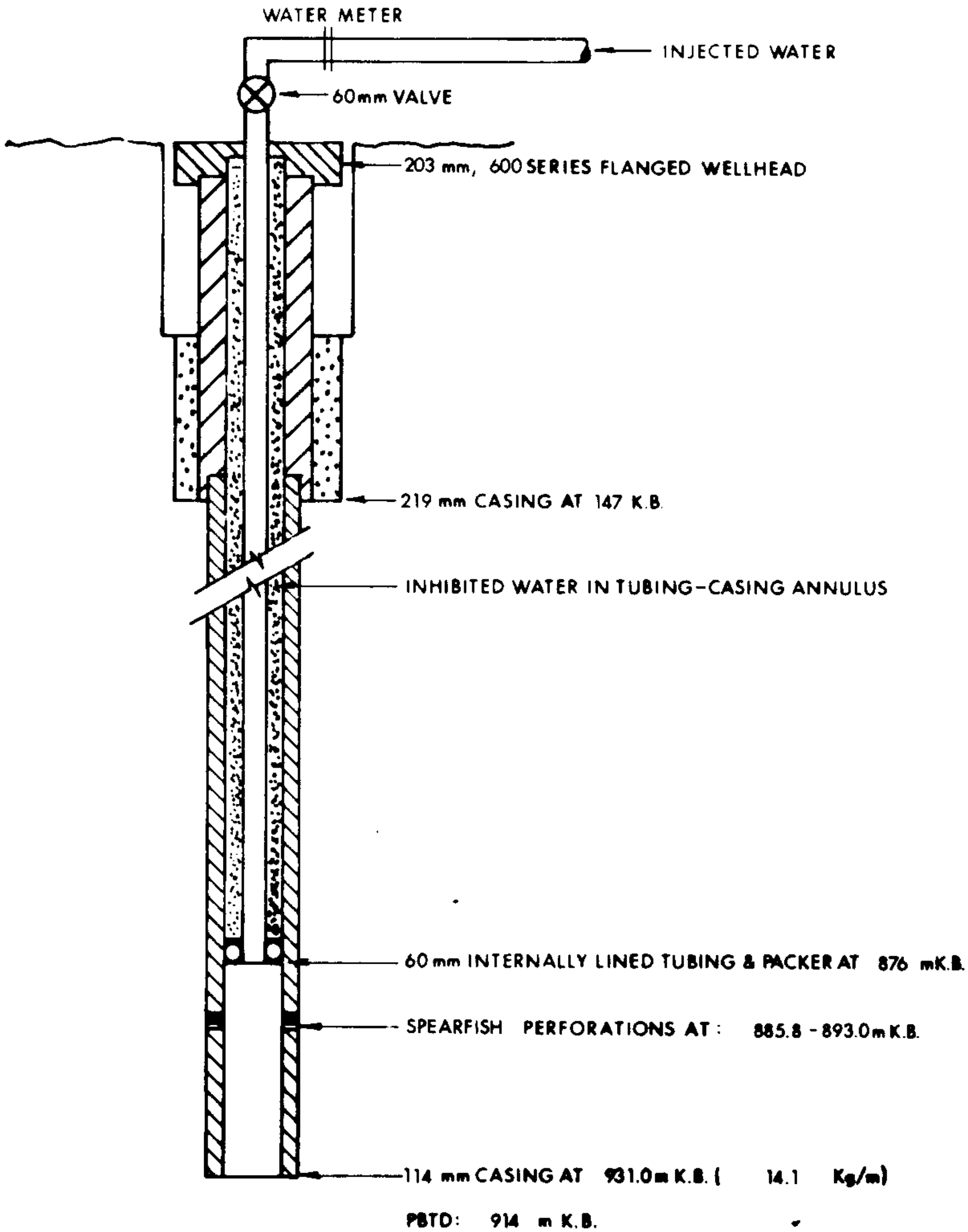
Yours truly,

ENRON OIL CANADA, LTD.

Rick A. Smith
Senior Reservoir Engineer

RAS/njg

# PROPOSED INJECTION WELL SUBSURFACE EQUIPMENT



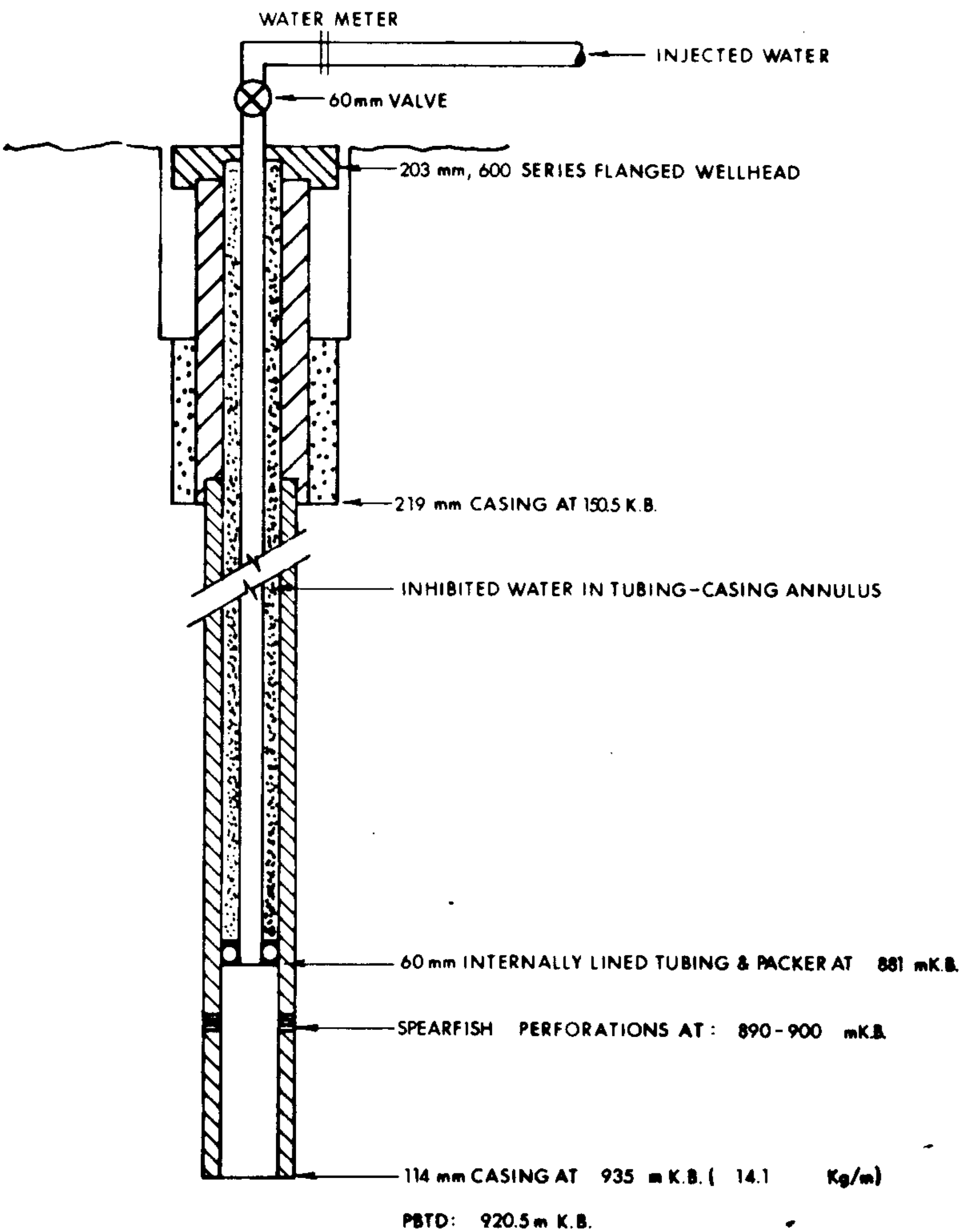

**ANDEX OIL CO. LTD.**

1501, 500 - 4th AVENUE S.W., CALGARY, ALBERTA PH: 403/261-2040

SCHEMATIC DIAGRAM
ANDEX ET AL WASKADA
11-4-2-25 WPM

| | | |
|---|---|---|
| DATE: 21-11-86 | BY: T. McKAY | FILE NO: |
| SCALE: NTS | REVISIONS: | |

# PROPOSED INJECTION WELL SUBSURFACE EQUIPMENT

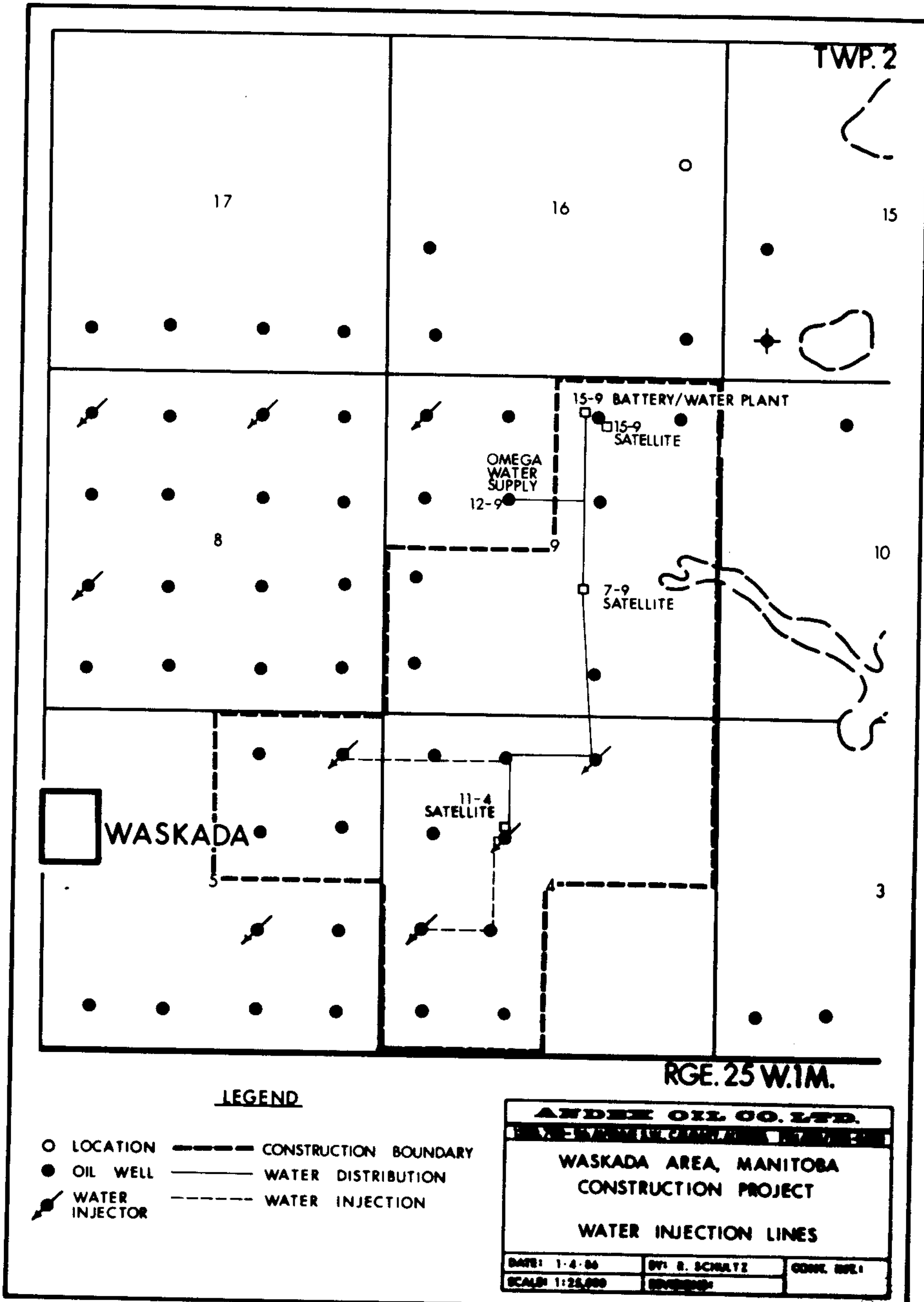



ANDEX OIL CO. LTD.

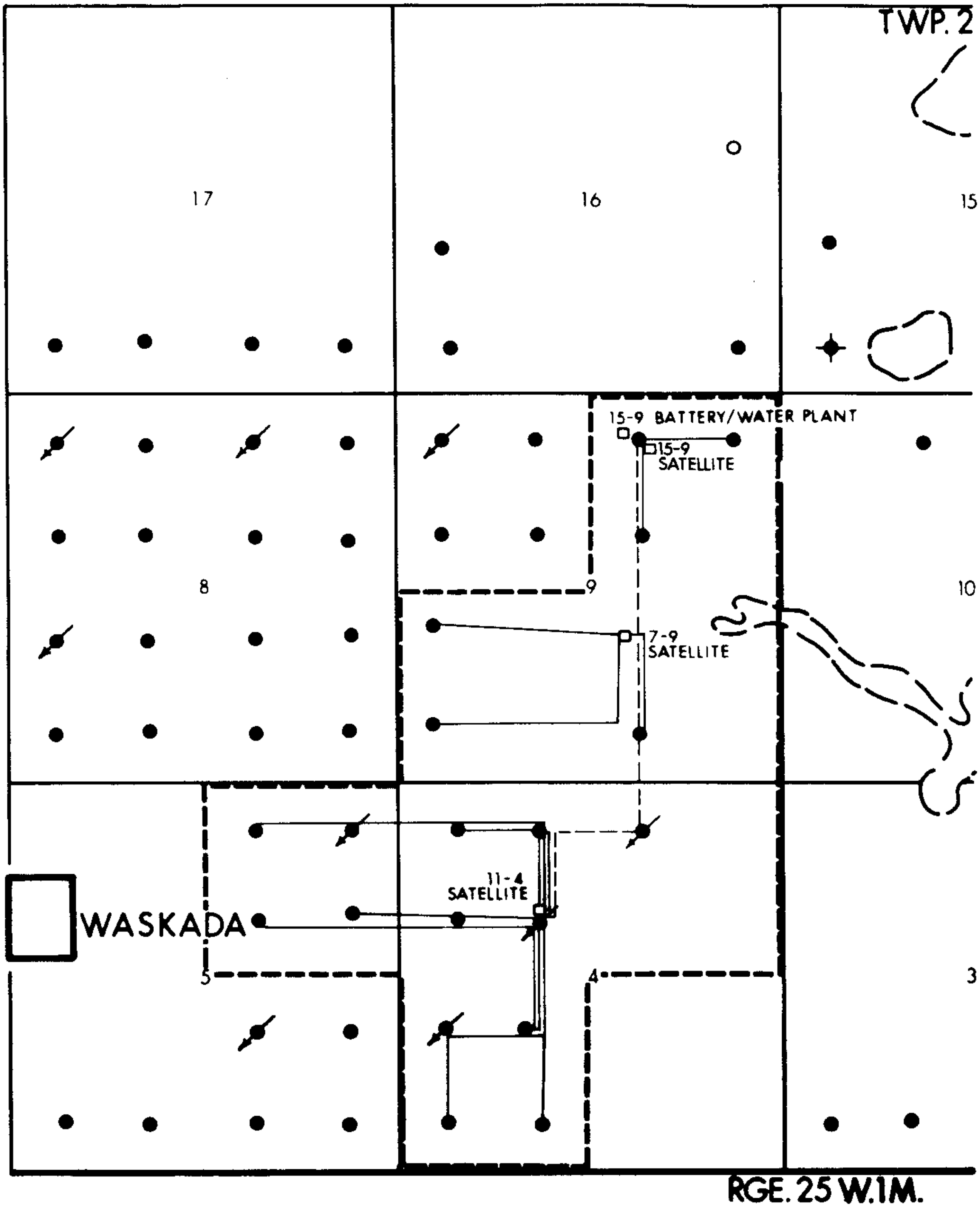
CALGARY

SCHEMATIC DIAGRAM
ANDEX ET AL WASKADA
5-4-2-25 WPM

| | | |
|---|---|---|
| DATE: 21-11-86 | BY: T. McKAY | FILE NO: |
| SCALE: NTS | REVISIONS: | |


TWP. 2
17
16
15
15-9 BATTERY/WATER PLANT
15-9
SATELLITE
OMEGA
WATER
SUPPLY
12-9
8
9
10
7-9
SATELLITE
11-4
SATELLITE
WASKADA
5
4
3
RGE. 25 W.1M.
LEGEND
LOCATION
OIL WELL
WATER
INJECTOR
CONSTRUCTION BOUNDARY
WATER DISTRIBUTION
WATER INJECTION
WASKADA AREA, MANITOBA
CONSTRUCTION PROJECT
WATER INJECTION LINES
SCALE: 1:25,000

MAP No. 3




LEGEND

- ○ LOCATION — CONSTRUCTION BOUNDARY (heavy dashed line)
- ● OIL WELL — OIL FLOWLINE (solid line)
- WATER INJECTOR — OIL GROUP LINE (dashed line)

ANDEX OIL CO. LTD.
[illegible]

WASKADA AREA, MANITOBA
CONSTRUCTION PROJECT

FLOWLINES

| | | |
|---|---|---|
| DATE: 1·4·86 | BY: R. SCHULTZ | CONT. INT.: |
| SCALE: 1:25,000 | REVISIONS: | |

OMEGA
HYDROCARBONS LTD.

1300 SUN LIFE PLAZA III
112 - 4th AVENUE S.W.
CALGARY, ALBERTA, CANADA T2P 0H3
TELEPHONE (403) 261-0743



November 28, 1986

Enron Oil Canada Ltd.
1300, 112 - 4th Avenue S.W.
Calgary, Alberta
T2P 3V4

**Attention: Mr. R. A. W. Smith, P. Eng.**
**Senior Reservoir Engineer**

Dear Sir:

**Re: Intervention To An Application By Enron Oil Canada Ltd. For Pressure Maintenance In Waskada Unit No 16**

Following a review of your recently completed reservoir model study, Omega Hydrocarbons Ltd. is of the opinion that the model study results support the concerns outlined in our intervention letter. However, based on a proposed change in injection well locations from 3-4, 12-4, 15-4 and 16-5-2-25 WPM to 5-4, 11-4, 15-4 and 16-5-2-25 WPM, we feel these concerns would be minimized. Attachments 1 and 2 illustrate the changes to the overswept and underswept areas effected by the proposed pressure maintenance project.

Omega Hydrocarbons Ltd. is willing to withdraw its intervention subject to the Manitoba Oil and Natural Gas Conservation Board approving the proposed pressure maintenance project with the revised injection well locations. We prefer to let our formal invention stand until the Board has completed its review in the event further modifications are required which impact on our decision.

It should also be noted that this letter in no way implys that our opinion of the detrimental effects caused by off pattern injection has changed. In this regard we intend to recommend to the Board that the pressure maintenance approval for Waskada Unit No. 16 contain a clause which specifically addresses the situation of premature water breakthrough caused by an off pattern injector.

Considering the negative impact that this senario could have on an offsetting pressure maintenance project we feel the best strategy would be to temporarily suspend injection at the suspect well until a course of action was jointly agreed upon.

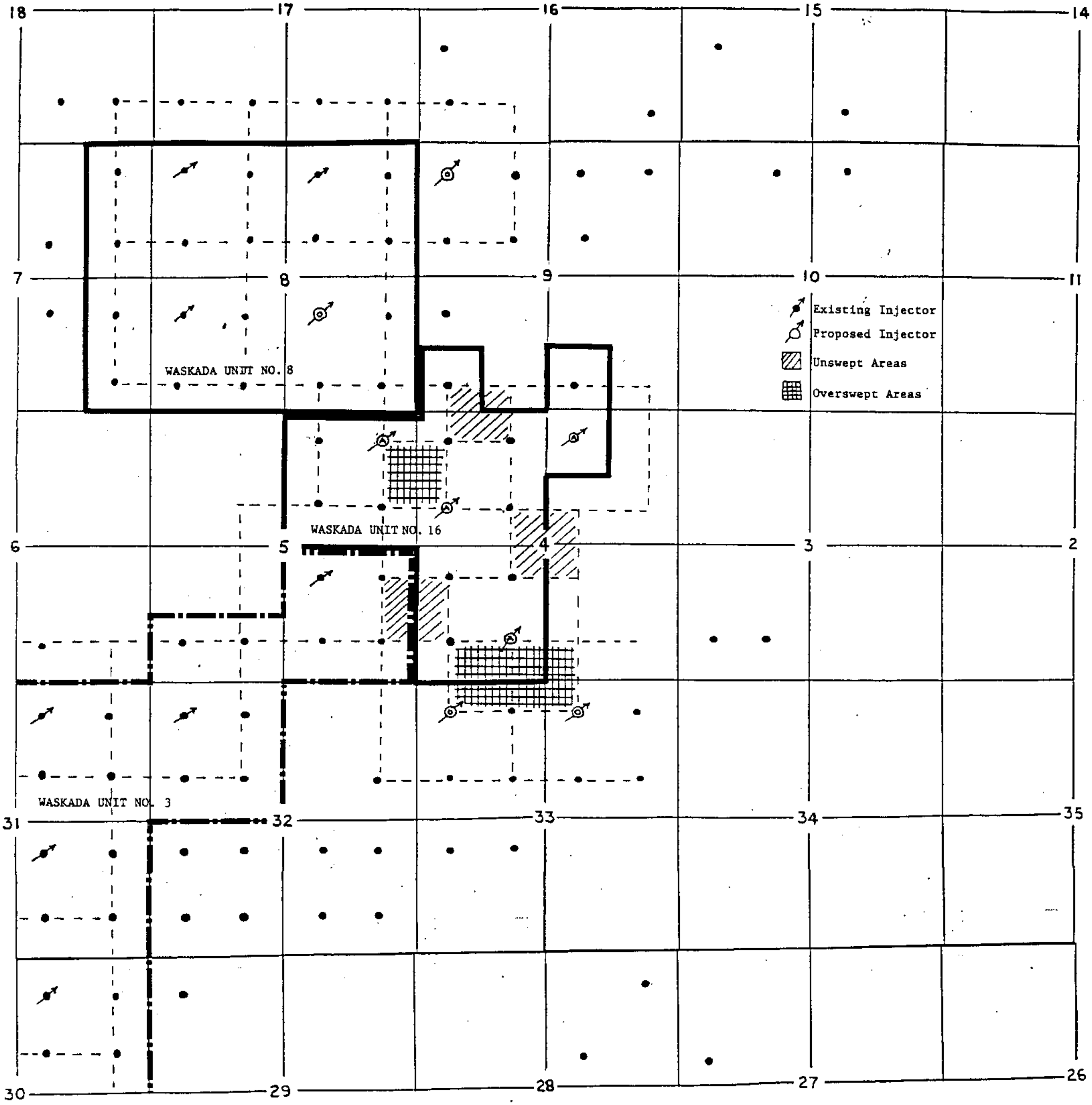
Yours truly,

OMEGA HYDROCARBONS LTD.

G. E. Patey
Vice President - Production

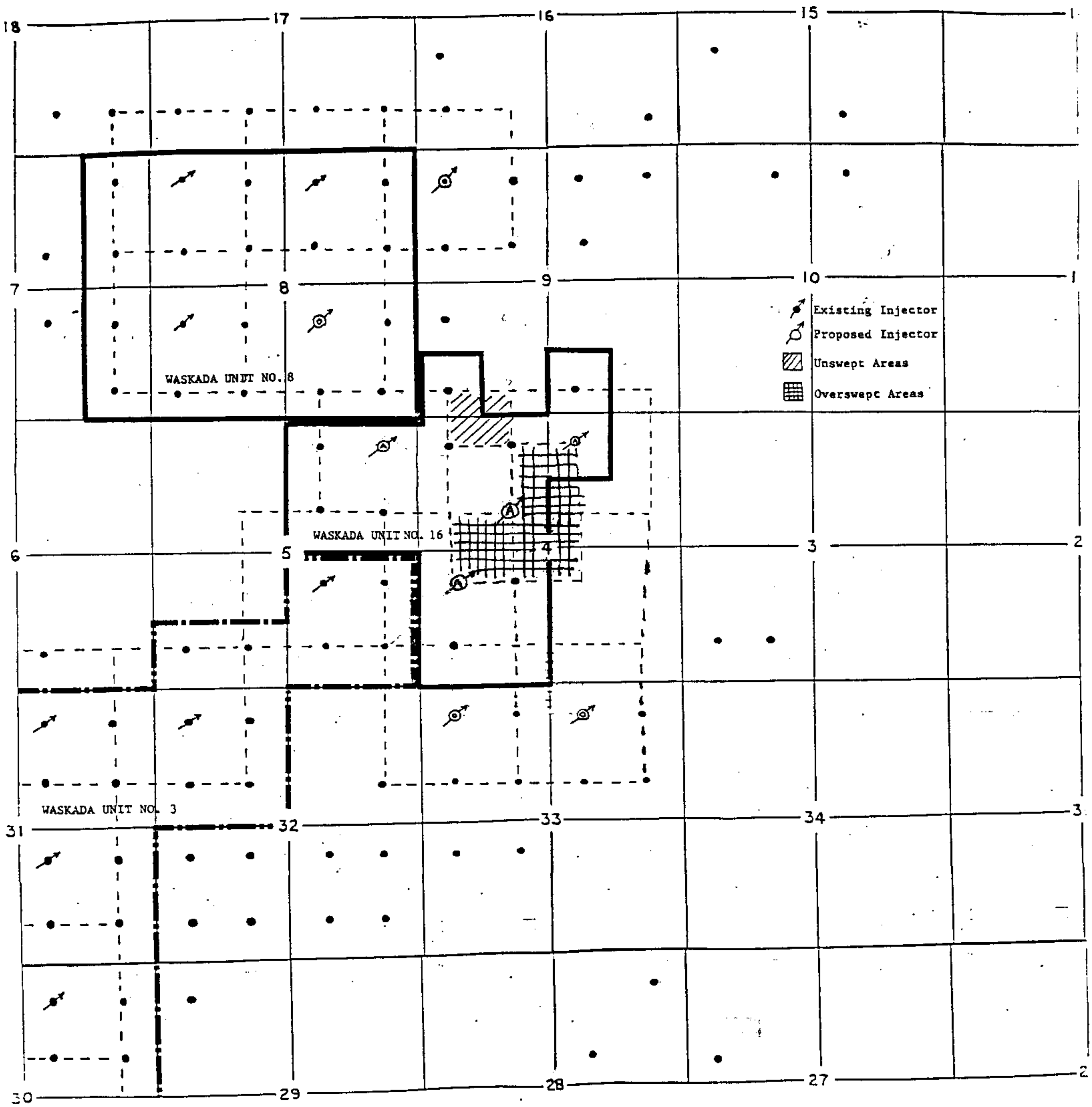
cc: Bob Dubreuil - Manitoba Petroleum Branch
Other Waskada Pressure Maintenance
Applications File

# The Detrimental Effects Caused By Off Pattern Injection In Waskada Unit No. 16 (Injectors 3-4, 12-4, 15-4 and 16-5-2-25 WPM)



Attachment 2

The Detrimental Effects Caused
By Off Pattern Injection
In Waskada Unit No. 16
(Injectors 5-4, 11-4, 15-4 and 16-5-2-25 WPM)



# WATERFLOOD STUDY
# WASKADA LOWER AMARANTH ZONE
# PROPOSED UNIT NO. 16

October 1986

Prepared by:

R.A.W. Smith, P.Eng.

T. Mckay, EIT

WATERFLOOD STUDY

WASKADA LOWER AMARANTH ZONE

PROPOSED UNIT NO. 16

Table of Contents

## DISCUSSION - MODEL DEVELOPMENT

### General Input Data

Much of the input data was previously discussed in the "Preliminary Engineering Study - Proposed Waskada Lower Amaranth Unit No. 16 - July 1986". A few amendments should be noted.

i) The relative permeability curves and capillary pressure curve have been updated to reflect the newer curves as used by Omega Hydrocarbons Ltd. (Irreducible Water Saturation = 0.37). Figures 1 through 3 exhibit the new curves used. The relative permeability curves from the Omega 1985 study were used for this study. The correlation curves were generated to have the same end points as the 1983 Omega curves.

ii) The oil-in-place and gas-in-place values are updated to reflect the new relative permeability curves and subsequent modified history match; also adding data for new wells 3-4 and 2-9; and finally, adding 4-9 to the Proposed Unit Area.

The hydrocarbon values for both the area of application and the study area are summarized as follows:

| Scheme Area | | Simulation Study Area |
|---|---|---|
| Area (acres) | 563 | 2,100 |
| Oil-in-place (MSTB) | 10,419 | 24,218 |
| Gas-in-place (MMscf) | 3,000 | 6,973 |
| Free gas-in-place (MMscf) | 0 | 0 |

### Grid Data

To recapitulate, the numerical grid (see Map 1) is a seventeen by twenty-one by three layer model. Rather than trying to model the specific lenses which vary areally and vertically, a generalist approach using three categories of permeability were used; thus three layers representing good, medium and poor permeability rock. Table 1 illustrates the actual numbers. The average of the three layers was calculated to represent the average horizontal permeability of the cored interval. The three layers were modelled with no vertical communication, thus simulating an effective anhydrite lens between each zone.

The net pay values were calculated as discussed in the previous report and presented again on Table 1. The three zones were each given an equal share of the total net pay.

The net pay and horizontal permeabilities were then adjusted to achieve the history match (discussed below) and compared to the original data as shown on Table 1.

The rock data, implemented into the model as the various grid arrays (layers 1 through 3) can be found in Exhibit A.

## DISCUSSION - HISTORY MATCH

A general summary of the assumptions and parameters used in the history match is presented as Table 1 of Exhibit A.

### Pressure Data

8672 kPa

An initial pressure was unavailable so the value of 1,258 psia as used in the CMG study was adopted. At the end of spring breakup 1986 with three months of shut in, four static gradients were run May 29-30, 1986, as well as several acoustic pressure surveys for the entire suite of wells within the study area. Table 2 is a summary of the pressure data; data in the last two columns will be used to history match the shut in period of the pool.

Data from Table 2 is also shown on Maps 2 and 3.

The pressure survey data, corrected to a pool datum of 1,444 ft SS (-440 m SS) and compared to the final history match results is shown on Table 3. Because of the long shut in time, the correction for simulation modelling as suggested by Peaceman was not applicable.

## Production Data

GOR values are not measured but water cut data can be used in the history matching directly if the well was "stress fraced only" and otherwise the water cut data was reviewed with consideration of communication with the Mississippian water zone. Map 4 summarizes the August 1986 water cut performance and identifies which wells were fraced with only a stress frac. The wells with only a stress frac are stimulated only in the very near wellbore region thus eliminating any chance of communicating with the Mississippian. The water cuts reflect this and leads to the conclusion that in this region of the pool, ie. model study area, the mobile water is reasonably low and water production yielding a water cut greater than 10% to 15% is suspect of communication. Table 3 summarizes the field and model water cut comparisons for August and September of 1986.

## Injection Data

The only producer converted to an injector by July 31, 1986 was 15-8. The rates used were those prior to May 1986 (available data) and carried forward.

## Grid Adjustments

The actual net pay and permeability data required to achieve a reasonable history match are shown as compared to the original calculated data on Table 1. In general, the net pay data was adjusted down from the calculated core value only if the log calculations indicated less pay and of course the adjustment was up if the log pay was higher than the core value. The net pay value of 10-5 on the boundary of the model, is unusually thick due to the uncompensated boundary effect, ie. to account for the undrilled (see Map 2) oil being drained from the west which isn't within the model, the net pay in that area had to be increased to produce the desired pressure match.

Net pay adjustments were always made equally to all three layers. Adjustments to permeability values were made to all three layers if possible, otherwise to only one or two to achieve the appropriate match.

## DISCUSSION - FORECASTS OF PRIMARY AND WATERFLOOD

The August and September productivity of the wells was matched to the actual field data as the following table illustrates:

| | August (STB/D) | September (STB/D) |
|---|---|---|
| Field | | |
| Enron Non-Unit | 48 | 54 |
| Unit No. 16 | 421 | 368 |
| Model | | |
| Enron Non-Unit | 49 | 59 |
| Unit No. 16 | 454 | 362 |

### Primary Forecast

The criteria (assumptions and parameters) used for the primary forecast is included as Table 1 of Exhibit B. Because there is some benefit from the Omega operated injector 15-8 and future conversions 13-9, 7-8 and 7-5, the primary case was run again (Primary B) with the intent to demonstrate actual recovery under a full primary only situation. To accomplish this all the proposed Omega injectors were not converted but remained as producers. Location 15-8 which had been injecting for ten months during the history match phase was turned off for the Primary B forecast. The recovery after thirty-five years of Primary A and Primary B was 11.8% and 8.8% respectively. A summary table of the production and injection forecast is also included in Exhibit B along with the graphical counterparts exhibiting oil rate and cumulative production versus time. Figures 4 through 6 show the comparison between the two primary cases.

**Waterflood A Forecast** (Enron initial injector locations)

A summary of forecast criteria is found in Exhibit C. The cumulative reservoir voidage at the commencement of injection (January 1, 1987) is about 200 MRB. Percentage recovery after ten years and thirty-five years is 12.5% and 24.2% respectively.

A summary table of the production and injection forecast is also included in Exhibit C along with the graphical counterparts. Figures 7 through 9 display the comparison between the three waterflood cases respecting recoveries and oil rates.

**Waterflood B Forecast** (standard pattern)

Reference to Exhibit D will give the forecast criteria. Cumulative voidage to commencement of water injection is of course the same as Pattern A above. Recovery after ten years and thirty-five years is 13.0% and 26.3% respectively. Comparisons to Case A and C are founded on Figures 7 through 9. Additional detail of the production and injection volumes of the forecast are presented in Exhibit D.

**Waterflood C Forecast** (Enron final injector locations)

Exhibit E presents the criteria used in the final waterflood forecast. Once again the cumulative voidage to commencement of water injection is the same as in Pattern A and B. The recovery after ten years is 12.6% while the extrapolated recovery to thirty-five years is 26.5%. For a comparison of all three cases refer to Figures 7 through 9.

TABLES

SIMCOMP.RES

# TABLE No. 1

WASKADA MANITOBA
SPEARFISH FORMATION
SIMULATION PARAMETERS

| WELL LOCATION | MID.PT PERFS (ft KB) | TOTAL CALCULATED NET PAY (ft) | NET PAY PER ZONE (ft) | LOG NET PAY PER ZONE (ft) | MODEL NET PAY PER ZONE (ft) | CORE POROSITY (%) | LOG POROSITY (%) | MODEL POROSITY (%) | CORE PERM. (Kh) (md)** | CALCULATED K(h) LAYER 1 | CALCULATED K(h) LAYER 2 | CALCULATED K(h) LAYER 3 | MODEL ADJUSTED K(x) LAYER 1 | MODEL ADJUSTED K(x) LAYER 2 | MODEL ADJUSTED K(x) LAYER 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-4-2-25W1 | 2939.6 | 23.8 | 7.9 | 4.74 | 4.80 | 18.8 | -- | 16.9 | 2.2 | 3.6 | 1.9 | 1.1 | 10.0 | 2.8 | 1.1 |
| 4-4-2-25W1 | 2944.6 | 14.8 | 4.9 | 4.92 | 3.20 | -- | 16.0 | 16.0 | -- | -- | -- | -- | 7.0 | 0.8 | 0.3 |
| 5-4-2-25W1 | 2936.4 | 18.7 | 6.2 | 6.23 | 3.40 | -- | 15.0 | 15.0 | -- | -- | -- | -- | 12.0 | 1.8 | 0.4 |
| 6-4-2-25W1 | 2921.6 | 11.9 | 4.0 | 3.97 | 2.00 | -- | 16.0 | 16.0 | -- | -- | -- | -- | 6.0 | 1.8 | 0.3 |
| 11-4-2-25W1 | 2918.0 | 38.1 | 12.7 | 3.31 | 2.90 | 15.8 | -- | 15.5 | 13.8 | 33.5 | 6.2 | 1.7 | 6.3 | 2.9 | 0.4 |
| 12-4-2-25W1 | 2913.4 | 8.6 | 2.9 | 2.88 | 2.00 | -- | 16.0 | 16.0 | -- | -- | -- | -- | 7.3 | 1.4 | 0.5 |
| 13-4-2-25W1 | 2901.9 | 26.6 | 8.9 | 6.01 | 15.90 | 15.8 | -- | 17.5 | 9.4 | 23.0 | 3.4 | 1.7 | 120.8 | 53.6 | 8.9 |
| 14-4-2-25W1 | 2923.2 | 21.4 | 7.1 | 7.14 | 15.80 | -- | 17.0 | 17.0 | -- | -- | -- | -- | 33.8 | 17.4 | 4.7 |
| 15-4-2-25W1 | 2924.9 | 44.8 | 14.9 | 7.71 | 2.70 | 16.3 | -- | 16.6 | 4.4 | 10.3 | 1.9 | 0.9 | 0.8 | 0.5 | 0.1 |
| 9-5-2-25W1 | 2919.9 | 13.2 | 4.4 | 4.41 | 5.30 | -- | 16.0 | 16.0 | -- | -- | -- | -- | 13.8 | 1.4 | 0.7 |
| 10-5-2-25W1 | 2919.9 | 9.0 | 3.0 | 4.12 | 23.50 | 12.9 | -- | 12.9 | 2.6 | 4.3 | 1.9 | 1.6 | 55.0 | 125.4 | 17.6 |
| 15-5-2-25W1 | 2929.8 | 14.9 | 5.0 | 2.15 | 2.10 | 15.1 | -- | 14.9 | 7.7 | 20.6 | 1.7 | 0.9 | 0.4 | 0.1 | 0.0 |
| 16-5-2-25W1 | 2923.2 | 23.5 | 7.8 | 2.05 | 4.70 | 16.0 | -- | 16.0 | 1.9 | 2.5 | 2.2 | 1.1 | 4.6 | 1.8 | 0.2 |
| 2-9-2-25W1 | 2919.9 | 29.6 | 9.9 | 5.33 | 7.20 | 14.3 | -- | 14.4 | 3.0 | 5.8 | 2.1 | 1.1 | 4.8 | 0.5 | 0.2 |
| 4-9-2-25W1 | 2911.7 | 29.2 | 9.7 | 2.19 | 3.40 | 13.0 | -- | 15.3 | 25.6 | 60.7 | 10.8 | 5.1 | 4.1 | 2.2 | 0.5 |
| 5-9-2-25W1 | 2906.8 | 40.8 | 13.6 | 3.36 | 7.20 | 15.2 | -- | 15.4 | 3.5 | 5.7 | 2.8 | 1.8 | 4.6 | 3.4 | 1.8 |
| 10-9-2-25W1 | 2900.3 | 9.4 | 3.1 | 3.14 | 2.80 | 16.3 | -- | 16.1 | 4.2 | 6.5 | 4.0 | 2.0 | 15.0 | 6.0 | 2.0 |
| 15-9-2-25W1 | 2896.3 | 14.4 | 4.8 | 4.81 | 3.00 | -- | 17.0 | 17.0 | -- | -- | -- | -- | 7.2 | 4.0 | 0.9 |
| 16-9-2-25W1 | 2893.7 | 19.6 | 6.5 | 9.08 | 3.80 | 17.0 | -- | 16.9 | 17.6 | 42.5 | 8.5 | 1.9 | 9.9 | 4.2 | 0.6 |

WASKPRES.SUM

# TABLE No. 2

## WASKADA PRESSURE SUMMARY

| WELL LOCATION | MAY 28 or JUNE 4 ACOUSTIC PRESSURE Pws (PSIA) | JUNE 10 or JUNE 17 ACOUSTIC PRESSURE Pws (PSIA) | JUNE 18 ACOUSTIC PRESSURE Pws (PSIA) | JUNE 23 ACOUSTIC PRESSURE Pws (PSIA) | JULY 31 ACOUSTIC PRESSURE Pws (PSIA) | STATIC GRADIENTS (PSIA) | ESTIMATED * ACTUAL PRESS. MAY 30 1986 Pws (PSIA) | ESTIMATED * ACTUAL PRESS. JULY 31 1986 Pws (PSIA) |
|---|---|---|---|---|---|---|---|---|
| 4-4-2-25W1 | 1022 | 1027 | --- | --- | --- | | 1022 | |
| 5-4-2-25W1 | 946 | 967 | --- | --- | 921 | | 946 | 921 |
| 6-4-2-25W1 | 991 | --- | 1007 | --- | --- | 989 | 989 | |
| 11-4-2-25W1 | 1087 | --- | 1169 | --- | --- | | 1087 | |
| 12-4-2-25W1 | 898 | 919 | --- | --- | --- | | 898 | |
| 13-4-2-25W1 | 929 | --- | 1245 | 1174 | --- | 1138 | 1138 | |
| 14-4-2-25W1 | 1141 | 1160 | --- | --- | --- | | 1141 | |
| 15-4-2-25W1 | 661 | 688 | --- | --- | 917 | | --- | 917 |
| 9-5-2-25W1 | 911 | --- | 915 | --- | 949 | 904 | 904 | 949 |
| 10-5-2-25W1 | 1173 | 1188 | --- | --- | --- | | 1173 | |
| 15-5-2-25W1 | 786 | 850 | --- | --- | 882 | | 840 | 882 |
| 16-5-2-25W1 | 939 | 927 | 973 | --- | --- | | 939 | |
| 4-9-2-25W1 | --- | 832 | 855 | --- | 889 | | 841 | 889 |
| 5-9-2-25W1 | --- | 1023 | 1020 | --- | --- | | 1020 | |
| 10-9-2-25W1 | --- | 919 | 1257 | 1247 | --- | | --- | |
| 15-9-2-25W1 | --- | 1091 | 1111 | --- | --- | | 1091 | |
| 16-9-2-25W1 | 1094 | --- | 1065 | --- | --- | 1046 | 1046 | |
| 14-10-2-25W1 | --- | --- | 1223 | --- | --- | | --- | |
| 5-15-2-25W1 | --- | --- | --- | --- | --- | | ** | |
| 10-15-2-25W1 | 1286 | 1294 | --- | --- | --- | | --- | |

NOTES : * AS OF JUNE 20/86
** WELL PRODUCED DURING TEST PERIOD

SIMCOMP.PRS

# TABLE No. 3

WASKADA MANITOBA
SPEARFISH FORMATION
FIELD VS MODEL PARAMETERS

| WELL LOCATION | MID.PT PERFS (ft KB) | MODEL MID-POINT DEPTH (ft) | FIELD PRESSURE MAY 31/86 (Psia) | MODEL PRESSURE MAY 31/86 (Psia) | FIELD PRESSURE JULY 31/86 (Psia) | MODEL PRESSURE JULY 31/86 (Psia) | FIELD AUG DAILY PRODUCTION (STB/DAY) | MODEL AUG DAILY PRODUCTION (STB/DAY) | FIELD AUG WATER CUT (%) | MODEL AUG WATER CUT (%) | FIELD SEPT DAILY PRODUCTION (STB/DAY) | MODEL SEPT DAILY PRODUCTION (STB/DAY) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-4-2-25W1 | 2939.6 | 2923.4 | -- | -- | -- | -- | 11.8 | 12.7 | 6.2 | 12.2 | 8.6 | 11.3 |
| 4-4-2-25W1 | 2944.6 | 2925.6 | 1042.8 | 1045.7 | -- | -- | 43.4 | 42.3 | 2.5 | 23.8 | 37.3 | 33.7 |
| 5-4-2-25W1 | 2936.4 | 2927.7 | 971.5 | 969.6 | 946.5 | 1012.6 | 67.9 | 79.3 | 8.8 | 19.2 | 54.3 | 57.7 |
| 6-4-2-25W1 | 2921.6 | 2918.0 | 1019.4 | 1014.7 | -- | -- | 54.7 | 67.7 | 5.7 | 19.7 | 48.9 | 32.0 |
| 11-4-2-25W1 | 2918.0 | 2919.5 | 1119.4 | 1120.8 | -- | -- | 13.8 | 14.7 | 4.6 | 11.7 | 12.6 | 13.3 |
| 12-4-2-25W1 | 2913.4 | 2918.0 | 931.5 | 937.8 | -- | -- | 30.2 | 35.7 | 13.7 | 9.4 | 26.0 | 28.3 |
| 13-4-2-25W1 | 2901.9 | 2930.0 | 1175.6 | 1166.4 | -- | -- | 20.1 | 21.0 | 52.3 | 16.1 | 17.7 | 19.7 |
| 14-4-2-25W1 | 2923.2 | 2923.9 | 1170.9 | 1176.6 | -- | -- | 18.9 | 20.0 | 9.5 | 7.9 | 18.4 | 18.7 |
| 15-4-2-25W1 | 2924.9 | 2918.4 | -- | 825.9 | 946.5 | 950.9 | -- | -- | -- | -- | -- | -- |
| 9-5-2-25W1 | 2919.9 | 2919.7 | 935.0 | 936.1 | 980.0 | 1018.1 | 74.2 | 84.0 | 11.8 | 7.5 | 65.6 | 66.7 |
| 10-5-2-25W1 | 2919.9 | 2930.8 | 1202.9 | 1193.9 | -- | -- | 8.2 | 8.3 | 10.0 | 16.0 | 15.8 | 8.0 |
| 15-5-2-25W1 | 2929.8 | 2921.1 | 867.6 | 878.7 | 909.6 | 887.7 | 18.2 | 24.3 | 30.3 | 19.5 | 10.7 | 13.3 |
| 16-5-2-25W1 | 2923.2 | 2928.4 | 968.0 | 971.1 | -- | -- | 12.6 | 13.3 | 22.6 | 28.6 | 12.2 | 12.3 |
| 2-9-2-25W1 | 2919.9 | 2923.6 | -- | -- | -- | -- | 46.5 | 49.0 | 9.2 | 8.0 | 39.8 | 47.0 |
| 4-9-2-25W1 | 2911.7 | 2922.7 | 875.0 | 866.0 | 923.0 | 952.0 | -- | -- | -- | -- | -- | -- |
| 5-9-2-25W1 | 2906.8 | 2919.6 | 1056.6 | 1059.9 | -- | -- | 2.5 | 2.3 | 91.0 | 15.7 | 4.7 | 2.3 |
| 10-9-2-25W1 | 2900.3 | 2918.4 | -- | 1165.9 | -- | -- | -- | -- | -- | -- | 14.0 | 13.7 |
| 15-9-2-25W1 | 2896.3 | 2918.5 | 1130.5 | 1130.5 | -- | -- | 18.9 | 20.6 | 3.4 | 11.1 | 11.2 | 18.0 |
| 16-9-2-25W1 | 2893.7 | 2911.9 | 1087.9 | 1082.3 | -- | -- | 26.4 | 27.7 | 5.7 | 5.0 | 24.2 | 25.0 |

NOTE : ALL PRESSURES CORRECTED TO A DATUM OF 1443.6 ft.(440.0m) SUBSEA

## FIGURES

FIGURE No 1

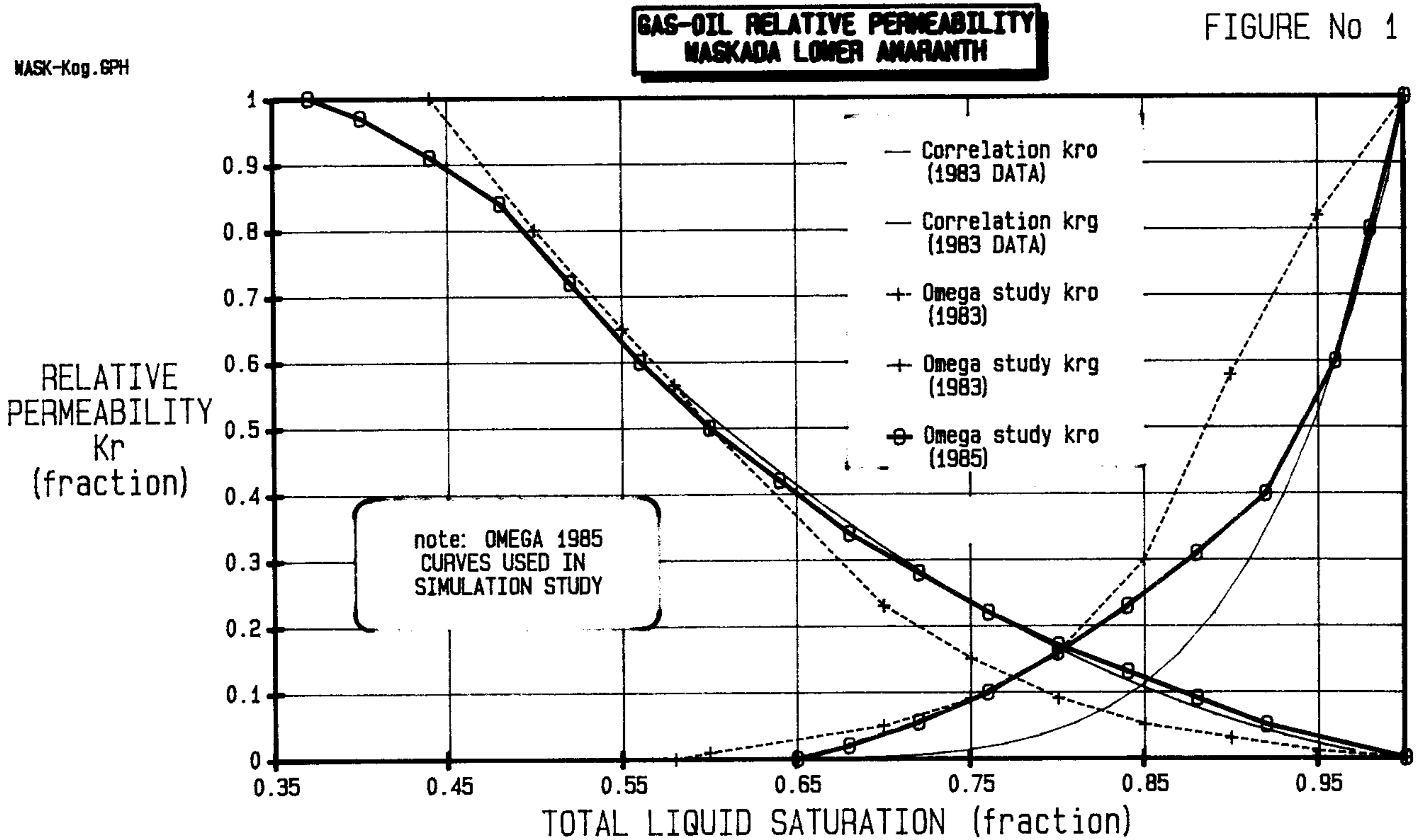
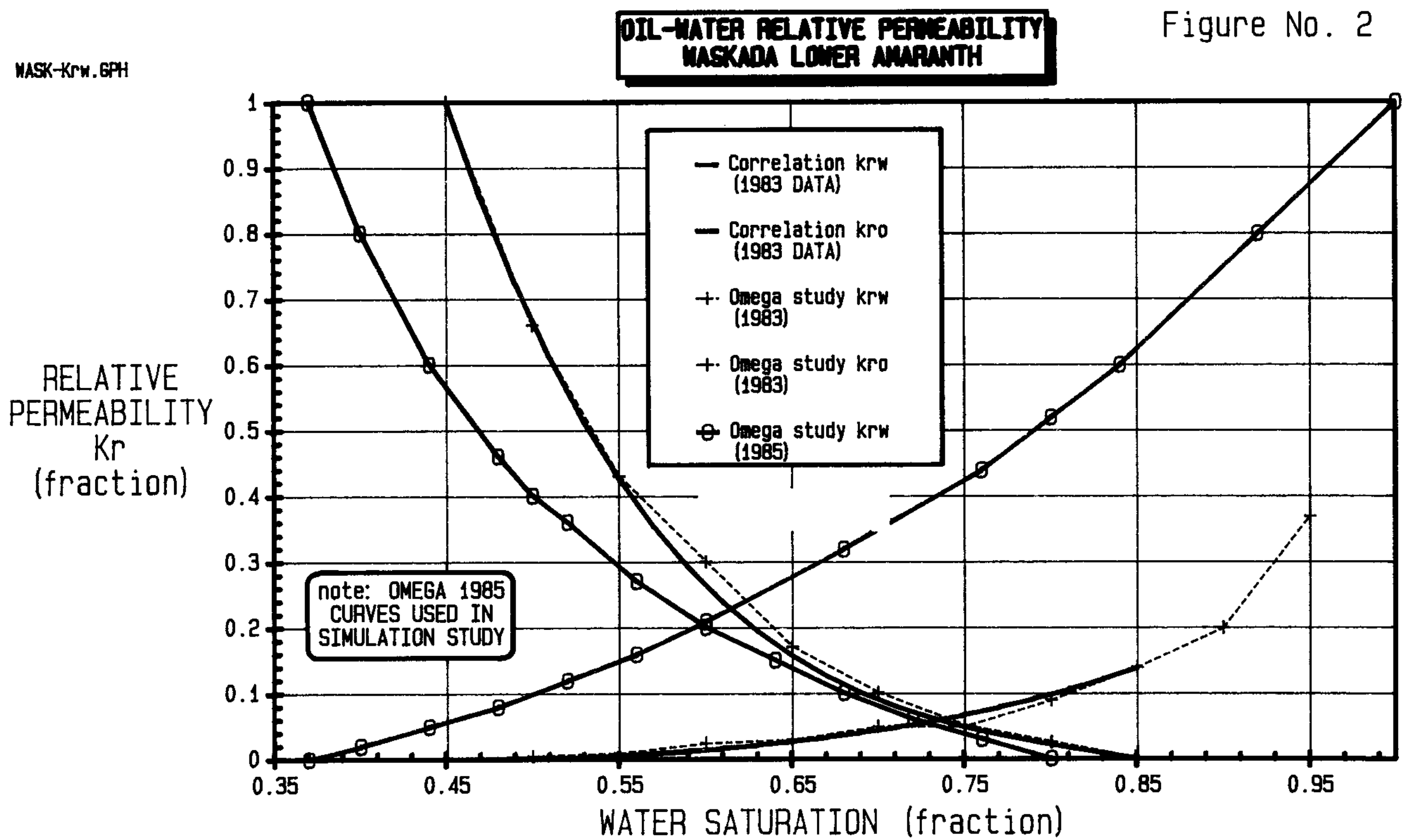

WASK-Kog.GPH
GAS-OIL RELATIVE PERMEABILITY
WASKADA LOWER AMARANTH
RELATIVE
PERMEABILITY
Kr
(fraction)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.35
0.45
0.55
0.65
0.75
0.85
0.95
TOTAL LIQUID SATURATION (fraction)
Correlation kro
(1983 DATA)
Correlation krg
(1983 DATA)
Omega study kro
(1983)
Omega study krg
(1983)
Omega study kro
(1985)
note: OMEGA 1985
CURVES USED IN
SIMULATION STUDY

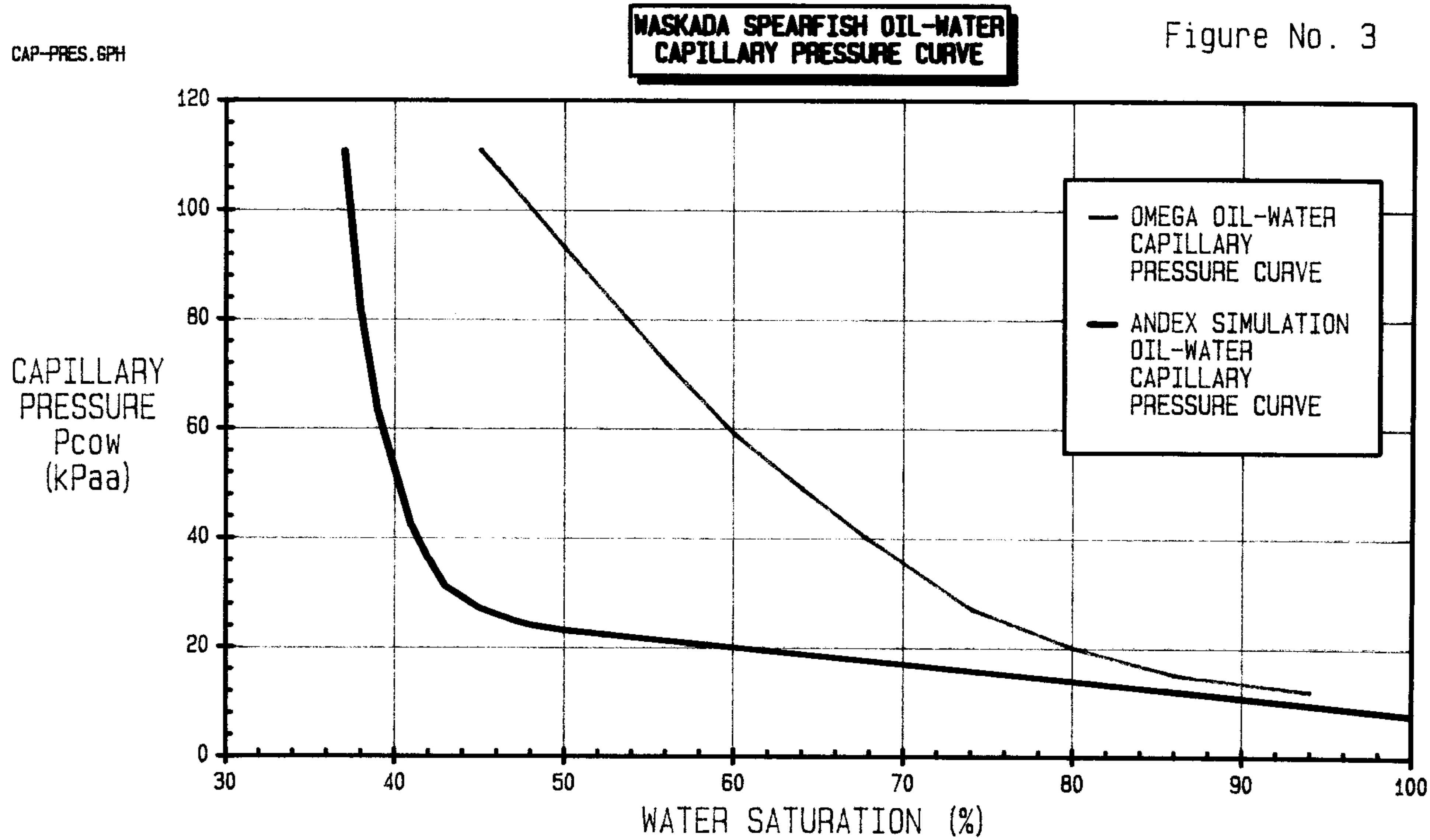
Figure No. 2



WASK-Krw.GPH
OIL-WATER RELATIVE PERMEABILITY
WASKADA LOWER AMARANTH
Correlation krw (1983 DATA)
Correlation kro (1983 DATA)
Omega study krw (1983)
Omega study kro (1983)
Omega study krw (1985)
note: OMEGA 1985 CURVES USED IN SIMULATION STUDY
RELATIVE PERMEABILITY Kr (fraction)
WATER SATURATION (fraction)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.35
0.45
0.55
0.65
0.75
0.85
0.95

CAP-PRES.GPH

Figure No. 3



WPRY%C.GPH

FIGURE No. 4

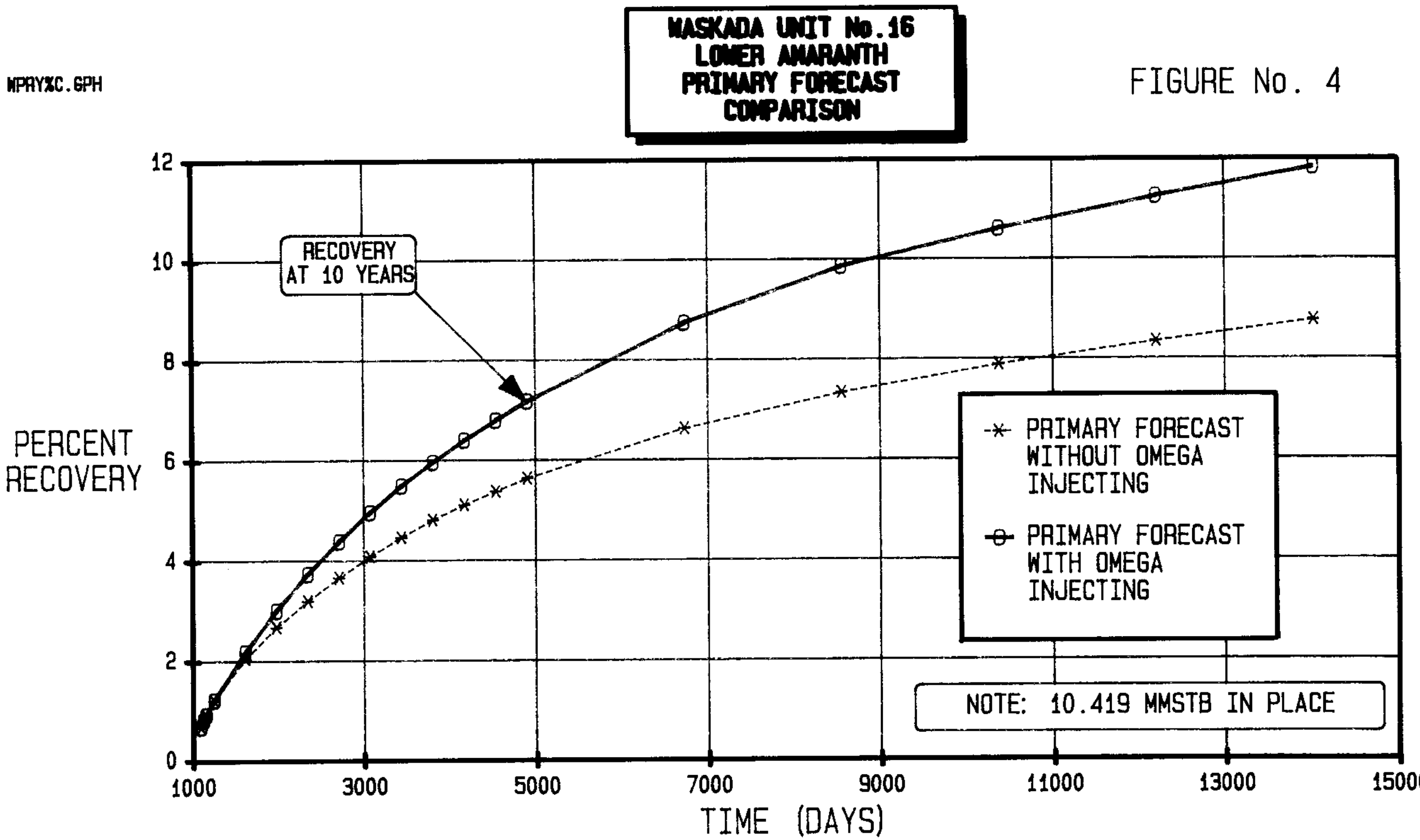


FIGURE No. 5

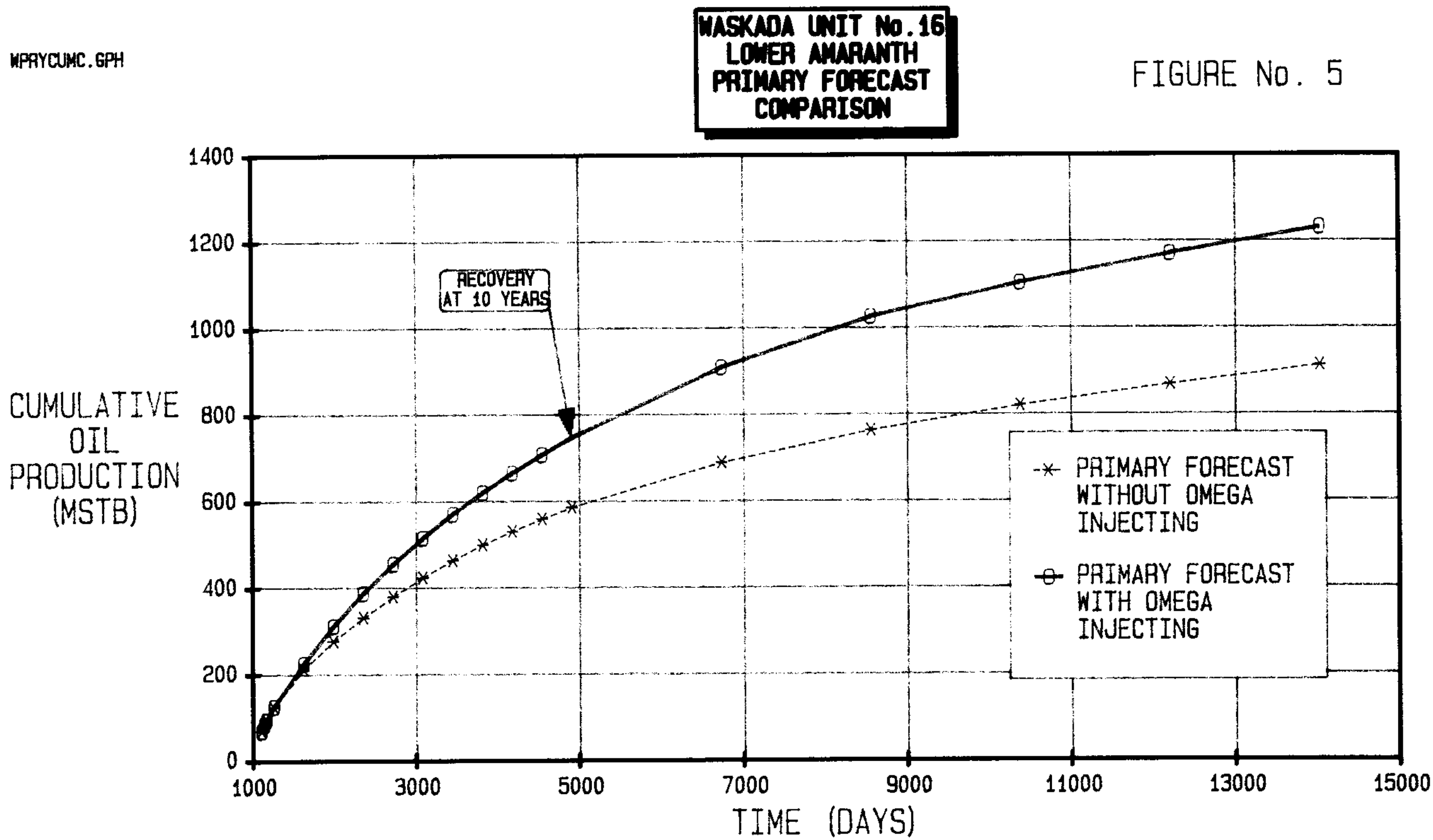
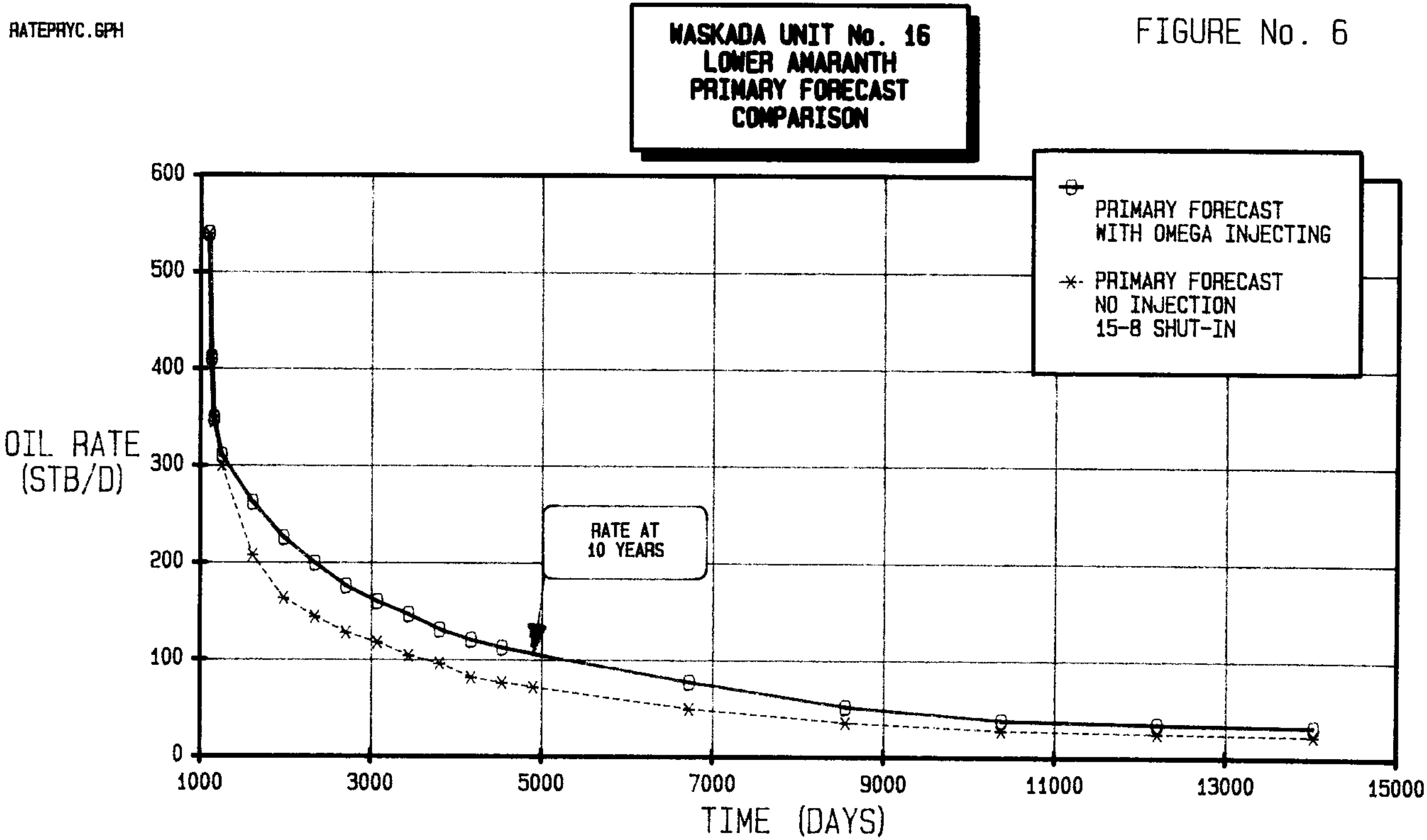

WPRYCUMC.GPH
WASKADA UNIT No.16
LOWER AMARANTH
PRIMARY FORECAST
COMPARISON
CUMULATIVE
OIL
PRODUCTION
(MSTB)
1400
1200
1000
800
600
400
200
0
1000
3000
5000
7000
9000
11000
13000
15000
TIME (DAYS)
RECOVERY
AT 10 YEARS
PRIMARY FORECAST
WITHOUT OMEGA
INJECTING
PRIMARY FORECAST
WITH OMEGA
INJECTING

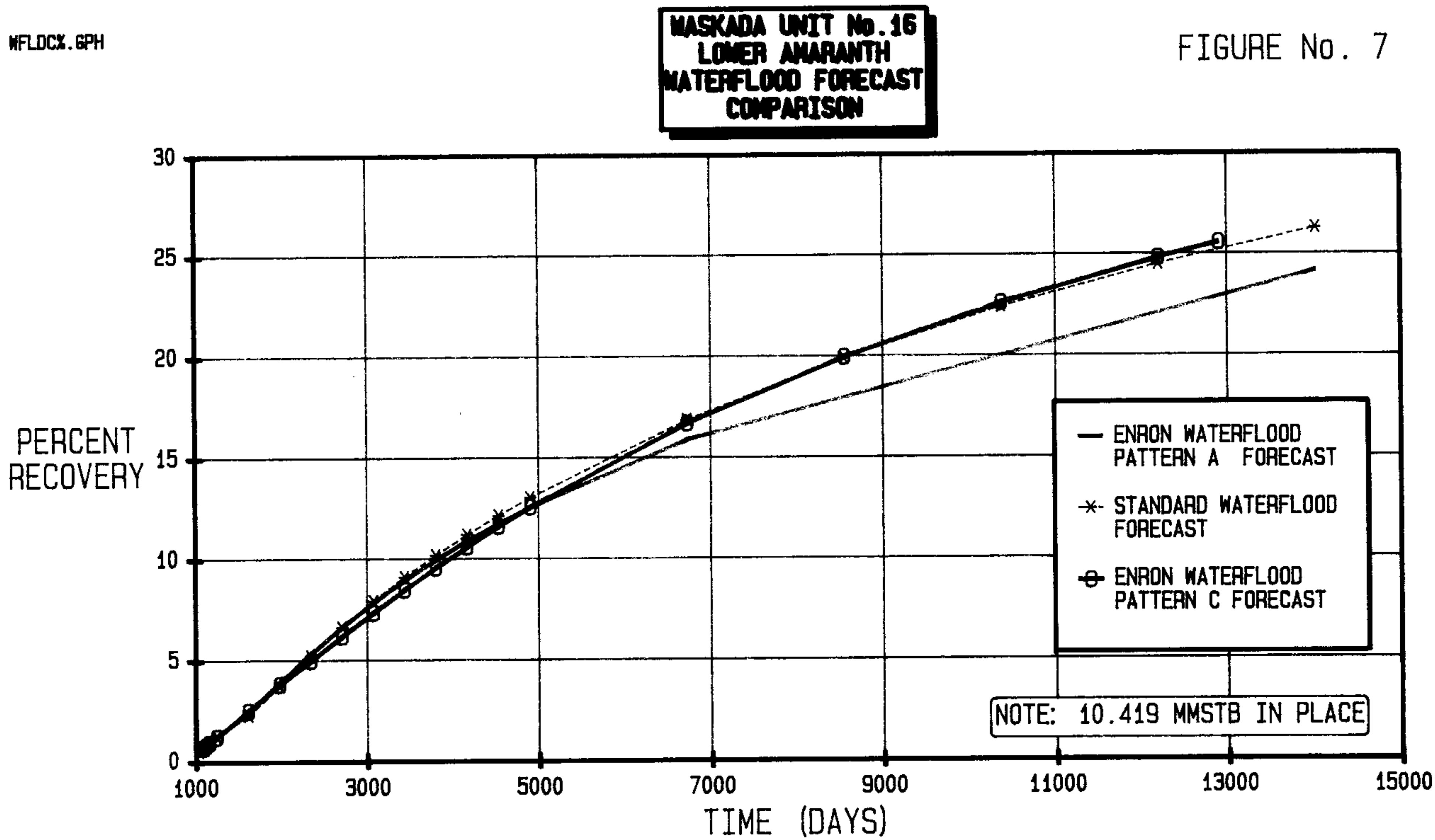
FIGURE No. 6



RATEPRYC.GPH
WASKADA UNIT No. 16
LOWER AMARANTH
PRIMARY FORECAST
COMPARISON
PRIMARY FORECAST
WITH OMEGA INJECTING
PRIMARY FORECAST
NO INJECTION
15-8 SHUT-IN
RATE AT
10 YEARS
OIL RATE
(STB/D)
600
500
400
300
200
100
0
1000
3000
5000
7000
9000
11000
13000
15000
TIME (DAYS)

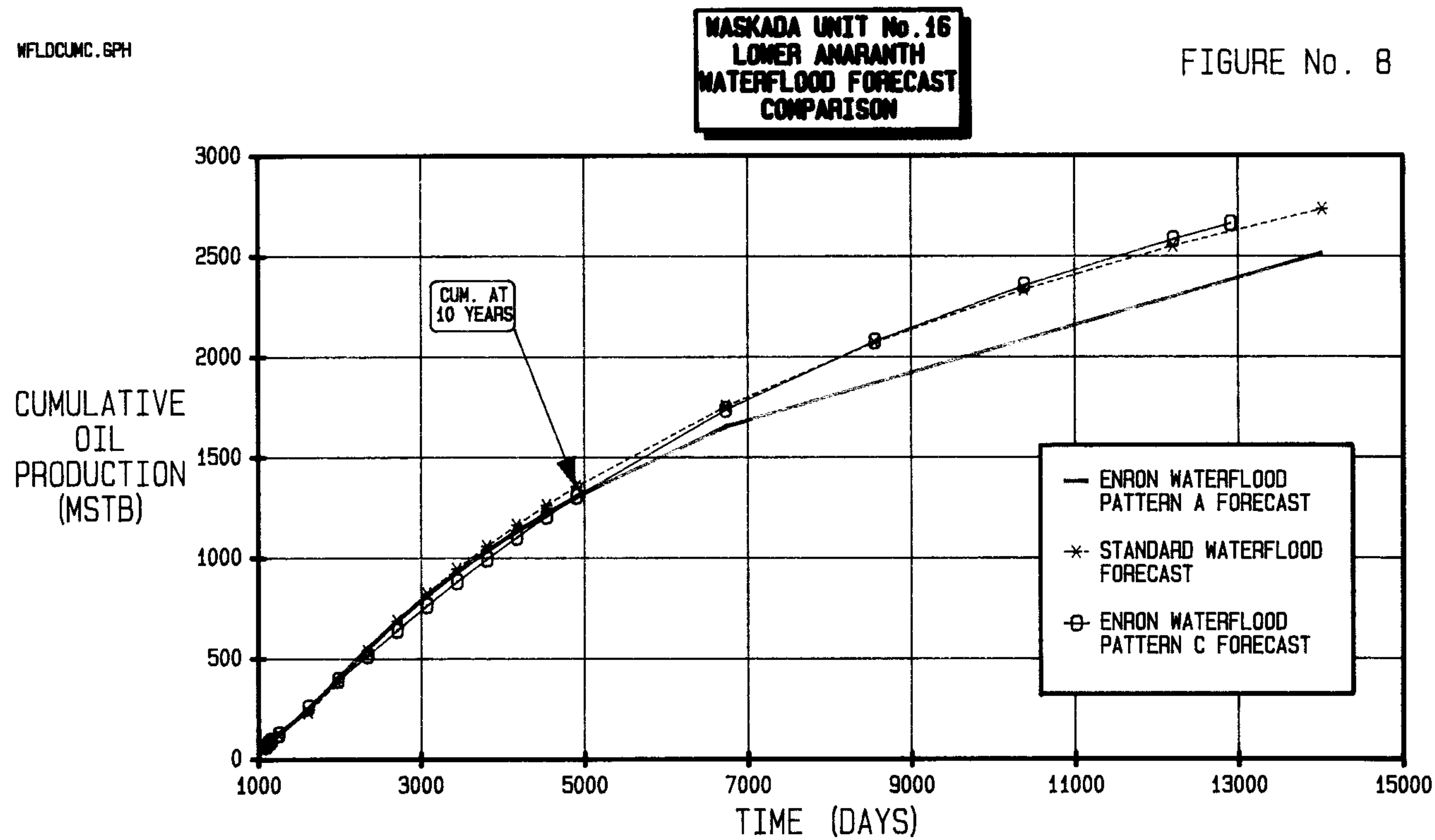
WFLDCX.GPH

FIGURE No. 7



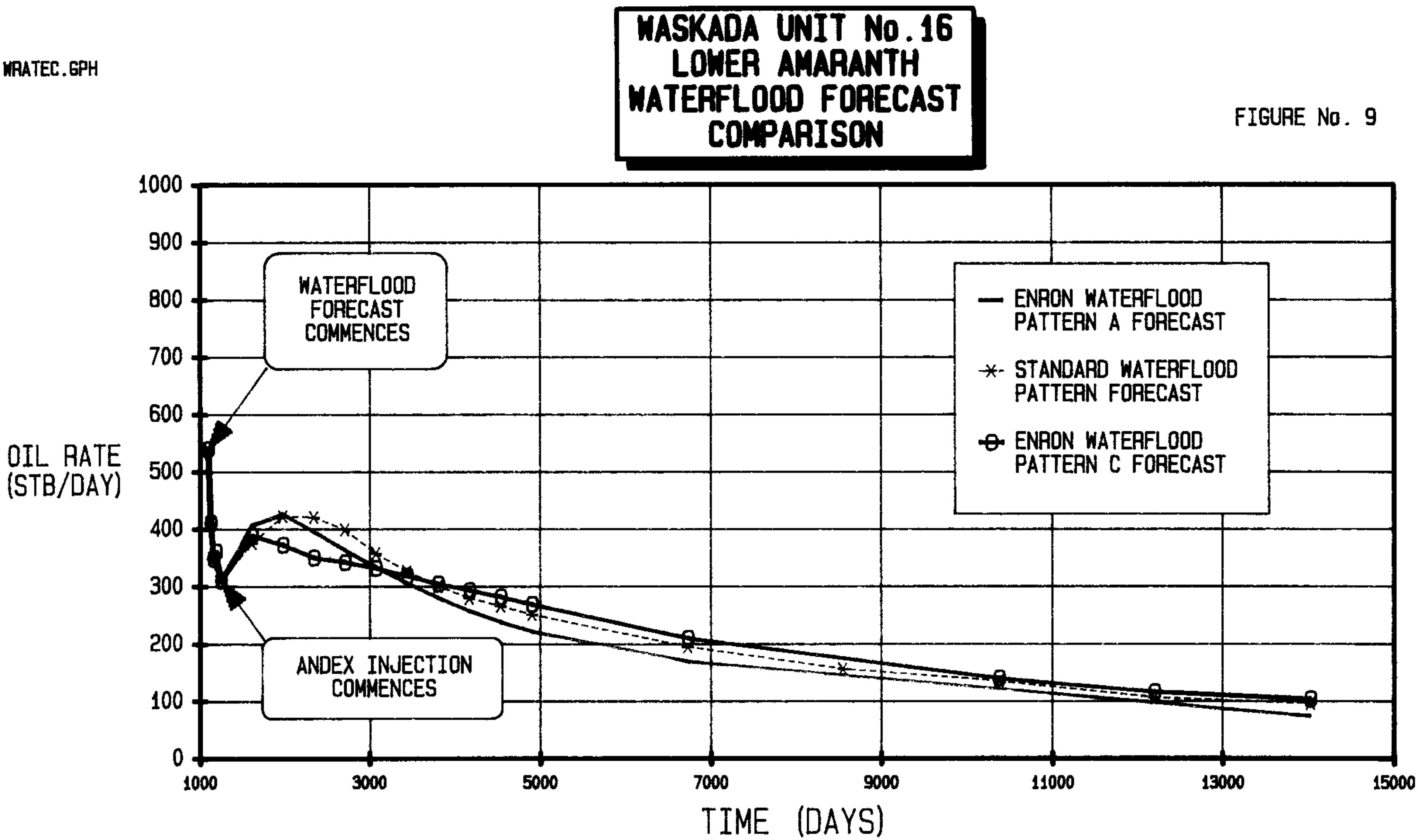
WFLDCUMC.GPH

FIGURE No. 8

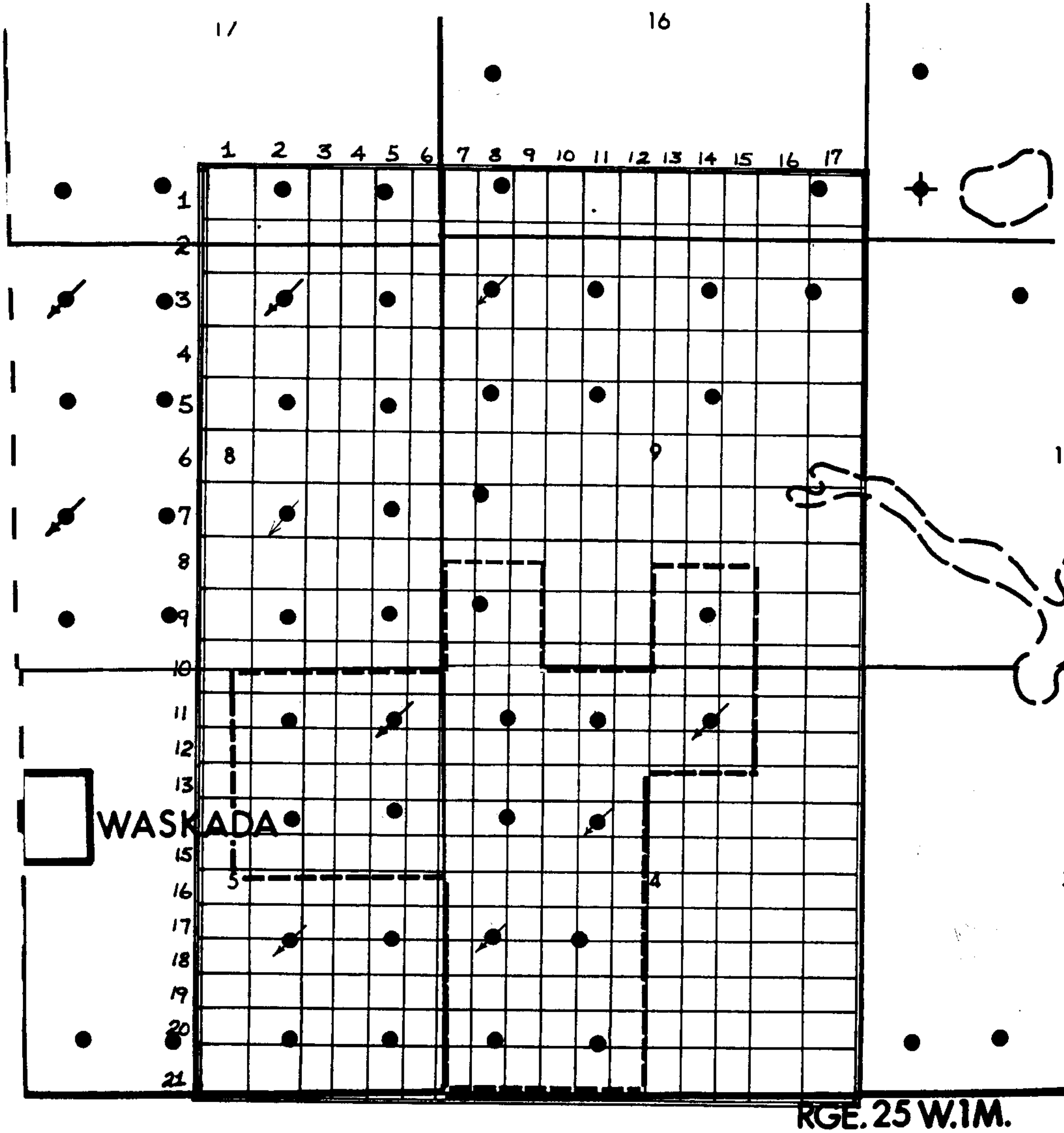


WRATEC.GPH

FIGURE No. 9



**MAPS**




LEGEND

○ LOCATION
● OIL WELL
— — — PROPOSED UNIT BOUNDARY

**ANDEX OIL CO. LTD.**

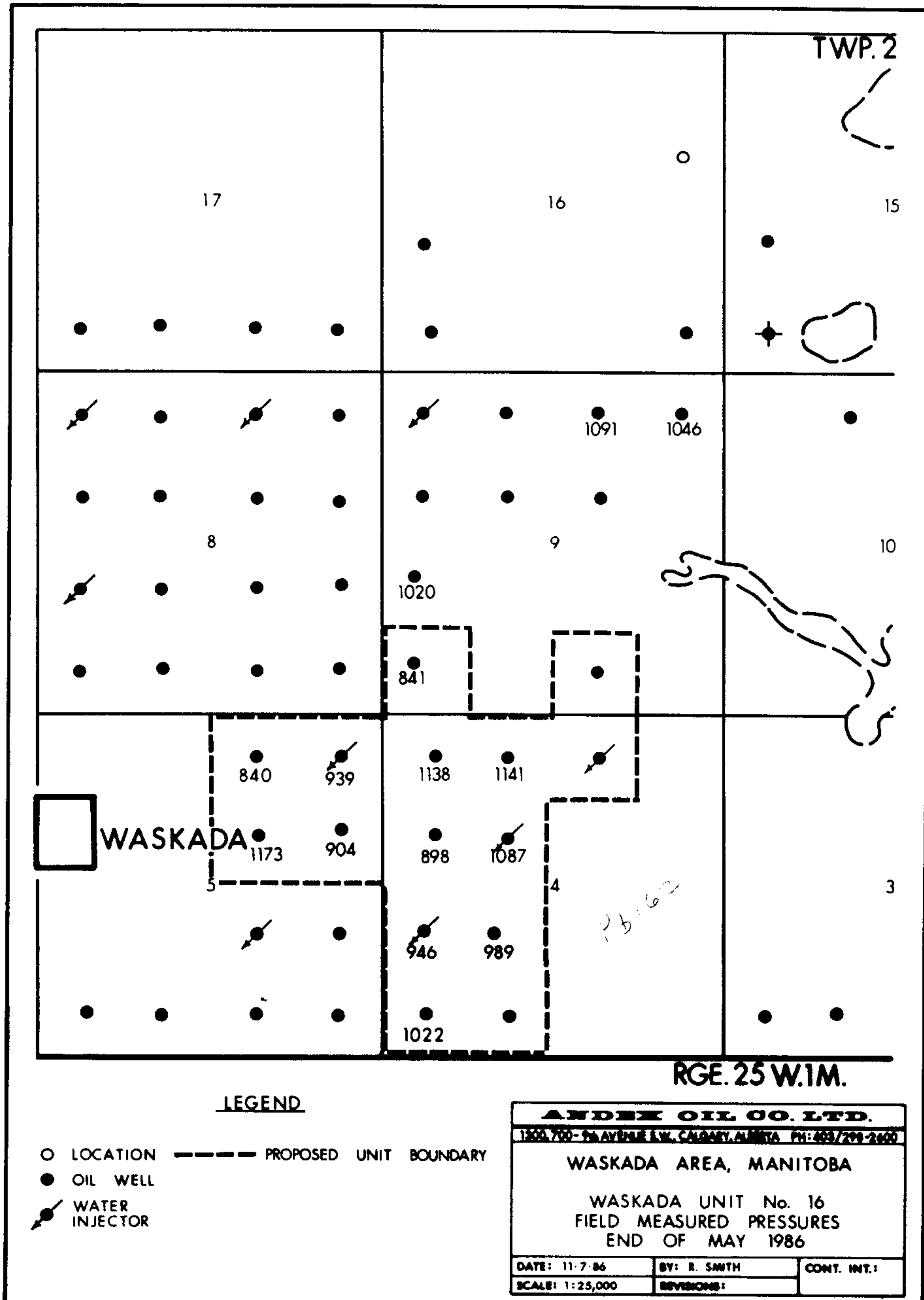
1300, 700 - 9th AVENUE S.W., CALGARY, ALBERTA PH: 403/[illegible]

WASKADA AREA, MANITOBA

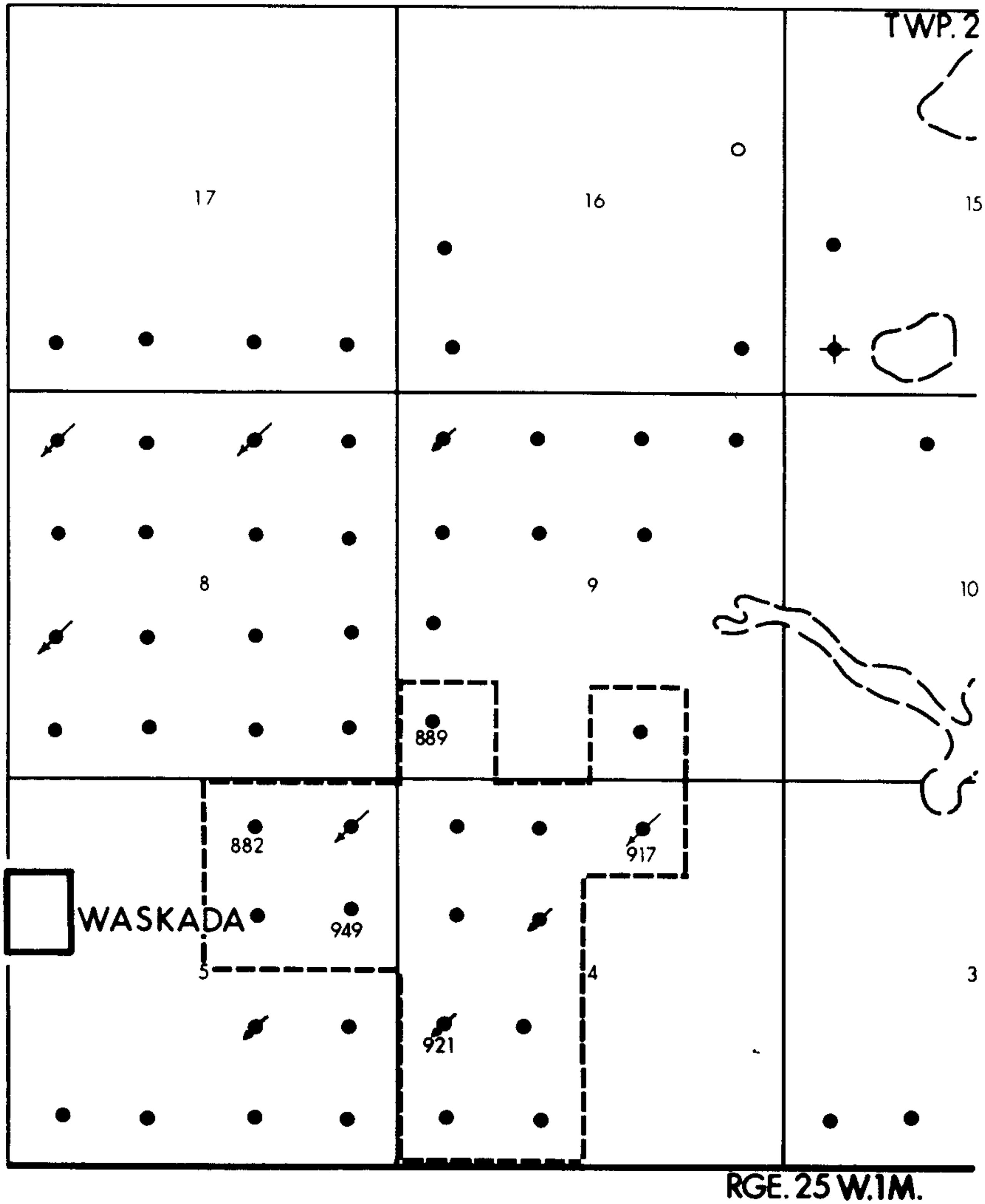
GRID DEFINITION OF STUDY AREA

JULY 1986

MAP No. 1


TWP. 2
17
16
15
8
9
10
5
4
3
1091
1046
1020
841
840
939
1138
1141
WASKADA
1173
904
898
1087
946
989
1022
RGE. 25 W.1M.
LEGEND
LOCATION
OIL WELL
WATER INJECTOR
PROPOSED UNIT BOUNDARY
ANDEX OIL CO. LTD.
WASKADA AREA, MANITOBA
WASKADA UNIT No. 16
FIELD MEASURED PRESSURES
END OF MAY 1986
DATE: 11-7-86
SCALE: 1:25,000
BY: R. SMITH
REVISIONS:
CONT. INT.:

MAP No. 2




LEGEND

- ○ LOCATION
- ● OIL WELL
- WATER INJECTOR
- — — — PROPOSED UNIT BOUNDARY

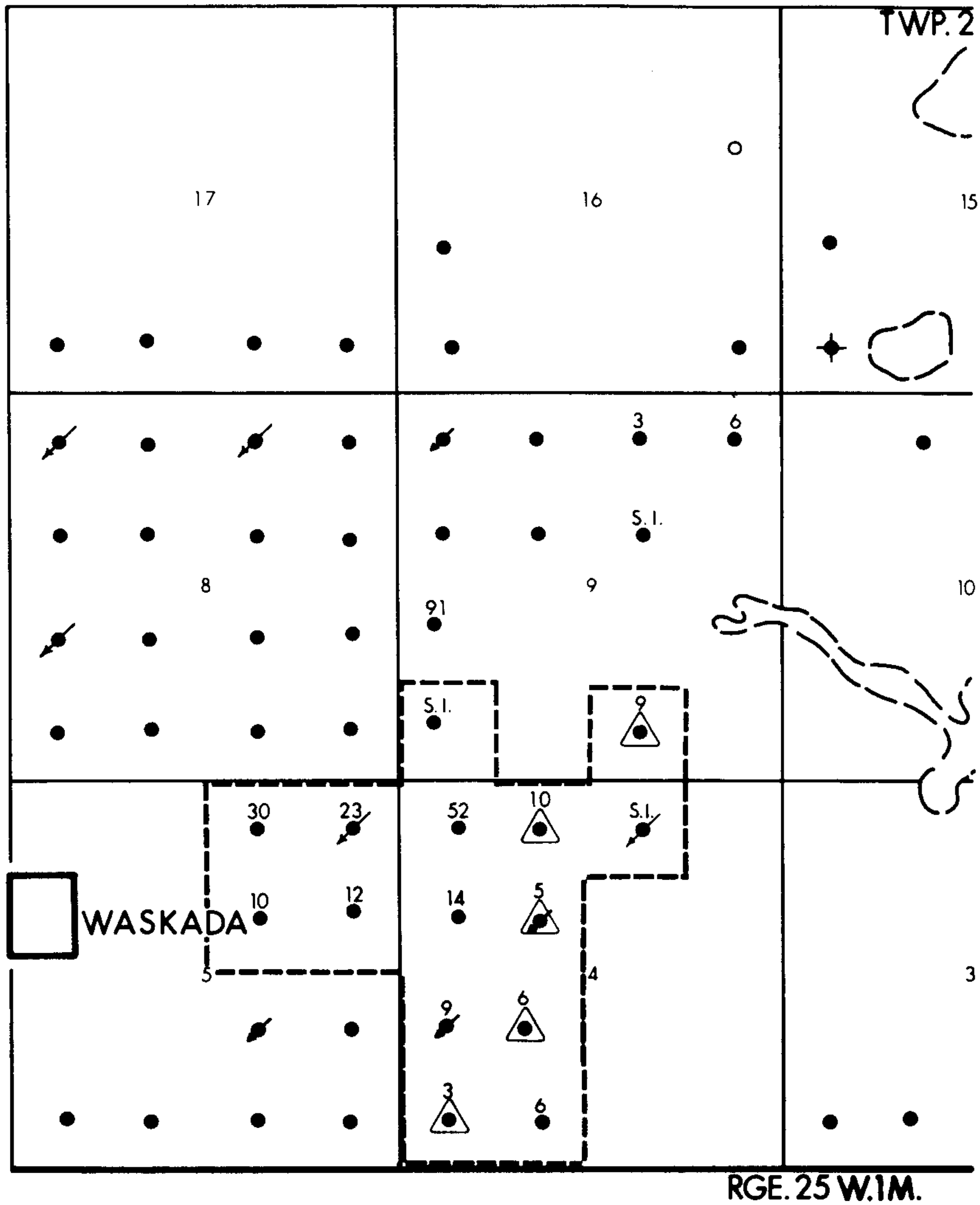
ANDEX OIL CO. LTD.

WASKADA AREA, MANITOBA

WASKADA UNIT No. 16
FIELD MEASURED PRESSURES
END OF JULY 1986

| | | |
|---|---|---|
| DATE: 11-7-86 | BY: R. SMITH | CONT. INT.: |
| SCALE: 1:25,000 | REVISIONS: | |

MAP No. 3




LEGEND

○ LOCATION

● OIL WELL

WATER INJECTOR

WELL WITH STRESS FRAC ONLY

- - - - PROPOSED UNIT BOUNDARY

**[illegible] OIL CO. LTD.**

[illegible]

WASKADA AREA, MANITOBA

WASKADA UNIT No. 16

AUGUST/86 WCUT %

| | | |
|---|---|---|
| DATE: [illegible] | BY: R. SMITH | CONT. INT.: |
| SCALE: 1:25,000 | REVISIONS: | |

**EXHIBIT A**

TABLE 1

EXHIBIT A

HISTORY MATCH PARAMETERS

1. The production data commences August 1, 1983 to include the full history of the Omega's wells (1-5, 2-5, 7-5, 8-5, 1-8, 2-8, 7-8, 8-8, 9-8, 10-8, 15-8, 16-8, 16-9, 12-9, 13-9 and 14-9-2-25 WPM) and ends July 31, 1986.

2. A black oil three layered model was used; layer 1 being high permeability, layer 2 medium and layer 3 low permeability. The grid size was 17 x 21 x 3 with average grid size of about 5 acres.

3. Water production in the model was limited to less than a 25% water cut. With the water cut at about 10% being most representative of the study area (see Table 3).

4. All PVT data was obtained from Omega's study (May 1983) on the Waskada Spearfish.

5. Relative permeability curves and capillary pressure curve were obtained by Enron from Omega study (1985) courtesy of Manitoba EMR.

6. The capillary pressure curve was used in layers 2 and 3 in order to model water production.

7. Since no GOR data was available it was not used in the history match. Therefore the GOR's in the model are based solely on PVT data.

8. An initial pressure was assumed to be the same as in Omega's study ie. 1,258 psia.

9. The pressure data used in history matching was acquired in May and July 1986 by static gradient or A.W.S. within the study area (see Tables 2 and 3).

10. The calculated permeability and net pay data were adjusted in the model in order to obtain a history match.

11. Since a capillary pressure curve was used to help simulate water production, grid blocks were adjusted up or down in order to obtain proper water saturation through the study area.

Waskada Spearfish Initialization DEPTH ARRAY (FEET ) LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 2914. | 2913. | 2912. | 2910. | 2908. | 2906. | 2904. | 2902. | 2900. | 2899. | 2897. | 2895. | 2892. | 2890. | 2888. | 2886. | 2885. |
| (2) | 2914. | 2913. | 2912. | 2910. | 2908. | 2906. | 2904. | 2902. | 2900. | 2898. | 2897. | 2895. | 2893. | 2891. | 2888. | 2887. | 2886. |
| (3) | 2914. | 2921. | 2920. | 2918. | 2916. | 2913. | 2911. | 2913. | 2907. | 2906. | 2914. | 2913. | 2911. | 2913. | 2907. | 2905. | 2905. |
| (4) | 2915. | 2914. | 2912. | 2910. | 2907. | 2904. | 2902. | 2900. | 2899. | 2898. | 2898. | 2897. | 2896. | 2894. | 2893. | 2891. | 2891. |
| (5) | 2912. | 2908. | 2909. | 2911. | 2912. | 2904. | 2901. | 2910. | 2910. | 2910. | 2916. | 2916. | 2916. | 2915. | 2896. | 2895. | 2895. |
| (6) | 2908. | 2907. | 2911. | 2912. | 2908. | 2904. | 2900. | 2898. | 2898. | 2900. | 2901. | 2902. | 2902. | 2901. | 2900. | 2899. | 2899. |
| (7) | 2910. | 2909. | 2906. | 2914. | 2911. | 2906. | 2902. | 2908. | 2900. | 2903. | 2905. | 2906. | 2906. | 2906. | 2905. | 2904. | 2903. |
| (8) | 2912. | 2911. | 2908. | 2912. | 2912. | 2908. | 2905. | 2913. | 2905. | 2907. | 2909. | 2910. | 2910. | 2910. | 2908. | 2907. | 2907. |
| (9) | 2914. | 2913. | 2914. | 2913. | 2913. | 2910. | 2907. | 2917. | 2908. | 2910. | 2913. | 2914. | 2914. | 2913. | 2911. | 2910. | 2909. |
| (10) | 2916. | 2915. | 2916. | 2915. | 2915. | 2910. | 2905. | 2903. | 2906. | 2904. | 2909. | 2909. | 2908. | 2906. | 2905. | 2904. | |
| (11) | 2915. | 2915. | 2916. | 2915. | 2919. | 2909. | 2901. | 2917. | 2902. | 2903. | 2911. | 2911. | 2909. | 2906. | 2905. | 2904. | |
| (12) | 2918. | 2918. | 2914. | 2914. | 2914. | 2909. | 2903. | 2903. | 2903. | 2902. | 2907. | 2908. | 2907. | 2906. | 2905. | 2904. | |
| (13) | 2916. | 2916. | 2919. | 2917. | 2915. | 2911. | 2907. | 2908. | 2906. | 2902. | 2905. | 2906. | 2906. | 2905. | 2904. | | |
| (14) | 2917. | 2916. | 2917. | 2916. | 2913. | 2914. | 2912. | 2914. | 2910. | 2911. | 2911. | 2912. | 2912. | 2912. | | | |
| (15) | 2917. | 2917. | 2918. | 2919. | 2919. | 2919. | 2919. | 2918. | 2916. | 2914. | 2912. | 2912. | 2912. | 2911. | | | |
| (16) | 2918. | 2919. | 2920. | 2914. | 2916. | 2918. | 2919. | 2918. | 2915. | 2918. | 2915. | 2913. | 2912. | | | | |
| (17) | 2919. | 2922. | 2914. | 2916. | 2919. | 2920. | 2922. | 2923. | 2919. | 2913. | 2913. | 2916. | 2915. | | | | |
| (18) | 2911. | 2912. | 2914. | 2917. | 2916. | 2919. | 2919. | 2919. | 2916. | 2915. | 2911. | 2907. | 2905. | | | | |
| (19) | 2912. | 2913. | 2916. | 2919. | 2918. | 2918. | 2921. | 2922. | 2920. | 2916. | 2912. | 2908. | 2905. | | | | |
| (20) | 2912. | 2919. | 2916. | 2919. | 2916. | 2918. | 2918. | 2919. | 2918. | 2916. | 2915. | 2910. | 2907. | | | | |
| (21) | 2913. | 2919. | 2916. | 2920. | 2917. | 2919. | 2919. | 2920. | 2920. | 2918. | 2916. | 2912. | 2909. | | | | |

DEPTH ARRAY (FEET ) LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 2919. | 2918. | 2917. | 2916. | 2914. | 2912. | 2910. | 2908. | 2906. | 2904. | 2902. | 2899. | 2897. | 2895. | 2893. | 2892. | 2891. |
| (2) | 2919. | 2919. | 2918. | 2916. | 2914. | 2912. | 2910. | 2908. | 2906. | 2904. | 2902. | 2900. | 2897. | 2895. | 2894. | 2892. | 2892. |
| (3) | 2920. | 2927. | 2926. | 2924. | 2922. | 2920. | 2918. | 2919. | 2914. | 2912. | 2919. | 2917. | 2915. | 2917. | 2912. | 2911. | 2910. |
| (4) | 2921. | 2920. | 2919. | 2917. | 2914. | 2912. | 2909. | 2907. | 2905. | 2904. | 2903. | 2901. | 2899. | 2898. | 2897. | 2896. | 2896. |
| (5) | 2918. | 2915. | 2916. | 2918. | 2920. | 2912. | 2909. | 2918. | 2917. | 2917. | 2921. | 2920. | 2919. | 2917. | 2900. | 2899. | 2899. |
| (6) | 2914. | 2913. | 2918. | 2919. | 2916. | 2912. | 2909. | 2906. | 2906. | 2906. | 2906. | 2906. | 2906. | 2905. | 2904. | 2904. | 2904. |
| (7) | 2917. | 2916. | 2913. | 2921. | 2919. | 2913. | 2910. | 2916. | 2907. | 2908. | 2910. | 2910. | 2910. | 2910. | 2909. | 2909. | 2909. |
| (8) | 2919. | 2918. | 2915. | 2919. | 2919. | 2915. | 2912. | 2919. | 2910. | 2912. | 2914. | 2915. | 2915. | 2915. | 2915. | 2914. | 2914. |
| (9) | 2920. | 2920. | 2921. | 2920. | 2920. | 2917. | 2913. | 2921. | 2912. | 2914. | 2918. | 2920. | 2920. | 2920. | 2919. | 2918. | 2918. |
| (10) | 2921. | 2920. | 2922. | 2922. | 2922. | 2916. | 2910. | 2907. | 2910. | 2908. | 2913. | 2916. | 2916. | 2916. | 2915. | 2914. | |
| (11) | 2920. | 2920. | 2921. | 2922. | 2926. | 2915. | 2907. | 2922. | 2907. | 2908. | 2916. | 2918. | 2918. | 2917. | 2917. | 2916. | |
| (12) | 2922. | 2922. | 2919. | 2919. | 2920. | 2914. | 2908. | 2908. | 2908. | 2907. | 2914. | 2916. | 2917. | 2917. | 2917. | 2916. | |
| (13) | 2919. | 2919. | 2923. | 2921. | 2919. | 2915. | 2911. | 2912. | 2911. | 2907. | 2912. | 2914. | 2915. | 2916. | 2916. | | |
| (14) | 2919. | 2919. | 2919. | 2919. | 2917. | 2917. | 2915. | 2917. | 2914. | 2916. | 2918. | 2920. | 2921. | 2922. | | | |
| (15) | 2919. | 2920. | 2920. | 2921. | 2922. | 2922. | 2921. | 2920. | 2920. | 2919. | 2918. | 2919. | 2920. | 2920. | | | |
| (16) | 2920. | 2921. | 2922. | 2917. | 2918. | 2920. | 2921. | 2921. | 2919. | 2922. | 2919. | 2919. | 2919. | | | | |
| (17) | 2921. | 2924. | 2916. | 2919. | 2922. | 2922. | 2925. | 2926. | 2922. | 2917. | 2917. | 2921. | 2921. | | | | |
| (18) | 2913. | 2914. | 2916. | 2919. | 2919. | 2922. | 2922. | 2923. | 2920. | 2920. | 2915. | 2913. | 2911. | | | | |
| (19) | 2915. | 2916. | 2918. | 2921. | 2921. | 2922. | 2925. | 2926. | 2924. | 2921. | 2918. | 2914. | 2911. | | | | |
| (20) | 2915. | 2921. | 2919. | 2922. | 2920. | 2921. | 2922. | 2924. | 2923. | 2922. | 2921. | 2917. | 2913. | | | | |
| (21) | 2916. | 2922. | 2919. | 2923. | 2920. | 2922. | 2923. | 2925. | 2925. | 2924. | 2923. | 2919. | 2915. | | | | |

Waskada Spearfish Initialization DEPTH ARRAY (FEET ) LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 2924. | 2924. | 2923. | 2923. | 2922. | 2921. | 2920. | 2918. | 2916. | 2914. | 2910. | 2907. | 2903. | 2901. | 2899. | 2898. | 2897. |
| (2) | 2924. | 2924. | 2923. | 2923. | 2922. | 2921. | 2920. | 2918. | 2916. | 2913. | 2910. | 2907. | 2903. | 2901. | 2899. | 2898. | 2898. |
| (3) | 2925. | 2932. | 2932. | 2931. | 2930. | 2928. | 2927. | 2929. | 2923. | 2921. | 2927. | 2923. | 2920. | 2922. | 2916. | 2916. | 2916. |
| (4) | 2926. | 2925. | 2924. | 2923. | 2922. | 2920. | 2918. | 2916. | 2914. | 2912. | 2910. | 2907. | 2904. | 2901. | 2901. | 2901. | 2901. |
| (5) | 2923. | 2919. | 2921. | 2924. | 2927. | 2920. | 2918. | 2928. | 2926. | 2924. | 2928. | 2925. | 2922. | 2920. | 2903. | 2903. | 2904. |
| (6) | 2919. | 2918. | 2923. | 2925. | 2923. | 2920. | 2917. | 2915. | 2914. | 2913. | 2912. | 2911. | 2909. | 2908. | 2908. | 2908. | 2908. |
| (7) | 2921. | 2920. | 2918. | 2927. | 2926. | 2921. | 2917. | 2924. | 2915. | 2915. | 2915. | 2915. | 2915. | 2914. | 2914. | 2914. | 2914. |
| (8) | 2923. | 2923. | 2920. | 2925. | 2926. | 2922. | 2918. | 2925. | 2916. | 2917. | 2919. | 2920. | 2921. | 2921. | 2921. | 2920. | 2920. |
| (9) | 2925. | 2925. | 2926. | 2926. | 2927. | 2922. | 2918. | 2925. | 2916. | 2919. | 2923. | 2925. | 2927. | 2927. | 2927. | 2926. | 2926. |
| (10) | 2926. | 2926. | 2928. | 2928. | 2928. | 2922. | 2916. | 2912. | 2914. | 2913. | 2918. | 2922. | 2924. | 2925. | 2925. | 2924. | |
| (11) | 2925. | 2925. | 2927. | 2928. | 2933. | 2922. | 2913. | 2929. | 2913. | 2913. | 2921. | 2925. | 2927. | 2929. | 2928. | 2927. | |
| (12) | 2926. | 2926. | 2924. | 2925. | 2926. | 2921. | 2914. | 2914. | 2913. | 2913. | 2920. | 2924. | 2927. | 2928. | 2928. | 2927. | |
| (13) | 2922. | 2922. | 2927. | 2927. | 2925. | 2920. | 2915. | 2916. | 2915. | 2913. | 2918. | 2922. | 2925. | 2926. | 2926. | | |
| (14) | 2921. | 2921. | 2923. | 2924. | 2922. | 2922. | 2919. | 2920. | 2918. | 2921. | 2925. | 2927. | 2929. | 2931. | | | |
| (15) | 2921. | 2921. | 2923. | 2925. | 2926. | 2925. | 2924. | 2923. | 2923. | 2923. | 2924. | 2925. | 2927. | 2928. | | | |
| (16) | 2921. | 2922. | 2924. | 2919. | 2922. | 2923. | 2925. | 2925. | 2922. | 2926. | 2923. | 2924. | 2925. | | | | |
| (17) | 2922. | 2925. | 2918. | 2921. | 2924. | 2925. | 2928. | 2930. | 2926. | 2920. | 2920. | 2925. | 2925. | | | | |
| (18) | 2914. | 2915. | 2917. | 2921. | 2921. | 2925. | 2925. | 2927. | 2924. | 2923. | 2919. | 2917. | 2915. | | | | |
| (19) | 2915. | 2916. | 2919. | 2923. | 2923. | 2924. | 2928. | 2930. | 2929. | 2926. | 2923. | 2919. | 2916. | | | | |
| (20) | 2915. | 2922. | 2919. | 2923. | 2921. | 2924. | 2926. | 2928. | 2928. | 2927. | 2927. | 2923. | 2919. | | | | |
| (21) | 2916. | 2922. | 2920. | 2924. | 2922. | 2925. | 2927. | 2929. | 2930. | 2930. | 2930. | 2925. | 2921. | | | | |

Waskada Spearfish Initialization BLOCK THICKNESS(FEET ) LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 4.0 | 4.1 | 4.2 | 4.4 | 4.5 | 4.4 | 4.2 | 4.0 | 4.1 | 4.2 | 4.3 | 4.4 | 3.3 | 3.5 | 3.8 | 4.1 | 4.3 |
| (2) | 4.0 | 4.1 | 4.3 | 4.6 | 4.7 | 4.8 | 4.7 | 4.6 | 4.6 | 4.5 | 4.5 | 4.4 | 3.2 | 3.3 | 3.6 | 3.9 | 4.1 |
| (3) | 4.0 | 4.2 | 4.5 | 4.9 | 5.2 | 5.5 | 5.6 | 5.5 | 5.3 | 5.0 | 4.7 | 4.4 | 3.0 | 3.0 | 3.2 | 3.5 | 3.8 |
| (4) | 4.0 | 4.3 | 4.8 | 5.3 | 5.8 | 6.3 | 5.7 | 5.7 | 5.4 | 5.6 | 5.0 | 4.3 | 2.6 | 2.4 | 2.5 | 2.8 | 3.0 |
| (5) | 4.0 | 4.4 | 5.0 | 5.7 | 6.4 | 7.0 | 6.4 | 6.5 | 6.1 | 6.2 | 5.3 | 4.4 | 3.5 | 2.8 | 3.0 | 3.2 | 3.3 |
| (6) | 5.3 | 5.7 | 6.5 | 6.0 | 6.7 | 7.4 | 7.0 | 7.2 | 6.5 | 6.5 | 5.6 | 4.8 | 4.1 | 3.5 | 3.3 | 3.2 | 3.0 |
| (7) | 5.4 | 5.9 | 6.7 | 6.1 | 6.8 | 7.3 | 6.8 | 7.2 | 6.4 | 6.4 | 5.8 | 5.3 | 4.9 | 4.6 | 4.2 | 3.8 | 3.5 |
| (8) | 5.4 | 5.8 | 6.6 | 6.0 | 6.6 | 6.7 | 5.6 | 5.2 | 5.0 | 5.6 | 5.6 | 5.8 | 5.9 | 5.9 | 5.4 | 4.8 | 4.3 |
| (9) | 4.0 | 4.3 | 5.1 | 5.9 | 6.4 | 6.1 | 4.6 | 3.4 | 3.9 | 4.8 | 5.4 | 6.2 | 6.9 | 7.2 | 6.5 | 5.6 | 5.0 |
| (10) | 2.3 | 2.5 | 3.1 | 4.0 | 4.5 | 4.2 | 14.3 | 11.9 | 11.7 | 13.9 | 15.8 | 19.2 | 2.4 | 2.6 | 2.3 | 6.1 | |
| (11) | 2.0 | 2.1 | 2.8 | 3.9 | 4.7 | 4.4 | 17.2 | 15.9 | 14.4 | 14.4 | 15.8 | 19.8 | 2.5 | 2.7 | 2.4 | 6.1 | |
| (12) | 1.9 | 1.9 | 2.5 | 3.4 | 4.0 | 3.9 | 15.7 | 14.6 | 14.3 | 15.4 | 17.6 | 20.6 | 2.5 | 2.5 | 2.3 | 6.0 | |
| (13) | 29.7 | 27.5 | 35.1 | 5.4 | 6.3 | 6.1 | 2.9 | 2.7 | 3.0 | 2.4 | 2.9 | 3.2 | 7.4 | 7.3 | 6.6 | | |
| (14) | 31.9 | 23.5 | 30.0 | 4.6 | 5.3 | 5.0 | 2.2 | 2.0 | 2.6 | 2.3 | 2.9 | 3.1 | 6.8 | 6.5 | | | |
| (15) | 44.0 | 33.4 | 32.2 | 4.2 | 4.5 | 4.3 | 2.0 | 2.0 | 2.4 | 2.1 | 2.5 | 2.7 | 6.0 | 5.8 | | | |
| (16) | 39.9 | 35.0 | 33.0 | 3.1 | 3.2 | 3.1 | 3.0 | 3.1 | 3.5 | 2.0 | 2.3 | 2.5 | 5.3 | | | | |
| (17) | 3.0 | 3.0 | 2.9 | 3.0 | 3.1 | 3.1 | 3.2 | 3.4 | 3.6 | 1.9 | 2.0 | 2.3 | 4.9 | | | | |
| (18) | 2.8 | 2.8 | 2.9 | 3.0 | 3.1 | 3.3 | 3.4 | 3.7 | 3.9 | 2.1 | 2.3 | 2.5 | 5.1 | | | | |
| (19) | 2.8 | 2.9 | 2.9 | 3.3 | 3.5 | 3.7 | 2.8 | 3.0 | 3.3 | 3.7 | 4.2 | 4.3 | 4.3 | | | | |
| (20) | 2.9 | 2.9 | 3.0 | 3.4 | 3.6 | 3.8 | 2.9 | 3.2 | 3.5 | 4.0 | 4.8 | 4.8 | 4.7 | | | | |
| (21) | 3.0 | 3.0 | 3.0 | 3.4 | 3.6 | 3.9 | 2.9 | 3.2 | 3.4 | 3.8 | 4.7 | 4.9 | 4.8 | | | | |

BLOCK THICKNESS(FEET ) LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 4.0 | 4.1 | 4.2 | 4.4 | 4.5 | 4.4 | 4.2 | 4.0 | 4.1 | 4.2 | 4.3 | 4.4 | 3.3 | 3.5 | 3.8 | 4.1 | 4.3 |
| (2) | 4.0 | 4.1 | 4.3 | 4.6 | 4.7 | 4.8 | 4.7 | 4.6 | 4.6 | 4.5 | 4.5 | 4.4 | 3.2 | 3.3 | 3.6 | 3.9 | 4.1 |
| (3) | 4.0 | 4.2 | 4.5 | 4.9 | 5.2 | 5.5 | 5.6 | 5.5 | 5.3 | 5.0 | 4.7 | 4.4 | 3.0 | 3.0 | 3.2 | 3.5 | 3.8 |
| (4) | 4.0 | 4.3 | 4.8 | 5.3 | 5.8 | 6.3 | 5.7 | 5.7 | 5.4 | 5.6 | 5.0 | 4.3 | 2.6 | 2.4 | 2.5 | 2.8 | 3.0 |
| (5) | 4.0 | 4.4 | 5.0 | 5.7 | 6.4 | 7.0 | 6.4 | 6.5 | 6.1 | 6.2 | 5.3 | 4.4 | 3.5 | 2.8 | 3.0 | 3.2 | 3.3 |
| (6) | 5.3 | 5.7 | 6.5 | 6.0 | 6.7 | 7.4 | 7.0 | 7.2 | 6.5 | 6.5 | 5.6 | 4.8 | 4.1 | 3.5 | 3.3 | 3.2 | 3.0 |
| (7) | 5.4 | 5.9 | 6.7 | 6.1 | 6.8 | 7.3 | 6.8 | 7.2 | 6.4 | 6.4 | 5.8 | 5.3 | 4.9 | 4.6 | 4.2 | 3.8 | 3.5 |
| (8) | 5.4 | 5.8 | 6.6 | 6.0 | 6.6 | 6.7 | 5.6 | 5.2 | 5.0 | 5.6 | 5.6 | 5.8 | 5.9 | 5.9 | 5.4 | 4.8 | 4.3 |
| (9) | 4.0 | 4.3 | 5.1 | 5.9 | 6.4 | 6.1 | 4.6 | 3.4 | 3.9 | 4.8 | 5.4 | 6.2 | 6.9 | 7.2 | 6.5 | 5.6 | 5.0 |
| (10) | 2.3 | 2.5 | 3.1 | 4.0 | 4.5 | 4.2 | 14.3 | 11.9 | 11.7 | 13.9 | 15.8 | 19.2 | 2.4 | 2.6 | 2.3 | 6.1 | |
| (11) | 2.0 | 2.1 | 2.8 | 3.9 | 4.7 | 4.4 | 17.2 | 15.9 | 14.4 | 14.4 | 15.8 | 19.8 | 2.5 | 2.7 | 2.4 | 6.1 | |
| (12) | 1.9 | 1.9 | 2.5 | 3.4 | 4.0 | 3.9 | 15.7 | 14.6 | 14.3 | 15.4 | 17.6 | 20.6 | 2.5 | 2.5 | 2.3 | 6.0 | |
| (13) | 29.7 | 27.5 | 35.1 | 5.4 | 6.3 | 6.1 | 2.9 | 2.7 | 3.0 | 2.4 | 2.9 | 3.2 | 7.4 | 7.3 | 6.6 | | |
| (14) | 31.9 | 23.5 | 30.0 | 4.6 | 5.3 | 5.0 | 2.2 | 2.0 | 2.6 | 2.3 | 2.9 | 3.1 | 6.8 | 6.5 | | | |
| (15) | 44.0 | 33.4 | 32.2 | 4.2 | 4.5 | 4.3 | 2.0 | 2.0 | 2.4 | 2.1 | 2.5 | 2.7 | 6.0 | 5.8 | | | |
| (16) | 39.9 | 35.0 | 33.0 | 3.1 | 3.2 | 3.1 | 3.0 | 3.1 | 3.5 | 2.0 | 2.3 | 2.5 | 5.3 | | | | |
| (17) | 3.0 | 3.0 | 2.9 | 3.0 | 3.1 | 3.1 | 3.2 | 3.4 | 3.6 | 1.9 | 2.0 | 2.3 | 4.9 | | | | |
| (18) | 2.8 | 2.8 | 2.9 | 3.0 | 3.1 | 3.3 | 3.4 | 3.7 | 3.9 | 2.1 | 2.3 | 2.5 | 5.1 | | | | |
| (19) | 2.8 | 2.9 | 2.9 | 3.3 | 3.5 | 3.7 | 2.8 | 3.0 | 3.3 | 3.7 | 4.2 | 4.3 | 4.3 | | | | |
| (20) | 2.9 | 2.9 | 3.0 | 3.4 | 3.6 | 3.8 | 2.9 | 3.2 | 3.5 | 4.0 | 4.8 | 4.8 | 4.7 | | | | |
| (21) | 3.0 | 3.0 | 3.0 | 3.4 | 3.6 | 3.9 | 2.9 | 3.2 | 3.4 | 3.8 | 4.7 | 4.9 | 4.8 | | | | |

Waskada Spearfish Initialization BLOCK THICKNESS(FEET ) LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 4.0 | 4.1 | 4.2 | 4.4 | 4.5 | 4.4 | 4.2 | 4.0 | 4.1 | 4.2 | 4.3 | 4.4 | 3.3 | 3.5 | 3.8 | 4.1 | 4.3 |
| (2) | 4.0 | 4.1 | 4.3 | 4.6 | 4.7 | 4.8 | 4.7 | 4.6 | 4.6 | 4.5 | 4.5 | 4.4 | 3.2 | 3.3 | 3.6 | 3.9 | 4.1 |
| (3) | 4.0 | 4.2 | 4.5 | 4.9 | 5.2 | 5.5 | 5.6 | 5.5 | 5.3 | 5.0 | 4.7 | 4.4 | 3.0 | 3.0 | 3.2 | 3.5 | 3.8 |
| (4) | 4.0 | 4.3 | 4.8 | 5.3 | 5.8 | 6.3 | 5.7 | 5.7 | 5.4 | 5.6 | 5.0 | 4.3 | 2.6 | 2.4 | 2.5 | 2.8 | 3.0 |
| (5) | 4.0 | 4.4 | 5.0 | 5.7 | 6.4 | 7.0 | 6.4 | 6.5 | 6.1 | 6.2 | 5.3 | 4.4 | 3.5 | 2.8 | 3.0 | 3.2 | 3.3 |
| (6) | 5.3 | 5.7 | 6.5 | 6.0 | 6.7 | 7.4 | 7.0 | 7.2 | 6.5 | 6.5 | 5.6 | 4.8 | 4.1 | 3.5 | 3.3 | 3.2 | 3.0 |
| (7) | 5.4 | 5.9 | 6.7 | 6.1 | 6.8 | 7.3 | 6.8 | 7.2 | 6.4 | 6.4 | 5.8 | 5.3 | 4.9 | 4.6 | 4.2 | 3.8 | 3.5 |
| (8) | 5.4 | 5.8 | 6.6 | 6.0 | 6.6 | 6.7 | 5.6 | 5.2 | 5.0 | 5.6 | 5.6 | 5.8 | 5.9 | 5.9 | 5.4 | 4.8 | 4.3 |
| (9) | 4.0 | 4.3 | 5.1 | 5.9 | 6.4 | 6.1 | 4.6 | 3.4 | 3.9 | 4.8 | 5.4 | 6.2 | 6.9 | 7.2 | 6.5 | 5.6 | 5.0 |
| (10) | 2.3 | 2.5 | 3.1 | 4.0 | 4.5 | 4.2 | 14.3 | 11.9 | 11.7 | 13.9 | 15.8 | 19.2 | 2.4 | 2.6 | 2.3 | 6.1 | |
| (11) | 2.0 | 2.1 | 2.8 | 3.9 | 4.7 | 4.4 | 17.2 | 15.9 | 14.4 | 14.4 | 15.8 | 19.8 | 2.5 | 2.7 | 2.4 | 6.1 | |
| (12) | 1.9 | 1.9 | 2.5 | 3.4 | 4.0 | 3.9 | 15.7 | 14.6 | 14.3 | 15.4 | 17.6 | 20.6 | 2.5 | 2.5 | 2.3 | 6.0 | |
| (13) | 29.7 | 27.5 | 35.1 | 5.4 | 6.3 | 6.1 | 2.9 | 2.7 | 3.0 | 2.4 | 2.9 | 3.2 | 7.4 | 7.3 | 6.6 | | |
| (14) | 31.9 | 23.5 | 30.0 | 4.6 | 5.3 | 5.0 | 2.2 | 2.0 | 2.6 | 2.3 | 2.9 | 3.1 | 6.8 | 6.5 | | | |
| (15) | 44.0 | 33.4 | 32.2 | 4.2 | 4.5 | 4.3 | 2.0 | 2.0 | 2.4 | 2.1 | 2.5 | 2.7 | 6.0 | 5.8 | | | |
| (16) | 39.9 | 35.0 | 33.0 | 3.1 | 3.2 | 3.1 | 3.0 | 3.1 | 3.5 | 2.0 | 2.3 | 2.5 | 5.3 | | | | |
| (17) | 3.0 | 3.0 | 2.9 | 3.0 | 3.1 | 3.1 | 3.2 | 3.4 | 3.6 | 1.9 | 2.0 | 2.3 | 4.9 | | | | |
| (18) | 2.8 | 2.8 | 2.9 | 3.0 | 3.1 | 3.3 | 3.4 | 3.7 | 3.9 | 2.1 | 2.3 | 2.5 | 5.1 | | | | |
| (19) | 2.8 | 2.9 | 2.9 | 3.3 | 3.5 | 3.7 | 2.8 | 3.0 | 3.3 | 3.7 | 4.2 | 4.3 | 4.3 | | | | |
| (20) | 2.9 | 2.9 | 3.0 | 3.4 | 3.6 | 3.8 | 2.9 | 3.2 | 3.5 | 4.0 | 4.8 | 4.8 | 4.7 | | | | |
| (21) | 3.0 | 3.0 | 3.0 | 3.4 | 3.6 | 3.9 | 2.9 | 3.2 | 3.4 | 3.8 | 4.7 | 4.9 | 4.8 | | | | |

Waskada Spearfish Initialization

BLOCK POROSITIES (.N) LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1519 | 0.1522 | 0.1526 | 0.1535 | 0.1549 | 0.1572 | 0.1603 | 0.1640 | 0.1679 | 0.1709 | 0.1721 | 0.1721 | 0.1719 |
| (2) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1519 | 0.1522 | 0.1527 | 0.1535 | 0.1549 | 0.1570 | 0.1600 | 0.1637 | 0.1677 | 0.1708 | 0.1716 | 0.1712 | 0.1709 |
| (3) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1520 | 0.1522 | 0.1527 | 0.1535 | 0.1547 | 0.1566 | 0.1592 | 0.1628 | 0.1667 | 0.1700 | 0.1699 | 0.1690 | 0.1687 |
| (4) | 0.1519 | 0.1519 | 0.1518 | 0.1519 | 0.1520 | 0.1523 | 0.1529 | 0.1536 | 0.1545 | 0.1558 | 0.1578 | 0.1605 | 0.1636 | 0.1661 | 0.1662 | 0.1657 | 0.1655 |
| (5) | 0.1521 | 0.1520 | 0.1520 | 0.1520 | 0.1522 | 0.1525 | 0.1530 | 0.1537 | 0.1542 | 0.1548 | 0.1559 | 0.1574 | 0.1593 | 0.1610 | 0.1611 | 0.1610 | 0.1610 |
| (6) | 0.1523 | 0.1523 | 0.1523 | 0.1523 | 0.1524 | 0.1527 | 0.1532 | 0.1539 | 0.1539 | 0.1539 | 0.1539 | 0.1539 | 0.1541 | 0.1544 | 0.1548 | 0.1554 | 0.1559 |
| (7) | 0.1526 | 0.1526 | 0.1527 | 0.1527 | 0.1528 | 0.1529 | 0.1532 | 0.1540 | 0.1537 | 0.1535 | 0.1528 | 0.1513 | 0.1495 | 0.1484 | 0.1490 | 0.1502 | 0.1511 |
| (8) | 0.1527 | 0.1529 | 0.1532 | 0.1534 | 0.1536 | 0.1534 | 0.1528 | 0.1522 | 0.1535 | 0.1544 | 0.1536 | 0.1510 | 0.1473 | 0.1442 | 0.1453 | 0.1472 | 0.1484 |
| (9) | 0.1522 | 0.1528 | 0.1536 | 0.1545 | 0.1553 | 0.1557 | 0.1549 | 0.1530 | 0.1564 | 0.1582 | 0.1576 | 0.1544 | 0.1494 | 0.1440 | 0.1459 | 0.1478 | 0.1487 |
| (10) | 0.1505 | 0.1518 | 0.1534 | 0.1555 | 0.1579 | 0.1606 | 0.1629 | 0.1645 | 0.1653 | 0.1654 | 0.1645 | 0.1615 | 0.1580 | 0.1551 | 0.1534 | 0.1526 | |
| (11) | 0.1466 | 0.1490 | 0.1518 | 0.1556 | 0.1600 | 0.1651 | 0.1703 | 0.1750 | 0.1727 | 0.1709 | 0.1700 | 0.1674 | 0.1661 | 0.1660 | 0.1613 | 0.1578 | |
| (12) | 0.1396 | 0.1425 | 0.1479 | 0.1546 | 0.1611 | 0.1665 | 0.1707 | 0.1731 | 0.1716 | 0.1694 | 0.1679 | 0.1669 | 0.1667 | 0.1664 | 0.1632 | 0.1600 | |
| (13) | 0.1317 | 0.1351 | 0.1431 | 0.1526 | 0.1609 | 0.1652 | 0.1670 | 0.1671 | 0.1656 | 0.1634 | 0.1617 | 0.1623 | 0.1632 | 0.1633 | 0.1616 | | |
| (14) | 0.1262 | 0.1290 | 0.1392 | 0.1505 | 0.1600 | 0.1623 | 0.1618 | 0.1600 | 0.1588 | 0.1570 | 0.1550 | 0.1573 | 0.1591 | 0.1596 | | | |
| (15) | 0.1268 | 0.1304 | 0.1386 | 0.1480 | 0.1552 | 0.1574 | 0.1567 | 0.1552 | 0.1547 | 0.1545 | 0.1545 | 0.1560 | 0.1570 | 0.1571 | | | |
| (16) | 0.1307 | 0.1339 | 0.1400 | 0.1466 | 0.1515 | 0.1532 | 0.1526 | 0.1517 | 0.1530 | 0.1549 | 0.1565 | 0.1572 | 0.1570 | | | | |
| (17) | 0.1356 | 0.1381 | 0.1423 | 0.1467 | 0.1499 | 0.1510 | 0.1506 | 0.1500 | 0.1533 | 0.1571 | 0.1600 | 0.1598 | 0.1584 | | | | |
| (18) | 0.1403 | 0.1422 | 0.1449 | 0.1479 | 0.1501 | 0.1513 | 0.1519 | 0.1530 | 0.1564 | 0.1602 | 0.1627 | 0.1624 | 0.1602 | | | | |
| (19) | 0.1441 | 0.1455 | 0.1474 | 0.1494 | 0.1513 | 0.1529 | 0.1545 | 0.1568 | 0.1602 | 0.1638 | 0.1659 | 0.1650 | 0.1622 | | | | |
| (20) | 0.1467 | 0.1478 | 0.1492 | 0.1508 | 0.1526 | 0.1546 | 0.1569 | 0.1600 | 0.1635 | 0.1669 | 0.1690 | 0.1674 | 0.1640 | | | | |
| (21) | 0.1481 | 0.1489 | 0.1500 | 0.1516 | 0.1534 | 0.1556 | 0.1583 | 0.1616 | 0.1651 | 0.1683 | 0.1699 | 0.1683 | 0.1648 | | | | |

BLOCK POROSITIES (.N) LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1519 | 0.1522 | 0.1526 | 0.1535 | 0.1549 | 0.1572 | 0.1603 | 0.1640 | 0.1679 | 0.1709 | 0.1721 | 0.1721 | 0.1719 |
| (2) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1519 | 0.1522 | 0.1527 | 0.1535 | 0.1549 | 0.1570 | 0.1600 | 0.1637 | 0.1677 | 0.1708 | 0.1716 | 0.1712 | 0.1709 |
| (3) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1520 | 0.1522 | 0.1527 | 0.1535 | 0.1547 | 0.1566 | 0.1592 | 0.1628 | 0.1667 | 0.1700 | 0.1699 | 0.1690 | 0.1687 |
| (4) | 0.1519 | 0.1519 | 0.1518 | 0.1519 | 0.1520 | 0.1523 | 0.1529 | 0.1536 | 0.1545 | 0.1558 | 0.1578 | 0.1605 | 0.1636 | 0.1661 | 0.1662 | 0.1657 | 0.1655 |
| (5) | 0.1521 | 0.1520 | 0.1520 | 0.1520 | 0.1522 | 0.1525 | 0.1530 | 0.1537 | 0.1542 | 0.1548 | 0.1559 | 0.1574 | 0.1593 | 0.1610 | 0.1611 | 0.1610 | 0.1610 |
| (6) | 0.1523 | 0.1523 | 0.1523 | 0.1523 | 0.1524 | 0.1527 | 0.1532 | 0.1539 | 0.1539 | 0.1539 | 0.1539 | 0.1539 | 0.1541 | 0.1544 | 0.1548 | 0.1554 | 0.1559 |
| (7) | 0.1526 | 0.1526 | 0.1527 | 0.1527 | 0.1528 | 0.1529 | 0.1532 | 0.1540 | 0.1537 | 0.1535 | 0.1528 | 0.1513 | 0.1495 | 0.1484 | 0.1490 | 0.1502 | 0.1511 |
| (8) | 0.1527 | 0.1529 | 0.1532 | 0.1534 | 0.1536 | 0.1534 | 0.1528 | 0.1522 | 0.1535 | 0.1544 | 0.1536 | 0.1510 | 0.1473 | 0.1442 | 0.1453 | 0.1472 | 0.1484 |
| (9) | 0.1522 | 0.1528 | 0.1536 | 0.1545 | 0.1553 | 0.1557 | 0.1549 | 0.1530 | 0.1564 | 0.1582 | 0.1576 | 0.1544 | 0.1494 | 0.1440 | 0.1459 | 0.1478 | 0.1487 |
| (10) | 0.1505 | 0.1518 | 0.1534 | 0.1555 | 0.1579 | 0.1606 | 0.1629 | 0.1645 | 0.1653 | 0.1654 | 0.1645 | 0.1615 | 0.1580 | 0.1551 | 0.1534 | 0.1526 | |
| (11) | 0.1466 | 0.1490 | 0.1518 | 0.1556 | 0.1600 | 0.1651 | 0.1703 | 0.1750 | 0.1727 | 0.1709 | 0.1700 | 0.1674 | 0.1661 | 0.1660 | 0.1613 | 0.1578 | |
| (12) | 0.1396 | 0.1425 | 0.1479 | 0.1546 | 0.1611 | 0.1665 | 0.1707 | 0.1731 | 0.1716 | 0.1694 | 0.1679 | 0.1669 | 0.1667 | 0.1664 | 0.1632 | 0.1600 | |
| (13) | 0.1317 | 0.1351 | 0.1431 | 0.1526 | 0.1609 | 0.1652 | 0.1670 | 0.1671 | 0.1656 | 0.1634 | 0.1617 | 0.1623 | 0.1632 | 0.1633 | 0.1616 | | |
| (14) | 0.1262 | 0.1290 | 0.1392 | 0.1505 | 0.1600 | 0.1623 | 0.1618 | 0.1600 | 0.1588 | 0.1570 | 0.1550 | 0.1573 | 0.1591 | 0.1596 | | | |
| (15) | 0.1268 | 0.1304 | 0.1386 | 0.1480 | 0.1552 | 0.1574 | 0.1567 | 0.1552 | 0.1547 | 0.1545 | 0.1545 | 0.1560 | 0.1570 | 0.1571 | | | |
| (16) | 0.1307 | 0.1339 | 0.1400 | 0.1466 | 0.1515 | 0.1532 | 0.1526 | 0.1517 | 0.1530 | 0.1549 | 0.1565 | 0.1572 | 0.1570 | | | | |
| (17) | 0.1356 | 0.1381 | 0.1423 | 0.1467 | 0.1499 | 0.1510 | 0.1506 | 0.1500 | 0.1533 | 0.1571 | 0.1600 | 0.1598 | 0.1584 | | | | |
| (18) | 0.1403 | 0.1422 | 0.1449 | 0.1479 | 0.1501 | 0.1513 | 0.1519 | 0.1530 | 0.1564 | 0.1602 | 0.1627 | 0.1624 | 0.1602 | | | | |
| (19) | 0.1441 | 0.1455 | 0.1474 | 0.1494 | 0.1513 | 0.1529 | 0.1545 | 0.1568 | 0.1602 | 0.1638 | 0.1659 | 0.1650 | 0.1622 | | | | |
| (20) | 0.1467 | 0.1478 | 0.1492 | 0.1508 | 0.1526 | 0.1546 | 0.1569 | 0.1600 | 0.1635 | 0.1669 | 0.1690 | 0.1674 | 0.1640 | | | | |
| (21) | 0.1481 | 0.1489 | 0.1500 | 0.1516 | 0.1534 | 0.1556 | 0.1583 | 0.1616 | 0.1651 | 0.1683 | 0.1699 | 0.1683 | 0.1648 | | | | |

Waskada Spearfish Initialization BLOCK POROSITIES (.N) LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1519 | 0.1522 | 0.1526 | 0.1535 | 0.1549 | 0.1572 | 0.1603 | 0.1640 | 0.1679 | 0.1709 | 0.1721 | 0.1721 | 0.1719 |
| (2) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1519 | 0.1522 | 0.1527 | 0.1535 | 0.1549 | 0.1570 | 0.1600 | 0.1637 | 0.1677 | 0.1708 | 0.1716 | 0.1712 | 0.1709 |
| (3) | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1520 | 0.1522 | 0.1527 | 0.1535 | 0.1547 | 0.1566 | 0.1592 | 0.1628 | 0.1667 | 0.1700 | 0.1699 | 0.1690 | 0.1687 |
| (4) | 0.1519 | 0.1519 | 0.1518 | 0.1519 | 0.1520 | 0.1523 | 0.1529 | 0.1536 | 0.1545 | 0.1558 | 0.1578 | 0.1605 | 0.1636 | 0.1661 | 0.1662 | 0.1657 | 0.1655 |
| (5) | 0.1521 | 0.1520 | 0.1520 | 0.1520 | 0.1522 | 0.1525 | 0.1530 | 0.1537 | 0.1542 | 0.1548 | 0.1559 | 0.1574 | 0.1593 | 0.1610 | 0.1611 | 0.1610 | 0.1610 |
| (6) | 0.1523 | 0.1523 | 0.1523 | 0.1523 | 0.1524 | 0.1527 | 0.1532 | 0.1539 | 0.1539 | 0.1539 | 0.1539 | 0.1539 | 0.1541 | 0.1544 | 0.1548 | 0.1554 | 0.1559 |
| (7) | 0.1526 | 0.1526 | 0.1527 | 0.1527 | 0.1528 | 0.1529 | 0.1532 | 0.1540 | 0.1537 | 0.1535 | 0.1528 | 0.1513 | 0.1495 | 0.1484 | 0.1490 | 0.1502 | 0.1511 |
| (8) | 0.1527 | 0.1529 | 0.1532 | 0.1534 | 0.1536 | 0.1534 | 0.1528 | 0.1522 | 0.1535 | 0.1544 | 0.1536 | 0.1510 | 0.1473 | 0.1442 | 0.1453 | 0.1472 | 0.1484 |
| (9) | 0.1522 | 0.1528 | 0.1536 | 0.1545 | 0.1553 | 0.1557 | 0.1549 | 0.1530 | 0.1564 | 0.1582 | 0.1576 | 0.1544 | 0.1494 | 0.1440 | 0.1459 | 0.1478 | 0.1487 |
| (10) | 0.1505 | 0.1518 | 0.1534 | 0.1555 | 0.1579 | 0.1606 | 0.1629 | 0.1645 | 0.1653 | 0.1654 | 0.1645 | 0.1615 | 0.1580 | 0.1551 | 0.1534 | 0.1526 | |
| (11) | 0.1466 | 0.1490 | 0.1518 | 0.1556 | 0.1600 | 0.1651 | 0.1703 | 0.1750 | 0.1727 | 0.1709 | 0.1700 | 0.1674 | 0.1661 | 0.1660 | 0.1613 | 0.1578 | |
| (12) | 0.1396 | 0.1425 | 0.1479 | 0.1546 | 0.1611 | 0.1665 | 0.1707 | 0.1731 | 0.1716 | 0.1694 | 0.1679 | 0.1669 | 0.1667 | 0.1664 | 0.1632 | 0.1600 | |
| (13) | 0.1317 | 0.1351 | 0.1431 | 0.1526 | 0.1609 | 0.1652 | 0.1670 | 0.1671 | 0.1656 | 0.1634 | 0.1617 | 0.1623 | 0.1632 | 0.1633 | 0.1616 | | |
| (14) | 0.1262 | 0.1290 | 0.1392 | 0.1505 | 0.1600 | 0.1623 | 0.1618 | 0.1600 | 0.1588 | 0.1570 | 0.1550 | 0.1573 | 0.1591 | 0.1596 | | | |
| (15) | 0.1268 | 0.1304 | 0.1386 | 0.1480 | 0.1552 | 0.1574 | 0.1567 | 0.1552 | 0.1547 | 0.1545 | 0.1545 | 0.1560 | 0.1570 | 0.1571 | | | |
| (16) | 0.1307 | 0.1339 | 0.1400 | 0.1466 | 0.1515 | 0.1532 | 0.1526 | 0.1517 | 0.1530 | 0.1549 | 0.1565 | 0.1572 | 0.1570 | | | | |
| (17) | 0.1356 | 0.1381 | 0.1423 | 0.1467 | 0.1499 | 0.1510 | 0.1506 | 0.1500 | 0.1533 | 0.1571 | 0.1600 | 0.1598 | 0.1584 | | | | |
| (18) | 0.1403 | 0.1422 | 0.1449 | 0.1479 | 0.1501 | 0.1513 | 0.1519 | 0.1530 | 0.1564 | 0.1602 | 0.1627 | 0.1624 | 0.1602 | | | | |
| (19) | 0.1441 | 0.1455 | 0.1474 | 0.1494 | 0.1513 | 0.1529 | 0.1545 | 0.1568 | 0.1602 | 0.1638 | 0.1659 | 0.1650 | 0.1622 | | | | |
| (20) | 0.1467 | 0.1478 | 0.1492 | 0.1508 | 0.1526 | 0.1546 | 0.1569 | 0.1600 | 0.1635 | 0.1669 | 0.1690 | 0.1674 | 0.1640 | | | | |
| (21) | 0.1481 | 0.1489 | 0.1500 | 0.1516 | 0.1534 | 0.1556 | 0.1583 | 0.1616 | 0.1651 | 0.1683 | 0.1699 | 0.1683 | 0.1648 | | | | |

Waskada Spearfish Initialization    X PERMEABILITY (MD)    LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 10.1 | 10.2 | 10.4 | 10.5 | 10.7 | 10.9 | 10.8 | 10.0 | 8.1 | 5.8 | 4.1 | 3.8 | 5.7 | 11.6 | 21.2 | 10.2 | 11.8 |
| (2) | 90.5 | 91.3 | 92.1 | 10.3 | 10.4 | 10.7 | 10.7 | 10.2 | 8.2 | 6.0 | 4.2 | 3.7 | 4.8 | 9.8 | 20.2 | 10.1 | 11.4 |
| (3) | 89.1 | 90.0 | 90.5 | 10.1 | 15.0 | 10.0 | 10.1 | 10.0 | 8.1 | 6.3 | 5.0 | 4.3 | 4.4 | 7.2 | 18.1 | 9.5 | 9.9 |
| (4) | 88.4 | 86.6 | 89.5 | 10.1 | 9.9 | 9.0 | 8.1 | 7.6 | 6.9 | 6.7 | 6.9 | 7.2 | 7.4 | 9.9 | 15.4 | 6.6 | 6.4 |
| (5) | 10.8 | 10.0 | 10.4 | 10.5 | 10.0 | 8.0 | 5.9 | 5.0 | 6.0 | 8.0 | 10.0 | 11.7 | 13.3 | 15.0 | 15.6 | 14.1 | 10.0 |
| (6) | 33.6 | 33.2 | 30.0 | 10.9 | 9.9 | 7.6 | 4.8 | 3.0 | 6.6 | 10.8 | 14.3 | 16.9 | 18.7 | 19.0 | 16.7 | 12.4 | 8.2 |
| (7) | 35.8 | 37.5 | 29.8 | 10.0 | 10.0 | 9.2 | 8.1 | 4.6 | 12.2 | 16.8 | 19.9 | 22.4 | 24.2 | 24.0 | 19.8 | 13.8 | 9.1 |
| (8) | 25.3 | 23.3 | 19.3 | 6.3 | 6.9 | 12.9 | 1.9 | 2.4 | 2.4 | 25.7 | 25.3 | 26.5 | 28.4 | 28.7 | 22.7 | 15.4 | 10.0 |
| (9) | 6.8 | 5.0 | 5.5 | 4.8 | 5.0 | 17.3 | 2.9 | 4.1 | 3.4 | 30.9 | 26.7 | 26.1 | 4.5 | 4.8 | 3.6 | 15.0 | 10.5 |
| (10) | 0.3 | 0.3 | 0.3 | 2.2 | 2.8 | 0.8 | 14.4 | 17.0 | 15.4 | 26.8 | 21.7 | 19.7 | 3.0 | 2.8 | 2.3 | 10.6 | |
| (11) | 0.4 | 0.4 | 0.5 | 3.7 | 4.6 | 1.0 | 135.8 | 120.8 | 121.7 | 20.0 | 33.8 | 12.8 | 1.5 | 0.8 | 0.9 | 5.6 | |
| (12) | 0.3 | 0.4 | 0.5 | 4.3 | 5.1 | 1.0 | 133.7 | 115.8 | 109.5 | 18.7 | 15.2 | 12.0 | 1.3 | 0.7 | 0.6 | 3.8 | |
| (13) | 74.5 | 105.4 | 176.3 | 2.7 | 13.3 | 13.5 | 7.3 | 6.6 | 6.2 | 5.4 | 4.8 | 3.9 | 2.9 | 2.0 | 6.5 | | |
| (14) | 29.6 | 55.0 | 150.0 | 2.6 | 13.8 | 14.2 | 7.9 | 7.3 | 7.1 | 6.5 | 6.3 | 5.2 | 4.0 | 3.1 | | | |
| (15) | 34.4 | 68.2 | 149.4 | 2.5 | 13.2 | 14.2 | 8.2 | 8.0 | 8.0 | 7.4 | 7.1 | 6.0 | 4.8 | 3.7 | | | |
| (16) | 60.5 | 92.2 | 155.9 | 21.2 | 27.2 | 29.9 | 30.6 | 30.7 | 31.2 | 6.3 | 6.0 | 5.2 | 20.4 | | | | |
| (17) | 86.8 | 110.0 | 154.1 | 19.4 | 25.0 | 41.4 | 43.8 | 12.0 | 30.8 | 6.2 | 6.0 | 5.0 | 19.5 | | | | |
| (18) | 9.5 | 10.5 | 12.3 | 15.1 | 19.0 | 23.0 | 26.7 | 28.8 | 28.8 | 5.4 | 4.9 | 4.1 | 16.6 | | | | |
| (19) | 10.4 | 10.3 | 9.6 | 9.7 | 11.8 | 17.5 | 6.2 | 7.2 | 6.8 | 21.7 | 16.9 | 14.4 | 12.8 | | | | |
| (20) | 10.7 | 10.0 | 7.3 | 4.9 | 5.0 | 12.8 | 5.6 | 7.0 | 6.2 | 16.9 | 10.0 | 9.0 | 9.5 | | | | |
| (21) | 10.4 | 9.0 | 5.9 | 3.3 | 4.0 | 11.0 | 5.0 | 6.3 | 5.6 | 15.0 | 8.7 | 7.1 | 7.8 | | | | |

X PERMEABILITY (MD)    LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 4.5 | 4.5 | 4.5 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.5 | 4.4 | 4.3 | 4.3 | 4.3 | 5.7 | 8.6 | 3.9 | 4.4 |
| (2) | 40.5 | 40.6 | 40.8 | 4.5 | 4.6 | 4.6 | 4.6 | 4.6 | 4.5 | 4.4 | 4.3 | 4.3 | 4.0 | 5.1 | 8.3 | 3.9 | 4.4 |
| (3) | 40.5 | 40.5 | 40.6 | 4.5 | 6.8 | 4.5 | 4.5 | 4.5 | 4.4 | 4.4 | 4.4 | 4.5 | 3.6 | 4.0 | 7.7 | 3.8 | 4.2 |
| (4) | 40.6 | 40.5 | 40.6 | 4.5 | 4.5 | 4.3 | 4.2 | 4.1 | 4.1 | 4.2 | 4.4 | 4.5 | 4.1 | 4.9 | 7.2 | 3.2 | 3.5 |
| (5) | 4.6 | 4.5 | 4.5 | 4.5 | 4.5 | 4.2 | 3.8 | 3.8 | 3.9 | 4.2 | 4.5 | 4.7 | 5.1 | 6.0 | 7.3 | 8.5 | 9.0 |
| (6) | 11.6 | 11.5 | 11.2 | 4.4 | 4.5 | 4.2 | 3.7 | 3.3 | 4.1 | 4.8 | 5.0 | 5.1 | 5.2 | 5.6 | 6.2 | 6.8 | 7.1 |
| (7) | 11.3 | 11.3 | 10.5 | 4.1 | 4.5 | 4.8 | 4.9 | 3.4 | 5.8 | 6.4 | 6.1 | 5.5 | 5.0 | 4.8 | 5.0 | 5.4 | 5.7 |
| (8) | 9.7 | 9.3 | 8.5 | 3.3 | 4.0 | 6.1 | 1.2 | 1.4 | 1.4 | 9.1 | 7.6 | 6.1 | 4.8 | 4.0 | 3.9 | 4.2 | 4.5 |
| (9) | 3.2 | 3.0 | 2.7 | 2.4 | 3.0 | 6.6 | 1.5 | 2.2 | 1.9 | 11.0 | 8.5 | 6.3 | 0.7 | 0.5 | 0.5 | 3.2 | 3.5 |
| (10) | 0.1 | 0.1 | 0.1 | 1.4 | 1.8 | 0.6 | 12.5 | 15.9 | 15.8 | 10.0 | 8.3 | 6.3 | 0.7 | 0.4 | 0.4 | 2.8 | |
| (11) | 0.1 | 0.1 | 0.1 | 1.5 | 1.8 | 0.5 | 52.3 | 53.6 | 76.1 | 8.1 | 17.4 | 6.4 | 0.7 | 0.5 | 0.4 | 2.8 | |
| (12) | 0.1 | 0.1 | 0.1 | 1.5 | 1.7 | 0.4 | 38.9 | 44.3 | 63.3 | 7.5 | 7.8 | 7.1 | 0.9 | 0.7 | 0.6 | 3.2 | |
| (13) | 29.9 | 29.7 | 29.4 | 0.3 | 1.3 | 1.5 | 1.0 | 1.3 | 1.7 | 2.4 | 2.7 | 2.5 | 2.2 | 1.8 | 4.9 | | |
| (14) | 31.3 | 125.4 | 31.0 | 0.3 | 1.4 | 1.5 | 1.1 | 1.4 | 1.7 | 2.5 | 2.9 | 2.7 | 2.5 | 2.2 | | | |
| (15) | 32.2 | 32.2 | 32.0 | 0.3 | 1.4 | 1.5 | 1.0 | 1.3 | 1.6 | 2.2 | 2.5 | 2.6 | 2.4 | 2.3 | | | |
| (16) | 32.8 | 32.7 | 32.7 | 3.0 | 3.0 | 3.1 | 3.4 | 3.9 | 4.7 | 2.2 | 2.5 | 2.7 | 7.0 | | | | |
| (17) | 33.0 | 33.0 | 33.0 | 3.0 | 3.0 | 4.4 | 4.4 | 1.8 | 3.6 | 1.6 | 1.8 | 2.1 | 6.0 | | | | |
| (18) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 2.8 | 2.8 | 3.0 | 1.3 | 1.5 | 1.7 | 4.8 | | | | |
| (19) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 0.7 | 0.7 | 0.7 | 3.0 | 3.2 | 3.5 | 3.9 | | | | |
| (20) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.8 | 0.8 | 0.7 | 2.8 | 2.8 | 3.0 | 3.1 | | | | |
| (21) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.8 | 0.8 | 0.7 | 2.7 | 2.7 | 2.8 | 2.8 | | | | |

Waskada Spearfish Initialization          X PERMEABILITY (MD)          LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 1.3 | 0.5 | 0.6 |
| (2) | 9.0 | 9.0 | 9.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 1.3 | 0.6 | 0.6 |
| (3) | 9.1 | 9.0 | 9.0 | 1.0 | 1.5 | 1.0 | 1.0 | 1.5 | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 | 0.9 | 1.3 | 0.6 | 0.6 |
| (4) | 9.1 | 9.0 | 8.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.4 | 0.9 | 0.9 | 0.9 | 1.1 | 1.2 | 1.4 | 1.5 | 0.5 | 0.4 |
| (5) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 | 1.0 | 1.0 | 1.3 | 1.7 | 2.0 | 1.8 | 1.4 | 1.0 |
| (6) | 2.6 | 2.5 | 2.3 | 0.9 | 1.0 | 1.1 | 1.2 | 1.2 | 1.4 | 1.4 | 1.4 | 1.6 | 1.8 | 1.9 | 1.6 | 1.3 | 1.0 |
| (7) | 2.6 | 2.5 | 2.3 | 0.9 | 1.0 | 1.4 | 1.7 | 1.8 | 2.1 | 2.1 | 2.0 | 1.8 | 1.7 | 1.6 | 1.4 | 1.2 | 1.0 |
| (8) | 2.6 | 2.5 | 2.2 | 0.8 | 1.1 | 1.9 | 0.3 | 0.3 | 0.3 | 3.0 | 2.5 | 2.0 | 1.6 | 1.4 | 1.2 | 1.1 | 1.0 |
| (9) | 1.0 | 1.0 | 0.8 | 0.8 | 1.5 | 2.2 | 0.3 | 0.5 | 0.4 | 3.5 | 2.7 | 2.0 | 0.2 | 0.2 | 0.2 | 0.9 | 1.0 |
| (10) | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.1 | 1.3 | 1.7 | 1.6 | 3.0 | 2.5 | 1.9 | 0.2 | 0.2 | 0.1 | 0.9 | |
| (11) | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.1 | 8.9 | 8.9 | 11.5 | 2.3 | 4.7 | 1.7 | 0.2 | 0.1 | 0.1 | 0.9 | |
| (12) | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 7.1 | 7.2 | 8.9 | 1.9 | 1.8 | 1.5 | 0.2 | 0.2 | 0.1 | 0.9 | |
| (13) | 15.2 | 15.0 | 14.6 | 0.2 | 0.6 | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.9 | | |
| (14) | 17.5 | 17.6 | 16.9 | 0.2 | 0.7 | 0.7 | 0.4 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | | | |
| (15) | 18.3 | 18.4 | 18.0 | 0.2 | 0.7 | 0.7 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | | | |
| (16) | 17.8 | 17.8 | 17.8 | 1.6 | 1.6 | 1.5 | 1.3 | 1.3 | 1.4 | 0.3 | 0.3 | 0.3 | 1.3 | | | | |
| (17) | 16.5 | 16.5 | 16.7 | 1.5 | 1.5 | 2.0 | 1.7 | 0.4 | 1.2 | 0.3 | 0.3 | 0.3 | 1.3 | | | | |
| (18) | 1.3 | 1.3 | 1.4 | 1.4 | 1.3 | 1.2 | 1.0 | 1.0 | 1.1 | 0.2 | 0.3 | 0.3 | 1.2 | | | | |
| (19) | 1.1 | 1.1 | 1.2 | 1.2 | 1.1 | 1.1 | 0.3 | 0.3 | 0.3 | 1.1 | 1.2 | 1.2 | 1.1 | | | | |
| (20) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.3 | 0.3 | 0.3 | 1.1 | 1.1 | 1.1 | 1.1 | | | | |
| (21) | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.2 | 0.3 | 0.3 | 1.0 | 1.1 | 1.1 | 1.0 | | | | |

Waskada Spearfish Initialization Y PERMEABILITY (MD) LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 10.1 | 10.2 | 10.4 | 10.5 | 10.7 | 10.9 | 10.8 | 10.0 | 8.1 | 5.8 | 4.1 | 3.8 | 5.7 | 11.6 | 21.2 | 10.2 | 11.8 |
| (2) | 90.5 | 91.3 | 92.1 | 10.3 | 10.4 | 10.7 | 10.7 | 10.2 | 8.2 | 6.0 | 4.2 | 3.7 | 4.8 | 9.8 | 20.2 | 10.1 | 11.4 |
| (3) | 89.1 | 90.0 | 90.5 | 10.1 | 15.0 | 10.0 | 10.1 | 10.0 | 8.1 | 6.3 | 5.0 | 4.3 | 4.4 | 7.2 | 18.1 | 9.5 | 9.9 |
| (4) | 88.4 | 86.6 | 89.5 | 10.1 | 9.9 | 9.0 | 8.1 | 7.6 | 6.9 | 6.7 | 6.9 | 7.2 | 7.4 | 9.9 | 15.4 | 6.6 | 6.4 |
| (5) | 10.8 | 10.0 | 10.4 | 10.5 | 10.0 | 8.0 | 5.9 | 5.0 | 6.0 | 8.0 | 10.0 | 11.7 | 13.3 | 15.0 | 15.6 | 14.1 | 10.0 |
| (6) | 33.6 | 33.2 | 30.0 | 10.9 | 9.9 | 7.6 | 4.8 | 3.0 | 6.6 | 10.8 | 14.3 | 16.9 | 18.7 | 19.0 | 16.7 | 12.4 | 8.2 |
| (7) | 35.8 | 37.5 | 29.8 | 10.0 | 10.0 | 9.2 | 8.1 | 4.6 | 12.2 | 16.8 | 19.9 | 22.4 | 24.2 | 24.0 | 19.8 | 13.8 | 9.1 |
| (8) | 25.3 | 23.3 | 19.3 | 6.3 | 6.9 | 12.9 | 1.9 | 2.4 | 2.4 | 25.7 | 25.3 | 26.5 | 28.4 | 28.7 | 22.7 | 15.4 | 10.0 |
| (9) | 0.7 | 0.5 | 0.5 | 4.8 | 5.0 | 17.3 | 0.9 | 1.2 | 1.0 | 30.9 | 26.7 | 26.1 | 4.5 | 4.8 | 3.6 | 15.0 | 10.5 |
| (10) | 0.3 | 0.3 | 0.3 | 2.2 | 2.8 | 4.2 | 0.7 | 0.8 | 0.8 | 26.8 | 21.7 | 19.7 | 3.0 | 2.8 | 2.3 | 10.6 | |
| (11) | 0.4 | 0.4 | 0.5 | 3.7 | 4.6 | 4.8 | 135.8 | 120.8 | 121.7 | 20.0 | 33.8 | 12.8 | 1.5 | 0.8 | 0.9 | 5.6 | |
| (12) | 0.2 | 0.2 | 0.3 | 4.3 | 5.1 | 5.1 | 133.7 | 115.8 | 109.5 | 18.7 | 15.2 | 12.0 | 1.3 | 0.7 | 0.6 | 3.8 | |
| (13) | 74.5 | 105.4 | 176.3 | 10.8 | 13.3 | 13.5 | 7.3 | 6.6 | 6.2 | 1.1 | 1.0 | 0.8 | 2.9 | 2.0 | 6.5 | | |
| (14) | 29.6 | 55.0 | 150.0 | 10.5 | 13.8 | 14.2 | 7.9 | 7.3 | 7.1 | 6.5 | 6.3 | 5.2 | 4.0 | 3.1 | | | |
| (15) | 34.4 | 68.2 | 149.4 | 10.1 | 13.2 | 14.2 | 8.2 | 8.0 | 8.0 | 7.4 | 7.1 | 6.0 | 4.8 | 3.7 | | | |
| (16) | 30.3 | 46.1 | 77.9 | 21.2 | 27.2 | 29.9 | 30.6 | 30.7 | 31.2 | 6.3 | 6.0 | 5.2 | 20.4 | | | | |
| (17) | 86.8 | 110.0 | 154.1 | 19.4 | 25.0 | 27.6 | 29.2 | 12.0 | 30.8 | 6.2 | 6.0 | 5.0 | 19.5 | | | | |
| (18) | 9.5 | 10.5 | 12.3 | 15.1 | 19.0 | 23.0 | 26.7 | 28.8 | 28.8 | 5.4 | 4.9 | 4.1 | 16.6 | | | | |
| (19) | 10.4 | 10.3 | 9.6 | 9.7 | 11.8 | 17.5 | 6.2 | 7.2 | 6.8 | 21.7 | 16.9 | 14.4 | 12.8 | | | | |
| (20) | 10.7 | 10.0 | 7.3 | 4.9 | 5.0 | 12.8 | 5.6 | 7.0 | 6.2 | 16.9 | 10.0 | 9.0 | 9.5 | | | | |
| (21) | 10.4 | 9.0 | 5.9 | 3.3 | 4.0 | 11.0 | 5.0 | 6.3 | 5.6 | 15.0 | 8.7 | 7.1 | 7.8 | | | | |

Y PERMEABILITY (MD) LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 4.5 | 4.5 | 4.5 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.5 | 4.4 | 4.3 | 4.3 | 4.3 | 5.7 | 8.6 | 3.9 | 4.4 |
| (2) | 40.5 | 40.6 | 40.8 | 4.5 | 4.6 | 4.6 | 4.6 | 4.6 | 4.5 | 4.4 | 4.3 | 4.3 | 4.0 | 5.1 | 8.3 | 3.9 | 4.4 |
| (3) | 40.5 | 40.5 | 40.6 | 4.5 | 6.8 | 4.5 | 4.5 | 4.5 | 4.4 | 4.4 | 4.4 | 4.5 | 3.6 | 4.0 | 7.7 | 3.8 | 4.2 |
| (4) | 40.6 | 40.5 | 40.6 | 4.5 | 4.5 | 4.3 | 4.2 | 4.1 | 4.1 | 4.2 | 4.4 | 4.5 | 4.1 | 4.9 | 7.2 | 3.2 | 3.5 |
| (5) | 4.6 | 4.5 | 4.5 | 4.5 | 4.5 | 4.2 | 3.8 | 3.8 | 3.9 | 4.2 | 4.5 | 4.7 | 5.1 | 6.0 | 7.3 | 8.5 | 9.0 |
| (6) | 11.6 | 11.5 | 11.2 | 4.4 | 4.5 | 4.2 | 3.7 | 3.3 | 4.1 | 4.8 | 5.0 | 5.1 | 5.2 | 5.6 | 6.2 | 6.8 | 7.1 |
| (7) | 11.3 | 11.3 | 10.5 | 4.1 | 4.5 | 4.8 | 4.9 | 3.4 | 5.8 | 6.4 | 6.1 | 5.5 | 5.0 | 4.8 | 5.0 | 5.4 | 5.7 |
| (8) | 9.7 | 9.3 | 8.5 | 3.3 | 4.0 | 6.1 | 1.2 | 1.4 | 1.4 | 9.1 | 7.6 | 6.1 | 4.8 | 4.0 | 3.9 | 4.2 | 4.5 |
| (9) | 0.3 | 0.3 | 0.3 | 2.4 | 3.0 | 6.6 | 0.5 | 0.7 | 0.6 | 11.0 | 8.5 | 6.3 | 0.7 | 0.5 | 0.5 | 3.2 | 3.5 |
| (10) | 0.1 | 0.1 | 0.1 | 1.4 | 1.8 | 3.2 | 0.6 | 0.8 | 0.8 | 10.0 | 8.3 | 6.3 | 0.7 | 0.4 | 0.4 | 2.8 | |
| (11) | 0.1 | 0.1 | 0.1 | 1.5 | 1.8 | 2.3 | 52.3 | 53.6 | 76.1 | 8.1 | 17.4 | 6.4 | 0.7 | 0.5 | 0.4 | 2.8 | |
| (12) | 0.1 | 0.1 | 0.1 | 1.5 | 1.7 | 1.9 | 38.9 | 44.3 | 63.3 | 7.5 | 7.8 | 7.1 | 0.9 | 0.7 | 0.6 | 3.2 | |
| (13) | 29.9 | 29.7 | 29.4 | 1.3 | 1.3 | 1.5 | 1.0 | 1.3 | 1.7 | 0.5 | 0.5 | 0.5 | 2.2 | 1.8 | 4.9 | | |
| (14) | 31.3 | 125.4 | 31.0 | 1.3 | 1.4 | 1.5 | 1.1 | 1.4 | 1.7 | 2.5 | 2.9 | 2.7 | 2.5 | 2.2 | | | |
| (15) | 32.2 | 32.2 | 32.0 | 1.3 | 1.4 | 1.5 | 1.0 | 1.3 | 1.6 | 2.2 | 2.5 | 2.6 | 2.4 | 2.3 | | | |
| (16) | 16.4 | 16.3 | 16.3 | 3.0 | 3.0 | 3.1 | 3.4 | 3.9 | 4.7 | 2.2 | 2.5 | 2.7 | 7.0 | | | | |
| (17) | 33.0 | 33.0 | 33.0 | 3.0 | 3.0 | 2.9 | 2.9 | 1.8 | 3.6 | 1.6 | 1.8 | 2.1 | 6.0 | | | | |
| (18) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 2.8 | 2.8 | 3.0 | 1.3 | 1.5 | 1.7 | 4.8 | | | | |
| (19) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 0.7 | 0.7 | 0.7 | 3.0 | 3.2 | 3.5 | 3.9 | | | | |
| (20) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.8 | 0.8 | 0.7 | 2.8 | 2.8 | 3.0 | 3.1 | | | | |
| (21) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.8 | 0.8 | 0.7 | 2.7 | 2.7 | 2.8 | 2.8 | | | | |

Waskada Spearfish Initialization  Y PERMEABILITY (MD)  LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 1.3 | 0.5 | 0.6 |
| (2) | 9.0 | 9.0 | 9.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 1.3 | 0.6 | 0.6 |
| (3) | 9.1 | 9.0 | 9.0 | 1.0 | 1.5 | 1.0 | 1.0 | 1.5 | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 | 0.9 | 1.3 | 0.6 | 0.6 |
| (4) | 9.1 | 9.0 | 8.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.4 | 0.9 | 0.9 | 0.9 | 1.1 | 1.2 | 1.4 | 1.5 | 0.5 | 0.4 |
| (5) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 | 1.0 | 1.0 | 1.3 | 1.7 | 2.0 | 1.8 | 1.4 | 1.0 |
| (6) | 2.6 | 2.5 | 2.3 | 0.9 | 1.0 | 1.1 | 1.2 | 1.2 | 1.4 | 1.4 | 1.4 | 1.6 | 1.8 | 1.9 | 1.6 | 1.3 | 1.0 |
| (7) | 2.6 | 2.5 | 2.3 | 0.9 | 1.0 | 1.4 | 1.7 | 1.8 | 2.1 | 2.1 | 2.0 | 1.8 | 1.7 | 1.6 | 1.4 | 1.2 | 1.0 |
| (8) | 2.6 | 2.5 | 2.2 | 0.8 | 1.1 | 1.9 | 0.3 | 0.3 | 0.3 | 3.0 | 2.5 | 2.0 | 1.6 | 1.4 | 1.2 | 1.1 | 1.0 |
| (9) | 0.1 | 0.1 | 0.1 | 0.8 | 1.5 | 2.2 | 0.1 | 0.1 | 0.1 | 3.5 | 2.7 | 2.0 | 0.2 | 0.2 | 0.2 | 0.9 | 1.0 |
| (10) | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.3 | 0.1 | 0.1 | 0.1 | 3.0 | 2.5 | 1.9 | 0.2 | 0.2 | 0.1 | 0.9 | |
| (11) | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.3 | 8.9 | 8.9 | 11.5 | 2.3 | 4.7 | 1.7 | 0.2 | 0.1 | 0.1 | 0.9 | |
| (12) | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.2 | 7.1 | 7.2 | 8.9 | 1.9 | 1.8 | 1.5 | 0.2 | 0.2 | 0.1 | 0.9 | |
| (13) | 15.2 | 15.0 | 14.6 | 0.6 | 0.6 | 0.6 | 0.4 | 0.4 | 0.4 | 0.1 | 0.1 | 0.1 | 0.3 | 0.3 | 0.9 | | |
| (14) | 17.5 | 17.6 | 16.9 | 0.7 | 0.7 | 0.7 | 0.4 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | | | |
| (15) | 18.3 | 18.4 | 18.0 | 0.7 | 0.7 | 0.7 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | | | |
| (16) | 8.9 | 8.9 | 8.9 | 1.6 | 1.6 | 1.5 | 1.3 | 1.3 | 1.4 | 0.3 | 0.3 | 0.3 | 1.3 | | | | |
| (17) | 16.5 | 16.5 | 16.7 | 1.5 | 1.5 | 1.3 | 1.1 | 0.4 | 1.2 | 0.3 | 0.3 | 0.3 | 1.3 | | | | |
| (18) | 1.3 | 1.3 | 1.4 | 1.4 | 1.3 | 1.2 | 1.0 | 1.0 | 1.1 | 0.2 | 0.3 | 0.3 | 1.2 | | | | |
| (19) | 1.1 | 1.1 | 1.2 | 1.2 | 1.1 | 1.1 | 0.3 | 0.3 | 0.3 | 1.1 | 1.2 | 1.2 | 1.1 | | | | |
| (20) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.3 | 0.3 | 0.3 | 1.1 | 1.1 | 1.1 | 1.1 | | | | |
| (21) | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.2 | 0.3 | 0.3 | 1.0 | 1.1 | 1.1 | 1.0 | | | | |

Waskada Spearfish Initialization

Z PERMEABILITY (MD) LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (2) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (3) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (4) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (5) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (6) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (7) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (8) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (9) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (10) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (11) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (12) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (13) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | |
| (14) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (15) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (16) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (17) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (18) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (19) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (20) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (21) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |

Z PERMEABILITY (MD) LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (2) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (3) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (4) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (5) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (6) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (7) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (8) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (9) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (10) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (11) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (12) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (13) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | |
| (14) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (15) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (16) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (17) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (18) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (19) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (20) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (21) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |

Waskada Spearfish Initialization Z PERMEABILITY (MD) LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (2) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (3) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (4) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (5) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (6) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (7) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (8) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (9) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (10) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (11) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (12) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (13) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | |
| (14) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (15) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (16) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (17) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (18) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (19) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (20) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (21) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |

Waskada Spearfish Initialization

INITIAL PRESSURES (PSIA) LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 1262.5 | 1262.3 | 1261.9 | 1261.3 | 1260.7 | 1260.0 | 1259.3 | 1258.7 | 1258.1 | 1257.5 | 1256.9 | 1256.2 | 1255.4 | 1254.6 | 1253.9 | 1253.3 | 1253.0 |
| (2) | 1262.5 | 1262.3 | 1261.9 | 1261.3 | 1260.6 | 1259.9 | 1259.2 | 1258.5 | 1258.0 | 1257.5 | 1256.9 | 1256.3 | 1255.6 | 1254.9 | 1254.1 | 1253.6 | 1253.3 |
| (3) | 1262.7 | 1265.1 | 1264.6 | 1263.9 | 1263.1 | 1262.3 | 1261.5 | 1262.2 | 1260.4 | 1260.0 | 1262.6 | 1262.2 | 1261.6 | 1262.3 | 1260.3 | 1259.8 | 1259.5 |
| (4) | 1262.9 | 1262.7 | 1262.1 | 1261.3 | 1260.4 | 1259.4 | 1258.5 | 1257.9 | 1257.5 | 1257.4 | 1257.2 | 1257.0 | 1256.6 | 1256.1 | 1255.6 | 1255.2 | 1255.0 |
| (5) | 1262.0 | 1260.7 | 1261.1 | 1261.5 | 1262.1 | 1259.3 | 1258.2 | 1261.5 | 1261.3 | 1261.5 | 1263.3 | 1263.3 | 1263.1 | 1262.8 | 1256.8 | 1256.4 | 1256.2 |
| (6) | 1260.6 | 1260.3 | 1261.6 | 1261.9 | 1260.7 | 1259.4 | 1258.1 | 1257.3 | 1257.4 | 1258.0 | 1258.4 | 1258.7 | 1258.7 | 1258.5 | 1258.1 | 1257.8 | 1257.7 |
| (7) | 1261.3 | 1261.0 | 1259.9 | 1262.5 | 1261.7 | 1259.8 | 1258.5 | 1260.5 | 1258.1 | 1258.9 | 1259.5 | 1259.9 | 1260.0 | 1259.8 | 1259.5 | 1259.2 | 1259.0 |
| (8) | 1262.1 | 1261.7 | 1260.7 | 1262.0 | 1262.0 | 1260.7 | 1259.7 | 1262.3 | 1259.5 | 1260.2 | 1260.9 | 1261.4 | 1261.4 | 1261.2 | 1260.8 | 1260.4 | 1260.2 |
| (9) | 1262.8 | 1262.4 | 1262.7 | 1262.4 | 1262.4 | 1261.3 | 1260.5 | 1263.6 | 1260.5 | 1261.3 | 1262.3 | 1262.7 | 1262.6 | 1262.2 | 1261.7 | 1261.3 | 1261.0 |
| (10) | 1263.2 | 1262.9 | 1263.2 | 1262.9 | 1262.8 | 1261.2 | 1259.5 | 1258.9 | 1259.8 | 1259.2 | 1260.8 | 1261.1 | 1260.7 | 1260.1 | 1259.6 | 1259.2 | |
| (11) | 1263.1 | 1262.9 | 1263.3 | 1263.0 | 1264.4 | 1260.9 | 1258.4 | 1263.5 | 1258.8 | 1259.1 | 1261.5 | 1261.5 | 1260.8 | 1260.0 | 1259.6 | 1259.4 | |
| (12) | 1264.0 | 1263.8 | 1262.7 | 1262.6 | 1262.6 | 1260.9 | 1258.9 | 1258.9 | 1259.1 | 1258.7 | 1260.4 | 1260.8 | 1260.5 | 1259.9 | 1259.6 | 1259.3 | |
| (13) | 1263.3 | 1263.2 | 1264.3 | 1263.8 | 1262.8 | 1261.5 | 1260.2 | 1260.7 | 1260.0 | 1258.6 | 1259.6 | 1260.0 | 1259.9 | 1259.6 | 1259.4 | | |
| (14) | 1263.5 | 1263.4 | 1263.5 | 1263.4 | 1262.4 | 1262.7 | 1262.0 | 1262.6 | 1261.4 | 1261.6 | 1261.7 | 1261.9 | 1261.9 | 1261.8 | | | |
| (15) | 1263.7 | 1263.8 | 1264.0 | 1264.2 | 1264.3 | 1264.3 | 1264.2 | 1263.8 | 1263.3 | 1262.6 | 1262.1 | 1261.9 | 1261.8 | 1261.8 | | | |
| (16) | 1263.9 | 1264.1 | 1264.5 | 1262.7 | 1263.3 | 1263.8 | 1264.2 | 1264.1 | 1263.1 | 1264.0 | 1262.8 | 1262.3 | 1262.1 | | | | |
| (17) | 1264.4 | 1265.2 | 1262.6 | 1263.4 | 1264.3 | 1264.5 | 1265.3 | 1265.6 | 1264.2 | 1262.3 | 1262.2 | 1263.2 | 1262.8 | | | | |
| (18) | 1261.6 | 1261.9 | 1262.6 | 1263.5 | 1263.3 | 1264.3 | 1264.2 | 1264.4 | 1263.4 | 1263.1 | 1261.5 | 1260.4 | 1259.7 | | | | |
| (19) | 1262.1 | 1262.4 | 1263.1 | 1264.1 | 1264.0 | 1264.1 | 1264.9 | 1265.2 | 1264.6 | 1263.4 | 1262.1 | 1260.7 | 1259.6 | | | | |
| (20) | 1262.1 | 1264.1 | 1263.2 | 1264.3 | 1263.4 | 1263.9 | 1264.1 | 1264.4 | 1264.1 | 1263.3 | 1262.9 | 1261.4 | 1260.3 | | | | |
| (21) | 1262.3 | 1264.3 | 1263.5 | 1264.5 | 1263.7 | 1264.1 | 1264.3 | 1264.7 | 1264.5 | 1263.8 | 1263.4 | 1262.0 | 1260.8 | | | | |

INITIAL PRESSURES (PSIA) LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 1264.3 | 1264.1 | 1263.7 | 1263.3 | 1262.7 | 1262.1 | 1261.4 | 1260.7 | 1260.0 | 1259.3 | 1258.6 | 1257.8 | 1257.0 | 1256.3 | 1255.7 | 1255.3 | 1255.1 |
| (2) | 1264.4 | 1264.2 | 1263.8 | 1263.3 | 1262.7 | 1262.0 | 1261.3 | 1260.6 | 1260.0 | 1259.3 | 1258.6 | 1257.9 | 1257.1 | 1256.5 | 1255.9 | 1255.5 | 1255.3 |
| (3) | 1264.6 | 1267.0 | 1266.6 | 1266.0 | 1265.4 | 1264.6 | 1263.8 | 1264.4 | 1262.5 | 1261.9 | 1264.3 | 1263.7 | 1263.0 | 1263.7 | 1261.9 | 1261.5 | 1261.4 |
| (4) | 1264.9 | 1264.7 | 1264.2 | 1263.6 | 1262.8 | 1261.9 | 1261.0 | 1260.3 | 1259.7 | 1259.3 | 1258.9 | 1258.4 | 1257.8 | 1257.3 | 1256.9 | 1256.7 | 1256.6 |
| (5) | 1264.1 | 1262.8 | 1263.3 | 1263.9 | 1264.6 | 1261.9 | 1260.9 | 1264.1 | 1263.7 | 1263.5 | 1264.9 | 1264.6 | 1264.2 | 1263.7 | 1257.9 | 1257.8 | 1257.8 |
| (6) | 1262.8 | 1262.4 | 1263.8 | 1264.3 | 1263.3 | 1262.1 | 1260.9 | 1260.1 | 1259.9 | 1260.0 | 1260.1 | 1260.1 | 1259.8 | 1259.6 | 1259.4 | 1259.3 | 1259.2 |
| (7) | 1263.5 | 1263.2 | 1262.2 | 1264.9 | 1264.3 | 1262.5 | 1261.2 | 1263.2 | 1260.4 | 1260.8 | 1261.2 | 1261.4 | 1261.4 | 1261.3 | 1261.1 | 1261.0 | 1260.9 |
| (8) | 1264.2 | 1263.9 | 1262.9 | 1264.3 | 1264.4 | 1263.1 | 1261.9 | 1264.3 | 1261.3 | 1261.9 | 1262.5 | 1263.0 | 1263.1 | 1263.0 | 1262.8 | 1262.6 | 1262.5 |
| (9) | 1264.7 | 1264.5 | 1264.9 | 1264.7 | 1264.7 | 1263.5 | 1262.2 | 1264.8 | 1261.9 | 1262.8 | 1263.8 | 1264.5 | 1264.7 | 1264.6 | 1264.3 | 1264.1 | 1263.9 |
| (10) | 1264.9 | 1264.8 | 1265.3 | 1265.1 | 1265.1 | 1263.4 | 1261.4 | 1260.4 | 1261.3 | 1260.6 | 1262.4 | 1263.2 | 1263.3 | 1263.2 | 1262.9 | 1262.7 | |
| (11) | 1264.6 | 1264.6 | 1265.1 | 1265.1 | 1266.7 | 1263.1 | 1260.4 | 1265.4 | 1260.4 | 1260.7 | 1263.2 | 1263.8 | 1263.9 | 1263.8 | 1263.5 | 1263.2 | |
| (12) | 1265.3 | 1265.2 | 1264.2 | 1264.3 | 1264.5 | 1262.8 | 1260.7 | 1260.7 | 1260.7 | 1260.4 | 1262.5 | 1263.4 | 1263.7 | 1263.7 | 1263.5 | 1263.4 | |
| (13) | 1264.3 | 1264.3 | 1265.5 | 1265.1 | 1264.3 | 1262.9 | 1261.6 | 1262.0 | 1261.5 | 1260.4 | 1261.8 | 1262.7 | 1263.1 | 1263.2 | 1263.2 | | |
| (14) | 1264.3 | 1264.3 | 1264.4 | 1264.4 | 1263.5 | 1263.7 | 1263.0 | 1263.6 | 1262.7 | 1263.3 | 1264.0 | 1264.5 | 1264.9 | 1265.1 | | | |
| (15) | 1264.4 | 1264.5 | 1264.7 | 1265.0 | 1265.1 | 1265.2 | 1265.0 | 1264.8 | 1264.5 | 1264.2 | 1264.0 | 1264.2 | 1264.5 | 1264.7 | | | |
| (16) | 1264.6 | 1264.8 | 1265.2 | 1263.5 | 1264.1 | 1264.7 | 1265.1 | 1265.1 | 1264.2 | 1265.4 | 1264.4 | 1264.3 | 1264.4 | | | | |
| (17) | 1265.1 | 1265.9 | 1263.4 | 1264.2 | 1265.1 | 1265.4 | 1266.3 | 1266.7 | 1265.4 | 1263.5 | 1263.5 | 1264.9 | 1264.9 | | | | |
| (18) | 1262.4 | 1262.7 | 1263.4 | 1264.3 | 1264.2 | 1265.3 | 1265.3 | 1265.6 | 1264.7 | 1264.5 | 1263.0 | 1262.2 | 1261.7 | | | | |
| (19) | 1262.9 | 1263.3 | 1264.0 | 1265.1 | 1265.0 | 1265.2 | 1266.1 | 1266.5 | 1266.0 | 1265.0 | 1263.9 | 1262.7 | 1261.7 | | | | |
| (20) | 1263.0 | 1265.0 | 1264.2 | 1265.2 | 1264.5 | 1265.0 | 1265.3 | 1265.8 | 1265.7 | 1265.1 | 1264.9 | 1263.5 | 1262.5 | | | | |
| (21) | 1263.2 | 1265.3 | 1264.4 | 1265.5 | 1264.8 | 1265.3 | 1265.6 | 1266.2 | 1266.2 | 1265.8 | 1265.6 | 1264.2 | 1263.0 | | | | |

Waskada Spearfish Initialization INITIAL PRESSURES (PSIA) LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 1265.9 | 1265.8 | 1265.7 | 1265.5 | 1265.3 | 1265.0 | 1264.6 | 1264.1 | 1263.4 | 1262.5 | 1261.4 | 1260.3 | 1259.1 | 1258.2 | 1257.6 | 1257.3 | 1257.1 |
| (2) | 1265.9 | 1265.9 | 1265.7 | 1265.5 | 1265.3 | 1264.9 | 1264.5 | 1263.9 | 1263.2 | 1262.4 | 1261.3 | 1260.2 | 1259.1 | 1258.2 | 1257.7 | 1257.4 | 1257.3 |
| (3) | 1266.1 | 1268.7 | 1268.5 | 1268.2 | 1267.8 | 1267.4 | 1266.9 | 1267.7 | 1265.7 | 1264.8 | 1266.8 | 1265.7 | 1264.7 | 1265.1 | 1263.4 | 1263.3 | 1263.2 |
| (4) | 1266.4 | 1266.3 | 1266.0 | 1265.6 | 1265.2 | 1264.6 | 1264.1 | 1263.4 | 1262.8 | 1262.1 | 1261.2 | 1260.2 | 1259.2 | 1258.4 | 1258.2 | 1258.2 | 1258.2 |
| (5) | 1265.6 | 1264.4 | 1265.0 | 1265.9 | 1266.9 | 1264.6 | 1263.9 | 1267.2 | 1266.6 | 1266.1 | 1267.1 | 1266.3 | 1265.4 | 1264.6 | 1259.0 | 1259.1 | 1259.2 |
| (6) | 1264.2 | 1264.0 | 1265.6 | 1266.3 | 1265.5 | 1264.6 | 1263.8 | 1263.0 | 1262.7 | 1262.4 | 1262.1 | 1261.7 | 1261.1 | 1260.7 | 1260.6 | 1260.6 | 1260.7 |
| (7) | 1265.0 | 1264.7 | 1264.0 | 1266.9 | 1266.4 | 1264.8 | 1263.8 | 1266.0 | 1262.8 | 1262.9 | 1263.1 | 1263.1 | 1262.9 | 1262.7 | 1262.6 | 1262.6 | 1262.6 |
| (8) | 1265.8 | 1265.5 | 1264.7 | 1266.3 | 1266.5 | 1265.2 | 1264.0 | 1266.2 | 1263.2 | 1263.6 | 1264.2 | 1264.7 | 1264.9 | 1264.9 | 1264.8 | 1264.7 | 1264.7 |
| (9) | 1266.4 | 1266.2 | 1266.7 | 1266.7 | 1266.8 | 1265.4 | 1263.9 | 1266.1 | 1263.3 | 1264.3 | 1265.5 | 1266.3 | 1266.8 | 1267.0 | 1266.9 | 1266.8 | 1266.6 |
| (10) | 1266.6 | 1266.5 | 1267.2 | 1267.2 | 1267.3 | 1265.4 | 1263.2 | 1262.0 | 1262.8 | 1262.1 | 1264.1 | 1265.3 | 1266.0 | 1266.3 | 1266.2 | 1265.9 | |
| (11) | 1266.2 | 1266.2 | 1267.0 | 1267.2 | 1269.0 | 1265.3 | 1262.5 | 1267.4 | 1262.2 | 1262.3 | 1264.9 | 1266.2 | 1267.0 | 1267.5 | 1267.2 | 1266.9 | |
| (12) | 1266.6 | 1266.6 | 1265.9 | 1266.3 | 1266.6 | 1264.8 | 1262.6 | 1262.5 | 1262.5 | 1262.2 | 1264.6 | 1266.0 | 1266.9 | 1267.4 | 1267.3 | 1267.1 | |
| (13) | 1265.4 | 1265.4 | 1266.9 | 1266.8 | 1266.2 | 1264.7 | 1263.1 | 1263.4 | 1263.0 | 1262.3 | 1264.1 | 1265.3 | 1266.2 | 1266.6 | 1266.7 | | |
| (14) | 1265.1 | 1265.1 | 1265.6 | 1265.8 | 1265.1 | 1265.2 | 1264.2 | 1264.6 | 1264.0 | 1265.0 | 1266.2 | 1267.0 | 1267.7 | 1268.1 | | | |
| (15) | 1264.9 | 1265.1 | 1265.6 | 1266.2 | 1266.4 | 1266.4 | 1266.1 | 1265.7 | 1265.6 | 1265.6 | 1265.8 | 1266.3 | 1266.8 | 1267.2 | | | |
| (16) | 1265.0 | 1265.3 | 1265.9 | 1264.4 | 1265.1 | 1265.7 | 1266.1 | 1266.1 | 1265.3 | 1266.5 | 1265.7 | 1265.9 | 1266.3 | | | | |
| (17) | 1265.4 | 1266.2 | 1263.9 | 1264.9 | 1266.0 | 1266.4 | 1267.4 | 1267.9 | 1266.4 | 1264.6 | 1264.5 | 1266.2 | 1266.4 | | | | |
| (18) | 1262.6 | 1262.9 | 1263.8 | 1264.9 | 1264.9 | 1266.2 | 1266.3 | 1266.8 | 1265.9 | 1265.7 | 1264.2 | 1263.5 | 1263.1 | | | | |
| (19) | 1263.0 | 1263.4 | 1264.3 | 1265.5 | 1265.6 | 1266.0 | 1267.2 | 1267.8 | 1267.5 | 1266.6 | 1265.5 | 1264.3 | 1263.2 | | | | |
| (20) | 1263.0 | 1265.1 | 1264.4 | 1265.6 | 1265.1 | 1265.9 | 1266.5 | 1267.2 | 1267.4 | 1267.1 | 1267.0 | 1265.5 | 1264.2 | | | | |
| (21) | 1263.2 | 1265.3 | 1264.6 | 1265.9 | 1265.4 | 1266.2 | 1266.8 | 1267.6 | 1268.0 | 1267.8 | 1267.8 | 1266.3 | 1264.9 | | | | |

Waskada Spearfish Initialization

INITIAL WATER SATURATION LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (2) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (3) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (4) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (5) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (6) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (7) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (8) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (9) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 |
| (10) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | |
| (11) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | |
| (12) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | |
| (13) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | |
| (14) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | |
| (15) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | |
| (16) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | | |
| (17) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | | |
| (18) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | | |
| (19) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | | |
| (20) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | | |
| (21) | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | 0.370 | | | | |

INITIAL WATER SATURATION LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.476 | 0.471 | 0.464 | 0.455 | 0.447 | 0.440 | 0.433 | 0.428 | 0.425 | 0.422 | 0.419 | 0.416 | 0.413 | 0.411 | 0.409 | 0.408 | 0.408 |
| (2) | 0.478 | 0.473 | 0.466 | 0.456 | 0.447 | 0.439 | 0.432 | 0.428 | 0.425 | 0.422 | 0.419 | 0.416 | 0.414 | 0.411 | 0.410 | 0.409 | 0.408 |
| (3) | 0.487 | 0.651 | 0.623 | 0.582 | 0.534 | 0.487 | 0.466 | 0.481 | 0.444 | 0.438 | 0.477 | 0.462 | 0.450 | 0.464 | 0.438 | 0.434 | 0.433 |
| (4) | 0.503 | 0.491 | 0.475 | 0.461 | 0.447 | 0.438 | 0.429 | 0.426 | 0.424 | 0.422 | 0.420 | 0.418 | 0.416 | 0.414 | 0.413 | 0.412 | 0.412 |
| (5) | 0.472 | 0.448 | 0.455 | 0.466 | 0.486 | 0.438 | 0.429 | 0.472 | 0.463 | 0.459 | 0.503 | 0.489 | 0.474 | 0.464 | 0.417 | 0.416 | 0.416 |
| (6) | 0.447 | 0.444 | 0.466 | 0.477 | 0.455 | 0.440 | 0.429 | 0.425 | 0.425 | 0.425 | 0.425 | 0.425 | 0.424 | 0.423 | 0.422 | 0.422 | 0.422 |
| (7) | 0.459 | 0.453 | 0.441 | 0.503 | 0.476 | 0.444 | 0.430 | 0.454 | 0.427 | 0.428 | 0.430 | 0.433 | 0.433 | 0.431 | 0.430 | 0.429 | 0.429 |
| (8) | 0.474 | 0.467 | 0.449 | 0.478 | 0.481 | 0.451 | 0.438 | 0.476 | 0.432 | 0.438 | 0.445 | 0.449 | 0.452 | 0.450 | 0.448 | 0.446 | 0.445 |
| (9) | 0.493 | 0.482 | 0.500 | 0.490 | 0.493 | 0.459 | 0.441 | 0.498 | 0.438 | 0.447 | 0.466 | 0.481 | 0.490 | 0.488 | 0.478 | 0.471 | 0.468 |
| (10) | 0.504 | 0.494 | 0.527 | 0.517 | 0.519 | 0.457 | 0.432 | 0.427 | 0.431 | 0.428 | 0.444 | 0.453 | 0.456 | 0.454 | 0.449 | 0.446 | |
| (11) | 0.488 | 0.485 | 0.516 | 0.517 | 0.627 | 0.451 | 0.427 | 0.538 | 0.427 | 0.428 | 0.453 | 0.466 | 0.467 | 0.464 | 0.459 | 0.454 | |
| (12) | 0.528 | 0.522 | 0.475 | 0.477 | 0.484 | 0.447 | 0.428 | 0.428 | 0.428 | 0.427 | 0.444 | 0.457 | 0.463 | 0.463 | 0.460 | 0.457 | |
| (13) | 0.478 | 0.476 | 0.543 | 0.516 | 0.476 | 0.449 | 0.434 | 0.439 | 0.434 | 0.427 | 0.437 | 0.446 | 0.451 | 0.454 | 0.454 | | |
| (14) | 0.478 | 0.476 | 0.480 | 0.478 | 0.459 | 0.463 | 0.449 | 0.461 | 0.447 | 0.456 | 0.468 | 0.484 | 0.502 | 0.519 | | | |
| (15) | 0.479 | 0.482 | 0.493 | 0.508 | 0.518 | 0.520 | 0.509 | 0.494 | 0.481 | 0.473 | 0.470 | 0.474 | 0.483 | 0.492 | | | |
| (16) | 0.488 | 0.496 | 0.526 | 0.459 | 0.471 | 0.490 | 0.515 | 0.516 | 0.475 | 0.534 | 0.479 | 0.476 | 0.480 | | | | |
| (17) | 0.516 | 0.571 | 0.457 | 0.474 | 0.519 | 0.538 | 0.601 | 0.631 | 0.534 | 0.460 | 0.459 | 0.500 | 0.499 | | | | |
| (18) | 0.443 | 0.447 | 0.457 | 0.478 | 0.473 | 0.532 | 0.529 | 0.551 | 0.490 | 0.482 | 0.450 | 0.441 | 0.435 | | | | |
| (19) | 0.449 | 0.455 | 0.470 | 0.513 | 0.504 | 0.521 | 0.587 | 0.613 | 0.580 | 0.510 | 0.466 | 0.446 | 0.435 | | | | |
| (20) | 0.450 | 0.510 | 0.473 | 0.525 | 0.483 | 0.510 | 0.532 | 0.566 | 0.558 | 0.519 | 0.504 | 0.460 | 0.444 | | | | |
| (21) | 0.454 | 0.527 | 0.480 | 0.544 | 0.494 | 0.530 | 0.552 | 0.591 | 0.593 | 0.564 | 0.551 | 0.474 | 0.451 | | | | |

Waskada Spearfish Initialization INITIAL WATER SATURATION LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.569 | 0.565 | 0.557 | 0.546 | 0.530 | 0.509 | 0.488 | 0.471 | 0.457 | 0.444 | 0.433 | 0.426 | 0.421 | 0.418 | 0.415 | 0.414 | 0.414 |
| (2) | 0.575 | 0.569 | 0.559 | 0.545 | 0.527 | 0.502 | 0.483 | 0.468 | 0.454 | 0.443 | 0.432 | 0.426 | 0.421 | 0.418 | 0.416 | 0.415 | 0.414 |
| (3) | 0.588 | 0.767 | 0.753 | 0.734 | 0.709 | 0.680 | 0.645 | 0.697 | 0.555 | 0.497 | 0.638 | 0.561 | 0.490 | 0.519 | 0.458 | 0.456 | 0.454 |
| (4) | 0.611 | 0.599 | 0.580 | 0.554 | 0.522 | 0.489 | 0.470 | 0.458 | 0.448 | 0.440 | 0.430 | 0.426 | 0.422 | 0.418 | 0.417 | 0.417 | 0.418 |
| (5) | 0.551 | 0.479 | 0.511 | 0.571 | 0.645 | 0.486 | 0.466 | 0.662 | 0.623 | 0.585 | 0.657 | 0.602 | 0.540 | 0.489 | 0.421 | 0.421 | 0.421 |
| (6) | 0.475 | 0.469 | 0.550 | 0.600 | 0.546 | 0.489 | 0.465 | 0.451 | 0.446 | 0.443 | 0.440 | 0.436 | 0.430 | 0.428 | 0.427 | 0.428 | 0.428 |
| (7) | 0.508 | 0.493 | 0.468 | 0.642 | 0.610 | 0.498 | 0.465 | 0.578 | 0.448 | 0.449 | 0.451 | 0.451 | 0.449 | 0.447 | 0.446 | 0.445 | 0.445 |
| (8) | 0.563 | 0.546 | 0.492 | 0.599 | 0.615 | 0.521 | 0.468 | 0.594 | 0.453 | 0.462 | 0.475 | 0.491 | 0.499 | 0.499 | 0.496 | 0.492 | 0.490 |
| (9) | 0.605 | 0.592 | 0.632 | 0.626 | 0.634 | 0.539 | 0.467 | 0.587 | 0.455 | 0.476 | 0.542 | 0.603 | 0.637 | 0.650 | 0.644 | 0.633 | 0.624 |
| (10) | 0.620 | 0.614 | 0.661 | 0.663 | 0.672 | 0.539 | 0.454 | 0.439 | 0.447 | 0.440 | 0.472 | 0.530 | 0.580 | 0.603 | 0.592 | 0.574 | |
| (11) | 0.590 | 0.594 | 0.648 | 0.666 | 0.788 | 0.527 | 0.444 | 0.680 | 0.441 | 0.442 | 0.504 | 0.593 | 0.650 | 0.685 | 0.667 | 0.643 | |
| (12) | 0.621 | 0.625 | 0.575 | 0.599 | 0.624 | 0.498 | 0.445 | 0.445 | 0.444 | 0.441 | 0.485 | 0.579 | 0.642 | 0.675 | 0.672 | 0.656 | |
| (13) | 0.535 | 0.539 | 0.644 | 0.638 | 0.590 | 0.492 | 0.452 | 0.458 | 0.451 | 0.442 | 0.471 | 0.533 | 0.591 | 0.623 | 0.630 | | |
| (14) | 0.512 | 0.514 | 0.548 | 0.567 | 0.517 | 0.522 | 0.473 | 0.485 | 0.468 | 0.509 | 0.594 | 0.653 | 0.699 | 0.729 | | | |
| (15) | 0.500 | 0.515 | 0.554 | 0.591 | 0.610 | 0.606 | 0.585 | 0.559 | 0.549 | 0.551 | 0.567 | 0.599 | 0.636 | 0.664 | | | |
| (16) | 0.506 | 0.529 | 0.573 | 0.479 | 0.517 | 0.560 | 0.588 | 0.588 | 0.529 | 0.616 | 0.559 | 0.569 | 0.597 | | | | |
| (17) | 0.535 | 0.595 | 0.467 | 0.500 | 0.580 | 0.606 | 0.675 | 0.711 | 0.611 | 0.486 | 0.483 | 0.592 | 0.607 | | | | |
| (18) | 0.445 | 0.449 | 0.465 | 0.500 | 0.500 | 0.596 | 0.604 | 0.635 | 0.572 | 0.560 | 0.475 | 0.460 | 0.452 | | | | |
| (19) | 0.450 | 0.458 | 0.477 | 0.546 | 0.552 | 0.582 | 0.664 | 0.704 | 0.683 | 0.623 | 0.546 | 0.478 | 0.454 | | | | |
| (20) | 0.451 | 0.518 | 0.479 | 0.554 | 0.516 | 0.573 | 0.612 | 0.664 | 0.675 | 0.654 | 0.652 | 0.541 | 0.474 | | | | |
| (21) | 0.454 | 0.533 | 0.488 | 0.571 | 0.535 | 0.592 | 0.634 | 0.693 | 0.718 | 0.708 | 0.705 | 0.598 | 0.499 | | | | |

Waskada Spearfish Initialization

INITIAL OIL SATURATIONS LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (2) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (3) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (4) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (5) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (6) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (7) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (8) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (9) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 |
| (10) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | |
| (11) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | |
| (12) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | |
| (13) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | |
| (14) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | |
| (15) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | |
| (16) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | | |
| (17) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | | |
| (18) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | | |
| (19) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | | |
| (20) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | | |
| (21) | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | 0.630 | | | | |

INITIAL OIL SATURATIONS LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.524 | 0.529 | 0.536 | 0.545 | 0.553 | 0.560 | 0.567 | 0.572 | 0.575 | 0.578 | 0.581 | 0.584 | 0.587 | 0.589 | 0.591 | 0.592 | 0.592 |
| (2) | 0.522 | 0.527 | 0.534 | 0.544 | 0.553 | 0.561 | 0.568 | 0.572 | 0.575 | 0.578 | 0.581 | 0.584 | 0.586 | 0.589 | 0.590 | 0.591 | 0.592 |
| (3) | 0.513 | 0.349 | 0.377 | 0.418 | 0.466 | 0.513 | 0.534 | 0.519 | 0.556 | 0.562 | 0.523 | 0.538 | 0.550 | 0.536 | 0.562 | 0.566 | 0.567 |
| (4) | 0.497 | 0.509 | 0.525 | 0.539 | 0.553 | 0.562 | 0.571 | 0.574 | 0.576 | 0.578 | 0.580 | 0.582 | 0.584 | 0.586 | 0.587 | 0.588 | 0.588 |
| (5) | 0.528 | 0.552 | 0.545 | 0.534 | 0.514 | 0.562 | 0.571 | 0.528 | 0.537 | 0.541 | 0.497 | 0.511 | 0.526 | 0.536 | 0.583 | 0.584 | 0.584 |
| (6) | 0.553 | 0.556 | 0.534 | 0.523 | 0.545 | 0.560 | 0.571 | 0.575 | 0.575 | 0.575 | 0.575 | 0.575 | 0.576 | 0.577 | 0.578 | 0.578 | 0.578 |
| (7) | 0.541 | 0.547 | 0.559 | 0.497 | 0.524 | 0.556 | 0.570 | 0.546 | 0.573 | 0.572 | 0.570 | 0.567 | 0.567 | 0.569 | 0.570 | 0.571 | 0.571 |
| (8) | 0.526 | 0.533 | 0.551 | 0.522 | 0.519 | 0.549 | 0.562 | 0.524 | 0.568 | 0.562 | 0.555 | 0.551 | 0.548 | 0.550 | 0.552 | 0.554 | 0.555 |
| (9) | 0.507 | 0.518 | 0.500 | 0.510 | 0.507 | 0.541 | 0.559 | 0.502 | 0.562 | 0.553 | 0.534 | 0.519 | 0.510 | 0.512 | 0.522 | 0.529 | 0.532 |
| (10) | 0.496 | 0.506 | 0.473 | 0.483 | 0.481 | 0.543 | 0.568 | 0.573 | 0.569 | 0.572 | 0.556 | 0.547 | 0.544 | 0.546 | 0.551 | 0.554 | |
| (11) | 0.512 | 0.515 | 0.484 | 0.483 | 0.373 | 0.549 | 0.573 | 0.462 | 0.573 | 0.572 | 0.547 | 0.534 | 0.533 | 0.536 | 0.541 | 0.546 | |
| (12) | 0.472 | 0.478 | 0.525 | 0.523 | 0.516 | 0.553 | 0.572 | 0.572 | 0.572 | 0.573 | 0.556 | 0.543 | 0.537 | 0.537 | 0.540 | 0.543 | |
| (13) | 0.522 | 0.524 | 0.457 | 0.484 | 0.524 | 0.551 | 0.566 | 0.561 | 0.566 | 0.573 | 0.563 | 0.554 | 0.549 | 0.546 | 0.546 | | |
| (14) | 0.522 | 0.524 | 0.520 | 0.522 | 0.541 | 0.537 | 0.551 | 0.539 | 0.553 | 0.544 | 0.532 | 0.516 | 0.498 | 0.481 | | | |
| (15) | 0.521 | 0.518 | 0.507 | 0.492 | 0.482 | 0.480 | 0.491 | 0.506 | 0.519 | 0.527 | 0.530 | 0.526 | 0.517 | 0.508 | | | |
| (16) | 0.512 | 0.504 | 0.474 | 0.541 | 0.529 | 0.510 | 0.485 | 0.484 | 0.525 | 0.466 | 0.521 | 0.524 | 0.520 | | | | |
| (17) | 0.484 | 0.429 | 0.543 | 0.526 | 0.481 | 0.462 | 0.399 | 0.369 | 0.466 | 0.540 | 0.541 | 0.500 | 0.501 | | | | |
| (18) | 0.557 | 0.553 | 0.543 | 0.522 | 0.527 | 0.468 | 0.471 | 0.449 | 0.510 | 0.518 | 0.550 | 0.559 | 0.565 | | | | |
| (19) | 0.551 | 0.545 | 0.530 | 0.487 | 0.496 | 0.479 | 0.413 | 0.387 | 0.420 | 0.490 | 0.534 | 0.554 | 0.565 | | | | |
| (20) | 0.550 | 0.490 | 0.527 | 0.475 | 0.517 | 0.490 | 0.468 | 0.434 | 0.442 | 0.481 | 0.496 | 0.540 | 0.556 | | | | |
| (21) | 0.546 | 0.473 | 0.520 | 0.456 | 0.506 | 0.470 | 0.448 | 0.409 | 0.407 | 0.436 | 0.449 | 0.526 | 0.549 | | | | |

Waskada Spearfish Initialization INITIAL OIL SATURATIONS LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0.431 | 0.435 | 0.443 | 0.454 | 0.470 | 0.491 | 0.512 | 0.529 | 0.543 | 0.556 | 0.567 | 0.574 | 0.579 | 0.582 | 0.585 | 0.586 | 0.586 |
| (2) | 0.425 | 0.431 | 0.441 | 0.455 | 0.473 | 0.498 | 0.517 | 0.532 | 0.546 | 0.557 | 0.568 | 0.574 | 0.579 | 0.582 | 0.584 | 0.585 | 0.586 |
| (3) | 0.412 | 0.233 | 0.247 | 0.266 | 0.291 | 0.320 | 0.355 | 0.303 | 0.445 | 0.503 | 0.362 | 0.439 | 0.510 | 0.481 | 0.542 | 0.544 | 0.546 |
| (4) | 0.389 | 0.401 | 0.420 | 0.446 | 0.478 | 0.511 | 0.530 | 0.542 | 0.552 | 0.560 | 0.570 | 0.574 | 0.578 | 0.582 | 0.583 | 0.583 | 0.582 |
| (5) | 0.449 | 0.521 | 0.489 | 0.429 | 0.355 | 0.514 | 0.534 | 0.338 | 0.377 | 0.415 | 0.343 | 0.398 | 0.460 | 0.511 | 0.579 | 0.579 | 0.579 |
| (6) | 0.525 | 0.531 | 0.450 | 0.400 | 0.454 | 0.511 | 0.535 | 0.549 | 0.554 | 0.557 | 0.560 | 0.564 | 0.570 | 0.572 | 0.573 | 0.572 | 0.572 |
| (7) | 0.492 | 0.507 | 0.532 | 0.358 | 0.390 | 0.502 | 0.535 | 0.422 | 0.552 | 0.551 | 0.549 | 0.549 | 0.551 | 0.553 | 0.554 | 0.555 | 0.555 |
| (8) | 0.437 | 0.454 | 0.508 | 0.401 | 0.385 | 0.479 | 0.532 | 0.406 | 0.547 | 0.538 | 0.525 | 0.509 | 0.501 | 0.501 | 0.504 | 0.508 | 0.510 |
| (9) | 0.395 | 0.408 | 0.368 | 0.374 | 0.366 | 0.461 | 0.533 | 0.413 | 0.545 | 0.524 | 0.458 | 0.397 | 0.363 | 0.350 | 0.356 | 0.367 | 0.376 |
| (10) | 0.380 | 0.386 | 0.339 | 0.337 | 0.328 | 0.461 | 0.546 | 0.561 | 0.553 | 0.560 | 0.528 | 0.470 | 0.420 | 0.397 | 0.408 | 0.426 | |
| (11) | 0.410 | 0.406 | 0.352 | 0.334 | 0.212 | 0.473 | 0.556 | 0.320 | 0.559 | 0.558 | 0.496 | 0.407 | 0.350 | 0.315 | 0.333 | 0.357 | |
| (12) | 0.379 | 0.375 | 0.425 | 0.401 | 0.376 | 0.502 | 0.555 | 0.555 | 0.556 | 0.559 | 0.515 | 0.421 | 0.358 | 0.325 | 0.328 | 0.344 | |
| (13) | 0.465 | 0.461 | 0.356 | 0.362 | 0.410 | 0.508 | 0.548 | 0.542 | 0.549 | 0.558 | 0.529 | 0.467 | 0.409 | 0.377 | 0.370 | | |
| (14) | 0.488 | 0.486 | 0.452 | 0.433 | 0.483 | 0.478 | 0.527 | 0.515 | 0.532 | 0.491 | 0.406 | 0.347 | 0.301 | 0.271 | | | |
| (15) | 0.500 | 0.485 | 0.446 | 0.409 | 0.390 | 0.394 | 0.415 | 0.441 | 0.451 | 0.449 | 0.433 | 0.401 | 0.364 | 0.336 | | | |
| (16) | 0.494 | 0.471 | 0.427 | 0.521 | 0.483 | 0.440 | 0.412 | 0.412 | 0.471 | 0.384 | 0.441 | 0.431 | 0.403 | | | | |
| (17) | 0.465 | 0.405 | 0.533 | 0.500 | 0.420 | 0.394 | 0.325 | 0.289 | 0.389 | 0.514 | 0.517 | 0.408 | 0.393 | | | | |
| (18) | 0.555 | 0.551 | 0.535 | 0.500 | 0.500 | 0.404 | 0.396 | 0.365 | 0.428 | 0.440 | 0.525 | 0.540 | 0.548 | | | | |
| (19) | 0.550 | 0.542 | 0.523 | 0.454 | 0.448 | 0.418 | 0.336 | 0.296 | 0.317 | 0.377 | 0.454 | 0.522 | 0.546 | | | | |
| (20) | 0.549 | 0.482 | 0.521 | 0.446 | 0.484 | 0.427 | 0.388 | 0.336 | 0.325 | 0.346 | 0.348 | 0.459 | 0.526 | | | | |
| (21) | 0.546 | 0.467 | 0.512 | 0.429 | 0.465 | 0.408 | 0.366 | 0.307 | 0.282 | 0.292 | 0.295 | 0.402 | 0.501 | | | | |

Waskada Spearfish Initialization

INITIAL GAS SATURATIONS LAYER # 1

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (2) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (3) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (4) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (5) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (6) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (7) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (8) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (9) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (10) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (11) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (12) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (13) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | |
| (14) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (15) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (16) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (17) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (18) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (19) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (20) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (21) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |

INITIAL GAS SATURATIONS LAYER # 2

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (2) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (3) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (4) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (5) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (6) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (7) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (8) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (9) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (10) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (11) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (12) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (13) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | |
| (14) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (15) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (16) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (17) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (18) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (19) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (20) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (21) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |

Waskada Spearfish Initialization INITIAL GAS SATURATIONS LAYER # 3

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (2) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (3) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (4) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (5) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (6) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (7) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (8) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (9) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| (10) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (11) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (12) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | |
| (13) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | |
| (14) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (15) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | |
| (16) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (17) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (18) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (19) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (20) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |
| (21) | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | | | | |

**EXHIBIT B**

## TABLE 1

## EXHIBIT B

## PRIMARY FORECAST PARAMETERS

1. The primary forecast begins August 1, 1986. Most of the Enron wells have been back on production from shut in due to spring breakup.

2. The production for the month of August compares to the simulator as follows:

| Location | August Field (STB/D) | August Field Water Cut (%) | August Model (STB/D) | August Model Water Cut (%) |
|---|---|---|---|---|
| 3-4 | 11.8 | 6.2 | 12.70 | 12.2 |
| 4-4 | 43.4 | 2.5 | 42.30 | 23.8 |
| 5-4 | 67.9 | 8.8 | 79.30 | 19.2 |
| 6-4 | 54.7 | 5.7 | 67.70 | 19.7 |
| 11-4 | 13.8 | 4.6 | 14.70 | 11.7 |
| 12-4 | 30.2 | 13.7 | 35.70 | 9.4 |
| 13-4 | 20.1 | 52.3 | 21.00 | 16.1 |
| 14-4 | 18.9 | 9.5 | 20.00 | 7.9 |
| 15-4 | Shut in | - | Shut in | - |
| 9-5 | 74.2 | 11.8 | 84.00 | 7.5 |
| 10-5 | 8.2 | 10.0 | 8.33 | 16.0 |
| 15-5 | 18.2 | 30.3 | 24.30 | 19.5 |
| 16-5 | 12.6 | 22.6 | 13.30 | 28.6 |
| 2-9 | 46.5 | 9.2 | 49.00 | 8.0 |
| 4-9 | Shut in | - | Shut in | - |
| 5-9 | 2.5 | 91.0 | 2.30 | 15.7 |
| 10-9 | Shut in | - | Shut in | - |
| 15-9 | 18.9 | 3.4 | 20.60 | 11.1 |
| 16-9 | 26.4 | 5.7 | 27.70 | 5.0 |

3. At the beginning of the forecast, the Omega injector 15-8 had been injecting for ten months and was continued at three-quarters of that rate. The reduction was simply to account for the injection loss to the east not accounted for in the model. Similarily, the rates of the proposed Omega injectors, ie 13-9, 7-8 and 7-5 were

estimated based on voidage requirements. Omega location 7-5 was scheduled to begin injection July 28, 1986. The injection schedule can be summarized as follows:

| Injection Location | Operator | Commencement of Injection | Initial Model Injection Rate (STB/D) | Jan 1/89 Model Injection Rate (STB/D) |
|---|---|---|---|---|
| 15-8 | Omega | Oct/85 | 250 | 67 |
| 13-9 | Omega | Oct/86 (assumed) | 225 | 60 |
| 7-8 | Omega | Jan/87 (assumed) | 225 | 60 |
| 7-5 | Omega | Aug/86 | 300 | 80 |
| | | | 1 000 | 267 |

The above rates are continued until December 31, 1987 at which time the injectors are all reduced proportionately to replace voidage only. This accounts for approximately 208 MRB of over injection but the pattern of high rates for about a year is consistent with field performance.

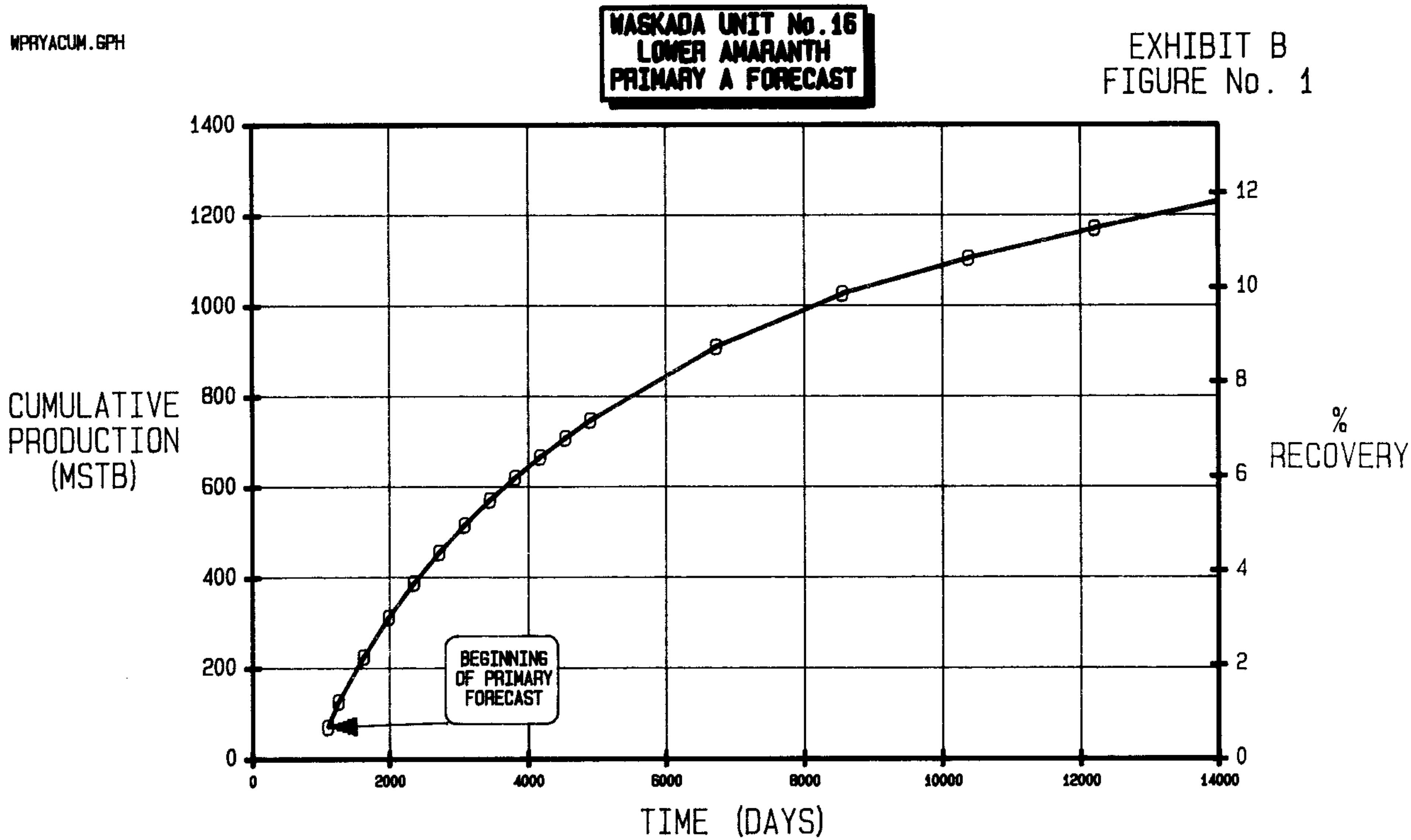
4. The economic limit of 4 STB/D was imposed on all producers starting January 1988. This delay was imposed due to the uncertainty in oil prices; assuming operators will maintain low rate wells until at least December 1987.

5. To simulate the injection rate enhancement due to fracture stimulation, the transmissibility of the cell containing the injector was increased by a factor of 10. This low value is evidence that the estimated cell permeabilities of the Omega injectors were obviously too high.

6. It should be noted that the gas in solution data used is the same as in the 1983 study by Omega (see Figure 4 of Preliminary Engineering Study - July 1983). In reality, the gas in solution should be much lower as confirmed by the experience of Omega. This will result in an optimistic primary forecast. Future work will investigate the impact on primary recovery if the solution gas values are reduced to half of the values used.

WPRYACUM.GPH

EXHIBIT B
FIGURE No. 1



WPRYARAT.GPH

EXHIBIT B
FIGURE No. 2

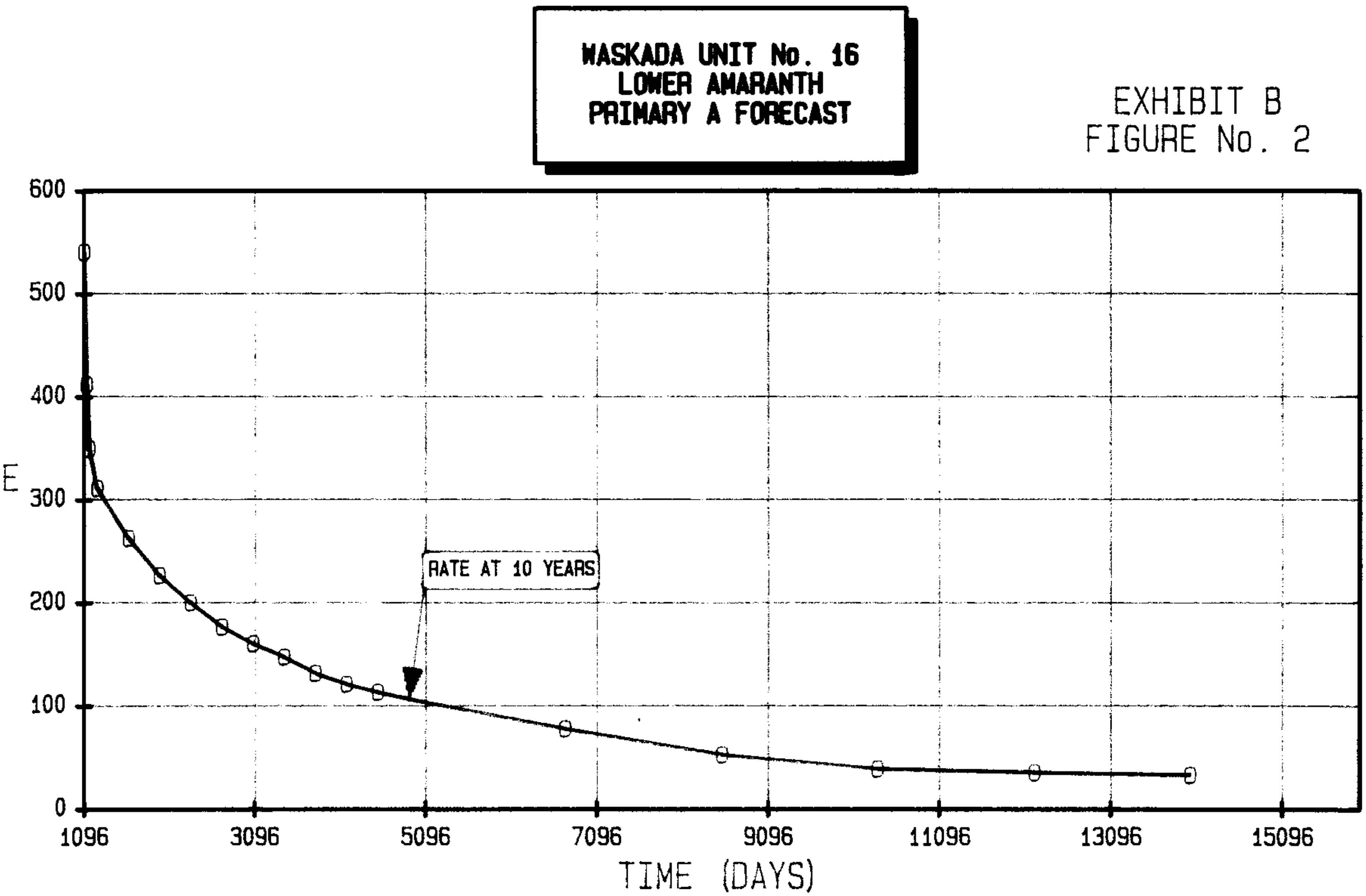
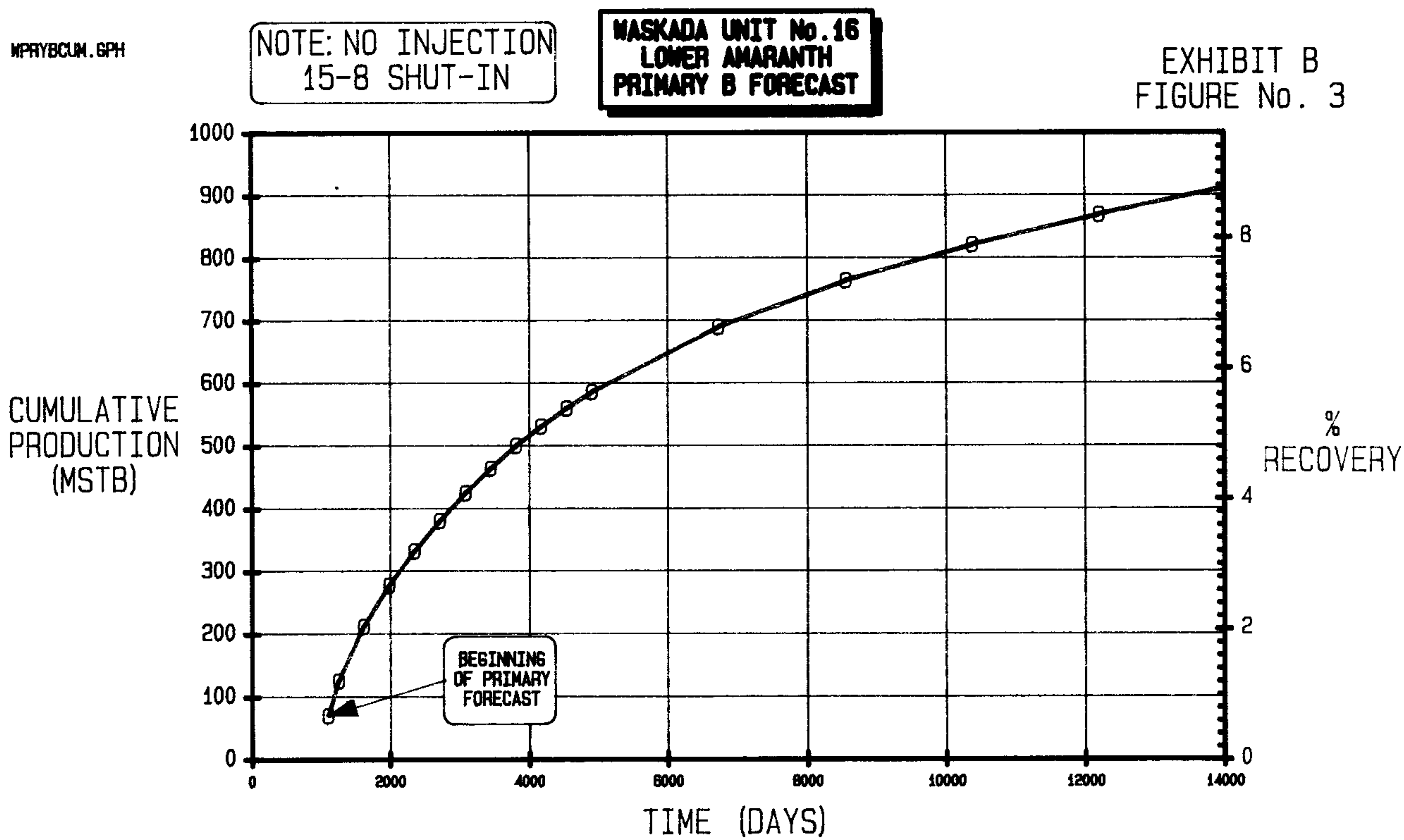


EXHIBIT B
FIGURE No. 3



Waskada Spearfish Primary Forecast

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 1096. DAYS (JULY, 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1096. | 236.8 | 161.19 | 0.07 | 46.47 | 37.4 | 14.24 | 0. | 0. | -550.0 | -99.05 |
| 2 | 1096. | 539.6 | 69.19 | 0.15 | 26.22 | 72.0 | 7.75 | 0. | 0. | 0. | 0. |
| 3 | 1096. | 54.2 | 12.26 | 0.02 | 3.53 | 4.6 | 0.82 | 0. | 0. | 0. | 0. |

TIME = 1126. DAYS (AUG , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1126. | 224.1 | 168.02 | 0.06 | 48.44 | 36.5 | 15.34 | 0. | 0. | -550.0 | -115.55 |
| 2 | 1126. | 411.1 | 82.81 | 0.18 | 31.54 | 73.3 | 10.00 | 0. | 0. | 0. | 0. |
| 3 | 1126. | 47.3 | 13.74 | 0.01 | 3.95 | 4.2 | 0.94 | 0. | 0. | 0. | 0. |

TIME = 1156. DAYS (SEP , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1156. | 220.1 | 174.65 | 0.06 | 50.35 | 36.7 | 16.44 | 0. | 0. | -550.0 | -132.05 |
| 2 | 1156. | 348.8 | 93.67 | 0.16 | 36.55 | 69.2 | 12.11 | 0. | 0. | 0. | 0. |
| 3 | 1156. | 57.8 | 15.50 | 0.02 | 4.46 | 5.1 | 1.10 | 0. | 0. | 0. | 0. |

TIME = 1249. DAYS (DEC , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1249. | 224.6 | 195.29 | 0.06 | 56.30 | 39.3 | 19.10 | 0. | 0. | -775.0 | -203.25 |
| 2 | 1249. | 310.5 | 125.25 | 0.14 | 50.72 | 57.2 | 18.72 | 0. | 0. | 0. | 0. |
| 3 | 1249. | 50.5 | 20.45 | 0.02 | 5.99 | 4.7 | 1.55 | 0. | 0. | 0. | 0. |

Waskada Spearfish Primary Forecast

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 1614. DAYS (DEC , 1987)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1614. | 211.4 | 268.42 | 0.06 | 77.43 | 66.1 | 36.11 | 0. | 0. | -1000.0 | -566.22 |
| 2 | 1614. | 262.2 | 224.53 | 0.10 | 91.78 | 39.0 | 34.36 | 0. | 0. | 0. | 0. |
| 3 | 1614. | 40.8 | 36.13 | 0.01 | 11.38 | 3.9 | 3.07 | 0. | 0. | 0. | 0. |

TIME = 1979. DAYS (DEC , 1988)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1979. | 166.1 | 334.82 | 0.05 | 96.64 | 66.4 | 60.43 | 0. | 0. | -266.2 | -671.46 |
| 2 | 1979. | 225.9 | 311.48 | 0.09 | 127.18 | 33.0 | 47.00 | 0. | 0. | 0. | 0. |
| 3 | 1979. | 35.1 | 49.34 | 0.01 | 15.86 | 3.1 | 4.26 | 0. | 0. | 0. | 0. |

TIME = 2344. DAYS (DEC , 1989)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2344. | 136.1 | 388.19 | 0.04 | 112.28 | 64.7 | 84.31 | 0. | 0. | -232.0 | -761.35 |
| 2 | 2344. | 199.5 | 387.71 | 0.08 | 159.07 | 30.0 | 58.28 | 0. | 0. | 0. | 0. |
| 3 | 2344. | 31.9 | 61.41 | 0.01 | 20.25 | 2.8 | 5.33 | 0. | 0. | 0. | 0. |

TIME = 2709. DAYS (DEC , 1990)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2709. | 111.7 | 432.72 | 0.03 | 125.53 | 60.8 | 107.30 | 0. | 0. | -202.3 | -840.50 |
| 2 | 2709. | 176.0 | 455.29 | 0.08 | 188.03 | 27.6 | 68.73 | 0. | 0. | 0. | 0. |
| 3 | 2709. | 28.9 | 72.37 | 0.01 | 24.56 | 2.6 | 6.30 | 0. | 0. | 0. | 0. |

Waskada Spearfish Primary Forecast

1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 4534. DAYS (DEC , 1995)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4534. | 47.0 | 563.67 | 0.02 | 166.86 | 34.9 | 188.83 | 0. | 0. | -112.5 | -1103.98 |
| 2 | 4534. | 112.4 | 707.46 | 0.06 | 307.74 | 24.1 | 115.04 | 0. | 0. | 0. | 0. |
| 3 | 4534. | 18.7 | 114.25 | 0.01 | 45.22 | 1.8 | 10.16 | 0. | 0. | 0. | 0. |

TIME = 4899. DAYS (DEC , 1996)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4899. | 43.5 | 580.01 | 0.02 | 172.60 | 33.6 | 201.26 | 0. | 0. | -107.6 | -1144.04 |
| 2 | 4899. | 105.8 | 746.93 | 0.06 | 328.90 | 23.9 | 123.79 | 0. | 0. | 0. | 0. |
| 3 | 4899. | 17.3 | 120.74 | 0.01 | 49.22 | 1.8 | 10.82 | 0. | 0. | 0. | 0. |

TIME = 6724. DAYS (DEC , 2001)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6724. | 21.6 | 639.21 | 0.01 | 196.92 | 14.0 | 248.20 | 0. | 0. | -40.0 | -1217.04 |
| 2 | 6724. | 77.2 | 909.39 | 0.05 | 424.00 | 21.4 | 164.95 | 0. | 0. | 0. | 0. |
| 3 | 6724. | 9.6 | 142.34 | 0.01 | 64.69 | 1.0 | 13.03 | 0. | 0. | 0. | 0. |

TIME = 8549. DAYS (DEC , 2006)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8549. | 14.3 | 670.90 | 0.01 | 212.62 | 12.5 | 272.25 | 0. | 0. | -40.0 | -1290.04 |
| 2 | 8549. | 51.9 | 1026.59 | 0.04 | 502.56 | 15.3 | 198.50 | 0. | 0. | 0. | 0. |
| 3 | 8549. | 0. | 154.52 | 0. | 75.06 | 0. | 14.33 | 0. | 0. | 0. | 0. |

Waskada Spearfish Primary Forecast

1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 3074. DAYS (DEC , 1991)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3074. | 97.6 | 470.14 | 0.03 | 136.93 | 58.2 | 128.90 | 0. | 0. | -186.9 | -911.13 |
| 2 | 3074. | 159.7 | 515.73 | 0.07 | 214.72 | 26.7 | 78.60 | 0. | 0. | 0. | 0. |
| 3 | 3074. | 26.3 | 82.30 | 0.01 | 28.82 | 2.3 | 7.18 | 0. | 0. | 0. | 0. |

TIME = 3439. DAYS (DEC , 1992)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3439. | 78.4 | 500.19 | 0.02 | 146.05 | 46.0 | 146.10 | 0. | 0. | -148.4 | -967.58 |
| 2 | 3439. | 146.6 | 570.89 | 0.07 | 239.95 | 26.0 | 88.16 | 0. | 0. | 0. | 0. |
| 3 | 3439. | 23.9 | 91.32 | 0.01 | 33.01 | 2.2 | 7.99 | 0. | 0. | 0. | 0. |

TIME = 3804. DAYS (DEC , 1993)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3804. | 61.8 | 525.39 | 0.02 | 153.99 | 40.8 | 161.84 | 0. | 0. | -127.8 | -1018.13 |
| 2 | 3804. | 130.8 | 620.12 | 0.06 | 263.32 | 24.7 | 97.23 | 0. | 0. | 0. | 0. |
| 3 | 3804. | 22.0 | 99.60 | 0.01 | 37.11 | 2.0 | 8.76 | 0. | 0. | 0. | 0. |

TIME = 4169. DAYS (DEC , 1994)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4169. | 51.8 | 545.89 | 0.02 | 160.69 | 36.6 | 175.89 | 0. | 0. | -115.3 | -1062.27 |
| 2 | 4169. | 120.4 | 665.43 | 0.06 | 285.89 | 24.4 | 106.19 | 0. | 0. | 0. | 0. |
| 3 | 4169. | 20.3 | 107.23 | 0.01 | 41.18 | 1.9 | 9.48 | 0. | 0. | 0. | 0. |

Waskada Spearfish Primary Forecast

1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME =10374. DAYS (DEC , 2011)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10374. | 8.7 | 693.92 | 0.00 | 224.47 | 5.5 | 292.83 | 0. | 0. | -38.9 | -1362.78 |
| 2 | 10374. | 38.3 | 1104.73 | 0.03 | 559.73 | 13.0 | 223.87 | 0. | 0. | 0. | 0. |
| 3 | 10374. | 0. | 154.52 | 0. | 75.06 | 0. | 14.33 | 0. | 0. | 0. | 0. |

TIME =12199. DAYS (DEC , 2016)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12199. | 4.0 | 708.93 | 0.00 | 232.78 | 1.4 | 302.78 | 0. | 0. | -17.6 | -1429.49 |
| 2 | 12199. | 34.7 | 1170.90 | 0.03 | 609.80 | 12.2 | 246.85 | 0. | 0. | 0. | 0. |
| 3 | 12199. | 0. | 154.52 | 0. | 75.06 | 0. | 14.33 | 0. | 0. | 0. | 0. |

TIME =14024. DAYS (DEC , 2021)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14024. | 0. | 709.33 | 0. | 233.00 | 0. | 302.92 | 0. | 0. | -40.0 | -1500.25 |
| 2 | 14024. | 32.2 | 1231.70 | 0.02 | 656.15 | 11.7 | 268.64 | 0. | 0. | 0. | 0. |
| 3 | 14024. | 0. | 154.52 | 0. | 75.06 | 0. | 14.33 | 0. | 0. | 0. | 0. |

**EXHIBIT C**

TABLE 1

EXHIBIT C

## WATERFLOOD FORECAST PARAMETERS
## ENRON'S WATERFLOOD PATTERN "A"

1. Omega's wells are producing and injecting identical to the primary case.

2. The Enron injectors start injecting January 1987, with stabilized injection rates as follows:

| | |
|---|---|
| 3-4 | 160 Bbls/d |
| 12-4 | 350 Bbls/d |
| 15-4 | 175 Bbls/d |
| 16-5 | 150 Bbls/d |
| | 835 Bbls/d |

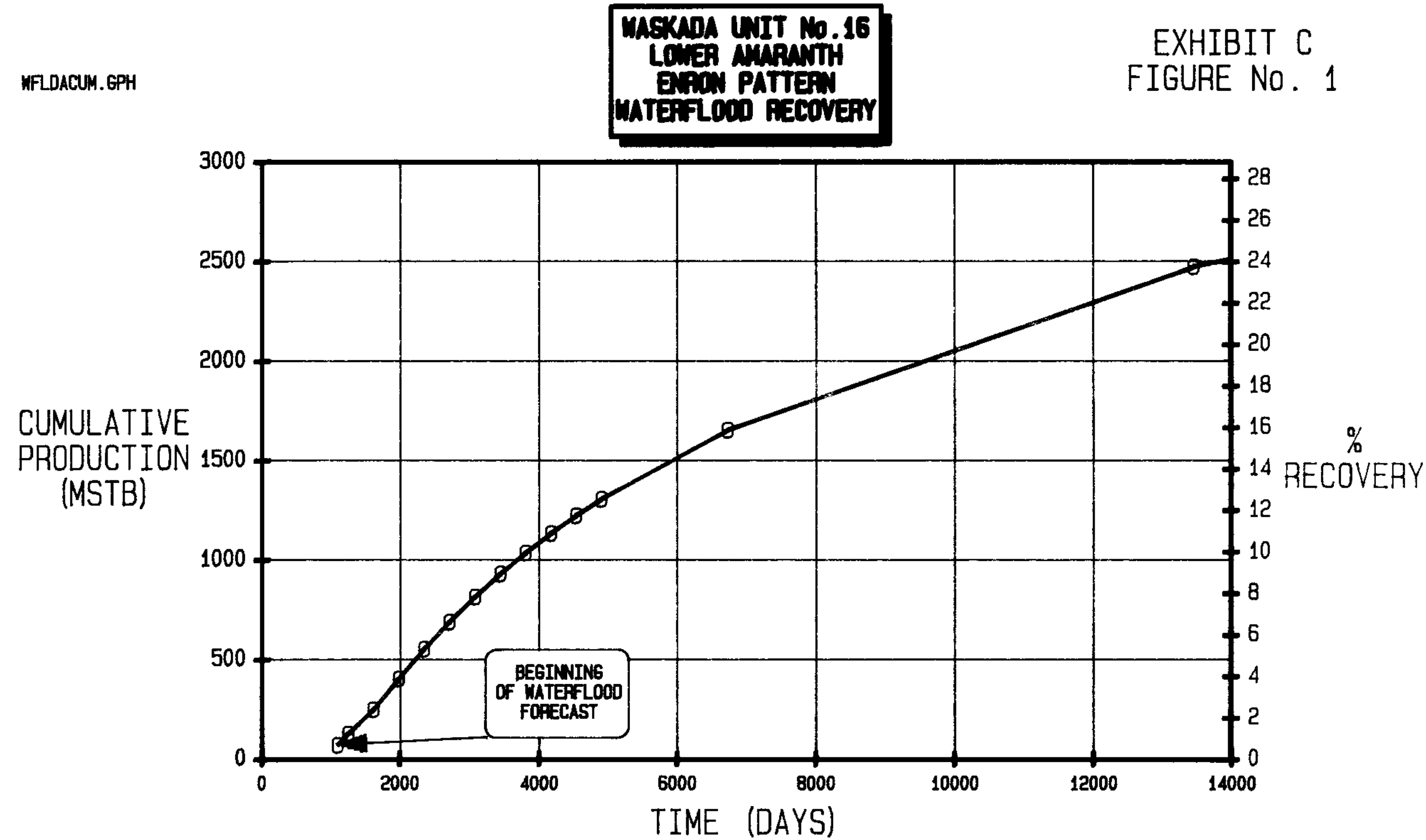
These rates are maintained (with some reduction due to injection pressure constraint) until the incremental withdrawals are less than the injection rates at which time the injectors are all cut back on a prorationed basis. As long as an offset producer is still producing (ie. rate is above the economic limit and WOR is less than 10) a specific injector remains injecting.

The transmissibilities of the grid blocks in which the injectors are located are modified by a factor of 100X (only in the grid block in which the injector is located). All injectors were constrained to inject with a BHP for either of the 3 layers of less than 3,000 psi. This should satisfy the constraint of keeping injection pressure below frac propagation levels.

3. An "individual well" economic limit of 4 STB/D and a maximum WOR limit of 10 were used for all producers in the model.

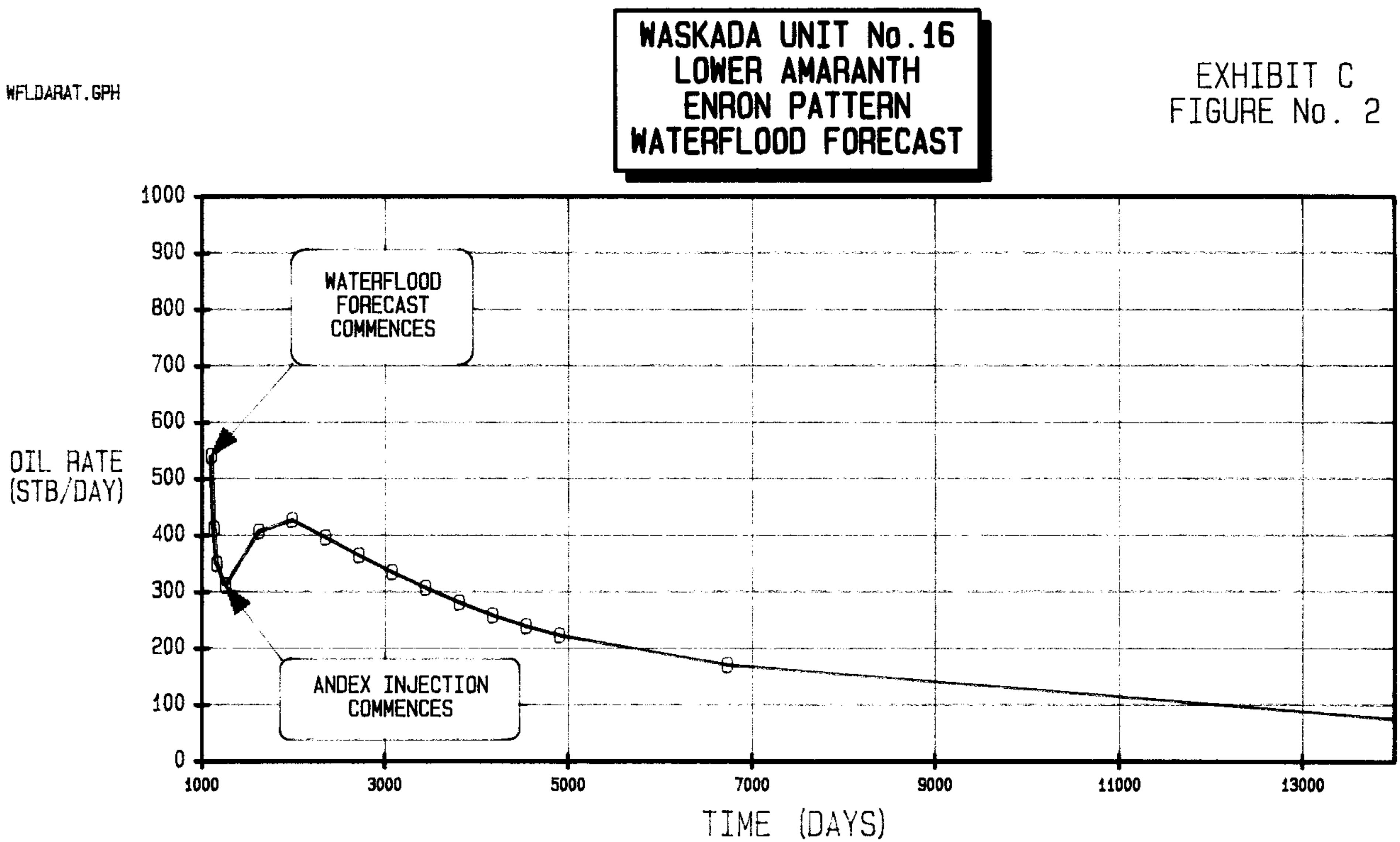
WFLDACUM.GPH

EXHIBIT C
FIGURE No. 1



WFLDARAT.GPH

EXHIBIT C
FIGURE No. 2



LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

Waskada Spearfish ANDEX Waterflood Pattern Forecast

TIME = 1096. DAYS (JULY, 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1096. | 236.8 | 161.19 | 0.07 | 46.47 | 37.4 | 14.24 | 0. | 0. | -550.0 | -99.05 |
| 2 | 1096. | 539.6 | 69.19 | 0.15 | 26.22 | 72.0 | 7.75 | 0. | 0. | 0. | 0. |
| 3 | 1096. | 54.2 | 12.26 | 0.02 | 3.53 | 4.6 | 0.82 | 0. | 0. | 0. | 0. |

TIME = 1126. DAYS (AUG , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1126. | 224.1 | 168.02 | 0.06 | 48.44 | 36.5 | 15.34 | 0. | 0. | -550.0 | -115.55 |
| 2 | 1126. | 411.1 | 82.81 | 0.18 | 31.54 | 73.3 | 10.00 | 0. | 0. | 0. | 0. |
| 3 | 1126. | 47.3 | 13.74 | 0.01 | 3.95 | 4.2 | 0.94 | 0. | 0. | 0. | 0. |

TIME = 1156. DAYS (SEP , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1156. | 220.1 | 174.65 | 0.06 | 50.35 | 36.7 | 16.44 | 0. | 0. | -550.0 | -132.05 |
| 2 | 1156. | 348.8 | 93.67 | 0.16 | 36.55 | 69.2 | 12.11 | 0. | 0. | 0. | 0. |
| 3 | 1156. | 57.8 | 15.50 | 0.02 | 4.46 | 5.1 | 1.10 | 0. | 0. | 0. | 0. |

TIME = 1249. DAYS (DEC , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1249. | 224.6 | 195.29 | 0.06 | 56.30 | 39.3 | 19.10 | 0. | 0. | -775.0 | -203.25 |
| 2 | 1249. | 310.5 | 125.25 | 0.14 | 50.72 | 57.2 | 18.72 | 0. | 0. | 0. | 0. |
| 3 | 1249. | 50.5 | 20.45 | 0.02 | 5.99 | 4.7 | 1.55 | 0. | 0. | 0. | 0. |

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

Waskada Spearfish ANDEX Waterflood Pattern Forecast

TIME = 1614. DAYS (DEC , 1987)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1614. | 222.1 | 269.79 | 0.06 | 77.81 | 67.2 | 35.86 | 0. | 0. | -1000.0 | -566.22 |
| 2 | 1614. | 405.8 | 247.95 | 0.12 | 92.10 | 43.4 | 30.52 | 0. | 0. | -835.0 | -262.89 |
| 3 | 1614. | 42.1 | 36.32 | 0.01 | 11.43 | 3.9 | 3.08 | 0. | 0. | 0. | 0. |

TIME = 1979. DAYS (DEC , 1988)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1979. | 190.2 | 343.45 | 0.05 | 99.01 | 71.0 | 61.25 | 0. | 0. | -292.2 | -677.73 |
| 2 | 1979. | 426.3 | 402.75 | 0.12 | 135.07 | 92.8 | 55.88 | 0. | 0. | -795.0 | -553.07 |
| 3 | 1979. | 39.2 | 50.59 | 0.01 | 16.00 | 3.1 | 4.27 | 0. | 0. | 0. | 0. |

TIME = 2344. DAYS (DEC , 1989)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2344. | 170.5 | 408.14 | 0.05 | 117.62 | 74.6 | 88.02 | 0. | 0. | -272.0 | -779.98 |
| 2 | 2344. | 395.4 | 551.28 | 0.11 | 176.42 | 154.3 | 104.09 | 0. | 0. | -740.0 | -823.17 |
| 3 | 2344. | 39.5 | 64.95 | 0.01 | 20.50 | 2.9 | 5.36 | 0. | 0. | 0. | 0. |

TIME = 2709. DAYS (DEC , 1990)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2709. | 157.8 | 467.31 | 0.05 | 134.64 | 78.1 | 116.07 | 0. | 0. | -260.0 | -876.64 |
| 2 | 2709. | 363.7 | 688.09 | 0.10 | 214.75 | 206.4 | 172.56 | 0. | 0. | -740.0 | -1093.27 |
| 3 | 2709. | 40.3 | 79.57 | 0.01 | 24.89 | 2.7 | 6.37 | 0. | 0. | 0. | 0. |

Waskada Spearfish ANDEX Waterflood Pattern Forecast

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 3074. DAYS (DEC , 1991)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3074. | 147.9 | 522.58 | 0.04 | 150.54 | 82.1 | 145.48 | 0. | 0. | -252.3 | -969.92 |
| 2 | 3074. | 333.9 | 813.80 | 0.09 | 250.19 | 250.4 | 258.17 | 0. | 0. | -740.0 | -1363.37 |
| 3 | 3074. | 40.3 | 94.28 | 0.01 | 29.26 | 2.6 | 7.32 | 0. | 0. | 0. | 0. |

TIME = 3439. DAYS (DEC , 1992)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3439. | 140.2 | 574.75 | 0.04 | 165.56 | 86.5 | 176.47 | 0. | 0. | -247.6 | -1061.01 |
| 2 | 3439. | 306.3 | 929.42 | 0.09 | 282.87 | 290.7 | 358.95 | 0. | 0. | -740.0 | -1633.47 |
| 3 | 3439. | 40.2 | 108.97 | 0.01 | 33.63 | 2.5 | 8.23 | 0. | 0. | 0. | 0. |

TIME = 3804. DAYS (DEC , 1993)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3804. | 129.8 | 623.38 | 0.04 | 179.55 | 84.9 | 207.55 | 0. | 0. | -234.4 | -1148.14 |
| 2 | 3804. | 280.3 | 1035.05 | 0.08 | 312.86 | 318.6 | 471.49 | 0. | 0. | -715.0 | -1894.44 |
| 3 | 3804. | 40.3 | 123.65 | 0.01 | 37.95 | 2.4 | 9.11 | 0. | 0. | 0. | 0. |

TIME = 4169. DAYS (DEC , 1994)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4169. | 124.0 | 669.42 | 0.04 | 192.80 | 88.5 | 239.36 | 0. | 0. | -231.1 | -1233.00 |
| 2 | 4169. | 257.5 | 1132.05 | 0.07 | 340.45 | 342.2 | 593.15 | 0. | 0. | -705.0 | -2151.77 |
| 3 | 4169. | 40.4 | 138.37 | 0.01 | 42.24 | 2.3 | 9.96 | 0. | 0. | 0. | 0. |

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

Waskada Spearfish ANDEX Waterflood Pattern Forecast

TIME = 4534. DAYS (DEC , 1995)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4534. | 118.8 | 713.48 | 0.03 | 205.48 | 92.2 | 272.50 | 0. | 0. | -228.7 | -1316.85 |
| 2 | 4534. | 238.1 | 1221.54 | 0.07 | 365.90 | 364.6 | 723.16 | 0. | 0. | -705.0 | -2409.09 |
| 3 | 4534. | 40.5 | 153.14 | 0.01 | 46.51 | 2.3 | 10.80 | 0. | 0. | 0. | 0. |

TIME = 4899. DAYS (DEC , 1996)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4899. | 114.3 | 755.79 | 0.03 | 217.65 | 95.8 | 306.98 | 0. | 0. | -227.0 | -1399.97 |
| 2 | 4899. | 221.8 | 1304.65 | 0.06 | 389.53 | 385.2 | 861.03 | 0. | 0. | -705.0 | -2666.42 |
| 3 | 4899. | 40.6 | 167.93 | 0.01 | 50.78 | 2.2 | 11.62 | 0. | 0. | 0. | 0. |

TIME = 6724. DAYS (DEC , 2001)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6724. | 95.2 | 945.00 | 0.03 | 272.11 | 112.7 | 498.38 | 0. | 0. | -222.0 | -1808.73 |
| 2 | 6724. | 169.4 | 1652.76 | 0.05 | 488.81 | 450.3 | 1630.94 | 0. | 0. | -695.0 | -3934.79 |
| 3 | 6724. | 40.1 | 241.73 | 0.01 | 72.08 | 2.1 | 15.58 | 0. | 0. | 0. | 0. |

TIME =14024. DAYS (DEC , 2021)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14024. | 49.2 | 1428.60 | 0.01 | 411.34 | 153.2 | 1447.23 | 0. | 0. | -209.2 | -3311.24 |
| 2 | 14024. | 73.5 | 2516.21 | 0.02 | 735.94 | 273.8 | 4863.56 | 0. | 0. | -416.7 | -8527.14 |
| 3 | 14024. | 30.4 | 499.24 | 0.01 | 148.33 | 4.6 | 37.85 | 0. | 0. | 0. | 0. |

**EXHIBIT D**

## TABLE 1

## EXHIBIT D

## WATERFLOOD FORECAST PARAMETERS
## STANDARD WATERFLOOD PATTERN

1. Omega's wells are producing and injecting identical to the primary case.

2. The Enron injectors start injecting January 1987, with stabilized injection rates as follows:

| | |
|---|---|
| 5-4 | 250 Bbls/d |
| 13-4 | 375 Bbls/d |
| 15-4 | 170 Bbls/d |
| 16-5 | 30 Bbls/d |
| | 825 Bbls/d |

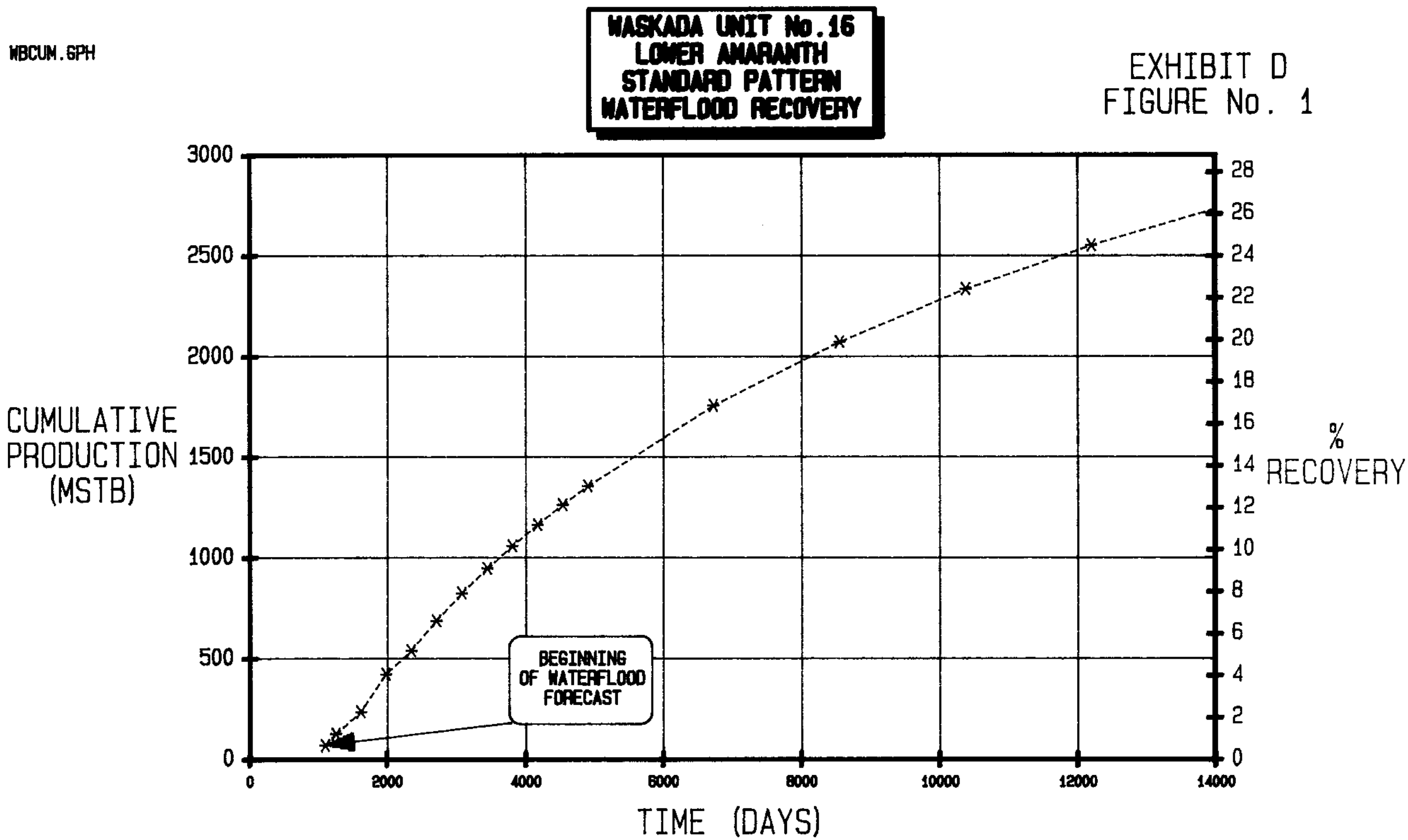
These rates are maintained (with some reduction due to injection pressure constraint) until the incremental withdrawals are less than the injection rates at which time the injectors are all cut back on a prorationed basis. As long as an offset producer is still producing (ie. rate is above the economic limit and WOR is less than 10) a specific injector remains injecting.

The transmissibilities of the grid blocks in which the injectors are located are modified by a factor of 100X (only in the grid block in which the injector is located). All injectors were constrained to inject with a BHP for either of the 3 layers of less than 3,000 psi. This should satisfy the constraint of keeping injection pressure below frac propagation levels.

3. An "individual well" economic limit of 4 STB/D and a maximum WOR limit of 10 were used for all producers in the model.

WBCUM.GPH

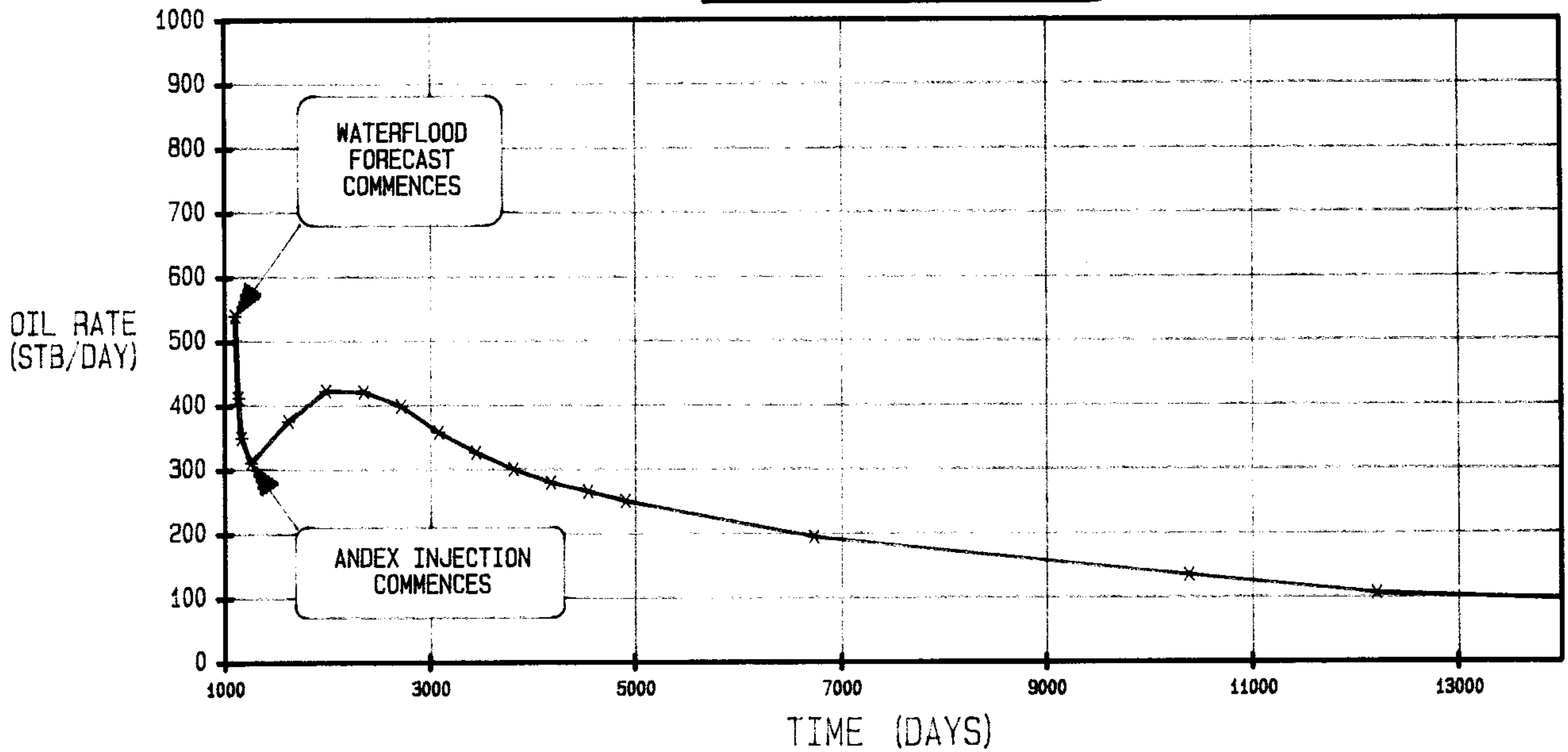
EXHIBIT D
FIGURE No. 1



WBRATE.GPH

EXHIBIT D
FIGURE No. 2

**WASKADA UNIT No.16
LOWER AMARANTH
STANDARD PATTERN
WATERFLOOD FORECAST**



Waskada Spearfish OMEGA Waterflood Pattern Forecast

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 1096. DAYS (JULY, 1986) — MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1096. | 236.8 | 161.19 | 0.07 | 46.47 | 37.4 | 14.24 | 0. | 0. | -550.0 | -99.05 |
| 2 | 1096. | 539.6 | 69.19 | 0.15 | 26.22 | 72.0 | 7.75 | 0. | 0. | 0. | 0. |
| 3 | 1096. | 54.2 | 12.26 | 0.02 | 3.53 | 4.6 | 0.82 | 0. | 0. | 0. | 0. |

TIME = 1126. DAYS (AUG , 1986) — MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1126. | 224.1 | 168.02 | 0.06 | 48.44 | 36.5 | 15.34 | 0. | 0. | -550.0 | -115.55 |
| 2 | 1126. | 411.1 | 82.81 | 0.18 | 31.54 | 73.3 | 10.00 | 0. | 0. | 0. | 0. |
| 3 | 1126. | 47.3 | 13.74 | 0.01 | 3.95 | 4.2 | 0.94 | 0. | 0. | 0. | 0. |

TIME = 1156. DAYS (SEP , 1986) — MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1156. | 220.1 | 174.65 | 0.06 | 50.35 | 36.7 | 16.44 | 0. | 0. | -550.0 | -132.05 |
| 2 | 1156. | 348.8 | 73.67 | 0.16 | 36.55 | 69.2 | 12.11 | 0. | 0. | 0. | 0. |
| 3 | 1156. | 57.8 | 15.50 | 0.02 | 4.46 | 5.1 | 1.10 | 0. | 0. | 0. | 0. |

TIME = 1249. DAYS (DEC , 1986) — MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1249. | 224.6 | 195.29 | 0.06 | 56.30 | 39.3 | 19.10 | 0. | 0. | -775.0 | -203.25 |
| 2 | 1249. | 310.5 | 125.25 | 0.14 | 50.72 | 57.2 | 18.72 | 0. | 0. | 0. | 0. |
| 3 | 1249. | 50.5 | 20.45 | 0.02 | 5.99 | 4.7 | 1.55 | 0. | 0. | 0. | 0. |

Waskada Spearfish OMEGA Waterflood Pattern Forecast

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 1614. DAYS (DEC , 1987)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1614. | 239.5 | 273.86 | 0.07 | 78.92 | 67.6 | 35.76 | 0. | 0. | -1000.0 | -566.22 |
| 2 | 1614. | 375.2 | 234.92 | 0.11 | 87.52 | 34.1 | 24.50 | 0. | 0. | -825.0 | -246.10 |
| 3 | 1614. | 42.1 | 36.32 | 0.01 | 11.43 | 3.9 | 3.08 | 0. | 0. | 0. | 0. |

TIME = 1979. DAYS (DEC , 1988)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1979. | 200.5 | 352.15 | 0.06 | 101.43 | 83.2 | 63.73 | 0. | 0. | -312.7 | -685.37 |
| 2 | 1979. | 422.0 | 384.29 | 0.12 | 129.31 | 60.9 | 42.32 | 0. | 0. | -810.0 | -541.75 |
| 3 | 1979. | 39.4 | 50.66 | 0.01 | 16.00 | 3.2 | 4.27 | 0. | 0. | 0. | 0. |

TIME = 2344. DAYS (DEC , 1989)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2344. | 180.1 | 420.30 | 0.05 | 121.02 | 97.0 | 97.42 | 0. | 0. | -303.6 | -797.57 |
| 2 | 2344. | 420.4 | 538.70 | 0.12 | 172.44 | 95.7 | 72.58 | 0. | 0. | -810.0 | -837.40 |
| 3 | 2344. | 40.1 | 65.17 | 0.01 | 20.52 | 2.9 | 5.37 | 0. | 0. | 0. | 0. |

TIME = 2709. DAYS (DEC , 1990)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2709. | 166.8 | 482.88 | 0.05 | 139.02 | 106.8 | 135.14 | 0. | 0. | -298.0 | -907.20 |
| 2 | 2709. | 398.3 | 687.10 | 0.11 | 214.17 | 125.0 | 114.05 | 0. | 0. | -750.0 | -1111.15 |
| 3 | 2709. | 41.2 | 80.09 | 0.01 | 24.96 | 2.8 | 6.41 | 0. | 0. | 0. | 0. |

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

Waskada Spearfish OMEGA Waterflood Pattern Forecast

TIME = 3074. DAYS (DEC , 1991)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3074. | 155.1 | 541.06 | 0.04 | 155.76 | 115.4 | 176.14 | 0. | 0. | -293.4 | -1015.07 |
| 2 | 3074. | 357.3 | 822.82 | 0.10 | 252.59 | 148.0 | 164.92 | 0. | 0. | -605.0 | -1331.97 |
| 3 | 3074. | 40.9 | 95.08 | 0.01 | 29.39 | 2.7 | 7.39 | 0. | 0. | 0. | 0. |

TIME = 3439. DAYS (DEC , 1992)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3439. | 144.4 | 595.16 | 0.04 | 171.32 | 122.7 | 219.99 | 0. | 0. | -288.5 | -1121.17 |
| 2 | 3439. | 326.0 | 945.80 | 0.09 | 287.33 | 172.6 | 224.56 | 0. | 0. | -605.0 | -1552.80 |
| 3 | 3439. | 40.1 | 109.82 | 0.01 | 33.74 | 2.6 | 8.35 | 0. | 0. | 0. | 0. |

TIME = 3804. DAYS (DEC , 1993)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3804. | 135.6 | 645.83 | 0.04 | 185.90 | 129.0 | 266.22 | 0. | 0. | -284.3 | -1225.67 |
| 2 | 3804. | 300.2 | 1058.83 | 0.09 | 319.31 | 196.6 | 293.04 | 0. | 0. | -605.0 | -1773.62 |
| 3 | 3804. | 39.7 | 124.37 | 0.01 | 38.03 | 2.5 | 9.27 | 0. | 0. | 0. | 0. |

TIME = 4169. DAYS (DEC , 1994)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4169. | 128.0 | 693.54 | 0.04 | 199.63 | 134.9 | 314.67 | 0. | 0. | -281.6 | -1328.91 |
| 2 | 4169. | 279.2 | 1163.43 | 0.08 | 348.98 | 218.6 | 369.92 | 0. | 0. | -605.0 | -1994.45 |
| 3 | 4169. | 39.4 | 138.79 | 0.01 | 42.28 | 2.5 | 10.18 | 0. | 0. | 0. | 0. |

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

**Waskada Spearfish OMEGA Waterflood Pattern Forecast**

TIME = 4534. DAYS (DEC , 1995)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4534. | 111.2 | 735.54 | 0.03 | 211.72 | 83.5 | 345.27 | 0. | 0. | -212.2 | -1408.39 |
| 2 | 4534. | 265.5 | 1262.37 | 0.08 | 376.99 | 248.7 | 457.01 | 0. | 0. | -605.0 | -2215.27 |
| 3 | 4534. | 39.1 | 153.11 | 0.01 | 46.51 | 2.4 | 11.07 | 0. | 0. | 0. | 0. |

TIME = 4899. DAYS (DEC , 1996)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4899. | 105.0 | 774.67 | 0.03 | 222.98 | 84.5 | 375.97 | 0. | 0. | -205.9 | -1484.51 |
| 2 | 4899. | 250.4 | 1355.74 | 0.07 | 403.52 | 271.1 | 553.07 | 0. | 0. | -605.0 | -2436.10 |
| 3 | 4899. | 38.7 | 167.29 | 0.01 | 50.73 | 2.4 | 11.93 | 0. | 0. | 0. | 0. |

TIME = 6724. DAYS (DEC , 2001)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6724. | 77.4 | 940.44 | 0.02 | 270.70 | 84.2 | 533.32 | 0. | 0. | -173.5 | -1833.53 |
| 2 | 6724. | 194.1 | 1754.48 | 0.06 | 517.23 | 345.3 | 1125.89 | 0. | 0. | -605.0 | -3540.23 |
| 3 | 6724. | 36.3 | 235.64 | 0.01 | 71.49 | 2.2 | 16.02 | 0. | 0. | 0. | 0. |

TIME = 8549. DAYS (DEC , 2006)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8549. | 66.3 | 1070.59 | 0.02 | 308.17 | 93.5 | 695.96 | 0. | 0. | -169.9 | -2146.32 |
| 2 | 8549. | 155.7 | 2071.98 | 0.04 | 608.02 | 382.3 | 1798.81 | 0. | 0. | -605.0 | -4644.35 |
| 3 | 8549. | 34.3 | 300.00 | 0.01 | 91.28 | 2.2 | 19.91 | 0. | 0. | 0. | 0. |

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

## Waskada Spearfish OMEGA Waterflood Pattern Forecast

TIME =10374. DAYS (DEC , 2011)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION | | | | | | INJECTION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | O I L | | G A S | | W A T E R | | G A S | | W A T E R | |
| | | R A T E (STB/DAY) | CUMULATIVE (MSTB) | R A T E (MMCF/DAY) | CUMULATIVE (MMCF) | R A T E (STB/DAY) | CUMULATIVE (MSTB) | R A T E (MMCF/DAY) | CUMULATIVE (MMCF) | R A T E (STB/DAY) | CUMULATIVE (MSTB) |
| 1 | 10374. | 54.2 | 1176.58 | 0.02 | 338.68 | 85.8 | 850.61 | 0. | 0. | -148.3 | -2423.66 |
| 2 | 10374. | 134.3 | 2334.89 | 0.04 | 683.32 | 420.0 | 2538.05 | 0. | 0. | -605.0 | -5748.48 |
| 3 | 10374. | 31.2 | 359.67 | 0.01 | 109.80 | 2.5 | 24.15 | 0. | 0. | 0. | 0. |

TIME =12199. DAYS (DEC , 2016)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION | | | | | | INJECTION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | O I L | | G A S | | W A T E R | | G A S | | W A T E R | |
| | | R A T E (STB/DAY) | CUMULATIVE (MSTB) | R A T E (MMCF/DAY) | CUMULATIVE (MMCF) | R A T E (BTB/DAY) | CUMULATIVE (MSTB) | R A T E (MMCF/DAY) | CUMULATIVE (MMCF) | R A T E (STB/DAY) | CUMULATIVE (MSTB) |
| 1 | 12199. | 48.6 | 1269.75 | 0.01 | 365.51 | 90.6 | 1011.77 | 0. | 0. | -146.7 | -2692.40 |
| 2 | 12199. | 105.9 | 2551.96 | 0.03 | 745.71 | 323.0 | 3215.28 | 0. | 0. | -478.7 | -6734.88 |
| 3 | 12199. | 27.9 | 413.62 | 0.01 | 126.76 | 3.1 | 29.32 | 0. | 0. | 0. | 0. |

TIME =14024. DAYS (DEC , 2021)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION | | | | | | INJECTION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | O I L | | G A S | | W A T E R | | G A S | | W A T E R | |
| | | R A T E (STB/DAY) | CUMULATIVE (MSTB) | R A T E (MMCF/DAY) | CUMULATIVE (MMCF) | R A T E (STB/DAY) | CUMULATIVE (MSTB) | R A T E (MMCF/DAY) | CUMULATIVE (MMCF) | R A T E (STB/DAY) | CUMULATIVE (MSTB) |
| 1 | 14024. | 40.3 | 1349.64 | 0.01 | 388.51 | 92.5 | 1178.58 | 0. | 0. | -139.1 | -2951.46 |
| 2 | 14024. | 96.0 | 2735.67 | 0.03 | 798.51 | 346.0 | 3827.84 | 0. | 0. | -487.4 | -7617.78 |
| 3 | 14024. | 25.3 | 461.64 | 0.01 | 142.20 | 3.8 | 35.59 | 0. | 0. | 0. | 0. |

EXHIBIT E

TABLE 1

EXHIBIT E

WATERFLOOD FORECAST PARAMETERS
ENRON'S WATERFLOOD PATTERN "C"

1. Omega's wells are producing and injecting identical to the primary case.

2. The Enron injectors start injecting January 1987, with stabilized injection rates as follows:

| | |
|---|---|
| 5-4 | 250 Bbls/d |
| 11-4 | 350 Bbls/d |
| 15-4 | 175 Bbls/d |
| 16-5 | 150 Bbls/d |
| | 925 Bbls/d |

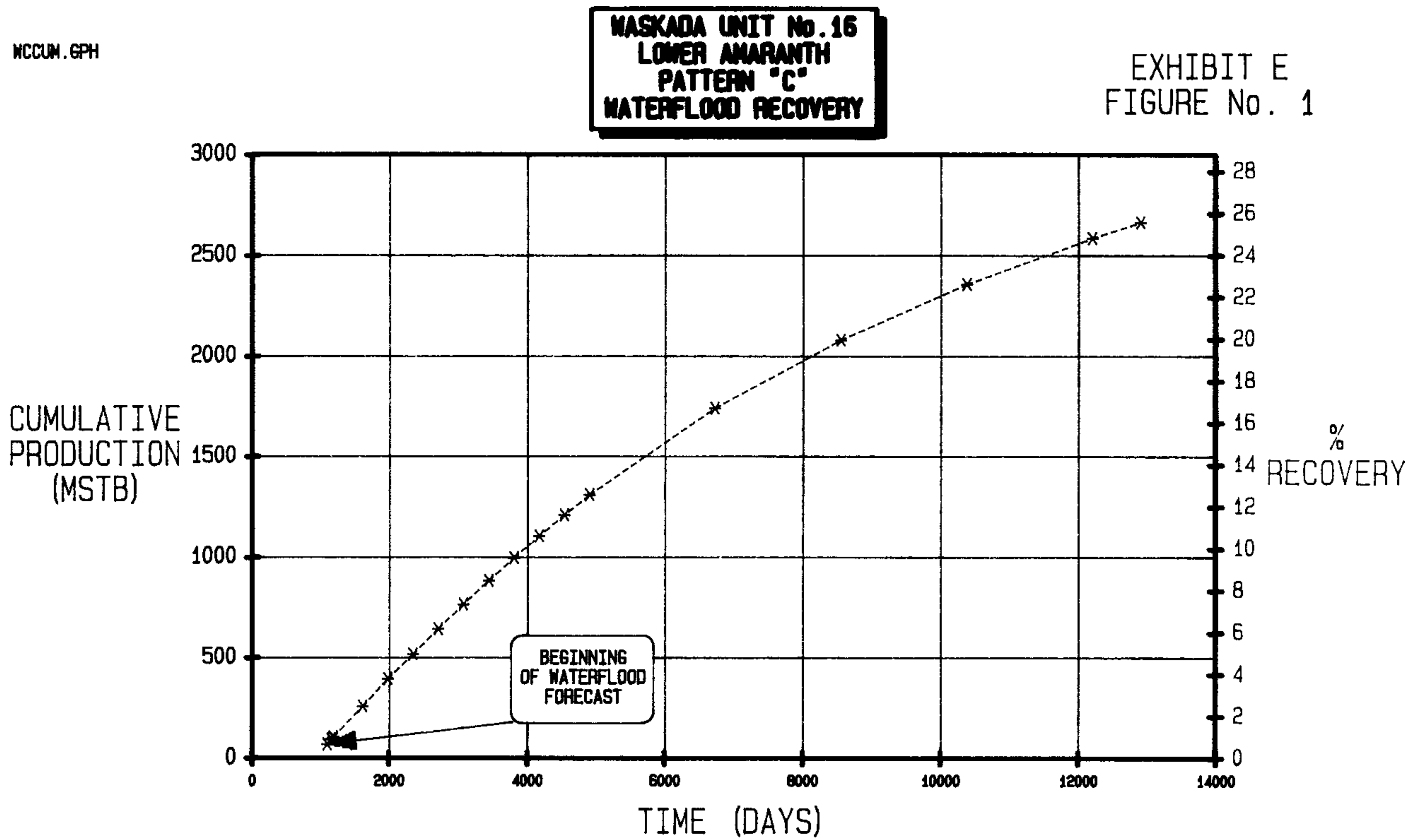
These rates are maintained (with some reduction due to injection pressure constraint) until the incremental withdrawals are less than the injection rates at which time the injectors are all cut back on a prorationed basis. As long as an offset producer is still producing (ie. rate is above the economic limit and WOR is less than 10) a specific injector remains injecting.

The transmissibilities of the grid blocks in which the injectors are located are modified by a factor of 100X (only in the grid block in which the injector is located). All injectors were constrained to inject with a BHP for either of the 3 layers of less than 3,000 psi. This should satisfy the constraint of keeping injection pressure below frac propagation levels.

3. An "individual well" economic limit of 4 STB/D and a maximum WOR limit of 10 were used for all producers in the model.

WCCUM.GPH

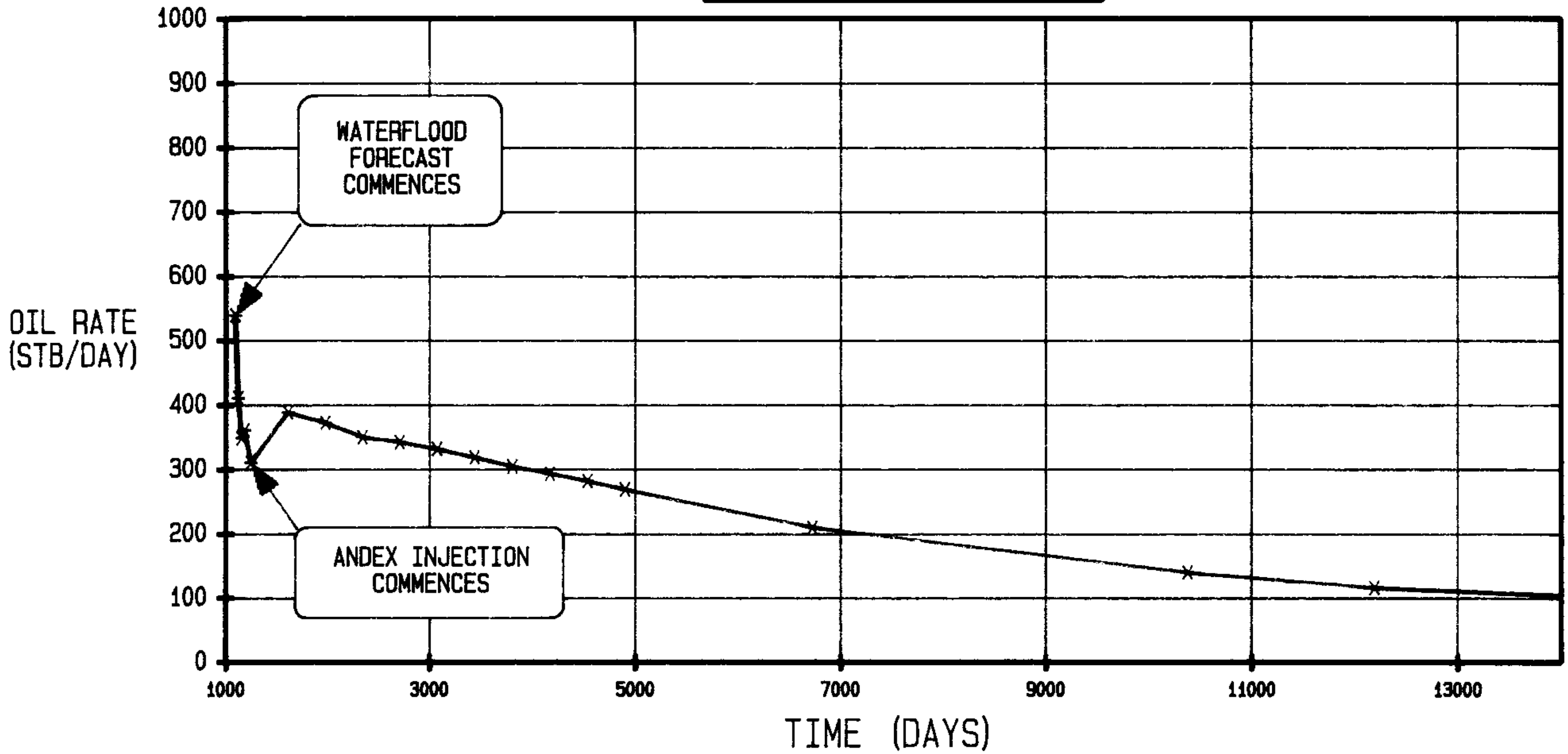
EXHIBIT E
FIGURE No. 1



WCRATE.GPH

EXHIBIT E
FIGURE No. 2

# WASKADA UNIT No.16 LOWER AMARANTH PATTERN "C" WATERFLOOD FORECAST



LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

Waskada Spearfish ANDEX Waterflood Pattern Forecast "C"

TIME = 1096. DAYS (JULY, 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1096. | 236.8 | 161.19 | 0.07 | 46.47 | 37.4 | 14.24 | 0. | 0. | -550.0 | -99.05 |
| 2 | 1096. | 539.6 | 69.19 | 0.15 | 26.22 | 72.0 | 7.75 | 0. | 0. | 0. | 0. |
| 3 | 1096. | 54.2 | 12.26 | 0.02 | 3.53 | 4.6 | 0.82 | 0. | 0. | 0. | 0. |

TIME = 1126. DAYS (AUG , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1126. | 224.1 | 168.02 | 0.06 | 48.44 | 36.5 | 15.34 | 0. | 0. | -550.0 | -115.55 |
| 2 | 1126. | 411.1 | 82.81 | 0.18 | 31.54 | 73.3 | 10.00 | 0. | 0. | 0. | 0. |
| 3 | 1126. | 47.3 | 13.74 | 0.01 | 3.95 | 4.2 | 0.94 | 0. | 0. | 0. | 0. |

TIME = 1156. DAYS (SEP , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1156. | 220.1 | 174.65 | 0.06 | 50.35 | 36.7 | 16.44 | 0. | 0. | -550.0 | -132.05 |
| 2 | 1156. | 348.8 | 93.67 | 0.16 | 36.55 | 69.2 | 12.11 | 0. | 0. | 0. | 0. |
| 3 | 1156. | 57.8 | 15.50 | 0.02 | 4.46 | 5.1 | 1.10 | 0. | 0. | 0. | 0. |

TIME = 1186. DAYS (OCT , 1986)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1186. | 220.1 | 181.24 | 0.06 | 52.25 | 37.2 | 16.67 | 0. | 0. | -775.0 | -154.42 |
| 2 | 1186. | 361.2 | 104.81 | 0.17 | 41.47 | 83.7 | 14.49 | 0. | 0. | 0. | 0. |
| 3 | 1186. | 55.1 | 17.17 | 0.02 | 4.96 | 4.9 | 1.25 | 0. | 0. | 0. | 0. |

Waskada Spearfish ANDEX Waterflood Pattern Forecast "C"

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 1614. DAYS (DEC , 1987)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1614. | 245.5 | 274.17 | 0.07 | 79.01 | 70.5 | 36.40 | 0. | 0. | -1000.0 | -580.57 |
| 2 | 1614. | 388.7 | 257.98 | 0.11 | 93.10 | 209.8 | 53.16 | 0. | 0. | -925.0 | -285.38 |
| 3 | 1614. | 42.0 | 36.36 | 0.01 | 11.44 | 3.9 | 3.08 | 0. | 0. | 0. | 0. |

TIME = 1979. DAYS (DEC , 1988)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1979. | 201.5 | 353.49 | 0.06 | 101.81 | 90.8 | 66.65 | 0. | 0. | -323.2 | -702.85 |
| 2 | 1979. | 372.6 | 395.48 | 0.10 | 131.66 | 302.1 | 151.93 | 0. | 0. | -885.0 | -608.41 |
| 3 | 1979. | 37.9 | 50.34 | 0.01 | 15.96 | 3.1 | 4.27 | 0. | 0. | 0. | 0. |

TIME = 2344. DAYS (DEC , 1989)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2344. | 180.4 | 422.14 | 0.05 | 121.55 | 108.3 | 103.75 | 0. | 0. | -314.2 | -818.31 |
| 2 | 2344. | 350.2 | 516.80 | 0.10 | 165.42 | 286.2 | 215.08 | 0. | 0. | -865.0 | -917.39 |
| 3 | 2344. | 36.9 | 63.94 | 0.01 | 20.41 | 2.9 | 5.37 | 0. | 0. | 0. | 0. |

TIME = 2709. DAYS (DEC , 1990)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2709. | 164.7 | 484.29 | 0.05 | 139.43 | 119.0 | 145.79 | 0. | 0. | -307.8 | -931.78 |
| 2 | 2709. | 342.5 | 642.79 | 0.10 | 200.78 | 331.6 | 329.79 | 0. | 0. | -865.0 | -1233.12 |
| 3 | 2709. | 36.7 | 77.35 | 0.01 | 24.70 | 2.7 | 6.38 | 0. | 0. | 0. | 0. |

Waskada Spearfish ANDEX Waterflood Pattern Forecast "C"

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME = 3074. DAYS (DEC , 1991)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3074. | 151.7 | 541.35 | 0.04 | 155.84 | 128.2 | 191.37 | 0. | 0. | -302.0 | -1042.90 |
| 2 | 3074. | 332.0 | 765.26 | 0.09 | 235.40 | 368.5 | 459.30 | 0. | 0. | -865.0 | -1548.84 |
| 3 | 3074. | 36.7 | 90.73 | 0.01 | 28.87 | 2.6 | 7.34 | 0. | 0. | 0. | 0. |

TIME = 3439. DAYS (DEC , 1992)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3439. | 141.1 | 594.19 | 0.04 | 171.04 | 136.7 | 240.15 | 0. | 0. | -298.0 | -1152.26 |
| 2 | 3439. | 318.7 | 883.44 | 0.09 | 268.93 | 398.3 | 600.81 | 0. | 0. | -865.0 | -1864.56 |
| 3 | 3439. | 36.7 | 104.13 | 0.01 | 32.95 | 2.5 | 8.27 | 0. | 0. | 0. | 0. |

TIME = 3804. DAYS (DEC , 1993)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3804. | 126.2 | 642.61 | 0.04 | 184.98 | 87.8 | 282.45 | 0. | 0. | -233.6 | -1250.31 |
| 2 | 3804. | 304.5 | 996.06 | 0.09 | 300.93 | 429.1 | 753.04 | 0. | 0. | -865.0 | -2180.29 |
| 3 | 3804. | 36.6 | 117.52 | 0.01 | 37.00 | 2.4 | 9.16 | 0. | 0. | 0. | 0. |

TIME = 4169. DAYS (DEC , 1994)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4169. | 113.8 | 685.62 | 0.03 | 197.36 | 84.3 | 313.54 | 0. | 0. | -215.8 | -1331.33 |
| 2 | 4169. | 293.6 | 1104.73 | 0.08 | 331.89 | 452.4 | 915.11 | 0. | 0. | -855.0 | -2492.36 |
| 3 | 4169. | 36.4 | 130.83 | 0.01 | 41.01 | 2.4 | 10.03 | 0. | 0. | 0. | 0. |

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

Waskada Spearfish ANDEX Waterflood Pattern Forecast "C"

TIME = 4534. DAYS (DEC , 1995)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4534. | 103.2 | 724.53 | 0.03 | 208.56 | 83.9 | 344.15 | 0. | 0. | -203.0 | -1407.05 |
| 2 | 4534. | 282.0 | 1209.28 | 0.08 | 361.72 | 472.3 | 1084.83 | 0. | 0. | -855.0 | -2804.44 |
| 3 | 4534. | 36.0 | 144.02 | 0.01 | 44.99 | 2.3 | 10.89 | 0. | 0. | 0. | 0. |

TIME = 4899. DAYS (DEC , 1996)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4899. | 98.1 | 760.99 | 0.03 | 219.05 | 85.9 | 375.25 | 0. | 0. | -198.9 | -1480.28 |
| 2 | 4899. | 268.7 | 1309.15 | 0.08 | 390.24 | 492.2 | 1261.87 | 0. | 0. | -855.0 | -3116.51 |
| 3 | 4899. | 35.7 | 157.10 | 0.01 | 48.96 | 2.3 | 11.72 | 0. | 0. | 0. | 0. |

TIME = 6724. DAYS (DEC , 2001)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6724. | 80.7 | 921.86 | 0.02 | 265.36 | 97.5 | 542.82 | 0. | 0. | -190.2 | -1833.03 |
| 2 | 6724. | 209.7 | 1740.32 | 0.06 | 513.57 | 574.7 | 2243.23 | 0. | 0. | -855.0 | -4676.89 |
| 3 | 6724. | 34.6 | 221.16 | 0.01 | 68.51 | 2.1 | 15.68 | 0. | 0. | 0. | 0. |

TIME = 8549. DAYS (DEC , 2006)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | PRODUCTION OIL CUMULATIVE (MSTB) | PRODUCTION GAS RATE (MMCF/DAY) | PRODUCTION GAS CUMULATIVE (MMCF) | PRODUCTION WATER RATE (STB/DAY) | PRODUCTION WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | INJECTION GAS CUMULATIVE (MMCF) | INJECTION WATER RATE (STB/DAY) | INJECTION WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8549. | 69.6 | 1058.07 | 0.02 | 304.57 | 108.4 | 731.52 | 0. | 0. | -188.4 | -2178.22 |
| 2 | 8549. | 167.5 | 2079.39 | 0.05 | 610.80 | 628.9 | 3348.30 | 0. | 0. | -855.0 | -6237.26 |
| 3 | 8549. | 33.4 | 283.23 | 0.01 | 87.49 | 2.0 | 19.43 | 0. | 0. | 0. | 0. |

Waskada Spearfish ANDEX Waterflood Pattern Forecast "C"

LEGEND
1 OMEGA WELLS
2 ANDEX UNIT WELLS
3 ANDEX NON-UNIT WELLS

TIME =10374. DAYS (DEC , 2011)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10374. | 53.8 | 1166.04 | 0.02 | 335.66 | 93.9 | 909.13 | 0. | 0. | -155.9 | -2480.47 |
| 2 | 10374. | 140.0 | 2356.94 | 0.04 | 690.33 | 667.3 | 4535.05 | 0. | 0. | -855.0 | -7797.64 |
| 3 | 10374. | 31.6 | 342.66 | 0.01 | 105.74 | 2.1 | 23.17 | 0. | 0. | 0. | 0. |

TIME =12199. DAYS (DEC , 2016)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12199. | 45.4 | 1252.82 | 0.01 | 360.65 | 94.2 | 1078.35 | 0. | 0. | -146.6 | -2749.88 |
| 2 | 12199. | 116.2 | 2585.72 | 0.03 | 756.06 | 561.0 | 5613.95 | 0. | 0. | -722.5 | -9193.42 |
| 3 | 12199. | 29.2 | 398.07 | 0.01 | 122.99 | 2.3 | 27.14 | 0. | 0. | 0. | 0. |

TIME =12902. DAYS (NOV , 2018)

MATERIAL BALANCES

| GATHERING CENTER NUMBER | | PRODUCTION OIL RATE (STB/DAY) | OIL CUMULATIVE (MSTB) | GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) | INJECTION GAS RATE (MMCF/DAY) | GAS CUMULATIVE (MMCF) | WATER RATE (STB/DAY) | WATER CUMULATIVE (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12902. | 44.0 | 1284.21 | 0.01 | 369.68 | 95.3 | 1145.01 | 0. | 0. | -146.1 | -2852.78 |
| 2 | 12902. | 103.7 | 2665.26 | 0.03 | 778.91 | 496.4 | 6011.48 | 0. | 0. | -621.4 | -9701.69 |
| 3 | 12902. | 28.4 | 418.27 | 0.01 | 129.33 | 2.4 | 28.78 | 0. | 0. | 0. | 0. |