



1300 SUN LIFE PLAZA III  
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December 23, 1986

Manitoba Petroleum Branch  
555 - 330 Graham Avenue  
Winnipeg, Manitoba  
R3C 4E3

**Attention: Mr. Bob Dubreuil**

Dear Sir:

**Re: Waskada Lower Amaranth Secondary Recovery  
1985 Reservoir Model Study Addendum**

While tidying up loose ends I realized that the Manitoba Petroleum Branch had not been notified of a correction made to the low permeability waterflood prediction in our "1985 Waskada Lower Amaranth Reservoir Model Study". Attachment 1 contains an internal memo which explains in detail the reason for the correction and copies of the revised simulation results. This correction will effect the oil production forecasts contained in the 1985 annual reservoir performance review. I plan to revise these forecasts to include both the correction to the low permeability waterflood prediction and all the pressure maintenance expansions in this year's upcoming performance review.

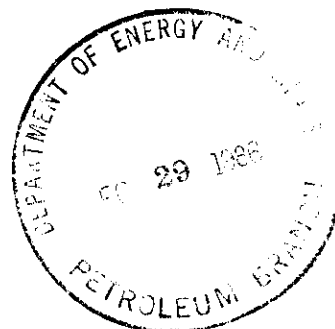
If you have any comments or questions related to this information please contact the undersigned at (403) 261-0743.

Merry Christmas and  
Happy New Year,

OMEGA HYDROCARBONS LTD.

R. A. Brekke, P. Eng.  
Petroleum Engineer

cc: Waskada (LAm) Waterflood  
Approvals File



## M E M O R A N D U M

DATE: November 12, 1986

TO: G. Patey  
R. Beamish

FROM: R. Brekke

RE: 1985 Waskada Reservoir Model Study  
Lower Amaranth A Pool  
Low Permeability Waterflood Prediction Correction

After reviewing the reservoir model study results carefully it was observed that the low permeability waterflood prediction had higher oil rates during the first four years of production than the average permeability waterflood prediction. Theory suggests that this is impossible since the only change made to the model was the  $\phi/k$  relationship and in fact the reverse should be true. This discrepancy was passed on to the Computer Modelling Group in April 1986 and a detailed investigation ensued.

The investigation uncovered that an error had been made in merging data sets for the low permeability waterflood prediction and that the final history matched rock type array had not been used. This error increased initial oil saturations throughout the model and resulted in more optimistic oil rates and oil recoveries. Rerunning the low permeability waterflood prediction using the correct data resulted in following recoveries,

	<u>Primary</u>	<u>Average</u> <u>Permeability</u>	<u>Waterflood</u> <u>Low</u> <u>Permeability</u> (Revised)	(Original)
Recovery at 20 years,				
10 <sup>3</sup> m <sup>3</sup>	40.4	118.6	51.1	86.8
%OOIP	9.1	26.7	11.5	19.6
Extrapolated Ultimate Recovery,				
10m <sup>3</sup> m <sup>3</sup>	40.4	168.9	97.4	161.6
%OOIP	9.1	38.2	22.0	36.5
Reservoir Life to Economic Limit,				
Years	6	41	50	58

Table 27, Table 28, Table B-8, Table B-9 and Table B-10 of the study report have been reprocessed and are attached to this memo. Figures 56 through to 60 in the report also require revisions to the low permeability waterflood prediction data, however, these corrections are not included.

A handwritten signature in black ink, appearing to read "Richard D. Bull", with a long horizontal line extending to the right.

cc: Waskada Model Study File

Table 27  
**EARLY FLUID PRODUCTION FORECAST FOR WATERFLOOD - LOW PERMEABILITY**  
**SENSITIVITY CASE**  
**Waskada Lower Amaranth Pool**

YEAR	OIL PROD. m3	RECOVERY/YR % OOIP	WATER PROD. m3	GAS PROD. m3	WOR	GOR	WATER INJ. m3
1	14480.0	3.27	6443.0	906000.0	0.44	62.6	2722.7
2	6430.0	1.45	6577.0	459000.0	1.02	71.4	1000.0
3	4480.0	1.01	7470.0	306000.0	1.67	68.3	1000.0
4	3300.0	0.74	8240.0	234000.0	2.50	70.9	1000.0
5	2500.0	0.55	8660.0	198000.0	3.32	76.4	1000.0
6	1600.0	0.36	8810.0	166000.0	4.08	78.9	1000.0
7	1730.0	0.39	8810.0	149000.0	5.09	80.1	1000.0
8	1490.0	0.34	8810.0	133000.0	5.93	80.3	1000.0
9	1350.0	0.30	8810.0	94000.0	6.65	80.6	1000.0
10	1140.0	0.26	8810.0	74000.0	7.94	80.9	1000.0
11	1210.0	0.27	8810.0	70000.0	8.51	81.1	1000.0
12	1050.0	0.24	8810.0	52000.0	9.76	81.4	1000.0
13	1170.0	0.25	8810.0	49000.0	10.85	81.7	1000.0
14	1030.0	0.23	8810.0	44000.0	11.50	81.9	1000.0
15	1220.0	0.26	8810.0	45000.0	12.62	82.1	1000.0
16	1140.0	0.25	8810.0	39000.0	13.04	82.2	1000.0
17	1260.0	0.27	8810.0	45000.0	13.59	82.3	1000.0
18	1210.0	0.26	8810.0	42000.0	14.91	82.4	1000.0
19	1330.0	0.28	8810.0	48000.0	16.12	82.5	1000.0
20	1220.0	0.27	8810.0	45000.0	17.77	82.6	1000.0
21	1370.0	0.29	8810.0	51000.0	18.85	82.7	1000.0
22	1320.0	0.28	8810.0	48000.0	20.45	82.8	1000.0
23	1370.0	0.29	8810.0	56000.0	21.55	82.9	1000.0
24	1300.0	0.28	8810.0	64000.0	23.83	83.0	1000.0
25	1730.0	0.39	8810.0	62000.0	25.54	83.1	1000.0
26	1710.0	0.38	8810.0	61000.0	26.64	83.2	1000.0
27	1720.0	0.38	8810.0	61000.0	27.66	83.3	1000.0
28	1710.0	0.38	8810.0	62000.0	28.79	83.4	1000.0
29	1700.0	0.38	8810.0	64000.0	29.72	83.5	1000.0
30	1690.0	0.38	8810.0	64000.0	30.82	83.6	1000.0
31	1690.0	0.38	8810.0	63000.0	31.99	83.7	1000.0
32	1620.0	0.36	8810.0	61000.0	33.22	83.8	1000.0
33	1530.0	0.34	8810.0	60000.0	34.55	83.9	1000.0
34	1530.0	0.34	8810.0	49000.0	35.74	84.0	1000.0
35	1540.0	0.34	8810.0	47000.0	36.44	84.1	1000.0
36	1540.0	0.34	8810.0	52000.0	37.13	84.2	1000.0
37	1540.0	0.34	8810.0	56000.0	38.08	84.3	1000.0
38	1540.0	0.34	8810.0	60000.0	39.17	84.4	1000.0
39	1540.0	0.34	8810.0	59000.0	40.25	84.5	1000.0
40	1540.0	0.34	8810.0	57000.0	41.55	84.6	1000.0
41	1540.0	0.34	8810.0	54000.0	42.99	84.7	1000.0
42	1540.0	0.34	8810.0	51000.0	44.50	84.8	1000.0
43	1540.0	0.34	8810.0	47000.0	46.00	84.9	1000.0
44	1540.0	0.34	8810.0	45000.0	47.35	85.0	1000.0
45	1540.0	0.34	8810.0	44000.0	48.80	85.1	1000.0

\* Original Oil in Place = 4.4330E+05 m3

Table 28

**CUMULATIVE FLUID PRODUCTION FORECAST FOR WATERFLOOD - LOW PERMEABILITY  
SENSITIVITY CASE  
Waskada Lower Amaranth Pool**

YEAR	CUM. OIL PRCD. m <sup>3</sup>	RECOVERY % OIP	CUM. WATER PROD. m <sup>3</sup>	CUM. GAS PROD. m <sup>3</sup>	CUM. WATER INJ. m <sup>3</sup>
1	144800.0	3.27	64430.0	906000.0	27230.0
2	209900.0	4.72	130200.0	1365000.0	135800.0
3	253300.0	5.73	204900.0	1671000.0	244900.0
4	288600.0	6.47	287300.0	1905000.0	354500.0
5	312800.0	7.06	373400.0	2103000.0	464600.0
6	334400.0	7.54	461500.0	2269000.0	575500.0
7	351700.0	7.93	549500.0	2418000.0	685500.0
8	366600.0	8.27	637900.0	2551000.0	795500.0
9	380100.0	8.57	727800.0	2679000.0	905500.0
10	391500.0	8.83	819300.0	2800000.0	1015500.0
11	400300.0	9.10	909200.0	2915000.0	1125500.0
12	407600.0	9.34	1000120.0	3024100.0	1235500.0
13	425500.0	9.61	1093310.0	3128900.0	1345500.0
14	436600.0	9.85	1184900.0	3230000.0	1455500.0
15	448800.0	10.12	1277900.0	3334000.0	1565500.0
16	4600200.0	10.38	1369500.0	3440000.0	1675500.0
17	4722800.0	10.67	1462600.0	3549000.0	1785500.0
18	4844900.0	10.94	1554470.0	3663000.0	1895500.0
19	498200.0	11.24	1644600.0	3779000.0	2005500.0
20	511000.0	11.53	1733700.0	3890000.0	2115500.0
21	524700.0	11.84	1833000.0	4000000.0	2225500.0
22	537900.0	12.13	1920900.0	4115000.0	2335500.0
23	553500.0	12.49	1990800.0	4230000.0	2445500.0
24	571600.0	12.89	2059700.0	4341700.0	2555500.0
25	589600.0	13.30	2136900.0	4448200.0	2665500.0
26	607600.0	13.69	2213500.0	4554400.0	2775500.0
27	624100.0	14.08	2296400.0	4660000.0	2885500.0
28	641100.0	14.46	2374100.0	4766000.0	2995500.0
29	658800.0	14.85	2455300.0	4872800.0	3105500.0
30	677900.0	15.23	2536100.0	4979000.0	3215500.0
31	692900.0	15.62	2616600.0	5085400.0	3325500.0
32	709900.0	16.00	2699700.0	5191800.0	3435500.0
33	726600.0	16.38	2777900.0	5298100.0	3545500.0
34	743700.0	16.76	2863100.0	5404500.0	3655500.0
35	759200.0	17.13	2944500.0	5510600.0	3765500.0
36	775100.0	17.48	3028900.0	5616700.0	3875500.0
37	790900.0	17.84	3111200.0	5722700.0	3985500.0
38	806400.0	18.15	3192300.0	5827000.0	4095500.0
39	821800.0	18.47	3272400.0	5931900.0	4205500.0
40	837400.0	18.82	3351000.0	6037100.0	4315500.0
41	85500.0	19.18	3422700.0	6142700.0	4425500.0
42	866100.0	19.54	3510600.0	6248700.0	4535500.0
43	888100.0	19.89	3599300.0	6354600.0	4645500.0
44	89600.0	20.23	3676500.0	6460300.0	4755500.0
45	911500.0	20.56	3760000.0	6565900.0	4865500.0
46	925500.0	20.88	3843500.0	6671300.0	4975500.0
47	93800.0	21.18	3933000.0	6776400.0	5085500.0
48	951200.0	21.46	4017000.0	6881100.0	5195500.0
49	963100.0	21.73	4104500.0	6985600.0	5305500.0
50	974400.0	21.98	4192600.0	7090000.0	5415500.0

\* Original Oil in Place = 4.4330E+05 m<sup>3</sup>

### Waskada Lower Amaranth Pool

```
time = 18250.0 (days)
```

plane z = 1		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
x	y	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
1	1	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
2	2	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
3	3	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
4	4	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
5	5	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
6	6	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7	7	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
8	8	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
9	9	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
10	10	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
11	11	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
12	12	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
13	13	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
14	14	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
15	15	15	73	56	37	13	4	5	6	87	11	17	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11

[illegible][illegible]

plane z =		4														
x =	z =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
y =	15	73.50	56.94	38.35	130.8	457.1	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	14	58.34	57.71	38.30	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	13	55.48	52.36	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	12	55.170	49.20	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	11	49.28	47.07	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	10	47.38	44.66	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	9	48.78	42.17	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	8	54.42	41.91	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	7	56.99	41.19	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	6	57.61	41.66	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	5	57.11	40.96	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	4	55.96	40.96	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	3	55.91	40.96	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	2	55.91	40.96	38.88	130.8	457.2	671.8	882.2	1183.2	1145.5	1122.9	1127.7	1115.2	1133.1	1187.5	1255.8
	1	83.42	89.97	104.42	118.02	142.10	145.05	148.95	152.71	122.34	119.33	108.95	76.61	76.75	106.65	172.57

average reservoir pressure = 6982.83 kPa  
 $P_{avg}(\text{excluding NY th layer}) = 6904.69 \text{ kPa}$

**Table B-9**

time= 18250.0 (days)

[illegible]

### Waskada Lower Amaranth Pool

[illegible]