

OILFIELD RESEARCH LABORATORIES

536 NORTH HIGHLAND - CHANUTE, KANSAS - PHONE HE1-2650

February 9, 1966

CRA, Incorporated
Box 445
Wellington, Kansas

Gentlemen:

Enclosed herewith is the report of the analysis of the Rotary core taken from the Woodward Lease, Well No. 18, Bourbon County, Kansas, and submitted to our laboratory on February 5, 1966.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Benjamin R. Pearman
Benjamin R. Pearman

BRP:rf

3 c. - Wellington, Kansas
1 c. - Muskogee, Oklahoma
1 c. - Independence, Kansas

Fresh water mud was used as the circulating fluid while taking this core. The core was sampled and the samples sealed in cans by a representative of Oilfield Research Laboratories. The well was drilled in virgin territory.

FORMATION CORED

The detailed log of the formation cored is as follows:

<u>Depth Interval,</u> <u>Feet</u>	<u>Description</u>
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651.0 - 653.0	Laminated sandy shale.
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653.0 - 655.5	Laminated sandstone and shale.
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655.5 - 657.0	Shale.
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657.0 - 658.5	Alternate layers of sandstone and shale.
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658.5 - 665.0	Brown, slightly shaly sandstone.
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665.0 - 665.5	Brown sandy limestone.
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665.5 - 676.5	Brown, slightly shaly sandstone.
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676.5 - 687.6	Brown and dark, laminated, carbonaceous, shaly sandstone.
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687.6 - 689.8	Dark, carbonaceous, calcareous sandstone.
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689.8 - 691.0	Sandy shale.
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Coring was started at a depth of 651.0 feet in sandy shale and completed at 691.0 feet also in sandy shale. This core shows a total of 34.8 feet of sandstone. For the most part, the pay is made up of brown, slightly shaly sandstone.

PERMEABILITY

For the sake of distribution, the core was divided into three sections. The weighted average permeability of the upper, middle and lower sections is 43.9, 58.5 and 8.7 millidarcys respectively; the

overall average being 37.6 (See Table III). By observing the data given on the coregraph, it is noticeable that the sand has a rather irregular permeability profile. The permeability of the sand varies from impermeable to a maximum of 151. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a good weighted average percent oil saturation, namely, 41.8. The weighted average percent oil saturation of the upper, middle and lower sections is 31.5, 45.4 and 39.6 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 58.3, 33.4 and 40.0 respectively; the overall average being 38.7 (See Table III). This gives an overall weighted average total fluid saturation of 80.5 percent.

The weighted average oil content of the upper, middle and lower sections is 370, 736 and 595 barrels per acre foot respectively; the overall average being 641. The total oil content, as shown by this core, is 22,613 barrels per acre of which 15,955 barrels are in the pay sand section (See Table III).

LABORATORY FLOODING TESTS

The sand in this core responded to laboratory flooding tests, as a total recovery of 6,058 barrels of oil per acre was obtained from 22.6 feet of sand. The weighted average percent oil saturation was reduced from 44.8 to 28.1, or represents an average recovery of 16.7 percent. The weighted average effective permeability of the samples is 3.39 millidarcys, while the average initial fluid production pressure is 26.2 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 36 samples tested, 22 produced water and oil. This indicates that approximately 61 percent of the sand represented by these samples is floodable pay sand. The tests also show that the sand has a wide variation in effective permeability to water.

CONCLUSION

The results of the laboratory tests indicate that efficient primary and secondary operations in the vicinity of this well should recover approximately 8,320 barrels of oil per acre or an average of 368 barrels per acre foot from the 22.6 feet of floodable pay sand analyzed in this core. These recovery values were calculated using the following data and assumptions:

Original formation volume factor	1.06
Reservoir water saturation, percent	22.0
Average porosity, percent	20.2
Oil saturation after flooding, percent	28.1
Performance factor, percent	50.0
Net floodable pay sand, feet	22.6

This core shows a pay sand section having a good oil saturation, a moderate water saturation and a wide variation in effective permeability to water.

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Inc. Lease Woodward Well No. 18

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
1	653.1	11.7	14	82	96	127	Imp.	0.5	0.5	64	0.00
2	654.1	14.9	44	48	92	508	4.5	1.0	1.5	508	4.50
3	655.1	15.9	29	59	88	357	0.43	1.0	2.5	357	0.43
4	657.1	18.6	20	50	70	288	Imp.	0.5	3.0	144	0.00
5	658.1	14.6	36	60	96	406	127.	1.0	4.0	406	127.00
6	659.1	22.6	40	33	73	701	78.	1.0	5.0	701	78.00
7	660.1	21.0	52	32	84	848	51.	1.0	6.0	848	51.00
8	661.1	23.1	56	27	83	1,001	151.	1.0	7.0	1,001	151.00
9	662.1	22.1	54	28	82	925	51.	1.0	8.0	925	51.00
10	663.1	20.6	45	33	78	719	50.	1.0	9.0	719	50.00
11	664.1	20.4	49	35	84	774	36.	1.5	10.5	1,161	54.00
12	665.1	14.5	24	67	91	270	Imp.	0.5	11.0	135	0.00
13	666.1	17.6	56	34	90	765	55.	1.0	12.0	765	55.00
14	667.1	19.3	37	37	74	554	19.	1.0	13.0	554	19.00
15	668.1	21.4	39	30	69	648	62.	1.0	14.0	648	62.00
16	669.1	21.9	41	27	68	697	48.	1.0	15.0	697	48.00
17	670.1	20.5	37	38	75	588	145.	1.0	16.0	588	145.00
18	671.1	20.9	50	34	84	811	78.	1.0	17.0	811	78.00
19	672.1	20.1	47	33	80	733	14.	1.0	18.0	733	14.00
20	673.1	22.4	58	28	86	1,008	59.	1.0	19.0	1,008	59.00
21	674.1	19.8	33	38	71	507	9.0	1.0	20.0	507	9.00
22	675.1	20.2	40	36	76	627	50.	1.0	21.0	627	50.00
23	676.1	21.6	48	28	76	805	52.	1.0	22.0	805	52.00
24	677.1	16.3	41	48	89	519	15.	1.1	23.1	571	16.50

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Inc. Lease Woodward Well No. 18

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
25	678.1	18.6	34	38	72	490	10.	1.0	24.1	490	10.00
26	679.1	18.5	31	43	74	444	21.	1.0	25.1	444	21.00
27	680.1	18.6	41	37	78	590	13.	1.0	26.1	590	13.00
28	681.1	20.5	35	39	74	556	23.	1.0	27.1	556	23.00
29	682.1	20.8	40	28	68	645	4.8	1.0	28.1	645	4.80
30	683.1	21.6	41	27	68	686	3.6	1.0	29.1	686	3.60
31	684.1	21.2	52	33	85	854	18.	1.0	30.1	854	18.00
32	685.1	12.7	15	82	97	148	4.0	1.0	31.1	148	4.00
33	686.1	18.4	48	42	90	684	0.66	1.0	32.1	684	0.66
34	687.1	20.5	48	34	82	762	0.30	1.0	33.1	762	0.30
35	688.1	18.9	37	44	81	541	0.33	1.0	34.1	541	0.33
36	689.1	20.0	50	26	76	775	0.36	1.2	35.3	930	0.43
								Total	-----	22,613	

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Inc. Lease Woodward Well No. 18

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
653.0 - 658.5	3.0	43.9	131.93
658.5 - 676.5	17.5	58.5	1,026.00
676.5 - 689.8	13.3	8.7	115.62
653.0 - 689.8	33.8	37.6	1,273.55

Depth Interval, Feet	Feet of Core Analyzed	Average Percent Porosity	Average Percent Oil Saturation	Average Percent Water Saturation	Average Oil Content Bbl./A. Ft.	Total Oil Content Bbl./Acre
653.0 - 658.5	4.0	15.2	31.5	58.3	370	1,479
658.5 - 676.5	18.0	20.8	45.4	33.4	736	13,233
676.5 - 689.8	13.3	19.0	39.6	40.0	595	7,901
653.0 - 689.8	35.3	19.4	41.8	38.7	641	22,613

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company		CRA, Inc.					Lease		Woodward			Well No.		18
Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc*	Effective Permeability Millidarcys**	Initial Fluid Production Pressure Lbs./Sq./In.		
			%	Bbbs./A. Ft.	%	Bbbs./A. Ft.	% Oil	% Water	Bbbs./A. Ft.					
1	653.1	12.0	15	140	0	0	15	81	140	0	Imp.	-		
2	654.1	14.8	46	528	0	0	46	50	528	0	Imp.	-		
3	655.1	15.9	30	370	0	0	30	60	370	0	Imp.	-		
4	657.1	18.8	21	306	0	0	21	51	306	0	Imp.	-		
5	658.1	14.8	34	390	0	0	34	61	390	0	Imp.	-		
6	659.1	22.1	40	685	12	206	28	63	479	228	18.78	10		
7	660.1	21.4	52	863	27	449	25	63	414	196	5.80	10		
8	661.1	23.0	56	998	30	534	26	64	464	291	12.30	10		
9	662.1	21.8	54	912	31	524	23	69	388	226	11.00	10		
10	663.1	20.2	45	704	25	392	20	72	312	165	5.40	10		
11	664.1	20.0	49	759	21	326	28	67	433	40	1.30	20		
12	665.1	14.7	26	296	0	0	26	66	296	0	Imp.	-		
13	666.1	18.1	56	786	14	197	42	54	589	23	0.600	20		
14	667.1	19.0	37	545	12	177	25	70	368	11	0.400	40		
15	668.1	21.0	39	635	19	309	20	71	326	111	3.40	20		
16	669.1	21.6	41	686	18	302	23	73	384	80	2.50	20		
17	670.1	20.0	37	573	10	155	27	71	418	132	4.20	20		
18	671.1	20.5	50	794	22	350	28	66	444	83	2.60	20		
19	672.1	19.8	47	721	20	307	27	66	414	13	0.556	20		
20	673.1	22.0	58	990	30	511	28	65	479	61	2.60	20		
21	674.1	19.6	34	516	0	0	34	39	516	0	Imp.	-		
22	675.1	20.5	40	636	9	143	31	66	493	46	1.30	20		
23	676.1	21.8	48	811	18	304	30	59	507	44	1.33	20		
24	677.1	16.5	41	524	6	77	35	48	447	6	0.300	45		

Notes: cc—cubic centimeter.

*—Volume of water recovered at the time of maximum oil recovery.

**—Determined by passing water through sample which still contains residual oil.

Oilfield Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Inc. Lease Woodward Well No. 18

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc*	Effective Permeability Millidarcys**	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
25	678.1	18.2	34	479	4	56	30	52	423	5	0.300	50
26	679.1	18.4	31	442	2	29	29	50	413	2	0.100	50
27	680.1	18.5	41	588	14	201	27	63	387	14	0.400	40
28	681.1	20.1	35	545	6	94	29	56	451	12	0.400	50
29	682.1	20.6	40	639	0	0	40	30	639	0	Imp.	-
30	683.1	21.9	42	713	0	0	42	28	713	0	Imp.	-
31	684.1	21.0	52	847	15	244	37	49	603	7	0.300	50
32	685.1	13.0	17	171	0	0	17	80	171	0	Imp.	-
33	686.1	18.0	50	698	0	0	50	43	698	0	Imp.	-
34	687.1	20.4	48	759	0	0	48	35	759	0	Imp.	-
35	688.1	18.6	38	547	0	0	38	45	547	0	Imp.	-
36	689.1	19.8	51	782	0	0	51	28	782	0	Imp.	-

Notes: cc—cubic centimeter.

*—Volume of water recovered at the time of maximum oil recovery.

**—Determined by passing water through sample which still contains residual oil.

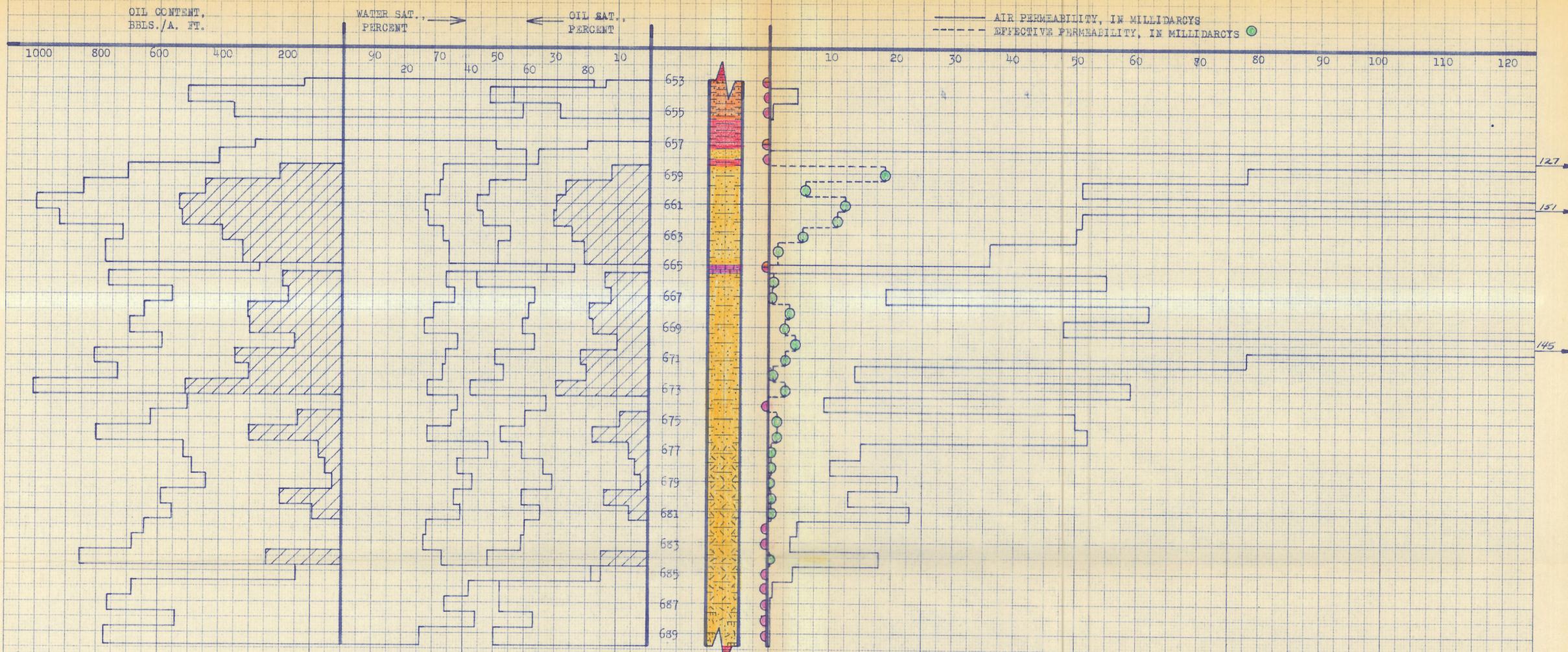
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SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company	CRA, Inc.	Lease	Woodward	Well No.	18
Depth Interval, Feet	658.5 - 676.5	676.5 - 789.8	658.5 - 689.8		
Feet of Core Analyzed	16.5	6.1	22.6		
Average Percent Porosity	20.8	18.8	20.2		
Average Percent Original Oil Saturation	47.5	39.0	44.8		
Average Percent Oil Recovery	19.9	7.8	16.7		
Average Percent Residual Oil Saturation	27.6	31.2	28.1		
Average Percent Residual Water Saturation	66.4	52.9	62.6		
Average Percent Total Residual Fluid Saturation	94.0	84.1	90.7		
Average Original Oil Content, Bbls./A. Ft.	755.	570.	706.		
Average Oil Recovery, Bbls./A. Ft.	324.	116.	268.		
Average Residual Oil Content, Bbls./A. Ft.	431.	454.	438.		
Total Original Oil Content, Bbls./Acre	12,477.	3,478.	15,955.		
Total Oil Recovery, Bbls./Acre	5,349.	709.	6,058.		
Total Residual Oil Content, Bbls./Acre	7,128.	2,769.	9,897.		
Average Effective Permeability, Millidarcys	4.53	0.300	3.39		
Average Initial Fluid Production Pressure, p.s.i.	18.1	47.5	26.2		

NOTE: Only those samples which recovered oil were used in calculating the above averages.



K&E STANDARD CROSS SECTION MILLIMETER

- | | | | |
|------------------------------|------------------------------------|-----------------|----------------------|
| FLOOD POT RECOVERY | CARBONACEOUS CALCAREOUS SANDSTONE | SANDY LIMESTONE | IMPERMEABLE TO AIR |
| SHALY SANDSTONE | ALTERNATE LAYERS SANDSTONE & SHALE | SANDY SHALE | IMPERMEABLE TO WATER |
| CARBONACEOUS SHALY SANDSTONE | LAMINATED SANDSTONE & SHALE | SHALE | |

CRA, INC.
WOODWARD LEASE WELL NO. 18
BOURBON COUNTY, KANSAS

DEPTH INTERVAL, FEET	FEET OF CORE ANALYZED	AVERAGE POROSITY, PERCENT	AVG. OIL SATURATION PERCENT	AVG. WATER SATURATION PERCENT	AVG. OIL CONTENT BBLs./A. FT.	TOTAL OIL CONTENT BBLs./ACRE	AVG. AIR PERMEABILITY, MILLIDARCYs	CALCULATED OIL RECOVERY, BBLs./ACRE
653.0 - 658.5	4.0	15.2	31.5	58.3	370	1,479	43.9	
658.5 - 676.5	18.0	20.8	45.4	33.4	736	13,233	58.5	
676.5 - 689.8	13.3	19.0	39.6	40.0	595	7,901	8.7	
653.0 - 689.8	35.3	19.4	41.8	38.7	641	22,613	37.6	8,320 (Primary & Secondary)

OILFIELD RESEARCH LABORATORIES
CHANUTE, KANSAS
FEBRUARY, 1966

KEMFEL MADE