OILFIELD RESEARCH LABORATORIES
536 NORTH HIGHLAND - CHANUTE, KANSAS - PHONE HE1-2650

February 11, 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. 19, Bourbon County, Kansas, and submitted to our laboratory on February 8, 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

Oilfield Research Laboratories

GENERAL INFORMATION & SUMMARY

Company CRA, Inc. Lease Woodward Well No. 19

Location 2315' EWL & 2120' NSL, NW

Section 12 Twp. 25S Rge. 21E County Bourbon State Kansas

Name of Sand	Bartlesville
Top of Core	655.0
Bottom of Core	690.0
Top of Sand (Analyzed)	659.0
Bottom of Sand (Analyzed)	685.5
Total Feet of Permeable Sand	16.6
Total Feet of Floodable Sand	13.0

Distribution of Permeable Sand: Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 1	1.5	1.5
1 - 10	3.1	4.6
10 - 20	3.0	7.6
20 - 50	6.0	13.6
50 & above	3.0	16.6

Average Permeability Millidarcys	28.1
Average Percent Porosity	17.5
Average Percent Oil Saturation	39.7
Average Percent Water Saturation	43.6
Average Oil Content, Bbls./A. Ft.	551.
Total Oil Content, Bbls./Acre	11,577.
Average Percent Oil Recovery by Laboratory Flooding Tests	19.4
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	286.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	3,708.
Total Calculated Oil Recovery, Bbls./Acre (Primary & Secondary)	4,420.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	1060.0

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:

Depth Interval, Feet	Description
655.0 - 659.0	Sandy shale.
659.0 - 671.0	Alternate layers of sandstone and shale.
671.0 - 672.6	Brown, laminated, shaly sandstone.
672.6 - 678.6	Brown, slightly shaly sandstone.
678.6 - 681.6	Brown, slightly laminated, slightly shaly sandstone.
681.6 - 682.6	Brown to dark, slightly carbonaceous sandstone.
682.6 - 684.0	Gray and brown, finely laminated sandstone and shale.
684.0 - 685.0	Brown to dark, slightly carbonaceous sandstone.
685.0 - 686.8	Dark, carbonaceous, slightly calcareous sandstone with a vertical fracture from 685.0 to 685.4.
686.8 - 690.0	Sandy shale.

Coring was started at a depth of 655.0 feet in sandy shale and completed at 690.0 feet also in sandy shale. 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 two sections. The weighted average permeability of the upper and lower sections is 6.4 and 35.2 millidarcys respectively; the overall average being 28.1

(See Table III). By observing the data given on the coregraph, it is noticeable that the sand has an irregular permeability profile. The permeability of the sand varies from impermeable to a maximum of 62. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a good weighted average percent oil saturation, namely, 39.7. The weighted average percent oil saturation of the upper and lower sections is 36.7 and 41.3 respectively. The weighted average percent water saturation of the upper and lower sections is 51.2 and 39.8 respectively; the overall average being 43.6 (See Table III). This gives an overall weighted average total fluid saturation of 83.3 percent.

The weighted average oil content of the upper and lower sections is 450 and 603 barrels per acre foot respectively; the overall average being 551. The total oil content, as shown by this core, is 11,577 barrels per acre of which 8,528 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 3,708 barrels of oil per acre was obtained from 13.0 feet of sand. The weighted average percent oil saturation was reduced from 45.0 to 25.6, or represents an average recovery of 19.4 percent. The weighted average effective permeability of the samples is 1.56 millidarcys, while the average initial fluid production pressure is 23.8 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the

22 samples tested, 14 produced water and 13 oil. This indicates that approximately 59 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

Based on the results of the laboratory tests it appears that efficient primary and secondary operations in the vicinity of this well should recover approximately 4,420 barrels of oil per acre or an average of 344 barrels per acre foot from the 13.0 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	24.0
Average porosity, percent	18.7
Oil saturation after flooding, percent	25.6
Performance factor, percent	50.0
Net floodable pay sand, feet	13.0

This core shows a pay sand section (672.6 - 682.6) 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. 19

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	659.1	15.2	48	37	85	565	0.78	0.5	0.5	283	0.39
2	661.1	14.3	34	61	95	377	Imp.	1.0	1.5	377	0.00
3	663.3	13.5	28	68	96	293	0.25	1.0	2.5	293	0.25
4	664.1	17.0	45	35	80	594	Imp.	1.0	3.5	594	0.00
5	665.9	17.5	48	32	80	651	19.	1.0	4.5	651	19.00
6	666.9	17.2	39	47	86	520	2.9	1.0	5.5	520	2.90
7	669.4	14.6	26	60	86	294	Imp.	1.0	6.5	294	0.00
8	671.1	14.3	27	70	97	299	5.8	0.6	7.1	179	3.48
9	672.1	18.6	53	32	85	764	11.	1.0	8.1	764	11.00
10	673.1	20.0	49	34	83	759	47.	1.0	9.1	759	47.00
11	674.1	19.3	49	39	88	733	44.	1.0	10.1	733	44.00
12	675.1	18.9	42	38	80	616	47.	1.0	11.1	616	47.00
13	676.1	19.5	48	36	84	726	52.	1.0	12.1	726	52.00
14	677.1	20.1	53	28	81	826	62.	1.0	13.1	826	62.00
15	678.1	20.6	49	35	84	781	55.	1.0	14.1	781	55.00
16	679.1	15.3	36	47	83	426	4.8	1.0	15.1	426	4.80
17	680.1	19.9	45	38	83	694	42.	1.0	16.1	694	42.00
18	681.1	19.3	40	40	80	599	25.	1.0	17.1	599	25.00
19	682.1	19.5	33	34	67	499	20.	1.0	18.1	499	20.00
20	683.1	13.9	22	63	85	237	Imp.	1.4	19.5	332	0.00
21	684.1	17.4	21	53	74	283	29.	1.0	20.5	283	29.00
22	685.1	17.6	51	23	74	696	2.3	0.5	21.0	348	1.15
								Total-	-------	-11,577	

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Inc. Lease Woodward Well No. 19

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
659.0 - 671.6	4.1	6.4	26.02
671.6 - 685.5	12.5	35.2	439.95
659.0 - 685.5	16.6	28.1	465.97

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 Bbls./Acre
659.0 - 671.6	7.1	15.6	36.7	51.2	450	3,191
671.6 - 685.5	13.9	18.5	41.3	39.8	603	8,386
659.0 - 685.5	21.0	17.5	39.7	43.6	551	11,577

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Inc. Lease Woodward Well No. 19

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.			
1	659.1	15.3	48	569	0	0	48	38	569	0	Imp.	-
2	661.1	14.0	36	391	0	0	36	62	391	0	Imp.	-
3	663.3	13.7	27	287	0	0	27	70	287	0	Imp.	-
4	664.1	17.0	45	593	0	0	45	37	593	0	Imp.	-
5	665.9	17.0	48	632	22	290	26	66	342	5	0.300	30
6	666.9	16.9	39	511	16	210	23	69	301	5	0.200	40
7	669.4	14.5	27	304	0	0	27	62	304	0	Imp.	-
8	671.1	14.5	27	304	0	0	27	69	304	0	Imp.	-
9	672.1	18.1	53	743	25	350	28	71	393	42	1.00	30
10	673.1	20.5	49	779	27	429	22	73	350	255	6.00	20
11	674.1	19.0	49	721	22	324	27	70	397	38	1.10	20
12	675.1	18.6	42	605	18	259	24	65	346	82	2.00	20
13	676.1	20.0	48	744	22	341	26	62	403	72	1.50	10
14	677.1	19.7	53	810	27	413	26	64	397	85	1.90	10
15	678.1	21.0	49	787	22	358	27	72	439	120	3.00	20
16	679.1	15.7	36	438	9	110	27	63	328	29	0.600	30
17	680.1	19.4	45	676	19	286	26	70	390	37	1.00	20
18	681.1	18.9	40	586	17	249	23	74	337	58	1.40	10
19	682.1	19.0	33	486	6	89	27	60	397	3	0.300	50
20	683.1	13.9	24	258	0	0	24	65	258	0	Imp.	-
21	684.1	17.0	21	276	0	0	21	67	276	4	0.200	50
22	685.1	17.4	52	701	0	0	52	25	701	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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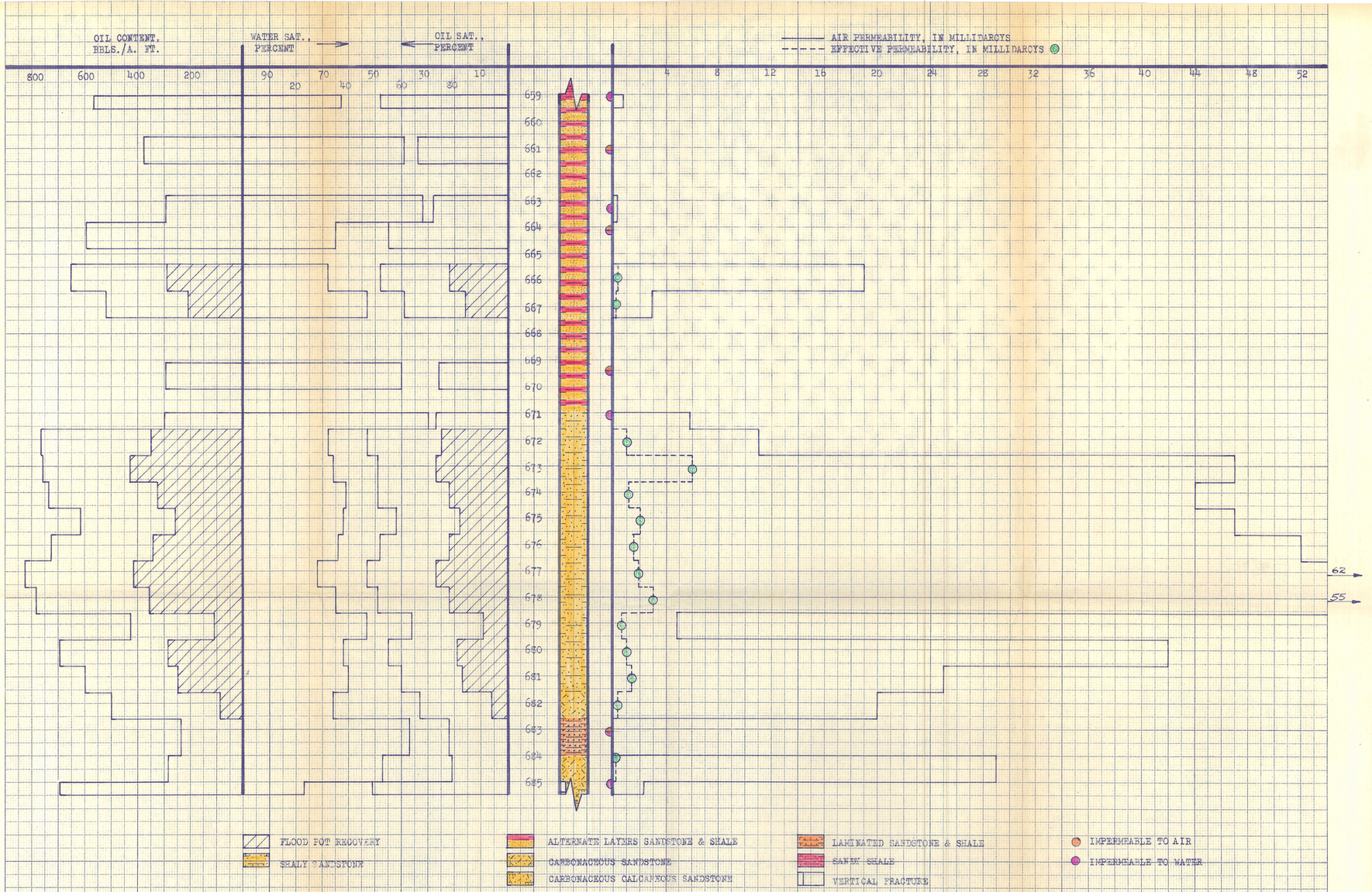
SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company CRA, Inc. Lease Woodward Well No. 19

Depth Interval, Feet	659.0 - 671.6	671.6 - 685.5	659.0 - 685.5
Feet of Core Analyzed	2.0	11.0	13.0
Average Percent Porosity	17.0	19.0	18.7
Average Percent Original Oil Saturation	43.5	45.2	45.0
Average Percent Oil Recovery	19.0	19.5	19.4
Average Percent Residual Oil Saturation	24.5	25.7	25.6
Average Percent Residual Water Saturation	67.5	67.6	67.6
Average Percent Total Residual Fluid Saturation	92.0	93.3	93.2
Average Original Oil Content, Bbls./A. Ft.	572.	672.	657.
Average Oil Recovery, Bbls./A. Ft.	250.	292.	286.
Average Residual Oil Content, Bbls./A. Ft.	322.	380.	371.
Total Original Oil Content, Bbls./Acre	1,143.	7,385.	8,528.
Total Oil Recovery, Bbls./Acre	500.	3,208.	3,708.
Total Residual Oil Content, Bbls./Acre	643.	4,177.	4,820.
Average Effective Permeability, Millidarcys	0.250	1.80	1.56
Average Initial Fluid Production Pressure, p.s.i.	35.0	21.8	23.8

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



CRA, INC.

WOODWARD LEASE WELL NO. 19

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
669.0 - 671.6	7.1	15.6	36.7	51.2	450	3,191	6.4	
671.6 - 685.5	13.9	18.5	41.3	39.8	603	8,386	35.2	
669.0 - 685.5	21.0	17.5	39.7	43.6	551	11,577	28.1	4,420(Primary & Secondary)

OILFIELD RESEARCH LABORATORIES
CHANUTE, KANSAS
FEBRUARY, 1966

KEUFFEL & ESSER CO.

K&E STANDARD © CROSS SECTION

OILFIELD RESEARCH LABORATORIES

RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Inc. Lease Woodward Well No. 19

Sample No.	Depth, Feet	Effective Porosity, Percent	Percent Saturation			Oil Content Bbls./A.Ft.	Perm. Mill.	Feet of Sand		Total Oil Content
			Oil	Water	Total			Feet	Cum. Feet	
1	659.1	15.2	48	37	85	565	0.78			
2	661.1	14.3	34	61	95	377	tmp.			
3	663.3	13.5	28	68	96	293	0.25			
4	664.1	17.0	45	35	80	594	tmp.			
5	665.9	17.5	48	32	80	651	19.			
6	666.9	17.2	39	47	86	520	2.9			
7	669.4	14.6	26	60	86	294	tmp.			
8	671.1	14.3	27	70	97	299	5.8			
9	672.1	18.6	53	32	85	764	11.			
10	673.1	20.0	49	34	83	759	47.			
11	674.1	19.3	49	39	88	733	44.			
12	675.1	18.9	42	38	80	616	47.			
13	676.1	19.5	48	36	84	726	52.			
14	677.1	20.1	53	28	81	826	62.			
15	678.1	20.6	49	35	84	781	55.			
16	679.1	15.3	36	47	83	426	4.8			
17	680.1	19.9	45	38	83	694	42.			
18	681.1	19.3	40	40	80	599	25.			
19	682.1	19.5	33	34	67	499	20.			
20	683.1	13.9	22	63	85	237	tmp.			
21	684.1	17.4	21	53	74	283	29.			
22	685.1	17.6	51	23	74	696	2.3			