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

August 15, 1966

CRA, Incorporated
Box 98
Willington, Kansas

Gentlemen:

Enclosed herewith is the report of the analysis of the Rotary core taken from the Woodward Lease, Well No. 33-I, Bourbon County, Kansas, and submitted to our laboratory on August 9, 1966.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

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, Incorporated Lease Woodward Well No. 33-I

Location 895' EWL & 50' NSL, NW¼

Section 13 Twp. 25S Rge. 21E County Bourbon State Kansas

Name of Sand	Bartlesville
Top of Core	610.0
Bottom of Core	657.0
Top of Sand (Analyzed)	612.0
Bottom of Sand (Analyzed)	656.6
Total Feet of Permeable Sand	31.5
Total Feet of Floodable Sand	7.1

Distribution of Permeable Sand: Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 1	8.0	8.0
1 - 10	5.2	13.2
10 - 50	10.6	23.8
50 - 100	3.7	27.5
100 & above	4.0	31.5

Average Permeability Millidarcys	35.7
Average Percent Porosity	18.1
Average Percent Oil Saturation	26.8
Average Percent Water Saturation	54.1
Average Oil Content, Bbls./A. Ft.	363.
Total Oil Content, Bbls./Acre	14,197.
Average Percent Oil Recovery by Laboratory Flooding Tests	5.8
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	84.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	599.
Total Calculated Oil Recovery, Bbls./Acre - (Primary & Secondary)	1,650.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

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
610.0 - 612.0	Sandy shale.
612.0 - 627.2	Light brown, slightly shaly sandstone.
627.2 - 628.0	Sandy shale.
628.0 - 633.6	Grayish brown, laminated, shaly sandstone.
633.6 - 639.7	Brown, laminated, shaly sandstone.
639.7 - 643.0	Alternate layers of sandstone and shale.
643.0 - 644.0	Brown shaly sandstone.
644.0 - 647.3	Dark, carbonaceous, shaly sandstone.
647.3 - 650.0	Light brown, calcareous sandstone.
650.0 - 657.0	Brown to dark, carbonaceous, shaly sandstone.

Coring was started at a depth of 610.0 feet in shale and completed at 657.0 feet in shaly, carbonaceous sandstone. For the most part, the pay is made up of brown, laminated, 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 48.1, 36.8 and 0.72 millidarcys respectively;

the overall average being 35.7 (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 142. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a fairly low weighted average percent oil saturation, namely, 26.8. The weighted average percent oil saturation of the upper, middle and lower sections is 19.3, 33.6 and 36.2 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 59.9, 44.4 and 49.3 respectively; the overall average being 54.1 (See Table III). This gives an overall weighted average total fluid saturation of 80.9 percent.

The weighted average oil content of the upper, middle and lower sections is 265, 488 and 466 barrels per acre foot respectively; the overall average being 363. The total oil content, as shown by this core, is 14,197 barrels per acre of which 3,436 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 599 barrels of oil per acre was obtained from 7.1 feet of sand. The weighted average percent oil saturation was reduced from 33.5 to 27.7, or represents an average recovery of 5.8 percent. The weighted average effective permeability of the samples is 2.56 millidarcys, while the average initial fluid production

pressure is 30.0 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 40 samples tested, 21 produced water and 7 oil. This indicates that approximately 17 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 1,650 barrels of oil per acre or an average of 233 barrels per acre foot from the 7.1 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	38.0
Average porosity, percent	18.6
Oil saturation after flooding, percent	27.7
Performance factor, percent	50.0
Net floodable pay sand, feet	7.1

This core shows a pay sand section (633.6 - 640.0) 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, Incorporated Lease Woodward Well No. 33-I

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	612.1	21.0	9	74	83	146	90.	0.6	0.6	88	54.00
2	613.1	17.8	17	66	83	234	33.	1.0	1.6	234	33.00
3	614.1	24.0	19	61	80	354	17.	1.0	2.6	354	17.00
4	615.1	19.8	9	60	69	138	33.	1.0	3.6	138	33.00
5	616.1	22.7	8	66	74	141	87.	1.0	4.6	141	87.00
6	617.1	19.6	12	52	64	182	107.	1.0	5.6	182	107.00
7	618.1	20.7	10	49	59	160	0.52	1.0	6.6	160	0.52
8	619.1	20.6	5	55	60	80	142.	1.0	7.6	80	142.00
9	620.1	15.9	18	65	83	222	26.	1.0	8.6	222	26.00
10	621.1	16.2	23	66	89	289	4.4	1.0	9.6	289	4.40
11	622.1	17.9	32	61	93	444	34.	1.0	10.6	444	34.00
12	623.1	22.6	6	63	69	105	107.	1.0	11.6	105	107.00
13	624.1	20.2	13	65	78	204	142.	1.0	12.6	204	142.00
14	625.1	20.4	16	59	75	253	30.	1.0	13.6	253	30.00
15	626.1	17.8	23	64	87	317	22.	1.6	15.2	506	35.20
16	628.1	15.7	27	59	86	328	5.4	0.6	15.8	197	3.24
17	629.1	16.4	38	59	97	483	0.95	1.0	16.8	483	0.95
18	630.1	14.3	25	60	85	277	Imp.	1.0	17.8	277	0.00
19	631.1	16.3	43	44	87	544	Imp.	1.0	18.8	544	0.00
20	632.1	13.6	18	62	80	190	Imp.	1.0	19.8	190	0.00
21	633.1	17.8	31	53	84	428	1.9	1.0	20.8	428	1.90
22	634.1	17.6	37	45	82	505	0.57	1.0	21.8	505	0.57
23	635.1	20.4	37	40	77	584	46.	1.0	22.8	584	46.00
24	636.1	17.2	29	49	78	387	6.3	1.0	23.8	387	6.30

Oilfield Research Laboratories

RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Incorporated Lease Woodward Well No. 33-I

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	637.1	20.5	29	46	75	461	36.	1.0	24.8	461	36.00
26	638.1	17.5	36	43	79	489	13.	1.0	25.8	489	13.00
27	639.1	19.0	31	43	74	456	62.	1.1	26.9	501	68.20
28	643.1	19.1	36	45	81	534	90.	1.0	27.9	534	90.00
29	644.1	21.5	42	30	72	700	2.1	0.6	28.5	420	1.26
30	645.1	17.0	34	47	81	448	0.28	1.0	29.5	448	0.28
31	646.1	16.4	37	40	77	470	0.31	1.0	30.5	470	0.31
32	647.1	16.9	44	28	72	576	0.57	0.7	31.2	404	0.40
33	648.1	14.2	29	66	95	319	0.33	1.3	32.5	415	0.43
34	650.1	14.9	32	55	87	369	Imp.	0.6	33.1	222	0.00
35	651.1	17.5	28	50	78	381	Imp.	1.0	34.1	381	0.00
36	652.1	16.4	33	52	85	419	Imp.	1.0	35.1	419	0.00
37	653.1	18.1	39	45	84	546	0.26	1.0	36.1	546	0.26
38	654.1	15.1	45	53	98	526	Imp.	1.0	37.1	526	0.00
39	655.1	16.9	33	56	89	432	1.8	1.0	38.1	432	1.80
40	656.1	15.7	44	53	97	534	Imp.	1.0	39.1	534	0.00
								Total		14,197	

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Incorporated Lease Woodward Well No. 33-I

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
612.0 - 633.6	17.8	48.1	858.21
633.6 - 640.0	7.1	36.8	260.07
640.0 - 656.6	6.6	0.72	4.74
612.0 - 656.6	31.5	35.7	1,123.02

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
612.0 - 633.6	20.8	18.6	19.3	59.9	265	5,519
633.6 - 640.0	7.1	18.8	33.6	44.4	488	3,461
640.0 - 656.6	11.2	16.5	36.2	49.3	466	5,217
612.0 - 656.6	39.1	18.1	26.8	54.1	363	14,197

Oilfield Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Incorporated Lease Woodward Well No. 33-I

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	612.1	20.8	10	161	0	0	10	80	161	210	12.50	10
2	613.1	17.8	16	221	0	0	16	77	221	41	1.50	20
3	614.1	24.3	19	358	0	0	19	79	358	365	14.30	10
4	615.1	20.0	8	124	0	0	8	88	124	90	4.20	20
5	616.1	22.3	8	145	0	0	8	90	145	329	16.00	10
6	617.1	19.7	13	199	0	0	13	78	199	169	6.60	10
7	618.1	20.6	12	192	0	0	12	80	192	9	0.380	35
8	619.1	20.6	8	128	0	0	8	83	128	116	4.00	20
9	620.1	16.2	19	239	0	0	19	68	239	11	0.400	35
10	621.1	16.2	22	276	0	0	22	69	276	14	0.500	25
11	622.1	17.9	31	430	0	0	31	67	430	228	14.40	10
12	623.1	22.4	8	139	0	0	8	90	139	391	38.60	10
13	624.1	20.0	12	186	0	0	12	72	186	150	4.80	10
14	625.1	20.5	14	222	0	0	14	81	222	293	28.60	10
15	626.1	18.0	22	307	0	0	22	74	307	172	7.60	10
16	628.1	15.5	28	336	0	0	28	60	336	0	Imp.	-
17	629.1	16.3	38	480	0	0	38	58	480	0	Imp.	-
18	630.1	14.4	25	279	0	0	25	62	279	0	Imp.	-
19	631.1	16.7	44	570	0	0	44	44	570	0	Imp.	-
20	632.1	13.3	17	175	0	0	17	64	175	0	Imp.	-
21	633.1	17.4	31	419	0	0	31	55	419	0	Imp.	-
22	634.1	17.4	37	499	8	108	29	64	391	0	0.015	50
23	635.1	20.0	37	573	7	109	30	69	464	192	4.90	20

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, Incorporated Lease Woodward Well No. 33-I

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc*	Effective Permeability Millidarcys**	Initial Field Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
24	636.1	17.2	29	386	2	27	27	62	359	12	0.300	40
25	637.1	20.1	29	452	3	47	26	71	405	61	1.40	30
26	638.1	17.0	36	474	7	92	29	64	382	5	0.200	30
27	639.1	19.4	31	466	4	60	27	72	406	227	6.00	20
28	643.1	19.3	36	539	10	150	26	69	389	193	4.70	20
29	644.1	21.6	43	720	0	0	43	33	720	0	Imp.	-
30	645.1	17.0	34	448	0	0	34	49	448	0	Imp.	-
31	646.1	16.5	37	472	0	0	37	40	472	0	Imp.	-
32	647.1	16.6	43	553	0	0	43	30	553	0	Imp.	-
33	648.1	14.2	28	308	0	0	28	67	308	0	Imp.	-
34	650.1	15.1	32	375	0	0	32	57	375	0	Imp.	-
35	651.1	17.4	28	378	0	0	28	50	378	0	Imp.	-
36	652.1	16.4	32	407	0	0	32	55	407	0	Imp.	-
37	653.1	18.0	40	559	0	0	40	47	559	0	Imp.	-
38	654.1	15.1	44	516	0	0	44	54	516	0	Imp.	-
39	655.1	16.9	32	419	0	0	32	58	419	0	Imp.	-
40	656.1	15.7	44	535	0	0	44	55	535	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.

Oilfield Research Laboratories

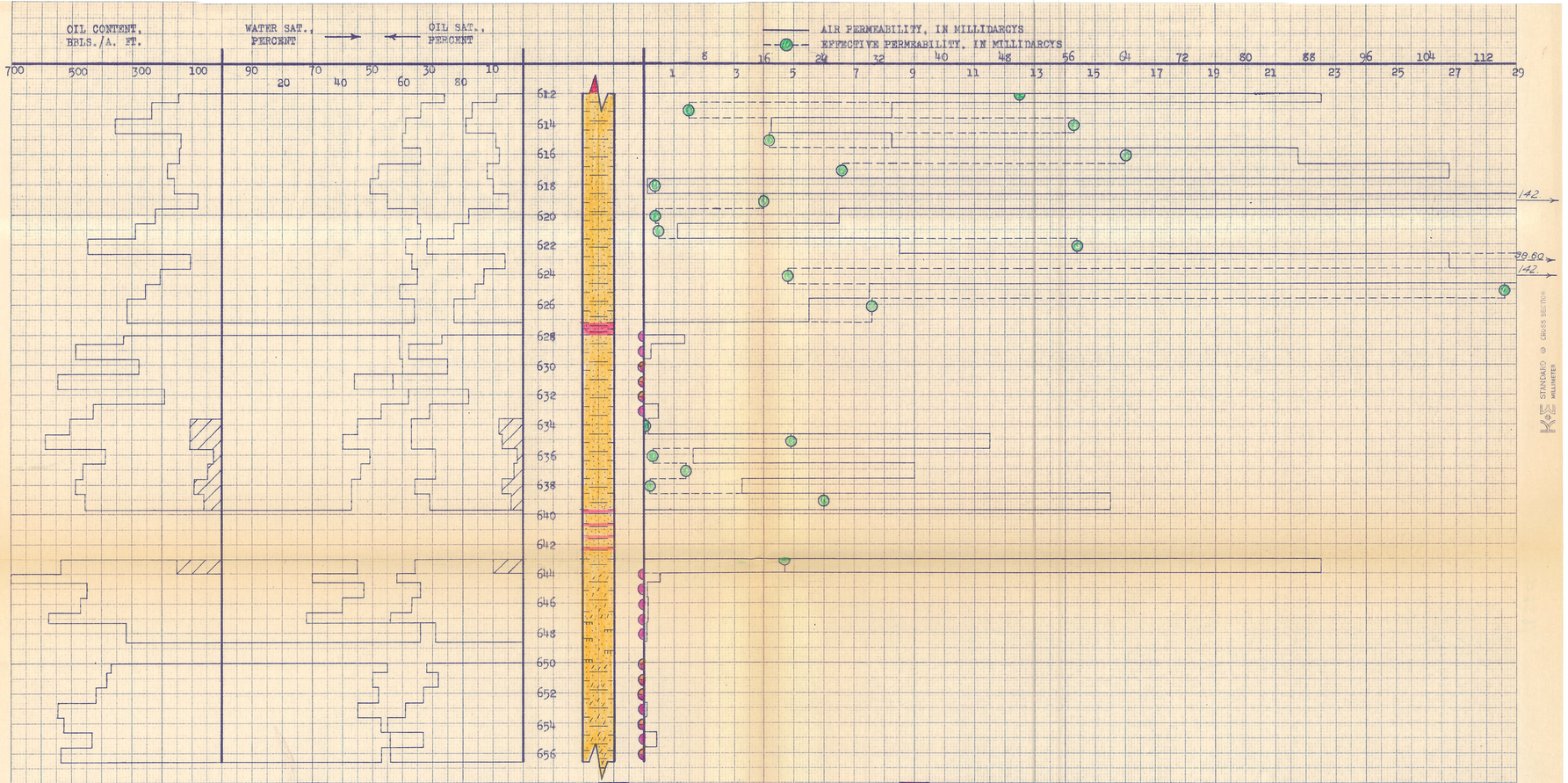
SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company CRA, Incorporated Lease Woodward Well No. 33-I

Depth Interval, Feet	633.6 - 640.0
Feet of Core Analyzed	7.1
Average Percent Porosity	18.6
Average Percent Original Oil Saturation	33.5
Average Percent Oil Recovery	5.8
Average Percent Residual Oil Saturation	27.7
Average Percent Residual Water Saturation	67.3
Average Percent Total Residual Fluid Saturation	95.0
Average Original Oil Content, Bbls./A. Ft.	486.
Average Oil Recovery, Bbls./A. Ft.	84.
Average Residual Oil Content, Bbls./A. Ft.	398.
Total Original Oil Content, Bbls./Acre	3,436.
Total Oil Recovery, Bbls./Acre	599.
Total Residual Oil Content, Bbls./Acre	2,837.
Average Effective Permeability, Millidarcys	2.56
Average Initial Fluid Production Pressure, p.s.i.	30.0

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



C. R. A., INC.

WOODWARD LEASE WELL NO. 33-I

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
612.0 - 633.6	20.8	18.6	19.3	59.9	265	5,519	48.1	
633.6 - 640.0	7.1	18.8	33.6	44.4	488	3,461	36.8	
640.0 - 656.6	11.2	16.5	36.2	49.3	466	5,217	0.72	
612.0 - 656.6	39.1	18.1	26.8	54.1	363	14,197	35.7	1,650 (Primary & Secondary)

OILFIELD RESEARCH LABORATORIES
CHANUTE, KANSAS
AUGUST, 1966

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