

OILFIELD RESEARCH LABORATORIES

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

February 28, 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. 22, Bourbon County, Kansas, and submitted to our laboratory on February 22, 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, Inc.	Lease	Woodward	Well No.	22
Location	485' NSL & 1855' EWL				
Section	12	Twp.	25S	Rge.	21E
				County	Bourbon
				State	Kansas
Name of Sand	-				Bartlesville
Top of Core	-				647.0
Bottom of Core	-				686.0
Top of Sand	(Analyzed)				647.0
Bottom of Sand	-				683.0
Total Feet of Permeable Sand	-				23.5
Total Feet of Floodable Sand	-				10.1
Distribution of Permeable Sand:					
Permeability Range Millidarcys	Feet		Cum. Ft.		
0 - 10	6.6		6.6		
10 - 50	10.3		16.9		
50 - 100	2.6		19.5		
100 & above	4.0		23.5		
Average Permeability Millidarcys	-				40.6
Average Percent Porosity	-				18.3
Average Percent Oil Saturation	-				33.4
Average Percent Water Saturation	-				46.4
Average Oil Content, Bbls./A. Ft.	-				471.
Total Oil Content, Bbls./Acre	-				11,082.
Average Percent Oil Recovery by Laboratory Flooding Tests	-				10.0
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	-				142.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	-				1,435.
Total Calculated Oil Recovery, Bbls./Acre	(Primary & Secondary)				2,970.
Packer Setting, Feet	-				
Viscosity, Centipoises @	-				
A. P. I. Gravity, degrees @ 60 °F	-				
Elevation, Feet	-				1062.

Fresh water mud was used as the circulating fluid while taking this core. The core was sampled and the samples sealed in plastic bags 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>Description</u>
<u>Feet</u>	

647.0 - 652.5	- Light brown, slightly shaly sandstone.
652.5 - 659.5	- Laminated sandy shale.
659.5 - 668.6	- Brown, slightly shaly sandstone.
668.6 - 670.0	- Gray sandy shale.
670.0 - 670.5	- Grayish light brown, shaly sandstone.
670.5 - 674.6	- Gray sandy shale.
674.6 - 677.3	- Grayish light brown, laminated, shaly sandstone.
677.3 - 683.0	- Brown, laminated, shaly sandstone.
683.0 - 686.0	- Shale.

Coring was started at a depth of 647.0 feet in shaly sandstone and completed at 686.0 feet in 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 three sections. The weighted average permeability of the upper, middle and lower sections is 98.5, 32.4 and 13.3 millidarcys respectively; the overall average being 40.6 (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 0.60 to a

maximum of 141. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a good weighted average percent oil saturation, namely, 33.4. The weighted average percent oil saturation of the upper, middle and lower sections is 16.4, 42.3 and 35.2 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 65.7, 33.1 and 48.0 respectively; the overall average being 46.4 (See Table III). This gives an overall weighted average total fluid saturation of 79.8 percent. This low total fluid saturation indicates some fluid was lost during coring most of which was probably oil.

The weighted average oil content of the upper, middle and lower sections is 261, 607 and 464 barrels per acre foot respectively; the overall average being 471. The total oil content, as shown by this core, is 11,082 barrels per acre of which 6,138 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 1,435 barrels of oil per acre was obtained from 10.1 feet of sand. The weighted average percent oil saturation was reduced from 42.4 to 32.4, or represents an average recovery of 10.0 percent. The weighted average effective permeability of the samples is 1.82 millidarcys, while the average initial fluid production pressure is 26.0 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 24 samples tested, 16 produced water and 10 oil. This indicates that

approximately 42 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 2,970 barrels of oil per acre or an average of 294 barrels per acre foot from the 10.1 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	25.0
Average porosity, percent	18.6
Oil saturation after flooding, percent	31.8
Performance factor, percent	50.0
Net floodable pay sand, feet	10.1

This core shows a pay sand section (659.5 - 668.6) 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. 22

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	647.1	18.4	14	68	82	200	60.	0.6	0.6	120	36.00
2	648.1	20.0	15	70	85	232	141.	1.0	1.6	232	141.00
3	649.1	22.8	19	61	80	336	113.	1.0	2.6	336	113.00
4	650.1	22.6	9	65	74	158	115.	1.0	3.6	158	115.00
5	651.1	19.5	26	67	93	393	127.	1.0	4.6	393	127.00
6	652.1	20.0	14	64	78	217	11.	0.9	5.5	195	9.90
7	660.1	20.6	34	32	66	542	29.	1.1	6.6	596	31.90
8	661.1	17.2	44	34	78	586	40.	1.0	7.6	586	40.00
9	662.1	18.3	36	41	77	511	10.	1.0	8.6	511	10.00
10	663.1	14.9	44	32	76	509	28.	1.0	9.6	509	28.00
11	664.1	18.3	39	34	73	553	24.	1.0	10.6	553	24.00
12	665.1	21.0	41	29	70	667	78.	1.0	11.6	667	78.00
13	666.1	18.2	49	33	82	691	21.	1.0	12.6	691	21.00
14	667.1	19.6	45	30	75	684	5.6	1.0	13.6	684	5.60
15	668.1	19.3	49	33	82	732	57.	1.0	14.6	732	57.00
16	670.1	16.8	49	33	82	638	1.2	0.5	15.1	319	0.60
17	675.1	16.8	38	49	87	494	1.6	1.0	16.1	494	1.60
18	676.1	11.1	12	85	97	103	0.60	1.0	17.1	103	0.60
19	677.1	18.2	38	41	79	536	5.0	0.7	17.8	375	3.50
20	678.1	18.0	33	41	74	460	39.	1.3	19.1	598	50.70
21	679.1	15.1	34	63	97	398	12.	1.0	20.1	398	12.00
22	680.1	18.2	38	40	78	536	15.	1.0	21.1	536	15.00
23	681.1	18.5	43	28	71	616	31.	1.0	22.1	616	31.00
24	682.1	16.5	38	46	84	486	2.5	1.4	23.5	680	3.50

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Inc. Lease Woodward Well No. 22

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
647.0 - 652.5	5.5	98.5	541.90
659.5 - 668.6	9.1	32.4	295.50
670.0 - 683.0	8.9	13.3	118.50
647.0 - 683.0	23.5	40.6	955.90

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
647.0 - 652.5	5.5	18.9	16.4	65.7	261	1434
659.5 - 668.6	9.1	18.6	42.3	33.1	607	5529
670.0 - 683.0	8.9	16.6	35.2	48.0	464	4119
647.0 - 683.0	23.5	18.3	33.4	46.4	471	11082

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Inc. Lease Woodward Well No. 22

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	647.1	17.9	16	222	0	0	16	73	222	108	2.50	10
2	648.1	20.4	15	237	0	0	15	79	237	340	13.79	10
3	649.1	22.6	18	315	0	0	18	70	315	344	23.00	10
4	650.1	22.3	7	121	0	0	7	84	121	171	17.62	10
5	651.1	20.0	24	372	0	0	24	74	372	344	32.25	10
6	652.1	19.6	12	182	0	0	12	85	182	188	7.30	10
7	660.1	20.1	34	529	6	94	28	58	435	34	0.898	30
8	661.1	17.6	44	600	16	218	28	59	382	63	2.00	20
9	662.1	18.0	36	502	6	84	30	59	418	22	0.700	30
10	663.1	15.4	44	525	14	167	30	64	358	58	2.50	30
11	664.1	18.6	39	562	11	159	28	68	403	62	2.70	30
12	665.1	20.9	41	664	11	178	30	63	486	119	6.00	20
13	666.1	17.9	49	680	10	139	39	59	541	30	0.700	20
14	667.1	19.1	45	666	7	104	38	55	562	10	0.300	30
15	668.1	19.6	49	744	14	212	35	56	532	80	2.40	10
16	670.1	16.5	50	639	0	0	50	35	639	0	Imp.	-
17	675.1	16.6	38	489	0	0	38	50	489	0	Imp.	-
18	676.1	10.9	14	118	0	0	14	85	118	0	Imp.	-
19	677.1	18.3	37	525	0	0	37	42	525	0	Imp.	-
20	678.1	18.3	35	496	0	0	35	42	496	0	Imp.	-
21	679.1	15.2	33	388	0	0	33	64	388	0	Imp.	-
22	680.1	18.2	38	536	0	0	38	42	536	0	Imp.	-
23	681.1	18.4	43	613	5	71	38	49	542	6	0.100	40
24	682.1	16.2	39	490	0	0	39	48	490	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

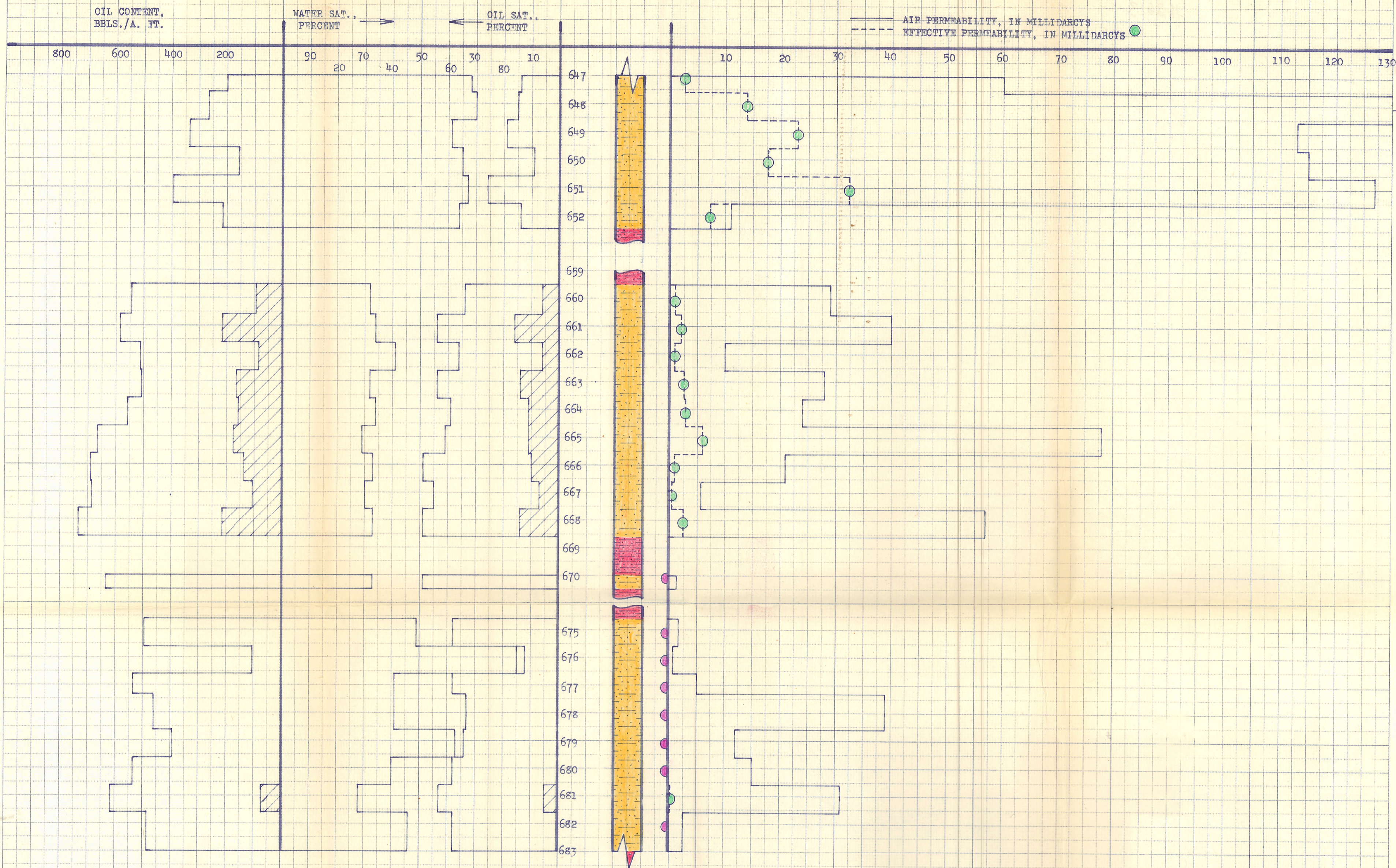
TABLE V

Company	Lease	Woodward	Well No.
CRA, Inc.			22
Depth Interval, Feet	659.5 - 668.6	670.0 - 683.0	659.5 - 683.0
Feet of Core Analyzed	9.1	1.0	10.1
Average Percent Porosity	18.6	18.4	18.6
Average Percent Original Oil Saturation	42.3	43.0	42.4
Average Percent Oil Recovery	10.5	5.0	10.0
Average Percent Residual Oil Saturation	31.8	38.0	32.4
Average Percent Residual Water Saturation	60.0	49.0	59.0
Average Percent Total Residual Fluid Saturation	91.8	87.0	91.4
Average Original Oil Content, Bbls./A. Ft.	608.	613.	608.
Average Oil Recovery, Bbls./A. Ft.	150.	71.	142.
Average Residual Oil Content, Bbls./A. Ft.	458.	542.	466.
Total Original Oil Content, Bbls./Acre	5525.	613.	6138.
Total Oil Recovery, Bbls./Acre	1364.	71.	1435.
Total Residual Oil Content, Bbls./Acre	4161.	542.	4703.
Average Effective Permeability, Millidarcys	2.01	0.100	1.82
Average Initial Fluid Production Pressure, p.s.i.	24.4	40.0	26.0

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

KEUFFEL & ESSER CO.
MADE IN U.S.A.

K&E STANDARD CROSS SECTION
WATERMETER



FLOOD POT RECOVERY
 SHALY SANDSTONE
 SANDY SHALE
 IMPERMEABLE TO WATER

CRA, INC.
 WOODWARD LEASE WELL NO. 22
 BOURBON COUNTY, KANSAS

DEPTH INTERVAL, FEET	FEET OF CORE ANALYZED	AVERAGE POROSITY, PERCENT	AVG. OIL SATURATION PERCENT	AVG. WATER SATURATION PERCENT	AVG. OIL CONTENT BBL./A. FT.	TOTAL OIL CONTENT BBL./ACRE	AVG. AIR PERMEABILITY MILLIDARCYS	CALCULATED OIL RECOVERY, BBL./ACRE
647.0 - 652.5	5.5	18.9	16.4	65.7	261	1,474	98.5	
659.5 - 668.6	9.1	18.6	42.3	33.1	607	5,529	32.4	
670.0 - 683.0	8.9	16.6	35.2	48.0	464	4,119	13.3	
647.0 - 683.0	23.5	18.3	33.4	46.4	471	11,082	40.6	2,970 (Primary & Secondary)