OIL FIELD RESEARCH LABORATORIES
CHANUTE, KANSAS

December 21, 1951

Oko Oil & Gas Company
Atlas Life Building
Tulsa, Oklahoma

Attention: Mr. T. F. Lavry

Gentlemen:

Enclosed herewith is the report of the analysis of the 2½" Rotary core taken from the Willson Lease, Well No. F-2, Anderson County, Kansas, and submitted to our laboratory on December 10, 1951.

Very truly yours,

OIL FIELD RESEARCH LABORATORIES

Clayton A. Hattier

CAH:bl
c.c. to Mr. D. K. Auld

CXO OIL & GAS COMPANY

COST ANALYSIS REPORT

WILLSON LEASE WELL NO. F-2

ANDERSON COUNTY, KANSAS

OIL FIELD RESEARCH LABORATORIES

CHANUTE, KANSAS

DECEMBER 21, 1951

Oil Field Research Laboratories

GENERAL INFORMATION & SUMMARY

Company Ohio Oil & Gas Company Lease Willson Well No. F-2

Location SE¼ of the SW¼

Section 8 Twp. 21S Rge. 20E County Anderson State Kansas

Name of Sand	Squirrel
Top of Core	793.00
Bottom of Core	830.00
Top of Pay Sand	793.25
Bottom of Sand	820.00
Total Feet of Permeable Sand (analyzed)	11.38
Total Feet of Floodable Sand (analyzed)	9.50

Distribution of Permeable Sand:

Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 2	1.75	1.75
2 - 4	3.43	5.18
4 - 8	2.66	7.84
8 - 12	2.41	10.25
12 & above	1.13	11.38

Average Permeability Millidarcys	5.81
Average Percent Porosity	16.55
Average Percent Oil Saturation	44.94
Average Percent Water Saturation	37.52
Average Oil Content, Bbls./A. Ft.	580.
Total Oil Content, Bbls./Acre	8,849.
Average Percent Oil Recovery by Laboratory Flooding Tests	14.07
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	204.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	2,094.
Total Calculated Oil Recovery, Bbls./Acre	1,450.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

It is not known whether fresh water or salt water was used in the coring of the sand in this well.

FORMATION CORED

The detailed log of the formation cored is as follows:

Depth Interval, Feet	Description
793.00 - 793.25	Laminated sandy shale.
793.25 - 793.42	Laminated sandstone and shale.
793.42 - 794.05	Laminated sandy shale.
794.05 - 794.20	Finely laminated shaley sandstone.
794.20 - 795.60	Laminated sandy shale.
795.60 - 795.85	Brown fine grained finely laminated micaceous shaley sandstone.
795.85 - 796.00	Laminated sandy shale.
796.00 - 796.10	Brown fine grained laminated micaceous shaley sandstone.
796.10 - 796.35	Brown fine grained micaceous sandstone.
796.35 - 796.75	Brown fine grained laminated micaceous shaley sandstone.
796.75 - 797.40	Brown fine grained micaceous sandstone.
797.40 - 798.25	Gray shale.
798.25 - 798.40	Brown fine grained micaceous sandstone.
798.40 - 798.55	Finely laminated sandstone and shale.
798.55 - 798.90	Brown fine grained finely laminated micaceous shaley sandstone.
798.90 - 799.25	Finely laminated sandy shale.
799.25 - 799.91	Brown fine grained micaceous sandstone.
799.91 - 800.37	Gray shale.
800.37 - 800.62	Brown fine grained laminated micaceous shaley sandstone.
800.62 - 800.80	Brown fine grained micaceous sandstone.

800.80 - 801.05 - Finely laminated sandstone and shale.

801.05 - 801.35 - Brown fine grained finely laminated micaceous shaley sandstone.

801.35 - 801.65 - Brown fine grained laminated micaceous shaley sandstone.

801.65 - 801.80 - Brown fine grained slightly laminated micaceous shaley sandstone.

801.80 - 802.25 - Gray shale.

802.25 - 802.50 - Brown fine grained micaceous sandstone.

802.50 - 802.72 - Laminated sandstone and shale.

802.72 - 802.90 - Brown fine grained laminated micaceous shaley sandstone.

802.90 - 803.10 - Laminated sandstone and shale.

803.10 - 803.25 - Finely laminated shaley sandstone.

803.25 - 803.75 - Brown fine grained micaceous sandstone.

803.75 - 804.05 - Brown fine grained slightly laminated micaceous shaley sandstone.

804.05 - 804.50 - Gray shale.

804.50 - 805.00 - Finely laminated sandstone and shale.

805.00 - 805.45 - Brown fine grained micaceous sandstone.

805.45 - 805.60 - Laminated shale and sandstone.

805.60 - 806.00 - Brown fine grained slightly laminated micaceous shaley sandstone.

806.00 - 806.15 - Laminated sandy shale.

806.15 - 806.45 - Brown fine grained micaceous sandstone.

806.45 - 807.00 - Brown fine grained slightly laminated micaceous shaley sandstone.

807.00 - 807.40 - Gray shale.

807.40 - 807.81 - Brown fine grained micaceous sandstone.

807.81 - 808.45 - Alternate layers of sandstone and shale.

808.45 - 808.75 - Finely laminated sandstone and shale.

808.75 - 809.00 - Brown fine grained micaceous sandstone.

809.00 - 809.15 - Gray sandy shale.

809.15 - 809.65 - Brown fine grained micaceous sandstone.

809.65 - 809.83 - Brown fine grained slightly laminated micaceous shaley sandstone.

809.83 - 810.62 - Gray shale.

810.62 - 810.95 - Brown fine grained micaceous sandstone.

810.95 - 811.70 - Gray sandy shale.

811.70 - 812.00 - Brown fine grained micaceous sandstone.

812.00 - 812.35 - Gray shale.

812.35 - 812.95 - Brown fine grained slightly laminated micaceous shaley sandstone.

812.95 - 813.35 - Gray sandy shale.

813.35 - 813.65 - Brown fine grained slightly laminated micaceous shaley sandstone.

813.65 - 813.80 - Finely laminated shaley sandstone.

813.80 - 814.10 - Gray shale.

814.10 - 814.50 - Brown fine grained slightly laminated micaceous shaley sandstone.

814.50 - 815.10 - Gray sandy shale.

815.10 - 816.00 - Brown fine grained micaceous shaley sandstone.

816.00 - 817.00 - Brown fine grained laminated micaceous shaley sandstone.

817.00 - 817.30 - Brown fine grained micaceous sandstone.

817.30 - 817.70 - Gray shale.

817.70 - 819.25 - Brown fine grained micaceous sandstone.

819.25 - 819.55 - Brown fine grained micaceous shaley sandstone.

819.55 - 820.00 - Brown fine grained micaceous sandstone.

820.00 - 820.50 - Gray sandy shale.

820.50 - 822.70 - Laminated sandy calcareous shale.

822.70 - 823.00 - Black shale.

823.00 - 830.00 - According to log, black shale (Discarded at well).

Coring was started at a depth of 793.00 feet in sandy shale and completed at 830.00 feet in black shale (According to log). This core shows a total of 15.79 feet of sandstone which is mainly brown fine grained micaceous sandstone and shaley sandstone. The sand section is badly broken by layers of shale and sandy shale.

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 6.77, 5.87 and 5.15 millidarcys respectively; while the overall weighted average is 5.81 millidarcys (See Table II). By observing the data given on the coregraph, it is noticeable that the sand has an irregular permeability profile.

OIL CONTENT

This core shows a good weighted average percent oil saturation, namely, 44.94. The weighted average percent oil saturation of the upper, middle and lower sections is 45.82, 47.13 and 42.45 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 36.34, 40.62 and 36.12 respectively; while the overall weighted average is 37.52 (See Table IV). This gives an overall weighted average total fluid saturation of 82.46 percent.

In an effort to determine the degree of flushing that occurred during coring, each of the saturation samples was analyzed for chloride content. The results of these tests, which are given in Tables VII and VIII, indicate that little flushing occurred during coring. It is possible that salt water was used as a circulating fluid.

The weighted average oil content of the upper, middle and lower sections is 575, 614 and 557 barrels per acre foot respectively; while the overall weighted average is 580 barrels per acre foot. The total oil content, as shown by this core, is 8,849 barrels per acre.

LABORATORY FLOODING TESTS

This core responded well to laboratory flooding tests in that a total oil recovery of 2,094 barrels per acre was obtained from 10.25 feet of sand analyzed. The weighted average percent oil saturation was reduced from 45.44 to 31.37 which represents an average recovery of 14.07 percent. The high residual oil saturation is due mainly to the fact that the sand has such a low effective permeability. The weighted average effective permeability of the samples is 0.408 millidarcy, while the average initial fluid production pressure is 29.6 pounds per square inch (See Table VI).

By observing the data given in Table V, you will note that of the 34 samples tested, 26 produced water and 25 oil. This indicates that most of the sand represented by these samples is floodable. The tests also show that the sand has a wide variation in effective permeability.

CONCLUSION

From a study of the above data, we believe that an efficient water flood within the vicinity of this well will recover approximately 1,450 barrels of oil per acre from the 9.50 feet of floodable sand analyzed. This is an average recovery of 153 barrels of oil per acre foot. In calculating the above recovery, an allowance was made for oil lost during coring. It was assumed that the true water saturation of the sand is 38 percent and that the sand is not pressured up.

If this well is to be used as an injection well, the effective permeability might be increased by injecting a solvent before water injection is started.

Oil Field Research Laboratories

RESULTS OF PERMEABILITY TESTS

TABLE I

Company Oko Oil & Gas Company Lease Willson Well No. F-2

Sample No.	Depth, Feet	Permeability Millidarcys	Feet of Core		Permeability Capacity Ft. x Md.
			Ft.	Cum. Ft.	
1	793.41	2.1	0.17	0.17	0.36
3	796.48	1.1	0.40	0.57	0.44
4	797.12	11.	0.50	1.07	5.50
5	797.37	5.3	0.15	1.22	0.80
6	798.74	0.64	0.35	1.57	0.22
7	799.32	12.	0.35	1.92	4.20
8	799.80	10.	0.31	2.23	3.10
9	800.65	2.7	0.18	2.41	0.49
10	801.22	Imp.	0.30	2.71	0.00
11	801.64	Imp.	0.30	3.01	0.00
12	802.33	4.2	0.25	3.26	1.05
13	802.80	13.	0.18	3.44	2.34
14	803.50	7.7	0.35	3.79	2.70
15	803.67	9.4	0.15	3.94	1.41
16	805.08	5.0	0.20	4.14	1.00
17	805.38	7.4	0.25	4.39	1.85
18	805.82	11.	0.40	4.79	4.40
19	806.54	5.1	0.55	5.34	2.80
20	807.70	7.4	0.41	5.75	3.04
21	808.20	3.9	0.10	5.85	0.39
22	808.80	3.9	0.25	6.10	0.98
23	809.63	3.7	0.50	6.60	1.85
24	810.65	3.7	0.33	6.93	1.23
25	812.83	8.3	0.60	7.53	4.98
26	813.78	1.3	0.15	7.68	0.20
27	814.14	0.74	0.40	8.08	0.30
28	815.56	2.0	0.90	8.98	1.80
29	816.46	2.4	0.70	9.68	1.68
30	816.85	3.3	0.30	9.98	0.99
31	817.88	5.3	0.50	10.48	2.65
32	818.40	15.	0.30	10.78	4.50
33	818.60	14.	0.30	11.08	4.20
34	818.97	9.3	0.45	11.53	4.19
35	819.58	1.1	0.45	11.98	0.50

Oil Field Research Laboratories

SUMMARY OF PERMEABILITY TESTS

TABLE II

Company Oko Oil & Gas Company Lease Willson Well No. F-2

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity, Ft. x Md.
793.25 - 803.75	3.34	6.77	22.61
805.00 - 810.95	2.99	5.87	17.54
812.35 - 820.00	5.05	5.15	25.99
793.25 - 820.00	11.38	5.81	66.14

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RESULTS OF SATURATION TESTS

TABLE III

Company Oko Oil & Gas Company Lease Willson Well No. F-2

Sat. No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content, Bbls./A. Ft.	Feet of Core		Total Oil Content Bbls./Acre
			Oil	Water	Total		Ft.	Cum. Ft.	
F- 1	793.35	15.4	42.7	-	-	511	0.17	0.17	87
4	795.78	15.4	42.4	45.8	88.2	506	0.25	0.42	127
5	796.28	15.4	48.2	35.0	83.2	577	0.25	0.67	144
6	796.95	16.7	50.5	25.8	76.3	655	0.65	1.32	426
F- 7	798.33	17.8	51.5	-	-	711	0.15	1.47	107
7	798.48	13.6	36.5	55.3	91.8	385	0.15	1.62	58
8	799.15	13.2	36.0	55.0	91.0	369	0.35	1.97	129
9	799.68	18.2	47.4	27.6	75.0	669	0.66	2.63	441
10	800.57	15.1	43.9	45.6	89.5	515	0.25	2.88	129
F-10	800.73	15.0	56.0	-	-	652	0.18	3.06	117
11	801.29	15.3	46.8	33.1	79.9	555	0.30	3.36	167
12	801.60	16.2	53.3	31.6	84.9	670	0.30	3.66	201
F-12	801.70	14.4	31.3	-	-	350	0.15	3.81	53
F-13	802.42	17.9	44.9	-	-	623	0.25	4.06	156
14	803.16	14.2	46.1	44.6	90.7	508	0.15	4.21	76
F-14	803.33	16.9	44.1	-	-	578	0.50	4.71	289
15	803.98	14.9	41.5	44.1	85.6	480	0.30	5.01	144
16	804.95	13.4	40.3	48.0	88.3	419	0.50	5.51	209
F-17	805.52	14.8	45.8	-	-	526	0.60	6.11	316
17	805.67	14.9	50.0	48.7	98.7	578	0.40	6.51	231
18	806.38	19.1	49.2	25.8	75.0	730	0.30	6.81	219

Oil Field Research Laboratories

RESULTS OF SATURATION TESTS

TABLE III

Company Oko Oil & Gas Company Lease Willson Well No. F-2

Sat. No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content, Bbls./A. Ft.	Feet of Core		Total Oil Content Bbls./Acre
			Oil	Water	Total		Ft.	Cum. Ft.	
19	806.88	17.2	40.6	45.3	85.9	542	0.55	7.36	298
20	807.57	19.0	46.2	30.7	76.9	681	0.41	7.77	279
21	808.65	13.7	43.3	55.2	98.5	461	0.30	8.07	138
F-21A	808.88	17.1	46.3	-	-	640	0.25	8.32	160
22	809.38	19.7	55.2	31.4	86.6	844	0.50	8.82	422
23	810.88	18.4	57.0	37.2	94.2	813	0.33	9.15	268
24	811.94	17.6	55.2	37.9	93.1	754	0.30	9.45	226
25	812.68	18.4	54.3	25.8	80.1	775	0.60	10.05	465
26	813.58	16.8	41.3	42.5	83.8	539	0.30	10.35	162
27	814.48	17.6	38.4	32.3	70.7	524	0.40	10.75	209
28	815.43	16.4	39.4	37.4	76.8	501	0.60	11.35	300
29	815.95	16.5	40.0	43.3	83.3	512	0.30	11.65	154
30	816.27	15.6	38.1	34.4	72.5	461	0.50	12.15	230
31	816.75	15.8	38.5	46.2	84.7	472	0.50	12.65	236
32	817.23	17.4	49.8	37.5	87.3	671	0.30	12.95	202
33	818.23	18.0	40.6	37.4	78.0	567	0.80	13.75	454
34	818.80	16.9	45.1	35.7	80.8	592	0.75	14.50	444
35	819.38	16.2	43.3	31.1	74.4	545	0.30	14.80	164
36	819.90	15.9	38.1	34.3	72.4	470	0.45	15.25	212
							Total - - - - -		8,849

"A" Sample was taken from the core after it was received in the laboratory.

Oil Field Research Laboratories

SUMMARY OF SATURATION TESTS

TABLE IV

Company Oko Oil & Gas Company Lease Willson Well No. F-2

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
793.25-803.75	4.71	16.09	45.82	36.34	575	2,707
803.75-812.00	4.74	16.60	47.13	40.62	614	2,910
812.35-820.00	5.80	16.88	42.45	36.12	557	3,232
793.25-820.00	15.25	16.55	44.94	37.52	580	8,849

Oil Field Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE V

Company Oko Oil & Gas Company Lease Willson Well No. F-2

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.
			Percent	Bbls./A. Ft.	Percent	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
1	795.35	18.4	42.7	511	12.1	145	30.6	52.2	366	2	0.083	40
4	795.65	15.2	41.9	495	9.2	109	32.7	64.2	388	0	0.017	80
5	796.15	15.3	47.4	563	7.8	93	39.6	57.6	470	0	0.010	40
6	796.65	16.8	51.4	670	21.4	279	30.0	60.0	391	10	0.307	25
7	796.85	17.8	51.3	711	23.4	325	28.1	64.8	386	26	0.416	20
8	796.95	13.3	38.0	392	0.0	0	38.0	55.0	392	0	Imp.	50+
9	799.35	17.9	49.3	668	20.7	266	28.6	59.0	400	18	0.478	20
10	800.75	15.0	56.0	652	24.8	289	31.2	62.0	363	4	0.205	25
11	801.10	15.1	46.9	549	0.0	0	46.9	39.5	549	0	Imp.	50+
12	801.70	14.4	31.3	350	0.0	0	31.3	62.1	350	0	Imp.	50+
13	802.42	17.9	44.9	623	16.0	222	28.9	60.7	401	7	0.290	25
14	803.35	16.9	44.1	578	9.7	127	34.4	53.4	451	2	0.180	40
15	803.65	14.8	40.6	486	0.0	0	40.6	54.5	486	0	Imp.	50+
16	804.82	13.9	40.6	436	0.0	0	40.6	56.1	436	0	Imp.	50+
17	805.52	14.8	45.8	526	11.9	137	33.9	58.1	389	8	0.185	30
18	806.24	19.4	50.1	765	22.3	336	27.8	70.6	419	27	0.825	20
19	806.73	17.4	38.4	518	8.2	110	30.2	61.3	408	6	0.257	35
20	807.45	18.7	46.2	670	15.1	219	31.1	56.3	451	12	0.353	25
21A	808.80	17.1	46.3	640	11.1	147	37.2	53.0	493	1	0.101	35
22	809.25	18.6	55.1	831	17.6	268	37.5	60.0	570	5	0.294	25
23	810.77	18.8	54.9	792	18.7	270	36.2	65.4	522	2	0.078	30
24	811.78	17.9	53.8	747	23.4	325	30.4	55.9	422	7	0.250	20
25	812.58	18.3	53.5	760	26.7	379	26.8	58.6	351	20	0.710	15
26	813.45	17.2	42.5	567	10.1	135	32.4	56.1	432	4	0.195	30
27	814.26	17.4	37.6	507	4.1	55	33.5	62.5	452	3	0.178	40
28	815.27	16.6	40.0	515	0.0	0	40.0	54.0	515	0	Imp.	50+
29	815.85	16.6	42.3	545	6.4	82	35.9	60.3	453	10	0.190	35
30	816.15	15.7	40.7	496	7.4	90	33.3	68.7	406	2	0.183	40
31	816.63	15.7	39.2	478	0.0	0	39.2	55.5	478	1	0.050	50
32	817.07	17.5	47.9	650	22.4	304	25.5	70.0	348	18	0.306	25
33	818.08	17.9	39.9	555	10.7	149	29.2	64.4	406	40	1.39	25
34	818.70	17.0	44.0	590	15.8	219	27.4	66.0	361	32	0.880	25
35	819.28	16.6	43.4	589	0.0	0	43.4	58.1	589	11	0.386	35
36	819.70	15.7	39.5	481	0.0	0	39.5	60.0	481	1	0.082	50

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.
"+" - Sample was taken from core after it was received in the laboratory.

Oil Field Research Laboratories

SUMMARY OF LABORATORY FLOODING TESTS

TABLE VI

Company Oko Oil & Gas Company Lease Willson Well No. F-2

	793.25 – 803.75	805.00 – 812.00	812.35 – 819.35	793.25 – 819.25
Depth Interval Feet				
Feet of Core Analyzed	3.06	3.34	3.95	10.25
Average Percent Porosity	16.75	17.77	17.28	17.28
Average Percent Original Oil Saturation	47.98	48.34	41.10	45.44
Average Percent Oil Recovery	16.58	15.25	11.16	14.07
Average Percent Residual Oil Saturation	31.40	33.09	29.94	31.37
Average Percent Residual Water Saturation	58.62	58.66	62.95	60.36
Average Percent Total Residual Fluid Saturation	90.22	92.75	92.89	91.73
Average Original Oil Content, Bbls./A. Ft.	625.	670.	587.	624.
Average Oil Recovery, Bbls./A. Ft.	218.	214.	186.	204.
Average Residual Oil Content, Bbls./A. Ft.	407.	456.	401.	420.
Total Original Oil Content, Bbls./Acre	1,911.	2,169.	2,216.	6,396.
Total Oil Recovery, Bbls./Acre	667.	693.	734.	2,094.
Total Residual Oil Content, Bbls./Acre	1,244.	1,476.	1,582.	4,302.
Average Effective Permeability, Millidarcys	0.259	0.280	0.627	0.408
Average Initial Fluid Production Pressure, p.s.i.	31.7	25.	29.1	29.6

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

Oil Field Research Laboratories

RESULTS OF WATER DIFFERENTATION TESTS

TABLE VII

Company Oko Oil & Gas Company Lease Willson Well No. F-2

Sample No.	Depth, Feet	Chloride Content of Brine in Sand ppm	Percent Water Saturation Connate	Drilling & Foreign	Total
4	795.78	20,500			
5	796.28	22,400			
6	796.95	18,900			
7	798.48	21,100			
8	799.15	20,900			
9	799.68	22,500			
10	800.57	24,800			
11	801.29	20,700			
12	801.60	24,200			
14	803.16	23,000			
15	803.98	13,700			
16	804.95	27,100			
17	805.67	19,000			
18	806.38	23,300			
19	806.88	16,100			
20	807.57	18,200			
21	808.65	23,200			
22	809.38	16,100			
23	810.88	15,900			
25	812.68	24,300			
26	813.58	22,900			
27	814.48	23,800			
28	815.43	10,500			
29	815.95	21,600			
30	816.27	27,500			
31	816.75	27,100			
32	817.23	21,000			
33	818.23	18,500			
34	818.80	17,600			
35	819.38	23,200			
36	819.90	21,200			

Note: ppm - parts per million.

Oil Field Research Laboratories

SUMMARY OF WATER DIFFERENTATION TESTS

TABLE VIII

Company Oko Oil & Gas Company Lease Willson Well No. F-2

Depth Interval, Feet	Chloride Content of Brine in Sand, ppm	Average Percent Connate Water	Average Percent Drilling & Foreign Water
795.60 - 803.25	21,598		
803.75 - 810.95	19,170		
812.35 - 820.00	21,012		
795.60 - 820.00	20,644		

Note: ppm - parts per million.