State of Illinois
William G. Stratton, Governor
DEPARTMENT OF REGISTRATION AND EDUCATION
Vera M. Binks, Director

Division of the

STATE GEOLOGICAL SURVEY

John C. Frye, Chief
Urbana

ILLINOIS PETROLEUM 73

SUMMARY OF WATER FLOOD OPERATIONS IN ILLINOIS OIL POOLS DURING 1954

By

Paul A. Witherspoon, Edwin G. Jackson, and Members of the
Illinois Secondary Recovery and Pressure Maintenance Study Committee

Reprint of the Report Published
by the Interstate Oil Compact Commission
1955

Urbana, Illinois
1955

PREFACE

The Interstate Oil Compact Commission, through its Secondary Recovery Division, with Albert E. Sweeney, Jr., director, and Paul D. Torrey, chairman of the Secondary Recovery and Pressure Maintenance Committee, takes great pleasure in presenting this "Summary of Water Flood Operations in Illinois Oil Pools During 1954."

We have heretofore cooperated with the State of Illinois in preparing and publishing the following reports:

"Summary, Water Flooding Operations in Illinois, 1950" covering the 1949 operations.

"Summary, Water Flooding Operations in Illinois to 1951" covering the operations in 1950.

"Summary of Water Flooding Operations in Illinois Oil Pools During 1951," in which the Compact Commission did not officially participate but did render all assistance possible to the state.

"Summary of Water Flood Operations in Illinois Oil Pools During 1952" covering the operations in 1952.

"Summary of Water Flood Operations in Illinois Oil Pools During 1953" covering the operations in 1953.

We are honored to cooperate fully in the publication of this pamphlet which has been prepared with the cooperation of the Illinois State Geological Survey, and we feel sure that this report, together with the others above mentioned, will be of great interest and most helpful not only to the State of Illinois and the Compact, but also to the other states and the oil and gas industries generally.

The Interstate Oil Compact Commission wishes to express its appreciation, especially to Paul A. Witherspoon, chairman, and members of the State Secondary Recovery and Pressure Maintenance Study Committee of the State of Illinois, and to all companies, organizations, and individuals who have assisted in gathering the data on this project. It is published in order that the states, the public in general, and the oil and gas industries in particular may have factual information regarding secondary recovery and pressure maintenance operations in the State of Illinois.

EARL FOSTER
Executive Secretary

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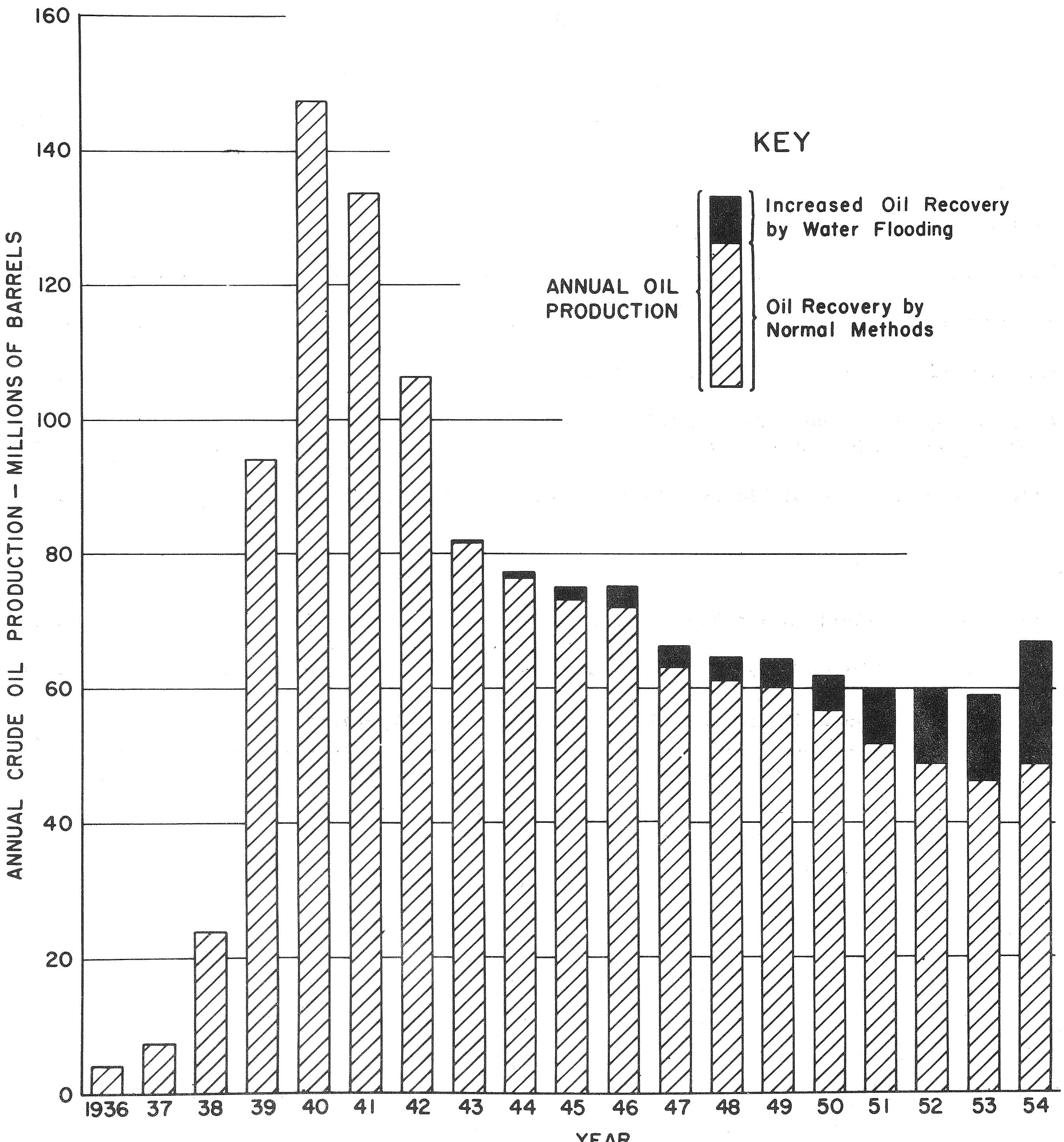
Figure 1

ANNUAL CRUDE OIL PRODUCTION IN ILLINOIS



Illinois State Geological Survey

SUMMARY OF WATER FLOOD OPERATIONS IN ILLINOIS OIL POOLS DURING 1954

ABSTRACT

During 1954, water flooding produced approximately 18,000,000 barrels of oil in Illinois. There were 232 water floods reported in operation, and these projects recovered 15,985,000 barrels of oil. An additional 2,129,000 barrels are estimated to have been produced by "dump" flooding. At the end of 1954, the cumulative water flood recovery was 73,800,000 barrels. Tables of statistics are included.

The history of the Lake Centralia-Salem field, the formation of the Salem Unit, and the initial water flood operations in this unit are summarized by Richard W. Love. Water flood operations in the old oil fields of eastern Illinois are reviewed by L. C. Powell.

INTRODUCTION

This report is the result of a joint effort by the Illinois State Geological Survey and the Illinois Secondary Recovery and Pressure Maintenance Study Committee of the Interstate Oil Compact Commission. The following persons were appointed to the Study Committee by Governor William G. Stratton to assist in the compilation of data on the water flood and pressure maintenance projects that were in operation in Illinois during 1954.

Paul A. Witherspoon, Chairman
Illinois State Geological Survey
Urbana, Illinois

Frederick Squires, HONORARY MEMBER
1003 West Church
Champaign, Illinois

Hugh S. Barger
Barger Engineering
Evansville, Indiana

A. H. Bell
Illinois State Geological Survey
Urbana, Illinois

J. S. Bottler
Carter Oil Company
Mattoon, Illinois

C. E. Brehm
Box 368
Mt. Vernon, Illinois

Allen Calvert
Calvert Drilling Company
Olney, Illinois

T. F. Lawry
Mahutska Oil Company
Robinson, Illinois

R. W. Love
The Texas Company
Salem, Illinois

A. J. Monzingo
Magnolia Petroleum Company
Salem, Illinois

Fred A. Noah
The Noah Petroleum Company
Albion, Illinois

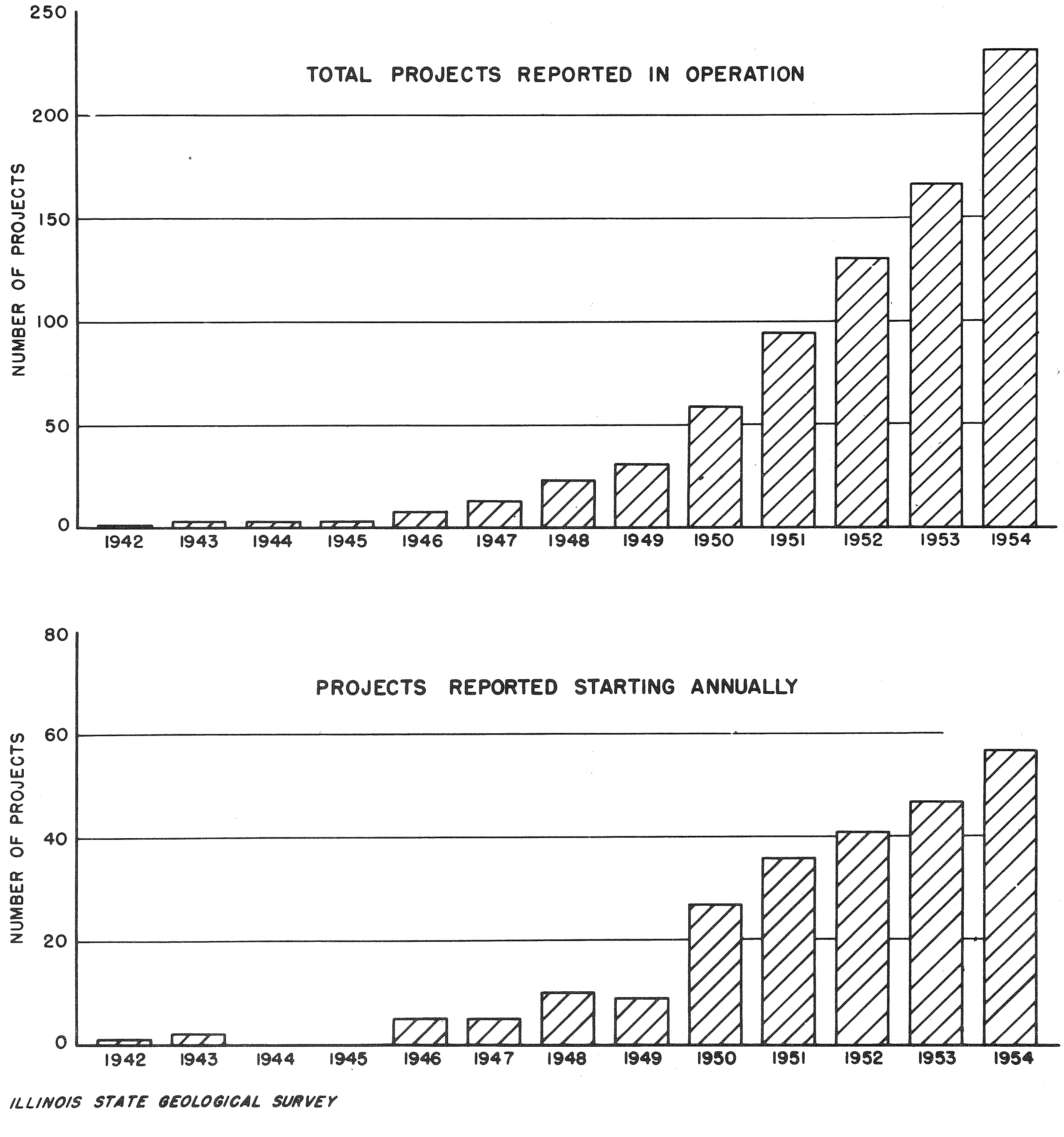
Paul Phillippi
Forest Oil Corporation
Casey, Illinois

Mark Plummer
The Pure Oil Company
Olney, Illinois

L. C. Powell
The Ohio Oil Company
Terre Haute, Indiana

Figure 2

REPORTED DEVELOPMENT OF WATER FLOOD PROJECTS IN ILLINOIS



R. E. Clark
Shell Oil Company
Centralia, Illinois

W. H. Davison
Davison and Company
Centralia, Illinois

R. E. Dunn
Walter Duncan Oil Properties
Mt. Vernon, Illinois

T. W. George
George & Wrather
Mt. Carmel, Illinois

C. H. Kallenberger
The Texas Company
Salem, Illinois

C. E. Skiles
Skiles Oil Corporation
Mt. Carmel, Illinois

Harry F. Swannack
Gulf Refining Company
Centralia, Illinois

Carl R. Temple
Sohio Petroleum Company
Centralia, Illinois

R. R. Vincent
C. L. McMahon, Inc.
Evansville, Indiana

R. A. Wilson
Tide Water Associated Oil Company
Robinson, Illinois

As a means to collect information on water injection and pressure maintenance projects in operation during 1954, the Study Committee met in Robinson, Illinois, and set up a questionnaire on January 13, 1955. The Geological Survey sent this questionnaire to all water flood operators in Illinois and compiled the data returned.

This report supplements five previous summaries of water flood operations as follows:

(1) "Summary of Water Flooding Operations in Illinois, 1950," which reported operations during 1949. Published by Interstate Oil Compact Commission and reprinted by Illinois State Geological Survey as Circular 165.

(2) "Summary of Water Flooding Operations in Illinois to 1951," which reported operations during 1950. Published by Interstate Oil Compact Commission and reprinted by Illinois State Geological Survey as Circular 176.

(3) "Summary of Water Flooding Operations in Illinois Oil Pools During 1951." Published by Interstate Oil Compact Commission and reprinted by Illinois State Geological Survey as Circular 182.

(4) "Summary of Water Flooding Operations in Illinois Oil Pools During 1952." Published by Interstate Oil Compact Commission and reprinted by Illinois State Geological Survey as Circular 185.

(5) "Summary of Water Flooding Operations in Illinois Oil Pools During 1953." Published by Interstate Oil Compact Commission and reprinted by Illinois State Geological Survey as Circular 193.

SUMMARY OF RESULTS

For the first time since 1940, annual oil production in Illinois has had a substantial increase over preceeding years. This rise in production may be mainly attributed to the large increase in oil recovered by means of water flooding. This method of secondary recovery produced approximately 18,000,000 barrels of oil during 1954, or 27 percent of the State's total recovery of 67,000,000 barrels. Of this water flood oil, 15,985,000 barrels are reported in Table I and an additional 2,129,000 barrels are estimated to have been recovered by "dump" flooding. The 1954 water flood recovery is 44 percent higher than the 1953 recovery of approximately 12,500,000 barrels.

Figure 3

WATER FLOOD AND PRESSURE MAINTENANCE OPERATIONS IN ILLINOIS DURING 1954

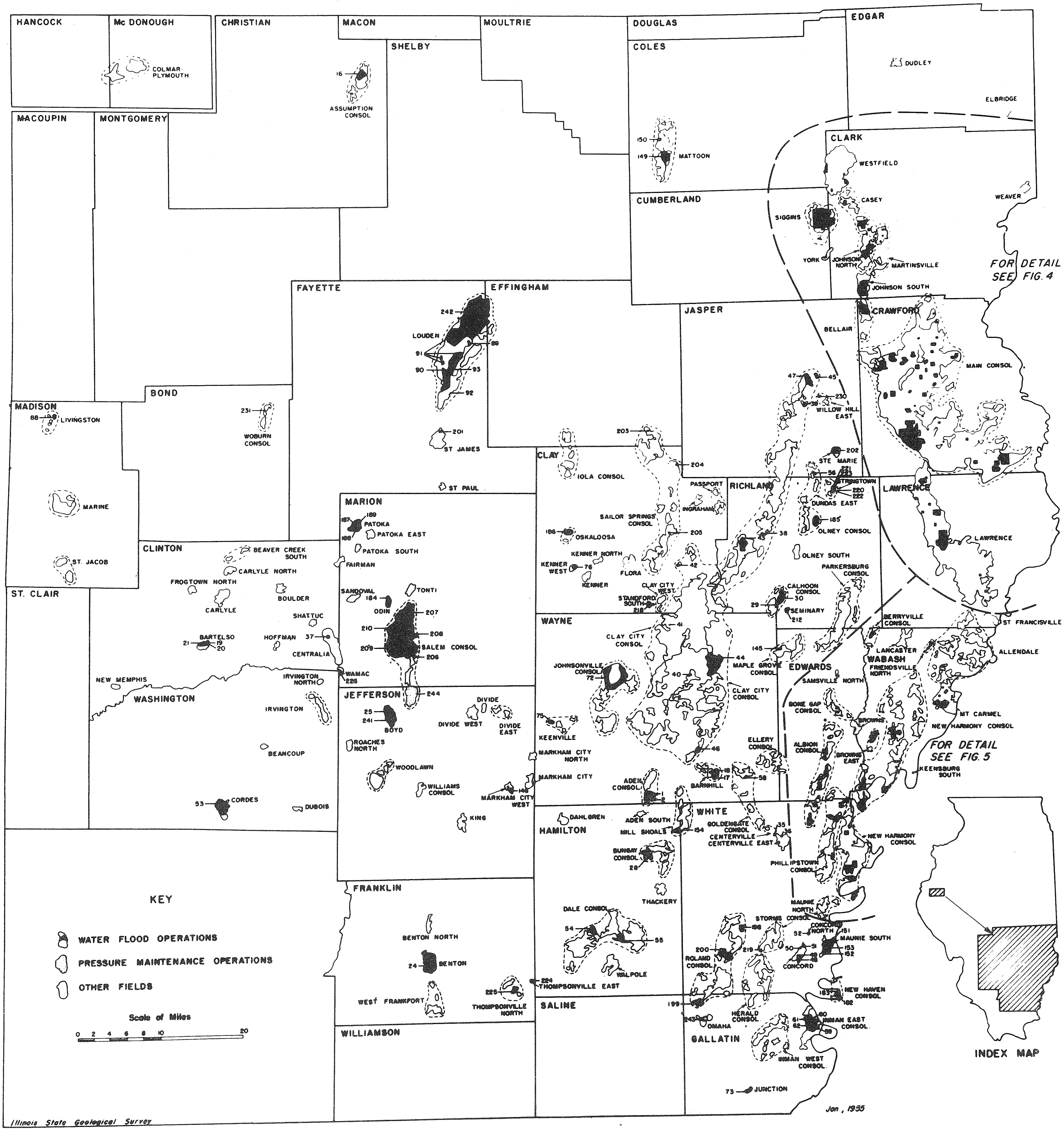


Figure 1 shows the effect of water flood (including "dump" flood) operations on the State's annual oil production since 1936. The cumulative water flood recovery at the end of 1954 was approximately 73,800,000 barrels, which includes 17,900,000 barrels of "dump" flood oil.

Table I presents a summary of the information collected on water flood projects in operation during 1954. The data are arranged alphabetically by fields and include 232 projects. Excluding the "dump" floods, there were approximately 245 water floods in operation during 1954. Table I provides data on 95 percent of these projects, although in terms of cumulative figures, this summary approaches 100 percent coverage.

Based on the reported data in Table I, a total of 176,012,000 barrels of water was injected during 1954 in recovering 15,985,000 barrels of water flood oil, or a ratio of 11.0 barrels of water for each barrel of oil. A cumulative total of 512,202,000 barrels of water had been injected by the end of 1954 in recovering 55,687,000 barrels of oil, or an overall input water-oil ratio of 9.2.

Figure 2 shows the reported development of water flood projects in Illinois by years since 1942. The rapid increase in the number of projects since 1949 is evident. As a result, the number of projects has increased by a factor of seven in the past five years from 33 projects at the end of 1949 to 232 projects at the end of 1954. As shown in Table I, these 232 projects had developed 59,027 acres for water flooding, or 12 percent of the State's total oil-productive acreage.

Table II presents data on the water flood projects that have been reported abandoned by the end of 1954. Only three projects were abandoned during 1954, bringing the total projects reported abandoned to eight.

Table III includes data on the six pressure maintenance operations that used water injection during 1954. The oil-production statistics in Table III include both primary recovery and any additional oil obtained by pressure maintenance operations.

Each project listed in Tables I, II, and III has been numbered, and corresponding numbers on Figures 3, 4, and 5 show the locations of the water flood and pressure maintenance operations. Figure 3 shows all reported projects, while Figures 4 and 5 are details or portions of the old oil fields and the Wabash Valley fields, respectively.

A generalized geologic column is given in Figure 6 which indicates the stratigraphic sequence of oil-producing formations in the Illinois Basin. Listed opposite these oil-producing formations are the number of reported water floods as taken from Table I. An index map of counties, townships, and ranges in Illinois is shown in Figure 7.

Figure 4

DETAIL OF WATER FLOOD OPERATIONS

From Figure 3

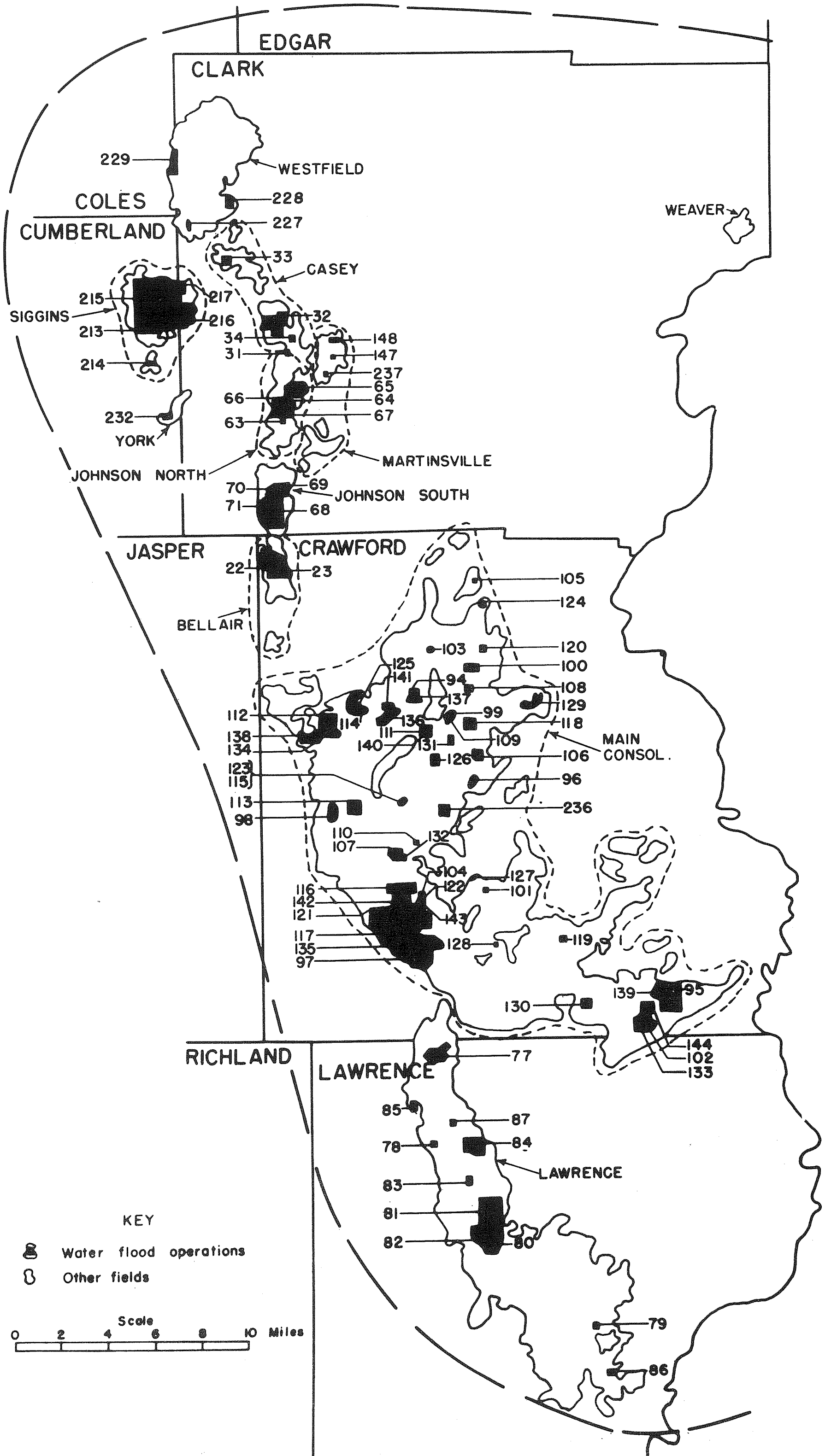


Figure 5

DETAIL OF WATER FLOOD AND PRESSURE MAINTENANCE OPERATIONS

From Figure 3

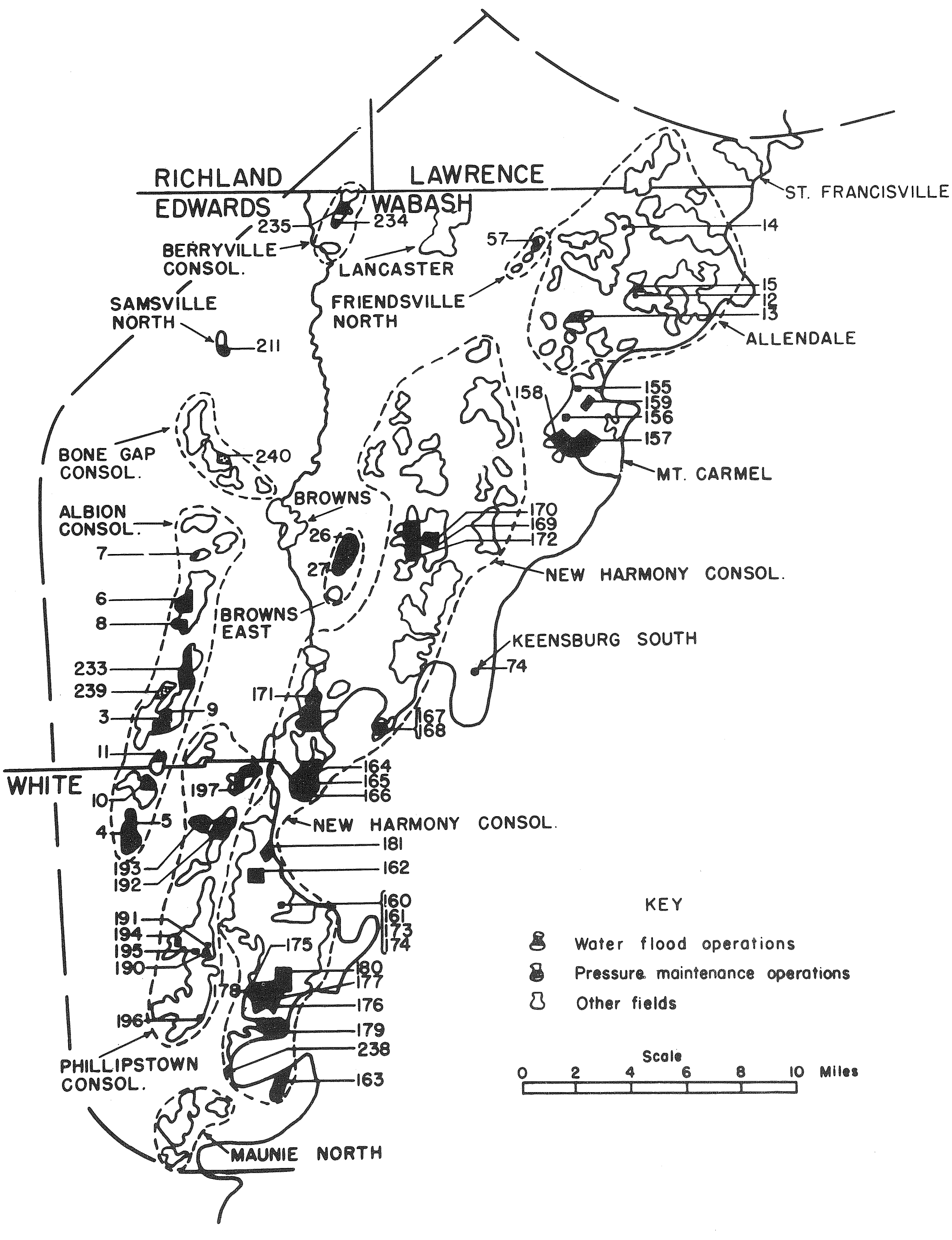
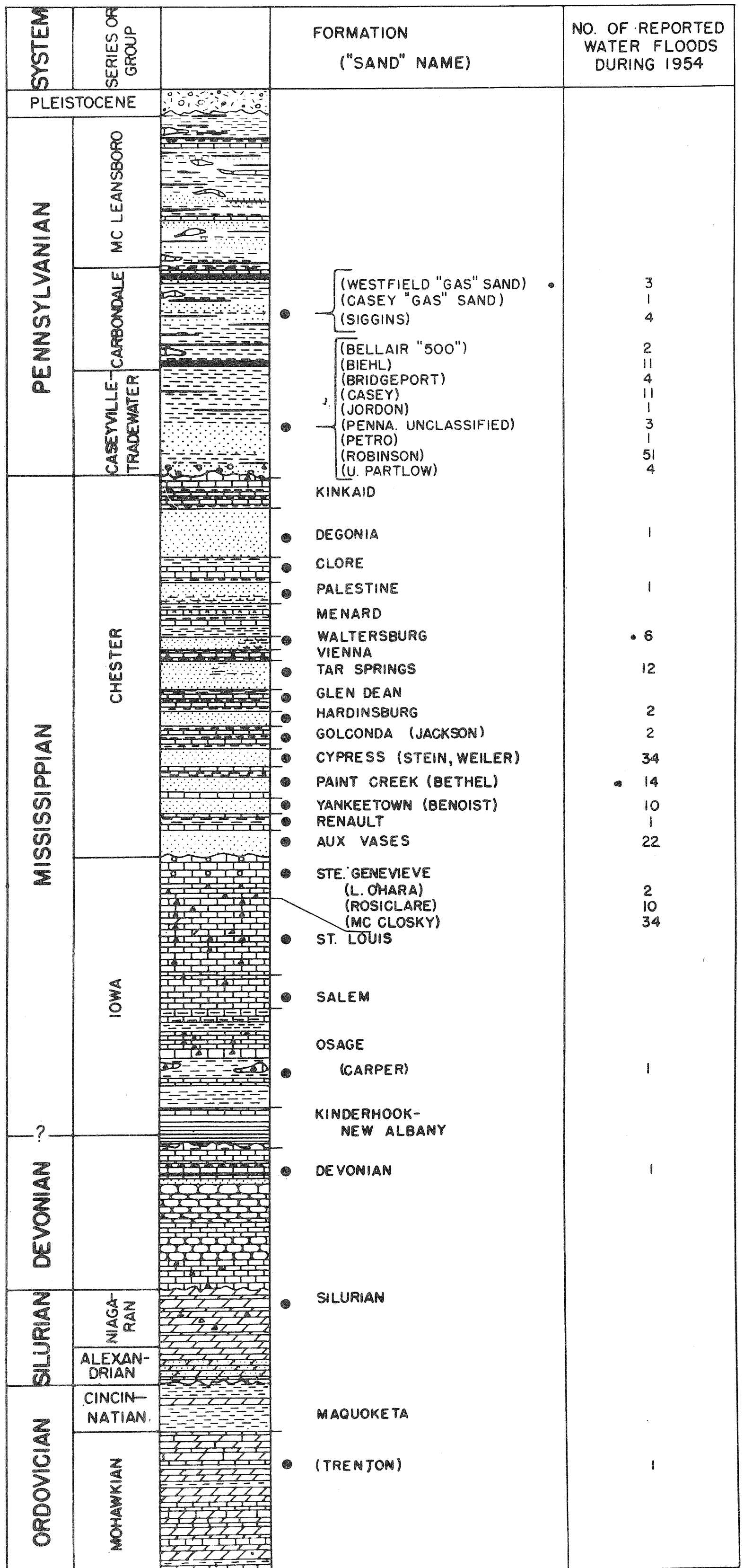


Figure 6

GENERALIZED GEOLOGIC COLUMN SHOWING FORMATIONS SUBJECTED TO WATER FLOODING IN THE ILLINOIS BASIN



(● OIL PRODUCING FORMATIONS)

Figure 7

INDEX MAP FOR COUNTIES, TOWNSHIPS, AND RANGES

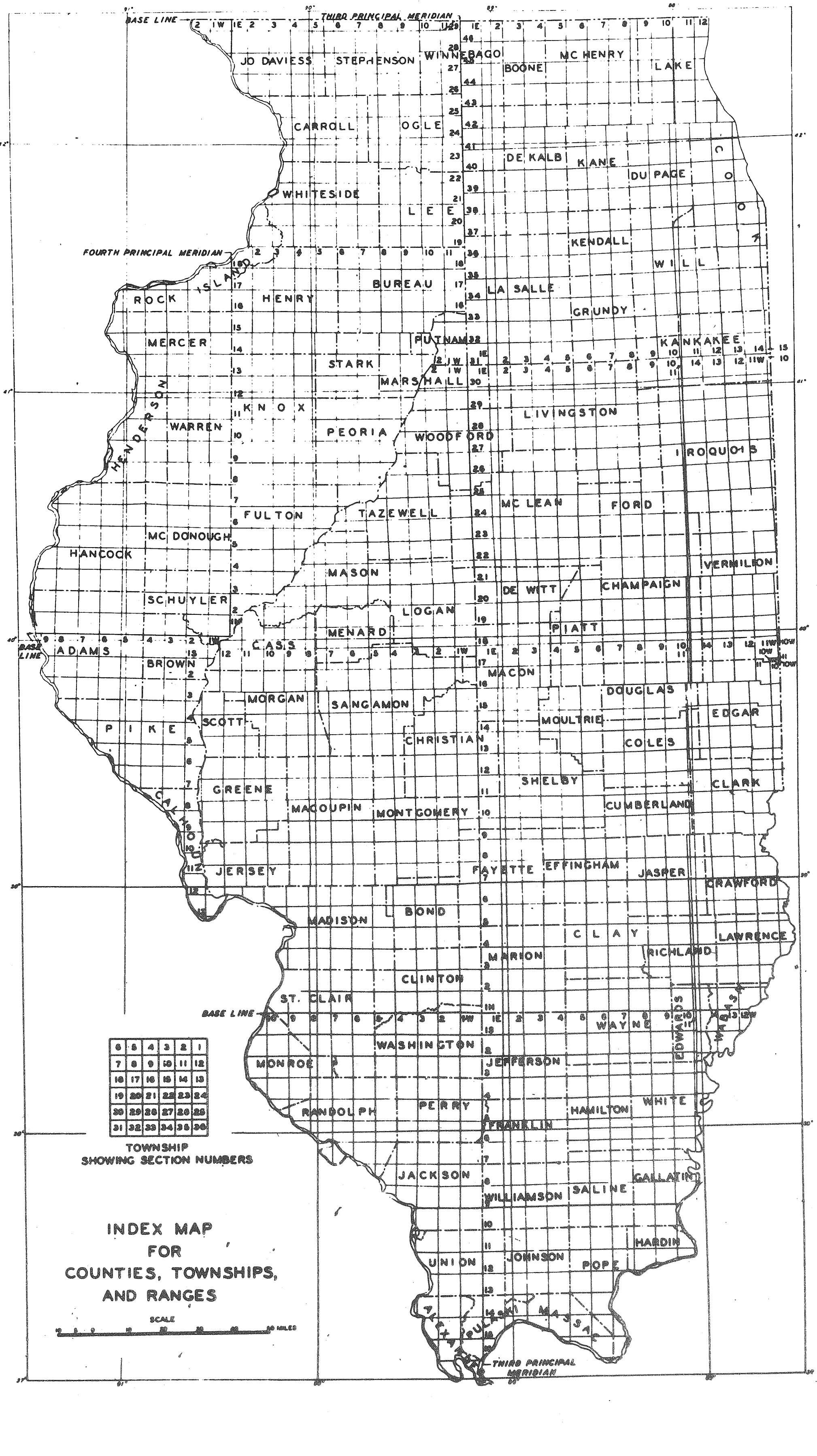


TABLE I

ILLINOIS WATER FLOOD PROJECTS REPORTED OPERATING DURING 1954

GENERAL INFORMATION

Map No.	Field	Operator	Project	Formation Sand (S), Lime (L)	County
1	Aden Consolidated	Texas	Aden	Aux Vases (S)	Wayne
2	Aden Consolidated	Texas	Aden	McClosky (L)	Wayne
3	Albion Consolidated	Carter	Albion	Lower Bridgeport (S)	Edwards
4	Albion Consolidated	Concho	—	Tar Springs (S)	White
5	Albion Consolidated	Concho	—	Cypress (S)	White
6	Albion Consolidated	Continental	Stafford	McClosky (L)	Edwards
7	Albion Consolidated	First National Petroleum Trust	Brown Lease	Aux Vases (S)	Edwards
8	Albion Consolidated	Jarvis Brothers and Marcel	—	McClosky (L)	Edwards
9	Albion Consolidated	Superior	South Albion S.R.P. #1	Biehl (S) Waltersburg (S)	Edwards
10	Albion Consolidated	Yingling	Biehl Unit #1	Biehl (S)	White
11	Albion Consolidated	Yingling	Biehl Unit #2	Biehl (S)	Edwards
12	Allendale	Bass and Hamman	White	Biehl (S)	Wabash
13	Allendale	Indiana Farm Bureau	Woods	Biehl (S)	Wabash
14	Allendale	B. Kidd	Allendale	Biehl (S) & Jordan (S)	Wabash
15	Allendale	F. C. Luecking	Mataliano et al.	Biehl (S)	Wabash
16	Assumption Consol.	Continental	Benoist	Benoist (S)	Christian
17	Barnhill	Ashland	Barnhill	McClosky (L)	Wayne
18	Barnhill	Wayne Development	Walter	McClosky (L)	Wayne
19	Bartelso	T. R. Kerwin	Belle Oil	Cypress (S)	Clinton
20	Bartelso	Robben Oil	Robben Oil Unit	Cypress (S)	Clinton
21	Bartelso	H. S. Woodard	H. S. Woodard, Trustee	Cypress (S)	Clinton
22	Bellair	Forest	Bellair	Bellair "500" (S)	Crawford
23	Bellair	Pure	Fulton	Bellair "500" (S)	Crawford
24	Benton	Shell	Benton Unit	Tar Springs (S)	Franklin
25	Boyd	Superior	Boyd Field Unit	Aux Vases (S)	Jefferson
26	Browns East	George & Wrather	Bellmont Association	Cypress (S)	Wabash
27	Browns East	Magnolia	Bellmont	Cypress (S)	Wabash
28	Bungay Consolidated	Texas	Blairsville	Aux Vases (S)	Hamilton
29	Calhoun Consolidated	Ashland	Calhoun	McClosky (L)	Richland
30	Calhoun Consolidated	Phillips	Bohlander	McClosky (L)	Richland
31	Casey	F. A. Bridge	States Oil	Casey (S)	Clark
32	Casey	Forest	Casey	Casey (S)	Clark
33	Casey	Franchot	North Casey	Casey (S)	Clark
34	Casey	Sapphire American	Shawver*	Casey (S)	Clark
35	Centerville	Lesh Drilling	East Centerville	Rosiclare (L)	White

PRODUCTION AND INJECTION STATISTICS (Barrels)

Location Section	Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Secondary Recovery Oil Production Total 1954	Secondary Recovery Oil Production Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
8,9,16,17,20	3S	7E	Aug., 1946	269,748	1,717,591	87,721	342,984	339,297*	793,448*	1
8,9,16,17,20	3S	7E	Aug., 1946	343,344	1,907,863	30,732	216,309	*	*	2
11,12	3S	10E	Dec., 1947	64,343	353,559	4,130	60,086	53,955	273,796	3
26,27,34,35	3S	10E	Oct., 1952	—	28,858*	—	None*	—	—	4
26,27,34,35	3S	10E	Oct., 1952	—	104,322*	—	None*	—	—	5
13	2S	10E	May, 1943	156,950	316,739*	2,608	31,100	156,950	316,739*	6
6	2S	11E	April, 1952	—	—	—	—	—	—	7
24	2S	10E	July, 1951	56,695	168,788	—	—	61,432	179,171	8
25,36 30,31	2S 2S	10E 11E	Dec., 1954	3,727	3,727	—	—	372	372	9
23	3S	10E	Aug., 1949	519,724	2,351,351	102,807	591,432	*	—	10
14	3S	10E	Dec., 1950	304,746	1,071,704	75,467	308,744	*	—	11
22	1N	12W	June, 1952	*	*	7,718	7,718**	—	—	12
20	1N	12W	Nov., 1953	—	22,563*	—	—	—	30,000*	13
3	1N	12W	Sept., 1953	131,003	164,903	18,582	18,582	—	—	14
15	1N	12W	June, 1952	—	45,050*	—	13,200*	—	22,800*	15
3,4,9,10,15, 16,21	13N	1E	July, 1950	1,025,583	2,993,918	168,645	588,513	407,412	809,051	16
26,34,35	2S	8E	Jan., 1951	428,800	912,800	128,008	526,008	277,800	277,800*	17
26	2S	8E	Dec., 1950	10,550	143,565	—	—	4,901	118,901	18
4	1N	3W	April, 1952	124,010	326,128	19,035	80,082*	69,384**	69,384**	19
4	1N	3W	Nov., 1953	409,233	453,443	104,665	108,175*	64,881	65,681	20
5,8	1N	3W	Jan., 1954	175,194	175,194	36,798*	36,798*	54,372	54,372	21
2,11,12	8N	14W	July, 1948	1,241,103	11,204,328*	62,064	432,188*	—	—	22
1,2,11,12	8N	14W	July, 1948	3,725,702	25,013,903	115,144	771,951*	1,965,549	9,033,767	23
23,24,25,26,35,36 18,30,31	6S 6S	2E 3E	Nov., 1949	10,601,344	50,979,092*	1,366,489	7,627,473	6,963,237	17,079,468	24
13,24,25 18,19,20,30	1S 1S	1E 2E	Aug., 1954	123,171	123,171	*	*	*	*	25
1,2,11,12	2S	14W	Jan., 1951	528,465	2,111,460	146,411	792,369*	286,745	499,973	26
2,11	2S	14W	Nov., 1947	55,300	655,753	44,719	491,916*	31,457	153,476	27
16,17,20,21	4S	7E	June, 1948	1,093.547	2,144,476	21,993	99,542	74,785	125,380	28
13 7,18	2N 2N	9E 10E	Sept., 1951	173,870	383,695	22,443	64,168*	168,500	168,500**	29
6,7	2N	10E	June, 1950	385,088	1,100,245	53,213	147,572	298,270	592,771	30
26	10N	14W	Jan., 1954	4,910	4,910	None	None	—	—	31
14,15,23	10N	14W	March, 1950	854,556	3,823,115*	54,953	276,758*	—	—	32
4 33	10N 11N	14W 14W	Dec., 1953	176,230	185,186	None	None	None	None	33
23,24	10N	14W	Aug., 1953	25,596*	48,586*	1,814*	1,814*	—	—	34
12	4S	9E	June, 1954	*	*	1,058**	1,058**	—	—	35

TABLE I (Continued)

	DEVELOPMENT AS OF 12-31-54						INJECTION WATER			
Map No.	No. of Wells Inj.	Prod.	Injection Pattern	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Total	Source	Type	Avg. Bbls. Per Day Per Well Per Foot	Average Wellhead Pressure PSI
1	6	20	Perimeter	—	640	1,050	Pennsylvanian Sand	Brine	12.3	1,473
2	6	20	Perimeter	—	520	920	Pennsylvanian Sand	Brine	4.4	1,348
3	1	5	Flank	—	60	60	Produced	Brine	13.6	200
4	4	—	Perimeter	—	—	—	River	Fresh	—	—
5	8	21	Perimeter	—	250	300	River	Fresh	—	—
6	1	1	—	—	80	80	Produced	Brine	107.5	0
7	1	1	Spot	—	30	50	Hardinsburg	Brine	—	—
8	1	6	—	—	140	140	—	Brine	5.2	25
9	1 5	21	Flank	—	222 325	222 325	Shallow Sand and Produced	Fresh and Brine	—	681
10	3	13	Flank	—	220	220	River and Produced	Fresh and Brine	27.9	757
11	1	6	Flank	—	90	90	Pennsylvanian Sand	Brine	37.9	759
12	1	2	—	—	30	70	600-700 Ft. Sands	Brine	—	0
13	5	7	—	10	147	147	Produced	Brine	—	—
14	1	4	5 Spot	—	60	60	Shallow Sand	Fresh	8.0	30
15	1	2	—	—	44	44	Shallow Sand	Fresh	—	—
16	13	29	Perimeter	—	450	450	Creek and Produced	Fresh and Brine	17.0	917
17	6	20	Irregular	—	260	320	Cypress	Brine	21.8	0
18	1	2	—	10	40	40	Cypress	Brine	1.6	—
19	5	5	5 Spot	5	40	40	Tar Springs	Brine	4.5	550
20	12	19	5 Spot	10	200	200	Benoist	Brine	7.8	343
21	4	10	5 Spot	10	80	—	Benoist	Brine	—	273
22	56	51	5 Spot	4.4	200	—	Gravel Bed	Fresh	1.6	248
23	131	125	5 Spot	4.4	443	443	Gravel Bed	Fresh	3.7	265
24	107	118	5 Spot	20	2,200	2,200	Lake & Produced	Fresh & Brine	7.8	487
25	1	85	Peripheral	—	569	569	Produced	Brine	67.6	459
26	15	18	5 Spot	20	290	330	Shallow Sand	Fresh	7.4	1,400
27	3	11	Line Drive	10	184	184	Tar Springs	Brine	—	—
28	10	17	—	—	640	640	Pennsylvanian Sand	Brine	19.3	1,018
29	3	8	Irregular	—	140	195	Cypress	Brine	26.5	0
30	3	10	Irregular	—	160	280	Upper Sand & Produced	Brine	35.2	856
31	2	0	—	4.4	—	—	Shallow Sand	Fresh	0.4	360
32	69	65	5 Spot	4.4	280	—	Gravel Bed	Fresh	3.4	220
33	15	4	5 Spot	4.4	48	560	Gravel Bed	Fresh	1.6	80
34	9*	4	5 Spot	4.4	13*	215	Shallow Sand	Fresh	0.7*	202
35	1*	1	—	—	20	20	Tar Springs	Brine	—	—

RESERVOIR STATISTICS (Average Values)						REMARKS	
Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises		Map No.
3,200	10	22	150	35.4	—	* Includes water production from McClosky. (See Map No. 2)	1
3,350	3.6	—	—	35.4	6.5 @ 100° F.	* See Map No. 1.	2
1,900	13	20	305	35	6.0 @ 111° F.		3
2,460	6	18	—	37	—	* As of 1-1-53.	4
2,850	12	18	—	37	—	* As of 1-1-53.	5
3,222	4	16.3	898	39	—	* Since 1-1-52.	6
3,005	21	—	—	—	—		7
3,150	30	—	—	37	—		8
2,025	7.1	18.6	807	36	5.4 @ 85° F.		9
2,400	12.3	18.5	74	36.1	4.7 @ 90° F.		
2,000	17	20.2	265	37.6	5.3 @ 88° F.	* Approximately 50 per cent water cut. Original BHP, 800 PSI.	10
1,950	22	19.3	303	35.8	6.0 @ 84° F.	* Approximately 68 per cent water cut.	11
1,450	17	—	—	—	—	* Dump Flood. ** Since 1-1-54.	12
1,520	15	—	—	28.4	8 to 9	* As of 1-1-54.	13
1,490	45	18	600	37	7.6 @ 79° F.		14
1,385	15	—	—	34.5	—	* As of 1-1-54.	15
1,050	12.7	19.4	103	39.8	—		16
3,350	9	—	—	39	—	* Since 1-1-54.	17
3,450	18	—	—	—	—		18
971	15	22.2	1,655	37	6.3 @ 71° F.	* Includes primary production since start of flood. ** Since 3-1-54.	19
980	12	20	110	36.9	6.3 @ 71° F.	* Includes primary production since start of flood.	20
970	15	21	210	36	—	* Includes primary production since start of flood.	21
550	38	17.1	148	32.4	16 @ 77° F.	* Corrected Figure. Previously subjected to gas injection.	22
560	21	18.6	149	32	18.7 @ 77° F.	* Corrected Figure.	23
2,100	35	19	65	40.4	3.5 @ 86° F.	* Corrected Figure.	24
2,130	11.9	21.4	240	36.8	4.4 @ 90° F.	* Included in Superior's Boyd Repressure (Benoist). Previously used for gas storage.	25
2,570	13	—	—	—	—	* Includes primary production since start of flood.	26
2,570	—	—	—	36	4.6 @ 90° F.	* Corrected Figure, includes primary production since start of flood.	27
3,330	15.5	19.6	92	35 to 40	1.8 @ 99° F.		28
3,150	6	—	—	37	—	* Includes primary production since start of flood. ** Since 1-1-54.	29
3,130	10	11.2	68	36	—		30
444	20	—	—	—	—		31
450	10	17.4	173	31.9	16.6 @ 70° F.	* Corrected Figure. Previously subjected to gas injection.	32
290	20	21.5	400	26.6	50 @ 60° F.		33
450	21.5	22.4	108	31.8	13.6 @ 65° F.	* Project abandoned July, 1954.	34
3,366	7	—	—	43	—	* Dump flood. ** Includes primary production since start of flood.	35

TABLE I (Continued)

GENERAL INFORMATION

Map No.	Field	Operator	Project	Formation Sand (S), Lime (L)	County
36	Centerville East	Sun	East Centerville	Tar Springs (S)	White
37	Centralia	Sohio	Copple Trenton	Trenton (L)	Clinton
38	Clay City Consolidated	Ashland	Noble North	McClosky (L)	Richland
39	Clay City Consolidated	Ashland	Secure	McClosky (L)	Jasper
40	Clay City Consolidated	F. & W.	Miller Lambrich Unit	O'Hara (L) Rosiclare (L) & McClosky (L)	Wayne
41	Clay City Consolidated	I. J. Neal	—	Aux Vases (S)	Wayne
42	Clay City Consolidated	Phillips	Minnie	Rosiclare (S)	Clay
43	Clay City Consolidated	Pure	Old Noble Area	McClosky (L)	Richland
44	Clay City Consolidated	Pure	Van Fossan Unit	McClosky (L)	Wayne
45	Clay City Consolidated	Robinson & Puckett	N. E. McClosky Unit #1	McClosky (L)	Jasper
46	Clay City Consolidated	Robinson & Puckett	South Puckett Unit #1	Aux Vases (S)	Wayne
47	Clay City Consolidated	Robinson & Puckett	S. W. McClosky Unit #2	McClosky (L)	Jasper
48	Concord	Great Lakes Carbon	McClosky	Rosiclare (L) & McClosky (L)	White
49	Concord	Phillips	Dallas	Rosiclare (L) & McClosky (L)	White
50	Concord	Phillips	Kerwin	Rosiclare (L) & McClosky (L)	White
51	Concord	Phillips	Tuley	McClosky (L)	White
52	Concord North	C. E. Brehm	Concord North	Aux Vases (S)	White
53	Cordes	Shell	Cordes Cooperative*	Benoist (S)	Washington
54	Dale Consolidated	Inland	North Rural Hill Unit	Aux Vases (S)	Hamilton
55	Dale Consolidated	Texas	West Dale Unit	Aux Vases (S)	Hamilton
56	Dundas East	Gulf	Dundas East	McClosky (L)	Jasper
57	Friendsville North	Magnolia	J. L. Litherland	Biehl (S)	Wabash
58	Goldengate Consol.	Cities Service	Goldengate Unit	McClosky (L) & O'Hara (L)	Wayne
59	Inman East Consol.	Carter	Big Barn	Upper Cypress (S)	Gallatin
60	Inman East Consol.	Natural Resources	Big Barn*	Tar Springs (S)	Gallatin
61	Inman East Consol.	Natural Resources	Big Barn*	Cypress (S)	Gallatin
62	Inman East Consol.	Sun	Inman East	Tar Springs (S)	Gallatin
63	Johnson North	Bass & Hamman	North Johnson	Casey (S)	Clark
64	Johnson North	McMahon	Block "A"	Casey (S)	Clark
65	Johnson North	McMahon	Block "B"	Casey (S)	Clark
66	Johnson North	H. V. Sherrill	V. Jones	Casey (S)	Clark
67	Johnson North	Tide Water	Clark County #1	Casey (S)	Clark
68	Johnson South	Forest	South Johnson	Upper Partlow (S)	Clark
69	Johnson South	Pure	Johnson Extension #1	Upper Partlow (S)	Clark
70	Johnson South	Pure	Pure-Kewanee	Upper Partlow (S)	Clark

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Secondary Recovery Oil Production Total 1954	Secondary Recovery Oil Production Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
7	4S	10E	Oct., 1950	53,639	188,544	7,533	31,770*	24,576	60,088	36
35	2N	1W	Nov., 1951	None*	236,144	None*	48,276**	None*	20,779	37
35	4N	9E	July, 1954	44,525	44,525	973*	973*	655	655	38
2	6N	10E	Sept., 1953	31,042	55,042	3,896	3,896	11,700*	11,700*	39
29	1N	8E	Aug., 1950	—	500,000*	—	—	—	—	40
26	2N	7E	April, 1953	*	*	None	None	—	—	41
24	3N	7E	July, 1953*	38,070	60,330*	6,573	68,292*	38,179	343,636*	42
4,5,8,9 32,33,34	3N 4N	9E 9E	Aug., 1954	1,168,801	1,168,801	None	None	None	None	43
14,15,22,23	1N	8E	Jan., 1953	2,621,236	3,863,725	49,987	49,987	184,881	184,881	44
13,14,24	7N	10E	May, 1953	155,957	286,708	27,284	42,601*	14,985	20,035	45
16	2S	8E	Aug., 1954	214,044	214,044	None	None	706	706	46
23,26	7N	10E	April, 1953	471,968	788,632	56,970	62,679*	58,739	76,559	47
28	6S	10E	June, 1953	146,084	233,490	5,132	5,132	42,869	44,366	48
28	6S	10E	Aug., 1953	75,892	121,698	1,978	1,978	7,056	7,056	49
21	6S	10E	Feb., 1953	95,910	260,052*	1,241	2,099	41,007	55,189	50
21	6S	10E	July, 1951	248,630	976,893	9,049	53,500	244,781	802,499	51
10	6S	10E	Dec., 1952	71,597	126,921*	9,801	9,801	None	None	52
14,15,22,23	3S	3W	Aug., 1950	1,093,944	5,651,137	268,158	1,796,868	947,268	3,163,950	53
5,6,7,8	6S	6E	Feb., 1952	817,610	1,830,848	127,752	213,031*	334,111	347,512*	54
11	6S	6E	July, 1951	418,953	1,343,351	55,586	96,245	135,701	239,167	55
23	5N	10E	May, 1954	49,268	49,268	None	None	—	—	56
1,12	1N	13W	July, 1947	66,006	449,636	6,311	134,347*	55,060	188,052	57
28,32,33	2S	9E	Oct., 1953	227,130	256,484	4,593	4,593	2,293	2,293	58
11	8S	10E	April, 1954	27,032	27,032	—	—	264	264	59
34 2,3,4,10,11	7S 8S	10E 10E	March, 1954	1,979,991	1,979,991	72,059**	72,059**	76,826	76,826	60
34 2,3,4,10,11	7S 8S	10E 10E	March, 1954	517,801	517,801	53,008**	53,008**	8,967	8,967	61
3	8S	10E	March, 1954	195,597	195,597	4,063	4,063	7,001	7,001	62
2,11	9N	14W	June, 1953	389,750	478,367	15,462	18,580	—	—	63
2	9N	14W	April, 1949	703,070	4,972,998	17,038	230,038	529,082	2,584,804	64
35,36	10N	14W	May, 1951	181,999	720,189	15,161	36,567	95,135	162,350	65
1,3	9N	14W	Sept., 1951	3,805*	75.475*	100*	1,235*	178*	2,438*	66
2	9N	14W	Feb., 1950	261,047	1,134,747	17,855	63,339	200,200	607,102	67
27,34,35	9N	14W	March, 1949	3,292,771	15,127,767*	106,182	505,575*	—	—	68
23,26	9N	14W	Jan., 1954	1,050,996	1,050,996	28,351	28,351	172,375	172,375	69
22,27	9N	14W	Jan., 1954	323,179	323,179	4,617	4,617	8,542	8,542	70

TABLE I (Continued)

DEVELOPMENT AS OF 12-31-54							INJECTION WATER			
Map No.	No. of Wells Inj.	Prod.	Injection Pattern	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Total	Source	Type	Avg. Bbls. Per Day Per Well Per Foot	Average Wellhead Pressure PSI
36	1	5	Flank	—	80	—	Gravel Bed	Fresh	24.5	1,256
37	0*	12	—	20	160	200	Devonian	Brine	*	*
38	1	1	—	—	20	40	Cypress	Brine	48.4	0
39	2	4	Flank	—	40	80	Gravel Bed & Produced	Fresh & Brine	5.3	0
40	4	11	Irregular	10	120	180	Cypress & Produced	Brine	—	—
41	1	2	—	—	—	30	Cypress	Brine	—	—
42	1	1	—	—	10	20	Produced	Brine	3.5	0
43	12	38	—	—	1,200	1,200	Cypress	Brine	63.6	0
44	16	29	Line Drive	113	1,810	1,810	Chester Sands	Brine	44.8	0
45	1	7	Modified Line	—	235	235	Shallow Sand & Produced	Fresh & Brine	68.9	1,149
46	7	11	Alternate Peripheral	—	243	243	Surface & Produced	Fresh & Brine	14.2	250
47	5	15	Modified Line	—	415	415	Shallow Sand & Produced	Fresh & Brine	31.5	998
48	3	8	Modified Peripheral	—	140	150	Gravel Bed	Fresh	6.1	0
49	1	5	—	—	40	60	Shallow Sand & Produced	Fresh & Brine	6.9	20
50	1	6	—	—	40	100	Shallow Sand & Produced	Fresh & Brine	8.8	0
51	1	5	Irregular	—	65	120	Upper Sand & Produced	Brine	22.7	0
52	1	3	Irregular	—	40	40	Gravel Bed	Fresh	16.3	782
53	36	68	5 Spot	20	640	640	Pottsville	Brine	5.9	389
54	11	16	5 Spot	20	310	325	Cypress	Brine	13.8	655
55	3	14	Flank	—	295	295	Shallow Sand & Produced	Fresh & Brine	27.3	517
56	1	2	—	—	20	20	Cypress	Brine	16.1	300*
57	2	3	5 Spot	10	12	50	Shallow Sand	Fresh	—	—
58	1	15	—	—	116	340	Pennsylvanian Sand	Brine	77.8	157
59	2	1	5 Spot	10	15	30	River	Fresh	8.3	492
60	50	50	Modified 5 Spot	20	750	796	Gravel Bed	Fresh	9.5	519
61	50	50	Modified 5 Spot	20	664	664	Gravel Bed	Fresh	3.9	519
62	2	2	5 Spot	10	40	40	Gravel Bed	Fresh	11.0	0
63	14	9	5 Spot	4.5	36	87	Gravel Bed	Fresh	3.5	285
64	27	18	5 Spot	4.4	125	—	Shallow Sand & Produced	Fresh & Brine	—	350
65	29	13	5 spot	4.4	80	—	Shallow Sand & Produced	Fresh & Brine	0.8	350
66	3*	2	5 Spot	4.4	15	65	Shallow Sand	Fresh	1.5*	125
67	15	19	5 Spot	4.4	80	102	Shallow Sand & Produced	Fresh & Brine	2.8	288
68	86	69	5 Spot	4.4	400	—	Produced	Brine	2.2	225
69	66	60	5 Spot	5	243	243	Gravel Bed	Fresh	1.2	245
70	20	13	5 Spot	4.4	53	67	Gravel Bed	Fresh	1.3	245

RESERVOIR STATISTICS (Average Values)						REMARKS	
Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises		Map No.
2,530	6	—	—	36.6	—	* Corrected Figure.	36
3,950	22	10	—	39.8	2.7	* Temporarily shut down as of 3-31-53. ** Includes primary production since start of flood.	37
3,000	5	—	—	38	—	* Includes primary production since start of flood.	38
2,645	8	—	—	40	3.2 @ 75° F.	* Since 4-1-54.	39
3,060	5	—	—	—	—	* As of 1-1-54. Dump flood.	40
2,496	10	—	—	39	—	* Dump flood.	41
2,990	30	—	—	—	—	* Previously affected by dump flood, surface injection began 7-9-53.	42
2,930	10	—	—	36	—		43
3,070	10	13	1 to 300	36	—		44
2,530	6.2	14	—	39.8	2.9 @ 92° F.	* Corrected Figure.	45
3,200	14.8	20.0	80	39	3.7 @ 100° F.		46
2,580	8.2	14	—	39.8	2.9 @ 92° F.	* Corrected Figure.	47
2,980	22	—	—	37.5	—		48
2,960	30	—	—	—	—		49
2,960	30	—	—	—	—	* Corrected Figure.	50
2,960	30	—	—	—	—		51
2,950	12	21.1	218	35.1	5 @ 103° F.	* Corrected Figure.	52
1,230	14	20	250	37	—	* Cooperative: Shell, Magnolia, McBride, Horton.	53
3,125	14.7	23.9	—	—	—	* Total Production since 1-1-53.	54
3,050	14	17	125	38.0	—	Previously subjected to gas injection.	55
2,941	14	16.6	775	37.8	2.5	* Orifice pressure. Dump flood.	56
1,620	—	—	—	35.6	7.5 @ 86° F.	* Corrected Figure, includes primary production since start of flood.	57
3,308	8	—	—	34	—		58
2,400	5.9	16.5	58	36.4	4.2 @ 92° F.		59
2,100	15	17.5	137	37.7	3.6 @ 63° F.	* Also includes J. L. Crawford, Sohio, Sun, Carter leases. ** Includes primary production since start of flood.	60
2,400	9.6	16.8	50	38	3.6 @ 63° F.	* Also includes J. L. Crawford, Sohio, Sun, Carter leases. ** Includes primary production since start of flood.	61
2,100	29	17.9	133	35.5	—		62
400	22	19.2	225	33	13.6		63
450	10 to 30	20.8	399	33.9	19	Previously subjected to gas injection.	64
480	22	18.3	66	33	10 @ 70° F.	Previously subjected to gas injection.	65
440	19	19.8	252	34.5	17 @ 67° F.	* Project temporarily shut down since 2-15-54.	66
425	17	20.6	415	33.9	10.7 @ 70° F.	Subjected to gas injection 1946-1947.	67
490	48	16.6	319	29.2	14.7 @ 77° F.	* Corrected Figure. Previously subjected to gas injection.	68
465	35	18.9	312	29.7	21 @ 65° F.		69
507	33	18.2	277	29.7	25.5 @ 65° F.	Previously subjected to air injection.	70

TABLE I (Continued)

GENERAL INFORMATION

Map No.	Field	Operator	Project	Formation Sand (S), Lime (L)	County
71	Johnson South	Pure	Weaver-Bennett	Upper Partlow (S)	Clark
72	Johnsonville Consol.	Texas	Johnsonville Unit	McClosky (L)	Wayne
73	Junction	J. A. Lewis, Engineering	Junction	Waltersburg (S)	Gallatin
74	Keensburg South	White & Vickery	—	Cypress (S)	Wabash
75	Keenville	W. Duncan	Keenville Unit	Aux Vases (S)	Wayne
76	Kenner West	Phillips	West Kenner Unit	Cypress (S)	Clay
77	Lawrence	George & Wrather	Klondike	Benoist (S)	Lawrence
78	Lawrence	W. W. Holden	Gray	Jackson (S) Benoist (S) Renault (S)	Lawrence
79	Lawrence	National Cylinder & Gas	Snyder	Cypress (S)	Lawrence
80-82	Lawrence	Ohio	3 Projects	Bridgeport (S)	Lawrence
83,84	Lawrence	Ohio	2 Projects	Cypress (S) & Paint Creek (S)	Lawrence
85	Lawrence	Sapphire American	Piper	Cypress (S)	Lawrence
86	Lawrence	Sapphire American	Waller	Cypress (S)	Lawrence
87	Lawrence	H. V. Sherrill	Applegate	Jackson (S) Cypress (S)	Lawrence
88	Livingston	W. H. Krohn	—	Pennsylvanian Sand (S)	Madison
89	Louden	J. P. Babcock	Rhodes & McCloy	Paint Creek (S) Benoist (S)	Fayette
90	Louden	D. L. Burtschi	—	Cypress (Stein) (S)	Fayette
91	Louden	Carter	Louden	Chester Sands (S)	Fayette
92	Louden	Jarvis Brothers & Marcel	Homan	Cypress (S)	Fayette
93	Louden	B. Kidd	Louden	Cypress (Weiler) (S)	Fayette
94	Main Consolidated	Arkansas Fuel	North Morris	Robinson (S)	Crawford
95	Main Consolidated	Ashland	Birds #1	Robinson (S)	Crawford
96	Main Consolidated	E. Constantin	J. S. Kirk	Robinson (S)	Crawford
97	Main Consolidated	E. Constantin	Sanders	Robinson (S)	Crawford
98	Main Consolidated	E. Constantin	Short	Robinson (S)	Crawford
99	Main Consolidated	E. Constantin	Smith	Robinson (S)	Crawford
100	Main Consolidated	E. Constantin	Wood	Robinson (S)	Crawford
101	Main Consolidated	Davison & Ryerson	Little John	Robinson (S)	Crawford
102	Main Consolidated	Franchot	Birds	Robinson (S)	Crawford
103	Main Consolidated	G. M. J.	Porterville	Robinson (S)	Crawford
104	Main Consolidated	Kewanee	Wright	Robinson (S)	Crawford
105	Main Consolidated	A. J. Leverton	Stanfield	Robinson (S)	Crawford
106	Main Consolidated	Logan	Alexander-Reynolds	Robinson (S)	Crawford

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Secondary Recovery Oil Production Total 1954	Secondary Recovery Oil Production Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
27	9N	14W	Jan., 1953	1,680,214	3,226,638	174,291	255,248*	888,999	1,065,348	71
21,26,27,28, 33,34,35	1N	6E	Nov., 1954	74,972	74,972	—	—	—	—	72
3,4 16	1S 9S	6E 9E	May, 1951	171,862	548,313*	49,264	80,989	52,039	107,747	73
27	2S	13W	Nov., 1954	9,594	9,594	142	142	—	—	74
28,29	1S	5E	April, 1954	164,300	164,300	30,700*	30,700*	—	—	75
23	3N	5E	Feb., 1952	965,094	1,998,294	11,246	13,576	52,486	62,539*	76
25	5N	13W	June, 1952	805,122	1,392,647*	136,495	222,429*	3,750	3,750**	77
13	4N	13W	May, 1953	135,042	218,843	4,855	5,311*	8,265	8,615	78
30	3N	11W	Oct., 1952	5,840	15,796	142*	567	36,500	69,350	79
—	—	—	Aug., 1948	6,010,159	20,903,715	1,077,689	3,388,437*	3,206,852	6,803,004	80-82
—	—	—	Jan., 1952	2,438,629	3,616,080	264,626	393,492*	283,728	354,226	83,84
2,11	4N	13W	Dec., 1953	63,246	69,423	18,427*	18,427*	—	—	85
5,6	2N	11W	March, 1953	315,931	725,978	4,250	9,175*	—	—	86
7	4N	12W	Sept., 1952	37,264*	162,495*	771*	3,008*	1,600*	3,600*	87
17	6N	6W	July, 1954	4,500	4,500	None	None	—	—	88
27,34	8N	3E	Jan., 1954	338,357	338,357	1,350	1,350	100	100	89
18	7N	3E	Oct., 1953	86,376	109,543	37,363	37,363	—	—	90
—	7N 8N	3E 3E	Oct., 1950	18,853,155	31,513,478	2,208,564	3,378,612	897,565	1,176,155	91
32	7N	3E	March, 1954	41,048	41,048	—	—	46,121	46,121	92
8	7N	3E	Sept., 1954	38,602	38,602	1,375	1,375	—	—	93
2	7N	13W	April, 1951	186,625	571,070	4,200	25,254	79,140	350,983	94
9,10,15,16	5N	11W	May, 1954	2,001,111	2,001,111	26,298	26,298	73,248	73,248	95
29,30,31,32	7N	12W	Aug., 1951	183,793	232,313	8,795	12,715	72,000	72,000*	96
1,2,3 26,34,35,36	5N 6N	13W 13W	Aug., 1952	1,570,513	2,479,636	21,510	34,140	360,000	360,000*	97
5,6 31,32	6N 7N	13W 13W	Feb., 1952	690,888	1,529,642	51,517	75,764	108,000	108,000*	98
7	7N	12W	March, 1954	150,485	150,485	157	157	300	300	99
12 31,32	7N 8N	13W 12W	Aug., 1952	796,981	1,484,425	36,034	43,494	124,000	124,000*	100
20	6N	12W	Oct., 1952	74,186*	145,480	293	763**	4,618	6,618	101
21,22	5N	11W	June, 1951	1,400,059	3,109,513*	82,505	136,829*	80,000	134,000*	102
25,36	8N	13W	April, 1954	79,500	79,500	1,090*	1,090*	—	—	103
23,26	6N	13W	Jan., 1953	412,539	663,871	709	994*	64,594	105,199	104
17	8N	12W	June, 1952	—	46,800*	—	430*	—	5,300*	105
20	7N	12W	Dec., 1951	245,623	538,456	51,012	68,296	57,400	77,650	106

TABLE I (Continued)

Map No.	No. of Wells Inj.	No. of Wells Prod.	Injection Pattern	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Productive Acreage Total	Source	Type	Avg. Bbls. Per Day Per Well Per Foot	Average Wellhead Pressure PSI
	DEVELOPMENT AS OF 12-31-54						INJECTION WATER			
71	38	34	5 Spot	4.4	114	151	Gravel Bed	Fresh	3.4	245
72	10	142-	Perimeter	—	3,400	3,400	Cypress (Weiler)	Brine	19.2	0
73	11	7	Modified 5 Spot	10	263	263	Gravel Bed	Fresh	3.3	829
74	1	1	—	—	60	60	Gravel Bed	Fresh	—	0
75	3	9	Perimeter	—	120	120	Shallow Sand	Fresh	15.3	—
76	7	20	Edge	10	160	300	Produced	Brine	14.5	630
77	10	14	5 Spot	13.5	195	300	Shallow Sand	Fresh	12.3	667
78	4	2	5 Spot	10	10	120	Pennsylvanian Sand	Brine	2.5	314
79	1	2*	—	2.5	10	230	Tar Springs	Brine	0.6	150**
80-82	107	179	—	—	986	—	Gravel Bed	2 Fresh 1 Brine	—	—
83, 84	65	77	—	—	609	—	Gravel Bed	Fresh	—	—
85	4	2	5 Spot	10	10	380	Shallow Sand	Brine	1.7	573
86	8	8	5 Spot	10	35	625	Gravel Bed	Fresh	2.2	197
87	4*	1	5 Spot	10	10	225	Gravel Bed	Fresh	1.7*	337
88	1	5	—	—	160	—	Pennsylvanian Sand	Brine	1.7	180 to 250
89	6	10	5 Spot	10	140	140	Tar Springs	Brine	6.6	170
90	1	3	—	10	20	—	*	Brine	7.9	150 to 350
91	236	569	5 Spot	20	7,914	16,000	Tar Springs	Brine	7.3	267
92	1	15	—	—	150	400	Produced & Tar Springs	Brine	6.7	4
93	1	4	5 Spot	20	40	50	Tar Springs	Brine	11.7	377
94	5	7	Modified 5 Spot	4.4	44	100	Buchanan	Brine	8.5	470
95	67	53	5 Spot	10	530	580	Pennsylvanian Sand	Brine	4.1	254
96	14	23	5 Spot	10	80	540	City Water	Fresh	0.7	—
97	72	101	5 Spot	10	650	1,640	Lower Pennsylvanian Sand	Brine	3.0	—
98	31	33	5 Spot	10	160	533	Lower Pennsylvanian & 300-Ft. Sands	Brine	2.5	—
99	6	2	5 Spot	10	50	260	Surface	Fresh	3.3	—
100	28	22	5 Spot	10	210	425	Lower Pennsylvanian Sand	Brine	2.6	—
101	2	9	Irregular	4.5	9	100	Lake & Shallow Sand	Fresh	4.2	138
102	32	26	5 Spot	10	245	1,600	Tar Springs	Brine	5.0	350
103	3	13	5 Spot	10	40	400	Lake & Produced	Fresh & Brine	3.3	274
104	15	34	5 Spot	10	113	210	Lake, Produced & Pennsylvanian Sand	Fresh & Brine	5.0	386
105	3	3	5 Spot	4.4	20	140	Shallow Sand & Produced	Fresh & Brine	—	—
106	16	20	5 Spot	—	60	330	Cypress	Brine	1.9	337

RESERVOIR STATISTICS (Average Values)						REMARKS	
Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises		Map No.
467	35.5	18.6	285	29.7	25.5 @ 65° F.	* Corrected Figure.	71
3,100	10	15.5	850	—	—		72
1,750	14	13.4	22	34.7	6.7 @ 81° F.	* Corrected Figure.	73
2,403	15	20.6	134	37.5	4.6 @ 91° F.		74
2,950	13	20	155	—	—	* Includes primary production since start of flood.	75
2,600	26	18	125	—	—	* Corrected Figure.	76
1,625	18	17.2	80	37.8	5.2 @ 80° F.	* Corrected Figure. ** Since 1-1-54.	77
1,428	8	18.4	93	—	5 @ 85° F.	* Includes primary production since 1-1-53.	78
1,611	14.5	14.6	15				
1,632	15	18.5	17				
1,580	25	21.2	125	38.6	4.1 @ 85° F.	* Temporarily shut down since 11-1-54. ** Sand face pressure. Dump flood.	79
—	—	—	—	—	—	* Includes primary production since start of floods. Previously subjected to gas injection.	80-82
—	—	—	—	—	—	* Includes primary production since start of floods.	83, 84
1,520	25	20.8	33	38.6	3.5 @ 86° F.	* Includes primary production since 1-1-54.	85
1,535	50	18.5	70	39.5	5 @ 85° F.	* Includes primary production since 1-1-53.	86
1,320	22.7	20.1	62	34.7	4.3 @ 81° F.	* Project temporarily shut down since 8-24-54. Pilot flood.	87
1,384	10	20.8	29				88
520	15	—	—	33.5	—		
1,554	25	—	—	36	—	Previously subjected to gas injection.	89
1,584							
1,492	30	—	—	—	—	* Water supplied by Carter. Previously subjected to gas injection.	90
1,500	30	20	105	38	2.6 @ 79° F.	Previously subjected to gas injection.	91
1,560	20	—	—	36	—		92
1,450	27	—	—	38(est.)	—		93
983	12	21	243	32	73 @ 65° F.	Pilot flood. Previously subjected to gas injection.	94
950	30	21	136	31	15 @ 75° F.		95
900	50	17	170	34	—	Previously subjected to gas injection. * Since 1-1-54.	96
880	20	21	205	32	—	Previously subjected to gas injection. * Since 1-1-54.	97
850	30	22	130	32	—	Previously subjected to gas injection. * Since 1-1-54.	98
900	25	18.0	70	34	—	Previously subjected to gas injection.	99
850	30	21	105	32	—	Previously subjected to gas injection. * Since 1-1-54.	100
850	24	20.0	50	—	10 @ 78° F.	* No water injected 6/54-8/54. ** Incl. primary production since start of flood. Previously subjected to gas injection.	101
850*	24	18.9	162	31.7	21 @ 60° F.	* Corrected Figure.	102
900	30	17.2	45	38.6	—	* Includes primary production since start of flood.	103
900	15	20	245	—	—	* Corrected Figure. Previously subjected to gas injection.	104
977	30	23	57	36	—	* As of 1-1-54.	105
940	22	20.5	167	36	7 @ 80° F.		106

TABLE I (Continued)

GENERAL INFORMATION

Map No.	Field	Operator	Project	Formation Sand (S) Lime (L)	County
107	Main Consolidated	Mahutska	Oil Center	Robinson (S)	Crawford
108	Main Consolidated	National Cylinder & Gas	Culver	Robinson (S)	Crawford
109	Main Consolidated	National Cylinder & Gas	Culver (Extension)	Robinson (S)	Crawford
110	Main Consolidated	National Cylinder & Gas	Meserve	Robinson (S)	Crawford
111-118	Main Consolidated	Ohio	8 Projects	Robinson (S)	Crawford
119	Main Consolidated	Partlow & Cochonour	Rich	Robinson (S)	Crawford
120	Main Consolidated	Petroleum Producing	—	Robinson (S)	Crawford
121	Main Consolidated	W. L. Pickens	Hughes-Robinson	Robinson (S)	Crawford
122	Main Consolidated	Red Head	"DIM"	Upper & Lower Robinson (S)	Crawford
123	Main Consolidated	E. C. Reeves	Billingsley	Robinson (S)	Crawford
124	Main Consolidated	Sapphire American	Bishop	Robinson (S)	Crawford
125	Main Consolidated	Sapphire American	Grogan	Robinson (S)	Crawford
126	Main Consolidated	Sapphire American	Mitchell	Robinson (S)	Crawford
127	Main Consolidated	Shakespeare	McIntosh Unit	Robinson (S)	Crawford
128	Main Consolidated	Shakespeare	Montgomery Unit	Robinson (S)	Crawford
129	Main Consolidated	Skiles	Correll-Gurley	Robinson #4 (S)	Crawford
130	Main Consolidated	Skiles	Weger	Robinson (S)	Crawford
131	Main Consolidated	Tide Water	Barrick Walters	Robinson (S)	Crawford
132	Main Consolidated	Tide Water	Birch #1	Robinson (S)	Crawford
133	Main Consolidated	Tide Water	Birds Area	Robinson (S)	Crawford
134	Main Consolidated	Tide Water	Clarke-Hulse	Robinson (S)	Crawford
135	Main Consolidated	Tide Water	Dennis-Hardin	Robinson (S)	Crawford
136	Main Consolidated	Tide Water	Henry-Ikemire	Robinson (S)	Crawford
137	Main Consolidated	Tide Water	W. A. Howard	Robinson (S)	Crawford
138	Main Consolidated	Tide Water	Lefever-Musgrave	Robinson (S)	Crawford
139	Main Consolidated	Tide Water	Montgomery-Seitzinger	Robinson (S)	Crawford
140	Main Consolidated	Tide Water	Stahl-Walters	Robinson (S)	Crawford
141	Main Consolidated	Tide Water	Stifle-Drake	Robinson (S)	Crawford
142	Main Consolidated	Tide Water	G. L. Thompson	Robinson (S)	Crawford
143	Main Consolidated	Wilson	Hughes-Walker	Robinson (S)	Crawford
144	Main Consolidated	Yingling	Lindsay	Robinson (S)	Crawford
145	Maple Gr. Consolidated	Ashland	Bennington	McClosky (L)	Edwards
146	Markham City West	Gulf	West Markham City Unit	Aux Vases (S) McClosky (L)	Jefferson
147	Martinsville	Magnolia	Carper	Carper (S)	Clark
148	Martinsville	Magnolia	Casey	Casey (S)	Clark

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Secondary Recovery Oil Production Total 1954	Secondary Recovery Oil Production Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
10,15	6N	13W	May, 1954	465,000	465,000	6,212	6,212	—	—	107
5,6,7	7N	12W	Feb., 1953	290,056	469,165	1,062	1,809*	29,550	37,470	108
18	7N	12W	March,1954	72,206	72,206	None	None	None	None	109
11	6N	13W	Nov., 1953	163,414*	189,965	682	828**	26,380	26,410	110
—	—	—	May, 1948	9,502,405	28,692,128	641,066	2,310,866*	3,188,706	8,729,332	111-118
35	6N	12W	Oct., 1954	6,000	6,000	61	61	180	180	119
29,32	8N	12W	Sept., 1951	89,280	264,855	—	—	—	—	120
22,27,28	6N	13W	June, 1951	884,230	1,339,020	62,815	88,925	203,606	215,106	121
25,26	6N	13W	July, 1953	336,614	375,980	3,838	3,838*	—	—	122
34,35	7N	13W	Dec., 1953	359,828	371,828	8,091	8,091*	645	645*	123
20	8N	12W	Nov., 1953	75,893	86,865	347	347*	—	—	124
4,9	7N	13W	Oct., 1953	84,228	135,945	462	615*	—	—	125
24,25	7N	13W	June, 1953	92,424	150,625	8,616	11,185*	—	—	126
17,18,19,20	6N	12W	July, 1954	28,290	28,290	None	None	2,675	2,675	127
4	5N	12W	May, 1954	42,347	42,347	None	None	5,700	5,700	128
32,33 10	6N 7N	12W 12W	July, 1951	395,955	1,003,769*	11,133	25,437*	82,100	155,160	129
18,19	5N	11W	Nov., 1952	233,098	443,107*	1,692	1,847	24,000	40,000	130
13,24 19	5N 7N	12W 12W	March, 1954	189,383	189,383	6,948	6,948	15,250	15,250	131
14	6N	13W	Aug., 1954	55,063	55,063	3,784	3,784	1,530	1,530	132
16,20,21	5N	11W	Feb., 1952	297,657	483,129	21,465	31,018	109,500	227,245	133
18	7N	13W	Jan., 1952	297,026	495,368	32,574	56,933	77,750	136,717	134
27,34	6N	13W	Aug., 1950	566,751	1,657,840	130,078	243,793	292,000	653,480	135
10,15	7N	13W	Feb., 1948	488,787	2,279,888	50,598	313,078*	283,000	977,440	136
11	7N	13W	Dec., 1952	86,155	192,197	7,138	14,456	52,050	91,090	137
13	7N	14W	Feb., 1954	142,556	142,556	4,430	4,430	8,173	8,173	138
15,16	5N	11W	May, 1954	42,983	42,983	1,092	1,092	14,580	14,580	139
13,14	7N	13W	Nov., 1954	8,406	8,406	164	164	305	305	140
10	7N	13W	June, 1952	186,026	469,769	8,433	8,433	42,000	96,426	141
26,27	6N	13W	Sept., 1952	152,103	290,790	10,674	12,070	16,425	19,357	142
26	6N	13W	Aug., 1950	—	—	13,407*	39,604*	39,800	56,290	143
16	5N	11W	Aug., 1950	35,497	2,252,848	18,240	91,900	—	—	144
7	IN	10E	Sept., 1952	17,950	100,550	20,989	38,064*	30,385	30,385**	145
3,4,9,10	3S	4E	April, 1954	143,441	143,441	3,410	3,410	32,976	32,976	146
30	10N	13W	Jan., 1951	157,298	1,110,949	2,347	10,055*	1,868	8,366	147
19	10N	13W	Aug., 1950	None*	872,185	126*	2,345**	3,337*	33,505	148

TABLE I (Continued)

	DEVELOPMENT AS OF 12-31-54						INJECTION WATER			
Map No.	No. of Wells Inj.	No. of Wells Prod.	Injection Pattern	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Productive Acreage Total	Source	Type	Avg. Bbls. Per Day Per Well Per Foot	Average Wellhead Pressure PSI
107	14	22	5 Spot	4.4	100	100	Pond, Shallow Sand, & Produced	Fresh & Brine	9.0	63
108	8	8	5 Spot	10	20	710	Lake	Fresh	2.0	269
109	2	0	5 Spot	4.5	6	114	Lake	Fresh	8.1	185
110	4	4	5 Spot	10	10	525	Pennsylvanian Sand	Brine	4.9	44
111-118	274	365	—	—	1,787	—	Gravel Bed —	4 Fresh 4 Fresh & Brine	—	—
119	3	7	Line Drive	5	40	100	Pennsylvanian Sand	Brine	1.9	175
120	4	2	5 Spot	10	40	700	Shallow Sand and Pond	Fresh	4.1	—
121	15	12	5 Spot	10	40	298	Shallow Sand	Fresh	5.4	350
122	16	10	5 Spot	10	103	—	Surface and Shallow Sand	Fresh and Brine	—	400
123	6	7	5 Spot	10	115	350	Pennsylvanian Sand	Brine	8.2	123
124	4	1	5 Spot	10	10	350	Pennsylvanian Sand	Brine	2.3	183
125	8	3	5 Spot	10	25	400	Pennsylvanian Sand	Brine	1.3	126
126	6	15	5 Spot	10	20	195	Pennsylvanian Sand	Brine	1.9	304
127	2	11	Peripheral	4.7	16	42	Pennsylvanian Sand	Brine	7.5	56
128	—	—	Modified 5 Spot	6 to 10	—	—	Pennsylvanian Sand	Brine	—	285
129	18	17	5 Spot	10	180	—	Creek and Pennsylvanian Sand	Fresh and Brine	3.0	563
130	9	11	5 Spot	10	90	110	Creek and Produced	Fresh and Brine	3.5	408
131	8	27	5 Spot	10	130	300	Mississippian Sand	Brine	4.1	158
132	2	11	5 Spot	10	20	80	Gravel Bed	Fresh	12.9	208
133	14	32	5 Spot	10	113	277	Tar Springs	Brine	3.2	300
134	13	21	5 Spot	7	59	98	Gravel Bed	Fresh	3.1	359
135	10	18	5 Spot	10	89	93.5	Gravel Bed	Fresh	4.6	315
136	22	44	5 Spot	4.4	100	115	Gravel Bed and Pennsylvanian Sand	Fresh and Brine	4.3	480
137	7	10	5 Spot	10	50	90	Gravel Bed and Pennsylvanian Sand	Fresh and Brine	2.6	351
138	6	9	5 Spot	10	25	110	—	Fresh	3.8	331
139	2	9	—	—	20	40	Tar Springs	Brine	6.3	202
140	4	5	—	—	25	25	Gravel Bed	Fresh	2.2	315
141	6	12	5 Spot	10	35	160	Pennsylvanian Sand	Brine	5.7	350
142	4	7	5 Spot	10	40	40	Gravel Bed	Fresh	5.0	339
143	8*	8	—	—	40*	40	Gravel Bed and Produced	Fresh and Brine	—	—
144	23	24	5 Spot	4.4.	160	360	1,300-Ft. Sand	Brine	0.1	500
145	1	7	Flank	—	110	110	Produced	Brine	9.8	0
146	4*	21	Flank	—	154 100	302 230	Cypress	Brine	—	104
147	4**	1	5 Spot	10**	10	50	Gravel Bed	Fresh	—	—
148	8*	3	5 Spot	10	23	110	Gravel Bed	Fresh	—	—

RESERVOIR STATISTICS (Average Values)						REMARKS	
Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises		Map No.
925	20	19.5	80	33	—	Previously subjected to gas injection.	107
950	50	22.7	101	—	10 @ 78° F.	* Includes primary production since 1-1-53.	108
945	14	20.8	154	32.4	—		109
950	22.7	21.9	89	—	10 @ 79° F.	* No water injected Oct. and Nov., 1954. ** Includes primary production since 1-1-53.	110
—	—	—	—	—	—	* Includes primary production since start of floods. Previously subjected to gas injection.	111-118
1,006	12	24.3	240	26	—		119
1,000	15	20	75	—	—		120
850	30	19.5	125	32	10 @ 80° F.		121
830	10	—	—	31	—	* Since 1-1-54. Previously subjected to gas injection.	122
925	20	30	45	35	—	* Since 1-1-54.	123
950	22.4	22.1	156	35.7	10 @ 78° F.	* Includes primary production since 1-1-54.	124
950	22.4	22.1	156	35	10 @ 78° F.	* Includes primary production since 1-1-53.	125
880	22.0	23.8	94	33.2	10 @ 78° F.	* Includes primary production since 1-1-53.	126
900-950	10	—	—	32.6	11.0		127
950-1,000	21	22.6	150	27.5	—		128
1,035	20	22.2	100	33	13.5 @ Reservoir temp.	* Corrected figure. Previously subjected to gas injection.	129
900	20	17	37	—	—	* Corrected figure.	130
950	19	20	152	35	7 @ 60° F.		131
881	14	19.1	108	32	—		132
950	18	19.4	197	30.1	—	Subjected to gas injection, 1946 to 1952.	133
910	20	19.9	278	34	—	Subjected to gas injection since 1941.	134
875	34	19.8	178	32.7	—	Subjected to gas injection, 1932 to 1950.	135
935	14	21	175	35	7 @ 60° F.	* Corrected figure. Subjected to gas injection, 1934 to 1948.	136
950	13	19.6	184	35.3	—	Subjected to gas injection, 1935 to 1953.	137
910	20	20.0	250	34	—		138
979	14	19	144	32	—		139
987	19	—	—	—	—		140
980	15	18.2	221	33.5	—	Subjected to gas injection since 1934.	141
860	21	19.8	108	33	—		142
880	25	19	83	32	—	* Due to Ohio line input wells. Previously subjected to gas injection.	143
960	31	19.1	135	31.6	17 @ 80° F.		144
3,100	5	—	—	38	—	* Includes primary production since start of flood. ** Since 1-1-54.	145
2,900	11.8	22.1	269	38	3.2 @ 99° F.	* Pilot flood, south end of field.	146
3,000	7	15.4	230	38	2.8 @ 104° F.		
1,334	—	—	—	—	—	* Includes primary production since start of flood. ** Pilot flood.	147
464	—	—	—	—	—	* Temporarily shut down. ** Includes primary production since start of flood.	148

TABLE I (Continued)

GENERAL INFORMATION

Map No.	Field	Operator	Project	Formation Sand (S), Lime (L)	County
149	Mattoon	Carter	Mattoon	Cypress (S) Rosiclare (S)	Coles
150	Mattoon	Phillips*	Mattoon	Rosiclare (S)	Coles
151	Maunie South	Magnolia	Palestine Sand Unit	Palestine (S)	White
152	Maunie South	Magnolia	Tar Springs Unit	Tar Springs (S)	White
153	Maunie South	Magnolia	Tar Springs Unit #2	Tar Springs (S)	White
154	Mill Shoals	Sohio	B. R. Gray, Trustee	Aux Vases (S)	Hamilton
155	Mt. Carmel	G. S. Engle	G. Dunkel	Biehl (S)	Wabash
156	Mt. Carmel	First National Petroleum Trust	Shaw Courter	Biehl (S)	Wabash
157	Mt. Carmel	O'Meara Brothers	Mt. Carmel	Cypress (S)	Wabash
158	Mt. Carmel	Shell	Mt. Carmel Unit	Cypress (S)	Wabash
159	Mt. Carmel	Texas	Stein	Tar Springs (S)	Wabash
160	New Harmony Consol.	Calstar	Ford "B"*	Bethel (S)	White
161	New Harmony Consol.	Calstar	Ford "B"*	Aux Vases (S)	White
162	New Harmony Consol.	Herndon and Ashland	Calvin	Aux Vases (S)	White
163	New Harmony Consol.	Inland	Bowman's Bend Unit	Tar Springs (S)	White
164	New Harmony Consol.	Luboil	Helm	Waltersburg (S)	Wabash
165	New Harmony Consol.	Luboil	Helm	Bethel (S)	Wabash
166	New Harmony Consol.	Luboil	Helm	Aux Vases (S)	Wabash
167	New Harmony Consol.	Phillips	Schultz	Upper Cypress (S)	Wabash
168	New Harmony Consol.	Phillips	Schultz	Lower Cypress (S)	Wabash
169	New Harmony Consol.	Skiles	East Maud	Cypress (S)	Wabash
170	New Harmony Consol.	Skiles	East Maud*	Bethel (S)	Wabash
171	New Harmony Consol.	Skiles	Siegert Bottoms	Bethel (S)	Edwards Wabash
172	New Harmony Consol.	Skiles	West Maud	Bethel (S)	Wabash
173	New Harmony Consol.	Sun	Ford "B"*	Bethel (S)	White
174	New Harmony Consol.	Sun	Ford "B"*	Aux Vases (S)	White
175	New Harmony Consol.	Sun	Greathouse	Cypress (S)	White
176	New Harmony Consol.	Sun	Greathouse	Bethel (S)	White
177	New Harmony Consol.	Sun	Greathouse	McClosky (L)	White
178	New Harmony Consol.	Superior	Kern-Hon Unit	Upper Tar Springs (S)	White
179	New Harmony Consol.	Superior	Waltersburg Sand Unit	Waltersburg (S)	White, Illinois & Posey, Indiana
180	New Harmony Consol.	Tide Water	E. S. Dennis "A"	Bethel (S)	White
181	New Harmony Consol.	Tide Water	O. R. Evans	Aux Vases (S)	White
182	New Haven Consol.	Hiawatha	New Haven Unit	Tar Springs (S)	White
183	New Haven Consol.	Hiawatha	New Haven Unit	Cypress (S)	White
184	Odin	Ashland	Odin	Cypress (S)	Marion
185	Olney Consolidated	Texas	East Olney Unit	McClosky (L)	Richland

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Secondary Recovery Oil Production Total 1954	Secondary Recovery Oil Production Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
35	12N	7E	May, 1952	689,191	1,120,486	43,071	79,549	125,346	163,977	149
22	12N	7E	Nov., 1950	119,459	248,682	2,712	3,571	54,894	86,926	150
13,24	6S	10E	Feb., 1953	1,596,131	2,332,381	583,540	650,028*	264,639	276,127	151
24 19	6S 6S	10E 11E	Aug., 1947	719,348	4,062,872	17,258	772,267*	386,374	1,638,023	152
24 19	6S 6S	10E 11E	Nov., 1949	42,008	639,215	1,224	60,344*	9,641	208,636	153
1	4S	7E	May, 1952	258,880	606,223	105,349	137,844*	44,106	69,361	154
5	1S	12W	June, 1952	—	75,610*	—	11,747*	—	—	155
7	1S	12W	Feb., 1950	—	—	—	—	—	—	156
17	1S	12W	July, 1954	192,952	192,952	25	25	—	—	157
17,18	1S	12W	July, 1954	288,541	288,541	230	230	2,074	2,074	158
5,8	1S	12W	Feb., 1952	98,868	220,457*	23,328	39,434	43,237	61,697	159
21	4S	14W	March, 1953	132,332	182,130	21,208	21,208	13,099	13,099	160
21	4S	14W	March, 1953	49,928	104,806	None	None	None	None	161
8	4S	14W	Nov., 1952	337,142	496,354*	—	21,349**	—	—	162
15,16,21,22	5S	14W	Dec., 1953	482,035	492,592	131,093*	131,093*	77,839	77,839	163
22	3S	14W	Dec., 1950	—	—	—	—	—	—	164
22	3S	14W	Dec., 1951	—	—	—	—	—	—	165
22	3S	14W	Dec., 1951	—	—	—	—	—	—	166
7	3S	14W	May, 1952	196,088	480,374	4,489	36,936	126,857	180,285	167
7	3S	13W	July, 1951	486,761	1,290,122	15,691	75,882	409,989	771,390	168
32,33 4,5	1S 2S	13W 13W	Nov., 1952	122,482	213,451	12,000	16,385	72,000	85,000	169
32,33 4,5	1S 2S	13W 13W	April, 1952	134,718	379,094	94,475	112,500	36,000	42,450	170
34 2,3,10	2S 3S	14W 14W	Oct., 1951	310,219	1,096,280*	145,880	282,446	42,000	48,680	171
32 5	1S 2S	13W 13W	Oct., 1950	253,984	936,055*	121,122	263,830*	108,000	135,800	172
21	4S	14W	March, 1953	82,534	132,608	4,917	4,917	1,716	1,716	173
21	4S	14W	March, 1953	38,911	85,465	None	None	None	None	174
33	4S	14W	Jan., 1953	54,940	208,055	None	None	None	None	175
33 4	4S 5S	14W 14W	Jan., 1949	393,811	1,909,115	59,441	138,833	84,628	333,085	176
33 4	4S 5S	14W 14W	Aug., 1947	117,084	873,369	13,324	111,374	33,367	167,783	177
32,33	4S	14W	Feb., 1954	161,626	161,626	74,661	74,661	9,340	9,340	178
4,5,9,10	5S	14W	Aug., 1946	4,761,951*	9,598,054*	317,372*	1,165,351*	345,021*	994,186*	179
28,33	4S	14W	July, 1951	1,845,219	4,499,272	137,679	322,624	331,242	531,370	180
4,5	4S	14W	Oct., 1949	251,922	624,639	16,662	76,848	67,329	118,373	181
17	7S	11E	July, 1954	3,916	3,916	5,085*	5,085*	300	300	182
17	7S	11E	July, 1954	101,343	101,343	4,902*	4,902*	600	600	183
1,12,13 6,7,18	2N 2N	1E 2E	Oct., 1949	503,174	2,080,024	119,033	1,016,033	383,800	383,800*	184
23,24,25,26	4N	10E	March, 1951	319,127	598,380	18,281	26,116	23,718	62,569	185

TABLE I (Continued)

	DEVELOPMENT AS OF 12-31-54						INJECTION WATER			
No. Map	No. of Wells Inj.	Prod.	Injection Pattern	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Total	Source	Type	Avg. Bbls. Per Day Per Well Per Foot	Average Wellhead Pressure PSI
149	14	22	5 Spot	20	231	360	Pennsylvanian Sand	Brine	10.4	427
150	2	5	Irregular	—	30	60	Produced	Brine	16.3	0
151	21	22	5 Spot	20	237	430	Gravel Bed	Fresh	—	—
152	12	12	5 Spot	20	230	240	Gravel Bed and Produced	Fresh and Brine	—	—
153	3	2	5 Spot	20	50	50	Gravel Bed and Produced	Fresh and Brine	—	—
154	7	6	5 Spot	20	170	170	Gravel Bed	Fresh	9.2	125
155	1	3	Modified	28.9	87	68	Shallow Sand	Fresh	—	—
156	1	2	Spot	—	30	30	Shallow Sand and Produced	Fresh and Brine	—	—
157	6	15	—	—	234	—	Shallow Sand	Fresh	17.5	296
158	12	22	5 Spot	20	325	570	Gravel Bed	Fresh	9.6	113
159	2	8	—	—	30*	73	Shallow Sand and Produced	Fresh and Brine	11.7	876
160	1*	3	—	20	20*	35	Gravel Bed	Fresh	30.2	665
161	1*	4	—	20	20*	80	Gravel Bed	Fresh	3.4	1,285
162	9	15	5 Spot	10	170	170	—	Fresh	—	—
163	3	19	Peripheral	—	200	200	Gravel Bed	Fresh	22.6	47
164	3	4	Irregular	3.3	10	15	Shallow Sand	Fresh	—	—
165	15	17	5 Spot	12	180	300	Shallow Sand	Fresh	—	—
166	8	10	Irregular & 5 Spot	12	50	150	Shallow Sand	Fresh	—	—
167	1	2	—	—	9	30	Shallow Sand and Produced	Fresh and Brine	53.7	474
168	2	5	Irregular	—	21	70	Shallow Sand and Produced	Fresh and Brine	33.3	719
169	2	12	5 Spot	20	20	100	Creek and Shallow Sand	Fresh	20.9	1,383
170	6	20	5 Spot	20	60	140	Creek and Shallow Sand	Fresh	7.2	383
171	18	21	5 Spot	20	170	—	Gravel Bed	Fresh	1.7	1,100
172	17	26	5 Spot	20	340	—	Creek and Shallow Sand	Fresh	9.2	1,383
173	1*	1	—	—	10*	20	Gravel Bed	Fresh	18.8	271
174.	1*	4	—	—	20*	80	Gravel Bed	Fresh	10.7	1,306
175	1*	—	—	—	10*	—	Gravel Bed	Fresh	15.1	966
176	6	10	5 Spot	20	130	—	Gravel Bed	Fresh	7.8	1,356
177	1	2	Flank	—	100	—	Gravel Bed	Fresh	64.1	1,385
178	3	8	Modified Split Line	—	121	121	Gravel Bed	Fresh	12.4	984
179	7	24	Split Line	—	725	725	Shallow Sand and Produced	Fresh and Brine	43.3	593
180	18	18	5 Spot	10	160	185	Gravel Bed and Produced	Fresh and Brine*	9.4	887
181	4	9	5 Spot	20	140	160	Shallow Sand	Fresh	7.2	1,304
182	3	5	—	—	—	—	Shallow Sand	Fresh	0.7	749
183	6	6	—	—	—	—	Shallow Sand	Fresh	9.3	749
184	10	22	Perimeter	—	230	290	Tar Springs	Brine	9.2	515
185	3	19	Flank	—	460	515	Cypress (Weiler) and Produced	Brine	54.9	714

RESERVOIR STATISTICS (Average Values)						REMARKS	
Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises		No. Map
1,750	13	16	84	39	1.7 @ 85° F.		149
1,950 1,952	10	15	990	37	—	* To be operated by Noknil, effective 1-1-55.	150
2,010	—	—	—	—	—	* Includes primary production since start of flood, corrected figure.	151
2,270	—	—	—	37.3	4.6 @ 89° F.	* Includes primary production since start of flood, corrected figure.	152
2,275	—	—	—	—	—	* Includes primary production since start of flood, corrected figure.	153
3,245	11	21	—	—	—	* Includes primary production since 1-1-53.	154
1,500	6.7	15.3	310	36.6	3.9 @ 104° F.	* As of 1-1-54. Oil production includes primary since start of flood.	155
1,375	16	—	—	40.2	4.7 @ 70° F.		156
2,140	10	—	—	33	—		157
2,075	13.6	19	182	—	—		158
2,040	11.6	18.9	221	36	4.0	* Corrected figure.	159
2,695	12	—	—	37.5	3.7 @ 96° F.	* Cooperative pilot flood with Sun.	160
2,850	40	—	—	33.1	3.7 @ 98° F.	* Cooperative pilot flood with Sun.	161
2,800	30	14	10	41	—	* Corrected figure. ** As of 1-1-54.	162
2,260	19.5	17.9	120	35.5	—	* Includes primary production since 1-1-54.	163
2,115	25	20.1	171	—	—		164
2,640	14	17.1	44	—	—		165
2,750	12	16	20	—	—		166
2,500	10	—	—	—	—		167
2,500	20	18	50	—	—		168
2,400	8	18.5	75	36.2	5.0 @ 90° F.		169
2,520	8.5	17	57	36.1	5.1 @ 94° F.	* Includes George and Wrather's Beckerman and Ceney leases.	170
2,680	18	17	75	36.5	3.8 @ 81° F.	* Corrected figure.	171
2,620	12	17.2	57	37	4.6 @ Reservoir Temp.	* Corrected figure.	172
2,696	12	—	—	32.5	—	* Cooperative pilot flood with Calstar.	173
2,855	10	13 (est.)	30 (est.)	32.5	—	* Cooperative pilot flood with Calstar.	174
2,650	10	—	—	36.9	—	* Pilot flood. Previously subjected to gas injection.	175
2,750	23.2	18	20	36.9	—	Previously subjected to gas injection.	176
2,900	5	—	—	36.9	—		177
2,250	13.3	17.3	44	38	5.5 @ 85° F.		178
2,200	43	19.2	475	36.8	2.9 @ 86° F.	* Includes Indiana data. Previously subjected to gas injection.	179
2,700	30	16	50	39	2.2 @ 92° F.	* Two separate injection systems. Previously subjected to gas injection.	180
2,800	24	14.5	50	39	—	Previously subjected to gas injection.	181
2,110	11	—	—	—	—	* Includes primary production since start of flood.	182
2,445	10	—	—	—	—	* Includes primary production since start of flood.	183
1,700	15	20	78	38	8.3 @ 69° F.	* Since 1-1-54.	184
3,100	5.3	13.8	522	36	2.6 @ 99° F.		185

TABLE I (Continued)

Map No.	Field	Operator	Project	GENERAL INFORMATION Formation Sand (S), Lime (L)	County
186	Oskaloosa	Texas	Oskaloosa Unit	Benoist (S)	Clay
187	Patoka	Sohio	Patoka Benoist	Benoist (S)	Marion
188	Patoka	Sohio	Patoka Rosiclare	Rosiclare (S)	Marion
189	Patoka	Sohio	Stein Unit	Cypress (Stein) (S)	Marion
190	Phillipstown Consol.	C. E. Brehm	Phillipstown Unit "A"	Pennsylvanian Sand (S)	White
191	Phillipstown Consol.	C. E. Brehm	Phillipstown Unit "B"	Cypress (S)	White
192	Phillipstown Consol.	British American	North Calvin	Pennsylvanian # 7 Sand (S)	White
193	Phillipstown Consol.	Magnolia	Schmidt-Seifried	Biehl (S)	White
194	Phillipstown Consol.	Phillips	Flora	Degonia (S)	White
195	Phillipstown Consol.	Phillips	Laura	Bethel (S)	White
196	Phillipstown Consol.	Sun	Phillipstown*	Tar Springs (S)	White
197	Phillipstown Consol.	Yingling	Grayville Unit	Lower Cypress (S)	White
198	Roland Consolidated	Carter	Stokes Unit	Hardinsburg (S)	White
199	Roland Consolidated	Indiana Farm Bureau	Omaha	Waltersburg (S)	Gallatin
200	Roland Consolidated	Shell	Iron Unit	Hardinsburg (S)	White
201	St. James	H. Rosenthal	Washburn	Cypress (S)	Fayette
202	Ste. Marie	J. R. Randolph	Ste. Marie	McClosky (L)	Jasper
203	Sailor Spgs. Consol.	Ashland	Bible Grove	McClosky (L)	Effingham
204	Sailor Spgs. Consol.	Cities Service	Wyatt	Aux Vases (S)	Clay
205	Sailor Spgs. Consol.	W. C. McBride	Duff Cypress	Cypress (S)	Clay
206	Salem Consolidated	Texas	Rosiclare Sand Unit	Rosiclare (S)	Marion
207	Salem Consolidated	Texas	Salem Unit	Benoist (S)	Marion
208	Salem Consolidated	Texas	Salem Unit	Renault (S) Aux Vases (S)	Marion
209	Salem Consolidated	Texas	Salem Unit	McClosky (L)	Marion
210	Salem Consolidated	Texas	Salem Unit	Devonian (L)	Marion
211	Samsville North	Ashland	West Salem	Benoist (S)	Edwards
212	Seminary	Pure	Seminary	McClosky (L)	Richland
213	Siggins	Bell Brothers	Flood #1	Upper Siggins (S)	Cumberland
214	Siggins	L. Fikes	Vevay Park	Siggins (S)	Cumberland
215	Siggins	Forest	Siggins	First Siggins (S)	Cumberland
216	Siggins	Pure	Union Group	1st. Siggins (S) 2nd. Siggins (S)	Clark Cumberland
217	Siggins	Ree*	Siggins	Casey (S)	Clark Cumberland
218	Stanford South	Gulf	South Stanford Unit	Aux Vases (S)	Clay
219	Storms Consolidated	Mabee	—	Waltersburg (S)	White
220	Stringtown	N. C. Davies	Stringtown	McClosky (L)	Richland
221	Stringtown	Helmerich & Payne	Stringtown	McClosky (L)	Richland
222	Stringtown	Noknil	—	McClosky (L)	Richland

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Secondary Recovery Oil Production Total 1954	Secondary Recovery Oil Production Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
26,27,34,35	4N	5E	Jan., 1953	884,907	1,466,505	197,331	270,160	213,801	238,111	186
20,21,28,29	4N	1E	Sept., 1943	3,544,057	35,380,455	83,682	6,072,458	2,961,955	25,842,907	187
21,28,29	4N	1E	1948	659,909	3,644,952	79,360	1,189,874*	234,365	1,038,566	188
28	4N	1E	Aug., 1951	103,219	280,334	12,265	36,125*	68,595	166,716	189
30 19,30	4S 4S	11E 14W	June, 1952	81,230	171,309	16,816	39,836*	3,110	8,570	190
19 19	4S 4S	11E 14W	Jan., 1954	27,947	27,947	12,796	12,796	None	None	191
31	3S	14W	June, 1951	286,441	1,280,686*	167,988	809,151	134,379	339,511	192
30,31	3S	11E	May, 1951	146,983	692,511	47,898	335,581*	77,653	180,466	193
24	4S	10E	Sept., 1953	112,931	147,650	25,378	30,639	63,828	73,737	194
19	4S	11E	March, 1952	5,300*	30,550	None	None	None	None	195
6	5S	11E	Jan., 1953	6,068*	57,598*	None*	None*	83,086*	251,333*	196
20	3S	14W	Aug., 1954	53,187	53,187	210	210	None	None	197
5	6S	9E	July, 1954	208,099	208,099	—	—	197	197	198
20,21,28,29	7S	8E	March, 1953*	—	593,951**	—	None**	—	13,500**	199
23,24,25	6S	8E	Dec., 1950	1,132,921	4,498,153	342,338	812,703	390,826	692,828*	200
30	6N	3E	March, 1954	70,000	70,000	26,600	26,600	—	—	201
5,6,7,8	5N	14W	Oct., 1948	255,500*	1,361,500*	14,600	104,908**	—	—	202
29	6N	7E	July, 1954	44,800	44,800	4,048*	4,048*	555	555	203
13	5N	7E	Sept., 1953	72,488	92,272	7,977	8,274	32,795	32,795	204
35	4N	7E	July, 1953	—	21,150*	—	4,232*	—	5,000*	205
15	1N	2E	April, 1950	195,233	837,447	8,320	55,441	25,176	87,210	206
—	1N 2N	2E 2E	Oct., 1950	28,762,104	44,423,964	2,128,178	2,266,635	3,159,503	4,343,362*	207
—	1N 2N	2E 2E	Oct., 1950	1,885,289	4,293,701	149,087	158,028	782,375	1,435,975*	208
—	1N 2N	2E 2E	April, 1951	11,108,344	20,560,478	485,449	733,208	2,482,842	4,374,197*	209
—	1N 2N	2E 2E	Oct., 1950	7,280,287	25,843,827	105,441	238,460	2,948,635	8,615,861*	210
30	1N	14W	Sept., 1954	16,737	16,737	790*	790*	1,720	1,720	211
17,20	2N	10E	Feb., 1954	781,537	781,537	8,013	8,013	51,476	51,476	212
13	10N	10E	Sept., 1950	47,591	240,603*	25,021	58,356	10,000	60,000	213
25	10N	14W	Dec., 1950	14,769	225,826	158	1,283	35,833	45,836	214
11,12,13,14 7	10N 10N	10E 11E	June, 1942	4,479,403	34,703,805*	652,238	5,809,915*	—	—	215
18 18	10N 10N	14W 11E	Dec., 1946	1,198,630	10,615,859	144,637	1,955,268*	1,145,976	7,187,351	216
7 7	10N 10N	14W 11E	Dec., 1951	319,590	846,285	4,321	6,258	15,019	42,414	217
8,9,16,17	2N	7E	May, 1954	418,677	418,677	79,741	79,741	110	110	218
22	6S	9E	July, 1951	None*	90,110*	None*	None*	None*	None*	219
31	5N	14W	Dec., 1953	47,850	52,800	2,160*	2,160*	50,400	50,400	220
31	5N	14W	Oct., 1954	5,464	5,464	None	None	None	None	221
31	5N	14W	Dec., 1953	—	—	—	—	—	—	222

TABLE I (Continued)

	DEVELOPMENT AS OF 12-31-54						INJECTION WATER			
Map No.	No. of Wells Inj.	Prod.	Injection Pattern	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Total	Source	Type	Avg. Bbls. Per Day Per Well Per Foot	Average Wellhead Pressure PSI
186	8	25	Perimeter	10	407	407	Pennsylvanian Sand	Brine	21.3	1,372
187	65	65	5 Spot	10	527	—	Tar Springs	Brine	5.5	445
188	16	11	Perimeter	—	445	445	Tar Springs	Brine	12.6	520
189	5	5	Peripheral	—	61	61	Tar Springs	Brine	5.7	610
190	1	5	Irregular	—	90	90	Pennsylvanian Sand	Brine	9.7	0
191	2	6	Irregular	—	80	80	Pennsylvanian Sand	Brine	3.2	1,297
192	9	15	5 Spot	10	130	130	Produced and 1,300-Ft. Sand	Brine	3.0	785
193	5	9	5 Spot	10	60	140	Shallow Sand	Fresh	—	1,320
194	2	5	5 Spot	10	25	70	Shallow Sand and Produced	Fresh & Brine	10.3	1,041
195	1*	3	—	—	16	40	Produced	Brine	2.5*	0
196	1*	9	—	—	10*	—	Produced	Brine	4.0*	1,070
197	3	6	Flank	10	128	128	City Water	Fresh	12.3	795
198	7	7	5 Spot	10	94	209	Bridgeport	Brine	13.9	107
199	9	22	Flank	10	336	336	Produced	Brine	—	—
200	20	22	5 Spot	20	390	430	Tar Springs	Brine	6.2	396
201	2	9	—	—	95	95	Produced	Brine	5.7	—
202	1	14	Spot	—	400	500	Cypress	Brine	—	0
203	1	3	—	—	30	55	Cypress	Brine	48.7	0
204	1	3	—	—	9.4	30	Pennsylvanian Sand	Brine	21.6	249
205	1**	4	5 Spot	20	50**	160	Produced and Tar Springs	Brine	—	—
206	3	5	Flank	—	100	100	Pennsylvanian Sand	Brine	12.7	638
207	160	772	Peripheral & 5 Spot	20	7,975	7,975	Gravel Bed and Produced	Fresh and Brine	17.6	111
208	15	427	Peripheral	—	4,881	4,881	Gravel Bed and Produced	Fresh and Brine	10.2	97
209	111	531	Peripheral	—	7,712	7,712	Gravel Bed and Produced	Fresh and Brine	13.7	228
210	29	108	Peripheral	—	5,414	5,414	Gravel Bed, Upper Sand and Produced	Fresh and Brine	36.2	0
211	1	1	—	—	20	35	Produced	Brine	27.4	283
212	2	4	—	—	173	173	Cypress	Brine	146.2	0
213	9*	7	5 Spot	4.4	80	80	Surface and Produced	Fresh and Brine	0.9	210
214	2	4	5 Spot	4.4	10	—	Surface and Produced	Fresh and Brine	1.3	0
215	474	404	5 Spot	4.4	1,800	—	Gravel Bed and Produced	Fresh and Brine	0.8	240
216	127	121	5 Spot	4.4	468	575	Gravel Bed	Fresh	0.8	245
217	27	20	5 Spot	4.4	135	227	Lake and Produced	Fresh and Brine	0.6	159
218	7	5	Modified 5 Spot	20	70	130	Pennsylvanian Sand	Brine	21.8	636
219	1*	2	—	—	40	40	Pennsylvanian Sand	Brine	—	—
220	2	3	—	—	91.5	—	Tar Springs	Brine	6.6	--
221	1	2	—	10	77	—	Cypress	Brine	—	—
222	1	2	—	—	—	—	—	—	—	—

RESERVOIR STATISTICS (Average Values)						REMARKS	
Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises		Map No.
2,600	14.2	15.6	54	37.8	6.4 @ 60° F.		186
1,410	27	19	110	39	—		187
1,550	9	18.8	223	40	4.1	* Includes primary production since start of flood.	188
1,280	10	21	32	39	5.5 @ 60° F.	* Includes primary production since start of flood.	189
1,912	23	13	36	38	4.5 @ 84° F.	* Includes primary production since start of flood.	190
2,750	12	—	—	—	—		191
1,550	29	17.6	86	32	20 @ Reservoir temp.	* Includes estimated 300,000 barrels in pilot flood from 4-49 to 5-51.	192
1,830	—	—	—	32.2	11.2@ 78° F.	* Includes primary production since start of flood. Pilot flood (1-input) from 9-47 to 5-51.	193
2,000	15	—	—	—	—		194
2,800	10	15	46	—	—	* Temporarily shut down since July 1954.	195
2,248	10	—	—	34.5	—	* Project abandoned May 1954, after unsuccessful input well fracture treatment.	196
2,800	9.6	18.6	64	34.5	5.2 @ 95° F.		197
2,530	11.6	18.8	259	38.5	—		198
1,695	14	19	200-250	29.2	8 @ 32° F.	* Injected gas 3 months before starting water, two sand zones affected. ** As of 1-1-54.	199
2,500	25	17.6	152	38.5	—	* Corrected figure.	200
1,595	20	—	—	34	—		201
2,860	7	—	—	—	—	* Dump flood (Estimated). ** Corrected figure.	202
2,850	5	—	—	37	—	* Includes primary production since start of flood.	203
2,771	9.2	21.9	164	34.2	—		204
2,600	12	19	60	38	—	* As of 1-1-54. ** Pilot flood.	205
2,093	14	11.5	43	36.5	—		206
1,770	28	17.9	150	37	3.9 @ 93° F.	* Since 1-1-52.	207
1,825	7	16.5	18		4.8 @ 93° F.	* Since 1-1-52.	208
	26	16.3	28	37	4.4 @ 93° F.		
1,950	20	15.8	700	37	—	* Since 1-1-52.	209
3,400	19	16.8	300	36.5	—	* Since 1-1-52.	210
2,930	5	—	—	—	—	* Includes primary production since start of flood.	211
3,000	8	—	—	36	—		212
320	16	18.9	73	34	12 @ 63° F.	* Injection in 15 line wells operated jointly with Forest, not included. Previously subjected to gas injection.	213
600	16	20.3	349	30.1	—		214
400	32	17.5	56	36.6	8 @ 60° F.	* Corrected figure. Previously subjected to gas injection.	215
404	25	18.5	45			* Corrected figure.	216
464	6	18.3	66	36	8.8 @ 68° F.		
447	56	21.5	40	33.8	10.5 @ 68° F.	* Since 9-1-54. Previously subjected to gas injection.	217
2,975	11.8	19.8	97	38.8	3.7		218
2,241	15	—	—	—	—	* Temporarily shut down, no water injection since 6-18-53.	219
3,000	10	18	—	—	—	* Includes primary production since 1-1-54.	220
3,026	—	—	—	38	—		221
—	—	—	—	—	—		222

TABLE I (Continued)

				GENERAL INFORMATION	
Map No.	Field	Operator	Project	Formation Sand (S), Lime (L)	County
223	Stringtown	Skelly	Stringtown	McClosky (L)	Richland
224	Thompsonville East	Carter	East Thompsonville	Aux Vases (S)	Franklin
225	Thompsonville North	J. & W. Production	Thompsonville Unit	Aux Vases (S)	Franklin
226	Wamac	D. Stinson	Wamac	Petro (S)	Marion
227	Westfield	Forest	Parker	"Gas Sand" (S)	Clark
228	Westfield	Ree*	Hawkins	"Gas Sand" (S)	Clark
229	Westfield	Ree*	Johnson	"Gas Sand" (S)	Coles Clark
230	Willow Hill East	M. M. Spickler	—	McClosky (L)	Jasper
231	Woburn Consolidated	Arrow Drilling	Spindler	Benoist (S)	Bond
232	York	Trans-Southern	York	Casey (S)	Cumberland

**TABLE II,
ILLINOIS WATER FLOOD PROJECTS REPORTED ABANDONED**

				GENERAL INFORMATION	
Map No.	Field	Operator	Project	Formation Sand (S), Lime (L)	County
233	Albion Consolidated	Superior	South Albion	Bridgeport (S)	Edwards
234	Berryville Consolidated	Phillips	Tarpley	McClosky (L)	Wabash
235	Berryville Consolidated	Phillips	Townsend	McClosky (L)	Wabash
34	Casey	Sapphire American	Shawver	Casey (S)	Clark
236	Main Consolidated	Skiles	Walter Community	Robinson #1 & #3 (S)	Crawford
237	Martinsville	J. B. Buchman	—	Carper (S)	Clark
238	New Harmony Consol.	Sun	Ford "A"	McClosky (L)	White
196	Phillipstown Consol.	Sun	Phillipstown	Tar Springs (S)	White

**TABLE III
ILLINOIS PRESSURE MAINTENANCE PROJECT USING WATER INJECTION DURING 1954**

				GENERAL INFORMATION	
Map No.	Field	Operator	Project	Formation Sand (S), Lime (L)	County
239	Albion Consolidated	Calvert	South Albion Lower Biehl	Biehl (S)	Edwards
240	Bone Gap Consolidated	Gallagher	—	Waltersburg (S)	Edwards
241	Boyd	Superior	Boyd Repressure	Benoist (S)	Jefferson
242	Louden	Carter	Louden Devonian	Devonian (L)	Fayette
243	Omaha	Carter	Omaha	Palestine (S)	Gallatin
244	Salem Consolidated	Carter	Dix	Benoist (S)	Jefferson

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Secondary Recovery Oil Production Total 1954	Secondary Recovery Oil Production Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
31	5N	14W	Dec., 1953	8,703*	9,726	359	479	1,477	1,477	223
12	7S	4E	July, 1954	65,120	65,120	—	—	4,069	4,069	224
10,15	7S	4E	March, 1954	142,938	142,938	921	921	1,541	1,541	225
30	IN	1E	May, 1954	19,200	19,200	5,000*	5,000*	None	None	226
30	11N	14W	June, 1950	91,544	564,452*	6,776	25,244*	—	—	227
20,21	11N	14W	Aug., 1951	None**	265,199	None**	1,982***	None**	44,000	228
7,18	11N	11E	June, 1951	160,256	664,199	1,498	3,247	5,788*	5,788*	229
18 36	11N 7N	14W 10E	June, 1952	*	*	1,048	2,121	—	—	230
10	6N	2W	Sept., 1951	—	121,247*	—	9,684*	—	121,247*	231
6	9N	11E	Oct., 1950	50,103	454,482	1,336	9,815	51,172	91,277	232
Totals of Reported Figures				176,011,718	512,201,581	15,985,405	55,687,159			

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Date Abandoned	Cumulative Water Injection	Cumulative Secondary Recovery Oil Production	Cumulative Water Production	Map No.
1,11,12	3S	10E	Aug., 1946	1952	854,511*	173,502*	789,679*	233
2	IN	14W	Sept., 1952	Feb., 1953	34,688	None	102,551	234
35	2N	14W	Feb., 1952	July, 1953	49,834	None	86,354	235
23,24	10N	14W	Aug., 1953	July, 1954	48,586	1,814	—	34
1 36	6N 7N	13W 13W	Dec., 1951	Dec., 1952	25,821	None	29,000	236
31	10N	13W	Oct., 1952	1954	282,697*	None*	4,800*	237
18	5S	14W	May, 1948	July, 1952	57,823	13,076	626	238
6	5S	11E	Jan., 1953	May, 1954	57,598	None	251,333	196
Totals of Reported Figures					1,411,558	188,392	1,264,343	

PRODUCTION AND INJECTION STATISTICS (Barrels)

Section	Location Twp.	Range	Date First Injection	Water Injection Total 1954	Water Injection Cumulative 12-31-54	Oil Production † Total 1954	Oil Production † Cumulative 12-31-54	Water Production Total 1954	Water Production Cumulative 12-31-54	Map No.
35,36	2S	10E	April, 1951	183,150	383,280*	75,018	422,834	137,895	330,763*	239
1 18	3S 1S	10E 14W	June, 1952	202,258	345,936	47,302	225,404	202,258	345,936	240
13,24,25	1S	1E	June, 1945	1,470,185	9,714,450*	450,600*	9,776,513*	1,389,487*	10,865,715*	241
18,19,20,30 —	1S 8N	2E 3E	Sept., 1943	11,424,561	98,470,393	511,085	14,886,419	9,953,747	96,693,712	242
33	7S	8E	Oct., 1944	114,707	895,687	81,824	1,722,220	109,496	996,394	243
4 3,4,9,10,15,16	8S 1S	8E 2E	Jan., 1948	897,406	3,419,890	311,701	7,116,076	256,931	3,128,448	244
Totals of Reported Figures				14,292,267	113,229,636	1,477,530	34,149,466	12,049,814	112,360,968	

† Includes both primary recovery and any additional oil obtained by pressure maintenance.

TABLE I (Continued)

No. Map	No. of Wells Inj.	No. of Wells Prod.	Injection Pattern	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Productive Acreage Total	Injection Water Source	Injection Water Type	Avg. Bbls. Per Day Per Well Per Foot	Average Wellhead Pressure PSI
	DEVELOPMENT AS OF 12-31-54						INJECTION WATER			
223	1	2	—	10	80	80	Produced	Brine	—	0
224	3	3	5 Spot	10	30	117	Cypress	Brine	6.6	88
225	4	8	Modified Peripheral	10	175	190	Lake	Fresh	7.4	393
226	4	24	5 Spot	10	10	200	City Water	Fresh	1.0	40
227	9	12	5 Spot	2.5	20	—	Gravel Bed	Fresh	1.1	125
228	15**	8	5 Spot	4.4	40	360	Devonian and Produced	Brine	—	—
229	26	13	5 Spot	4.4	70	467	Lake and Produced	Fresh and Brine	0.5	150
230	1*	1	—	—	20	20	—	Brine	—	—
231	1	4	Spot	—	20	20	Produced	Brine	—	—
232	3	7	Line Drive	4.4	15	125	Shallow Sand and Produced	Fresh and Brine	4.6	108
					59,027†					

† Includes only 8,800 acres for the Salem Unit.

TABLE II (Continued)

Map No.	No. of Wells Inj.	No. of Wells Prod.	Injection	Spacing Acres Per Input Well	Productive Acreage Subjected To Inj.	Productive Acreage Total	Injection Water Source	Injection Water Type
	MAXIMUM DEVELOPMENT DURING OPERATION						INJECTION WATER	
233	3	14	—	—	203	—	Produced	Brine
234	1	2	—	—	14	30	Produced & Tar Springs	Brine
235	1	2	—	—	27	30	Produced & Tar Springs	Brine
34	9	4	5 Spot	4.4	13	215	Shallow Sand	Fresh
236	5	6	5 Spot	10	40	—	Upper Pennsylvanian Sand	Brine
237	2	6	5 Spot	20	40	40	Shallow Sand	Fresh
238	1	1	Spot	—	40	40	Gravel Bed	Fresh
196	1*	9	—	—	10	—	Produced	Brine

TABLE III (Continued)

Map No.	No. of Wells Inj.	No. of Wells Prod.	Injection Pattern	Productive Acreage Subjected To Inj.	Productive Acreage Total	Injection Water Source	Injection Water Type	Average Wellhead Pressure PSI
	DEVELOPMENT AS OF 12-31-54					INJECTION WATER		
239	2	7	Peripheral	60	119	Produced	Brine	1,008
240	1	11	—	40	120	Produced	Brine	450
241	4	85*	Peripheral	1,564	1,564	Surface & Produced	Fresh and Brine	132
242	6	69	Peripheral	2,600	2,600	Produced	Brine	125
243	1	15	Flank	260	260	Produced	Brine	225
244	4	64	Peripheral	1,200	1,200	Tar Springs & Produced	Brine	120

Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises	REMARKS	Map No.
3,002	12	—	—	36	—	* No injection, Feb. 1954 - Oct. 1954	223
3,200	18	21.1	98	38	—		224
3,120	16	19.5	50	38.6	3.5 @ 90° F.		225
750	20	21.3	220	35	18.7 @ 60° F.	* Estimated. Includes primary production since start of flood.	226
270	25	17.9	153	28.1	54 @ 60° F.	* Corrected figure. Previously subjected to gas injection.	227
290	30	22	120	30	28 @ 62° F.	* Since 9-1-54. ** Project temporarily shut down during 1954. *** Includes primary production since start of flood.	228
320	35	21.5	86	29	—	* Since 9-1-54.	229
2,615	10+	—	—	—	—	* Dump flood.	230
1,006	14	—	—	—	—	* As of 1-1-54. Oil production includes primary production since start of flood.	231
590	10	21.9	231	30.3	10 @ 75° F.		232

Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises	REMARKS	Map No.
1,900	20	19.7	304	32.5	6.3 @ 95° F.	* As of 6-1-52. Stopped injection early in 1952. Now disposal project.	233
2,890	10	—	—	—	—		234
2,890	10	—	—	—	—		235
450	21.5	22.4	108	31.8	13.6 @ 65° F.		34
950 1,010	10 15	20.1	93	36	12.5 @ Reservoir Temp.		236
1,346	40	16	11	30	—	* As of 12-31-53.	237
2,900	7	—	—	38	—		238
2,248	10	—	—	34.5	—	* Abandoned after unsuccessful input well fracture treatment.	196

Depth Feet	Net Pay Thickness Feet	Porosity Per Cent	Permeability Millidarcys	Oil Gravity API	Oil Viscosity Centipoises	REMARKS	Map No.
2,080	9.2	16.8	384	32.3	10.4 @ 85° F.	* Since May 1952.	239
2,310	20	18	120	34.6	5.6 @ 85° F.		240
2,065	17.3	17.5	173	39.5	3.2 @ 90° F.	* Includes Superior's Boyd Field Unit (Aux Vases). Previously used for gas storage.	241
3,100	—	—	—	29	6.5 @ 96° F.		242
1,700	17	18.9	427	27	17 @ 76° F.		243
1,950	12	16.4	128	39	2.5 @ 87° F.		244

WATER FLOOD OPERATIONS LAKE CENTRALIA-SALEM FIELD-SALEM UNIT

By

Richard W. Love

The Texas Company

PART I

LOCATION AND AREAL EXTENT

Located approximately sixty-five miles due east of St. Louis and more specifically between the cities of Salem and Centralia, Marion County, Illinois, is an oil producing area which has an outstanding production history and now after unitization the area is believed to have a good future potential by water flood. This area is known as the Lake Centralia-Salem Field.

The field is located on an elongated asymetrical anticline extending six and one-half miles in length and two and one-half miles in width and covers approximately 9,500 productive acres.

The name, Lake Centralia-Salem, was chosen from the field's geographical location. The discovery well was approximately one-half mile from the western edge of Lake Centralia, an artificial reservoir covering approximately 400 acres owned and controlled by the City of Centralia as a source of domestic water supply. As the field was developed to the east, it was named the Lake Centralia Field. Later development, further to the north and east, placed its northern boundary near the City of Salem, thus, the field was later named Lake Centralia-Salem.

DEVELOPMENT AND PRODUCTION HISTORY

The field was discovered in July, 1938, with the completion of the Texas Company's E. Tate No. 1. This first well proved the existence of oil in the Benoist, Renault, Aux Vases sands and McClosky Lime. Subsequent development in the field revealed the underlying St. Louis-Salem, Devonian and Trenton production. With no conservation or spacing regulations field development resulted in boom conditions.

A total of approximately 2,400 wells were drilled in the field from which a wealth of subsurface information has been obtained.

Fifty percent of the accumulative production as of September 1, 1950, was produced within the first two years of the life of the field. This in itself is a key to the history of the production of the early life of the field. Production had declined to an average of 4 1/2 barrels per day per well at the time Unit operations started.

The producing horizons in the field have been generally grouped as follows: Sand, which includes the Benoist, Renault and Aux Vases; the upper limes, which include the McClosky, Salem and St. Louis; and the lower limes consisting of the Devonian and Trenton. All producing zones are being flooded simultaneously except the Salem, St. Louis, and Trenton which are not adequate to water flooding.

OPERATING AND ROYALTY INTEREST

As of July 1, 1948, at which time the first endeavor was made to unitize the field for water flood development, there were 27 different and separate operating interests. It can be noted that the Texas Company has the largest interest with approximately 70 percent, the Magnolia Company, the Ohio Oil Company, Kingwood Oil Company, Shell Oil Company and Rock Hill Oil Company following in order of their ownership in the field, leaving the remaining 10 percent to be divided between some twenty-two other operating interests. This fact is of interest when considering the matter of unitization. As of this date all operating interests have signed the operating account, a small lease approximately 16 rods square. This in itself indicates the extent which the program of unitization has met with wholehearted approval of the operating interests.

The royalty interests, which were given primary consideration during the development of the Unit, consisted of approximately 2,000 royalty accounts. These 2,000 accounts were found in forty-four states and seven foreign countries. However, 46 percent of the total interests were found within a radius of 100 miles of the City of Salem. This 46 percent accounted for only 450 accounts. The program for unitization met with wholehearted approval of these accounts in that at present all but approximately 100 have signed the unitization agreement.

THE FORMATION OF THE UNIT - JULY, 1948, TO SEPTEMBER, 1950

The first meeting of the Operators for the purpose of unitizing the field for water flood development was held in Tulsa, Oklahoma on July 1, 1948, just twenty-six months prior to the time the Unit was placed in actual operation. It was generally agreed at this first meeting that unitized operation would accomplish the following:

1. Accomplish a very substantial increase in ultimate recovery.
2. Achieve the ultimate in conservation of both oil and gas.
3. Give to every owner his equitable share of a greater production of oil and gas than would otherwise have been recovered.

The first meeting resulted in the formation of a Steering Committee composed of a representative of each operator, and this Committee, in turn, appointed other committees to work out the details and plans for the formation of the Unit and the policy for its operation. Primary committees consisted of the following: Steering, Engineering, Land, Legal, and Accounting.

STEERING COMMITTEE

Between July 1, 1948, and July 18, 1950, the Steering Committee held ten meetings and so directed the work of the Engineering, Land, Legal, and Accounting Committees, enabling the Unit to be placed in operation on September 1, 1950. To the writer it is interesting to note the manner in which this Steering Committee so successfully operated in that in all decisions the vote of the operator with a 2 percent interest carried the same weight as the one with 70 percent.

ENGINEERING COMMITTEE

This Committee held their first meeting July 8, 1948, and completed their study and made their recommendations on June 8, 1949. The Committee was composed of one member from each operator.

Keplinger & Wanenmacher, Petroleum Engineers of Tulsa, Oklahoma, were employed by the Steering Committee as a disinterested party to review the work of the Engineering Committee and check the data presented. It was their suggestion that led to the use of two sets of equities, one for primary and one for secondary reserves.

In general, the Engineering Committee accomplished the following:

1. Calculated estimated primary reserves.
2. Estimated secondary reserves available by unitized flooding operations.
3. Designed a formula whereby an equitable participation factor for each operating interest and/or each royalty interest could be computed.
4. Calculated the participation factors for each tract within the Unit.

The primary reserves were calculated using current rate of decline with an economic limit of .7 B/D per well. It was agreed that each tract would share in these primary reserves in the same proportion that its current daily average production bore to the total current field daily average production from the same formation.

In the calculation of the secondary reserves, the Committee concluded that due to the physical characteristics of the sands and limes, separate calculations would necessarily have to be made for each reservoir. Final analysis indicated that acre-foot of pay was the controlling factor in the computation of the secondary reserves of the sand formations. For the lime formations, it was agreed that surface productive acreage was the most practical basis for calculation of participation factors.

From the above each tract would share in the secondary reserves from the sand according to its proportionate share of its acre-feet of pay in those sands as compared to the field total acre-feet of pay in the same sands, and each tract would share in secondary reserves from the lime reservoirs according to the proportionate share of its surface productive acres in those lime formations as compared to the total surface productive acres of each lime reservoir. This expressed mathematically is as follows:

Participation in Primary Reserves:

$$F_{tp} = \frac{P_t}{P_f} \times 100$$

Where: F_{t_p} = Tract primary participation factor

P_t = Average daily production from tract during period from July 1, 1947, to July 1, 1948.

P_f = Average daily production from field during period from July 1, 1947, to July 1, 1948.

Participation in Secondary Reserves:

$$F_{t_s} = \left[\left(\frac{AFS_t}{AFS_f}\right)\left(\frac{SR_s}{SR_f}\right) + \left(\frac{SAM_t}{SAM_f}\right)\left(\frac{SR_m}{SR_f}\right) + \left(\frac{SAD_t}{SAD_f}\right)\left(\frac{SR_d}{SR_f}\right)\right] \times 100$$

Where: F_{ts} = Tract secondary participation factor.

AFS_t = Acre feet sand production for tract.

AFS_f = Acre feet sand production field.

SAM_t = Surface acres production from McClosky for tract.

SAM_f = Surface acres production from McClosky for field.

SAD_t = Surface acres production from Devonian for tract.

SAD_f = Surface acres production from Devonian for field.

$\frac{SR_s}{SR_f}$ = Ratio of Secondary Reserves in Sands to Total Secondary Reserves in Field.

$\frac{SR_d}{SR_f}$ = Ratio of Secondary Reserves in Devonian to Total Secondary Reserves in Field.

$\frac{SR_m}{SR_f}$ = Ratio of Secondary Reserves in McClosky to Total Secondary Reserves in Field.

In applying the formula it was necessary that a satisfactory determination of sand thickness and surface productive areas be made.

After much investigation, the conclusion was reached that net feet of pay could be determined satisfactorily for this application by using the method discussed by Mr. H. G. Doll in his paper entitled "The S. P. Log: Theoretical Analysis and Principles of Interpretation" which was presented before the American Institute of Mining and Metallurgical Engineers in New York on February 16-19, 1948. In general, this method is formulated as follows:

$$\text{Sand thickness} = \frac{\text{Area under the S. P. Log}}{\text{Total emf}}$$

It was established that the water table in the three productive sand zones was 1,355 feet subarea and this depth was used as the base of the pay unless substantiating information was available to prove otherwise.

As to the determination of the area to be called productive surface area, the following rules were established to determine the boundary of the Unit by the reservoirs:

1. Any edge well at a proven productive location in the reservoir being considered and which is in suitable mechanical condition for use as an injection well or a producing well in that reservoir will be accredited with 10 productive acres in the form of a square with the well located at its geometric center.

2. All rectangular corridors less than 661 feet in width formed by accredited acreage will be included as productive acreage.

3. Any rectangular tract of 10 acres or less which is offset diagonally on opposite corners by 10 accredited acres in the form of a square will be given 1/2 credit by drawing a diagonal line between the two corners which are offset.

In the application of the above boundary rules it was found necessary to allow three exceptions which were as follows:

1. No productive acreage shall be accredited to leases on which there are no wells which satisfy conditions in Rule No. 1.

2. In application to the sand reservoirs, when the contour line denoting zero pay thickness crosses acreage within the above defined boundary, the zero contour line will then be accepted as the boundary.

3. In certain areas where twenty-acre spacing governed the location pattern, the distance under Rule No. 2 shall read 1,321 feet.

Complete analysis by the Committee indicated that the Salem, St. Louis, and Trenton Limes were not adaptable for flooding and accordingly only primary reserves of these reservoirs were considered.

RESERVOIR STATISTICS

Isopachous maps were constructed covering the three sands and the acre-feet contained in each was determined. The following tabulation presents the results of this work:

	ACRE FEET	PERCENT
Benoist	230,838	58.8
Renault	35,544	9.0
Aux Vases	126,307	32.2
	392,687	100.0

*As of 7-1-48

The permeability distribution of the sand was reviewed. By the use of curves a plot of equal permeability increments was made against the percentage of occurrence of each increment. Similar curves were also made by plotting permeability versus cumulative percent of occurrence.

The weighted average values for porosity and residual oil and interstitial water for the total sands were developed with the following results:

POROSITY

Benoist	17.9 x .588 =	10.5
Renault	16.5 x .090 =	1.5
Aux Vases	16.3 x .322 =	5.2
Weighted Average		17.2

RESIDUAL OIL

Benoist	18.9 x .588 =	11.1
Renault	17.0 x .090 =	1.5
Aux Vases	19.0 x .322 =	6.1
Weighted Average		18.7

INTERSTITIAL WATER

Benoist	24.6 x .588 =	14.5
Renault	33.6 x .090 =	3.0
Aux Vases	34.1 x .322 =	11.0
Weighted Average		28.5

OIL VISCOSITIES

	Centipoises @ 93°
Benoist	3.91
Renault	4.85
Aux Vases	4.35

Sufficient gas-oil ratio data and analysis of bottom hole fluid was available to set the formation volume factor for the sands at 1.1232. The recovery factor was estimated at 80 percent based on a 98 percent water cut.

The above data when calculated resulted in the following:

Original stock tank oil in place	950.4 B/A ft.
Residual oil in place	249.5 B/A ft.
Primary recovery	331.2 B/A ft.
Recoverable secondary oil	296. B/A ft.

It is to be noted that all three reservoirs were considered together because of their past production history and location in geologic table.

After complete study of the reservoirs of the McClosky and Devonian it was concluded that the most efficient and practical method of considering the secondary recovery factors of these reservoirs was by comparison between recovery by water drive and recovery by primary depletion for the same reservoirs in other fields of the same areas. The validity of these correlations was studied by comparing the reservoir characteristics and production history of the McClosky and Devonian limes of similar fields. The water flood efficiencies for the Devonian and McClosky were further weighted with respect to the probable response to flooding of each formation as determined by comparing the reservoir characteristics of that formation with the reservoir characteristics of the other lime formation and the sand formations.

This investigation led to recovery factors of 80 percent for the McClosky and 100 percent for the Devonian compared to their respective primary ultimate production.

More specifically, the McClosky limestone reservoir consists of three main oolitic limestone pay zones and various small miscellaneous pay sections extending over an area of approximately 8,650 acres with average pay thickness of 20.2 feet. The productive closure of the structure is approximately 200 feet. The average permeability is 434 millidarcies, however, a very wide range in permeabilities is present, ranging from only a few millidarcies to as high as 3,000.

Devonian reservoir consists of 6,284 productive acres. There are three pay zones of the Devonian. Zone II, the most important, has a thickness of from 17 to 23 feet and lies from 62 to 82 feet from the top of the Devonian Lime. Core analysis indicates the Lime to have a permeability average of 71.0 millidarcies with a range of from 2-713; porosity (%) 17.7, with a range of 9.7 - 28.7, oil saturation (%) 27.0 and water saturation (%) 21.7. The porosity is in large part the result of its vugular characteristics. Individual vugs range from microscopic to finger size. The permeability and porosity values, as calculated, are probably low, since the better part of the pay is usually in the nonrecovered sections of the core. The initial production being high with a high rate of decline also suggests average permeabilities of over 71 millidarcies.

LAND COMMITTEE

The work accomplished by the Land Committee held the key to the success or failure as to all the previous work which had been accomplished, inasmuch as it was their job to secure approval of royalty owners.

The working committee consisted of six men who first started the task of signing the royalty interest on February 14, 1950, and had obtained the signatures of 90 percent of the royalty interest on July 3, 1950. After each member of this Committee was schooled in the program to be presented, each was assigned a definite area within the United States. As persons were contacted, regular reports were made to the Central Office in Salem. If the representative in New York called on a royalty owner and found he was on vacation in Florida he immediately forwarded the information to the Florida man who handled the case. Or if John Doe was contacted in New York and his wife was vacationing in California, then after his signature was obtained the matter was immediately handled by the representative on the West Coast.

All accounts within the States and Canada were contacted in person, those in foreign countries by mail.

ACCOUNTING AND INVENTORY

The Accounting and Inventory Committee was responsible for the development of that part of operating agreement outlining the accounting procedure to be used in connection with the operation of the Unit. The initial inventory of the Unit was by far the largest task of this Committee. The physical inventory required the service of 20 men working 95 days for a total of 14,300 man hours. The inventory value of general lease equipment amounted to $6,698,409.96 plus $355,628.41 for the field electrical system. The inventory was priced at 50 percent of the current market value. The inventory shows 1,700,000 feet of the pipe in each place. Each operator within the Unit was given an adjusted credit or debit to the Unit based upon his calculated participation factor within the Unit.

As for credit for subsurface equipment and/or material, an allowance of $1,800.00 for each Sand well, $2,000.00 for each McClosky well and $3,500.00 for each Devonian well was given, which is roughly $1.00 per foot. Casing in the hole was priced as follows: 4-1/2" - 25¢, 5-1/2" - 30¢, 7" - 35¢ for inventory purposes.

PROPOSED PLAN FOR WATER FLOOD DEVELOPMENT

The magnitude of this project is indicated by the estimate that there will be injected during the life of the flood 1,680,000,000 barrels of water into the Benoist, Renault-Aux Vases, McClosky and Devonian reservoirs. It is estimated that 607 wells will be utilized for input purposes.

To realize these expectations, it is estimated that the project will entail an over-all expenditure of some 60 to 70 million dollars.

To design a system to meet the above requirements, the following premises were made:

1. Minimum life of the flood was set at 20 years, broken down into:

   (a) 5 years - development

   (b) 12 years - steady rate flooding

   (c) 3 years - salvaging

2. Wells selected for injection are presently producing, gas injection, or temporarily abandoned wells.

3. The method of water front advancement selected is the peripheral type. Development of the flood was planned over a five year period.

4. At the direction of the Salem Unit Steering Committee, the Engineering Committee considered the possibilities of the Benoist, Renault and Aux Vases Sands and the McClosky and Devonian Limestone formations for water flooding.

The Engineering Committee's findings substantiated by Keplinger and Wanenmacher, Consulting Engineers, endorsed the belief that these five formations were profitably susceptable to water flood operations. Due to the stratigraphic interrelations of these formations the flood program was laid out to treat the project in four separate Units:

(a) Benoist Sand

(b) Combined Renault and Aux Vases Sands

(c) The McClosky Limestone

(d) The Devonian Limestone

The final selection of a method of flooding after consideration of a number of factors resulted in the choice of a modified perimeter type flood, in other words, development could be converted to the pattern type at any time.

The flooding program will actually consist of four separate projects which will operate independently of one another with the exception of a common water supply system. The function of inside injection wells will be to direct the advancing water flood front continuously upstructure and generally speed up the flooding rate.

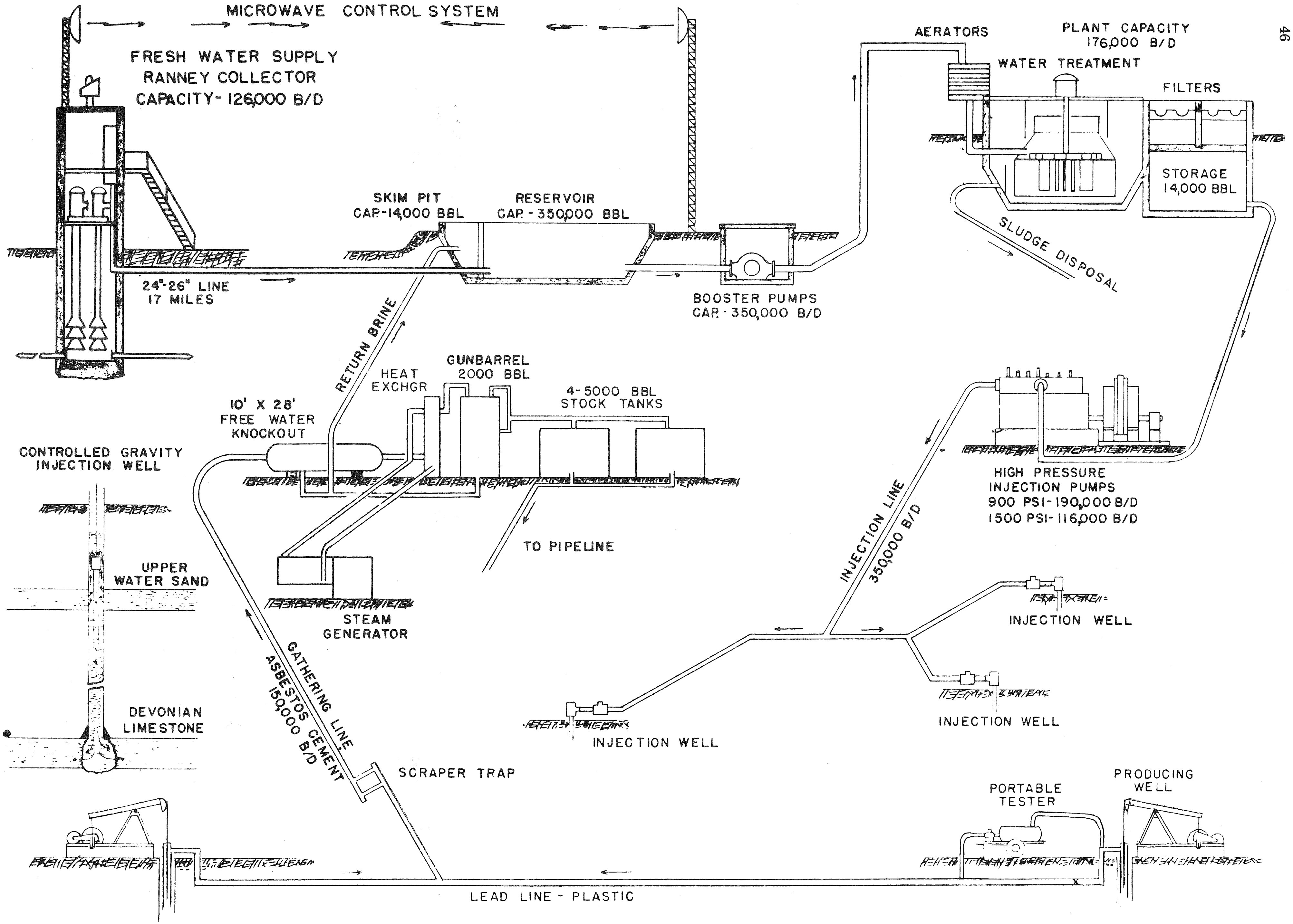


FIGURE I FLOW PLAN - SALEM UNIT

The decision to flood the Renault and Aux Vases formations together was reached after consideration of the following factors:

1. The areal extent, shape and location of the two zones are similar.

2. In parts of the field the Renault and Aux Vases are separated by only a thin shale break.

3. Flooding of the two zones together will provide a continuous passage across the field.

PART II

DEVELOPMENT OF WATER SUPPLY

Engineering estimates indicated that some 1,680,000,000 barrels of water would be required for injection purposes during the 20 year life of the flood. It was further estimated that a maximum of 350,000 B/D would be required at peak conditions of which 185,000 B/D would be make-up water.

To develop this water supply extensive investigations were made of all possible sources in the area surrounding the Salem Pool, however, studies indicated that no economical supply was available. Additional investigations, however, indicated a source of supply in a gravel terrace along the Kaskaskia River approximately 17 miles northwest of the field.

Hydrogeological studies of the area indicated that sixteen (16) conventional wells located over a wide area along the river would be required to produce the desired 185,000 B/D of make-up water and that the area provided excellent locations for two Ranney type collectors (Figure No. 2) each having the ability to produce approximately 26,000 B/D.

In comparing the conventional type well with the Ranney type collector economic studies indicated that for this area the Ranney collector could save 23 percent over the cost of conventional wells. Further studies indicated that the Ranney collector would be some 60 percent less than that of a salt water source developed in the field proper.

The collector as constructed for our system consists of a caisson (concrete) 13 feet ID with 18-feet reinforced walls. This caisson was sunk through the water bearing gravel terrace to a total depth of 68 feet. The caisson is sealed at the bottom with a heavy plug of reinforced concrete.

To serve as the collector system perforated screen, pipes eight inches in diameter were projected horizontally into the aquifer. These pipes were projected 150 feet in length by means of water flushing and/or the use of hydraulic jacks. The continuous flushing of water through the perforated pipes during installation created a gravel pack around the pipe by the washing away of the fine material.

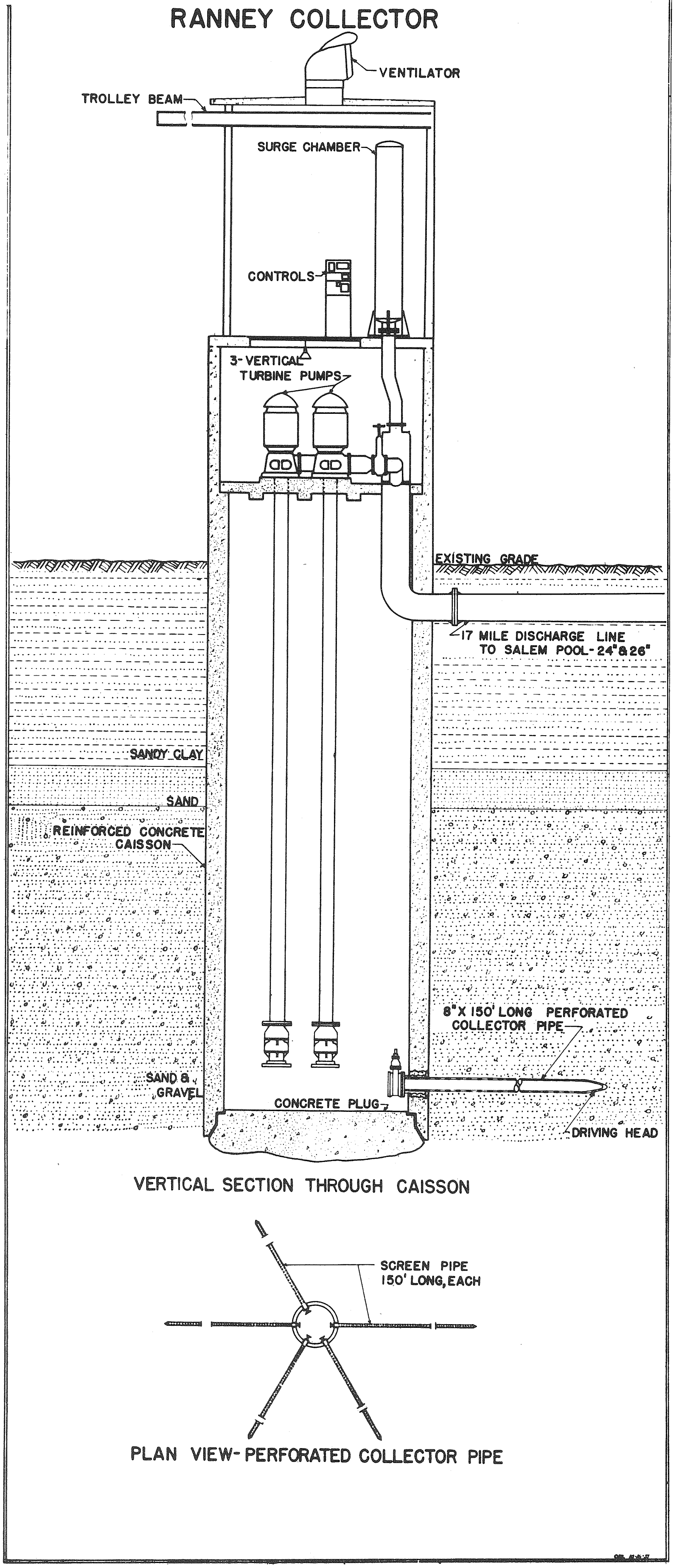
This type of collector presents three definite advantages over the conventional vertical hole. They are:

1. In the collector you have 750 feet of exposed zone of the aquifer as compared to 40 feet for a single vertical well.

2. The low velocities of water into the screen pipe reduce the entrant head loss between the aquifer and the collector being measured in inches as compared to feet of head loss into a conventional well.

3. This low head loss tends to eliminate many causes for mechanical failures to conventional wells resulting from sanding or encrustation of such materials as salt and iron oxide.

FIGURE 2 RANNEY METHOD WATER COLLECTOR



The collector is equipped with three vertical turbine pumps sized to delivery 68,500, 102,500 and 137,000 B/D respectively to the Salem field. The control of the pumps is by Microwave located in the Water Treatment Plant building.

These pumps transport the water to the Salem field via a tapered 24-26 inch welded steel line. The line is protected against external corrosion by conventional means using enamel, glass fiber and asbestos felt paper. The line is further protected by the use of a rectifier rated at 20 volts, 30 amps DC output. This Unit currently protects the entire 17 miles of line by an output of approximately 3 volts and 4 amps. As the line and its protective coating age and deteriorate higher outputs will be required. No internal protection has been provided.

WATER TREATMENT

For discussion purposes the water treatment may be divided as follows: (Figure No. 3 shows an areal view of the Water Treatment Plant and Injection Station.)

A. Collection and mixing
B. Chemical treatment
C. Filtration

A concrete basin 509' x 351' x 12' was constructed to provide storage of produced water and facilities for mixing this brine with the fresh water required. All produced brine enters into a 168' x 40' section in the northwest corner of the basin where facilities are available to skim any oil which may be present before it is mixed with the fresh water. Water leaving this skim section is then mixed with the fresh water, supplied by the Ranney Collector. A concrete division wall in the basin along with the necessary manifold arrangements permits the use of either side of the basin independently of the other. In addition the manifold is constructed so the water may be pumped directly into a treatment plant by-passing the basin completely if necessary.

Four 75 HP centrifugal electrically powered pumps with a capacity of 87,000 B/D each provide the means of moving the water from the basin to the aerators located adjacent to the treatment building. From this point water is moved by gravity flow to the injection pumps.

Two forced draft type aerators with a capacity of 88,000 B/D each are used for aeration.

For chemical treatment two 48' x 48' x 16' deep rapid reaction chambers with a capacity of 88,000 B/D each of brine containing 100,000 ppm chloride are in use. These vessels are of concrete construction and are of the accelator type.

For filtration the plant contains four 29 x 24 x 9 gravity sand and gravel filters each containing 27 inches of filter media.

The bottom floor of the Treatment Building holds a 68' x 120' x 10' clear well which provides a storage, or suction chamber, for the injection pumps of 14,000 barrels of treated water.

The design of the Treatment Plant presented a problem of providing a plant, first, capable of treating almost 100 percent fresh water, but as the flood developed the same facilities would be called upon to handle 100 percent produced fluids. The present plant is capable of treating 176,000 B/D with provisions for doubling the capacity without interrupting operation.

INJECTION STATION

The Injection Station center right hand side Figure No. 4 consists of three 600 HP septuplex pumps, two 500 HP quintuplex pumps, two 300 HP triplex pumps and two 125 HP quintuplex pumps, two 300 HP triplex pumps and two 125 HP variable stroke triplex pumps which have a combined capacity of 190,000 B/D at 900 psi (Interior view Figure No. 4).

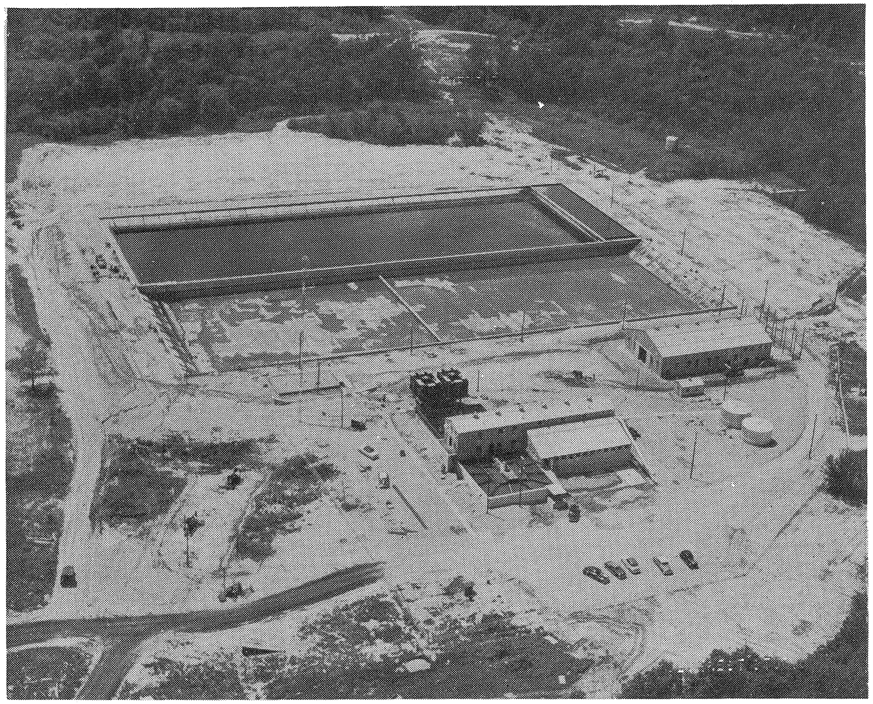


FIG 3 WATER TREATMENT AND HIGH PRESSURE INJECTION STATION

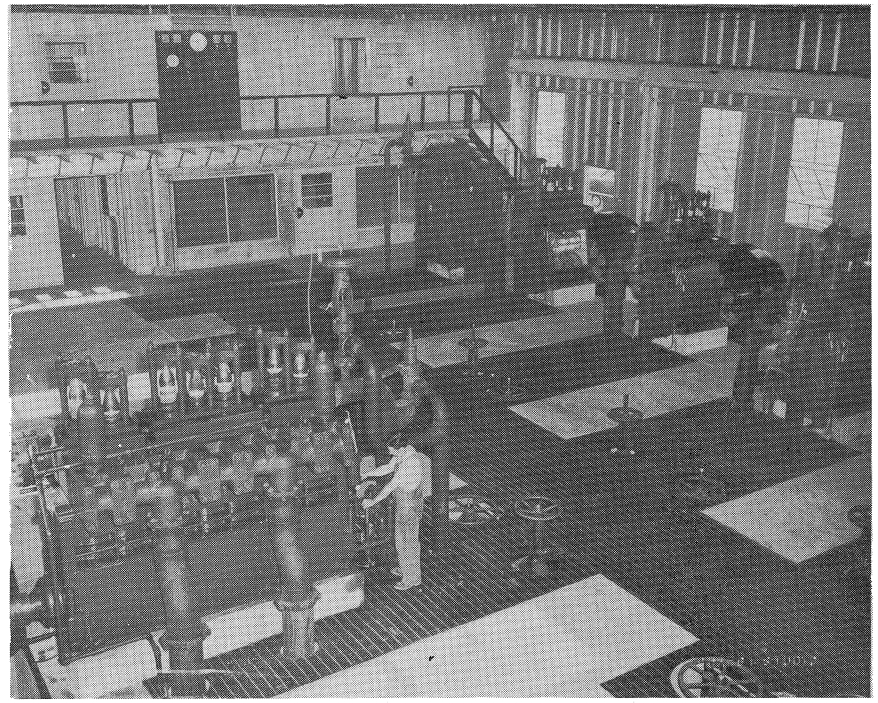


FIG 4 INTERIOR VIEW OF HIGH PRESSURE INJECTION STATION

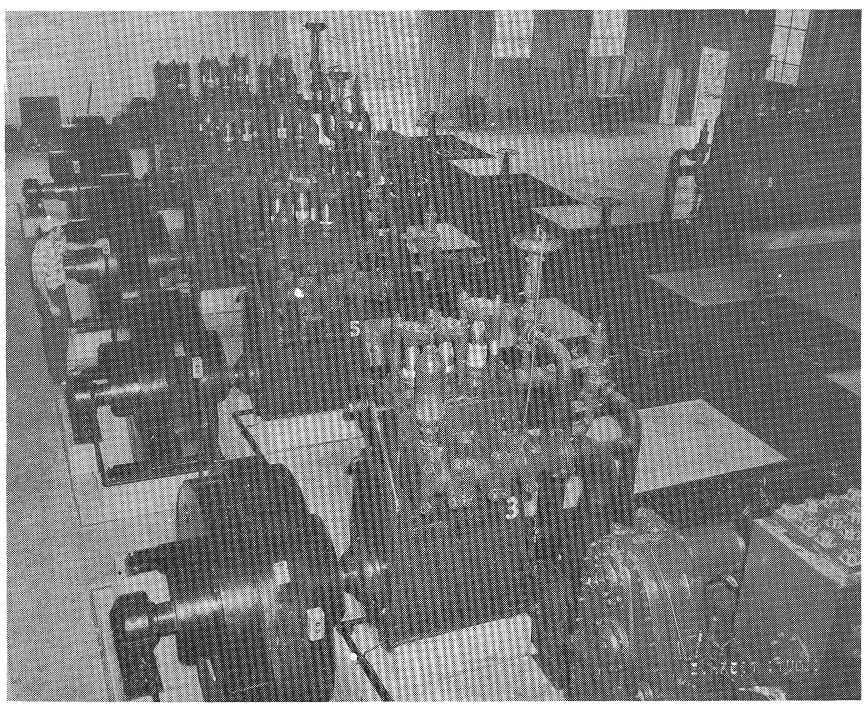


FIG 5 HIGH PRESSURE INJECTION PUMPS AND MOTORS

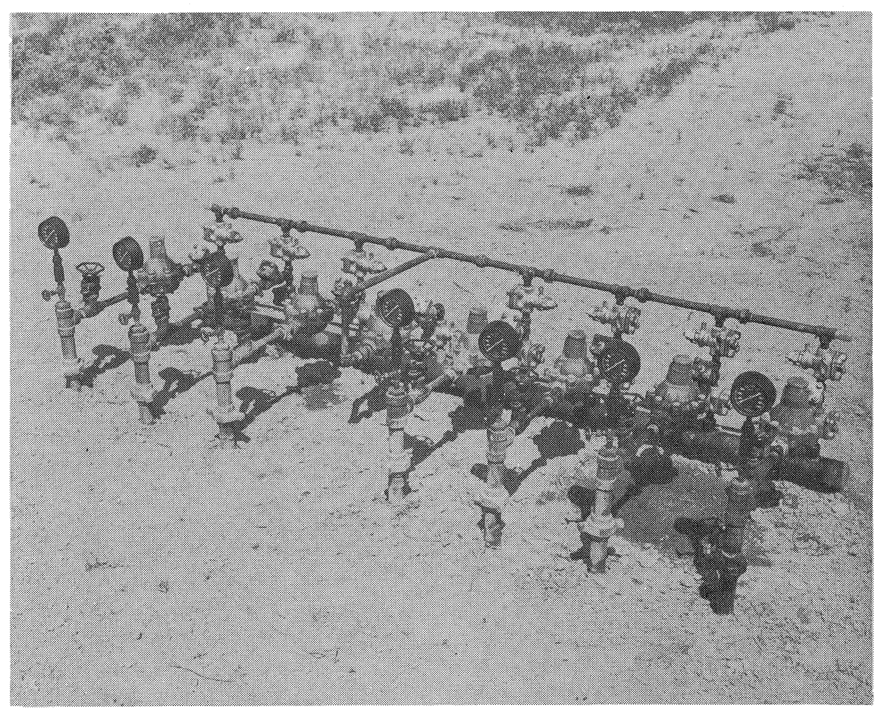


FIG 6 METER BANK - HIGH PRESSURE DISTRIBUTION SYSTEM

The plant is so designed that a capacity of 350,000 B/D at 1,500 psi may be reached by the placement of additional pumps. To meet this demand a total of 22 pumps would be required with 11,150 connected HP.

The combination of the septuplex, quintuplex, and triplex pumps (Figure No. 5) provides a means of delivering a wide range of injection water volumes as the flood develops and increased volumes are required. The variable rate pumps are in the system to provide a means of maintaining a constant selected line pressure or volume.

All pumps are driven by slow speed (277 rpm) direct connected synchronous motors with the exception of the variable rate pumps which have induction motors.

HIGH PRESSURE DISTRIBUTION SYSTEM

The injection system designed to handle 350,000 B/D at 1,500 psi contains 18 miles of line grading in size from 8" to 14". The line follows a peripheral pattern around the field (Figure No. 7) with three sections leaving the plant and one line extending across the center of the field to provide flexibility to the system. In addition, block gate valves were installed at one mile intervals and at all main junction points which provide a means of isolating any one segment in the line without disruption of service to the remainder of the systems. To this main trunk system are connected some 53 miles of lateral lines which complete the injection system to the individual injection wells.

Metering of injection volumes is obtained by the use of one inch bronze meters of the wobble plate type. Central metering stations are located around the field with each station having a bank of from two to nine meters serving the same number of injection wells. Each bank includes a by-pass system whereby any meter in the group may be tested against a test meter (Figure No. 6).

OIL GATHERING AND TREATING SYSTEM

The oil gathering system was designed on a basis that the maximum well head pressure would be 50 pounds and the flow lines sized accordingly. To eliminate corrosion problems, all lines are plastic or cement asbestos. For economic reasons plastic pipe was used for line sizes 2" through 5" while the cement asbestos pipe was used for lines sizes 6" up to 14".

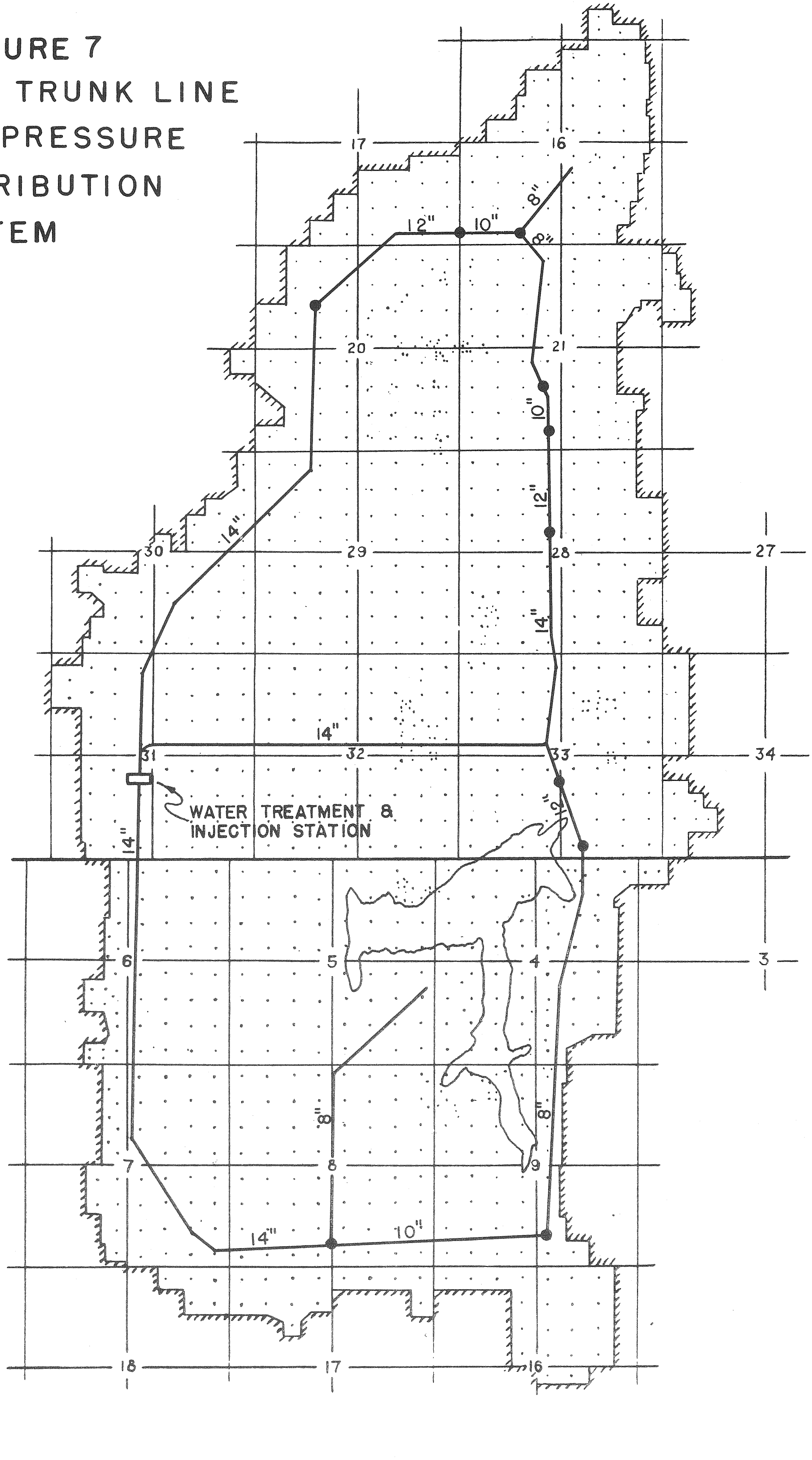
Scraper traps were installed at all junction points of the cement asbestos line. A by-pass at each scraper trap permits continuous operation of the system while placing or removing a pipe line pig in the system. No similar provisions were made for the plastic lines in that it has been our experience at Salem that paraffin does not adhere to the plastic pipe. The scraper traps were installed in concrete boxes constructed approximately five feet below ground level. Prefabricated steel buildings with 3'6" sides provide a coverage for the pits.

Two large tank batteries now serve the field in the place of some 365 individual batteries, which were in use at the time the Unit was formed. Each battery consists of two 10' x 28' horizontal free water knockouts, two 2,000,000 and one 4,000,000 BTU horizontal steam generators, three 2,000 barrel gun barrels with vertical steam-to-oil heat exchangers and six 5,000 barrel cone bottom storage tanks.

CURRENT OPERATING STATUS

As of October 1, 1954, the Unit development program is approximately 95 percent complete. Over 300 wells have been converted to water injection with water being injected at the rate of some 137,000 B/D into the five formations which are to be flooded. Figure No. 8 provides a curve showing the oil production (PLR) and water injection rate to October 1, 1954.

FIGURE 7
MAIN TRUNK LINE HIGH PRESSURE DISTRIBUTION SYSTEM



PRODUCTION & WATER INJ. CURVES
SALEM UNIT

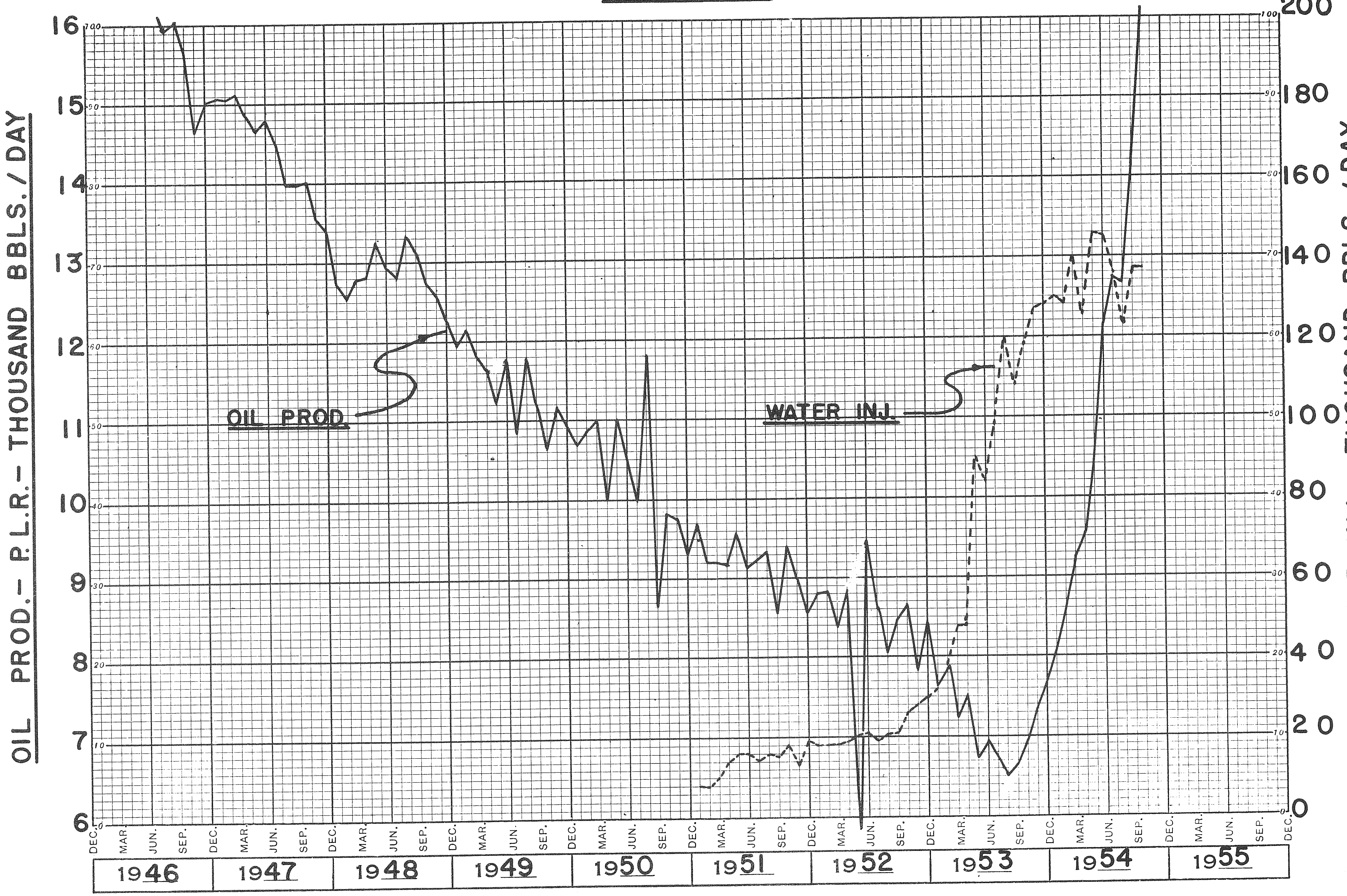


FIGURE 8

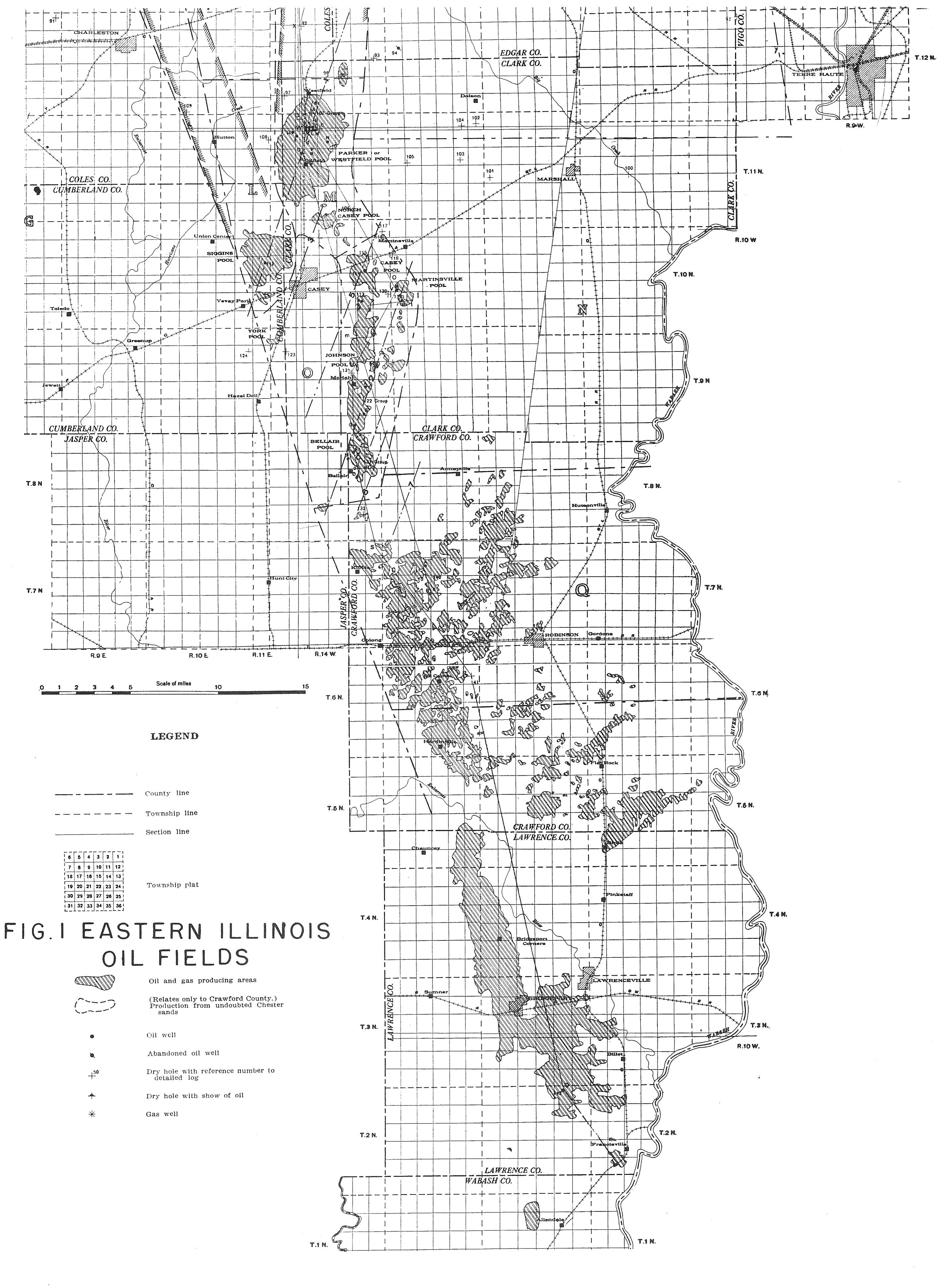


FIG. I EASTERN ILLINOIS OIL FIELDS

WATER FLOODING IN THE OLD FIELDS OF ILLINOIS

By

L. C. Powell

The Ohio Oil Company

"The Old Fields of Illinois" is a very appropriate name attached to a series of both large and small oil pools drilled along the crest of a geological structure known as the LaSalle anticline. Individual pools from a continuous development from the Northwest corner of Clark County to the Southeast portion of Lawrence County, a distance of some sixty-five miles (Figure 1). Both drilling and production increased tremendously from 1904 to 1908. More than 25,000 wells were drilled in Clark, Crawford, and Lawrence Counties from 1904 to 1917. Peak production was obtained in 1908 when some 33,500,000 barrels were produced. This amounted to 19 percent of the total production for the United States; placing Illinois as the third largest producer of all the States. The early years were confined mostly to drilling of the sands of the Pennsylvanian age, which occur from depths of 400 to 1,000 feet. Deeper drilling soon followed to establish productive zones in the Mississippian section.

The usual methods of increasing the production rates and, theoretically, the ultimate recovery, were applied to these fields as normal decline followed after a few years of flush production. Vacuum connected to the casinghead of some lease line wells was applied as early as 1913, although the practice of "pulling vacuum" on all wells did not become general until about 1920. During the 1930's, the injection of air or gas was begun as another means of stimulating production. By this time, many wells had been abandoned because of casing failures, high water production, or low oil rates. Something had to be done to prevent many leases from going into the red side of the ledger. Although the injection of small quantities of air or gas into hundreds of old wells cannot be compared to the present day efficiencies of pressure maintenance programs, it was the savior of many leases that otherwise would have been abandoned prior to water flooding.

In the early days of searching for new oil fields, oil men from Pennsylvania began a westward movement through Ohio, Indiana, and Illinois. The history of water flooding followed closely the same path taken by the early "wildcatters" some fifty years before. Fortunately for the operators in Illinois, these men with previous experience in water flooding jumped over Ohio and Indiana and moved into Illinois, Kansas and Oklahoma.

The successful flooding of the shallow Siggins sand in Clark County was the first indication that water flooding of the old fields of Illinois was feasible. The first attempt to flood the Siggins sand was actually a failure (Figure 2). The Forest Oil Company decided to try a flowing flood on their original pilot operations. The injection pressure required to build up a reservoir pressure sufficient to flow the producing wells resulted in a water break-through from the injection wells that had been drilled in a four-acre, "five-spot" pattern. The Forest people realized that a change in plans was necessary. Another series of "five-spot" developments were started adjacent to the original pilot flood where low pressures were maintained while producers were pumped regularly. Within a year, production had increased sufficiently to indicate that the essential troubles were solved. Expansion of this pilot flood began two years later in 1944, and has continued throughout each year to the present time.

Perhaps a little better idea should be given of the depths and types of geological formations encountered by the men who drilled the original wells back in the days when operations were carried out by man power and horsepower that was primarily animal rather than mechanical. The Pennsylvanian age sands, occurring at depths from 400 to 650 feet, contributed most of the production of Clark County. Crawford County has also produced principally from the Pennsylvanian sands known locally as Robinson sand. These wells encountered productive sands from depths varying from 800 to over 1,000 feet. There are three main sand lenses that develop and then shale out in local areas. Usually, there are not over two lenses well developed in any one locality, although there are isolated spots where all three or even a fourth member may be found. Attempting to correlate individual sand stringers from well to well is sometimes difficult if not impossible. A similar development of Pennsylvanian sands at approximately the same

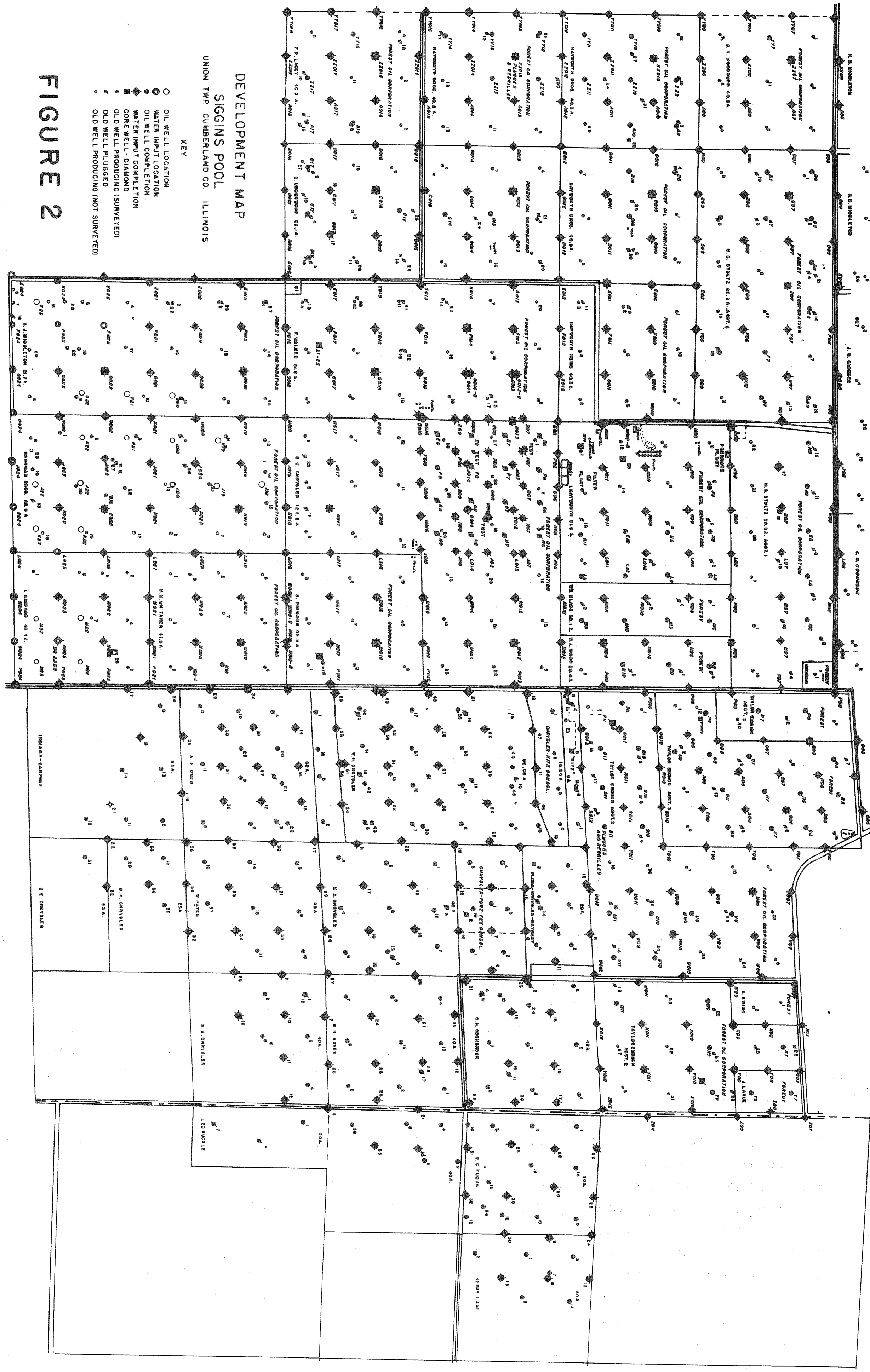

DEVELOPMENT MAP
SIGGINS POOL
UNION TWP CUMBERLAND CO. ILLINOIS
KEY
OIL WELL LOCATION
WATER INPUT LOCATION
OIL WELL COMPLETION
WATER INPUT COMPLETION
CORE WELL - DIAMOND
OLD WELL PRODUCING (SURVEYED)
OLD WELL PLUGGED
OLD WELL PRODUCING (NOT SURVEYED)

FIGURE 2

depths occurs over about one-half of the Lawrence County field. Other formations contributing to the major portion of production in Lawrence County are the Buchanan sand, Kirkwood (a local name for Cypress sand), Paint Creek, Benoist, and Aux Vases sands, also the McClosky limestone. These all occur in the Mississippian section between 1,200 and 1,800 feet. All of these have local areas of development except the Kirkwood, or Cypress, sand which is predominant throughout the entire Lawrence County field. Natural water drives have been active in the Buchanan sand and some areas of the McClosky lime production. The oil found in the Pennsylvanian and Mississippian formations is generally in a range of gravity from 30 to 36 degrees. Viscosities vary from 6 to 12 centipoises.

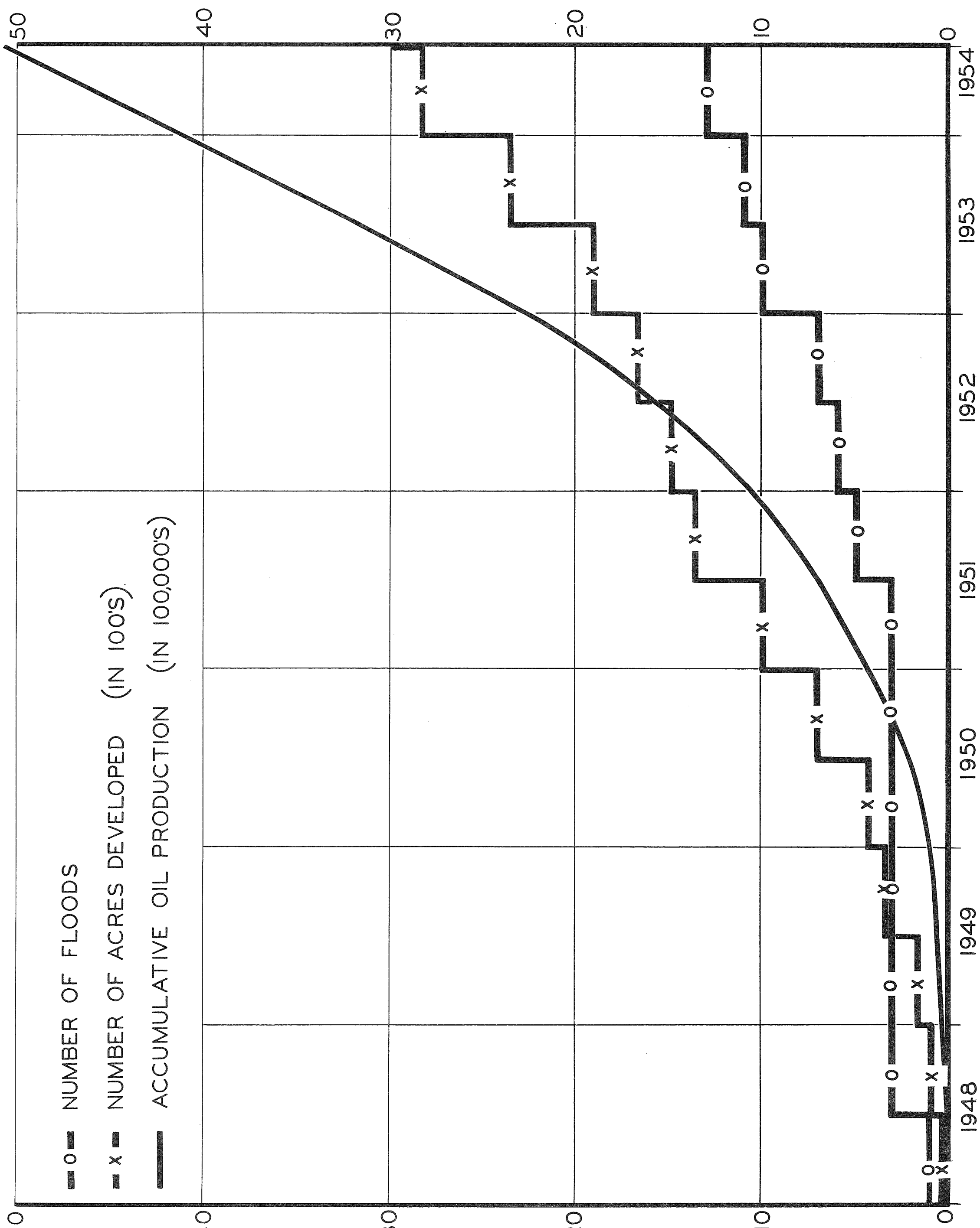
The Ohio Oil Company decided to try a pilot flood in the Kirkwood sand in 1947. The fact that the Kirkwood sand was known to be strictly a gas-expansion-type reservoir eliminated any possibility of trouble with bottom hole water or low residual oil due to movement of a natural water drive. However, our first pilot flood met the same fate as Forest Oil Company's first attempt. The same mistakes were not repeated, but the results were the same. With a certain degree of stubbornness in the following year in 1948, two more pilot floods were begun. Formations were changed by going to the Pennsylvanian sands in Crawford and Lawrence Counties. Two "five-spots", one on a close 440-foot spacing and the other on approximately 700-foot spacing, were developed by drilling new injection wells and utilizing old oil wells for producers. Primary production from these leases had been in the range of 12,000 to 18,000 barrels per acre. Repressuring with gas for several years had nearly doubled production rates for both areas selected. The injection of some 60,000 barrels of water during the next three months resulted in a definite increased production at the pilot flood drilled on 440-foot spacing. Approximately a half million barrels of water were injected before results were obtained in the pilot with 700-foot spacing. A third pilot flood was then started in late 1948. During the early part of 1949, the pilot flood in Crawford County was expanded by drilling 12 more injection wells and, at the same time, 5 more wells were added to the flood in Lawrence County. The encouraging results of these pilot floods in 1949 provided the stimulant needed to begin a general expansion and to widen our views of prospective flood development. It might also be mentioned that the average price of crude advancing from $1.38 to $2.72 during the period from 1944 to 1948 gave added incentive for making sizeable expenditures to obtain additional reserves. A study was then made of all the old producing properties to evaluate the flooding possibilities of each. An over-all flood program was made that included a tentative schedule for an orderly development of the properties considered economically feasible at that time.

The search for large volumes of water required for expansion in both Crawford and Lawrence Counties was intensified. After those areas of plentiful water from alluvial gravel beds were located, the planning and installation of main water systems and distribution lines to individual plants was begun. The area to be flooded extended over so many square miles of oil fields that the decision was made to build relatively small filtering and treating plants to serve individual floods rather than several centrally located plants. Individual flood prospects were divided into areas varying in size from 200 to 600 lease acres. Electrification of these plants, as well as all pumping units, called for a similar planning to acquire and install electric power systems. Except for temporary operations, public service companies or rural co-operatives have been depended upon to furnish power to central metering points. In most instances, the co-operation from these people has been wonderful.

An accelerated program of development began in 1950, which has been maintained up to the present time. Other operators became active in the old fields and increased their acreage developed from 2,500 acres in 1951 to 6,000 acres in 1954. A graphical picture of the development by The Ohio Oil Company and the resulting production is shown in Figure 3. The number of Company-operated floods has increased from three to fourteen during the past six years. The developed acreage has increased from approximately 40 acres to over 3,000 acres since 1948. During this same period, water flood oil recovered amounts to some 5,000,000 barrels.

Pattern flooding with a ten-acre, "five-spot" has been used in most instances. The condition of the old wells, plus the disregard of any modern method of locating them, has eliminated the use of many of the original wells. Approximately 200 old wells are still being used in the flood areas that now include a total of over 600 Company-operated oil wells. The annual rate of water injected has increased from 200,000 barrels in 1948 to 12,000,000 barrels in 1953. The Company will probably inject some 16,000,000 barrels of water during 1954, a large part of which is produced water, treated and returned to the producing formation.

FIGURE 3


NUMBER OF FLOODS
NUMBER OF ACRES DEVELOPED (IN 100'S)
ACCUMULATIVE OIL PRODUCTION (IN 100,000'S)
0
10
20
30
40
50
1948
1949
1950
1951
1952
1953
1954

3

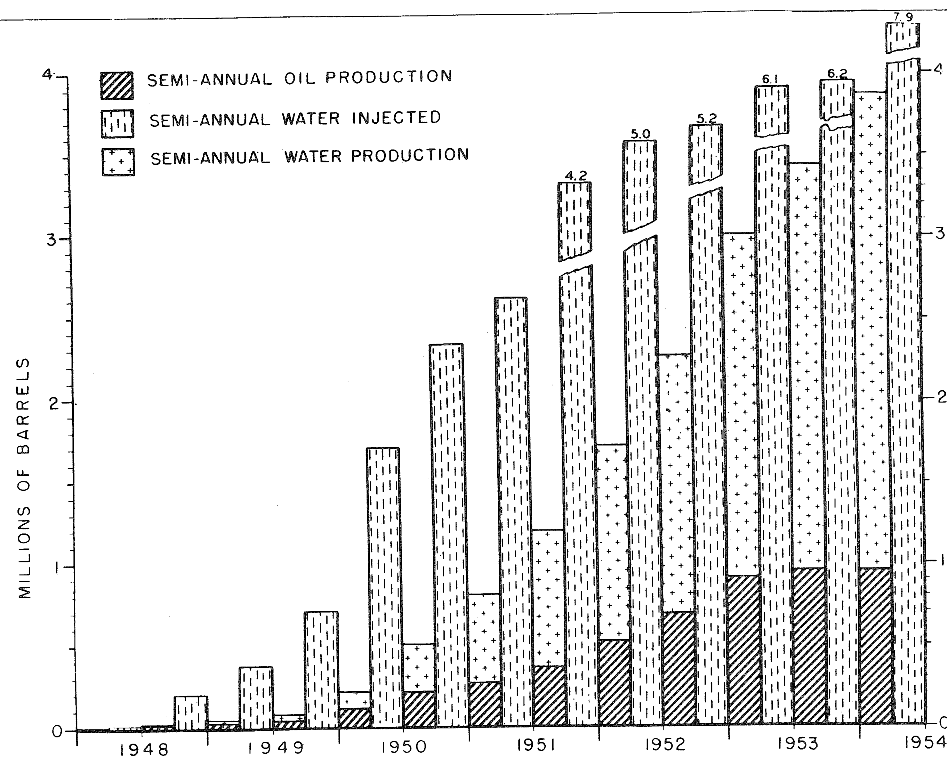
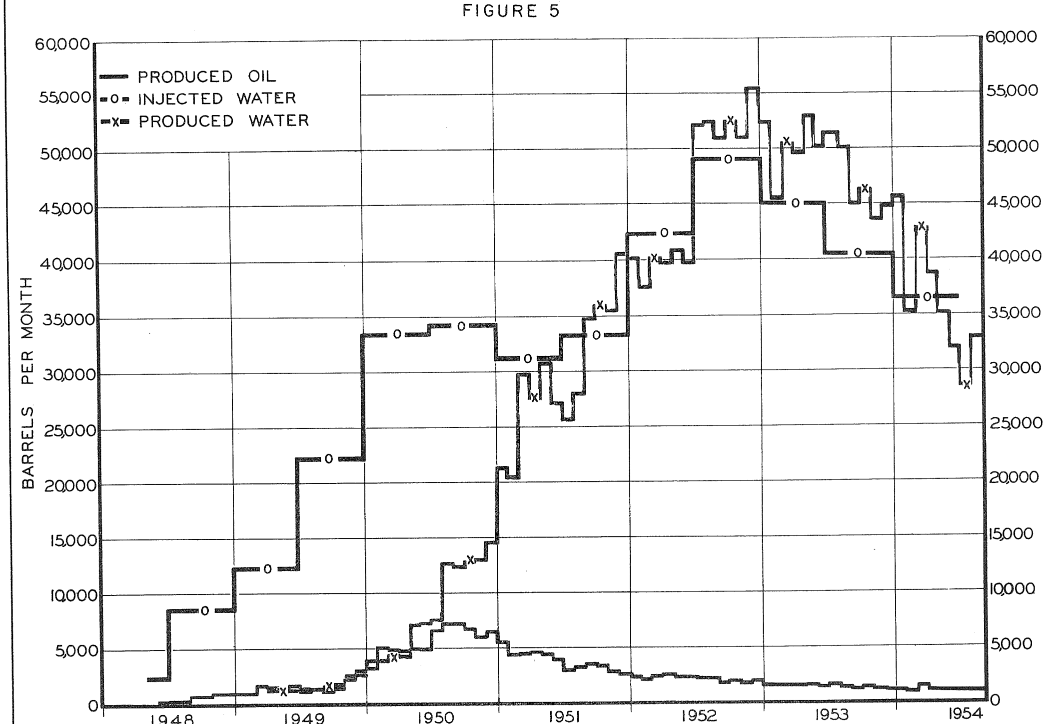


FIGURE 4

4

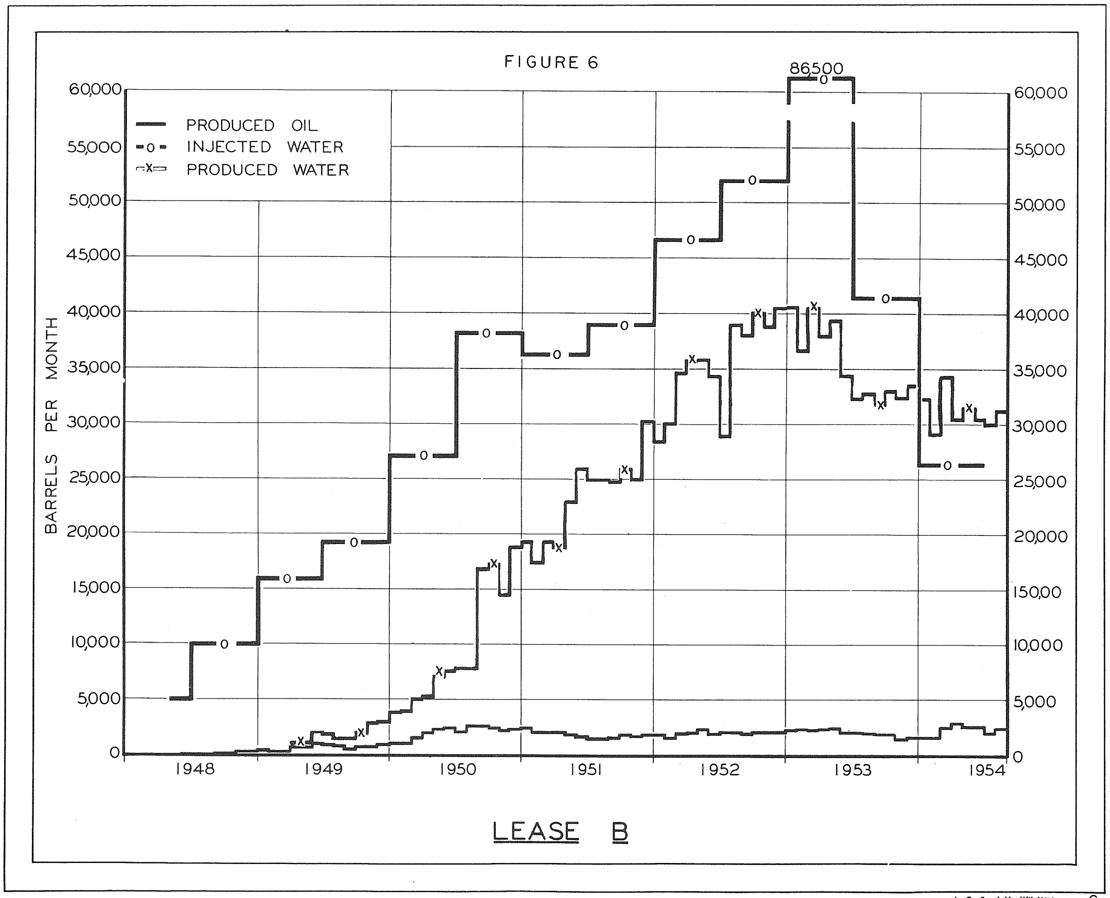
FIGURE 5



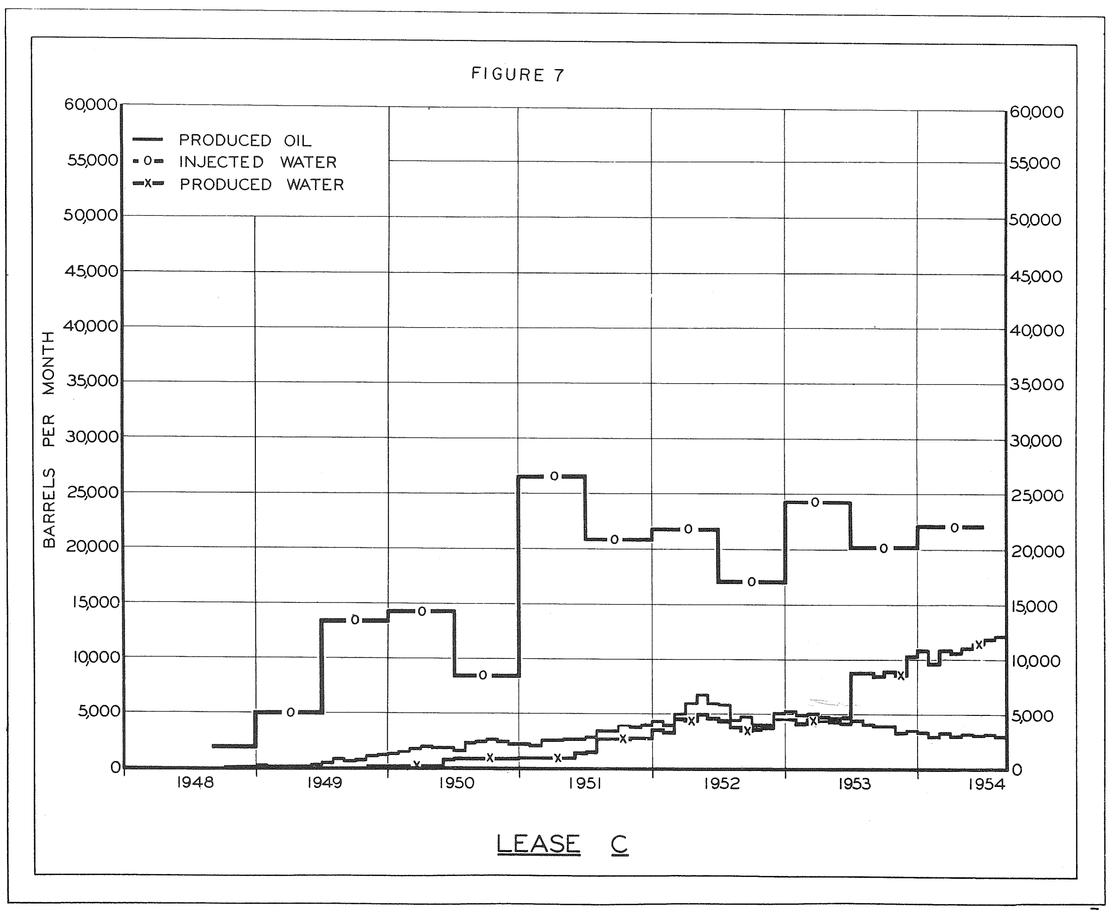
LEASE A

J.H. WILKIN

5



L. C. & J. H. WILKIN 6



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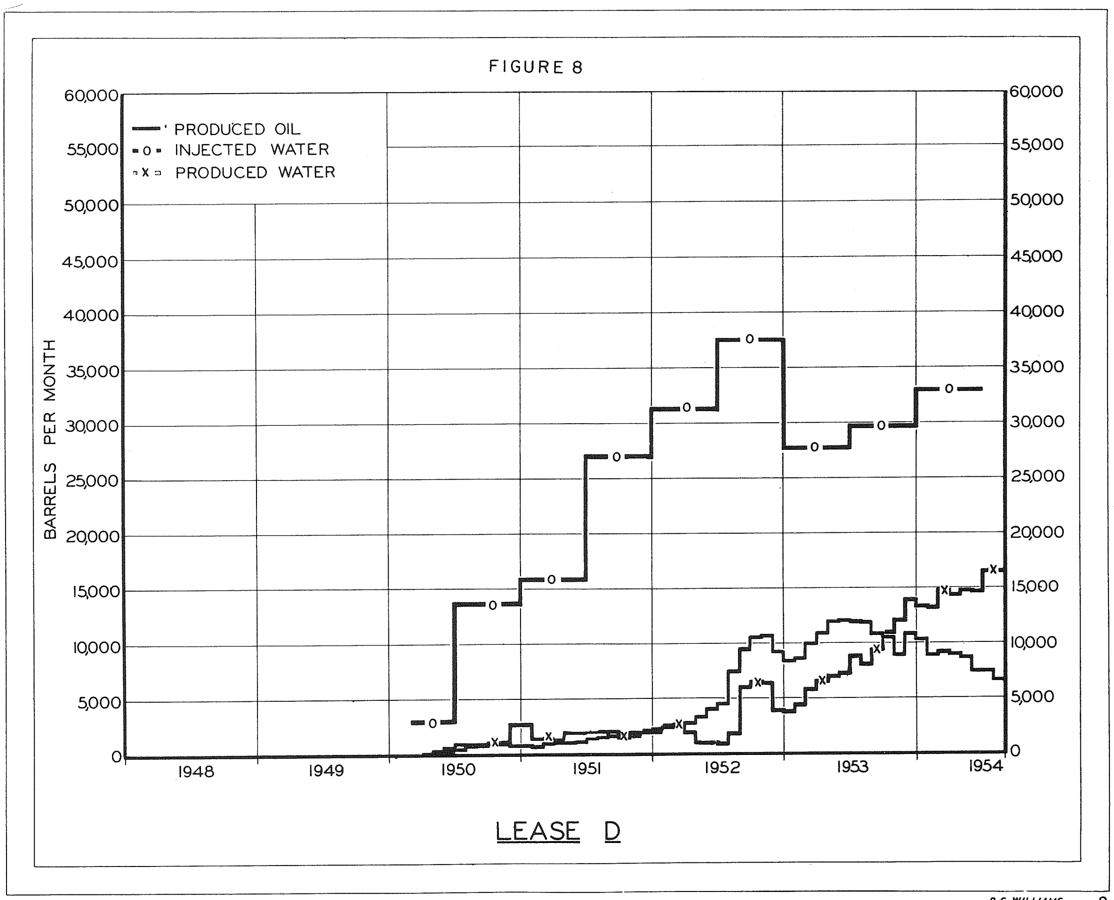
In Figure 4 is shown the semiannual oil and water production, and water injection rates, up to July, 1954. Since the individual floods are in various stages of development, and production, the over-all water-oil ratio is not too indicative of individual flood performance. The ratio of water produced to oil has been approximately 3:1 during the first six months of 1954. The present ratio of water injected to oil produced is 8:1. Accumulated water injected compared with total water flood oil produced shows that forty-two and a half million barrels of water have been injected for a recovery of five million barrels of oil; a ratio of 8.5:1. The over-all performance of the 2,200 acres affected by flooding has been relatively good. This includes sands in both the Pennsylvanian and Mississippian sections of the old field.

The performance of individual floods has varied, as has individual leases within one flood area. To illustrate these variations in flood performances, five leases were selected to show graphically the monthly oil production, water injection, and water produced.

The performance of Lease "A" is shown in Figure 5. Lease "A" is located in one of the oldest floods where old wells were used for all producing wells. New injection wells were drilled on a 440-foot spacing. Core samples were analyzed to give us the following information. The productive zone was one main sand member with high permeability streaks (2,000 m.d.) with an average permeability of 500 m.d. A long primary life, plus five years of gas repressuring, has established a low oil saturated zone in the upper six to eight feet of sand. Generally, there was no evidence of bottom water or indication of any water movement into the oil zone. The oil and water rates and ratios are typical of the average successful flood throughout the five and one-half years shown on this slide. The graph indicates that more water is being produced than injected during the last half of 1953 and most of 1954. This is due to an error in estimating the percentage of total water that actually moved into this lease from line wells around the perimeter of the lease. Selective plugging material used on twelve of the injection wells in March of this year helped to reduce the produced water rate with no decrease in oil rate. Summary figures for this lease show a total of over 2,000,000 barrels of water injected for a total production of 186,000 barrels of oil. The ratio of water injected to oil produced would then be approximately 12:1. Oil recovery to date has been 182 barrels per acre-foot of sand reservoir. The current water-oil ratio is 38:1, which is near the economic limit. A change in flood pattern or additional remedial work will be necessary to extend the economic life of this lease beyond 1955.

The performance of Lease "B" is shown in Figure 6. Lease "B" lies adjacent to Lease "A". The sand member being flooded in Lease "A" dips structurally into water along the East side of Lease "B". Also, as the sand drops structurally, it becomes more shaly and thins in localized areas. As was mentioned before, the sands are lenticular and develop into two or more lenses in some areas. On this particular lease, there is a 25-acre development of an upper Robinson sand that has not been flooded separately from the lower member. The production graph clearly shows that the normal peak production with a relatively rapid decline has never been attained. It can be seen that injection rates with a corresponding increase in water production was tried in 1952 and early 1953. No appreciable change in oil rate resulted. During the last half of 1953 and 1954, the injection rates were gradually reduced and the existing oil production rate was still maintained. Low flood efficiencies are evident, requiring the handling of large volumes of water but nevertheless has maintained a constant oil rate for the past four and one-half years. The current water-oil ratio is 12:1 with an over-all production ratio of nearly 22 barrels of water for each barrel of oil produced. The injection rate for both Lease "A" and "B" has been approximately five barrels per day per foot of sand. Oil recovery to date has been only 84 barrels per acre-foot of sand reservoir.

The performance of Lease "C" is shown in Figure 7. Lease "C" is located in another flood with slightly different reservoir conditions. This reservoir is divided into two sand lenses which are not separated for injection or production. Both sands have a lower permeability which is quite uniform throughout the section, the average being slightly over 100 m.d. Although gas repressuring was applied to this lease with discouraging results, the oil saturations were normal or above for the entire sand section. The performance curves bring out the facts that water injection has been slower, approximately two barrels per foot of sand per day, and the oil rate has had a very steady increase with relatively low water production. The ratio of water injected to oil produced is a very comfortable 5.7:1. Oil recovery to date is some 125 barrels per acre-foot of sand with a performance which indicates that the ultimate may reach 200 barrels per



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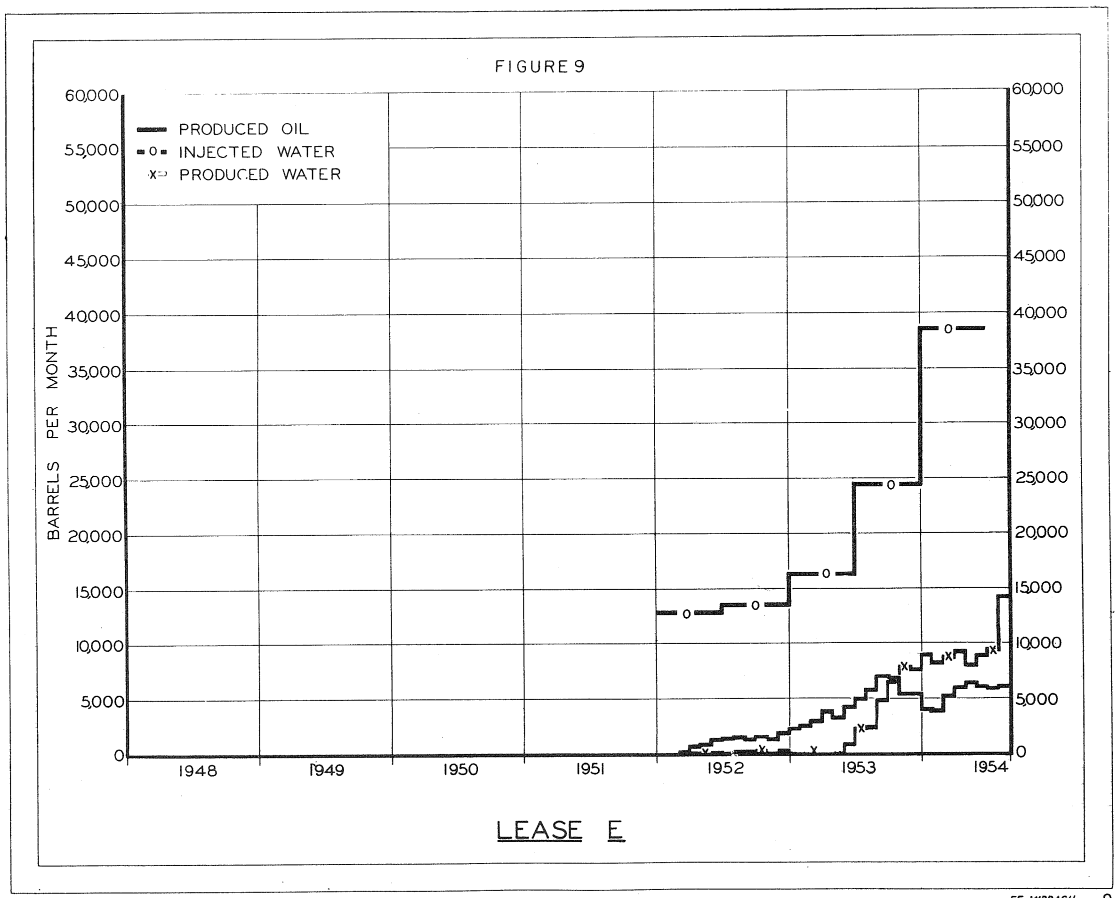

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acre-foot. Variations in injection rates were due to periodic cleaning of injection wells, changes in well regulation, or minor interruptions in the water supply. None of these have seriously affected oil production rates or, apparently, flood efficiencies. Water flood recoveries should match the primary for this lease.

The performance of Lease "D" is shown in Figure 8. Lease "D" is the kind of lease which one would like to own or be able to claim some form of interest, whether as operator or royalty. The sand in this reservoir has good porosity, high and fairly uniform permeability, confined to one well-developed sand body. To date the ratio of water injected to oil produced is about 5:1. The present water-oil ratio is 2.5:1. The recovery of oil per acre foot is 135 barrels with an estimated ultimate of 220 barrels. This is hoped to be conservative, and it would be desirable to have more of this type reservoir in the old fields.

The performance of Lease "E" is shown in Figure 9. Lease "E" is one of the first developments in the Kirkwood or better-known Cypress sand. Production history, as can be seen, is rather brief; enough, however, to indicate a potentially successful water flood. The substantial changes of water injected during 1953 and 1954 are due to the expansion of the acreage included in the flood rather than an increase in the rate per well. This sand is finer grained with lower, measured permeability but still with good porosity. Injection rates have been higher than anticipated, ranging from five to ten barrels per foot of sand. The current oil recovery is 72 barrels per acre-foot.

These graphs have shown four good flood performances to one rather poor one. Although anyone will naturally select their better prospects first, it is believed that the number of poor results can be confined to a reasonable minimum if care is taken when investigating the prospective flood area, and then follow it with the very best operating practices that are known. The methods used in water flood or any type of secondary recovery should continue to improve. Everyone knows that experience is a good teacher. A few mistakes are known that have been made during the past six or seven years that should not be repeated. It seems that education comes awfully slow in this business, but some consolation can always be gained by realizing that the person or company that never makes a mistake probably has not done much.

Some minor problems that seemed big at the time we were wrestling with them have been encountered. However, most of them have been common to anyone connected with secondary recovery. In a way, it is believed that we have been lucky comparing our troubles with those encountered by people operating in other areas. Some attempts to increase over-all flood efficiencies have resulted in some experimental failure, but as long as there is still high residual oil remaining in these or any other oil fields, attempts to improve will continue.

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