State of Illinois
Adlai E. Stevenson, Governor
DEPARTMENT OF REGISTRATION AND EDUCATION
Noble J. Puffer, Director

Division of the

STATE GEOLOGICAL SURVEY

M. M. Leighton, Chief

Urbana

CIRCULAR NO. 165

SUMMARY OF WATER-FLOODING OPERATIONS IN ILLINOIS 1950

By

Frederick Squires, and Members of the
Secondary Recovery Study Committee for Illinois,
Secondary Recovery Division, Interstate Oil Compact Commission

Reprint of the Report Published
by The Interstate Oil Compact Commission,
September 1950

Printed by Authority of The State of Illinois

Urbana, Illinois
1950

PREFACE

The Secondary Recovery Division of the Interstate Oil Compact Commission with Albert E. Sweeney, Jr., Director, and Mr. Paul D. Torrey, Chairman of the Secondary Recovery Advisory Committee, has undertaken the accumulation and publication of information in regard to secondary recovery projects in the United States. This publication represents the work of the Committee appointed upon the recommendation of Mr. Clarence T. Smith, Official Representative of Governor Adlai E. Stevenson of Illinois, with Mr. Frederick Squires of the Illinois Geological Survey as Chairman of the Committee.

The Interstate Oil Compact Commission wishes to express its appreciation to all companies, organizations, and individuals who have assisted this Committee in gathering data on water-flooding operations in Illinois. This information is being published in order that the oil industry and the public in general may have factual information regarding the progress of water flooding in Illinois.

Earl Foster
Executive Secretary

FOREWORD

In conformity with the action of the Executive Committee of the Interstate Oil Compact Commission, taken at Fort Worth, Texas, October 4, 1949, the State of Illinois is proud to be a leader in the organization of a Secondary Recovery Committee to cooperate with the Compact in the study of methods for increasing the recovery of oil.

According to information presented at the recent Summer Meeting of the Interstate Oil Compact Commission, held at French Lick, Indiana, August 3, 4, and 5, 1950, the estimated oil reserves of Illinois recoverable in the future by secondary methods exceed 350,000,000 barrels. This is mainly additional to the estimated proved reserves of 508,500,000 barrels recoverable from existing wells largely by primary methods. The production of this great secondary reserve could easily double the life of the Illinois oil industry, and, thereby, result in impressive benefits to the State and to the counties in which oil is produced in the form of taxes, to the people of Illinois in the form of wages and royalty payments, in addition to the substantial benefits which will accrue to the oil industry itself, and to the nation.

Patriotic obligations should cause us to devote a great deal of thought and attention to the enactment of appropriate laws and to essential technical studies for the purpose of making large secondary reserves of oil available to aid in meeting expected increased armed services needs in the future.

The State of Illinois is eager to encourage the application of methods which will insure the maximum economic recovery of oil from every field.' For this reason it is a pleasure to commend the constructive work of the Illinois Secondary Recovery Committee which has resulted in the report on "Summary of Water-Flooding Operations in Illinois, 1950." To the men who have labored so industriously in the preparation of this report, the thanks of the State are extended. It is also urged that every producer of oil in Illinois cooperate actively with the Committee in order that it may serve, in connection with the secondary recovery work of the Compact, as a clearinghouse for information which will prove to be of great and lasting value to the State of Illinois and its people.

Adlai E. Stevenson
Governor of Illinois

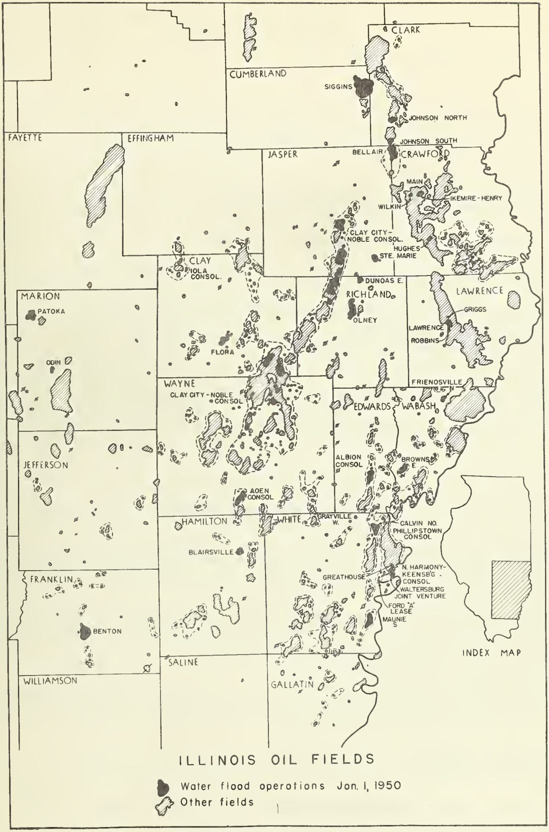


FIGURE I
INDEX MAP OF WATER-FLOOD OPERATIONS IN SOUTHERN ILLINOIS

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

SUMMARY OF WATER-FLOODING OPERATIONS IN

ILLINOIS, 1950

INTRODUCTION

Early in 1950, the Secondary Recovery Study Committee for Illinois was appointed by Earl Foster, Executive Secretary, Interstate Oil Compact Commission, upon the recommendation of Clarence T. Smith, official representative of Governor Adlai E. Stevenson. The report that follows is largely the result of the work done by that committee. The committee members are as follows:

Frederick Squires, Chairman
Illinois State Geological Survey
100 Natural Resources Building
Urbana, Illinois

A. H. Bell
Illinois State Geological Survey
100 Natural Resources Building
Urbana, Illinois

H. R. Bolton
The Ohio Oil Company
Terre Haute, Indiana

C. V. Cameron
Shell Oil Company
Centralia, Illinois

W. S. Corwin
Tide Water Associated Oil Company
Keensburg, Illinois

R. E. Dunn
Magnolia Petroleum Company
P. O. Box 501
Salem, Illinois

R. W. Love
The Texas Company
P. O. Box 299
Salem, Illinois

R. J. Cassin, Secretary
Illinois State Geological Survey
100 Natural Resources Building
Urbana, 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

Harry Swaneck
Gulf Refining Company
Centralia, Illinois

Ray Vincent
Sohio Petroleum Company
Box 352
Centralia, Illinois

E. C. Wells
Carter Oil Company
Mattoon, Illinois

M. R. Wilson
The Texas Company
Salem, Illinois

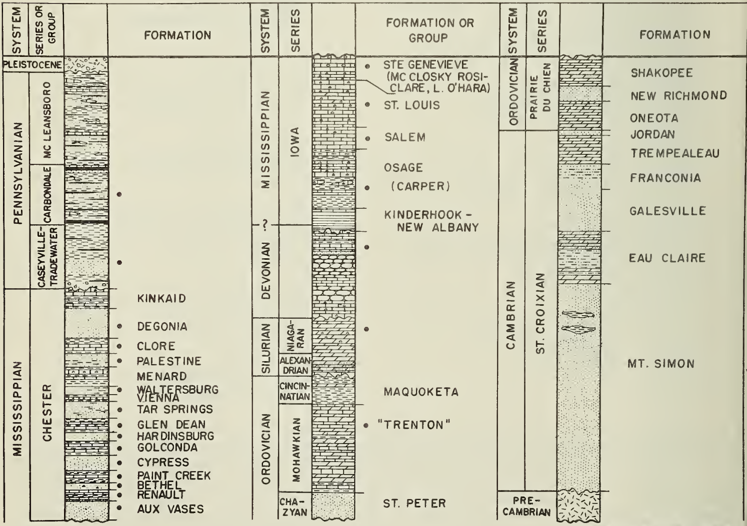
Albert E. Sweeney, Jr., Director, Secondary Recovery Division, Interstate Oil Compact Commission, attended the committee meetings and gave helpful support to the committee's work.

As a result of this study, it was found that there were 31 controlled water-flood operations in Illinois as of January 1, 1950 (see map Fig. 1). Summary data for these are given in Table I, Data for Illinois Controlled Water Floods, January 1, 1950. Production and water input graphs for 14 floods and development maps for 10 floods are included. Six floods have been selected for more detailed discussion herein (1) Siggins, Cumberland County, (2) Bellair, Crawford County, (3) Ikemire-Henry, Crawford County, (4) Maunie South, White County, (5) W. E. Robins, Lawrence County, and (6) Patoka, Marion County.

Data for four of the six descriptions of water floods were taken in part from University of Illinois Master of Science theses undertaken in cooperation with the Illinois State Geological Survey. Dr. J. L. Hough, Department of Geology, University of Illinois, was in charge of all four theses. These reports are (1) The Bellair Flood by William Lang, (2) The Ikemire-Henry Flood by William Vineyard, (3) The Maunie South Flood by R. M. Stephens, and (4) The W. E. Robins Flood by Jack Foster. Data for the Siggins floods were assembled by R. J. Cassin and the illustrations for the Patoka flood were taken from the article by H. S. Barger published in the PRODUCERS MONTHLY and the OIL AND GAS JOURNAL.

Descriptions of pressure maintenance and dump flooding operations were omitted from the report because data for these were not available.

FIGURE 2
GEOLOGIC COLUMN FOR SOUTHERN ILLINOIS
SHOWING OIL PRODUCING STRATA(•)



ILLINOIS STATE GEOLOGICAL SURVEY

DATA ON 31 ILLINOIS CONTROLLED WATER FLOODS

On January 1, 1950, Illinois had 31 active controlled floods, Table 1. These, together with the many McClosky dump floods, had produced about 15,400,000 barrels of flood oil to January 1, 1950. This oil was obtained from sands with an average thickness of about 20 feet which took water at the rate of 10 barrels per day per foot. Porosities averaged about 20 per cent and permeabilities approximately 150 millidarcys. The fluid saturations at the start of flooding averaged 64 per cent oil and 20 per cent water and the ratio of water input to flood oil produced was about 5 to 1 at the end of 1949. The over-all recovery to January 1, 1950, from the 8,450 acres in the controlled floods was 1,213 barrels per acre. This last figure is very encouraging considering the early stage of development of many of the floods. As only a small part of the State's total oil-producing area of 376,000 acres has been affected by controlled water floods, there remains an extensive territory which has good prospects for oil recovery by water flooding.

TABLE I
DATA FOR ILLINOIS CONTROLLED WATER FLOODS, JANUARY 1, 1950

Line No.	Field	County	Project	Water-Flood Pay	Average Depth to Water-Flood Pay	Operator	Date of First Water Input
1	Aden Consolidated	Wayne	Aden	Aux Vases	3200	Texas	Aug. 46
2	Aden Consolidated	Wayne	Aden	McClosky	3350	Texas	Aug. 46
3	Albion Consolidated	Edwards	Albion	Bridgeport	1900	Superior	Aug. 46
4	Albion Consolidated	White	Biehl	Upper Biehl	1900	Yingling	Aug. 49
5	Bellair	Crawford	Forest-Bellair	Bellair "500"	550	Forest	Jul. 48
6	Bellair	Crawford	Fulton	Bellair "500"	560	Pure	Jul. 48
7	Benton	Franklin	Benton	Tar Springs	2100	Shell	Nov. 49
8	Blairsville	Hamilton	Blairsville	Aux Vases	3275	Texas	Jun. 48
9	Browns East	Wabash	North Bellmont	Cypress	2600	Magnolia	Nov. 47
10	Friendsville North	Wabash	Friendsville North	Biehl	1500	Magnolia	Jul. 47
11	Iola Consolidated	Clay	Iola East	Aux Vases	2350	Texas	Mar. 48
12	Johnson North	Clark	Pickens Flood	Casey	450	Pickens	May 49
13	Johnson South	Clark	South Johnson	Upper Partlow	490	Forest	Mar. 49
14	Lawrence	Lawrence	Robins	Bridgeport	900	Ohio	Aug. 48
15	Lawrence	Lawrence	Griggs	Kirkwood	1350	Ohio	Jul. 47
16	Main	Crawford	Henry-Ikemire	Robinson	935	Tidewater	Feb. 48
17	Main	Crawford	Wilkin	Robinson	950	Ohio	May 48
18	Main	Crawford	Hughes	Robinson	890	Ohio	Sept. 48
19	Maunie South	White	Tar Springs Unit	Tar Springs	2200	Magnolia	Aug. 47
20	New Harmony-Keensburg Consolidated	White	Greathouse	Bethel	2750	Sun	Jan. 49
21	New Harmony-Keensburg Consolidated	White	Ford "A"	McClosky	2900	Sun	May 48
22	New Harmony-Keensburg Consolidated	White	Greathouse	McClosky	2900	Sun	Aug. 47
23	New Harmony Keensburg Consolidated	White-Ill. Posey-Ind.	Waltersburg	Waltersburg	2220	Superior	Aug. 46
24	Odin	Marion	Odin	Cypress	1750	Ashland	Oct. 49
25	Olney Consolidated	Richland	Olney	McClosky	3060	Texas	Nov. 46
26	Patoka	Marion	Benoist Flood	Benoist	1410	Sohio	Sept. 43
27	Patoka	Marion	Rosiclare	Rosiclare	1550	Sohio	48
28	Phillipstown Consolidated	White	North Calvin	Biehl	1800	Magnolia	Sept. 47
29	Siggins	Clark, Cumberland	Forest	1st Siggins	400	Forest	42
30	Siggins	Clark, Cumberland	Pure	1st Siggins	404	Pure	Dec. 46
31	Siggins	Clark, Cumberland	Pure	2nd Siggins	464	Pure	Dec. 46

Acres Flooded (As of January 1, 1950)	Total Acres Water-Flood Pay in Field	No. of Wells: Producers	No. of Wells: Input	Plant Pressure	Water-Flood Oil Production (1949)	Water Production (1949)	Water Input (1949)	Average Input Barrels per Day per Foot of Pay (1949)	Line No.
300	400	10	3	1210	28,332	10,620	230,264	18.0	1
300	2,000	12	2						2
192	250	30	3	-	59,061	156,520	219,577	10.0	3
172		10	2	966	20,188	3,173	111,227	22.0	4
200		24	56	285	29,181	100,000 [4]	2,211,655	2.8	5
443		124	131	250	53,700	141,335	2,894,101	2.8	6
1,900	2,400	120	84	320	None	8,400	815,600	8.2	7
	640	16	2	960	3,722	9,273	208,582	18.0	8
174	174	12	3	1543	90,877	918	139,241	11.5	9
40	120	3	2	1386	33,421	12,575	50,760	9.9	10
40		3	1	687	None	8,750	39,103	1.5	11
60	825	17	18	200	4,554	1,000	445,000	8.7	12
160	1,710	13	24	250	61,585	100,000 [4]	1,080,663	3.4	13
114	5,050	29	9	260	32,987	22,917	295,109	1.7	14
35	16,200	9	4	-	5,116	15,722	63,745	1.9	15
45	34,320	10	12	130	41,250	21,000	237,200	3.9	16
113	34,320 [5]	36	25	-	29,979	40,128	601,383	3.0	17
89		28	24	-	8,461	434	188,304	.6	18
[illegible]30		13	11	777	280,054	140,263	533,150	8.5	19
20		4	4	1200	543		230,588	7.0	20
40		1	1	15	2,596	None	14,610	5.7	21
60		2	2	1100	13,366	20,000 [4]	234,359	64.0	22
490		43	3	0	115,791	92,759	469,486	10.7	23
196	210	20	1	20	None	None	13,877	12.3	24
60	940	1	1	225	7,958	18,684	71,464	20.0	25
527	565	81	62	250	350,000 [4]	2,800,000 [4]	3,900,000 [4]	-	26
469	469	12	14	-	120,000 [4]	50,000 [4]	200,000 [4]	-	27
10		4	1	1250	9,254	7,134	43,343	10.8	28
1,300		247	314	200-280	682,574	1,500,000 [4]	3,526,599	1.0	29
402	3,190	121	127	177	426,137	836,803	1,543,263	1.6	30
269	350								31
Totals 8,450	69,813	1,055	946		2,510,687	6,118,408	20,612,253	9.9 (Av.)	

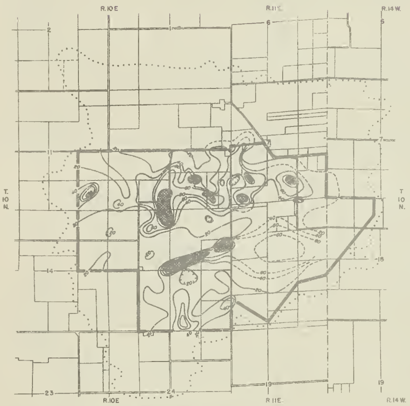
TABLE I (Continued)

Line No.	Cumulative Production and Input to January 1, 1950: Water-Flood Oil Production	Water Production	Water Input	Input Water: Type	Source	Chemically Treated	Number of Old Wells Used as Producers	Inputs	Are Wells Cored	Shot
1							10	3	Yes	Yes
	28,952	34,605	542,801	Brine	Penn. sand	Yes				
2							12	1	Yes	No
3	119,942	248,280	402,596	Brine	Produced	Yes	30	3	Yes	Yes
4	20,188	3,173	111,227	Fresh Brine	Run off Penn. sand	No	10	1	Yes	Yes
5	29,181	90,000 4/	2,719,268	Fresh	Gravel bed	No	9	None	Yes	Yes
6	53,700	141,335	3,936,711	Fresh	Gravel bed	Yes	47	2	Yes	Yes
7	None	8,400	815,600	Fresh	Lake	Yes	119	83	Yes	Yes
8	3,722	13,542	252,611	Brine	Cypress sand	No	16	2	Yes	Yes
9	166,653	918	235,319	Brine	Tar Springs sand	No	11	2	Yes	Yes
10	70,389	14,808	102,092	Fresh	Penn sand (300 feet)	No	3	1	Yes	Yes
11	None	14,504	62,662	Brine	Produced	No	3	1	Yes	Yes
12	4,554	1,000	445,000	Fresh Brine	Gravel beds Produced	No	11	3	Yes	Yes
13	61,485	100,000 4/	1,080,663	Fresh Brine	Gravel beds Produced	Yes	9	None	Yes	Yes
14	44,037	22,917	364,786	Fresh	Gravel bed	No	27	None	Yes	Yes
15	9,627	31,460	307,690	Brine	Buchanan sand	No	7	None	Yes	Yes
16	45,000	25,440	342,500	Brine	Penn. sand	No	5	1	Yes	Yes
17	34,400	44,429	714,894	Fresh	Gravel bed	No	35	None	Yes	Yes
18	9,070	434	218,923	Fresh	Penn. sand	No	24	None	Yes	Yes
19	528,086	167,917	1,148,565	Brine	Penn. sand	No	13	11	Yes	Yes
20	543	20,000 4/	230,588	Fresh	Gravel bed	No	4	3	Yes	Yes
21	2,596	None	24,894	Fresh	Gravel bed	No	1	1	Yes	Yes
22	13,366	10,000 4/	259,338	Fresh	Gravel bed	No	2	2	Yes	No
23	315,252	144,458	1,886,225	Brine	Produced	Yes	43	3	Yes	Yes
24	None	None	13,877	Brine	Tar Springs	No	18	None	Yes	Yes
25	25,660	23,920	345,844	Brine	Produced	No	1	1	No	No
26	5,405,226	9,000,000 4/	15,593,206	Brine	Tar Springs	Yes	-	-	Yes	Yes
27	195,378	50,000 4/	394,904	Brine	Tar Springs	Yes	-	-	Yes	Yes
28	24,936	9,306	86,690	Brine	Penn. sand	No	4	None	Yes	Yes
29	2,497,797	4,000,000 4/	14,321,908	Brine Fresh	Produced Gravel beds	Yes No	181	None	Yes	Yes
30										
	689,151	1,115,333	4,021,594	Fresh	Gravel beds	Yes	92	2	Yes	Yes
31										
Totals	10,392,891	15,336,179	50,982,976				747	126		

Total Controlled Floods	10,398,891
Plus McClosky' Dump Floods	5,000,000 4/
Cumulative Illinois Water-Flood Production to January 1, 1950	15,398,891

Flood Pay: Net Thickness Feet	Flood Pay: Average Porosity Per cent	Flood Pay: Average Permeability Millidarcys	At Start of Water Flood Percent of Pore Space Saturated 1/: Oil	At Start of Water Flood Percent of Pore Space Saturated 1/: Water	Oil Characteristics: Viscosity Centipoises	Oil Characteristics: A P I Gravity	Water-Flood Pattern	Input to Oil Well Distances	Remarks	Line No
10	22.0	150	-	42.0	7.6 at 100 ° F.	35.4	Perimeter		Dual completions in Aux Vases & McClosky	1
3.6	-	-	-	-						2
20	19.7	304	22.0	29.0	6.3 at 95 ° F.	32.5	Spot			3
17.1	20.2	265	-	23.6	5.1 at 88 ° F.	37.6	Flank Inj.		Water injected below oil water contact	4
38	17.1	148	35.5	42.7	16 at 77 ° F.	32.4	5-spot	300	Flowing flood	5
22	18.6	149	35.9	43.4	18.7 at 77 ° F.	32.0	5-spot	300	Flowing flood	6
37	19.0	65	50.6	26.4 2/	3.5 at 86 ° F.	38.0	5-spot	660		7
15.5	19.0	92	-	-	4.2 at 99 ° F.	37.6	Perimeter			8
11	18.0	144	83.0	15.0 2/	4.6 at 92 ° F.	36.0	Line	1,500		9
7	16.0	81	76.0	18.0 2/	7.5 at 86 ° F.	35.6	Near 5-spot	500		10
7	15.7	80	-	-		37.0	Spot		Pilot Flood	11
15	19.0	200	42.0 est.	25.0	5 to 6 at 60 ° F.	31.0	5-spot (Irreg.)			12
48	16.6	319	33.6	55	14.7 at 77 ° F.	29.2	5-spot	300		13
52	21.6	-	-	-			5-spot (Irreg.)	400		14
23	20.0	-	-	-			5-spot			15
14	21.5	175	40.0	15 3/	7.0 at 60 ° F.	35.0	5-spot	300		16
22	22.0	-	-	-			5-spot			17
25-45	20.1	-	-	-			5-spot			18
15.7	18.5	529	73.0	17 3/	4.6 at 89 ° F.	37.3	5-spot	660		19
23	17.0	20	-	30		38.0	5-spot		Pilot Flood	20
7	-	-	-	-			Spot	660		21
5	-	-	-	-			Spot			22
40	19.2	200	-	25	3.8 at 86 ° F.	36.8	Line			23
15	20.0	78	28.0	33	8.3 at 70 ° F.	37.0	Perimeter	700	Average oil content start of flood estimated 65 per cent	24
10	-	-	-	-			Perimeter			25
27	19.0	110	53.0	20.0 3/		39.0	5-spot	460		26
9	18.8	223	65.0	30.0 3/		40.0	Perimeter			27
11	19.0	85	69.0	18.0 3/	11.2 at 78 ° F.	32.2	5-spot	550		28
32	17.5	56	36.7	46.7	8 at 60 ° F.	36.6	5-spot	300		29
25	18.5	45	29.8	52.2	8.8 at 68 ° F.	36.0	5-spot	300		30
6	18.3	66	26.7	52.5						
Averages 20.1	18.9	156	63.7 3/	19.8 3/		35.6				

1/ Actual core analyses
2/ Based on well cored in oil
3/ Corrected for invasion
4/ Estimated figures
5/ Represents same acreage as Line 16

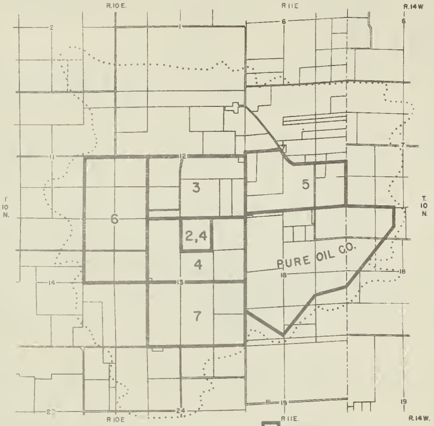


· · · · APPROXIMATE LIMIT OF SIGGINS PRODUCTION
LIMIT OF FLOOD
CONTOUR, INTERVAL 20 MILLIDARCYS
100-200 MILLIDARCYS
200-400 MILLIDARCYS

PERMEABILITY MAP OF SIGGINS POOL
FIRST SIGGINS SAND

FIGURE 3

Prepared by R. J. Cassin from permeability data furnished by Forest Oil Corporation and Pure Oil Company



· · · · APPROXIMATE LIMIT OF SIGGINS PRODUCTION
7 NUMBER OF FOREST FLOOD

LOCATION OF SIGGINS POOL FLOODS

FIGURE 4

SIGGINS WATER FLOODS

Introduction and History

The primary production history of the Siggins field, Township 10 N., Ranges 10 and 11 East, Clark and Cumberland Counties, Illinois, is given in Illinois Geological Survey Bulletin 54 by L. A. Mylius, and the early water flood is described by Frederick Squires in Illinois Geological Survey Circular 125, "Flood Tide in Illinois." This chapter will be devoted to a description of the current Siggins floods. (Fig. 4)

Water-Flood History

Systematic water flooding was first begun in the Siggins field in 1942 when the Forest Oil Corporation redrilled and flooded 40 acres of the 1st Siggins sand near the center of the field (flood 2, Fig. 4). Since 1942 the flooding has been expanded to 2,000 acres in both 1st and 2nd Siggins sands. These floods are operated by the Forest Oil Corporation and Pure Oil Company. Field daily average production increased from 100 barrels or less per day in 1940 to 3,000 barrels per day in October, 1949, with a cumulative water-flood production to January 1, 1950, of 3,187,000 barrels.

Water-Flood Development

With few exceptions the old wells were plugged and a new five-spot pattern drilled with input wells 440 feet apart and input to oil well distances about 300 feet (Fig. 5). Insofar as possible input wells are completed to have only net pay open to injection and are selectively shot to minimize the natural permeability differences. Forest Oil Corporation input wells are completed by running a rag packer on 1 1/2-inch tubing with a few sacks of cement to hold it. Only surface casing is used. The input wells of the Pure Oil Company are completed by inserting perforated tubing opposite the pay and gravel packing the annular space. The tubing is then cemented in place and the casing removed. Well-head equipment on the input wells of both companies consists of a meter between two valves with an additional valve located off the injection line, making it possible to check pressures. Oil wells are conventionally completed pumping wells.

Water Source and Treatment

By the first of January, 1950, 18,344,000 barrels of water had been injected into the 1st and 2nd Siggins sands. This water was obtained from fresh water wells and produced salt water. The fresh water comes from a 100-foot deep glacial gravel in Hurricane Creek. Turbine pumps at the wells lift the water and push it 6 miles through 6-inch pipe to the field where it is used in Forest Oil Corporation floods 2, 3, and 6, and in Pure Oil Company's flood. Producing wells furnish the brine. After separation from the oil the brine is aerated, chemically treated and filtered. Brine is used in Forest Oil Corporation floods 4, 5, and 7, and will be used in future Forest Oil Corporation floods 8 and 9. Booster pumps force the water at 200-280 pounds pressure through a series of cement-lined mains, laterals and individual lines to each of the injection wells. Sand face pressures are kept below the maximum safe pressure of one pound per square inch per foot of depth. Daily average injection rates for 1949 average slightly in excess of 1 barrel of water per foot of exposed sand.

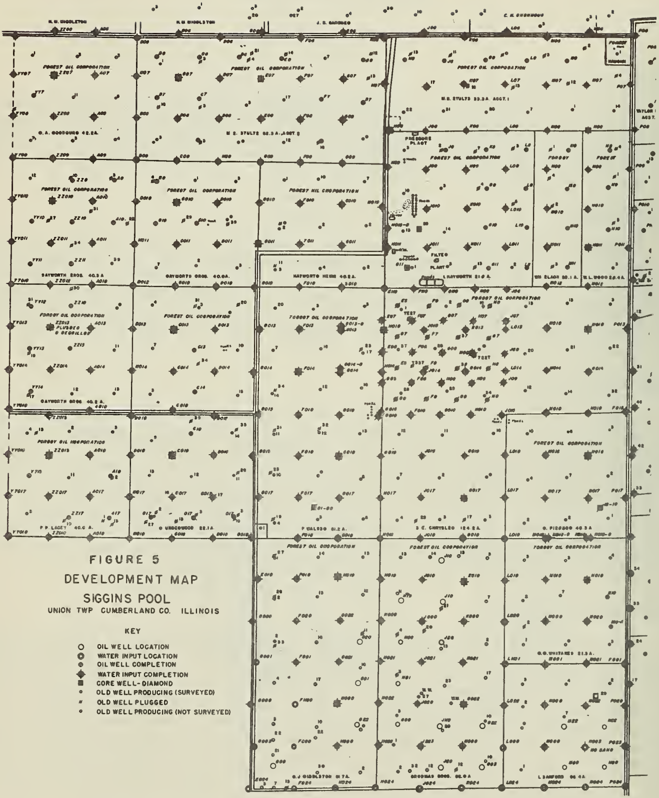
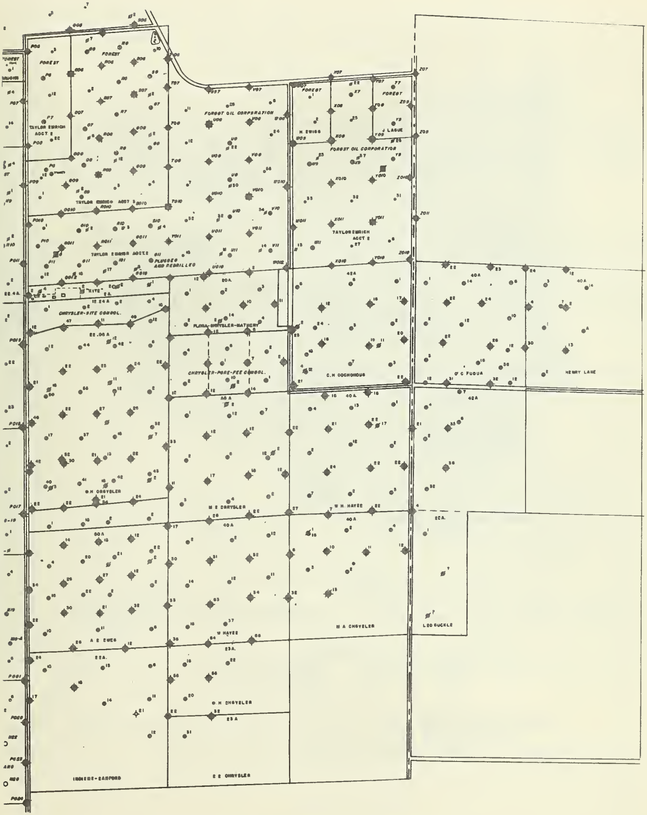
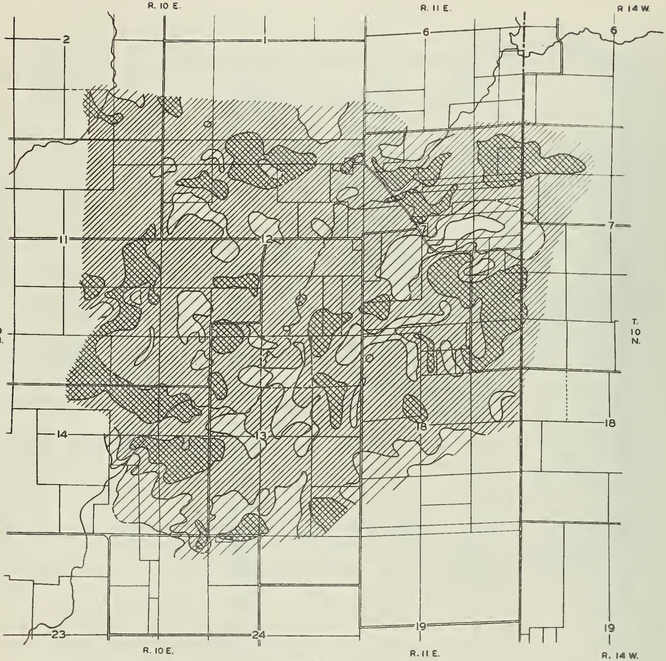


FIGURE 5
DEVELOPMENT MAP
SIGGINS POOL
UNION TWP CUMBERLAND CO. ILLINOIS

Prepared by R. J. Cassin from data obtained from



Forest Oil Corporation and Pure Oil Company.



LEGEND

0 TO 25 FEET
25 TO 50 FEET
50 TO 75 FEET
OVER 75 FEET

FIGURE 6

THICKNESS MAP, 1ST SIGGINS SAND, SIGGINS POOL, CLARK AND CUMBERLAND COUNTIES

Results Obtained

During the period 1942 through January 1, 1950, the Siggins field has produced 3,187,000 barrels of water-flood oil and, as of January 1, 1950, was producing in excess of 3,000 barrels daily. Yields per acre are not yet representative of flood value because most properties are far from being flooded out. However, water-flood yields per acre to January 1, 1950, on some leases have been as high as 8,000 barrels. Production curves of Forest Oil Corporation floods (Fig. 7), with all floods shown as though they had been started at the same time, show a gradual decrease in production after the peak is reached. The marked similarity in decline slope indicates a predictable future life for each flood if present injection and production methods are continued. From the decline rates it seems certain that Siggins floods will continue at a commercial level of production many years after peak production is reached.

Summary

The Siggins water flood is one of the most successful in the State--at present it ranks third in cumulative water-flood production, Table I, the Patoka and basin McClosky floods ranking first and second.

The reservoir characteristics as shown in Table I, Data for Illinois Controlled Water Floods, January 1, 1950, do not show superior conditions for flooding, but the careful evaluation and efficient operating techniques employed are proving successful.

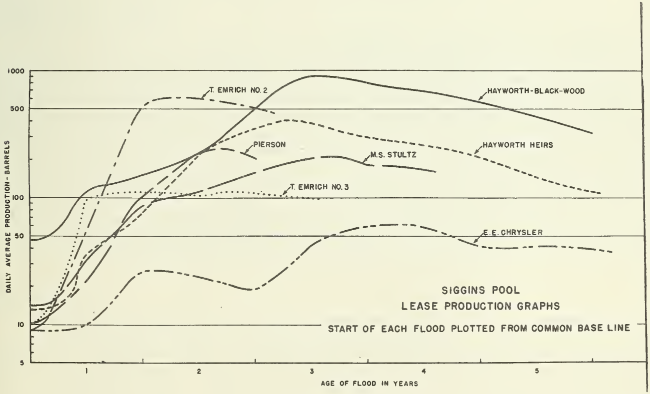


FIGURE 7
GRAPH OF DAILY AVERAGE PRODUCTION BY MONTHS BY LEASES IN THE SIGGINS FLOODS

BELLAIR WATER FLOOD

Introduction and History

The Bellair field is located in Township 8 N., Range 14 W., Crawford County (Fig. 1). L. A. Mylius, in Illinois Geological Survey Bulletin 54, has described the primary history of this pool. The field has three pays, the 500- and 800-foot Pennsylvanian sands, and the 900-foot Mississippian sand. Only the 500-foot Pennsylvanian sand is discussed here since it is the only one so far flooded.

Water-Flood History

The Bellair "500" flood is operated by Forest Oil Corporation and Pure Oil Company, covering 700 acres near the center of the field. Water was first injected in July, 1948, and flood production first obtained about the middle of 1949. The daily average production for December, 1949, was approximately 550 barrels of oil.

Water-Flood Development

With a few exceptions, old wells were plugged and new wells drilled in a five-spot pattern. Input wells are usually 400 to 440 feet apart, with input to oil well distances about 300 feet (Fig. 8).

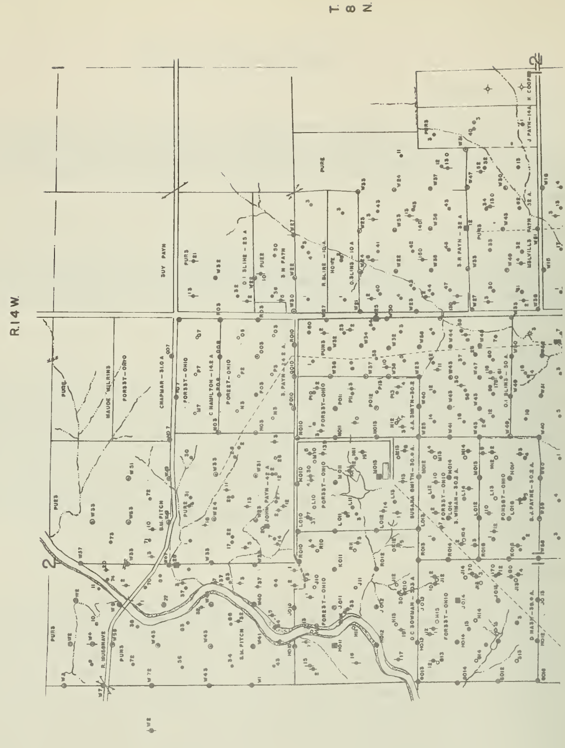
Pure Oil Company's producing wells are completed with casing cemented at the top of the producing zone and wells are flowed through the casing. Input wells are completed by running 1 1/2-inch tubing perforated opposite the pay, filling the annular space to the top of the pay with gravel, and then adding about five feet of sand topped with a few sacks of cement. Casing is then removed from the hole. Forest Oil Corporation completes producing and input wells by running 1 1/2-inch tubing with a rag packer cemented opposite the top of the injection interval. Only surface casing is left in the wells. Both companies shoot the sand to even the permeability profiles and equip each input well with a water-flow meter.

Water Source and Treatment

Fresh water alone is used in the Bellair flood with approximately 6,656,000 barrels injected into the sand to the first of January, 1950. Water is obtained from gravel beds 100 feet deep, 1/2 to 3/4 miles SW of the Bellair field (Fig. 8). Turbine pumps lift the water and push it through the 6-inch main lines. Pure Oil Company uses two diesel engines close to the source wells to raise the pressure to 400 pounds per square inch, a pressure sufficient to move the water 1 1/2 miles to the filter plant, through the pressure filters, and into the wells at a pressure of about 225 pounds per square inch. Forest Oil Corporation uses the turbine pumps at the wells to lift and push the water to their booster pump and filter station about 1 1/4 miles away (Fig. 8). Forest Oil Corporation's well-head pressures are about 250 pounds per square inch. Both companies use closed systems with pressure filtrations. Iron precipitates on the filter elements have caused considerable difficulty. Recently "Calgon" and Calcium Hypochlorite treatment have been added by Pure Oil Company. The 225-280 pounds per square inch well-head pressure plus the static head is close to the maximum safe flooding pressure of one pound per square inch per foot of depth.

Results Obtained

Because the Bellair "500" flood is new, yields per acre, cumulative production, or other yardsticks of flood productivity are not yet significant. However, a few interesting points of flood behavior of the Bellair "500" are now known. Production since the start of water flood to January 1, 1950, was 83,000 barrels with daily production increasing from a few barrels in June to 550 barrels in December, 1949. Water was produced from the start of flood production and had increased to a 70 per cent water cut by January 1, 1950. The production from the wells of Pure Oil Company which are flowed continuously and from those of Forest Oil Corporation which are flowed intermittently is similar.



Prepared by William Lang from data furnished by Forest Oil Corporation and Pure Oil Company.

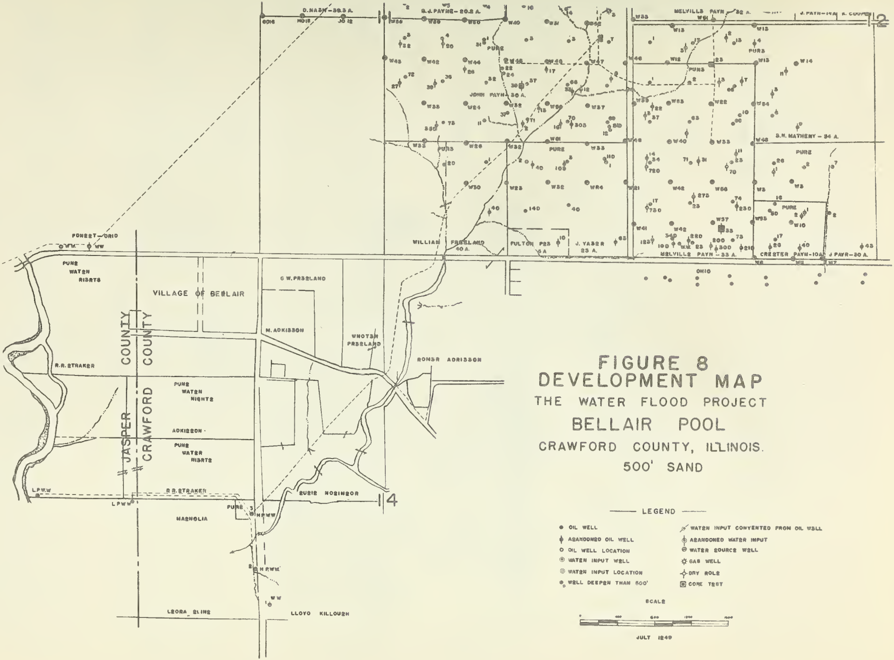
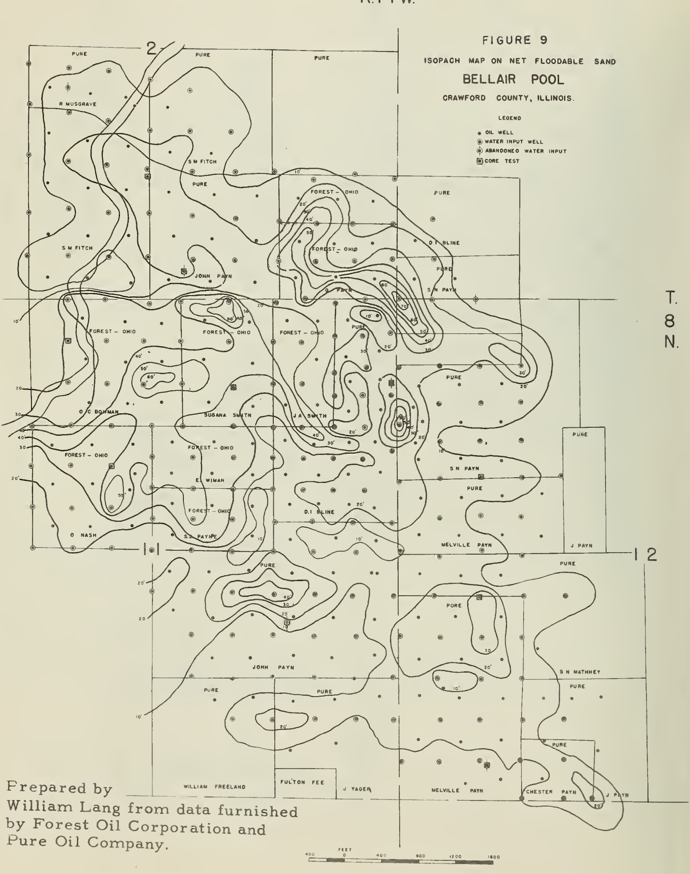


FIGURE 8
DEVELOPMENT MAP
THE WATER FLOOD PROJECT
BELLAIR POOL
CRAWFORD COUNTY, ILLINOIS.
500' SAND



Prepared by
William Lang from data furnished
by Forest Oil Corporation and
Pure Oil Company.

IKEMIRE-HENRY LEASE FLOOD IN THE MAIN POOL, CRAWFORD COUNTY

Introduction and History

The following is a description of the Tide Water Associated Oil Company flood of the Robinson sand on the Ikemire - Henry lease of secs. 10 and 25, T. 7 N., R. 13 W., Crawford County (Fig. 1), and a brief history of primary and secondary recovery prior to the new flood.

Oil was discovered in this area in 1906, and the Ikemire-Henry lease was developed in 1907 and 1908. The wells had average initial productions of 80 barrels of oil per day. In 1911 daily production was down to 3 barrels of oil per well per day. In attempts to increase production vacuum was used in 1919 and air injection in 1932. These methods recovered 800-1,000 barrels per acre over a 14-year period. The present Ikemire-Henry water flood was started in 1946.

General Geologic Conditions

The Ikemire-Henry flood pay is a small Robinson sand lens 1/2 x 1 mile, trending NE-SW (Fig. 10). Sand thickness ranges from about 35 feet at the center to zero at the lens edge. The main Robinson sand body underlies the lens and in most places is separated from it by a considerable thickness of shale, but at some places by only a thin shalv sand (Fig. 11). The top of the lens is about 940 feet below the surface.

Water-Flood History

The Tide Water Associated Oil Company first injected water into the Ikemire-Henry lens in February, 1948, and flood production was first obtained in August, 1948, when production of the 45-acre flood area increased from a few barrels to 35 barrels per day. By the end of December, 1949, the daily average production was 140 barrels of oil and cumulative water-flood production was 45,000 barrels.

Water-Flood Development

A somewhat irregular five-spot pattern is used in the Ikemire-Henry lease flood (Fig. 10). Input to input well distances are generally 440 feet; oil well to input well distances are about 300 feet. Variation in spacing results from the use of a few original wells in the five-spot pattern.

Wells are drilled with cable tools and shot to equalize permeability profiles. Producing wells are completed with 5 1/2-inch casing and pumped through 2 3/8-inch tubing. Input wells are completed with 4 1/2-inch casing cemented through the drained upper part of the sand. Individual meters are used on input wells.

Water Source and Treatment

One old oil well deepened to a basal Pennsylvanian sand at 1,200 feet has furnished the entire 342,500 barrels of water injected into the Ikemire-Henry lens to January 1, 1950. A conventional oil well pump is used to lift the water and distribute it to the nine injection wells. Iron precipitates have caused a reduction of intake rates at times, but acid treatment has been an aid in remedying this condition. The daily injection rate as of January 1, 1950, was approximately 670 barrels of water at 130 pounds per square inch, or 4 barrels per foot of sand per day.

Results Obtained

By the end of December, 1949, the 45-acre flooded area of the Ikemire-Henry lease had produced 45,000 barrels of flood oil and the rate of production was increasing each month. The per cent water cut has increased, from 38 per cent in September, 1948, to 51 per cent in December, 1949. Table I, Data on Illinois Controlled Floods, January 1, 1950, shows the Ikemire-Henry lens to have high oil and low water content. This fact, together with the encouraging early water flood recovery, promises success for this flood.

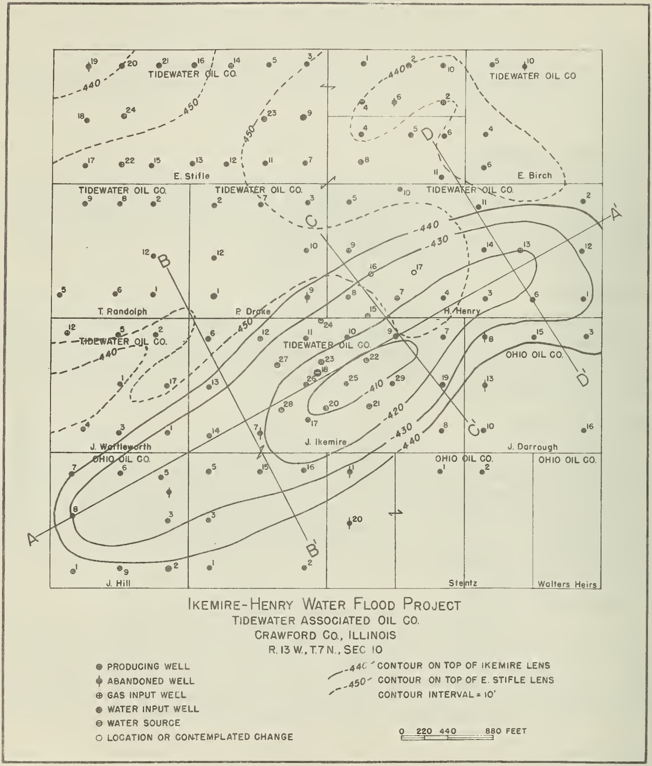
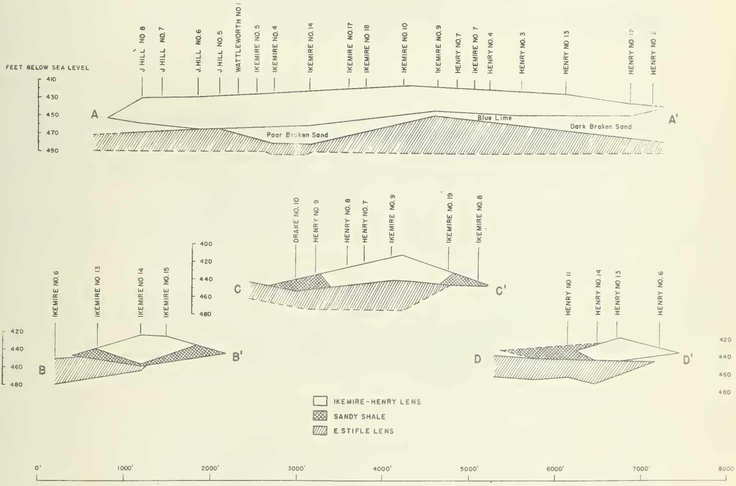


FIGURE 10
DEVELOPMENT AND STRUCTURE MAP

Prepared by William Vineyard from data furnished by Tide Water Associated Oil Company.

FIGURE 11

CROSS SECTIONS OF THE IKEMIRE-HENRY LENS
AND THE UNDERLYING E. STIFLE LENS SAND



Prepared by William Vineyard from data furnished by Tide Water Associated Oil Company.

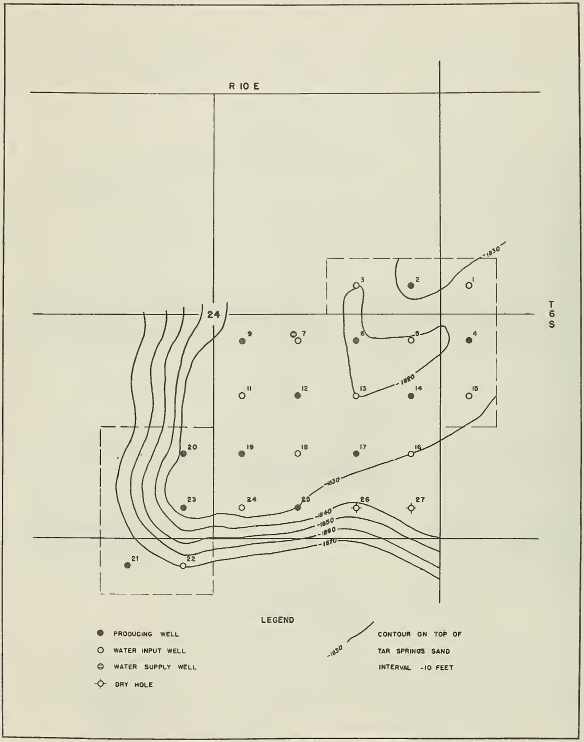


FIGURE 12

TAR SPRINGS STRUCTURE IN THE MAUNIE SOUTH, FIELD, WHITE COUNTY, ILLINOIS

Prepared by R. M. Stephens from data furnished by Magnolia Petroleum Company.

MAUNIE SOUTH WATER FLOOD

Introduction and History

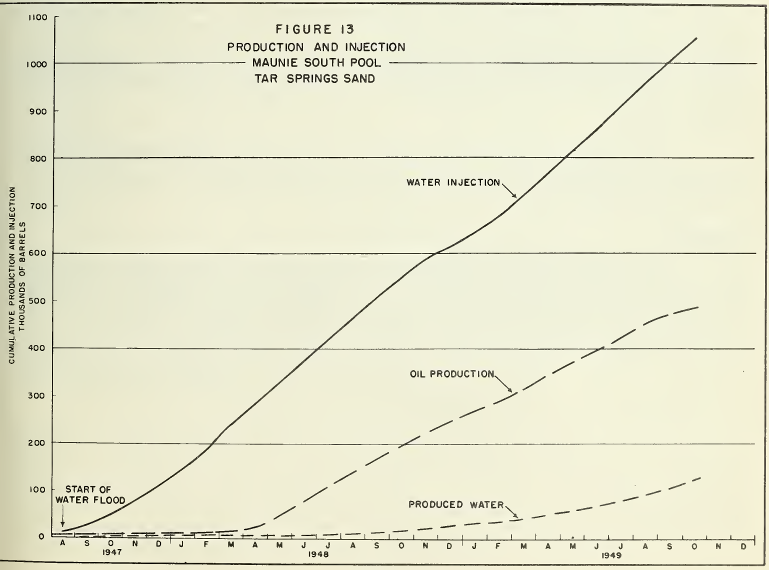
The Maunie South field is located in the southeast part of White County in Township 6 S., Range 10 and 11 E., (Fig. 1). The water-flooded area is in secs. 24 and 25, T. 6 S., R. 10 E. and in sec. 19, T. 6 S., R. 11 E. Since the discovery of the field in 1941, 10 pays have been found in the Pennsylvanian and Mississippian systems. Only the water-flooded sand, the Tar Springs of the Upper Mississippian, is discussed here. Initial production from Tar Springs wells ranged from 10 to 500 barrels of oil per day. Primary production from the Tar Springs is not accurately known because production from the many pays was not separated, but it is estimated at 486,000 barrels.

General Geologic Conditions

The Maunie South Tar Springs reservoir is on a NE-SW elongated rise with little closure, 25 feet, and of varying sand thickness, 10-30 feet. It is about 20 miles southeast of the deepest part of the Illinois basin. The structurally highest Tar Springs in the Maunie South field is 1,820 feet below sea level (Fig. 12).

Water-Flood History

Water was first injected into the Tar Springs sand August 11, 1947, and by January 1, 1950, 1,148,565 barrels of water had been injected into the 230 acres of water-flooded sand.



Water-Flood History (Continued)

Immediately prior to water flooding, Tar Springs oil production from the flood acreage was about 40 barrels per day; in July, 1948, it was 1,040 barrels per day. The cumulative water-flood production to January 1, 1950, was 528,086 barrels.

Water-Flood Development

A five-spot pattern was made by converting alternate wells of a regular 10-acre spacing to water-input wells (Fig. 12). This arrangement puts input to input wells 930 feet apart and input to oil wells 660 feet apart. Water is injected through tubing with upside-down hookwall packers. Water lines and tubing are plastic lined and each input well is equipped with a meter. Producers are conventional pumping wells.

Water Source and Treatment

Water is obtained from a Pennsylvanian sand by one well located 20 feet NW of the NE NW SE, sec. 24, T. 6 S., R. 10 E. (Fig. 12). In September, 1948, this water source was augmented by returning produced water to the sand. Water injection is maintained in a closed system without treatment although occasional acid treatments have been used to clean tight wells. A Reda pump is used in the source well and two horizontal triplex plunger pumps furnish the line pressure. Initially input wells took water under vacuum or with very little pressure. In December, 1949, plant pressures of approximately 800 pounds per square inch were used and a daily injection rate was maintained of close to 1,550 barrels, or about 8.5 barrels per day per foot of sand.

Results Obtained

By the end of December, 1949, 528,086 barrels of flood oil had been produced from the 230-acre flooded area. This is approximately 2,300 barrels per acre, or 144 barrels per acre foot. Daily average production has remained high with cumulative production showing a constant rate of increase.

Summary

The Tar Springs flood in the Maunie South field was the first 10-acre spacing sand flood in Illinois and the first in Illinois to convert producing wells to input wells. Its success has greatly influenced water-flood procedures in the State, because of the great saving in cost of the operation in comparison with the drilling of new wells for input wells and of closer spacing of wells. The secondary recovery to January 1, 1950, of 528,086 barrels is greater than the primary production of 486,000 barrels, and the secondary recovery production rate at the end of 1949 is still high. The success of the Maunie South flood is of particular importance to the new fields of Illinois where there is much pay sand of similar physical characteristics.

Introduction and History

The W. E. Robins Bridgeport Water Flood is being operated by the Ohio Oil Company in Lawrence Field, Lawrence County, Illinois.

The flooded zone is the lower Bridgeport sand. The part of the flood now active covers the whole of the Robins lease which occupies the SE 1/4 of Section 5, T. 3 N., R. 12 W. (Fig. 1).

The first Bridgeport producer in this area was completed in 1906, and the Robins lease was developed between 1909 and 1913. The initial production of the wells averaged 80 barrels of oil per day, but production dropped off rapidly to a few barrels of oil per day.

Repressuring by air and gas was used from 1944 to 1948 in an attempt to increase production. Production which had been 450 barrels per week for the lease was increased to a maximum of 900 barrels per week as a result of the operation. The present flood on the Robins lease was started in 1948.

General Geologic Conditions

The W. E. Robins Bridgeport water-flood pay is located on the eastern flank of the La Salle Anticline just down dip from the crest. The sand thickness ranges from a few feet to slightly over 100 feet in the center of the lease. On the west side of the lease the sand body is largely replaced by shale (Fig. 15). The top of the lower Bridgeport sand is about 900 feet below the surface.

Water-Flood History

The Ohio Oil Company first injected water in the lower Bridgeport sand on the Robins lease in August, 1948, and a definite increase in production was noticed by April, 1949. A total of 1,306,585 barrels of water had been injected into the twenty-nine intake wells of the flood by July 31, 1950. An estimated 35,000 barrels of water-flood oil have been produced from the start of the flood to July 31, 1950.

Water-Flood Development

An irregular five-spot pattern is used in the Robins flood. The distance between wells is quite variable as a result of including the original producing wells in the five-spot pattern (Fig. 14).

The intake wells are drilled with a rotary rig and completed with 4 1/2-inch casing set with cement through a depleted zone in the upper part of the sand. The wells are cleaned with a wall-scratcher prior to water injection. Water is injected through the 4 1/2-inch casing. Each injection well is equipped with an individual meter. The producers on the lease are pumped, some from a central power unit and others from individual units powered by electric motors.

Although 34 injection wells were completed, water was being supplied to the 24 wells on and immediately adjacent to the Robins lease due to limitations of water supply.

Water Source and Treatment

During the early part of the flood, water was supplied from a well in the Buchanan sand, and injected into the reservoir through a closed system without treatment. Since October, 1949, a fresh water well in alluvial gravels along the Embarras River six miles north of the lease has supplied the water for the flood. The water is pumped through a pressure filter enroute to the intake wells. The water system is closed. No chemical treatment is used. Water is supplied to the well-heads at pressures up to 325 pounds per square inch, but most of the intake wells receive water at little or no pressure. Reduction of intake rates due to plugging of the sand face has been corrected by the use of scratchers. Intake rates range from 0.5 barrels per foot of sand per day to 10 barrels per foot per day with an average of five barrels per foot per day.

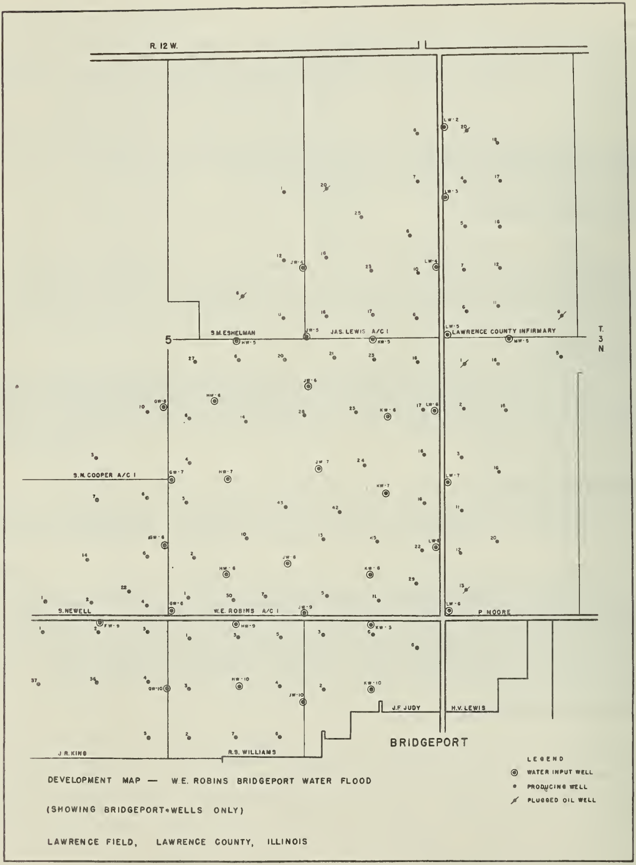


FIGURE 14

Prepared by Jack Foster from information furnished by the Ohio Oil Company.

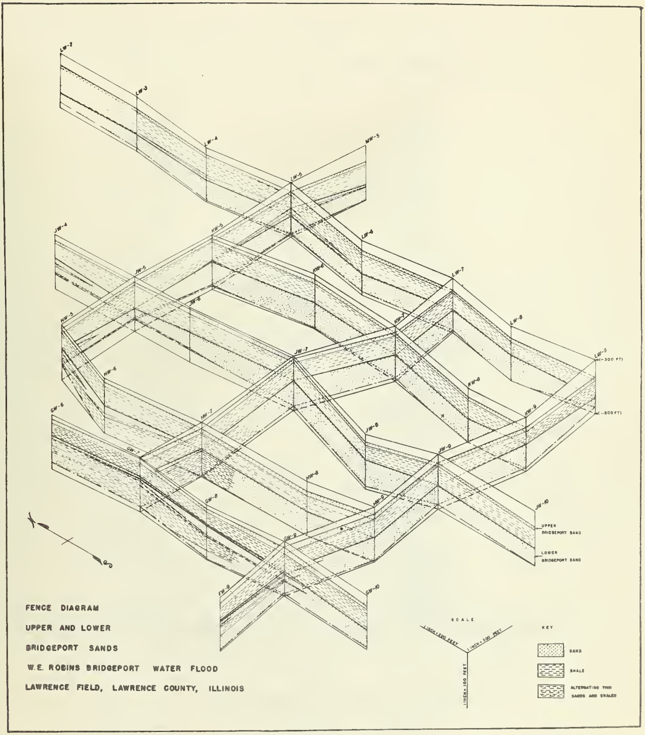

LW-2
LW-3
LW-4
MW-5
LW-5
JW-4
KW-5
LW-6
JW-5
KW-6
LW-7
JW-6
HW-5
KW-7
LW-8
JW-7
LW-9
(-300 FT)
HW-6
KW-8
GW-6
HW-7
JW-8
KW-9
GW-7
JW-9
HW-8
GW-8
HW-9
JW-10
UPPER
BRIDGEPORT SAND
LOWER
BRIDGEPORT SAND
GW-9
FW-9
GW-10
FENCE DIAGRAM
UPPER AND LOWER
BRIDGEPORT SANDS
W.E. ROBINS BRIDGEPORT WATER FLOOD
LAWRENCE FIELD, LAWRENCE COUNTY, ILLINOIS
SCALE
1 INCH = 200 FEET
1 INCH = 200 FEET
1 INCH = 100 FEET
KEY
SAND
SHALE
ALTERNATING THIN
SANDS AND SHALES

FIGURE 15

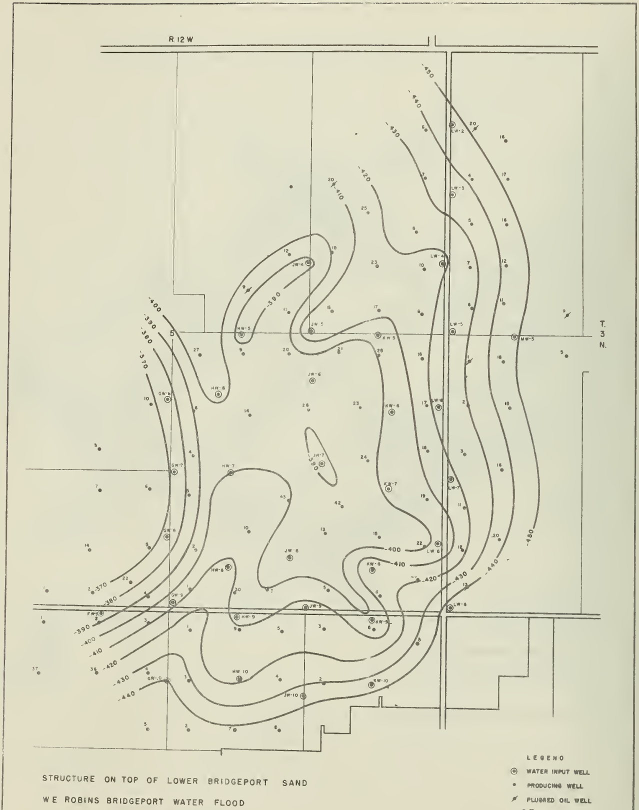
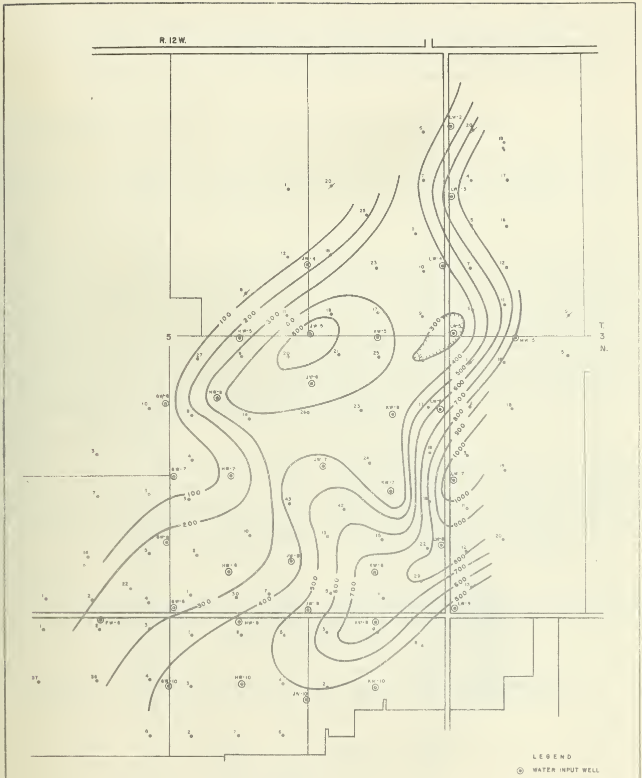

R 12 W
T. 3 N.
STRUCTURE ON TOP OF LOWER BRIDGEPORT SAND
W E ROBINS BRIDGEPORT WATER FLOOD
LAWRENCE FIELD, LAWRENCE COUNTY, ILLINOIS
LEGEND
WATER INPUT WELL
PRODUCING WELL
PLUGGED OIL WELL
CONTOUR INTERVAL 10 FEET
SEA LEVEL DATUM

FIGURE 16



ISOPERM OF PAY ZONE IN LOWER BRIDGEPORT SAND

W.E. ROBINS BRIDGEPORT WATER FLOOD

LAWRENCE FIELD, LAWRENCE COUNTY, ILLINOIS

FIGURE 17

Results Obtained

Because the W. E. Robins Bridgeport flood is new, the ultimate productivity of the flood is difficult to estimate. Since the start of the flood in 1948, 95,000 barrels of oil have been produced from the Robins. Daily production has almost tripled since the start of the flood although fill-up has not been attained in all segments of the flood pattern. Fluids produced averaged about 30 per cent water during the month of July, 1950.

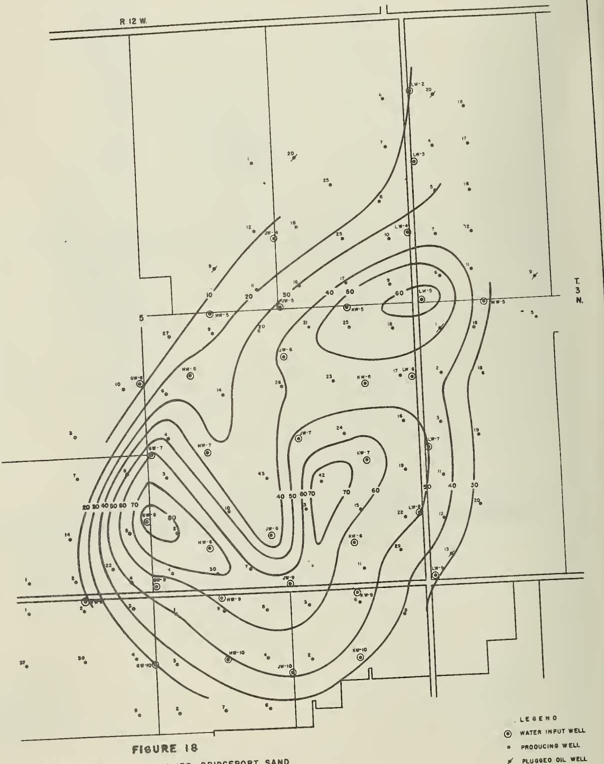


FIGURE 18

ISOPACH OF OIL PAY IN LOWER BRIDGEPORT SAND

W.E. ROBINS BRIDGEPORT WATER FLOOD

LAWRENCE FIELD, LAWRENCE COUNTY, ILLINOIS

PATOKA WATER FLOOD

Introduction and History

The complete history, both primary and flood production, has been given by Hugh S. Barger in his article in the May 25, 1950, issue of the OIL AND GAS JOURNAL. A summary description is included here because the operation was skillfully designed and operated and the results in oil production were spectacular. The field was discovered in February, 1937, and was developed by 132 wells on 700 acres.

Water-Flood History

A history of water flooding in the Benoist sand of the Patoka Field is shown graphically in Figures 22 and 23. This flood was begun in 1943 and the first increase in production was realized early in 1944. A slight increase over immediate pre-flood production still exists.

Water-Flood Development

By August, 1946, 59 intakes and 39 new producing wells were completed. Forty off-pattern wells in the original drilling were abandoned, and three were plugged back and recompleted in the Tar Springs as brine supply wells. The water-flooding pattern is in general a ten-acre five-spot with somewhat wider spacing at the extreme north and shorter and less regular spacing in the south near the town of Patoka. The final water-flood development included the drilling of sixty-two intake wells and forty oil wells, which combined with the wells retained from the original development gives a total of eighty producers on 566 acres. All wells were completed with cemented-in casing. Flooding water is being introduced into the casing in input wells and the oil wells pumped through tubing in the usual way.

Water Source and Treatment

The flooding water is obtained from three wells completed in the Tar Springs sand, one of which is capable of producing 15,000 barrels per day. The supply and produced water is aerated, settled, chemically treated, and then filtered. Water in sufficient volume at first entered the sand with a vacuum on the casing. The line pressures were advanced as increasing resistance was encountered until it now operates at 500 pounds per square inch.

Results Obtained

The entire water injected as of March, 1950, was 16,300,000 barrels and the cumulative oil produced was 5,451,000 barrels. This ratio of 2.9 is unusually good.

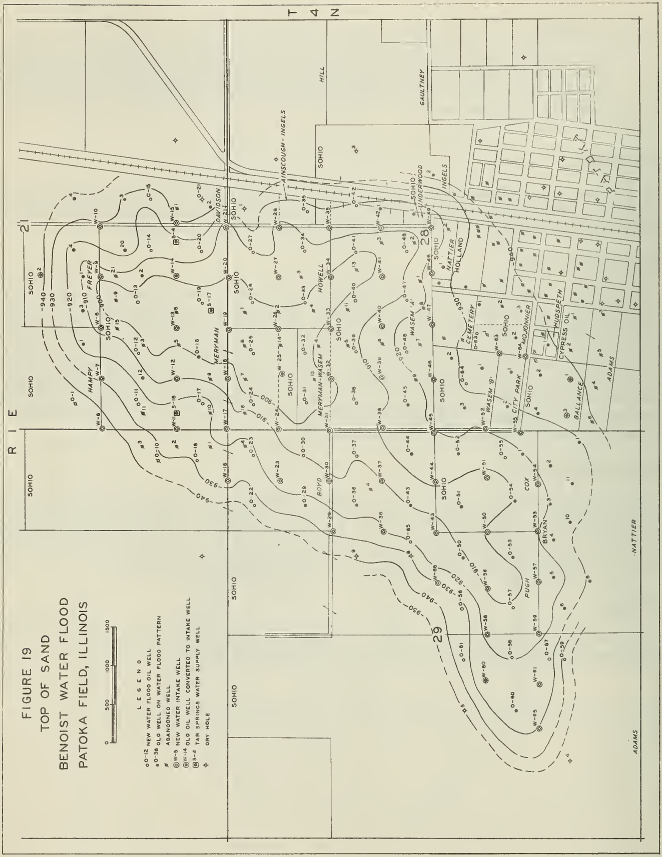


FIGURE 19
TOP OF SAND
BENOIST WATER FLOOD
PATOKA FIELD, ILLINOIS

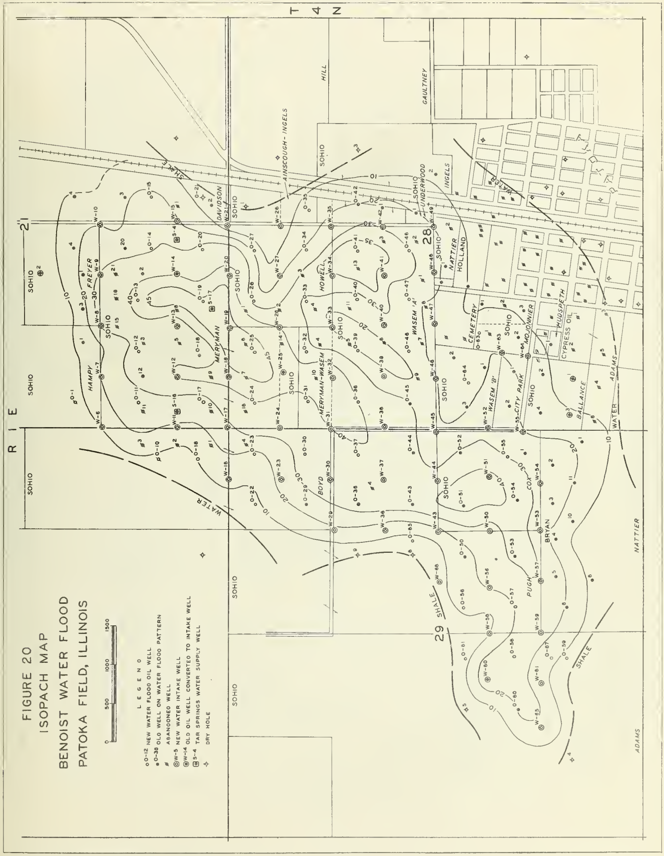
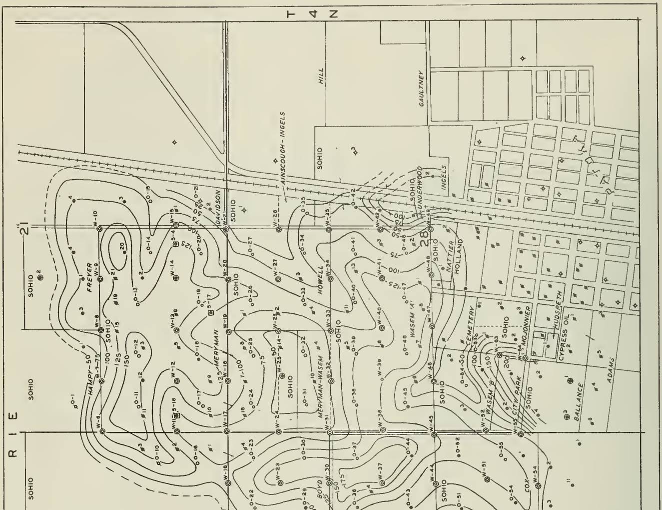


FIGURE 20
ISOPACH MAP
BENOIST WATER FLOOD
PATOKA FIELD, ILLINOIS
0 500 1000 1500
L E G E N D
O-12 NEW WATER FLOOD OIL WELL
O-38 OLD WELL ON WATER FLOOD PATTERN
ABANDONED WELL
W-5 NEW WATER INTAKE WELL
W-14 OLD OIL WELL CONVERTED TO INTAKE WELL
S-4 TAR SPRINGS WATER SUPPLY WELL
DRY HOLE
R I E
T 4 N



After Barger, H. S., OIL AND GAS JOURNAL, May 25, 1950.

FIGURE 22
PATOKA BENOIST WATER FLOOD
DAILY FLOOD PERFORMANCE
TOTAL FIELD

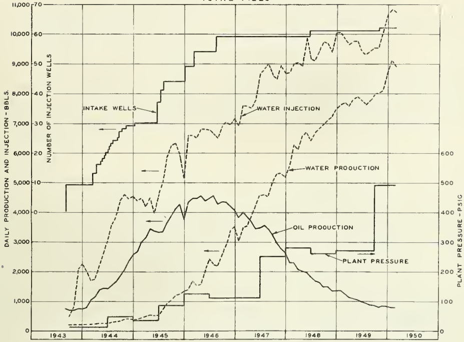
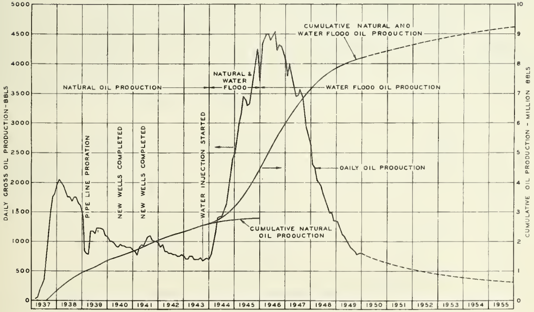


FIGURE 23
PATOKA BENOIST WATER FLOOD
NATURAL AND WATER FLOOD PERFORMANCE
TOTAL FIELD



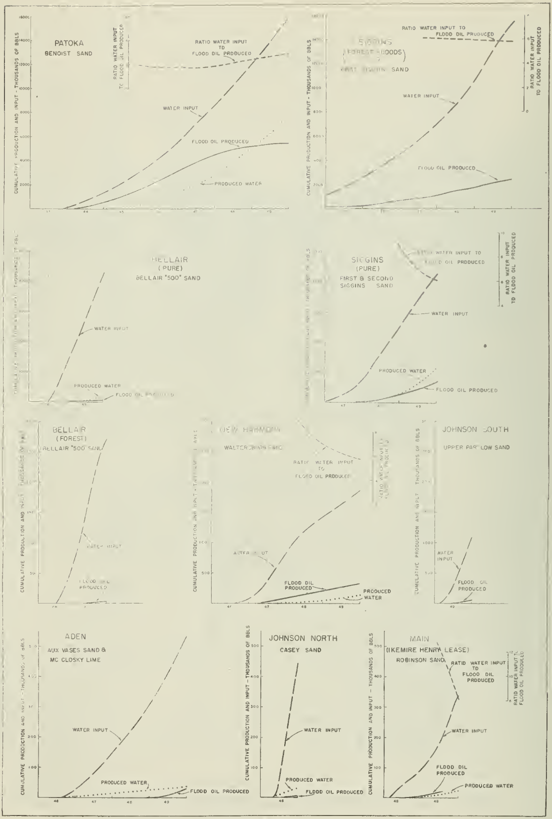


FIGURE 24
GRAPH OF WATER INPUT AND OIL PRODUCED BY WATER FLOODING

CONCLUSIONS FROM A COMPARISON OF THE SIX DESCRIBED FLOODS

The six floods described have some notable similarities. Probably the most important of these is that much was known concerning the physical characteristics of the reservoir rocks and fluids before the floods were started. Other similarities are that all of the floods are pattern floods and that flood development covers an extensive area. Some of the more important dissimilarities are different operating techniques, different geologic ages of flood pays, and the great difference in the term of primary production.

The data given above for the six floods will be useful in considering the flooding possibilities of other areas where some information on reservoir characteristics is available. In addition the behavior of these six floods should furnish a sound basis on which to check computations on fill-up time, water requirements, oil production, and life of flood production once a flood project is started.

General Conclusions

Although all of the thirty-one controlled floods tabulated in this report were started since 1942, five out of the seven Chester (upper Mississippian) sand zones and the two most important lower Mississippian producing zones now have water floods in operation. These Mississippian floods plus the fifteen floods in the many Pennsylvanian sands give Illinois a nearly complete check on the general floodability of its many producing zones.

The Pennsylvanian sand floods are numerically in the lead because of their shallow depth and because they are closer to primary depletion than the more recently drilled producing formations. McClosky floods are next in numerical order primarily because their high permeability makes flooding on the primary well spacing feasible and because McClosky producing areas have generally been favored by abundant water supplies in the shallower formations. The remaining zones undergoing water flooding in Illinois have from 1 to 3 floods each. Of these zones, two have been outstandingly successful, the Tar Springs in Maunie South, and the Benoist in the Patoka Field. The three floods in the high water content Aux Vases sand have not yet settled the question of the floodability of the Aux Vases sand, but the progress of these floods has improved the prospects for the eventual successful flooding of this horizon.

There does not appear to be any "best" formation for flooding in Illinois. All formations seem capable of possessing the necessary characteristics for successful flooding in one or more places within the state.

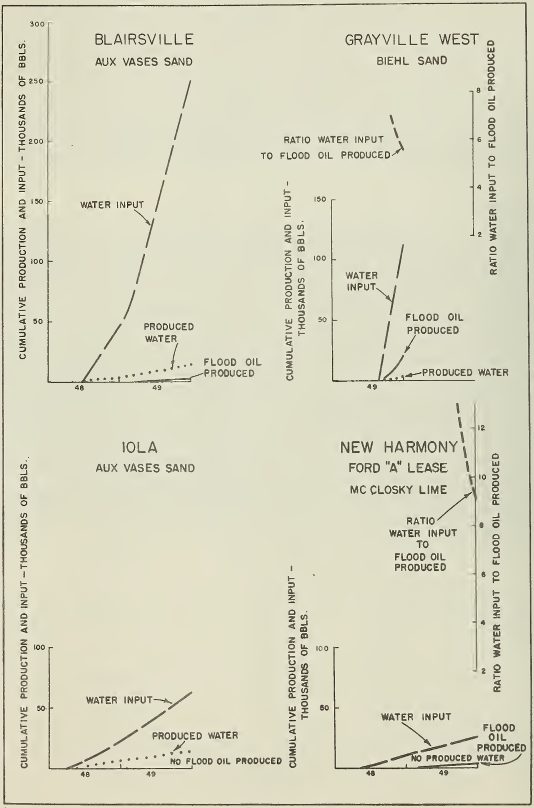


FIGURE 25
GRAPH OF WATER INPUT AND OIL PRODUCED BY WATER FLOODING

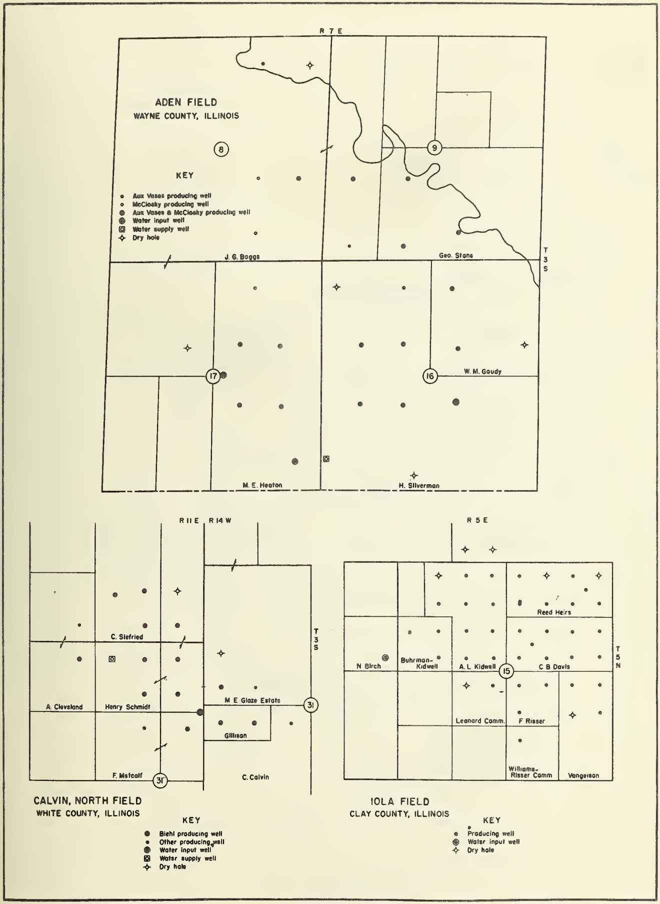


FIGURE 26
DEVELOPMENT MAPS

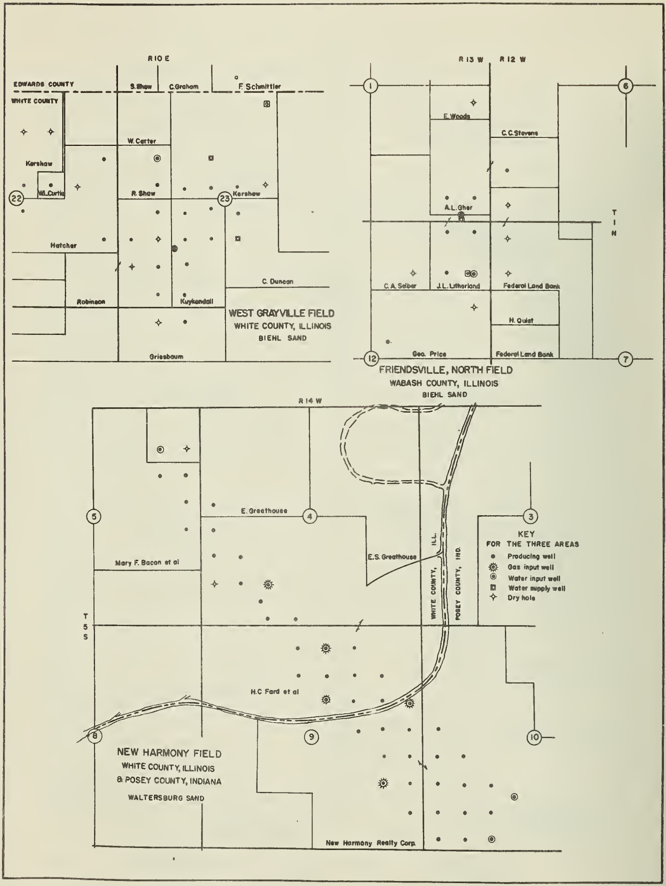


FIGURE 27
DEVELOPMENT MAPS