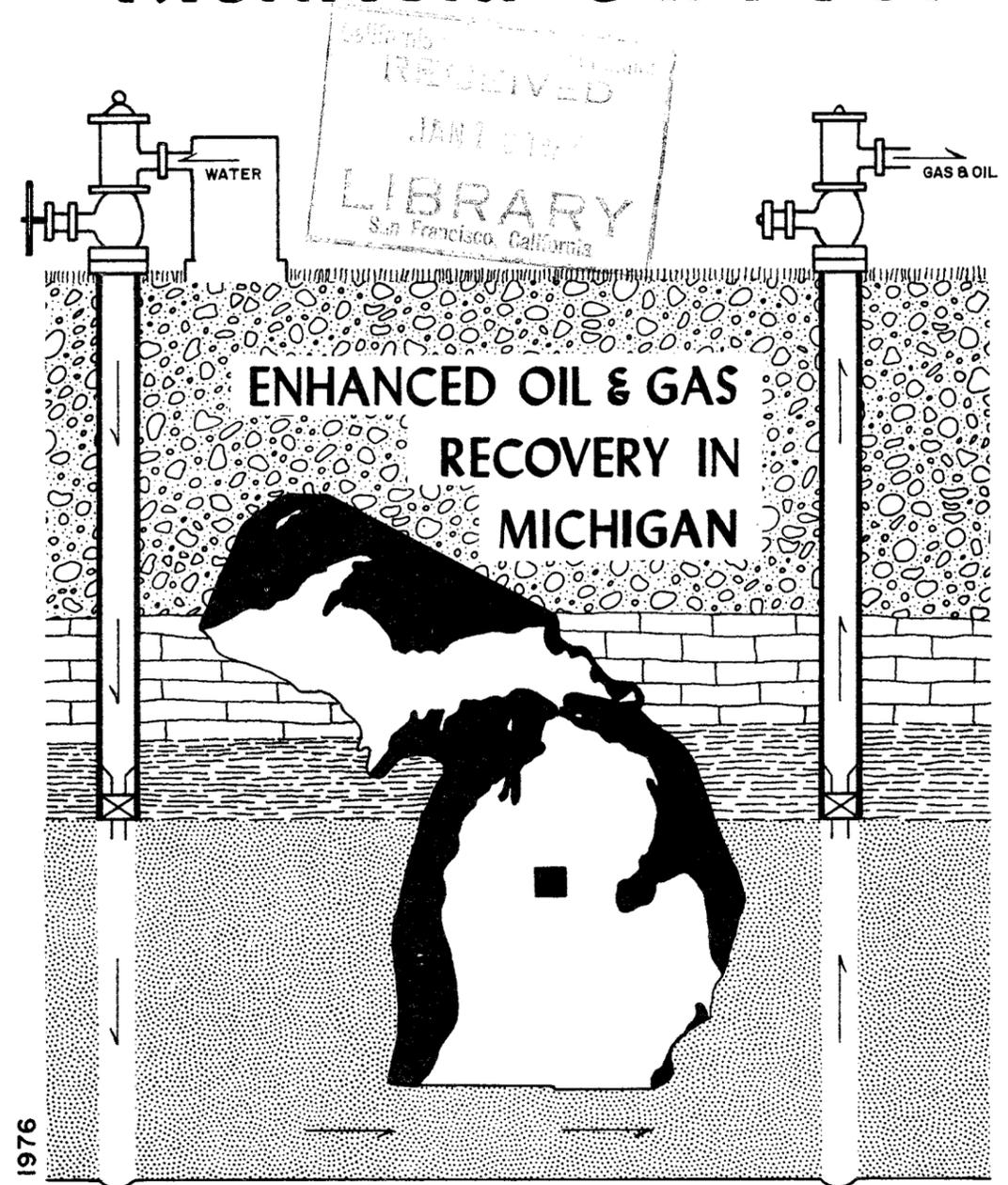


Hamilton Field Richfield Oil Pool



DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY DIVISION

PRODUCTION AND PRORATION UNIT
SECONDARY RECOVERY REPORT NO. 1



The State Geological Survey collects, interprets, and disseminates basic information on the geology and mineral resources of Michigan.

Its activities are guided by public service available to all who are interested in the use or development of our resources, the protection of our environment, and sound land use management.



GEOLOGICAL SURVEY
DIVISION

SECONDARY RECOVERY REPORT NO. 1

Hamilton Field Richfield Oil Pool

ENHANCED OIL & GAS
RECOVERY IN MICHIGAN

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LANSING, MICHIGAN 1976

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PREFACE

This is the first in a series of reports on projects to enhance recovery of oil in Michigan. A compiled volume is planned when all of the reports have been completed on fields subjected to secondary recovery. These reports are an effort by the Production and Proration Unit of the Geological Survey Division to better serve the State of Michigan, the petroleum industry, and the public by making its information and expertise more readily available to all interested parties. The project has been in the formative stage for a long time. Hopefully, the project will be completed within a shorter time interval.

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HAMILTON FIELD

RICHFIELD OIL POOL

Enhanced Oil and Gas Recovery in Michigan

Abstract

The Richfield Oil Pool of the Hamilton Field in Clare County, Michigan is a successful waterflood project. This was the first waterflood project in the state to use the computer to predict production. Cumulative production has exceeded original production estimates made by Sun Oil Company.

INTRODUCTION

The purpose of this report is to provide useful information on a successful and ongoing waterflood project involving the Richfield pool reservoir in the Hamilton Field. The Hamilton Oil Field is a multi-pool field associated with an anticlinal structure located in parts of Frost, Hayes, and Hamilton townships of Clare County. The uppermost pool, found at a depth of about 1,500 feet, is a gas reservoir contained in Mississippian age sandstone of the Michigan and Marshall formations. Discovered in 1940, the gas reservoir was subsequently developed and then converted to a gas storage reservoir, its present status. The area now covered by the gas storage reservoir generally conforms to the area now referred to as the Hamilton Field, but for purposes of recognition the gas storage area is called North Hamilton. In 1940 an oil reservoir was found in Rogers City - Dundee limestones of Devonian age at a depth of about 4,050 feet. Only three Rogers City - Dundee wells were completed as producers in this pool, which was abandoned in 1959. This production is now included with the Richfield production. In 1952 an oil reservoir was found in the Richfield interval of the Lucas Formation, Detroit River Group at a depth of about 5,150 feet. During the next four years the Hamilton Richfield pool was outlined by the completion of 44 additional producing wells, and by 1957 a waterflood project had been initiated.

RICHFIELD RESERVOIR ROCKS

Richfield reservoir rocks are assigned to the basal part of the Lucas Formation, Detroit River Group. The Lucas Formation is a dolomite, limestone, salt, and anhydrite sequence of Devonian age. The Richfield, often erroneously given formation status, is poorly defined in terms of widespread, easily recognized marker beds outside the main area of salt deposition. In the deeper, central part of the basin, where most Richfield

pools are found, Richfield pay zones are keyed to recognition of certain salt and anhydrite beds near the base of the Lucas Formation. According to Hautau (1952, p. 1), ".....the Richfield generally includes all the section that produces sweet crude below the massive anhydrites that underlie the lowest Detroit River salt beds, and above the highest fossiliferous black coralline limestones." The black coralline limestones are assigned to the Amherstburg Formation, the lower formation of the Detroit River Group. Richfield pay zones appear to span about 200 feet of section made up of dolomite beds of various thickness and separated by thin anhydrite beds and some limestone lenses. At least six of the beds within the Richfield interval have shown oil saturation and several others are considered important reservoirs. Between these reservoir rocks are relatively impervious evaporites. The vertical succession of these beds within the Richfield interval is an important element in the success of the waterflood project.

GENERAL HAMILTON FIELD RICHFIELD POOL HISTORY

The discovery well for this Richfield pool was Sun Oil Company's Arlie Iutzi No. 1, located in section 5, Hamilton Township, and completed in May, 1952. A drilling unit and well spacing order was issued by the Supervisor of Wells on July 1, 1952. This order established 40-acre drilling units with the well to be located in the center of the NW 1/4 of a governmental surveyed quarter-quarter section of land. No proration order, which would have established daily oil and gas allowables, was ever issued for the pool. Following the discovery well and the establishment of a drilling and well spacing order, 44 additional wells were drilled and completed during the next 4 years. Originally two separate Richfield pools were thought to occur but gas-oil ratios, bottom-hole pressures, and reservoir fluid analyses indicated one reservoir. Subsequent drill core analyses substantiated the single reservoir theory. In 1957 legal action was initiated to unitize the pool for waterflood operations. Since only two producing wells were not owned by Sun Oil Company, unitization proceeded smoothly.

Water injection began in the Fall of 1957. According to Sun Oil Company engineers, this was one of the first waterflood projects to use the computer to predict recovery performance of a field. An analog model, using the Stiles Method, was made based on the thickness and permeability of the producing Richfield pay zones. The Richfield reservoir was originally classified as solution gas-driven with a reservoir bottom-hole pressure of 2,570 psi and an average G.O.R. of 945 cubic feet of gas per barrel. To maximize oil recovery and help maintain bottom-hole pressure, wells are produced by use of intermitters. Currently there are 27 producing wells and 17 water injection wells. Nearly all are open-hole completions.

Before water injection began in 1957, the pool had produced 1,646,385 barrels of oil which is about 59 percent of the originally estimated 2,800,000 barrels of primary recoverable oil. Combined primary and secondary production at the end of 1974 amounted to 5,891,194 barrels. This figure exceeds Sun Oil Company's original production estimates by 298,194 barrels. This cumulative figure includes a minor amount of oil produced from the Rogers City - Dundee pool during the years 1940 to 1959. Historical oil production and water injection data are shown on the following graphs and tables.

STRATIGRAPHIC POSITION	INFORMAL TERMS	PAYS
Basal sandstones of Saginaw Fm. _____	Parma sandstone	
In lower part of Michigan _____	{ triple gyp brown lime stray-stray ss stray dol stray ss	Gas Gas & Oil
Marshall Ss. _____		Gas & Oil
Coldwater Sh. _____	{ Coldwater lime Weir sand Coldwater red-rock	Gas
In upper part of Ellsworth Sh. _____	"Berea" (Western Michigan)	Oil & Gas
Berea Ss. _____	Berea sand (Eastern Michigan)	Oil & Gas
Squaw Bay Ls. _____	Squaw Bay	Oil & Gas
Upper part of Traverse Group in Western Michigan _____	{ Traverse formation Traverse lime Stoney Lake zone	Oil & Gas Oil & Gas
Rogers City Ls. _____		Oil & Gas
Dundee Ls. _____		Oil & Gas
Dundee Ls. (?), Upper part of Lucas Fm. (?) _____	Reed City zone	Oil & Gas
In Lucas Fm. _____	{ massive salt big salt sour zone massive anhydrite big anhydrite Richfield zone	Oil & Gas Oil & Gas
Amherstburg Fm. _____	black lime	
Part of Salina Group E Unit _____	E zone (or Kintigh zone)	Oil
Divisions of A-2 Carbonate in Western Michigan _____	{ A-2 dolomite A-2 lime	Gas
A-1 Carbonate _____	A-1 dolomite	Oil & Gas
Upper part of Niagaran Series _____	{ brown Niagaran gray Niagaran white Niagaran	Oil & Gas
Part of Niagaran Series _____	Clinton shale (Eastern Michigan)	
Trenton Group _____		Oil & Gas
Black River Group _____	{ Black River formation Black River shale Van Wert zone	Oil & Gas
Oneota Dol. _____		Oil

Table 1. Principal oil and gas pays and informal terms used in petroleum exploration applied to parts of formations or groups of formations in the subsurface of the Michigan Basin.

Hamilton Field
Richfield Waterflood Project

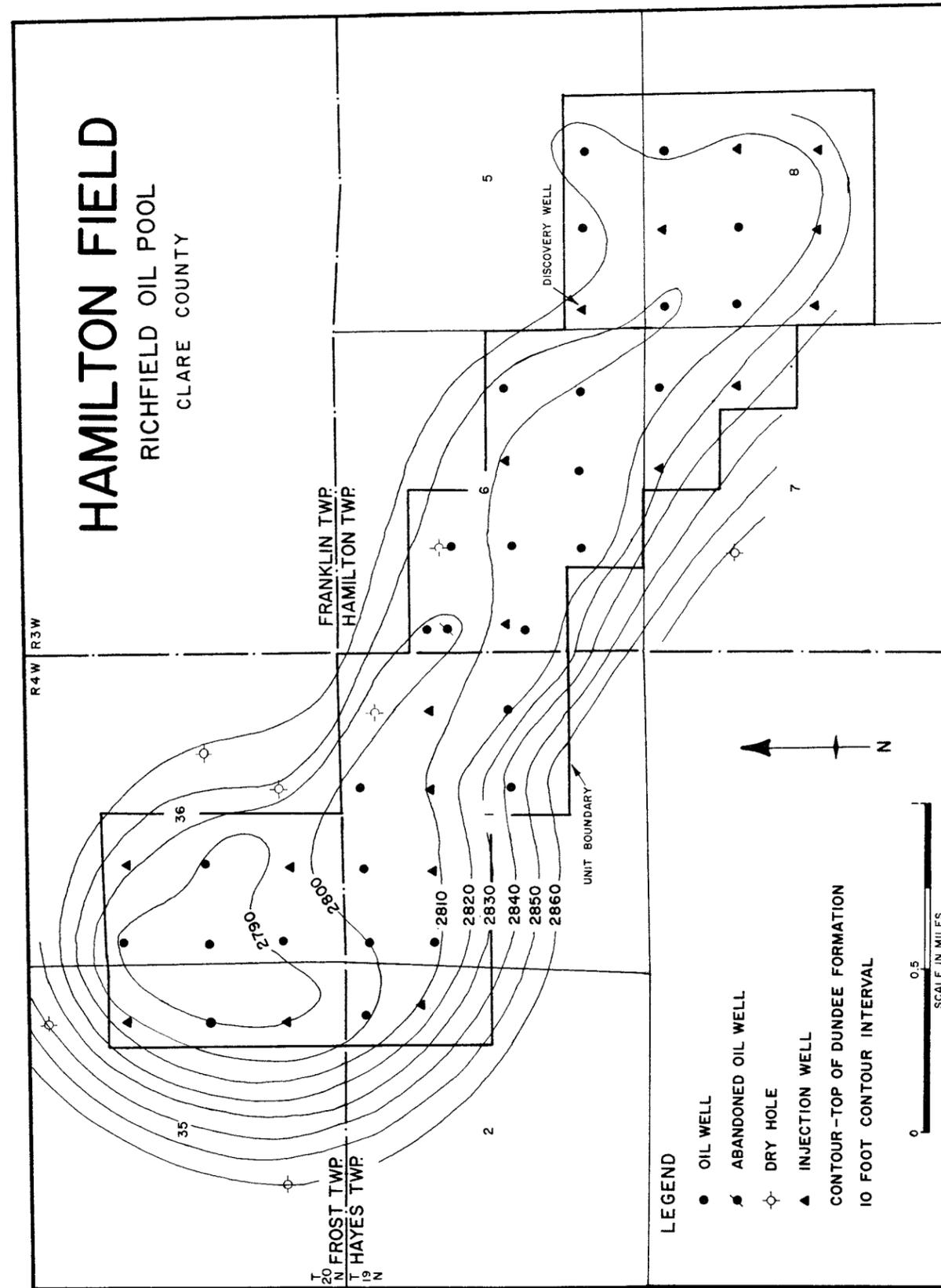


Figure 2: Structure of the Hamilton Field contoured on top of the Dundee Formation.

GENERAL POOL DATA

Location	Clare County, Hamilton Twp. T19N, R3W; Hayes Twp. T19N, R4W; and Frost Twp. T20N, R4W
Date of pool discovery	April 17, 1952
Discovery well	Sun Oil Company A. Iutzi #1, Permit number 17382
Producing formation	Richfield (Detroit River Group)
Pay lithology	Dolomite
Type of trap	Anticline
Drilled acres	1800
Unit acres	1800
Reservoir area, estimated	1620 acres

ENGINEERING DATA

Type of reservoir energy	Solution gas
Original reservoir pressure	2570 psi
Reservoir temperature	117°F
Viscosity of original reservoir oil	0.5 cp
Bubble point pressure	2,031 psig
Formation volume factor	1.4830
API oil gravity	42.2°
Original solution gas-oil ratio	945 cfpb
Average porosity	16.2%
Average permeability	9.8 md
Connate water, estimated	35.0%
Net oil pay thickness	12.3 ft.
Acre feet of oil pay	22,140

RECOVERABLE HYDROCARBON DATA*

Estimated original stock tank oil in place	13,300,000 bbls.
Estimated original recoverable stock tank oil	2,800,000 bbls. (recovered)
Calculated recoverable stock tank oil per acre foot	126 bbls. primary; 253 bbls. primary and secondary
Original gas in solution	12,250 MMcf
Estimated original recoverable gas	5,000 MMcf
Estimated additional recoverable oil due to secondary recovery methods	2,793,000 bbls.

* Estimations by Sun Oil Company prior to initiation of waterflood. Oil production to the end of 1974 exceeds production estimates by 298,194 barrels.

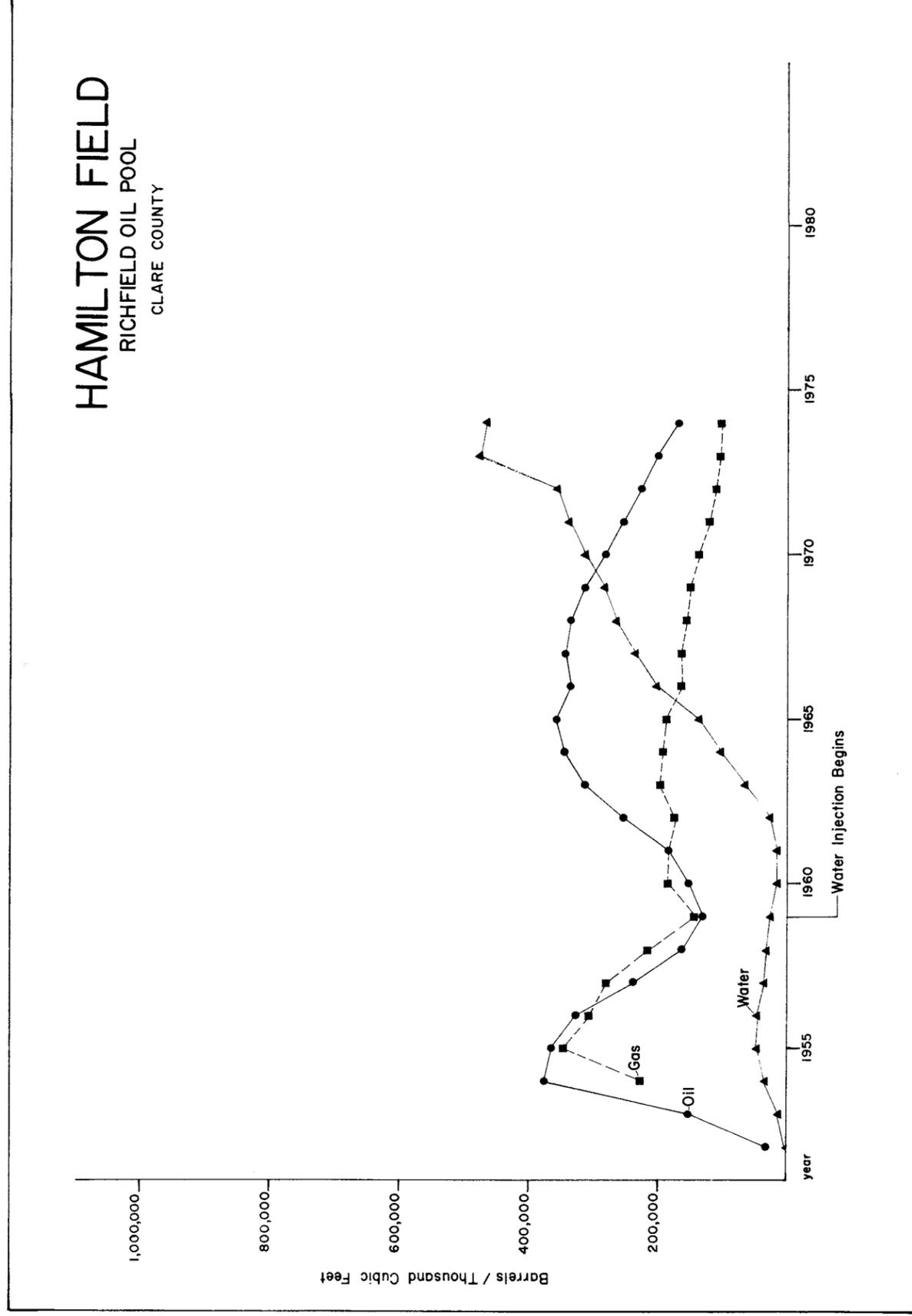


Figure 3: Oil, gas, and water production from the Richfield Pool, Hamilton Field, Clare County. Oil and water production is shown in barrels. Gas production is shown in thousand cubic feet (MCF).

Hamilton Field, Richfield Waterflood, Clare County						
Year	Production Data					
	Gas		Oil		Water (estimated)	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1952			33,445	33,445	1,620	1,620
1953	229,410	229,410	150,173	183,618	14,235	15,855
1954	347,859	577,269	375,141	558,759	33,215	49,070
1955	306,386	883,655	365,041	914,800	47,085	96,155
1956	280,634	1,164,289	328,625	1,243,425	45,990	142,145
1957	212,564	1,376,853	239,510	1,482,935	36,865	179,010
1958	143,140	1,519,993	163,450	1,646,385	32,850	211,860
1959	188,885	1,708,878	130,896	1,777,281	25,900	237,760
1960	183,420	1,892,298	153,958	1,931,239	12,891	250,651
1961	175,628	2,067,926	182,292	2,113,531	16,294	266,945
1962	198,050	2,265,976	254,355	2,367,886	28,105	295,050
1963	192,886	2,458,862	311,915	2,725,594	64,605	359,655
1964	187,067	2,645,929	344,927	3,070,521	100,375	460,030
1965	164,444	2,826,261	358,506	3,429,027	137,970	598,000
1966	163,106	2,989,367	336,668	3,765,695	200,020	798,020
1967	157,540	3,146,907	343,358	4,109,053	235,338	1,033,358
1968	150,654	3,297,561	336,217	4,445,270	265,355	1,298,713
1969	138,205	3,435,766	313,709	4,758,979	282,875	1,581,588
1970	120,141	3,555,907	280,597	5,039,576	311,345	1,892,933
1971	111,521	3,667,428	253,635	5,293,211	339,450	2,232,383
1972	103,852	3,771,280	227,894	5,521,105	356,605	2,588,988
1973	102,012	3,783,292	200,190	5,721,295	478,150	3,067,138
1974			169,899	5,891,194	464,828	3,531,966

Table 1. Oil, gas, and water production from the Richfield Pool, Hamilton Field, Clare County. Oil and water production is shown in barrels. Gas production is shown in thousand cubic feet (MCF).

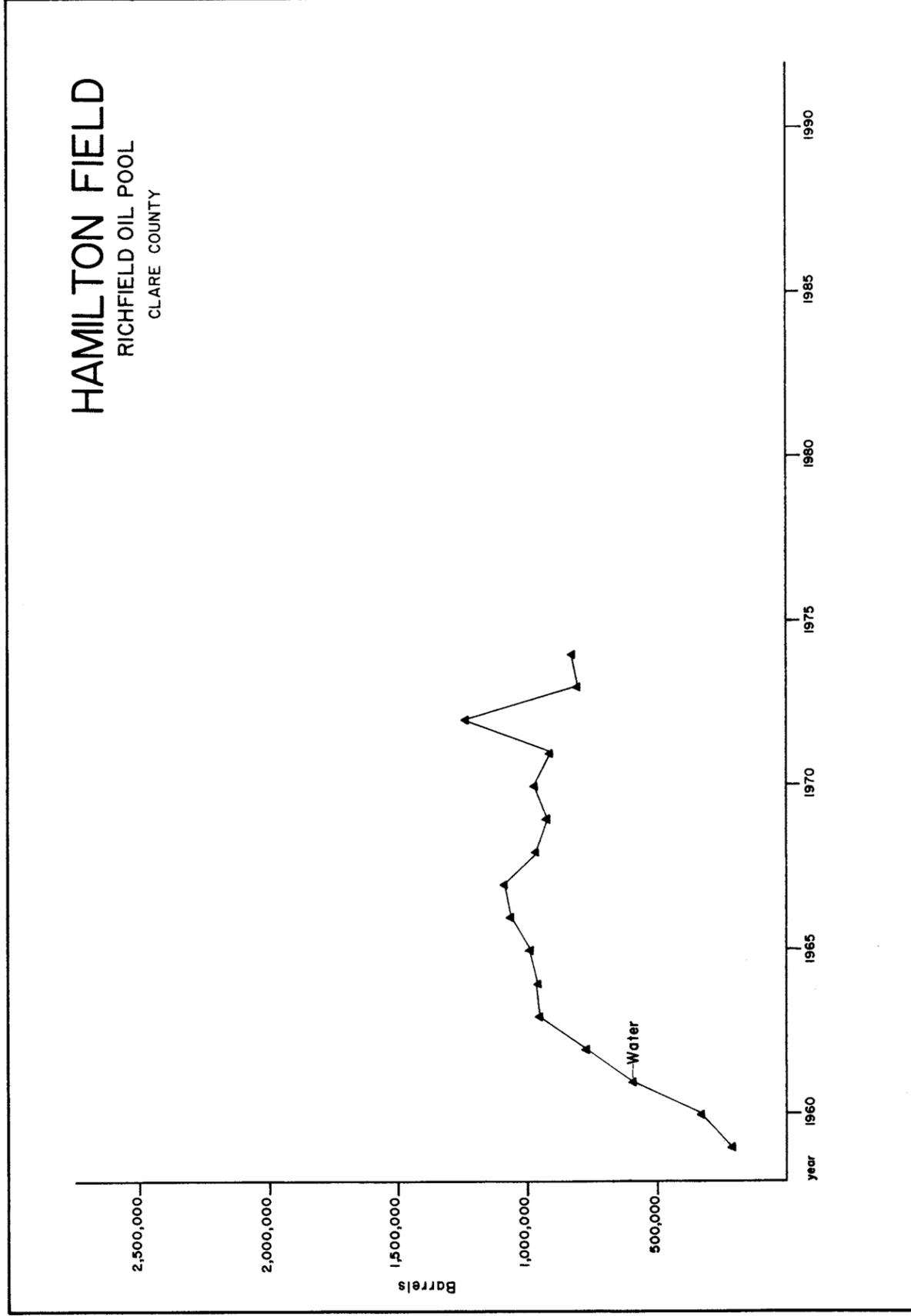


Figure 4: Water injected into the Richfield Pool, Hamilton Field. Injected water is shown in barrels.

Hamilton Field, Richfield Waterflood, Clare County							
Year	Injection Data				Pressure		
	Gas		Water		Gas	Water	Water
	No. Wells	Annual	Cumulative	No. Wells			
1958				4	214,434	214,434	1,873
1959				6	330,683	545,117	1,972
1960				11	599,274	1,144,391	2,317
1961				17	774,818	1,919,209	2,470
1962				17	955,366	2,874,575	2,263
1963				17	963,824	3,838,399	2,457
1964				17	993,406	4,831,805	2,372
1965				17	1,068,425	5,900,230	2,490
1966				17	1,091,091	6,991,321	2,700
1967				17	969,203	7,960,524	2,600
1968				17	926,461	8,886,985	2,600
1969				17	975,896	9,862,881	1740/2500
1970				17	918,989	10,781,870	1100/2500
1971				17	1,246,305	12,028,175	1100/2500
1972				17	810,492	12,838,667	1100/2400
1973				17	831,749	13,670,416	
1974				17			

Table 2. Water injection data for the Richfield Pool, Hamilton Field. Water figures are in barrels.

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