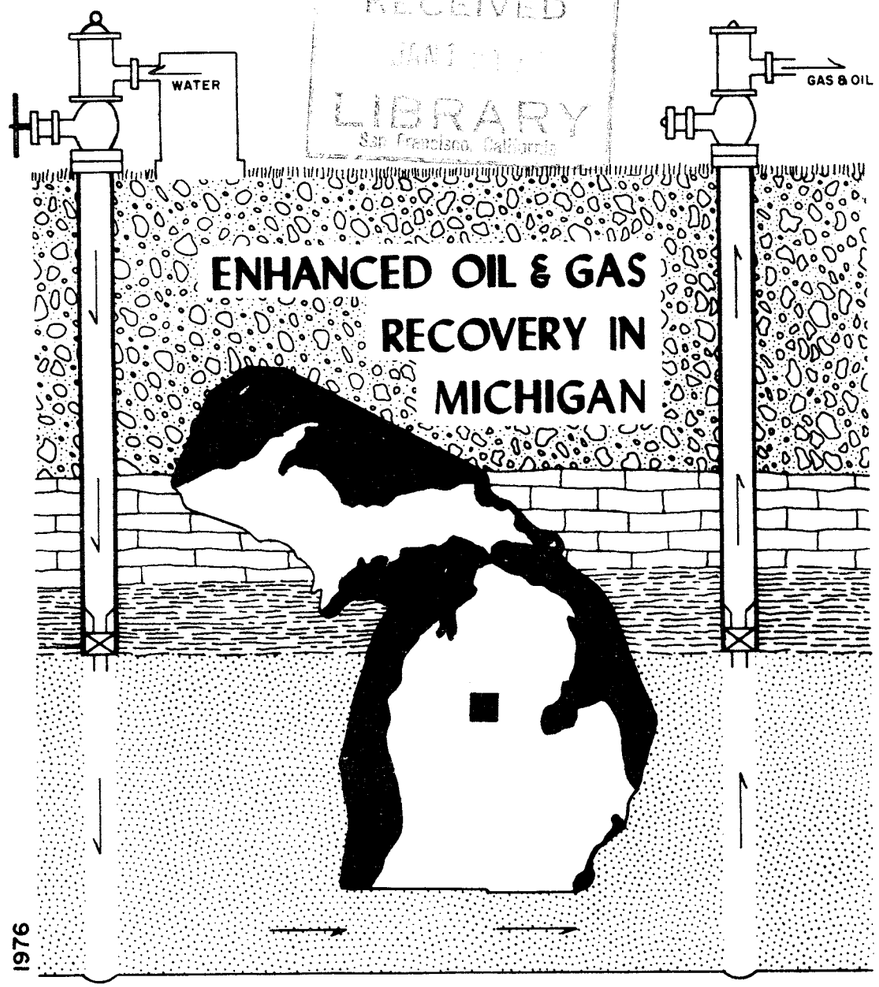
Cranberry Lake Field
Richfield Oil Pool



DEPARTMENT OF NATURAL RESOURCES
GEOLOGY DIVISION

PRODUCTION AND PRORATION UNIT
SECONDARY RECOVERY REPORT NO. 3

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

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GEOLOGY DIVISION

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Cranberry Lake Field Richfield Oil Pool

ENHANCED OIL & GAS RECOVERY IN MICHIGAN

BY
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PREFACE

This is the third in a series of reports on projects to enhance recovery of oil in Michigan. These projects are an effort by the Production and Proration Unit of the Geology 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. Future reports are planned and will be published as they are finished. A compiled volume is planned when all of the reports have been completed.

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CRANBERRY LAKE FIELD, RICHFIELD OIL POOL
Enhanced Oil and Gas Recovery in Michigan

Abstract

The Cranberry Lake Field is a multilevel reservoir in northwestern Clare County. The Richfield Pool interval is being successfully waterflooded.

INTRODUCTION

As is common in Michigan, the Cranberry Lake Field is multipooled and associated with an anticlinal structure. The Cranberry Lake-Richfield Oil Pool waterflood project is located within the boundaries of Sections 1, 2, 11, and 12 of Winterfield Township in northwestern Clare County. In 1943, at a depth of 1,300 feet, gas production from the Michigan Stray section was discovered. The Michigan Stray structure covers an area slightly larger than the Richfield structure beneath. The gas field was fully developed and later converted to a gas storage field, its current status. In 1952, at a depth of about 3,100 feet, a Traverse Oil Pool was discovered at Cranberry Lake Field. This pool was abandoned in 1965 and its production combined with Dundee and Richfield production for statistical purposes. In 1943, at a depth of about 3,800 feet, a Dundee Oil Pool was discovered and is currently producing. In 1953, at a depth of about 4,800 feet, a Detroit River Sour Zone Pool was added to the list of discoveries. In 1962 this pool was also abandoned and the accumulated production combined with Dundee and Richfield production for the field. In 1951 the Richfield proved a producer from a depth of about 5,000 feet. In 1969 the Richfield Pool was unitized and waterflooding began.

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 formational 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 lowermost formation of the

Detroit River Group. The Richfield pay zones appear to span about 200 feet of section made up of dolomite beds of various thickness separated by thin anhydrite beds and occasional 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 dolomites 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 CRANBERRY LAKE FIELD, RICHFIELD OIL POOL HISTORY

In October 1951, Louis Rose drilled the Frank Brocht #1 - the discovery well for this Richfield Oil Pool. The well is located in Section 2 inside of the present waterflood-unit boundary. The first spacing order, issued in November of 1951, directed that all Richfield Oil Pool wells in the Cranberry Lake Field should be located in the center of the NW¼ of a governmentally-surveyed quarter-quarter section of land. This spacing order was abrogated on December 19, 1963, decreasing the area effected by the 1951 order. On September 1, 1969, the 1951 spacing order was totally abrogated thereby ending the regular spacing of Richfield wells in the Cranberry Lake Field. No proration order, which would have established daily oil and gas allowables, was ever issued for this pool. Since Lease Management Incorporated owned and operated all of the wells within the proposed unit, unitization proceeded smoothly. A unitization order was issued in 1969 and water injection began soon after.

Seventeen wells have been completed in the solution gas drive Richfield Pool to the present time. Oil is produced from thirteen laterally correlative oolitic dolomite lenses. The identification of pay zones was accomplished through the application of general Richfield lithologic knowledge in conjunction with analyses of laterlogs, micrologs, and cores that were available from many of the wells. Productive zones range from 1 to 20 feet thick in a total pay thickness of 185 feet. Zones 1 to 9 are separated by well defined anhydrite intervals and zones 10 to 13 are found as streaks which occur within a limestone section. Each dolomite zone is limited by permeability pinchouts with no evidence of bottom or edge water in these zones. In the original completion of Cranberry Lake Richfield Wells free gas was found to be present only in one well; namely the Wolcott State Winterfield #A-1 well in three upper productive zones.

The injection pattern is best described as that in which the edge locations have been converted to water injectors. All wells are open well completions with zones 1 to 4 generally isolated with packers from zones 5 to 13 through which both water injection is accomplished and oil production is achieved. Fresh water with treatment from glacial drift sources is used for injection and brine disposal is accomplished in the Traverse formation through the Neyer State Winterfield #2 well. Engineering and recoverable hydrocarbon data is found summarized in Data Sheet No. 1

STRATIGRAPHIC POSITION	INFORMAL TERMS	PAYS
Basal sandstones of Saginaw Fm.	Parma sandstone	
In lower part of Michigan	triple gyp	
	brown lime	
	stray-stray ss	Gas
	stray dol.	
	stray ss	Gas & Oil
Marshall Ss.		Gas & Oil
Coldwater Sh.	Coldwater lime	
	Weir sand	Gas
	Coldwater red-rock	
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	Oil & Gas
	Stoney Lake zone	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	Oil & Gas
	massive anhydrite	
	big anhydrite	
	Richfield zone	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	Gas
	A-2 lime	
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

Figure 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.

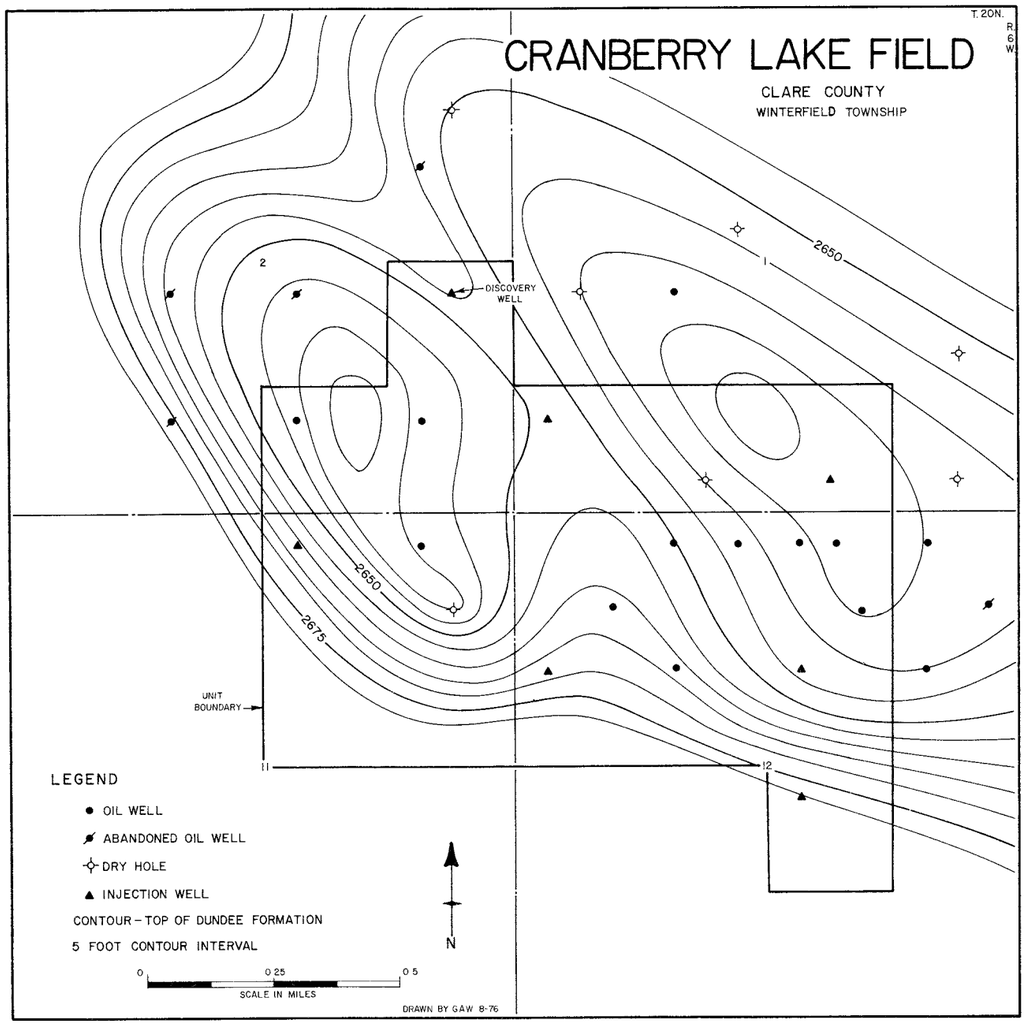

Figure 2: Structure of the Cranberry Lake Field contoured on top of the Dundee Formation.

Data Sheet No. 1

CRANBERRY LAKE FIELD

Richfield Waterflood Project

GENERAL POOL DATA

Location	Clare County, Winterfield Twp. T20N, R6W
Date of pool discovery	October 3, 1951
Discovery Well	Louis Rose, F. Brocht #1
	Permit Number 16747
Producing formation	Richfield
Pay lithology	Dolomite
Type of trap	Anticlinal
Drilled area	680 acres
Unit area	680 acres
Reservoir area, estimated	660 acres

ENGINEERING DATA

Type of reservoir energy	Solution gas
Original reservoir pressure	2400 psi
Reservoir temperature	125°F (1976 BHP Temp)
Viscosity of original reservoir oil	0.2 cp
Bubble point pressure	2000 psi
Formation volume factor	1.47
API oil gravity	50°
Original solution gas-oil ratio	980
Average porosity	13.1 to 19%
Average permeability	.06 to 14.5 md
Connate water, estimated	30%
Net oil pay thickness	14.3 feet
Acre feet of oil pay	8666

RECOVERABLE HYDROCARBON DATA

Estimated original stock tank oil in place	4,930,000 bbls.
Estimated original recoverable stock tank oil	1,177,232 bbls.
Calculated recoverable stock tank oil per acre foot	145 bbls.
Original gas in solution	NA
Estimated original recoverable gas	NA
Estimated additional recoverable oil due to secondary recovery methods	840,000 bbls.

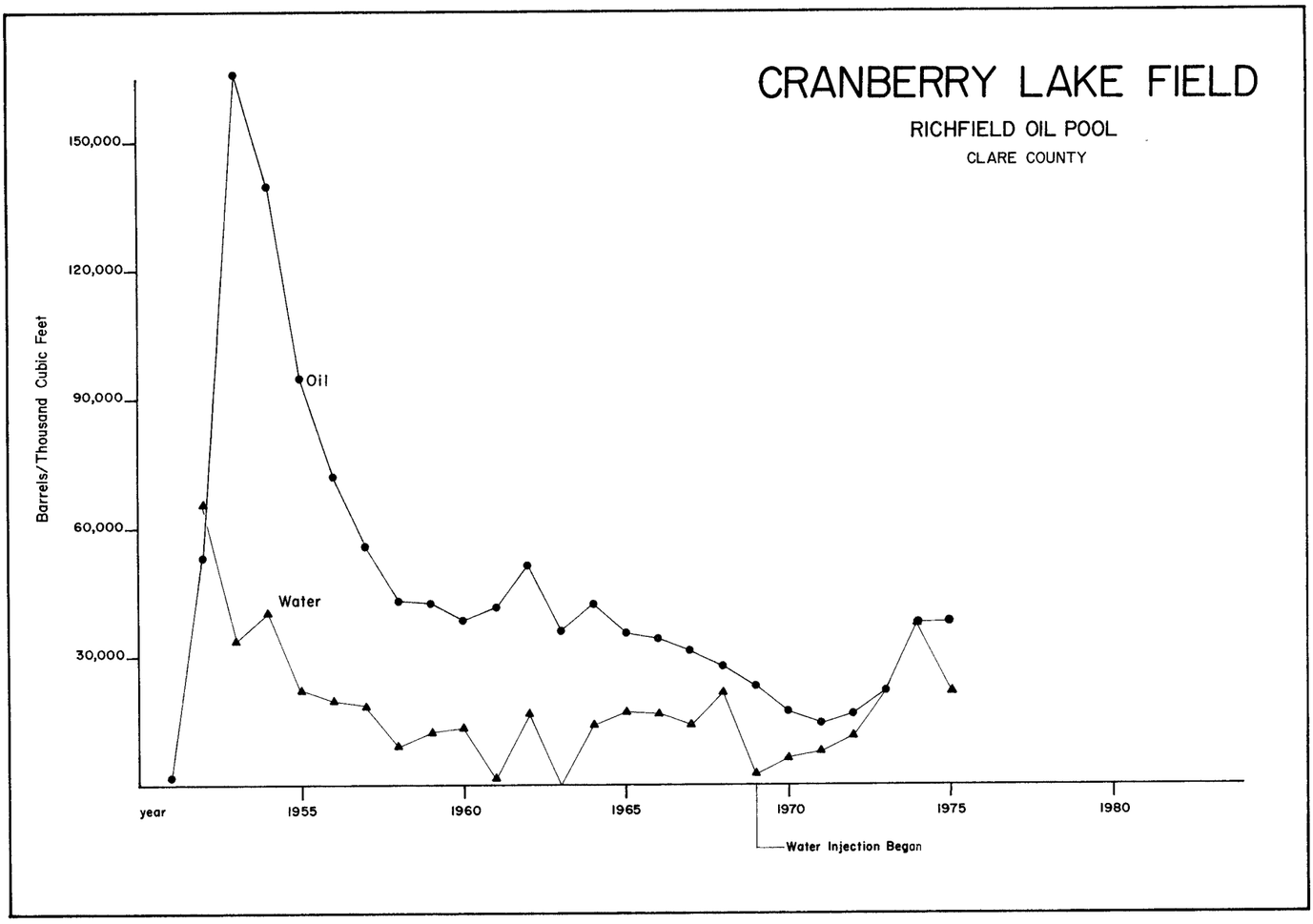

Figure 3: Oil, gas, and water production from the Richfield Pool, Cranberry Lake Field. Oil and water production is shown in barrels. Gas production is shown in thousand cubic feet (MCF).

Cranberry Lake Field, Richfield Waterflood, Clare County							
Year	Production Data						Remarks
	Gas		Oil		Water (estimated)		
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	
1951			1,784	1,784	0	0	
1952			53,690	55,474	65,700	65,700	
1953			166,164	221,638	23,725	89,425	
1954			139,590	361,228	40,315	125,940	
1955			94,967	456,195	21,900	151,840	
1956			72,143	528,338	19,710	171,350	
1957			55,799	584,137	18,615	190,165	
1958			43,120	627,257	9,125	199,290	
1959			45,579	669,836	12,410	211,700	
1960			38,734	708,570	13,505	225,205	
1961			41,854	750,424	2,190	227,395	
1962			51,192	801,616	16,790	244,185	
1963			35,921	837,537	0	244,185	
1964			42,006	879,543	13,870	258,055	
1965			35,198	914,741	17,155	275,210	
1966			34,358	949,099	16,790	292,000	
1967			31,429	980,528	14,235	306,235	
1968			27,639	1,008,167	21,535	327,770	
1969			22,917	1,031,084	2,920	330,690	Waterflood project began.
1970			17,259	1,048,699	6,205	336,895	
1971			14,624	1,063,323	8,395	345,290	
1972			16,550	1,079,873	11,680	356,970	
1973			22,019	1,101,892	21,900	378,870	
1974			37,023	1,138,915	37,595	416,465	
1975			37,315	1,176,230	21,900	438,365	

Table 1. Oil and water production from the Richfield Pool, Cranberry Lake Field. Oil and water production is shown in barrels.

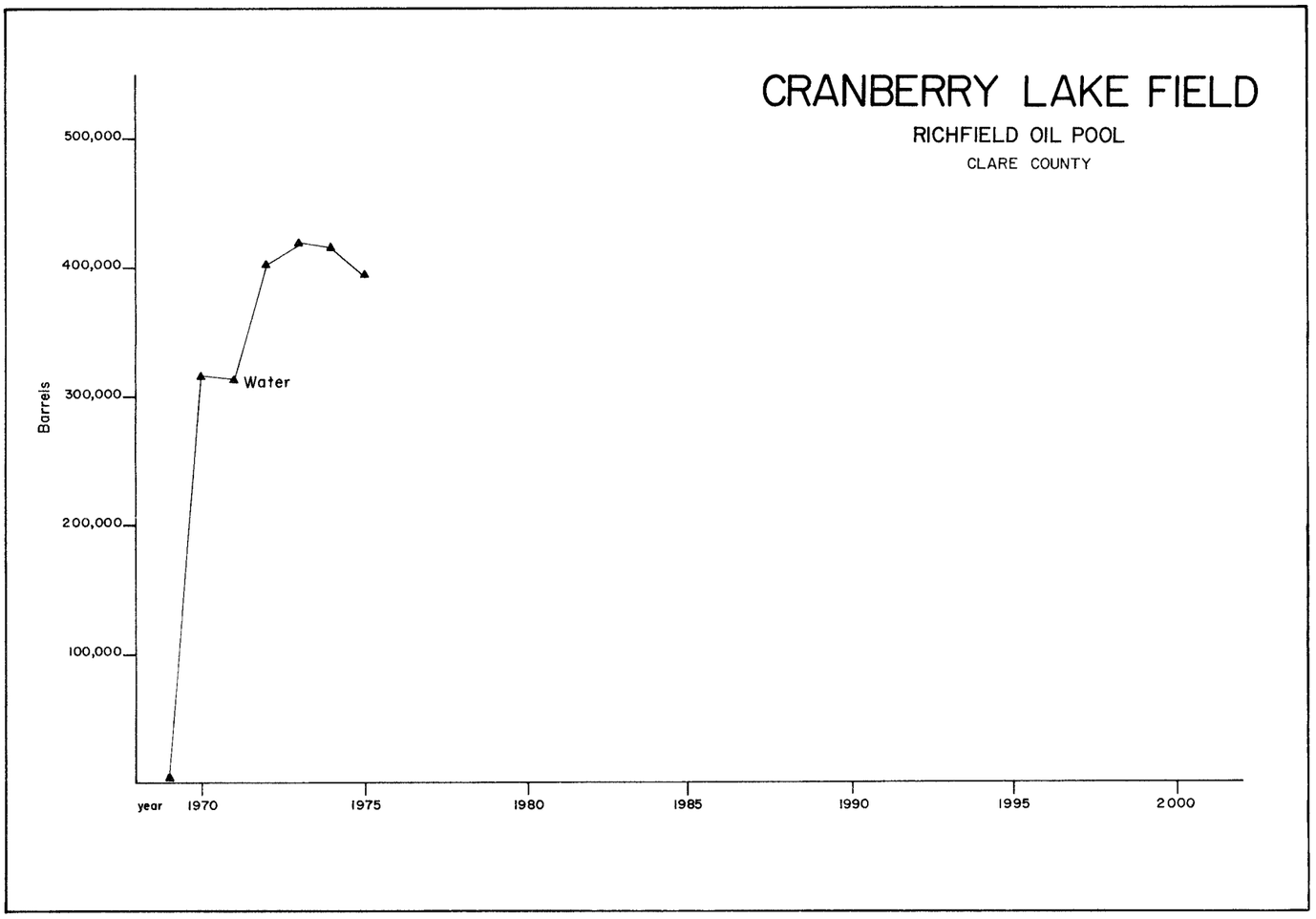

Figure 4: Water injected into the Richfield Pool, Cranberry Lake Field, to enhance oil and gas recovery. Injection water is shown in barrels.

Cranberry Lake Field, Richfield Waterflood, Clare County								
Year	Injection Data							
	Gas				Water			
	No. Wells	Annual	Cumulative	Pressure	No. Wells	Annual	Cumulative	Pressure
1968								
1969					Flood begins	6,161	6,161	1,593
1970					7 Inj. wells	330,783	336,544	2,068
1971					7 Inj. wells	325,855	662,399	2,280
1972					7 Inj. wells	403,976	1,066,375	2,528
1973					7 Inj. wells	439,935	1,506,310	2,723
1974					7 Inj. wells	430,468	1,936,778	2,650
1975					7 Inj. wells	396,265	2,333,043	2,650

Table 2. Water injection data for the Richfield Pool, Cranberry Lake Field. Water figures are shown in barrels and pressure is in pounds per square inch.

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