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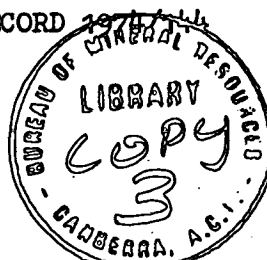


BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

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WATERFLOOD SUSCEPTIBILITY TESTS ON SOME CORE SAMPLES
FROM OIL RESERVOIRS IN KINGFISH A-1, KINGFISH B-1,
MACKEREL NO. 2 AND MACKEREL NO. 3 IN THE OFFSHORE
GIPPSLAND BASIN

by

B.A. McKAY

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SUMMARY

Waterflood tests were carried out in the Petroleum Technology Laboratory on 43 core samples from oil reservoirs in the Kingfish A-1, Kingfish B-1, Mackerel No. 2, and Mackerel No. 3 wells in the offshore Gippsland Basin. The purpose of the tests was to determine the efficiency of natural water drive in the oil reservoirs in these two fields in particular, and by inference, in other fields in the Basin.

The conclusions based on the results of the tests are as follows:

a) Oil recovery at depletion of 99 percent water cut in both fields is greater than 60 percent of oil in place, and at 96 percent water cut is about 55 percent.

b) These oil recovery factors are probably conservative, because some reservoir sections could not be tested because of their poor consolidation indicating high porosity and permeability characteristics.

INTRODUCTION

The Offshore Gippsland Basin contains several oil and gas-condensate fields. Some of these, notably the Halibut, Kingfish, Marlin, and Barracouta fields, are currently in full production, while others like Mackerel, Tuna, and Snapper are expected to commence production in the near future.

The reservoir production mechanism in these fields appears to be a natural water drive, with solution and/or cap gas drive of secondary importance. The associated aquifer system is extensive, and complete water displacement will probably occur in all the fields.

The following tests were carried out to determine the recovery efficiency of water displacing oil from reservoirs in two of the fields viz. Kingfish and Mackerel.

SAMPLE PREPARATION

Forty three core samples were selected for the displacement tests - 14 from Kingfish A-1, 11 from Kingfish B-1, 10 from Mackerel No. 2 and 8 from the Mackerel No. 3 main oil reservoirs. The samples were drilled perpendicular to the bedding planes from slabbed cores. Three plugs were also drilled parallel to the bedding planes from the Kingfish A-1 and Mackerel No. 3 core samples.

The $1\frac{1}{8}$ inch diameter plugs were trimmed to approximately $1\frac{1}{4}$ inches in length and after cleaning with toluene in a centrifugal extractor, they were oven dried at 105°C for 24 hours. After cooling, porosity and permeability were measured with respect to nitrogen. Subsequently, the surface of each plug was thinly coated with epoxy resin (end faces excepted) to avoid grain losses during later test work.

WATERFLOOD TESTS

The waterflood tests were carried out in the following manner: each plug was saturated with brine of 40 000 ppm NaCl for Kingfish, and 20 000 ppm NaCl for Mackerel. The plugs were then flushed with viscous mineral oil until residual water saturation was obtained. The mineral oil was replaced with a light refined oil of 1.77 cp. viscosity in the case of the Kingfish samples and 1.55 cp. viscosity in the case of Mackerel samples. The viscosities were measured at 18°C .

After permeability to the respective oil was measured in each of the samples, waterflood susceptibility tests were carried out in a rubber sleeved Hassler cell. The tests were conducted at a producing water-oil viscosity ratio of approximately 1.66 in the case of Kingfish samples and 1.50 in the case of Mackerel samples. (These values approximate the water-oil viscosity ratio in the respective reservoirs in each field). Water flooding was continued in each case until a 99.9% water cut was obtained.

DISCUSSION OF RESULTS

The results of the tests are as follows:

- (1) Porosity, permeability and residual water saturations are shown in Tables 1 and 3.
- (2) Oil recovery characteristics by water drive and the water 'cut' at various stages during displacement are shown in Tables 2 and 4 and in Figures 1 - 43.
- (3) Average oil recovery and water saturation characteristics are shown in Figures 44, 45, 46 and 47.

The results shown in Tables 2 and 3 and Figures 1 to 47 reveal generally favourable oil recovery characteristics by water drive for both fields. The average oil recovery at water breakthrough for the two Kingfish wells was 36% and 39% of oil in place, while recovery from the two Mackerel wells averaged 43% and 46% of oil in place.

A very significant proportion of oil was recovered from both groups of core samples, Kingfish and Mackerel, after water breakthrough. However, the Kingfish samples showed lower oil recovery at breakthrough and greater oil production after breakthrough than the Mackerel samples. This is probably due to different pore size distribution characteristics, the Mackerel samples having slightly better grain sorting than those of Kingfish.

The oil recovery at depletion can be determined by reference to the curves in Figures 44 - 47. At 96% water saturation in the effluent as a cut-off point for oil production, the tests indicate an average recovery of 54% of oil in place for Kingfish A-1 and Mackerel No. 2 and 56% for Kingfish B-1 and Mackerel No. 3. If a 99% water cut is accepted, then the corresponding average recoveries will be 61% of oil in place for

each of Mackerel Nos 2 and 3, and Kingfish A-1 wells, and 68% of oil in place for Kingfish B-1.

However, most of these recovery factors are probably conservative; much of the core material from the four wells from which the sample plugs were taken was very poorly consolidated. Plugs had to be drilled with liquid nitrogen coolant to avoid disintegration during sampling, and several intervals could not be sampled because the core material was completely unconsolidated. It may be assumed, therefore, that the porosity and particularly the permeability values of the 'lost' core material are higher than those of the samples used in these tests, even if overburden pressure is considered. Similar conclusions could also be drawn concerning the oil recovery characteristics of the unsampled material.

TABLE 1

WELL - KINGFISH A-1

Sample Number	Depth (feet)	Porosity (% bulk volume)	Permeability (millidarcy)			Residual water saturation before waterflood (% pore volume)	Lithology
			To dry nitrogen	To oil at residual water saturation (before flood)	To water at residual oil saturation (after flood)		
1	7514	23.9	2578	2315	1179	19.2	Sst;m.gr. to c.gr. sl.slt
2	7528	22.2	2093	1834	1122	30.6	Sst;f.gr. to c.gr. slty
3	7544	22.8	788	259	144	29.6	Sst;f.gr. to m. gr., sl. slty
4	7559	22.3	335	166	91	28.2	as above
5(V)	7569	24.8	906	712	374	17.7	Sst;m.gr., sl. slty
5(H)	7569	24.0	1940	1939	917	17.5	As above
6	7600	25.6	826	804	297	14.8	Sst;v.f.gr. to f.gr.
8	7667	24.6	2919	1589	1545	29.4	Sst;f.gr. to m. gr., sl. slty
9	7673	18.1	554	276	92	17.4	Sst;f.gr. to v. c.gr., sl. slty
11(V)	7722	16.7	835	513	18.3	23.8	Sst;f.gr. to c. gr., arg.
11(H)	7722	14.9	750	514	200	24.0	As above
12	7728	13.0	705	461	146	28.9	As above
13	7739	18.1	3460	2938	1524	32.7	Sst; m.gr. to c.gr. sl. arg.
14	7745	17.1	1337	977	685	32.0	Sst; c.gr. slty.

WELL - KINGFISH B-1

Table 1 (contd.)

1	7423	15.6	537	497	338	27.4	Sst; m.gr. to o. gr., sl. slty.
2	7434	19.1	1915	1825	1738	17.1	Sst; m.gr. to c.gr.
3	7455	22.3	113	55	31	42.2	Sst; f.gr. to o. gr., slty.
4	7487	23.4	307	142	60	21.2	Sst; f.gr. to m. gr., sl. mic.
5	7608	21.0	2083	1840	1350	23.1	Sst; f.gr. to c.gr.
6	7618	24.8	2488	1787	1446	25.3	Sst; m.gr.
7	7627	26.5	1689	1079	496	27.2	As above
8	7639	21.5	944	531	330	31.8	Sst; m.gr. to c.gr.
9	7649	21.2	1192	938	937	32.7	Sst; o.gr., sl. slty.
10	7656	22.8	2132	2002	892	36.5	Sst; f.gr. to o.gr.
11	7661	19.8	111	45	12	26.2	Sst; f.gr. to tr. o.gr.

TABLE 2

WELL - KINGFISH A-1

Water Salinity - 40,000 ppm NaCl
Producing water/oil viscosity ratio - 1.6

Sample Number	Depth (feet)	Oil Recovery										Water Cut			
		% pore volume					% hydrocarbon volume					(% total production)			
		B.T.	1 P.V.	5 P.V.	10 P.V.	20 P.V.	B.T.	1 P.V.	5 P.V.	10 P.V.	20 P.V.	1 P.V.	5 P.V.	10 P.V.	20 P.V.
1	7514	26.3	36.5	43.9	47.0	49.0	32.8	45.8	54.7	58.6	61.1	95.5	99.0	99.8	99.9
2	7528	26.8	35.2	45.0	48.7	51.5	38.3	50.7	64.8	70.2	74.2	94.5	98.8	99.7	99.8
3	7544	26.4	37.0	47.0	50.2	52.0	37.5	52.5	66.7	71.3	73.8	93.0	99.0	99.7	99.8
4	7559	25.9	38.5	49.0	51.5	53.5	36.1	53.6	68.2	71.7	74.5	92.5	99.2	99.7	99.8
5(V)	7569	38.7	49.0	57.3	60.5	63.0	47.0	59.5	69.6	73.5	76.5	94.5	99.1	99.6	99.8
5(H)	7569	34.0	49.0	59.8	62.0	64.0	41.2	59.4	72.5	75.1	77.6	91.0	99.0	99.7	99.9
6	7600	43.6	52.5	60.2	62.5	65.0	51.1	61.6	70.6	73.3	76.3	96.5	99.4	99.7	99.8
8	7667	39.1	46.5	55.0	57.0	59.0	55.4	65.4	77.9	80.7	83.6	93.6	99.3	99.7	99.9
9	7673	37.2	46.5	54.4	56.0	57.8	45.0	56.3	65.8	67.8	69.9	94.0	99.4	99.7	99.9
11(V)	7722	37.4	42.0	45.2	47.0	50.0	49.1	55.1	59.3	61.7	65.6	98.0	99.5	99.6	99.9
11(H)	7722	27.5	35.0	42.2	44.0	45.5	36.2	46.0	55.5	57.8	59.8	95.0	99.0	99.7	99.8
12	7728	9.5	16.7	20.8	22.8	25.0	13.4	23.5	29.2	32.1	35.1	97.0	99.2	99.6	99.9
13	7739	26.9	33.2	42.8	45.0	46.0	39.9	49.3	63.6	66.8	68.3	94.5	99.0	99.6	99.9
14	7745	18.0	26.5	35.8	38.5	41.0	26.4	38.9	52.6	56.6	60.3	95.0	99.0	99.5	99.8
AVERAGE		29.8	38.9	47.0	49.5	51.5	39.2	51.3	62.2	65.5	68.3	94.6	99.1	99.7	99.85

WELL - KINGFISH B-1

1	7423	18.1	37.0	50.1	54.8	58.0	24.9	50.9	69.0	75.5	79.9	88.0	98.8	99.3	99.8
2	7434	33.7	44.0	59.0	61.8	66.2	40.3	53.1	71.1	74.5	79.8	92.0	98.7	99.8	99.8
3	7455	7.5	19.5	30.4	35.0	39.2	12.9	33.7	52.6	60.5	67.8	94.7	98.9	99.5	99.8
4	7487	34.4	48.5	57.0	59.5	62.0	43.6	61.5	72.3	75.5	78.7	94.0	99.2	99.7	99.9

WELL - KINGFISH B-1

5	7608	27.5	37.8	47.0	51.0	55.0	35.7	49.1	61.1	66.3	71.5	95.0	98.9	99.4	99.8
6	7618	33.8	39.5	48.0	51.2	53.3	45.2	52.9	64.2	68.5	71.3	95.5	99.0	99.6	99.8
7	7621	35.6	47.5	55.0	58.3	61.0	48.9	65.2	75.5	80.0	83.8	96.6	99.1	99.6	99.9
8	7639	27.3	36.5	44.8	48.7	52.0	40.0	53.5	65.7	71.4	76.2	96.0	99.0	99.6	99.8
9	7649	22.4	29.2	39.0	42.9	45.0	33.3	43.4	57.9	63.7	66.8	95.0	98.8	99.6	99.8
10	7656	17.5	33.5	44.5	47.5	49.5	27.6	52.7	70.1	74.8	77.9	93.0	99.0	99.6	99.8
11	7661	35.5	41.7	50.0	52.8	54.0	48.1	56.5	67.7	71.5	73.2	95.4	99.0	99.7	99.9
AVERAGE		31.0	37.7	47.7	51.2	54.1	36.4	52.0	66.1	71.1	75.2	94.0	98.9	99.5	99.8

TABLE 3

WELL - MACKEREL NO. 2

Sample Number	Depth (feet)	Porosity (% bulk volume)	Permeability (Millidarcy)			Residual water saturation before waterflood (% pore volume)	Lithology
			To dry nitrogen	To oil at residual water saturation (before flood)	To water at residual oil saturation (after flood)		
1	7590	20.8	78	71	37	30.6	Sst; f.gr. to v. c.gr., sl. mic.
2	7599	17.7	27	16	5	29.1	As above
3(H)	7621	21.4	449	373	35	28.9	Sst; m.gr.
5	7726	27.0	751	710	375	21.7	Sst; m.gr., sl. glau
6	7753	24.0	52	51	18	26.4	Sst; f.gr. to m. gr., mic. glauc
8	7819	23.8	1642	1300	1059	21.2	Sst; m.gr. to c. gr., v. pyr.
9	7846	23.5	983	808	346	16.1	Sst; f.gr. to c. gr., mic.
10	7858	24.5	987	565	486	24.3	Sst; f.gr. to c. gr.
11	7886	23.6	424	359	105	29.3	Sst; m.gr. to c. gr.
12	7903	23.1	457	410	87	23.8	Sst; f.gr. to c. gr., sl. arg.

WELL - MACKEREL NO. 3

2	7858	22.7	1404	667	670	28.6	Sst; m.gr. sl. pyr.
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3	7874	19.6	388	381	113	25.9	Sst; m.gr. to c. gr.
4	7885	22.6	426	255	169	18.9	Sst; f.gr. to c. gr.
5(V)	7896	18.0	1244	1178	399	25.6	Sst; f.gr. to v.c. gr.
5(H)	7896	17.8	1163	890	475	22.4	As above
6	7908	27.3	856	632	63	26.0	Sst; f.gr. to m. g. mic, sl. arg.
7	7919	25.1	456	182	104	25.5	Sst; v.f.gr. to f.gr., sl. slty.
8	7929	23.4	860	645	92	24.0	Sst; f.gr. to c. gr., slty, mic.

TABLE 4

WELL - MACKEREL NO. 2

Water Salinity - 20,000 ppm NaCl
Producing water/oil viscosity ratio - 1.50

Sample Number	Depth (feet)	Oil Recovery										Water Cut			
		% pore volume					% hydrocarbon volume					(% total production)			
		B.T.	1 P.V.	5 P.V.	10 P.V.	20 P.V.	B.T.	1 P.V.	5 P.V.	10 P.V.	20 P.V.	1 P.V.	5 P.V.	10 P.V.	20 P.V.
1	7590	17.4	26.0	30.3	34.0	37.1	25.1	37.5	43.6	48.9	53.4	96.4	98.7	99.4	99.8
2	7599	16.5	29.0	35.2	38.0	40.6	23.3	40.9	49.6	53.6	57.3	96.0	99.0	99.5	99.9
3(H)	7621	25.5	37.2	44.6	48.8	51.7	35.8	52.3	62.7	68.6	72.7	97.0	98.8	99.4	99.8
5	7726	44.4	52.0	55.7	56.0	56.4	56.7	66.4	71.1	71.5	72.0	98.6	99.4	99.9	99.9
6	7753	36.8	41.0	48.1	50.0	53.0	50.0	55.7	65.3	67.9	72.0	96.0	99.2	99.6	99.9
8	7819	41.3	47.8	53.0	55.1	56.7	52.4	60.6	67.2	69.9	71.9	97.0	99.0	99.8	99.9
9	7846	41.4	55.7	59.0	60.0	61.0	49.3	66.4	70.3	71.5	72.7	97.5	99.6	99.9	99.9
10	7858	44.9	50.8	55.8	58.5	61.0	59.3	67.1	73.7	77.3	80.6	97.0	99.2	99.8	99.9
11	7886	32.0	38.0	45.2	47.0	48.2	45.3	53.7	63.9	66.5	68.2	95.0	99.0	99.8	99.9
12	7903	28.6	34.7	39.1	40.0	41.2	37.5	45.5	51.3	52.5	54.0	97.0	99.2	99.8	99.9
AVERAGE		32.8	41.2	46.6	48.7	50.7	43.5	54.6	61.8	64.8	67.5	96.7	99.1	99.7	99.9

WELL - MACKEREL NO. 3

2	7858	45.2	50.0	54.8	56.4	57.8	63.3	70.0	76.7	79.0	80.9	97.2	99.3	99.8	99.9
3	7874	21.4	36.0	44.8	46.3	48.8	28.8	48.6	60.4	62.5	64.8	94.0	99.5	99.6	99.9
4	7885	42.3	48.0	54.2	55.8	57.0	52.1	59.2	66.8	68.8	70.3	95.0	99.5	99.7	99.8
5(V)	7896	40.2	49.0	52.0	52.8	53.0	54.0	65.8	69.9	70.9	71.2	98.5	99.7	99.9	99.9
5(H)	7896	38.3	52.0	59.1	60.2	62.0	49.3	67.0	76.1	77.6	79.8	95.0	99.7	99.8	99.9
6	7908	19.6	23.2	27.0	28.0	29.8	26.4	31.3	36.5	37.8	40.3	98.0	99.5	99.7	99.9
7	7919	37.7	44.5	52.2	55.3	58.0	50.6	59.7	70.0	74.2	77.8	95.7	99.5	99.6	99.8
8	7929	36.2	38.4	40.0	40.8	41.5	47.6	50.5	52.6	53.7	54.6	99.5	99.9	99.9	99.9
AVERAGE		35.1	42.6	48.0	49.4	50.9	46.5	56.5	63.6	65.6	67.5	96.6	99.6	99.7	99.9

FIGURE 1

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7514'

POROSITY-23.9%

PERMEABILITY-2315 Md.(Ko)

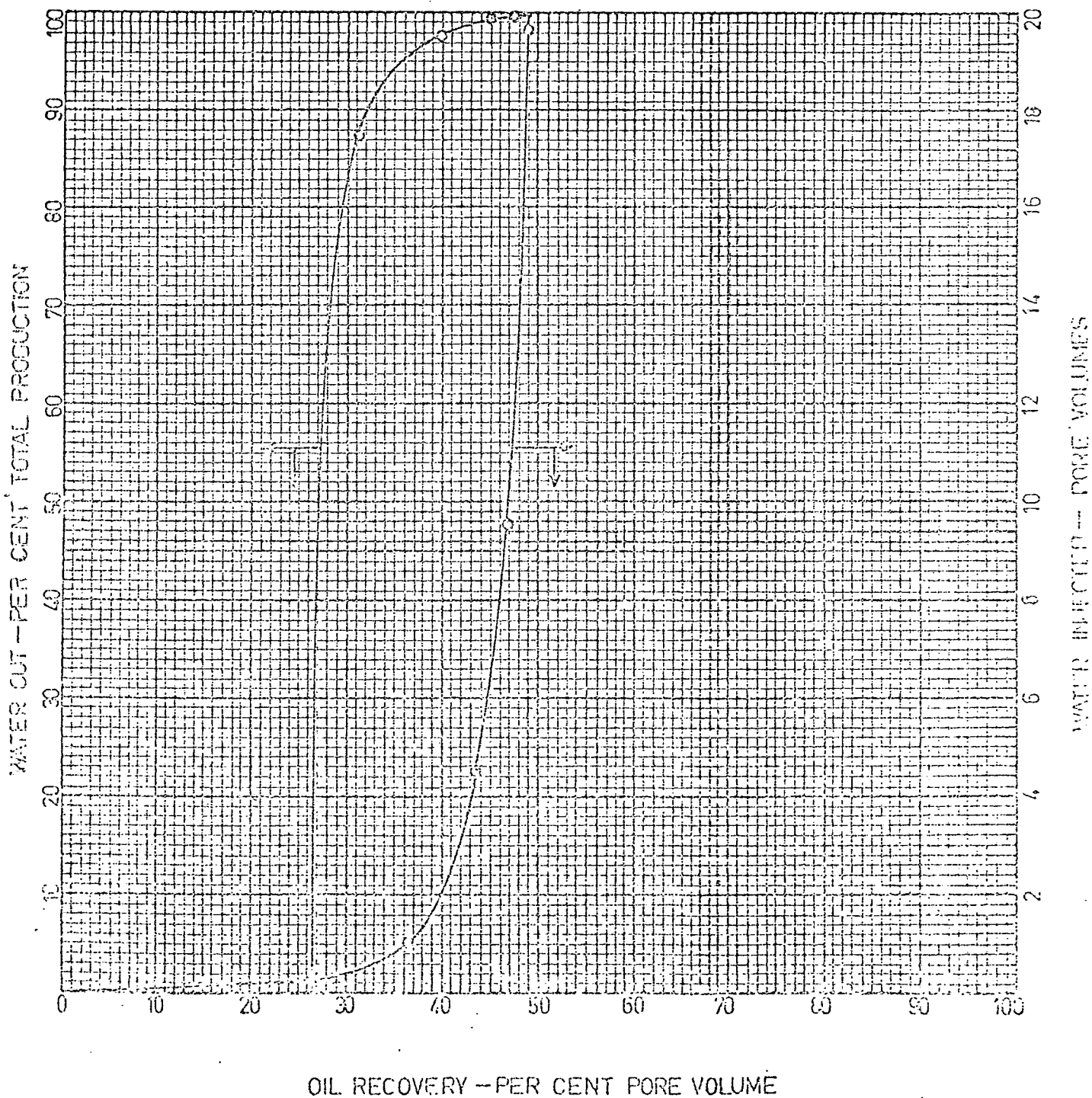


FIGURE 2

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7528'

POROSITY-22.2 %

PERMEABILITY-1834 Md. (Ko)

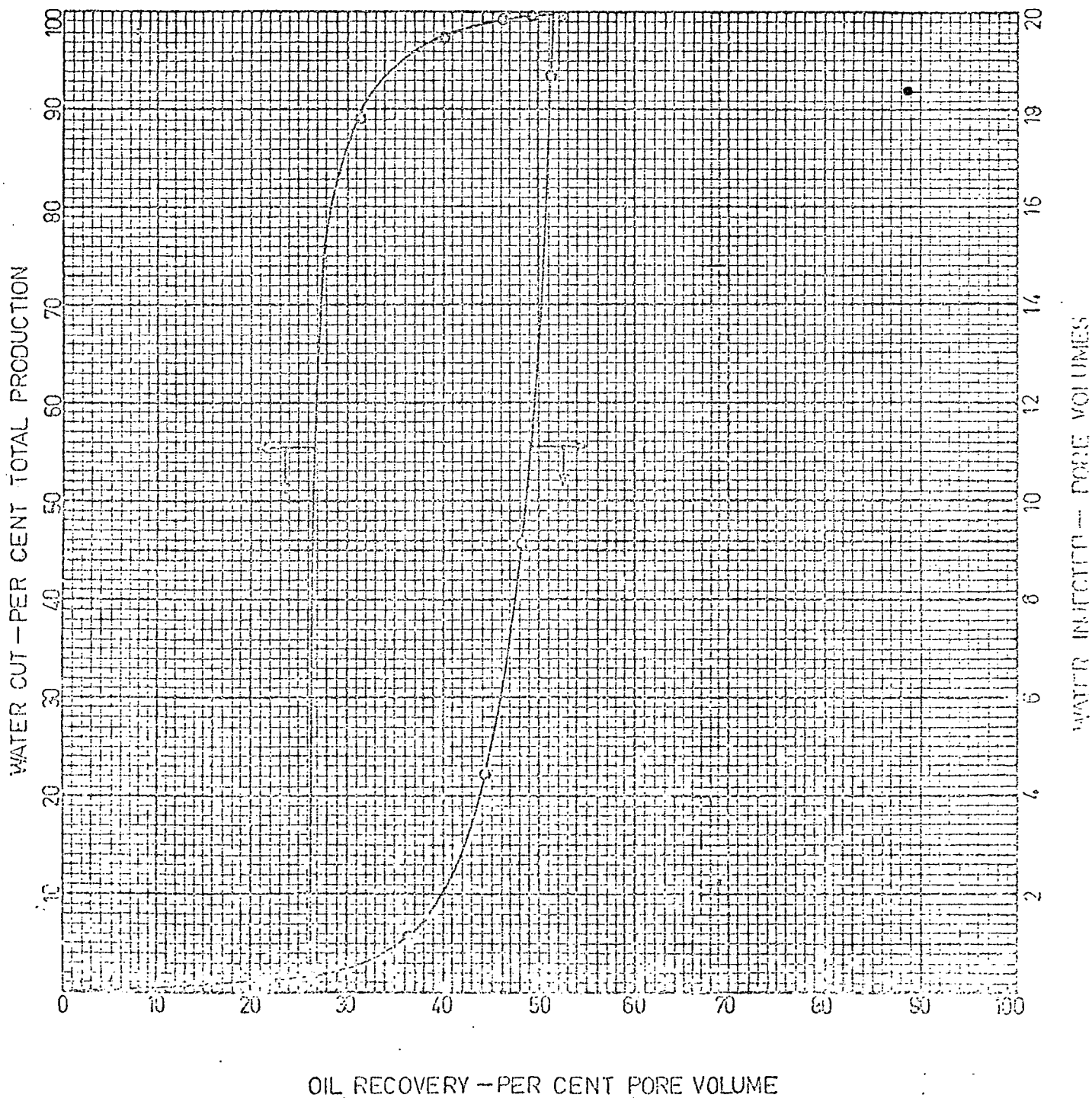


FIGURE 3

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7544'

POROSITY - 22.8%

PERMEABILITY - 259 Md. (Ko)

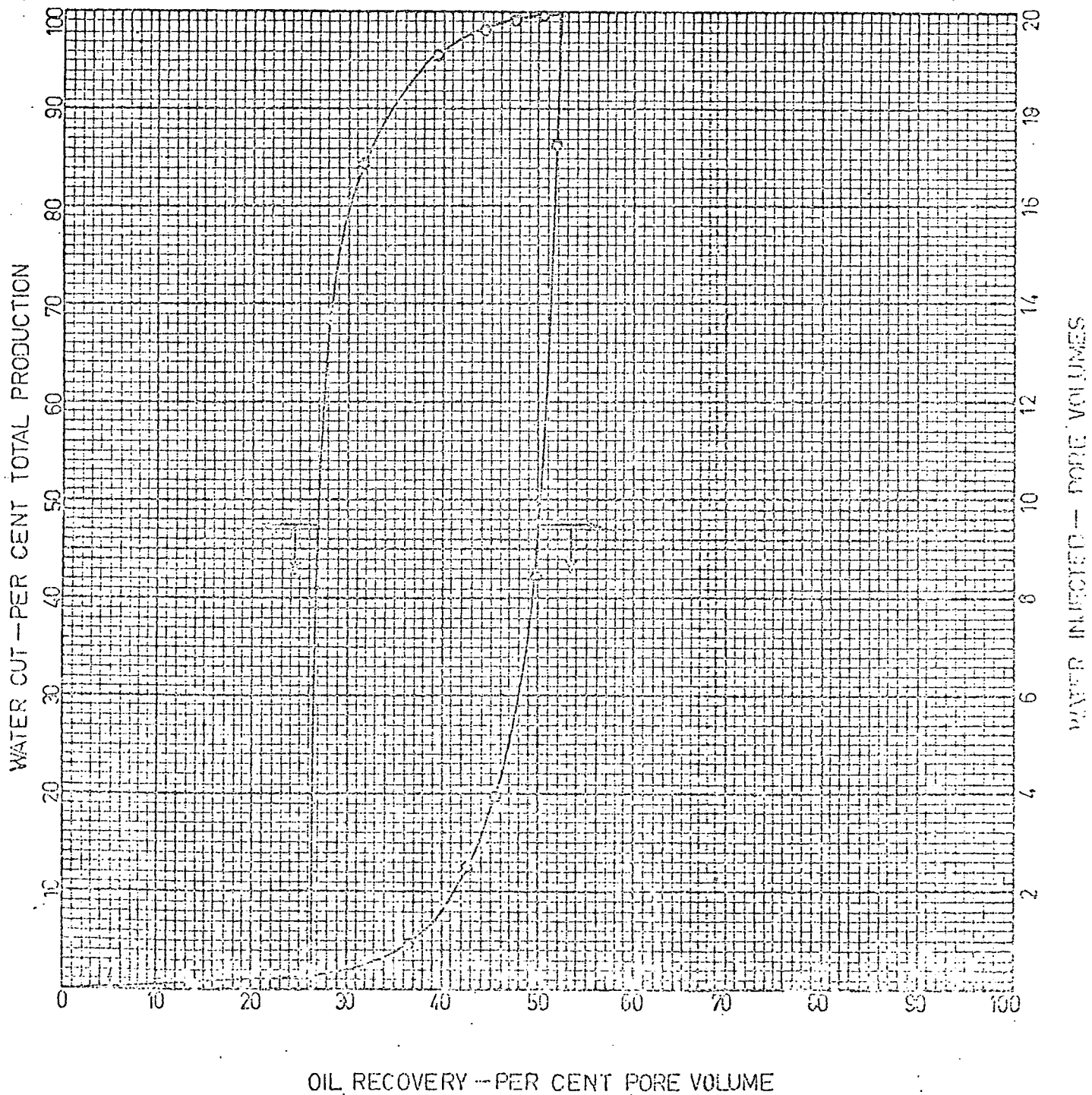


FIGURE 4

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7559'

POROSITY-22.3%

PERMEABILITY-166 Md.(Ko)

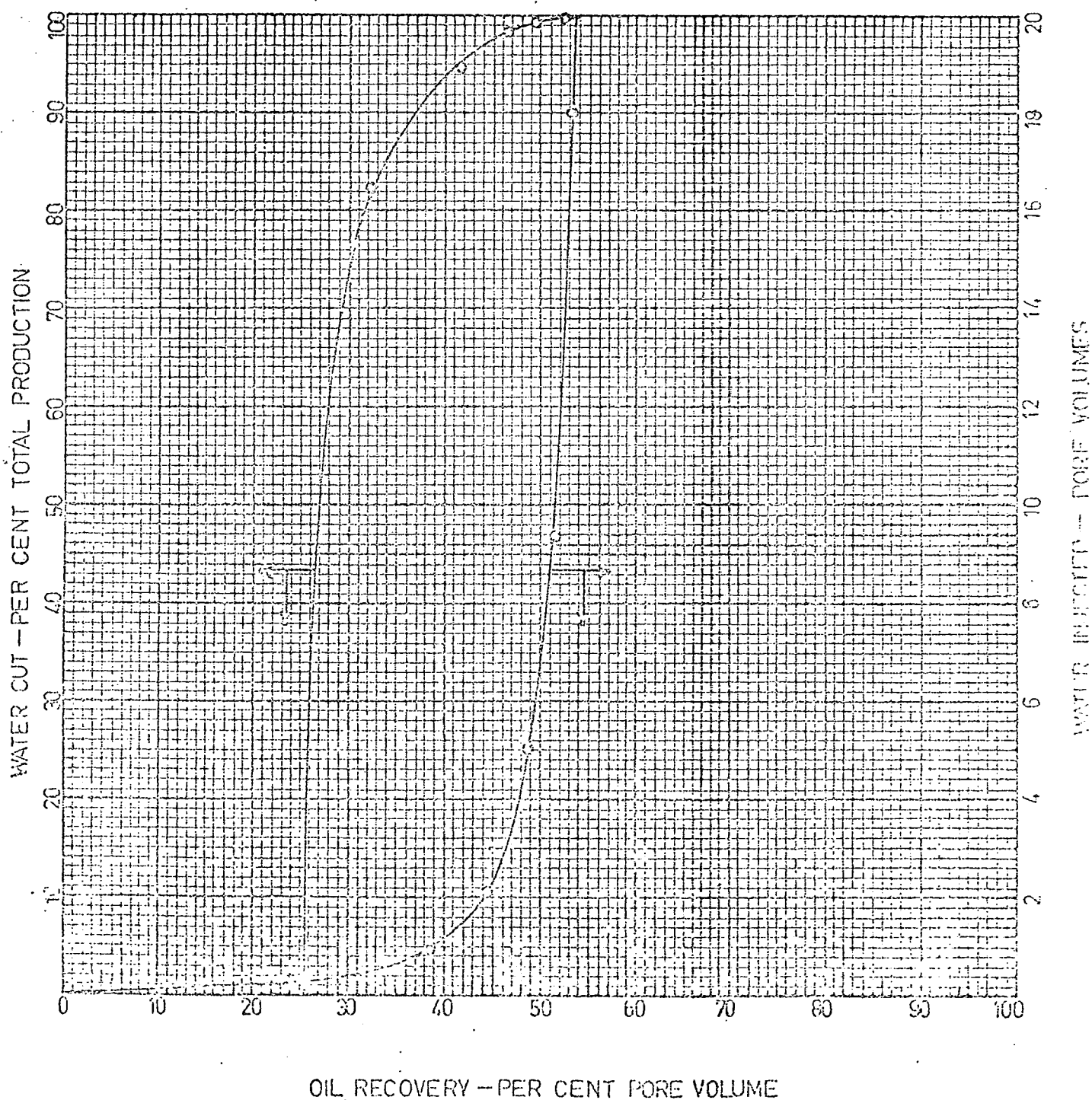


FIGURE 5

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7569'

POROSITY-24.8%

PERMEABILITY-712 Md.(Ko)

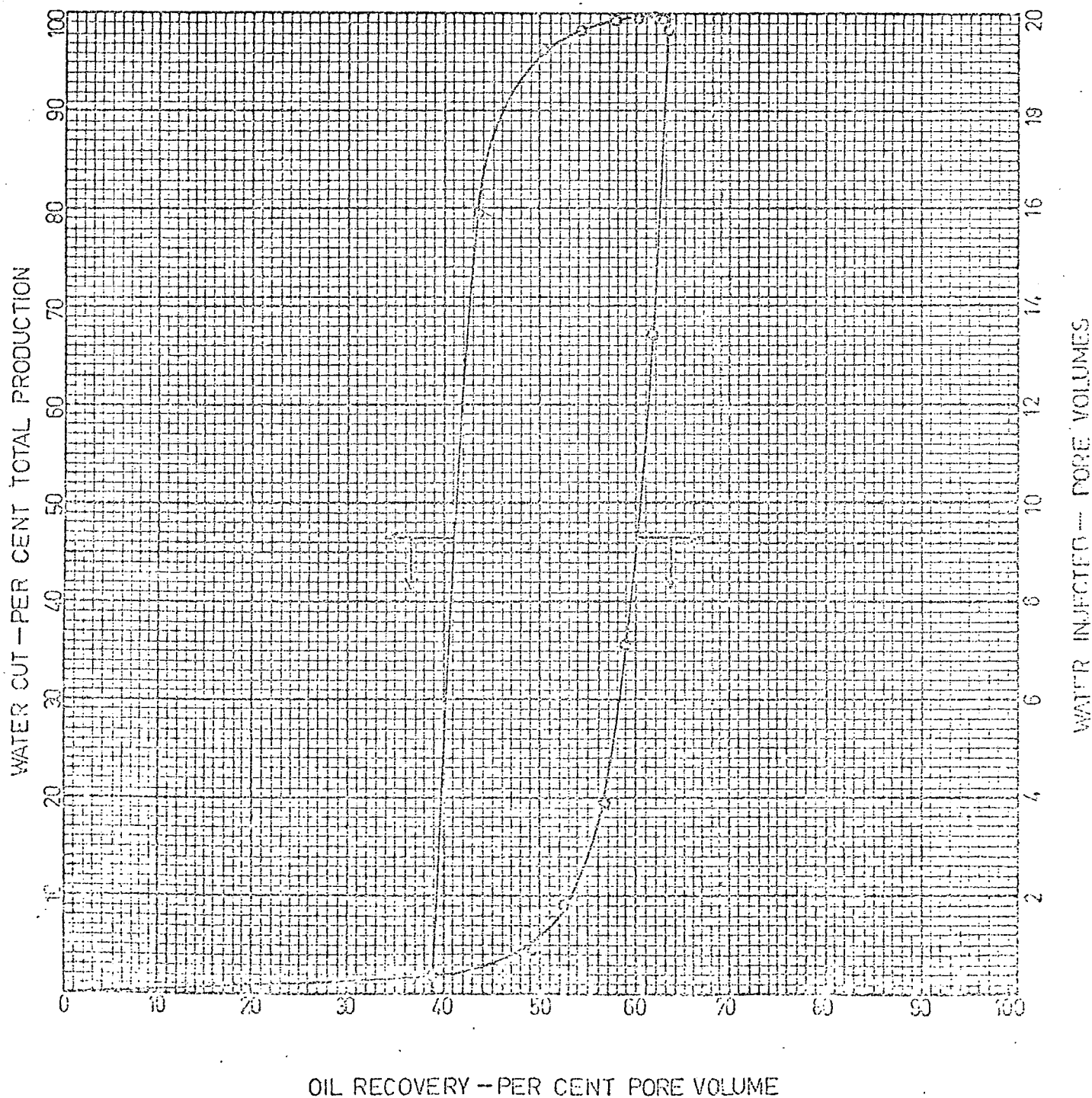


FIGURE 6

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7569'(H)

POROSITY - 24.0 %

PERMEABILITY - 1939 Md.(Ko)

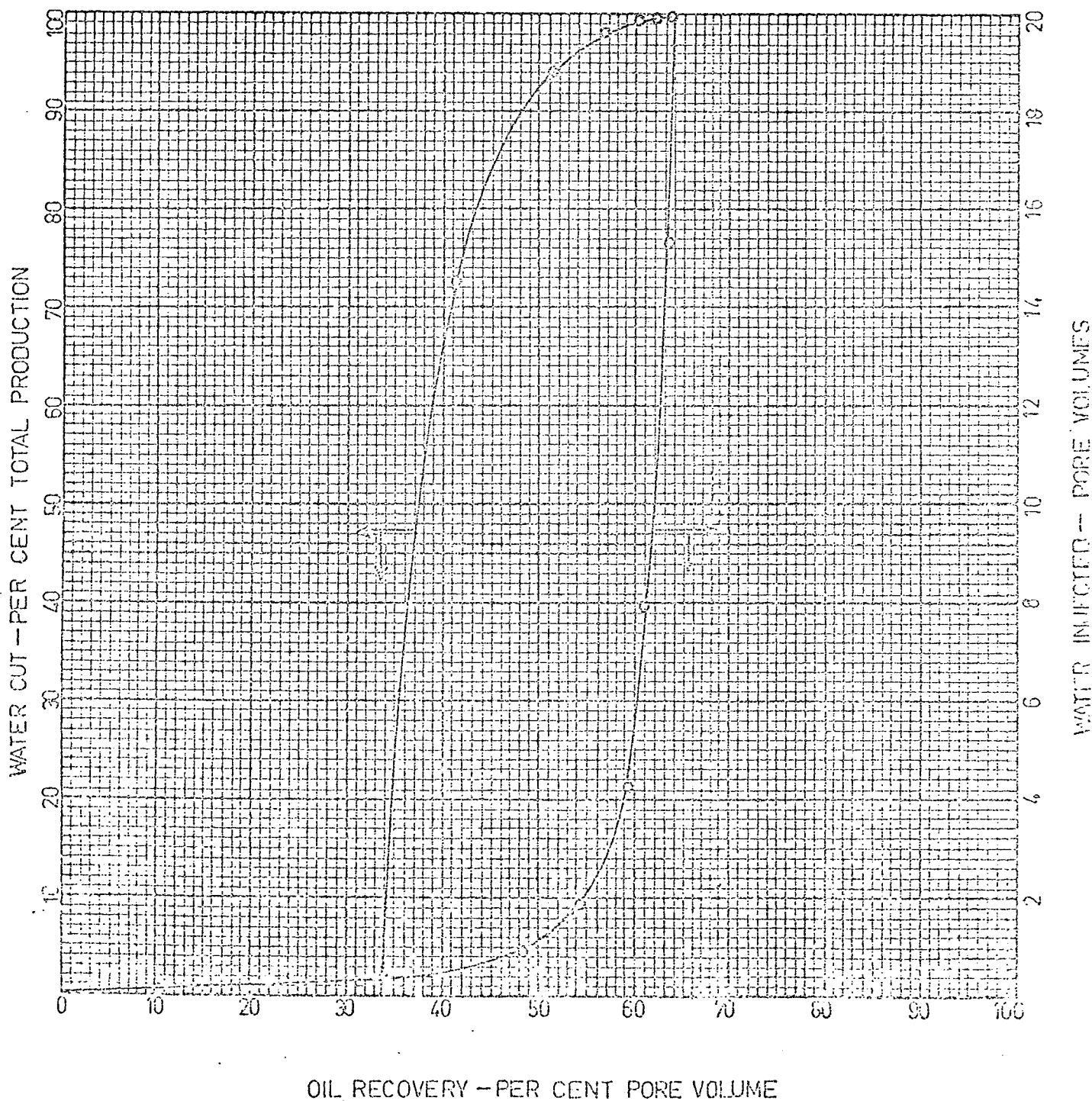


FIGURE 7

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7600'

POROSITY - 25.6%

PERMEABILITY - 904 Md. (Ko)

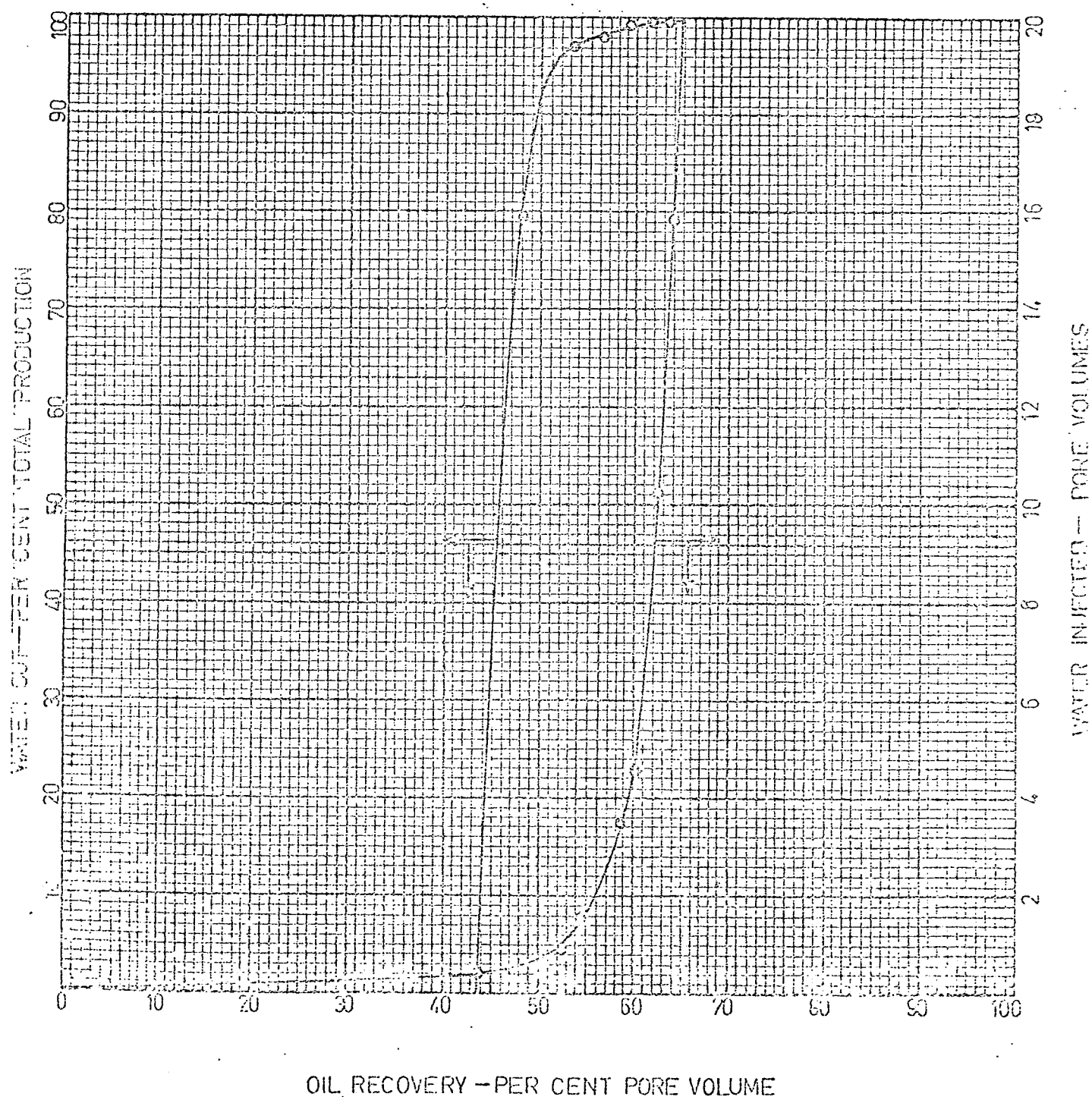


FIGURE 8

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7667'

POROSITY - 24.6 %

PERMEABILITY - 1589 Md. (ko)

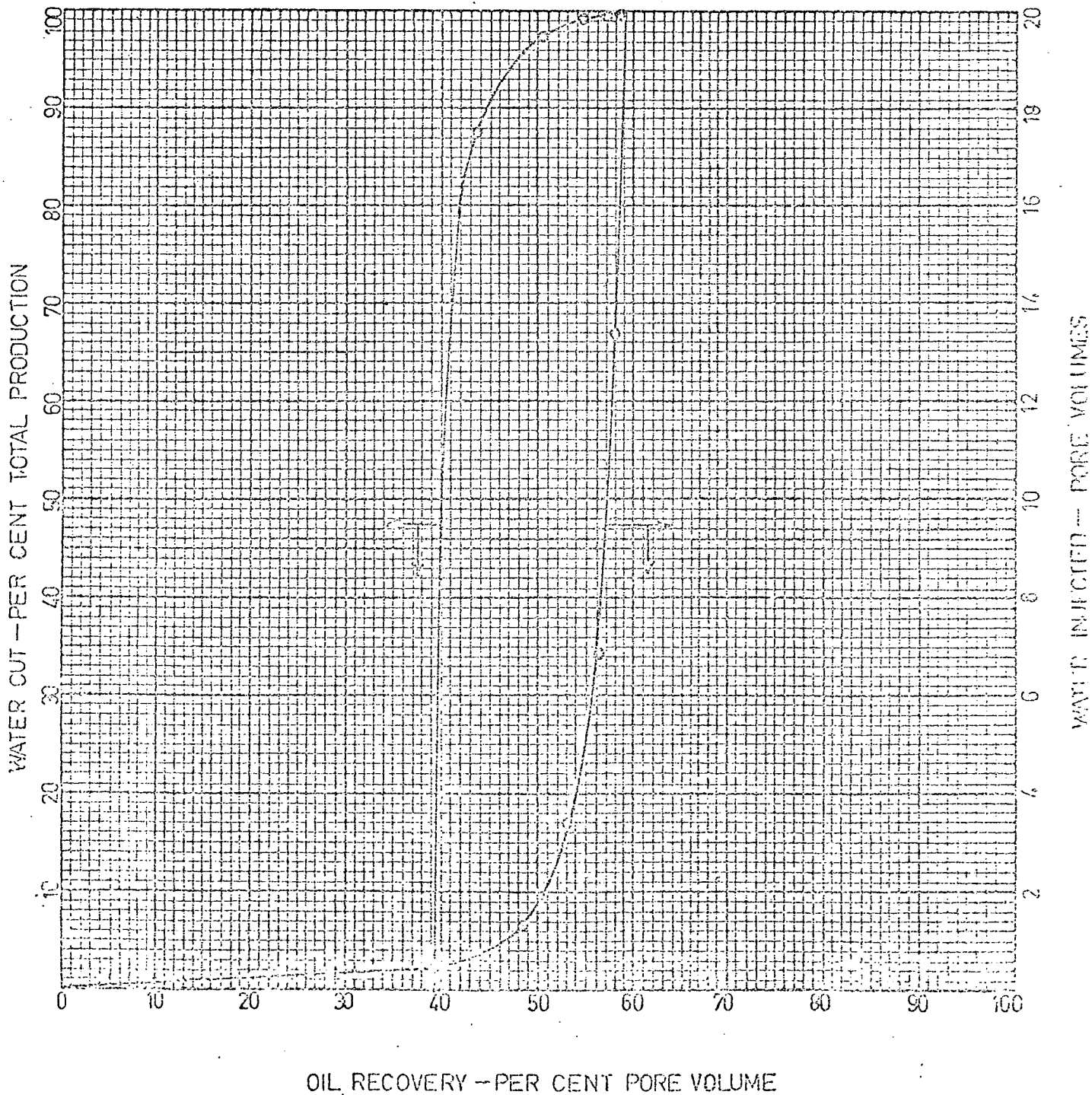


FIGURE 9

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7673'

POROSITY-18.1%

PERMEABILITY - 276 Md. (Ko)

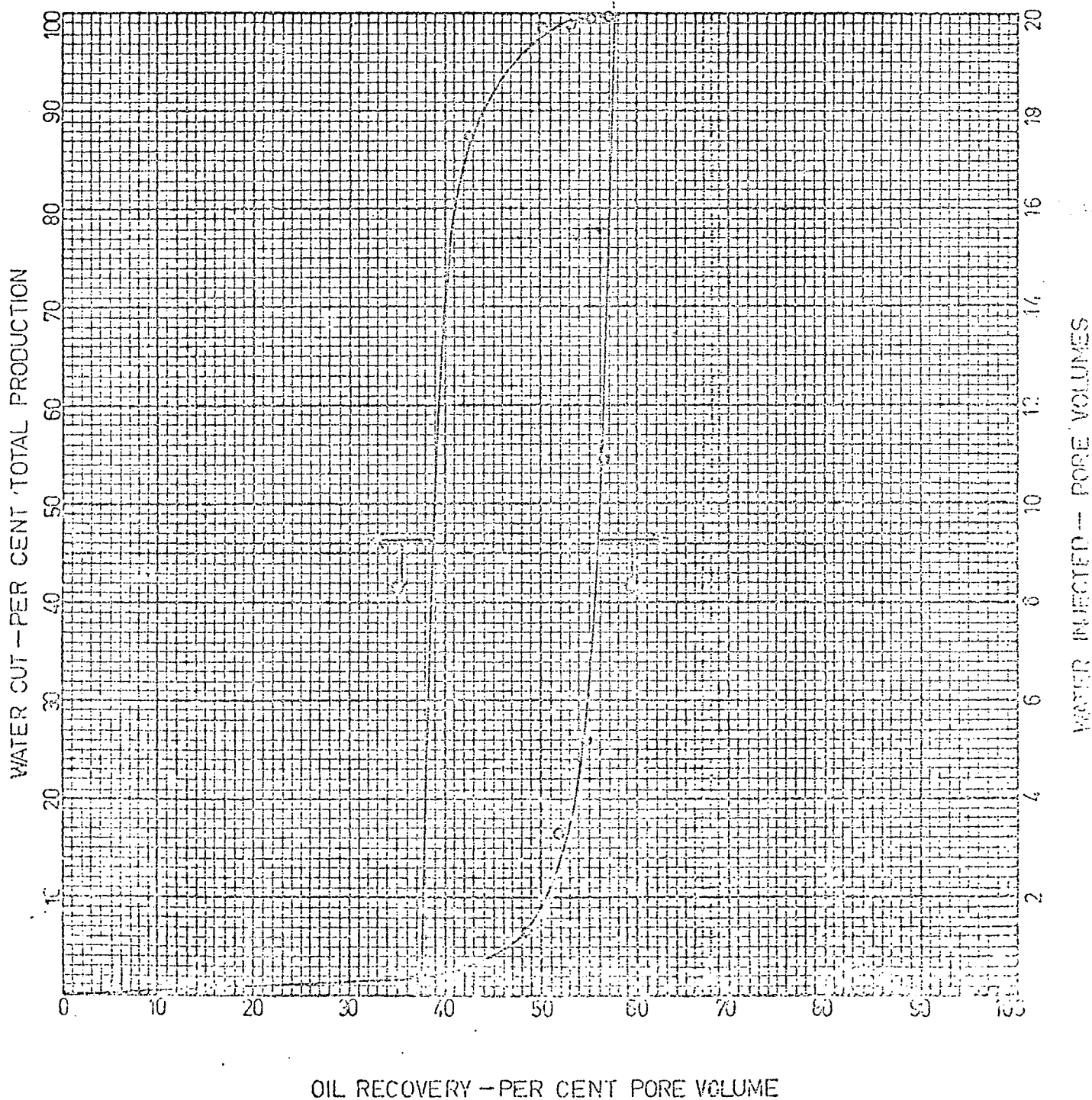


FIGURE 10

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER—KINGFISH A-1

DEPTH INTERVAL—7722'

POROSITY—16.7%

PERMEABILITY—513 Md. (Ko)

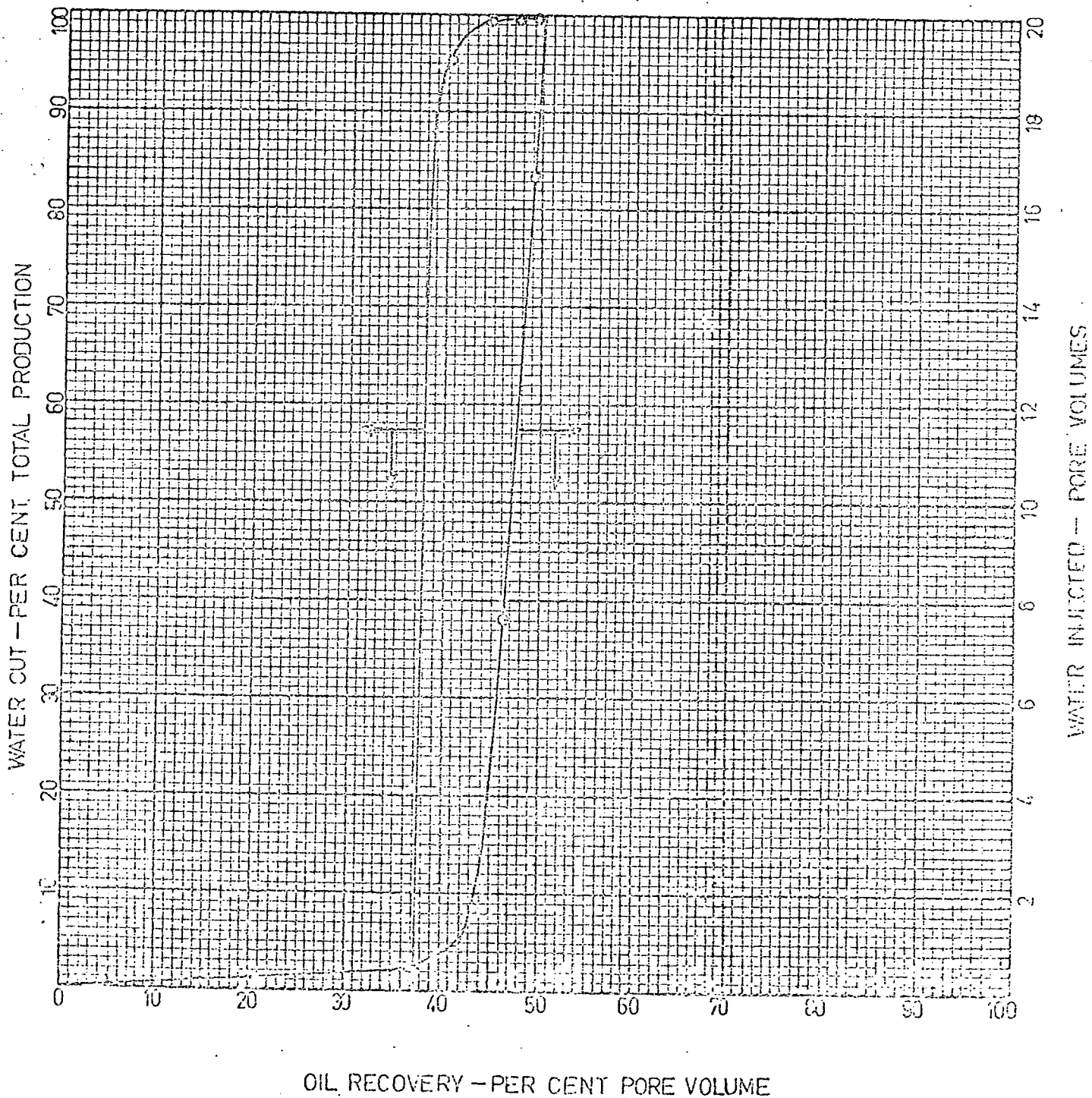


FIGURE 11

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH A-1

DEPTH INTERVAL - 7722' (H)

POROSITY - 14.9%

PERMEABILITY - 514 Md (Ko)

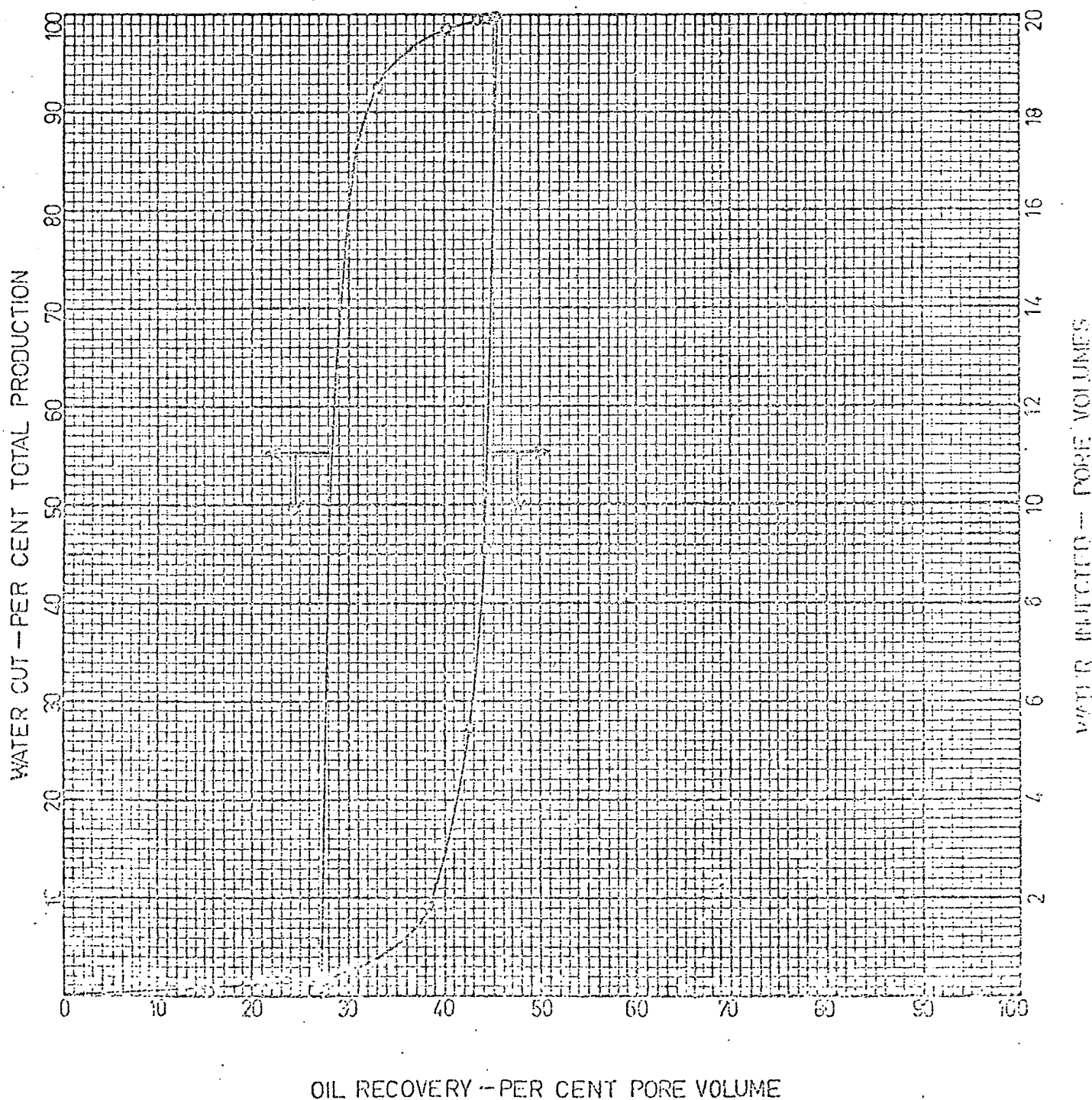


FIGURE 12

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH A-1

DEPTH INTERVAL - 7728'

POROSITY - 13.0 %

PERMEABILITY - 461 Md. (Ko)

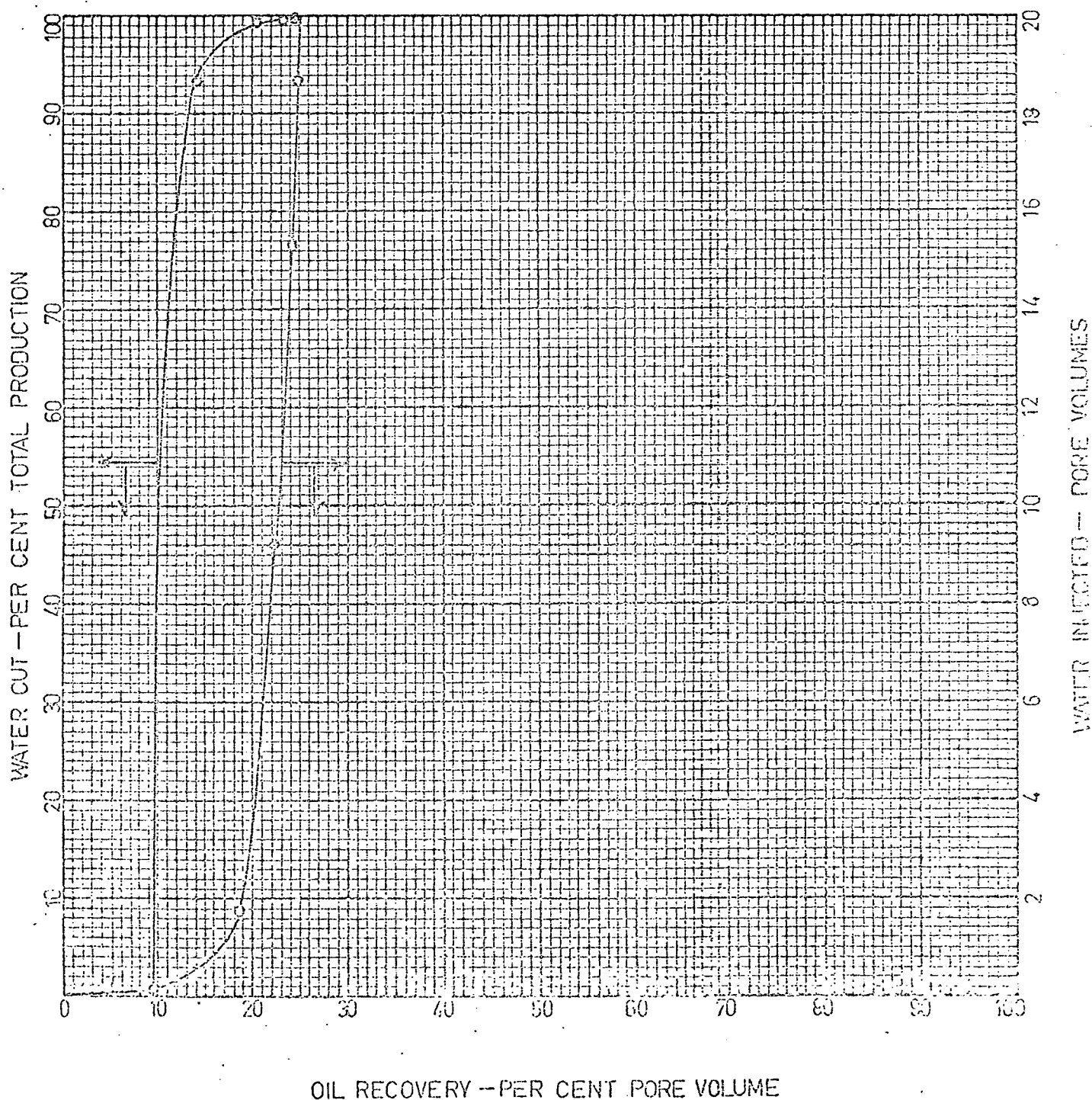


FIGURE 13

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7739'

POROSITY-18.1%

PERMEABILITY-2938 Md. (Ko)

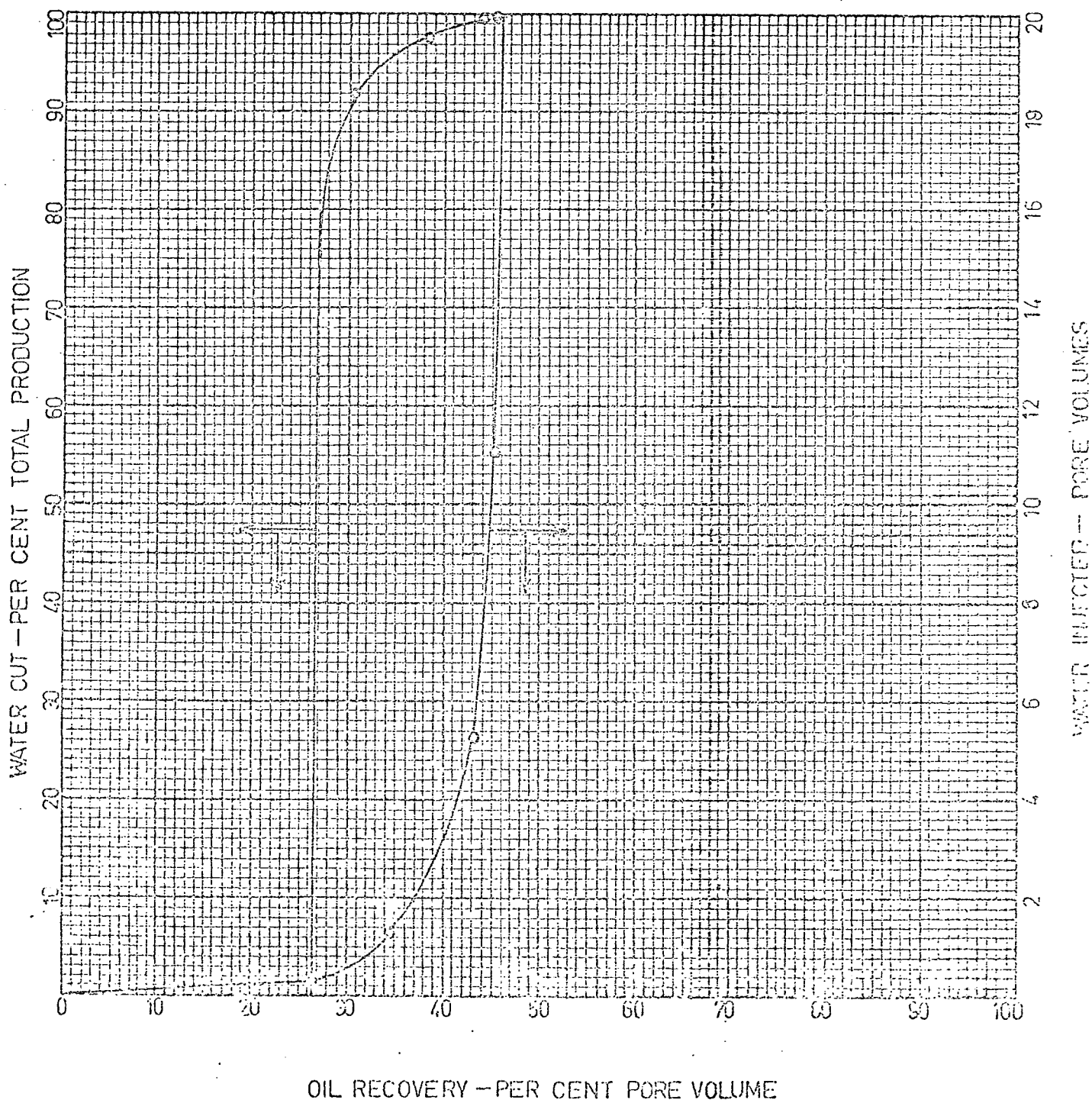


FIGURE 14

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH A-1

DEPTH INTERVAL-7745'

POROSITY - 17.1 %

PERMEABILITY - 977 Md. (Ko)

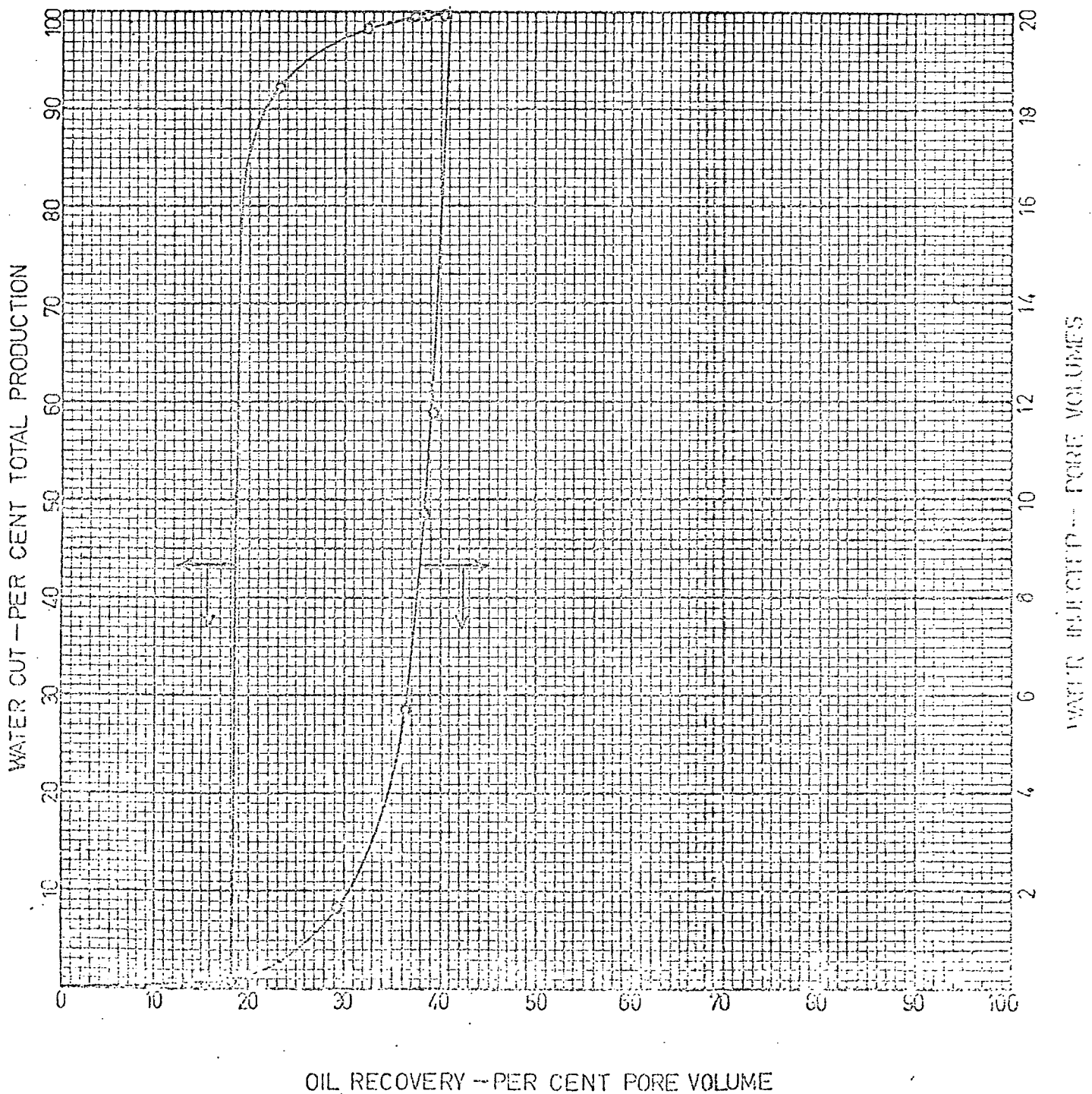


FIGURE 15

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH B-1

DEPTH INTERVAL - 7423'

POROSITY - 15.6%

PERMEABILITY - 497 Md. (Ko)

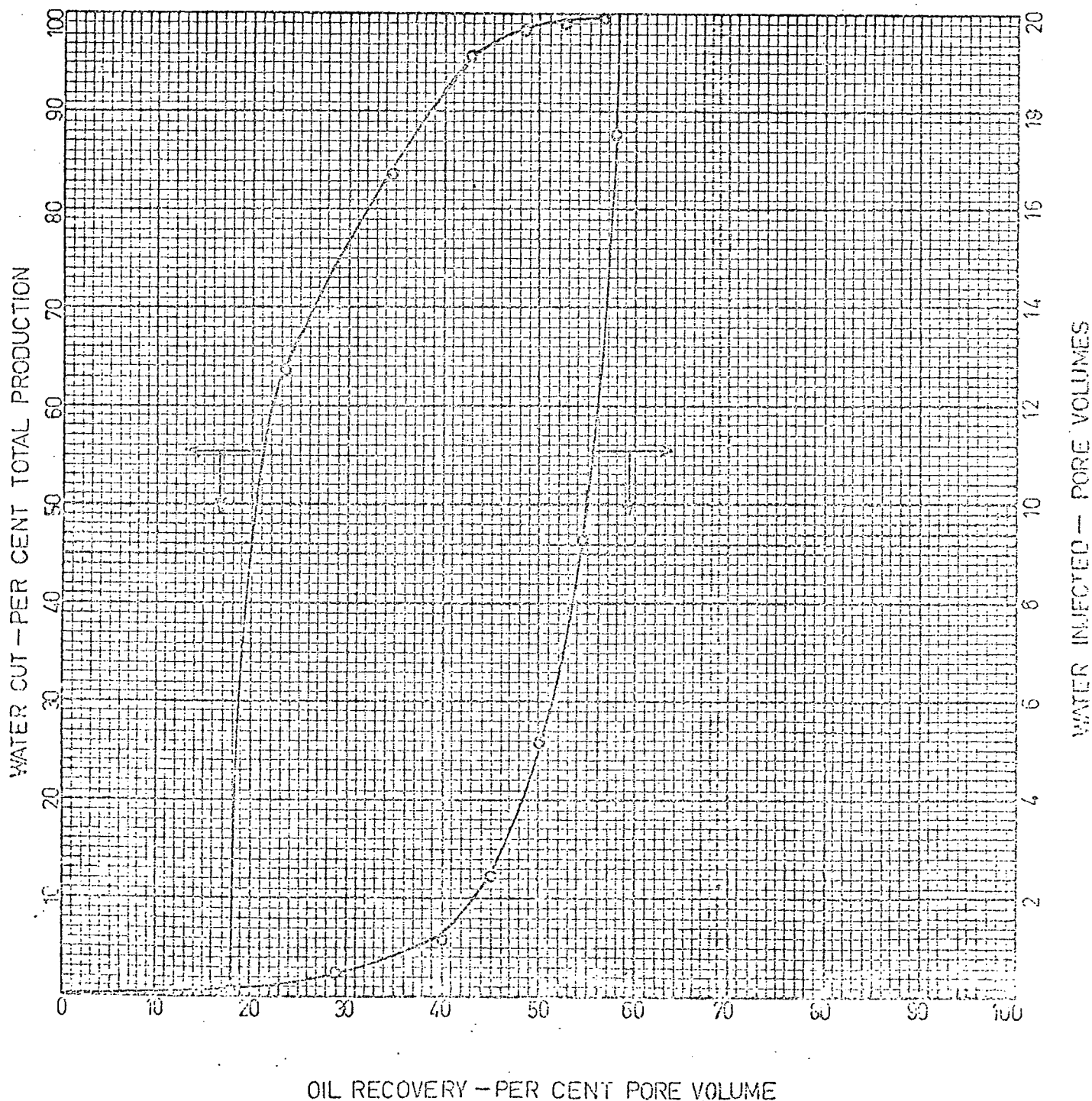


FIGURE 16

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH B-1

DEPTH INTERVAL - 7434'

POROSITY - 19.1 %

PERMEABILITY - 1825 Md (K_D)

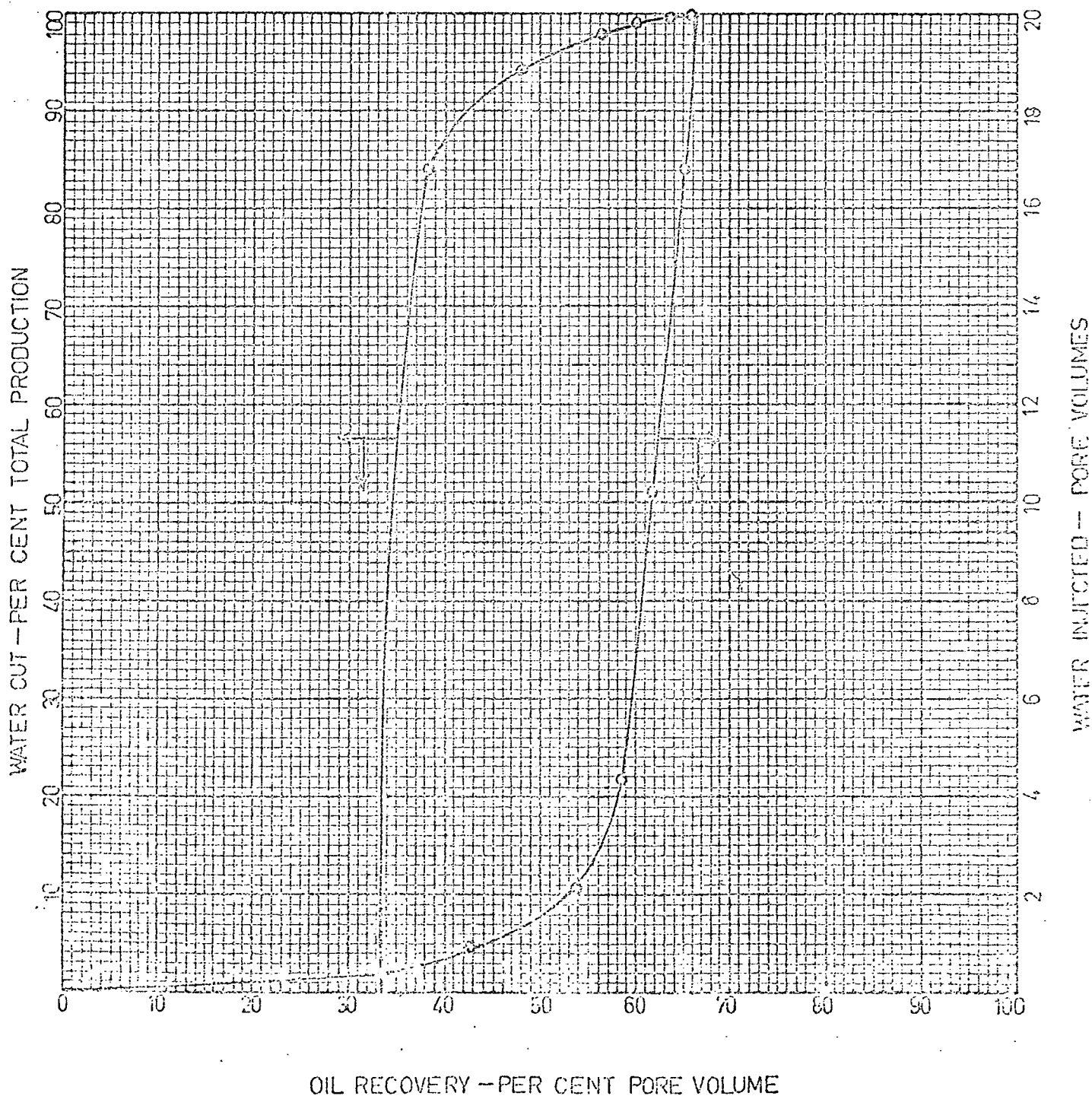


FIGURE 17

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH B-1

DEPTH INTERVAL - 7455'

POROSITY - 22.3%

PERMEABILITY - 55 Md. (Ko)

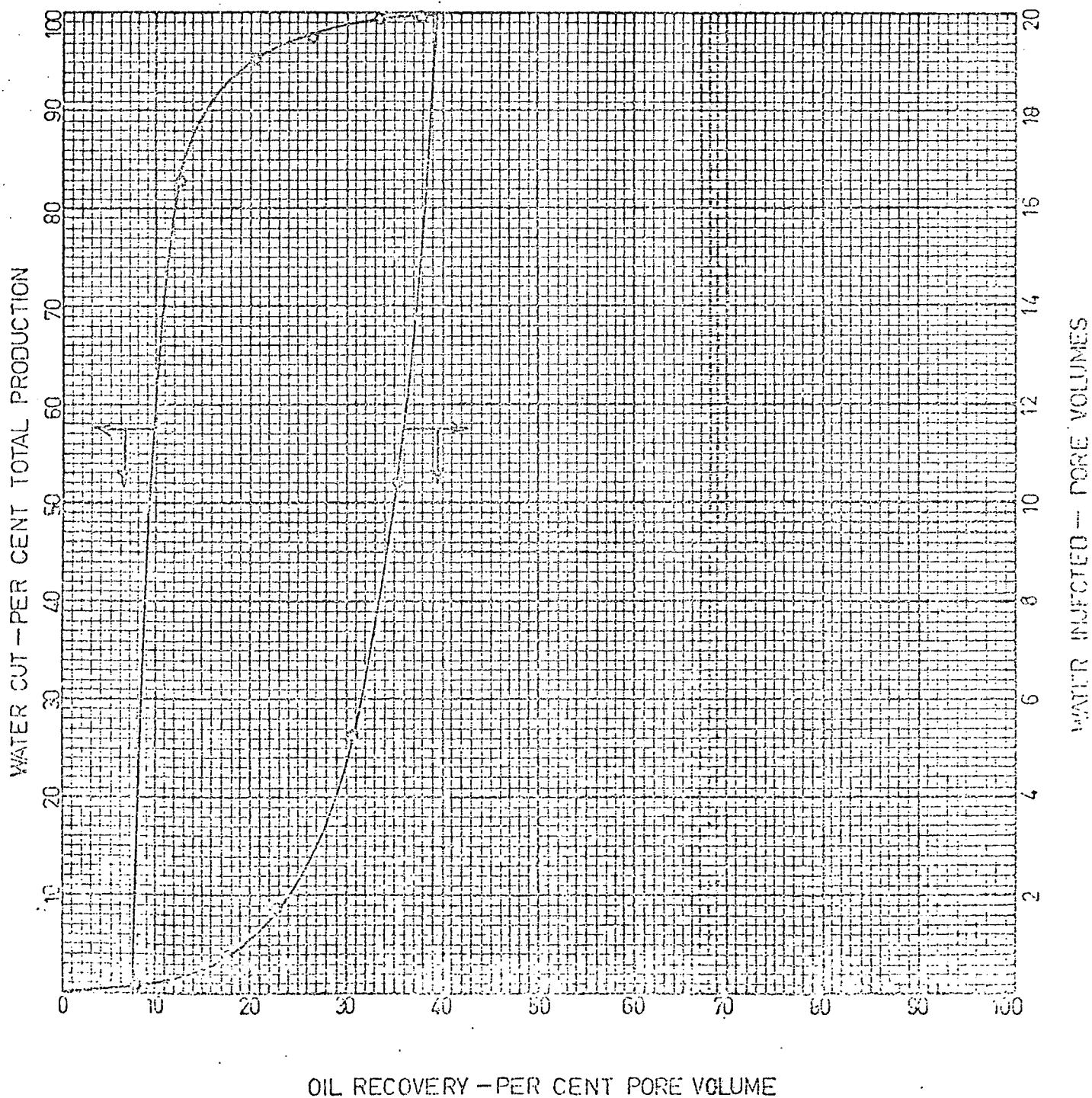


FIGURE 18

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH B-1

DEPTH INTERVAL-7487'

POROSITY-23.4 %

PERMEABILITY-142 Md. (Ko)

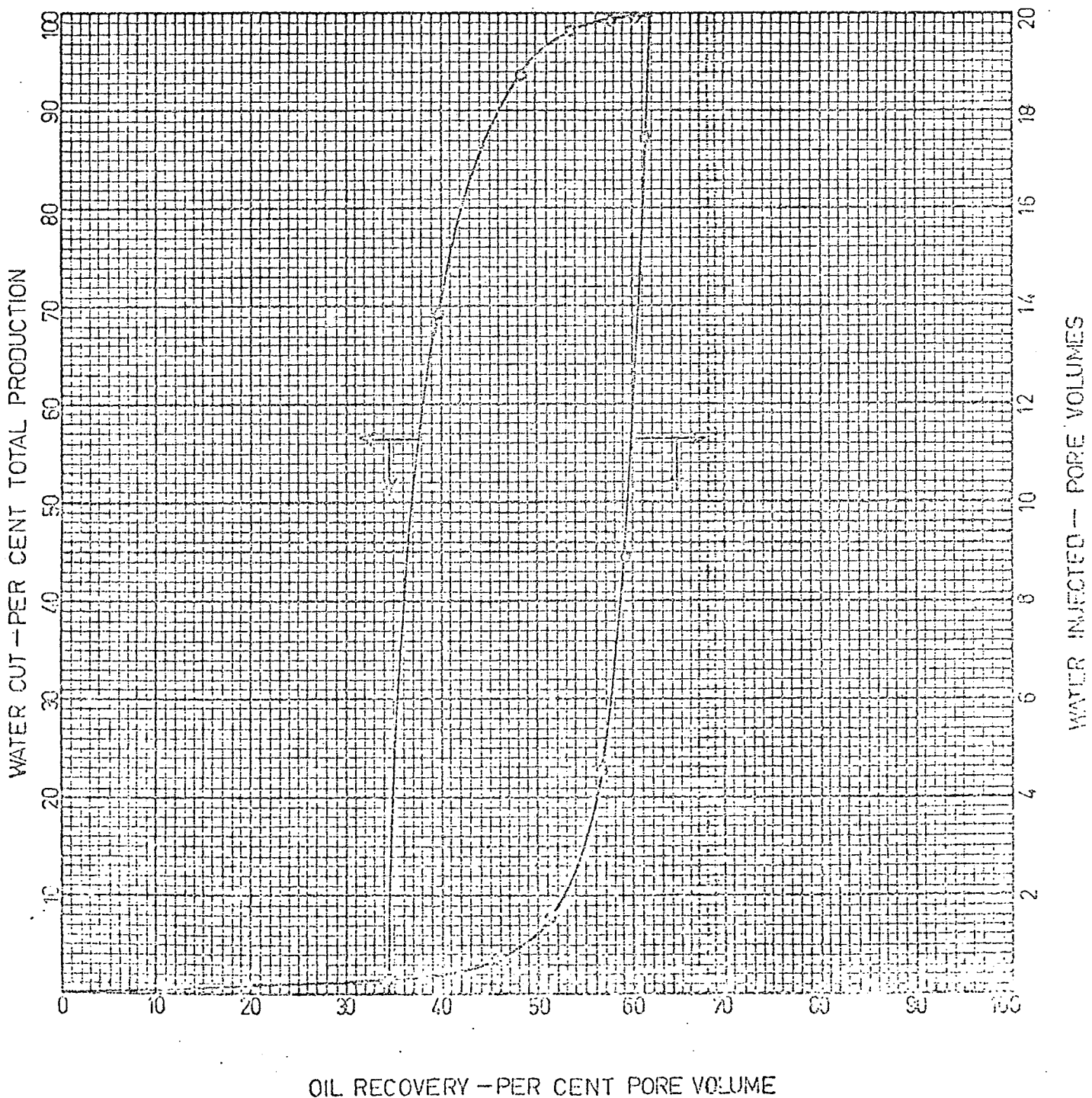


FIGURE 19

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH B-1

DEPTH INTERVAL-7608'

POROSITY - 21.0 %

PERMEABILITY - 1840 Md. (Ko)

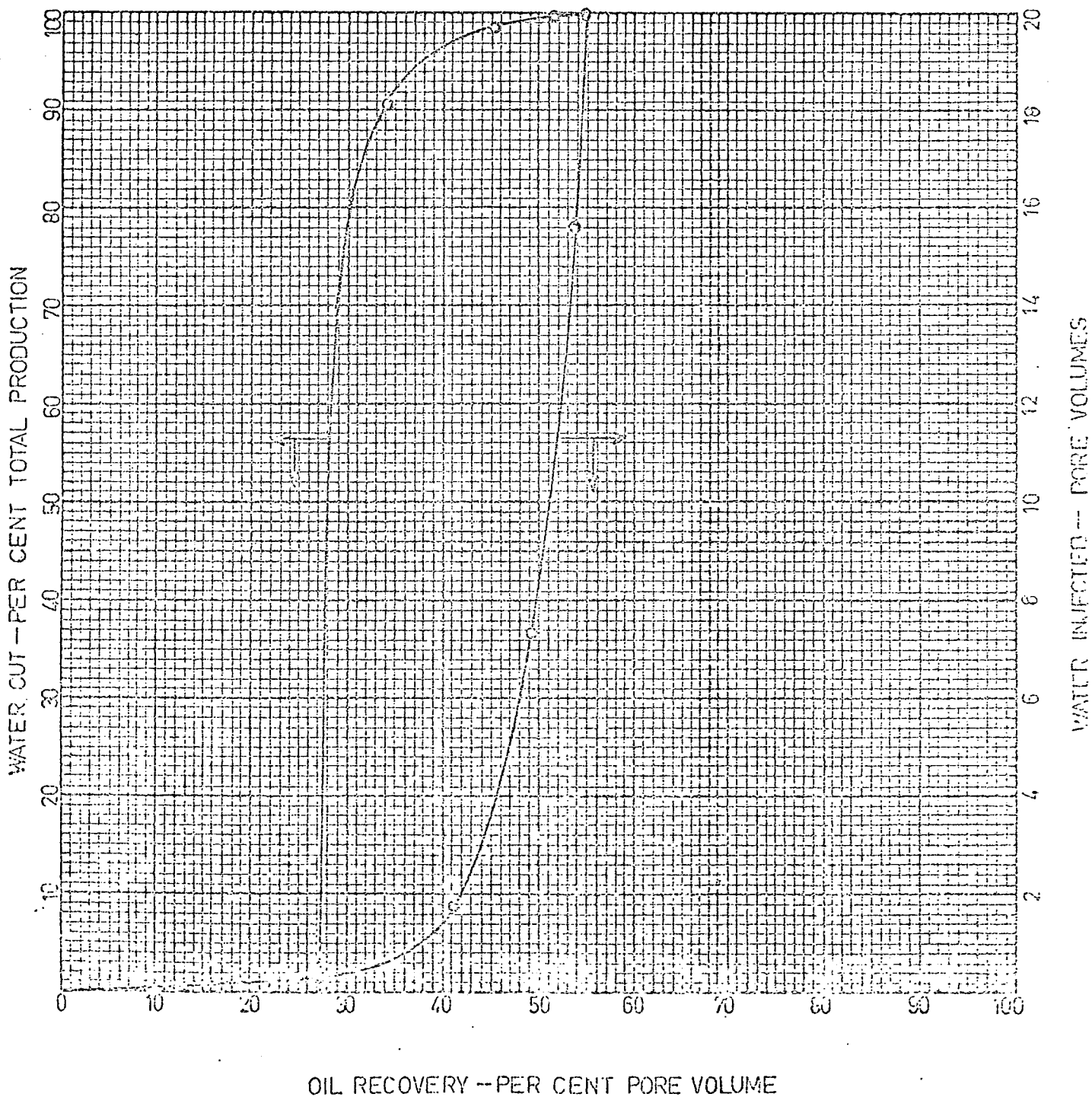


FIGURE 20

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH B-1

DEPTH INTERVAL-7618'

POROSITY - 24.8%

PERMEABILITY - 1787 Md. (Ko)

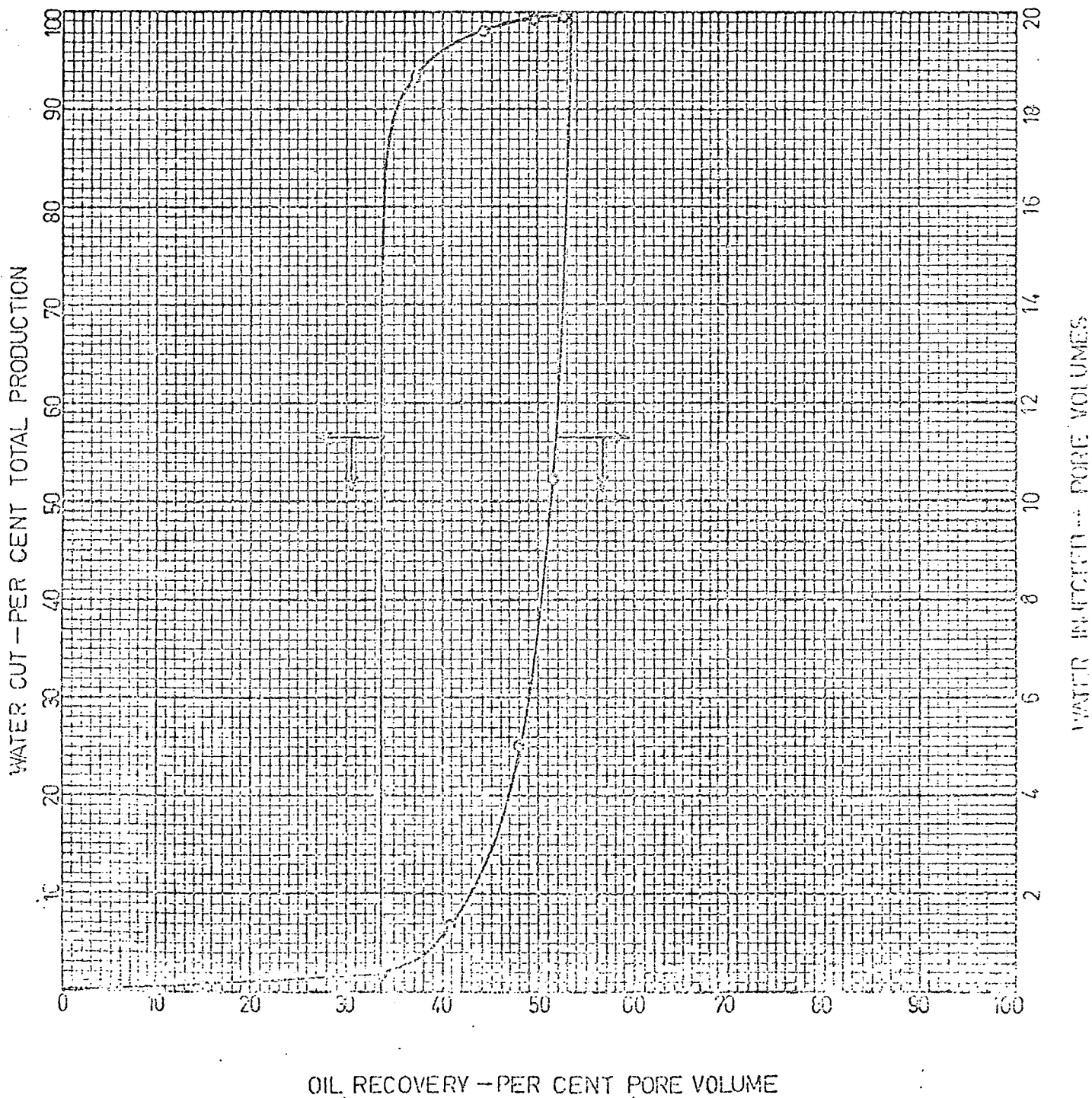


FIGURE 21

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH B-1

DEPTH INTERVAL - 7627'

POROSITY - 26.5%

PERMEABILITY - 1079 Md (Ko)

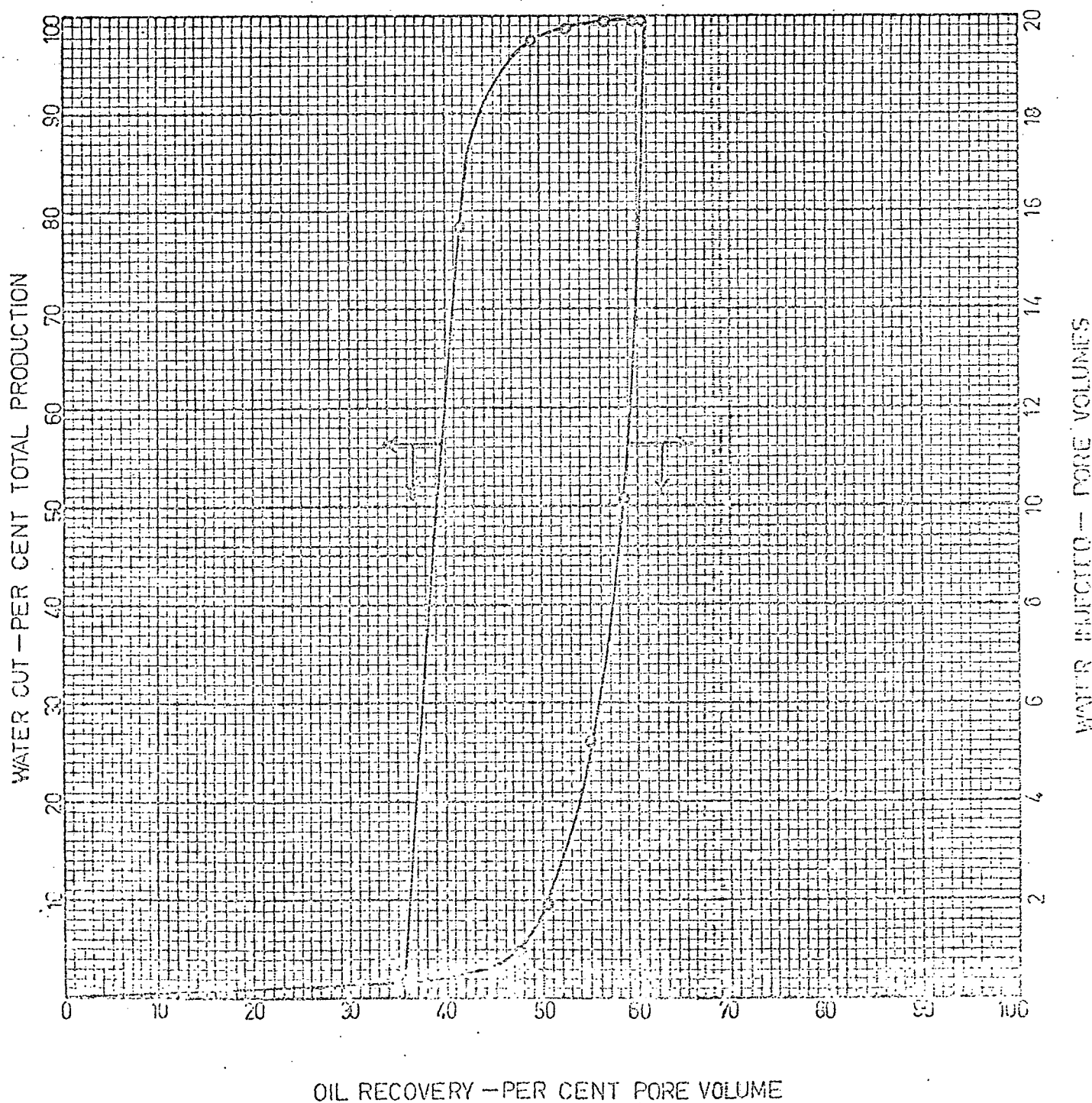


FIGURE 22

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH B-1

DEPTH INTERVAL - 7639'

POROSITY - 21.5 %

PERMEABILITY - 531 Md (Ko)

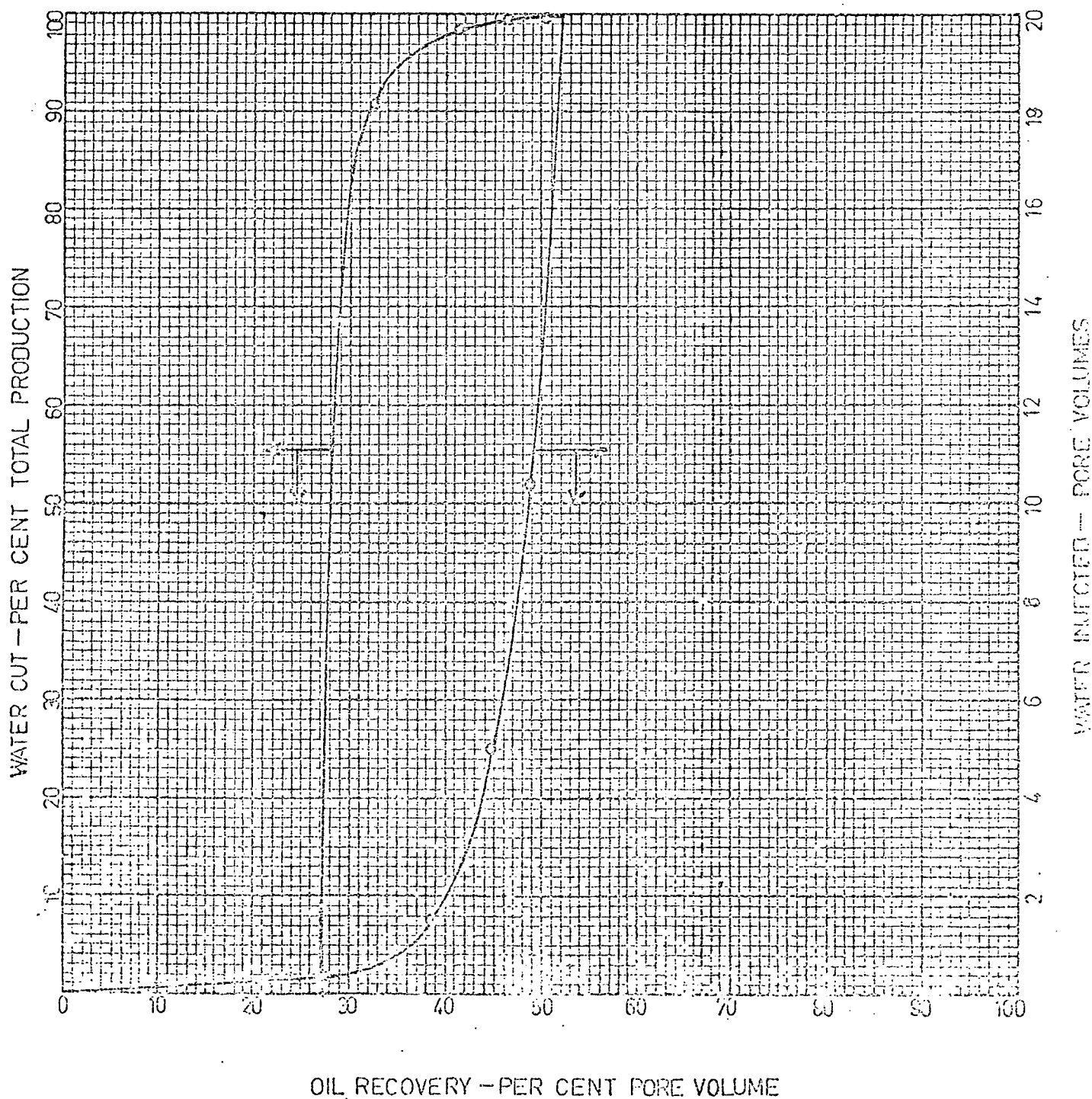


FIGURE 23

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-KINGFISH B-1

DEPTH INTERVAL-7649'

POROSITY-21.2 %

PERMEABILITY-938 Md. (Ko)

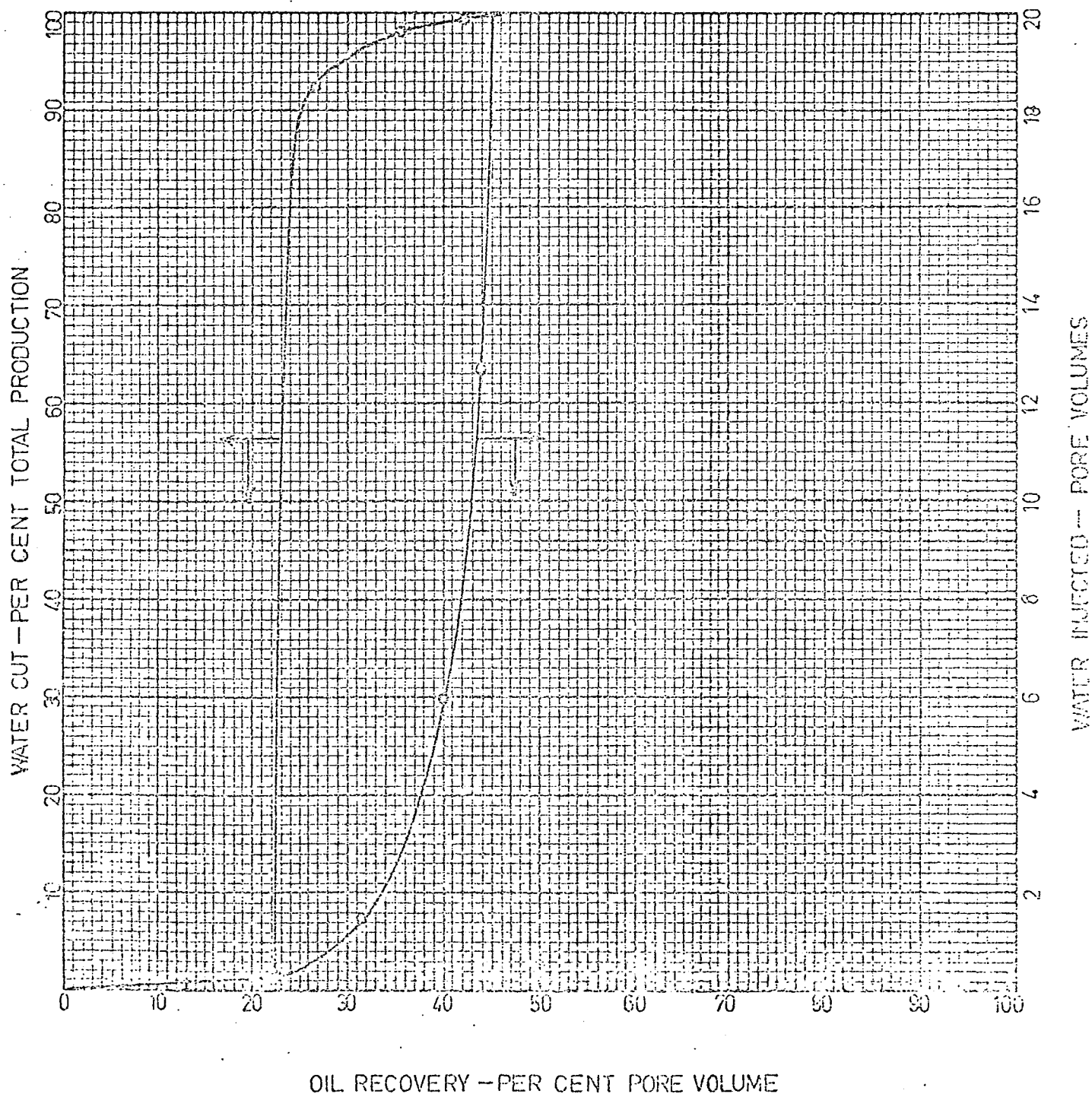


FIGURE 24

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH B-1

DEPTH INTERVAL - 7656'

POROSITY - 22.8%

PERMEABILITY - 2002 Md. (Ko)

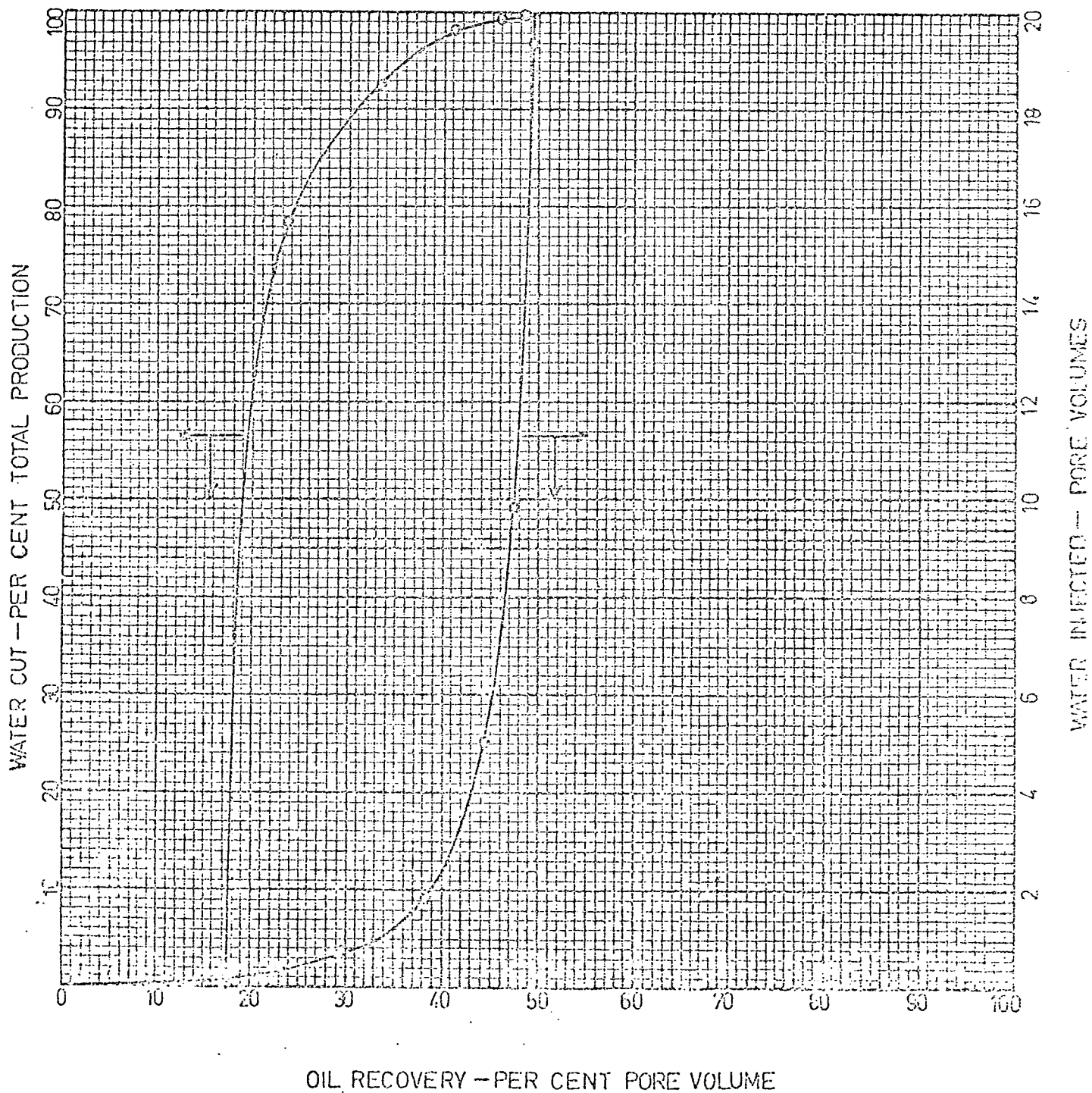


FIGURE 25

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH B-1

DEPTH INTERVAL - 7661'

POROSITY - 19.8 %

PERMEABILITY - 45 Md. (Ko)

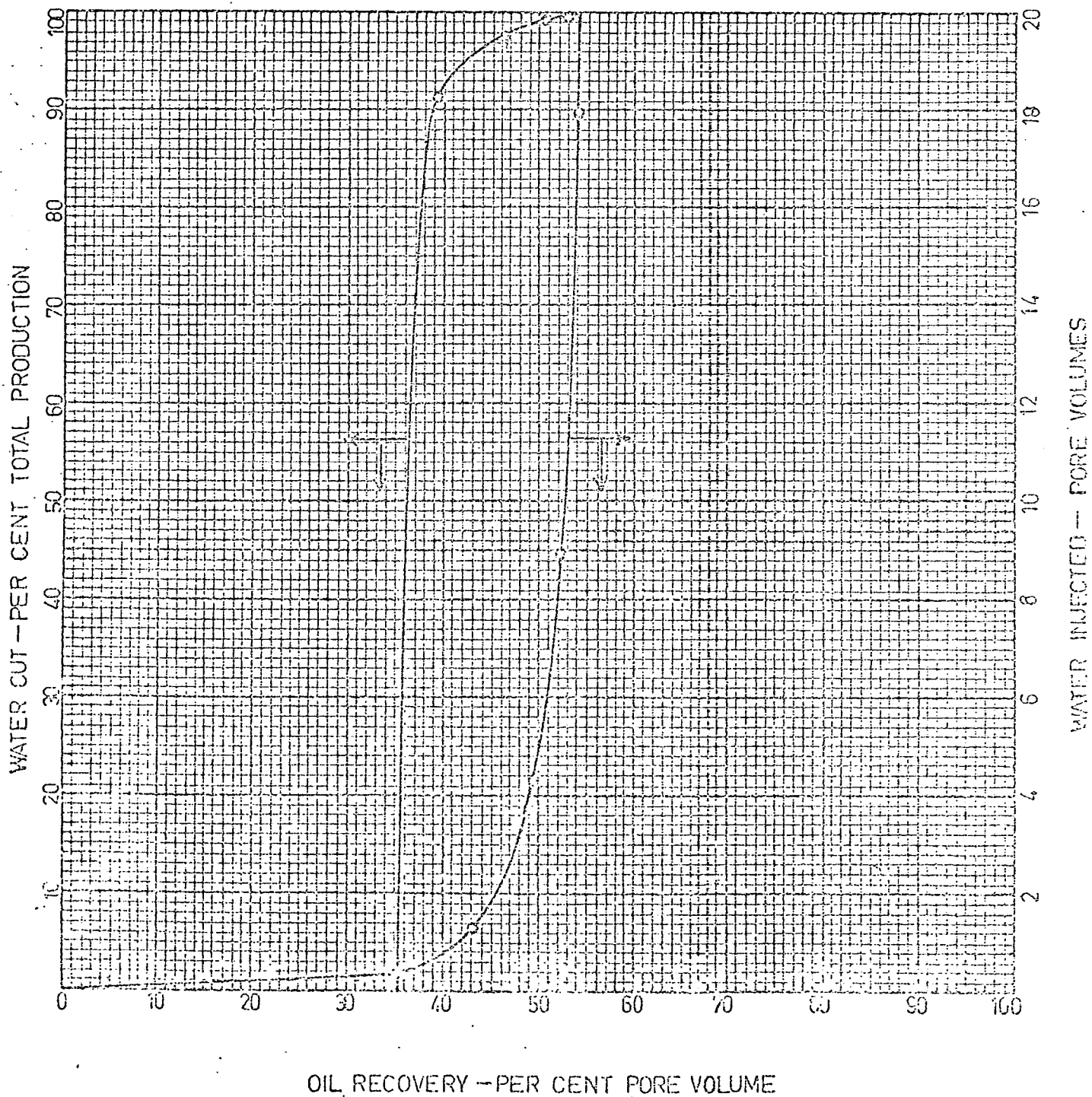


FIGURE 26

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 2

DEPTH INTERVAL-7590'

POROSITY - 20.8 %

PERMEABILITY - 71 Md(Ko)

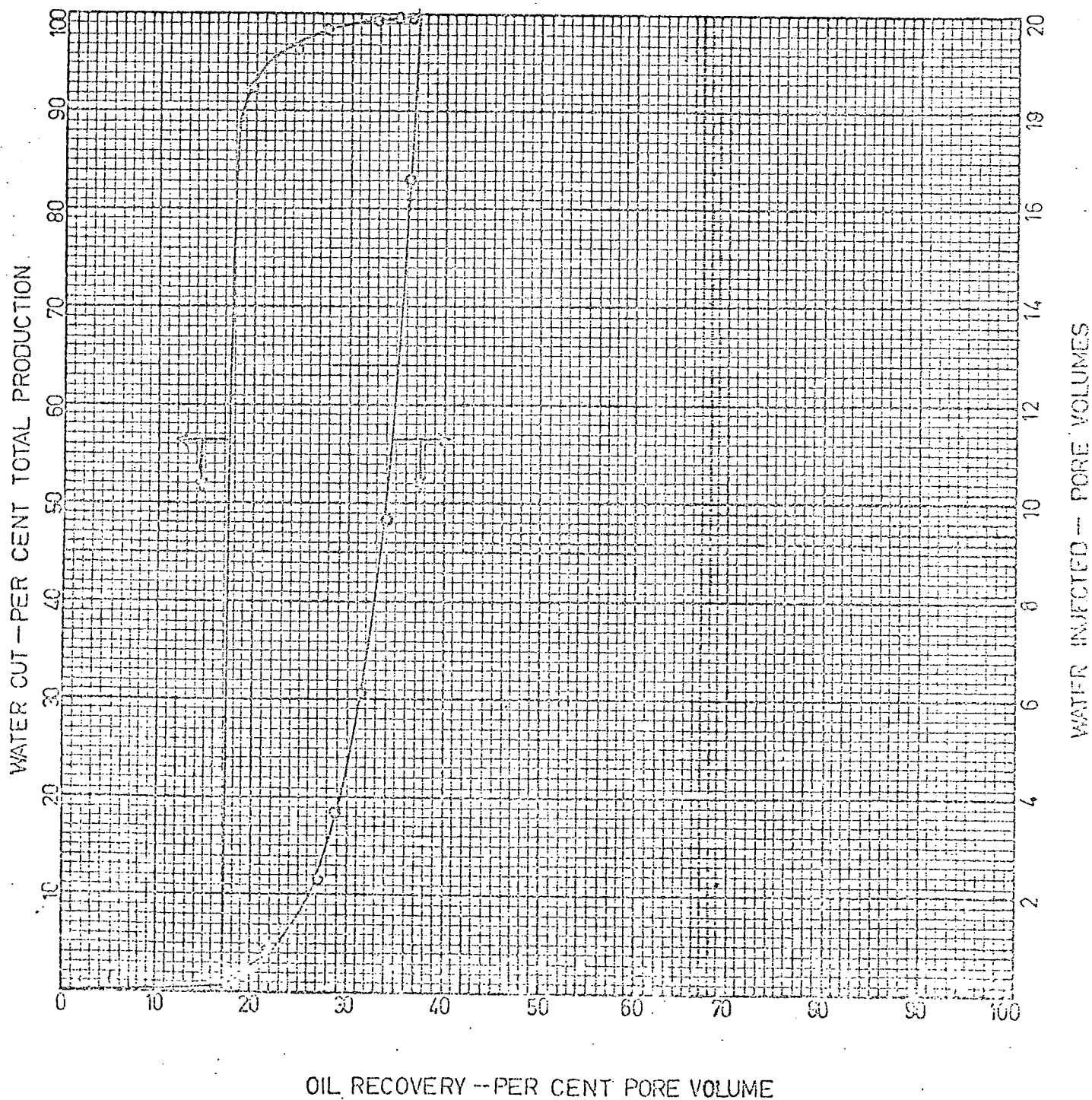


FIGURE 27

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - MACKEREL 2

DEPTH INTERVAL - 7599'

POROSITY - 17.7 %

PERMEABILITY - 16 Md. (Ko)

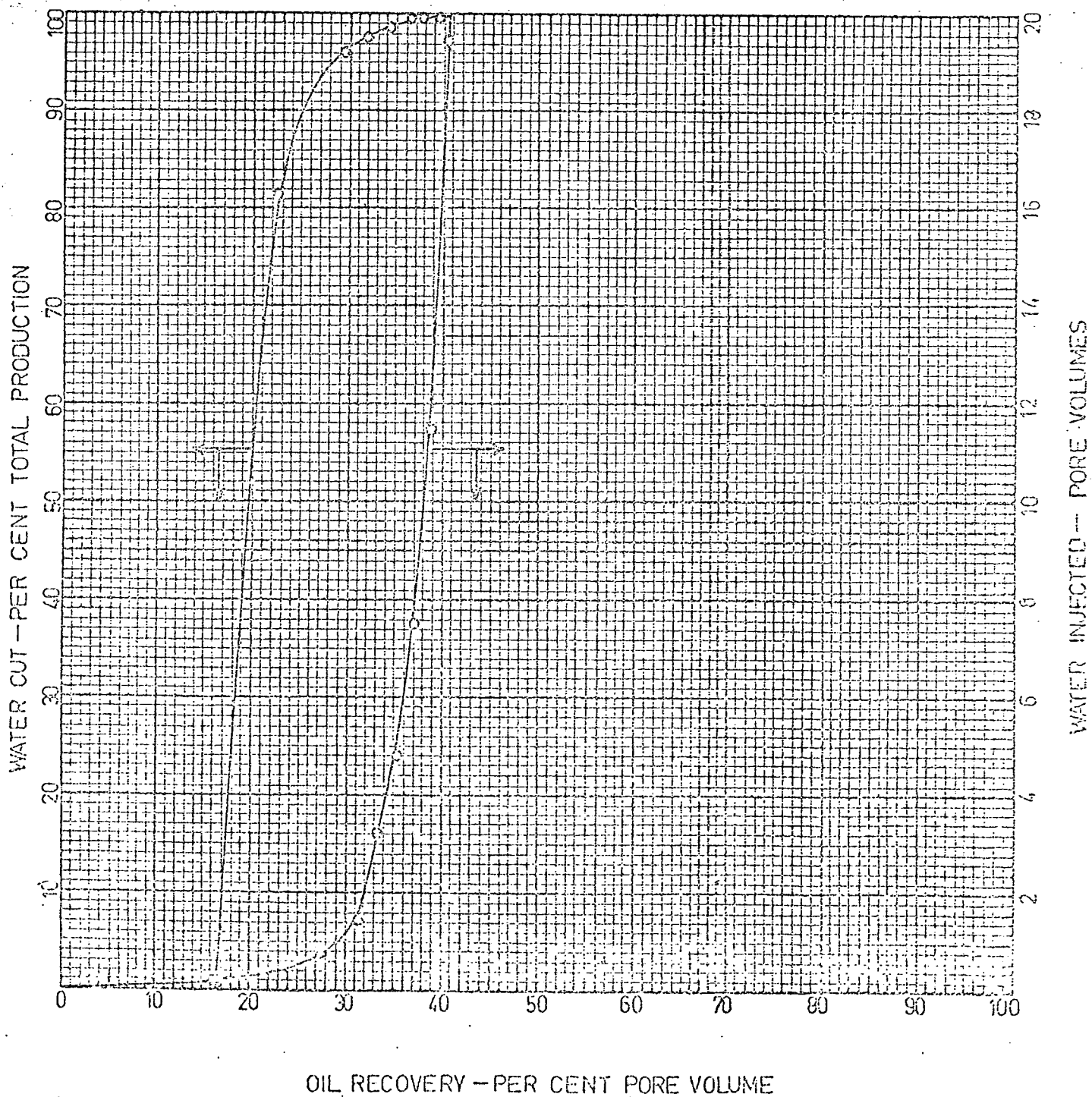


FIGURE 28

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 2

DEPTH INTERVAL-7621'(H)

POROSITY - 21.4 %

PERMEABILITY-373 Md. (Ko)

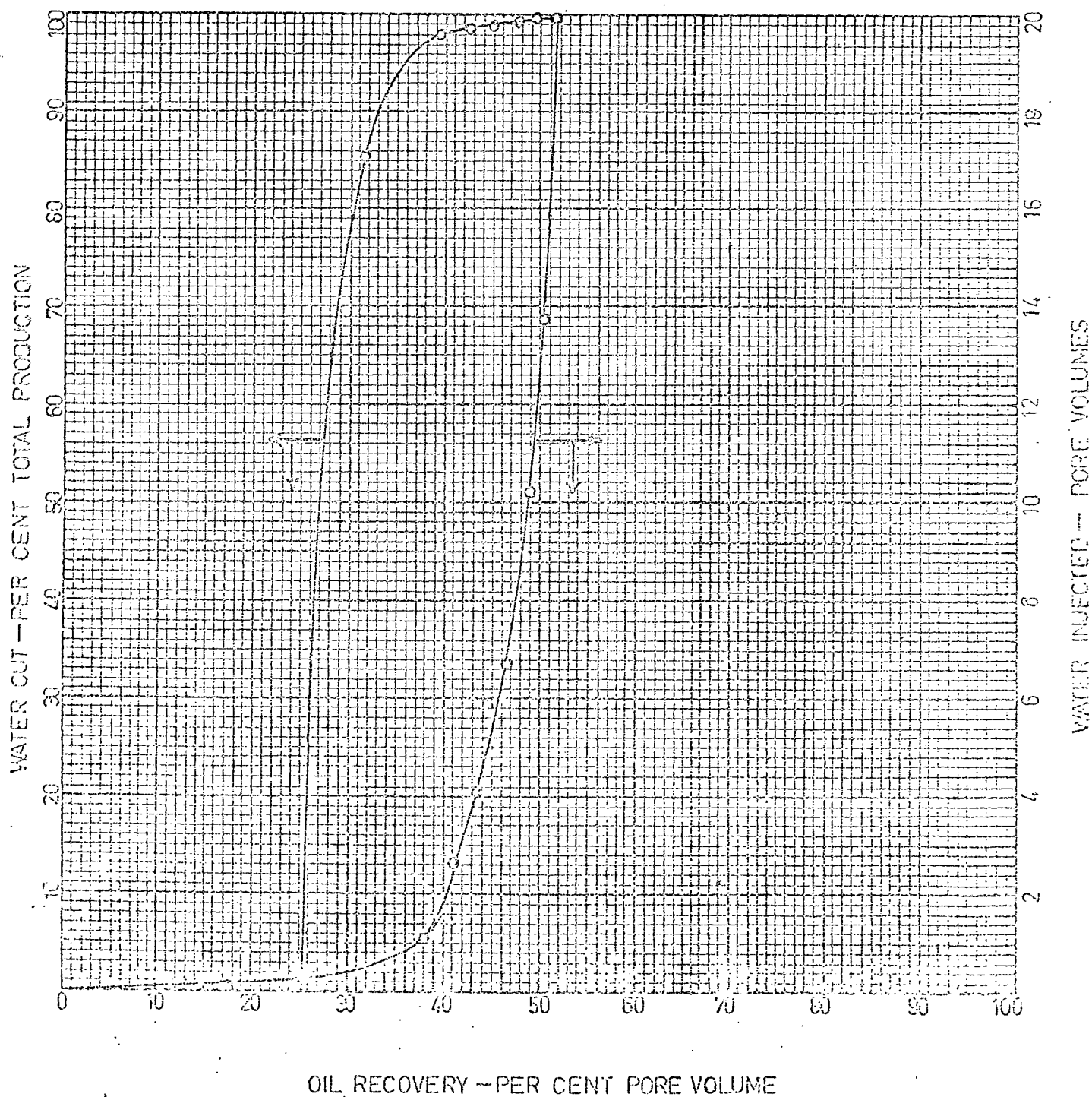


FIGURE 29

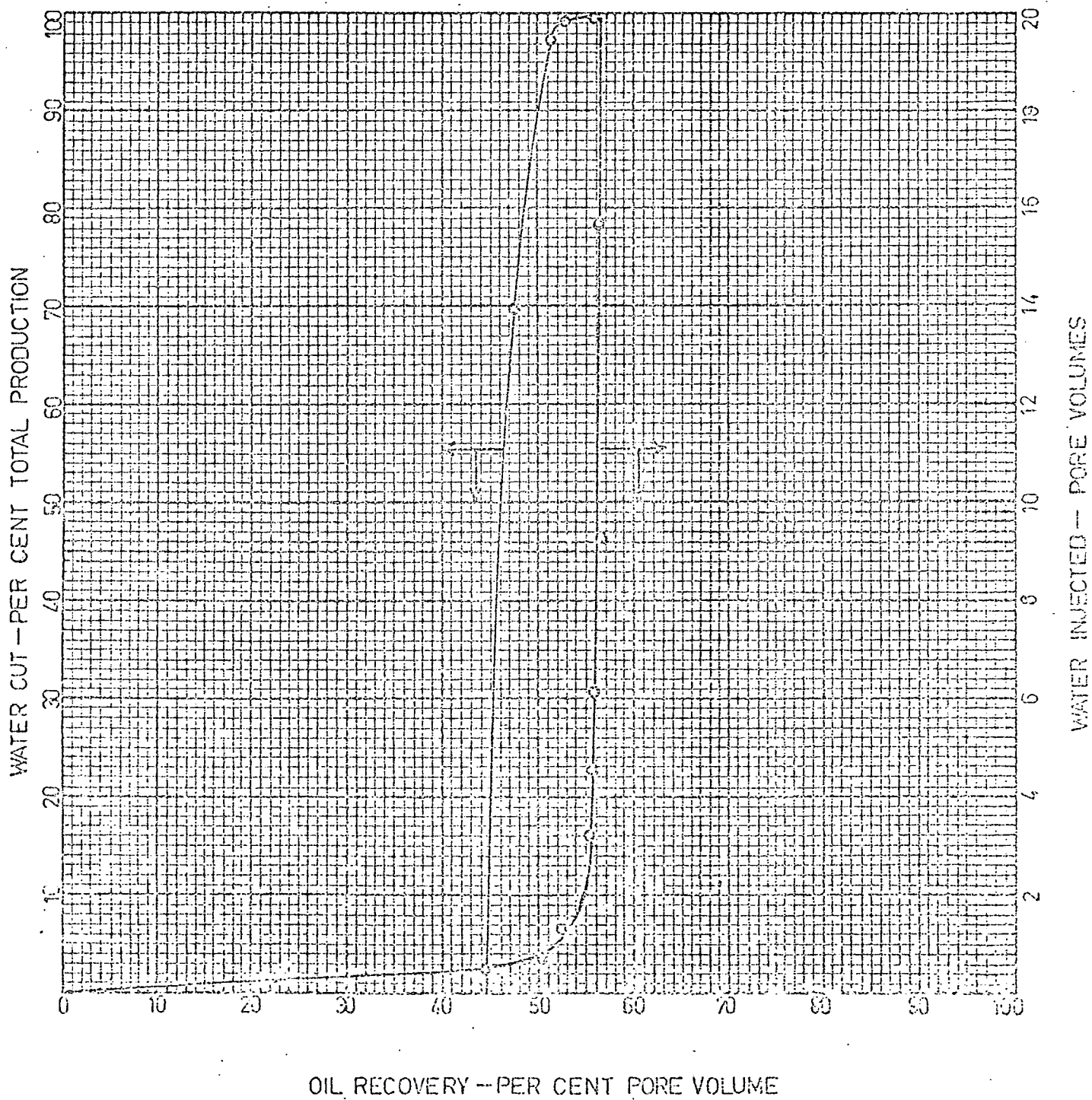
WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 2

DEPTH INTERVAL-7726'

POROSITY-27.0%

PERMEABILITY-1185 Md.(Ko)



OIL RECOVERY--PER CENT PORE VOLUME

FIGURE 30

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - MACKEREL 2

DEPTH INTERVAL - 7753'

POROSITY - 24.0 %

PERMEABILITY - 51 Md. (Ko)

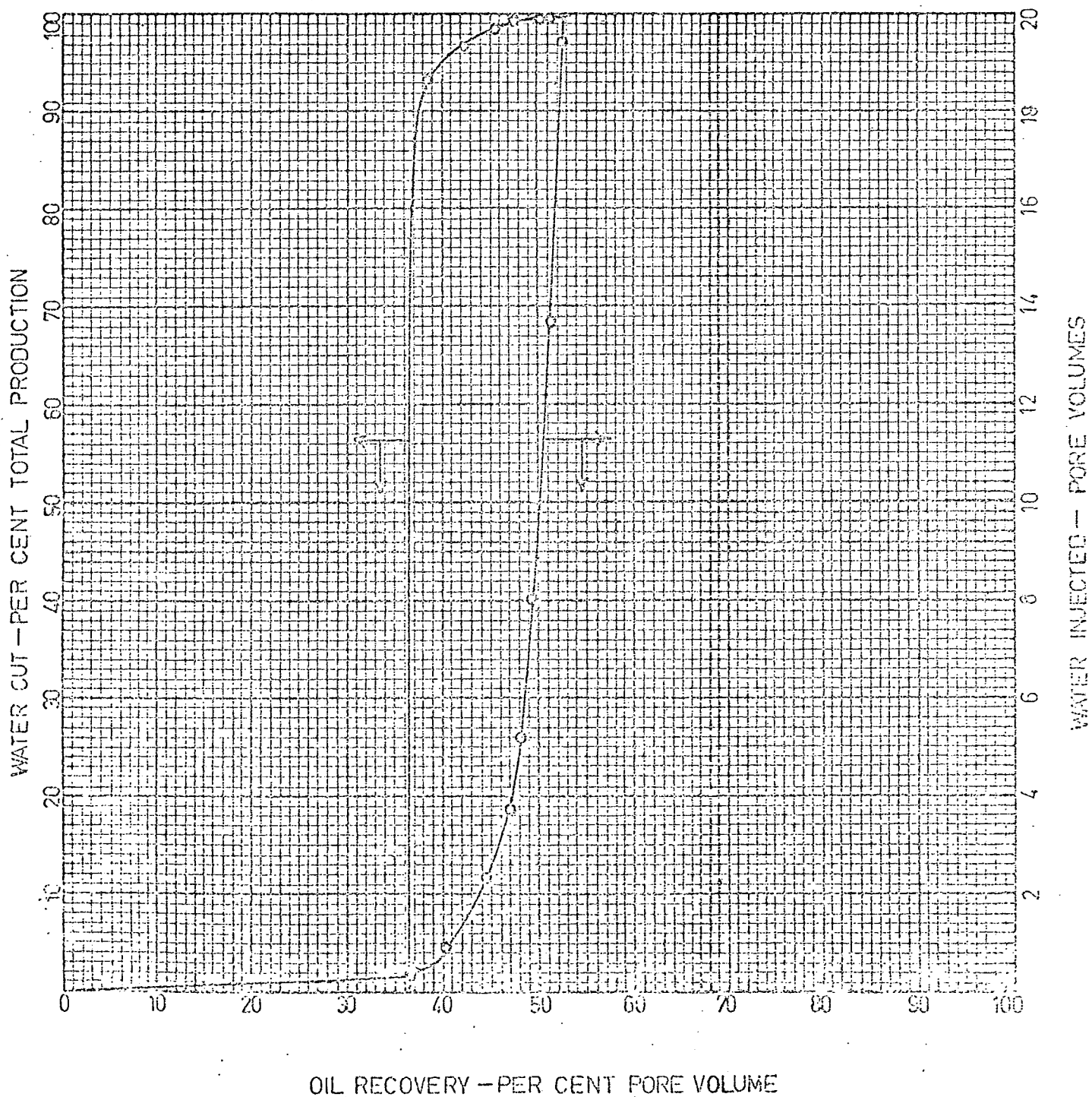


FIGURE 31

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 2

DEPTH INTERVAL-7819'

POROSITY-23.8%

PERMEABILITY-1300 Md. (Ko)

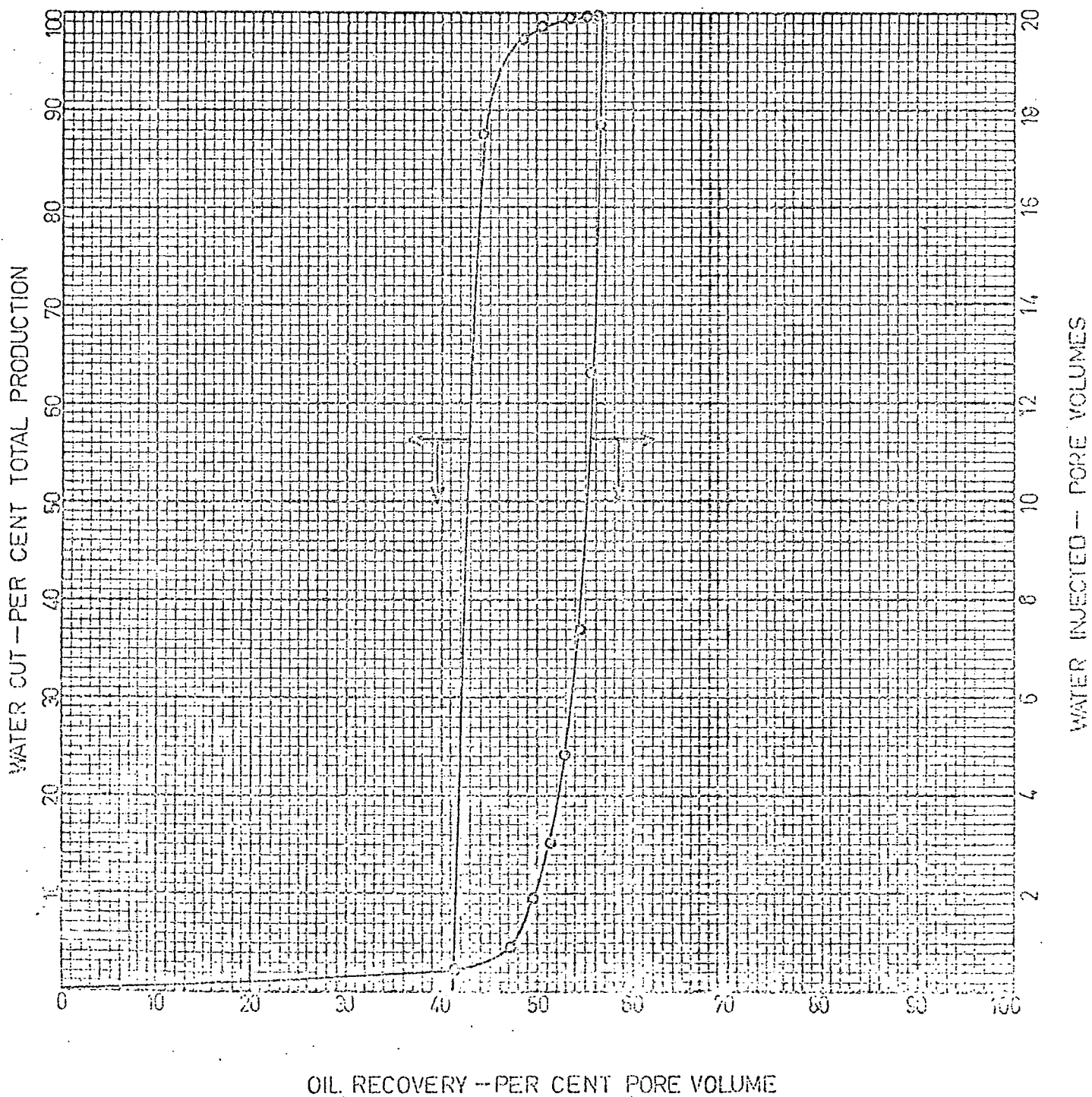


FIGURE 32

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 2

DEPTH INTERVAL-7846'

POROSITY-23.5%

PERMEABILITY-808 Md.(Ko)

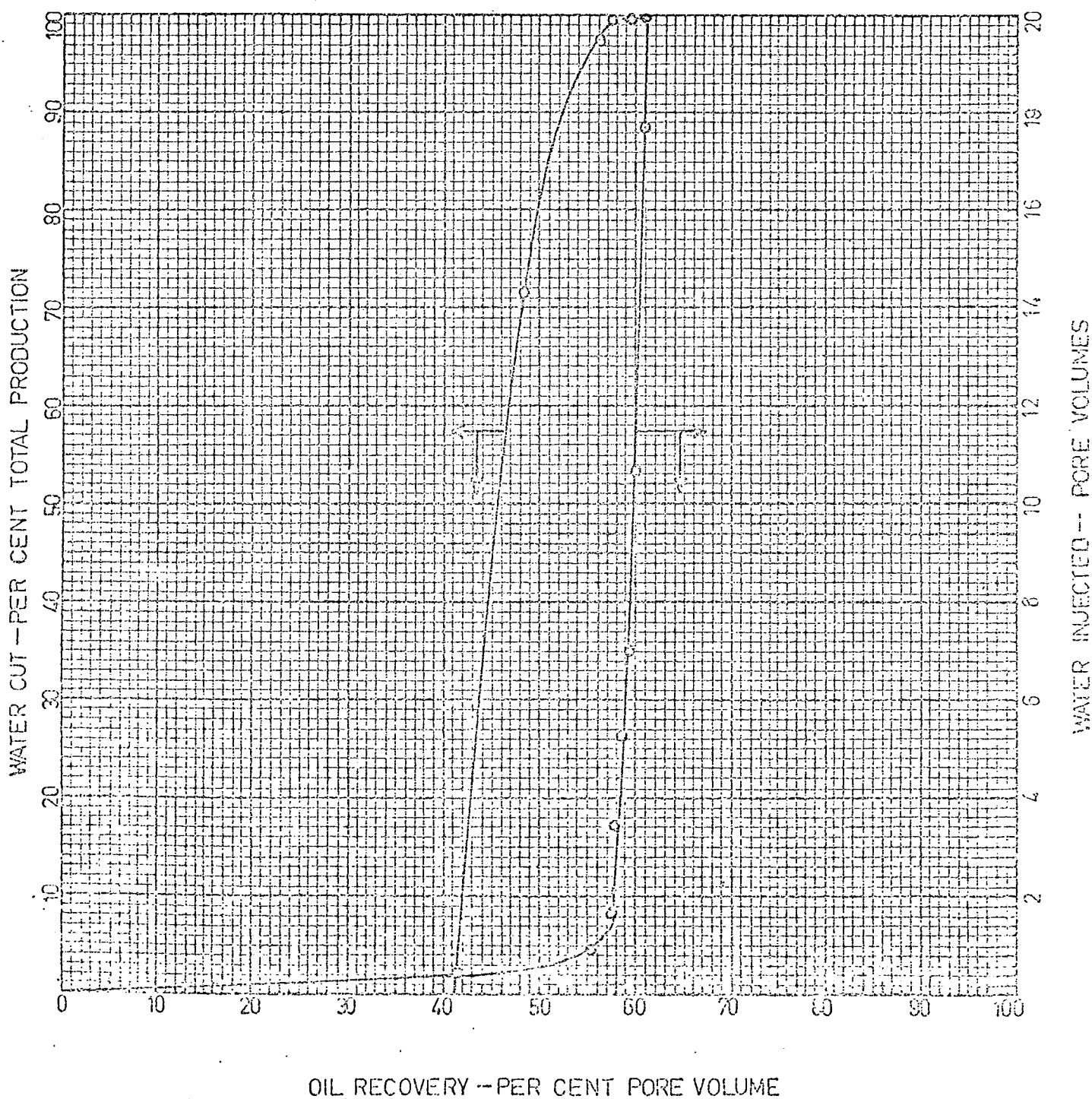


FIGURE 33

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER—MACKEREL 2

DEPTH INTERVAL—7858'

POROSITY—24.5%

PERMEABILITY—565 Md. (Ko)

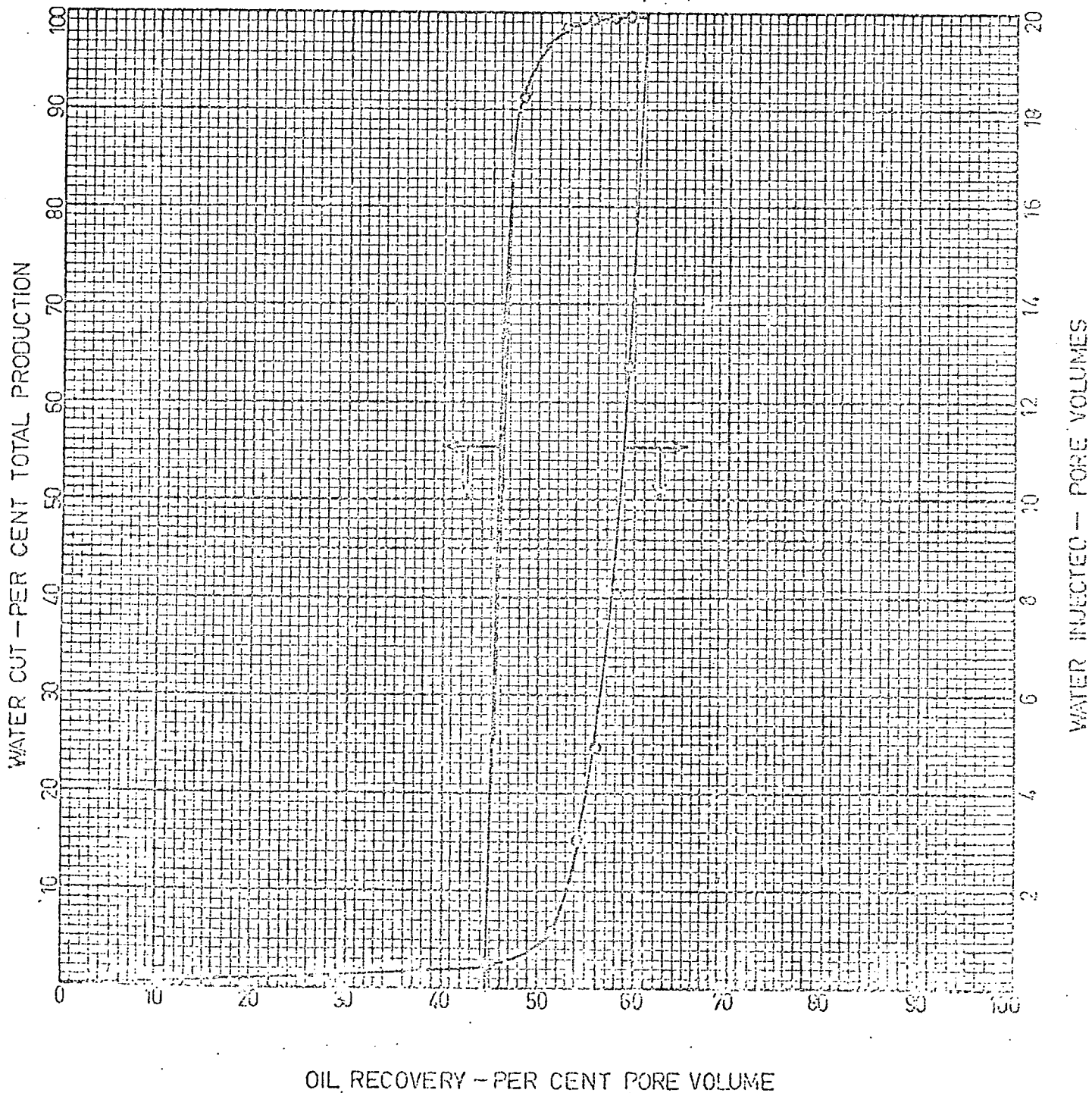


FIGURE 34

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 2

DEPTH INTERVAL-7886'

POROSITY - 23.6 %

PERMEABILITY - 359 Md (Ko)

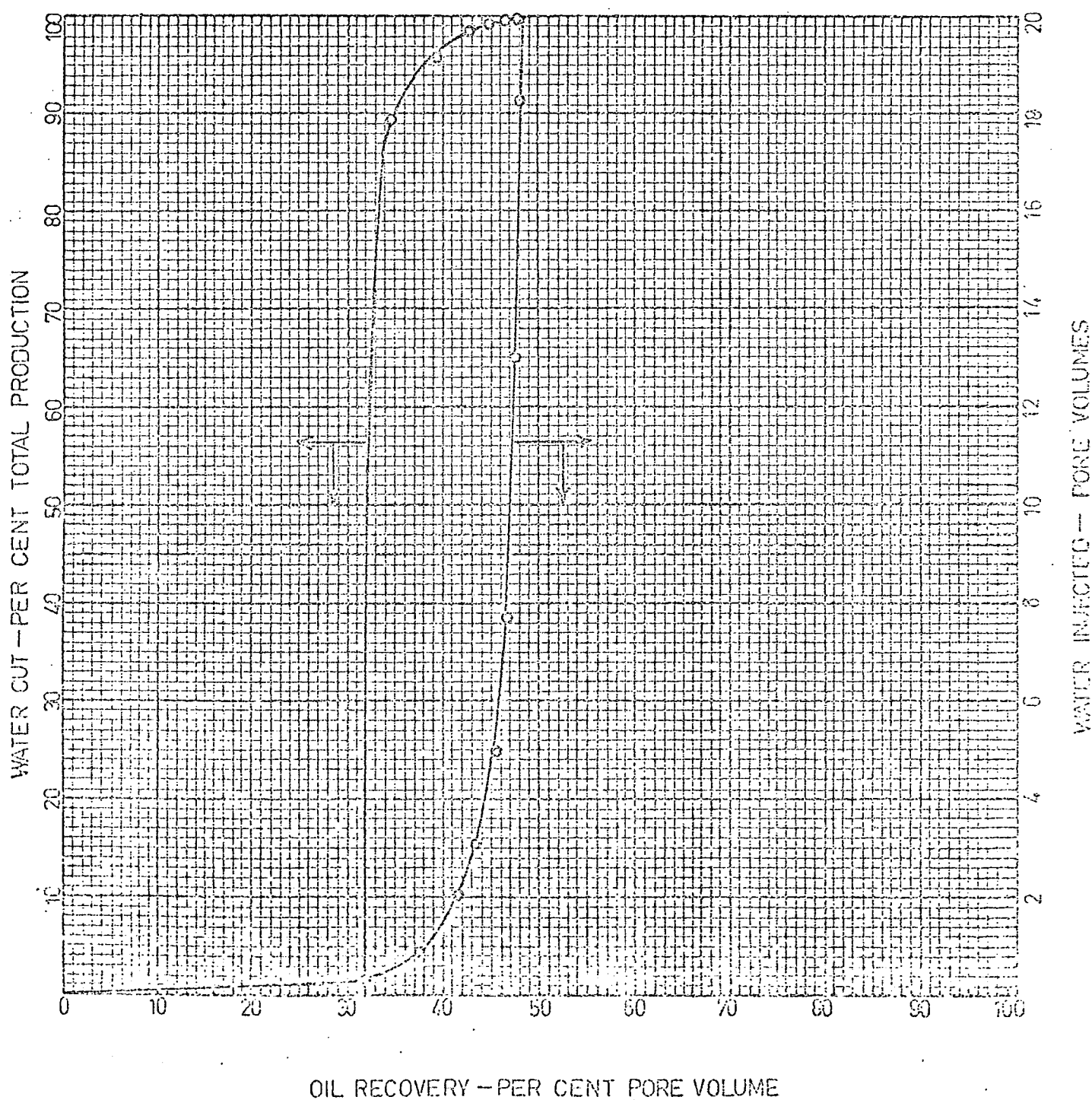


FIGURE 35

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - MACKEREL 2

DEPTH INTERVAL - 7903'

POROSITY - 23.1 %

PERMEABILITY - 410 Md (Ko)

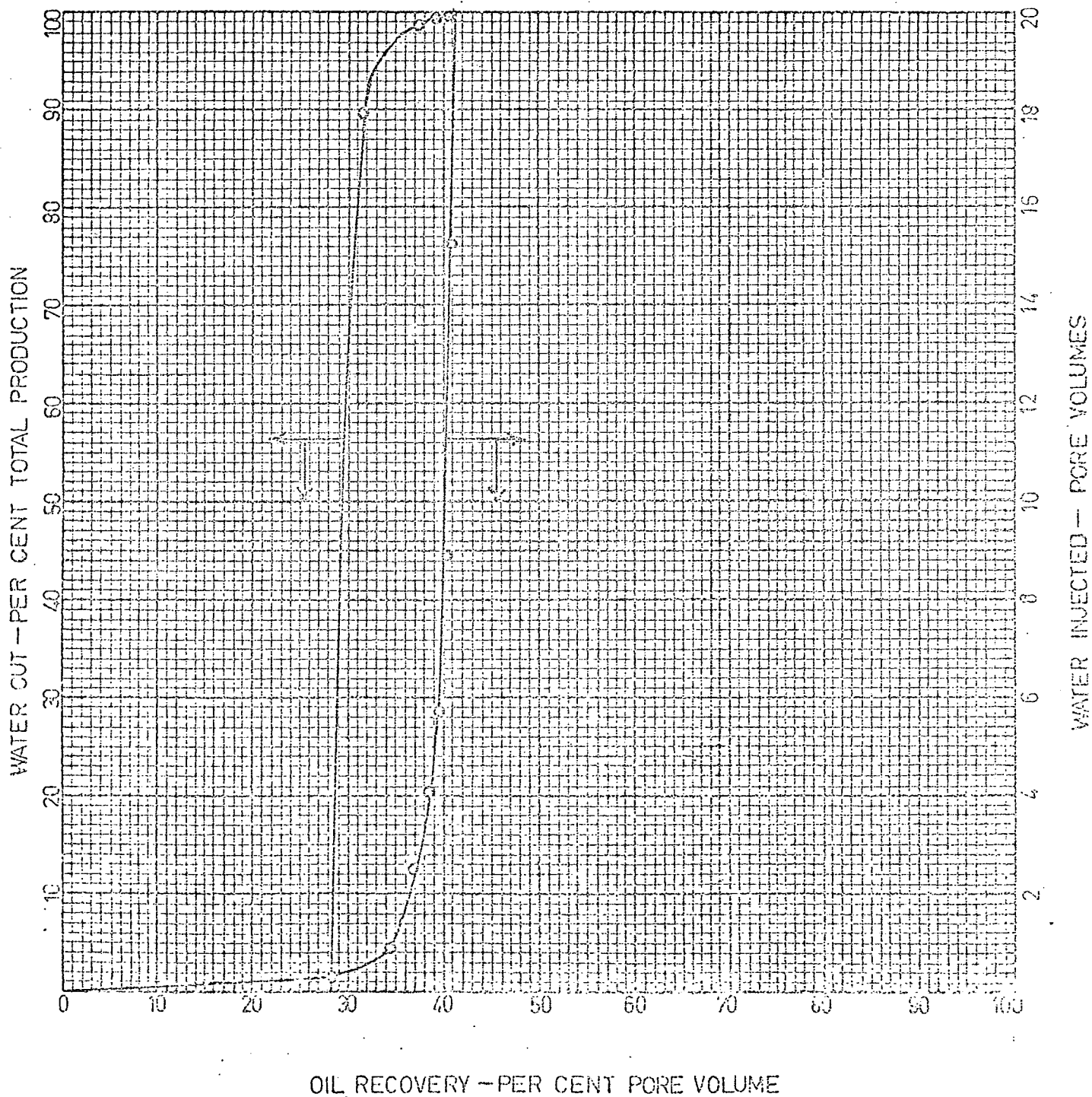


FIGURE 36

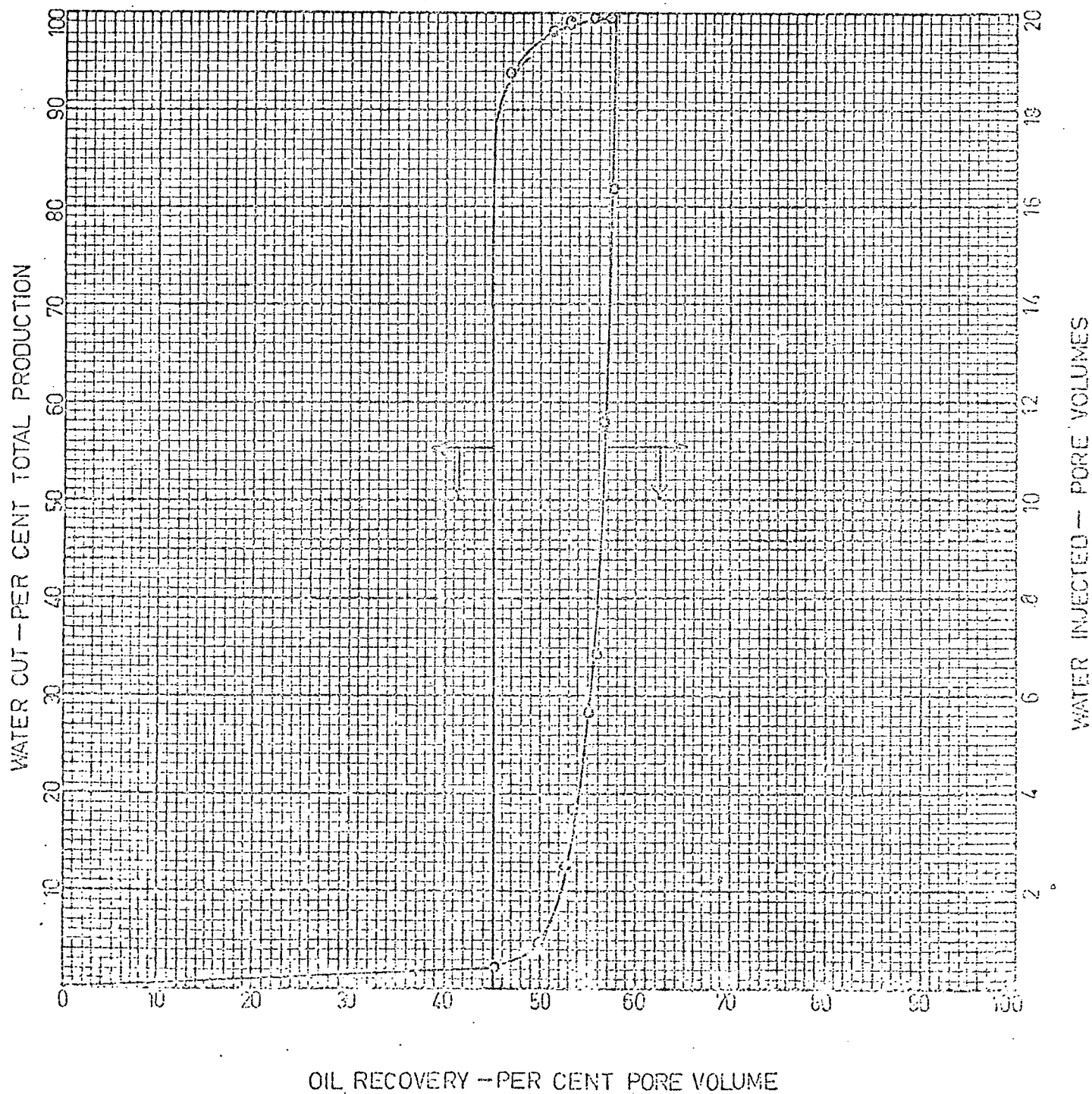
WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - MACKEREL 3

DEPTH INTERVAL - 7858'

POROSITY - 22.7%

PERMEABILITY - 667 Md. (Ko)



OIL RECOVERY - PER CENT PORE VOLUME

FIGURE 37

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - MACKEREL 3

DEPTH INTERVAL - 7874'

POROSITY - 19.6%

PERMEABILITY - 381 Md. (Ko)

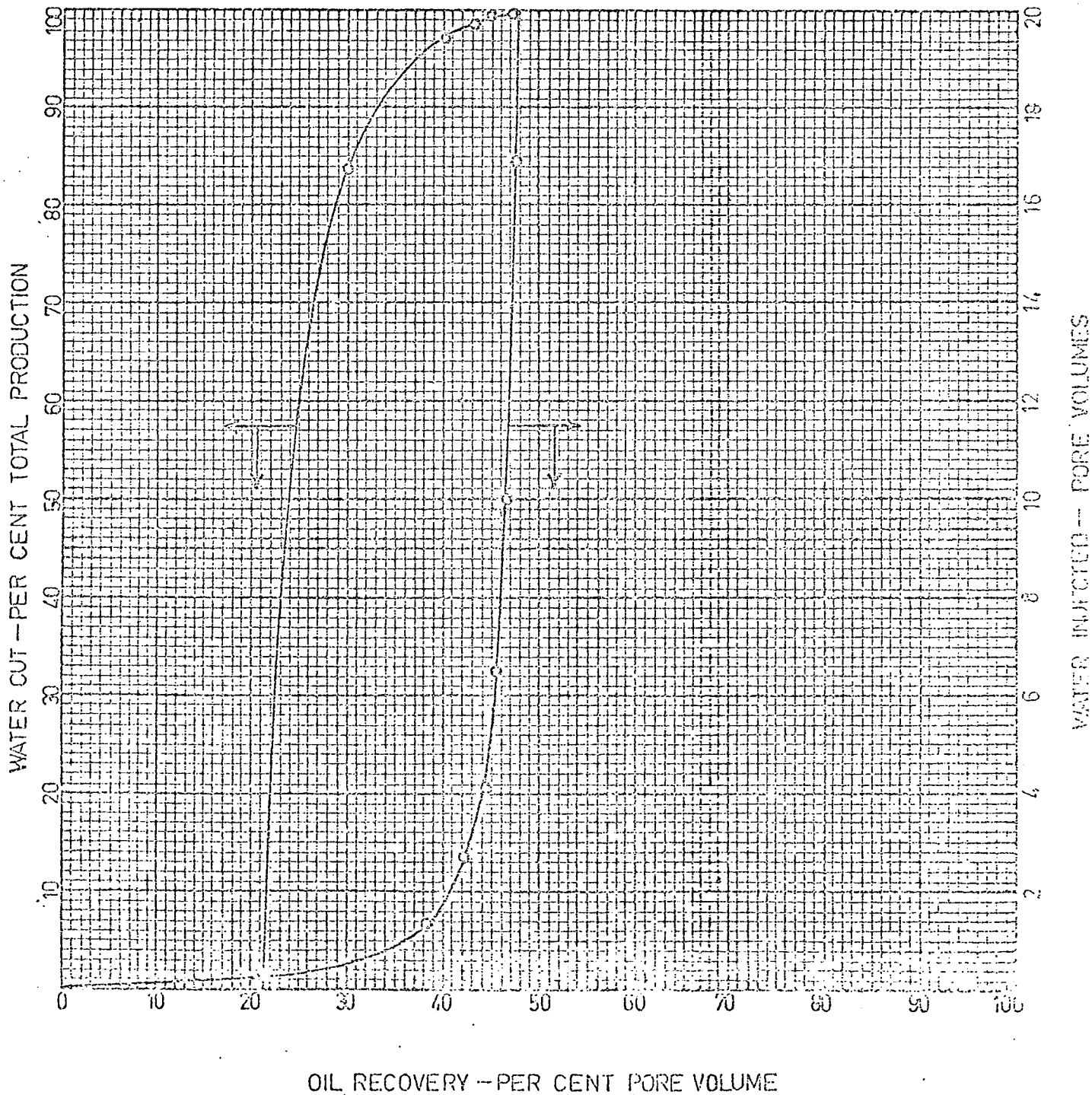


FIGURE 38

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 3

DEPTH INTERVAL-7885'

POROSITY-22.6%

PERMEABILITY-255 Md.(Ko)

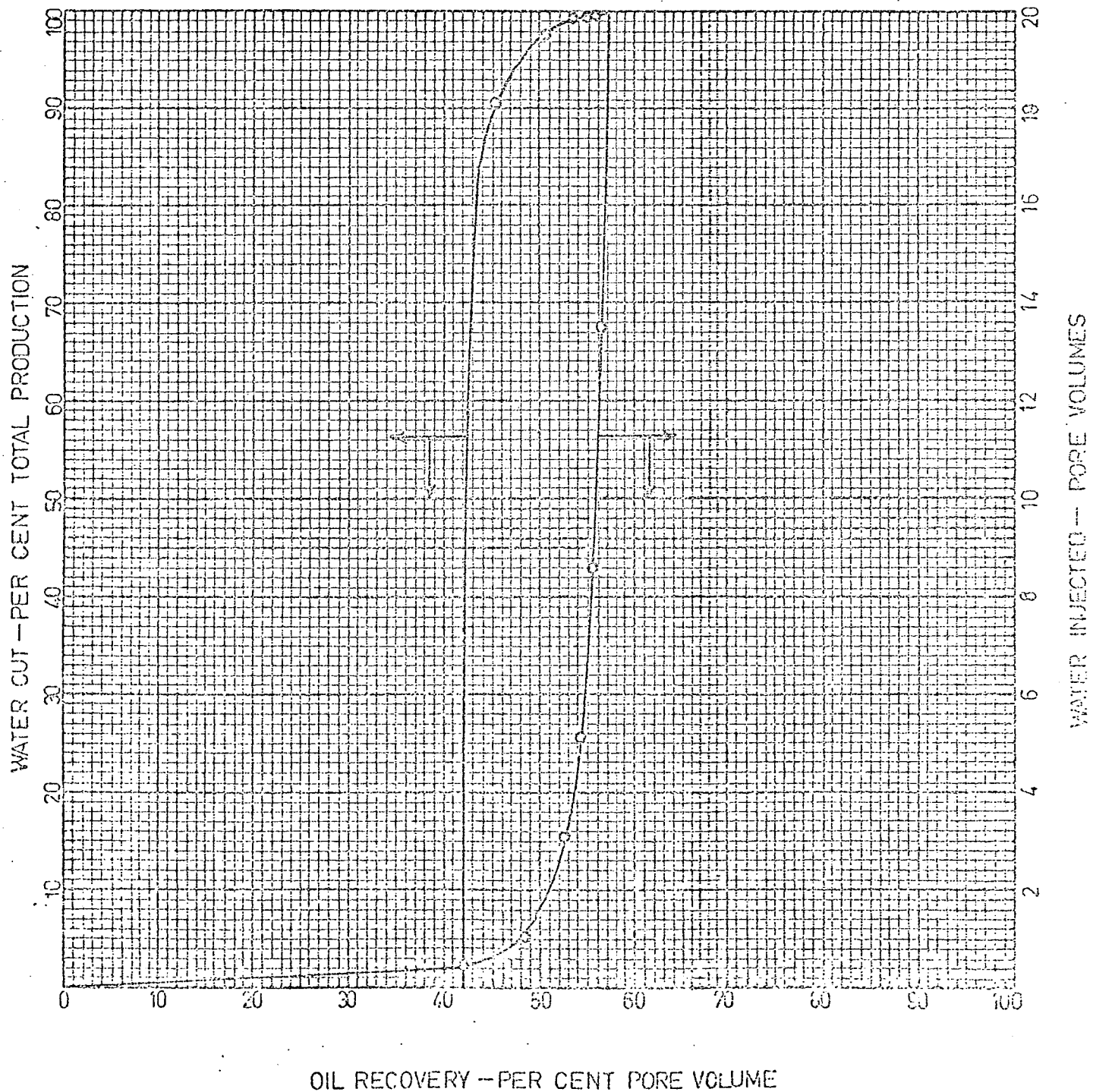


FIGURE 39

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 3

DEPTH INTERVAL-7896'

POROSITY - 18.0%

PERMEABILITY - 1178 Md. (K_o)

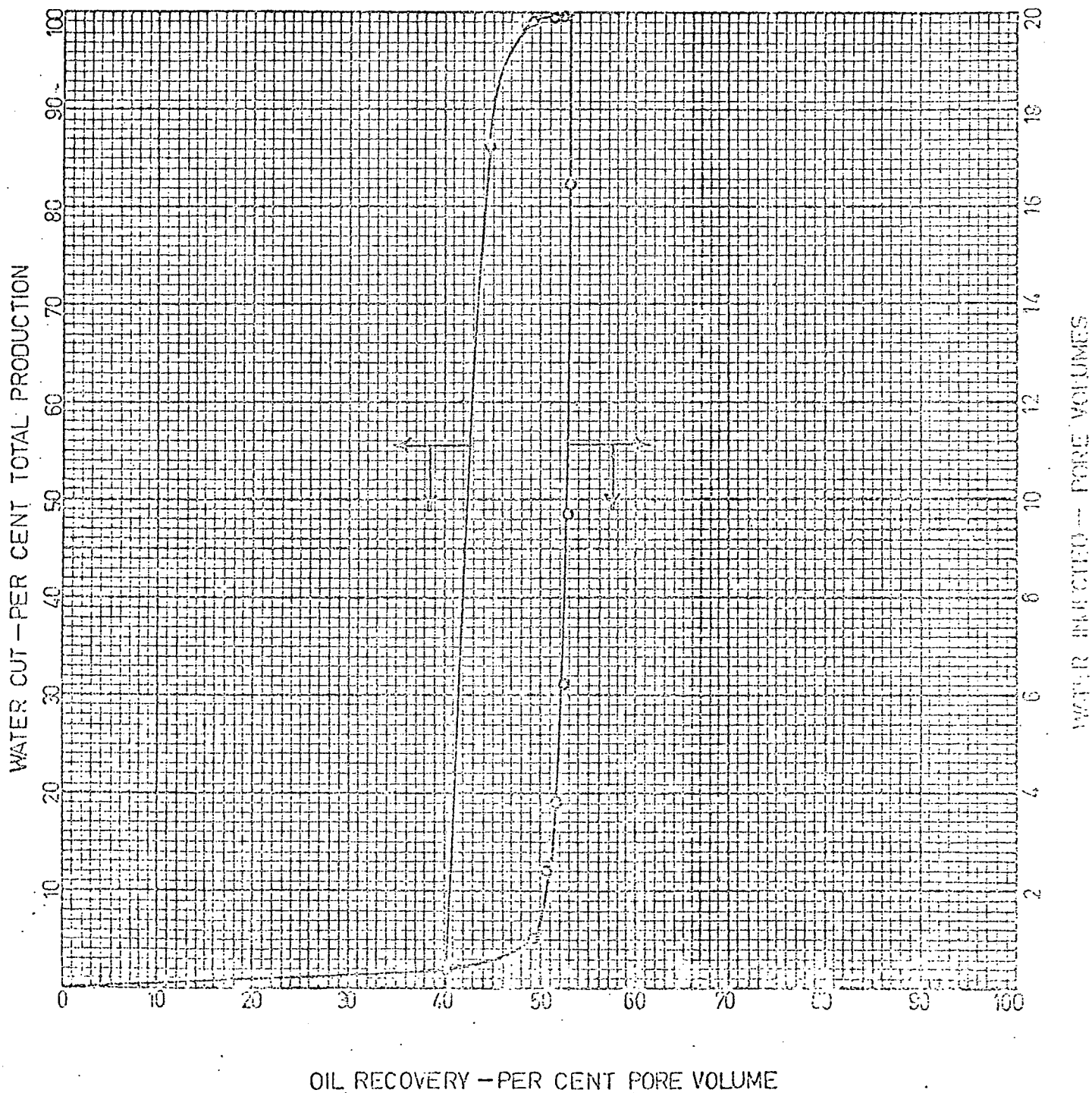


FIGURE 40

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 3

DEPTH INTERVAL-7896'(H)

POROSITY - 17.8 %

PERMEABILITY - 890 Md. (Ko)

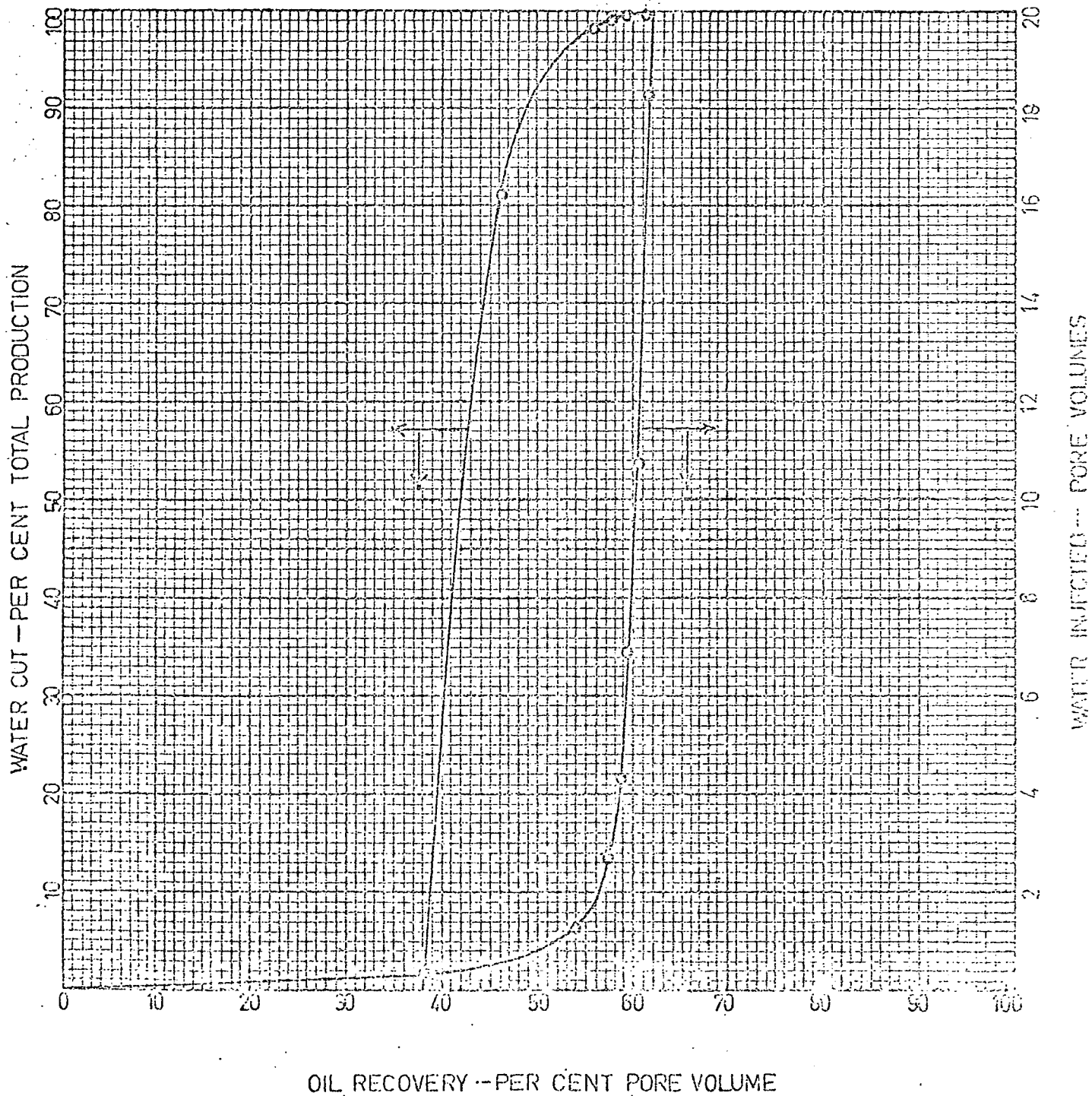


FIGURE 41

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 3

DEPTH INTERVAL-7908'

POROSITY - 27.3 %

PERMEABILITY - 632 Md. (Ko)

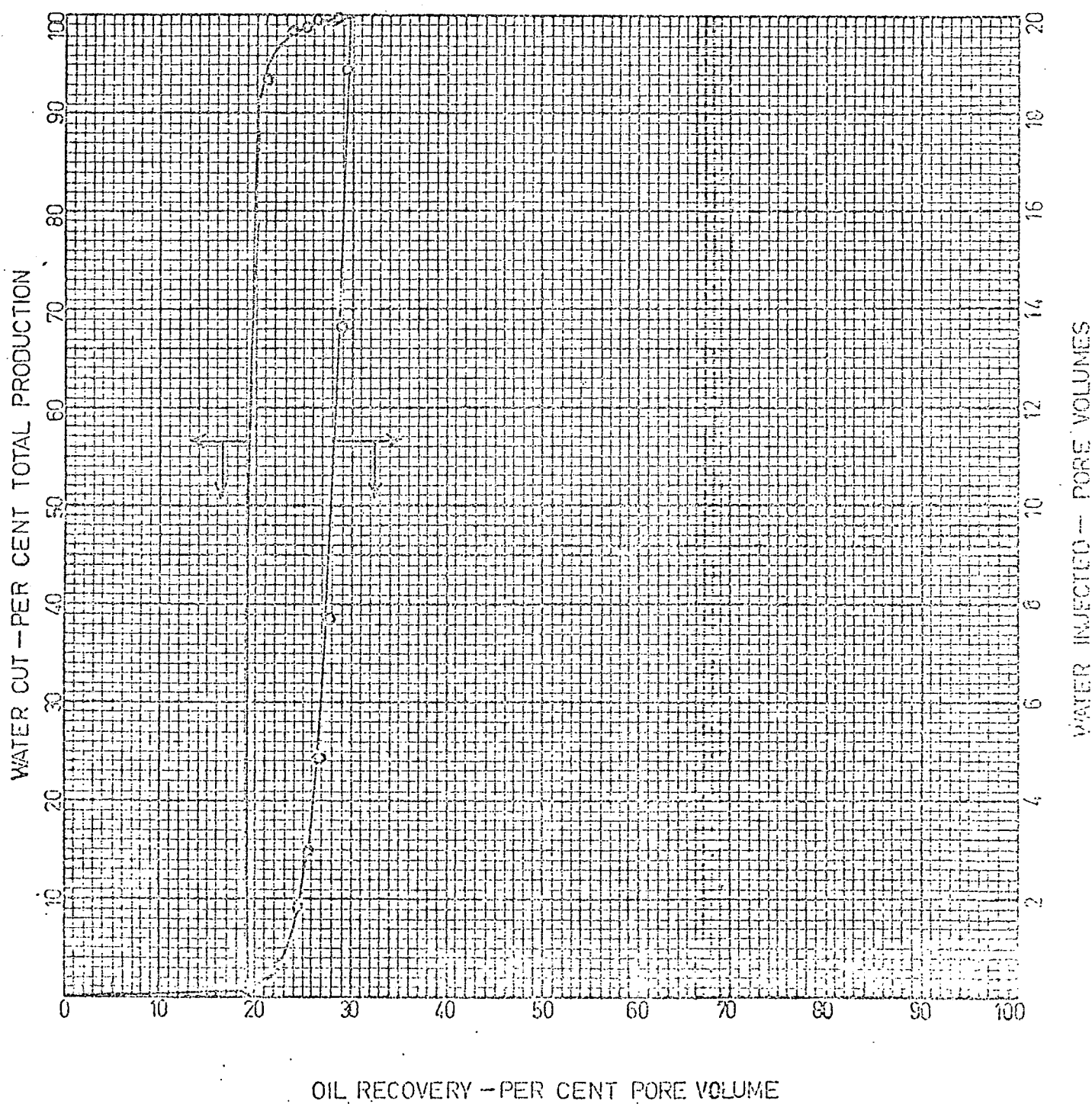


FIGURE 42

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 3

DEPTH INTERVAL-7919'

POROSITY-25.1%

PERMEABILITY-182 Md.(Ko)

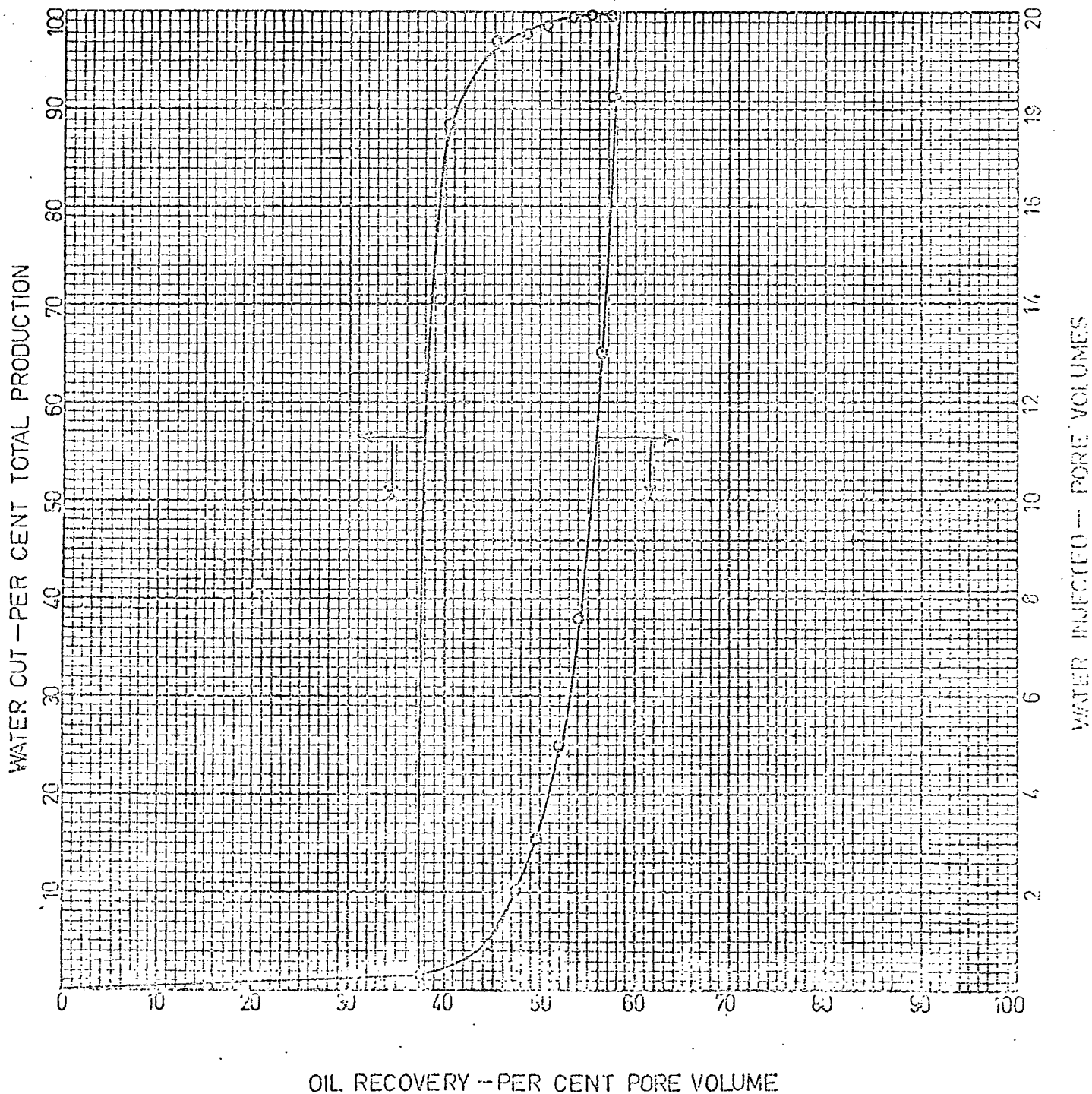


FIGURE 43

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER-MACKEREL 3

DEPTH INTERVAL-7929'

POROSITY - 23.4%

PERMEABILITY - 645 Md. (Ko)

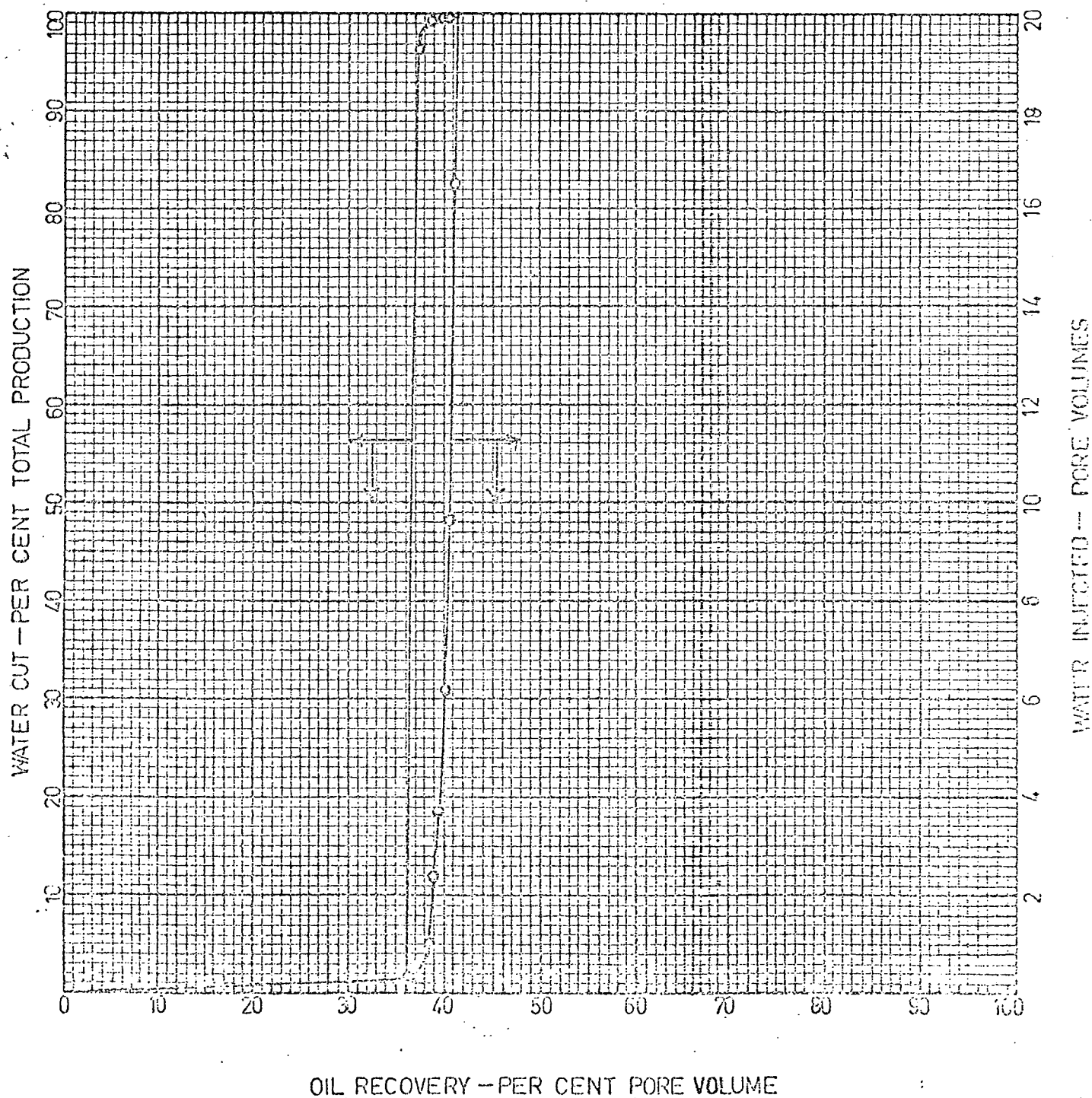


FIGURE 44

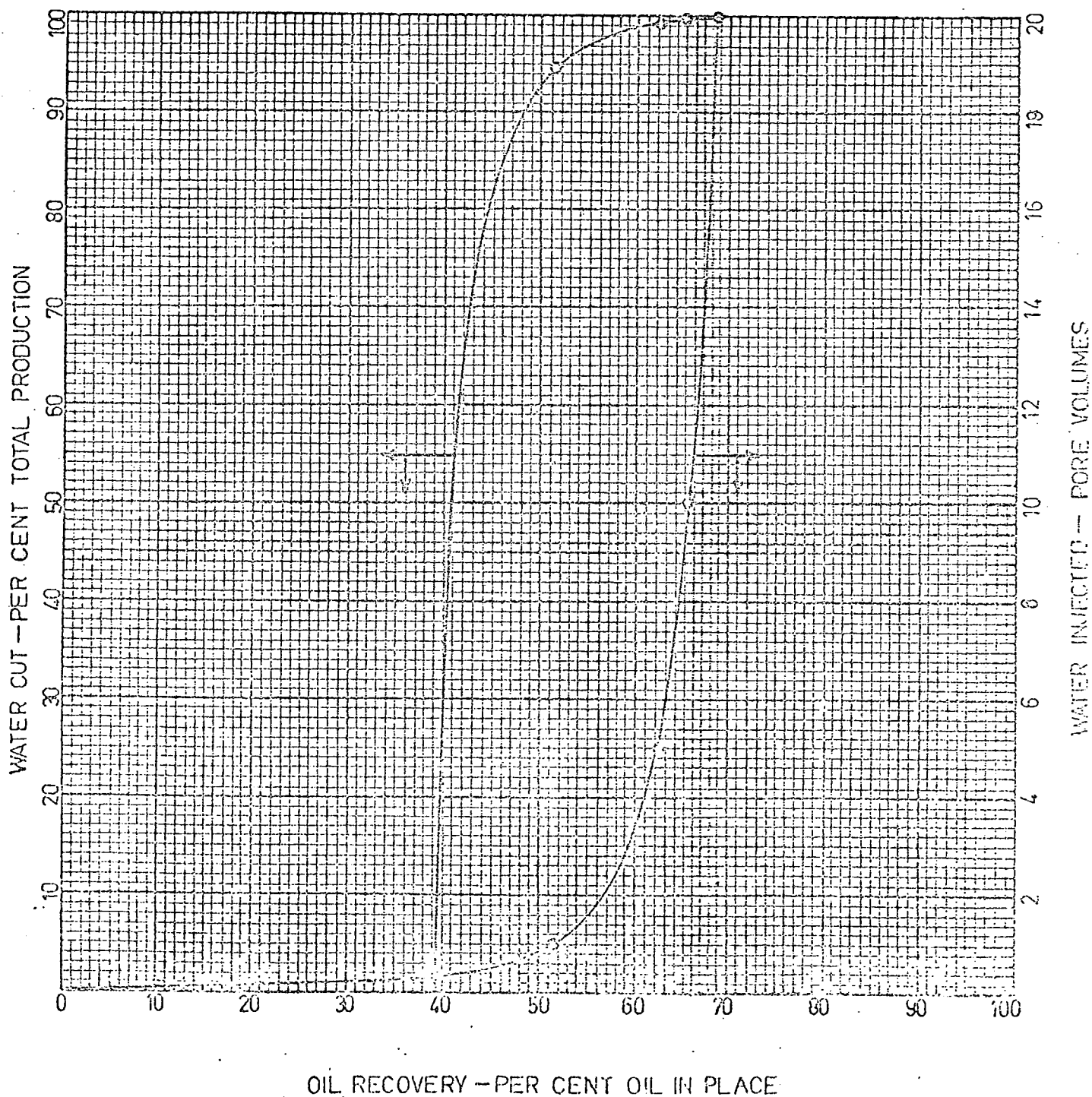
AVERAGE WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH A1

DEPTH INTERVAL - 7514' to 7745'

POROSITY

PERMEABILITY



WATER INJECTED - PORE VOLUMES

AVERAGE WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - KINGFISH B1

DEPTH INTERVAL - 7423' to 7661'

POROSITY

PERMEABILITY

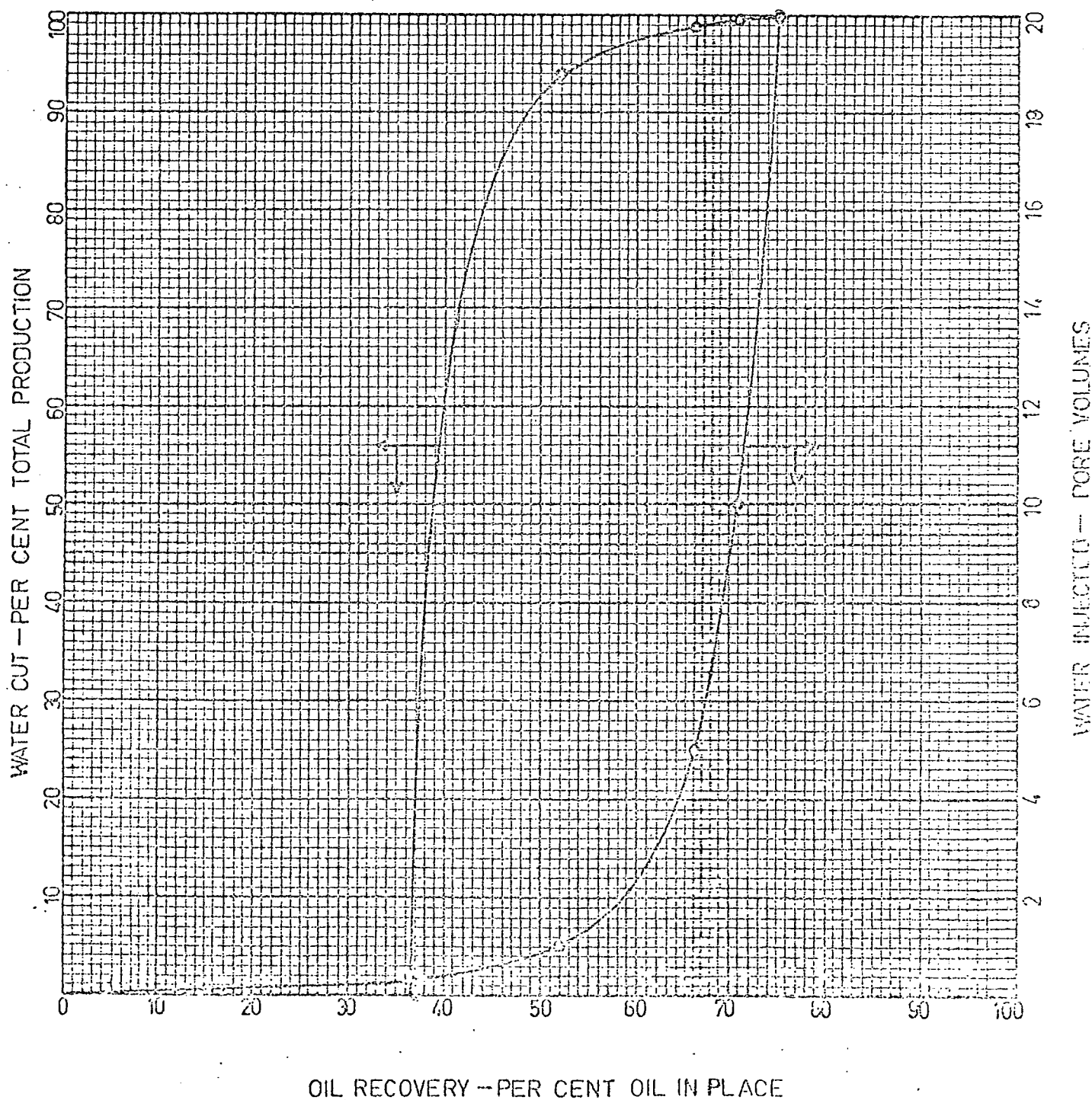


FIGURE 46

AVERAGE WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - MACKEREL 2

DEPTH INTERVAL - 7590' to 7903'

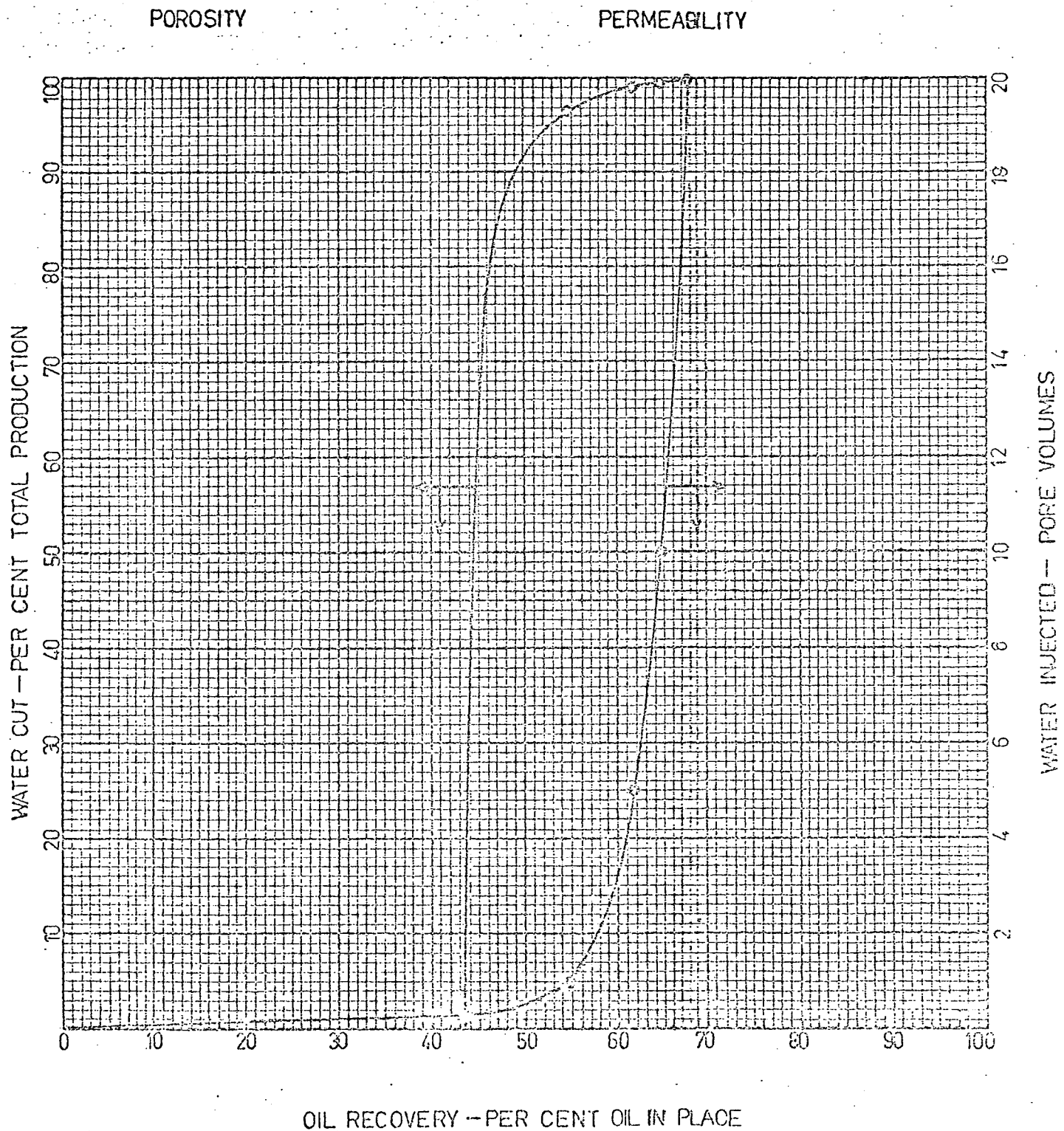


FIGURE 47.

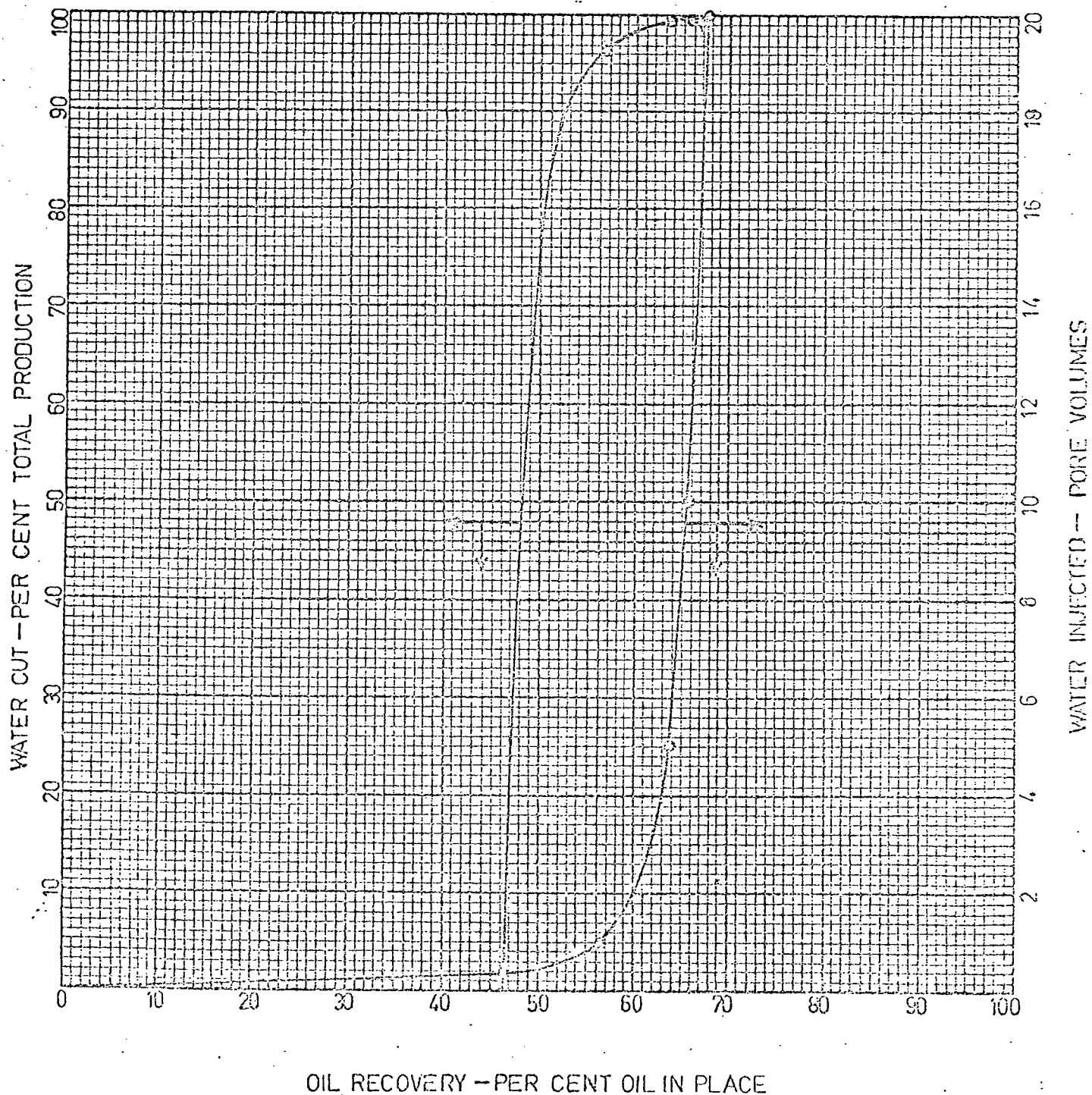
AVERAGE WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - MACKEREL 3

DEPTH INTERVAL - 7858' to 7929'

POROSITY

PERMEABILITY



OIL RECOVERY - PER CENT OIL IN PLACE