

THE CALIFORNIA STANDARD COMPANY

C O N F I D E N T I A L

DALY UNIT NO. 3

PROPOSAL FOR WATER FLOOD EXPANSION NO. 2

DALY FIELD, MANITOBA

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CONFIDENTIAL

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The pilot water flood has been in operation 23 months. This report presents the results to date, a discussion of these results, the conclusions to be drawn, and a proposal for a further expansion of water flooding.

Results to Date

1. Water Injection History

<u>Injection Well</u>	<u>Date on Injection</u>	<u>Initial Injection Rate bbls/day</u>	<u>Current Injection Rate bbls/day</u>	<u>Cumulative Injection at May 31/55 - bbls.</u>
10-1A	July 14, 1953	400	30	54,327
14-1	July 17, 1953	600	160	174,051
2-12	July 11, 1953	350	180	203,317
16-1	July 20, 1953	650	60	88,077
8-11	Nov. 27, 1954	350	240	47,988
6-12	Dec. 6, 1954	400	250	44,814
12-12	Dec. 6, 1954	750	150	40,133
			1,070	652,707

2. Water Flood Oil Production

<u>Producing Wells</u>	<u>Act. Cum. Prod. to May 31/55 bbls.</u>	<u>Extrap. Prim. Production to May 31, 1955 bbls.</u>	<u>Production Gain to May 31/55 bbls.</u>	<u>Injection Wells</u>	<u>Extrapolated Prod. Loss to May 31/55 bbls.</u>
13-1	20,911	18,161	2,750	10-1A	3,037
15-1	31,335	12,211	19,124	14-1	11,892
1-11	33,076	26,305	6,771	16-1 **	11,060
3-12	96,220	56,569	39,651	8-11	2,668
4-12	66,280	50,225	16,055	2-12	17,004
5-12	36,192	32,512	3,680	6-12	2,004
6-12 *	11,197	10,259	938	12-12	1,248
7-12	27,355	24,486	2,869		
11-12	20,466	20,197	269		
	343,032	250,925	92,107		48,913
Net Production gained due to water flooding					<u>43,194 bbls.</u>
Current net increase in production rate					<u>220 bbls/day</u>

(Production Decline Curves and Water Injection Curves are attached)

* Converted to water injection December, 1954

** Production decline curves assumed same as Daly 15-1

3. Costs

Total capital expenditure for pilot flood project - \$225,000 (includes costs of water treatment and injection plant, conversion of wells to injection, water supply well).

Discussion

Since the first moderate expansion of the pilot flood took place (conversion to water injection of 8-11, 6-12 and 12-12), some significant effects have occurred. Daly 3-12 has increased to 185 bbls/day from a previous high of 115 bbls/day and from a rate before flooding of 60 bbls/day. Daly 5-12, the other central producing well, has increased to 50 bbls/day from a rate of 27 bbls/day before Water Flood Unit No. 2 was formed. Some effect has also been felt at Daly 1-11, 7-12 and 11-12 from the additional injection wells. The original five-spot central producing well, Daly 15-1, is up to 40 bbls/day from 7 bbls/day at start of injection. Water breakthrough has not occurred in any producing wells to date.

Oil recoveries and life expectancies have been calculated to water breakthrough by two methods, Dykstra and Parsons' (1) and Welges' (2). Estimates were made for the central producing wells as follows:

Central Prod. Wells	Prod. Since Flooding at May 31/55 bbls.	Calculated Rec. at Breakthrough bbls.	Recovery Factor %	Current Prod. Rate bbls/day	Time to Breakthrough at Current Rate - years
15-1	21,000	98,000 (D&P) (1) 250,000 (Wel) (2)	5 12	39	6 16
3-12 ($\frac{1}{2}$ five-spot)	66,000	60,000 (D&P) (1) 150,000 (Wel) (2)	5 12	115	- 2
5-12	6,000	98,000 (D&P) (1) 250,000 (Wel) (2)	5 12	50	5 13

- (1) Dykstra, H. and Parsons, R. L.: "The Prediction of Oil Recovery by Water Flood"; Secondary Recovery of Oil in the United States, A.P.I., 1950, p. 160.
- (2) Welge, H. J.: "A Simplified Method for Computing Oil Recovery by Gas or Water Drive"; Petroleum Technology, April, 1952, p. 91.

Daly 3-12 was considered as a half five-spot with the injection wells 14-1 and 2-12 since the third injection well, 6-12, began to affect the production only recently. As can be seen, the total oil production of 3-12 since the flood began has exceeded the Dykstra and Parson prediction and is now approaching the Welge prediction. The addition of 6-12 as an injection well and the increase in production at 3-12 to about 185 bbls/day does not alter the concept that when water breakthrough occurs at 3-12, from 2-12 and 14-1, it will determine the recovery factor at breakthrough in relation to the two prediction methods.

The maximum efficient rate of production should be considered the amount the well will produce. Fluid withdrawal from the reservoir in the flood area will not likely exceed the fluid injection. Considering the area affected by the water flood (the 8 wells listed under results), the total oil production is 450 bbls/day and the total water injection is 1,070 bbls/day. Using the analogy of a water drive reservoir, the fluid replacement efficiency at reservoir conditions (applying formation volume factor for oil and water compressibility) is 220%. This means not only is the original reservoir pressure being maintained, but in fact the pressure is being increased. In the 80 acre five-spot unit centred by 3-12, it is estimated that 290 bbls/day of water is being injected and 185 bbls/day of oil is being withdrawn for a fluid replacement efficiency of 150%. This considers that most of the water injected into 14-1 and 2-12 flows toward 3-12 due to the higher permeability zone, as indicated by the Carter Analyzer Study (see proposal for Expansion of Pilot Water Flood, October, 1954).

The 450 bbls/day production credited to the existing flood pattern of 15 injection and producing wells indicates an average of 30 bbls/day per well which is certainly far from an excessive rate.

The pilot flood to date has indicated sufficiently satisfactory results to provide a basis for a further water flooding extension. Our present injection plant, located at Daly 15-1, can be readily enlarged to handle about 3,000 bbls. of water per day. Salt water production, especially in the south-west part of the field, is becoming a problem and its use in water flooding would solve disposal while providing a supplementary water supply.

Conclusions

1. Primary production of wells in the major portion of the Daly field, excluding the south-west area, decline rapidly (see production decline curves for Daly 15-1, 3-12).
2. The indicated oil production for a typical 80 acre five-spot unit is:
 - a) A peak and sustained production rate of 50 bbls/day.
 - b) An oil recovery to water breakthrough of 250,000 bbls.
 - c) A producing life to water breakthrough of 15 years.

The oil recovery was estimated to be similar to Daly 15-1. The production rate was estimated to be 22.5% greater than the 15-1 five-spot unit by comparing the rate-cumulative decline curves in Figures 2 and 3.

3. Capacity of the present injection plant at Daly 15-1 can be doubled by increasing the electric motor on the injection pump from 50 H.P. to 100 H.P., adding another filter and changing the manifolding as required.
4. The salt water disposal problem is taken care of by using produced salt water for flooding. Laboratory tests indicate that produced salt water can be satisfactorily inhibited to prevent corrosion and permit its use.

Recommendations

It is recommended that approval be given to the proposed Water Flood Expansion No. 2 for the Daly Field (see Figure 1, attached).

The plan involves:

- a) Drilling 6 new injection wells: 6-11, 10-11, 12-11, 14-11, 16-11 and 2-14.
- b) Converting to water injection 4-13 and 8-14.
- c) Drilling 9 new producing wells and forming the appropriate units for proration of royalty interests to the injection wells and producing wells.
- d) Extending the water injection lines from 8-11 to serve new wells 6-11, 10-11, 12-11 and 14-11, and from 12-12 to serve new wells 16-11, 4-13, 2-14 and 8-14.
- e) Enlarging the injection plant at Daly 15-1 to handle approximately 3,000 bbls/day of water.

It must be remembered that the proposed flood area is largely undeveloped and thus an exploration problem. There are indications that part of the Mississippian limestone section becomes dolomitized, tight and non-oil saturated, to the north. Development drilling will be cautious and slight modifications in the proposed five-spots may be necessary if a tight section is evidenced.

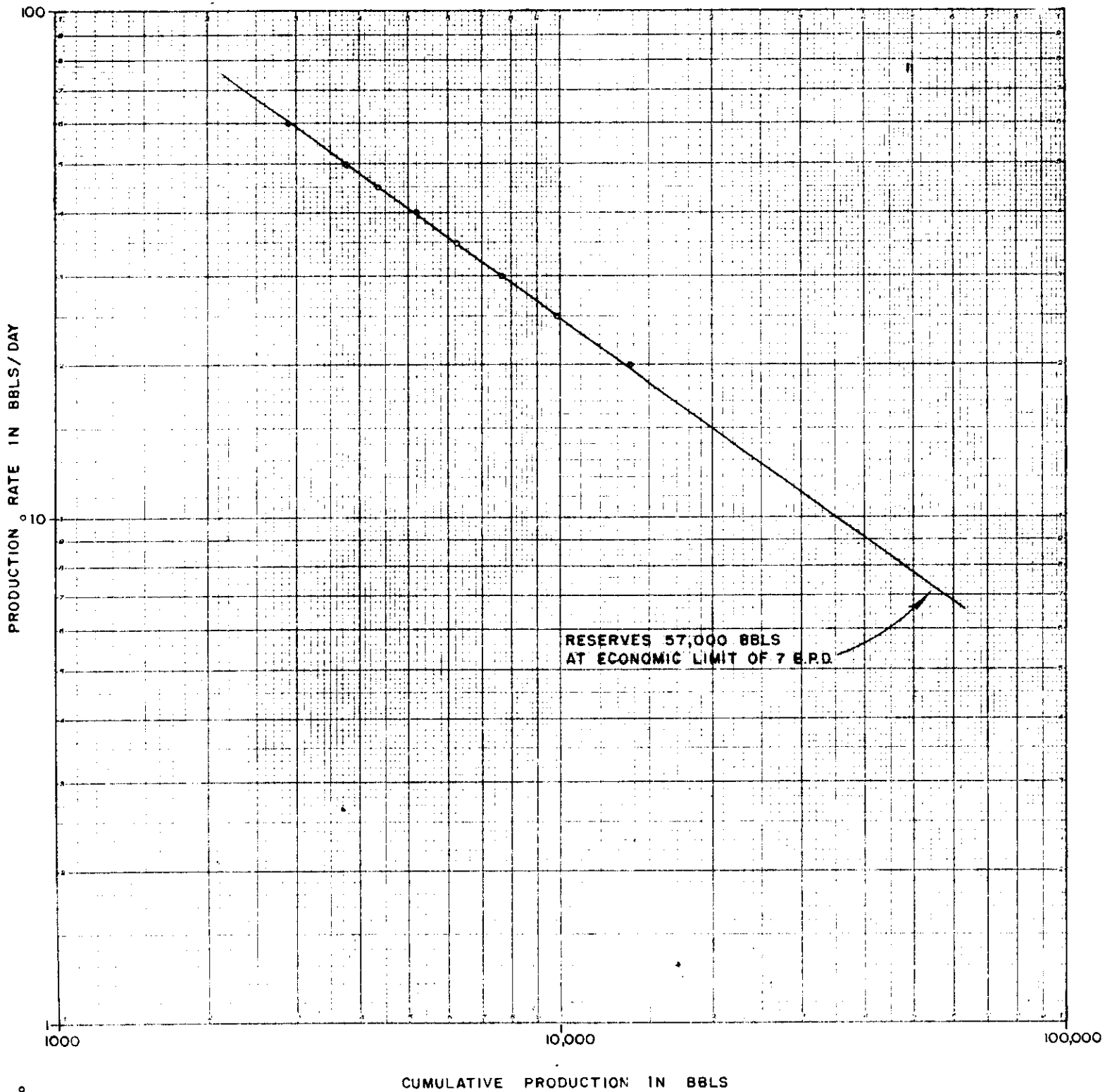
DALY FIELD

(excluding southwest Daly area)

AVERAGE RATE-CUMULATIVE DECLINE CURVE

(73 WELLS)

FIG. 2

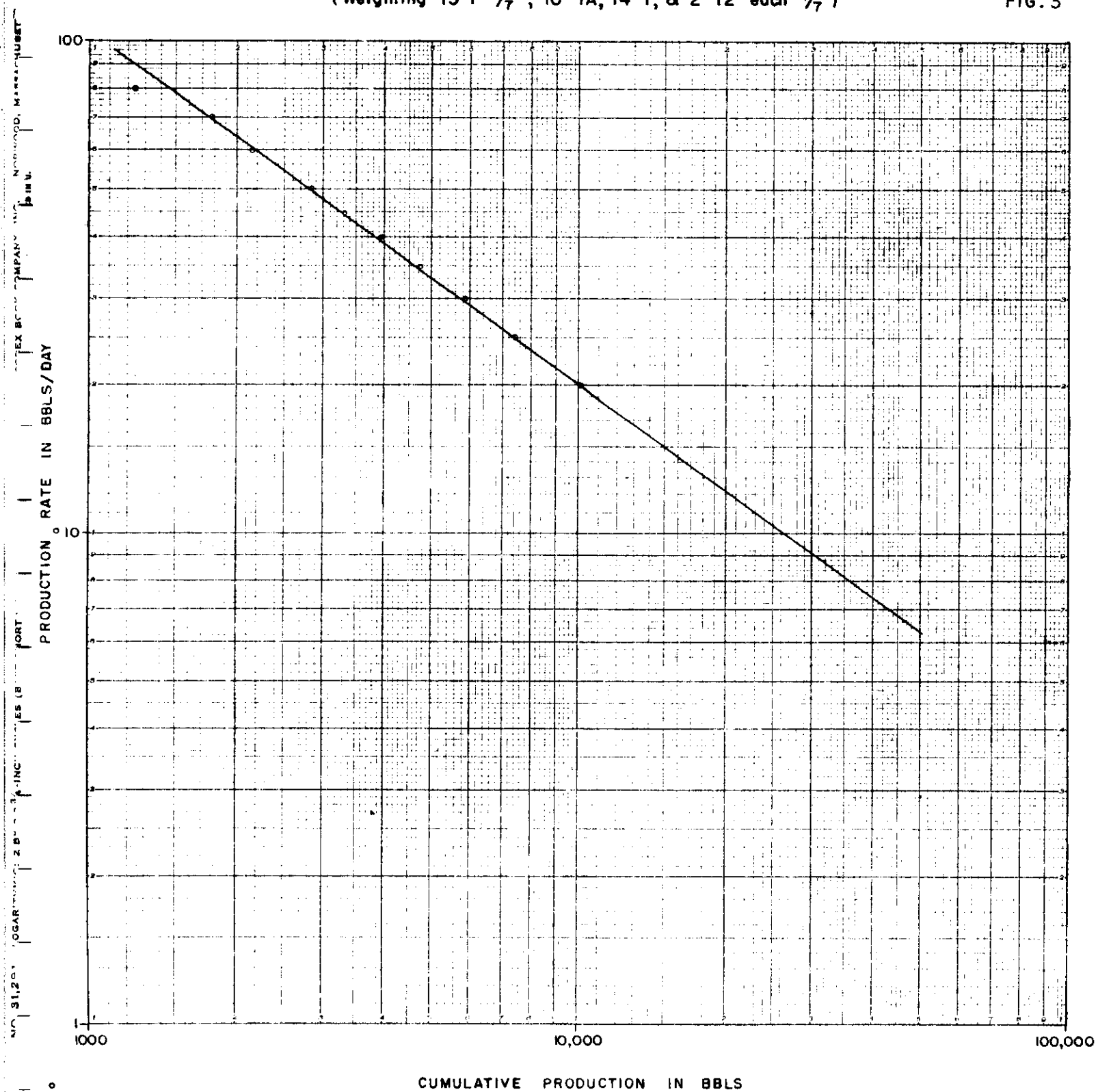


DALY PILOT FIVESPOT

AVERAGE RATE-CUMULATIVE DECLINE CURVE

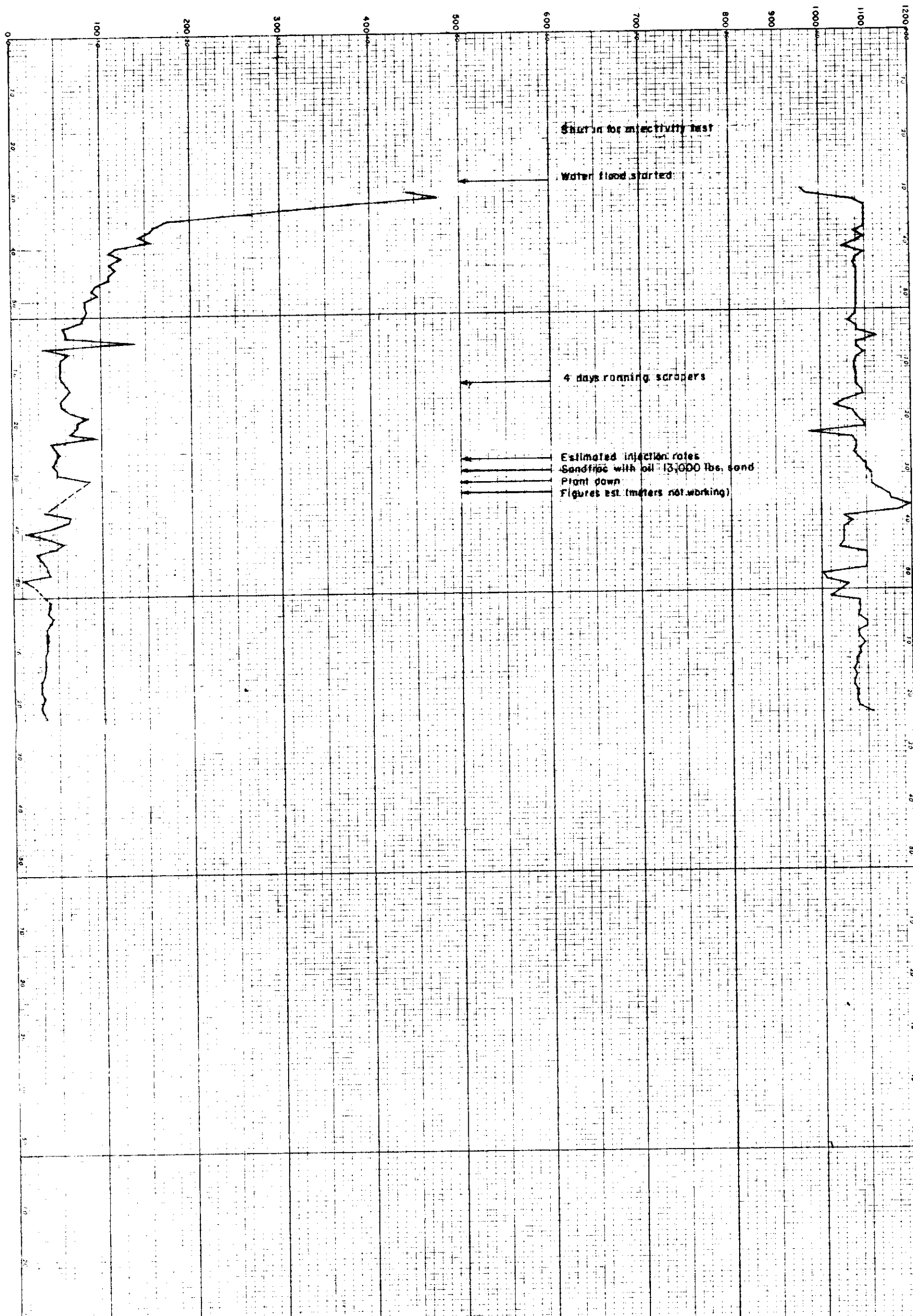
(Weighting 15-1 $\frac{4}{7}$; 10-1A, 14-1, & 2-12 each $\frac{1}{7}$)

FIG. 3



INJECTION RATE BPD

INJECTION PRESSURE



1953

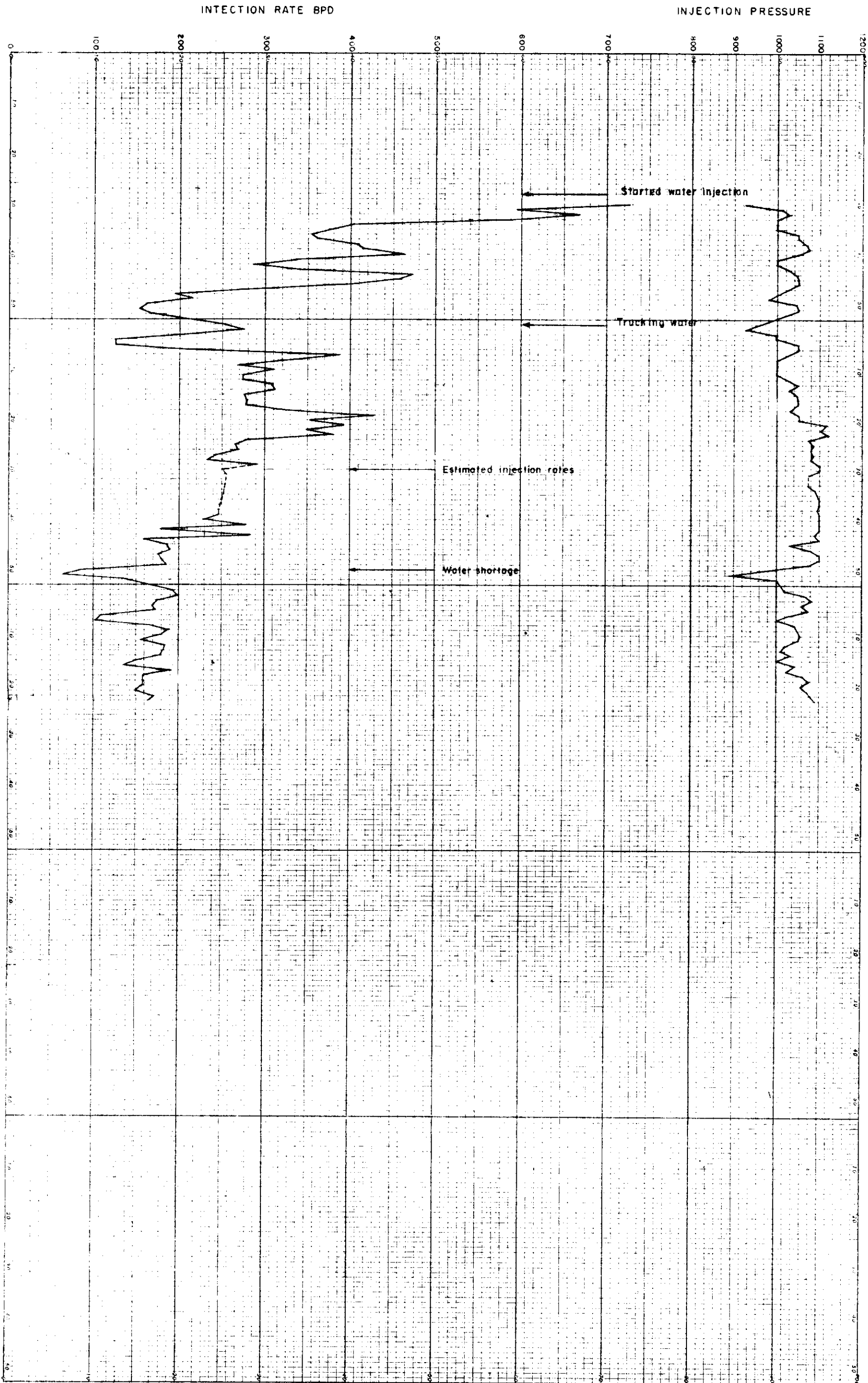
1954

1955

1956

1957

WATER INJECTION CURVE
DALY 14-1



1953

1954

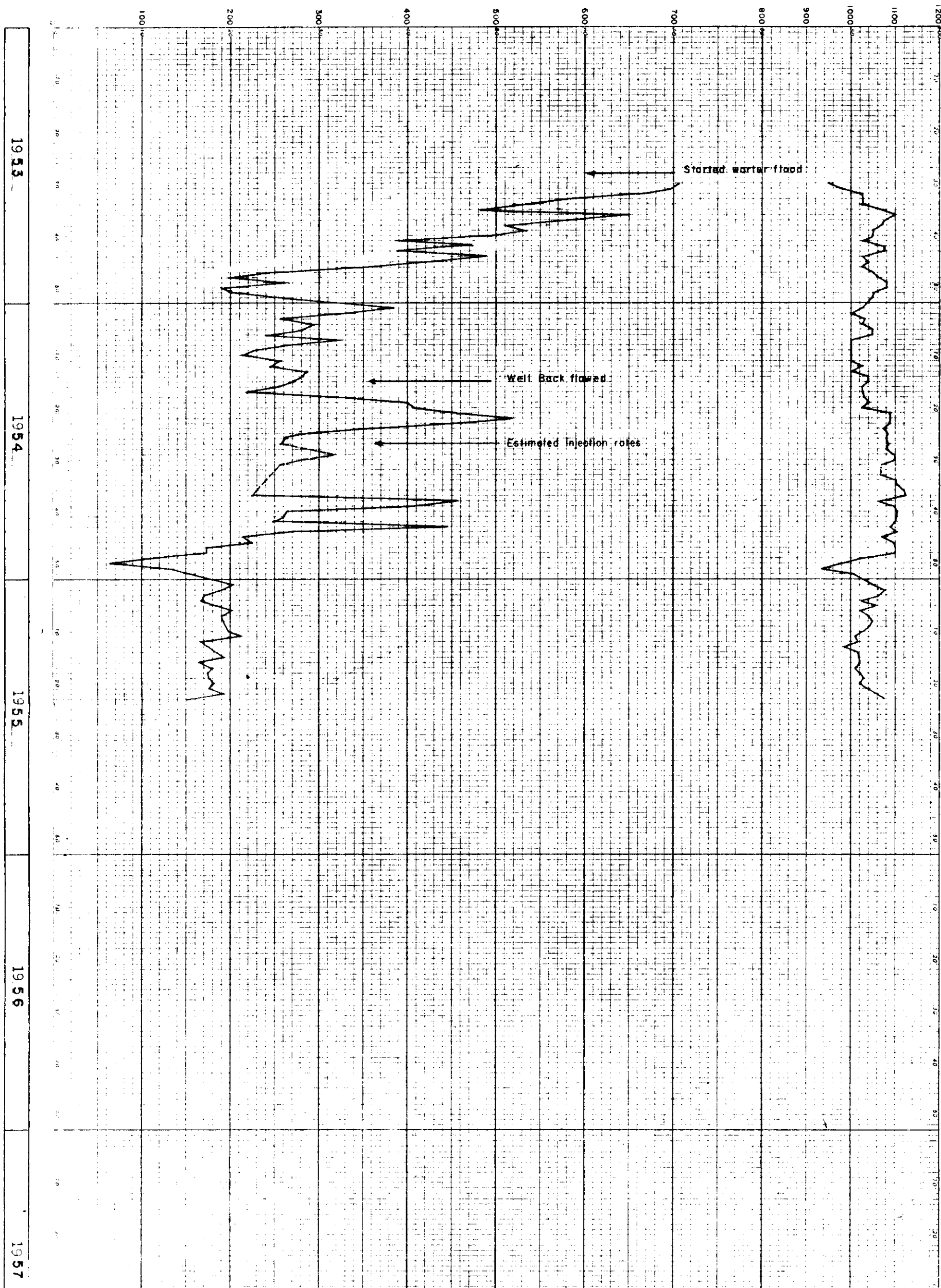
1955

1956

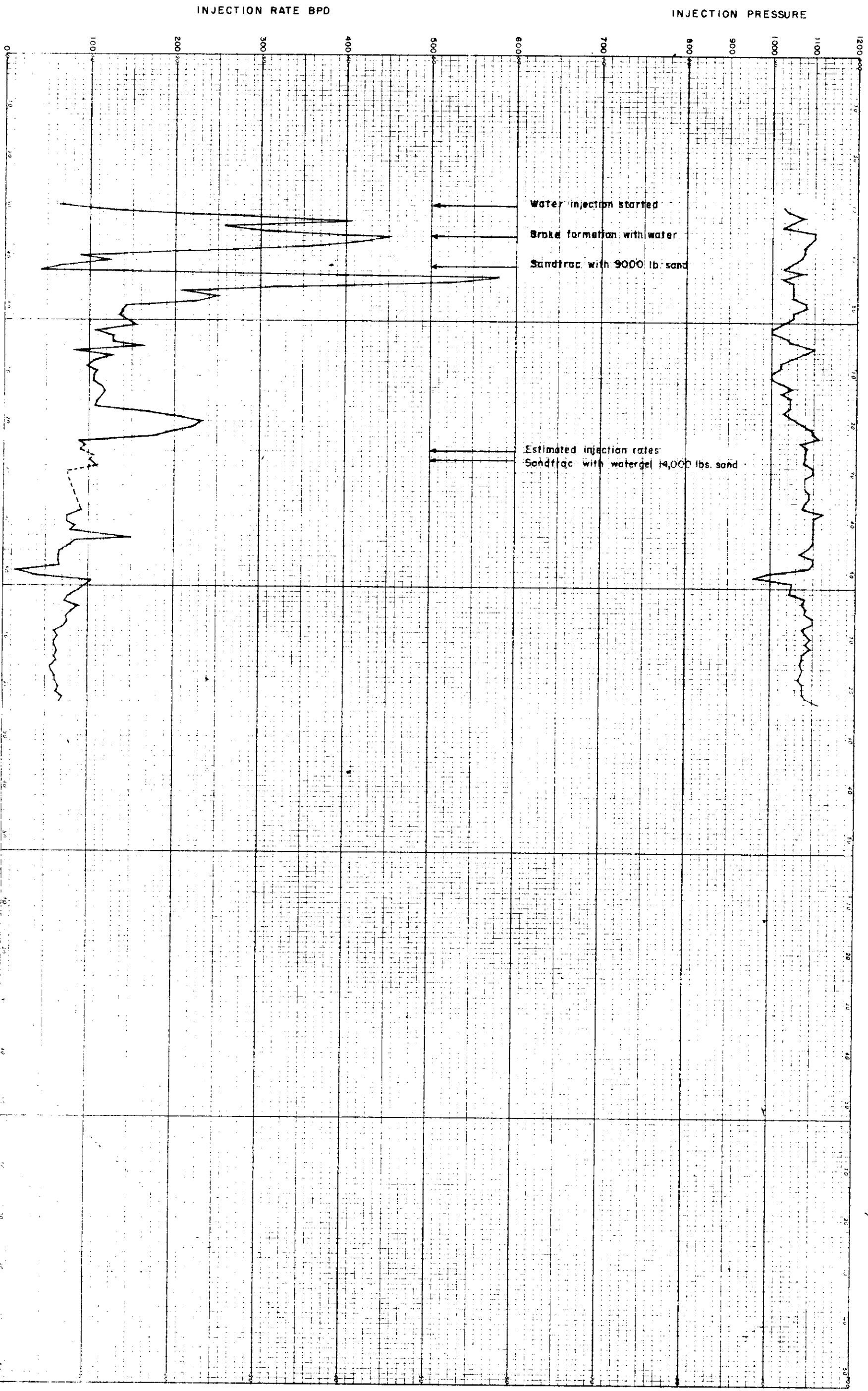
1957

INJECTION RATE BPD

INJECTION PRESSURE



WATER INJECTION CURVE DALY 16-1



19 53

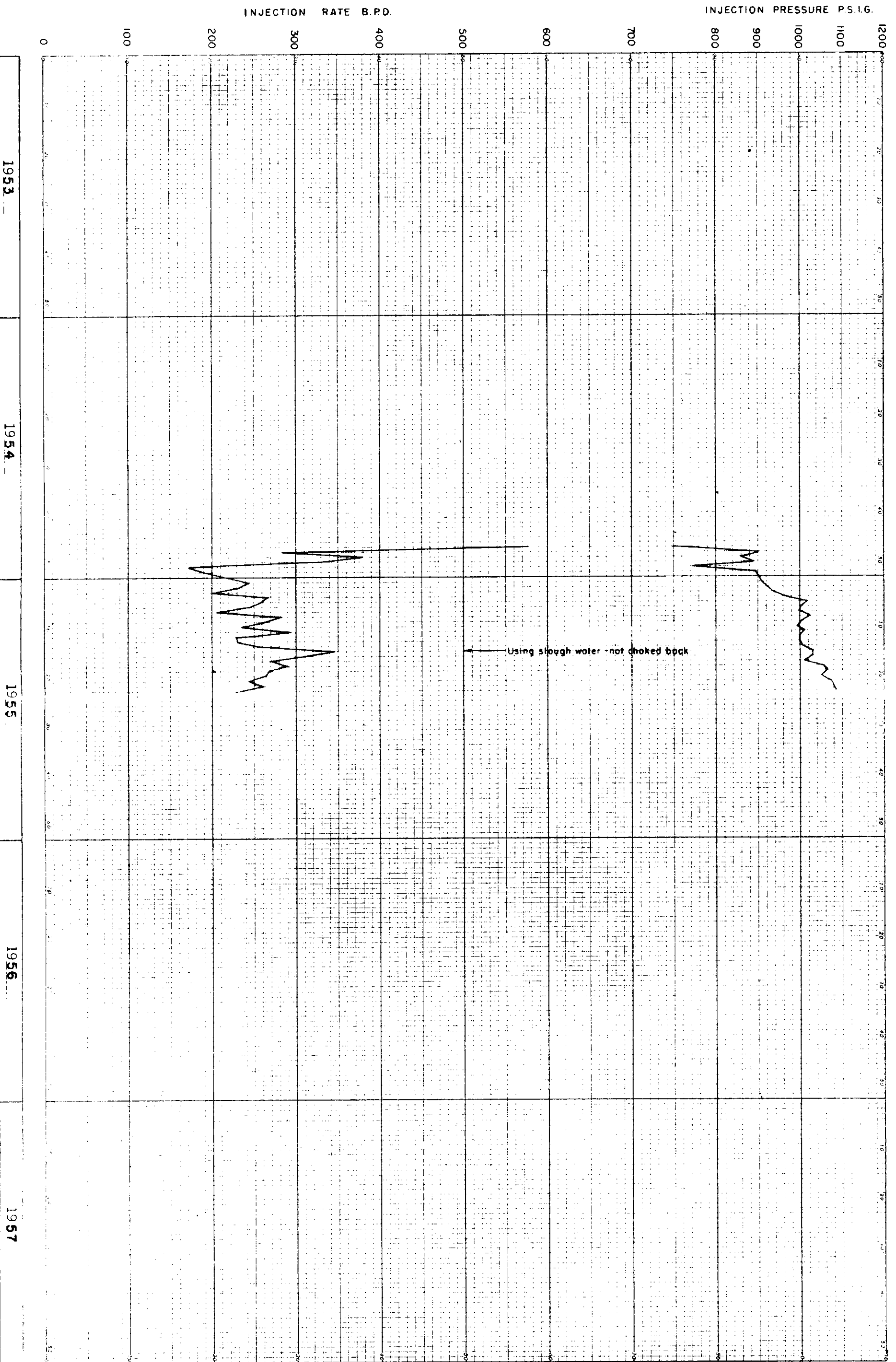
19 54

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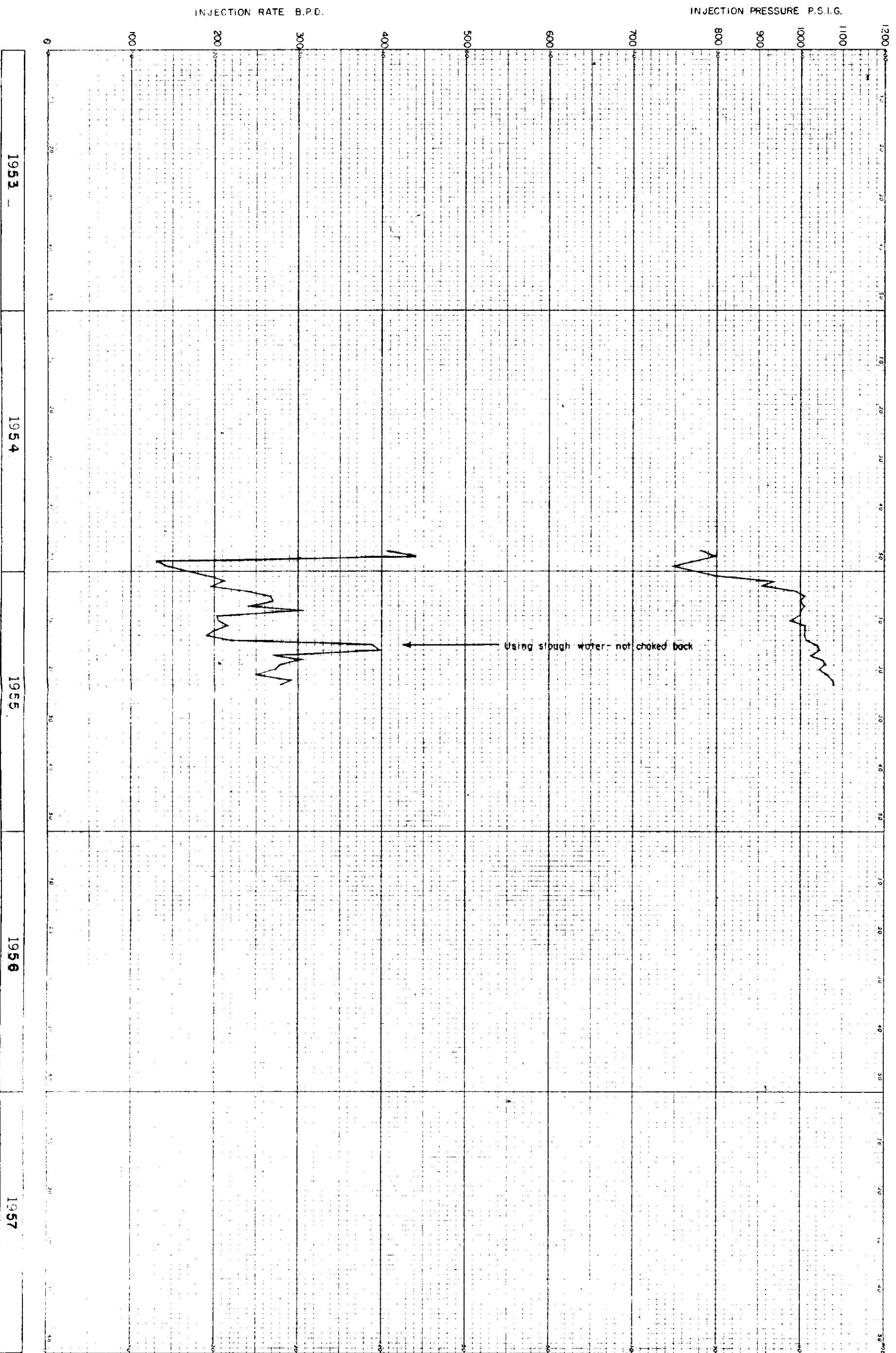
19 57

DALY PILOT FLOOD DALY 8-11



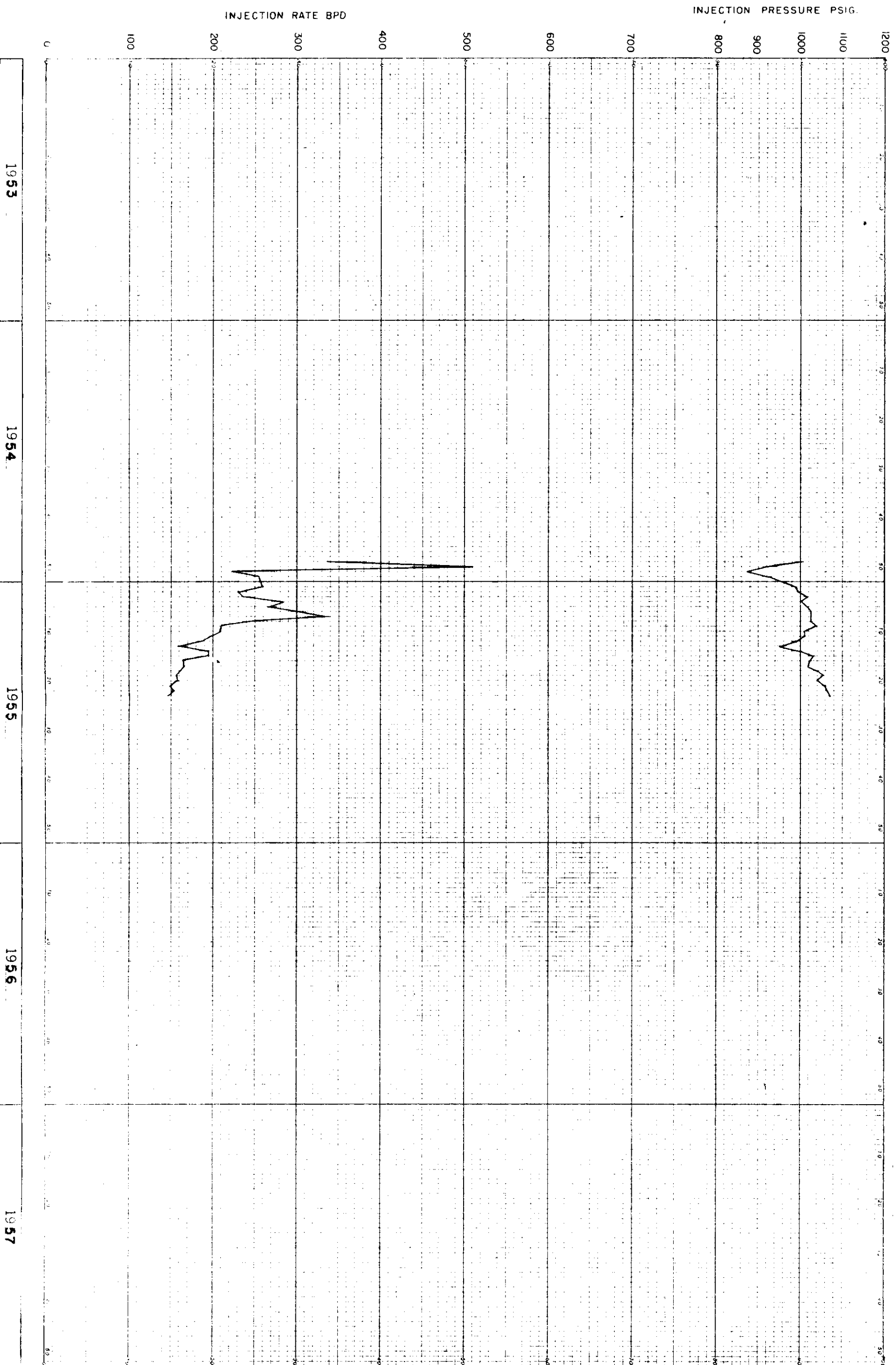
DALY PILOT FLOOD

DALY 6-12



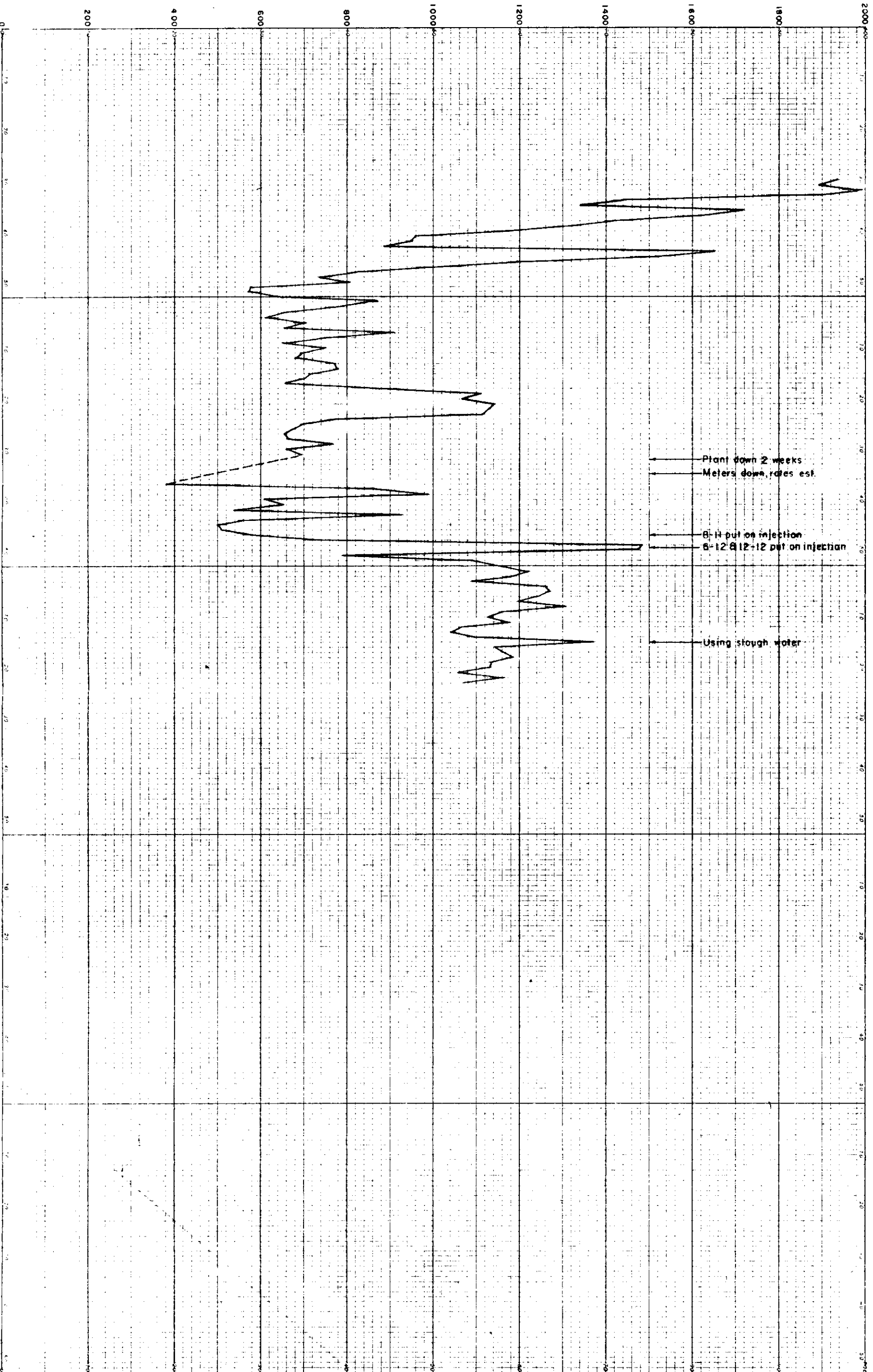
DALY PILOT FLOOD

DALY 12-12



DAILY PILOT FLOOD
TOTAL DAILY WATER INJECTION

INJECTION RATE B.P.D.



1953

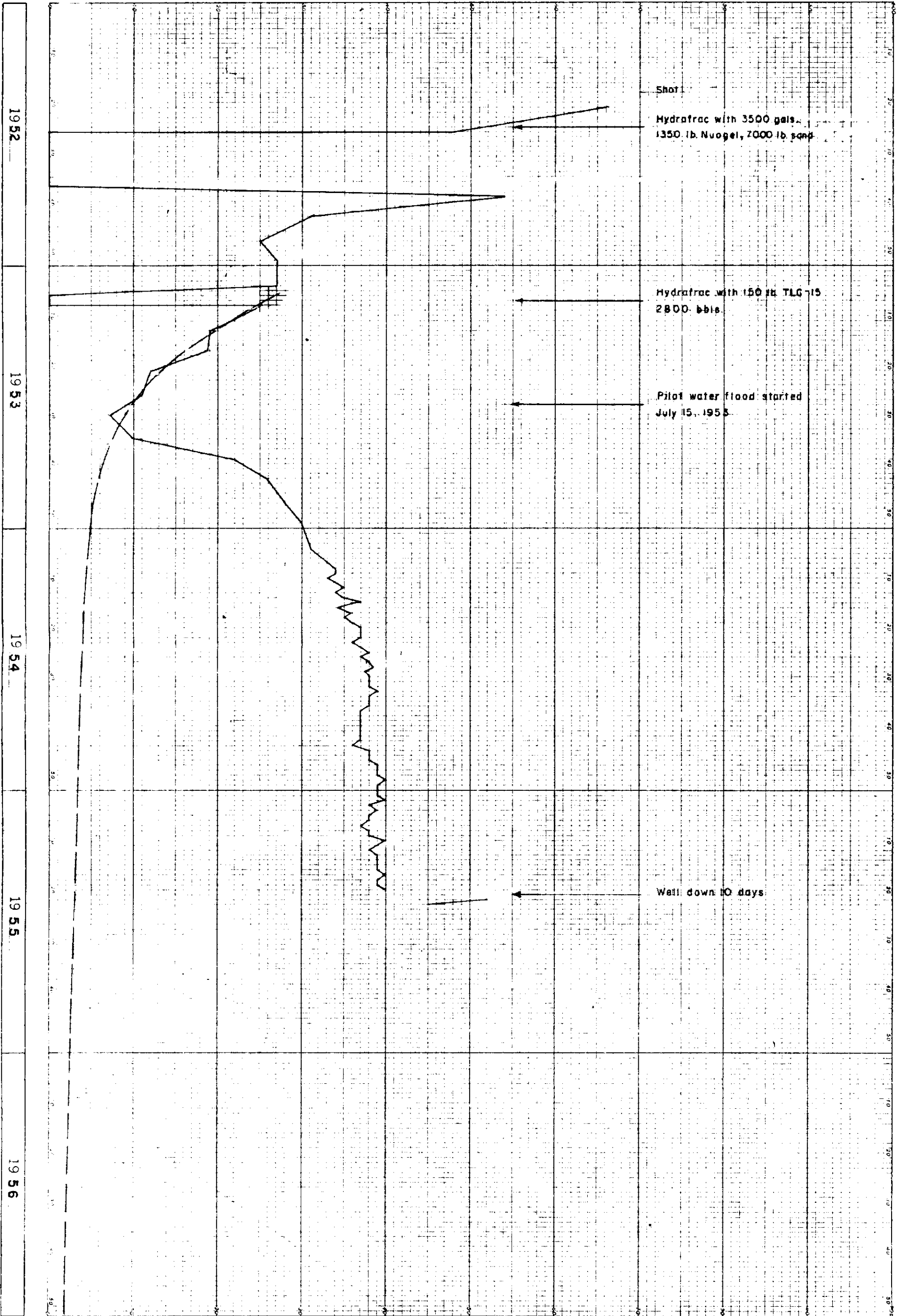
1954

1955

1956

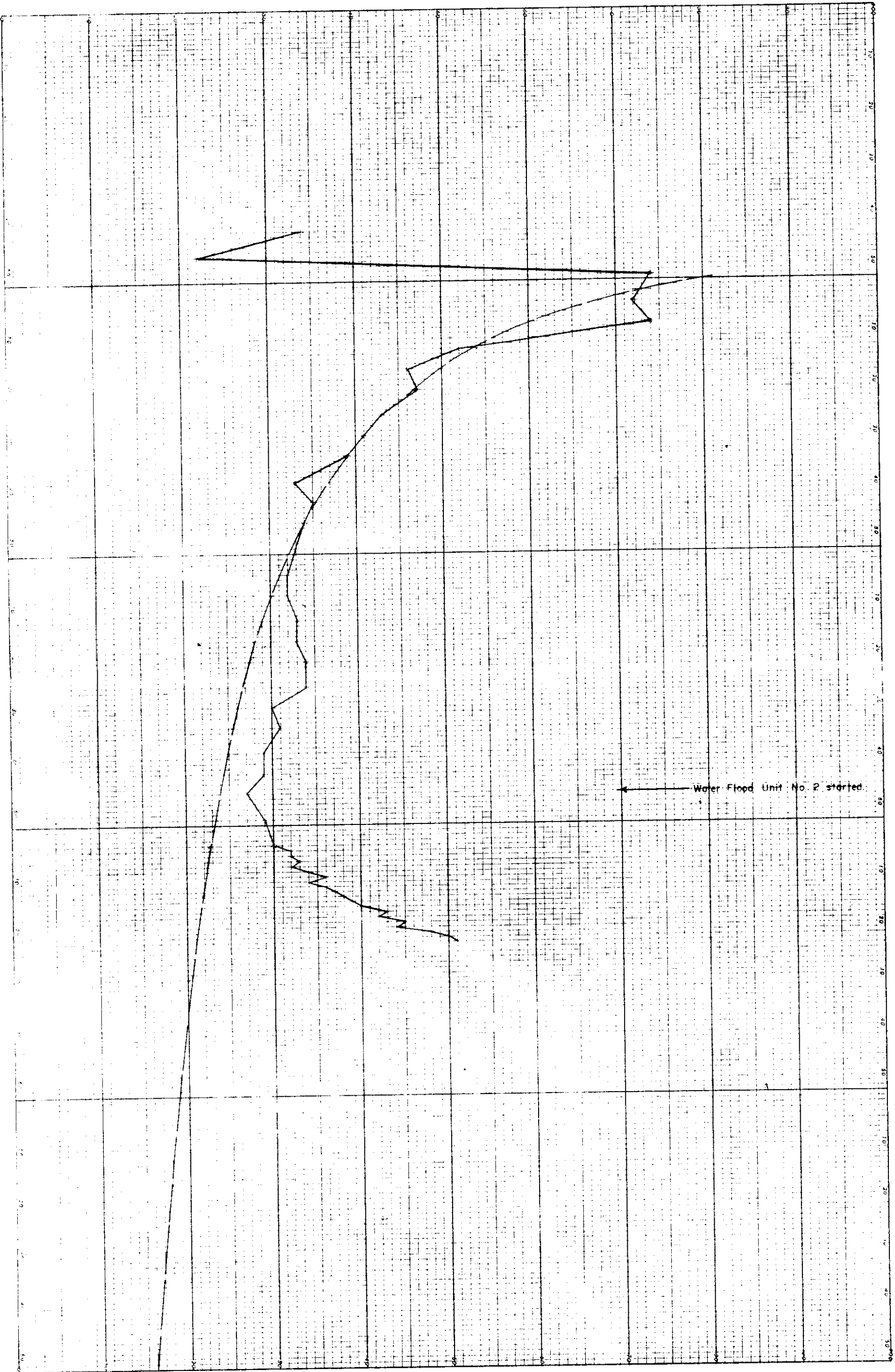
1957

PRODUCTION DECLINE CURVE
DALY 15-1



PRODUCTION RATE BARRELS / DAY

PRODUCTION DECLINE CURVE
DAILY 5-12



1952

1953

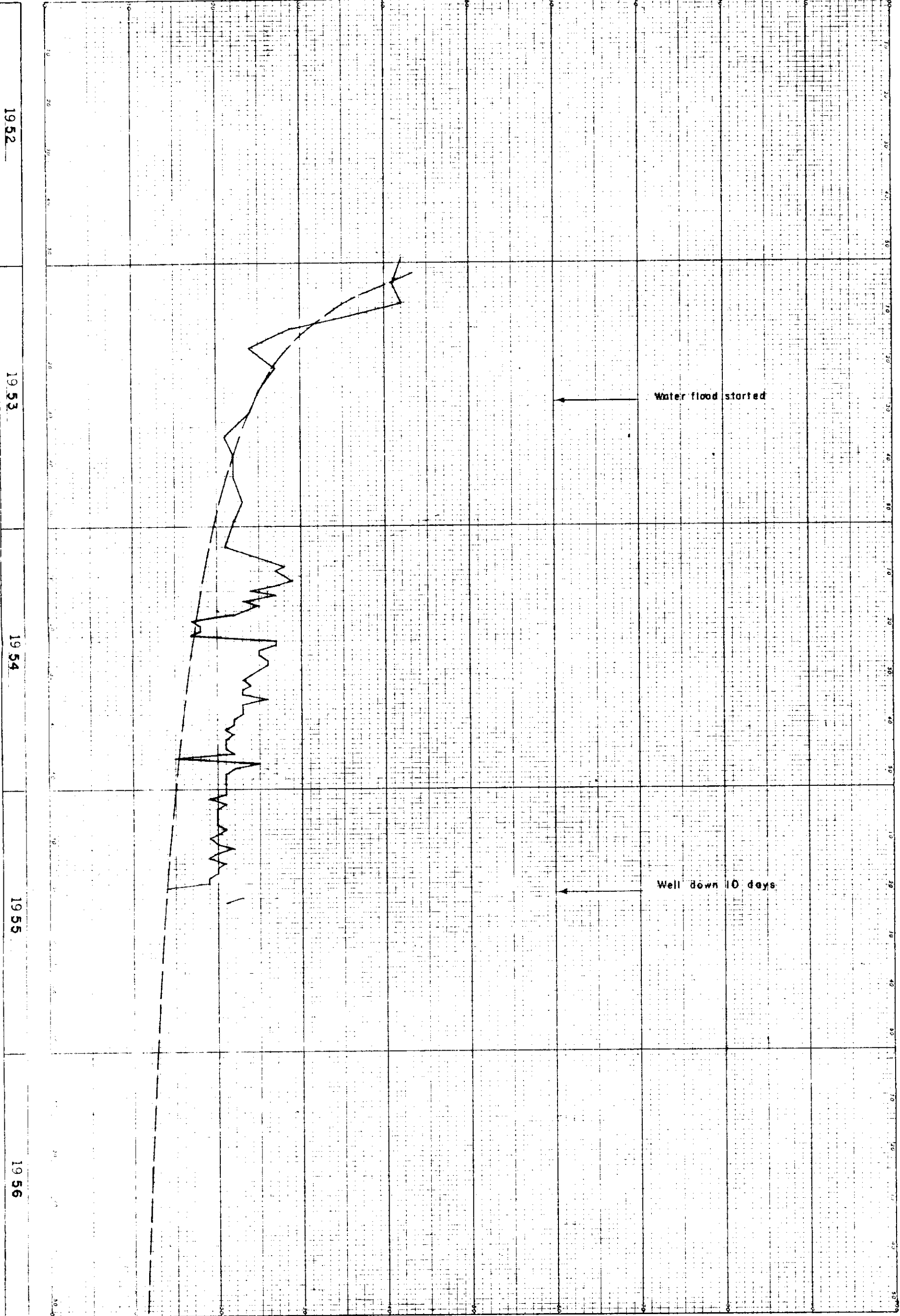
1954

1955

1956

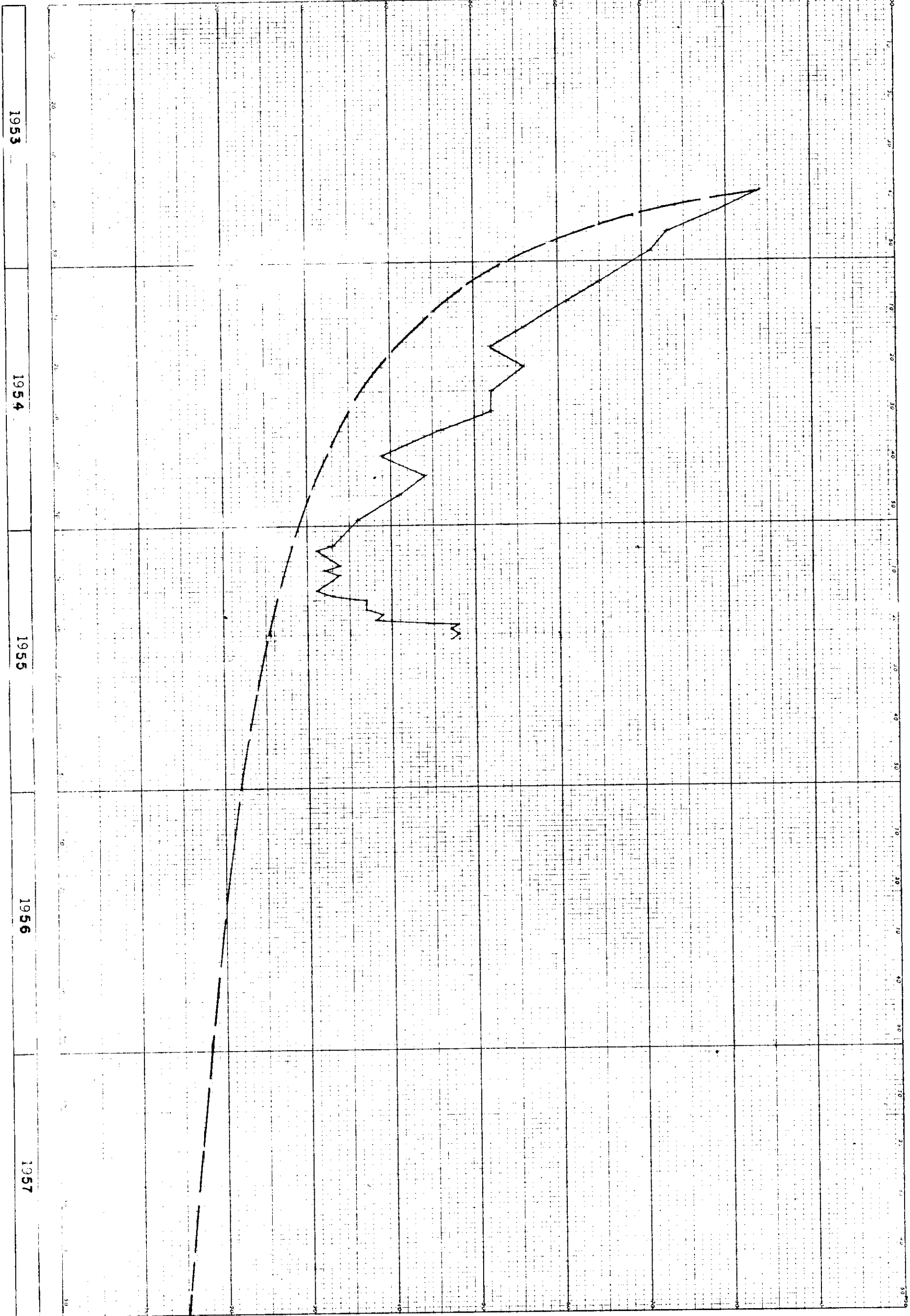
PRODUCTION RATE BARRELS / DAY

PRODUCTION DECLINE CURVE
DALY 13-1



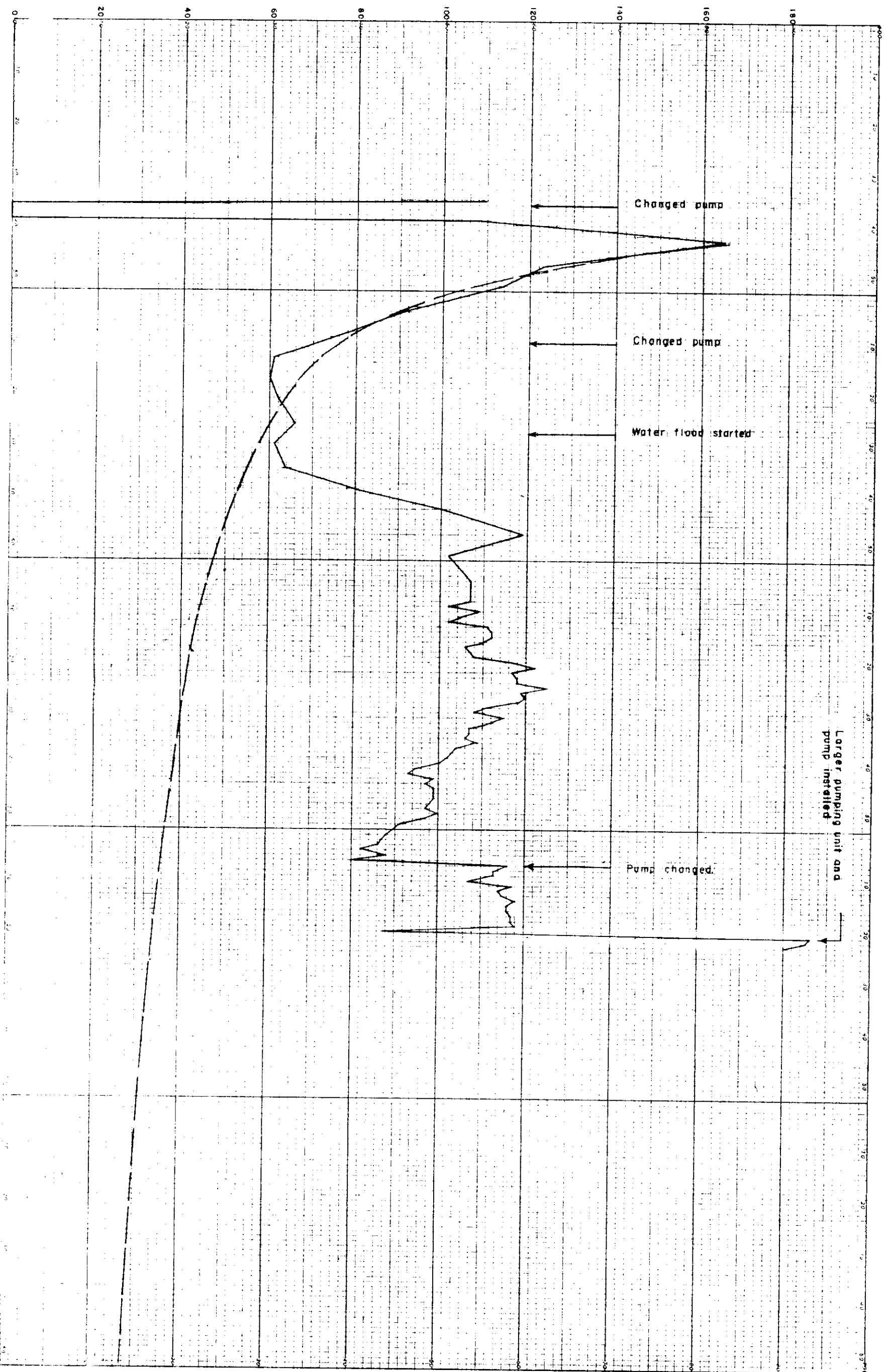
PRODUCTION RATE BARRELS / DAY

PRODUCTION DECLINE CURVE
DALY 1-11



PRODUCTION DECLINE CURVE
DALY 3-12

PRODUCTION RATE BARRELS/DAY



1952

1953

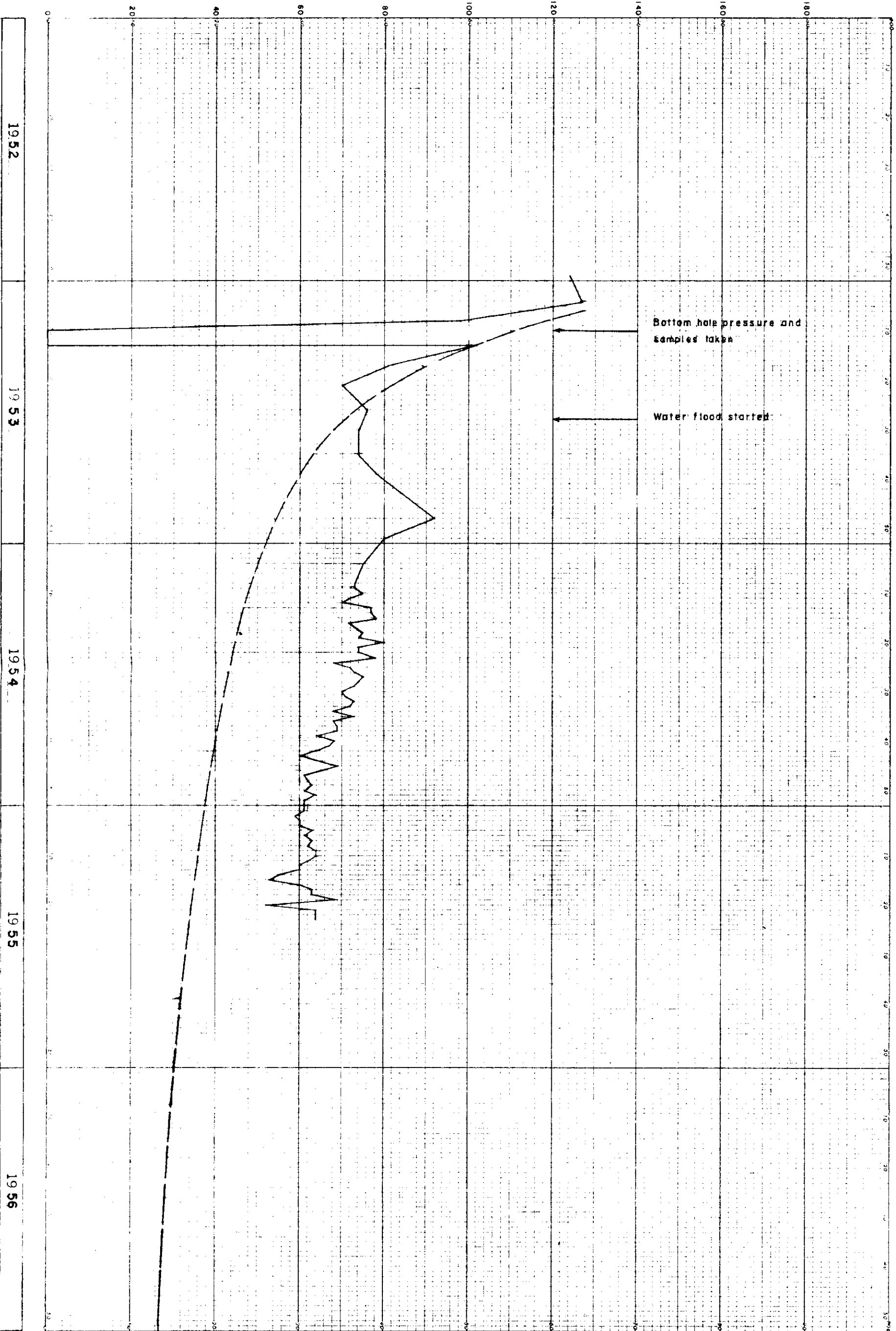
1954

1955

1956

PRODUCTION RATE BARRELS/DAY

PRODUCTION DECLINE CURVE
DAILY 4-12



PRODUCTION RATE BARRELS/DAY

PRODUCTION DECLINE CURVE
DALY 6-12

Sandfrac with 9500 lb sand
and 260 bbls. oil

Converted to water injection well

1953

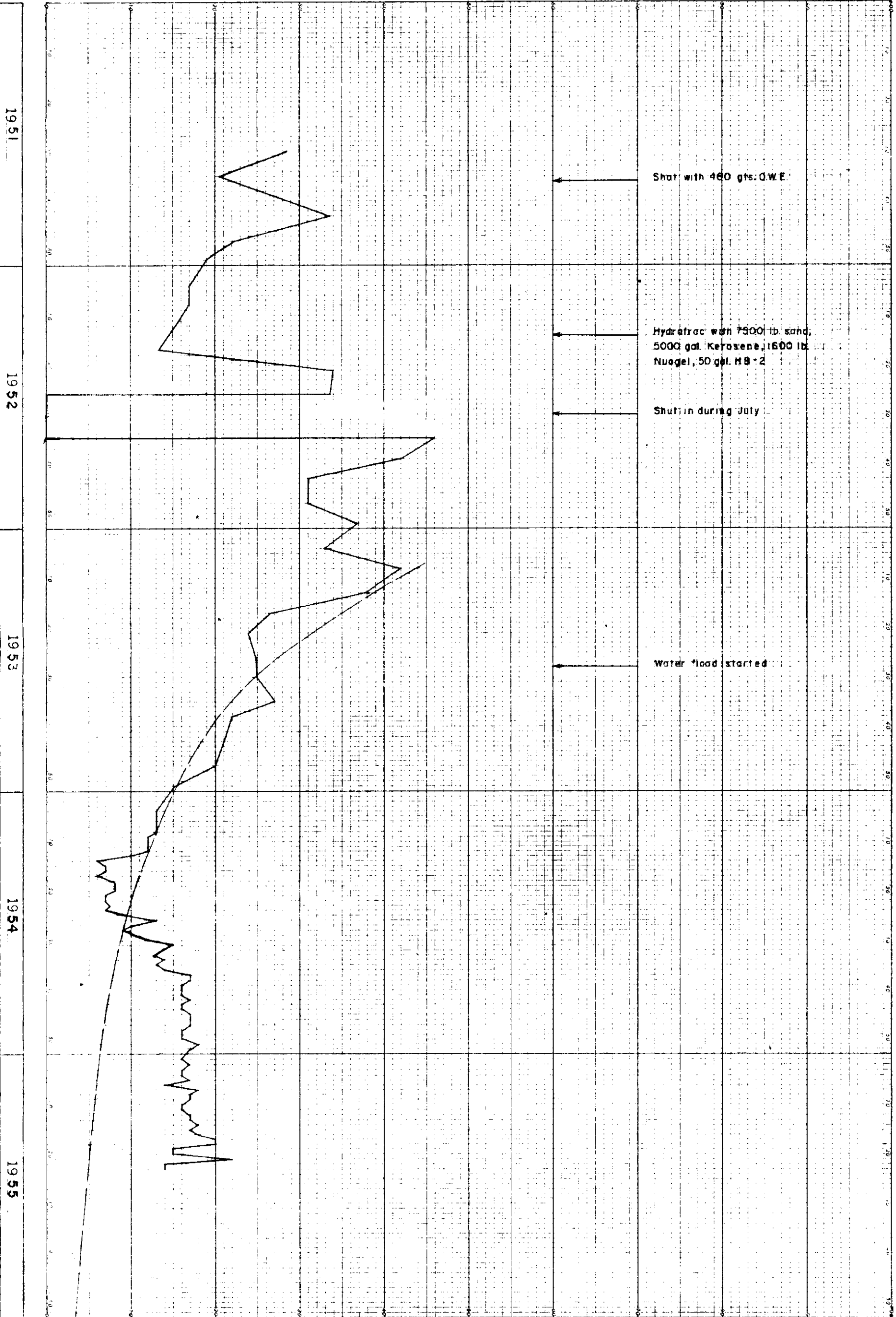
1954

1955

1956

1957

PRODUCTION DECLINE CURVE
DALY 7-12



PRODUCTION RATE BARRELS/DAY

PRODUCTION DECLINE CURVE
DALY 11-12

