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# COLUMBIA RIVER FLOW-TIME CALCULATIONS

by

J. K. Soldat

Regional Monitoring Operation

RADIATION PROTECTION OPERATION
HANFORD LABORATORIES OPERATION

November 21, 1958

HANFORD ATOMIC PRODUCTS OPERATION
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## COLUMBIA RIVER FLOW-TIME CALCULATIONS

J. K. Soldat, Regional Monitoring Operation

Re-appraisal of the available data on flow times of the Columbia River between the reactor areas and Pasco was undertaken to permit extrapolation of the flow-time curves to lower river flow rates. Comparisons were made between data collected by the U.S. Corps of Engineers(1) and Regional Monitoring(2) and with the equation for calculation of flow times developed by H. T. Norton(3). Extrapolation of the Regional Monitoring float study data to a flow of $3 \times 10^5$ gallons per second was accomplished by comparison with the slope of the curve obtained from the U.S. Corps of Engineers data; the latter covered flow times from 100-F Area to Pasco over a range of $3.4 \times 10^5$ gps to $3.7 \times 10^6$ gps. The revised flow-time curves are illustrated in Figures 1 through 6.

The mileage scale used in these six figures is the one established by J. F. Honstead in 1950. On this scale, Mile 0 is at the 107-B Outfall (bubble) and subsequent mileage is measured downstream along the shoreline. Other scales in use employ mileage along the main channel measured from either the mouth of the Columbia River or from the point where the Canadian Border crosses the river. Table I summarizes the relationship of these various scales.

### TABLE I

### Comparison of Various Columbia River Mileage Scales

| Regional Monitoring Scale | Miles from Mouth of Columbia | Miles from Canadian Border | Location |
|---|---|---|---|
| 0 | 384.2 | 364.5 | 107-B Outfall |
| 2.5 | 382.0 | 366.7 | 181-KE & 107 KE&KW Outfall |
| 7.2 | 377.3 | 371.4 | 107-D Outfall |
| 11.1 | 372.5 | 376.2 | 107-H Outfall |
| 14.5 | 368.5 | 380.0 | 107-F Outfall |
| 20.5 | 361.4 | 387.0 | Hanford Ferry Crossing |
| 31.5 | 350.4 | 398.3 | Power Line Crossing |
| 37.0 | 345.0 | 403.8 | Just above 300 Area |
| 41.1 | 340.9 | 408.0 | Richland Ferry Crossing |
| 43.0 | 339.0 | 410.2 | Richland (opposite Central Fire Hall) |
| 53.5 | 327.9 | 421.0 | Pasco Pumping Plant Intake |

Since the equation of H. T. Norton no longer applies, a new pair of equations were derived to fit the curves of Figure 1 over the range of $(>3 \text{ to} <30) \times 10^5$ gps.

(1) $Y = \frac{a}{X^{0.67}}$ (2) $Y = \frac{b}{X^{0.4}}$

where: Y is the river flow-time to Pasco in hours
X is the river flow rate in units of $10^5$ gps,

while a and b take the values listed in Table II.

TABLE II

| | 100-B, C | 100-KW, KE | 100-D, DR | 100-H | 100-F |
|---|---|---|---|---|---|
| a | 86 | 82 | 76 | 70 | 67 |
| b | 47 | 46 | 43 | 39 | 36 |

Equation (1) applies over the range of (>3 to<10) x $10^5$ gps. It fits the extrapolated curves to within 3% between (3.5 and 9.0) x $10^5$ gps, and is up to 10% low of the extremes of 3 x $10^5$ and 10 x $10^5$ gps.

Equation (2) applies over the range of river flows of (10 to<30) x $10^5$ gps. This equation fits the flow-time curves to within 3% from (10 to 20) x $10^5$ gps. The calculated flow times are up to 5% low at 25 x $10^5$ gps and up to 10% low at 30 x $10^5$ gps.

Flow-times between points other than one reactor area and Pasco can be found from Figures 2 through 6. In addition, the flow-times between two reactor locations can be obtained from either equations (1) and (2) or Figure 1 by calculating the difference between the flow-times from each of the reactor areas to Pasco.

An attempt was made to establish a set of equations for calculating the flow times from any reactor area to 100-F. Such equations would avoid the compounding of errors encountered when subtracting two calculated results. In most instances three equations were needed to describe the flow times to 100-F over the whole range of flows (3 to 35) x $10^5$ gps needed. Because of this multiplicity of equations, the procedure outlined above for subtraction of two calculated results should be more convenient and should yield results within ±10% of the value obtainable from the flow-time curves, Figures 2 to 6.

A significant break in the slope of the flow-time curves is apparent when the data are plotted on logarithmic paper. This break occurs at a river flow of about 1 x $10^6$ gps. A major change in the shape of the river cross-section and/or a significant change in the distribution of velocities across the river must occur near this flow rate. There are two locations within the project where the main river channel shifts at high water flow. In both instances the new channel flows through previously dry sloughs, creating islands. Inspection of charts of river flow rates versus water elevations at 181-F Building, and of river sounding charts, revealed that the dry slough above 100-F should become filled with water at about 1.0 x $10^6$ gps. The dry slough below 100-F should be filled at a flow of 1.5 x $10^6$ gps. At Savage Island, a breakthrough of water around the northeast side of the island (through Jap Slough) also should occur at about 1.5 x $10^6$ gps. No major shift in main river channel occurs at Savage Island at high water flows, but the change in relative velocity distribution has some effect on the river travel time.

## LITERATURE CITED

(1) Roebeck, G. G., Hendersen, D., Palange, R. C. - GEH-21,328 - Water Quality Studies on the Columbia River, U. S. Public Health Service, 1954.

(2) Soldat, J. K. - HW-41275, Unclassified, Columbia River Travel Time Measurements by Float Methods.

(3) Letter from H. T. Norton, Radiological Chemical Analysis Operation, dated April 2, 1957, and containing the following equation:

$$y = \frac{48a + bx}{a + x}$$

where: $y$ = Travel time to Pasco in hours
$x$ = River flow in $10^5$ gallons per second

while a and b were defined as follows:

| Reactor Area | a | b |
|---|---|---|
| B, C | 7.99 | 3.12 |
| KW, KE | 7.10 | 3.58 |
| D, DR | 6.07 | 4.14 |
| H | 4.91 | 4.67 |
| F | 4.24 | 4.54 |

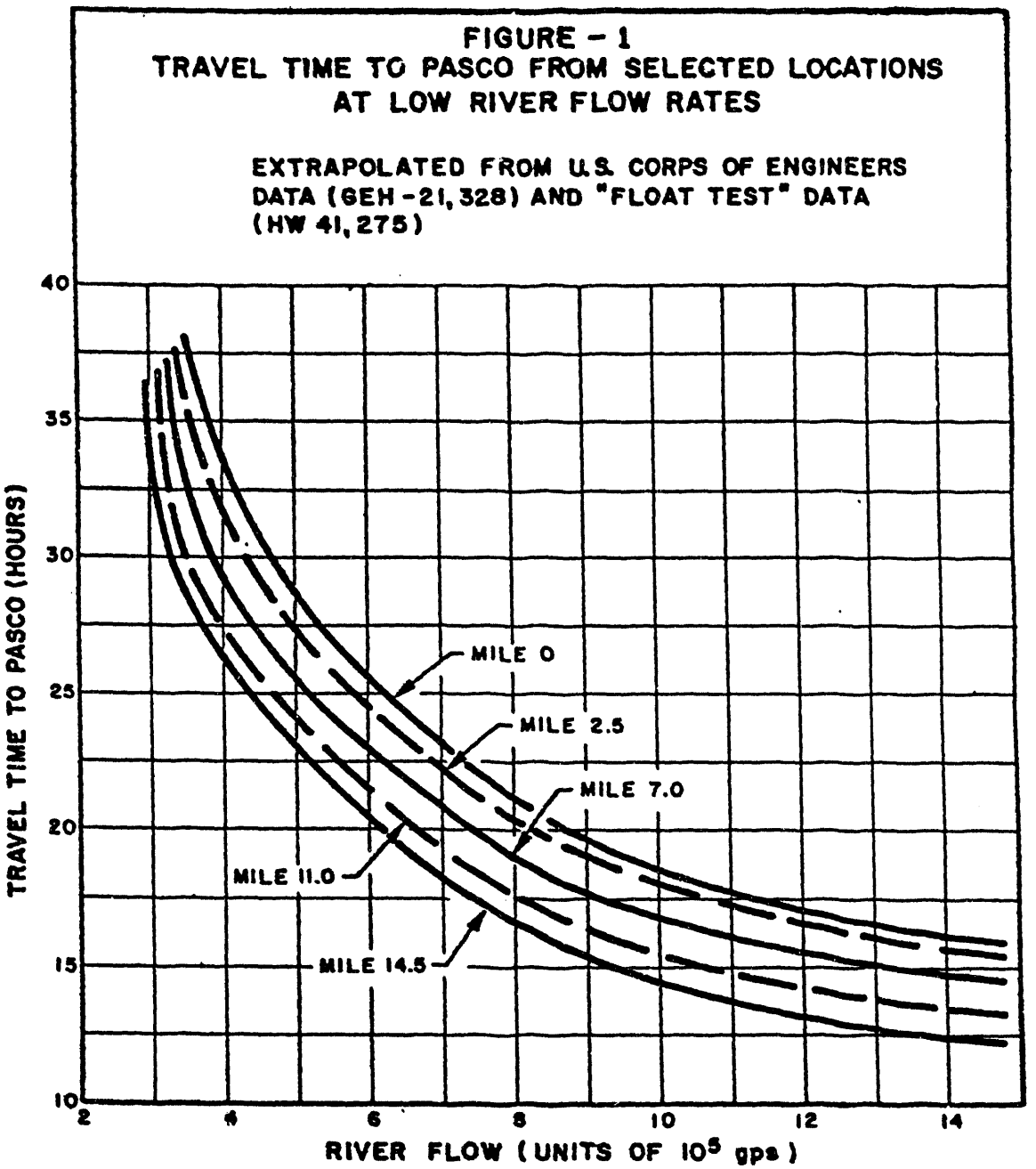
FIGURE - 1
TRAVEL TIME TO PASCO FROM SELECTED LOCATIONS
AT LOW RIVER FLOW RATES
EXTRAPOLATED FROM U.S. CORPS OF ENGINEERS
DATA (GEH-21,328) AND "FLOAT TEST" DATA
(HW 41,275)
TRAVEL TIME TO PASCO (HOURS)
40
35
30
25
20
15
10
2
4
6
8
10
12
14
RIVER FLOW (UNITS OF 10^5 gps)
MILE 0
MILE 2.5
MILE 7.0
MILE 11.0
MILE 14.5

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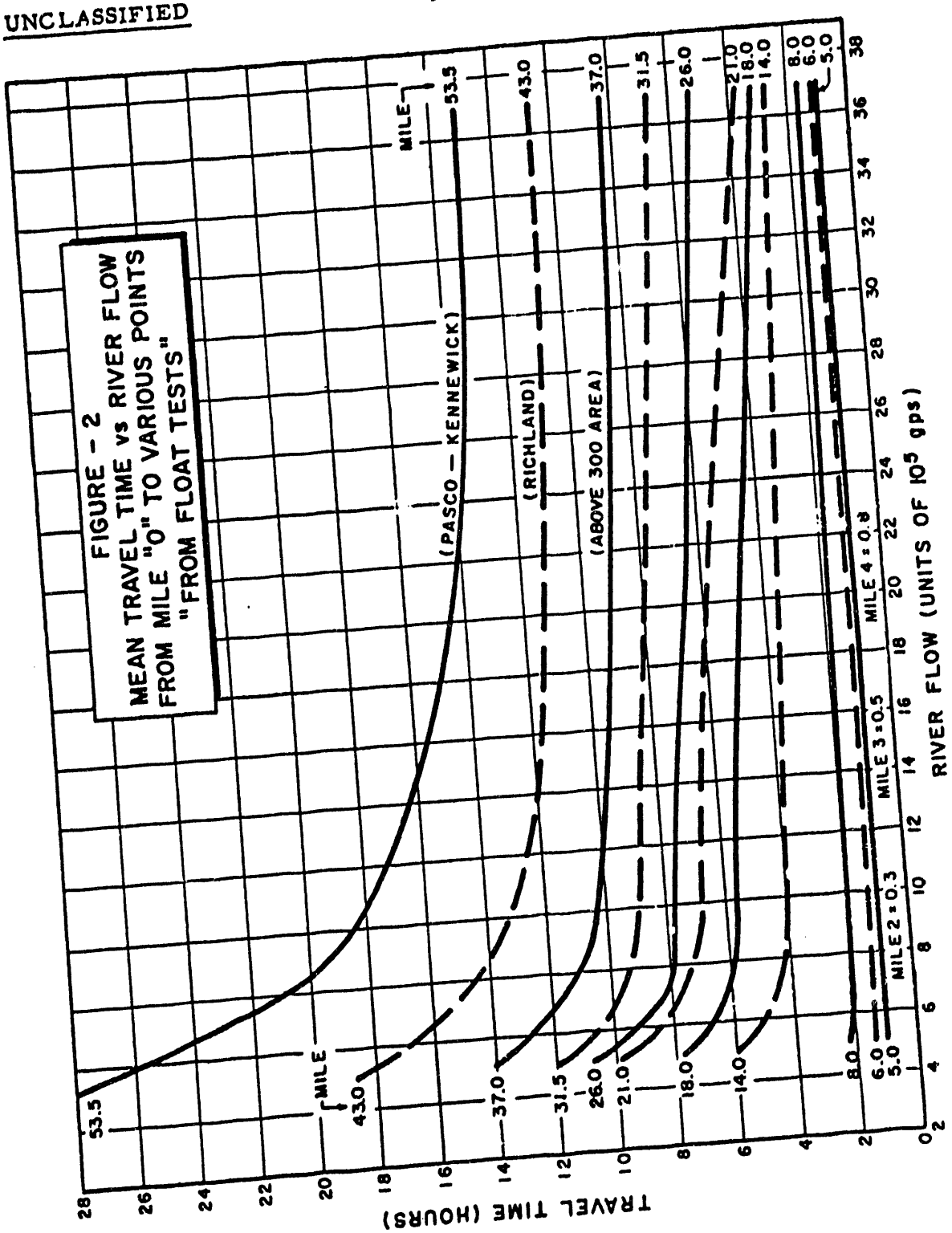


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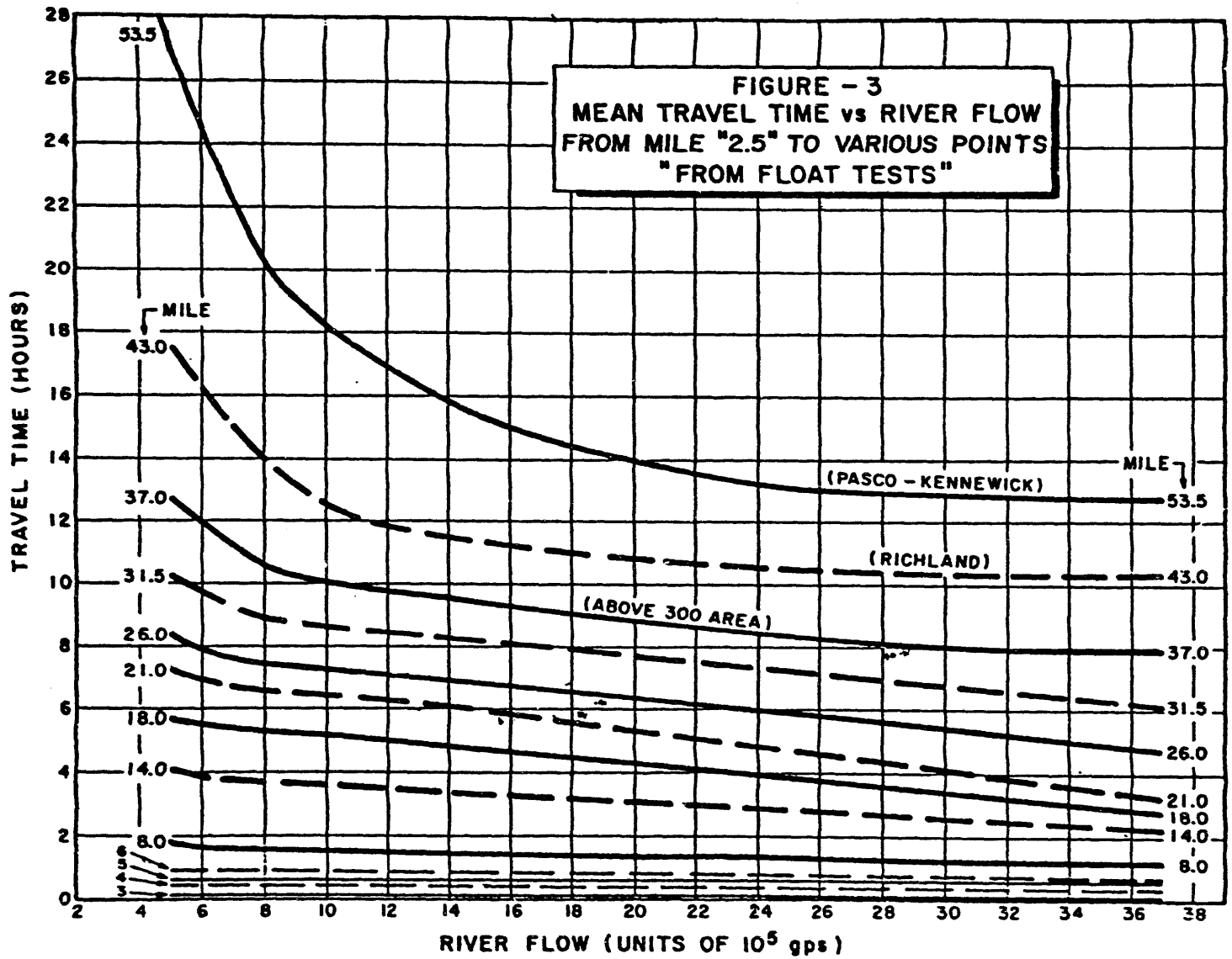


FIGURE - 3
MEAN TRAVEL TIME vs RIVER FLOW
FROM MILE "2.5" TO VARIOUS POINTS
"FROM FLOAT TESTS"
TRAVEL TIME (HOURS)
RIVER FLOW (UNITS OF 10^5 gps)
MILE
(PASCO - KENNEWICK)
(RICHLAND)
(ABOVE 300 AREA)
53.5
43.0
37.0
31.5
26.0
21.0
18.0
14.0
8.0
6
5
4
3

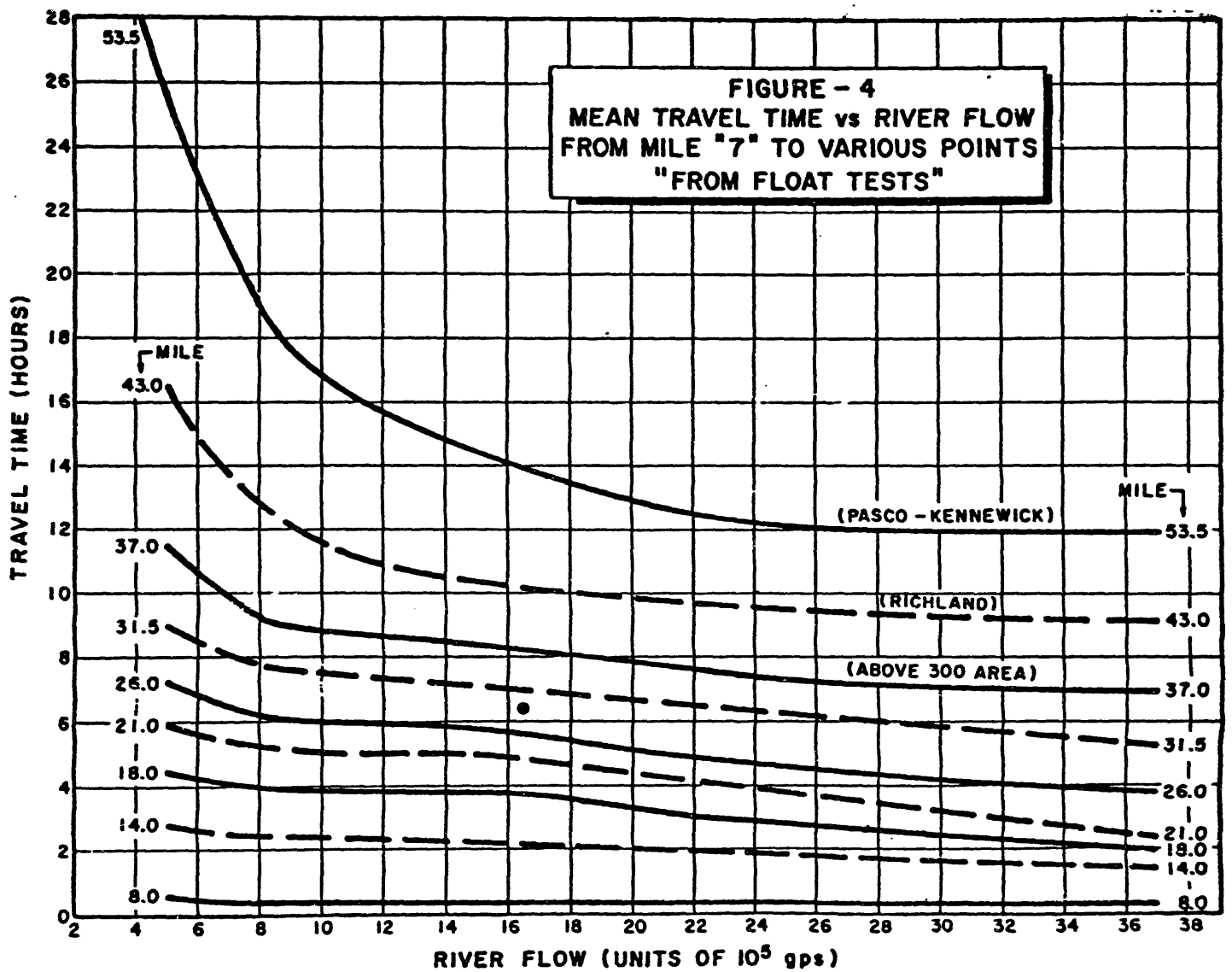
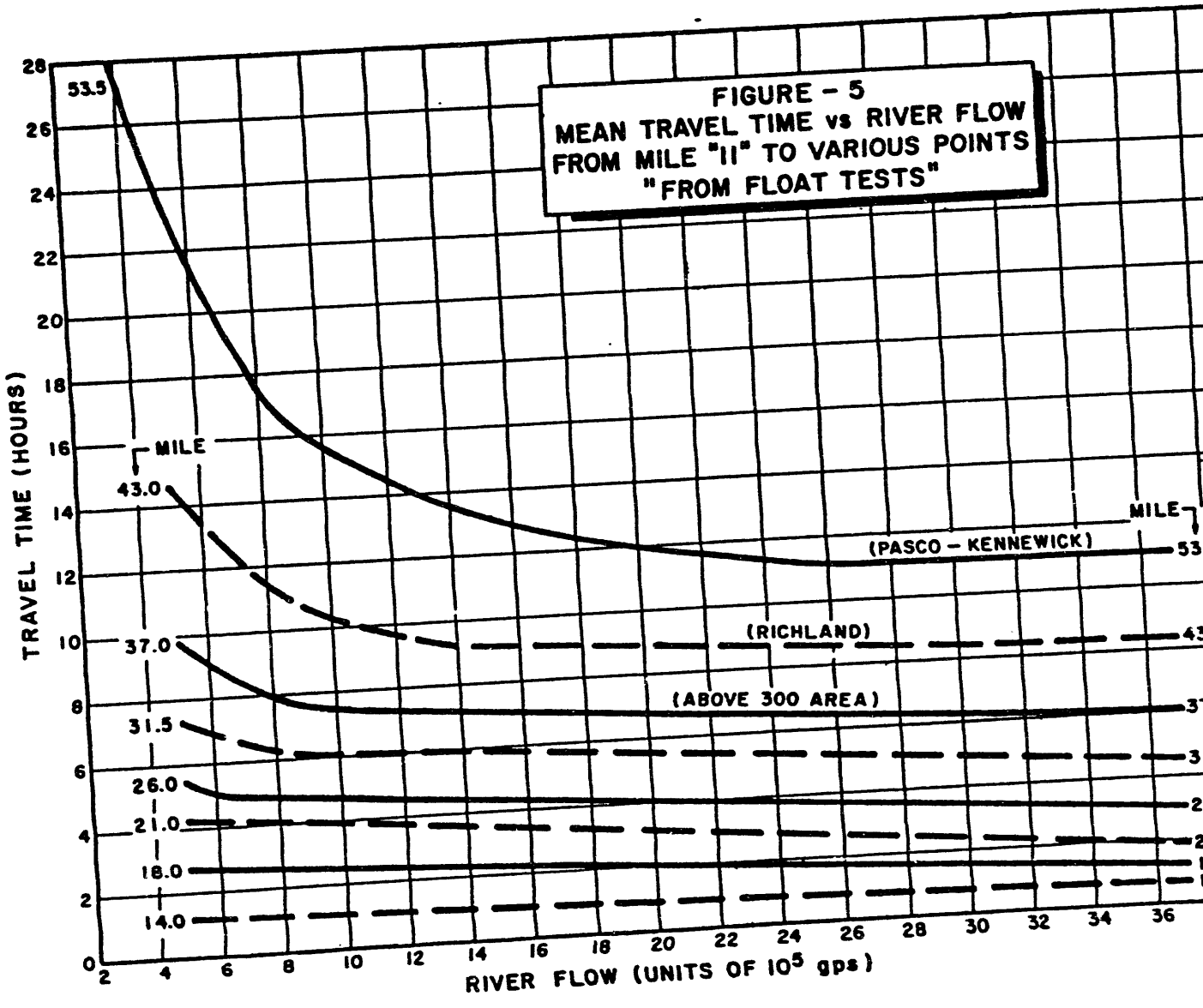


FIGURE - 4
MEAN TRAVEL TIME vs RIVER FLOW
FROM MILE "7" TO VARIOUS POINTS
"FROM FLOAT TESTS"
TRAVEL TIME (HOURS)
RIVER FLOW (UNITS OF $10^5$ gps)
MILE
53.5
43.0
37.0
31.5
26.0
21.0
18.0
14.0
8.0
(PASCO - KENNEWICK)
(RICHLAND)
(ABOVE 300 AREA)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38

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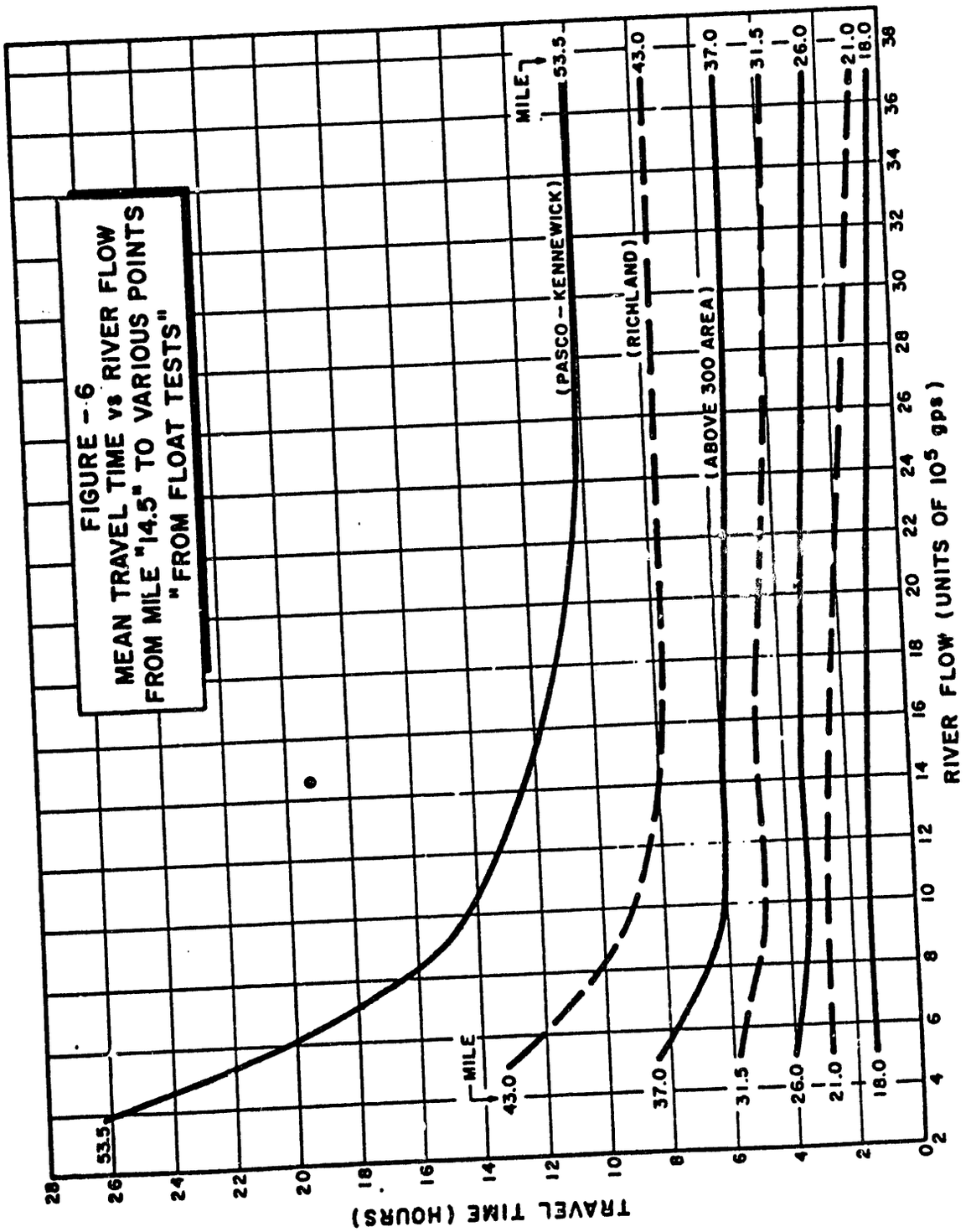


FIGURE – 6
MEAN TRAVEL TIME vs RIVER FLOW
FROM MILE "14.5" TO VARIOUS POINTS
"FROM FLOAT TESTS"

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