UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC DOWNPULL COMPUTATIONS FOR GLENDO DAM FIXED-WHEEL GATE MISSOURI RIVER BASIN PROJECT, WYOMING

Report No. Hyd-524

Hydraulics Branch
DIVISION OF RESEARCH

OFFICE OF CHIEF ENGINEER
DENVER, COLORADO

April 3, 1964

CONTENTS

ABSTRACT

The hydraulic downpull forces that will be caused by 2-minute closures of the 16.5- by 21.0 foot Glendo Dam outlet works fixed-wheel gate were computed. Previous model studies (Hydraulics Laboratory Report No. Hyd-421, February 8, 1957) evaluated the hydraulic downpull for a stable condition of flow with the gate stationary at various openings. The present computation showed the added downpull caused by water trapped in the shaft above the gate during rapid closures to be about 4,500 pounds for gate openings larger than 3 feet. No additional downpull occurred at openings smaller than 3 feet. The maximum downpull of 40,000 pounds that occurs at 0.25 foot gate opening remains the maximum and unchanged.

DESCRIPTORS--*Hydraulic downpull/*hydraulics/*fixed wheel gates/high pressure gates

IDENTIFIERS--Glendo Dam/emergency gate/tunnel gates

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Report No. Hyd-524
Author: D. Colgate
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HYDRAULIC DOWNPULL COMPUTATIONS FOR GLENDO DAM FIXED-WHEEL GATE--MISSOURI RIVER BASIN PROJECT, WYOMING

PURPOSE

These computations were made to determine the effect of rapid gate closures on the hydraulic downpull on the fixed-wheel gate at Glendo Dam.

CONCLUSIONS

The maximum hydraulic downpull on the Glendo Dam fixed-wheel gate will be about 40,000 pounds, and will occur at a gate opening of 0.25 feet, with the reservoir at maximum elevation, and sufficient water in the downstream tunnel to submerge the gate. This maximum value will not be exceeded regardless of any expected gate opening or closing times.

Rapid closure of the gate under emergency conditions will cause an increase in hydraulic downpull in certain noncritical gate opening ranges (Figure 6). These ranges do not include the gate opening producing maximum downpull, and the maximum force is unaffected.

INTRODUCTION

Glendo Dam is located on the North Platte River in southeastern Wyoming about 5 miles from the town of Glendo (Figure 1). The intake structure for the combined power and outlet works penstock is about 2,500 feet upstream from the dam. The 2,323-foot-long penstock passes under a narrow peninsula that forms a bend in the river on which the dam is located (Figure 2). The emergency gate for the penstock is a 16.5- by 21-foot upstream seal, fixed-wheel gate (Figure 3) placed 515 feet from the intake structure.

Model studies were completed in 1957 concerning the hydraulic downpull on the fixed-wheel gate. The results are shown in Figure 7, Report No. Hyd-421, 1/ and are repeated in Figure 6, Curve A, of this report. For the model study, an assumption was made that the penstock was ruptured, or fully opened, at the downstream end, and the head downstream from the emergency gate reflected the tunnel losses from the gate to the opened end. Also, the water surface in the gate shaft was assumed to be the same as the head downstream from the gate. The results were plotted for various positions of the gate under stable conditions; i.e., no relative change of water depth in the gate shaft with respect to time, and no changes in upstream or downstream discharges. The study indicated that a maximum hydraulic downpull of about 40,000 pounds occurred when the gate was opened 3 inches, and the hoisting mechanism was designed to handle this load.

Actually, all of the water which drains from the gate shaft passes between the downstream face of the gate and the gate shaft wall. The head differential between the shaft and the downstream tunnel will depend on the position of the gate and the direction and velocity of gate movement. The total downpull will be affected by this added differential, and worst conditions will occur during a rapid closure when the water backed up in the gate shaft by normal penstock pressure has too little time to drain from the shaft. To determine the magnitude of this additional force, computations were requested by the design engineers. The approximate minimum closure time of 2 minutes was used in the computations.*

The computations in this report are based on the model study results shown in Report No. Hyd-421, but with the additional head in the gate shaft resulting from a gate closure time of 2 minutes.

COMPUTATION

The installation of the Glendo fixed-wheel gate is shown in Figure 3. The area of the flow passage between the upstream face of the gate and seal seat is 4.13 square feet when the gate is 3 feet or more open. When the gate is between 0 and 3 feet open, this

1/Model Studies of Hydraulic Downpull Forces that Act on the Palisades-type Regulating Slide Gate, and on the Glendo Fixed-wheel Gate, Bureau of Reclamation, February 8, 1957.
*The gate closure time is not a constant, but will vary with the closing conditions. Two minutes is about a minimum.

flow passage is closed. The area between the gate and the downstream face of the gate shaft is 72.9 square feet. The gate shaft cross-sectional area is 202.5 square feet, and the gate cross-sectional area is 68.7 square feet.

Figure 4A shows the relationship between the downstream tunnel head and the gate opening in feet, and the elapsed time in seconds, for the emergency closure condition shown in Report No. Hyd-421, Figure 7A. The downpull shown in Report No. Hyd-421 was based on the downstream tunnel head.

The computed discharge from the upstream tunnel into the gate shaft, and the discharge from the gate shaft into the downstream tunnel is shown in Figure 4B. A discharge coefficient of 1.0 was assumed for this computation since the flow passages are of odd and irregular shape and an exact coefficient could be determined only by calibration. The discharge into the gate shaft from the upstream tunnel is based on the differential between the reservoir, and the gate shaft water surface. The discharge from the shaft into the downstream tunnel is based on the head differential between the gate shaft and the downstream tunnel.

The next step in the computation concerned the water volume change in the gate shaft as the water surface subsided, the volumes of water discharged into the shaft upstream from the gate and the volumes of water discharged out of the shaft into the downstream tunnel (Figure 5A). The computation was based on the conditions that existed at 1-second intervals for the initial 10 seconds of gate movement, 2-second intervals for the next 40 seconds, and 5-second intervals for the remaining 70 seconds. The results were computed for an elapsed time of 104 seconds, at which time the gate will reach a 3-foot opening and the top seal will stop inflow into the gate shaft (Figure 5A).

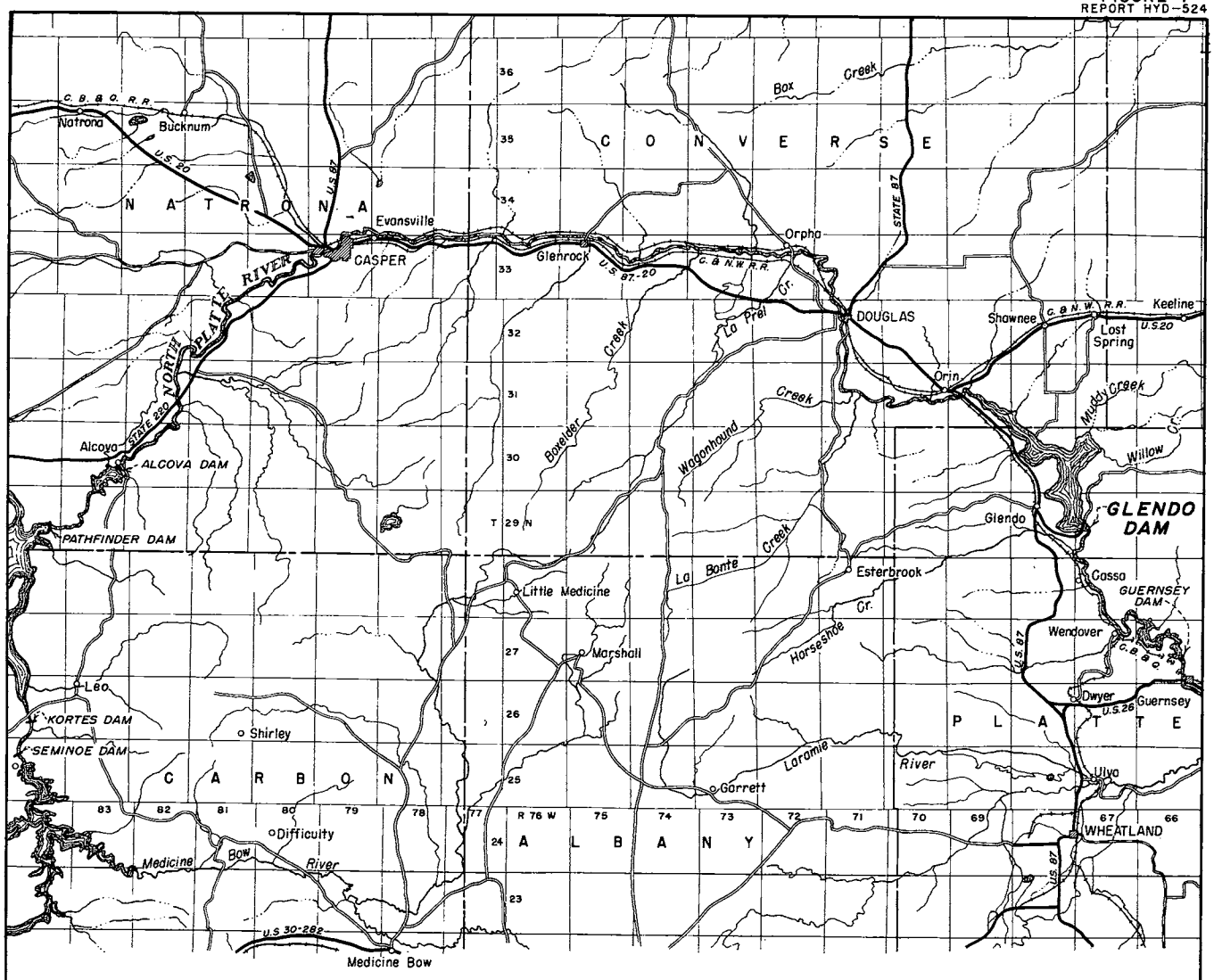
By combining the total volume discharged and the computed discharge curve shown in Figure 4B, a curve was drawn showing the head differential between the gate shaft and the downstream tunnel (Figure 5B). This curve shows that the maximum differential of 1.7 feet will occur after a gate travel time of 5 seconds, or when the gate is approximately 20 feet open (Figure 4A).

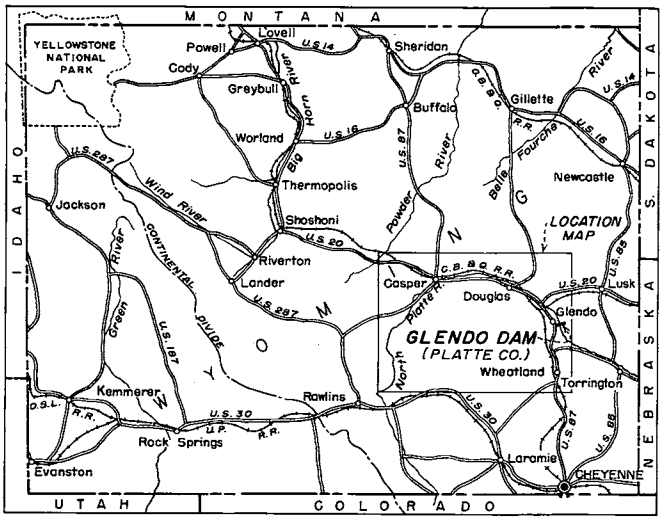
The results of the present computation and the model studies performed in 1957 are shown in Figure 6. Curve B, Figure 6, is the additional downpull which will result from the head differential shown in Figure 5B, Curve A is the downpull as shown in Report No. Hyd-421, and Curve C is the combined total downpull.

In the model studies of the Glendo fixed-wheel gate, the maximum downpull was determined to be 39,750 pounds and occurred at a gate opening of 0.25 feet. In the range of gate opening from 0 to 3 feet, there will be no additional downpull since there will be no flow past the upstream seal into the gate shaft; and, therefore, no additional head above the gate. For gate openings larger than 3 feet, the additional downpull will average about 4,500 pounds, with a peak additional downpull of 7,400 pounds occurring at a gate opening of 20.3 feet. The revised total hydraulic downpull curve, Figure 6, Curve C, shows that the maximum downpull of about 40,000 pounds will not be exceeded.

The Glendo Dam fixed-wheel gate hoisting mechanism designed for the dead weight of the system plus 40,000 pounds hydraulic downpull (with suitable safety factors) is adequate. Gate closure times as rapid as 2 minutes will not cause hydraulic downpull in excess of 40,000 pounds.

FIGURE 1
REPORT HYD-524





KEY MAP

LEGEND

OILED OR PAVED ROADS
GRAVELED ROADS
IMPROVED ROADS

N.

10 0 10 20
SCALE OF MILES

6 - 26 - 58 700	ADDED GLENDO LAKE

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MISSOURI RIVER BASIN PROJECT
OREGON TRAIL DIVISION - GLENDO UNIT - WYO.

GLENDO DAM

LOCATION MAP

DRAWN R. B. R. - E. C. P. SUBMITTED J. J. Hammond
TRACED W. J. O. RECOMMENDED [illegible]
CHECKED [illegible] APPROVED L. N. McClellan
CHIEF ENGINEER

DENVER, COLORADO, AUG. 30, 1954

449-D-110

FIGURE 2
REPORT HYD-524

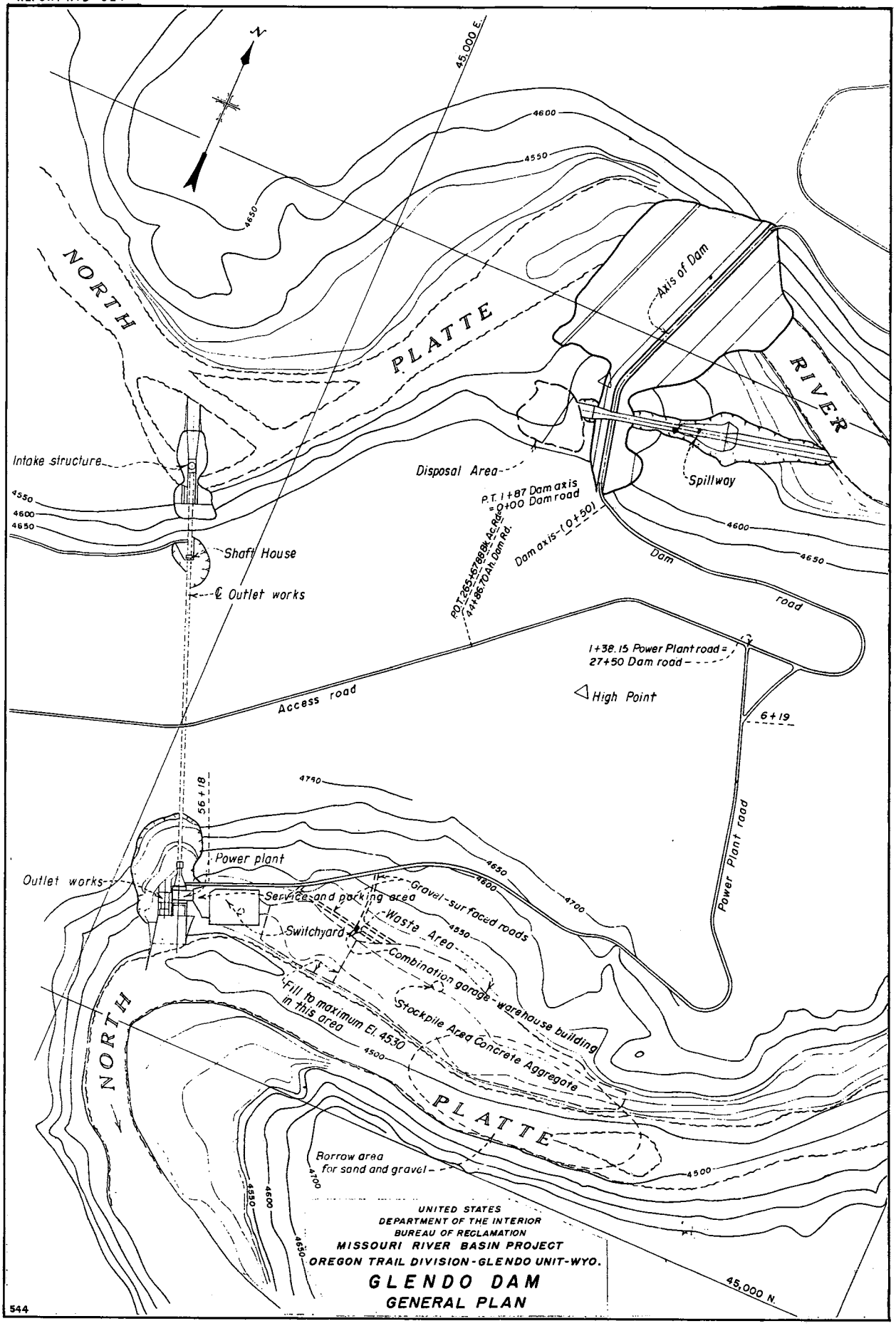
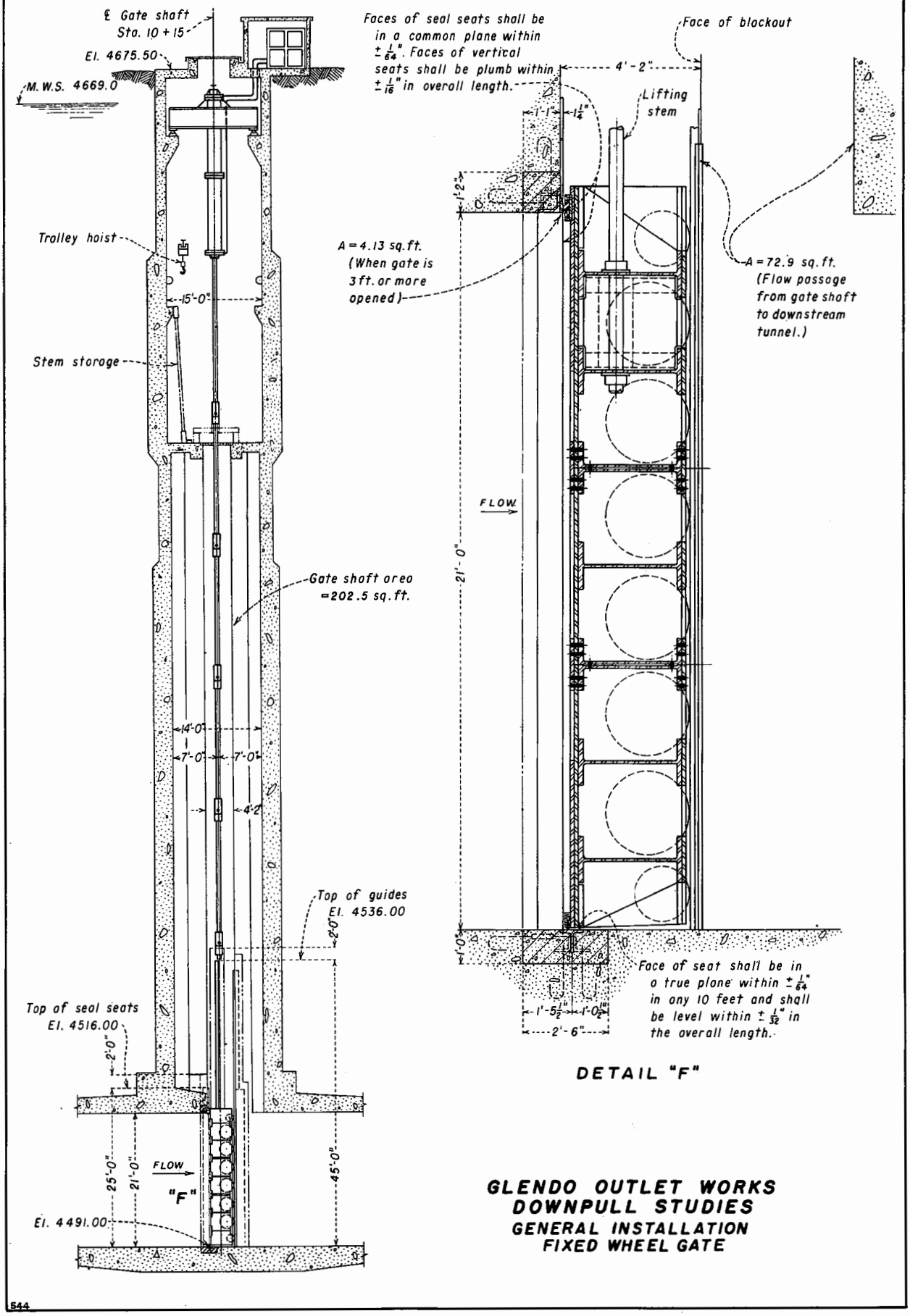


FIGURE 3
REPORT HYD-524



DETAIL "F"

GLENDO OUTLET WORKS
DOWNPULL STUDIES
GENERAL INSTALLATION
FIXED WHEEL GATE

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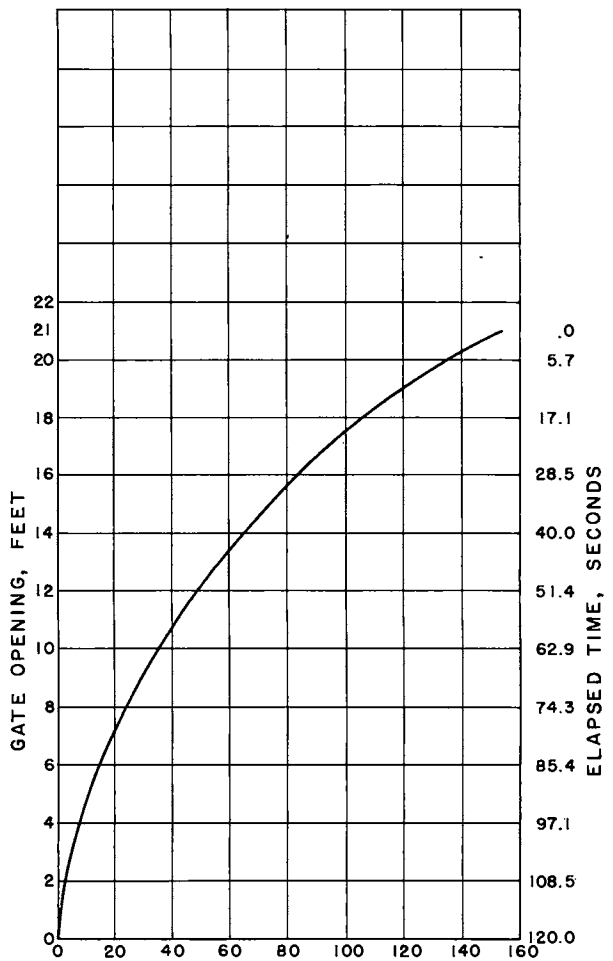
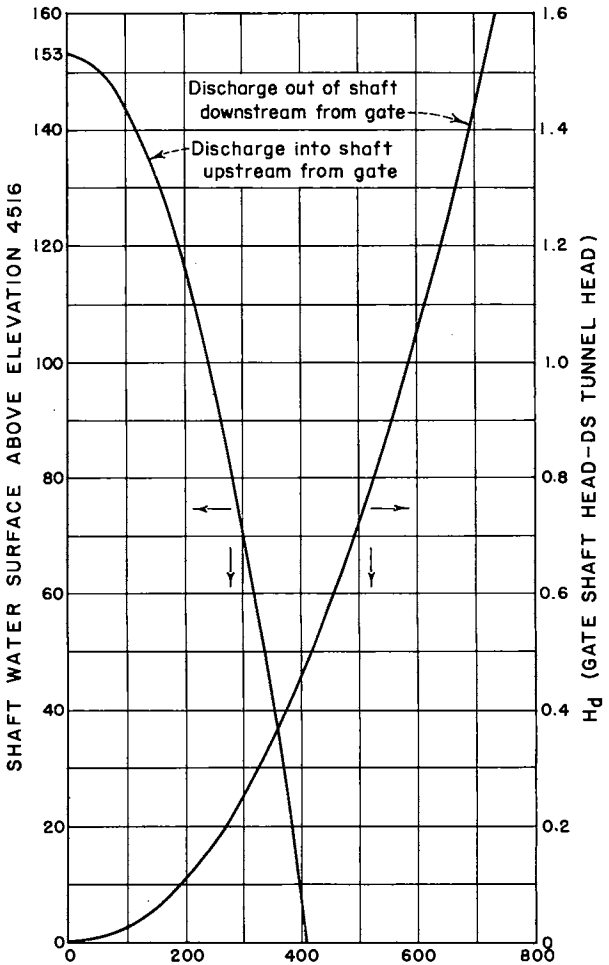


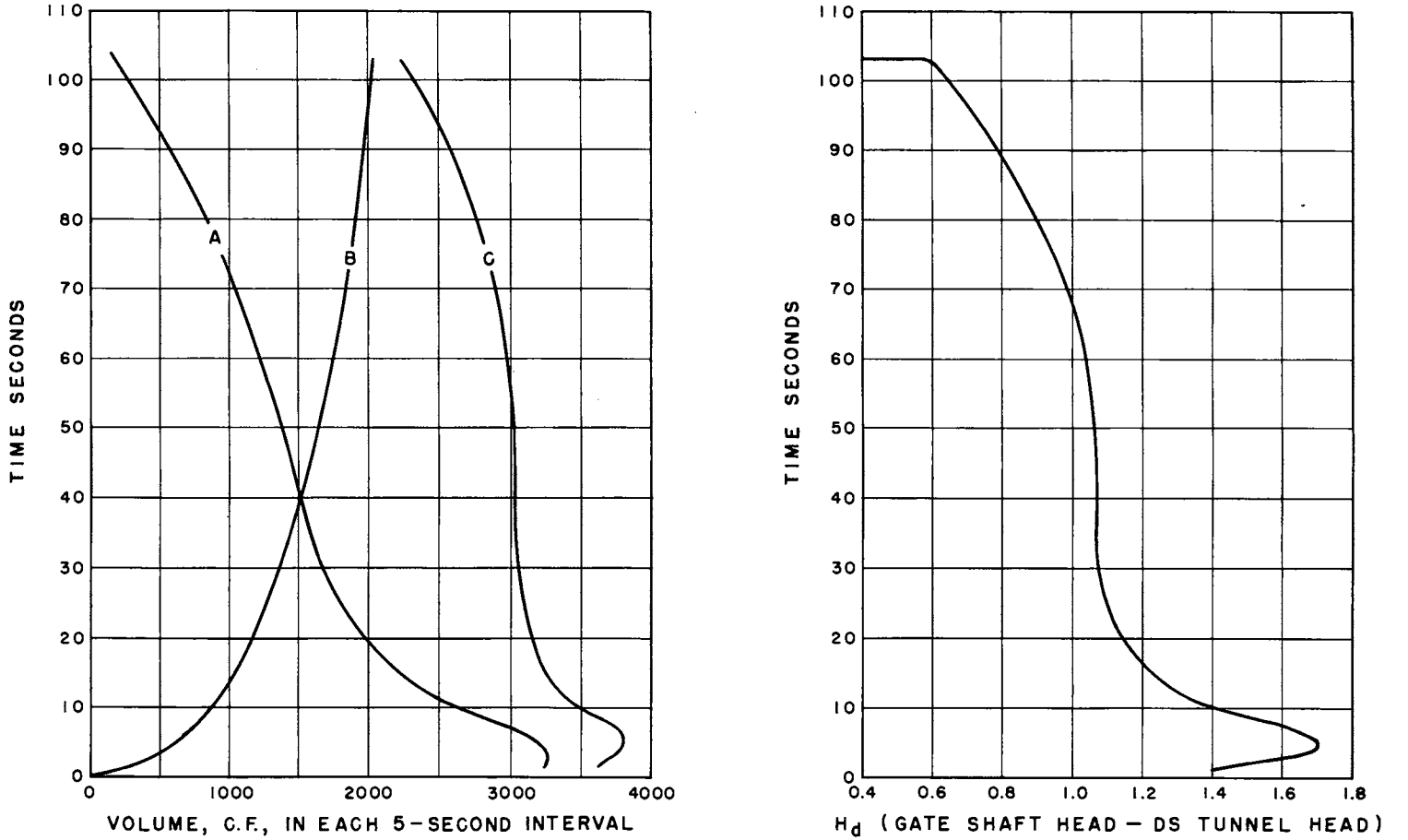
A. TUNNEL HEAD VS GATE OPENING AND TIME



B. DISCHARGE INTO AND OUT OF SHAFT

GLENDO OUTLET WORKS DOWNPULL STUDIES

TUNNEL HEAD AND DISCHARGE INTO
AND OUT OF SHAFT

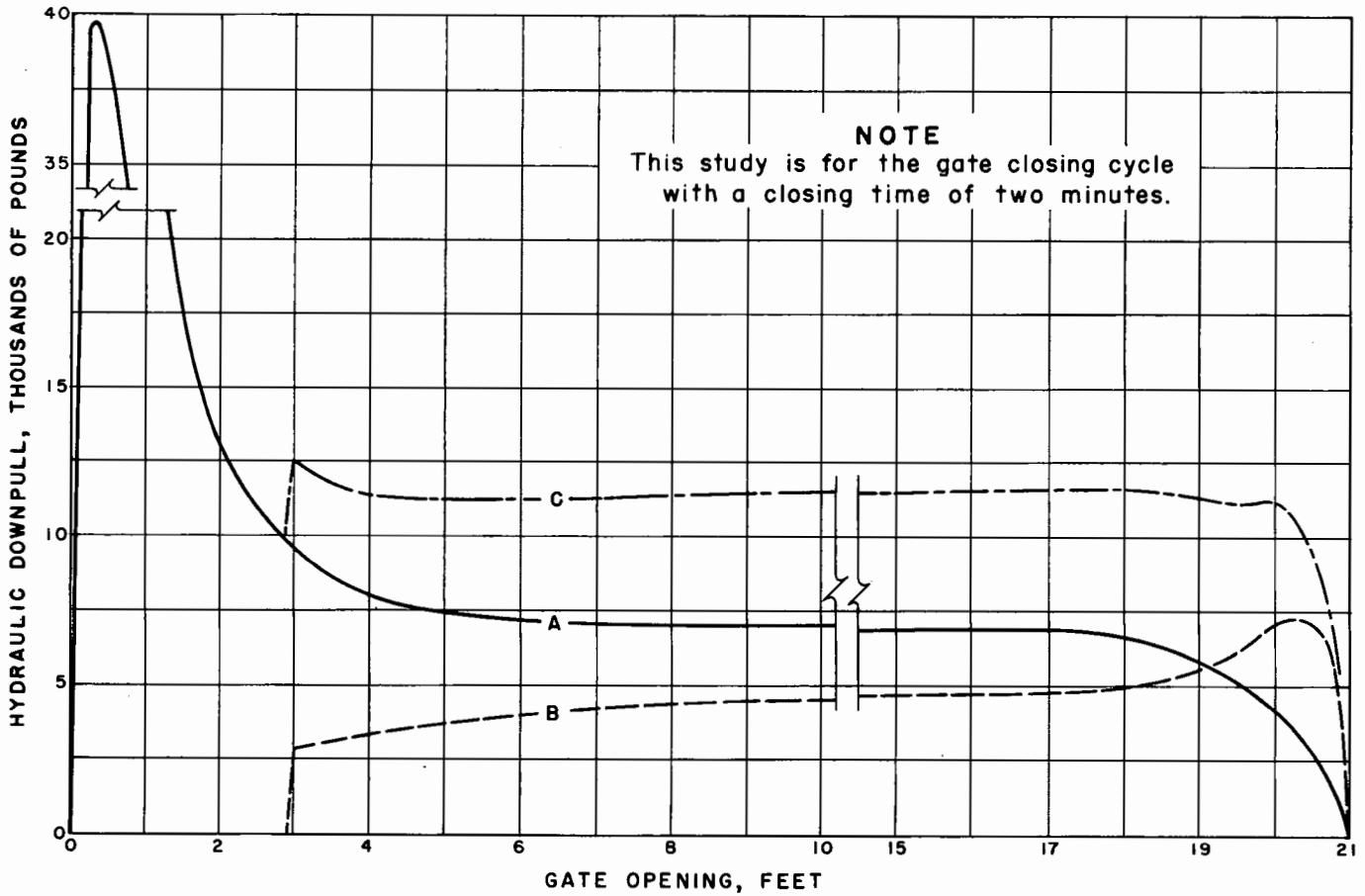


A – Volume discharged from shaft due to dropping water surface.
B – Volume discharged into shaft upstream from gate.
C – Total volume discharged from shaft downstream from gate.

GLENDO OUTLET WORKS DOWNPULL STUDIES

SHAFT WATER VOLUME CHANGE, AND
SHAFT-TUNNEL HEAD DIFFERENTIAL

FIGURE 5
REPORT HYD-524



A — Hydraulic downpull based on the head in the downstream tunnel, as determined from the model studies. (Report No. Hyd.—421, Figure 7B.)

B — Computed additional downpull due to head in the gate shaft above that in the tunnel.

C — Total downpull.

GLENDO OUTLET WORKS DOWNPULL STUDIES

HYDRAULIC DOWNPULL

GPO 841-065

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