UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF ROBLES DIVERSION DAM SPILLWAY

Hydraulic Laboratory Report No. Hyd-427

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

November 8, 1956

FOREWORD

Hydraulic model studies of Robles Diversion Dam Spillway, a part of the Ventura River Project, were conducted in the Hydraulic Laboratory of the Bureau of Reclamation at Denver, Colorado, during September and October of 1956.

During the course of these studies, Mr. Fred Houck of the Concrete Dams Section visited the laboratory to observe the model tests and to discuss test results.

These studies were conducted by G. L. Beichley aided by Wai-Han Cheng under the direct supervision of A. J. Peterka and J. W. Ball under the Hydraulic Laboratory direction of H. M. Martin.

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Commissioner's Office--Denver
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Structures and Equipment Section
Denver, Colorado
November 8, 1956

Laboratory Report No. Hyd-427
Compiled by: G. L. Beichley
Reviewed by: A. J. Peterka
Submitted by: H. M. Martin

Subject: Hydraulic model studies of Robles Diversion Dam Spillway

SUMMARY

Hydraulic model studies of Robles Diversion Dam Spillway, Figures 1 and 2, were made on a 1:12 scale sectional model of the crest, Figure 3, for the primary purpose of determining the effect of roughness of the crest profile on the discharge coefficient, Figure 4. Rock blankets, using rocks of various sizes to form the crest profile, were compared with a smooth concrete profile, and with flow passing over the core wall standing alone. Flow conditions and rock stability were also checked.

The coefficient of discharge for the design flow was found to be 3.44 for the proposed rock blanket, Figure 4. Using smaller rocks, the coefficient was 3.39, and with a smooth concrete crest profile the coefficient was 3.46. The overall variation in discharge coefficient is within 2 percent, therefore, the reduction in discharge coefficient resulting from use of a rough profile is not of major significance. Water surface profiles resulting from the use of the rock blanket were satisfactory, Figures 5 and 6. The stability of the proposed rock size was excellent. The proposed rock blanket is recommended; however, smaller rocks might be used, particularly on the upstream side of the spillway.

INTRODUCTION

Robles Diversion Dam is a part of the Ventura River Project in California. The dam, Figure 1, is a rock structure approximately 500 feet long that joins a dike on the left and a concrete sluiceway on the right. The entire length of the rock dam acts as a spillway and is constructed in cross section as shown in Figure 2. The crest of the spillway is at elevation 765 at the top of a treated timber sheet piling core wall that is set in an impervious backfill. The maximum water surface in the reservoir area is to be at elevation 770 while the maximum tail water elevation is at elevation 767.0. The dam is designed to discharge 28,900 second-feet over the rock crest and through the sluiceway.

THE MODEL

The model shown in Figure 3 is a 1:12 scale reproduction of a 21-foot length of the spillway section. It was constructed and tested in the Bureau of Reclamation Hydraulic Laboratory at the Denver Federal Center.

The timber core wall was represented in the model by a 1-5/8-inch-thick board 7-1/2 inches high sealed to the floor and side walls of a rectangular test flume. The crest section was formed of selected rocks having a general shape similar to those available in the field and with length and volume characteristics based on the model length scale, 1:12. The rocks were carefully hand placed to form the profile shown in Figure 2. The floor of the test flume was at elevation 757.5.

Water surface elevations upstream of the spillway were determined at two locations by use of two point gages, one 42 feet upstream from the crest and the other 81 feet upstream. Tail water elevations were measured with a point gage located 68 feet downstream from the crest. The tail water elevation was controlled by a tailgate at the downstream end of the model.

THE INVESTIGATION

The investigation was primarily concerned with the efficiency of the proposed rock crest section in discharging the design flow as compared to a smooth concrete crest section having the same profile. The efficiency of the crest using other rock sizes was also investigated as were the flow patterns downstream from the crest and the stability of various rock sizes in the blanket cover.

Crest Efficiency

The proposed crest in Figure 2 was calibrated in the model using the rocks shown in Figure 3. The discharge-head relationship and the coefficient of discharge curve are both plotted as Test No. 1 in Figure 4 for tail water elevation not controlled. For a total head of 5 feet (0.15 foot of which is velocity head at a point 42 feet upstream from the crest), the discharge per foot of crest length is 38.5 second-feet, and the discharge coefficient is 3.44. With the tail water controlled to elevation 767 which will probably be the case with sluiceway also discharging, the coefficient was reduced to 3.42 and the discharge per foot of crest length is 38.3 second-feet. This is shown on Figure 4 as a single point, Test 2.

With the crest section rebuilt using smaller rocks, Tests No. 3 and 4 in Figure 4, the discharge appeared to be reduced slightly. However, the reduction was of the order of 1 percent, and it might be concluded that there was little, if any, change, since experimental errors might also be included in this figure.

With a smooth concrete crest in place of the rock blanket the discharge coefficient was increased to 3.46 with the tail water uncontrolled, Test 5, Figure 4. In this case, raising the tail water to elevation 767 had no effect on the discharge. Since the percent increase in discharge coefficient over that for the rough rock blanket was only of the order of one-half of 1 percent, it is of little benefit in increasing the capacity of the spillway. The proposed rock blanket is recommended.

With only the timber core wall in place with no rock or concrete surfaces either upstream or down, the discharge coefficient was reduced to 3.32 with the tail water controlled to elevation 767, Test 8, Figure 4. However, with the tail water lowered 3 or 4 feet below the crest, the discharge coefficient increased to nearly 4.0 when the undernappe was not ventilated, Test 6, Figure 4. When the undernappe was adequately ventilated, the coefficient was reduced to 3.54 for the design flow, Test 7, Figure 4.

<u>Appearance</u>

The appearance of the design flow over the crest in the proposed design was smooth but was rough downstream with tail water elevation 767 as shown in Figure 5. Two standing waves occurred above the horizontal portion of the cross section. The waves occurred because a hydraulic jump was about to form on the horizontal portion of the profile. The jump actually did form when the tail water was raised slightly. When smaller rocks were used to form the profile, the standing waves were smaller, and a little more tail water was required to form a jump.

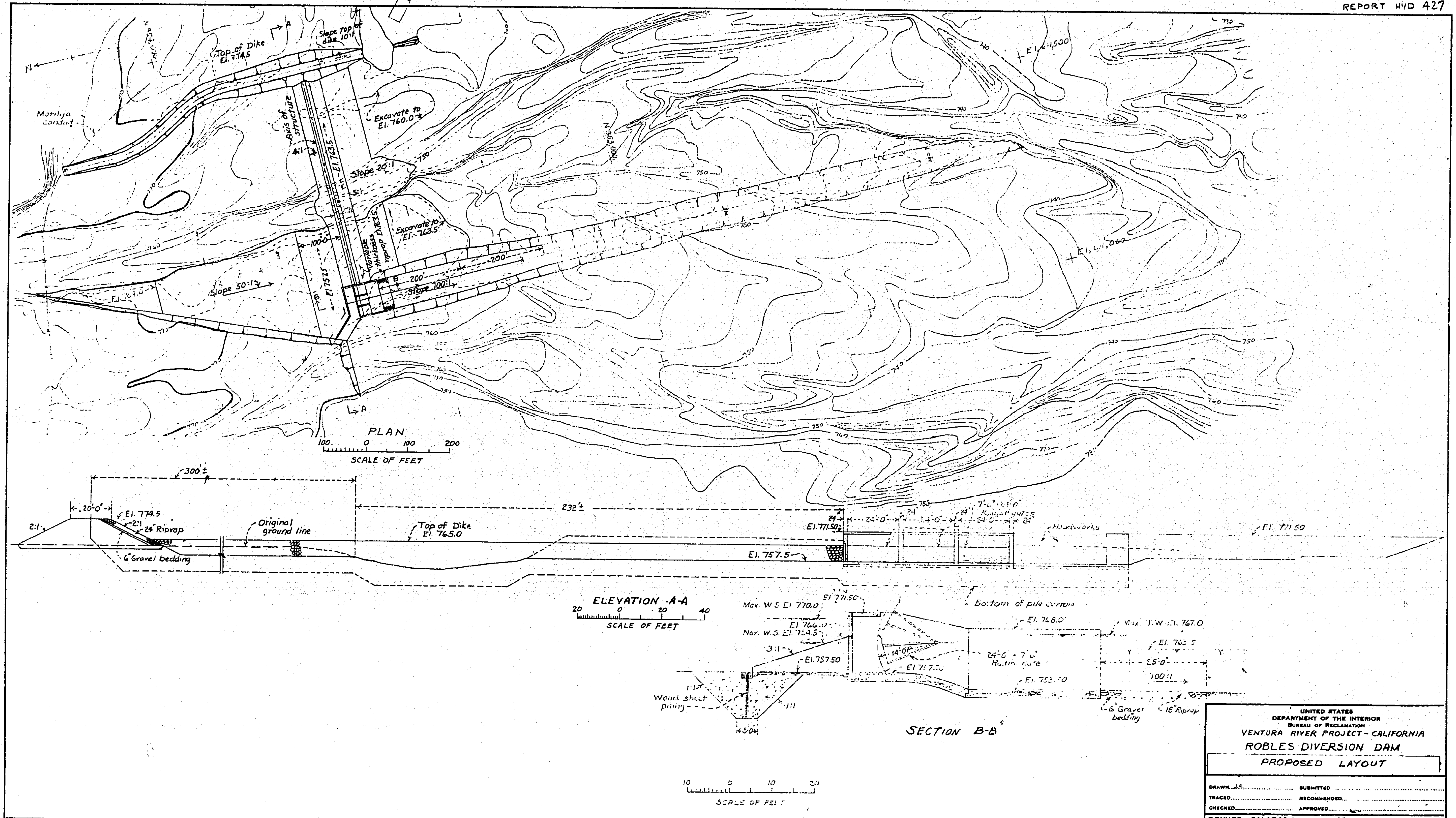
When only the core wall was used, the tail water surface was quite smooth. However, a submerged jump or roller action formed near the crest that apparently reduced the efficiency of the crest in discharging the design flow.

The concrete crest produced a smooth water surface over both the crest and the horizontal section downstream as shown in Figure 5. A hydraulic jump formed downstream on the 10:1 slope with the tail water at elevation 767.

Rock Stability

The rocks in the preliminary design were found to be quite stable. In fact, rocks as small as 1/4 cubic foot used in calibration Test No. 3 did not move on the upstream 4:1 slope of the dam, although they were carried away if prodded. Some of the proposed rocks, however, did move from the downstream 5:1 slope and appeared ready to move from the horizontal portion of the profile. Velocity and water surface profile measurements were made as shown in Figure 6. Velocities were measured by a Pitot tube placed as close to the rock blanket as possible. In the regions where velocities of 13.04 and 11.46 feet per second were measured rocks larger than 1 cubic foot were moved when they were placed on top of the blanket, but rocks 1/4 of a cubic foot in size placed between larger rocks and below the profile did not move. This occurred, probably, because of an interlocking effect and because the velocity on the surface of the blanket was less than at the lowest possible elevation of the Pitot tube.

On the basis of these observations, rocks as small as 1/4 cubic foot might be used in the upstream portion of the 4:1 sloping blanket, and rocks as small as 1 cubic foot might be used near the top of the crest if they were intermingled with larger rocks. Rocks downstream from the crest should be as specified in the proposed design except that no rock need exceed 1/2 cubic yard, and the largest of the rocks should be used in the 5:1 sloping portion of the blanket.



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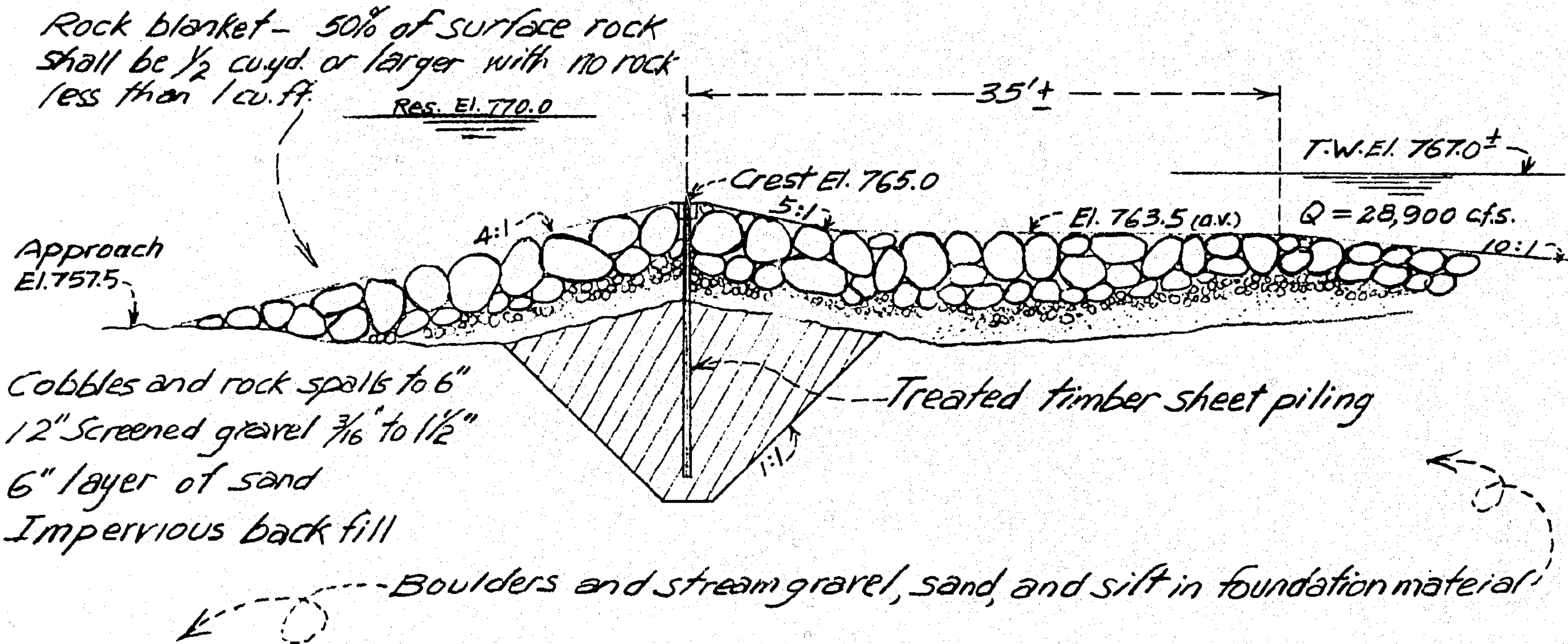
VENTURA RIVER PROJECT - CALIFORNIA
ROBLES DIVERSION DAM
PROPOSED LAYOUT

DRAWN ... SUBMITTED ...
TRACED ... RECOMMENDED ...
CHECKED ... APPROVED ...
DENVER, COLORADO, 1956



Note: This proposed rock crest is recommeded for prototype construction.

Ventura Project - Calif.
ROBLES DIVERSION DAM
PROPOSED ROCK CREST SECTION

File #572

FIGURE 2
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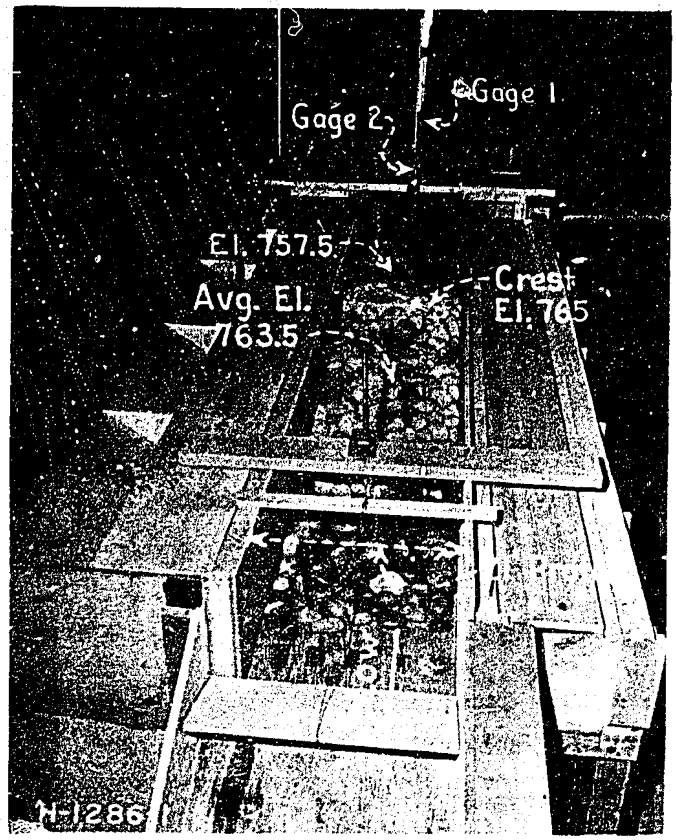
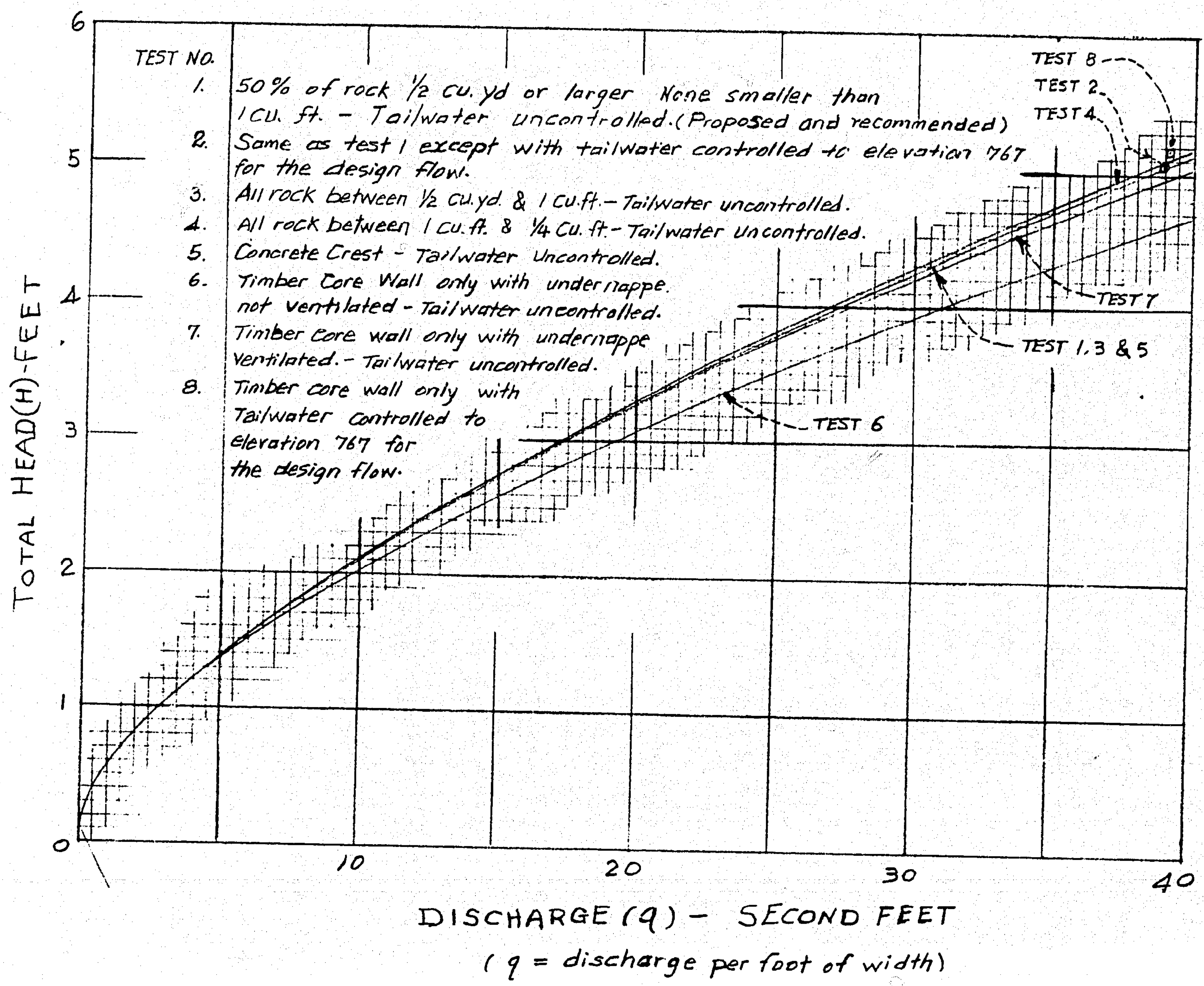
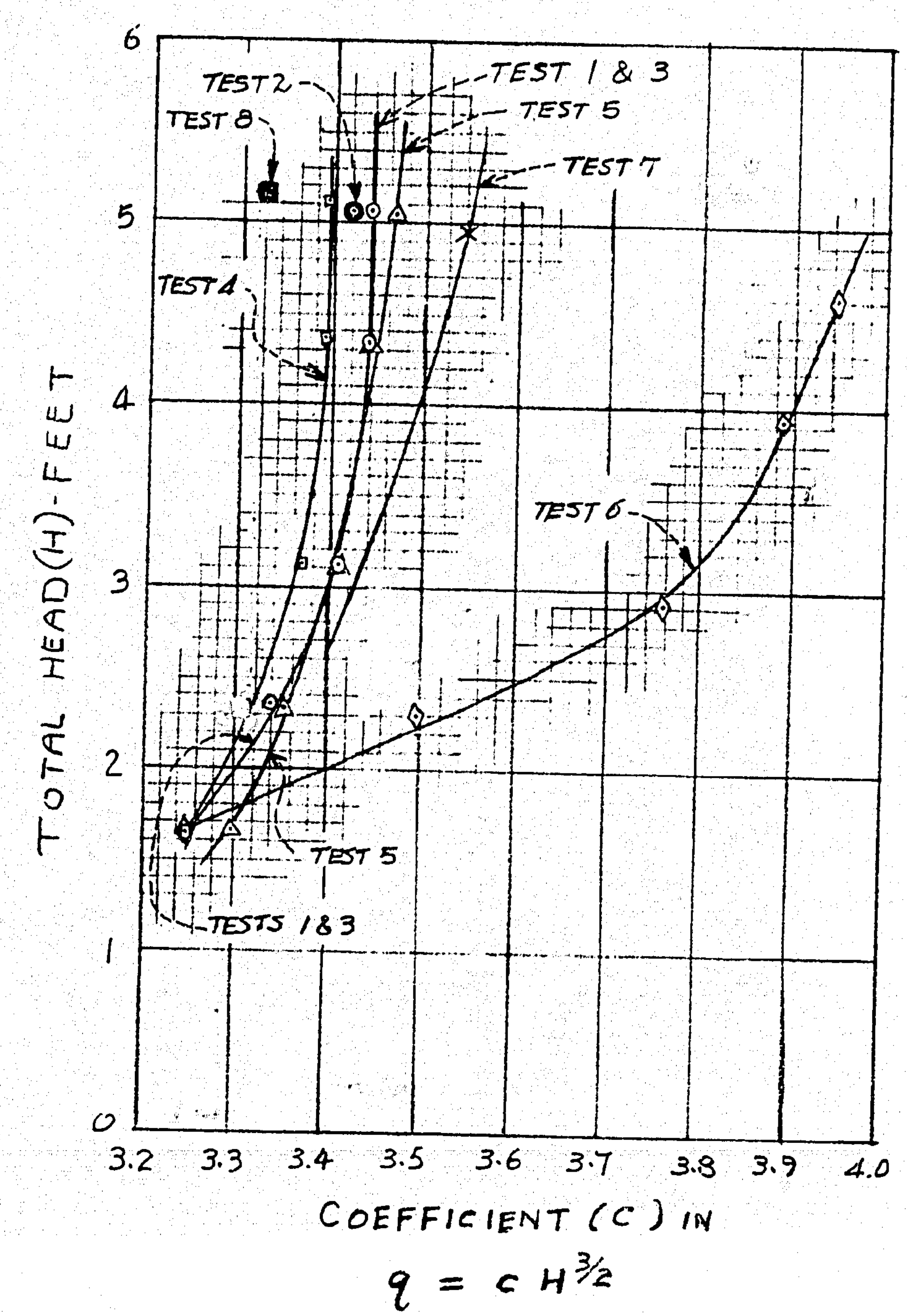


Looking upstream

50% of model rocks are 13.5 cu. inches or larger.
No rock is less than 1 cu. in..

ROBLES DIVERSION DAM
THE MODEL
1:12 SCALE MODEL



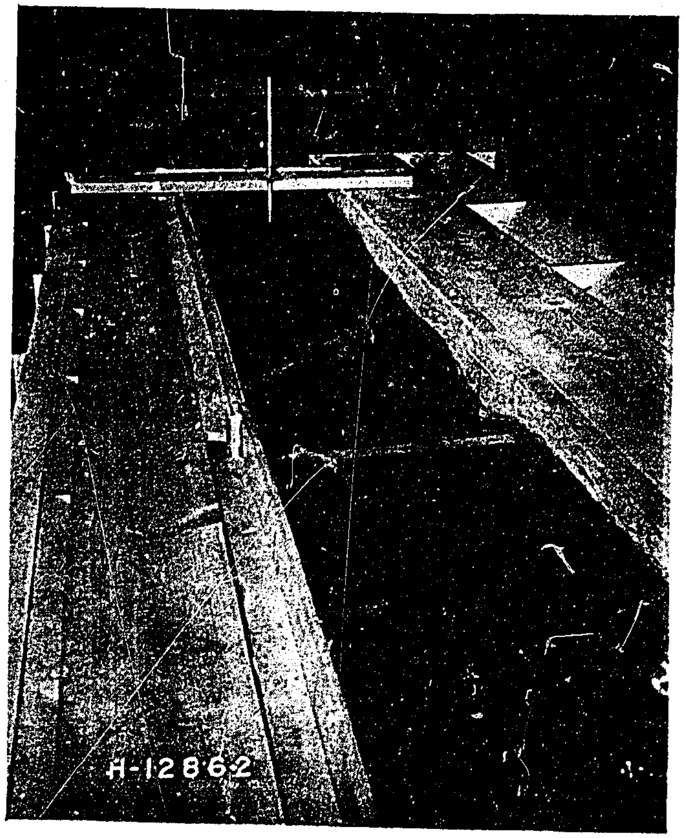


ROBLES DIVERSION DAM

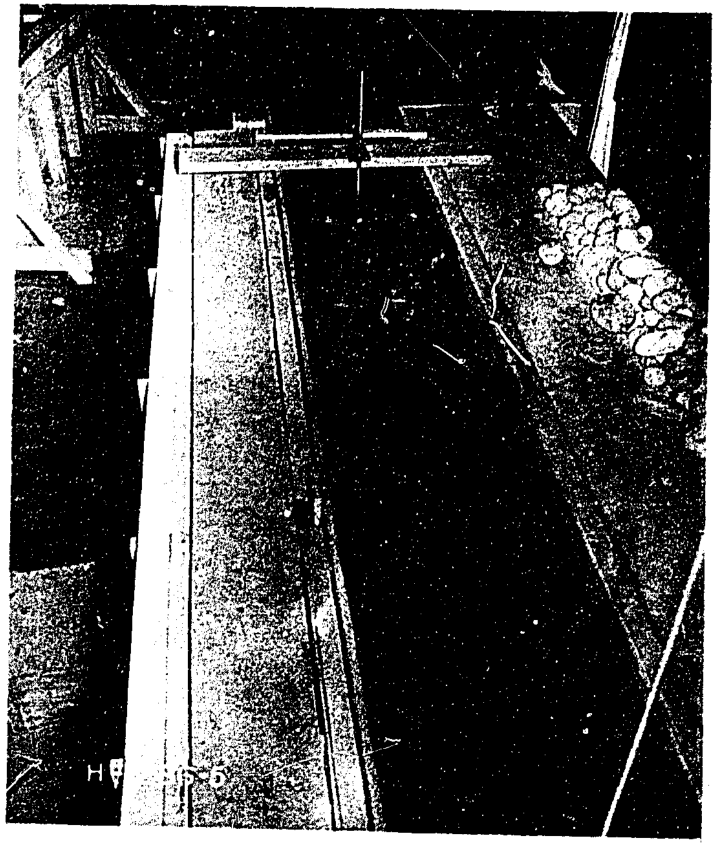
DISCHARGE AND DISCHARGE COEFFICIENT CURVES

1:12 SCALE MODEL

File # 572

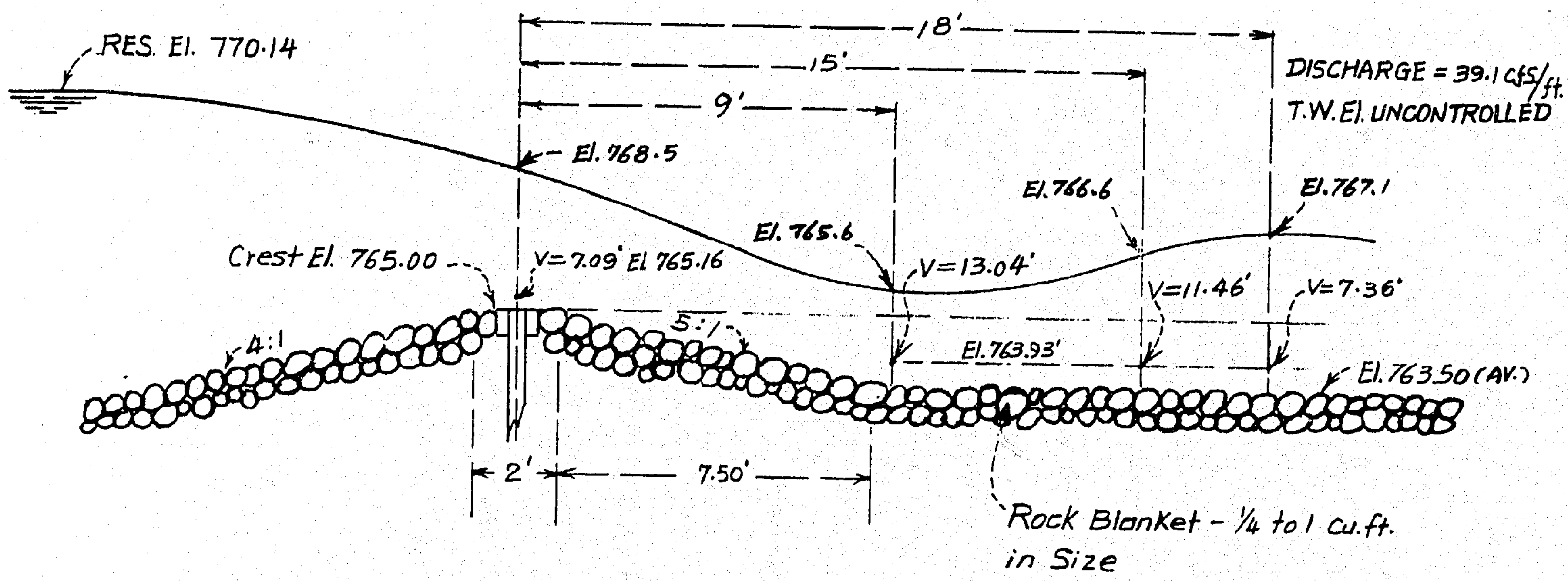


Proposed Rock Blanket



Concrete Blanket

ROBLES DIVERSION DAM
CREST SECTION DISCHARGING THE DESIGN FLOW
1:12 SCALE MODEL



Note: All measurements are in prototype feet.

ROBLES DIVERSION DAM

WATERSURFACE PROFILS AND VELOCITY MEASUREMENTS

1:12 SCALE MODEL

File # 572

FIGURE 6
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