376

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE CONCRETE DROP AT STATION 997+00, WASTEWAY AT STATION 1188+56.50, AND INTERCEPTING DITCH CHUTE AT STATION 1+31.68 WYOMING CANAL--RIVERTON PROJECT, WYOMING

Hydraulic Laboratory Report No. Hyd-376

ENGINEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

October 5, 1953

FOREWORD

The Wyoming Canal is a part of the Riverton Project and is designed to carry water from the Wind River to land approximately 20 miles north and west of Riverton, Wyoming, Figure 1. Several drops, checks, and siphons were required to cross the irregular terrain and deliver the water to laterals north of Riverton. To protect the Wyoming Canal from damage by flash floodwaters, an intercepting ditch was constructed along the upwash side of the canal to intercept and evacuate the floodwaters into Five Mile Creek.

This report covers the hydraulic model studies made on three Wyoming Canal structures, namely: the rectangular drop at Station 997+00, Figure 2; the wasteway at Station 1188+56.5, Figure 3; and the intercepting ditch chute into Five Mile Creek at Station 1+31.68. The studies on the three structures were conducted more or less simultaneously and the results of one were applied to the other two. Each of the above mentioned structures has a notched control wall either to hold the hydraulic jump in the stilling basin or to prevent drawdown of the water surface as the flow drops into the structure.

The three structures are covered separately in the report. Although only one drop structure was modeled and tested, the studies covered a wide range of flow conditions so that the experimental results may be applied to other structures of similar design in the project.

CONTENTS

CONTENTS--Continued

PART II--WYOMING CANAL WASTEWAY

PART III--INTERCEPTING DITCH CHUTE

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Design and Construction Division
Engineering Laboratories Branch
Denver, Colorado
October 5, 1953

Laboratory Report No. Hyd-376
Hydraulic Laboratory Section
Compiled by: W. E. Wagner
Reviewed and
checked by: A. J. Peterka
J. N. Bradley

Subject: Hydraulic model studies of the concrete drop at Station 997+00, wasteway at Station 1188+56.50, and intercepting ditch chute at Station 1+31.68--Wyoming Canal--Riverton Project, Wyoming

SUMMARY

This report covers the hydraulic model studies of three structures on the Wyoming Canal, namely: the concrete drop at Station 997+00, the wasteway at Station 1188+56.50, and the chute on the intercepting ditch at Station 1+31.68. A model of each structure was constructed and tested. To avoid confusion in presenting the results, each is discussed under a separate heading.

PART I--WYOMING CANAL DROP

Hydraulic model studies of the drop structure were made to check the size of the notches in the control wall and to determine the adequacy of the stilling basin. The results and recommendations are based on studies conducted on a 1:12 scale model, Figures 5 and 6.

A series of tests using two control notches were made to determine the best location of the control wall with reference to the chute, Figure 8. In developing the proper number and size of control notches for the structure, extensive general studies were made to determine the effect on the head-discharge curves with different notch arrangements. Head-discharge curves were obtained for the following: two control notches placed different distances apart, Figure 9; two control notches with beveled, square and sharp edges, Figure 11; and one to four control notches of equal area, Figure 12. A summary of the general conclusions reached from the above tests is listed on page 7.

Except for installing a row of baffle piers to reduce the waves in the downstream canal, the preliminary basin was adequate. The baffle pier studies are summarized in Figure 15.

Water-surface profiles for the recommended design at maximum flow are shown in Figure 16.

PART II--WYOMING CANAL WASTEWAY

The wasteway studies were made on a 1:12 scale model to determine the size and location of control notches required to maintain an efficient hydraulic jump in the stilling basin.

Three notched control walls were tested, Figure 20. The stilling pool operation for the three designs are shown in Figures 21 to 23.

After determining the size of control notches required to form an efficient jump for all flows and tail-water elevations, erosion tests were made using different end sills and lengths of apron downstream from the control wall. The depth of scour was reduced by extending the apron of the stilling basin 10 feet downstream, Figure 24. No appreciable improvement in the scour pattern was obtained by adding either a 1:1 or 2:1 end sill at the downstream end of the apron extension.

PART III--INTERCEPTING DITCH CHUTE

A 1:12 scale model was constructed to study the intercepting ditch chute into Five Mile Creek. The model was used to check the distribution of flow on the chute, and to determine the size of control notches required to hold an efficient hydraulic jump in the stilling basin.

The distribution of flow in the chute was very satisfactory, Figure 27. However, the notched control wall of the preliminary design offered insufficient resistance to the flow to form a good hydraulic jump at all tail-water elevations. Four additional notched control walls were tested in developing the recommended design, Figure 26. A summary of the notch tests is listed in Figure 28. Flow in the stilling basin at two tail-water elevations is shown in Figure 29.

Erosion patterns and water-surface profiles for the recommended design are shown in Figures 30 and 31, respectively.

To provide a means of measuring the ditch flow into Five Mile Creek, a calibration curve is shown in Figure 32 for the control section at the upstream end of the chute.

PART I--WYOMING CANAL DROP AT STATION 997+00

INTRODUCTION

The drop structure, located approximately 25 miles northwest of Riverton, Wyoming, is one of three drops on the Wyoming Canal. The other two drops which are similar in design, except for the amount of fall, are located at Stations 1016+50 and 1502+00, Figure 1. Although model studies were conducted only on the drop at Station 997+00, the results and recommendations evolved from the study may be applied to the other two structures.

The preliminary design of the drop structure consisted of a check wall with three notches, trapezoidal in cross section; a chute on a 1-1/2:1 slope which lowers the canal grade 17 feet; and a stilling basin, Figures 5 and 6. The notches in the check wall are designed to pass a given quantity of water at the normal canal depth for that discharge. At the maximum discharge of 1,203 second feet, the normal depth is 9.5 feet.

Hydraulic model studies of the structure were made to check the size of the control notches and to determine the performance and adequacy of the stilling basin.

THE 1:12 SCALE MODEL

The model of the drop structure was built to a geometrical scale of 1:12 and included an approach channel, 6 feet in length; the drop structure; and an outlet channel approximately 10 feet in length, Figure 6. The approach and outlet channels had the same cross-sectional shape as the Wyoming Canal and represented the canal upstream and downstream from the drop structure. Except for sand in the bottom of the outlet channel, the model was constructed of concrete screeded to metal templates. Initially, the notched control wall was made from redwood; later in the studies 14-gage sheet metal was used to facilitate changes in the size and location of the control notches.

Water was supplied to the model by a vertical turbine pump and was metered through a combination Venturi and orifice meter. Depth of water in the canal both upstream and downstream from the drop structure was measured by point gages mounted over the center of the canal.

THE INVESTIGATION

General

Primarily, the model studies of the drop structure were made to develop a notched control wall which would discharge 1,203 second feet at a head of approximately 9.5 feet, to determine the best location for the control wall such that the flow was evenly distributed as it entered the stilling basin, and to determine the adequacy of the stilling basin. Extensive general studies were made to determine the effect on head-discharge curves with different notch arrangements.

The preliminary design of the stilling basin was found satisfactory except that one row of baffle piers was installed in the basin to reduce the height of waves in the downstream canal.

Control Notch Studies

Initially, the model was built according to the preliminary design, Figure 5, and operated at discharges of 1,203, 600, and 300 second feet, Figure 7. At the maximum discharge of 1,203 second feet, the upstream canal depth was 8.2 feet or 1.3 feet below the design depth of 9.5 feet. Also, water passed over the top of the notched control wall to a depth of approximately 6 inches. After passing through the control notches, the flow spread laterally and formed two large fins of water in the chute between the notches and a smaller fin of water along each training wall, Figure 7. The stilling basin operation was fairly uniform but rough with comparatively high waves in the downstream canal.

At the lower flows of 600 and 300 second feet, the flow distribution down the chute and through the stilling basin was similar to maximum flow except for a reduction in the height of waves and fins of water.

To prevent the high fins of water from forming downstream from the notched control wall, the downstream side of the wall between the notches was streamlined in several different shapes. Although streamlining the flow downstream from the notches eliminated the fins of water, this solution was considered impractical and expensive to construct.

Several tests were then made using three notches of various sizes and shapes, located at different distances from the chute. From visual observations of these tests, it was found that the fins of water in the chute could be reduced or eliminated by moving the control wall upstream from the chute, forming a horizontal section of channel in which the flow could spread laterally before entering the chute and stilling basin. From these preliminary tests, it was decided to determine:

(1) the best location for the control wall with reference to the chute;
(2) the number, size, and spacing of the notches in the control wall.

For the purpose of locating the control wall with reference to the chute, two symmetrical notches, made from 14-gage sheet metal, were used. Each notch was 11 feet 3 inches high with a bottom width of 3 feet 9 inches and a top width of 9 feet 4-1/2 inches. The center lines of the notches were 15 feet apart and the notch edges were square. Tests were made with the control wall located 32, 37, 42, and 47 feet upstream from the chute, Figure 8. At 32 feet, the flow concentrated at the outer edges of the chute and basin, while the concentration of flow shifted to the center of the structure with the control wall 47 feet upstream from the chute. At the two intermediate distances, 37 and 42 feet, the flow distribution on the chute was fairly uniform. To keep the over-all length of the structure at a minimum with comparatively uniform flow distribution in the stilling basin, the decision was made to place the control wall 37 feet upstream from the chute.

After the best location for the control wall had been established, a series of tests were made to determine the general effect on the head-discharge relationship under the following varied notch arrangements:

a. The center lines of two symmetrical notches placed 11.75, 15.00, and 18.75 feet apart.

b. Two symmetrical notches shaped with sharp, square, and beveled edges.

c. One to four notches, both symmetrical and unsymmetrical, placed in the control wall. In each case, the total area of the notch (or notches) was equal.

Figure 9 shows the results of the studies using two symmetrical notches placed different distances apart. The control wall was constructed of 14-gage sheet metal with the edges of the notches machined to a sharp edge. Head-discharge curves were obtained with the center lines of the notches set 11.75, 15.00, and 18.75 feet apart. From Figure 9, it can be seen that identical discharge curves were obtained with the three test arrangements. Therefore, the spacing of the notches in the control wall is not critical as far as the head-discharge relationship is concerned, and any reasonable notch arrangement may be used. Figure 10 shows the three notch arrangements and the flow distribution downstream from the notches for the maximum discharge of 1,203 second feet.

The results of the tests using different edges on the notches are shown in Figure 11. For these studies, the control wall was constructed

from redwood with a prototype thickness of 8 inches. Two symmetrical notches, placed 15 feet apart, were placed in the control wall. Tests were made with a square edge and 4- and 8-inch 45° beveled edges on the notches. Identical discharge curves were obtained using the two beveled edges, while approximately 10 percent less discharge was observed with square edges on the notches. For comparison, the discharge curve for sharp-edged notches, taken from Figure 9, is also shown on Figure 11. Although the contraction of the jet, and therefore the discharge, for sharp- and square-edged notches should be similar, these results show approximately 3 percent less discharge when sharp-edged notches are used. This apparent discrepancy was no doubt due to the degree of sharpness of the notch edges used in the two tests. Fourteen-gage sheet metal, which was used to construct the sharp-edged notches, can be sharpened to a higher degree than wood, which was used in the tests on square-edged notches.

The above tests showed that for a given head, the discharge was the same through a notch with either 4- or 8-inch 45° chamfered edges, while the discharge for the same head was decreased by 10 to 13 percent (depending on the sharpness of the edges) when square- or sharp-edged notches are used.

Tests were next run using one, two, three, and four notches, both symmetrical and unsymmetrical, with 4-inch, 45° chamfered edges, Figure 12. Regardless of the number of notches, the area of the openings was the same for each test. The notched control wall, which was 8 inches thick, was made of redwood.

In general, the discharge for a given head increased with the number of notches and the highest discharge was recorded for four symmetrical notches. Although the number of contractions increased with the number of openings, apparently the total cross-sectional area of the venae contractae for each test set-up also increased as more notches were placed in the control wall.

To determine whether notches of different shapes affect the discharge, calibration curves were obtained for flow through a symmetrical notch and a notch with one side vertical, Figure 12. Results of this test showed that the head-discharge relationship was the same for the two notch arrangements.

Figures 13 and 14 show the pattern of flow through the different notch arrangements.

To summarize the above tests on the various notch arrangements, shown in Figures 9, 11, and 12, the following general conclusions are listed:

a. The notches may be placed any reasonable distance apart without affecting the head-discharge relationship.

b. A notch with a beveled edge facing upstream will pass from 10 to 13 percent more flow for a given head than a square- or sharp-edged notch.

c. The head-discharge curves for notches having 4- and 8-inch 45° beveled edges are the same.

d. The head-discharge curves for a symmetrical and unsymmetrical notch are the same.

e. In general, when the flow passes through one or several notches whose total area in each case is equal, the discharge for a given head increases with the number of notches.

By comparing the flow pattern for the various notch arrangements in Figures 13 and 14, it can be seen that four notches give the best flow distribution downstream from the control wall. The fins of water between the notches and along the training walls are considerably reduced and a comparatively uniform jump forms in the stilling basin. Both control wall designs with four notches, Figure 12, passed the maximum discharge of 1,203 second feet at heads approximating 9.25 feet. Since it is desirable that the lower range of flows be passed at heads as high as possible without obstructing the passage of weeds and other debris, the control wall with four notches, each having the narrower width of 17-1/4 inches, was chosen for the recommended design.

Stilling Basin Studies

After the control wall was moved upstream and the number of notches was increased to four, the operation of the preliminary stilling basin was satisfactory. The flow was well distributed in the basin and the hydraulic jump formed well up on the base of the chute. However, surges in the water surface caused waves approximately 4 feet high in the downstream canal.

To reduce the height of waves in the canal, a series of tests was conducted using a row of baffle piers in the stilling basin. Two sizes of baffle piers, as shown in Figure 15, were tested. Each baffle pier arrangement was evaluated by moving the row of piers from 2 to 8 feet downstream from the toe of the drop and recording the height of waves in the canal downstream from the drop structure for the maximum discharge of 1,203 second feet. The recorded wave height was the average vertical distance in feet between the crest and trough of the waves on the 2:1 slope of the canal bank at the downstream end of the transition.

The height of waves varied from 4.0 feet with the baffle piers removed to 1.4 feet with the 3-foot high piers located 4 feet downstream from the toe of the drop. Therefore, to keep the height of waves at a minimum, it is recommended that a row of stepped baffle piers, 3 feet in height, be placed 4 feet downstream from the toe of the drop, as shown in the table, Figure 15. Otherwise, the preliminary stilling basin design is adequate.

Figure 16 shows the water-surface profile at the maximum discharge of 1,203 second feet for the recommended design with the baffle piers removed from the basin.

The prototype drop structure near Station 997+00 is shown in Figure 17. The amount of flow through the structure is unknown.

PART II--WYOMING CANAL WASTEWAY

INTRODUCTION

The wasteway on the Wyoming Canal at Station 1188+56.50 is located at the upstream entrance to the siphon under Five Mile Creek approximately 4 miles north of Pavillion, Wyoming, Figure 1. Designed to prevent overloading of the siphon and overtopping of the canal banks, the wasteway regulates the canal flow by passing excess water through two 12- by 5-foot top seal radial gates which are manually operated, Figure 18. The elevation of the top of the head wall above the radial gates is 5510.78 feet and, in emergencies, excess canal flow may pass over the head wall. Stop logs also may be placed above the head wall to prevent the operation of the wasteway at near maximum flows.

After passing through the radial gates, the wasteway flow passes over a vertical curve and drops approximately 20 feet into a rectangular stilling basin. The floor of the stilling basin is set at approximately the same level as the bed of Five Mile Creek. A notched control wall is placed near the downstream end of the stilling basin to maintain a hydraulic jump in the basin.

The model studies were made primarily to determine the adequacy of the stilling basin and the size of control notches required to maintain an efficient hydraulic jump.

THE 1:12 SCALE MODEL

The wasteway model, which was built to a geometrical scale of 1:12, included a short section of the Wyoming Canal, the wasteway structure, and a sand-filled tail box to represent the channel bed of

Five Mile Creek, Figure 19. The chute and stilling basin floor of the wasteway was constructed of concrete screeded to metal templates, and the notched control wall was cut from redwood. Since no hydraulic problems are anticipated in the flow through the radial gates and to keep the construction costs to a minimum, two slide gates were substituted for the radial gates to control the flow in the model wasteway.

Water was supplied to the model by a vertical turbine pump and metered through a combination Venturi and orifice meter. The proper headwater was maintained in the Wyoming Canal by means of a staff gage and raising or lowering the slide gates controlling the flow to the wasteway. A point gage was used to set the tail water in Five Mile Creek.

THE INVESTIGATION

General

The wasteway is designed to pass the maximum discharge of 1,208 second feet without serious erosion in the downstream channel both when the creek is dry and when the water in the creek is 5 feet deep. To meet these two requirements, the model was operated with no tail water and with a tail-water depth of 5 feet. With no tail water, the notched control wall is designed to form and maintain an efficient hydraulic jump in the stilling basin. Three different notched walls were tested in developing the proper size of notches. The adequacy of the control walls was determined by visual observations. After the notch size was established, erosion tests were made to evaluate various extensions to the stilling basin with end sills. The erosion tests were run for 30 minutes.

Prior to any of the stilling basin studies, a velocity traverse at Station 0+70, Figure 18, was made in the model to assure that the velocity of the model flow was representative of the computed velocity in the prototype. The velocity traverse for the maximum discharge of 1,208 second feet showed the mean model velocity to be approximately 6 percent less than that computed for the prototype. This difference in velocities was considered insufficient to affect the results of the model study.

Control Notch Studies

The control notches of the preliminary design shown in Figure 18 were initially installed in the stilling basin and operated with discharges of 1,208 and 400 second feet. At the maximum discharge of 1,208 second feet and with no tail water downstream from the control wall, the beginning of the hydraulic jump formed about halfway between the control wall and the toe of the chute, Figure 21. Thus, about one-half of the stilling basin

was utilized in dissipating the high velocity flow, and water passed over the top of the control wall to a depth of about 12 inches. At 400 second feet, the jump moved upstream but there was a distinct flow concentration along the center line of the basin. When the tail water was raised to a height 5 feet above the stilling basin floor, the jump moved slightly upstream at maximum flow. At the lower flows an unstable jump formed with the concentration of flow shifting to opposite sides of the stilling basin.

The tests on the preliminary control wall clearly indicated the notches in the control wall were too large. In Design 2, the control wall was raised to a height of 9 feet and the bottom width of the control notches was reduced from 19 to 16 inches, Figure 20.

With Design 2, the hydraulic jump moved well upstream but the beginning of the jump still failed to form at the base of the chute, Figure 22. With the longer jump, the stilling basin was more efficient and the surges and waves were less pronounced. The height of the control wall appeared satisfactory since only occasionally did water splash over the control wall with 5 feet of tail water. The operation of the stilling basin at 400 second feet was similar to the preliminary design.

To force the hydraulic jump to form well up on the chute, the size of the notches was further reduced in Design 3, Figure 20. The bottom and top widths were reduced to 15 inches and 3 feet 9-3/4 inches, respectively.

Figure 23 shows the operation of Design 3 with discharges of 400 and 1,208 second feet. At maximum discharge, the jump formed well up on the chute with both zero flow and 5 feet of tail water in Five Mile Creek. The flow was well distributed over the basin and the jump appeared very efficient. When 400 second feet was put through the model, the flow again concentrated along the center line of the basin. With 5 feet of tail water, the concentration of flow tended to shift erratically from the center of the basin with swirling eddies immediately upstream from the control wall. It was felt that to further stabilize the jump at the lower flows would require shortening the dividing wall downstream from the control gates and otherwise changing the upstream end of the structure to secure better flow distribution on the chute. Since construction of the structure in the field was already underway, no major changes in the upstream end of the structure could be made. Therefore, the chute and stilling basin of the preliminary design with the notched control wall of Design 3 is included in the recommended design.

Erosion Studies

After the size of notches in the control wall had been established, erosion tests were made using a 10-foot extension on the basin

apron with end sills installed. Each erosion test was made with the model discharging 1,208 second feet for 30 minutes and no flow in Five Mile Creek.

With the 10-foot apron extension removed (Preliminary Design), Figures 18 and 24A, the erosion downstream from the basin was very severe. Two erosion pockets--one near the end of each training wall--reached the floor of the tail box.

Figure 24B shows the erosion test results with the basin apron extended downstream a distance of 10 feet. The erosion pattern was similar to that obtained with the preliminary design but less severe at the ends of the training walls.

Sills with a 2:1 and a 1:1 slope were installed separately at the downstream end of the extended apron and tested, Figures 24C and D, respectively. It was hoped an end sill would pull sand back against the cut-off wall at the end of the stilling basin. However, it can be seen in Figure 24 that the end sill provided no appreciable reduction in the depth of scour at the cut-off wall. Therefore, Design 3, Figure 24B, is recommended for construction in the field.

PART III--INTERCEPTING DITCH CHUTE

INTRODUCTION

The intercepting ditch, which is approximately 4 miles long, is located southwest of Five Mile Creek along the upwash side of the Wyoming Canal about 4 miles northwest of Pavillion, Wyoming, Figure 1. As its name implies, the intercepting ditch intercepts floodwaters from natural drainage channels and conveys the flow into Five Mile Creek, which carries the run-off over the Wyoming Canal siphon without endangering the canal. The model studies were concerned with the hydraulics of the chute and stilling basin of the intercepting ditch where the flow drops approximately 30 feet into Five Mile Creek.

Like the Wyoming Canal wasteway, the chute stilling basin was placed at the same elevation as the creek bed and a notched control wall was required to form and hold a hydraulic jump in the stilling basin. The model studies were made to study the flow in the chute and to determine the size of notches in the control wall required to form a satisfactory hydraulic jump.

THE 1:12 SCALE MODEL

Included in the model of the intercepting ditch chute, which was built to a geometrical scale of 1:12, was 50 feet of straight channel

upstream from the structure, the chute and stilling basin, and a large tail box filled with sand representing approximately 200 feet of the channel of Five Mile Creek, Figures 4 and 25. The bottoms of the upstream channel, chute, and stilling basin were finished in smooth concrete screeded to metal templates while the training walls were formed from wood and lined with 30-gage sheet metal. The notched control wall and buttresses were made from redwood.

Water was supplied to the model from a vertical turbine pump and metered through a Venturi-orifice meter. Tail-water elevations in Five Mile Creek were varied by means of a tailgate at the downstream end of the tail box.

THE INVESTIGATION

The model was initially built according to the preliminary design with the notched control wall shown as Design A in Figure 26. Except for the size of notches, the preliminary design is the same as shown in Figure 4.

After operating the model through the complete range of discharges, it was found that the flow in the chute was very satisfactory. At all discharges, the flow spread laterally over the width of the chute and entered the stilling basin in a well-distributed pattern, Figure 27. With 5 feet of water in Five Mile Creek (tail-water elevation of 5487 feet), the beginning of the hydraulic jump formed at the base of the chute for all flows. However, with the tail water dropped to elevation 5482 feet, the jump swept well into the stilling basin for discharges between 270 second feet and the maximum flow of 350 second feet, indicating the control wall offered insufficient resistance to the flow when there was no flow in Five Mile Creek, Figures 27 and 28.

The resistance to the flow in the basin could be increased by either raising the height of the control wall or reducing the size of the control notches. In Design B, the height of the control wall was increased from 4 feet 8 inches to 5 feet 8 inches while maintaining the same bottom width and side slopes of the notches. The range of flows with a satisfactory jump was increased slightly with Design B, but for discharges above 293 second feet the jump still swept into the stilling basin when the tail-water elevation was 5482 feet.

The top width of each of the control notches was reduced 1 foot in Design C, Figure 26. With the smaller control notches, the jump was well up on the chute for all flows and tail-water elevations, and a discharge of 397 second feet was required to sweep the beginning of the jump to the toe of the chute, Figure 28. Figure 29 shows the stilling basin

operation for Design C with discharges of 117 and 350 second feet and high and low tail-water elevations. Although the stilling basin operation was satisfactory for all flows with the control notches of Design C, it was decided to reduce the height of the control wall and see if equally satisfactory results could be obtained.

Maintaining the same bottom width and side slopes in the notches, the height of the control wall was reduced from 5 feet 8 inches to 4 feet 8 inches in Design D. From the data shown in Figure 28, it can be seen that Design D operated satisfactorily for discharges up to 315 second feet. At this discharge, the jump started to sweep into the basin when the tail-water elevation was at 5482 feet.

Since Design D was unsatisfactory for discharges above 315 second feet, the design section computed a new control notch based on the above studies and the control notch studies on the Wyoming Canal drop and wasteway described in Part I and II of this report. The dimensions of those control notches are shown as Design E, Figure 26.

Tests on Design E showed the jump to be well up on the chute for the complete range of flows and tail-water elevations. Although no photographs were taken of Design E in operation, the flow distribution appeared to be the same as that observed for Design C, Figure 29.

THE RECOMMENDED DESIGN

The recommended design, which includes control notch Design E, is shown in Figure 4. Although the control notches of Design C, Figure 26, gave satisfactory stilling basin operation for all flows and tail-water elevations, Design E is recommended since the size of its control notches were computed using data from the wasteway and drop models as well as the results from these studies.

Erosion tests on the recommended design were made for the maximum discharge of 350 second feet and tail-water elevations of 5482 and 5487 feet. These results are shown in Figure 30. Sand was used as the erodible material, and each erosion test was run for 1 hour.

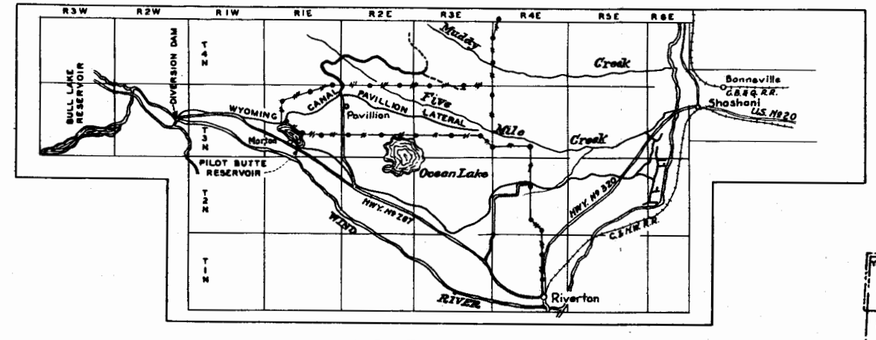
With the tail water at elevation 5482 feet, the scour was rather severe around the downstream ends of the training walls due to eddies which formed at the sides of the outlet channel, Figure 30. Although the eddies cut deeply into the sidebanks of the channel, the deepest scour occurred at the ends of the training walls, where the scour depth was 4 feet below the stilling basin floor.

However, with the tail water raised 5 feet to elevation 5487 feet, the side eddies did not form and the erosion at the ends of the training walls was negligible.

Water-surface profiles for the recommended design are shown in Figure 31. The profiles were recorded for the maximum discharge of 350 second feet with tail-water elevations of 5482 and 5487 feet.

To provide a means of measuring the flow entering Five Mile Creek from the intercepting ditch, a head-discharge curve was obtained from the model for the control section at the upstream end of the chute, Figure 32. The head-discharge relationship is based on the head (depth of flow) measured in the intercepting ditch at Station 1+88.00 or 70 feet upstream from the chute.

FIGURE 1
REPORT HYD. 376

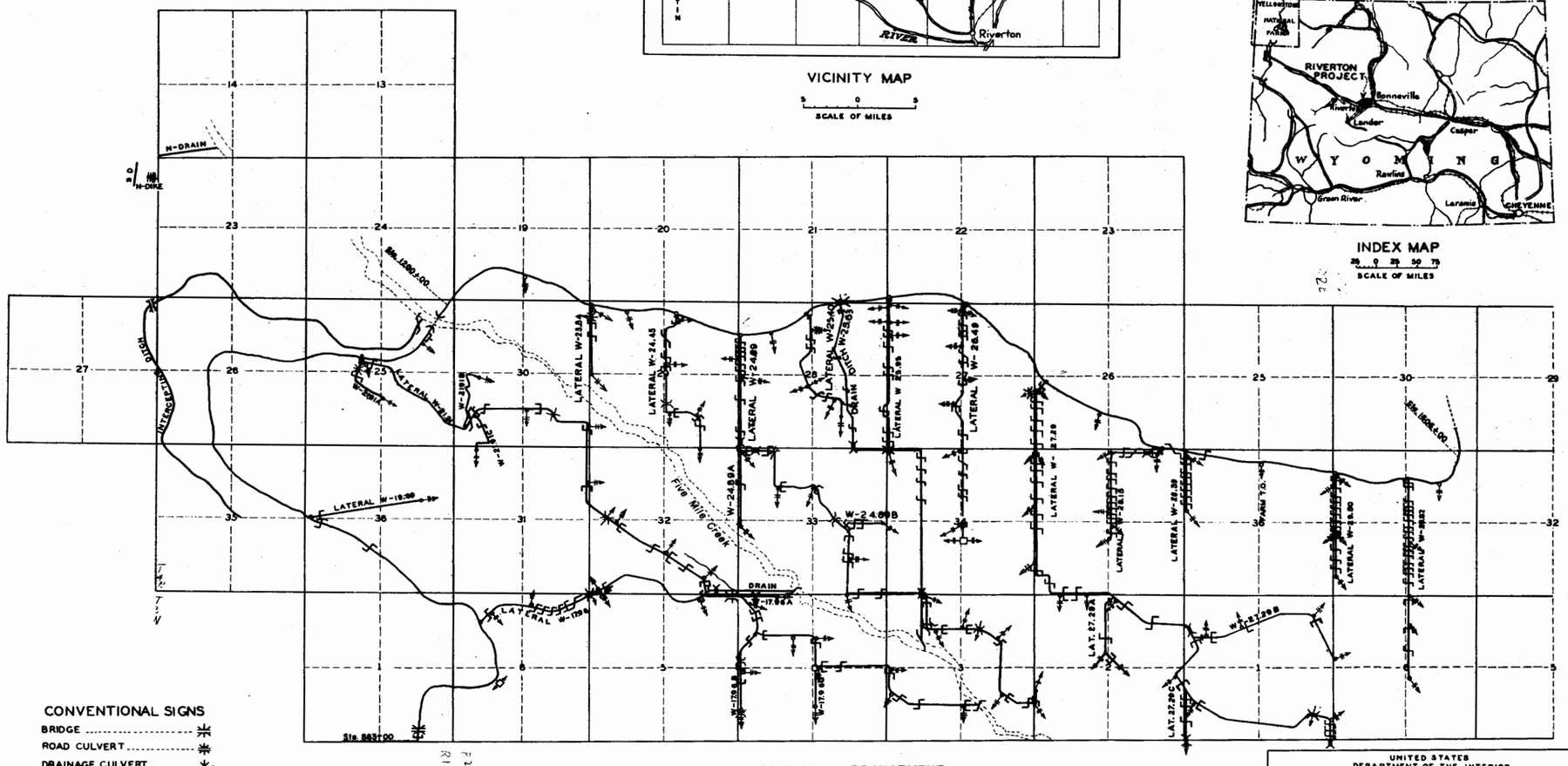


VICINITY MAP

5 0 5
SCALE OF MILES

INDEX MAP

25 0 25 50 75
SCALE OF MILES



CONVENTIONAL SIGNS

- BRIDGE
- ROAD CULVERT
- DRAINAGE CULVERT
- DROP
- CHECK
- CHUTE
- FARM T.O. & WEIR
- WEIR
- WASTEWAY
- SIPHON
- DIVISION BOX

SCHEDULE ARRANGEMENT

Schedule No. 1. Wyoming canal- Sta. 883+00 to Sta. 1200+00, intercepting ditch, N-Dike and N-Drain.

Schedule No. 2. Wyoming canal- Sta. 1200+00 to Sta. 1606+00,

Schedule No. 3. Laterals W-1796, W-1989, W-2191 and sub-laterals and Drain parallel to W-1796A.

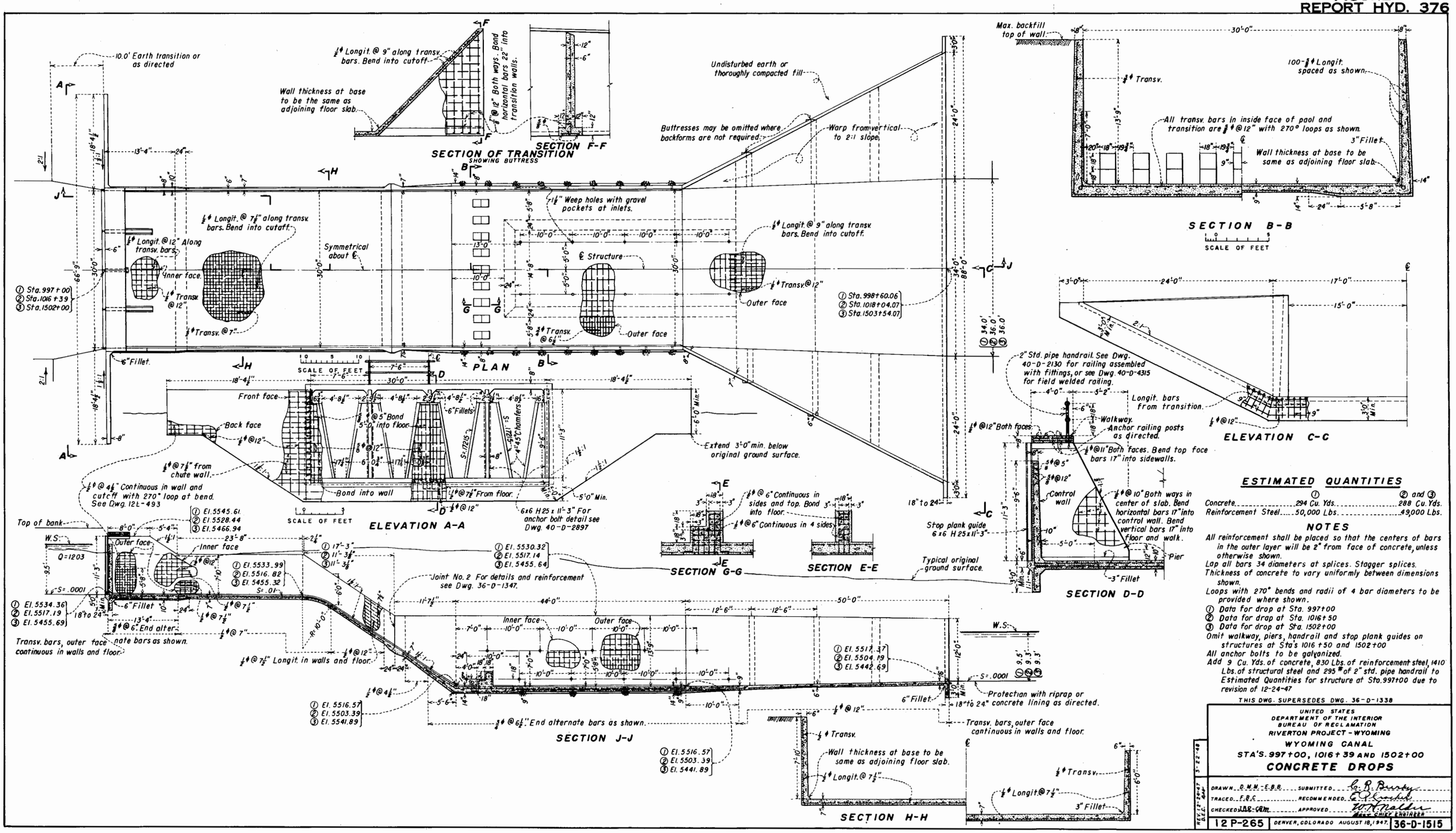
Schedule No. 4. Laterals W-2384 to W-2982 and sub-laterals and Drain Ditch W-2563.

Note: Schedules No. 3 and No. 4 not included in this contract.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIVERTON PROJECT-WYO.
WYOMING CANAL STA. 883-1607 AND LATERALS
EARTHWORK AND STRUCTURES
LOCATION MAP

DRAWN R.J. SUBMITTED
TRACED J.L. RECOMMENDED
CHECKED E.R.B. APPROVED
CHIEF ENGINEER

RIVERTON, WYO.-APRIL 1946 | 36-D-1321



ESTIMATED QUANTITIES

	①	② and ③
Concrete	294 Cu. Yds.	288 Cu. Yds.
Reinforcement Steel	50,000 Lbs.	49,000 Lbs.

NOTES

All reinforcement shall be placed so that the centers of bars in the outer layer will be 2" from face of concrete, unless otherwise shown.

Lap all bars 34 diameters at splices. Stagger splices.

Thickness of concrete to vary uniformly between dimensions shown.

Loops with 270° bends and radii of 4 bar diameters to be provided where shown.

① Data for drop at Sta. 997+00

② Data for drop at Sta. 1016+50

③ Data for drop at Sta. 1502+00

Omit walkway, piers, handrail and stop plank guides on structures at Sta's 1016+50 and 1502+00

All anchor bolts to be galvanized.

Add 9 Cu. Yds. of concrete, 830 Lbs. of reinforcement steel, 1410 Lbs. of structural steel and 295 # of 2" std. pipe handrail to Estimated Quantities for structure at Sta. 997+00 due to revision of 12-24-47

THIS DWG. SUPERSEDES DWG. 36-D-1338

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIVERTON PROJECT - WYOMING

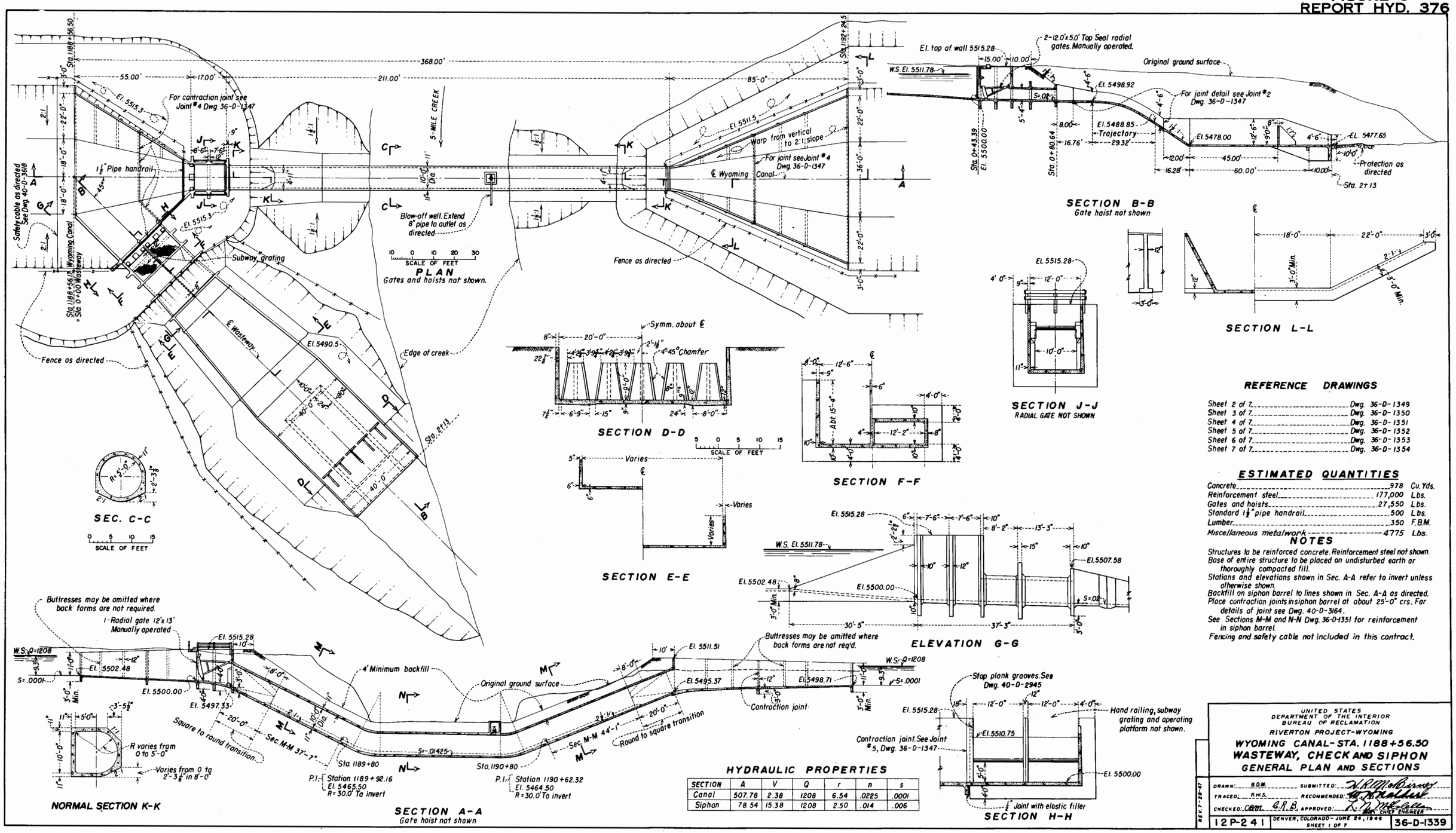
WYOMING CANAL
STA'S. 997+00, 1016+39 AND 1502+00
CONCRETE DROPS

REV. 12-24-47 DEC. 1947

DRAWN D.M.M.-E.B.B. SUBMITTED G. B. Burky
TRACED F.B.C. RECOMMENDED G. D. Crouch
CHECKED J.R.E.-C.A.M. APPROVED W. H. Nalder
ASST. CHIEF ENGINEER

12 P-265 | DENVER, COLORADO AUGUST 18, 1947. | 36-D-1515

FIGURE 3
REPORT HYD. 376



REFERENCE DRAWINGS

Sheet 2 of 7	Dwg. 36-D-1349
Sheet 3 of 7	Dwg. 36-D-1350
Sheet 4 of 7	Dwg. 36-D-1351
Sheet 5 of 7	Dwg. 36-D-1352
Sheet 6 of 7	Dwg. 36-D-1353
Sheet 7 of 7	Dwg. 36-D-1354

ESTIMATED QUANTITIES

Concrete	978	Cu. Yds.
Reinforcement steel	177,000	Lbs.
Gates and hoists	27,550	Lbs.
Standard 1½" pipe handrail	500	Lbs.
Lumber	350	F.B.M.
Miscellaneous metalwork	4775	Lbs.

NOTES

Structures to be reinforced concrete. Reinforcement steel not shown.
Base of entire structure to be placed on undisturbed earth or thoroughly compacted fill.
Stations and elevations shown in Sec. A-A refer to invert unless otherwise shown.
Backfill on siphon barrel to lines shown in Sec. A-A as directed.
Place contraction joints in siphon barrel at about 25'-0" crs. For details of joint see Dwg. 40-D-3164.
See Sections M-M and N-N Dwg. 36-D-1351 for reinforcement in siphon barrel.
Fencing and safety cable not included in this contract.

HYDRAULIC PROPERTIES

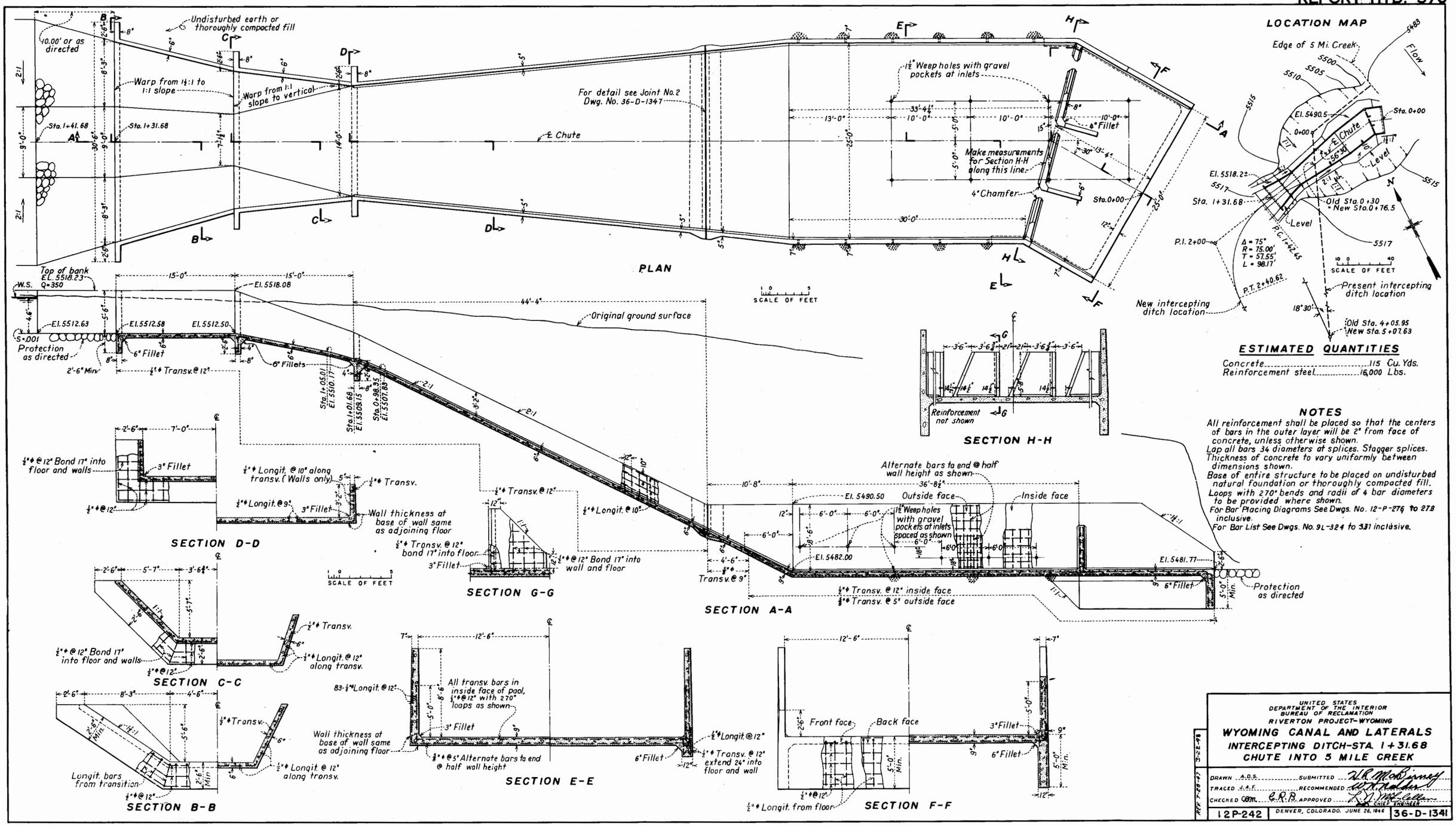
SECTION	A	V	Q	r	n	s
Canal	507.78	2.38	1208	6.54	.0225	.0001
Siphon	78.54	15.38	1208	2.50	.014	.006

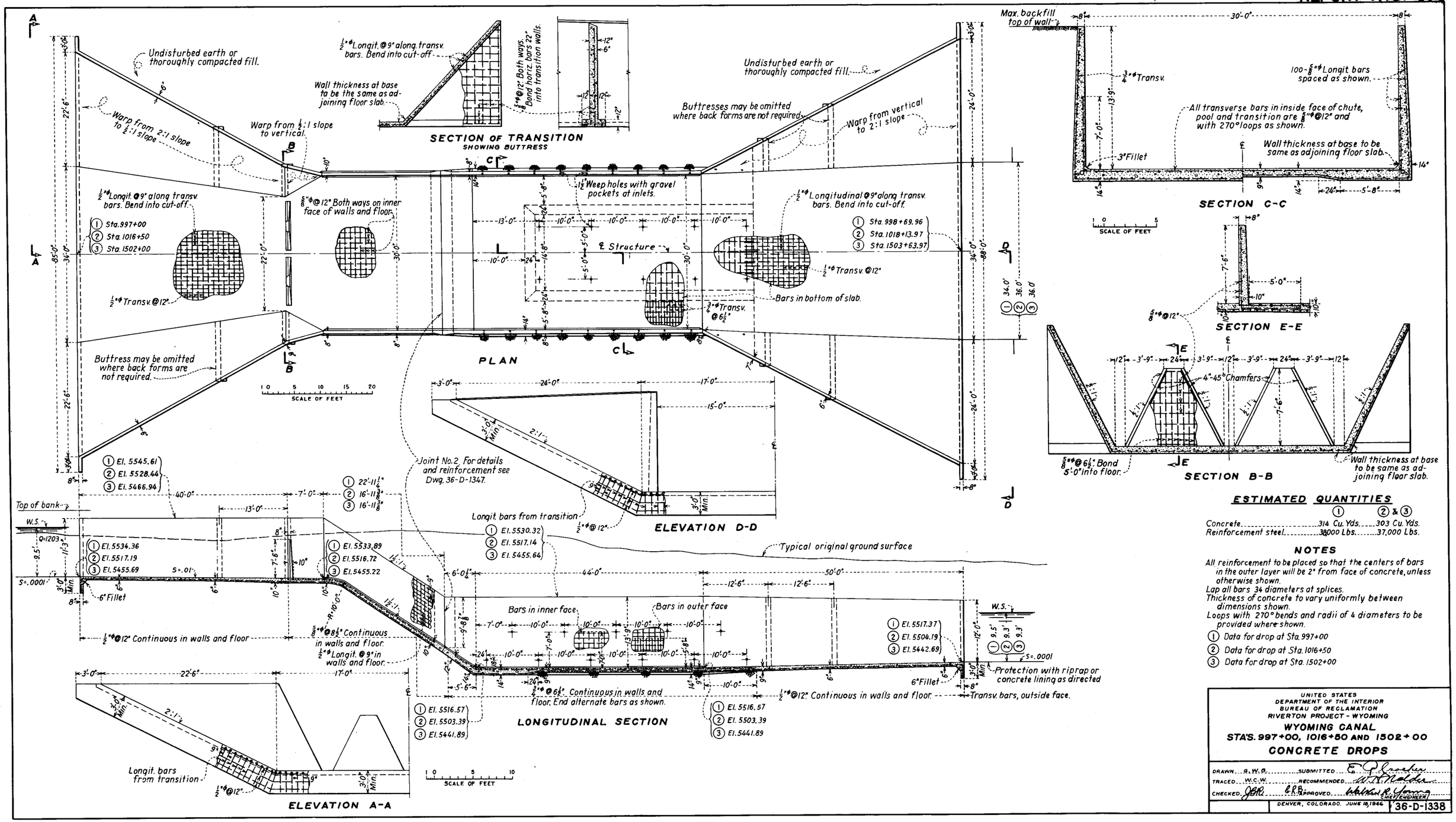
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIVERTON PROJECT-WYOMING

WYOMING CANAL-STA. 1188+56.50 WASTEWAY, CHECK AND SIPHON GENERAL PLAN AND SECTIONS

DRAWN: B.D.M. SUBMITTED: W. H. McBirney
TRACED: R.W.S. RECOMMENDED: W. H. Nordell
CHECKED: C.A.M. C.R.B. APPROVED: L. N. McClellan, CHIEF ENGINEER
REV. 7-26-47
12P-241 DENVER, COLORADO-JUNE 24, 1946 SHEET 1 OF 7 36-D-1339

FIGURE 4
REPORT HYD. 376





ESTIMATED QUANTITIES

	(1)	(2) & (3)
Concrete	314 Cu. Yds.	303 Cu. Yds.
Reinforcement steel	38,000 Lbs.	37,000 Lbs.

NOTES

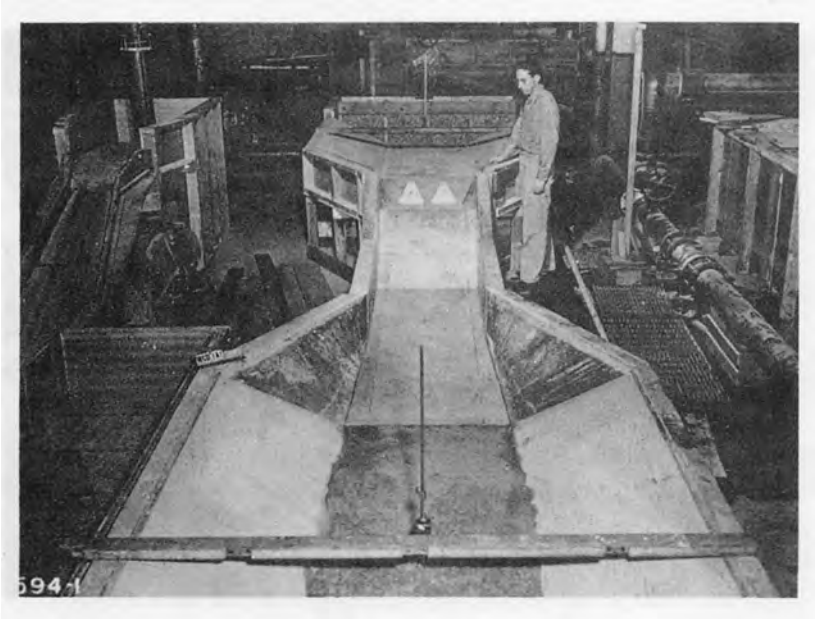
All reinforcement to be placed so that the centers of bars in the outer layer will be 2" from face of concrete, unless otherwise shown.
Lap all bars 34 diameters at splices.
Thickness of concrete to vary uniformly between dimensions shown.
Loops with 270° bends and radii of 4 diameters to be provided where shown.

(1) Data for drop at Sta. 997+00
(2) Data for drop at Sta. 1016+50
(3) Data for drop at Sta. 1502+00

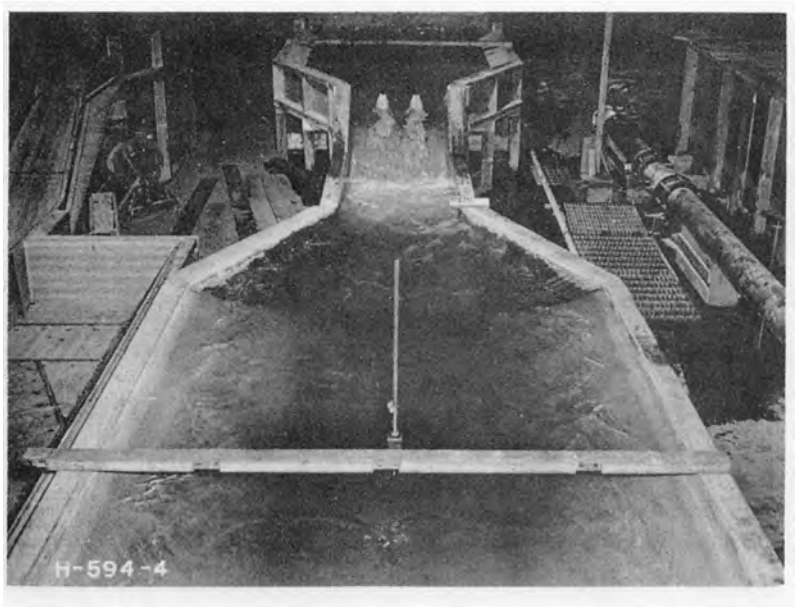
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RIVERTON PROJECT - WYOMING

WYOMING CANAL
STA'S. 997+00, 1016+50 AND 1502+00
CONCRETE DROPS

DRAWN R.W.B. SUBMITTED E. P. Goodner
TRACED W.C.W. RECOMMENDED W. H. Nolder
CHECKED J.G.R. E.P.G. APPROVED Walker R. Young CHIEF ENGINEER
DENVER, COLORADO, JUNE 18, 1946 36-D-1338



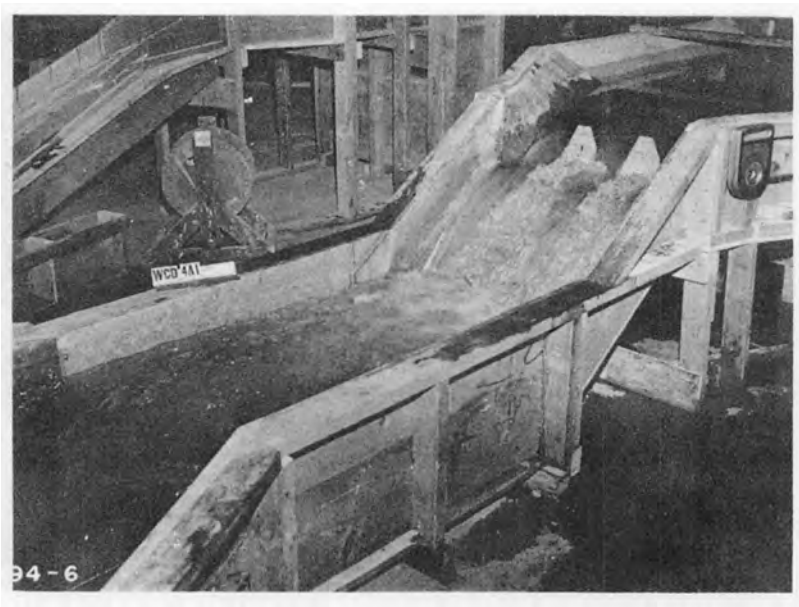
The 1:12 Scale Model



Discharge = 1203 second-feet

WYOMING CANAL DROP
Preliminary Design

Discharge = 1203 second-feet

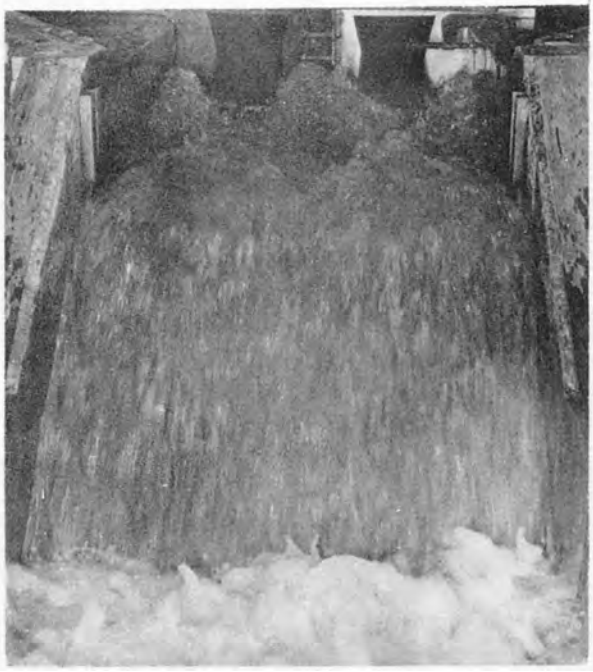


Discharge = 600 second-feet

WYOMING CANAL DROP
Preliminary Design
1:12 Scale Model

32 feet upstream from Drop

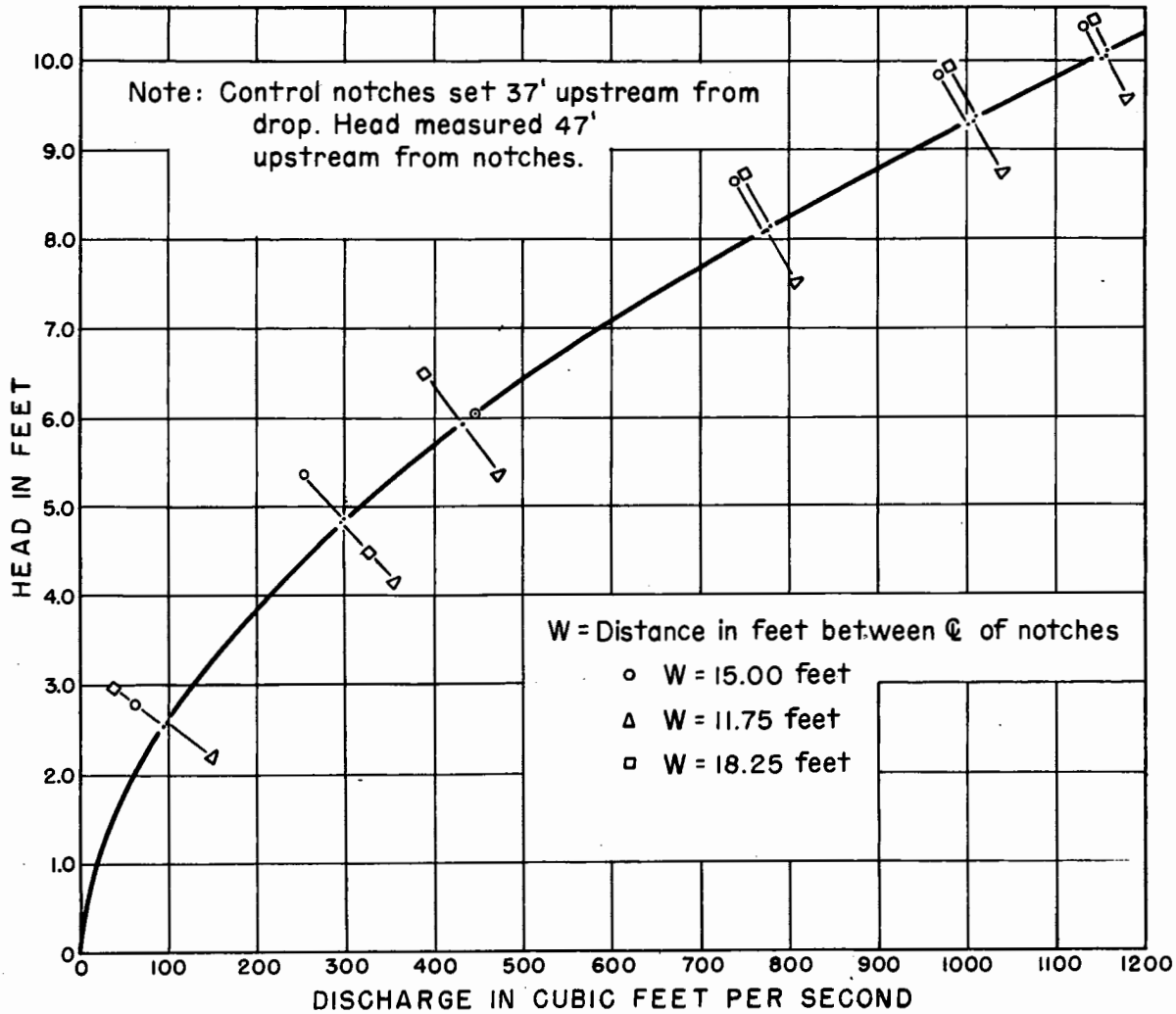
37 feet upstream from Drop

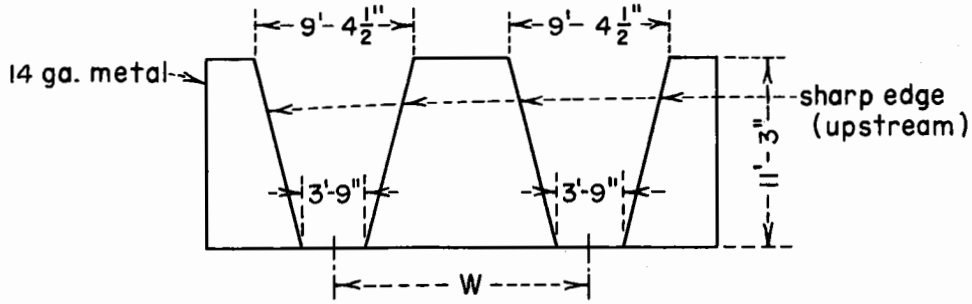


42 feet upstream from Drop

47 feet upstream from Drop

WYOMING CANAL DROP
Operation of Two Control Notches Located 32 to 47 feet upstream from Drop
Discharge = 1203 second-feet
1:12 Scale Model





SIZE AND LOCATION OF CONTROL NOTCHES

WYOMING CANAL DROP

EFFECT ON HEAD-DISCHARGE CURVE
WITH 2 NOTCHES SET DIFFERENT DISTANCES APART

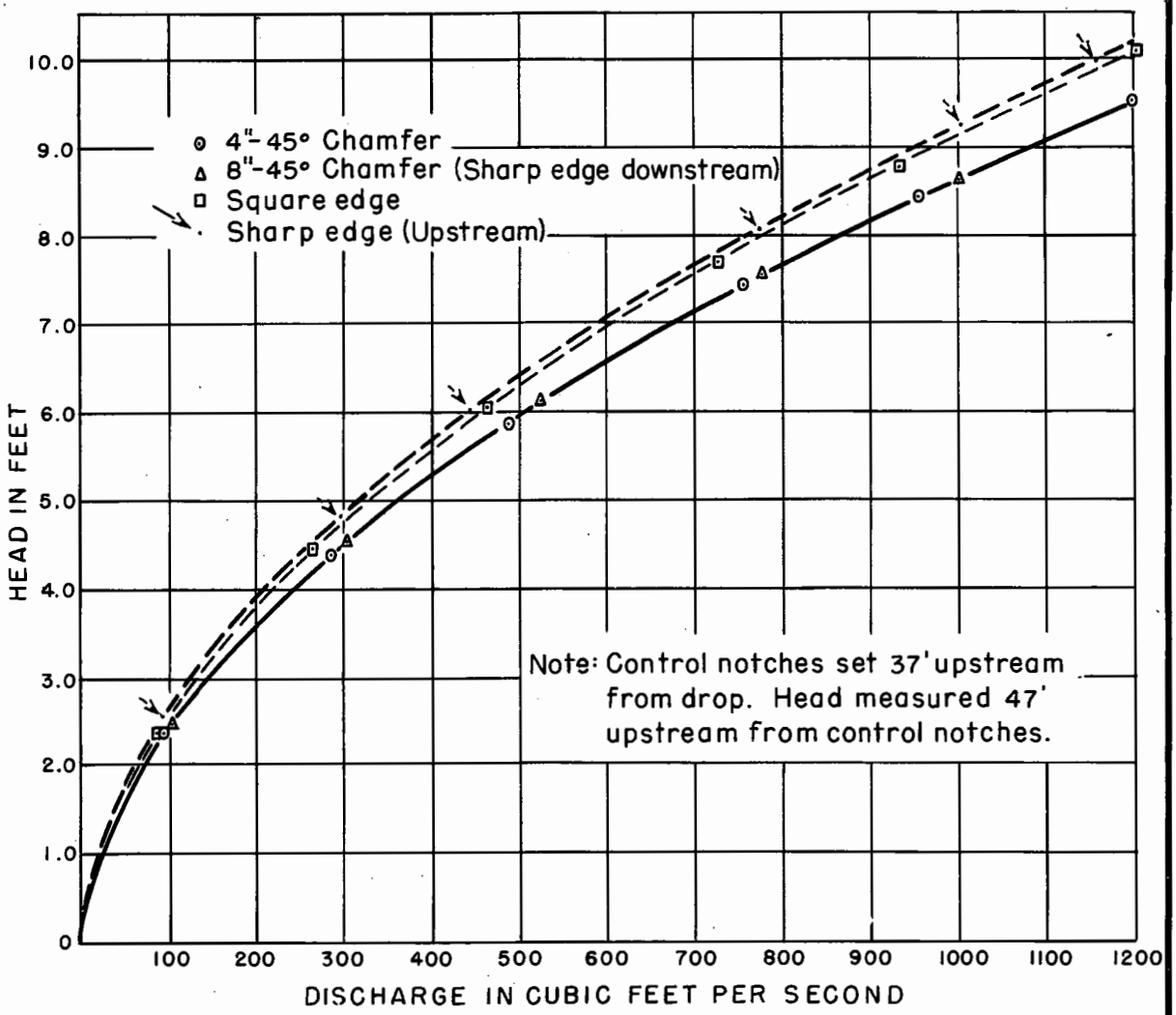
1:12 SCALE MODEL

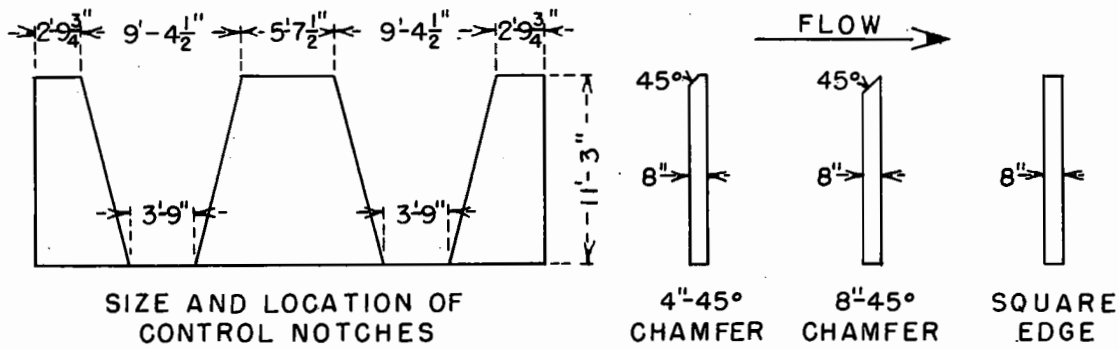
15 feet between Notch Center lines

11.75 feet between notch center lines

18.25 feet between notch center lines

WYOMING CANAL DROP
Operation of Two Notches at Varying Spacing
(Notches Located 37 feet upstream from Drop)
Discharge = 1203 second-feet
1:12 Scale Model



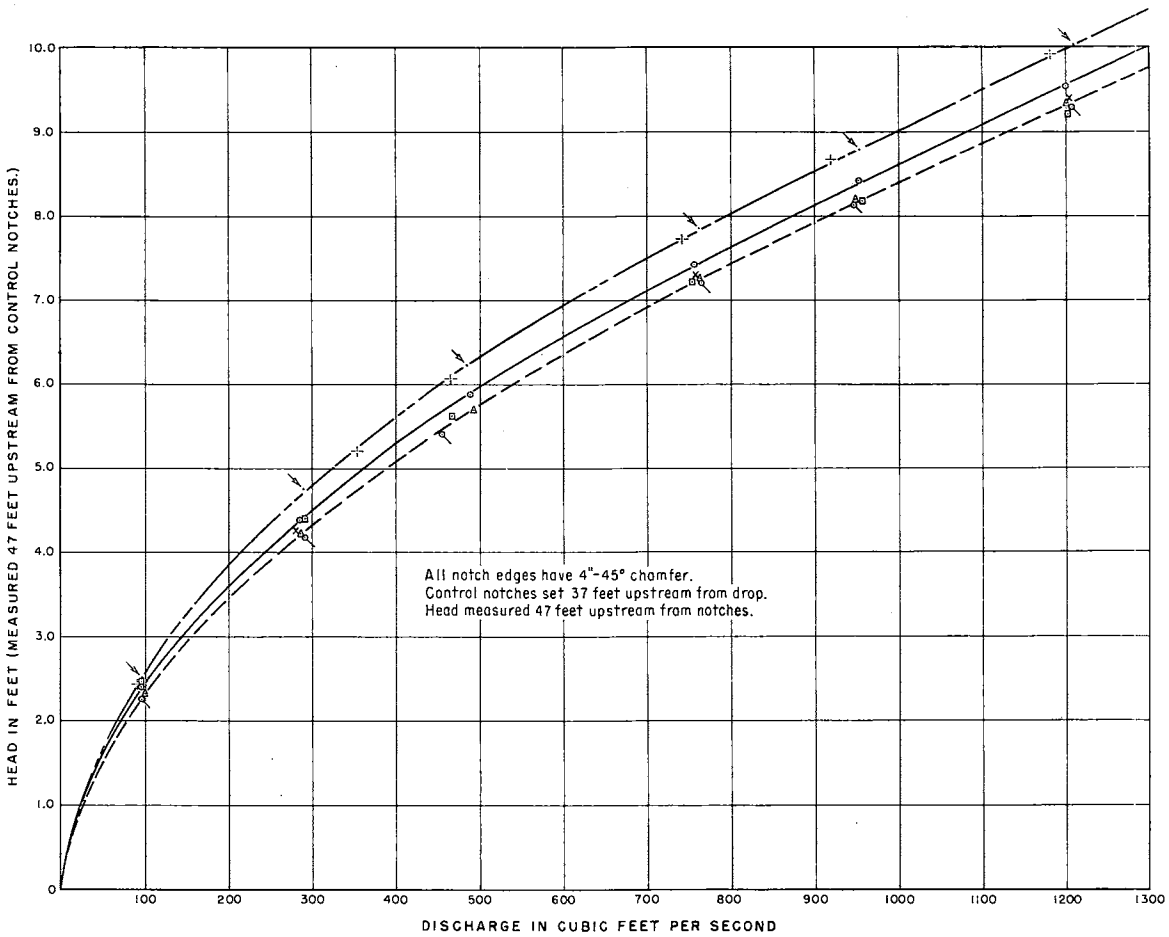


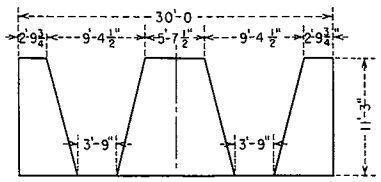
WYOMING CANAL DROP

EFFECT ON HEAD DISCHARGE CURVES
USING DIFFERENT EDGES ON NOTCHES

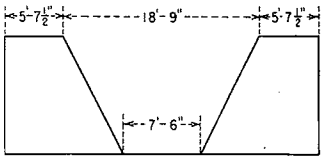
1:12 SCALE MODEL

FIGURE 12
REPORT HYD. 376

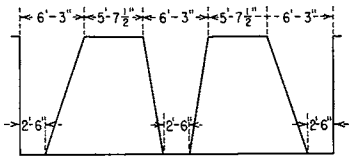




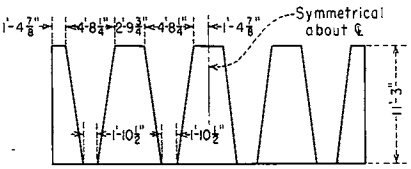
⊙ TWO SYMMETRICAL CONTROL NOTCHES



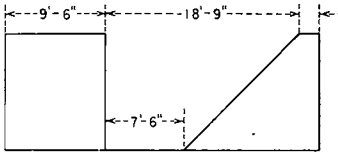
↘ ONE SYMMETRICAL NOTCH



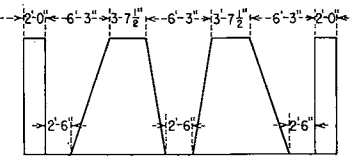
X CENTER NOTCH-SYMMETRICAL
OUTER NOTCHES-UNSYMMETRICAL



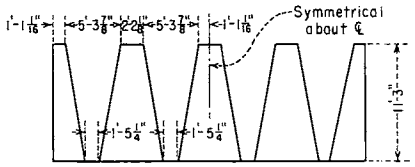
⊙ FOUR SYMMETRICAL NOTCHES



⊣ ONE UNSYMMETRICAL NOTCH



△ SAME AS ABOVE EXCEPT OUTER
NOTCHES SET 2' FROM TRAINING WALL



⊡ SAME AS ABOVE EXCEPT NOTCHES ARE
WIDER AT TOP AND NARROWER AT BOTTOM
(RECOMMENDED DESIGN)

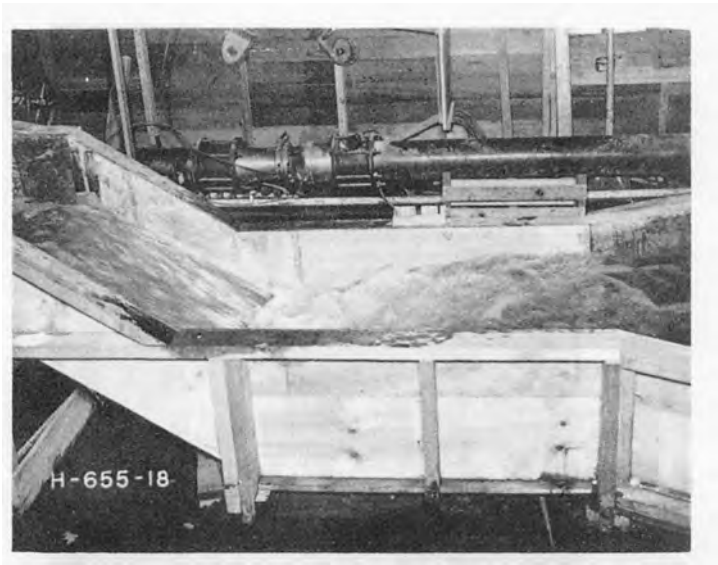
WYOMING CANAL DROP

COMPARISON OF DISCHARGE CURVES FOR ONE TO FOUR CONTROL NOTCHES OF EQUAL AREA

1:12 SCALE MODEL

281

Flow through notches



Flow in stilling basin

Two symmetrical notches

One Symmetrical Notch

One Unsymmetrical Notch

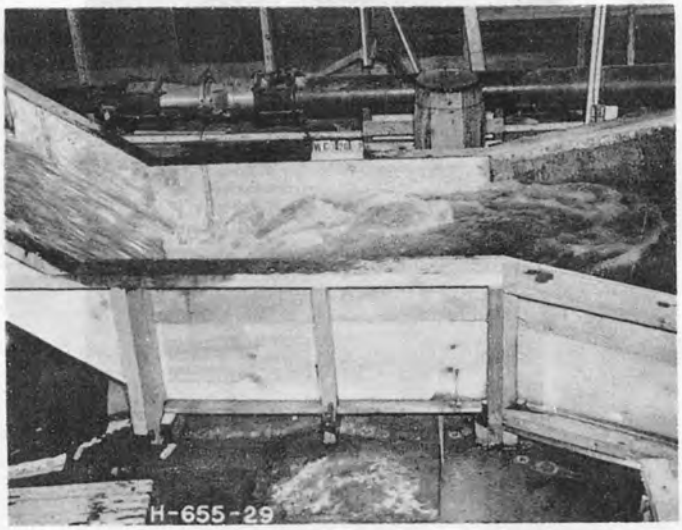
WYOMING CANAL DROP
Operation of One and Two Control Notches
(Notch(es) Located 37 feet upstream from Drop)
Discharge = 1203 second-feet
1:12 Scale Model

Vertical edge of outside notches flush with training walls

Vertical edge of outside notches offset 2 feet from training walls

Three Notches - Center notch symmetrical and outside notches unsymmetrical

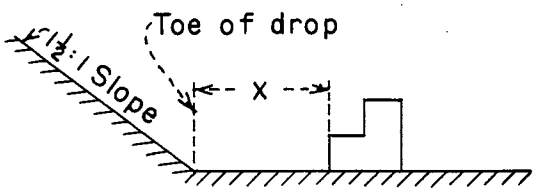
Flow through notches

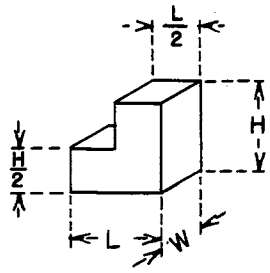


Flow in stilling basin

Four Symmetrical Notches

WYOMING CANAL DROP
Operation of Three and Four Control Notches
(Notches Located 37 feet upstream from Drop)
Discharge = 1203 second-feet
1:12 Scale Model





DISTANCE X IN FEET	SIZE OF BAFFLE PIERS IN FEET			WIDTH OF SPACE BETWEEN PIERS IN FEET	HEIGHT * OF WAVES IN FEET
	H	L	W		
—	None			—	4.0
2	3	3	1.5	1.65	1.6
3	3	3	1.5	1.65	1.5
** 4	3	3	1.5	1.65	1.4
5	3	3	1.5	1.65	1.5
6	3	3	1.5	1.65	1.8
7	3	3	1.5	1.65	1.8
8	3	3	1.5	1.65	2.0
3	2	2	1.5	1.65	2.4
4	2	2	1.5	1.65	2.2

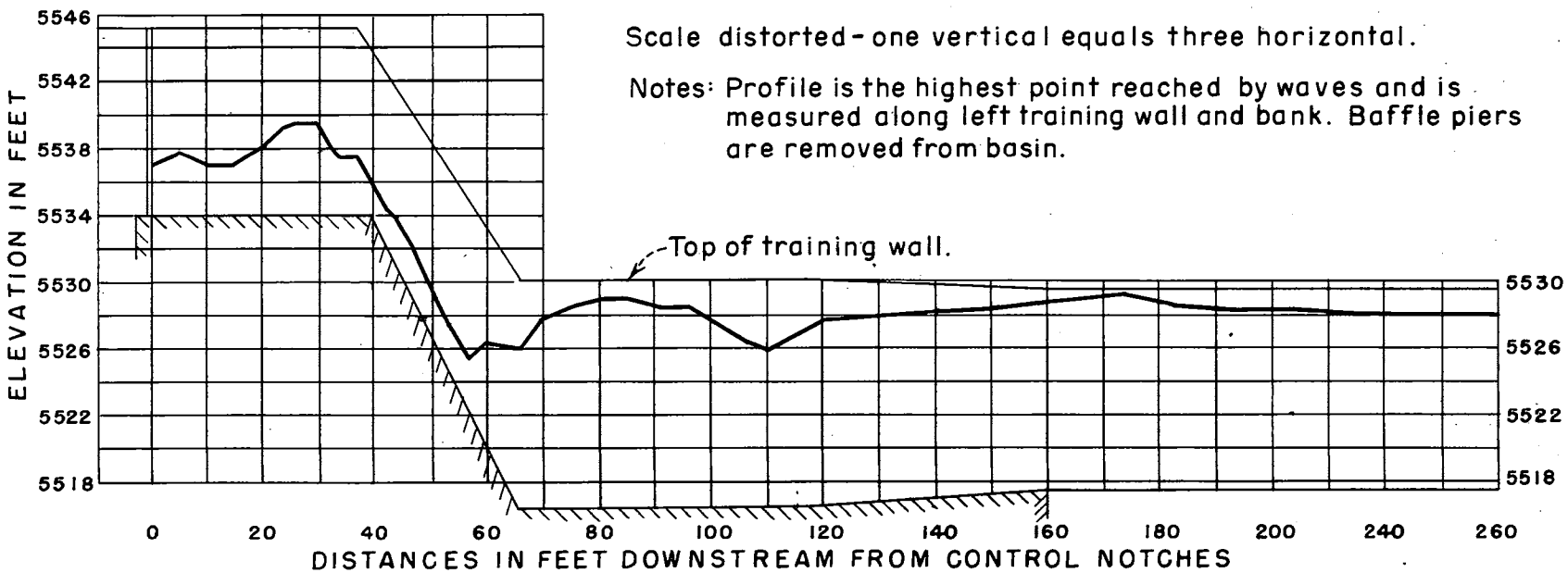
* Vertical distance in feet between trough and crest of waves measured on the 2:1 slope of the canal immediately downstream from the drop structure.

** Recommended baffle pier arrangement.

WYOMING CANAL DROP

STUDIES TO DETERMINE LOCATION AND SIZE OF BAFFLE PIERS

1:12 SCALE MODEL



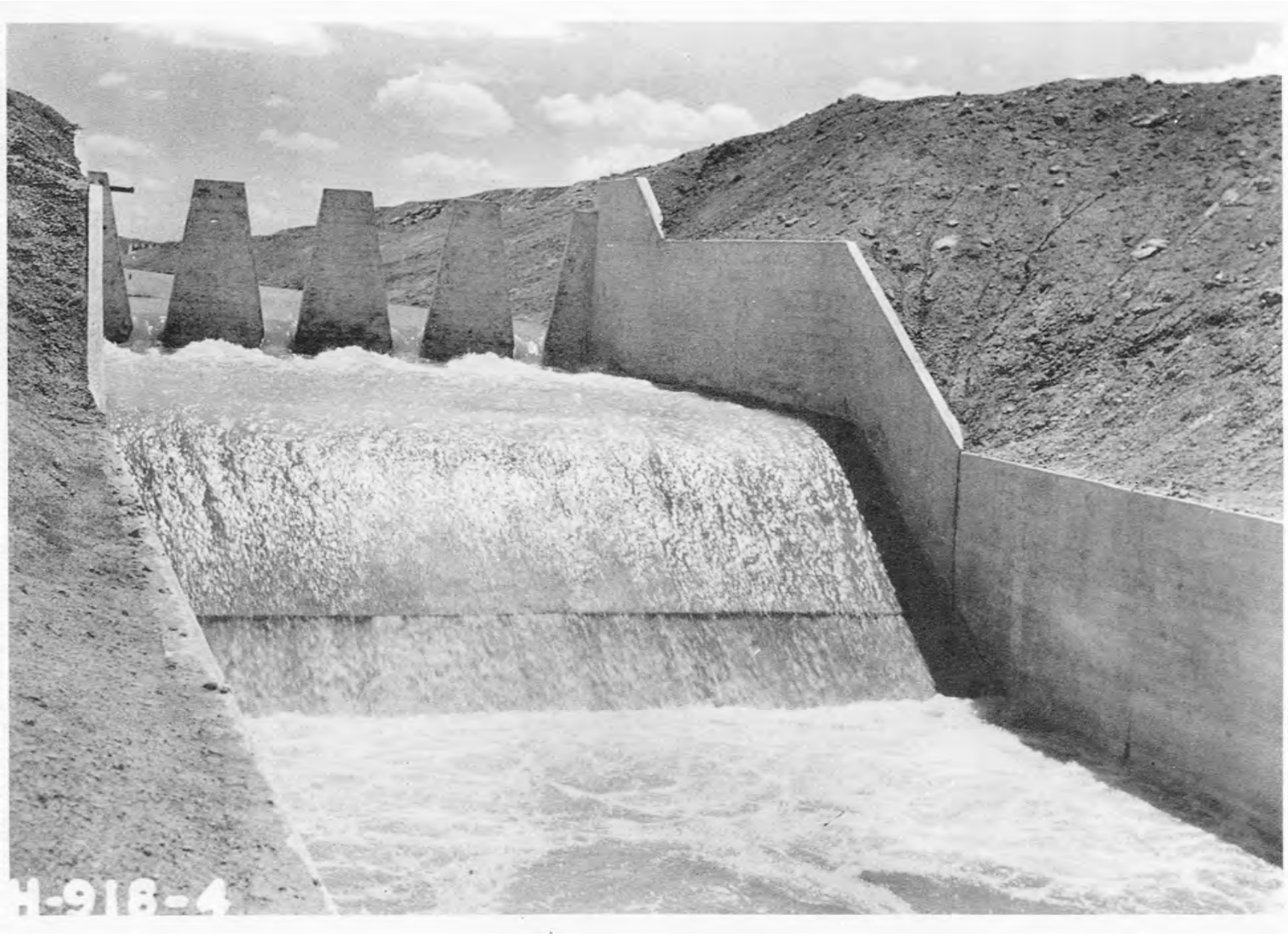
WYOMING CANAL DROP

WATER SURFACE PROFILE

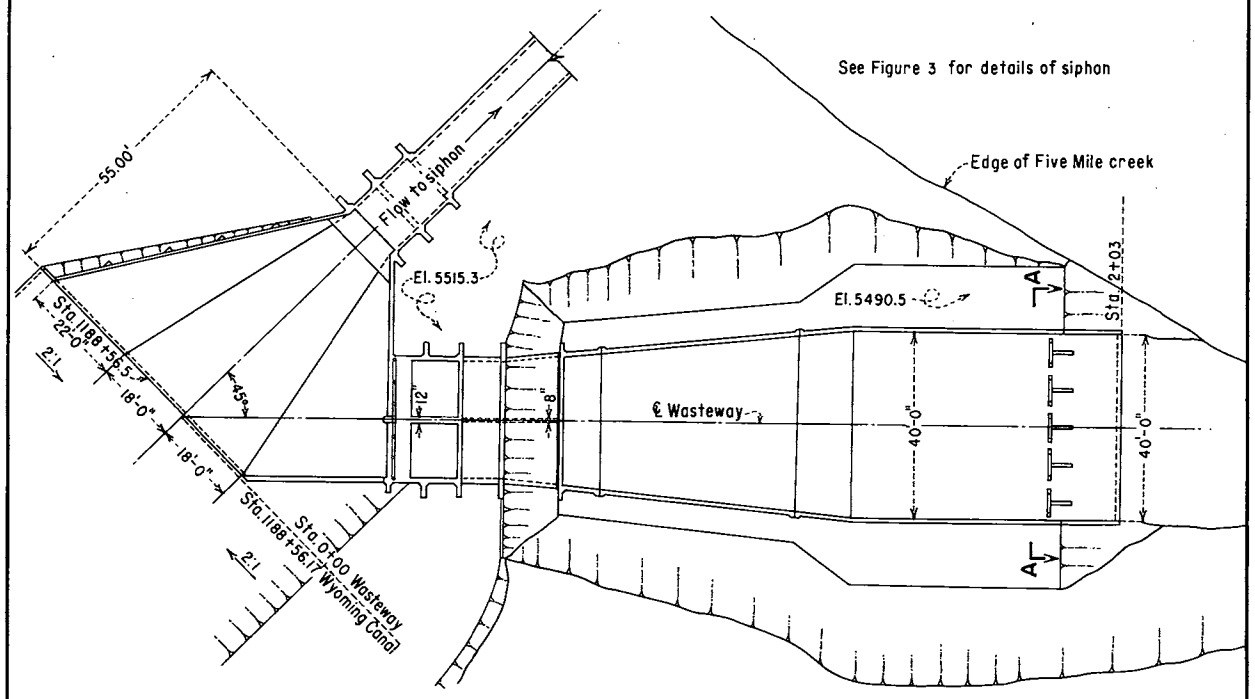
4 SYMMETRICAL NOTCHES - RECOMMENDED DESIGN

DISCHARGE = 1203 SECOND-FEET

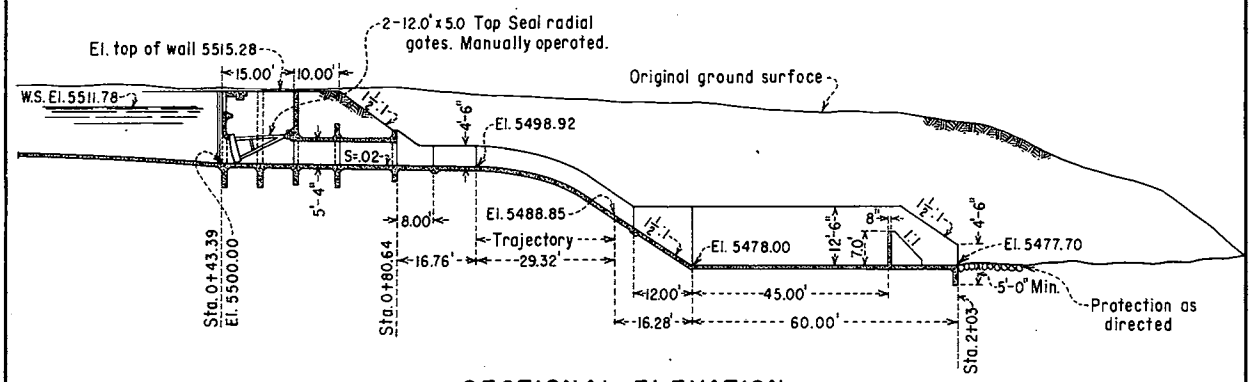
1:12 SCALE MODEL



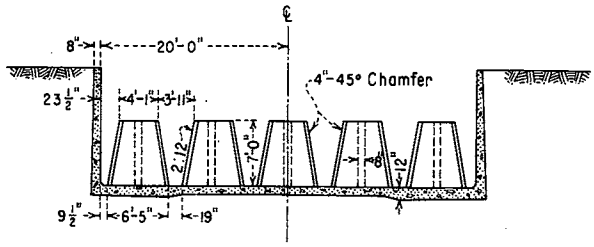
WYOMING CANAL DROP
The Prototype at Station 997+00



PLAN



SECTIONAL ELEVATION



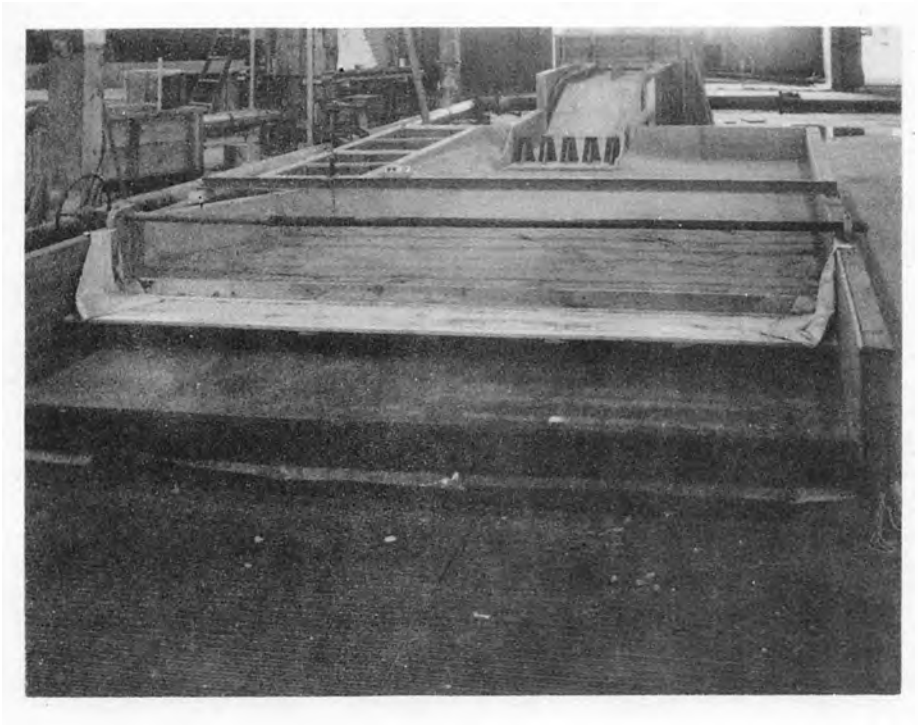
SECTION A-A

WYOMING CANAL WASTEWAY

PRELIMINARY DESIGN

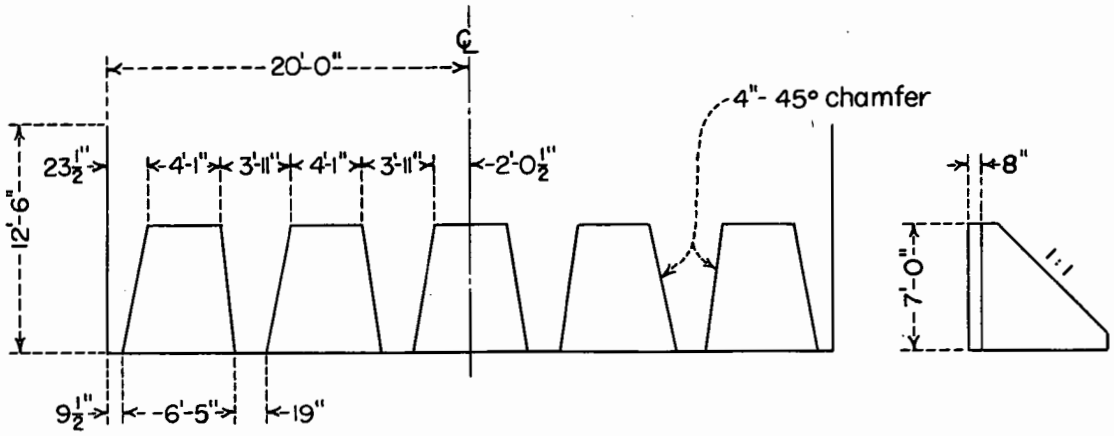
1 : 12 SCALE MODEL

281

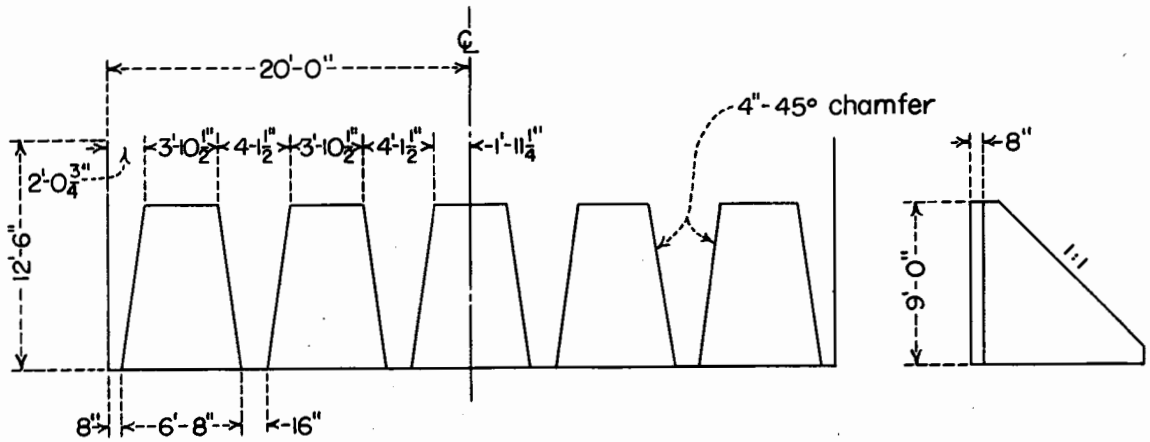


The 1:12 Scale Model

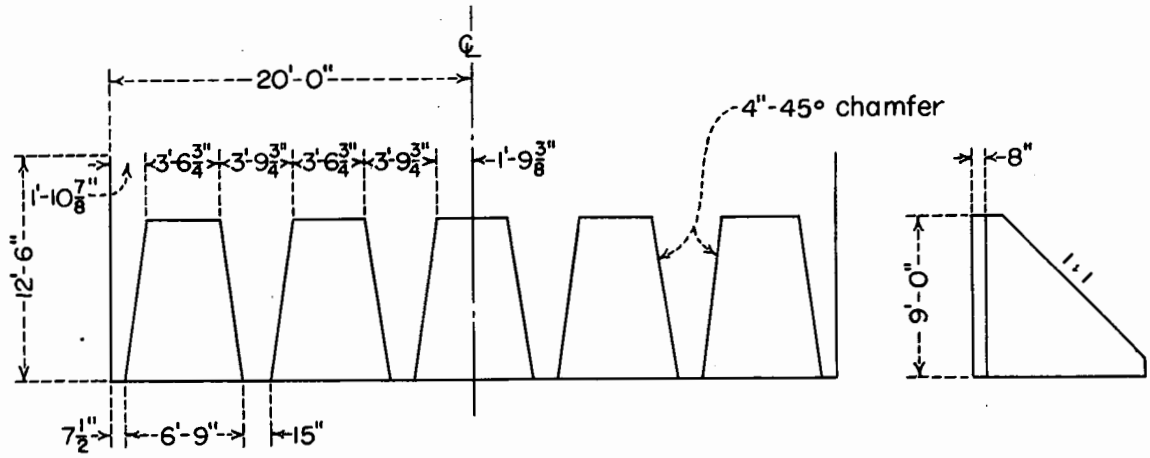
WYOMING CANAL WASTEWAY



PRELIMINARY DESIGN



DESIGN 2



DESIGN 3

WYOMING CANAL WASTEWAY
DETAILS OF CONTROL NOTCH DESIGNS
1:12 SCALE MODEL

No Tailwater

5 feet of tailwater

Discharge = 1208 Second-feet

No Tailwater

5 feet of tailwater

Discharge = 400 Second-feet

WYOMING CANAL WASTEWAY
Preliminary Design
1:12 Scale Model

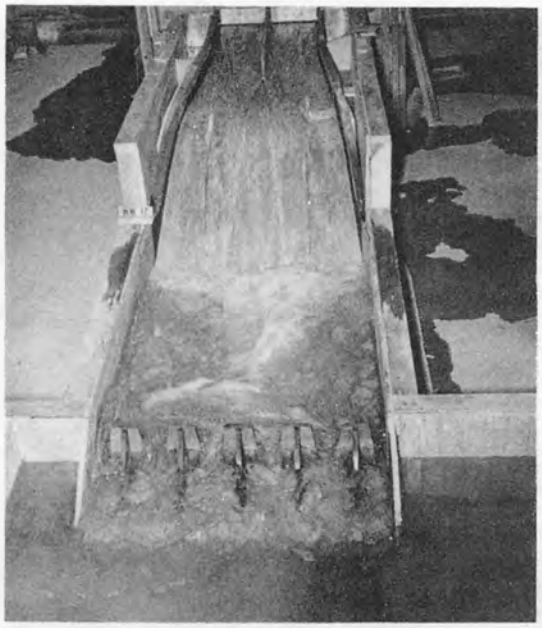
Figure 22
Report Hyd - 376

No Tailwater

5 feet of tailwater

Discharge = 1208 Second-feet

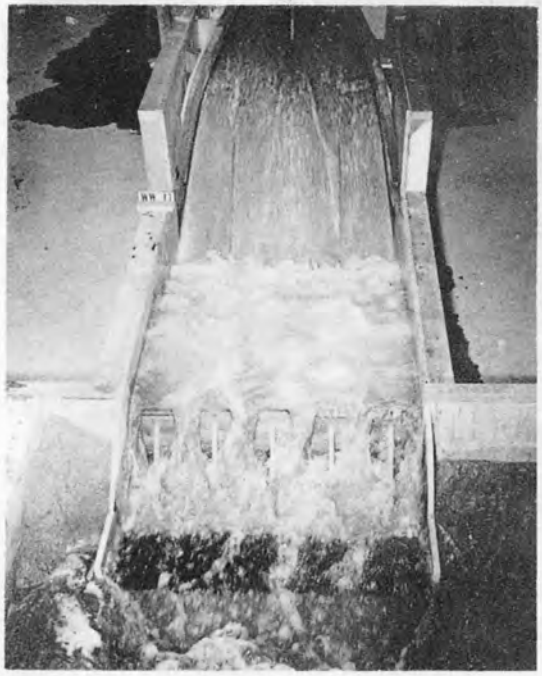
No Tailwater

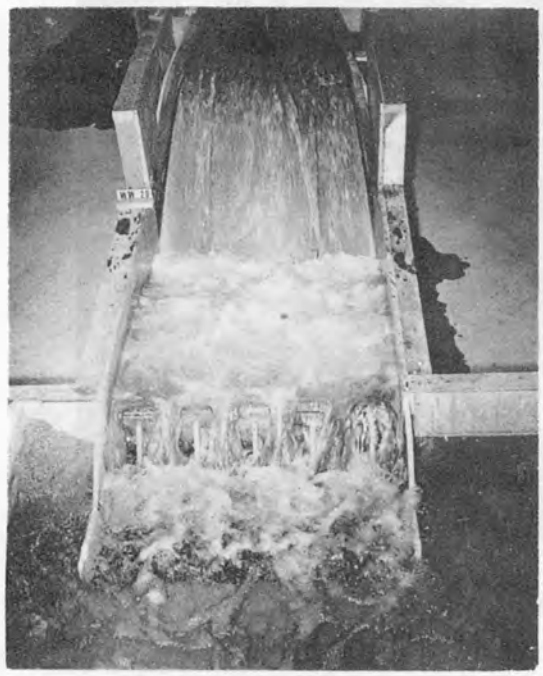


5 feet of tailwater

Discharge = 400 Second-feet

WYOMING CANAL WASTEWAY
Design 2
1:12 Scale Model

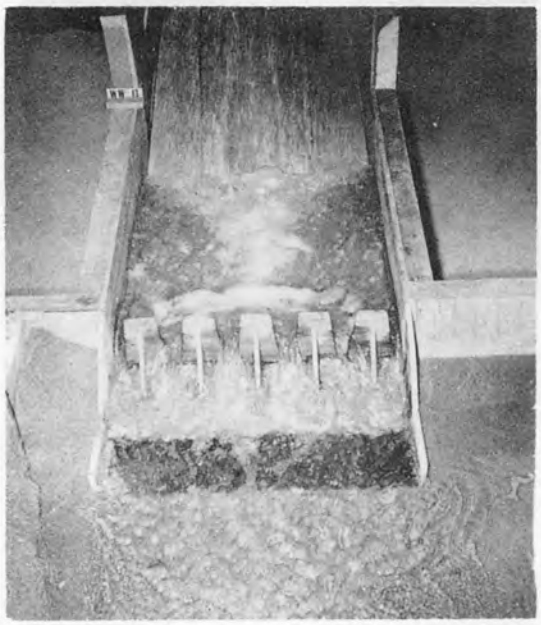


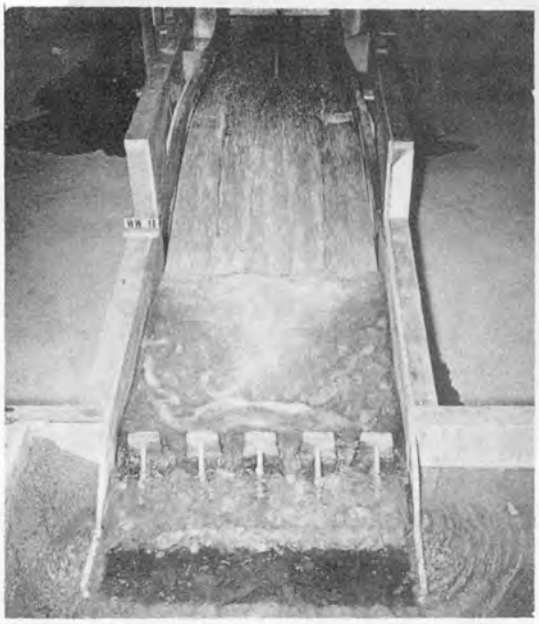


No Tailwater

5 feet of tailwater

Discharge = 1208 Second-feet





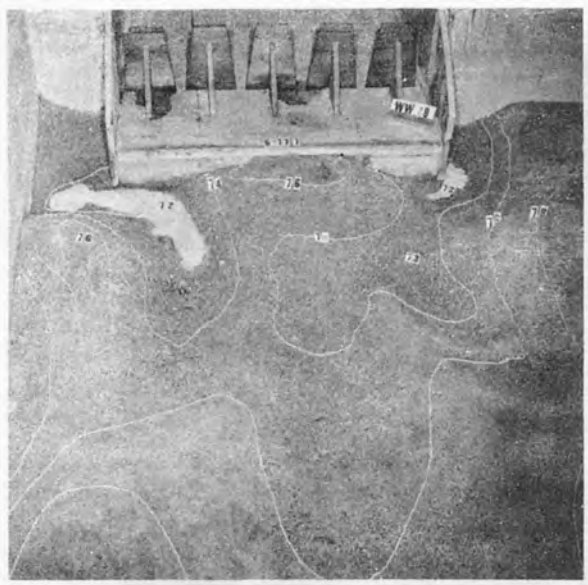
No Tailwater

5 feet of tailwater

Discharge = 400 Second-feet

WYOMING CANAL WASTEWAY
Design 3 (Recommended)
1:12 Scale Model

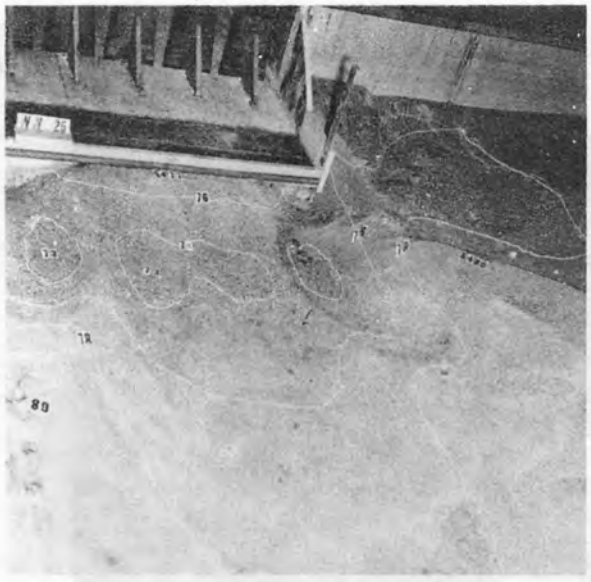
Figure 24
Report Hyd - 376



A. 10-foot apron extension removed

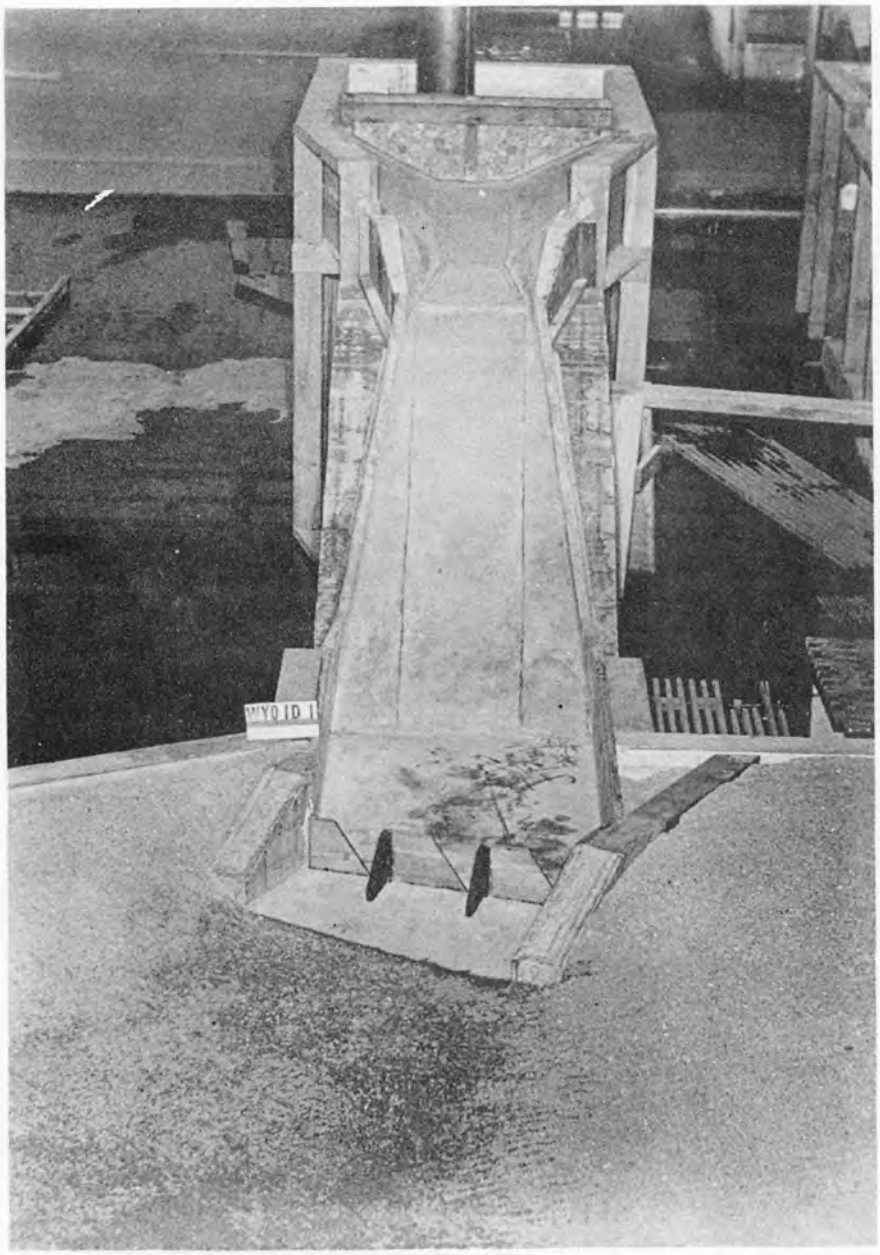
B. Design 3 (Recommended)

C. 2:1 End sill installed



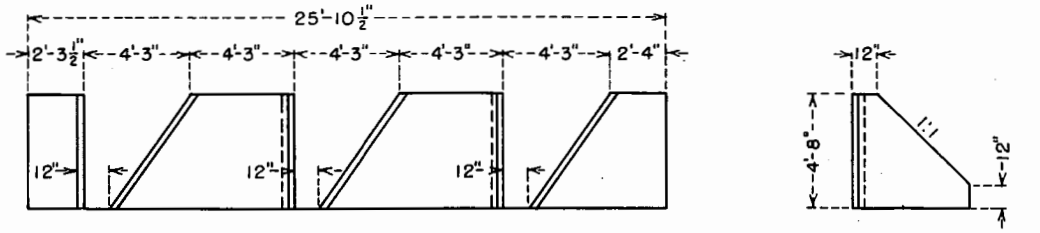
D. 1:1 End sill installed

WYOMING CANAL WASTEWAY
Channel Erosion for variations in Design 3
after Discharge of 1208 Second-feet
1:12 Scale Model

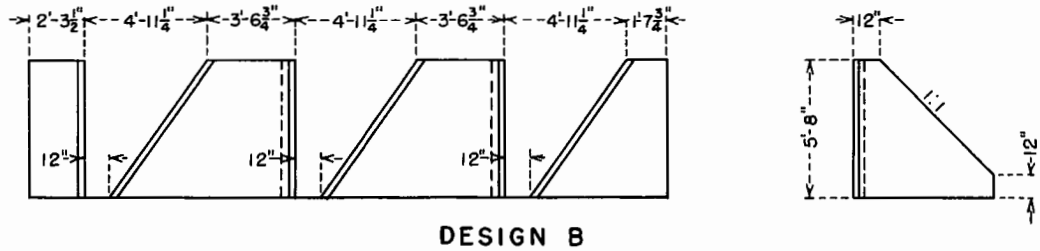


The 1:12 Scale Model

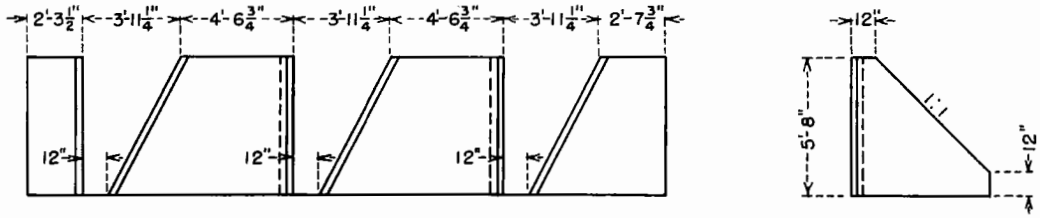
WYOMING CANAL INTERCEPTING DITCH



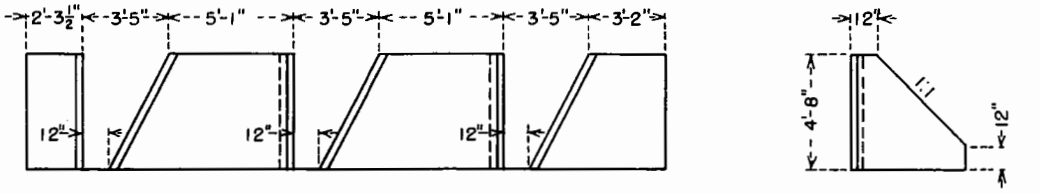
DESIGN A
(Preliminary)



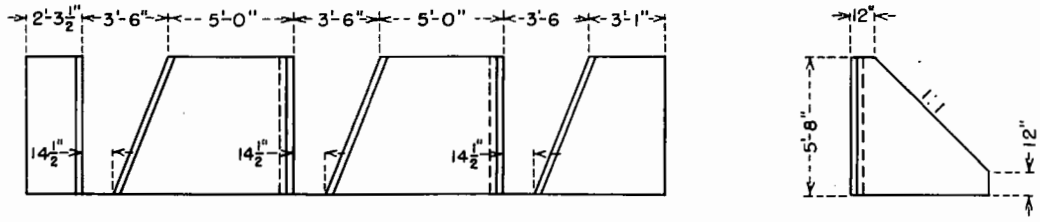
DESIGN B



DESIGN C



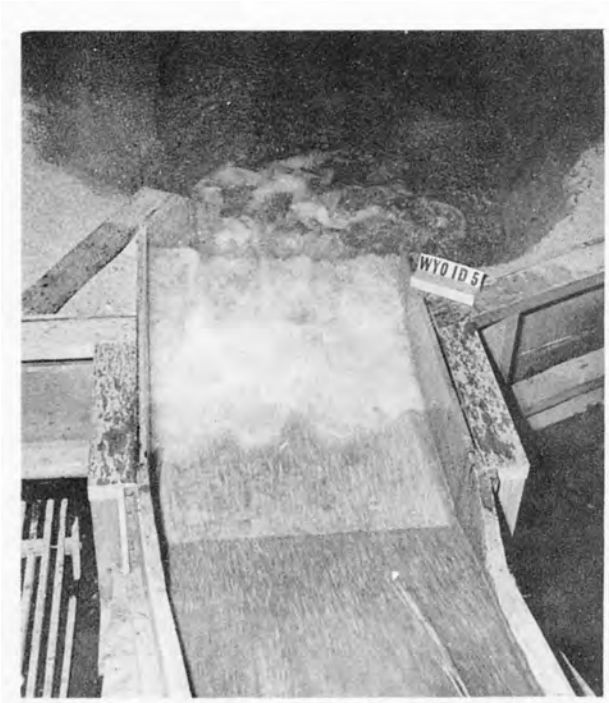
DESIGN D



DESIGN E
(Recommended)

WYOMING CANAL INTERCEPTING DITCH
VARIOUS CONTROL NOTCHES TESTED
1:12 SCALE MODEL

Flow conditions near top of chute

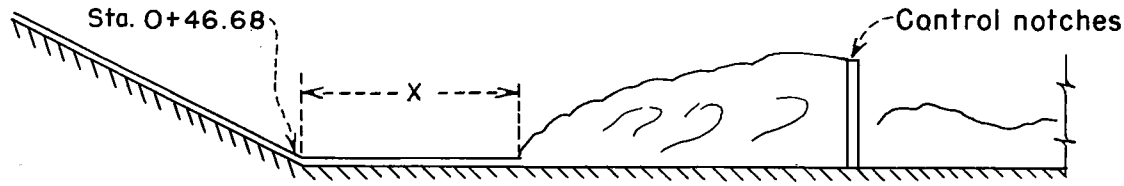


Tailwater elev. = 5482 feet

Tailwater elev. = 5487 feet

Flow conditions in stilling basin

WYOMING CANAL INTERCEPTING DITCH
Preliminary Design
Discharge = 350 Second-feet
1:12 Scale Model

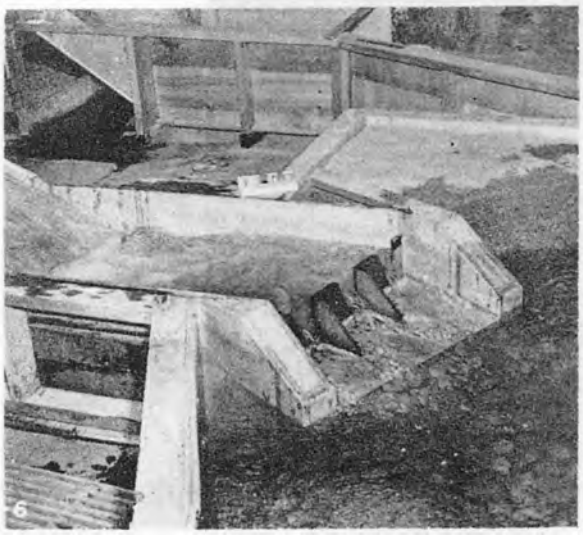


CONTROL NOTCHES				DISCHARGE CFS	TAILWATER ELEV., FEET	DISTANCE "X" FEET
DESIGN	BOTTOM WIDTH, FEET	TOP WIDTH, FEET	HEIGHT, FEET			
A	1.0	4.25	4.67	350	5482	14.75'
				350	5486	9.30'
				350	5486.5	0
				350	5487	on chute
				270	5482	0
B	1.0	4.94	5.67	350	5482	12.75'
				350	5486	0
				350	5487	on chute
				293	5482	0
C	1.0	3.94	5.67	350	5482	on chute
				350	5487	on chute
				397	5482	0
D	1.0	3.42	4.67	350	5482	13.0'
				350	5486.1	0
				350	5487	on chute
				315	5482	0
E	1.21	3.50	5.67	350	5482	on chute
				350	5487	on chute

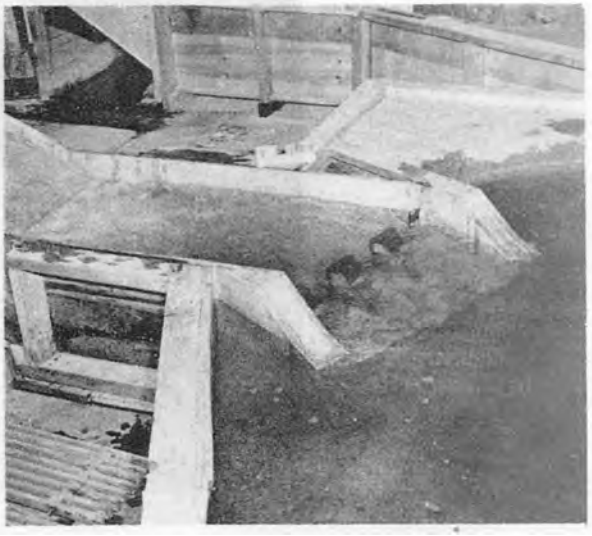
WYOMING CANAL INTERCEPTING DITCH

JUMP POSITION FOR DIFFERENT DESIGNS AND FLOW CONDITIONS

1:12 SCALE MODEL

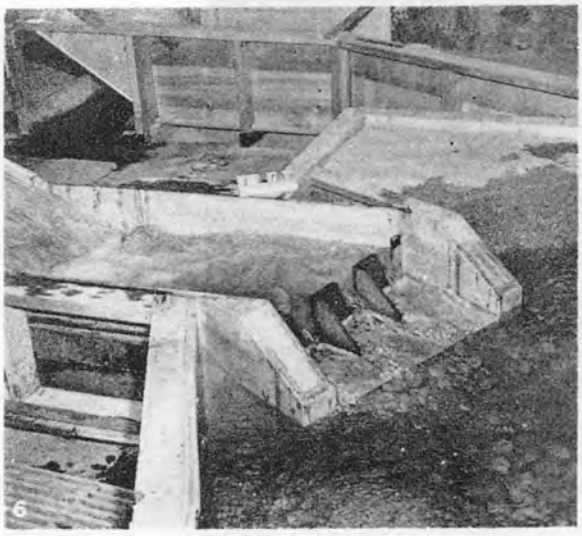


Tailwater elev. = 5482 feet

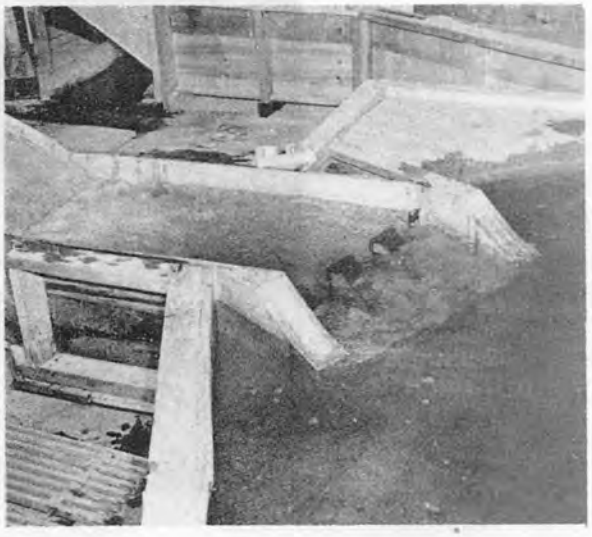


Tailwater elev. = 5487 feet

Discharge = 350 Second-feet



Tailwater elev. = 5482 feet



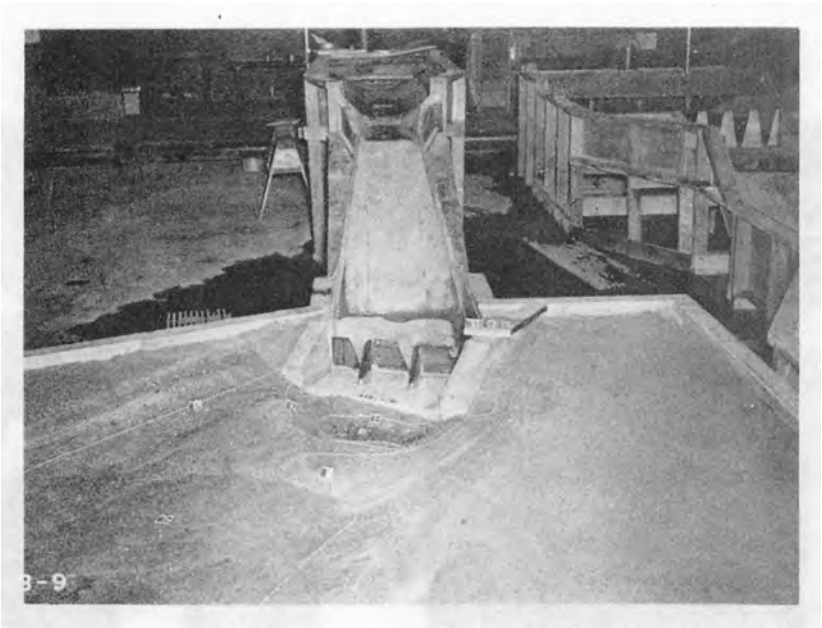
Tailwater elev. = 5487 feet

Discharge = 117 Second-feet

WYOMING CANAL INTERCEPTING DITCH
Operation of Design C
1:12 Scale Model

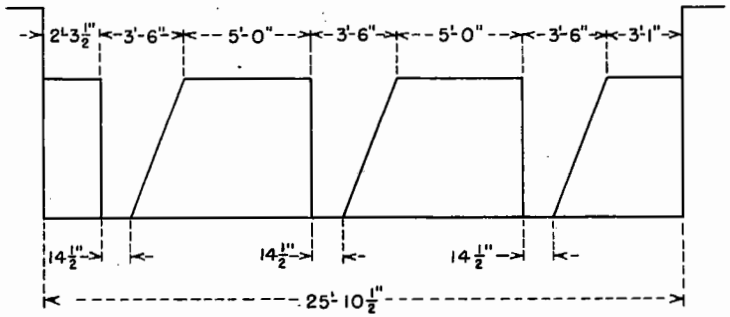
Figure 30
Report Hyd - 376

With tailwater at elev. 5482 feet



With tailwater at elev. 5487 feet

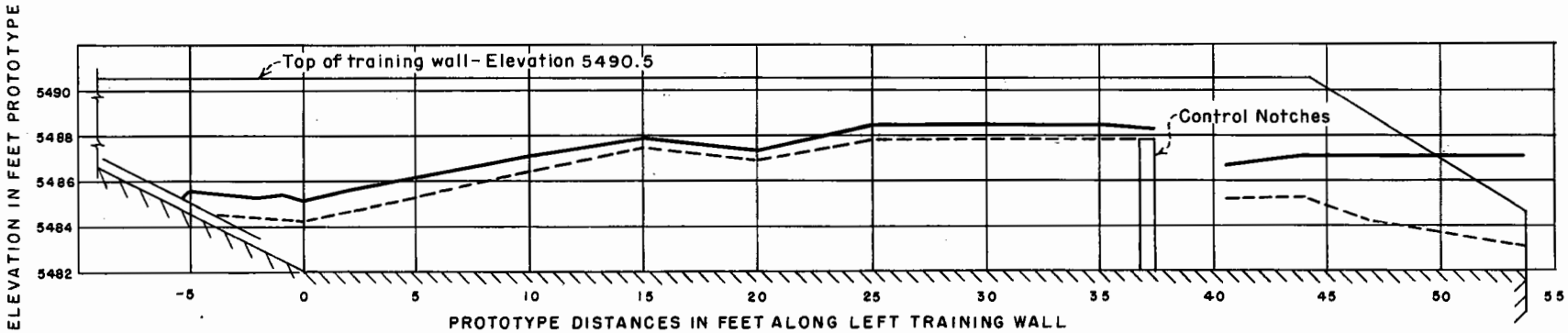
WYOMING CANAL INTERCEPTING DITCH
Erosion Results for Recommended Design
after Discharge of 350 Second-feet
1:12 Scale Model



CONTROL NOTCHES
DESIGN E (Recommended)

Tailwater Elevation =5487.0 feet

Tailwater Elevation below 5482.0 feet



WYOMING CANAL INTERCEPTING DITCH

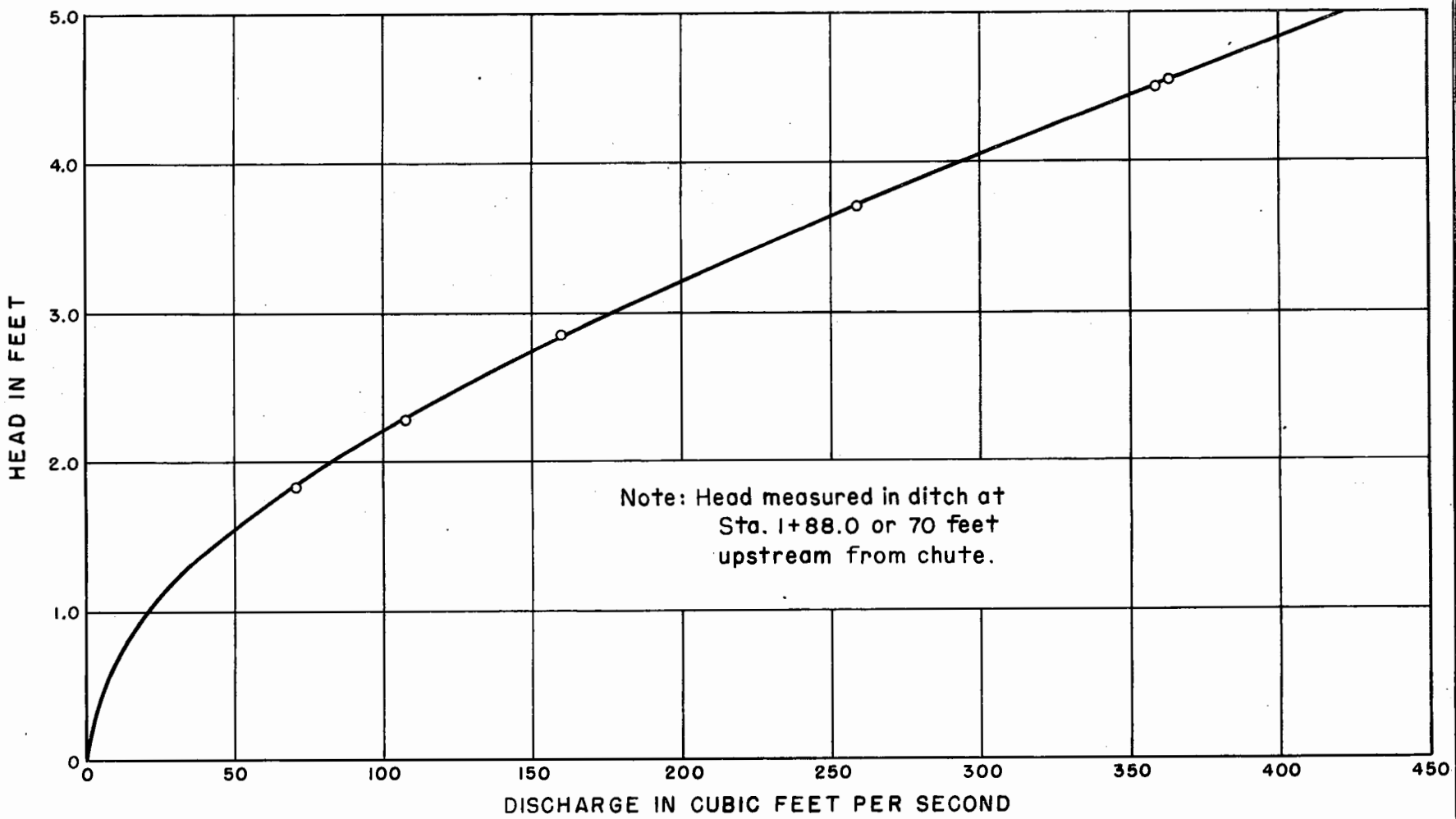
WATER SURFACE PROFILES

DESIGN E (Recommended)

DISCHARGE =350 SECOND-FEET

1:12 SCALE MODEL

FIGURE 31
REPORT HYD. 376



WYOMING CANAL INTERCEPTING DITCH

HEAD-DISCHARGE CURVE FOR DITCH UPSTREAM FROM CHUTE

1:12 SCALE MODEL

281

Interior - Reclamation - Denver, Colo.