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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

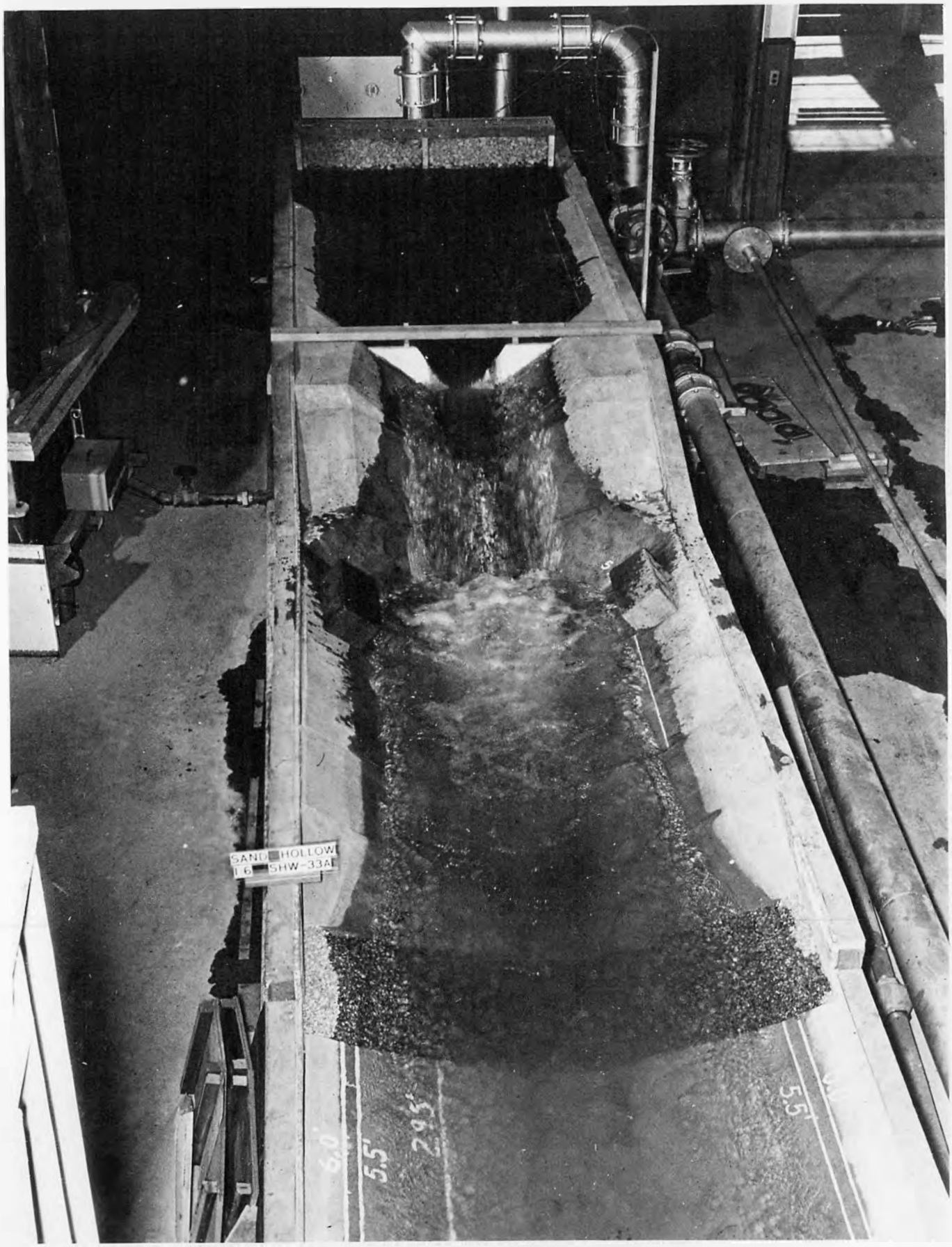
HYDRAULIC MODEL STUDIES OF TRAPEZOIDAL DROP STRUCTURES FOR SAND HOLLOW WASTEWAY--BOISE PROJECT, IDAHO

Hydraulic Laboratory Report No. Hyd. 250

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

MAY 19, 1949



Recommended design in operation at the maximum discharge of 200 second-feet.

CONTENTS

LIST OF FIGURES

Number

UNITED STATES
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Branch of Design and Construction
Research and Geology Division

Denver, Colorado
Date: May 19, 1949

Laboratory Report No. 250
Hydraulic Laboratory
Compiled by: L. J. Glasier and W. E. Wagner
Reviewed by: A. J. Peterka

Subject: Hydraulic model study of trapezoidal drop structures for Sand Hollow Wasteway (east branch)--Boise Project, near Caldwell, Idaho.

SUMMARY

Hydraulic model studies were made to develop a drop structure of trapezoidal cross section for use in a flow system, which would (1) dissipate the energy in the water at the base of the drop, (2) provide uniform flow distribution across the entire trapezoidal section at the end of the paved apron, and (3) provide a smooth water surface at the entrance to and in the lower canal. In addition, it was necessary to develop a control notch for use above the drop structure which would provide a predetermined stage-discharge relationship up to a discharge of 200 second-feet. Tests indicated that the basin and the control are interrelated and that satisfactory operation of the basin is greatly dependent on the type of control used.

A 1:6 scale model of the Sand Hollow Wasteway trapezoidal drop was constructed and tested in the laboratory, Figure 3. Tests were made on five different controls, Figures 3, 6, and 7A, and on two different lengths of stilling basin, Figure 8. The effect of baffle piers on the stilling-basin performance was also studied.

The recommended design, Figure 13, was determined after considering not only the laboratory aspects but also the field limitations of the problem.

Laboratory tests showed that the recommended design performed satisfactorily for all conditions tested. The control consisted of two walls which formed a V-shaped notch located upstream from the drop, Figure 13. The chute and stilling basin had sloping side walls and peaked bottoms. Baffle piers were installed near the upstream end of the basin to reduce the wave heights in the canal and to provide better distribution of flow in the stilling basin, Figure 18. However, the basin will perform satisfactorily, but with higher waves, if for any reason the baffle piers become damaged or entirely destroyed, Figures 17A and B.

INTRODUCTION

Drop structures of trapezoidal cross section which have been built in the past have exhibited various undesirable characteristics.1/ In part this can be attributed to the fact that an inefficient hydraulic jump was formed in the stilling basin of the structure, and only a relatively small amount of the total energy contained in the water was dissipated in the stilling pool. This is evident from observations of prototype structures in operation. In some cases a single current appeared to shoot through the basin in an unstable fashion and failed to spread out across the entire cross-sectional area of the basin. Because of this instability, waves were formed on the surface of the canal section below the drop and caused serious erosion of the canal banks. At higher flows strong side rollers formed just below the structure and water swept back in along the sides of the pool, causing erosion of the canal banks and transition lining. At some flows an unstable whirlpool formed in the stilling basin instead of the intended hydraulic jump. Again, in other ranges of flows, the jump swept completely out of the stilling basin and formed in the canal section below the drop.

The poor operation just described is caused by the inherent tendency of the trapezoidal drop to concentrate the flow of water entering the pool into a relatively narrow jet which shoots along the bottom of the pool and fails to spread out across the entire cross-sectional area of the stilling pool, particularly in the triangular areas on each side bounded by the basin sides and the water surface. Despite the difficulties encountered in the operation of previous trapezoidal drops it was decided that, if a structure of this type could be made to perform satisfactorily without expensive additions, savings in construction cost would be considerable. The major saving would result from almost complete elimination of form work for placing the concrete and a sizeable reduction in the quantity of reinforcing steel required in the conventional rectangular drop. In this study, a trapezoidal drop was constructed and modified to perform satisfactorily over the desired range of operating conditions, always with the thought in mind that the aforementioned advantages of the trapezoidal shape should be maintained.

The Sand Hollow Wasteway (east branch) is located about 9 miles north of Caldwell, Idaho, on the Boise Project, Payette Division. See Figure 1 for location map.

1/ Hydraulic Laboratory Report No. 41, November 7, 1938, United States Department of the Interior, Bureau of Reclamation, "Model studies of the structures at Stations 581+00, 677+00, 738+85, and the slope canal headworks on the Sun River Project, Montana."

There are eight trapezoidal drop structures, all alike, located on the wasteway, being so spaced that the control notch of one structure forms the tail-water control for the structure immediately above it. Each structure lowers the water 10 feet in elevation and is designed for a maximum flow of 200 cubic feet per second. Figure 2 shows the profile and Figure 3 the section drawings of the wasteway.

DESCRIPTION AND OPERATION OF MODEL

A 1:6 scale model of the original design of the trapezoidal drop structure was constructed according to the prototype drawings shown on Figure 3. Model drawing, Figure 4, shows the relative location of the main features of the model.

The upper canal, the control, and a short section of canal before the drop were contained in the metal-lined head box and the chute, stilling basin, and lower canal were contained in the tail box. The control was constructed of wood in all tests except in the last phase of Test 3, in which a sheet metal control, for greater accuracy, was installed in the model. The original model was constructed of concrete except for the peaked bottom of the chute and stilling basin which were of plaster or wood.

After Test 13 was concluded, the model stilling basin was lengthened to 35 feet and the canal section immediately downstream from the end of the concrete transition was lined with pea gravel to allow a study of possible erosion action on the canal banks.

Water was supplied to the model from an 8-inch portable pump and discharges were measured with an orifice-venturi meter. In starting a test, the model discharge, representing a desired prototype discharge, was set and the elevation of the water surface in the upper canal was determined by a hook gage, Figure 4. By use of the tail gate and the staff gage, the elevation of the water surface in the lower canal was set to correspond to the stage indicated on the stage-discharge curve for the particular flow being used. The stage-discharge curve, Curve A, Figure 5, submitted to the laboratory by the design section indicates that the stage for any given discharge is the same in the upper and lower canal sections.

To observe and measure the wave heights in the lower canal, reference lines corresponding to the proper tail-water depth for discharges of 200 second-feet and 50 second-feet were painted on the canal banks. These are shown in the Frontispiece as the elevation 5.5 and the elevation 2.95 foot lines, respectively. Wave heights were determined by noting at a wave measuring station the point on the canal bank to which the highest wave splashed and computing the vertical distance of this point above the tail-water reference line. This method was used because comparative tests showed that wave heights determined in this manner were greater than those read on a staff gage in the channel. The locations of the various wave

measuring stations are given in the footnotes of Tables 1, 2, and 3. A line at elevation 6.0 feet was also used to aid in visual comparison of wave heights at the maximum design flow of 200 second-feet. For Tests 1-19, wave heights were measured only for the 200-second-foot discharge but to aid in comparison of the various baffle pier designs of Tests 20-31, wave heights were also measured at a flow of 50 second-feet.

THE INVESTIGATION

The tests conducted in this model study were divided into two general classifications; the first to develop a satisfactory control notch, Tests 1-5, and the second to develop a satisfactory stilling-basin design, Tests 6-31.

In the tests on the control notches, the results of which are shown in Table 1, Page 10, the primary purpose was to develop a control at the upstream end of the drop structure which would maintain a predetermined stage-discharge relationship in the upper canal for a range of discharges up to 200 second-feet. The secondary purpose of this group of tests was to develop a notch having proper outflow characteristics, since the distribution of flow in the chute had considerable effect on the hydraulic jump in the stilling basin.

The tests on the stilling basin were made to develop a stilling basin which would operate satisfactorily when the recommended control notch was installed in the model.

Control Notch Tests

In the first tests the main consideration given the control notch was that it provide the proper stage-discharge relationship, but as the testing progressed it became apparent that the shape and location of the control structure had a great influence on the distribution of flow of water in the two valleys of the chute and consequently upon the action of the hydraulic jump in the stilling basin. Also, to secure uniform flow distribution in the basin it was, of course, necessary to divide the water evenly between the two valleys of the chute. Another factor affecting the practicability of the control was the susceptibility of the various control structures for becoming obstructed with floating weeds and debris.

Test 1, Figures 3 and 14A, showed that the control pier of the original design did not maintain the desired water level in the canal. The control structures of Tests 2-5, Figures 6 and 7A, in all cases maintained the water surface just slightly above the desired level. The control notch designs of Tests 1, 2, and 5 were considered unsatisfactory because of the relatively greater possibility of becoming obstructed with trash and because the flow in the chute, particularly for flows less than maximum, was not evenly distributed. The design used in Test 4

had the same control notch as Test 3, but because it was located further downstream it provided poor distribution of flow in the chute. Figures 14 and 15 show the model operation for a discharge of 200 second-feet with the various control notches installed.

The control notch of Test 3 was selected as the control structure most nearly providing the desired performance. Figure 13 shows the recommended design. Figure 5 shows the head-discharge curve obtained for the recommended notch and indicates that it maintained very nearly the desired water level in the canal above the drop for the desired range of discharges. Further, it was considered least likely to be obstructed by floating trash and debris, and for all discharges tested the distribution of flow in the chute valleys was satisfactory. The stage-discharge relationship shown in Figure 5 was made with the control notch accurately constructed of sheet metal.

Effect of notch discharge on stilling-basin performance. Although sufficient tests were not made to evaluate each notch in terms of identical basins, certain characteristics of flow were noted, and provide a clue to the reasons for the successful operation of the notch of Test 3. In Tests 4 and 5, with a peaked bottom and a discharge of 200 second-feet, the flow was concentrated on the outside slopes of the chute. As a result, the two jets were deflected by the basin sides, causing them to intersect about halfway down the basin length. This was evident when the tail water in the lower canal was lowered, Figure 15C.

In Tests 1, 2, and 3, the flow in general for 200 second-feet was well distributed in the chute. For Tests 1 and 2, with a flat bottom, and for Test 3, with a short length of peaked bottom, the two jets intersected at the bottom of the pool somewhere near the lower end of the basin. Thus, for the notch of Test 3, a more uniform distribution of flow occurred in the chute and also throughout the length of the stilling basin, Figure 15B. Since it also maintained the desired stage-discharge relationship the notch of Test 3 was selected for use in the apron tests and ultimately for use in the recommended design.

Stilling-Basin Tests

With the recommended control of Test 3 installed in the model, Tests 6-31 were conducted to develop a stilling-basin design which would produce, at all flows, a smooth evenly distributed flow of water in the basin and lower canal section. The stilling-basin length was 25 feet, in Tests 6-13, and was lengthened to 35 feet in Tests 14-31, Figure 8. These groupings of tests will hereafter be referred to as tests on the short and long basin. Table 2, Page 12, gives the results of the tests on the short basin, and Table 3, Page 13, contains the results of the tests on the long basin. It is to be noted that these two tables give the elevation of the highest wave for each test, and also describe the action in the pool and the character of the canal surface.

After the proper control notch had been selected and the peaked bottoms installed in the stilling basin, it was found that the performance of the various stilling basins could best be evaluated by measuring and comparing the wave heights in the lower canal. In practically every test the efficiency of the jump and its ability to dissipate energy and provide uniform flow was reflected in the height of the waves which existed in the lower canal. For this reason the discussion of the stilling-basin tests centers around wave heights. However, the above-mentioned tables give a brief description of the action in the pool and the photographs of the model in operation show the extent of the turbulent water in the model.

Tests on Short Basin

Tests 6-13 were conducted on the short basin, 25 feet long. Test 6, Figure 8A, was conducted with no baffle piers installed in the basin. Tests 7, 8, 9, 10, and 11, Figures 7 and 9, were conducted to study the effect of different baffle pier designs. For Test 12, Figure 10A, a fillet was installed at the intersection of the chute and basin valleys. For Test 13, Figure 10B, a false floor of sheet metal was installed over the chute valleys to produce a flat chute bottom.

A comparison of the results of Tests 7, 8, 9, 10, and 11, Table 2, Page 12, showed that the baffle pier designs of Tests 8 and 9 were most effective in reducing the wave heights in the canal section downstream from the drop. For the maximum flow of 200 second-feet the waves splashed up to about 6.0 feet for both tests, making the actual wave height above the normal water surface about one-half foot. The wave heights of Tests 7, 10, and 11 were considerably higher, as shown in Table 2.

In Tests 7, 8, 9, and 11, the most effective location of the baffle piers, was determined by the following procedure: While the model was operating at maximum design flow the baffle piers, which were mounted on sheet metal strips bent to fit the floor of the basin, were inserted at the upstream end of the stilling basin and slowly moved downstream to about the middle of the basin. The wave heights were noted as the baffle piers were moved and the location at which the waves were a minimum was chosen as the most effective.

The piers of Test 10 were tested only at the location given in Figure 9B. The fillet of Test 12 and the flat chute bottom of Test 13 had only a small effect on the reduction of wave heights in the canal below the basin as shown in Table 2, Page 12.

In Test 6, with the short basin and no baffle piers installed, the wave heights in the canal below the drop were about 1-1/2 feet. With the baffle piers of either Test 8 or 9 installed, the wave heights were reduced to about one-half foot. This reduction of wave heights fully justified the use of baffle piers in the basin.

For some installations, the short basin equipped with baffle piers, similar to those of Tests 8 or 9, Figures 7 and 9, might be considered adequate. However, since baffle piers in the prototype structure might be damaged in various ways, it was desired to develop, if possible, a stilling basin of economic proportions that would operate satisfactorily even if the baffle piers were destroyed completely. Accordingly, the stilling basin was lengthened to 35 feet and the tests on the long basin were made.

Tests on Long Basin

Tests 14-31, Table 3, Page 13, were performed on the stilling basin after it had been lengthened to 35 feet, Figure 8B. Test 14, Figure 8B, was made without baffle piers and Tests 15, 16, and 17, Figure 11, were conducted with various sizes of baffle piers installed in the basin. Tests 18 and 19, Figure 16, were performed to determine the effect on the action of the jump in the basin when the baffle piers of Test 16 were obstructed with trash. Tests 20-30, Figures 12A and B, were made to determine the most effective method of placing the baffle piers in two rows to reduce the possibility of their becoming obstructed with floating trash and debris. Test 31, Figure 12C, was made to determine the effectiveness of an arrangement of baffle piers proposed by the design section.

A comparison of the wave heights, Table 3, Page 13, of Test 14 with those of Tests 15, 16, and 17 showed that baffle piers reduced materially the height of waves in the canal section below the drop. Since sufficient reinforcing steel could be placed in the 7-inch wide piers of Test 16 to meet all structural requirements, this pier was selected for further tests. The distribution of flow in the stilling basin and a visual comparison of the height of waves in Tests 14 and 16 are shown in Figure 17. Tests showed that small bits of debris and weeds introduced into the flow above the control would lodge on and between the piers spaced as shown in Test 16.

It is possible that during field operation of the prototype the baffle piers will become completely obstructed with floating trash and debris. Consequently, for Tests 18 and 19, rags were fastened to the front of the baffle piers to assimilate the field conditions where the piers were completely obstructed, Figure 16A. In both tests the flow of water was deflected vertically upward over the piers and the resulting pool surface was very rough, Figure 16B. Additional tests were then made to prevent clogging of the openings between the piers.

Tests 20-30 showed that there was an effective method of staggering the 7-inch wide piers into two rows to increase the clearance between the piers and yet provide a smooth water surface in the lower canal. By comparing the results of these tests in Table 3, Page 13, it was apparent that the location of piers in Tests 21 and 22, Figure 12A, produced the most effective reduction of wave heights. The location and arrangement of baffle piers of Test 21, is recommended by the laboratory because it is considered less likely to become obstructed with floating trash and debris. Figure 18 shows the operation of the model at a discharge of 200 second-feet using the piers of Test 21.

It was evident that wave heights became progressively higher as the piers were moved downstream as a group; also that, in general, moving the

downstream row of piers downstream with the upstream row in a fixed position, gave progressively higher wave heights.

Discussion of Results of Stilling-Basin Tests

A study of the results of the tests on the short basin showed that the baffle pier designs of Tests 8 and 9 were most effective in reducing the turbulence and wave action in the canal section downstream from the drop. At the maximum design flow, the wave heights for the short basin without baffle piers were 1.5 feet compared to wave heights of one-half foot when piers of the design of either Test 8 or 9 were installed in the basin. If the canal banks were of a material able to withstand waves of this magnitude the short basin with properly designed baffle piers installed could be used. There were no particularly undesirable hydraulic characteristics apparent on the model at lower flows in either Test 8 or 9. The fact that most of the flow was along the sides of the pool at low flows was not considered serious, since harmful affects did not extend to the end of the apron.

Lengthening the stilling basin 10 feet was thought to be justified for this particular installation on the Sand Hollow Wasteway since the long basin without baffle piers produced waves appreciably lower than those of the short basin, with no piers installed. Additional tests showed that the wave heights could be further reduced by the addition of baffle piers to the long basin. With properly placed piers in the long basin, the waves were reduced from 0.9 feet to 0.3 feet high. The location of baffle piers in Test 20 produced slightly more reduction of wave heights at the maximum design flow, but the location of baffle piers in Test 21 was recommended by the laboratory since tests showed that this arrangement of piers was less likely to become obstructed with floating trash and debris.

At the request of the design section, the pier arrangement of Test 31 was tested in the model. This arrangement differed from Test 21 in that the small outside piers of the upstream row were removed and the upstream row of piers were moved 6 inches farther downstream as shown in Figure 12C. The action in the pool and lower canal was just as satisfactory as that produced by the pier arrangement of Test 21, Figure 19. Further tests on the pier arrangement of Test 31 showed that the openings between the piers would not become clogged with trash.

For all flows tested, the pool and canal surfaces were relatively smooth and the flow of water was evenly distributed at the end of the paved apron of the drop. There was no evidence of measurable erosion in the gravel-lined section of canal immediately below the drop.

Since the arrangement of piers for Test 31 performed satisfactorily they were adopted for use in the recommended structure.

RECOMMENDED DESIGN OF DROP STRUCTURE

Based on the results of hydraulic model tests and on field limitations, the structure recommended for prototype construction consisted of the long basin, Figure 8B, with the baffle pier arrangement of Test 31, shown in Figure 12C, and the control notch of Test 3, Figure 6B. As a result of the tests made to reduce wave heights, it was possible to reduce the vertical height of the stilling basin from the originally proposed 10 feet to 9 feet. The entire structure is also shown on Figure 13, and an over-all view of the model is shown in the Frontispiece.

Table 1

RESULTS OF TESTS ON CONTROL NOTCH (TESTS 1-5)

Test	Description of test design	Q	Elevation of* highest wave	Desired head**	Actual head in model	Remarks
1	See Figure 3	200	6.5'	5.50'	4.51'	Pronounced side rollers in pool and canal surface very rough. Flow concentrated in chute grooves. See Figure 14A. Two jets intersect near end of basin.
		100	--	4.02'	3.31'	Pool and canal surface rough. Flow down chute grooves tends to outside slopes of grooves.
2	See Figure 6A	200	7.0'	5.5'	5.63'	Pronounced side rollers. Pool and canal surface extremely rough. Flow concentrated more on outside slopes of chute grooves. See Figure 14B. Two jets intersect below middle of pool.
		100	--	4.02'	4.28'	Pool and canal surface rough. Flow shifted to inside slopes of chute grooves.

*Elevation to which highest wave splashed on left channel bank 8 feet downstream from end of transition.

**Desired head--Head from Curve A, Figure 5, corresponding to discharge for test.

Table 1 (Continued)

Test	Description of test design	Q	Elevation of highest wave	Desired head	Actual head in model	Remarks
3	See Figure 6B	200	6.25'	5.5'	5.66'	Side rollers in pool. Pool and canal surface very rough. Peaked basin bottom seemed to straighten flow through pool. Distribution of flow down chute valleys uniform for different flows. See Figures 14C and 15B.
		100	--	4.02'	4.14'	Pool and canal surface rough.
4	See Figure 6C	200	6.75'	5.5'	5.57'	Control notch of Test 3 moved to this position to spread flow of water onto outside slopes of chute valleys. Flow deflected back by side slopes of basin peak, two jets intersecting about center of basin. Pronounced side rollers. Pool and canal surface very rough. See Figure 14D.
		100	--	4.02'	4.13'	Pool and canal surface rough. Flow of water still on outside slopes of chute valleys.
5	See Figure 7	200	6.75'	5.5'	5.62'	Pool and canal surface very rough. Pronounced side rollers. Flow of water riding outside slopes of chute valleys. Deflected back to center of pool by outside slopes of basin. Jets intersect about center of pool. See Figure 15.
		100		4.02'	4.45'	Pool and canal surface rough.

Table 2

RESULTS OF TESTS ON "SHORT" STILLING BASIN

Test	Description of test design	Q	Elev. of highest wave*	Distribution of flow**	Remarks
6	See Figure 8A	200	7.0'	Poor	Pool and canal surface very rough, pronounced side rollers.
7	See Figure 7B	200	6.25'	Fair	Pool and canal surface rough, side rollers in upper pool.
		50	--	Fair	Flow mostly along sides of basin. Pool and canal surface rough.
8	See Figure 7C	200	6.0'	Fair	Pool and canal surface rough. Piers deflected jets of water up above normal pool surface. Side rollers in upper pool.
		50	--	Fair	Pool and canal surface rough. Flow mostly along sides of pool.
9	See Figure 9A	200	6.0'	Fair	Pool and canal surface rough. Piers deflected jets of water up above normal pool surface. Side rollers in upper pool.
		50	--	Fair	Pool and canal surface rough. Flow mostly along sides of pool.
10	See Figure 9B	200	6.5'	Poor	Pool and canal surface rough. Piers intercepted practically all incoming flow, causing jets to shoot well above normal pool surface. Most of flow along surface of pool.
11	See Figure 9C	200	6.5'	Fair	Pool and canal surface rough. Flow deflected to outsides of pool eliminating side roller.
12	See Figure 10A	200	6.5'	Poor	Pool and canal surface very rough. Bottom fillet did not break up flow of incoming jets. Pronounced side rollers in pool.
13	See Figure 10B	200	6.5'	Poor	Pool and canal surface rough. Flow well distributed on chute bottom but concentrated into two jets by side slopes of peaked basin bottom and basin sides. Pronounced side rollers in pool.

*Elevation to which highest wave splashed on left channel bank 8 feet downstream from end of transition.

**At downstream end of transition.

Table 3

RESULTS OF TESTS ON "LONG" STILLING BASIN

Test	Description of test design	Q	Elev. of waves*	Distribution of flow	Remarks
14	See Figure 8B	200	6.4'	Poor	Pool and canal surface fairly rough, side rollers on both sides of stilling pool. See Figure 17A.
15	See Figure 11A	200	6.1	Good	Pool and canal surface smooth. Small side rollers in upper pool.
		100	--	Fair	Flow mostly along sides of pool. Pool and canal surface smooth.
		50	--	Fair	Flow mostly along sides of pool. Pool and canal surface smooth.
16	See Figure 11B	200	5.9	Good	Pool and canal surface smooth. Small side rollers in upper pool. See Figure 17B.
		50	--	Fair	Flow mainly along sides of pool. Pool and canal surface fairly smooth.
17	See Figure 11C	200	5.9	Good	Pool and canal surface fairly smooth. Side rollers in upper pool.
		50	--	Fair	Flow mainly along sides of pool. Pool and canal surface fairly smooth.
18	See Figure 16A	200	6.5 on l b 6.1 on r b	Fair	Clogged piers deflected jet of water 3 feet up above normal pool surface. Rapid flow along right bank, flow along left bank slower and mostly on surface.
		50	--	Poor	Clogged piers deflected jet of water 18 inches above normal pool surface. Very little flow along left bank.
19	See Figure 16B	200	6.6 both banks	Poor	Clogged piers deflected incoming jets 3 feet above normal pool surface. Pool and canal surface very rough. Flow mostly on surface of pool. See Figure 16C.

*Elevation to which highest wave splashed on left bank 18 feet below end of transition for 100 sf. Elevation to which highest wave splashed on right bank 18 feet below end of transition for 50 sf.

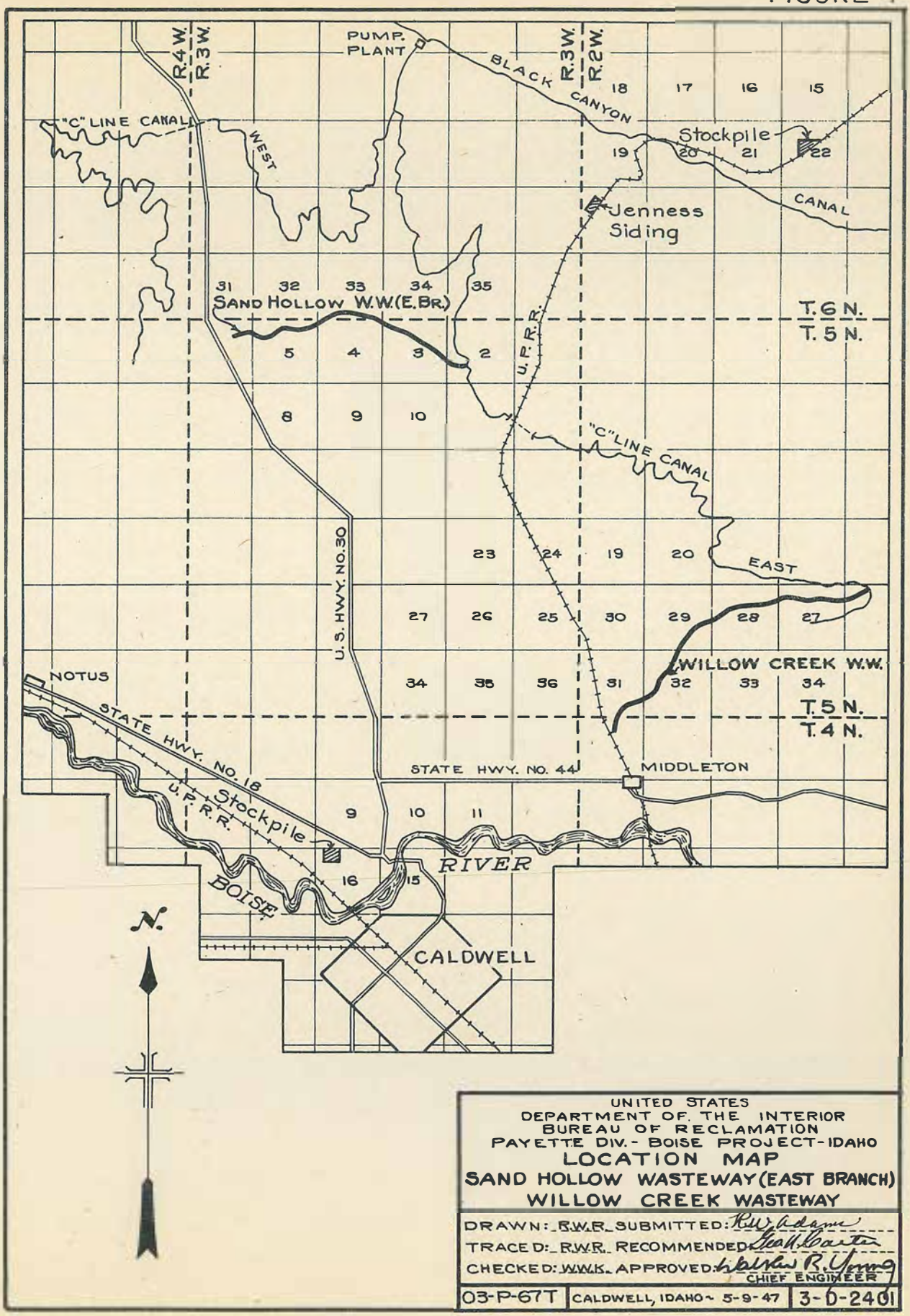
Table 3 (Continued)

Test	Description of test design	Q	Elev. of waves	Distribution of flow	Remarks
		50	--	Poor	Clogged piers deflected incoming jets 18 inches above normal pool surface. Flow mainly on surface and along sides of pool.
20	See Figure 12A A=1.5' B=1.5'	200	5.8	Very good	Pool and canal surface very smooth. Small side rollers in upper pool.
		50	3.2	Good	Pool surface smooth, flow of water unstable in center of pool just below piers.
21	See Figure 12A A=1.5' B=3'	200	5.9	Very good	Pool and canal surface very smooth. Small side rollers in upper pool. See Figure 18.
		50	3.15	Good	Pool surface smooth but flow unstable in center of pool just below piers.
22	See Figure 12A A=1.5' B=4.5'	200	6.0	Good	Pool and canal surface smooth. Small side rollers in upper pool.
		50	3.25	Good	Pool and canal surface fairly smooth. Flow of water unstable in center of pool just below piers.
23	See Figure 12A A=1.5' B=6'	200	6.0	Good	Pool and canal surface became rougher as second row of piers was moved downstream. Side rollers became larger.
		50	3.25	Good	Pool and canal surface became rougher as second row of piers was moved downstream. Unstable flow between rows of piers, center of pool.
24	See Figure 12B A=1.5' B=1.5'	200	5.9	Very good	Pool and canal surface very smooth. Small side rollers in upper pool.
		50	3.3	Good	Pool and canal surface very smooth. No unstable area below piers.
25	See Figure 12B A=1.5' B=3.0'	200	6.0	Good	Pool and canal surface smooth. Small side rollers in upper pool.
		50	3.25	Good	Pool and canal surface fairly smooth. No unstable flow below piers.
26	See Figure 12B A=1.5' B=4.5'	200	6.0	Good	Pool and canal surface became rougher as second row of piers was moved downstream. Side rollers became larger.
		50	3.25	Fair	Fluctuating horizontal roller formed between row of piers.

Table 3 (Continued)

Test	Description of test design	Q	Elev. of waves	Distribution of flow	Remarks
27	See Figure 12A A=3' B=1.5'	200	5.9	Very good	Pool and canal surface smooth. Small side rollers in upper pool.
		50	3.2	Good	Pool and canal surface fairly smooth. Fluctuating horizontal roller formed in center of pool just below lower row of piers.
28	See Figure 12A A=3' B=3'	200	6.1	Good	Pool and canal surface fairly smooth. Side rollers in upper pool.
		50	3.2	Fair	Pool and canal surface became rougher as second row of piers was moved downstream. Unstable horizontal roller formed in center of pool just below lower row of piers.
29	See Figure 12A A=4.5' B=1.5'	200	6.0	Good	Pool and canal surface fairly smooth. Side rollers in upper pool.
		50	3.4	Fair	Pool and canal surface rather rough. Flow mainly along left side of pool.
30	See Figure 12A A=4.5' B=3'	200	6.0	Good	Pool and canal surface fairly smooth. Side rollers larger than in Test 28.
		50	3.3	Fair	Flow mainly along left side of pool. Side roller along right bank in upper three-fourths of pool.
31	See Figure 12C	200	5.9	Very good	Pool and canal surface very smooth. Small side rollers in upper half of pool. See Figure 19.
		50	3.15	Good	Pool and canal smooth but flow of water just below downstream row of piers unstable. See Figure 19.

FIGURE 1



UNITED STATES
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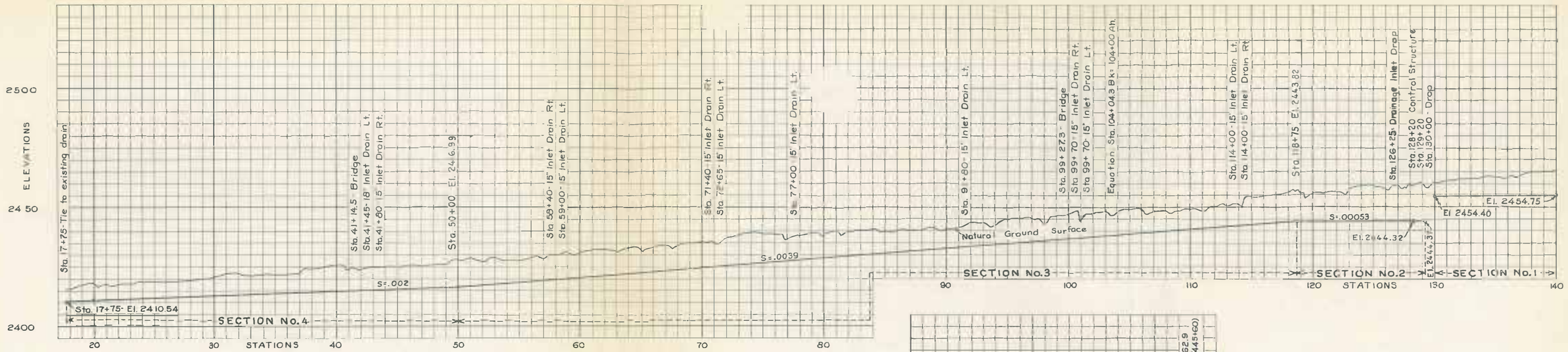
PAYETTE DIV. - BOISE PROJECT - IDAHO

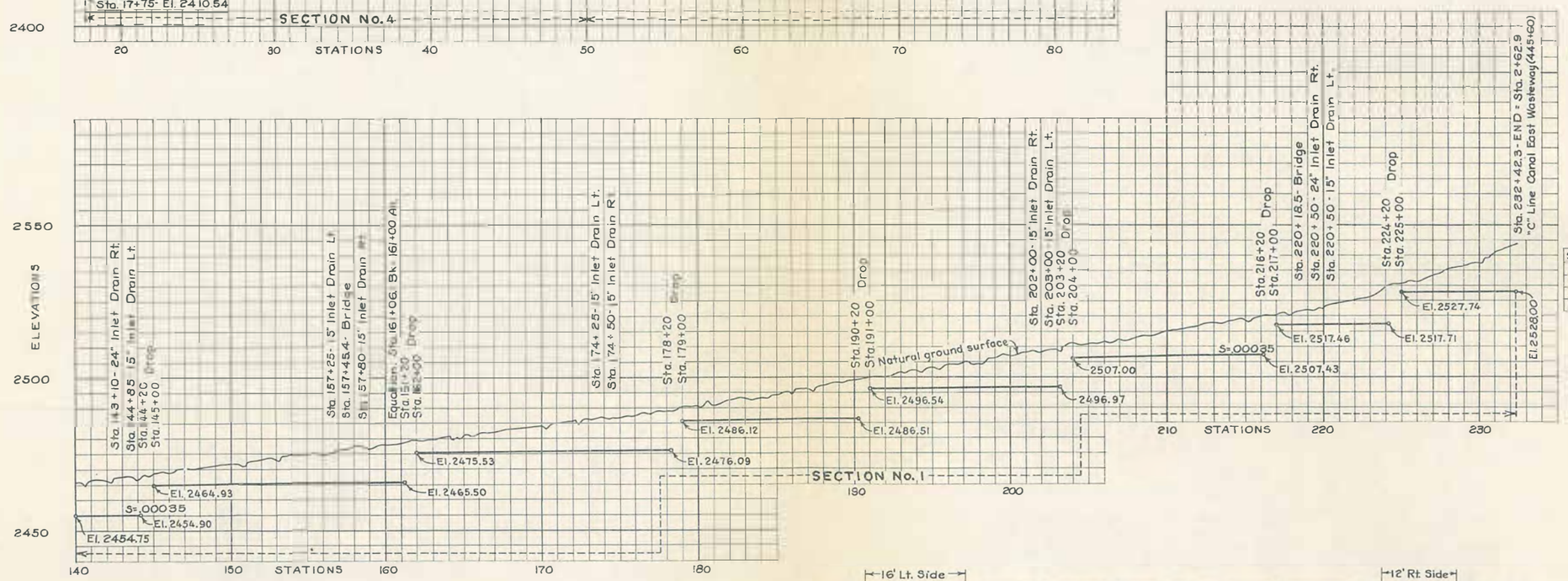
LOCATION MAP

SAND HOLLOW WASTEWAY (EAST BRANCH)
WILLOW CREEK WASTEWAY

DRAWN: R.W.R. SUBMITTED: R.W. Adams
TRACED: R.W.R. RECOMMENDED: Geo. H. Carter
CHECKED: W.W.K. APPROVED: Walker R. Young
CHIEF ENGINEER

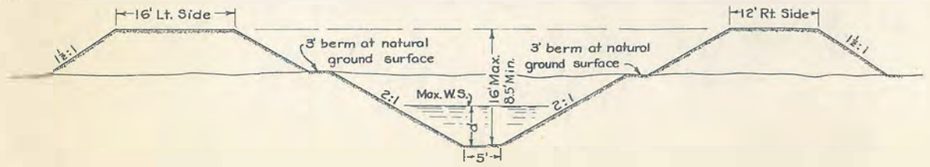
03-P-67T | CALDWELL, IDAHO ~ 5-9-47 | 3-D-2401





HYDRAULIC PROPERTIES

SECTION	d	A	r	n	s	v	Q
No. 1	5.5	88.00	2.97	.025	.00035	2.29	200
No. 2	5.0	75.00	2.74	.025	.00053	2.66	200
No. 3	3.18	36.15	1.88	.025	.0039	5.54	200
No. 4	3.71	.08	2.13	.025	.002	4.34	200



EARTH SECTION

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PAYETTE DIVISION ~ BOISE PROJECT-IDAHO

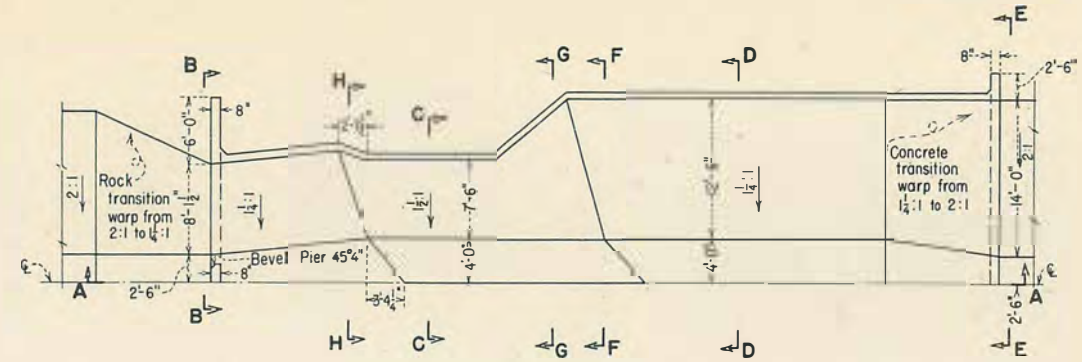
PROFILE & SECTIONS

SAND HOLLOW WASTEWAY
(EAST BRANCH)

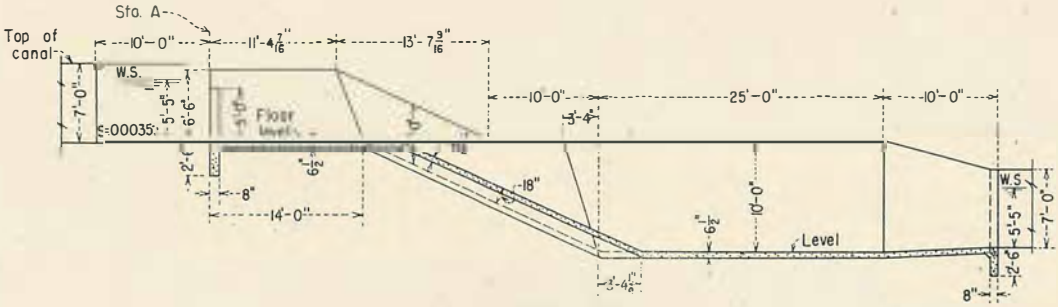
DRAWN: R.W.A. SUBMITTED: [illegible]
TRACED: R.W.R. RECOMMENDED: [illegible]
CHECKED: W.W.K. APPROVED: [illegible] CHIEF ENGINEER

03-P-68W | CALDWELL, IDAHO ~ 10-16-47 | 3-D-2402

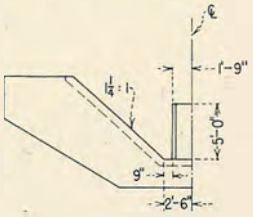
FIGURE 3



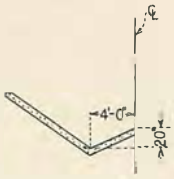
HALF PLAN



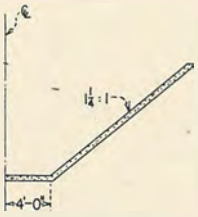
SECTION A-A



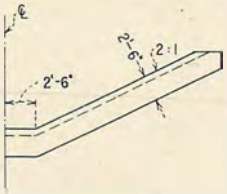
SECTION B-B



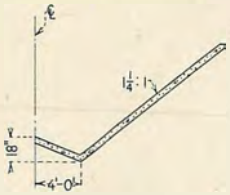
SECTION C-C



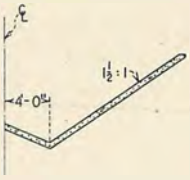
SECTION D-D



SECTION E-E



SECTION F-F



SECTION G-G

SECTION H-H

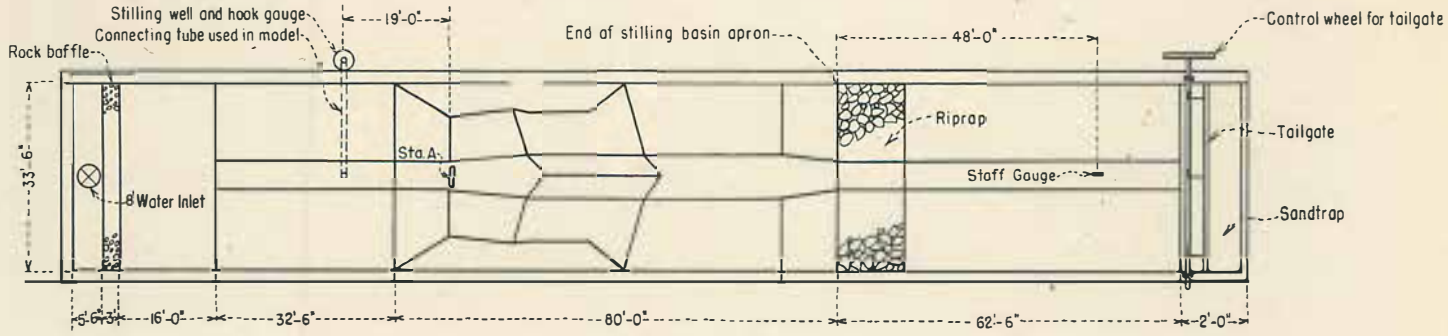
SCALE OF FEET

SAND HOLLOW WASTEWAY (EAST BRANCH)

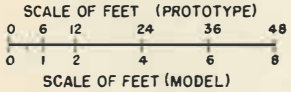
TRAPEZOIDAL CONCRETE DROPS

VERTICAL FALL 10.0' DISCHARGE = 200 SECOND FEET

ORIGINAL DESIGN



PLAN OF MODEL



SAND HOLLOW WASTEWAY

TRAPEZOIDAL CONCRETE DROPS

EXTENT AND LAYOUT OF 1:6 SCALE MODEL

ORIGINAL DESIGN

FIGURE 4

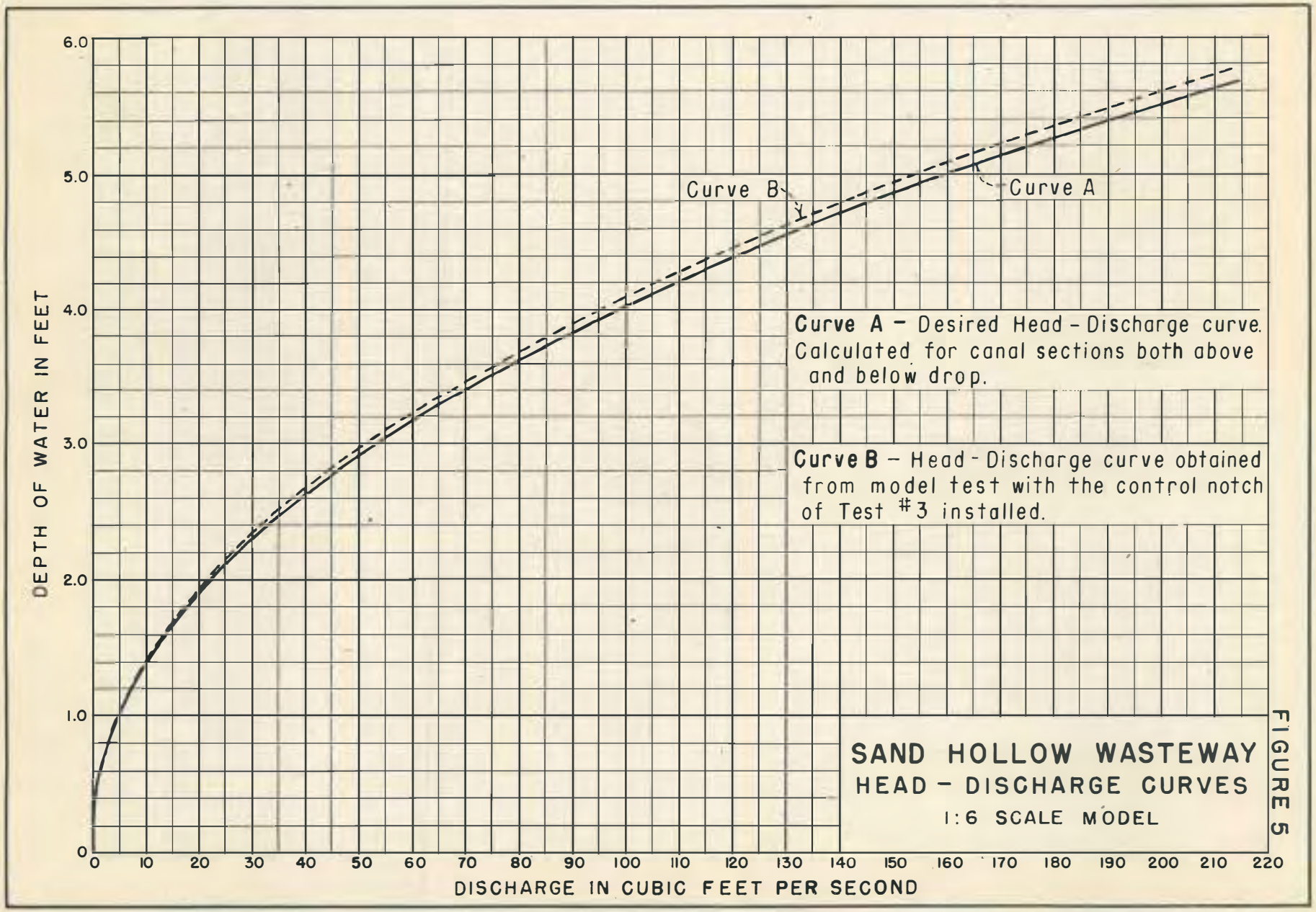
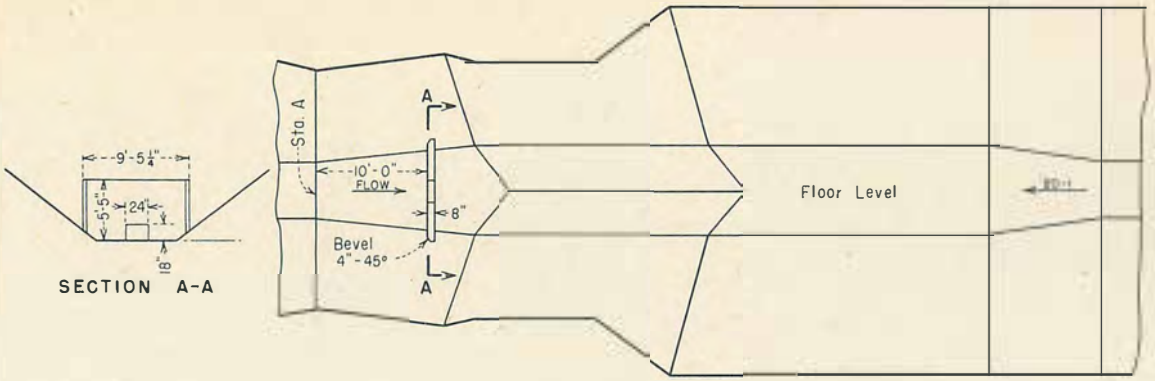
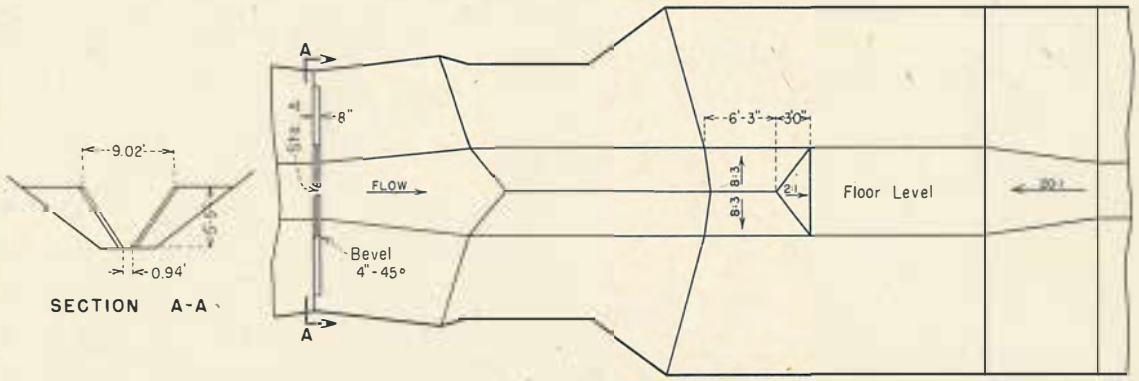

DEPTH OF WATER IN FEET
6.0
5.0
4.0
3.0
2.0
1.0
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
DISCHARGE IN CUBIC FEET PER SECOND
Curve B
Curve A
Curve A – Desired Head - Discharge curve. Calculated for canal sections both above and below drop.
Curve B – Head - Discharge curve obtained from model test with the control notch of Test #3 installed.
SAND HOLLOW WASTEWAY
HEAD – DISCHARGE CURVES
1:6 SCALE MODEL

FIGURE 5

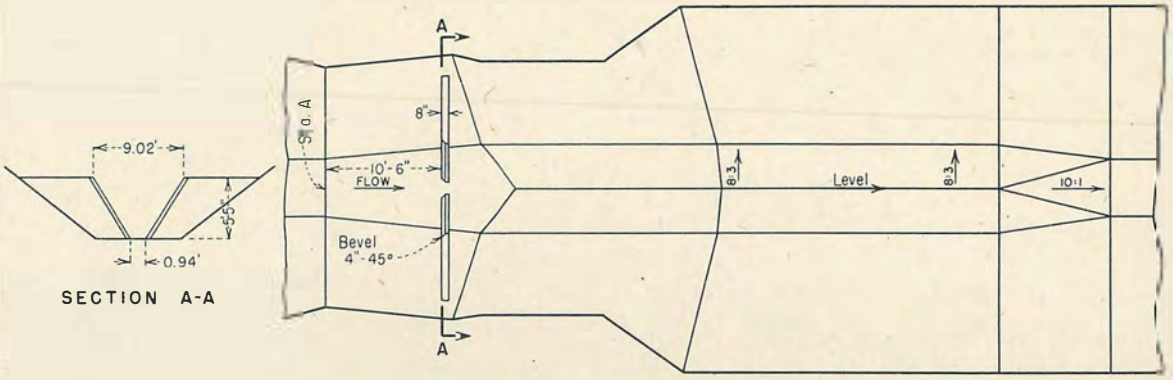
Note: For location of Sta. A see Fig. 13.



A. TEST 2. TWO NOTCHES AND ORIFICE LOCATED 10'-0" DOWNSTREAM FROM STATION A.



B. TEST 3. RECOMMENDED NOTCH DESIGN WITH ONE NOTCH AT STATION A.

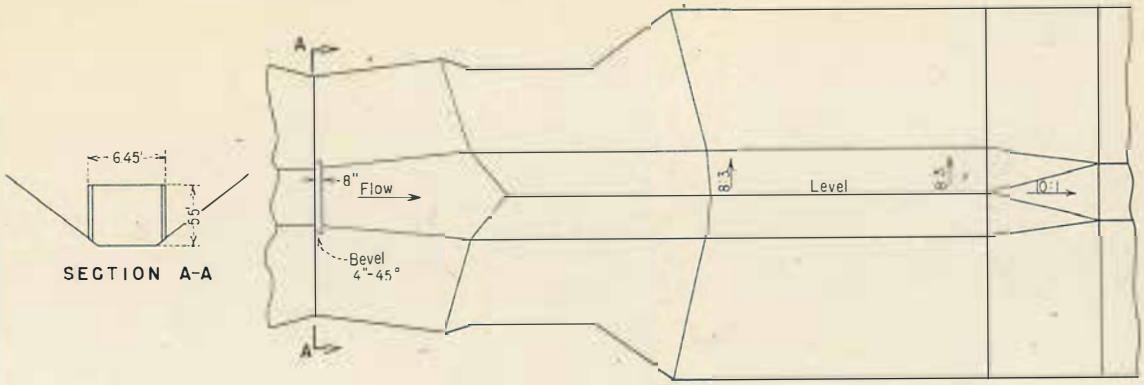


C. TEST 4. SAME NOTCH AS TEST 3 EXCEPT NOTCH IS LOCATED 10'-6" DOWNSTREAM FROM STATION A.

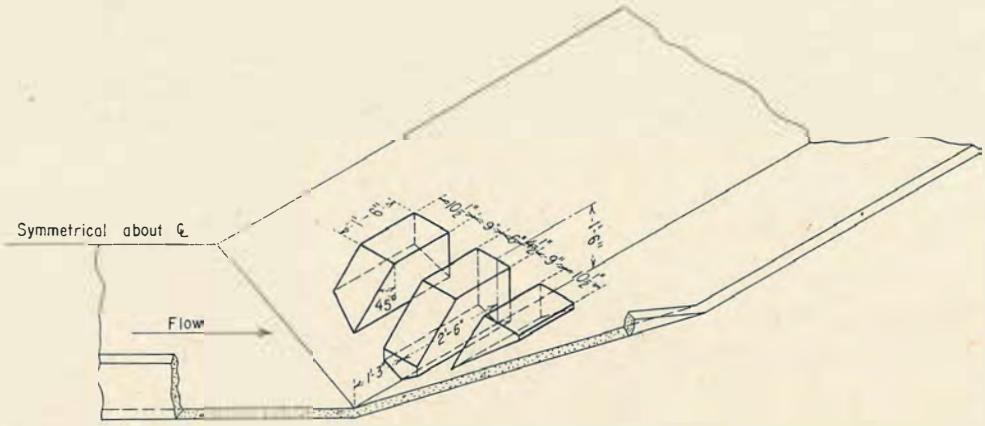
SAND HOLLOW WASTEWAY

TYPES OF CONTROL NOTCHES TESTED

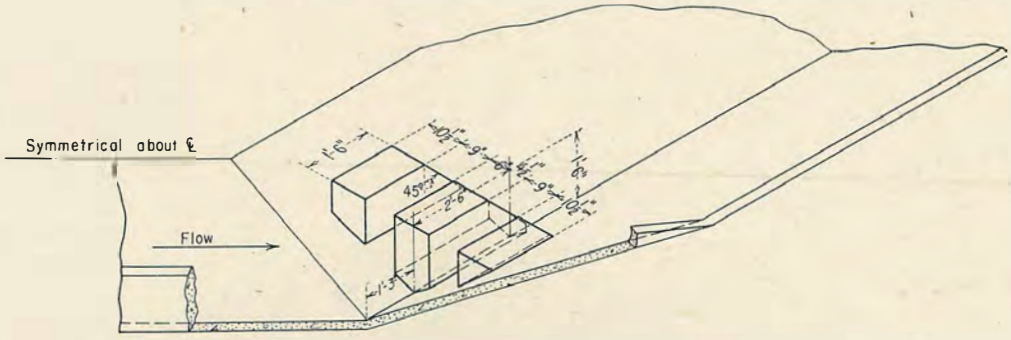
1:6 SCALE MODEL



A. TEST 5 TWO NOTCHES LOCATED AT STATION A



B. BAFFLE PIER DETAILS USED IN TEST 7

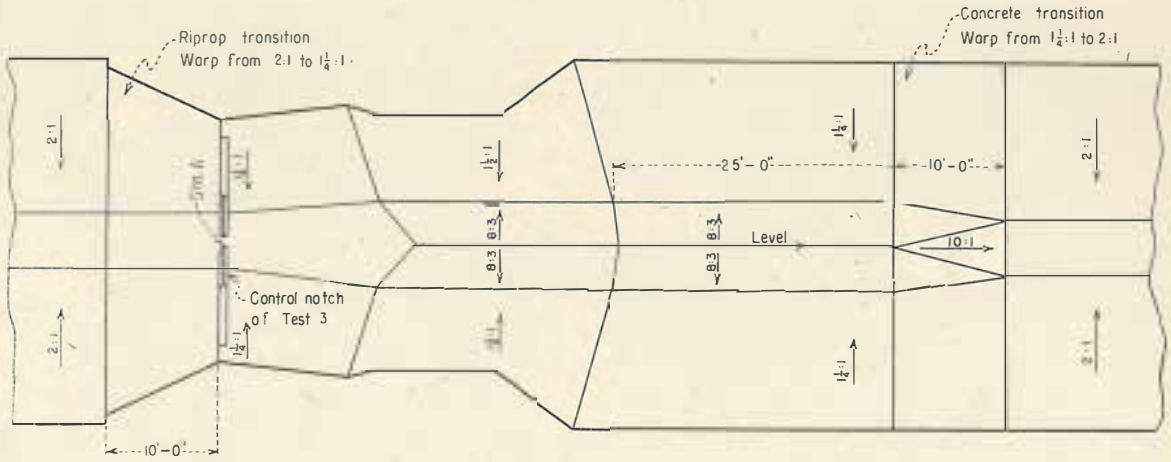


C. BAFFLE PIER DETAILS USED IN TEST 8

SAND HOLLOW WASTEWAY

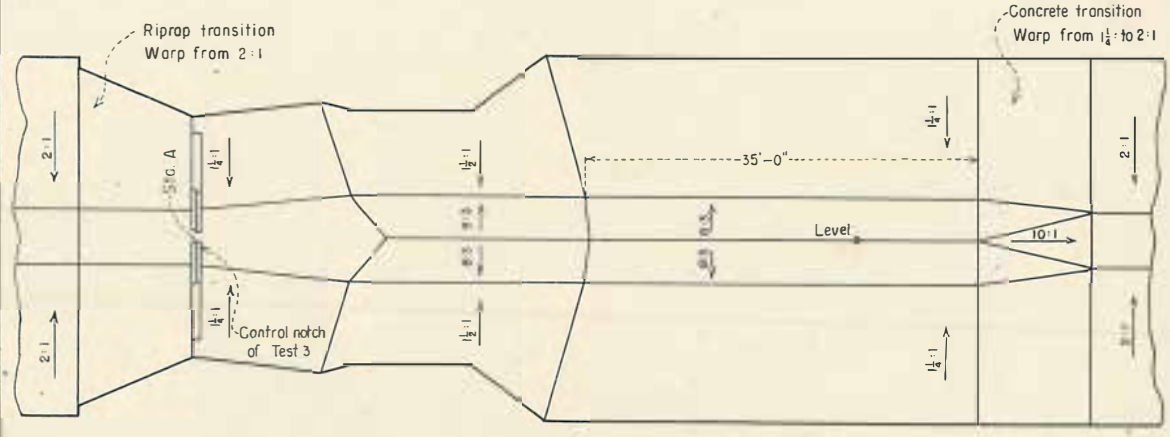
CONTROL NOTCH AND TYPES OF BAFFLE PIERS TESTED

1:6 SCALE MODEL



PLAN OF MODEL

A. TEST 6. SHORT STILLING BASIN WITHOUT BAFFLE PIERS



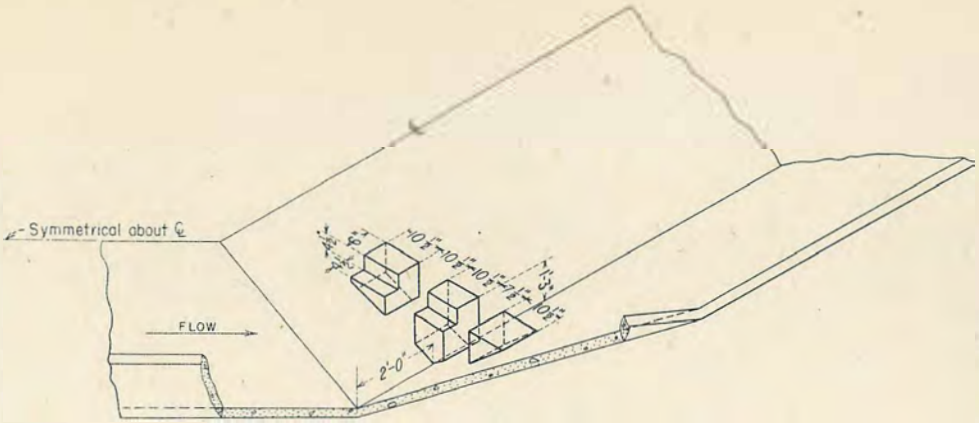
PLAN OF MODEL

B. TEST 14. LONG STILLING BASIN WITHOUT BAFFLE PIERS

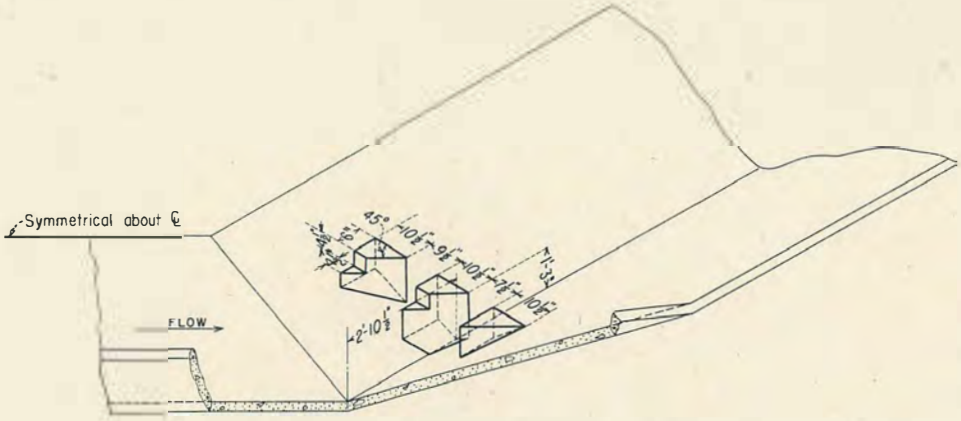
SAND HOLLOW WASTEWAY

DETAILS OF STILLING BASINS TESTED

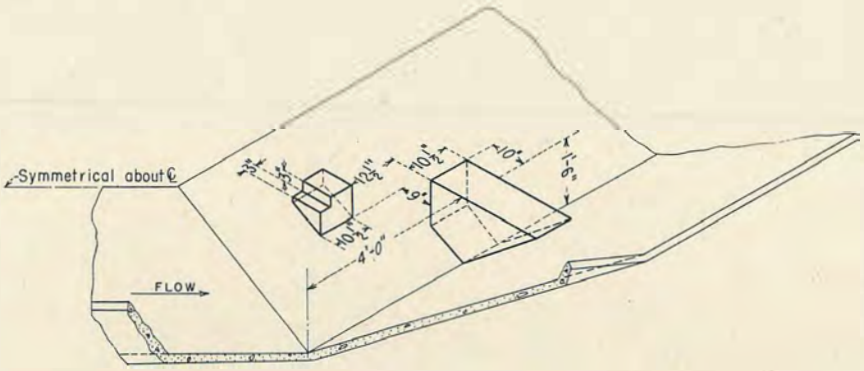
1:6 SCALE MODEL



A. TEST 9. BAFFLE PIER DETAILS



B. TEST 10. BAFFLE PIER DETAILS

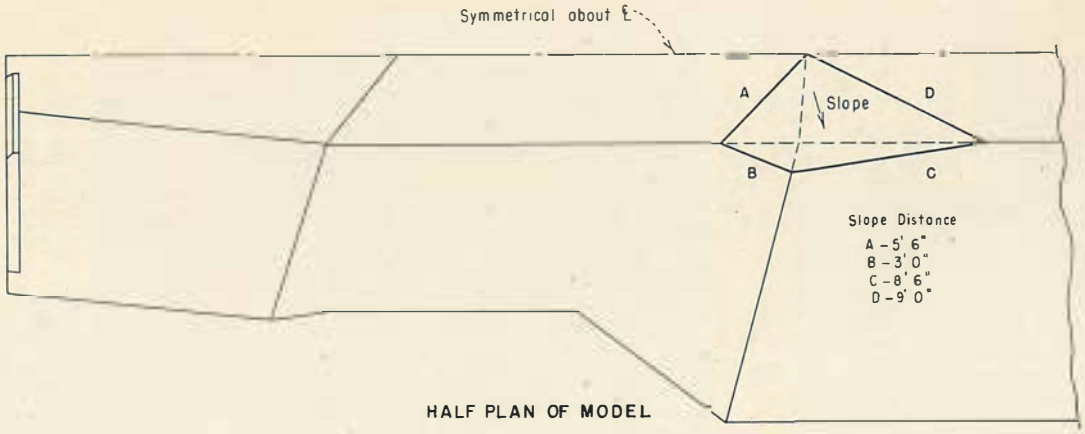


C. TEST 11. BAFFLE PIER DETAILS

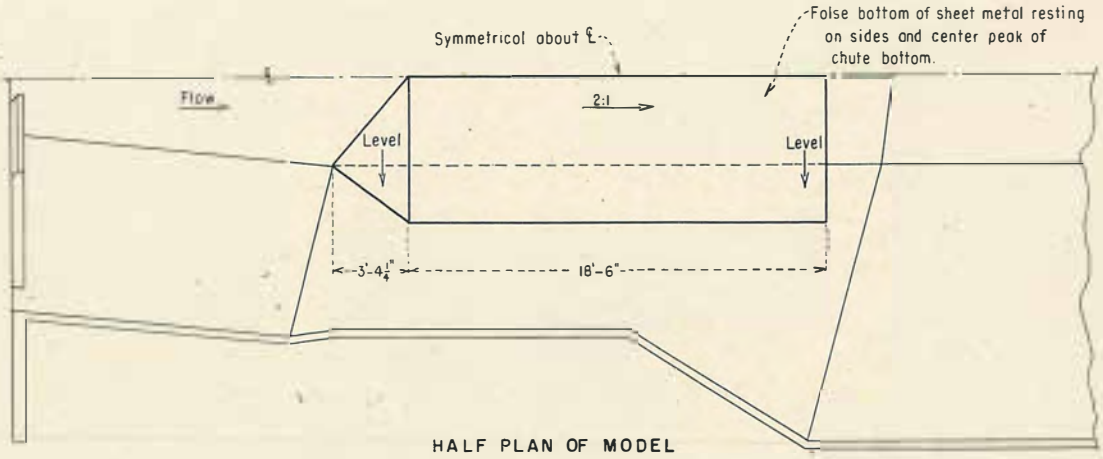
SAND HOLLOW WASTEWAY

TYPES OF BAFFLE PIERS TESTED

1:6 SCALE MODEL



A. TEST 12. FILLET AT INTERSECTION OF CHUTE AND STILLING BASIN FLOOR

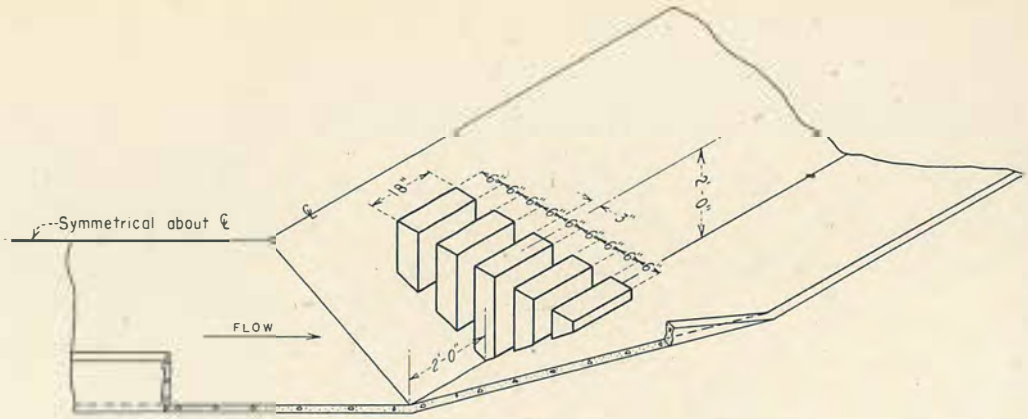


B. TEST 13. FALSE FLOOR PLACED OVER CHUTE VALLEYS

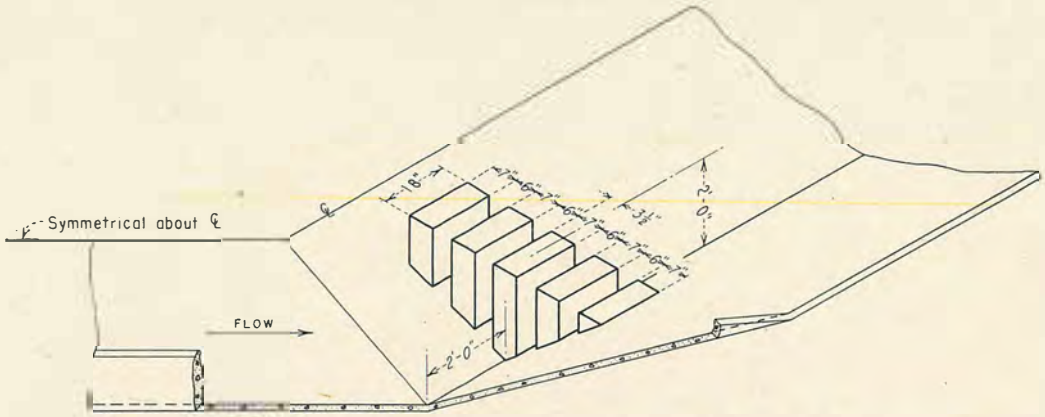
SAND HOLLOW WASTEWAY

TESTS TO IMPROVE DISTRIBUTION OF FLOW IN STILLING BASIN

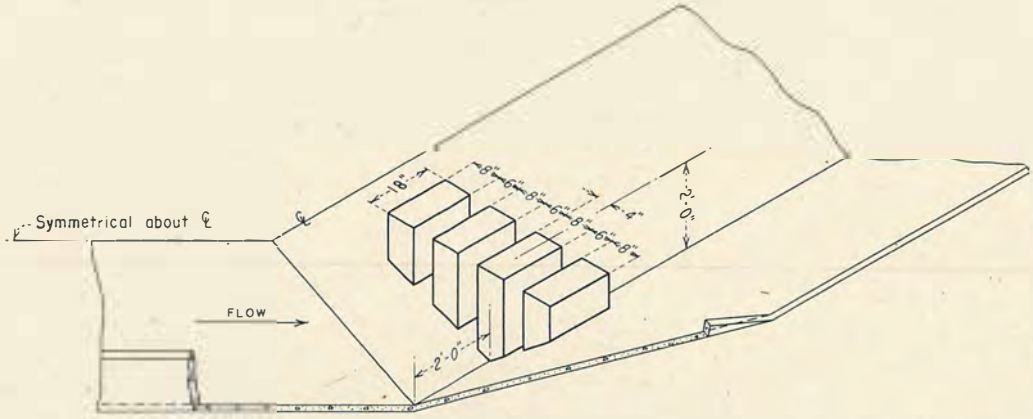
1:6 SCALE MODEL



A. TEST 15. BAFFLE PIER DETAILS



B. TEST 16. BAFFLE PIER DETAILS

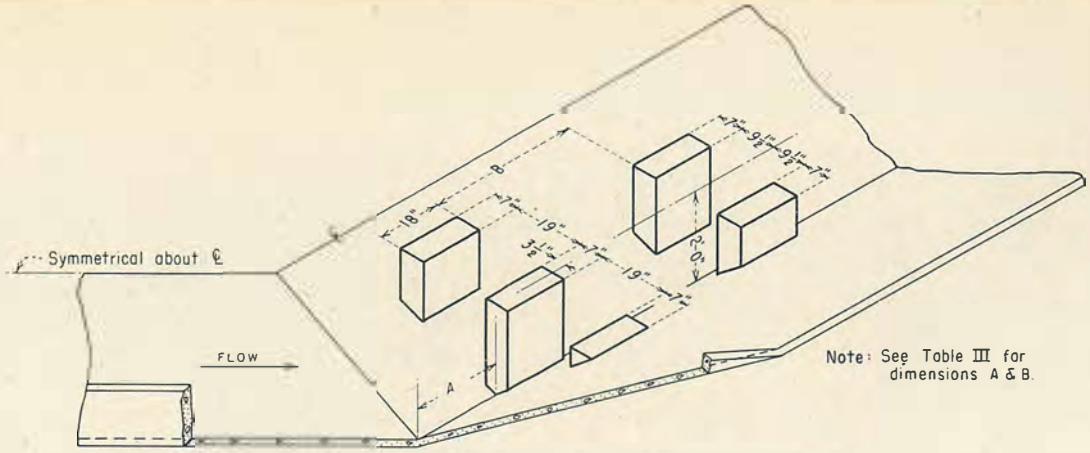


C. TEST 17. BAFFLE PIER DETAILS

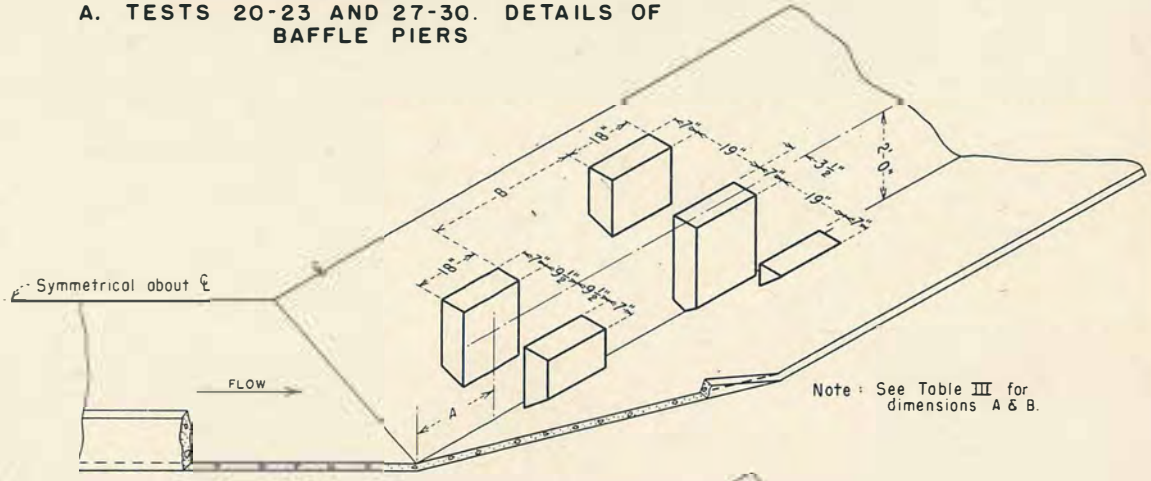
SAND HOLLOW WASTEWAY

TYPES OF BAFFLE PIERS TESTED

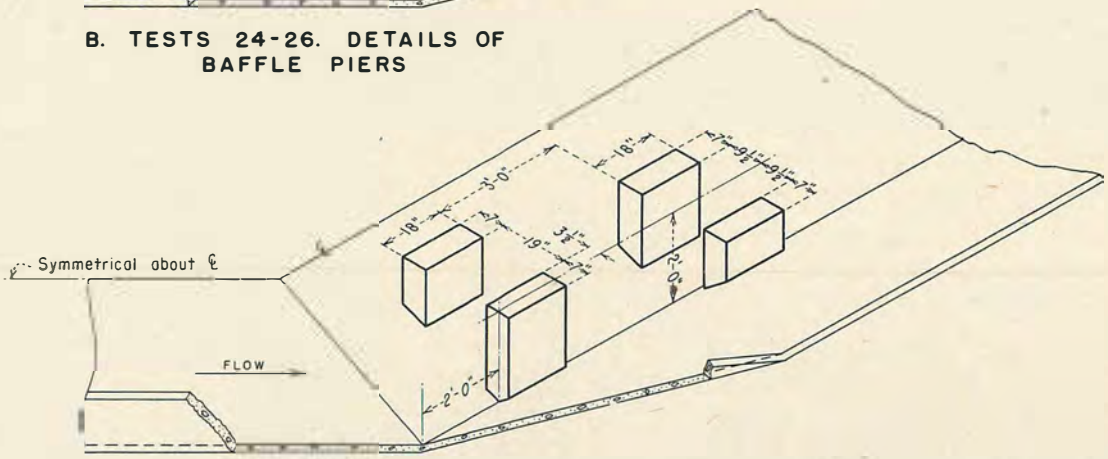
1:6 SCALE MODEL



A. TESTS 20-23 AND 27-30. DETAILS OF BAFFLE PIERS



B. TESTS 24-26. DETAILS OF BAFFLE PIERS

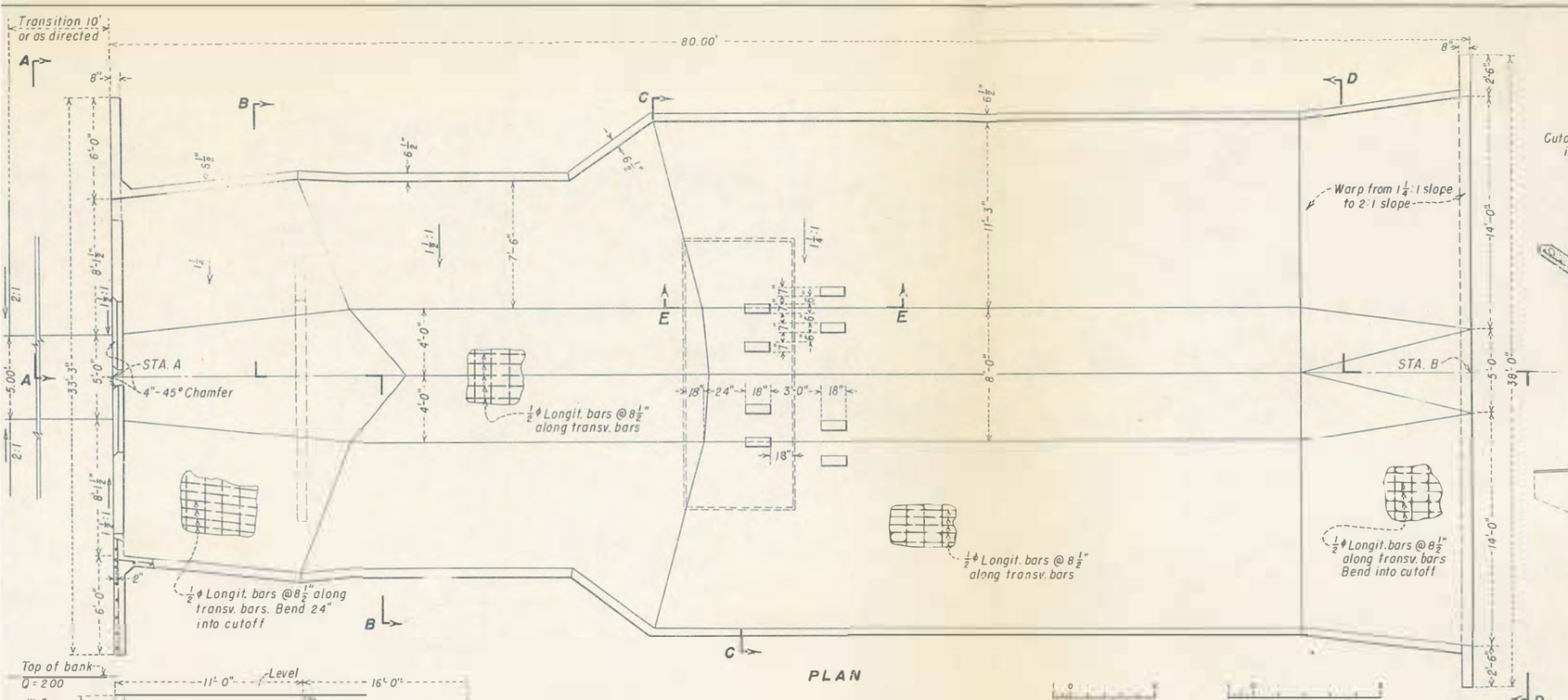


C. TEST 31. DETAILS OF BAFFLE PIERS

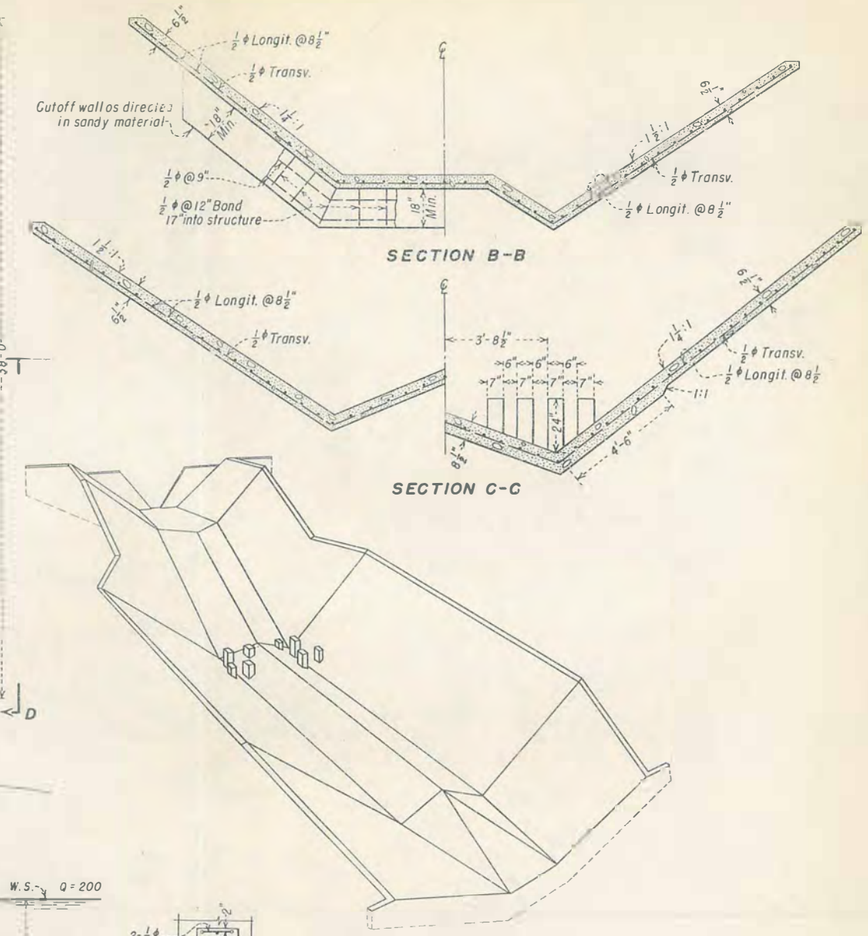
SAND HOLLOW WASTEWAY

TYPES AND LOCATION OF BAFFLE PIERS TESTED

1:6 SCALE MODEL



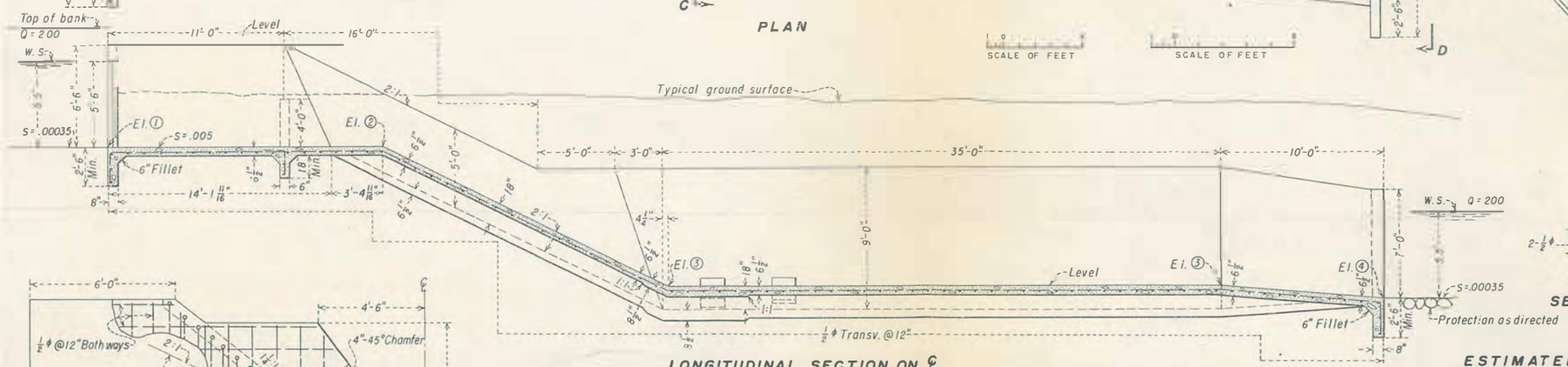
PLAN



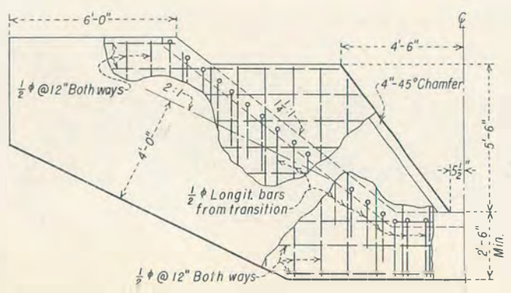
SECTION B-B

SECTION C-C

PERSPECTIVE VIEW

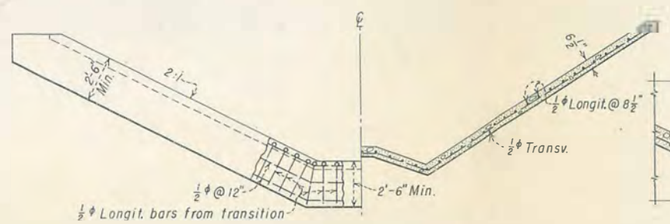


LONGITUDINAL SECTION ON ℄

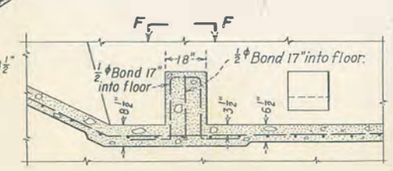


SECTION A-A

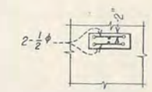
Symmetrical about ℄



SECTION D-D



SECTION E-E



SECTION F-F

ESTIMATED QUANTITIES

Concrete (For one structure only) 59 Cu. Yds.
Reinforcement steel. (For one structure only) 4600 Lbs.

STRUCTURE DATA

STA A	ELEV. ①	ELEV. ②	ELEV. ③	ELEV. ④	STA. B
225+00	2527.74	2527.65	2518.74	2517.71	224+20
217+00	2517.46	2517.37	2508.46	2507.43	216+20
204+00	2507.00	2506.91	2498.00	2496.97	203+20
191+00	2496.54	2496.45	2487.54	2486.51	190+20
179+00	2486.12	2486.03	2477.12	2476.09	178+20
162+00	2475.53	2475.44	2466.53	2465.50	161+20
145+00	2464.93	2465.84	2455.93	2454.90	144+20
130+00	2454.40	2454.31	2445.40	2444.37	129+20

NOTES

All reinforcement shall be placed so that the centers of bars in the outer layer will be 2½" from face of concrete unless otherwise shown.
Lap all bars 34 diameters at splices. Stagger splices.
Entire structure to be placed on undisturbed earth or thoroughly compacted fill.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BOISE PROJECT - IDAHO
PAYETTE DIVISION

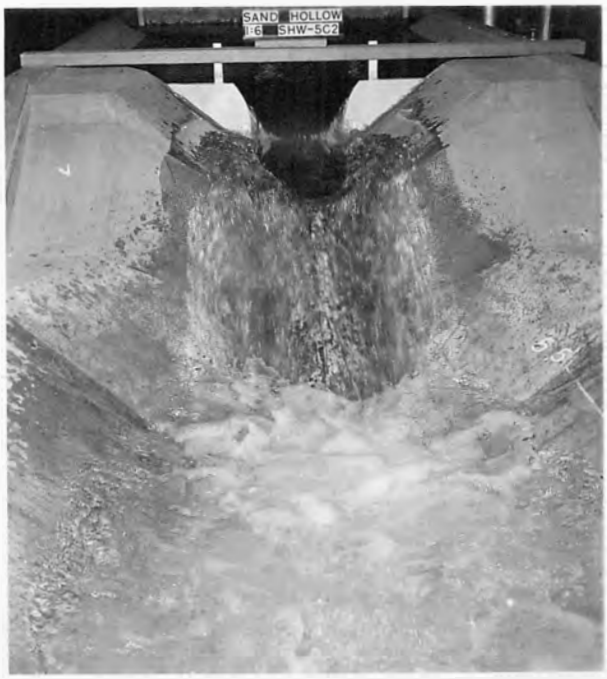
# SAND HOLLOW WASTEWAY (EAST BRANCH)
# TRAPEZOIDAL CONCRETE DROPS
F = 10.0' Q = 200

DRAWN W.A.K. L.B.H. SUBMITTED
TRACED R.F.N. M.H.Z. RECOMMENDED
CHECKED APPROVED
CHIEF ENGINEER

DENVER, COLORADO OCT. 3, 1947 3-D-2404

A. Test 1. Flow through notches using control of original design at Station A.

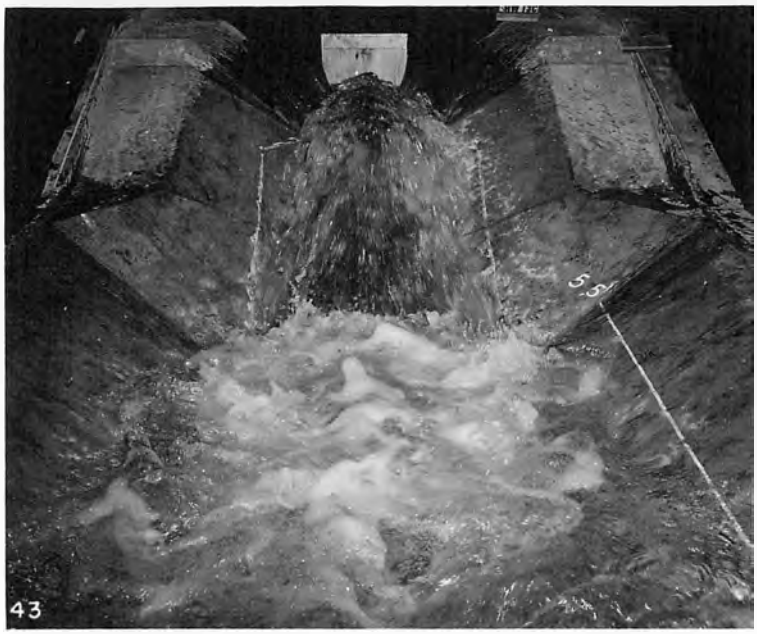
. Test 2. Smaller notches with orifice moved 10 feet downstream from Station A.



Test 3. Single notch at Station A. Note the even distribution of flow through the chute valleys.

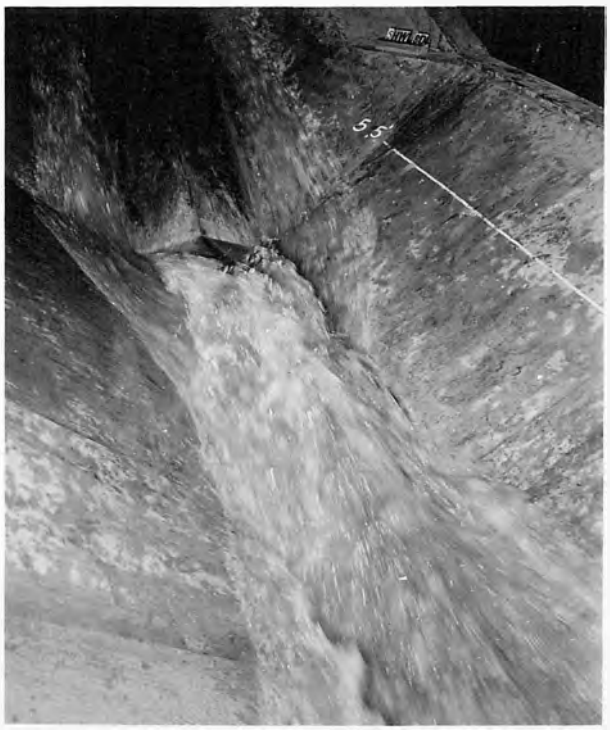
D. Test 4. Single notch moved 10'6" downstream. Note th water riding the outside slopes of the chute.

SAND HOLLOW WASTEWAY
FLOW CONDITIONS WITH NOTCHES OF TESTS 1-4
Discharge--200 second-feet
1:6 scale model



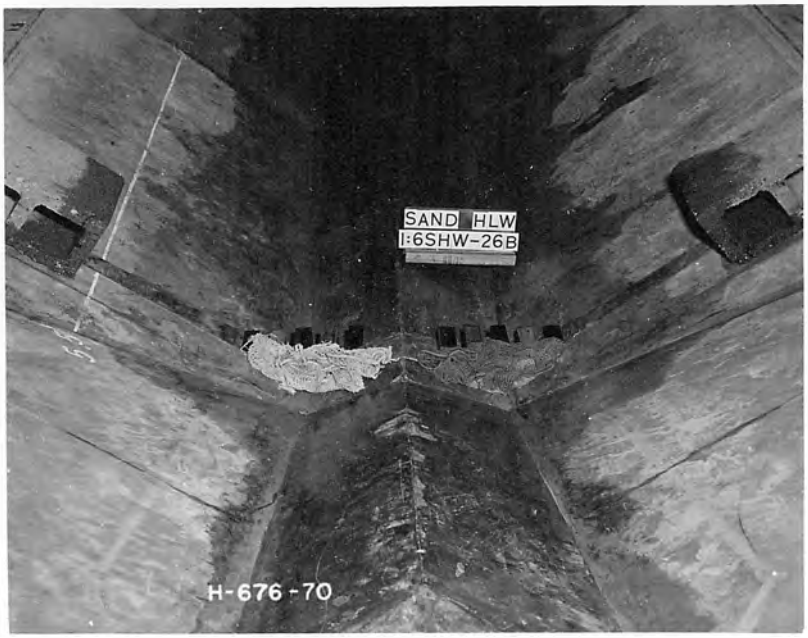
A. Test 5. Two notches without orifice located at Station A.

B. Test 3. Single notch located at Station A. Note that jets remain in the valleys throughout the basin length.

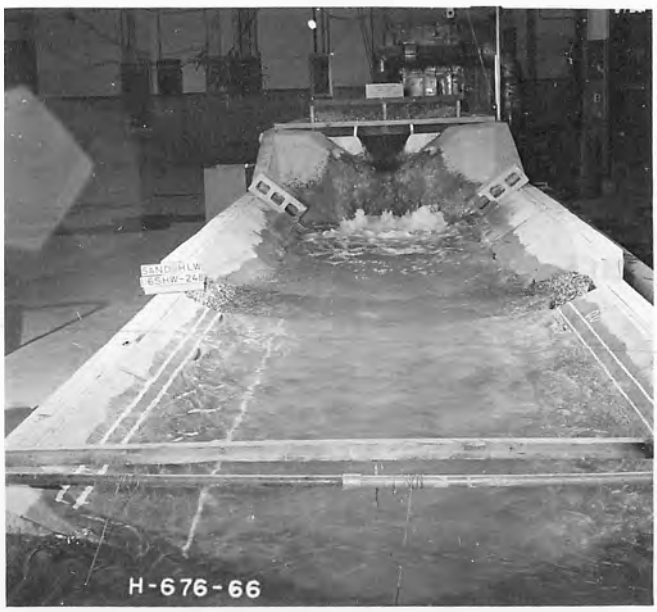


C. Test 4. Single notch moved 10'6" downstream from Station A. Note the joining of the two jets in the center of the stilling basin.

SAND HOLLOW WASTEWAY
FLOW CONDITIONS USING NOTCHES OF TESTS 3-5
Discharge--200 second-feet
1:6 scale model



A. Method used to clog baffle piers for Test 19.



B. Test 19. Discharge of 200 second-feet with piers clogged as in A above.

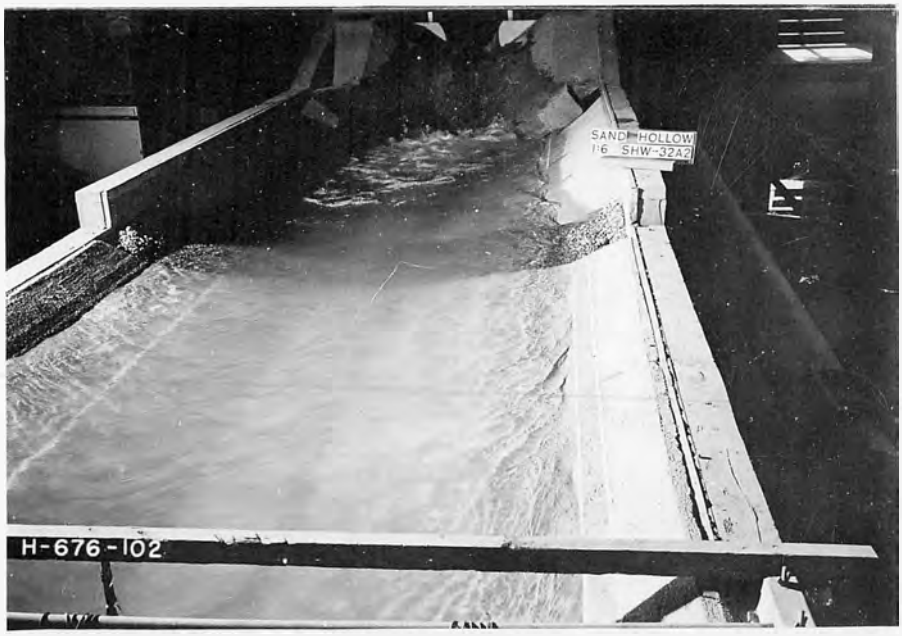
SAND HOLLOW WASTEWAY
FLOW CONDITIONS WITH PIERS CLOGGED
1:6 scale model

A. Test 14. No baffle piers. Stilling-basin operation satisfactory but turbulent with surges and waves extending into the canal.

B. Test 16. Baffle piers installed. Stilling-basin and canal water surface comparatively smooth.

SAND HOLLOW WASTEWAY
STILLING-BASIN PERFORMANCE WITH AND WITHOUT PIERS
Discharge--200 second-feet
1:6 scale model

A. Test 21. Flow conditions in stilling basin with two rows of piers installed.



B. Test 21. Waves along the canal banks with same two rows of piers installed.

SAND HOLLOW WASTEWAY
FLOW CONDITIONS WITH PIERS OF TEST 21 INSTALLED
Discharge--200 second-feet
1:6 scale model

A. Test 31. Discharge 200 second-feet. Piers installed. Water surface in stilling basin and canal relatively smooth.

B. Test 31. Discharge 50 second-feet. Flow concentrated at side slopes of trapezoidal stilling basin. Waves negligible.

SAND HOLLOW WASTEWAY
FLOW IN RECOMMENDED STILLING BASIN
1:6 scale model