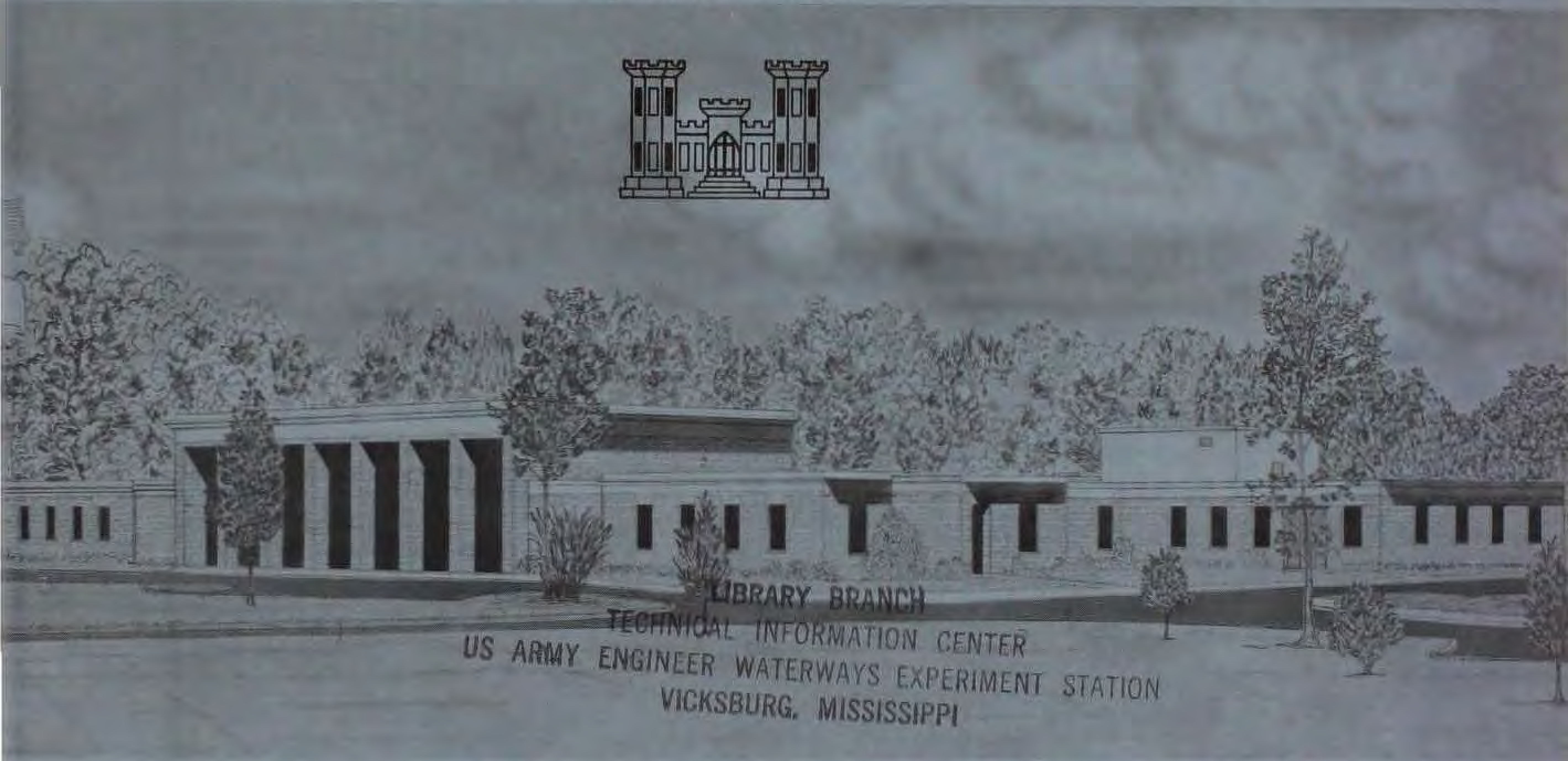
TECHNICAL REPORT H-74-2

SOUTH ELLENVILLE FLOOD CONTROL PROJECT, RONDOUT CREEK BASIN NEW YORK

Hydraulic Model Investigation

by

E. S. Melsheimer



April 1974

Sponsored by U. S. Army Engineer District, New York

Conducted by U. S. Army Engineer Waterways Experiment Station
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ARMY-MRC VICKSBURG, MISS

FOREWORD

Model investigation of the Flood Control Project, North Gully, South Ellenville, New York, was authorized by the Office, Chief of Engineers, in a second indorsement, dated 28 August 1970, to basic letter, dated 18 August 1970, from the U. S. Army Engineer District, New York, through the U. S. Army Engineer Division, North Atlantic.

The study was conducted during the period January 1971 to January 1972 in the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES) under the direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory, and Mr. T. E. Murphy, Chief of the Structures Division, and under the general supervision of Mr. J. L. Grace, Jr., Chief of the Spillways and Channels Branch. The engineer in immediate charge of the model was Mr. E. S. Melsheimer, assisted by Messrs. Benjamin Perkins and W. A. Walker. This report was prepared by Mr. Melsheimer.

During the course of the study Messrs. Jesse Rosen, Frank Krhoun, Andrew Petallides, and F. L. Panuzio of the New York District visited WES to discuss the model tests, observe the model in operation, and correlate test results with the concurrent design work.

Directors of WES during the conduct of the study and the preparation and publication of this report were BG E. D. Peixotto, CE, and COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
miles (U. S. statute)	1.609344	kilometers
square miles	2.58999	square kilometers
cubic yards	0.764555	cubic meters
acres	4046.856	square meters
acre-feet	1233.482	cubic meters
pounds	0.45359237	kilograms
feet per second	0.3048	meters per second
cubic feet per second	0.02831685	cubic meters per second

SUMMARY

Model investigations of the proposed channel improvements for flood control on North Gully and Sandburg Creek at South Ellenville, New York, were conducted to supplement and verify hydraulic computations for the original design and to develop alterations effecting improved hydraulic performance and reduced construction costs. A 1:20-scale model was used to verify and improve design features including the chute entrance, chute alignment, superelevation in bends, effect of large materials in the chute on flow disturbances in the chute, hydraulic performance of the stilling basin, wall heights, and elevation of bridges, and to determine the need for riprap protection below the stilling basin. The model reproduced portions of the overall project including proposed improvements along the lower 2200 ft of North Gully and approximately 600 ft of Sandburg Creek below the junction with North Gully.

Tests of the original design indicated flow conditions within the proposed chute to be generally satisfactory. However, unsatisfactory flow conditions were observed at the entrance to the high-velocity chute in North Gully, where discharges of 1200 cfs or more in North Gully overtopped the left chute wall 30 to 40 ft downstream of the chute entrance. At low flows (300 to 1500 cfs) a cross-wave disturbance at sta 4+55.36 resulted in unequal distribution of flow entering the stilling basin. This unequal flow distribution coupled with the submergence effect of the end sill at low discharges resulted in eddy action in the stilling basin. Debris entering the high-velocity chute tended to choke the stilling basin and create a damming effect in Sandburg Creek immediately below the stilling basin. Improvements in flow conditions at these locations were effected by:

- a. Installing a 7.25-ft-high weir at the entrance to the high-velocity chute.
- b. Flattening the slope of the transition section upstream of the basin and modifying the parabolic drop entering the basin to provide a more vertical drop.
- c. Increasing the height of the debris barrier to prevent passage of debris into the chute.

Design wall heights were determined from the profiles of the water surface obtained in the model along each wall with the design discharge (3750 cfs).

The exit area below the stilling basin in Sandburg Creek will require a concrete splash pad and adjacent riprap protection for about 260 ft to ensure prevention of scour.

The 2-ft-high and 4-in.-wide concrete wearing surface along the bottom of the chute walls had little apparent effect on flow characteristics in the chute.

Fig. 1. Vicinity map

SOUTH ELLENVILLE FLOOD CONTROL PROJECT

RONDOUT CREEK BASIN, NEW YORK

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The project area is located in the village of Ellenville in Ulster County in the southern part of New York State (fig. 1). Ellenville is in the very narrow Rondout Valley that trends northeast-southwest and is bordered by Shawangunk Mountain on the east and the uplifted Catskill Plateau on the west. The proposed project improvement will provide local works for the protection of Ellenville from the overflow of North Gully and backwater from Sandburg Creek.

2. North Gully, known locally as Mountain Brook, is a short flashy stream about 2.4 miles* long with a drainage area of about 2.1 square miles. At Ellenville, the stream flows through developed residential and industrial areas before discharging into Sandburg Creek (fig. 2). The headwaters of North Gully serve as a source of water supply for the village of Ellenville.

3. Extensive damage has occurred along the banks of North Gully, from its junction at Sandburg Creek to a point upstream of the Route 52 highway bridge. The principal cause of flooding is the inability of the existing channel to accommodate the precipitation runoff without experiencing severe deposition due to an excessive bed load from upstream. The flood area for which protection will be provided by the plan of improvement consists of approximately 53 acres of land on the left and right banks of North Gully.

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* A table of factors for converting British units of measurement to metric units is presented on page vii.

Fig. 2. General plan, North Gully, original design

Project Plan

4. The plan of improvement to provide protection from the design flood will involve the construction of an upstream debris barrier, 2033 ft of concrete chute, a terminal stilling basin, 325 ft of transition and floodwalls, 782 ft of levee, a ponding area of 1.4 acre-foot capacity, and interior drainage structures along North Gully and the right bank of Sandburg Creek in South Ellenville, N. Y. (fig. 2).

5. Flow will be carried through the paved portions of the proposed improvement at velocities up to 54 fps. Since existing structures limited the alignment of the chute, various horizontal curves were necessary. Spiral transitions were provided at the beginning and end of all horizontal curves to permit gradual increase and decrease of the superelevation. The superelevation was rotated about the center line, but the low channel invert was designed to provide free drainage. The following criteria governed the design of the project:

a. Discharge in cfs:

	Design	Capacity	Maximum Flood
North Gully	3,750	5,000	1,000 (1955)
Sandburg Creek	13,500	27,000	10,000 (1955)

b. Freeboard. The heights of walls along various portions of the project were determined based on the respective depths of flow with the design discharge and freeboards of 5 ft for the upstream end of the chute, 2 ft for the remainder of the chute, 5 ft for the stilling basin, and 3 ft for the floodwall and levee along Sandburg Creek. The minimum clearance between the low steel of the bridge structures and the design flow line was set at 2 ft.

c. Superelevation. Invert superelevation was provided through the curves in accordance with the guidance presented in Engineer Manual 1110-2-1601, "Hydraulic Design of Flood Control Channels," and was computed by the following equation:

$$1.2 \times \frac{\text{Velocity}^2 \times \text{channel width}}{\text{Radius of curve at center line} \times \text{gravity}}$$

Spiral curves were based on "Modified Spiral Curve Tables," dated June 1948, prepared by the U. S. Army Engineer District, Los Angeles, Calif.

d. Roughness. Roughness factors (Manning's n) of 0.013 and 0.035 were assumed for the concrete and natural channels, respectively.

Need for Model Study

6. The necessity for providing numerous short-radius curves in the high-velocity chute made a model study desirable for verification of design computations. Also, it was considered that a model study would be valuable in developing optimum designs for such features as: spiral transitions and superelevation for bends, entrance and junction transitions, bridge clearances, and the stilling basin at the end of the high-velocity chute. Also of importance was observation of flow conditions in the entire reach of the chute as affected by the presence of material in the chute, and of erosion tendencies in Sandburg Creek below the stilling basin.

PART II: THE MODEL

Description

7. The 1:20-scale model reproduced North Gully from a point about 200 ft upstream of the Route 52 highway bridge, the entire chute (2033 ft), the stilling basin, and approximately 600 ft of Sandburg Creek at the channel junction (fig. 3).

8. The model chute was constructed of plastic-coated plywood (the tangents) and sheet metal (the curves) supported by a steel frame which could be adjusted to provide a variation in longitudinal slope. The superelevation in the bottom of the curved portions of the chute was molded in cement mortar to sheet metal templates. The stilling basin at the downstream end of the chute was constructed of plastic-coated plywood. The exit area below the basin was molded in sand covered by a thin crust of mortar for velocity and current-direction studies. Part of this mortar crust was later removed for erosion studies.

9. Discharge in the model was measured with venturi meters. Water-surface profiles were obtained with a point gage, and velocities were measured with a pitot tube. Tailwater elevations were regulated by means of an adjustable tailgate at the downstream end of the model.

Scale Relations

10. The accepted equations of hydraulic similitude, based on Froude's law, were used to express mathematical relations between dimensions and hydraulic quantities of the model and prototype. The resulting scale relations are as follows:

Dimension	Ratio	Scale Relation
Length	$L_r = L$	1:20
Area	$A_r = L_r^2$	1:400
Velocity	$V_r = L_r^{1/2}$	1:4.472

(Continued)

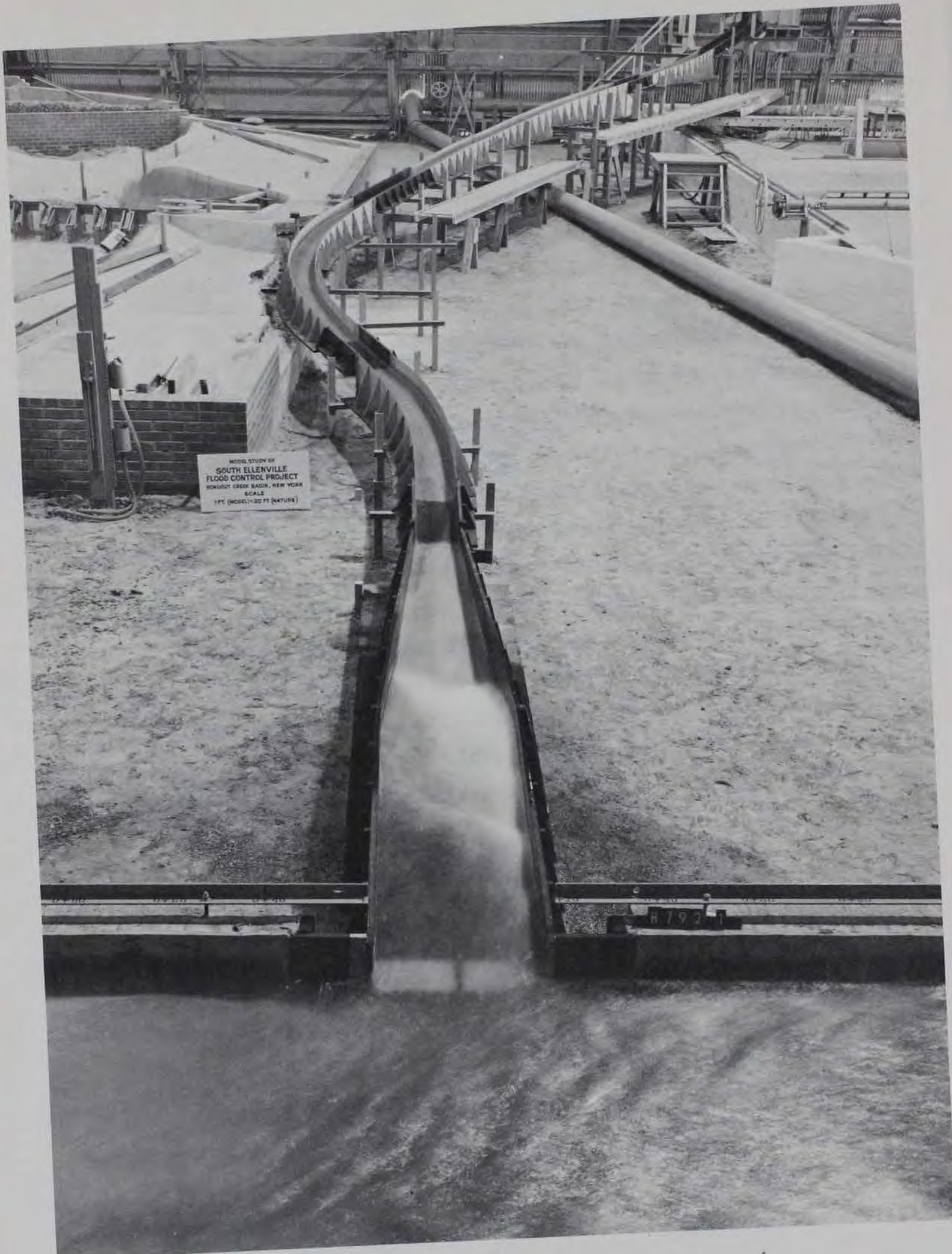

Fig. 3. North Gully, looking upstream

Dimension	Ratio	Scale Relation
Discharge	$Q_r = L_r^{5/2}$	1:1789
Time	$T_r = L_r^{1/2}$	1:4.472
Roughness coefficient	$N_r = L_r^{1/6}$	1:1.648

11. Quantitative transfer of measurements of discharge, water-surface elevation, and velocity from model to prototype dimensions by means of these scale relations is considered reliable. Experimental data also indicate that the prototype-to-model scale ratio is valid for scaling riprap in the sizes used in this investigation.

Model Adjustment

12. The assumed roughness (Manning's n) of the proposed prototype concrete chute was 0.013. For a geometrically similar 1:20-scale model, the model "n" should be $\frac{0.013}{1.648} = 0.0078$. However, preliminary tests revealed an actual "n" for the model surfaces of 0.0091, and thus a 30 percent supplementary slope was added to the South Ellenville chute so that computed mean depths and velocities of the prototype were reproduced in the model.

PART III: TESTS AND RESULTS, NORTH GULLY

13. Model tests involved the investigation of the overall performance of the high-velocity chute, including (a) the adequacy of the debris barrier and entrance transition upstream of the chute; (b) flow conditions throughout the entire reach of the chute, particularly as affected by the presence of boulders in the chute and the proximity of the bends; (c) performance of the stilling basin; and (d) erosion tendencies and riprap protection required downstream of the stilling basin, particularly where flow from North Gully enters Sandburg Creek. Test results pertinent to each component of the project are presented in order of its position, beginning with the debris barrier and entrance transition.

Debris Barrier and Entrance Transition

Type 1 (original) design

14. Initial observations revealed unsatisfactory flow conditions in North Gully at the original design entrance to the high-velocity chute (sta 23+90). Supercritical flow developed in the approach channel to the chute entrance with discharges of 1200 to 1500 cfs and was furnished little or no realignment by the angular transition walls. This resulted in standing waves that overtopped the left chute wall approximately 30 to 40 ft downstream of the chute entrance. While some improvement was provided by excavation of existing ground along the right bank of North Gully, the left chute wall was still overtopped at a discharge of 2300 cfs (design flow 3750 cfs). The resulting unbalanced flow in the chute propagated waves for a considerable distance down the chute.

Types 2 and 3 designs

15. In an effort to decelerate the velocities entering the chute to subcritical conditions, several entrance transitions involving a low weir and guide walls were investigated. Details of these designs are shown in plate 1.

16. Satisfactory subcritical flow conditions were obtained in the approach to the chute for the full range of flows by providing a simple weir (5 ft high) with quadrant wing walls (type 2 design, plate 1) as shown in photos 1a, b, and c. This design permitted flows as large as 5000 cfs to enter the chute without overtopping the 10-ft-high chute walls. Even for conditions in which the debris barrier was fully choked and debris was level with the top of the weir downstream of the barrier (photos 2a, b, c, and d), flow conditions in the entrance to the chute were satisfactory. Although the type 2 design entrance was satisfactory, the proximity of the weir to the proposed new bridge on Route 52 resulted in moving the entrance to the chute 23.7 ft upstream into North Gully (type 3 design, plate 1). Flow conditions were satisfactory for all discharges, and even the presence of large rocks and boulders choking the debris barrier and chute entrance had little effect on flow conditions at the entrance to the chute (photos 3a, b, c, and d).

Type 4 design

17. Following the investigation of the type 3 design entrance, the U. S. Army Engineer District, New York, decided that debris storage was the overriding consideration for the selection of an entrance design. Accordingly, the weir was returned to its original location (sta 23+90) and designated the type 4 design entrance (plate 1). As this design was very similar to the satisfactory type 2 design entrance in which the debris barrier was located at sta 25+05 and el 458.0,* tests were mainly concerned with the effect of location and elevation of the debris barrier in the approach on entrance conditions.

18. Shown in plate 2 are the locations and elevations of the various debris barriers investigated in conjunction with the type 4 design entrance. Photos 4a, b, c, and d show a dry-bed view and flow conditions with the type 4 design entrance installed in the model. The following are general conclusions as to the effect of location and height of the debris barriers in North Gully on entrance conditions to the high-velocity chute:

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* All elevations (el) cited herein are in feet referred to mean sea level.

a. Location of the debris barrier less than 90 ft upstream of the chute entrance, regardless of the height of the barrier (15 to 25 ft), resulted in unbalanced flow at the entrance and overtopping of the chute walls (1 to 3 ft) for discharges of 2500 and 3750 cfs. The resulting unbalanced wave pattern in the entrance was carried into the first downstream spiral of the chute.

b. The upstream channel cross section where the debris barrier is located plays an important part in flow conditions at the chute entrance. The more uniform the cross section, the more balanced the flow entering the chute.

c. The lower debris barriers (15 to 16 ft high) within 90 ft of the entrance improved flow conditions at the lower flows (500 to 1500 cfs). However, at the higher flows (2500 to 3750 cfs) the lower barriers tended to pile up flow at the entrance to the chute.

d. Debris trapped between the barrier and the weir had little effect on flow conditions at the entrance to the chute if the barrier was located a minimum of 90 ft upstream of the entrance.

It was also noted in the model that evenly distributed material (stones) behind the barrier tended to distribute flow more evenly across the channel below the barrier.

Type 5 (adopted) design

19. Tests of the type 4 entrance revealed that a minimum clearance of 90 ft was required between the debris barrier and the chute entrance to provide satisfactory flow conditions in the approach. To maintain this criterion and to obtain additional debris storage, the debris barrier (el 468.0) and the chute entrance were moved downstream to sta 24+55 and 23+65, respectively (type 5 design, plate 1, photo 5a). In order to improve flow conditions, the height of the weir was raised from 5 ft to 7.25 ft.

20. This arrangement resulted in the center line of the chute being offset an additional 8 to 9 ft to the right of the center line of the approach channel, and caused the lower flows (1500 and 2500 cfs) to be concentrated along the left bank of the approach (photos 5c and d). This resulted in considerable runup and splash-over along the 10-ft-high left chute wall in the vicinity of the Route 52 bridge. With the design discharge (3750 cfs), flow was more evenly distributed across the

approach channel at the entrance to the chute (photo 5b); and no overtopping of the chute walls occurred downstream of the weir. Tests with the debris barrier choked with rock revealed better flow conditions at the chute entrance than those observed with the unchoked barrier (photos 6a, b, c, and d).

21. In an effort to improve flow conditions at the type 5 entrance with the lower discharges, the angularity of the left training wall was reduced to 39 deg (plate 1). Observations revealed only slight improvement with this modification. However, the use of a stub wall (30 ft long and 5 ft high) in the approach adjacent to the training wall (plate 1) improved flow conditions for the full range of discharges. Observations also indicated that the 1-ft-wide drainage slot in the proposed weir causes disturbance of flow over the weir and should be replaced with a pipe for low-flow drainage.

22. To obtain additional debris storage, the height of the debris barrier with the type 5 design entrance was raised 10.5 ft to el 478.5. The barrier was reproduced by use of a solid plywood wall and simulated a fully choked barrier with 90 to 95 percent of flow forced over the barrier (photo 7a). The higher barrier increased turbulence at the entrance to the chute (photos 7b, c, d, e, and f), and resulted in some overtopping of the 10-ft-high chute walls in the initial 100 ft of chute downstream of the entrance (design discharge 3750 cfs, plate 3). Entrance disturbances were not noticeable in the chute downstream of the first spiral (No. 200) and the design discharge easily cleared the low steel of the Route 52 bridge. At a discharge of 5000 cfs (1.33 design discharge), splash-over of 4 to 5 ft was observed at the right chute wall from sta 23+00 to 23+30. This was sufficiently high to impinge upon the low steel of the Route 52 bridge. The average depth of flow in this area was about 9 ft. With this exception (4- to 5-ft splash-over), a minimum freeboard of about 3 ft was maintained along the 10-ft-high chute walls.

23. Photos 8a, b, c, d, and e show a dry-bed view and flow conditions at the entrance to the chute resulting from material exceeding the capacity of the debris barrier and being trapped between the barrier and

chute entrance. The presence of this material (900 cu yd) accentuated turbulence at the chute entrance, particularly along the left chute wall. However, while the incident of overtopping increased along the wall, the magnitude was similar to that observed with no debris upstream of the weir (plate 3); and no impingement of flow on the low steel of the Route 52 bridge was observed. While it was recognized that the type 5 entrance was not ideal, the pressing need for maximum debris storage justified the selection of this entrance for prototype construction. To allow for the turbulence and splash-over, the chute walls downstream of the entrance should be increased in height as predicted by the profile in plate 3.

High-Velocity Chute, Original Design

24. The North Gully chute was designed to pass a discharge of 3750 cfs with uniform depth transversely across the chute and with minimum cross-wave disturbances. The basic design wall heights provided a 2-ft freeboard for the design discharge. Details of the original chute alignment, bottom elevation, and superelevation are shown in plates 4 and 5.

25. Reproduced in the model was the entire section of the high-velocity chute from the entrance at sta 23+90 to the junction with Sandburg Creek at sta 0+98.23 (see fig. 3, page 6).

26. As mentioned in paragraph 12, preliminary observations revealed a roughness factor of 0.0091 (Manning's n) for the plywood and sheet metal model chute. A roughness factor of 0.0078 would have been required to simulate the prototype design roughness factor of 0.013 for the concrete chute. Since it was not feasible to make the model surface any smoother, a supplementary slope (30%) was added to the model to compensate for the higher roughness factor. This adjustment resulted in close agreement between model and computed flow lines at the design discharge (3750 cfs).

27. In tests of the original design, flow conditions were generally satisfactory throughout the reach for the full range of discharge

(photos 9 and 10). However, a cross-wave pattern originating at S.C. sta 4+55.36 and continuing to T.S. sta 4+05.86 was observed at a flow of 1500 cfs (see photo 11). This wave pattern resulted in uneven flow distribution in the stilling basin at the lower discharges (300 to 1500 cfs).

28. Water-surface profiles and velocities throughout the reach of the original design chute are shown in plates 6-17. Although these profiles and velocities were obtained with the type 2 entrance installed, check tests with the adopted type 5 entrance installed revealed little or no differences in profiles and velocities downstream of the first spiral (No. 200, S.T. sta 20+38.39). These data revealed that generally the maximum depth of flow occurred at the outside of the curves for flows of 2500 to 3750 cfs (design flow), and at the inside of the curves for flows of 1500 cfs and less. The following tabulation indicates the maximum depth of flow in the chute together with the maximum water-surface differential and location for the discharges investigated:

Discharge cfs	Depth of Flow ft	Water-Surface Differential ft*	Location Station
3750	5.86	1.78	S.C. 7+14.83
2500	4.26	1.18	3+60.40
1500	3.66	--	T.S. 4+05.86
1500	--	2.06	S.C. 4+55.86

* From left to right side of chute.

The maximum depth of flow and maximum water-surface differential occurred in the lower third of the model where the higher velocities and sharper curves existed.

29. Observation tests to determine the disturbance effect of large boulders in the chute revealed that stones simulating boulders as large as 5 ft in diameter would pass freely down the chute for flows as small as 600 cfs. Indications are that flows that move a boulder into the chute will also transport this boulder through the chute. The 2-ft-high, 4-in.-wide concrete wearing surface installed along the bottom of

the chute walls in the model had little apparent effect on surface roughness of flow in the chute.

30. In an effort to improve flow distribution in curves 2 and 3 near the lower end of the chute, the original superelevation in the curves (3.0 and 3.34 ft, respectively) was reduced to 1.5 ft in both curves. As expected, examination of the test data and visual observation revealed some improvement in flow distribution in the chute at the lower discharges; however, this was offset by the adverse effect of the reduced superelevation on water-surface differentials in the chute at the higher flows (see table 1). As the adverse effect of the reduced superelevation on the higher flows outweighed improvements at low flows, the New York District office accepted the original design superelevation for incorporation in the South Ellenville project. No modification to the chute alignment was made during the course of the model study.

Stilling Basin

Type 1 (original) basin

31. At the downstream end of the high-velocity chute, a hydraulic-jump type basin, roughly rectangular in shape, will be provided for dissipation of the energy of the supercritical flow and reduction of velocities to prevent erosion of the opposite bank of Sandburg Creek. The original design (type 1) basin was 36 ft wide and 76 ft long, located at el 304.8 (plate 18). The end sill was of the impact type, 6.33 ft high, with a broad crest (10.27 ft) and a 1.0-ft notch for drainage. The end sill, by acting as a control, insures the jump regardless of tailwater deficiency.

32. With the end sill as the control, flow conditions in the original design stilling basin were satisfactory at the intermediate and design flows (2500 and 3750 cfs), although the toe of the jump extended downstream into the stilling basin some 25 to 30 ft at the design discharge of 3750 cfs (photos 12a and b). However, at the smaller discharges (600 to 1500 cfs), end-sill control tended to submerge the jump with resulting eddy action in the basin (photos 12c and d). In several

cases when the end sill was removed and tailwater levels were reduced, the eddy action continued, influenced by unbalanced flow entering the basin at the low discharges. This eddy action also was apparent when high flows in Sandburg Creek submerged jump action in the North Gully basin (photos 13a and b). With rocks or gravel in the basin, these eddies could cause considerable abrasion to the stilling basin. Flow conditions at the junction of North Gully and Sandburg Creek appeared satisfactory when the latter was flowing full (photos 14a and b); however, when flow through North Gully was considerable with little or no flow in Sandburg Creek, flow from North Gully tended to attack the bottom and sides of Sandburg Creek at the junction of the two streams (photos 15a, b, and c).

Type 2 (adopted) basin

33. In an effort to reduce or eliminate the eddy action at low flows in the original basin, the type 2 basin was installed (plate 18). This design, which flattened the transition upstream of the basin and modified the entrance drop to a more vertical drop, improved basin action for all discharges and greatly reduced the tendency for eddy action at the lower flows (compare photos 16a, b, c, and d with photos 12a, b, c, and d). Although some slight circulation occurred along the right side of the basin at the lower flows, materials introduced into the basin were deposited along the end sill and did not circulate to cause abrasive damage. With a discharge of 2500 cfs in North Gully, a tailwater of 324.5 (4.2 ft above normal) was required in Sandburg Creek to cause eddy action in the basin. The tailwater could not be raised sufficiently to cause the design flow of 3750 cfs to eddy, and debris from the chute was either deposited against the end sill or washed into Sandburg Creek. The original basin wall height (el 327.41) was adequate for all expected flows. Flow conditions at the junction of North Gully and Sandburg Creek were satisfactory when there was flow in both streams (photos 17a, b, and c); however, when all flow was confined to North Gully with little or no flow in Sandburg Creek, the flow from North Gully tended to attack the bottom and sides of Sandburg Creek at the junction of the two streams (photos 18a, b, and c).

34. Initial scour tests within an area of Sandburg Creek (100 ft upstream and 160 ft downstream of the North Gully stilling basin) covered with riprap simulating prototype stone with an average weight of 360 lb and a thickness of 48 in. revealed no failure with any combined flow in North Gully and Sandburg Creek. However, with flow through North Gully only, discharges of 1500 to 3750 cfs displaced riprap as shown in photo 19. Photo 20 shows the results of scour of 2-hr duration (model) with a paved splash pad (40 ft long and 52 ft wide) below the type 2 basin. No failure of the riprap occurred although the area was exposed to flows from North Gully only of 1500 to 3750 cfs and combined flows in North Gully and Sandburg Creek up to 15,000 cfs (5,000 cfs North Gully, 10,000 cfs Sandburg Creek).

35. Pressure profiles, for a full range of discharges, obtained on the parabolic drop of the type 2 basin are shown in plate 19. The trajectory of the drop was based on a velocity of 40 fps (2500-cfs discharge). Maximum negative pressures were only about -0.5 ft of water for a discharge of 2500 cfs and decreased to -2.0 and -3.5 ft of water for discharges of 3750 and 5000 cfs, respectively. In view of the satisfactory results of these tests, the type 2 basin was selected for prototype construction.

PART IV: TESTS AND RESULTS, SANDBURG CREEK

36. Flow conditions at the junction of North Gully and Sandburg Creek (below the type 2 basin) appeared satisfactory when the latter was flowing full (photos 17a, b, and c); however, when flow through North Gully was considerable with little or no flow in Sandburg Creek, the discharge tended to attack the bottom and sides of Sandburg Creek (see paragraph 33). This condition was corrected by providing the splash pad shown in photo 20. Flow patterns and bottom velocities in Sandburg Creek for various combinations of flows are shown in plates 20 and 21. With the exception of the paved splash pad area, velocities were not considered excessive and no displacement of the riprap occurred in Sandburg Creek.

37. Tests were conducted to determine the effects of debris accumulation on flow conditions at the junction of North Gully and Sandburg Creek. Plate 22 shows the profiles of the deposits observed in the stilling basin and exit area as well as water-surface elevations in Sandburg Creek due to the introduction of various volumes of debris into the chute for a given test condition. Photo 21 is a dry-bed view of the debris deposit in this area due to the introduction of a volume of 3900 cu yd of debris, the design discharge of 3750 cfs in North Gully, and a discharge and tailwater elevation of 9750 cfs and 320.2, respectively, in Sandburg Creek. Plate 22 shows that deposition of the debris occurred downstream of the basin for volumes up to 1000 cu yd; above this amount, debris was steadily deposited in the basin until it was completely choked after a volume of 3900 cu yd had been introduced into North Gully chute. Observations also indicated that, with a combined flow of 3750 cfs in North Gully and 9750 cfs in Sandburg Creek, the maximum accumulation of debris in and below the basin resulted in the original basin walls (el 327.4) being overtopped by some 8 to 10 ft. Concurrently, with the deposition of debris in and below the stilling basin, the water-surface elevation at sta 1+40 in Sandburg Creek upstream of the junction gradually increased. A volume of 2500 cu yd resulted in a water surface approximately the height of the proposed levee and flood

wall in this area (el 325.9). With 3900 cu yd of debris, the floodwall and levees were overtopped about 1.7 ft (see plate 22). The deposit of 3900 cu yd of debris shown in photo 21 caused considerable constriction in the cross-sectional area and flow conditions in Sandburg Creek as shown in photos 22a, b, and c. For these conditions, supercritical flow occurred along the left bank of Sandburg Creek and bottom velocities as high as 22 fps were recorded in this area (sta 1+80 D.S.). However, little or no displacement of the original riprap (average weight 360 lb) occurred. With a discharge of 3750 cfs through North Gully and no flow in Sandburg Creek (photo 23), some degrading of the debris occurred and some displacement of the riprap on Sandburg Creek bank directly across from the stilling basin was observed.

PART V: DISCUSSION

38. Hydraulic model investigation of the high-velocity chute for North Gully revealed the adequacy of the overall scheme of the proposed project; however, certain modifications were developed that greatly improved the hydraulic performance of certain facilities.

39. The use of a small weir and quadrant walls at the entrance (type 5) to the North Gully chute greatly improved flow conditions in this area. The formation of a subcritical pool by the small weir (7.25 ft high) permitted flows up to 3750 cfs (design flow) to enter the chute without excessive turbulence or pileup at the entrance.

40. With the debris barrier a minimum of 90 ft upstream from the chute entrance, a top elevation of 478.5 could be used without materially affecting flow conditions at the entrance to the chute.

41. Although tests indicated that reducing the proposed superelevation in the curves in the lower end of the model would improve flow distribution in this area at the lower flows (300 to 1500 cfs), the adverse effect of this reduced superelevation with the larger discharges did not warrant such change.

42. Design of a satisfactory stilling basin at the downstream end of the chute (sta 3+60.40) was complicated by the uneven distribution of flow entering the basin as well as the excessive submergence effect created by the end sill with low flows. Satisfactory stilling action was obtained by flattening the transition upstream of the basin which decelerated the flow and tended to redistribute the energy across the channel, and by modifying the parabolic drop entering the basin to provide a more vertical drop which permitted deflection of the jet and offered greater resistance and dissipation of the energy of flow.

43. Tests of the junction section (North Gully and Sandburg Creek) indicated generally satisfactory flow conditions in the area for all combinations of discharge. However, a concrete splash pad is required immediately below the stilling basin together with riprap protection in Sandburg Creek. Debris should not be permitted to accumulate in the stilling basin or in Sandburg Creek as the jump will be lost in the

basin and the damming effect of debris in Sandburg Creek will cause overtopping of levees and floodwalls in the junction area.

Table 1

Depth of Flow in Chute as Affected by Superelevation

Station	Superelevation Average	Depth of Flow, ft — Discharge 1500 cfs — Left Bank	Center Line	Right Bank	Discharge 2500 cfs — Left Bank	Center Line	Right Bank	Discharge 3750 cfs — Left Bank	Center Line	Right Bank
S.T. 10+11.49	None*	2.52	2.40	2.30	3.44	3.36	3.42	4.71	4.36	4.52
S.T. 10+11.49	None**	2.52	2.40	2.30	3.48	3.42	3.42	4.76	4.38	4.56
C.S. 9+36.49	3.0	2.58	2.28	2.16	3.52	3.30	3.50	4.46	4.32	4.70
C.S. 9+36.49	1.5	2.12	2.34	2.58	2.82	3.14	3.88	3.90	4.26	5.34
8+75.89	3.0	2.65	2.34	2.08	3.60	3.25	3.54	4.50	4.30	4.80
8+75.89	1.5	1.94	2.30	2.86	2.10	3.46	4.44	2.96	4.48	6.40
8+25.89	3.0	2.74	2.34	2.02	3.76	3.22	3.58	4.56	4.22	4.86
8+25.89	1.5	2.34	2.22	2.40	3.36	3.02	3.88	4.08	4.26	5.44
7+75.89	3.0	2.76	2.36	2.06	3.58	3.36	3.44	4.82	4.60	4.94
7+75.89	1.5	2.16	2.18	2.70	2.86	3.50	3.62	4.12	4.54	5.06
S.C. 7+14.83	3.0	2.80	2.38	2.10	3.54	3.12	3.96	4.08	4.32	5.86
S.C. 7+14.83	1.5	2.02	2.34	2.62	2.60	3.04	4.86	3.24	4.16	6.46
T.S. 6+39.83	None*	2.28	2.38	2.86	3.62	3.46	3.92	4.62	4.70	4.78
T.S. 6+39.83	None**	2.26	2.50	2.60	3.62	3.02	3.48	4.76	4.44	4.50
S.T. 5+85.14	None*	2.26	2.24	2.92	3.30	3.22	4.18	4.56	4.34	4.80
S.T. 5+85.14	None**	2.26	2.12	2.80	3.04	3.20	3.44	4.62	4.66	5.20
C.S. 5+35.14	3.34	2.84	2.42	1.82	3.90	3.46	3.14	4.82	4.66	4.42
C.S. 5+35.14	1.50	2.96	2.36	2.10	3.98	3.16	3.22	4.96	4.54	4.36
4+95.50	3.34	1.86	2.34	2.68	3.74	3.76	2.70	5.66	4.66	4.00
4+95.50	1.50	2.28	2.60	1.50	3.86	3.84	1.92	5.28	4.48	3.46
S.C. 4+55.86	3.34	1.36	2.00	3.42	3.20	3.20	4.00	5.36	4.68	4.36
S.C. 4+55.86	1.50	2.64	2.24	2.42	4.36	3.36	2.20	6.28	5.24	2.48
T.S. 4+05.86	None*	3.66	2.24	2.42	3.34	3.72	3.52	5.00	4.58	5.08
T.S. 4+05.86	None**	2.40	2.66	2.34	3.40	3.22	3.60	5.34	4.26	5.38
3+60.40	None*	2.58	2.50	1.84	4.26	3.40	3.08	4.56	4.70	4.80
3+60.40	None**	2.34	2.08	2.22	2.32	3.56	3.72	3.36	3.94	5.12
2+40.40	None*	1.02	1.52	1.52	1.90	1.72	2.16	3.34	3.18	3.22
2+40.40	None**	1.48	1.44	1.34	2.20	2.10	2.66	3.24	2.98	3.52
2+09.20	None*	1.14	1.34	1.14	1.58	1.58	1.76	2.40	2.14	2.26
2+09.20	None**	1.38	1.30	1.26	2.10	1.88	1.52	2.52	2.08	2.04

Note: No change was made in the slope along the center line of the chute. The revised superelevation merely rotated around the original elevation at the chute center line.

* Original chute.

** Revised chute (not adopted for construction).

a. Discharge 3750 cfs (design)

b. Discharge 2500 cfs

Photo 1. Flow conditions in approach to North Gully chute, type 2 entrance (sheet 1 of 2)

c. Discharge 1500 cfs

Photo 1. (sheet 2 of 2)

a. Dry bed

b. Discharge 3750 cfs

Photo 2. Type 2 entrance, debris accumulated upstream of barrier and weir (sheet 1 of 2)

c. Discharge 2500 cfs

d. Discharge 1500 cfs

Photo 2. (sheet 2 of 2)

a. Dry bed

b. Discharge 3750 cfs

Photo 3. Type 3 entrance, debris upstream of barrier
(sheet 1 of 2)

c. Discharge 2500 cfs

d. Discharge 1500 cfs

Photo 3. (sheet 2 of 2)

a. Dry bed

b. Discharge 3750 cfs

Photo 4. Type 4 entrance, debris upstream of barrier; sta 25+05, el 458.0. (sheet 1 of 2)

c. Discharge 2500 cfs

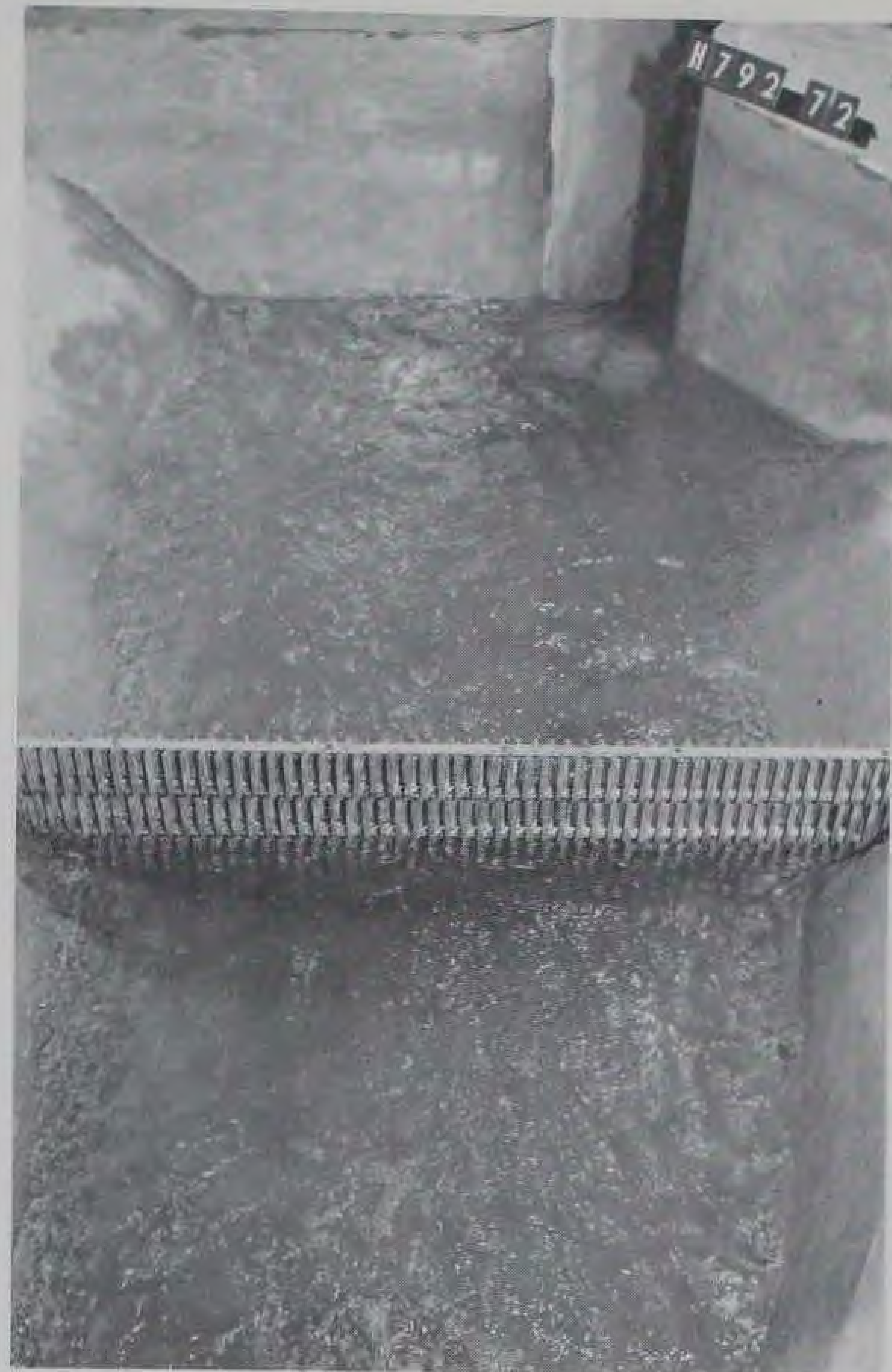
d. Discharge 1500 cfs

Photo 4. (sheet 2 of 2)

a. Dry bed

b. Discharge 3750 cfs; flow is distributed across approach channel

Photo 5. Type 5 entrance, unchoked debris barrier; sta 24+55, el 468.0. (sheet 1 of 2)



c. Discharge 2500 cfs; majority of flow along left bank of approach channel

d. Discharge 1500 cfs; majority of flow along left bank of approach channel

Photo 5. (sheet 2 of 2)

a. Dry bed

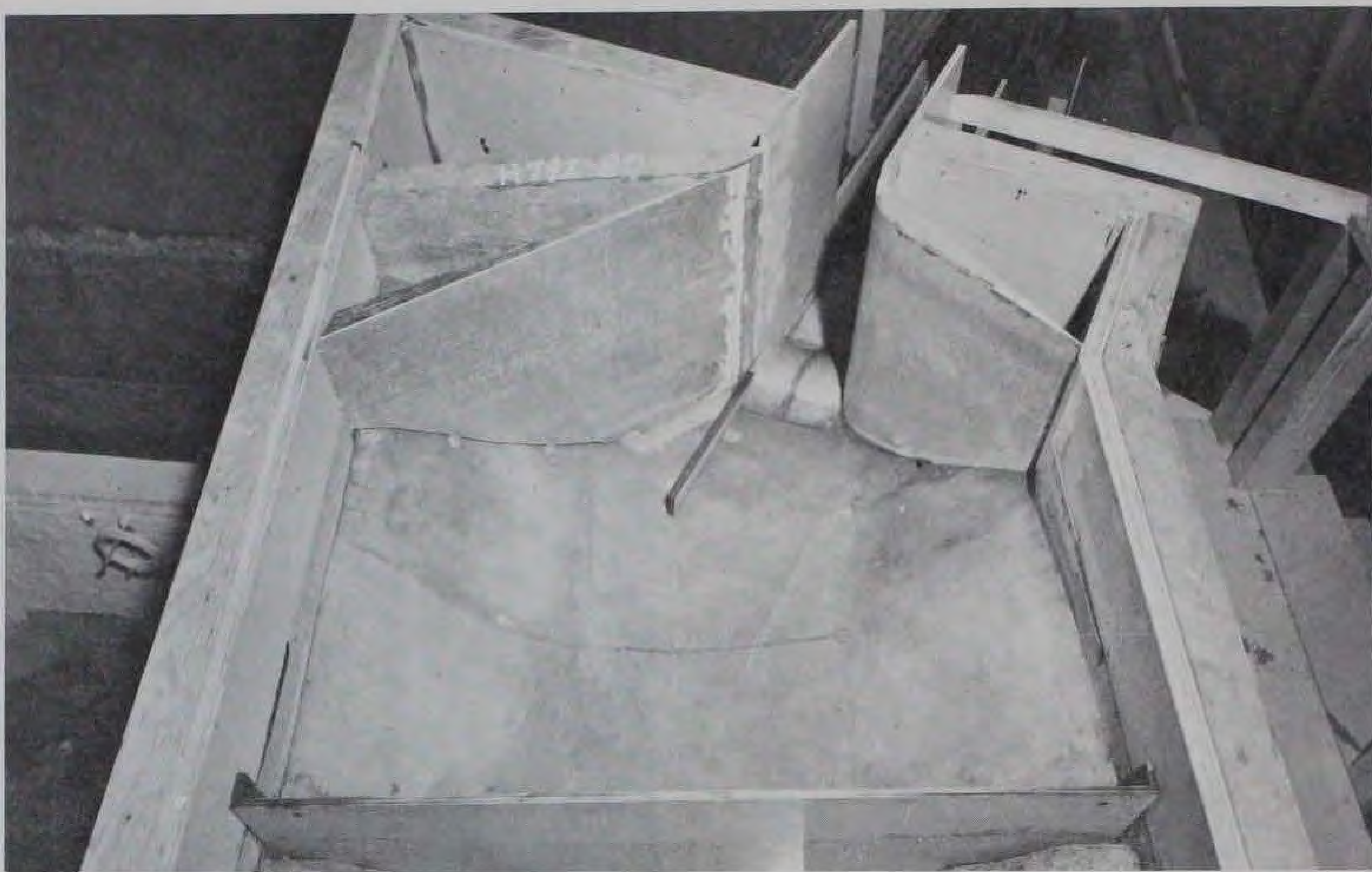
b. Discharge 3750 cfs

Photo 6. Type 5 entrance, fully choked debris barrier; sta 24+55, el 468.0. (sheet 1 of 2)

c. Discharge 2500 cfs

d. Discharge 1500 cfs

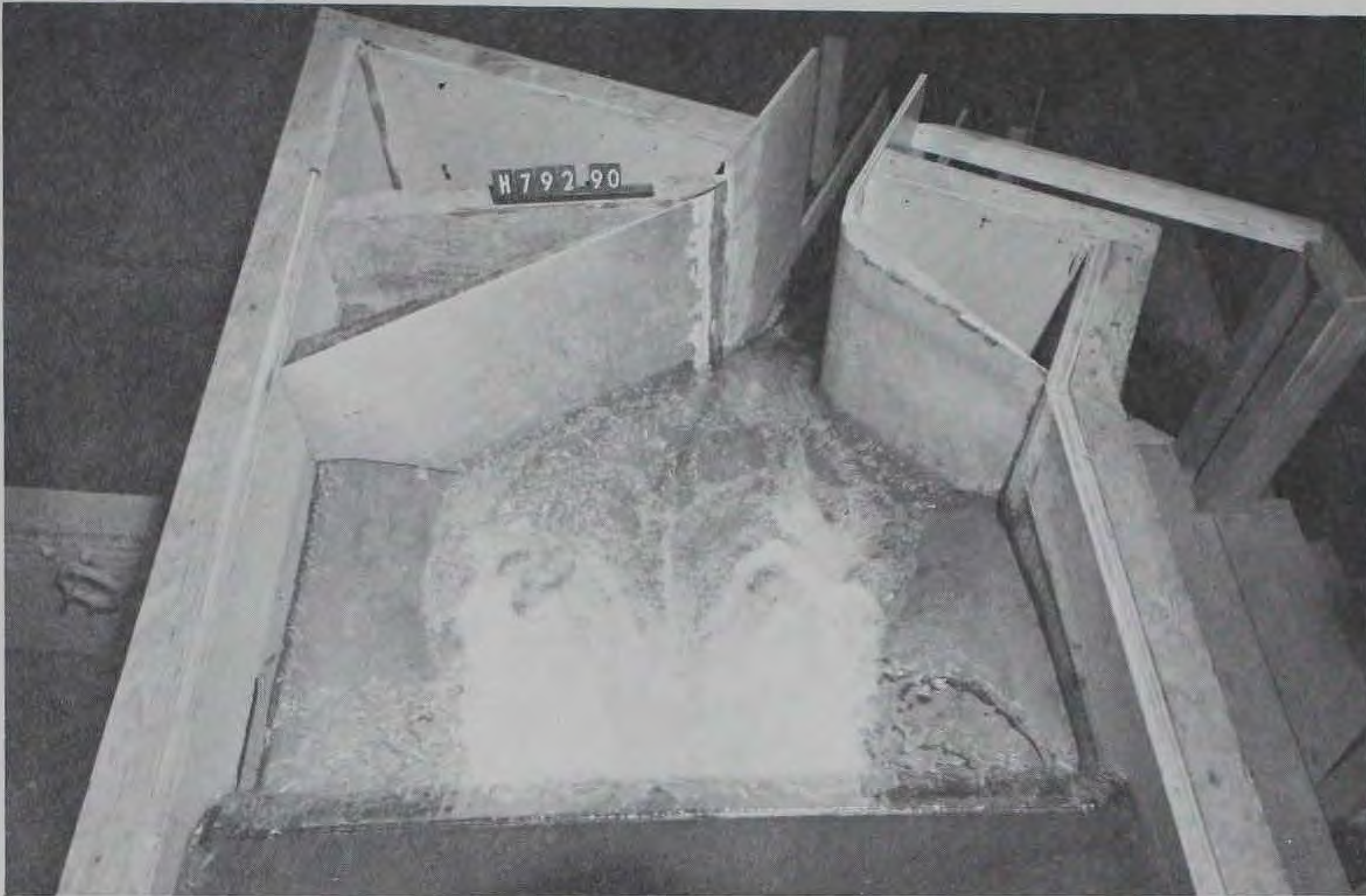
Photo 6. (sheet 2 of 2)



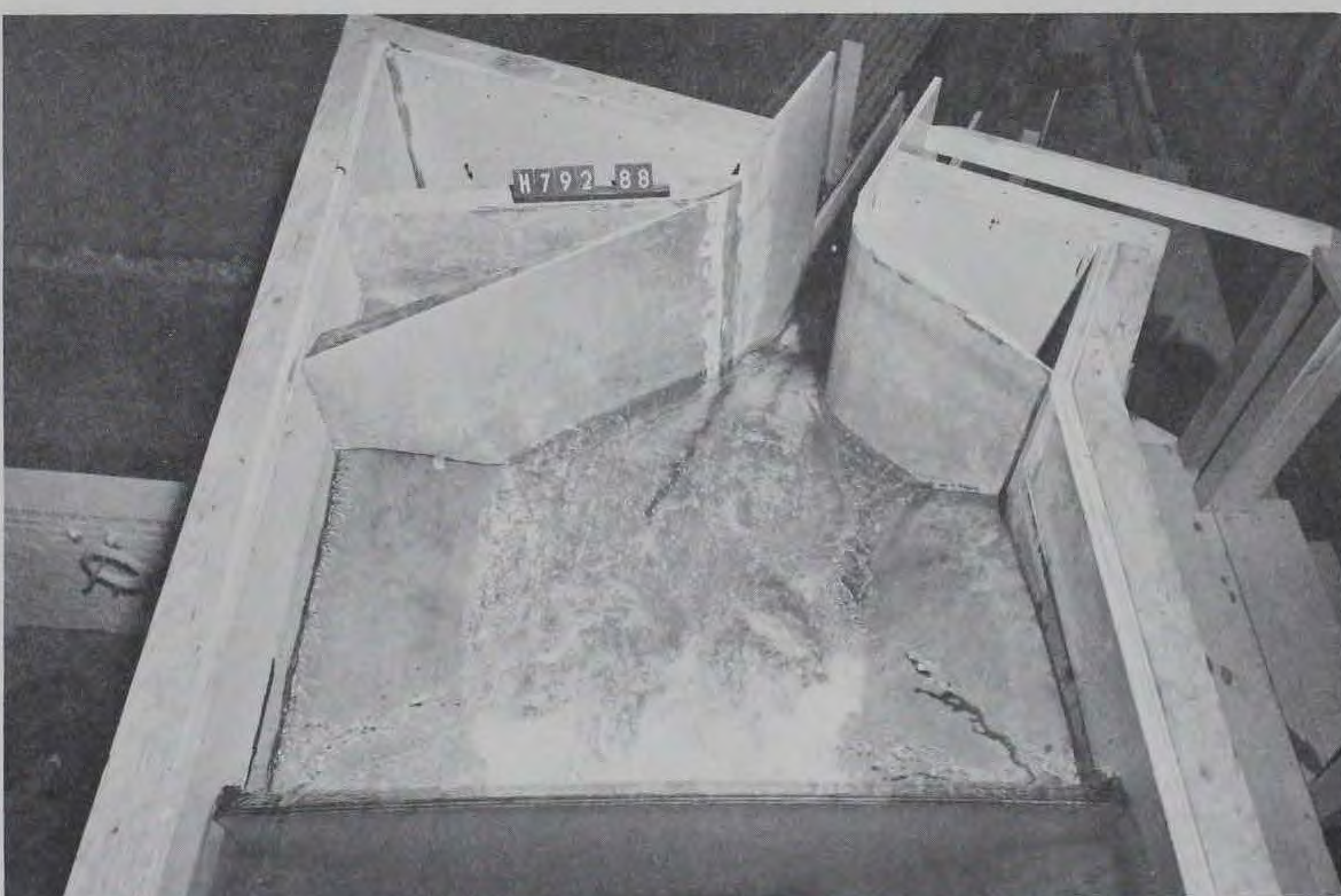
a. Dry bed

b. Discharge 3750 cfs

Photo 7. Type 5 entrance, choked debris barrier; sta 24+55, el 478.5. (sheet 1 of 3)

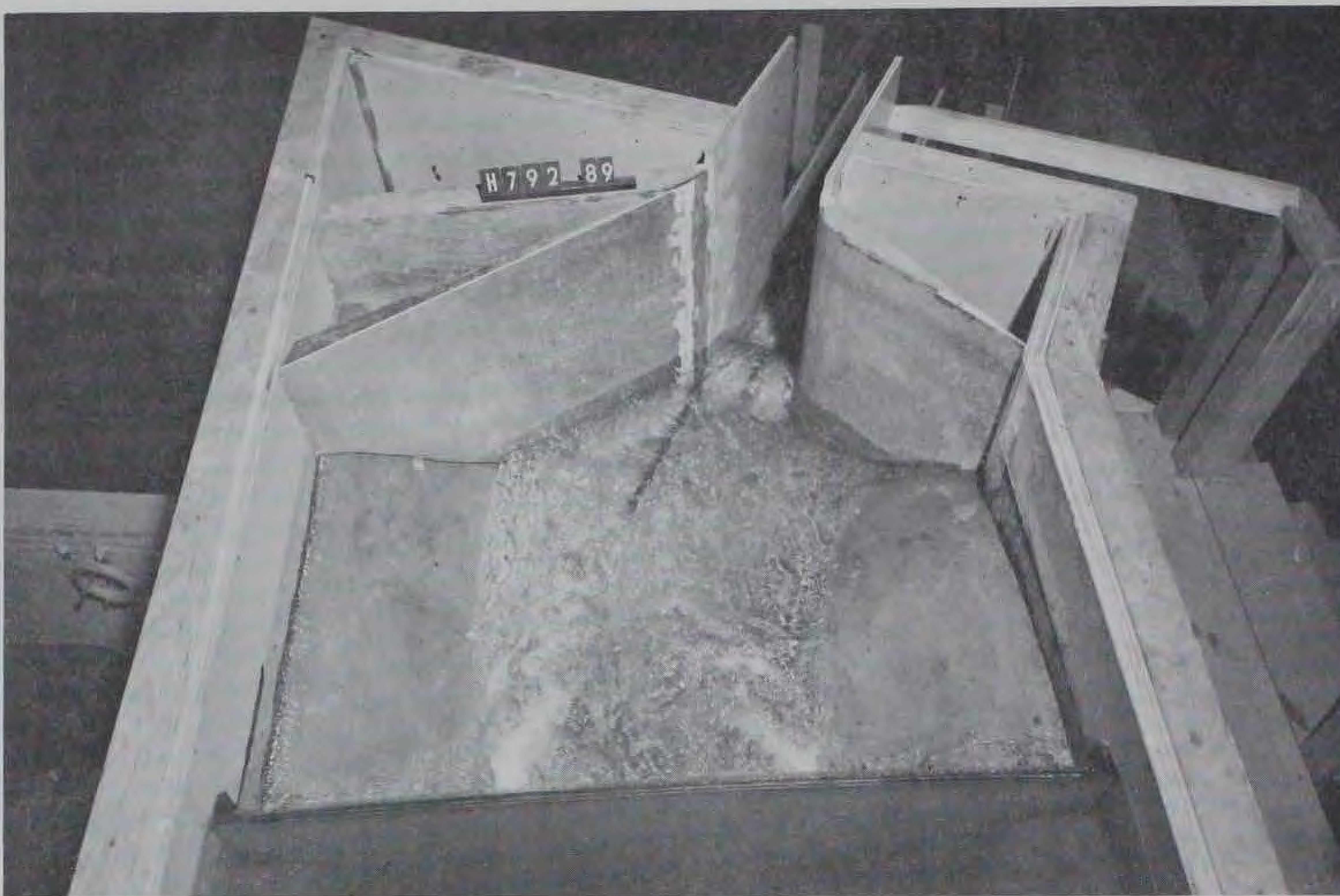


c. Discharge 2500 cfs

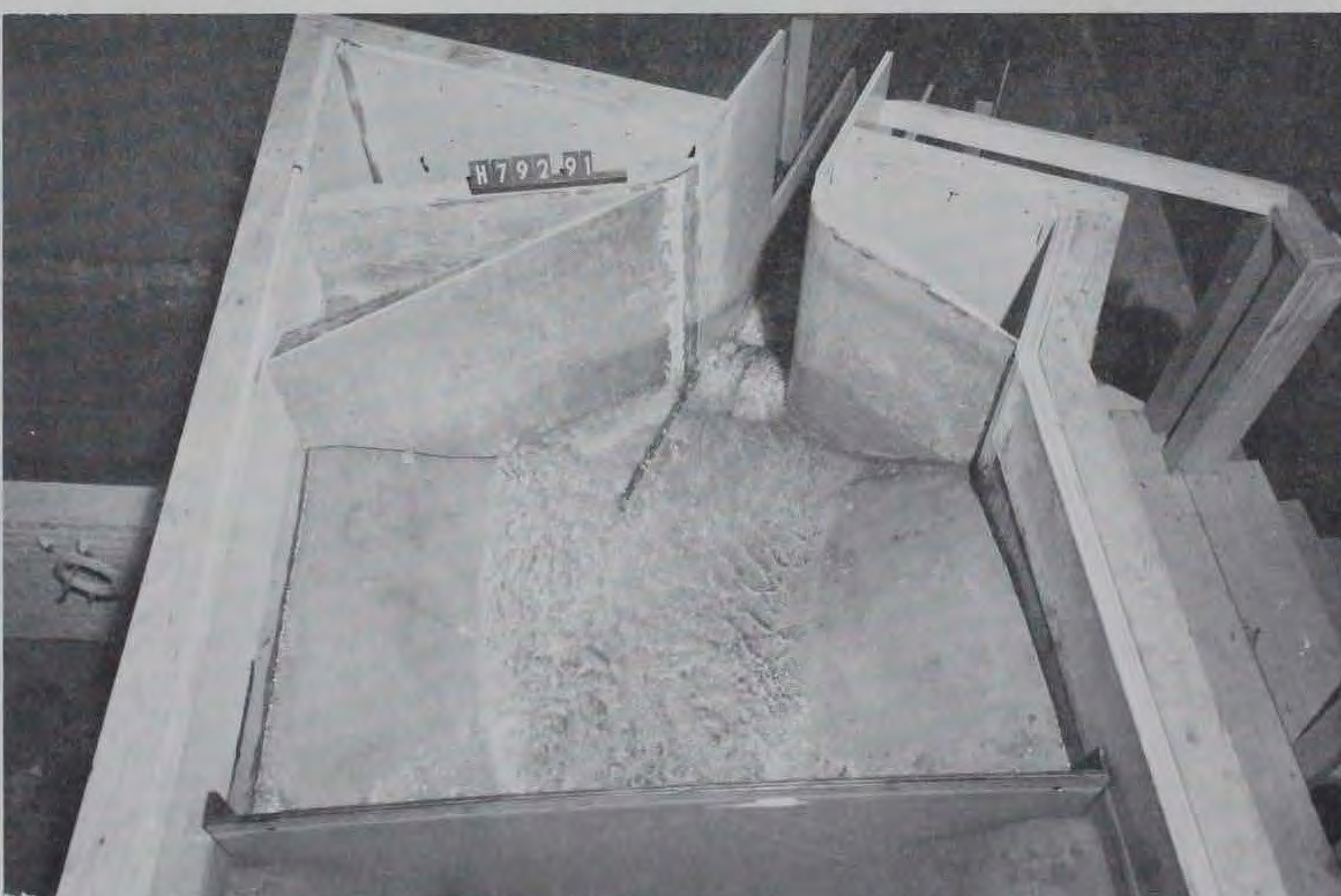


d. Discharge 1500 cfs

Photo 7. (sheet 2 of 3)

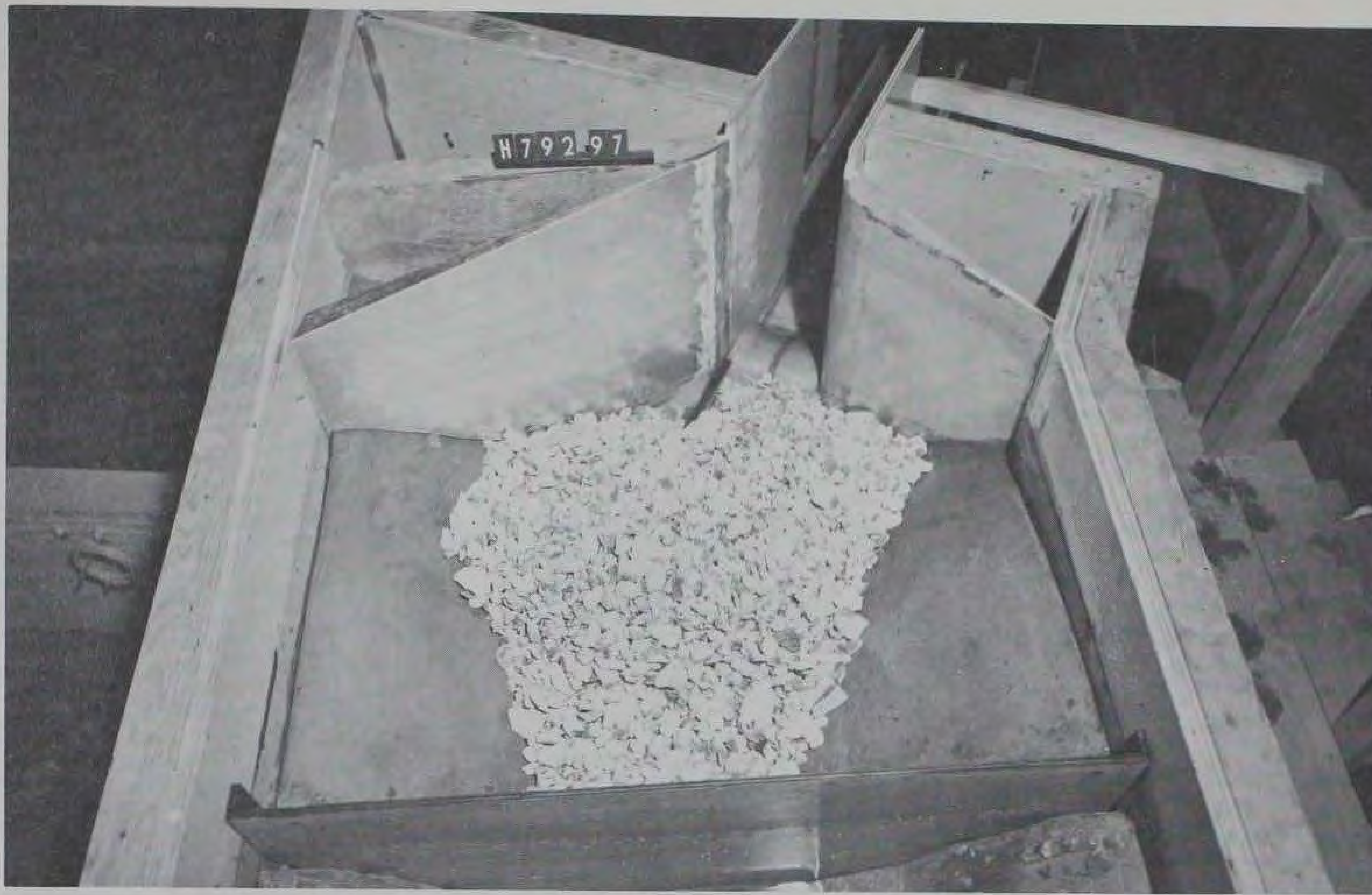


e. Discharge 1000 cfs

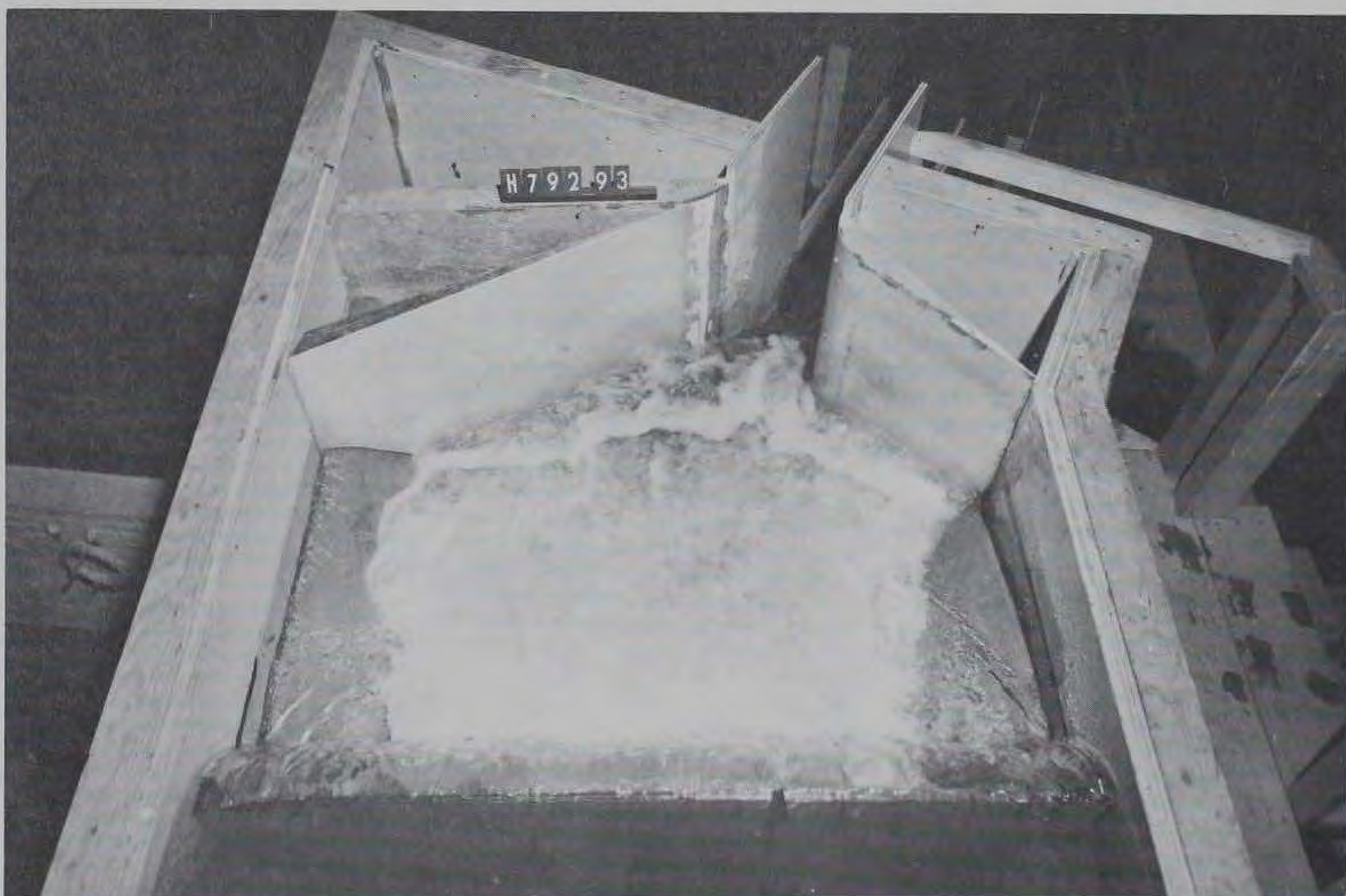


f. Discharge 730 cfs

Photo 7. (sheet 3 of 3)



a. Dry bed



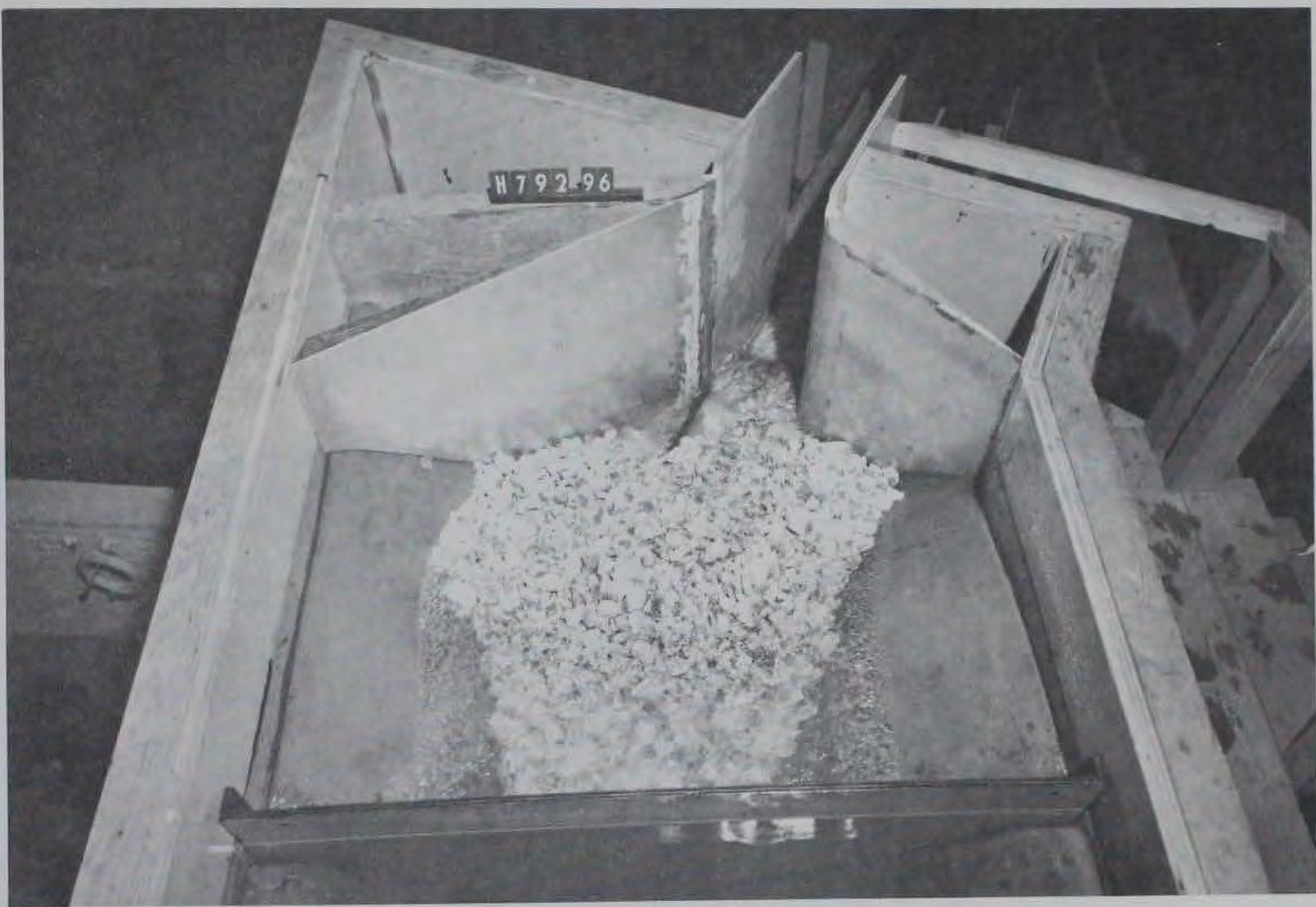
b. Discharge 3750 cfs

Photo 8. Type 5 entrance, choked debris; sta 24+55, el 478.5. Debris represents 900 cu yd of material (sheet 1 of 3)

c. ·Discharge 2500 cfs

d. Discharge 1500 cfs

Photo 8. (sheet 2 of 3)



e. Discharge 730 cfs

Photo 8. (sheet 3 of 3)

a. Discharge 3750 cfs

b. Discharge 2500 cfs

Photo 9. Flow conditions in original chute looking upstream from sta 11+59.46 (sheet 1 of 2)

c. Discharge 1500 cfs

Photo 9. (sheet 2 of 2)

a. Discharge 3750 cfs

b. Discharge 2500 cfs

Photo 10. Flow conditions in original chute looking downstream from sta 10+11.49 (sheet 1 of 2)

c. Discharge 1500 cfs

Photo 10. (sheet 2 of 2)

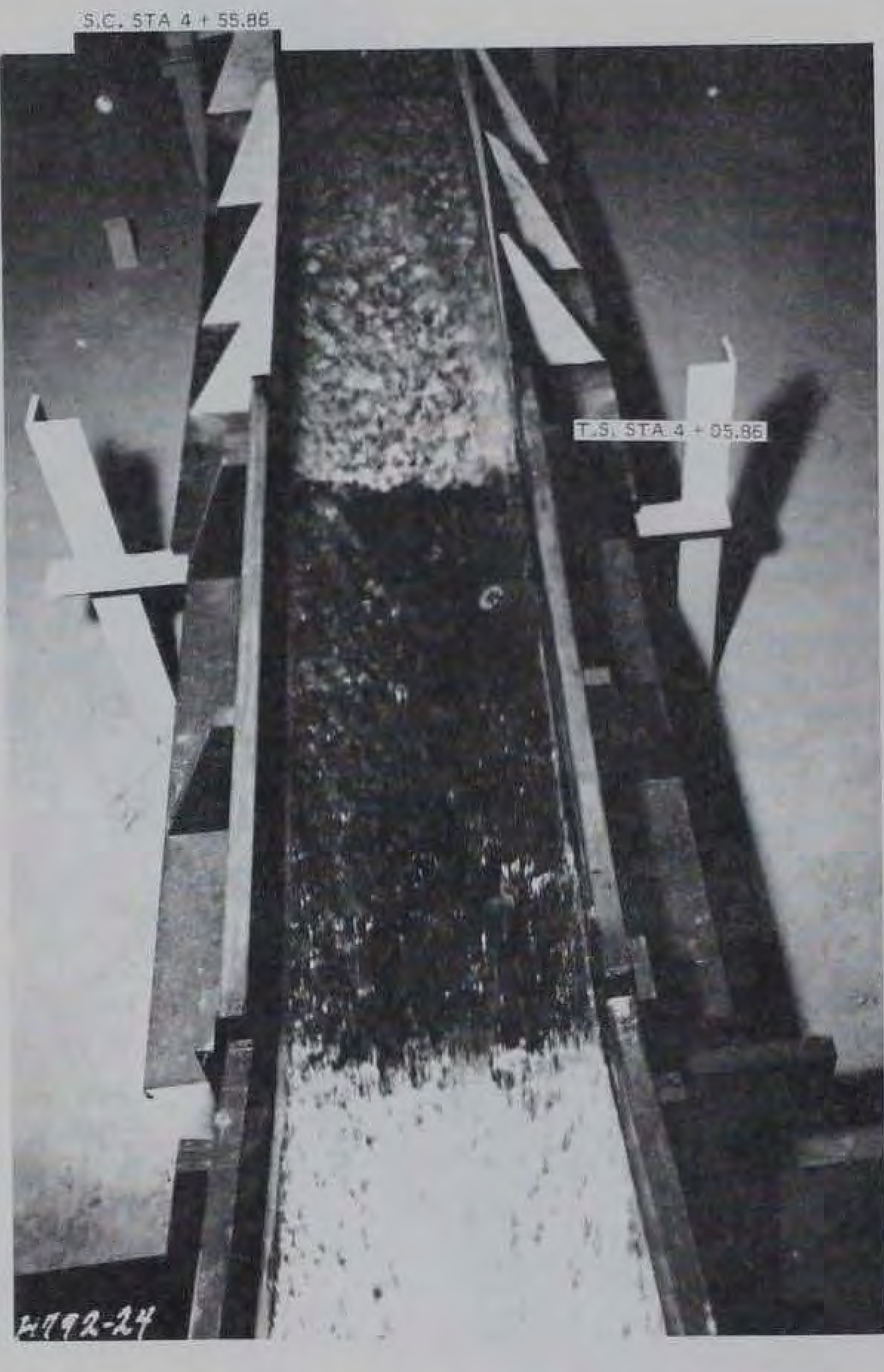
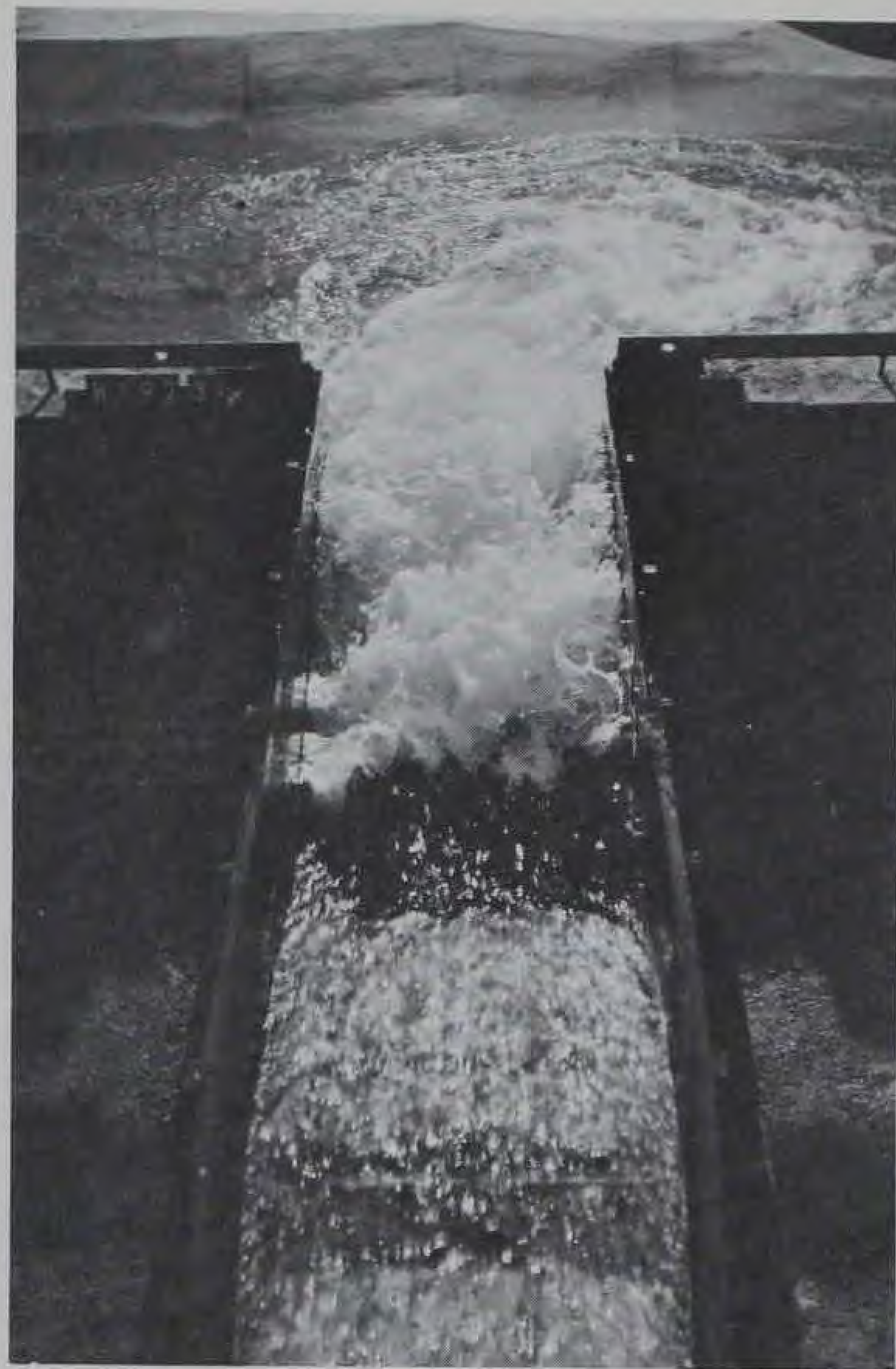
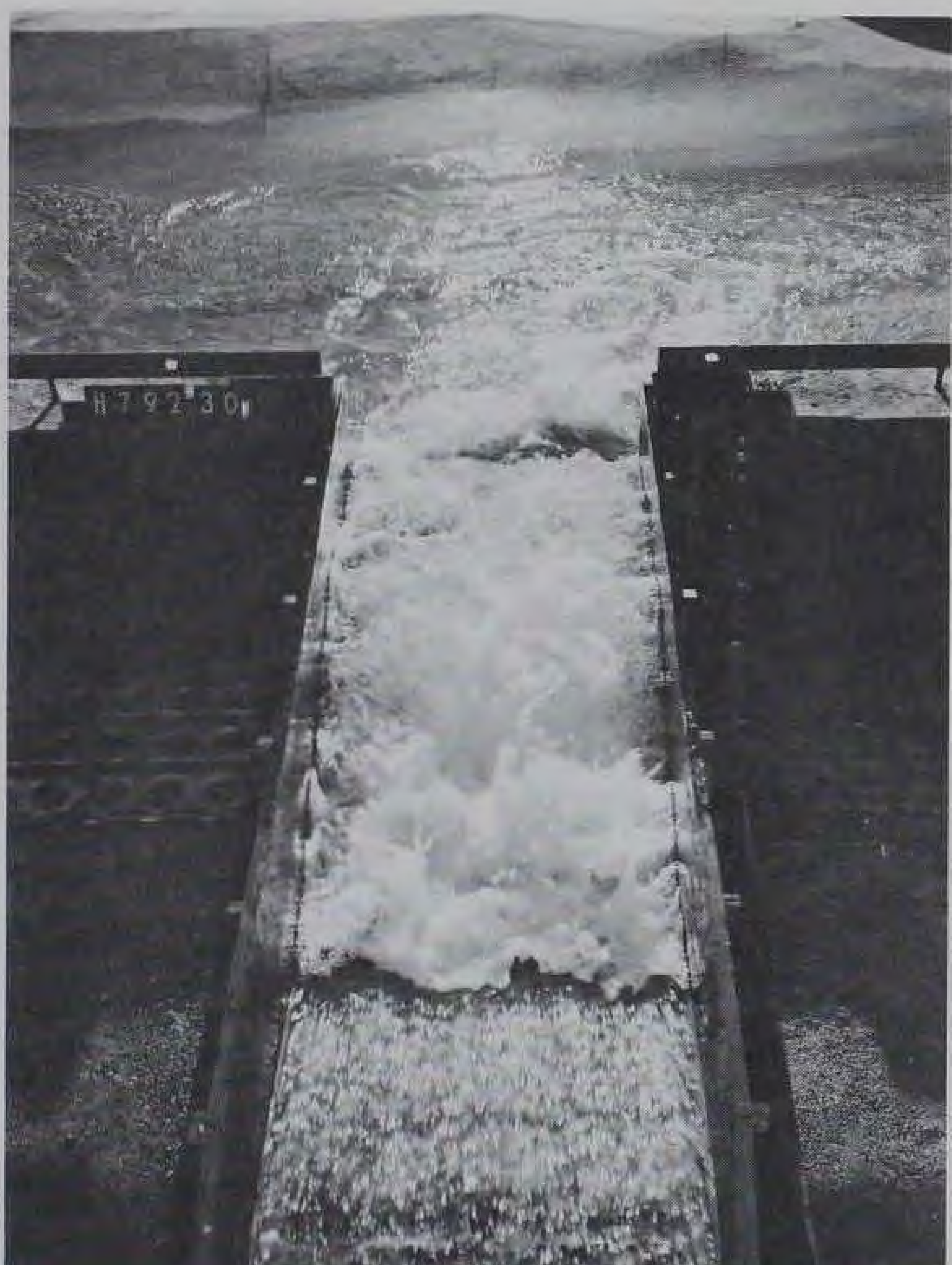


Photo 11. Cross-wave pattern originating at sta 4+55.36 continuing to sta 4+05.86

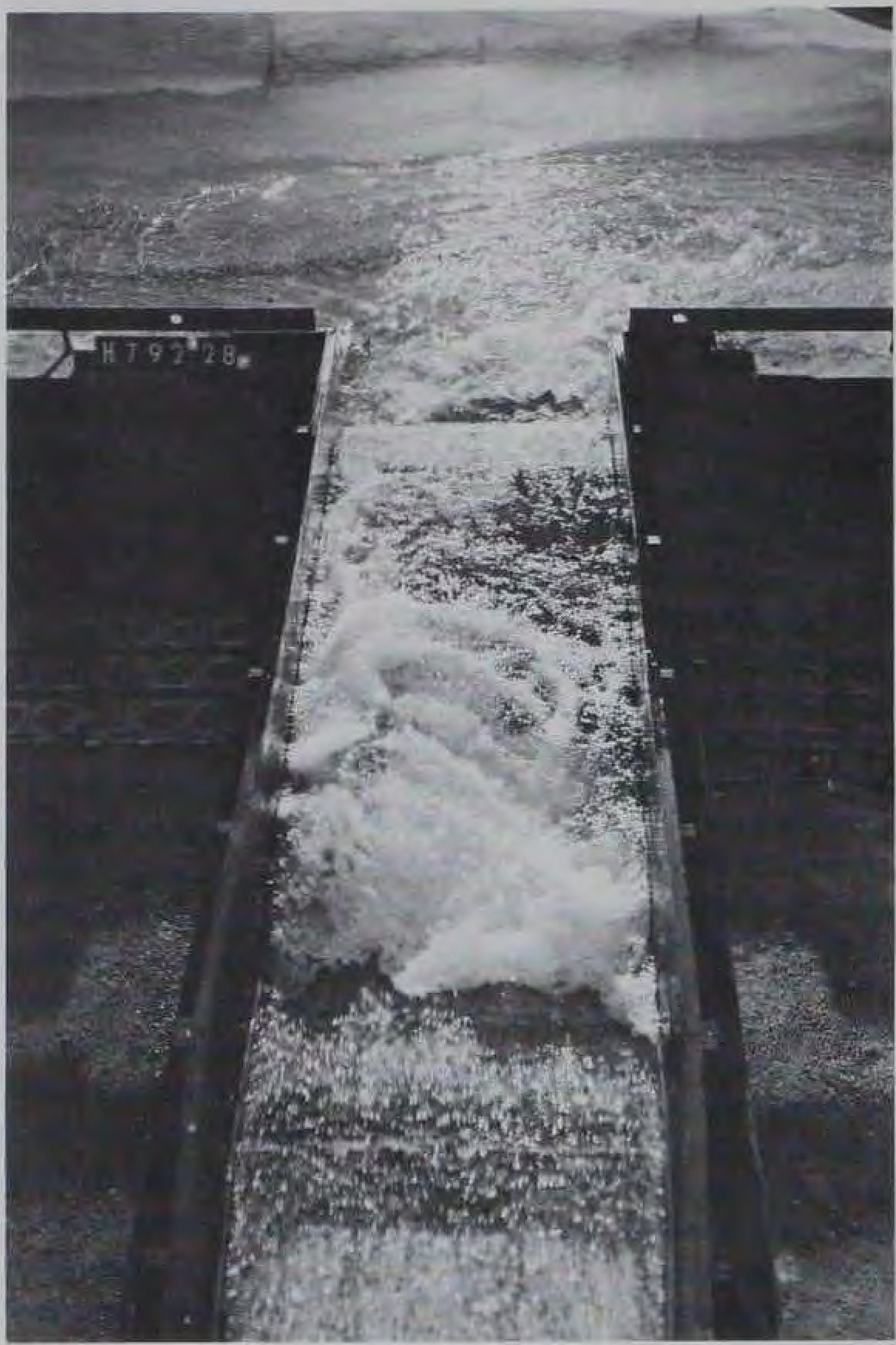
a. Discharge:
North Gully 3750 cfs
Sandburg Creek 0 cfs





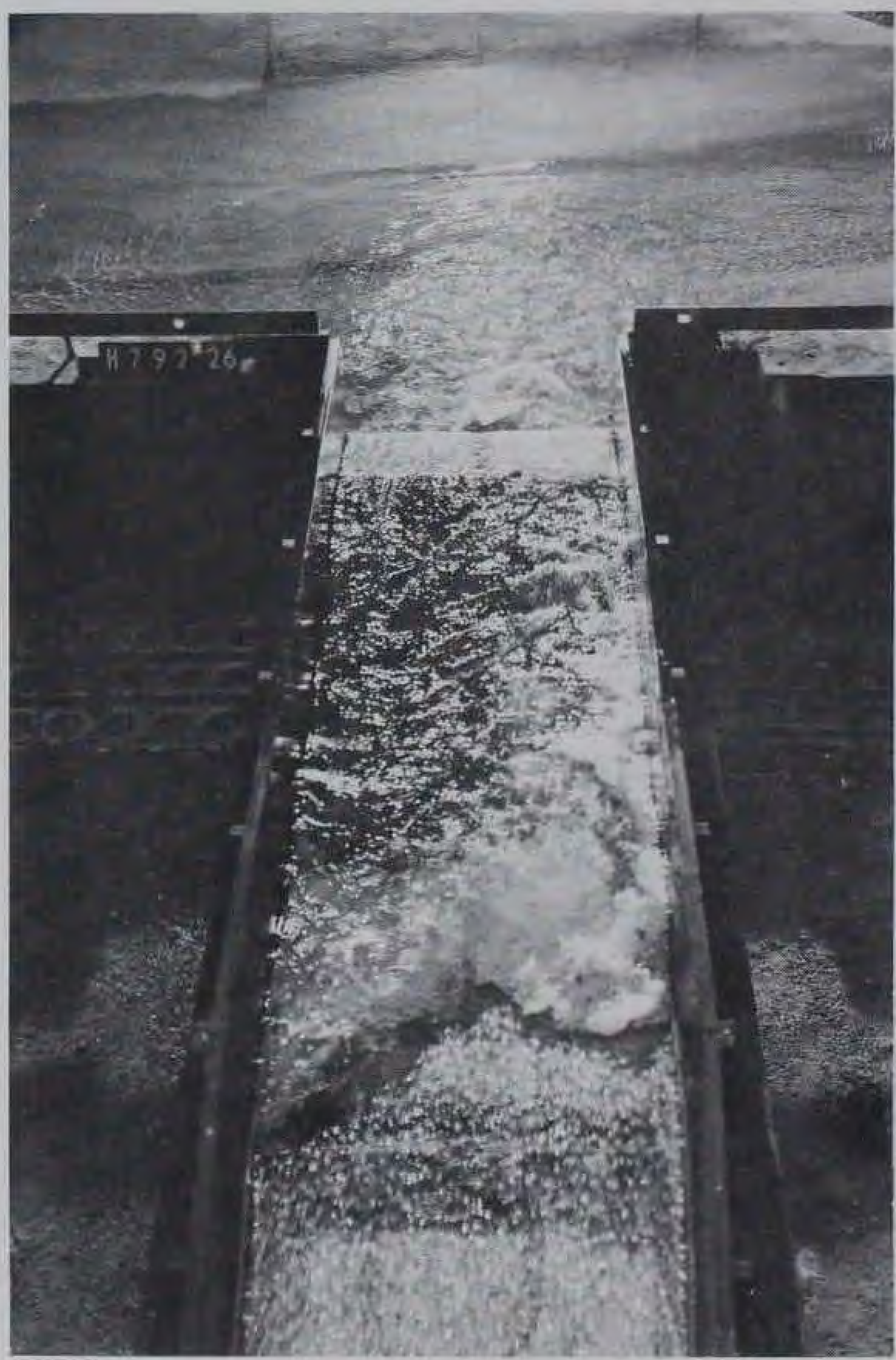
b. Discharge:
North Gully 2500 cfs
Sandburg Creek 0 cfs

Photo 12. Flow conditions in the original design stilling basin, end-sill control (sheet 1 of 2)



c. Discharge:

North Gully	1500 cfs
Sandburg Creek	0 cfs

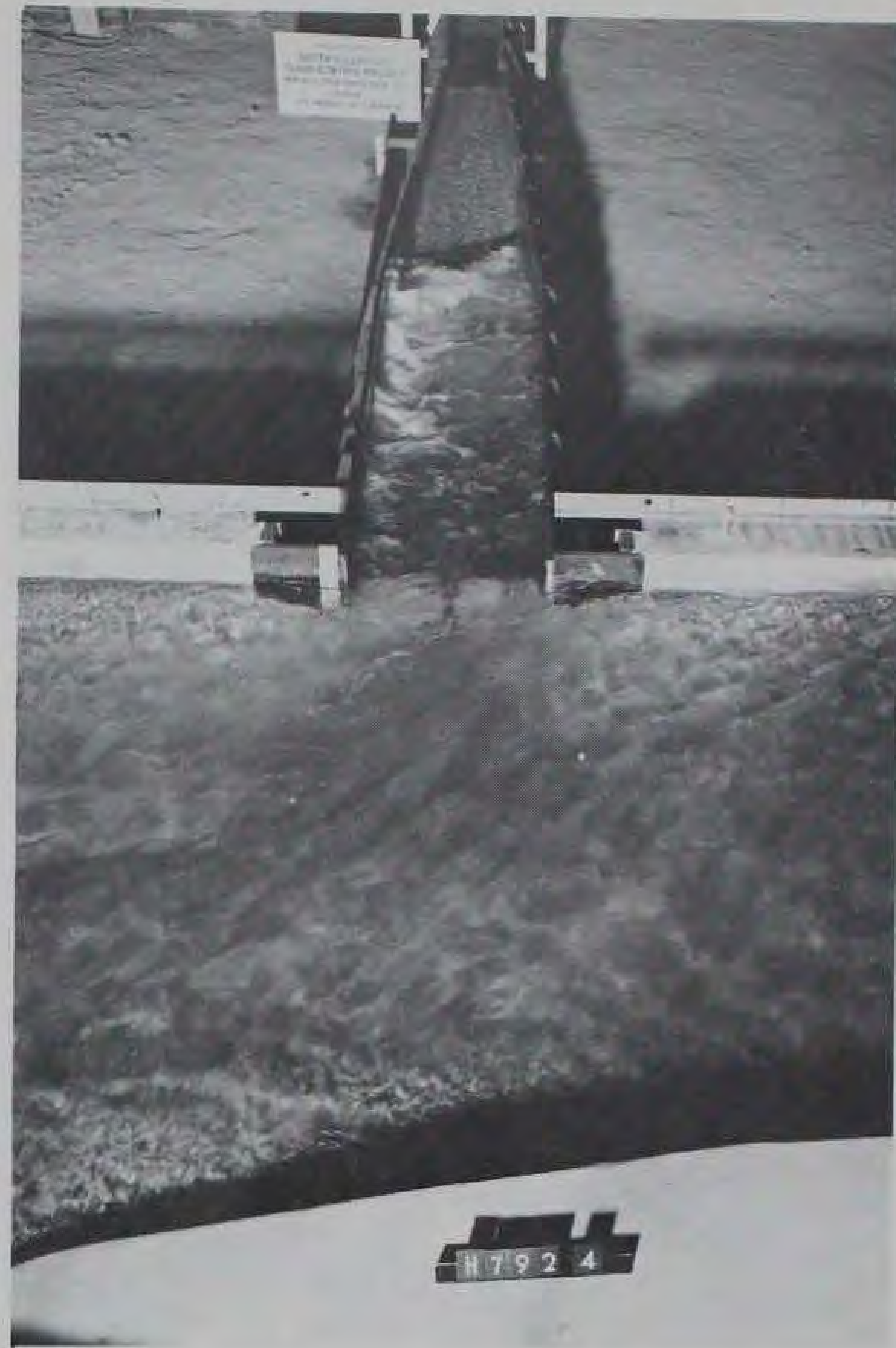


d. Discharge:

North Gully	600 cfs
Sandburg Creek	0 cfs

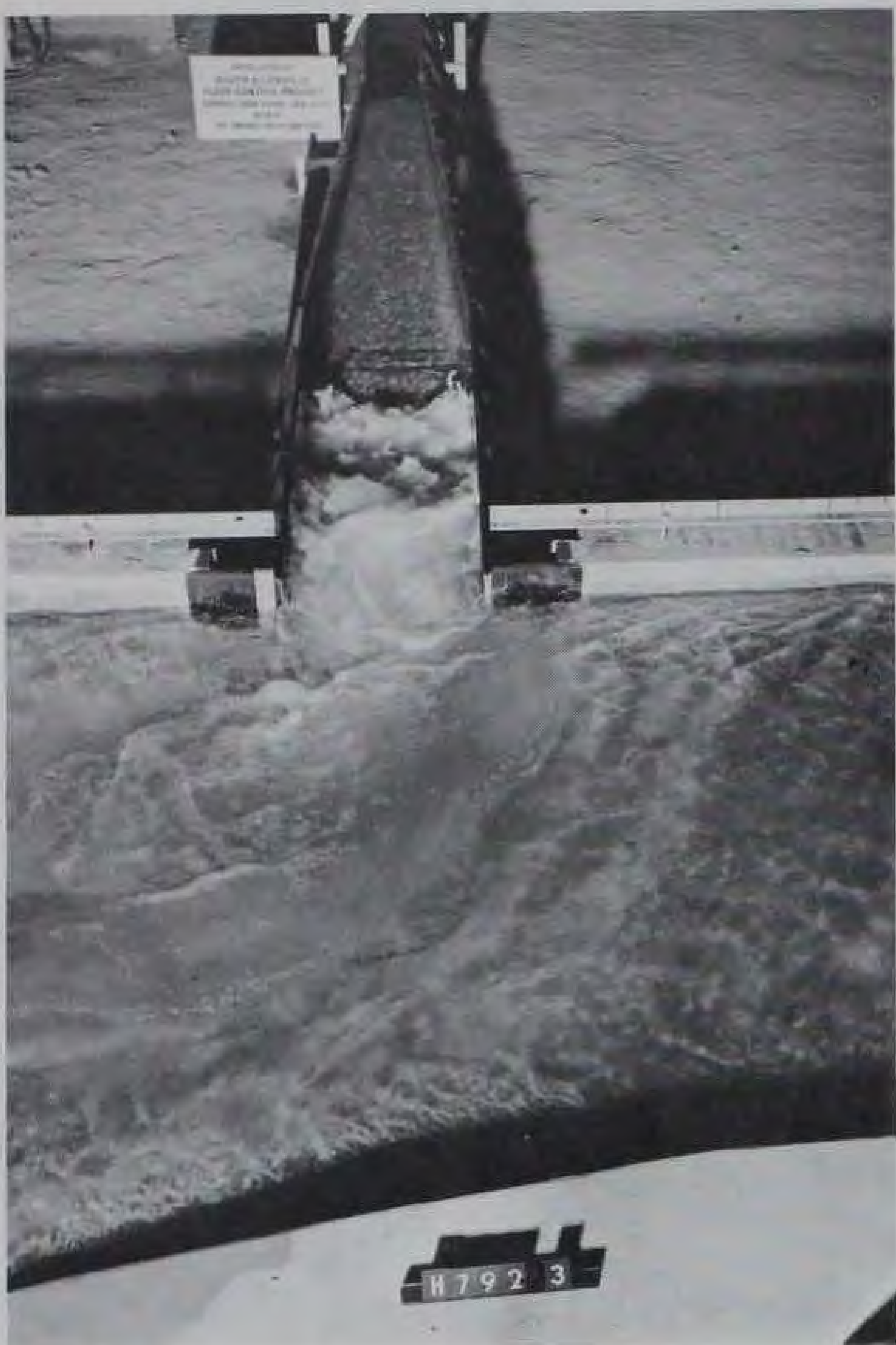
Photo 12. (sheet 2 of 2)

a. Discharge:
North Gully 1,500 cfs
Sandburg Creek 12,000 cfs



b. Discharge:
North Gully 600 cfs
Sandburg Creek 9400 cfs

Photo 13. Flow conditions in original design stilling basin. Discharges 600 and 1500 cfs in North Gully and 9400 and 12,000 cfs in Sandburg Creek

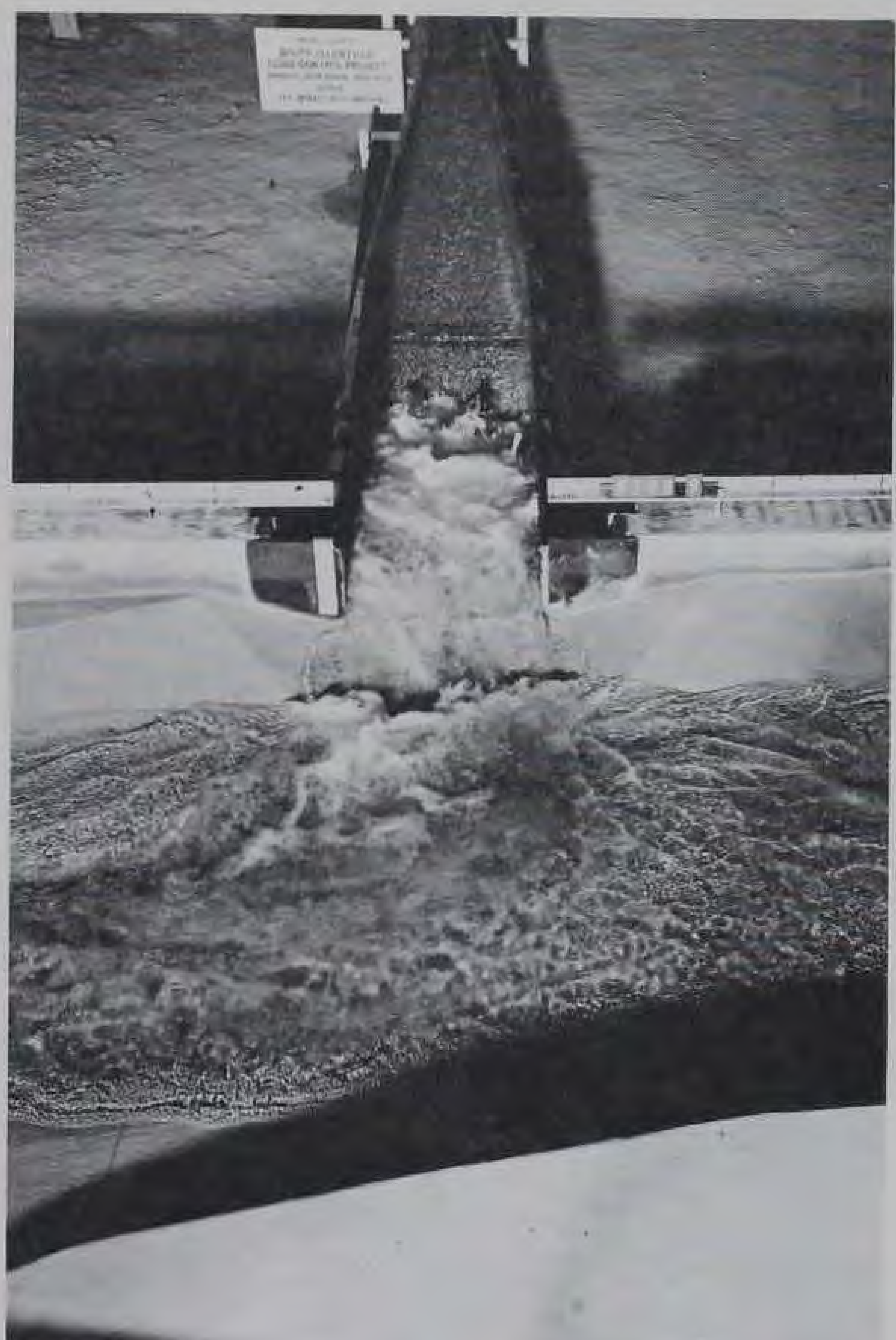


a. Discharge:
North Gully 3750 cfs
Sandburg Creek 9750 cfs

b. Discharge:
North Gully 2500 cfs
Sandburg Creek 2500 cfs

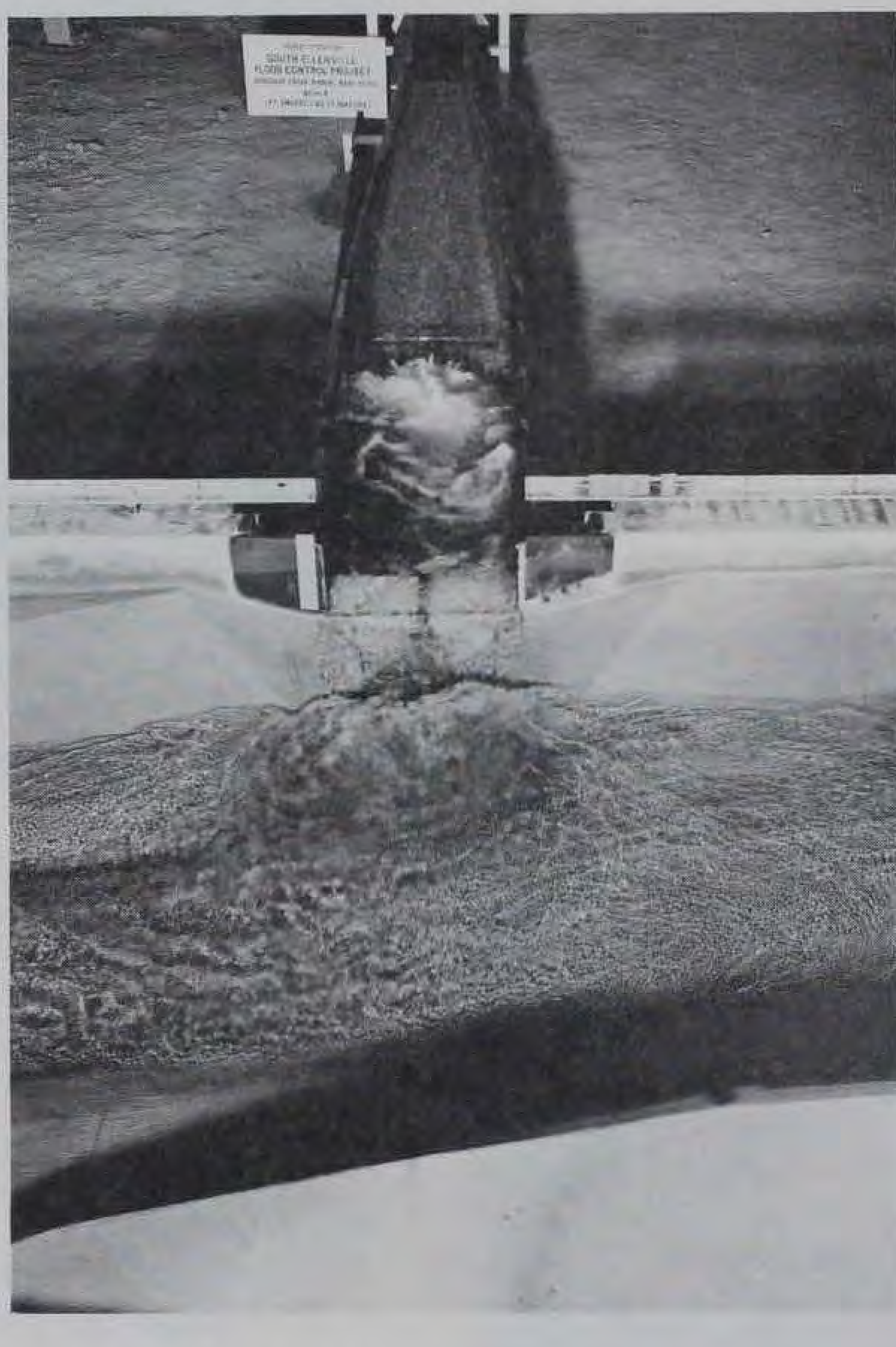
Photo 14. Flow conditions at the junction of North Gully and Sandburg Creek in original design stilling basin. Discharges 2500 and 3750 cfs in North Gully and 2500 and 9750 cfs in Sandburg Creek

a. Discharge:
North Gully 3750 cfs
Sandburg Creek 0 cfs



b. Discharge:
North Gully 2500 cfs
Sandburg Creek 0 cfs

Photo 15. Flow conditions at the junction of North Gully and Sandburg Creek in original design stilling basin. Discharges 1500, 2500, and 3750 cfs in North Gully and 0 cfs in Sandburg Creek (sheet 1 of 2)

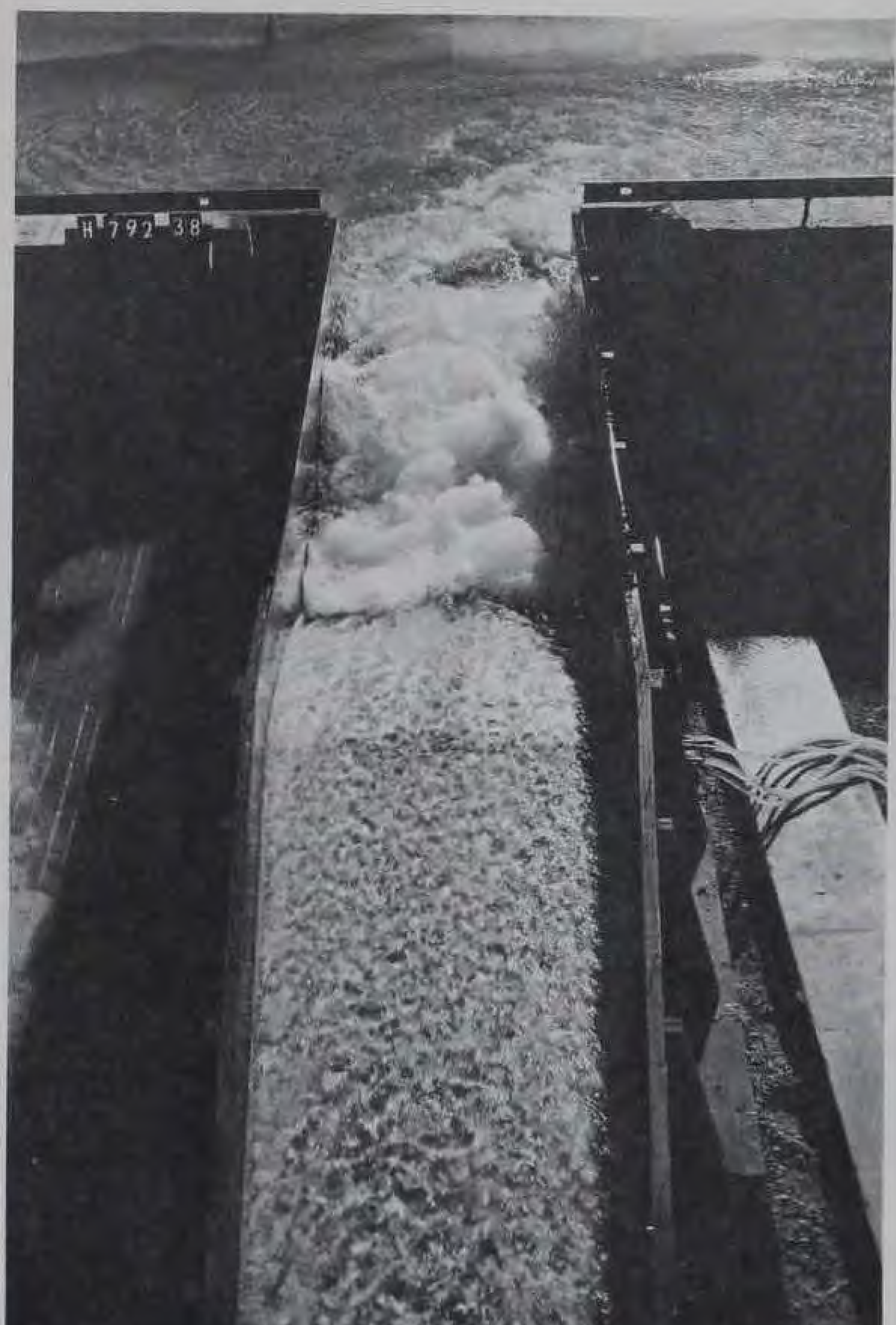


c. Discharge:

North Gully	1500 cfs
Sandburg Creek	0 cfs

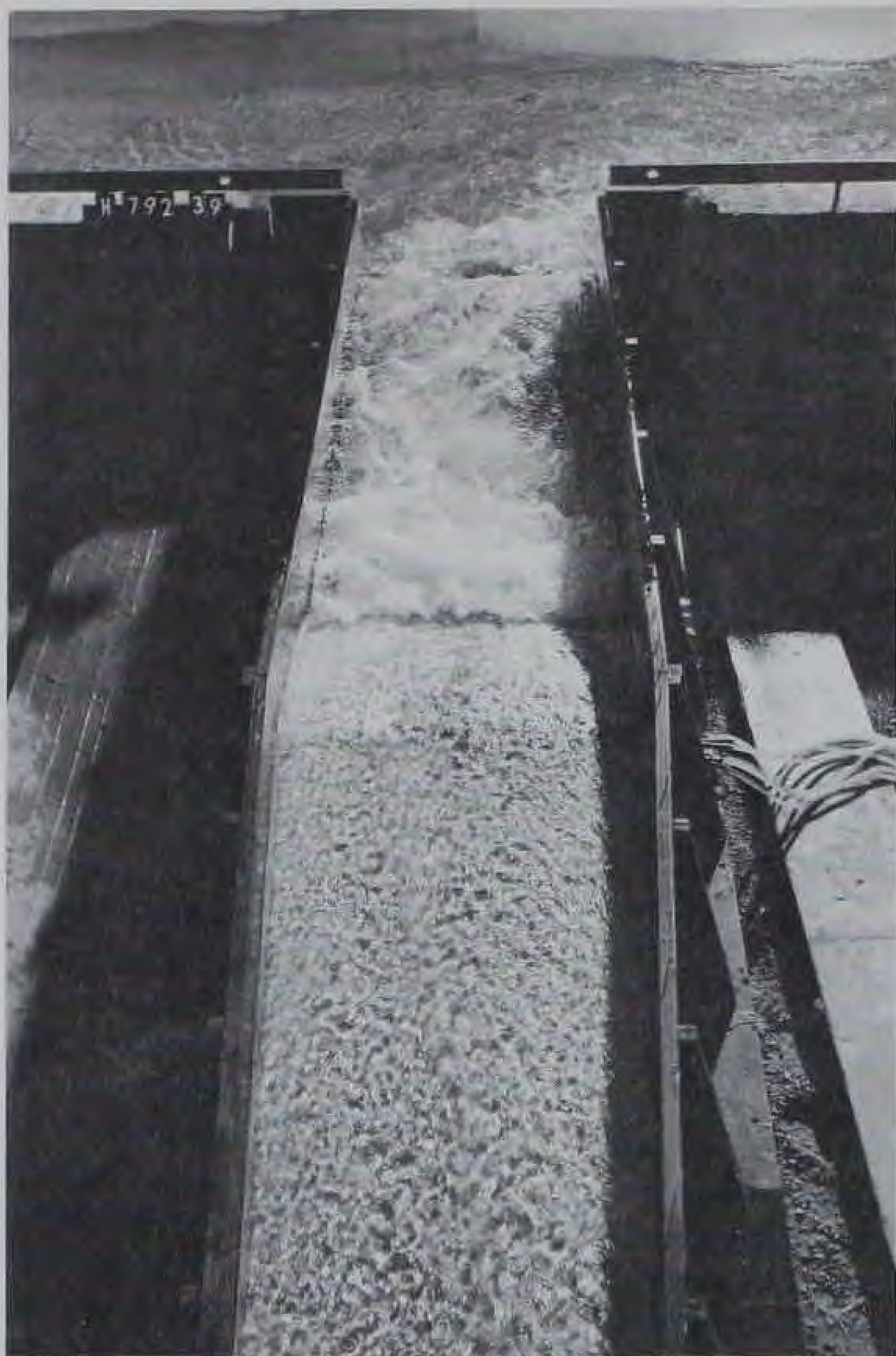
Photo 15. (sheet 2 of 2)

a. Discharge:
North Gully 3750 cfs
Sandburg Creek 0 cfs



b. Discharge:
North Gully 2500 cfs
Sandburg Creek 0 cfs

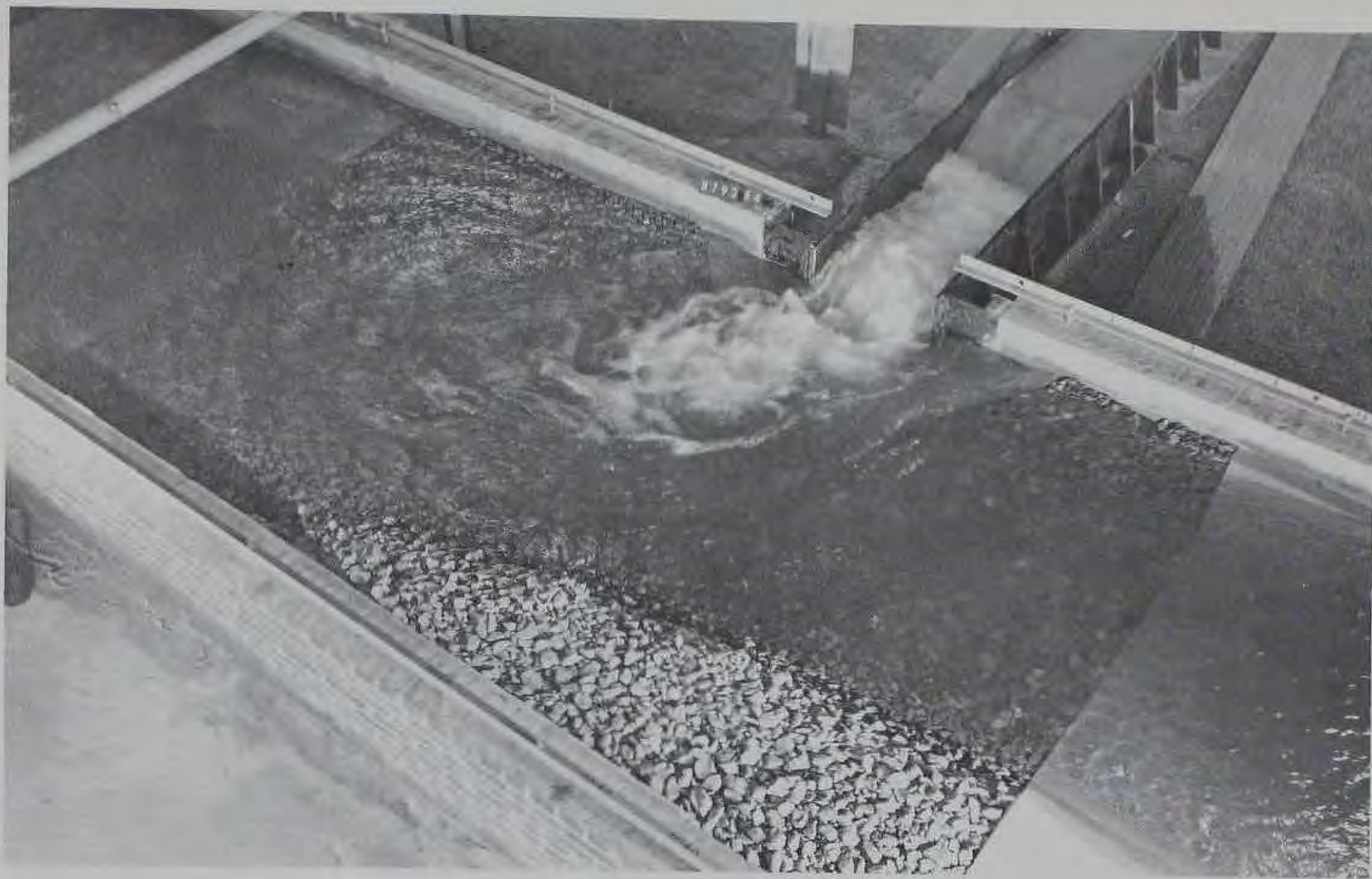
Photo 16. Flow conditions in the type 2 design stilling basin, end-sill control (sheet 1 of 2)



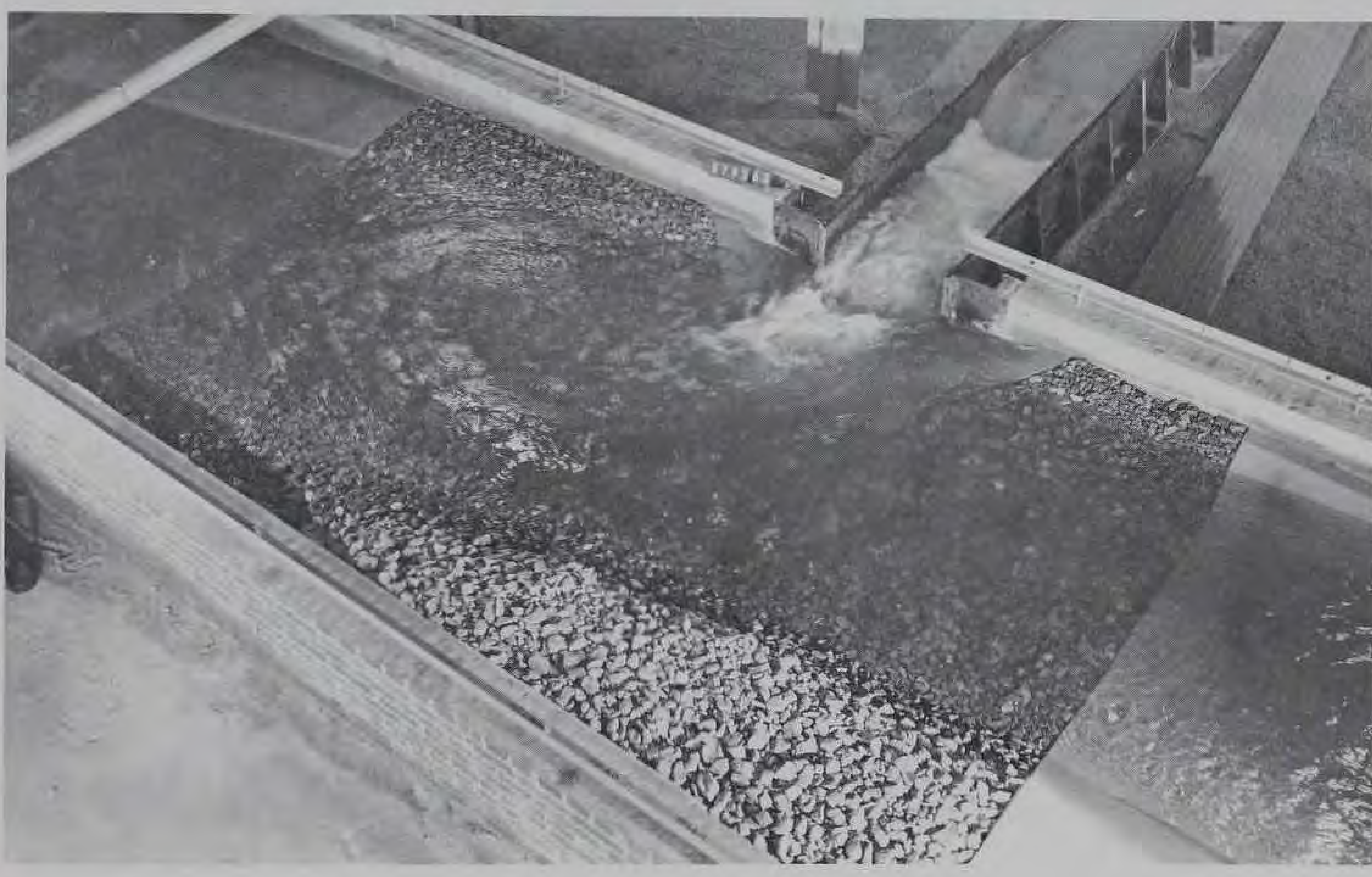
c. Discharge:
North Gully 1500 cfs
Sandburg Creek 0 cfs

d. Discharge:
North Gully 600 cfs
Sandburg Creek 0 cfs

Photo 16. (sheet 2 of 2)

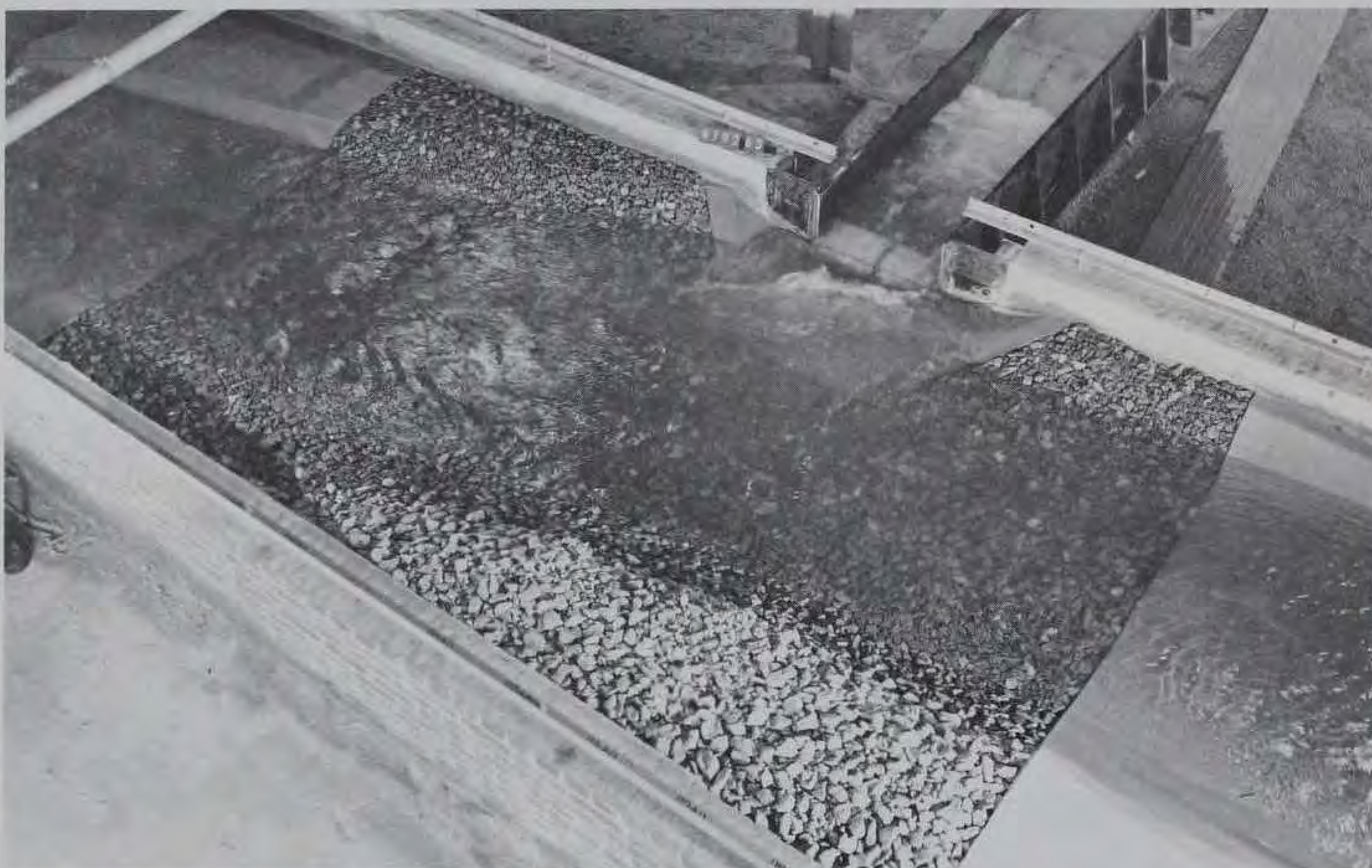


a. Discharge: North Gully 3750 cfs, Sandburg Creek 3750 cfs



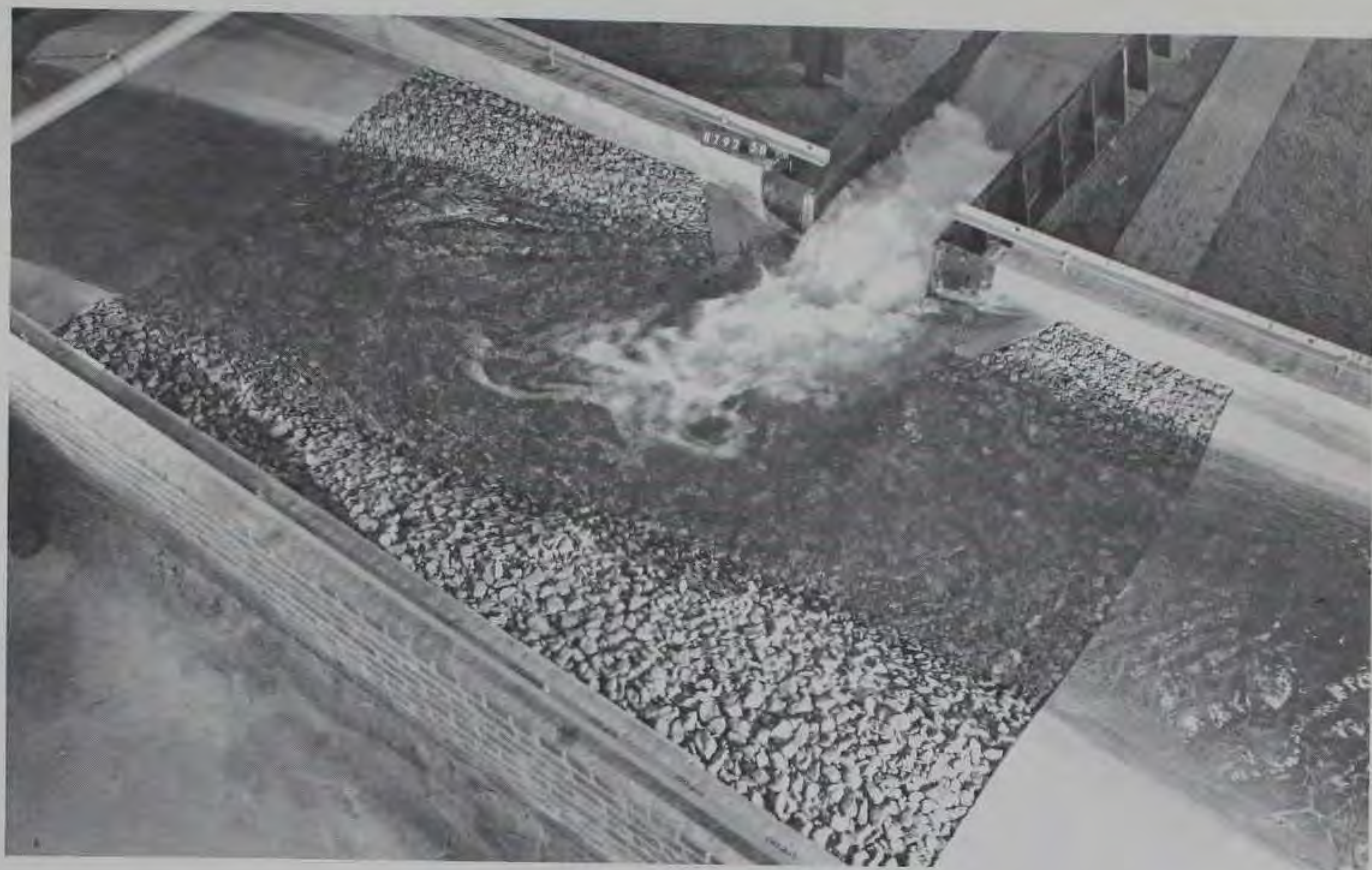
b. Discharge: North Gully 2500 cfs, Sandburg Creek 2500 cfs

Photo 17. Flow conditions at the junction of North Gully and Sandburg Creek in the type 2 stilling basin, with identical flows in North Gully and Sandburg Creek (sheet 1 of 2)



c. Discharge: North Gully 1500 cfs, Sandburg Creek 1500 cfs

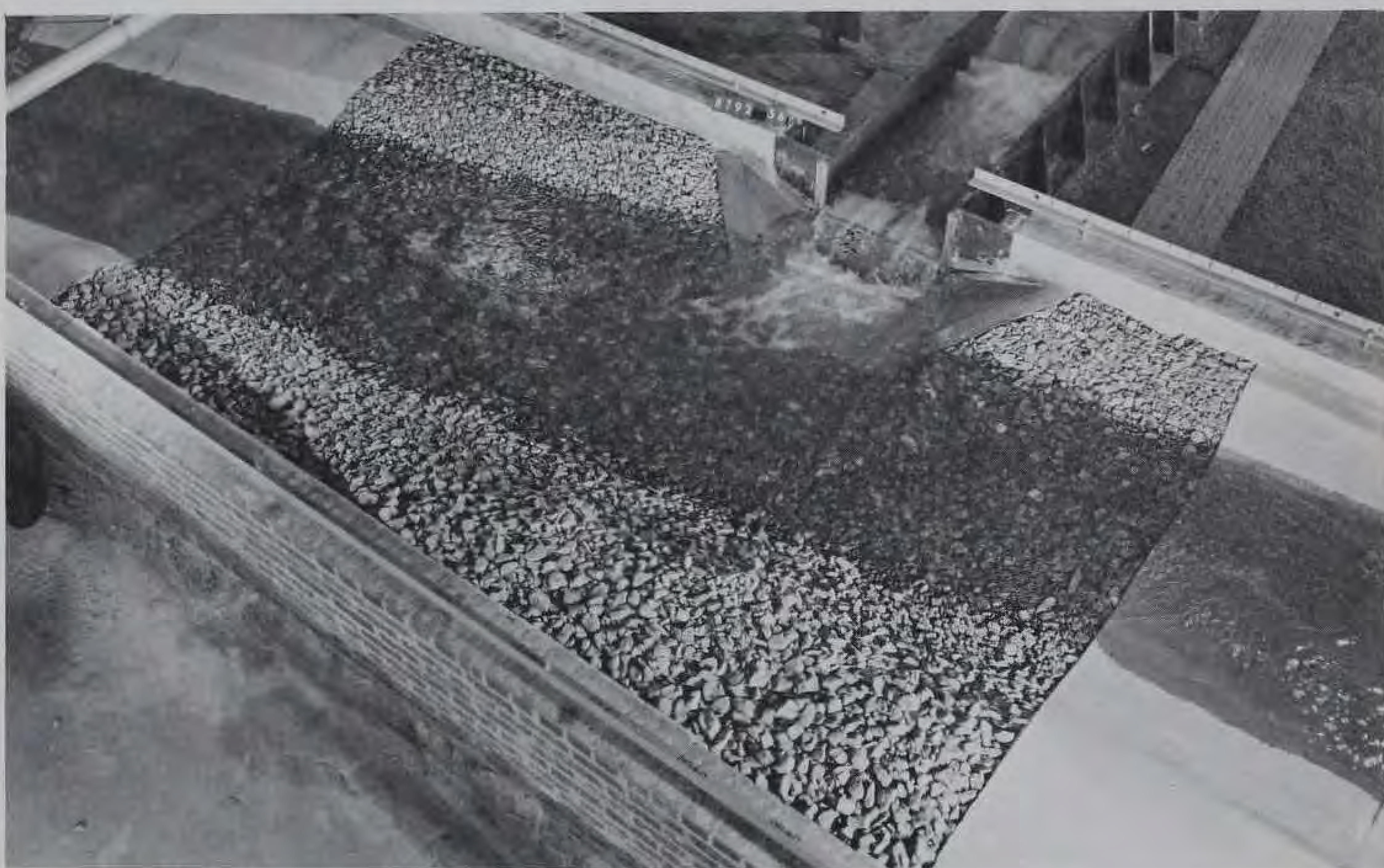
Photo 17. (sheet 2 of 2)



a. Discharge: North Gully 3750 cfs, Sandburg Creek 0 cfs

b. Discharge: North Gully 2500 cfs, Sandburg Creek 0 cfs

Photo 18. Flow conditions at the junction of North Gully and Sandburg Creek in type 2 stilling basin. Discharges 1500, 2500, and 3750 cfs in North Gully and 0 cfs in Sandburg Creek (sheet 1 of 2)



c. Discharge: North Gully 1500 cfs, Sandburg Creek 0 cfs

Photo 18. (sheet 2 of 2)

Photo 19. Results of scour tests of 45-min duration (model) with the type 2 stilling basin and riprap simulating prototype stone with an average weight of 360 lb (48-in.-thick layer). Discharge varied from 1500 to 3750 cfs in North Gully; no flow in Sandburg Creek

Photo 20. Results of scour test of 2-hr duration (model) with a paved section below the type 2 basin and riprap simulating prototype stone with an average weight of 360 lb (48-in.-thick layer). Discharge varied from 1500 to 3750 cfs in North Gully; no flow in Sandburg Creek. Also combined flows up to 15,000 cfs in North Gully and Sandburg Creek.

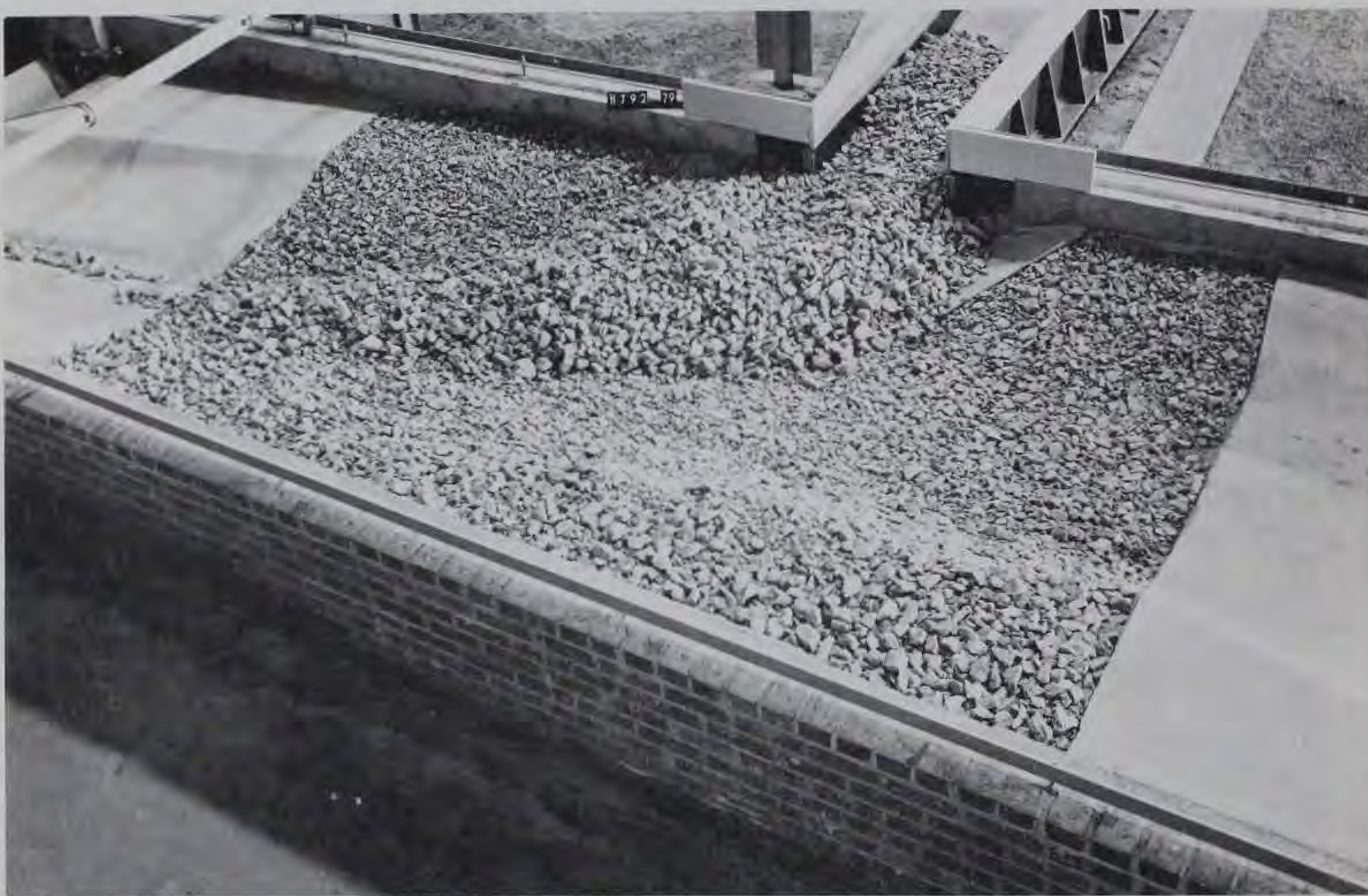
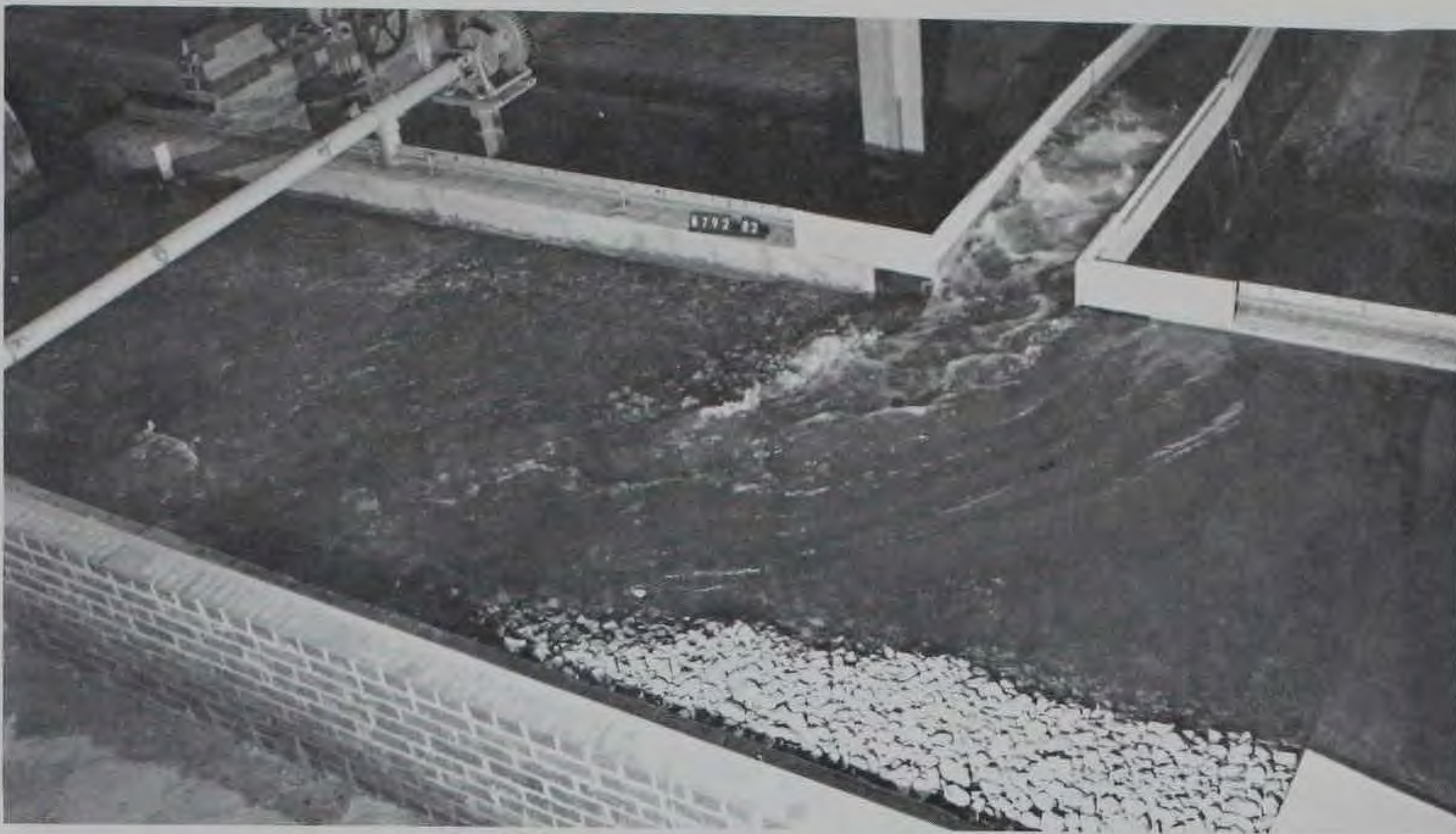
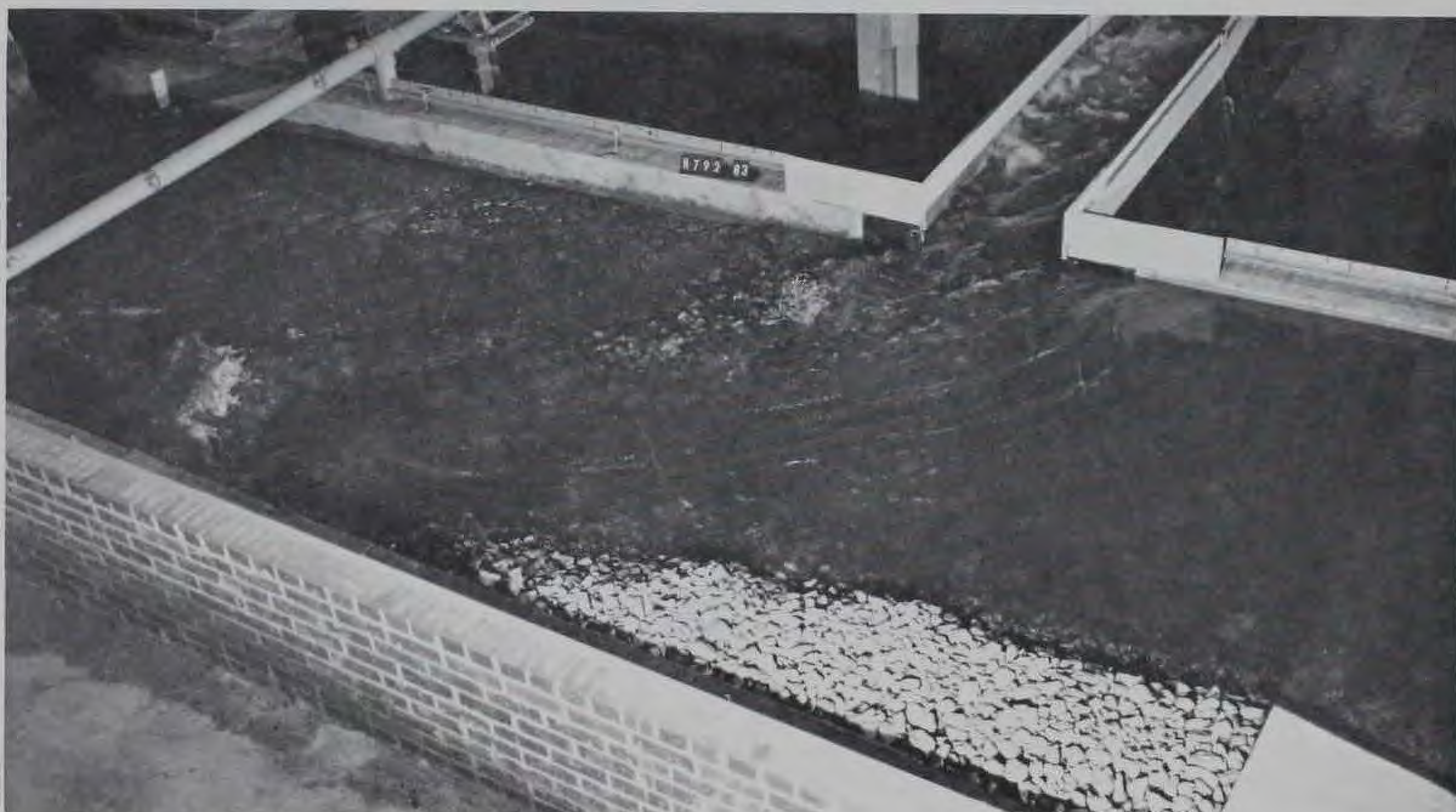


Photo 21. Area at the junction of North Gully and Sandburg Creek. The accumulation of rocks in and below the stilling basin simulate stones with an average weight of 360 lb (prototype) and represent approximately 3900 cu yd of material. This material was introduced at the entrance to North Gully under the following flow conditions: 3750 cfs North Gully, 9750 cfs Sandburg Creek. Material completely chokes the stilling basin to el 328.0 and the elevation of the bar downstream of the basin is approximately 326.0

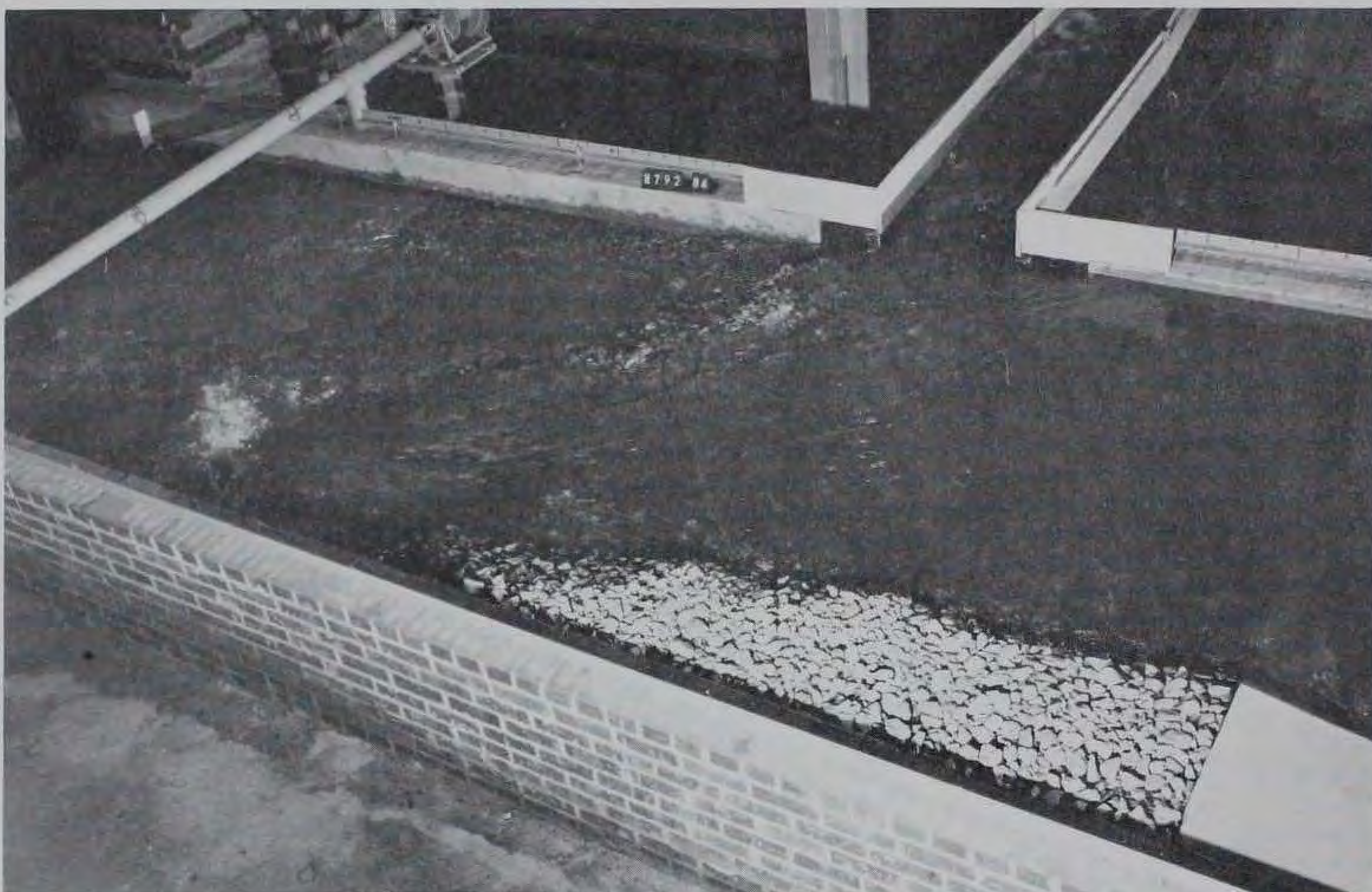


a. Discharge 3750 cfs North Gully and 9750 cfs Sandburg Creek; tailwater el 320.2



b. Discharge 2500 cfs North Gully and 9750 cfs Sandburg Creek; tailwater el 320.2

Photo 22. Combined flow conditions in and below the North Gully stilling basin (type 2 design) with 3900 yd of debris in and downstream of basin. Eddy action in basin. All flow along right side (sheet 1 of 2)



c. Discharge 1500 cfs North Gully and 9750 cfs Sandburg Creek; tailwater el 320.2

Photo 22. (sheet 2 of 2)

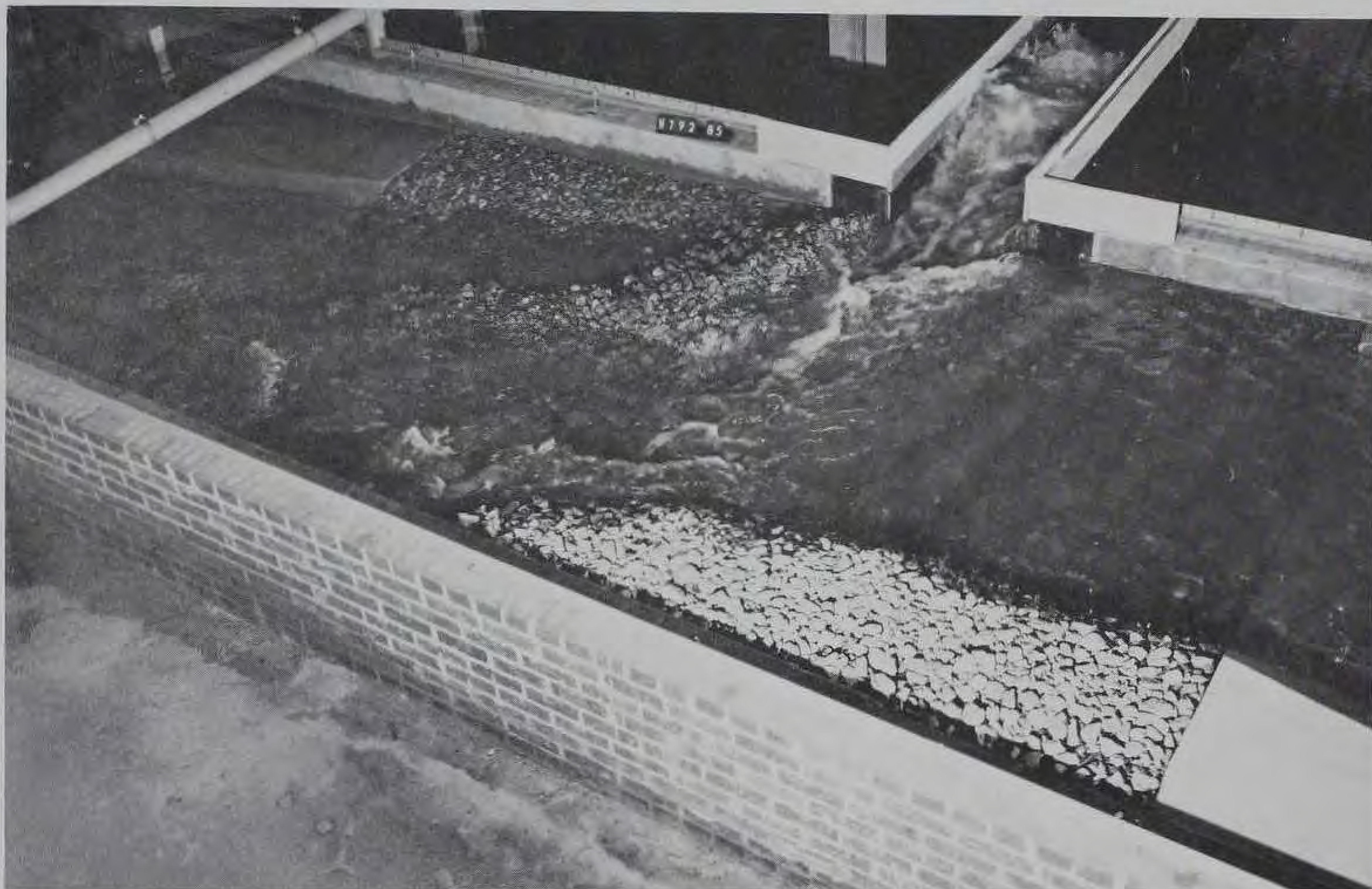
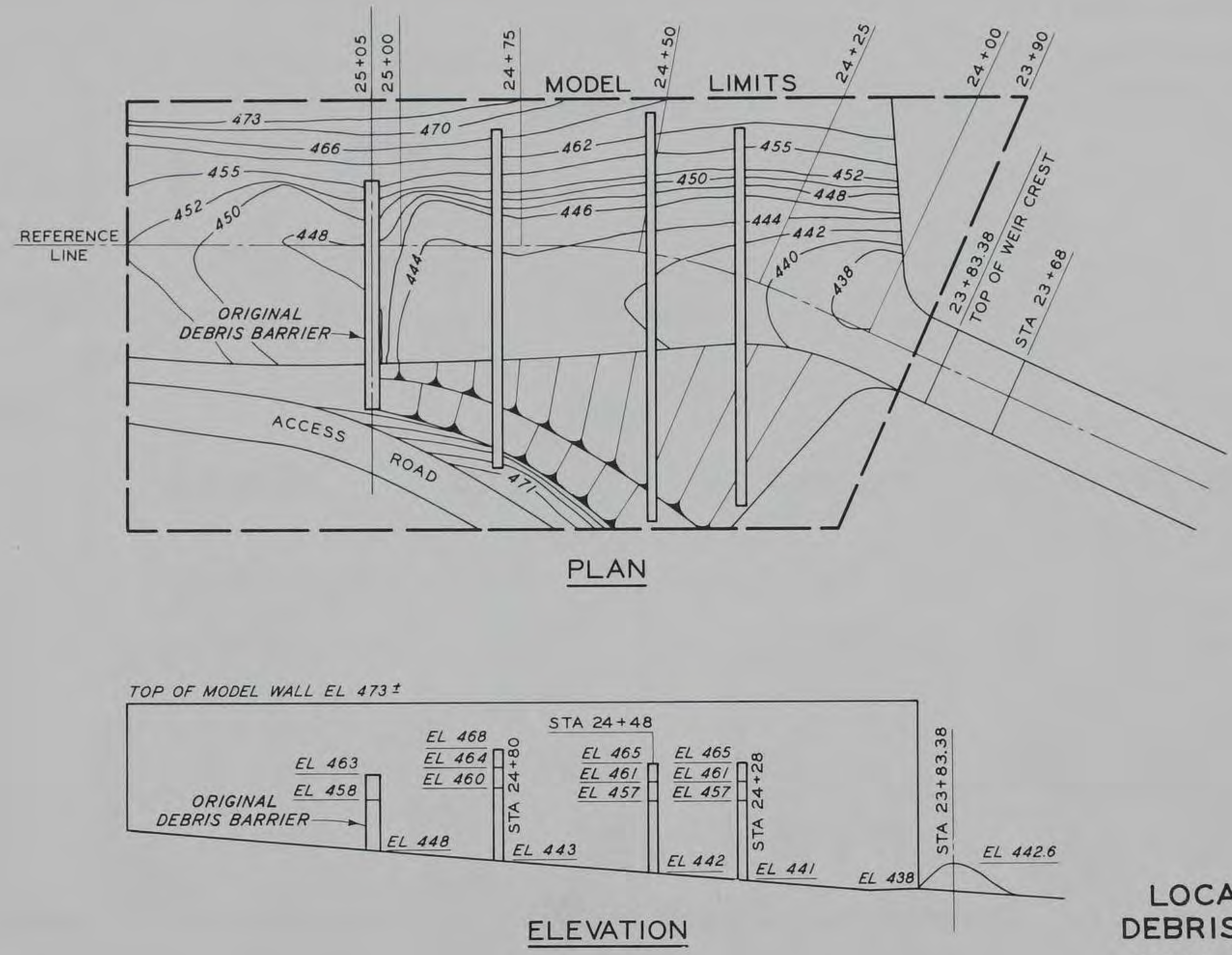


Photo 23. Flow conditions in and below the North Gully stilling basin (type 2 design) with 3900 cu yd of debris in and downstream of the basin. Discharge 3750 cfs North Gully and 0 cfs Sandburg Creek; tailwater el 314.0

DETAILS OF
ENTRANCE TRANSITIONS
TYPES 1–5 DESIGNS

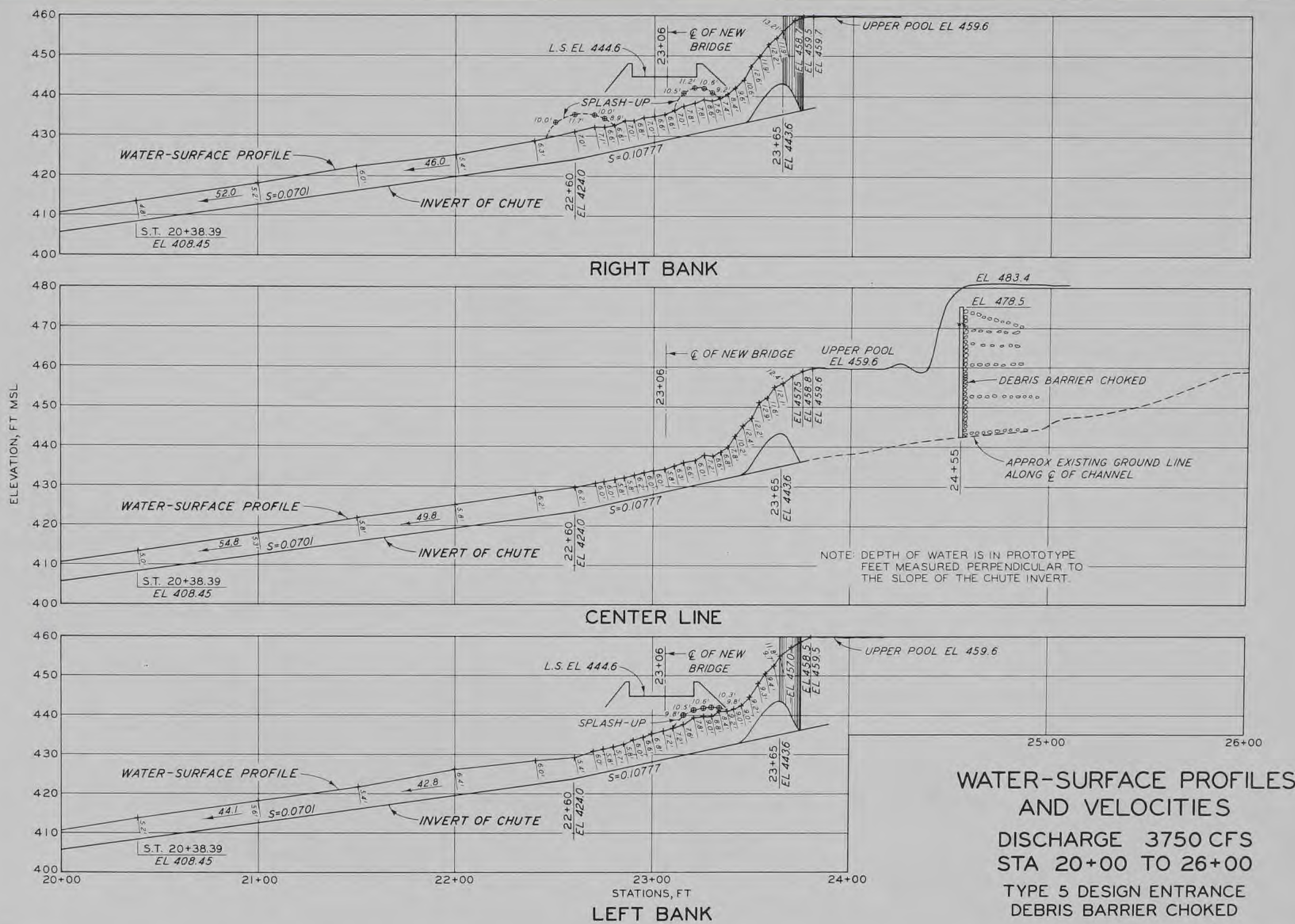


LOCATIONS OF DEBRIS BARRIERS

TYPE 4 ENTRANCE

SCALE IN FEET

20 0 20 40



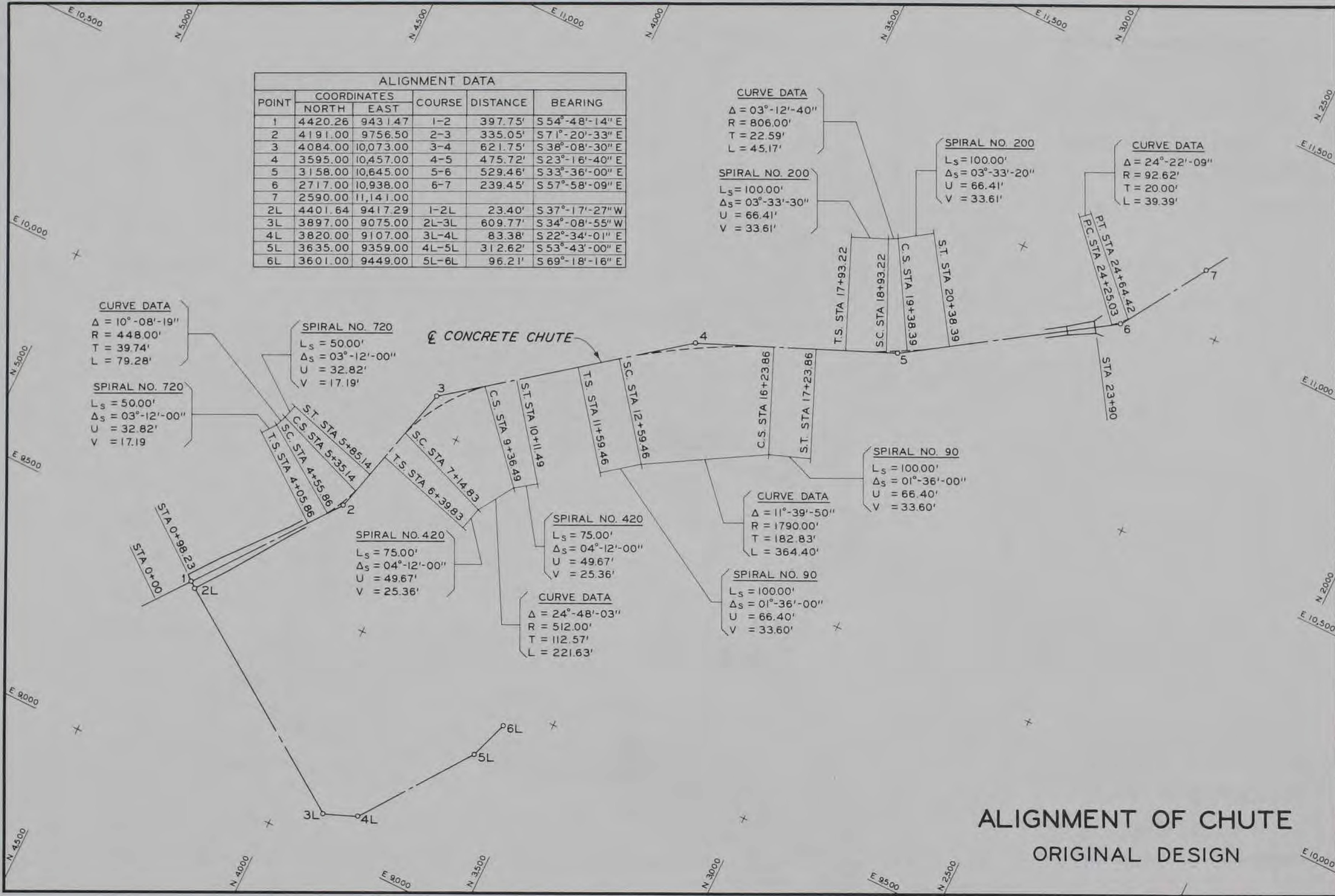
WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 3750 CFS

STA 20+00 TO 26+00

TYPE 5 DESIGN ENTRANCE

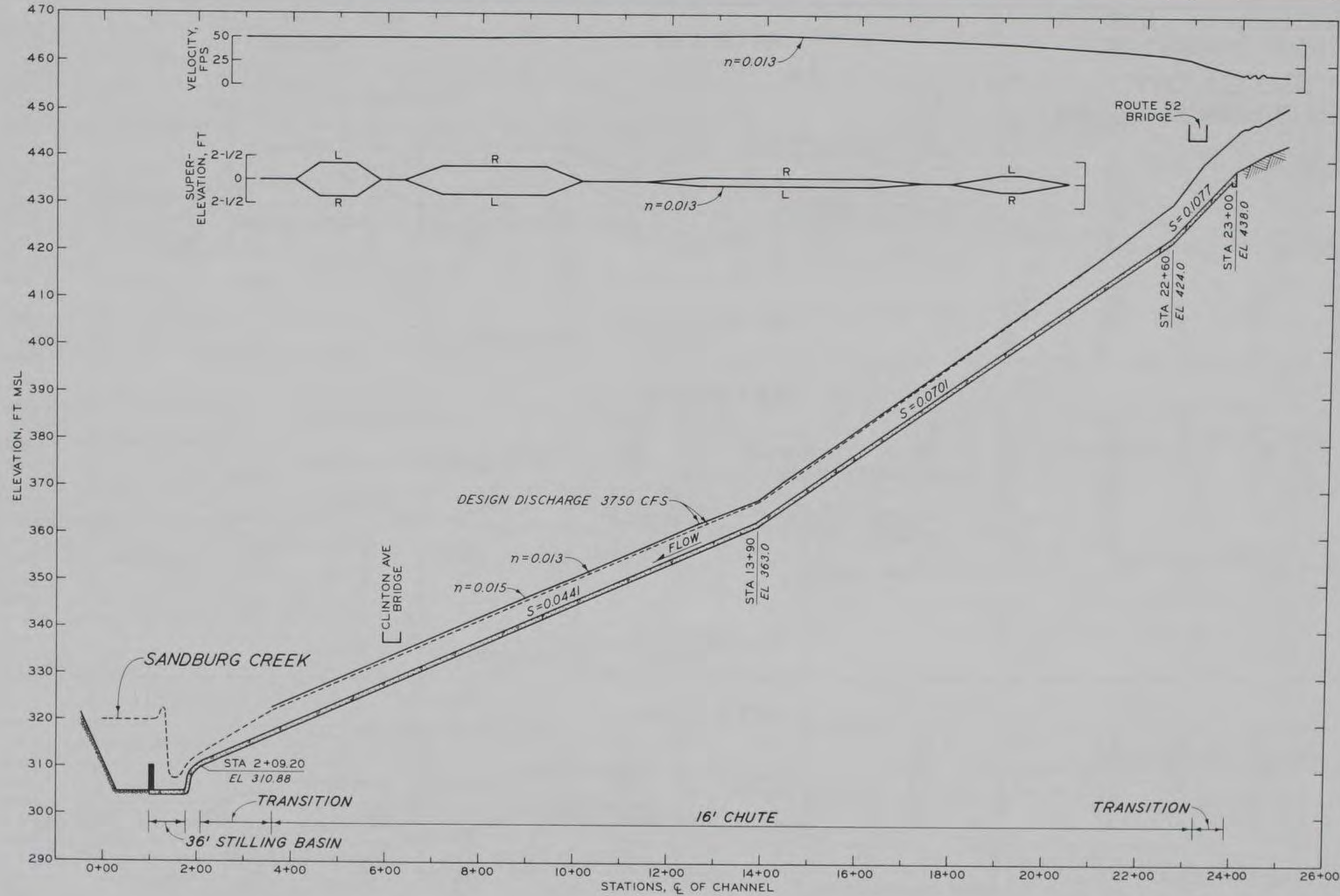
DEBRIS BARRIER CHOKED



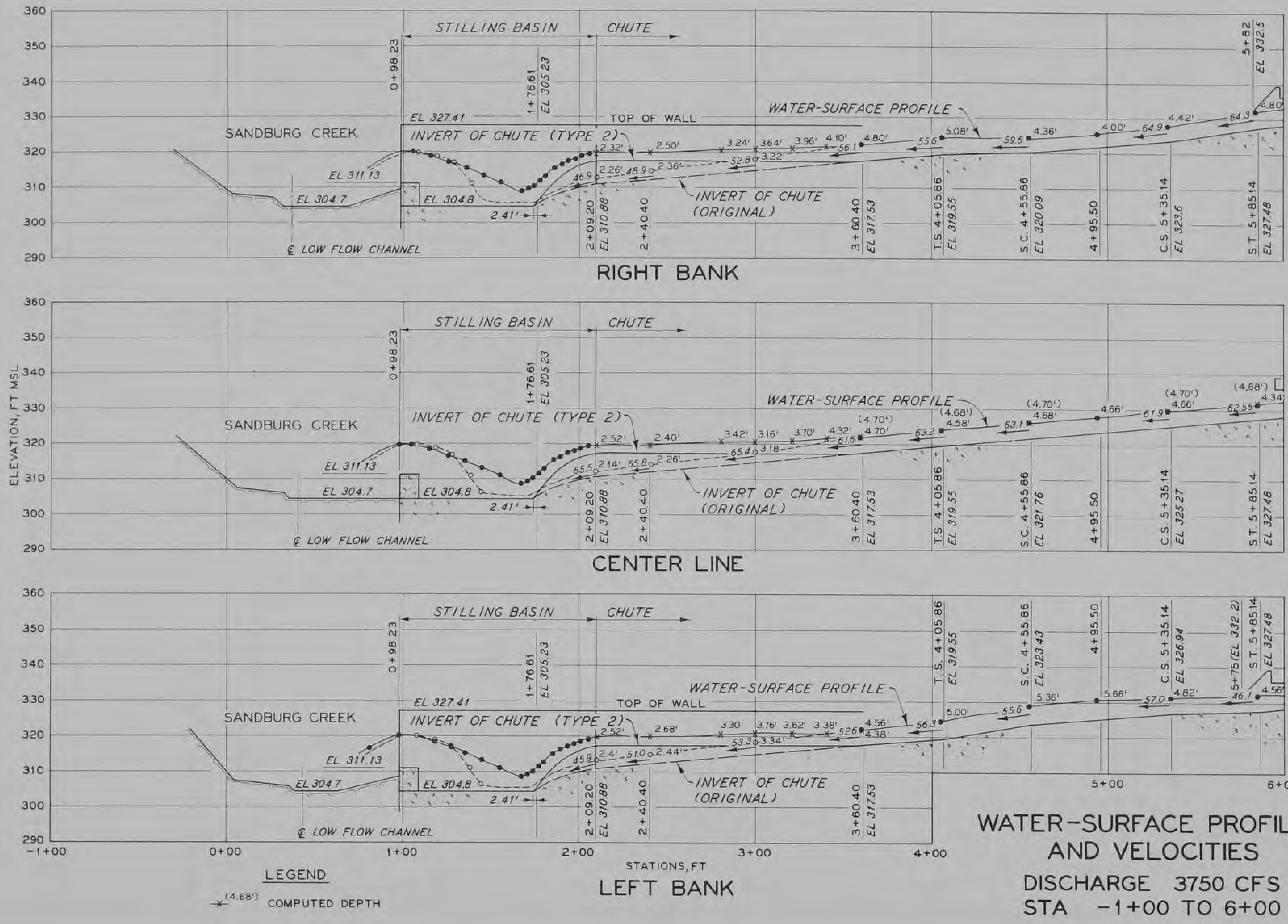
ALIGNMENT DATA					
POINT	COORDINATES NORTH	COORDINATES EAST	COURSE	DISTANCE	BEARING
1	4420.26	9431.47	1-2	397.75'	S 54°-48'-14" E
2	4191.00	9756.50	2-3	335.05'	S 71°-20'-33" E
3	4084.00	10,073.00	3-4	621.75'	S 38°-08'-30" E
4	3595.00	10,457.00	4-5	475.72'	S 23°-16'-40" E
5	3158.00	10,645.00	5-6	529.46'	S 33°-36'-00" E
6	2717.00	10,938.00	6-7	239.45'	S 57°-58'-09" E
7	2590.00	11,141.00			
2L	4401.64	9417.29	1-2L	23.40'	S 37°-17'-27" W
3L	3897.00	9075.00	2L-3L	609.77'	S 34°-08'-55" W
4L	3820.00	9107.00	3L-4L	83.38'	S 22°-34'-01" E
5L	3635.00	9359.00	4L-5L	312.62'	S 53°-43'-00" E
6L	3601.00	9449.00	5L-6L	96.21'	S 69°-18'-16" E

ALIGNMENT OF CHUTE

ORIGINAL DESIGN



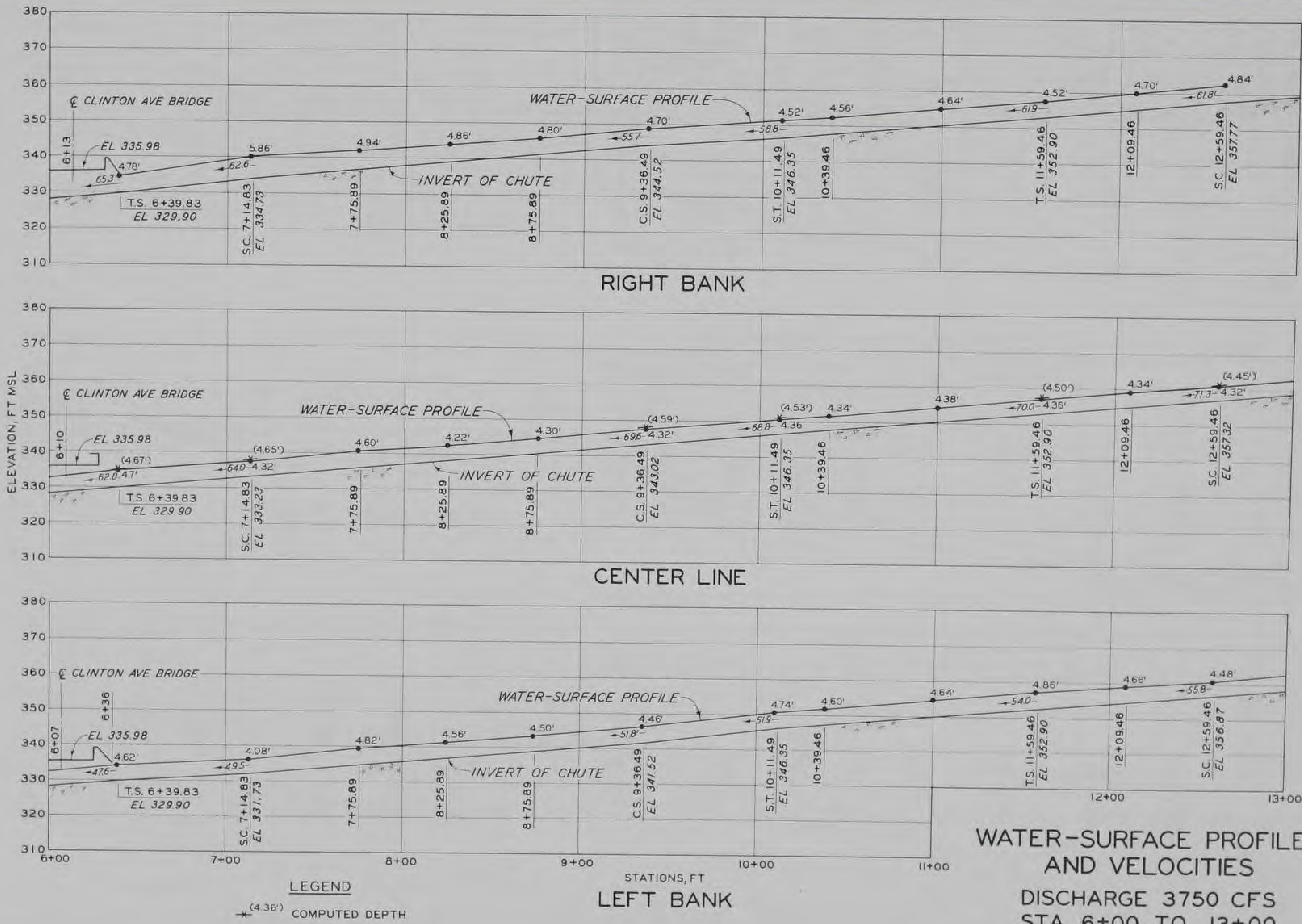
PROFILE AND
SUPERELEVATION OF CHUTE
ORIGINAL DESIGN



WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 3750 CFS

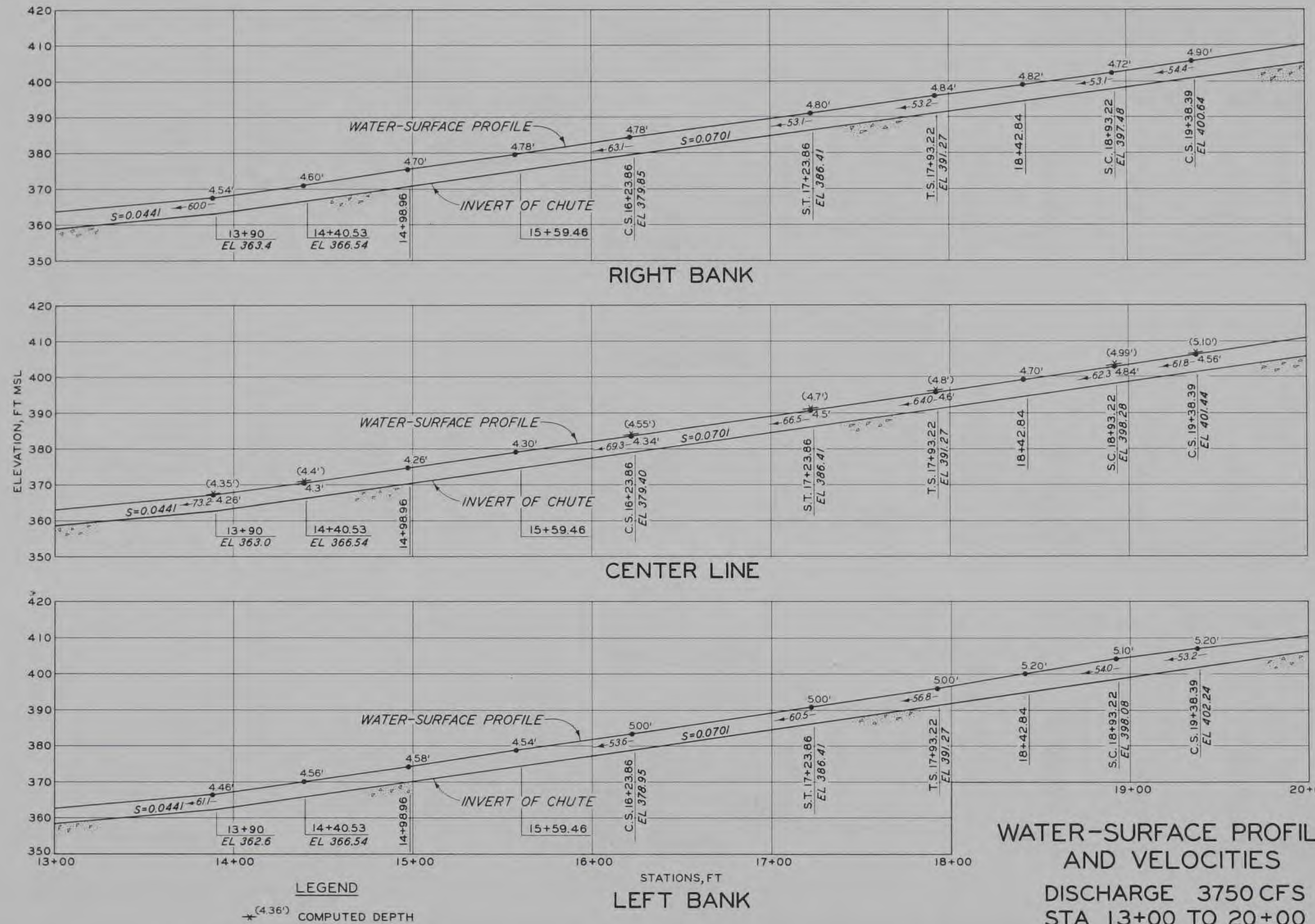
STA −1+00 TO 6+00



WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 3750 CFS
STA 6+00 TO 13+00

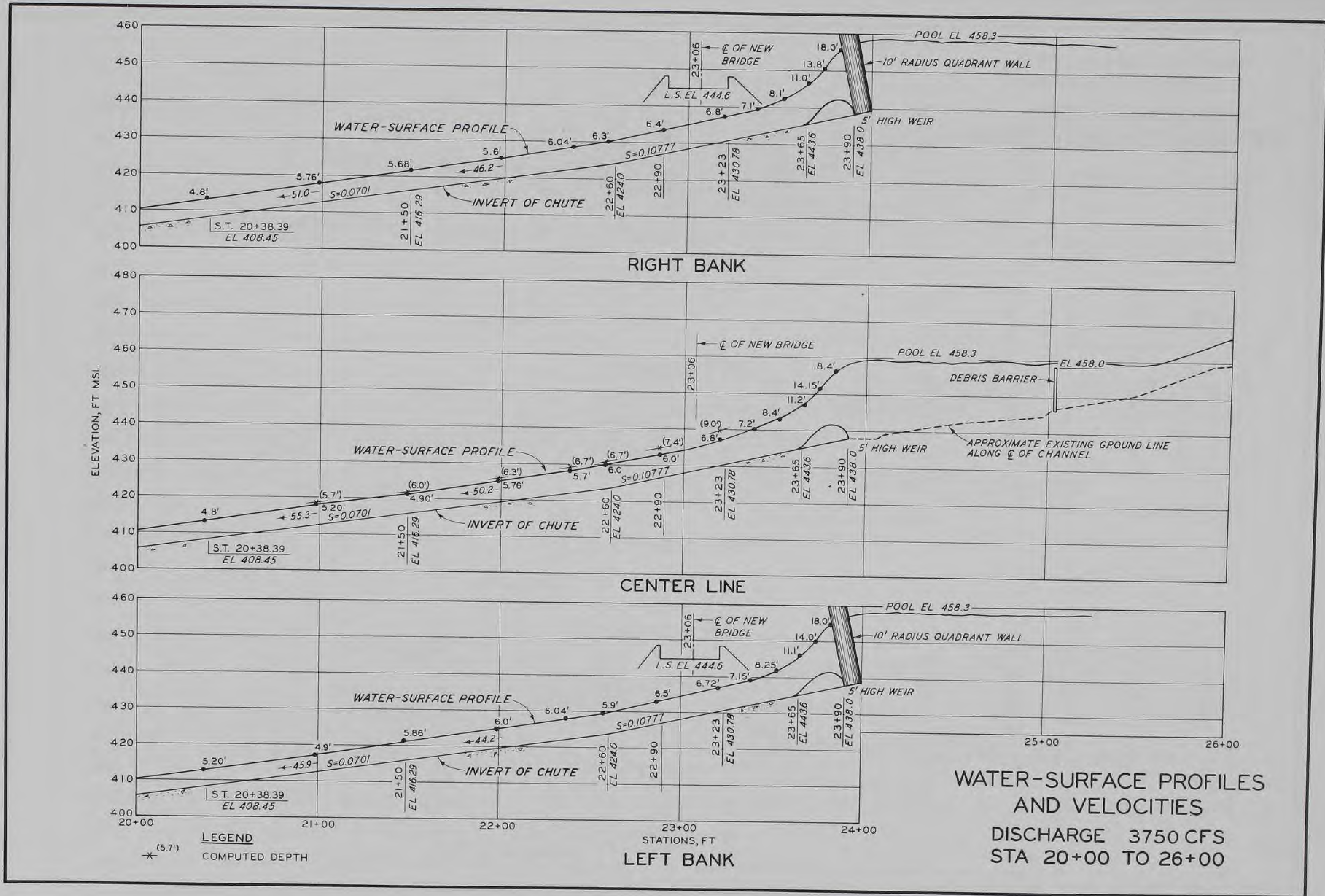
PLATE 8



WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 3750 CFS

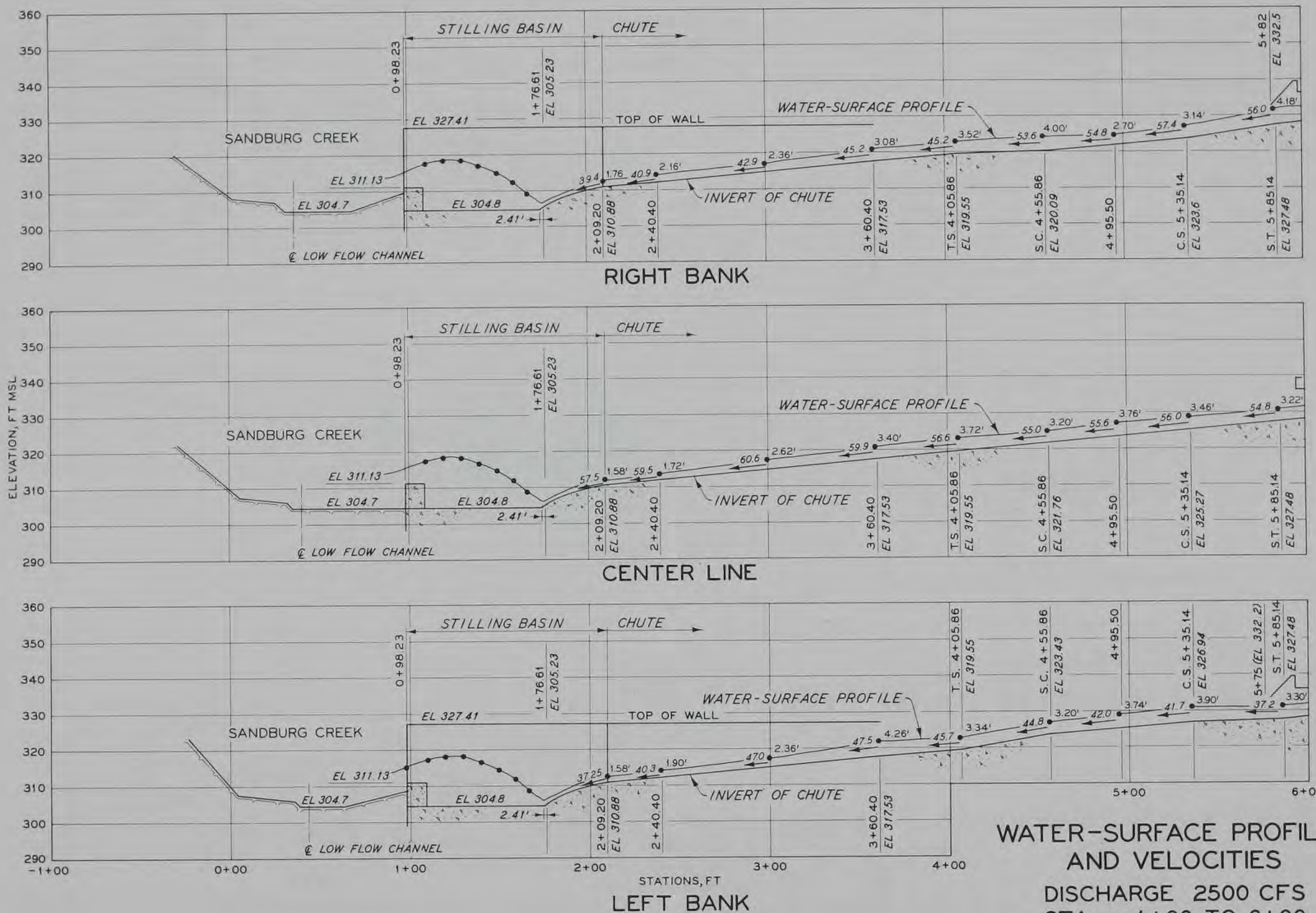
STA 13+00 TO 20+00



RIGHT BANK
CENTER LINE
LEFT BANK
ELEVATION, FT MSL
STATIONS, FT
20+00
21+00
22+00
23+00
24+00
25+00
26+00
POOL EL 458.3
10' RADIUS QUADRANT WALL
€ OF NEW BRIDGE
L.S. EL 444.6
5' HIGH WEIR
WATER-SURFACE PROFILE
INVERT OF CHUTE
S=0.0701
S=0.10777
S.T. 20+38.39 EL 408.45
21+50 EL 416.29
22+60 EL 424.0
22+90
23+06
23+23 EL 430.78
23+65 EL 443.6
23+90 EL 438.0
DEBRIS BARRIER
EL 458.0
APPROXIMATE EXISTING GROUND LINE ALONG € OF CHANNEL
LEGEND
(5.7') COMPUTED DEPTH
WATER-SURFACE PROFILES AND VELOCITIES
DISCHARGE 3750 CFS
STA 20+00 TO 26+00

PLATE 9

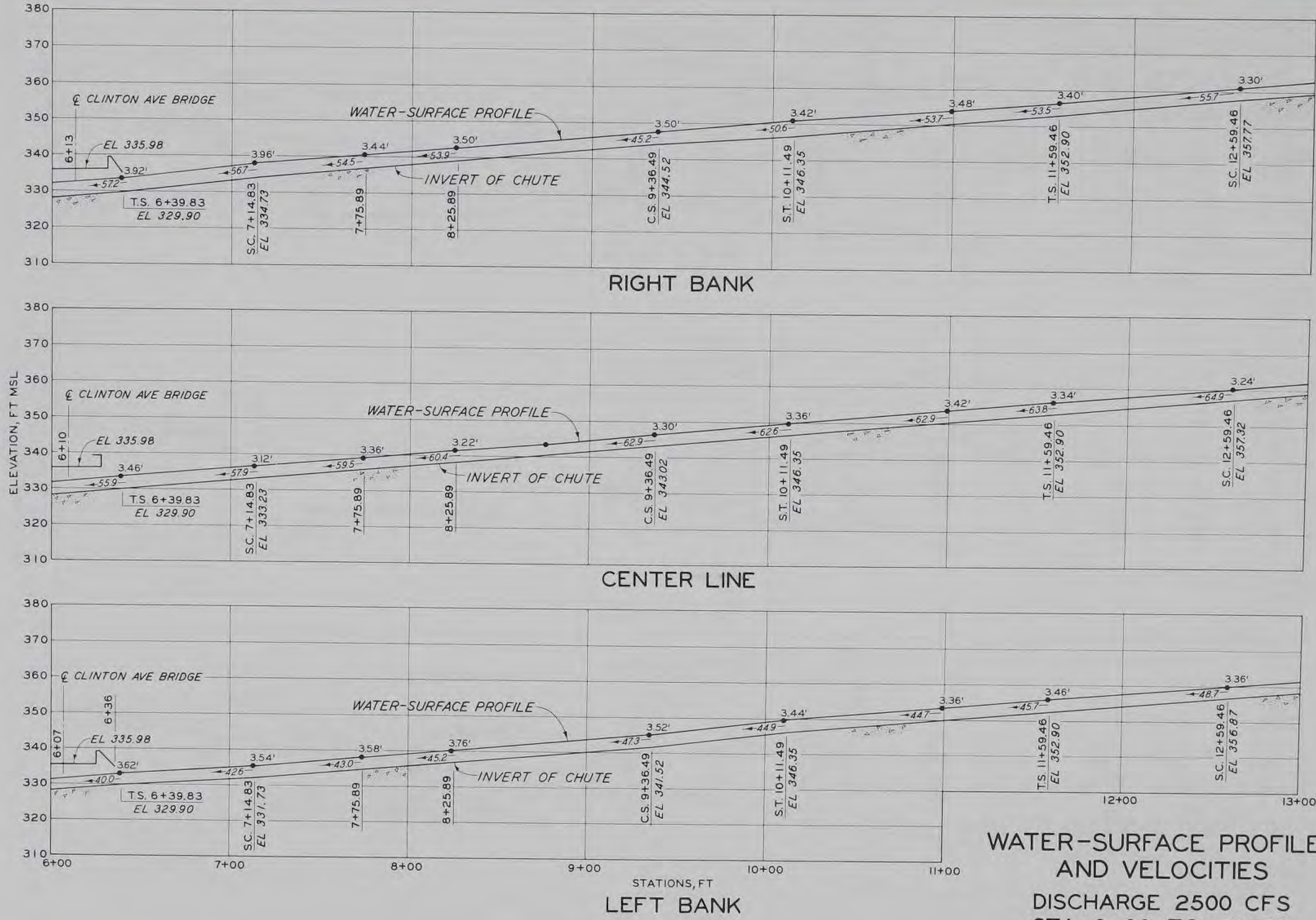
PLATE 10



WATER–SURFACE PROFILES AND VELOCITIES

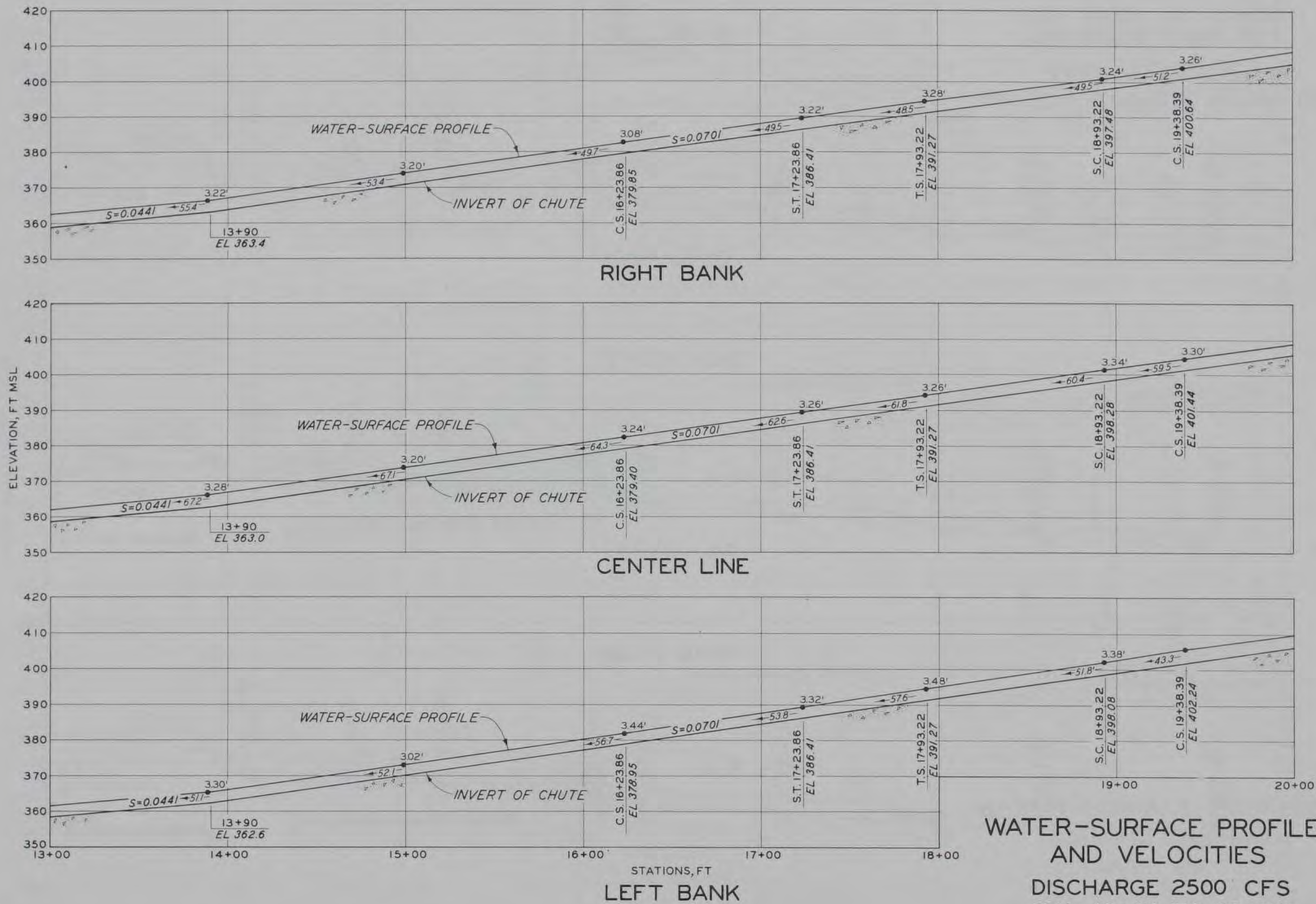
DISCHARGE 2500 CFS

STA -1+00 TO 6+00



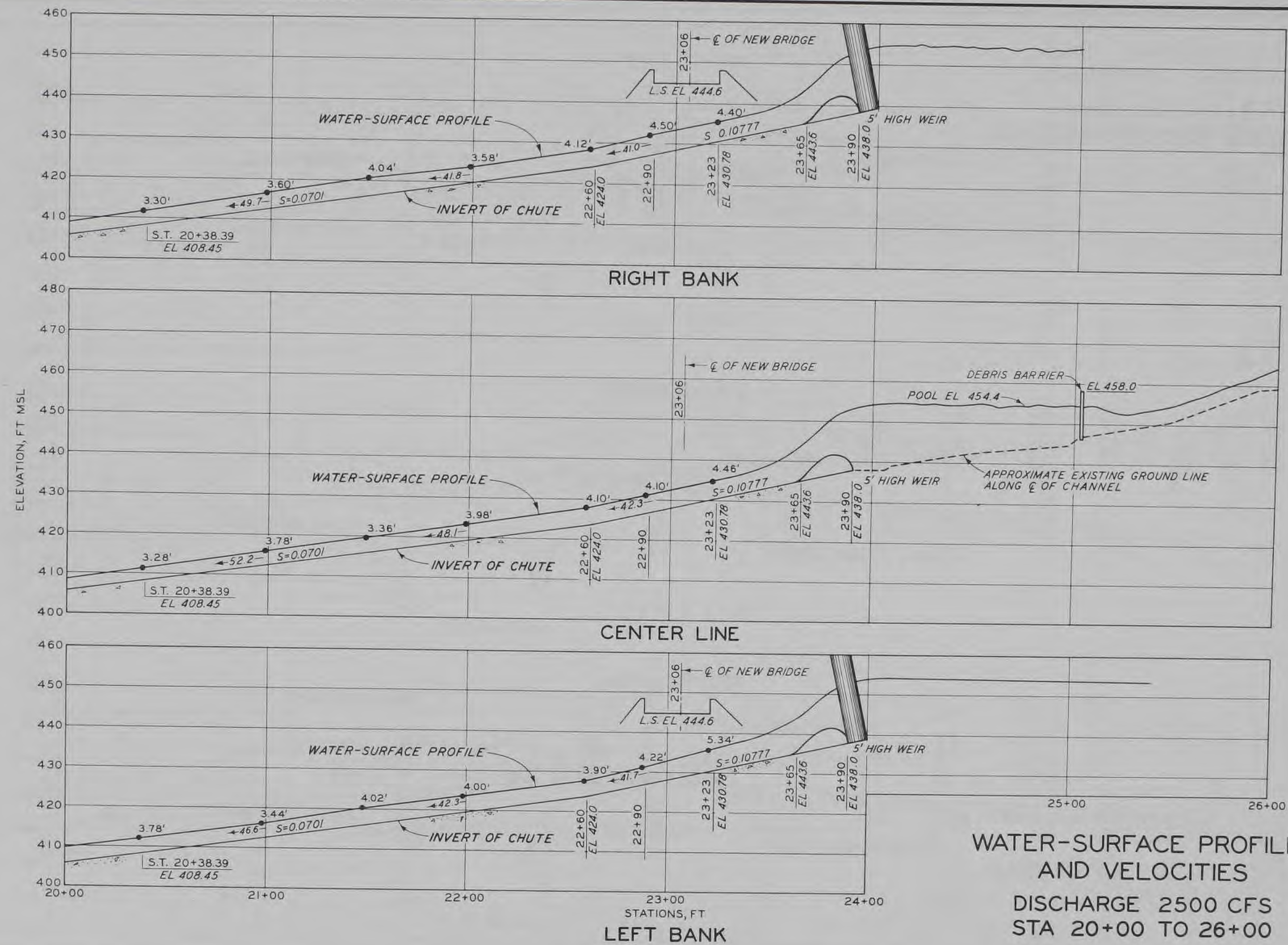
WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 2500 CFS
STA 6+00 TO 13+00



WATER-SURFACE PROFILES
AND VELOCITIES

DISCHARGE 2500 CFS
STA 13+00 TO 20+00



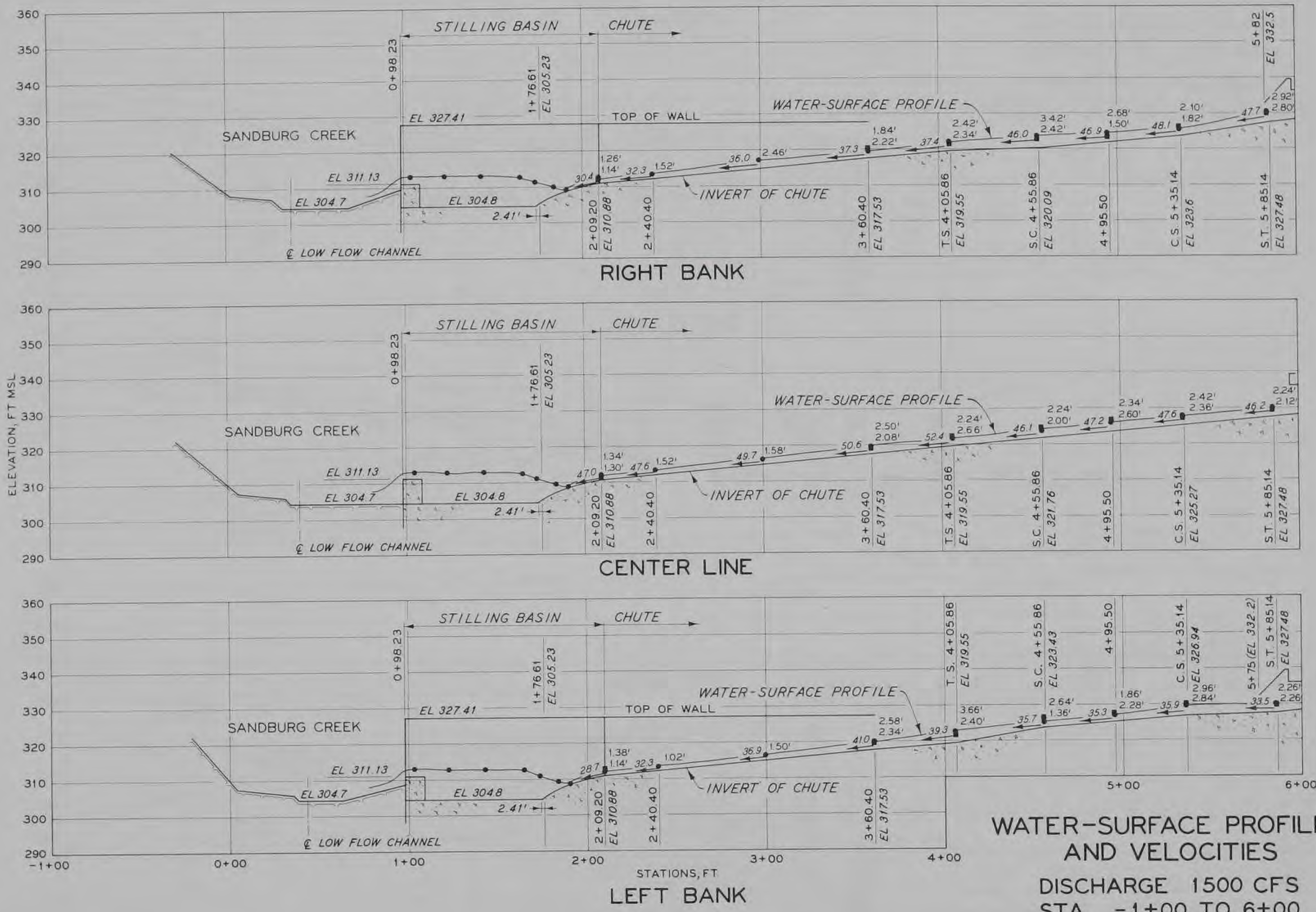
WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 2500 CFS

STA 20+00 TO 26+00

PLATE 13

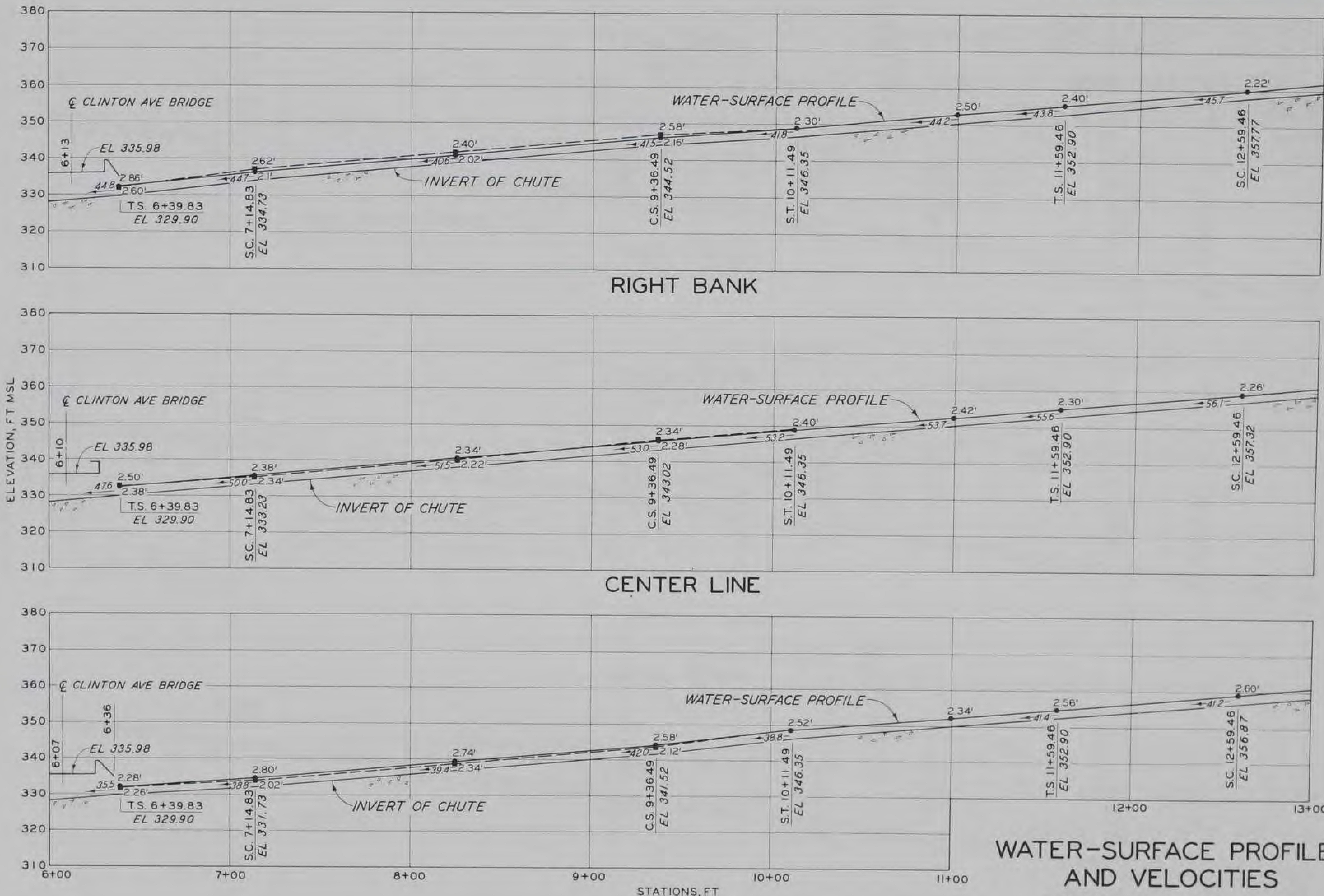
PLATE 14



WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 1500 CFS

STA −1+00 TO 6+00

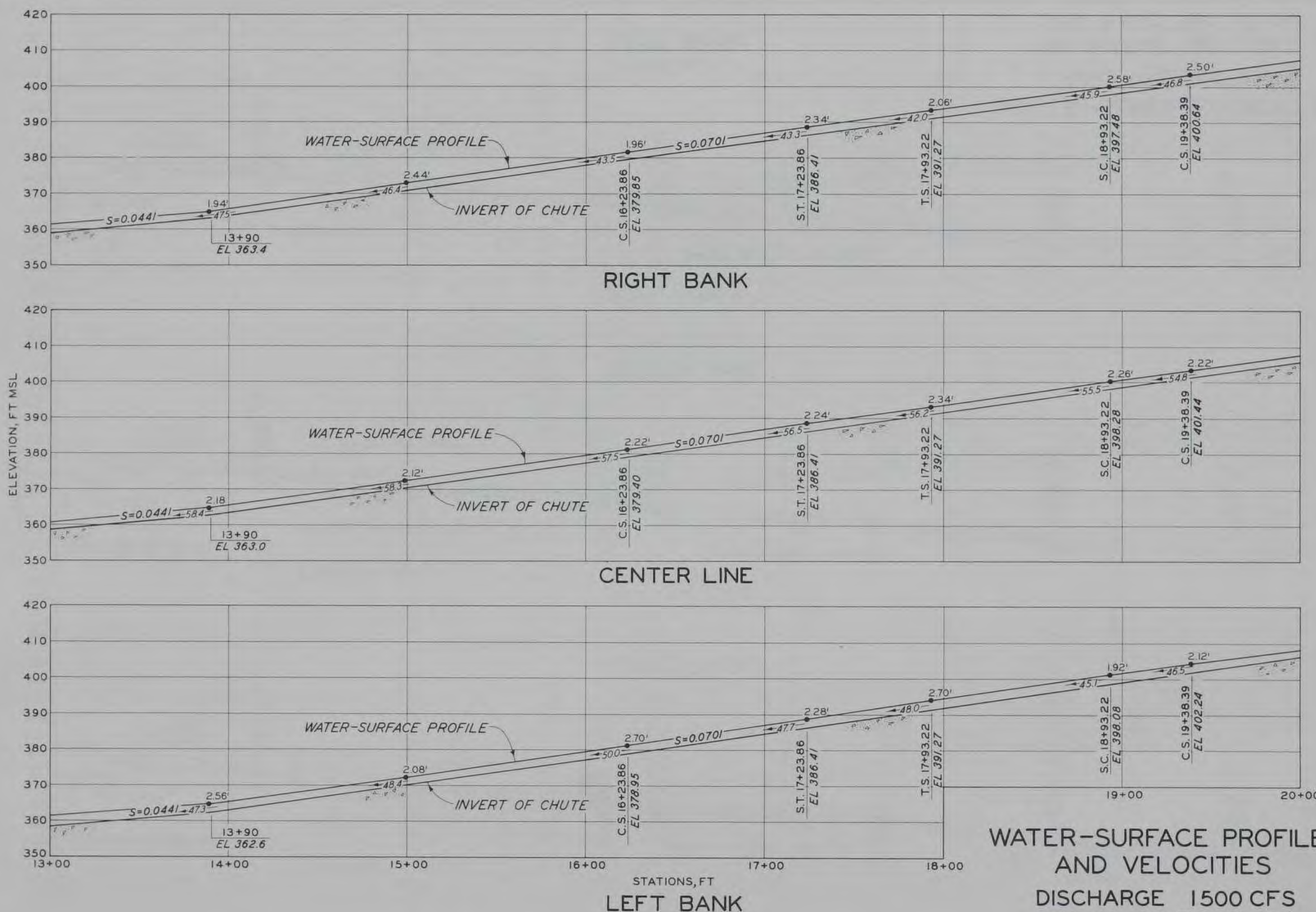


WATER-SURFACE PROFILES AND VELOCITIES

DISCHARGE 1500 CFS

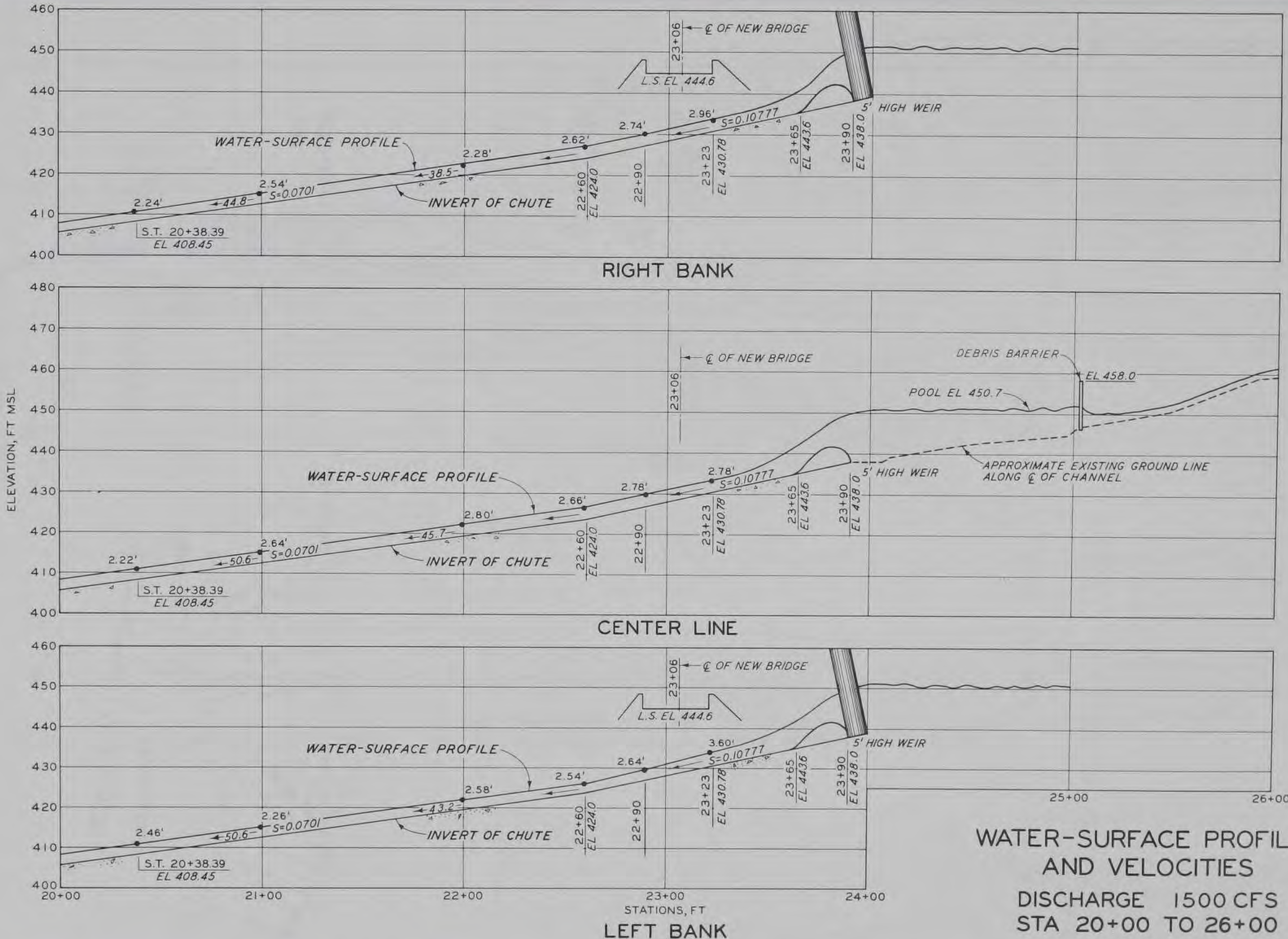
STA 6+00 TO 13+00

PLATE 15



WATER-SURFACE PROFILES
AND VELOCITIES

DISCHARGE 1500 CFS
STA 13+00 TO 20+00

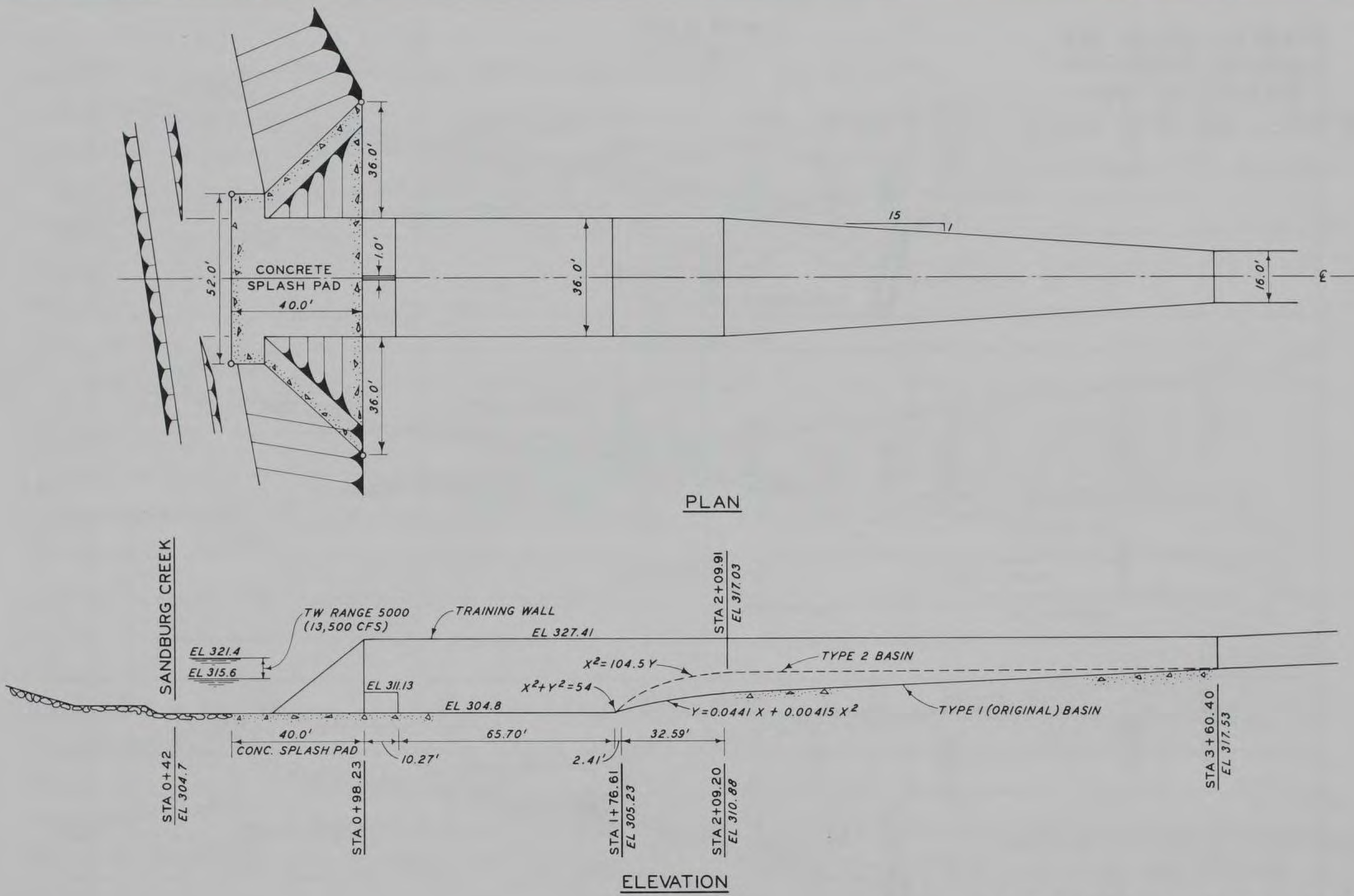


WATER-SURFACE PROFILES
AND VELOCITIES

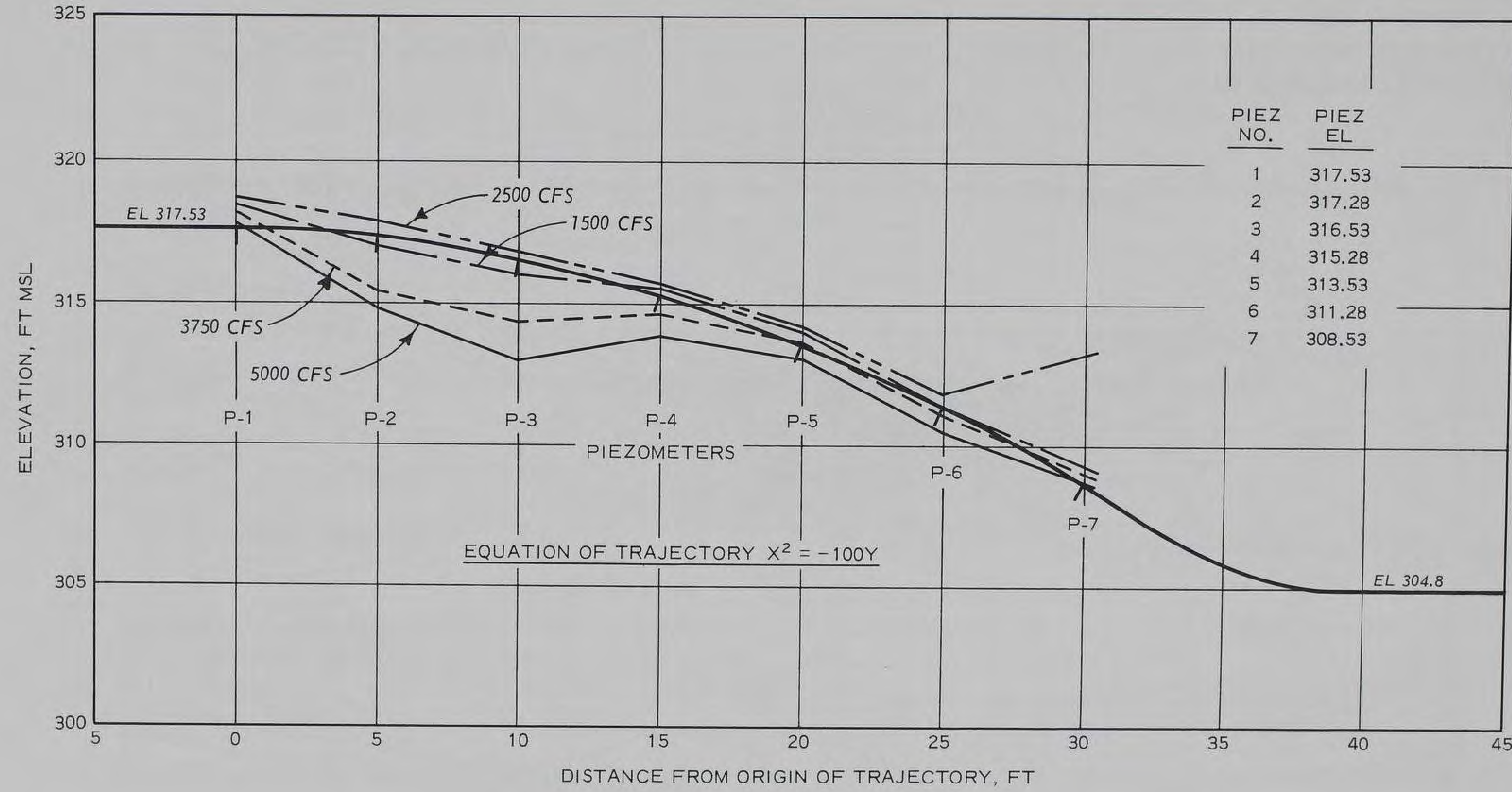
DISCHARGE 1500 CFS
STA 20+00 TO 26+00

PLATE 17

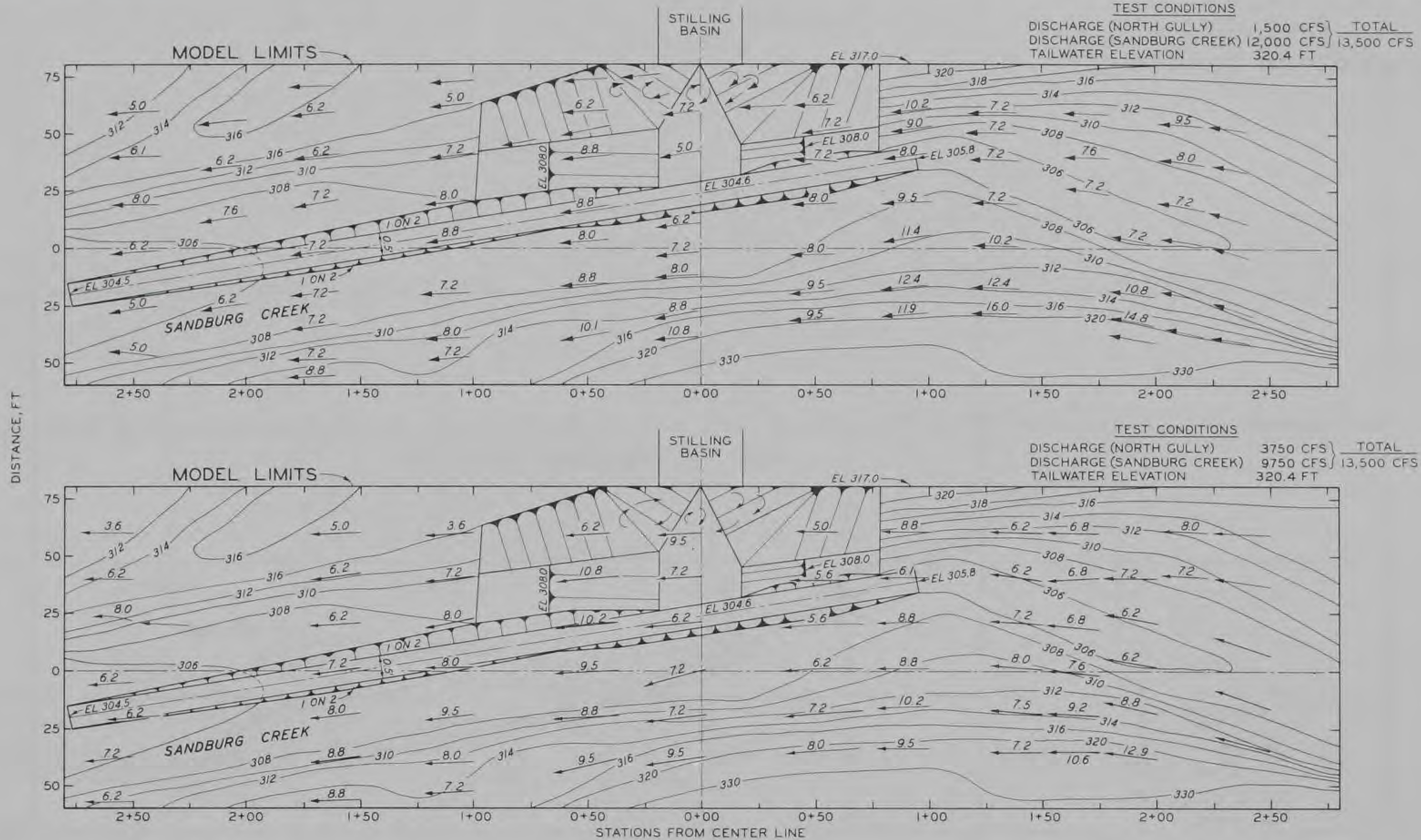
PLATE 18



DETAILS OF TYPES 1 AND 2 BASINS



PRESSURE PROFILES
TYPE 2 PARABOLIC DROP

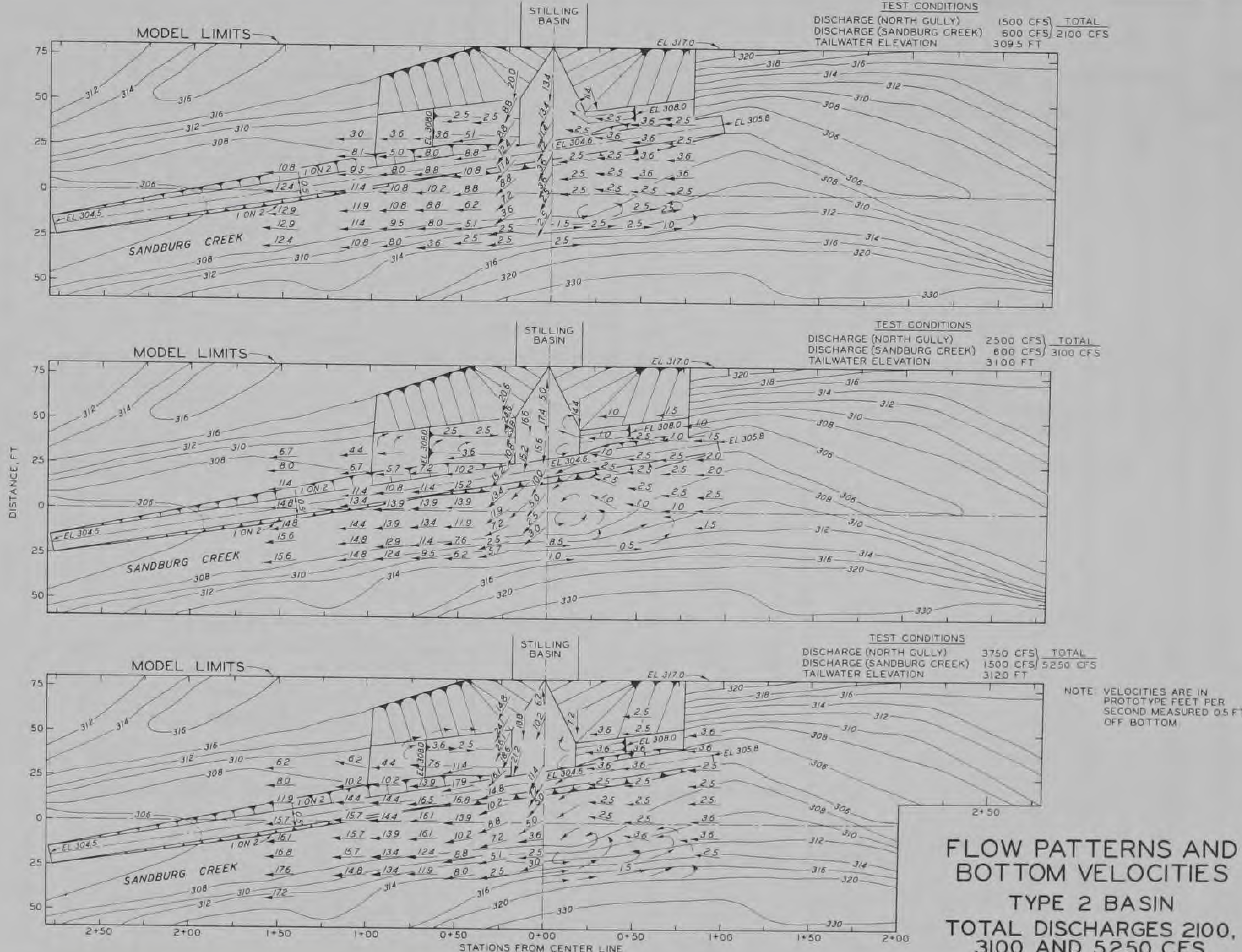


NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND MEASURED 0.5FT OFF BOTTOM.

FLOW PATTERNS AND BOTTOM VELOCITIES

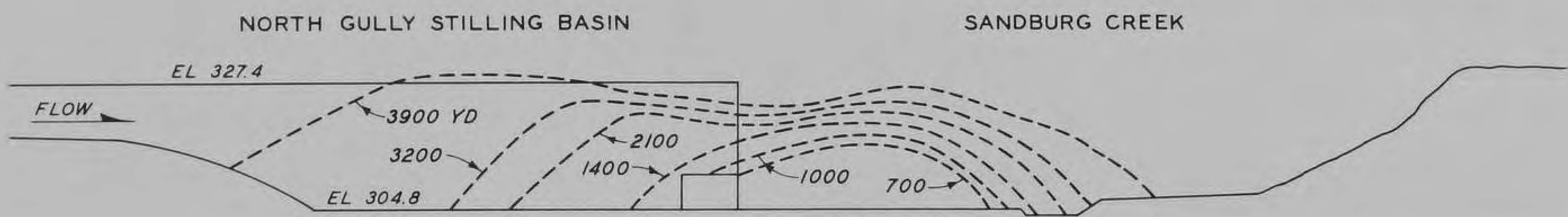
TYPE 2 BASIN

TOTAL DISCHARGES 13,500 CFS

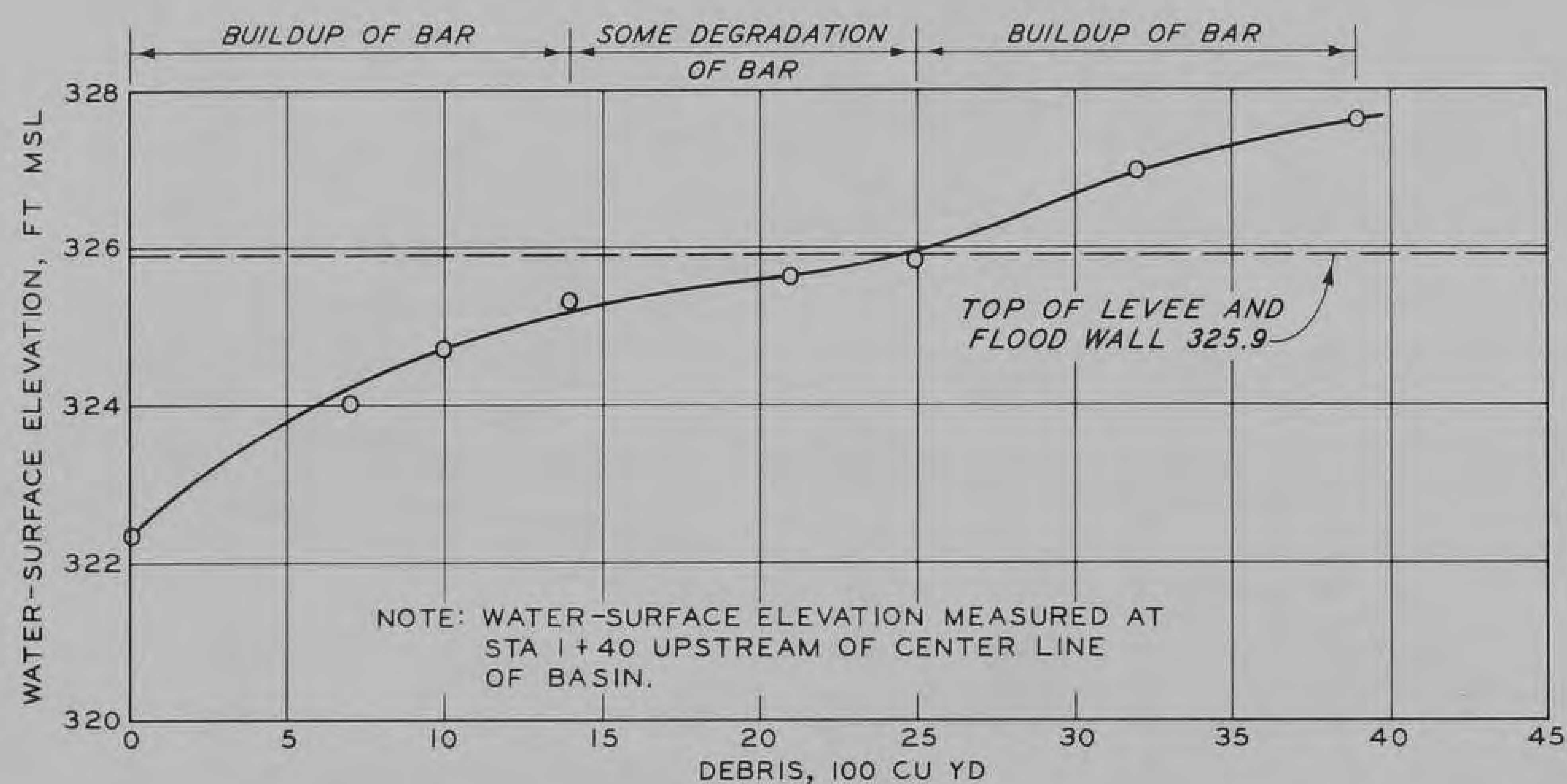


FLOW PATTERNS AND BOTTOM VELOCITIES
TYPE 2 BASIN
TOTAL DISCHARGES 2100, 3100 AND 5250 CFS

NOTE: DEBRIS SIMULATES STONES WITH AN AVERAGE WEIGHT OF 360 LB (PROTOTYPE)



DEPOSITION OF DEBRIS IN BASIN AND EXIT AREA



TEST CONDITIONS

DISCHARGE NORTH GULLY........3750 CFS
DISCHARGE SANDBURG CREEK...9750 CFS
TAILWATER EL 320.2

TAILWATER MEASURED AT STA 1 + 20 DOWNSTREAM OF CENTER LINE OF STILLING BASIN.

EFFECT OF DEBRIS ON WATER-SURFACE ELEVATION IN SANDBURG CREEK

SCALE IN FEET

20 0 20 40

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

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5. AUTHOR(S) (First name, middle initial, last name)

Edwin S. Melsheimer

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13. ABSTRACT

Model investigations of the proposed channel improvements for flood control on North Gully and Sandburg Creek at South Ellenville, New York, were conducted to supplement and verify hydraulic computations for the original design and to develop alterations effecting improved hydraulic performance and reduced construction costs. A 1:20-scale model was used to verify and improve design features including the chute entrance, chute alignment, superelevation in bends, effect of large materials in the chute on inflow disturbances in the chute, hydraulic performance of stilling basin, wall heights, and elevation of bridges, and to determine the need for riprap protection below the stilling basin. The model reproduced portions of the overall project including proposed improvements along the lower 2200 ft of North Gully and approximately 600 ft of Sandburg Creek below the junction with North Gully. Tests of the original design indicated flow conditions within the proposed chute to be generally satisfactory. However, unsatisfactory flow conditions were observed at the entrance to the high-velocity chute in North Gully, where discharges of 1200 cfs or more in North Gully overtopped the left chute wall 30 to 40 ft downstream of the chute entrance. At low flows (300 to 1500 cfs) a cross-wave disturbance at sta 4+55.36 resulted in unequal distribution of flow entering the stilling basin. This unequal flow distribution coupled with the submergence effect of the end sill at low discharges resulted in eddy action in the stilling basin. Debris entering the high-velocity chute tended to choke the stilling basin and create a damming effect in Sandburg Creek immediately below the stilling basin. Improvements in flow conditions at these locations were effected by: (a) installing a 7.25-ft-high weir at the entrance to high-velocity chute, (b) flattening the slope of the transition section upstream of the basin and modifying the parabolic drop entering the basin to provide a more vertical drop, and (c) increasing the height of the debris barrier to prevent passage of debris into the chute. Design wall heights were determined from the profiles of the water surface obtained in the model along each wall with the design discharge (3750 cfs). The exit area below the stilling basin in Sandburg Creek will require a concrete splash pad and adjacent riprap protection for about 260 ft to ensure prevention of scour. The 2-ft-high and 4-in.-wide concrete wearing surface along the bottom of the chute walls had little apparent effect on flow characteristics in the chute.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Ellenville, N. Y.--Flood protection						
Hydraulic models						
Hydraulic structures						
Sandburg Creek, N. Y.						
South Ellenville Flood Control Project						
Rondout Creek Basin, N. Y.						

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