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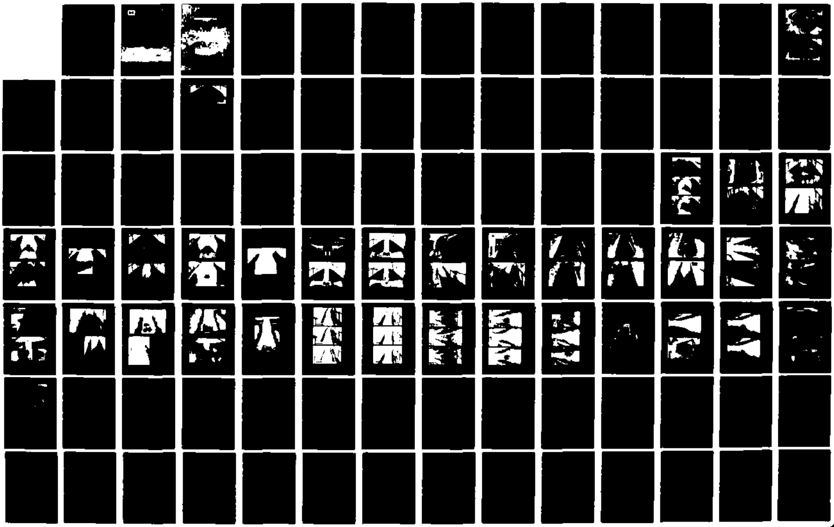

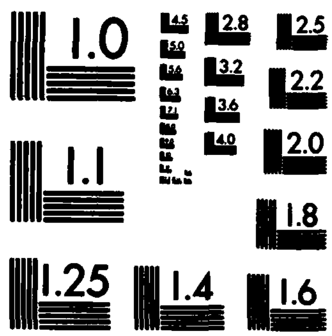

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TECHNICAL REPORT HL-82-19

KAHOMA STREAM CHANNEL IMPROVEMENT PROJECT, MAUI, HAWAII

Hydraulic Model Investigation

by

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August 1982
Final Report

Prepared for U. S. Army Engineer Division, Pacific Ocean
Fort Shafter, Hawaii 96858

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report HL-82-19	2. GOVT ACCESSION NO. AD-A120777	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) KAHOMA STREAM CHANNEL IMPROVEMENT PROJECT, MAUI, HAWAII; Hydraulic Model Investigation		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John F. George		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Hydraulics Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Engineer Division, Pacific Ocean Building 230 Fort Shafter, Hawaii 96858		12. REPORT DATE August 1982 13. NUMBER OF PAGES 104
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Channel improvement
Hydraulic models
Kahoma Stream
Streams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Tests were conducted on a 1:30-scale model of Kahoma Stream to determine the adequacy of proposed channel improvements for Kahoma Stream and the offshore area. The model reproduced approximately 6,100 ft of Kahoma Stream and approximately a 350-ft-long by 500-ft-wide offshore area. The model was constructed so that the slopes of the high-velocity channel could be adjusted to reproduce various energy gradients equivalent to those resulting from different prototype Manning's n roughness factors.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

Unsatisfactory flow conditions were observed in the debris basin due to entrance conditions into the debris basin. Large cross waves were also present in the transition just downstream of the debris basin which resulted in pronounced superelevation of the water surface several hundred feet downstream in the high-velocity channel. A weir and transition design, which consisted of a three-sided weir with a wedge-type transition, was developed that provided satisfactory flow conditions in the transition, but little improvement in flow conditions was observed in the debris basin. Improvements in flow conditions in the debris basin were observed when debris was present in the basin resulting from debris tests or when the invert of the debris basin was unlined.

The slopes of the high-velocity channel were initially adjusted to produce an energy gradient resulting from a Manning's n roughness factor of 0.015 in the prototype. Satisfactory flow conditions were observed in the high-velocity channel from the transition just downstream of the weir to the bridge transition at Cane Haul Road. However, flow conditions from Cane Haul Road Bridge to the downstream end of the channel were unsatisfactory due to the bridge transition design. This wedge-type transition design caused cross waves to develop in the transition and trapezoidal channel downstream. A warped-surface transition design with a 60-ft width significantly reduced the cross waves in the transition which provided satisfactory flow conditions throughout the transitions and trapezoidal channel.

The slopes of the high-velocity channel were adjusted to reproduce the energy gradient resulting from a Manning's n roughness factor of 0.013 in the prototype. An increase in surface waves in some areas of the channel was indicated when compared with those measured with a channel slope simulating a Manning's roughness value of 0.015, but flow conditions were still satisfactory throughout the proposed high-velocity channel.

Additional roughness placed on the channel invert downstream from Front Street Bridge for aesthetic purposes increased water-surface elevations that exceeded proposed wall heights between Front Street Bridge and the end of the trapezoidal channel. Raising the elevation of the left slope and placing a vertical wall on the right slope contained the increased water-surface elevation, thus providing adequate protection for this reach of channel.

During a Standard Project Flood hydrograph, a large scour hole developed in the offshore area just downstream of the high-velocity channel and a considerable amount of deposition occurred between the two rock groins. Extending the trapezoidal channel and placing a boulder concrete section immediately downstream of the channel minimized the scour and deposition that occurred in the offshore area.

PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers (OCE), U. S. Army, on 29 June 1979, at the request of the U. S. Army Engineer Division, Pacific Ocean (POD). The studies were conducted by personnel of the Hydraulics Laboratory, U. S. Army Engineer Waterways Experiment Station (WES), during the period April 1980 to August 1981. All studies were conducted under the direction of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory, and J. L. Grace, Jr., Chief of the Hydraulic Structures Division. The tests were conducted by Messrs. J. F. George, J. H. Riley, C. L. Dent, and T. E. Murphy, Jr., under the supervision of Mr. G. A. Pickering, Chief of the Locks and Conduits Branch. This report was prepared by Mr. George.

Messrs. S. B. Powell and T. Munsey of OCE, C. Lee and K. Keller of POD, and R. Hayashi and F. Araki from the County of Maui visited WES during the study to discuss test results and to correlate these results with concurrent design work.

Commanders and Directors of WES during the testing program and the preparation and publication of this report were COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
feet per mile	0.189393	metres per kilometre
feet per second	0.3048	metres per second
inches	25.4	millimetres
miles (U. S. statute)	1.609344	kilometres
pounds (mass)	0.4535924	kilograms
square miles (U. S. statute)	2.589988	square kilometres

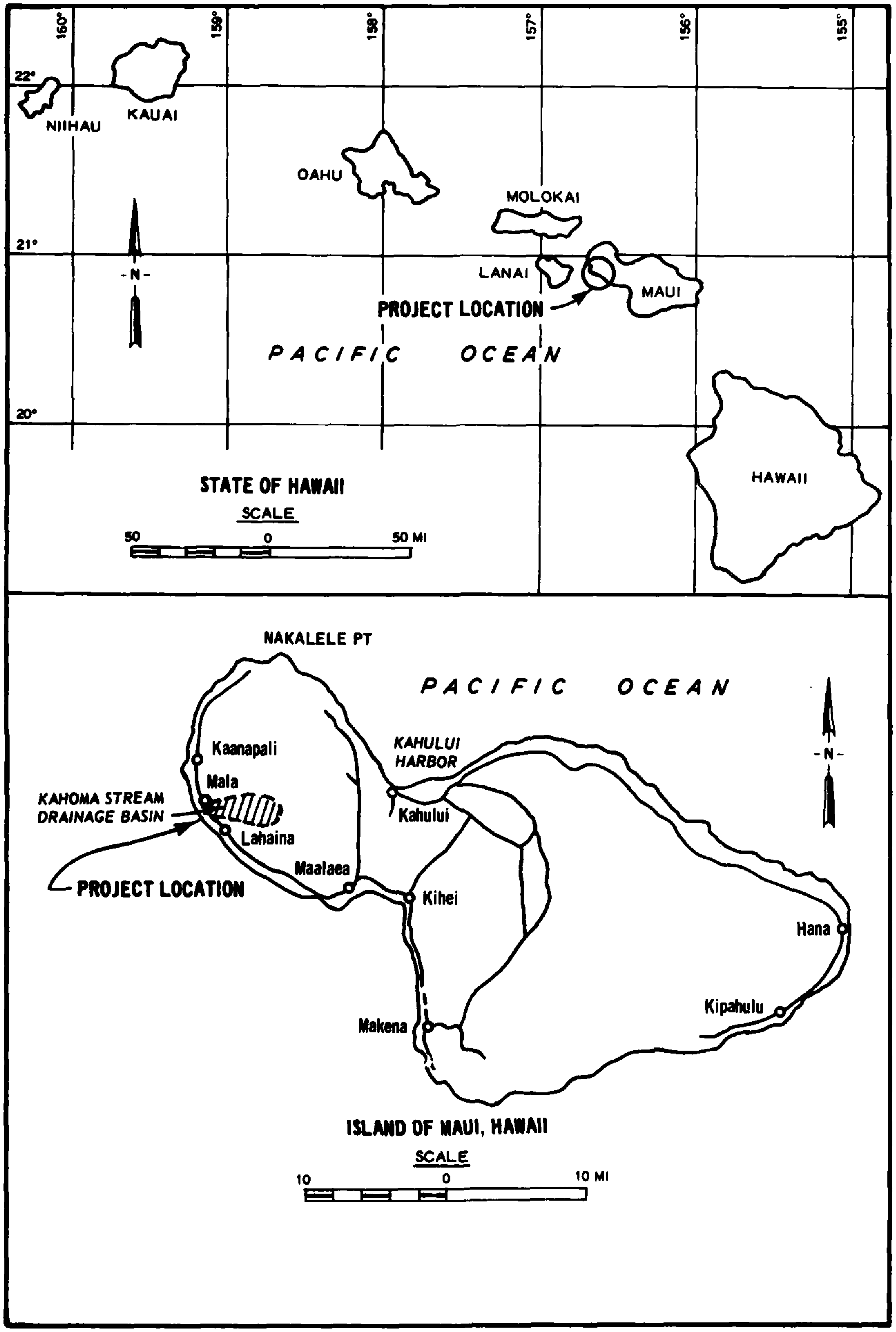

Figure 1. Location map

KAHOMA STREAM CHANNEL IMPROVEMENT PROJECT

MAUI, HAWAII

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The Kahoma Stream channel improvement project (Figure 1) is located on the Island of Maui, the second largest island in the State of Hawaii. The drainage basin comprises an area of 5.4 square miles* with the upper basin area being mountainous with an average slope of about 700 ft/mile, while the coastal area of the drainage basin has a slope of about 100 ft/mile. Kahoma Stream follows a westerly course through the northern part of the town of Lahaina, discharging into the Pacific Ocean.

2. Flood flows on Kahoma Stream and its tributaries, Kanaha and Halona Streams, are characterized by sharp rises resulting from concentrated storms that produce rapid runoff. Peak flows occur approximately an hour at the end of a heavy rainfall then recede rapidly, returning to normal within a few hours.

3. The proposed Kahoma Stream flood-control project will be designed to accommodate Standard Project Flood (SPF) conditions with a peak discharge of 15,200 cfs. The proposed improvements will begin in the Kelawea residential area and extend downstream to the Pacific Ocean north of Mala Wharf. These improvements consist of a debris basin with a concrete weir that has a storage capacity of 55,000 cu yd, a concrete-lined trapezoidal channel from the debris basin to the Pacific Ocean, and new bridges at Front Street, Honoapiilani Highway, and Cane Haul Road to accommodate the design flood.

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* A table of factors for converting metric (SI) units of measurement to U. S. customary units is presented on page 3.

Purpose of Model Investigation

4. A model was considered necessary to verify the adequacy of and develop desirable modifications to the debris basin and weir, the high-velocity channel with superelevated curves, and the offshore area immediately downstream of the high-velocity channel. Specifically, the model study was to determine:

- a. Flow conditions within the debris basin with and without debris conditions reproduced.
- b. Flow conditions and water-surface profiles throughout the high velocity channel for simulated Manning's n roughness values of 0.013 and 0.015.
- c. Flow conditions resulting from transitions, expansions, and contractions.
- d. Optimum protection for the offshore area.

PART II: THE MODEL

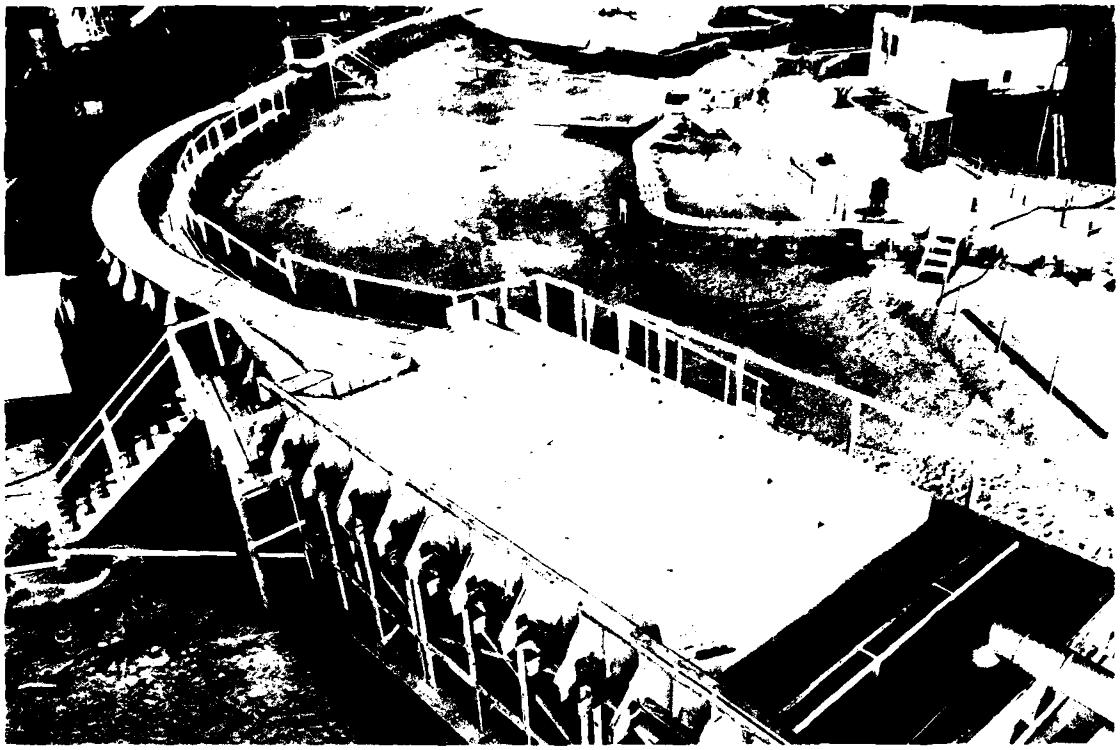
Description

5. The 1:30-scale model reproduced approximately 6,100 ft of Kahoma Stream beginning 700 ft upstream of the proposed weir in the debris basin and terminating in an approximately 350-ft-long by 500-ft-wide offshore area (Figure 2a, Plates 1-3). Portions of the high-velocity channel not requiring superelevation were constructed of plastic-coated plywood, while portions that were superelevated were constructed of concrete with a very smooth finish. The weir was constructed of transparent plastic and the trashracks of copper tubing (Figure 2b, Plate 4). The debris basin was molded in sand and cement mortar to sheet-metal templates and the offshore area was molded in sand. The model was constructed with the invert of the high-velocity channel adjustable to reproduce various energy gradients equivalent to those resulting from different prototype Manning's n roughness factors.

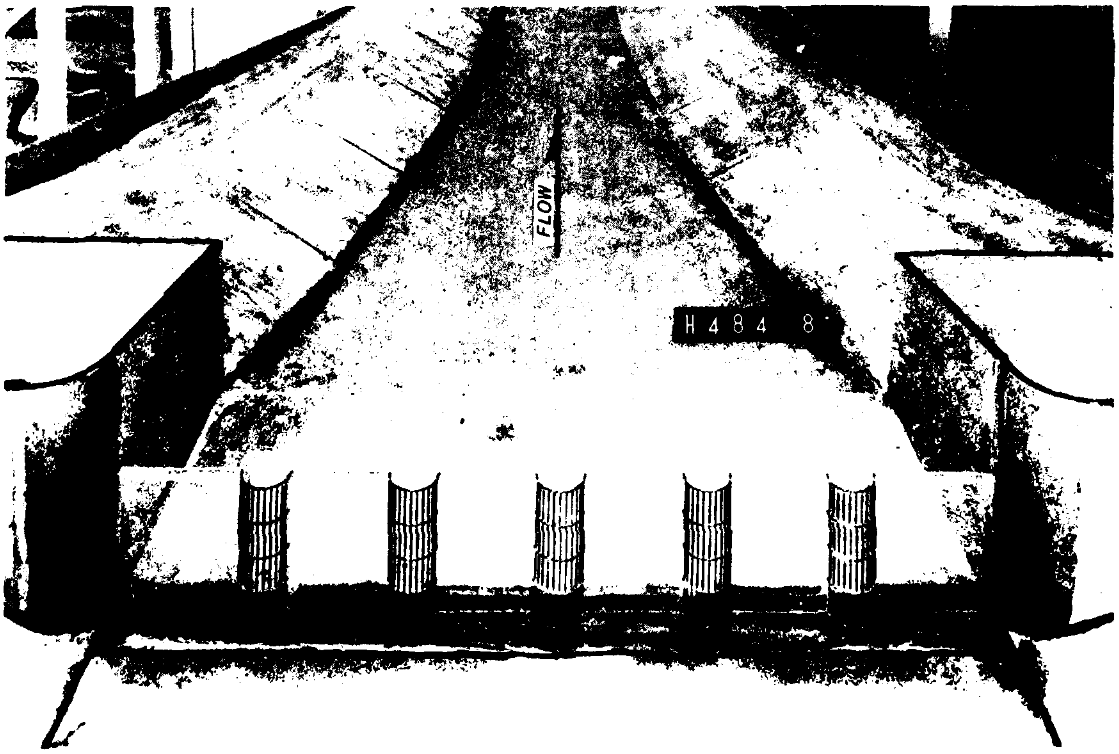
6. The coefficient of roughness of the model surface of the high-velocity channel had previously been determined to be approximately 0.009 (Manning's n). Basing similitude on the Froudian relation, the above n value would be equivalent to a prototype n of 0.0154. The n value used in the design and analysis of the prototype channel varied from 0.013 to 0.015; therefore, supplementary slopes were added to the model to correct for this difference in the n values of the model and prototype.

Model Appurtenances

7. Water used in the operation of the model was supplied by a circulating system. Discharges were measured by means of venturi meters installed in the flow lines and were baffled when entering the model. Velocities were measured with pitot tubes that were mounted to permit measurement of flow from any direction and at any depth. Water-surface elevations were measured with point gages. Different designs, along



a. General view



b. Close-up of type 1 design weir and trashrack

Figure 2. The 1:30-scale model

with various flow conditions, were recorded photographically.

Scale Relations

8. The accepted equations of hydraulic similitude, based on the Froudian criteria, were used to express mathematical relations between the dimensions and hydraulic quantities of the model and prototype. General relations for the transference of model data to prototype equivalents are presented below:

Characteristic	Dimension*	Model:Prototype
Length	L_r	1:30
Area	$A_r = L_r^2$	1:900
Velocity	$V_r = L_r^{1/2}$	1:5.477
Discharge	$Q_r = L_r^{5/2}$	1:4,929.5
Volume	$V_r = L_r^3$	1:27,000
Weight	$W_r = L_r^3$	1:27,000
Time	$T_r = L_r^{1/2}$	1:5.477

* Dimensions are in terms of length.

Model measurements of discharge, water-surface elevations, and velocities can be transferred quantitatively to prototype equivalents by means of the scale relations. Experimental data also indicate that the model-to-prototype scale ratio is valid for scaling stone in the sizes used in this investigation. Evidences of sand scour are considered only qualitatively reliable, since it is not yet possible to reproduce quantitatively in a model the resistance to erosion of fine-grained, prototype bed material.

PART III: TESTS AND RESULTS

9. Tests were conducted to observe general flow conditions and determine the adequacy of the proposed channel improvements for Kahoma Stream and the offshore area. The Manning's n roughness coefficient of the prototype channel could range from 0.013 to 0.015 depending on the quality of construction. Initial tests were conducted with the invert slopes of the high-velocity channel adjusted to reproduce the energy gradient associated with an n value of 0.015.

Debris Basin and Transition Immediately Downstream

Original design

10. The proposed debris basin (Plates 1 and 2) initially begins with an invert width of 70 ft at sta 61+50 which expands on a very steep slope to a uniform invert width of 120 ft from sta 58+00 to the weir at sta 55+00. The side slopes of the debris basin are 1V on 2H. The weir, which is 120 ft wide by 18 ft high (el 158.0*), has five slots with trashracks (Plate 4) that are utilized during low-flow conditions. Abutment walls are placed on each side of the weir from sta 55+00 to sta 54+50. The transition just downstream of the abutment walls begins at sta 54+50 with an invert width of 120 ft and converges to an invert width of 50 ft at sta 51+60.71.

11. Flow conditions with discharges ranging from 2,000 to 15,200 cfs (design discharge) were observed in the debris basin without debris and found to be unsatisfactory. Entrance conditions into the debris basin along with the invert expansion caused the majority of flow to concentrate along one side of the basin, which resulted in a large eddy developing upstream of the weir (Photo 1). Velocities measured in the debris basin are shown in Plate 5.

12. With the design discharge, significant cross waves developed

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* All elevations (el) cited herein are in feet referred to the National Geodetic Vertical Datum (NGVD).

in the transition section (Photo 2) which resulted in pronounced superelevation of the water surface for several hundred feet downstream in the high-velocity channel as shown in Plates 6 and 7 and listed in Table 1.

Alternate designs

13. Tests of different modifications to the weir and transition section immediately downstream from the weir were conducted in an effort to reduce significant cross waves that developed in the transition with the design discharge. Vertical walls varying 2 to 6 ft in height were positioned at different locations in the transition to prevent cross waves from developing, but little improvement was observed with this type of modification.

14. The abutment walls were removed and the length of weir was increased to approximately 192 ft to meet the 1V-on-2H slopes of the debris basin (type 6 design weir and transition). With the design discharge, unsatisfactory flow conditions were observed in the debris basin and in the transition section immediately downstream.

15. Various sizes and arrangements of baffle blocks were then positioned on the channel invert between sta 54+85 and 52+00 in an attempt to improve flow conditions in the transition section. The type 21 design weir and transition (Plate 8) eliminated the cross waves that developed in the transition section, and provided satisfactory flow conditions in the transition and downstream channel. Water-surface profiles with the design discharge are shown in Plates 9 and 10. Calibration data showing the head on the type 1 and type 21 design weirs for various discharges are provided in Plate 11.

16. The weir height was increased 1.5 ft to el 159.5 (Figure 3, type 22 design weir and transition) to increase the capacity of the debris basin. With the additional weir height, satisfactory flow conditions were still observed in the transition and downstream channel as shown in Photos 3 and 4. However, this design did not improve flow conditions in the debris basin (Photo 5).

17. Debris tests were conducted to determine the performance of the debris basin with the type 22 design weir and transition.

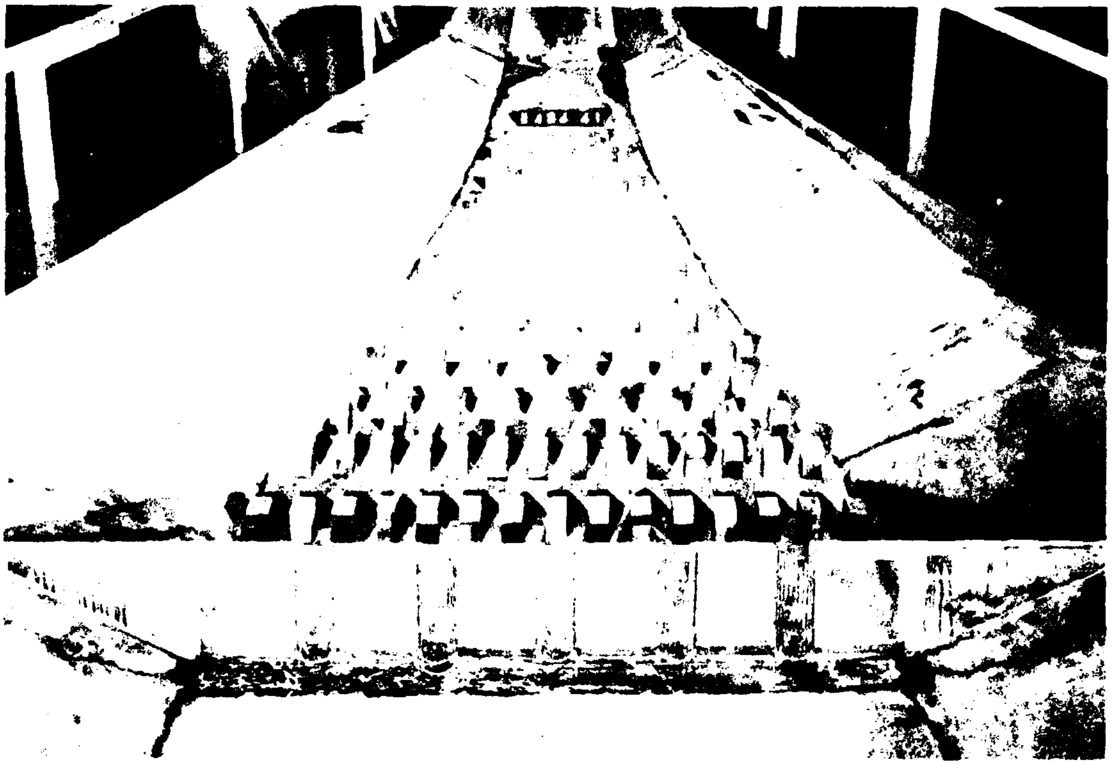


Figure 3. Type 22 design weir and transition

Approximately 48,000 cu yd (prototype) of material was introduced at sta 61+00 during an SPF hydrograph (Plate 12). The rate at which material was introduced into the debris basin was varied according to the rate of change in discharge in the SPF hydrograph. The material used for the debris tests consisted of approximately 88 percent sand and 12 percent stones which represented prototype material ranging from sandy gravel to boulders with an average diameter of 2 ft. As the debris basin filled with material, flow conditions improved significantly. The eddy condition that developed without material present did not develop when the debris basin was full of material. When the debris basin was full (Photo 6), the remaining portion of material introduced passed through the basin and high-velocity channel into the offshore area. Flow conditions during the debris test were satisfactory throughout the trapezoidal channel. Only minor deposits of material were observed in the channel at the end of the test.

18. Efforts were continued in developing a more economical design that would produce satisfactory flow conditions downstream of the weir. Tests were conducted to determine the hydraulic performance of a three-sided weir (type 23 design) downstream of the debris basin. The type 23 design weir (Plate 13) consisted of a 19.5-ft-high rectangular-shaped weir formed by two 40-ft-long walls parallel to the center line of the downstream channel and a connecting 50-ft-long wall perpendicular to flow and the channel. The transition section immediately downstream was modified to a 1V-on-2H trapezoidal channel with a 50-ft-wide invert from sta 55+00 to 51+60.71.

19. Flow conditions with the type 23 design weir transition were observed with discharges ranging from 2,000 to 15,200 cfs. Unsatisfactory flow conditions were observed in the debris basin with the design discharge which resulted in a large eddy developing upstream of sta 55+00. Flow conditions immediately downstream of the weir were also unsatisfactory with the design discharge, since large cross waves were present that extended several hundred feet downstream and overtopped the trapezoidal channel at several locations.

20. The weir was extended upstream 10 ft, and a warped transition was installed between sta 55+00 and 53+50 (Photo 7a, Plate 14) to improve flow conditions in the downstream trapezoidal channel. This was designated the type 24 design weir and transition. The cross waves were reduced significantly and satisfactory flow conditions were obtained in the high-velocity channel with the design discharge (Photo 7b). The proposed channel wall heights were adequate in containing the 50-year frequency (6,600 cfs), 100-year frequency (8,800 cfs), and SPF (15,200 cfs) flows as shown in Plates 15-20 and listed in Tables 2-4. No noticeable improvement in flow conditions in the debris basin was observed with this design (Photo 8).

21. The concrete invert of the debris basin was removed and replaced with various size stones and sand to determine what effects an erodible channel invert would have on flow conditions in the debris basin. During the SPF hydrograph, a significant portion of the channel invert eroded between sta 61+00 and 58+50 and deposited just downstream

of sta 58+00. The scour and deposition of material within the debris basin resulted in significant improvements in flow conditions in the debris basin.

22. Debris tests were then conducted to determine the performance of the debris basin with the erodible channel invert and the type 24 design weir and transition. The same type of debris test conducted with the type 22 design (paragraph 17) was conducted with this design. Satisfactory flow conditions were observed in the debris basin during the SPF hydrograph. When the debris basin was full, the remaining portion of material introduced passed through the debris basin and high-velocity channel into the offshore area. Only minor deposits of material were observed in the channel at the end of the test. Results of the debris test are shown in Photo 9 and Plate 21.

Recommended design

23. Additional tests were conducted to determine the hydraulic performance of a three-sided weir with a broken-back or wedge-type transition (type 25 design) downstream of the debris basin. The broken-back transition consisted of a rectangular section with 18-ft-high vertical walls at sta 55+00 which transitioned to a trapezoidal section with 1V-on-2H slopes at sta 53+50. A type 2 trashrack design (Plate 22), which reduced the opening between the vertical bars from 0.5 ft (type 1 trashrack design) to 0.25 ft in order to retain finer material was also included in the type 25 design weir. Details of the type 25 design weir and transition are shown in Photo 10 and Plate 23.

24. The type 25 design weir and transition were initially tested after a slope adjustment was made to the high-velocity channel to reproduce the energy gradient for a Manning's n of 0.013, as discussed in paragraph 33 later in the report. However, this slope adjustment had little if any effect on flow conditions at the weir and in the transition. The hydraulic performance of the type 25 design was dependent upon flow conditions in the debris basin and shape or configuration of the weir and transition section.

25. With the type 25 design, satisfactory flow conditions were observed in the transition for discharges ranging from 500 to 15,200 cfs

with only mild cross waves present with the higher discharges. Flow conditions with the warped transition (type 24 design) previously tested did provide slightly better flow conditions in the transition section as compared with the type 25 design. However, the type 25 design did provide satisfactory results and is more economical to construct; therefore, it is recommended for the prototype. Flow conditions with the type 25 design transition with discharges of 6,600 cfs (50-year frequency), 8,800 cfs (100-year frequency), and 15,200 cfs (SPF) are shown in Photo 10. Velocities measured in the debris basin are provided in Plate 24. Calibration data showing the head on the type 25 weir for various discharges are presented in Plate 25.

High-Velocity Channel

26. The high-velocity channel consists of a trapezoidal channel with 1V-on-2H side slopes and an invert width of 50 ft, except in the vicinity of the Cane Haul Road, Honoapiilani Highway, and Front Street Bridges, where the invert widths vary up to 70 ft.

Manning's n of 0.015

27. Flow conditions in the reach of channel just downstream of the transition (sta 49+00) to the Cane Haul Road Bridge (sta 29+50) were generally satisfactory for the full range of discharges tested. The channel heights in this reach were adequate to contain design flood conditions (Photos 11 and 12, Plates 6 and 7). It should be noted in these photographs that the wall heights in the model are higher than those proposed for the prototype.

28. Unsatisfactory flow conditions were observed in the original transition design (type 1) under the Cane Haul Road, Honoapiilani Highway, and Front Street Bridges (Photos 13-15) with the design discharge. The type 1 design transition caused cross waves to develop that raised the water surface immediately downstream from each transition section (Photos 16-18). Water-surface profiles for this portion of the high-velocity channel are shown in Plates 6 and 7. Velocities measured at Front Street Bridge (Plate 26) were a further indication of

unsymmetrical flow conditions present in the transition.

29. Modifications to the bridge transitions were tested to improve flow conditions under the bridges and in the trapezoidal channel immediately downstream. Several broken-back transition designs were tested and found to be inadequate in providing satisfactory flow conditions in the bridge transition sections. The high velocity caused cross waves to develop in these transitions that extended several hundred feet downstream in the channel.

30. A warped-surface transition design (type 5 design bridge transition, Plate 27) was then tested and found to provide satisfactory flow conditions under the bridge and in the downstream channel for the full range of expected discharges. The warped transition significantly reduced the cross waves under the bridge and in the trapezoidal channel. Flow conditions in the channel with the type 5 design bridge transition are shown in Photo 19.

31. Tests were conducted to determine the effects of reducing the 70-ft-wide Front Street Bridge opening to 50 and 60 ft for the full range of discharges. The invert width was initially reduced to 50 ft to determine the effects on flow conditions with the design discharge. Unsatisfactory flow conditions were observed under the Front Street Bridge. Water-surface profiles indicated that the reduction in width restricted flow sufficiently to cause overtopping of the wall heights and bridge.

32. Tests were then conducted with the invert width increased to 60 ft. Satisfactory flow conditions were observed throughout the transition sections (Photo 20) and the proposed wall heights contained the design flood. Fairly uniform velocity distribution was also observed throughout this reach of channel. A comparison of water-surface profiles (Plate 28) and velocities (Plates 29-31) with the 50-, 60- and 70-ft widths indicated that the 60-ft width provided the best flow conditions throughout the transition section and therefore is the recommended design.

<u>Manning's n of 0.013</u>

33. The slopes of the model downstream from sta 55+00 were adjusted to reproduce the energy gradient to be expected with the value of

Manning's n roughness coefficient of 0.013.

34. The type 24 design weir and transition and the 60-ft-wide type 5 design bridge transitions were installed in the model after the slope adjustment. Water-surface profiles recorded for a discharge of 15,200 cfs (Table 5, Plates 32 and 33) indicated an increase in surface waves in some areas of the high-velocity channel when compared with those measured with a slope simulating a Manning's n roughness value of 0.015 (compare with Table 4 and Plates 19 and 20). This occurred because the decrease in channel roughness increased the velocities and magnified the heights of standing waves throughout the trapezoidal channel. However, flow conditions were still satisfactory throughout the proposed high-velocity channel as shown in Photos 21-25.

Increased channel roughness
(sta 4+50 to 0+85)

35. Additional roughness was placed on the channel invert between sta 4+50 and 0+85 to simulate a 50 percent coverage of 6-in.-high stones proposed for the prototype channel invert for aesthetic reasons (Photo 26). Flow conditions observed in the channel were satisfactory for the full range of discharges. However, water-surface elevations were increased as expected, and the wall heights would have to be raised to contain the design discharge. Water-surface profiles measured in this area with discharges of 8,800 cfs and 15,200 cfs are shown in Plate 34.

36. Due to the increased water-surface elevations and right-of-way problems downstream of Front Street Bridge, the right slope could not be extended to a higher elevation. Therefore, tests were conducted to determine the effects of modifications to the right side of the trapezoidal channel. The modifications involved extending the warped surface transition 35 ft downstream and positioning a vertical wall on the 1V-on-2H slope (Photo 27, Plate 35).

37. Satisfactory flow conditions were observed in the modified trapezoidal channel for discharges ranging up to 15,200 cfs. Photographs of flow conditions in this reach of channel are shown in Photo 27.

38. Additional tests were conducted in the modified trapezoidal

channel to determine what effects positioning the vertical wall on the right slope closer to the center line of the channel would have on offshore flow conditions. Test results indicated that the vertical wall could be positioned 40 ft to the right of the center line without having any significant effect on offshore flow conditions. However, the location of the vertical wall as shown in Plate 35 will be provided in the recommended design.

Offshore Area

39. Tests were conducted to develop a plan of protection at the downstream end of the high-velocity channel in the offshore area (Photo 28). Initial measurements were made to determine the areas of scour and deposition without any protection immediately downstream of the channel. During an SPF hydrograph test, a large scour hole developed just downstream of the channel and a considerable amount of deposition occurred between the two rock groins. Also, during the hydrograph a small eddy developed between the channel and smaller rock groin which caused significant erosion along the left bank. Cross sections of the scour in this area are shown in Plate 36. These are only qualitatively reliable and, therefore, cannot be used to predict exact prototype depths of scour and deposition; however, data can be used to determine the relative merits of various designs.

40. The trapezoidal channel was extended various distances downstream from sta 1+20 to determine what effect this would have on the scour and deposition pattern offshore. Different sizes of grouted riprap sections were also positioned immediately downstream of the channel to provide additional protection to the offshore area. Test results indicated that the trapezoidal section should be extended 35 ft to sta 0+85 and a grouted riprap section (4,500-lb stones) 100 ft wide by 70 ft long with a cutoff wall placed downstream (Photo 29, Plate 35) to provide adequate protection for the offshore area. During an SPF hydrograph with this design, minimal deposition occurred between the two rock groins and the erosion along the left bank was reduced. Some scour did

occur near the cutoff wall surrounding the grouted riprap section, as was expected. The offshore area after an SPF hydrograph test is shown in Photo 30. The increased roughness added to the channel invert previously discussed in paragraph 35 had little effect on the scour and deposition pattern in the offshore area.

Recommended Design

41. The overall recommended design determined from test results incorporates into the original proposed design the type 25 design weir and transition, the type 5 design bridge transition with a 60-ft-wide invert, the modified trapezoidal channel with 6-in.-high stones on the channel invert downstream of sta 4+50, the channel extension to sta 0+85, and the boulder concrete section immediately downstream of the high-velocity channel. Water-surface profiles with the recommended design with discharges of 6,600, 8,800, and 15,200 cfs are shown in Plates 37-42 and listed in Tables 6-8. Velocities measured in the trapezoidal channel with the design discharge are provided in Plate 43. Cross sections of the offshore area after hydrographs with peak discharges of 6,600, 8,800, and 15,200 cfs were also recorded and are shown in Plate 44.

PART IV: DISCUSSION OF RESULTS

42. Tests to determine the adequacy of channel improvements for Kahoma Stream indicated that the original design with certain modifications would effectively contain design flood conditions.

43. Entrance conditions into the debris basin along with the invert expansion caused flow to concentrate on one side of the basin when the basin was void of debris, resulting in a large eddy in the basin and unsymmetrical flow at the weir. Also, large cross waves were present in the transition section just downstream of the weir that resulted in pronounced superelevation of the water surface several hundred feet downstream in the trapezoidal channel. By extending the weir length to the side slopes of the debris basin, and placing baffle blocks on the channel invert in the transition (type 21 design weir and transition), significantly improved flow conditions were obtained downstream of the weir. The water-surface elevations increased in the transition due to the baffle blocks; but the cross waves did not develop, resulting in satisfactory flow conditions in the transition. Little improvement in flow conditions was observed in the debris basin. However, flow conditions were satisfactory when debris was introduced into the model during an SPF hydrograph. Since debris will be present in the prototype during these high flows, the unequal distribution of flow should not be a problem.

44. Although the type 21 design weir and transition performed satisfactorily, a three-sided weir with a broken-back or wedge-type transition immediately downstream (type 25 design weir and transition) was tested and found to provide satisfactory flow conditions downstream from the weir for the full range of expected discharges. This design eliminated the use of baffle blocks in the channel, maintained a 50-ft-wide channel invert throughout the transition, and would be more economical to construct and maintain than the type 21 design weir and transition. Therefore, the type 25 design weir and transition is recommended for construction in the prototype. Flow conditions did not improve in the debris basin with the type 25 design.

45. When debris was introduced into the model during an SPF hydrograph, most of the debris was trapped in the basin, indicating that the basin functioned satisfactorily for any of the basin designs so tested. Most of the small amount of debris that was not trapped in the basin passed through the high-velocity channel into the offshore area with only minor deposits of material in the downstream portion of the channel. These deposits were insignificant and had no effect on flow in the channel.

46. It was anticipated that the Manning's n roughness coefficient of the prototype concrete-lined channel could range from 0.013 to 0.015, depending on the quality of construction. Water-surface elevations would be slightly higher with the large n value, and flow velocities and waves created by disturbances would be slightly higher with the smaller n value. Thus, tests were conducted with the slopes of the high-velocity channel adjusted to simulate the energy gradient resulting from both of the n values.

47. Flow conditions were satisfactory in the original design high-velocity channel from the debris basin weir to the bridge transition at Cane Haul Road. The channel heights were adequate to contain the design flow in this reach. However, all of the bridge transitions as originally designed caused cross waves to develop which raised the water surface immediately downstream from each bridge. In some reaches of the channel the water surface exceeded the channel height.

48. Since a broken-back or wedge-type transition with straight line forming would be less expensive to construct in the prototype than a warped transition, several modified versions of this type of transition were tested in an effort to reduce the cross waves. None of these designs were successful. A warped-surface transition was developed that greatly reduced the cross waves under each bridge and in the trapezoidal channel. Thus, it is recommended that all of the prototype bridge transitions have warped surfaces.

49. Since the base width of the trapezoidal channel was 50 ft, tests were conducted to determine if the invert width at the bridge openings could be reduced to 50 ft. However, this opening was too small

and flow overtopped the bridge and walls. Based on test results, it is recommended that all of the bridge openings be 60 ft wide.

50. Additional roughness placed on the channel invert downstream from Front Street Bridge, which simulated 50 percent coverage of 6-in.-high stones proposed for the prototype, increased water-surface elevations as expected. Flow conditions were satisfactory, but the increase in water-surface elevations exceeded the channel heights. Extending the left slope to a higher elevation and placing a vertical wall on the right slope contained the increased water-surface elevations, thus providing adequate protection for the reach of channel downstream of Front Street Bridge.

51. By using water-surface elevations measured in the model with the recommended improvements installed and both n values simulated, the required heights of the prototype channel can be determined.

52. During an SPF hydrograph test of the original design offshore area, a large scour hole developed just downstream of the channel and a considerable amount of deposition occurred between the two rock groins. By extending the trapezoidal section 35 ft downstream and placing a boulder concrete section 100 ft wide by 70 ft long at the end of the channel, minimal deposition occurred between the two rock groins and the erosion along the left bank was reduced. This design provided adequate protection for the offshore area and is recommended for use in the prototype.

Table 1

Water-Surface Elevations, Discharge 15,200 cfs, n = 0.015, Type 1 Design Weir, Type 1 Design Bridge Transition

	Elevation			Elevation			Elevation	
Station	Left Side	Right Side	Station	Left Side	Right Side	Station	Left Side	Right Side
61+70	186.1	184.3	39+00	67.7	66.2	19+50	17.8	15.1
61+00	177.3	176.6	38+50	67.6	63.9	19+00	17.0	16.0
60+00	164.7	165.9	38+00	65.4	60.7	18+50	15.6	16.9
59+00	165.1	163.0	37+50	62.2	58.5	18+00	15.5	16.3
58+54	163.9	163.6	37+00	60.2	55.4	17+50	12.7	13.8
58+00	166.4	167.2	36+50	57.0	52.7	17+16.20	19.7	19.4
57+00	166.2	169.0	36+00	54.7	50.2	16+50	14.7	16.7
56+00	164.6	168.4	35+50	52.7	48.3	16+00	14.4	13.5
55+00	163.7	165.0	35+00	49.5	46.2	15+50	9.4	12.3
54+77	150.5	163.5	34+50	47.9	45.0	15+32.91	11.8	12.2
54+40.70	148.0	145.9	34+00	46.0	43.8	15+00	18.1	13.7
54+00	151.7	148.2	33+50	44.7	42.5	14+70.91	19.3	15.3
53+50	145.2	150.3	33+00	41.6	41.1	14+00	15.3	13.2
53+00	140.6	144.1	32+50	40.7	39.2	13+50	15.7	13.0
52+50	147.0	139.8	32+00	40.2	37.8	13+00	12.9	13.9
52+00	144.7	144.0	31+50	38.2	35.0	12+50	13.6	16.0
51+50	139.7	138.5	31+00	36.1	32.6	12+00	15.8	13.9
51+00	136.9	135.3	30+50	34.4	31.0	11+50	13.4	13[illegible]
50+50	133.3	138.0	30+00	32.1	28.7	11+00	14.6	13.0
50+00	130.3	135.9	29+48	30.4	26.5	10+50	15.9	12.1
49+50	128.1	126.5	28+98	26.4	29.4	10+00	15.3	13.9
48+72	126.3	120.9	28+48.91	23.4	26.2	9+50	11.9	13.6
48+00	123.9	115.5	28+00	22.2	23.8	9+00	12.9	14.3
47+00	111.6	112.5	27+50	25.8	25.6	8+50	12.5	14.5
46+50	107.7	110.9	27+00	23.7	22.5	7+73.61	13.6	12.0
46+00	103.6	107.7	26+50	22.8	21.8	7+23.61	11.1	11.1
45+50	100.5	102.1	26+00	21.1	19.7	6+74.50	13.0	9.8
45+00	100.4	98.7	25+50	22.4	20.4	6+09.90	9.7	11.1
44+50	99.2	93.3	25+00	21.6	20.0	5+50	9.7	10.8
44+00	97.9	90.9	24+50	22.9	21.8	5+00	8.5	10.2
43+50	95.4	87.7	24+00	21.4	23.8	4+50	10.2	12.0
43+00	92.6	85.3	23+50	24.7	20.0	4+00	13.2	11.7
42+50	89.1	82.5	23+00	19.1	19.7	3+50	10.6	11.3
42+00	85.7	80.3	22+50	18.1	20.4	3+00	9.4	11.4
41+50	81.6	79.7	22+00	17.6	20.7	2+50	11.3	12.5
41+00	78.9	78.9	21+50	19.6	18.2	2+00	8.7	10.8
40+50	76.4	73.5	21+00	19.0	18.1	1+50	8.6	9.4
40+00	73.3	71.3	20+50	17.0	17.0	1+20	9.4	8.7
39+50	70.0	69.4	20+00	15.5	20.2			

Note: Sides of channel are referenced to downstream direction.

Table 2

Water-Surface Elevations, Discharge 6,600 cfs, n = 0.015, Type 24 Design Weir, Type 5 Design Transition

	Elevation				Elevation				Elevation		
Station	Left Side	Center Line	Right Side	Station	Left Side	Center Line	Right Side	Station	Left Side	Center Line	Right Side
61+70	185.2	186.3	181.4	40+50	74.8	73.4	74.7	21+50	16.7	14.7	16.25
61+00	177.2	175.7	172.9	40+00	71.8	71.4	71.3	21+00	17.0	14.4	15.7
60+00	164.4	162.1	163.0	39+50	69.7	68.4	69.4	20+50	15.25	14.3	14.5
59+00	162.5	162.2	162.9	39+00	67.8	65.9	66.2	20+00	14.4	13.7	14.5
58+00	163.4	161.2	163.1	38+50	65.0	63.5	63.6	19+50	11.0	9.5	12.25
57+00	164.9	160.3	162.9	38+00	63.2	60.8	60.6	19+00	13.6	12.6	13.8
56+00	166.4	163.1	165.7	37+50	60.4	58.7	58.3	18+50	12.6	12.2	13.4
55+00	163.1	152.4	162.8	37+00	58.25	56.1	55.3	18+00	12.8	11.7	12.9
54+50	146.8	142.7	148.0	36+50	56.3	53.4	52.9	16+50	11.4	10.7	11.3
54+00	143.3	143.4	142.4	36+00	53.6	50.9	50.8	15+32.91	11.6	11.4	11.2
53+50	145.1	139.8	142.7	35+50	50.6	48.4	48.3	15+00	11.9	11.2	11.6
53+00	141.1	137.2	141.9	35+00	48.0	46.0	45.9	14+50	13.0	9.9	10.8
52+50	138.7	136.7	137.6	34+50	46.25	44.5	44.7	14+00	11.6	10.4	11.9
52+00	133.9	134.7	136.7	34+00	44.8	42.9	43.4	13+50	10.6	10.2	12.25
51+50	133.6	132.1	135.5	33+50	41.3	41.7	42.0	13+00	9.6	10.1	12.2
51+00	132.9	130.6	132.4	33+00	41.3	40.0	40.9	12+50	11.25	10.1	10.75
50+50	129.4	128.3	129.7	32+50	40.1	38.8	39.25	12+00	12.1	9.4	10.1
50+00	130.2	127.8	127.6	32+00	38.9	37.2	37.6	11+50	11.9	9.5	9.6
49+50	127.0	124.0	124.2	31+50	37.5	35.4	34.9	11+00	11.0	9.4	10.75
49+22.52	124.5	122.4	122.9	31+00	35.3	33.2	32.5	10+50	10.4	8.9	10.6
48+72	122.2	119.4	119.7	30+50	33.6	31.3	31.3	10+00	9.75	9.9	10.25
48+00	117.9	113.7	113.5	30+00	32.6	29.6	28.5	9+50	11.0	8.9	10.1
47+00	109.5	106.7	110.9	29+48	29.7	27.2	26.9	9+00	10.6	9.0	9.4
46+50	105.75	103.2	107.25	28+98	26.7	25.5	26.9	8+50	10.1	8.75	9.6
46+00	102.6	103.5	103.1	28+48.91	23.4	23.2	26.6	7+73.61	9.0	8.75	9.7
45+50	101.6	99.2	99.4	27+00	22.1	20.0	20.5	7+24	9.4	7.9	9.7
45+00	100.1	95.7	95.9	26+00	22.6	18.3	20.2	6+00	7.9	8.1	9.2
44+50	98.2	93.7	93.4	25+50	21.8	20.5	19.3	4+50	8.0	7.8	7.5
44+00	95.0	90.7	90.9	25+00	20.5	19.1	18.6	4+00	8.4	6.4	9.1
43+50	92.6	89.9	87.7	24+50	19.25	18.1	22.75	3+50	7.4	7.3	8.1
43+00	89.4	86.5	85.3	24+00	19.0	17.2	19.7	3+00	7.4	6.2	8.6
42+50	86.8	83.8	83.3	23+50	18.4	16.6	20.75	2+50	7.8	6.2	7.4
42+00	83.5	81.2	82.1	23+00	17.4	17.3	18.5	2+00	7.0	6.2	6.2
41+50	81.25	78.5	79.8	22+50	16.1	16.3	17.6	1+20	6.5	6.1	6.3
41+00	77.2	75.7	76.5	22+00	18.2	15.1	16.7				

Note: Sides of channel are referenced to downstream direction.

Table 3

Water-Surface Elevations, Discharge 8,800 cfs, n = 0.015, Type 24 Design Weir, Type 5 Design Transition

	Elevation				Elevation				Elevation		
Station	Left Side	Center Line	Right Side	Station	Left Side	Center Line	Right Side	Station	Left Side	Center Line	Right Side
61+70	185.7	187.1	182.75	40+50	76.6	73.5	74.6	22+00	17.0	16.6	17.4
61+00	180.0	176.5	173.2	40+00	73.2	71.7	72.5	21+50	19.0	14.9	17.0
60+00	165.4	162.4	163.7	39+50	69.8	69.6	69.2	21+00	17.5	14.3	16.5
59+00	164.0	164.7	164.75	39+00	69.2	66.2	67.4	20+50	17.0	14.9	15.6
58+00	166.1	163.1	164.0	38+50	66.6	63.6	63.3	20+00	15.3	14.0	14.7
57+00	165.6	161.6	163.6	38+00	64.0	61.3	61.1	19+50	14.9	13.5	15.4
56+00	165.0	161.9	164.3	37+50	60.7	58.0	58.9	19+00	14.0	12.3	15.0
55+00	166.3	154.6	163.9	37+00	59.7	57.0	55.7	18+50	13.3	12.5	13.6
54+50	147.7	144.8	147.7	36+50	57.5	54.1	53.4	18+00	14.1	12.3	13.4
54+00	144.0	144.6	143.5	36+00	55.0	51.7	51.5	16+50	11.8	11.6	11.5
53+50	144.4	140.75	142.5	35+50	51.4	49.4	48.8	15+32.91	12.0	11.5	12.7
53+00	142.9	137.8	142.8	35+00	49.5	46.5	47.0	15+00	12.3	10.9	11.9
52+50	139.1	136.8	138.75	34+50	47.7	45.1	46.1	14+50	12.6	10.8	11.9
52+00	135.2	135.4	136.9	34+00	46.0	43.5	44.4	14+00	13.0	10.3	12.0
51+50	134.2	133.0	137.9	33+50	44.6	42.0	43.1	13+50	11.6	10.3	12.1
51+00	133.6	130.6	134.9	33+00	41.7	40.7	40.7	13+00	10.8	10.3	12.2
50+50	130.8	128.6	130.75	32+50	40.5	39.2	39.6	12+50	12.0	10.2	11.9
50+00	129.6	128.8	128.6	32+00	39.5	37.4	37.6	12+00	12.2	9.7	11.3
49+50	127.8	124.4	125.2	31+50	38.0	35.5	35.4	11+50	12.0	10.1	10.5
49+22.52	125.2	122.4	122.75	31+00	36.0	33.3	33.2	11+00	11.8	9.5	10.4
48+72	122.4	118.4	118.7	30+50	34.7	31.7	31.5	10+50	12.0	9.6	11.2
48+00	118.3	114.8	114.1	30+00	32.8	29.7	28.8	10+00	10.7	9.4	11.3
47+00	110.2	107.2	112.0	29+48	30.0	27.6	27.0	9+50	9.8	9.5	11.7
46+50	106.6	103.9	108.1	28+98	27.6	25.8	27.3	9+00	11.4	9.2	11.0
46+00	102.8	103.2	104.0	28+48.91	24.3	24.0	27.5	8+50	11.4	9.0	9.7
45+50	100.8	100.6	99.8	27+00	21.8	20.5	20.8	7+73.61	10.5	9.0	10.4
45+00	101.3	96.6	96.4	26+00	23.4	18.7	20.7	6+00	9.1	8.6	8.4
44+50	99.7	93.8	93.3	25+50	22.4	21.1	19.5	4+50	8.5	8.2	8.6
44+00	95.8	91.0	90.7	25+00	21.1	19.1	18.8	4+00	8.5	7.0	8.8
43+50	93.2	88.8	87.8	24+50	20.0	18.8	23.0	3+50	8.1	7.0	8.2
43+00	90.4	87.6	85.0	24+00	19.5	17.7	21.0	3+00	7.2	6.8	8.6
42+50	87.6	84.4	82.8	23+50	19.0	16.6	20.3	2+50	7.4	6.7	8.8
42+00	81.3	82.1	81.2	23+00	18.0	18.2	19.6	2+00	7.2	6.7	7.5
41+50	81.7	79.0	80.3	22+50	16.5	16.0	17.8	1+20	7.5	6.1	6.7
41+00	79.0	76.3	77.9								

Note: Sides of channel are referenced to downstream direction.

Table 4

Water-Surface Elevations, Discharge 15,200 cfs, n = 0.015, Type 24 Design Weir, Type 5 Design Bridge Transition

Station	Elevation Left Side	Elevation Center Line	Elevation Right Side	Station	Elevation Left Side	Elevation Center Line	Elevation Right Side	Station	Elevation Left Side	Elevation Center Line	Elevation Right Side
61+70	184.2	188.2	185.6	40+00	75.3	72.0	72.9	22+00	17.4	17.2	19.1
61+00	174.3	177.4	183.1	39+50	71.8	70.6	71.3	21+50	17.8	16.6	17.9
60+00	167.7	163.8	167.9	39+00	69.4	68.1	68.7	21+00	18.8	15.8	17.4
59+58	171.9	164.4	170.4	38+50	66.3	65.25	66.9	20+50	17.4	15.1	17.2
59+00	171.3	174.9	171.4	38+00	67.2	62.2	62.6	20+00	17.2	15.0	15.75
58+00	173.8	168.6	171.1	37+50	65.7	59.7	59.8	19+50	17.3	14.0	15.4
57+00	173.6	166.25	170.25	37+00	62.5	56.9	56.9	19+00	16.2	14.0	15.1
56+00	173.3	167.4	170.4	36+50	59.9	54.5	54.5	18+50	14.9	13.6	15.5
55+00	171.1	161.6	173.0	36+00	57.7	52.4	51.9	18+00	17.75	12.9	15.4
54+50	153.9	147.4	151.2	35+50	55.3	50.9	48.8	16+50	13.2	13.7	13.2
54+00	146.75	146.3	147.4	35+00	52.2	48.1	46.4	15+32.91	14.7	12.3	13.6
53+50	144.2	142.6	147.3	34+50	49.5	45.75	45.25	15+00	14.7	12.5	12.9
53+00	145.6	139.4	145.75	34+00	48.3	44.5	45.8	14+50	14.6	12.3	11.5
52+50	142.4	138.0	142.9	33+50	46.4	42.8	44.7	14+00	14.8	11.4	13.2
52+00	139.0	137.8	138.7	33+00	43.6	39.8	42.1	13+50	14.7	11.25	13.8
51+50	136.4	135.25	135.9	32+50	42.6	40.5	40.6	13+00	13.2	11.0	13.5
51+00	136.4	132.0	134.7	32+00	40.5	39.5	39.4	12+50	12.7	11.9	12.7
50+50	134.0	130.1	134.2	31+50	38.7	37.25	36.8	12+00	13.1	10.9	12.5
50+00	130.6	129.75	131.0	31+00	38.0	34.7	34.0	11+50	14.9	10.4	11.75
49+50	127.0	127.4	127.4	30+50	37.4	32.8	32.6	11+00	14.1	10.5	10.9
48+72	125.8	120.6	122.5	30+00	35.7	30.4	30.4	10+50	13.8	11.0	10.4
48+00	123.5	115.4	117.6	29+48	33.6	28.4	28.5	10+00	12.8	8.25	10.7
47+00	111.7	109.75	111.25	28+98	30.25	27.2	28.4	9+50	12.2	8.0	12.2
46+50	108.2	107.3	108.6	28+48.91	26.6	25.8	27.8	9+00	11.1	10.2	11.1
46+00	104.2	103.9	106.3	28+00	25.4	22.8	25.4	8+50	10.9	11.25	10.3
45+50	102.6	101.25	102.7	27+50	24.1	22.5	23.6	7+73.61	12.3	9.6	10.1
45+00	103.4	98.3	98.2	27+00	24.4	21.6	21.25	7+24	12.6	9.6	10.4
44+50	98.7	95.75	94.4	26+50	24.2	21.4	22.8	6+00	9.1	10.0	11.0
44+00	98.8	92.7	92.3	26+00	23.8	20.6	21.5	4+50	11.1	8.7	8.6
43+50	96.6	89.7	89.1	25+50	24.0	21.3	20.5	4+00	10.1	8.9	8.7
43+00	94.0	86.9	86.6	25+00	22.8	20.2	20.3	3+50	9.6	8.3	9.9
42+50	91.4	85.3	84.3	24+50	20.8	19.1	21.7	3+00	8.9	8.1	10.0
42+00	87.4	83.1	81.2	24+00	20.5	19.1	21.9	2+50	7.25	8.4	10.2
41+50	83.75	80.4	80.8	23+50	20.1	18.1	20.25	2+00	7.9	8.0	8.9
41+00	80.9	77.4	79.2	23+00	20.0	17.8	19.6	1+20	10.0	7.0	8.1
40+50	77.9	74.6	77.6	22+50	18.4	17.8	20.3				

Note: Sides of channel are referenced to downstream direction.

Table 5

Water-Surface Elevations, Discharge 15,200 cfs, n = 0.013, Type 24 Design Weir, Type 5 Design Bridge Transition

Station	Elevation Left Side	Elevation Center Line	Elevation Right Side	Station	Elevation Left Side	Elevation Center Line	Elevation Right Side	Station	Elevation Left Side	Elevation Center Line	Elevation Right Side
61+50	177.0	179.4	176.3	39+50	73.2	74.0	71.6	21+00	17.6	16.3	17.4
61+00	180.0	175.7	173.0	39+00	69.7	66.4	69.2	20+50	19.4	15.2	16.5
60+00	166.9	163.4	165.4	38+50	66.5	64.0	66.5	20+00	17.3	14.1	15.7
59+00	167.3	172.4	168.8	38+00	64.4	63.0	64.3	19+50	17.8	14.0	15.7
58+00	169.1	166.7	169.1	37+50	60.6	59.8	60.8	19+00	17.4	14.5	15.3
57+00	170.5	165.0	169.2	37+00	58.4	57.4	58.6	18+50	14.4	12.8	14.3
56+00	171.7	166.2	169.0	36+50	59.0	54.8	55.1	18+00	14.3	13.5	15.6
55+00	170.5	161.0	171.0	36+00	56.6	52.3	53.1	17+50	13.8	12.0	18.6
54+50	151.0	141.7	152.9	35+50	54.3	49.7	50.7	17+00	9.6	11.6	17.1
54+00	149.5	146.7	147.2	35+00	51.7	47.2	48.3	16+50	15.4	14.4	14.2
53+50	146.7	142.3	143.7	34+50	50.4	46.3	46.0	16+00	12.8	11.8	14.4
53+00	146.9	139.5	144.6	34+00	59.2	44.5	43.5	15+32.91	15.8	11.8	12.7
52+50	142.4	137.6	143.6	33+50	47.0	42.8	42.6	15+83	16.8	11.3	11.7
52+00	137.5	137.0	138.3	33+00	45.1	41.2	40.5	14+33	16.2	12.3	10.3
51+50	134.6	135.9	135.5	32+50	44.0	40.0	40.7	13+50	15.8	10.6	17.8
51+00	133.2	131.6	134.7	32+00	41.4	38.5	38.9	13+00	11.9	10.3	15.5
50+50	133.6	129.7	133.2	31+50	39.7	36.1	38.0	12+50	12.1	9.7	14.5
50+00	132.2	128.0	131.6	31+00	37.3	33.7	35.6	12+00	10.6	10.0	14.3
49+50	127.0	127.0	126.3	30+50	35.1	32.4	33.5	11+50	9.3	11.0	15.2
48+72	126.1	121.0	119.3	30+00	33.0	30.3	31.4	11+00	13.0	10.2	14.6
48+00	122.0	115.5	117.0	29+48	31.3	28.8	29.1	10+50	12.4	8.9	12.7
47+00	112.5	108.5	111.4	28+48.91	27.4	25.0	28.2	10+00	12.7	10.7	14.4
46+50	108.3	104.4	108.2	28+00	26.0	22.7	26.0	9+50	12.6	10.7	12.9
46+00	104.2	104.9	106.0	27+50	25.8	21.7	22.8	9+00	12.1	9.5	10.9
45+50	100.9	101.2	103.0	27+00	22.8	22.4	21.2	8+50	12.7	10.4	12.0
45+00	96.6	97.7	101.1	26+50	23.3	20.6	21.0	7+73	12.8	9.8	11.3
44+50	101.0	95.0	94.9	26+00	23.5	19.7	21.2	7+23.61	10.8	9.8	11.5
44+00	99.3	92.5	93.0	25+50	24.7	21.1	20.5	6+50	13.3	9.6	10.6
43+50	95.7	89.7	89.8	25+00	23.5	20.1	19.7	6+00	9.0	9.7	8.5
43+00	93.4	86.4	87.5	24+50	21.9	19.7	19.1	5+50	11.7	9.6	11.7
42+50	91.0	85.0	83.7	24+00	20.2	19.5	23.2	4+50	9.0	9.0	11.3
42+00	88.3	83.8	81.7	23+50	19.6	17.7	21.3	4+00	8.9	8.9	10.1
41+50	85.0	80.0	78.4	23+00	19.5	17.0	20.1	3+50	9.4	7.6	11.3
41+00	81.6	78.0	75.6	22+50	18.8	16.9	20.4	3+00	10.0	7.5	10.6
40+50	78.4	75.0	75.5	22+00	17.3	17.5	20.5	2+50	8.7	7.7	8.9
40+00	75.7	72.0	74.3	21+50	16.6	15.8	18.8	1+20	10.0	6.6	8.6

Note: Sides of channel are referenced to downstream direction.

Table 6

Water-Surface Elevations, Discharge 6,600 cfs, n = 0.013, Recommended Design

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
61+00	175.2	174.5	175.1	175.1	175.9	44+00	93.9	91.7	89.5	88.2	90.0	30+00	30.6	29.7	28.1	27.0	29.1
60+00	162.8	162.3	163.8	161.0	161.8	43+50	91.0	89.5	86.8	85.1	86.6	29+48.91	28.7	27.7	26.3	24.5	26.3
59+00	156.2	153.8	151.0	153.7	156.2	43+00	88.6	86.5	83.9	82.1	83.6	29+00	28.1	26.2	26.8	26.5	29.1
58+00	151.1	148.4	147.6	146.0	150.1	42+50	86.1	84.1	82.8	79.6	81.2	28+48.91	24.0	21.5	22.5	23.7	26.4
57+00	161.8	159.1	158.7	159.6	162.7	42+00	83.3	81.6	80.0	77.6	79.0	28+00	23.8	20.3	20.5	21.3	23.9
56+00	161.5	159.7	159.5	159.7	161.8	41+50	80.6	79.3	77.7	75.2	76.6	27+50	23.8	20.2	20.0	19.9	22.8
55+00	161.9	160.8	150.9	160.9	163.4	41+00	78.8	75.6	74.6	74.0	75.6	27+00	22.6	20.1	19.2	19.2	21.9
54+50	145.1	144.1	141.8	143.6	144.9	40+50	76.1	74.2	71.9	71.5	74.2	26+50	22.7	20.5	18.7	19.2	21.1
54+00	140.3	139.7	141.0	141.3	143.6	40+00	72.0	71.6	69.3	69.9	70.8	26+00	22.6	20.1	17.7	18.5	20.3
53+50	141.1	138.3	138.7	138.7	141.5	39+50	69.0	69.0	66.4	66.9	69.5	25+50	21.6	19.4	19.1	17.3	19.3
53+00	140.2	137.0	136.5	136.8	138.9	39+00	66.5	66.5	63.8	64.6	66.8	25+00	20.7	18.5	18.6	16.6	18.6
52+50	138.1	135.1	134.2	134.7	136.7	38+50	64.0	64.0	61.6	62.1	64.1	24+50	19.4	17.4	17.7	17.5	19.0
52+00	134.6	132.5	133.5	132.7	135.2	38+00	61.6	61.6	59.2	59.4	61.4	24+00	18.4	16.5	16.8	17.3	20.5
51+50	131.6	130.4	131.2	130.6	131.9	37+50	59.0	59.0	56.9	56.9	58.9	23+50	18.4	16.1	15.7	16.9	19.3
51+00	132.0	129.2	129.1	129.5	133.1	37+00	56.5	56.5	54.7	54.0	56.4	23+00	17.8	15.4	15.1	16.7	18.8
50+50	135.4	127.8	126.9	128.4	130.1	36+50	54.5	54.0	52.5	53.0	54.2	22+50	16.5	14.6	16.0	15.7	17.6
50+00	128.1	125.7	126.0	125.6	129.0	36+00	53.0	51.5	50.3	48.4	50.1	22+00	15.4	13.9	15.4	14.6	16.3
49+50	124.1	124.0	122.9	122.7	124.7	35+50	50.2	49.0	48.0	45.7	47.2	21+50	16.6	14.1	14.1	14.1	15.5
49+22.52	122.1	120.8	121.0	120.7	122.3	35+00	48.0	46.8	45.6	43.5	44.9	21+00	16.6	15.2	13.6	13.5	15.4
48+72	121.7	119.1	117.6	116.4	117.5	34+50	47.4	45.2	44.5	42.7	45.0	20+50	16.4	13.4	12.8	12.8	15.0
48+00	117.4	115.1	113.1	111.2	113.5	34+00	45.3	43.5	42.0	41.1	43.5	20+00	15.0	13.1	13.1	11.9	13.9
47+50	113.0	111.8	109.1	109.0	110.0	33+50	43.0	42.2	40.6	39.9	41.9	19+50	14.2	12.0	12.5	12.0	13.7
47+00	108.6	108.4	105.7	106.6	109.1	33+00	40.8	40.5	38.8	38.6	40.3	19+00	13.1	11.0	11.3	11.9	15.1
46+50	106.1	105.5	102.7	104.5	106.3	32+50	39.1	39.1	37.3	37.9	39.6	18+50	12.2	10.6	10.9	12.2	13.5
46+00	102.7	102.7	99.5	101.2	103.5	32+00	37.7	37.7	36.0	36.2	37.8	18+00	11.4	10.0	10.6	11.3	13.8
45+50	99.6	99.6	97.0	97.9	99.5	31+50	35.6	35.6	33.5	34.0	35.7	17+50	11.2	9.1	10.4	11.2	14.2
45+00	96.6	96.6	94.3	94.3	94.7	31+00	33.6	33.6	32.1	31.8	33.9	17+00	12.6	10.4	10.5	11.2	13.7
44+50	98.2	94.3	92.0	90.6	91.8	30+50	31.7	31.7	30.2	29.5	31.8	16+50	12.8	10.3	9.8	10.9	13.6

(Continued)

Table 6 (Concluded)

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
16+00	12.9	10.0	9.3	10.2	12.5	2+00	8.5	7.5	7.4	7.1	8.6						
15+50	12.3	10.1	10.7	9.6	11.4	1+50	8.8	7.5	7.4	7.1	7.5						
15+00	12.1	9.8	10.3	8.3	9.7	1+00	8.3	6.6	6.2	6.2	7.8						
14+32.91	12.8	10.6	9.4	8.4	11.3	0+50		2.6	5.5	2.7							
14+00	11.9	10.1	9.0	9.7	11.0	0+00		1.9	0.3	1.9							
13+50	11.1	9.0	8.9	10.3	11.8	-0+50		2.5	2.3	2.2							
13+00	8.9	7.2	9.2	10.0	12.8	-1+00		2.8	2.2	2.1							
12+50	9.0	6.9	9.2	9.8	12.3	-1+50		2.5	2.2	2.1							
12+00	10.0	7.8	8.8	9.5	12.3	-2+00		2.5	2.5	2.5							
11+50	10.0	8.1	8.8	9.0	12.2												
11+00	9.4	7.8	8.2	8.5	10.8												
10+50	8.9	7.3	8.1	8.9	11.4												
10+00	9.1	7.2	7.6	9.0	11.4												
9+50	8.5	6.8	8.2	8.2	10.9												
9+00	10.3	8.0	7.4	7.4	9.5												
8+50	9.9	8.1	7.3	6.7	8.8												
8+23.61	9.9	7.7	7.9	6.5	8.3												
7+73.61	8.4	6.6	6.8	7.4	9.1												
7+00	9.0	6.5	6.5	6.3	7.8												
6+50	10.7	8.6	7.5	6.9	8.7												
6+00	8.8	7.0	7.3	6.7	7.4												
5+50	8.6	6.5	6.4	7.6	9.7												
5+00	7.8	6.1	7.2	7.5	9.6												
4+50	7.5	6.6	6.6	6.9	8.9												
4+00	7.6	6.5	6.7	6.9	8.6												
3+50	6.9	6.0	6.3	6.9	8.1												
3+00	8.3	6.9	7.1	7.3	8.8												
2+50	8.0	6.6	5.9	6.2	7.5												

Note: Sides of channel are referenced to downstream direction.

Table 7

Water-Surface Elevations, Discharge 8,800 cfs, n = 0.013, Recommended Design

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
61+00	176.2	175.2	175.8	176.3	176.8
60+00	163.3	162.5	162.9	162.6	162.6
59+00	159.0	156.8	158.4	156.3	159.0
58+00	154.2	150.2	150.4	148.3	154.8
57+00	164.8	161.8	160.5	162.3	166.1
56+00	165.1	162.2	161.9	162.3	165.1
55+00	162.9	161.8	151.8	162.0	164.5
54+50	147.4	146.0	145.8	146.0	148.0
54+00	143.1	142.2	142.8	143.6	144.2
53+50	141.4	140.0	140.8	140.5	143.0
53+00	141.5	138.7	137.4	138.2	140.4
52+50	139.6	136.6	135.5	135.9	138.0
52+00	135.1	133.9	135.5	133.9	135.9
51+50	132.3	131.7	132.6	131.7	132.3
51+00	134.1	130.8	130.3	130.8	134.1
50+50	131.1	129.1	127.9	129.5	131.1
50+00	129.9	127.1	127.1	126.7	128.8
49+50	125.1	123.5	124.9	123.6	125.6
48+72	121.8	120.3	118.9	117.5	119.3
48+00	119.1	116.0	113.8	112.6	115.4
47+50	114.0	112.0	111.0	110.5	111.2
47+00	109.9	108.7	107.1	107.5	109.8
46+50	105.9	105.4	103.6	105.5	106.5
46+00	102.7	102.6	100.5	102.5	103.9
45+50	99.9	99.6	98.8	98.9	100.9
45+00	96.8	96.6	95.9	95.8	96.8
44+50	95.7	94.2	93.1	91.8	92.4
44+00	95.2	92.7	90.8	89.1	91.0

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
43+50	92.9	90.7	87.9	86.4	88.1
43+00	89.9	88.3	85.1	83.5	84.7
42+50	87.7	85.5	82.9	80.7	81.8
42+00	84.8	83.0	81.8	78.5	79.6
41+50	82.1	80.1	79.5	76.1	77.3
41+00	78.6	77.1	76.5	74.4	75.3
40+50	75.8	74.4	73.5	72.4	74.1
40+00	73.8	71.9	70.8	70.1	72.4
39+50	71.1	68.9	68.1	68.7	69.4
39+00	67.2	66.1	65.1	65.6	67.4
38+50	64.0	64.0	63.3	63.0	64.7
38+00	61.6	61.6	61.6	60.7	61.0
37+50	59.4	59.0	58.5	57.4	59.4
37+00	58.2	56.7	55.9	55.7	56.6
36+50	55.9	54.8	53.3	52.5	53.8
36+00	53.8	52.5	50.7	50.0	52.2
35+50	51.8	50.2	48.8	47.3	48.6
35+00	49.2	47.7	47.2	44.1	45.5
34+50	47.7	46.2	45.2	43.0	44.6
34+00	47.1	45.0	43.8	41.7	43.0
33+50	44.8	43.1	41.8	40.6	41.4
33+00	41.1	43.0	40.2	39.4	40.8
32+50	41.3	39.0	38.9	38.4	39.8
32+00	37.5	39.2	37.1	37.0	38.1
31+50	36.3	35.7	35.2	34.8	36.1
31+00	34.6	33.7	33.3	33.1	34.3
30+50	32.1	31.6	31.5	30.9	32.7
30+00	31.0	29.7	29.1	28.8	30.4

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
29+48	29.8	28.0	27.0	26.5	27.6
28+98	26.7	24.9	25.7	25.6	27.0
28+48.91	24.1	22.2	23.7	24.6	26.8
28+00	24.7	21.6	21.8	22.2	23.3
27+50	23.8	22.2	21.5	20.7	21.3
27+00	22.9	22.2	20.1	19.2	20.2
26+50	23.8	21.9	19.6	19.6	21.2
26+00	23.4	21.4	19.1	19.3	20.7
25+50	22.3	20.4	20.1	18.1	19.5
25+00	21.5	19.7	19.3	17.4	18.8
24+50	20.2	18.5	18.8	18.0	21.0
24+00	19.2	17.5	17.9	18.6	20.6
23+50	18.2	17.0	16.8	18.1	19.5
23+00	18.3	16.5	16.5	17.2	20.6
22+50	17.6	15.6	16.5	16.9	19.0
22+00	17.3	14.9	15.8	16.1	17.5
21+50	18.0	15.5	15.5	15.1	16.6
21+00	18.2	16.2	14.6	14.4	16.5
20+50	18.0	14.6	13.8	13.7	15.5
20+00	17.1	14.6	14.6	13.1	15.2
19+50	16.2	13.1	13.3	12.5	14.2
19+00	14.5	12.3	12.9	13.3	15.0
18+50	13.3	11.5	12.0	12.8	15.5
18+00	12.4	11.0	11.5	12.7	14.6
17+50	12.3	10.5	12.0	12.9	14.9
17+00	13.2	10.6	12.0	12.2	15.8
16+50	13.3	11.7	11.3	11.7	14.0
16+00	13.2	11.5	10.3	11.2	13.4

(Continued)

Table 7 (Concluded)

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
15+50	13.8	11.7	11.7	10.7	12.4	1+50	10.7	8.8	8.6	8.2	10.3						
15+32.91	12.7	10.8	11.0	10.0	11.4	1+00	10.3	8.7	8.6	8.4	10.1						
14+82.91	12.4	10.7	10.1	8.7	9.9	0+50		2.8	6.1	2.6							
14+32.91	14.0	11.4	10.3	9.4	11.8	0+00		2.6	-0.2	0.9							
14+00	12.8	11.2	10.1	10.0	12.5	-0+50		2.4	0.1	2.4							
13+50	12.4	10.3	9.5	10.8	12.7	-1+00		2.9	3.3	2.7							
13+00	10.7	8.7	9.9	11.4	13.8	-1+50		3.0	2.9	3.0							
12+50	10.4	8.1	9.6	10.7	14.0	-2+00		2.6	2.6	2.6							
12+00	11.3	8.6	9.9	10.8	13.5												
11+50	10.5	8.5	9.6	10.4	13.2												
11+00	11.8	9.2	9.5	9.9	12.1												
10+50	11.3	8.9	9.4	9.3	11.7												
10+00	10.4	8.6	9.1	9.9	12.3												
9+50	11.0	8.4	9.5	9.9	12.2												
9+00	10.9	8.7	9.1	9.3	11.5												
8+50	12.6	9.6	9.1	9.0	10.9												
7+33.61	11.7	9.2	9.4	8.6	9.9												
7+00	11.6	9.4	8.1	8.9	10.7												
6+50	11.1	8.3	8.5	8.3	10.3												
6+00	10.4	8.0	8.3	8.5	11.8												
5+50	10.5	7.8	7.8	8.7	11.2												
5+00	10.1	10.1	8.2	8.0	9.7												
4+50	8.4	7.4	7.8	8.3	9.9												
4+00	9.1	7.7	8.0	8.5	10.7												
3+50	9.0	7.2	7.9	8.5	10.5												
3+00	9.6	8.2	8.5	8.8	11.2												
2+50	9.7	7.5	7.2	7.6	10.3												
2+00	10.3	8.5	8.5	8.3	10.2												

Note: Sides of channel are referenced to downstream direction.

Table 8

Water-Surface Elevations, Discharge 15,200 cfs, n = 0.013, Recommended Design

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
61+00	178.5	177.4	176.8	178.0	178.7	44+00	96.4	93.8	91.8	90.7	92.5	30+00	32.0	30.5	28.6	28.6	30.1
60+00	166.9	163.8	165.6	162.2	165.4	43+50	94.6	91.1	88.8	87.8	88.6	29+48.91	31.0	29.0	26.9	26.3	27.5
59+00	163.4	160.3	164.2	159.4	163.5	43+00	92.1	89.1	86.1	84.7	85.5	29+00	29.3	27.2	27.8	27.8	29.4
58+00	158.5	154.5	154.3	155.0	157.9	42+50	90.5	86.7	83.4	81.7	83.0	28+48.91	28.0	24.6	23.4	24.7	27.5
57+00	169.6	163.9	164.0	165.1	170.2	42+00	88.0	85.1	82.9	79.5	80.9	28+00	24.4	21.3	21.5	22.1	24.6
56+00	169.4	165.1	164.3	164.0	171.0	41+50	85.5	82.6	80.0	77.0	78.0	27+50	25.3	21.9	20.9	20.4	22.8
55+00	171.2	168.0	157.1	166.8	172.3	41+00	81.9	79.1	75.9	74.8	77.2	27+00	22.8	21.9	19.9	19.3	21.1
54+50	153.2	150.0	149.8	149.6	151.7	40+50	76.1	74.3	73.7	72.8	73.5	26+50	24.4	21.7	19.3	19.4	21.2
54+00	145.7	144.9	146.1	146.9	148.2	40+00	73.5	72.0	70.9	69.9	72.3	26+00	23.7	21.1	18.1	18.9	20.7
53+50	143.2	141.6	142.4	142.0	146.4	39+50	71.1	69.2	67.5	68.7	70.6	25+50	23.4	20.3	19.5	17.7	19.9
53+00	146.5	139.7	139.0	140.3	145.1	39+00	67.6	66.7	64.9	65.6	67.4	25+00	21.7	19.4	18.6	17.0	18.6
52+50	141.7	138.8	137.1	138.5	140.8	38+50	66.0	64.4	63.4	62.8	64.9	24+50	21.2	18.1	18.3	18.1	20.2
52+00	138.2	135.1	137.8	135.5	137.6	38+00	63.4	61.7	61.6	60.7	61.9	24+00	19.0	16.9	17.7	18.0	21.5
51+50	134.9	133.6	134.1	133.1	134.3	37+50	60.5	59.5	58.4	57.6	60.3	23+50	18.4	16.4	16.5	18.0	19.7
51+00	137.2	131.8	131.8	132.2	136.8	37+00	58.4	57.0	56.1	55.3	57.4	23+00	19.1	16.1	15.9	17.2	20.6
50+50	135.3	131.1	129.4	130.7	136.1	36+50	56.3	54.3	52.8	52.3	54.2	22+50	18.0	15.1	16.7	17.1	19.3
50+00	130.6	128.4	128.5	129.3	131.8	36+00	53.9	52.1	50.3	49.7	51.8	22+00	16.3	14.1	15.1	15.8	17.7
49+50	127.1	124.4	126.8	125.9	127.8	35+50	52.2	49.6	48.1	47.0	48.5	21+50	16.9	14.8	15.4	14.7	16.6
49+22.52	125.2	123.1	124.8	123.2	125.2	35+00	50.0	47.4	46.2	44.2	46.1	21+00	18.7	14.5	14.3	14.0	15.7
48+72	122.4	121.4	120.2	119.6	120.8	34+50	48.1	45.9	45.0	42.6	44.4	20+50	17.0	15.5	13.4	13.2	15.5
48+00	123.9	119.3	116.3	115.1	118.6	34+00	46.8	44.5	43.1	41.2	42.6	20+00	17.6	14.4	13.7	12.8	14.9
47+50	119.6	114.7	112.4	115.7	120.7	33+50	44.9	42.9	41.6	40.0	41.3	19+50	15.2	13.2	13.5	12.3	14.1
47+00	113.9	110.9	109.7	110.6	111.3	33+00	43.1	41.0	39.7	39.0	40.5	19+00	14.6	12.1	12.5	12.5	13.7
46+50	109.0	107.2	108.5	107.7	108.8	32+50	40.5	39.5	38.6	37.8	41.0	18+50	12.7	11.3	11.7	12.5	15.6
46+00	105.7	103.8	105.3	104.4	106.7	32+00	40.0	39.0	37.0	36.7	38.5	18+00	12.3	10.7	11.1	12.8	14.6
45+50	102.2	100.3	101.3	101.9	103.7	31+50	38.0	36.0	35.0	34.8	36.0	17+50	12.0	9.8	11.0	12.4	16.0
45+00	99.6	97.8	98.0	98.3	100.2	31+00	36.0	34.0	33.1	32.6	34.4	17+00	12.3	9.5	11.9	11.2	15.5
44+50	100.5	94.0	94.4	93.5	95.1	30+50	34.5	32.4	31.1	30.8	33.1	16+50	13.9	10.2	10.9	11.6	16.0

(Continued)

Table 8 (Concluded)

Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side	Station	High-Water Mark Left Side	Water Surface Left Side	Center Line	Water Surface Right Side	High-Water Mark Right Side
16+00	14.8	11.4	9.8	10.7	13.7	2+00	10.4	7.8	7.2	8.7	10.5						
15+50	13.5	11.4	10.4	10.4	12.4	1+50	10.7	8.1	8.0	8.2	10.5						
15+00	13.7	10.6	11.2	8.9	10.8	1+100	11.0	7.3	7.2	8.5	10.5						
14+32.91	14.2	11.0	10.1	8.9	10.0	0+50		3.6	7.5	3.8							
14+00	13.7	11.0	9.7	8.7	12.9	0+00		0.7	1.0	1.0							
13+50	12.2	9.9	8.9	11.0	12.1	-0+50		1.2	2.1	1.8							
13+00	9.8	8.2	9.3	10.2	13.3	-1+00		1.6	0.9	2.2							
12+50	9.1	7.8	9.8	11.0	13.6	-1+50		2.8	2.6	2.6							
12+00	11.2	7.3	9.5	10.2	13.4	-2+00		3.0	3.0	3.0							
11+50	11.7	9.1	9.0	10.2	12.8												
11+00	11.7	8.7	9.1	9.3	11.9												
10+50	11.0	8.5	9.2	9.0	10.5												
10+00	11.2	8.7	8.7	9.0	11.2												
9+50	10.3	8.2	8.5	9.0	12.5												
9+00	10.5	8.4	8.7	9.0	10.7												
8+50	11.1	9.0	8.4	8.4	10.9												
8+32.61	12.1	9.1	8.6	8.5	10.7												
7+73.61	11.1	8.8	8.6	7.7	10.0												
7+00	12.0	8.9	8.1	7.9	9.8												
6+50	10.8	8.1	8.0	7.9	10.0												
6+00	9.4	7.4	7.8	7.7	10.9												
5+50	8.6	7.3	7.4	8.7	11.0												
5+00	9.4	7.3	7.8	9.8	11.5												
4+50	7.8	7.1	7.1	9.3	11.0												
4+00	9.3	7.3	7.3	9.4	12.0												
3+50	8.1	6.7	7.2	10.7	12.5												
3+00	9.3	7.8	7.1	10.0	11.5												
2+50	9.3	6.9	7.0	8.5	10.0												

NOTE: Sides of channel are referenced to downstream direction.

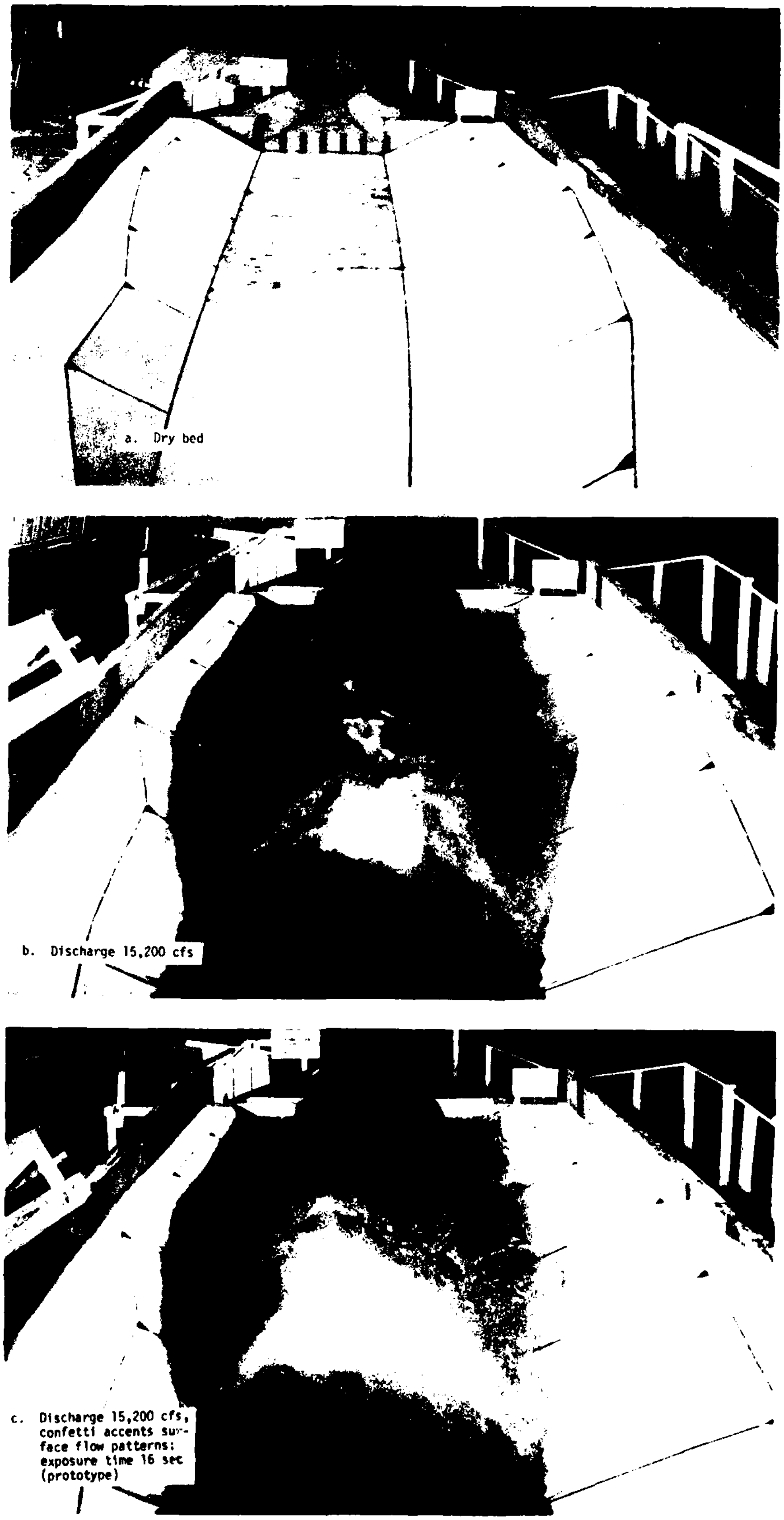


Photo 1. Debris basin with type 1 design weir and transition

a. Dry bed, looking upstream

b. Looking downstream at cross waves in the transition section; discharge 15,200 cfs

Photo 2. Type 1 design weir and transition

Photo 3. Flow conditions in the type 22 design weir and transition; discharge 15,200 cfs

Photo 4. Flow conditions just downstream of the type 22 design weir and transition; discharge 15,200 cfs

a. Discharge 15,200 cfs

b. Discharge 15,200 cfs, confetti accents surface flow patterns; exposure time 16 sec (prototype)

Photo 5. Flow conditions in the debris basin with the type 22 design weir and transition

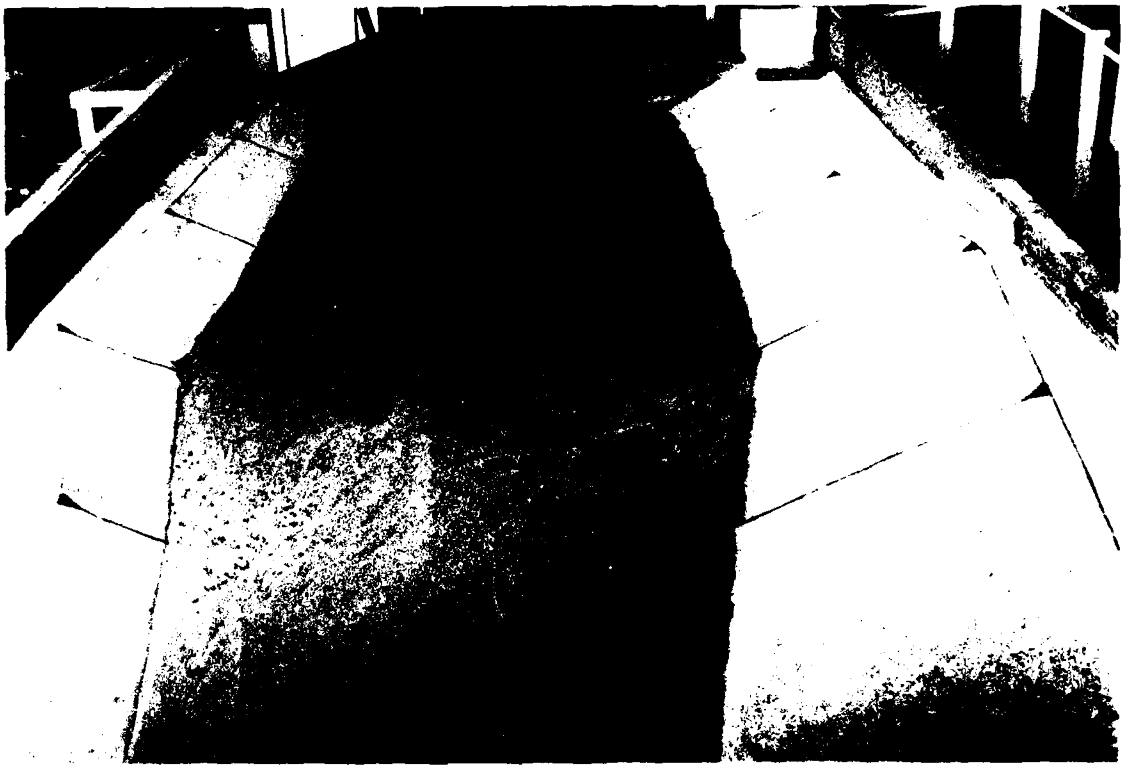
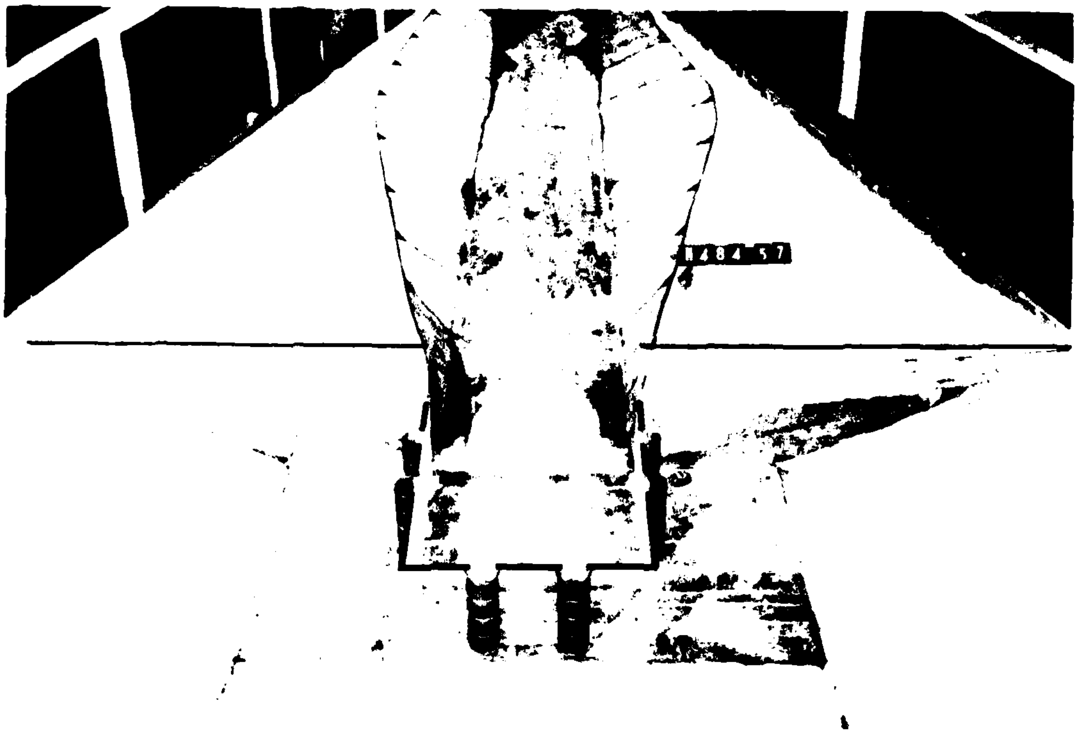
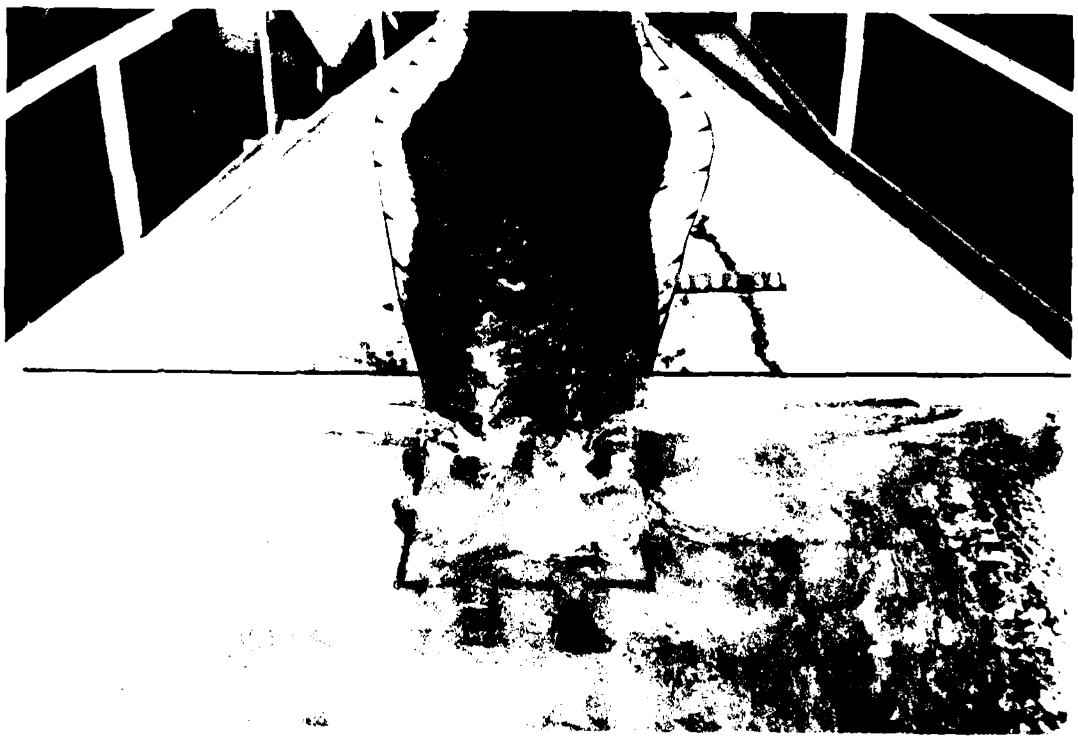


Photo 6. Debris basin after debris test during SPF hydrograph with the type 22 weir and transition design



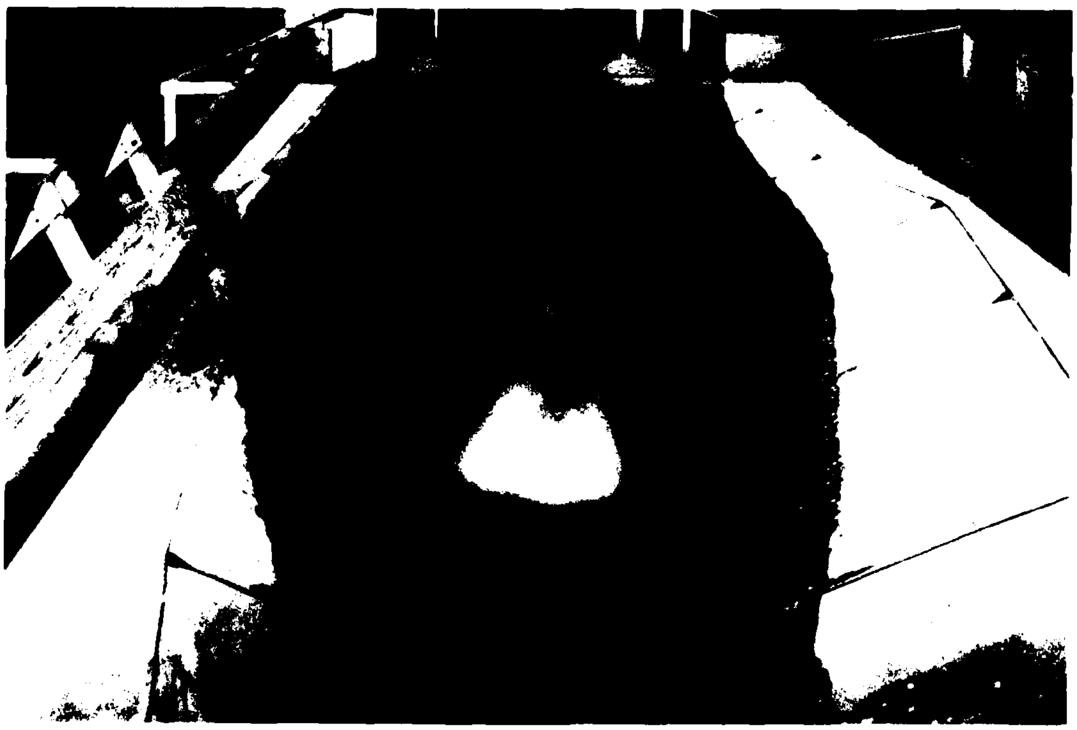
a. Dry bed



b. Discharge 15,200 cfs

Photo 7. Looking downstream at the type 24 design weir and transition

a. Discharge 15,200 cfs



b. Discharge 15,200 cfs, confetti accents surface flow patterns; exposure time 16 sec (prototype)

Photo 8. Flow conditions in debris basin with the type 24 design weir and transition

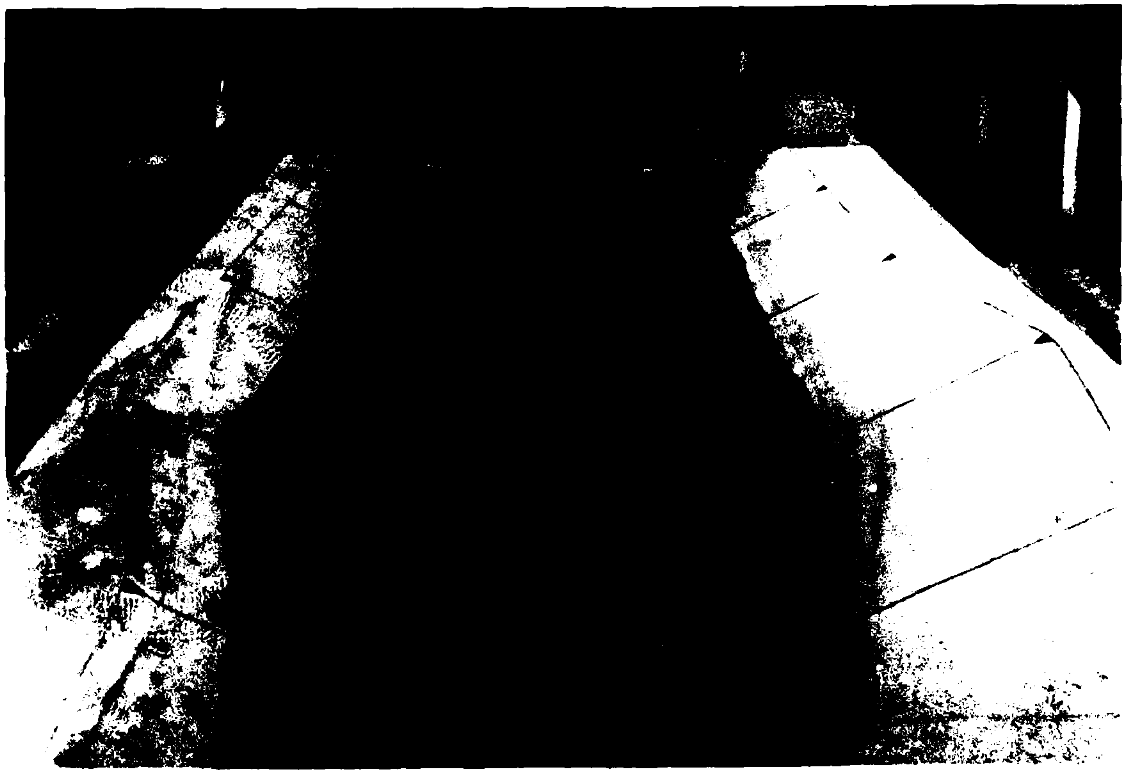
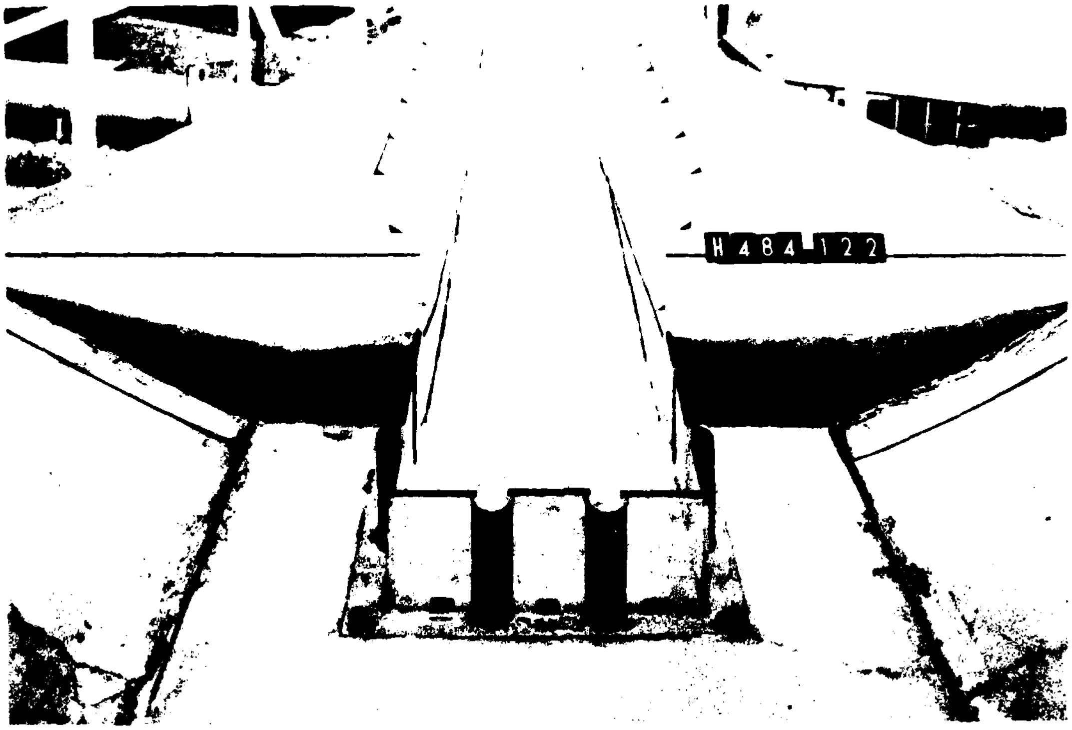
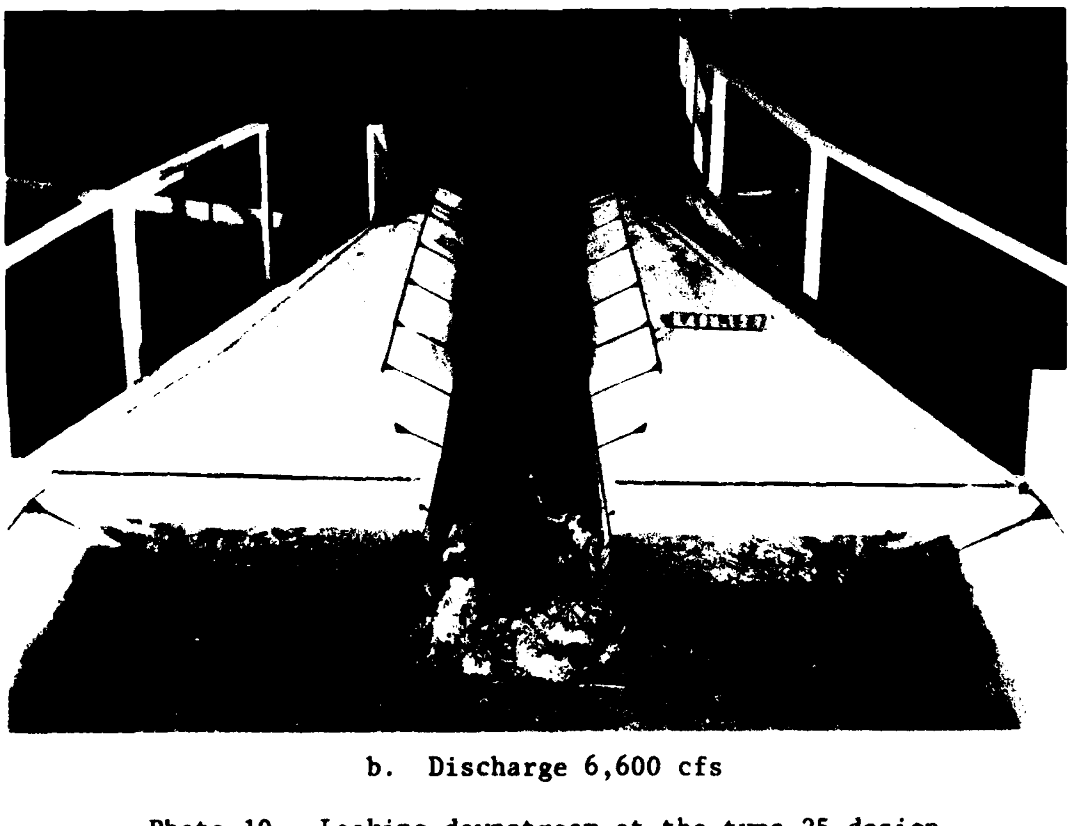


Photo 9. Debris basin after debris test during SPF hydrograph with the type 24 design weir and transition

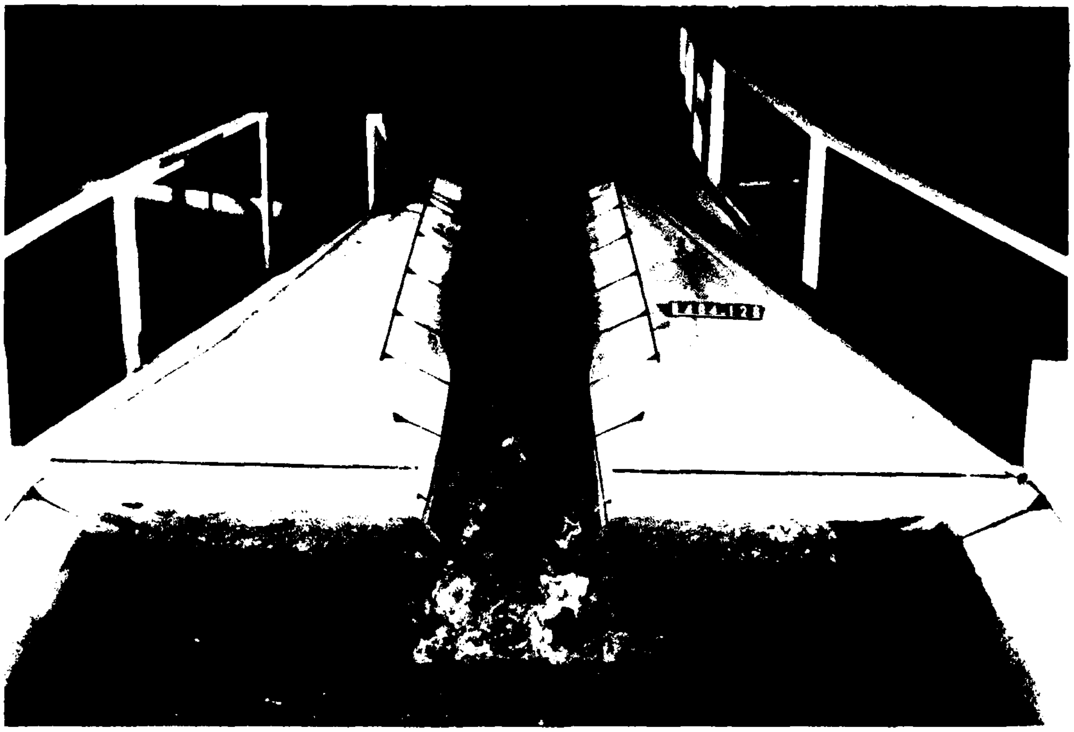


a. Dry bed

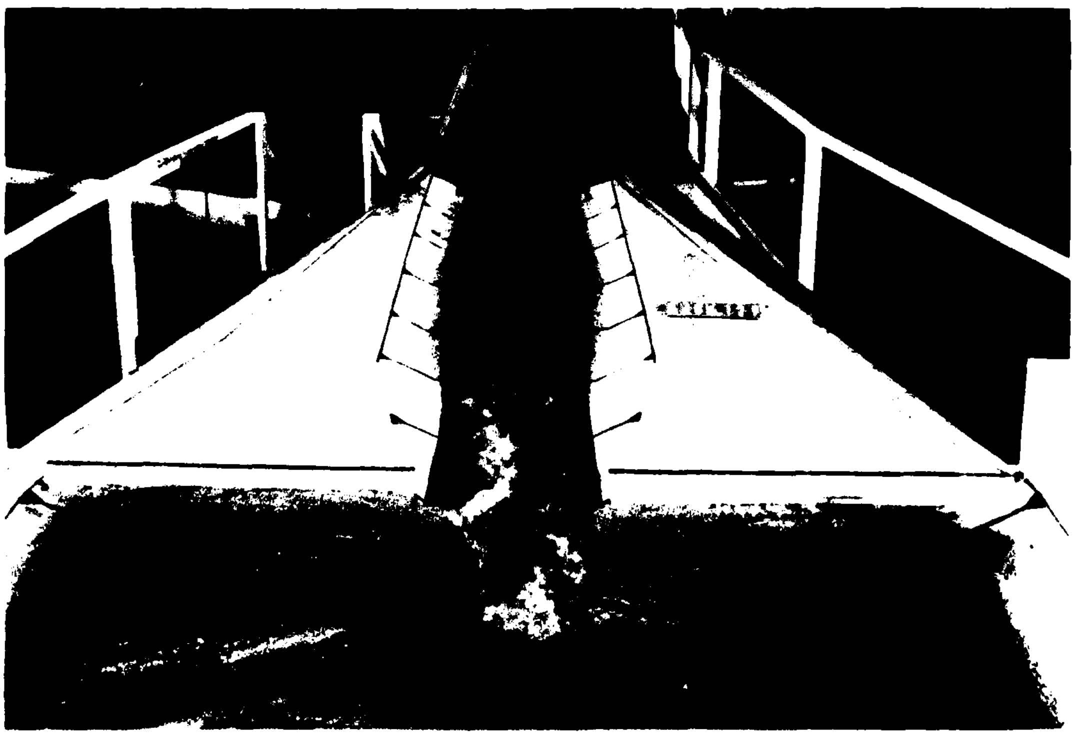


b. Discharge 6,600 cfs

Photo 10. Looking downstream at the type 25 design weir and transition (Sheet 1 of 2)

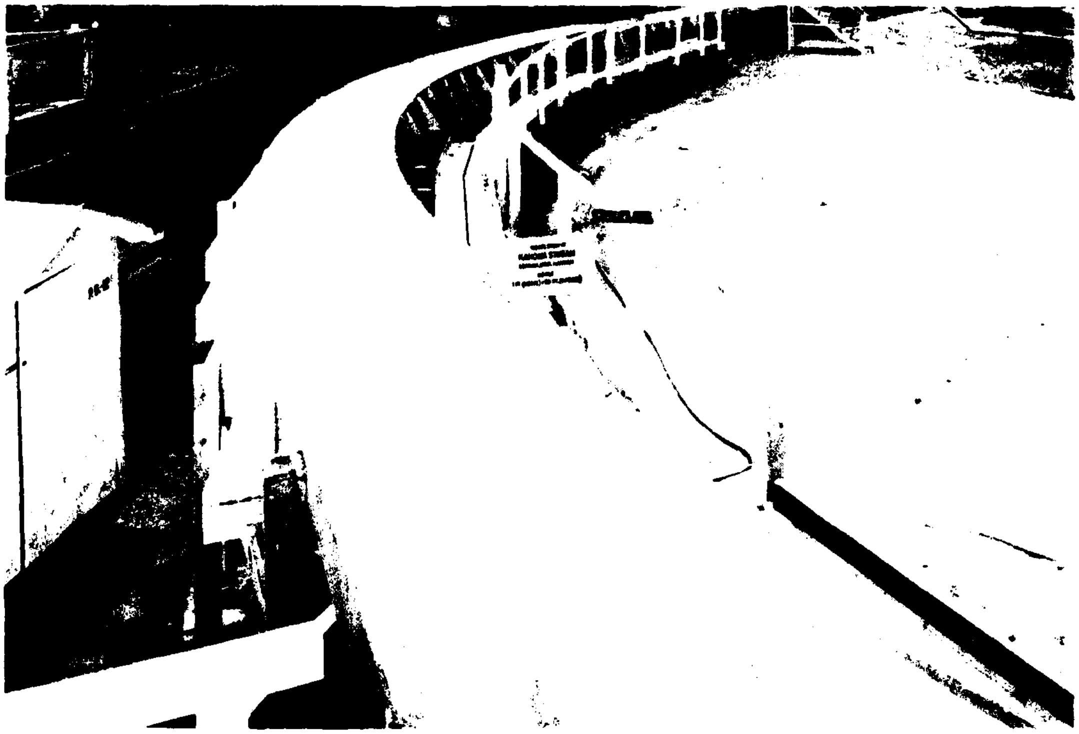


c. Discharge 8,800 cfs



d. Discharge 15,200 cfs

Photo 10. (Sheet 2 of 2)

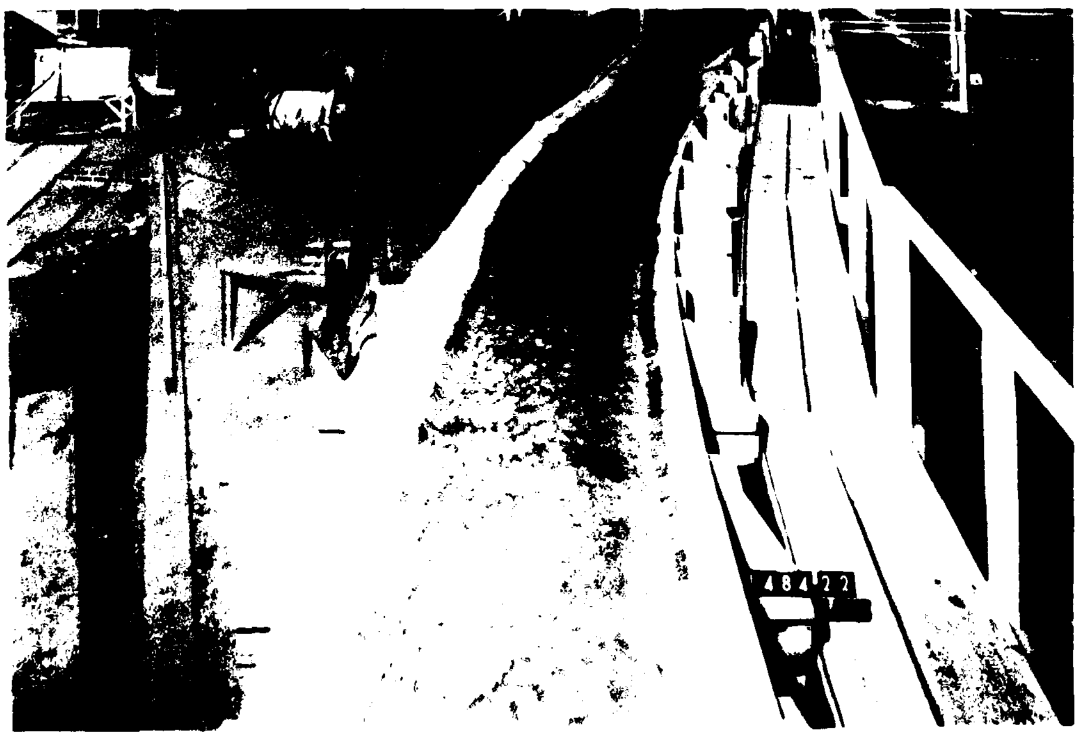


a. Dry bed

b. Discharge 15,200 cfs, n = 0.015

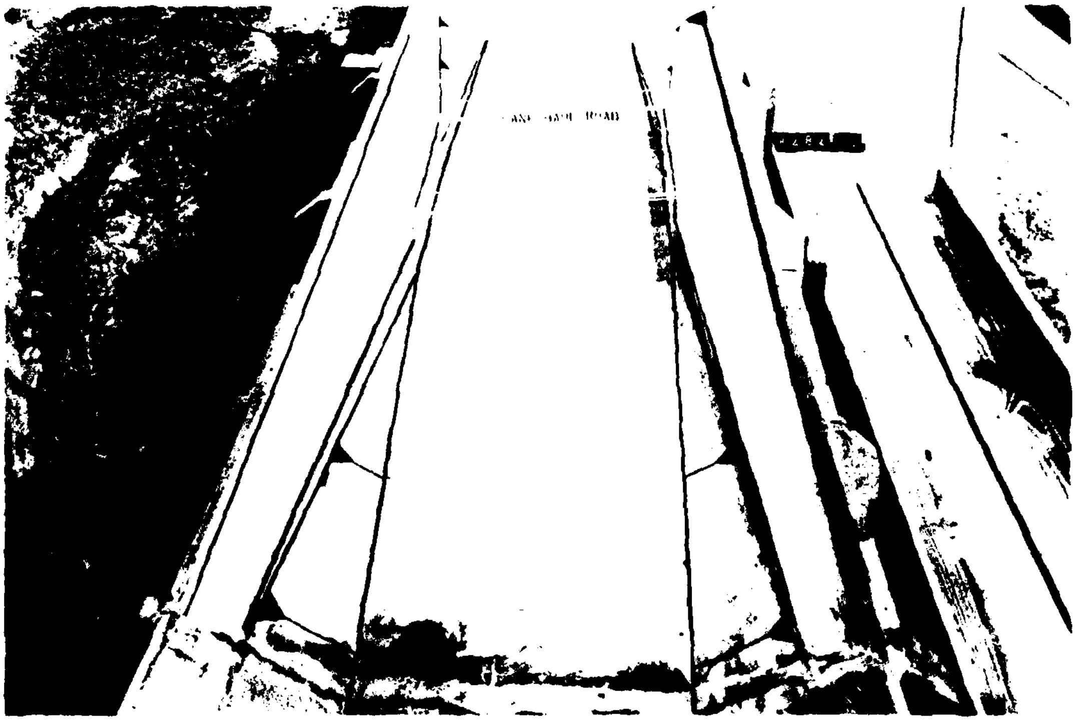
Photo 11. High-velocity channel between sta 51+50 and 35+00

a. Dry bed

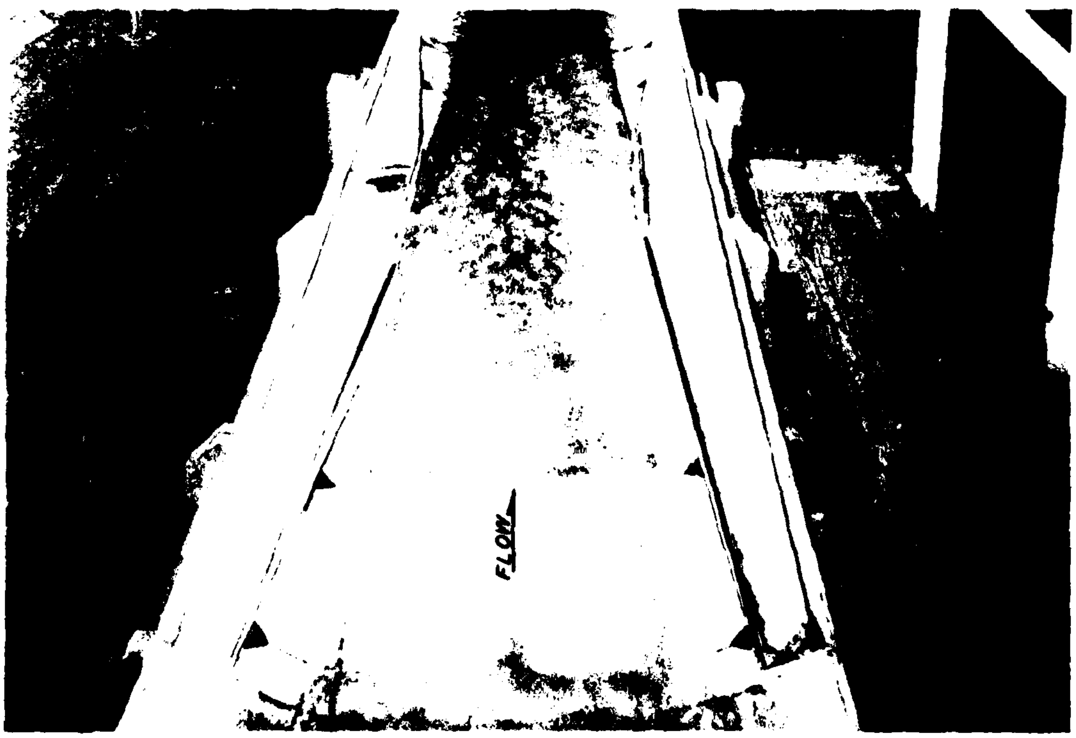


b. Discharge 15,200 cfs, n = 0.015

Photo 12. High-velocity channel between sta 35+00 and 29+50



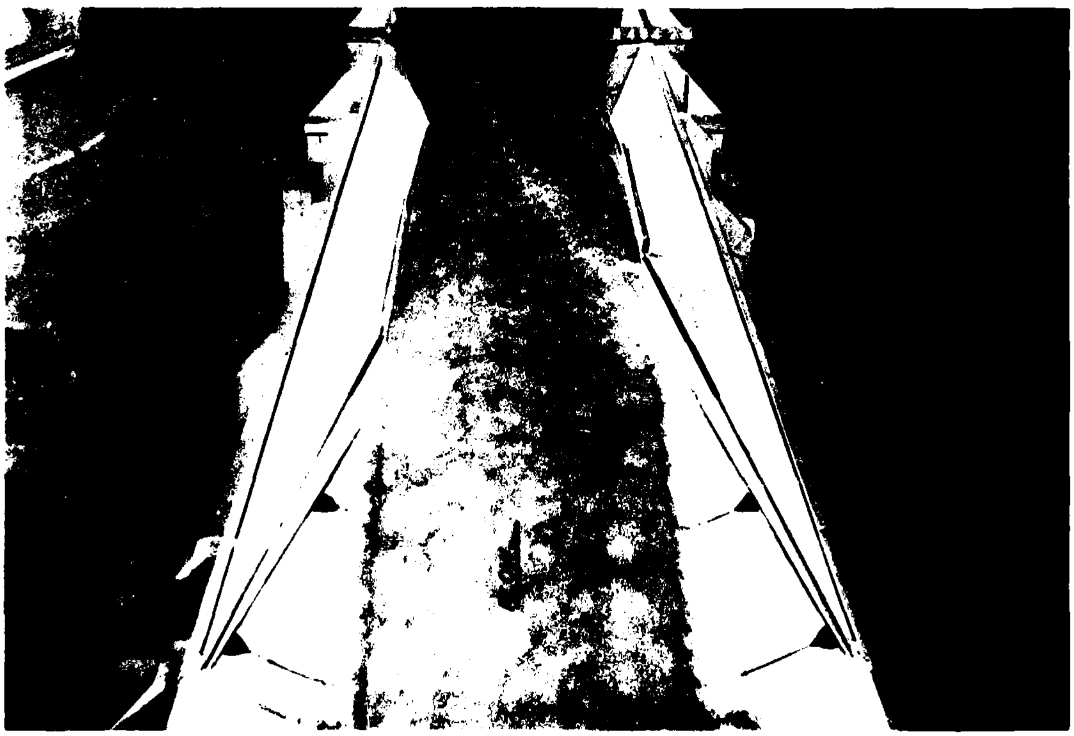
a. Dry bed



b. Discharge 15,200 cfs, n = 0.015

Photo 13. Cane Haul Road Bridge with type 1 design bridge transition between sta 28+48.91 and 26+00

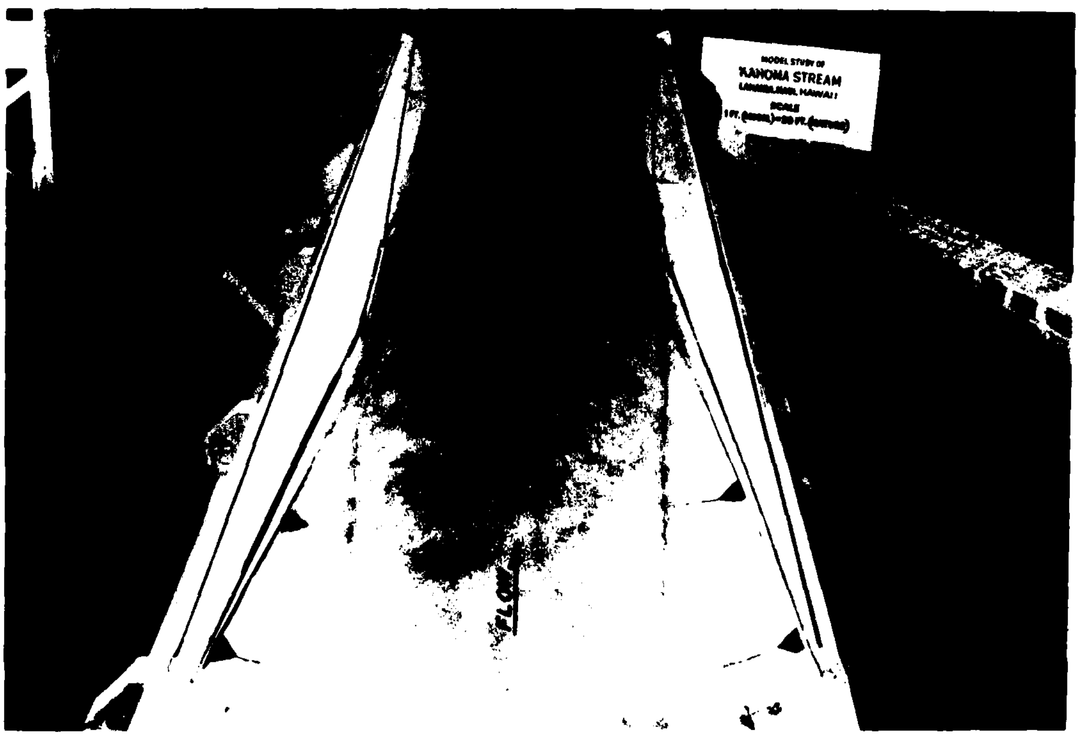
a. Dry bed



b. Discharge 15,200 cfs, n = 0.015

Photo 14. Honoapiilani Highway Bridge with the type 1 bridge transition between sta 18+00 and 15+32.91

a. Dry bed



b. Discharge 15,200 cfs, n = 0.015

Photo 15. Front Street Bridge with the type 1 design bridge transition between sta 7+23.61 and 4+50

a. Dry bed

b. Discharge 15,200 cfs, n = 0.015

Photo 16. High-velocity channel between sta 26+00 and 18+00

a. Dry bed

b. Discharge 15,200 cfs, n = 0.015

Photo 17. High-velocity channel between sta 15+32.91 and 7+23.61

a. Dry bed

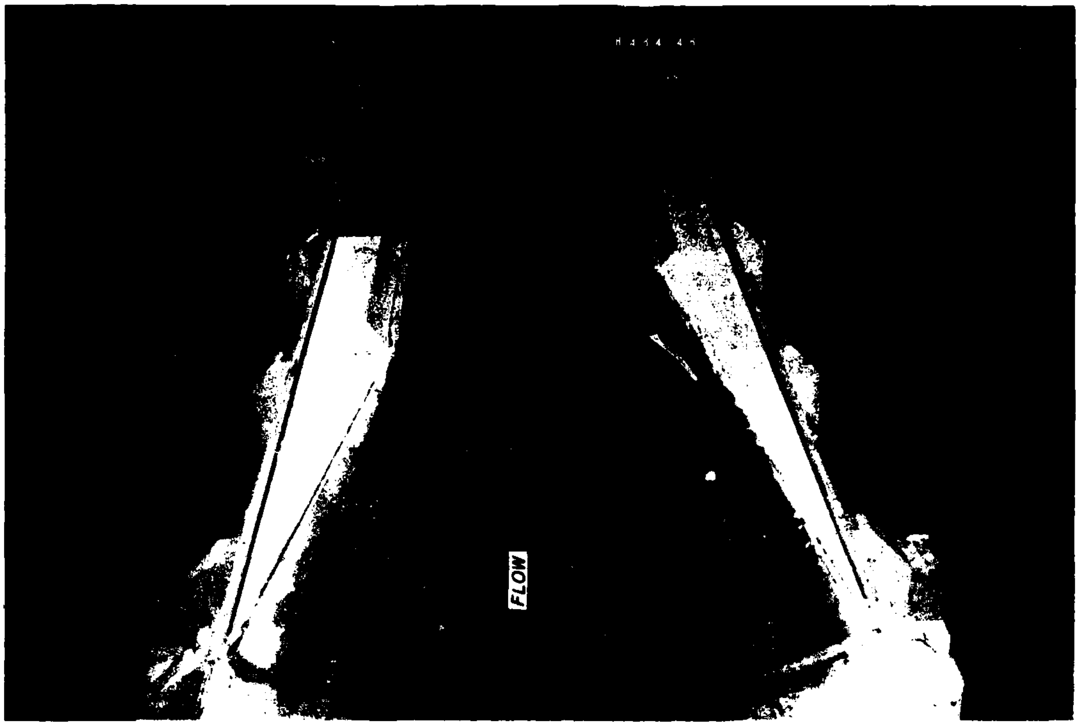
b. Discharge 15,200 cfs, n = 0.015

Photo 18. High-velocity channel between sta 4+50 and 1+20

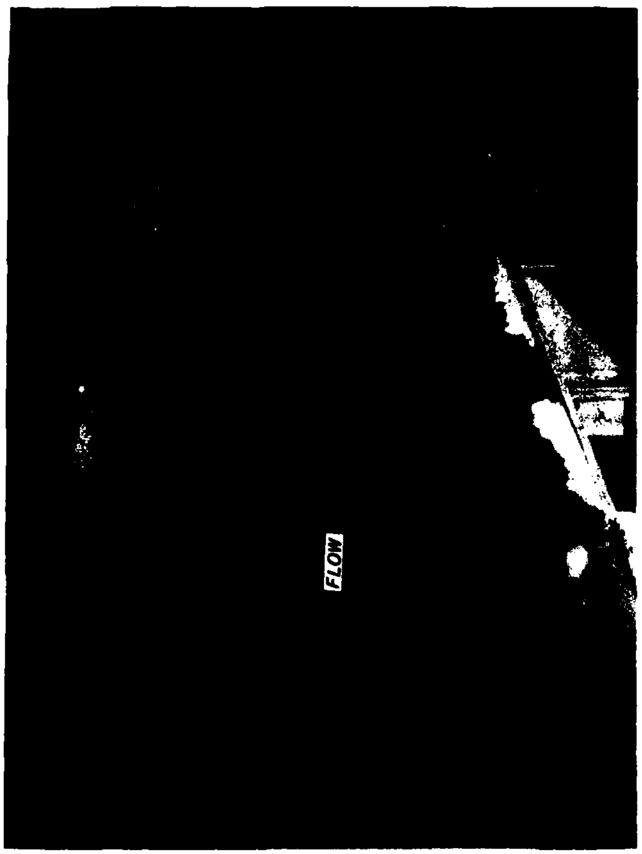
a. At Cane Haul Road Bridge between sta 28+48.91 and 26+00

b. Between sta 26+00 and 18+00

Photo 19. Flow conditions with the type 5 design bridge transition installed; discharge 15,200 cfs, n = 0.015 (Sheet 1 of 3)

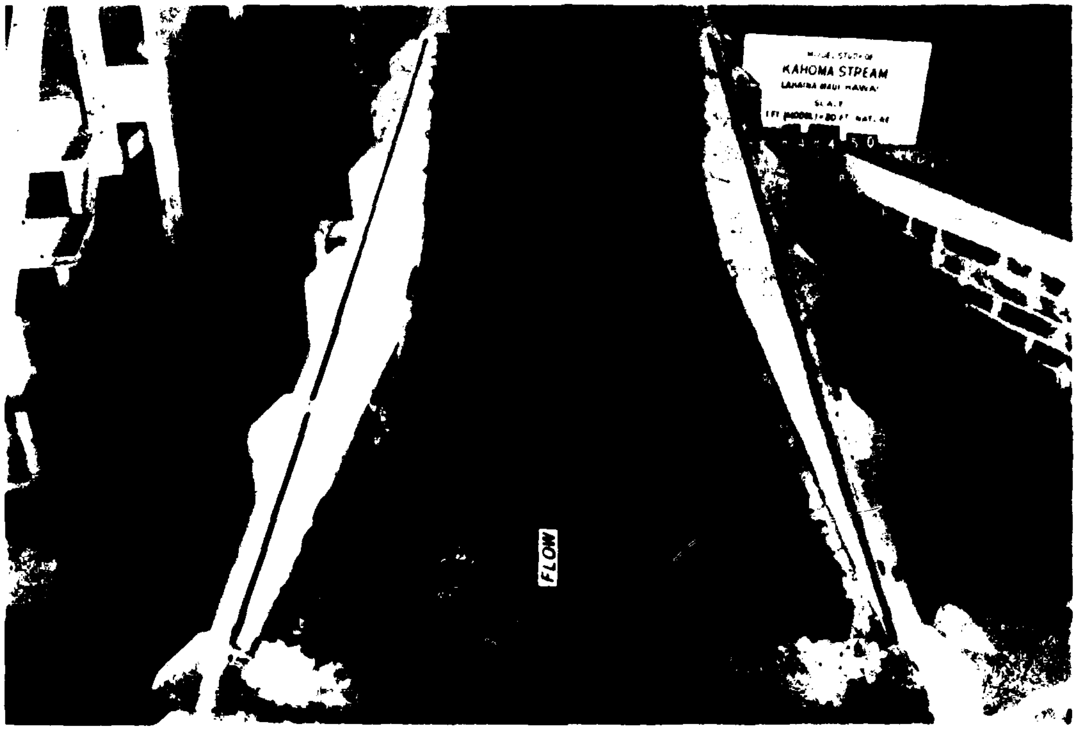


c. At Honoapiilani Highway Bridge between sta 18+00 and 15+32.91

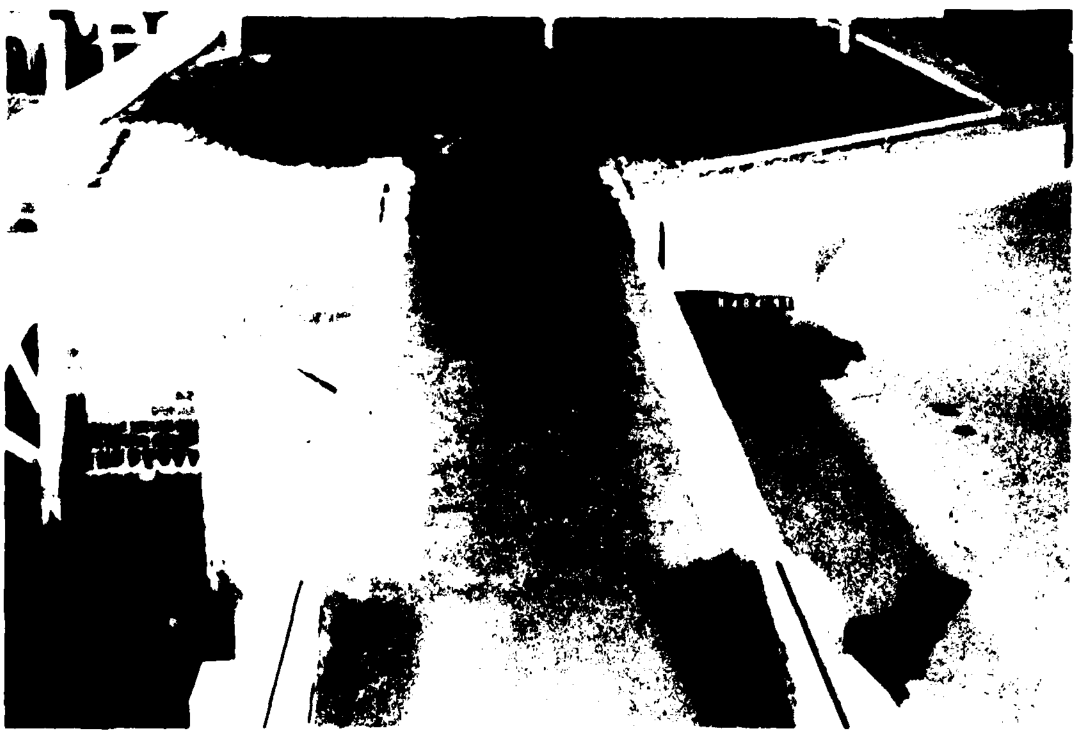


d. Between sta 15+32.91 and 7+23.61

Photo 19. (Sheet 2 of 3)



e. At Front Street Bridge between sta 7+23.61 and 4+50



f. Between sta 4+50 and 1+20

Photo 19. (Sheet 3 of 3)

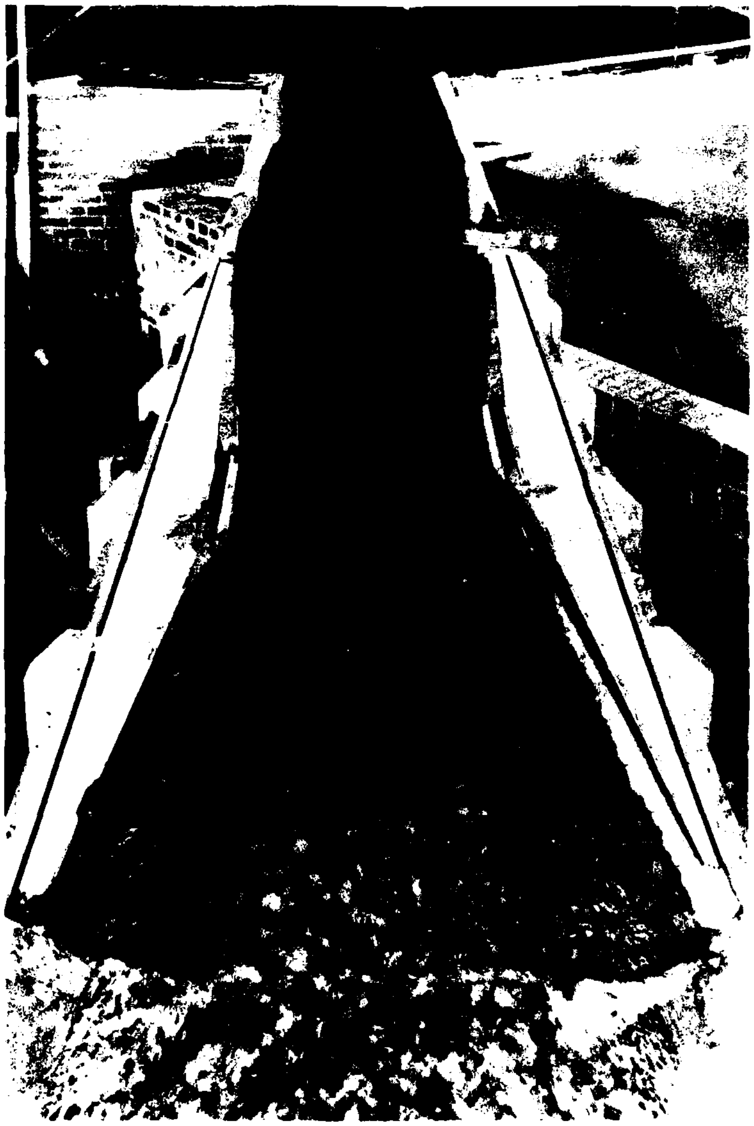


Photo 20. Flow conditions at Front Street Bridge with the 60-ft-wide type 5 design bridge transition; discharge 15,200 cfs, n = 0.015

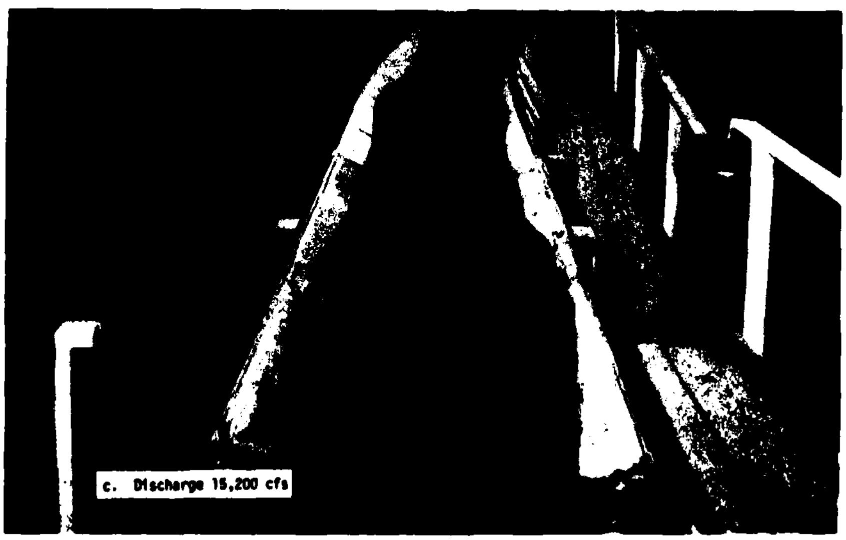


Photo 21. Looking downstream from sta 51+60 at flow conditions in the high-velocity channel; n = 0.013

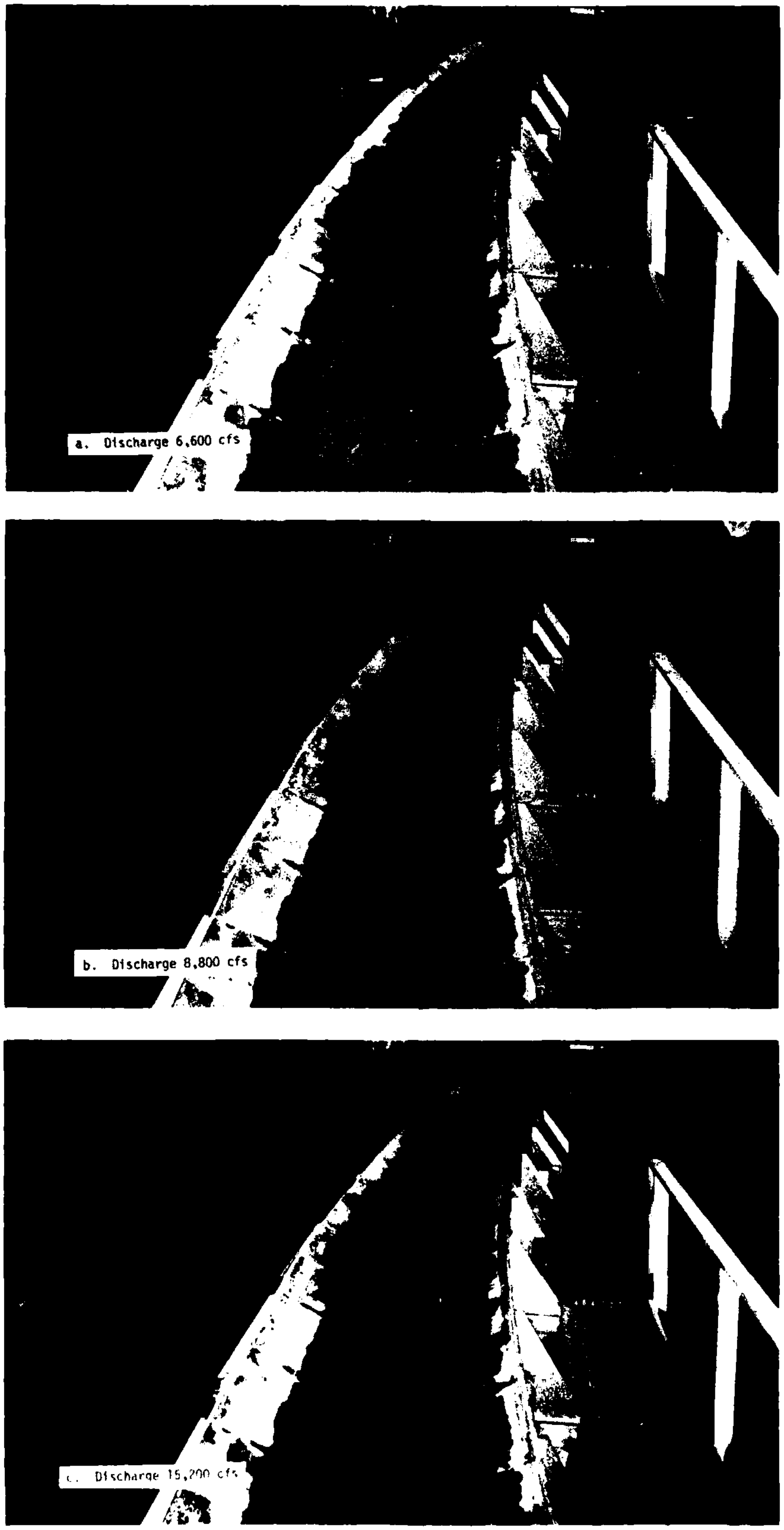
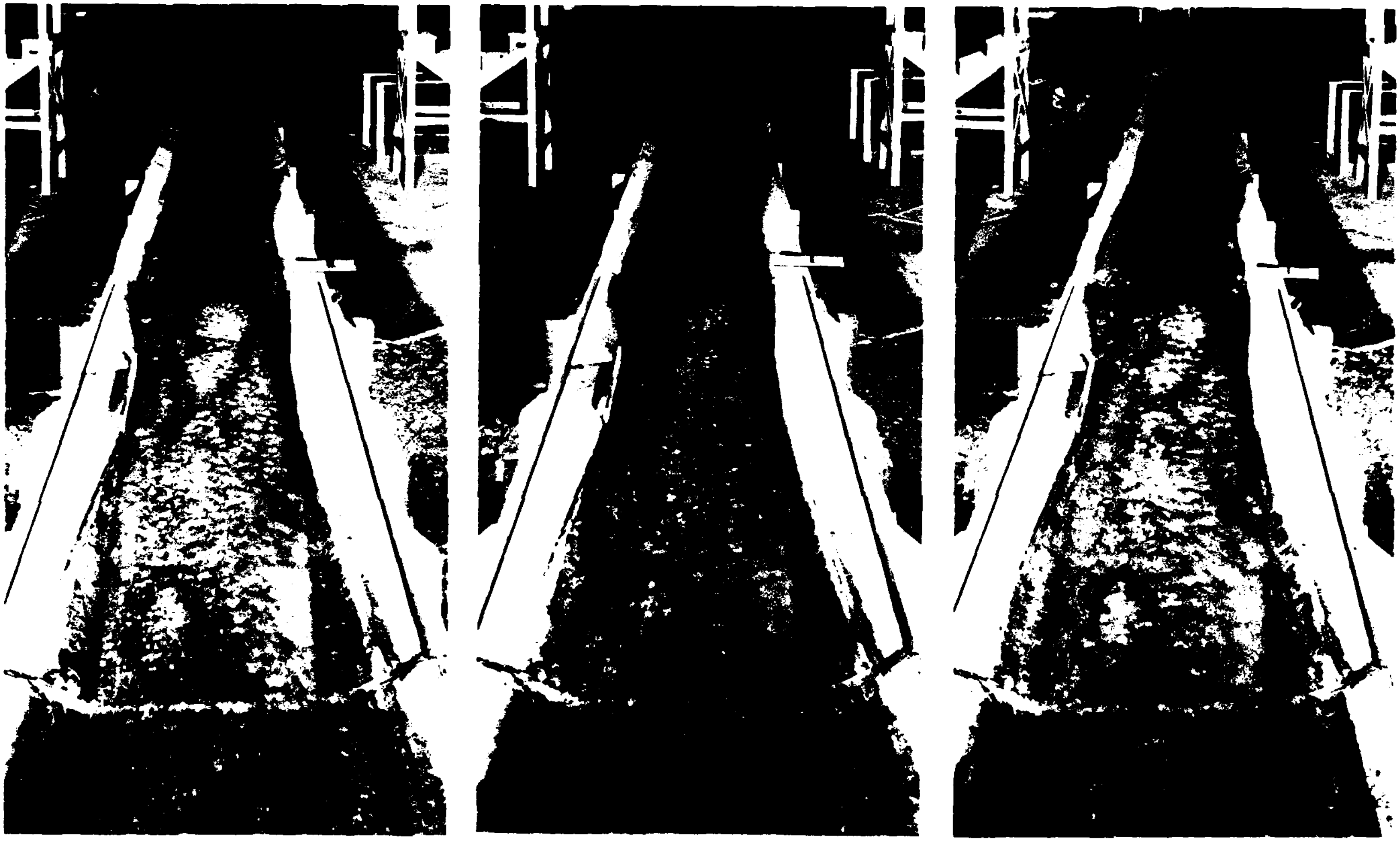
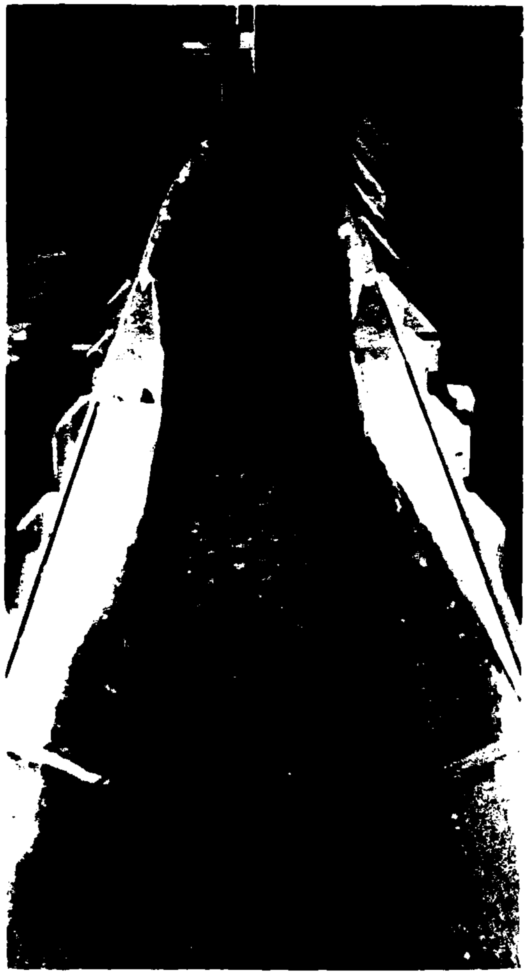


Photo 22. Looking downstream from sta 38+00 at flow conditions in the high-velocity channel; n = 0.013



a. Discharge 6,600 cfs   b. Discharge 8,800 cfs   c. Discharge 15,200 cfs

Photo 23. Looking downstream from sta 29+00 at flow conditions in the high-velocity channel; n = 0.013

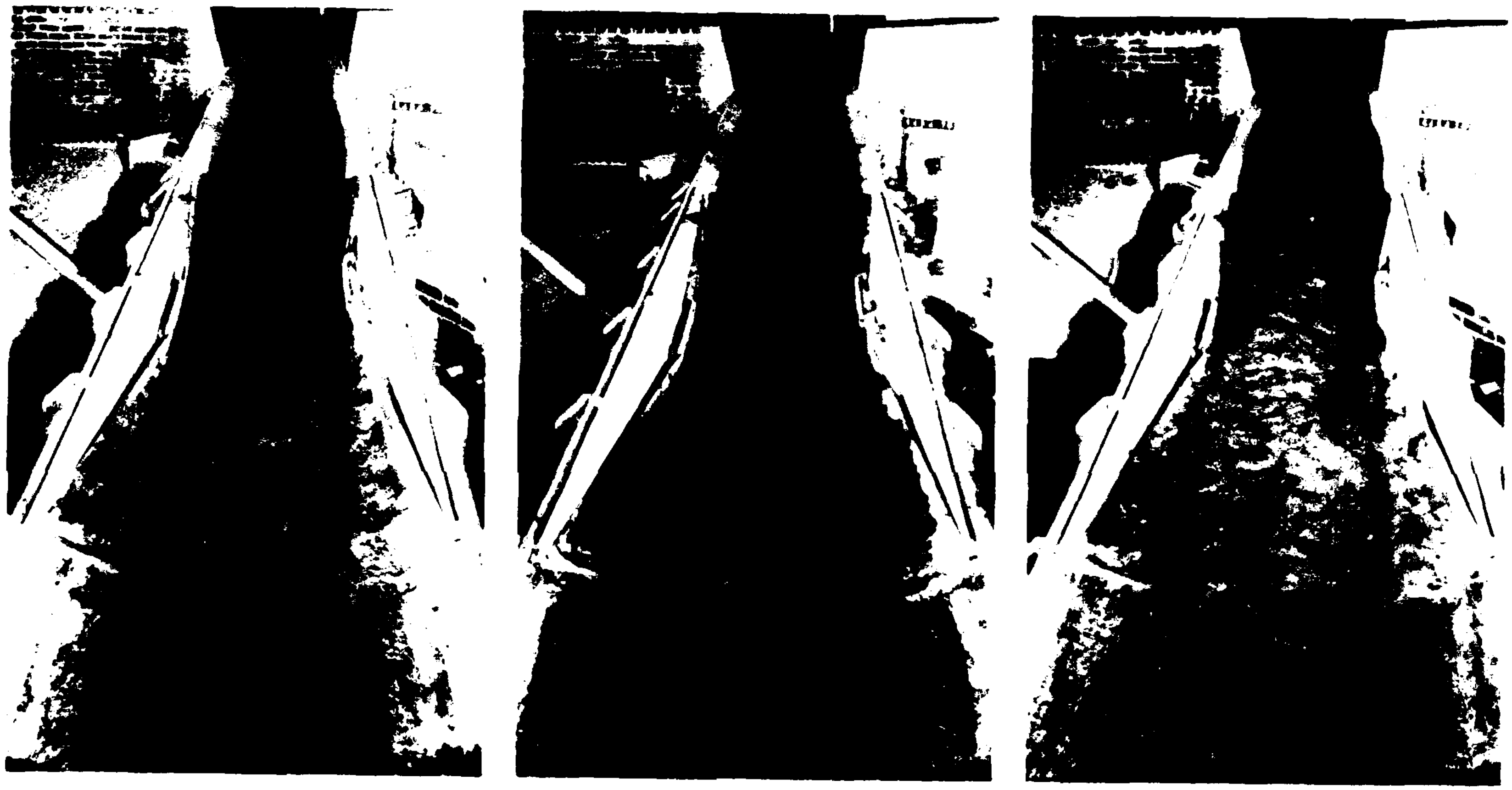


a. Discharge 6,600 cfs

b. Discharge 8,800 cfs

c. Discharge 15,200 cfs

Photo 24. Looking downstream from sta 18+50 at flow conditions in the high-velocity channel; $n = 0.013$



a. Discharge 6,600 cfs

b. Discharge 8,800 cfs

c. Discharge 15,200 cfs

Photo 25. Looking downstream from sta 7+75 at flow conditions in the high-velocity channel; n = 0.013

Photo 26. 6-in.-high stones placed on channel invert between sta 4+50 and 0+85

a. Dry bed

b. Discharge 6,600 cfs

Photo 27. Warped surface extension and vertical wall modification downstream of sta 4+50 (Sheet 1 of 2)

c. Discharge 8,800 cfs

d. Discharge 15,200 cfs

Photo 27. (Sheet 2 of 2)

Photo 28. Offshore area (original design)

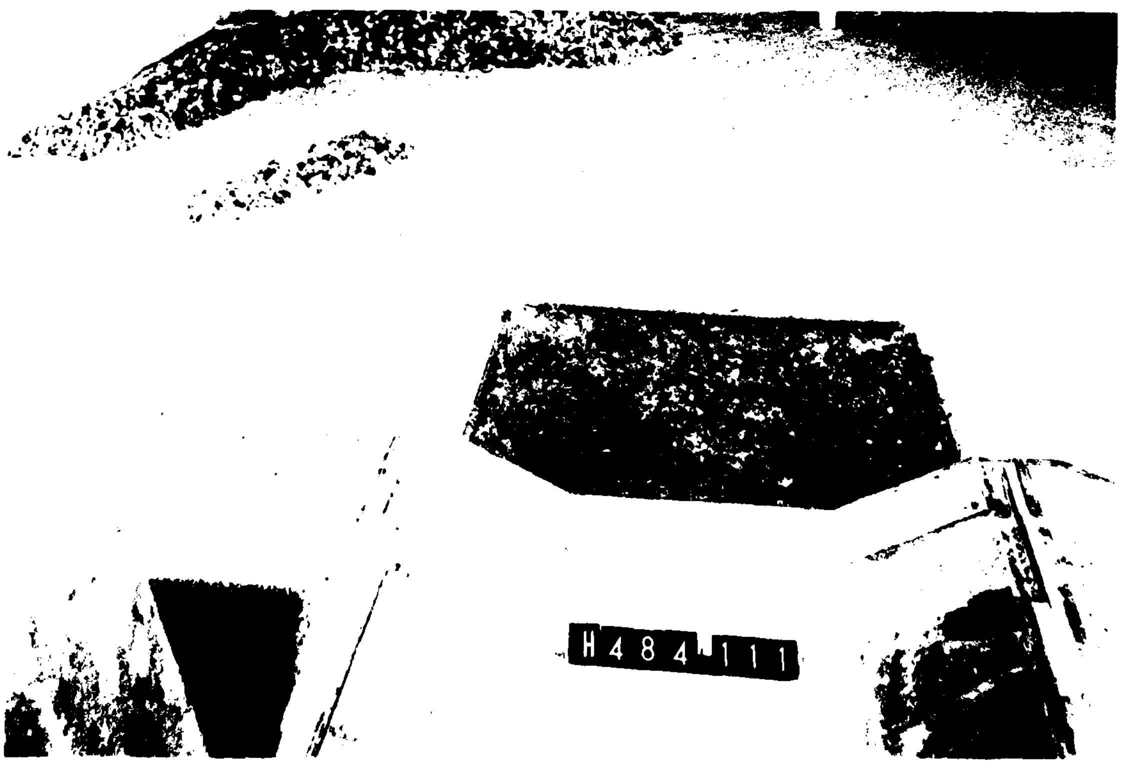
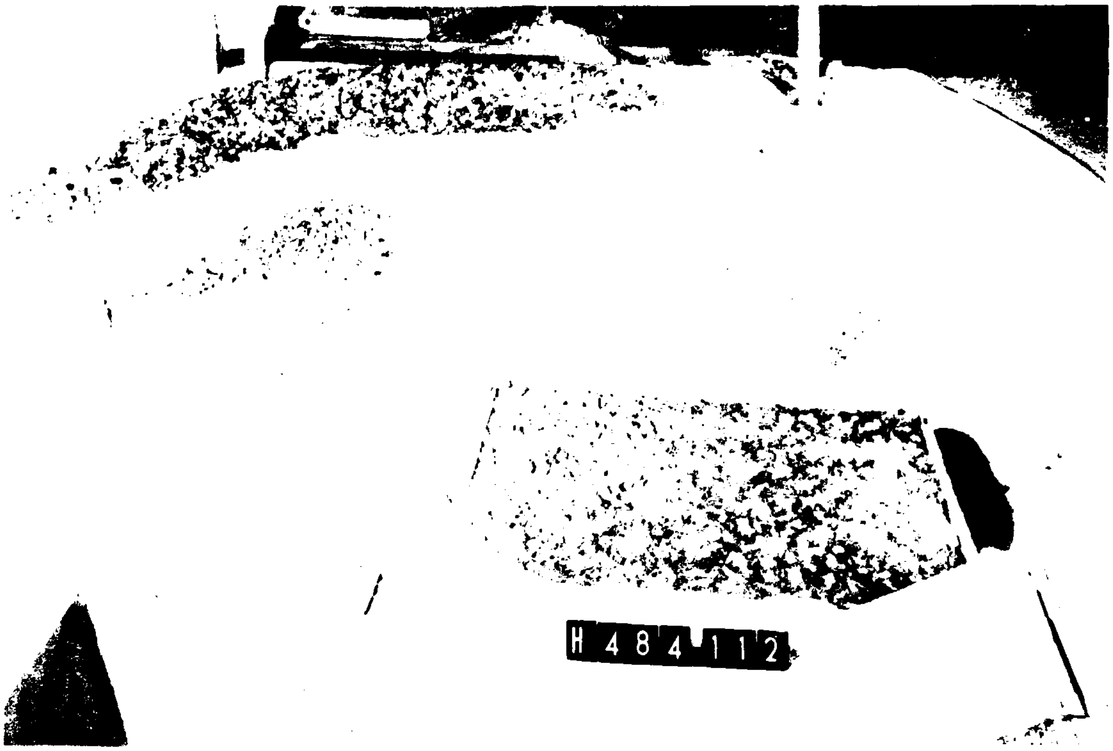
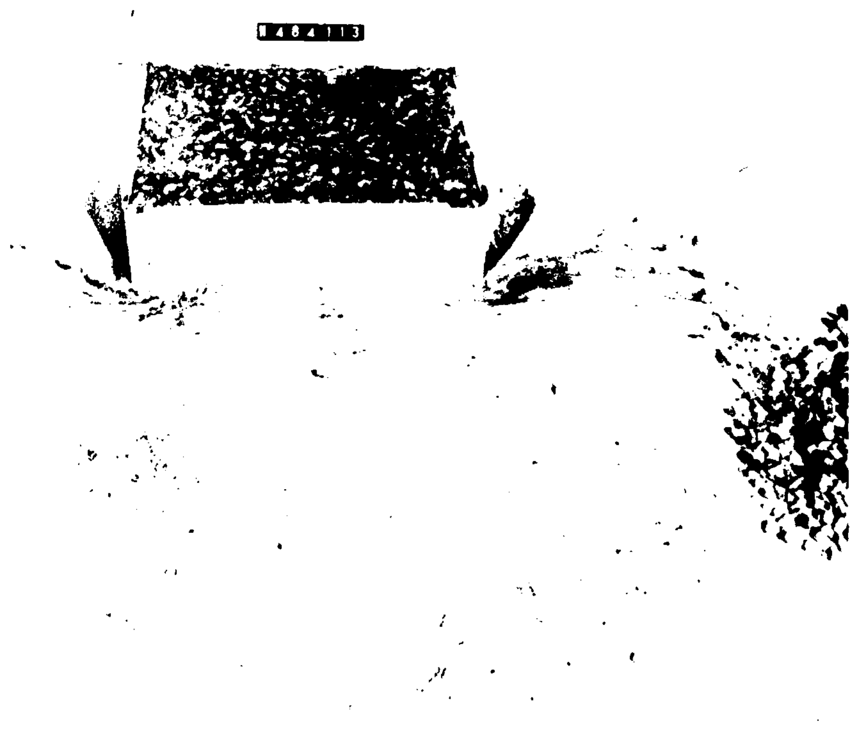


Photo 29. Looking downstream at channel extension to sta 0+85 and 100-ft-wide by 70-ft-long grouted riprap with cutoff wall

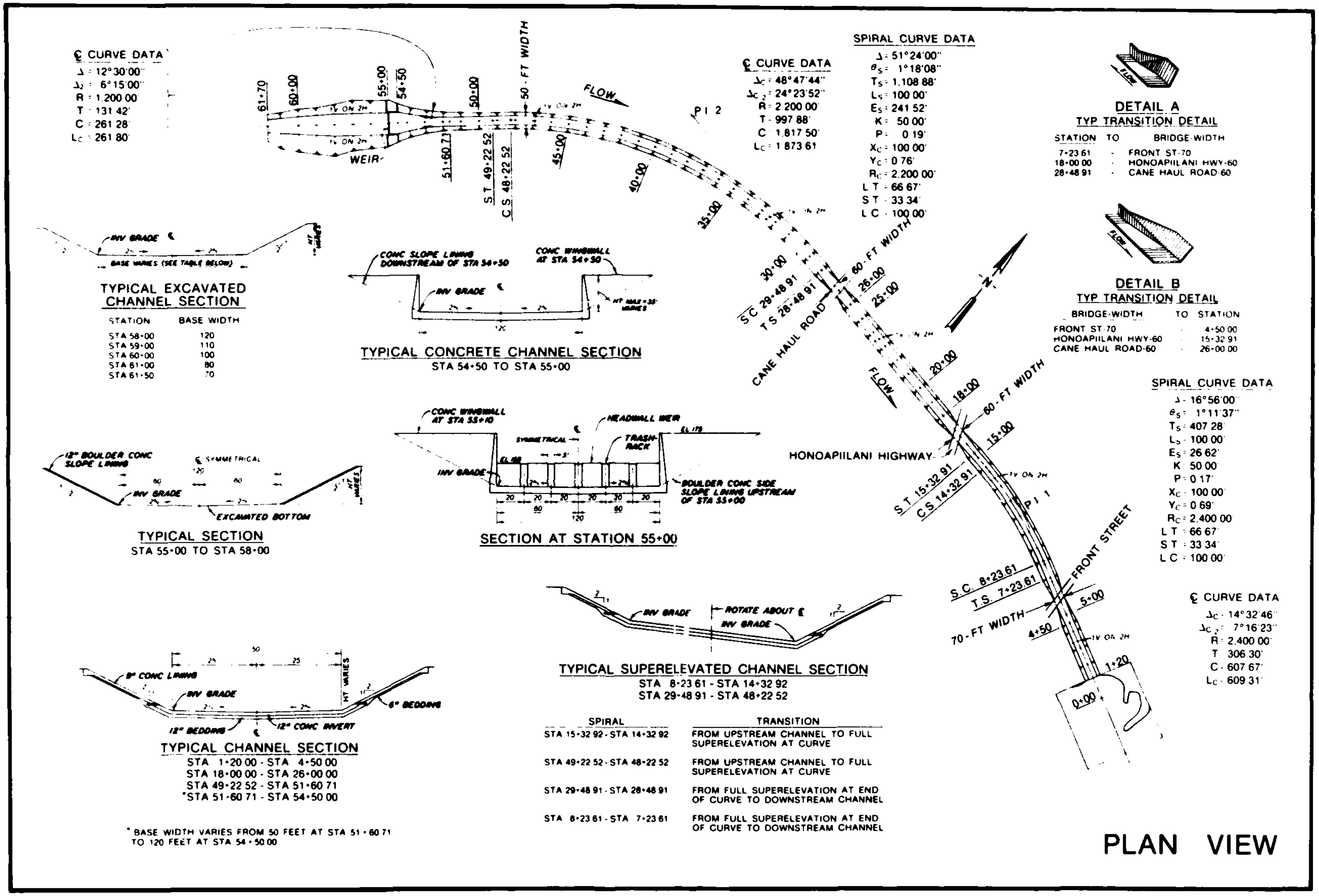


a. Looking downstream



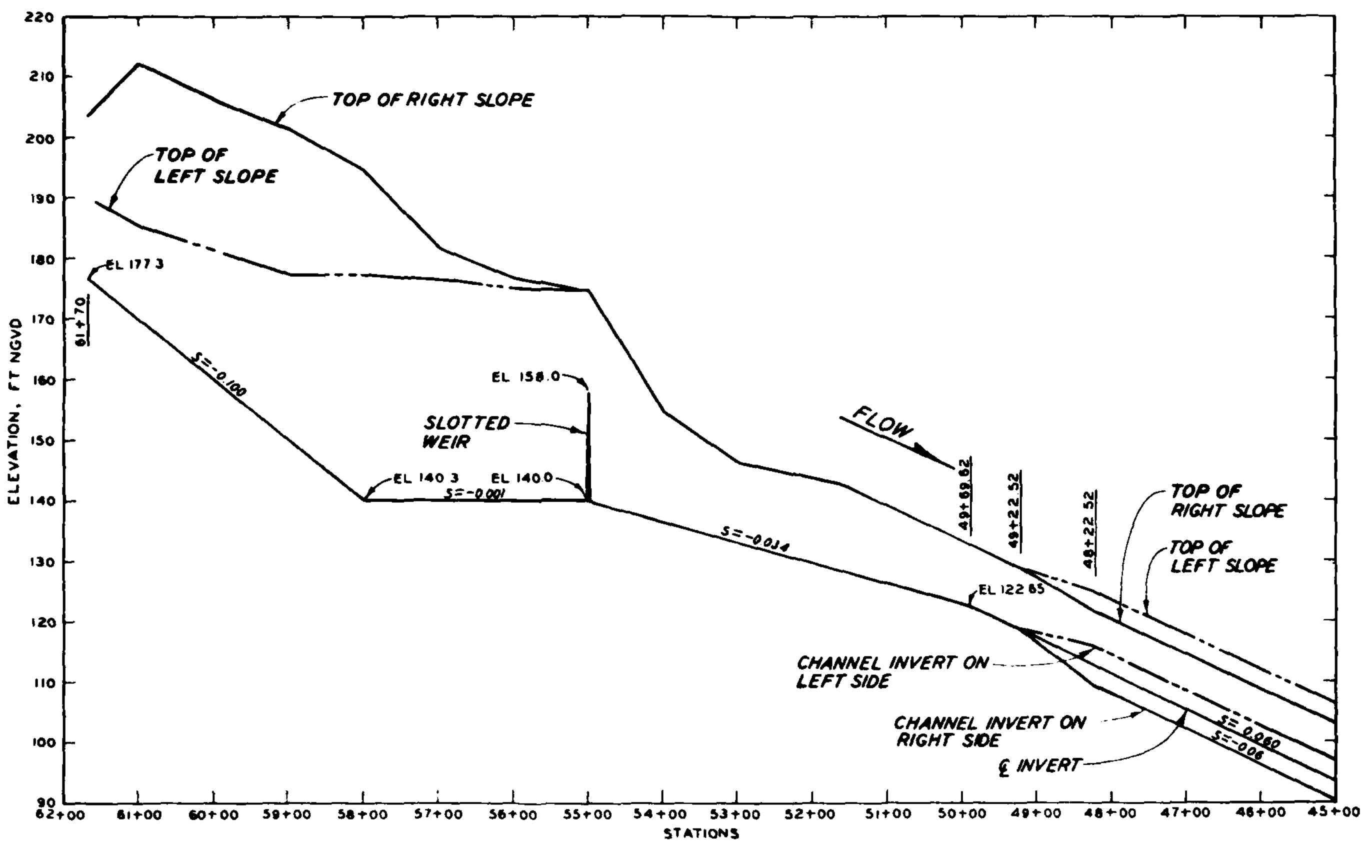
b. Looking upstream

Photo 30. Offshore area after SPF hydrograph



℄ CURVE DATA
Δ = 12°30'00"
Δ2 = 6°15'00"
R = 1,200.00
T = 131.42'
C = 261.28
Lc = 261.80
WEIR
50 - FT WIDTH
FLOW
P I 2
℄ CURVE DATA
Δc = 48°47'44"
Δc/2 = 24°23'52"
R = 2,200.00'
T = 997.88'
C = 1,817.50'
Lc = 1,873.61
SPIRAL CURVE DATA
Δ = 51°24'00"
θs = 1°18'08"
Ts = 1,108.88'
Ls = 100.00'
Es = 241.52'
K = 50.00'
P = 0.19'
Xc = 100.00'
Yc = 0.76'
Rc = 2,200.00'
L T = 66.67'
S T = 33.34'
L C = 100.00'
DETAIL A
TYP TRANSITION DETAIL
STATION TO BRIDGE-WIDTH
7+23.61 - FRONT ST-70
18+00.00 - HONOAPIILANI HWY-60
28+48.91 - CANE HAUL ROAD-60
DETAIL B
TYP TRANSITION DETAIL
BRIDGE-WIDTH TO STATION
FRONT ST-70 4+50.00
HONOAPIILANI HWY-60 15+32.91
CANE HAUL ROAD-60 26+00.00
S.T. 49+22.52
C.S. 48+22.52
S.C. 29+48.91
T.S. 28+48.91
CANE HAUL ROAD
60 - FT WIDTH
HONOAPIILANI HIGHWAY
S.T. 15+32.91
C.S. 14+32.91
P I 1
FRONT STREET
S.C. 8+23.61
T.S. 7+23.61
70 - FT WIDTH
SPIRAL CURVE DATA
Δ = 16°56'00"
θs = 1°11'37"
Ts = 407.28'
Ls = 100.00'
Es = 26.62'
K = 50.00
P = 0.17'
Xc = 100.00'
Yc = 0.69'
Rc = 2,400.00
L T = 66.67'
S T = 33.34'
L C = 100.00'
℄ CURVE DATA
Δc = 14°32'46"
Δc/2 = 7°16'23"
R = 2,400.00'
T = 306.30'
C = 607.67'
Lc = 609.31'
TYPICAL EXCAVATED CHANNEL SECTION
BASE VARIES (SEE TABLE BELOW)
STATION BASE WIDTH
STA 58+00 120
STA 59+00 110
STA 60+00 100
STA 61+00 80
STA 61+50 70
CONC SLOPE LINING DOWNSTREAM OF STA 54+50
CONC WINGWALL AT STA 54+50
TYPICAL CONCRETE CHANNEL SECTION
STA 54+50 TO STA 55+00
12" BOULDER CONC SLOPE LINING
EXCAVATED BOTTOM
TYPICAL SECTION
STA 55+00 TO STA 58+00
CONC WINGWALL AT STA 55+10
HEADWALL WEIR
TRASH-RACK
BOULDER CONC SIDE SLOPE LINING UPSTREAM OF STA 55+00
SECTION AT STATION 55+00
ROTATE ABOUT ℄
INV GRADE
TYPICAL SUPERELEVATED CHANNEL SECTION
STA 8+23.61 - STA 14+32.92
STA 29+48.91 - STA 48+22.52
SPIRAL TRANSITION
STA 15+32.92 - STA 14+32.92 FROM UPSTREAM CHANNEL TO FULL SUPERELEVATION AT CURVE
STA 49+22.52 - STA 48+22.52 FROM UPSTREAM CHANNEL TO FULL SUPERELEVATION AT CURVE
STA 29+48.91 - STA 28+48.91 FROM FULL SUPERELEVATION AT END OF CURVE TO DOWNSTREAM CHANNEL
STA 8+23.61 - STA 7+23.61 FROM FULL SUPERELEVATION AT END OF CURVE TO DOWNSTREAM CHANNEL
9" CONC LINING
12" BEDDING
12" CONC INVERT
6" BEDDING
HT VARIES
TYPICAL CHANNEL SECTION
STA 1+20.00 - STA 4+50.00
STA 18+00.00 - STA 26+00.00
STA 49+22.52 - STA 51+60.71
*STA 51+60.71 - STA 54+50.00
* BASE WIDTH VARIES FROM 50 FEET AT STA 51+60.71 TO 120 FEET AT STA 54+50.00
PLAN VIEW

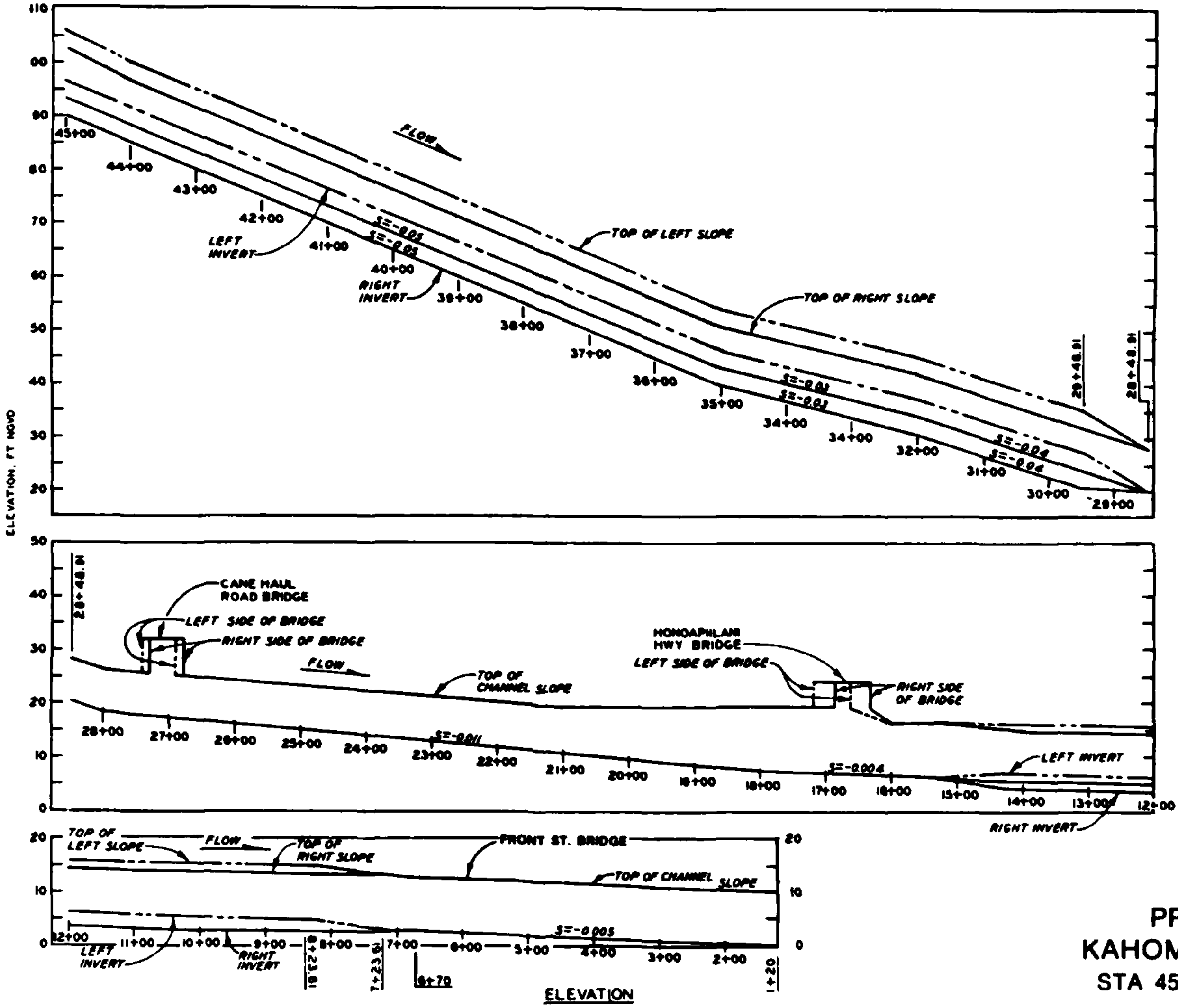
PLATE 1



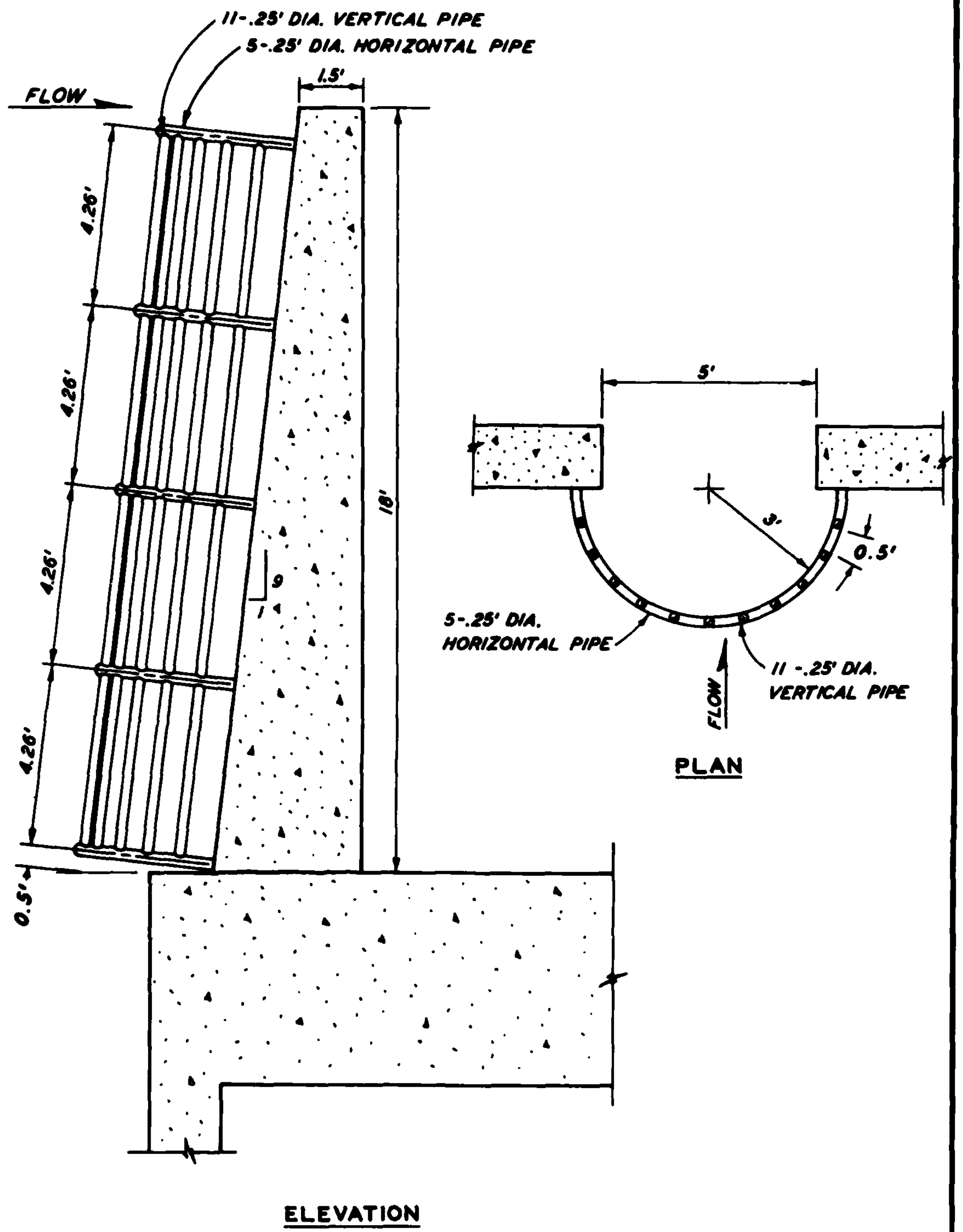
ELEVATION

PROFILE
KAHOMA STREAM
STA 61+70 TO 45+00

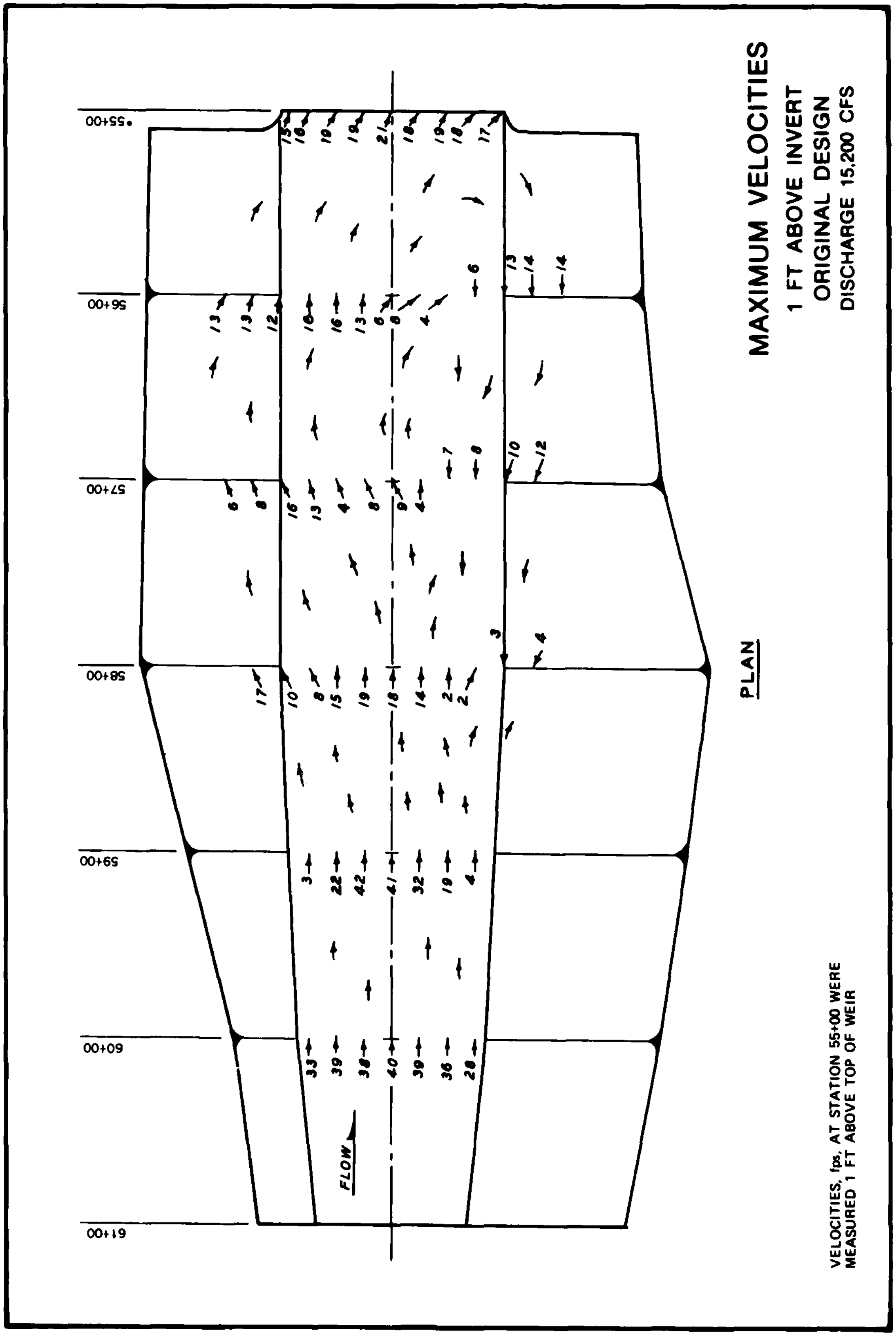
PLATE 2



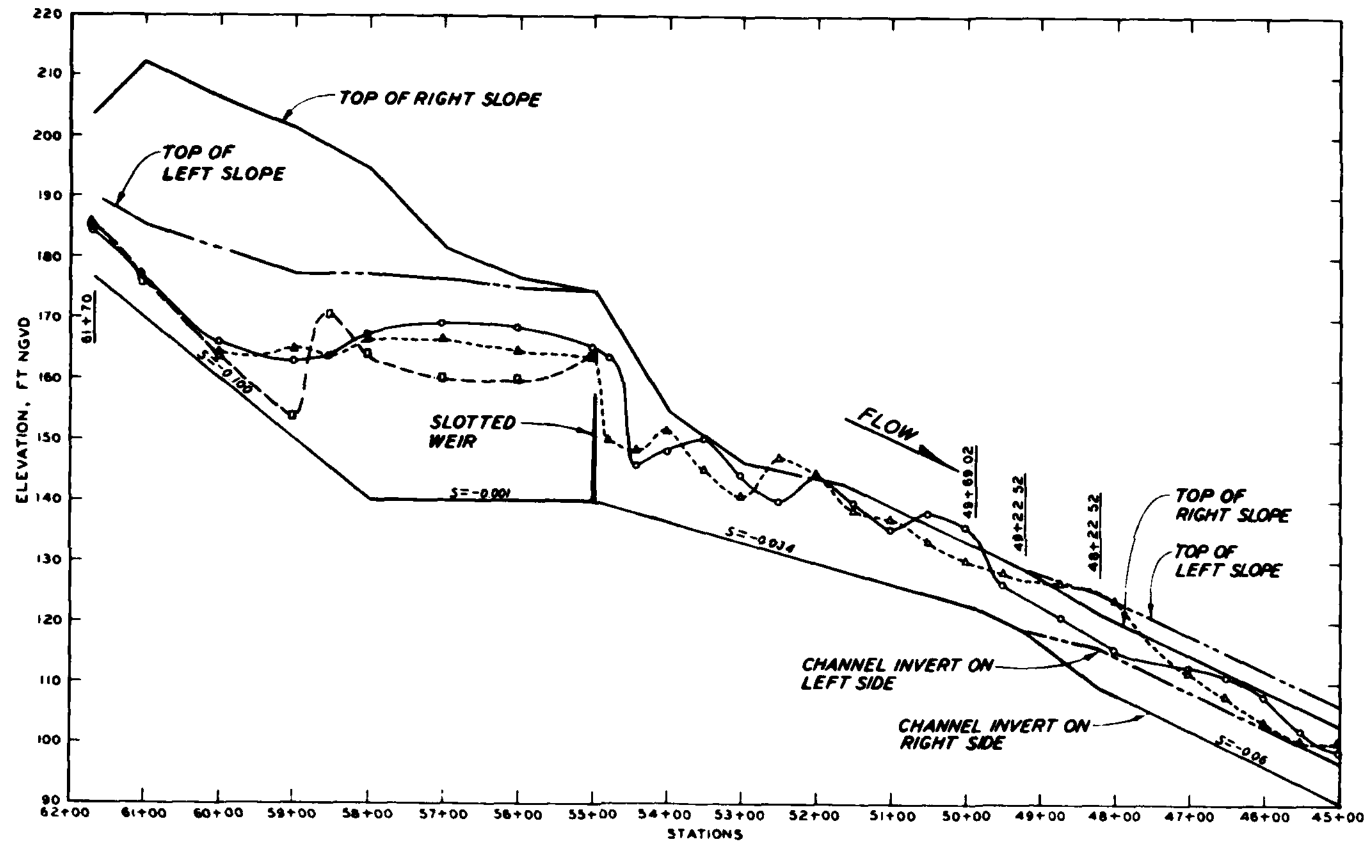
PROFILE
KAHOMA STREAM
STA 45+00 TO 1+20



TRASHRACK DETAILS
TYPE 1 DESIGN



MAXIMUM VELOCITIES
1 FT ABOVE INVERT
ORIGINAL DESIGN
DISCHARGE 15,200 CFS



ELEVATION

LEGEND

LOOKING DOWNSTREAM

- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL
- CENTER LINE

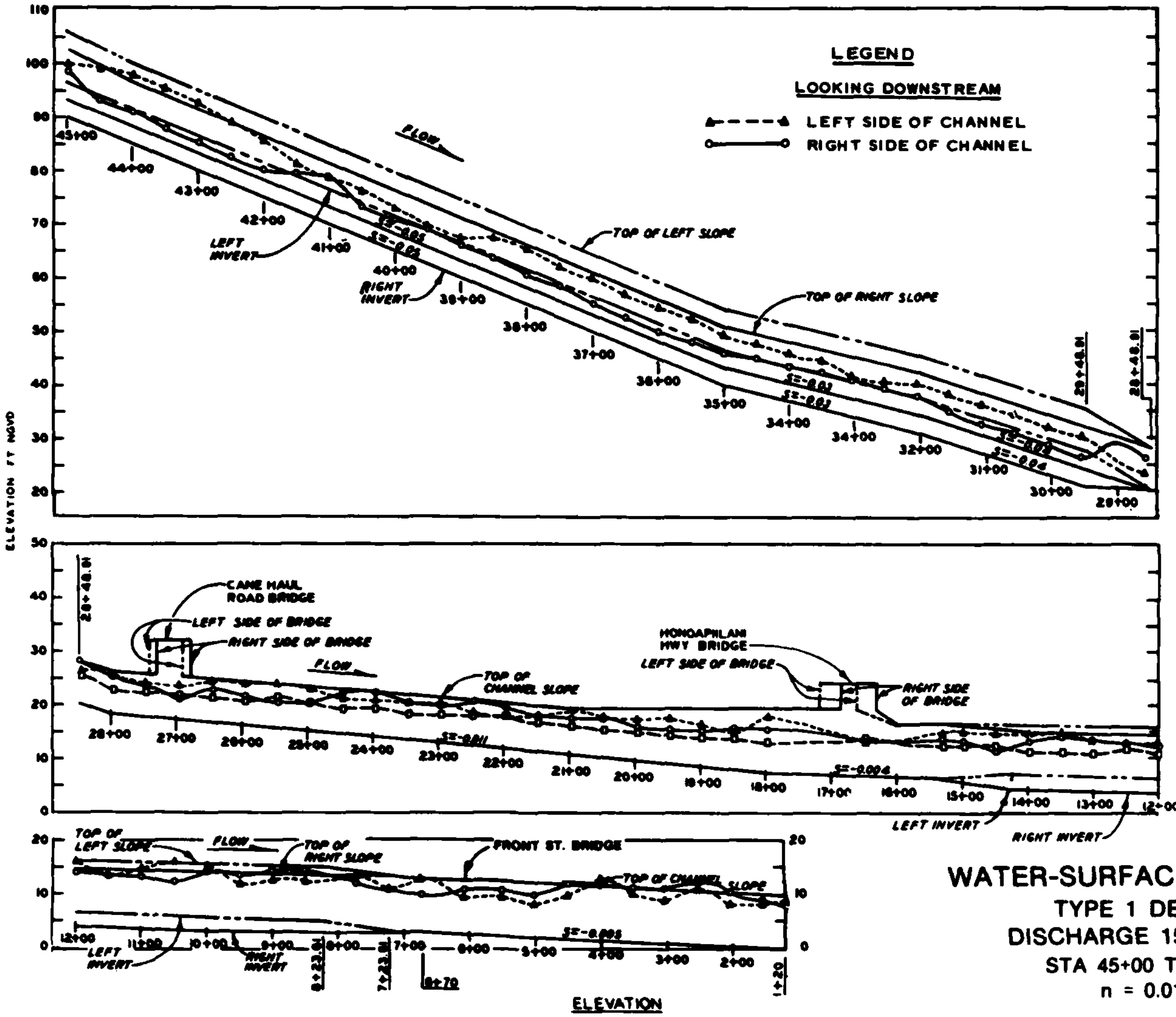
WATER-SURFACE PROFILES

TYPE 1 DESIGN

DISCHARGE 15,200 CFS

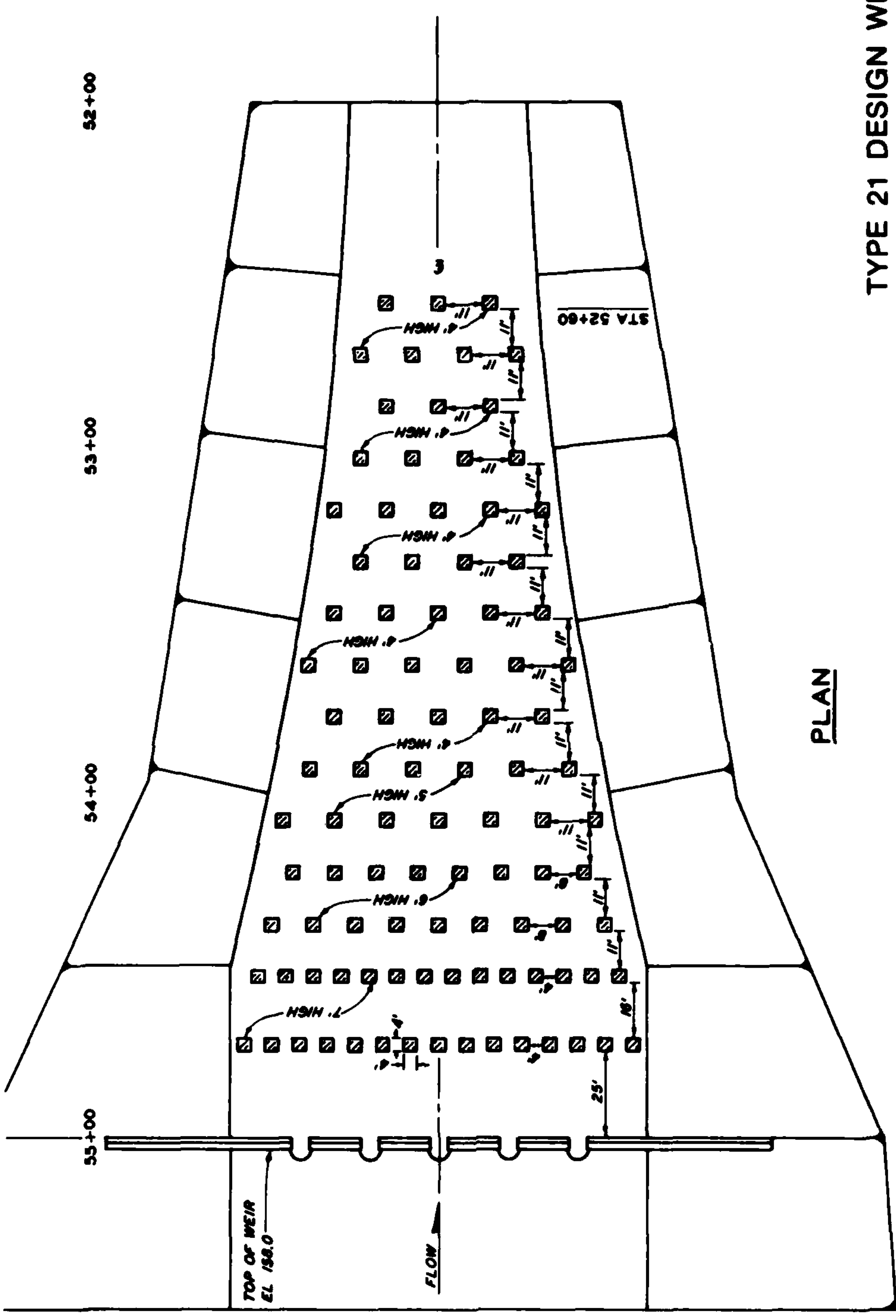
STA 61+70 TO 45+00

n = 0.015



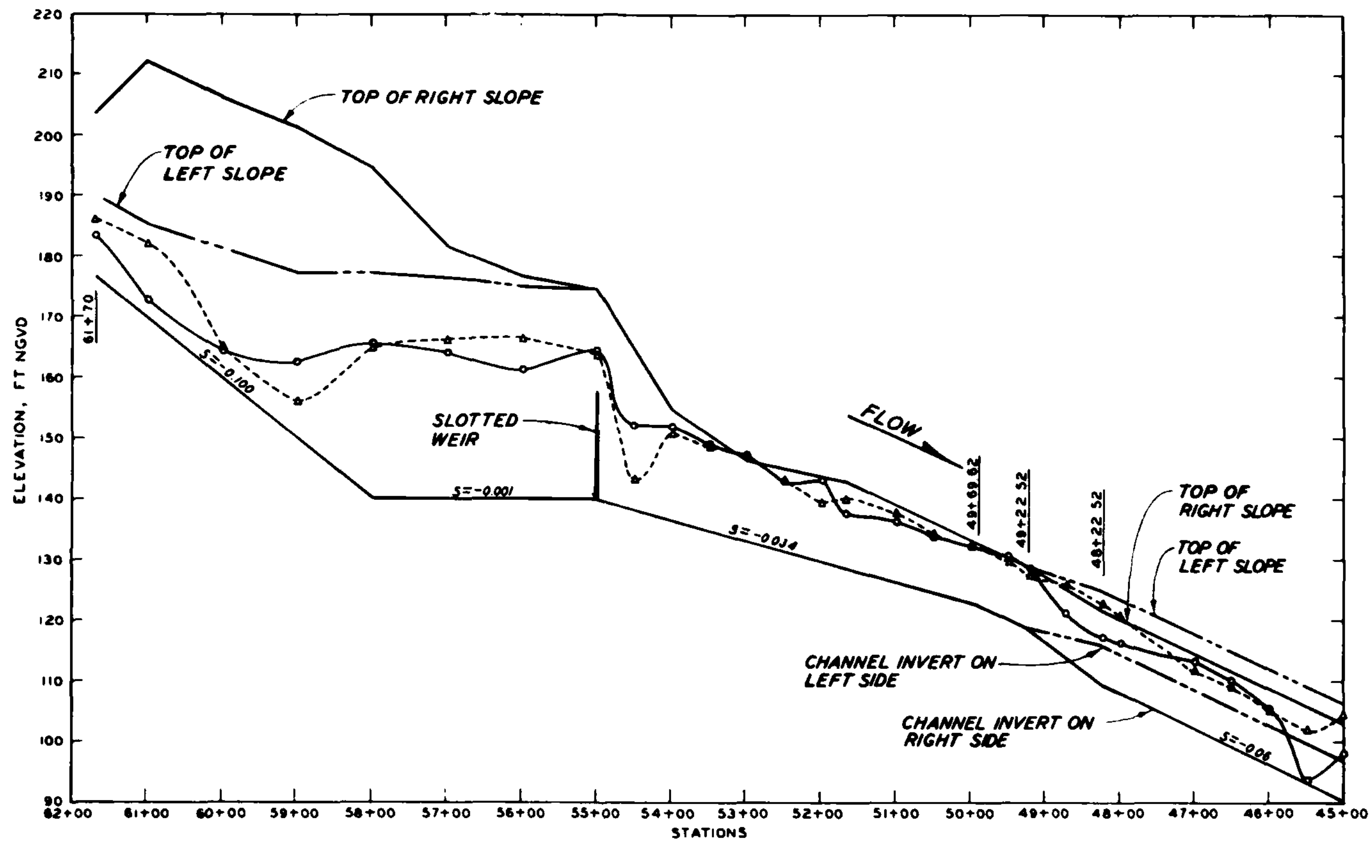
WATER-SURFACE PROFILES
TYPE 1 DESIGN
DISCHARGE 15,200 CFS
STA 45+00 TO 1+20
n = 0.015

TYPE 21 DESIGN WEIR AND TRANSITION



PLAN

PLATE 8



ELEVATION

LEGEND

LOOKING DOWNSTREAM

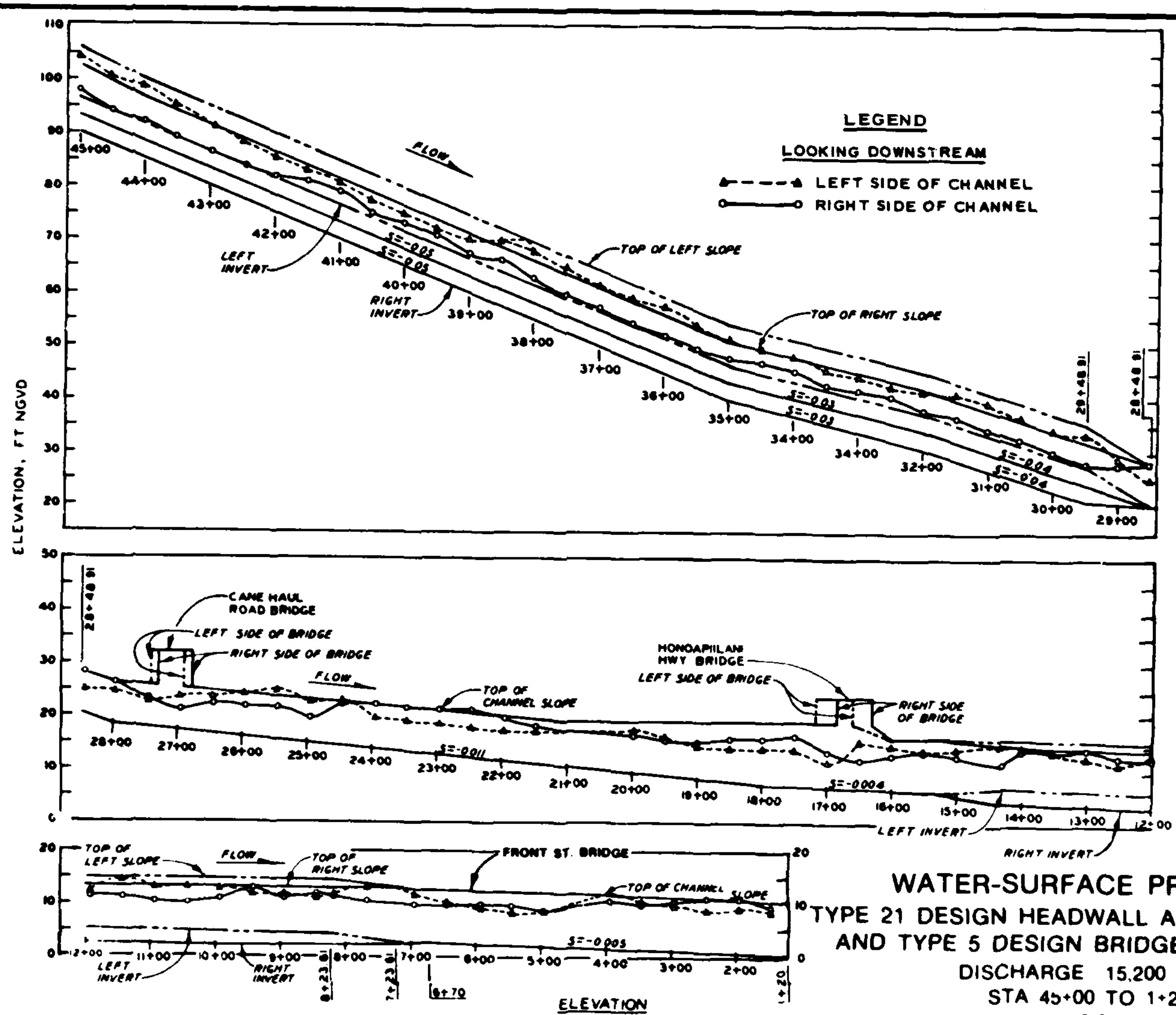
▲- - - -▲ LEFT SIDE OF CHANNEL

○———○ RIGHT SIDE OF CHANNEL

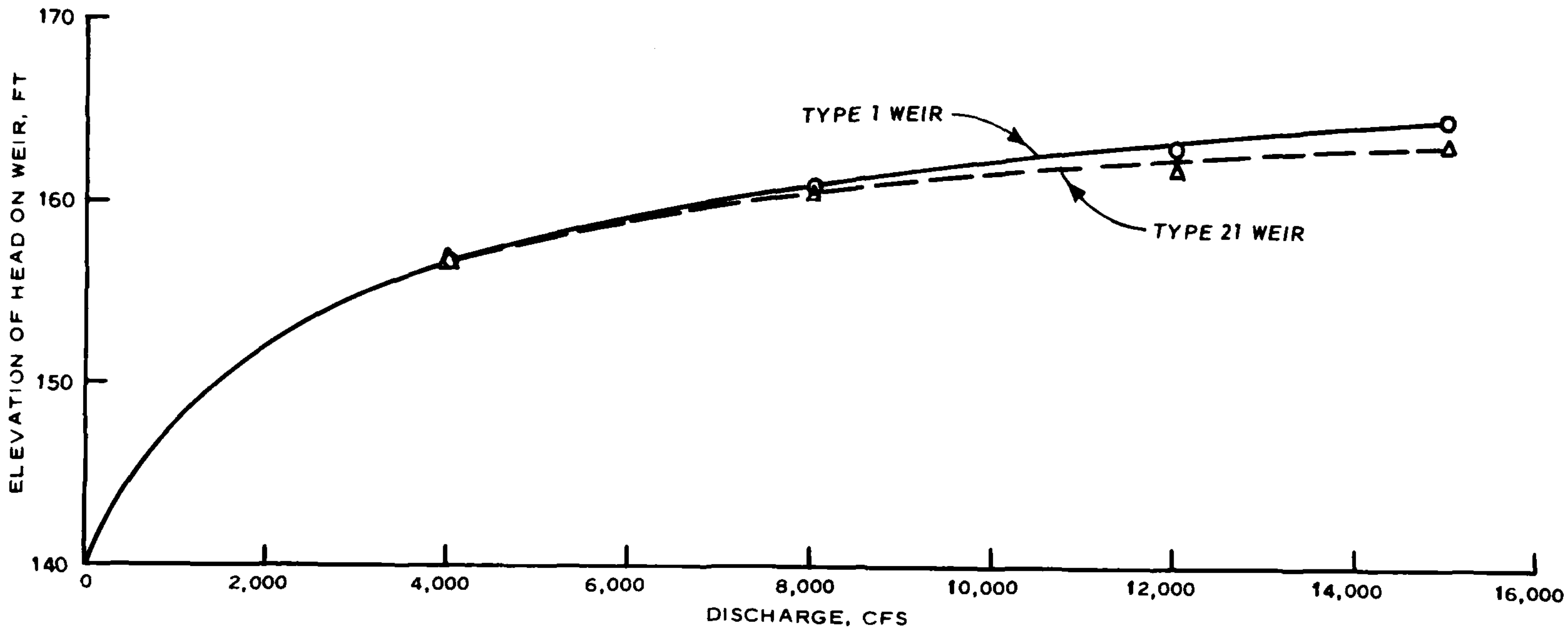
WATER-SURFACE PROFILES

TYPE 21 DESIGN WEIR AND TRANSITION AND TYPE 5 DESIGN BRIDGE TRANSITION

DISCHARGE 15,200 CFS
STA 61+70 TO 45+00
n = 0.015



WATER-SURFACE PROFILES
TYPE 21 DESIGN HEADWALL AND TRANSITION
AND TYPE 5 DESIGN BRIDGE TRANSITION
DISCHARGE 15,200 CFS
STA 45+00 TO 1+20
n = 0.015



NOTE WATER-SURFACE ELEVATIONS MEASURED AT STATION 56+00

HEAD ON WEIR

WEIR ELEVATION 158.0 FT

STANDARD PROJECT
FLOOD HYDROGRAPH

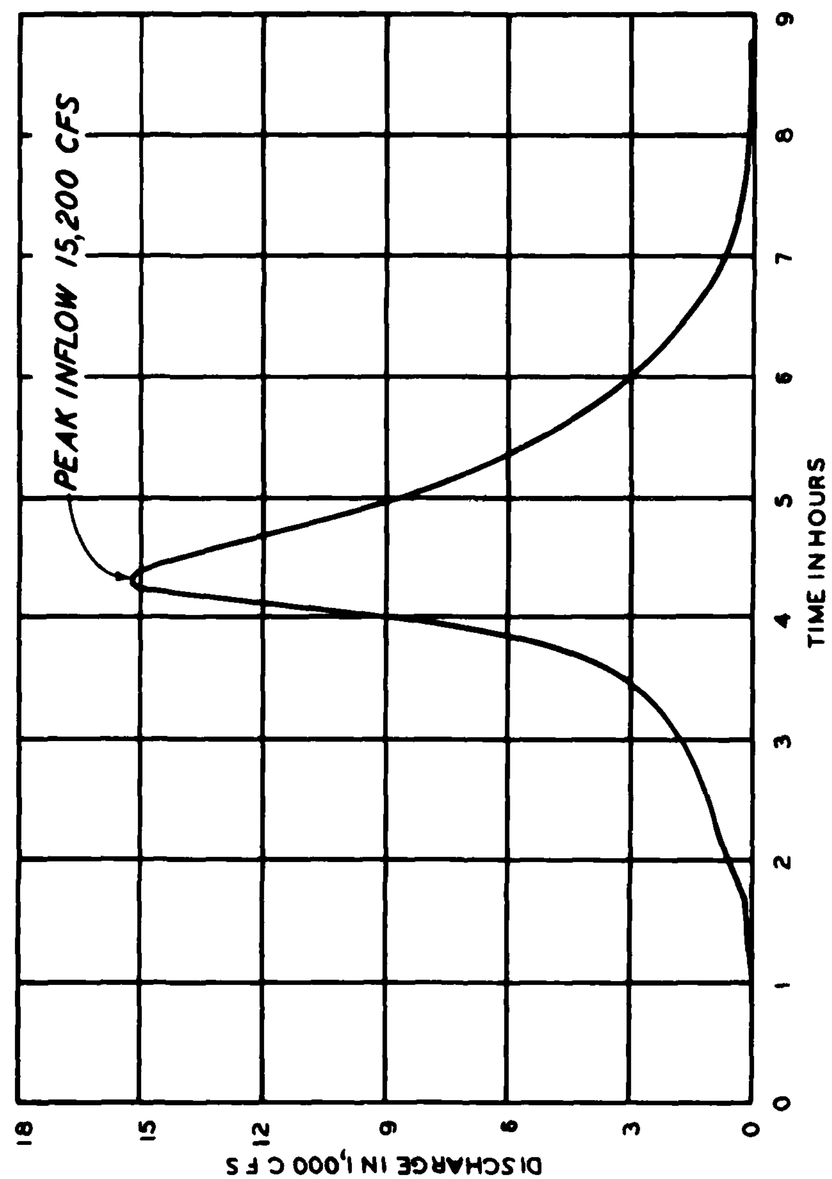
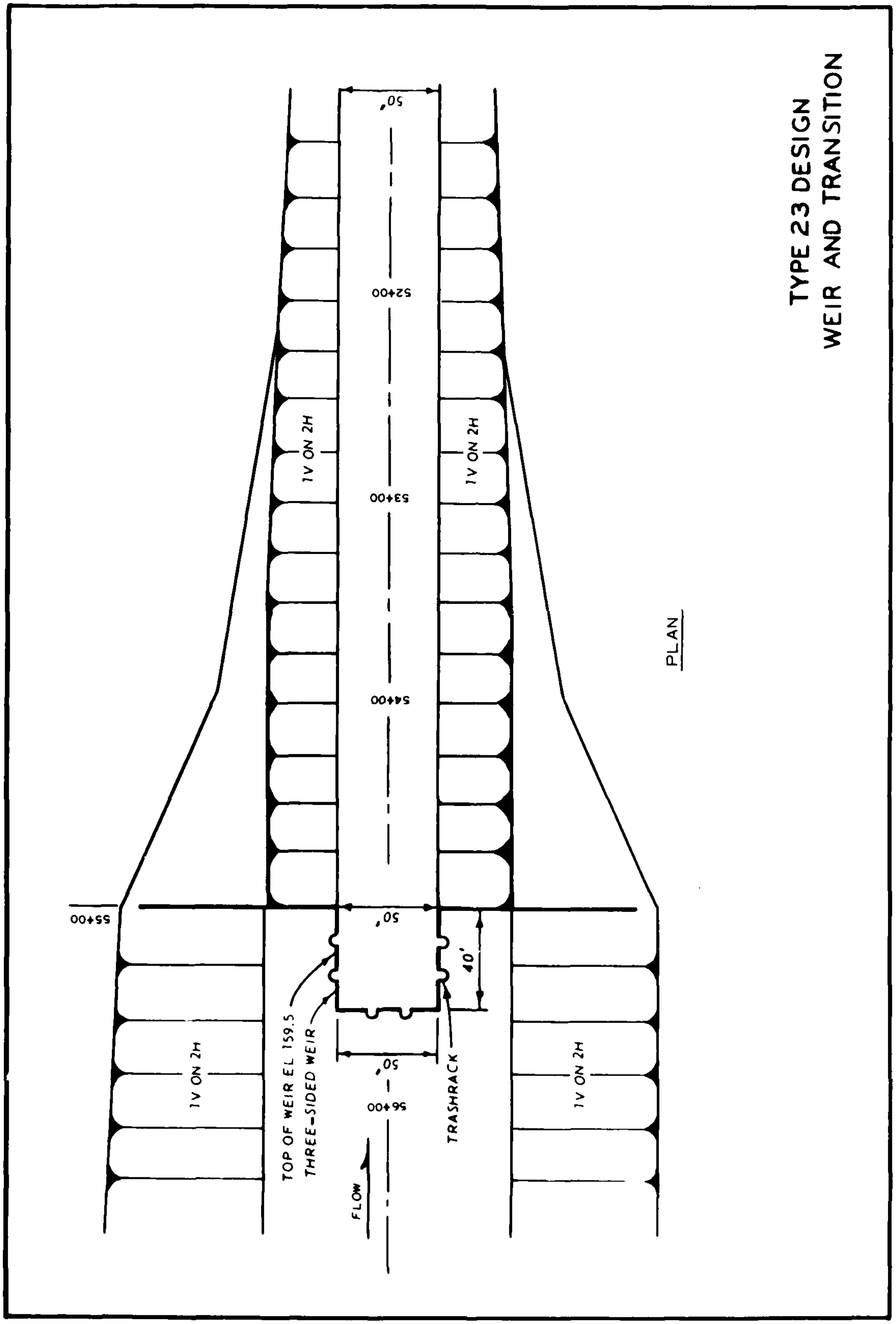
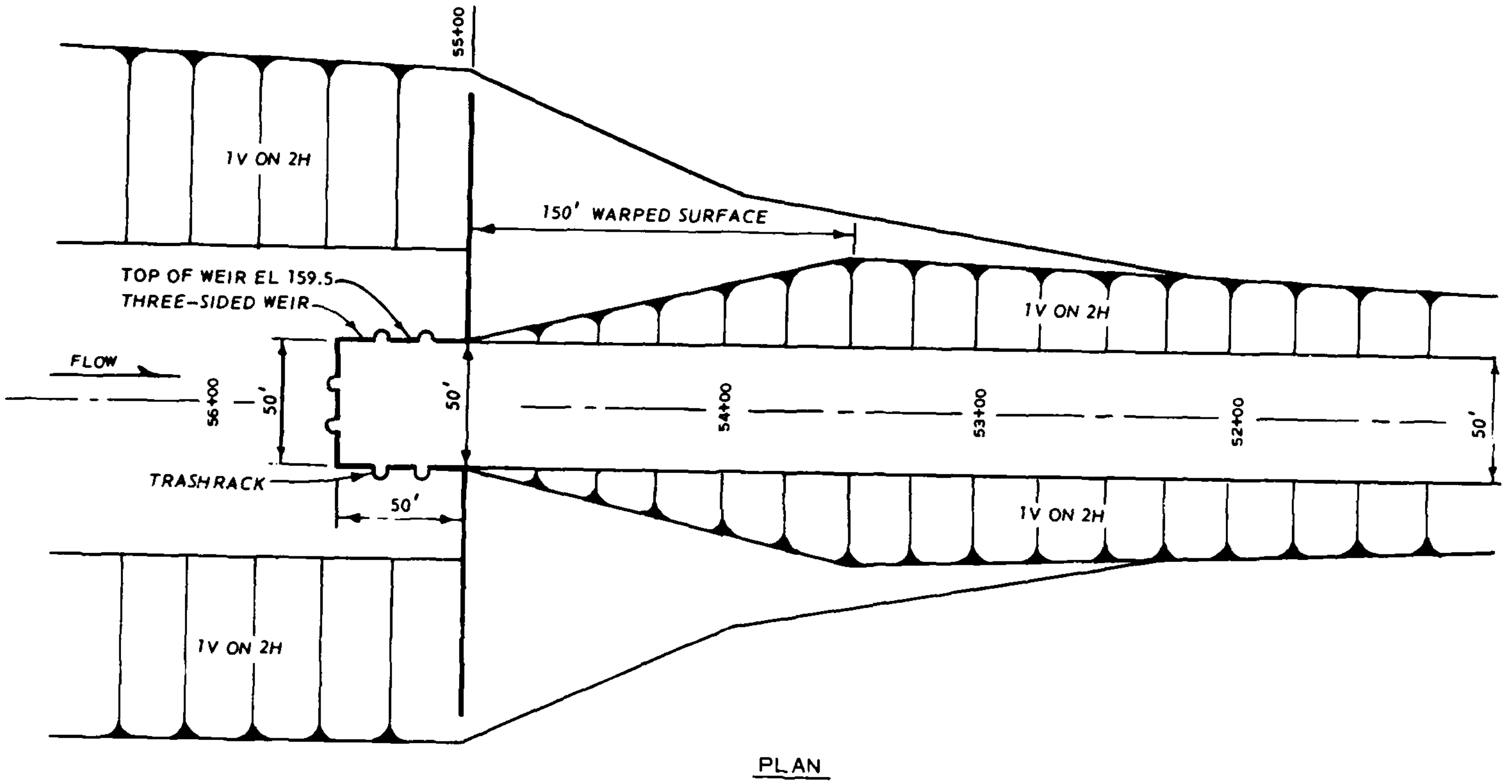
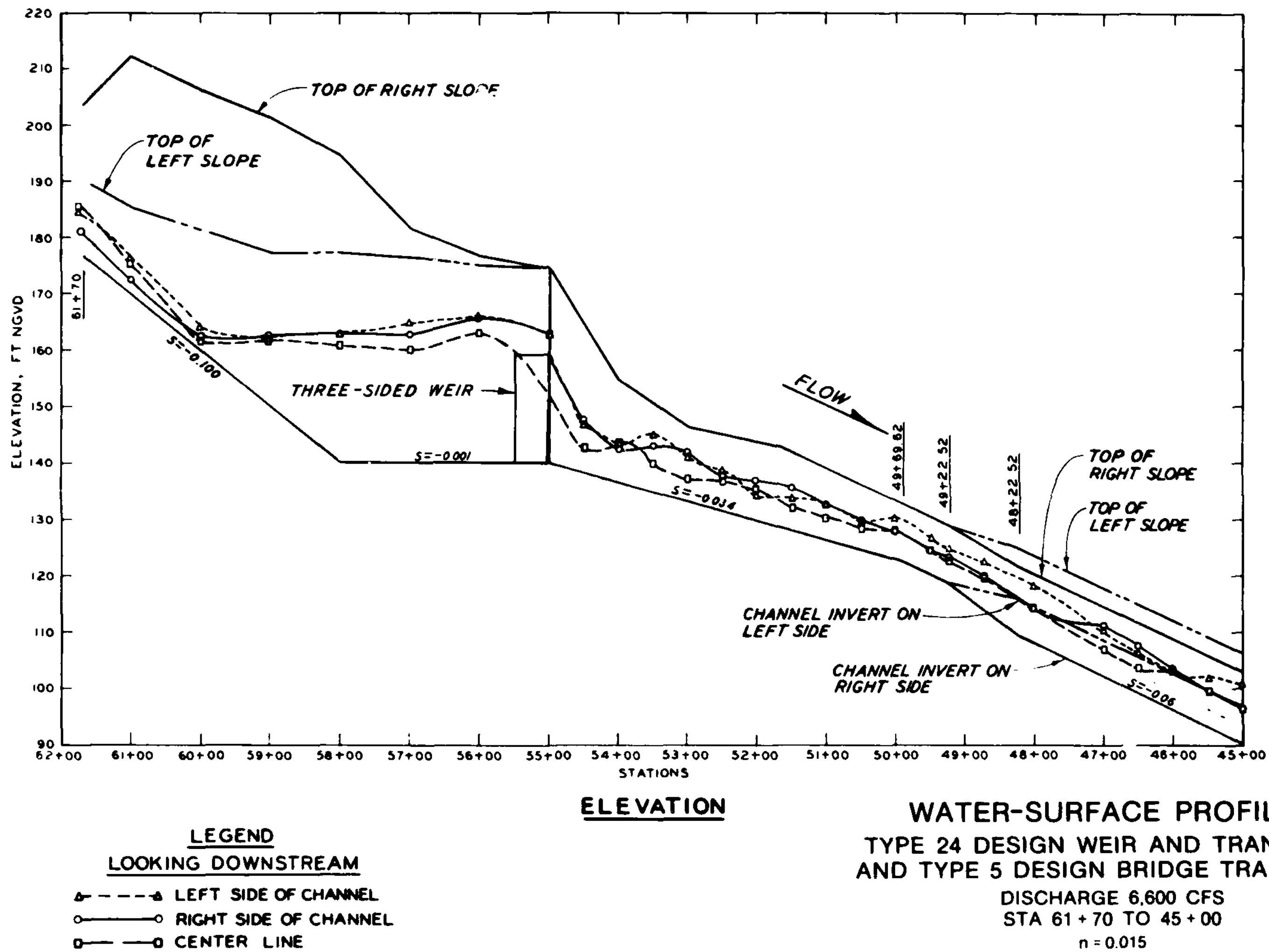


PLATE 12


TYPE 23 DESIGN
WEIR AND TRANSITION
PLAN
50'
52+00
53+00
54+00
55+00
56+00
1V ON 2H
40'
TOP OF WEIR EL 159.5
THREE-SIDED WEIR
TRASHRACK
FLOW



TYPE 24 DESIGN WEIR AND TRANSITION



ELEVATION

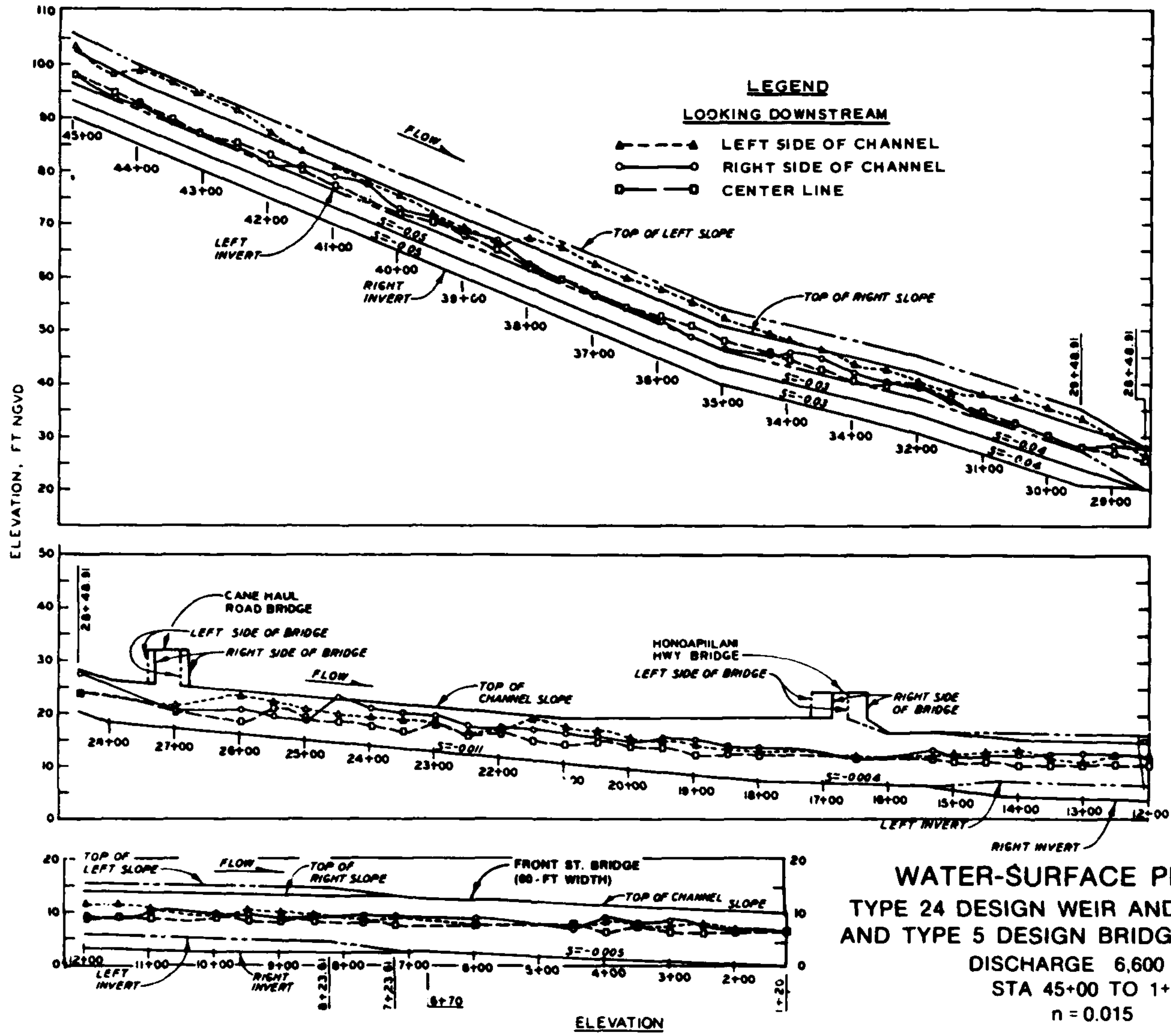
WATER-SURFACE PROFILES

TYPE 24 DESIGN WEIR AND TRANSITION AND TYPE 5 DESIGN BRIDGE TRANSITION

DISCHARGE 6,600 CFS

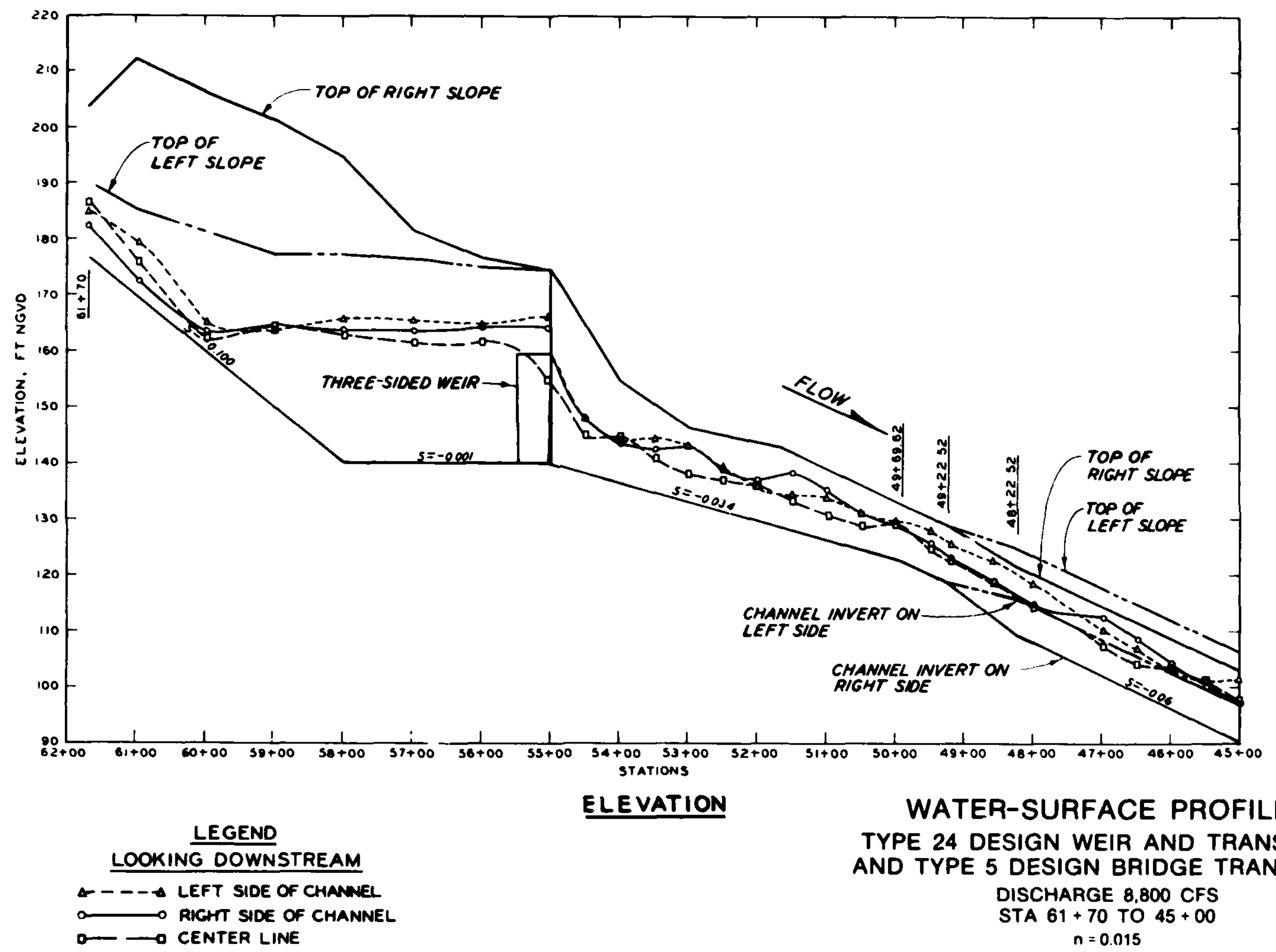
STA 61 + 70 TO 45 + 00

n = 0.015



WATER-SURFACE PROFILES
TYPE 24 DESIGN WEIR AND TRANSITION
AND TYPE 5 DESIGN BRIDGE TRANSITION
DISCHARGE 6,600 CFS
STA 45+00 TO 1+20
n = 0.015

PLATE 16

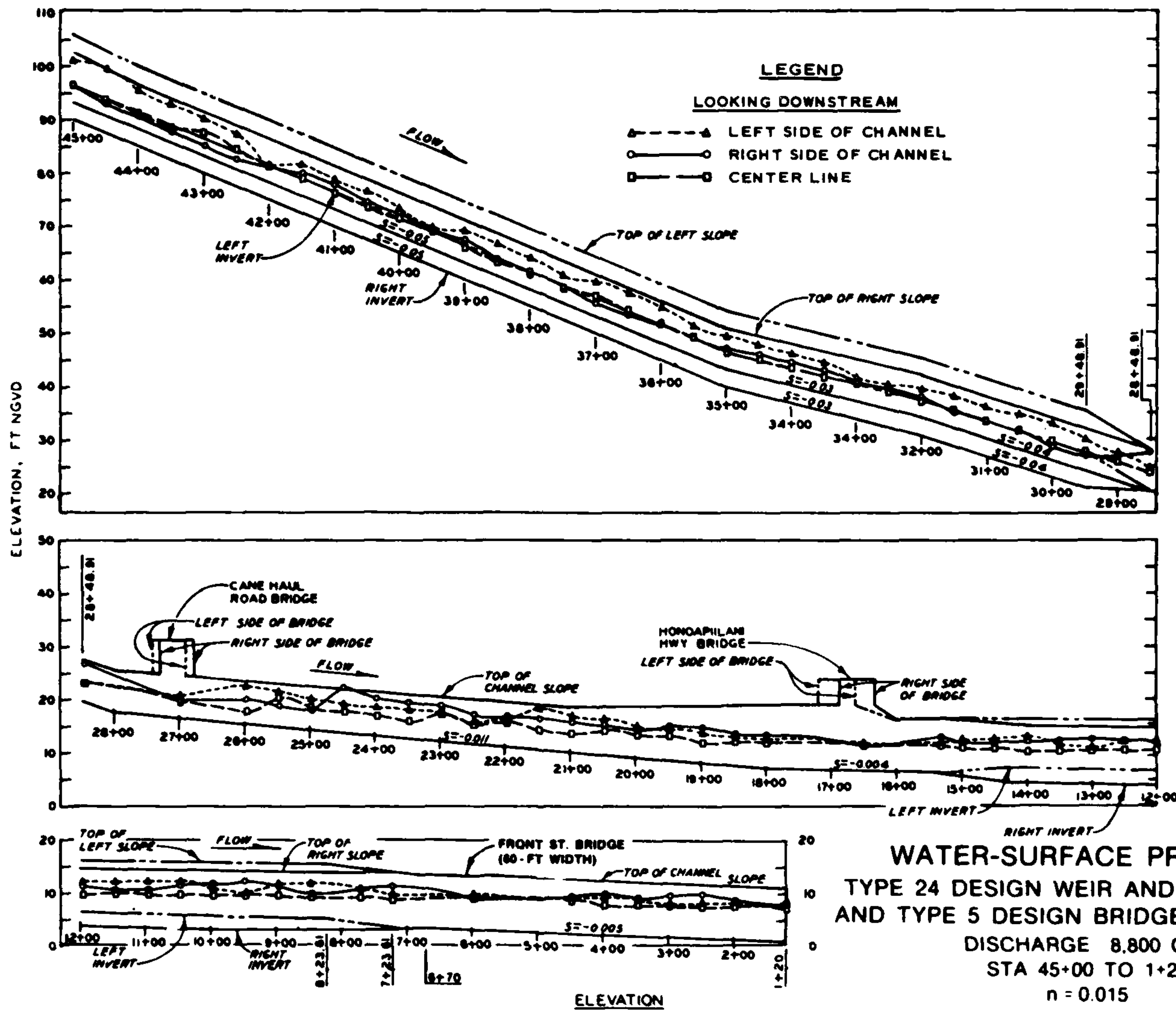


ELEVATION

WATER-SURFACE PROFILES

TYPE 24 DESIGN WEIR AND TRANSITION
AND TYPE 5 DESIGN BRIDGE TRANSITION

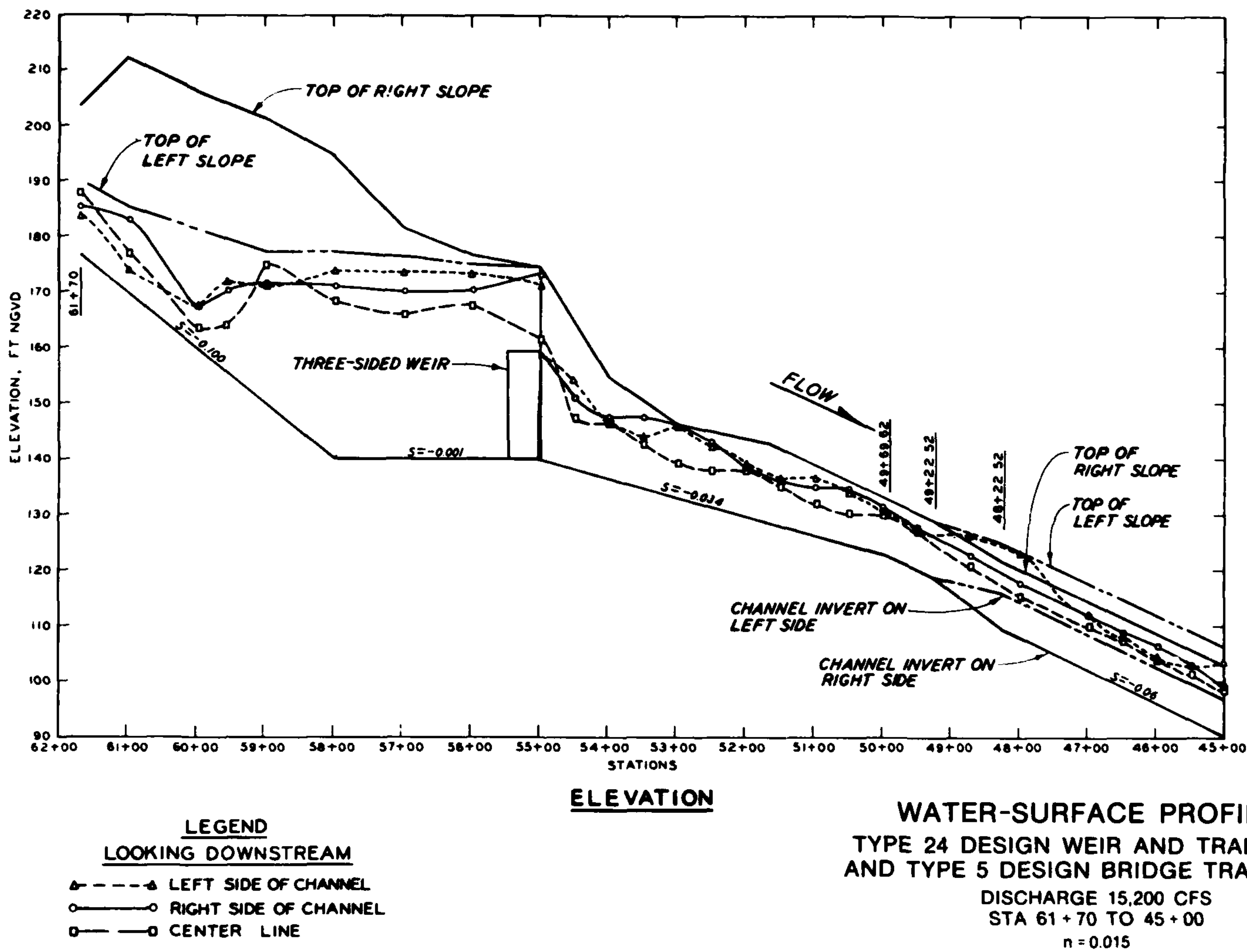
DISCHARGE 8,800 CFS
STA 61 + 70 TO 45 + 00
n = 0.015



WATER-SURFACE PROFILES

TYPE 24 DESIGN WEIR AND TRANSITION
AND TYPE 5 DESIGN BRIDGE TRANSITION

DISCHARGE 8,800 CFS
STA 45+00 TO 1+20
n = 0.015

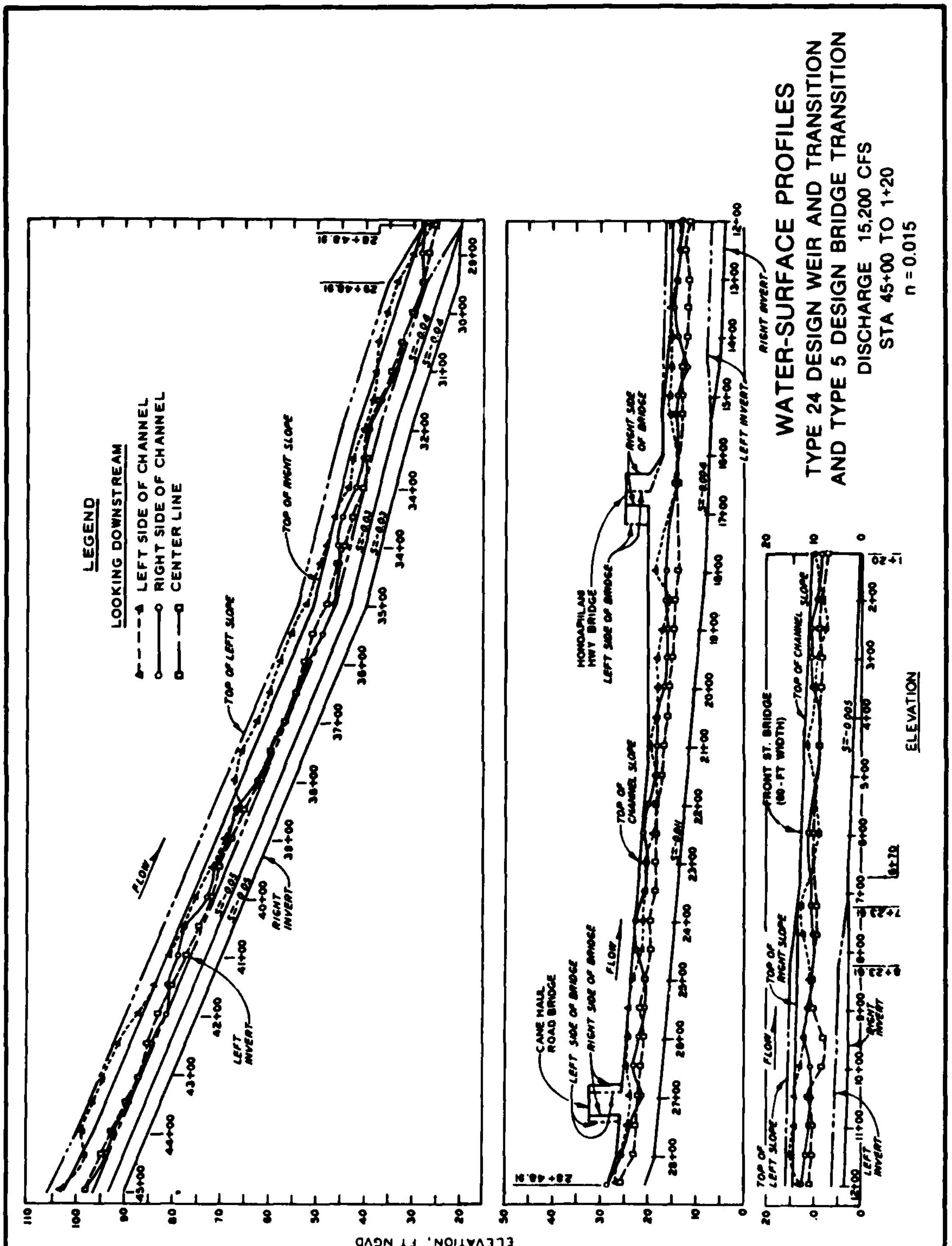


ELEVATION

WATER-SURFACE PROFILES

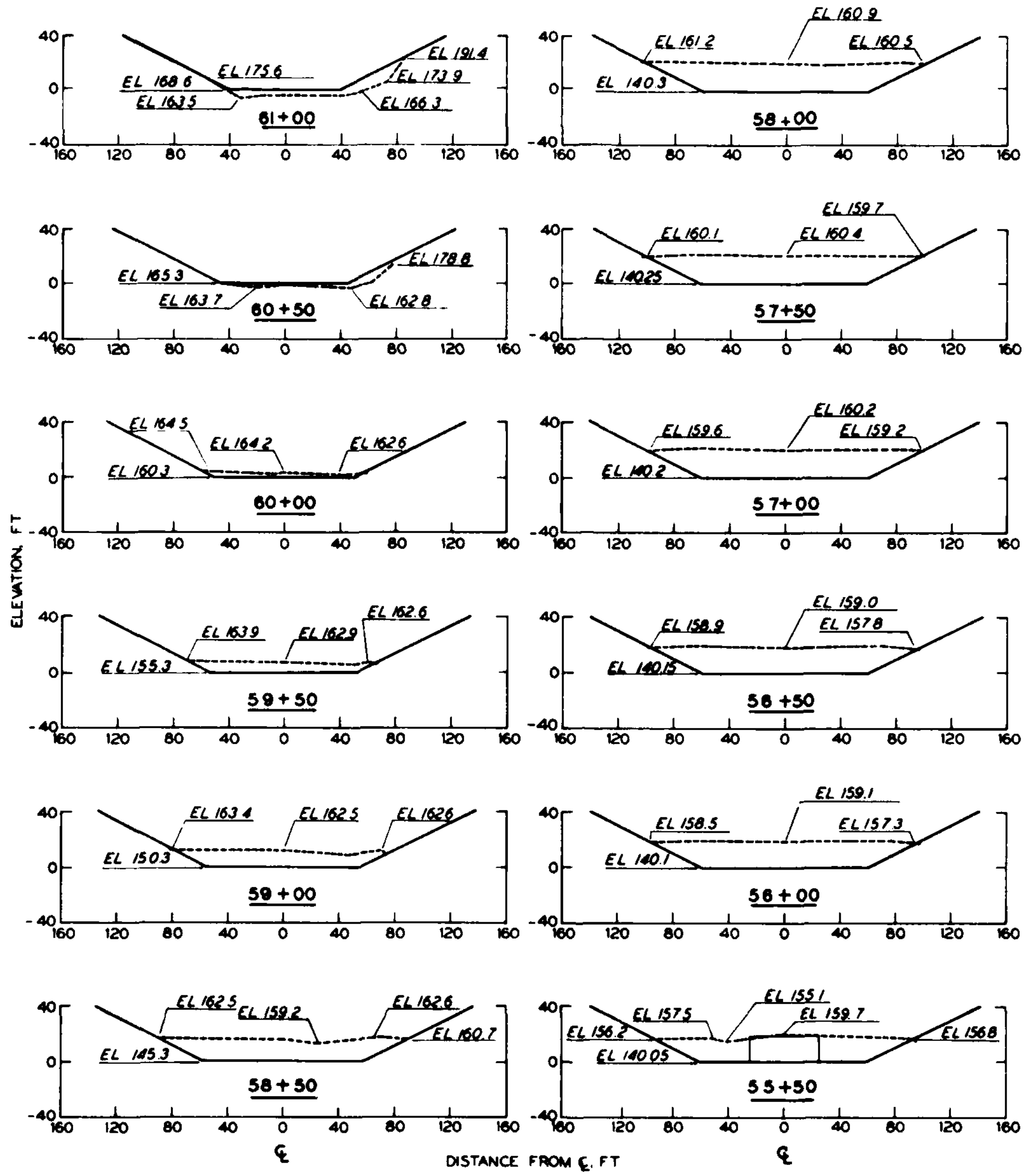
TYPE 24 DESIGN WEIR AND TRANSITION AND TYPE 5 DESIGN BRIDGE TRANSITION

DISCHARGE 15,200 CFS
STA 61 + 70 TO 45 + 00
n = 0.015



WATER-SURFACE PROFILES
TYPE 24 DESIGN WEIR AND TRANSITION
AND TYPE 5 DESIGN BRIDGE TRANSITION
DISCHARGE 15,200 CFS
STA 45+00 TO 1+20
n = 0.015
LEGEND
LOOKING DOWNSTREAM
LEFT SIDE OF CHANNEL
RIGHT SIDE OF CHANNEL
CENTER LINE
ELEVATION, FT NGVD
FLOW
TOP OF LEFT SLOPE
TOP OF RIGHT SLOPE
LEFT INVERT
RIGHT INVERT
CANE HAUL ROAD BRIDGE
LEFT SIDE OF BRIDGE
RIGHT SIDE OF BRIDGE
TOP OF CHANNEL SLOPE
FRONT ST. BRIDGE (60-FT WIDTH)
ELEVATION

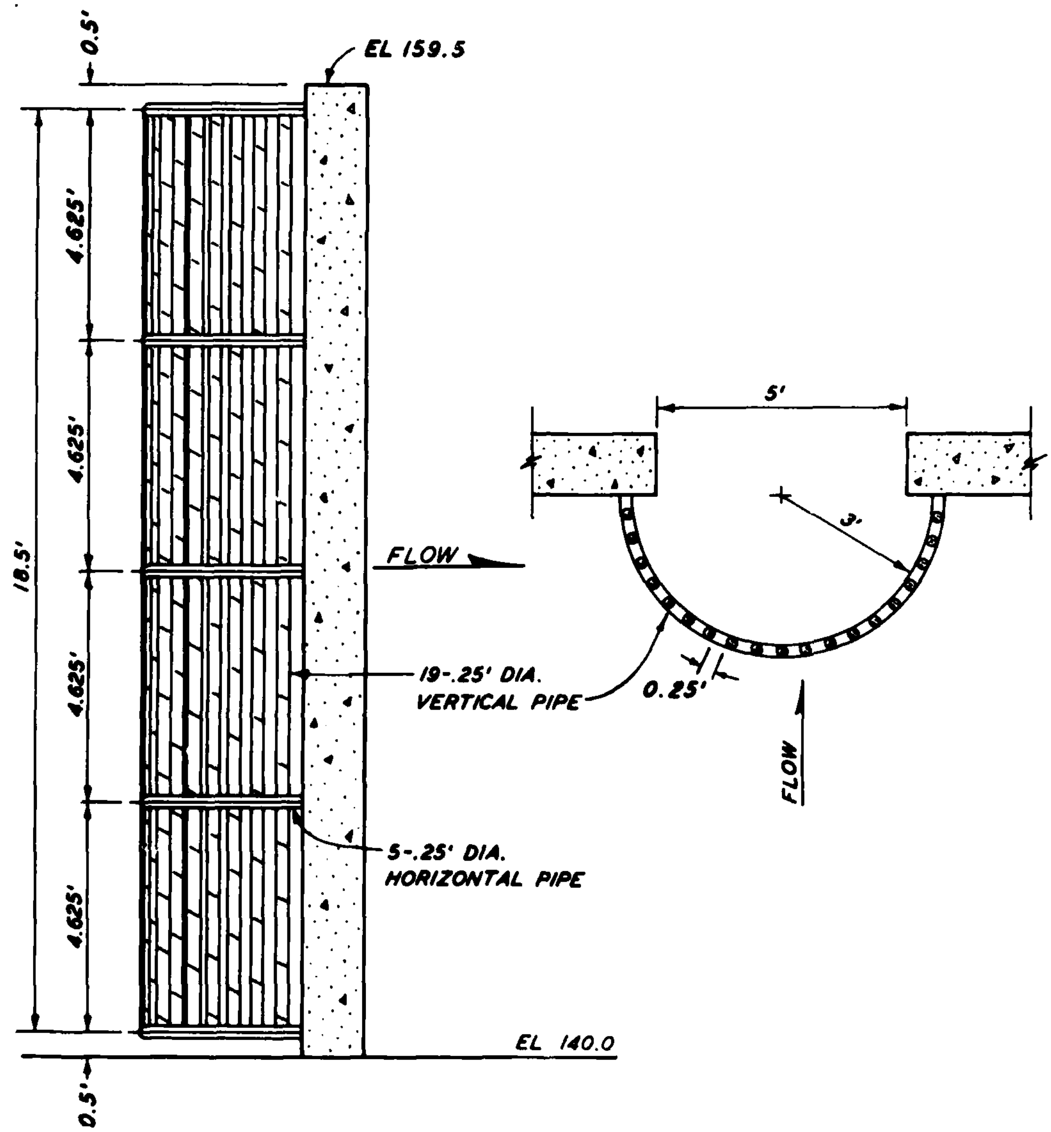
PLATE 20



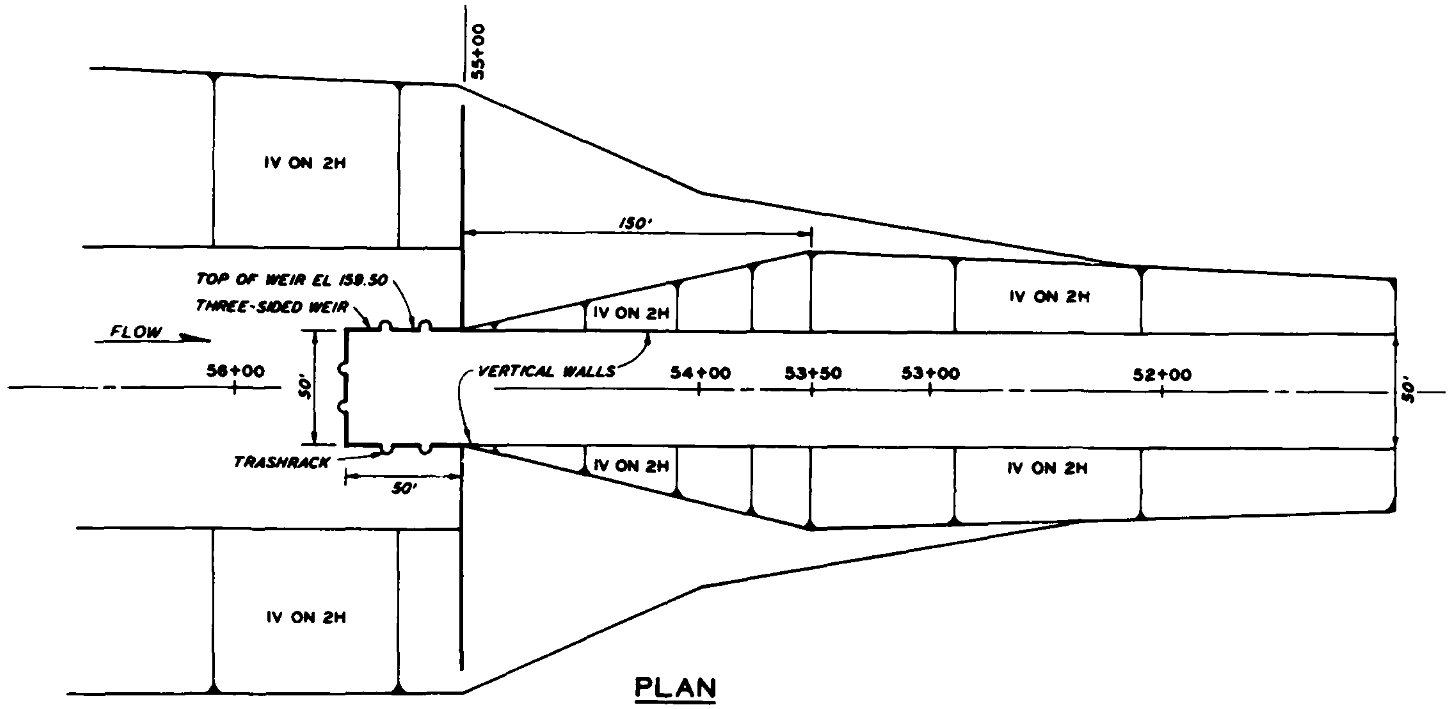
LEGEND

—— TOPOGRAPHY BEFORE SPF HYDROGRAPH
----- TOPOGRAPHY AFTER SPF HYDROGRAPH

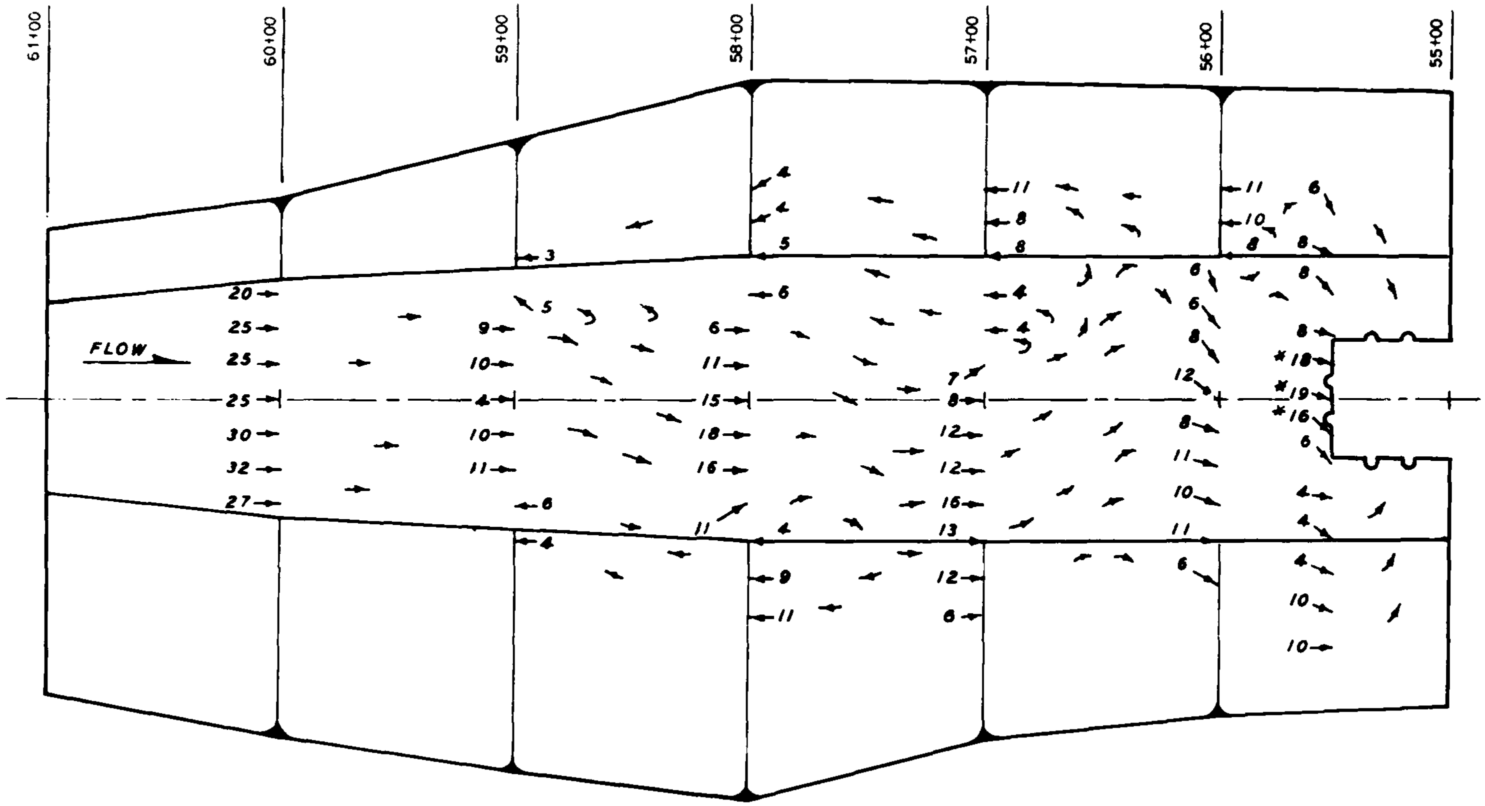
CROSS SECTIONS
RESULTS OF DEBRIS TEST DURING SPF HYDROGRAPH
TYPE 24 DESIGN WEIR



TRASHRACK DETAILS
TYPE 2 DESIGN



TYPE 25 DESIGN
WEIR AND TRANSITION



PLAN

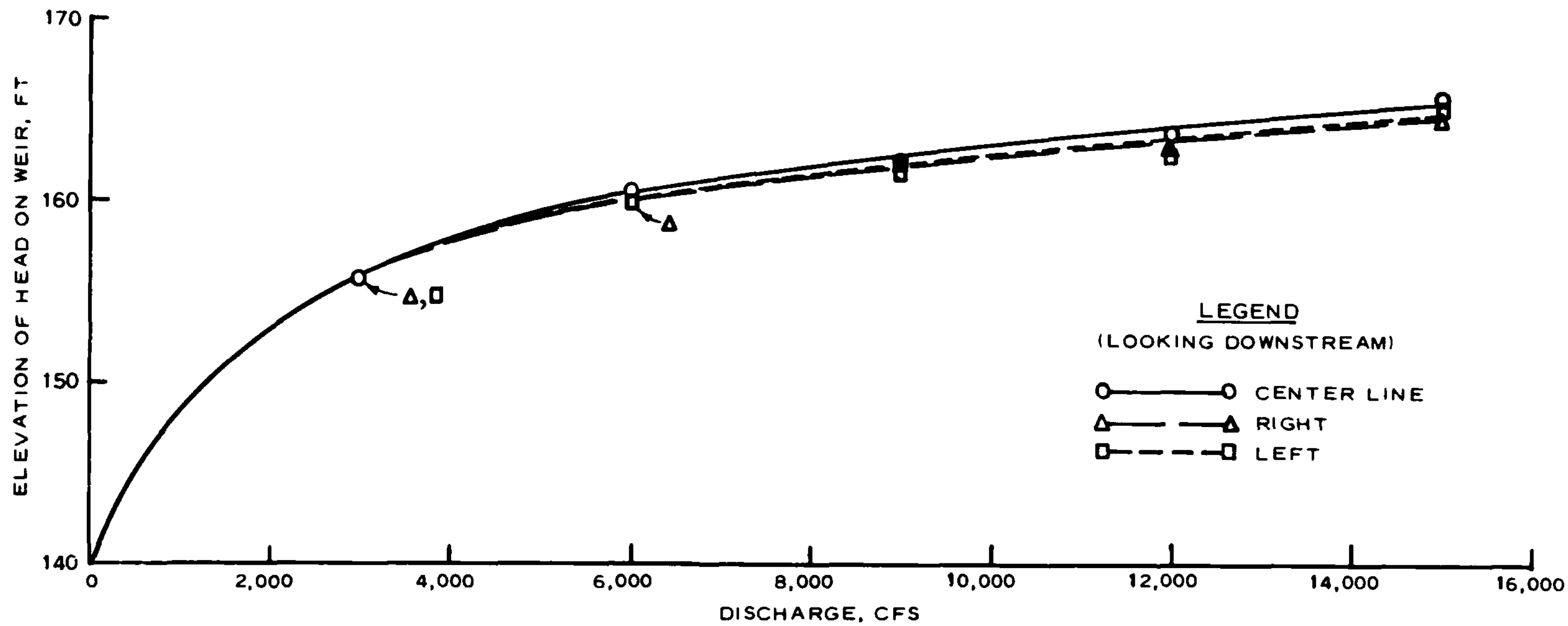
MAXIMUM VELOCITIES

1 FT ABOVE INVERT

TYPE 25 DESIGN WEIR AND TRANSITION

DISCHARGE 15,200 CFS

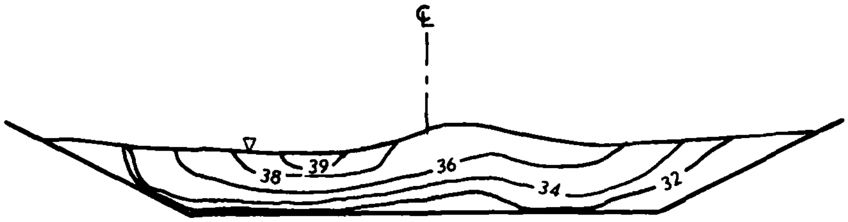
VELOCITIES, fps, MEASURED 1 FT ABOVE TOP OF WEIR



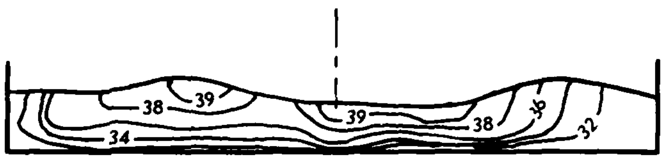
NOTE: WATER-SURFACE ELEVATIONS MEASURED AT CENTER LINE OF EACH SIDE OF THREE-SIDED WEIR

HEAD ON TYPE 25 DESIGN WEIR

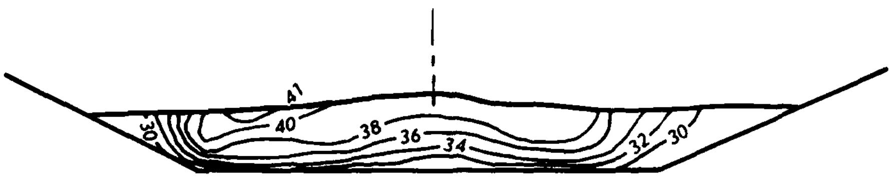
WEIR ELEVATION 159.5 FT



STATION 4+50



STATION 6+00



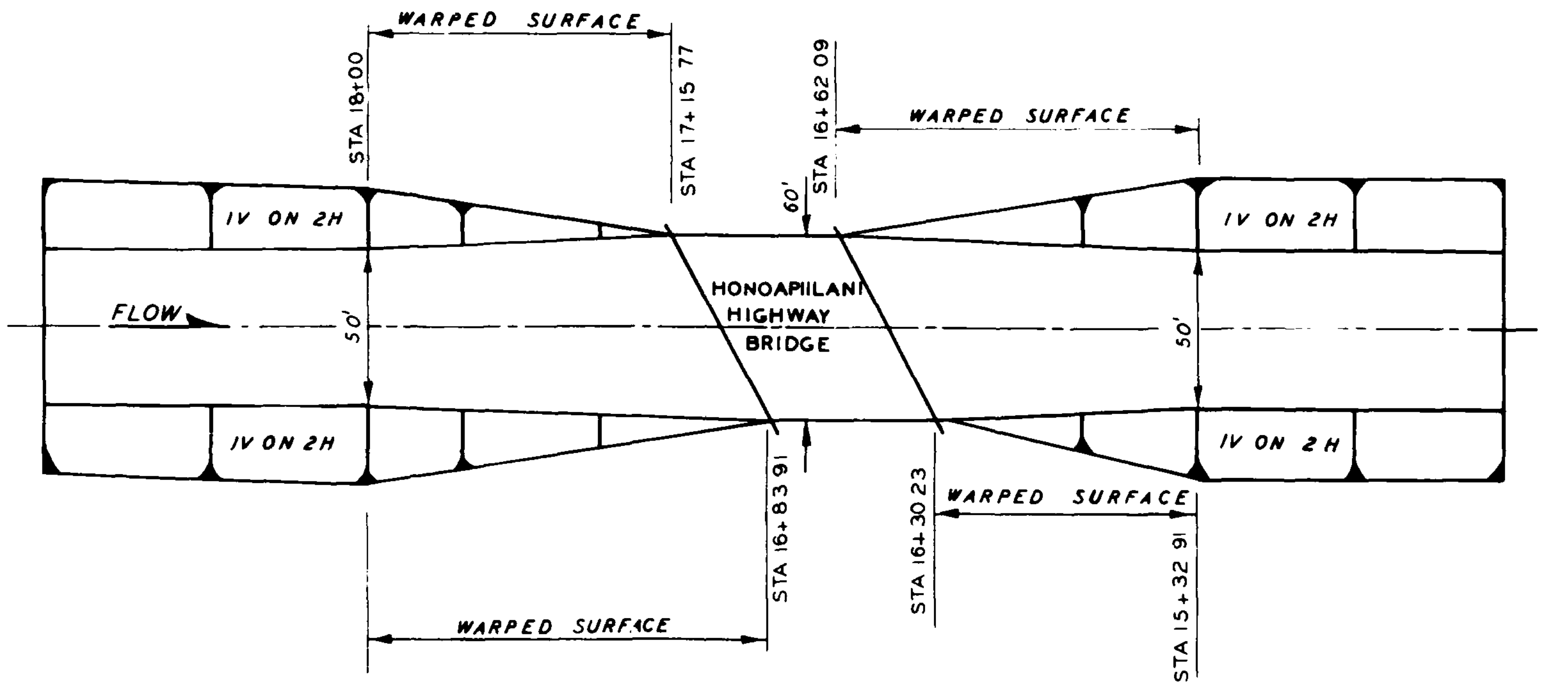
STATION 7+24

ELEVATION (LOOKING DOWNSTREAM)

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

ISOVELS
FRONT STREET BRIDGE
TYPE 1 BRIDGE TRANSITION
DISCHARGE 15,200 CFS
n = 0.015

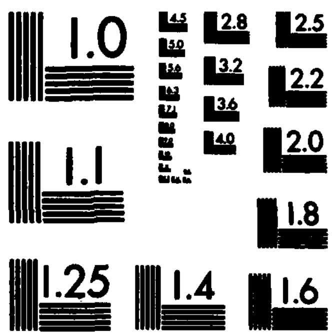
PLATE 26



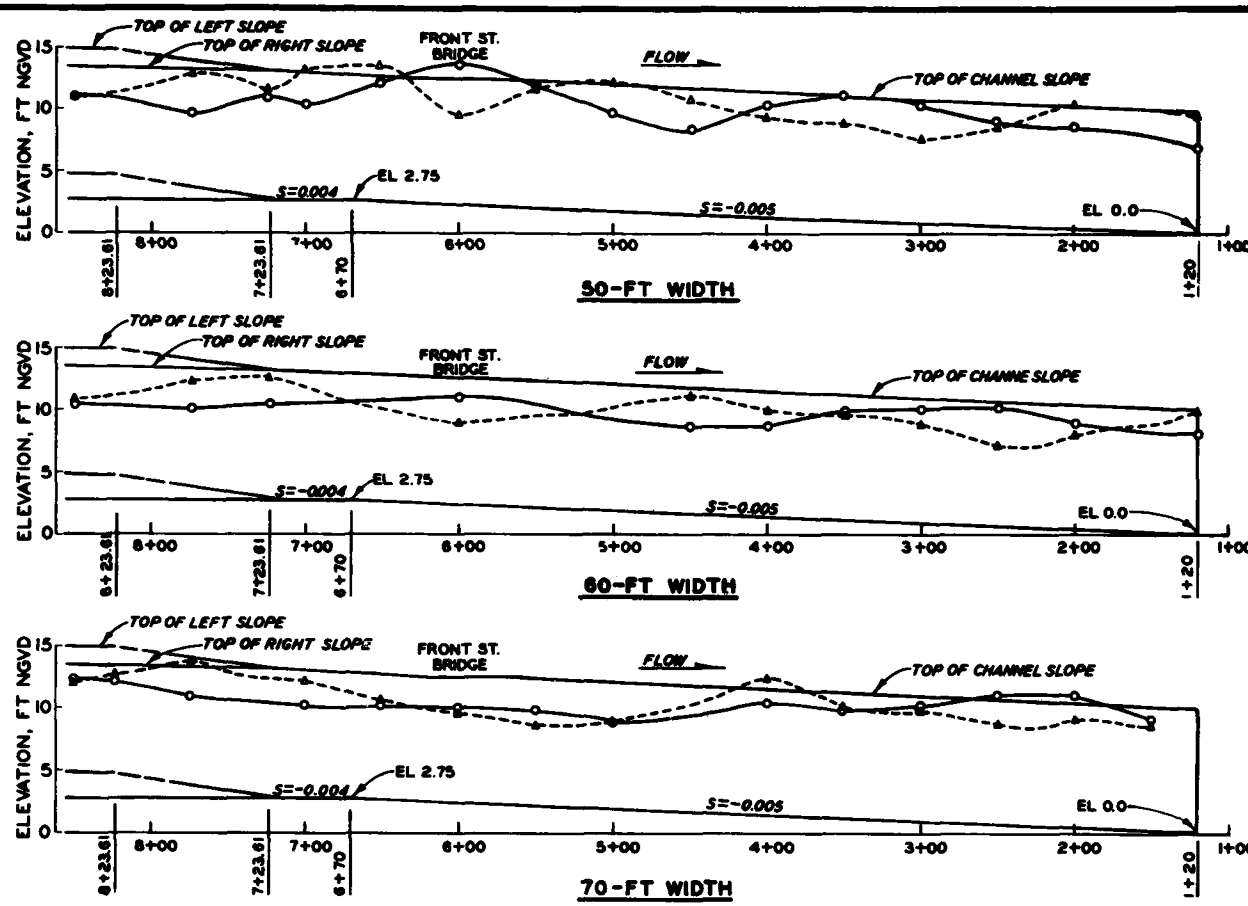
TYPE 5 DESIGN
BRIDGE TRANSITION

AD-A120 777 KAHOMA STREAM CHANNEL IMPROVEMENT PROJECT MAUI HAWAII 2/2
HYDRAULIC MODEL INV..(U) ARMY ENGINEER WATERWAYS
EXPERIMENT STATION VICKSBURG MS HYDRA.. J F GEORGE
UNCLASSIFIED AUG 82 WES/TR/HL-82-19 F/G 8/8 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



ELEVATION

LEGEND

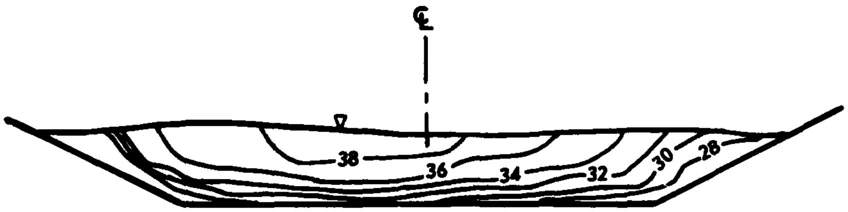
- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL

WATER - SURFACE PROFILES

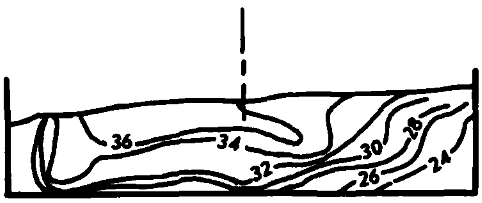
FRONT STREET BRIDGE
TYPE 5 BRIDGE TRANSITION

DISCHARGE 15,200 CFS

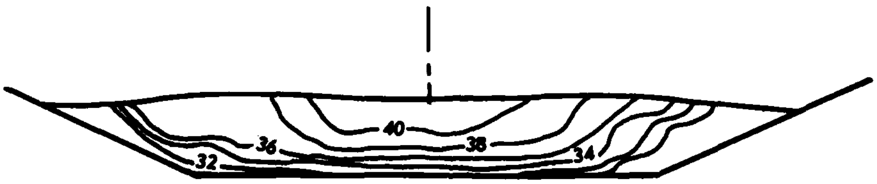
n - 0.015



STATION 4+50



STATION 6+00



STATION 7+24

ELEVATION (LOOKING DOWNSTREAM)

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

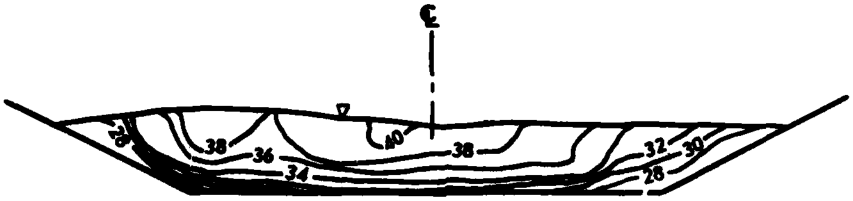
ISOVELS

FRONT STREET BRIDGE

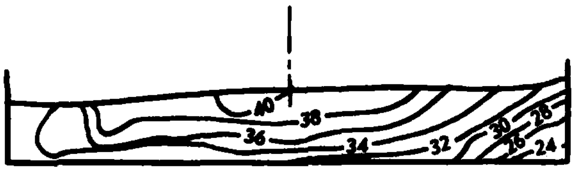
TYPE 5 BRIDGE TRANSITION

DISCHARGE 15,200 CFS

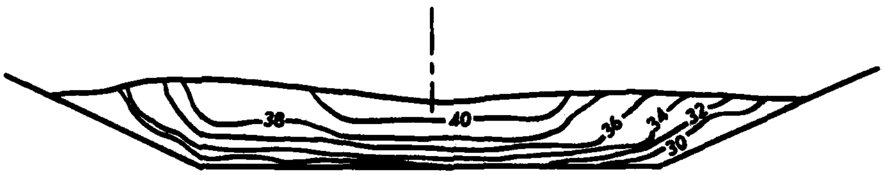
50-FT WIDTH n = 0.015



STATION 4+50



STATION 6+00



STATION 7+24

ELEVATION (LOOKING DOWN [illegible] AM)

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

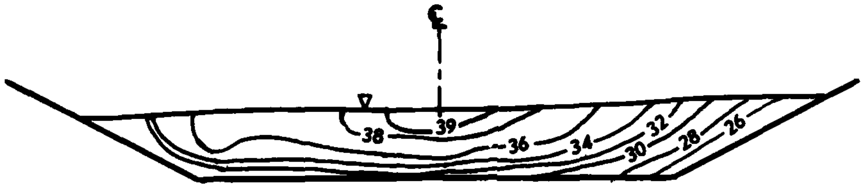
ISOVELS

FRONT STREET BRIDGE

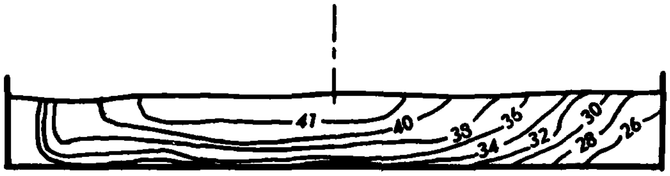
TYPE 5 BRIDGE TRANSITION

DISCHARGE 15,200 CFS

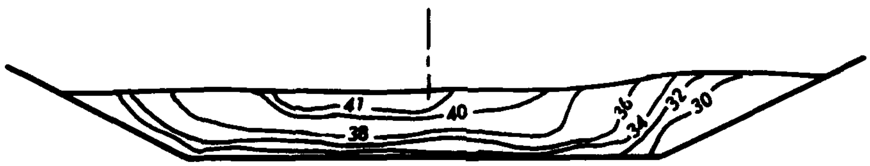
60-FT WIDTH n = 0.015



STATION 4+50



STATION 6+00

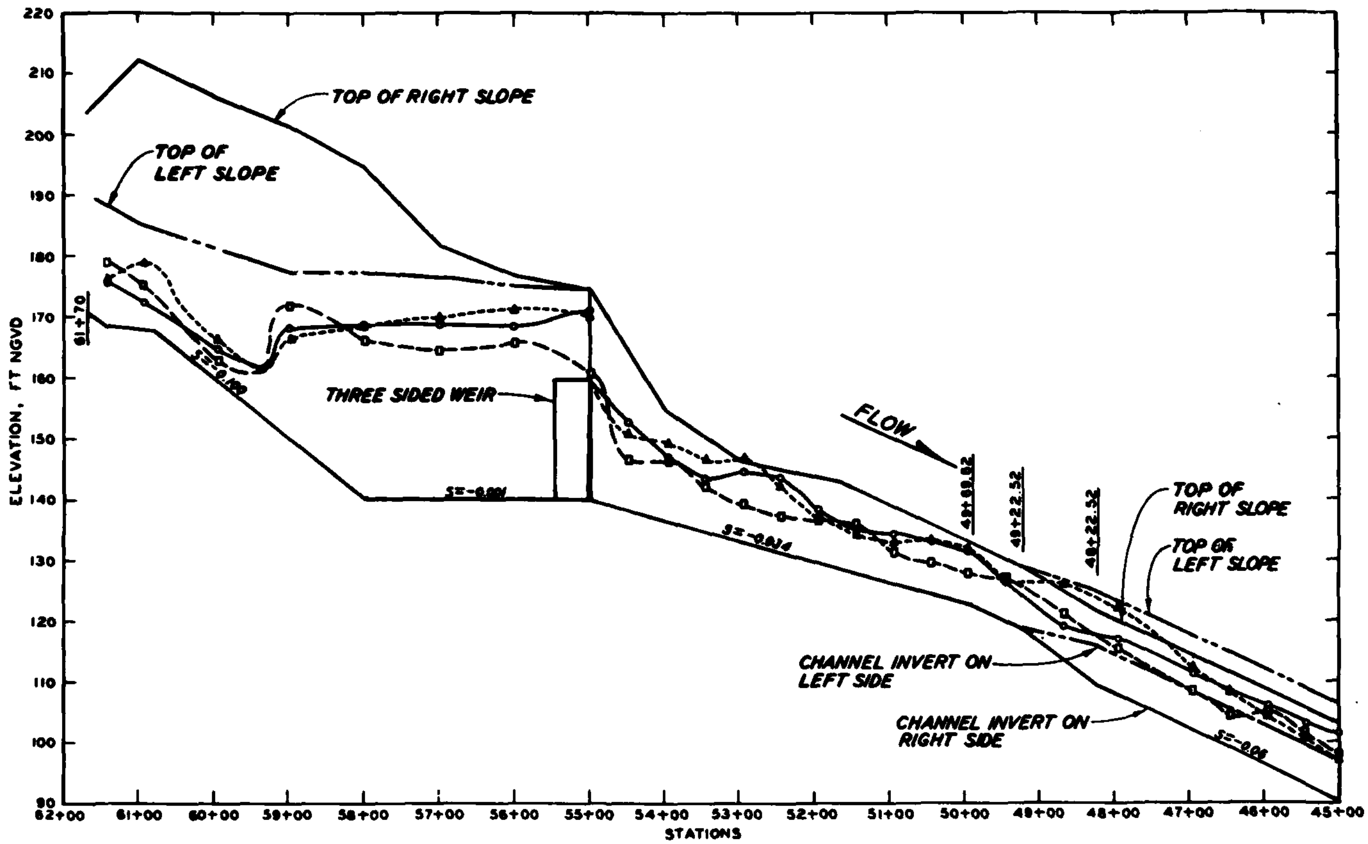


STATION 7+24

ELEVATION (LOOKING DOWNSTREAM)

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND

ISOVELS
FRONT STREET BRIDGE
TYPE 5 BRIDGE TRANSITION
DISCHARGE 15,200 CFS
70-FT WIDTH n = 0.015

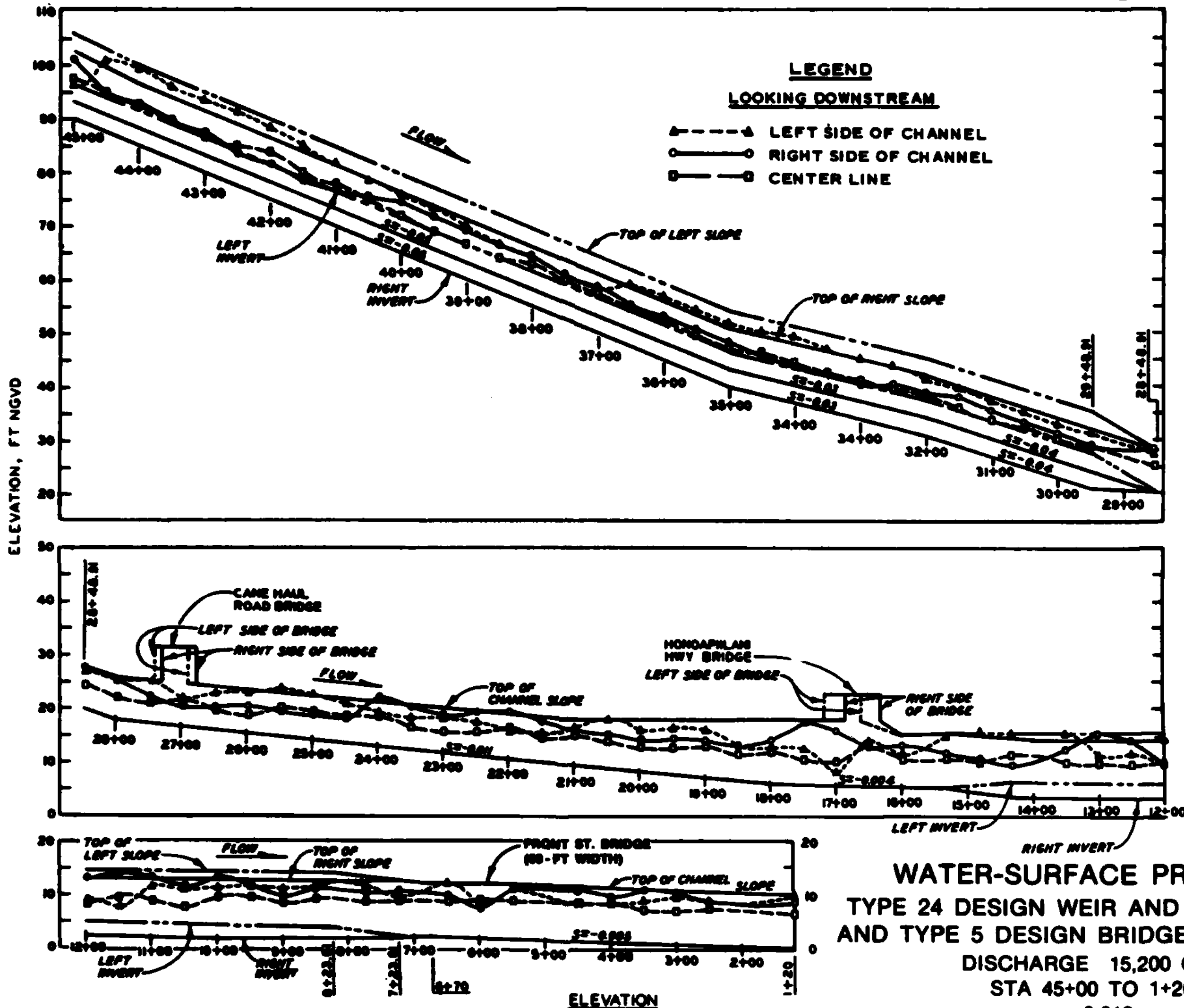


ELEVATION

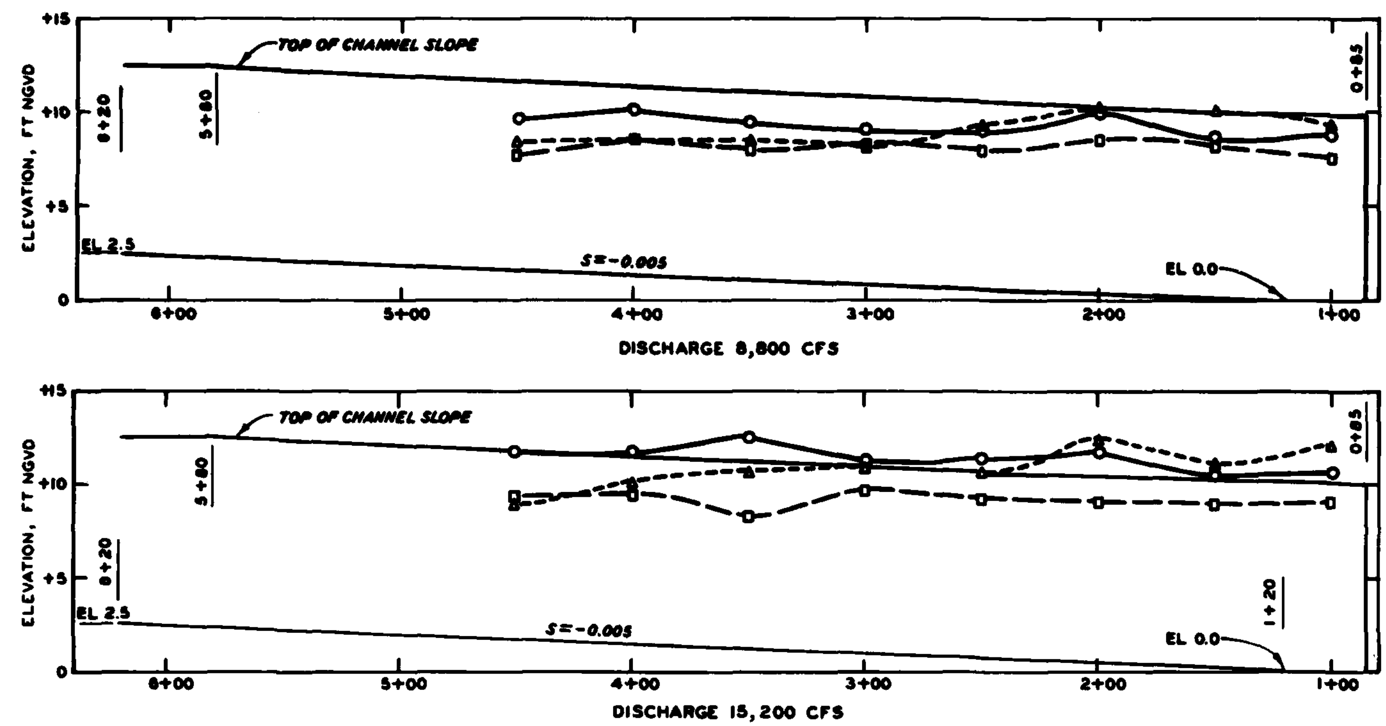
LEGEND
LOOKING DOWNSTREAM

- ▲- - - -▲ LEFT SIDE OF CHANNEL
- ○———○ RIGHT SIDE OF CHANNEL
- □— —□ CENTER LINE

WATER-SURFACE PROFILES
TYPE 24 DESIGN WEIR AND TRANSITION, AND TYPE 5 DESIGN BRIDGE TRANSITION
DISCHARGE 15,200 CFS
STA 61+70 TO 45+00
n = 0.013



WATER-SURFACE PROFILES
TYPE 24 DESIGN WEIR AND TRANSITION
AND TYPE 5 DESIGN BRIDGE TRANSITION
DISCHARGE 15,200 CFS
STA 45+00 TO 1+20
n = 0.013



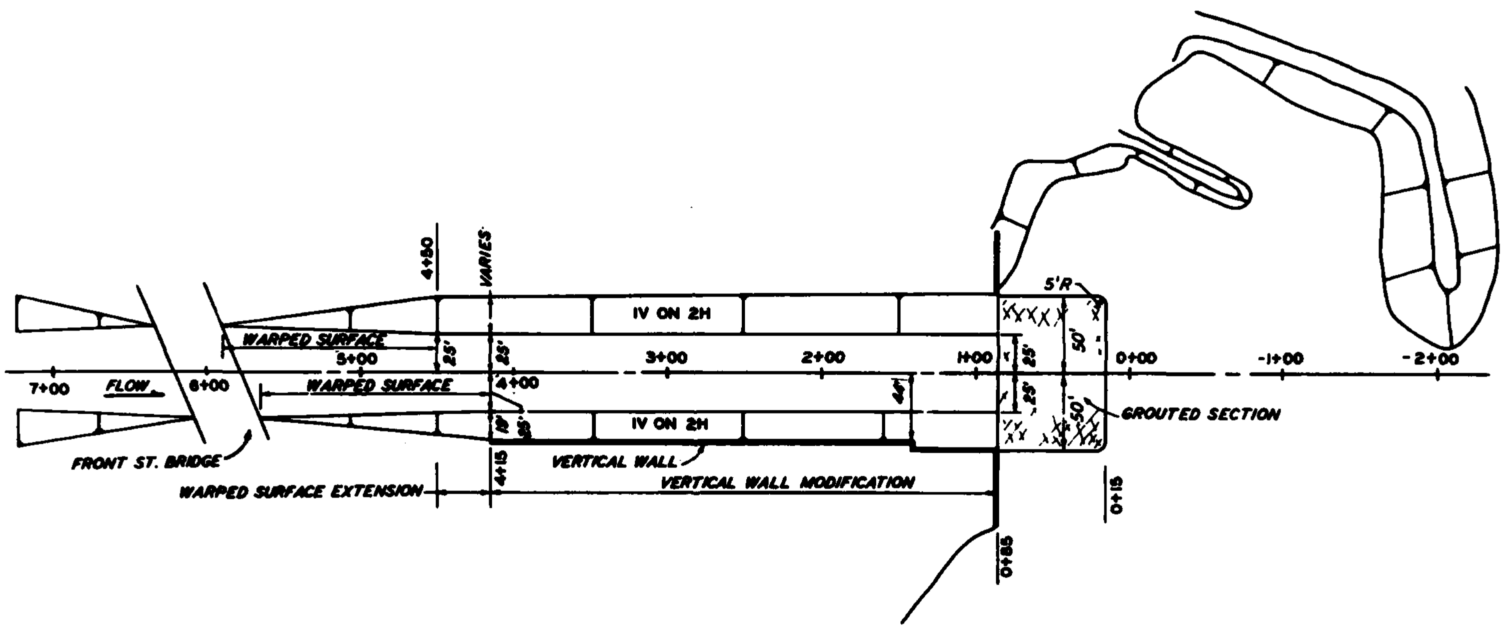
PROFILE

LEGEND

- MAXIMUM WATER SURFACE LEFT SIDE
- MAXIMUM WATER SURFACE RIGHT SIDE
- CENTER LINE

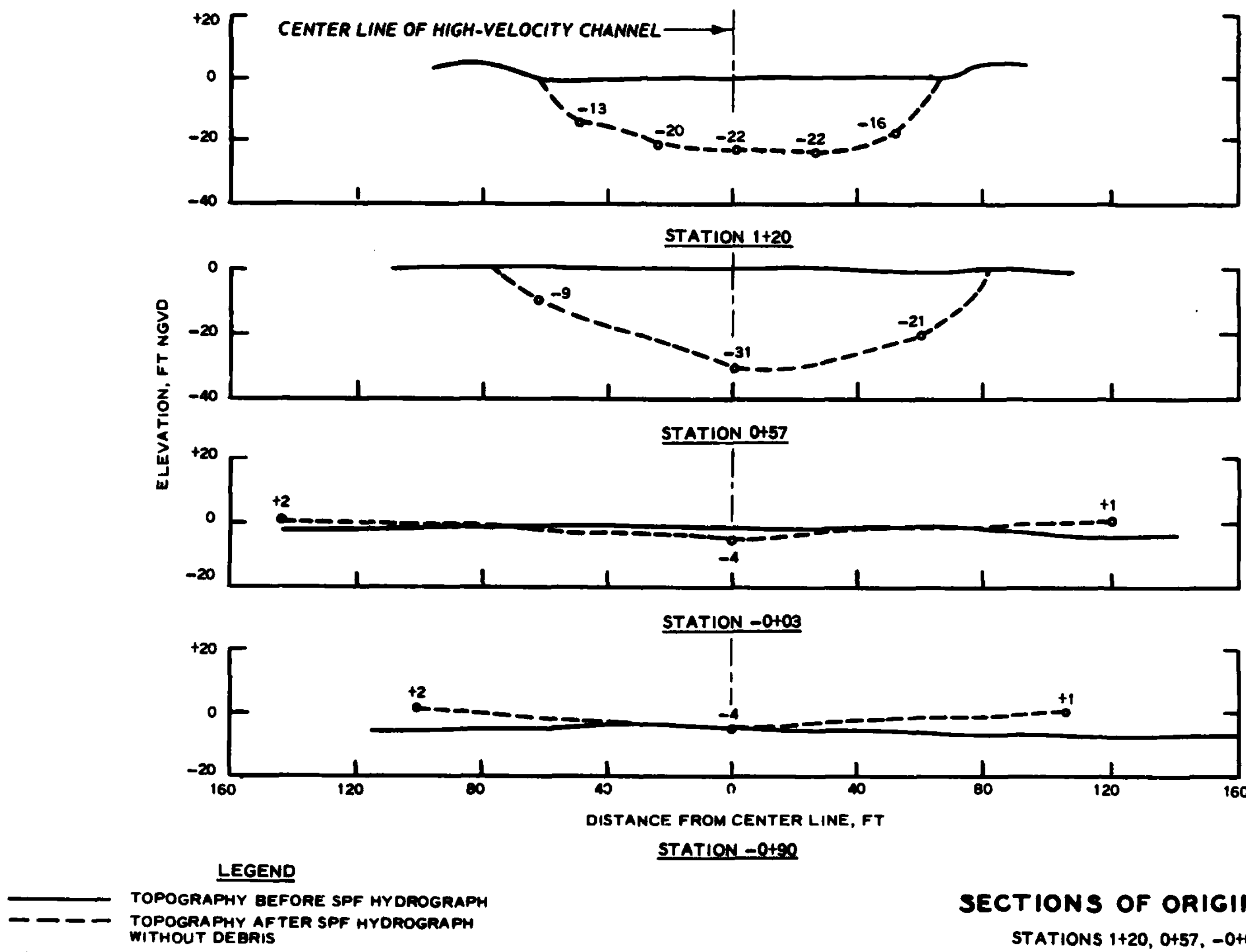
WATER-SURFACE PROFILES

EXTRA ROUGHNESS IN CHANNEL
BETWEEN STA 4+50 AND 0+85
n = 0.013



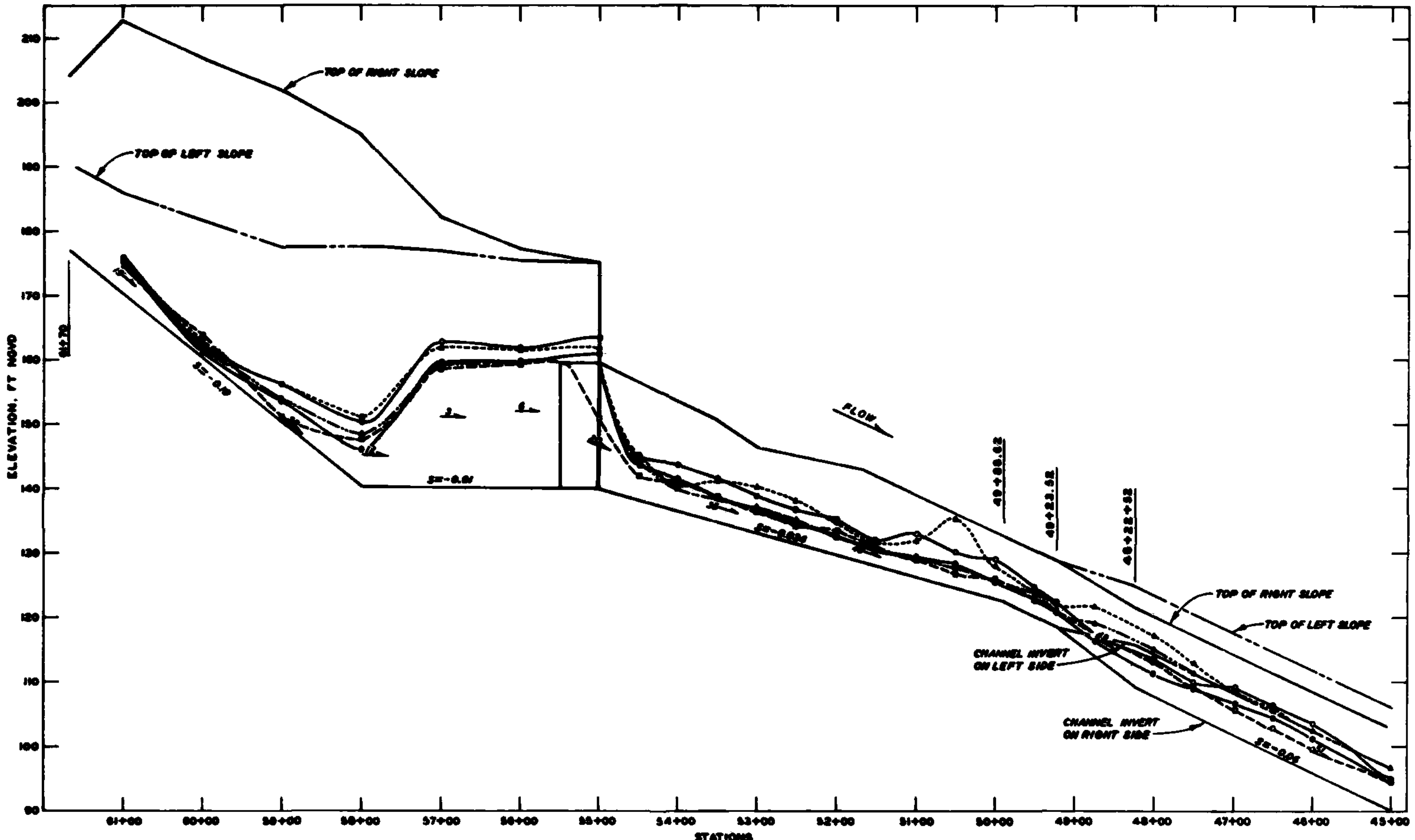
PLAN

VERTICAL WALL AND TRANSITION MODIFICATION



SECTIONS OF ORIGINAL DESIGN

STATIONS 1+20, 0+57, -0+03, AND -0+90



ELEVATION

LEGEND
LOOKING DOWNSTREAM

- HIGH-WATER MARK, LEFT SIDE OF CHANNEL
- HIGH-WATER MARK, RIGHT SIDE OF CHANNEL
- CENTER LINE
- AVERAGE WATER SURFACE, LEFT SIDE
- AVERAGE WATER SURFACE, RIGHT SIDE
- MAXIMUM VELOCITY, FPS

WATER-SURFACE PROFILES
RECOMMENDED DESIGN
DISCHARGE 6,600 CFS

STATION 61+70 TO 45+00

n = 0.013

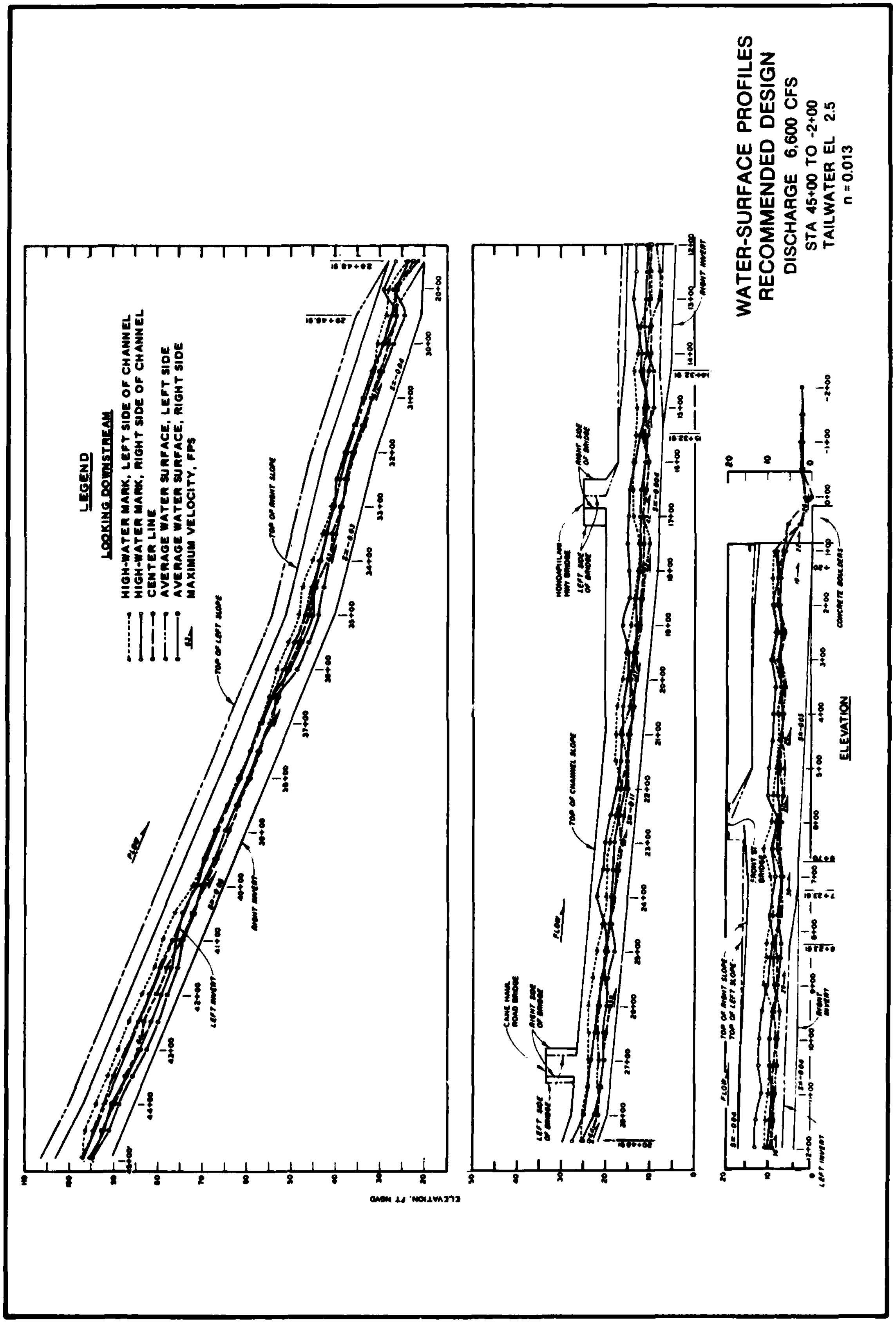
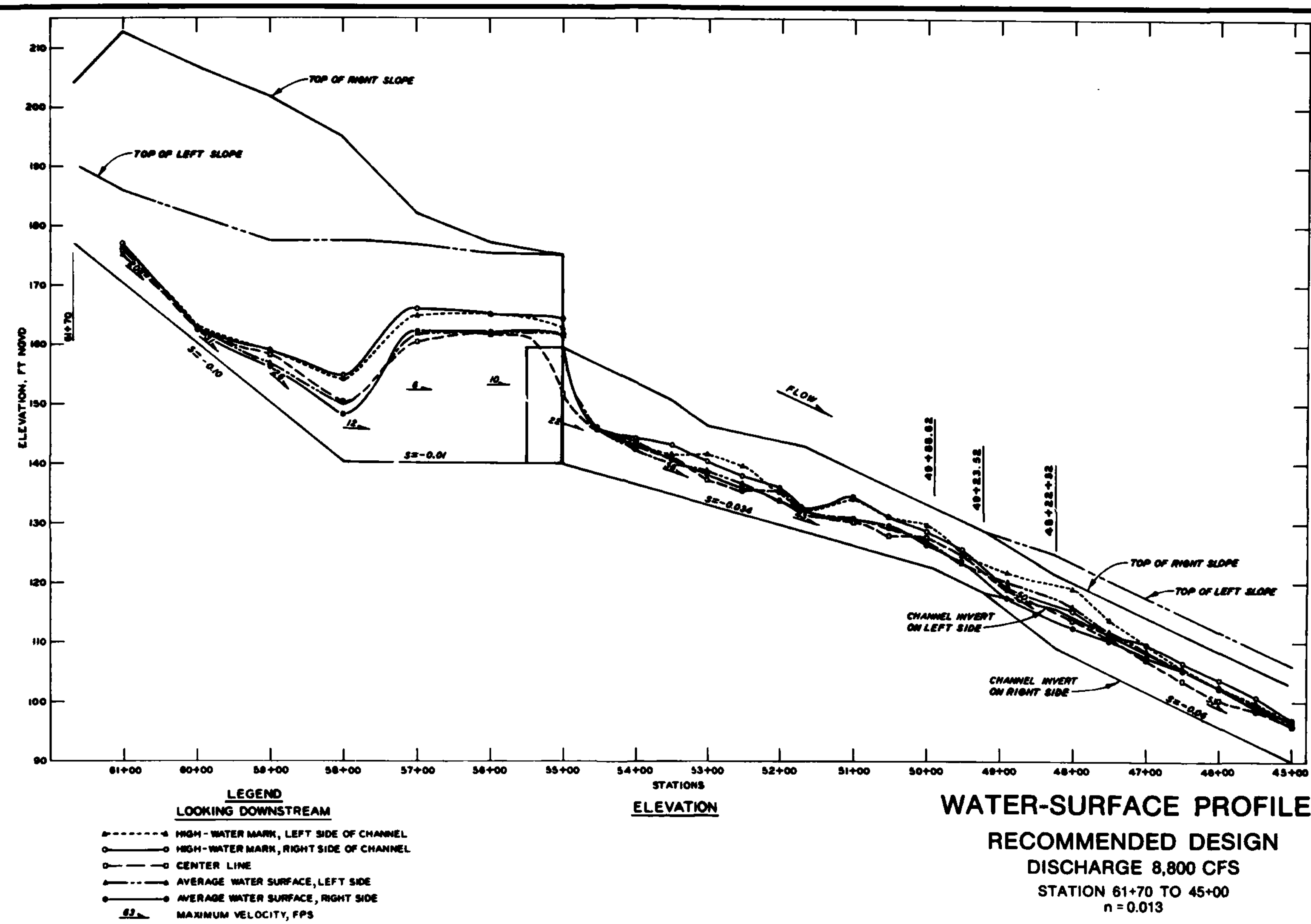
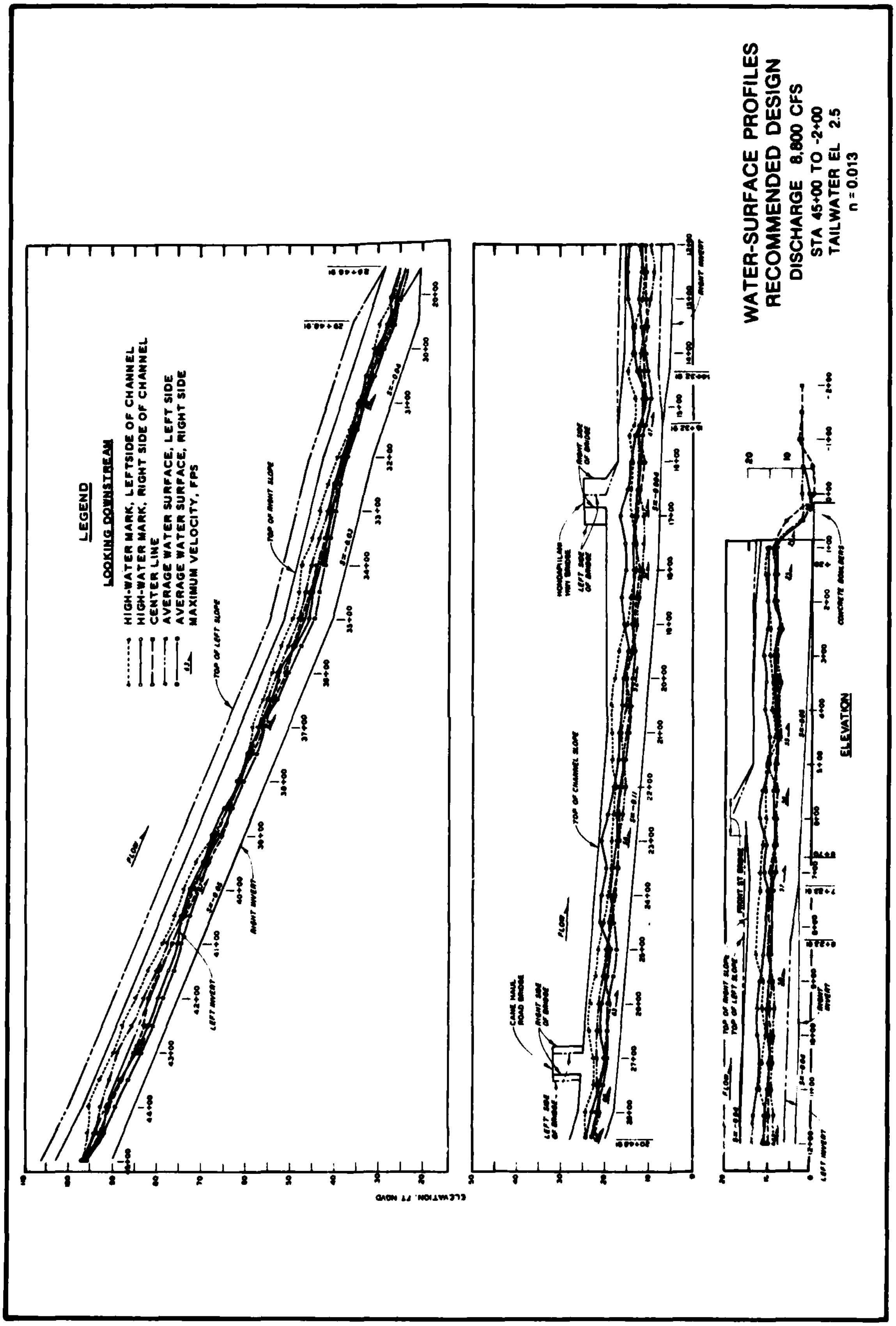

WATER-SURFACE PROFILES
RECOMMENDED DESIGN
DISCHARGE 6,600 CFS
STA 45+00 TO -2+00
TAILWATER EL 2.5
n = 0.013
LEGEND
LOOKING DOWNSTREAM
HIGH-WATER MARK, LEFT SIDE OF CHANNEL
HIGH-WATER MARK, RIGHT SIDE OF CHANNEL
CENTER LINE
AVERAGE WATER SURFACE, LEFT SIDE
AVERAGE WATER SURFACE, RIGHT SIDE
MAXIMUM VELOCITY, FPS
ELEVATION, FT NGVD
ELEVATION

PLATE 38

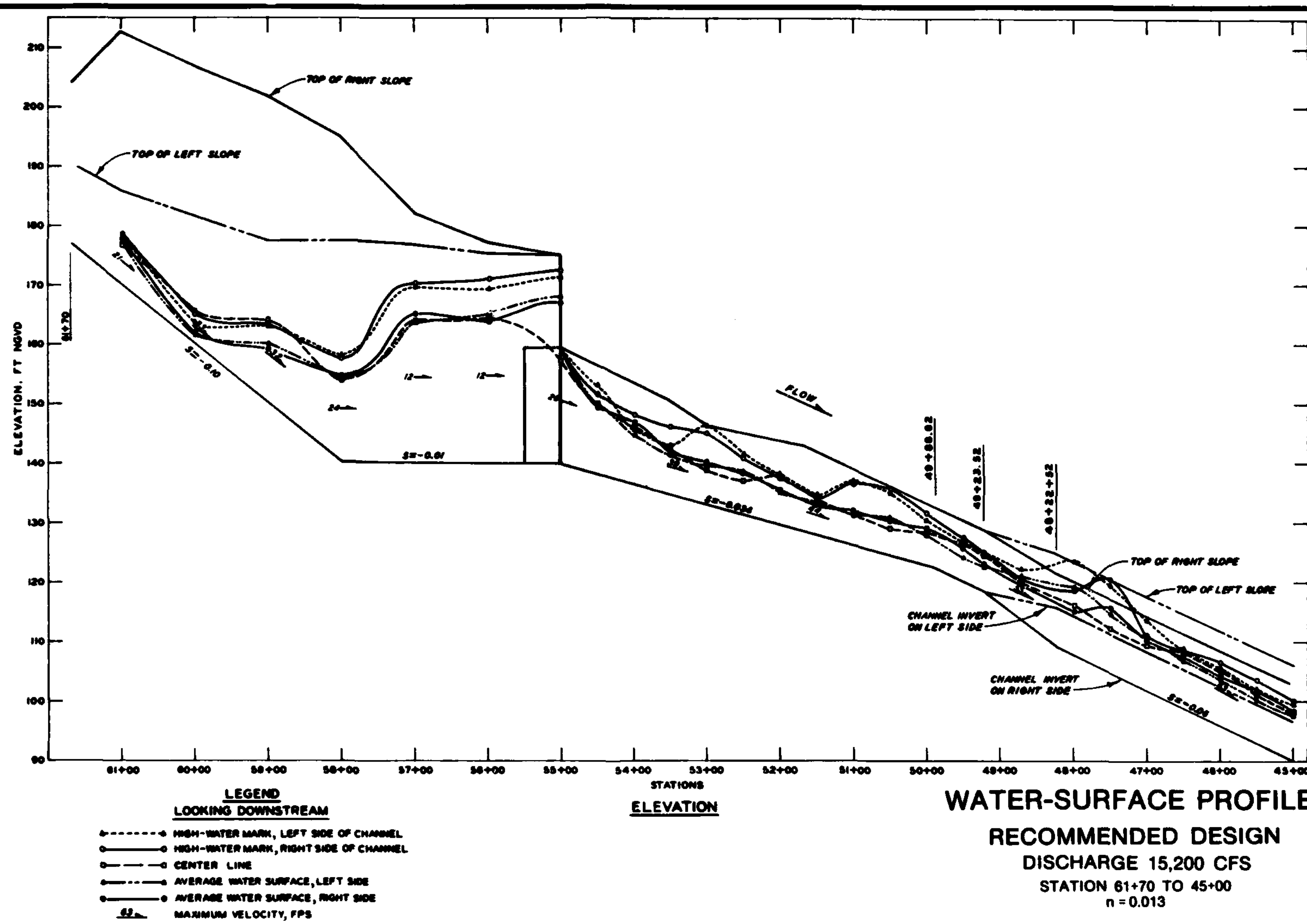


WATER-SURFACE PROFILES
RECOMMENDED DESIGN
DISCHARGE 8,800 CFS
STATION 61+70 TO 45+00
n = 0.013



WATER-SURFACE PROFILES
RECOMMENDED DESIGN
DISCHARGE 6,800 CFS
STA 45+00 TO -2+00
TAILWATER EL 2.5
n = 0.013
LEGEND
LOOKING DOWNSTREAM
HIGH-WATER MARK, LEFTSIDE OF CHANNEL
HIGH-WATER MARK, RIGHT SIDE OF CHANNEL
CENTER LINE
AVERAGE WATER SURFACE, LEFT SIDE
AVERAGE WATER SURFACE, RIGHT SIDE
MAXIMUM VELOCITY, FPS
ELEVATION, FT NGVD
ELEVATION
TOP OF LEFT SLOPE
TOP OF RIGHT SLOPE
TOP OF CHANNEL SLOPE
LEFT INVERT
RIGHT INVERT
FLOW
CONCRETE BOULDERS

PLATE 40



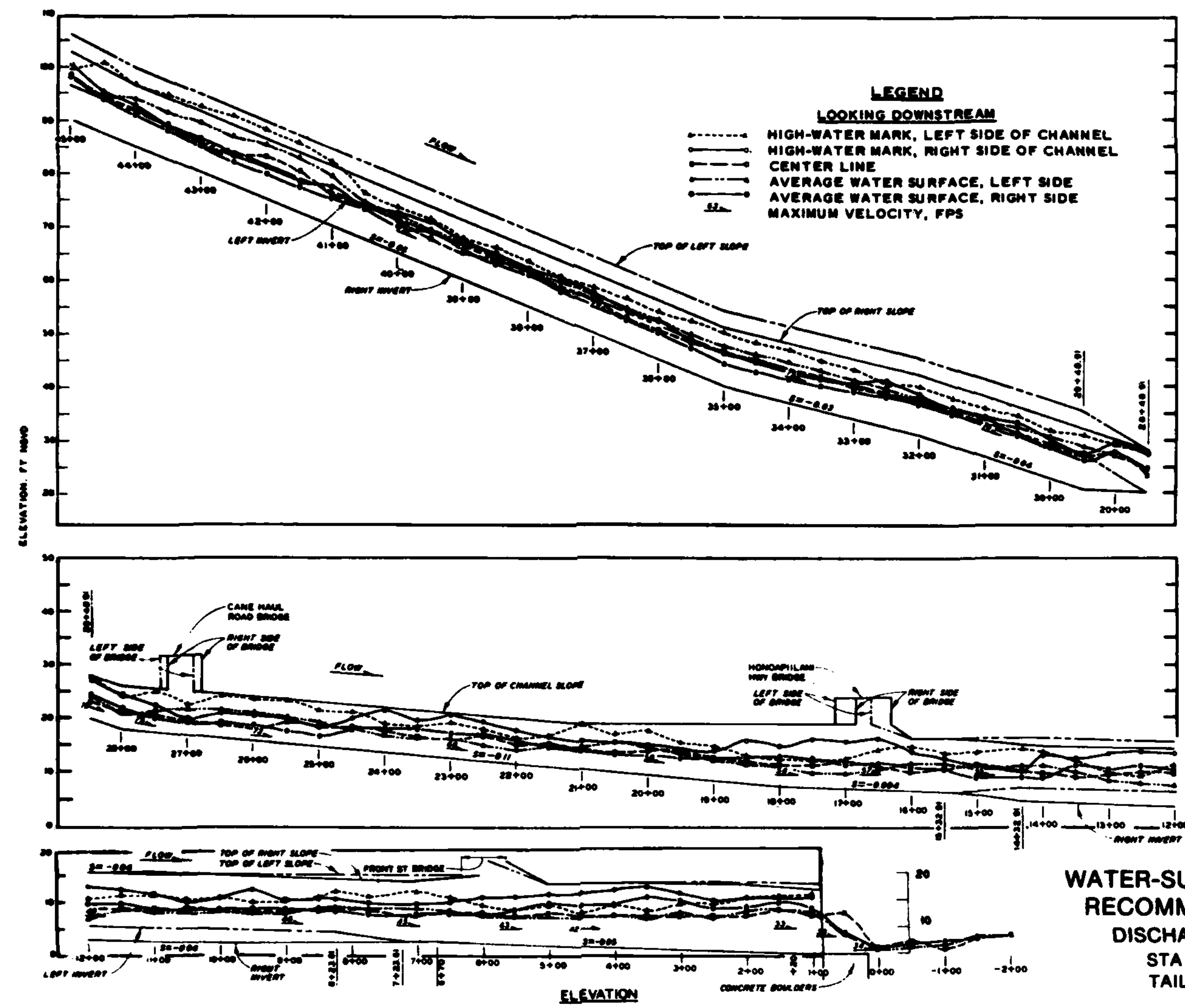
WATER-SURFACE PROFILES

RECOMMENDED DESIGN

DISCHARGE 15,200 CFS

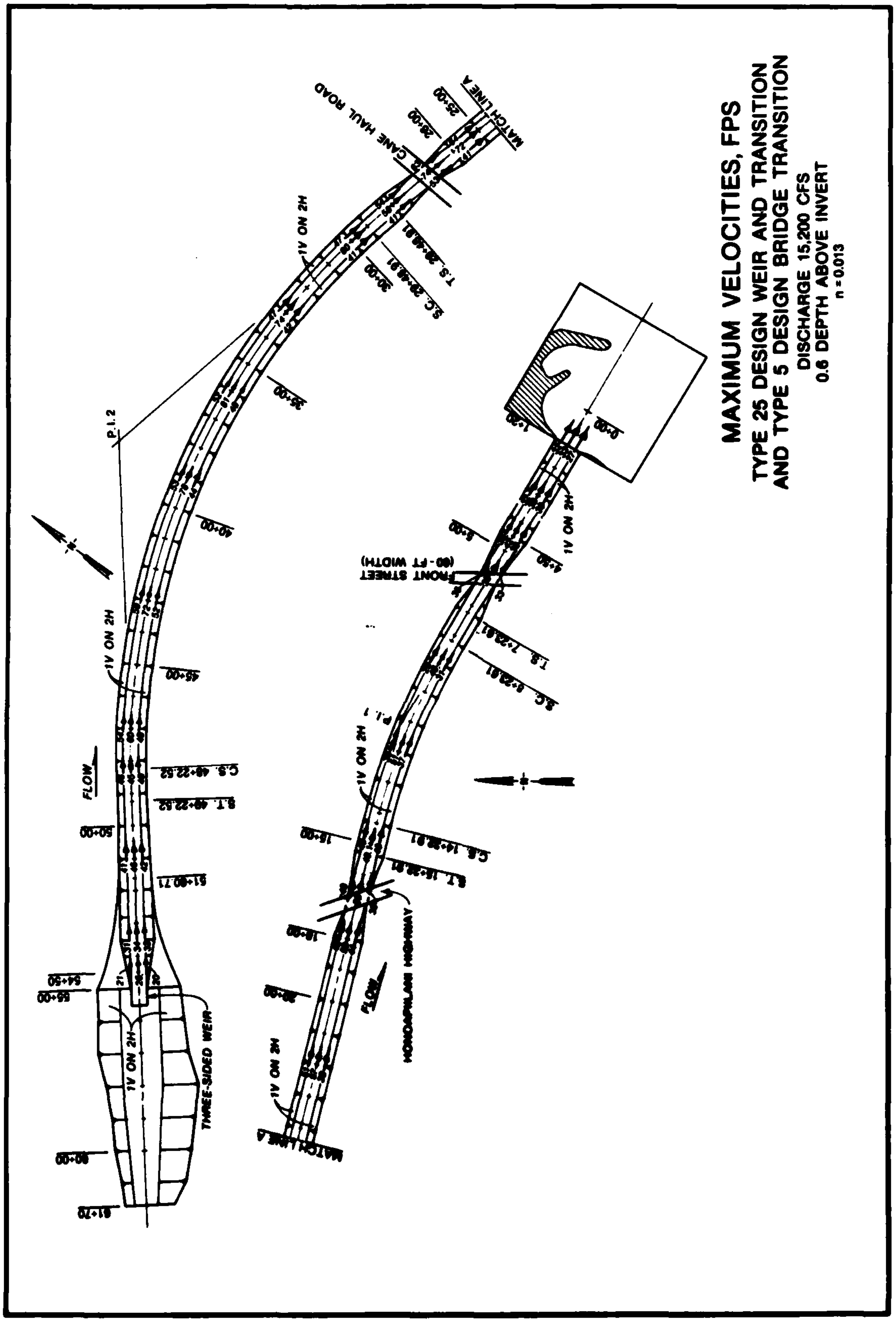
STATION 61+70 TO 45+00

n = 0.013



WATER-SURFACE PROFILES
RECOMMENDED DESIGN
DISCHARGE 15,200 CFS
STA 45+00 TO -2+00
TAILWATER EL 2.5
n = 0.013

PLATE 42



MAXIMUM VELOCITIES, FPS
TYPE 25 DESIGN WEIR AND TRANSITION
AND TYPE 5 DESIGN BRIDGE TRANSITION
DISCHARGE 15,200 CFS
0.6 DEPTH ABOVE INVERT
n = 0.013

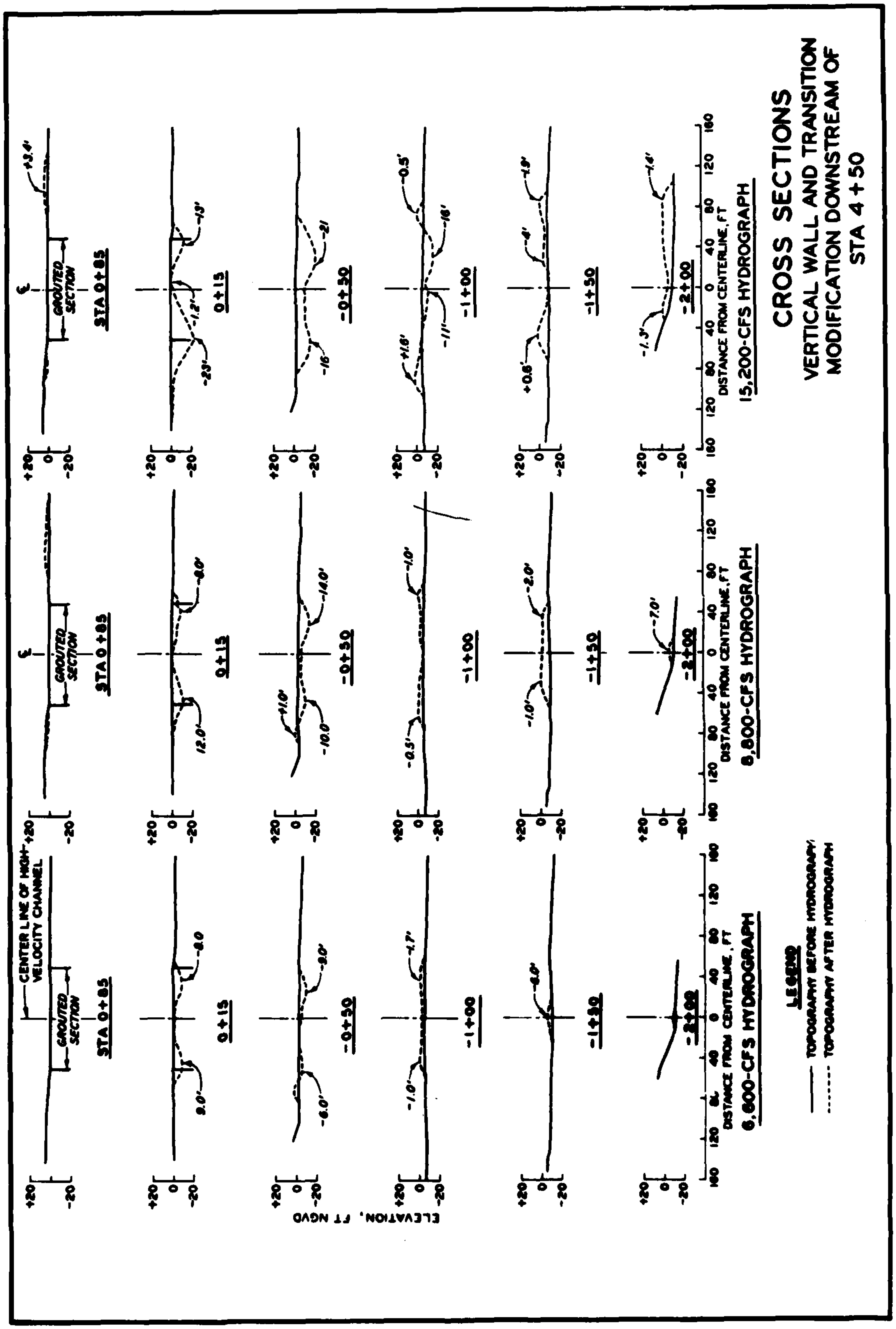

CROSS SECTIONS
VERTICAL WALL AND TRANSITION
MODIFICATION DOWNSTREAM OF
STA 4+50
6,600-CFS HYDROGRAPH
8,800-CFS HYDROGRAPH
15,200-CFS HYDROGRAPH
DISTANCE FROM CENTERLINE, FT
ELEVATION, FT NGVD
CENTER LINE OF HIGH-VELOCITY CHANNEL
GROUTED SECTION
STA 0+85
0+15
-0+50
-1+00
-1+50
-2+00
LEGEND
TOPOGRAPHY BEFORE HYDROGRAPH
TOPOGRAPHY AFTER HYDROGRAPH

PLATE 44

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

George, John F.
Kahoma Stream Channel Improvement Project, Maui, Hawaii : Hydraulic Model Investigation / by John F. George (Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. ; available from NTIS, 1982.
65 p. in various pagings, 44 p. of plates : ill. ; 27 cm. -- (Technical report ; HL-82-19)
Cover title.
"August 1982."
Final report.
"Prepared for U.S. Army Engineer Division, Pacific Ocean."

1. Channels (Hydraulic engineering). 2. Hydraulic models. 3. Kahoma Stream (Hawaii). 4. Rivers. I. United States. Army. Corps of Engineers. Pacific Ocean Division. II. U.S. Army Engineer Waterways Experiment Station. Hydraulics Laboratory. III. Title

George, John F.
Kahoma Stream Channel Improvement Project: ....1982.
(Card 2)

IV. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; HL-82-19.
TA7.W34 no.HL-82-19