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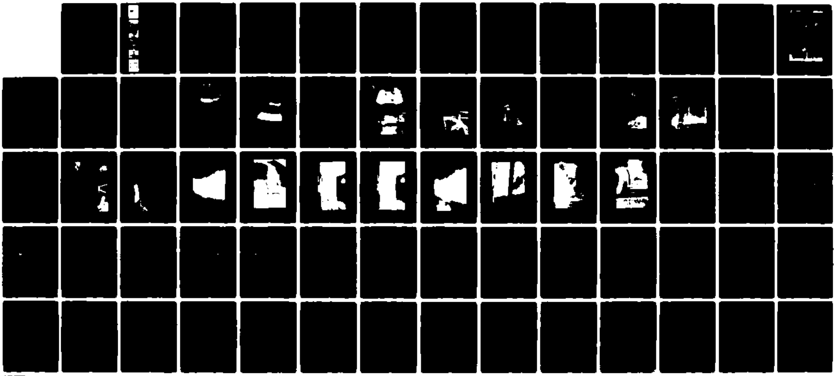

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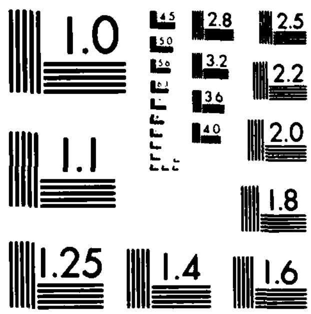

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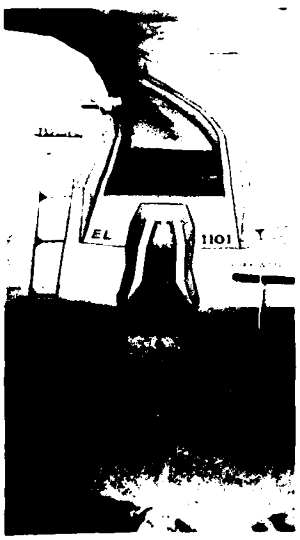

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TECHNICAL REPORT HL-83-7

BIG CREEK FLOOD-CONTROL PROJECT CLEVELAND, OHIO

Hydraulic Model Investigation

by

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U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

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Final Report

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Tests were conducted on a 1:40-scale model of Big Creek to investigate the hydraulic performance of a proposed floodway channel and a section of modified channel. The model reproduced the entire proposed floodway channel, a portion of the existing Big Creek main channel, and a section of modified channel downstream from the existing channel.

Distribution of flow between the existing channel and the floodway channel
(Continued)

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20. ABSTRACT (Continued).

was found to be slightly different than anticipated, but this difference was so small that it had no significant effect on flow conditions in either channel.

Flow conditions were satisfactory in the concrete chute of the upstream end of the proposed floodway channel. A hydraulic jump formed at the lower end of the chute structure, resulting in satisfactory flow conditions at the entrance to the natural channel.

The original design gabion drop structures used in the floodway to reduce the grade along the channel caused flow to concentrate near the middle of the channel, resulting in high velocities. Also, depths of flow in several reaches of the channel were less than anticipated. Revisions to these drop structures resulted in good flow conditions throughout the floodway channel.

Although the flood-control project did not include improvements to the Big Creek main channel, velocities and water-surface elevations were measured in the reach reproduced in the model.

A concrete transition between the downstream end of a three-barrel conduit and the modified channel caused flow to concentrate in the channel which resulted in movement of the riprap immediately downstream from the transition and along the left bank. The concrete transition was removed, and the area was shaped with riprap. This resulted in satisfactory flow conditions in the modified channel.

PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers (OCE), U. S. Army, on 26 February 1981, at the request of the U. S. Army Engineer District, Buffalo (NCB). The studies were conducted by personnel of the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES) during the period June 1981 to August 1982 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. W. B. Fenwick, J. F. George, 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. Pickering.

During the course of the model investigation, Messrs. Sam Powell and Tom Munsey, OCE; Jose Ordonez, North Central Division; and Thomas Pieczynski, Rao Yalamanchili, and George Brooks, NCB, visited WES to discuss test results and correlate these results with concurrent design work.

Commanders and Directors of WES during the conduct of the study 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.

CONTENTS

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
feet	0.3048	metres
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

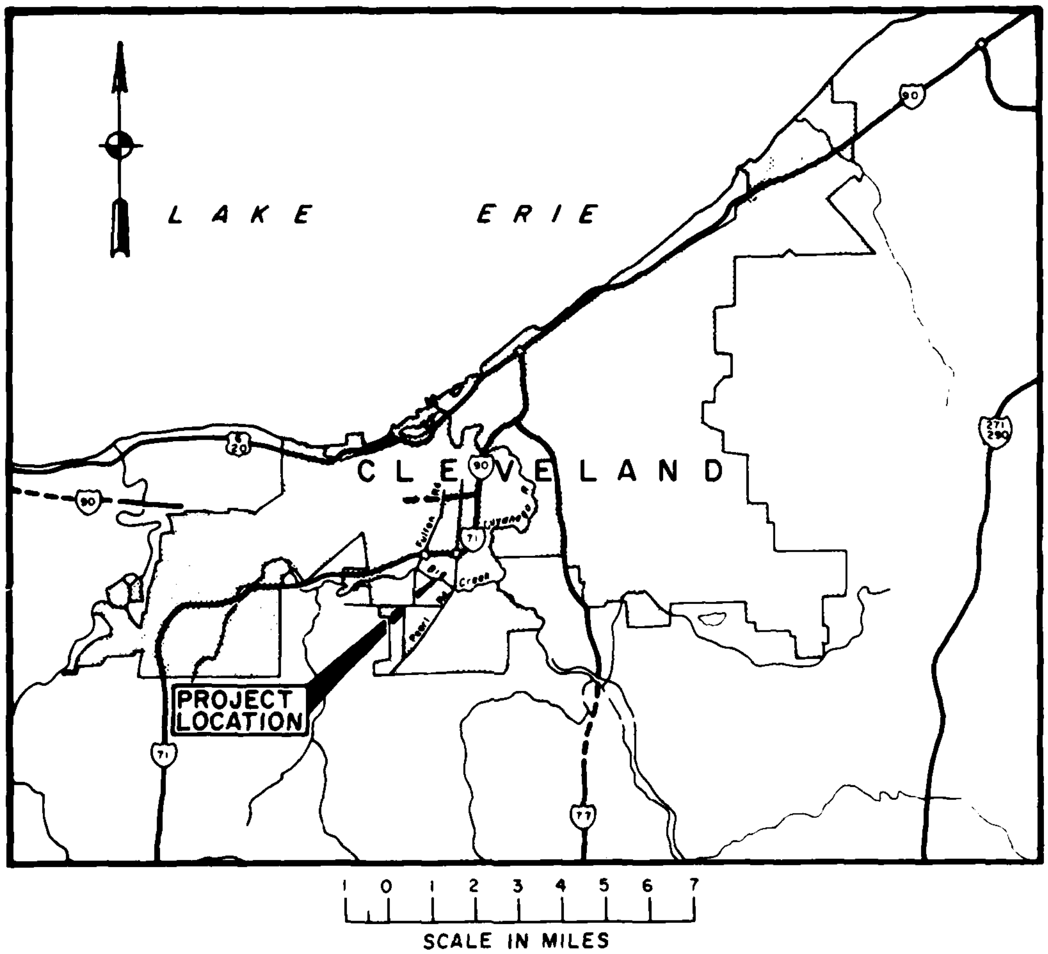

Figure 1. Vicinity map

BIG CREEK FLOOD-CONTROL PROJECT, CLEVELAND, OHIO

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The Big Creek flood-control project is located in the city of Cleveland, Ohio (Figure 1). It extends from approximately 1 mile* upstream from the creek's confluence with the Cuyahoga River, upstream into Brookside Park, approximately 2.3 miles from the confluence. The Big Creek drainage basin covers an area of approximately 38 square miles. About 70 percent of the watershed is urbanized. The floodplain is used for recreation, transportation, and industry and is occupied by the Metroparks Zoo and Brookside Industrial Park. At the present time, all life, property, and industry within the floodplain are subject to flood damage. The proposed flood-control project will provide protection of these resources against flood damage from a 100-year (one percent probability of occurrence) discharge of 12,000 cfs. The flood-control plan involves constructing a floodway channel, modifying sections of the existing channel, and constructing a diversion channel. A layout of the plan is shown in Plate 1.

2. The floodway channel was designed to convey excess discharge so that the main stream improvements will not be overtaxed; design discharge for the floodway channel is 6,000 cfs. A reach of this channel at the upstream end will be constructed over an existing two-barrel conduit. The channel will start 280 ft downstream from the inlet of the two-barrel conduit and will extend 2,700 lin ft to where it joins the existing channel of Big Creek. The upper 550 ft of the channel will be a concrete chute; the remainder of the channel will be excavated into overburden and rock. Five gabion drop structures in this reach will reduce the grade along the channel.

3. Channel improvements in Big Creek will be provided along a 260-ft reach between the downstream end of the existing three-barrel conduit and the

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

confluence with the floodway channel. These improvements will consist of minor realignment and slope protection. Design discharge for this reach of modified channel is 6,000 cfs. A transition from the downstream end of the three-barrel conduit to the modified channel will be provided.

4. Channel improvements will also be provided along a 1,860-ft reach of the existing stream between its confluence with the floodway channel downstream to the West 25th Street Bridge area. This reach is designed to convey the full project discharge of 12,000 cfs.

5. At the lower end of the project, a diversion channel will extend 1,000 ft from the upstream side of the West 25th Street Bridge to the existing Big Creek channel and will cut off a loop of the existing channel. Design discharge in this channel is 7,000 cfs with the remaining 5,000 cfs from the design discharge being conveyed by the existing channel.

Purpose of Model Study

6. This investigation was concerned primarily with the floodway channel and that portion of the modified channel immediately downstream from the three-barrel conduit. Because of the difficulty in assessing the junction losses upstream and downstream from the floodway channel, a hydraulic model was needed to determine flow distributions in the existing channel and the floodway channel in order to optimize the floodway channel size and protective measures. Also, energy dissipation at the downstream ends of both the two-barrel and three-barrel conduits was uncertain. Specifically, the model study was to determine:

a. Distribution of flow between the existing two-barrel conduit and the proposed floodway channel.

b. Flow conditions on the concrete chute at the upstream end of the floodway channel.

c. Riprap requirements at the downstream end of the chute.

d. Optimum design of the five gabion drop structures.

e. Flow conditions in the existing Big Creek channel between the outlet of the two-barrel conduit and the inlet to the three-barrel conduit.

f. Flow conditions at the culvert outlets and protective measures required in those areas.

PART II: THE MODEL

Description

7. A 1:40-scale model reproduced approximately 150 ft of the existing Big Creek channel upstream from the two-barrel conduit, the entire length of the two-barrel conduit, the entire floodway channel, the existing Big Creek channel between the two-barrel conduit and the three-barrel conduit, the entire length of this conduit, and approximately 500 ft of the modified channel downstream (Figure 2). The model limits and general layout are shown in Plate 1; details are shown in Plates 2 and 3. The channel topography was molded in cement mortar to sheet-metal templates with crushed stone in the areas where riprap will be provided. All elevations are in feet referred to the National Geodetic Vertical Datum (NGVD). Scaled gabions, consisting of wire baskets filled with rock, were used for the drop structures. The chute and walls were constructed of plastic-coated plywood, and the conduits were made of plastic.

Appurtenances

8. Water used in operation of the model was supplied by a circulating system. Discharges, which were baffled when entering the model, were measured by means of venturi meters installed in the flow lines. Steel rails graded to specific elevations were placed along both sides of the model to serve as supports for measuring devices and to provide a convenient means of establishing stations and elevations in 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. Tailwater depths were regulated by a flap gate at the downstream end of the model. Different designs, along with flow conditions, were recorded photographically. A video tape of the model and flow conditions was recorded.

Scale Relations

9. The accepted equations of hydraulic similitude, based on the

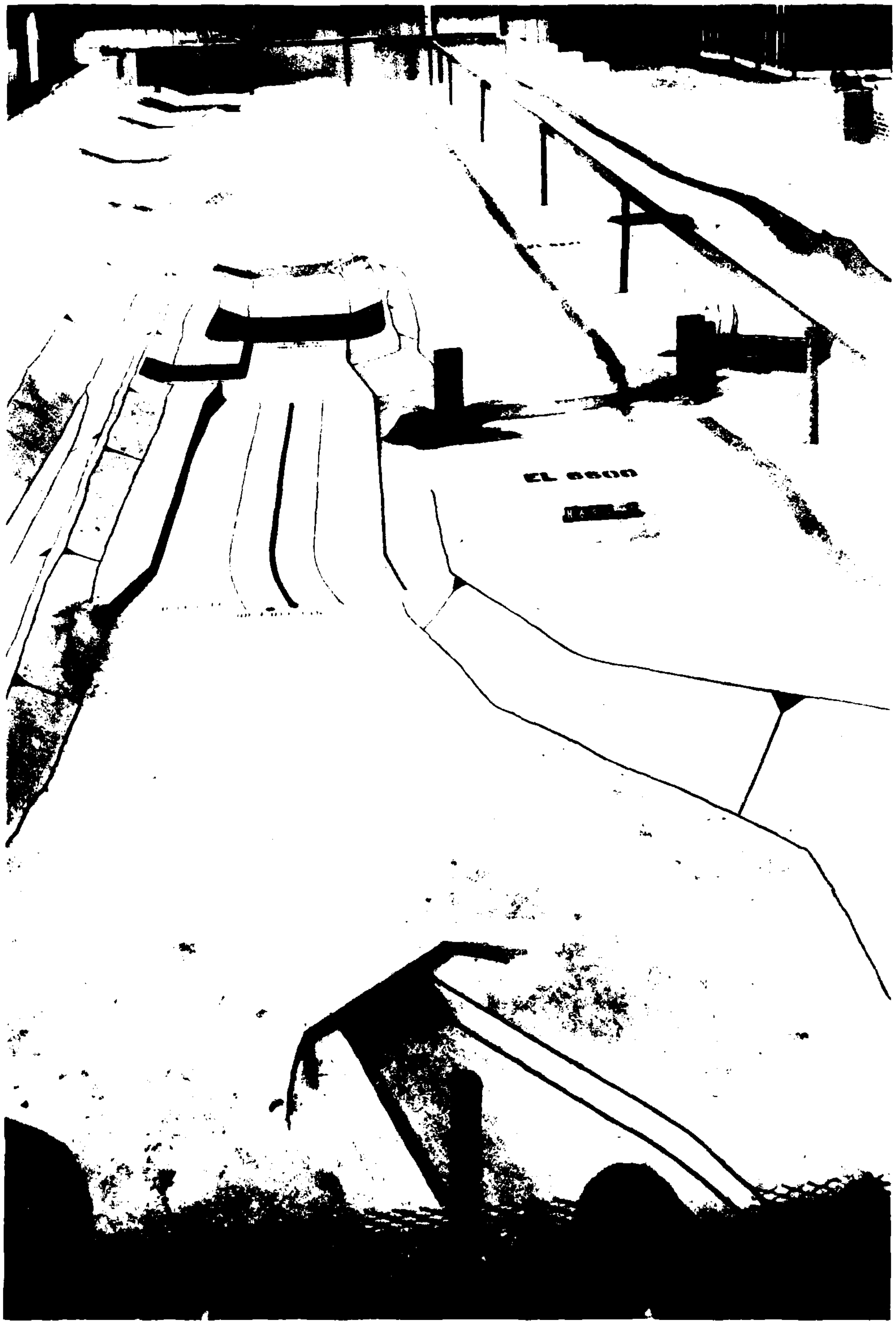


Figure 2. General view of model looking downstream

Froudian relation which assumes gravity to be the predominant factor of flow, were used to express mathematical relations between dimensions and hydraulic quantities of model and prototype. General relations for transference of model data to prototype equivalents are as follows:

Characteristic	Dimension*	Model:Prototype
Length	L_r	1:40
Area	$A_r = L_r^2$	1:1600
Velocity	$V_r = L_r^{1/2}$	1:6.325
Discharge	$Q_r = L_r^{5/2}$	1:10,119
Volume	$V_r = L_r^3$	1:64,000
Weight	$W_r = L_r^3$	1:64,000
Time	$T_r = L_r^{1/2}$	1:6.325

* Dimensions are in terms of length.

PART III: TESTS AND RESULTS

Flow Distribution

10. Initial tests were conducted to determine distribution of flow between the existing conduits and channel and the floodway channel (Plates 2 and 3). Since the discharge in each of the channels could not be measured directly in the model, the distribution was determined by blocking off the floodway channel upstream from the concrete chute and measuring the amount of flow passing through the two-barrel conduit with various water-surface elevations at the entrance to the conduit. These calibration data are shown in Plate 4. The blockage was removed from the floodway channel and again water-surface elevations were recorded with various discharges. These data are shown as the total discharge in Plate 4. By subtracting the conduit flow from the total flow for a given head, the amount of flow passing through the floodway channel can be obtained. For example, with the design total discharge of 12,000 cfs, a head on the invert of the conduit of 19.6 ft was measured. The calibration curve in Plate 4 shows a discharge of about 6,300 cfs for the two-barrel conduit with this head; thus about 5,700 cfs was passing through the floodway channel. The floodway channel was designed for a discharge of 6,000 cfs. There was slightly less flow than anticipated in the floodway channel and slightly more flow in the existing channel with the total design flow. However, this difference was so small that it had no significant effect on flow conditions in either channel.

Floodway Chute

11. A concrete chute will be provided at the upstream end of the floodway channel (Figure 2). The upstream end of the chute, which will be constructed over an existing two-barrel conduit, will channel flows that overtop the entrance of the conduit and provide conditions to create a hydraulic jump to dissipate energy of the flow before it enters the floodway channel downstream. It is also designed to act as a roadway for an existing road which presently extends along the site of the chute. The total length of the chute will be 550 ft; the width will vary from 130 to 90 ft; and the height of the walls will vary from 5.3 to 11.7 ft. Vertical curves will be

provided at changes in grade to accommodate vehicular traffic. A median strip and curbs will be provided in the chute. A plan and profile of the chute are shown in Plate 2.

12. Standing waves developed along the chute as shown in Photo 1. However, these waves did not cause excessive water-surface elevations along the chute walls as shown by the water-surface profiles in Plate 5. A hydraulic jump formed at the toe of the steep slope (sta 114+50F) as shown in Photo 1 and Plate 5. Velocities measured near the bottom of the chute, both upstream and downstream from the hydraulic jump, are shown in Plate 6. Velocities at the end of the concrete chute (sta 112+80) ranged from 3 to 9 fps.

13. Although flow conditions in the floodway chute were satisfactory with the original design, several different wall configurations were evaluated to determine if improvements could be made. None of these modifications significantly improved flow conditions, and the chute as originally designed was recommended for prototype construction.

Floodway Channel

Original design

14. The floodway channel downstream from the concrete chute will extend 2,150 ft to where it joins the existing Big Creek channel and will be excavated into overburden and rock. The trapezoidal channel will have 1V-on-2.5H side slopes with a bottom width of 85 to 100 ft. There will be five gabion drop structures to reduce the grade along the channel. The channel invert grade will vary between 0.071 and 0.69 percent. A plan and profile of the channel are shown in Plates 2 and 3. Details of the drop structures are shown in Plate 7, and a closeup view of one of the drop structures in the model is shown in Figure 3.

15. Water-surface profiles and velocities measured throughout the channel with the design discharge are shown in Plates 5 and 6, respectively. Flow depths and velocities between the concrete chute and drop structure No. 1 were generally satisfactory. The 12-in. (d_{50}) riprap downstream from the concrete chute was stable for all flows including the design discharge; gradation of the riprap used in the model is shown in Plate 8.

16. The drop structures as originally designed (Plate 7) caused flow to concentrate near the middle of the channel downstream from each structure

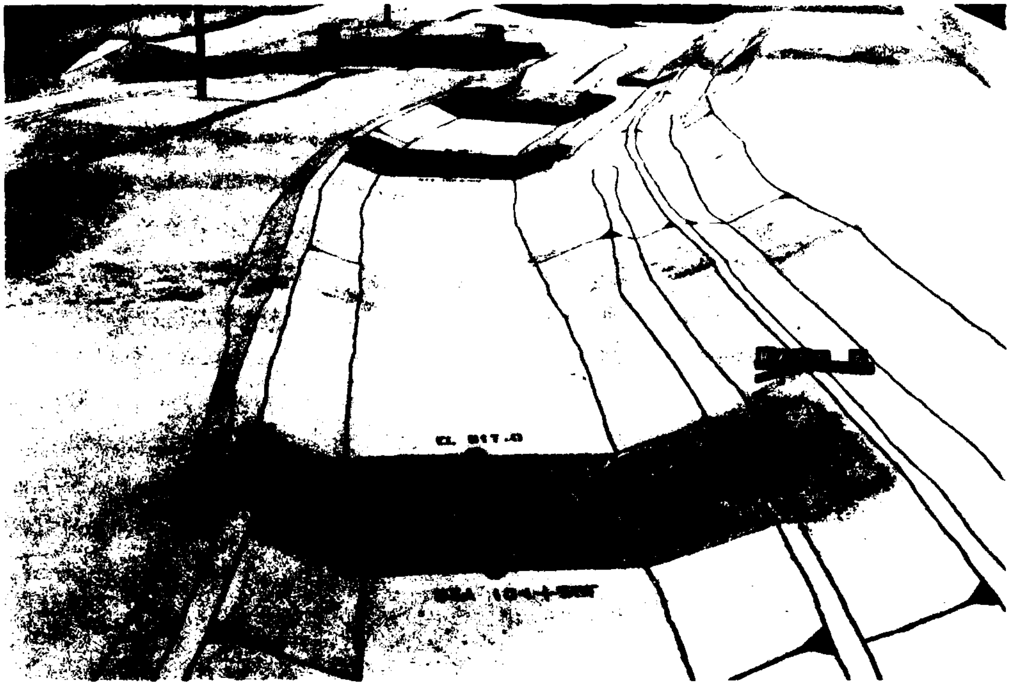


Figure 3. Original design drop structure

as shown in Photo 2. This contraction resulted in velocities in excess of 20 fps (Plate 6). Also, depths of flow in several reaches of the channel were less than anticipated. This resulted in average velocities higher than could be tolerated in an earth-lined channel. The gabions used to construct the drop structures were stable for all flows up to and including the design flow.

Alternate designs

17. The wedges were removed from the sides of the drop structures so that the channel side slopes were uniform through the drop structures as shown in Plate 9. The amount of invert drop at the drop structures was not changed from the original design. This modification (type 2 design drop structure) eliminated the contraction of flow through the drop structures; but water-surface elevations throughout the channel (Plate 10) were lowered considerably because of the reduced flow control area at each drop structure. This caused the hydraulic jump in the concrete chute to move downstream about 100 ft. Also, average velocities throughout the channel were higher because of the decreased flow depths. Velocities measured with the type 2 design

drop structure and the design discharge are shown in Plate 9.

18. The invert of the drop structures was raised to increase the depth of flow in the section of channel upstream from each drop structure. The configuration of the revised drop structures (type 3 design drop structure) is shown in Plate 11. Design of these drop structures was based on information in Engineer Technical Letter 1110-2-194 "Gabion Channel Control Structures," dated 30 August 1974. Drop structure No. 1 (type 3 design) in the model is shown in Figure 4. Several different heights were tested to determine the height of each drop structure required to obtain satisfactory water-surface profiles and velocities in the channel. The various dimensions tested at each drop structure are shown in the tables in Plate 11.

Figure 4. Drop structure No. 1, type 3 design

Final design

19. In the original design, the base width of the channel was 100 ft upstream from drop structure No. 2 and 85 ft downstream from the structure. This resulted in unsatisfactory flow conditions downstream from the drop structure because of the sudden contraction of flow. Thus the channel width was gradually reduced from 100 to 85 ft between sta 107+80 and 106+20

upstream from drop structure No. 2 in the final design (Plate 12). This improved flow conditions at this drop structure.

20. Dimensions of the type 3 design drop structure recommended for the final design are shown in the table under test 7 in Plate 11. It was necessary to raise the crest elevation of drop structure No. 5 considerably higher than that of the other drop structures in order to reduce velocities in the channel between drop structures Nos. 4 and 5. For example, velocities downstream from drop structure No. 4 exceeded 15 fps during test 6 when the crest of drop structure No. 5 was at el 609.1, just 2 ft lower than the final test (Plate 11). This was attributed to the steep channel slope between drop structures Nos. 4 and 5. The height of the right bank levee had to be increased to contain flow in the vicinity of drop structure No. 5 as shown in Plate 13.

21. Velocities and water-surface profiles measured with the final design are shown in Plates 12 and 13, respectively. Flow conditions were greatly improved over the original design, and average velocities in most reaches of the channel were 6 to 7 fps. Flow conditions with the design discharge are shown in Photos 3 and 4. The gabions used to construct the drop structures were stable during all tests with the design flow.

22. After all of the regular tests were completed with the recommended design, a final test was conducted to determine the effect of higher discharges on flow conditions in the floodway channel and stability of the gabions and protective material. To accomplish this, observations were made as the discharge was gradually increased. With a total discharge of 15,000 cfs, flow began to splash over the top of the chute wall at the downstream corner of the entrance to Brookside Drive at sta 113+80F as shown in Photo 5. Also, flow was near the top of the right levee downstream from drop structure No. 1 at sta 108+15F. As the flow was gradually increased, the hydraulic jump in the concrete structure moved downstream. With a discharge of 18,000 cfs, the jump became unstable (Photo 6), and the 12-in. riprap downstream from the chute began to move. Flow overtopped the right levee between sta 108+50F and 107+70F downstream of drop structure No. 1 as shown in Photo 7. With a discharge of 20,000 cfs, some of the gabions on the drop structures were displaced and considerable scour of the riprap occurred. Figure 5 shows the riprap scour downstream from the chute after a discharge of 20,000 cfs for 1 hr (prototype), and Figure 6 shows drop structure No. 1 with the displaced

Figure 5. Riprap scour downstream from chute structure

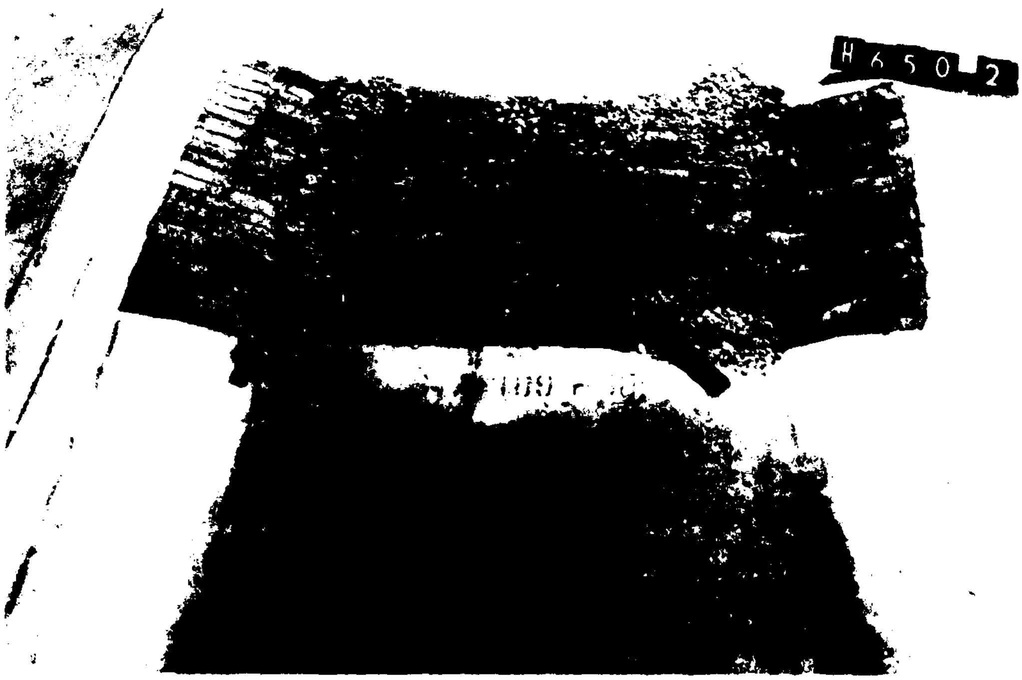


Figure 6. Displaced gabions at drop structure No. 1

gabions. The gabions were not wired together in the model as they are in prototype construction; thus the gabions in the prototype drop structures will probably be stable with discharges larger than those experienced in the model.

Main Channel

23. Although the flood-control project did not include improvements to the main Big Creek channel between the outlet to the two-barrel conduit (sta 115+50M) and the intake to the three-barrel conduit (sta 105+10M), tests were conducted to determine flow conditions in this reach (Plate 2). Water-surface profiles measured with the design discharge are shown in Plate 14. Velocities are shown in Plate 6. Flow conditions were satisfactory in most areas and flow was contained within the channel or levees.

24. Velocities as high as 17 fps were measured at the outlet of the two-barrel conduit. This eroded the 12-in. (d_{50}) riprap placed in the area (Figure 7, Plate 15). Flow conditions at the outlet are shown in Photo 8.

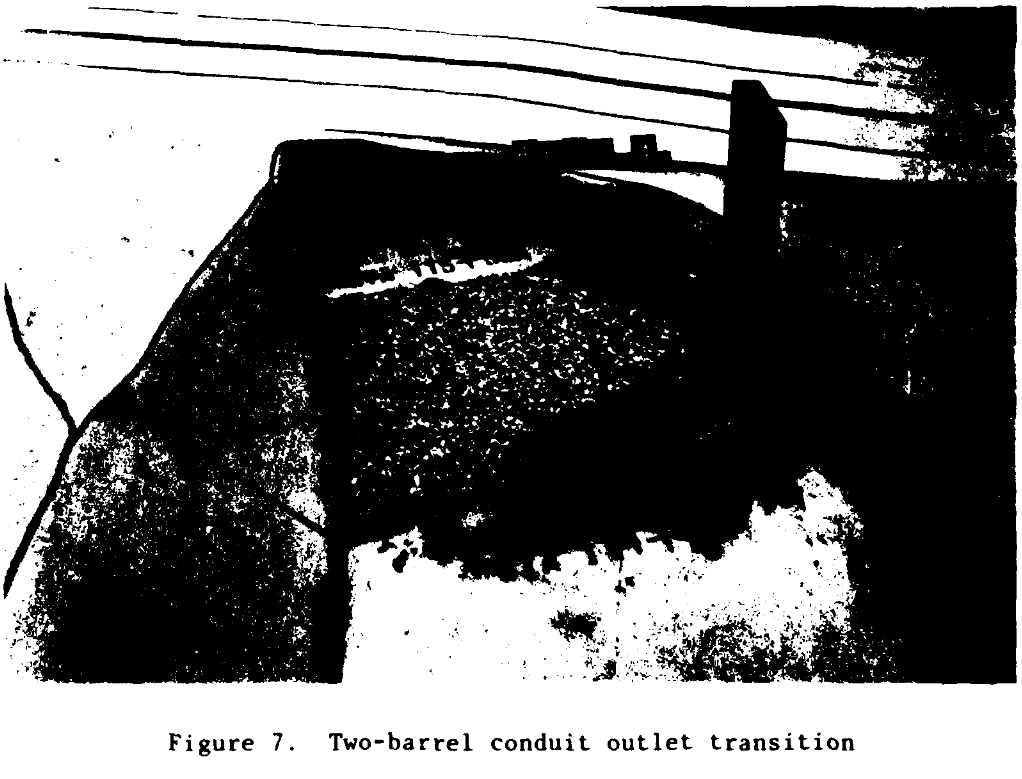


Figure 7. Two-barrel conduit outlet transition

The riprap in this area was replaced with a 48-in.-thick blanket of riprap with average size (d_{50}) of 24 in.; the gradation of this riprap is shown in Plate 8. A few pieces of this riprap were displaced by the design flow; however, failure did not occur. The riprap was replaced with 12-in.-thick gabions. However, the gabions were not stable, and several of the baskets were washed downstream after only 15 min (prototype time) operation with the design flow. Therefore, the 24-in. (d_{50}) riprap was recommended if protection is provided in this area.

25. Velocities of 12 to 13 fps were measured near the Fulton Road Bridge piers (Figure 8) in the channel downstream from the two-barrel outlet (Plate 6). Riprap with an average size (d_{50}) of 18 in. was stable in the area around these bridge piers; gradation of the riprap used in the model is shown in Plate 8.

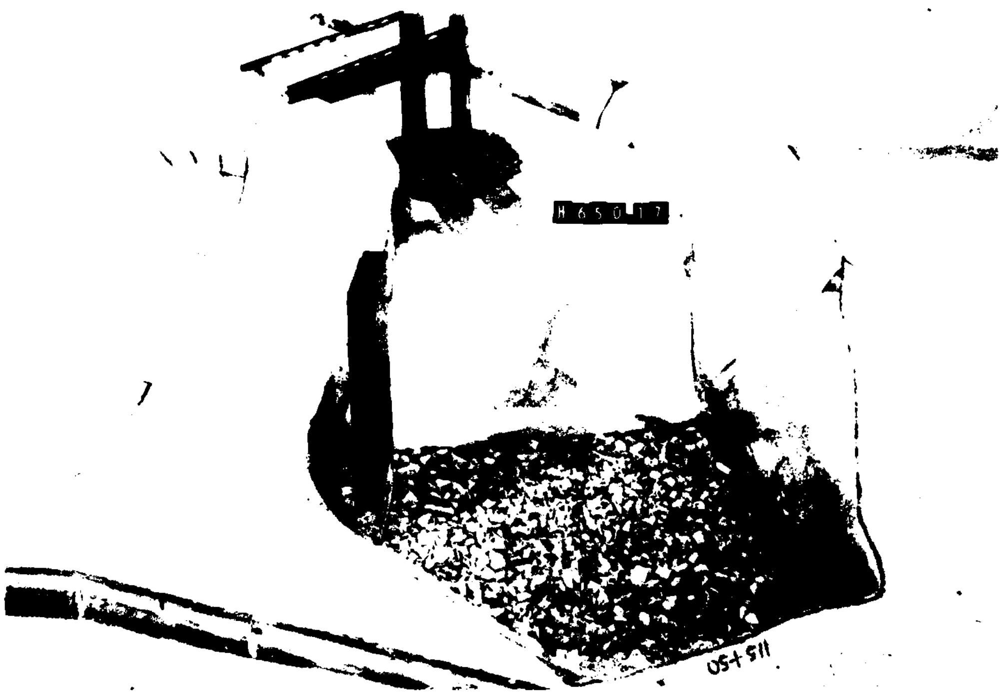


Figure 8. Bridge piers in main channel

Modified Channel

Original design

26. Channel improvements will be provided along a 260-ft reach of the

existing stream downstream from the three-barrel conduit and upstream from the confluence with the floodway channel. This channel was designed for 6,000 cfs. The typical channel section proposed for this reach has a 30-ft bottom width and 1V-on-2.5H side slopes with riprap or gabion protection. A concrete transition was provided between the downstream end of the three-barrel conduit and the modified channel. The transition tied into an existing slab and wing walls at the upstream end. A plan and profile of the transition and modified channel are shown in Plate 16; this area of the model is shown in Figure 9.

27. Although 12-in. gabions were proposed for the area immediately downstream from the transition and along the left bank of the modified channel, 12-in. riprap (d_{50}) was initially placed in these areas of the model to expedite construction (Figure 9). The concrete transition caused flow to concentrate in the channel as shown in Photo 9, which resulted in movement of the riprap immediately downstream from the transition and along the left bank. The riprap was then grouted as an expedient in the model so that velocities and water-surface profiles could be measured. These data are shown in Plates 6 and 14.

Final design

28. The concrete transition was removed and the area downstream from the conduit was shaped as shown in Plate 17 and Figure 10. Riprap with an average size (d_{50}) of 24 in. was placed in this area and along the left bank. The existing concrete slab and wing walls were left intact. Flow conditions were greatly improved by this modification (Photo 10) and velocities were reduced. The 24-in. riprap was stable during all tests. Water-surface profiles and velocities in the modified channel are shown in Plates 18 and 12, respectively.

29. The 24-in. riprap was replaced with 18-in. (d_{50}) riprap; this stone was stable during all tests. A few of the stones on the invert immediately downstream from the existing slab were displaced; thus smaller riprap was not tested in this area. The 12-in. (d_{50}) riprap on the right bank downstream from sta 89+00M was stable during all tests.

30. The 12-in. gabions proposed in the original design were not tested in the area downstream from the three-barrel conduit because it was obvious that they would be stable with the revised channel design. Also, previous

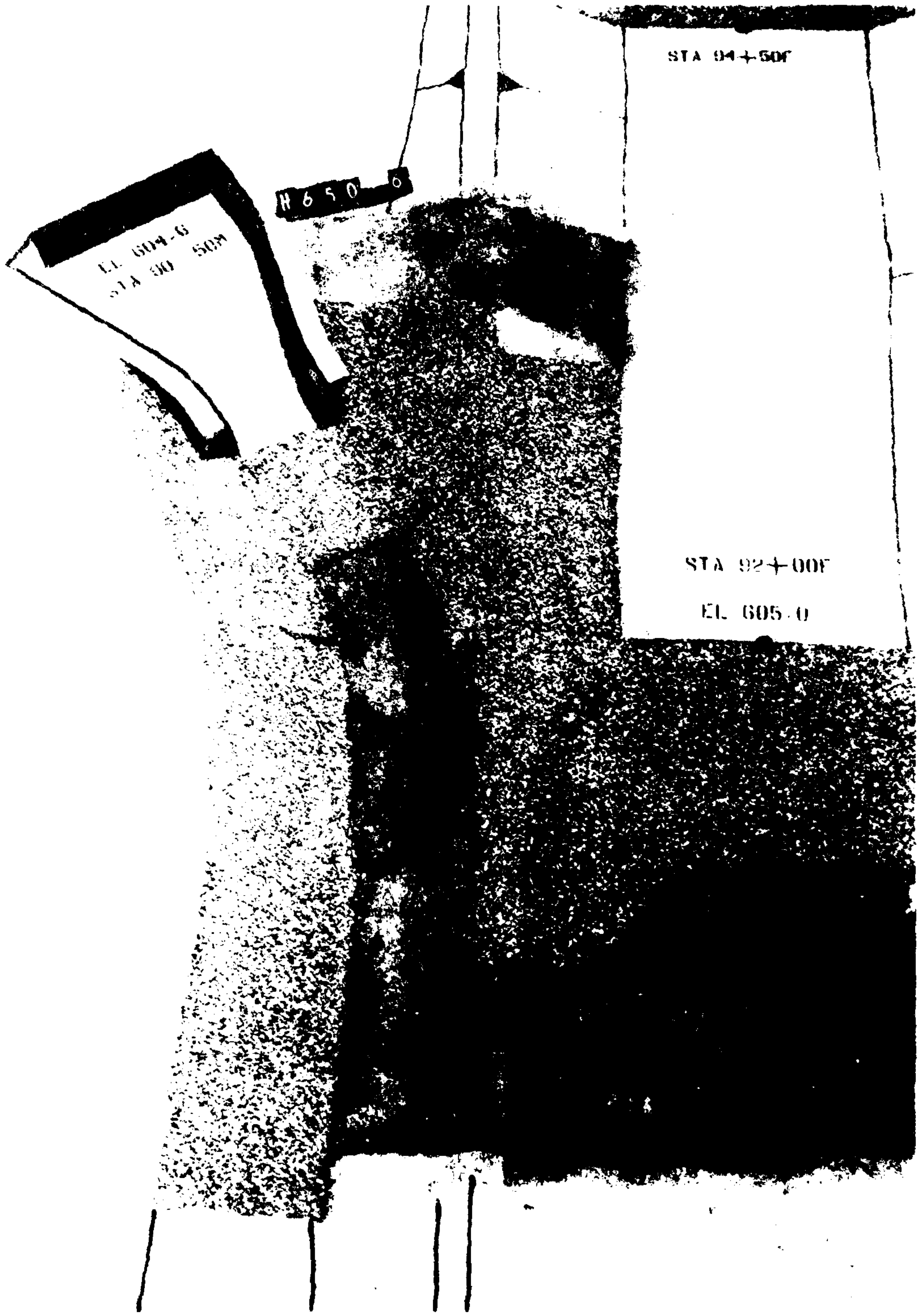


Figure 9. Three-barrel conduit outlet transition and modified channel (original design)

Figure 10. Riprap transition at three-barrel conduit outlet (recommended design)

model tests* had shown that 12-in.-thick gabions, 12 ft long by 3 ft wide, would be stable when a 36-in.-thick layer of riprap with a d_{50} of 18 in. would not. Thus it was concluded that either of these protective materials could be used in the prototype.

* N. R. Oswalt, J. F. George, and G. A. Pickering. 1975 (Dec). "Fourmile Run Local Flood-Control Project, Alexandria and Arlington County, Virginia; Hydraulic Model Investigation," Technical Report H-75-19, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

PART IV: DISCUSSION

31. At the present time, property and industry located within certain areas of the floodplain of the Big Creek watershed are subject to flood damage. The proposed flood-control plan was designed to prevent flood damages in these areas for a 100-year discharge of 12,000 cfs. In development of adequate protection plans, design engineers were confronted with many difficult problems. Flow distributions essential to the operation of this complex multichannel/conduit project could not be computed with sufficient accuracy to optimize the channel size and protective measures. The energy dissipators or transitions of the conduit outlets had configurations that were unsymmetrical which could result in unequal flow distribution downstream from these structures. The drop structures in the flood-control channel were unique with side contractions that could produce turbulent eddies for a considerable distance downstream. A model study was the only reliable means to resolve these problems.

32. The project was designed so that 6,000 cfs of the total design flow of 12,000 cfs would pass through the existing channel with the remaining 6,000 cfs being conveyed by the proposed floodway channel. Model tests indicated that 6,300 cfs would pass through the existing floodway channel. This difference was so small that it had no significant effect on flow conditions in either channel.

33. Standing waves that developed along the concrete chute at the upstream end of the floodway channel did not result in excessive water-surface elevations along the chute walls, and all flow was contained within the chute. A hydraulic jump formed in the downstream portion of the chute, as anticipated. This resulted in good energy dissipation. The concrete chute as originally designed will function satisfactorily for the design discharge.

34. Several modifications to the floodway channel were necessary to improve flow conditions and reduce velocities to an acceptable level. The gabion drop structures were revised to reduce contraction of flow downstream from the drop structures and increase flow depths upstream. The channel bottom width was gradually changed in a reach of channel upstream from drop structure No. 2 to eliminate unsatisfactory flow conditions that occurred downstream from the drop structure. The height of the right bank levee in the vicinity of drop structure No. 5 had to be raised to contain flow in the

channel. Because part of this levee was a common levee with the modified existing channel downstream from the three-barrel conduit, available area did not permit construction on a 1V-on-2.5H slope. It will be necessary to alter the levee slopes or construct a short vertical wall in this area.

35. The concrete transition downstream from the three-barrel conduit caused high velocities and unsatisfactory flow conditions. This structure was removed and a riprap channel transition was developed in the model to provide a smooth transition of flow from the conduits to the modified channel. This modification should result in a considerable cost savings for the project.

36. The flood-control project with the modifications developed in the model will function satisfactorily to provide flood protection against the design discharge of 12,000 cfs. Also, tests with discharges greater than the design flow indicate that only minor damage would occur with discharges up to 18,000 cfs. However, with discharges greater than 18,000 cfs, major repairs to the floodway channel would probably be necessary.

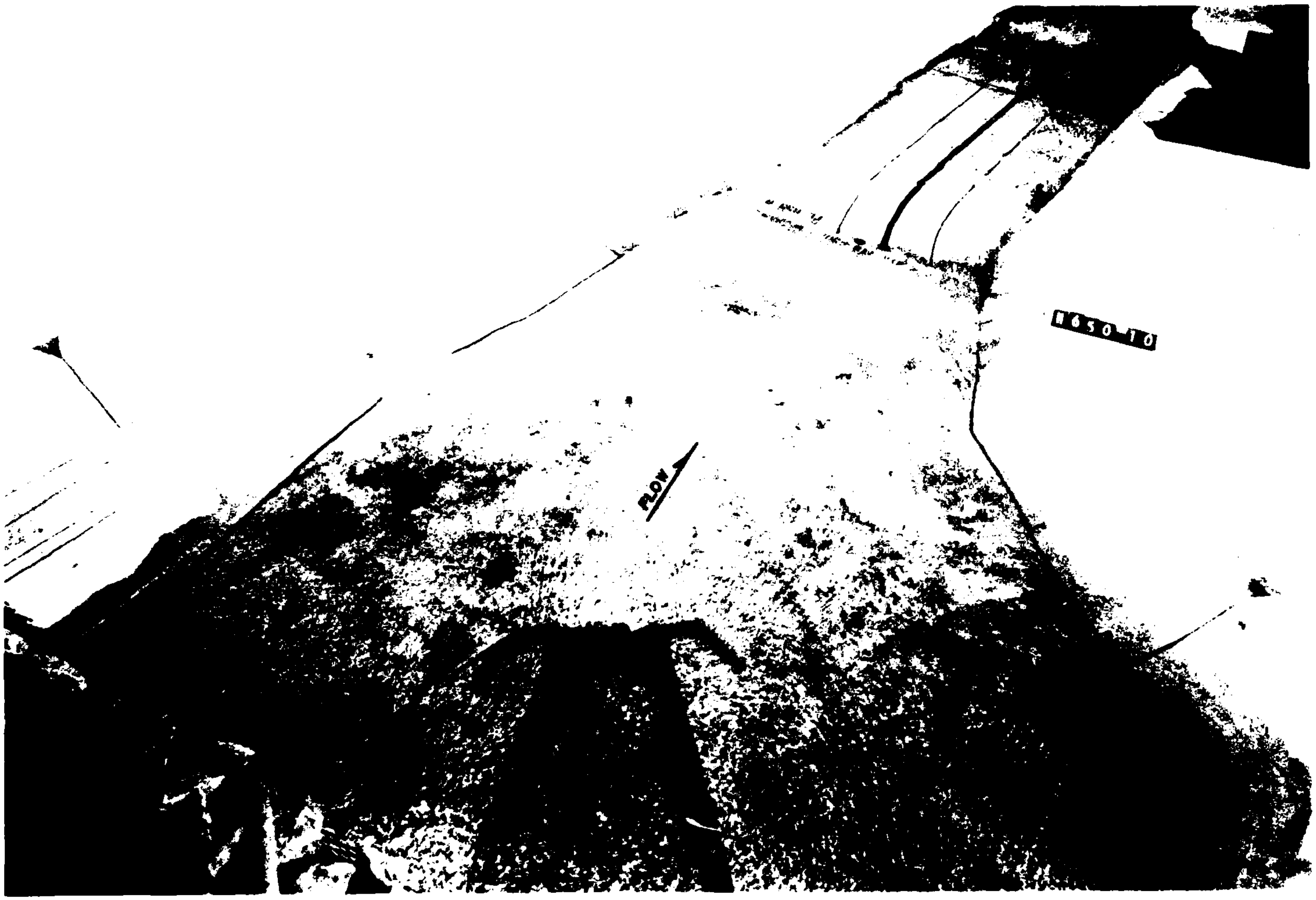


Photo 1. Entrance to two-barrel conduit and floodway chute; total discharge 12,000 cfs, floodway discharge 5,700 cfs

Photo 2. Looking upstream at flow over drop structure No. 1; original design; discharge 5,700 cfs

Photo 3. Looking upstream at flow over drop structure No. 1; recommended design; discharge 5,700 cfs

Photo 4. Looking upstream at floodway channel; recommended design; floodway discharge 5,700 cfs, total discharge 12,000 cfs

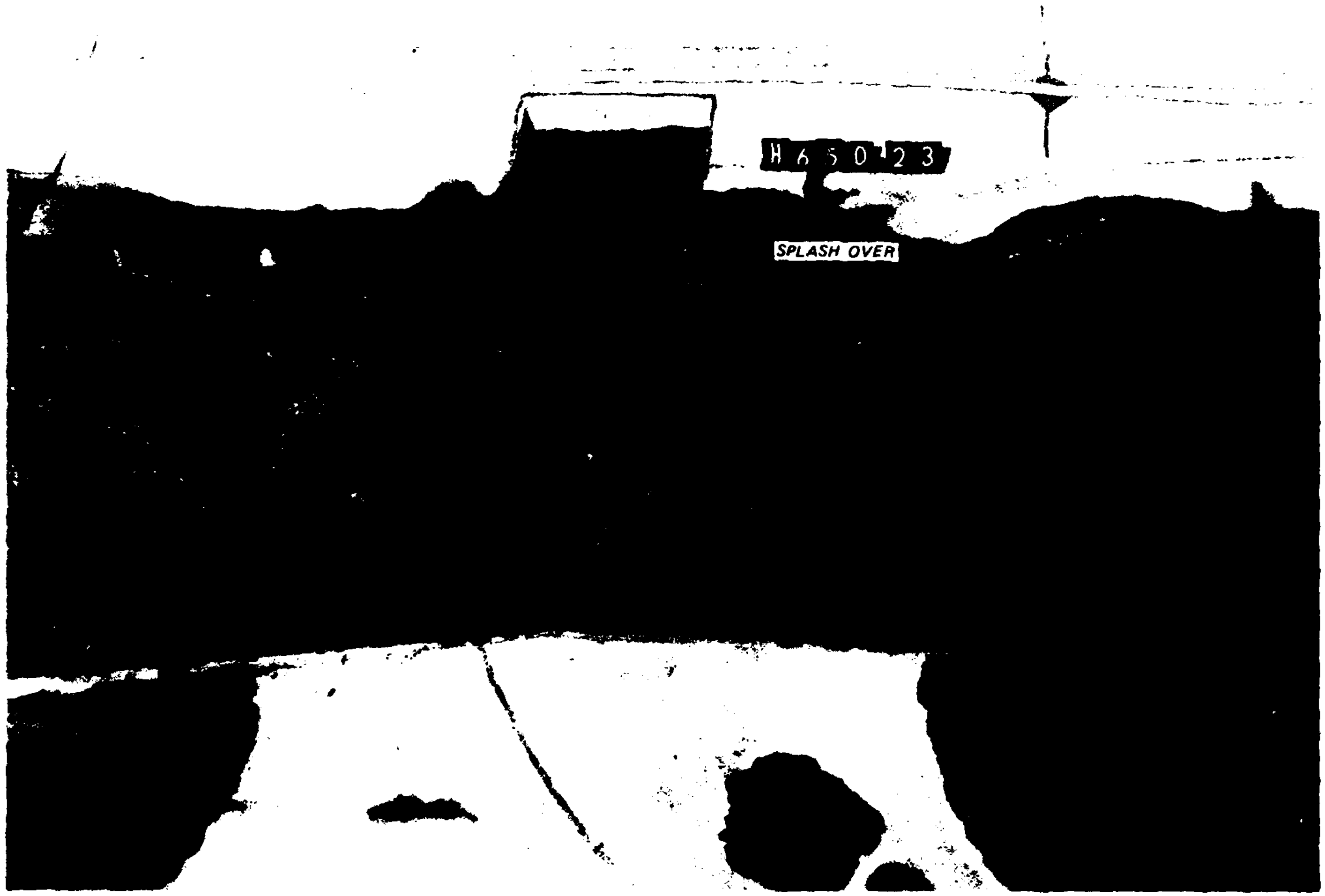


Photo 5. Downstream portion of concrete *chute at Brookside* Drive; total discharge 15,000 cfs, floodway discharge 8,500 cfs

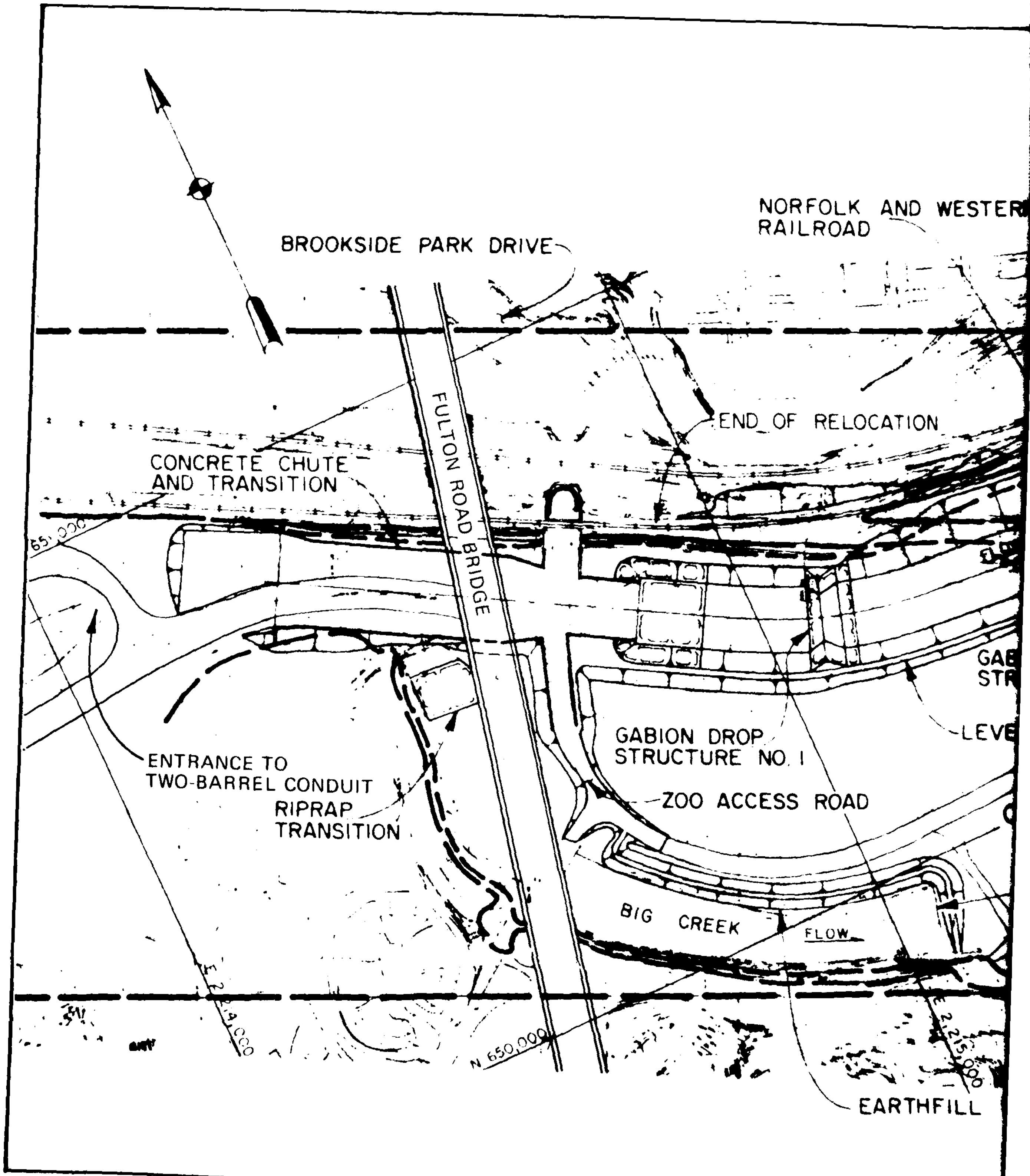
Photo 6. Downstream portion of concrete chute; total discharge 18,000 cfs, floodway discharge 11,300 cfs

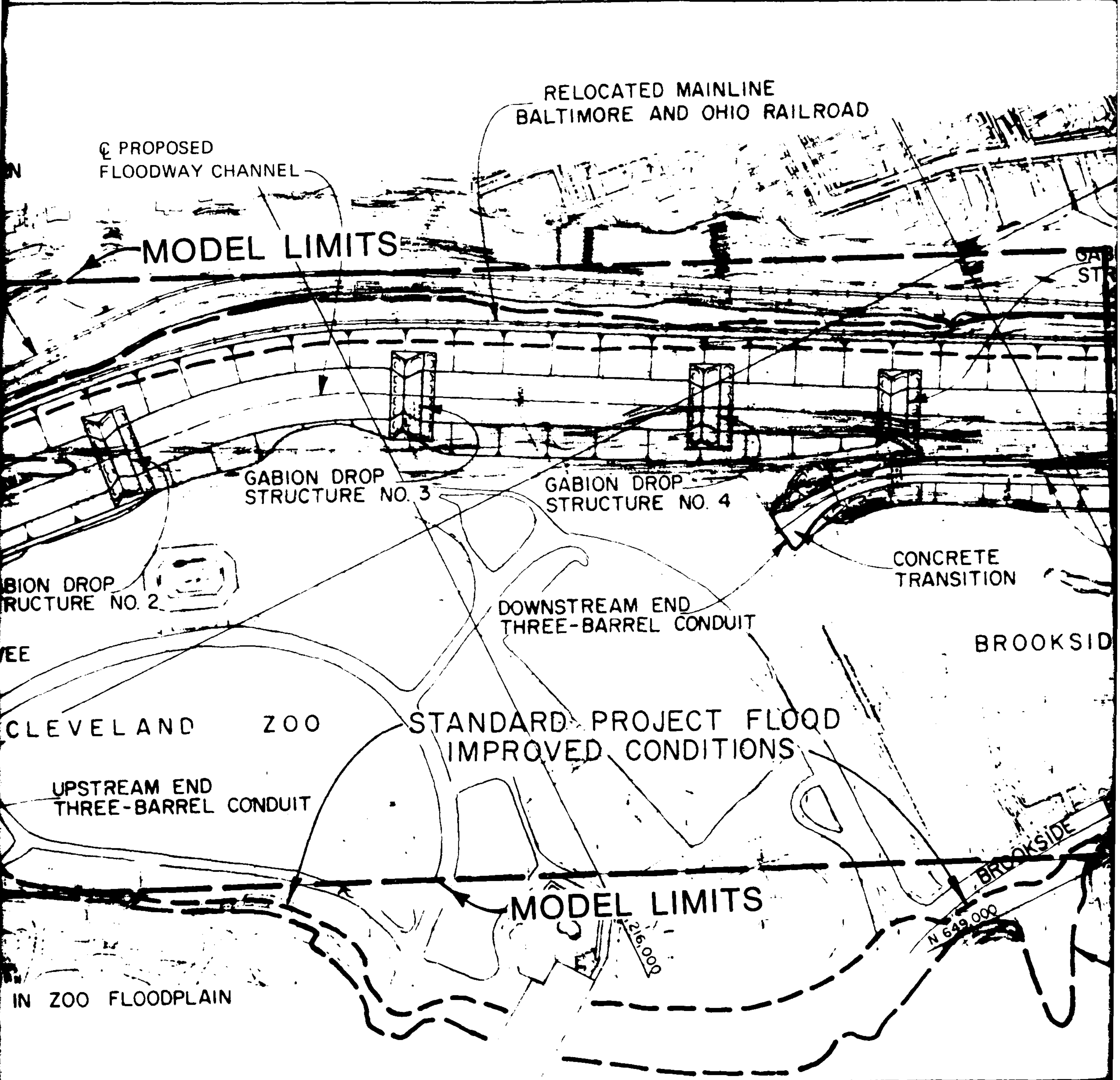
Photo 7. Looking upstream at flow over drop structure No. 1; total discharge 18,000 cfs, floodway discharge 11,300 cfs

Photo 8. Two-barrel conduit outlet; discharge 6,300 cfs

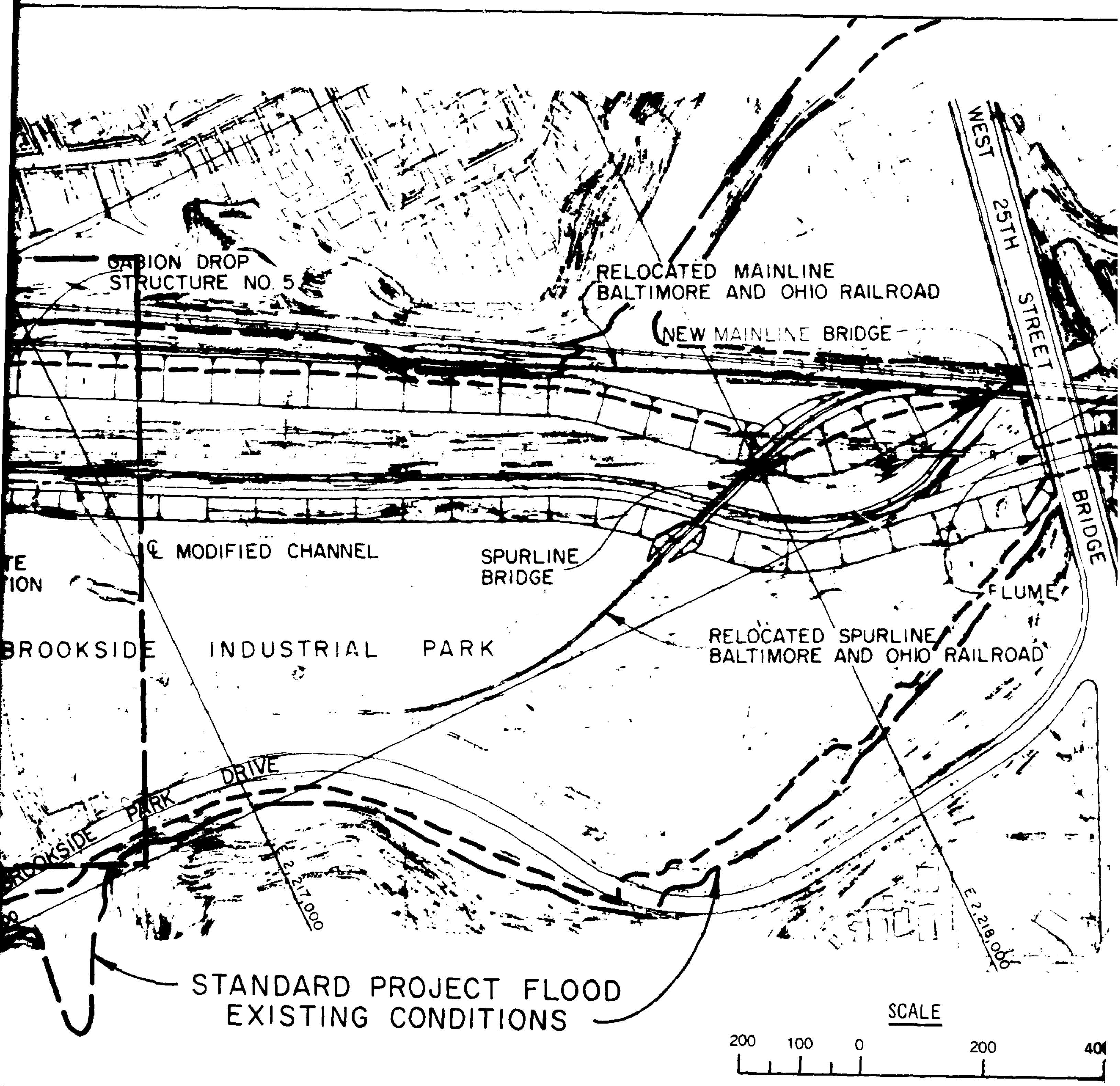
Photo 9. Two-barrel conduit outlet transition; original design; modified channel discharge 6,300 cfs, floodway discharge 5,700 cfs

Photo 10. Confluence of floodway and modified channels; recommended design; floodway discharge 5,700 cfs, modified channel discharge 6,300 cfs

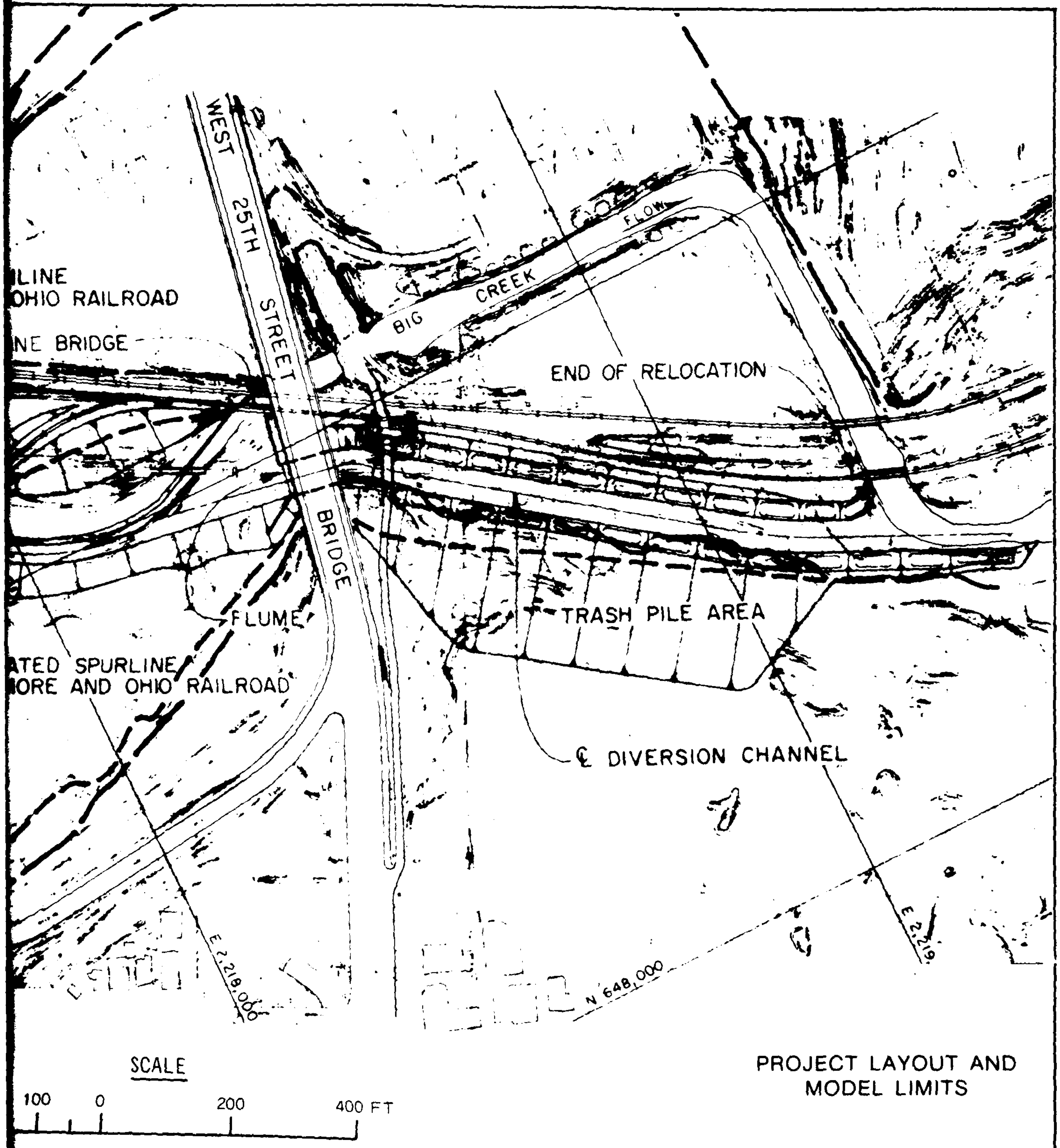

NORFOLK AND WESTER
RAILROAD
BROOKSIDE PARK DRIVE
FULTON ROAD BRIDGE
END OF RELOCATION
CONCRETE CHUTE
AND TRANSITION
GABION DROP
STRUCTURE NO. 1
ENTRANCE TO
TWO-BARREL CONDUIT
RIPRAP
TRANSITION
ZOO ACCESS ROAD
BIG CREEK
FLOW
EARTHFILL
N 650,000
E 2,215,000



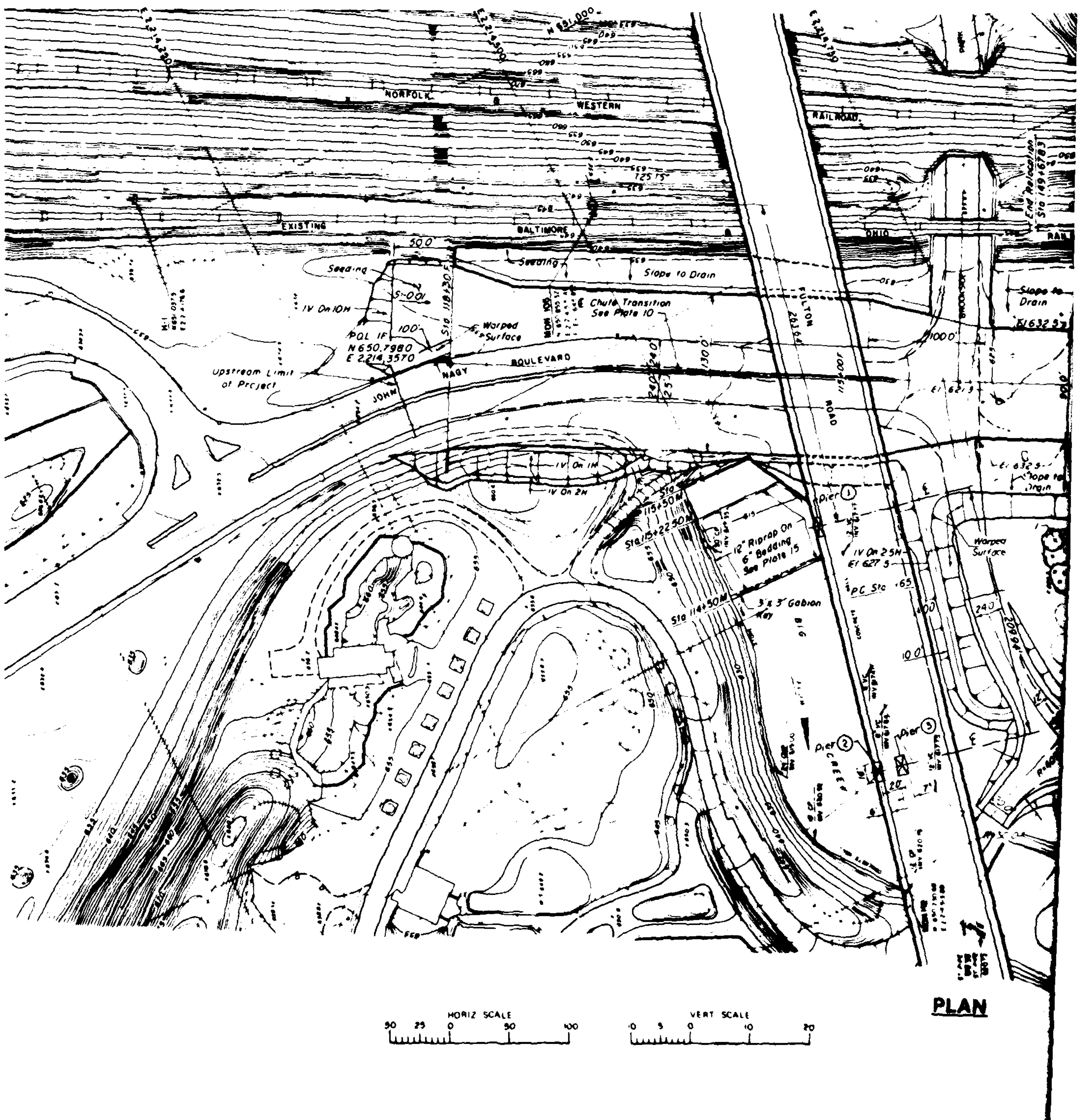
RELOCATED MAINLINE
BALTIMORE AND OHIO RAILROAD
℄ PROPOSED
FLOODWAY CHANNEL
MODEL LIMITS
GABION DROP
STRUCTURE NO. 3
GABION DROP
STRUCTURE NO. 4
CONCRETE
TRANSITION
BION DROP
RUCTURE NO. 2
DOWNSTREAM END
THREE-BARREL CONDUIT
BROOKSID
EE
CLEVELAND ZOO
STANDARD PROJECT FLOOD
IMPROVED CONDITIONS
UPSTREAM END
THREE-BARREL CONDUIT
BROOKSIDE
MODEL LIMITS
216,000
N 649,000
IN ZOO FLOODPLAIN


GABION DROP
STRUCTURE NO. 5
RELOCATED MAINLINE
BALTIMORE AND OHIO RAILROAD
NEW MAINLINE BRIDGE
WEST 25TH STREET BRIDGE
℄ MODIFIED CHANNEL
SPURLINE
BRIDGE
FLUME
RELOCATED SPURLINE
BALTIMORE AND OHIO RAILROAD
BROOKSIDE INDUSTRIAL PARK
BROOKSIDE PARK DRIVE
E 2,217,000
E 2,218,000
STANDARD PROJECT FLOOD
EXISTING CONDITIONS
SCALE
200 100 0 200 400

2

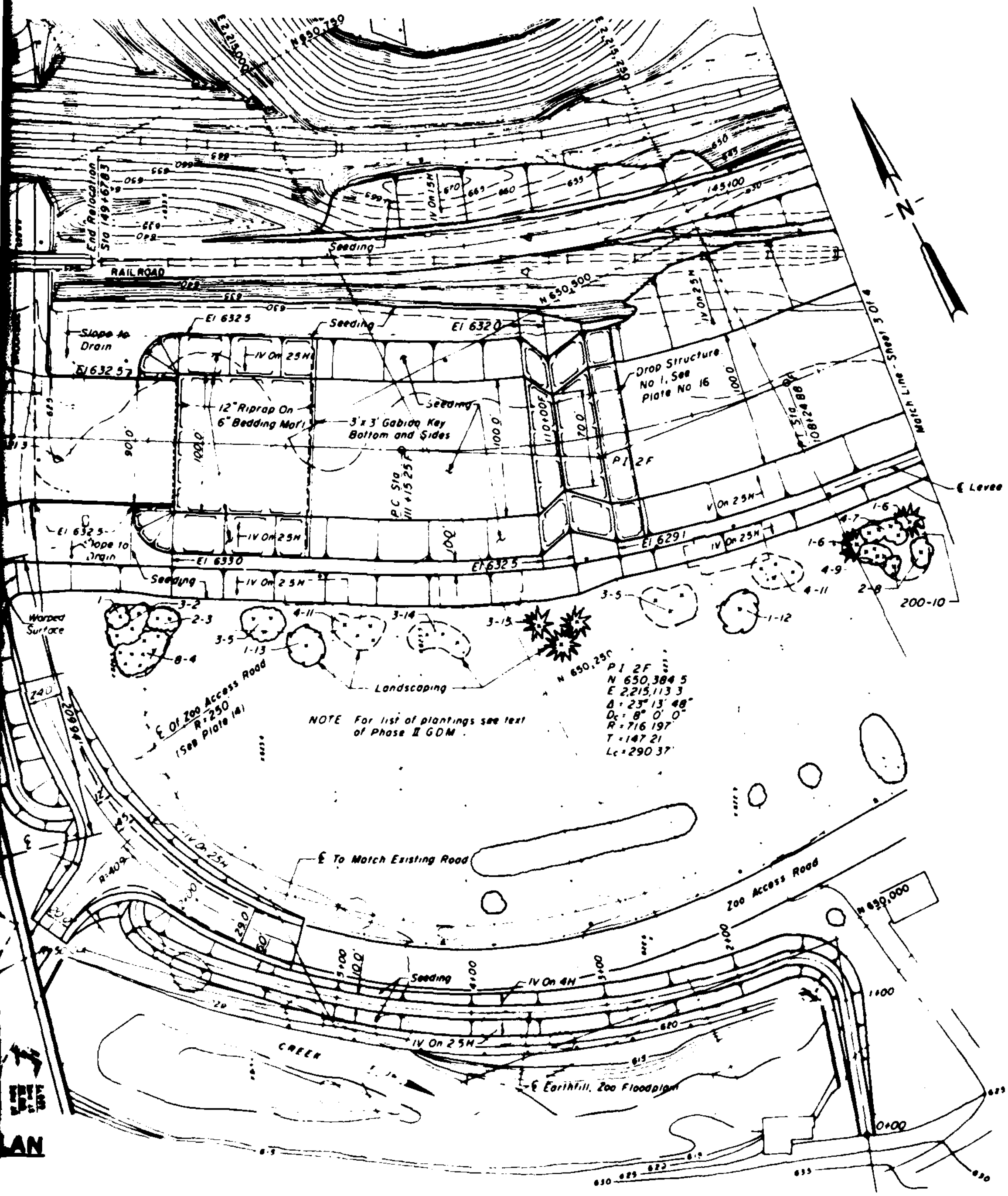


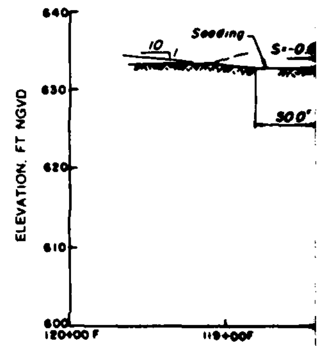
PROJECT LAYOUT AND MODEL LIMITS



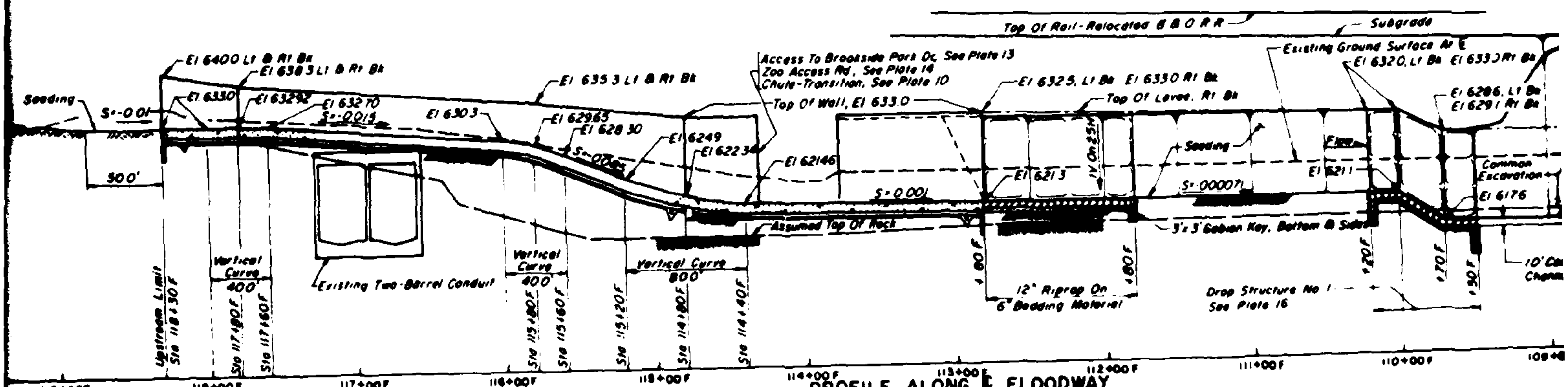
NORFOLK
WESTERN
RAILROAD
EXISTING
BALTIMORE
OHIO
Seeding
Slope to Drain
Chute Transition
See Plate 10
1V On 10H
Warped Surface
PGL 1F
N 650,7980
E 2,214,3570
Upstream Limit of Project
JOHN
NAGY
BOULEVARD
FULTON
ROAD
1V On 1H
1V On 2H
12" Riprap On 6" Bedding See Plate 15
3' x 3' Gabion Key
Pier 1
Pier 2
Pier 3
1V On 2.5H
Warped Surface
End Relocation
HORIZ SCALE
VERT SCALE

PLAN


N
RAILROAD
End Relocation Sta 149+67.83
Seeding
145+00
N 650,900
El 632.0
El 632.5
Slope to Drain
El 632.57
1V On 2.5H
12" Riprap On 6" Bedding Mat'l
3'x 3' Gabion Key Bottom and Sides
P.C. Sta 111+15.25 F
110+00 F
P.I. 2F
Drop Structure No. 1, See Plate No. 16
P.T. Sta 108+24.86
Match Line - Sheet 3 of 4
℄ Levee
El 629.1
El 633.0
El 632.5
Warped Surface
Landscaping
200-10
N 650,250
P.I. 2F
N 650,384.5
E 2,215,113.3
Δ = 23° 13' 48"
Dc = 8° 0' 0"
R = 716.197
T = 147.21
Lc = 290.37
NOTE: For list of plantings see text of Phase II GDM.
℄ Of Zoo Access Road R=250 (See Plate 14)
℄ To Match Existing Road
Zoo Access Road
N 650,000
1V On 4H
1V On 2.5H
Seeding
CREEK
℄ Earthfill, Zoo Floodplain
0+00
1+00
2+00
3+00
4+00

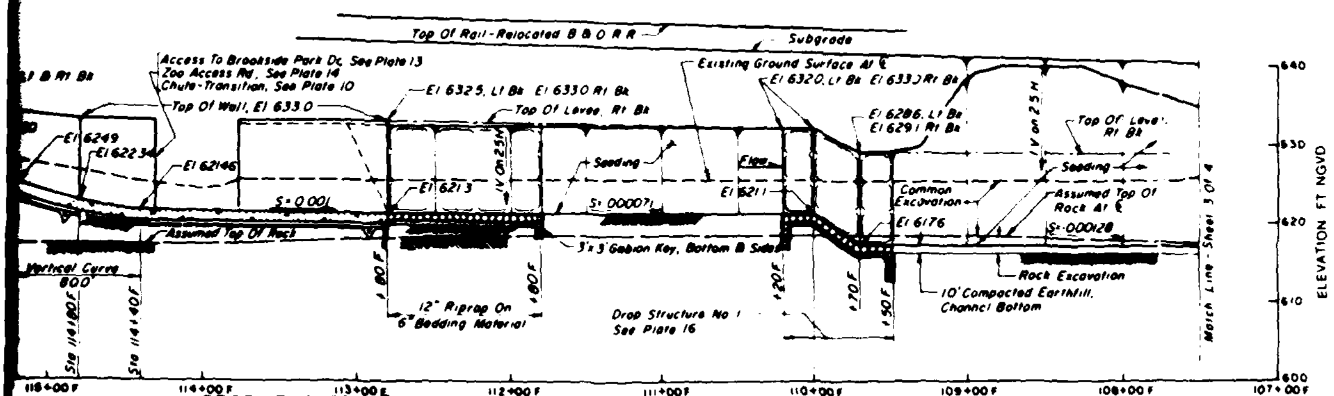

ELEVATION, FT NGVD
Seeding
640
630
620
610
600
120+00 F
119+00F

LAN



PROFILE ALONG ℄ FLOODWAY

PROFILES



PROFILE ALONG ℄ FLOODWAY

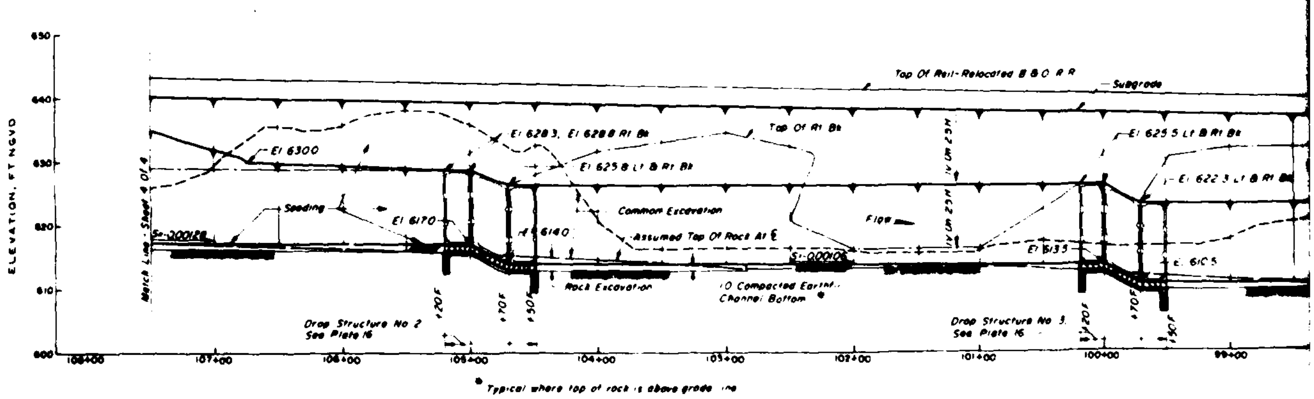
PROFILES

FLOODWAY CHUTE

PLAN AND PROFILES

PLATE 2

2 1 4



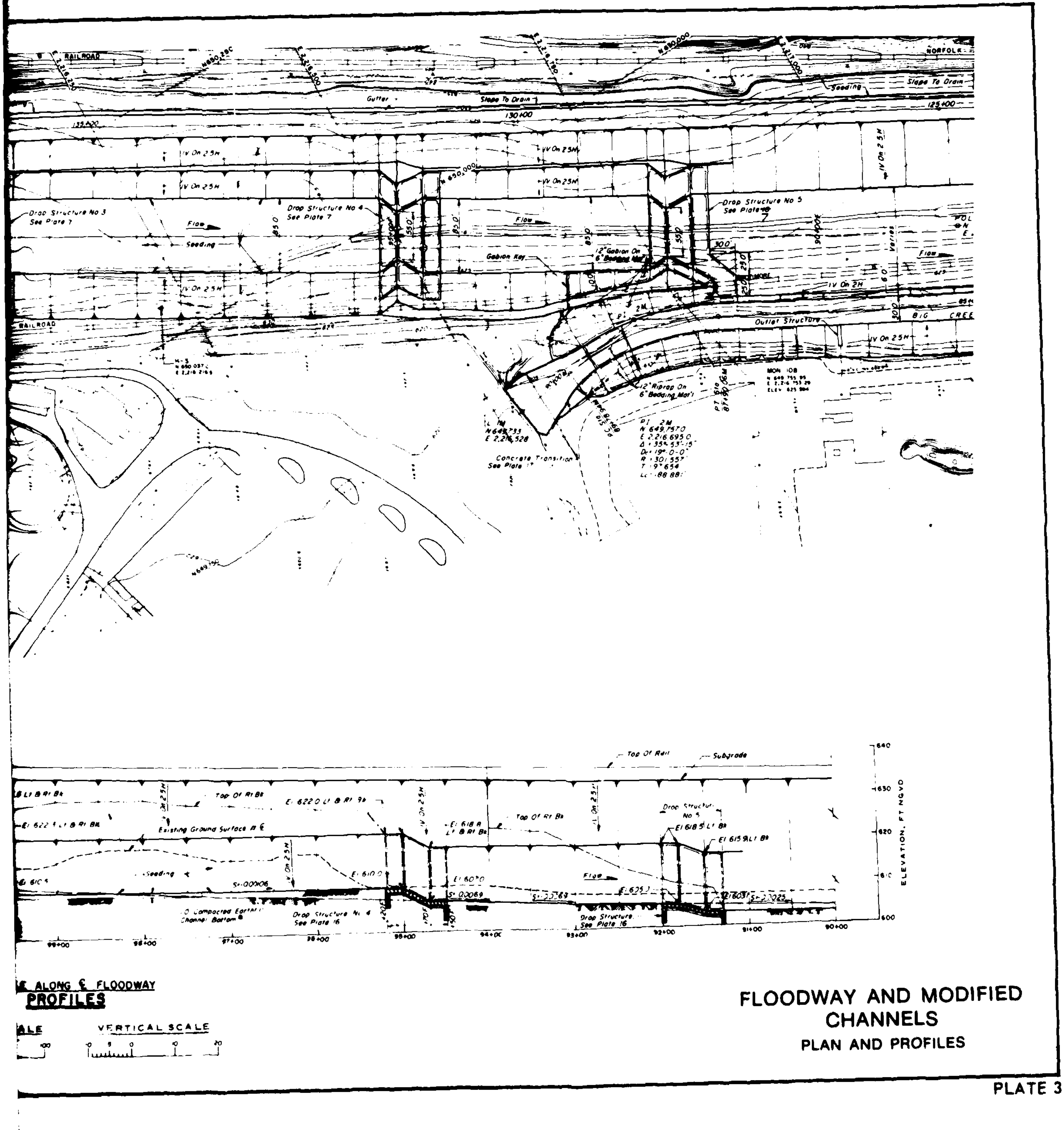
PROFILE ALONG ℄ FL

PROFILES

HORIZONTAL SCALE

50 25 0 50 100

VE



FLOODWAY AND MODIFIED CHANNELS

PLAN AND PROFILES

PLATE 3

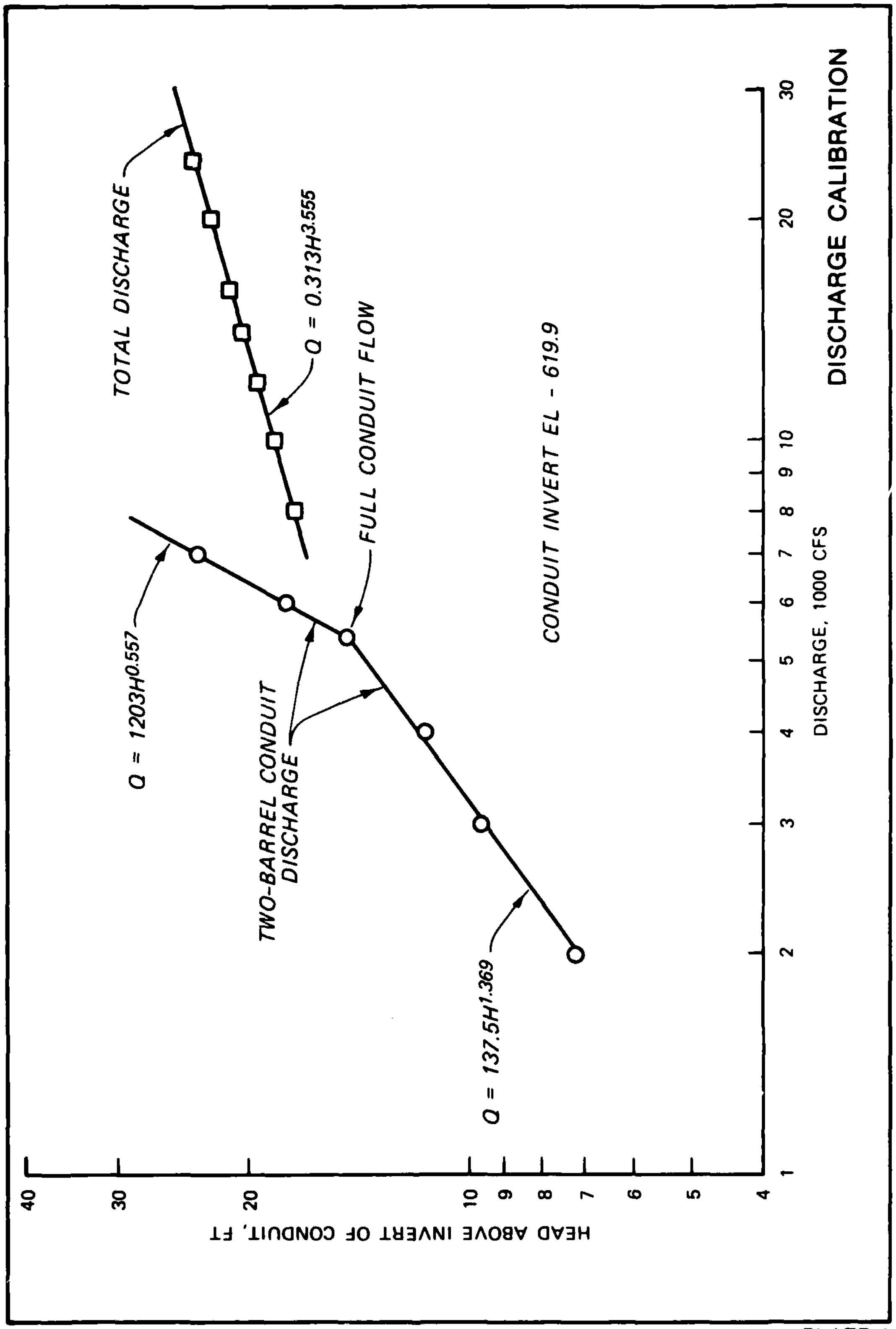
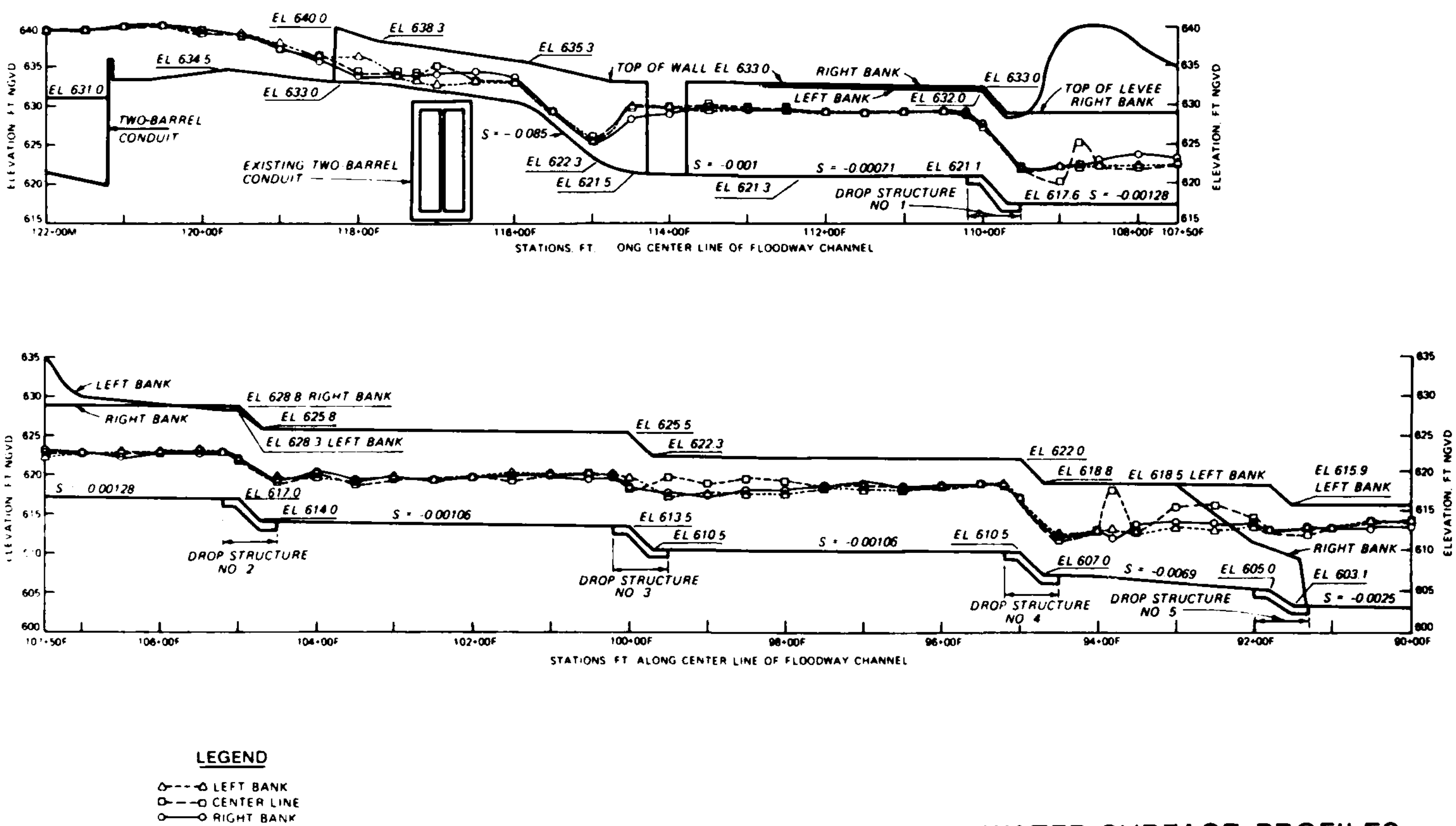

DISCHARGE CALIBRATION
TOTAL DISCHARGE
Q = 0.313H^3.555
FULL CONDUIT FLOW
CONDUIT INVERT EL - 619.9
Q = 1203H^0.557
TWO-BARREL CONDUIT DISCHARGE
Q = 137.5H^1.369
DISCHARGE, 1000 CFS
HEAD ABOVE INVERT OF CONDUIT, FT
1
2
3
4
5
6
7
8
9
10
20
30
40

PLATE 4

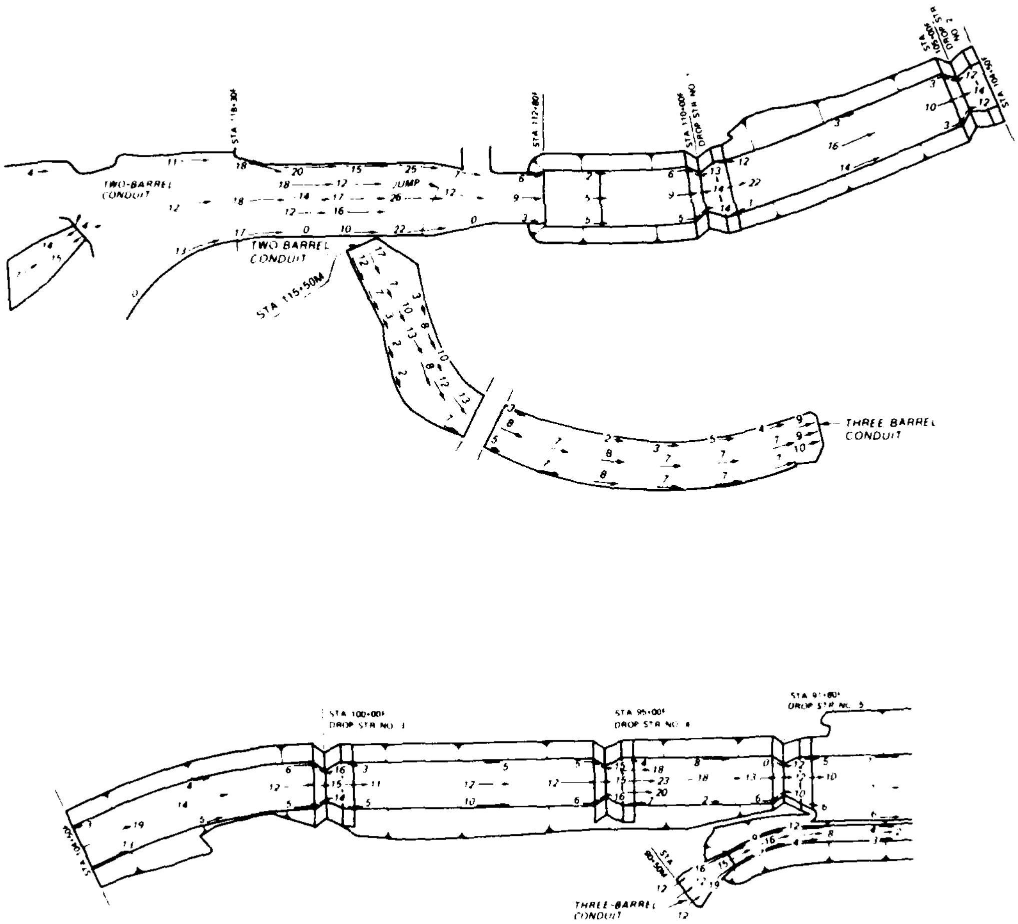


WATER-SURFACE PROFILES

ORIGINAL DESIGN

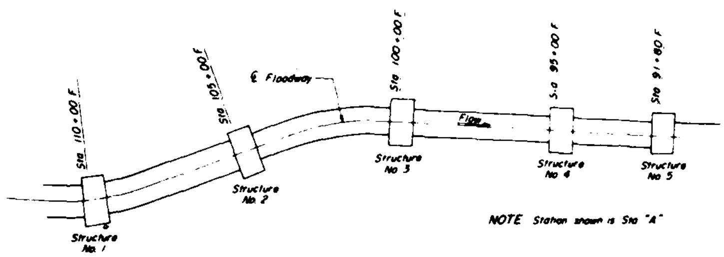
FLOODWAY CHANNEL DISCHARGE 5,700 CFS
TOTAL DISCHARGE 12,000 CFS

PLATE 5



NOTE VELOCITIES ARE IN PROTOTYPE FEET PER SECOND
VELOCITIES MEASURED ONE FOOT ABOVE CHANNEL BOTTOM
STATIONS FOLLOWED BY F INDICATE FLOODWAY AND
STATIONS FOLLOWED BY M INDICATE MAIN OR MODIFIED CHANNEL

VELOCITIES IN FLOODWAY AND MODIFIED CHANNEL
ORIGINAL DESIGN
FLOODWAY CHANNEL DISCHARGE 5,700 CFS
TOTAL DISCHARGE 12,000 CFS

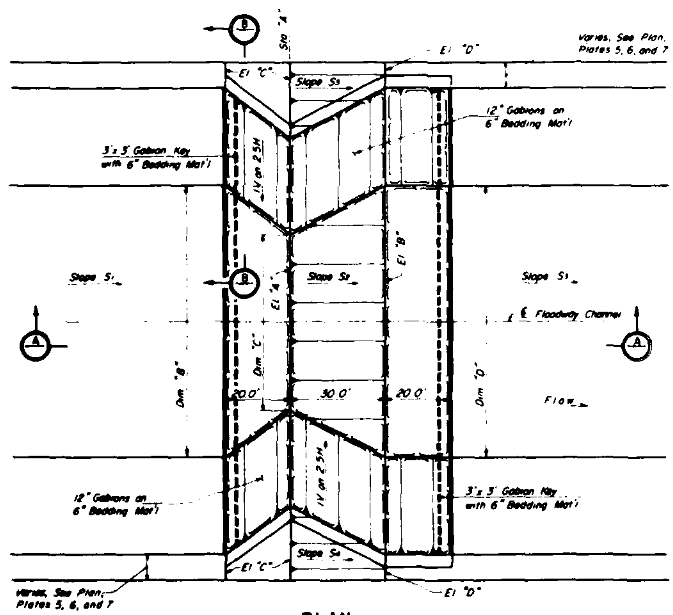


PLAN

LOCATION OF DROP STRUCTURES

SCALE

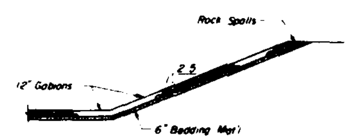
200 100 0 200 400



PLAN

SCALE

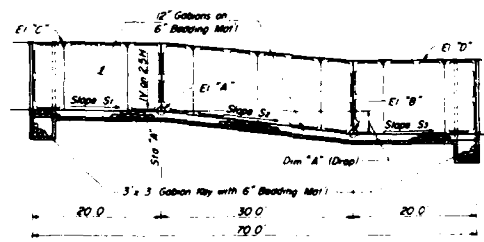
20' 10' 0 20' 40'



SECTION B

SCALE 1" = 10'

10 5 0 10 20



SECTION A

SCALE 1" = 10'

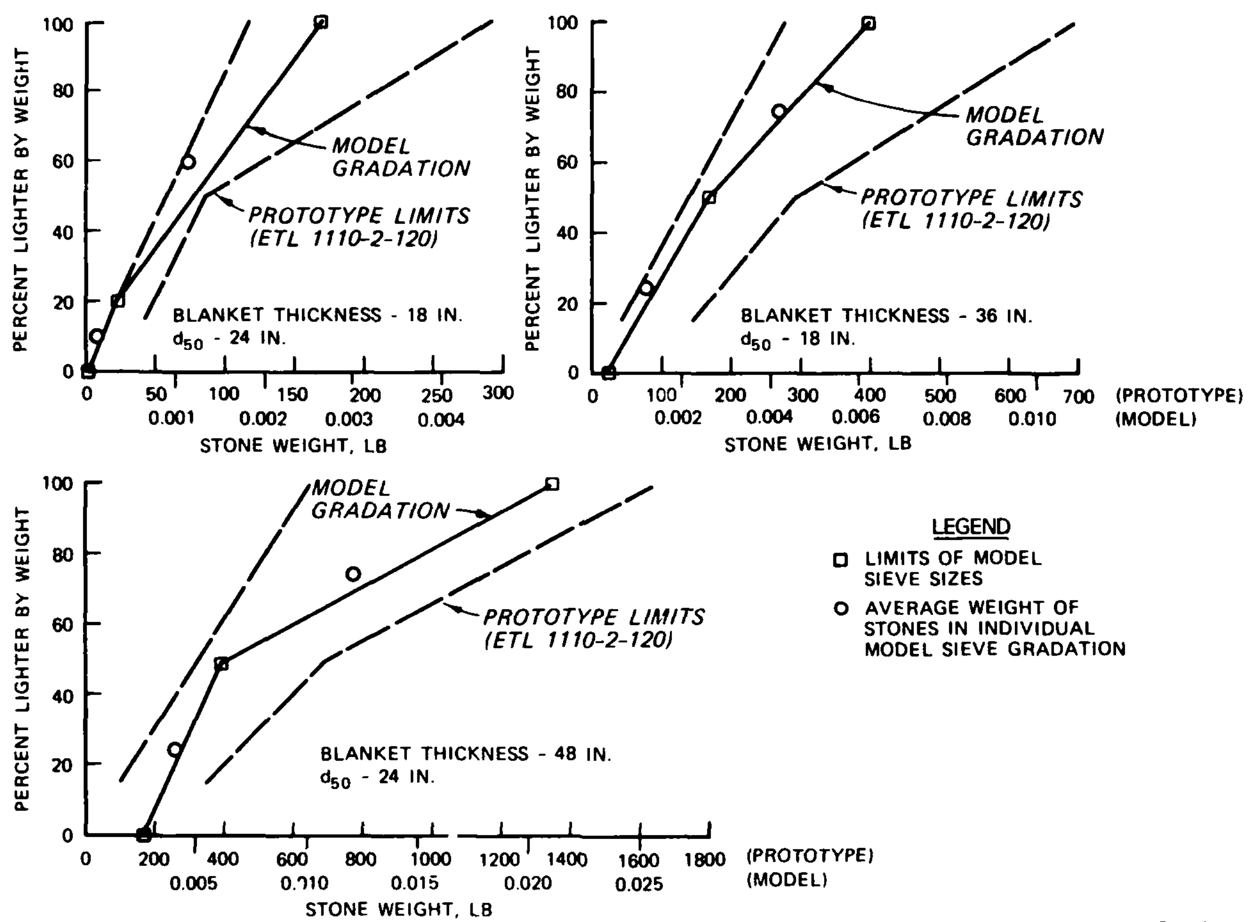
DROP STRUCTURES

TABLE FOR DIMENSIONS, ELEVATIONS, AND SLOPES OF DROP STRUCTURES

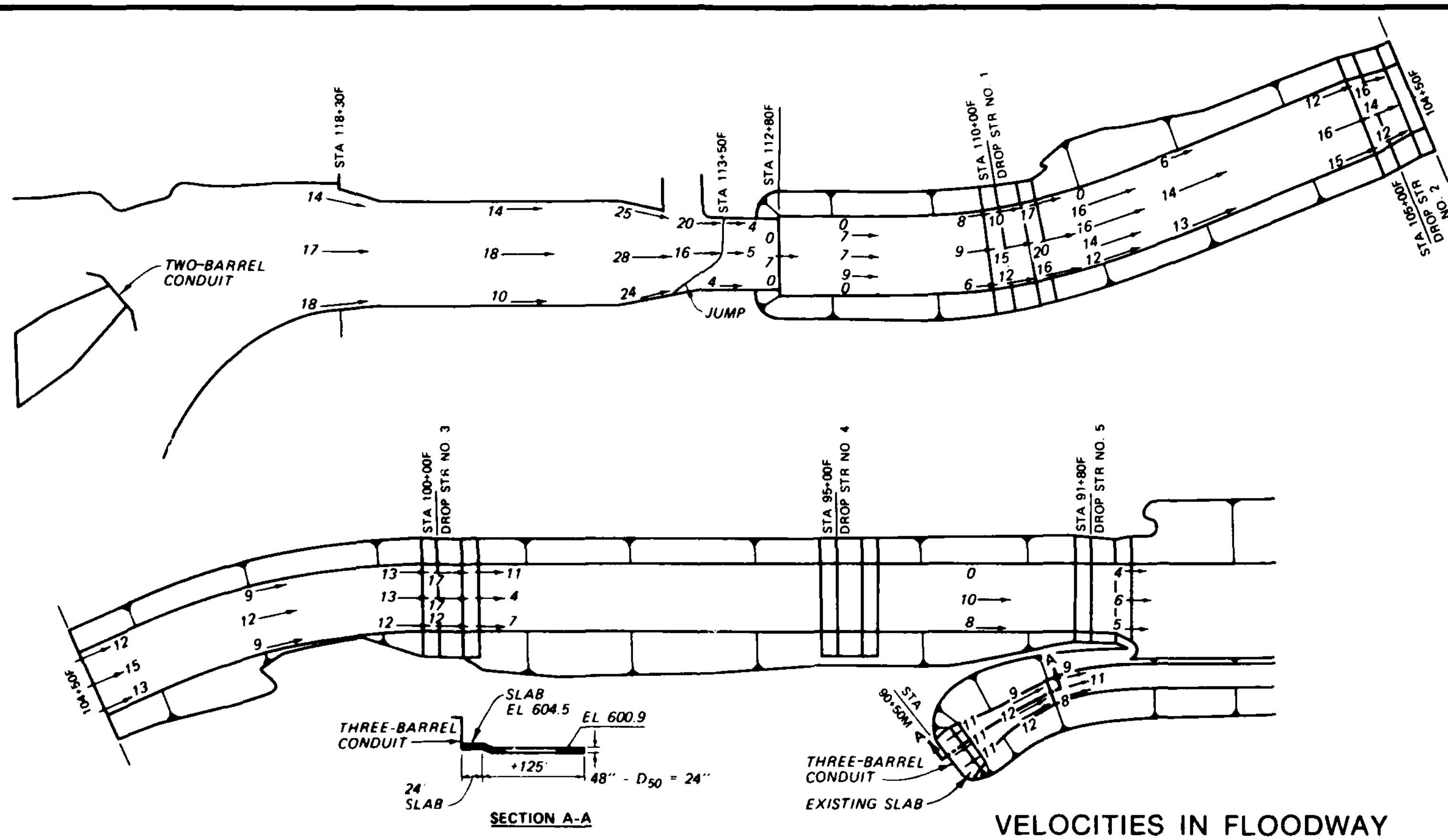
DROP STRUCTURE NUMBER	STA "A"	DIM "A" (DROP)	DIM "B"	DIM "C"	DIM "D"	EL "A"	EL "B"	EL "C"		EL "D"		SLOPE S_1	SLOPE S_2	SLOPE S_3	SLOPE S_4	SLOPE S_5
								RT BANK	LT BANK	RT BANK	LT BANK					
1	110+00F	3.5	100.0	70.0	100.0	621.1	617.6	632.5	632.0	629.1	628.6	-0.00071	-0.116667	-0.00128	-0.11333	-0.11333
2	105+00F	3.0	100.0	65.0	85.0	617.0	614.0	628.8	628.3	625.8	625.8	-0.00128	-0.10000	-0.00106	-0.10000	-0.08333
3	100+00F	3.0	85.0	55.0	85.0	613.5	610.5	625.5	625.5	622.3	622.3	-0.00106	-0.10000	-0.00106	-0.10666	-0.10666
4	95+00F	3.0	85.0	55.0	85.0	610.0	607.0	622.0	622.0	618.8	618.8	-0.00106	-0.10000	-0.00690	-0.10666	-0.10666
5	91+80F	1.9	85.0	55.0	85.0	605.0	603	[illegible]	618.5	608.05	615.9	-0.00690	-0.06333	-0.00253	-0.06666	-0.08666

NOTE ALL DIMENSIONS ARE IN FEET
ALL ELEVATIONS ARE IN FT NGVD

GABION DROP STRUCTURES
ORIGINAL DESIGN



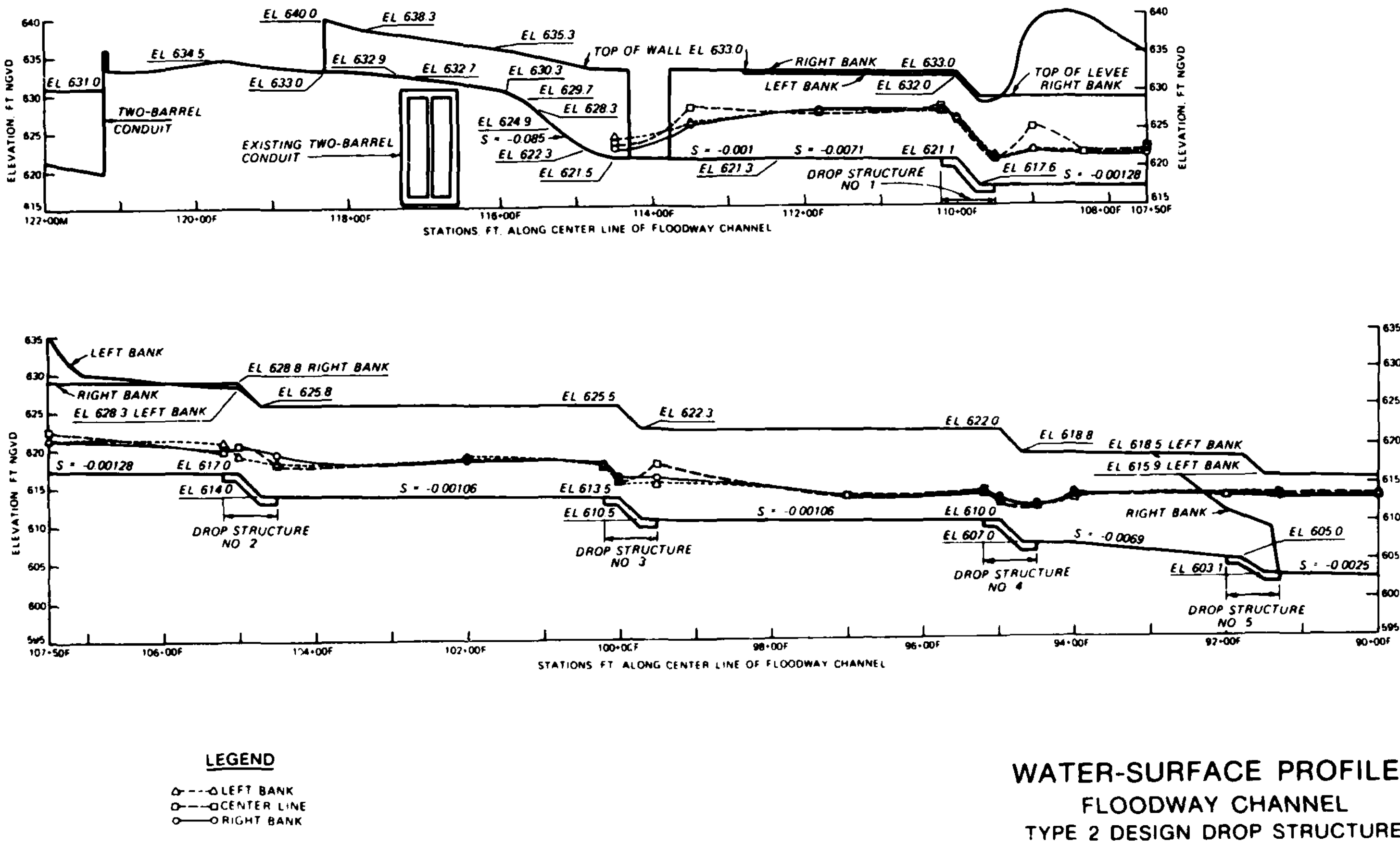
RIPRAP GRADATIONS



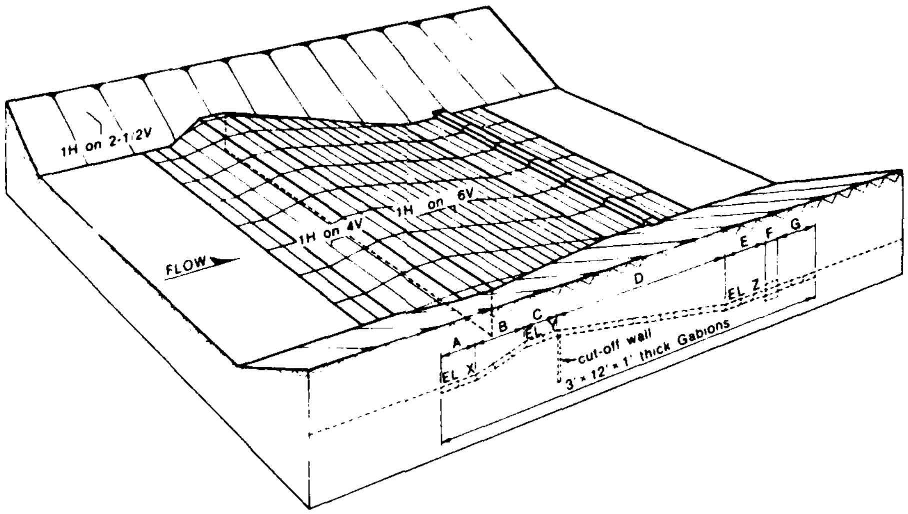
NOTE VELOCITIES ARE IN PROTOTYPE FEET PER SECOND
VELOCITIES MEASURED ONE FOOT ABOVE CHANNEL BOTTOM

VELOCITIES IN FLOODWAY
AND MODIFIED CHANNEL
TYPE 2 DESIGN DROP STRUCTURE
RIPRAP TRANSITION IN MODIFIED CHANNEL
FLOODWAY CHANNEL DISCHARGE 5,700 CFS
TOTAL DISCHARGE 12,000 CFS

PLATE 9



WATER-SURFACE PROFILES
FLOODWAY CHANNEL
TYPE 2 DESIGN DROP STRUCTURE
FLOODWAY DISCHARGE 5,700 CFS
TOTAL DISCHARGE 12,000 CFS



TEST #4

		DS #1	DS #2	DS #3	DS #4	DS #5
DIM	A	6'	6'	6'	6'	6'
	B	9'	9'	9'	9'	12'
	C	6'	6	6'	6'	6'
	D	33'	33'	33'	33'	30'
	E	9'	9'	9	9'	9'
	F	3'	3'	3'	3'	3'
	G	9'	9'	9'	9'	9'
EL	X	621.1	617.0	613.5	610.0	605.0
	Y	623.1	619.5	616.0	612.5	608.1
	Z	617.6	614.0	610.5	607.0	603.1

TEST #5

		DS #1	DS #2	DS #3	DS #4	DS #5
DIM	A	6	6'	6	6'	6'
	B	9'	9'	18'	15'	12'
	C	6	6	6'	6'	6
	D	33'	33'	45'	39'	30'
	E	9'	9'	9'	9'	9'
	F	3'	3'	3'	3'	3'
	G	9	9'	9'	9	9'
EL	X	621.1	617.0	613.5	610.0	605.0
	Y	623.1	619.5	618.0	613.5	608.1
	Z	617.6	614.0	610.5	607.0	603.1

TEST #6

		DS #1	DS #2	DS #3	DS #4	DS #5
DIM	A	6'	6'	6'	6'	6'
	B	9'	9'	18'	15	12'
	C	6'	6'	6	6'	6
	D	33'	33'	45'	39'	30'
	E	9'	9'	9'	9'	9'
	F	3'	3'	3'	3'	3'
	G	9'	9'	9'	9	9'
EL	X	621.1	617.0	613.5	610.0	605.0
	Y	623.1	619.5	617.0	613.5	609.1
	Z	617.6	614.0	610.5	607.0	603.1

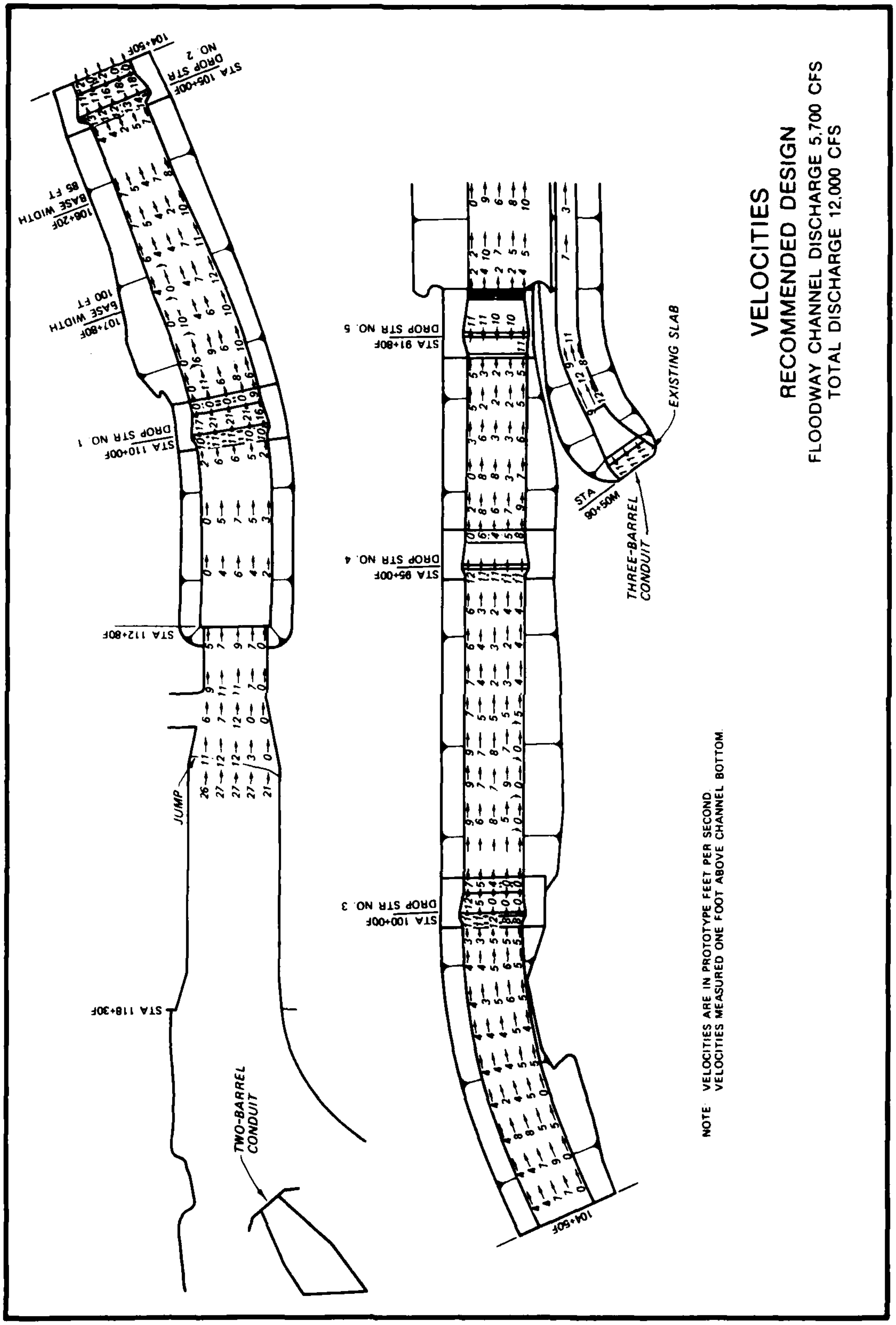
TEST #7 (FINAL DESIGN)

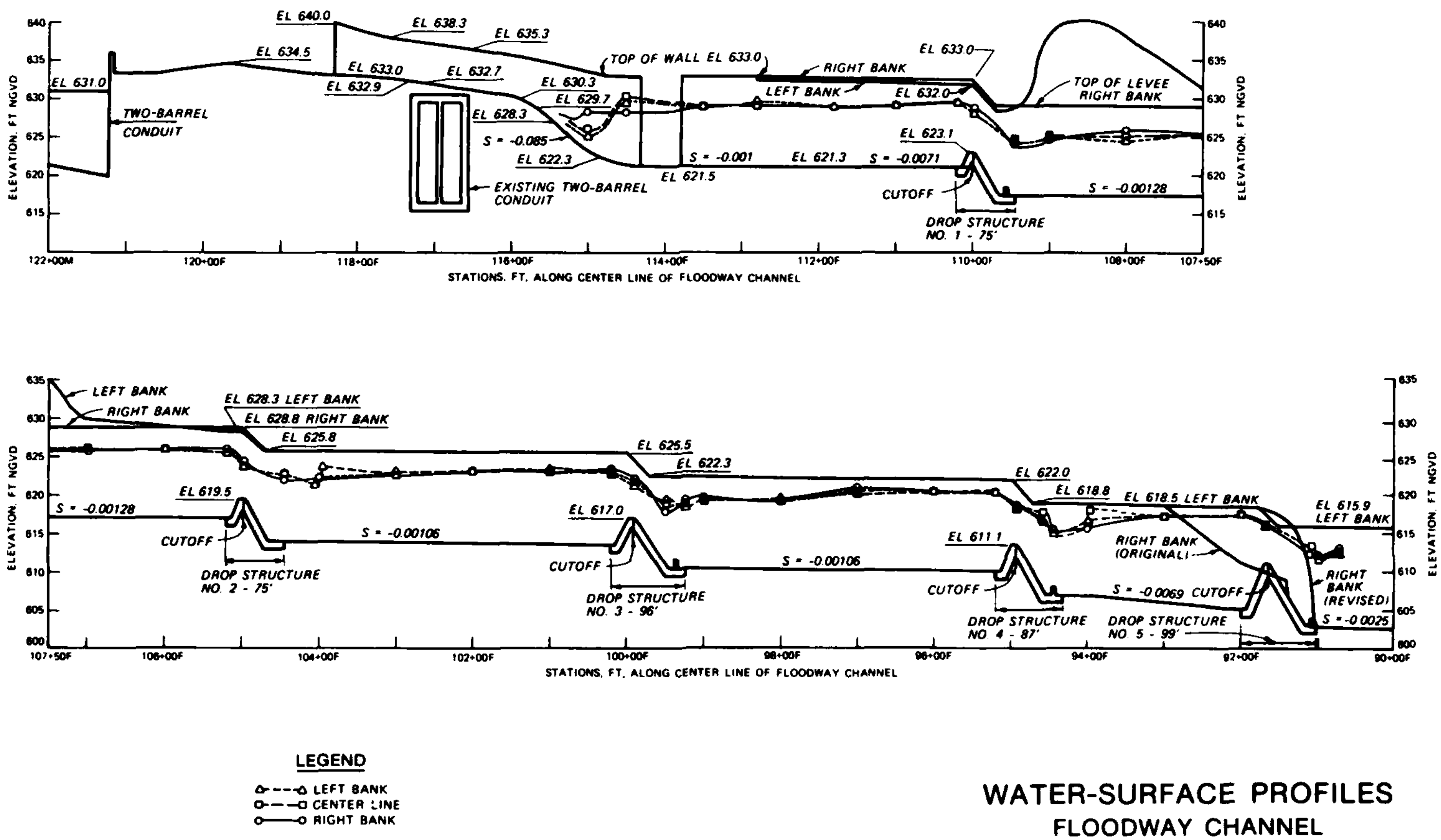
		DS #1	DS #2	DS #3	DS #4	DS #5
DIM	A	6	6'	6'	6	6'
	B	9	9'	18'	15'	24'
	C	6'	6'	6'	6'	6'
	D	33	33'	45'	39'	48'
	E	9	9	9'	9'	6'
	F	3'	3'	3'	3'	3'
	G	9'	9	9'	9'	6'
EL	X	621.1	617.0	613.5	610.0	605.0
	Y	623.1	619.5	617.0	613.5	611.1
	Z	617.6	614.0	610.5	607.0	603.1

NOTE: ELEVATIONS ARE IN FT NGVD

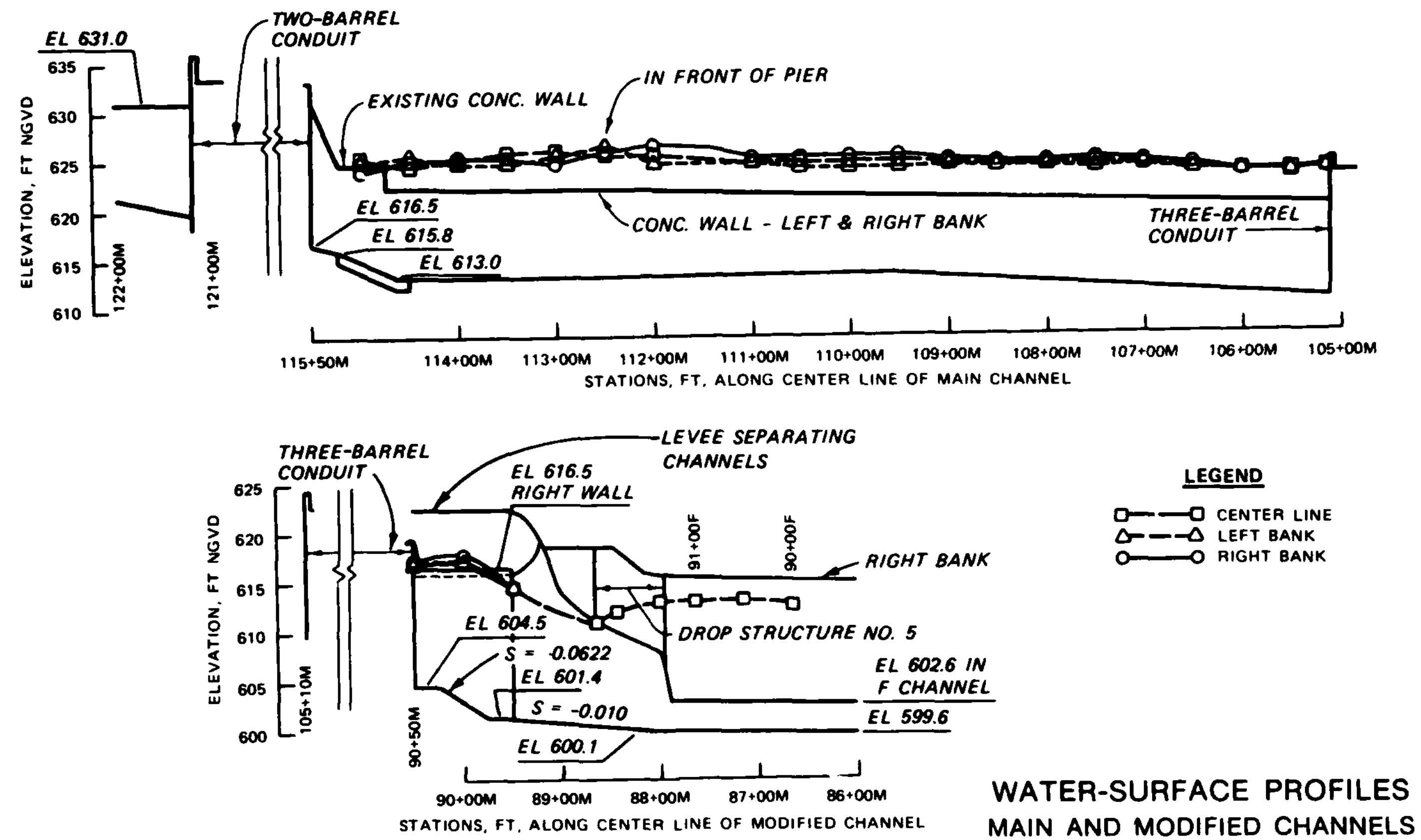
TYPE 3 DESIGN DROP STRUCTURE

PLATE 11

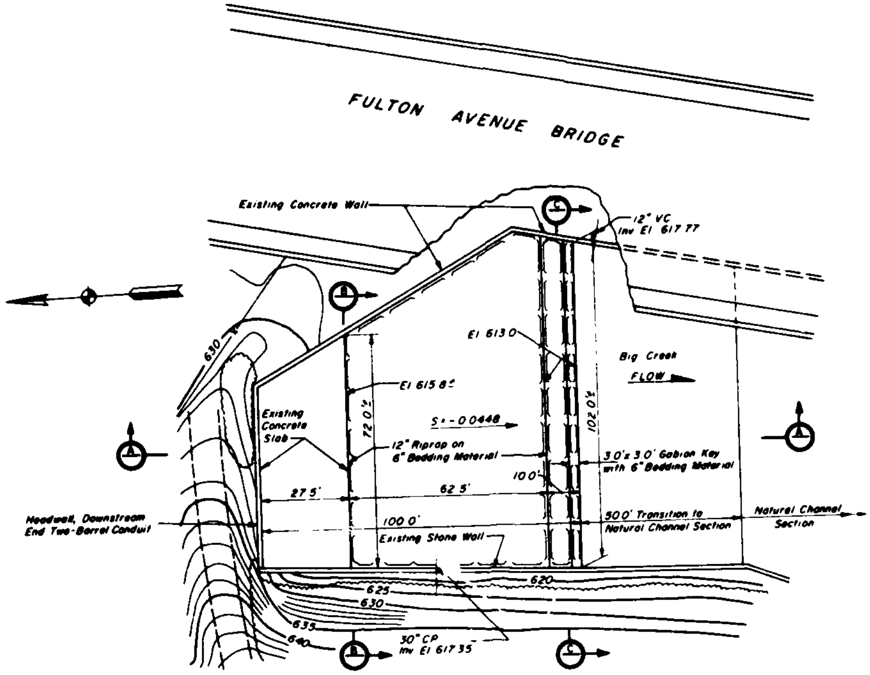

VELOCITIES
RECOMMENDED DESIGN
FLOODWAY CHANNEL DISCHARGE 5,700 CFS
TOTAL DISCHARGE 12,000 CFS
NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.
VELOCITIES MEASURED ONE FOOT ABOVE CHANNEL BOTTOM.
STA 105+00F DROP STR NO. 2
104+50F
106+20F BASE WIDTH 85 FT
107+80F BASE WIDTH 100 FT
STA 110+00F DROP STR NO. 1
STA 112+80F
JUMP
STA 118+30F
TWO-BARREL CONDUIT
STA 91+80F DROP STR NO. 5
STA 95+00F DROP STR NO. 4
STA 100+00F DROP STR NO. 3
104+60F
EXISTING SLAB
STA 90+50M
THREE-BARREL CONDUIT



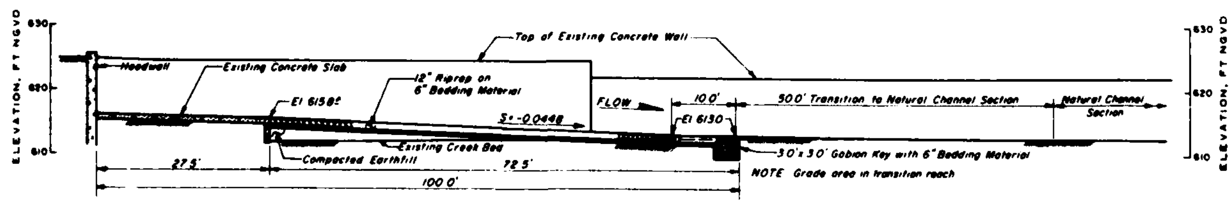
WATER-SURFACE PROFILES
FLOODWAY CHANNEL
RECOMMENDED DESIGN
FLOODWAY CHANNEL DISCHARGE 5,700 CFS
TOTAL DISCHARGE 12,000 CFS



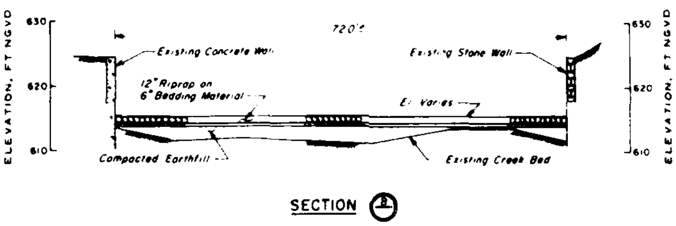
WATER-SURFACE PROFILES
MAIN AND MODIFIED CHANNELS
ORIGINAL DESIGN
MAIN CHANNEL DISCHARGE 6,300 CFS
TOTAL DISCHARGE 12,000 CFS

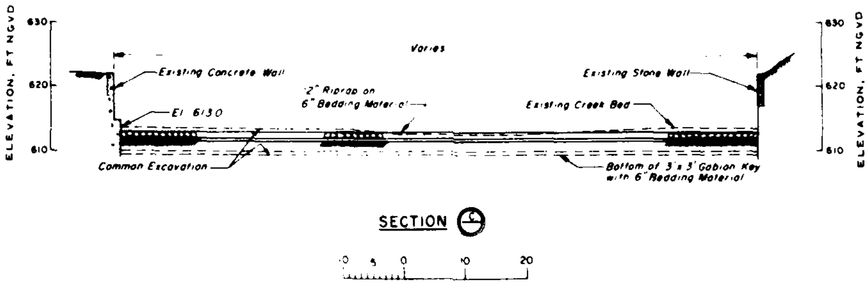


PLAN



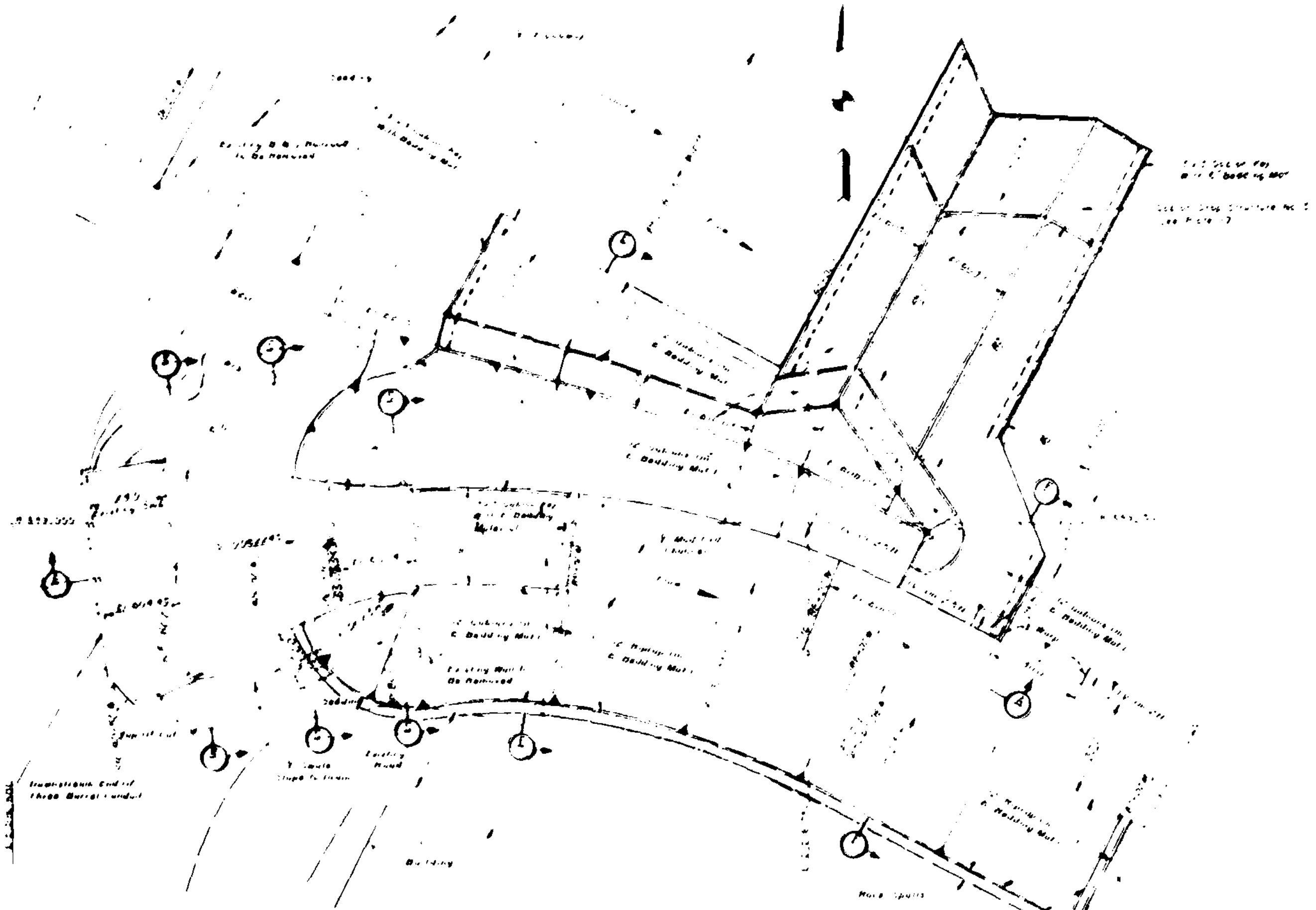
SECTION A





RIPRAPPED TRANSITION

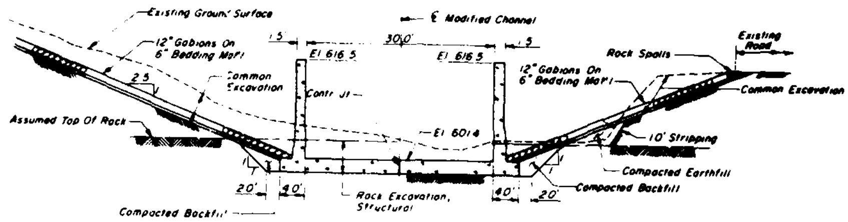
TWO-BARREL OUTLET TRANSITION
MAIN CHANNEL
ORIGINAL DESIGN



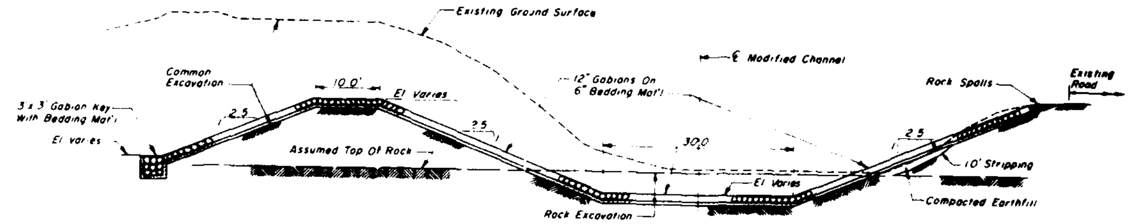
PLAN

SCALE

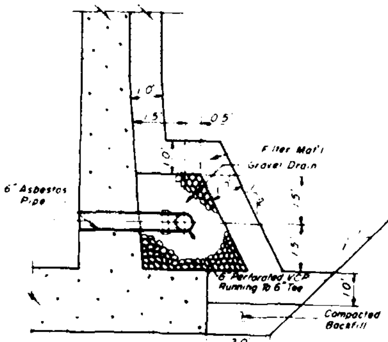
1



SECTION D



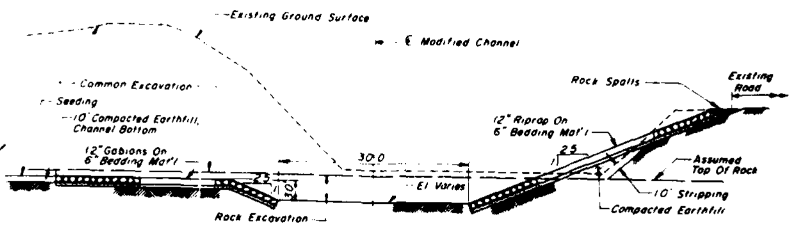
SECTION E



DETAIL "A"

WALL DRAIN

NOT TO SCALE



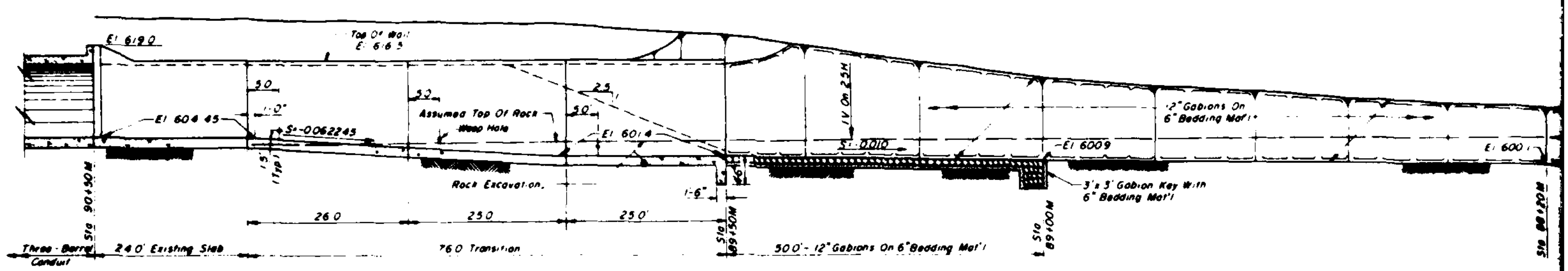
SECTION F

SCALE

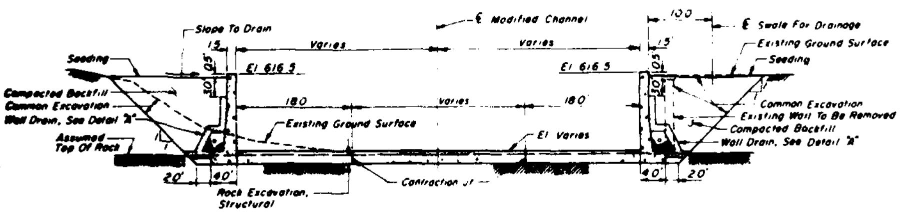
10 5 0 10 20

2

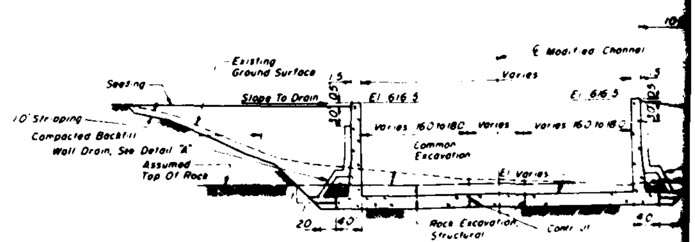
1



SECTION A



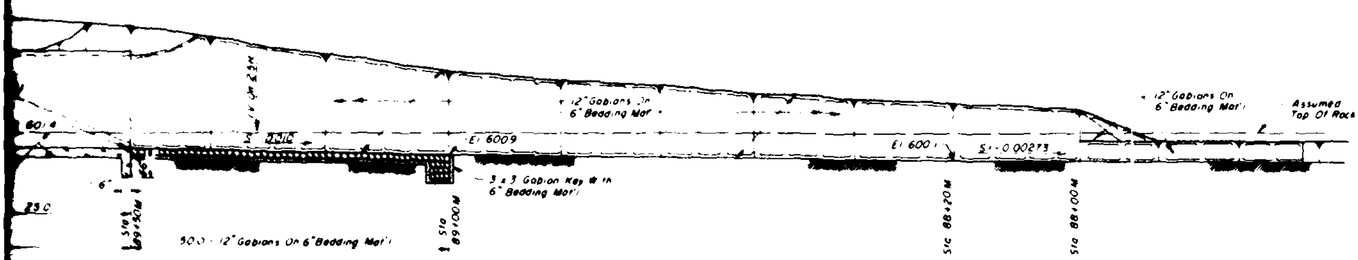
SECTION B



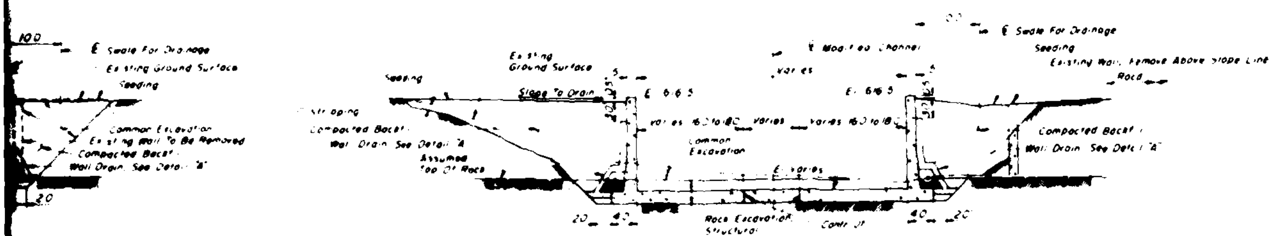
SECTION C

FLOODWA

3

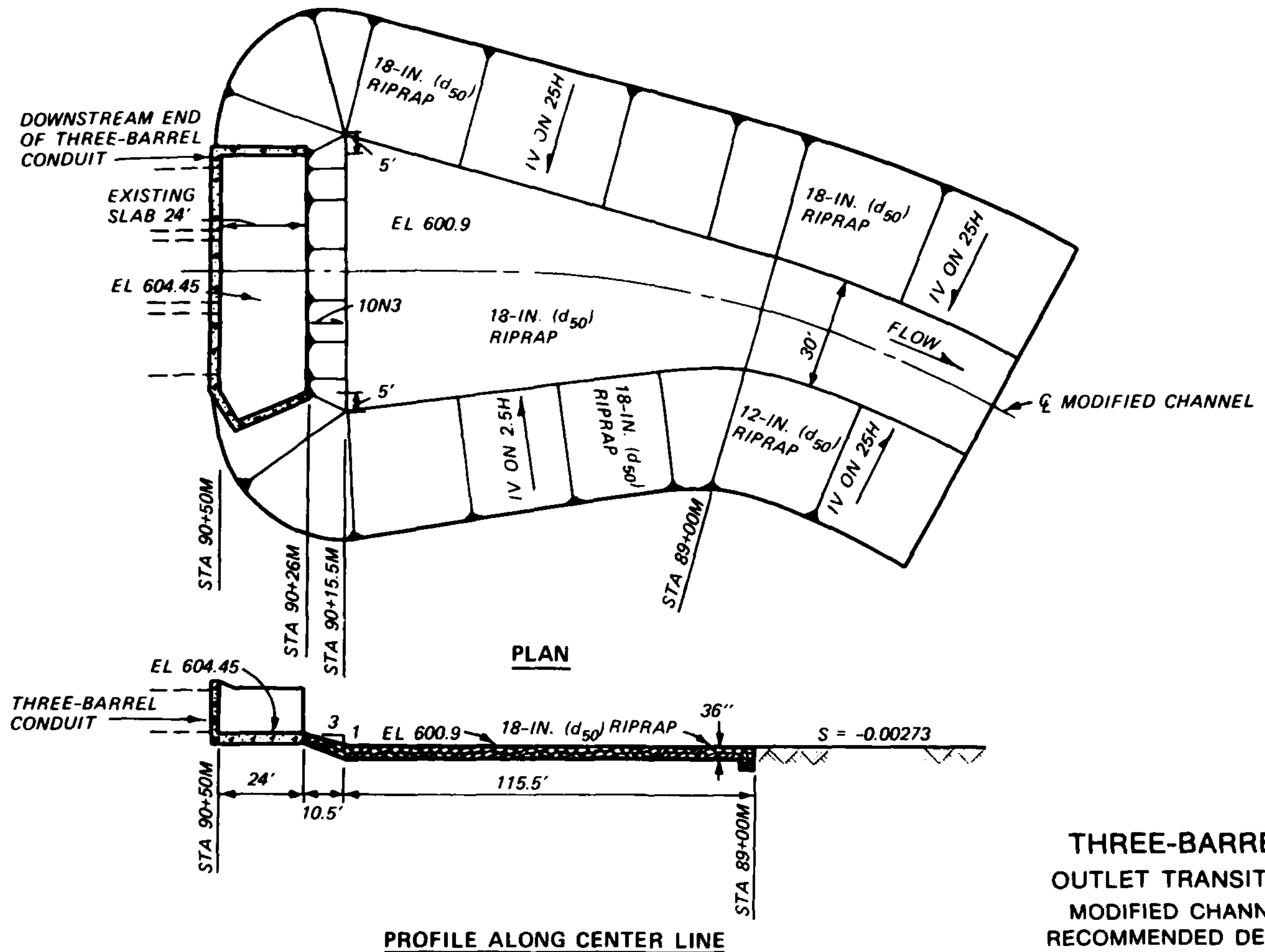


SECTION (A)

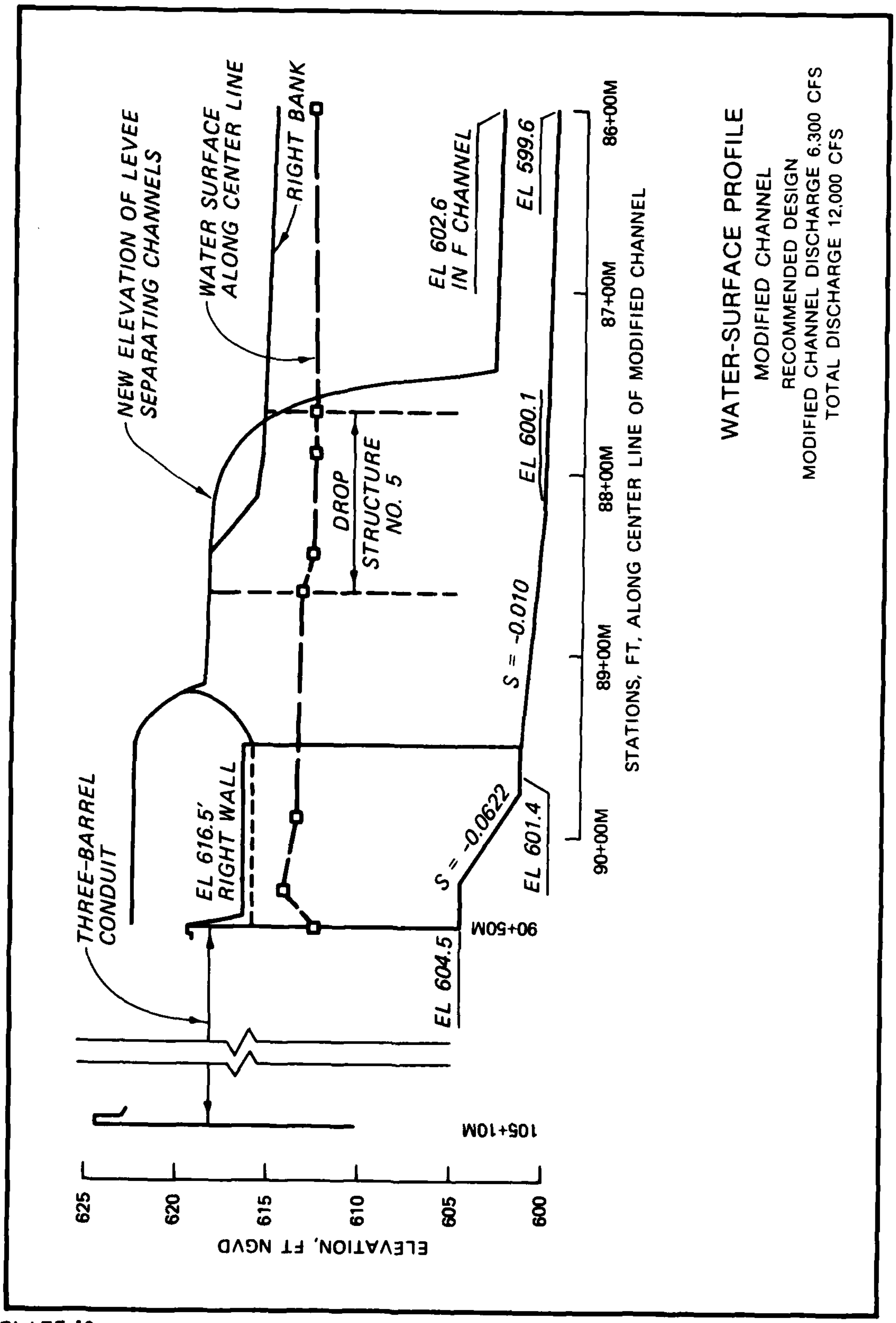


SECTION (C)

FLOODWAY AND MODIFIED CHANNELS
CONFLUENCE AREA
ORIGINAL DESIGN



THREE-BARREL
OUTLET TRANSITION
MODIFIED CHANNEL
RECOMMENDED DESIGN


WATER-SURFACE PROFILE
MODIFIED CHANNEL
RECOMMENDED DESIGN
MODIFIED CHANNEL DISCHARGE 6,300 CFS
TOTAL DISCHARGE 12,000 CFS
NEW ELEVATION OF LEVEE SEPARATING CHANNELS
WATER SURFACE ALONG CENTER LINE
RIGHT BANK
EL 602.6 IN F CHANNEL
EL 599.6
EL 600.1
DROP STRUCTURE NO. 5
S = -0.010
S = -0.0622
EL 601.4
EL 604.5
THREE-BARREL CONDUIT
EL 616.5' RIGHT WALL
90+50M
105+10M
90+00M
89+00M
88+00M
87+00M
86+00M
STATIONS, FT, ALONG CENTER LINE OF MODIFIED CHANNEL
ELEVATION, FT NGVD
625
620
615
610
605
600

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.

Pickering, Glenn A.
Big Creek Flood-control Project, Cleveland Ohio : Hydraulic Model Investigation / by Glenn A. Pickering (Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, 1983.
23 p., 18 p. of plates : ill., photos ; 27 cm. -- (Technical report ; HL-83-7)
Cover title.
"April 1983."
Final repc t.
"Prepared for U.S. Army Engineer District, Buffalo."

1. Big Creek (Ohio). 2. Channels (Hydraulic engineering). 3. Flood control. 4. Hydraulic models. I. United States. Army. Corps of Engineers. Buffalo District. II. U.S. Army Engineer Waterways Experiment Station. Hydraulics Laboratory. III. Title IV. Series:

Pickering, Glenn A.
Big Creek Flood-control Project, Cleveland, Ohio : ... 1983.
(Card 2)

Technical report (U.S. Army Engineer Waterways Experiment Station) ; HL-83-7.
TA7.W34 no.HL-83-7

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