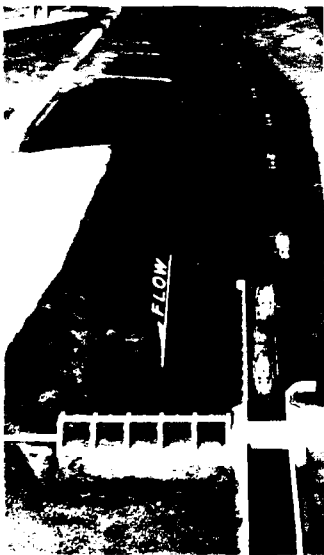




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TECHNICAL REPORT HL-88-12

STEELE BAYOU GRAVITY CONTROL STRUCTURE VICKSBURG, MISSISSIPPI

Hydraulic Model Investigation

by

W. B. Fenwick

Hydraulics Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631



June 1988

Final Report

Approved For Public Release, Distribution Unlimited

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Vicksburg, Mississippi 39180-0060

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) A hydraulic model was used to evaluate various schemes to eliminate the severe turbulence and eddies that have caused drastic erosion problems downstream of the Steele Bayou drainage structure. Significant bottom scouring and bank sloughing have occurred during the outflows following spring floods. The study was conducted to develop a solution for the excessive scour in the channel reach between Mississippi Highway Bridge No. 465 and the Steele Bayou structure where a 40-ft-deep by 600-ft-wide scour hole developed in the prototype. The longitudinal dikes, recommended as a result of the model tests, were installed in 1985 and have performed well through a period of relatively high water. <i>Reynolds</i>					
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PREFACE

The model investigation reported herein was authorized by the US Army Engineer Division, Lower Mississippi Valley (LMVD), on 8 September 1983 at the request of the US Army Engineer District, Vicksburg, (LMK).

The study was conducted during the period September 1983 to September 1984 in the Hydraulics Laboratory (HL) of the US Army Engineer Waterways Experiment Station (WES), under the direct supervision of Messrs. H. B. Simmons and F. A. Herrmann, Jr., former and present Chiefs, HL, respectively, and under the general supervision of Messrs. J. L. Grace, Jr., and G. A. Pickering, former and present Chiefs, Hydraulic Structures Division, respectively; and N. R. Oswalt, Chief, Spillways and Channels Branch. The project engineer for the model study was Mr. W. B. Fenwick, assisted by Messrs. J. Rucker and E. Jefferson and Mrs. J. McAlpin, all of the Spillways and Channel Branch. This report was prepared by Mr. Fenwick and edited by Mrs. N. Johnson, Information Products Division, under the Inter-Governmental Personnel Act.

During the course of the investigation, Messrs. P. G. Combs, B. K. Arthur, W. J. Hill, Jr., J. E. Henley, and R. O. Smith, LMK; R. H. Resta, LMVD; and S. Powell and T. Munsey, Headquarters, US Army Corps of Engineers, visited WES to discuss test results and to correlate these results with concurrent design work.

COL Dwayne G. Lee, CE, is the Commander and Director of WES.
Dr. Robert W. Whalin is Technical Director.



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CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI
(metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
acres	4,046.873	square metres
cubic feet	0.02831685	cubic metres
feet	0.3048	metres
miles (US statute)	1.609347	kilometres
square miles (US statute)	2.589998	square kilometres

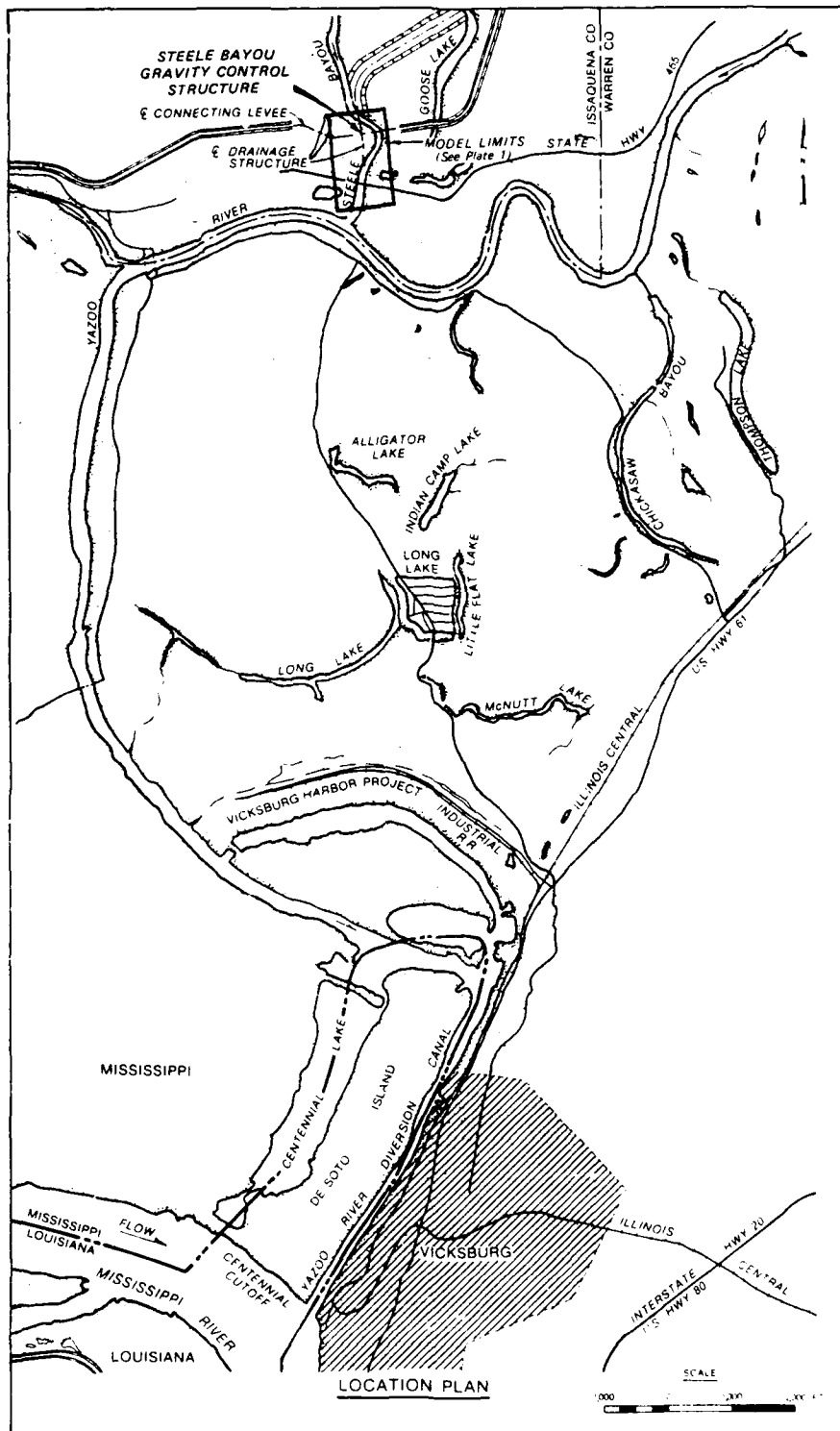


Figure 1. Location map

STEELE BAYOU GRAVITY CONTROL STRUCTURE

VICKSBURG, MISSISSIPPI

Hydraulic Model Investigation

PART I: INTRODUCTION

Prototype

General features

1. The Steele Bayou gravity control structure is part of the Yazoo backwater project, which is a system of levees and channels designed to protect approximately 750,000 acres of alluvial lands from flooding by backwater of the Mississippi River. The locations of the principal streams and drainage areas which affect the project are shown in Figure 1. The project consists of an area of about 1,550 square miles and has four geographic divisions. The Steele Bayou gravity control structure is located in one of these divisions known as the Yazoo area.

Yazoo area

2. The Yazoo area lies west of the Yazoo River and the lower auxiliary channel. This area contains about 82 percent of the entire backwater project. The protection plan for the Yazoo area includes a levee about 30 miles long which extends from the lower end of the main-line Mississippi River levee to a connection with the west guide levee of the lower auxiliary channel. The levee height is designed to contain the greatest flood on record, but would overtop in a project flood to provide additional protection for the main Mississippi River levee. Interior drainage is provided by two drainage structures located in the Steele Bayou and the Sunflower River sumps. These sump areas are connected by an open channel located landward and generally parallel to the levee between the Big Sunflower River and Steele Bayou.

Structure description

3. The structure is located in a Steele Bayou bendway cutoff 1,800 ft north of Mississippi State Highway Bridge No. 465, three-quarters of a mile

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

north of Yazoo River mile 9.7, and 7 miles north-northwest of Vicksburg, Mississippi. The concrete structure has a center-line length of 300 ft, consisting of a 129-ft concrete approach apron, a 53-ft gate structure, a 40-ft chute, and a 78-ft stilling basin with baffle blocks. The overall width, 513.5 ft, includes 120 ft of gated openings for evacuating runoff from the landside area of the levee. Four steel vertical lift gates, 23.5 ft high by 32 ft wide with an invert elevation of 60,* are used to control the waterway opening. Concrete cantilever "T" type retaining walls are provided to form the channel through the structure and retain the earth fills. A 24-ft-wide roadway bridge at el 110 is provided across the structure for vehicular traffic. The concrete structure is tied to existing levees of standard Mississippi River levee cross section, which consists of 1V on 4H riverside slopes, 1V on 5.5H landside slopes, and a 10-ft crown. The approach and discharge channels are 200 ft wide with 1V on 3H side slopes. Plate 1 shows a plan view of the project. Plates 2 and 3 show plan and section views, respectively, of the structure.

Pertinent data

4. Other pertinent data for the project and structure are presented below:

<u>Item</u>	<u>Quantity</u>
Drainage area, Yazoo River	4,093 square miles
Yazoo area levee, crown elevation	107 ft
Mississippi River project design flood, elevation	109 ft
Sump level, maximum design water surface elevation	96.9 ft
Yazoo River low water, elevation	43 ft
Top of roadway, elevation	110 ft
Stilling basin floor, elevation	50 ft
Stilling basin end sill, elevation	53 ft
Approach slab, elevation	60 ft

Purpose and Scope of Model Study

5. Since the initial construction of the Steele Bayou drainage structure, there has been a continuous instability problem in the downstream channel. After the severe flood outflows during the spring of 1983, significant

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

bottom scouring and bank sloughing were noted. A model study was conducted to examine the flow conditions that caused these problems and to develop practical modifications that will permit the structure to perform satisfactorily for all anticipated flow and operational conditions.

PART II: MODEL

Description

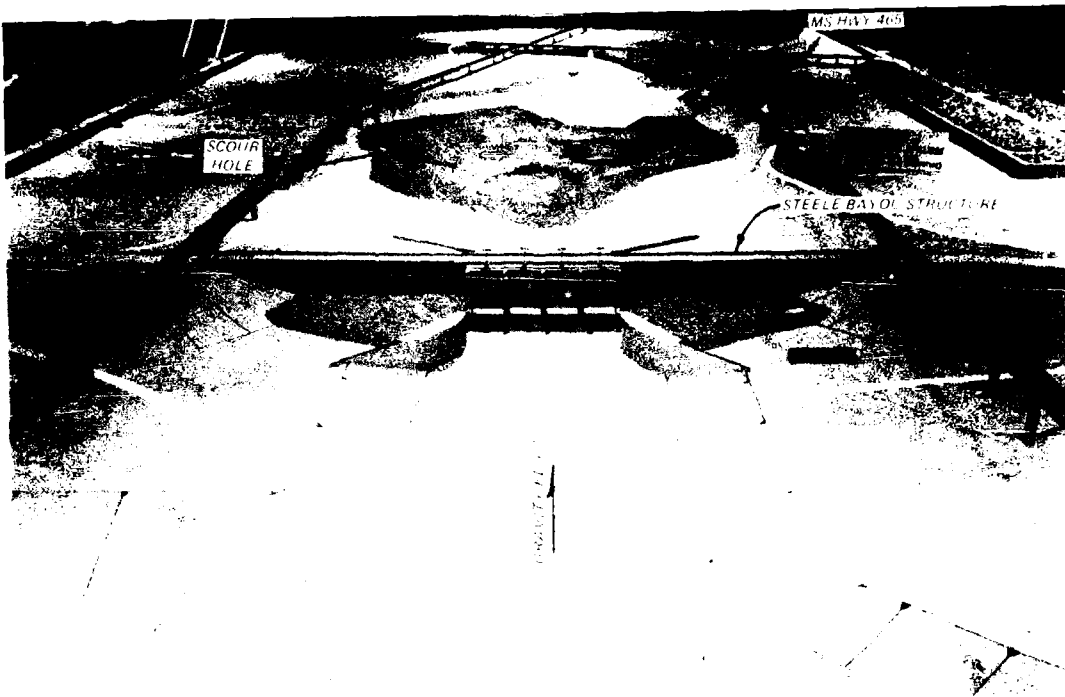
6. A 1:36-scale model (Plate 1) was constructed to reproduce adequate approach and exit areas, the entire structure, and riprap protection as required. The approach and overbank areas were molded of sand-cement mortar to sheet metal templates. The structure was made of plywood and sheet metal. Figure 2 shows downstream and upstream views of the overall model as originally built (type 1). The dark area, visible near the center of the photographs, represents the large scour hole that developed downstream from the prototype structure. This area was molded to male templates for future moveable bed tests.

7. A 1:48-scale, two-dimensional, section model (Figure 3) was used to expedite screening of some proposed modifications considered appropriate prior to tests in the three-dimensional model. The section model was constructed in a 1-ft-wide flume that simulated a 48-ft-wide section of the channel and structure, including a 200-ft-long reach of the approach channel, the structure, and a 400-ft-long reach of the exit channel. Riprap upstream and downstream from the structure was simulated.

8. Flow through the models was recirculated by centrifugal pumps, and discharges were measured with venturi meters. Steel rails set to grade provided reference planes for measuring devices. Water-surface elevations were measured with point gages. Velocities were measured with pitot tube and electromagnetic velocity meters. Water current directions and patterns were determined by injecting dye into the water and sprinkling confetti on the water surface.

Interpretation of Model Results

9. The accepted equations of hydraulic similitude, based on the Froudian criteria, were used to express the mathematical relations between the dimensions and hydraulic quantities of the model and the prototype. General



a. Looking downstream



b. Looking upstream

Figure 2. 1:36-scale model, Steele Bayou structure

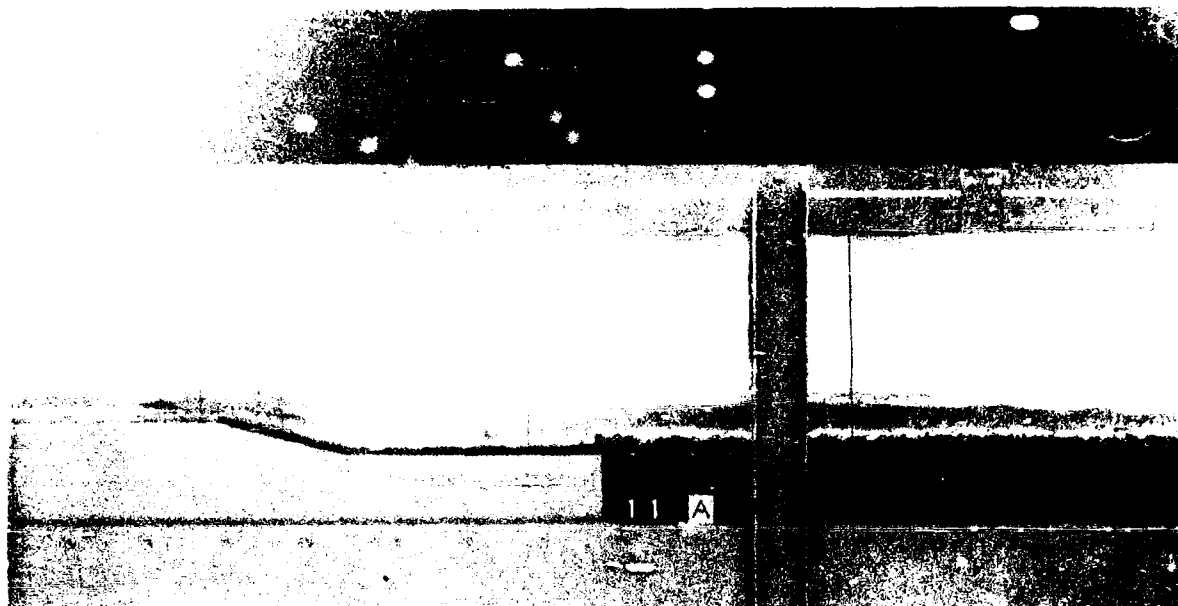


Figure 3. 1:48-scale section model

relations expressed in terms of the model scale or length, L_r , are presented in the following tabulation.

Dimension*	Ratio	Scale Relations	
		Model:Prototype	
Length	L_r	1:36	1:48
Area	$A_r = L_r^2$	1:1,296	1:2,304
Velocity	$V_r = L_r^{1/2}$	1:6.0	1:6.93
Discharge	$Q_r = L_r^{5/2}$	1:7,776	1:15,963
Time	$T_r = L_r^{1/2}$	1:6.0	1:6.93

* Dimensions are in terms of length.

PART III: TESTS AND RESULTS

Discharge Characteristics

Flow conditions

10. Tests were conducted to determine the discharge characteristics of the spillway structure for each of the following flow conditions:

- a. Free uncontrolled flow. Gates fully open; upper pool unaffected by the tailwater.
- b. Submerged uncontrolled flow. Gates fully open; upper pool controlled by the submergence effect of the tailwater.
- c. Free controlled flow. Gates partially open; upper pool controlled by gate opening and unaffected by the tailwater.
- d. Submerged controlled flow. Gates partially open; upper pool controlled by gate opening and the submergence effect of the tailwater.

These four flow regimes are illustrated in Figure 4.

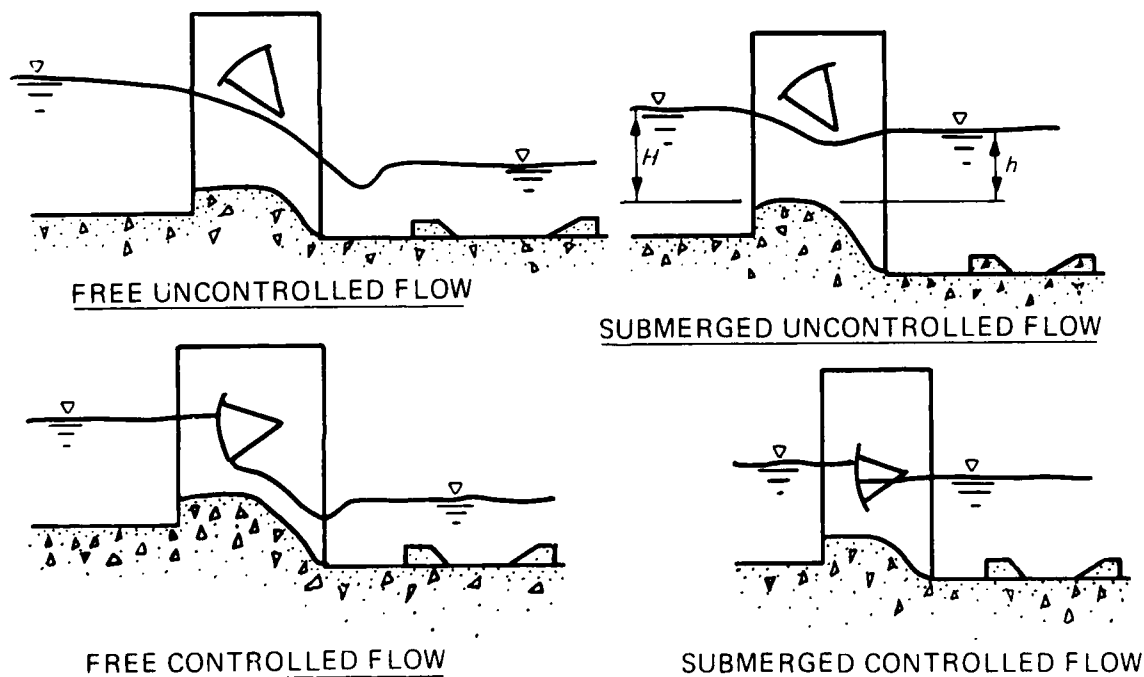


Figure 4. Four flow regimes

Description of tests

11. Tests were conducted to determine the discharge characteristics of the structure for free uncontrolled flows by introducing various discharges into the model, with the tailwater not affecting the upper pool, and observing the corresponding upper pool elevations. Sufficient time was allowed for stabilization of the upstream flow conditions. Upper pool elevations were measured near the upstream end of the right approach wall (approximately 200 ft upstream of the axis of the structure). Tailwater elevations were measured at a point approximately 200 ft downstream of the Highway 465 Bridge. A similar procedure was followed for various partial gate openings to determine the discharge characteristics of free controlled flow.

12. Submerged flow discharge characteristics for both controlled and uncontrolled flows were determined by introducing several constant discharges into the model and varying the tailwater in small increments for each flow from an elevation at which no interference with spillway flow was evident to an elevation at which the flow was practically 100 percent submerged. The elevation of the upper pool was noted at each of the respective tailwater elevations.

Presentation and analysis of data

13. Basic data obtained from the model are presented in plots of pool elevation versus tailwater elevation for various discharges. These data are shown in Plates 4-8.

14. The head on the crest, H , was plotted for various discharges for free uncontrolled flow conditions as shown in Plate 9. The equation for the curve is the best empirical fit determined by the method of least squares. To determine the discharge through the structure for a known pool elevation if free uncontrolled flow conditions exist, the following equation can be used:

$$Q = 1.80LH^{1.68} \quad (1)$$

where

Q = discharge

L = length of spillway, ft

15. The effect of tailwater submergence for uncontrolled flows was determined by plotting the percent of submergence (depth of tailwater above crest/depth of upper pool above crest) versus a percent reduction in the

free-flow coefficient (C_1 /free-flow coefficient) as shown in Plate 10. This plot can be used to determine discharges during submerged uncontrolled flow conditions by using the equation

$$Q = C_1 L H^{1.68} \quad (2)$$

As the plot of Plate 10 indicates, the C_1/C value approaches unity at an h/H or value of about 0.7 and thus free-flow conditions exist with values smaller than this.

16. The free controlled flow data were plotted as shown in Plate 11. The relation between discharge, gate opening, G_o , and head on the gate, H_g = head on crest - $G_o/2$, was found to be

$$Q = 2.88 L G_o H_g^{0.66} \quad (3)$$

This equation can be used to determine discharge with various gate openings and pool elevations for free-flow conditions.

17. The equation used to satisfy the submerged controlled flow calibration data was

$$Q = C_{g_s} L h \sqrt{2g\Delta H} \quad (4)$$

where

C_{g_s} = coefficient of discharge for submerged controlled flow

ΔH = difference between the upper pool and tailwater elevations, ft

g = acceleration due to gravity, fps

The submerged controlled flow discharge coefficient is a function of tailwater depth above the crest/gate openings. This coefficient can be obtained from Plate 12 for known gate openings and tailwater elevations.

18. An analysis of the controlled flow data was made to determine when free- or submerged-flow conditions exist. A flow regime is shown in Plate 13. This plot can be used to determine when the free-flow or submerged-flow equation should be used to compute discharges.

Downstream Channel

19. As mentioned previously in this report, a large scour hole developed downstream from the prototype structure during several flood events. Also, a considerable amount of bank sloughing occurred during this time. Details of this area are shown in Plate 14. Large eddies formed in this area with certain discharge and tailwater conditions. This increased the scour potential downstream from the structure.

Type 1 exit area

20. Initial tests were conducted with the scour hole reproduced in the model (type 1 exit area). Severe eddies formed in the exit area as shown in Photo 1. Flow conditions downstream from the scour hole and through the Highway 465 Bridge are shown in Photo 2. Flow conditions in the stilling basin are shown in Photo 3. Tailwater elevations shown in the photos were measured at the Highway 465 Bridge. The tailwater elevation at the structure could be slightly different depending on the flow conditions in the exit area.

Alternate design exit areas

21. Several modifications to the exit area were tested in an effort to improve flow conditions and reduce scouring potential. The objective of these tests was to develop a practical and economical modification that would perform satisfactorily for all anticipated flow and operational conditions. To accomplish this objective, the side eddies had to be eliminated or reduced by confining flow in the channel, and the turbulence caused by the scour hole had to be reduced. Modifications included spur dikes, longitudinal dikes, baffles in and downstream from the stilling basin, a floating baffle over the end sill, and riprap in various areas. A sketch of some of the designs tested is shown in Plate 15.

22. Initial modifications included designs with spur dikes on both sides of the channel (types 2-4, Plate 15). These modifications did not significantly reduce the adverse flow conditions.

23. Because of the curvature of the channel downstream from the structure and the large amount of scour that had occurred along the left bank, a longitudinal dike was placed along the left bank with two spur dikes on the right bank (type 4a exit area). The magnitude of the eddies was reduced with this design but considerable turbulence and standing waves occurred in the exit channel as shown in Photo 4. Various numbers of baffle blocks and baffle

heights immediately downstream of the stilling basin were evaluated. One of these designs (type 5 exit area) is shown in Photo 5. As shown in this photograph, a secondary jump formed downstream from the blocks causing high velocities and a high level of turbulence. Riprap, 3.5 ft in diameter, was grouted on the channel bottom and side slopes for a distance of 150 ft downstream from the stilling basin (type 7 exit area). Flow conditions were improved but the turbulence and standing waves still occurred as shown in Photo 6. The length of grouted rock was increased to 200 ft (type 8 exit area) and little improvement was shown.

24. Longitudinal dikes were placed on both sides of the exit area and the scour hole was filled to various levels. These tests indicated that the longitudinal dikes should be parallel to each other and that the invert should be filled to el 45 down to the Highway 465 Bridge. Photo 7 shows flow conditions with the longitudinal dikes with 1V on 3H side slopes with the invert at el 45 and a base width of channel at 120 ft (type 9 exit area). Photo 8 shows flow conditions with the same dikes with the invert lowered to el 35 resulting in a base width of 60 ft (type 10 exit area). A higher level of turbulence and surface waves was observed with the lower channel invert.

Recommended (type 11) exit area

25. The recommended exit area design consisted of two parallel longitudinal dikes with 1V on 2H side slopes with a top el of 80, and a base width of the channel at 120 ft with an invert el of 45. Details of this design are shown in Plates 16 and 17. The model with the type 11 exit area and various flow conditions is shown in Photo 9. Flow conditions were greatly improved with this design. The eddies and turbulence that occurred with the type 1 design area were eliminated and flow passing under the Highway 465 Bridge was better aligned with the bridge piers.

26. Velocities were measured with the type 11 exit area over a range of discharges and tailwater elevations. Five measurements were taken at each of fourteen stations 1 ft above the bottom, three across the lowest section, and one on each side slope. A velocity depth profile was also obtained at the channel center line. These data are presented in Table 1.

27. Construction of the longitudinal prototype dikes using type 11 design was completed during the winter of 1984-85. Flows during the spring and summer of 1985 and 1986 were free of eddies and flow concentrations with uniform subcritical flow from the structure through the Highway 465 Bridge.

The prototype structure, with modifications to the exit area installed, is shown in Figure 5.



Figure 5. Prototype structure

Stilling Basin Performance

28. Tests to observe stilling basin performance and define flow conditions were conducted in both a 1:48-scale section model and a 1:36-scale general model.

Section model

29. The section model was constructed in a glass-sided flume so that flow conditions within the basin could be easily observed. Photo 10 shows flow conditions in the basin with various pool elevations, gate openings, and tailwater elevations. Sketches of flow conditions and velocities measured in

the vicinity of the stilling basin are shown in Plates 18-20. A riding jet with standing waves, shown in Photo 10d and Plate 18, occurred for some gate opening, pool elevation, and tailwater elevation combinations. This occurred when the Froude No. at section A-A in Plate 18 was approximately 1.2. Attempts to improve hydraulic performance consisted of increasing the height of the baffle blocks to 15 ft, which is the measured depth of flow, D_1 , entering the stilling basin for the design flow of 45,000 cfs. The baffles were located as shown in Plate 21 and flow conditions were not improved. An overhanging baffle as shown in Plate 22 was placed across the basin in an attempt to reduce the waves downstream. For some flow conditions, when the baffle controlled flow, hydraulic performance was improved, but the baffle was considered inadequate because an unstable condition developed as flow control shifted from the breast wall or gate lip to the suspended baffle.

General model

30. Tests were conducted in the general model to determine the tailwater elevations where the hydraulic jump would sweep out of the stilling basin and spray off of the baffle blocks. This flow condition in the model is shown in Photo 11. The tailwater was lowered until flow swept out of the stilling basin for various discharges and then raised until the jump returned to the basin. These tests were conducted with both the types I and II exit areas and results are shown in Plate 23. The tailwater elevations shown were measured at the Highway 465 Bridge. The tailwater elevation at the end of the structure relative to the tailwater elevation at the bridge was different for the two exit area designs. A tailwater curve at the bridge with no backwater from the Yazoo River and resulting tailwater elevations at the structure for the type II exit area design are shown in Plate 24. With the type I exit area, the eddies and turbulence downstream from the stilling basin caused a buildup of flow at the structure with higher discharges which resulted in a considerably higher tailwater in this area relative to the elevation of the bridge. With lower discharges, flow plunged into the scour hole and less tailwater over the end sill was present with the type I exit area than with the type II where the channel controlled the flow. This accounts for the spray curve for the type I design being lower than the type II with higher discharges. However, the type II exit area did not permit spray with discharges of 35,000 cfs or less whereas the type I sprayed with discharges as low as 30,000 cfs. Thus, the type II exit area has an advantage in that

tailwater at the structure is less dependent on tailwater in the Yazoo River with these flows.

31. Observations of flow conditions in the stilling basin were made with a number of discharges and tailwater elevations with the type 11 exit area. Results of these tests are shown in Table 2. The riprap in the exit area (Plate 17) was stable for the full range of flow conditions.

PART IV: DISCUSSION OF RESULTS AND CONCLUSION

32. The large scour hole and bank sloughing that developed downstream from the structure during several flood events caused large eddies to form downstream from the prototype structure. This increased the scour potential in this area. The scoured area was initially reproduced in the model to determine flow conditions that had caused the scour.

33. Several modifications to the exit area were tested in an effort to improve flow conditions and reduce scouring potential. These modifications included spur dikes, longitudinal dikes, baffles, and riprap. The recommended design, which consisted of two parallel longitudinal dikes with a riprap invert at el 45, eliminated the adverse flow conditions. Also, the tailwater elevation at the structure relative to the tailwater at the Highway 465 Bridge was increased by the modifications. The hydraulic jump remained in the stilling basin with higher discharges when tailwater elevations were controlled by the exit channel (low stages in the Yazoo River). Thus, the tailwater at the structure is less dependent on tailwater in the Yazoo River during certain flows.

34. Although several modifications to the stilling basin were tested in an effort to improve flow conditions downstream from the structure, no modifications were recommended for the stilling basin, since the modifications in the exit area were successful in eliminating the adverse flow conditions.

35. Discharge through the structure can be determined for various flow regimes using the equations and discharge coefficients developed from the model data. With this information, gate rating curves can be developed for known headwater and tailwater elevations.

36. The recommended type 11 design was incorporated into the prototype and resulted in a satisfactory hydraulic performance.

Table 1

1:36-Scale Velocity Data (Recommended), Type 11 Design

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity					Velocity Depth Profile, fps						Water- Surface El
				Cross Section, fps					16 ft 11 ft 6 ft						
				1	2	3	4	5	Surface	Bottom	Above	Bottom	Above	Bottom	
15,000	82.5	80	13+00	Velocities less than 3 fps					Velocities less than 3 fps						80.0
			14+00												80.0
			15+00												80.0
			16+00												80.1
			17+00												80.3
			18+00												80.3
			19+00												80.3
			20+00												80.2
			21+00												80.1
			22+00												80.1
			23+00												80.1
			24+00												80.1
			25+00												80.1
			26+00												80.0
15,000	77.5	75	13+00	Velocities less than 3 fps					Velocities less than 3 fps						74.7
			14+00												74.8
			15+00												74.7
			16+00												74.7
			17+00												74.7
			18+00												74.7
			19+00												74.7
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			24+00												74.7
			25+00												74.7
			26+00												74.7

(Continued)

(Continued)

Note: Bottom velocities taken 1 ft above bottom. See Plate 1 for station locations.

(Sheet 1 of 16)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity					Velocity Depth Profile, fps						Water- Surface El
				Cross Section, fps					16 ft 11 ft 6 ft						
				1	2	3	4	5	Surface	Above		Above		Bottom	
				Velocities less than 3 fps					Velocities less than 3 fps						
15,000	74	70	13+00	Velocities less than 3 fps					Velocities less than 3 fps						69.8
			14+00												70.0
			15+00												69.9
			16+00												69.9
			17+00												69.9
			18+00												69.9
			19+00												69.9
			20+00												69.9
			21+00												69.9
			22+00												69.9
			23+00												69.9
			24+00												69.9
			25+00												69.9
			26+00												69.8
15,000	74	65	13+00	Velocities less than 3 fps					Velocities less than 3 fps						65.0
			14+00												65.3
			15+00												61.6
			16+00												--
			17+00												--
			18+00												--
			19+00												--
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			22+00												--
			23+00												--
			24+00												65.0
			25+00												65.1
			26+00												64.9

(Continued)

(Sheet 2 of 16)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity					Velocity Depth Profile, fps						Water- Surface El	
				Cross Section, fps					16 ft 11 ft 6 ft							
				1	2	3	4	5	Surface	Above		Above		Above		
										Bottom	Bottom	Bottom	Bottom	Bottom		
15,000	74	60	13+00	Velocities less than 3 fps					Velocities less than 3 fps						61.2	
			14+00												62.2	
			15+00												61.0	
			16+00												61.0	
			17+00												61.3	
			18+00												61.3	
			19+00												61.2	
			20+00												61.1	
			21+00												60.8	
			22+00												60.7	
			23+00												60.4	
			24+00												60.4	
			25+00												60.3	
			26+00												60.1	
20,000	77.8	75	13+00	1	3	2	3	2	5	5	4	3	2	75.0		
			14+00	2	3	2	3	2	5	5	4	4	2	75.1		
			15+00	4	4	3	4	3	6	6	5	5	3	75.1		
			16+00	3	3	4	4	4	5	5	4	4	4	75.2		
			17+00	4	4	4	5	4	5	5	5	5	4	75.3		
			18+00	3	4	4	5	4	6	6	5	5	4	75.5		
			19+00	3	5	4	4	4	6	6	6	6	4	75.5		
			20+00	3	4	3	4	4	5	5	5	4	3	75.2		
			21+00	4	5	3	5	4	6	6	6	5	3	75.0		
			22+00	3	4	3	4	3	6	6	6	4	3	75.1		
			23+00	5	5	4	4	4	6	6	5	5	4	75.0		
			24+00	4	4	4	4	4	6	6	5	5	4	75.0		
25+00	3	4	3	2	1	5	5	5	5	3	75.0					
26+00	2	3	4	2	1	6	5	5	4	4	74.8					

(Continued)

(Sheet 3 of 16)

Table 1 (Continued)

Q, cfs	Pool water El	Tail- water El	Sta	Bottom Velocity Cross Section, fps					Velocity Depth Profile, fps						Water- Surface El				
				1	2		3		4		5	Surface	16 ft			11 ft		6 ft	
										Above			Bottom	Above		Bottom	Above	Bottom	
20,000	75	70	13+00	3	4	4	4	3	3	8	--	--	7	6	4	69.7			
			14+00	4	3	3	3	4	4	8	--	--	6	5	3	69.8			
			15+00	3	4	--	--	3	3	8	--	--	2	4	--	69.7			
			16+00	4	4	4	3	3	2	6	--	--	5	5	3	70.0			
			17+00	4	4	4	4	4	2	6	--	--	6	5	4	70.1			
			18+00	4	4	4	4	4	4	6	--	--	5	5	4	70.3			
			19+00	2	3	3	2	3	2	6	--	--	5	5	2	70.2			
			20+00	2	3	3	2	3	2	6	--	--	5	3	2	70.1			
			21+00	2	3	3	3	3	2	4	--	--	4	3	3	69.8			
			22+00	3	2	2	2	3	3	5	--	--	5	4	2	69.8			
			23+00	3	3	3	3	3	2	6	--	--	5	3	3	69.7			
			24+00	3	3	3	3	3	2	5	--	--	5	4	3	69.7			
			25+00	3	3	3	3	4	2	7	--	--	5	4	3	69.7			
			26+00	4	5	3	3	2	--	6	--	--	6	5	3	69.7			
20,000	75	65	13+00	8	8	8	8	7	6	14	--	--	--	13	8	65.4			
			14+00	5	6	8	8	9	5	12	--	--	--	11	8	65.4			
			15+00	4	6	7	7	6	3	13	--	--	--	10	7	64.9			
			16+00	3	4	5	5	5	4	12	--	--	--	9	5	65.8			
			17+00	5	7	4	4	5	4	12	--	--	--	10	4	65.8			
			18+00	4	4	6	6	6	4	10	--	--	--	10	6	65.8			
			19+00	5	7	6	6	5	5	10	--	--	--	10	6	65.6			
			20+00	5	5	5	5	5	5	10	--	--	--	8	5	65.4			
			21+00	4	4	5	5	5	5	10	--	--	--	9	5	64.9			
			22+00	5	6	5	5	5	5	10	--	--	--	9	5	64.8			
			23+00	5	6	5	5	5	4	9	--	--	--	9	5	64.5			
			24+00	5	5	5	5	5	3	10	--	--	--	10	5	64.4			
			25+00	5	5	5	3	3	2	10	--	--	--	8	3	64.2			
			26+00	3	5	5	5	4	2	9	--	--	--	8	5	64.2			

(Continued)

(Sheet 4 of 16)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity					Velocity Depth Profile, fps						Water- Surface El	
				Cross Section, fps					16 ft							
				1	2				Surface	11 ft		6 ft		Bottom		
					3	4	5	Above Bottom		Below Bottom	Above Bottom	Below Bottom				
25,000	79.4	75	13+00	5	6	6	6	5	10	11	10	8	8	6	74.5	
			14+00	6	7	7	6	5	8	8	8	8	8	7	75.0	
			15+00	6	7	6	6	6	9	9	8	7	7	6	74.8	
			16+00	5	5	6	6	5	7	7	7	7	7	6	75.0	
			17+00	5	6	6	6	6	8	8	7	7	7	6	75.2	
			18+00	5	6	6	6	6	8	7	6	6	6	6	75.6	
			19+00	5	6	6	6	5	7	7	7	7	7	6	75.5	
			20+00	5	5	6	6	5	7	7	7	6	6	6	75.2	
			21+00	5	6	6	5	5	7	7	7	6	6	6	75.1	
			22+00	5	5	5	6	5	7	6	6	5	5	5	75.1	
			23+00	5	5	5	5	5	7	7	6	5	5	5	75.1	
			24+00	4	5	5	5	5	7	7	7	7	7	5	75.1	
			25+00	5	6	6	5	4	7	7	7	7	7	6	75.2	
			26+00	5	5	5	5	3	7	7	6	6	6	5	75.1	
25,000	79.4	70	13+00	6	8	8	7	6	11	--	11	11	9	9	8	70.1
			14+00	7	7	8	7	10	11	--	10	10	8	8	8	70.3
			15+00	4	6	6	6	5	10	--	8	8	8	6	6	70.2
			16+00	4	6	6	5	5	10	8	7	6	6	6	6	70.4
			17+00	5	6	6	6	5	9	9	8	7	6	6	6	70.6
			18+00	5	5	5	5	6	8	8	6	6	6	5	5	70.8
			19+00	6	6	6	6	6	8	8	8	8	6	6	6	70.7
			20+00	5	5	6	6	5	8	8	7	6	6	6	6	70.5
			21+00	5	5	6	7	5	8	8	7	6	6	6	6	70.3
			22+00	5	5	6	5	5	8	8	7	7	7	6	6	70.2
			23+00	4	6	6	6	5	8	8	8	8	7	6	6	70.1
			24+00	5	6	7	5	4	8	8	8	7	7	7	7	70.1
			25+00	5	7	5	5	4	8	8	8	8	8	8	5	70.1
			26+00	5	6	6	4	4	8	8	8	8	8	7	6	70.1

(Continued)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity Cross Section, fps					Velocity Depth Profile, fps										Water- Surface El
				1	2		3		4	5	Surface	16 ft		11 ft		6 ft			
												Above	Bottom	Above	Bottom	Above	Bottom		
25,000	79.4	65	13+00	11	11	10	10	10	11	16	--	--	--	--	14	10	65.9		
			14+00	10	10	11	10	10	12	14	--	--	--	--	14	10	66.2		
			15+00	7	9	11	8	9	13	13	--	--	--	--	12	11	65.9		
			16+00	6	7	9	8	7	14	14	--	--	--	--	11	9	66.3		
			17+00	6	8	8	8	7	13	13	--	--	11	10	10	8	66.1		
			18+00	6	6	8	8	8	13	13	--	--	11	10	10	8	66.5		
			19+00	7	8	8	8	8	11	11	--	--	11	9	9	8	66.5		
			20+00	7	8	8	8	8	11	11	--	--	11	9	9	8	66.2		
			21+00	8	8	8	7	6	11	11	--	--	10	10	10	8	65.9		
			22+00	7	8	8	8	6	11	11	--	--	11	10	10	8	65.8		
			23+00	8	9	9	8	7	11	11	--	--	11	11	11	9	65.6		
			24+00	8	8	9	8	6	11	11	--	--	11	10	10	9	65.3		
			25+00	6	8	8	6	6	11	11	--	--	11	10	10	8	65.3		
			26+00	6	8	8	7	5	11	11	--	--	11	10	10	8	65.3		
30,000	81	70	13+00	6	6	6	7	7	6	14	--	--	14	12	12	6	69.8		
			14+00	8	7	7	5	8	14	0	0	12	11	11	7	69.5			
			15+00	2	5	5	5	6	13	0	0	10	8	8	5	69.7			
			16+00	2	4	5	0	0	11	11	10	9	6	5	5	70.1			
			17+00	0	0	4	5	4	11	10	8	8	7	4	4	70.3			
			18+00	0	3	2	5	5	10	11	8	8	7	2	2	70.6			
			19+00	4	4	2	4	0	10	--	--	8	7	2	2	70.4			
			20+00	4	4	4	4	0	9	--	--	8	6	4	4	70.2			
			21+00	0	0	0	2	0	10	--	--	8	8	0	0	70.0			
			22+00	2	5	2	4	0	9	--	--	8	7	3	3	70.0			
			23+00	4	5	5	0	0	8	--	--	8	5	5	5	70.0			
			24+00	5	5	4	4	0	9	--	--	7	7	4	4	70.0			
			25+00	0	4	0	4	0	8	--	--	7	7	0	0	70.0			
			26+00	0	0	4	5	4	9	--	--	7	6	4	4	69.9			

(Continued)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity Cross Section, fps				Velocity Depth Profile, fps						Water- Surface El		
				1	2		3	4	5	16 ft		11 ft			6 ft	
					Above	Bottom				Above	Bottom	Above	Bottom		Above	Bottom
30,000	81	65	13+00	12	10	10	8	8	17	--	--	--	15	10	65.3	
			14+00	11	12	13	8	8	22	--	--	--	20	13	65.0	
			15+00	0	11	8	4	4	19	--	--	17	13	8	64.2	
			16+00	0	9	8	7	5	19	--	--	16	14	8	64.3	
			17+00	5	7	8	8	0	17	--	--	14	13	8	65.1	
			18+00	6	6	8	7	4	16	--	--	14	12	8	65.6	
			19+00	2	6	8	5	4	5	--	--	5	11	8	65.2	
			20+00	4	7	6	6	0	16	--	--	14	10	6	65.2	
			21+00	0	6	6	8	4	14	--	--	12	11	6	64.6	
			22+00	6	8	6	6	0	14	--	--	12	11	6	64.6	
			23+00	6	9	8	6	4	14	--	--	12	12	7	64.1	
			24+00	5	8	9	6	2	14	--	--	12	12	8	63.9	
			25+00	0	7	7	4	4	13	--	--	13	11	7	64.4	
			26+00	8	8	6	4	0	13	--	--	12	10	6	64.3	
30,000	81	60	13+00	11	10	11	8	12	18	--	--	--	17	11	65.8	
			14+00	13	12	13	13	14	23	--	--	--	20	13	62.5	
			15+00	0	8	13	8	0	23	--	--	23	20	13	61.7	
			16+00	0	9	10	10	0	22	--	--	20	17	10	62.9	
			17+00	0	6	10	9	11	21	--	--	21	17	10	62.4	
			18+00	0	8	10	9	6	20	--	--	18	14	10	63.0	
			19+00	0	9	8	7	4	19	--	--	17	14	8	62.2	
			20+00	6	9	10	7	5	19	--	--	17	15	10	61.9	
			21+00	6	9	8	8	5	18	--	--	17	16	8	62.0	
			22+00	8	8	8	9	6	18	--	--	17	16	8	61.7	
			23+00	0	12	10	10	8	19	--	--	--	18	10	60.3	
			24+00	5	8	11	10	8	19	--	--	--	18	11	59.4	
			25+00	8	10	10	7	0	18	--	--	--	15	10	59.4	
			26+00	7	10	8	6	4	18	--	--	--	16	8	59.0	

(Continued)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity					Velocity Depth Profile, fps						Water- Surface El	
				Cross Section, fps					Surface	16 ft		11 ft		6 ft		
				1	2	3	4	5		Above	Bottom	Above	Bottom	Above		Bottom
35,000	84	60	13+00	16	14	13	14	6	25	0	0	23	13	66.1		
			14+00	6	12	14	12	6	18	--	19	19	14	61.8		
			15+00	7	10	11	14	7	23	--	--	20	11	66.0		
			16+00	6	9	10	5	7	26	--	--	22	10	63.4		
			17+00	8	10	8	8	6	20	--	19	15	8	60.5		
			18+00	6	9	11	7	8	25	--	23	17	11	67.1		
			19+00	6	11	10	7	7	19	--	18	14	10	62.6		
			20+00	10	10	13	8	7	22	--	23	19	13	62.6		
			21+00	8	11	10	9	8	17	--	17	16	10	62.6		
			22+00	8	10	8	8	8	18	--	18	15	8	62.7		
			23+00	8	7	12	9	8	19	--	18	17	12	61.3		
			24+00	7	10	11	11	8	19	--	--	17	11	60.5		
30,000	81	80	25+00	8	12	8	8	0	19	--	17	15	8	60.2		
			26+00	7	12	10	7	0	19	--	--	16	10	60.3		
			13+00	0	5	2	4	4	10	10	7	5	2	79.3		
			14+00	0	5	4	4	0	9	9	7	7	4	79.4		
			15+00	2	4	2	0	4	8	8	5	6	2	79.4		
			16+00	2	4	3	3	0	8	7	6	5	3	79.7		
			17+00	0	2	0	0	0	7	6	4	4	0	79.9		
			18+00	0	2	3	0	0	7	6	0	0	3	80.1		
			19+00	0	0	0	0	0	6	7	6	5	0	79.9		
			20+00	0	4	4	0	0	7	6	5	4	4	79.7		
			21+00	4	4	4	0	0	7	7	5	5	4	79.6		
			22+00	4	3	1	4	0	7	6	5	5	1	79.7		
23+00	4	4	0	0	0	6	6	6	6	0	79.6					
24+00	0	4	0	4	0	6	6	5	5	0	79.8					
25+00	4	4	0	0	0	5	5	4	4	0	79.7					
26+00	0	4	0	0	0	5	5	5	4	0	79.4					

(Continued)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity Cross Section, fps			Velocity Depth Profile, fps								Water- Surface El		
				1	2		3	4	5	Surface	16 ft		11 ft			6 ft	
					1	2					Above	Bottom	Above	Bottom		Above	Bottom
30,000	81	76	13+00	4	5	4	6	4	10	--	10	9	4	74.8			
			14+00	6	4	6	4	4	10	--	8	7	6	74.9			
			15+00	2	1	0	4	2	8	8	7	5	5	0	74.8		
			16+00	0	4	4	7	0	8	7	5	5	4	4	75.1		
			17+00	4	0	2	0	0	7	7	6	4	4	2	75.3		
			18+00	2	2	4	4	--	8	8	5	5	5	4	75.5		
			19+00	4	4	0	4	4	6	7	6	4	4	0	75.4		
			20+00	5	4	0	0	0	7	7	5	4	4	0	75.2		
			21+00	4	4	0	0	0	7	6	5	6	6	0	74.6		
			22+00	0	5	2	4	2	6	6	5	5	5	2	75.0		
			23+00	2	4	0	0	0	7	7	5	5	5	2	74.9		
			24+00	3	4	4	4	0	6	7	5	5	5	4	74.9		
			25+00	2	4	0	4	0	7	6	6	5	5	0	74.9		
			26+00	2	4	2	2	0	6	7	6	5	5	2	74.9		
35,000	84	75	13+00	5	5	4	5	0	12	--	11	9	4	74.0			
			14+00	0	6	6	5	4	11	--	9	8	6	74.4			
			15+00	0	4	6	5	5	12	11	8	7	7	6	74.4		
			16+00	0	4	6	0	4	10	10	7	7	6	6	74.4		
			17+00	0	4	6	0	4	9	10	8	7	7	6	74.9		
			18+00	0	5	5	5	4	8	8	8	7	7	5	75.0		
			19+00	0	8	10	0	4	9	--	9	7	10	74.9			
			20+00	4	0	0	6	0	8	8	7	5	0	74.5			
			21+00	0	4	0	4	0	9	7	7	5	0	75.0			
			22+00	5	5	4	0	0	9	7	7	6	4	74.6			
			23+00	0	6	0	4	0	9	8	7	8	0	74.6			
			24+00	0	4	5	4	4	9	--	7	5	5	74.1			
			25+00	0	4	0	0	0	7	8	6	6	0	74.3			
			26+00	0	0	0	0	0	8	7	6	5	0	74.2			

(Continued)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity Cross Section, fps					Velocity Depth Profile, fps								Water- Surface El	
				1	2				5	Surface	16 ft		11 ft		6 ft			
					3	4	8	7			8	Above	Bottom	Above	Bottom	Above		Bottom
35,000	84	70	13+00	8	8	8	8	4	17	--	--	17	14	14	8	68.8		
			14+00	7	8	7	8	7	16	--	--	14	11	11	7	69.0		
			15+00	0	7	5	5	0	15	--	--	13	11	11	5	69.3		
			16+00	0	5	6	5	0	15	--	--	11	10	10	6	69.9		
			17+00	0	6	7	7	6	13	--	--	10	8	8	7	69.7		
			18+00	0	5	6	5	7	13	--	--	9	7	7	6	70.4		
			19+00	0	7	5	5	0	12	--	--	10	9	9	5	69.8		
			20+00	0	7	8	0	0	13	--	--	10	9	9	8	69.4		
			21+00	0	7	8	8	5	13	--	--	10	8	8	8	69.4		
			22+00	7	6	7	8	0	12	--	--	10	10	10	7	69.4		
			23+00	6	7	7	7	4	12	--	--	11	9	9	7	69.3		
			24+00	4	5	5	5	0	12	--	--	11	9	9	7	69.3		
			25+00	0	8	7	4	0	12	--	--	10	9	9	7	68.9		
			26+00	0	0	0	0	0	11	--	--	10	9	9	0	69.0		
35,000	84	65	13+00	13	15	12	13	11	22	--	--	--	21	21	12	68.6		
			14+00	7	13	13	14	8	25	--	--	--	8	8	13	62.8		
			15+00	5	12	10	13	7	23	--	--	22	17	17	10	63.2		
			16+00	0	7	8	12	0	23	--	--	21	14	14	8	65.0		
			17+00	0	8	10	9	5	23	--	--	22	17	17	10	65.0		
			18+00	0	8	9	10	5	20	--	--	19	14	14	9	65.0		
			19+00	7	7	10	10	9	20	--	--	19	16	16	10	63.8		
			20+00	7	8	12	10	5	19	--	--	18	15	15	12	64.5		
			21+00	6	10	9	8	5	19	--	--	18	14	14	9	64.8		
			22+00	7	9	10	7	7	17	--	--	16	14	14	10	64.3		
			23+00	7	10	11	8	8	17	--	--	17	16	16	11	63.6		
			24+00	5	8	11	10	7	17	--	--	17	14	14	11	62.9		
			25+00	8	11	9	7	0	17	--	--	16	13	13	9	63.1		
			26+00	6	8	6	5	9	16	--	--	15	13	13	7	63.2		

(Continued)

Table 1 (Continued)

Q, cfs	Pool water El	Tail- water El	Sta	Bottom Velocity Cross Section, fps					Velocity Depth Profile, fps						Water- Surface El			
				1	2		3	4		5	Surface	16 ft		11 ft		6 ft		
					1	2		1	2			1	2	1		2		
																	Above	Bottom
40,000	86	75	13+00	7	5	0	5	0	14	--	--	12	9	0	74.1			
			14+00	7	6	6	7	6	13	--	--	10	8	6	74.8			
			15+00	6	7	7	6	5	13	--	--	10	8	7	74.7			
			16+00	5	6	7	5	4	13	--	--	10	8	7	75.0			
			17+00	7	7	8	7	5	12	--	--	11	10	8	75.4			
			18+00	5	7	5	6	5	11	--	--	10	8	5	75.4			
			19+00	6	5	8	6	5	11	--	--	11	10	8	75.5			
			20+00	7	5	5	4	5	10	--	--	9	7	5	74.8			
			21+00	6	7	6	7	5	10	--	--	10	8	6	74.6			
			22+00	7	6	5	5	5	10	--	--	9	8	5	74.6			
			23+00	5	6	5	6	5	8	--	--	9	8	5	74.3			
			24+00	5	5	5	5	4	9	--	--	9	8	5	74.2			
			25+00	4	5	5	0	0	10	--	--	8	8	5	74.6			
			26+00	5	5	6	4	0	9	--	--	8	6	6	74.3			
40,000	86	70	13+00	10	8	5	6	7	17	--	--	14	13	5	69.5			
			14+00	8	10	10	6	7	16	--	--	15	14	10	70.3			
			15+00	7	8	7	7	6	16	--	--	14	13	7	69.3			
			16+00	4	6	7	7	5	14	--	--	13	11	7	70.0			
			17+00	5	7	7	7	6	14	--	--	13	11	7	70.0			
			18+00	5	7	6	7	5	14	--	--	11	10	6	70.6			
			19+00	7	6	8	6	5	14	--	--	12	11	8	70.3			
			20+00	6	7	7	6	6	14	--	--	12	11	7	70.0			
			21+00	7	7	8	7	7	14	--	--	13	11	8	70.0			
			22+00	7	7	7	7	5	14	--	--	12	11	7	70.1			
			23+00	6	8	7	6	7	14	--	--	12	10	7	69.5			
			24+00	8	5	7	10	5	13	--	--	12	10	7	69.5			
			25+00	5	7	8	5	0	13	--	--	12	10	8	70.0			
			26+00	5	5	5	0	0	13	--	--	11	10	5	69.7			

(Continued)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity Cross Section, fps					Velocity Depth Profile, fps							Water- Surface El		
				1	2		3	4		5	Surface	16 ft		11 ft			6 ft	
													Above	Bottom	Above		Bottom	Above
35,000	84	80	13+00	0	5	6	4	4	0	11	--	10	8	6	79.1			
			14+00	0	5	4	4	0	10	10	10	7	4	79.4				
			15+00	4	0	4	0	0	9	8	8	7	4	79.6				
			16+00	0	0	4	0	0	10	8	7	6	4	80.0				
			17+00	0	0	4	0	0	9	10	6	5	4	80.0				
			18+00	0	0	4	0	0	9	8	8	5	4	80.2				
			19+00	0	0	0	0	0	8	8	7	5	0	79.6				
			20+00	0	4	0	0	0	7	7	7	5	0	80.1				
			21+00	0	0	0	0	0	8	8	6	5	0	79.8				
			22+00	0	0	0	5	4	7	6	5	5	0	79.4				
45,000	87	80	23+00	0	0	0	0	0	7	7	5	5	0	79.6				
			24+00	5	5	0	0	0	8	6	7	6	0	79.4				
			25+00	0	0	0	0	0	7	5	7	6	0	79.2				
			26+00	0	0	0	0	0	7	7	7	6	0	79.4				
			13+00	4	5	8	5	5	14	--	13	11	8	79.2				
			14+00	7	7	5	5	5	12	--	10	7	5	79.8				
			15+00	5	7	5	5	5	12	11	10	8	5	79.4				
			16+00	5	5	5	5	5	12	10	8	7	5	79.7				
			17+00	5	7	5	5	5	22	22	8	8	5	80.0				
			18+00	4	5	5	5	5	11	10	8	8	5	80.3				
			19+00	5	5	7	5	5	11	11	8	8	7	80.1				
			20+00	5	7	6	5	5	10	8	8	7	6	80.1				
			21+00	5	5	5	5	5	8	8	8	7	5	80.0				
			22+00	6	5	5	5	5	10	9	8	7	5	79.7				
			23+00	5	6	5	5	5	10	8	7	6	5	80.0				
			24+00	5	7	4	5	5	10	8	8	7	4	80.0				
			25+00	4	6	5	0	0	10	10	8	7	5	80.0				
			26+00	0	7	0	0	0	10	8	8	7	0	80.0				

(Continued)

(Sheet 12 of 16)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity Cross Section, fps				Velocity Depth Profile, fps								Water- Surface El									
				1	2			3	4			5	16 ft				11 ft				6 ft				
					1	2	3		4	5	Above		Bottom	Above	Bottom		Above	Bottom	Above	Bottom	Above	Bottom			
																							Surface	Bottom	Bottom
45,000	87	75	13+00	5	7	7	7	7	5	17	--	--	14	13	7	7	73.5								
			14+00	7	8	5	5	9	5	15	--	--	13	7	5	5	74.6								
			15+00	5	5	7	5	5	5	17	14	14	12	10	7	7	74.2								
			16+00	0	5	6	6	6	4	14	13	13	11	9	6	6	74.8								
			17+00	6	7	5	4	5	5	14	13	13	10	7	5	5	75.1								
			18+00	5	7	7	7	7	0	13	12	12	10	8	7	7	75.1								
			19+00	6	7	7	6	6	5	12	12	12	10	8	7	7	75.0								
			20+00	5	6	7	5	5	5	12	11	11	10	10	7	7	74.8								
			21+00	5	7	5	7	7	4	12	11	11	10	8	5	5	74.9								
			22+00	7	6	0	6	6	0	12	11	11	10	10	0	0	74.7								
			23+00	0	7	5	6	6	0	13	12	12	11	10	5	5	74.3								
			24+00	6	5	5	6	6	5	12	11	11	10	10	5	5	74.4								
			25+00	5	6	5	5	5	0	11	11	11	11	10	5	5	74.4								
			26+00	0	5	8	0	0	0	12	11	11	11	10	8	5	74.1								
40,000	86	80	13+00	5	6	5	5	5	0	11	12	12	11	9	5	5	5	79.3							
			14+00	4	5	5	6	0	10	11	9	8	5	5	5	5	5	80.1							
			15+00	5	5	6	5	0	11	10	9	7	6	6	6	6	6	80.0							
			16+00	4	5	6	5	4	11	9	8	7	6	6	6	6	6	80.2							
			17+00	0	5	6	6	4	9	10	9	7	6	6	6	6	6	80.0							
			18+00	5	6	7	6	5	11	10	9	8	7	7	7	7	7	80.3							
			19+00	5	6	6	6	0	9	9	8	7	6	6	6	6	6	80.3							
			20+00	5	5	6	6	5	8	7	8	7	6	6	6	6	6	80.4							
			21+00	5	6	6	5	0	8	8	8	7	6	6	6	6	6	80.0							
			22+00	5	5	5	5	0	8	8	8	6	5	5	5	5	5	80.1							
			23+00	5	5	5	5	5	9	8	8	6	5	5	5	5	5	80.0							
			24+00	5	5	5	4	0	8	7	8	7	5	5	5	5	5	80.0							
			25+00	6	7	5	4	0	8	8	8	7	5	5	5	5	5	80.0							
			26+00	11	6	5	6	0	8	8	8	7	5	5	5	5	5	79.6							

(Continued)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity Cross Section, fps					Velocity Depth Profile, fps						Water- Surface El		
				1	2		3	4	5	Surface	16 ft		11 ft			6 ft	
					Above	Bottom					Above	Bottom	Above	Bottom		Above	Bottom
50,000	88	75	13+00	5	7	8	6	0	17	--	--	15	11	8	74.7		
			14+00	0	7	7	7	5	17	--	--	13	11	7	75.1		
			15+00	5	7	7	7	5	16	16	16	14	12	7	74.9		
			16+00	7	7	7	7	5	14	15	15	12	10	7	75.3		
			17+00	5	5	7	7	6	14	14	14	10	10	7	74.9		
			18+00	4	7	8	6	5	14	14	14	11	10	8	75.5		
			19+00	5	5	8	8	7	14	14	14	12	11	8	75.4		
			20+00	5	7	7	5	5	13	11	10	10	8	7	75.8		
			21+00	5	7	7	5	5	12	11	11	11	11	7	75.3		
			22+00	7	7	7	5	5	12	11	11	11	10	7	75.3		
			23+00	5	7	7	5	5	11	12	11	11	10	7	75.1		
			24+00	5	7	6	5	0	12	12	11	11	8	6	74.8		
			25+00	6	5	7	5	0	12	11	10	10	8	7	75.1		
			26+00	0	5	5	5	0	12	121	11	11	8	5	74.9		
55,000	89	80	13+00	0	5	7	7	0	16	15	15	14	13	7	79.1		
			14+00	7	6	6	6	0	14	15	13	13	11	6	79.7		
			15+00	5	5	6	6	5	14	13	11	10	6	79.7			
			16+00	5	5	5	6	5	14	13	11	10	5	80.0			
			17+00	4	7	5	6	4	14	12	11	10	5	80.0			
			18+00	4	5	7	6	4	13	12	11	8	7	80.2			
			19+00	5	4	7	6	6	13	12	10	10	7	80.1			
			20+00	6	5	5	5	4	12	11	10	8	5	79.9			
			21+00	6	6	6	5	5	11	11	8	8	6	79.8			
			22+00	6	6	8	8	6	12	11	10	9	8	79.6			
			23+00	6	7	7	6	5	12	11	10	8	7	79.7			
			24+00	5	5	7	6	5	11	10	9	8	7	79.6			
25+00	6	7	7	5	0	10	10	10	8	7	79.6						
26+00	5	7	7	4	0	10	10	8	8	7	79.3						

(Continued)

(Sheet 14 of 16)

Table 1 (Continued)

Q, cfs	Pool El	Tail- water El	Sta	Bottom Velocity					Velocity Depth Profile, fps						Water- Surface El	
				Cross Section, fps					Surface	16 ft		11 ft		6 ft		
				1	2	3	4	5		Above	Bottom	Above	Bottom	Above		Bottom
55,000	89	75	13+00	5	7	10	7	0	20	19	17	16	10	80.8		
	14+00	5	8	10	5	4	19	19	16	14	10	76.1				
	15+00	6	7	8	8	5	18	18	17	12	8	74.6				
	16+00	5	7	7	7	5	16	14	13	12	7	75.0				
	17+00	7	7	8	6	6	16	15	13	12	8	76.0				
	18+00	5	7	7	7	6	14	14	11	12	7	76.2				
	19+00	5	6	8	7	6	15	14	13	12	8	76.4				
	20+00	5	6	7	6	5	14	13	11	10	7	75.6				
	21+00	7	7	7	7	5	14	13	11	10	7	75.2				
	22+00	6	7	7	6	6	14	13	12	10	7	75.0				
	23+00	7	7	8	7	5	14	14	13	12	8	75.0				
	24+00	4	4	8	5	4	14	13	12	11	8	74.7				
60,000	91	80	25+00	5	6	6	4	0	13	14	12	10	6	74.7		
			26+00	0	6	6	4	0	13	12	11	10	6	74.5		
			13+00	0	6	6	5	0	17	16	14	12	6	79.8		
			14+00	0	6	8	6	0	15	14	13	11	8	80.4		
			15+00	5	6	6	6	4	15	14	12	9	6	80.0		
			16+00	4	6	5	5	4	14	13	11	8	5	80.2		
			17+00	5	5	7	7	4	14	13	10	9	7	80.6		
			18+00	4	6	6	6	5	14	12	10	10	6	80.6		
			19+00	6	5	5	7	4	13	12	10	8	5	80.4		
			20+00	7	6	7	7	4	13	11	10	8	7	80.5		
			21+00	7	7	7	8	5	12	12	11	10	7	80.2		
			22+00	5	7	5	6	4	12	11	10	9	5	80.2		
23+00	5	6	6	5	5	12	11	10	8	6	80.2					
24+00	5	6	4	4	4	12	11	11	10	4	79.9					
25+00	6	7	7	4	0	12	12	11	10	7	80.0					
26+00	4	5	5	0	0	11	11	10	8	5	79.8					

(Continued)

Table 1 (Concluded)

Q, cfs	Pool water El	Tail- water El	Sta	Bottom Velocity Cross Section, fps				Velocity Depth Profile, fps										Water- Surface El
				1	2		3	4	5	Surface	16 ft		11 ft		6 ft			
					Above	Bottom					Above	Bottom	Above	Bottom	Above	Bottom		
60,000	91	75	13+00	5	7	10	7	0	21	--	--	18	16	10	74.9			
			14+00	7	6	11	5	0	18	--	--	17	14	11	75.4			
			15+00	0	5	8	7	4	20	--	--	16	14	8	75.4			
			16+00	4	7	7	5	4	18	--	--	14	11	7	76.3			
			17+00	4	5	7	6	4	17	--	--	14	12	7	76.1			
			18+00	4	6	7	6	4	15	--	--	13	12	7	75.9			
			19+00	5	5	7	7	0	16	--	--	13	11	7	76.2			
			20+00	5	5	7	6	5	16	--	--	13	12	7	75.7			
			21+00	6	7	7	7	5	16	--	--	12	10	7	75.9			
			22+00	5	5	7	6	5	16	--	--	13	10	7	75.6			
			23+00	7	8	7	7	5	14	--	--	14	12	7	75.3			
			24+00	6	5	7	6	0	14	--	--	13	12	7	75.1			
			25+00	5	7	7	4	0	14	--	--	13	4	7	75.2			
			26+00	0	4	5	4	0	14	--	--	12	8	5	75.3			
50,000	88	80	13+00	0	5	10	7	4	14	20	13	11	11	10	79.1			
			14+00	5	7	6	5	5	14	13	11	10	10	6	80.1			
			15+00	5	5	7	5	5	13	13	10	8	8	7	79.7			
			16+00	5	7	5	5	5	16	12	8	8	8	5	80.2			
			17+00	5	5	5	7	5	11	11	10	8	8	5	80.2			
			18+00	5	5	5	5	5	12	11	8	8	8	5	80.3			
			19+00	5	7	7	5	5	11	8	8	8	8	7	80.3			
			20+00	5	7	7	5	5	11	10	8	7	7	7	80.2			
			21+00	5	7	7	5	5	11	10	8	8	8	7	79.7			
			22+00	5	7	5	6	5	8	7	7	7	7	5	79.6			
			23+00	5	6	5	5	5	9	8	8	7	7	5	79.2			
			24+00	0	6	5	5	4	9	8	7	7	7	5	79.3			
			25+00	0	5	5	5	0	8	8	8	7	7	5	79.4			
			26+00	5	6	5	5	0	8	10	8	8	7	5	79.1			

Table 2
Flow Conditions in Stilling Basin, Type 11
Exit Area in General Model

Q cfs	Pool El	Tail- water El	Observations
15,000	82.5	80	Basin submerged. Tailwater controlling pool
15,000	77.5	75	Basin submerged. Tailwater controlling pool
15,000	74	70	Basin submerged. Tailwater controlling pool
15,000	74	65	Weak jump at lower end of basin
15,000	74	60	Weak, rough jump in lower basin
20,000	77.8	75	Basin submerged. Tailwater controlling pool
20,000	75	70	Weak jump at toe of slope
20,000	75	65	Weak jump in basin
20,000	75	60	Weak jump in basin
25,000	79.4	75	Basin submerged. Tailwater controlling pool
25,000	79.4	70	Weak jump at toe of slope
25,000	79.4	65	Weak jump in basin
25,000	79.4	60	Weak jump in basin
30,000	81	80	Weak hydraulic jump about midslope above stilling basin
30,000	81	75	Good hydraulic jump about midslope above stilling basin
30,000	81	70	Excellent hydraulic jump in upper basin
30,000	81	65	Good hydraulic jump in midbasin
30,000	81	60	Good hydraulic jump in midbasin
35,000	84	80	Weak hydraulic jump about midslope above basin
35,000	84	75	Weak hydraulic jump at toe of slope in upper basin
35,000	84	70	Weak hydraulic jump at toe of slope in upper basin
35,000	84	65	Good hydraulic jump at toe of slope in upper basin
			Significant waves and flow undulation for about 200 ft downstream of basin
35,000	84	60	Same as TW = 65 except waves occur for about 700 ft downstream of basin
40,000	86	80	Very weak jump just downstream of piers. Surface waves in stilling basin
40,000	86	75	Weak jump at toe of slope in upper basin
40,000	86	70	Good jump at toe of slope in upper basin
40,000	86	68	Jump swept out of basin
45,000	87	80	Weak submerged jump just below structure piers
45,000	87	75	Good jump at toe of slope in upper basin
45,000	87	70	Jump swept out of basin

(Continued)

Table 2 (Concluded)

Q	Pool	Tail-	
cfs	El	water	
		El	Observations
50,000	88	80	Weak submerged jump just below structure piers
50,000	88	75	Good jump at toe of slope in upper basin
50,000	88	72	Jump swept out of basin
55,000	89	80	Weak jump just below structure piers
55,000	89	75	Good jump at toe of slope in upper basin
55,000	89	73	Jump swept out of basin
60,000	91	80	Weak jump just below structure piers
60,000	91	75	Unstable jump in lower basin
60,000	91	74	Jump swept out of basin

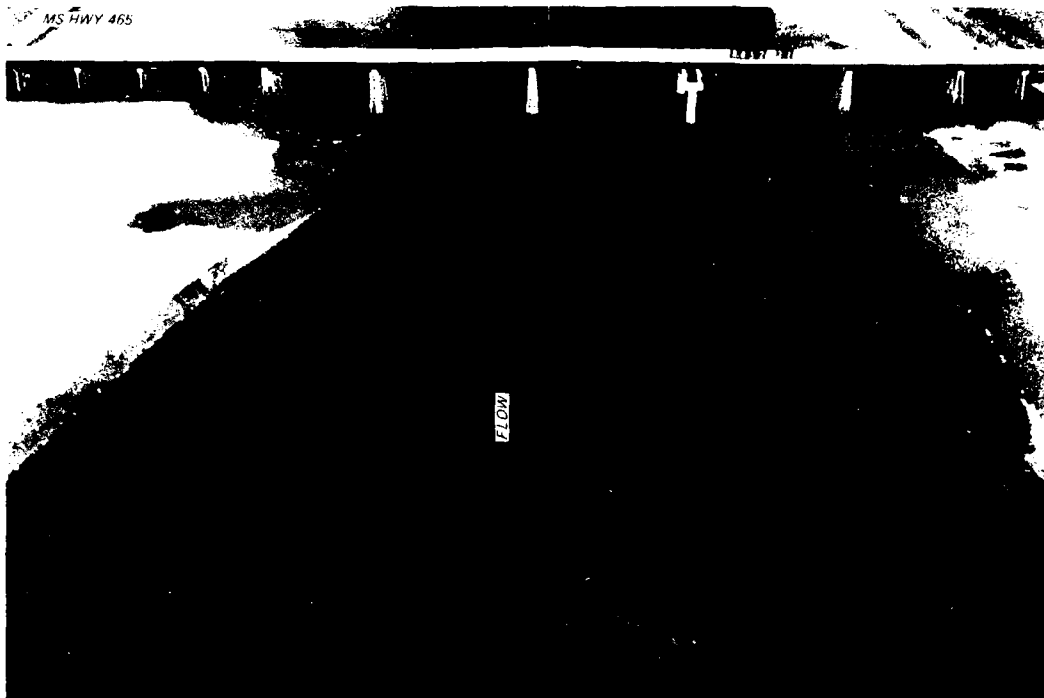


a. Discharge 20,000 cfs, pool el 78



b. Discharge 60,000 cfs, pool el 91

Photo 1. Eddies in area downstream from stilling basin;
type 1 exit area, tailwater el 75

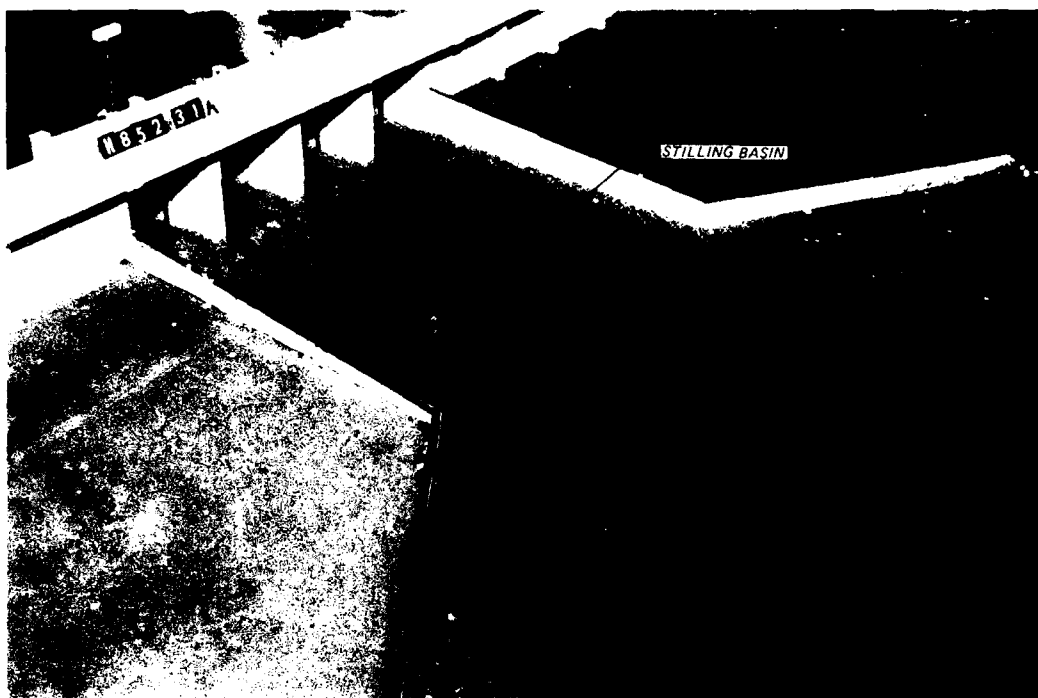


a. Discharge 20,000 cfs, pool el 78

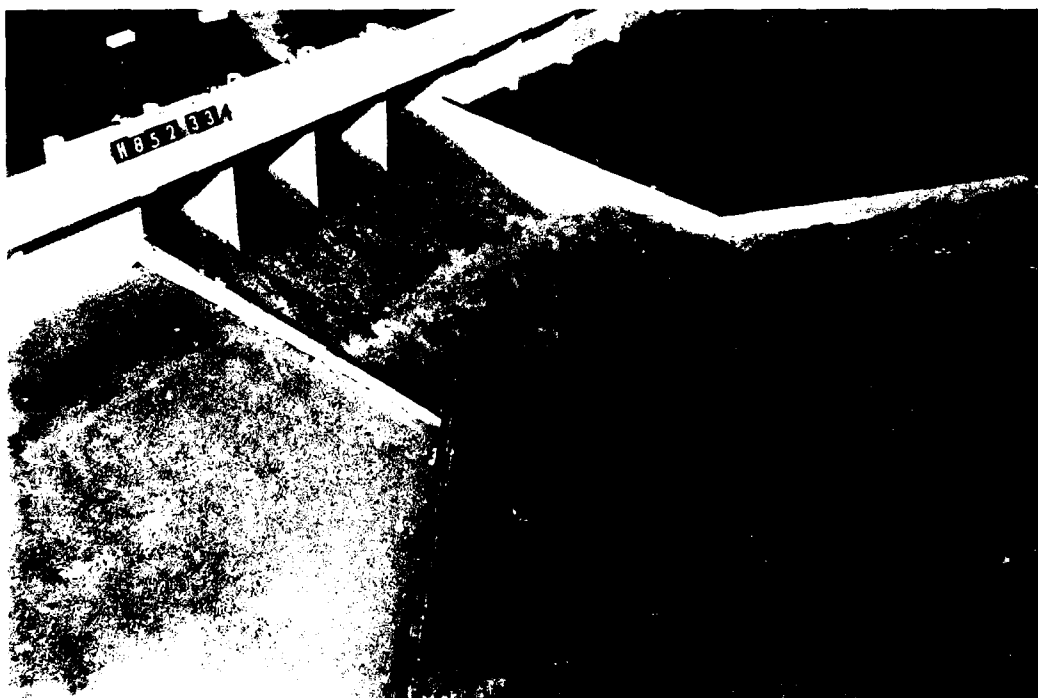


b. Discharge 60,000 cfs, pool el 91

Photo 2. Flow conditions through Highway 465 Bridge;
type 1 exit area, tailwater el 75

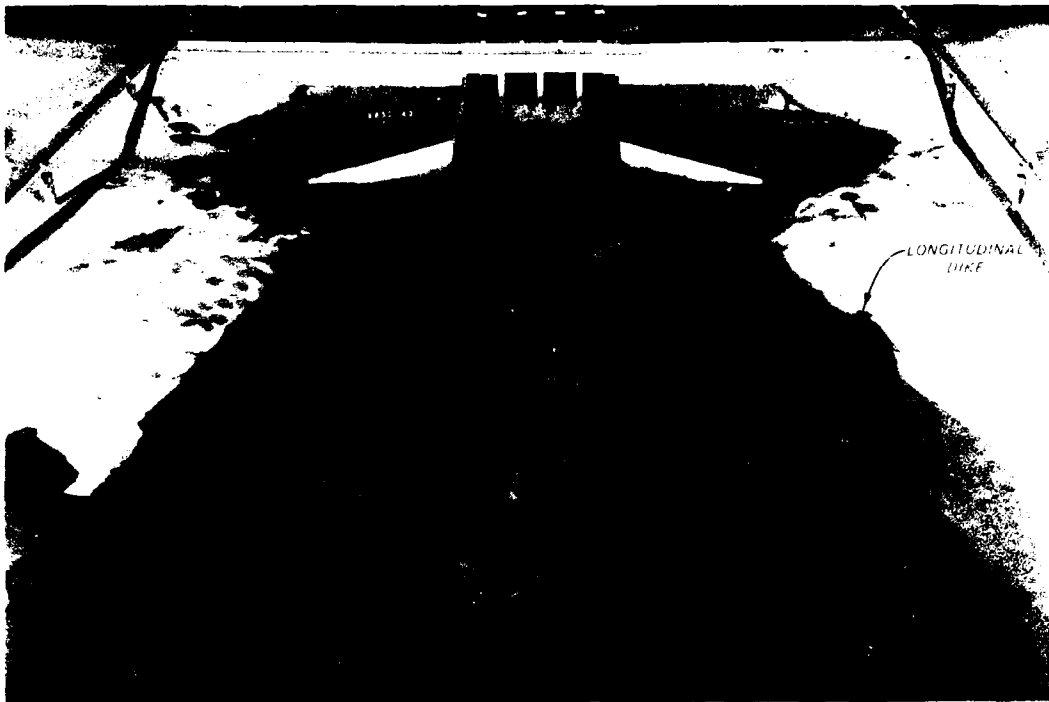


a. Discharge 20,000 cfs, pool el 78

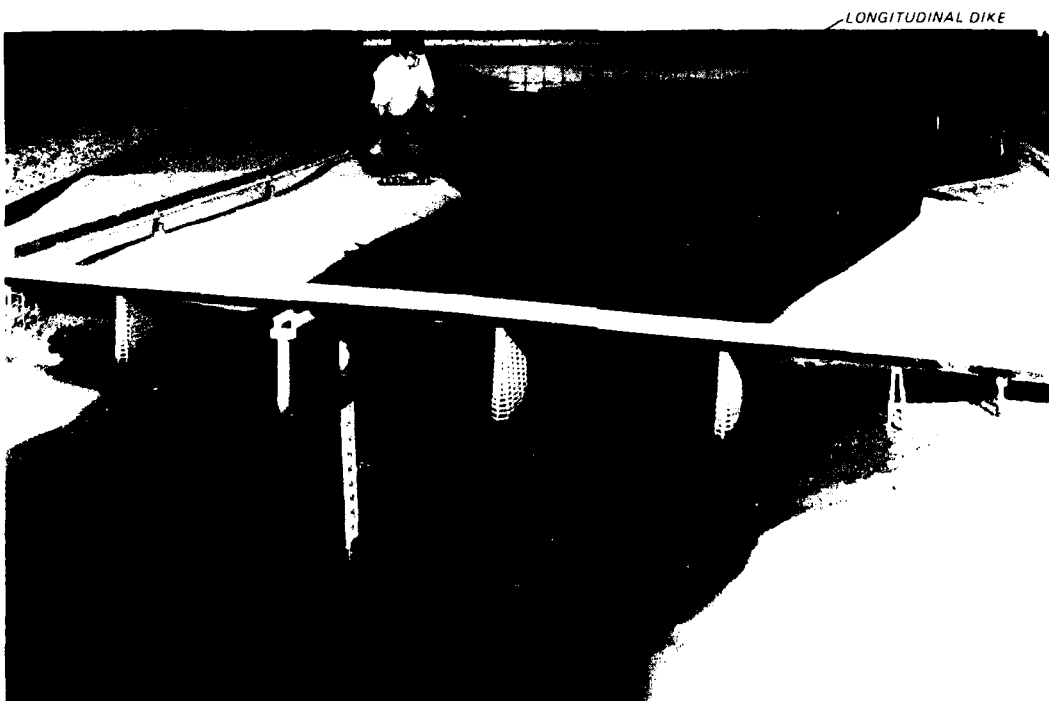


b. Discharge 60,000 cfs, pool el 91

Photo 3. Flow conditions in stilling basin;
type 1 exit area, tailwater el 75

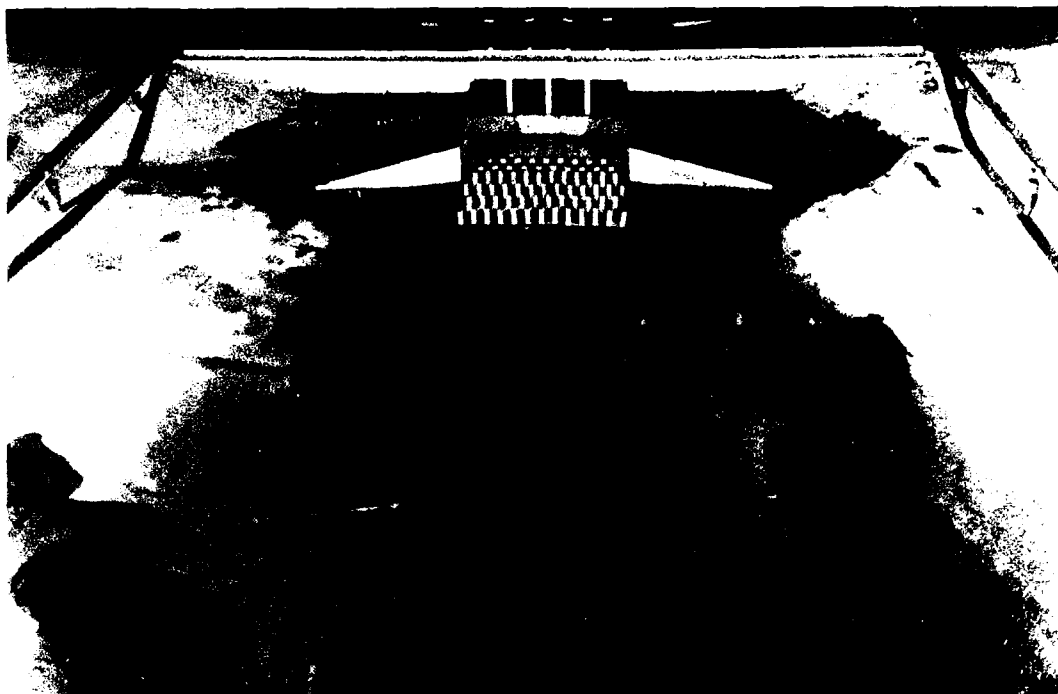


a. Looking upstream at stilling basin



b. Looking upstream over Highway 465 Bridge

Photo 4. Type 4a exit area; discharge 60,000 cfs,
pool el 91, tailwater el 64



a. Dry bed looking upstream



b. Discharge 60,000 cfs, pool el 91, tailwater el 67

Photo 5. Type 5 exit area

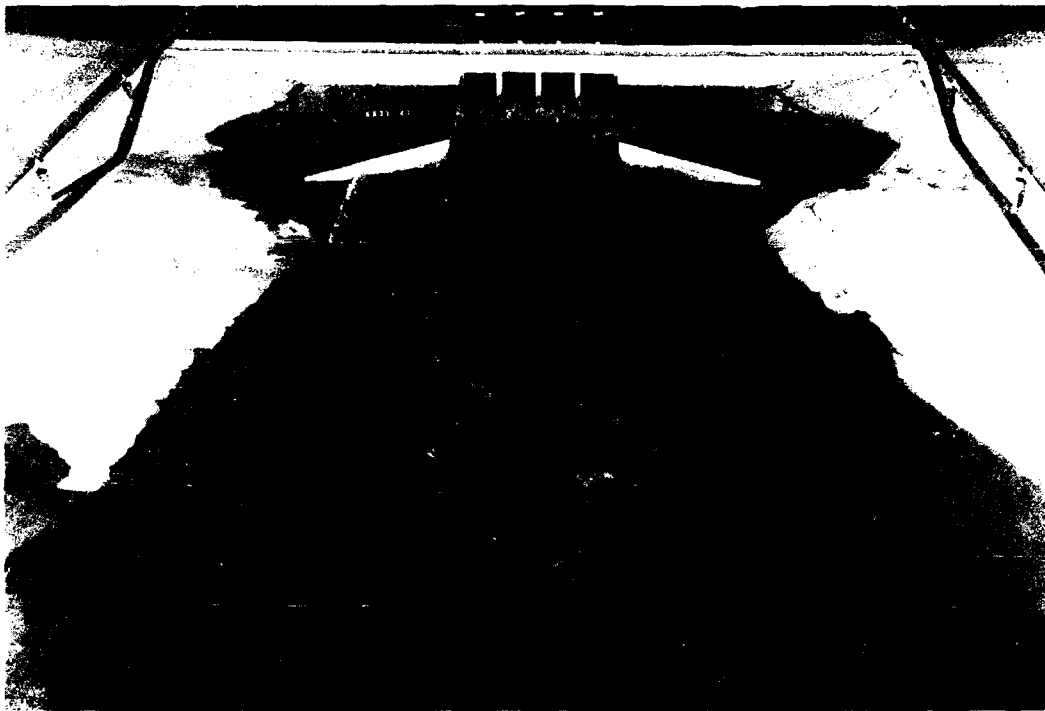


Photo 6. Type 7 exit area; discharge 60,000 cfs,
pool el 91, tailwater el 66

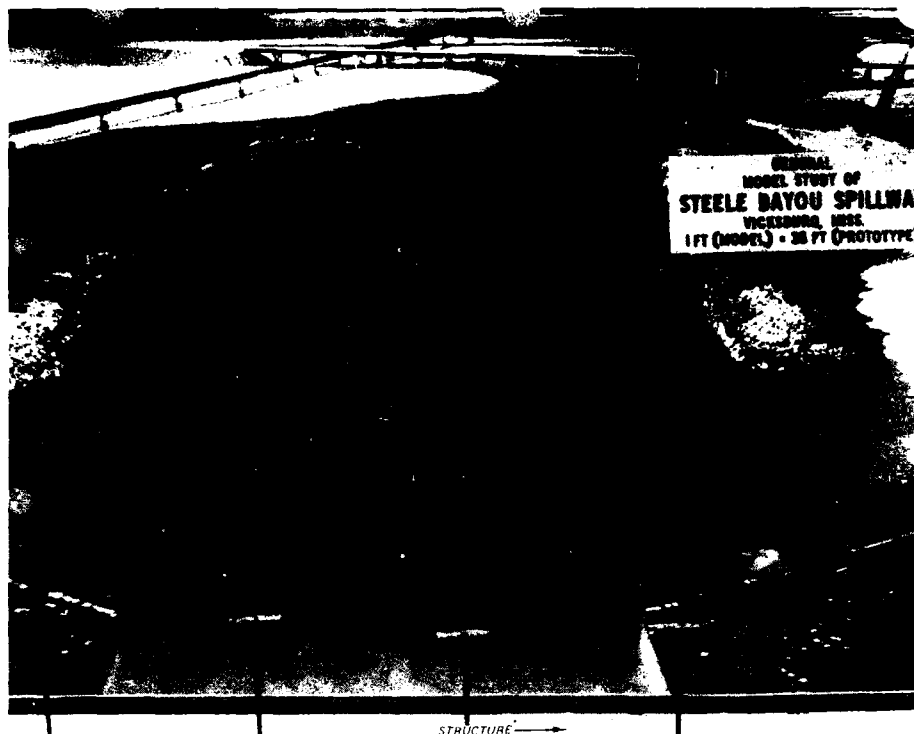
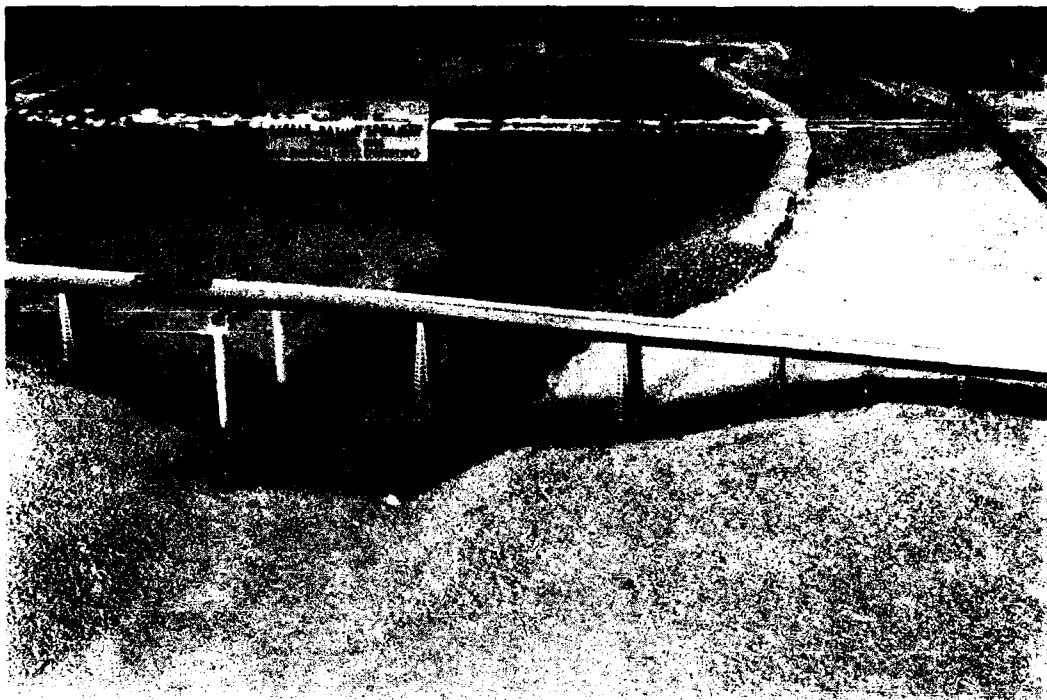


Photo 7. Type 9 exit area looking downstream from stilling basin; discharge 60,000 cfs, pool el 91, tailwater el 76



Photo 8. Type 10 exit area looking upstream; discharge 60,000 cfs, pool el 91, tailwater el 66

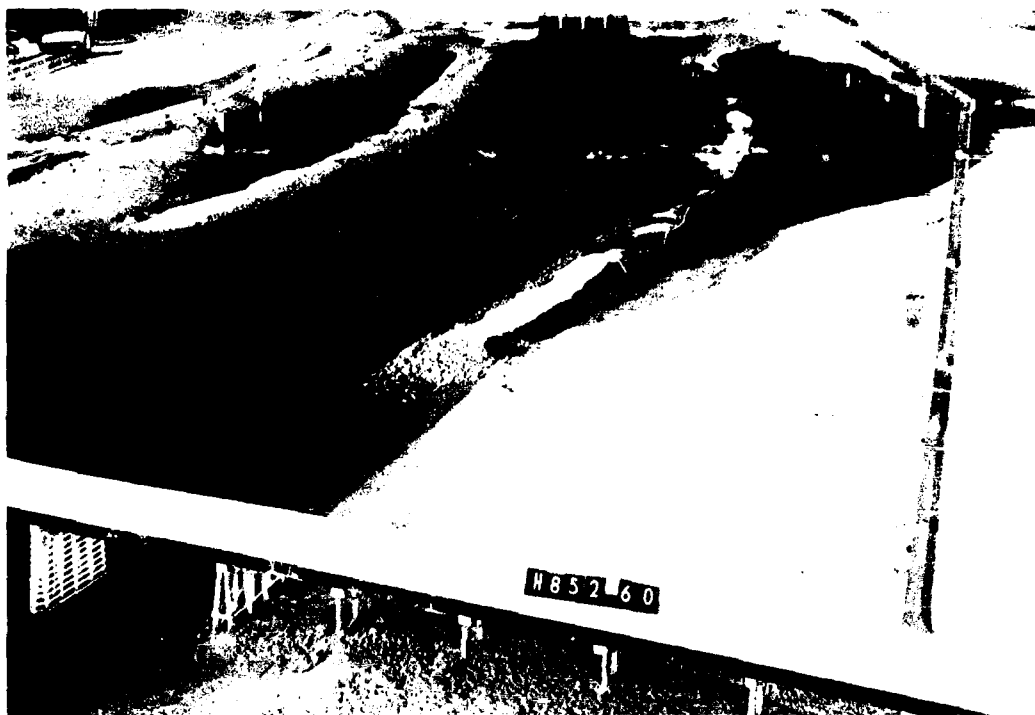


a. Dry bed

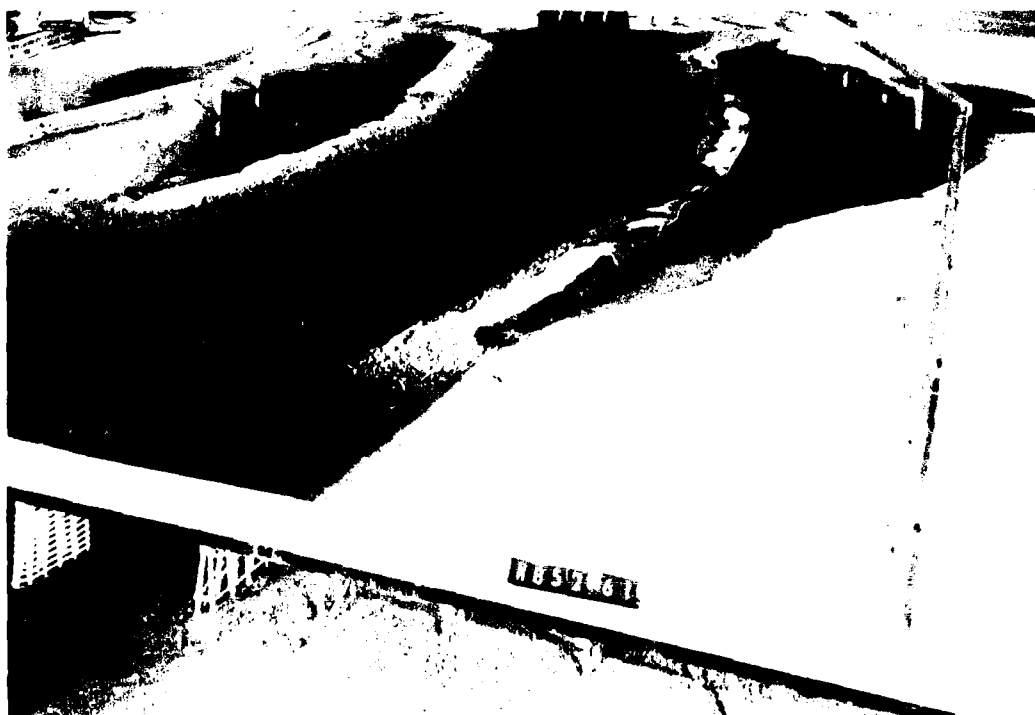


b. Discharge 20,000 cfs, pool el 76, tailwater el 65

Photo 9. Type 11 (recommended) exit area; looking upstream
(Sheet 1 of 3)



c. Discharge 30,000 cfs, pool el 81, tailwater el 74



d. Discharge 40,000 cfs, pool el 84, tailwater el 74



e. Discharge 50,000 cfs, pool el 88, tailwater el 75



f. Discharge 60,000 cfs, pool el 91, tailwater el 75

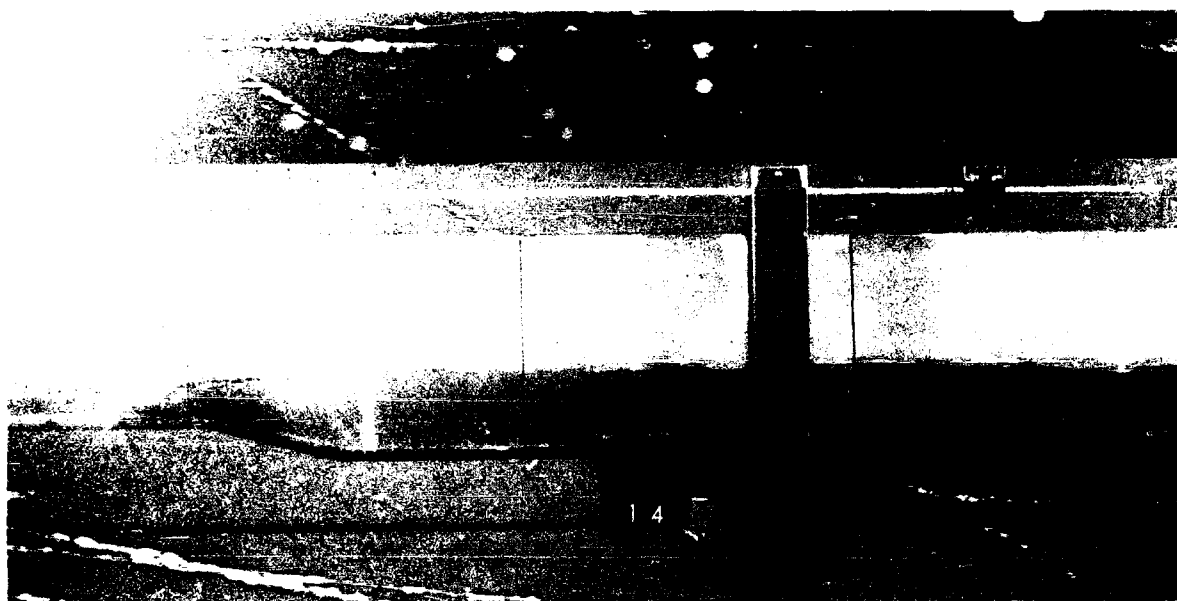


a. Pool el 75, tailwater el 53, gate opening 5 ft

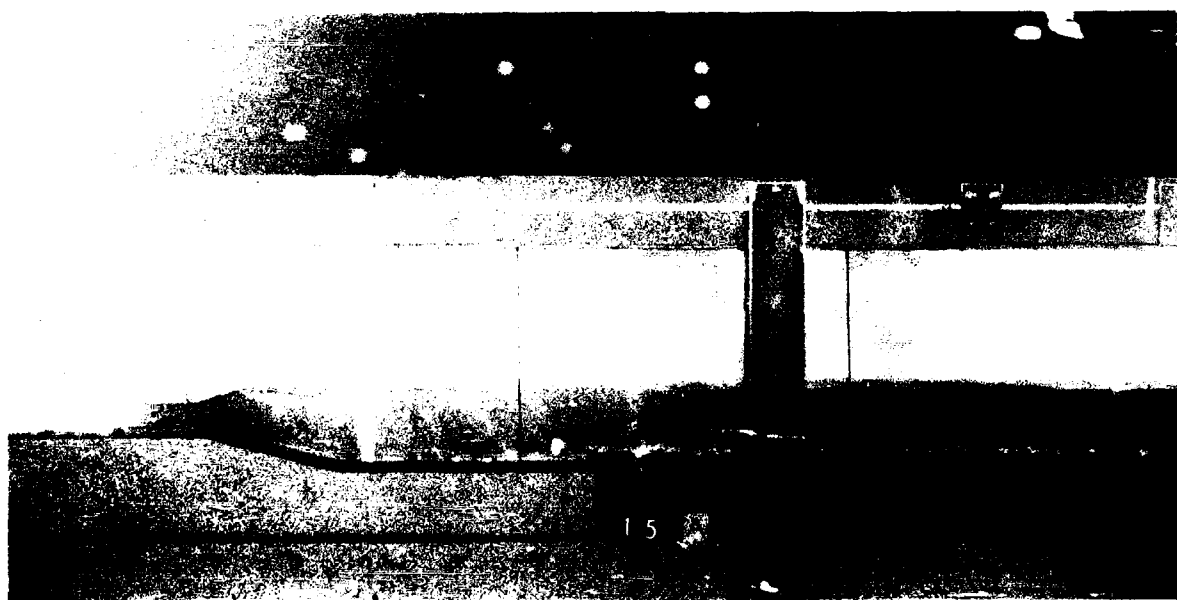


b. Pool el 82.5, tailwater el 53, gate opening 5 ft

Photo 10. Flow conditions in stilling basin;
1:48-scale section model (Sheet 1 of 3)



c. Pool el 83, tailwater el 72, gate opening 5 ft

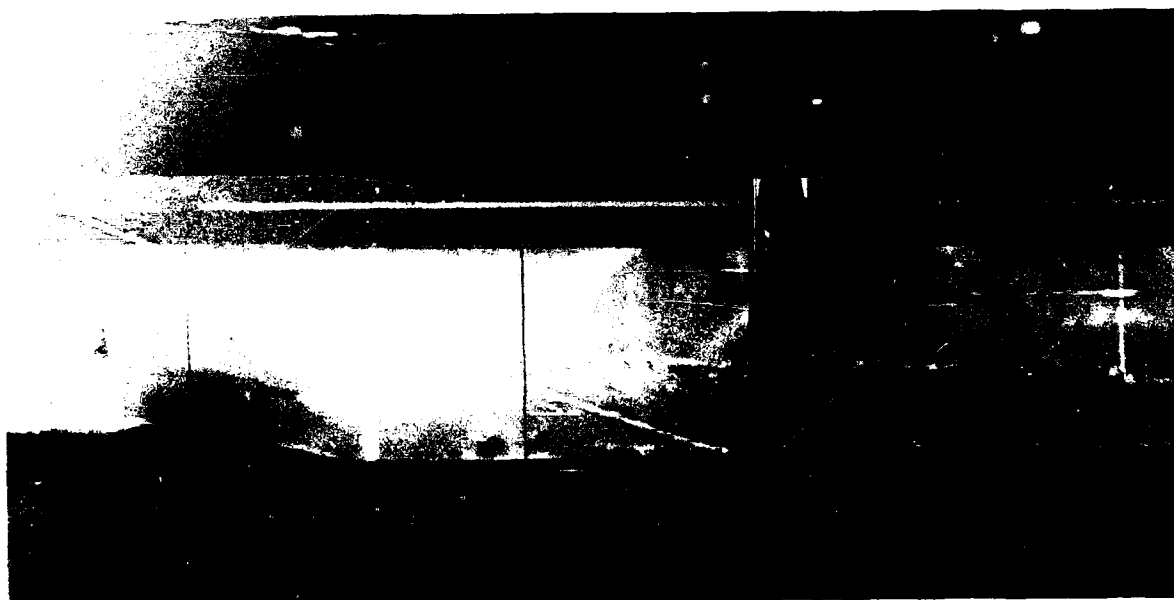


d. Pool el 74, tailwater el 71, gate opening 10 ft

Photo 10. (Sheet 2 of 3)



e. Pool el 99, tailwater el 91, gate open full

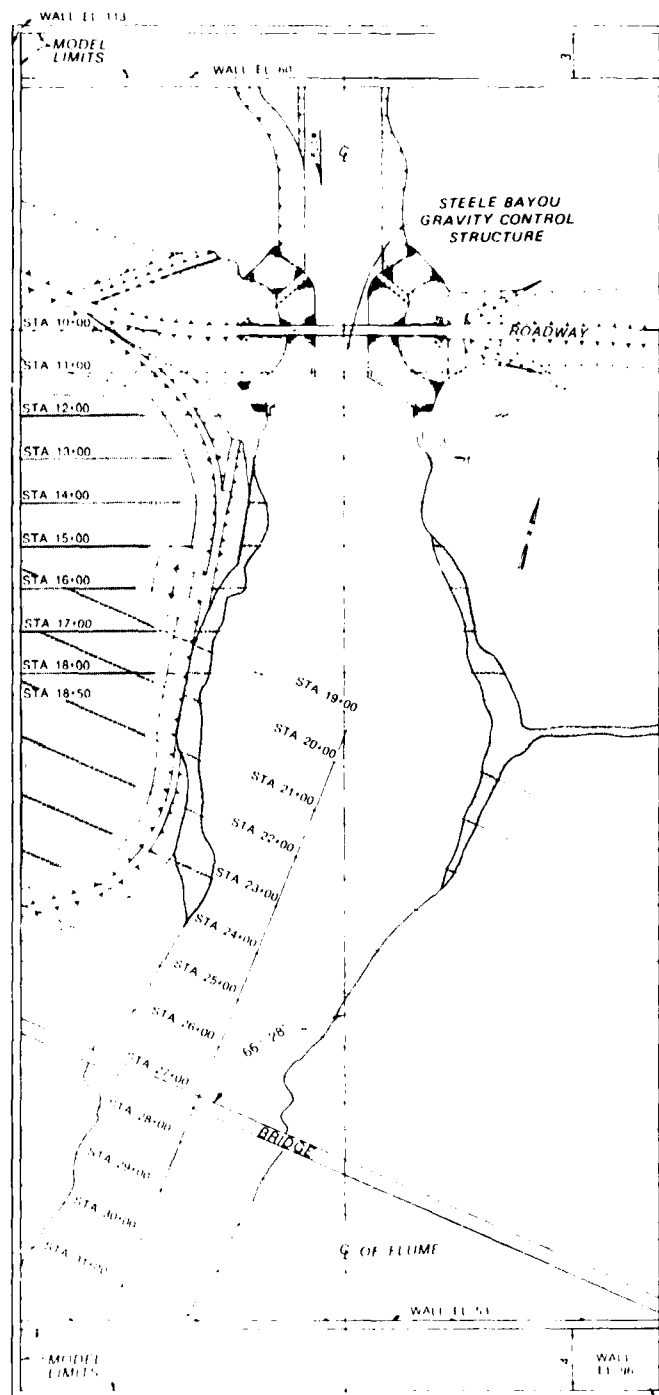


f. Pool el 79, tailwater el 72, gate open full

Photo 10. (Sheet 3 of 3)



Photo 11. Spray off baffle blocks, type 6 exit area;
discharge 60,000 cfs, pool el 91, tailwater el 67



STEELE BAYOU
(1:36)

PLAN VIEW OF MODEL LIMITS

PLATE 1

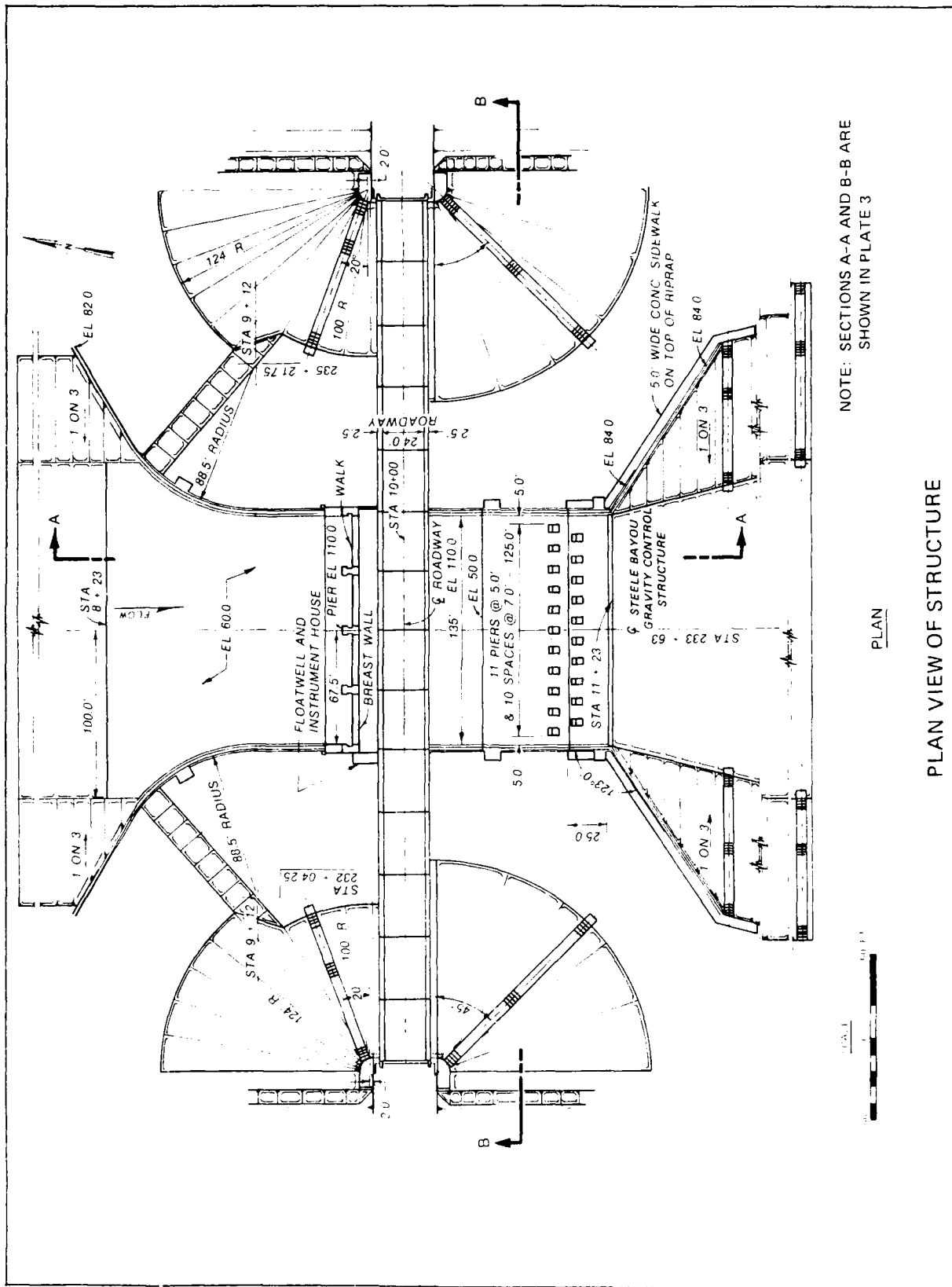
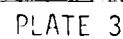


PLATE 2

PLAN VIEW OF STRUCTURE

PLAN

NOTE: SECTIONS A-A AND B-B ARE SHOWN IN PLATE 3



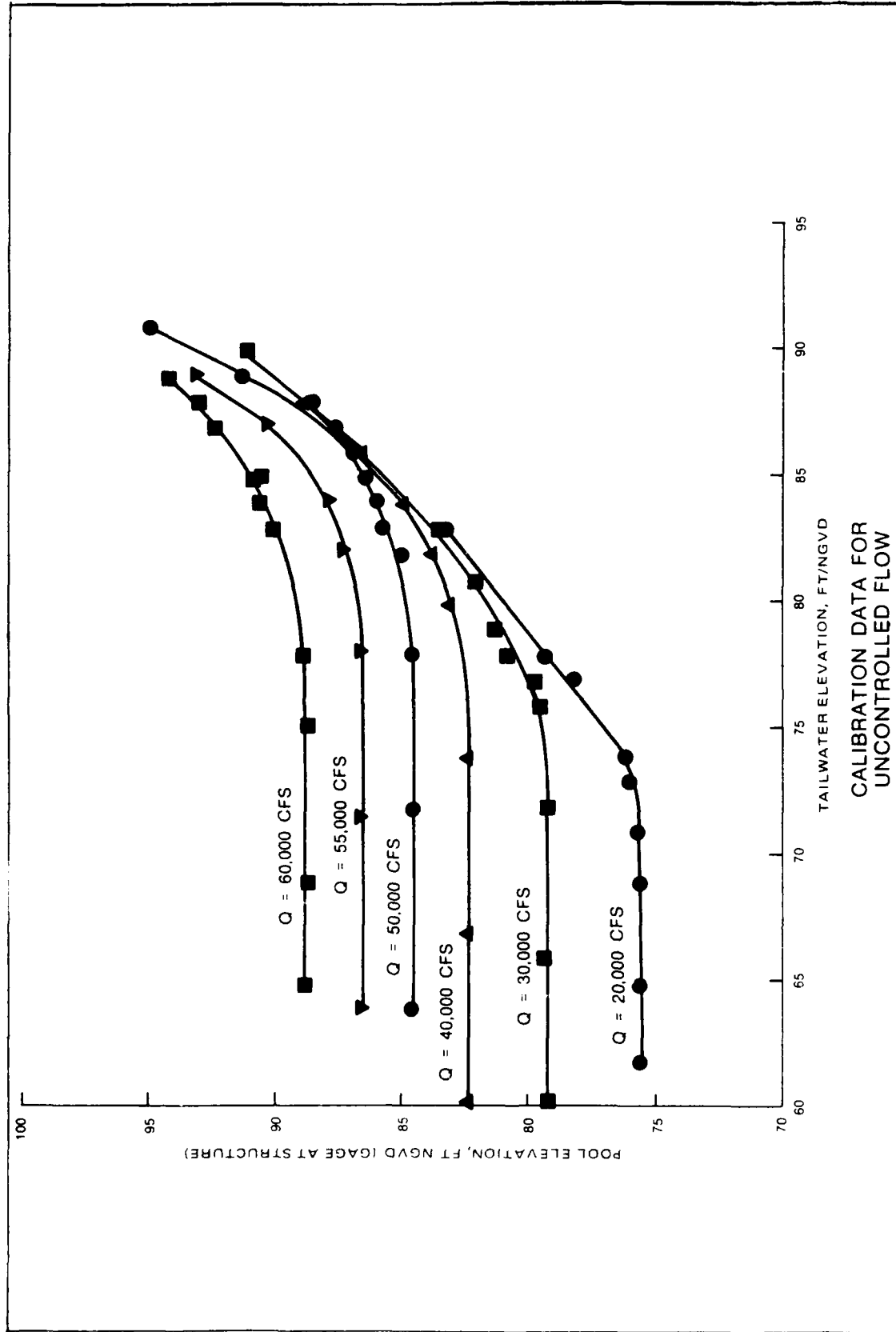
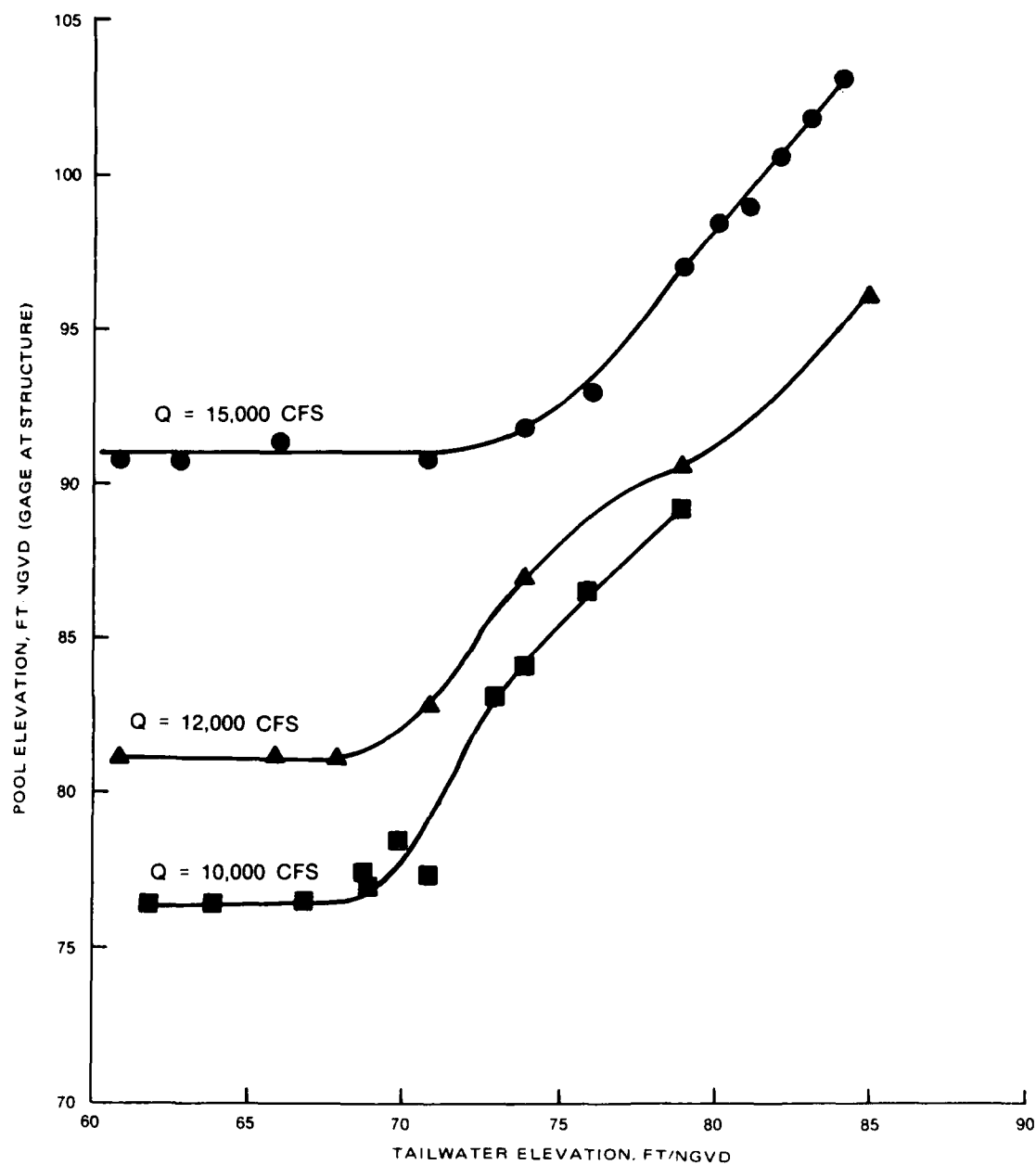
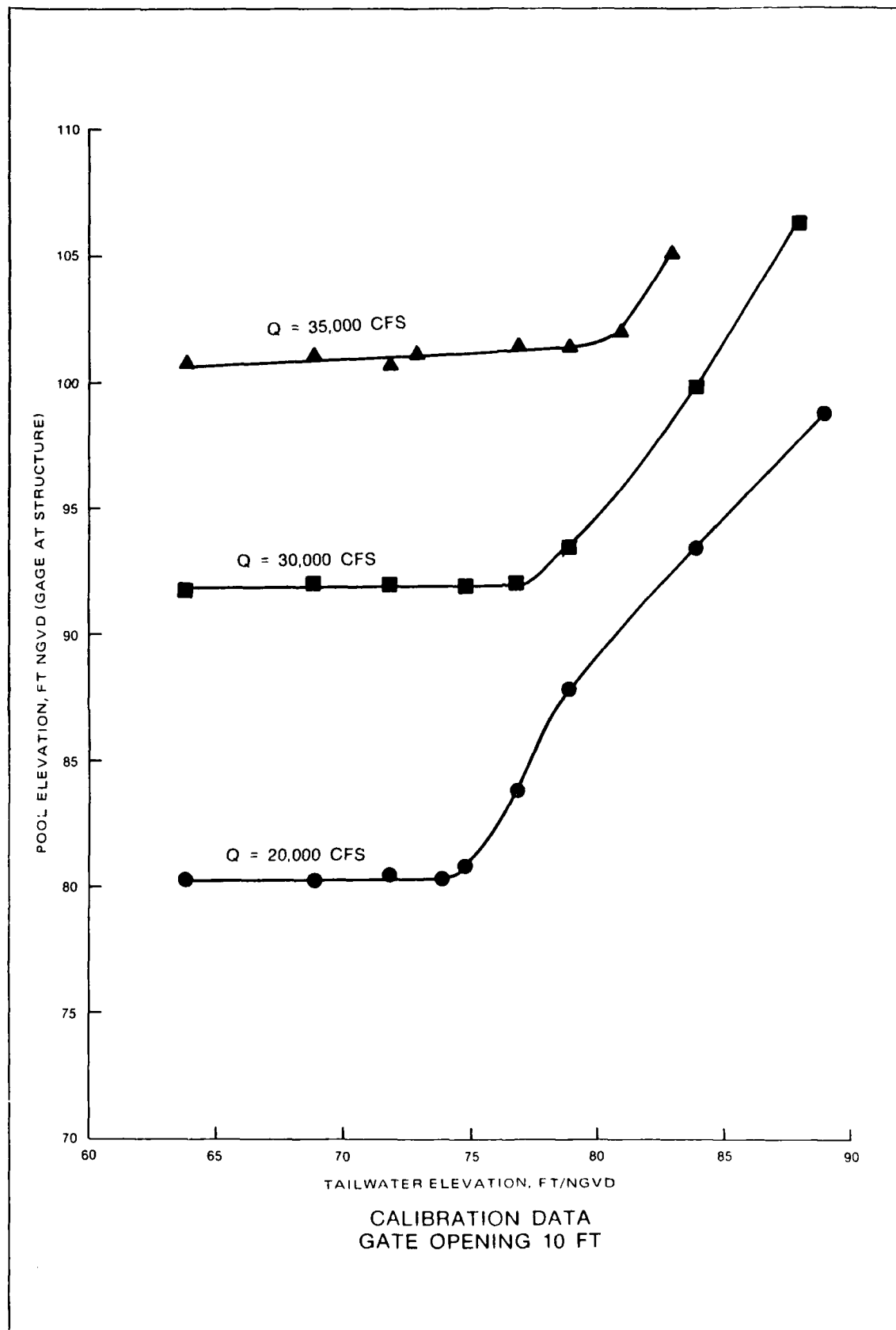
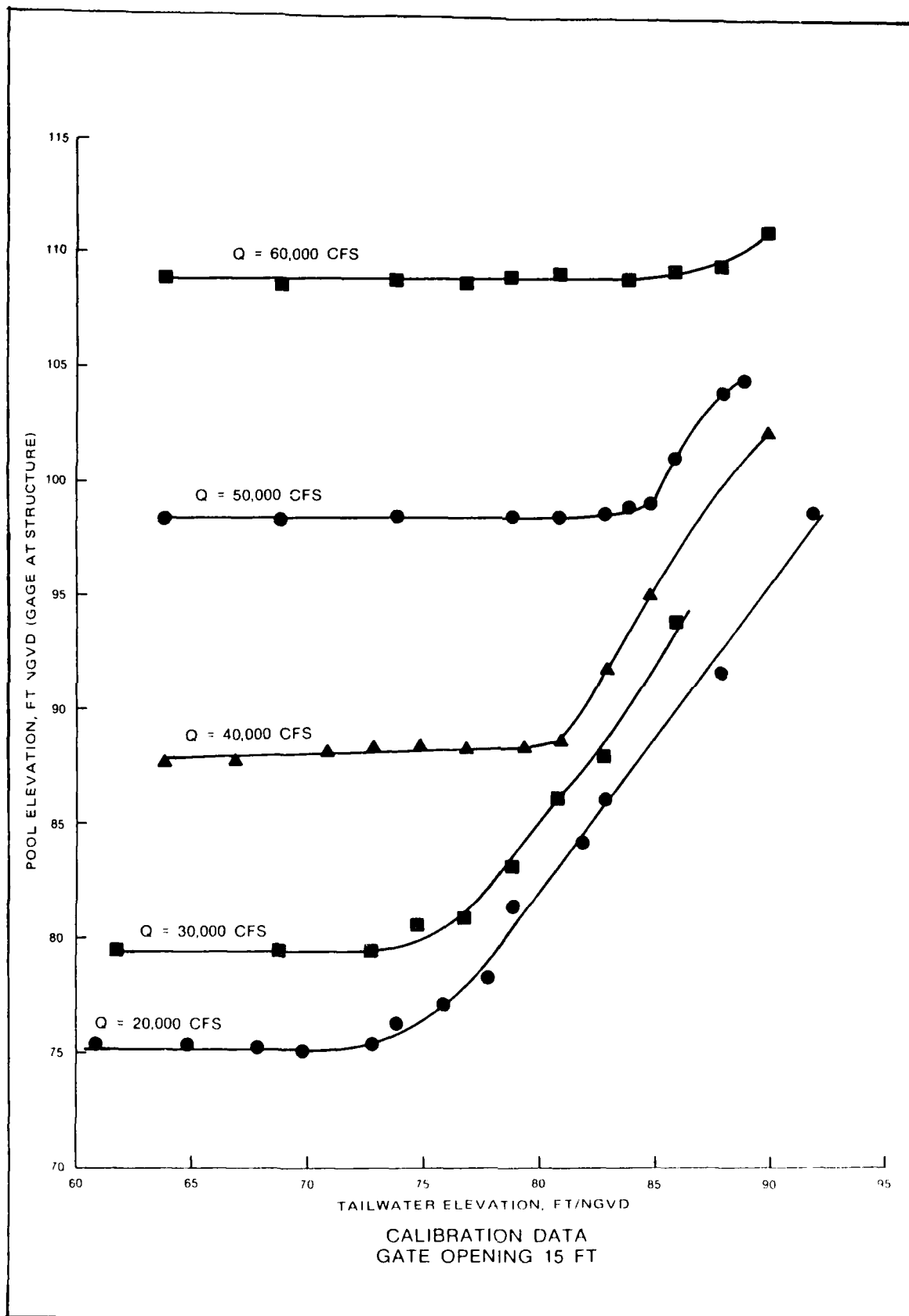


PLATE 4



CALIBRATION DATA
GATE OPENING 5 FT





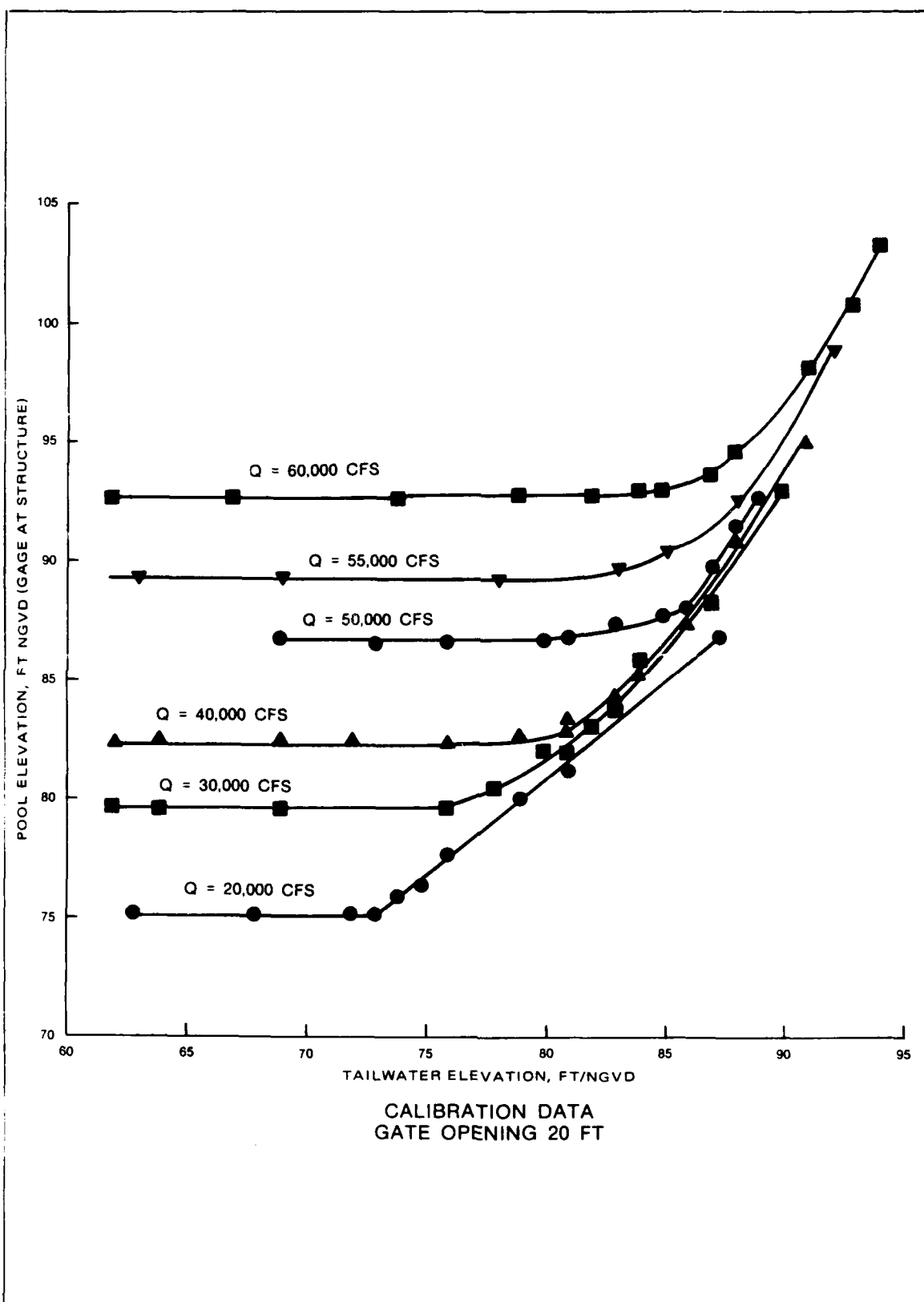
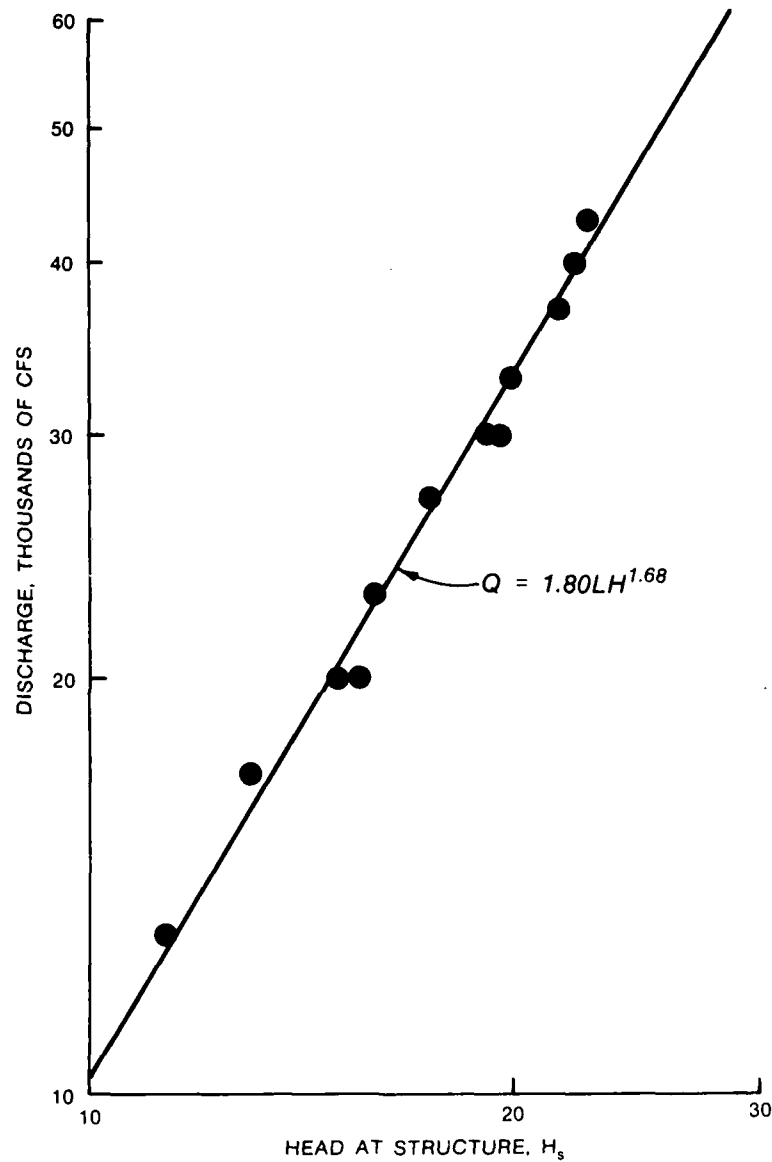


PLATE 8



DISCHARGE-HEAD RELATIONSHIP
FOR FREE UNCONTROLLED FLOW
CREST EL = 60 FT

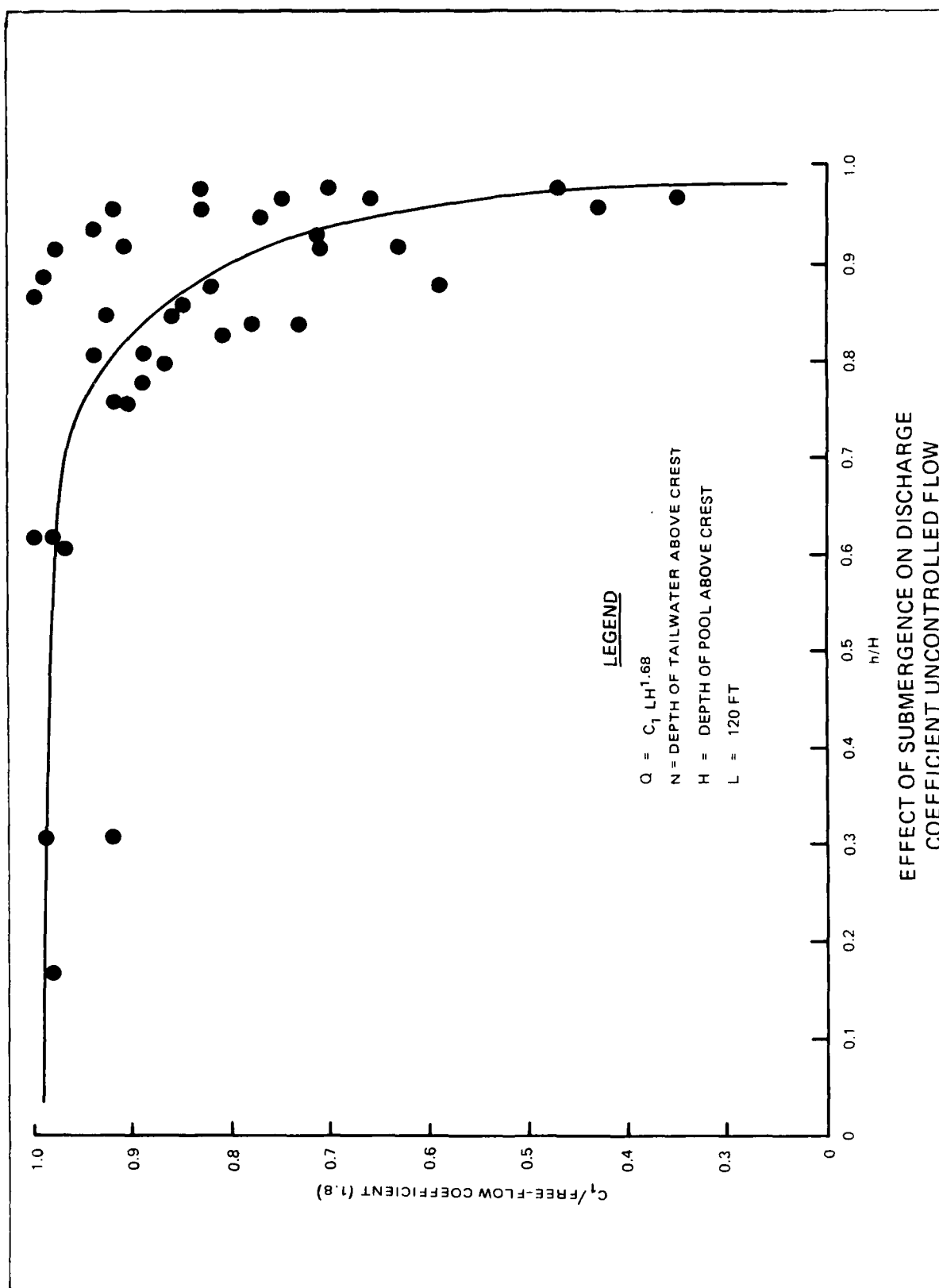
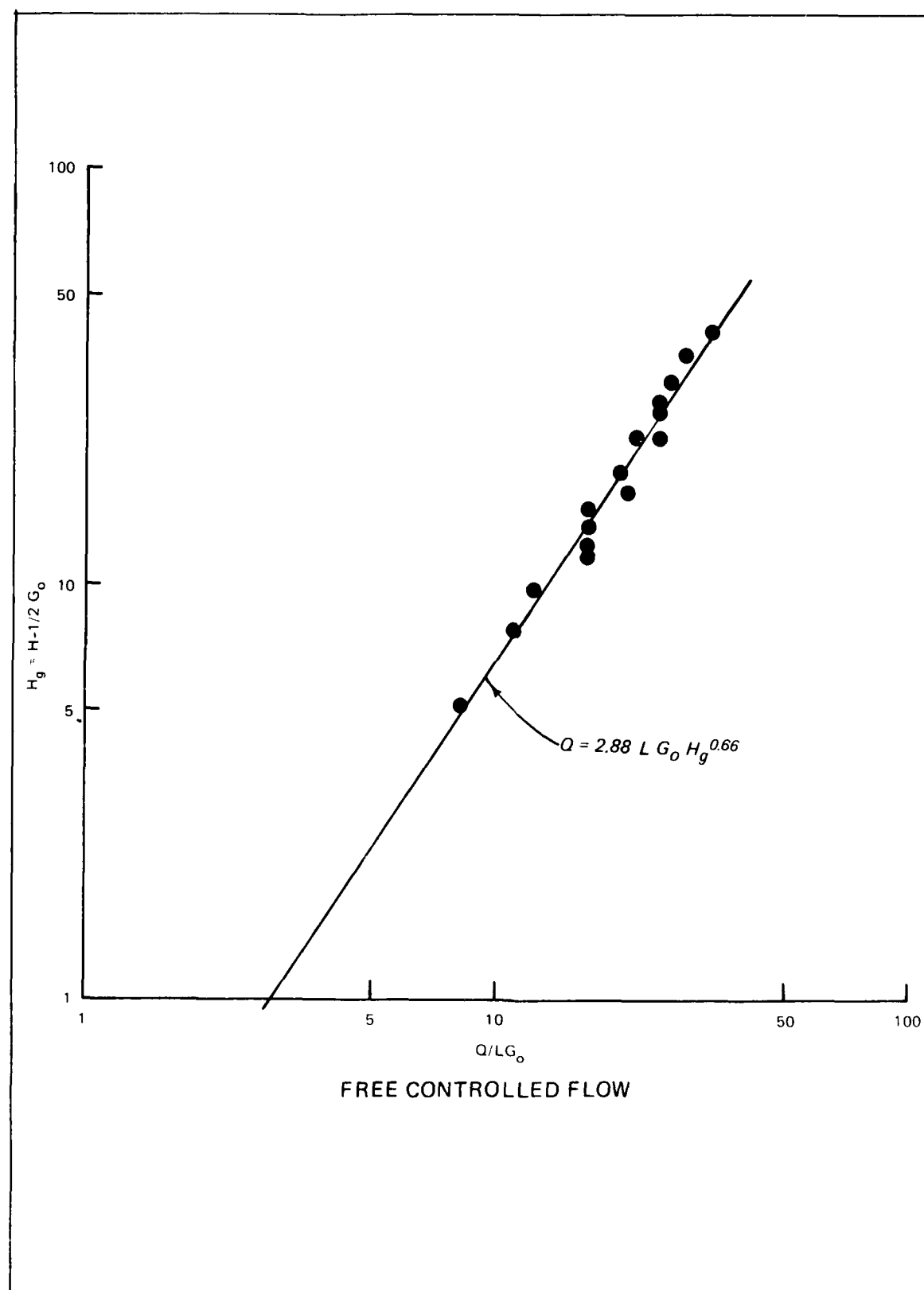
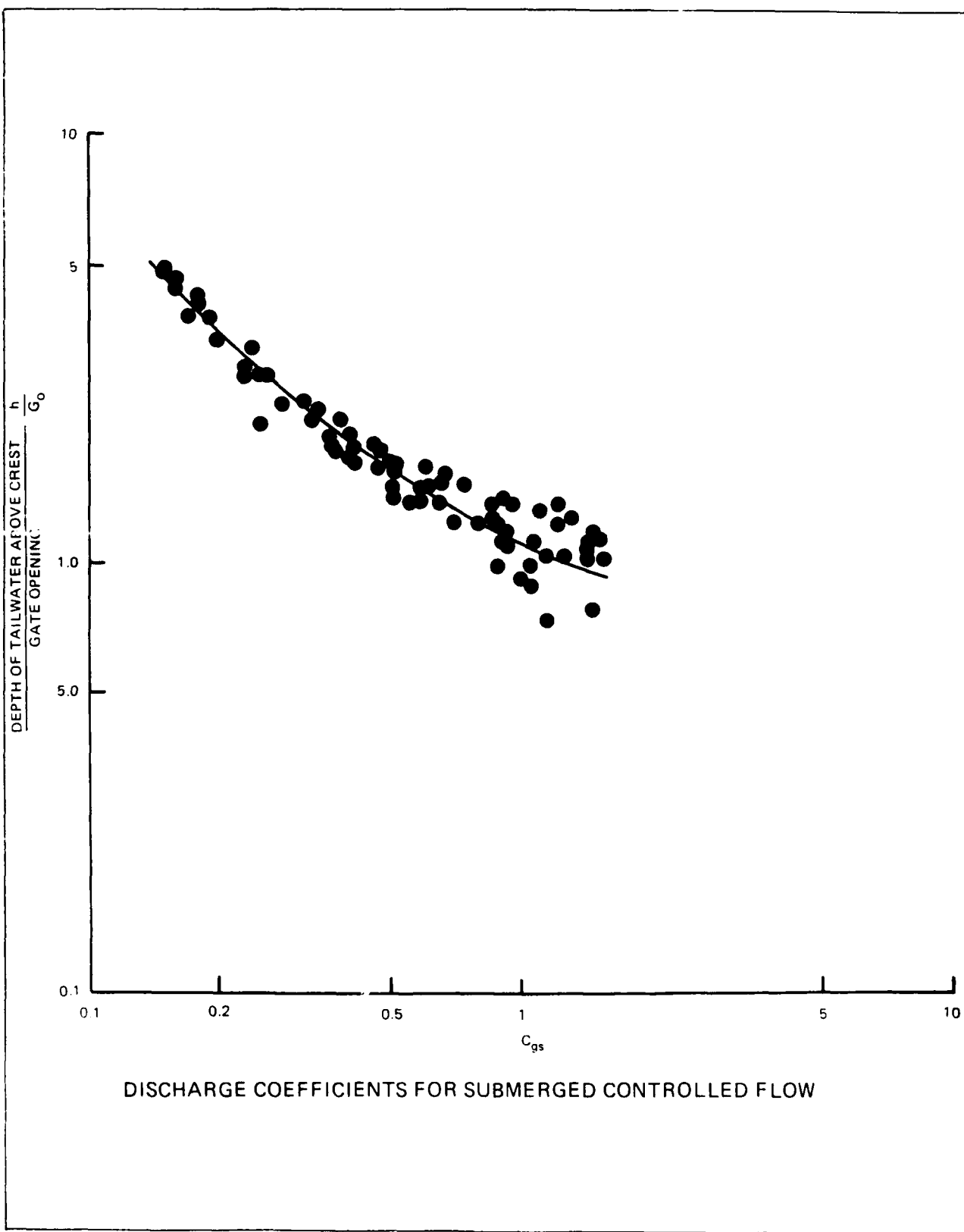
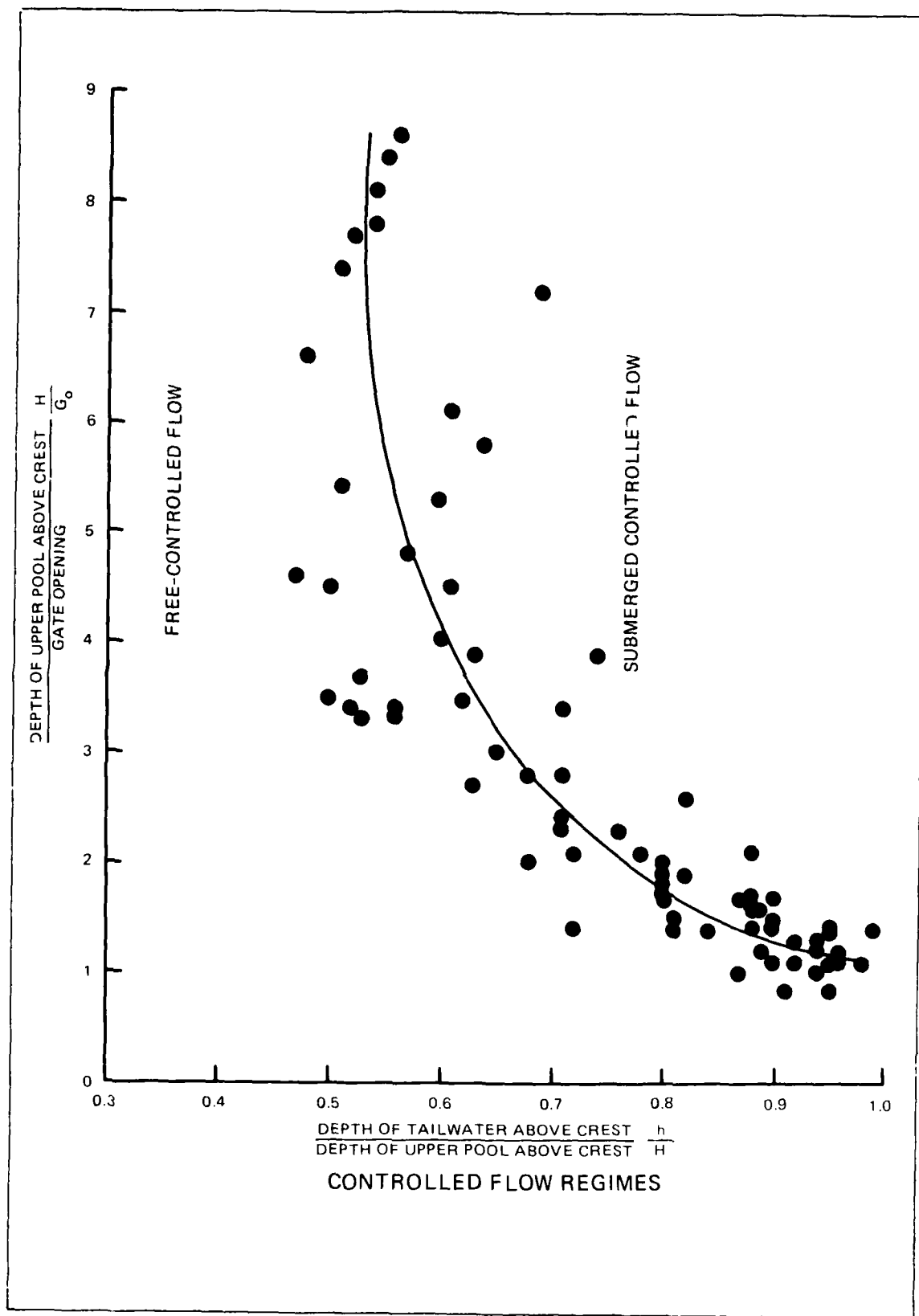
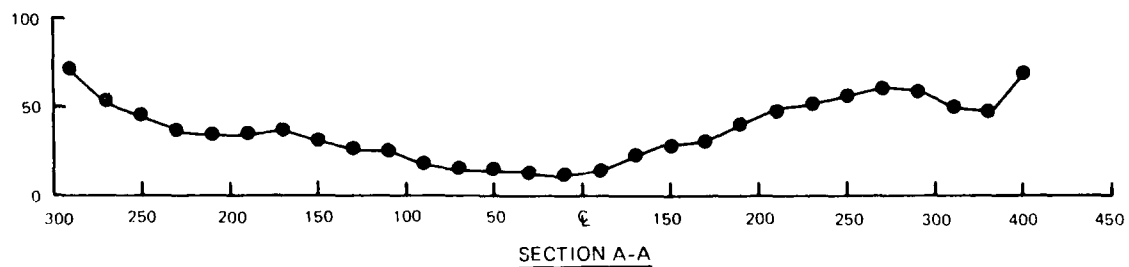
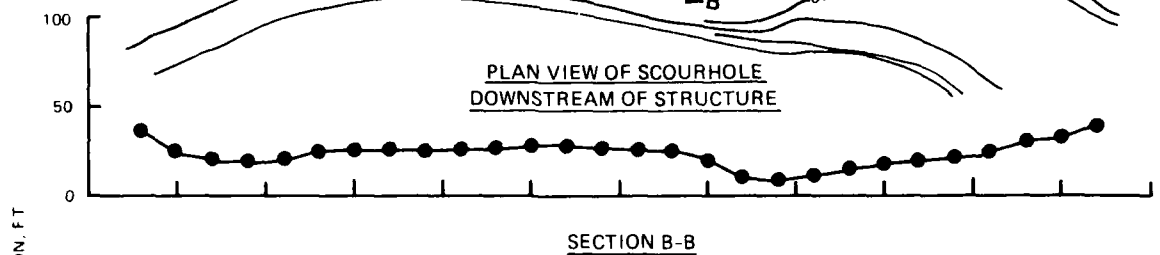
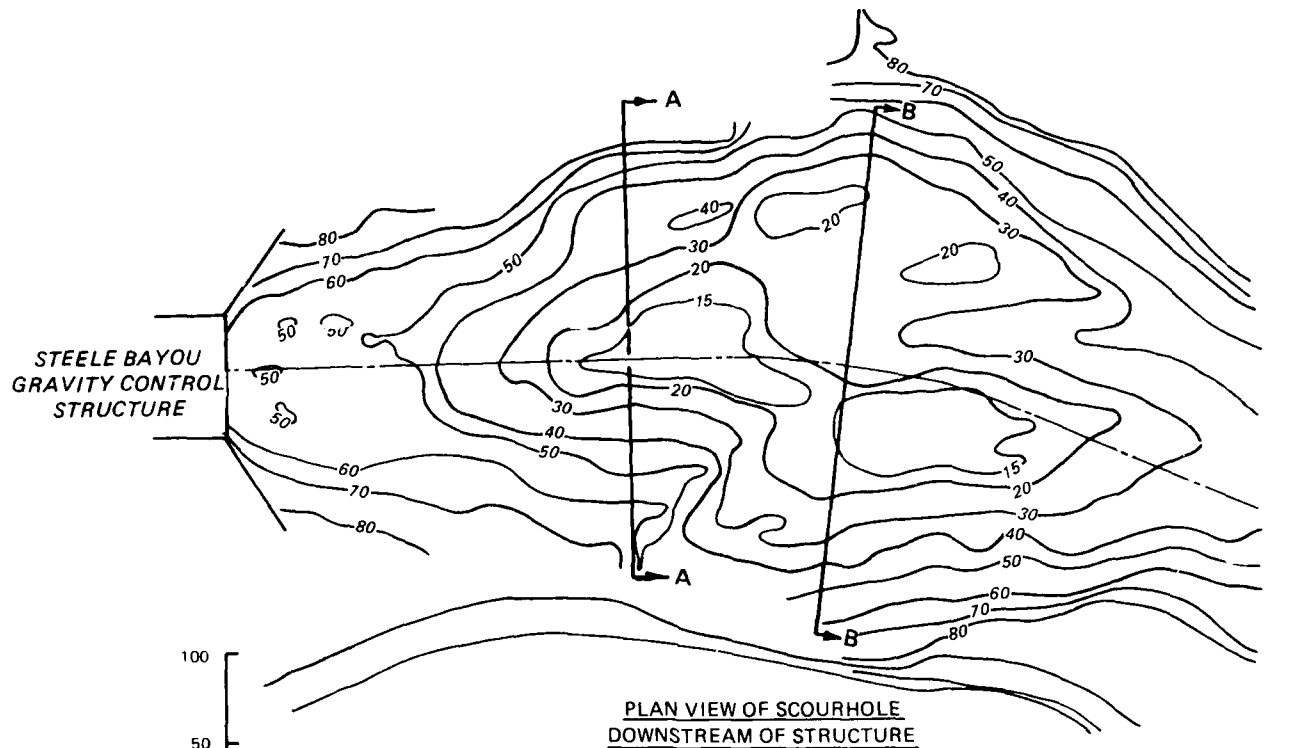


PLATE 10

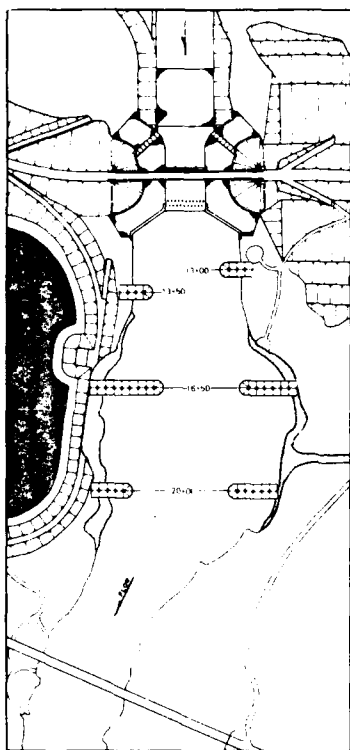




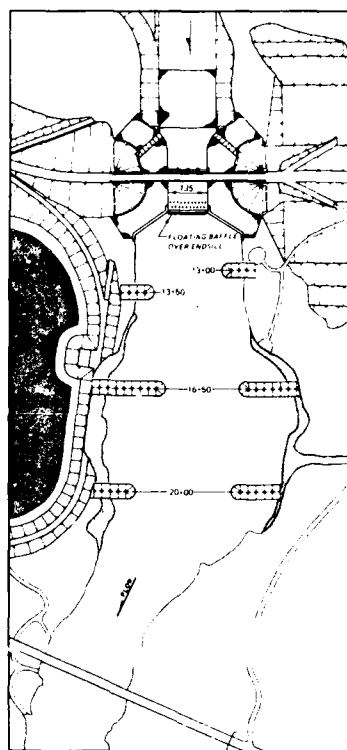




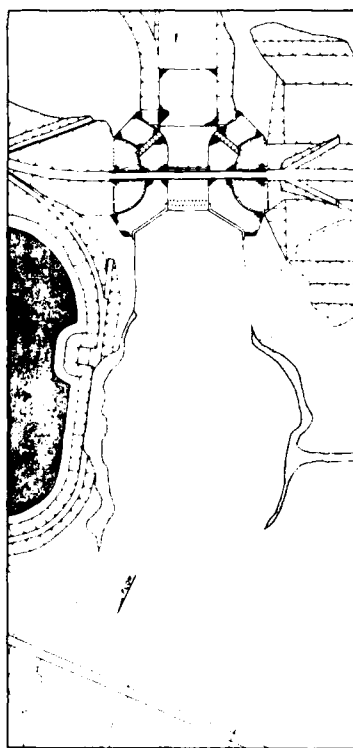
DETAILS OF SCOUR HOLE DOWNSTREAM OF STRUCTURE



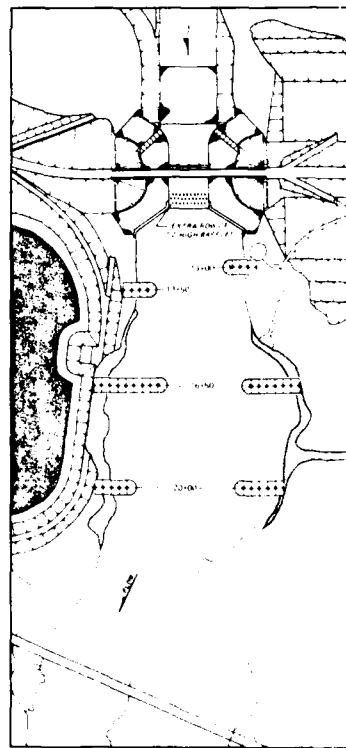
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3

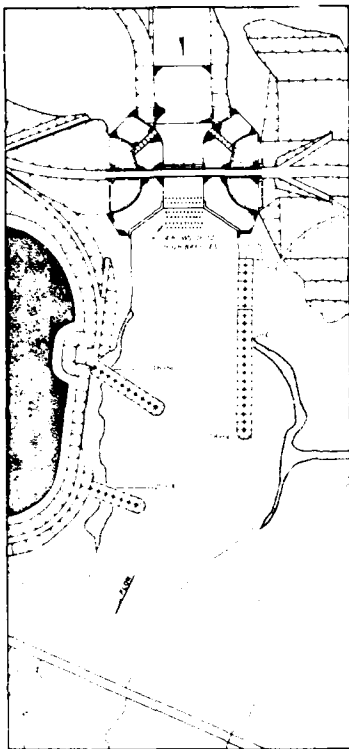


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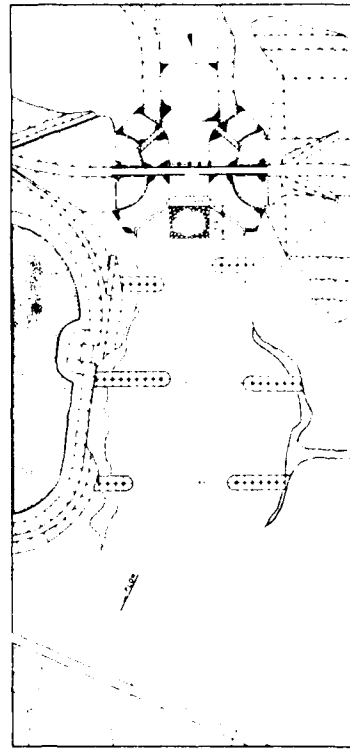


4

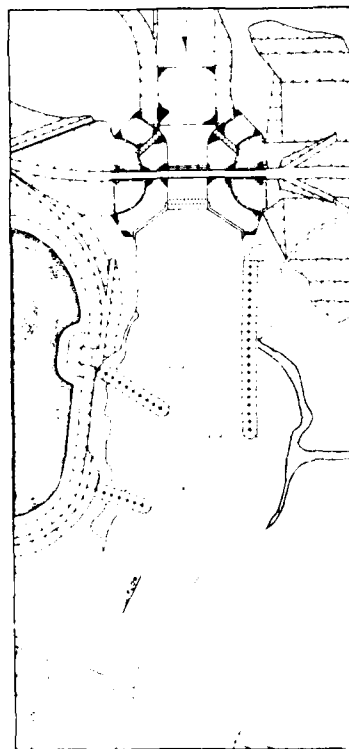
EXIT AREA DESIGNS 1 THROUGH 4



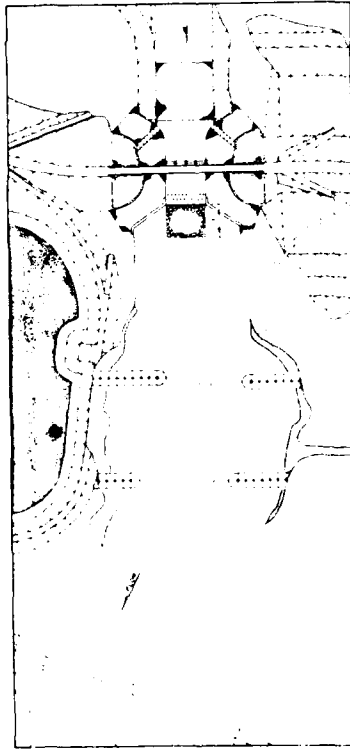
5



5B

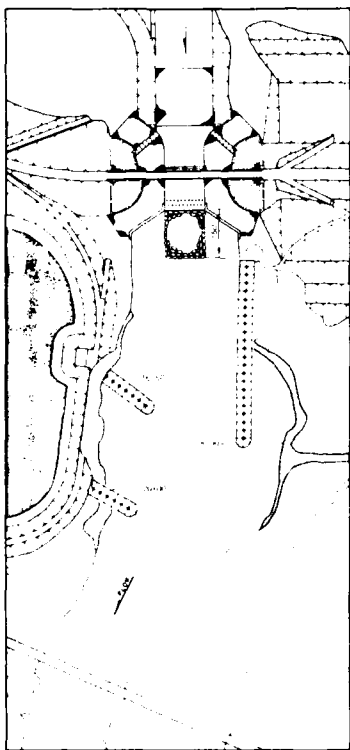


4A

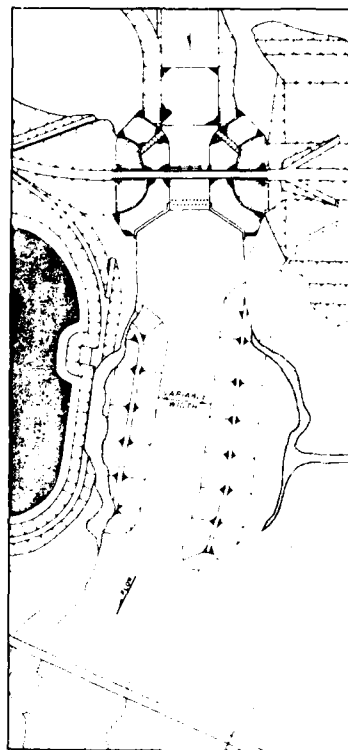


5A

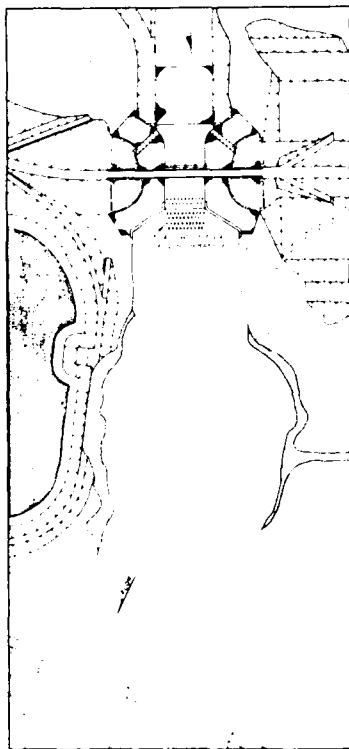
EXIT AREA DESIGNS 4A THROUGH 5B



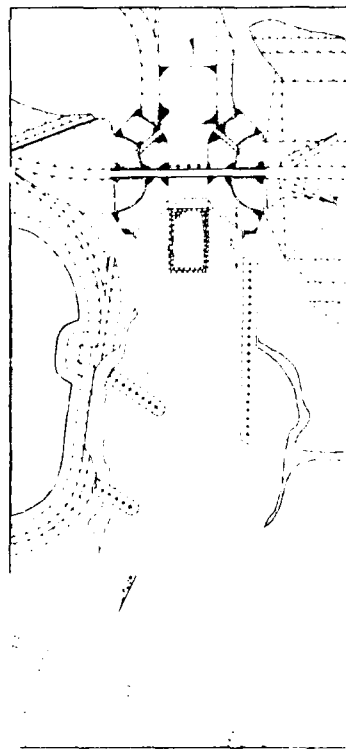
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8A

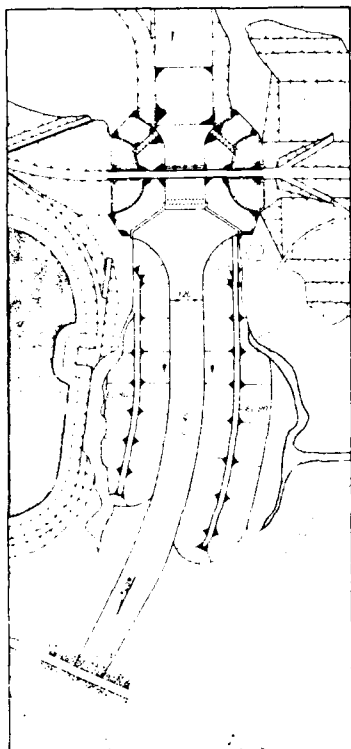


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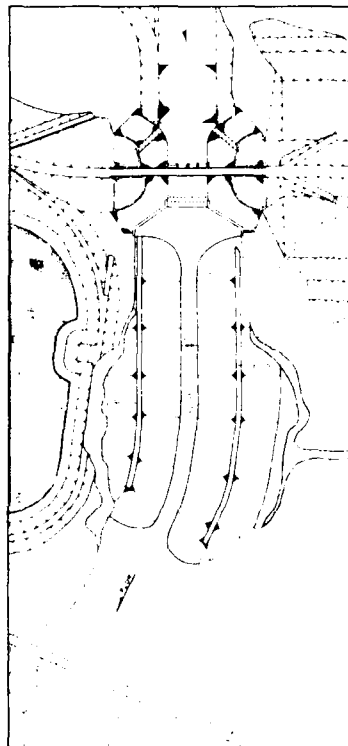


8

EXIT AREA DESIGNS 6 THROUGH 8A

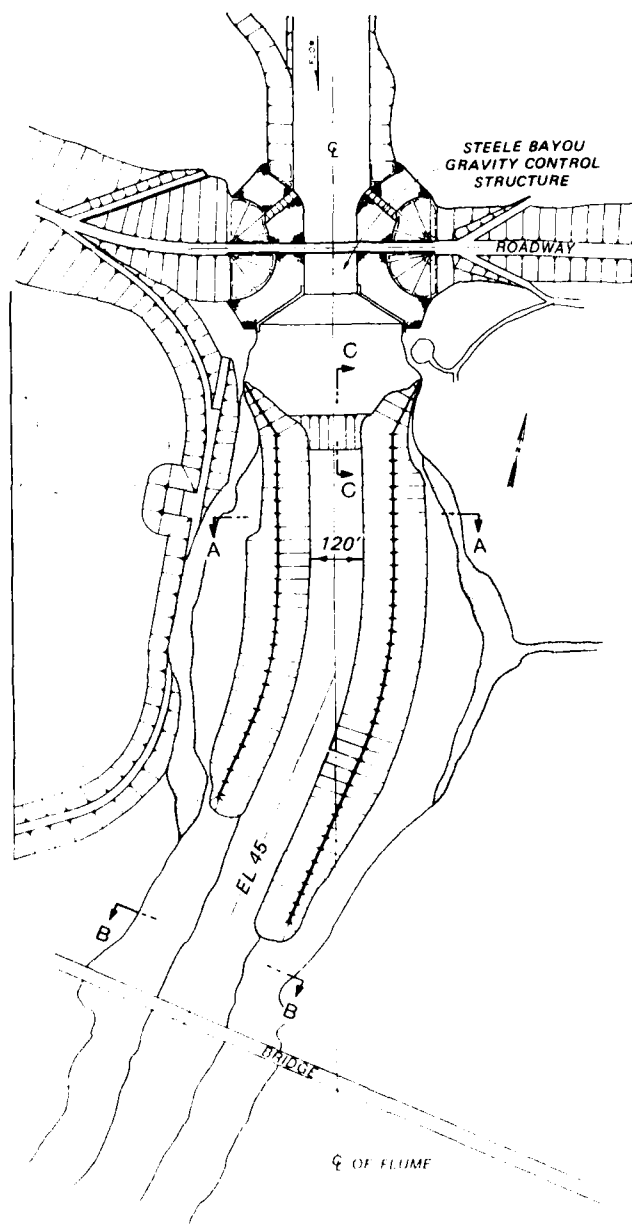


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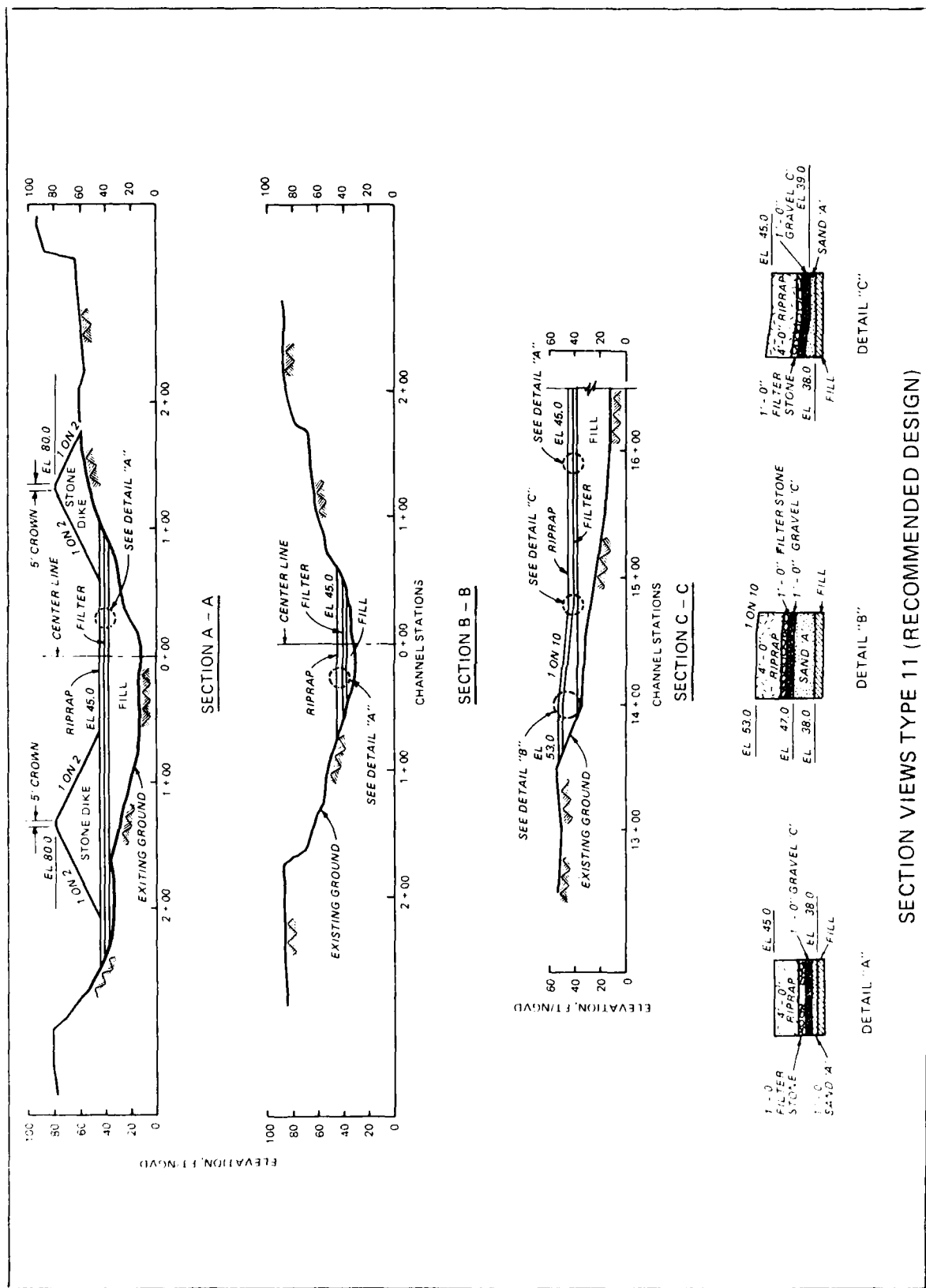


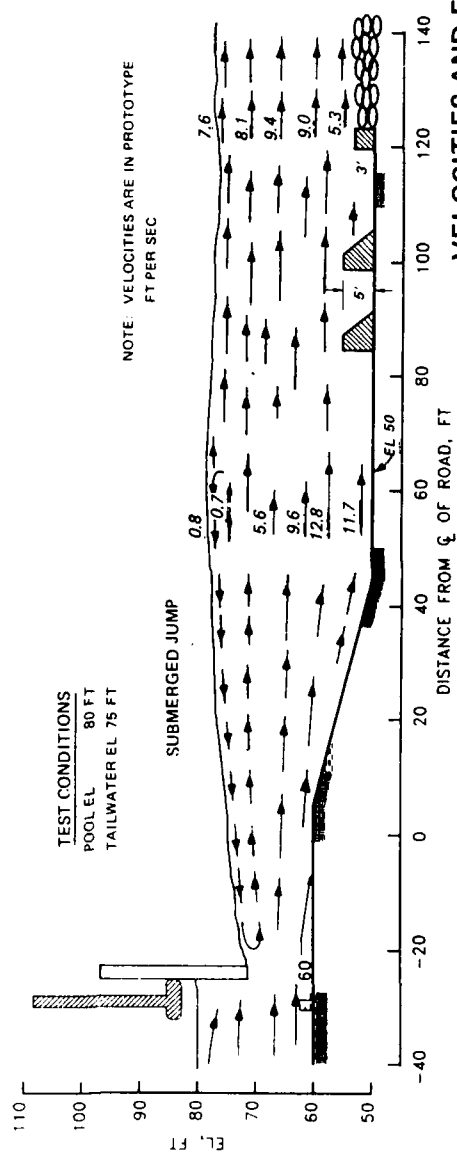
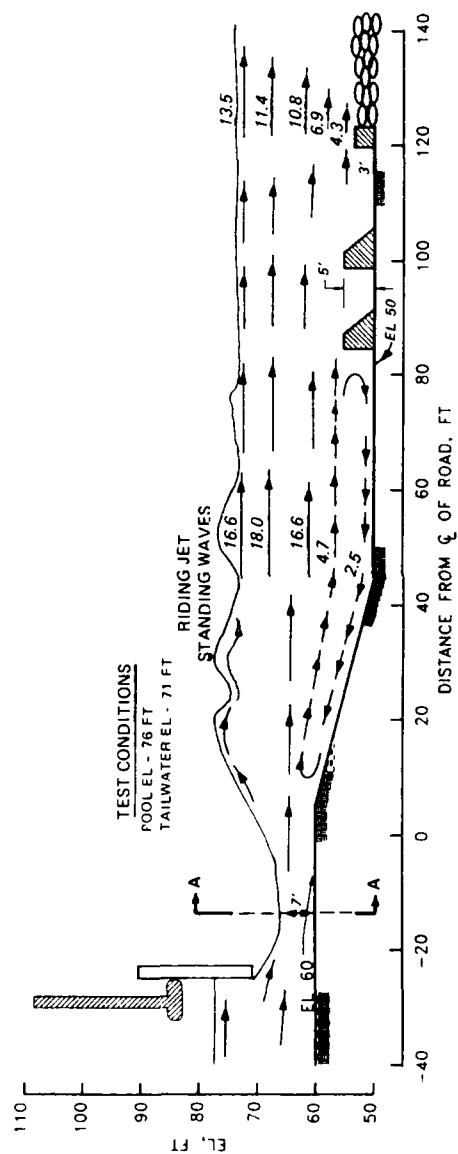
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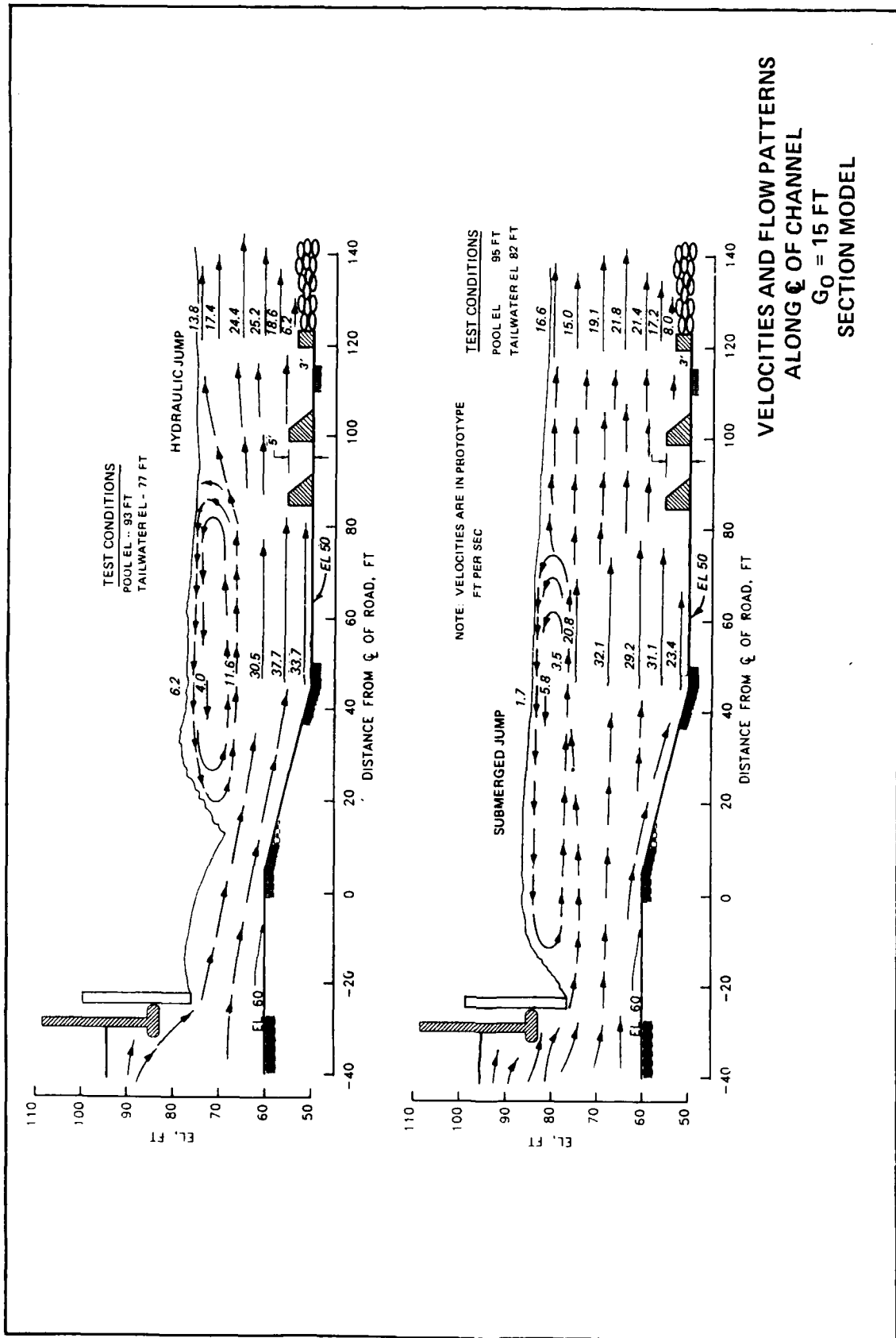
EXIT AREA DESIGNS 9 AND 10

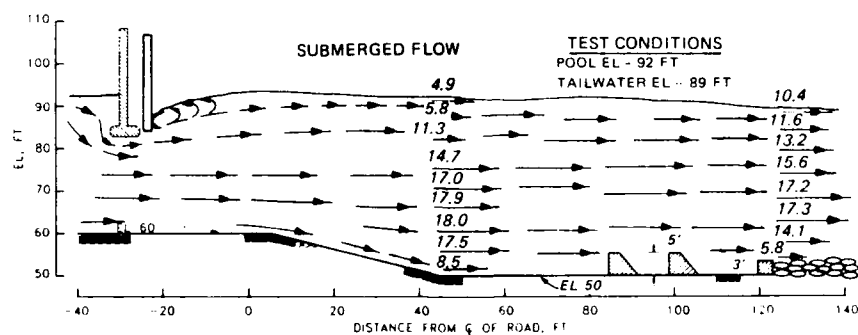
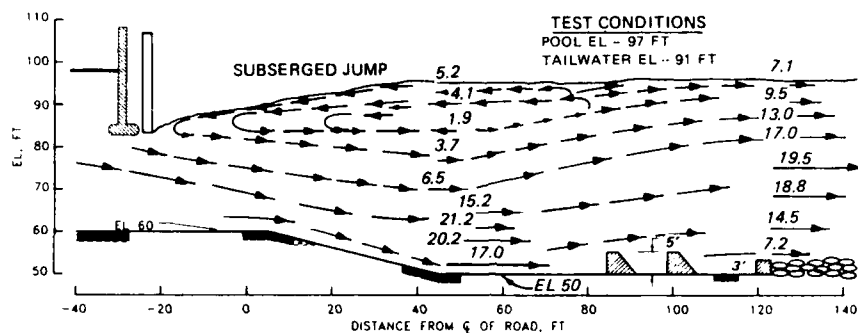
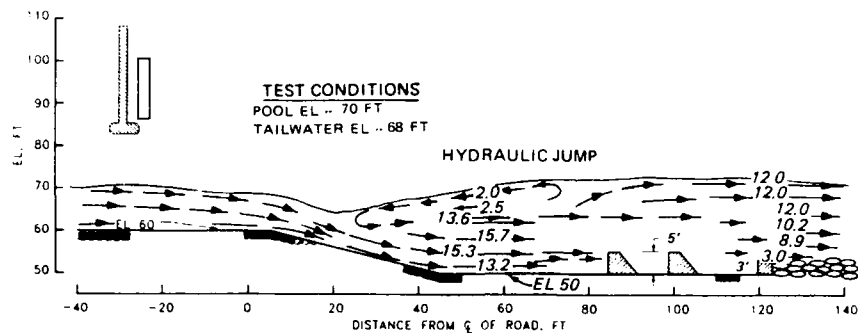


PLAN VIEW TYPE 11 (RECOMMENDED DESIGN)

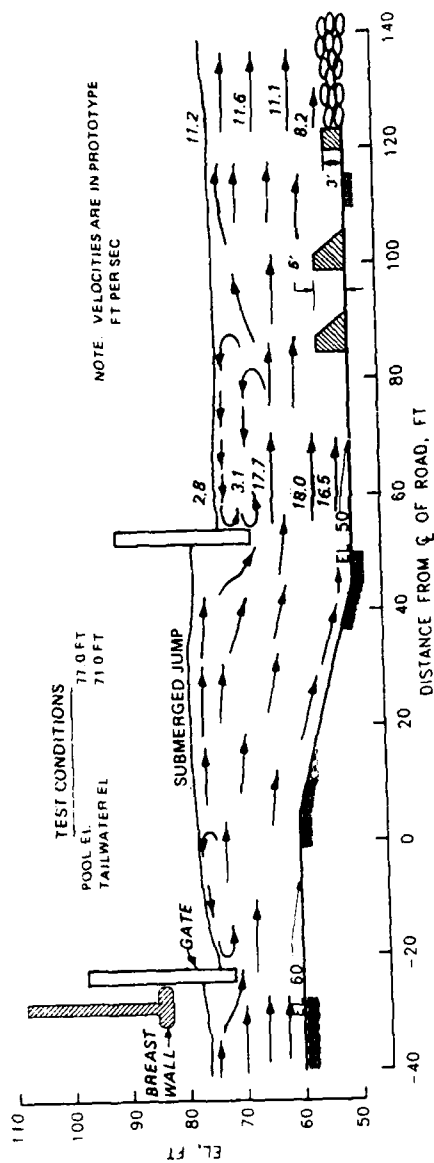




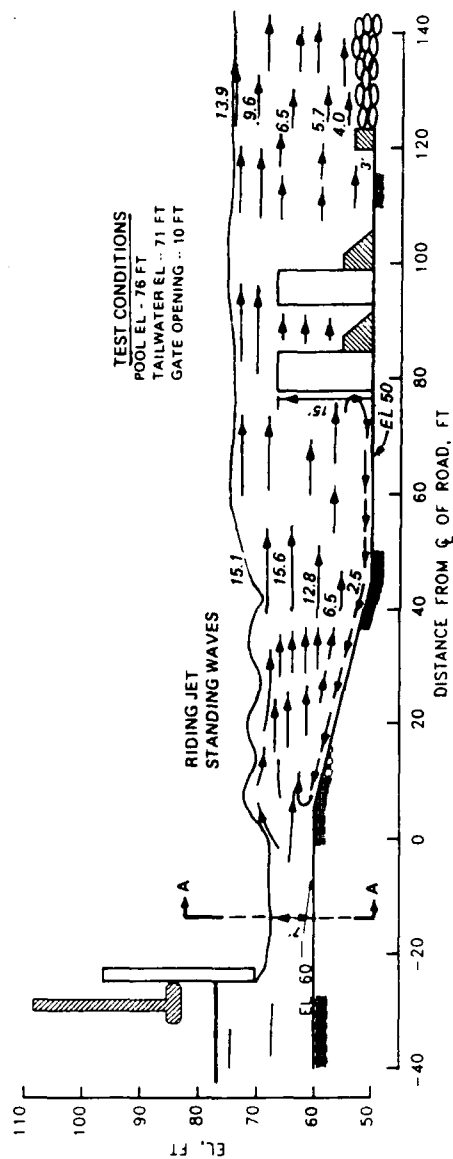




VELOCITIES AND FLOW PATTERNS
 ALONG C OF CHANNEL
 G_0 = FULL
 SECTION MODEL



VELOCITIES AND FLOW PATTERNS
 ALONG C OF CHANNEL
 15-FT HIGH BAFFLE BLOCKS
 GO = 10 FT
 SECTION MODEL



VELOCITIES AND FLOW PATTERNS
 ALONG C OF CHANNEL
 OVERHANGING BAFFLE
 GO = 10 FT
 SECTION MODEL

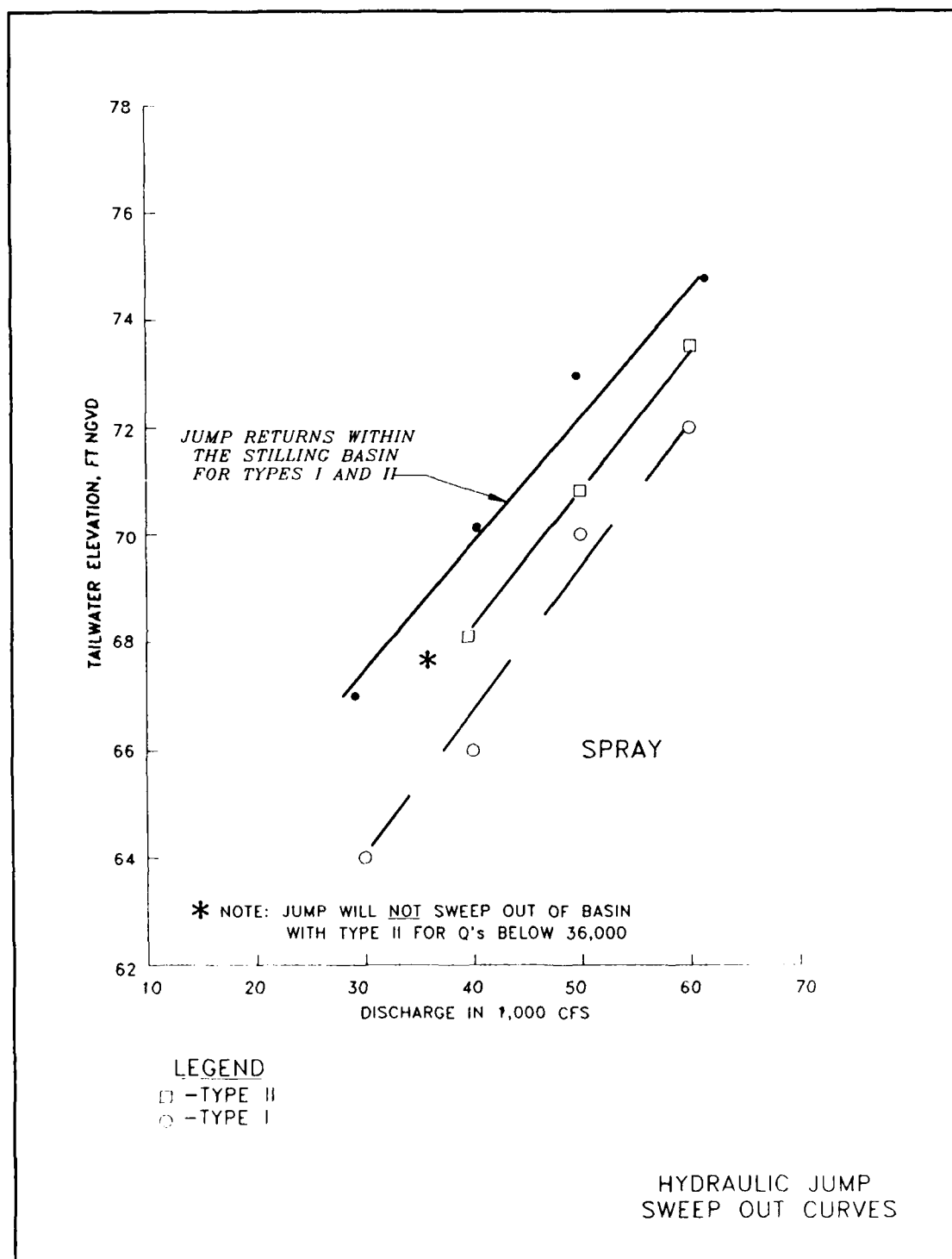


PLATE 23

