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KASKASKIA RIVER GRADE-CONTROL STRUCTURE AND NAVIGATION CHANNEL FAYETTEVILLE, ILLINOIS,

Hydraulic Model Investigation,

LEVEL II

by

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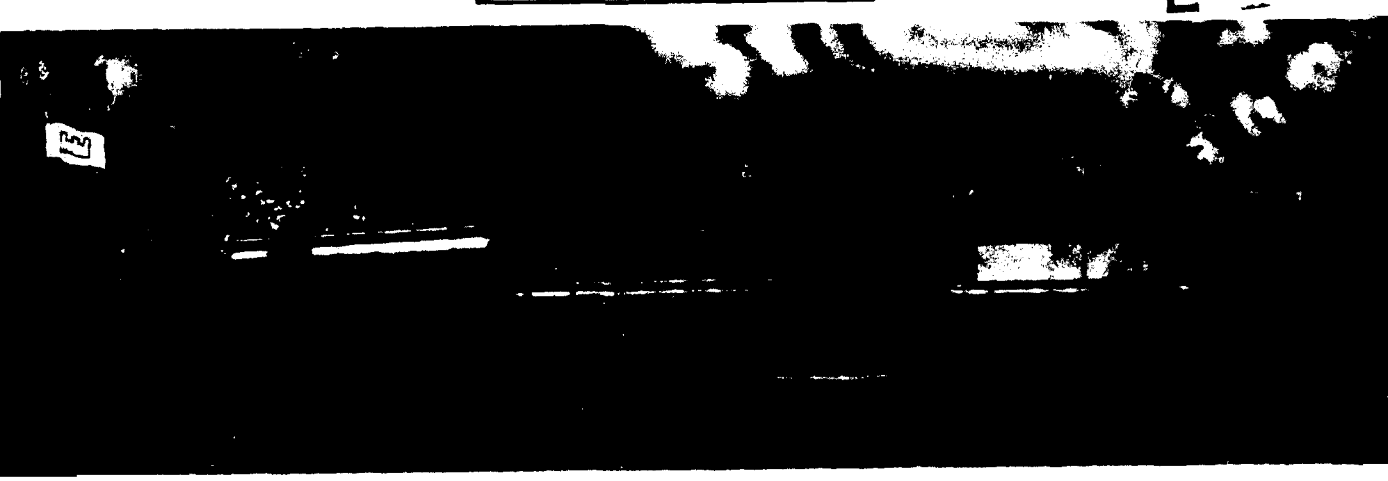

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The structure proposed at the head of the Kaskaskia River navigation channel near Fayetteville~~, Illinois,~~ was designed to provide grade control which is required to permit dredging of the navigation channel and maintain existing water surfaces without aggravating head cutting and upstream bank erosion. A 1:25-scale model investigation was conducted to evaluate the hydraulic performance of the proposed structure including discharge characteristics of the weir,
(Continued)

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velocities of flow through the structure and in the downstream navigation channel, general flow patterns, and riprap needed for stability of the structure and for protection of the navigation channel. The proposed grade-control structure will be constructed of riprap and an additional 800 ft of bank protection will be provided immediately downstream of the structure. The total structure width will be about 600 ft and will include a trapezoidal weir with a base width of 120 ft at el 364 in the center of the existing Kaskaskia River navigation channel. The original design grade-control structure performed satisfactorily with discharges ranging from 1,000 to 35,000 cfs; however, the headwater was below desirable levels. Several modifications of the weir portion of the structure were developed to maintain existing headwaters and provide satisfactory hydraulic performance. The structural modifications included narrowing the weir from 160 to 120 ft while maintaining the 1V-on-3H side slopes from weir invert el 364 to el 384, and providing a rounded transition to 1V-on-13.3H (right bank) and 1V-on-16H (left bank) side slopes.

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Errata Sheet

No. 1

KASKASKIA RIVER GRADE-CONTROL
STRUCTURE AND NAVIGATION CHANNEL
FAYETTEVILLE, ILLINOIS

Hydraulic Model Investigation

Technical Report HL-80-20

December 1980

1. Form 1473, second page, Item 20, line 3. Change to read:

...and for protection of the navigation channel. The proposed grade-control structure, as designed, would be constructed of riprap and an additional 800 ft of bank structure would be provided immediately downstream of the structure. The total structure width would be about 600 ft and would include a trapezoidal weir with a base width....

PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers, U. S. Army, on 28 February 1979, at the request of the U. S. Army Engineer District, St. Louis (LMS).

The study was conducted in the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES) during the period February to October 1979 under the direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory, and Mr. J. L. Grace, Jr., Chief of the Hydraulic Structures Division, and under the general supervision of Mr. N. R. Oswalt, Chief of the Spillways and Channels Branch. The engineers in immediate charge of the model were Messrs. S. T. Maynord and P. Bhramayana, assisted by Messrs. R. Bryant and J. Rucker. This report was prepared by Messrs. Grace and Bhramayana.

During the model investigation, Messrs. Charles W. Denzel, Michael E. Hamm, Steve Redington, Lester Boyer, and Mrs. Chien (Nancy) H. Hsieh of LMS; Messrs. Frank N. Johnson, Max Lamb, and Malcomb Dove of the Lower Mississippi Valley Division visited WES to observe the model, discuss results of the tests, and correlate these results with concurrent design studies. Acknowledgment is given to Dr. Campbell Little, SEA Laboratory, U. S. Department of Agriculture, Oxford, Miss., for his advice to LMS during design of the structure.

Commanders and Directors of WES during the testing program and the preparation and publication of this report were COL John L. Cannon, CE, and COL Nelson P. Conover, 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

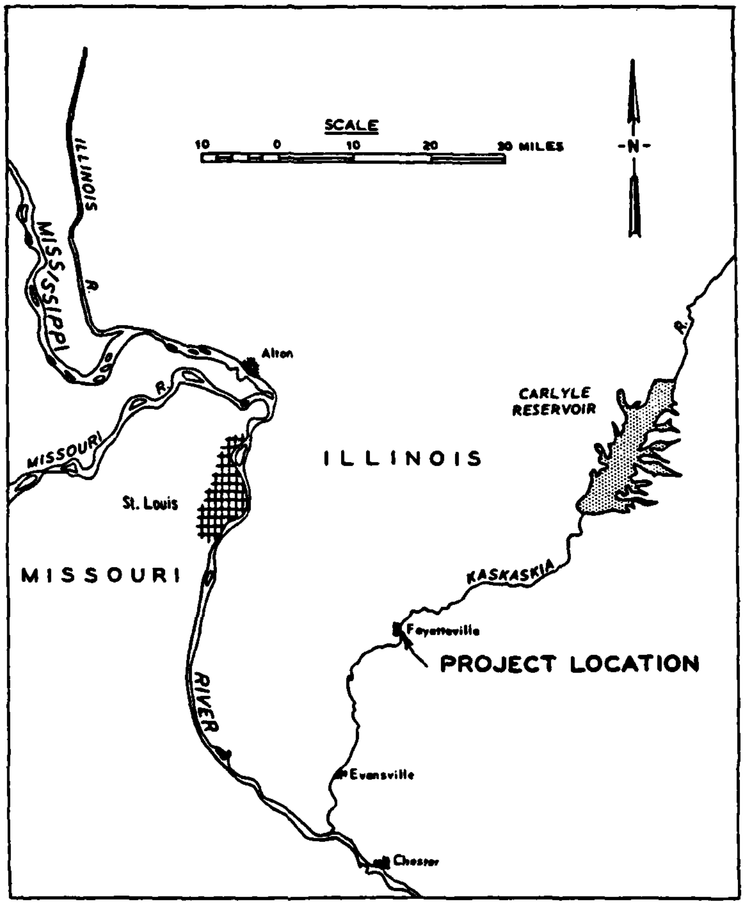

Figure 1. Vicinity map

KASKASKIA RIVER GRADE-CONTROL STRUCTURE AND NAVIGATION CHANNEL, FAYETTEVILLE, ILLINOIS

Hydraulic Model Investigation

PART I: INTRODUCTION

Location of Project

1. The subject grade-control structure is proposed at the head of the navigation channel on the Kaskaskia River about 700 ft* downstream from the U. S. Highway 460 Bridge at Fayetteville in St. Clair County, Illinois (Figure 1).

The Prototype

2. The Kaskaskia River grade-control structure will consist of a weir-type rock structure (Plate 1). The rock structure has a length of 460 ft parallel to the riverflow with an additional 800 ft of bank protection immediately downstream on both banks. The total grade-control structure width of 600 ft will include a 160-ft length of weir with crest at el 364.** The structure, weir, and a 460-ft reach of channel banks and bottom will be constructed of type A graded stone (Plate 1). Both banks of the adjacent downstream exit channel will be protected with type C graded stone.

Purpose of Study

3. The grade-control structure proposed at the head of the Kaskaskia River navigation channel is needed to provide vertical control which is required to permit dredging of the navigation channel and to

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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.

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

maintain existing water surfaces without aggravating channel bottom "head cutting" and upstream bank erosion. The purposes of the model study included:

a. Determination of the discharge characteristics of the proposed structure and current patterns and velocities in the downstream navigation channel.

b. Determination of the water-surface elevation for the full range of flows and modification of the structure as needed to maintain existing water surfaces.

c. Determination of the velocities of flow through the structure and in the exit channel.

d. Determination of the adequacy of riprap protection proposed for the structure and exit channel.

PART II: THE MODEL

Description

4. The Kaskaskia River grade-control structure model (Figure 2) was constructed to a scale of 1:25. The overall model simulated a 600-ft-wide by 1960-ft-long channel reach including 700 ft of approach channel, 460-ft length of structure, and 800 ft of exit channel. The

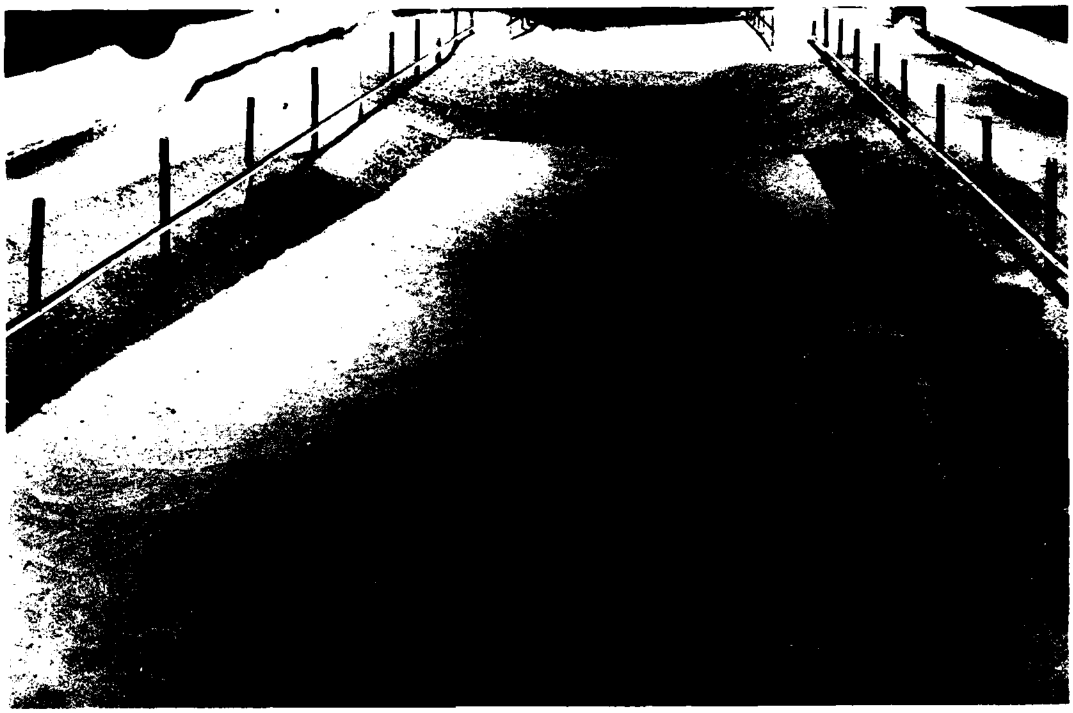


Figure 2. 1:25-scale model (dry bed before flow)

approach area was molded in cement mortar to sheet-metal templates. A sheet-pile* cutoff wall was extended the full 600-ft width of the structure as shown in Plates 1 and 11. The weir crest was retained at el 364 for all tests. Crushed rock simulating type A graded stone was placed 6 ft thick (prototype) on both sides of the structure and along

* A test without sheet pile was also performed after the tests with sheet pile were completed.

the bed and banks as shown in Plate 1. A riprap blanket reproducing 18-in.-thick type C graded stone was placed in the 800-ft-long exit channel (Plate 1) to permit study of the stability of the downstream riprap protection. All model riprap was placed on a fabric used to segregate the crushed rock from the underlying sand.

Appurtenances

5. Water used in the operation of the model was supplied by a pump and discharges were measured with calibrated venturi meters. Steel rails set to grade along both sides of the flume provided a reference plane for measuring devices. Water-surface elevations were measured using point gages. Larger velocities in the model (2.0 fps or greater) were measured with a pitot tube and smaller velocities were estimated using a stopwatch to time displacements of dye and floats. Tailwater elevations were regulated by a vertical tailgate located at the downstream end of the model. Current patterns were determined by means of dye injected into the water and confetti sprinkled on the water surface.

Scale Relation

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

Dimension	Ratio	Scale Relation
Length	L_r	1:25
Area	$A_r = L_r^2$	1:625
Volume	$V_r = L_r^3$	1:15,625
Velocity	$V_r = L_r^{1/2}$	1:5
Discharge	$Q_r = L_r^{5/2}$	1:3,125
Time	$T_r = L_r^{1/2}$	1:5

7. Model measurements of length, discharge, water-surface elevation, and velocity can be transferred quantitatively to prototype equivalents by means of the preceding scale relations. Experience indicates that these model-prototype scale ratios are valid for scaling riprap sizes used in this investigation.

PART III: TESTS AND RESULTS

Test Procedure

8. The flows of the Kaskaskia River were reproduced by introducing the proper discharges and associated tailwater elevations as indicated in the tailwater rating curve (Plate 2). All conditions were permitted to stabilize before any data were recorded. Velocities equal to or greater than 2 fps were measured with a pitot tube and by timing the travel of dye over a 1-ft distance with a stopwatch for flows less than 2 fps. Confetti was used to determine surface flow direction throughout the model. Subsurface current directions were determined by injecting dye at the point of interest. These procedures were applied throughout the model investigation.

Approach Conditions

9. Tests were conducted to compare the hydraulic performance with various flow conditions. A discharge rating curve relatively close to the Fayetteville gage (located on the Fayetteville Bridge 700 ft upstream of the proposed structure) was preferred by the sponsor instead of the lower rating curve expected after dredging the navigation channel (Plate 2). Various discharge rating curves were developed by varying the base width of the weir and the height of the grade-control structure (Plates 3-8). Discharges of 1,000 to 5,000 cfs were considered typical summer discharges on the Kaskaskia River. A discharge of 42,000* cfs was used to check the stability of the grade-control structure without the sheet-pile cutoff wall simulated in the model. Developments and tests of the grade-control structure are given in the following paragraphs.

* Maximum discharge capacity of the model facility.

Type I (Original) Design Structure

10. Type I was the original design proposed for the grade-control structure located 700 ft downstream from Fayetteville Bridge. The type I design (Plate 1) reproduced a 460-ft length of the grade-control structure, the sheet-pile cutoff wall, and 800 ft of exit channel with riprap bank protection. The original length of the weir was 160 ft at el 364 with a 1V-on-6.4H sloping apron to el 357 and a 350-ft horizontal apron (Plate 9). Details of the type I (original) design grade-control structure are shown in Plates 10 and 11.

11. Basic data for various flows obtained from the model are presented in Table 1. The observed rating curve with the type I design grade-control structure was approximately 1 ft below the headwater rating curve at the Fayetteville gage for flows up to 30,000 cfs (Plate 3). Flows above 30,000 cfs resulted in headwaters similar to the existing preproject condition.

12. Velocities at a position simulating 2 ft below the water surface were measured for flows of 5,000, 25,000, and 35,000 cfs; the maximum velocities occurred at the weir (5.8, 8.9, and 9.6 fps, respectively, as shown in Plates 12, 13, and 14). The maximum differential head of 1.3 ft was recorded with a discharge of 35,000 cfs.

13. Flows of 5,000, 25,000, and 35,000 cfs generated the flow patterns presented in time-lapse (10-sec exposure, prototype) Photos 1, 2, and 3. With total discharges of 5,000 cfs and less, the unit discharge (discharge per foot of width) in the exit jet downstream of the structure was concentrated to about 6 and 4 times that flowing upstream of and through the structure, respectively. With a total discharge of 25,000 cfs, the unit discharge of flow downstream of the structure was about 4 and 2 times that flowing upstream of and through the structure, respectively. The unit discharge downstream of the structure was about 3 and 2 times that flowing upstream of and through the structure with a total discharge of 35,000 cfs. The original riprap protection proposed for the grade-control structure remained stable. Velocities of 5 to 10 fps near the water surface were associated with the flow patterns

shown in Photo 3 and Plate 14, for a 35,000-cfs discharge.

Type II Design Structure

14. For the type II design, the grade-control structure was modified by narrowing the weir to a width of 140 ft and reducing the side slopes to 1V on 3.5H in an effort to raise the headwater closer to that of the existing Fayetteville gage rating curve. Tests were conducted to determine changes in the headwater and to observe flow patterns with all discharges up to 35,000 cfs. Comparison of this rating curve with the Fayetteville gage (Plate 4) indicated that the type II design grade-control structure provided headwaters approximately 1.5 to 0.6 ft less than those existing with flows ranging from 6,000 to 14,000 cfs. Flows above 14,000 cfs created a gradual increase in headwater up to the existing Fayetteville gage stage at 30,000 cfs as shown in Plate 4. Flows of 30,000 to 32,000 cfs had essentially the same stage as currently exists.

Type III Design Structure

15. For the type III design structure, the width of the weir was reduced to 120 ft while retaining the crest at el 364 and the weir side slopes were flattened to 1V on 4H (with respect to the original type I). The model tests with discharges up to 35,000 cfs indicated that the narrower grade-control structure improved performance relative to matching existing stages. Comparison of stage relations of the Fayetteville gage and the type III design structure discharge rating curve is shown in Plate 5. The flow patterns and the surface waves remained essentially unchanged relative to those of the original design structure.

Types IV and V Design Structures

16. It was evident from the test results of the types I, II, and III designs of the proposed grade-control structure that narrowing the

weir decreased the flow area and increased the headwater. However, decreasing the width of the weir to 100 ft (type IV design structure) resulted in velocities greater than 8 fps (the maximum allowable velocity desired with low flows of 1,000 to 5,000 cfs). Therefore, for the type V design, a 120-ft-wide weir was retained with crest at el 364, but the weir side slope was steepened (with respect to type III) to 1V on 3.5H. Rating curves of the type V design structure and the Fayetteville gage are compared in Plate 6. Varying the side slopes of the weir as shown in Plate 15 had a minimum effect on flow patterns, current velocities, and water-surface profiles; therefore, the original 1V-on-3H side slope was considered appropriate.

Type VI (Recommended) Design Structure

17. Tests of the type VI (recommended) design structure were conducted using the existing topography furnished during the study by the U. S. Army Engineer District, St. Louis (LMS). Representatives from the U. S. Army Engineer Waterways Experiment Station, Lower Mississippi Valley Division, and LMS reviewed results of all grade-control structure designs and selected the type VI design as the most appropriate (Plates 16 and 17). The type VI (recommended) design structure consisted of a 120-ft-wide weir with its crest at el 364 and 1V-on-3H side slopes up to el 384. Rounded transitions were provided to the upper slopes which were 1V on 16H and 1V on 13.3H at the left and right respective banks of the grade-control structure (looking downstream) and which extended up to el 390 as shown in Plate 18. Note that the top of the left bank is el 394 and the top of the right bank is el 396. Other details of the type VI (recommended) design grade-control structure are shown in Plate 18 also.

18. The type VI recommended design structure was tested with and without a sheet-pile cutoff wall for performance comparison purposes. Expected flows ranging from 1,000 to 35,000 cfs were used in all tests. The model of the proposed rock-constructed structure was tested with and without the sheet-pile cutoff wall and found to be stable and performed

satisfactorily for all discharges investigated. The rating curves of the type VI (recommended) design (with and without a sheet-pile cutoff wall) are compared with the Fayetteville gage structure curve in Plates 7 and 8, respectively. The headwaters for the model structure with a simulated sheet-pile cutoff wall were only slightly higher (0.2 ft maximum) than those of the structure without the simulated sheet-pile cutoff wall under the same flow conditions. This is probably due to water seepage through the model riprap that may be more permeable than the prototype structure. The headwaters due to the type VI design structure and the average velocities measured 2 ft below the surface in the center of the weir with and without the simulated cutoff wall are presented in Tables 2 and 3.

19. Discharges of 1,000 to 5,000 cfs were considered typical of summer discharges for the Kaskaskia River. Typical surface flow patterns for the range of summer flows (discharges of 1,000 to 5,000 cfs) are shown in Photos 4-8. The magnitude and direction of flows measured 2 ft below the water surface (Plates 19-23) indicated that a maximum mean surface velocity of 6.3 fps (maximum allowable 8 fps) occurred with the discharge of 5,000 cfs. Velocities ranging from 2.3 to 6.3 fps were measured throughout the 150-ft reach of approach channel and the 200-ft reach of the exit channel with the discharge of 5,000 cfs as shown in Plate 23. Although eddies formed downstream of the grade-control structure, no severe crosscurrents and/or waves that are considered adverse to small navigation craft were observed. With total discharges of 1,000 to 5,000 cfs, the unit discharge of flow in the exit jet downstream of the type VI (recommended) design structure was concentrated to about 3 and 2 times that flowing upstream of and through the structure, respectively. This was a flow concentration of only one half that observed with the type I original design structure.

20. Additional tests of the type VI (recommended) design structure were conducted to evaluate riprap stability, observe flow patterns, and measure current velocities for discharges of 10,000, 20,000, and 35,000 cfs, with tailwaters of 374.5, 380.5, and 385.6, respectively (Photos 9, 10, and 11). For each of these discharges, several eddies

formed upstream and downstream of the grade-control structure. With a discharge of 10,000 cfs (Photo 9) eddies with velocities <2 fps occurred on the upstream left bank (looking downstream, Plate 24). These eddies were altered to complex forms with the higher discharges (Photos 10 and 11, Plates 25 and 26). With total discharges of 10,000 and 20,000 cfs, the unit discharges in the exit jet downstream were only 3 and 2 times that flowing upstream of and through the structure also. The unit discharge in the exit jet downstream of the type VI (recommended) design structure was only 2 and 1.5 times that flowing upstream of and through the structure, respectively, with a discharge of 35,000 cfs. A discharge of 35,000 cfs resulted in a maximum near-surface velocity of 10.2 fps near the center of channel. A maximum eddy velocity of 5.7 fps was measured with the 20,000-cfs discharge as shown in Plate 25. Although these eddies and currents were nonsymmetrical throughout the channel, there was no evidence that either bank was attacked severely during the full range of flows. However, it appeared that the flow tended to concentrate on the left side of the exit channel with a larger and stronger eddy or eddies along the right bank due to the unsymmetrical approach and flow concentration downstream that results when the exit channel is significantly wider than the structure. The magnitudes and directions of near-surface velocities measured 2 ft below the water surface are provided in Plates 24, 25, and 26, and Photos 9, 10, and 11, respectively. Eddy velocities of less than 2 fps were also measured as indicated in Plate 26. Test results indicate that the sheet pile has no effect on the stability of riprap and very little effect on the velocity and headwater.

Riprap Protection

21. A dry-bed photograph of the type VI (recommended) grade-control structure (Figure 3), taken after a full range of flows, shows some scour of the exit channel downstream of the 400-ft length of bottom riprap protection. The type C graded stone was adequate protection against currents and surface waves on the downstream channel banks for

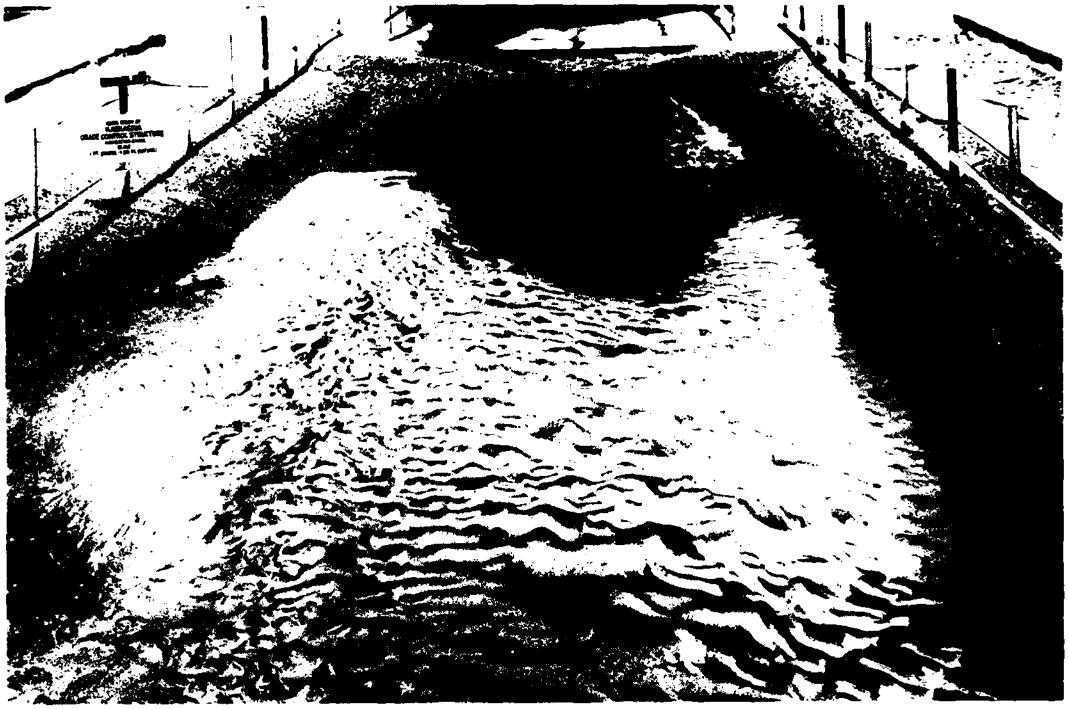


Figure 3. Dry bed after full range of discharges up to 42,000 cfs

800 ft downstream of the 400-ft bottom protection. The type A graded stone (Plate 1) remained stable for discharges of 1,000 to 42,000 cfs. Continued testing with the full range of flows caused no serious displacement of either the type A or type C graded stone. Therefore, the type A and type C graded stone was considered sufficient for the structure and the banks of the Kaskaskia River grade-control structure and navigation channel.

PART IV: SUMMARY OF RESULTS AND CONCLUSIONS

22. The original design grade-control structure performed satisfactorily with all expected discharges of 1,000 to 35,000 cfs with the exception that the headwater was below desirable levels. Several modifications of the weir portion of the structure were developed to increase the headwater and maintain adequate hydraulic performance. The structural modifications included narrowing the width of the weir from 160 to 120 ft, maintaining the 1V-on-3H side slopes from the weir invert el 364 to el 384, providing a rounded transition to the upper slopes, and providing a 1V-on-16H slope to the top of the left bank and a 1V-on-13.3H slope to the top of the right bank (looking downstream). The recommended type VI design structure (Plate 18) incorporated the above modifications.

23. Model test results indicated that the simulated sheet pile had no effect on the stability of the outer layer of riprap and little effect on the headwater or seepage through the structure. Satisfactory hydraulic performance and a stable grade-control structure were observed for all discharges with and without the simulated sheet pile.

24. The general conclusions based on the results of the observed flow conditions and measured data in both the entrance and exit channel, the riprap structure, and the adjacent bank protection are that:

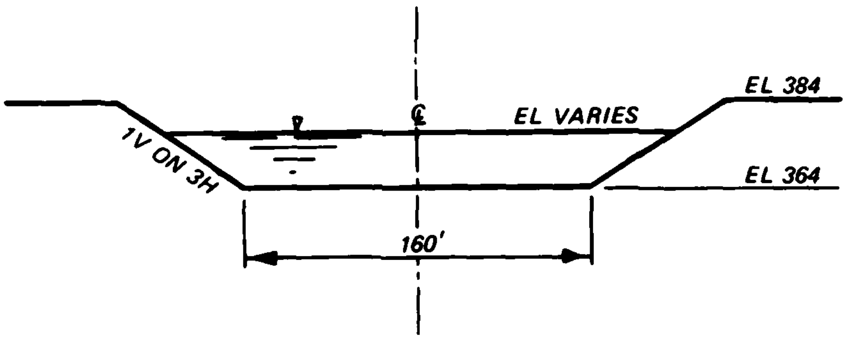
- a. The original approach channel was satisfactory, with no need for further modifications.
- b. The type VI (recommended) design with a structure weir base width of 120 ft at el 364 was optimum for maintaining existing stage-discharge relations.
- c. The minor scour downstream of the riprapped channel bottom should not endanger the integrity of the structure with discharges up to 42,000 cfs, the maximum possible in the model facility.
- d. The type A graded stone for the structure and type C graded stone for bank protection were sufficient to withstand the range of discharges from 1,000 to 35,000 cfs.
- e. A 400-ft-long blanket of type A graded stone is considered the minimum allowable for adequate protection of the downstream banks and exit channel invert. An

additional 800 ft of type C graded stone is required on each bank downstream to prevent bank erosion due to currents and surface wave action.

Table 1

Type I Design Grade-Control Structure Rating Data and Average Channel Velocity

Discharge cfs	Headwater* el, ft	Tailwater* el, ft	Velocity** fps
5,000	371.2	370.6	5.3
10,000	375.2	374.5	--
15,000	378.6	377.9	6.5
20,000	381.4	380.5	--
25,000	383.4	382.4	7.5
30,000	385.4	384.1	7.8
35,000	386.9	385.6	7.9



* Measured at 700 ft from center of structure upstream and downstream.
** Measured at 2 ft below water surface in the center of the weir.

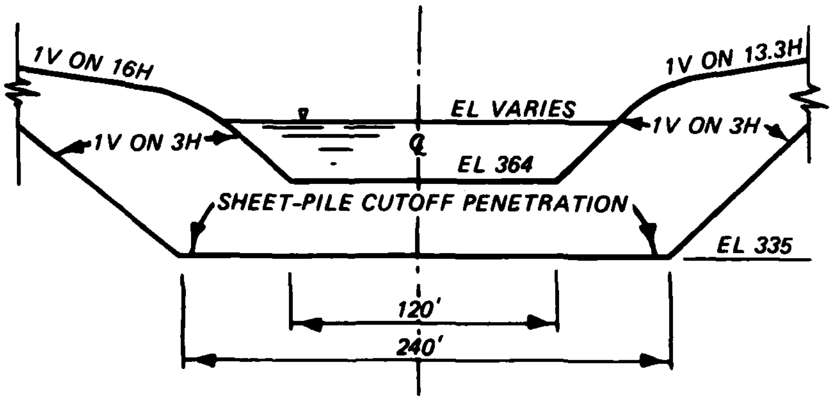
Table 2

Type VI Design Grade-Control Structure Rating Data

and Average Channel Velocity

(with Sheet Pile)

Discharge cfs	Headwater* el, ft	Tailwater* el, ft	Velocity** fps
1,000	368.5	368.2	2.9
2,000	369.1	368.7	4.0
3,000	369.8	369.3	4.2
4,000	370.7	369.9	6.4
5,000	371.6	370.6	7.3
10,000	375.6	374.5	7.8
15,000	379.1	377.9	--
20,000	381.9	380.5	7.9
25,000	384.2	382.5	--
30,000	385.9	384.1	--
35,000	387.1	385.6	--

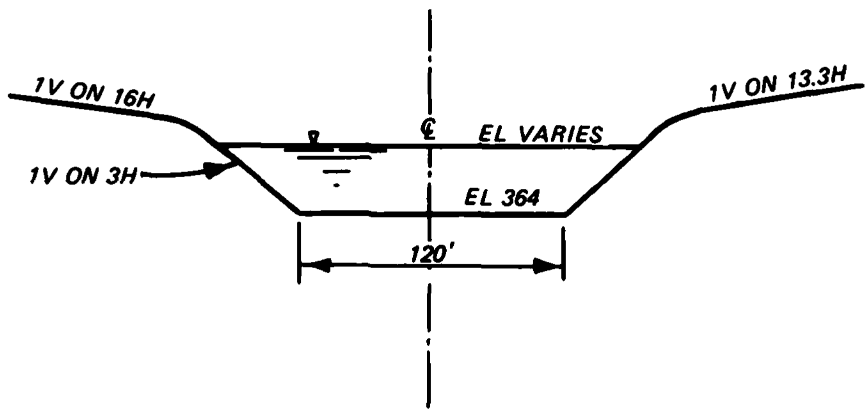


* Measured at 700 ft from center of structure upstream and downstream.
** Measured at 2 ft below water surface in the center of the weir.

Table 3

Type VI Design Grade-Control Structure Rating Data and Average Channel Velocity (Without Sheet Pile)

Discharge cfs	Headwater* el, ft	Tailwater* el, ft	Velocity** fps
1,000	368.5	368.2	2.5
2,000	369.1	368.7	3.5
3,000	369.7	369.2	3.9
4,000	370.6	370.0	5.4
5,000	371.4	370.6	5.9
10,000	375.7	374.5	7.1
15,000	379.1	377.9	--
20,000	381.9	380.5	8.2
25,000	384.1	382.4	--
30,000	385.8	384.1	--
35,000	387.1	385.6	9.0



* Measured at 700 ft from center of structure upstream and downstream.
** Measured at 2 ft below water surface in the center of the weir.

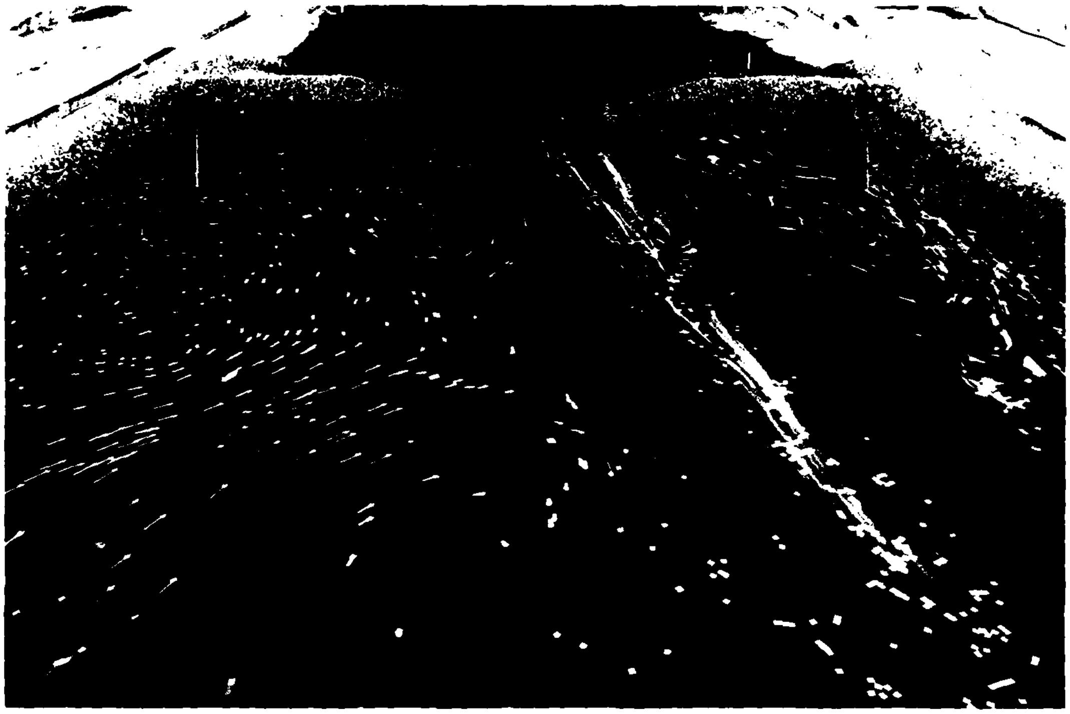


Photo 1. Flow patterns, type I (original) design; discharge 5,000 cfs, headwater 371.2, tailwater el 370.6

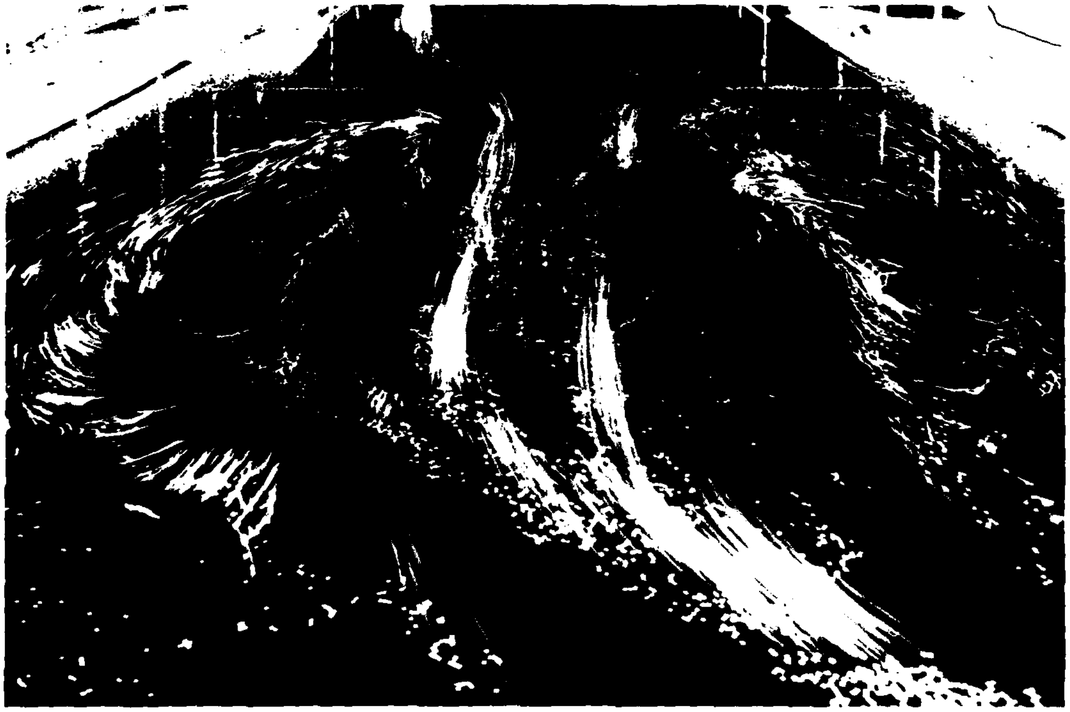


Photo 2. Flow patterns, type I (original) design; discharge 25,000 cfs, headwater 383.4, tailwater el 382.4

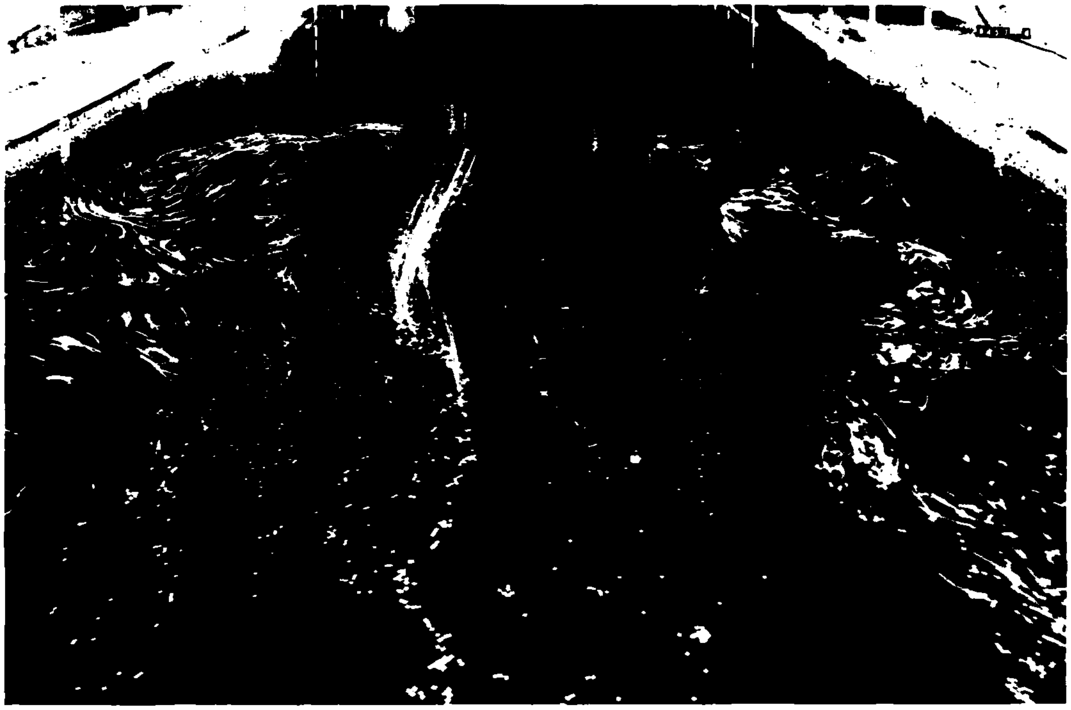


Photo 3. Flow patterns, type I (original) design; discharge 35,000 cfs, headwater 386.9, tailwater el 385.6

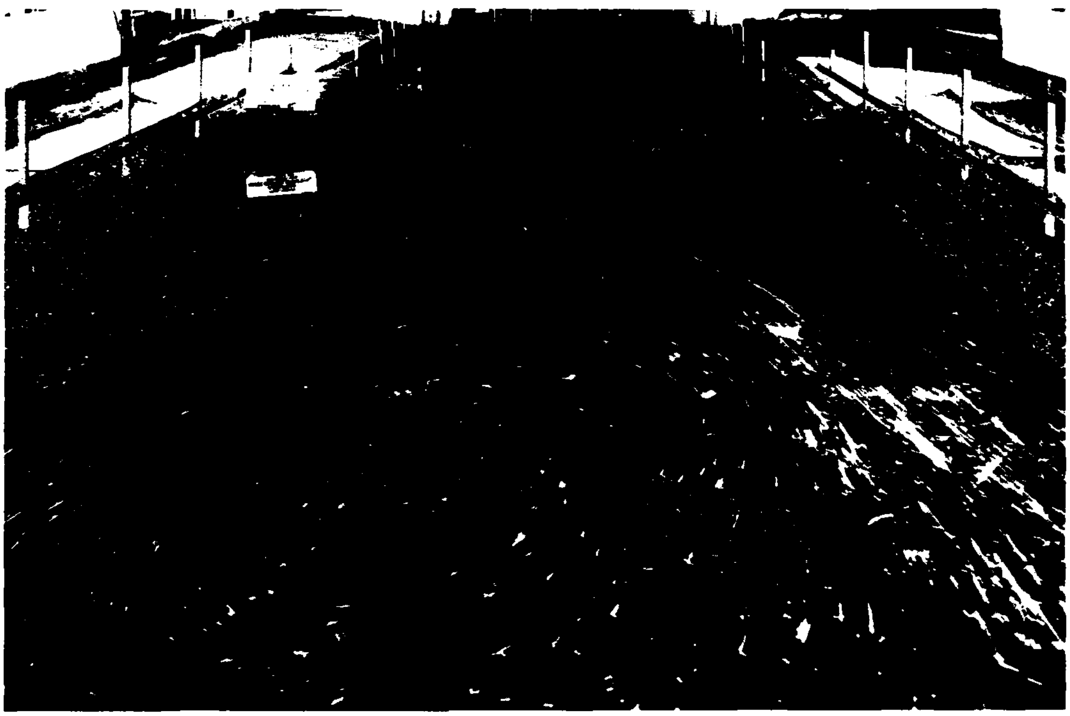


Photo 4. Flow patterns, type VI (recommended) design; discharge 1,000 cfs, headwater 368.5, tailwater el 368.2

Photo 5. Flow patterns, type VI (recommended) design; discharge 2,000 cfs, headwater 369.1, tailwater el 368.7

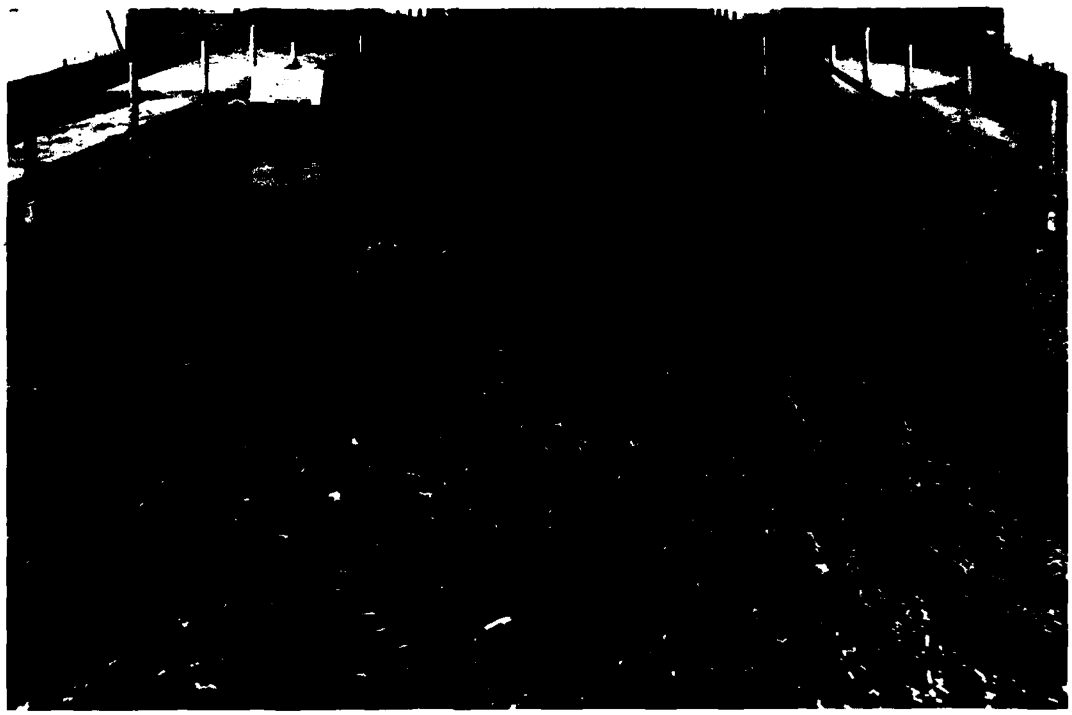


Photo 6. Flow patterns, type VI (recommended) design; discharge 3,000 cfs, headwater 369.7, tailwater el 369.2

Photo 7. Flow patterns, type VI (recommended) design; discharge 4,000 cfs, headwater 370.6, tailwater el 370.0

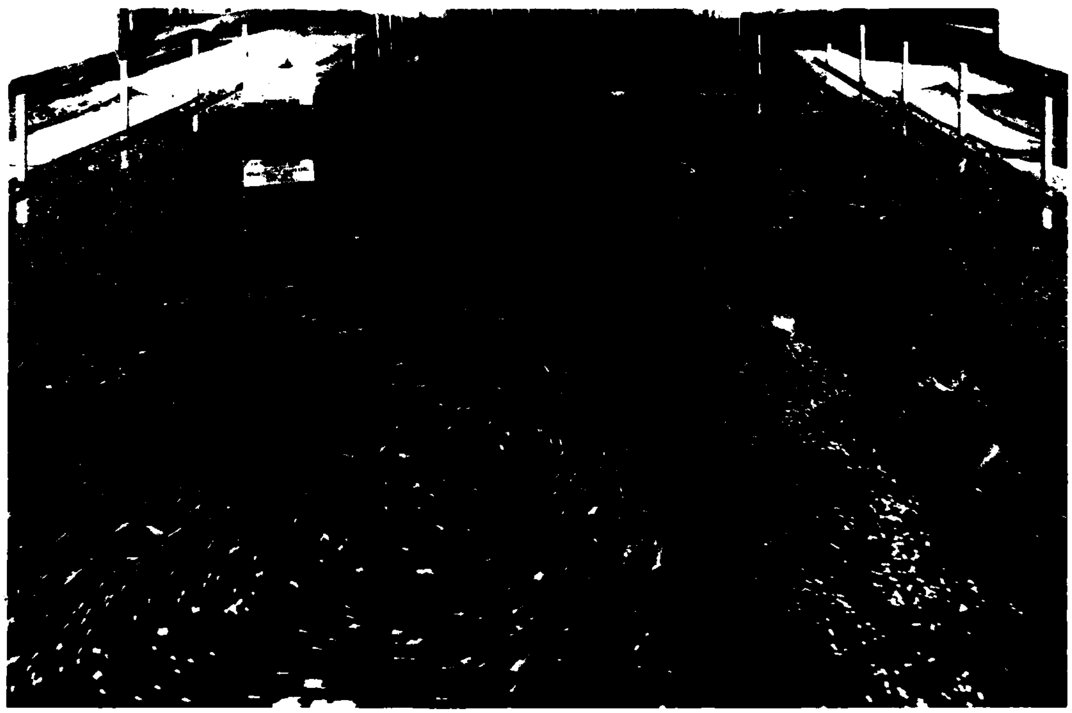


Photo 8. Flow patterns, type VI (recommended) design; discharge 5,000 cfs, headwater 371.4, tailwater el 370.6

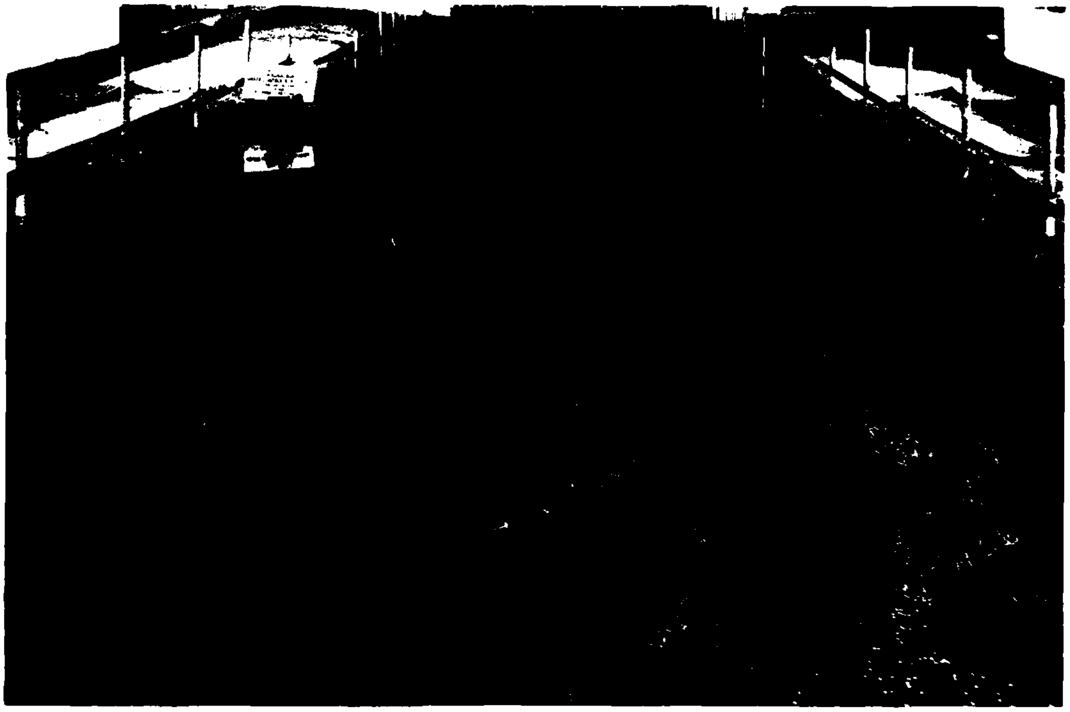


Photo 9. Flow patterns, type VI (recommended) design; discharge 10,000 cfs, headwater 375.7, tailwater el 374.5

Photo 10. Flow patterns, type VI (recommended) design; discharge 20,000 cfs, headwater 381.9, tailwater el 380.5

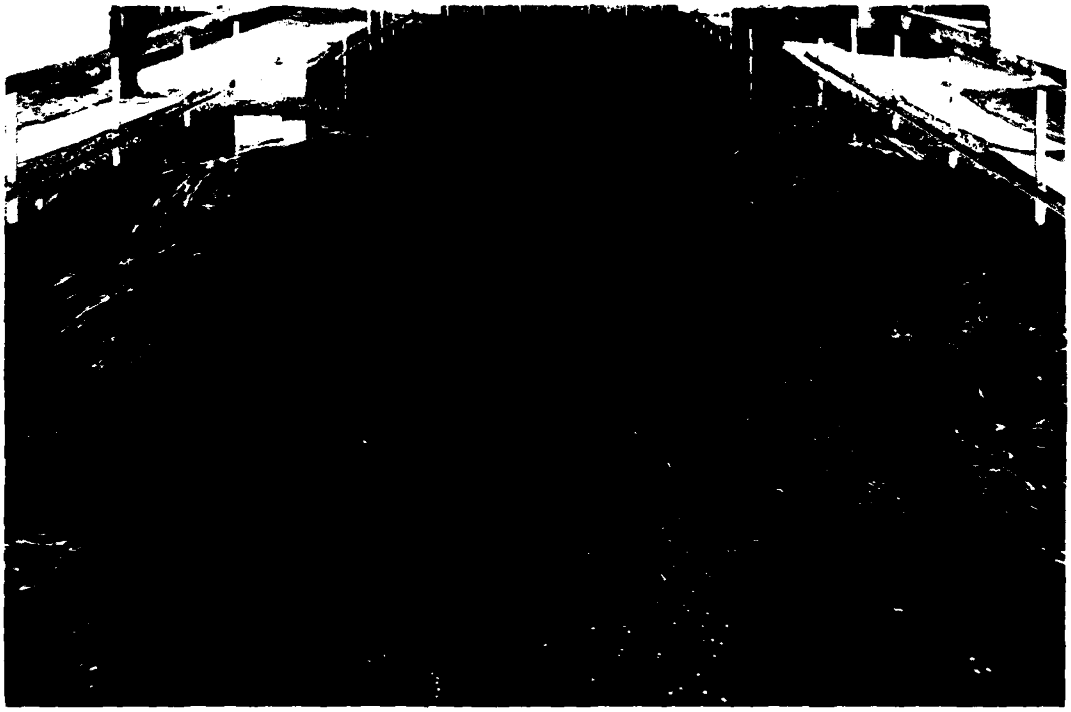
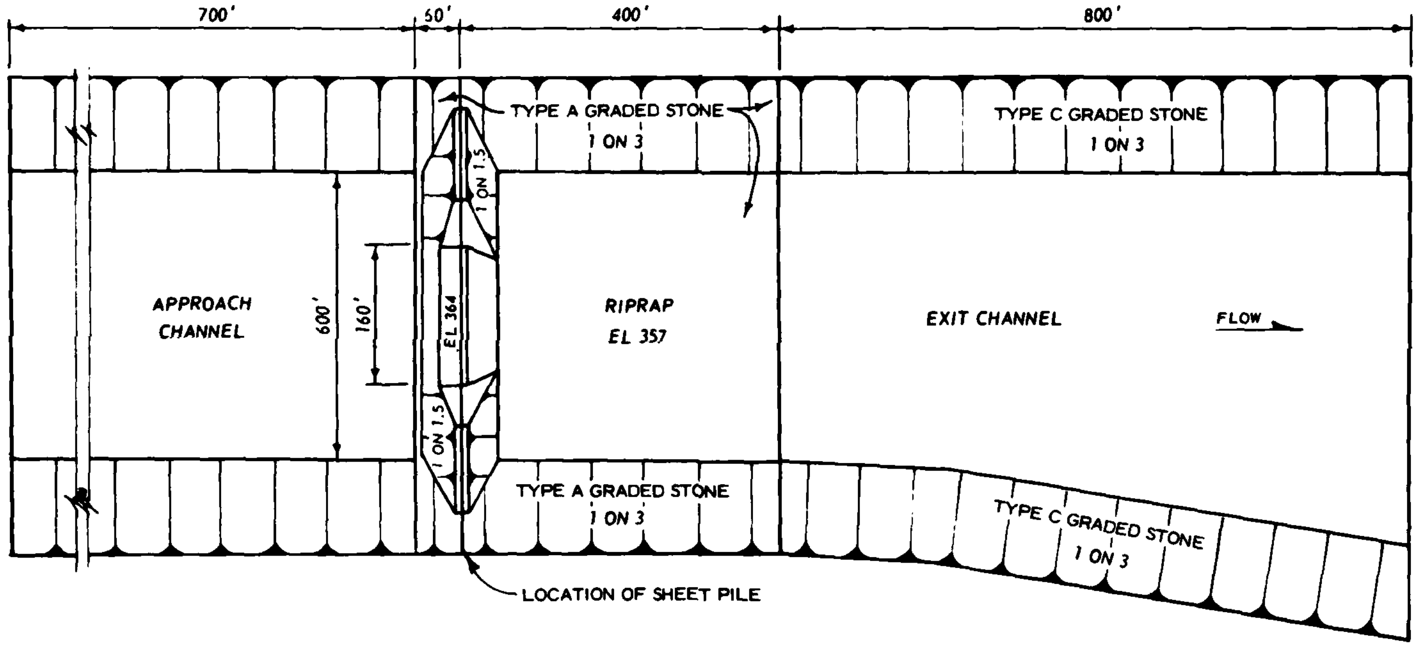


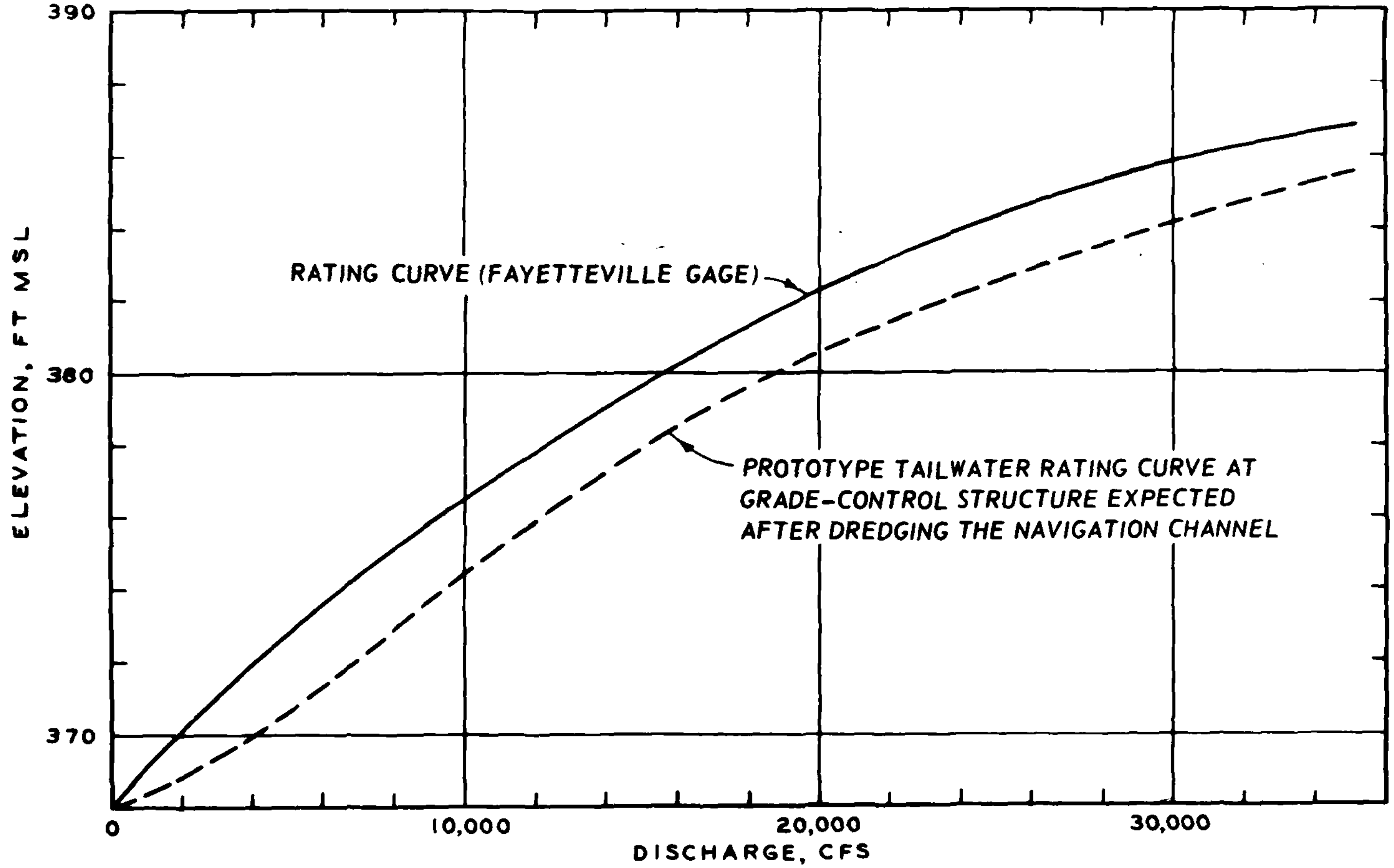
Photo 11. Flow patterns, type VI (recommended) design; discharge 35,000 cfs, headwater 387.1, tailwater el 385.6



CUMULATIVE PERCENT FINER BY WEIGHT	TYPE A GRADED STONE WEIGHT, LB
100	5000
70–100	2500
40–65	500
20–45	100
0–15	5
0–5	1

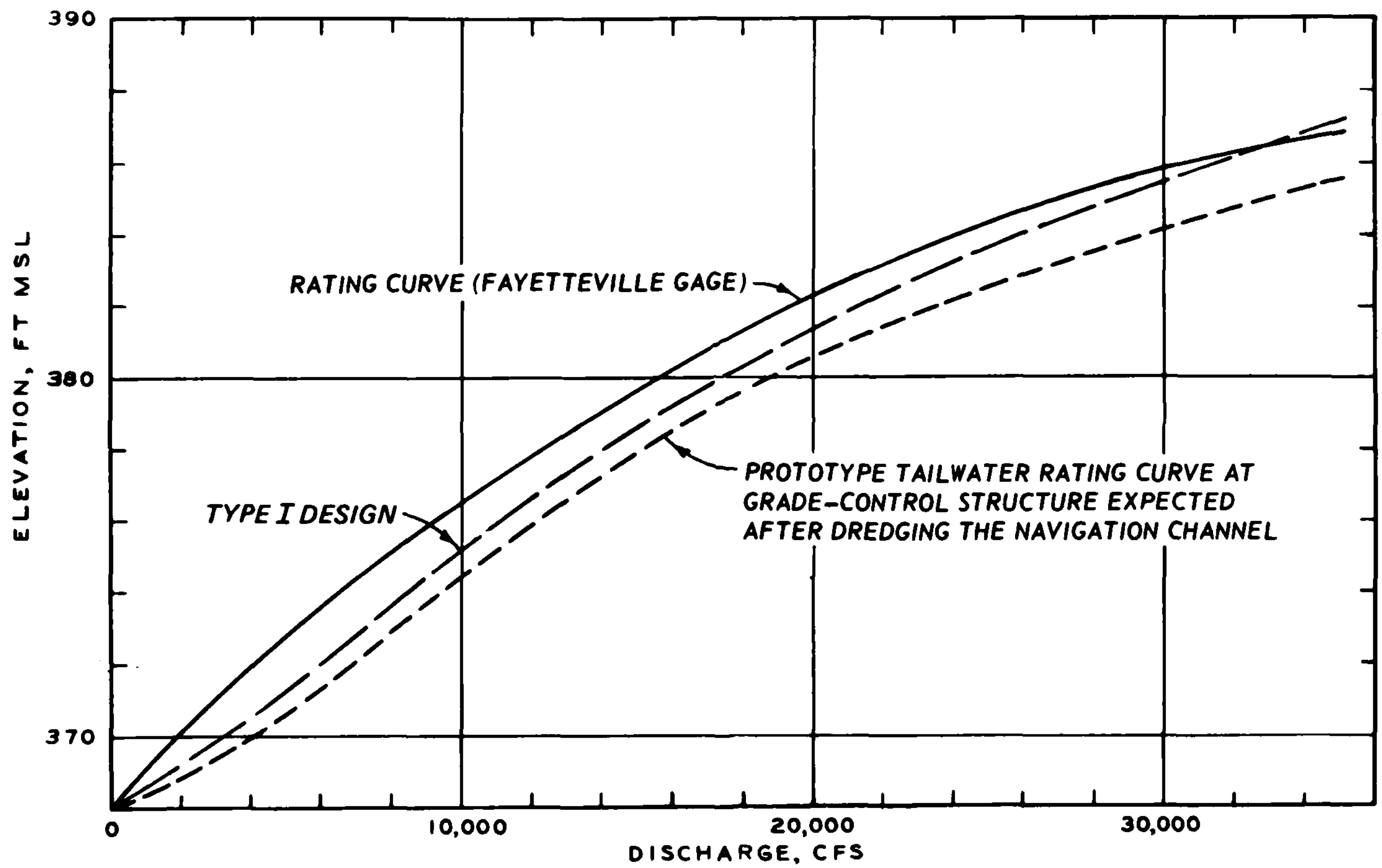
CUMULATIVE PERCENT FINER BY WEIGHT	TYPE C GRADED STONE WEIGHT, LB
100	400
70–100	250
50–80	100
32–58	30
15–34	5
2–20	1
0–5	< 1/2" MAX.

GENERAL PLAN OF
TYPE I (ORIGINAL) DESIGN
GRADE-CONTROL STRUCTURE

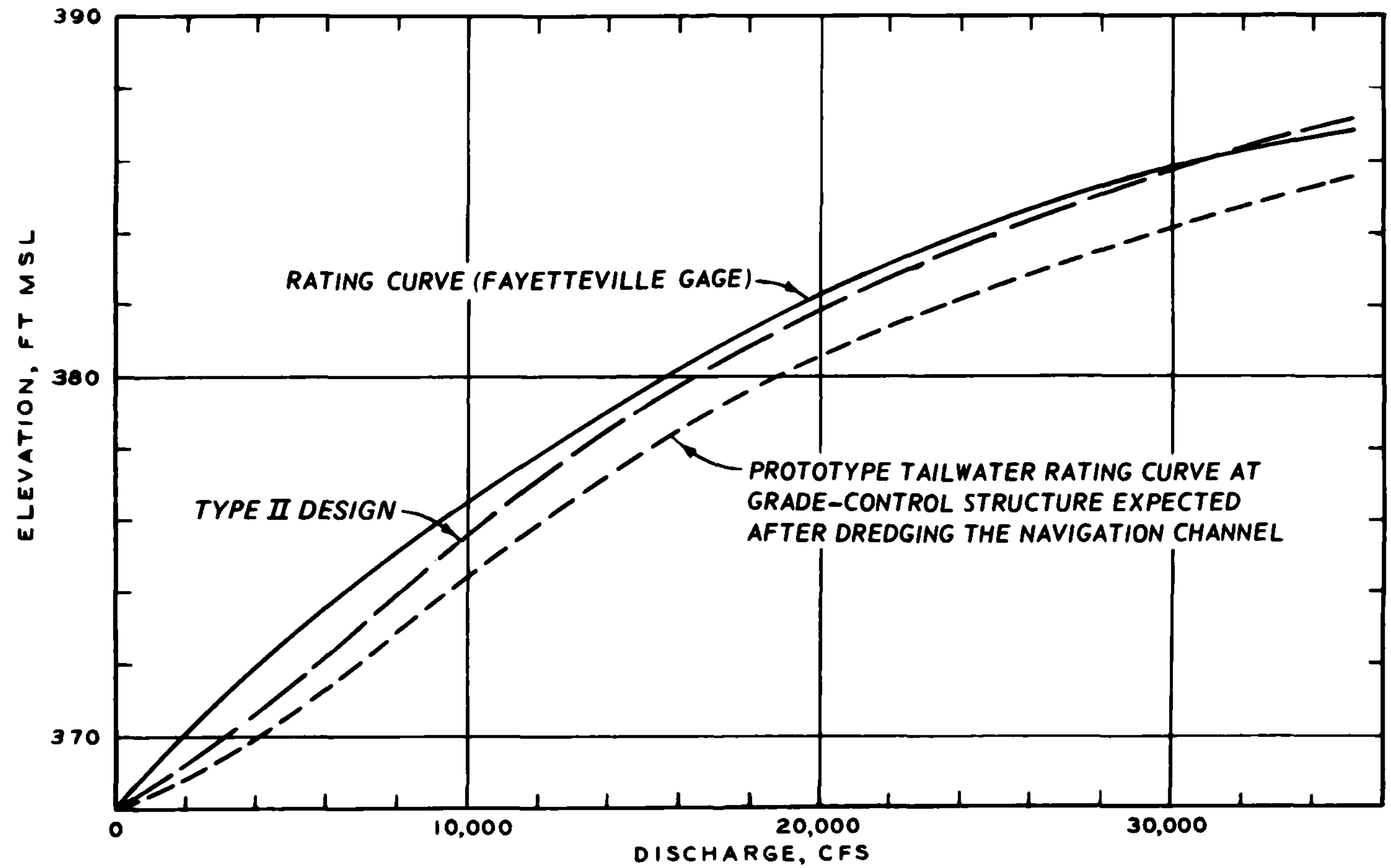


KASKASKIA RIVER
RATING CURVES

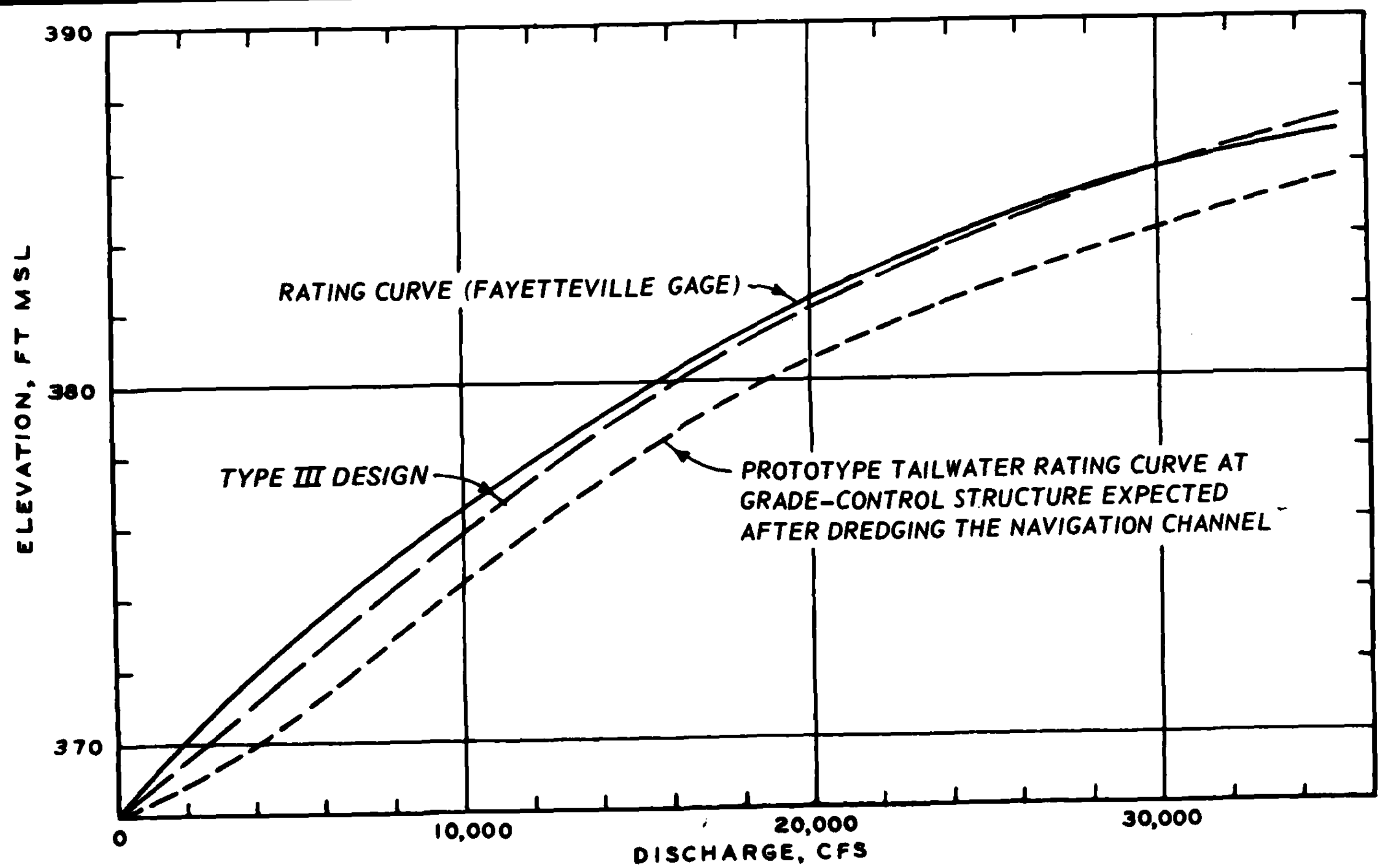
PLATE 2



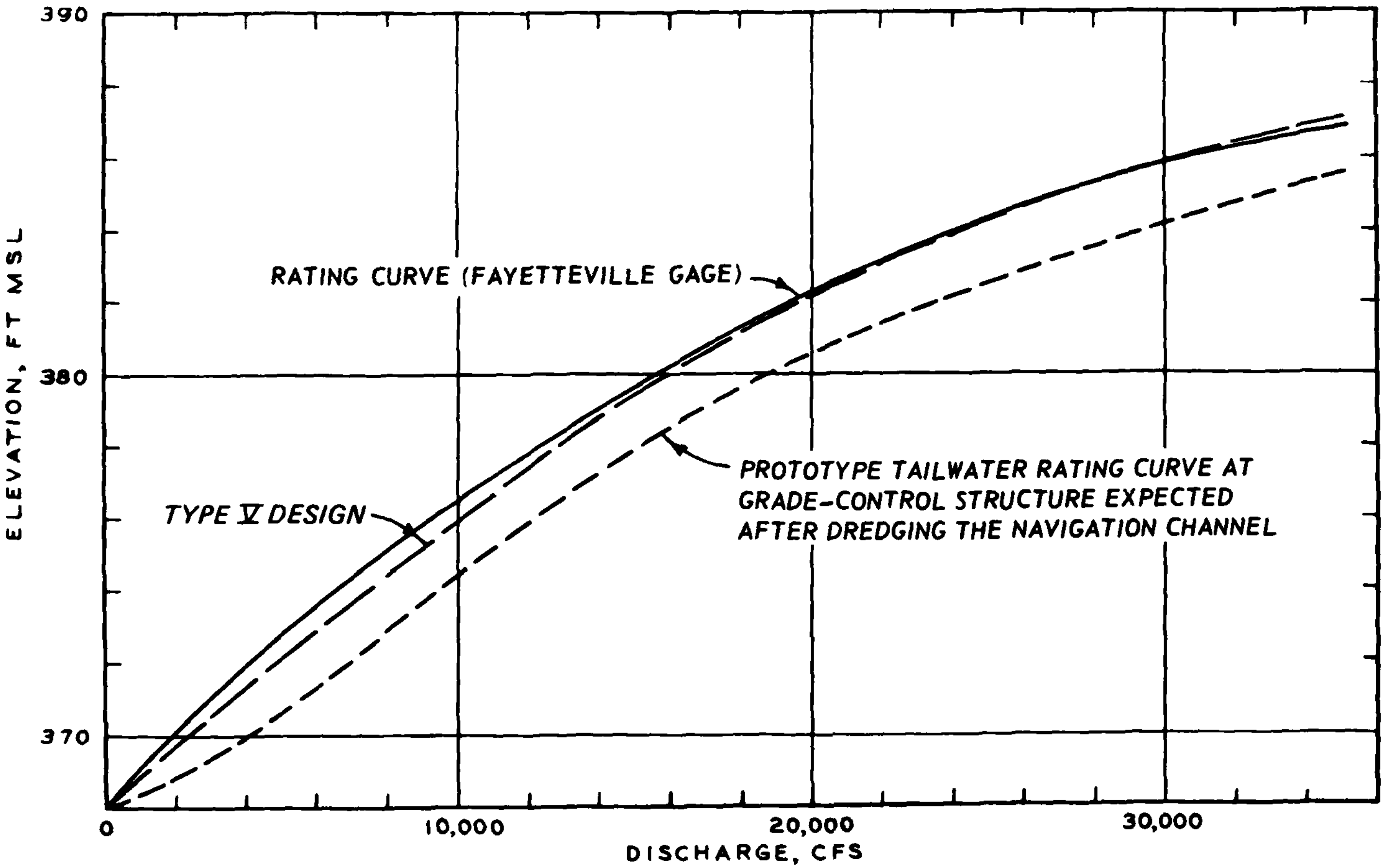
GRADE-CONTROL
STRUCTURE RATING CURVES
TYPE I (ORIGINAL) DESIGN



GRADE-CONTROL
STRUCTURE RATING CURVES
TYPE II DESIGN

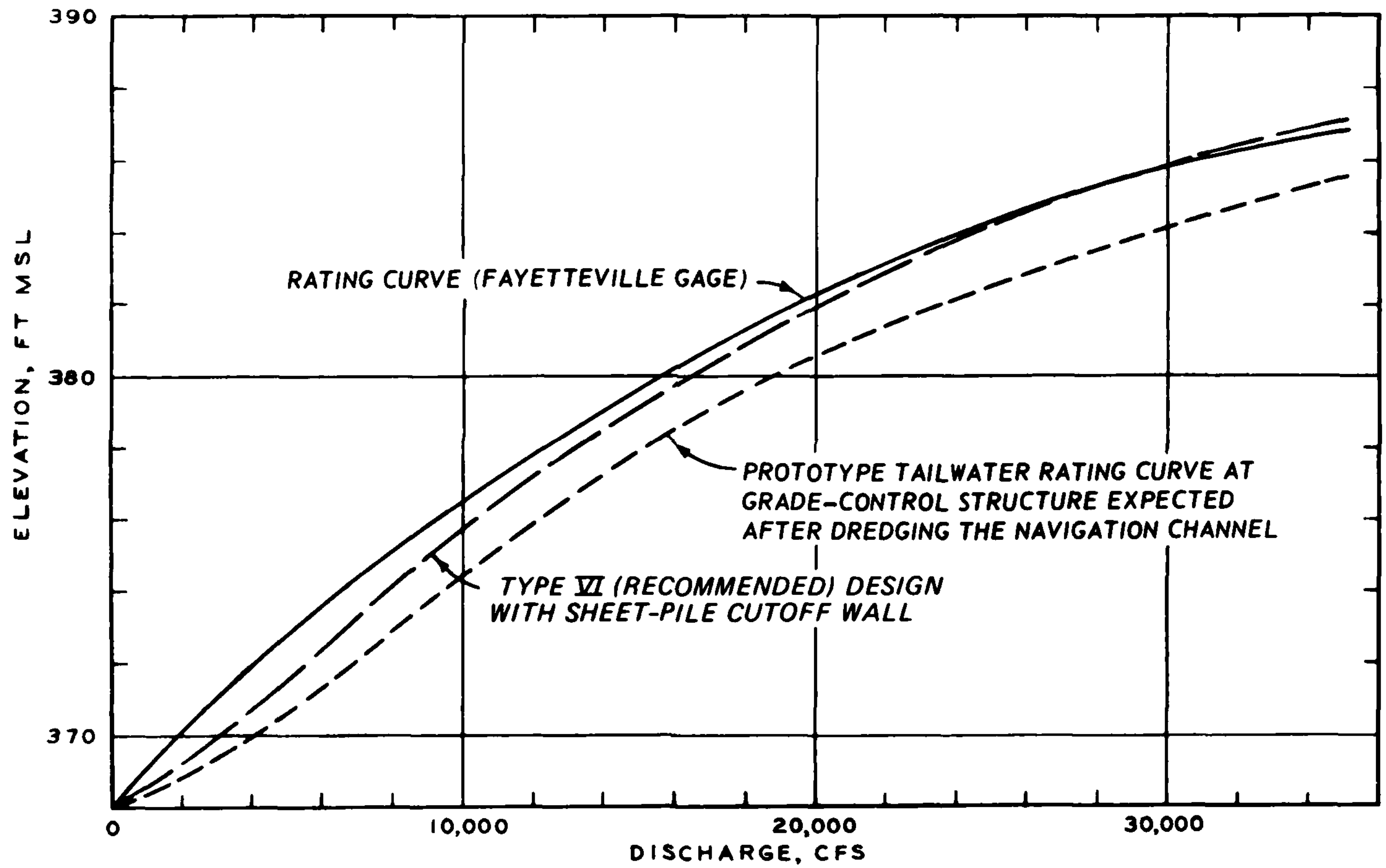


GRADE-CONTROL
STRUCTURE RATING CURVES
TYPE III DESIGN

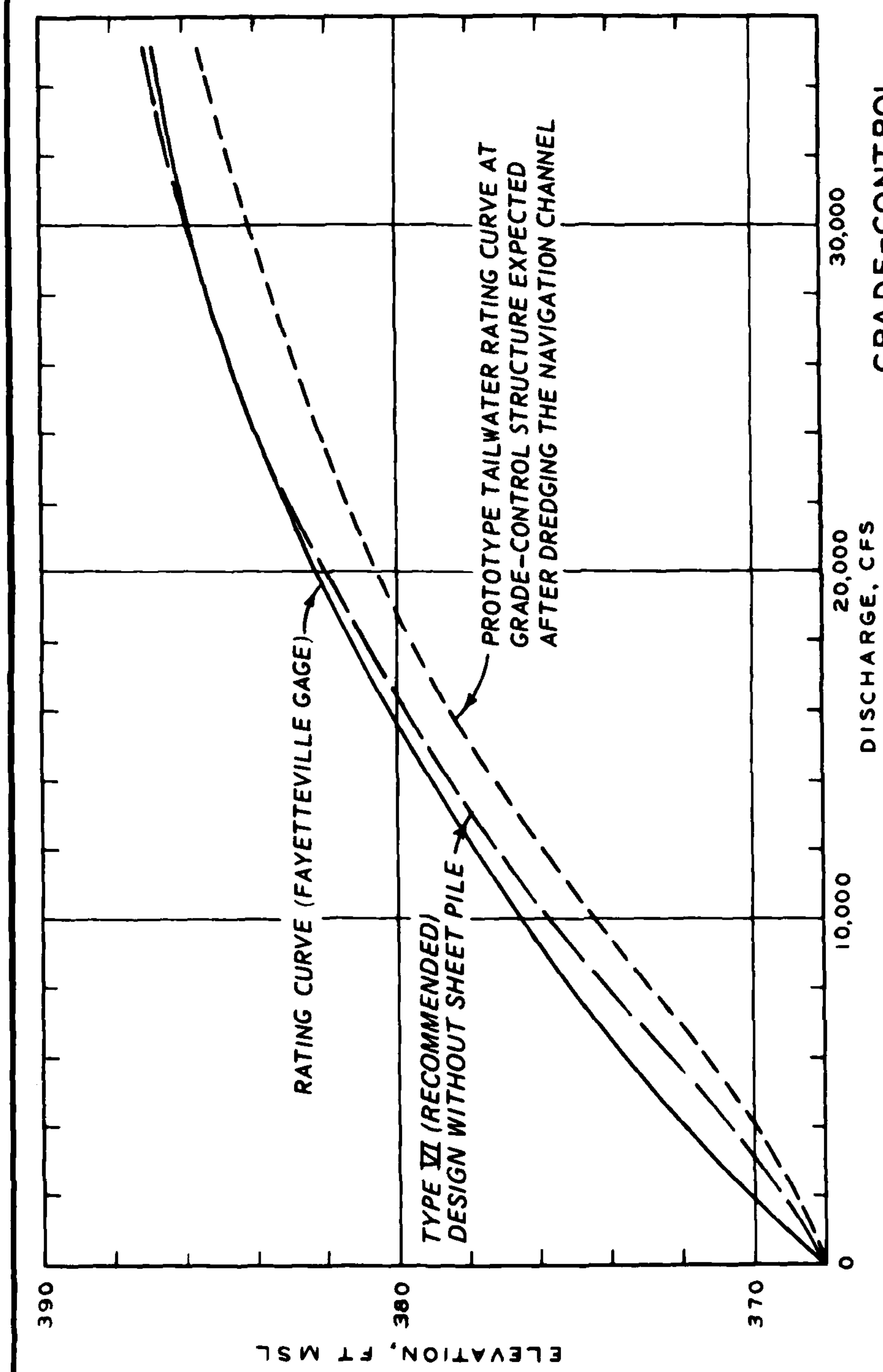


GRADE-CONTROL STRUCTURE RATING CURVES

TYPE V DESIGN

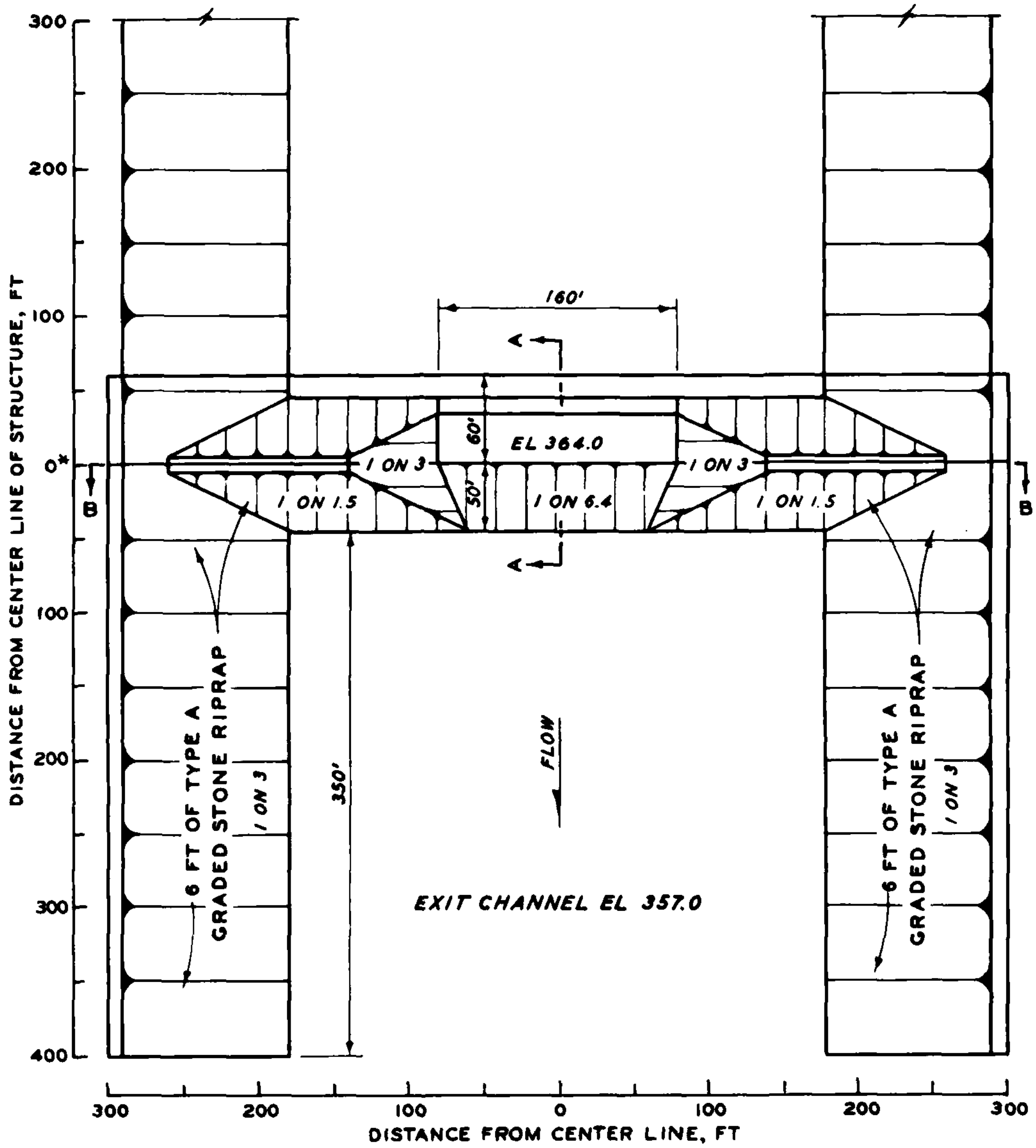


GRADE-CONTROL
STRUCTURE RATING CURVES
TYPE VI (RECOMMENDED) DESIGN



GRADE-CONTROL STRUCTURE RATING CURVES
TYPE VI (RECOMMENDED) DESIGN
(WITHOUT SHEET-PILE CUTOFF)

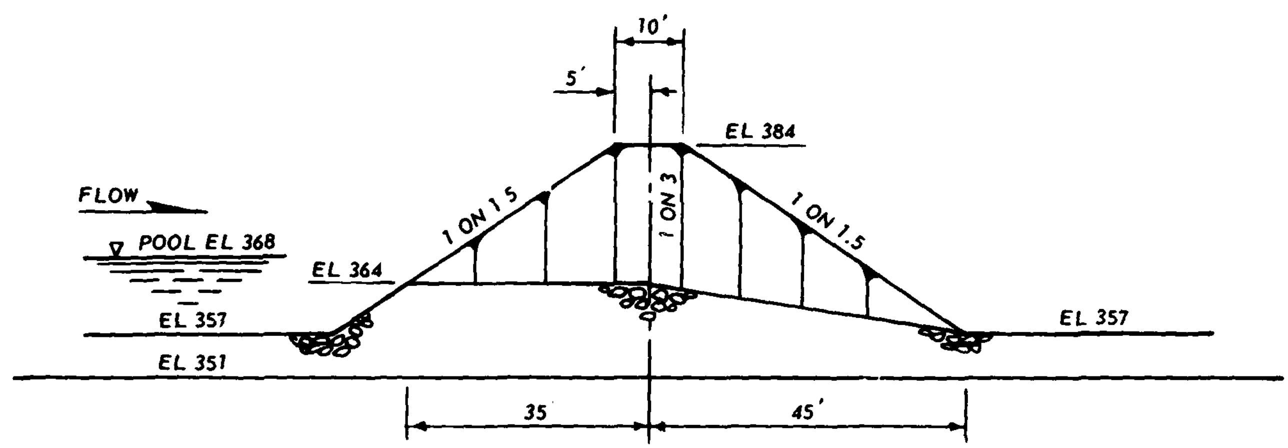
PLATE 8



NOTE: FOR DETAILS OF SECTIONS A-A AND B-B SEE PLATES 10 AND 11.

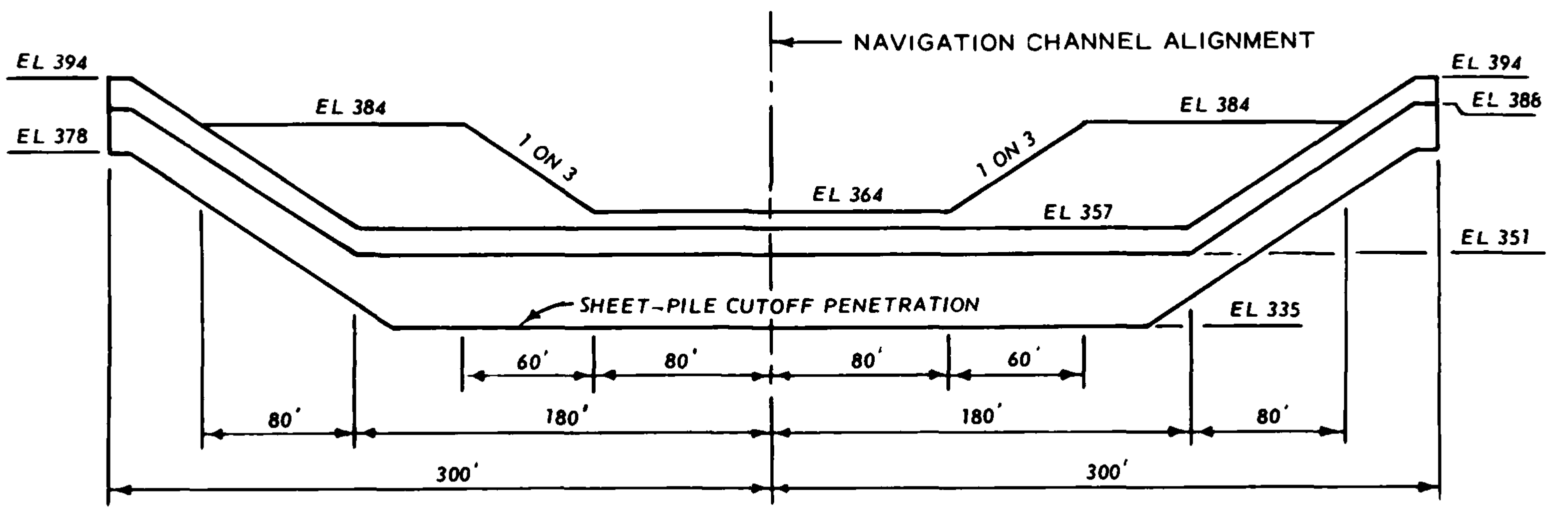
* SHEET-PILE LOCATION

GRADE-CONTROL STRUCTURE
TYPE I DESIGN



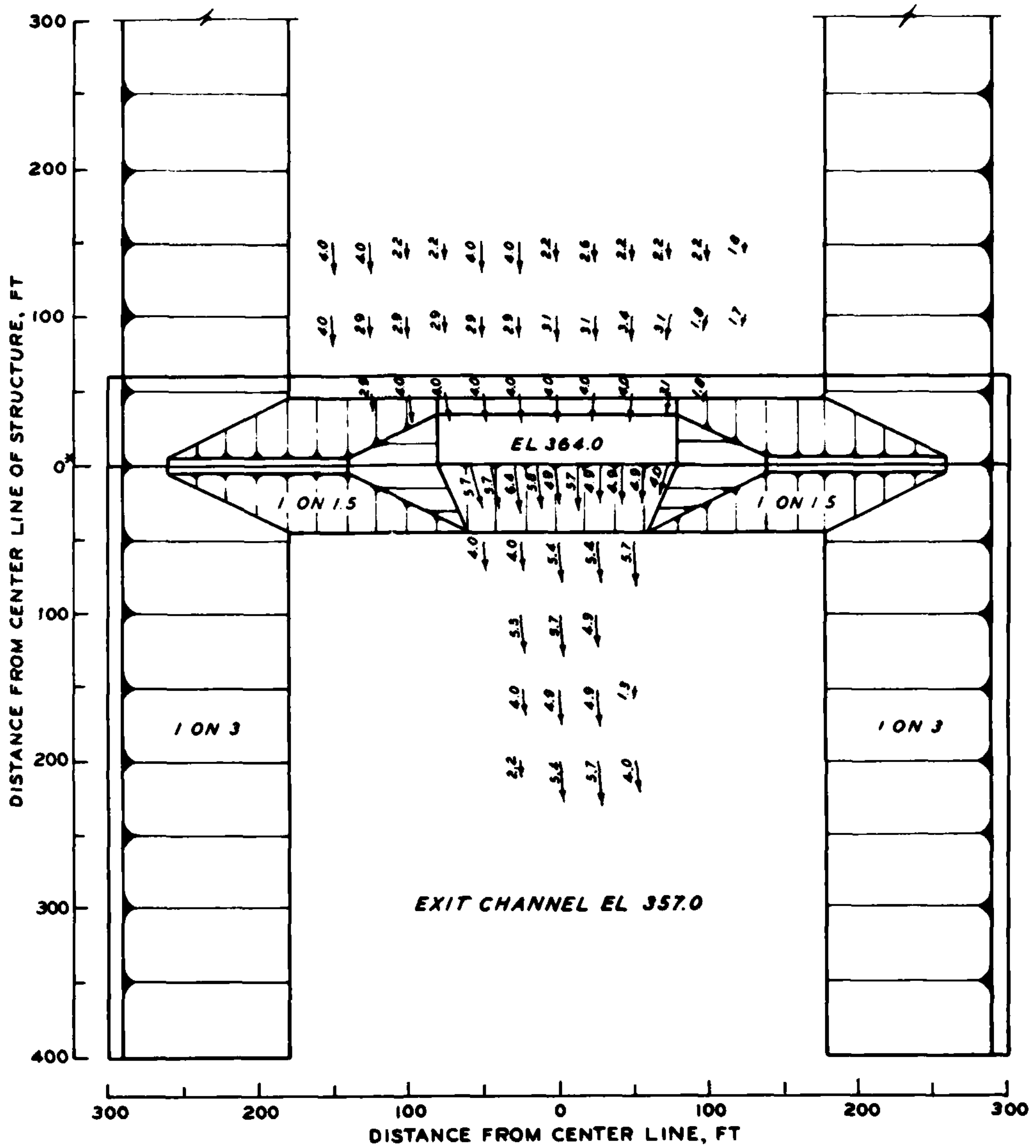
SECTION A-A

DETAILS OF
TYPE I (ORIGINAL) DESIGN
GRADE-CONTROL STRUCTURE



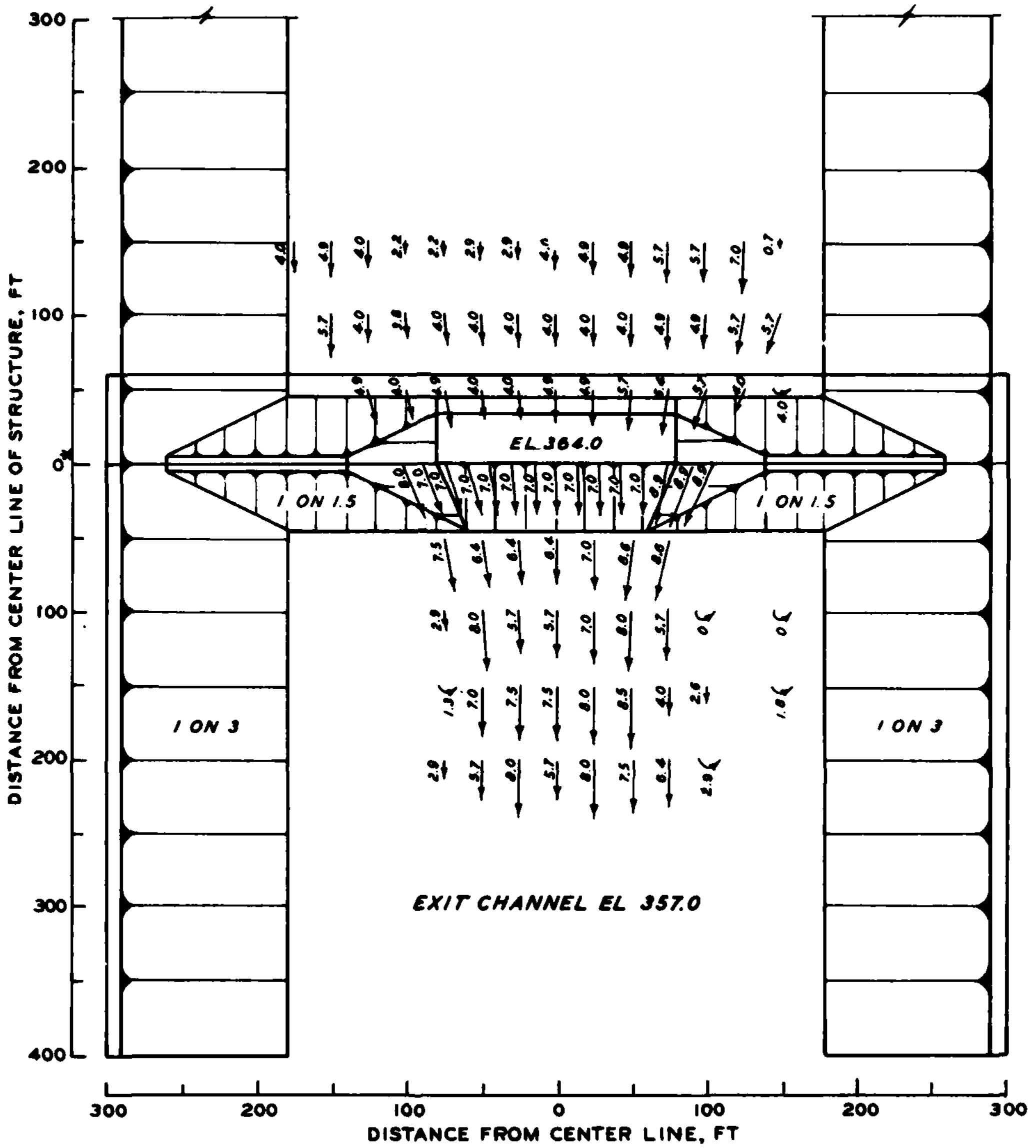
SECTION B-B

TYPE I (ORIGINAL) DESIGN



*SHEET-PILE LOCATION

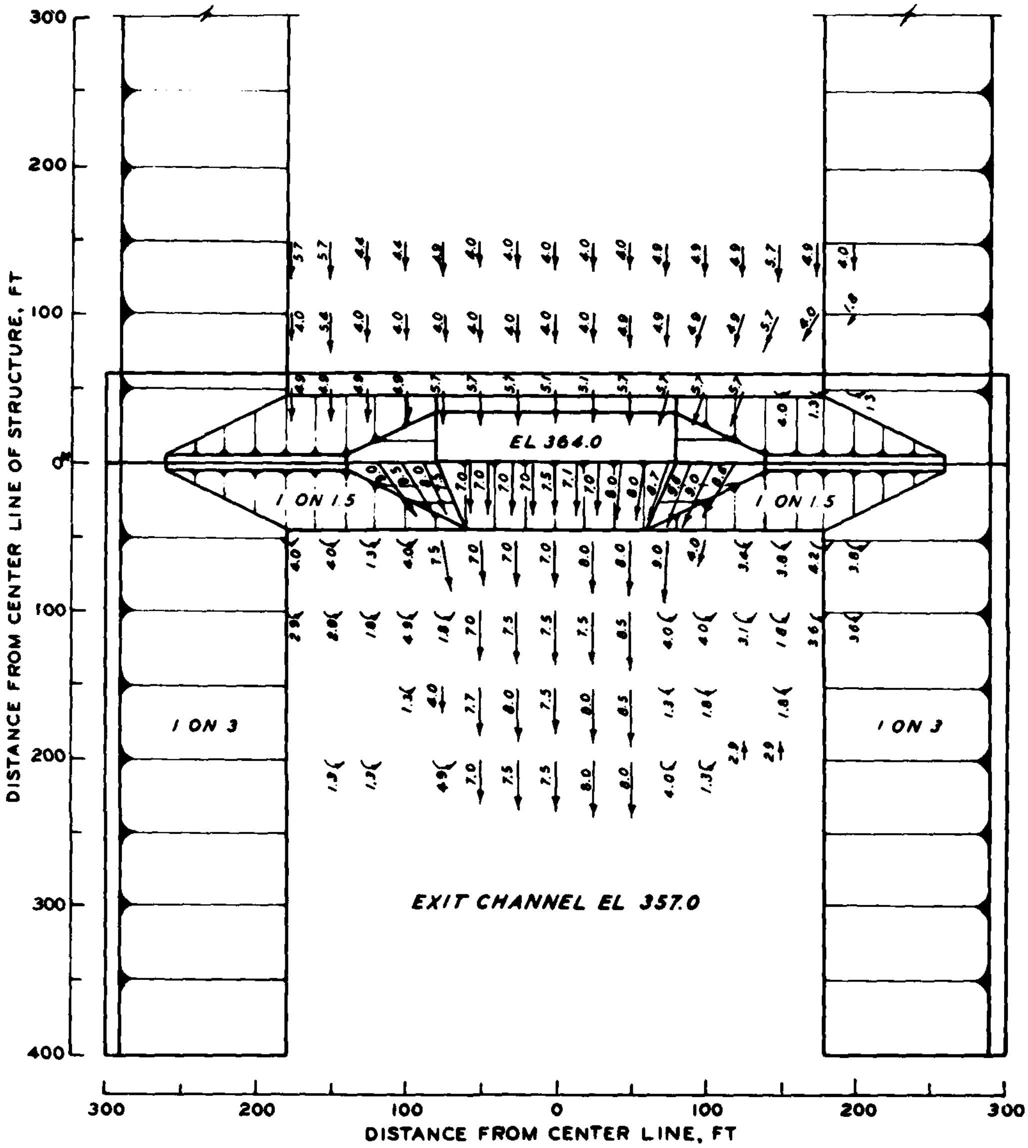
VELOCITIES
TYPE I DESIGN STRUCTURE
DISCHARGE 5000 CFS
TAILWATER EL 370.6



* SHEET-PILE LOCATION

VELOCITIES
TYPE I DESIGN STRUCTURE

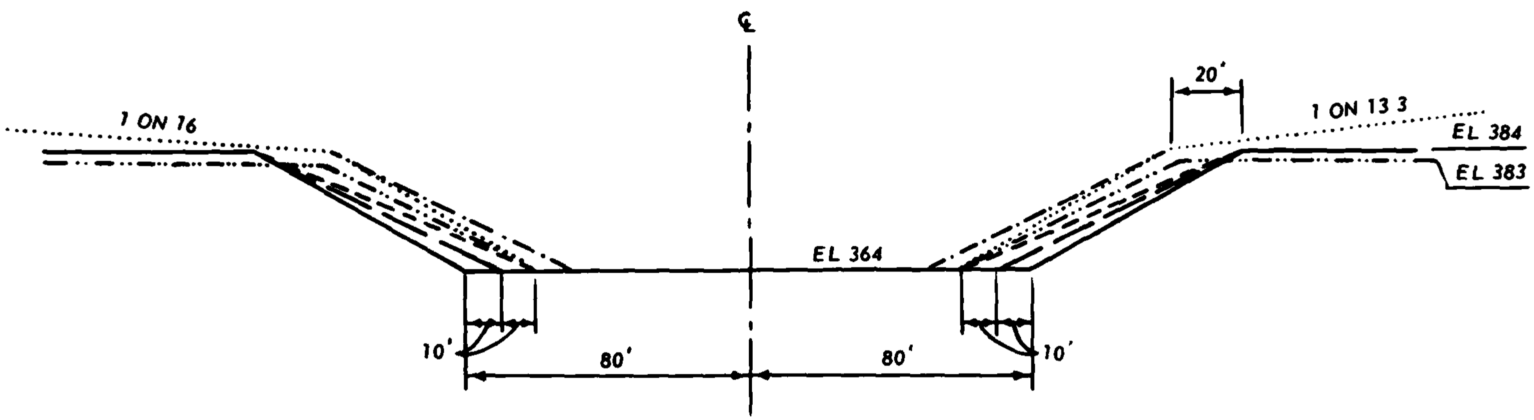
DISCHARGE 25,000 CFS
TAILWATER EL 382.4



*SHEET-PILE LOCATION

VELOCITIES
TYPE I DESIGN STRUCTURE

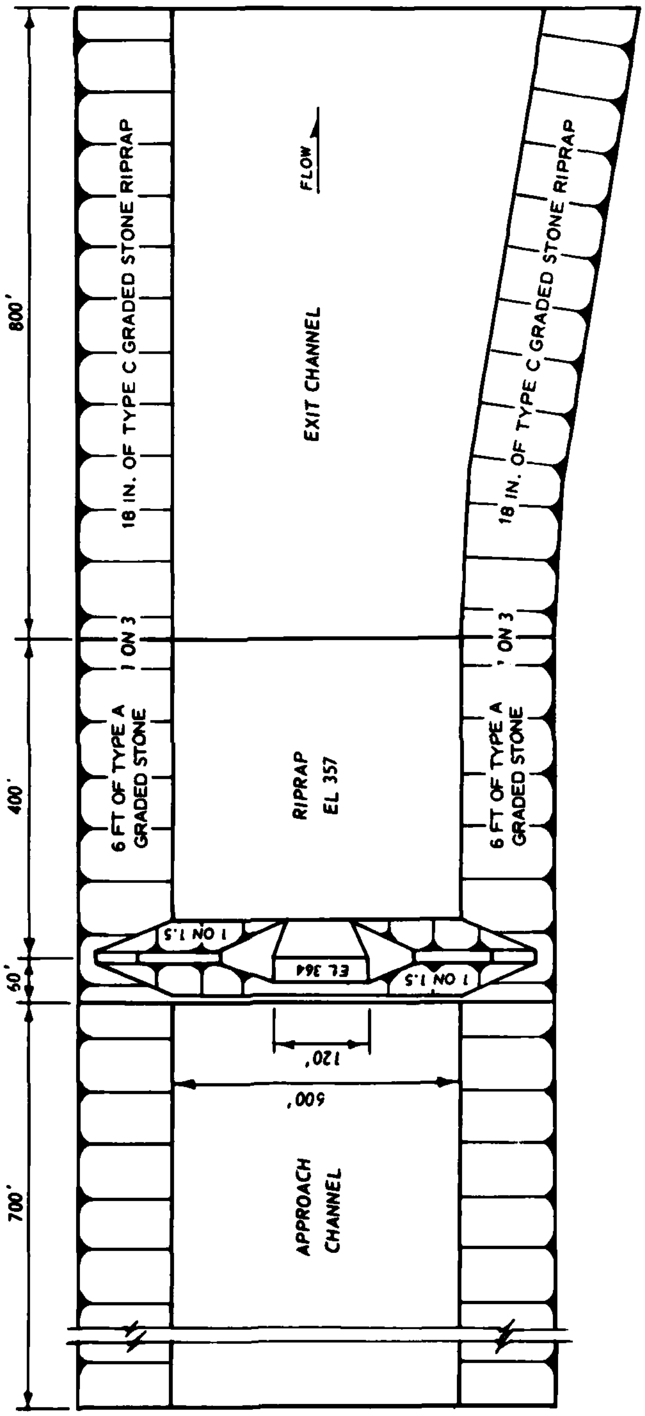
DISCHARGE 35,000 CFS
TAILWATER EL 385.6



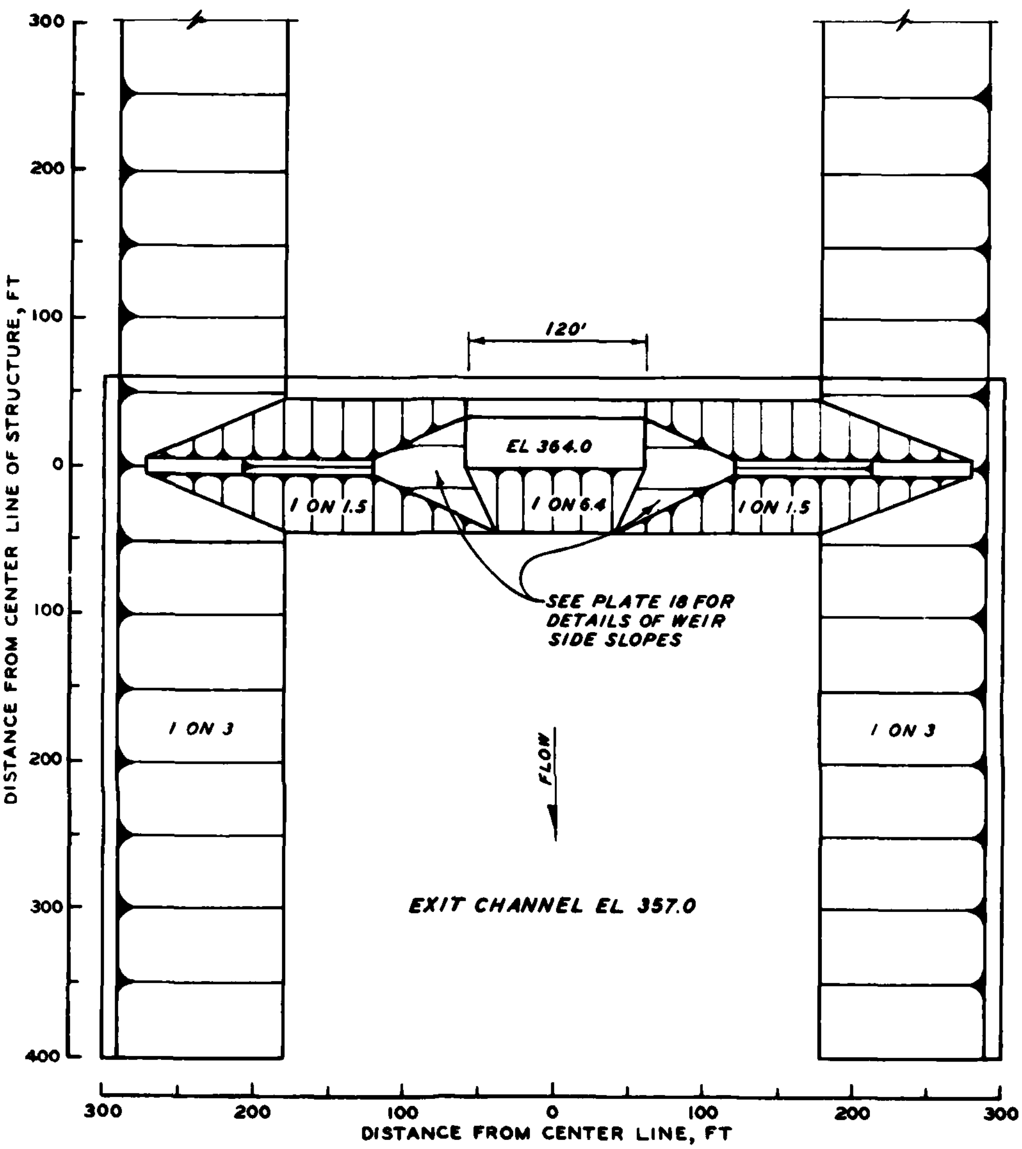
LEGEND

- TYPE I (ORIGINAL) DESIGN STRUCTURE
- TYPE II DESIGN STRUCTURE
- TYPE III DESIGN STRUCTURE
- TYPE IV DESIGN STRUCTURE
- TYPE V DESIGN STRUCTURE
- TYPE VI DESIGN STRUCTURE

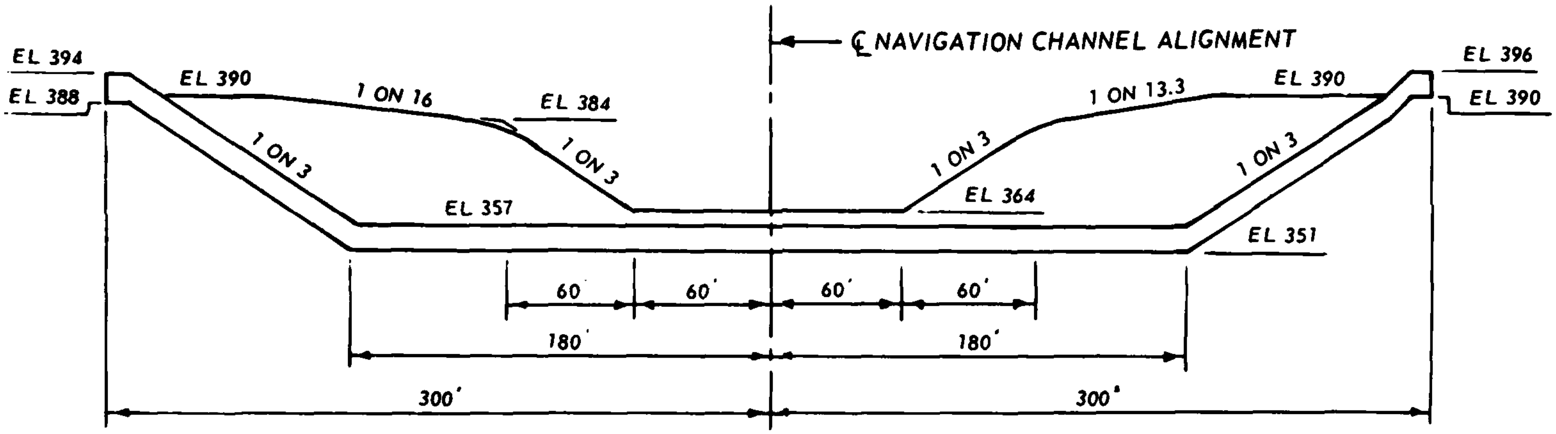
STRUCTURE DESIGNS
I, II, III, IV, V, AND VI
(LOOKING DOWNSTREAM)



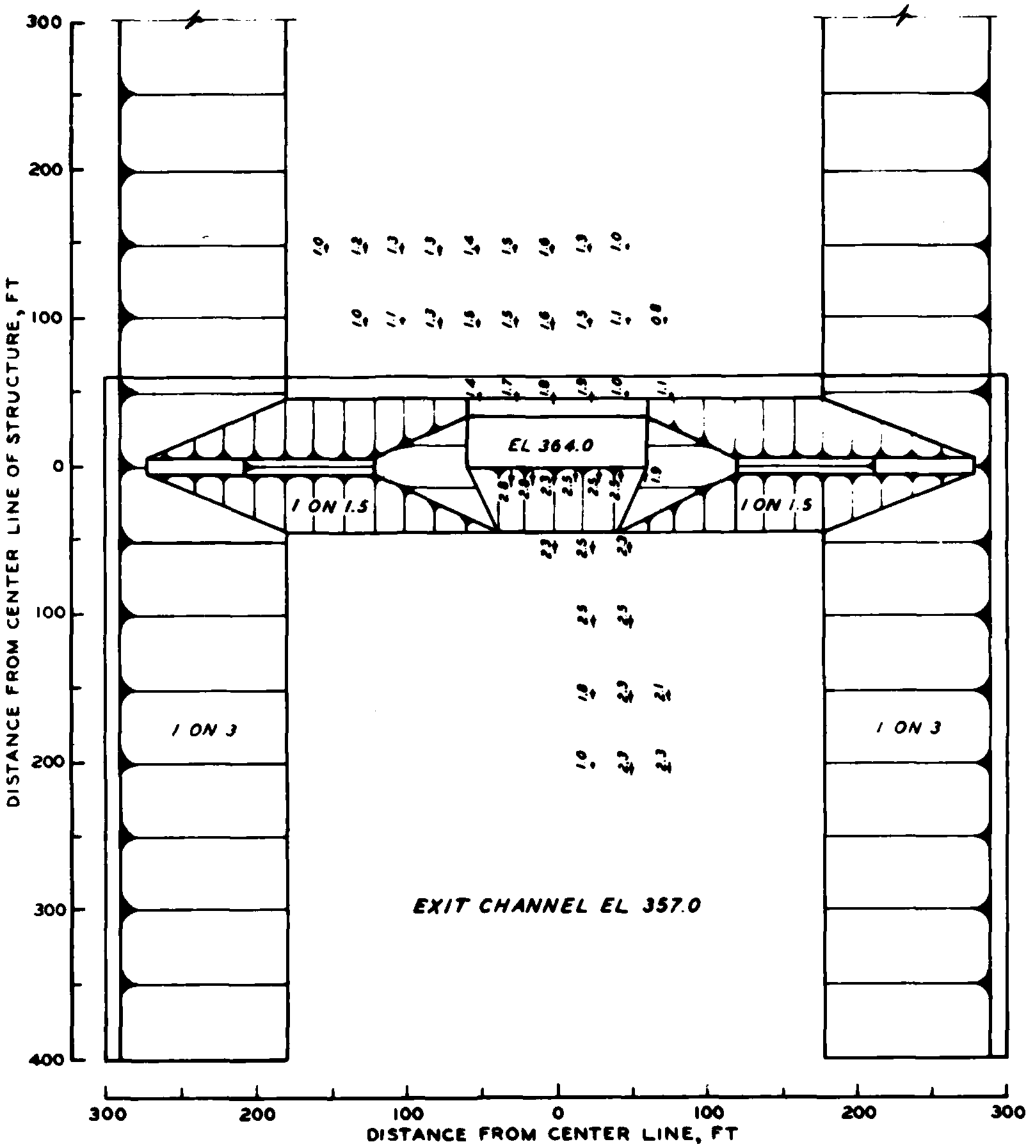
GENERAL PLAN OF
TYPE VI (RECOMMENDED) DESIGN
GRADE-CONTROL STRUCTURE



TYPE VI (RECOMMENDED) DESIGN
GRADE-CONTROL STRUCTURE

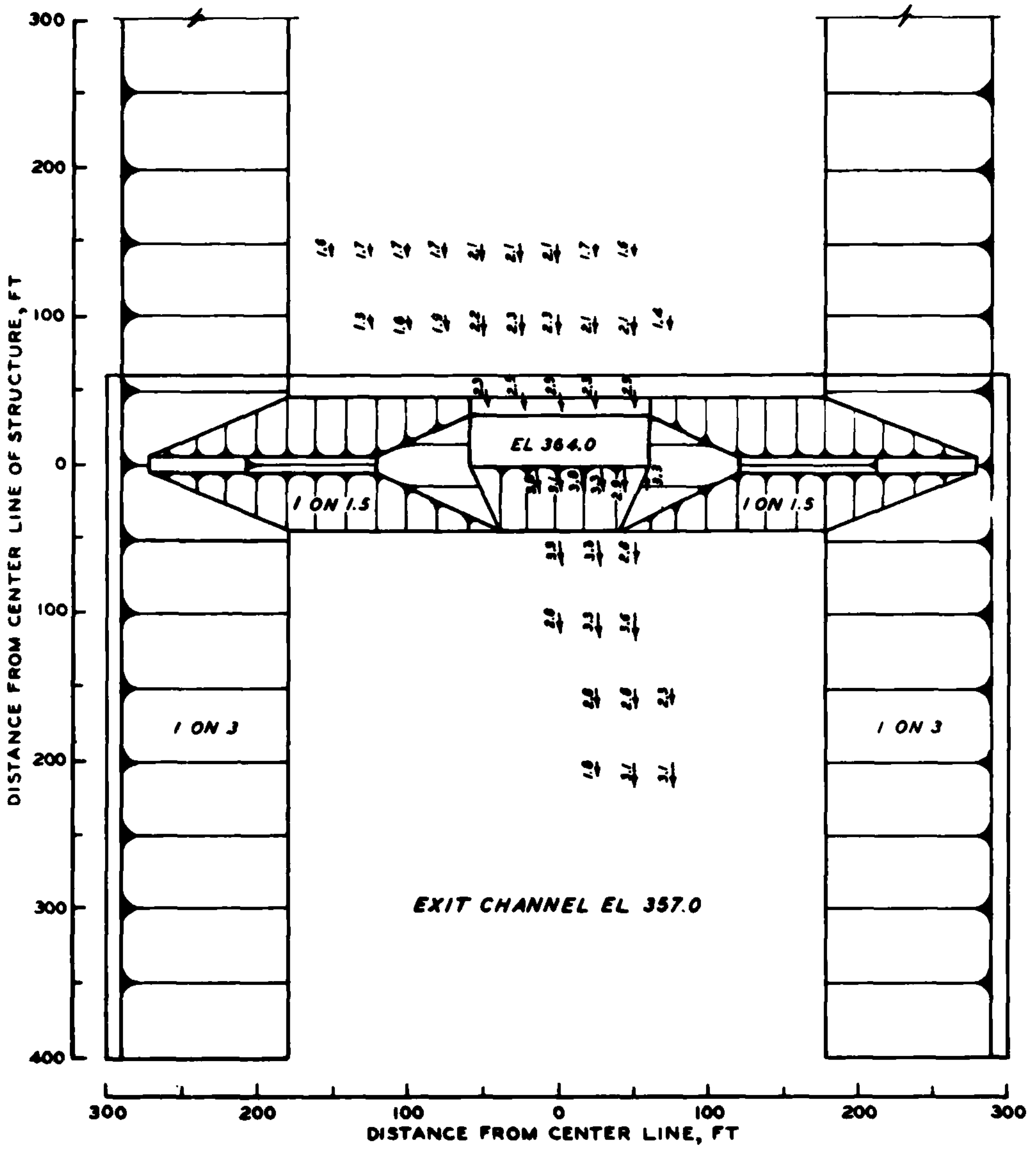


TYPE VI (RECOMMENDED)
DESIGN STRUCTURE
(LOOKING DOWNSTREAM)



VELOCITIES
TYPE VI (RECOMMENDED)
DESIGN STRUCTURE

DISCHARGE 1000 CFS
TAILWATER EL 368.2

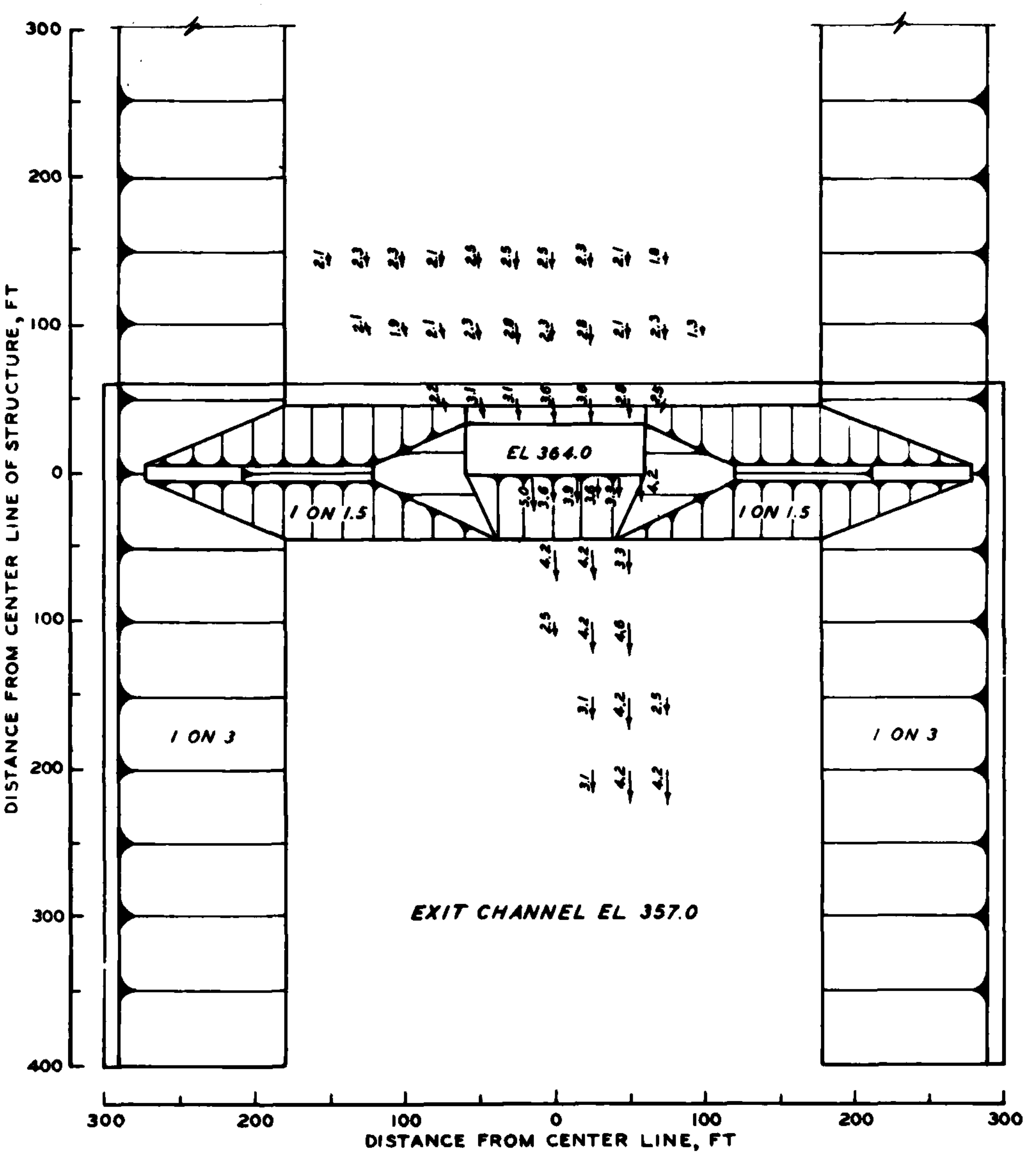


VELOCITIES

TYPE VI (RECOMMENDED) DESIGN STRUCTURE

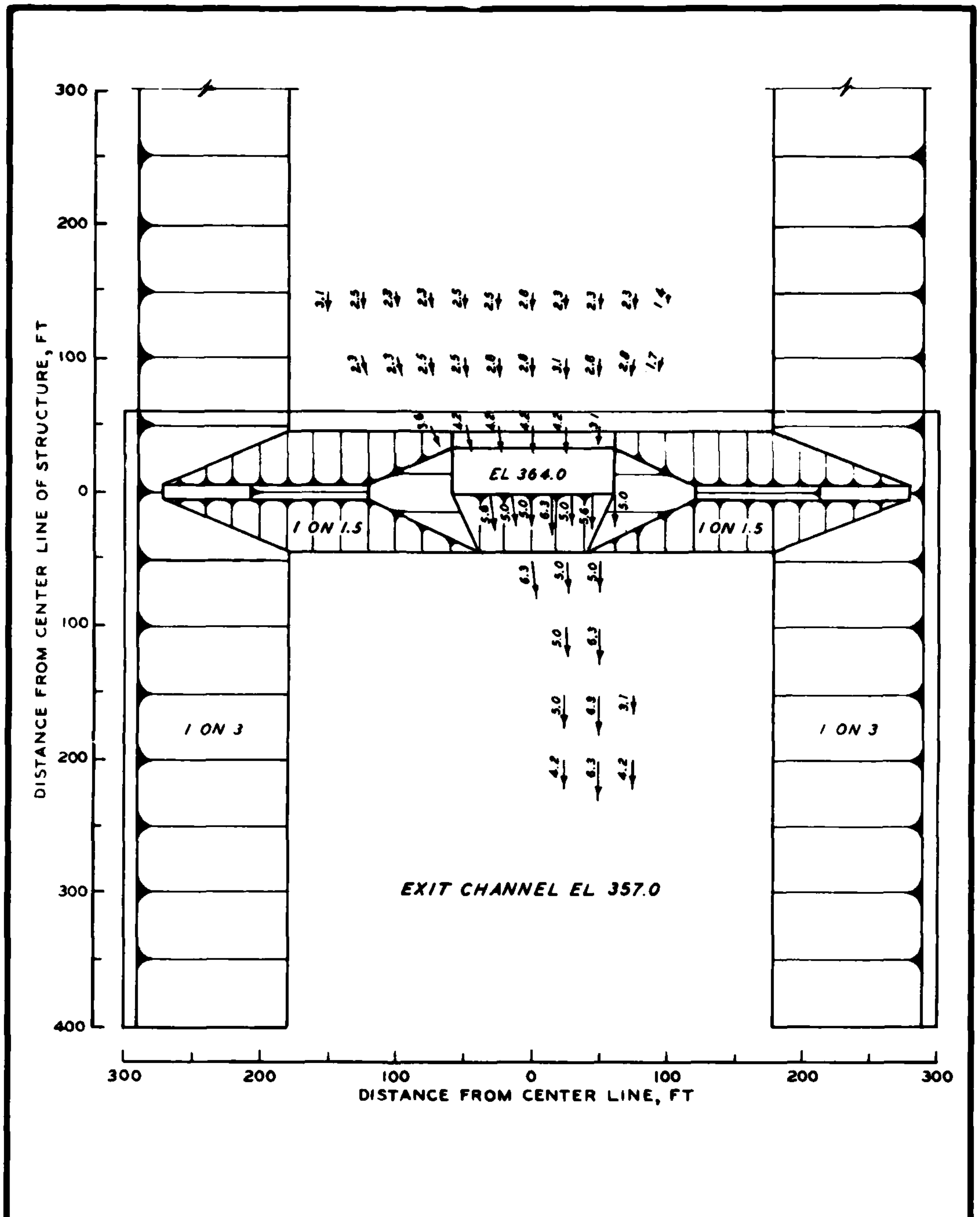
DISCHARGE 2000 CFS

TAILWATER EL 368.7



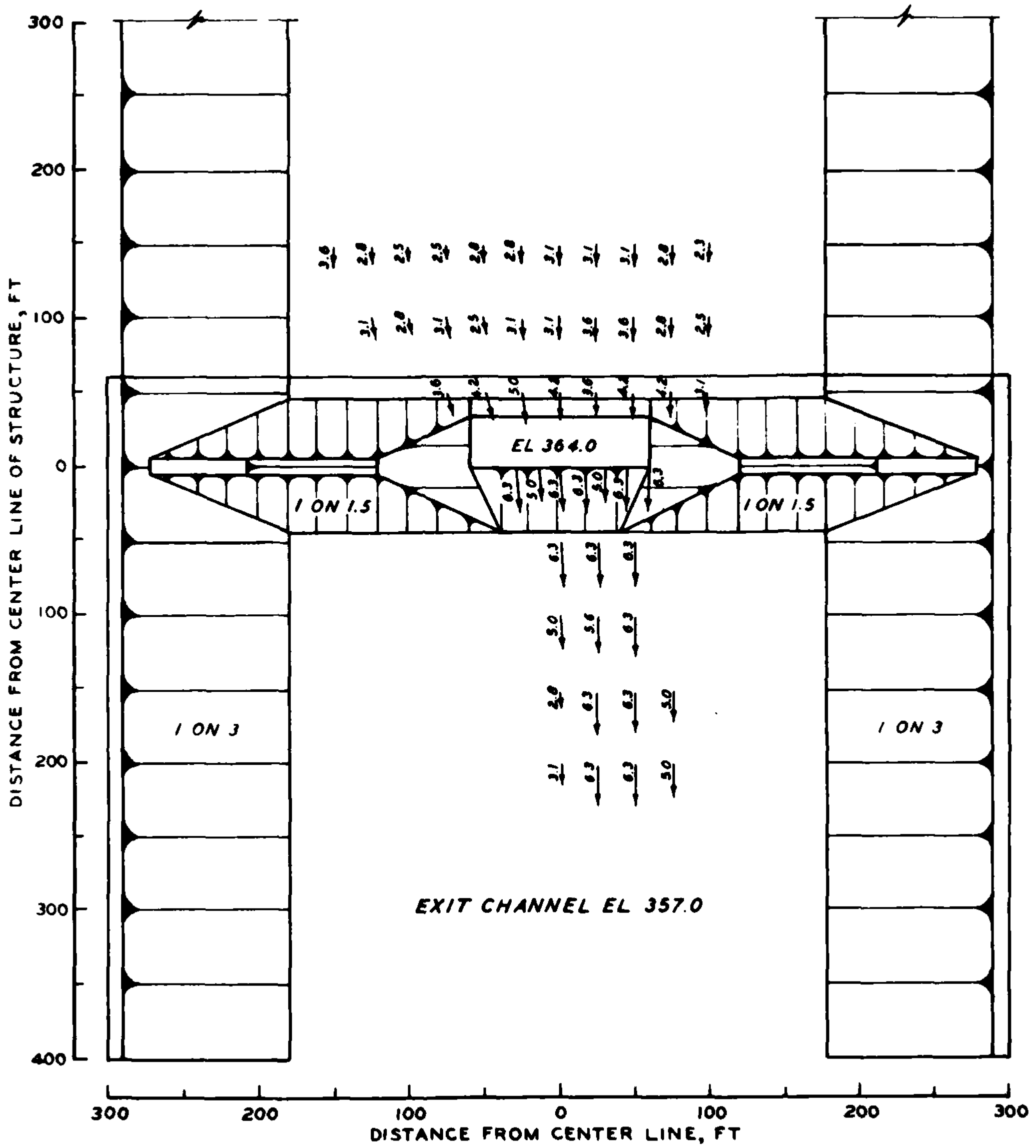
VELOCITIES
TYPE VI (RECOMMENDED)
DESIGN STRUCTURE

DISCHARGE 3000 CFS
TAILWATER EL 369.3



VELOCITIES
TYPE VI (RECOMMENDED)
DESIGN STRUCTURE
DISCHARGE 4000 CFS
TAILWATER EL 369.9

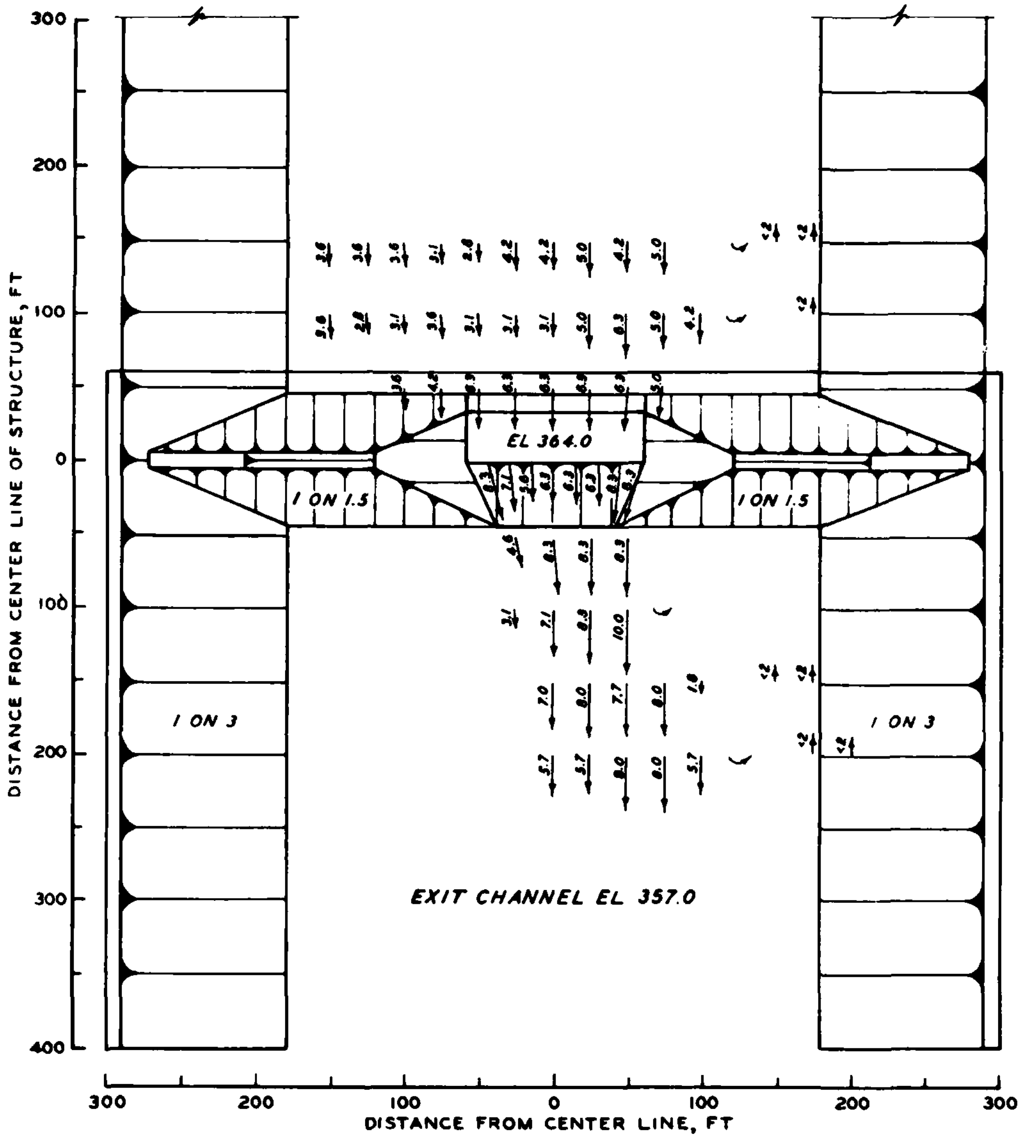
PLATE 22



VELOCITIES

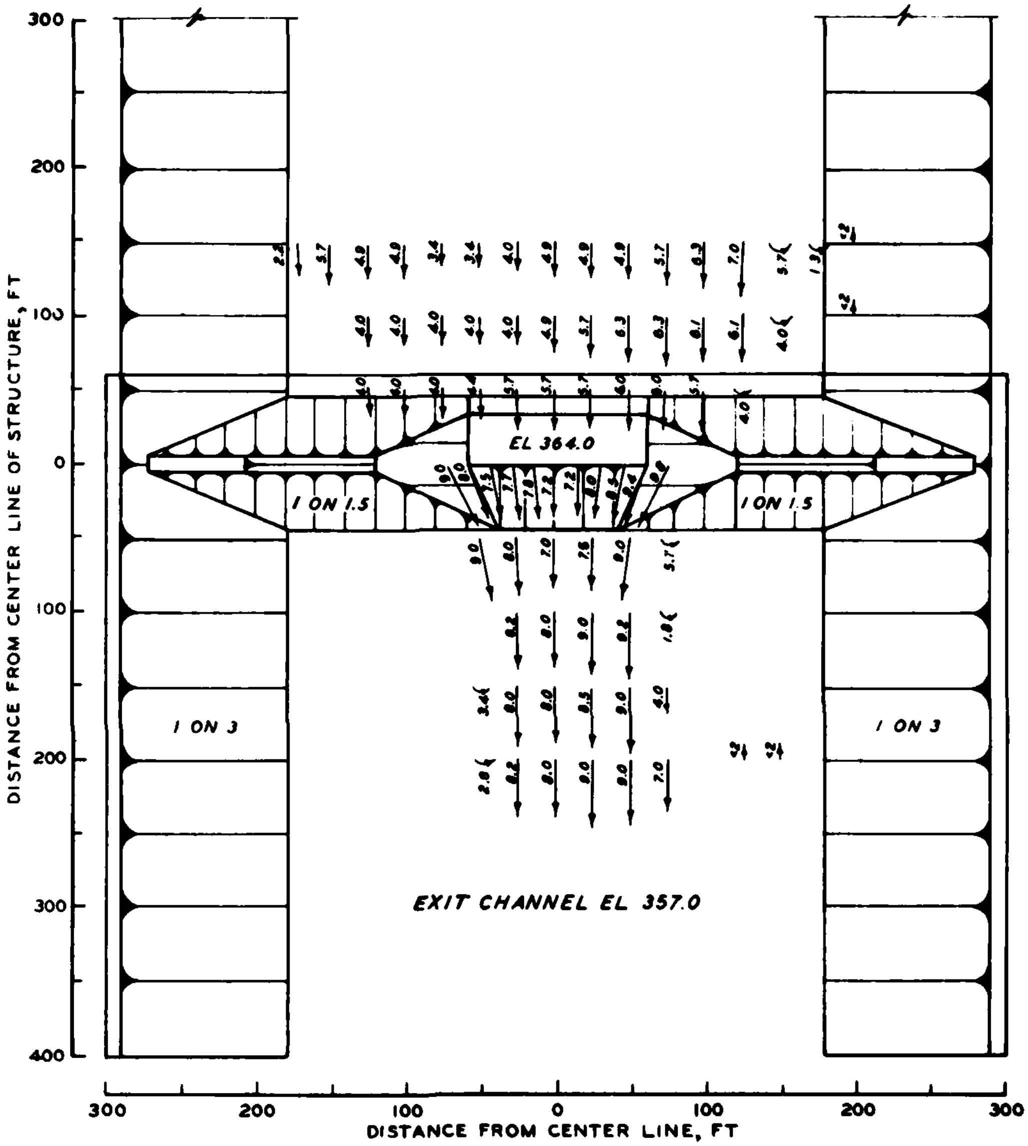
TYPE VI (RECOMMENDED)
DESIGN STRUCTURE

DISCHARGE 5000 CFS
TAILWATER EL 370.7



VELOCITIES
TYPE VI (RECOMMENDED)
DESIGN STRUCTURE

DISCHARGE 10,000 CFS
TAILWATER EL 374.5



VELOCITIES
TYPE VI (RECOMMENDED)
DESIGN STRUCTURE

DISCHARGE 20,000 CFS
TAILWATER EL 380.5

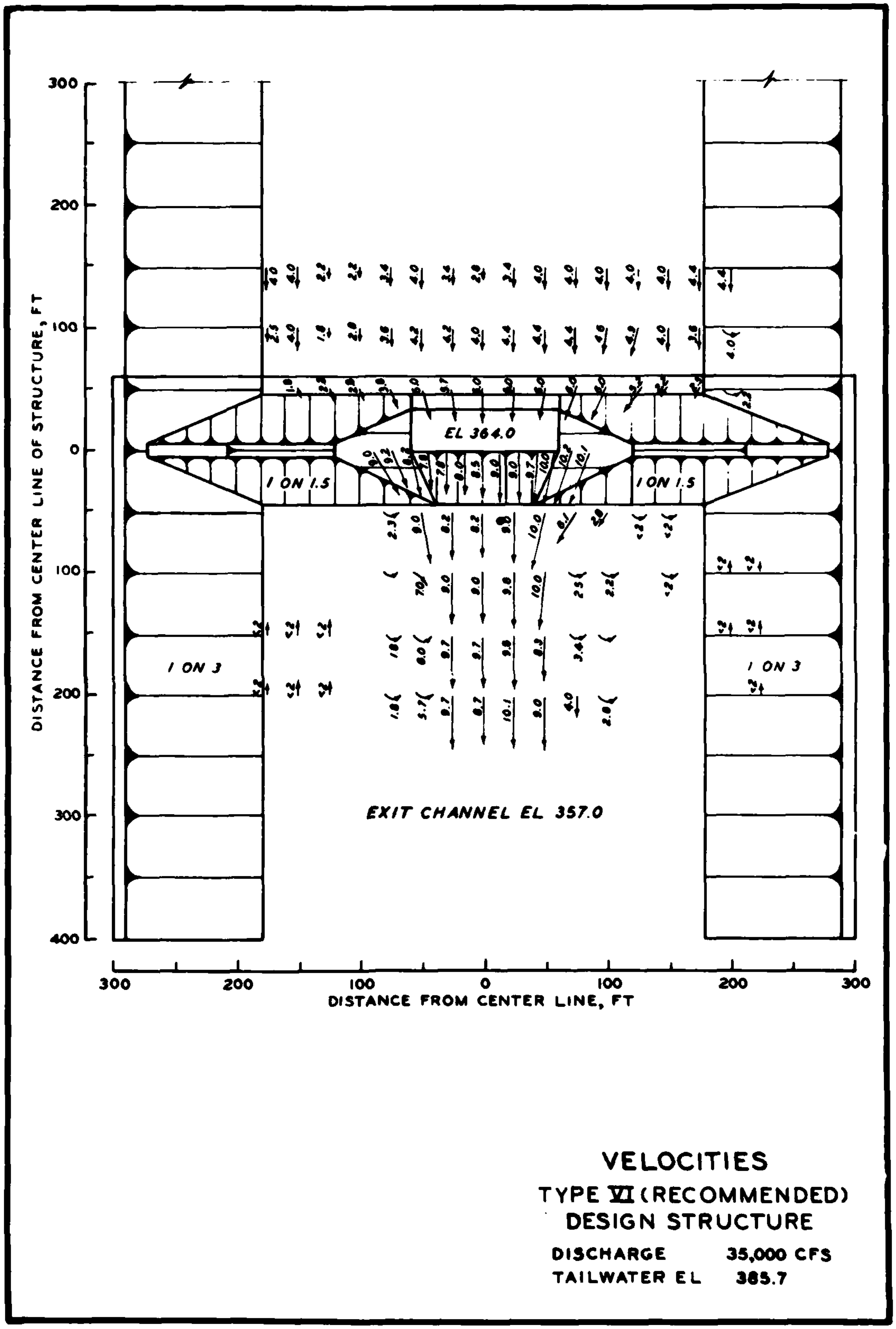

DISTANCE FROM CENTER LINE OF STRUCTURE, FT
EL 364.0
1 ON 1.5
1 ON 1.5
1 ON 3
1 ON 3
EXIT CHANNEL EL 357.0
DISTANCE FROM CENTER LINE, FT
VELOCITIES
TYPE VI (RECOMMENDED)
DESIGN STRUCTURE
DISCHARGE 35,000 CFS
TAILWATER EL 385.7

PLATE 26

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.

Grace, John L

Kaskaskia River grade-control structure and navigation channel, Fayetteville, Illinois; hydraulic model investigation / by John L. Grace, Jr., Potong Bhramayana. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.

18, [9] p. [26] leaves of plates : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; HL-80-20)

Prepared for U. S. Army Engineer District, St. Louis, St. Louis, Missouri.

1. Control structures. 2. Dredging. 3. Hydraulic models. 4. Hydraulic structures. 5. Kaskaskia River. 6. Navigation channels. I. Bhramayana, Potong, joint author. II. United States. Army. Corps of Engineers. St. Louis District. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; HL-80-20.

TA7.W34 no.HL-80-20