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TECHNICAL REPORT H-69-1

KASKASKIA RIVER NAVIGATION PROJECT, ILLINOIS

Hydraulic Model Investigation

by

J. J. Franco
C. D. McKellar, Jr.

January 1969

Sponsored by

U. S. Army Engineer District
St. Louis

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

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FOREWORD

The model investigation reported herein was authorized by the Office, Chief of Engineers, in an indorsement dated 20 January 1966, to the Division Engineer, U. S. Army Engineer Division, Lower Mississippi Valley. The study was conducted for the U. S. Army Engineer District, St. Louis, in the Hydraulics Division of the U. S. Army Engineer Waterways Experiment Station during the period March 1966 to March 1967.

During the course of the model study, the St. Louis District was kept informed of the progress of the study through monthly reports and interim reports of the results of special tests. In addition, Mr. J. P. Davis of the Office, Chief of Engineers; Messrs. A. J. Davis, F. B. Toffaleti, W. E. Best, E. J. Williams, and C. L. Sumrall, Jr., of the Lower Mississippi Valley Division; Messrs. G. W. Demeritt and J. S. Miller of the Fort Worth District; and COL James B. Meanor, Messrs. N. L. Rupani, W. T. Stehle, H. M. McKinney, E. E. Siebert, and L. A. Buchhold of the St. Louis District visited the Waterways Experiment Station at intervals to observe model tests and discuss test results.

The investigation was conducted under the general supervision of Mr. E. P. Fortson, Jr., Chief of the Hydraulics Division, and under the direct supervision of Mr. J. J. Franco, Chief of the Waterways Branch. The engineer in immediate charge of the model was Mr. C. D. McKellar, Jr., assisted by Messrs. H. R. Anderson, S. T. Mattingly, T. P. Williams, and D. N. Corbin. This report was prepared by Messrs. Franco and McKellar.

Directors of the Waterways Experiment Station during the course of this investigation and preparation and publication of this report were COL J. R. Oswalt, Jr., CE, and COL Levi A. Brown, CE. Technical Director was Mr. J. B. Tiffany.

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CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

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

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
miles	1.609344	kilometers
square miles	2.58999	square kilometers
feet per second	0.3048	meters per second
cubic feet per second	0.0283168	cubic meters per second

SUMMARY

The proposed Kaskaskia River navigation project will provide a 50-mile-long, 9-ft-deep by 200-ft-wide channel from the mouth of the river to Fayetteville, Ill., by means of channel enlargement and realignment; alterations to bridges to obtain proper clearance; and construction of a gated dam surmounted by two 60-ft-wide by 30-ft-high tainter gates, and an 84- by 600-ft navigation lock located at mile 0.8. A 1:120-scale, fixed-bed model, reproducing 2.0 miles of the Kaskaskia River and 1.8 miles of the Mississippi River, was used to: (a) demonstrate and study flow conditions in the lock approaches and in critical reaches reproduced in the model; (b) determine adequacy of the proposed design for the spillway, stilling basin, and exit channel; (c) determine the optimum arrangement of the guide or guard walls; (d) determine areas requiring special protection and navigation conditions in the lock approaches and in critical reaches; and (e) develop modifications required to produce satisfactory flow and navigation conditions.

Results of the investigation indicated the following:

a. The spillway approach walls should be flared, and the stilling basin should be lengthened and its elevation lowered with an increase in the width of the exit channel to provide satisfactory flow conditions through the structure.

b. The upper and lower lock approach walls should be guard walls on the river side of the lock.

c. Navigation conditions within the bend upstream of the lock could be improved by decreasing the radius of the bend by placing a fill along the right bank and compensating excavation along the left bank.

d. A fill or dike would be required along the right bank of the new channel to provide satisfactory navigation conditions through the lower reach and in the lower lock approach with overbank flow during high stages.

e. The upper lock approach channel should be widened at least 50 ft to the right at the end of the upper guard wall to provide satisfactory navigation conditions in the upper lock approach during high flows. The alignment of the lower reach of the Kaskaskia River channel appeared to be satisfactory, with no need for modifications.

Fig. 1. Vicinity map

KASKASKIA RIVER NAVIGATION PROJECT, ILLINOIS

Hydraulic Model Investigation

PART I: INTRODUCTION

Location and Description of Prototype

1. The Kaskaskia River (fig. 1), the second largest stream wholly within the State of Illinois, rises in Champaign County in eastern Illinois about 5 miles* northwest of Urbana, flows southwesterly in a meandering course for a distance of about 325 miles, and empties into the Mississippi River about 118 miles above the mouth of the Ohio River, about 60 miles downstream from St. Louis, Mo. The Kaskaskia's drainage basin, approximately 5840 square miles, has a median length of about 175 miles, an extreme width of 55 miles, and an average width of 33 miles. Elevations vary from 740.0** in the headwaters area to about 385.0 at the bluff line where the Kaskaskia emerges into the Mississippi River floodplain. The total fall of the stream is 390 ft, averaging from 2.6 ft per mile in the upper reaches to 0.1 ft per mile in the lower 23 miles. The streambed slope from the mouth to Fayetteville is 0.4 ft per mile, and the average width of the stream is 186 ft. The lower reaches of the Kaskaskia are subject to overflow from headwater runoff, backwater from the Mississippi River, or a combination thereof. The Kaskaskia is subject to backwater up to New Athens, about 41 miles above the mouth, about 50 percent of the time. Backwater exists when Mississippi River stages equal or exceed el 355.0 at the mouth of the Kaskaskia.

Proposed Improvement Plan

2. The project for the Kaskaskia River consists of improvements of

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

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

the river for navigation to provide a 9-ft-deep by 200-ft-wide channel from the mouth to Fayetteville by enlarging the present channel where required, making overbank cuts to eliminate sharp bends, and constructing a single lock and dam at river mile 0.8. The plan of improvement included the following principal features and requirements:

a. A lock and dam in the Mississippi River floodplain to be constructed on land within an oxbow bend in the Kaskaskia River at mile 0.8 on the relocated channel. The dam with a crest elevation of 340.0, which approximates natural streambed, would have two nonsubmersible tainter gates 60 ft wide by 30 ft high (plate 1). Top of the gates will be at el 370.0, 2 ft above maximum regulated pool at el 368.0. The lock would be 84 ft wide by 600 ft long with a maximum lift of 29.2 ft. The tops of the lock walls will be at el 385.0 which is about 1 to 1-1/2 ft below record high water (1943) on the Kaskaskia River, and 2 ft above the stage at which navigation would cease. The upper and lower guide or guard walls* would consist of floating pontoons held in place by piers.

b. The channel would be realigned to eliminate tortuous curves and oxbow bends and enlarged to a minimum bottom width of 223 ft and a minimum depth of 9 ft. Realigning the channel from the mouth to Fayetteville would reduce the river miles in this reach from the present 50 miles to 36.2 miles.

c. Six bridges (four railroad and two highway) would be removed and five bridges (three railroad and two highway) would be replaced with high-level spans to provide the minimum horizontal and vertical clearance required for navigation.

d. The channel would be dredged 2 ft below design depth during original construction to accommodate siltation and minimize dredging over a period of several years.

3. The plan of operation provides for the upper pool level to be maintained at el 368.0 during all flows of 5000 cfs or less. The pool level would be gradually lowered for flows greater than 5000 cfs until an elevation of 363.0 is reached with a flow of 10,000 cfs with open river condition. Tailwater elevations would be controlled by flow in the Mississippi River. The low-water reference plane for the Mississippi River at this point is 338.8 with a discharge of 54,000 cfs based on a 50-year record.

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* Guide walls placed on the land side of the lock are referred to as guide walls in this report; guide walls placed on the river side of the lock to serve as guide and guard walls are referred to as guard walls.

The design low-water discharge for the Mississippi River was 40,000 cfs with a water-surface elevation of 341.0 (initial conditions) and 336.0 with the estimated retrogression over a 50-year period. Some model tests were conducted with a Mississippi River discharge of 30,000 cfs and tailwater elevation of 338.8.

Need for and Purpose of Model Study

4. The general design of the Kaskaskia River navigation project was based on sound theoretical design practice and experience with structures similar in type. However, it was desired to ensure that the design provide the optimum channel width and alignment and location of the guard walls from the standpoint of eliminating undesirable flow conditions that might make navigation difficult or hazardous for tows entering or leaving the lock and the optimum entrance and exit channel conditions in the vicinity of the dam. Since an analytical determination of the hydraulic effects that can be expected to result from a particular design is both difficult and uncertain, a comprehensive model study was considered necessary. The purposes of the model study were to:

a. Determine navigation conditions that will occur in the upper and lower lock approaches under various flow conditions and to develop corrective measures that might be necessary to eliminate undesirable navigation conditions.

b. Determine the optimum arrangement of the guide and guard walls.

c. Study flow conditions in the spillway approach and exit channels and to determine corrective measures that might be necessary to eliminate undesirable conditions.

d. Measure velocities in the spillway exit channel to be used in evaluating stone protection requirements for the channel.

e. Measure swellhead.

f. Study navigation conditions at the mouth of the Kaskaskia River and the effect of overbank flow which could produce objectionable crosscurrents when the flow in the Mississippi River is high and to develop corrective measures that might be necessary to eliminate undesirable navigation conditions.

g. Obtain data for use in the development of a spillway rating curve.

h. Demonstrate to navigation interests the flow conditions resulting from the proposed modifications and to satisfy these interests as to their acceptability from a navigation standpoint.

PART II: THE MODEL

Description

5. The Kaskaskia River model (fig. 2) was a scale reproduction of a 2-mile reach of the Kaskaskia River and adjacent overbank to the levee on the right side and to the railroad embankment on the left side and 1.8 miles of the Mississippi River from its left bank to about the river ends of the right bank dikes. It was of the fixed-bed type with the channel

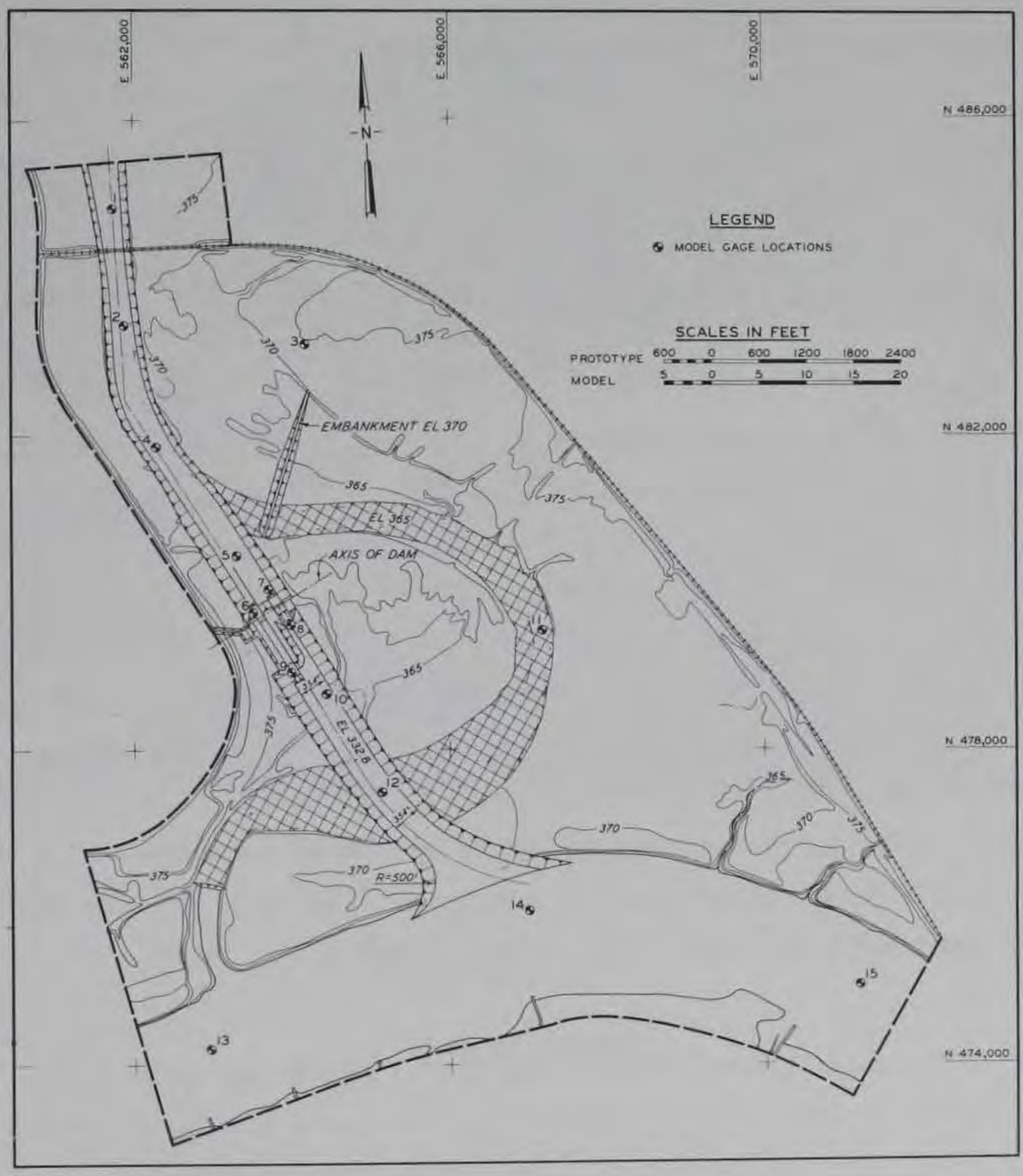

Fig. 2. Model layout and location of gages

Fig. 3. Model with the Mississippi River channel in the foreground

and overbank areas molded in sand-cement mortar (fig. 3). The Kaskaskia River section of the model channel was molded to conform to sections furnished by the St. Louis District. The Mississippi River section of the model was molded to topography shown in survey dated 5 February 1963. Overbank areas were molded to topography shown in cross sections dated August 1963 and special maps dated November 1964. The piers, lock, guide and guard walls, dam, and spillway were constructed of sheet metal to ensure against any change in elevation due to warping once the structures were graded. The permeable pile dikes in the model were made of a row of metal rods; the stone dikes were of concrete. The lock and dam gates were simulated schematically with simple sheet metal slide gates.

Appurtenances

6. Water was supplied to the model by a 10-cfs axial-flow pump operating in a circulating system. The Mississippi River inflow was measured by means of a 12- by 6-in. venturi meter for high flows and a 6- by 3-in.

venturi meter for low flows. The Kaskaskia River inflow was measured by means of a 6-in. Van Leer weir. Water-surface elevations were measured by means of 15 point gages (fig. 2) connected to a centrally located pit. Upper pool stages were controlled by opening and closing the slide gates on the dam, and the tailwater elevations were controlled by means of a tailgate located at the lower end of the model.

7. A radio-controlled model tow and towboat, equipped with screw-type propellers powered by two small electric motors operating from batteries located in the tow, were used to study and demonstrate the effects of currents on navigation (fig. 4). The towboat could be operated in forward or reverse, at various speeds comparable to that of towboats expected to travel the Kaskaskia River, and with variable rudder settings.

Fig. 4. Remote-controlled towboat and tow

Scale Relations

8. The model was built to an undistorted linear scale of 1:120, model to prototype, to effect accurate reproduction of velocities, crosscurrents, and eddies that would affect navigation. Other scale ratios resulting from linear scale ratios were: area, 1:14,400; velocity and time, 1:10.95;

discharge, 1:157,743; and roughness (Manning's n), 1:2.22. Measurements of discharge, water-surface elevation, and current velocities can be transferred quantitatively from model to prototype equivalents by means of these scale relations.

Model Adjustment

9. The model was constructed with a brushed cement-mortar finish to provide a roughness (Manning's n) of about 0.012, which corresponds to a prototype channel roughness of about 0.026. Adjustment of the model consisted of adjusting the roughness until it accurately reproduced the prototype current directions for flows of 51,600, 142,000, and 503,500 cfs. However, to reproduce the current directions and velocities, additional roughness in the form of light stucco was required along the left side of the channel, resulting in an average roughness over the channel area corresponding to a prototype Manning's n of about 0.30. Folded strips of screen wire were used to simulate the roughness effects of overbank growth such as trees and underbrush.

PART III: TESTS AND RESULTS

10. Tests in the model were concerned with the study of flow patterns; measurement of velocities in the Kaskaskia River channel (particularly in the lock approaches) from the new Missouri Pacific Railroad bridge to the Mississippi River; the behavior of the model tow on entering or leaving the lock under various flow conditions; swellhead; and flow conditions and velocities at the entrance to the spillway and in the spillway exit channel.

Test Procedure

11. The controlled river flows were reproduced by introducing the proper discharge, setting the tailwater elevation for that discharge, and manipulating the dam gate openings until the required upper pool elevation was obtained. Uncontrolled river flows were reproduced by introducing the proper discharge with the dam gates fully open and manipulating the tailgate to obtain the proper tailwater elevation. The tailwater was controlled in the Mississippi River at the mouth of the Kaskaskia River. All stages were permitted to stabilize before data were recorded. Current directions were determined by plotting the paths of wooden floats with respect to ranges established for that purpose; floats were submerged to a depth equivalent to an 8-ft draft of a loaded barge. Velocities were measured by timing the travel of the floats over known distances. No data were obtained with the model tow other than observations of its behavior in the Kaskaskia River channel, in the lock approaches, and in the entrance to the Kaskaskia River at its confluence with the Mississippi River.

12. Flows used for testing included the following:

Kaskaskia River	Description
84,000 cfs	Maximum flood of record (1943), cessation of navigation
64,000 cfs	10-year frequency
40,000 cfs	Maximum discharge at normal upper pool elevation

(Continued)

Mississippi River	Description
720,000 cfs 666,000 cfs	Combined with Kaskaskia River flow to produce total of 750,000 cfs, cessation of navigation
40,000 cfs	Design minimum discharge

Other flows were selected arbitrarily for special tests.

Plan A

Description

13. Plan A was the original design proposed for the structures and for the reach of river reproduced in the model. The features of this plan included the following:

a. A single lock having clear chamber dimensions of 84 by 600 ft with 600-ft-long upper and lower guard walls (plate 1), which consisted of floating pontoons held in place by piers (photograph 1). The elevation of the top of the lock walls was 385.0.

b. A 150-ft-long dam consisting of one 10-ft-wide pier and two 60-ft-wide by 30-ft-high tainter gates located at mile 0.8 (plates 1 and 2). The spillway crest was placed at el 340.0, which is approximately natural streambed. The dam was connected to each bank by means of a cutoff wall with a top elevation of 385.0, extending along the axis of the dam 120 ft from the esplanade to the right lock wall, 150 ft from the left lock wall to the right dam pier, and 180 ft from the left dam pier to the left bank.

c. An upper lock and dam approach channel 369 ft wide with a bottom elevation of 340.0. A spillway exit channel having a bottom width of 63 ft at el 332.8 extending downstream to the end of the lock. From this point to its confluence with the Mississippi River, the channel was 354 ft wide with a bottom elevation of 332.8. The channel in the lower reach followed a direct route to the Mississippi River cutting across the neck of a large bend as shown in plate 2.

Results

14. Results of the plan A test, shown in photograph 2 and tables 1 and 2, indicated that:

a. Flow moving from each side of the channel over the spillway approach walls produced disturbances (vortexes) along each side of the approach to the spillway (photographs 2a

and 2b) and tended to reduce the capacity of the spillway. With a Mississippi River discharge of 30,000 cfs, the maximum discharge which could be passed through the dam with an upper pool elevation of 363.0 was 38,000 cfs.

b. Eddies formed along the left bank of the channel downstream of the spillway, attributed to the slope of the left bank which extended into the channel downstream of the stilling basin, and along the right side just below the lock where the channel width increased to provide for the lock approach.

c. With a 30,000-cfs flow in the Kaskaskia River, flow from the spillway would follow the channel with little disturbance. With a 60,000-cfs discharge, flow would tend to sweep out of the stilling basin with surface waves forming downstream (photograph 2c). The high-velocity currents moved away from the left side of the channel. The waves and currents moved toward the right across the approach channel. Because of the turbulent flow and direction of currents, tows would experience considerable difficulty in approaching the lower guard wall.

d. A maximum velocity of 26.0 fps was measured along the embankment between the exit channel and lock with the 60,000-cfs flow (table 1). Maximum velocities in the entrance to the spillway exit channel varied from about 15.3 fps at sta 1 (60,000-cfs flow) to 20.2 fps at sta 3 (84,000-cfs flow); maximum velocities at the end of the channel varied from about 21.1 fps at sta 7 (38,000-cfs flow) to 25.0 fps at sta 6 (60,000-cfs flow). In general, maximum velocities in the exit channel were obtained with a flow of 60,000 cfs.

e. Flow from the channel to the overbank upstream of the dam during high flows would return to the channel downstream of the dam, creating considerable turbulence and loss of channel efficiency.

f. Water-surface elevations indicate that the drop through the dam (gages 7 and 8) would vary from about 3.9 to 10.3 ft and that the total drop through the structures (gages 5 and 10) would vary from 13.1 to 23.7 ft with uncontrolled Kaskaskia River flows varying from 20,000 to 84,000 cfs and a minimum flow of 30,000 cfs in the Mississippi River (table 2).

Plan B

Description

15. Plan B was designed to improve flow conditions, decrease velocities in the spillway exit channel, and improve flow conditions at the

entrance to the spillway. Modifications for plan B were as follows (plate 3):

a. The entire spillway was shifted 15.6 ft to the left of its location for plan A and the stilling basin was lowered 3 ft to el 322.0.

b. The left bank, from the dam to a point 150 ft downstream of the end of the lock wall, was dredged to provide a spillway exit channel 130 ft wide with a bottom elevation of 325.0. At a point 196.8 ft downstream of the end of the lock wall, the total channel width was 467.8 ft and the bottom elevation was 332.8. From that point, the left bank was flared to the right reducing the channel width to 354 ft at a point 1138.0 ft downstream, tying in with the plan A channel.

c. The spillway approach walls were modified to provide a 1-on-4 flare in the walls and the left bank was modified to tie in with the left approach wall.

Results

16. Observation of conditions with this plan indicated objectionable currents in the exit and lower lock approach channel and the need for additional improvements. Accordingly, no data were obtained with this plan.

Plan C

Description

17. Plan C was designed to improve flow conditions in the channel downstream of the end of the lock wall and was the same as plan B except for the following modifications of the left bank and changes in the channel bottom (plate 4):

a. Width of channel in the vicinity of the lower guard wall was increased by changing the alignment of the left bank making it generally parallel to the right bank to a point 100 ft downstream of the end of the lower guard wall.

b. The bottom of the channel in the reach and downstream was lowered 2.8 ft to el 330.0.

Results

18. Flow conditions in the spillway exit channel and in the lower lock approach were considerably better than with plan B for flows of 40,000 cfs or less. With flows above 40,000 cfs the stilling basin was ineffective with the jump becoming unstable or being swept completely out of the

stilling basin. Velocities in the spillway exit channel within about 300 ft of the dam were generally higher than with plan A in the reach within 300 ft of the dam and lower downstream with the higher flows (table 3).

19. Modification of the spillway approach walls and the left bank upstream improved flow conditions in the spillway approach and increased the capacity of the spillway. A maximum discharge of 40,000 cfs could be passed through the spillway with an upper pool elevation of 363.0, compared with 38,000 with plan A (table 4).

Plans D and D Modified

Description

20. Plan D was the same as plan C except for the following changes designed to eliminate the adverse flow conditions in the spillway exit channel noted in the previous test (plate 5).

a. Stilling basin was lowered from el 322.0 (plan C) to 317.0, and its length increased from 37.7 to 70 ft with baffles as shown in plate 5.

b. The designs for the baffles and stilling basin were developed during a series of tests with a larger scale model of a section of the spillway.

c. The exit channel immediately downstream of the stilling basin was modified as shown in section A-A, plate 5.

21. Plan D modified was the same as plan D except that the level reach at el 315.0 immediately downstream of the stilling basin was shortened from 84 to 54 ft as shown in plate 6.

Results

22. Results of tests of plan D are shown in tables 5 and 6 and plates 7-11 and are discussed below:

a. The drop in water surface through the dam (gages 7 and 8) during uncontrolled flows (Kaskaskia flows 40,000 to 84,000 cfs with 40,000 cfs in the Mississippi River) would vary from about 15.6 to 22.6 ft (table 5). Water-surface elevations with a total flow of 750,000 cfs in the model (84,000 Kaskaskia and 666,000 Mississippi) varied from 382.5 near the mouth of the Kaskaskia River (gage 14) to 383.0 at gage 1.

b. Modification of the stilling basin and the section

immediately downstream of the stilling basin would reduce velocities in the spillway exit channel. Reductions in velocities measured in the exit channel varied from 5.7 to 7.6 fps with flows of 60,000 cfs in the Kaskaskia River and 40,000 cfs in the Mississippi River and from 4.5 to 7.5 fps with flows of 84,000 cfs in the Kaskaskia River and 40,000 cfs in the Mississippi River (table 6). Reducing the length of the excavated reach immediately downstream of the stilling basin (plan D modified) had little effect on velocities in the spillway exit channel (table 6).

c. The stilling basin as modified functioned satisfactorily with the hydraulic jump forming within the basin with all flows. With a 40,000-cfs flow, the tailwater elevation could be lowered as much as 3 ft below normal without affecting the performance of the stilling basin. However, when the tailwater elevation was lowered to 5.0 ft below normal, the jump was swept out of the basin, and chuting flow obtained immediately downstream in the spillway exit channel. The jump was restored within the basin when the tailwater was gradually raised and it reached 3.0 ft below normal.

23. Current directions and velocities in the lock approaches are shown in plates 7-11. These results and observations of the effects of currents on the movement of the model tow indicate that navigation conditions in the lower lock approach would be generally satisfactory with low flows in the Mississippi River. With sufficient flow in the Mississippi to produce stages above bank-full along the Kaskaskia River channel, crosscurrents would develop within the channel that would make it difficult for tows to navigate within the channel and to approach the lower guard wall. The difficulty that would be encountered by navigation would increase with an increase in Mississippi River discharge (plates 10 and 11). The intensity of the crosscurrents would be higher just downstream of the end of the lower guard wall where upbound tows would have to reduce speed and lose steerageway. With low flows in the Mississippi River, some eddies would form in the lower approach. The velocity of currents in the eddy was high along the right bank with a high flow in the Kaskaskia River. However, the direction of these currents was such that an upbound tow would be moved upstream and toward the guard wall.

24. Navigation conditions in the upper approach with a 40,000-cfs discharge in the Kaskaskia River and low Mississippi River discharge were

satisfactory although velocity of currents approaching the guard wall was generally high (plate 8). With an 84,000-cfs discharge, an eddy formed along the right bankline extending about 1000 ft upstream of the end of the upper guard wall (plate 9). Currents moving from the bankline toward the river side of the eddy would force the head of a downbound tow riverward. Directing the head of a downbound tow toward the right bank for the approach would place the stern of the tow in the high-velocity currents and the tow would tend to be rotated, making it difficult to become aligned for the approach. With a high discharge in the Mississippi River some of the flow from the Kaskaskia River would move from the channel toward the left overbank, producing crosscurrents between the right bank and the end of the lower guard wall (plate 10). The intensity of the crosscurrents was generally low, and tows could approach the guard wall without serious difficulties.

Plans E, E-1, and E-2

Description

25. Plan E was designed to improve navigation conditions in the upper and lower lock approach channels noted in tests of plan D and to determine a suitable location for the placement of dredge spoil.

26. Plan E was the same as plan D except for the following:

a. The width of the upper approach channel was increased by 50 ft opposite the end of the upper guard wall by dredging along the right bank as shown in plate 12.

b. Spoil areas were placed along the left and right overbank areas with top elevations of 376.0 and 378.0 as shown in plate 12.

c. A fill with a top elevation of 375.0 was placed along the left top bank extending from the left dam embankment downstream across the old Kaskaskia River channel as shown in plate 15.

d. Spoil in the old Kaskaskia River channel along the right side of the new channel was raised to el 370.0 at the upstream end and sloped down to el 365.0 at the downstream end (plate 14).

e. The upper and lower lock approach walls were modified in the model to permit testing and demonstration of the walls

on the land side (guide wall) and river side (guard wall) of the lock.

f. Plan E-1 was the same as plan E except for the construction of a dike across the old Kaskaskia channel about 1500 ft to the right of the new channel (plate 18). Plan E-2 was the same as plan E-1 except for the addition of a dike connecting the spoil bank on the right overbank and the fill along the right of the new channel which extended across the old Kaskaskia River channel (plate 19).

Results

27. The widening of the upper approach channel improved navigation conditions, particularly for downbound tows, by providing additional maneuver area on the lock side of the guard wall and improving the alignment of currents approaching the lock. The intensity and size of the eddies forming in the approach channel were less than with plan D and were confined mostly along the right bank except with the 100,000-cfs flow (plates 13-15). With the 100,000-cfs flow (plate 15) the eddy extended partly into the approach channel but its size and intensity were not sufficient to seriously affect the movement of tows approaching the upper guard wall. Because of the alignment of currents and short radius of curvature of the bend upstream of the lock, tows moving close along the right bank would experience difficulties in negotiating the bend during high flows. This difficulty can be avoided by tows passing through the reach along the center or left side of the channel.

28. The modifications included in plan E would have little or no effect on navigation conditions in the lower lock approach when flows in the Mississippi River are bank-full or lower. With a high Mississippi River discharge, there was a greater concentration of flow from the overbank moving across the Kaskaskia River channel just downstream of the end of the lower guard wall (plates 16 and 17). The velocity of the cross-currents was sufficient to seriously affect the movement of upbound tows attempting to maneuver for the approach to the lock.

29. Placement of a dike across the old Kaskaskia River channel (plan E-1) reduced the concentration of flow across the channel near the end of the lower guard wall and improved navigation conditions through the lower reach (plate 18). Although the crosscurrents near the end of the lower

guard wall were not eliminated, the velocity of these currents was reduced appreciably.

30. Installation of the dike extending from the spoil bank along the right overbank to the fill across the old river channel along the right bank of the Kaskaskia River channel (plan E-2) would block all flow across the channel immediately downstream of the lower guard wall and increase the concentration of flow downstream of the end of the dike (plate 19). With plan E-2, a large eddy formed downstream of the end of the guard wall extending from the right bank to about the middle of the channel. Velocities of currents within the eddy were generally low and upbound tows would have little difficulty in approaching the guard wall.

31. A study of currents and observation of the effects of these currents on the movement of the model towboat and tow approaching the upper and lower guide and guard walls indicate that conditions would be better with the guard walls (on the river side of the lock). In the upper approach, currents moving toward the spillway would tend to move the tow away from the guide wall placed on the land side of the lock. A tow attempting to approach the guide wall at a slight angle in an effort to overcome the effects of these currents would have its stern in high-velocity currents which would tend to move that end toward the spillway. A tow could be flanked toward the land-side wall, but without mooring lines attached to the wall, tows would experience considerable difficulty in becoming aligned for the approach into the lock, particularly during the higher flows. In the lower approach, the eddy would tend to move a tow away from the land-side guide wall. A tow placed along the wall would gradually drift riverward during most flows.

32. A study of the currents near the mouth of the Kaskaskia River indicated that navigation conditions would be generally satisfactory and observations did not indicate the need for a change in the alignment of that portion of the channel. Tows moving upstream in the Mississippi River would experience no serious difficulties in entering the Kaskaskia River channel. With high flows in the Kaskaskia River, tows moving downstream in the Mississippi River would experience difficulty in making the turn into the Kaskaskia River channel. Under such conditions, downbound tows

in the Mississippi River would have to make a turn and enter the Kaskaskia River channel in an upstream direction.

33. In order to provide data for use in the development of a spillway rating curve, special tests were conducted with various combinations of Mississippi River and Kaskaskia River flows. The results of these tests, consisting of water-surface elevations shown in table 7, were obtained with all Kaskaskia River flows passing through the spillway. Velocity measurements were obtained along the land side of the spillway approach walls for use in determining the protection required along the slope. These results, shown in table 8, indicate that maximum velocities would vary from about 6.3 fps with a 40,000-cfs flow to about 13.1 fps with a 100,000-cfs flow.

Plans F-1 and F-2

Description

34. Plans F-1 and F-2 were the same as plan E except for fills placed upstream of the lock designed to eliminate or reduce the difficulty tows would experience in negotiating the turn in the bend when moving close along the bank during high flows. These plans involved the placing of a fill along the right bank to increase the radius of the bend. The fill extended a maximum of 30 ft riverward with plan F-1 and 75 ft with plan F-2 (plate 20).

Results

35. Current directions and velocities observed during tests of plans F-1 and F-2 are shown in plates 21 and 22, respectively. These results and observations of the movement of the towboat indicated some improvement with the fill of plan F-1 but the difficulty in negotiating the bend from along the right bank was not eliminated. The difficulty within the bend was eliminated, but because of the increase in velocities, a large eddy formed in the upper approach to the lock, particularly during the 84,000-cfs flow (plate 22). Because of the crosscurrents which developed, tows would experience more difficulty in approaching the guard wall. In general, the results indicate that unless the channel along the opposite bank is excavated to compensate for the loss in cross-sectional area caused by the fill, conditions would be better without the fill.

Plans G-1 and G-2

Description

36. Plans G-1 and G-2 (plate 23) were the same as plan F-2 except for the dredging along the left bank opposite the fill in the bend upstream of the dam, designed to reduce the velocity of currents observed in the previous test. Plan G-1 involved the maximum amount of dredging considered practicable; plan G-2 was the same as plan G-1 except that the amount of dredging was reduced to determine its effect on currents in the reach.

Results

37. The results of tests of plans G-1 and G-2 are shown in plates 24 and 25. These results indicate that with the excavation of plan G-1 the velocity of currents through the bend would be reduced and most of the eddy and crosscurrents in the lock approach noted in the test of plan F-2 would be eliminated, particularly with the 84,000-cfs flow. With the improvements developed with plan G-1, downbound tows should have little difficulty in approaching the guard wall for entrance into the lock. With the reduction in the amount of dredging included in plan G-2, velocities in the reach were increased above those obtained with plan G-1. The alignment of the currents was changed sufficiently to affect the movement of the boat. With the excavation of plan G-2, downbound tows would experience some difficulty in maneuvering for the approach with the 84,000-cfs flow. In general, conditions with plan G-2 were considerably better than with plan F-2, but not as good as with plan G-1.

PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

Limitations of the Model

38. The analysis of the results of this investigation is based principally upon a study of current directions and velocities in the Kaskaskia River from the bend upstream of the lock to its mouth at the confluence with the Mississippi River, flow conditions in the vicinity of the spillway and stilling basin, and observation of the effects of currents on the movement of the model towboat. Velocities at the spillway and the spillway exit channel were measured with a midget current meter and current direction velocities were indicated by wooden floats submerged 8 ft (prototype). In evaluating test results obtained with the floats, it should be borne in mind that small changes in the direction of flow or in velocities are not necessarily changes produced by a change in plan, since several floats introduced at the same point under the same flow conditions may follow different paths or move at different velocities or both, because of pulsating currents and eddies. Because of the small model scale, it was difficult to reproduce or to measure water-surface elevations within an accuracy greater than $\pm$0.1 ft (prototype). This limitation should be considered when evaluating data showing the swellhead produced by the lock and dam structures, action within the stilling basin, and velocity measurements.

Results and Conclusions

39. The investigation resulted in the development of modifications which should provide: satisfactory flow conditions in the entrance to the spillway, the stilling basin, and spillway exit channel, and satisfactory navigation conditions. In general, the results indicated the following:

a. The upper and lower guide walls should also act as guard walls and be located on the river side of the lock approach channel to provide satisfactory navigation conditions in the approaches to the lock with all flows.

b. The spillway approach walls should be flared at least 1 on 4 to reduce velocities and turbulence near the entrance to the

spillway and to increase the capacity of the spillway.

c. The stilling basin should be lowered and its length increased to provide satisfactory stilling basin action and reduce velocities in the spillway exit channel.

d. The width of the spillway exit channel should be increased to at least 130 ft and the width of the channel downstream from the lower end of the lock to a point 100 ft downstream of the lower guard wall should be increased to about 445 ft to reduce velocities and the effects of currents on navigation in the lower lock approach.

e. Overbank flow from the Mississippi River during high stages would tend to sweep tows out of the lower reach of the Kaskaskia River channel and produce strong crosscurrents near the end of the lower guard wall. This effect can be eliminated by a fill or dike placed along the right bank of the Kaskaskia River channel or by a dike or fill across the right overbank.

f. Navigation conditions for downbound tows approacning the upper guard wall during high flows could be improved considerably by increasing the excavation along the right at least 50 ft opposite the end of the upper guard wall.

40. The alignment of the entrance to the Kaskaskia River channel appeared to be satisfactory, with no need for modifications.

41. Downbound tows moving close along the right bank would experience difficulty in negotiating the bend upstream of the lock. This difficulty could be avoided by tows moving along the center of the channel or toward the left side and can be eliminated by fill along the right bank to increase the radius of curvature of the bend and by dredging along the left bank to compensate for the loss in cross section.

Table 1

Velocities, Plan A

Discharge cfs		Velocity Station Numbers								Maximum	Channel
Kaskaskia River	Mississippi River	1	2	3	4	5	6	7	8	Velocity*	Station
10,000**	30,000	3.5	6.8	8.3	9.0	9.0	8.6	0	1.7	9.9	7+05.7B
20,000**	30,000	5.1	7.3	9.4	11.1	10.5	12.5	4.8	2.0	13.6	7+05.7B
20,000	30,000	7.0	9.6	11.3	12.4	12.8	13.1	4.9	2.0	16.3	7+05.7B
38,000	30,000	11.6	14.0	16.4	14.9	15.9	5.1	21.1	3.6	22.1	7+27.3B
60,000	30,000	15.3	17.7	19.8	16.1	15.6	25.0	20.8	23.5	26.0	7+41.7B
84,000	30,000	14.0	18.5	20.2	16.7	16.7	23.3	9.3	14.0	24.2	7+41.7B

Note: Velocities are in feet per second.
Velocity stations shown in plate 2.

* Maximum velocities between sta 6+55B and 7+75.3 obtained at toe of right bank of spillway channel at stations as shown.

** Upper pool controlled with dam gates.

Table 2

Water-Surface Elevations, Plan A

Gage No.	Discharge in 1000 cfs: K, 10* M, 30	K, 20* M, 30	K, 20 M, 30	K, 30 M, 30	K, 38 M, 30	K, 60 M, 30	K, 84 M, 30
1	363.0	363.0	356.4	360.5	363.5	371.1	374.1
2	363.0	363.0	356.0	360.1	363.2	370.6	373.1
3	--	--	--	--	--	--	--
4	363.0	363.0	355.2	359.7	363.0	370.4	373.0
5	363.0	363.0	355.2	359.8	363.0	370.5	373.1
6	363.0	363.0	355.3	359.8	363.0	370.5	373.0
7	362.9	362.5	353.9	358.1	361.2	368.5	373.1
8	345.5	349.9	350.0	353.3	355.9	360.9	362.8
9	341.4	342.3	342.3	343.3	345.0	345.6	350.0
10	341.3	342.1	342.1	343.2	344.8	346.8	349.9
11	Dry	Dry	Dry	Dry	Dry	Dry	371.6
12	341.6	342.9	342.9	344.2	345.9	348.1	350.9
13	341.6	342.8	342.8	344.1	346.2	347.8	350.6
14**	341.4	342.7	342.7	344.0	346.0	347.7	350.3
15	340.9	342.1	342.1	343.4	345.5	347.0	350.0

Note: All elevations are in feet referred to mean sea level.
Gage locations shown in plate 2.
K denotes Kaskaskia River; M denotes Mississippi River.
* Upper pool controlled with dam gates.
** Control gage.

Table 3

Velocities, Plan C

Velocity Station No.	Discharge, cfs K, 60,000 M, 40,000	Discharge, cfs K, 84,000 M, 40,000
1	22.3	17.0
2	18.7	18.0
3	23.1	22.6
4	14.7	16.6
5	15.2	16.5
6	11.3	10.1
7	2.7	--
8	1.2	--
9	9.3	--
10	3.3	--
11	10.4	--

Note: Velocities are in feet per second.
K denotes Kaskaskia River; M denotes Mississippi River.
Velocity stations shown in plate 4.

Table 4

Water-Surface Elevations, Plan C

Gage No.	Discharge, cfs K, 40,000 M, 40,000	Discharge, cfs K, 60,000 M, 40,000	Discharge, cfs K, 84,000 M, 40,000
1	363.5	370.1	374.0
2	363.1	369.7	372.9
3	Dry	Dry	Dry
4	363.0	369.4	372.9
5	362.0	369.5	373.0
6	363.0	369.9	373.1
7	362.6	369.2	372.9
8	346.0	346.5	350.4
9	347.8	350.2	352.8
10	347.8	349.9	352.7
11	Dry	Dry	371.6
12	347.8	350.6	353.2
13	347.7	350.4	353.0
14*	347.5	350.3	352.9
15	347.0	349.8	352.5

Note: Gage locations shown in plate 4.
All elevations are in feet referred to mean sea level.
K denotes Kaskaskia River; M denotes Mississippi River.
* Control gage.

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Table 5

Water-Surface Elevations, Plan D

Gage No.	Discharge in 1000 cfs								
	K, 40 M, 40	K, 60 M, 40	K, 64 M, 30	K, 84* M, 30	K, 84 M, 40	K, 84 M, 70	K, 100 M, 120	K, 84 M, 666	K, 30 M, 720
1	363.5	370.1	371.2	375.4	373.9	374.0	375.8	383.0	382.5
2	363.2	369.6	370.7	374.6	372.8	372.9	374.3	382.7	382.5
3	Dry	Dry	Dry	374.6	Dry	Dry	374.2	382.7	382.5
4	362.8	369.4	370.6	374.7	372.8	372.9	374.3	382.7	382.5
5	362.9	369.5	370.7	374.7	373.0	373.0	374.8	382.8	382.5
6	363.0	369.5	370.8	375.0	373.0	373.1	374.7	382.8	382.6
7	362.7	369.2	370.3	374.4	372.9	372.9	374.5	382.8	382.6
8	347.1	349.2	348.5	350.2	350.3	354.2	358.8	381.9	381.9
9	347.7	350.7	349.7	352.1	352.9	356.0	361.5	382.7	382.5
10	347.7	350.6	349.7	351.9	352.8	355.9	361.4	382.7	382.6
11	Dry	Dry	Dry	Dry	372.0	371.5	372.4	382.7	382.6
12	347.8	350.6	349.7	352.3	353.2	356.2	361.5	382.7	382.6
13	347.7	350.5	349.7	351.8	353.1	355.8	360.8	382.8	382.7
14**	347.5	350.3	349.6	351.7	352.9	355.6	360.5	382.5	382.5
15	347.0	349.8	349.2	351.3	352.5	355.2	360.2	381.6	381.6

Note: All elevations are in feet referred to mean sea level.
Gage locations shown in plate 5.
K denotes Kaskaskia River; M denotes Mississippi River.
* Left overbank raised so that all flow is in channel and through spillway.
** Control gage.

Table 6

Velocities, Plans D and D Modified

Velocity Station No.	Discharge, cfs K, 60,000 M, 40,000	K, 64,000 M, 30,000	K, 84,000 M, 40,000
	Plan D		
1	7.6	7.7	7.2
2	6.7	7.6	7.4
3	14.7	15.5	15.3
4	13.3	15.5	14.7
5	9.0	9.4	9.2
6	8.7	10.3	10.2
7	9.7	10.6	9.4
8	7.7	8.2	7.3
9	Eddy	1.5*	1.2*
10	8.1	9.7	8.7
11	5.8	6.0	5.2
12	8.4	9.2	9.1

Discharge: K, 84,000 cfs; M, 40,000 cfs

Velocity Station No.	Velocity	Velocity Station No.	Velocity
	Plan D Modified**		
1	7.0	13	12.0
2	7.5	14	9.1
3	15.3	15	10.4
4	16.1	16	10.4
5	16.3	17	9.3
6	15.6	18	8.6
7	15.3	19	5.5
8	14.7	20	1.1
9	13.9	21	8.8
10	13.5	22	4.9
11	11.1	23	9.3
12	13.1		

Note: K denotes Kaskaskia River; M denotes Mississippi River.
Velocities are in feet per second.
Velocity stations for plan D shown in plate 5; those for plan D modified shown in plate 6.

* Current flowing from right to left along toe of slope.

** Section immediately downstream of stilling basin set at el 315.0 shortened from 84 to 54 ft.

Table 7

Water-Surface Elevations, Plan E

Gage No.	Discharge in 1000 cfs							
	K, 5 M, 40	K, 10 M, 40	K, 20 M, 40	K, 30 M, 40	K, 40 M, 40	K, 64 M, 40	K, 84 M, 40	K, 100 M, 40
1	349.9	352.2	355.8	360.2	363.7	371.4	377.3	382.1
2	349.5	351.7	355.3	359.6	363.4	370.8	376.7	381.7
3	Dry	Dry	Dry	Dry	Dry	Dry	376.6	381.7
4	348.3	349.7	354.2	359.1	363.0	370.6	376.6	381.7
5	346.3	349.5	354.3	359.2	363.2	370.7	376.7	381.6
6	346.3	349.5	354.3	359.2	363.2	370.9	376.8	381.7
7	346.2	349.4	354.1	358.9	362.9	370.5	376.3	381.4
8	341.5	342.5	344.5	345.5	347.5	349.0	345.5	346.7
9	342.2	343.3	345.3	346.6	348.2	350.9	352.4	353.0
10	342.2	343.3	345.3	346.6	348.1	350.7	352.2	353.0
11	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
12	342.3	343.3	345.2	346.6	348.1	351.1	353.0	354.3
13	342.4	343.4	345.3	346.5	348.0	351.0	353.1	354.6
14*	342.2	343.2	345.0	346.4	347.8	350.8	352.9	354.4
15	341.7	342.6	344.5	345.8	347.3	350.4	352.6	354.3

Note: All elevations are in feet referred to mean sea level.
K denotes Kaskaskia River; M denotes Mississippi River.
All Kaskaskia flow through spillway.
Gage locations shown in plate 12.
* Control gage.

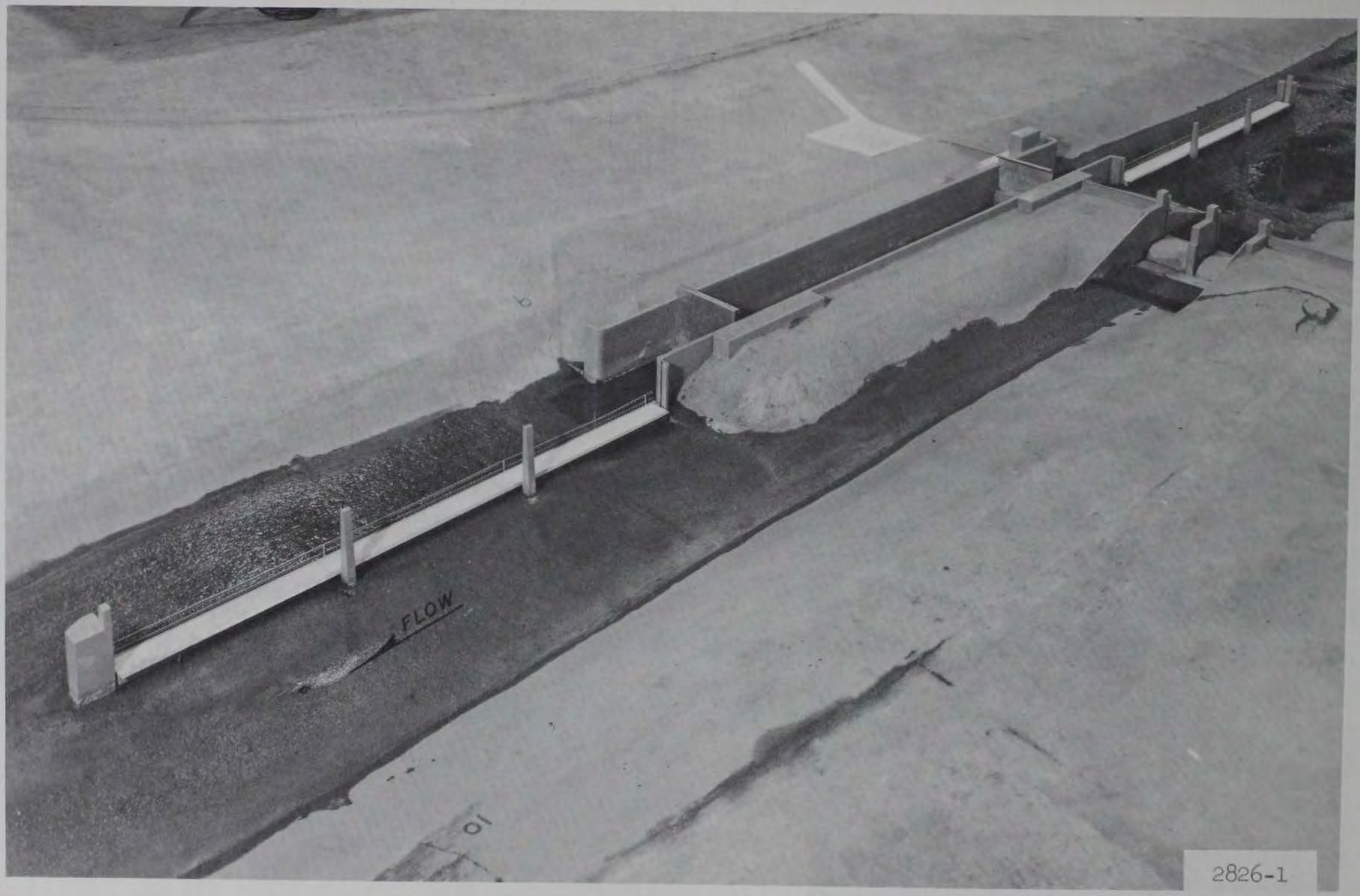
Table 8

Maximum Velocities Along

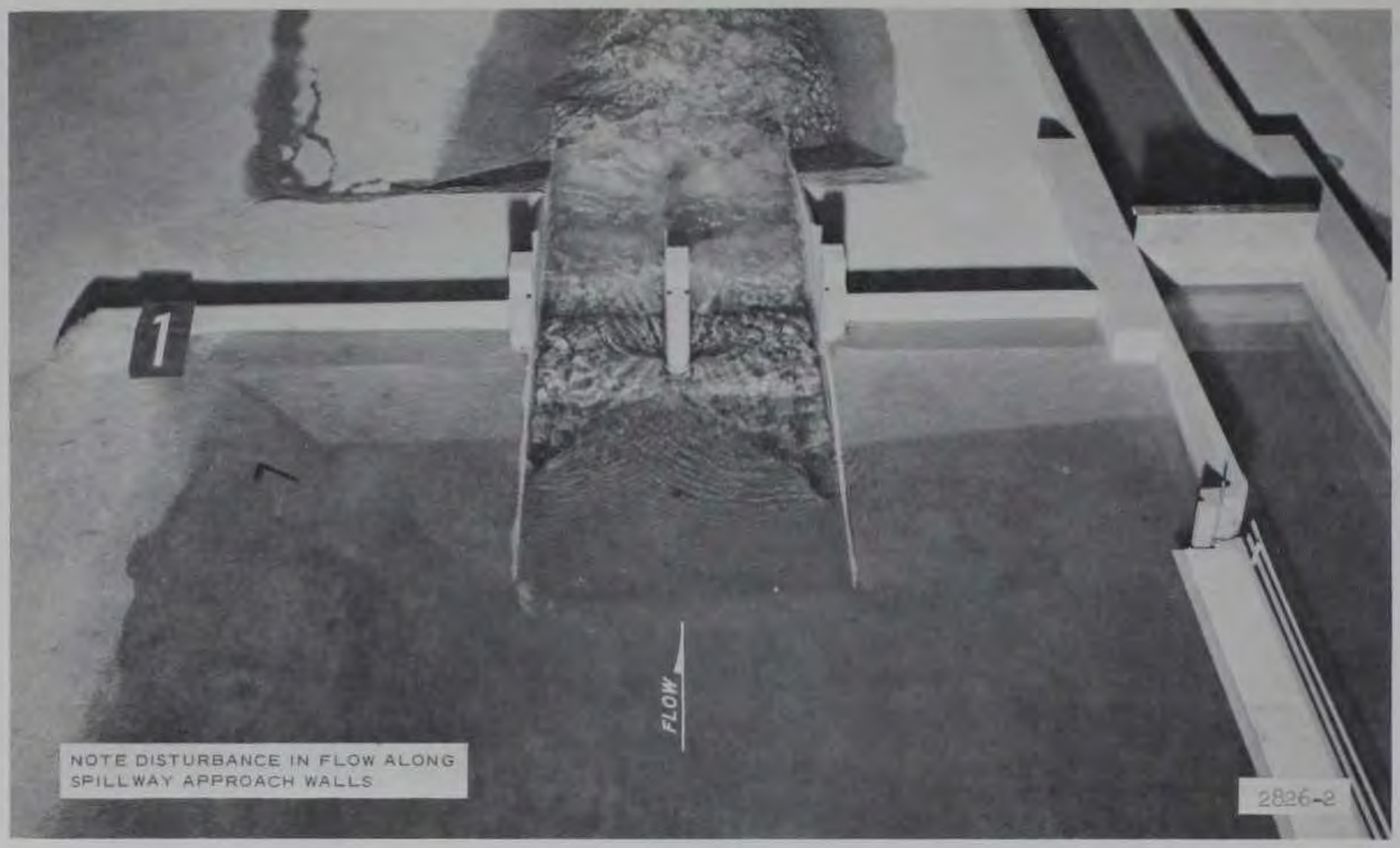
Spillway Approach Walls, Plan E

Discharge cfs	Left Side		Right Side	
	Maximum Velocity* fps	Distance Normal to Dam Axis, ft	Maximum Velocity fps	Distance Normal to Dam Axis, ft
K, 40,000 M, 40,000	6.3	80	9.4	90
K, 64,000 M, 40,000	8.8	55	11.1	65
K, 84,000 M, 40,000	9.4	50	10.7	55
K, 100,000 M, 40,000	13.1	30	12.7	30

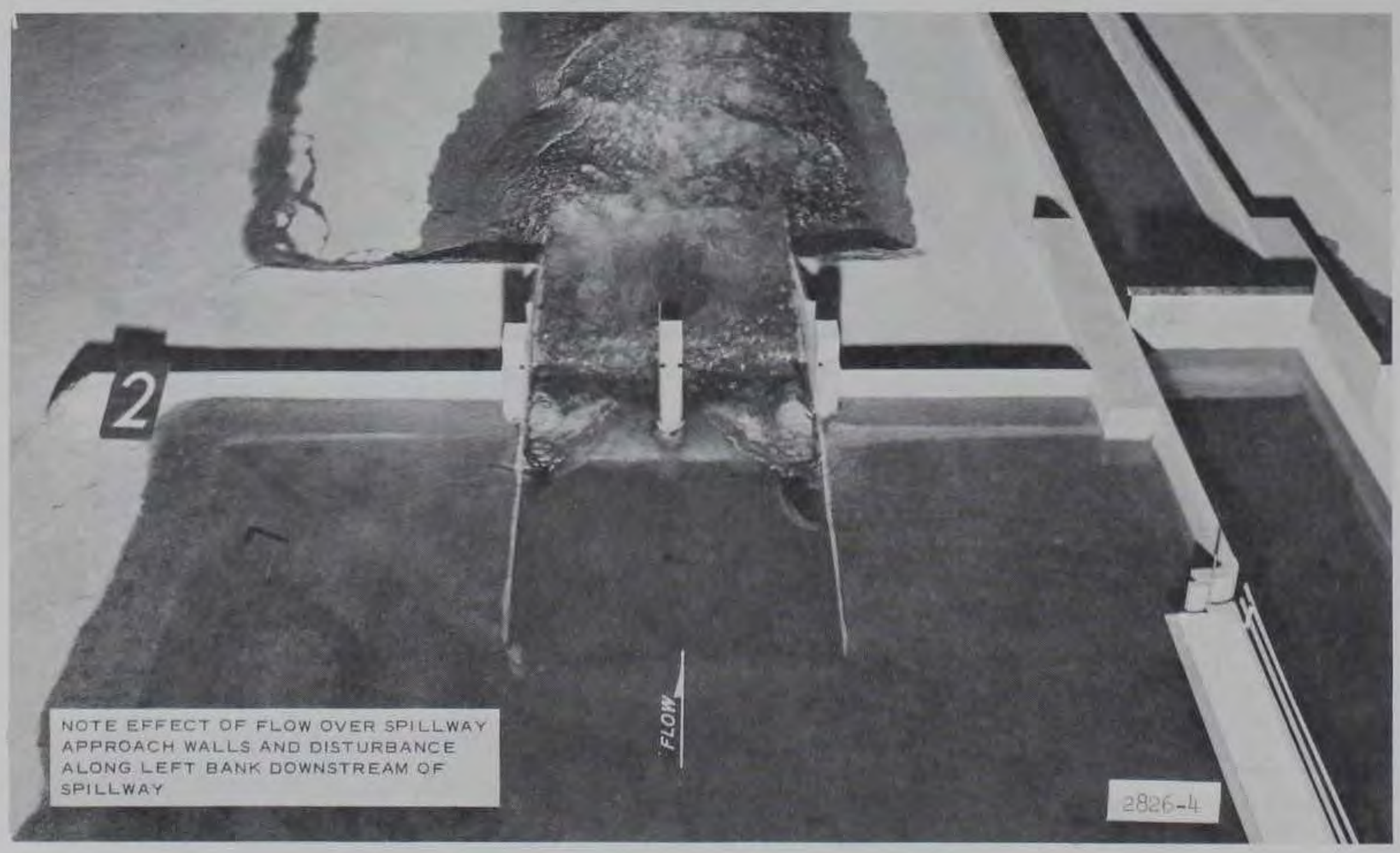
* Velocities measured along slope 5 ft landward of river edge of wall.



Photograph 1. Plan A (original design)

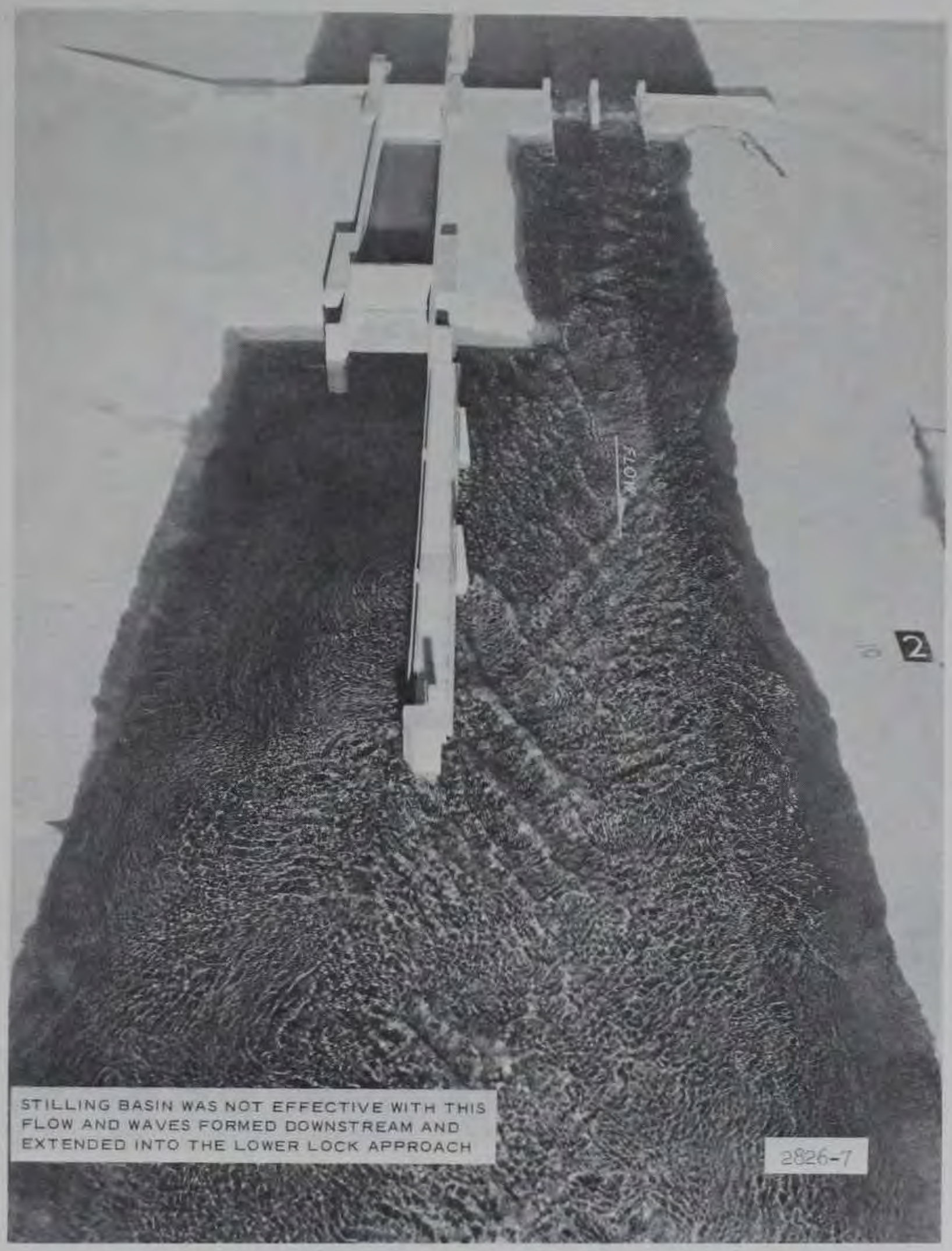


a. Discharges: Kaskaskia River, 30,000 cfs;
Mississippi River, 30,000 cfs



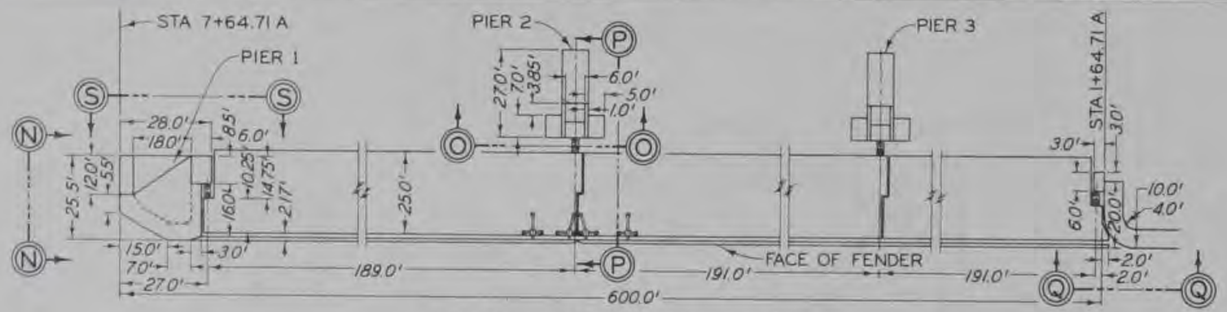
b. Discharges: Kaskaskia River, 60,000 cfs;
Mississippi River, 30,000 cfs (upstream view)

Photograph 2. Flow conditions with plan A (original design) installed in model (1 of 2 sheets)

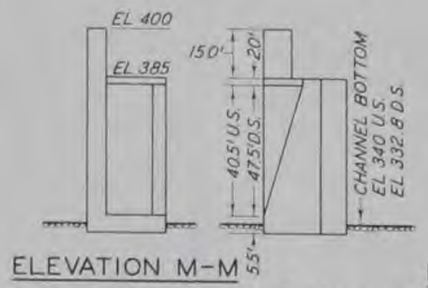


c. Discharges: Kaskaskia River, 60,000 cfs; Mississippi River, 30,000 cfs (downstream view)

Photograph 2. (2 of 2 sheets)

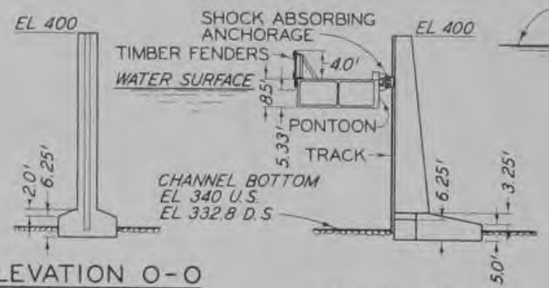


GUIDE WALL DETAILS



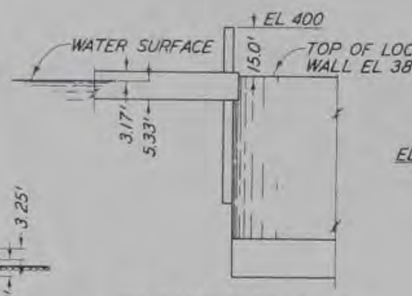
ELEVATION M-M

ELEVATION N-N



ELEVATION O-O

ELEVATION P-P



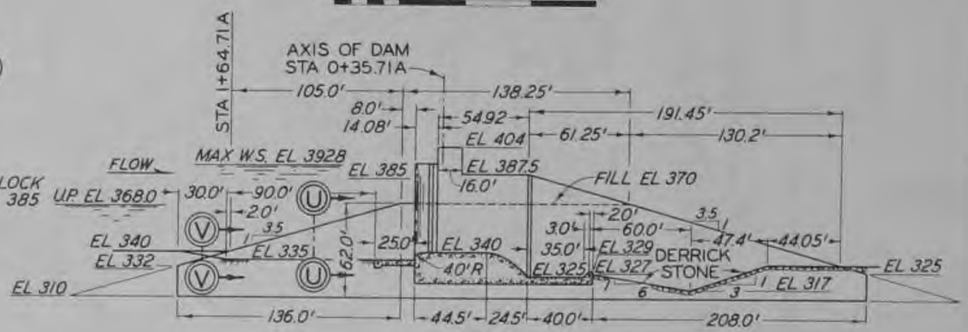
ELEVATION Q-Q

SECTION U-U

SECTION V-V

SCALE IN FEET

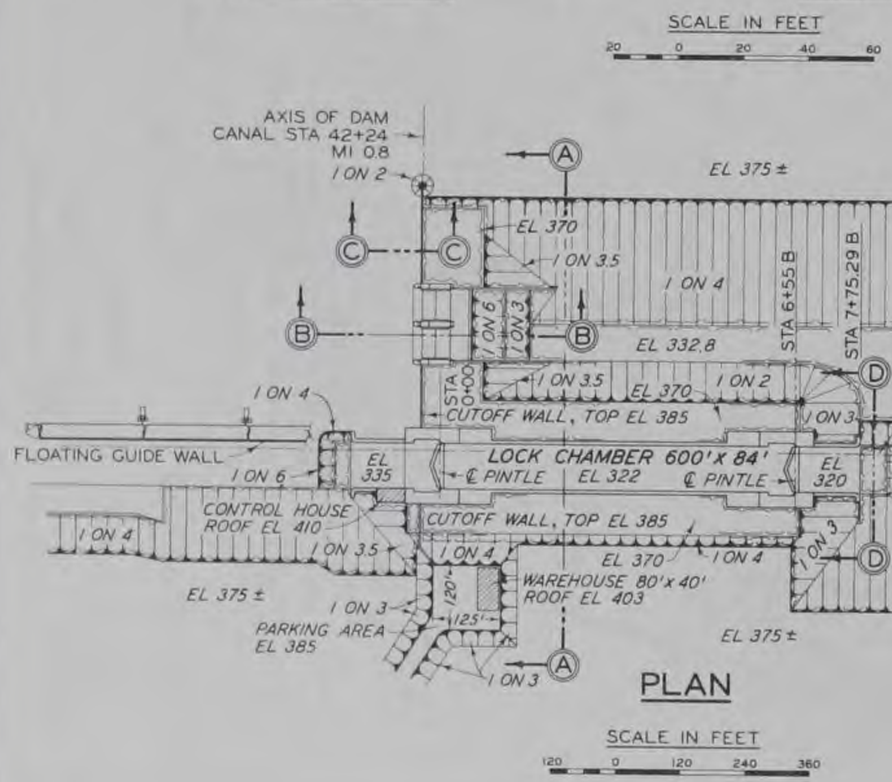
40 0 40 80 120



SECTION B-B

SCALE IN FEET

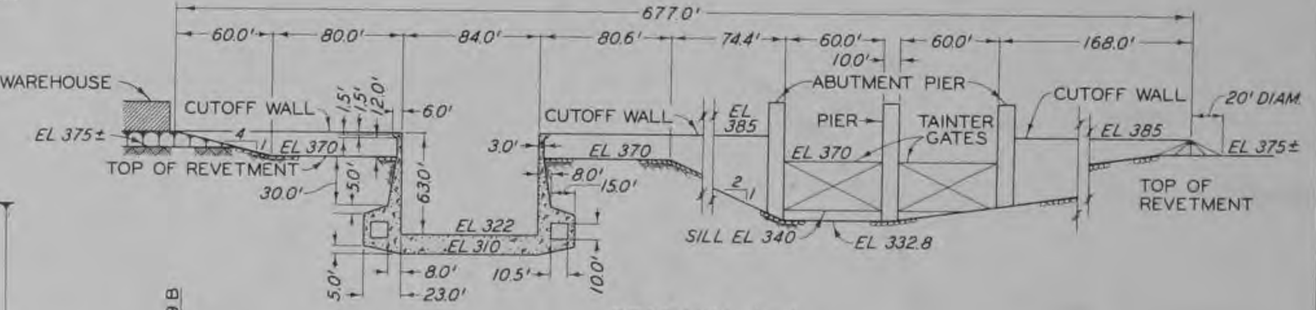
40 0 40 80 120



PLAN

SCALE IN FEET

120 0 120 240 360



SECTION A-A

SECTION C-C

SCALE IN FEET

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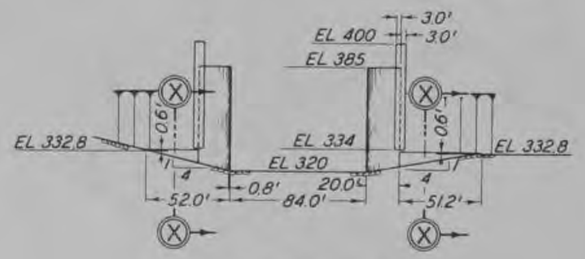


SECTION D-D

SCALE IN FEET

40 0 40 80 120

SECTION X-X

SCALE IN FEET

40 0 40 80 120

DETAILS OF LOCK AND DAM

PLATE I

E 562,000

E 566,000

E 570,000

N 486,000

N 482,000

N 478,000

N 474,000

N

375

370

365

EMBANKMENT EL 370

EL 365

AXIS OF DAM

SEE DETAIL A

EL 332.8

R=500'

354'

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

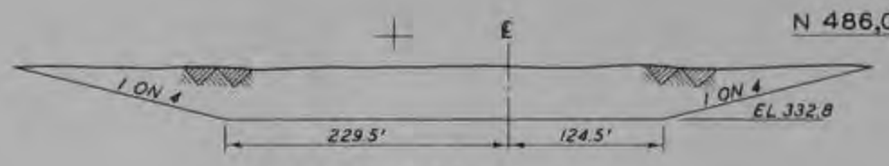
A

B

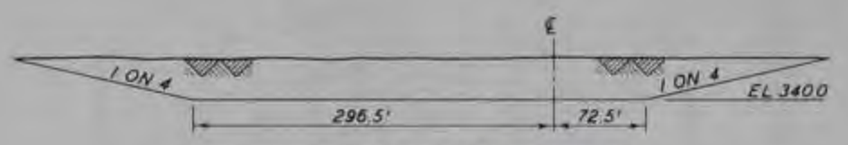
C

C

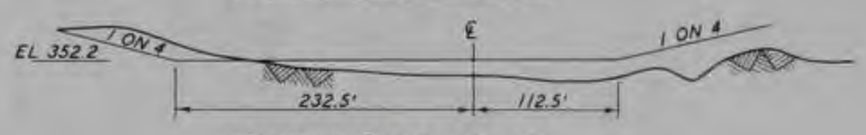
SECTION A-A



SECTION B-B



SECTION C-C



SCALE IN FEET

80 0 80 160

DETAIL A

SCALE IN FEET

200 0 200 400

LEGEND

- MODEL GAGE LOCATIONS
- VELOCITY STATIONS

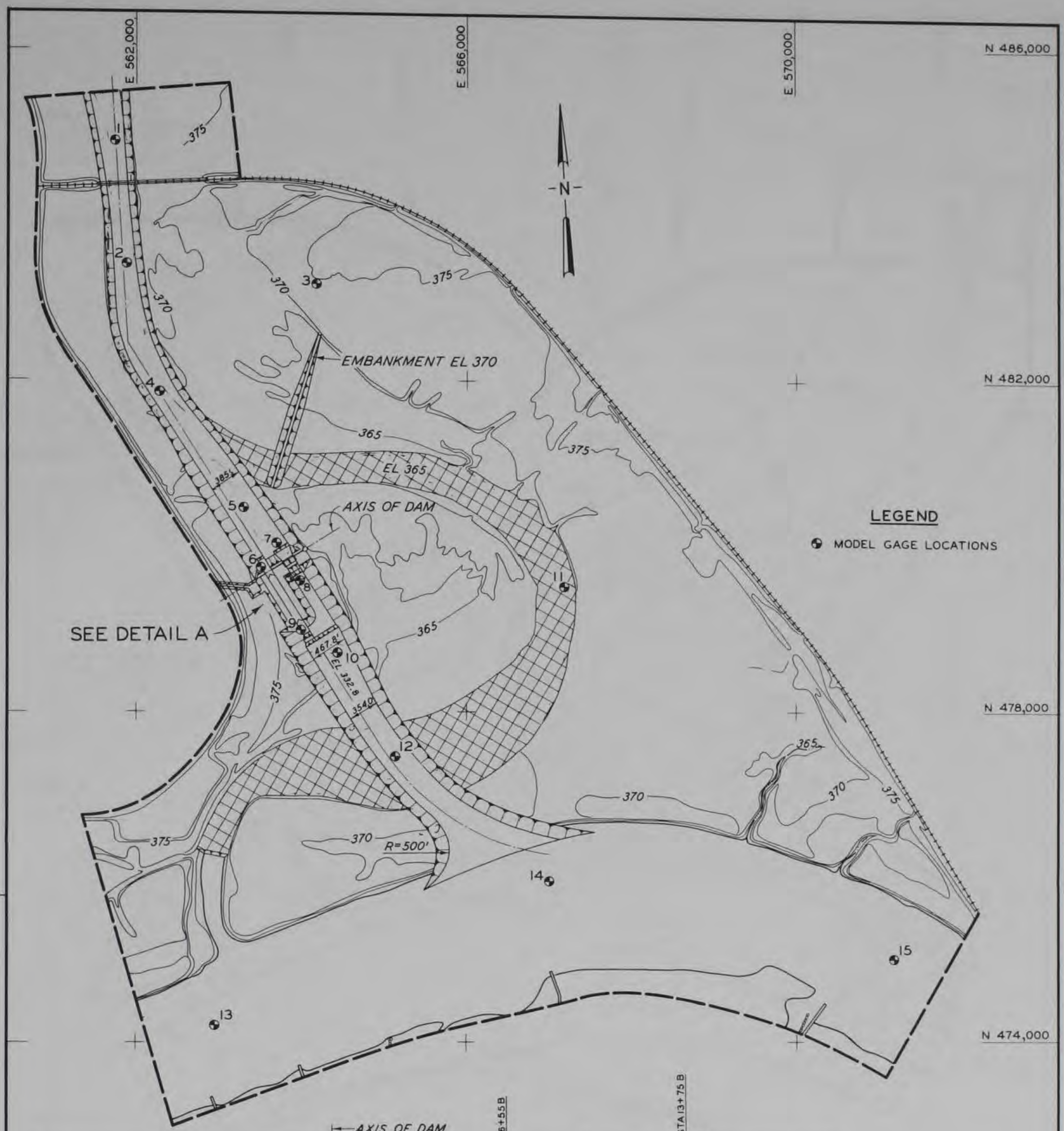
PLAN A

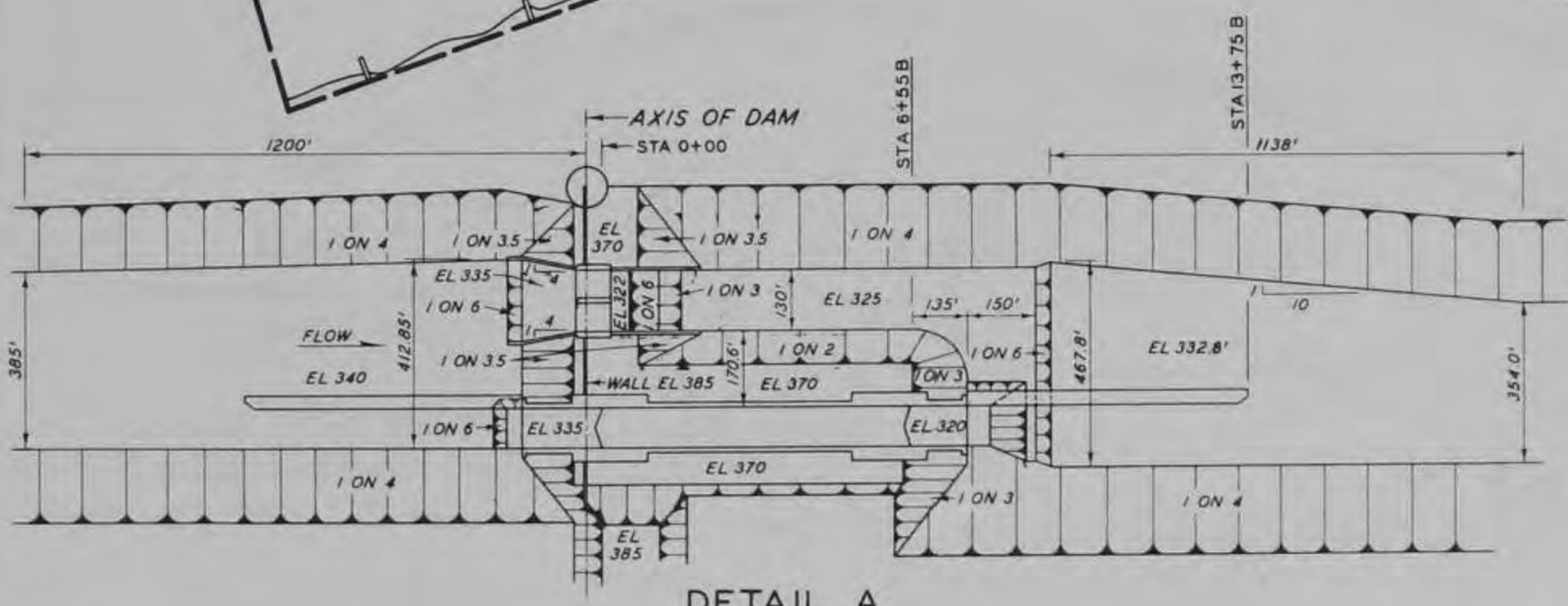
SCALES IN FEET

PROTOTYPE 600 0 600 1200 1800

MODEL 5 0 5 10 15

PLATE 2





DETAIL A

SCALE IN FEET

200 0 200 400

PLAN B

SCALES IN FEET

PROTOTYPE 600 0 600 1200 1800

MODEL 5 0 5 10 15

PLATE 3

E 562,000

E 566,000

E 570,000

N 486,000

N 482,000

N 478,000

N 474,000

N

375

370

365

EMBANKMENT EL 370

EL 365

AXIS OF DAM

SEE DETAIL A

R=500'

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

445.4'

914'

354.0'

LEGEND

MODEL GAGE LOCATIONS

VELOCITY STATIONS

PLAN C

SCALES IN FEET

PROTOTYPE 600 0 600 1200 1800

MODEL 5 0 5 10 15

AXIS OF DAM

STA 0+00

STA 6+55 B

STA 13+75 B

1 ON 4

1 ON 3.5

1 ON 3

1 ON 2

1 ON 6

EL 370

EL 335

EL 322

EL 325

EL 340

EL 330

EL 320

EL 385

WALL EL 385

FLOW

412.85'

130'

170.6'

135'

150'

100'

914'

445.4'

354.0'

DETAIL A

SCALE IN FEET

200 0 200 400

PLATE 4

E 562,000

E 566,000

E 570,000

N 486,000

N 482,000

N 478,000

N 474,000

N

375

370

375

EMBANKMENT EL 370

365

EL 365

375

AXIS OF DAM

SEE DETAIL A

365

370

375

370 R=500'

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

WALL

2'

6'

6'

6'

2'

2'

2'

130'

PLAN OF BAFFLES

SCALE IN FEET

10 0 10 20

AXIS OF DAM
STA 0+00

STA 6+55 B

STA 13+75 B

1 ON 4

1 ON 3.5

A

A

1 ON 3.5

1 ON 4

EL 335

EL 340

EL 325

EL 330

1 ON 3.5

1 ON 2

1 ON 3

1 ON 6

84'

EL 315

445.4'

100'

DETAIL A

SCALE IN FEET

200 0 200 400

EL 327

EL 321

EL 320

EL 317

EL 315

EL 325

40'

12'

13'

5'

6

30'

84'

30'

70'

SECTION A-A

SCALE IN FEET

20 0 20 40

LEGEND

- MODEL GAGE LOCATIONS
- VELOCITY STATIONS

PLAN D

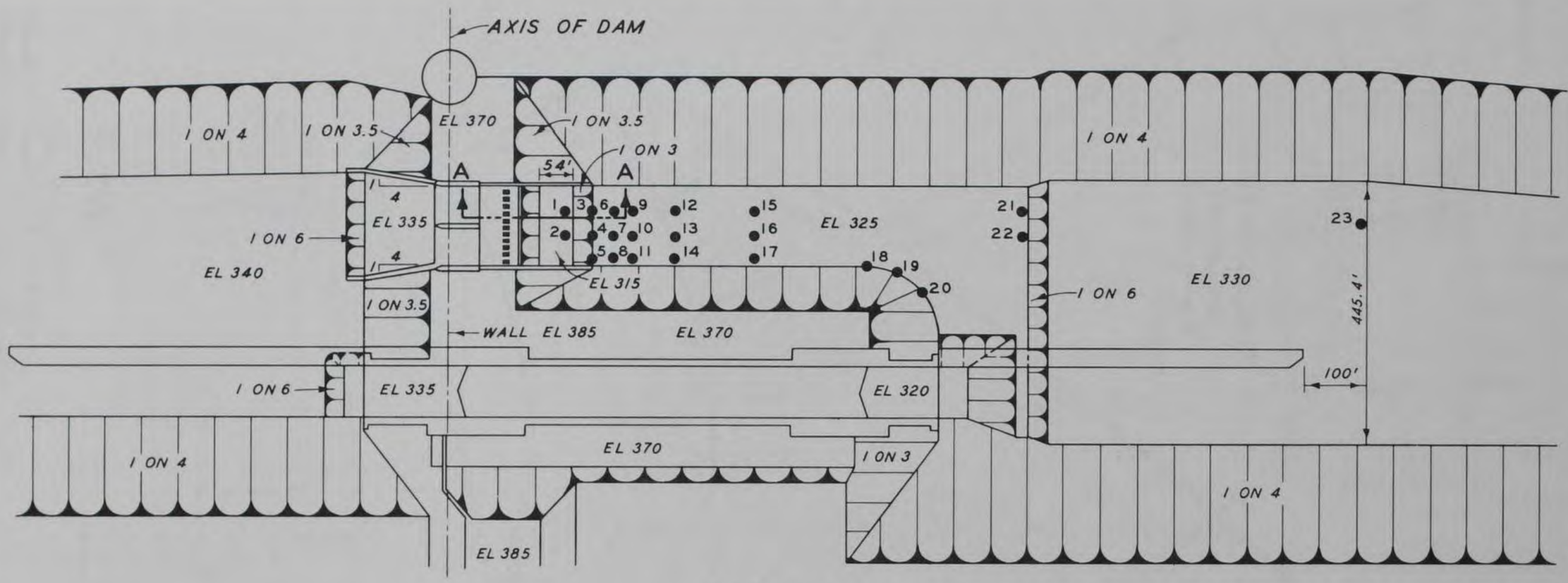
SCALES IN FEET

PROTOTYPE 600 0 600 1200 1800 2400

MODEL 5 0 5 10 15 20

PLATE 5

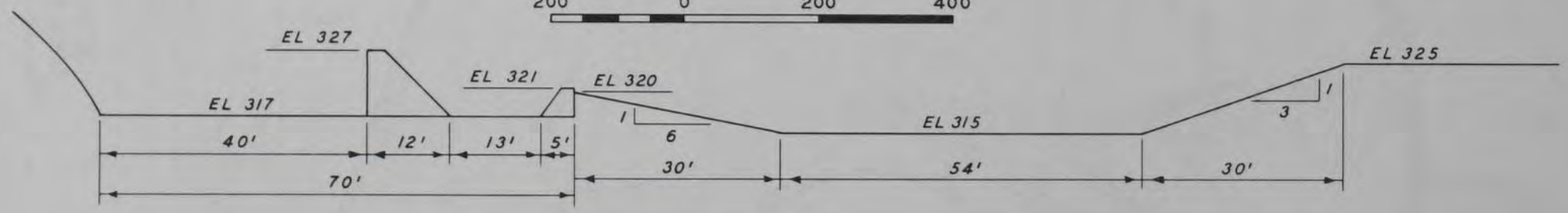
PLATE 6



DETAIL A

SCALE IN FEET

200 0 200 400



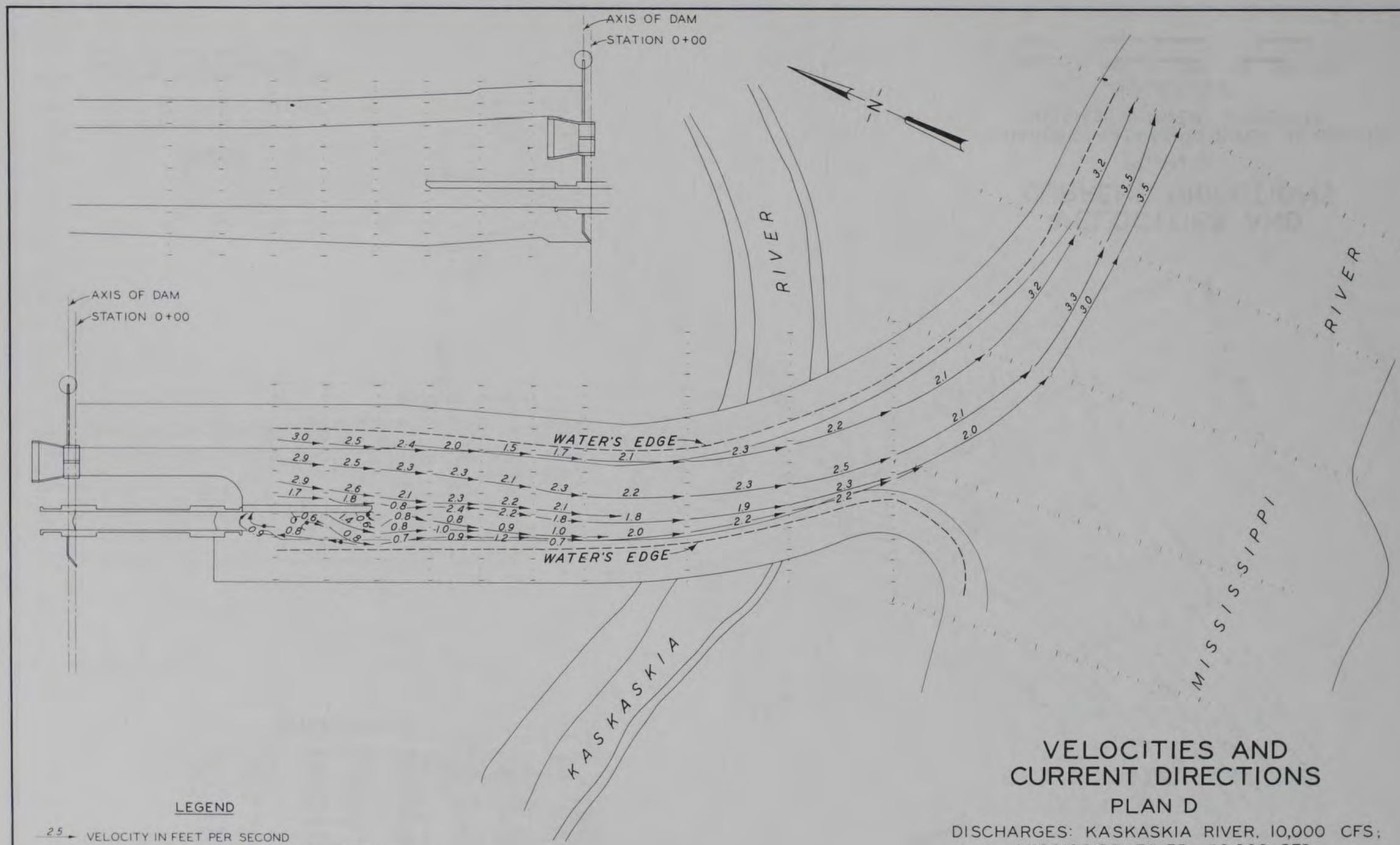
SECTION A-A

SCALE IN FEET

20 0 20 40

LOCATION OF VELOCITY STATIONS

PLAN D MODIFIED



VELOCITIES AND CURRENT DIRECTIONS

PLAN D

DISCHARGES: KASKASKIA RIVER, 10,000 CFS; MISSISSIPPI RIVER, 40,000 CFS

LEGEND

25 → VELOCITY IN FEET PER SECOND

•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

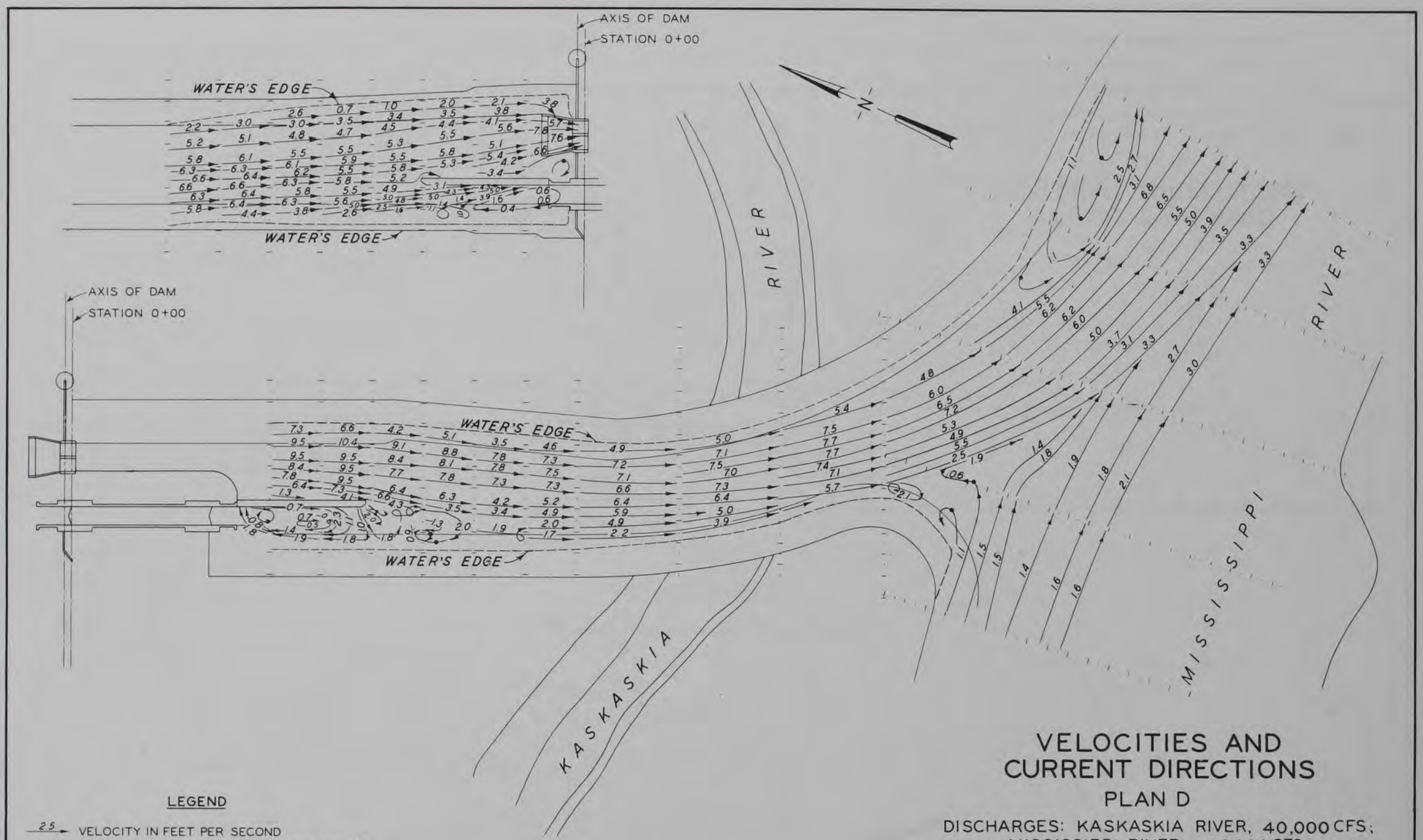
SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6

PLATE 7

PLATE 8



VELOCITIES AND CURRENT DIRECTIONS

PLAN D

DISCHARGES: KASKASKIA RIVER, 40,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS

LEGEND

2.5 → VELOCITY IN FEET PER SECOND

→• VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6

AXIS OF DAM
STATION 0+00

AXIS OF DAM
STATION 0+00

RIVER

SLACK

WATER'S EDGE

WATER'S EDGE

KASKASKIA

MISSISSIPPI

RIVER

N

LEGEND

2.5 → VELOCITY IN FEET PER SECOND

→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN D

DISCHARGES: KASKASKIA RIVER, 84,000 CFS; MISSISSIPPI RIVER, 40,000 CFS

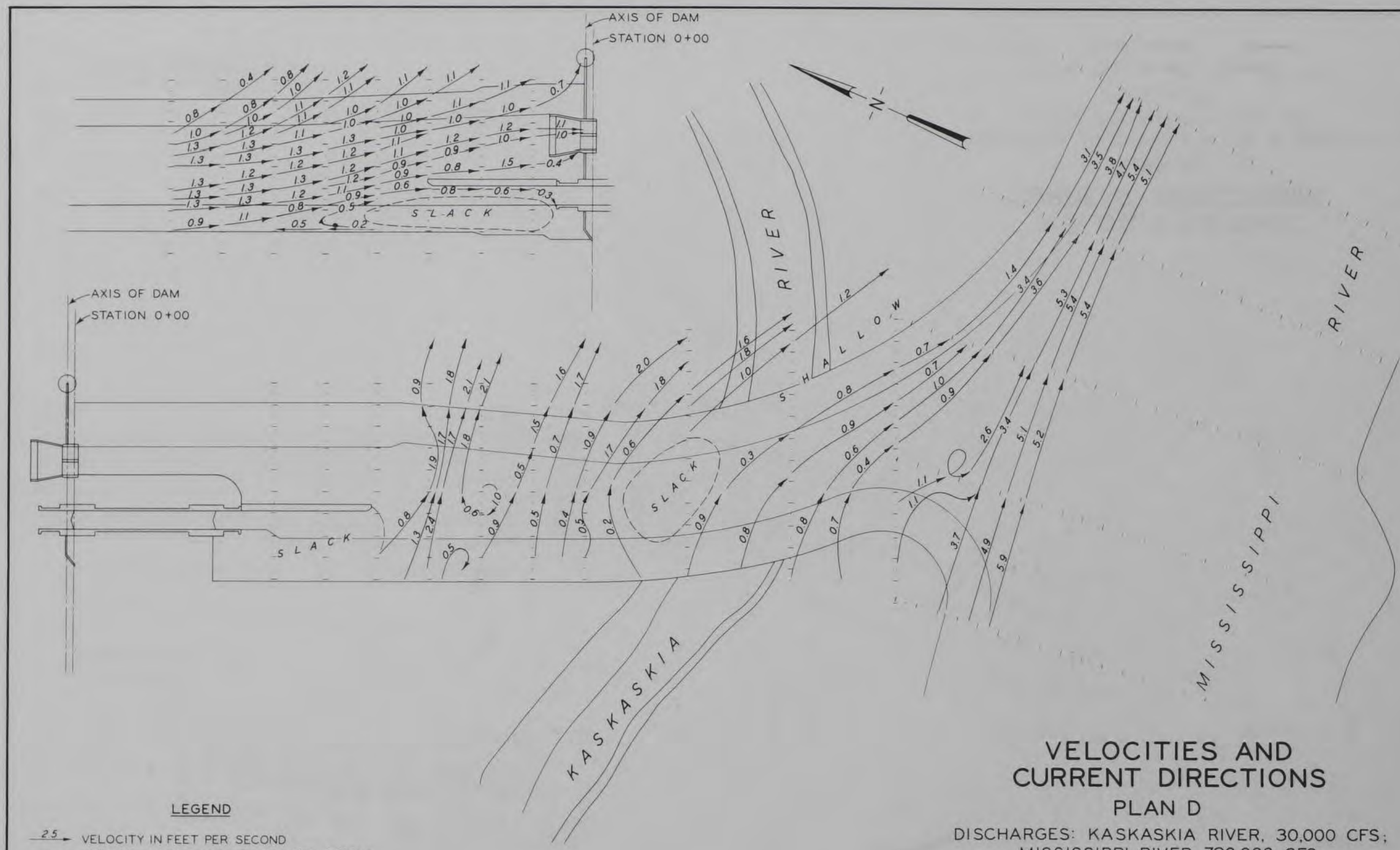
SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6

PLATE 9

PLATE 10



LEGEND

25 → VELOCITY IN FEET PER SECOND

—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

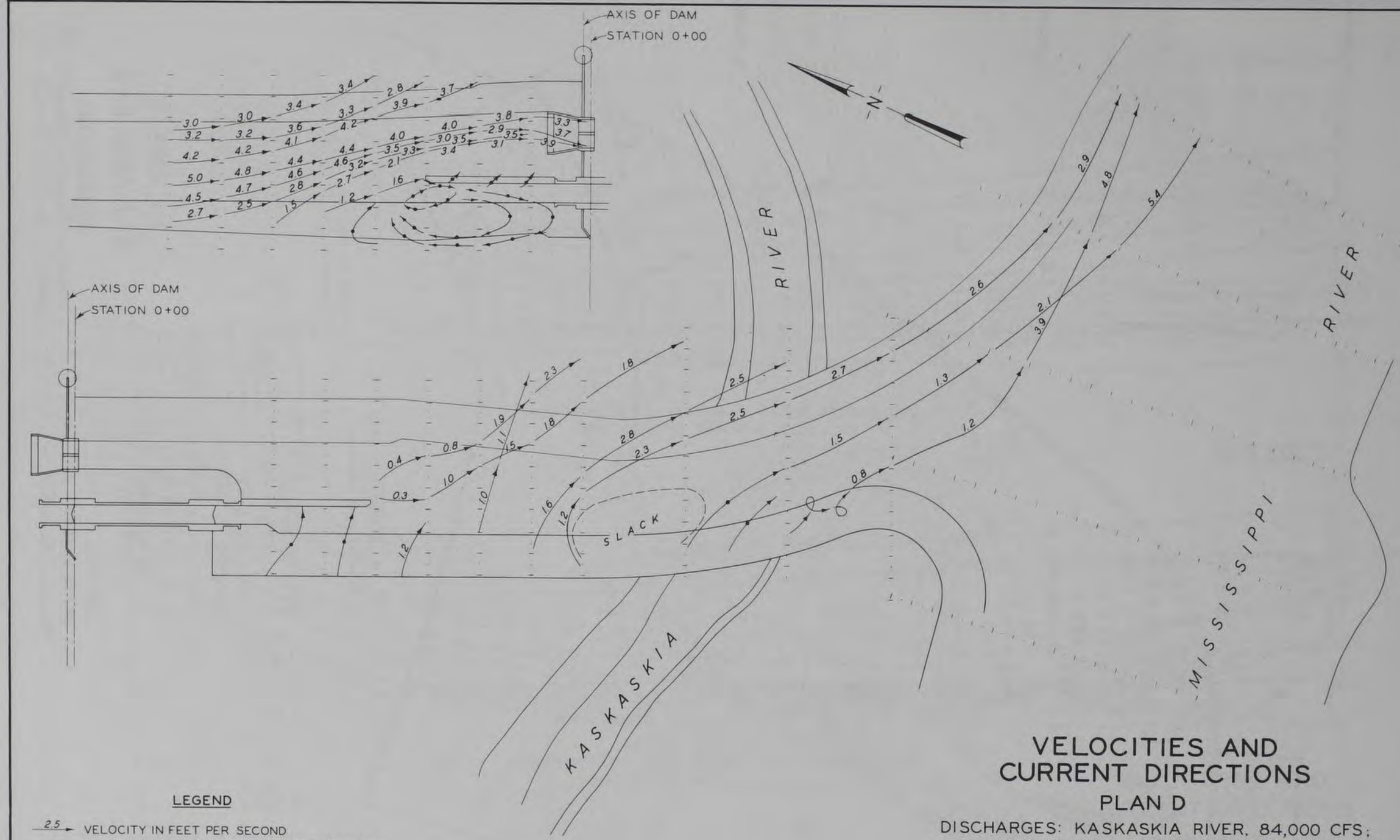
PLAN D

DISCHARGES: KASKASKIA RIVER, 30,000 CFS; MISSISSIPPI RIVER, 720,000 CFS

SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6



VELOCITIES AND CURRENT DIRECTIONS

PLAN D

DISCHARGES: KASKASKIA RIVER, 84,000 CFS;
MISSISSIPPI RIVER, 666,000 CFS

LEGEND

2.5 → VELOCITY IN FEET PER SECOND

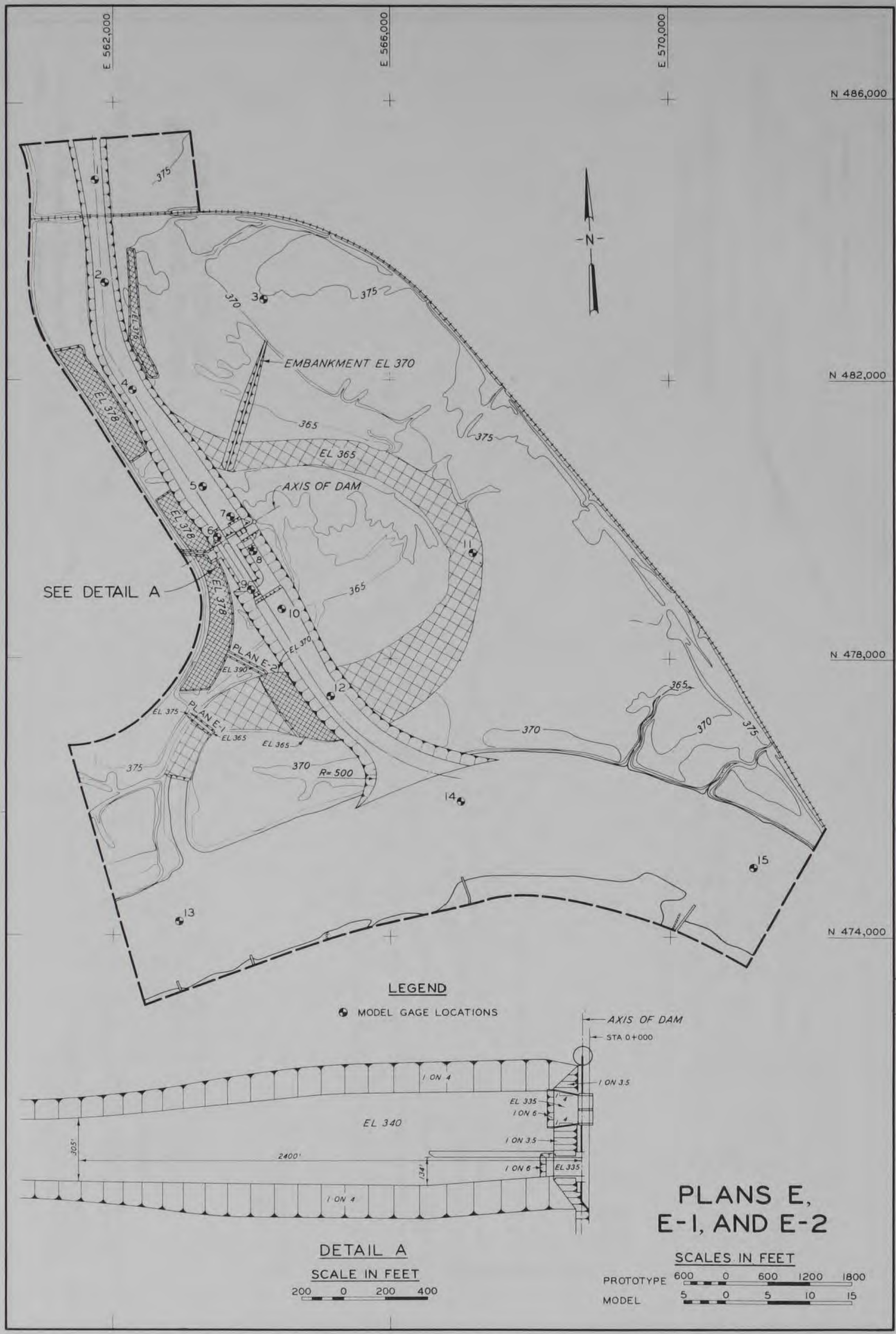
→• VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

SCALE IN FEET

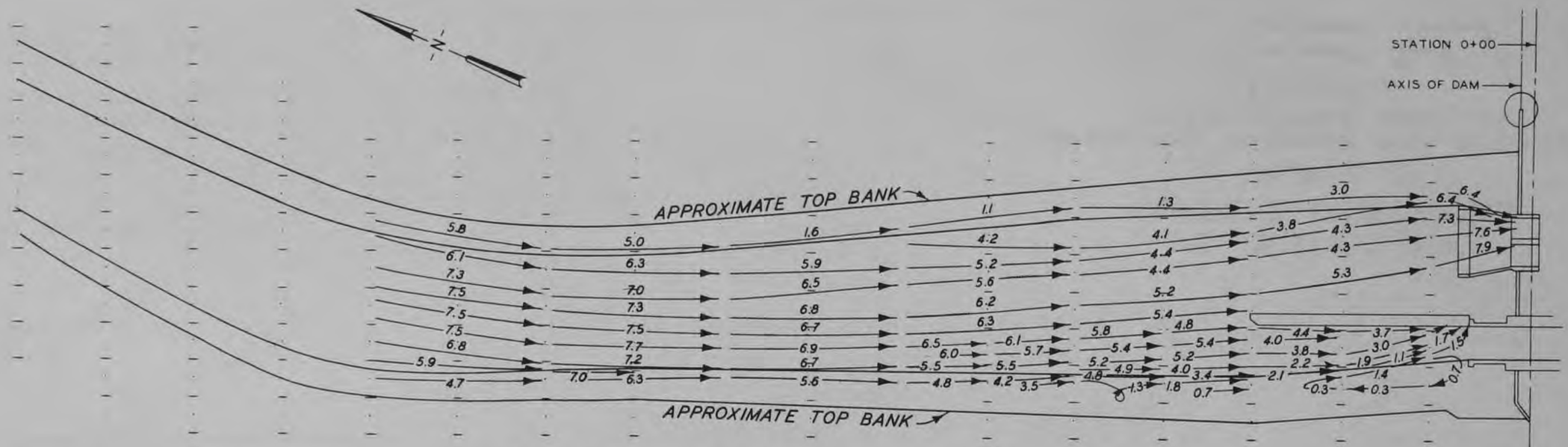
PROTOTYPE	200	0	200	400	600	800	
MODEL	2	0	2	4	6		

PLATE 11

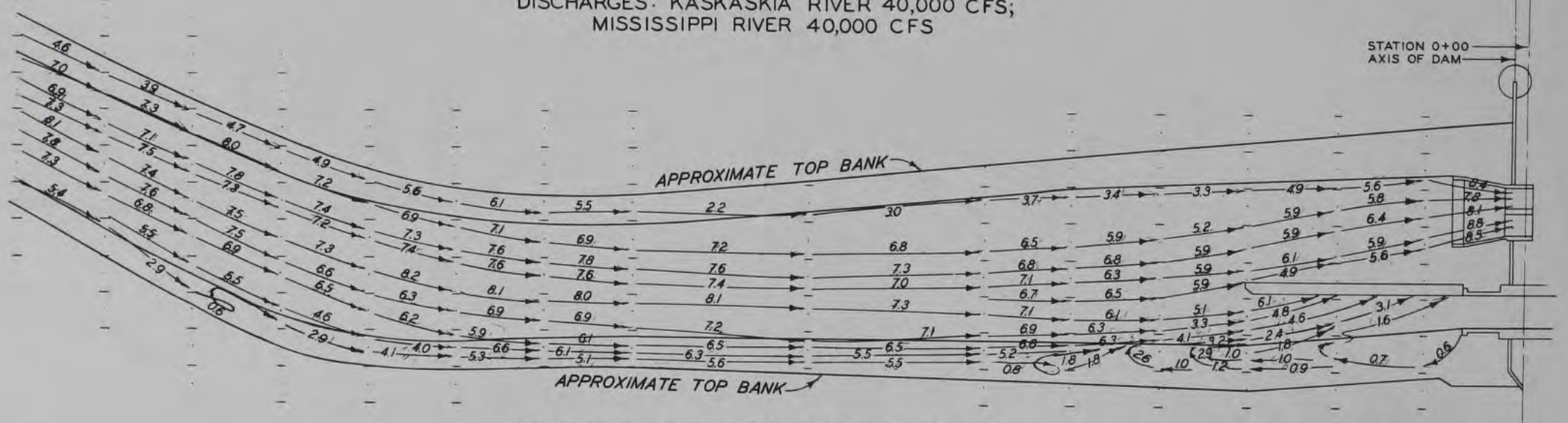


PLANS E, E-1, AND E-2

PLATE 12



DISCHARGES: KASKASKIA RIVER 40,000 CFS;
MISSISSIPPI RIVER 40,000 CFS



DISCHARGES: KASKASKIA RIVER, 64,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS

LEGEND

2.5 → VELOCITY IN FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN E

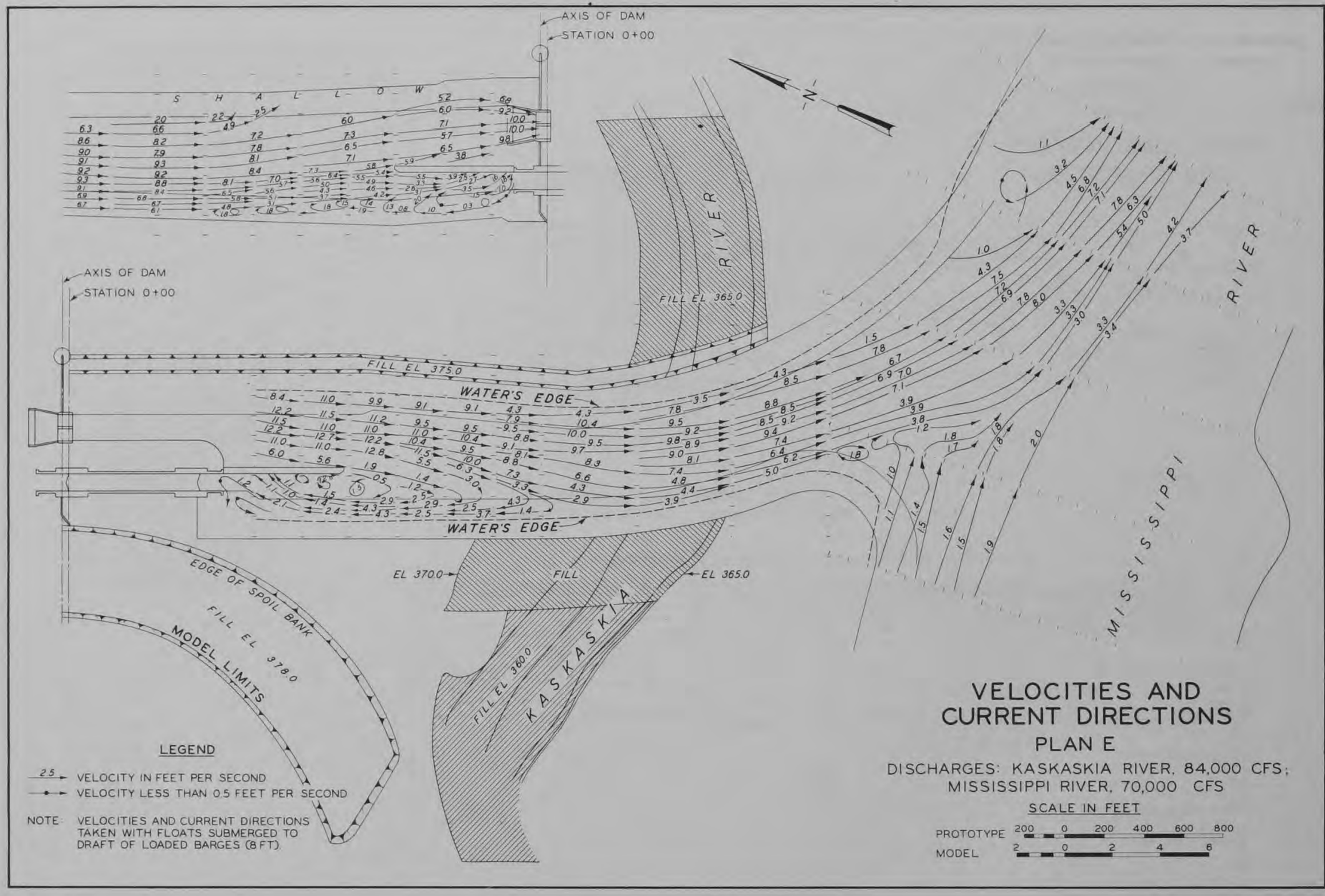
SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 2 0 2 4 6

PLATE 13

PLATE 14



VELOCITIES AND CURRENT DIRECTIONS

PLAN E

DISCHARGES: KASKASKIA RIVER, 84,000 CFS; MISSISSIPPI RIVER, 70,000 CFS

SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6

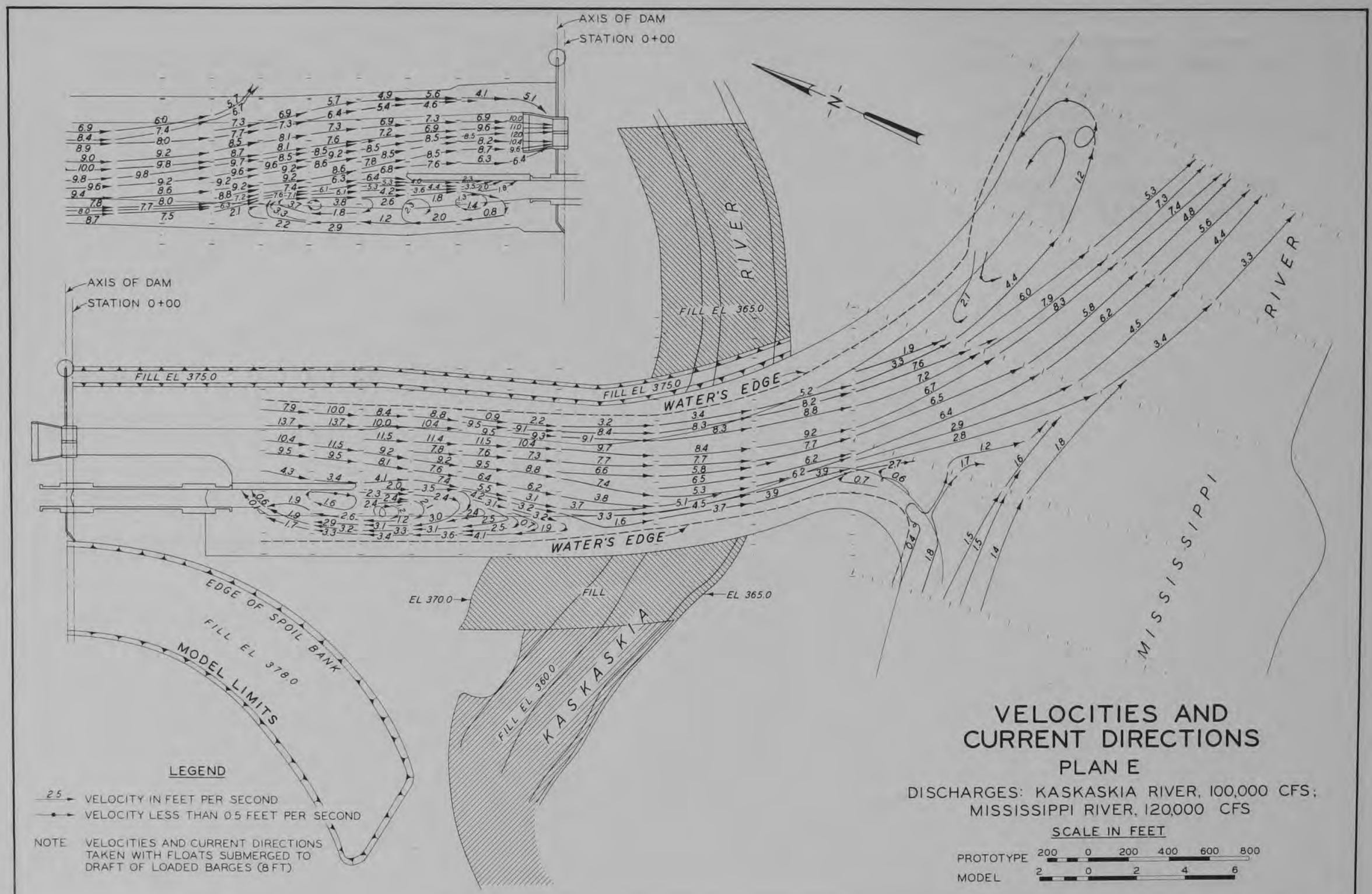
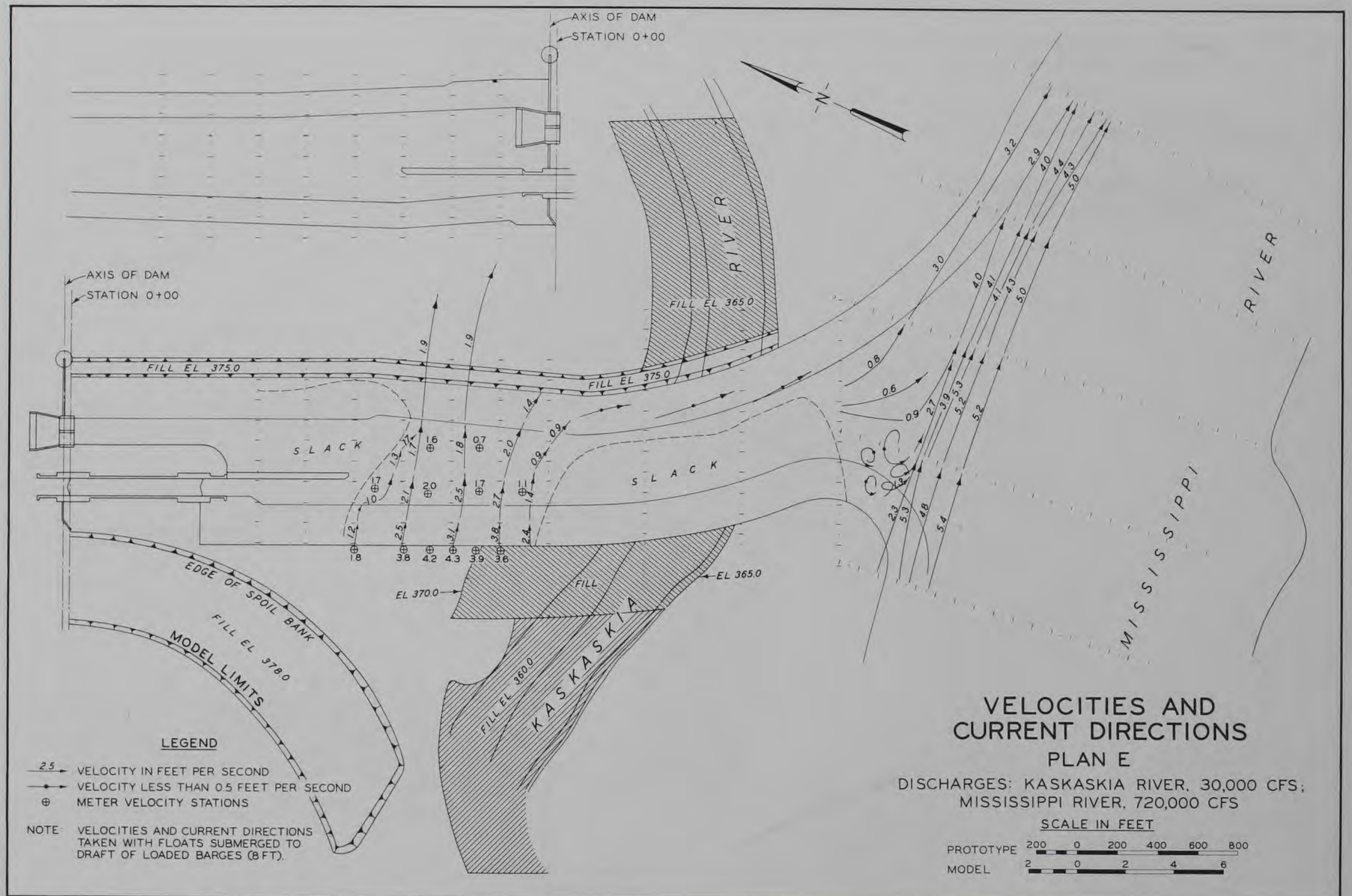

AXIS OF DAM
STATION 0+00
AXIS OF DAM
STATION 0+00
RIVER
FILL EL 365.0
FILL EL 375.0
FILL EL 375.0
WATER'S EDGE
WATER'S EDGE
RIVER
MISSISSIPPI
EDGE OF SPOIL BANK
FILL EL 378.0
MODEL LIMITS
EL 370.0
FILL
EL 365.0
FILL EL 360.0
KASKASKIA
LEGEND
2.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT)
N
VELOCITIES AND CURRENT DIRECTIONS
PLAN E
DISCHARGES: KASKASKIA RIVER, 100,000 CFS; MISSISSIPPI RIVER, 120,000 CFS
SCALE IN FEET
PROTOTYPE 200 0 200 400 600 800
MODEL 2 0 2 4 6

PLATE 15

PLATE 16



LEGEND

2.5 → VELOCITY IN FEET PER SECOND

→• VELOCITY LESS THAN 0.5 FEET PER SECOND

⊕ METER VELOCITY STATIONS

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

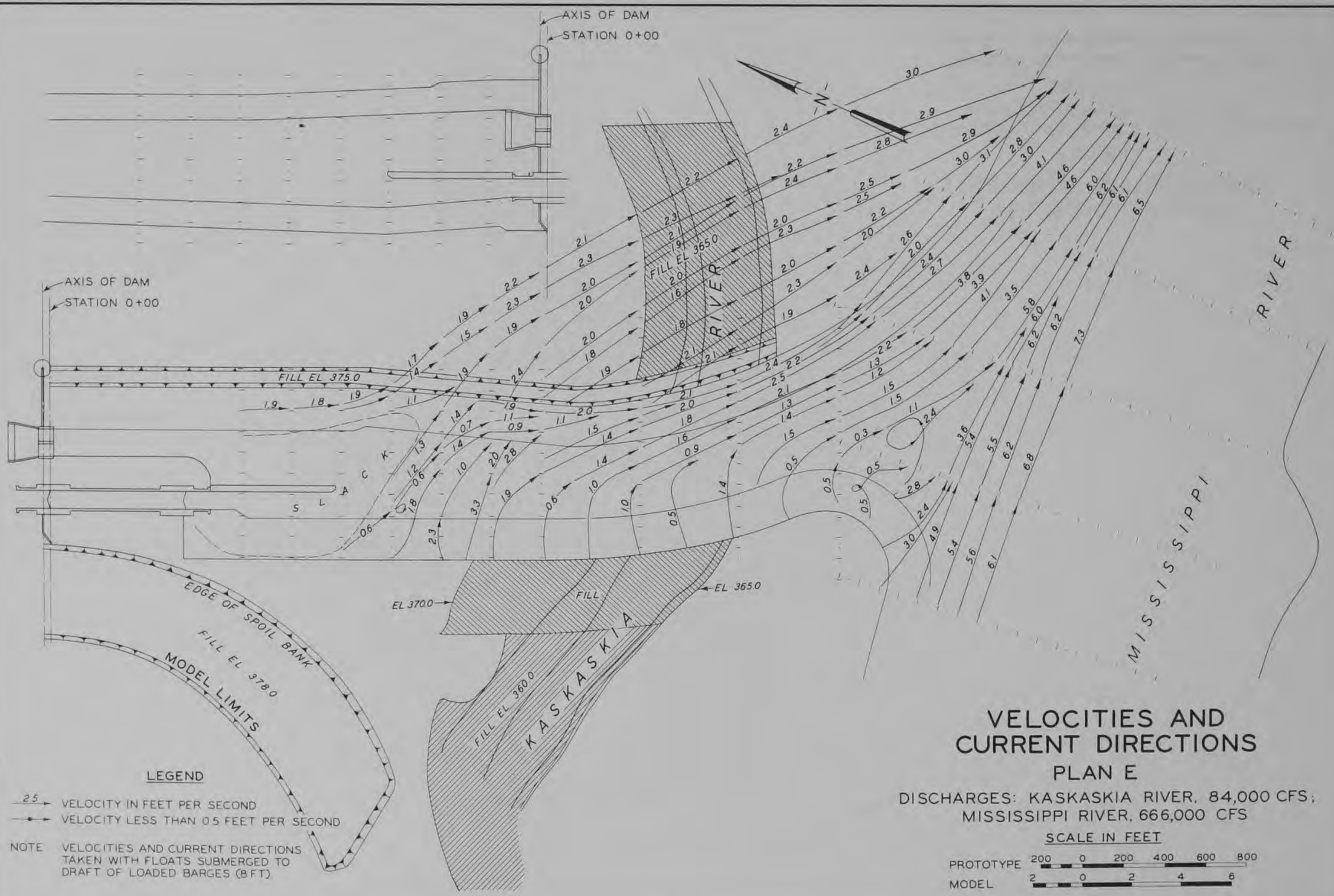
PLAN E

DISCHARGES: KASKASKIA RIVER, 30,000 CFS; MISSISSIPPI RIVER, 720,000 CFS

SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6



LEGEND

25 → VELOCITY IN FEET PER SECOND

→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT)

VELOCITIES AND CURRENT DIRECTIONS

PLAN E

DISCHARGES: KASKASKIA RIVER, 84,000 CFS; MISSISSIPPI RIVER, 666,000 CFS

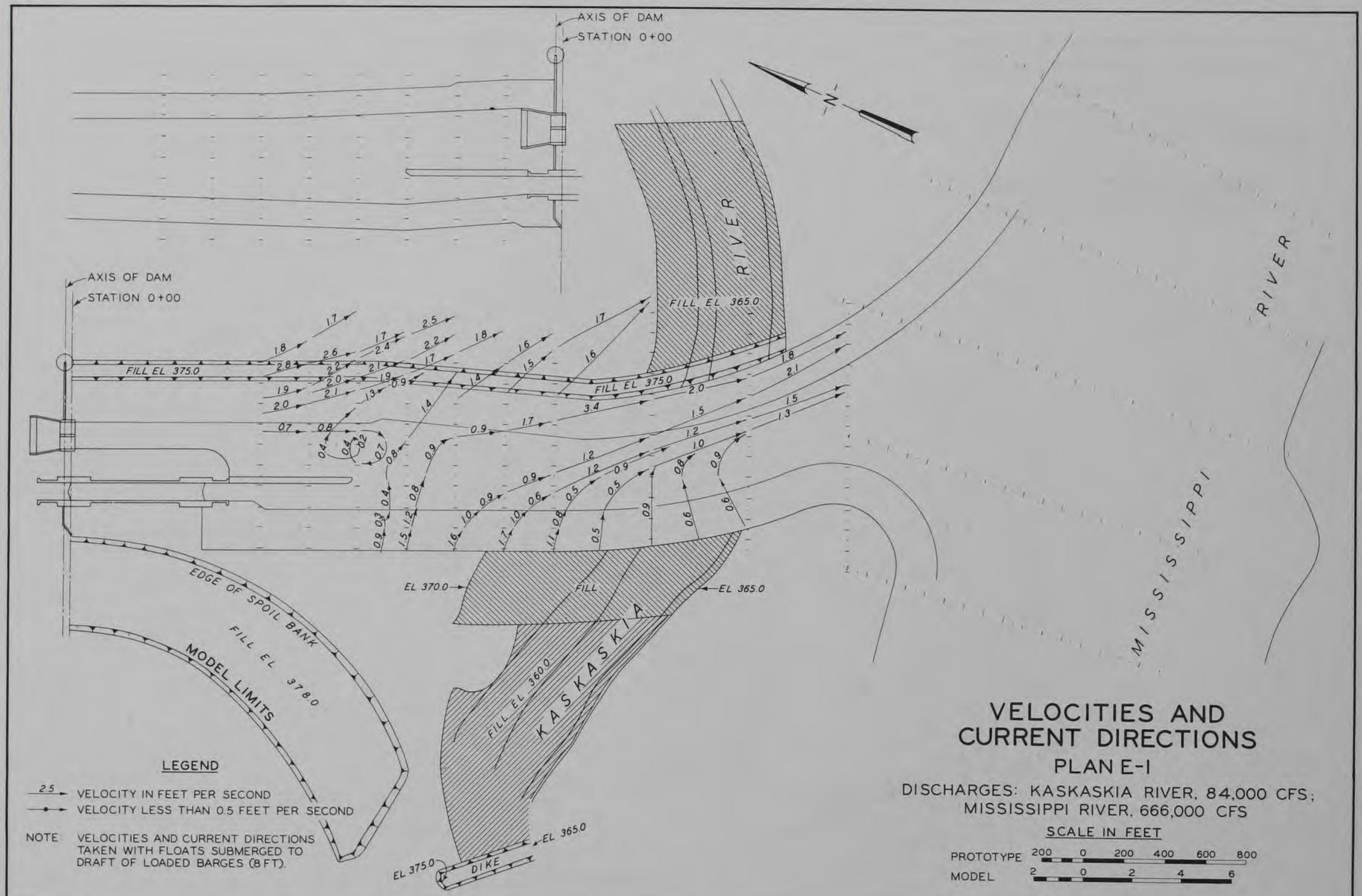
SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6

PLATE 17

PLATE 18



LEGEND

2.5 → VELOCITY IN FEET PER SECOND

→• VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

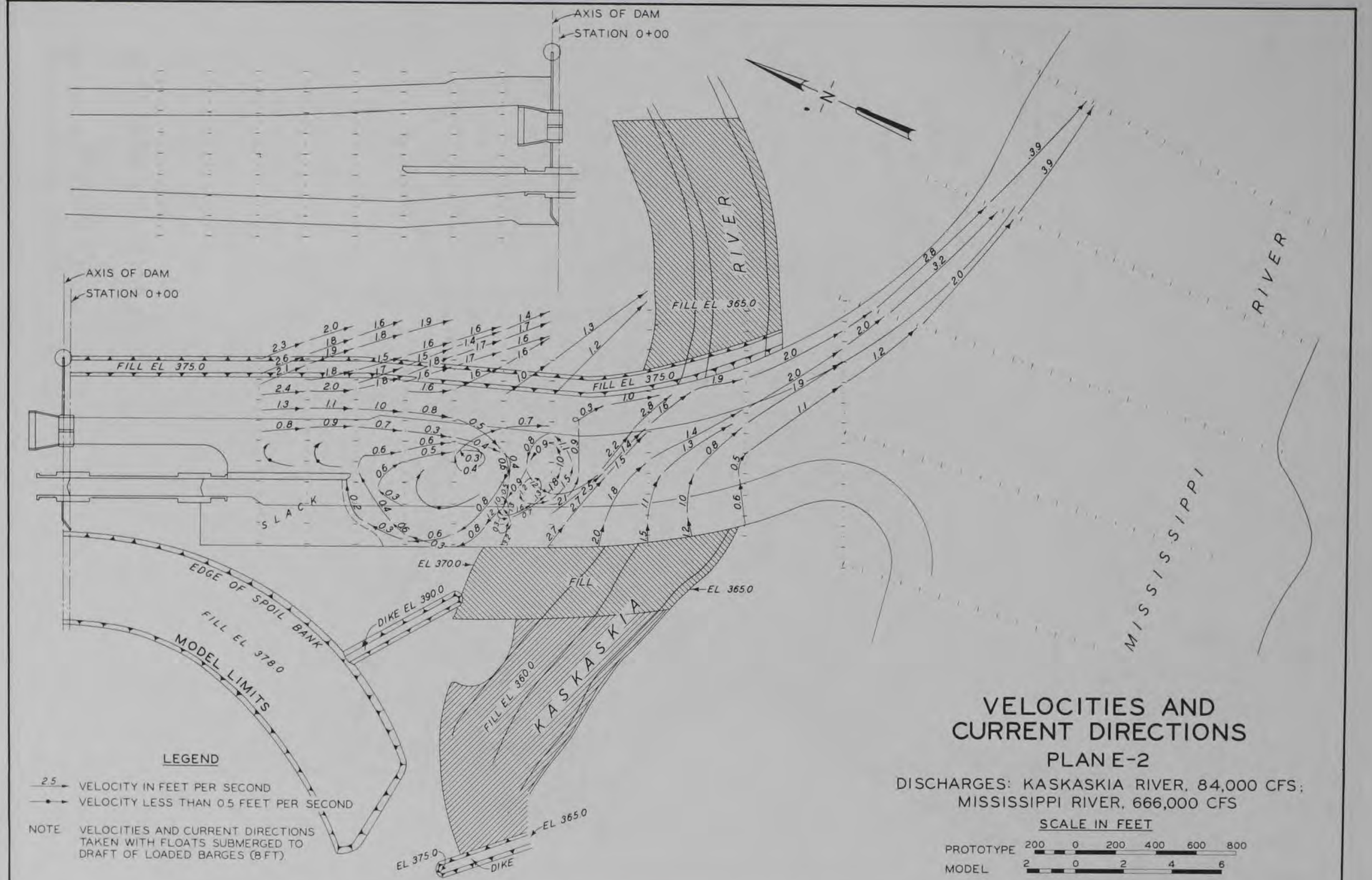
PLAN E-1

DISCHARGES: KASKASKIA RIVER, 84,000 CFS; MISSISSIPPI RIVER, 666,000 CFS

SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6



LEGEND

2.5 → VELOCITY IN FEET PER SECOND

→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN E-2

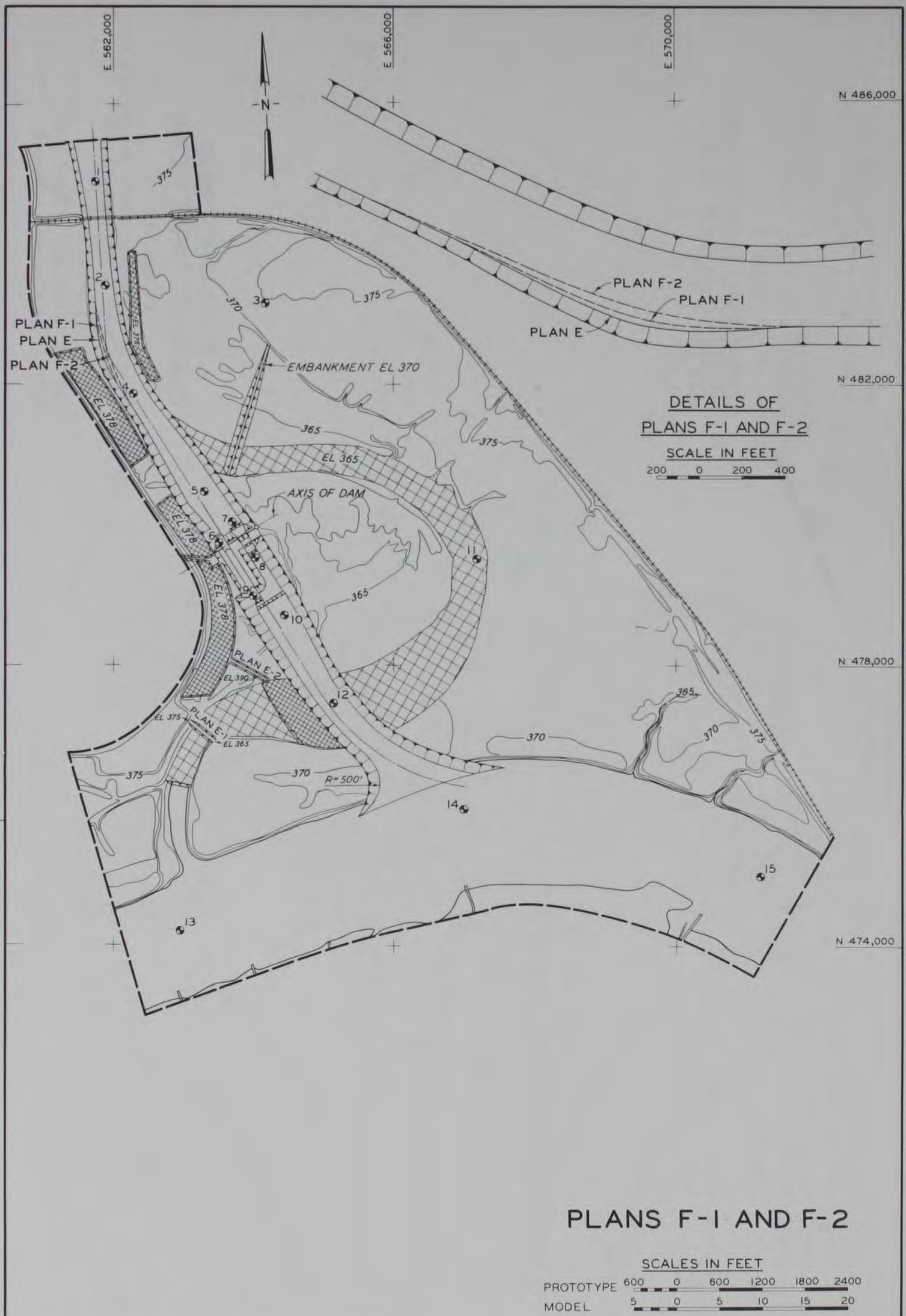
DISCHARGES: KASKASKIA RIVER, 84,000 CFS; MISSISSIPPI RIVER, 666,000 CFS

SCALE IN FEET

PROTOTYPE 200 0 200 400 600 800

MODEL 2 0 2 4 6

PLATE 19



DETAILS OF PLANS F-1 AND F-2

SCALE IN FEET

200 0 200 400

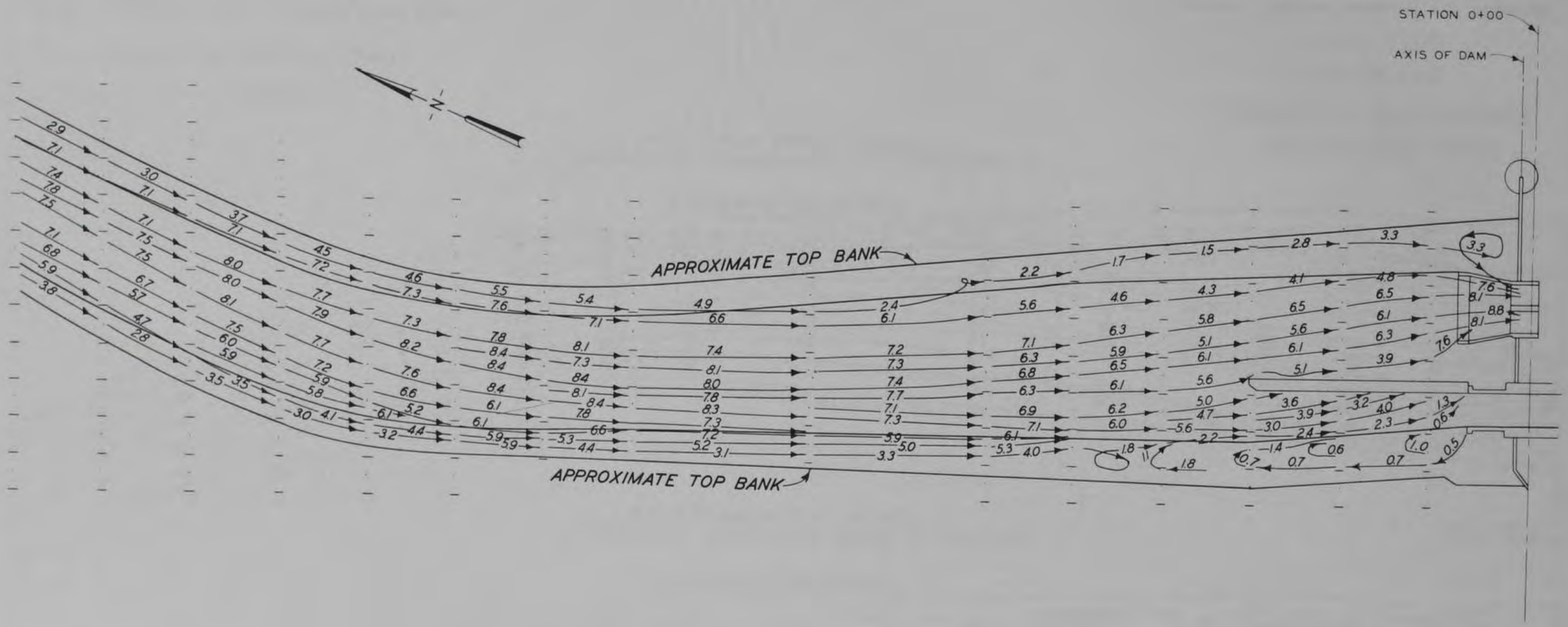
PLANS F-1 AND F-2

SCALES IN FEET

PROTOTYPE 600 0 600 1200 1800 2400

MODEL 5 0 5 10 15 20

PLATE 20



LEGEND

2.5 → VELOCITY IN FEET PER SECOND

→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN F-1

DISCHARGES: KASKASKIA RIVER, 64,000 CFS; MISSISSIPPI RIVER, 40,000 CFS

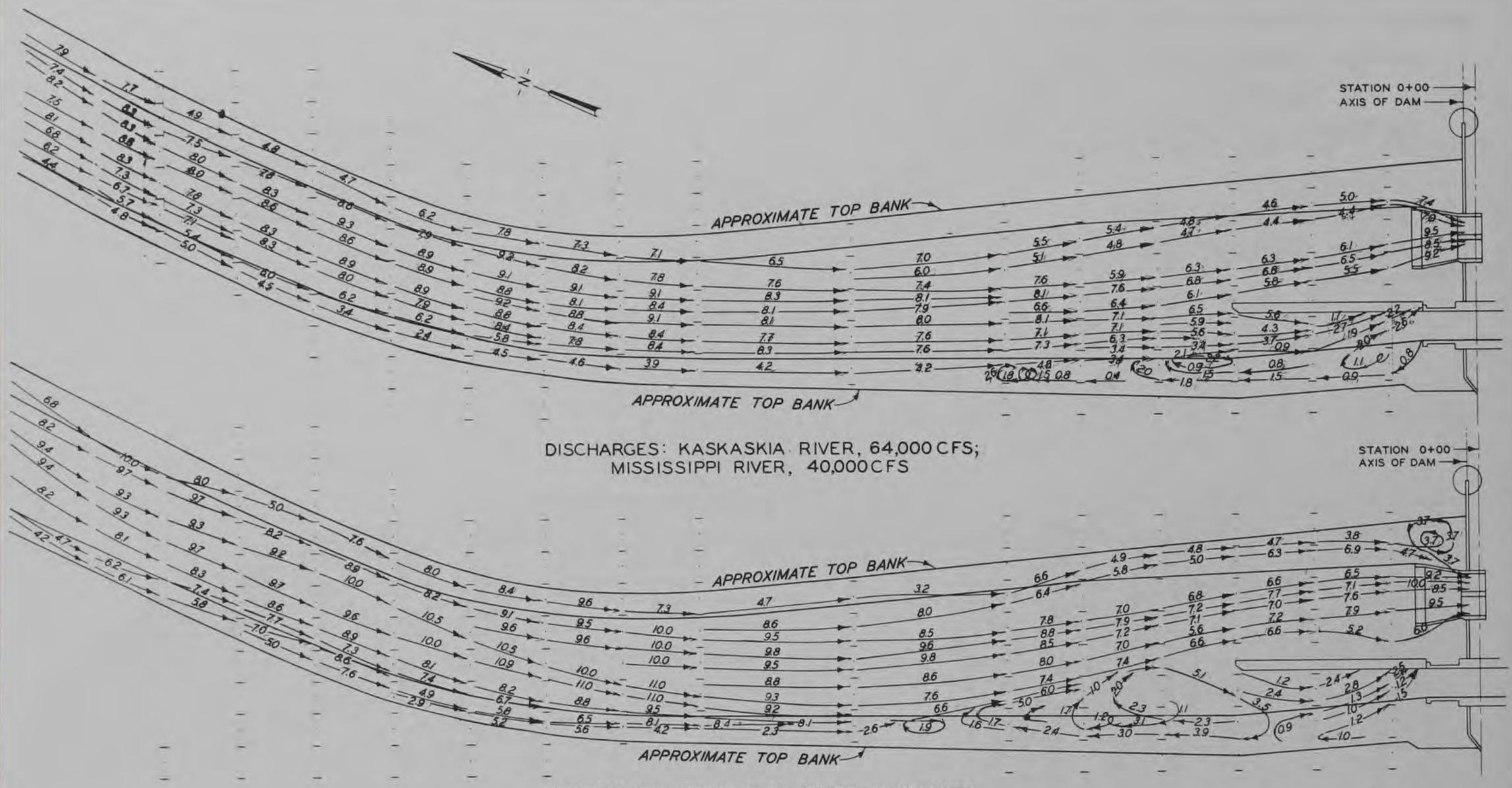
SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 2 0 2 4 6

PLATE 21

PLATE 22



DISCHARGES: KASKASKIA RIVER, 64,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS

DISCHARGES: KASKASKIA RIVER, 84,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS

LEGEND

2.5 → VELOCITY IN FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

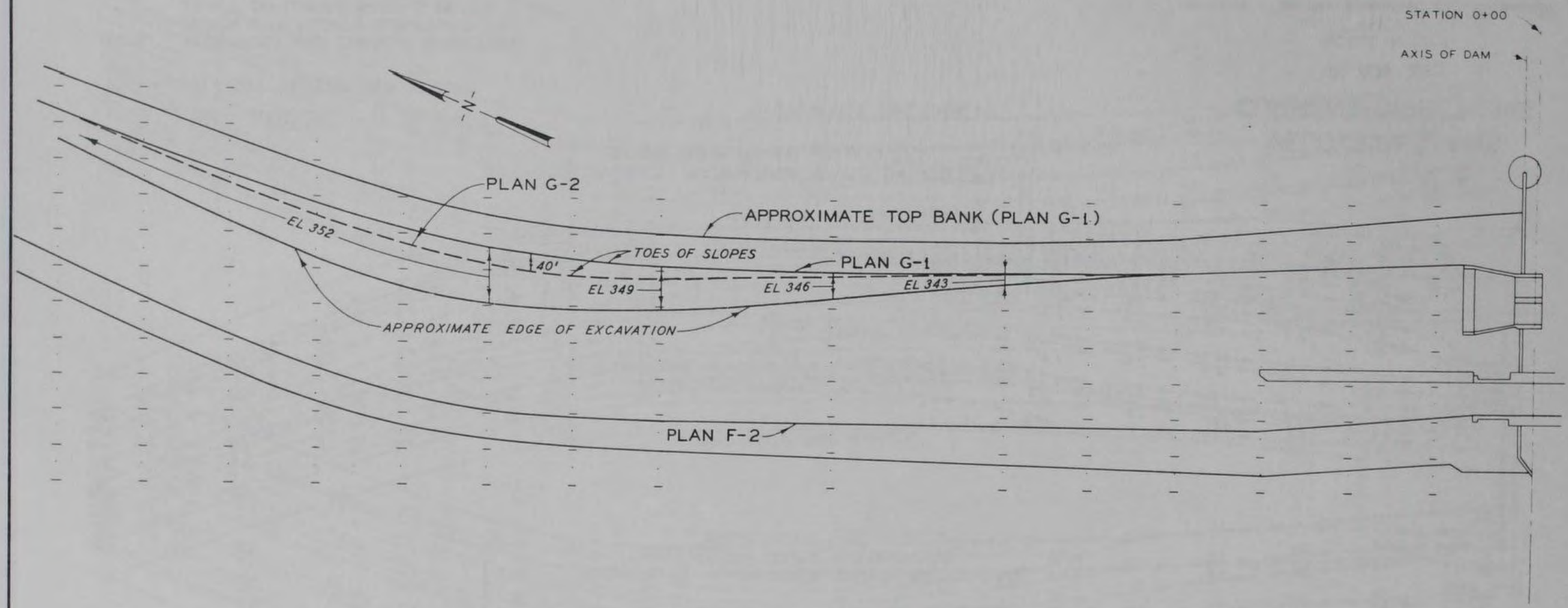
VELOCITIES AND CURRENT DIRECTIONS

PLAN F-2

SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 2 0 2 4 6



PLANS G-1 AND G-2

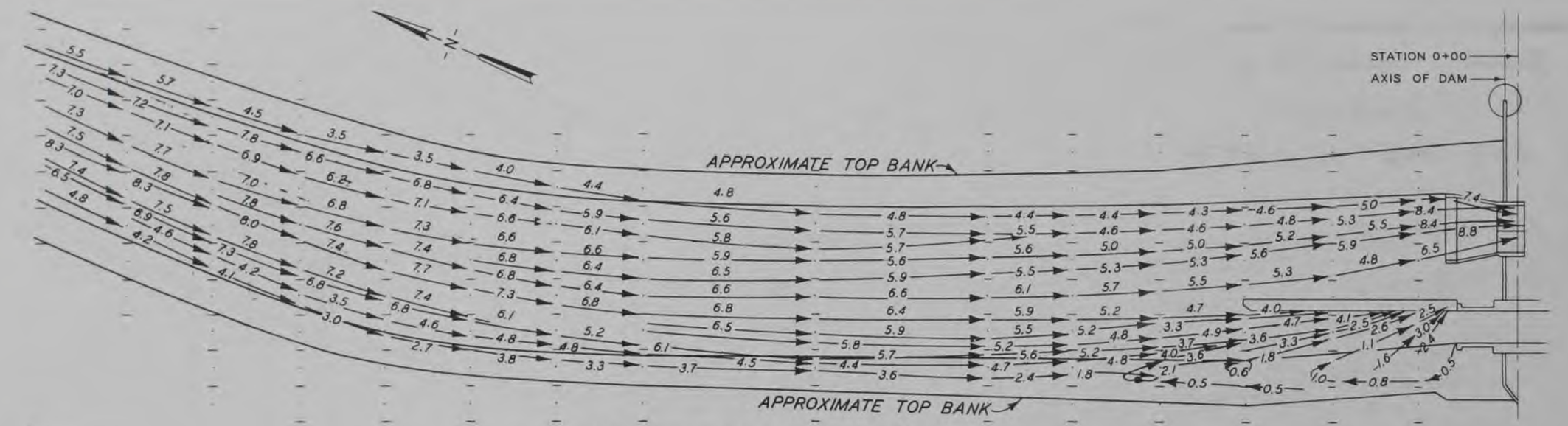
SCALE IN FEET

PROTOTYPE 200 0 200 400 600

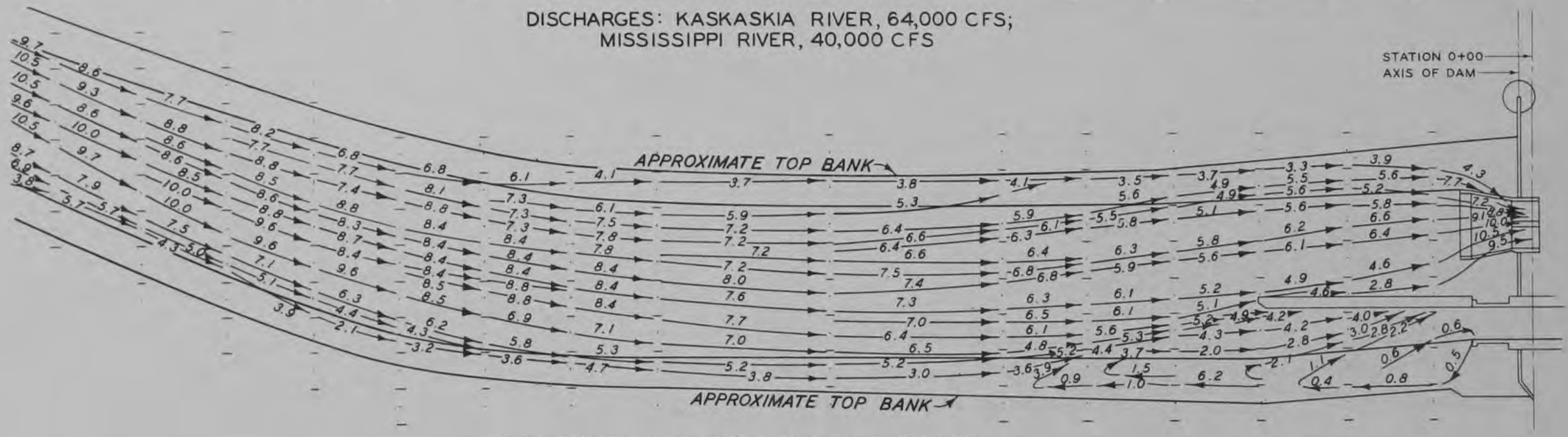
MODEL 2 0 2 4 6

PLATE 23

PLATE 24



DISCHARGES: KASKASKIA RIVER, 64,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS



DISCHARGES: KASKASKIA RIVER, 84,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS

LEGEND

7.8 → VELOCITY IN FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

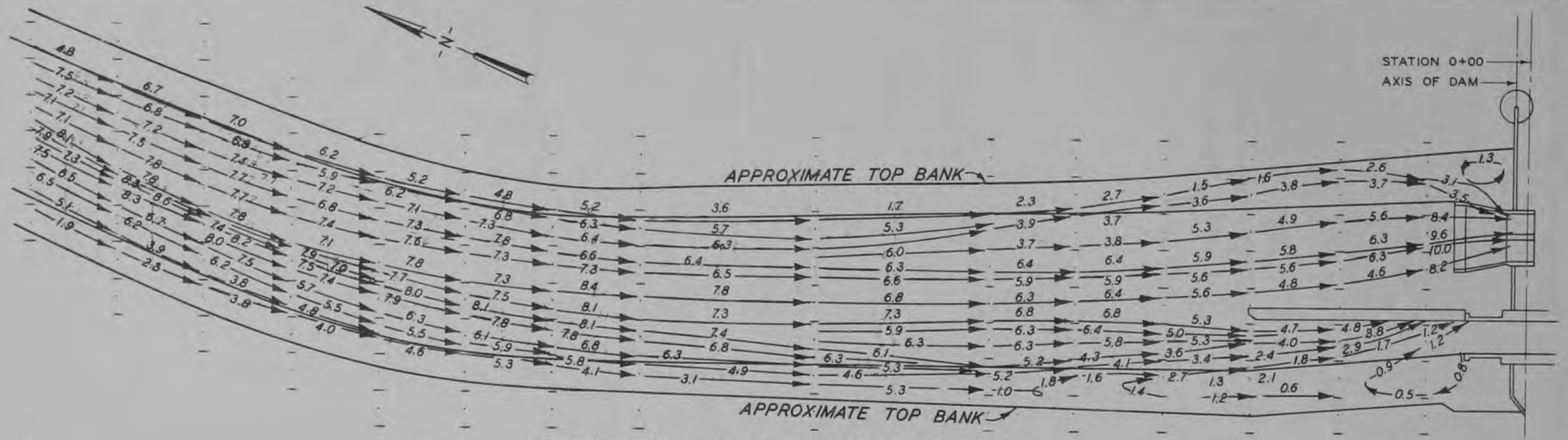
VELOCITIES AND CURRENT DIRECTIONS

PLAN G-1

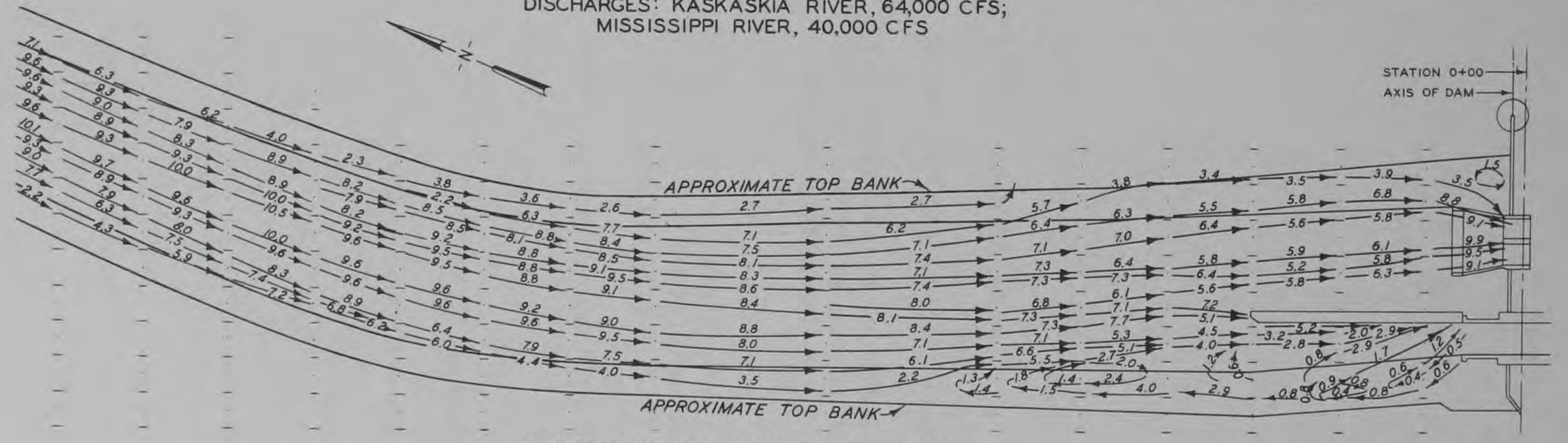
SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 2 0 2 4 6



DISCHARGES: KASKASKIA RIVER, 64,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS



DISCHARGES: KASKASKIA RIVER, 84,000 CFS;
MISSISSIPPI RIVER, 40,000 CFS

LEGEND

7.8 → VELOCITY IN FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS TAKEN WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGES (8 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN G-2

SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 2 0 2 4 6

PLATE 25

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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	2b. GROUP

3. REPORT TITLE

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

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

John J. Franco
Cody D. McKellar, Jr.

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13. ABSTRACT The proposed Kaskaskia River navigation project will provide a 50-mile-long, 9-ft-deep by 200-ft-wide channel from the mouth of the river to Fayetteville, Ill., by means of channel enlargement and realignment; alterations to bridges to obtain proper clearance; and construction of a gated dam surmounted by two 60- by 30-ft tainter gates, and an 84- by 600-ft navigation lock. A 1:120-scale, fixed-bed model, reproducing 2.0 miles of the Kaskaskia River and 1.8 miles of the Mississippi River, was used to: demonstrate and study flow conditions in lock approaches and in critical reaches; determine adequacy of proposed design for the spillway, stilling basin, and exit channel; determine optimum arrangement of the guide or guard walls; determine areas requiring special protection and navigation conditions in lock approaches and in critical reaches; and develop modifications required to produce satisfactory flow and navigation conditions. Results of the investigation indicated the following. Spillway approach walls should be flared, and stilling basin should be lengthened and its elevation lowered with an increase in the width of exit channel to provide satisfactory flow conditions through the structure. Upper and lower lock approach walls should be guard walls on the river side of the lock. Navigation conditions within the bend upstream of the lock could be improved by decreasing the radius of the bend by placing a fill along the right bank and compensating excavation along the left bank. A fill or dike would be required along the right bank of the new channel to provide satisfactory navigation conditions through the lower reach and in the lower lock approach with overbank flow during high stages. The upper lock approach channel should be widened at least 50 ft to the right at the end of the upper guard wall to provide satisfactory navigation conditions in the upper lock approach during high flows.

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