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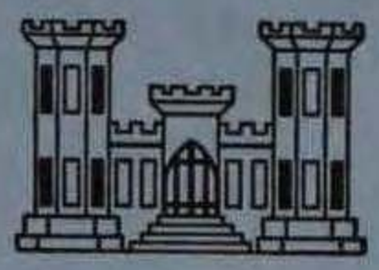
TECHNICAL REPORT H-69-3

NAVIGATION CONDITIONS AT LOCK AND DAM NO. 7, ARKANSAS RIVER

Hydraulic Model Investigation

by

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



February 1969

Sponsored by

U. S. Army Engineer District
Little Rock

Conducted by

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Vicksburg, Mississippi

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FOREWORD

The model investigation reported herein was authorized by the Office, Chief of Engineers, in an indorsement dated 13 May 1964 to the Division Engineer, U. S. Army Engineer Division, Southwestern. The study was conducted for the U. S. Army Engineer District, Little Rock, in the Hydraulics Division of the U. S. Army Engineer Waterways Experiment Station during the period June 1964 to September 1967.

During the course of the model study, the Little Rock 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. E. B. Madden of the Southwestern Division, Mr. V. L. Vanzant of the Ohio River Division, and LTC Henry A. Pate, Messrs. John Matsek, F. D. Spencer, T. Schmidgall, Joe T. Clements, Jr., W. A. Thomas, C. W. Shelton, D. R. Rippey, M. W. Willis, and M. G. Wilbur of the Little Rock District visited the Waterways Experiment Station at intervals to observe model tests and discuss test results. The model was also demonstrated for representatives of the Arkansas Highway Department and U. S. Coast Guard.

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., Chief of the River Regulation Section, assisted by Messrs. H. R. Anderson, S. T. Mattingly, T. P. Williams, and D. E. Barnes. 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 Alex G. Sutton, Jr., CE, COL J. R. Oswalt, Jr., CE, and COL Levi A. Brown, CE. Technical Director was Mr. J. B. Tiffany.

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CONTENTS

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
feet per second	0.3048	meters per second
cubic feet per second	0.0283168	cubic meters per second

SUMMARY

Lock and Dam No. 7 will consist of a 110- by 600-ft lock and a 980-ft-long, gated, nonnavigable dam. A 1:120-scale, semifixed-bed model, reproducing about 7 miles of the Arkansas River, adjacent overbank areas, the lock and dam structures, and other structures that might affect flow conditions, was used to study navigation conditions in the lock approaches, the design of the upstream guard wall, and location and design of any training works needed to improve navigation conditions and distribution of flow through the spillway and along the overbank. Results of the investigation indicated the following:

a. Downbound tows would experience difficulties in making a satisfactory approach to the lock with the original design because of the alignment of currents moving from along the right bank toward the spillway, particularly during the higher flows. With the original plan, distribution of flow through the first three gates was adversely affected by the currents moving across the approach channel and by the shape of the end of the upper guard wall. No difficulties were indicated for upbound or downbound tows in the lower lock approach.

b. Satisfactory navigation conditions could be developed in the upper lock approach with the following modifications: (1) downstream extension and raising of the elevation of the right bank revetment along the upper approach channel to improve the alignment of currents and reduce the intensity of the crosscurrents in the upper lock approach; and (2) moving the revetment at least 50 ft landward to provide additional maneuver area and reduce the danger of tows hitting or moving over the top of the revetment.

c. The revetment along the right bank could be terminated at a point opposite and just upstream of the end of the upper guard wall.

d. Distribution of flow through the three gates near the lock could be improved by the downstream extension and raising of the revetment along the right bank, and by modification of the end of the upper guard wall.

e. The elevation of the right bank of the upper approach channel will be below normal upper pool level and could constitute a hazard to navigation, particularly during high flows and severe weather conditions and high winds.

f. Construction of the proposed I-430 Bridge and embankment would have little effect on currents in the main channel with or without a relief opening. Velocities at the channel end of the embankment without a relief opening will tend to be high.

g. Because of the low elevation of the revetment along the left bank of the bend upstream of the bridge, tows moving close along the revetment would tend to be moved toward and over it by currents moving from the channel toward the overbank during high flows.

h. Because of the alignment of currents and the location of the navigation span in the proposed I-430 Bridge, downbound tows would have to approach the bridge along the center of the channel for some distance upstream.

i. Placement of the navigable span toward the left of that proposed would facilitate the passage of downbound tows through the span but would increase the difficulty tows would experience in becoming aligned for the approach to the lock after passing through the bridge.

j. Location of the bridge span in a crossing as proposed could produce difficulties in maintaining a satisfactory and stable channel alignment and adequate low-water depths.

NAVIGATION CONDITIONS AT LOCK AND DAM NO. 7
ARKANSAS RIVER
Hydraulic Model Investigation

PART I: INTRODUCTION

Present Development Plan for the Arkansas River

1. Although the Arkansas River is considered a navigable stream from its mouth to the mouth of the Verdigris River, during periods of low water the controlling depths of the river are about 2 ft* from its mouth to Little Rock, and about 1 ft from Little Rock to the mouth of the Verdigris River. In this section, the slope of the stream averages 0.9 ft per mile above Little Rock and 0.7 ft per mile between Little Rock and the Mississippi River. Water-surface elevations and slopes in the lower river are affected by backwater from the Mississippi; at times these effects extend as far upstream as the vicinity of Pine Bluff (mile 111).

2. As presently authorized, the Arkansas River multipurpose project provides for the improvement of the Arkansas River and its tributaries in Arkansas and Oklahoma through the construction of coordinated developments to serve navigation, produce hydroelectric power, afford additional flood control, and provide related benefits such as public facilities for recreation and conservation of fish and wildlife. The navigation feature of the project provides for a 9-ft-deep channel from Catoosa, Okla., on the Verdigris River, 52 miles downstream to the Arkansas River at mile 458, thence down the Arkansas River to Arkansas Post, about 46 miles from its mouth (fig. 1). From this point the Arkansas Post Canal will connect the Arkansas River with the White River. The navigation channel will then continue down the White River for about 10 miles to its junction with the Mississippi River. The 9-ft-deep channel will be provided by a system of locks and dams, some of which will be used not only for navigation but also for the production of hydroelectric power. Lock chambers will be 110 by 600 ft

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

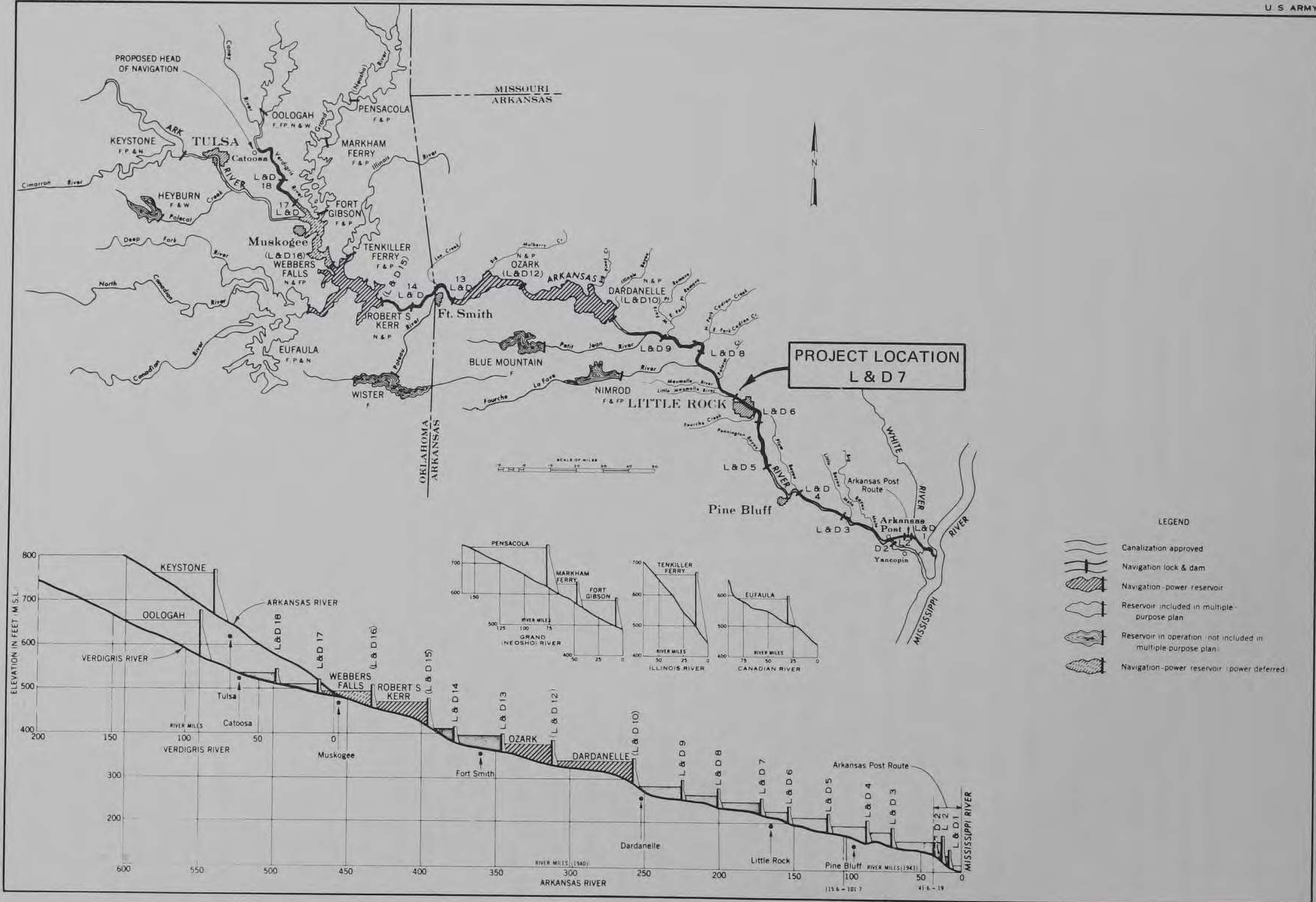

Fig. 1. Vicinity map

on the Arkansas River and in the Arkansas Post Canal, and 83 by 600 ft on the Verdigris River. A minimum channel width of 150 ft is proposed for the Verdigris River section, 250 ft for the Arkansas and White River sections, and 300 ft for the Arkansas Post Canal. Bank stabilization and channel rectification works such as training dikes, cutoffs, and revetments are included in the multipurpose plan and are part of the proposed overall development of the Arkansas River.

Description of Structures and Improvements, Lock and Dam No. 7

3. Lock and Dam No. 7 is one unit of the navigation portion of the multipurpose plan for development of the Arkansas River. The structures will consist of a 110- by 600-ft lock and a nonnavigable dam 980 ft long (fig. 2). The dam, as proposed, will consist of fourteen 60-ft-wide spillway bays and fifteen 10-ft-wide piers. The spillway will be controlled by

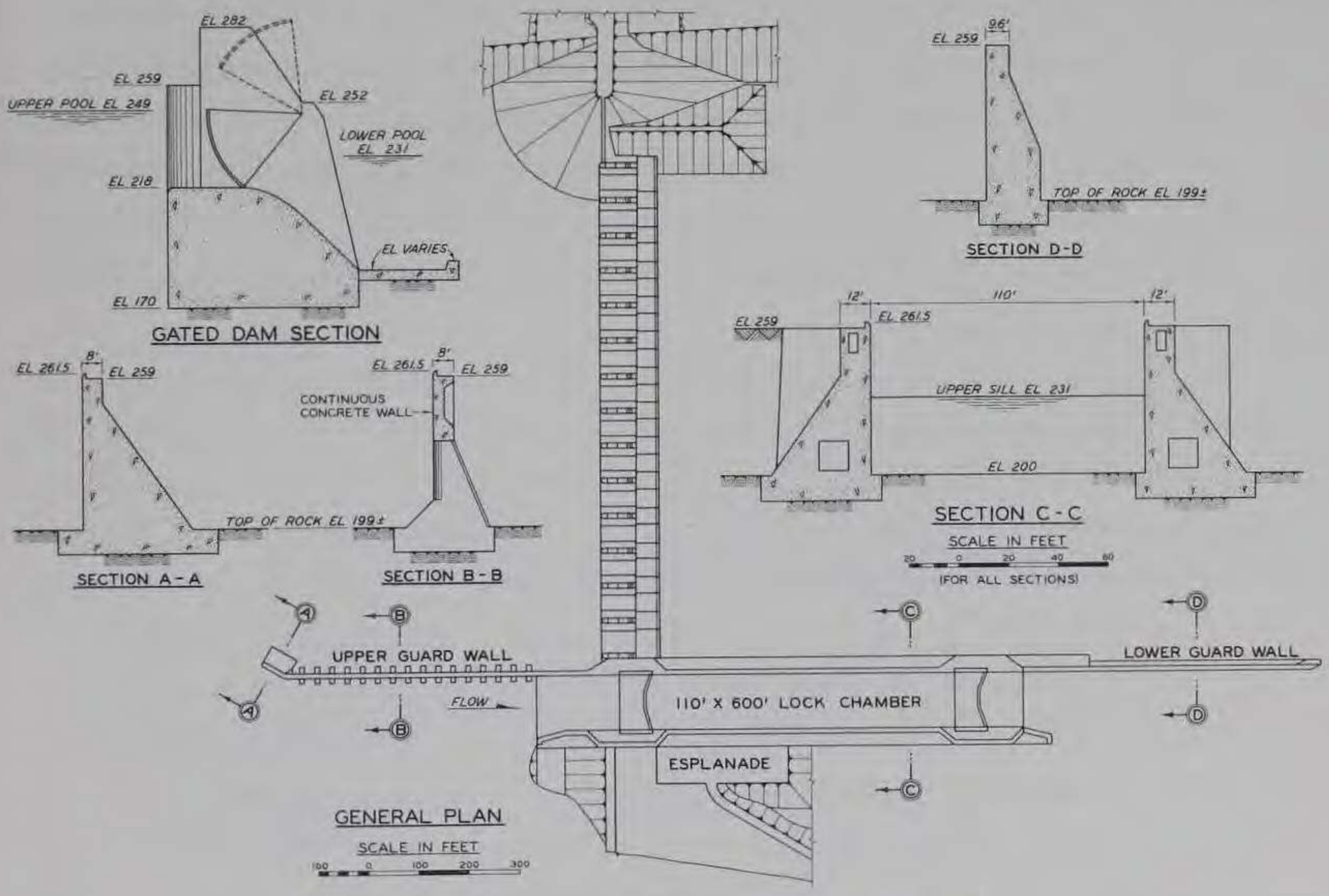

Fig. 2. General plan of lock and dam

fourteen 60- by 33-ft conventional tainter gates with the sills set at el 218.0.* The site of Lock and Dam No. 7 will be at river mile 172 (1940 survey) along the right bank in Pulaski County, Ark., approximately 6.6 miles upstream from the Main Street Bridge at Little Rock, Ark. The proposed pool will extend approximately 29 miles upstream and will be located in Pulaski, Faulkner, and Perry Counties, Ark. In general, the pool will be contained within the existing banks. The normal upper pool at Lock and Dam No. 7 will be at el 249.0, and the normal lower pool, established by Dam No. 6, will be at el 231.0. The normal lift will be 18 ft. For short periods of time during low flows, the upper pool may be raised to el 251.0 to facilitate navigation; consequently, a maximum lift of 20 ft is possible. The maximum navigation stage is based on a 10-year-frequency flood of 350,000 cfs and will result in upper and lower pool elevations of 256.4 and 255.2, respectively. Therefore, the Lock and Dam No. 7 lifts will vary between about 1 and 20 ft. The tops of the approach walls and lock walls will be set at el 259.0. This will provide for the higher of either a 10-ft freeboard above the normal upper pool elevation or a 2-ft freeboard above the 10-year-frequency flood elevation. Because the upper pool elevation for a 10-year-frequency flood is 256.4, the 10-ft freeboard above the normal pool el 249.0 will control and establish the top of walls at el 259.0. Both the upstream and downstream guard walls will be 600 ft long.

4. Embankments will be constructed at each end of the lock and dam to tie the structure into high ground and provide access to the lock. The left embankment will be about 2500 ft long with a crest elevation of 252.0, providing a freeboard 3 ft above the pool. The embankment will be overtopped for total river discharge of 270,000 cfs about once in four years. It will have a crest width of 20 ft and will be protected with riprap designed to resist overflow conditions. The right embankment, approximately 210 ft long, will abut the landward lock wall and extend to the steep right bank. This embankment includes a portion of the lock esplanade and access road. All these features are set at el 259.0 to provide lock access during

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

all navigation flood conditions. The right embankment will be overtopped for total river discharges above about 412,000 cfs which occur about once in 25 years. Consequently, flows over the right embankment are relatively insignificant except for maximum flood condition. The upstream and downstream slopes will be protected with riprap designed to provide resistance to scour during overflow periods.

Purpose of Model Study

5. The general design of Lock and Dam No. 7 was based on sound theoretical design practice and experience with similar structures. However, since the configuration and alignment of the river channel and its flow conditions are not the same at any two locations, an analytical determination of the hydraulic effects that can be expected to result from a particular design is not only difficult to achieve, but also uncertain in its findings. With Lock and Dam No. 7, it was important to ensure that the design provide the best arrangement and method of operation of the locks and dam from the standpoint of eliminating undesirable flow conditions that might make navigation difficult or hazardous for tows entering or leaving the locks. Therefore, a comprehensive model study was considered necessary for this project. The purposes of this study were to:

a. Study navigation conditions in the lock approaches.

b. Study the design of the upper guard wall.

c. Develop plans for training works needed in the vicinity of the lock and dam to improve navigation approach conditions and distribution of flow through the spillway.

d. Ascertain water-surface profiles and the amount of swellhead as affected by the lock and dam structures.

e. Determine the best location and length of navigable span on the proposed Arkansas Interstate 430 (I-430) Bridge and the effects of various embankment plans on navigation, water-surface elevations, and distribution of flow.

f. Determine the flow distribution between the channel and overbank.

g. Develop such design modifications as might be necessary to eliminate conditions unfavorable to navigation.

The model was also used to demonstrate for interested parties the conditions resulting from the proposed design in order that they could satisfy themselves as to its acceptability from a navigation standpoint.

PART II: THE MODEL

Description

6. The Lock and Dam No. 7 model (fig. 3) was a scale model reproduction of a 7-mile reach of the Arkansas River, extending 3 miles above and 4 miles below the proposed site for the structures at mile 172 (1940 survey). It was of the semifixed-bed type, with the channel and portions of the banks where changes were anticipated molded with pea gravel; the remainder of the overbank areas were molded in sand-cement mortar to sheet metal templates. The model included sufficient overbank areas along both banks to permit a reasonably accurate reproduction of the flood flows. The model channel and overbank were molded to simulate conditions shown by surveys made in 1963 and 1964. The piers, lock, guide and guard walls, dam, and spillway were constructed of sheet metal to prevent any change in elevation caused by expansion or warping after the structures were set.

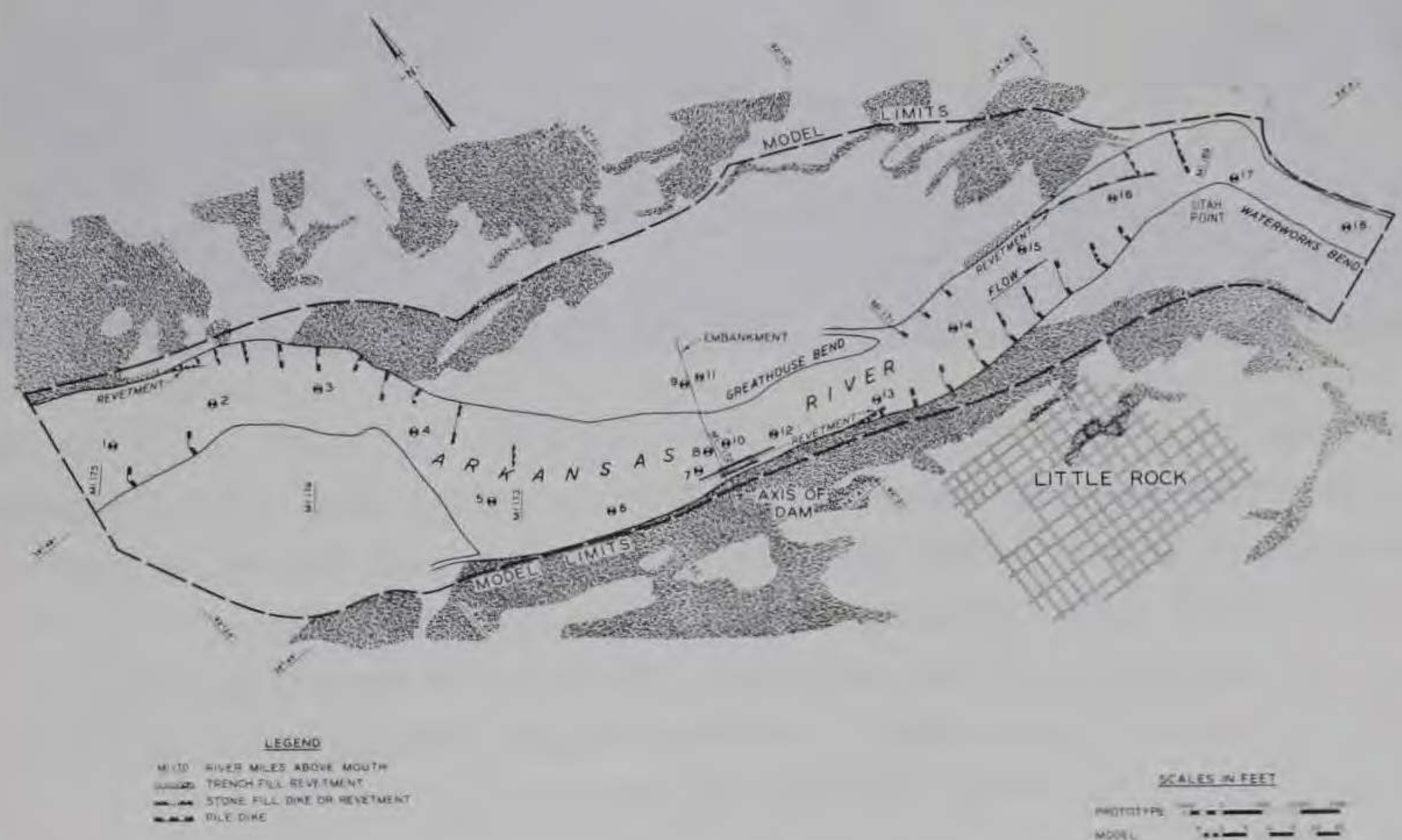

Fig. 3. Model layout and location of gages

7. Pile dikes were simulated in the model by a row of metal rods spaced to provide the desired permeability. The lock and dam gates were simulated schematically with simple, sheet metal slide gates. Water was supplied to the model by a comprehensive water-supply system, and 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. Water-surface elevations were measured by 18 piezometers (fig. 3) connected to a centrally located pit.

8. A model tow and towboat (fig. 4) were used to determine the

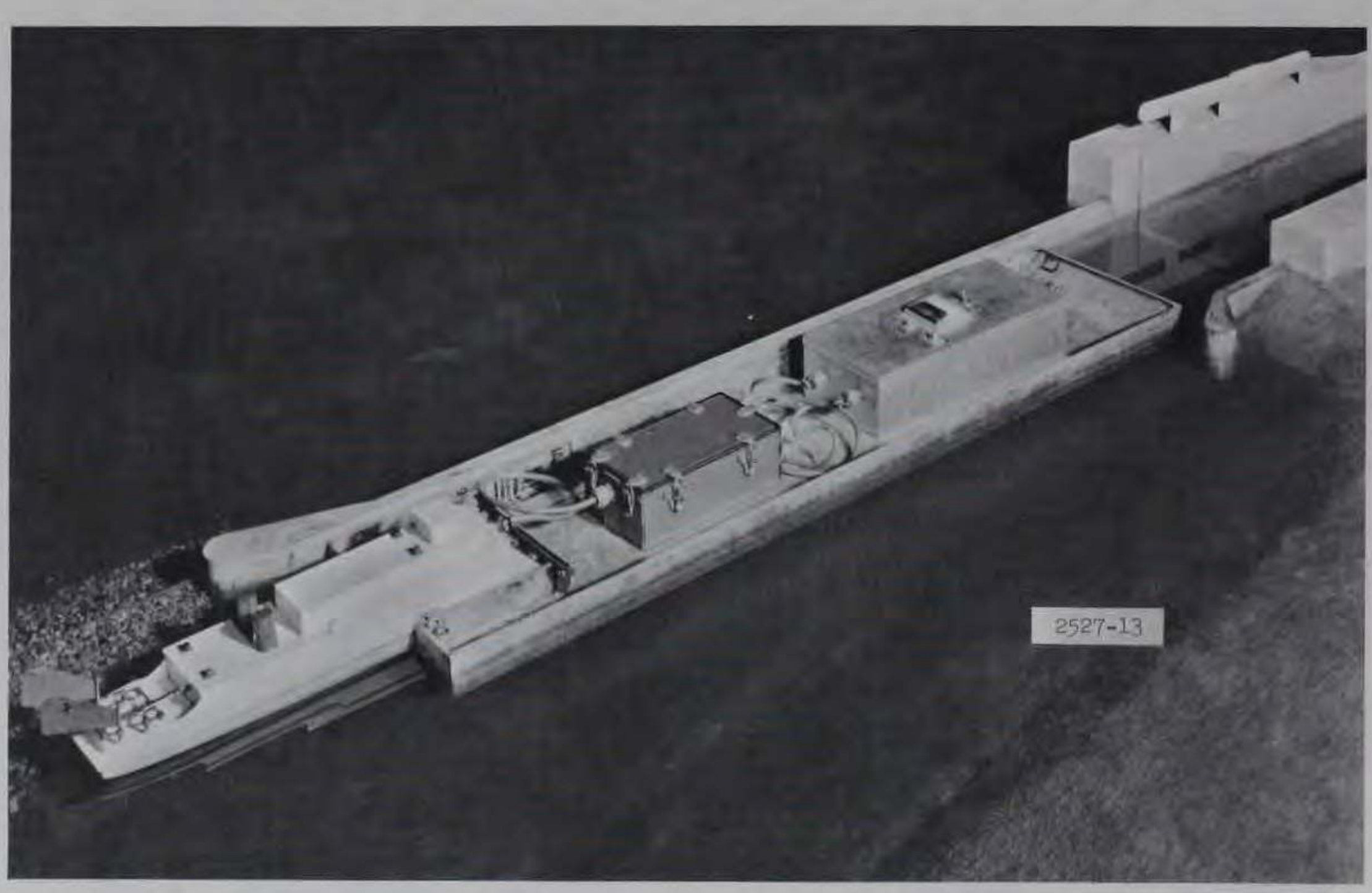

Fig. 4. Remote-controlled towboat and tow

effects of currents on navigation passing through the proposed I-430 Bridge and approaching and leaving the locks. The towboat was propelled by a small electric motor operating from batteries located in the tow; the rudders and speed were remote-controlled. The power of the towboat was adjusted by means of a rheostat to a maximum speed comparable to that of the towboats which will travel the Arkansas River.

Scale Relations

9. The model was built to an undistorted linear scale ratio of 1:120, model to prototype, to effect an accurate reproduction of velocities, crosscurrents, and eddies that would affect navigation. Other scale ratios resulting from the linear scale ratio 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 elevations, and current directions and velocities can be transferred quantitatively from model to prototype equivalents by means of these scale relations.

Model Adjustment

10. Before the installation of the locks and dam, the model roughness was adjusted until the model accurately reproduced the computed water-surface elevations furnished by the Little Rock District for flows of 50,000, 100,000, 200,000, 300,000, 400,000, 500,000, and 625,000 cfs. The model banks and overbanks were constructed with a brushed cement-mortar finish that provided a roughness factor (Manning's n) of about 0.012, which corresponds to a prototype roughness of about 0.026. Additional roughness required for the overbank was provided in the form of folded strips of No. 8 mesh wire. The wire was placed in areas shown on aerial photographs to have vegetation, and the density of the vegetation of each area was based on an estimate of degree of roughness furnished by the Little Rock District (Manning's n factors varied from 0.05 to 0.10). The channel bed, which was molded of pea gravel, had a higher roughness than required. Adjustments were made in channel cross sections to compensate for the additional roughness.

PART III: TESTS AND RESULTS

11. Tests on the model were concerned with the study of flow patterns, measurements of velocities in the lock approaches and at the proposed I-430 Bridge, effects of currents on the movement of the model tow passing through the proposed bridge and in critical reaches and maneuvering within the approaches to the locks under various flow conditions, water-surface elevations, and distribution of flow.

Test Procedure

12. Tests were conducted by reproducing stages and discharges which provided the following flow conditions: (a) controlled river flow, 100,000 cfs; (b) maximum flow at normal upper pool el 249.0, 200,000 cfs; (c) maximum navigable flow, 350,000 cfs. Studies were also conducted with flows up to a maximum of 625,000 cfs for the study of water-surface profiles and swellhead. The controlled river flows were reproduced by introducing the proper discharges, setting the tailwater elevation for that discharge, and manipulating the dam gates until the required upper pool elevation was obtained. All controlled river flow tests were conducted with all dam gates opened equal amounts. 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 below the dam. 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 of 8 ft, equivalent to the draft of a loaded barge. Velocities were measured by timing the travel of floats over known distances.

13. No data were obtained with the model tow other than visual observations of its behavior with the different plans tested.

14. Steady flows of 350,000, 450,000, and 625,000 cfs were used in conducting the flow distribution tests.

Existing Conditions

15. Before the start of tests with the lock and dam, tests were

conducted with conditions existing in the prototype at the time of the 1963-1964 channel surveys (plate 1). These tests were made to obtain current directions and velocities and water-surface elevations which could be used in the development of plans and in determining channel configurations which could be expected with the proposed plans. The data obtained during these tests are shown in table 1 and plates 2-4.

Plan A

Description

16. Plan A was the original design proposed for Lock and Dam No. 7. The essential features of this plan described below included the lock and dam structures with overflow embankments and channel training structures designed to provide the required channel alignment and depths and satisfactory navigation conditions in the approaches (fig. 2 and plate 5).

17. The lock, located along the right bank, had clear chamber dimensions of 110 by 600 ft with 600-ft-long upper and lower guard walls. The elevation of the top of the lock walls and guard walls was at el 259.0. The upper guard wall contained fifteen 20-ft-wide and two 10-ft-wide ports. All ports were 25 ft high with top and bottom elevations of 234.0 and 209.0, respectively. The gated spillway, located at mile 172 (1940 survey), was 980 ft long and contained fourteen 60-ft gate bays with 10-ft-wide piers (fig. 2). The spillway was controlled by fourteen 60- by 33-ft conventional tainter gates with the sills set level at el 218.0, approximately 2 ft below the thalweg. The elevation of the stilling basin sloped from el 206.0 at the lock wall to 192.9 at the center of the pier 275 ft to the left of the lock, and from that point to 186.0 at the left end of the dam. Embankments will be constructed at each end of the lock and dam to connect the structures with high ground. The embankment along the left overbank was about 2500 ft long with a crest elevation of 252.0, extending from the left abutment of the spillway to high ground on the left bank of an old lake bed. The embankment along the right overbank was about 210 ft long, abutting the esplanade and extending to high ground on the right bank. Top elevation of the right embankment was at 259.0 to provide lock access during the higher flows.

18. The training structures included in this plan were as follows:

a. Construction of a dike along the right bank at mile 174.4 and revetting of the right bank at about mile 174.2 and from about mile 173.5 to 172.5 (plate 5).

b. Extension of and addition of "L" heads to left bank dikes 173.7L, 173.6L, and 173.4L.

c. Lengthening of right bank dikes 170.8R through 170.0R and extension of the existing stone-fill dike (mile 171) along the ends of the existing and modified spur dikes from sta 18+15 to 44+30 (2615 ft) (plate 5).

d. Construction of dikes 171.5L, 171.3L, and 171.2L and extension of three existing dikes on the left bank just downstream of mile 171.

e. Extension of the stone-fill revetment along the left bank (mile 169) from sta 58+50 to sta 89+00 (3050 ft). Since the model was not of the movable-bed type the channel configuration was modified before the start of tests, based on changes which could be anticipated from the proposed structures and on typical cross sections furnished by the Little Rock District.

Results

19. Results of the plan A tests are shown in tables 2 and 3 and plate 6. Velocity measurements and current directions obtained during the test of this plan indicated a strong outdraft in the upper approach channel (plate 6). Although velocities in the approach channel just upstream of the upper guard wall were not excessive even with the higher flows, the direction of currents moving from along the right bank toward the spillway were such that tows could not make an approach to the lock wall without considerable difficulty. Also because of the direction of flow near the end of the guard wall aggravated by the shape of the end or nose of the upper guard wall, flow through the first two gates near the lock was 25 to more than 40 percent less than the average through the remainder of the gates (table 2). The effect was greater with the higher flow (350,000 cfs) than with the 200,000-cfs flow.

20. The drop in water-surface elevation through the dam (gages 8 and 10) during uncontrolled river flows (200,000 to 625,000 cfs) varied from 0.2 to 0.4 ft (table 3). The increase in water-surface elevation (gage 8) resulting from the installation of plan A varied from about 0.2 ft during

the lower uncontrolled river flows (200,000 cfs) to about 0.6 ft for the higher flows.

Plan B

Description

21. Plan B was the same as plan A except that the right bank revetment was extended downstream to tie in with the fill on the land side of the lock as shown in plate 7, and the revetment was raised 3 ft from sta 32+00 to 58+50, placing the top 13 ft above the construction reference plane (CRP). Final grade of the revetment sloped, parallel to the CRP, from el 241.5 at sta 0+00 to el 240.3 at the lock wall. This modification was designed to reduce flow along the right side of the approach channel in an effort to minimize the outdraft noted in the test of plan A.

Results

22. The results of current directions and velocity measurements obtained during tests of this plan are shown in plate 8. These results indicate considerable improvement in the alignment of currents approaching the lock. Because of the reduction in cross-sectional area along the right bank, velocities in the approach channel were somewhat higher than with plan A. However, navigation conditions in the approach were much better because of the improvement in the alignment of currents. Currents resulting from flow over the revetment along the right side of the approach channel move from the right toward the guard wall at a rather sharp angle. These currents tend to affect the head of a tow drifting into the lock approach. Observations indicated that navigation could be improved by providing additional space between the guard wall and the revetment, particularly during the higher flows.

23. Discharge distribution through the dam was not measured during this test, but the alignment of currents approaching the second gate from the dam appeared to be better.

Plan C

Description

24. Plan C was the same as plan B except for a change in the

alignment and length of the right bank revetment immediately upstream of the dam, based on the results of tests of plan B. This plan involved the realignment and reduction in the length of the revetment along the right bank above the lock. The revetment was moved 50 ft landward near the end of the upper guard wall, starting at sta 63+70 and terminating near the end of the wall at sta 82+05 (plate 7). The modification was designed to provide additional maneuver area for tows approaching and leaving the lock.

Results

25. The results of the tests of plan C are shown in table 2 and plates 9-11. Current directions indicate some improvement in the alignment of currents in the upper approach. Because of this improvement and the additional maneuver area available, tows could approach or leave the lock with little difficulty. Since the top of the revetment to the right of the approach channel is several feet (8 to 9) below normal upper pool, tows moving too far to the right would be in danger of going aground, or over the revetment during some flows.

26. The alignment of currents approaching the dam was better than with plan A, resulting in a better distribution of flow through the dam, particularly with the 350,000-cfs flow (table 2). The flow through the first two gates near the lock was increased on an average of about 23 percent over that measured during the test of plan A with the higher flow.

Plan D

Description

27. Plan D was the same as plan C except that the nose of the upper guard wall was revised (plate 12) to reduce its effect on currents near the end of the wall and improve the alignment of currents approaching the dam.

Results

28. In general, the results of the tests of plan D indicate little difference in velocities and current directions in the upper lock approach with the modified end of the upper guard wall (plate 13). There was some improvement in the alignment of currents approaching the gate bays near the lock, particularly with the 350,000-cfs flow. Flow through the gate bay

near the lock was increased about 9 percent above that with plan C with a discharge of 350,000 cfs, with small changes in flow through the other gates.

Plan E

Description

29. Plan E was the same as plan D except that the proposed I-430 Bridge piers forming the navigation span and the highway embankment extending along the left overbank were placed in the model as shown in plate 14. Tests of this plan were conducted with and without a relief opening to determine the effect of the embankment and relief opening on navigation conditions, water-surface elevations, and distribution of flow.

Results

30. Before the installation of the highway embankment, current directions and velocities were obtained to provide a basis for comparing the effects of the embankment. The results of tests without the embankment are shown in plates 15-17; results of tests with the embankment are shown in plates 18-24.

31. Current directions and velocities with the maximum navigable flow indicate that downbound tows would have to approach the bridge by moving along the center of the channel for some distance upstream to become aligned for passage through the bridge span. Because of the low elevation of the revetment along the left bank upstream of the bridge, tows would have to move at a considerable distance riverward of the revetment to prevent them from being moved toward and against the revetment by currents moving over the revetment toward the left overbank during higher flows. Tows passing through the bridge span and maintaining satisfactory alignment should encounter little difficulty in making a satisfactory approach to the lock even during high flows.

32. Results of tests with and without the embankment indicate that with the 350,000-cfs flow the effects of the embankments would be mostly local with little effect on currents affecting navigation (plates 19 and 20). With the higher flows the effects of the embankments were greater, with some effects in the form of increased velocities noted within the

channel (plates 21-24). Velocities at the end of the embankment without the relief opening varied from about 8.4 fps with the 450,000-cfs flow to about 9.9 fps with the 625,000-cfs flow. With both flows velocities were somewhat higher just downstream of the end of the embankment. With the relief opening, velocities near the end of the embankment were considerably lower.

33. It should be noted that the bridge span is located in a crossing where channel alignment and depth are generally difficult to maintain. Since the model was not of the movable-bed type, the difficulties that could be experienced at the bridge could not be fully developed. A study of currents during the higher flows indicates that high-velocity currents would move across the low-water channel and the path which would be followed by tows during low water (plates 15-17). Also, the velocity of currents moving through the bridge span was considerably lower than that for currents along the left side of the channel. This condition is aggravated by the flow moving across the low revetment along the left bank upstream of the bridge. The results of this test indicate that some difficulties can be expected in maintaining the low channel alignment and depth during periods of prolonged high water.

34. Water-surface elevations indicate that the highway embankment would raise stages upstream of the embankment (gages 1-6) about 0.2 to 0.3 ft with a flow of 350,000, 0.4 to 0.5 ft with a flow of 450,000, and 0.4 to 0.7 ft with a flow of 625,000 cfs (table 4). Stages upstream of the embankment obtained with a relief opening from sta 625+00 to the high ground on the left bank were about 0.1 to 0.2 ft lower than those obtained with no relief opening.

35. The distribution of flow along the axis of the dam was affected appreciably by the embankments tested (table 5). The distribution of flow between the spillway and overbank was about the same with the relief opening in the embankment with flows of 350,000 and 625,000 cfs; with the 450,000-cfs discharge, flow through the spillway was about 3.5 percent higher. Without the relief opening, flow through the spillway was from 3 to 10 percent higher; the higher percentage was with the 450,000-cfs flow.

Plan E Modified

Description

36. Plan E modified was the same as plan E except that the right bank revetment upstream of the dam was shortened to terminate 860 ft upstream of the axis of the dam (plate 14). The purpose of this test was to determine if the revetment could be terminated outside of the lock cofferdam and completed before the cofferdam is removed without affecting navigation entering and leaving the lock.

Results

37. The results of this test indicate that shortening the revetment as included in this plan would have little effect on current directions and velocities in the lock approach (plate 25). The eye of the eddy in the upper lock approach was increased, but there was little change in its intensity and no navigation difficulties were indicated. Whether or not the revetment is carried back to the bank should have no appreciable effect on currents in the eddy, provided the area behind the revetment is filled. The eddy did not appear to be of sufficient intensity to produce any serious scour of material placed landward of the revetment.

Plan F

Description

38. Plan F was the same as plan E modified except that the navigation span on the proposed I-430 Bridge was modified by moving the right pier 65 ft toward the right bank to provide for a center-to-center spacing of the piers of 425 ft.

Results

39. Observations of the behavior and maneuvering required with downbound tows approaching the bridge indicate that navigation conditions were improved considerably by the modification. The improvement is attributed principally to the increase in the length of span. Because of the shift in the right pier, downbound tows could become aligned for the approach to the lock with less difficulty. Downbound tows approaching the bridge from

along the left side of the channel will have to make a greater change in direction to take full advantage of the increase in span width. The effects of currents moving at an angle to the direction of the tow could be reduced or minimized by starting the turn farther upstream or by moving closer toward the center of the channel, particularly during the higher flows. As was the case with the shorter span, no serious navigation difficulties were indicated.

PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

Limitations of the Model

40. The analysis of the results of this investigation is based principally upon a study of current directions and velocities in the upper and lower lock approaches and the effects of these currents on the behavior of the model tow. In evaluating test results, 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. Current directions and velocities shown in the plates were obtained with wooden floats submerged 8 ft and are indicative of currents that will affect tows.

41. The model was of the semifixed-bed type and not designed to simulate the movement of sediment in the prototype; therefore, the changes in channel configurations and slopes which can be expected from changes in regulating works could not be developed naturally. Changes in the model channel were based initially on estimated cross sections and were modified according to interpretation of changes in flow conditions. Because of the small model scale, it was difficult to reproduce or to measure water-surface elevations with an accuracy greater than ±0.1 ft (prototype). This should be considered when evaluating data involving water-surface elevations.

Conclusions

42. The following conclusions and indications were developed during the investigation:

a. Downbound tows would experience difficulties in making a satisfactory approach to the lock with the original design because of the alignment of currents moving from along the right bank toward the spillway, particularly during the higher flows. With the original plan, distribution of

flow through the first three gates was adversely affected by the currents moving across the approach channel and by the shape of the end of the upper guard wall. No difficulties were indicated for upbound or downbound tows in the lower lock approach.

b. Satisfactory navigation conditions could be developed in the upper lock approach with the following modifications: (1) downstream extension and raising of the elevation of the right bank revetment along the upper approach channel to improve the alignment of currents and reduce the intensity of the crosscurrents in the upper lock approach; and (2) moving the revetment at least 50 ft landward to provide additional maneuver area and reduce the danger of tows hitting or moving over the top of the revetment.

c. The revetment along the right bank could be terminated at a point opposite and just upstream of the end of the upper guard wall.

d. Distribution of flow through the three gates near the lock could be improved by the downstream extension and raising of the revetment along the right bank as mentioned in subparagraph b above, and by modification of the end of the upper guard wall.

e. The elevation of the right bank of the upper approach channel will be below normal upper pool level and could constitute a hazard to navigation, particularly during high flows and severe weather conditions and high winds.

f. Construction of the proposed I-430 Bridge and embankment would have little effect on currents in the main channel with or without a relief opening. Velocities at the channel end of the embankment without a relief opening will tend to be high.

g. Because of the low elevation of the revetment along the left bank of the bend upstream of the bridge, tows moving close along the revetment would tend to be moved toward and over it by currents moving from the channel toward the overbank during high flows.

h. Because of the alignment of currents and the location of the navigation span in the proposed I-430 Bridge, downbound tows would have to approach the bridge along the center of the channel for some distance upstream.

i. Placement of the navigable span toward the left of that proposed would facilitate the passage of downbound tows through the span but would increase the difficulty tows would experience in becoming aligned for the approach to the lock after passing through the bridge.

j. Location of the bridge span in a crossing as proposed could produce difficulties in maintaining a satisfactory and stable channel alignment and adequate low-water depths.

Table 1

Water-Surface Elevations

Existing Conditions

Gage No.	Discharge in 1000 cfs							
	50	100	200	300	350	400	500	625
1	237.5	244.4	252.3	257.2	259.2	260.8	263.6	266.7
2	237.0	244.0	251.8	256.5	258.6	260.3	263.0	266.3
3	236.6	243.5	251.2	256.1	258.2	260.1	262.8	265.9
4	236.3	243.1	250.8	255.7	257.8	259.7	262.5	265.4
5	235.9	242.7	250.4	255.4	257.5	259.4	262.2	265.2
6	235.5	242.2	249.9	255.0	257.0	259.0	261.8	264.8
7	235.1	241.7	249.2	254.3	256.4	258.3	261.2	264.1
8	235.0	241.6	249.0	254.0	256.1	258.0	260.9	263.9
9	Dry	Dry	Dry	253.8	255.9	257.8	260.7	263.6
10	234.9	241.4	248.8	253.9	256.0	258.0	260.8	263.7
11	Dry	Dry	248.6	253.7	255.9	257.8	260.7	263.5
12	234.7	241.2	248.6	253.6	255.8	257.7	260.5	263.4
13	234.2	240.7	248.0	253.0	255.1	257.1	260.0	263.0
14	233.7	240.1	247.3	252.3	254.5	256.5	259.6	262.6
15	233.3	239.5	246.6	251.6	253.9	255.9	259.0	262.0
16*	233.2	239.4	246.3	251.4	253.6	255.6	258.6	261.5
17	233.1	239.3	246.1	251.0	253.1	255.1	258.0	260.7
18	233.0	239.1	245.8	250.4	252.3	254.2	256.7	258.9

Note: All elevations are in feet referred to mean sea level. Gage locations shown in fig. 3.

* Control gage.

Table 2

Distribution of Flow Through Dam

Plans A, C, and D

Gate No.*	Percent of Total Discharge 200,000 cfs			Percent of Total Discharge 350,000 cfs		
	Plan A	Plan C	Plan D	Plan A	Plan C	Plan D
1	5.1	5.9	5.9	4.9	5.7	6.2
2	5.5	5.5	5.5	4.1	5.4	5.3
3	7.3	7.8	7.6	7.2	7.5	7.6
4	7.6	7.5	7.7	7.8	7.4	7.5
5	7.7	7.5	7.6	7.9	7.4	7.4
6	7.6	7.5	7.7	7.8	7.5	7.5
7	7.6	7.9	7.4	7.9	7.6	7.6
8	7.6	7.5	7.5	7.7	7.7	7.6
9	7.7	7.5	7.5	7.9	7.8	7.8
10	7.7	7.6	7.6	7.9	7.6	7.5
11	7.5	7.4	7.6	7.7	7.4	7.4
12	7.6	7.4	7.5	7.6	7.3	7.3
13	7.8	7.4	7.3	7.0	7.2	6.9
14	5.7	5.6	5.6	6.6	6.5	6.4

* Gates numbered from right to left.

Table 3

Water-Surface Elevations, Plan A

Gage No.	Discharge in 1000 cfs						
	100	200	300	350	400	500	625
1	249.8	251.8	257.2	259.1	261.0	264.1	267.3
2	249.6	251.2	256.6	258.5	260.4	263.5	266.6
3	249.5	250.7	256.3	258.2	260.1	263.2	266.3
4	249.3	250.3	255.9	257.9	259.8	262.8	265.8
5	249.3	250.0	255.7	257.7	259.6	262.6	265.6
6	249.2	249.7	255.3	257.4	259.3	262.3	265.3
7	249.0*	249.2	254.8	257.0	258.7	261.9	264.9
A	249.0	249.2	254.8	257.0	258.8	261.9	265.0
8	249.0	248.8	254.3	256.4	258.4	261.5	264.4
9	Dry	Dry	254.8	256.6	258.4	261.4	264.4
10	240.3	248.5	253.9	256.2	258.1	261.2	264.2
11	Dry	248.4	253.8	256.1	258.2	261.2	264.3
12	240.4	248.2	253.5	255.7	257.7	260.8	263.9
13	240.2	247.8	253.1	255.3	257.3	260.4	263.4
14	239.7	247.0	252.3	254.6	256.7	259.9	262.9
15	239.5	246.6	251.7	254.1	256.0	259.3	262.2
16	239.3	246.3	251.4	253.6	255.6	258.6	261.5
17	239.2	246.1	251.0	253.2	255.0	257.9	260.7
18*	239.1	245.7	250.5	252.5	254.2	256.7	258.9

Note: All elevations are in feet referred to mean sea level. Gage locations shown in fig. 3.

* Control gage.

Table 4

Water-Surface Elevations, Plan E

Highway Embankment Tests

Gage No.	Discharge in 1000 cfs										
	180*	280**	350†	350*	350††	450†	450*	450††	625†	625**	625††
1	251.3	256.1	259.2	259.5	259.4	262.5	263.0	262.9	267.3	267.7	267.6
2	250.8	255.5	258.6	259.0	258.9	262.0	262.5	262.4	266.7	267.2	267.0
3	250.4	255.1	258.3	258.7	258.6	261.7	262.2	262.1	266.3	267.0	266.9
4	250.0	254.7	258.0	258.3	258.2	261.3	261.8	261.7	265.9	266.5	266.4
5	249.8	254.5	257.8	258.0	258.0	261.1	261.5	261.4	265.6	266.2	266.1
6	249.4	254.0	257.4	257.7	257.7	260.8	261.1	261.1	265.3	265.7	265.7
7	249.0*	253.4	257.0	257.1	257.1	260.3	260.5	260.4	264.9	265.0	265.0
8	248.7	252.9	256.5	256.7	256.7	259.9	260.1	260.1	264.5	264.6	264.6
A	248.9	253.5	256.9	257.1	257.1	260.3	260.5	260.5	264.9	265.1	265.1
9	Dry	253.5	256.6	256.7	256.8	259.8	260.0	260.0	264.4	264.4	264.4
10	246.7	252.5	256.2	256.4	256.4	259.6	259.7	259.7	264.2	264.2	264.2
11	246.6	252.4	256.2	256.4	256.4	259.6	259.8	259.7	264.3	264.3	264.3
12	246.4	252.1	255.8	255.9	255.9	259.2	259.3	259.3	263.9	263.9	263.9
13	246.0	251.7	255.3	255.4	255.4	258.7	258.9	258.9	263.4	263.4	263.4
14	245.3	250.7	254.7	254.7	254.7	258.2	258.3	258.3	262.9	262.9	262.9
15	244.7	250.1	254.1	254.1	254.1	257.5	257.7	257.7	262.2	262.2	262.2
16	244.4	249.6	253.6	253.6	253.7	256.8	257.0	257.0	261.5	261.5	261.5
17	244.2	249.3	253.2	253.2	253.2	256.3	256.4	256.4	260.7	260.7	260.7
18‡	243.9	248.8	252.5	252.5	252.5	255.3	255.3	255.3	258.9	258.9	258.9
B	248.7	--	256.7	256.9	--	260.0	260.2	--	264.6	264.7	--
C	248.8	--	256.8	257.0	--	260.0	260.2	--	264.6	264.7	--
D	246.2	--	256.0	256.3	--	259.5	259.7	--	264.4	264.2	--
E	246.3	--	256.2	256.3	--	259.6	259.7	--	264.4	264.2	--
F	--	--	--	258.5	--	--	261.6	--	--	266.4	--
G	--	--	--	258.2	--	--	261.5	--	--	266.1	--
H	--	--	--	256.5	--	--	260.3	--	--	264.8	--
I	--	--	--	257.4	--	--	260.4	--	--	264.8	--

Note: All elevations are in feet referred to mean sea level. Gage locations shown in fig. 3 and plate 14.

* Highway embankment installed.

** Flow with 1-ft depth over left embankment.

† Without highway embankment.

†† Relief opening in highway embankment.

‡ Control gage.

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Table 5

Distribution of Flow, Plan E

Embankment Tests

100-ft Section* No.	Q = 350,000 cfs			Q = 450,000 cfs			Q = 625,000 cfs		
	Without Embankment	With Embankment	With Relief Opening	Without Embankment	With Embankment	With Relief Opening	Without Embankment	With Embankment	With Relief Opening
1	5,770	6,670	6,260	8,190	9,510	8,530	12,110	18,810	12,600
2	4,940	5,260	4,220	5,540	7,140	5,530	8,520	16,890	8,860
3	4,580	5,350	4,460	5,320	5,440	4,820	8,530	15,060	9,100
4	3,400	3,720	3,240	5,130	5,390	5,400	9,220	10,760	8,060
5	2,730	3,530	2,920	5,180	5,660	5,160	8,650	9,010	8,290
6	2,630	3,270	3,130	5,050	5,270	5,430	8,650	9,190	8,600
7	2,630	3,300	3,470	5,090	5,270	5,190	8,610	8,410	8,080
8	3,170	2,560	3,020	5,730	5,410	5,710	8,430	8,710	8,770
9	2,820	3,310	2,880	5,460	5,050	5,830	8,790	8,910	8,690
10	2,810	3,210	2,670	5,210	4,550	5,620	8,320	8,430	8,140
11	3,110	2,190	2,970	5,440	4,280	5,600	7,830	8,600	7,820
12	2,550	3,070	2,230	5,140	4,430	4,780	7,990	8,260	7,820
13	2,720	3,010	2,770	5,140	4,310	5,000	8,160	8,110	7,820
14	2,410	2,550	2,300	5,020	3,830	4,840	7,380	7,930	7,370
15	2,340	2,190	2,230	4,270	3,830	4,450	6,760	7,350	6,920
16	2,190	2,270	2,520	4,690	3,740	4,780	6,150	7,060	6,630
17	2,190	2,110	1,950	4,350	3,960	4,220	5,990	6,490	6,190
18	2,550	2,110	1,950	4,020	3,210	3,780	6,150	6,490	6,040
19	2,040	1,860	2,110	3,770	3,110	3,250	5,840	5,600	5,600
20	2,620	2,190	2,160	5,050	3,890	3,950	6,830	6,400	6,380
21	2,110	1,650	1,950	4,070	2,530	3,460	5,770	5,660	6,190
22	2,260	1,500	1,950	4,270	2,450	3,360	6,060	4,630	6,630
23	1,760	1,410	1,650	4,170	2,270	3,360	6,060	4,630	5,670
24	1,970	1,570	1,730	4,470	2,490	3,670	6,300	4,900	5,890
25	2,040	2,260	2,590	3,800	3,110	3,330	5,840	5,060	6,380
26	3,170	2,130	2,620	4,340	2,520	3,260	7,580	3,880	7,860
27	3,280	2,110	3,170	3,870	1,750	2,590	8,760	2,970	7,860
28	--	--	--	2,170	--	1,040	3,590	2,380	1,720
29	--	--	--	470	230	220	2,460	3,300	2,460
30	--	--	--	590	310	260	2,250	2,600	2,520
31	--	--	--	740	320	690	3,070	2,880	2,520
32	--	--	--	920	990	810	3,690	2,640	2,870
33	--	--	--	870	1,060	860	2,620	2,880	2,800
34	--	--	--	720	800	720	2,840	2,880	2,330
35	--	--	--	1,120	570	800	3,500	3,320	2,580
36	320	30	310	1,930	720	1,480	4,000	3,940	2,850
37	510	70	480	1,890	1,040	1,890	3,790	3,360	2,650
38	770	170	680	2,170	2,010	2,110	4,380	3,680	2,980
39	1,170	530	1,300	2,600	2,330	2,220	4,480	3,720	3,560
40	1,640	700	1,620	2,950	2,330	2,770	4,370	3,960	4,050
41	1,220	700	1,620	2,870	2,250	2,510	4,370	3,570	4,190
42	1,360	890	1,680	2,690	2,100	2,680	3,970	3,240	5,530
43	1,310	860	1,460	2,870	1,400	2,770	4,100	2,760	5,530
44	1,310	750	1,460	2,780	2,100	2,770	4,360	2,760	5,530
45	1,360	920	1,620	2,310	2,100	2,770	4,230	2,640	5,530
46	1,150	530	1,340	2,530	2,180	2,650	4,360	2,400	5,300
47	1,190	690	1,530	1,790	2,330	1,700	4,230	2,060	5,300
48	910	610	1,300	2,530	2,250	2,650	4,480	2,170	5,860
49	1,280	470	1,220	2,170	1,880	2,520	4,260	2,160	5,970
50	830	410	820	2,290	1,750	2,280	4,380	1,740	5,300
51	660	170	530	2,290	1,750	2,160	4,200	1,630	4,910
52	460	120	720	1,830	1,750	1,980	4,380	1,630	4,130
53	150	Dry	240	1,740	1,500	1,910	3,790	1,630	3,340
Total	94,390	85,000	95,050	181,610	152,450	172,210	305,430	290,330	306,480
Spillway Gate**									
1	16,650	17,260	17,060	15,840	16,820	16,000	22,160	22,020	21,340
2	13,390	14,230	12,510	14,310	15,750	14,450	20,920	22,020	20,770
3	19,860	20,530	19,560	19,670	20,830	20,390	19,460	19,780	19,350
4	19,620	21,230	20,240	20,180	23,500	21,420	23,650	24,800	23,330
5	18,930	20,060	18,650	20,950	22,700	20,920	22,750	23,690	23,040
6	19,890	19,600	18,880	20,180	22,700	20,390	23,350	24,530	22,760
7	19,860	19,600	19,560	19,670	22,160	21,170	23,350	24,250	23,330
8	19,160	19,590	19,100	20,180	22,700	21,170	23,650	23,970	22,190
9	19,620	19,830	19,790	20,440	22,430	21,420	23,050	24,520	23,330
10	18,930	19,590	19,790	21,210	22,960	21,160	23,350	24,250	23,330
11	18,470	19,590	18,190	19,990	21,890	20,900	22,750	23,970	23,040
12	18,010	19,130	18,650	19,160	21,630	20,130	21,860	23,970	22,470
13	18,240	18,430	17,510	18,400	20,560	19,360	21,560	22,850	21,900
14	14,780	16,330	15,460	17,880	20,560	18,580	20,360	22,300	21,050
Total	255,610	265,000	254,950	268,060	297,190	277,460	312,260	326,920	311,230
Right overbank	0	0	0	330	360	330	7,310	7,750	7,290
Relief opening			21,780			37,040			78,040

* Sections numbered from right to left on left overbank.
** Gates numbered from right to left.

LEGEND

MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER

STONE-FILL REVETMENT OR DIKE

TRENCH-FILL REVETMENT

PILE DIKE WITH STONE FILL

PILE REVETMENT WITH STONE FILL

MODEL LIMITS

92°24'00"

92°23'00"

34°49'00"

92°22'00"

800'R

7500'R

200'

174.5L

174.4L

174.2L

173.9L

173.7L

173.6L

173.4L

173.2L

173.0L

174.8R

174.6R

MI 175

MI 174

MI 173

APPROXIMATE TOP BANK

34°48'00"

MATCH LINE

92°20'00"

92°19'00"

MODEL LIMITS

MI 170

169.4L

169.2L

MI 169

34°47'00"

MATCH LINE

MI 171

STA 3+00

500'R

8058.36'R

PCC-1

7053.39'R

STA 58+50

170.7L

170.8L

171.0L

170.2R

170.4R

170.5R

170.6R

170.8R

171.0R

171.1R

171.2R

171.3R

171.4R

MI 172

APPROXIMATE TOP BANK

34°47'00"

92°20'00"

92°19'00"

EXISTING CONDITIONS

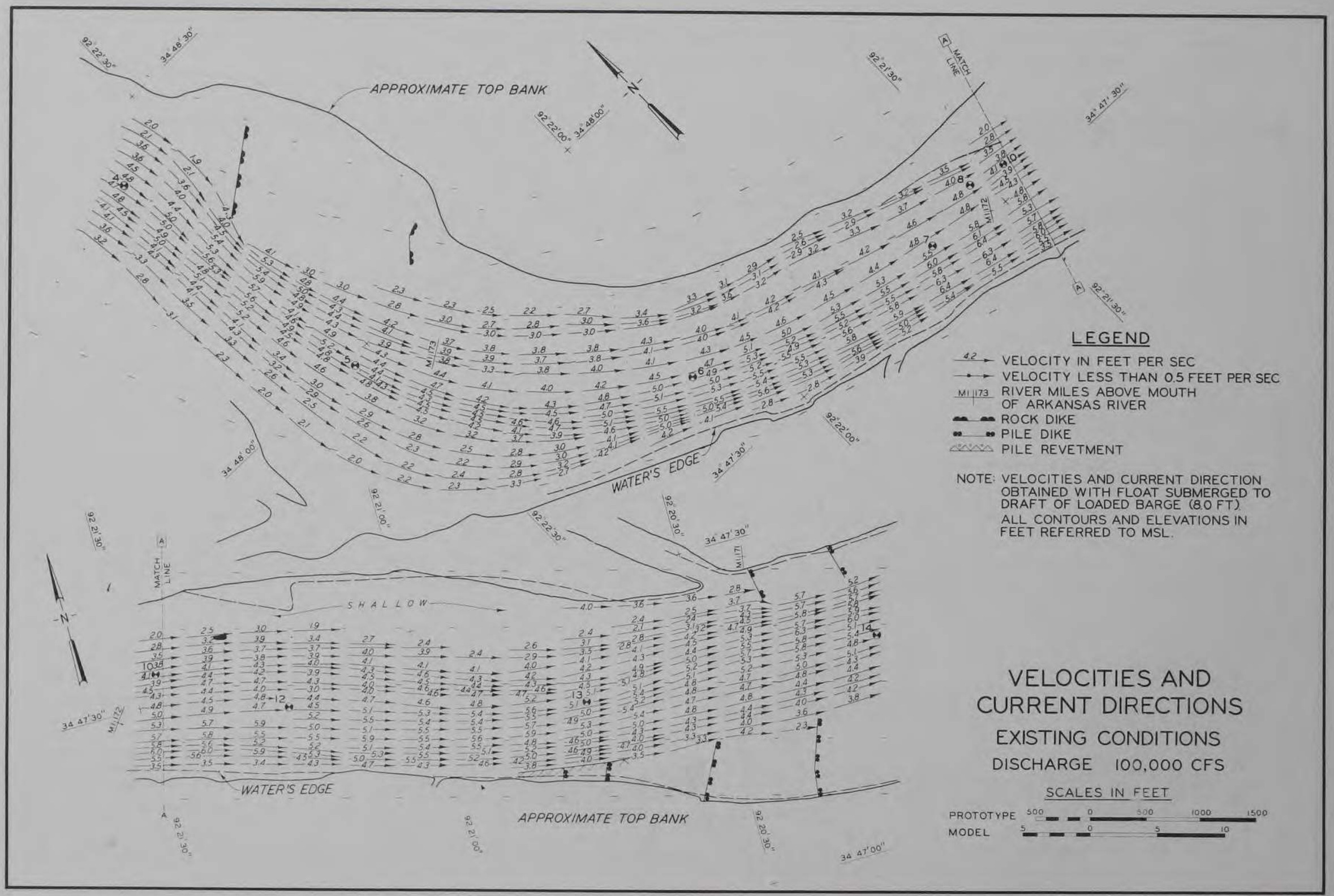
SCALES IN FEET

PROTOTYPE 1000 0 1000 2000 3000

MODEL 10 0 10 20 30

PLATE 1

PLATE 2



LEGEND

- 4.2 → VELOCITY IN FEET PER SEC
- → VELOCITY LESS THAN 0.5 FEET PER SEC
- M 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE
- PILE DIKE
- PILE REVETMENT

NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL.

VELOCITIES AND CURRENT DIRECTIONS

EXISTING CONDITIONS

DISCHARGE 100,000 CFS

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10

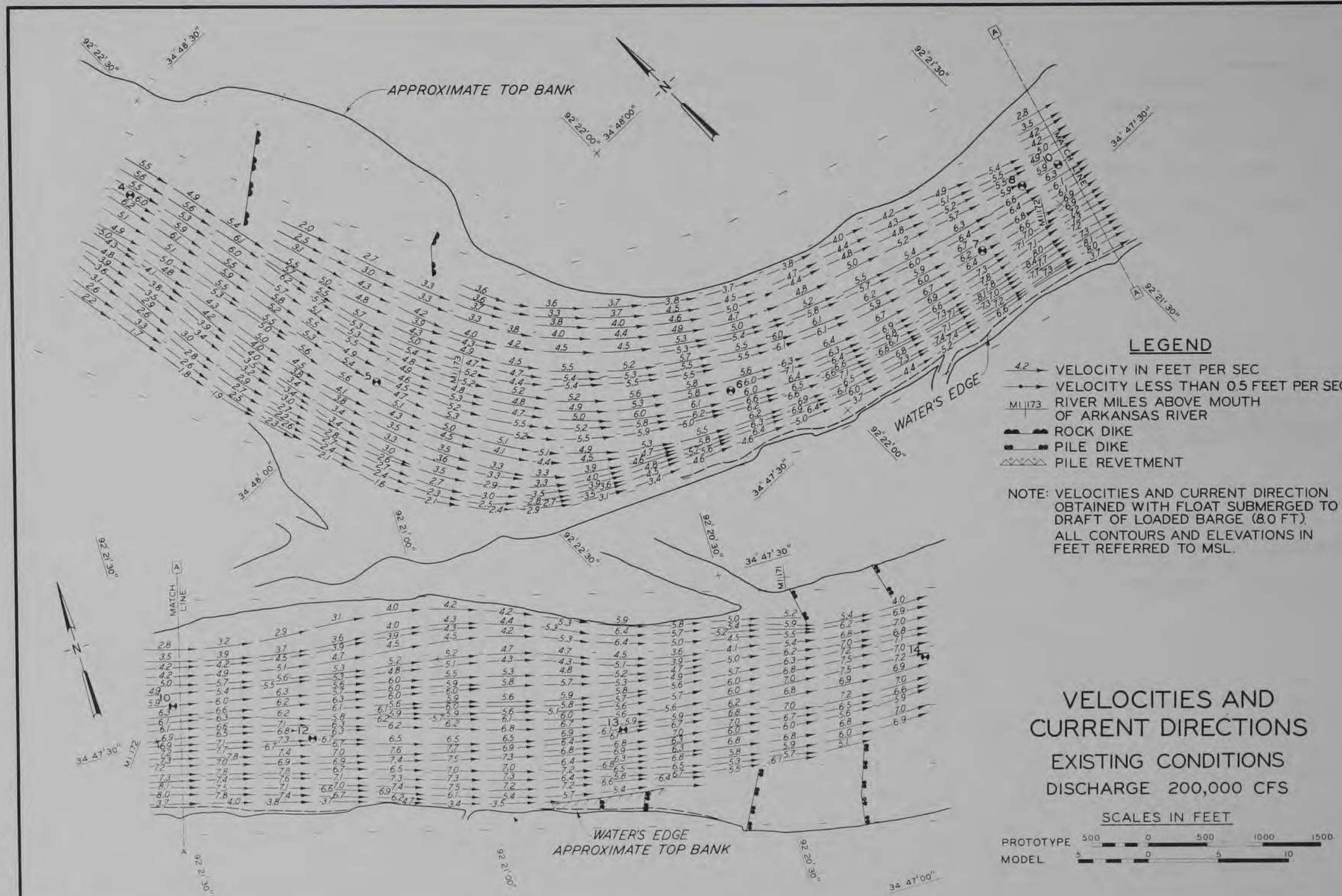
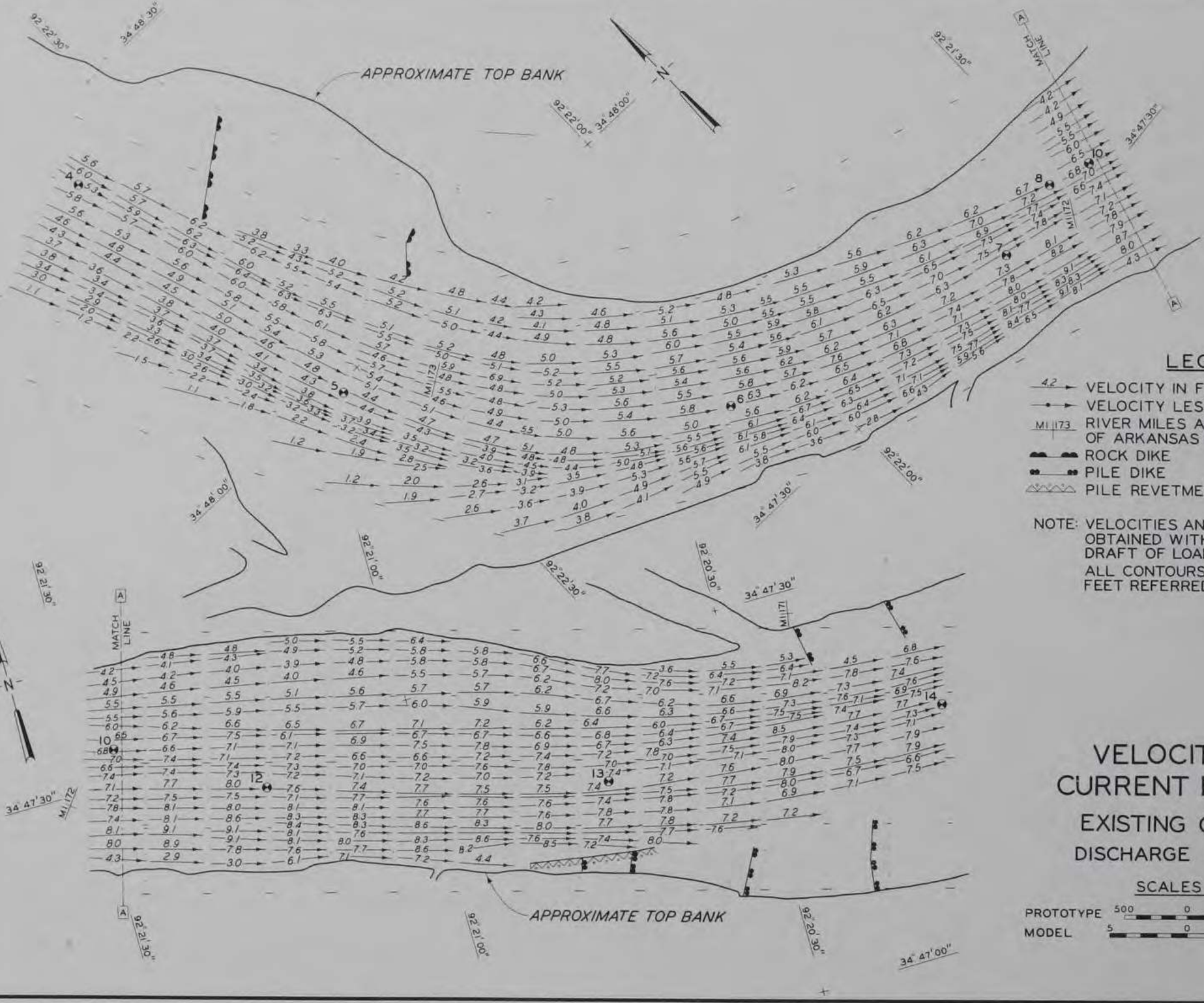

APPROXIMATE TOP BANK
WATER'S EDGE
APPROXIMATE TOP BANK
WATER'S EDGE
MATCH LINE
MATCH LINE
92° 22' 30"
34° 48' 30"
92° 21' 30"
92° 22' 00"
34° 48' 00"
34° 47' 30"
92° 21' 00"
92° 20' 30"
34° 47' 00"
M 173
M 172
N
LEGEND
4.2 VELOCITY IN FEET PER SEC
VELOCITY LESS THAN 0.5 FEET PER SEC
MI 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
ROCK DIKE
PILE DIKE
PILE REVETMENT
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL.
VELOCITIES AND CURRENT DIRECTIONS
EXISTING CONDITIONS
DISCHARGE 200,000 CFS
SCALES IN FEET
PROTOTYPE 500 0 500 1000 1500
MODEL 5 0 5 10

PLATE 3

PLATE 4



LEGEND

- 4.2 → VELOCITY IN FEET PER SEC
- → VELOCITY LESS THAN 0.5 FEET PER SEC
- MI 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE
- PILE DIKE
- PILE REVETMENT

NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL.

VELOCITIES AND CURRENT DIRECTIONS

EXISTING CONDITIONS

DISCHARGE 350,000 CFS

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10

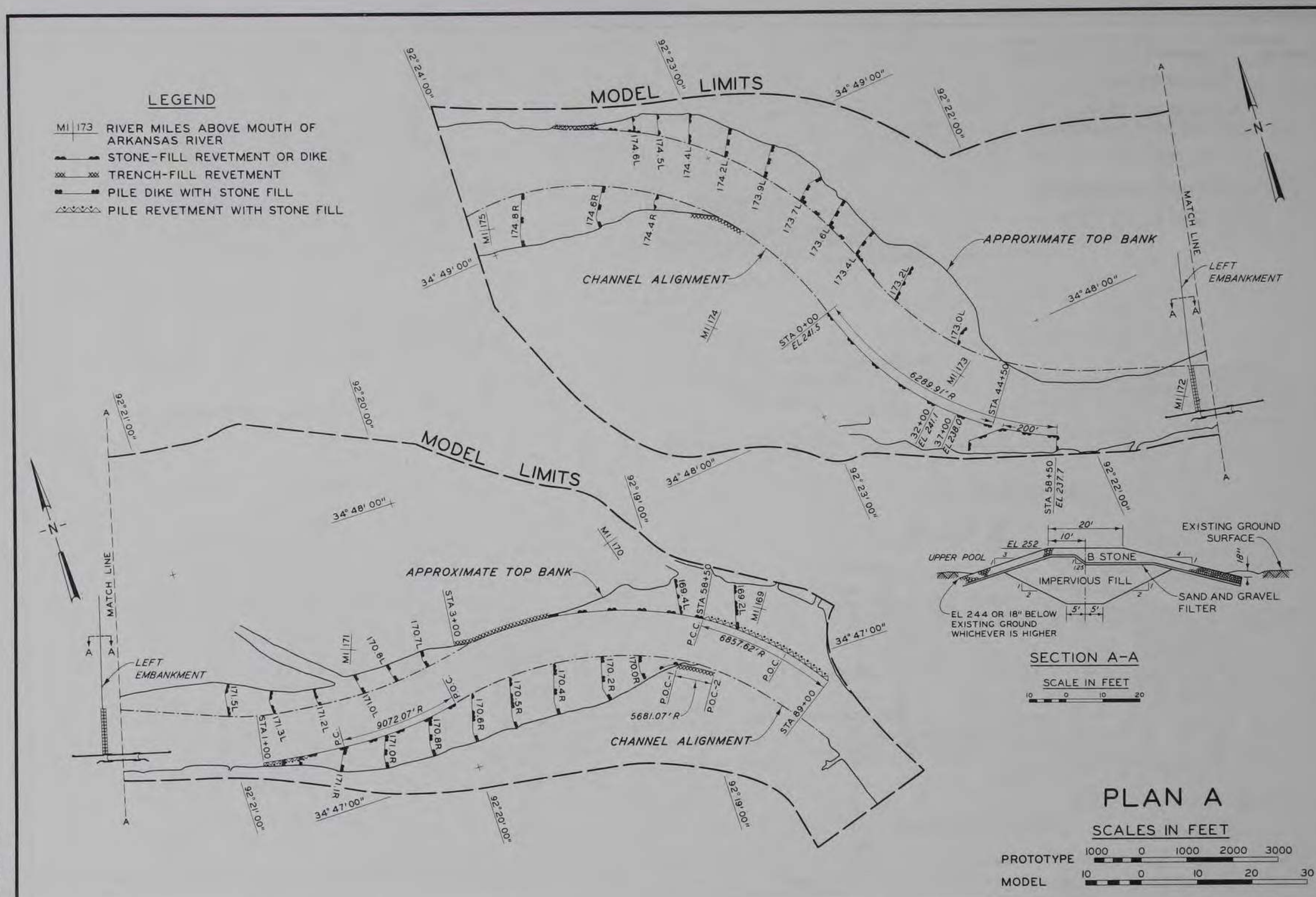
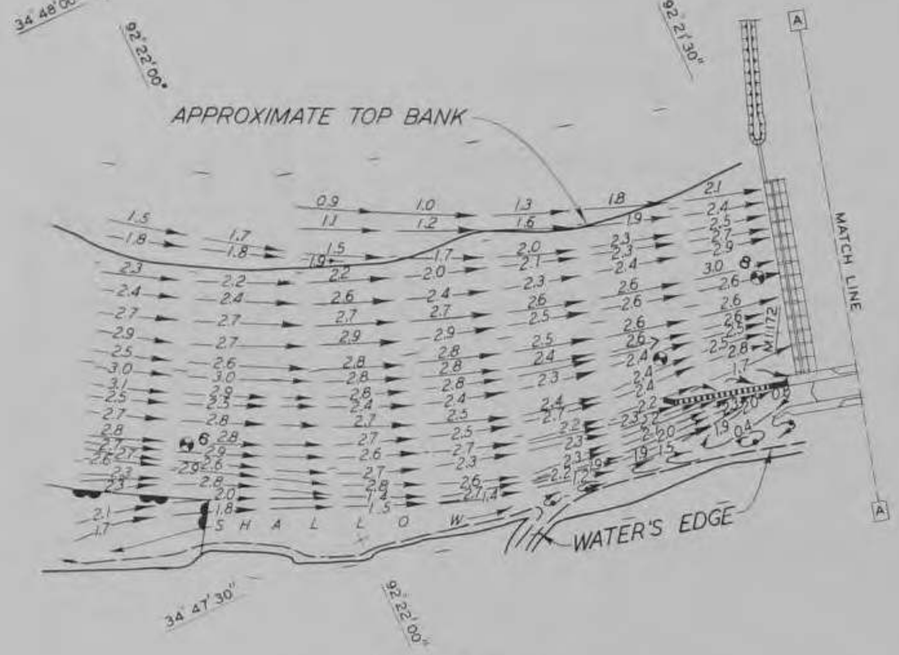
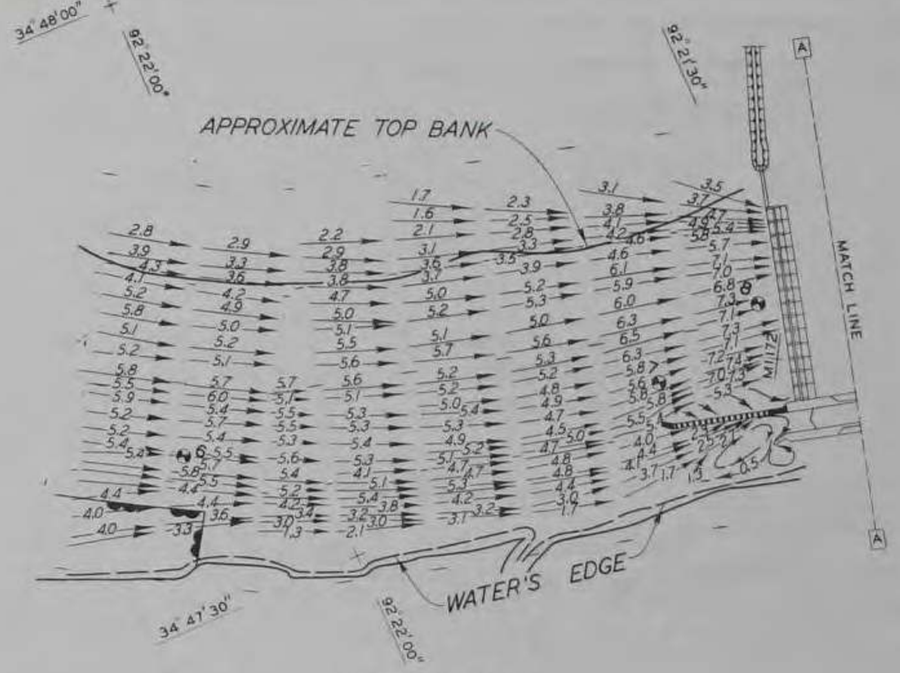

LEGEND
M| 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
STONE-FILL REVETMENT OR DIKE
TRENCH-FILL REVETMENT
PILE DIKE WITH STONE FILL
PILE REVETMENT WITH STONE FILL
MODEL LIMITS
92° 24' 00"
92° 23' 00"
92° 22' 00"
34° 49' 00"
34° 48' 00"
34° 47' 00"
92° 21' 00"
92° 20' 00"
92° 19' 00"
N
MATCH LINE
A
LEFT EMBANKMENT
APPROXIMATE TOP BANK
CHANNEL ALIGNMENT
M| 175
M| 174
M| 173
M| 172
M| 171
M| 170
M| 169
174.8R
174.6R
174.4R
174.6L
174.5L
174.4L
174.2L
173.9L
173.7L
173.6L
173.4L
173.2L
173.0L
171.5L
171.3L
171.2L
171.0L
170.8L
170.7L
171.1R
170.8R
170.6R
170.5R
170.4R
170.2R
170.0R
169.4L
169.2L
STA 0+00 EL 241.5
STA 3+00
STA 11+00
STA 32+00 EL 241.1
STA 37+00 EL 238.0
STA 44+50
STA 58+50 EL 237.7
6289.91' R
9072.07' R
5681.07' R
6857.62' R
P.C.
P.O.C.
P.O.C.-1
P.O.C.-2
200'
20'
10'
EL 252
UPPER POOL
B STONE
IMPERVIOUS FILL
SAND AND GRAVEL FILTER
EXISTING GROUND SURFACE
18"
EL 244 OR 18" BELOW EXISTING GROUND WHICHEVER IS HIGHER
5'
SECTION A-A
SCALE IN FEET
10 0 10 20
PLAN A
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000 3000
MODEL 10 0 10 20 30

PLATE 5

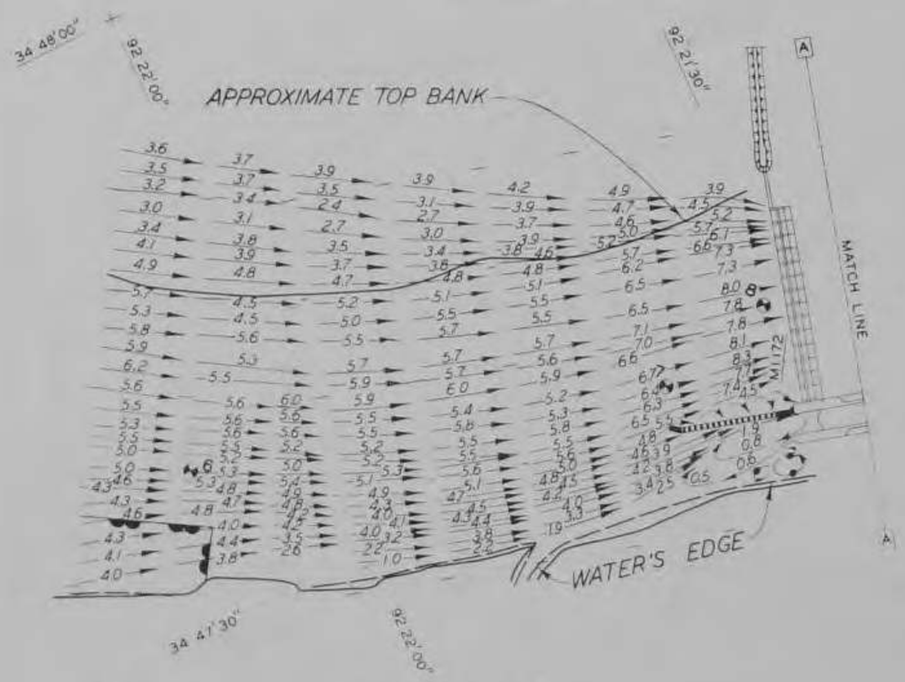
PLATE 6



100,000 CFS



200,000 CFS



350,000 CFS

LEGEND

- 4.2 → VELOCITY IN FEET PER SEC
- → VELOCITY LESS THAN 0.5 FEET PER SEC
- MI 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE
- PILE DIKE
- PILE REVETMENT

NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT)

ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL

VELOCITIES AND CURRENT DIRECTIONS

PLAN A

DISCHARGES 100,000, 200,000 AND 350,000 CFS

SCALES IN FEET

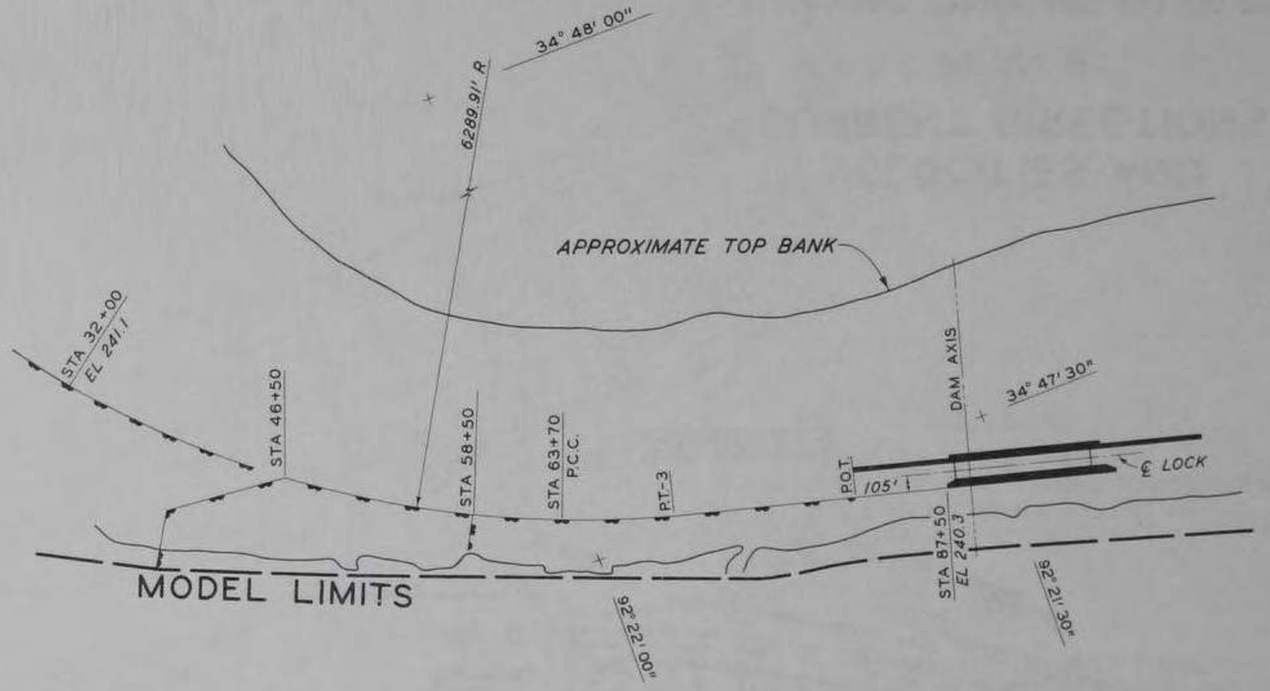
PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10

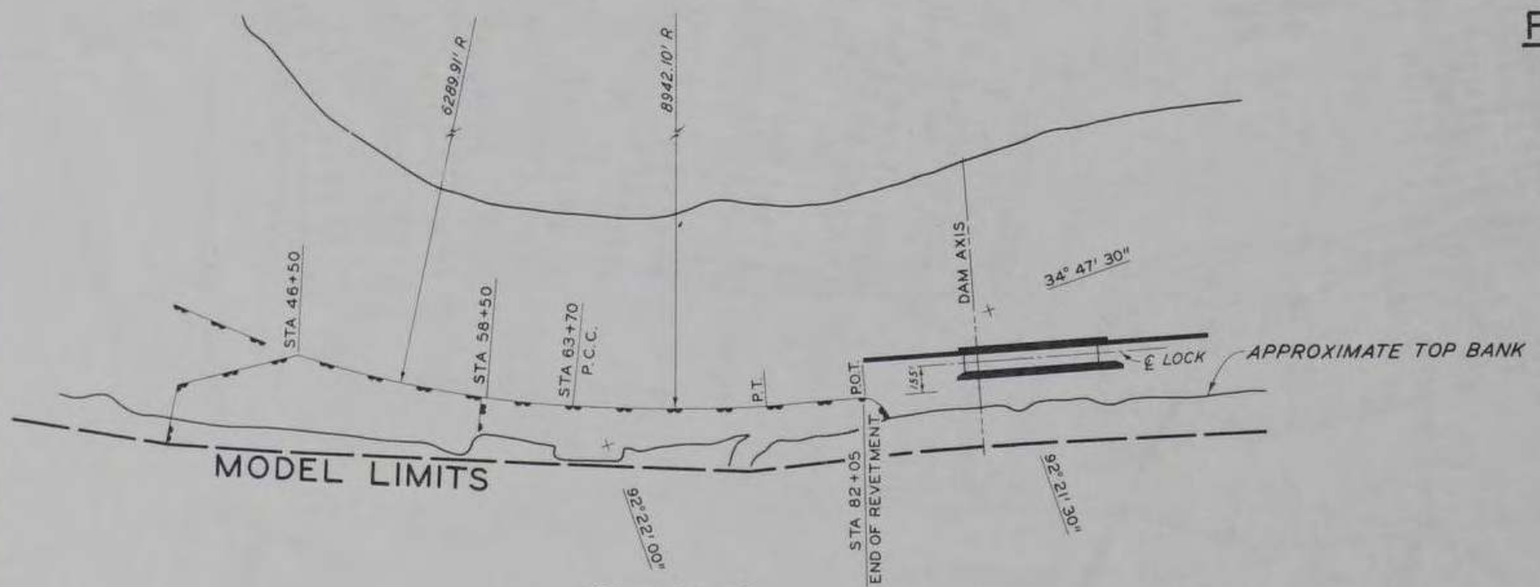
LEGEND

STONE-FILL REVETMENT OR DIKE

PILE DIKE WITH STONE FILL



PLAN B



PLAN C

STONE FILL REVETMENT SECTION

SCALE IN FEET

10 0 10 20 30

PLANS B AND C

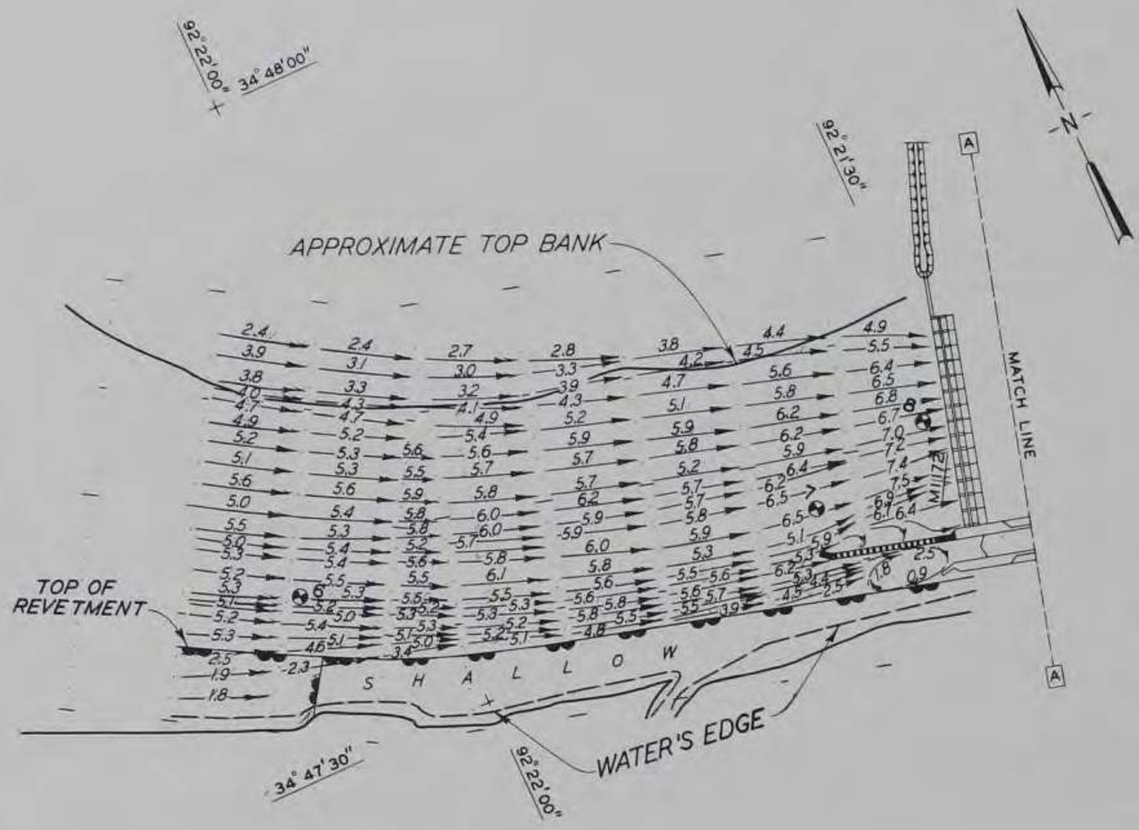
SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

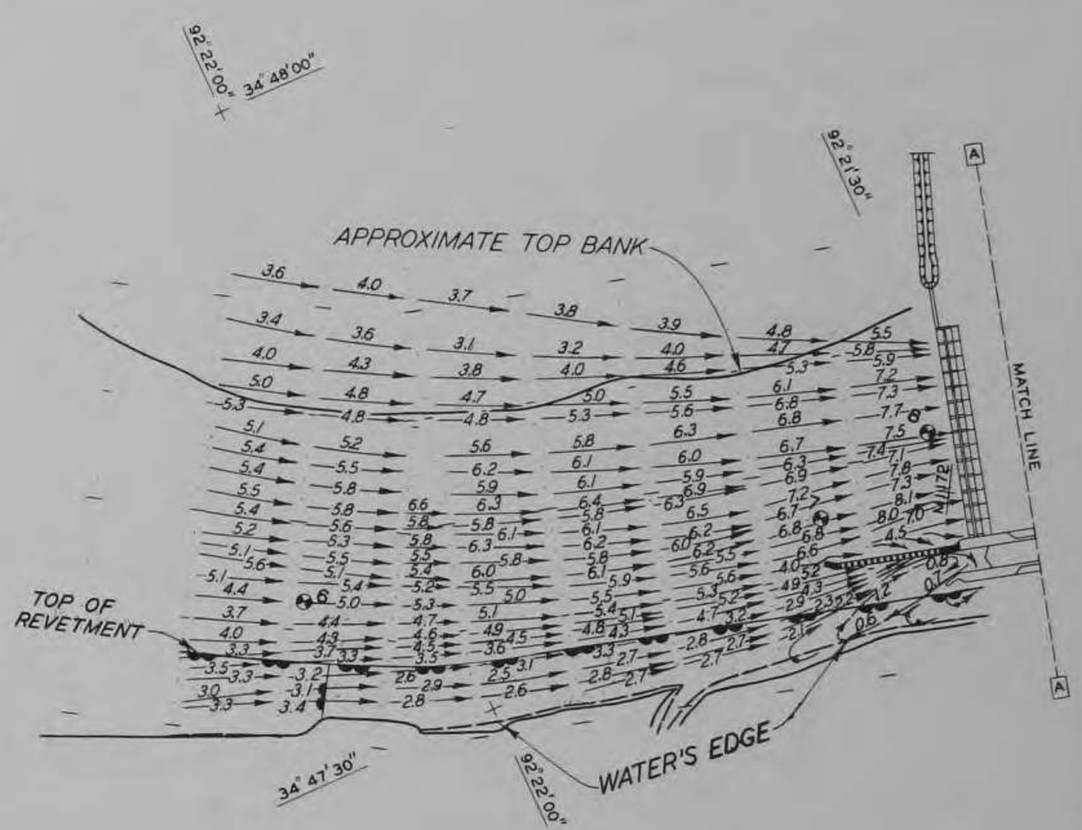
MODEL 4 0 4 8 12

PLATE 7

PLATE 8



200,000 CFS



350,000 CFS

LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- —•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

VELOCITIES AND CURRENT DIRECTIONS

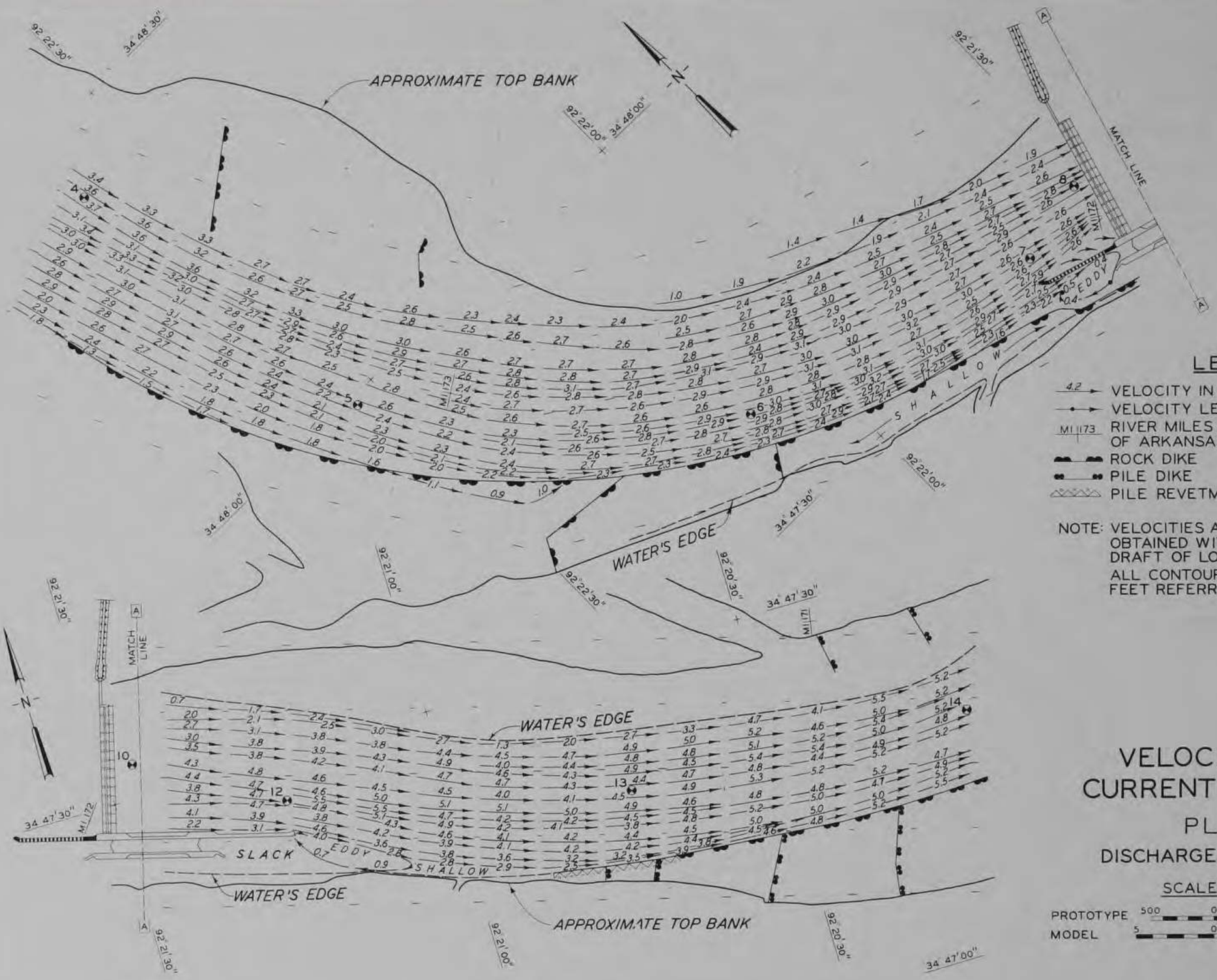
PLAN B

DISCHARGES 200,000 AND 350,000 CFS

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10



LEGEND

- 4.2 → VELOCITY IN FEET PER SEC
- → VELOCITY LESS THAN 0.5 FEET PER SEC
- M1 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE
- PILE DIKE
- PILE REVETMENT

NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT)
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL.

VELOCITIES AND CURRENT DIRECTIONS

PLAN C

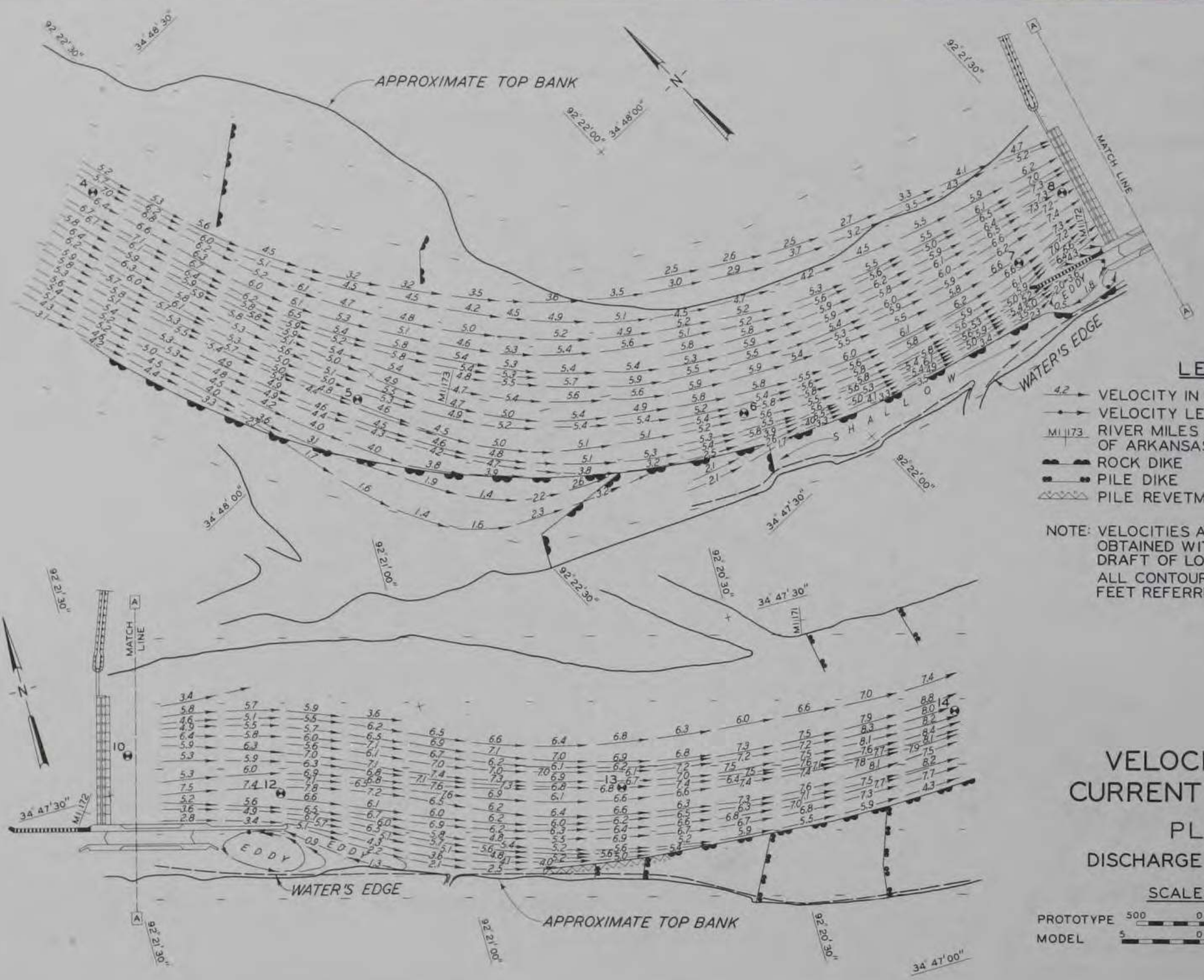
DISCHARGE 100,000 CFS

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500
MODEL 5 0 5 10

PLATE 9

PLATE 10



LEGEND

- 4.2 → VELOCITY IN FEET PER SEC
- → VELOCITY LESS THAN 0.5 FEET PER SEC
- MI 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE
- PILE DIKE
- PILE REVETMENT

NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL.

VELOCITIES AND CURRENT DIRECTIONS

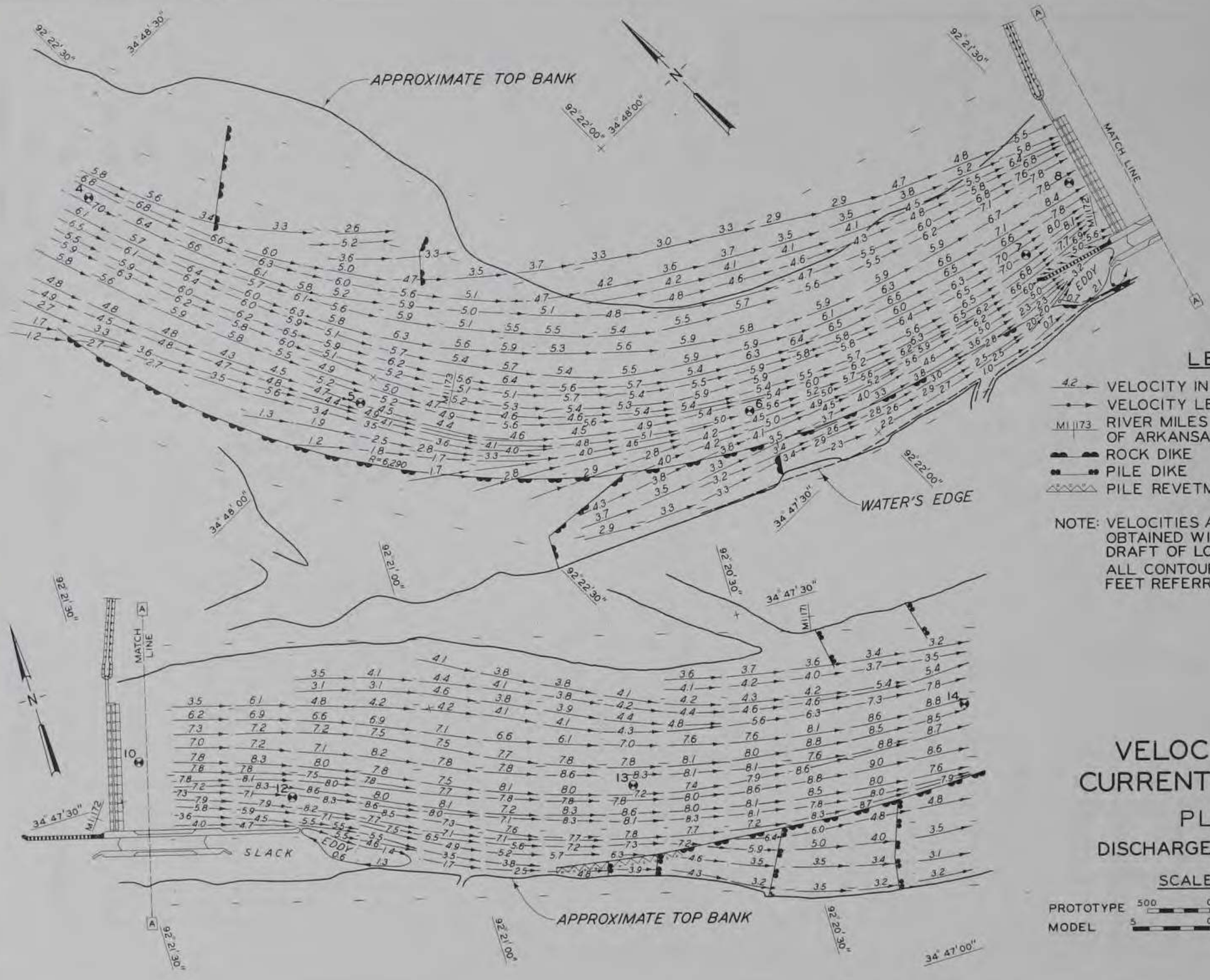
PLAN C

DISCHARGE 200,000 CFS

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10



LEGEND

- 4.2 → VELOCITY IN FEET PER SEC
- → VELOCITY LESS THAN 0.5 FEET PER SEC
- M 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE
- PILE DIKE
- PILE REVETMENT

NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL.

VELOCITIES AND CURRENT DIRECTIONS

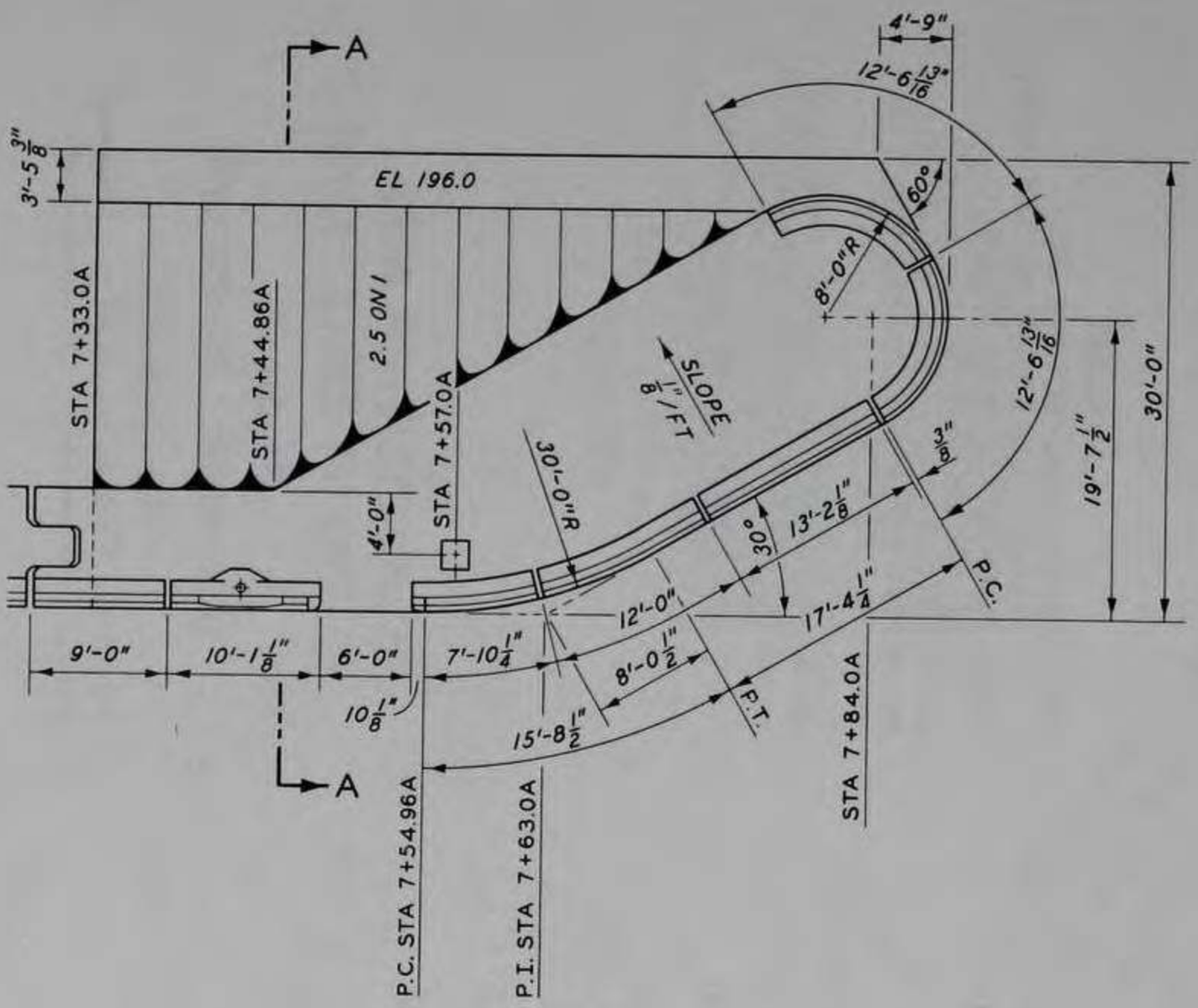
PLAN C

DISCHARGE 350,000 CFS

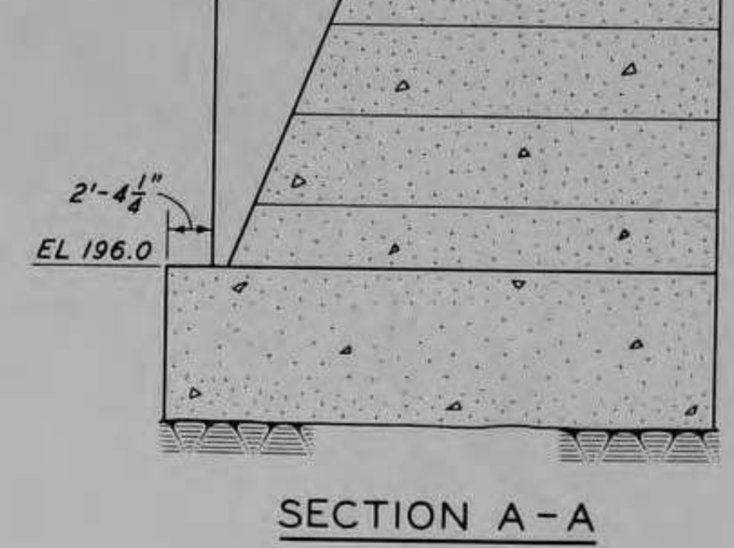
SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500
MODEL 5 0 5 10

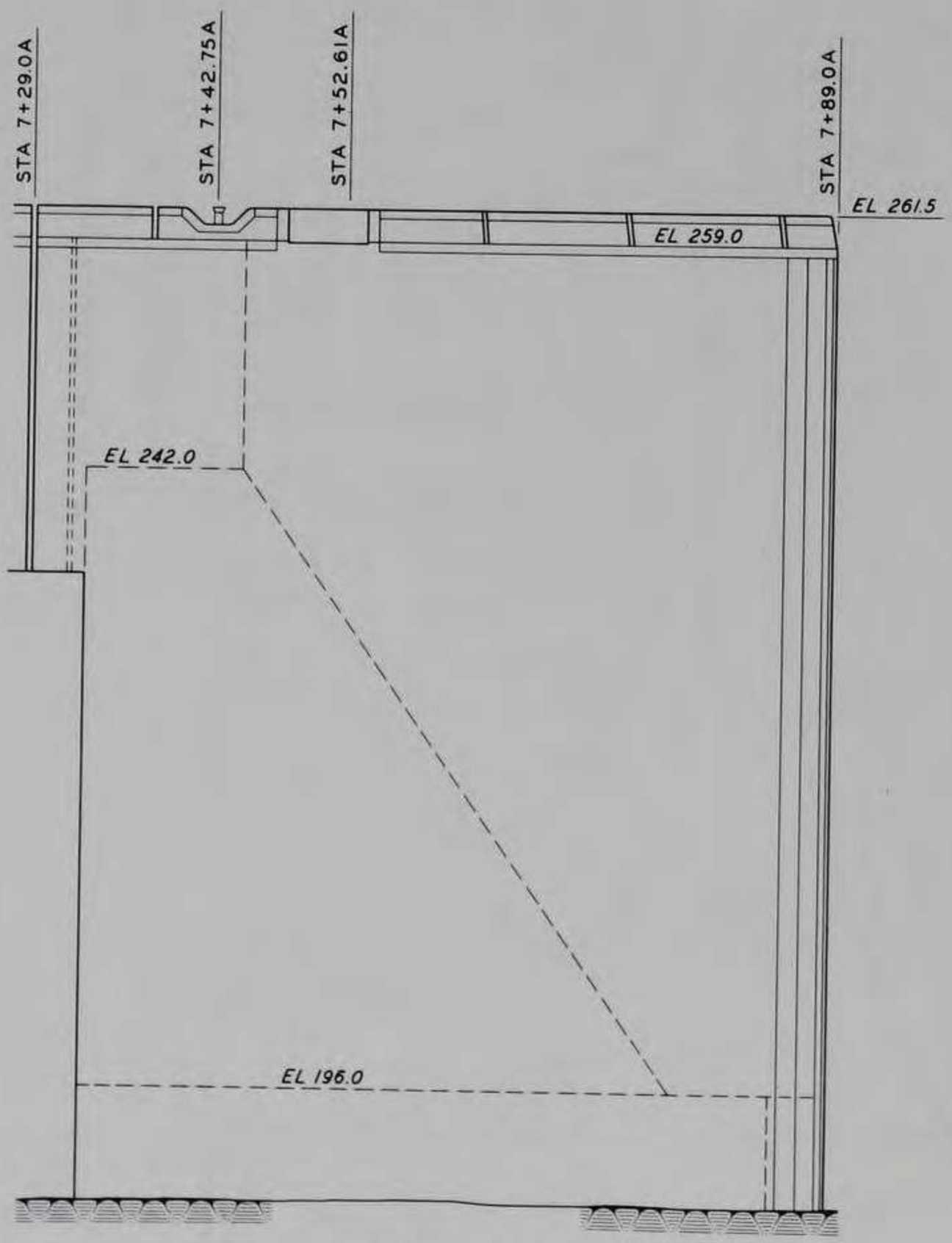
PLATE 11



PLAN



SECTION A-A



ELEVATION

NOSE OF UPPER GUARD WALL

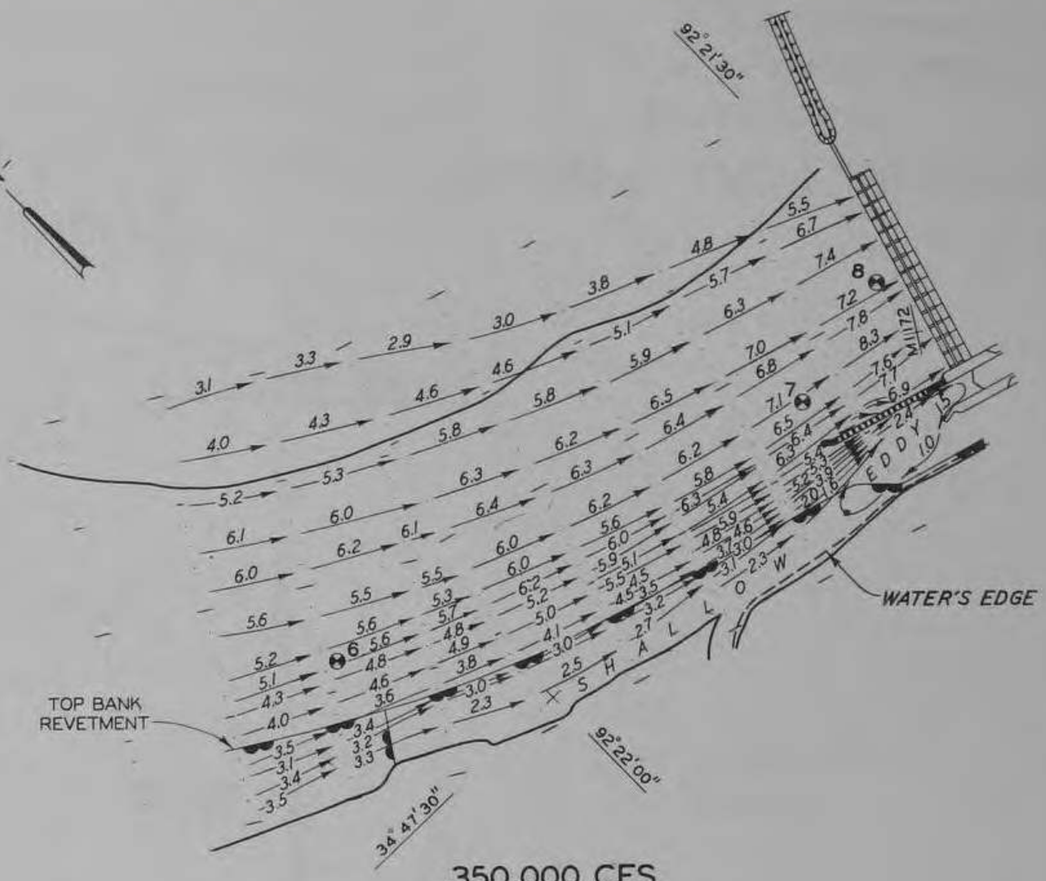
PLAN D

SCALE IN FEET

5 0 5 10 15 20

PLATE 12

200,000 CFS



350,000 CFS

LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- —•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN D

DISCHARGES 200,000 AND 350,000 CFS

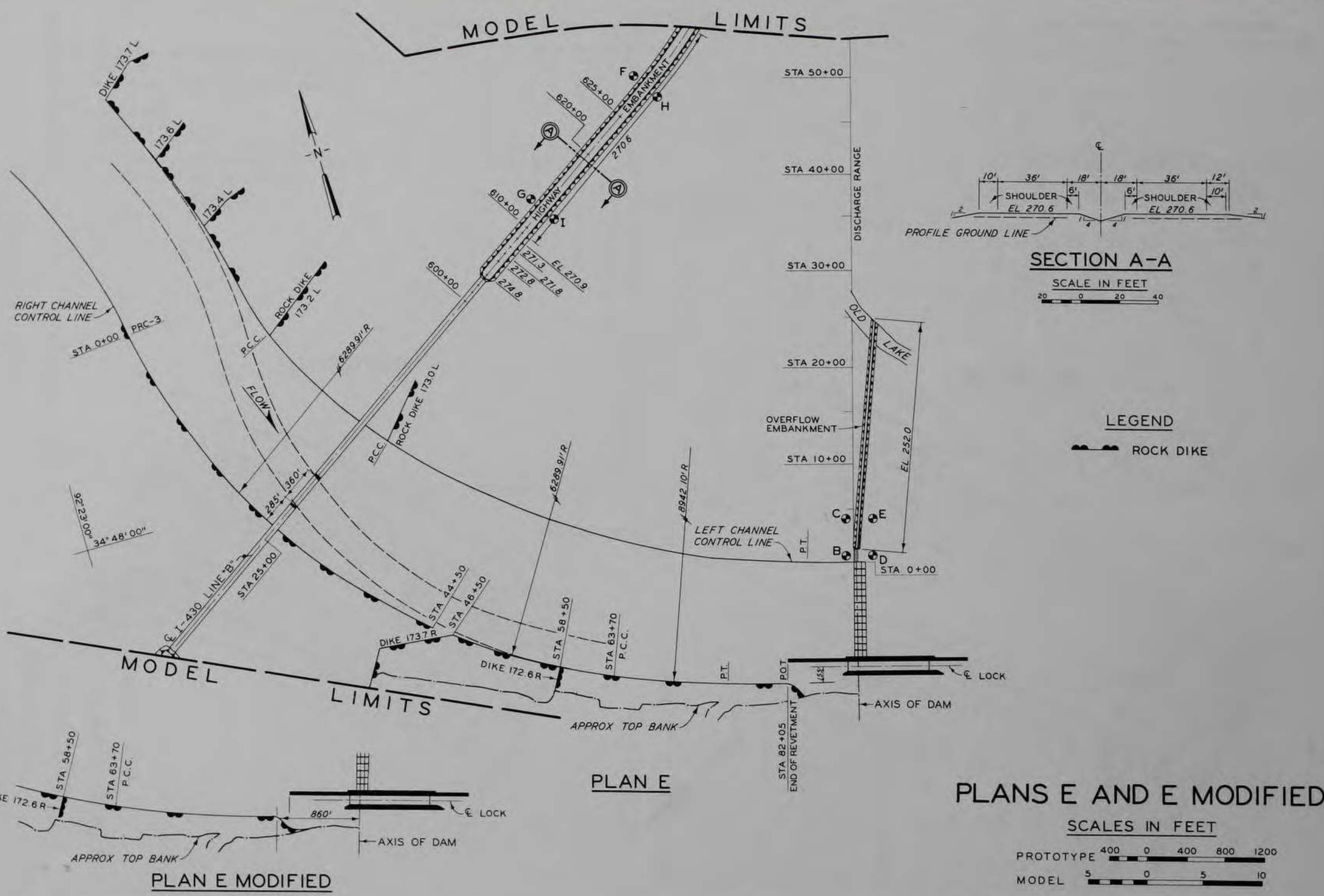
SCALES IN FEET

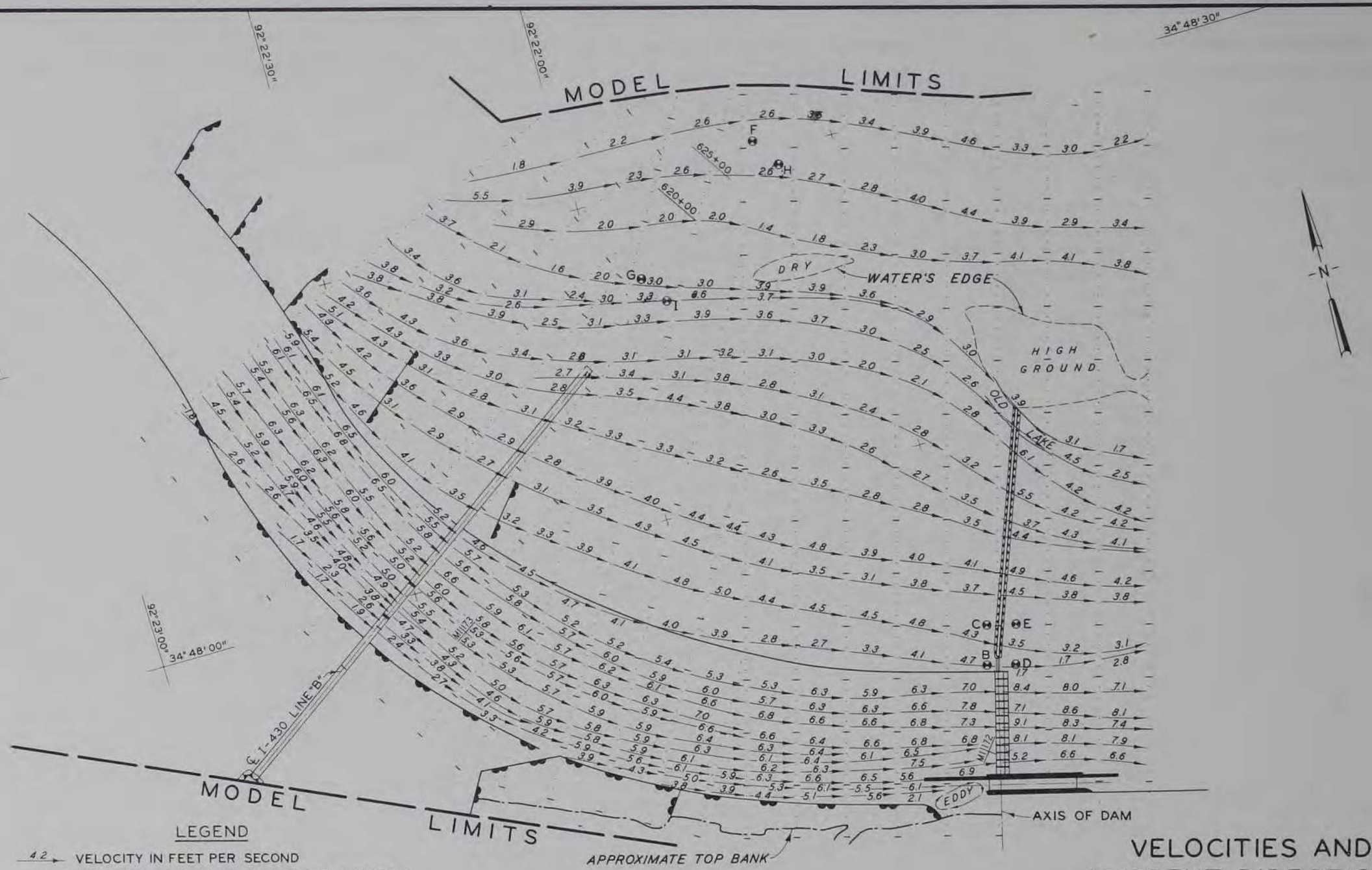
PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10

PLATE 13

PLATE 14


MODEL LIMITS
DIKE 173.7 L
173.6 L
173.4 L
ROCK DIKE 173.2 L
RIGHT CHANNEL CONTROL LINE
STA 0+00
PRC-3
P.C.C.
6289.91' R
FLOW
ROCK DIKE 173.0 L
285'
360'
62°23'00"
34°48'00"
℄ I-430 LINE "B"
STA 25+00
STA 44+50
STA 46+50
STA 58+50
STA 63+70
P.C.C.
DIKE 173.7 R
DIKE 172.6 R
MODEL LIMITS
APPROX TOP BANK
P.T.
P.O.T.
℄ LOCK
AXIS OF DAM
STA 82+05
END OF REVETMENT
600+00
610+00
620+00
625+00
HIGHWAY
EMBANKMENT
270.6
271.3
272.8
274.8
271.8
EL 270.9
F
G
H
I
A
A
STA 50+00
STA 40+00
STA 30+00
STA 20+00
STA 10+00
DISCHARGE RANGE
OLD
LAKE
OVERFLOW EMBANKMENT
EL 252.0
8942.10' R
LEFT CHANNEL CONTROL LINE
C
E
B
D
STA 0+00
N
PLAN E
PLAN E MODIFIED
℄
10'
36'
18'
18'
36'
12'
SHOULDER
EL 270.6
6'
6'
SHOULDER
EL 270.6
10'
PROFILE GROUND LINE
SECTION A-A
SCALE IN FEET
20 0 20 40
LEGEND
ROCK DIKE
PLANS E AND E MODIFIED
SCALES IN FEET
PROTOTYPE 400 0 400 800 1200
MODEL 5 0 5 10



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- ●→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

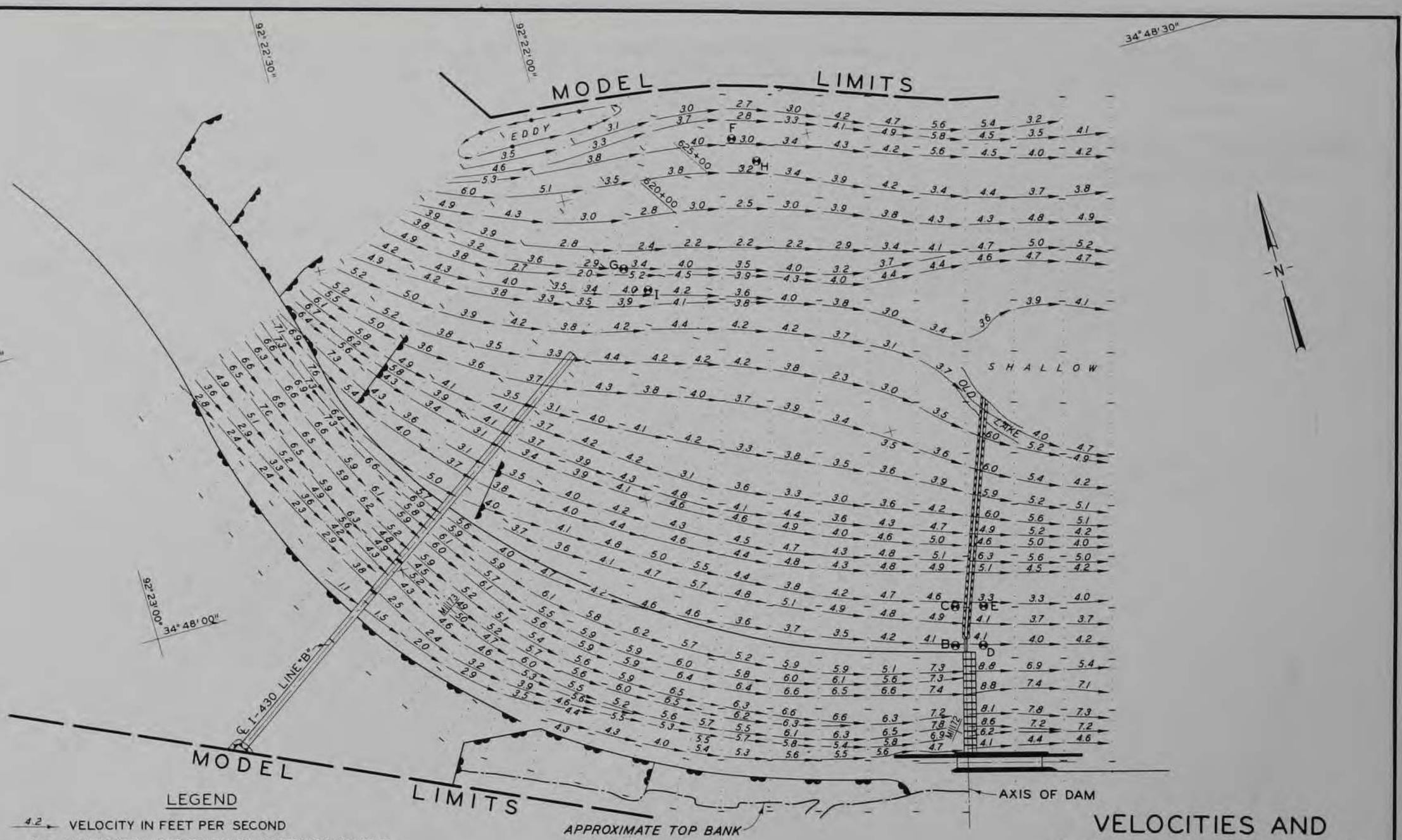
PLAN E

NO HIGHWAY EMBANKMENT

DISCHARGE 350,000 CFS

PLATE 15

PLATE 16



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- —•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

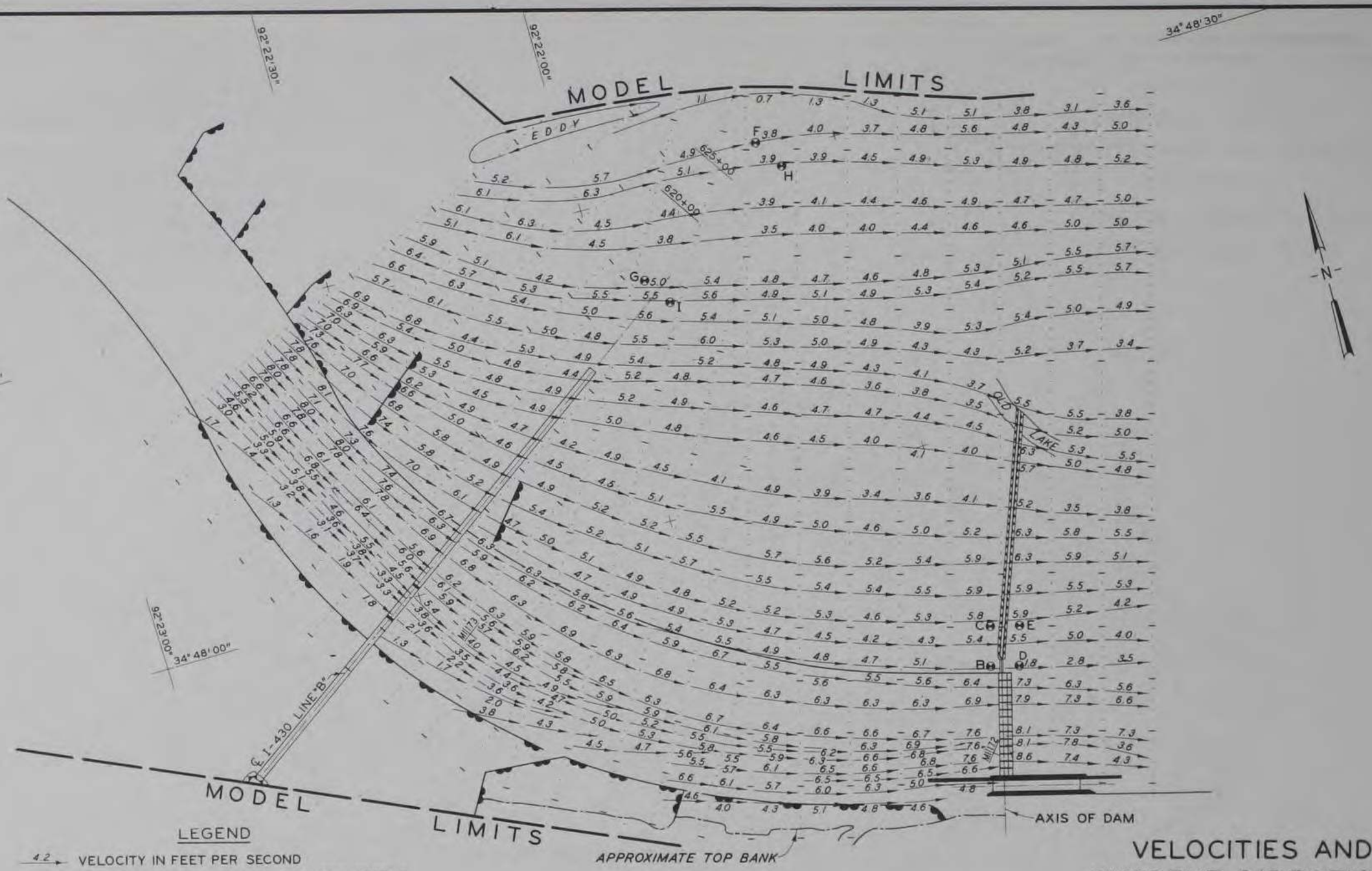
MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

PLAN E

NO HIGHWAY EMBANKMENT

DISCHARGE 450,000 CFS



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- —•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- M1 | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

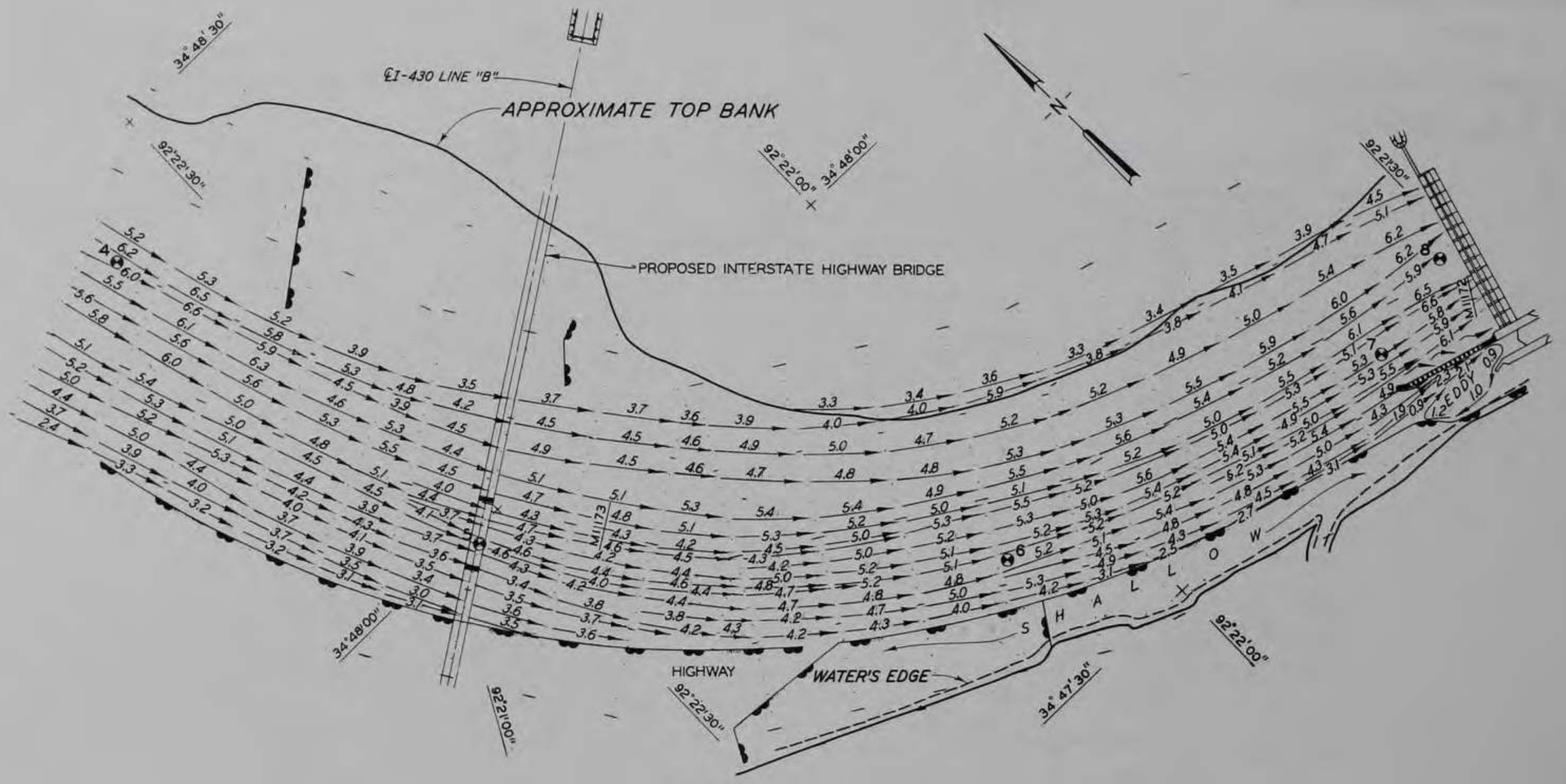
PLAN E

NO HIGHWAY EMBANKMENT

DISCHARGE 625,000 CFS

PLATE 17

PLATE 18



180,000 CFS

LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- —•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ▬▬ ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN E

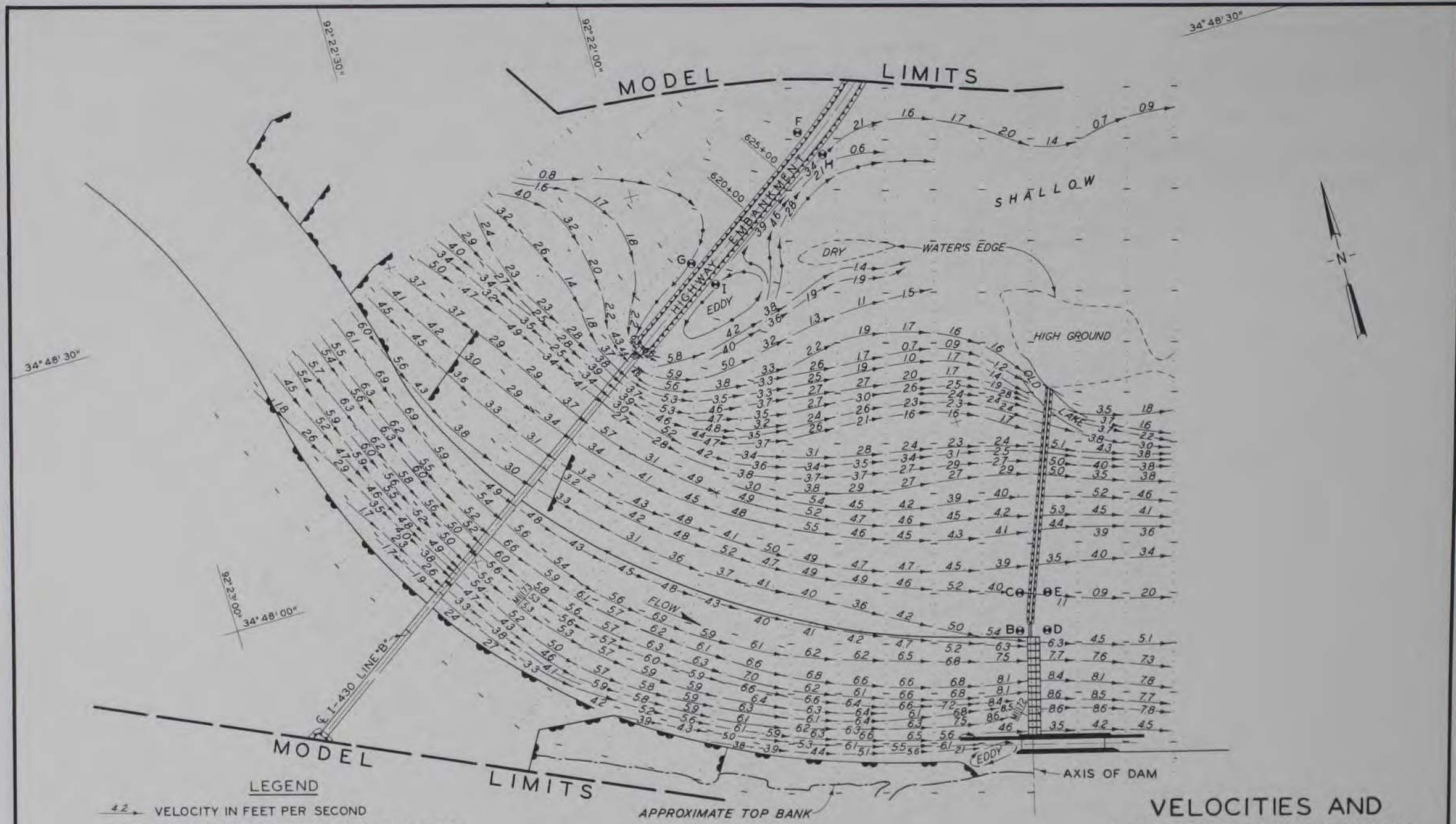
WITH HIGHWAY EMBANKMENT

DISCHARGE 180,000 CFS

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- → VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

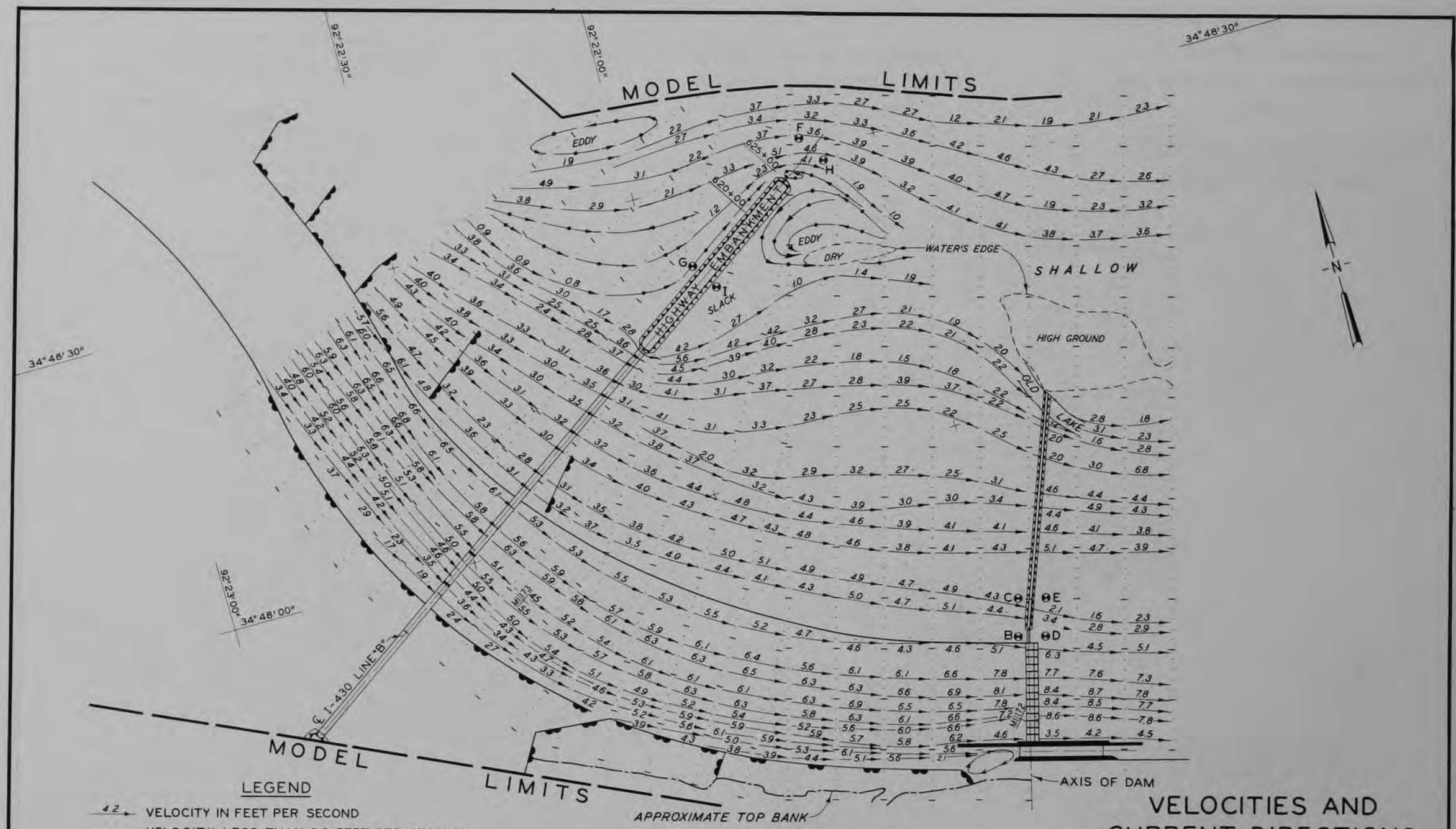
PLAN E

WITH HIGHWAY EMBANKMENT

DISCHARGE 350,000 CFS

PLATE 19

PLATE 20



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- → VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

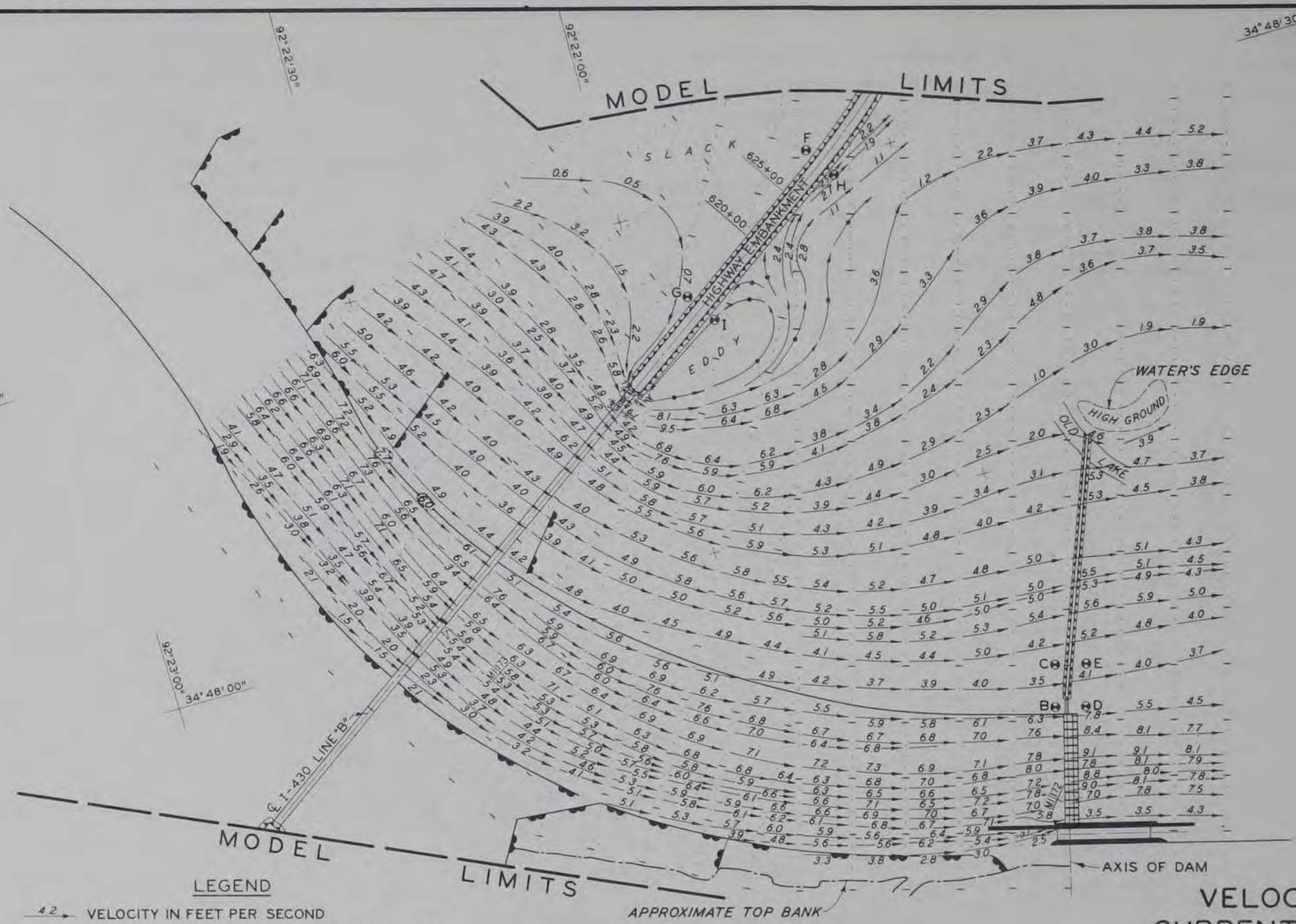
MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

PLAN E

HIGHWAY EMBANKMENT WITH RELIEF OPENING

DISCHARGE 350,000 CFS



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- → VELOCITY LESS THAN 0.5 FEET PER SECOND
- M1 | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

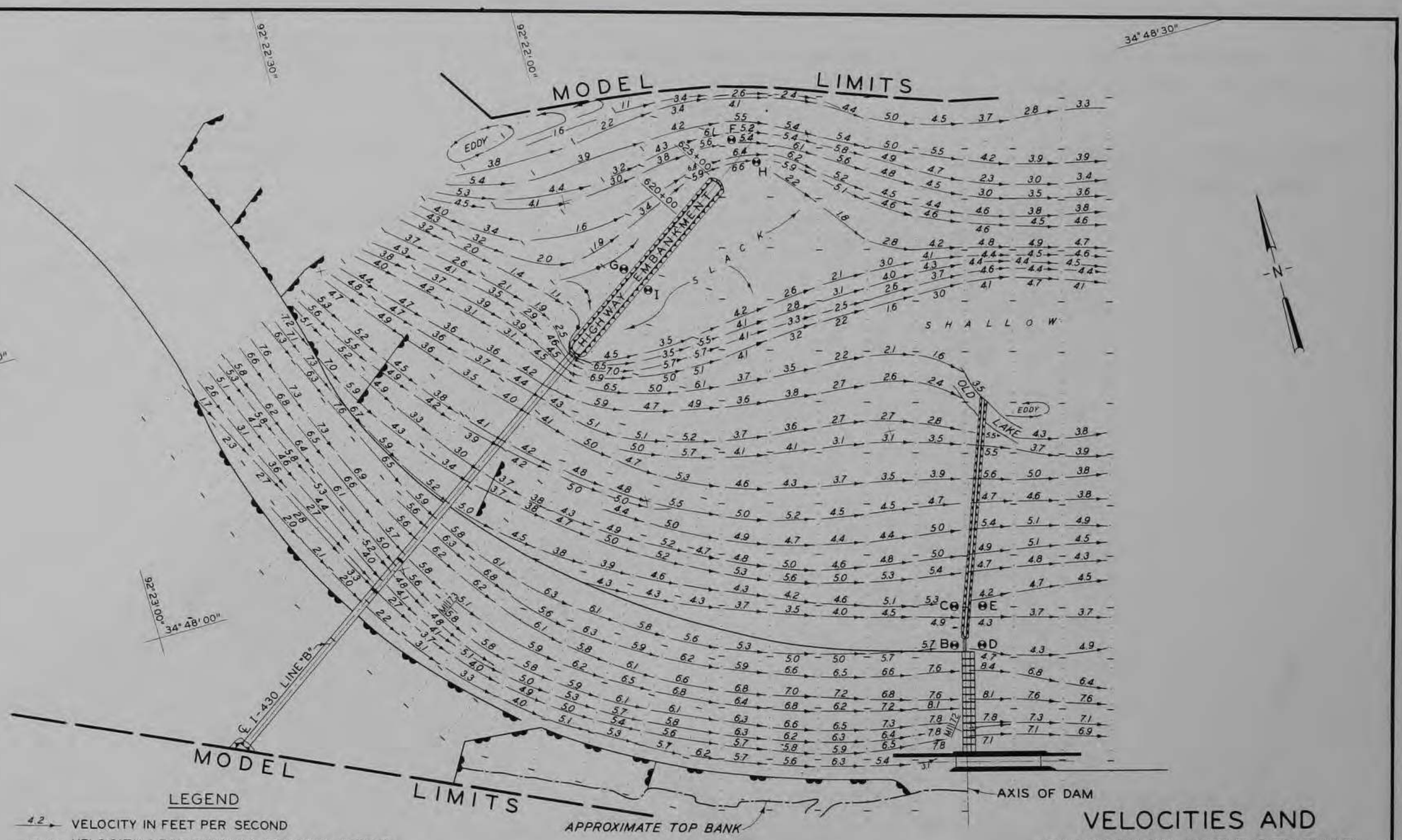
PLAN E

WITH HIGHWAY EMBANKMENT

DISCHARGE 450,000 CFS

PLATE 21

PLATE 22



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- → VELOCITY LESS THAN 0.5 FEET PER SECOND
- M1 | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

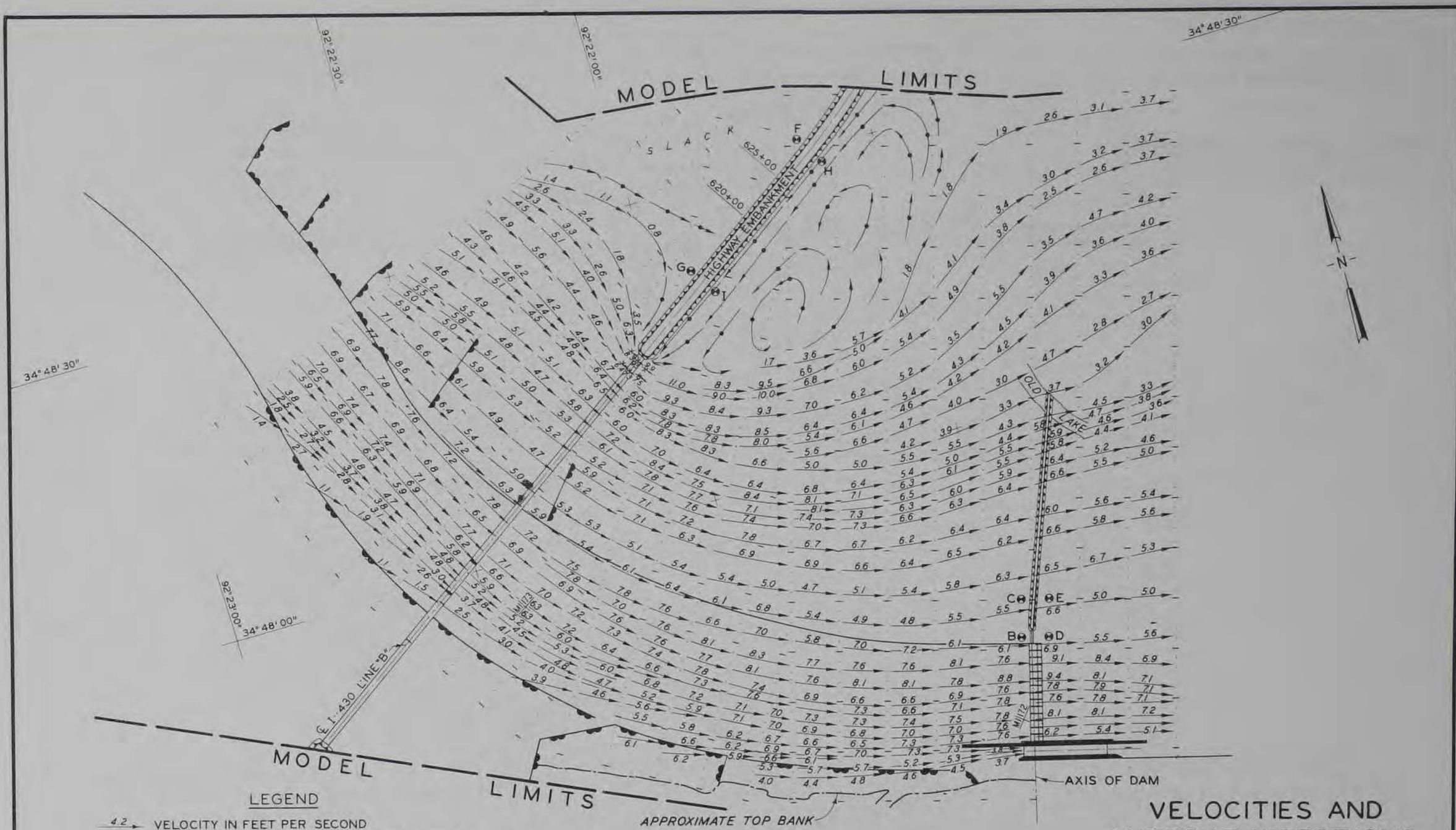
MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

PLAN E

HIGHWAY EMBANKMENT WITH RELIEF OPENING

DISCHARGE 450,000 CFS



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- → VELOCITY LESS THAN 0.5 FEET PER SECOND
- M 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

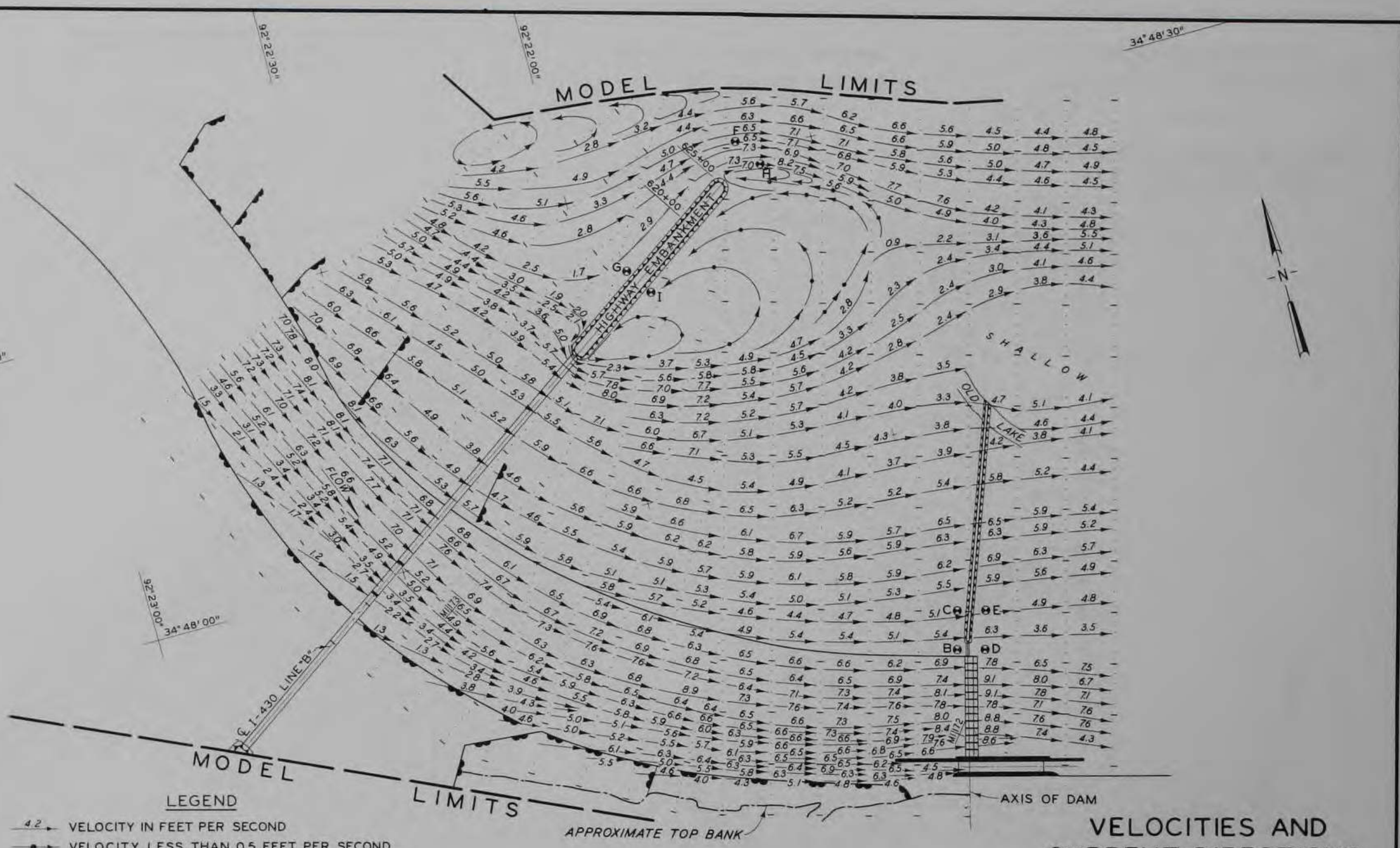
PLAN E

WITH HIGHWAY EMBANKMENT

DISCHARGE 625,000 CFS

PLATE 23

PLATE 24



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- ●→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- MI | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

SCALES IN FEET

PROTOTYPE 400 0 400 800 1200

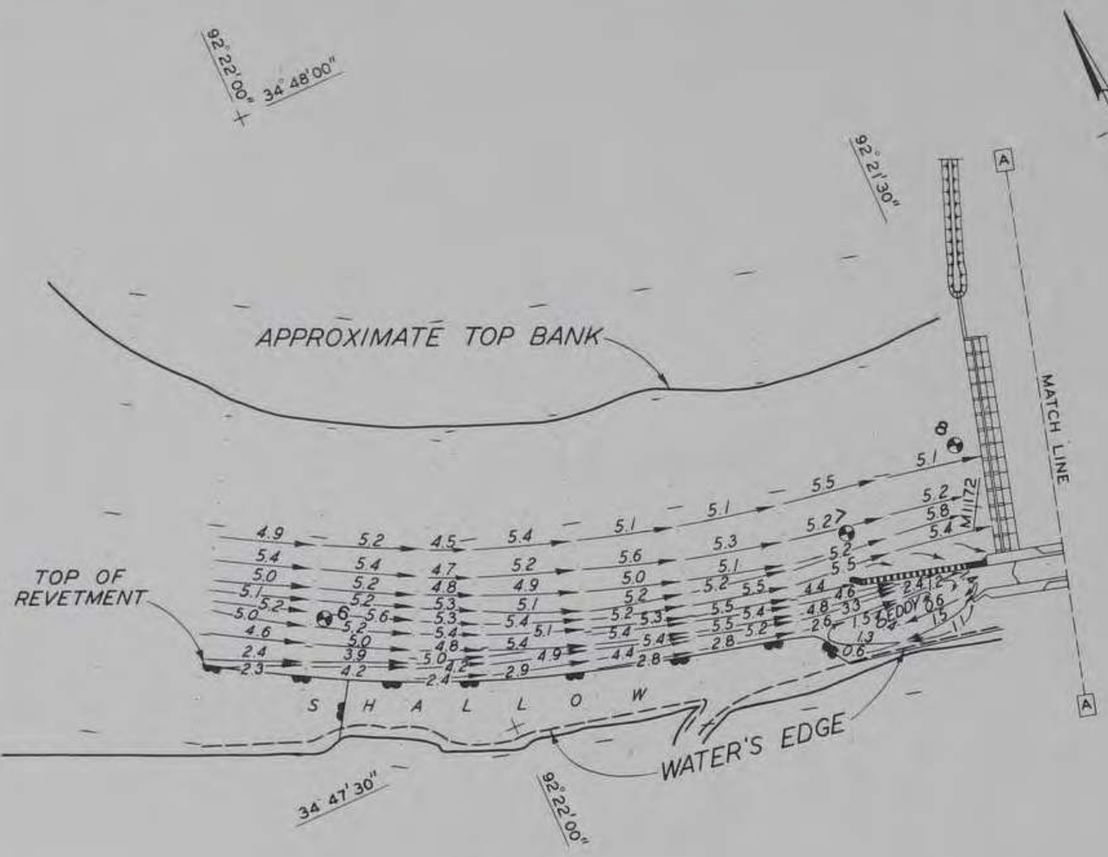
MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

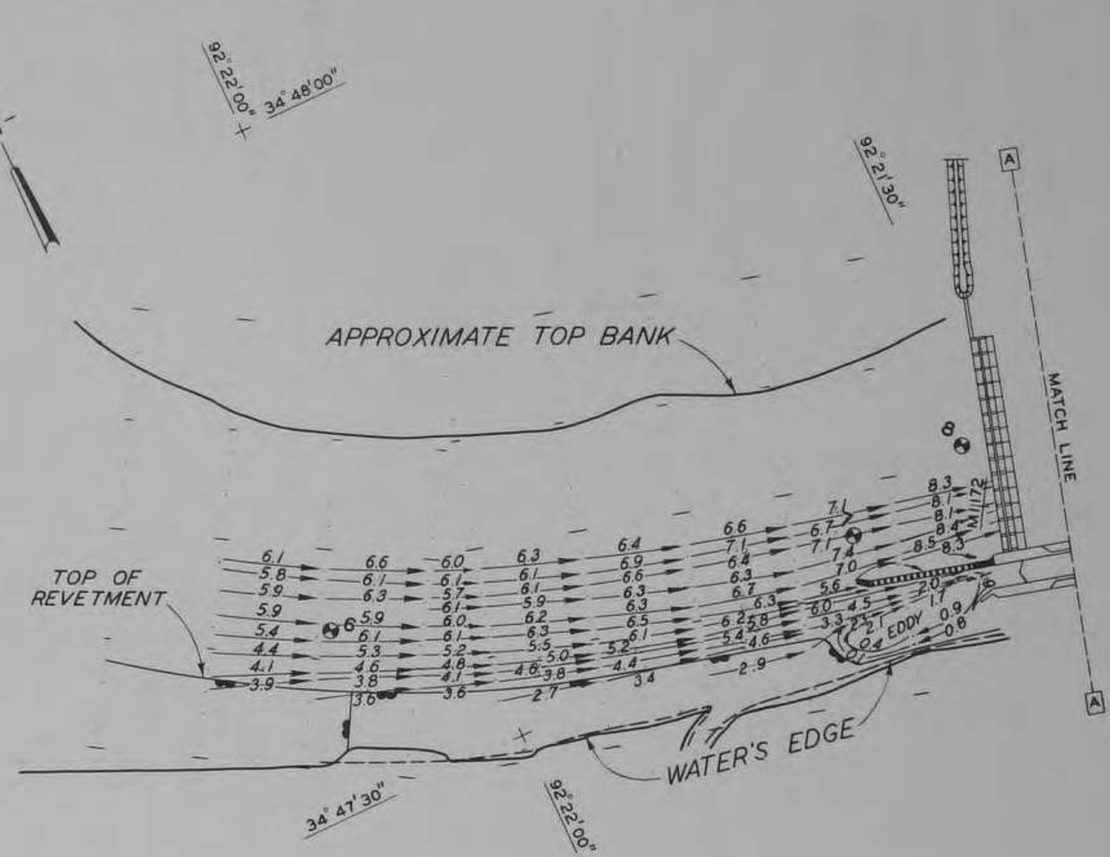
PLAN E

HIGHWAY EMBANKMENT WITH RELIEF OPENING

DISCHARGE 625,000 CFS



180,000 CFS



350,000 CFS

LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- —●→ VELOCITY LESS THAN 0.5 FEET PER SECOND
- M1 | 173 RIVER MILES ABOVE MOUTH OF ARKANSAS RIVER
- ROCK DIKE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT).

VELOCITIES AND CURRENT DIRECTIONS

PLAN E MODIFIED

DISCHARGES 180,000 AND 350,000 CFS

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500

MODEL 5 0 5 10

PLATE 25

Unclassified

Security Classification

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer District Little Rock, Arkansas

13. ABSTRACT Lock and Dam No. 7 will consist of a 110- by 600-ft lock on the right bank and a 980-ft-long, nonnavigable dam of 14 gated spillway bays. A 1:120-scale, semifixed-bed model, reproducing about 7 miles of the Arkansas River, adjacent overbank areas, the lock and dam, and other structures that might affect flow conditions, was used to study navigation conditions in the lock approaches, the design of the upstream guard wall, and the location and design of any training works needed to improve navigation conditions and distribution of flow through the spillway and along the overbank. A self-propelled model towboat and tow were used to study current effects on navigation passing through the locks and through the proposed I-430 Bridge to be located about a mile upstream of the lock and dam. Results of the investigations indicated: (a) Downbound tows would have difficulty in approaching the lock with the upper lock approach as originally designed because of current alignment; no difficulties were found in the lower lock approach. Satisfactory navigation conditions could be developed in the upper approach by revising the extent and placement of the right bank revetment. (b) Distribution of flow through the three dam gates near the lock, unsatisfactory with the original design, could be improved by revision of the right bank revetment and end of the upper guard wall. (c) Navigation hazards will be created by the elevation of the right bank of the upper approach channel, the elevation of the revetment along the left bank of the bend upstream of the proposed I-430 Bridge, and the navigation span of the bridge; however, these hazards can be minimized by careful navigation.

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Navigation conditions						