TECHNICAL REPORT NO. 110-1

LITTLE GOOSE DAM
SNAKE RIVER, WASHINGTON

HYDRAULIC MODEL INVESTIGATION

BY
R. L. JOHNSON
L. Z. PERKINS

APRIL 1975

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WALLA WALLA

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U.S. ARMY ENGINEERS DIVISION, NORTH PACIFIC
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A 1:100-scale hydraulic model was used to study the alignment of structures, excavation requirements, and flow conditions at Little Goose Dam. Tests of first-step construction led to relocation of the temporary fishway, use of rockfill groins along the north shore, selection of limits for disposal fills, and reductions of excavation, number of cofferdam cells, and height of embankments. The tests indicated that flow conditions during the first phase of second-step construction would be acceptable and that excavation planned for the second phase could be reduced. (continued)

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20. ABSTRACT (continued)

Approach flow into the completed spillway and powerhouse was satisfactory. The excavated tailrace could be raised 20 ft without decreasing head on the powerhouse. Poor entrance conditions into the lower lock approach were eliminated by shortening and reshaping a protective fill along the river side of the approach. Performance of the fish collection system improved when the north fishway entrance was moved upstream and a 90-ft-long rock dike was placed adjacent to the right wall of the spillway roller bucket.

Differences between final design (model) and contract (prototype) structures and excavation plans had no significant effect on flow conditions in the tailrace. Should the dentates in the spillway bucket erode, the hydraulic jump will move downstream, desired head between the fishway entrances will be eliminated, and erosion of the riverbed will be increased.

PREFACE

Hydraulic model studies for the Little Goose Project were authorized 17 April 1961 by the Office, Chief of Engineers at the request of the U. S. Army Engineer District, Walla Walla. The tests described in this report were made from October 1961 to December 1967 at the Bonneville Hydraulic Laboratory, Bonneville, Oregon. The Laboratory was transferred from the Portland District to the North Pacific Division 1 July 1963 and renamed the North Pacific Division Hydraulic Laboratory.

The studies began under the general supervision of the Portland District and Mr. L. R. Metcalf, who was in charge of the Hydraulic Section of that office. The model investigations were conducted under the supervision of Messrs. H. P. Theus, former Director of the Laboratory, and A. J. Chanda, Chief of the Hydraulics Branch. Present Director is Mr. P. M. Smith. Mr. R. L. Johnson, engineer in immediate charge of the general model group, was assisted by Messrs. J. J. Smith, A. G. Nissila, J. H. Canova, and F. S. Bahler. This report was prepared by R. L. Johnson and L. Z. Perkins.

The Walla Walla District was informed of test results through progress reports and preliminary data. Messrs. J. Douma and S. B. Powell from the Office, Chief of Engineers, H. A. Smith of the North Pacific Division, and G. C. Richardson and A. L. McCormmach of the Walla Walla District visited the Laboratory to observe flow conditions in the model, to discuss the tests, and to correlate the test results with design work that was in progress. Model demonstrations and conferences were held to obtain the advice and concurrence of navigation and fisheries interests concerning plans for navigation and fish passage at the project.

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	25.4	meters
feet	30.48	centimeters
miles	1.609344	kilometers
cubic feet per second	0.028317	cubic meters per second
head in feet of water	0.30480	head in meters of water

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LITTLE GOOSE DAM

SNAKE RIVER, WASHINGTON

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

Description

1. Little Goose Dam, on the Snake River 70.3 miles upstream from Pasco, Washington, is 28.7 miles upstream from Lower Monumental Dam and 37.2 miles downstream from the site of Lower Granite Dam.* Fig. 1 is a vicinity map of the area. The project is the third in a series of multiple-purpose dams that are being constructed by the U. S. Army Corps of Engineers in the Lower Snake River Basin for power, navigation, and other uses. The minimum and maximum flows recorded at the site were 10,600 cfs (August 1931) and 409,000 cfs (June 1894). Preliminary designs for the project were made on the basis that existing reservoirs on the Upper Snake River would reduce the 1894 flood crest to 340,000 cfs at Little Goose Dam (standard project flood). Later the standard project flood was increased to 420,000 cfs. The probable maximum (project design) flood has a peak discharge of 850,000 cfs and a 7-month runoff volume of 81 million acre-feet.

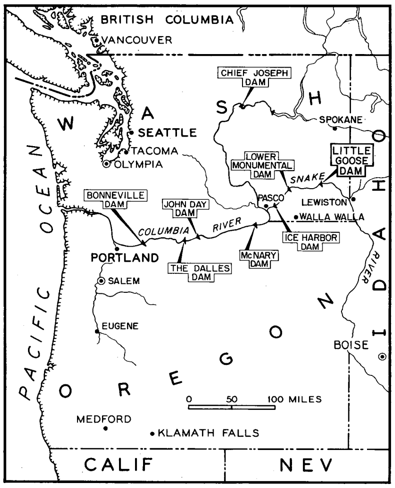

Fig. 1. Vicinity map.

2. Salient features of the project include the spillway, powerhouse, navigation lock and approaches, facilities to pass migratory fish upstream over the dam, and excavated tailrace (plate 1). Descriptions of adopted

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

plans for these features are as follows:

a. Spillway: The gravity-type spillway consists of eight 50-ft-wide bays and seven 14-ft-wide piers. The crest of the spillway, at elev 581.0, is 57.0 ft below normal pool elev 638.* The downstream face of the spillway ends in a dentated, 50-ft-radius bucket with invert at elev 466.5.

b. Powerhouse: The powerhouse has room for six Kaplan-type turbine-generators spaced on 90-ft centers. Units 1 to 3, at the south end of the powerhouse, were completed initially. Units 4 to 6 were left in skeletonized form to be completed later. The initial powerhouse capacity is 405,000 kilowatts at 0.95 power factor; ultimate capacity will be 810,000 kilowatts (nameplate rating of six units).

c. Navigation Lock and Approaches: A navigation lock, with clear dimensions of 86 by 675 ft, top of walls at elev 646, upstream sill at elev 618, downstream sill at elev 522, and maximum single lift of 101 ft, is located on the left bank. The lock hydraulic system is of the split-lateral type, with intakes and two longitudinal culverts in the right wall. One culvert supplies a group of five transverse laterals in the upstream portion of the lock chamber. The other culvert supplies a downstream group of six laterals. The lock empties through two culverts that discharge into the powerhouse tailrace. The upstream gate is a submersible tainter gate 22.7 ft high and 91.0 ft long. The 118.0-ft-high downstream miter gate consists of two leaves that span 92.67 ft between abutment bearings. A gravity guide wall on the landward side and a 309-ft-long floating guard wall, flared 20 degrees, on the river side are used to aid river traffic entering or leaving the upper end of the lock. A 735-ft-long guide wall with top at elev 552 is located on the landward side of the lower lock approach. The riverward side wall flares to provide a channel width of 250 ft approximately 750 ft downstream from the miter gate. The approach is excavated to elev 520 to provide a minimum depth of 17 ft.

d. Fish Facilities: Facilities for fish on the north shore include a 90-ft-long protective dike, two 6-ft-wide, overflow-weir entrances facing downstream at the end of the right training wall, and a 6-ft-wide side entrance from the stilling basin 41 ft upstream from the end of the training wall. The side entrance will be used only during periods of little or no flow over the spillway in lieu of one of the downstream entrances. Total attraction flow from the north fishway entrances will vary from approximately 560 to 800 cfs. A 17.5-ft-wide transportation channel leads from the north fishway entrance to the powerhouse collection system. Discharges through the two fishway entrances

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* Elevations are in feet above mean sea level.

at the north end of the powerhouse will vary from 500 to 600 cfs; total flow from the 10 floating orifices in powerhouse units 1 to 5 will be a constant 600 cfs; and the discharge from the south shore entrances will vary from 500 to 600 cfs. A 20-ft-wide fish ladder with floor slope of 1V on 10H is located between the powerhouse and navigation lock. Auxiliary attraction flow for the fishway system (about 2,550 cfs) is supplied by three turbine-driven pumps in the erection bay of the powerhouse.

e. Excavated Tailrace: Except for the transmission tower fill and the runout slopes downstream from the spillway and powerhouse, the entire tailrace north of the left bank of the navigation channel is excavated to elev 520.

Purpose of Model Study

3. Data from a general model, including flow conditions before, during, and after completion of the project, were needed to determine excavation limits and the best arrangement of principal structures for navigation, power, and fish passage.

The Model

Description

4. The river channel and pertinent overbank areas 1.35 miles upstream and 1.90 miles downstream from the project axis were reproduced in a 1:100-scale model (plate 2). Natural topography, excavation, and fill were molded in concrete between sheet-metal templates that conformed to field surveys and design plans. Structures added to the model were constructed of plastic, waterproofed wood, and plywood. Piezometers that corresponded with prototype river gages and where additional water-surface elevations were desired were piped to a central gage pit. High- and low-water piezometer openings were used at gages 8, 8-1, 9, and 11.

5. Roughness in the form of stippled concrete and small gravel (fig. 2) was adjusted until prototype flow patterns, velocities, and water-surface elevations were reproduced for river discharges between 17,300 and 136,200 cfs. Tailwater was controlled according to the curves on plate 3. The maximum difference between prototype and model water-surface profiles shown on plate 4 was 0.2 ft or less for this range of flows.

6. Water was pumped to the model through a recirculating system and was measured by means of calibrated orifices in the supply lines. The

model spillway and powerhouse flows were calibrated independently to reproduce prototype flow quantities. Standard laboratory procedures were used to measure water-surface elevations and velocities. Some flow conditions were recorded photographically.

Scale Relationships

7. The following accepted equations of hydraulic similitude, based on Froudian relationships, were used to express the mathematical ratios between the dimensions and hydraulic characteristics of the model and the prototype:

Dimension	Ratio	Scale Relation
Length	$L_r = L$	1:100
Area	$A_r = L_r^2$	1:10,000
Velocity	$V_r = L_r^{1/2}$	1:10
Time	$T_r = L_r^{1/2}$	1:10
Discharge	$Q_r = L_r^{5/2}$	1:100,000

Fig. 2. Views of general model after verification of original river channel. The project axis is the white line across the model.

PART II: DIVERSION STUDIES

Original First-Step Cofferdam And Diversion Channel

Description

8. The first-step cofferdam, which enclosed all concrete structures of the dam, consisted of 16 steel cells along the river leg and flanking embankments that extended to high ground on the south bank (fig. 3 and plates 5 and 6). The steel cells (top elev 547) were designed to withstand river flows to 250,000 cfs (5-yr flood) with Lower Monumental forebay at elev 540.0. The upstream embankment at elev 552 and the downstream embankment at elev 549 were designed to withstand flows to 320,000 cfs without overtopping. The 500-ft-wide diversion channel between the river leg of the cofferdam and the north shore was excavated to elev 500 or to bedrock, whichever was higher. The width and invert of the channel were based on (a) velocities of 10 fps or lower for navigation and fish passage; (b) extent and cost of slope protection; and (c) operation of the temporary fishway. However, commercial navigation was not possible until Lower Monumental Dam was completed and the reservoir filled. The temporary fishway, tentatively located between cells 15 and 16, included vertical baffles on 10-ft centers, 12-in.-wide slots, and a minimum depth of about 6 ft. An average drop of 1 ft per baffle was to exist at the fishway design discharge of 200,000 cfs. The temporary fishway was not reproduced for initial tests of the first-step cofferdam. Since current directions and velocities at the entrance and exit of the temporary fish ladder were of primary importance, only the outline of the fishway was used during subsequent tests.

Results

9. Although the pool above Lower Monumental Dam might be filled before first-step construction at Little Goose Dam, velocities affecting upstream fish passage and design of the diversion channel would be more critical under natural conditions. For this reason, natural tailwater elevations at river mile 68.5 (gage 14, plate 2) were used during most tests of the first-step cofferdam and diversion channel. Water-surface elevations at

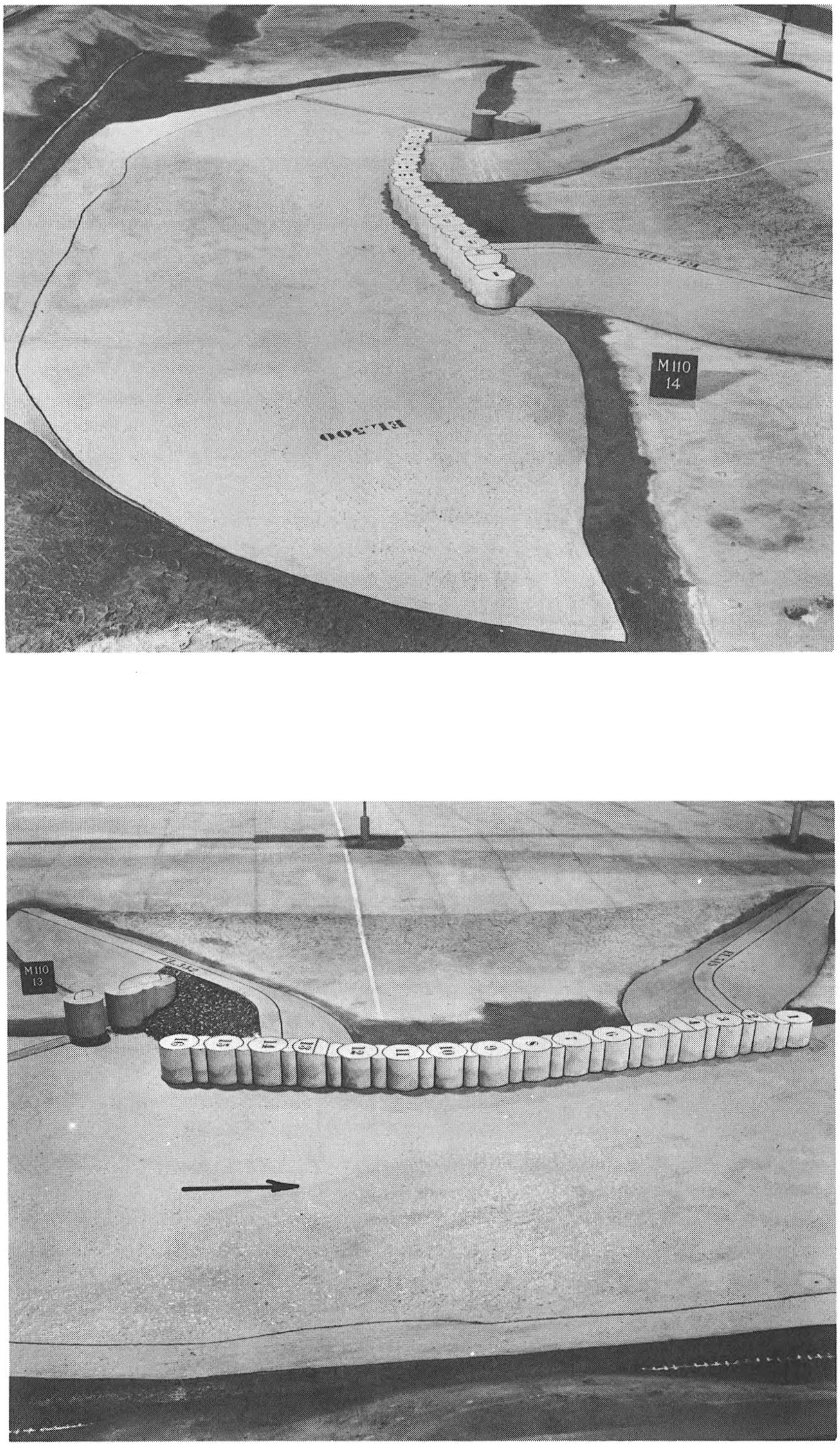

Fig. 3. Plan A (original design) first-step cofferdam and diversion channel. The cells upstream from cell 16 were not part of this plan.

river gages in the model are shown in table A for discharges of 15,000 to 300,000 cfs. Drawdown through the diversion area (from gage 7 to gage 7-1, plates 2 and 5) increased from 0.4 to 5.0 ft for this range of discharge. At 200,000 cfs, velocities greater than 10 fps in the diversion channel would repel fish moving upstream, except in a narrow path adjacent to the cell (plates 5 and 6). Drawdown at cell 16 was 8.1 ft, and velocities at that location reached 17 fps (plate 6). The alignment of the first-step cofferdam was satisfactory; however, bottom velocities greater than 3 fps along the river face of the upstream embankment indicated that this area should be protected with riprap.

Location Of Temporary Fish Ladder

10. The previous test had indicated that a temporary fish ladder was required and that the ladder could be placed between cells 15 and 16. Additional tests showed that velocities at cell 16 exceeded 10 fps for river flows above 35,000 cfs. Therefore, the temporary fishway must be operable from 35,000 cfs to the design flow of 200,000 cfs.

11. Protective cells upstream from the main cofferdam (plates 7 and 8) would reduce head drops along the temporary fishway, reduce the fishway length and cost, lower velocities and riprap requirements along the upper embankment, and improve flow conditions at both ends of the fishway. However, the additional cells were considered too costly, and the adopted fishway was located between cells 15 and 16 (plates 10 to 15).

Modifications Of First-Step Cofferdam And Diversion Channel

12. After a model demonstration on 3 February 1963, the decision was made to use riprap along the upstream embankment. To minimize velocities during closure of the upstream embankment, the water-surface differential between gage 7-1 and the high point on cell 16 should not exceed 3.0 ft during a river discharge of 75,000 cfs. Disposal fills (especially the upstream fill on the right bank) should be adjusted in the model so that, with normal tailwater, velocities along the upstream leg of the cofferdam would not be increased at a river flow of 200,000 cfs.

Description

13. Alternative designs for the diversion channel (plate 9) were studied to obtain the best balance between excavation costs and optimum flow conditions. The channel exit was tested as it was first designed (plan A) and in a probable eroded condition (plan B). As the tests progressed, the locations of disposal areas along the right bank were adjusted to minimize their effects on flow conditions at high discharges. The plan 3A upstream disposal fill, plan 4C downstream disposal fill, and plan M diversion channel entrance were adopted (plates 10 to 15). The best location of rock groins to reduce velocities along the right bank and assist fish migrating upstream were determined after the plan M diversion channel entrance was selected. An aerial view of the prototype first-step cofferdam, diversion channel, and right bank is shown in fig. 4.

Results

14. Flow conditions in the original diversion channel (plates 5 and 6) can be compared with those for the adopted channel on plates 10 to 15. The data on plates 10 to 14 were obtained for natural tailwater elevations and with the original channel exit. Flow along the south bank was deflected by cell 16 (photograph 1), and eddies or low velocities existed adjacent to the cofferdam for all discharges. Velocities at cell 16 were lower than 10 fps until a flow of approximately 35,000 cfs was exceeded. Head on the temporary fishway between cells 15 and 16 was 0.5 ft at 25,000 cfs and 6.9 ft at 200,000 cfs (plates 10 and 13). Flow conditions at the entrance and exit of the temporary fishway were satisfactory. The drop in water surface through the diversion channel (gages 7 and 7-1) was 4.2 ft at a river flow of 200,000 cfs (table B). Head on the temporary fishway and velocities along the right bank were increased slightly at the higher discharges by anticipated erosion in the downstream portion of the diversion channel (plan B exit). Several lengths and locations of rock groins to reduce velocities along the right bank were investigated. The groins were 20 ft wide at elev 540, and the sides sloped 1V on 2H. A 60-ft-long groin at station 50+65 and a 75-ft groin at station 52+80 were satisfactory.

Fig. 4. Aerial view, looking upstream, of prototype first-step cofferdam.

15. The water-surface elevations shown in table B and on plate 14 indicated that freeboard was more than adequate for a discharge of 250,000 cfs and that construction costs could be reduced by lowering the cells and embankments about 3 ft. Although these changes were not made in the model (plates 10 to 15), water-surface profiles showed that the elev 549 upstream embankment would overtop at 370,000 to 380,000 cfs with natural tailwater and 305,000 cfs with Lower Monumental pool raised to elev 540. For the latter condition, cell 5 lowered to elev 544 would be overtopped at a river flow of 255,000 cfs with the plan A exit channel and 260,000 cfs with the plan B exit channel.

Contractor's Dike

16. The contractor for the first-step cofferdam requested permission to use a temporary earth fill to protect the work area against river discharges to 75,000 cfs. Several alignments for the temporary dike were studied in the model. The best design, shown in photograph 2 and on plate 16, would need riprap protection at the upstream corner and along a portion of the riverward side. Velocities in the river channel were such that fish could pass upstream without difficulty.

Second-Step Diversion

Description

17. After removal of the first-step cofferdam, flow would pass through powerhouse skeleton units 4 to 6 and the diversion channel adjacent to the north nonoverflow section (photograph 3 and plates 17 to 19). This was termed phase I of second-step diversion. In phase II, the river would be diverted through the three powerhouse skeleton units during construction of the right embankment shown on plate 20. Fish would pass upstream through the skeleton units during one low-water season (August to February). The powerhouse intake gates would be closed and the pool filled during March; operation of the project would begin in April.

18. Average velocities in the open portion of the river during phase I would be less than those with the first-step cofferdam. However, high velocities around the north nonoverflow section might block fish passing

upstream. Low velocities upstream from the powerhouse were desired to reduce erosion and transport of debris into the skeleton units during both phases of the second-step diversion.

19. The initial, plan A, powerhouse intake diversion channel (photograph 4 and plate 20) was to be excavated from elev 489 at the intakes of units 4 to 6 to elev 510 about 900 ft upstream from the structure. With this plan, some excavation would be required outside of the first-step cofferdam. The depth of the intake channel, based on natural tailwater elevations, was designed to limit velocities 100 ft upstream from the powerhouse to 6 fps during a river discharge of 75,000 cfs. The critical discharge for this velocity would be 100,000 cfs with Lower Monumental pool at elev 540. For design, head on the skeleton units was considered the difference between water-surface elevations at gage F-1 and at the downstream face of the powerhouse at unit 6. The skeleton units at John Day and Little Goose Projects were to be similar. The following discharges and heads obtained during studies of the first-step cofferdam and rating data from a previous John Day model study* were used to operate the model during tests of phase I second-step diversion:

Discharge in CFS			Feet of Head on
River	Diversion Channel	Skeleton Units	Skeleton Units
30,000	25,000	5,000	0.1
100,000	83,000	17,000	0.5
150,000	120,000	30,000	1.0
200,000	161,000	39,000	1.5
250,000	202,000	48,000	2.2
300,000	243,000	57,000	2.9

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* U. S. Army Engineer Division, North Pacific, Division Hydraulic Laboratory, CE, "John Day Dam, Columbia River, Oregon and Washington, Hydraulic Model Investigations," Technical Report No. 90-1, June 1972.

20. Similarly, heads on the skeleton units during phase II of second-step diversion were as follows:

River and Powerhouse Discharge in CFS	Feet of Head on Skeleton Units
25,000	0.7
50,000	2.8
75,000	6.3
100,000	11.1
120,000	16.1

Results

21. Information regarding excavation requirements upstream from the powerhouse was required before phase I of second-step diversion was investigated. For this reason, the final plan for excavation in the upstream approach for phase II was incorporated in the tests of phase I (plates 17 to 19). Other details of the phase I diversion channel were similar to those on plates 10 to 15. With Lower Monumental forebay at elev 540, velocities in the phase I diversion channel would not delay the upstream passage of fish until the discharge exceeded 200,000 cfs (plates 17 and 18). At this flow, a velocity of 11 fps existed for a short distance around the north nonoverflow section, but other areas were available for the passage of fish. High velocities in the diversion channel would block fish when the discharge increased to 300,000 cfs (plate 19). Water-surface elevations upstream from the constricted channel were from 0.1 to 0.5 ft lower (table C) than they were during first-step diversion (table (table B).

22. With the plan A channel for phase II diversion, maximum velocities 100 ft upstream from the powerhouse were 2 and 6 fps for river discharges of 25,000 and 120,000 cfs, respectively (photograph 4 and plate 20). The low velocities indicated that excavation in the diversion channel, especially that portion outside the cofferdam, could be reduced by moving the toe of the left bank riverward and leveling part of the approach to elev 510 (plan G channel, photograph 5). Flow directions and velocities in the plan G diversion channel were satisfactory (plate 21). Fish passage

through the skeleton units would be limited to flows of about 37,000 cfs and lower (head on powerhouse 1.55 ft). However, this was acceptable because phase II diversion would occur during the low-flow portion of fish migration.

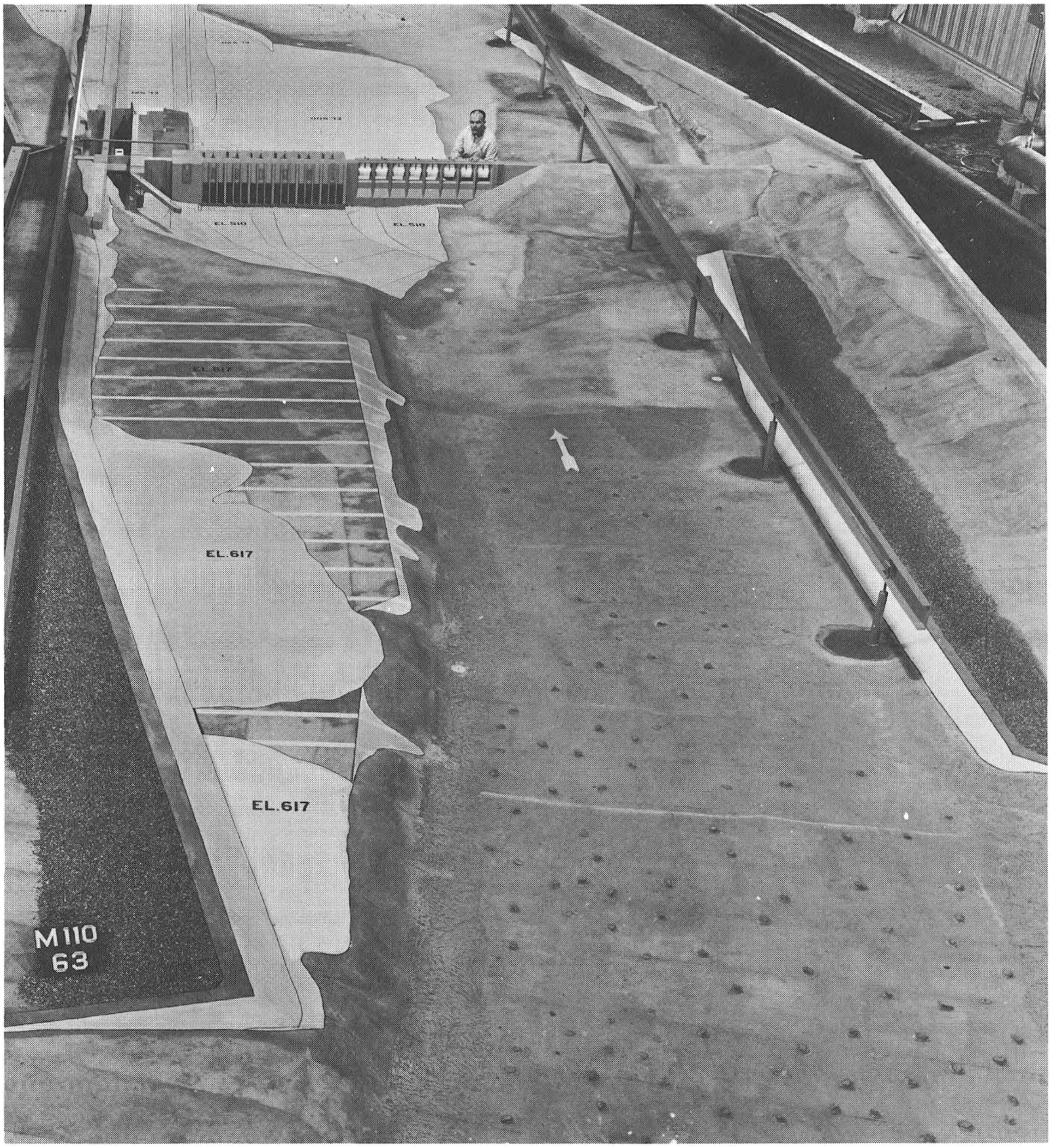

Fig. 5A. View upstream from plan A (original design) structures.

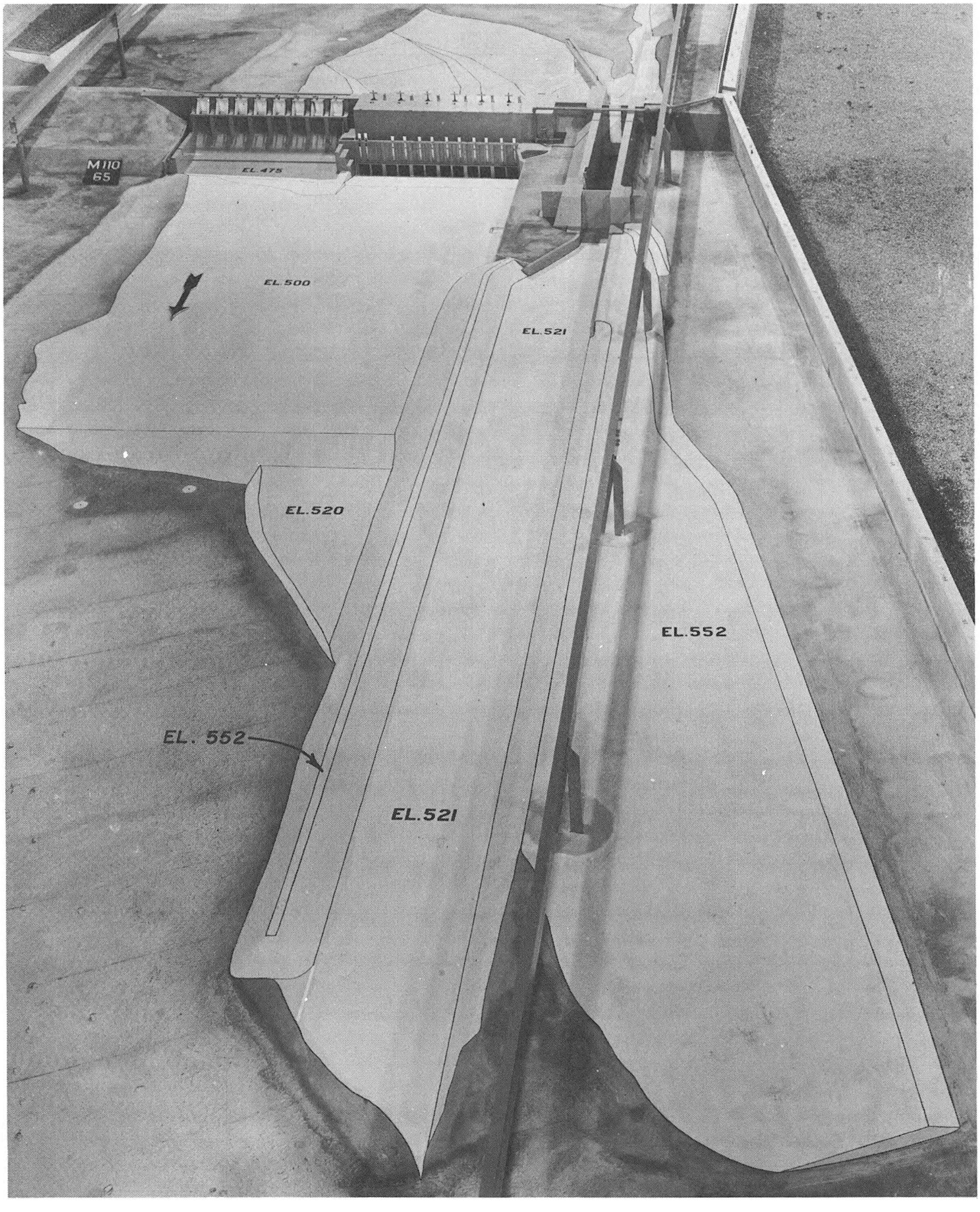

Fig. 5b. View downstream from plan A (original design) structures.

PART III: TESTS OF PERMANENT STRUCTURES

Original Design

Description

23. The proposed structures and excavation plans for Little Goose Dam (fig. 5 and plates 22 to 24) differed from the contract plans described in paragraph 2 as follows:

a. The proposed stilling basin (plan A, plate 22) required an extensive drainage system for the concrete slab to eliminate uplift produced by an artesian condition that existed at the site. Preliminary tests in the spillway model indicated that a suitable basin could be designed without the concrete slab.* The original structures tested in the general model included the plan D basin (plate 22) from which the slab was eliminated.

b. A 553-ft-long floating upstream guard wall on the river side of the navigation lock was proposed. A 480-ft-long guard wall was used in the model (plate 24). The contract length of 309 ft was adopted after completion of the model study.

c. The downstream lock approach was excavated to a bottom width of 250 ft along an extension of the lock axis. The riverward side was flared to obtain the 250-ft width and was protected by a 2800-ft-long rock-and-earth fill with top at elev 552.

d. The tailrace was excavated to elev 500 for a distance of 1600 ft below the runout slope downstream from the powerhouse (plates 23 and 24).

Results

24. Tests of the original structures and excavation plan indicated that flow conditions upstream from the dam were satisfactory (photograph 6 and plates 24 to 28). However, low velocities adjacent to the upstream lock guard wall indicated that the length of this wall could be reduced. Head on the powerhouse decreased from 98.0 ft at a river discharge of 25,000 cfs to 92.5 ft at 340,000 cfs. Low velocities over most of the tailrace showed that it could be at a higher elevation without significant loss of head on the powerhouse.

25. Water-surface elevations at gage T-4 downstream from the lower

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* U. S. Army Engineer Division, North Pacific, Division Hydraulic Laboratory, CE, "Spillway For Little Goose Dam, Snake River, Washington, Hydraulic Model Investigation," Technical Report No. 114-1, April 1975.

miter gate were lower than those at the lock outlet (gage T-3) for river discharges between 100,000 and 340,000 cfs (table D). With this condition, heads of 0.2 to 1.4 ft would exist on the miter gate. If the gate was opened under these heads, hawser forces on barge tows within the lock chamber would suddenly increase in a downstream direction, and reverse flow would occur through the lock emptying culverts until the emptying valves were closed. In other studies, approximately 1 ft of head was eliminated by opening the miter gate during the peak of undertravel in the lock chamber. Additional reduction could be obtained by shortening the unusually long rock guard wall. The confetti traces in photographs 7 and 8 show directions and relative velocities of surface currents in the tailrace. Strong downstream currents, with velocities to 7 fps (plate 28) at the end of the lock approach channel would make entrance into the channel difficult for upstream river traffic. Visual observations indicated that the rock guard wall along the lower lock approach was at least 800 ft longer than necessary.

26. Criteria for design of the fishways required that water-surface elevations at the south end of the powerhouse be higher than those at the north fishway entrance (gage T-5) to produce flow in the channel that was to carry fish from the north entrance through the spillway to the powerhouse collection system. At least 1.0 ft of head was desired at a river discharge of 225,000 cfs. The water surface sloped in the wrong direction when the spillway was used. The differential varied from -0.2 ft at 100,000 cfs to -1.3 ft when powerhouse units 1 to 3 were operated at a river flow of 340,000 cfs (table D). In this report, a negative differential means an adverse slope in the fishway channel.

Modified Original Design

Description

27. The modified tailrace (plan B) was excavated to elev 520 instead of elev 500 as in plan A, and the excavated area was extended downstream to the lower end of the navigation lock approach (photograph 9 and plate 23). All other details of the model were similar to those shown in fig. 5 and on plates 24 to 28.

Results

28. Water-surface elevations in the plan B tailrace are shown in table E. The data in tables D and E indicate that raising the tailrace 20 ft did not reduce head on the powerhouse for discharges to and including 225,000 cfs. At 340,000 cfs, the head was reduced 0.2 ft. Water-surface elevations at the lock outlet and north fishway entrance remained higher than those just downstream from the lock miter gate and south end of the powerhouse. There was no change in flow conditions at the downstream end of the lock approach channel.

Development Of Other Modifications

Description

29. Initial concern was with modifications that would eliminate crossflow at the downstream end of the lock approach channel, show the best location for a fill to support transmission towers, and provide adequate water-surface slope in the fish transportation channel. During this phase of the study, only enough data were taken to establish the layout for structures and excavation. The training wall between the spillway and powerhouse was revised for structural reasons during the tests, but this change had no effect on flow conditions in the model. Since adoption of the plan D stilling basin now appeared doubtful, the original plan A stilling basin (plate 22) was installed for most of the development tests. The sides of the navigation lock outlet were raised to elev 520 (plan B outlet, photograph 10) to meet the plan B tailrace.

30. The downstream approach to the navigation lock and the transmission tower fill were investigated first. Details of lock approach plans A to D and the plan C transmission tower fill are shown on plate 23. The first locations of the transmission tower fill (plans A and B) are shown in photograph 11.

31. Lock approach: Tests indicated that the protective fill on the right side of the downstream lock approach could be reduced to a short circular fill for supporting transmission line towers (plan C fill, plate 23). The plan C fill deflected powerhouse flow toward the main river channel and provided a large area of low velocities within the lock

approach (photograph 12). Increasing the channel entrance to the width indicated by plan C left bank (plates 23 and 29) was not required. Instead, the minor excavation required for plan D left bank was adequate (plates 23 and 30). Space for barge traffic was ample, and flow conditions in the plan D approach were satisfactory for river discharges between 100,000 and 225,000 cfs (photograph 13 and plates 30 and 31). Except for two minor revisions, this plan was accepted by navigation interests during a model demonstration and conference 6 October 1964. Excavation at the downstream end of the left guide wall was offset 50 ft to reduce the likelihood of grounding barge tows on the revetted bank slope when entering along the left wall. The left side of the plan C transmission tower fill was straightened to improve alignment for tows entering along the right wall (compare plate 30 with plate 36).

32. Tailrace: The effects of anticipated erosion to minimum elev 485 in the spillway channel (plan C tailrace, plate 23) and increased excavation just downstream from the powerhouse (tailrace plans D to F) were investigated. The plan C tailrace and the relatively small areas that were modified in tailrace plans D to F did not change general flow patterns from those with the plan B tailrace (plate 29). For river discharges to and including 100,000 cfs, no significant increase in head on the powerhouse was obtained with any alternative tailrace plan. The increase of head at higher flows was 0.5 ft or less. Since discharges smaller than 100,000 cfs will occur more than 85 percent of the time, the additional costs of tailrace plans D to F were not economical.

33. North fishway dike: A short dike downstream from the north nonoverflow section was suggested to improve conditions for fish passage by reducing return flow into the stilling basin and lowering water-surface elevations at the north fishway entrance. Details of the fishway dike plans that were tested are shown on plate 32. A spur dike parallel to and downstream from the right wall of the north fishway reduced tailwater elevations at the fishway entrance below those at the south end of the powerhouse. With the plan B tailrace and 190-ft-long plan A fishway dike, the water-surface differential was 0.9 ft at 225,000 cfs and 1.8 ft at 340,000 cfs. Current directions and velocities adjacent to the plan A fishway dike are shown on plate 33.

34. An eddy formed along the riverward side of the plan B fill during discharges equal to or greater than 150,000 cfs (plate 34), but downstream velocities of 8 fps or lower existed between the eddy and spillway flow. With the plan B fill and powerhouse units 1 to 3 in operation, differences of 0.9 and 2.3 ft between water-surface elevations at the north and south fishway entrances at discharges of 225,000 and 340,000 cfs, respectively, were reduced to 0.2 and 1.6 ft by the plan C tailrace (eroded spillway channel). Additional tests led to the tentative selection of a 130-ft-long dike (plan E, plate 32) for use with the plan A stilling basin and plan C tailrace. With the plan E dike and powerhouse tailrace plans D to F, differential on the fishway system was 0.8 ft when powerhouse units 1 to 3 were operated at a river discharge of 225,000 cfs.

35. The plan E north fishway dike was not satisfactory when tested with the subsequently adopted plan P-6 roller bucket shown on plate 22. At 225,000 cfs, the differential was -0.3 ft. At 340,000 cfs, there was 0.6 ft of head on the system. Fill lengths up to 380 ft and extensions of the right wall of the fishway as long as 420 ft were tried without success. Additional differential was obtained by moving the fishway entrance 20 ft upstream into an area of lower water-surface elevations (plan B fishway entrance, plate 32).

36. Continuing investigations of the plan B fishway entrance led to selection of a 90-ft-long fishway dike with sides sloped 1V on 2H as the final design (plan F-3 dike, plate 29). An 8-ft-high extension of the north training wall was used to protect the toe of the fill against high-velocity spillway flow. Tests of the final design are described in paragraphs 40 to 44. The dike side slopes were increased to 1V on 1.75H in the contract plan (see paragraph 45).

Performance Of Stilling Basin

Plan A (Original Design)

37. Performance of the plan A stilling basin in the general model was compared with that of the same basin in the three-bay spillway model. Plywood walls 1000 ft in length (prototype) were used to eliminate flow expansion and lateral return flow into the basin. This arrangement

produced flow conditions that were similar to those in the spillway model. With tailwater elev 563.9 set at gage T-14, the following results were obtained with tailrace plan C for a river and spillway discharge of 850,000 cfs:

a. The toe of the hydraulic jump remained upstream in the stilling basin before the side walls were installed.

b. The toe of the jump was downstream from the P.T. of the bucket, but sweepout did not occur when walls enclosed the entire spillway.

c. With walls isolating bays 2 to 4 (downstream topography at approximate elev 485), the toe of a stable hydraulic jump remained at the middle of the stilling basin.

d. The jump washed out of the stilling basin when the walls enclosed spillway bays 5 to 7 (average downstream topography at elev 495).

Plan P-6 (Final Design)

38. A similar comparison was made with and without temporary walls that isolated bays 1 to 3 in the adopted plan P-6 roller bucket (photograph 18) that was developed in the spillway model. The plan C channel bottom in this area was at average elev 488. Without the walls, energy dissipation was excellent, and stable flow occurred in the spillway bucket for all test flows. Normal tailwater was about 8 ft higher than the minimum tailwater required to hold the roller in the bucket at 850,000 cfs. Use of the walls lowered tailwater within the simulated flume and reduced the capacity for energy dissipation to about 800,000 cfs. A tailwater elevation 2.2 ft above normal at gage T-1 was required to prevent sweepout in bays 1 to 3 during the 850,000-cfs flow.

39. Tailwater data used in subsequent operation of the spillway model were obtained at gage T-1 in the general model without temporary walls or powerhouse flow (plate 35). Minimum tailwater requirements in the spillway model were determined with the exit channel at elev 520 and at elev 488 (right and left sides, respectively, of the tailrace in the general model). As in the general model, with bays 1 to 3 isolated, capacity of the roller bucket was approximately 800,000 cfs with the low topography. The tailwater deficiency at 850,000 cfs was 1.3 ft. With the higher topography, performance at 850,000 cfs was satisfactory. Flow conditions at 340,000 cfs were good with either exit channel elevation.

Final Design

Description

40. Elements of the final structures and excavation plan included the plan P-6 roller bucket (plate 22), plan B lock outlet, plan C tailrace with eroded spillway channel, plan C transmission tower fill, and plan D downstream lock approach (plate 23), plan A upstream lock approach and floating guard wall (plate 24), plan B north fishway entrance, and plan F-3 north fishway dike (plate 29).

Results

41. The upstream channel width and alignment provided uniform flow into the structures (photograph 15). Surface velocities adjacent to the floating upstream navigation lock guard wall were less than 1 fps for all test conditions. Flow conditions downstream from the structures were satisfactory when the spillway was closed or when the spillway gates were opened uniformly (photographs 16 to 21 and plates 36 to 50). Velocities downstream from the powerhouse varied from 4 fps (three units, river discharge 25,000 cfs) to 8 fps (six units, discharge 150,000 cfs). The energy dissipation in the plan P-6 roller bucket indicated that anticipated erosion in the spillway channel should not endanger the structure. The spillway flow moved straight downstream, and bottom velocities varied from 3 fps at 100,000 cfs to 21 fps at 420,000 cfs (the revised standard project flood).

42. With Little Goose forebay at elev 638.0 and tailwater regulated by Lower Monumental Dam, head on the powerhouse ranged from 98.0 ft (powerhouse units 1 to 3, river discharge 25,000 cfs) to 89.2 (six units, river discharge 420,000 cfs). Water-surface elevations that existed downstream from the structures when the spillway gates were opened uniformly are shown in table F. There was no significent difference between water-surface elevations at the navigation lock outlet and at the lower miter gate (gages T-3 and T-4, respectively) when powerhouse units 1 to 3 were operated. Tailwater at the lower miter gate was about 0.5 ft lower than it was at the lock outlet when six powerhouse units were operated at river discharges of 150,000 and 225,000 cfs. Maximum heads

on the left training wall of the stilling basin were 16.1 and 33.9 ft for river discharges of 340,000 and 850,000 cfs, respectively (table G). Conditions for river navigation and fish passage downstream from the structures were excellent.

43. Flow patterns for river discharges between 100,000 and 225,000 cfs (plates 47 to 50) indicated that the fishway entrances will be accessible to fish migrating upstream. There was 0.6 ft of head between the south and north fishway entrances when three powerhouse units were operated during a river flow of 225,000 cfs. The head was 0.1 ft or less when six units were operated at the 225,000-cfs discharge or when the river flow was less than 150,000 cfs. However, the fishway entrances can be used with no differential head.* Wave action downstream from the dam was greatest for spillway flows above 150,000 cfs (about 4 ft at the downstream end of the north fishway dike at a river discharge of 225,000 cfs). Wave heights were 1.0 ft or less when the discharge was 100,000 cfs or lower.

44. Flow conditions with crowned spillway operation** (plates 51 to 53) were less desirable than those with uniform gate openings, but the difference was not as evident as it was during model studies of other projects. This was attributed to the spreading effect of the dentated bucket. Water-surface elevations downstream from the powerhouse usually were from 0.2 to 0.5 ft lower than they were when the spillway gates were opened uniformly (tables H and F, respectively). Although this would benefit power production, a reverse slope existed between water surfaces at the north and south fishway entrances (-0.3 ft at 225,000 cfs). Crowned gate operation intensified side flow into the spillway bucket; this would adversely affect passage of fish, especially at the north fishway entrance.

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* Approximately 0.3 ft of head will be required to move flow from the south end of the powerhouse fish collection system to the north shore entrance. With equal water-surface elevations on both sides of the river, this head differential can be provided by the wing gates in the north nonoverflow section.

** Gate openings diminish uniformly from center of spillway to reduce velocities and wave action along shorelines.

Modified Final Design (Contract Plan)

Description

45. Several changes in the prototype design were made after model tests of the final structures and excavation plans were completed. A submerged berm (average elev 520) remained in that portion of the river channel downstream from spillway bays 4 to 8 after the first-step cofferdam was removed (photograph 22 and plates 54 to 57). High river discharges were expected to sweep away this material. The north fishway dike was tested with side slopes of 1V on 2H (plan F-3, plate 32), but the dike was constructed with side slopes of 1V on 1.75 (plan I).

46. Contract plans for the powerhouse tailrace and left bank of the downstream navigation lock approach also differed from those of final model design. A small step in the 1V- on 4H-slope downstream from the powerhouse (plate 1) was not reproduced in the model. The difference between final design and contract plans for the downstream lock approach consisted of not excavating the triangular-shaped corner at the downstream end on the left bank (photograph 23). Tests of the final design were made with the spillway channel eroded to average elev 488 (plates 36 to 53). Tests of the contract plan were made with the tailrace excavated to elev 520 and with original riverbed contours below elev 520.

Results

47. Data obtained with the contract tailrace are shown in photographs 23 to 25, in table I, and on plates 54 to 57. Maximum bottom velocities of 16 and 20 fps were measured downstream from the spillway during river discharges of 225,000 and 340,000 cfs, respectively. These velocities were higher than they were with the tailrace of final design (plates 42 to 45), but no danger to the structure should result from the increase in velocity. Operating head on the fishway system was 1.0 ft (three units, discharge 225,000 cfs).

48. Increasing the side slopes of the fishway and realigning the left bank downstream from the navigation lock had no detrimental effects on flow conditions or water-surface elevations in the exit channel. The reduced channel capacity opposite the transmission tower fill increased the

maximum head differential between the navigation lock outlet (gage T-3) and the downstream miter gate (gage T-4) to 1.0 ft when six powerhouse units were operated at a river discharge of 225,000 cfs.

Effects Of Destruction Of Dentates In Roller Bucket

Description

49. The dentates at the downstream end of the spillway bucket (plate 22) will be subjected to erosion and may wear away during the life of the project. Information concerning water-surface elevations and flow conditions with no dentates and with maximum erosion of the spillway channel was requested.

Results

50. The results of tests with dentates removed from the spillway bucket are shown in table J and in photographs 26 to 28. Discharges smaller than 100,000 cfs were not reproduced because studies in the spillway model had indicated that the teeth had little effect on flow conditions at lower flows. Water-surface elevations in portions of the tailrace where the greatest change would occur were about 0.2 ft lower for discharges of 100,000 to 340,000 cfs than they were during tests of the final design compare tables F and J). Water-surface elevations at 420,000 cfs were slightly higher, and at 850,000 cfs they were a few tenths of feet higher and lower than in the previous test. With powerhouse units 1 to 3 in operation, there was no differential head on the fish collection system for river discharges between 100,000 and 225,000 cfs. Removing the dentates had no effect on the head (0.1 ft) when six units were operated.

51. At the spillway design discharge of 850,000 cfs, removing the dentates changed the flow from roller action to a turbulent modified hydraulic jump (photograph 28). Energy dissipation was adequate, although the hydraulic jump was completed on the excavated area downstream from the roller bucket. Tests in the spillway model showed that loss of the dentates would increase bottom velocities and accelerate erosion of the tailrace.

TABLE A

WATER-SURFACE ELEVATIONS

Plan A First-Step Cofferdam

Gage No.	River Discharge In 1000 CFS								
	15	25	35	50	100	150	200	250	300
5	521.0	522.9	524.4	526.2	531.1	534.9	538.1	541.2	544.0
6	522.1	524.0	525.5	527.2	532.0	535.9	539.2	542.3	545.1
7	518.0	520.3	522.2	524.7	530.0	534.0	537.3	540.5	543.3
7-1	517.6	519.7	521.1	522.9	527.6	531.1	533.7	536.2	538.3
8	521.2	522.6	523.6	524.9	529.9	533.8	537.0	540.1	543.0
8-1	517.6	519.7	521.2	523.1	528.0	531.5	534.4	537.0	539.1
8-2	517.5	519.6	521.0	522.8	527.4	530.7	533.4	536.0	538.1
9	517.5	519.5	520.8	522.4	526.7	530.0	533.0	535.8	538.2
10	517.5	519.4	520.8	522.3	526.6	530.1	533.1	536.0	538.5
11	517.1	519.0	520.3	521.9	526.1	529.2	532.0	534.5	536.9
12	517.0	518.9	520.2	521.8	526.0	529.0	531.7	534.2	536.5
13	514.7	517.0	518.5	520.1	524.5	527.3	530.1	532.8	535.3
14 (TW)	513.9	515.5	516.7	518.4	522.9	526.5	529.6	532.3	534.9

NOTES: 1. Tailwater set for natural conditions.

2. Gage locations are shown on plates 2 and 5.

TABLE B

WATER-SURFACE ELEVATIONS

First-Step Cofferdam

Final Design Conditions*

Gage No.	River Discharge In 1000 CFS													
	25	50	100	150	200	250	300	355	375	250	260	290	310	330
	Natural Tailwater									Lower Monumental Pool Elev 540				
5	523.0	526.6	531.6	535.5	538.9	542.0	544.9	548.2	549.3	546.8	547.1	547.4	549.3	550.3
6	524.2	527.7	532.7	536.8	540.3	543.6	546.6	550.0	551.1	547.8	548.0	549.5	550.5	551.5
7	520.4	524.9	530.3	534.3	537.8	541.0	544.0	547.3	548.4	546.3	546.6	547.9	548.8	549.8
7-1	519.7	522.9	527.5	531.0	533.6	536.0	538.2	540.3	541.0	543.7	544.0	544.7	545.1	545.8
8	522.0	524.9	530.2	534.2	537.5	540.7	543.5	546.8	547.9	546.0	546.3	547.6	548.4	549.4
8-1	519.7	523.2	528.1	531.6	534.4	536.9	-	-	-	544.1	-	-	-	-
8-2	519.6	522.8	527.0	530.5	533.1	535.2	537.4	539.4	540.2	543.5	543.8	544.4	544.8	545.4
9	519.4	522.4	526.7	529.9	532.9	535.7	538.2	540.8	541.6	544.0	544.3	545.1	545.7	546.3
10	519.4	522.4	526.4	529.7	532.9	535.9	538.4	541.0	541.8	544.1	544.2	545.2	545.7	546.5
11	519.0	521.9	526.1	529.2	531.9	534.5	536.9	539.5	540.3	543.7	544.0	544.7	545.3	546.0
12	518.9	521.8	526.0	529.0	531.7	534.2	536.5	539.0	539.9	543.5	543.8	544.6	545.1	545.8
13	516.9	520.3	524.6	527.4	530.1	532.8	535.3	537.9	538.9	543.3	543.6	544.4	544.9	545.6
14 (TW)	515.5	518.4	522.9	526.5	529.6	532.3	534.9	537.5	538.4	543.2	543.4	544.2	544.7	545.3

* Plan A cofferdam and diversion channel exit, disposal areas 3A and 4C, plan M diversion channel entrance, plan I temporary fishway, rock groins at stations 50+65 and 52+80 along right bank (plates 9 and 10).

NOTE: Gage locations are shown on plates 2 and 5.

TABLE C

WATER-SURFACE ELEVATIONS

Phase I, Second-Step Diversion

Gage No.	River Discharge In 1000 CFS					
	50	100	150	200	250	300
5	540.4	541.1	542.9	544.8	546.6	548.7
6	540.5	541.6	543.3	545.3	547.3	549.6
7	540.3	541.2	542.6	544.3	546.1	548.1
8	540.3	541.3	542.5	544.2	545.9	547.8
F-1	540.3	541.2	542.6	544.3	546.0	548.0
F-3	540.3	541.2	542.5	544.3	546.0	548.1
Unit 6	540.2	540.7	541.6	542.8	543.8	545.1
T-1	540.1	540.6	541.5	542.7	543.8	545.1
T-2	540.1	540.7	541.5	542.8	544.0	545.2
T-3	540.1	540.7	541.6	542.9	544.1	545.4
T-4	540.2	540.7	541.6	542.9	544.1	545.4
T-5	540.2	541.0	541.6	542.9	544.0	545.3
8-1	540.1	540.8	541.9	543.3	544.7	546.2
9	540.1	540.7	541.6	542.8	544.0	545.3
10	540.1	540.7	541.7	543.0	544.2	545.7
11	540.1	540.6	541.4	542.5	543.7	545.0
12	540.1	540.6	541.3	542.5	543.5	544.8
13	540.1	540.6	541.3	542.3	543.3	544.6
14 (TW)	540.1	540.5	541.2	542.2	543.2	544.4

NOTES: 1. Tailwater for Lower Monumental pool elev 540.

2. Gage locations are shown on plates 2 and 17.

TABLE D

WATER-SURFACE ELEVATIONS

Plan A Structures, Powerhouse Tailrace, and Navigation Lock Approach

Plan D Stilling Basin

Flow Distribution In 1000 CFS				Tailwater Elevations In Feet M.S.L.																	
River	Powerhouse		Spwy	River Gages											Fishway Entrances			Pump-house	Powerhouse Units		
	Units	Flow		14 (TW)	13	12	11	10	9	8-1	T-1	T-2	T-3	T-4	North T-5	Unit 6	South		1	3	5
25	1 to 3	24.9	0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	537.0	-	-	-
25	1 to 3	24.9	0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	-	-	-
50	1 to 3	49.9	0	537.2	537.2	537.2	537.2	537.3	537.2	537.2	537.2	537.2	537.3	537.2	537.2	537.3	537.3	537.2	537.3	537.2	537.3
50	1 to 3	49.9	0	540.1	540.1	540.1	540.1	540.2	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.0	540.0	540.0	540.0
100	1 to 3	65.4	34.5	540.5	540.5	540.5	540.6	540.9	540.3	540.8	540.8	540.7	540.8	540.6	540.7	540.6	540.5	540.5	540.5	540.4	540.5
100	1 to 6	99.9	0	540.5	540.5	540.5	540.6	540.9	540.3	540.8	540.8	540.8	540.8	540.5	540.7	540.6	540.6	540.5	540.6	540.6	540.6
150	1 to 3	66.3	83.6	541.2	541.3	541.4	541.4	542.0	541.7	541.7	541.7	541.7	541.8	541.4	541.5	541.3	541.1	541.1	541.2	541.2	541.3
150	1 to 6	133.8	16.1	541.2	541.3	541.3	541.4	542.0	541.1	541.9	541.9	541.9	542.0	541.4	541.7	541.5	541.5	541.5	541.5	541.5	541.5
225	1 to 3	67.8	157.1	542.6	542.8	542.9	543.0	543.8	543.5	543.4	543.4	543.4	543.5	543.0	543.2	542.9	542.8	542.8	542.8	542.8	542.8
225	1 to 6	136.2	88.7	542.6	542.7	542.8	543.0	544.0	543.5	543.9	543.9	543.9	544.0	543.0	543.7	543.2	543.2	543.2	543.2	543.3	543.2
340	1 to 3	70.2	269.7	545.6	545.8	545.9	546.1	547.7	546.3	546.1	546.1	546.2	546.3	546.0	546.7	545.5	545.4	545.5	545.5	545.6	545.5
340	1 to 6	140.4	199.5	545.6	545.8	545.9	546.1	548.0	547.2	547.3	547.4	547.4	547.4	546.0	547.0	546.6	546.6	546.7	546.6	546.7	546.6
340	Closed	0	340.0	545.6	545.8	545.9	546.1	545.5	542.3	545.8	545.4	544.4	-	546.0	545.1	-	-	-	-	-	-
450	Closed	0	450.0	549.1	549.5	549.4	549.6	549.1	544.8	549.1	548.5	546.8	-	549.6	547.9	-	-	-	-	-	-
550	Closed	0	550.0	552.5	553.0	552.8	553.1	551.5	547.8	552.1	551.2	548.9	549.3	553.0	550.5	-	-	-	-	-	-
680	Closed	0	680.0	557.4	558.0	557.3	557.6	555.3	550.5	555.4	555.0	553.5	-	557.1	554.1	-	-	-	-	-	-
750	Closed	0	750.0	560.0	560.5	559.9	560.4	556.7	557.7	557.2	556.6	555.0	554.2	558.9	555.6	-	-	-	-	-	-
850	Closed	0	850.0	563.9	564.7	562.2	562.5	564.0	556.0	556.1	557.7	556.7	556.9	560.1	554.5	556.8	556.9	557.1	-	-	-

NOTES:

1. Fish ladder discharge 75 cfs for all river flows except 340,000 cfs and higher with spillway closed; spillway gates opened uniformly or closed.
2. Gage locations shown on plates 2 and 24.
3. Details of stilling basin shown on plate 22; tailrace and lock approach plans shown on plate 23.

TABLE D

TABLE E

WATER-SURFACE ELEVATIONS

Plan A Structures And Navigation Lock Approach

Plan B Powerhouse Tailrace And Plan D Stilling Basin

Flow Distribution In 1000 CFS				Tailwater Elevations In Feet M.S.L.																	
River	Powerhouse		Spwy	River Gages											Fishway Entrances			Pump-house	Powerhouse Units		
	Units	Flow		14 (TW)	13	12	11	10	9	8-1	T-1	T-2	T-3	T-4	North T-5	Unit 6	South		1	3	5
100	1 to 3	65.4	34.5	540.5	540.5	540.5	540.6	540.8	540.8	540.8	540.8	540.7	540.8	540.6	540.7	540.6	540.5	540.5	540.5	540.4	540.5
100	1 to 6	99.9	0	540.5	540.5	540.5	540.6	540.9	540.7	540.8	540.8	540.6	540.8	540.5	540.8	540.9	540.9	540.9	540.9	540.9	540.8
150	1 to 3	66.3	83.6	541.2	541.3	541.4	541.4	542.0	541.8	541.6	541.6	541.7	541.7	541.4	541.7	541.2	541.2	541.1	541.2	541.2	541.2
150	1 to 6	133.8	16.1	541.2	541.2	541.3	541.4	541.8	541.7	541.8	541.7	541.6	541.8	541.4	541.8	541.7	541.8	541.7	541.8	541.8	541.8
225	1 to 3	67.8	157.1	542.6	542.8	542.9	543.0	544.0	543.5	543.3	543.2	543.5	543.4	543.0	543.3	542.8	542.8	542.8	542.8	542.8	542.8
225	1 to 6	136.2	88.7	542.6	542.7	542.8	543.0	544.0	543.7	543.6	543.6	543.6	543.8	543.0	543.7	543.5	543.5	543.4	543.6	543.6	543.6
340	1 to 3	70.2	269.7	545.6	545.8	545.9	546.1	547.9	546.6	546.1	546.0	546.5	546.5	546.0	546.2	545.6	545.8	545.6	545.8	545.7	545.6
340	1 to 6	140.4	199.5	545.6	545.8	545.9	546.1	548.0	547.2	547.0	546.9	547.1	547.3	546.0	547.0	546.8	546.9	546.8	546.9	546.9	546.8
340	Closed	0	340.0	545.6	545.8	545.9	546.3	546.2	546.2	545.9	545.1	543.1	543.7	546.2	543.4	-	-	-	-	-	-
450	Closed	0	450.0	549.1	549.5	549.7	549.9	549.2	549.5	549.2	548.4	545.8	546.5	549.6	546.5	-	-	-	-	-	-
550	Closed	0	550.0	552.5	552.9	553.0	553.2	552.2	552.4	552.0	550.9	547.5	548.3	552.6	548.9	-	-	-	-	-	-
680	Closed	0	680.0	557.4	557.9	557.9	557.9	555.7	556.7	555.9	552.2	549.2	550.2	556.3	554.4	-	-	-	-	-	-
750	Closed	0	750.0	560.0	560.5	560.6	560.2	557.8	559.0	558.0	553.3	550.1	551.2	558.4	556.9	-	-	-	-	-	-
850	Closed	0	850.0	563.9	564.8	565.0	564.0	561.1	561.4	561.5	556.4	552.4	553.3	561.5	560.4	560.0	559.9	560.0	-	-	-

NOTES:
1. Fish ladder discharge 75 cfs for all river flows except 340,000 cfs and higher with spillway closed; spillway gates opened uniformly or closed.
2. Gage locations shown on plates 2 and 24.
3. Details of stilling basin shown on plate 22; tailrace and lock approach plans shown on plate 23.

TABLE F

WATER-SURFACE ELEVATIONS

Final Structures And Excavation

Uniform Spillway Operation

Flow Distribution In 1000 CFS				Tailwater Elevations In Feet M.S.L.																	
River	Powerhouse		Spwy	River Gages											Fishway Entrances			Pump-house	Powerhouse Units		
	Units	Flow		14 (TW)	13	12	11	10	9	8-1	T-1	T-2	T-3	T-4	North T-5	Unit 6	South		1	3	5
25	1 to 3	24.9	0	537.0	537.0	537.0	537.1	537.1	537.1	537.1	537.0	537.0	537.0	537.0	537.0	537.0	637.0	537.0	537.0	537.0	537.0
25	1 to 3	24.9	0	540.0	540.0	540.0	540.0	540.1	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0
50	1 to 3	49.9	0	537.2	537.2	537.2	537.2	537.3	537.2	537.2	537.2	537.2	537.3	537.2	537.2	537.3	537.3	537.3	537.3	537.3	537.3
50	1 to 3	49.9	0	540.1	540.1	540.1	540.1	540.2	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1	540.1
100	1 to 3	65.4	34.5	540.5	540.6	540.6	540.6	540.8	540.8	540.8	540.8	540.8	540.9	540.7	540.6	540.6	540.6	540.5	540.6	540.6	540.6
100	1 to 6	99.9	0	540.5	540.6	540.6	540.6	540.8	540.8	540.8	540.8	540.8	540.9	540.7	540.7	540.8	540.8	540.7	540.8	540.8	540.8
150	1 to 3	66.3	83.6	541.2	541.3	541.4	541.4	541.9	541.8	541.8	541.9	541.8	541.9	541.8	541.3	541.4	541.4	541.3	541.4	541.4	541.4
150	1 to 6	133.8	16.1	541.2	541.3	541.4	541.4	541.8	541.6	541.8	541.8	541.8	542.0	541.5	541.6	541.7	541.6	541.6	541.7	541.7	541.7
225	1 to 3	67.8	157.1	542.6	542.7	543.0	543.1	543.9	543.5	543.4	543.4	543.3	543.4	543.5	542.2	542.8	542.8	542.7	542.8	542.8	542.8
225	1 to 6	136.2	83.7	542.6	542.8	543.1	543.2	543.9	543.6	543.8	543.8	543.8	543.9	543.5	543.4	543.5	543.5	543.4	543.5	543.5	543.5
340	1 to 3	70.2	269.7	545.6	545.8	546.2	546.4	547.6	546.5	546.2	546.3	546.3	546.4	546.5	545.0	545.5	545.7	545.7	545.5	545.5	545.4
340	1 to 6	140.4	199.5	545.6	545.8	546.2	546.4	547.7	547.1	547.1	547.0	547.0	547.1	546.9	546.3	546.6	546.6	546.5	546.7	546.7	546.6
340	Closed	0	340.0	545.6	545.8	546.0	546.2	546.2	546.1	546.1	545.8	543.9	544.1	546.4	544.7	-	-	-	-	-	-
420	1 to 3	70.0	349.9	548.0	548.2	548.5	548.9	550.1	548.5	548.1	548.2	548.5	548.6	548.8	547.0	547.6	547.6	547.8	547.7	547.5	547.6
420	1 to 6	140.0	279.9	548.0	548.3	548.5	548.9	550.4	549.3	549.0	549.2	549.3	549.4	549.2	548.0	548.8	548.8	548.9	548.9	548.6	548.7
450	Closed	0	450.0	549.1	549.4	549.7	549.9	549.3	549.0	549.2	548.9	546.0	546.2	549.7	547.7	-	-	-	-	-	-
550	Closed	0	550.0	552.5	552.9	553.1	553.2	552.0	551.9	552.2	551.8	547.7	547.7	552.7	550.5	-	-	-	-	-	-
680	Closed	0	680.0	557.4	558.0	557.7	557.8	555.8	555.6	556.1	555.5	549.5	549.4	557.1	555.0	-	-	-	-	-	-
750	Closed	0	750.0	560.0	560.7	560.3	560.1	557.8	557.6	558.3	557.6	555.1	550.8	559.3	557.2	-	-	-	-	-	-
850	Closed	0	850.0	563.9	564.6	564.5	563.9	560.9	560.7	561.7	561.0	552.9	553.0	562.6	562.5	-	-	-	-	-	-

NOTES: 1. Fish ladder discharge 75 cfs for all river flows except 340,000 cfs and higher with spillway closed; spillway gates opened uniformly or closed.

2. Gage locations shown on plates 2 and 36.

TABLE G

WATER-SURFACE ELEVATIONS AROUND LEFT TRAINING WALL OF SPILLWAY

Final Structures And Excavation

Uniform Spillway Operation

River Discharge (CFS)	Location	Left Side	Right Side	Center	Head (Ft)
850,000*	D.S. End	--	--	543.8	--
	20 Ft U.S.	552.4	537.3	--	15.1
	40 Ft U.S.	552.9	526.1	--	26.8
	60 Ft U.S.	553.1	519.2	--	33.9
340,000**	D.S. End	--	--	544.3	--
	20 Ft U.S.	545.4	539.1	--	6.3
	40 Ft U.S.	545.6	539.2	--	6.4
	60 Ft U.S.	545.6	529.5	--	16.1

* Powerhouse closed.
** Powerhouse discharge 70,200 cfs; units 1 to 3 operating.

TABLE H

WATER-SURFACE ELEVATIONS

Final Structures And Excavation

Crowned Spillway Operation; Powerhouse Flow Through Units 1 To 3

Location	River Discharge In CFS		
	100,000	150,000	225,000
<u>River Gages</u>	Tailwater Elevations In Feet M.S.L.		
14 (TW)	540.5	541.2	542.6
13	540.6	541.4	542.8
12	540.7	541.5	543.0
11	540.7	541.5	543.1
10	540.9	541.9	543.9
9	540.8	541.7	543.3
8-1	540.8	541.6	543.0
T-1	540.7	541.4	542.9
T-2	540.6	541.4	543.0
T-3	540.8	541.6	543.2
T-4	540.7	541.6	543.3
<u>Fwy Entrances</u>			
North (T-5)	540.6	541.2	542.8
Unit 6	540.4	541.0	542.5
South	540.3	541.1	542.5
<u>Pumphouse</u>	540.3	541.1	542.5
<u>Pwhse Units</u>			
1	540.4	540.9	542.6
3	540.4	540.9	542.5
5	540.4	541.0	542.5

NOTES: 1. Gage locations shown on plates 2 and 51.

2. Flow distribution is shown on plates 51 to 53.

TABLE I

WATER-SURFACE ELEVATIONS

Contract Structures And Excavation

Uniform Spillway Operation

Flow Distribution In 1000 CFS				Tailwater Elevation In Feet M.S.L.														
River	Powerhouse		Spwy	River Gages											Fishway Entrances			Powerhouse Units		
	Units	Flow		14-TW	13	12	11	10	9	8-1	T-1	T-2	T-3	T-4	North T-5	Unit 6	South	1	3	5
100	1 to 3	65.4	34.5	540.5	540.5	540.5	540.6	540.8	540.6	540.7	540.7	540.7	540.8	540.5	540.5	540.5	540.5	540.5	540.5	540.5
100	1 to 6	99.9	0	540.5	540.5	540.5	540.6	540.8	540.6	540.7	540.7	540.7	540.8	540.5	540.7	540.8	540.7	540.8	540.7	540.8
150	1 to 3	66.3	83.6	541.2	541.3	541.4	541.4	541.9	541.6	541.6	541.7	541.8	541.9	541.5	541.2	541.4	541.4	541.4	541.4	541.4
150	1 to 6	133.8	16.1	541.2	541.2	541.4	541.4	541.8	541.5	541.7	541.7	541.9	542.1	541.4	541.7	541.9	541.9	541.8	541.6	541.7
225	1 to 3	67.8	157.1	542.6	542.7	542.9	543.0	543.8	543.2	543.0	543.0	543.3	543.3	543.1	541.6	542.7	542.6	542.7	542.6	542.6
225	1 to 6	136.2	88.7	542.6	542.7	542.9	543.0	543.7	543.3	543.4	543.4	543.9	544.1	543.1	543.1	543.8	544.0	543.9	543.6	543.8
340	1 to 3	70.2	269.7	545.6	545.8	546.0	546.4	547.6	546.2	545.8	545.7	546.4	546.4	546.3	543.6	545.4	545.4	545.6	545.4	545.4
340	1 to 6	140.4	199.5	545.6	545.8	546.1	546.3	547.5	546.7	546.6	546.5	547.2	547.4	546.5	545.0	546.8	547.0	547.0	546.6	546.8

NOTES: 1. Fish ladder discharge 75 cfs for all river flows.

2. Gage locations shown on plates 2 and 54.

TABLE J

WATER-SURFACE ELEVATIONS

Final Structures And Excavation

No Dentates In Spillway Bucket

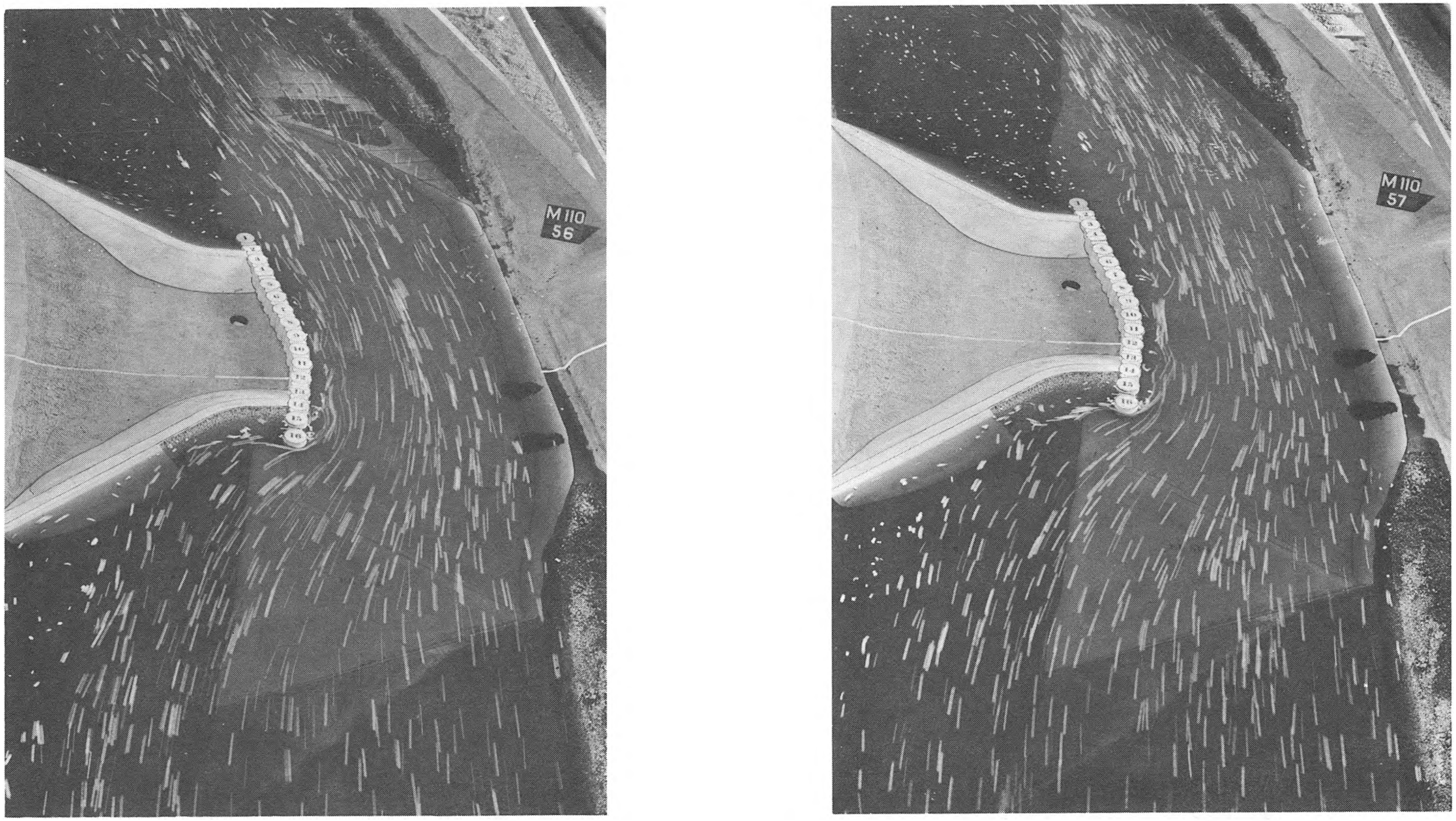
Uniform Spillway Operation

Plan C Eroded Tailrace

Flow Distribution In 1000 CFS				Tailwater Elevations in Feet M.S.L.																
River	Powerhouse		Spwy	River Gages											Fishway Entrances			Powerhouse Units		
	Units	Flow		14 (TW)	13	12	11	10	9	8-1	T-1	T-2	T-3	T-4	North T-5	Unit 6	South	1	3	5
100	1 to 3	65.4	34.5	540.5	540.5	540.5	540.6	540.8	540.7	540.7	540.7	540.6	540.7	540.6	540.4	540.5	540.3	540.4	540.4	540.5
150	1 to 3	66.3	83.6	541.2	541.2	541.4	541.5	541.9	541.7	541.7	541.7	541.5	541.7	541.7	541.3	541.2	541.2	541.2	541.2	541.2
150	1 to 6	133.8	16.1	541.2	541.3	541.4	541.5	541.8	541.6	541.8	541.8	541.8	542.0	541.5	541.6	541.7	541.7	541.7	541.4	541.6
225	1 to 3	67.8	157.1	542.6	542.7	543.0	543.1	543.9	543.5	543.4	543.4	543.3	543.4	543.5	542.8	542.7	542.7	542.8	542.6	542.6
225	1 to 6	136.2	88.7	542.6	542.7	543.0	543.1	543.9	543.7	543.7	543.7	543.7	543.9	543.5	543.4	543.4	543.5	543.5	543.0	543.3
340	1 to 3	70.2	269.7	545.6	545.8	546.2	546.4	547.5	546.6	546.3	546.4	546.4	546.5	546.7	545.0	545.5	545.6	545.6	545.3	545.5
340	1 to 6	140.4	199.5	545.6	545.8	546.2	546.4	547.7	547.0	547.1	547.1	547.1	547.3	546.9	545.8	546.3	546.7	546.2	546.2	546.1
420	1 to 3	70.2	349.9	548.0	548.3	548.6	548.9	550.2	548.8	548.5	548.5	548.6	548.8	548.9	547.3	547.6	547.8	547.5	547.7	547.7
420	1 to 6	140.0	279.9	548.0	548.2	548.6	548.9	550.5	549.5	549.2	549.4	549.5	549.6	549.4	548.9	548.7	548.8	548.9	548.5	548.7
850	Closed	0	850.0	563.9	564.7	564.4	563.9	560.3	559.3	561.0	560.6	551.4	551.4	562.5	560.3	553.5	554.2	554.2	552.1	550.9

NOTES: 1. Fish ladder discharge 75 cfs for all river flows except 850,000 cfs.

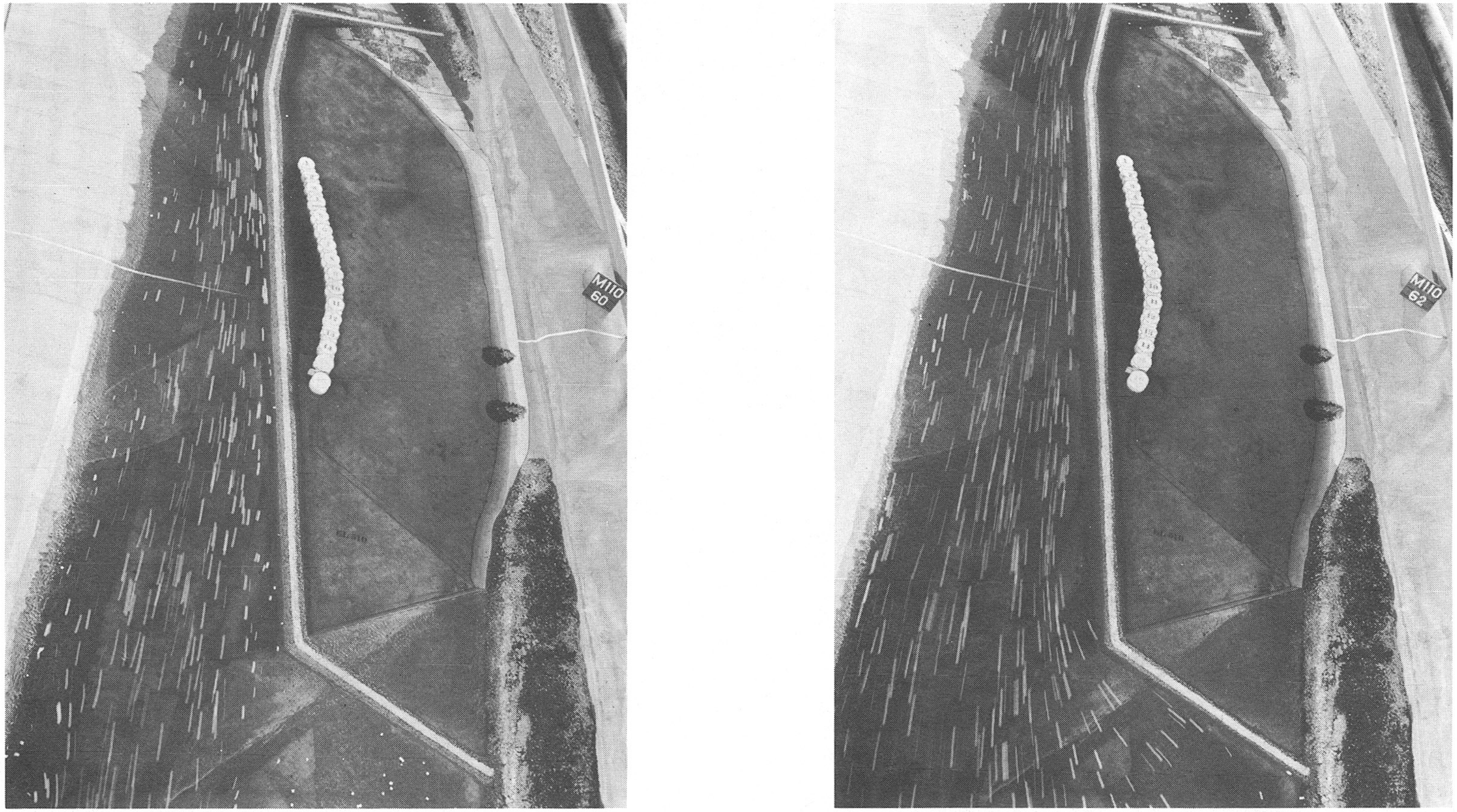
2. Gage locations shown on plates 2 and 36.



Plan A exit area

Plan B exit area

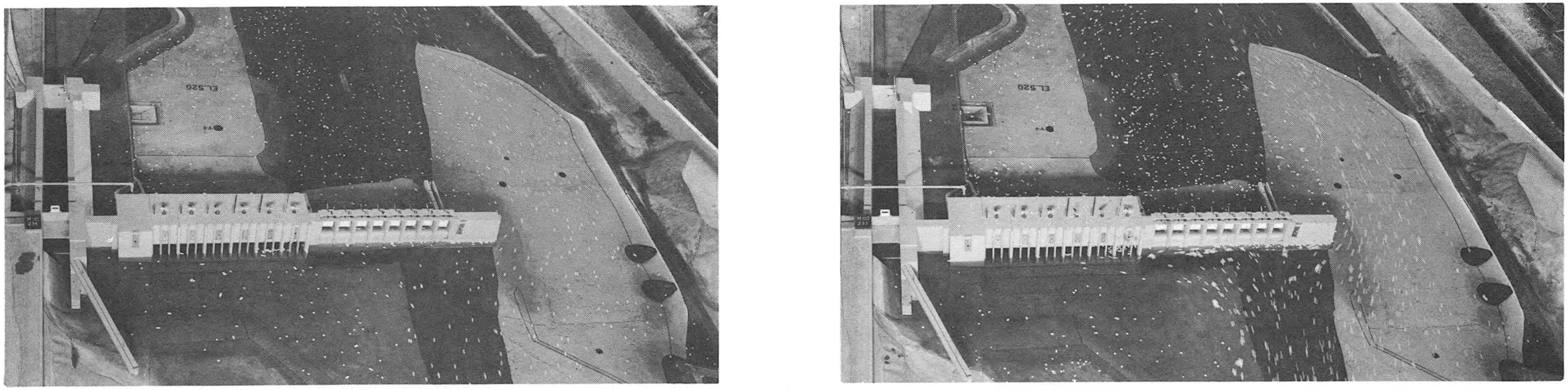
Photograph 1. Flow patterns: plan A first-step cofferdam, plan M diversion channel (final design); river discharge 200,000 cfs. Note rock groins along right bank.



River discharge 30,000 cfs

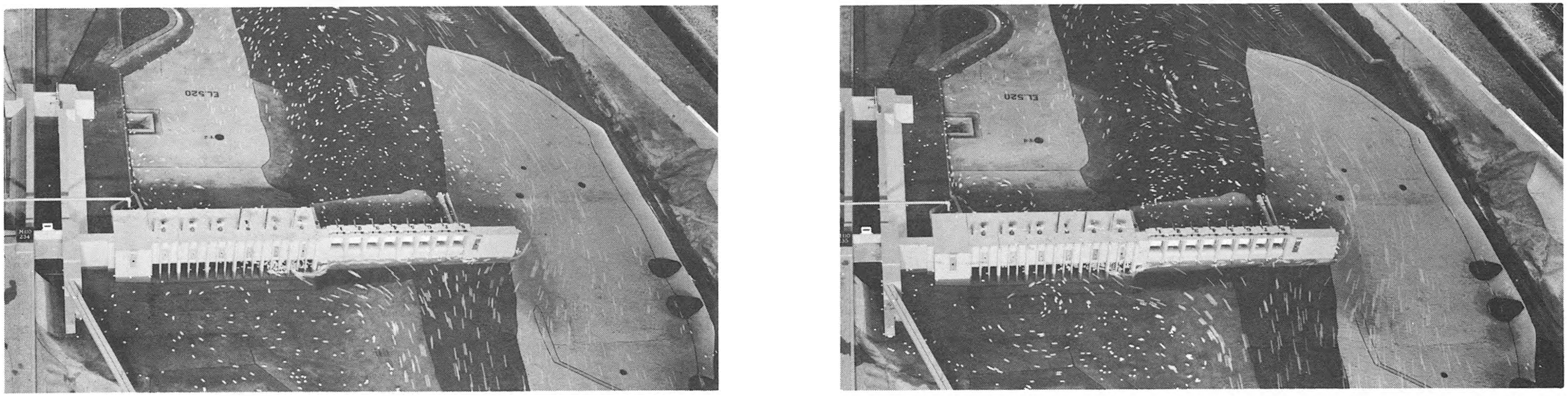
River discharge 75,000 cfs

Photograph 2. Flow patterns: contractor's dike, first-step cofferdam.



River discharge 50,000 cfs

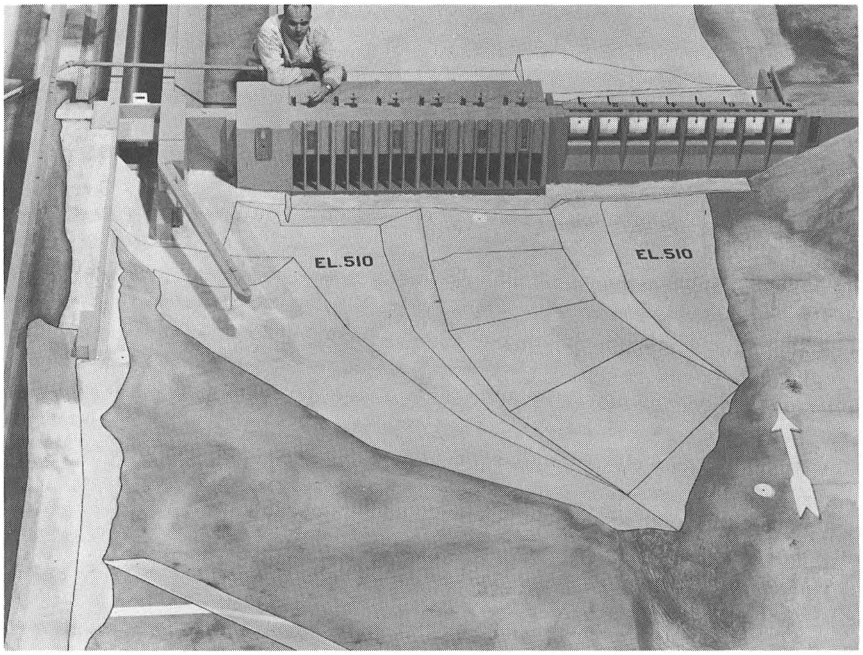
River discharge 100,000 cfs



River discharge 200,000 cfs

River discharge 300,000 cfs

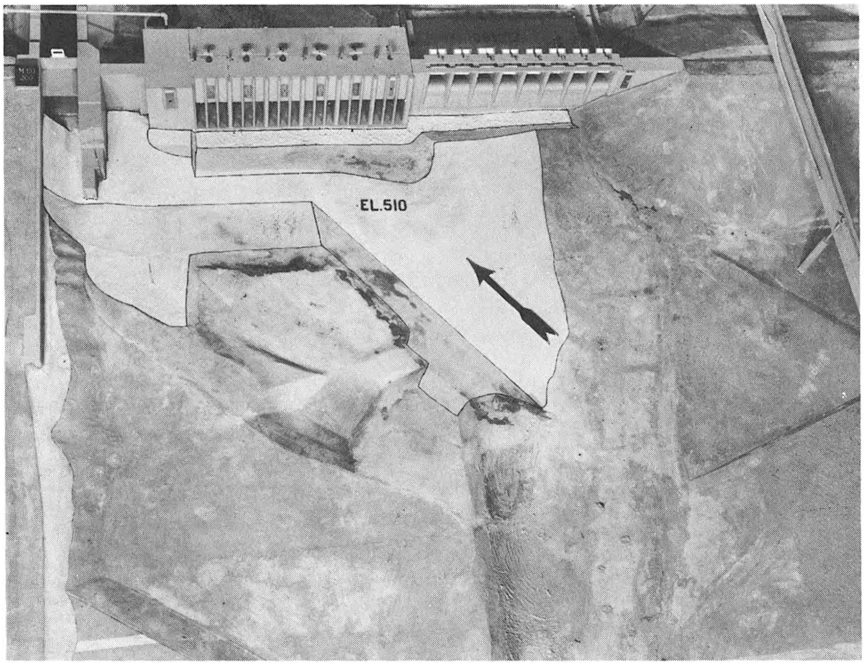
Photograph 3. Flow patterns: Phase I, second-step cofferdam.



Dry bed

Flow patterns: river discharge 120,000 cfs

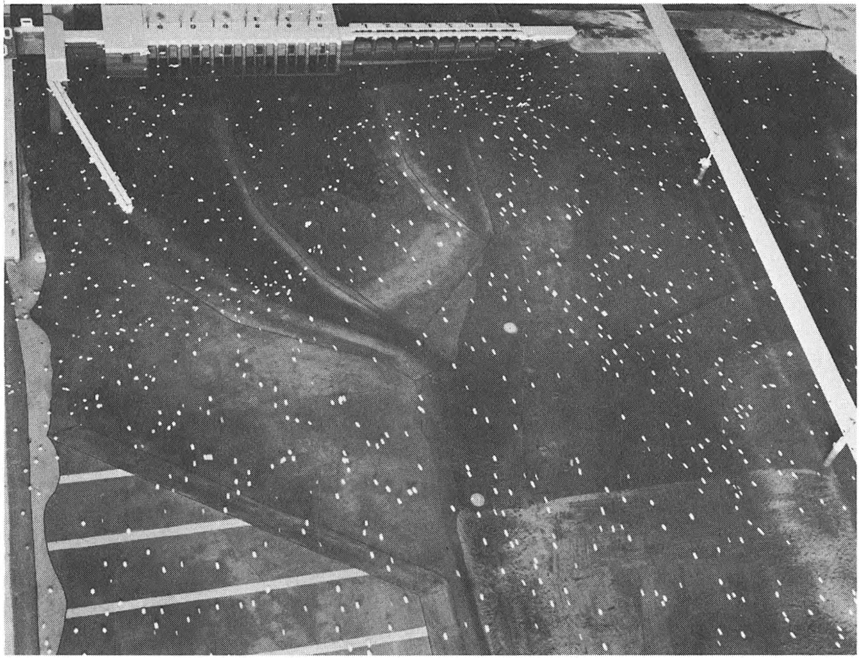
Photograph 4. Phase II second-step diversion; plan A diversion channel (original design).



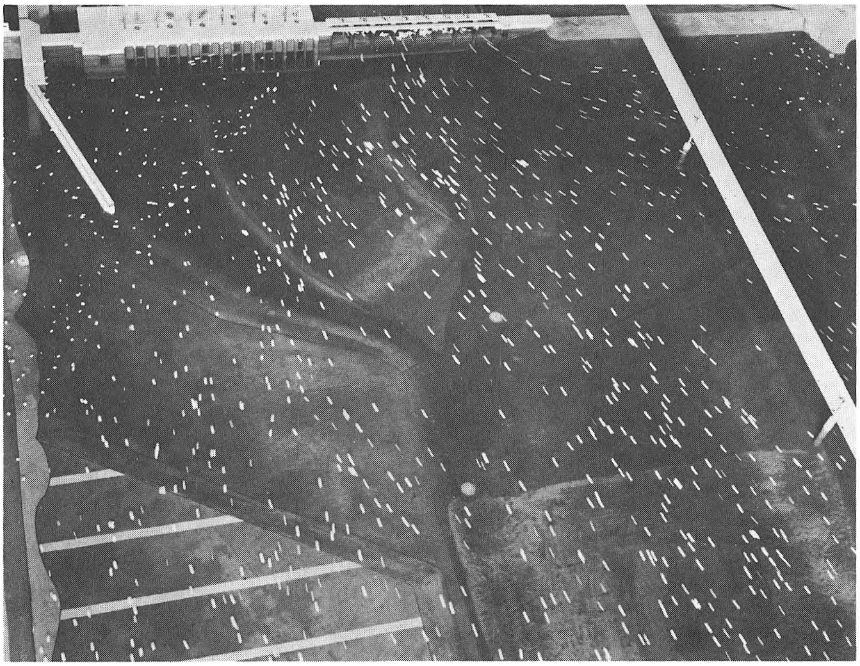
Dry bed

Flow patterns: river discharge 120,000 cfs

Photograph 5. Phase II second-step diversion; plan G diversion channel (final design).

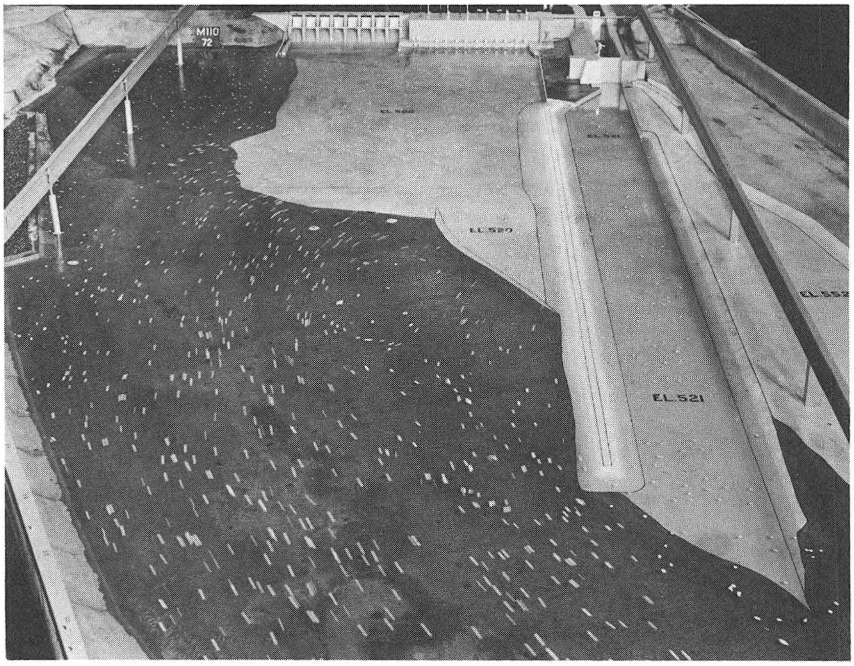


River discharge 150,000 cfs

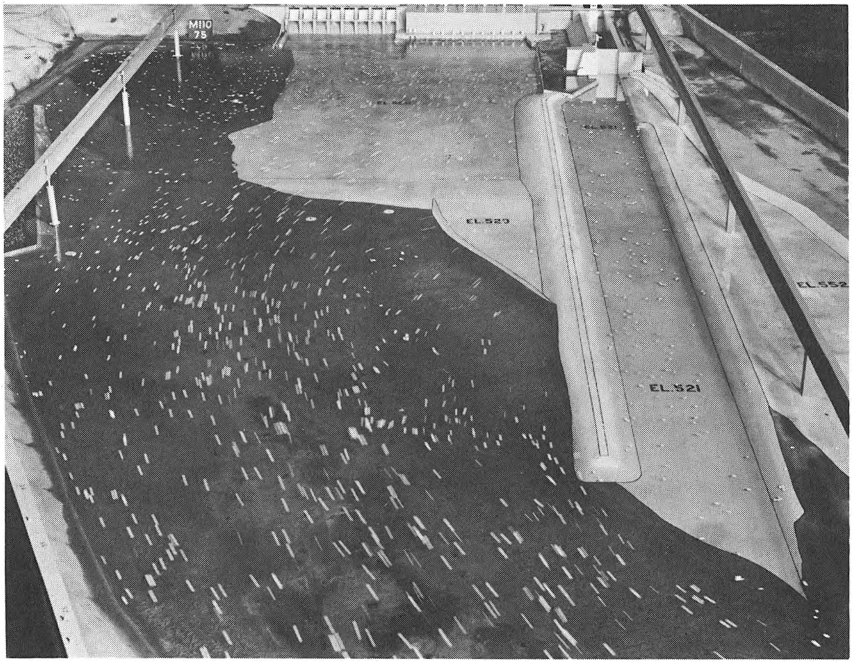


River discharge 340,000 cfs

Photograph 6. Flow patterns upstream from original structures. Powerhouse units 1 to 3 operating, spillway gates opened uniformly.

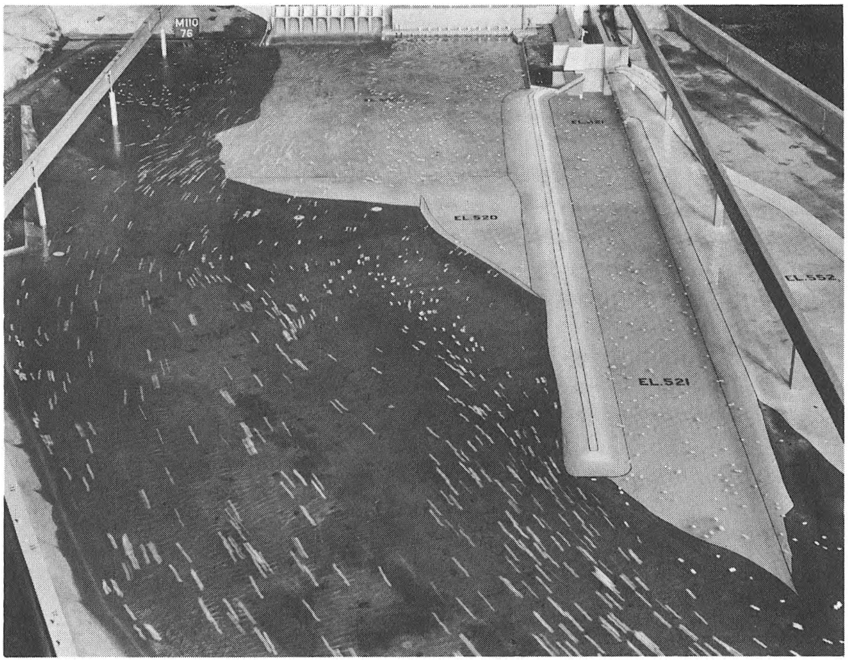


River discharge 100,000 cfs

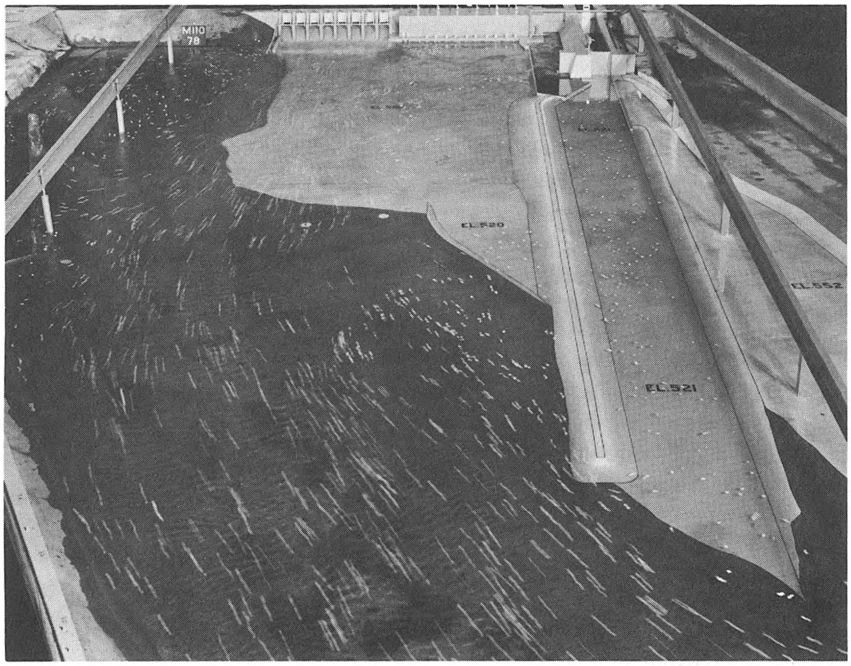


River discharge 150,000 cfs

Photograph 7. Flow patterns: plan A structures and tailrace (original design). Powerhouse units 1 to 3 operating, spillway gates opened uniformly.

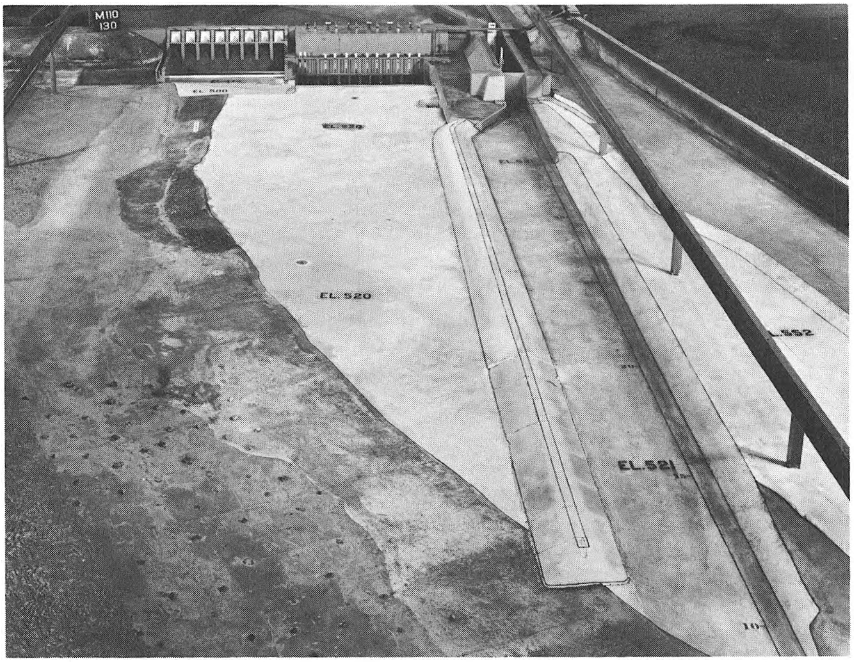


River discharge 225,000 cfs

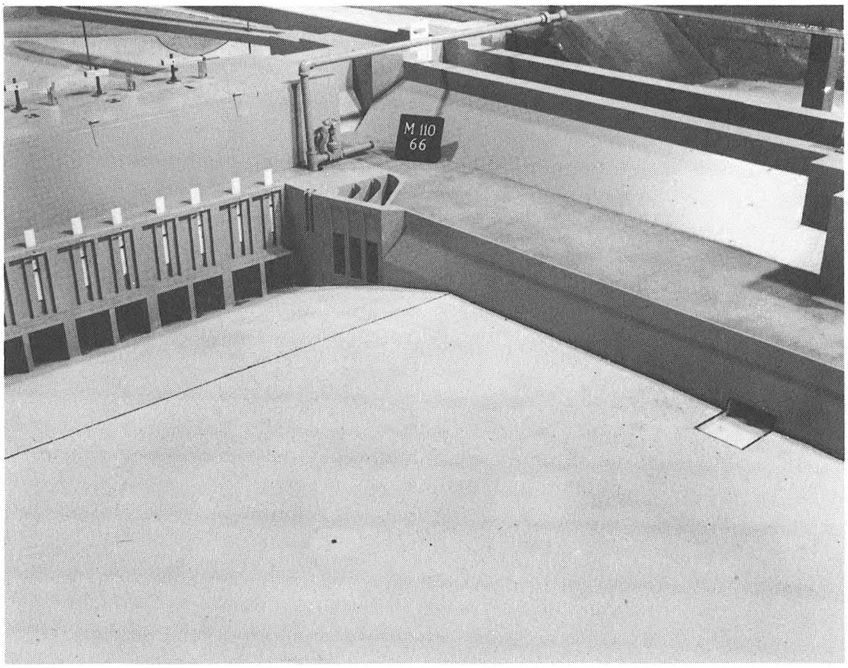


River discharge 340,000 cfs

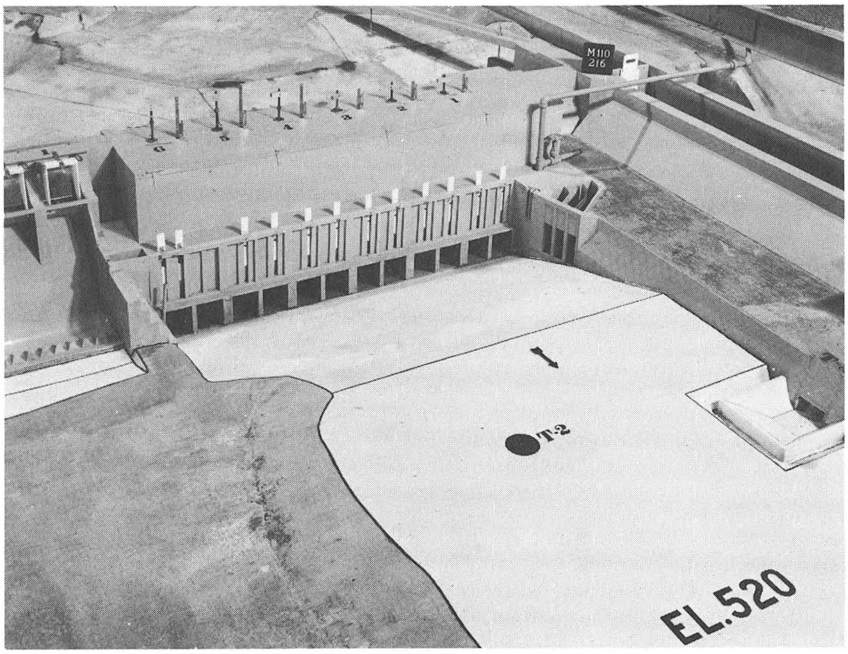
Photograph 8. Flow patterns: plan A structures and tailrace (original design). Powerhouse units 1 to 3 operating, spillway gates opened uniformly.



Photograph 9. Plan B (elev 520) tailrace.

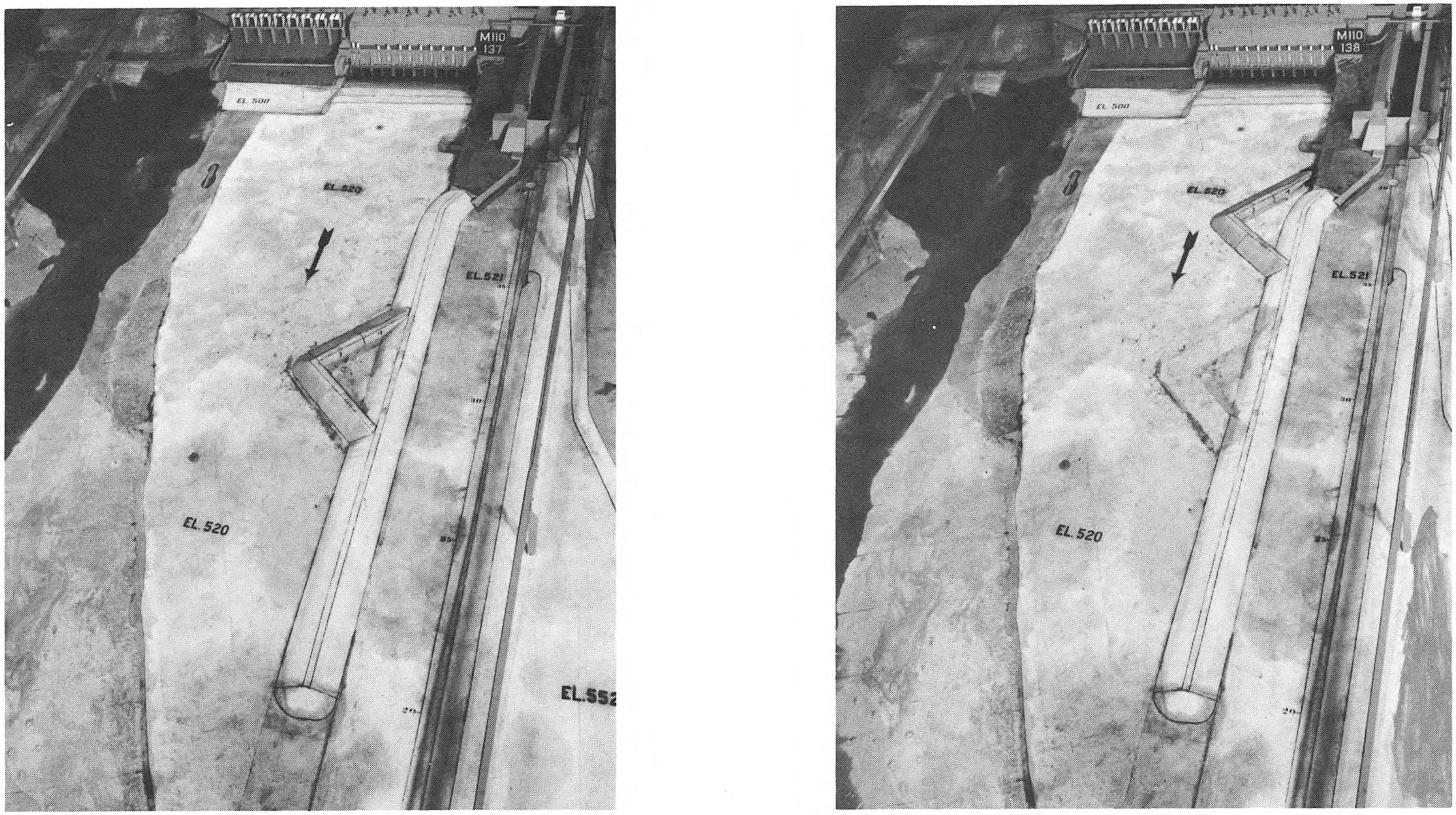


Plan A outlet (right center) in plan A tailrace



Plan B outlet and elev 520 (plan B) tailrace

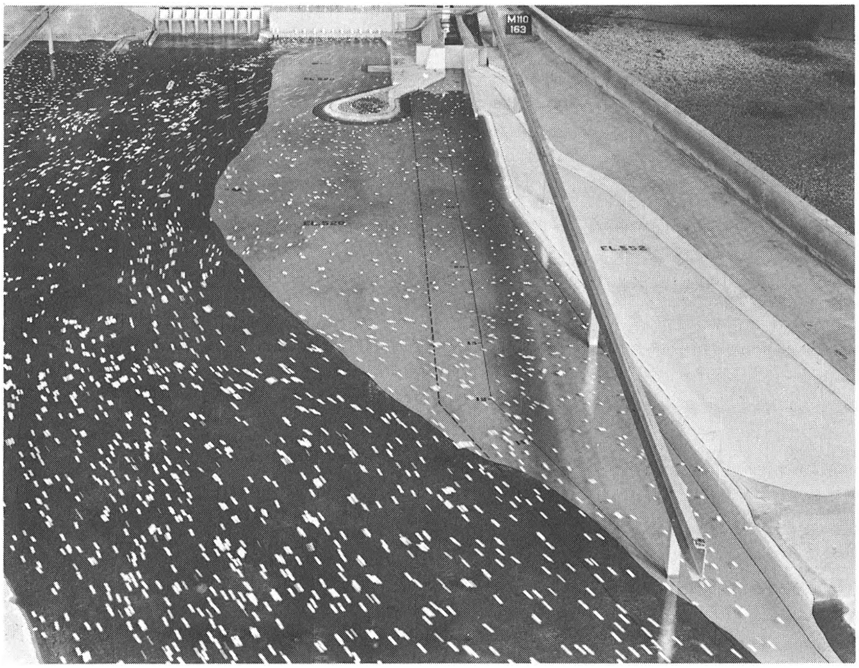
Photograph 10. Navigation lock outlet plans A and B.



Plan A

Plan B

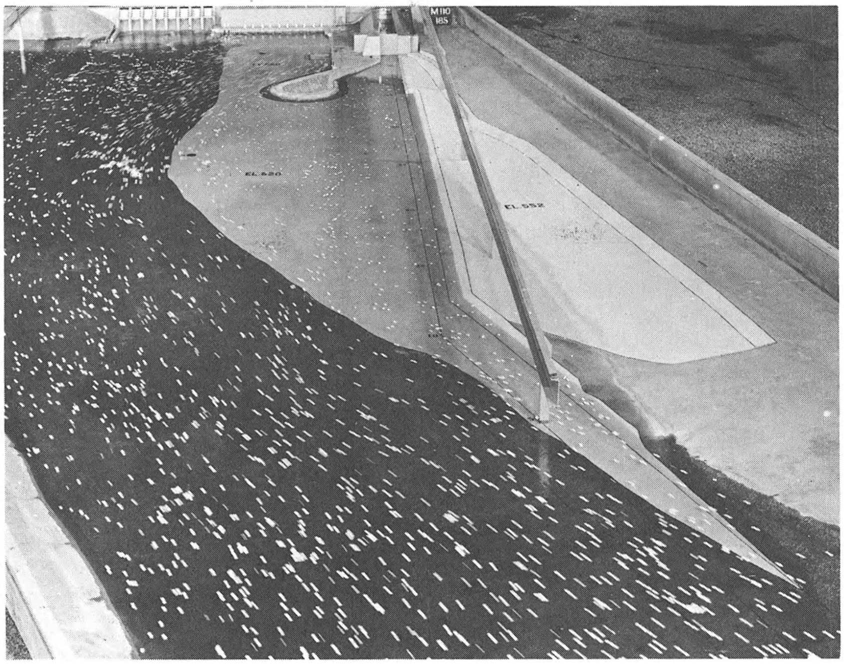
Photograph 11. Transmission tower fill locations A and B.



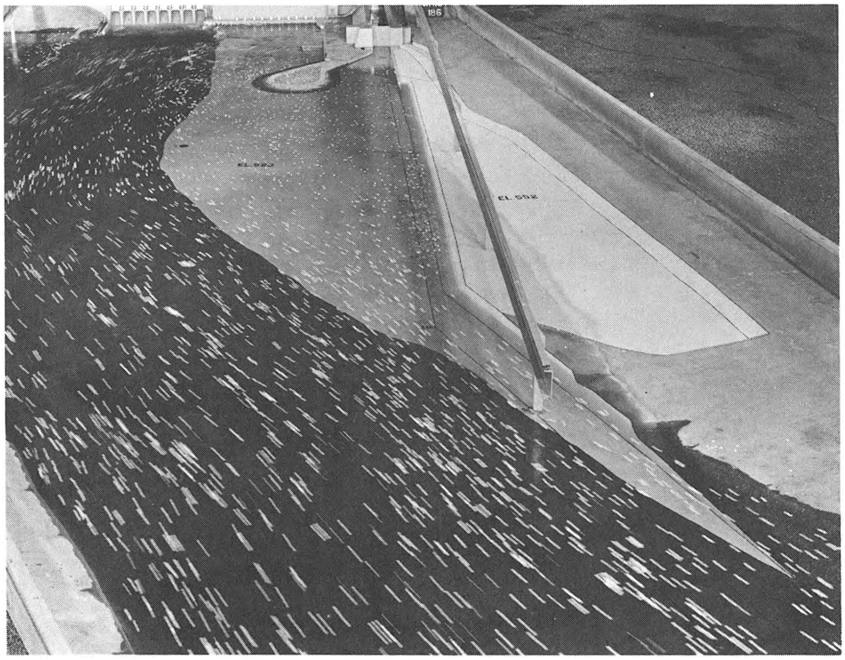
River discharge 100,000 cfs

River discharge 225,000 cfs

Photograph 12. Flow patterns: plan C lock approach and plan C transmission tower fill.

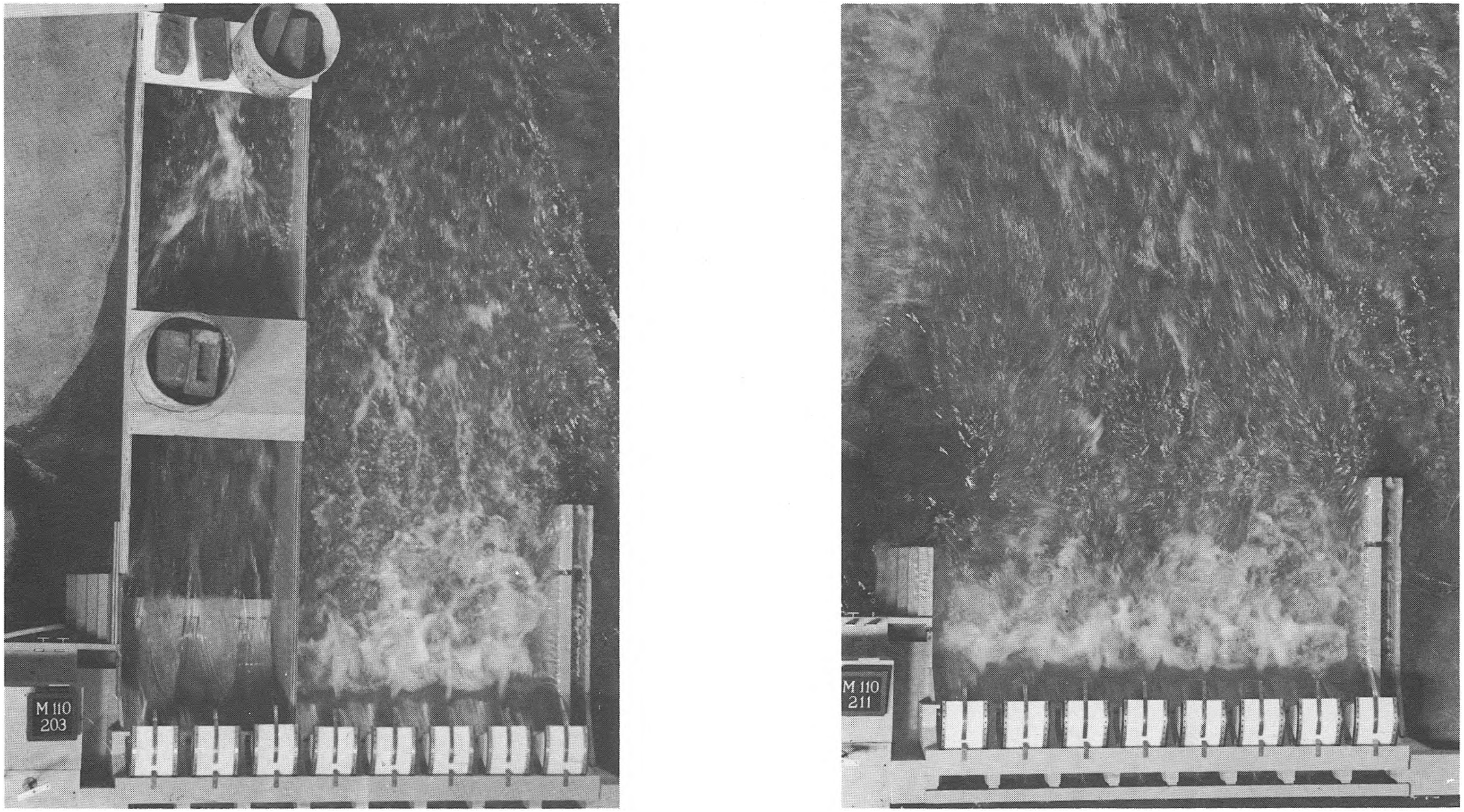


River discharge 100,000 cfs



River discharge 225,000 cfs

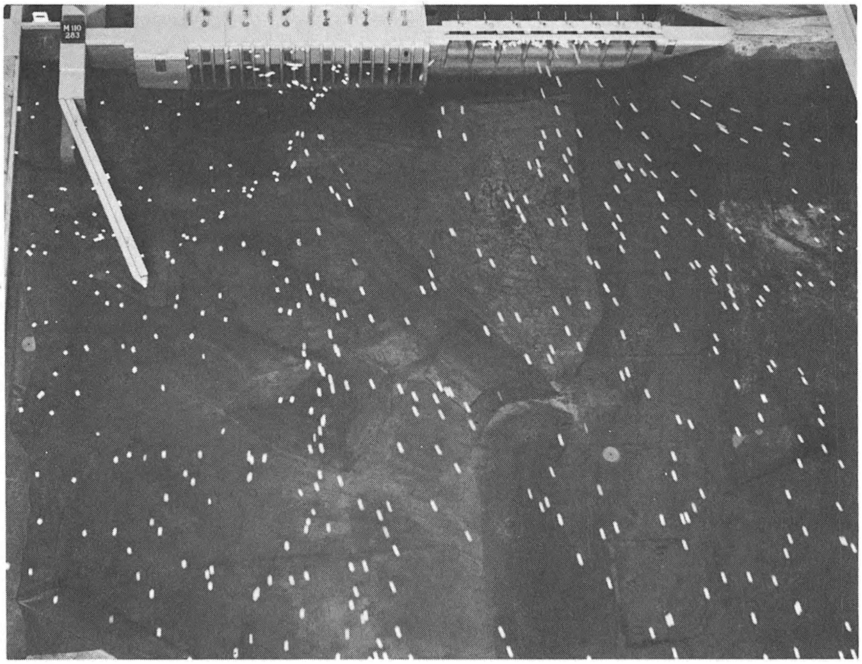
Photograph 13. Flow patterns: plan D lock approach and plan C transmission tower fill.



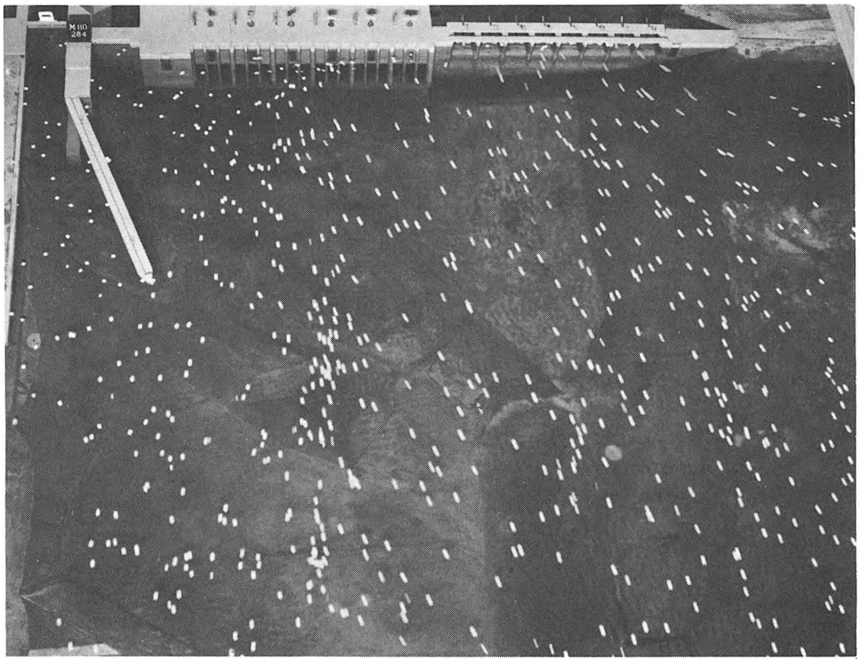
With walls at bays 1 and 3

Without walls

Photograph 14. Flow conditions with and without temporary walls in plan P-6 spillway bucket (final design); river and spillway discharge 850,000 cfs. The walls produced conditions similar to those in a three-bay spillway model.



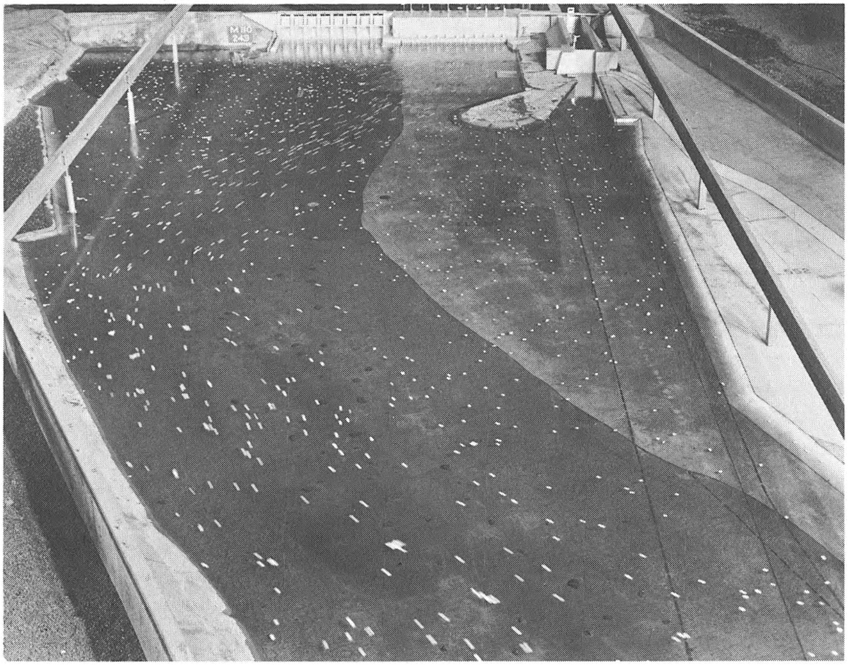
Powerhouse units 1 to 3 in operation



Powerhouse units 1 to 6 in operation

Photograph 15. Flow patterns in upstream approach; final structures and excavation plan. River discharge 340,000 cfs.

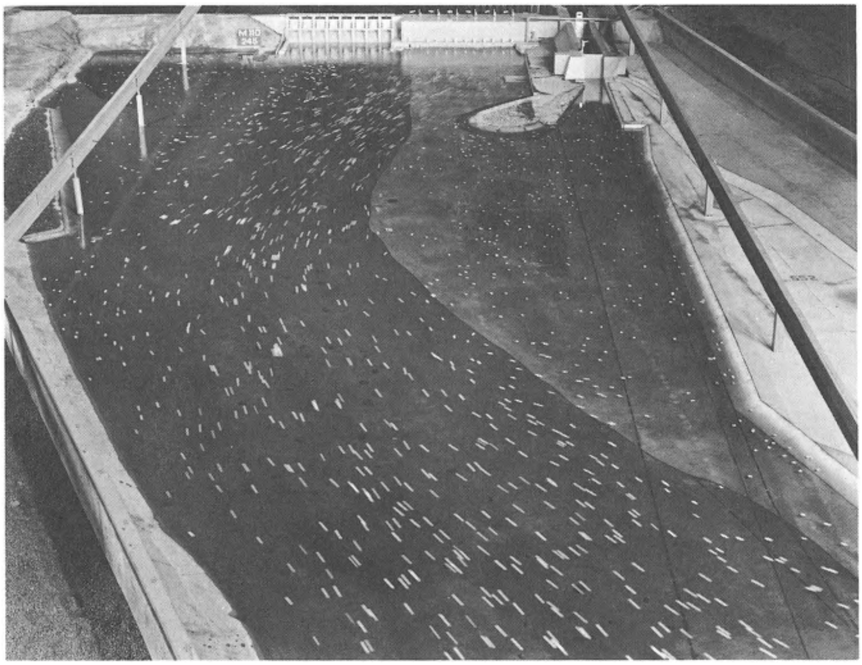
River discharge 25,000 cfs



River discharge 50,000 cfs

Photograph 16. Flow patterns in tailrace; final structures and excavation plan. River discharges 25,000 and 50,000 cfs. Spillway closed, powerhouse units 1 to 3 in operation.

Powerhouse units 1 to 3 in operation



Powerhouse units 1 to 6 in operation

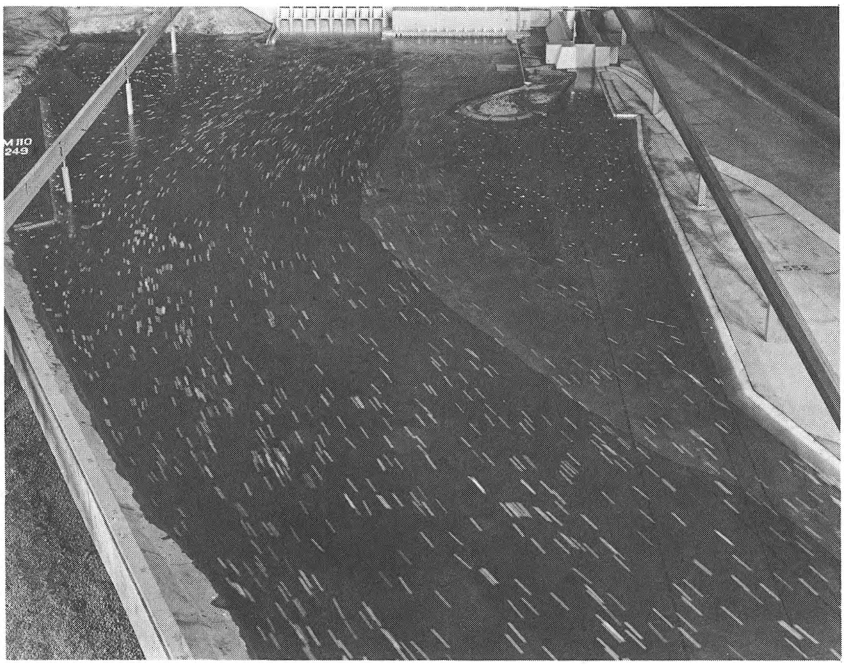
Photograph 17. Flow patterns in tailrace; final structures and excavation plan. River discharge 100,000 cfs.

Powerhouse units 1 to 3 in operation

Powerhouse units 1 to 6 in operation

Photograph 18. Flow patterns in tailrace; final structures and excavation plan. River discharge 150,000 cfs.

Powerhouse units 1 to 3 in operation



Powerhouse units 1 to 6 in operation

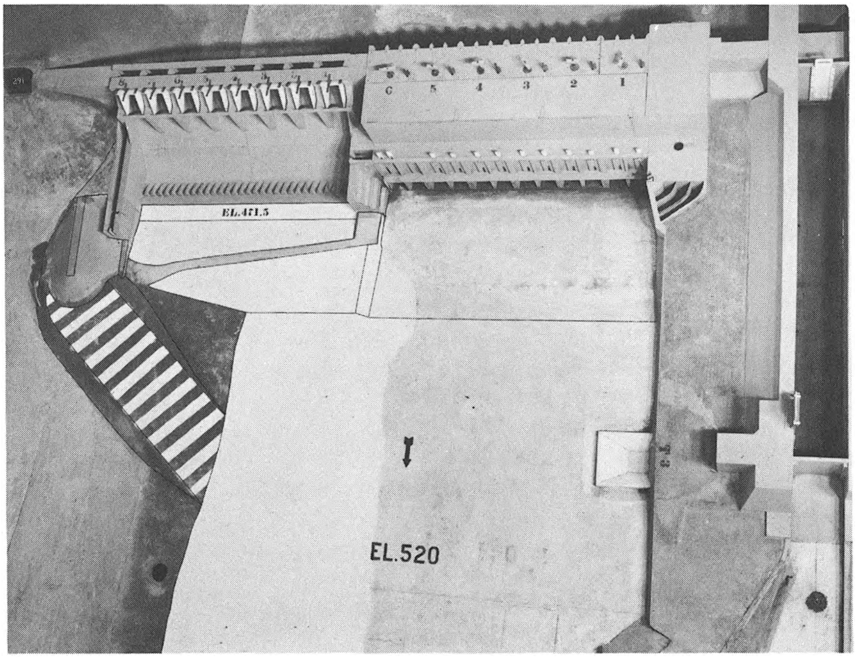
Photograph 19. Flow patterns in tailrace; final structures and excavation plan. River discharge 225,000 cfs.

Powerhouse units 1 to 3 in operation

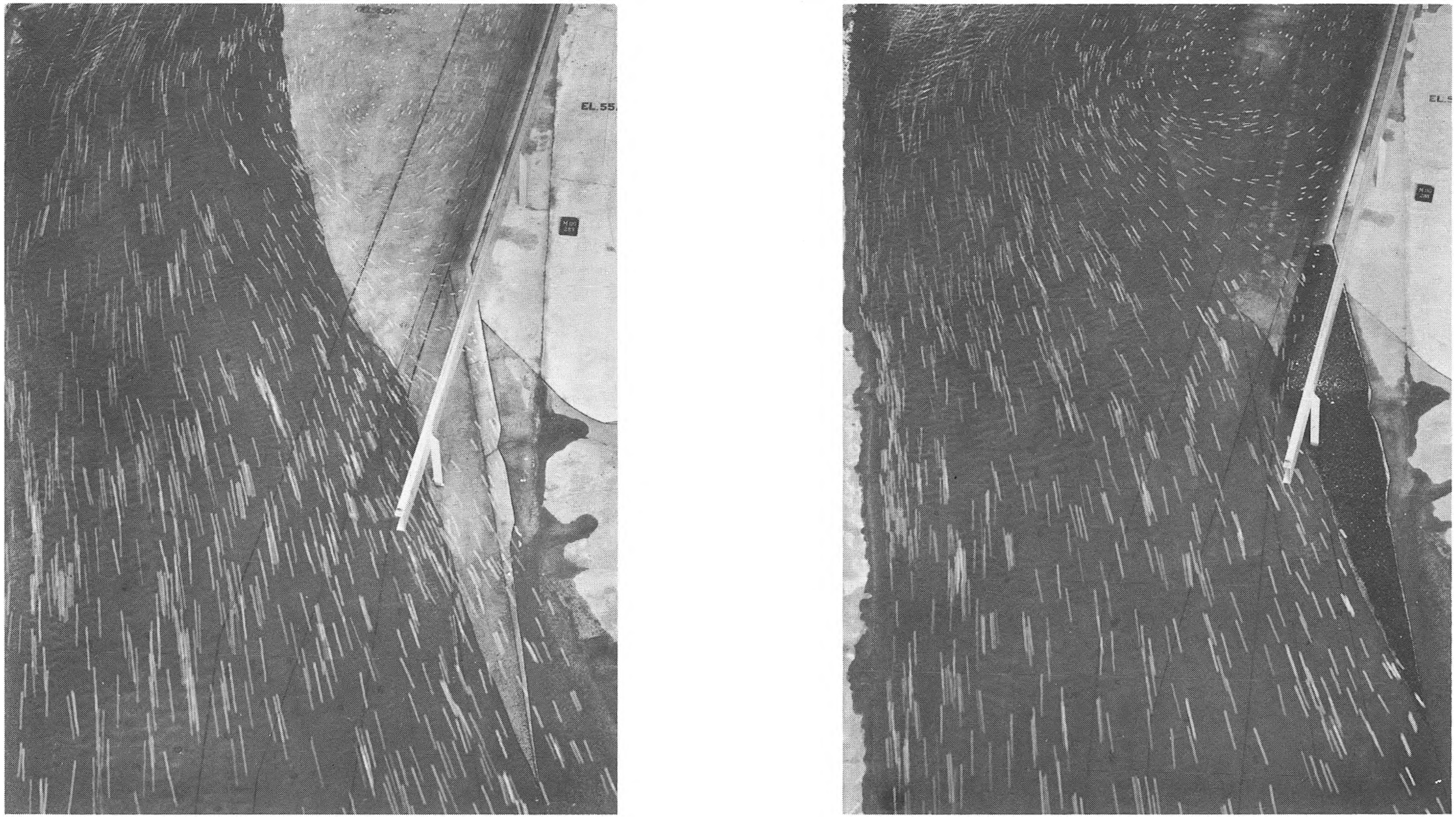
Powerhouse units 1 to 6 in operation

Photograph 20. Flow patterns in tailrace; final structures and excavation plan. River discharge 340,000 cfs.

Photograph 21. Flow patterns in tailrace; final structures and excavation plan. River discharge 850,000 cfs, powerhouse closed.



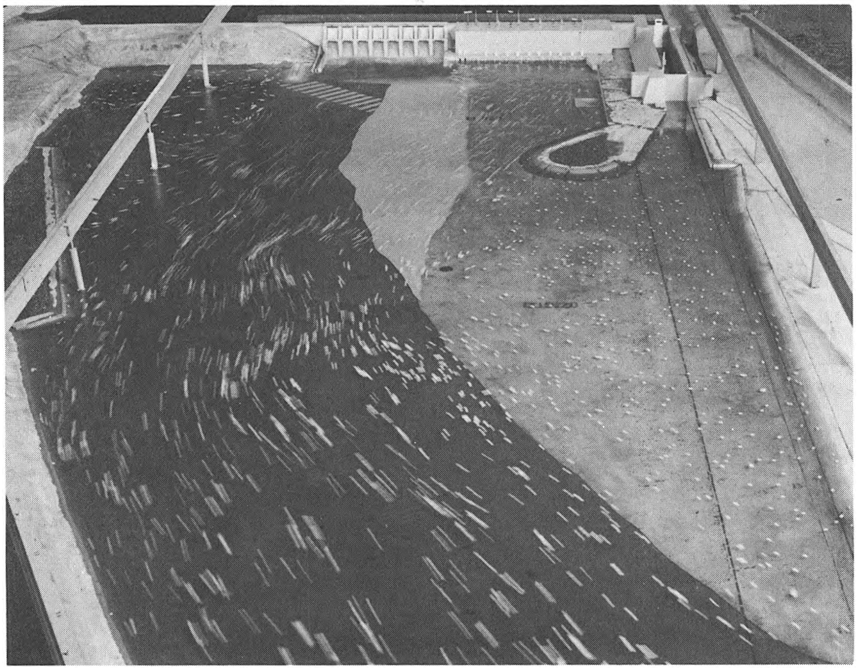
Photograph 22. Contract plan excavation downstream from spillway and powerhouse. The striped area represents that portion of first-step cofferdam below elev 520.



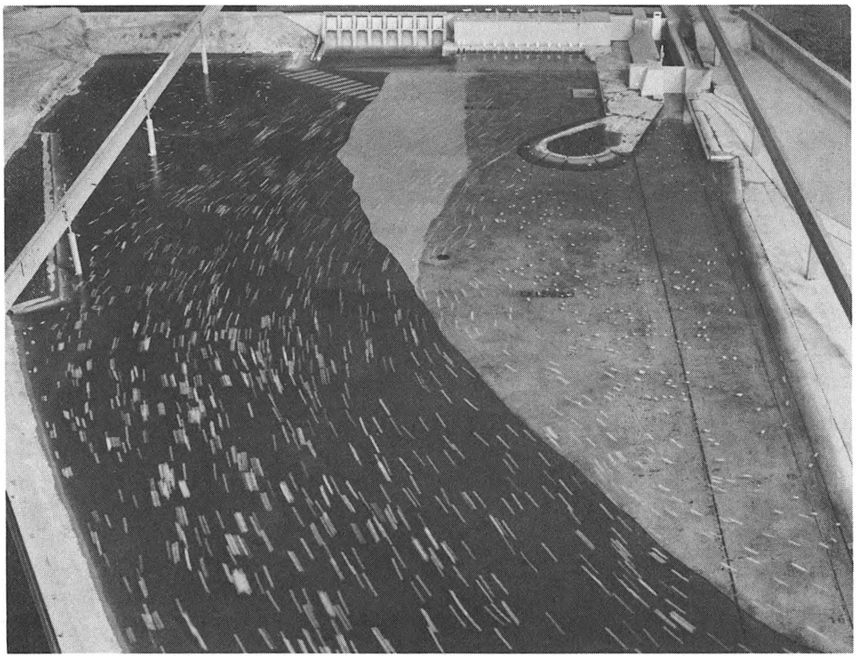
Final plan

Contract plan

Photograph 23. Flow patterns at downstream end of excavation for navigation lock approach. River discharge 420,000 cfs, powerhouse units 1 to 3 in operation.

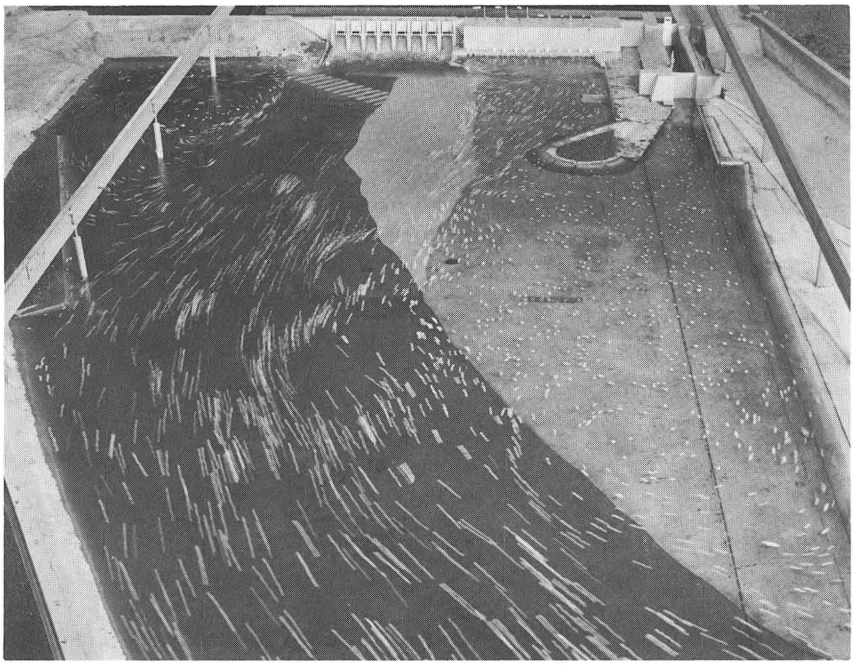


Powerhouse units 1 to 3 in operation

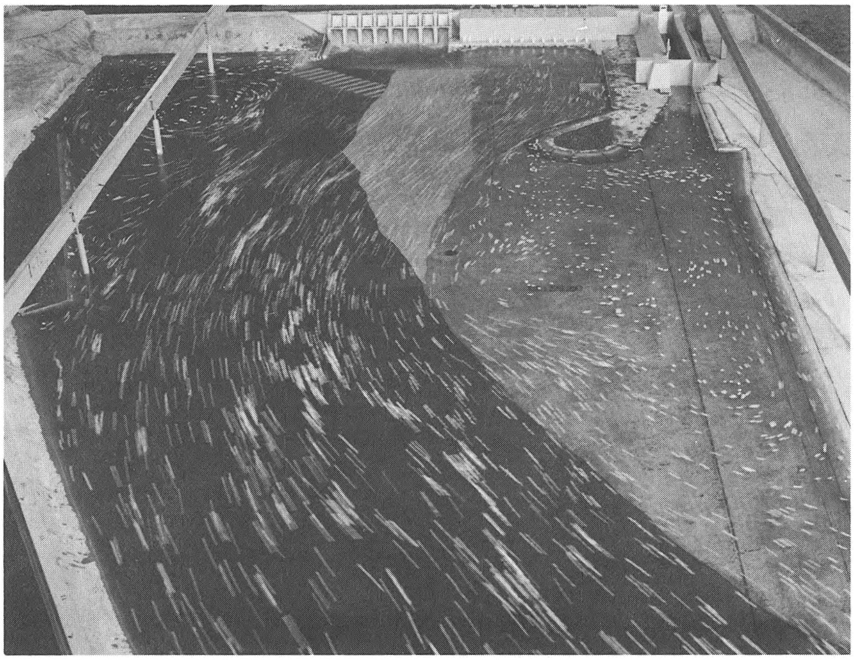


Powerhouse units 1 to 6 in operation

Photograph 24. Flow patterns in contract plan tailrace; river discharge 225,000 cfs.

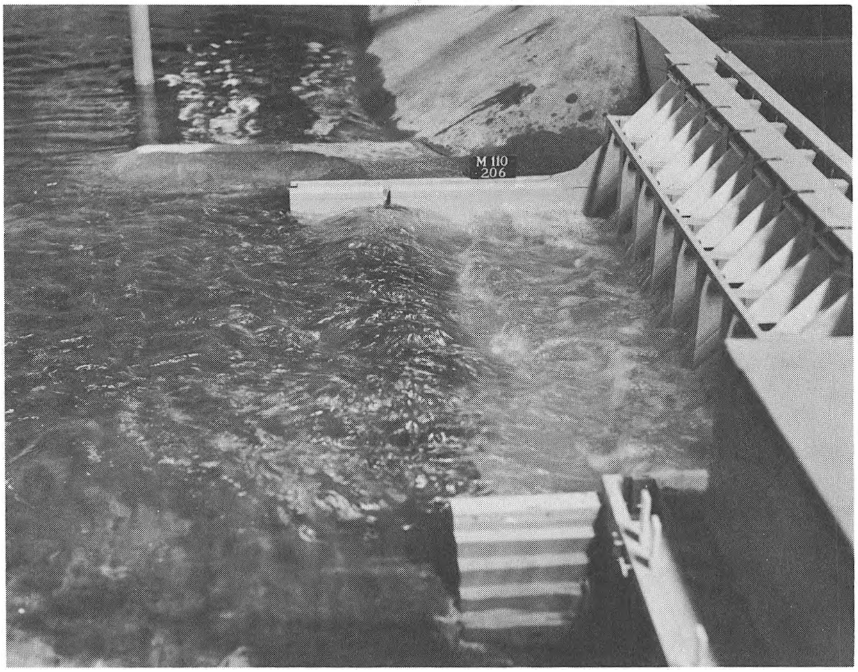


Powerhouse units 1 to 3 in operation

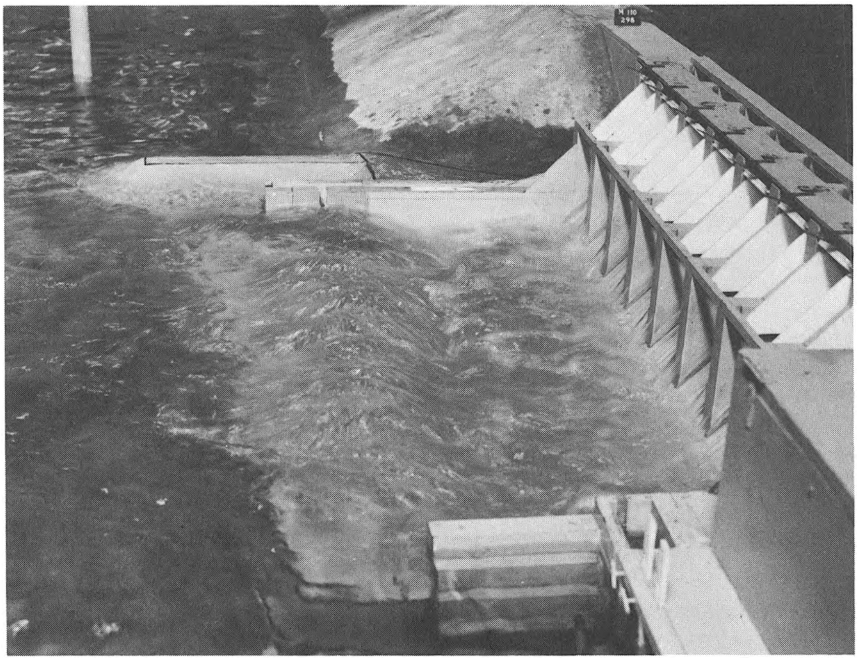


Powerhouse units 1 to 6 in operation

Photograph 25. Flow patterns in contract plan tailrace; river discharge 340,000 cfs.

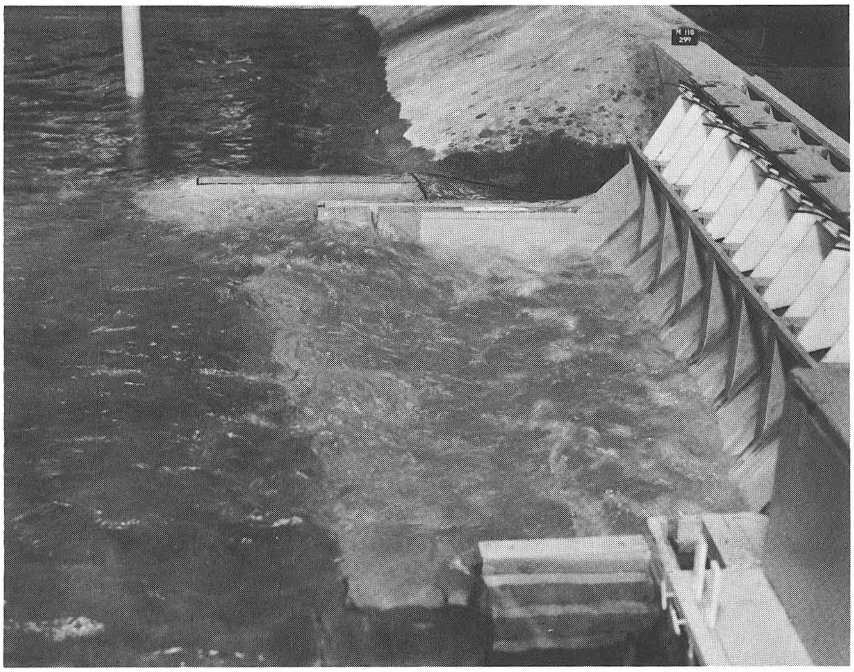


With dentates

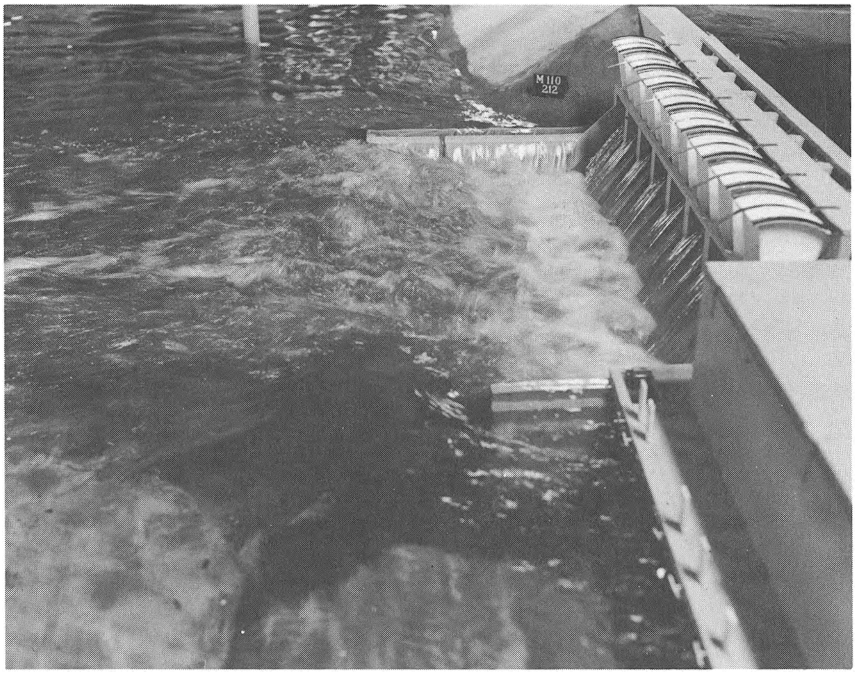


Without dentates

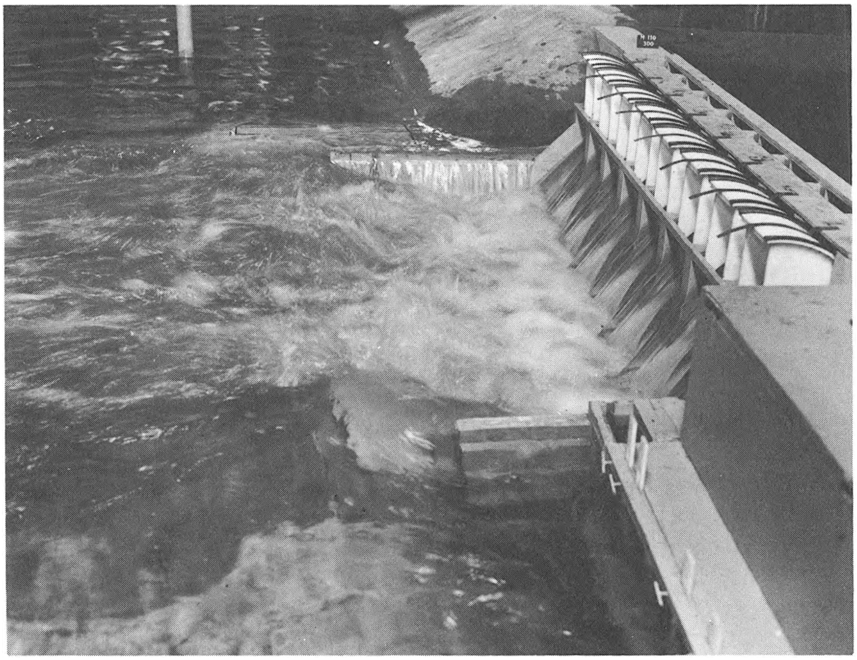
Photograph 26. Stilling action with plan P-6 spillway bucket. River discharge 225,000 cfs, spillway discharge 157,125 cfs, powerhouse discharge 67,800 cfs, units 1 to 3.



Photograph 27. Stilling action without dentates in plan P-6 spillway bucket. River discharge 420,000 cfs, spillway discharge 349,905 cfs, powerhouse discharge 70,020 cfs, units 1 to 3.



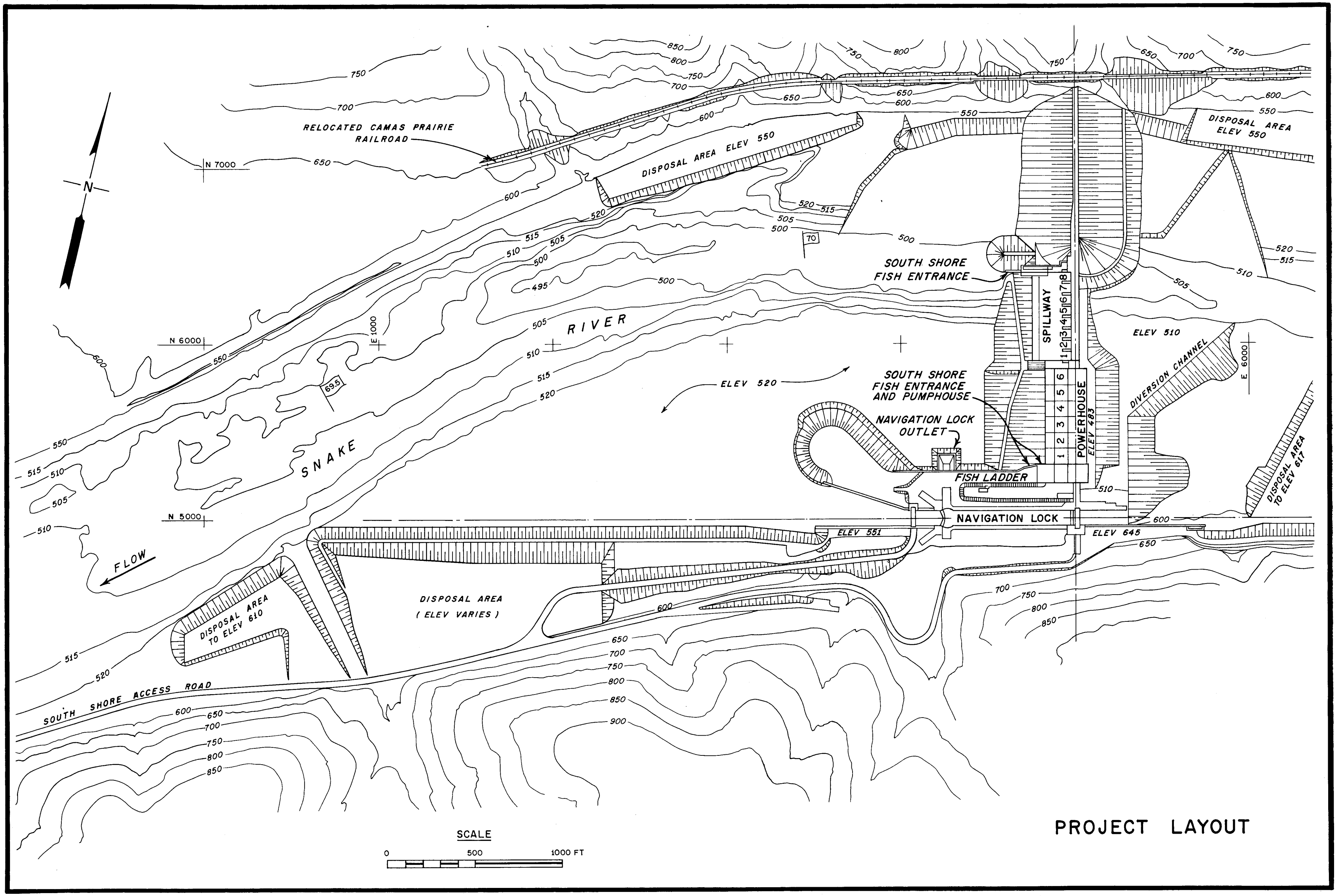
With dentates



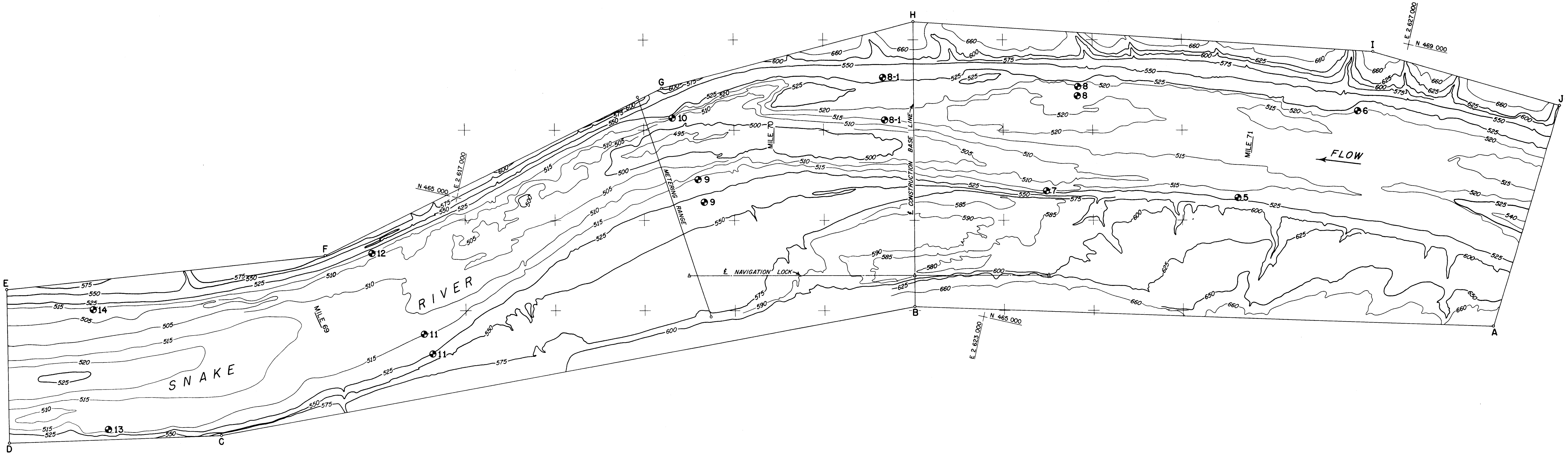
Without dentates

Photograph 28. Stilling action with plan P-6 spillway bucket. River and spillway discharge 850,000 cfs, powerhouse closed.

PLATE 1



PROJECT LAYOUT



MODEL LAYOUT

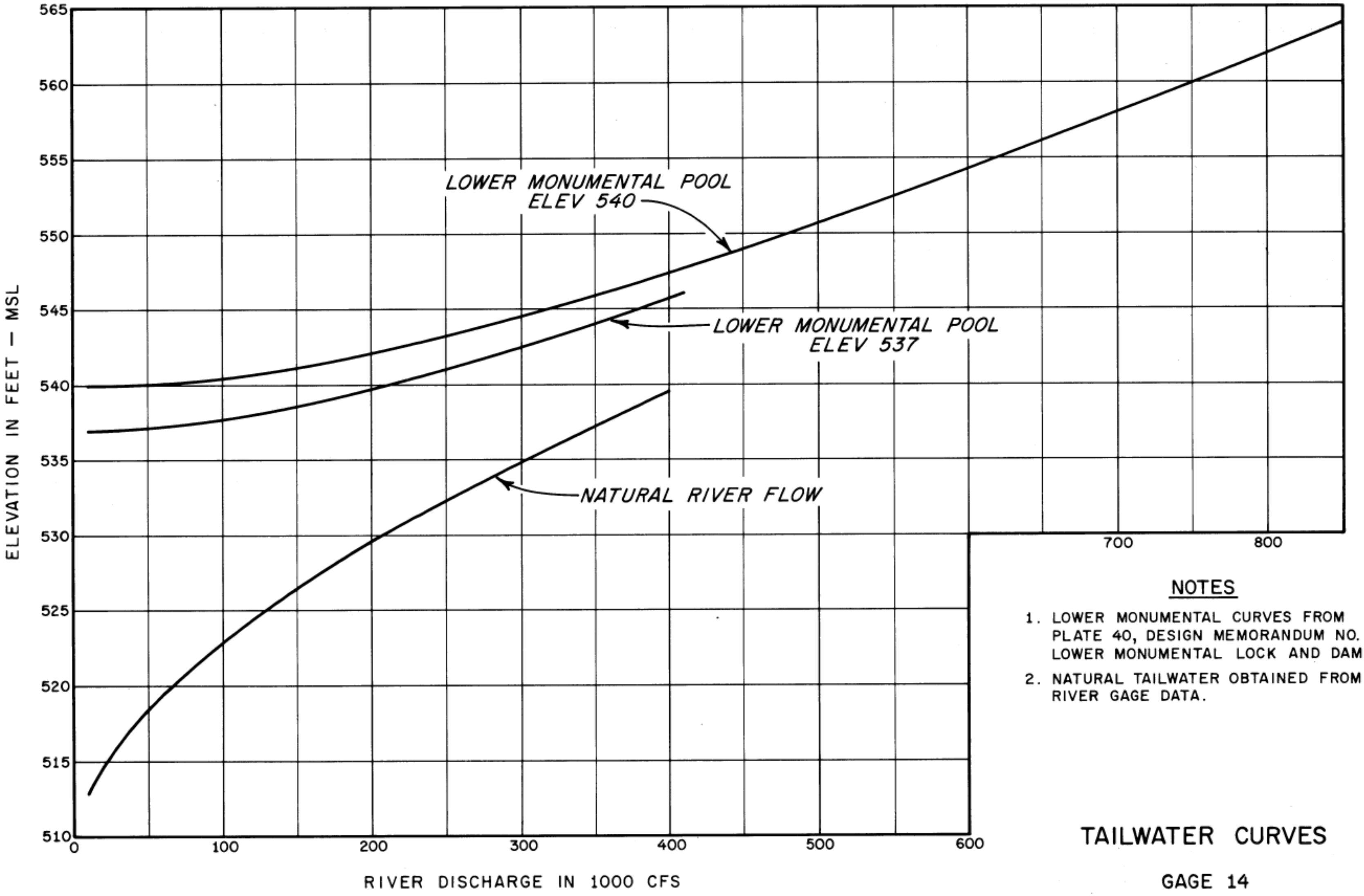
NOTE

MILES ARE ABOVE RIVER MOUTH

SCALES

0 500 1000 2000 FT PROTOTYPE

0 1 2 3 4 5 10 20 FT MODEL



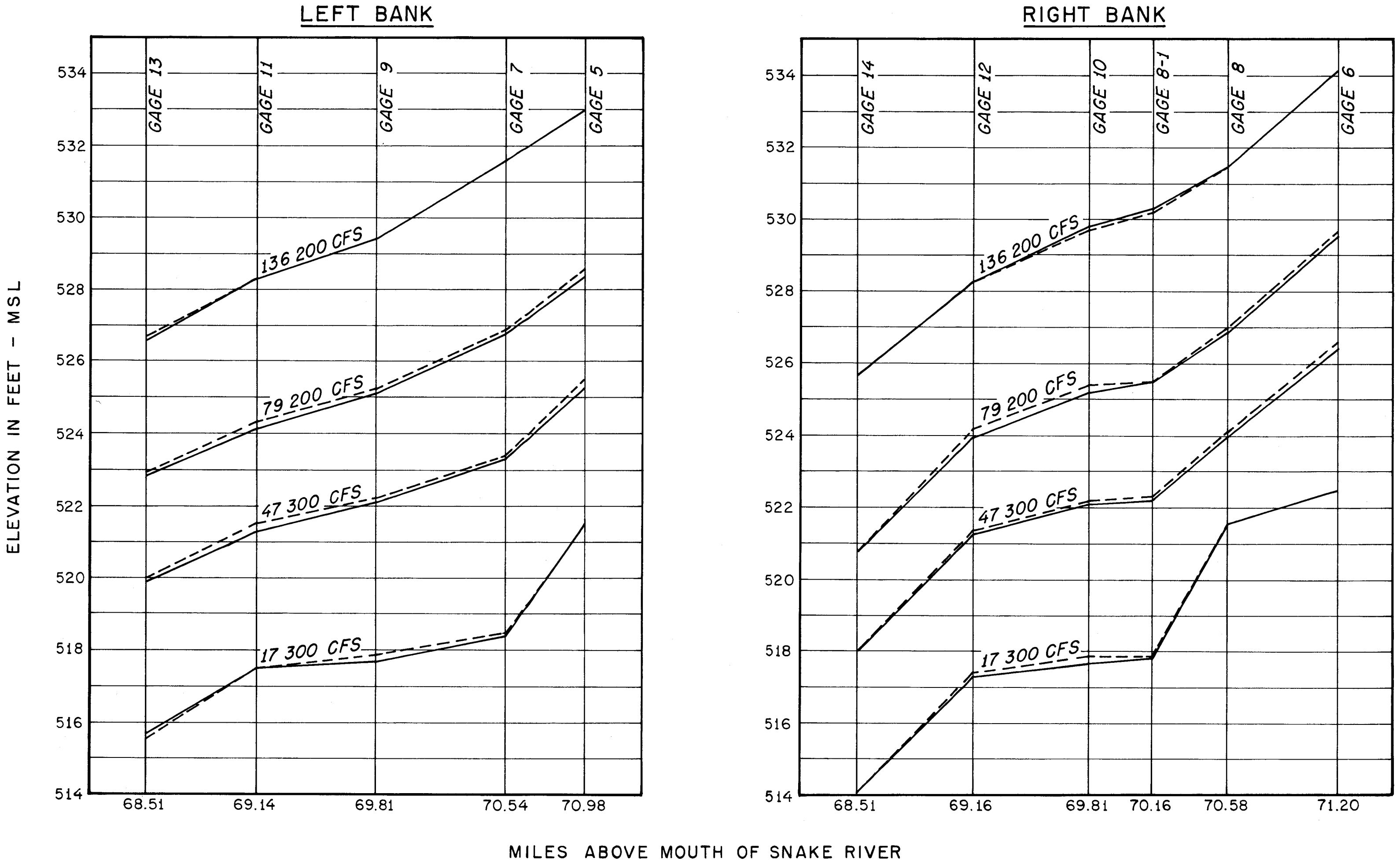
NOTES

1. LOWER MONUMENTAL CURVES FROM PLATE 40, DESIGN MEMORANDUM NO. 1, LOWER MONUMENTAL LOCK AND DAM.
2. NATURAL TAILWATER OBTAINED FROM RIVER GAGE DATA.

TAILWATER CURVES

GAGE 14

RIVER MILE 68.5



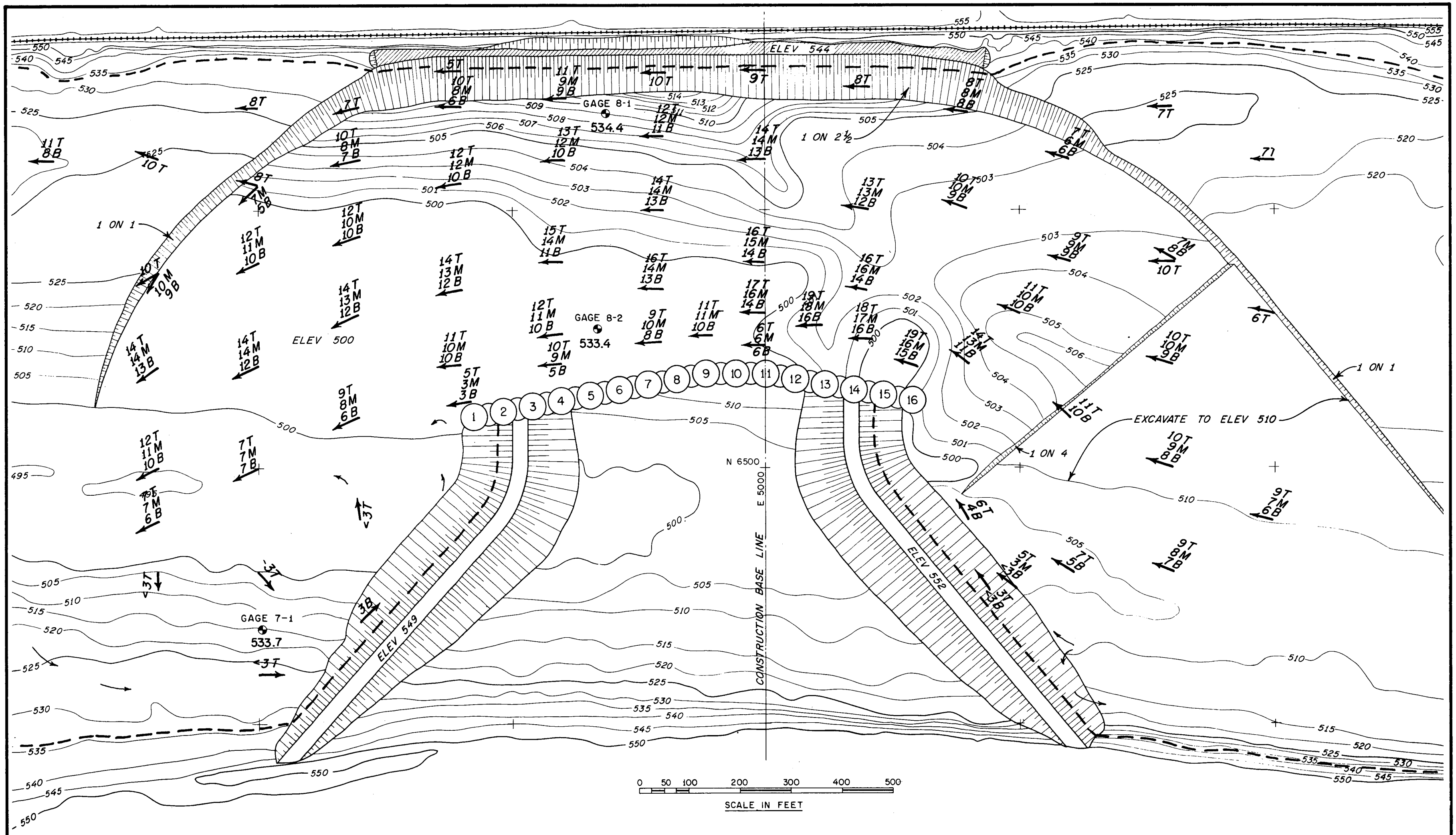
LEGEND

——— PROTOTYPE OBSERVATIONS
– – – – MODEL OBSERVATIONS

NOTE

GAGE LOCATIONS SHOWN ON PLATE 2.

WATER-SURFACE PROFILES
VERIFICATION



LEGEND

←4 VELOCITY MEASUREMENTS IN FPS

T 5-FT DEPTH

M MID-DEPTH

B 5 FT ABOVE BOTTOM

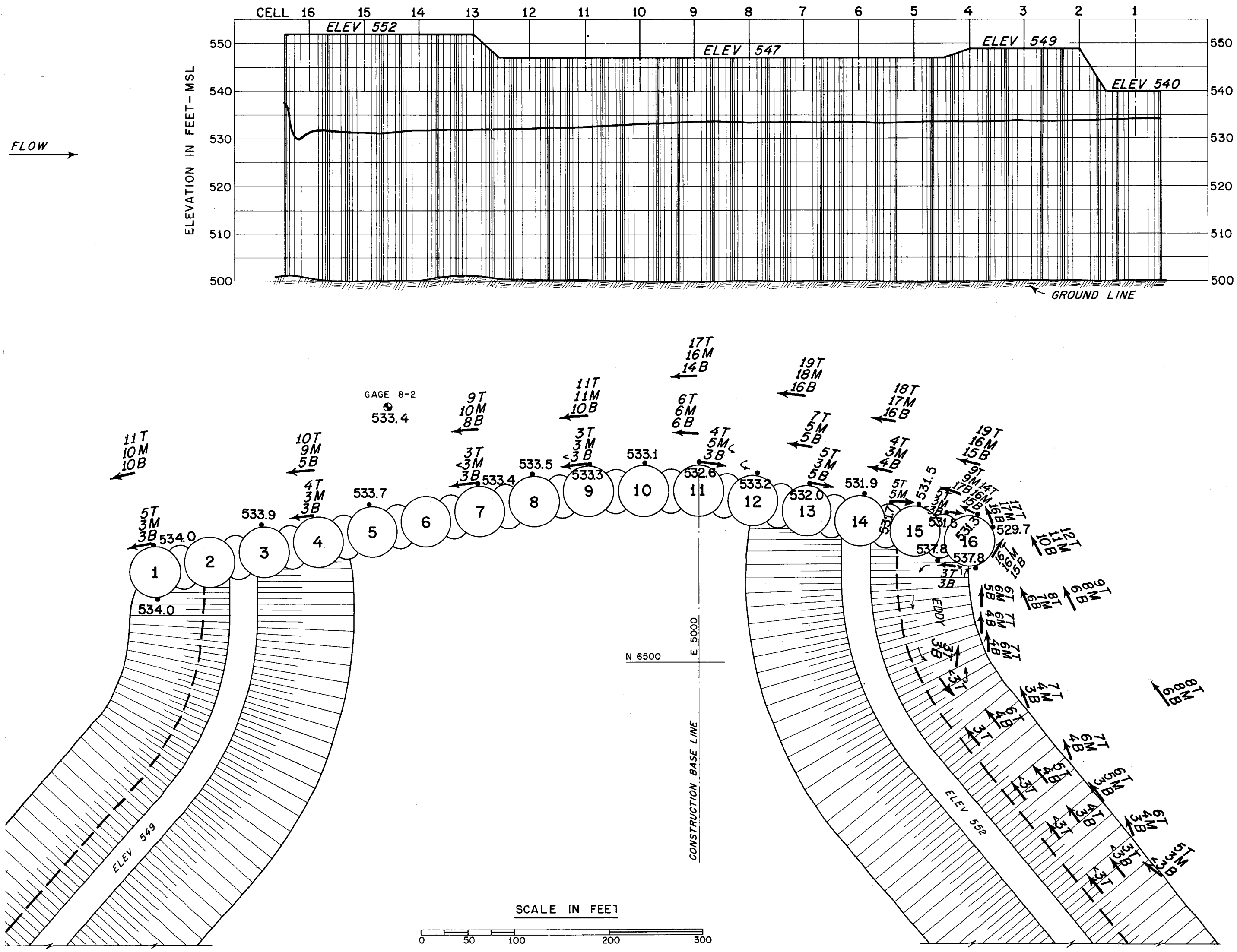
NOTE

MAIN PORTION OF DIVERSION CHANNEL EXCAVATED TO ELEV 500 OR BEDROCK WHICHEVER IS HIGHER.

FLOW CONDITIONS
PLAN A FIRST-STEP COFFERDAM AND DIVERSION CHANNEL

RIVER DISCHARGE 200 000 CFS

PLATE 6

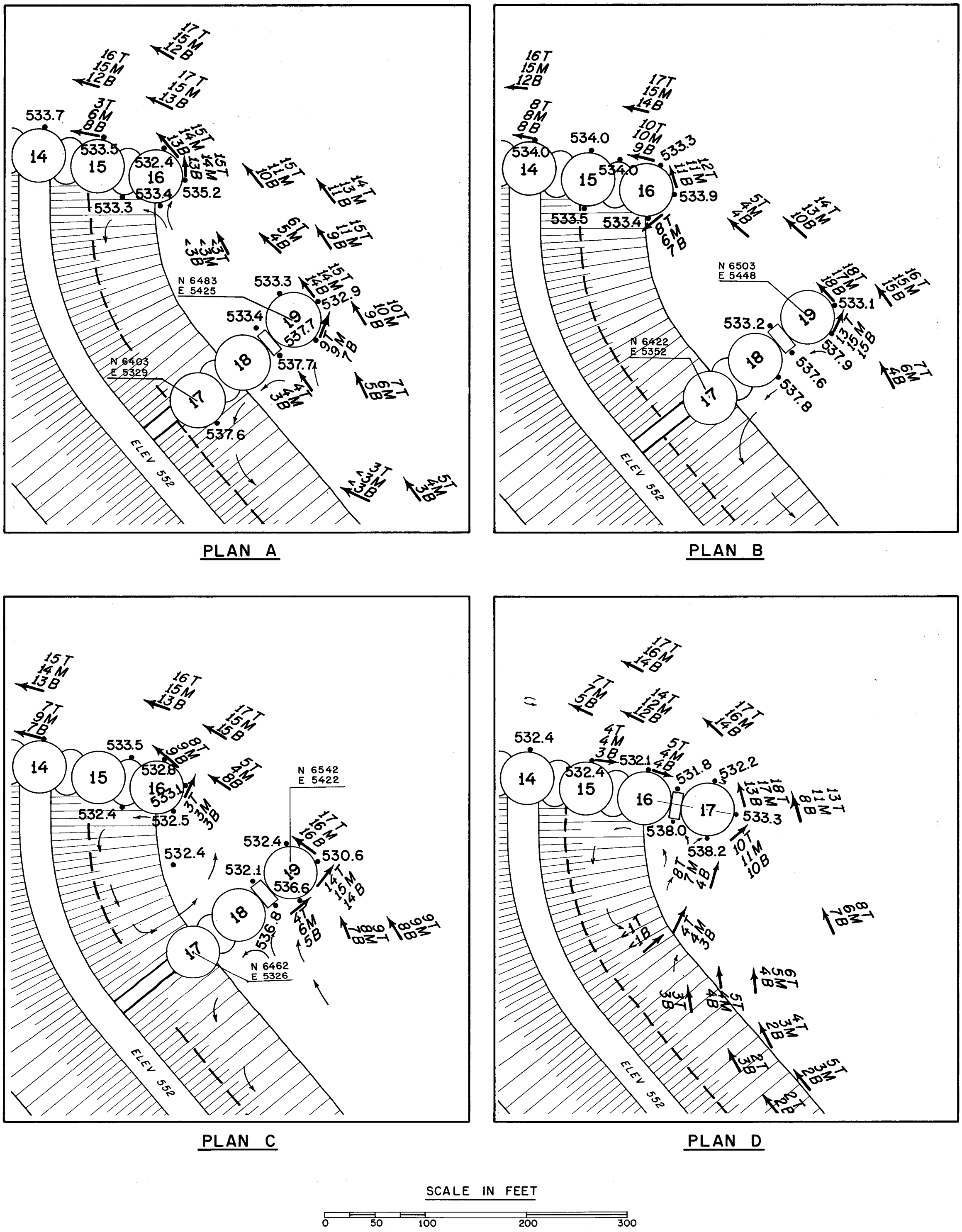


GAGE	WATER-SURFACE ELEVATION
7	537.3
7-1	533.7
8	537.0
8-1	534.4
9	533.0
10	533.1
14 — T.W.	529.6

LEGEND

← 8	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
529.7 ●	WATER-SURFACE ELEVATION

VELOCITIES
AND
WATER-SURFACE PROFILES
PLAN A FIRST-STEP COFFERDAM
RIVER DISCHARGE 200 000 CFS



PLAN A

PLAN B

PLAN C

PLAN D

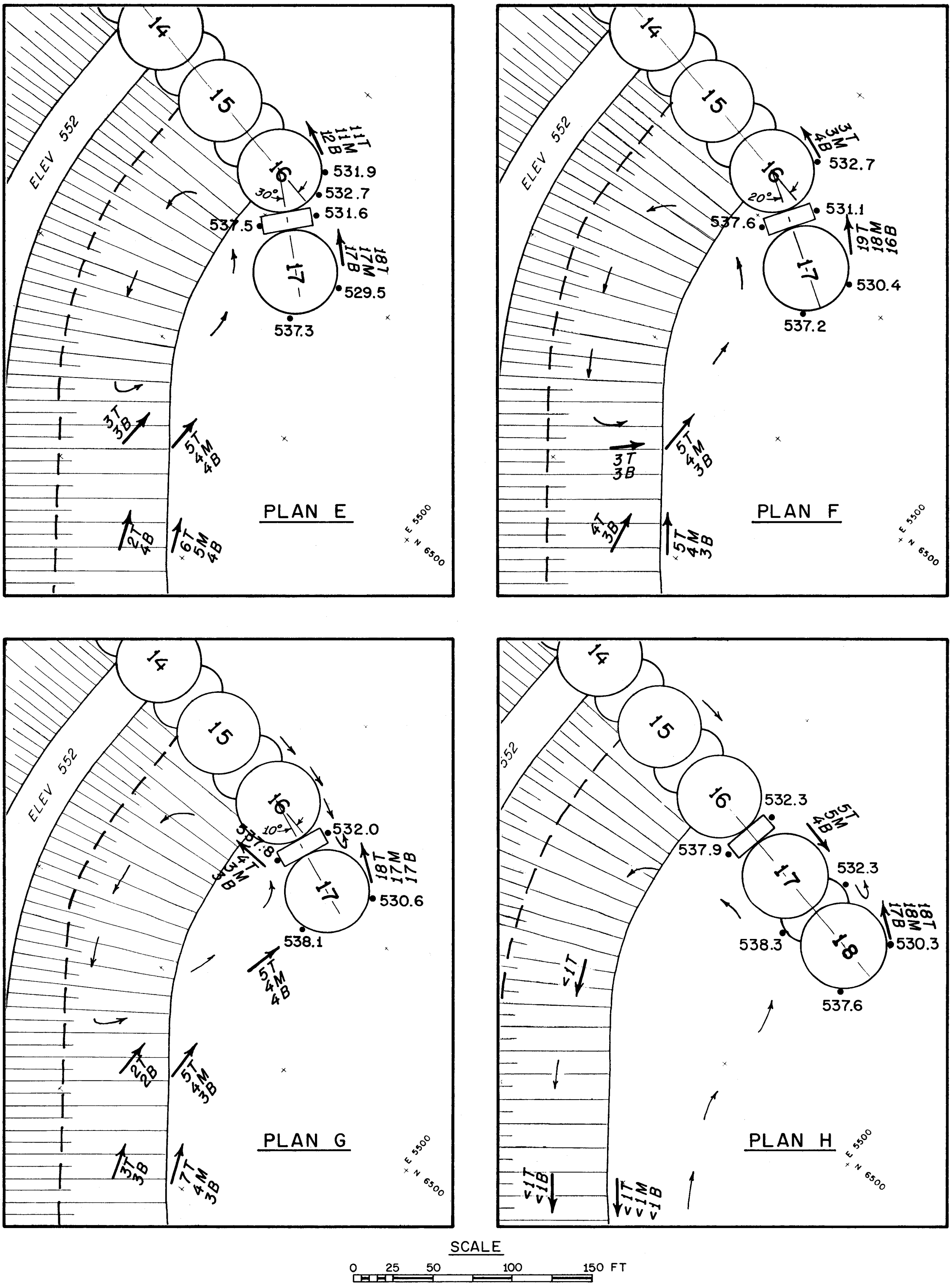
LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5-FT ABOVE BOTTOM
537.7 ●	WATER-SURFACE ELEVATION

FLOW CONDITIONS
PLAN A FIRST-STEP COFFERDAM

TEMPORARY FISHWAY PLANS A TO D

RIVER DISCHARGE 200000 CFS



LEGEND

←7 VELOCITY MEASUREMENTS IN FPS

T 5-FT DEPTH

M MID-DEPTH

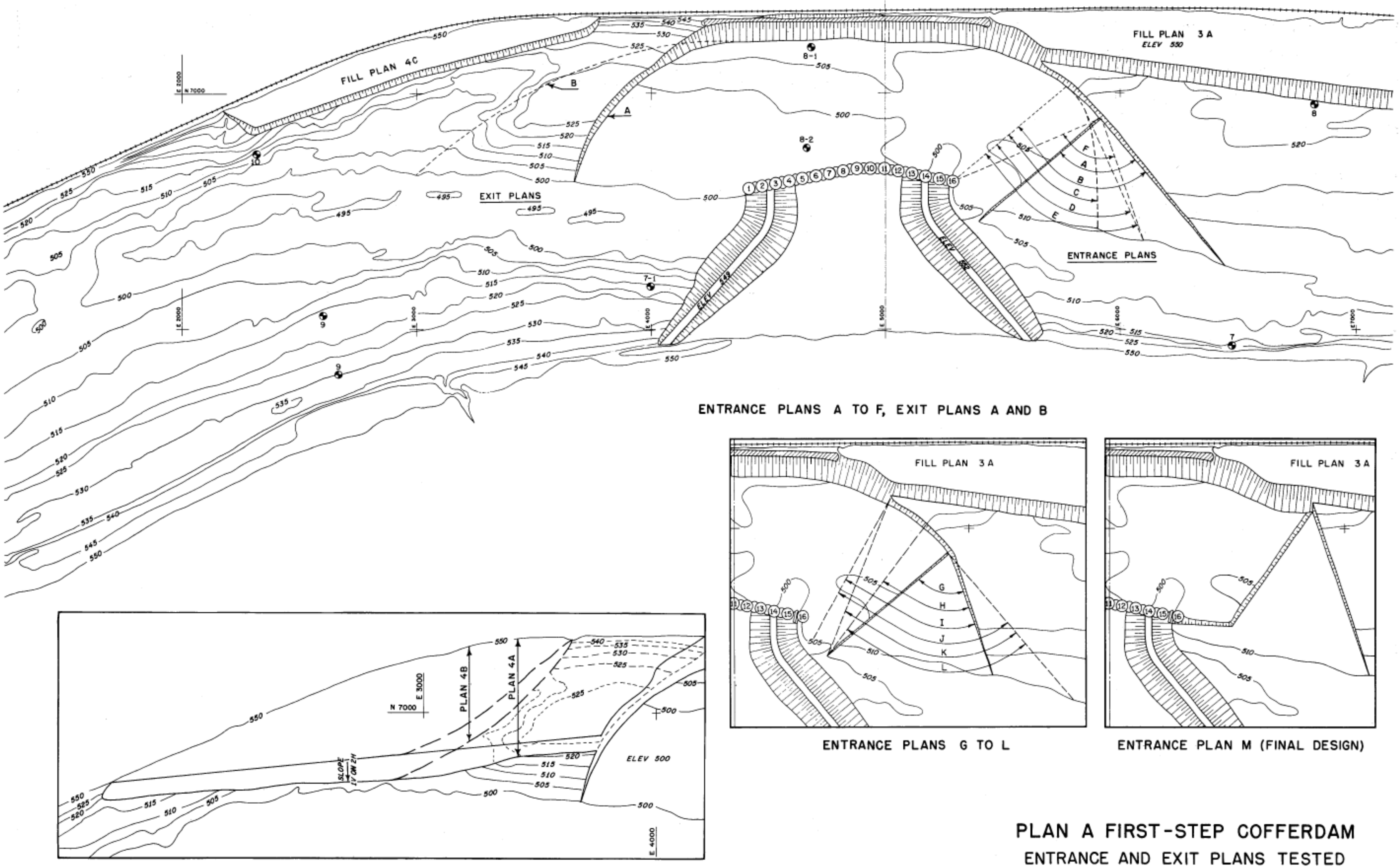
B 5 FT ABOVE BOTTOM

538.1 ● WATER-SURFACE ELEVATION

FLOW CONDITIONS

PLAN A FIRST-STEP COFFERDAM

TEMPORARY FISHWAY PLANS E TO H
RIVER DISCHARGE 200 000 CFS



ENTRANCE PLANS A TO F, EXIT PLANS A AND B

DOWNSTREAM FILL PLANS 4A AND 4B

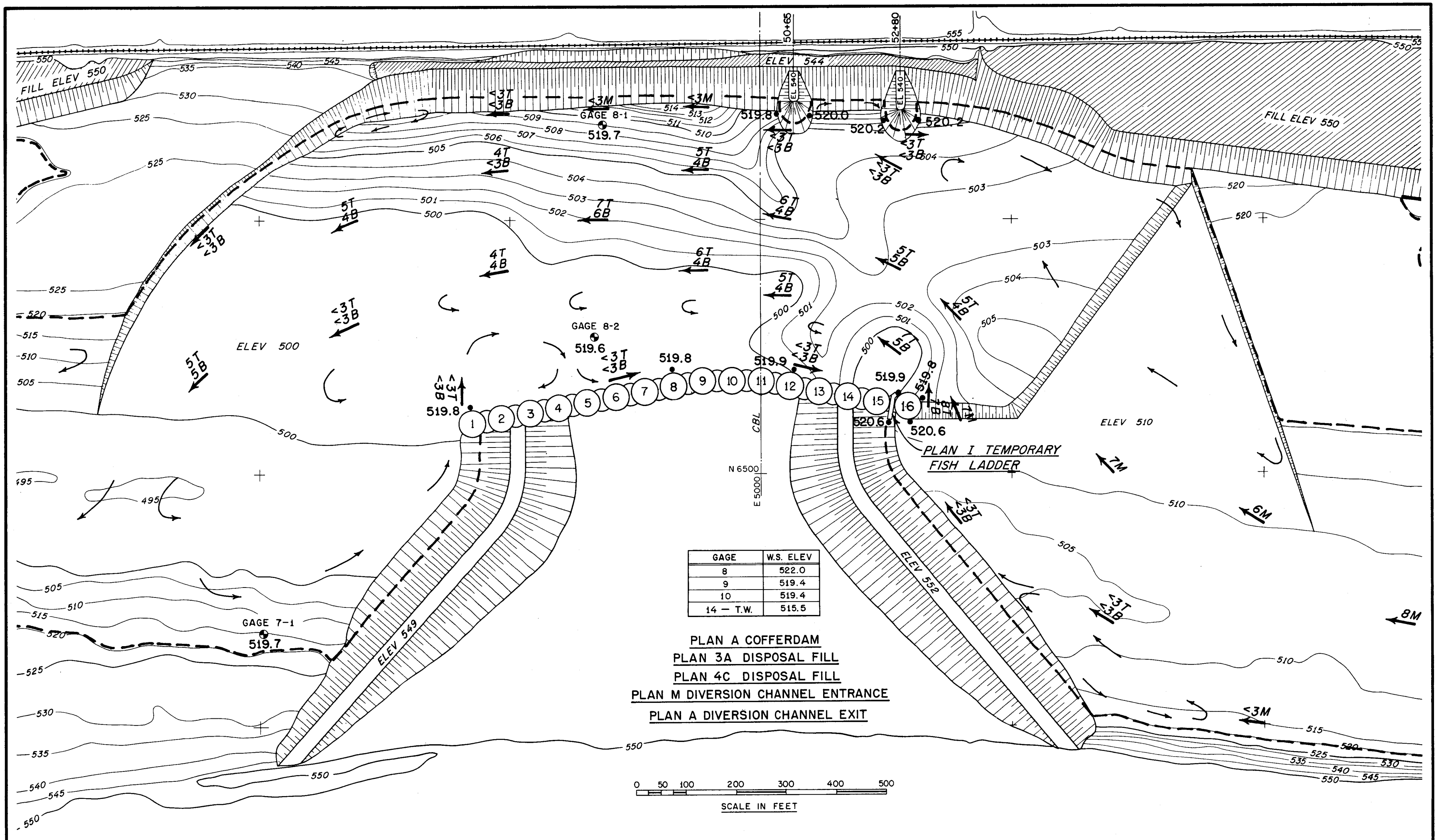
ENTRANCE PLANS G TO L

ENTRANCE PLAN M (FINAL DESIGN)

PLAN A FIRST-STEP COFFERDAM

ENTRANCE AND EXIT PLANS TESTED

DIVERSION CHANNEL PLANS A TO M



GAGE	W.S. ELEV
8	522.0
9	519.4
10	519.4
14 — T.W.	515.5

LEGEND

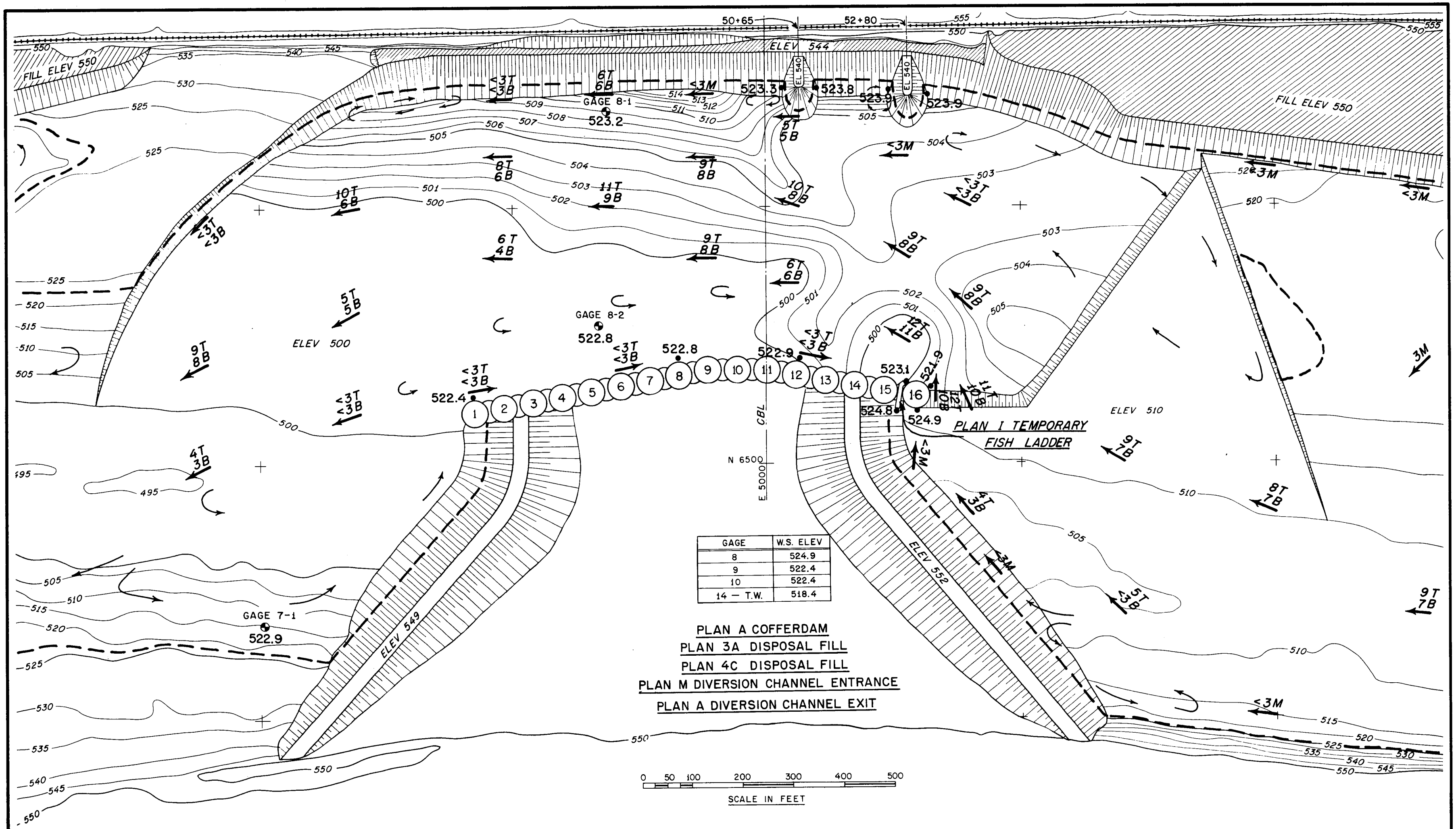
⟵ 5	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
519.8 ●	WATER-SURFACE ELEVATION

NOTES

1. DATA ARE SHOWN FOR NATURAL TAILWATER CONDITIONS.
2. SEE PLATE 9 FOR LOCATIONS OF GAGES 8 TO 10.

FLOW CONDITIONS
ADOPTED FIRST-STEP COFFERDAM AND DIVERSION CHANNEL

RIVER DISCHARGE 25 000 CFS



GAGE	W.S. ELEV
8	524.9
9	522.4
10	522.4
14 — T.W.	518.4

PLAN A COFFERDAM

PLAN 3A DISPOSAL FILL

PLAN 4C DISPOSAL FILL

PLAN M DIVERSION CHANNEL ENTRANCE

PLAN A DIVERSION CHANNEL EXIT

LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
522.4 •	WATER-SURFACE ELEVATION

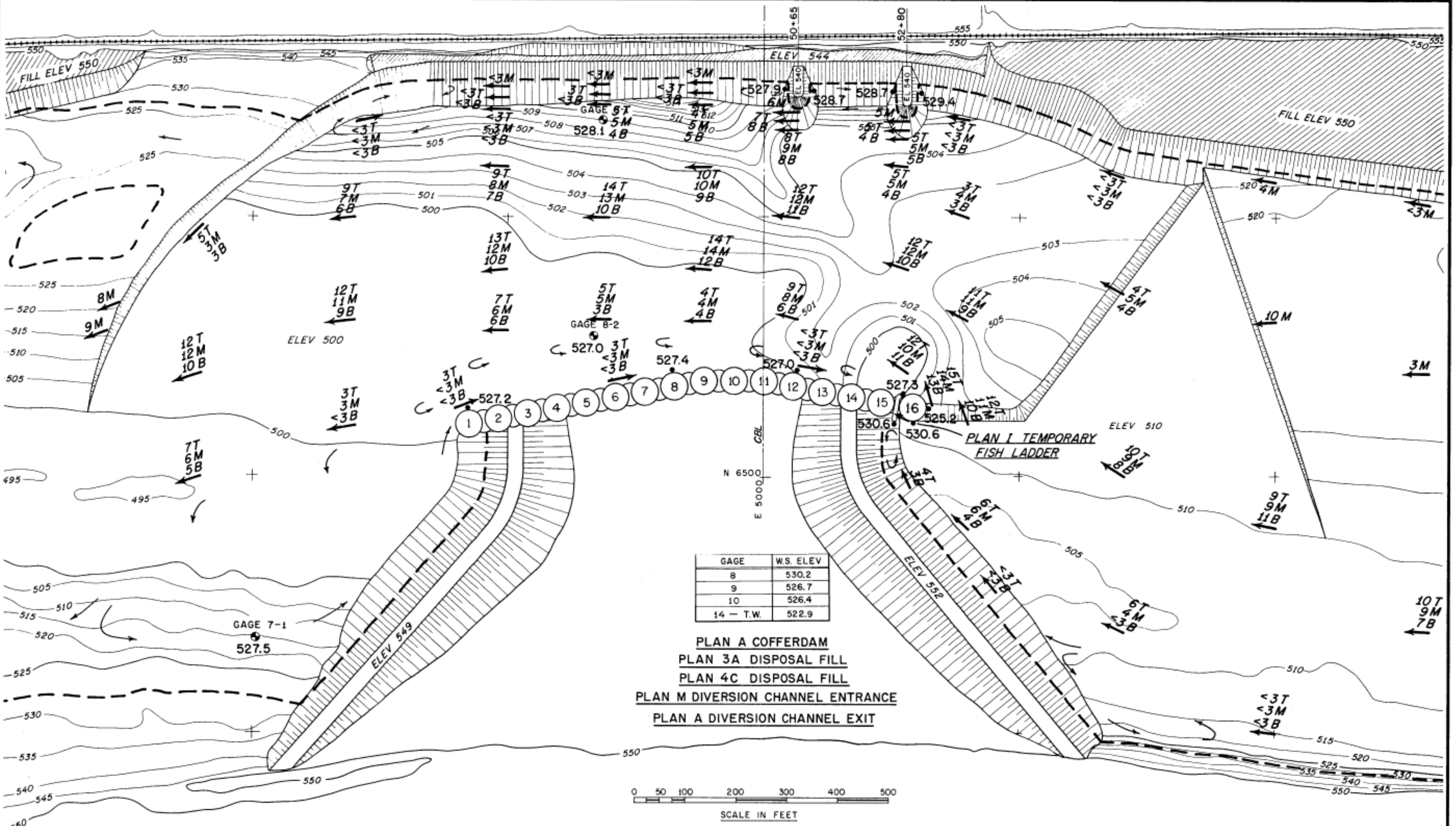
NOTES

1. DATA ARE SHOWN FOR NATURAL TAILWATER CONDITIONS.
2. SEE PLATE 9 FOR LOCATIONS OF GAGES 8 TO 10.

FLOW CONDITIONS

ADOPTED FIRST-STEP COFFERDAM AND DIVERSION CHANNEL

RIVER DISCHARGE 50 000 CFS



GAGE	W.S. ELEV
8	530.2
9	526.7
10	526.4
14 — T.W.	522.9

PLAN A COFFERDAM
PLAN 3A DISPOSAL FILL
PLAN 4C DISPOSAL FILL
PLAN M DIVERSION CHANNEL ENTRANCE
PLAN A DIVERSION CHANNEL EXIT

0 50 100 200 300 400 500
SCALE IN FEET

LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
527.2 ●	WATER-SURFACE ELEVATION

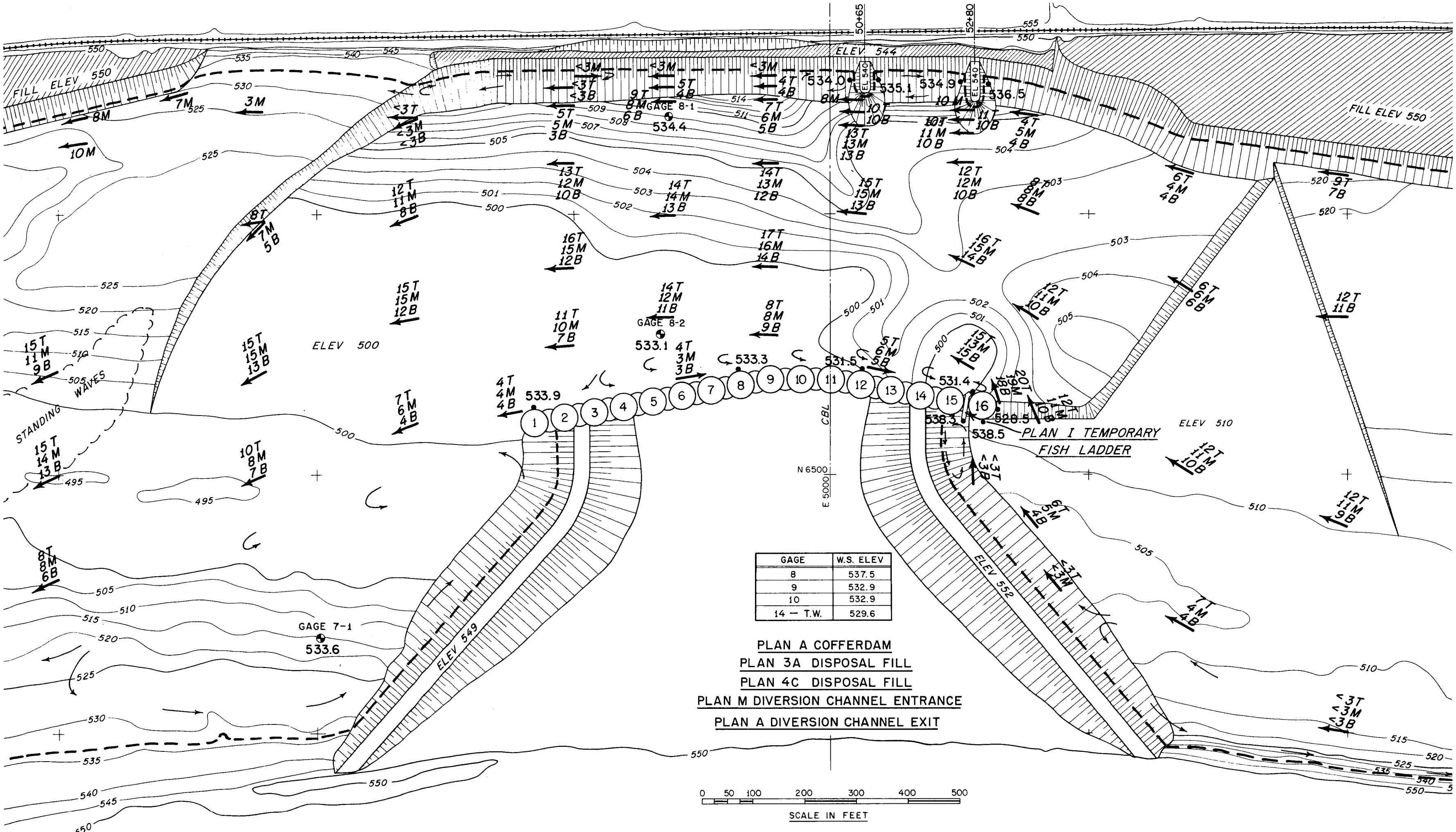
NOTES

1. DATA ARE SHOWN FOR NATURAL TAILWATER CONDITIONS.
2. SEE PLATE 9 FOR LOCATIONS OF GAGES 8 TO 10.

FLOW CONDITIONS

ADOPTED FIRST-STEP COFFERDAM
AND DIVERSION CHANNEL

RIVER DISCHARGE 100 000 CFS



GAGE	W.S. ELEV
8	537.5
9	532.9
10	532.9
14 — T.W.	529.6

PLAN A COFFERDAM

PLAN 3A DISPOSAL FILL

PLAN 4C DISPOSAL FILL

PLAN M DIVERSION CHANNEL ENTRANCE

PLAN A DIVERSION CHANNEL EXIT

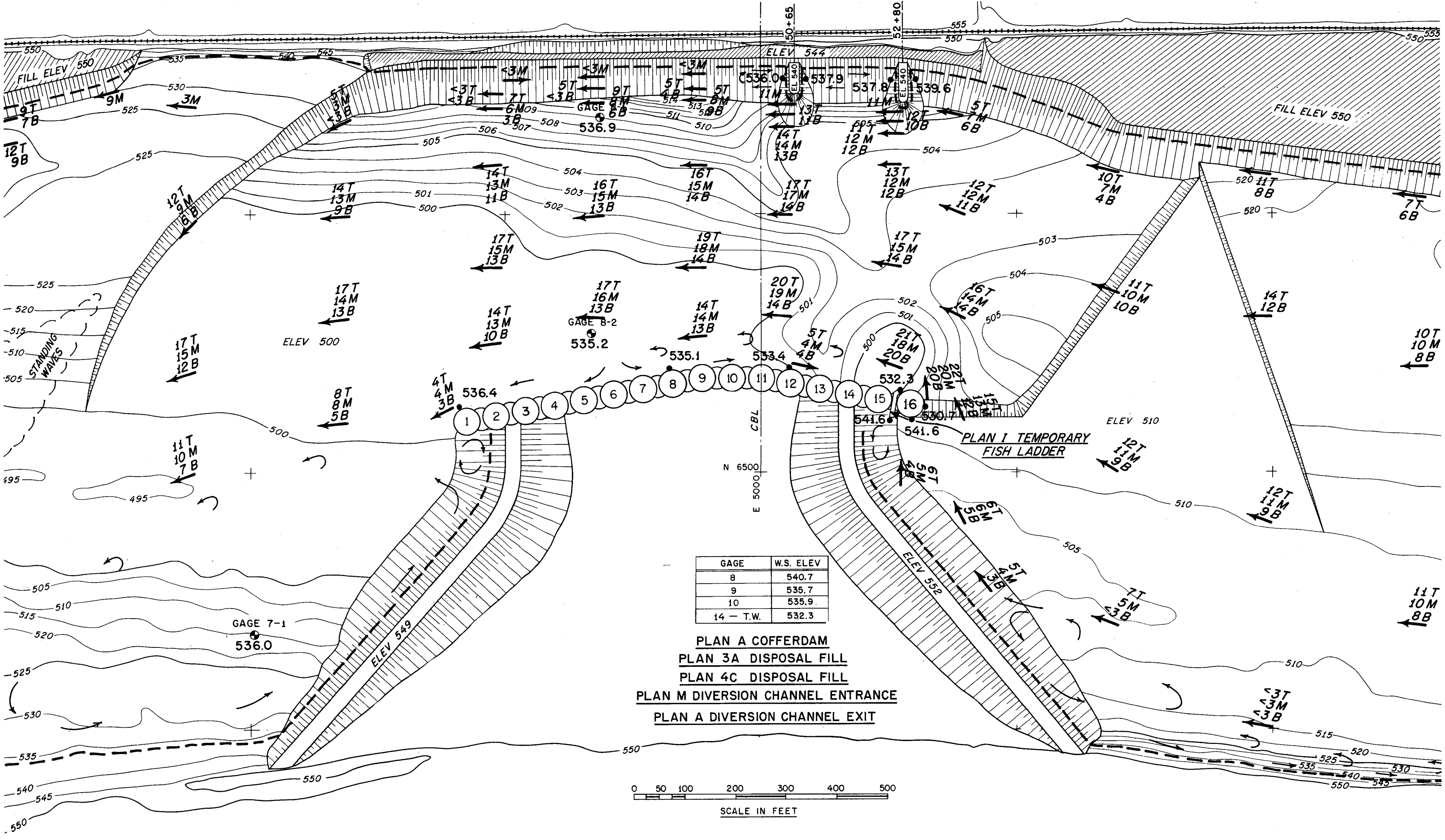
LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
531.4 ●	WATER-SURFACE ELEVATION

NOTES

1. DATA ARE SHOWN FOR NATURAL TAILWATER CONDITIONS.
2. SEE PLATE 9 FOR LOCATIONS OF GAGES 8 TO 10.

FLOW CONDITIONS
ADOPTED FIRST-STEP COFFERDAM AND DIVERSION CHANNEL
RIVER DISCHARGE 200 000 CFS



GAGE	W.S. ELEV
8	540.7
9	535.7
10	535.9
14 — T.W.	532.3

PLAN A COFFERDAM
PLAN 3A DISPOSAL FILL
PLAN 4C DISPOSAL FILL
PLAN M DIVERSION CHANNEL ENTRANCE
PLAN A DIVERSION CHANNEL EXIT

LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
536.4●	WATER-SURFACE ELEVATION

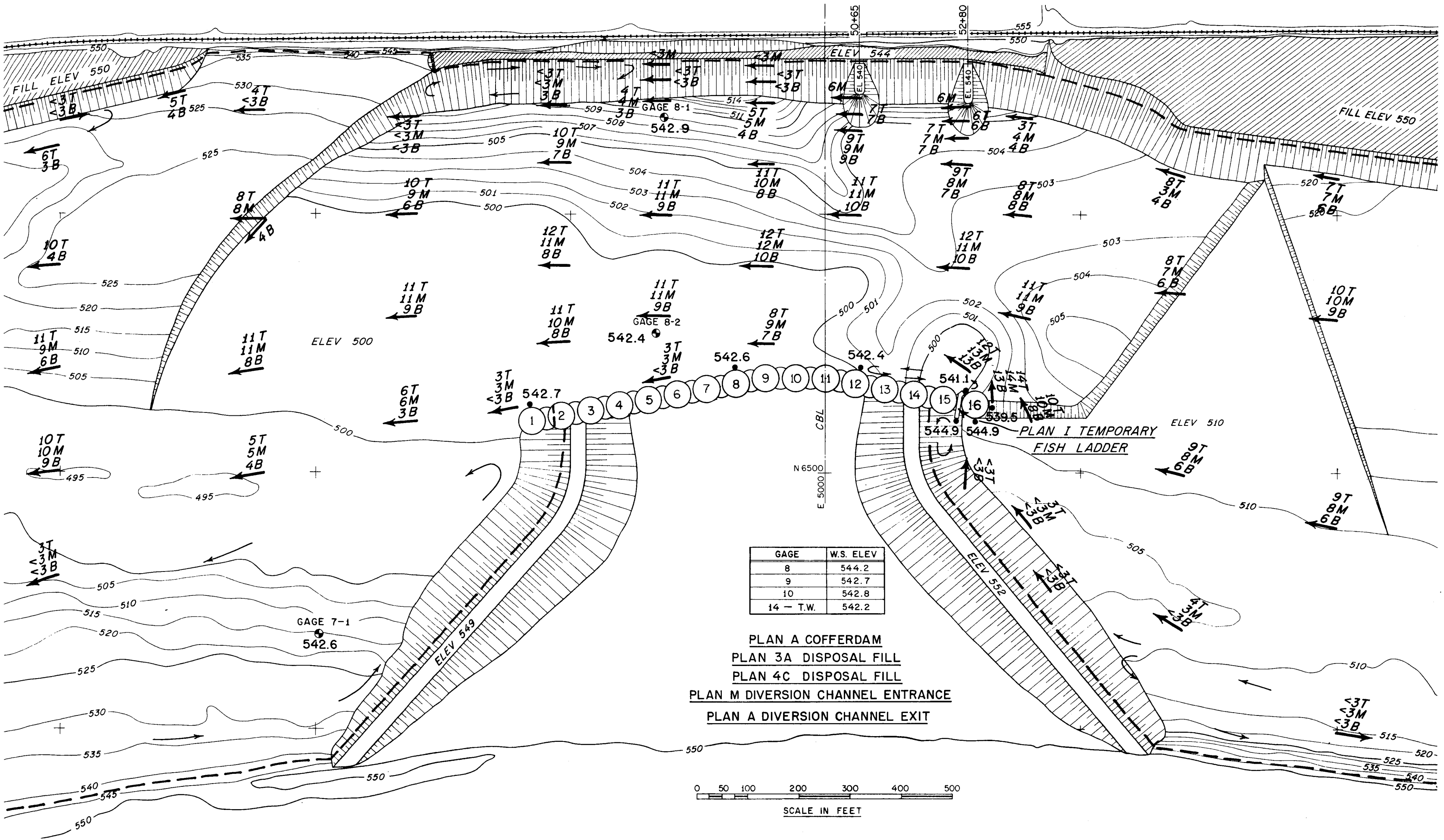
NOTES

1. DATA ARE SHOWN FOR NATURAL TAILWATER CONDITIONS
2. SEE PLATE 9 FOR LOCATIONS OF GAGES 8 TO 10.

FLOW CONDITIONS

ADOPTED FIRST-STEP COFFERDAM
AND DIVERSION CHANNEL

RIVER DISCHARGE 250 000 CFS



GAGE	W.S. ELEV
8	544.2
9	542.7
10	542.8
14 — T.W.	542.2

PLAN A COFFERDAM
PLAN 3A DISPOSAL FILL
PLAN 4C DISPOSAL FILL
PLAN M DIVERSION CHANNEL ENTRANCE
PLAN A DIVERSION CHANNEL EXIT

LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
542.6 ●	WATER-SURFACE ELEVATION

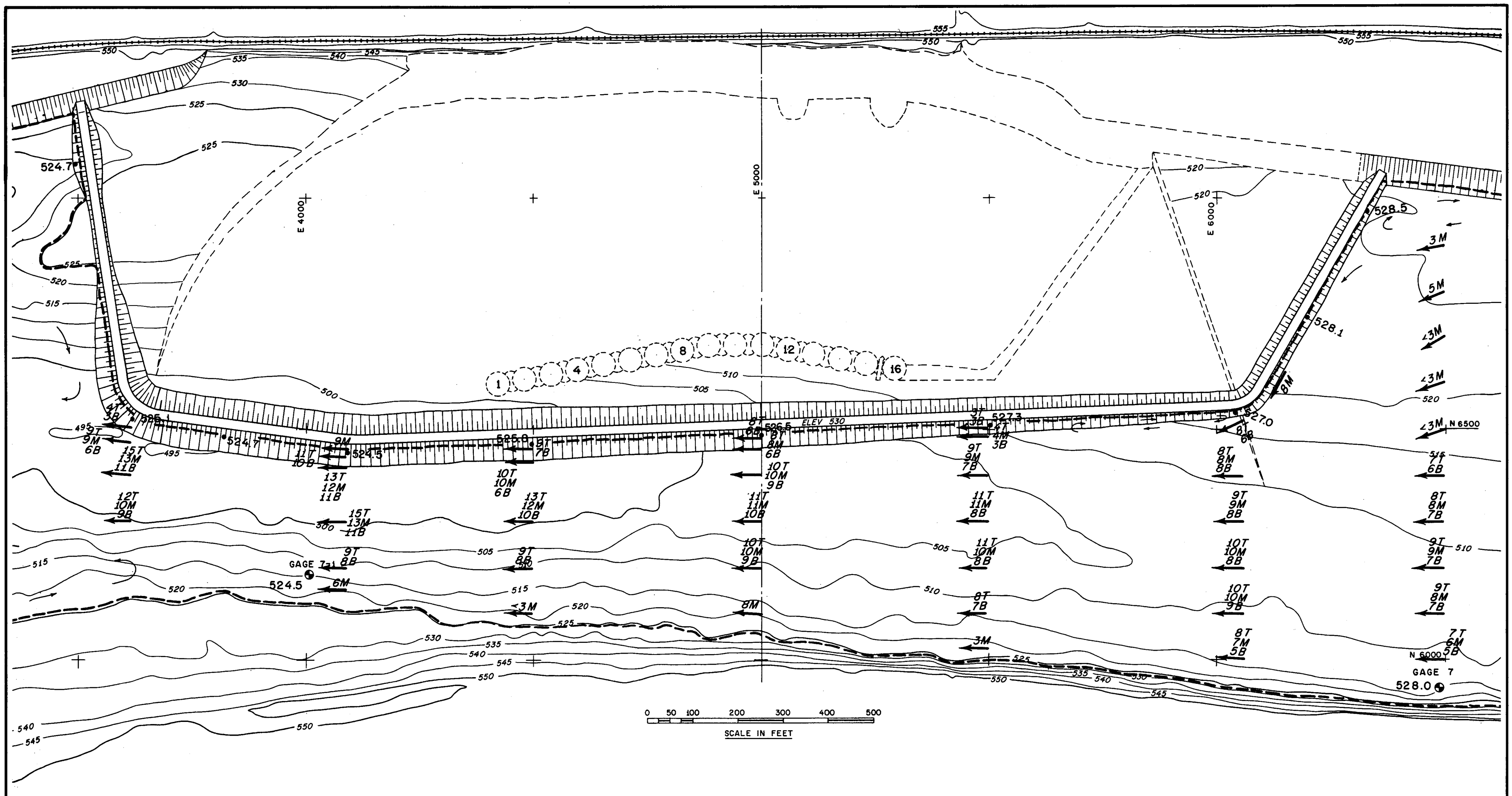
NOTE

SEE PLATE 9 FOR LOCATIONS OF GAGES 8 TO 10.

FLOW CONDITIONS

ADOPTED FIRST-STEP COFFERDAM AND DIVERSION CHANNEL

RIVER DISCHARGE 200 000 CFS
LOWER MONUMENTAL POOL ELEV 540



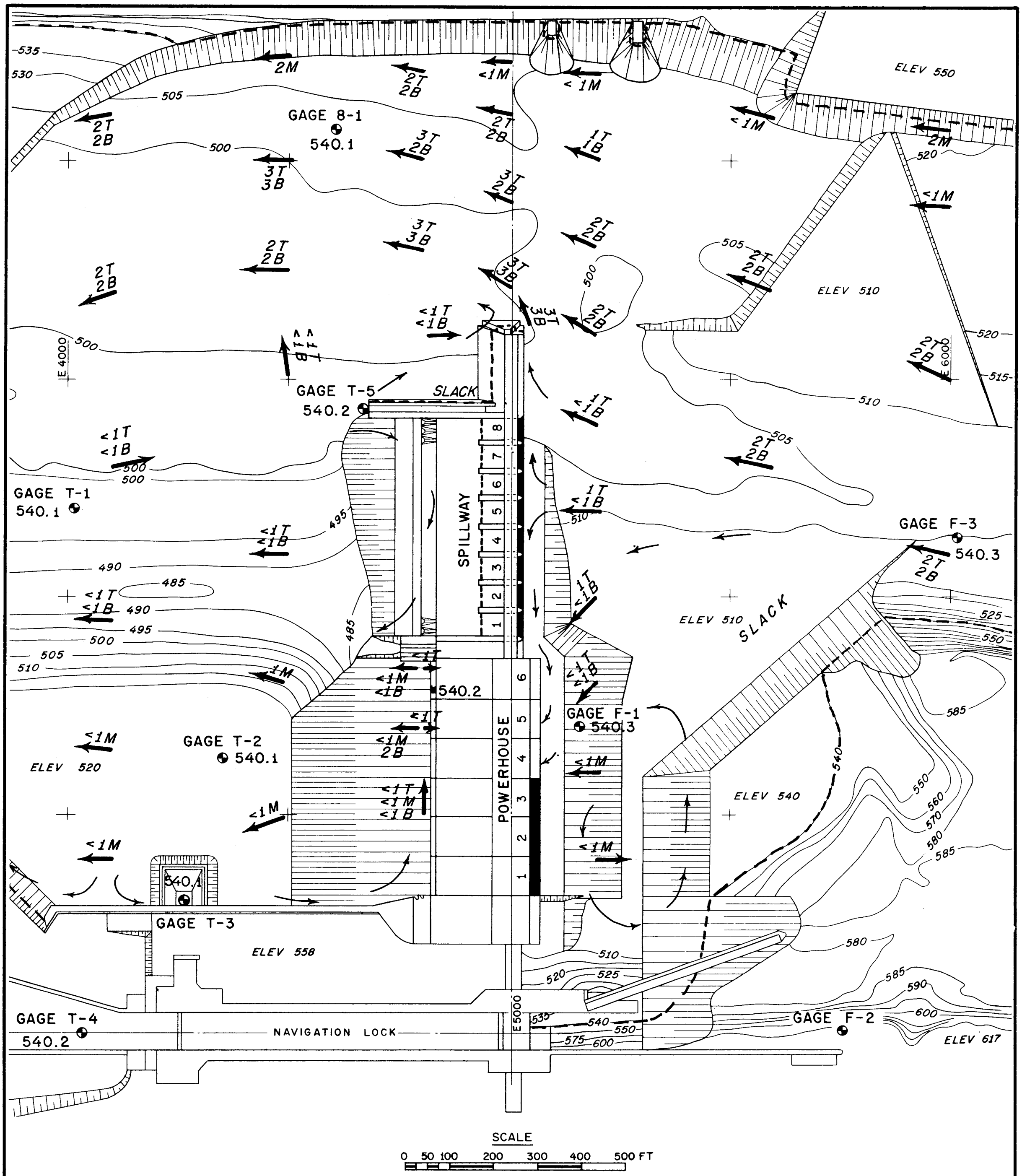
LEGEND

← 6	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
525.8 •	WATER-SURFACE ELEVATION

FLOW CONDITIONS

CONTRACTORS DIKE
FIRST-STEP COFFERDAM

RIVER DISCHARGE 75 000 CFS



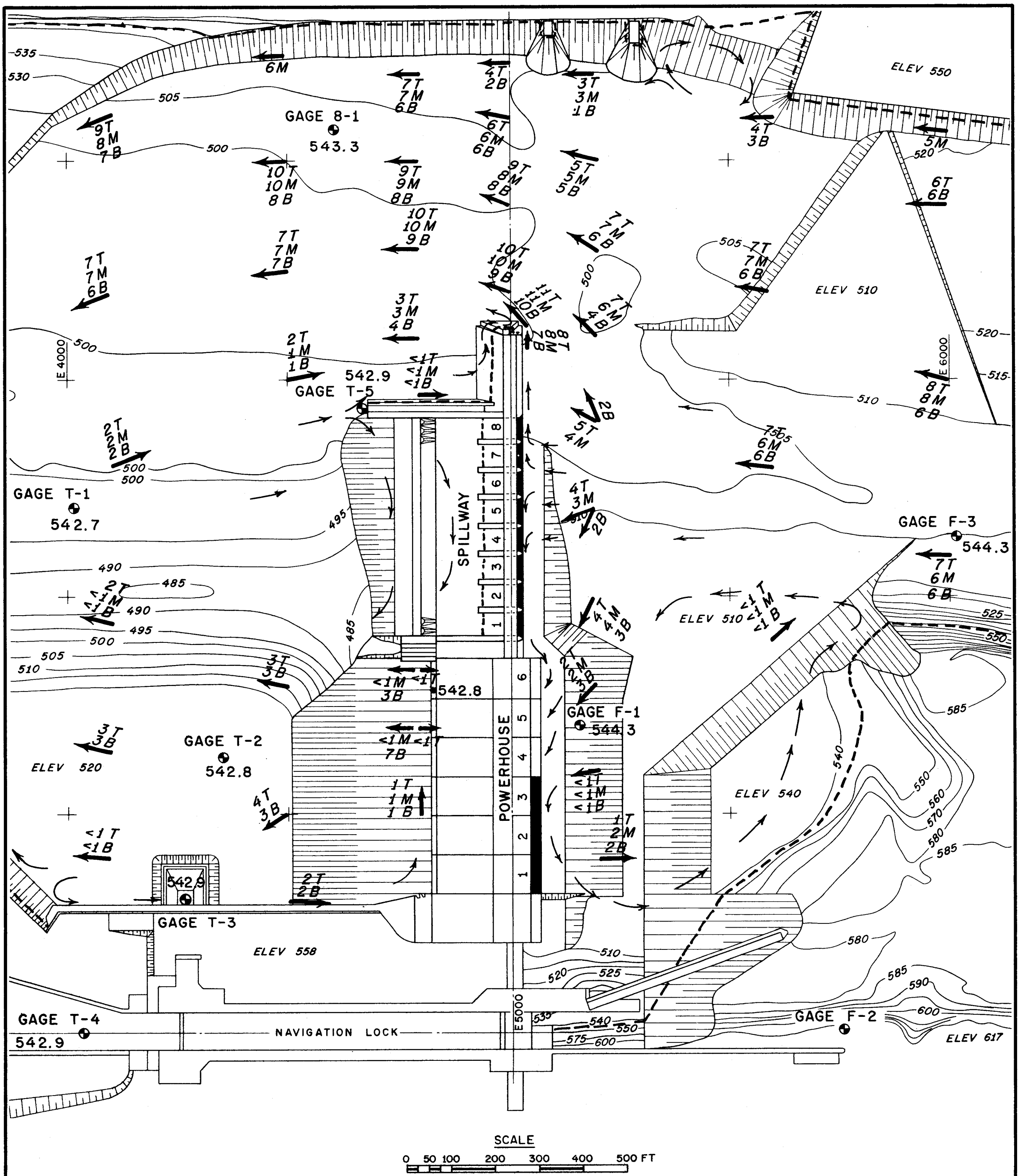
LEGEND

- $\xleftarrow{4}$ VELOCITY MEASUREMENTS IN FPS
- T 5- FT DEPTH
- M MID-DEPTH
- B 5 FT ABOVE BOTTOM
- 540.1 ● WATER-SURFACE ELEVATIONS

FLOW CONDITIONS

PHASE I, SECOND-STEP DIVERSION

RIVER DISCHARGE 50 000 CFS



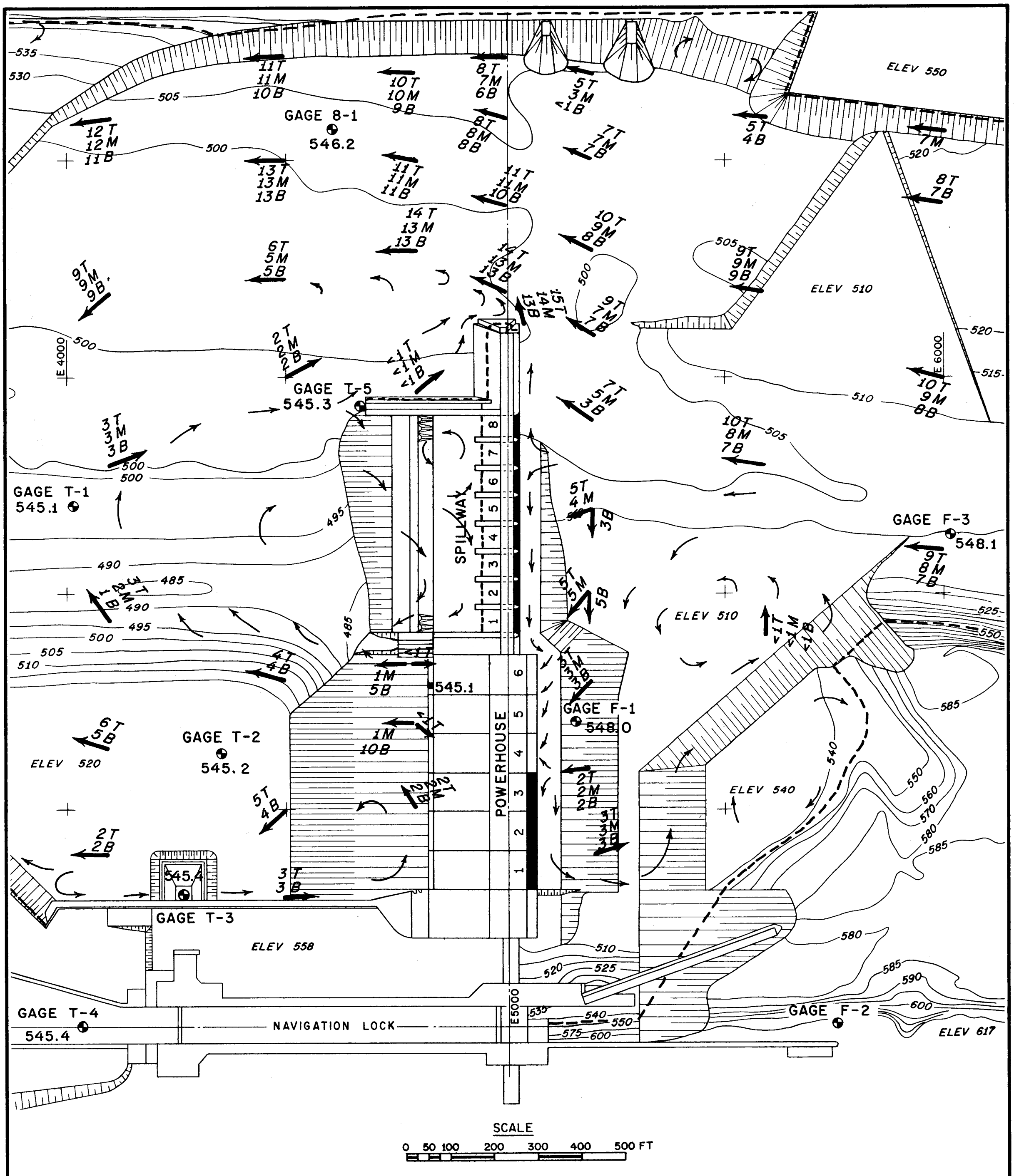
LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
542.8 ●	WATER-SURFACE ELEVATIONS

FLOW CONDITIONS

PHASE I, SECOND-STEP DIVERSION

RIVER DISCHARGE 200 000 CFS



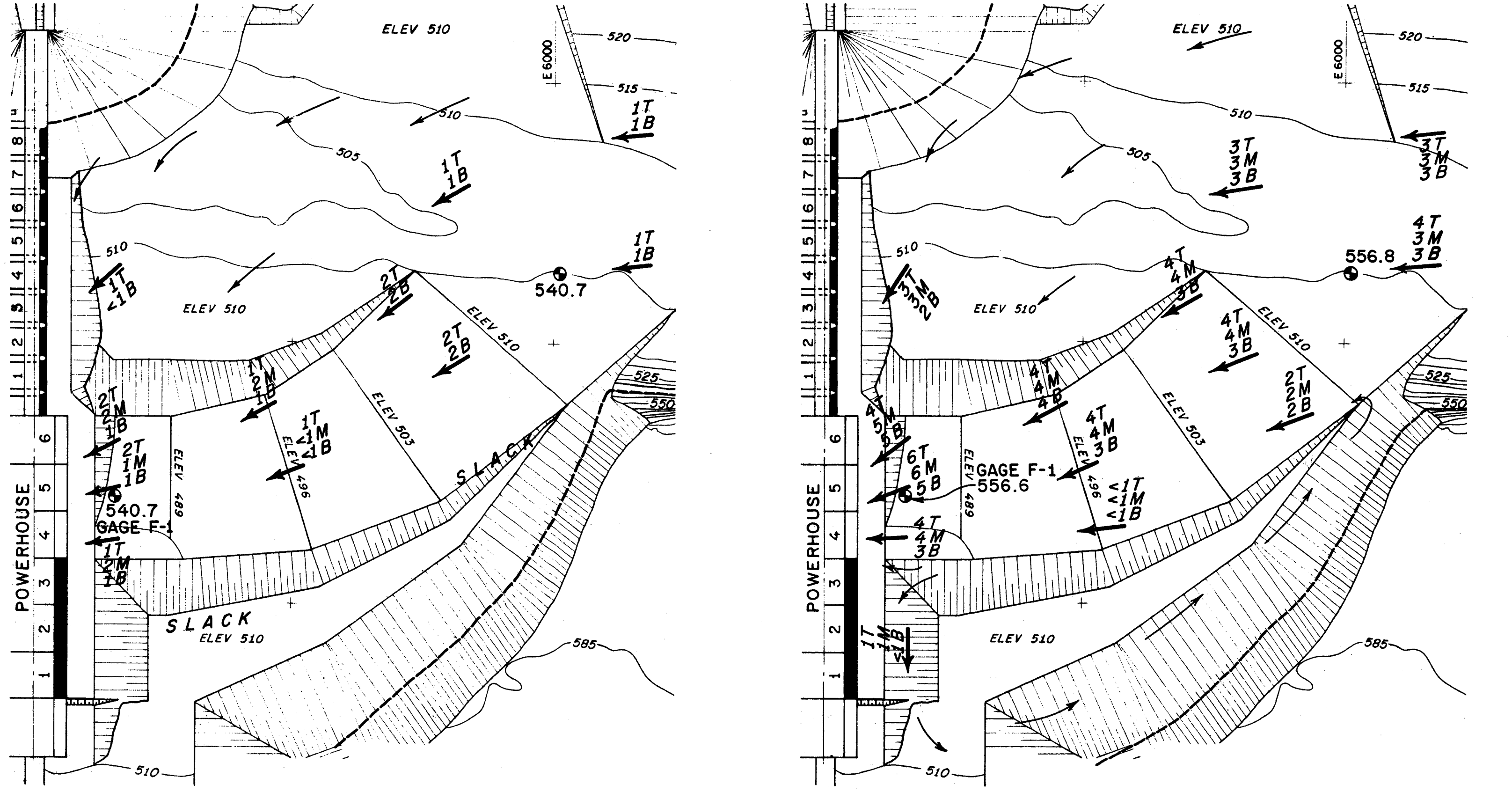
LEGEND

- 4 VELOCITY MEASUREMENTS IN FPS
- T 5-FT DEPTH
- M MID-DEPTH
- B 5 FT ABOVE BOTTOM
- 545.1 ● WATER-SURFACE ELEVATIONS

FLOW CONDITIONS

PHASE I, SECOND-STEP DIVERSION

RIVER DISCHARGE 300000 CFS



RIVER DISCHARGE 25 000 CFS

HEAD ON POWERHOUSE 0.7 FT, TAILWATER ELEV 540.0 AT UNIT 6

RIVER DISCHARGE 120 000 CFS

HEAD ON POWERHOUSE 16.1 FT, TAILWATER ELEV 540.5 AT UNIT 6

SCALE

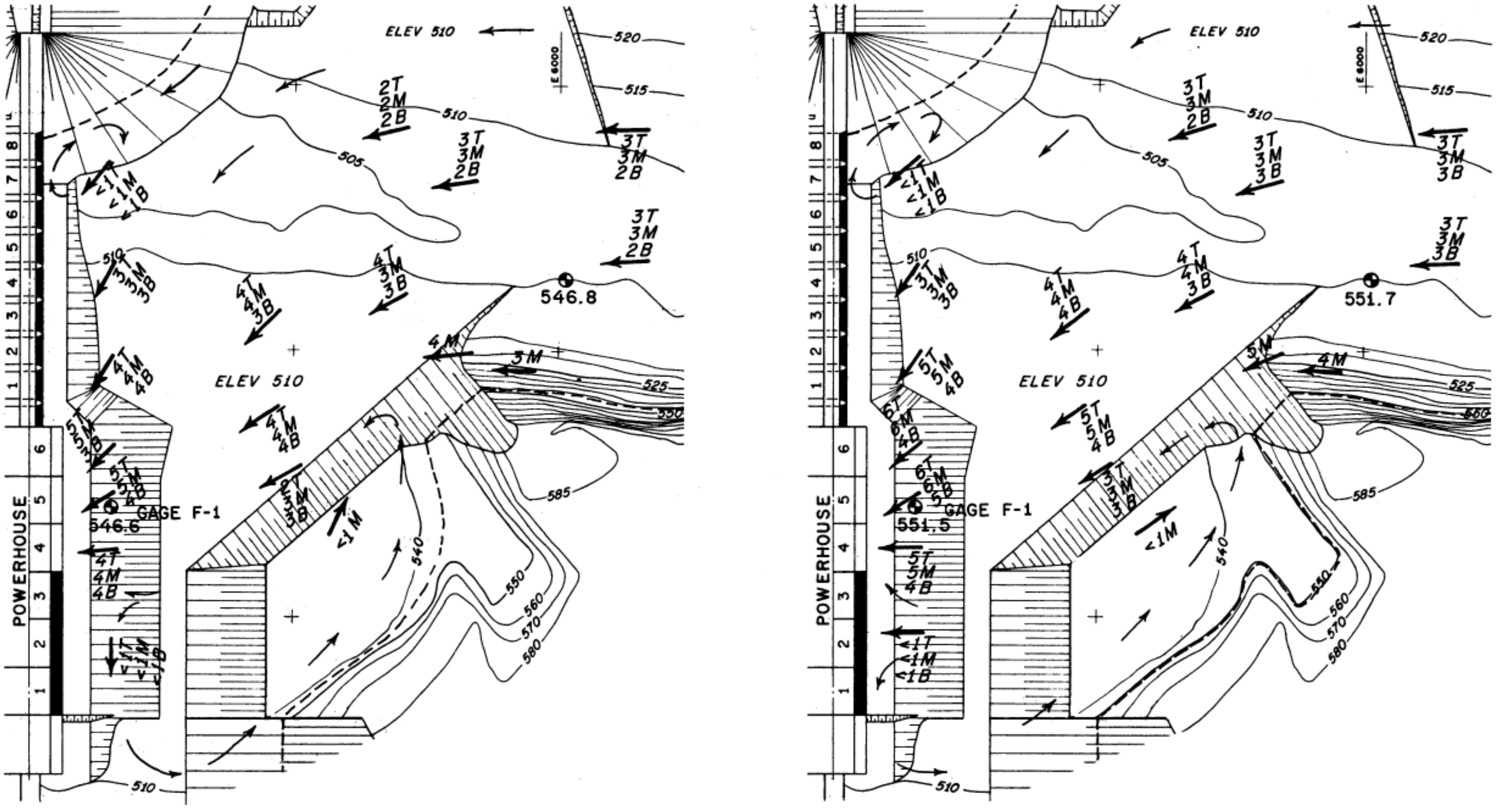
0 50 100 200 300 400 500 FT

LEGEND

← 7	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM

FLOW CONDITIONS

PHASE II SECOND-STEP DIVERSION
PLAN A DIVERSION CHANNEL



RIVER DISCHARGE 75 000 CFS

HEAD ON POWERHOUSE 6.3 FT, TAILWATER ELEV 540.3 AT UNIT 6

RIVER DISCHARGE 100 000 CFS

HEAD ON POWERHOUSE 11.1 FT, TAILWATER ELEV 540.4 AT UNIT 6

SCALE

0 50 100 200 300 400 500 FT

LEGEND

7 ← VELOCITY MEASUREMENTS IN FPS

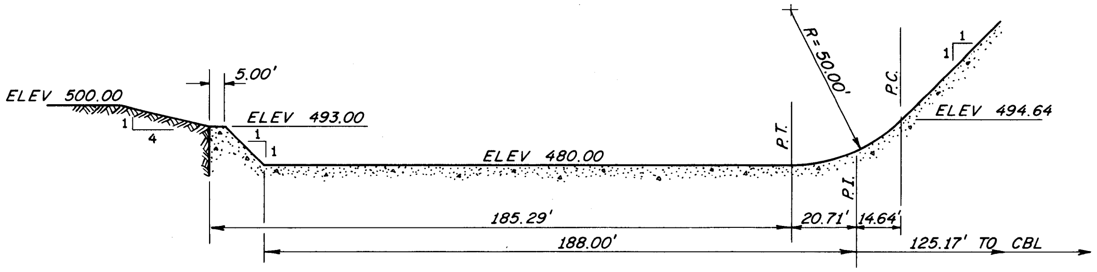
T 5-FT DEPTH

M MID-DEPTH

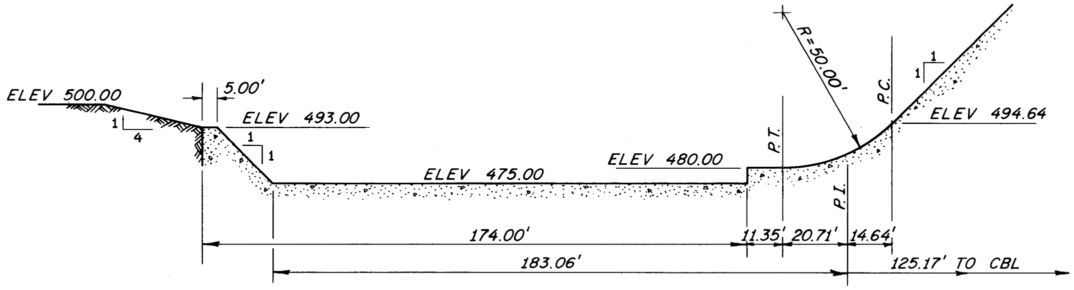
B 5 FT ABOVE BOTTOM

FLOW CONDITIONS

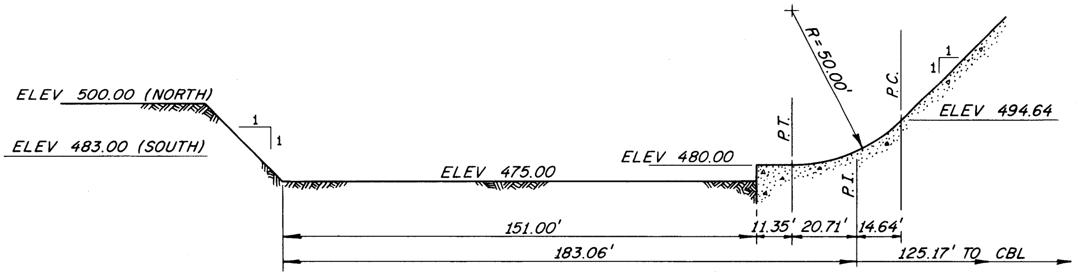
PHASE II SECOND-STEP DIVERSION
PLAN G DIVERSION CHANNEL



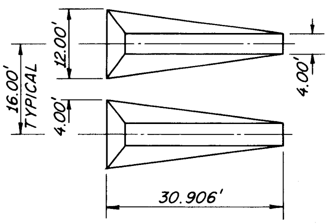
PLAN A
(ORIGINAL DESIGN)



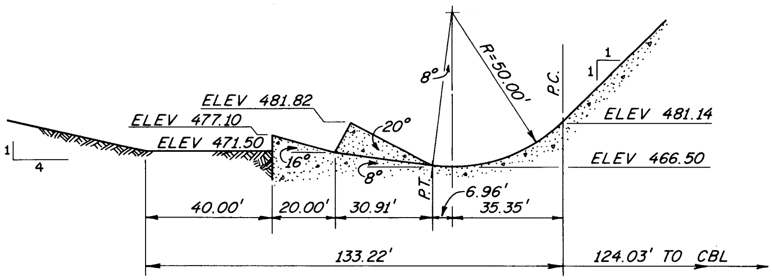
PLAN B



PLAN D



BUCKET TOOTH DETAIL



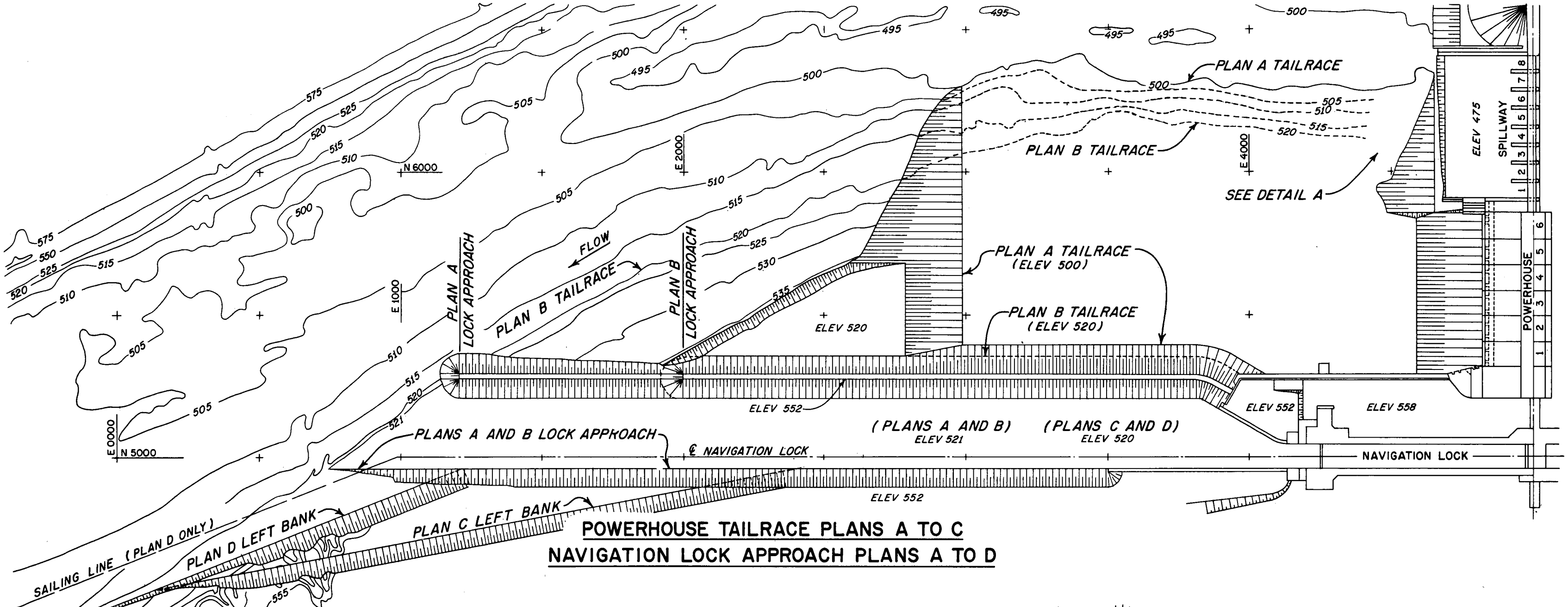
PLAN P-6
(FINAL DESIGN)

NOTES

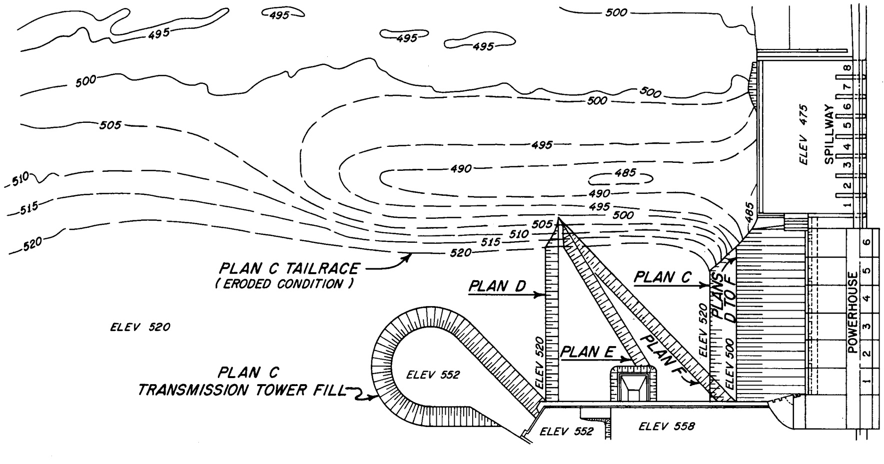
1. BASIN WIDTH 498.00 FT.
2. DOWNSTREAM TOPOGRAPHY SAME FOR PLANS D AND P-6.

STILLING BASIN PLANS A, B, AND D

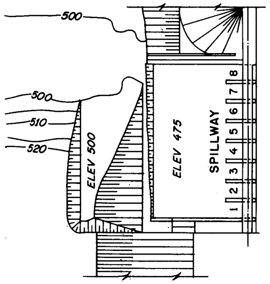
ROLLER BUCKET PLAN P-6



POWERHOUSE TAILRACE PLANS A TO C
NAVIGATION LOCK APPROACH PLANS A TO D



POWERHOUSE TAILRACE PLANS C TO F



DETAIL A
(PLAN B TAILRACE)

NOTES

1. ASSUMED EROSION FROM SPILLWAY USE WAS SIMULATED WITH TAILRACE PLANS C TO F.
2. STILLING BASIN DESIGN VARIED. SEE PLATE 22.
3. PLAN C TRANSMISSION TOWER FILL TESTED WITH NAVIGATION LOCK APPROACH PLANS C AND D AND POWERHOUSE TAILRACE PLANS C TO F.

CHANNEL LAYOUTS
POWERHOUSE TAILRACE PLANS A TO F
NAVIGATION LOCK APPROACH PLANS A TO D

SCALE
0 100 200 300 400 500 FT

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	49 925 CFS
SPILLWAY CLOSED	0 CFS
FISH LADDER	75 CFS

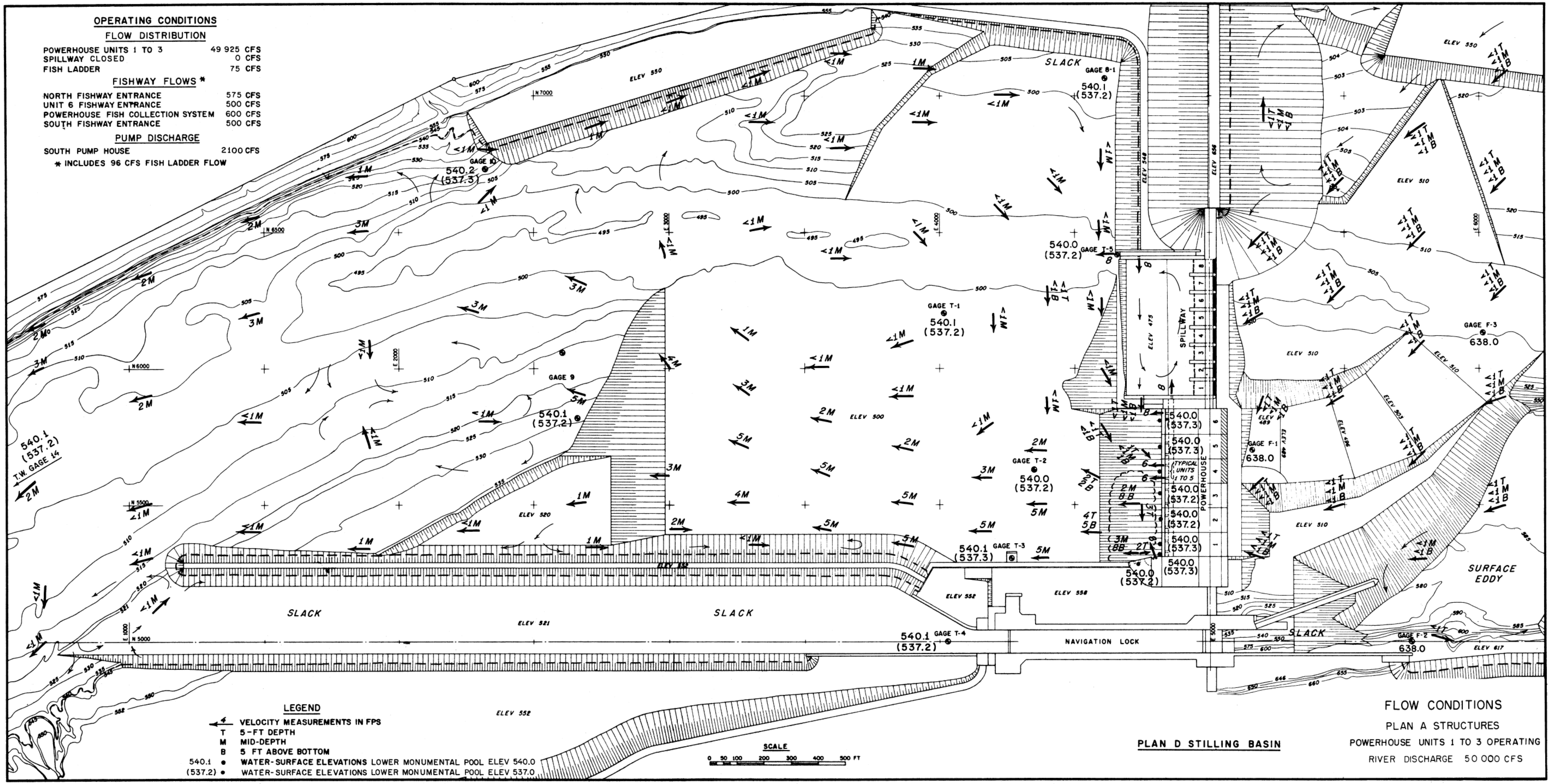
FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	575 CFS
UNIT 6 FISHWAY ENTRANCE	500 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	500 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2100 CFS

* INCLUDES 96 CFS FISH LADDER FLOW



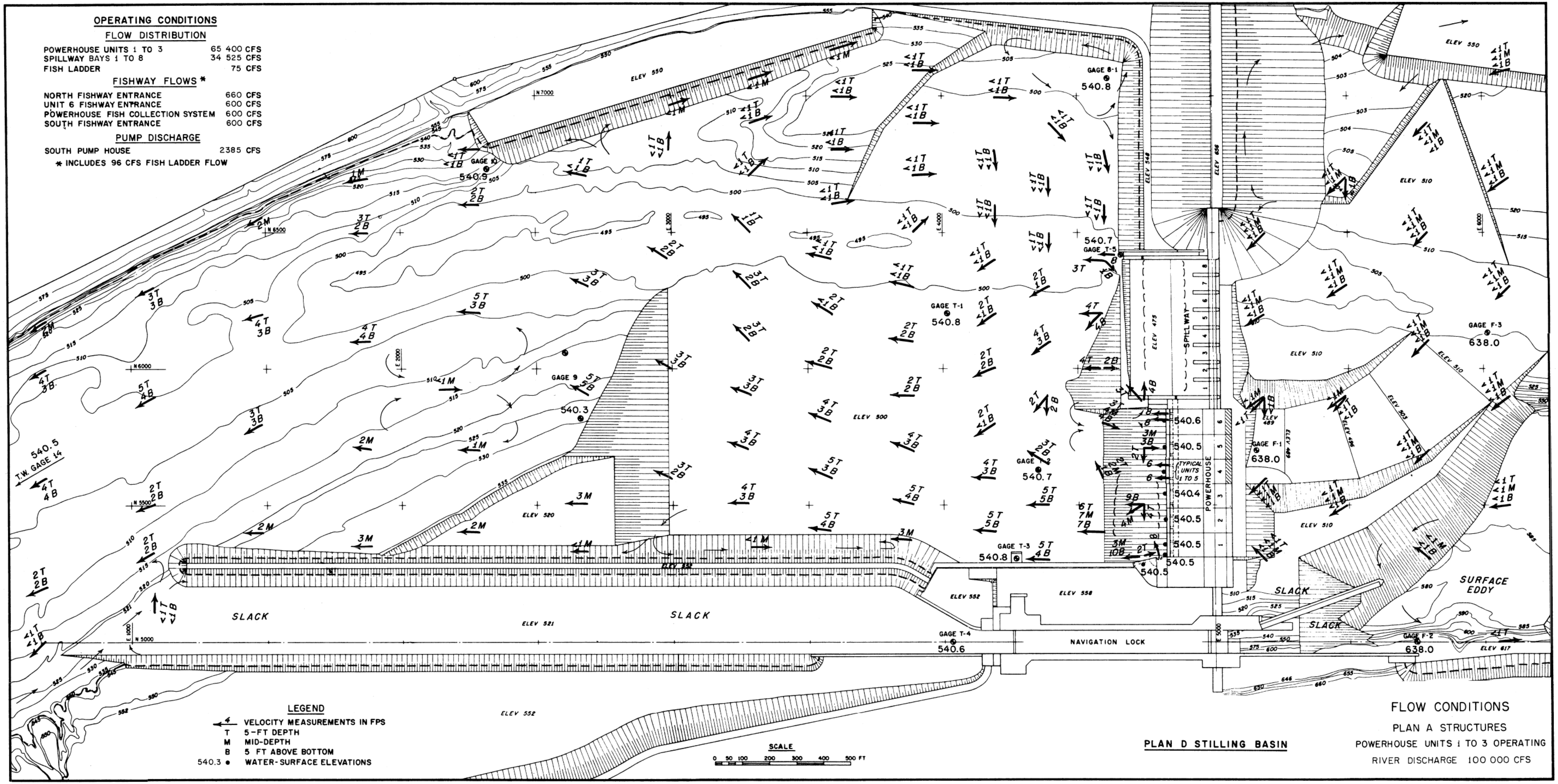
LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.1 ●	WATER-SURFACE ELEVATIONS LOWER MONUMENTAL POOL ELEV 540.0
(537.2) ●	WATER-SURFACE ELEVATIONS LOWER MONUMENTAL POOL ELEV 537.0

PLAN D STILLING BASIN

FLOW CONDITIONS

PLAN A STRUCTURES
POWERHOUSE UNITS 1 TO 3 OPERATING
RIVER DISCHARGE 50 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	65 400 CFS
SPILLWAY BAYS 1 TO 8	34 525 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	660 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2385 CFS

* INCLUDES 96 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.3 ●	WATER-SURFACE ELEVATIONS

SCALE

0 50 100 200 300 400 500 FT

PLAN D STILLING BASIN

FLOW CONDITIONS

PLAN A STRUCTURES

POWERHOUSE UNITS 1 TO 3 OPERATING

RIVER DISCHARGE 100 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	66 300 CFS
SPILLWAY BAYS 1 TO 8	83 625 CFS
FISH LADDER	75 CFS

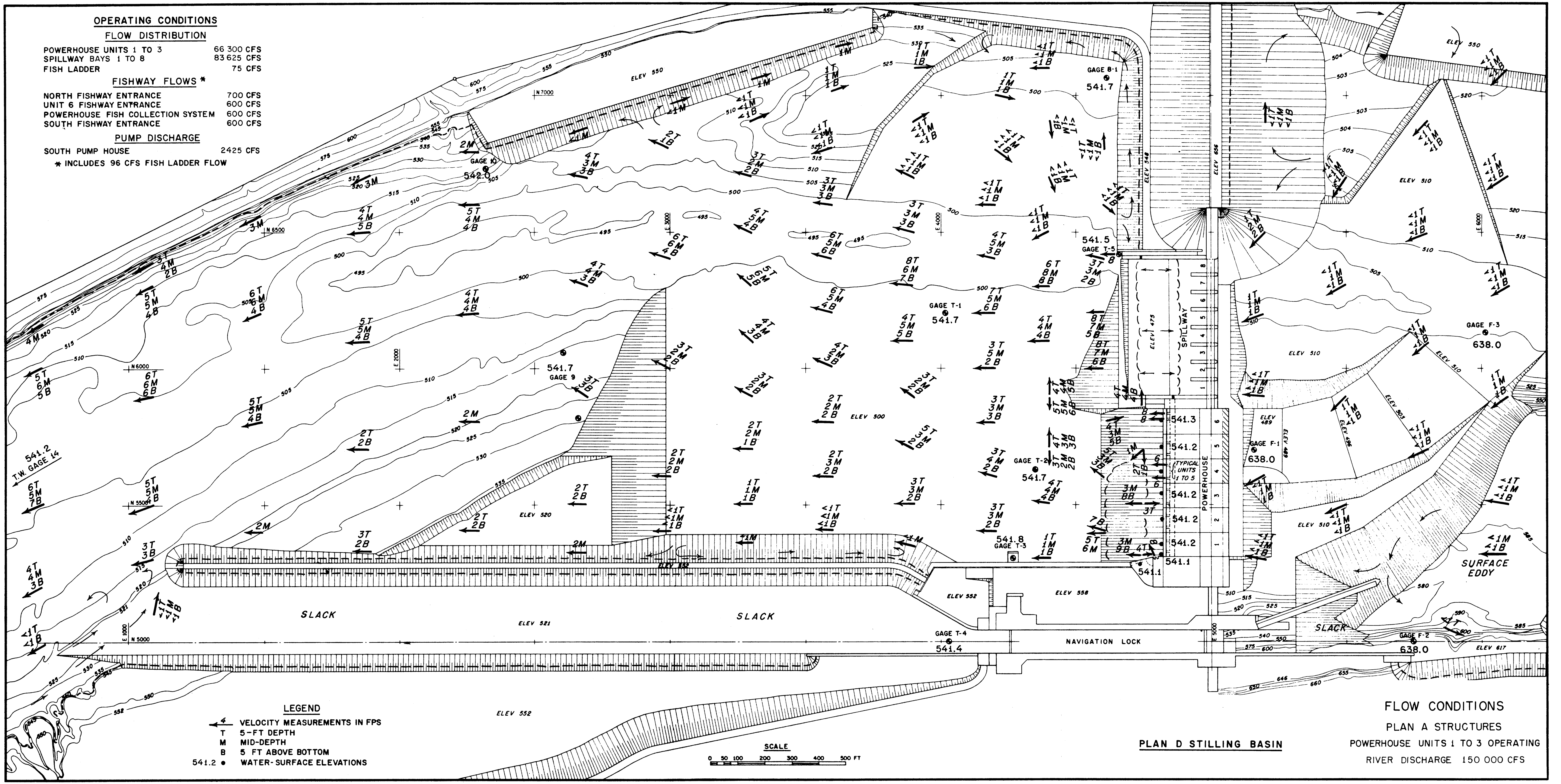
FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	700 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2425 CFS

* INCLUDES 96 CFS FISH LADDER FLOW



LEGEND

- 4 VELOCITY MEASUREMENTS IN FPS
- T 5-FT DEPTH
- M MID-DEPTH
- B 5 FT ABOVE BOTTOM
- 541.2 ● WATER-SURFACE ELEVATIONS

PLAN D STILLING BASIN

FLOW CONDITIONS

PLAN A STRUCTURES

POWERHOUSE UNITS 1 TO 3 OPERATING

RIVER DISCHARGE 150 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	67 800 CFS
SPILLWAY BAYS 1 TO 8	157 125 CFS
FISH LADDER	75 CFS

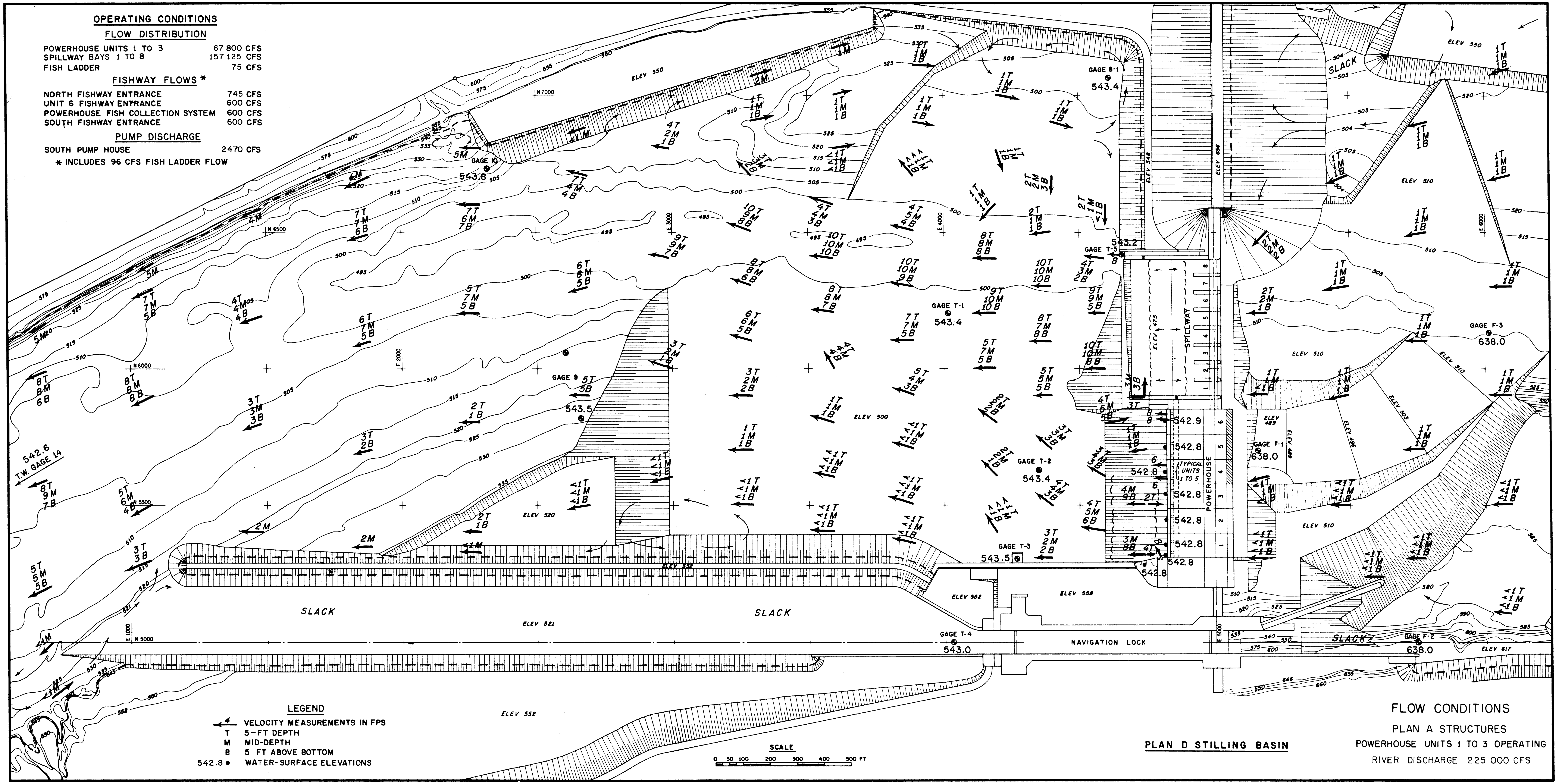
FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	745 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2470 CFS

* INCLUDES 96 CFS FISH LADDER FLOW



LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
542.8 ●	WATER-SURFACE ELEVATIONS

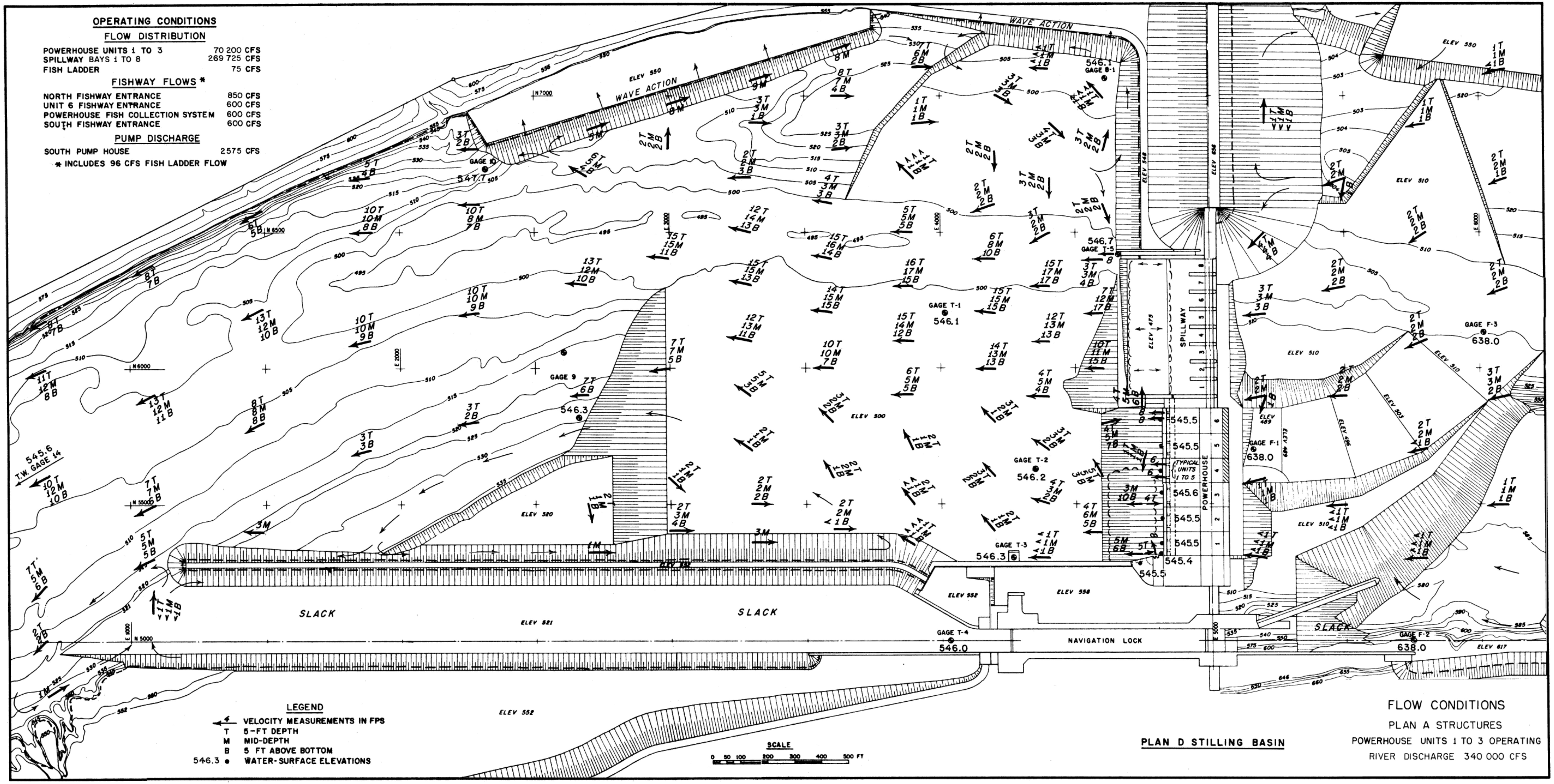
PLAN D STILLING BASIN

FLOW CONDITIONS

PLAN A STRUCTURES

POWERHOUSE UNITS 1 TO 3 OPERATING

RIVER DISCHARGE 225 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	70 200 CFS
SPILLWAY BAYS 1 TO 8	269 725 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	850 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2575 CFS

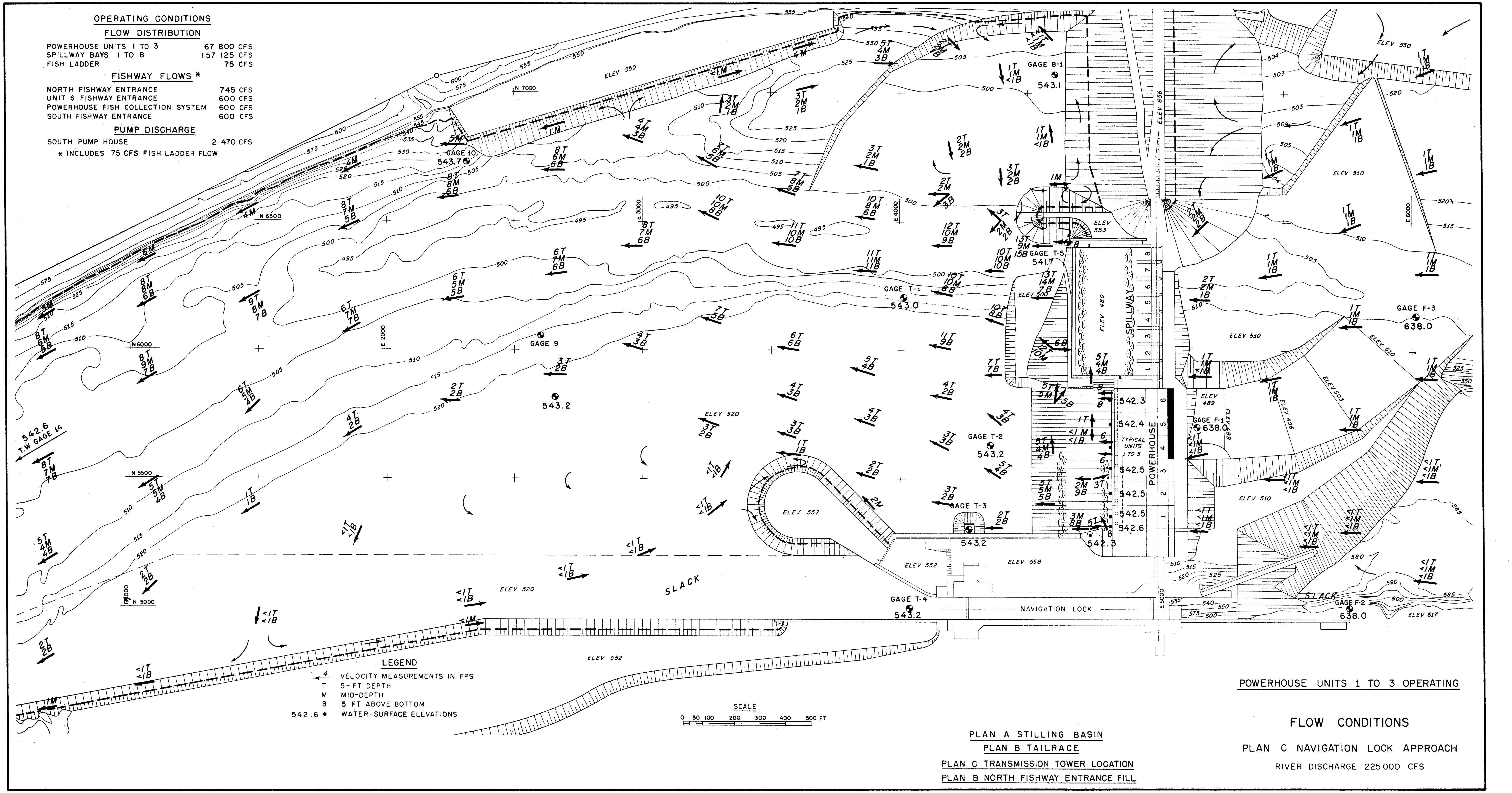
* INCLUDES 96 CFS FISH LADDER FLOW

LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
546.3 ●	WATER-SURFACE ELEVATIONS

PLAN D STILLING BASIN

FLOW CONDITIONS
PLAN A STRUCTURES
POWERHOUSE UNITS 1 TO 3 OPERATING
RIVER DISCHARGE 340 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	67 800 CFS
SPILLWAY BAYS 1 TO 8	157 125 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	745 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 470 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

4 →	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
542.6 ●	WATER-SURFACE ELEVATIONS

SCALE
0 50 100 200 300 400 500 FT

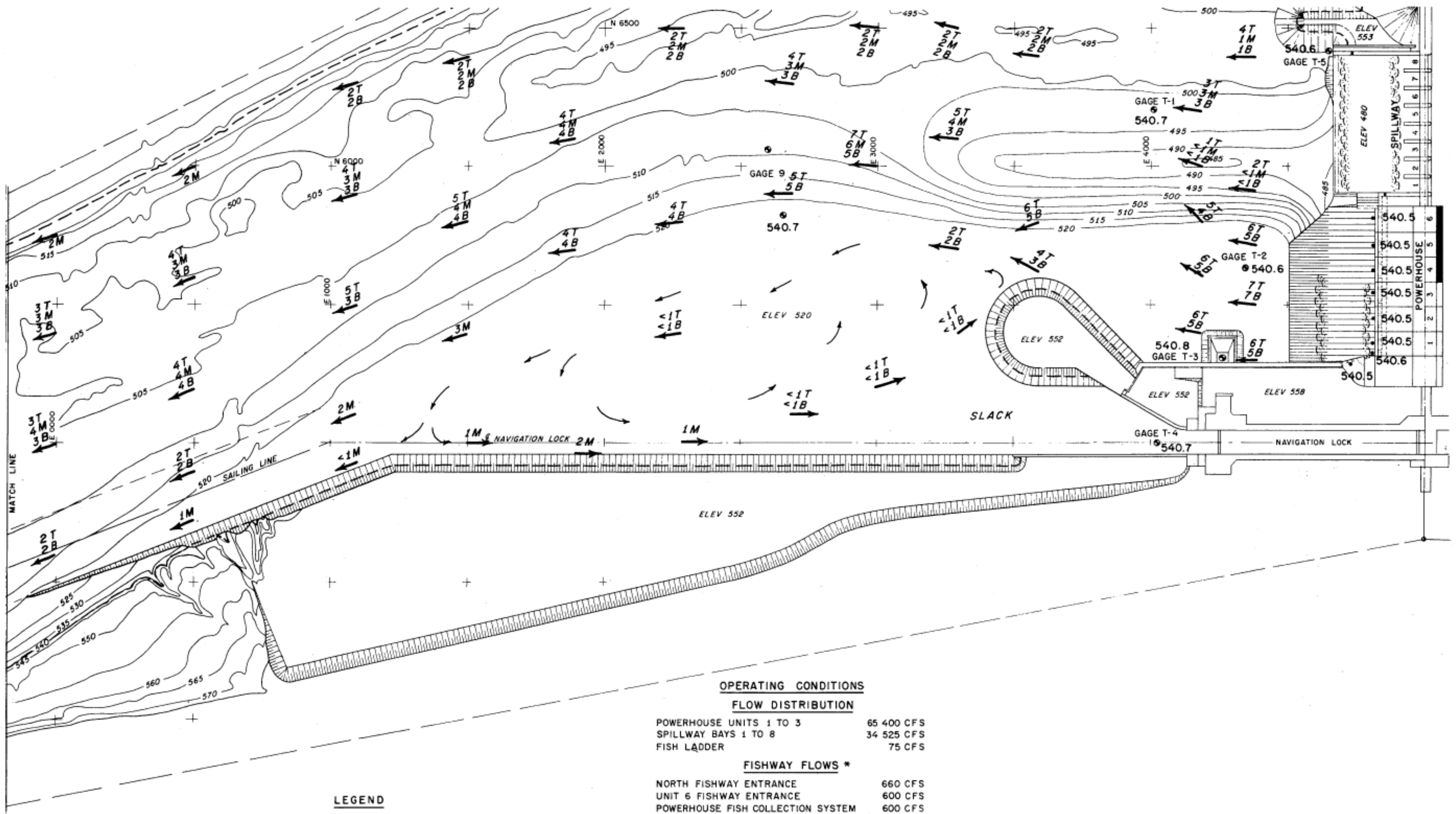
PLAN A STILLING BASIN
PLAN B TAILRACE
PLAN C TRANSMISSION TOWER LOCATION
PLAN B NORTH FISHWAY ENTRANCE FILL

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

PLAN C NAVIGATION LOCK APPROACH

RIVER DISCHARGE 225 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	65 400 CFS
SPILLWAY BAYS 1 TO 8	34 525 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	660 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2385 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN CFS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.6 ●	WATER-SURFACE ELEVATIONS

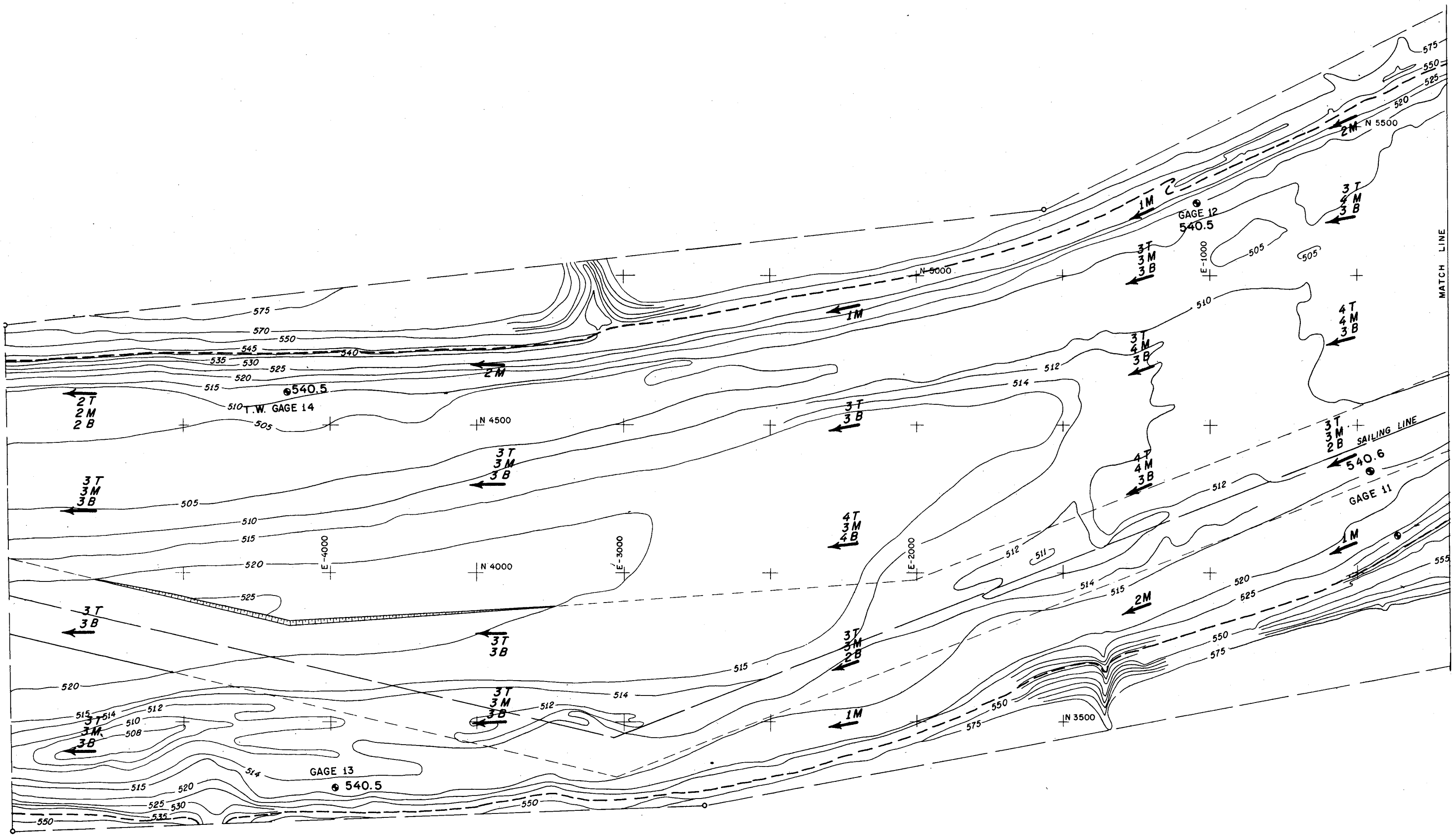
SCALE
0 100 200 300 400 500 FT

FLOW CONDITIONS

PLAN D NAVIGATION LOCK APPROACH

RIVER DISCHARGE 100 000 CFS

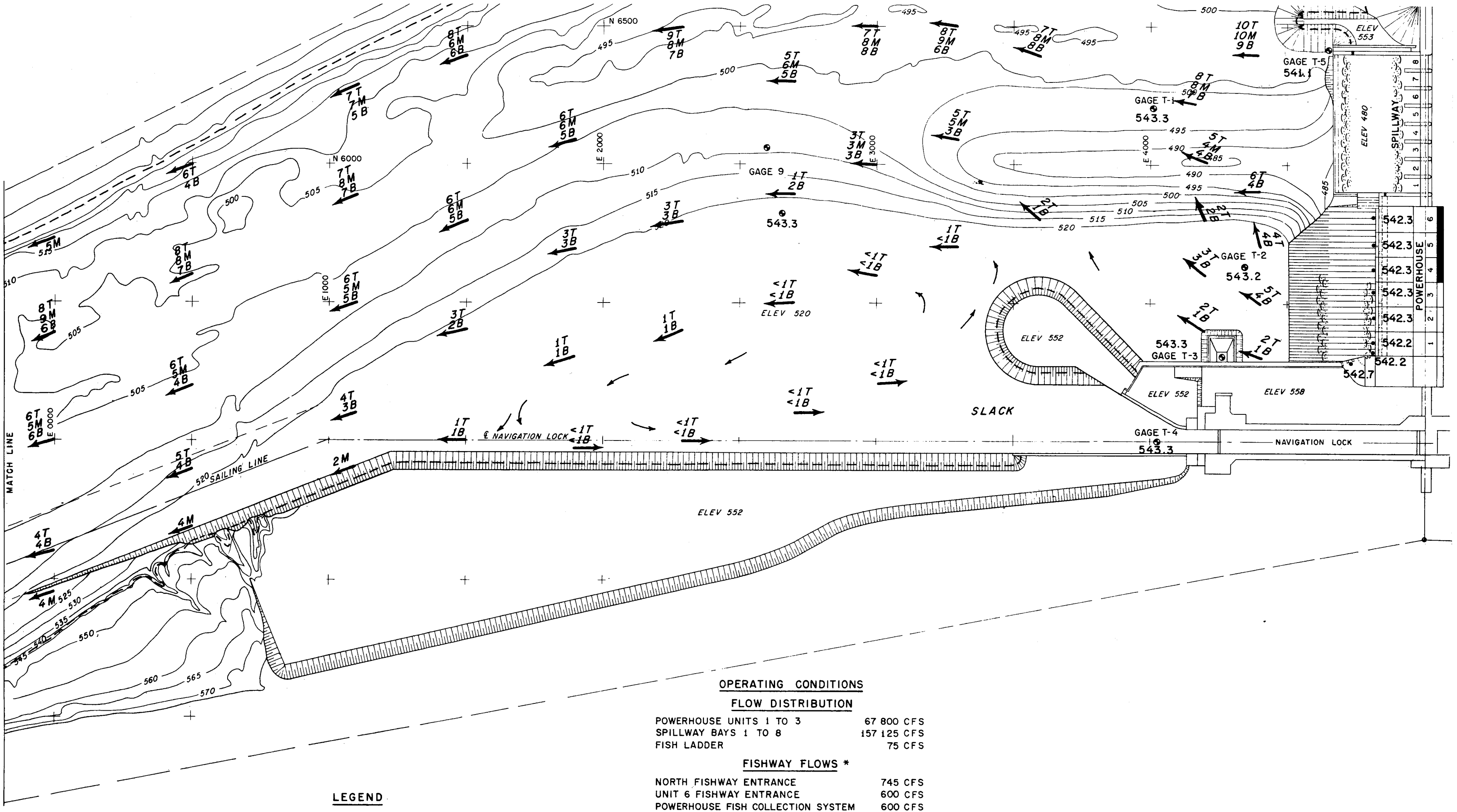
PLATE 30 (CONT'D)



FLOW CONDITIONS

PLAN D NAVIGATION LOCK APPROACH

RIVER DISCHARGE 100 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	67 800 CFS
SPILLWAY BAYS 1 TO 8	157 125 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	745 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2470 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN CFS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
542.6 ●	WATER-SURFACE ELEVATIONS

SCALE

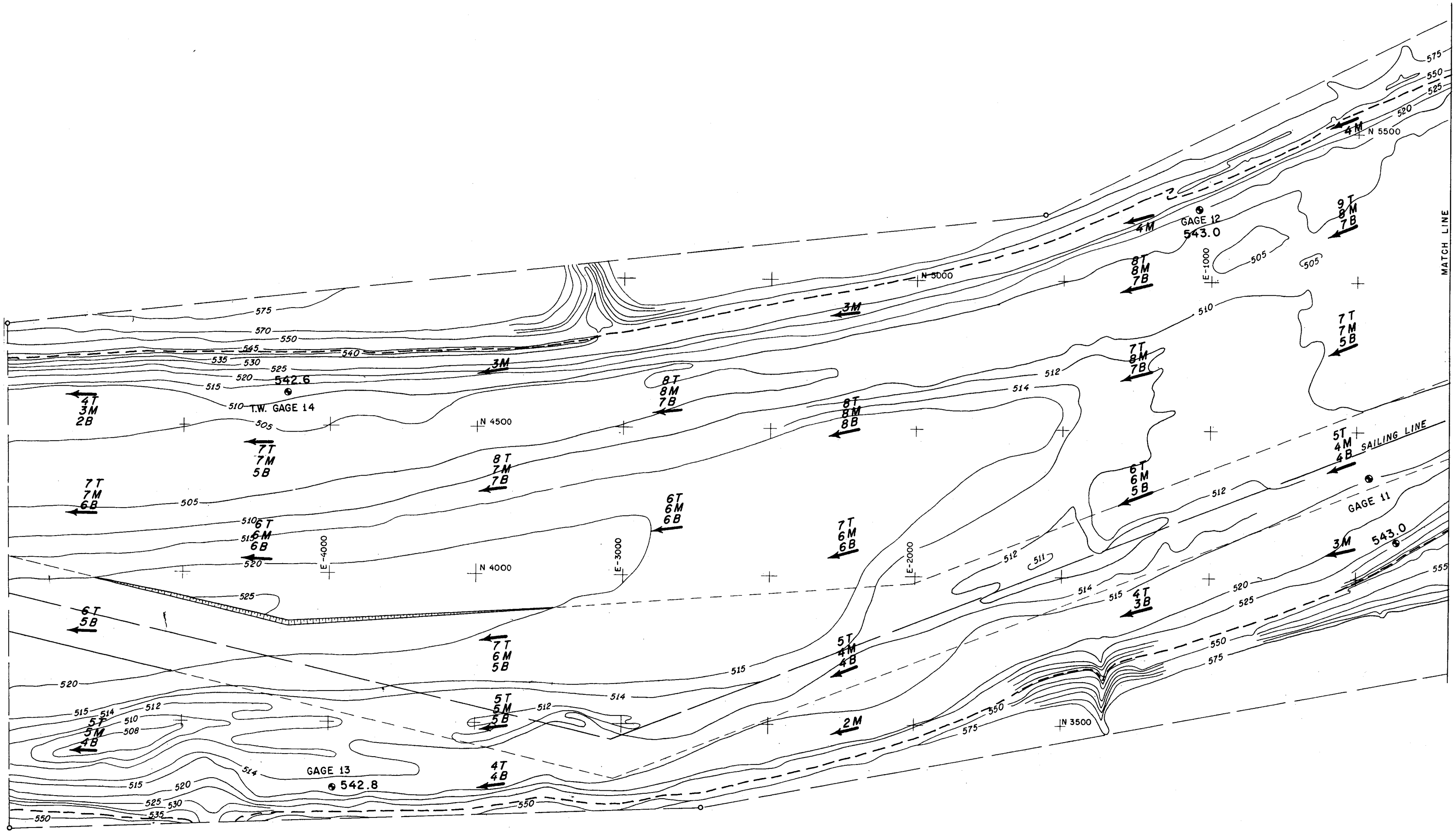
0 100 200 300 400 500 FT

FLOW CONDITIONS

PLAN D NAVIGATION LOCK APPROACH

RIVER DISCHARGE 225000 CFS

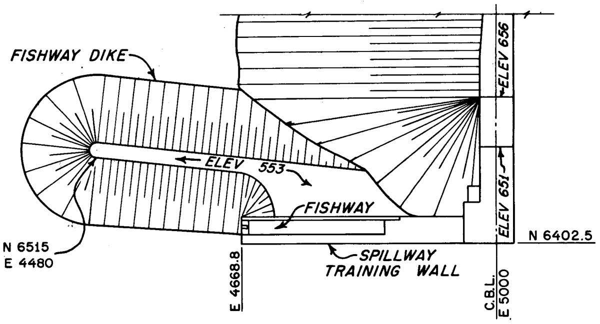
PLATE 31 (CONT'D)



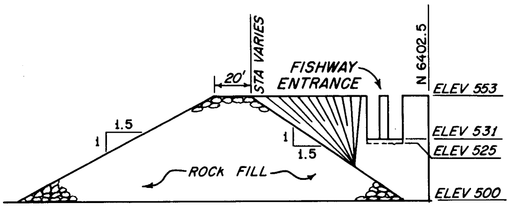
FLOW CONDITIONS

PLAN D NAVIGATION LOCK APPROACH

RIVER DISCHARGE 225 000 CFS



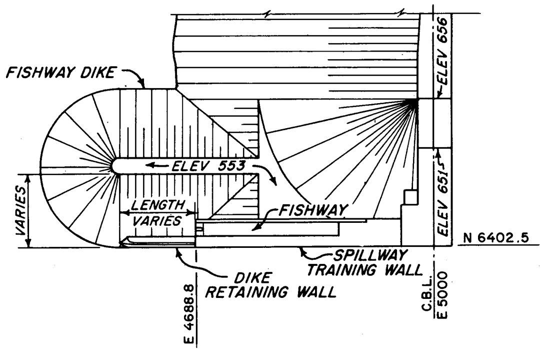
PLAN



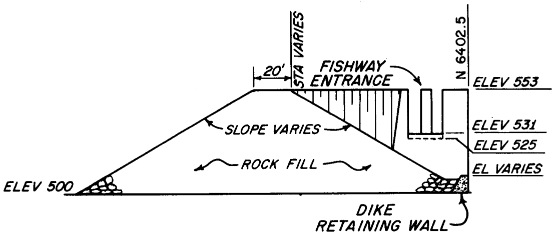
SECTION

DIKE PLAN A

FISHWAY PLAN A



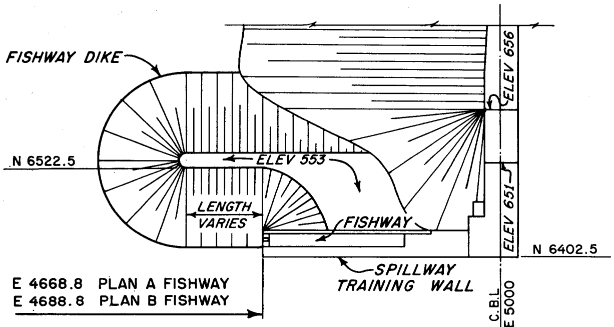
PLAN



SECTION

DIKE PLANS F TO I

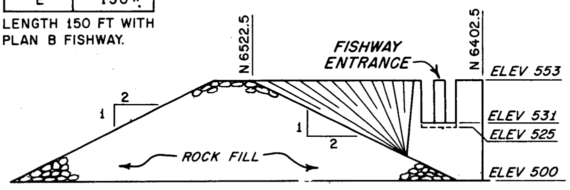
FISHWAY PLAN B



PLAN

DIKE PLAN	LENGTH IN FEET
B	100
C	135
D	125
E	130*

* LENGTH 150 FT WITH PLAN B FISHWAY.



SECTION

DIKE PLANS B TO E

FISHWAY PLANS A AND B

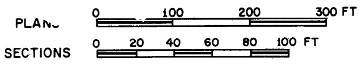
DIKE PLAN	LENGTH IN FEET	STA AT ELEV 553 SO. EDGE OF DIKE	SIDE SLOPES	RETAINING WALL HEIGHT IN FEET
F	130	N 6495.5	1 ON 2	8
F-1	100	N 6495.5	1 ON 2	8
F-2	65	N 6495.5	1 ON 2	8
F-3	90	N 6495.5	1 ON 2	8
G	130	N 6480.5	1 ON 1.5	13
H	130	N 6467.5	1 ON 1.5	3
I*	90	N 6495.5	1 ON 1.75	8

* CONTRACT PLAN

NOTE

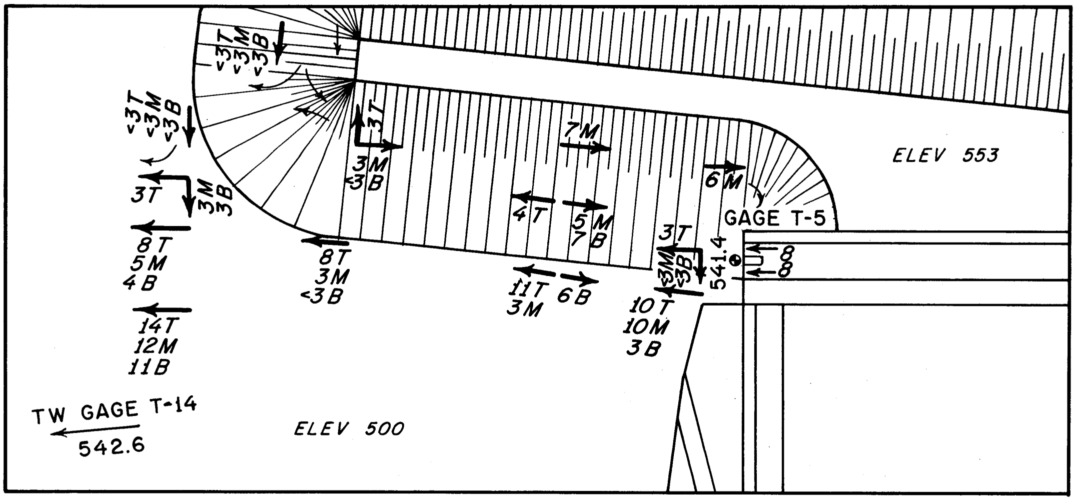
DIKE LENGTHS MEASURED FROM END OF FISHWAY.

SCALES

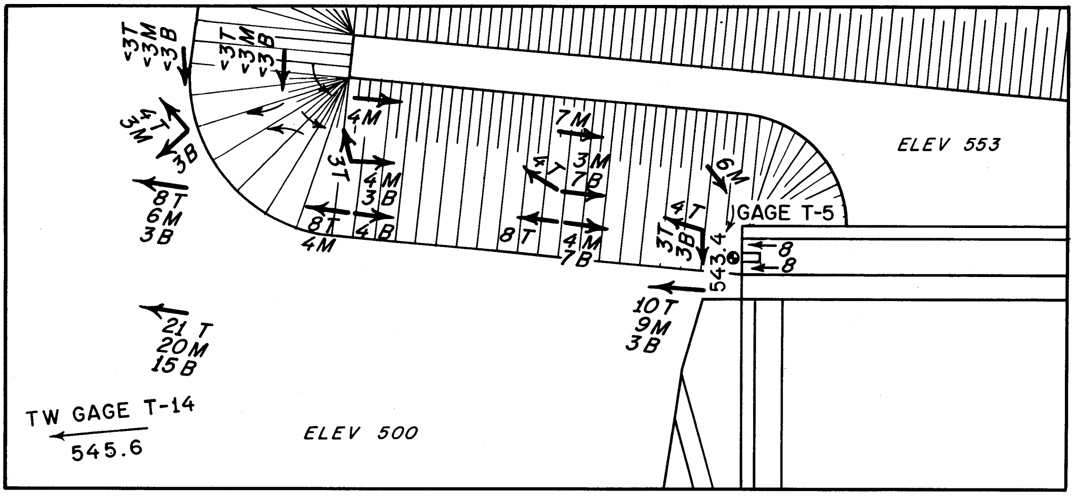


NORTH SHORE FISHWAY DIKE PLANS A TO I

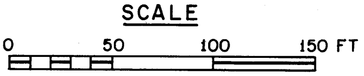
NORTH SHORE FISHWAY PLANS A AND B



RIVER DISCHARGE 225 000 CFS



RIVER DISCHARGE 340 000 CFS



LEGEND

←4 VELOCITY MEASUREMENTS IN FPS

T 5-FT DEPTH

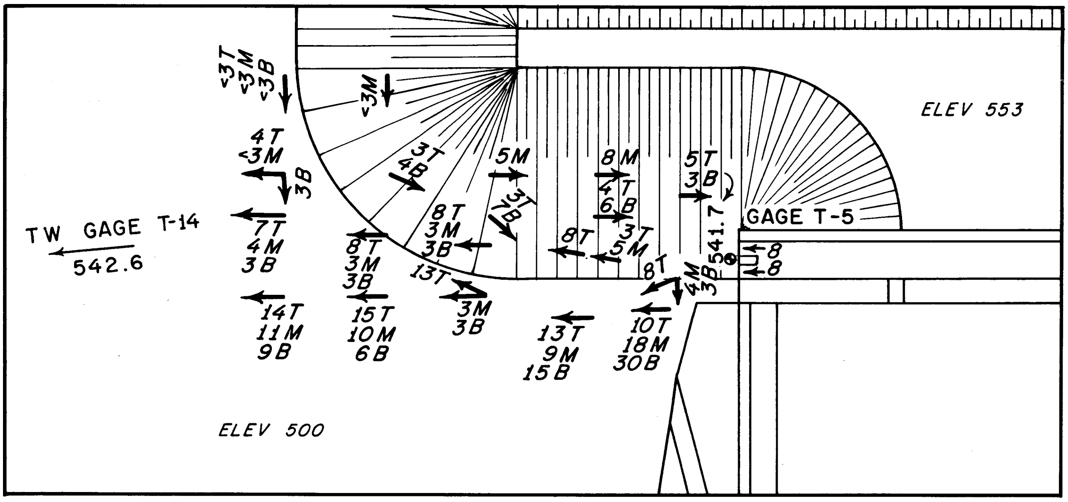
M MID-DEPTH

B 5 FT ABOVE BOTTOM

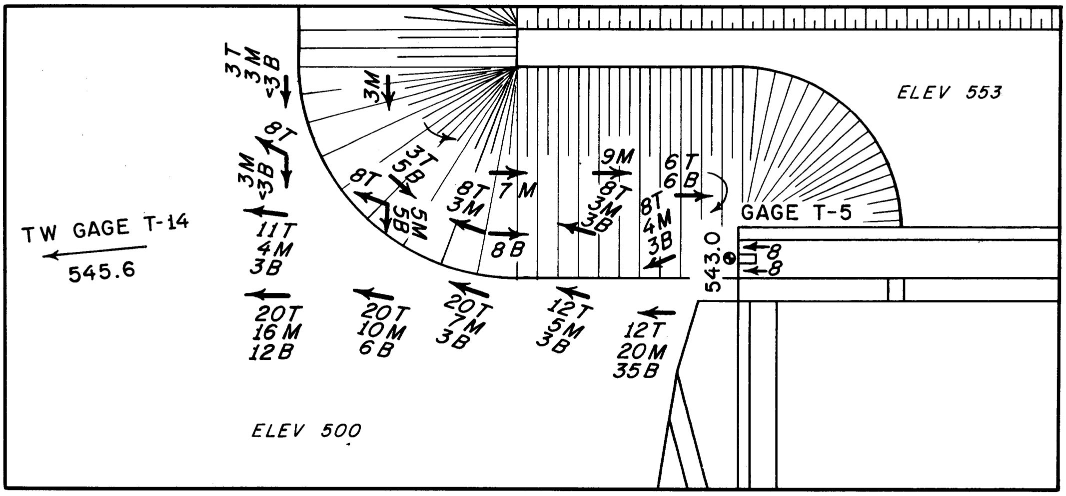
543.4● WATER-SURFACE ELEVATION

FLOW PATTERNS

PLAN A NORTH FISHWAY DIKE

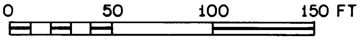


RIVER DISCHARGE 225 000 CFS



RIVER DISCHARGE 340 000 CFS

SCALE

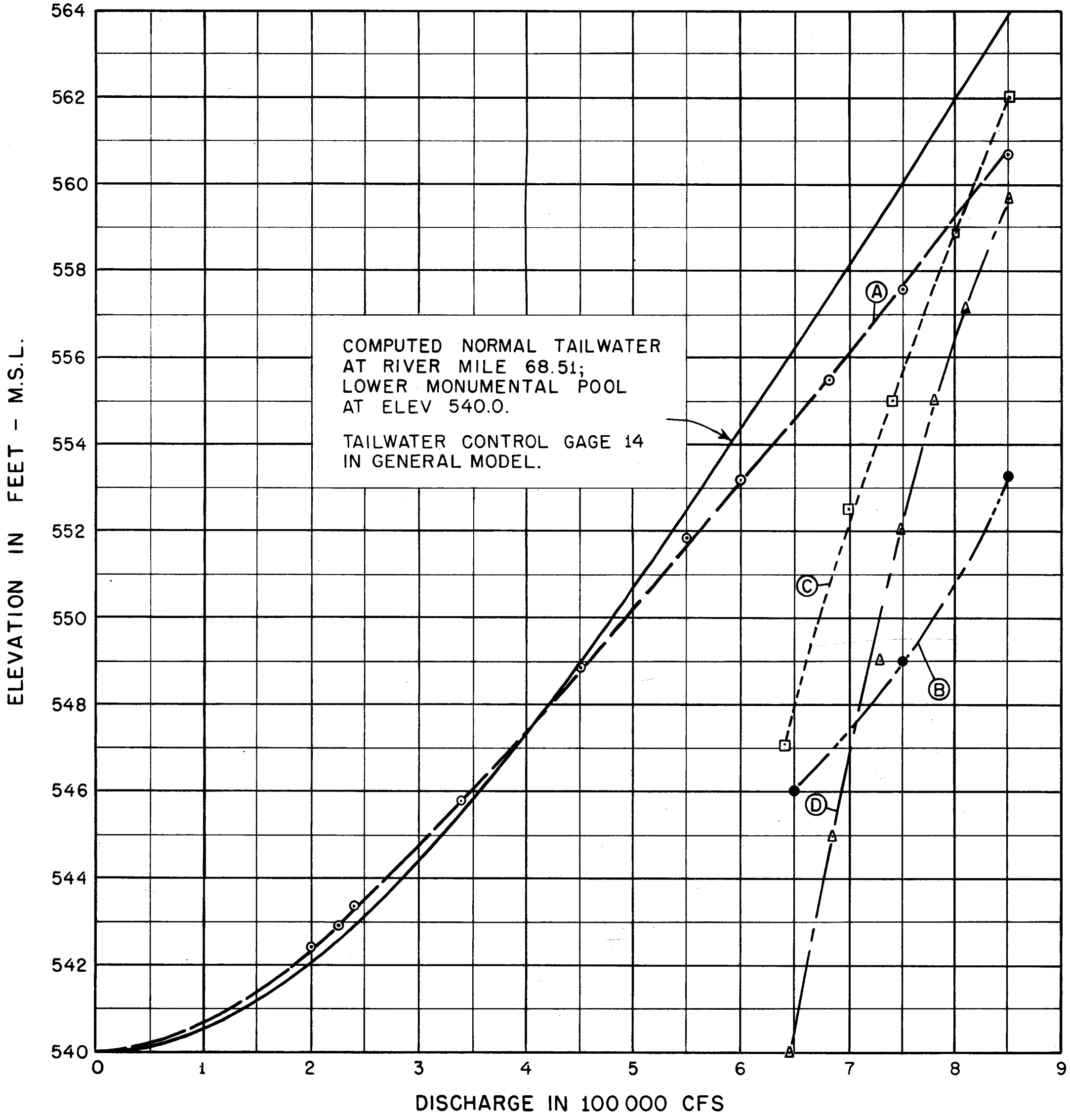


LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
543.0 ●	WATER-SURFACE ELEVATION

FLOW PATTERNS

PLAN B NORTH FISHWAY DIKE



LEGEND

Ⓐ OBSERVED TAILWATER 1000 FT DOWNSTREAM FROM CREST AXIS AT GAGE T-1 IN GENERAL MODEL ; POWERHOUSE CLOSED; FLOW DISTRIBUTED UNIFORMLY AMONG ALL SPILLWAY BAYS; PLAN C TAILRACE.

Ⓑ MINIMUM TAILWATER AT GAGE T-1 FOR ROLLER ACTION IN GENERAL MODEL FOR ABOVE OPERATING CONDITIONS.

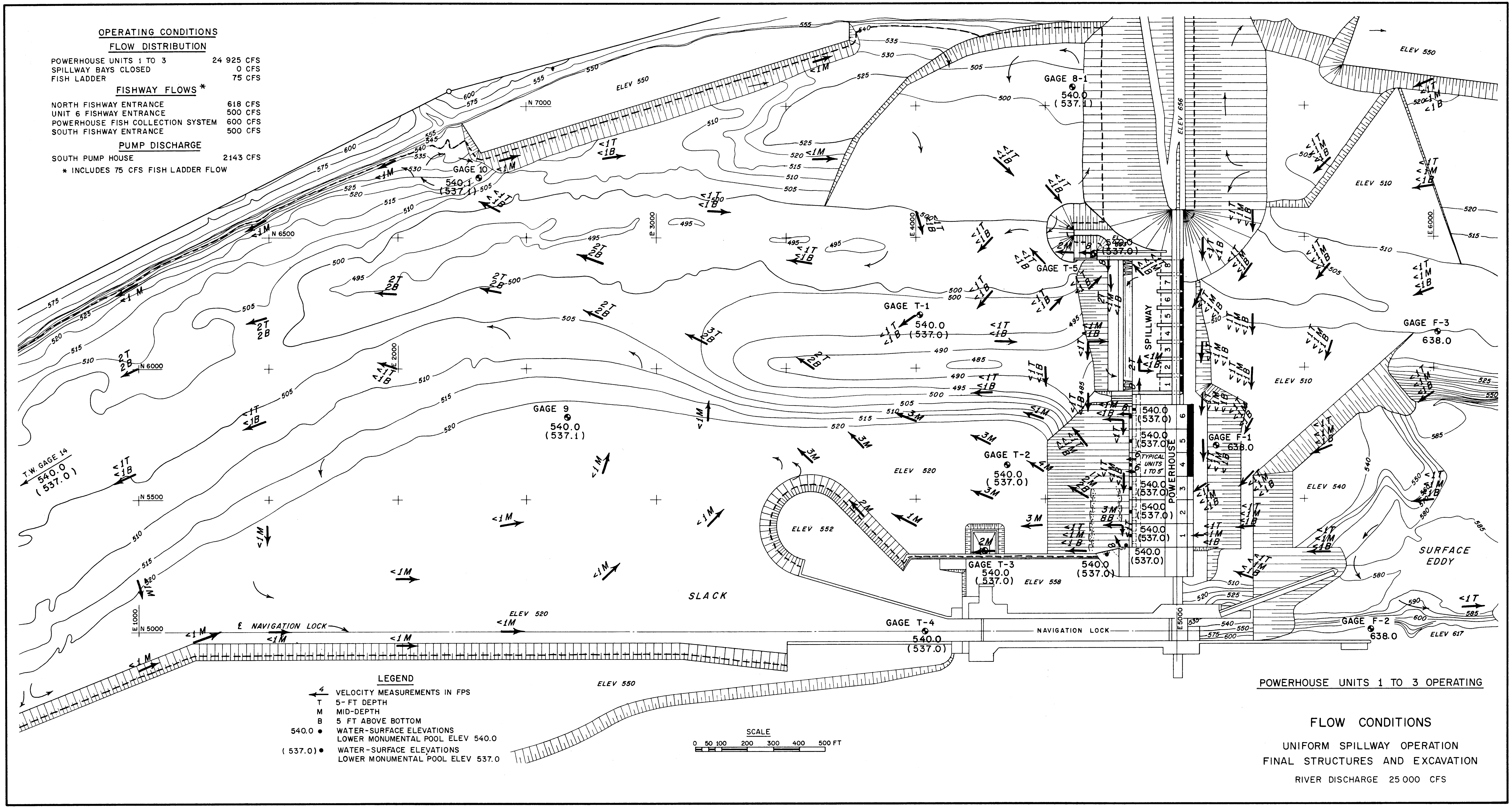
Ⓒ MINIMUM TAILWATER 1000 FT DOWNSTREAM FROM SPILLWAY AXIS FOR ROLLER ACTION IN SPILLWAY MODEL WITH DOWNSTREAM CHANNEL AT ELEV 488 (TYPE XXIX TOPOGRAPHY).

Ⓓ AS ABOVE, BUT DOWNSTREAM CHANNEL AT ELEV 500 (TYPE XXX TOPOGRAPY).

TAILWATER CURVES

PLAN P-6 ROLLER BUCKET (FINAL DESIGN)

FREE FLOW OVER SPILLWAY



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	24 925 CFS
SPILLWAY BAYS CLOSED	0 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	618 CFS
UNIT 6 FISHWAY ENTRANCE	500 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	500 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2143 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.0 ●	WATER-SURFACE ELEVATIONS LOWER MONUMENTAL POOL ELEV 540.0
(537.0) ●	WATER-SURFACE ELEVATIONS LOWER MONUMENTAL POOL ELEV 537.0

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 25 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	49 925 CFS
SPILLWAY BAYS CLOSED	0 CFS
FISH LADDER	75 CFS

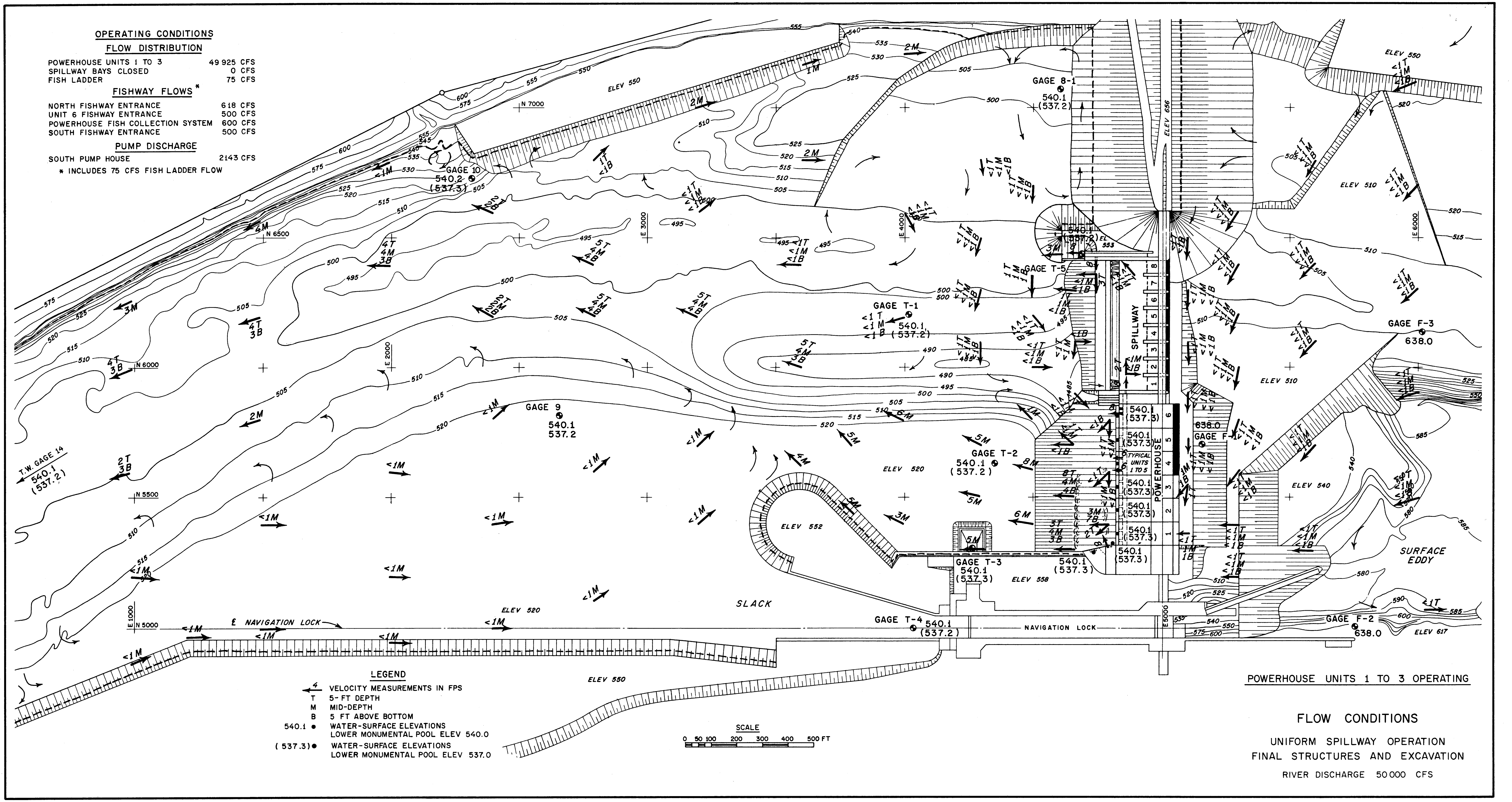
FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	618 CFS
UNIT 6 FISHWAY ENTRANCE	500 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	500 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2143 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.1 ●	WATER-SURFACE ELEVATIONS LOWER MONUMENTAL POOL ELEV 540.0
(537.3)●	WATER-SURFACE ELEVATIONS LOWER MONUMENTAL POOL ELEV 537.0

SCALE
0 50 100 200 300 400 500 FT

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 50000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	65 400 CFS
SPILLWAY BAYS 1 TO 8	34 525 CFS
FISH LADDER	75 CFS

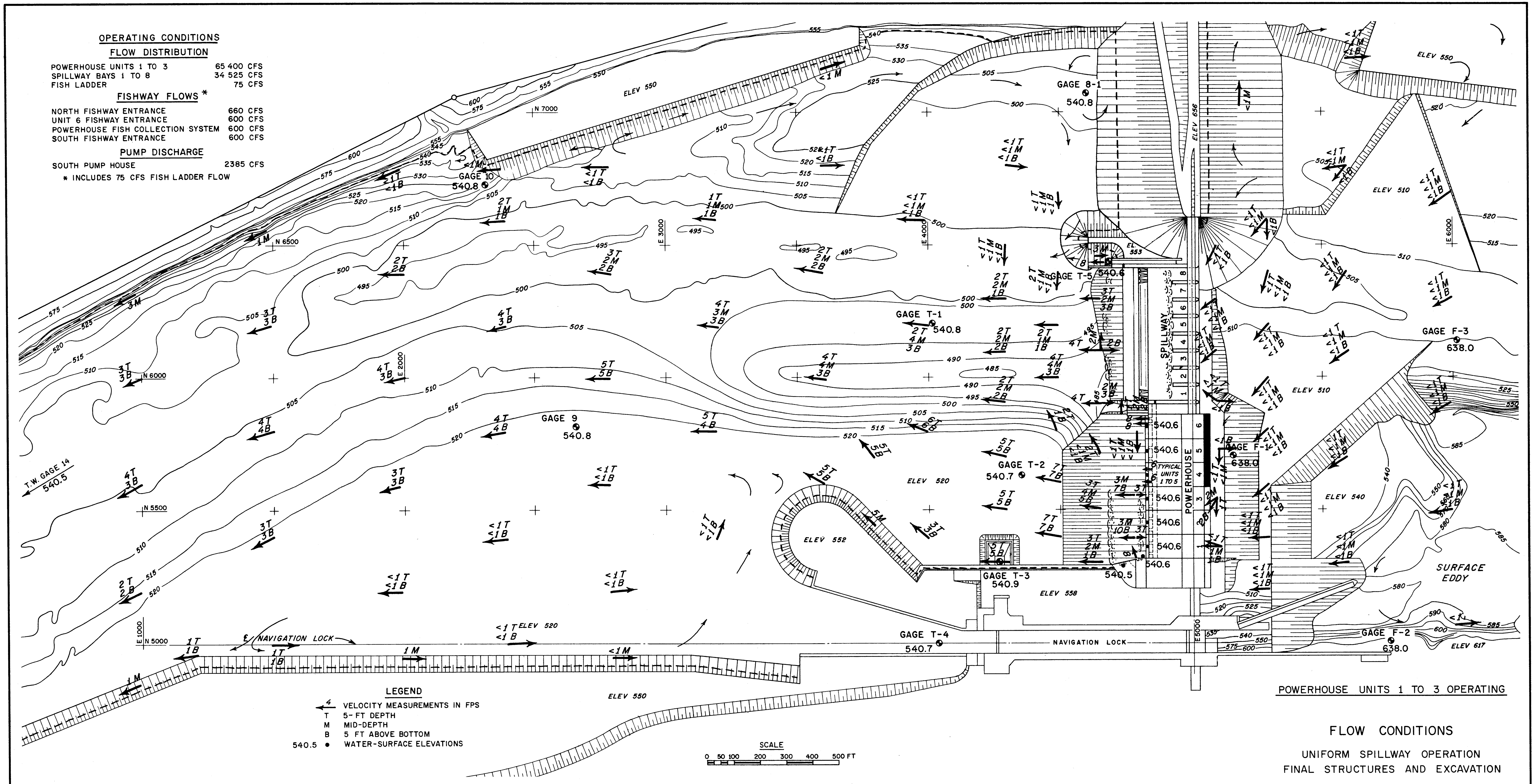
FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	660 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2385 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

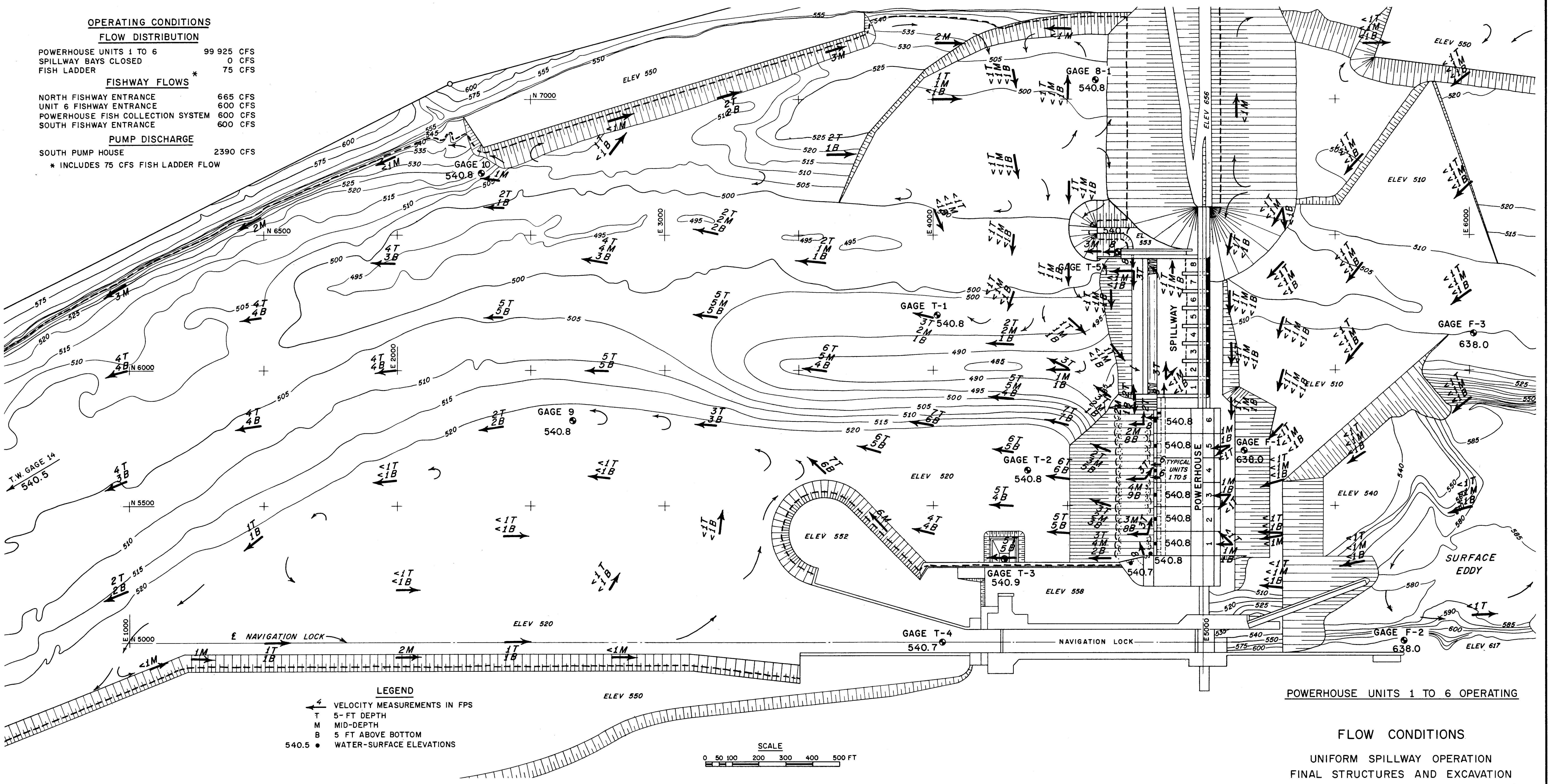
←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.5 ●	WATER-SURFACE ELEVATIONS

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION

RIVER DISCHARGE 100 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	99 925 CFS
SPILLWAY BAYS CLOSED	0 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	665 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2390 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

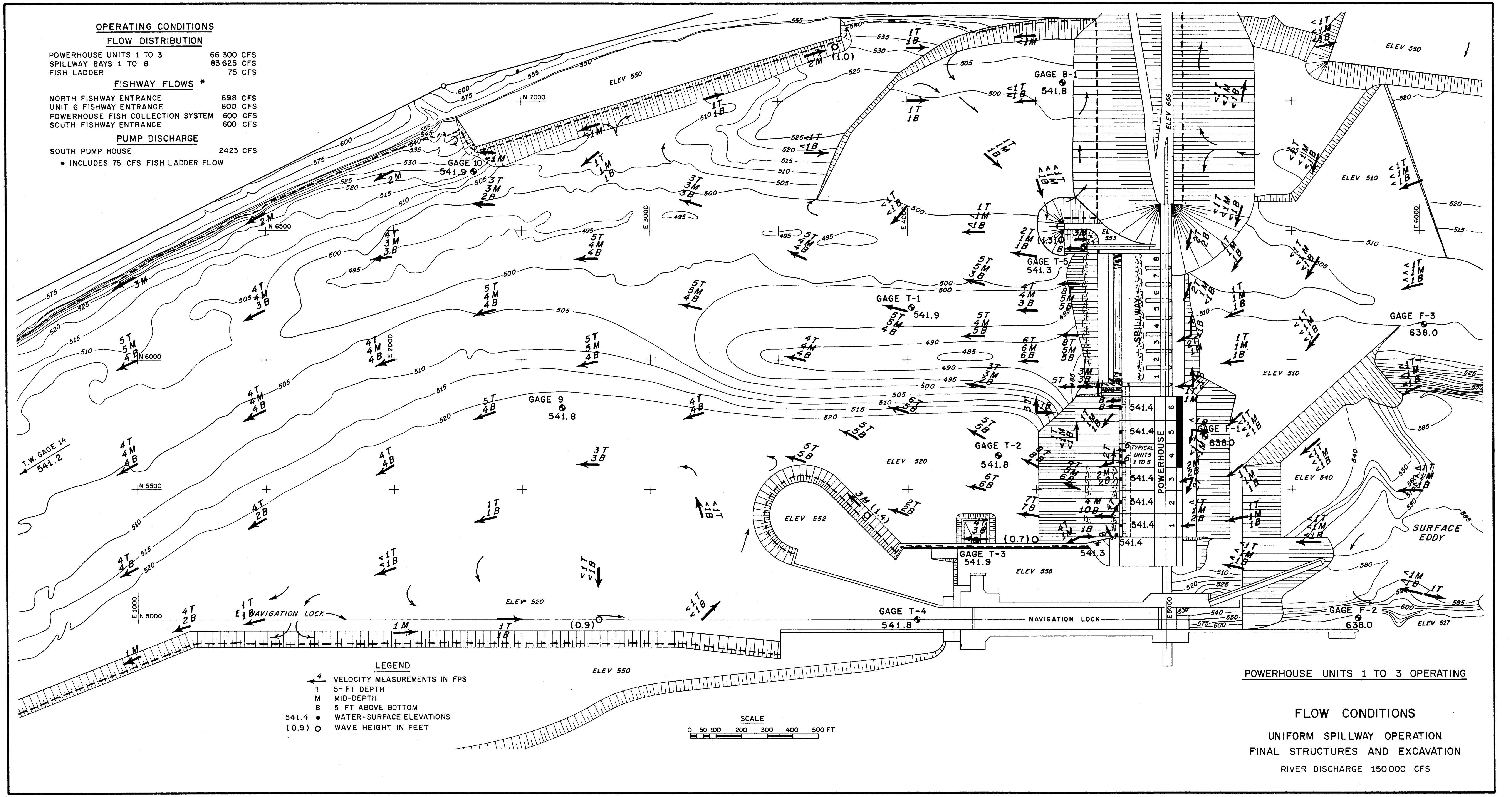
←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.5 ●	WATER-SURFACE ELEVATIONS

POWERHOUSE UNITS 1 TO 6 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION

RIVER DISCHARGE 100 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	66 300 CFS
SPILLWAY BAYS 1 TO 8	83 625 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	698 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2423 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5- FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
541.4 ●	WATER-SURFACE ELEVATIONS
(0.9) ○	WAVE HEIGHT IN FEET

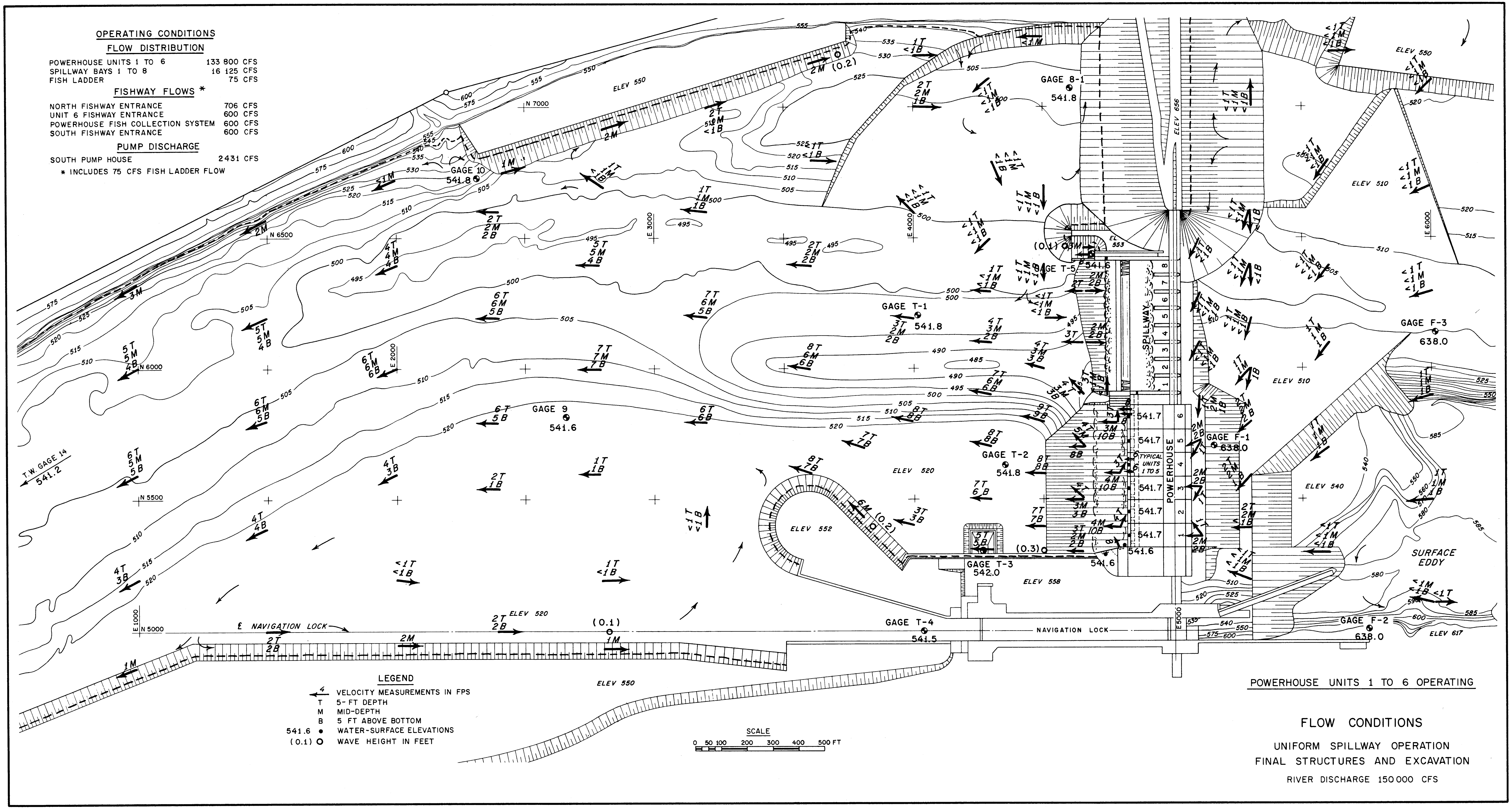
SCALE

0 50 100 200 300 400 500 FT

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 150 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	133 800 CFS
SPILLWAY BAYS 1 TO 8	16 125 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	706 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2431 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5- FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
541.6 ●	WATER-SURFACE ELEVATIONS
(0.1) ○	WAVE HEIGHT IN FEET

POWERHOUSE UNITS 1 TO 6 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 150 000 CFS

PLATE 41

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	67 800 CFS
SPILLWAY BAYS 1 TO 8	157 125 CFS
FISH LADDER	75 CFS

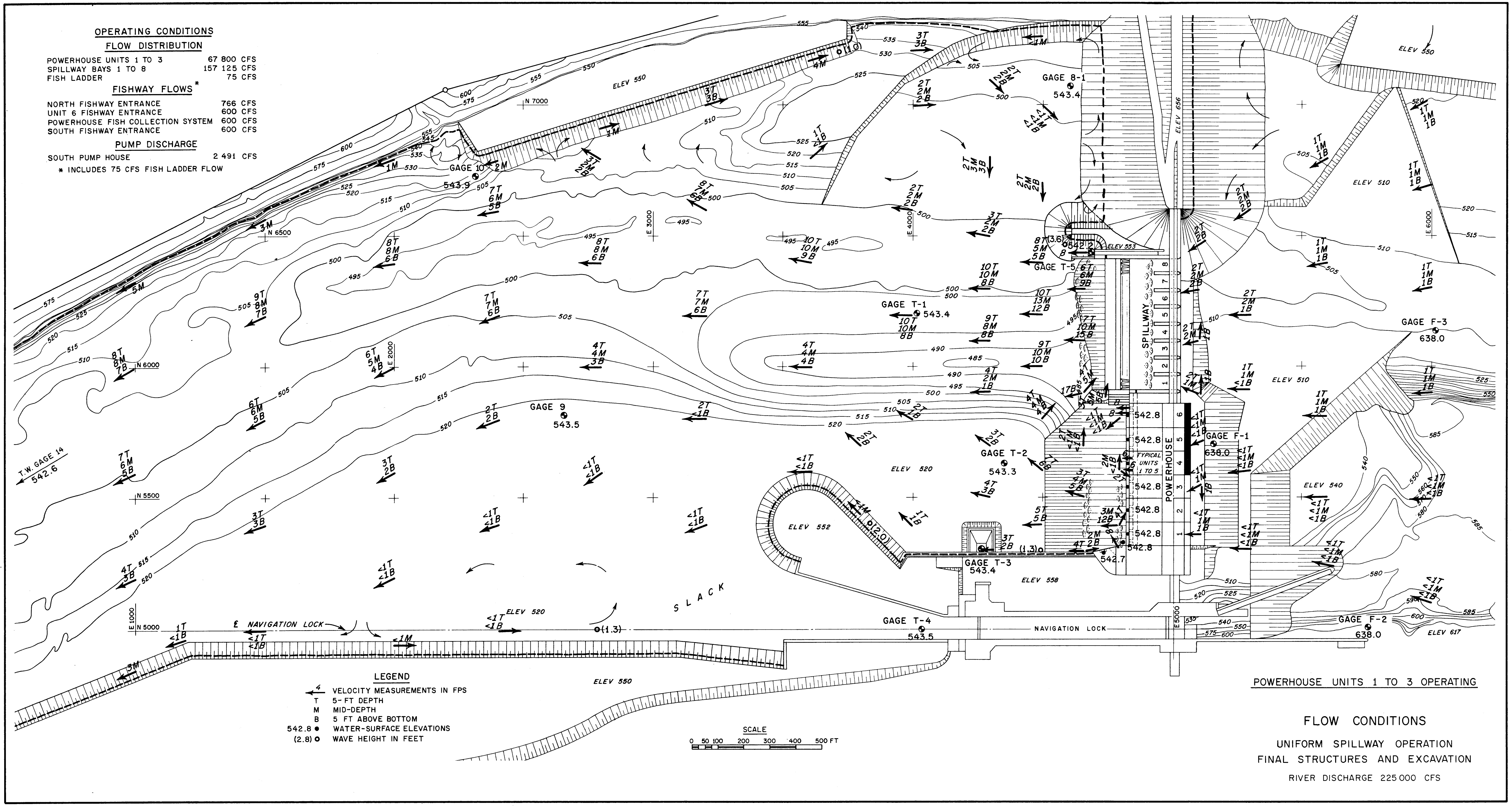
FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	766 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 491 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

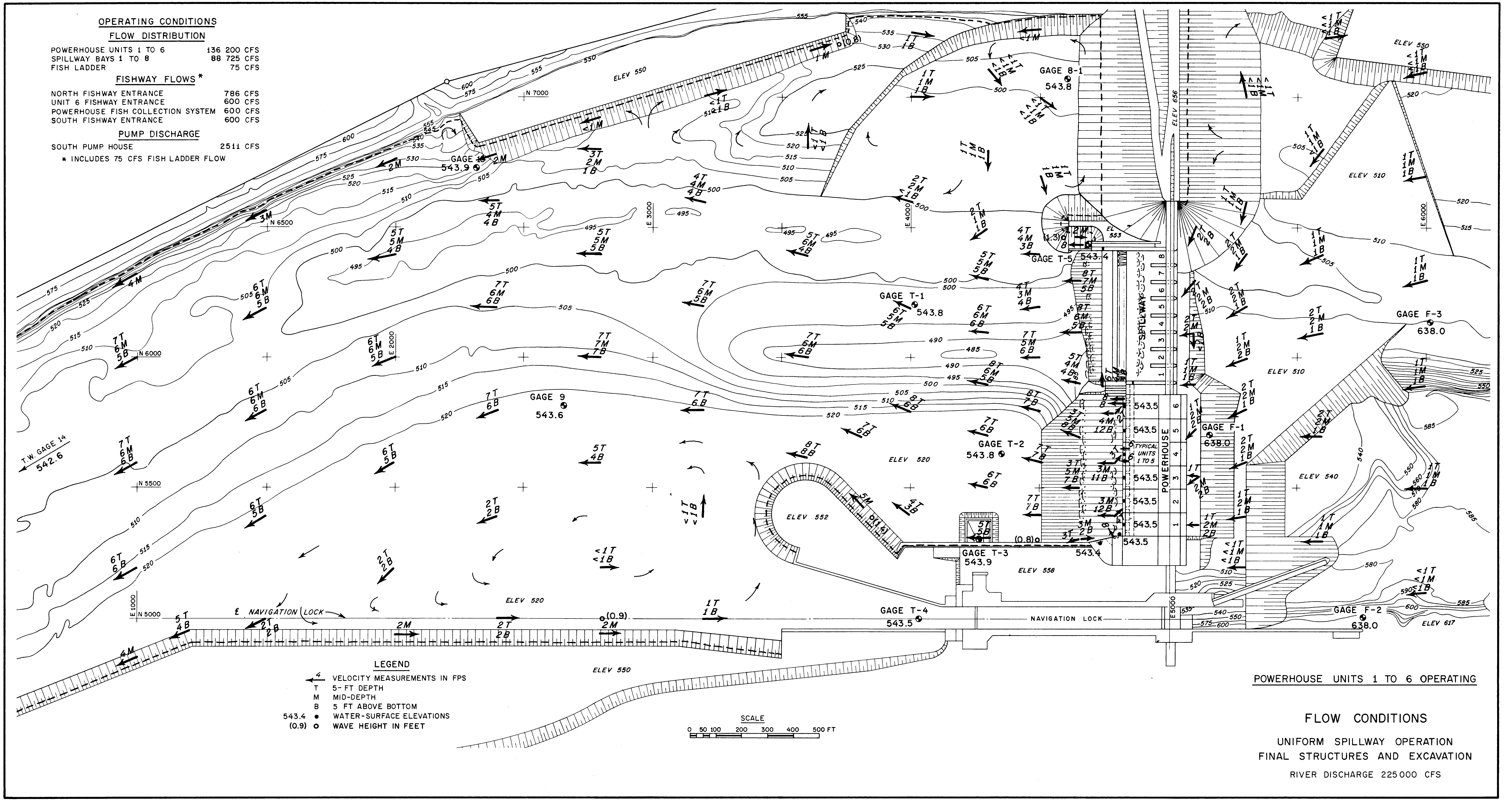
4 ←	VELOCITY MEASUREMENTS IN FPS
T	5- FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
542.8 ●	WATER-SURFACE ELEVATIONS
(2.8) ○	WAVE HEIGHT IN FEET

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION

RIVER DISCHARGE 225 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	136 200 CFS
SPILLWAY BAYS 1 TO 8	88 725 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	786 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2511 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
543.4 ●	WATER-SURFACE ELEVATIONS
(0.9) ○	WAVE HEIGHT IN FEET

SCALE
0 50 100 200 300 400 500 FT

POWERHOUSE UNITS 1 TO 6 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 225 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	70 200 CFS
SPILLWAY BAYS 1 TO 8	269 725 CFS
FISH LADDER	75 CFS

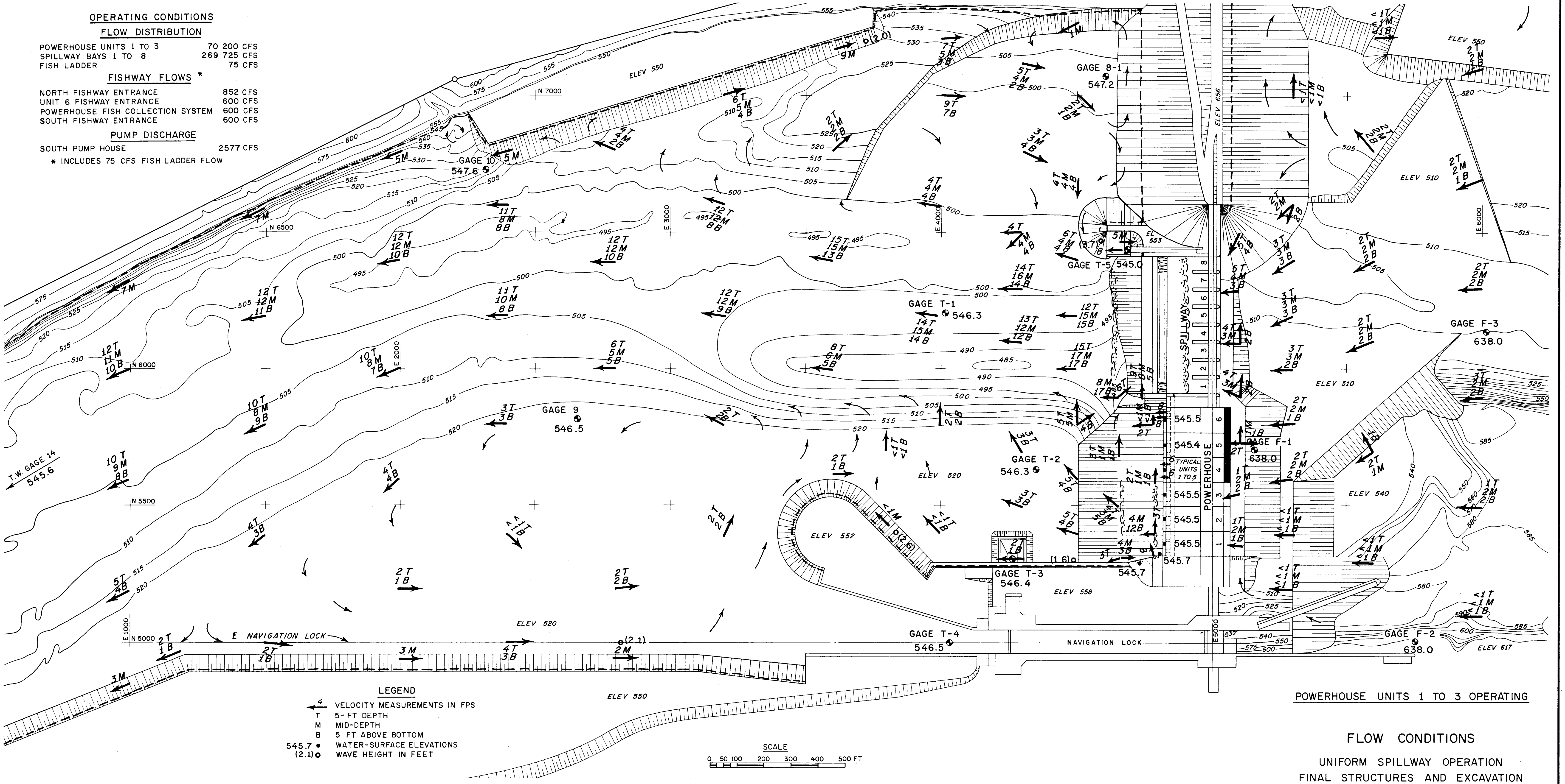
FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	852 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2577 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

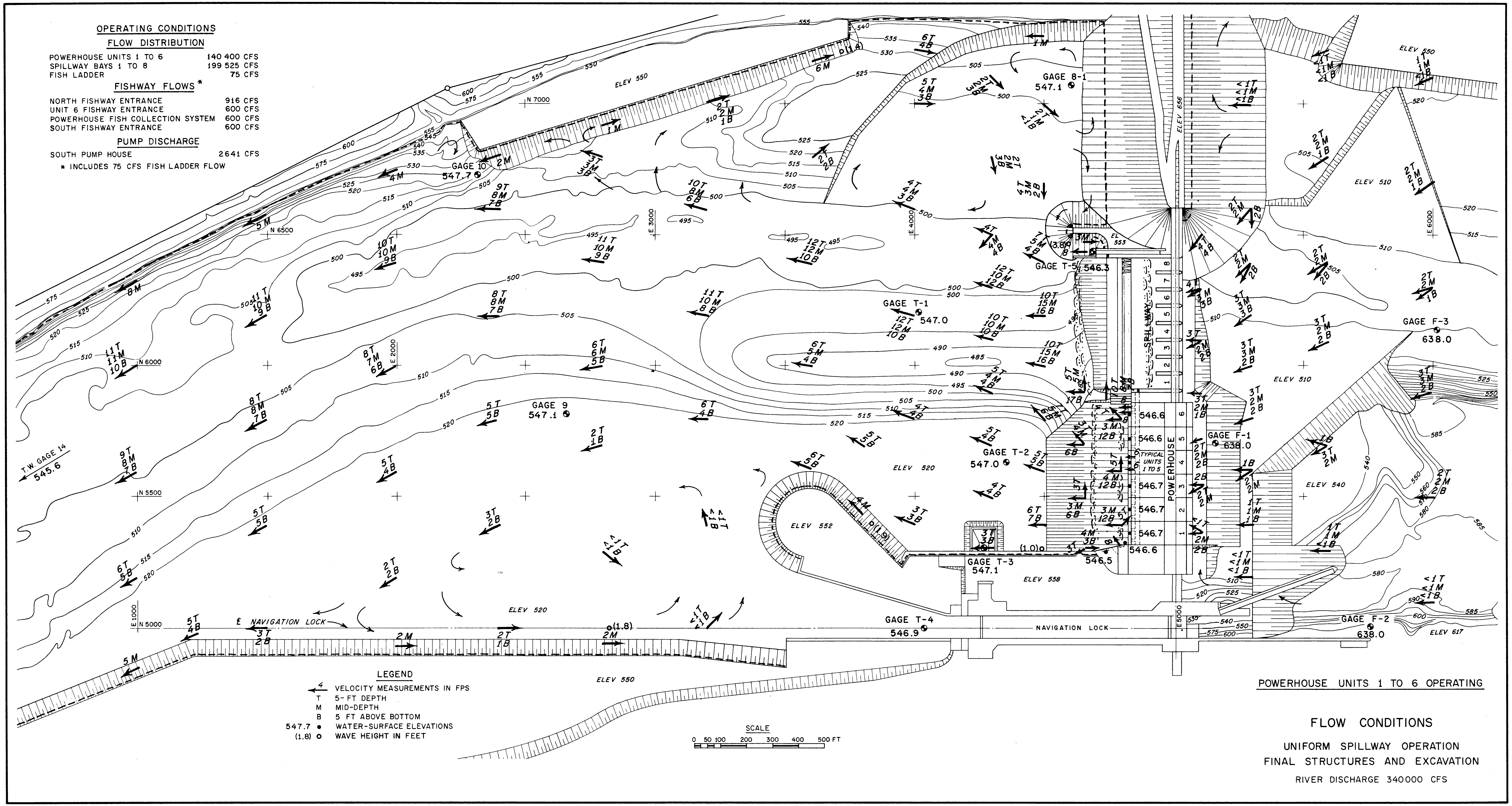
4 ←	VELOCITY MEASUREMENTS IN FPS
T	5- FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
545.7 ●	WATER-SURFACE ELEVATIONS
(2.1)○	WAVE HEIGHT IN FEET

SCALE
0 50 100 200 300 400 500 FT

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 340 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	140 400 CFS
SPILLWAY BAYS 1 TO 8	199 525 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	916 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2641 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5- FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
547.7 ●	WATER-SURFACE ELEVATIONS
(1.8) ○	WAVE HEIGHT IN FEET

POWERHOUSE UNITS 1 TO 6 OPERATING

FLOW CONDITIONS

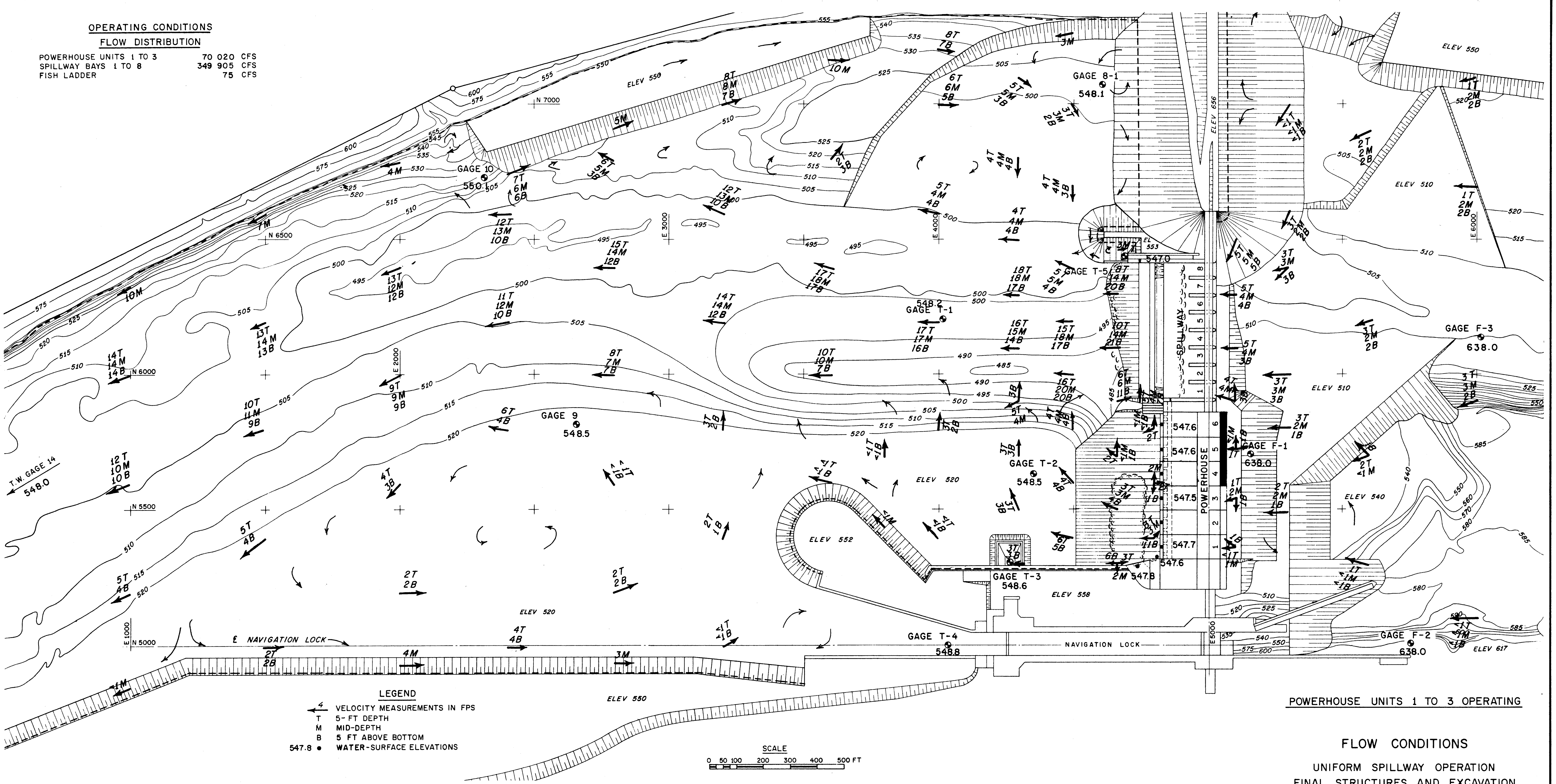
UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 340000 CFS

PLATE 45

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	70 020 CFS
SPILLWAY BAYS 1 TO 8	349 905 CFS
FISH LADDER	75 CFS



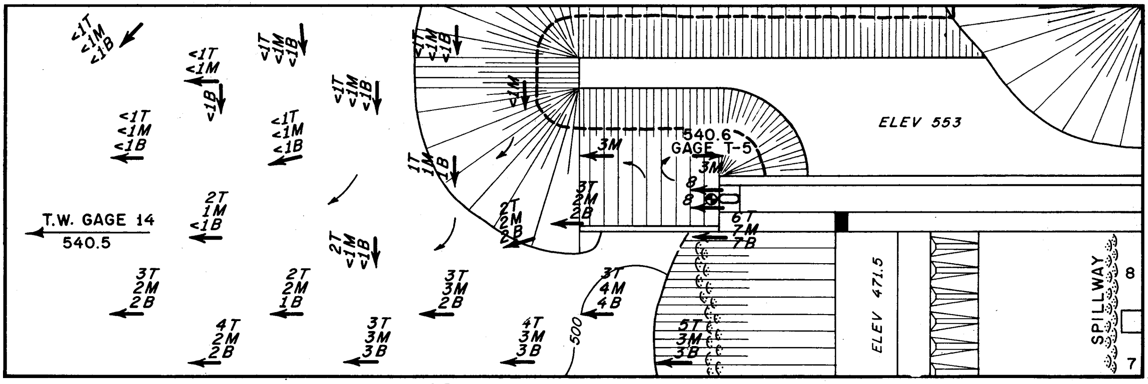
LEGEND

- VELOCITY MEASUREMENTS IN FPS
- T 5-FT DEPTH
- M MID-DEPTH
- B 5 FT ABOVE BOTTOM
- 547.8 ● WATER-SURFACE ELEVATIONS

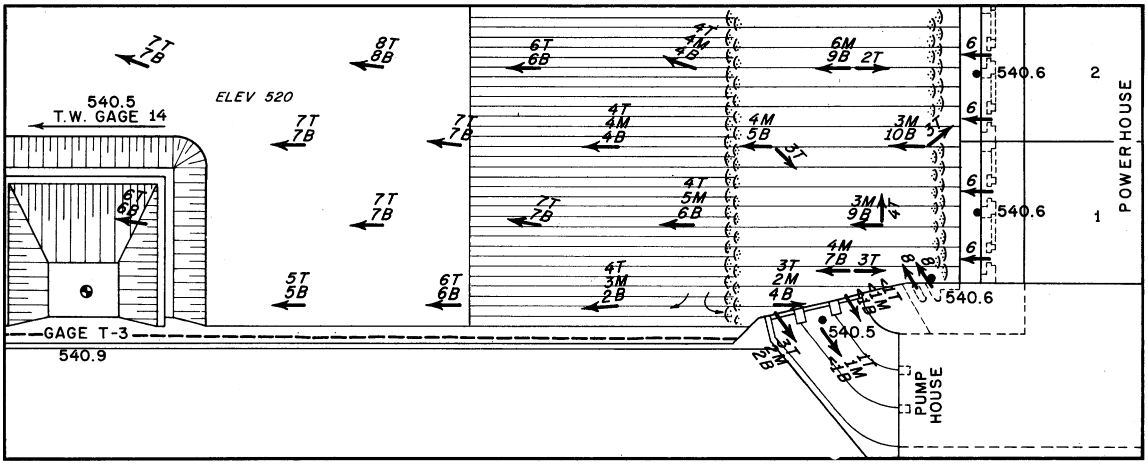
POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

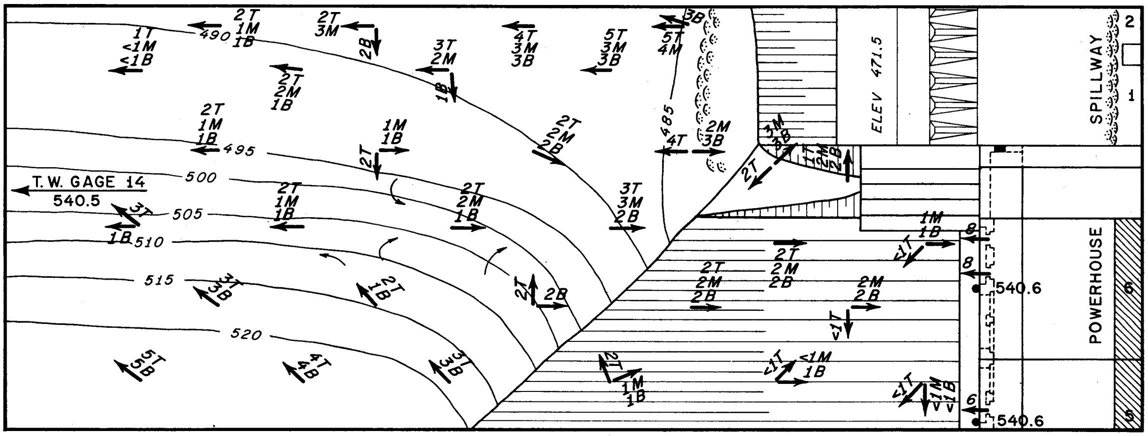
UNIFORM SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 420 000 CFS



NORTH FISHWAY ENTRANCE



SOUTH FISHWAY ENTRANCE



UNIT 6 FISHWAY ENTRANCE

SCALE

0 50 100 150 200 FT

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS.
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.5●	WATER-SURFACE ELEVATIONS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	65 400 CFS
SPILLWAY BAYS 1 TO 8	34 525 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	660 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 385 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

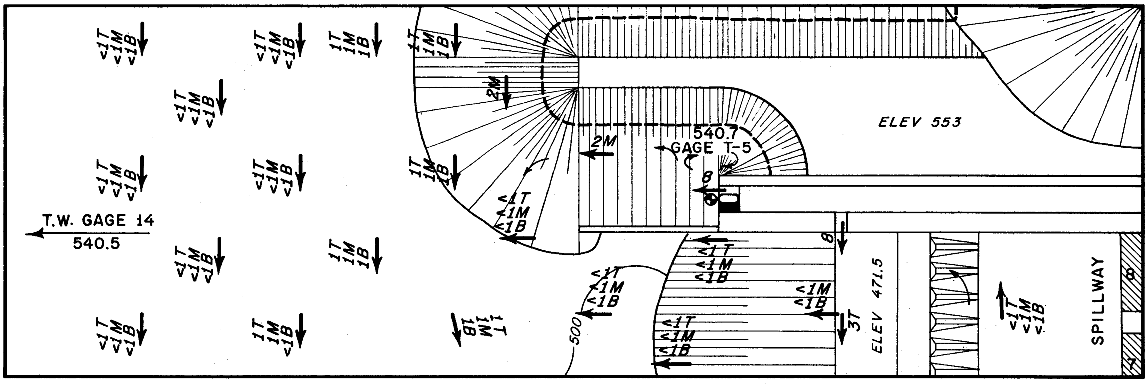
POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW PATTERNS AT FISHWAY ENTRANCES

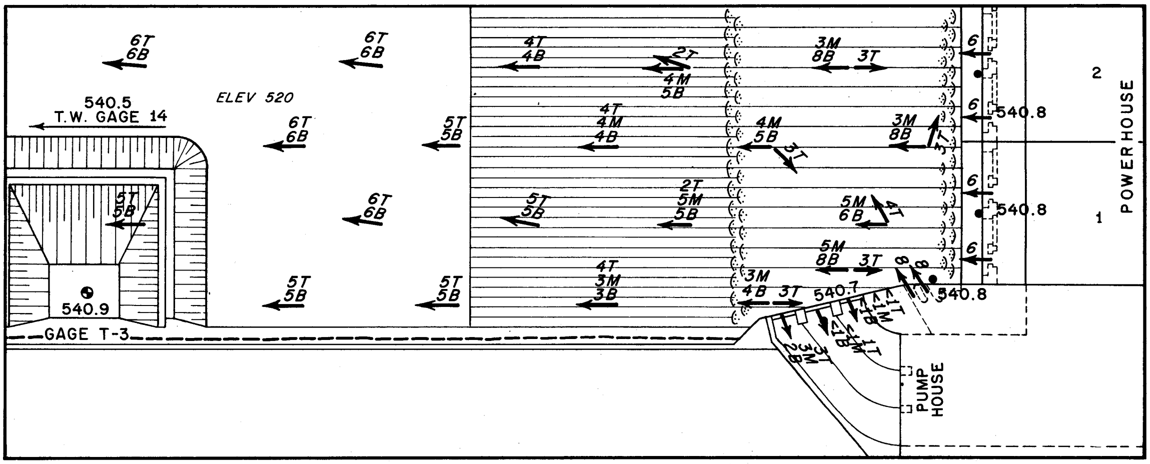
FINAL STRUCTURES AND EXCAVATION

UNIFORM SPILLWAY OPERATION

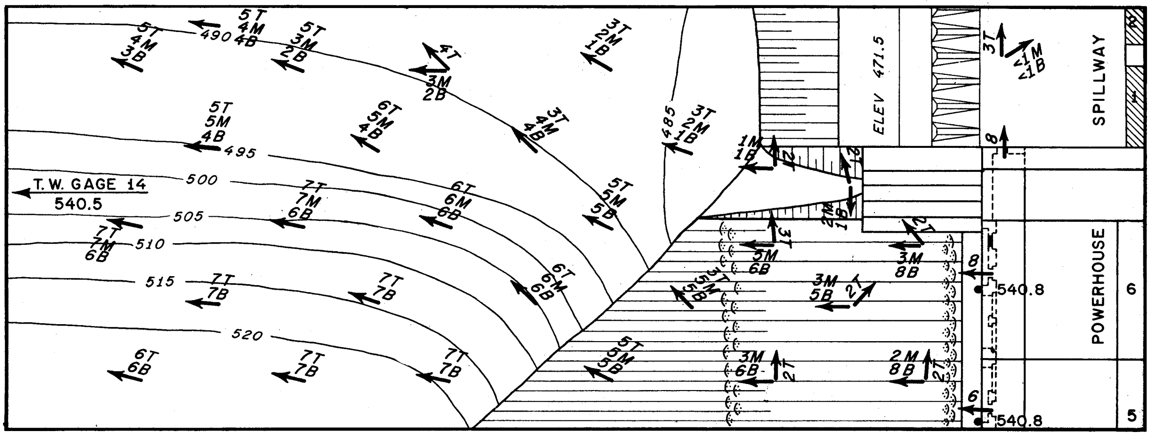
RIVER DISCHARGE 100 000 CFS



NORTH FISHWAY ENTRANCE

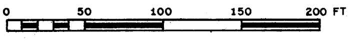


SOUTH FISHWAY ENTRANCE



UNIT 6 FISHWAY ENTRANCE

SCALE



LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS.
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.5●	WATER-SURFACE ELEVATIONS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	99 925 CFS
SPILLWAY BAYS CLOSED	0 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	665 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 390 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

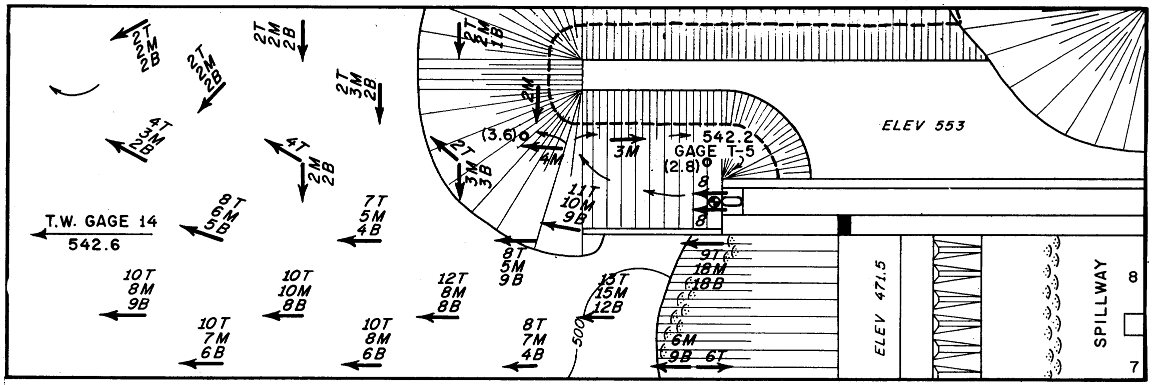
POWERHOUSE UNITS 1 TO 6 OPERATING

FLOW PATTERNS AT FISHWAY ENTRANCES

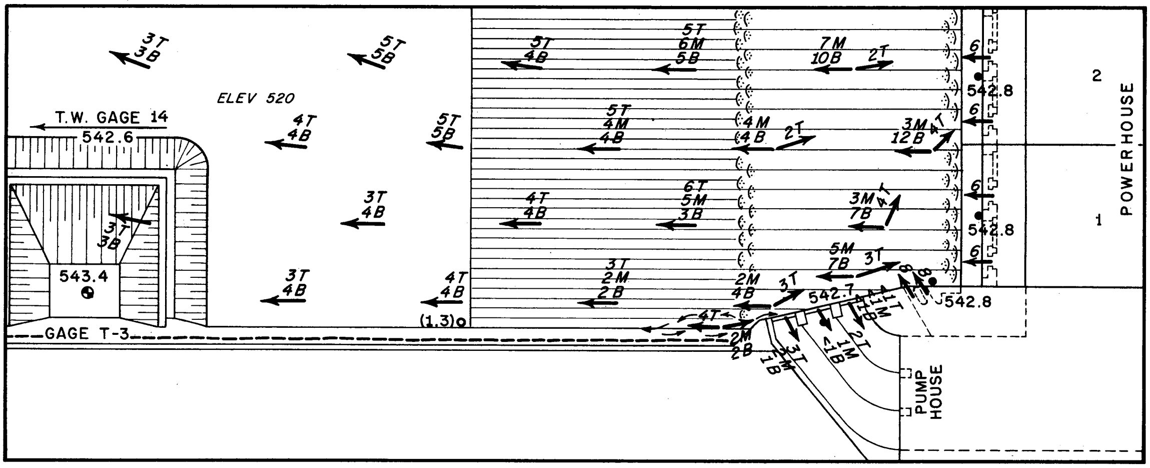
FINAL STRUCTURES AND EXCAVATION

UNIFORM SPILLWAY OPERATION

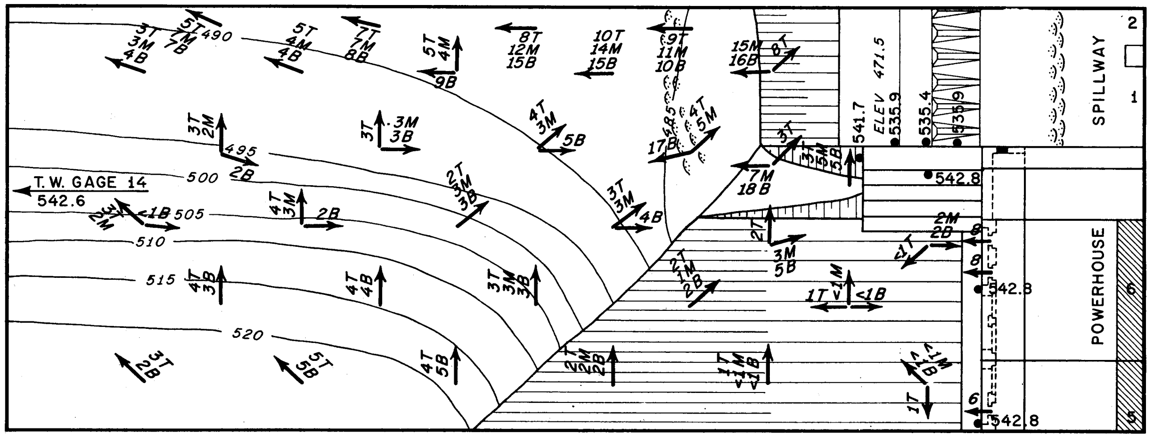
RIVER DISCHARGE 100 000 CFS



NORTH FISHWAY ENTRANCE



SOUTH FISHWAY ENTRANCE



UNIT 6 FISHWAY ENTRANCE

SCALE

0 50 100 150 200 FT

LEGEND

←8	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
542.8 ●	WATER-SURFACE ELEVATIONS
(1.3) ○	WAVE HEIGHT IN FEET

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	67 800 CFS
SPILLWAY BAYS 1 TO 8	157 125 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	766 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 491 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

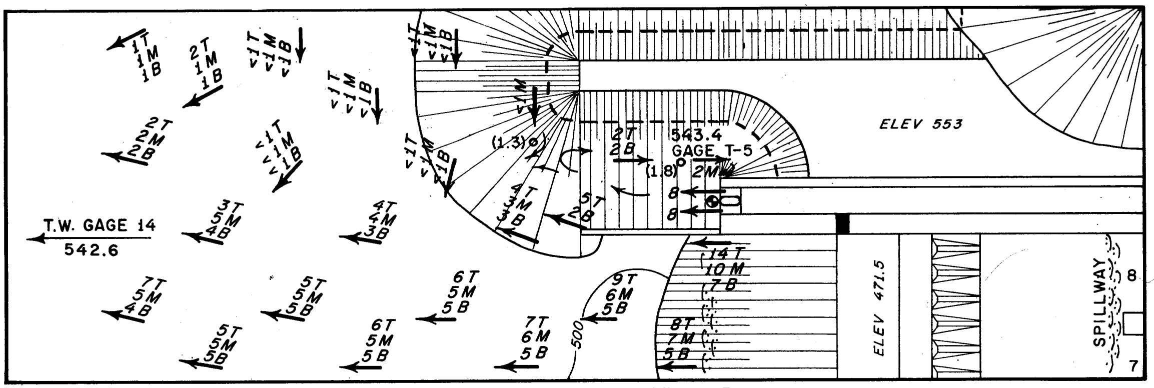
POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW PATTERNS AT FISHWAY ENTRANCES

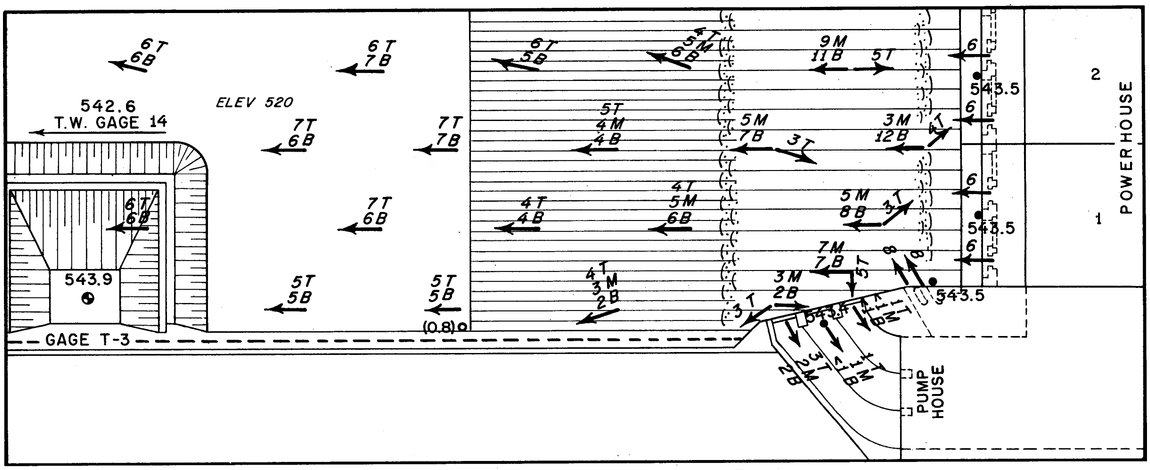
FINAL STRUCTURES AND EXCAVATION

UNIFORM SPILLWAY OPERATION

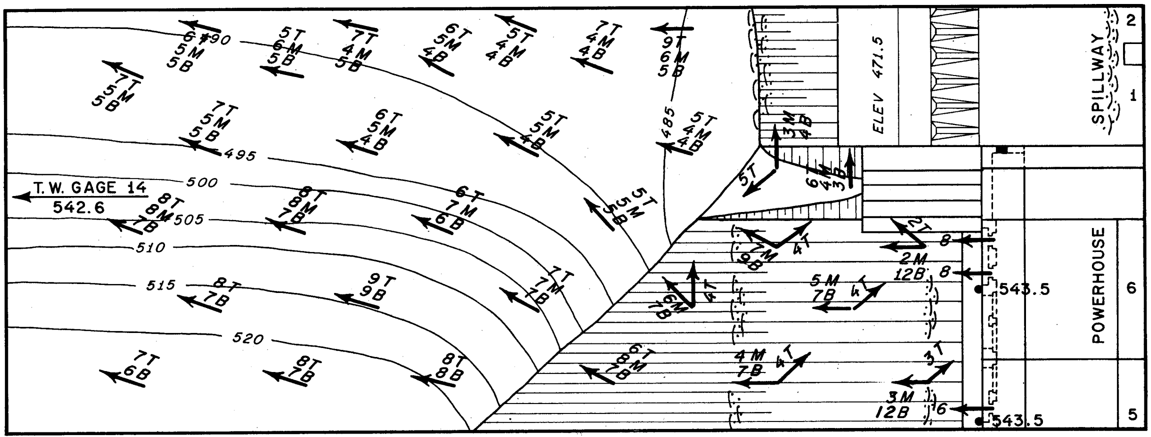
RIVER DISCHARGE 225 000 CFS



NORTH FISHWAY ENTRANCE

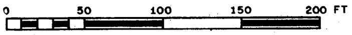


SOUTH FISHWAY ENTRANCE



UNIT 6 FISHWAY ENTRANCE

SCALE



LEGEND

← 8	VELOCITY MEASUREMENTS IN FPS.
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
543.4 ●	WATER-SURFACE ELEVATIONS
(0.8) ○	WAVE HEIGHT IN FEET

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	136 200 CFS
SPILLWAY BAYS 1 TO 8	88 725 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	786 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2511 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

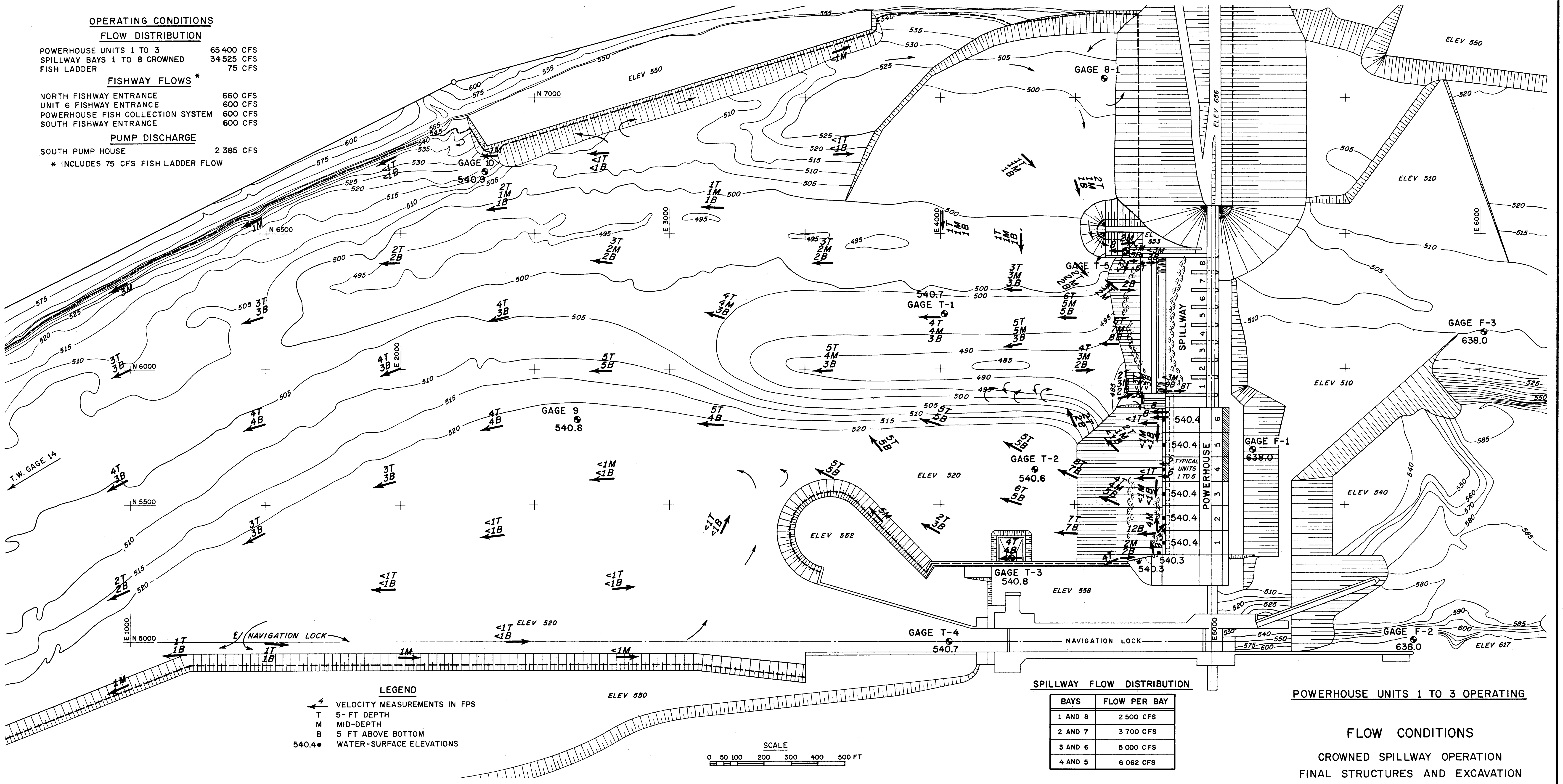
POWERHOUSE UNITS 1 TO 6 OPERATING

FLOW PATTERNS AT FISHWAY ENTRANCES

FINAL STRUCTURES AND EXCAVATION

UNIFORM SPILLWAY OPERATION

RIVER DISCHARGE 225 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	65 400 CFS
SPILLWAY BAYS 1 TO 8 CROWNED	34 525 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	660 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 385 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5- FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.4●	WATER-SURFACE ELEVATIONS

SPILLWAY FLOW DISTRIBUTION

BAYS	FLOW PER BAY
1 AND 8	2 500 CFS
2 AND 7	3 700 CFS
3 AND 6	5 000 CFS
4 AND 5	6 062 CFS

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

CROWNED SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 100 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	66 300 CFS
SPILLWAY BAYS 1 TO 8	83 625 CFS
FISH LADDER	75 CFS

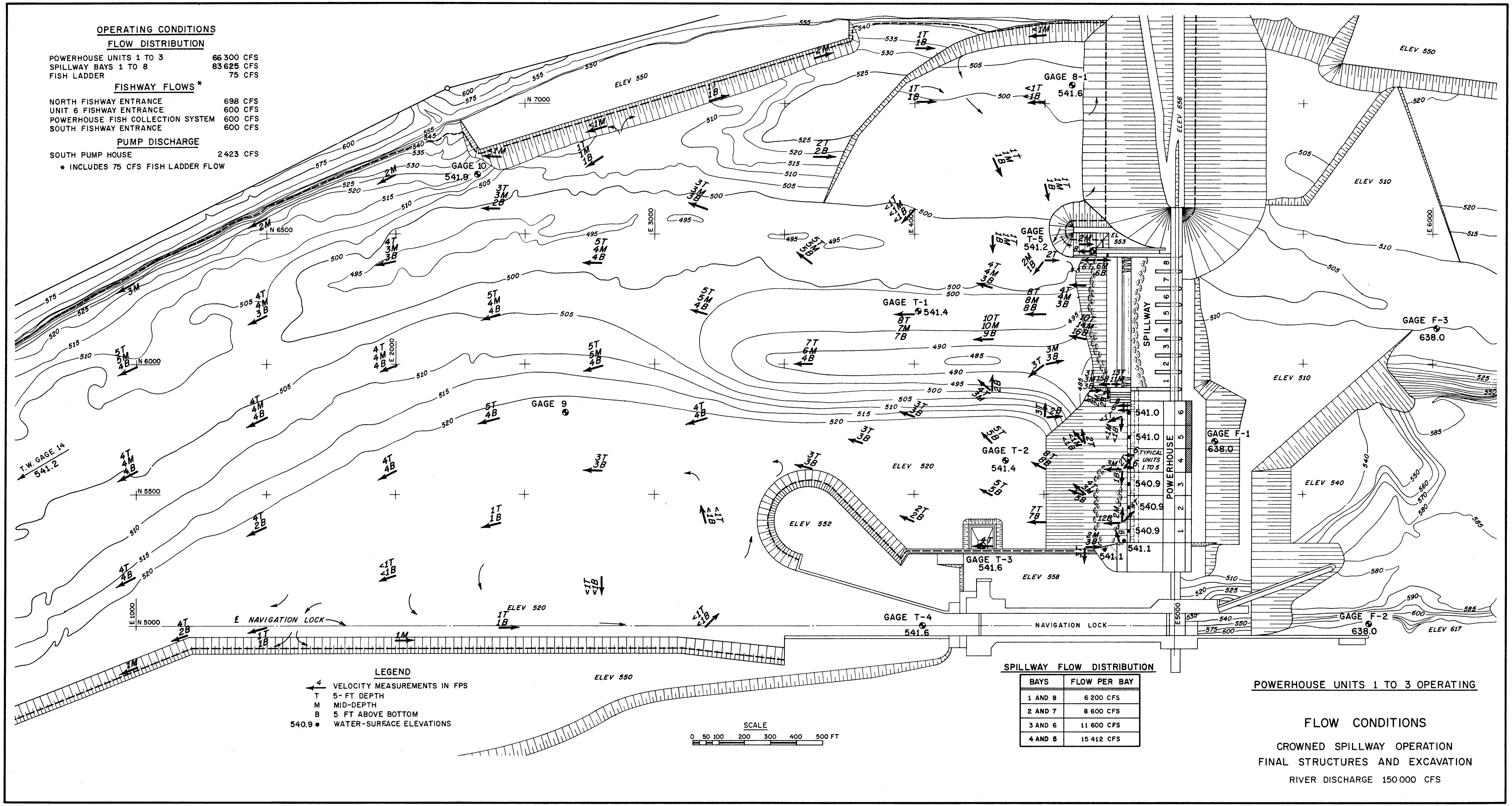
FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	698 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 423 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5- FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
540.9 ●	WATER-SURFACE ELEVATIONS

SCALE

0 50 100 200 300 400 500 FT

SPILLWAY FLOW DISTRIBUTION

BAYS	FLOW PER BAY
1 AND 8	6 200 CFS
2 AND 7	8 600 CFS
3 AND 6	11 600 CFS
4 AND 5	15 412 CFS

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

CROWNED SPILLWAY OPERATION

FINAL STRUCTURES AND EXCAVATION

RIVER DISCHARGE 150 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	67 800 CFS
SPILLWAY BAYS 1 TO 8 CROWNED	157 125 CFS
FISH LADDER	75 CFS

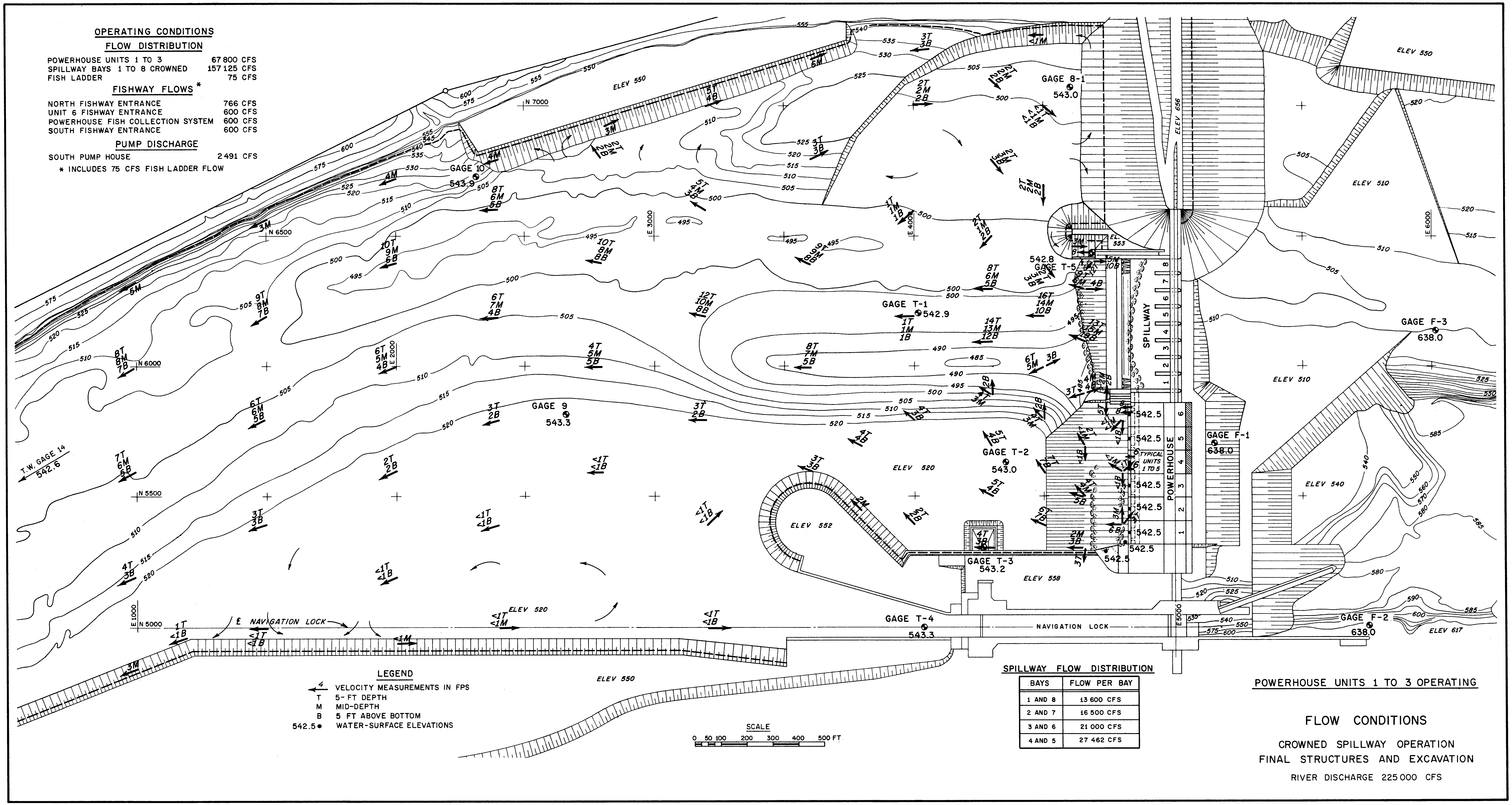
FISHWAY FLOWS *

NORTH FISHWAY ENTRANCE	766 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2 491 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

VELOCITY MEASUREMENTS IN FPS
T 5- FT DEPTH
M MID-DEPTH
B 5 FT ABOVE BOTTOM
542.5● WATER-SURFACE ELEVATIONS

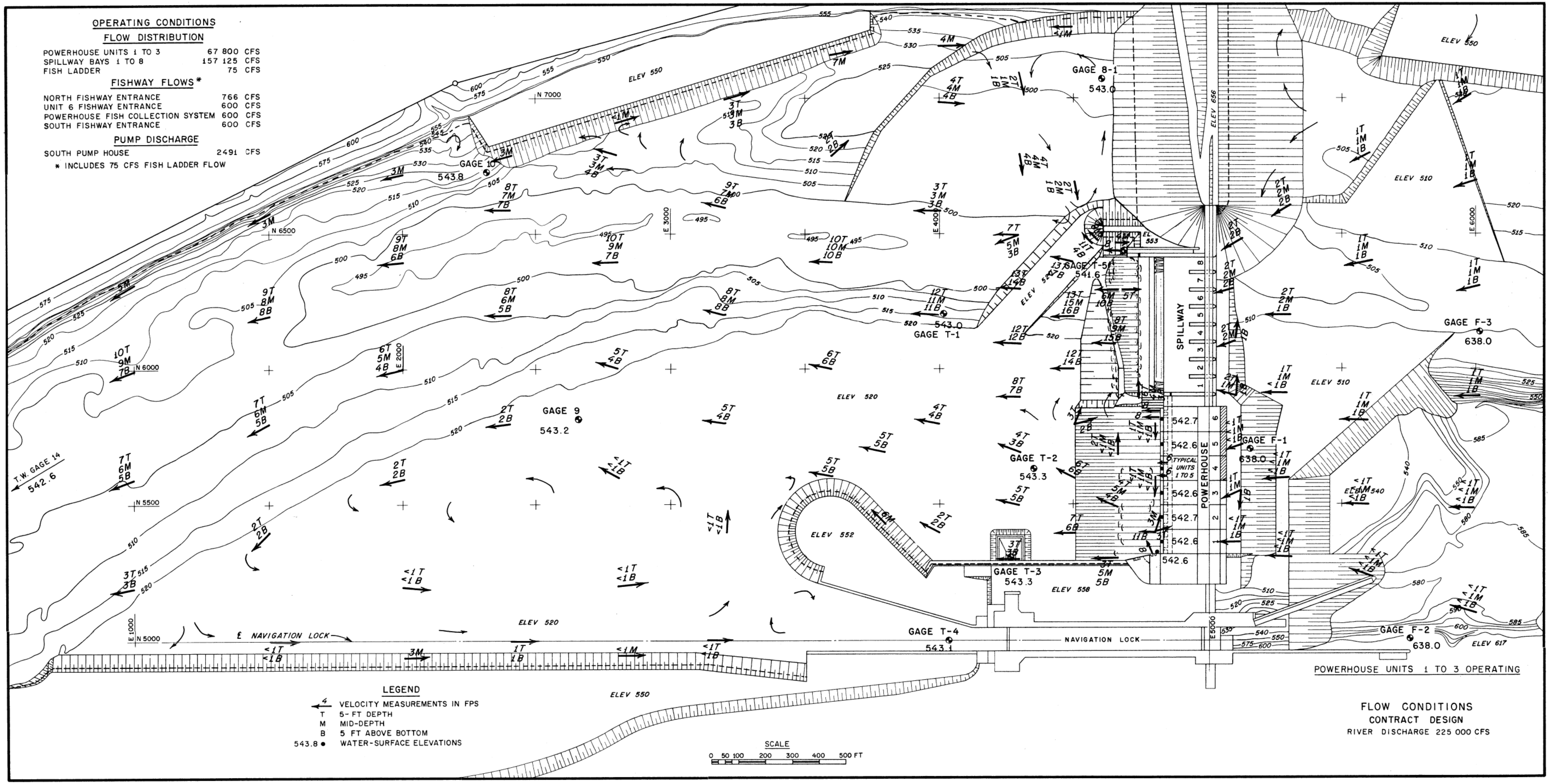
SPILLWAY FLOW DISTRIBUTION

BAYS	FLOW PER BAY
1 AND 8	13 600 CFS
2 AND 7	16 500 CFS
3 AND 6	21 000 CFS
4 AND 5	27 462 CFS

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS

CROWNED SPILLWAY OPERATION
FINAL STRUCTURES AND EXCAVATION
RIVER DISCHARGE 225 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	67 800 CFS
SPILLWAY BAYS 1 TO 8	157 125 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	766 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2491 CFS

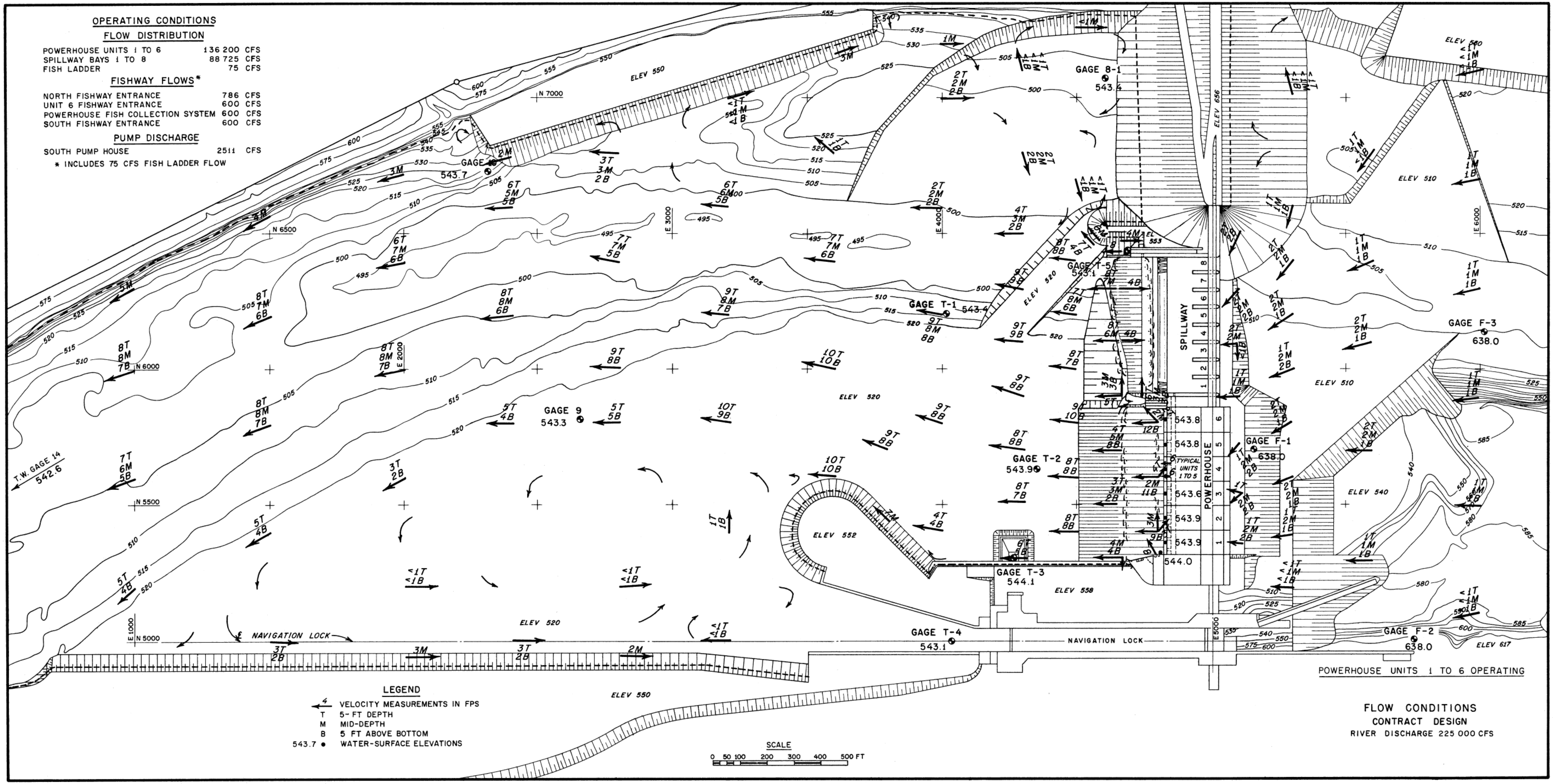
* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
543.8 ●	WATER-SURFACE ELEVATIONS

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS
CONTRACT DESIGN
RIVER DISCHARGE 225 000 CFS



OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	136 200 CFS
SPILLWAY BAYS 1 TO 8	88 725 CFS
FISH LADDER	75 CFS

FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	786 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2511 CFS

* INCLUDES 75 CFS FISH LADDER FLOW

LEGEND

←4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
543.7 ●	WATER-SURFACE ELEVATIONS

FLOW CONDITIONS
CONTRACT DESIGN
RIVER DISCHARGE 225 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 3	70 200 CFS
SPILLWAY BAYS 1 TO 8	269 725 CFS
FISH LADDER	75 CFS

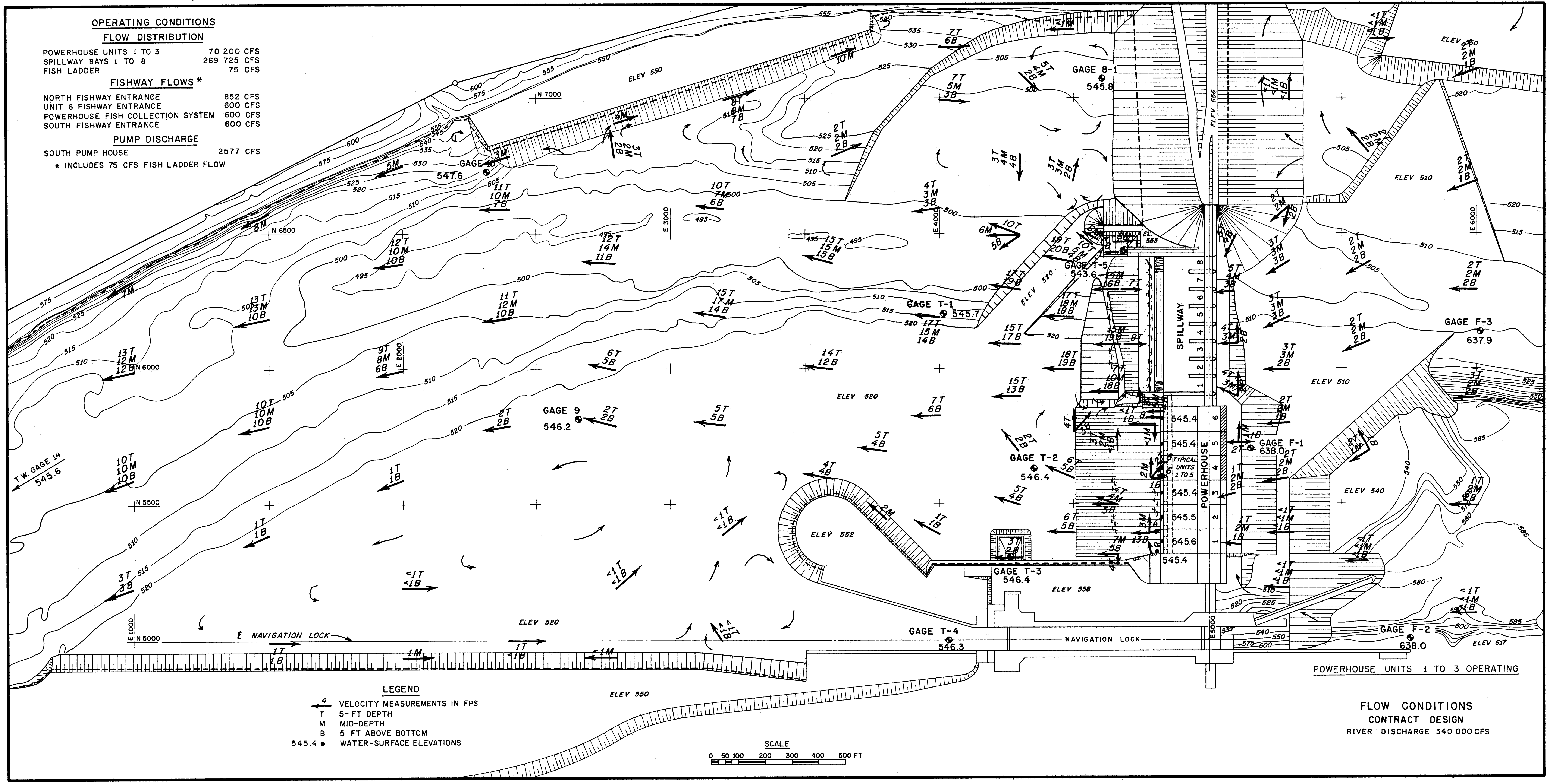
FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	852 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2577 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
545.4 ●	WATER-SURFACE ELEVATIONS

SCALE

0 50 100 200 300 400 500 FT

POWERHOUSE UNITS 1 TO 3 OPERATING

FLOW CONDITIONS
CONTRACT DESIGN
RIVER DISCHARGE 340 000 CFS

OPERATING CONDITIONS

FLOW DISTRIBUTION

POWERHOUSE UNITS 1 TO 6	140 000 CFS
SPILLWAY BAYS 1 TO 8	199 525 CFS
FISH LADDER	75 CFS

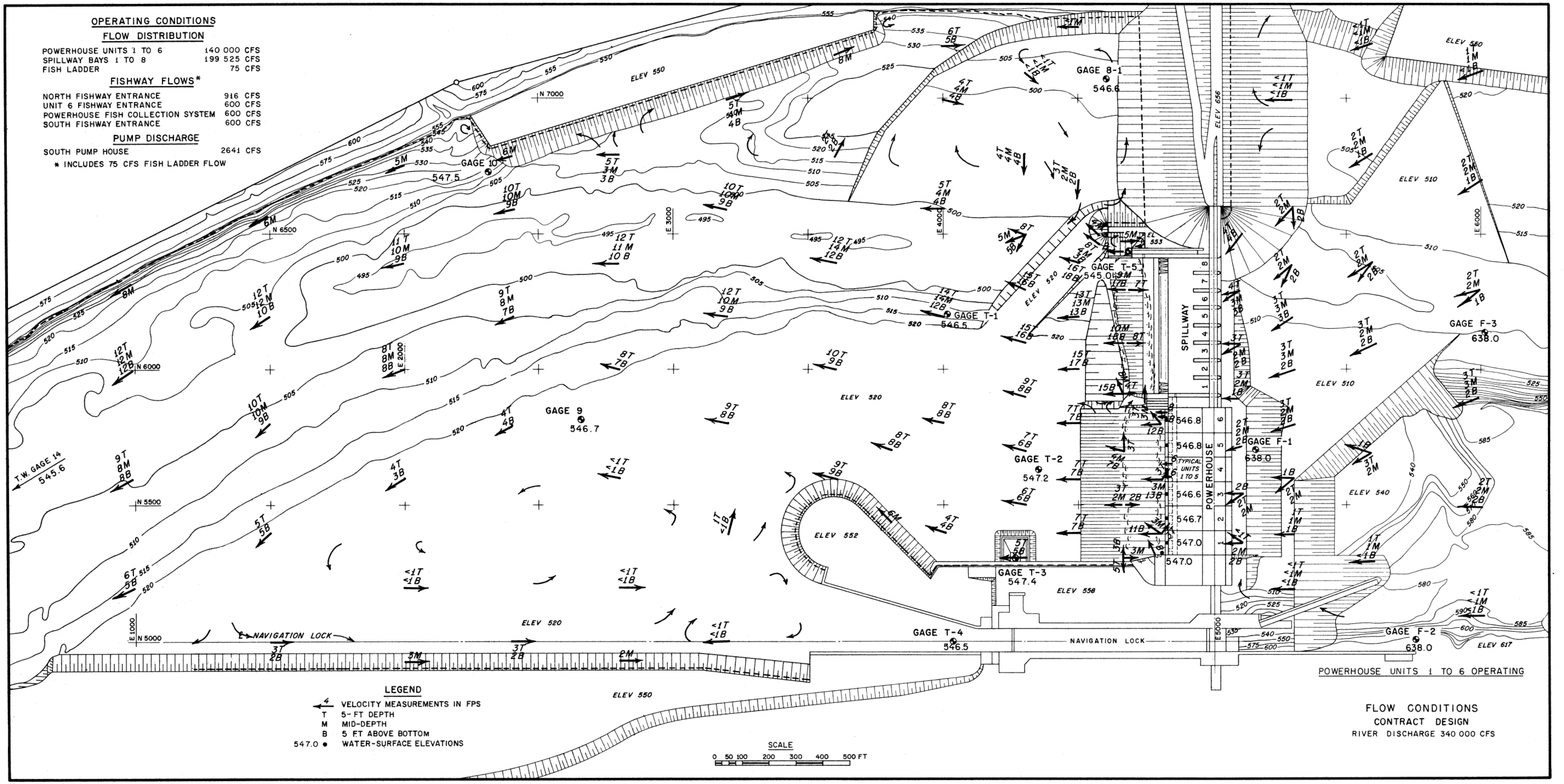
FISHWAY FLOWS*

NORTH FISHWAY ENTRANCE	916 CFS
UNIT 6 FISHWAY ENTRANCE	600 CFS
POWERHOUSE FISH COLLECTION SYSTEM	600 CFS
SOUTH FISHWAY ENTRANCE	600 CFS

PUMP DISCHARGE

SOUTH PUMP HOUSE	2641 CFS

* INCLUDES 75 CFS FISH LADDER FLOW



LEGEND

← 4	VELOCITY MEASUREMENTS IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
547.0 ●	WATER-SURFACE ELEVATIONS

SCALE
0 50 100 200 300 400 500 FT

FLOW CONDITIONS
CONTRACT DESIGN
RIVER DISCHARGE 340 000 CFS