UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF MERRITT DAM CANAL OUTLET WORKS

Hydraulic Laboratory Report No. Hyd-456

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

August 15, 1961

CONTENTS

	Page
Summary	1
Acknowledgment	2
Introduction	2
The Model	2
The Investigation	3
Preliminary Design	4
Scheme No. 2	4
Schemes No. 3 through 22	5
Recommended Design, Scheme No. 13	6

	Figure
Merritt Dam--Location Map	1
Merritt Dam--General Plan	2
Merritt Dam--Outlet Works Plan and Sections	3
Merritt Dam--Canal Outlet Works Control House and Anchor Block	4
Merritt Dam--Canal Outlet Works Stilling Basin	5
Merritt Dam--Canal Outlet Works Wave Suppressor and Parshall Flume Plan and Sections	6
Model Layout Preliminary Design	7
The 1:16 Scale Model of the Preliminary Design	8
Discharge Curve for Reservoir Elevation 2949.80	9
Tail Water Curve	10
Preliminary Design	11
Preliminary Design--850 and 1,340 cfs--Maximum Reservoir	12
Preliminary Design--580 cfs--Maximum Reservoir	13
Preliminary Design--100 cfs--Maximum Reservoir	14
Scheme No. 2 Without Wave Suppressor--1,340 and 850 cfs--Maximum Reservoir	15
Scheme No. 2 Without Wave Suppressor--580 cfs--Maximum Reservoir	16
Scheme No. 2 Without Wave Suppressor--100 cfs--Maximum Reservoir	17
Water Surface Fluctuations at Station 19+54.85--Scheme No. 2 Without Wave Suppressor	18
Water Surface Fluctuations--Scheme No. 2 Without Wave Suppressor--580 cfs	19
Water Surface Fluctuations--Scheme No. 2 With Wave Suppressor--580 cfs	20
Water Surface Fluctuations--Scheme No. 3--580 cfs	21
Water Surface Fluctuations--Scheme No. 4	22
Water Surface Fluctuations--Station 19+54.85--Scheme No. 5	23

CONTENTS--Continued

	Figure
Water Surface Fluctuations--Station 19+54.85--Scheme No. 7 . .	24
Water Surface Fluctuations--Station 19+54.85--Scheme No. 8 . .	25
Water Surface Fluctuations--Station 19+54.85--Scheme No. 9 . .	26
Water Surface Fluctuations--Station 19+54.85--Scheme No. 10 . .	27
Water Surface Fluctuations--Station 19+54.85--Scheme No. 11 . .	28
Water Surface Fluctuations--Station 19+54.85--Scheme No. 12 . .	29
Water Surface Fluctuations--Scheme No. 15	30
Wave Heights--Scheme No. 15	31
Water Surface Fluctuations--Scheme No. 19	32
Wave Heights--Scheme No. 19	33
Water Surface Fluctuations--Scheme No. 21	34
Wave Heights--Scheme No. 21	35
Recommended Design--Scheme No. 13	36
Scheme No. 13 (Recommended)--1,340 and 850 cfs--Maximum Reservoir	37
Scheme No. 13 (Recommended)--580 cfs--Maximum Reservoir	38
Scheme No. 13 (Recommended)--100 cfs--Maximum Reservoir	39
Wave Heights--Scheme No. 13 (Recommended)	40
Water Surface Fluctuation--Station 19+54.85--Scheme No. 13 (Recommended)	41

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Office of Assistant Commissioner and Chief Engineer
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Structures and Equipment Section
Denver, Colorado
August 17, 1961

Laboratory Report No. Hyd-456
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Subject: Hydraulic model studies of Merritt Dam Canal outlet works

SUMMARY

Hydraulic model studies of the Merritt Dam Canal outlet works were conducted on a 1:16 scale model to develop the hydraulic design of the outlet works stilling basin and the canal wave suppressor, Figure 3. These structures were developed to help provide uniform flow having a smooth water surface at the Parshall flume gaging station located a short distance downstream from the suppressor. Tranquil flow conditions in the flume are necessary for accurate discharge determinations from the staff gage or stilling well readings.

The studies showed that the concept of the preliminary design, Figure 11, was good, but that the stilling basin and wave suppressor could be modified to provide better hydraulic performance. More than 22 different schemes were investigated before the best arrangement of the stilling basin and wave suppressor was established.

In the recommended design, Figure 6, the center dividing wall in the stilling basin was reduced to one-half the apron length and the dentated end sill was found to be unnecessary. Thus, a more economical structure resulted and the hydraulic performance was not adversely affected.

The preliminary wave suppressor was of the type recommended in Hydraulic Laboratory Report No. Hyd-399, having a headwall at the upstream end of the wave suppressor. In operation, waves were reflected upstream by the headwall, and at times collided with waves moving downstream. The resulting wave peaks produced disturbances greater than either of the component waves.

The suppressor was modified and improved by removing the conventional upstream headwall (leaving only the downstream headwall) and installing a hanging baffle above the suppressor roof. The hanging baffle

intercepted and changed the character of the waves formerly reflected from the headwall. This reduced the peaking upstream from the suppressor and smoothed the water surface in the canal downstream. The roof of the suppressor was lowered sufficiently to be effective for discharges as low as 100 cubic feet per second.

The recommended design, Scheme No. 13, is shown operating in Figures 38, 39, and 40. The improvement in performance may be seen by comparing these photographs with those of the preliminary design, Figures 12, 13, and 14.

ACKNOWLEDGMENT

The final plans evolved from this study were developed through the cooperation of the staffs of the Spillway and Outlet Works Section, the Canals and Pipeline Section, and the Hydraulic Laboratory. Model tests were conducted during the period May 1959 to July 1959.

INTRODUCTION

Merritt Dam is part of the Missouri River Basin Project. It is located in Nebraska, Figure 1. The dam, Figure 2, has an outlet works, Figures 3, 4, and 5, to control the discharge of irrigation water. Flow is released through two 4- by 4-foot high pressure slide gates and is discharged through the stilling basin before it enters the downstream concrete-lined canal. The canal is designed for a capacity of 580 cubic feet per second, however, it is possible to discharge a maximum of 850 cubic feet per second through one gate or 1,340 cubic feet per second through both gates fully open with maximum reservoir elevation. A Parshall flume, installed in the canal approximately 210 feet downstream from the end of the horizontal apron of the stilling basin, Figure 6, is used to measure the discharge. To increase the accuracy of discharge measurements in the Parshall flume, a wave suppressor was placed between the basin and the flume to provide a smooth water surface at the gage.

THE MODEL

The canal outlet works model, Figures 7 and 8, is a 1:16 scale reproduction of the prototype. The model included the 4- by 4-foot high pressure slide gates, the stilling basin, and approximately 117 feet of canal section extending downstream from the basin. A wave suppressor was installed in the canal section.

The gate housing was constructed of sheet metal, the gate leaves of brass. Threaded brass rods were used to raise and lower the gate leaves to any position. The basin and the canal were constructed of plywood except for one wall made from 3/8-inch transparent plastic. Flow in the basin, under the wave suppressor, and in the canal could thereby be observed through the transparent wall. The wave suppressor was constructed of plywood. The preliminary suppressor was held in place with screw clamps to make it easily removable. Later designs were supported on a center wall.

In operating the model, the discharge and the gate openings were regulated in accordance with the computed curves shown in Figure 9. These curves show the relationship between discharge and gate opening for one and two-gate operation and include the effect of hydraulic losses computed from the reservoir water surface to the gate chamber. To insure maximum test velocities, minimum hydraulic losses were used in the computations. In running a test, the gate opening and the discharge were set by the model operator; no consideration was given to the head or pressure in the model gate chamber. For one valve operation, the right valve was used so that flow in the operating bay could be observed through the transparent wall. The tail water elevation was regulated in accordance with the tail water curve for Station 19+54.85, Figure 10, located downstream from the wave suppressor. A staff gage was placed on the wall of the model canal at this station. Stoplogs at the downstream end of the model were used to regulate the tail water elevation.

THE INVESTIGATION

The primary purpose of the investigation was to develop the hydraulic design of the stilling basin and the wave suppressor to provide satisfactory performance for a wide range of operating conditions.

The structures, Figures 4, 5, and 6, were designed for (1) the maximum discharge of 1,340 cubic feet per second at maximum reservoir elevation 2949.80 with both gate valves fully open, and (2) 850 cfs with only one gate valve fully open, Figure 9. At maximum reservoir elevation, 580 cfs can be discharged through two gates approximately 38 percent open, or through one gate approximately 72 percent open, Figure 9. Most of the testing was concerned with 580 cfs, the design capacity of the canal. A discharge of 580 cfs through two gates open 38 percent provides a Froude number for the flow of 11.9 at Station 17+41.85, Figure 4. This value was determined from measurements made in the model and was verified by computations. From the analysis and classification of jumps given in Hydraulic Laboratory Report No. Hyd-399,1/ it may be expected that for F = 11.9, a good, but rough jump will occur.

1/Hyd-399 "Progress Report II--Research Study on Stilling Basins, Energy Dissipators and Associated Appurtenances" by J. N. Bradley and A. J. Peterka.

Preliminary Design

The hydraulic performance of the preliminary structure, Figure 11, is shown in Figures 12, 13, and 14. The basin was slightly longer than necessary for 850 cfs through one gate valve fully open and was much longer than necessary for all other discharges. The dentated end sill appeared to serve little or no purpose. For all discharges of 500 cfs or more, the water surface was rough.

For 580 cfs from two gates 38 percent open with the reservoir at maximum elevation 2949.80, the water surface fluctuated about 8 feet on the upstream side of the suppressor and about 9 inches (prototype) on the downstream side. Approximately the same wave heights occurred for 580 cfs from one gate 72 percent open at maximum reservoir. For 100 cfs, the wave suppressor was inoperative because the water surface was below the flow surface of the suppressor. Water surface fluctuations were approximately 6 inches at the gage when 100 cfs at maximum head was discharging from either one or both gates. Fluctuations at the gage were greater than desired and attempts were made, therefore, to improve the performance of the suppressor.

Scheme No. 2

In Scheme No. 2, the preliminary design was modified by removing the dentated end sill from the basin, and, in addition, reducing the length of the center dividing wall to one-half the length of the basin apron. The basin was not shortened as had been indicated in the tests of the preliminary design because this would have necessitated lengthening the transition downstream from the basin. Since both are of concrete construction, there would be little, if any, advantage in moving the start of the transition upstream.

To evaluate the effectiveness of the basin the wave suppressor was removed. Thus, there was no interference of reflected waves from the wave suppressor with waves from the stilling basin. This modified basin performed very well as shown in Figures 15, 16, and 17. Since the basin in Scheme No. 2 would cost less to construct and did not sacrifice good hydraulic performance, it was used in all succeeding tests and was included in the recommended design.

To evaluate the effectiveness of the wave suppressor, tests were made both with and without the suppressor in place. The hydraulic performance of Scheme No. 2, without the suppressor, is shown in Figures 15, 16, and 17. Wave heights were recorded at Station 19+54.85 (downstream from the suppressor) using an electronic measuring device to record water surface fluctuations continuously over a period of time, Figure 18. For 100 cfs discharging through two gates, 6 percent open, the maximum water surface fluctuation was approximately 5 inches. For the same discharge through one gate 12 percent open, the fluctuation was approximately 6 inches. For 580 cfs discharged through two gates 38 percent open, the fluctuation was approximately 30 inches. Maximum wave heights obtained from visual observations of the staff gage are shown in Figure 19. The maximum fluctuations obtained visually agreed very well with those taken electronically. For 580 cfs through larger gate openings, at reduced head, the maximum fluctuation was reduced as shown by the visual staff gage record in Figure 19.

With the wave suppressor in place, water surface fluctuations were recorded from visual observations made both upstream and downstream from the suppressor. For 580 cfs at maximum head from either one or both gates together, waves upstream from the suppressor were increased to about 8 feet, Figure 20 because of wave reflections from the suppressor headwall. The reflected waves from the suppressor headwall collided with those traveling downstream to create a wave peak shown in Figure 13B. The waves were reduced to 9 inches at Station 19+54.8 downstream from the suppressor for either one-gate or two-gate operation.

<u>Schemes No. 3 through 22</u>

Many schemes were tested in an attempt to reduce the water surface fluctuations at Station 19+54.85 downstream from the suppressor. Tests were made for discharges of 580 cfs and 100 cfs; each flow was discharged through both gates at maximum head. Additional wave suppressors were installed both upstream and downstream from the preliminary suppressor, hanging baffle walls were installed in the basin and in the transition wave suppressor, variations in the shape of the wave suppressors were investigated, and baffle piers of several types were tested in various positions in the stilling basin. During the tests, water surface fluctuations were either visually or electronically measured upstream and downstream from the suppressor. For schemes that appeared to be promising, in at least some respects, the data were electronically recorded. Most of the recorded data is shown in Figures 21 through 37.

The most helpful, and perhaps the simplest modification was the removal of the upstream headwall of the suppressor, Scheme No. 3, Figure 21. Waves and surges could then travel over the roof of the wave suppressor to the downstream headwall before being reflected upstream. The shallow water above the roof changed the character of the wave as it moved downstream and the magnitude of the reflected wave was greatly reduced. Removal of the headwall resulted in the maximum water surface fluctuation upstream from the suppressor being reduced from 8 feet to approximately 3.25 feet for 580 cfs discharged at maximum head through both gates 38 percent open, Figure 21. A second helpful modification was the installation of a hanging baffle above the wave suppressor, Scheme No. 4, Figure 22. The baffle functioned in two ways; first, it intercepted and broke up the larger waves and provided an artificial beach for the smaller waves, and secondly, it prevented large waves from reflecting directly upstream. Combined action of intercepting the wave moving downstream and delaying the return of the reflected wave reduced the intensity of the action so that water surface fluctuations were only 2.5 feet, Figure 22. As a result, the fluctuation downstream from the suppressor was reduced to 7 inches for one-gate operation and to 2 inches for two-gate operation. However, additional improvement was desirable, particularly for discharges of approximately 150 cfs or less when the wave suppressor roof was above the water surface.

In Scheme No. 11, Figure 28, the water surface fluctuation resulting from 580 cfs through one gate was reduced to 5 inches by using a longer and flatter hanging baffle than had been used in Scheme No. 4. A second hanging baffle located upstream from the suppressor was used in Scheme No. 15, Figures 30 and 31, to obtain improved performance. The advantage of this design was that the sloping baffle could be extended downward into the flow to suppress waves for all discharges. For 100 cfs from two gates 6 percent open, the fluctuation was reduced to approximately 1/4 inch on the downstream side of the suppressor. However, for 580 cfs, Scheme No. 15 was not as effective as were Schemes No. 19 and 21, Figures 32 and 34, respectively, and for discharges greater than 580 cfs up to the maximum possible flow of 1,340 cfs, waves in the canal upstream from the suppressor overtopped the training walls more frequently and to a greater extent than in Schemes No. 19 and 21. Compare Figures 31, 33, and 35.

Baffle piers were placed in the stilling basin in Scheme No. 19, Figures 32 and 33, and the wave suppressor was lowered 6 inches. For this scheme, the maximum fluctuation downstream from the suppressor for 100 cfs (discharging from two gates 6 percent open) was reduced to approximately 1 inch, and for 580 cfs (discharged from one gate 72 percent open) to 4 inches. Chute blocks were added to the basin in Scheme No. 21, Figures 34 and 35. The chute blocks helped to reduce the waves in the basin for the larger flows, but were the cause of water surface roughness in the basin for the smaller flows.

Recommended Design, Scheme No. 13

The hydraulic performance of the recommended design, Figure 36, is shown in Figures 37, 38, and 39 for discharges of 1,340, 850, 580, and 100 cfs. Performance was improved over the preliminary design, particularly for 580 cfs, since waves did not reflect upstream to peak with those traveling downstream as occurred in the preliminary design. Compare Figures 37, 38, and 39 with Figures 12, 13, and 14.

The stilling basin performed very well in dissipating the energy in the flow from the slide gates. Even for the unusual maximum possible flows of 1,340 cfs from two gates 100 percent open or 850 cfs from one gate 100 percent open, the basin was adequate. The length of the center dividing wall was 32 feet, compared to 45 feet in the preliminary design and the dentated end sill in the preliminary design was eliminated. Water surface profiles in the basin were measured from the photograph in Figure 38B for the structural design of the center dividing wall. It was recommended that the actual depth of water in the upstream portion of the basin as measured in the photograph be reduced by 33 percent due to air entrainment. On the other side of the dividing wall, water stood at tail water elevation since only the one valve was operating to represent the severest operating condition.

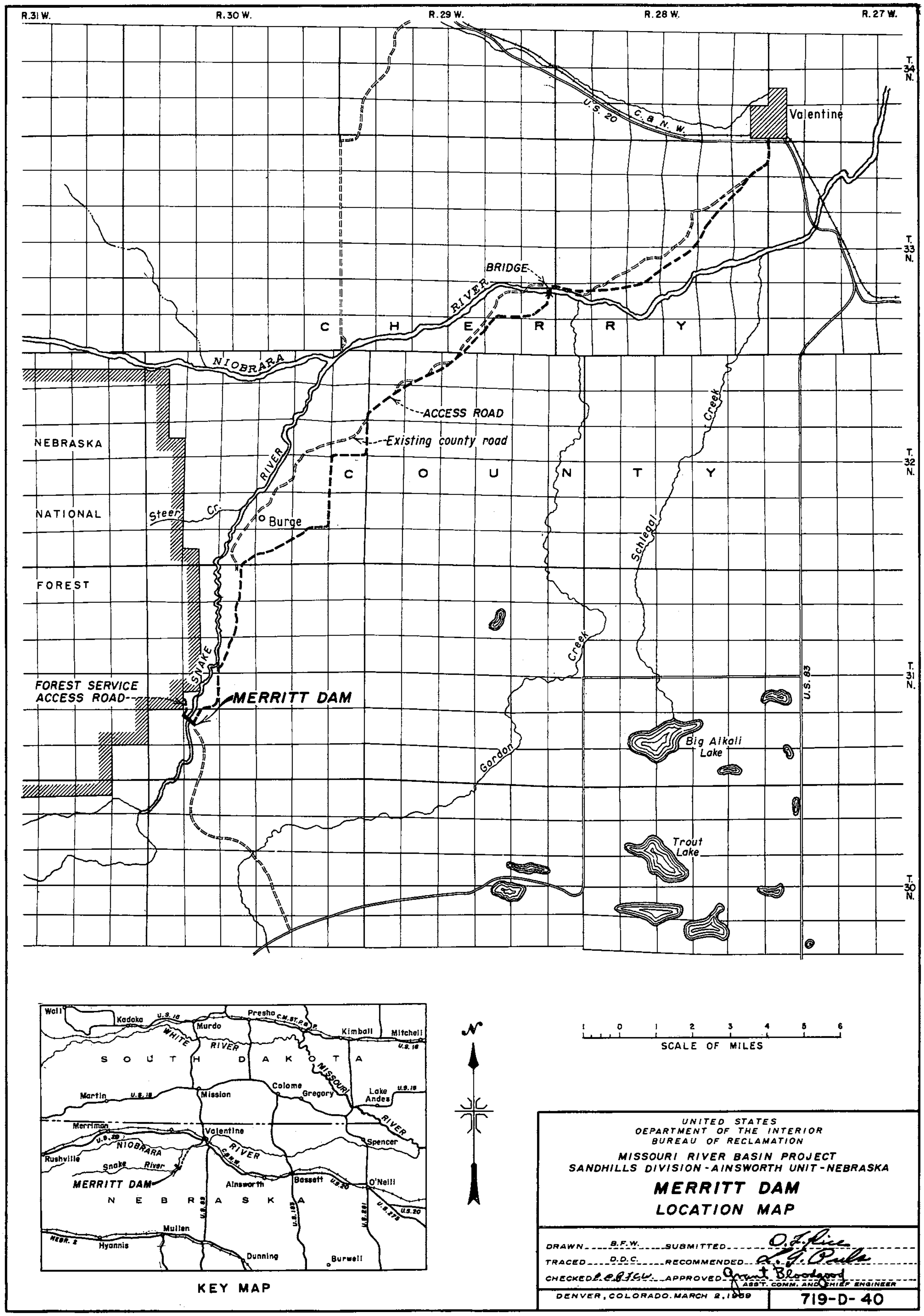
Waves upstream from the suppressor were recorded by observing and marking on the left training wall maximum and minimum water surface fluctuations for discharges of 580 cfs, 850 cfs, and 1,340 cfs as shown in Figure 40. For 580 cfs, the water surface did not reach the top of the training walls, but for 850 cfs from one gate or 1,340 cfs from two gates, waves sometimes did extend 1 to 2 feet higher than the top of the wall. The wall heights should be increased or an overhang constructed if it is desirable to prevent flow over the wall for these unusual operating conditions.

The refinements made in Schemes No. 15, 19, and 21 reduced the maximum water surface fluctuations downstream from the wave suppresor for some discharges as described above; however, the slight improvement afforded by these schemes did not warrant their cost. Therefore, Scheme No. 13 in Figures 36 and 41 was recommended for field construction. This scheme utilized a wave suppressor quite similar to the one described for Scheme No. 4 except that the hanging baffle was longer and was placed at a flatter angle, and the suppressor was placed 6 inches lower to be effective for discharges down to about 100 cfs. The hydraulic performance of this scheme was identical to that described for Scheme No. 4, page 9. However, Scheme No. 13 provided even more improvement over the preliminary design than did Scheme No. 4.

The water surface fluctuations downstream from the wave suppressor at Station 19+54.85 were recroded by means of an electronic device and are shown in Figure 41 for discharges of 100 cfs and 580 cfs. The maximum water surface fluctuations downstream from the suppressor were:

1 inch for 100 cfs from two gates 6 percent open,
3 inches for 100 cfs from one gate 12 percent open,
3 inches for 580 cfs from two gates 38 percent open, and
5 inches for 580 cfs from one gate 72 percent open.

FIGURE NO. 1
REPORT HYD 456



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MISSOURI RIVER BASIN PROJECT
SANDHILLS DIVISION - AINSWORTH UNIT - NEBRASKA

MERRITT DAM
LOCATION MAP

DRAWN B.F.W. SUBMITTED O.L. Rice
TRACED D.D.C. RECOMMENDED L.G. Puls
CHECKED E.E.G.J.C.W. APPROVED Grant Bloodgood ASST. COMM. AND CHIEF ENGINEER
DENVER, COLORADO, MARCH 2, 1959 | 719-D-40

FIGURE NO. 2
REPORT HYD 456

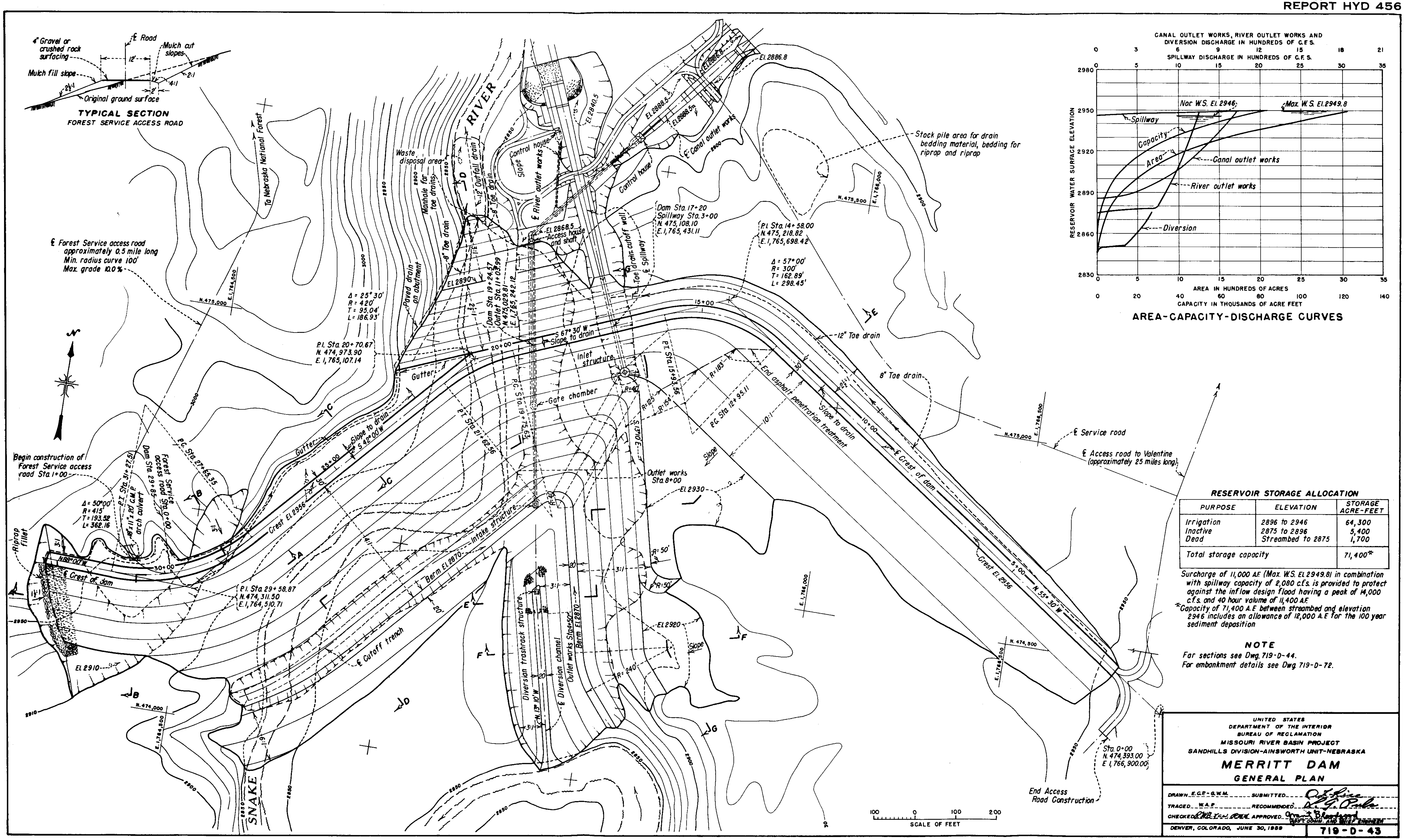
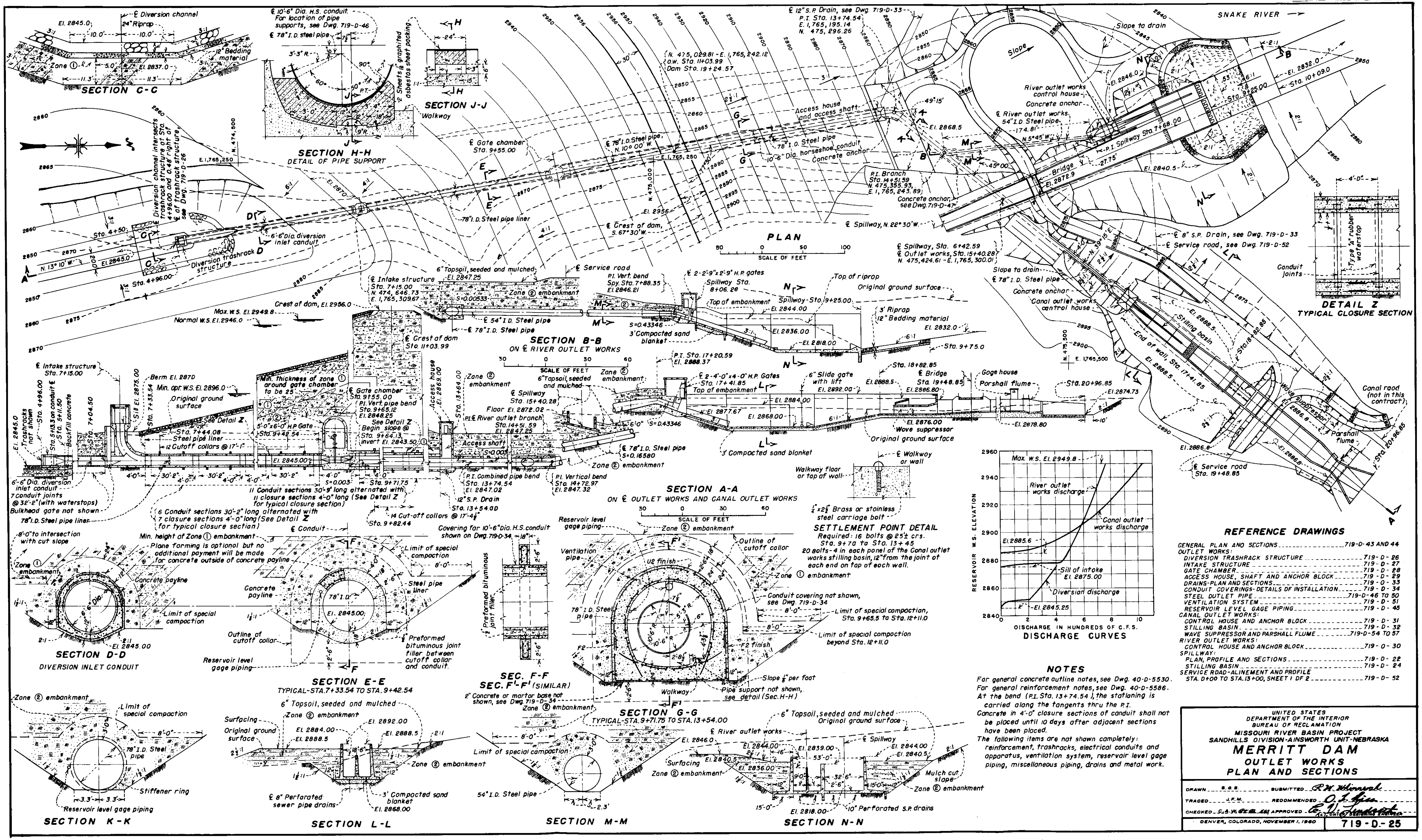
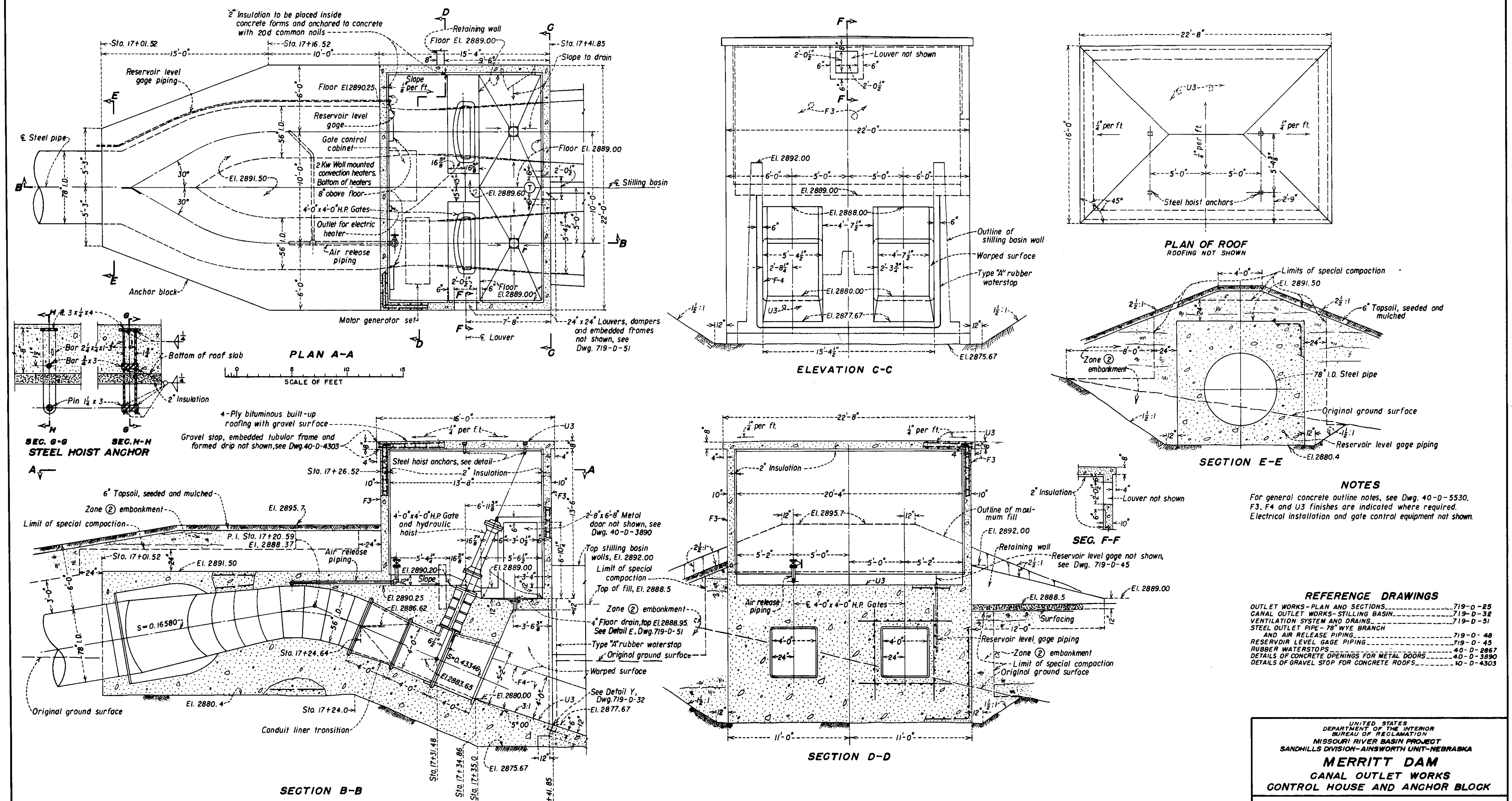


FIGURE NO. 3
REPORT HYD 456





NOTES

For general concrete outline notes, see Dwg. 40-D-5530.
F3, F4 and U3 finishes are indicated where required.
Electrical installation and gate control equipment not shown.

REFERENCE DRAWINGS

OUTLET WORKS-PLAN AND SECTIONS	719-D-25
CANAL OUTLET WORKS-STILLING BASIN	719-D-32
VENTILATION SYSTEM AND DRAINS	719-D-51
STEEL OUTLET PIPE-78" WYE BRANCH AND AIR RELEASE PIPING	719-D-48
RESERVOIR LEVEL GAGE PIPING	719-D-45
RUBBER WATERSTOPS	40-D-2867
DETAILS OF CONCRETE OPENINGS FOR METAL DOORS	40-D-3890
DETAILS OF GRAVEL STOP FOR CONCRETE ROOFS	40-D-4303

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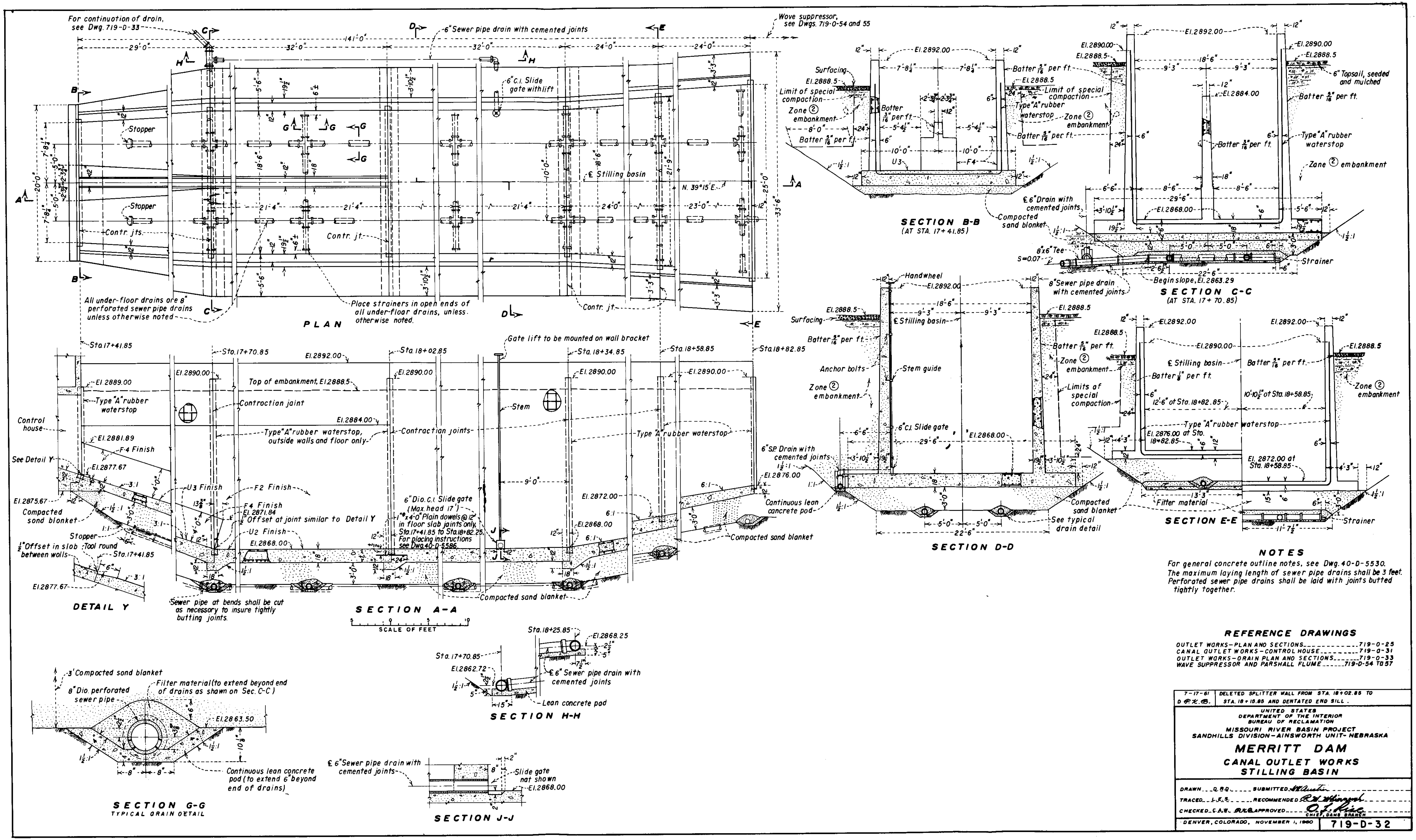
MISSOURI RIVER BASIN PROJECT
SANDHILLS DIVISION-AINSWORTH UNIT-NEBRASKA

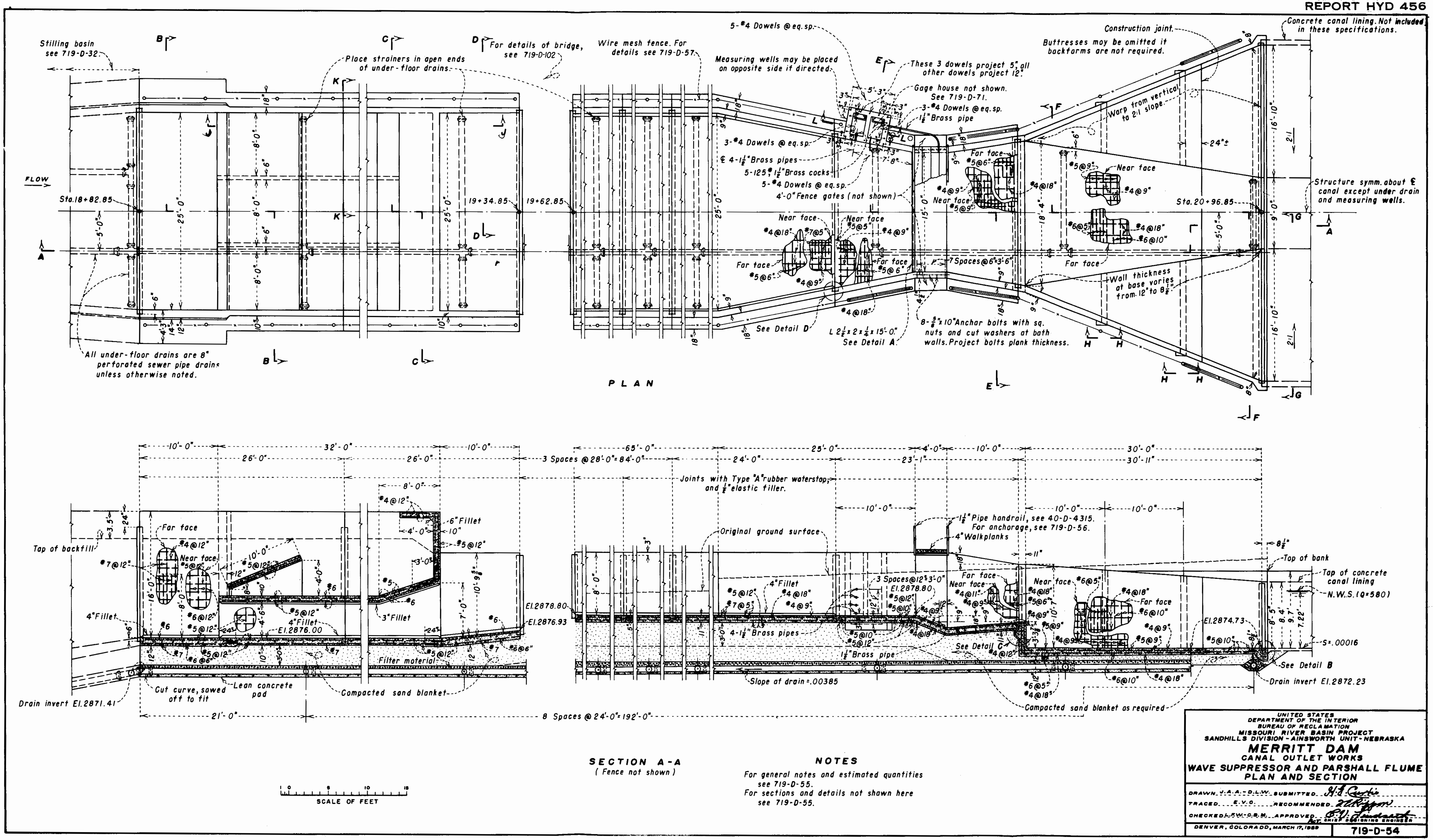
MERRITT DAM

CANAL OUTLET WORKS
CONTROL HOUSE AND ANCHOR BLOCK

DRAWN R.E.J. SUBMITTED
TRACED J.L. RECOMMENDED
CHECKED S.A.W. APPROVED
CHIEF, DAMS BRANCH
DENVER, COLORADO, NOVEMBER 1, 1960 719-D-31

FIGURE NO. 5
REPORT HYD 456




PLAN
SECTION A-A
(Fence not shown)
NOTES
For general notes and estimated quantities see 719-D-55.
For sections and details not shown here see 719-D-55.
FLOW
Stilling basin see 719-D-32.
Place strainers in open ends of under-floor drains.
For details of bridge, see 719-D-102
Wire mesh fence. For details see 719-D-57.
Measuring wells may be placed on opposite side if directed.
These 3 dowels project 5", all other dowels project 12".
Gage house not shown. See 719-D-71.
Construction joint.
Buttresses may be omitted if backforms are not required.
Concrete canal lining. Not included in these specifications.
Warp from vertical to 2:1 slope
Structure symm. about ℄ canal except under drain and measuring wells.
Wall thickness at base varies from 12" to 8½".
All under-floor drains are 8" perforated sewer pipe drains unless otherwise noted.
8-⅝"x10" Anchor bolts with sq. nuts and cut washers at both walls. Project bolts plank thickness.
Joints with Type "A" rubber waterstop, and ½" elastic filler.
Top of backfill
Original ground surface
1½" Pipe handrail, see 40-D-4315. For anchorage, see 719-D-56.
4" Walkplanks
Top of bank
Top of concrete canal lining
N.W.S. (Q=580)
S=.00016
See Detail B
Drain invert El. 2872.23
Drain invert El. 2871.41
Cut curve, sawed off to fit
Lean concrete pad
Compacted sand blanket
Filter material
Slope of drain = .00385
Compacted sand blanket as required
8 Spaces @ 24'-0" = 192'-0"
3 Spaces @ 28'-0" = 84'-0"
SCALE OF FEET
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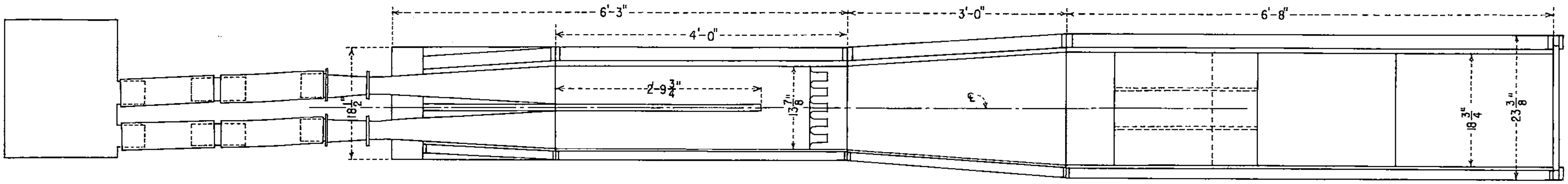
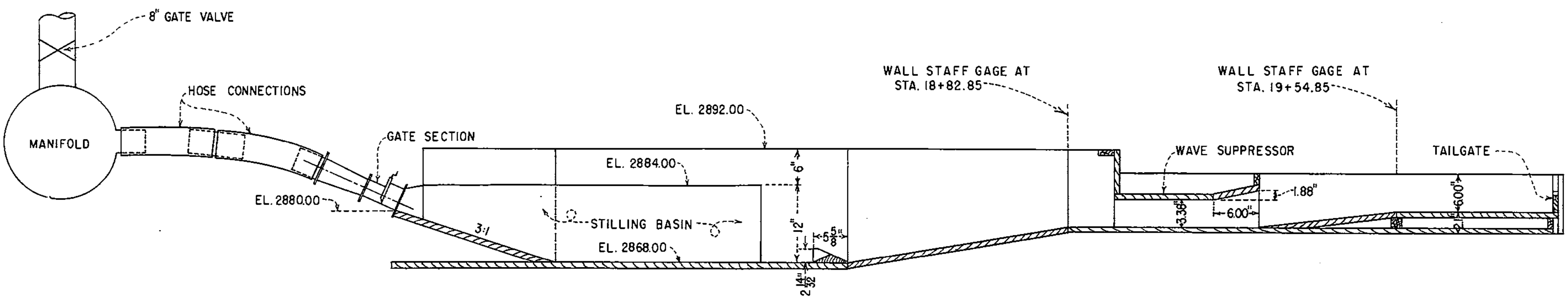
MISSOURI RIVER BASIN PROJECT
SANDHILLS DIVISION - AINSWORTH UNIT - NEBRASKA
MERRITT DAM
CANAL OUTLET WORKS
WAVE SUPPRESSOR AND PARSHALL FLUME
PLAN AND SECTION
DENVER, COLORADO, MARCH 17, 1959
719-D-54



PLAN



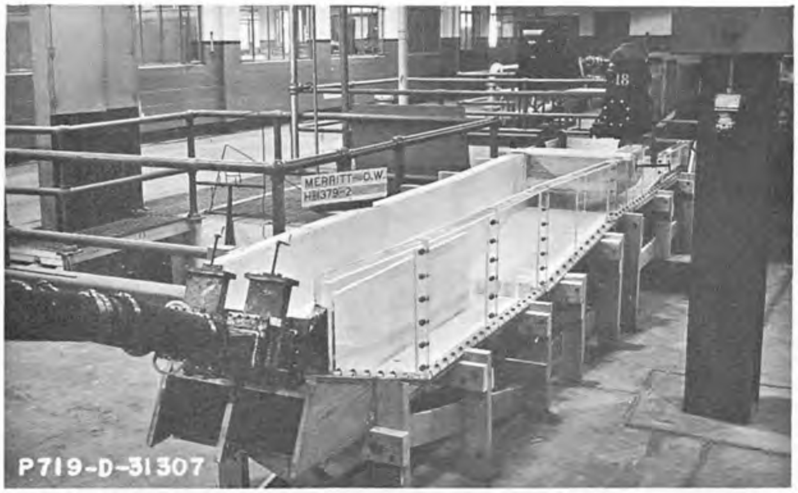
SECTION ON CENTERLINE

MERRITT DAM CANAL OUTLET WORKS

MODEL LAYOUT - PRELIMINARY DESIGN

1:16 SCALE MODEL

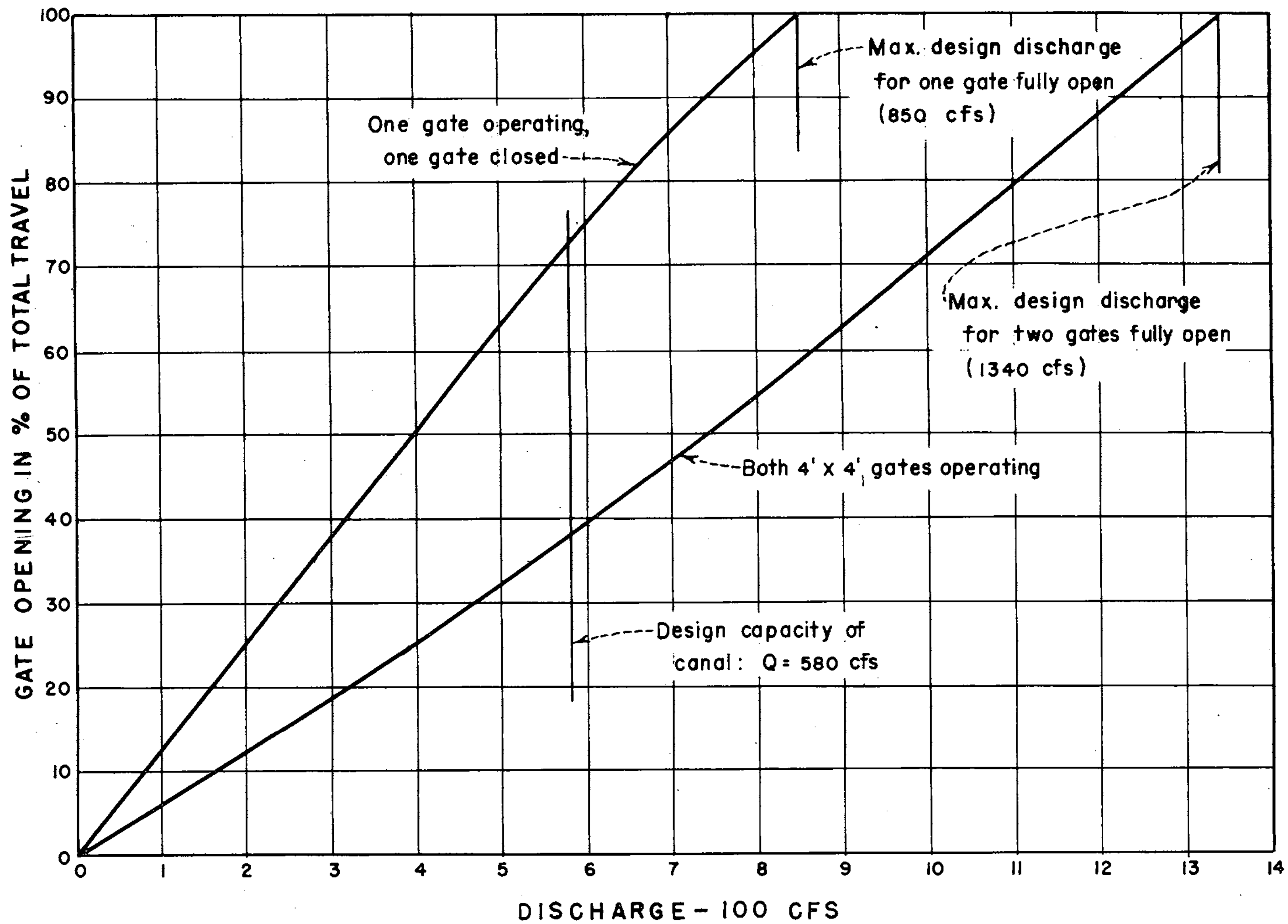
FIGURE 7
REPORT HYD. 456



Looking downstream. High pressure slide gates are in foreground.

Wave suppressor, held in place with clamps to facilitate removal from model, helps to produce smooth water surface at measuring station downstream.

MERRITT DAM CANAL OUTLET WORKS
THE 1:16 SCALE MODEL OF THE
PRELIMINARY DESIGN



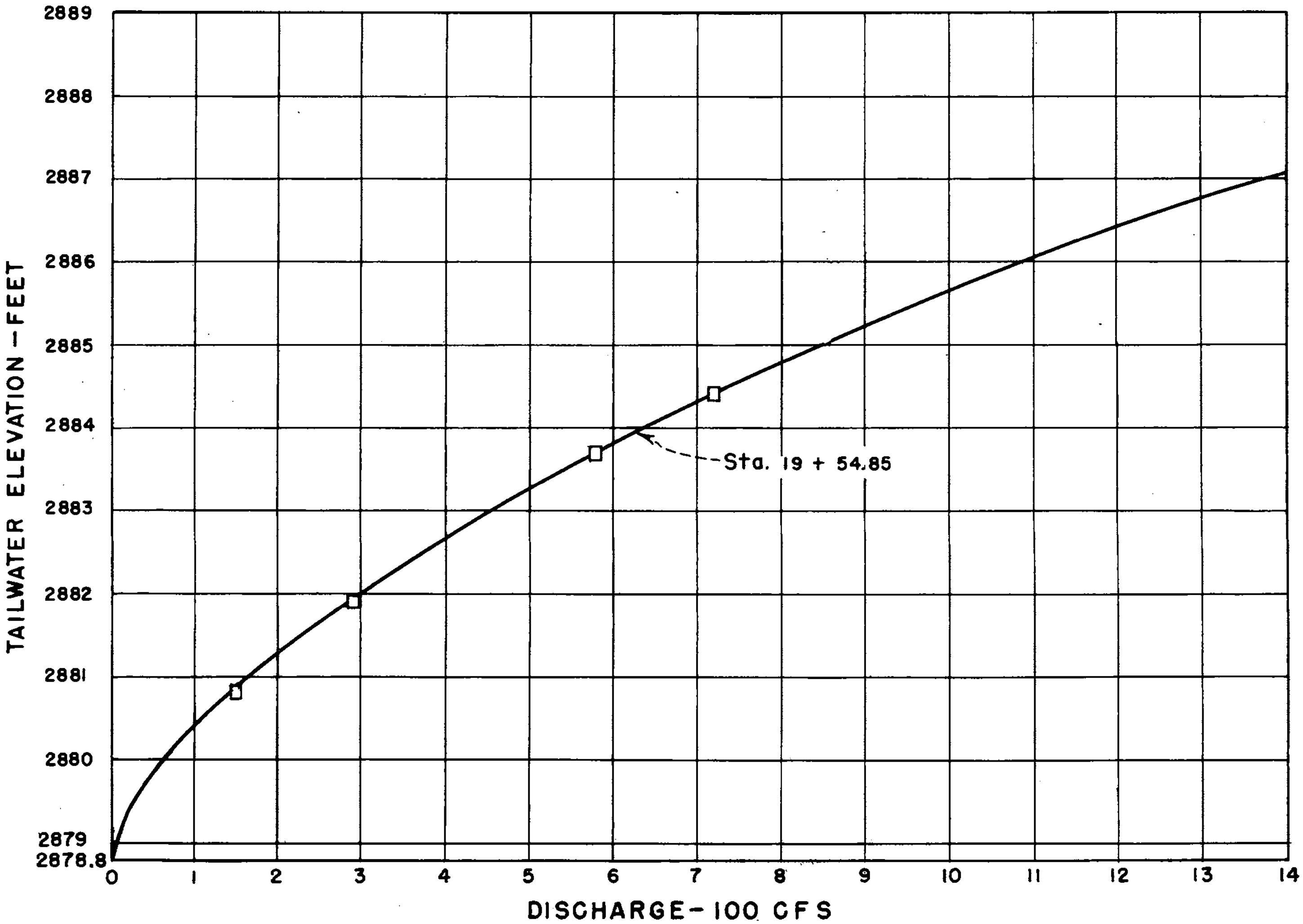
MERRITT DAM CANAL OUTLET WORKS

DISCHARGE CURVE FOR RESERVOIR El. 2949.80

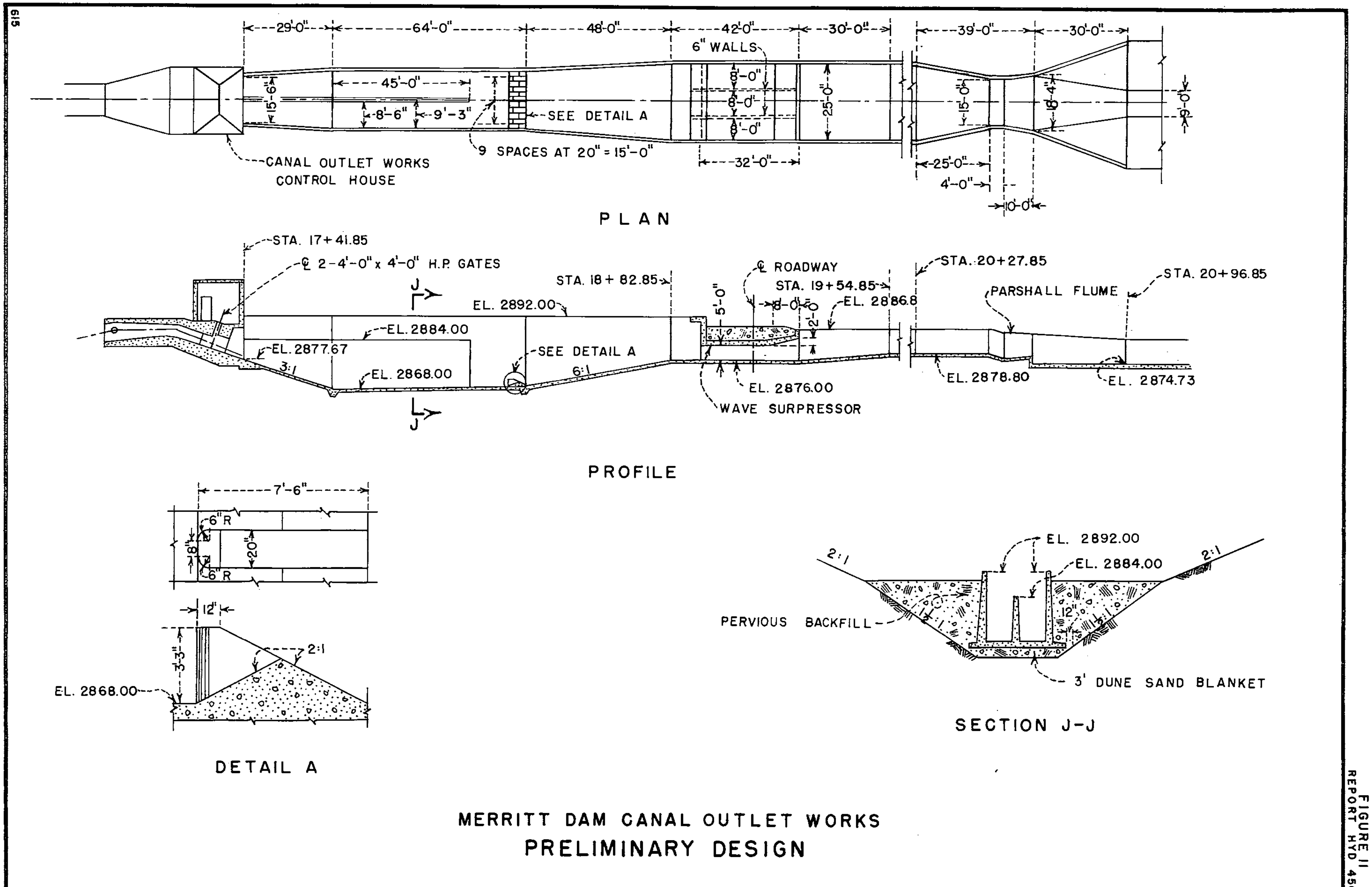
FIGURE 9
REPORT HYD. 456

FIGURE 10
REPORT HYD.456

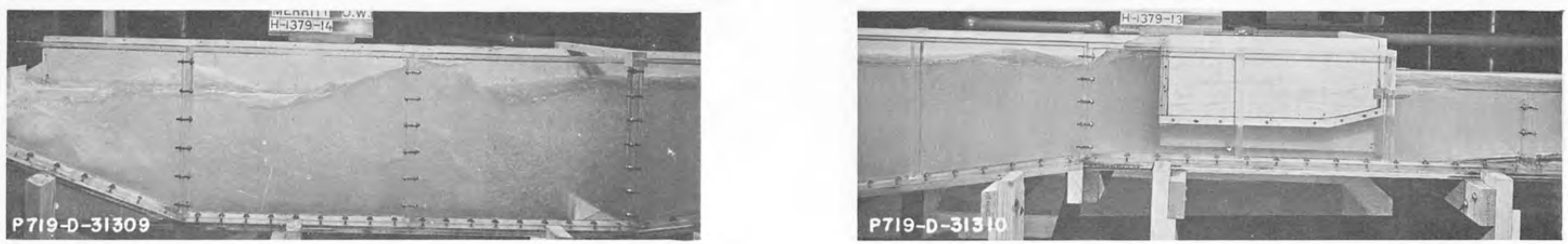
615



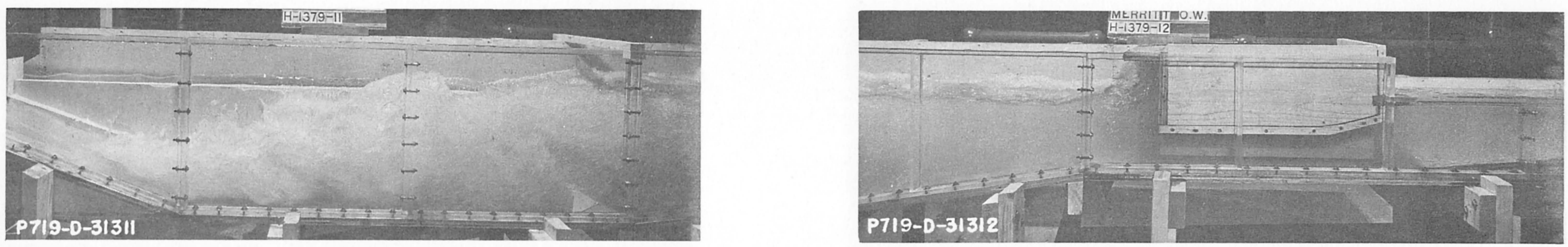
MERRITT DAM CANAL OUTLET WORKS
TAILWATER CURVE



MERRITT DAM CANAL OUTLET WORKS
PRELIMINARY DESIGN

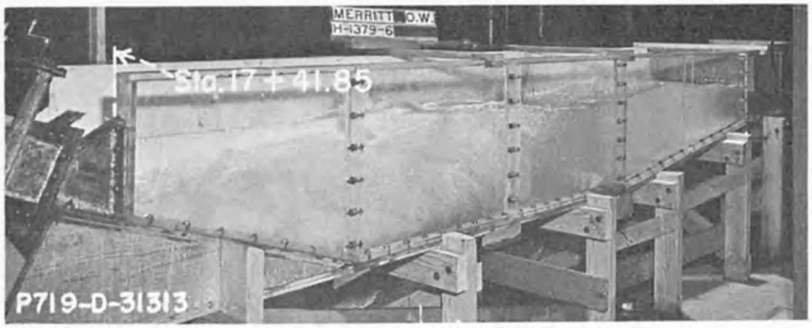


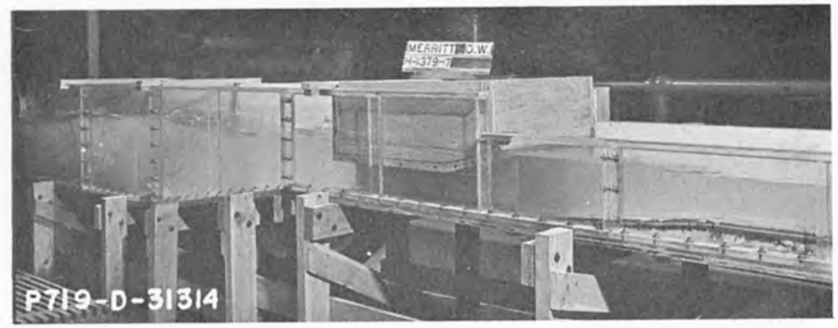
A. 1,340 cfs--Two gates 100 percent open



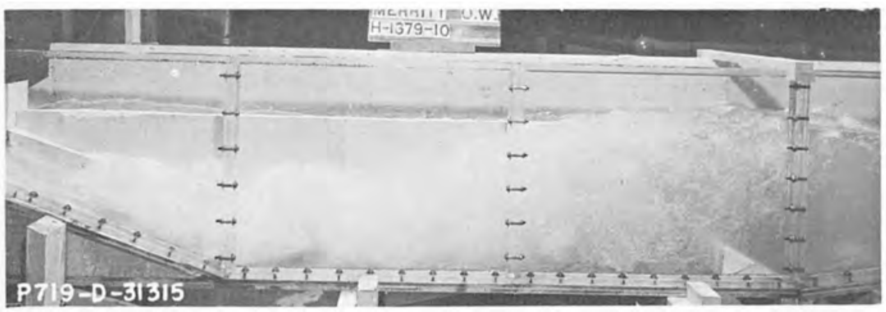
B. 850 cfs--One gate 100 percent open

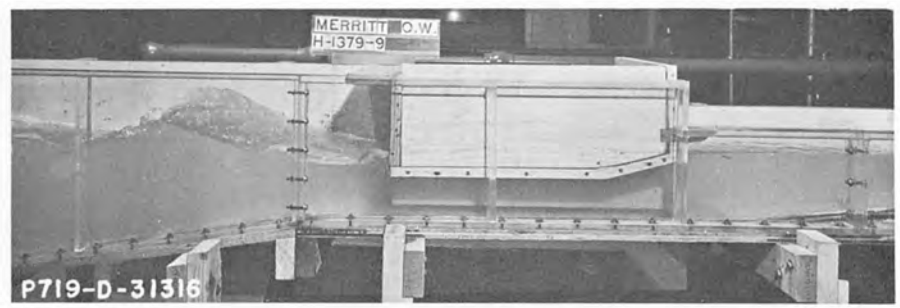
MERRITT DAM CANAL OUTLET WORKS
PRELIMINARY DESIGN--850 & 1,340 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL





A. Two gates 38 percent open
Froude number at Station 17+41.85 = 11.9

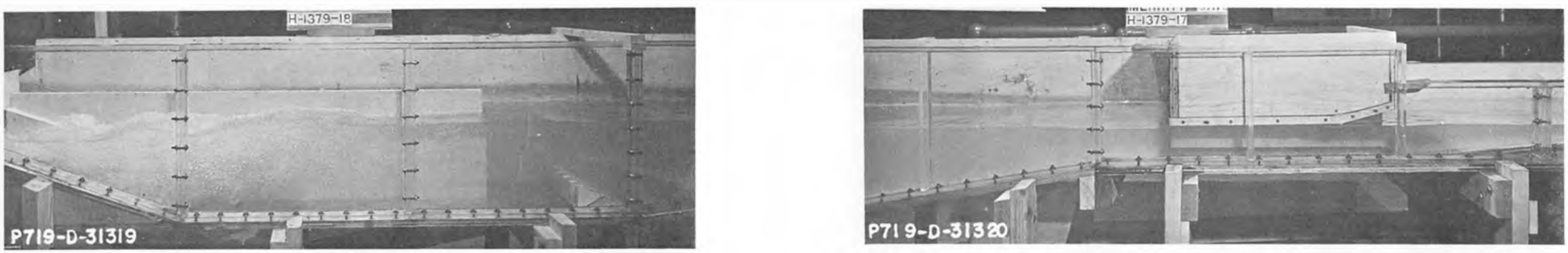




B. One gate 72 percent open

MERRITT DAM CANAL OUTLET WORKS
PRELIMINARY DESIGN--580 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL

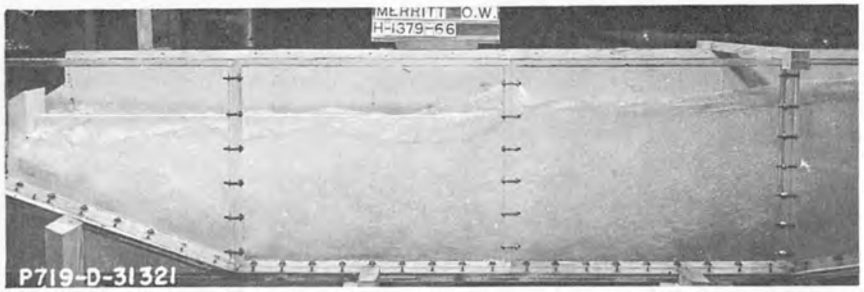
A. Two gates 12 percent open

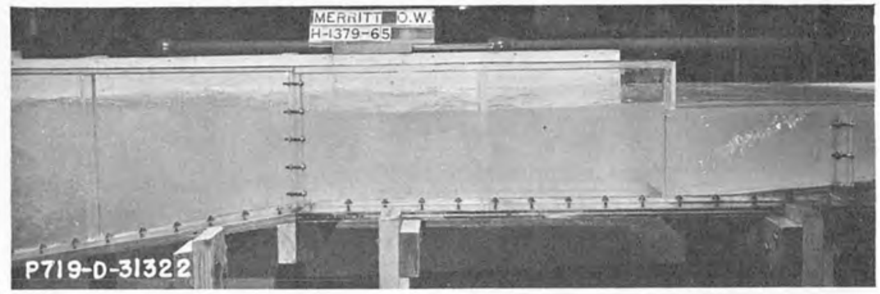


B. One gate 6 percent open

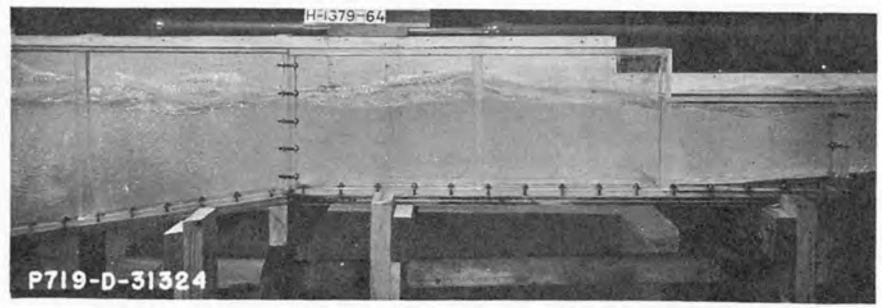
MERRITT DAM CANAL OUTLET WORKS
PRELIMINARY DESIGN--100 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL

Figure 14
Report HYD 456





A. 1, 340 cfs--Two gates 100 percent open



B. 850 cfs--One gate 100 percent open

MERRITT DAM CANAL OUTLET WORKS
SCHEME 2 WITHOUT WAVE SUPPRESSOR
1, 340 & 850 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL

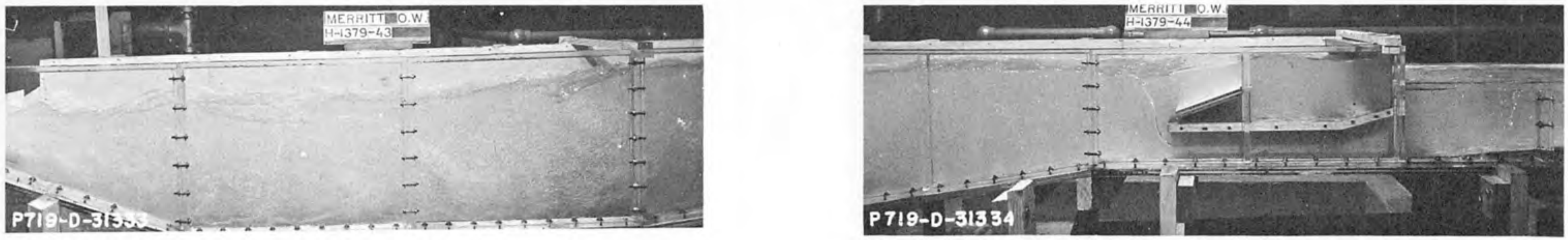
Figure 15
Report HYD 456

A. Two gates 38 percent open
Froude number at Station 17+41.85 = 11.9

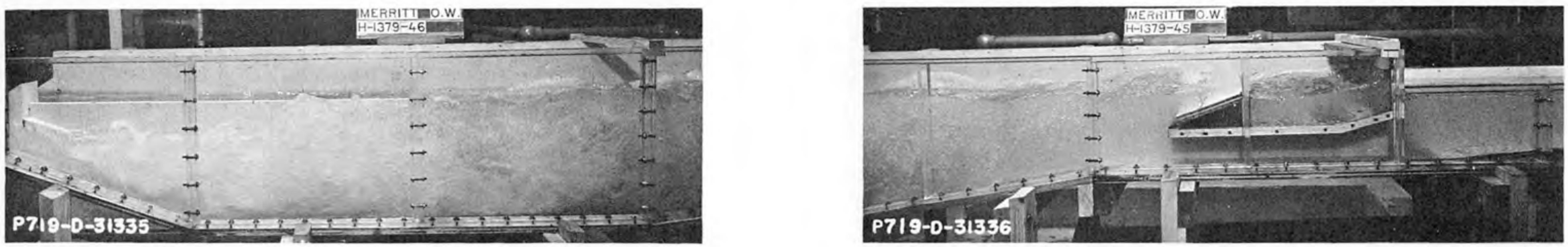
B. One gate 72 percent open

MERRITT DAM CANAL OUTLET WORKS
SCHEME 2 WITHOUT WAVE SUPPRESSOR
580 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL

Figure 16
Report HYD 456

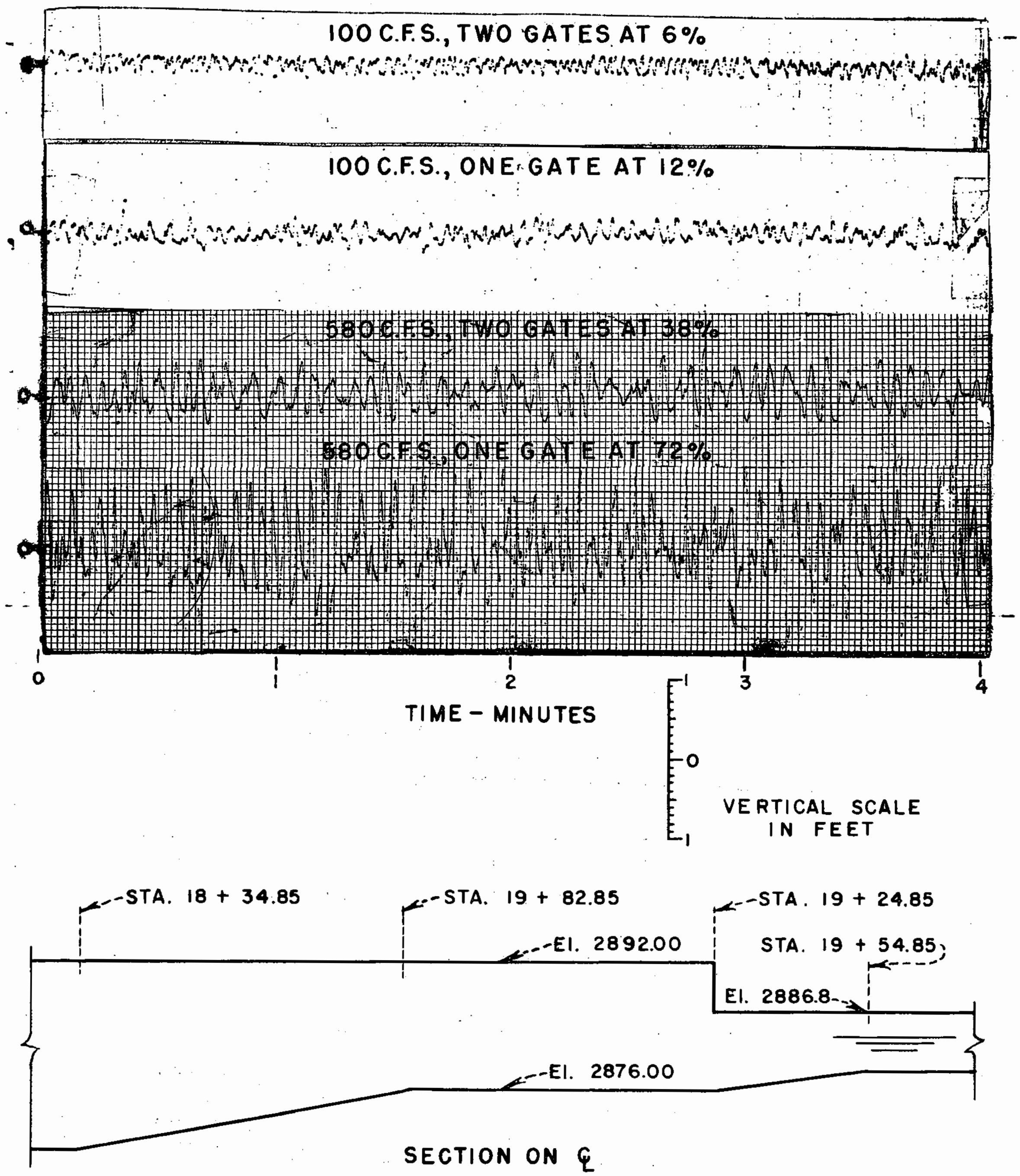


A. Two gates 6 percent open



B. One gate 12 percent open

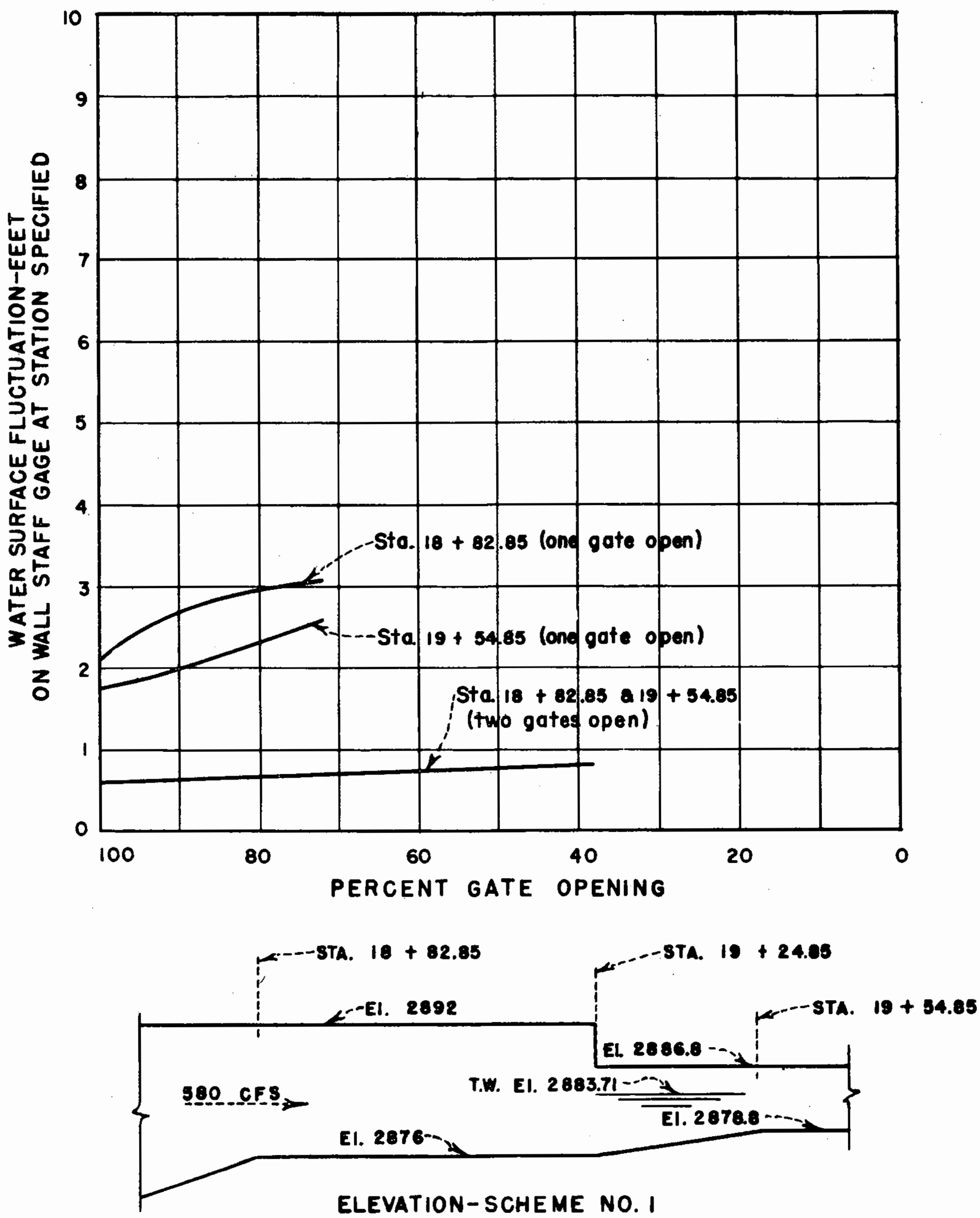
MERRITT DAM CANAL OUTLET WORKS
SCHEME 2 WITHOUT WAVE SUPPRESSOR
100 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL



MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19+54.85
SCHEME 2 WITHOUT WAVE SUPPRESSOR

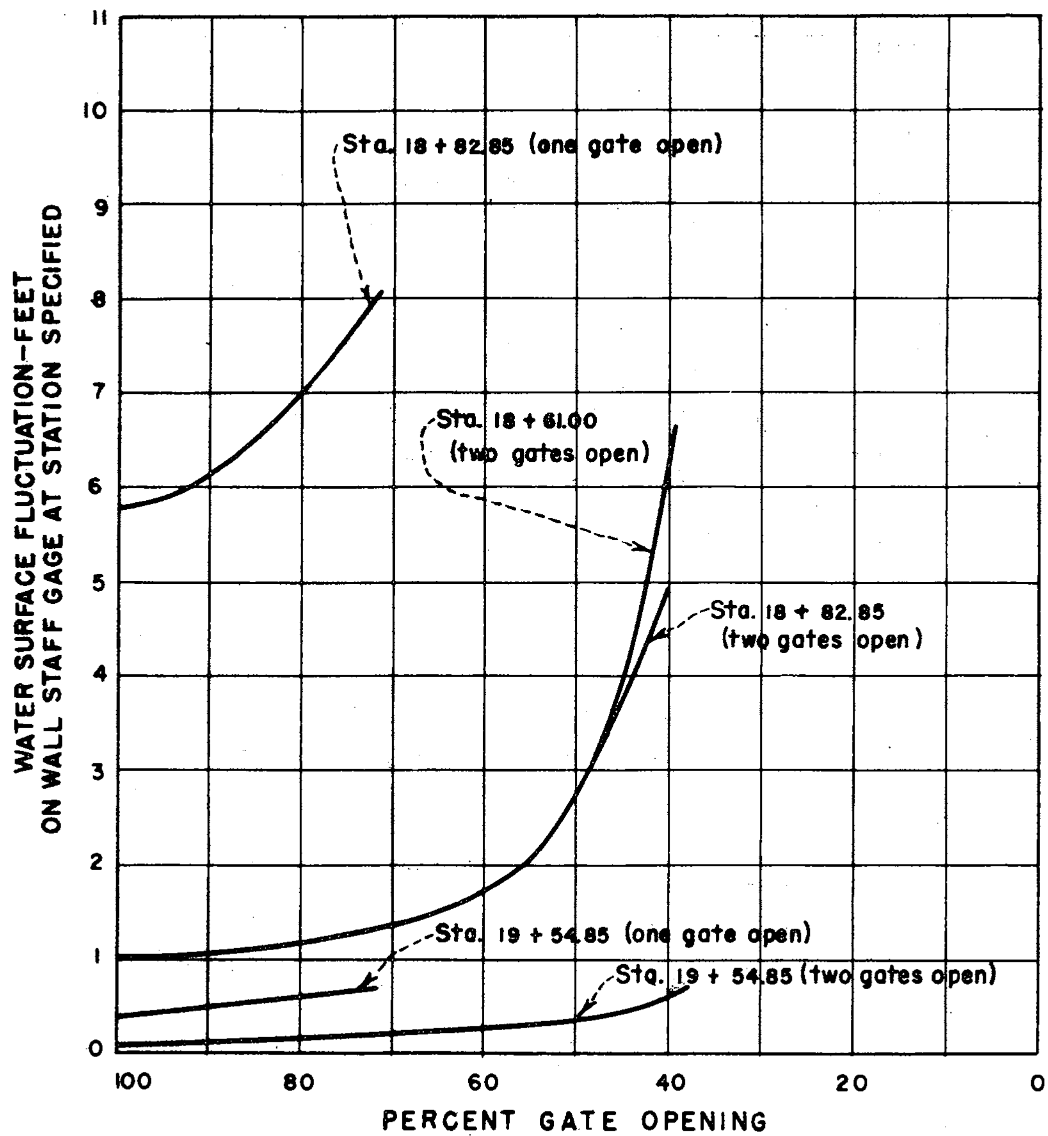
1:16 SCALE MODEL

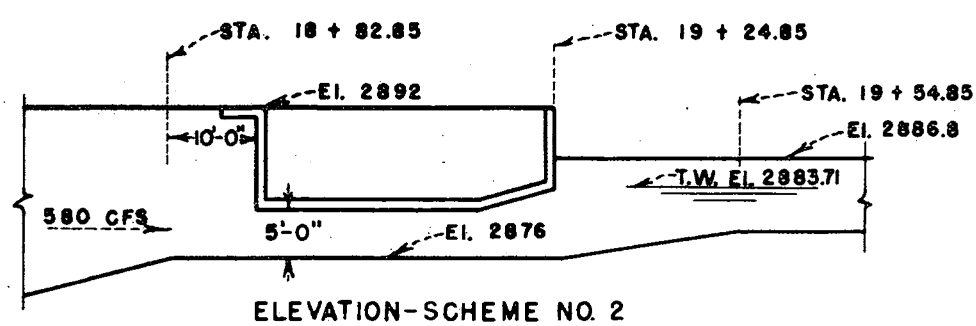


MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS--SCHEME # 2 WITHOUT WAVE SUPPRESSOR--580 CFS

1:16 SCALE MODEL



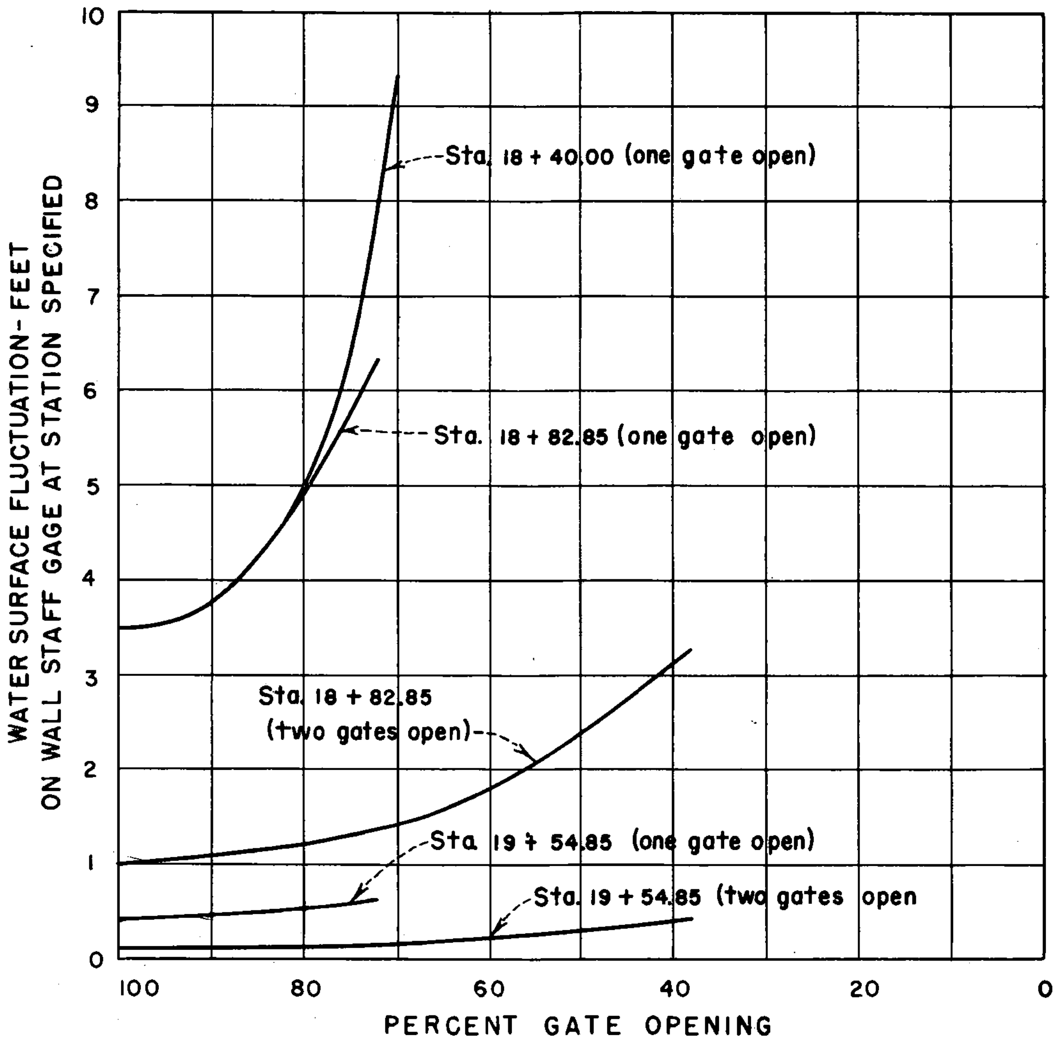


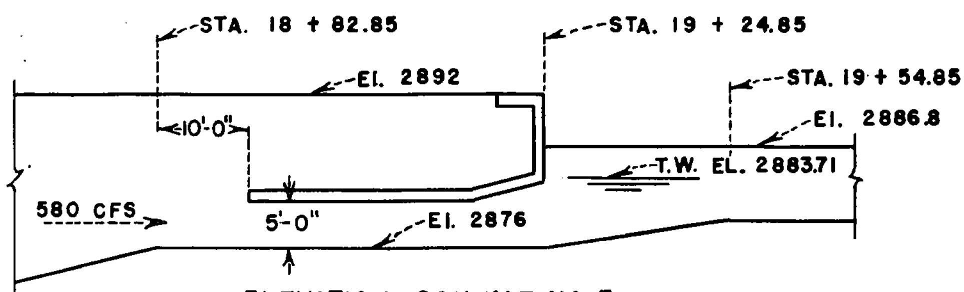
ELEVATION-SCHEME NO. 2

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATION--SCHEME #2 WITH WAVE SUPPRESSOR--580 CFS

1:16 SCALE MODEL





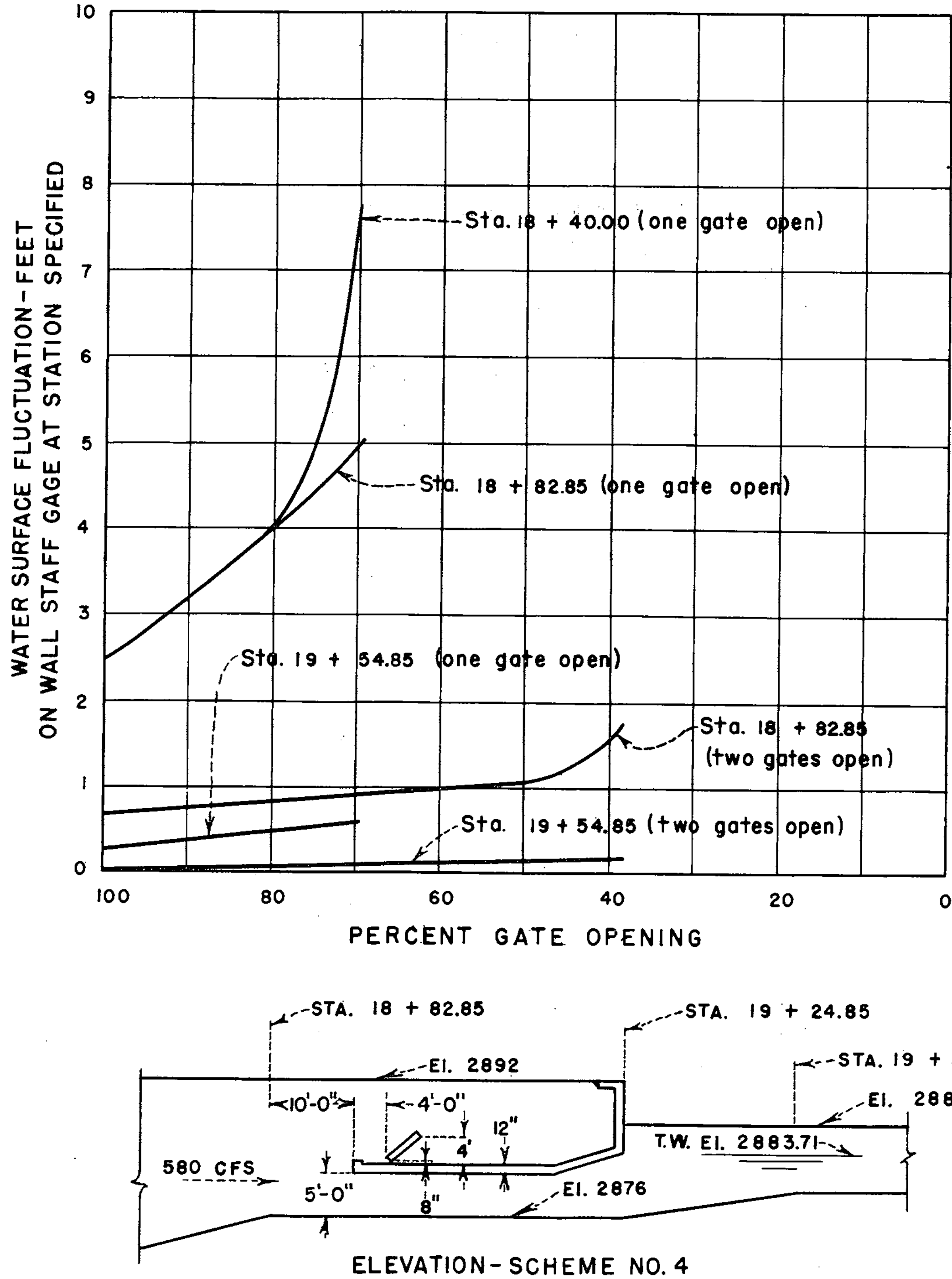
ELEVATION-SCHEME NO. 3

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATION --SCHEME #3--580 CFS

1:16 SCALE MODEL

NOTE: 11' fluctuation at Sta. 18 + 34.85 for 850 cfs from one gate 100 percent open. 7' fluctuation at Sta. 18 + 34.85 for 1340 cfs from two gates 100 percent open.



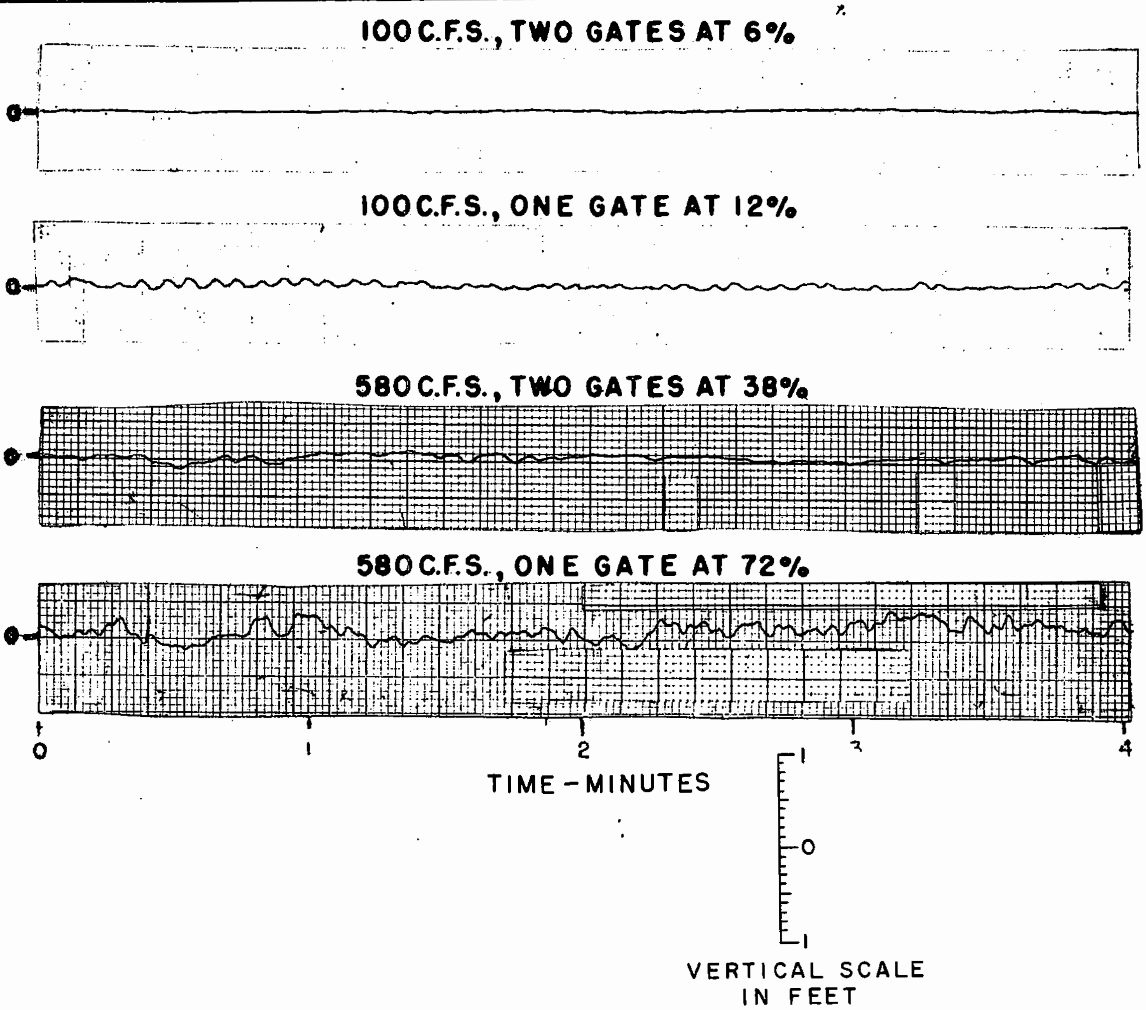
ELEVATION - SCHEME NO. 4

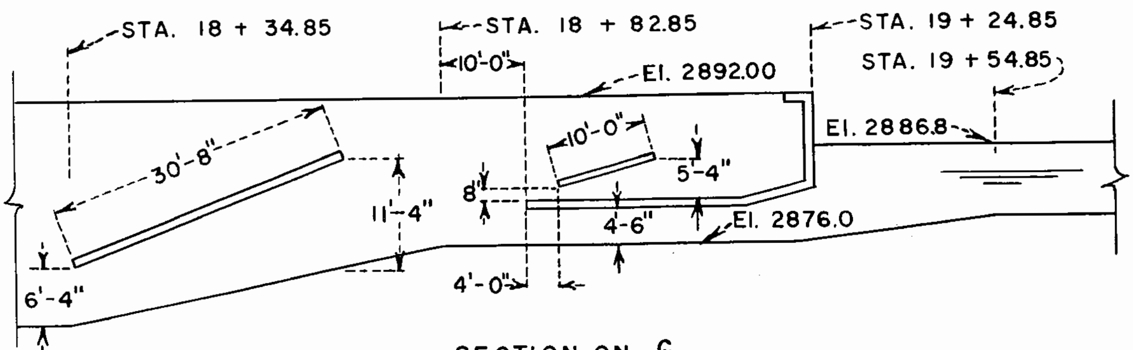
MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATION - SCHEME # 4

1:16 SCALE MODEL

FIGURE 23
REPORT HYD. 456



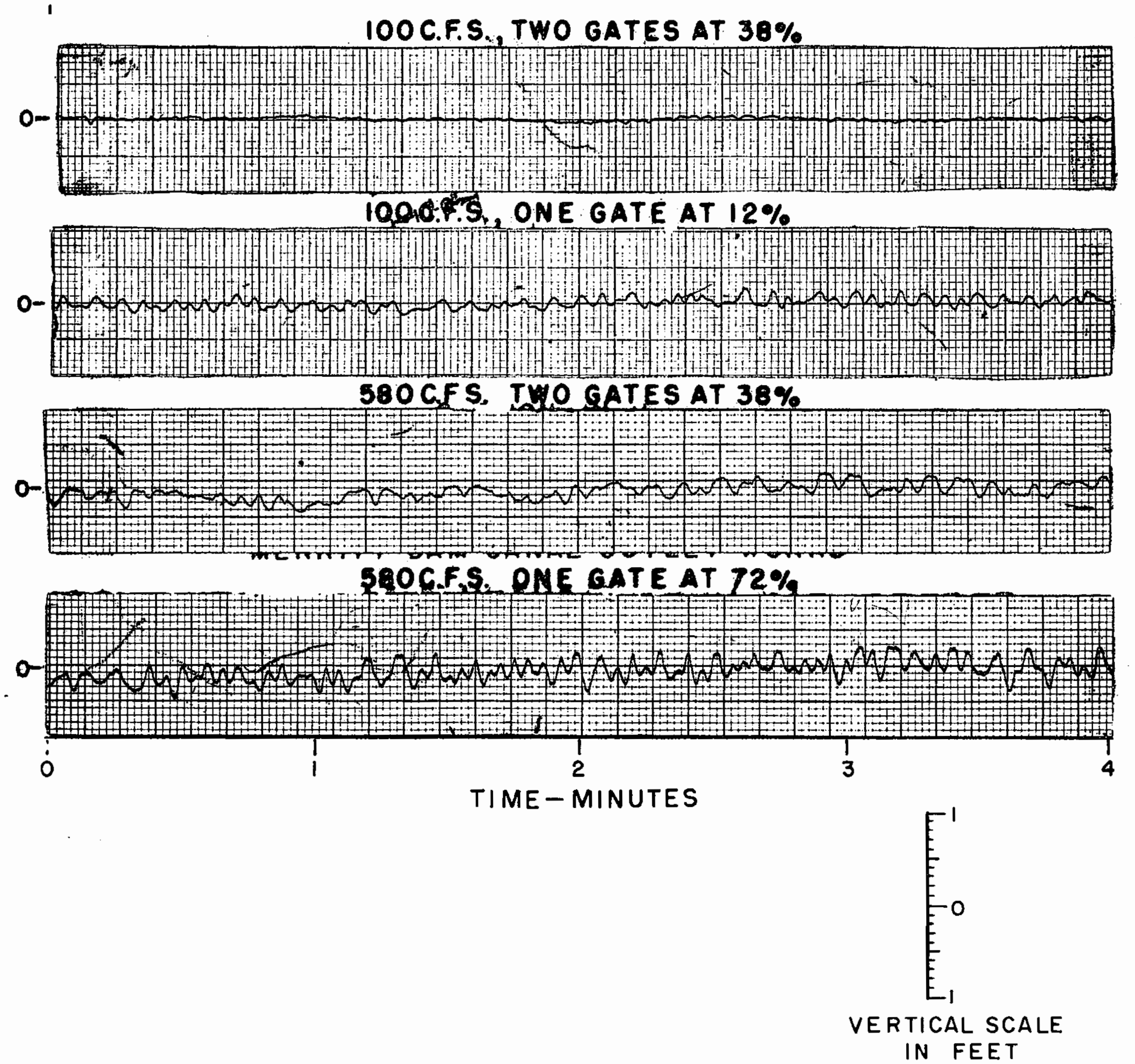


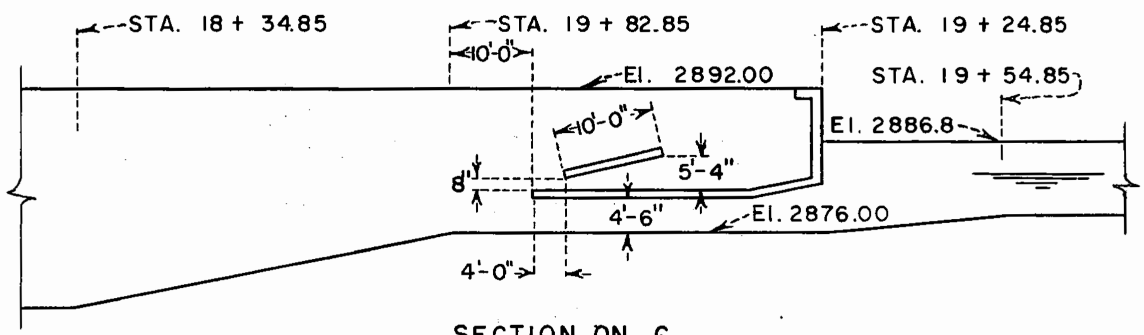
SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19 + 54.85
SCHEME 5

615

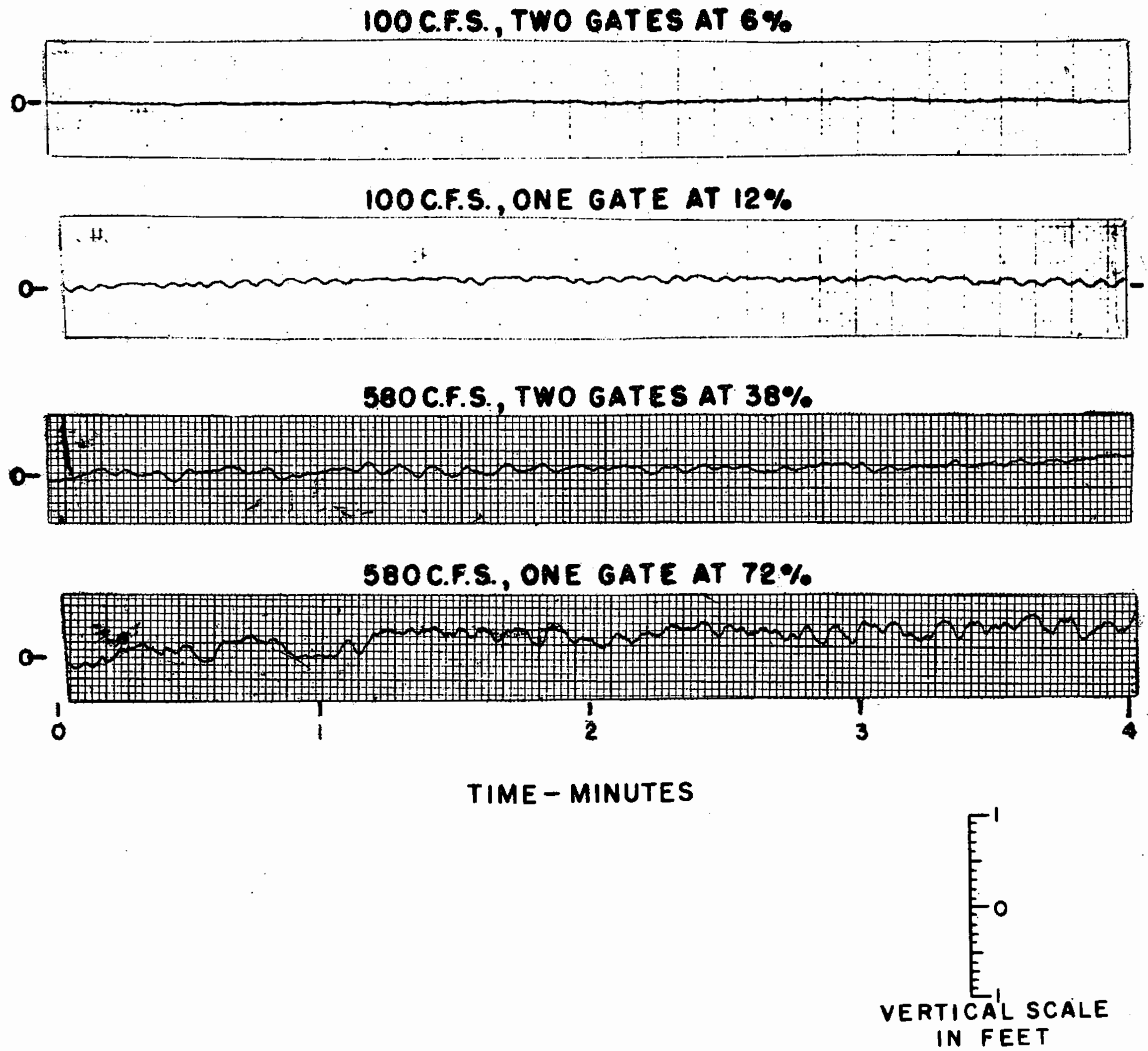


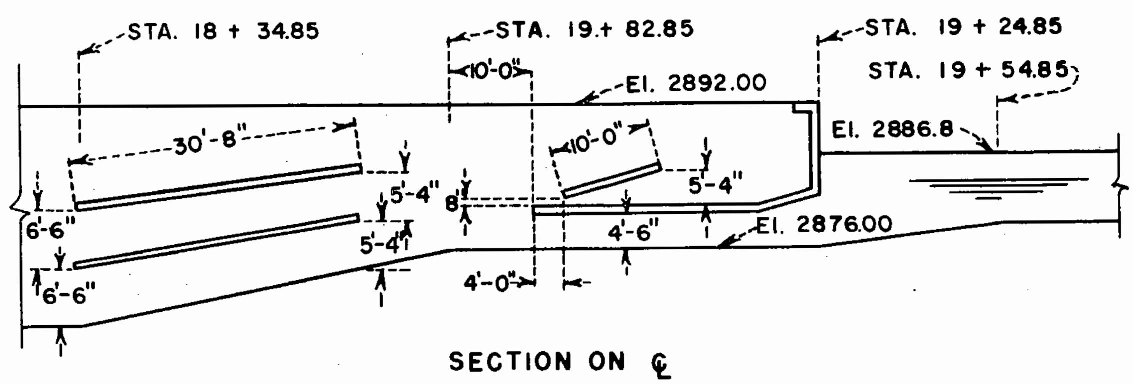


SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19 + 54.85
SCHEME 7



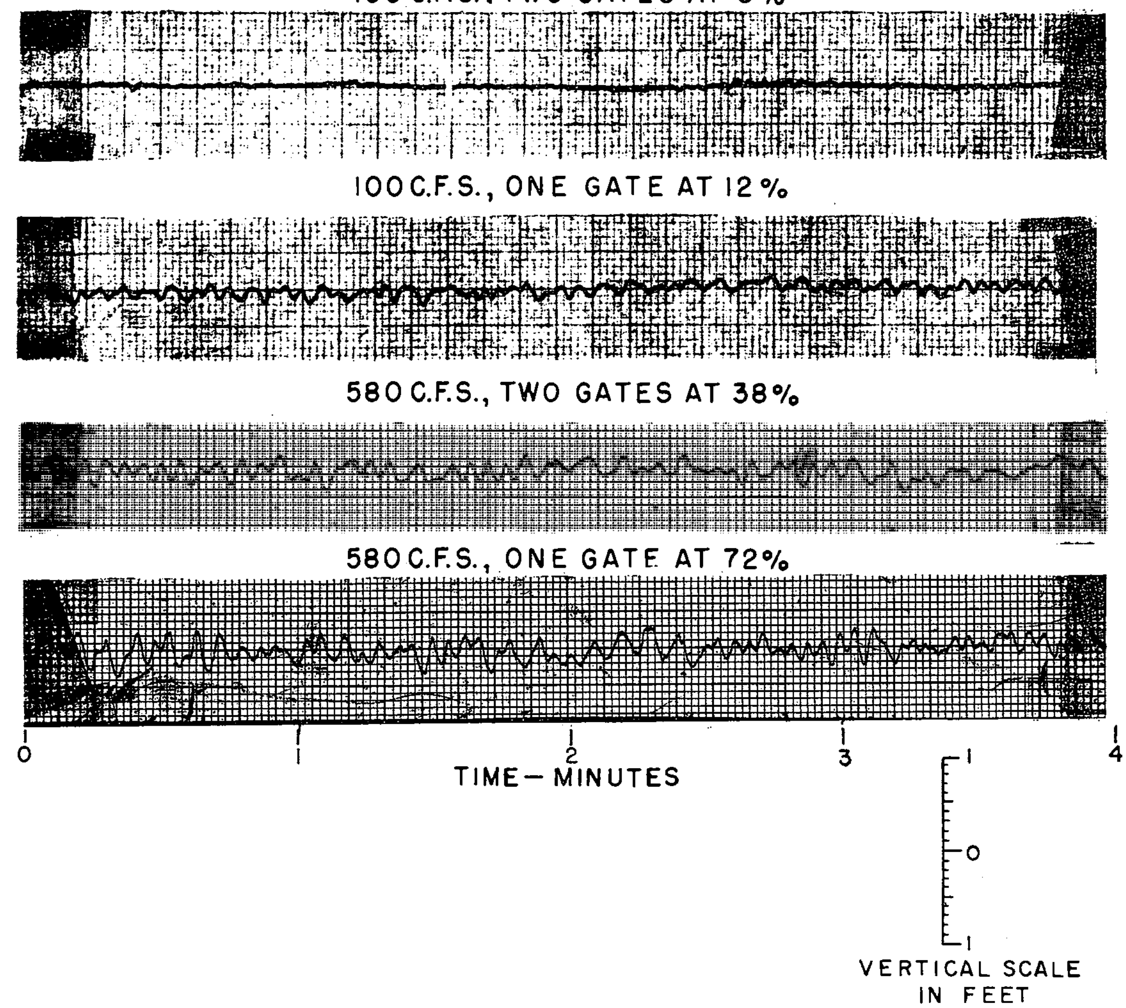


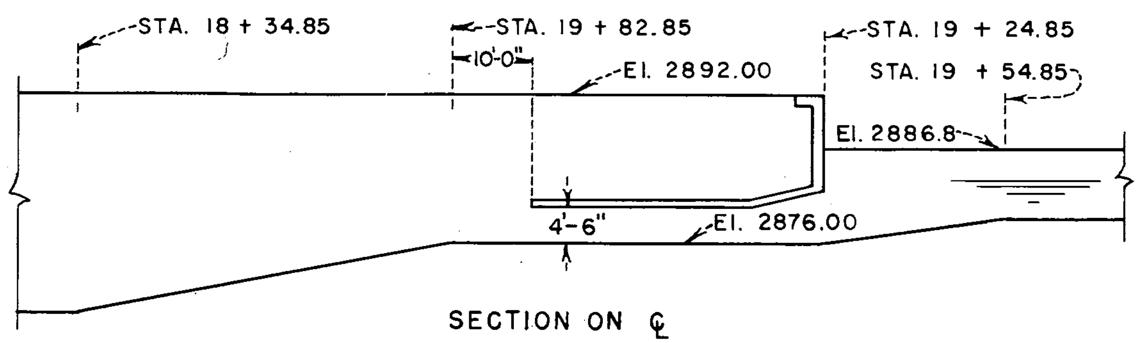
SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19 + 54.85
SCHEME 8

FIGURE 26
REPORT HYD. 456



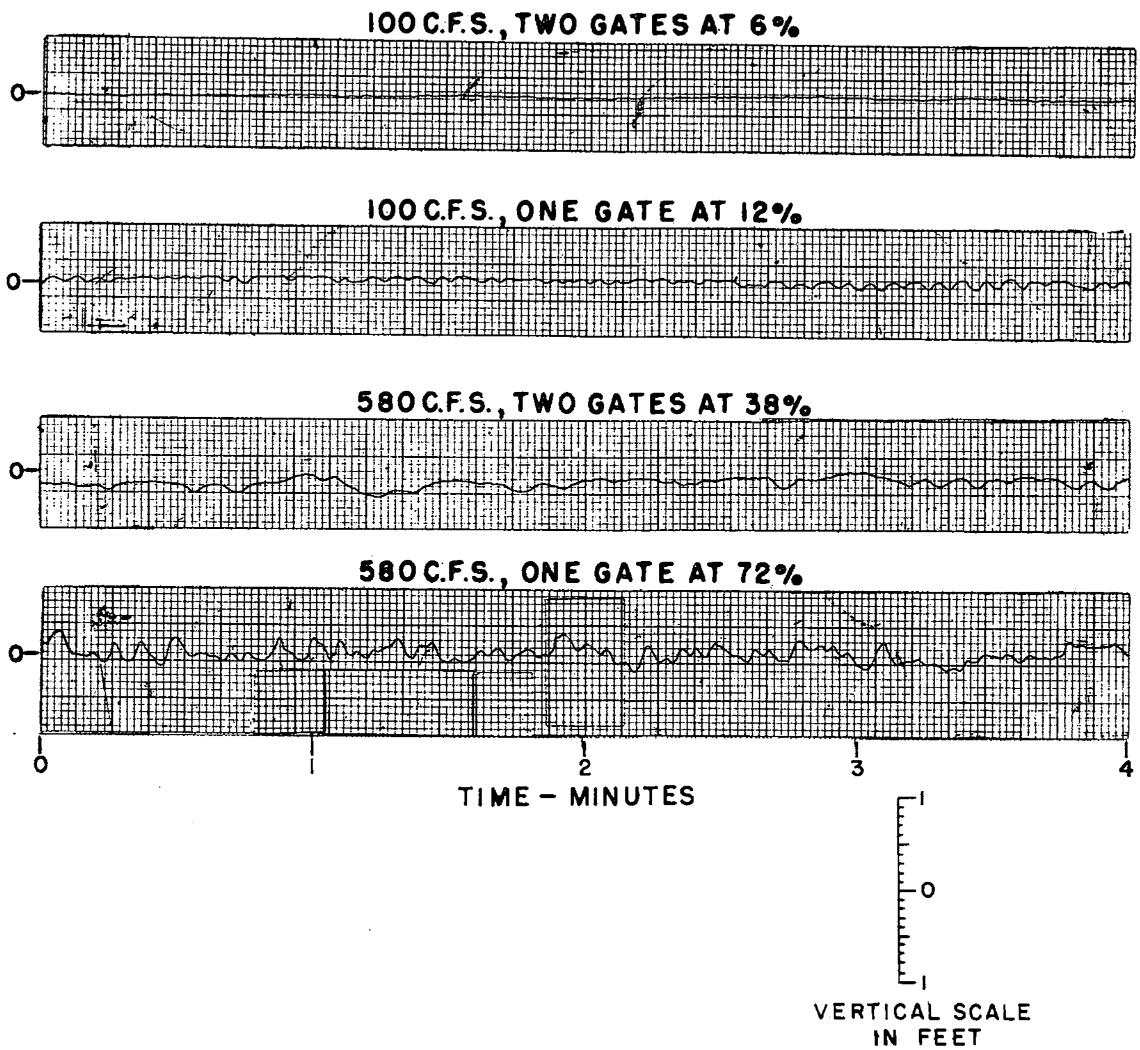


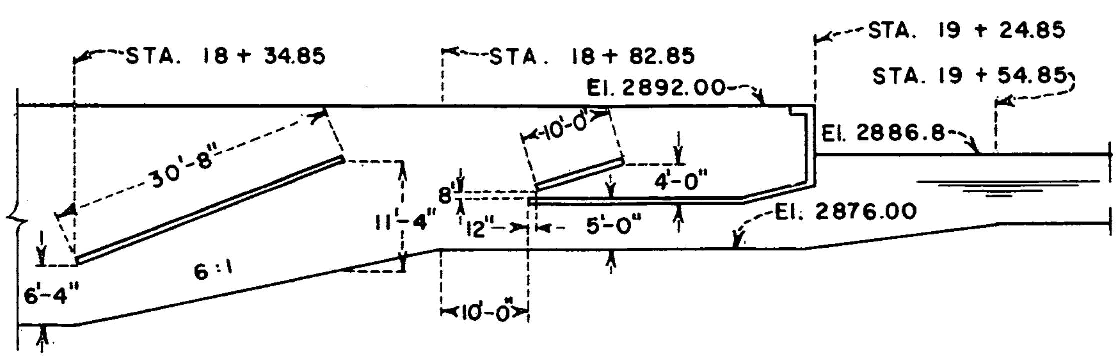
SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19+54.85
SCHEME 9

615

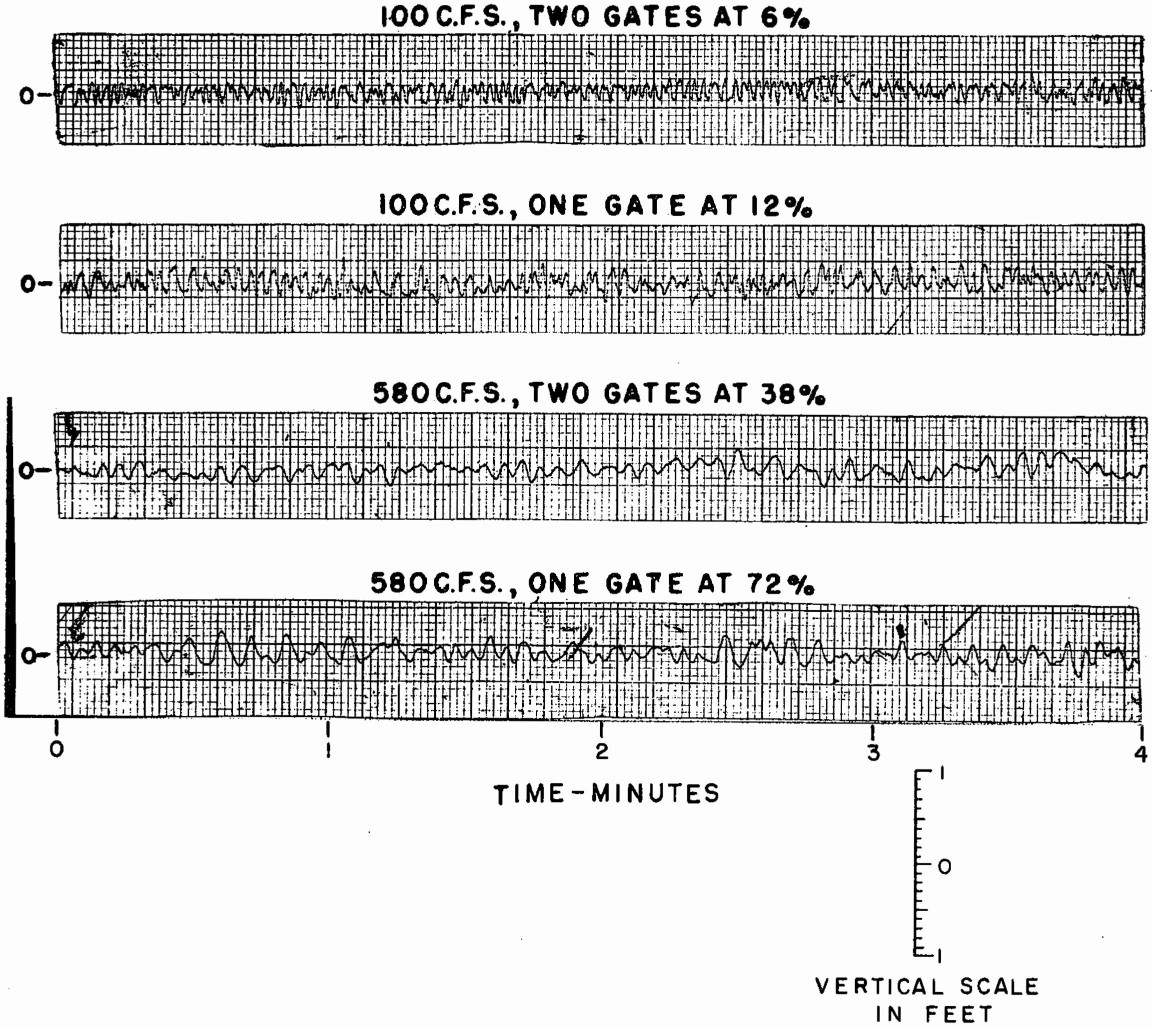


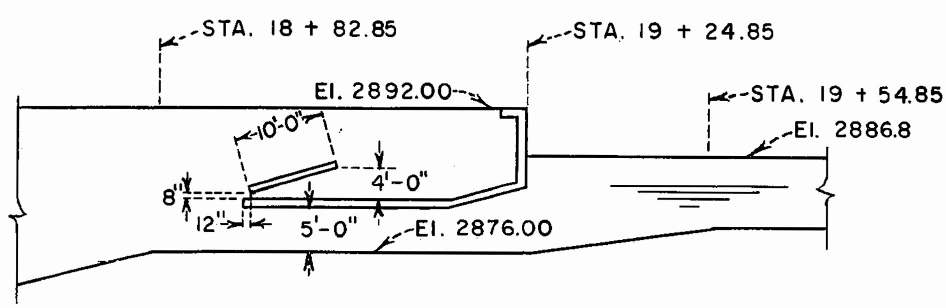


SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19+54.85
SCHEME 10



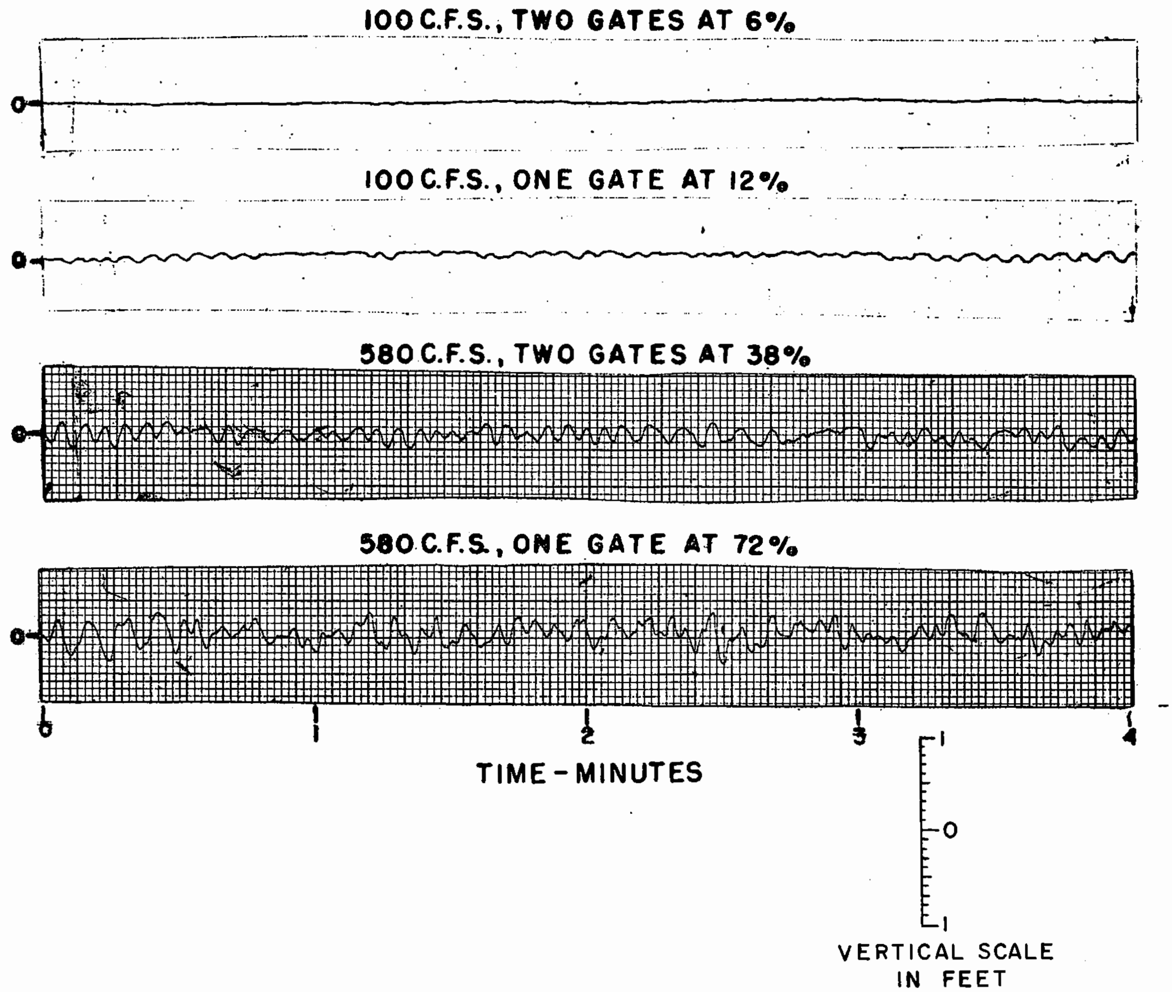


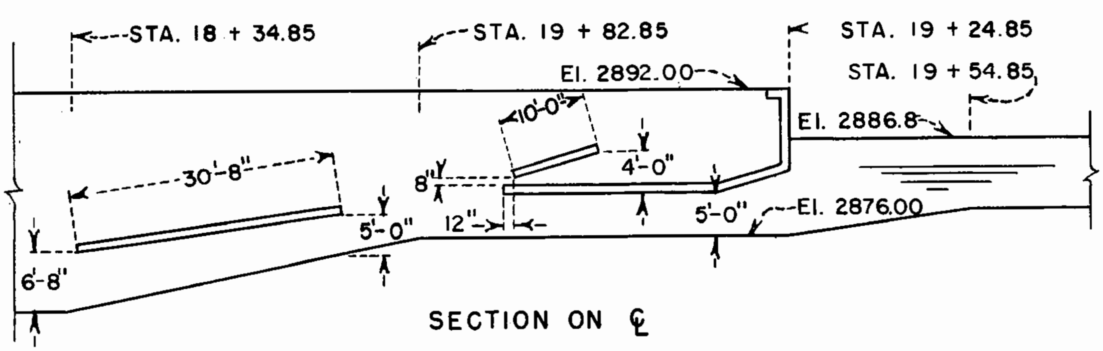
SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19+54.85
SCHEME II

FIGURE 29
REPORT HYD. 456



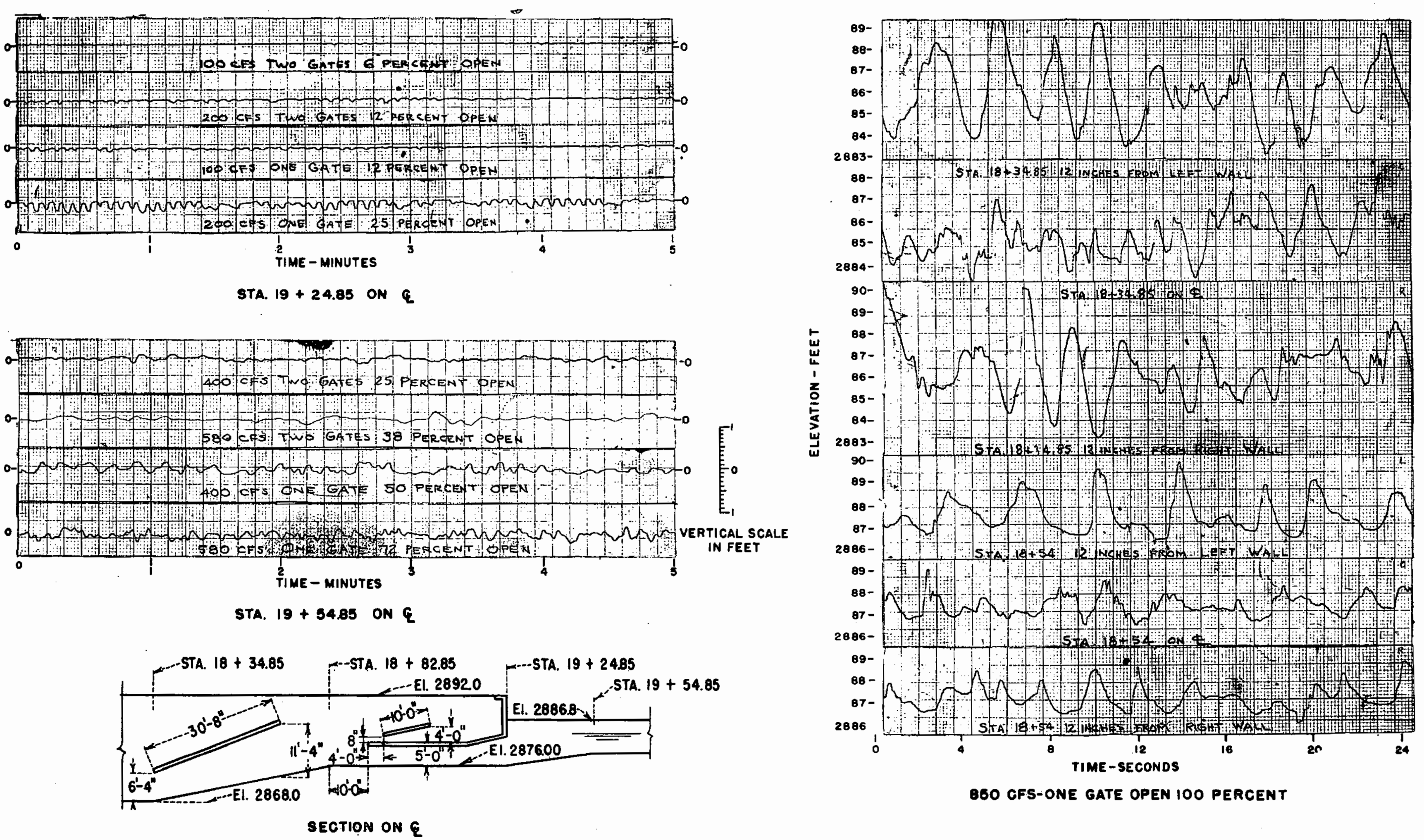


SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19 + 54.85
SCHEME 12

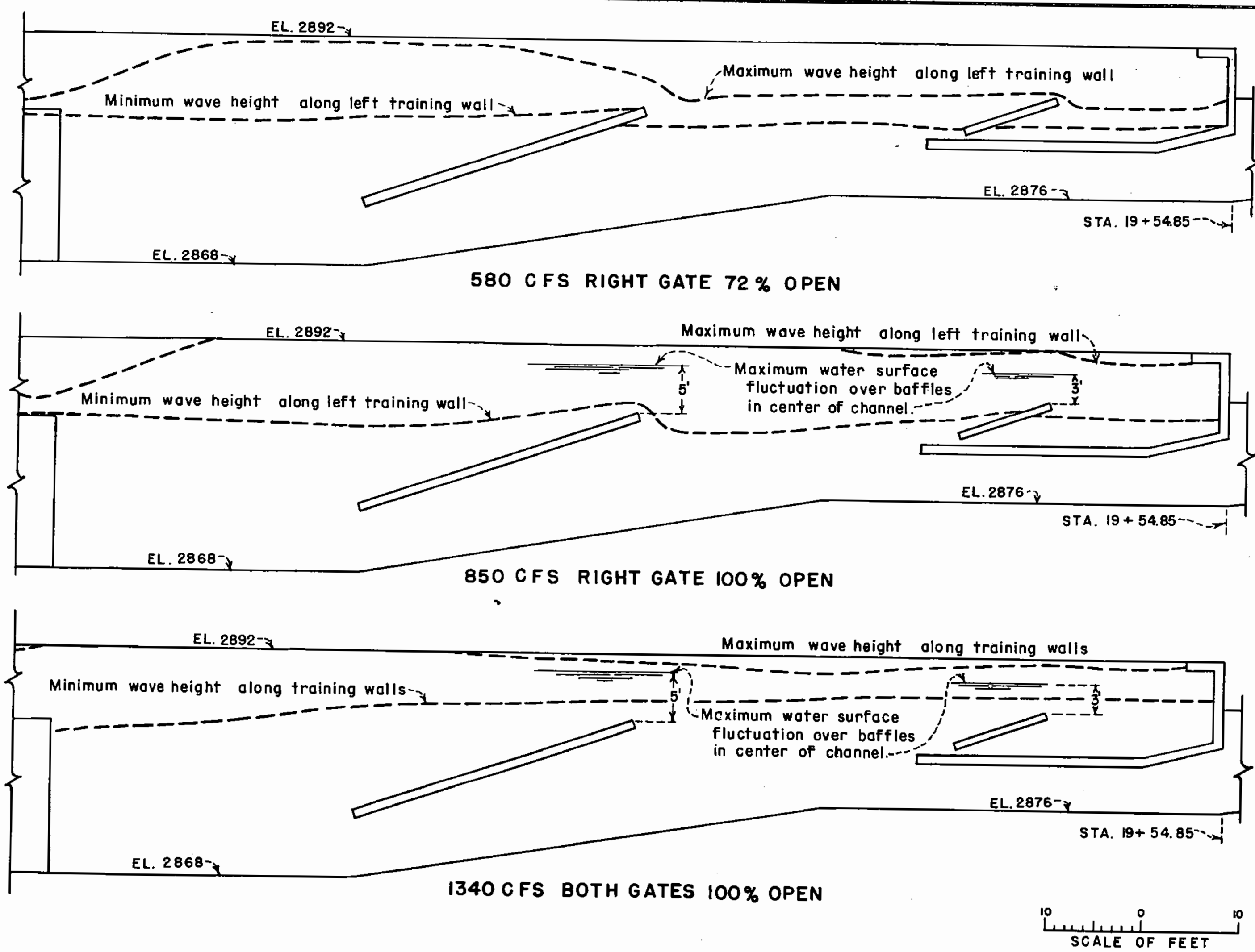
615



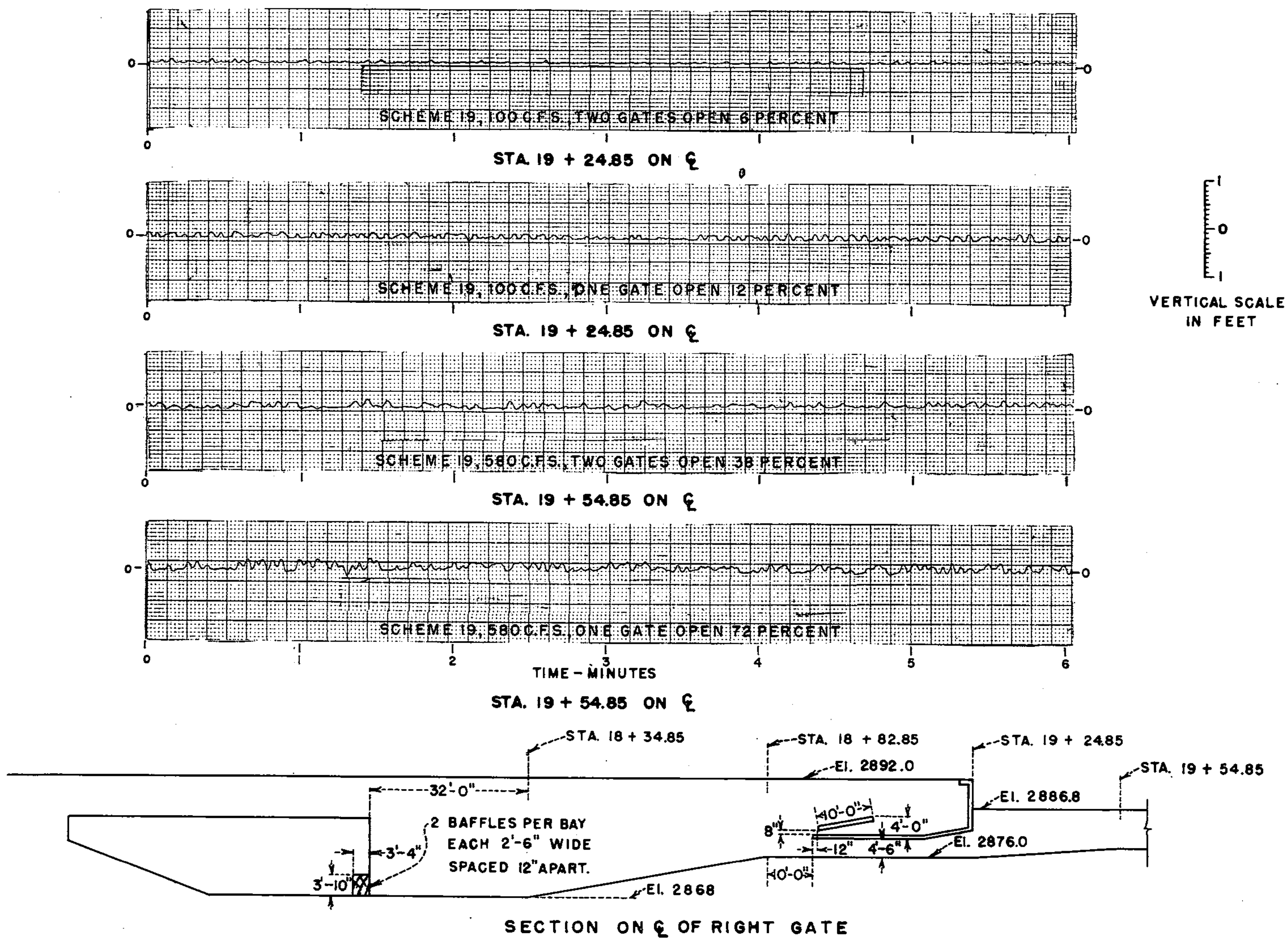
MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS -- SCHEME 15

FIGURE 30
REPORT HYD. 416



MERRITT DAM CANAL OUTLET WORKS
WAVE HEIGHTS SCHEME NO. 15
1:16 SCALE MODEL



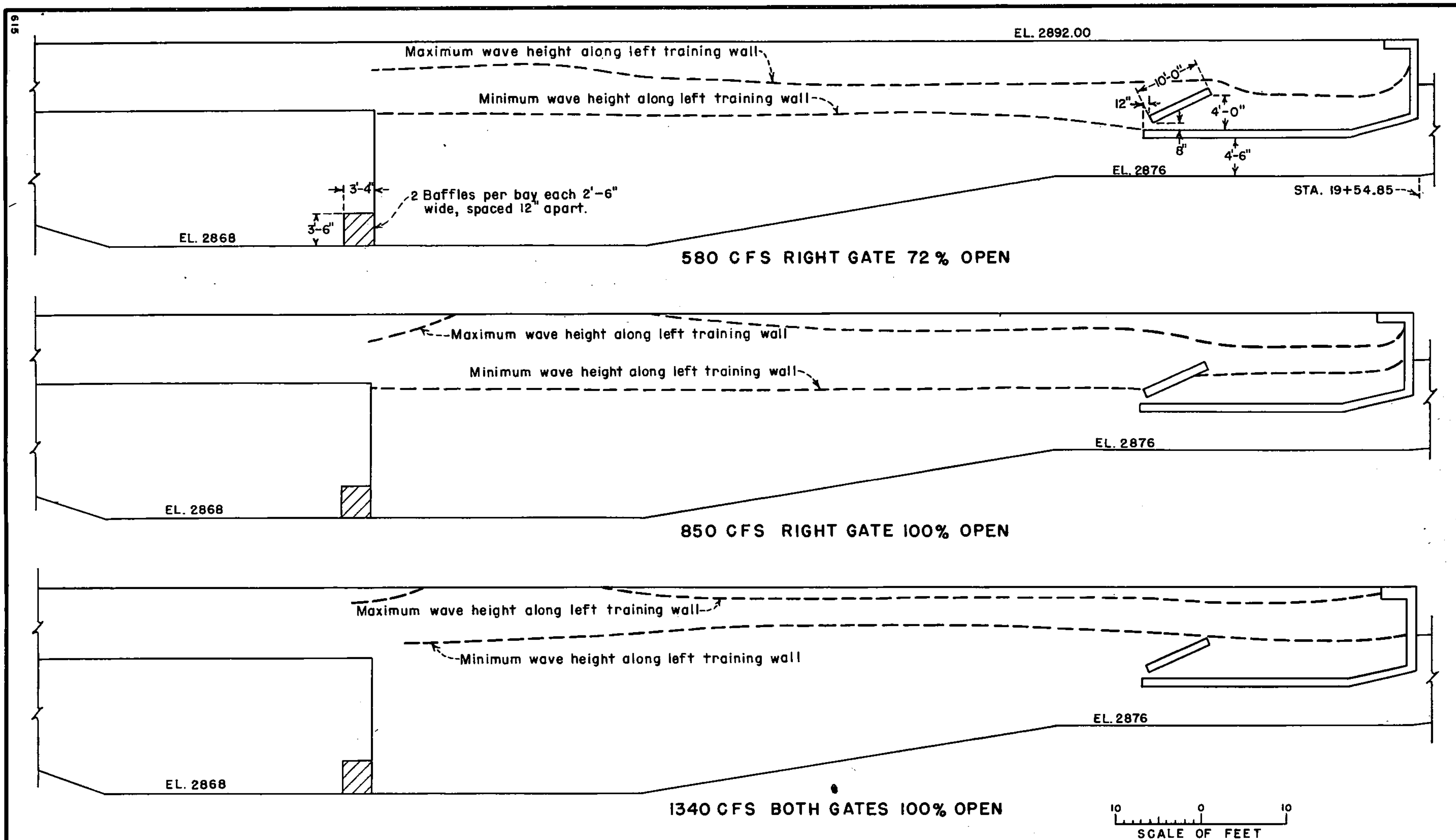
MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS -- SCHEME 19

1:16 SCALE MODEL

FIGURE 32
REPORT HYD. 456

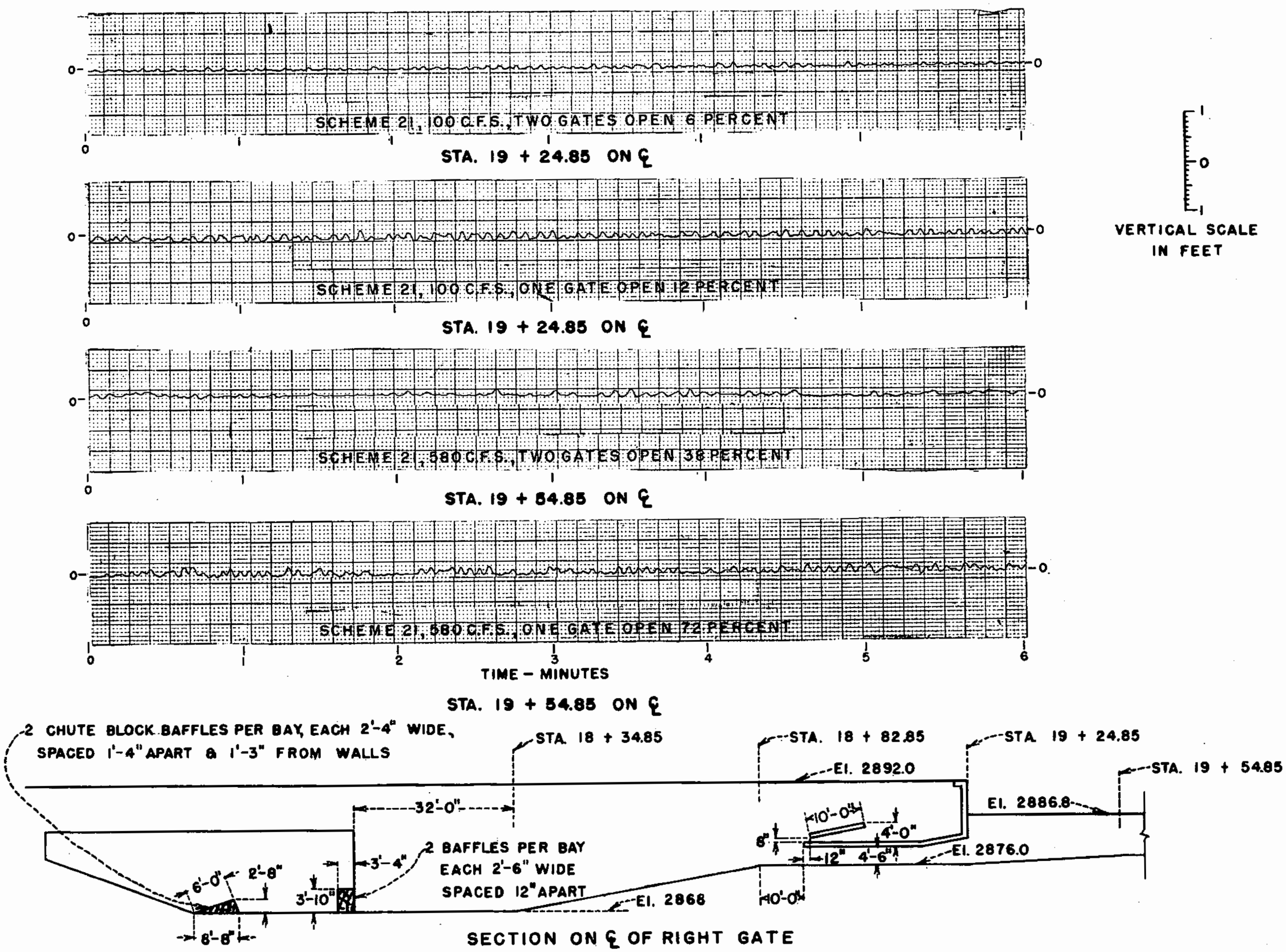
FIGURE 33
REPORT HYD. 456



MERRITT DAM CANAL OUTLET WORKS

WAVE HEIGHTS SCHEME NO. 19

1:16 SCALE MODEL

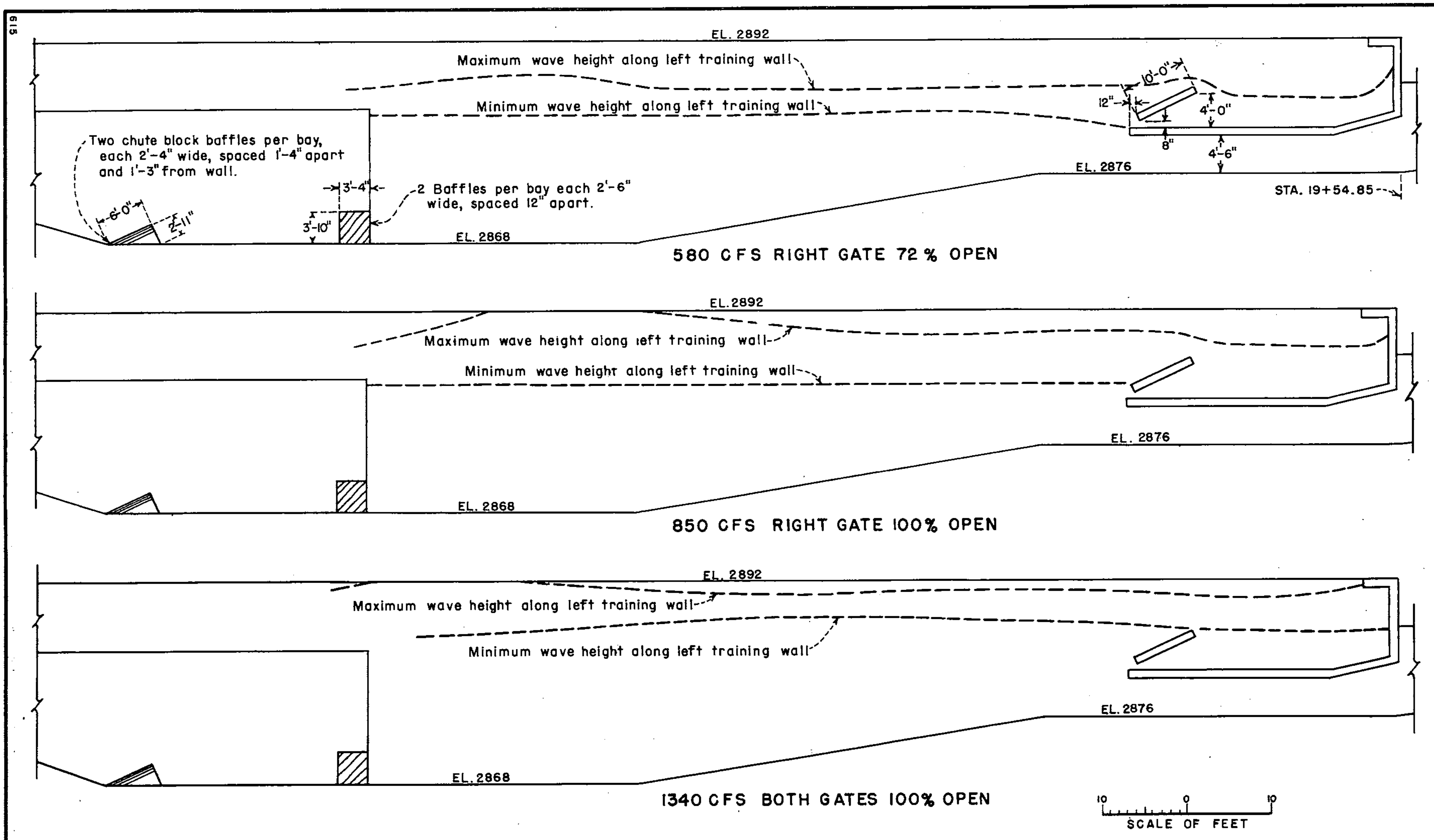


MERRITT DAM CANAL OUTLET WORKS

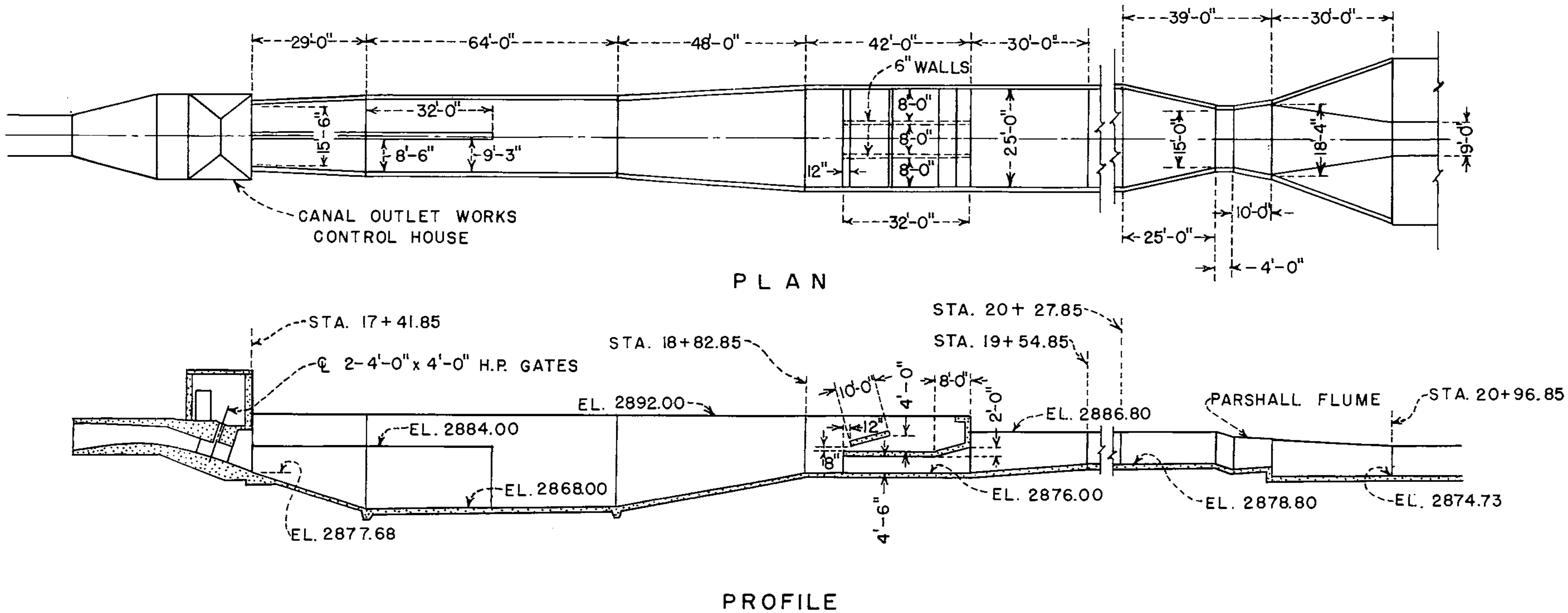
WATER SURFACE FLUCTUATIONS -- SCHEME 21

1:16 SCALE MODEL

FIGURE 34
REPORT HYD. 456



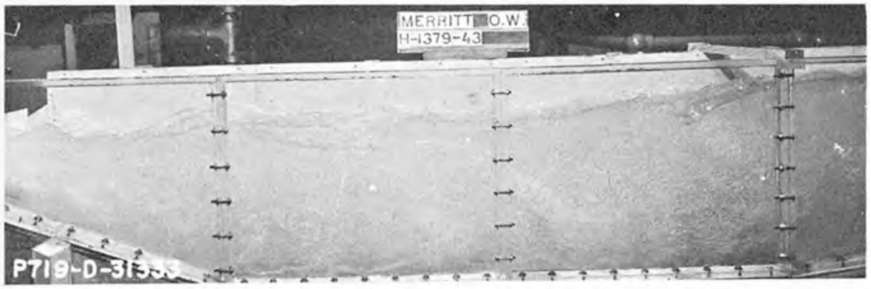
MERRITT DAM CANAL OUTLET WORKS
WAVE HEIGHTS SCHEME NO. 21
1:16 SCALE MODEL

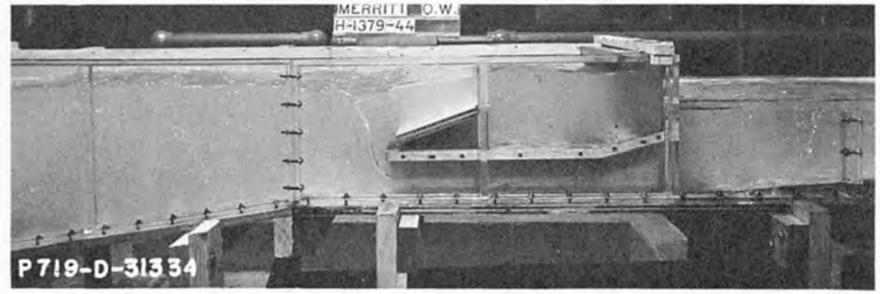


MERRITT DAM CANAL OUTLET WORKS

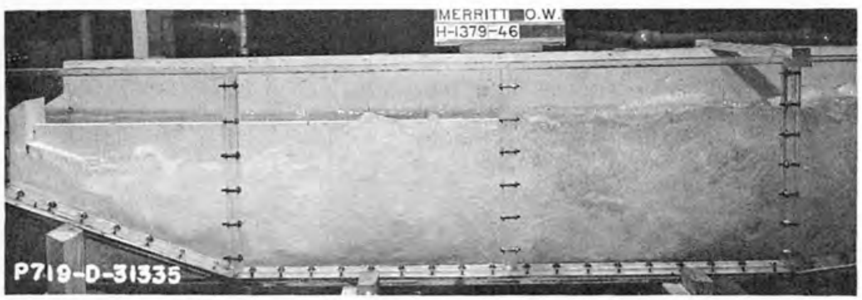
RECOMMENDED DESIGN - SCHEME NO. 13

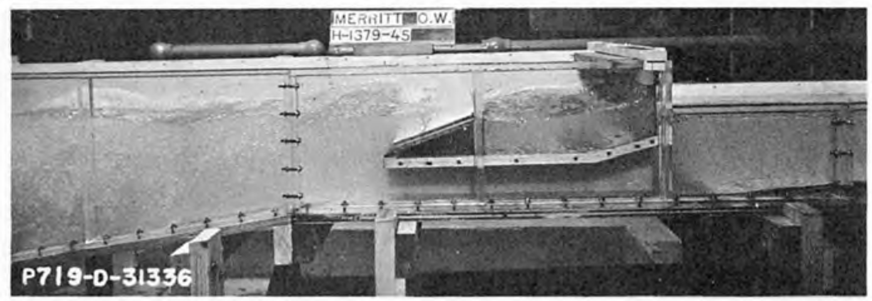
FIGURE 36
REPORT HYD 456





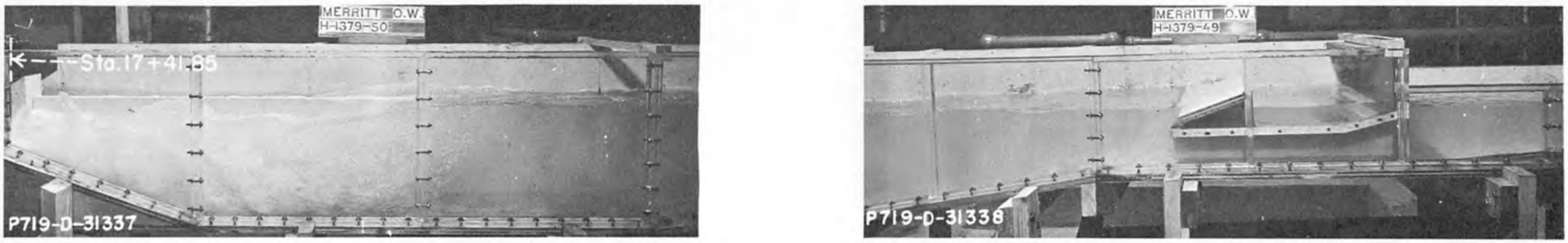
A. 1,340 cfs--Two gates--100 percent open
Note the vortex immediately upstream from the wave suppressor.



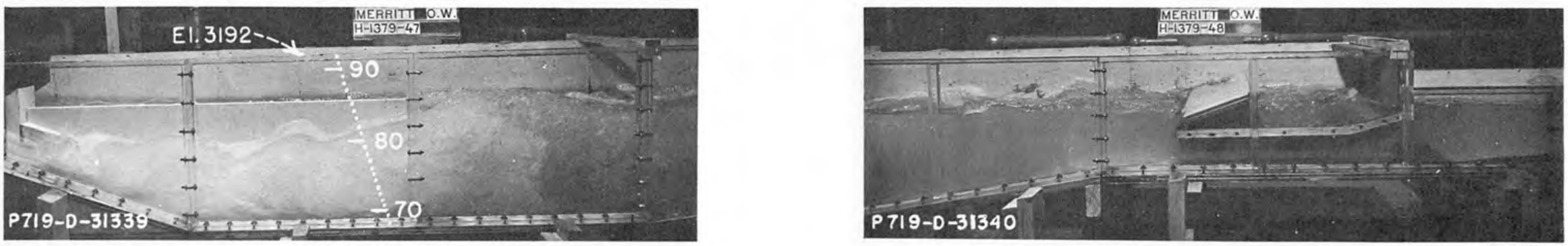


B. 850 cfs--One gate--100 percent open

MERRITT DAM CANAL OUTLET WORKS
SCHEME NO. 13 (RECOMMENDED)--1,340 & 850 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL



A. Two gates 38 percent open
Froude number at Sta. 17+41.85 = 11.9

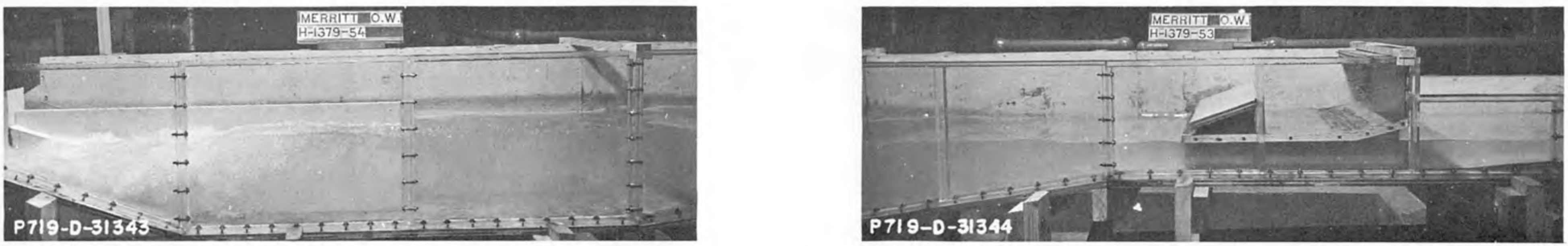


B. One gate 72 percent open

Note: The scale in B applies to all four photos and to the photos in Figures 37 and 39. Air entrainment in the horizontal upstream portion of the basin in "A" is estimated at 25 percent and in "B" it is estimated at 33 percent.

MERRITT DAM CANAL OUTLET WORKS
SCHEME NO. 13 (RECOMMENDED)--580 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL

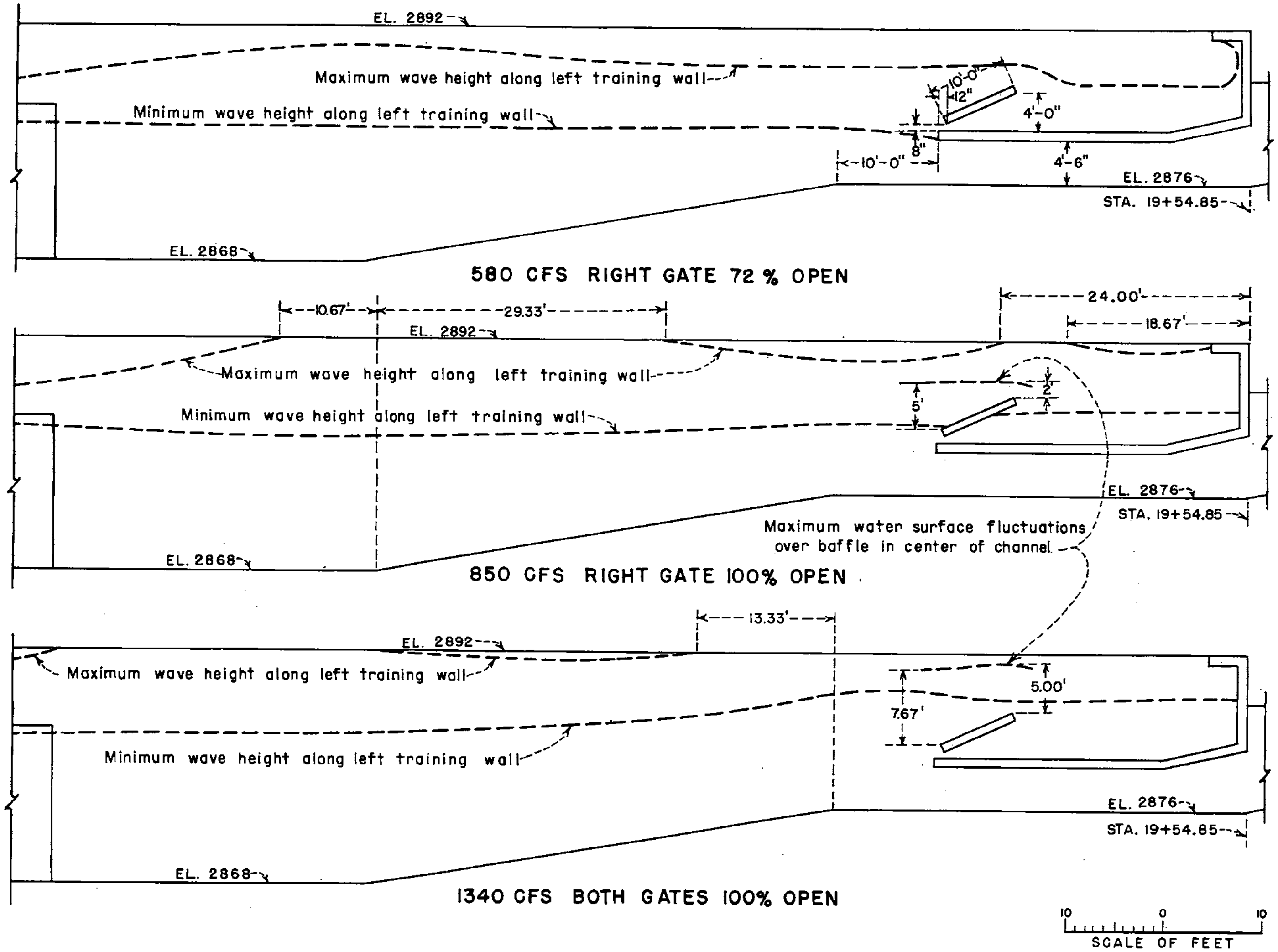
A. Two gates 6 percent open



B. One gate 12 percent open

MERRITT DAM CANAL OUTLET WORKS
SCHEME NO. 13 (RECOMMENDED)--100 CFS--MAXIMUM RESERVOIR
1:16 SCALE MODEL

Figure 39
Report HYD 456

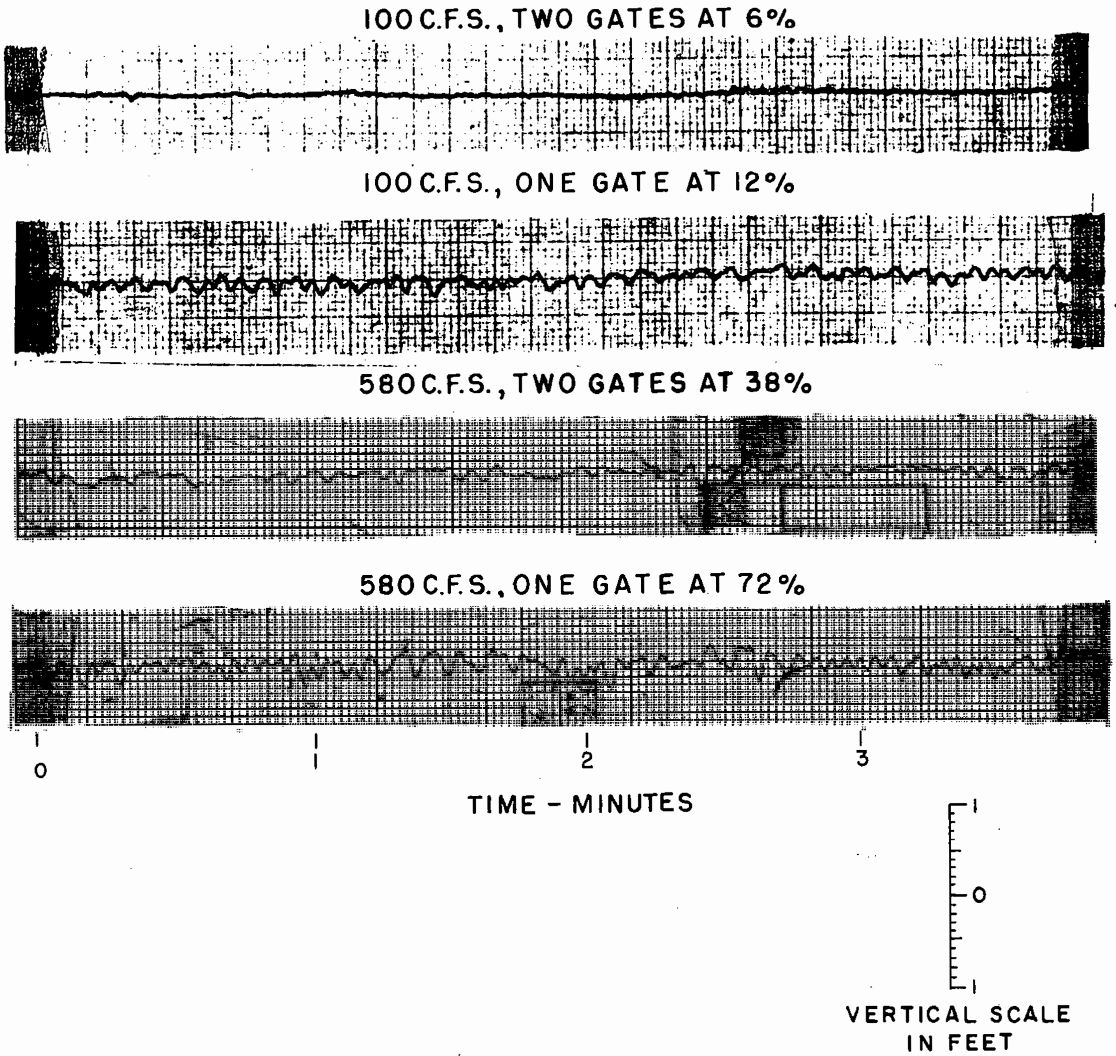


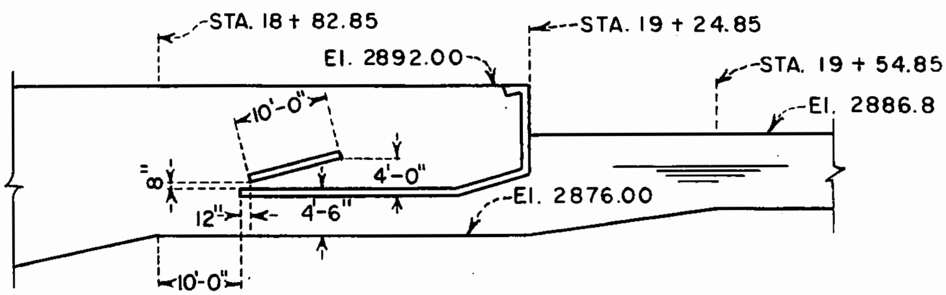
MERRITT DAM CANAL OUTLET WORKS

WAVE HEIGHTS SCHEME NO. 13 (RECOMMENDED)

1:16 SCALE MODEL

FIGURE 40
REPORT HYD 456





SECTION ON ℄

MERRITT DAM CANAL OUTLET WORKS

WATER SURFACE FLUCTUATIONS AT STA. 19 + 54.85

SCHEME 13 (RECOMMENDED)

GPO 852821