DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

MISSISSIPPI RIVER COMMISSION

SLUICES, HULAH DAM
CANEY RIVER, OKLAHOMA

MODEL INVESTIGATION

TECHNICAL MEMORANDUM NO. 2-253

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

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SLUICES, HULAH DAM, CANEY RIVER, OKLAHOMA

Model Investigation

SYNOPSIS

The model investigation of sluices for Hulah Dam was conducted to determine the hydraulic performance of nine sluices, each 5.0 ft wide by 6.5 ft high with tetrahedral deflectors on the floor of the outlet portals, discharging into a stilling basin developed from consideration of spillway flow. The stilling basin consisted of a horizontal apron 104 ft long at elevation 695, supporting two rows of baffle piers 8 ft high, and terminated by a stepped end sill 7 ft high. The sluices were horizontal in alignment with their inverts at elevation 702. The model reproduced three complete sluices and a proportionate width of stilling basin.

The sluice of basic design and one modification thereof were investigated. While the sluice of basic design was adequate in every respect, it was possible, with the pool at spillway crest, to increase the capacity of the sluice about 19 per cent by eliminating the 0.75-ft constriction in the roof of the outlet portal. Although the increase in discharge produced slightly more severe hydraulic conditions than those which obtained with the basic design, pressures, velocities, and erosion tendencies remained within normal allowable limits.

PART I: INTRODUCTION

1. Hulah Dam is to be constructed on Caney River near the community of Hulah, Oklahoma, about 4-1/2 mi south of the Oklahoma-Kansas State line and about 16 mi upstream (northwest) from Bartlesville, Oklahoma (see plate 1). The project provides for a small permanent conservation pool and a storage basin for flood control, but makes no provision for power.

2. The dam will be a rolled earth-fill embankment, side slopes of which will be protected by heavy blankets of dumped rock. The embankment will be about 5,200 ft long with a base width in the valley section of 651 ft and a top width of 25 ft. The top of the dam -- at elevation 778.4* -- will be 61 ft above the valley floor.

3. Spillway and flood-control outlets for Hulah Dam will be located in a saddle through the right abutment, about 1,500 ft from the right end of the dam. The spillway -- a concrete gravity overflow weir with its crest at elevation 740 -- will be surmounted by ten vertical-lift gates each 40 ft wide by 25 ft high. The spillway is designed to pass a discharge of 285,000 cfs under a head of 33.7 ft.

4. Normal flow through the reservoir will be regulated by nine gate-controlled sluices, each 5 ft wide by 6.5 ft high, located along the center line of the spillway piers.

5. Hydraulic conditions are such at Hulah Dam that development by established equations of a stilling basin for dissipation of energy

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* All elevations are referred to feet above mean sea level.

of flow over the spillway was possible. The basin so developed consisted of a horizontal apron 104 ft long, supporting two rows of baffle piers 8 ft high, and terminated by an end sill 7 ft high. However, existing data were not sufficient to predict accurately the performance of this stilling basin with respect to dissipation of energy of sluice flow. For this reason, the District Engineer, Tulsa District, CE, recommended in a letter to the Chief of Engineers that the design of the sluices be investigated by means of small-scale model tests. Authority for the study was granted by the Chief of Engineers in an indorsement dated 23 December 1946 to the above letter. The model study was conducted at the Waterways Experiment Station, CE, during the period February-April 1947.

6. The general purpose of the model tests was to check the over-all performance of the sluices and to provide means for correcting any unfavorable conditions found to exist. The investigation was conducted on a model built to a linear scale of 1:20 (see photograph 1). There were reproduced in the model three complete sluices (including the bell-mouth intakes, sluice gates and exit portals), that portion of the spillway face below elevation 727, a section of the stilling basin 256 ft wide, and 200 ft of the exit channel. The reservoir area was represented by a reinforced concrete headbay of sufficient size and properly baffled to provide quiet approach conditions to the model. The sluice intakes, gates and exit portals were fabricated of transparent plastic; the spillway face was molded in cement mortar to sheet-metal templets. The stilling basin was molded in cement mortar to wood screeds which were used thereafter as nailing strips for the baffle piers and end

sill. That portion of the model downstream from the stilling basin was molded flat in sand for scour tests; for velocity tests the same bed was stabilized by a thin coating of cement mortar.

7. The model study was accomplished in the Hydraulics Division of the Waterways Experiment Station. Personnel of the Experiment Station actively connected with the study were Messrs. E. P. Fortson, Jr., F. R. Brown, T. E. Murphy, C. Kestenbaum, Engineers, and W. H. Sadler, Jr., Engineering Aide. During the testing program Mr. R. H. Berryhill of the Tulsa District visited the Experiment Station in an advisory capacity.

PART II: TESTS AND RESULTS

8. There were investigated in the model the sluice of basic design, designated type A in this report, and one modification thereof, designated type A-1. Tests were conducted with the reservoir at elevation 731, conservation pool; elevation 740, spillway crest; and elevation 765, top of gates. Tailwater elevations were set in accordance with the computed minimum tailwater curve (plate 5). In some instances it was not possible to lower the tailwater in the model to the computed minimum; during such tests the tailwater was set as low as possible.

Type A Sluice

9. The type A sluice was horizontal throughout its total length of approximately 56 ft. The sluice invert was at elevation 702. Elliptical entrance curves were designed to guide the water into the sluice with minimum disturbance, and a tetrahedral deflector in the downstream end of the sluice was designed to disperse the jet as it left the sluice and entered the stilling basin (see plates 2-4).

10. Tests to establish head-discharge relations of flow through the type A sluice indicated that the capacity of the sluice was adequate in that the discharge through the model sluice was slightly greater than that computed. Model and computed rating curves are shown on plate 6.

11. Pressure conditions were satisfactory. Piezometer locations are shown on plate 3; pressures are recorded in table 1. The pressure gradient through the intake indicated minimum disturbance in the sluice

entrance. The minimum pressure observed on the walls of the outlet portal was -0.5 ft.

12. With the pool at elevation 731, flow from one type A sluice (photograph 2) did not diffuse from the outlet deflector with sufficient energy to force the tailwater back and permit lateral spreading of the jet. However, the jet was dispersed by the baffle piers, and velocities over the end sill did not exceed 10 ft per sec (plate 7). A test run of one hour's duration eroded the sand bed to a depth of only 3 ft below the end sill (plate 8). When the pool was raised to elevation 740, the outlet deflector served to partially disperse the flow from one type A sluice (photograph 3) and velocities and erosion tendencies in the exit area were about the same as those obtaining with the pool at elevation 731, as shown by a comparison of plates 9 and 10 with plates 7 and 8. Since it was considered improbable that only one sluice would be in operation with the pool at elevation 765 (top of spillway gates), no velocity or scour data were taken for this condition, but observation of flow revealed that the outlet deflector dispersed the jet to a greater extent than it did when the pool was at elevation 740 (compare photographs 4 and 3).

13. With three sluices operating, the tailwater set for a discharge from only three sluices, and the pool at elevation 731 or 740, spread of the jets was dependent mainly upon diffusion by the baffle piers as in the case of a single sluice operating (see photographs 5 and 6). However, when the pool was raised to elevation 765, energy of flow from the three sluices was sufficient to sweep the tailwater back and allow the deflectors to spread the flow equally across the stilling

basin (see photograph 7). With three sluices operating and the tailwater set for a discharge from all nine sluices, the sluice outlets were completely submerged (see photograph 8). Velocity and scour data for three sluices operating, with the tailwater set for a discharge from only three sluices and pool at elevation 740, are presented on plates 11 and 12. While these conditions produced the most severe flows measured in the exit area, the maximum velocity recorded over the end sill was only 11 ft per sec and a test of one hour's duration eroded the sand bed to a depth of only 4 ft below the elevation of the end sill. With the pool at elevation 765, the tailwater set for a discharge from all nine sluices, and three sluices operating, velocity and scour conditions in the exit area were not severe (see plates 13 and 14).

Type A-1 Sluice

14. Since, with the pool at elevation 740, the pressure grade line in the type A sluice immediately upstream from the outlet portal was 11.25 ft above the roof of the sluice, it was believed that the outlet portal was exerting more back pressure than necessary for satisfactory conditions. Thus the constriction in the roof of the outlet portal was removed and the resulting sluice (designated type A-1) was tested.

15. At pool elevation 740 discharge through the type A-1 sluice was about 19 per cent greater than that through the type A sluice. A comparison of discharge curves is presented on plate 6. With the pool at elevation 740 the pressure grade line immediately above the outlet

portal (piezometer 33) was only 1.75 ft above the roof of the sluice. It appeared, therefore, that the outlet portal for the type A-1 sluice produced very little reduction in discharge over that which would have resulted had the conduit been carried to the face of the spillway at its basic rectangular cross section.

16. Minimum pressures measured on the walls of the outlet portal were -1.5 ft at pool elevation 731, -2.5 ft at pool elevation 740, and -4.0 ft at pool elevation 765. A tabulation of pressures is presented in table 2.

17. Flow conditions in the stilling basin below the type A-1 sluice, illustrated by photographs 9-15, were similar to those below the type A sluice except that the additional discharge created slightly more turbulence. Likewise, the general patterns of velocities and erosion tendencies shown by plates 15-22 were very similar, though generally slightly greater in extent, than those produced by flow from the type A sluice. As in the case of the type A sluice, the most severe flows of any of the conditions tested were produced by three sluices operating with pool at elevation 740 and tailwater set for a discharge from only three sluices. Maximum velocities measured in the exit area below the type A-1 sluice were 13 ft per sec (plate 19) as opposed to 11 ft per sec below the type A sluice (plate 11). Also, a test of one hour's duration on the type A-1 sluice eroded the sand bed to a depth of 5 ft below the end sill (plate 20) as opposed to 4 ft (plate 12) for a similar test on the type A sluice.

PART III: CONCLUSIONS

18. While the sluice of basic design was adequate, tests demonstrated that for normal operating conditions the tetrahedral floor deflector assisted only slightly in energy dissipation. Flow from the sluice was not diffused from the outlet deflector with sufficient energy to force the tailwater back and permit lateral spreading of the jet. Performance probably could have been improved by placing the sluices at a higher elevation but, for structural reasons, this was undesirable.

19. Conditions at Fort Gibson* and Fall River**Dams are more favorable for the use of deflector-type sluice outlets than those at Hulah Dam. At the former two installations normal operating heads are higher -- and tailwaters with respect to the inverts of the outlet portals are lower -- than those at Hulah Dam. Also flow from the sluices contains sufficient energy to fan out from the deflector and spread into the tailwater.

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* "Supplementary Model Study of Stilling Basin for Spillway and Sluices, Fort Gibson Dam, Grand River, Oklahoma," Waterways Experiment Station Technical Memorandum No. 2-228.

** "Model Study of Sluices for Fall River Dam, Fall River, Kansas," Waterways Experiment Station Technical Memorandum No. 2-230.

TABLE 1

MODEL STUDY OF SLUICES, HULAH DAM

Pressures - Type A Design

Piezometer Number	Piezometer Zero	Discharge - 948 cfs Pool Elev - 731.0 Pressure	Discharge - 1077 cfs Pool Elev - 740.0 Pressure	Discharge - 1425 cfs Pool Elev - 765.0 Pressure
1	709.2	15.0	21.5	39.5
2	708.8	11.0	16.5	30.5
3	708.6	10.0	14.5	27.5
4	708.5	9.5	14.5	27.0
5	708.5	10.0	14.5	28.0
6	708.5	10.0	14.5	28.0
7	708.5	9.5	14.5	26.5
8	705.3	18.5	25.0	42.5
9	705.3	16.5	22.0	37.5
10	705.3	14.5	20.0	34.0
11	705.3	13.5	18.5	31.5
12	705.3	13.0	18.0	30.5
13	701.3	23.0	30.0	48.0
14	701.7	19.5	25.0	40.0
15	701.9	17.0	22.0	35.5
16	702.0	16.5	21.5	34.0
17	702.0	16.5	21.5	34.0
18	702.0	16.5	21.5	34.0
19	702.0	16.5	21.0	33.0
20	708.5	9.5	14.0	25.5
21	705.3	12.5	17.5	29.5
22	702.0	16.0	20.5	32.5
23	708.5	9.0	13.5	25.0
24	705.3	12.0	16.5	28.5
25	702.0	15.5	20.0	32.0
26	708.5	8.5	13.0	24.5
27	705.3	11.5	16.5	28.0
28	702.0	15.0	20.0	31.0
29	708.5	7.5	12.0	23.0
30	705.3	10.5	15.5	26.5
31	702.0	13.5	18.5	29.0
32	708.5	7.5	12.0	23.0
33	705.3	10.5	14.5	25.0
34	702.0	13.5	17.5	27.5
35	707.5	8.0	12.0	22.0
36	707.5	6.0	10.0	18.5
37	707.5	3.0	5.5	10.5
38	705.3	7.5	12.0	20.5
39	705.3	5.0	9.0	16.5
40	705.3	3.0	5.5	10.0
41	705.3	1.0	1.5	3.0
42	705.3	-0.5	-0.5	0.0
43	705.3	0.5	0.5	2.0
44	703.0	10.0	14.0	22.5
45	703.0	6.0	8.0	12.5
46	703.0	1.0	3.0	3.5
47	703.0	0.0	1.5	1.5
48	703.0	1.0	1.5	3.5
49	703.0	1.0	2.0	3.5
50	703.0	1.0	1.0	2.0

NOTE: Pressures are recorded in prototype ft of water to the nearest half ft.
Location of piezometers are shown on plate 3.

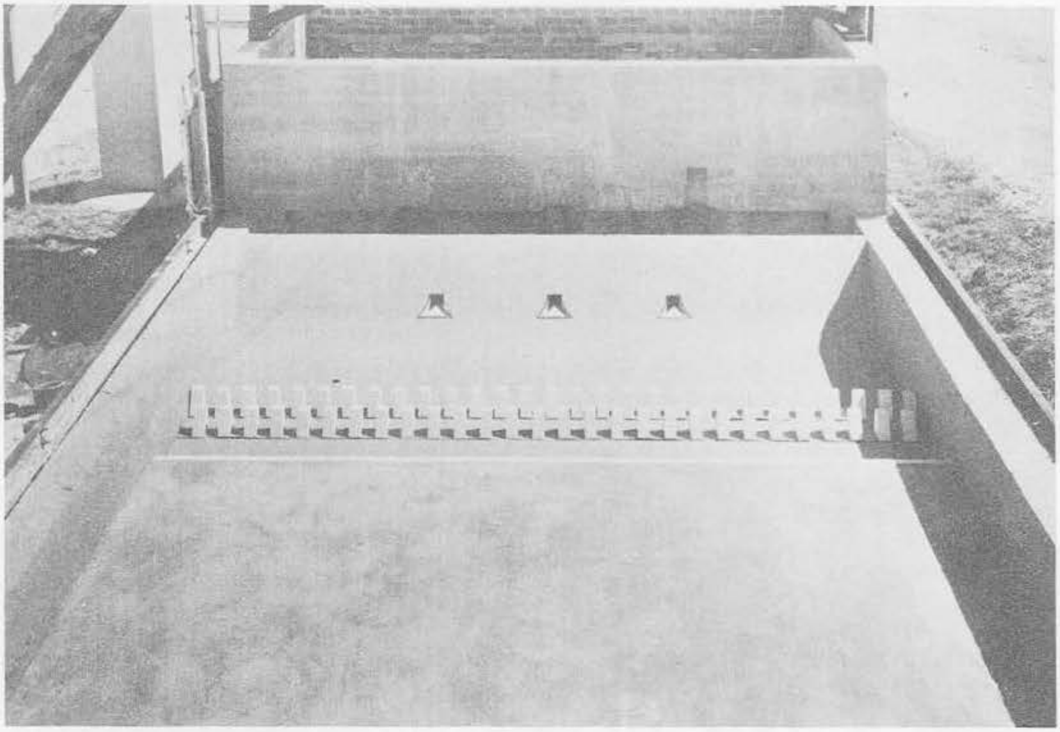
TABLE 2

MODEL STUDY OF SLUICES, HULAH DAM

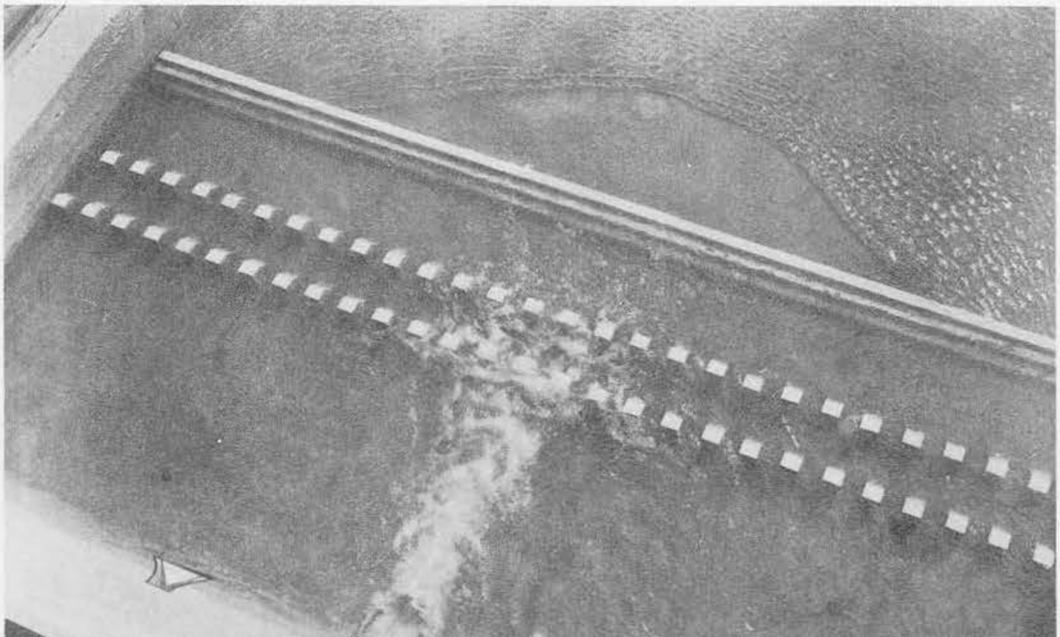
Pressures - Type A-1 Design

Piezometer Number	Piezometer Zero	Discharge - 1107 cfs Pool Elev - 731.0 Pressure	Discharge - 1283 cfs Pool Elev - 740.0 Pressure	Discharge - 1708 cfs Pool Elev - 765.0 Pressure
1	709.2	11.5	16.5	31.0
2	708.8	6.0	9.0	16.5
3	708.6	4.0	6.5	13.0
4	708.5	4.0	6.0	12.5
5	708.5	4.0	6.5	13.5
6	708.5	4.5	6.5	13.5
7	708.5	4.0	6.0	12.5
8	705.3	15.5	20.5	30.0
9	705.3	12.0	15.5	26.5
10	705.3	9.5	13.0	21.5
11	705.3	8.0	10.5	17.5
12	705.3	7.5	10.0	16.5
13	701.3	20.0	25.5	40.5
14	701.7	15.0	18.5	29.0
15	701.9	12.0	14.5	22.0
16	702.0	11.5	13.5	20.5
17	702.0	11.0	13.5	20.5
18	702.0	11.0	13.0	20.0
19	702.0	10.5	2.5	19.0
20	708.5	3.5	6.0	12.0
21	705.3	7.5	9.0	15.5
22	702.0	10.0	2.0	18.5
23	708.5	3.0	5.0	10.5
24	705.3	6.5	8.0	13.5
25	702.0	9.5	11.5	17.0
26	708.5	3.0	4.5	-0.5
27	705.3	6.0	7.5	2.5
28	702.0	9.5	11.0	6.5
29	708.5	1.5	3.0	-3.5
30	705.3	5.0	6.0	0.0
31	702.0	8.0	9.0	3.0
32	708.5	0.5	1.5	4.5
33	705.3	4.0	5.0	8.0
34	702.0	7.5	8.5	11.5
35	707.5	0.5	1.0	2.5
36	707.5	0.0	0.0	0.5
37	707.5	-1.0	-1.5	-2.0
38	705.3	2.5	3.0	5.5
39	705.3	1.5	1.5	3.0
40	705.3	0.5	-0.5	-0.5
41	705.3	-1.5	-2.5	-4.0
42	705.3	-1.5	-2.0	-3.5
43	705.3	0.0	-0.5	0.0
44	703.0	5.5	7.0	10.0
45	703.0	2.5	2.0	2.5
46	703.0	-1.0	-2.0	-4.0
47	703.0	-1.0	-2.0	-3.5
48	703.0	0.0	-0.5	-1.0
49	703.0	0.5	0.5	1.0
50	703.0	0.5	0.5	1.0

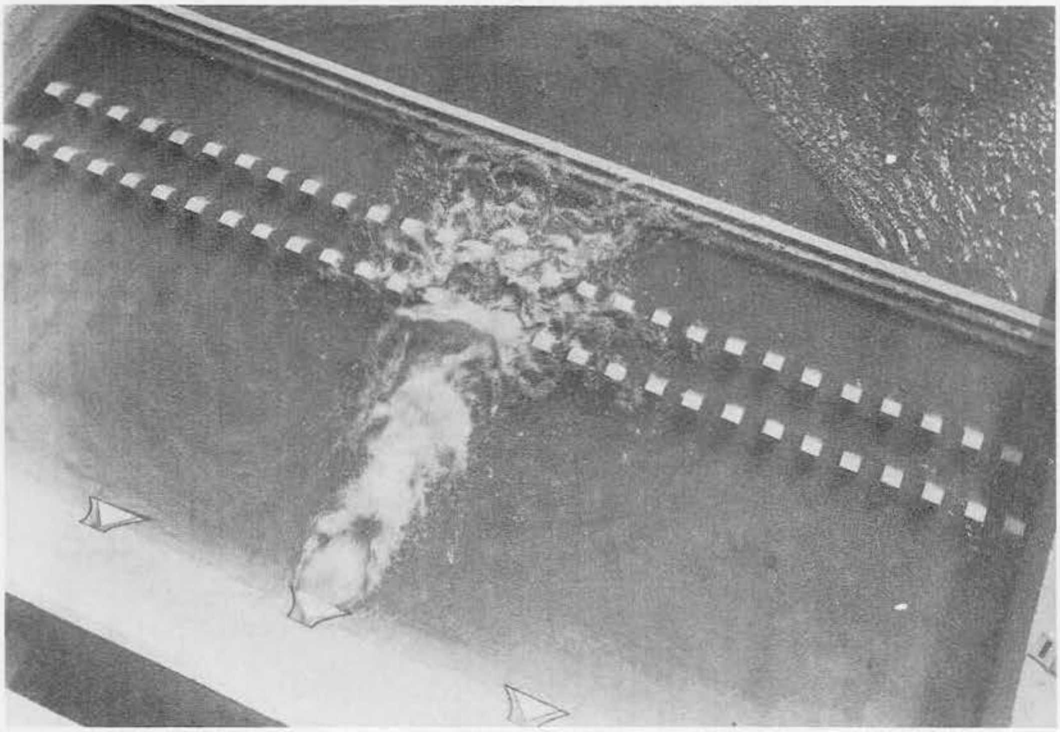
NOTE: Pressures are recorded in prototype ft of water to the nearest half ft. Location of piezometers are shown on plate 3.



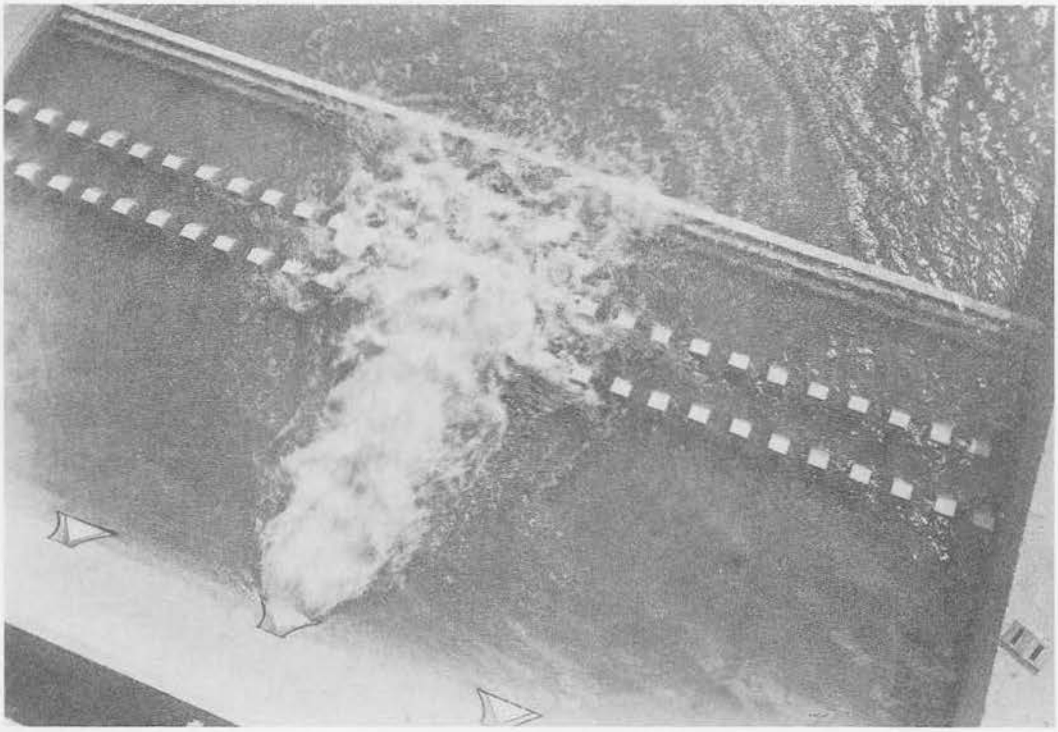
PHOTOGRAPH 1. The model, linear scale 1:20.



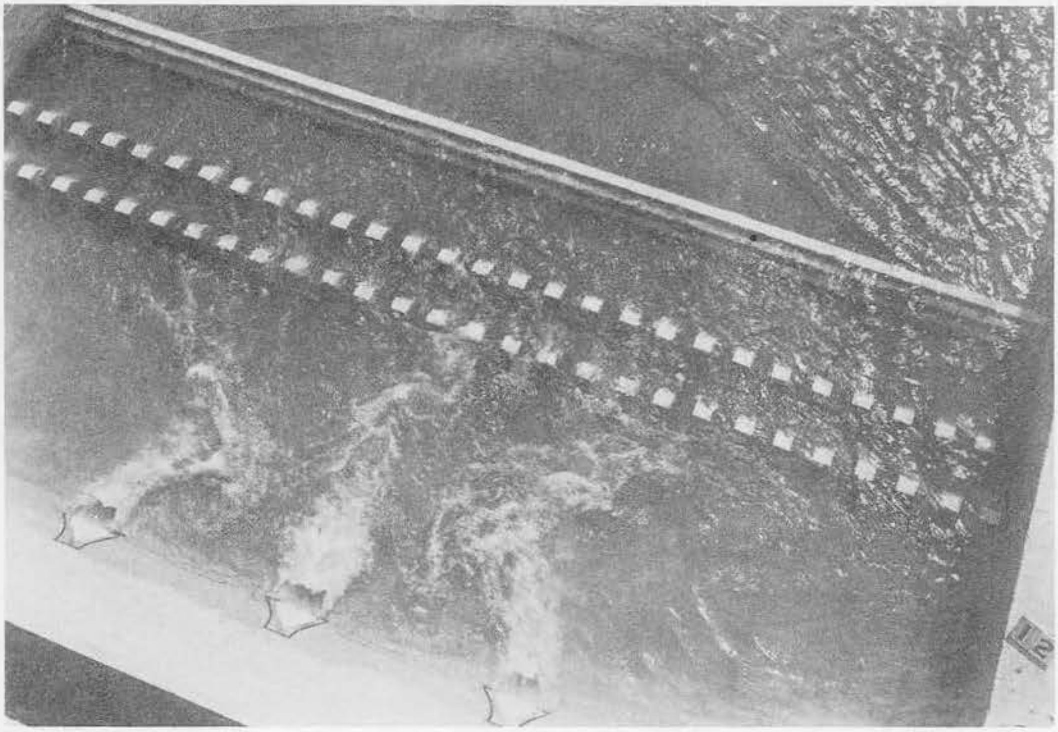
PHOTOGRAPH 2. One type A sluice in operation
Discharge 948 cfs, pool elev 731.0, tailwater elev 703.2



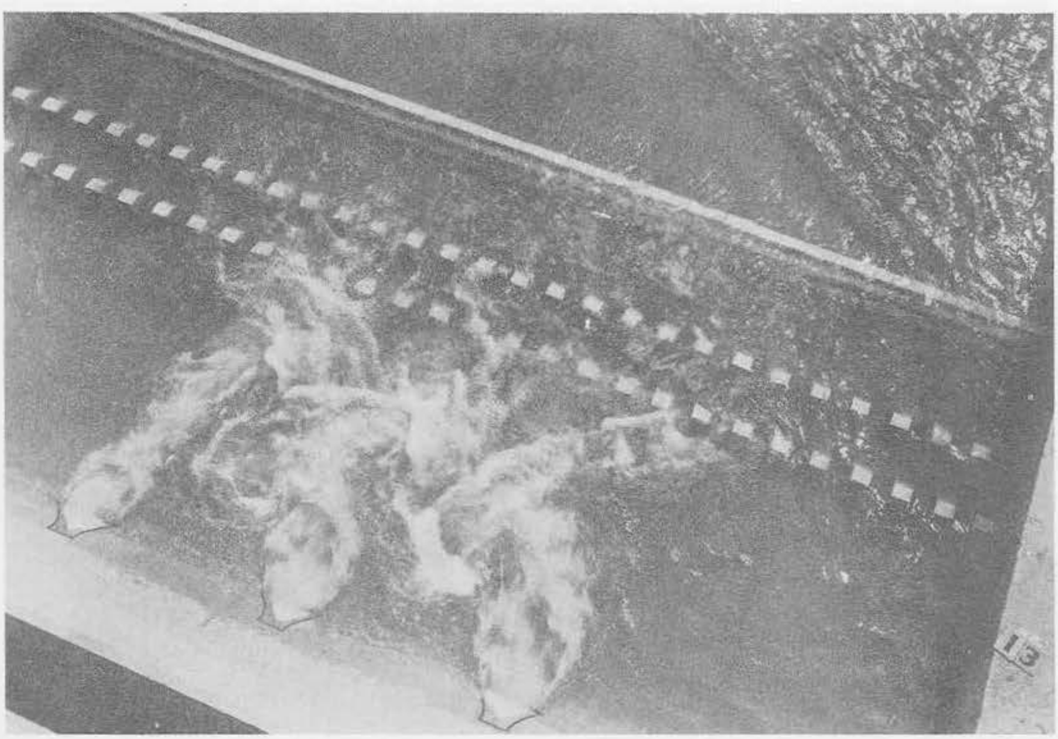
PHOTOGRAPH 3. One type A sluice in operation
Discharge 1,077 cfs, pool elev 740.0, tailwater elev 703.4



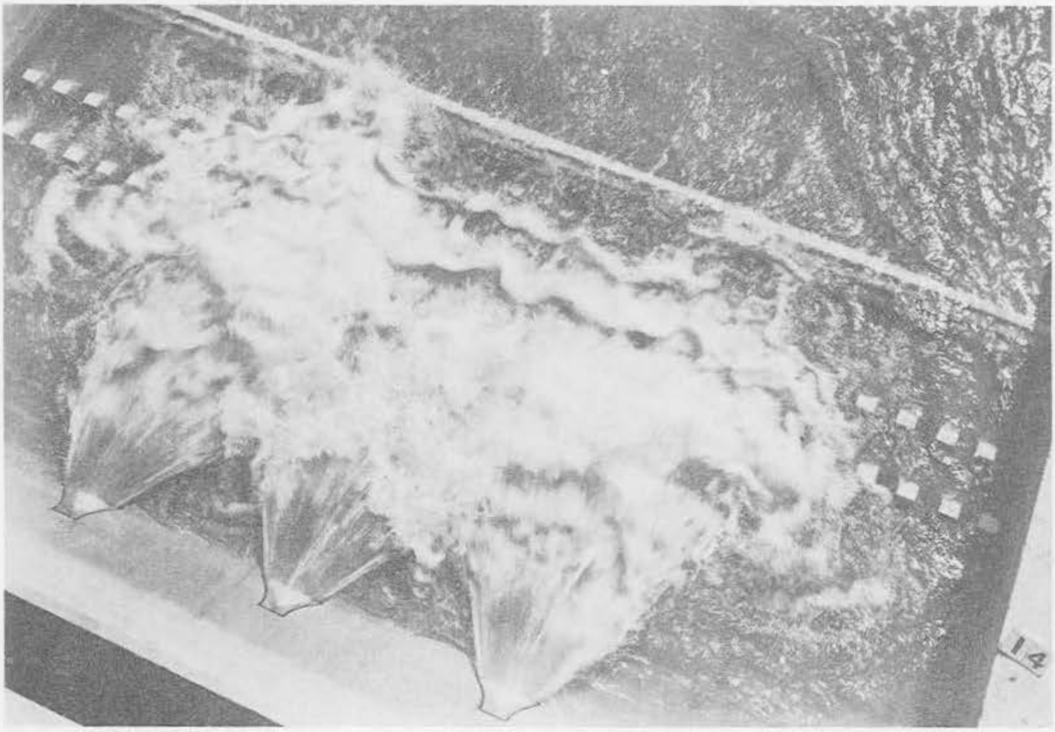
PHOTOGRAPH 4. One type A sluice in operation
Discharge 1,425 cfs, pool elev 765.0, tailwater elev 703.9



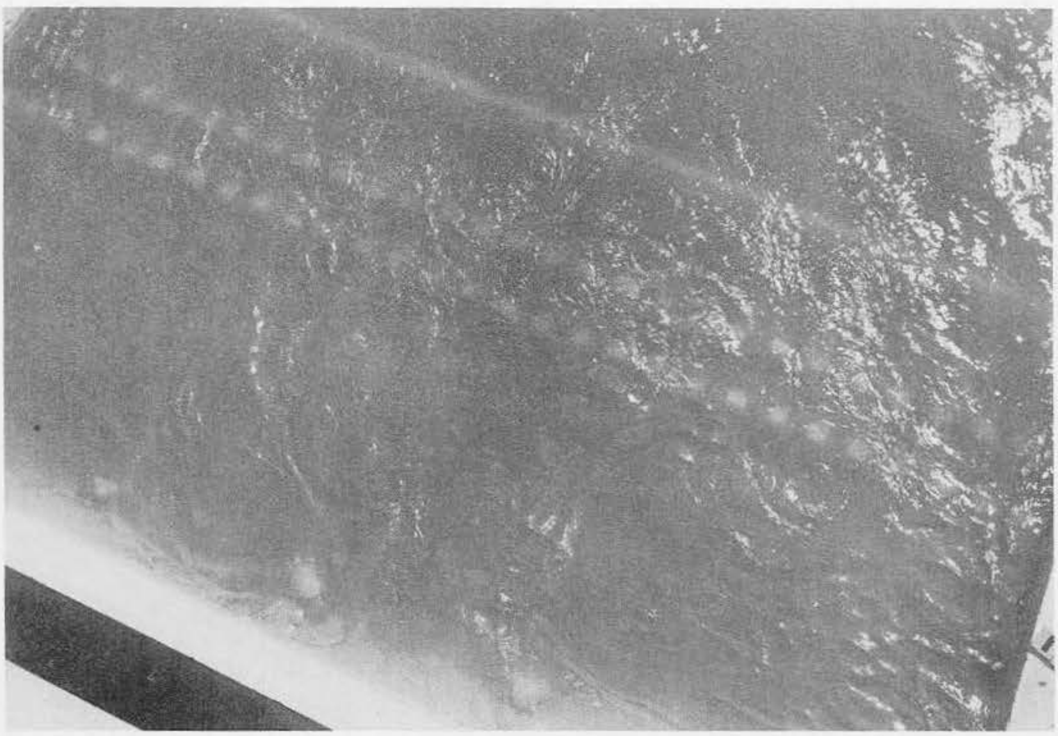
PHOTOGRAPH 5. Three type A sluices in operation
Discharge 2,845 cfs, pool elev 731.0, tailwater elev 704.3



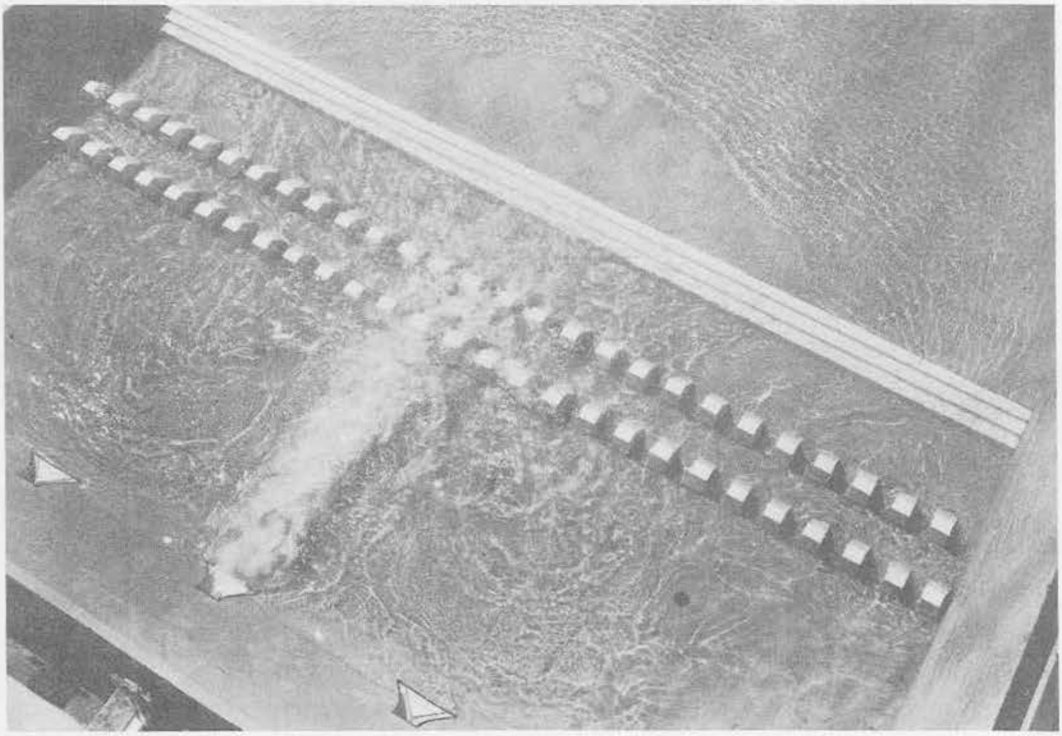
PHOTOGRAPH 6. Three type A sluices in operation
Discharge 3,230 cfs, pool elev 740.0, tailwater elev 704.6



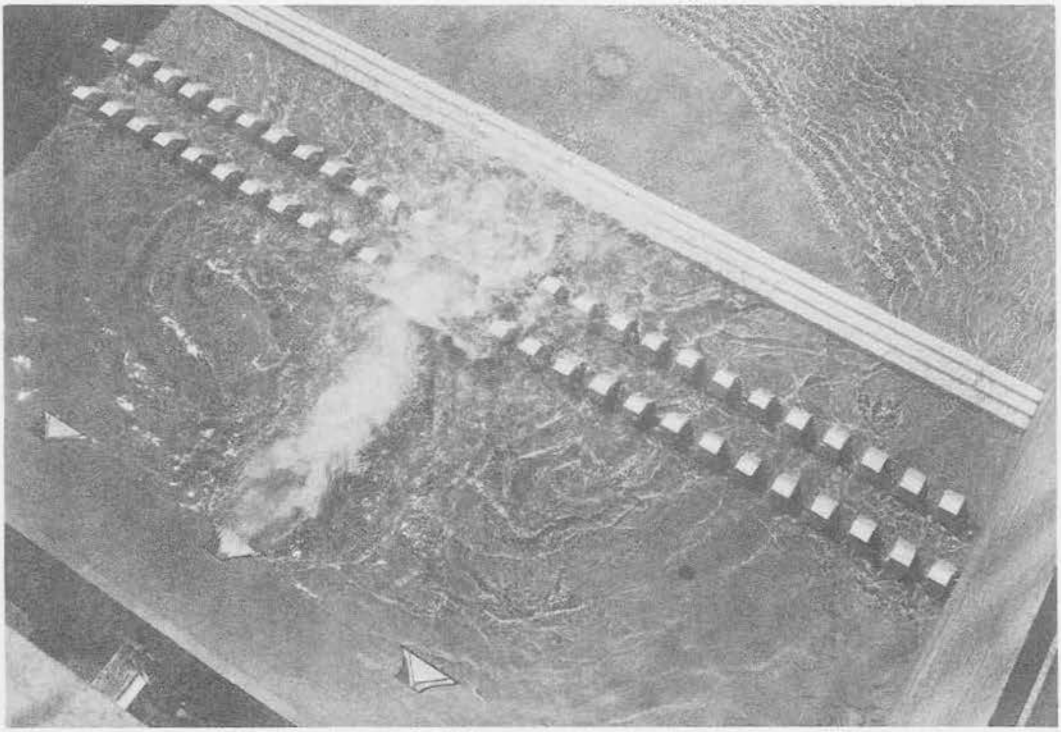
PHOTOGRAPH 7. Three type A sluices in operation
Discharge 4,275 cfs, pool elev 765.0, tailwater elev 705.5



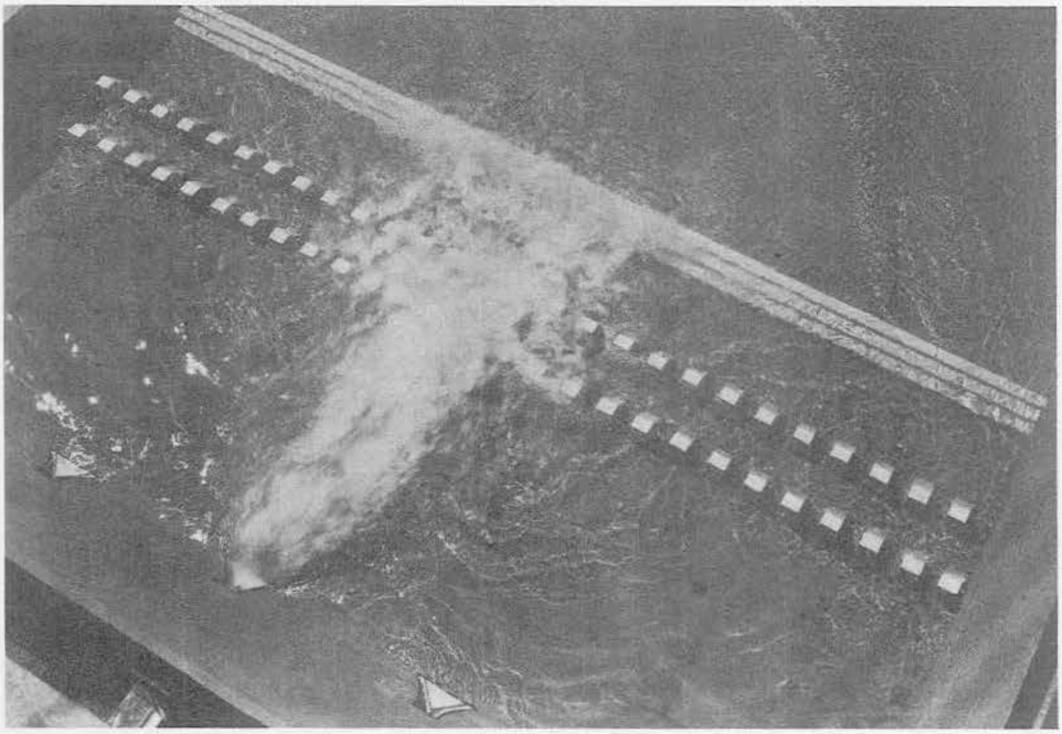
PHOTOGRAPH 8. Nine type A sluices in operation
Discharge 11,820 cfs, pool elev 765.0, tailwater elev 717.7



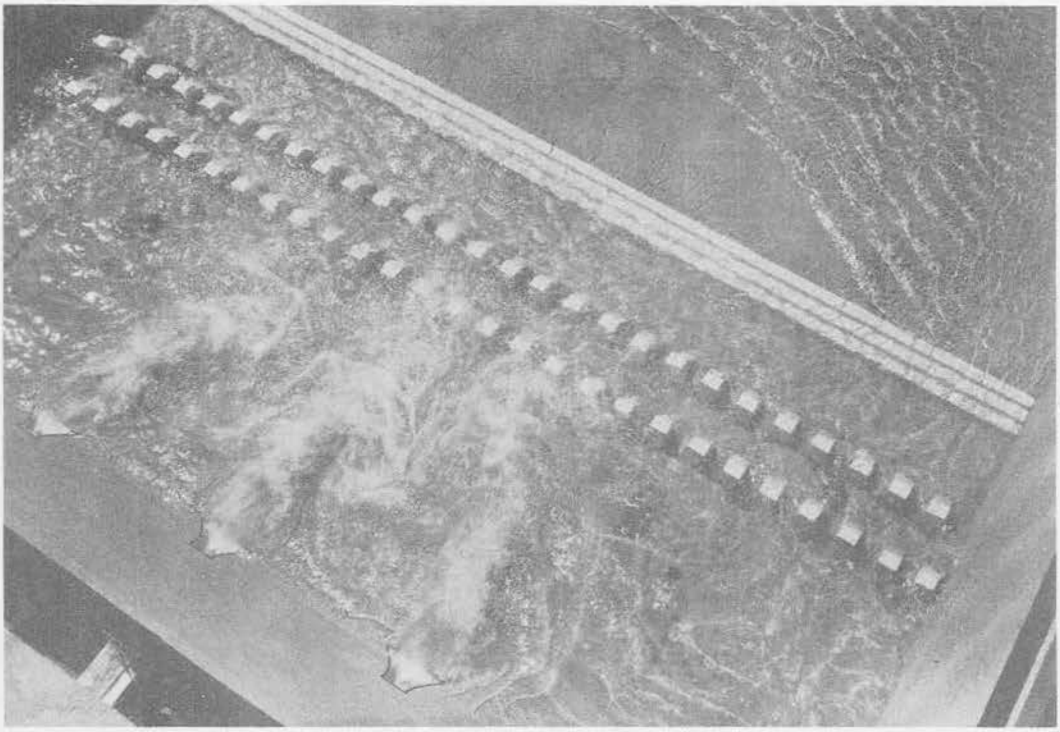
PHOTOGRAPH 9. One type A-1 sluice in operation
Discharge 1,107 cfs, pool elev 731.0, tailwater elev 703.5



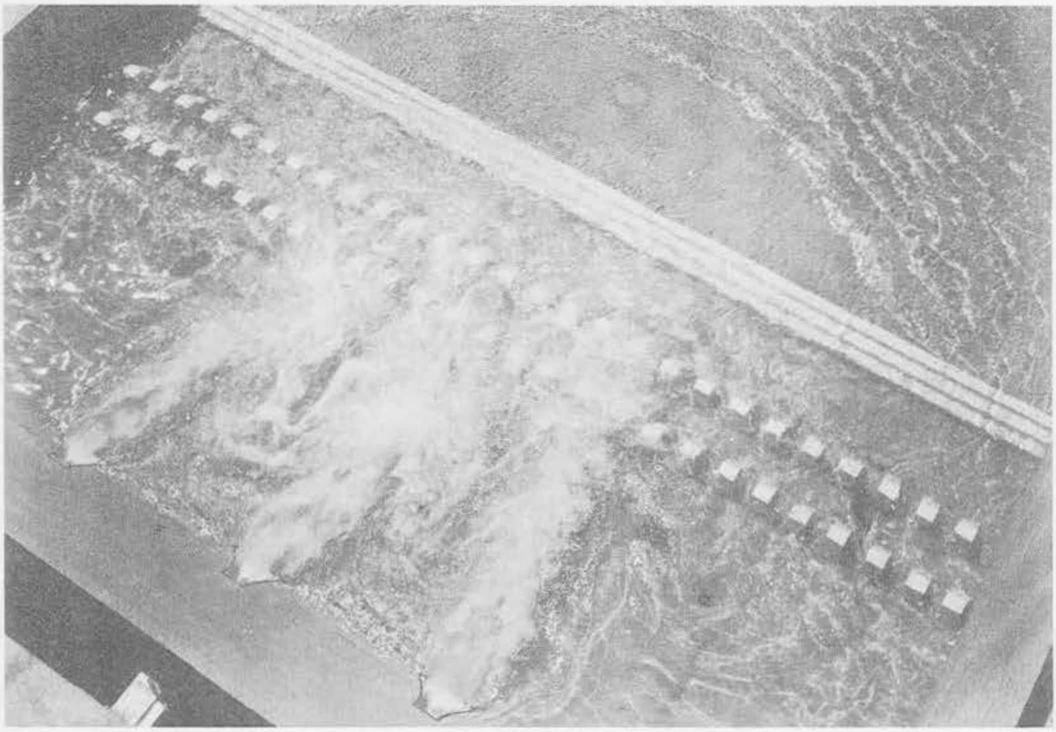
PHOTOGRAPH 10. One type A-1 sluice in operation
Discharge 1,283 cfs, pool elev 740.0, tailwater elev 703.7



PHOTOGRAPH 11. One type A-1 sluice in operation
Discharge 1,708 cfs, pool elev 765.0, tailwater elev 704.0

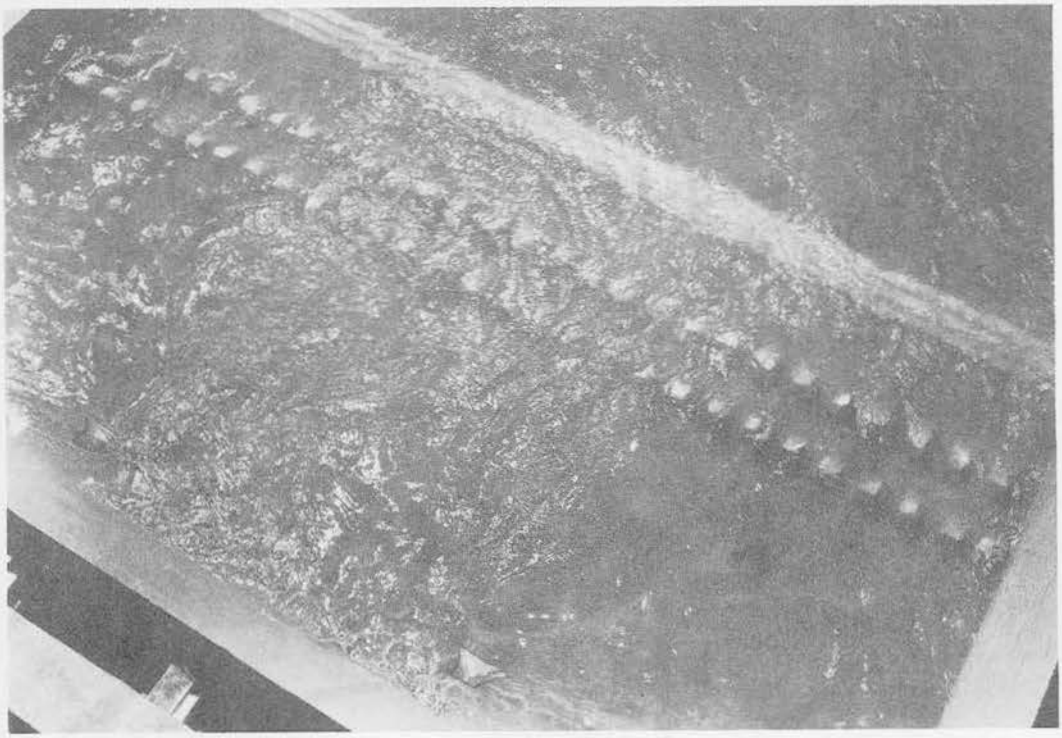


PHOTOGRAPH 12. Three type A-1 sluices in operation
Discharge 3,320 cfs, pool elev 731.0, tailwater elev 704.7



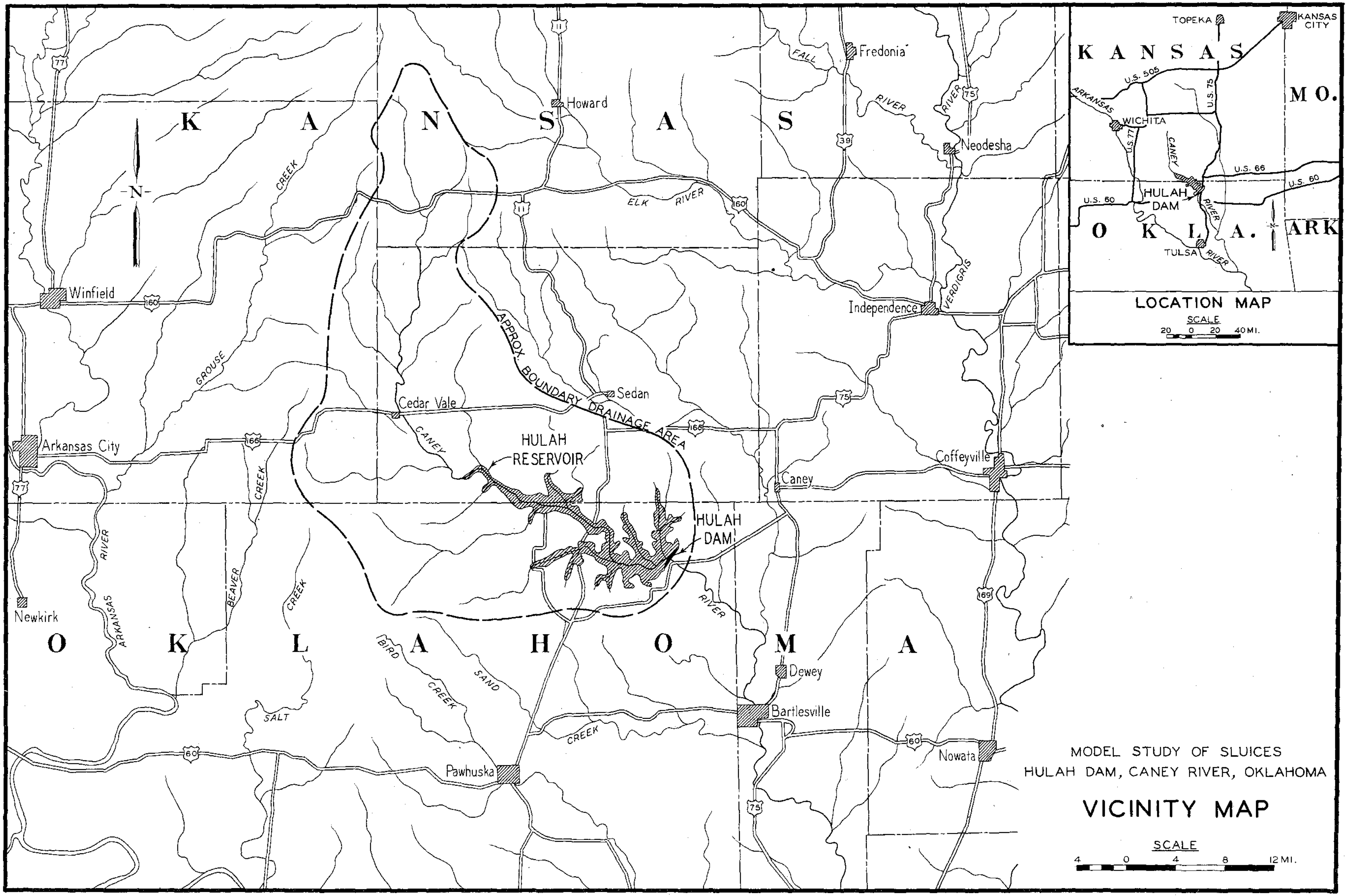
PHOTOGRAPH 13. Three type A-1 sluices in operation
Discharge 3,850 cfs, pool elev 740.0, tailwater elev 705.0

PHOTOGRAPH 14. Three type A-1 sluices in operation
Discharge 5,080 cfs, pool elev 765.0, tailwater elev 707.0



PHOTOGRAPH 15. Nine type A-1 sluices in operation
Discharge 14,040 cfs, pool elev 765.0, tailwater elev 718.9

PLATE 1


MODEL STUDY OF SLUICES
HULAH DAM, CANEY RIVER, OKLAHOMA
VICINITY MAP
SCALE
4 0 4 8 12 MI.
LOCATION MAP
SCALE
20 0 20 40 MI.
KANSAS
OKLAHOMA
MO.
ARK
TOPEKA
KANSAS CITY
WICHITA
TULSA
HULAH DAM
HULAH RESERVOIR
APPROX. BOUNDARY DRAINAGE AREA
Winfield
Arkansas City
Newkirk
Howard
Fredonia
Neodesha
Independence
Cedar Vale
Sedan
Caney
Coffeyville
Dewey
Bartlesville
Pawhuska
Nowata
CANEY RIVER
ELK RIVER
FALL RIVER
VERDIGRIS RIVER
ARKANSAS RIVER
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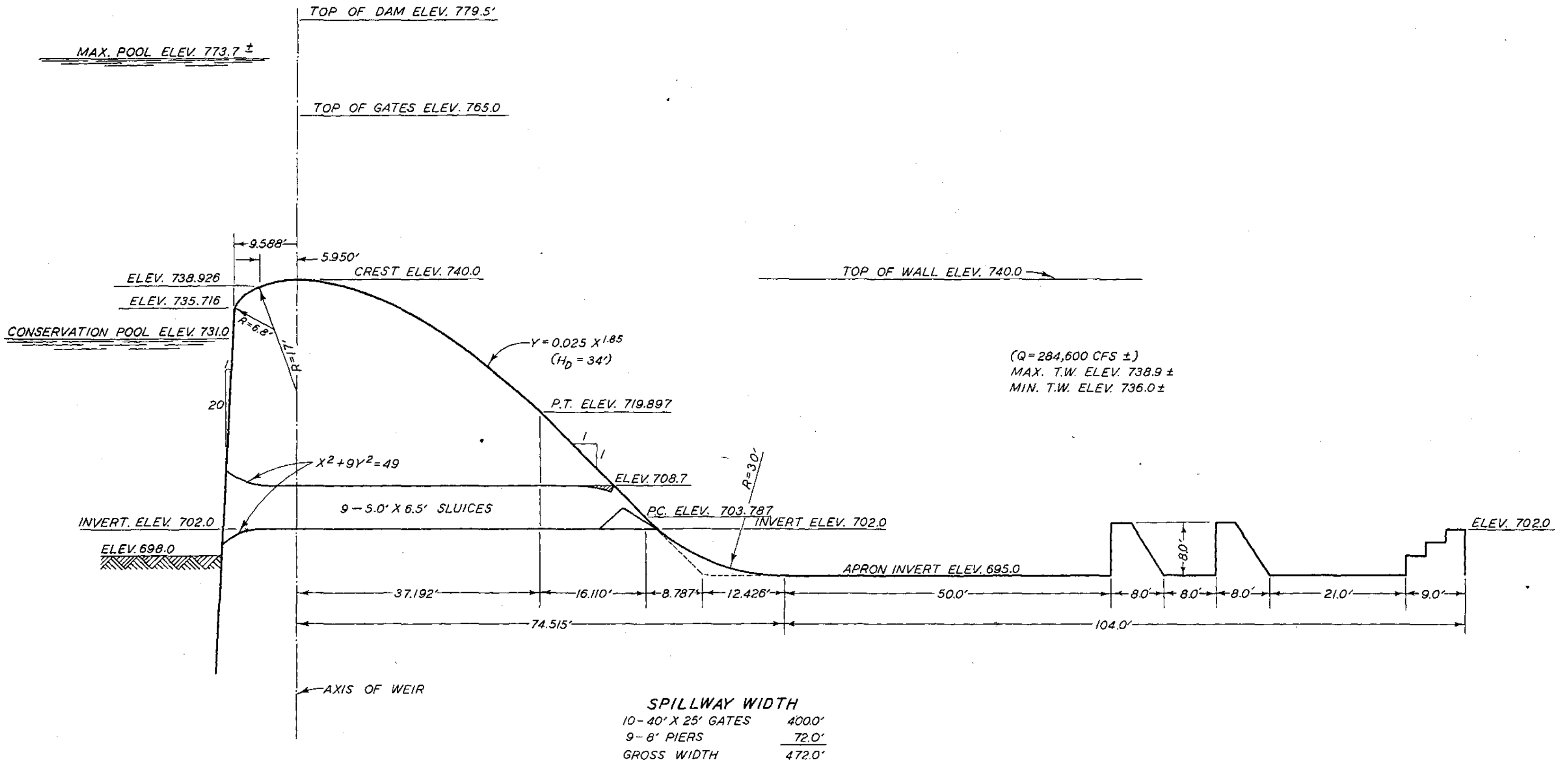
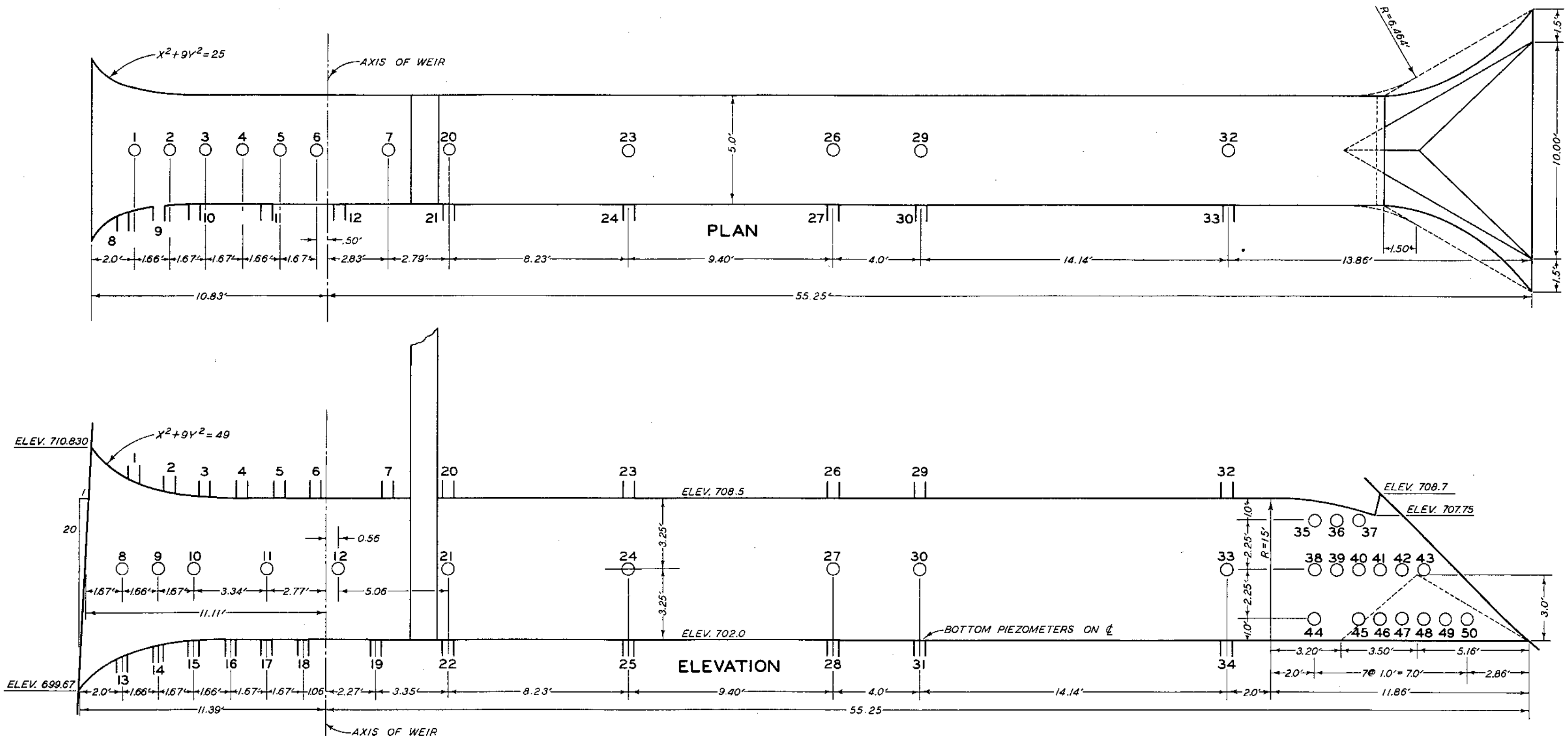
BEAVER CREEK
BIRD CREEK
SAND CREEK
SALT CREEK



MODEL STUDY OF SLUICES
HULAH DAM, CANEY RIVER, OKLAHOMA

SPILLWAY, STILLING BASIN, AND SLUICES

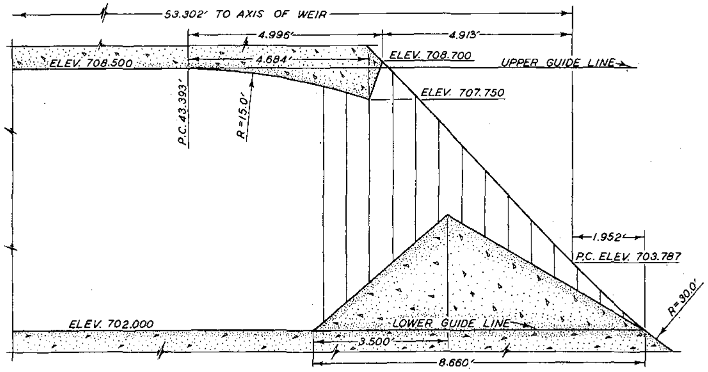
PLATE 2



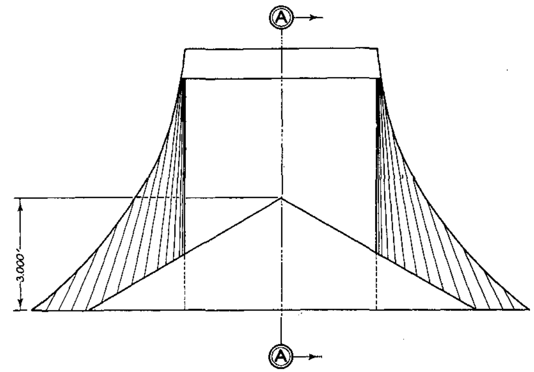
NOTE: TYPE A-1 DESIGN IS THE TYPE A DESIGN WITHOUT ROOF CONSTRUCTION IN THE EXIT PORTAL.

MODEL STUDY OF SLUICES
HULAH DAM, CANEY RIVER, OKLAHOMA

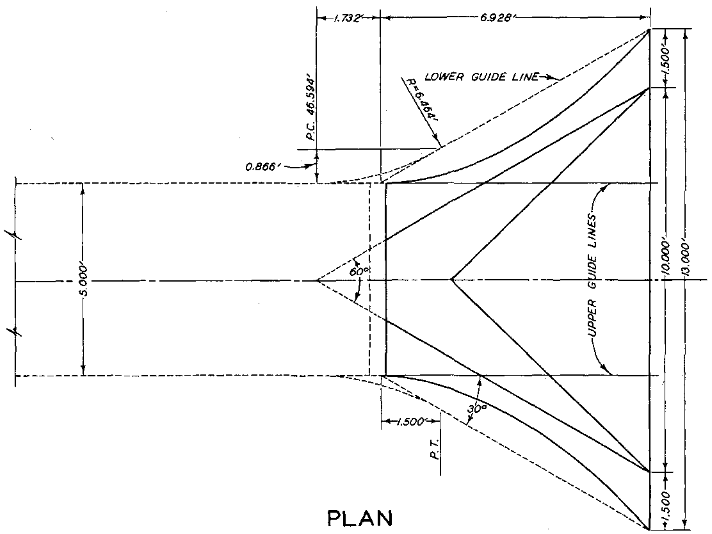
PIEZOMETER LOCATIONS



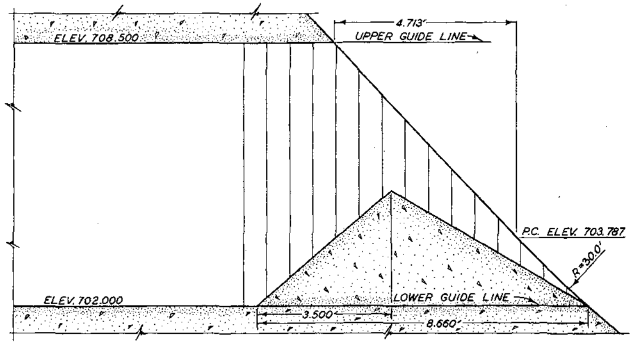
SECTION A-A



FRONT ELEVATION



PLAN



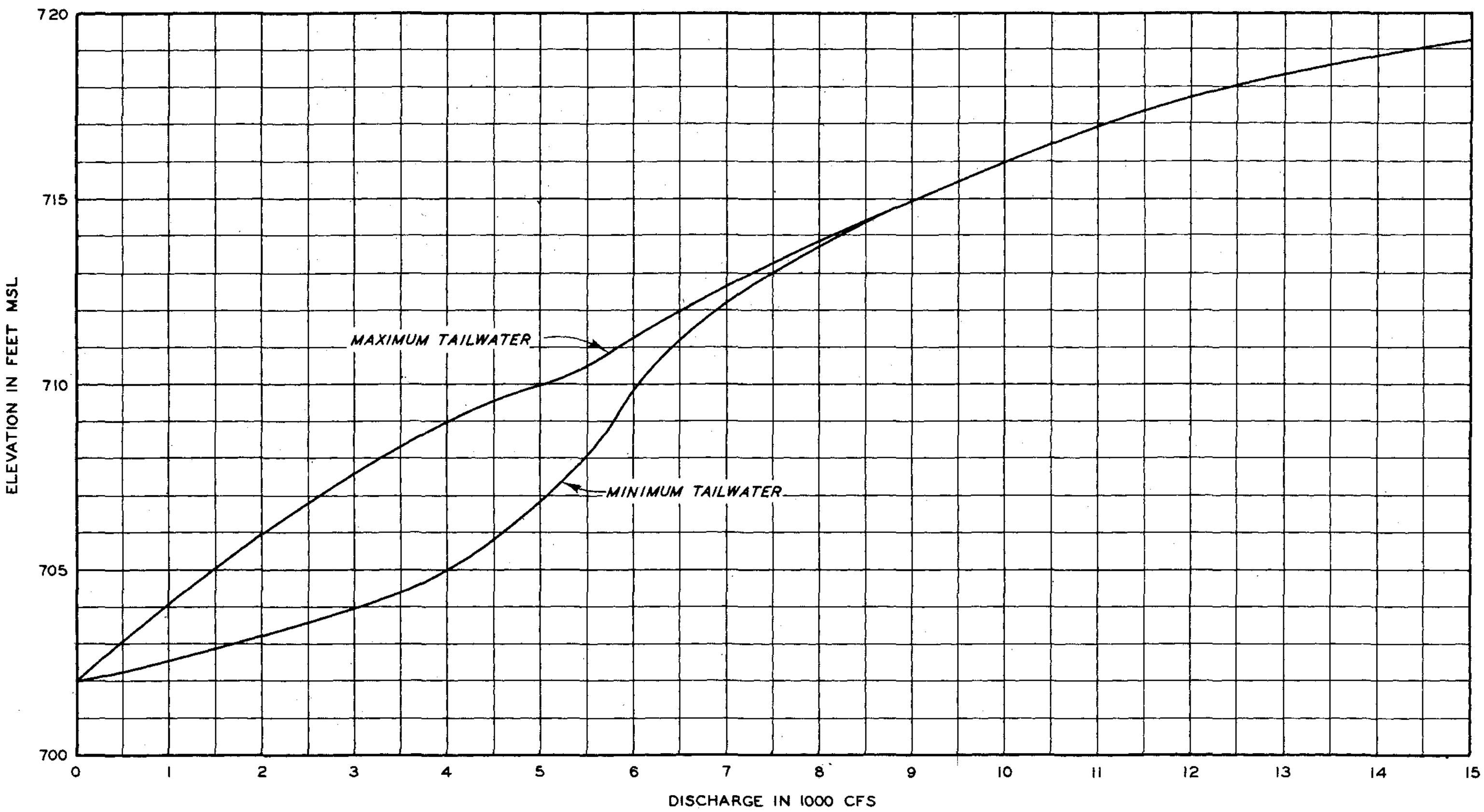
TYPE A-1 DESIGN

TYPE A DESIGN

MODEL STUDY OF SLUICES
HULAH DAM, CANEY RIVER, OKLAHOMA

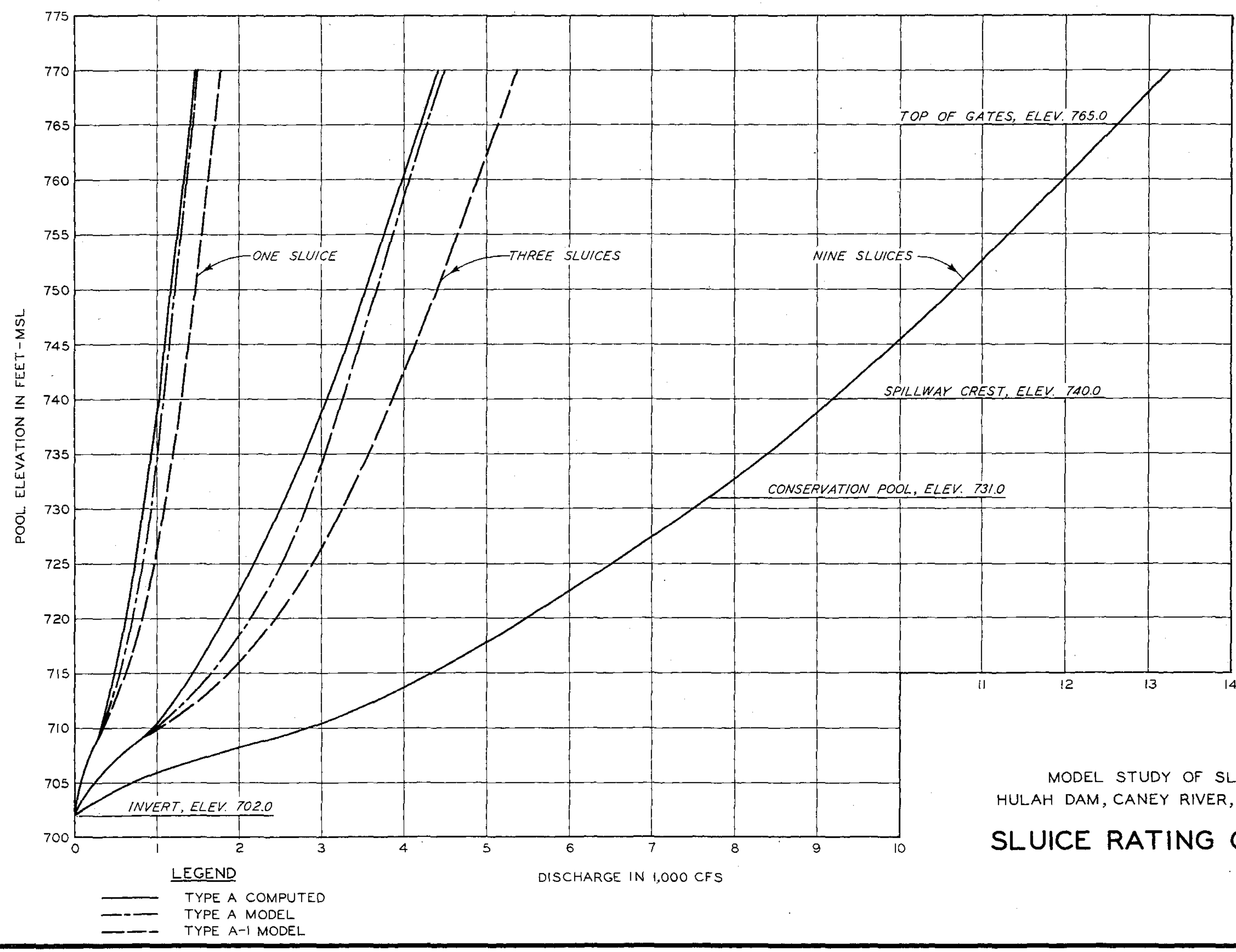
OUTLET PORTALS

PLATE 4



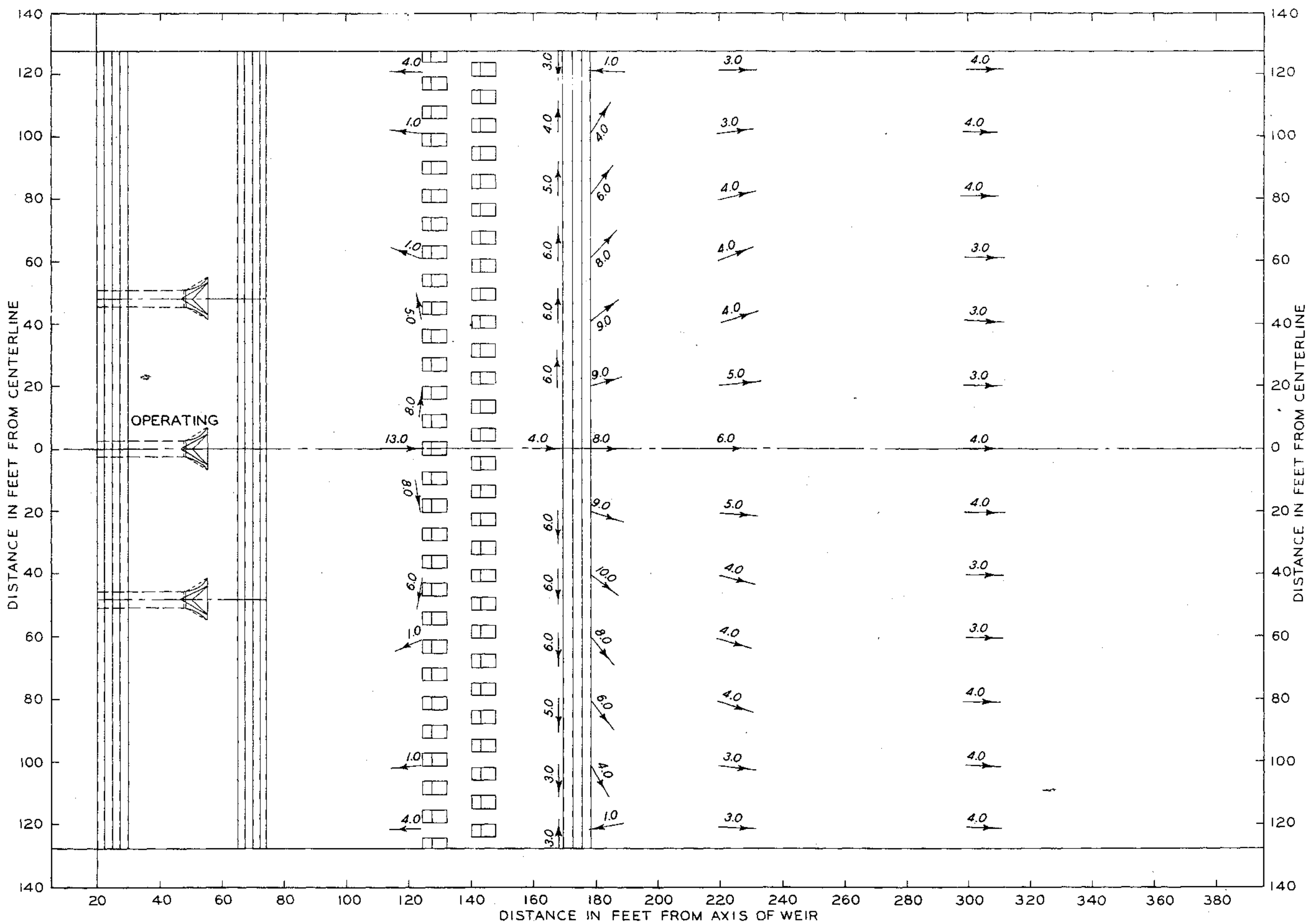
MODEL STUDY OF SLUICES
HULAH DAM, CANEY RIVER, OKLAHOMA

TAILWATER RATING CURVE



MODEL STUDY OF SLUICES
HULAH DAM, CANEY RIVER, OKLAHOMA

SLUICE RATING CURVES



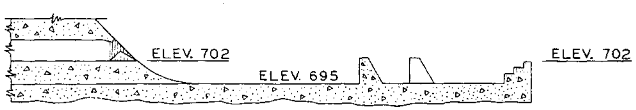
TEST CONDITIONS

DISCHARGE 948 CFS
POOL ELEV 731.0
TAILWATER ELEV 703.2 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

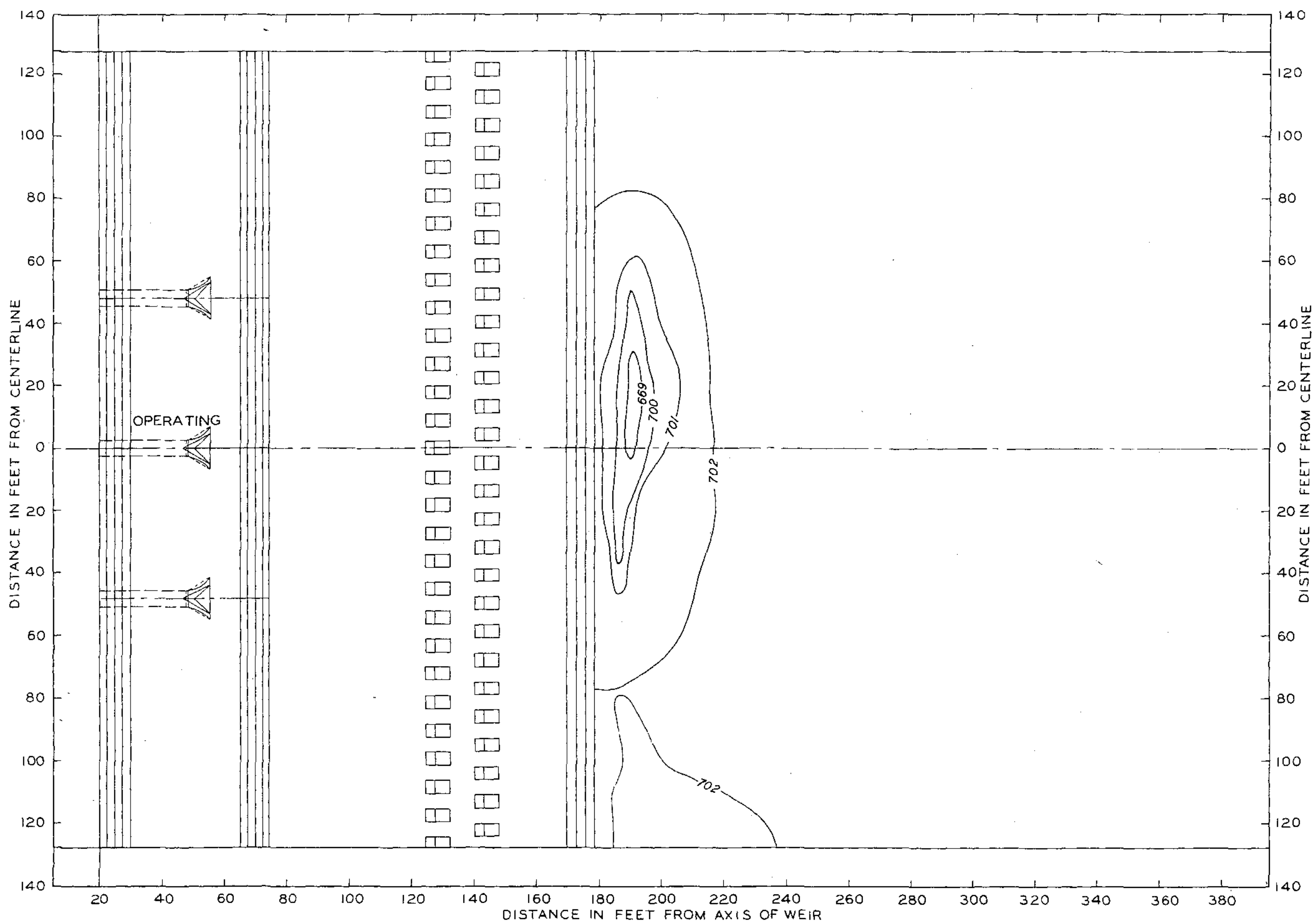


SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES
TYPE A

PLATE 7

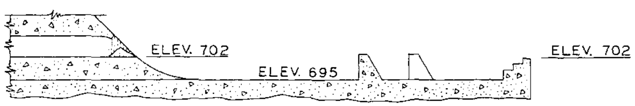


TEST CONDITIONS

DISCHARGE 948 CFS
POOL ELEV 731.0
TAILWATER ELEV 703.2 *

BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

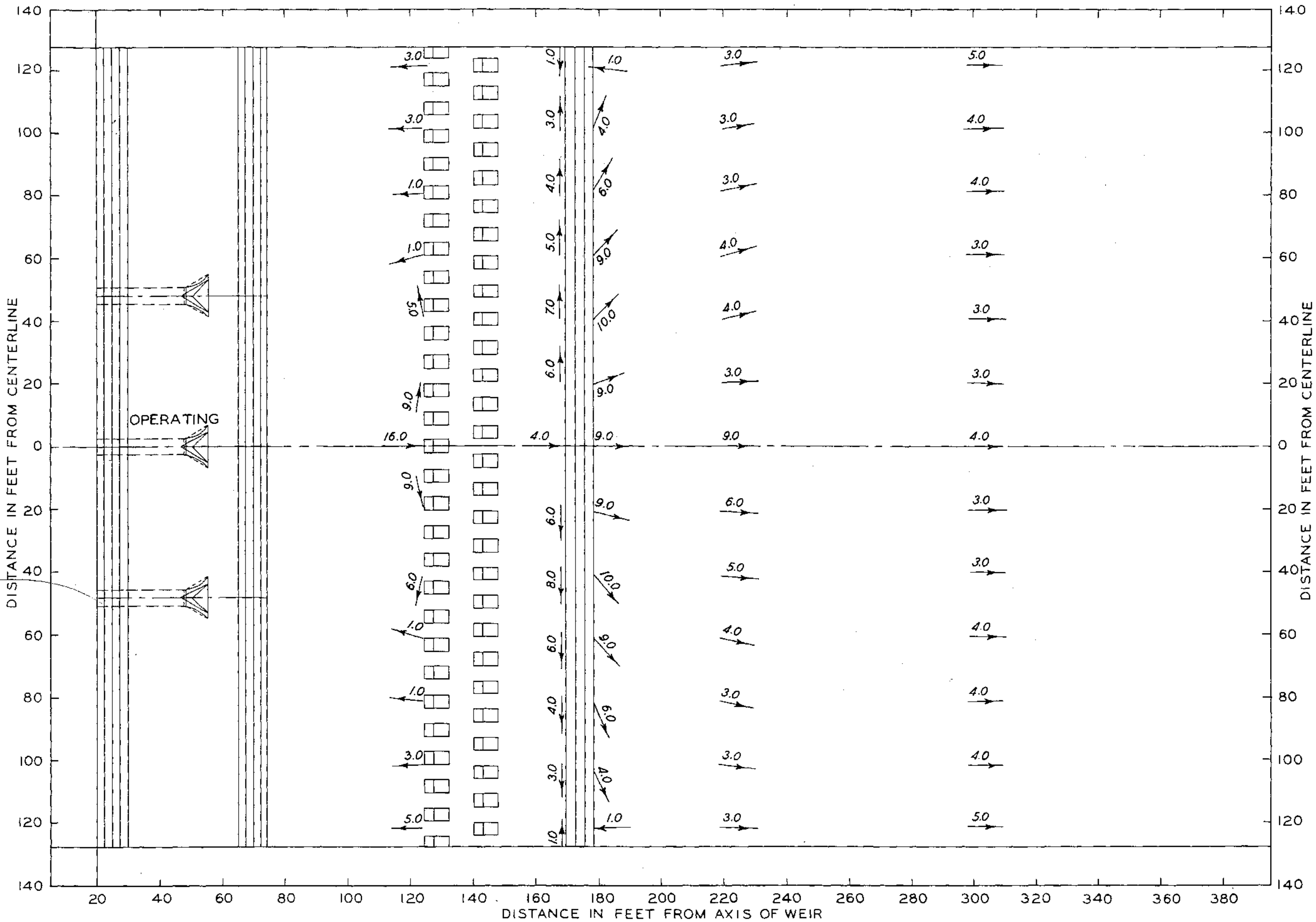


SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN
TYPE A

PLATE 8



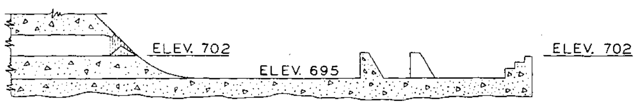
TEST CONDITIONS

DISCHARGE	1077 CFS
POOL ELEV	740.0
TAILWATER ELEV	703.4 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

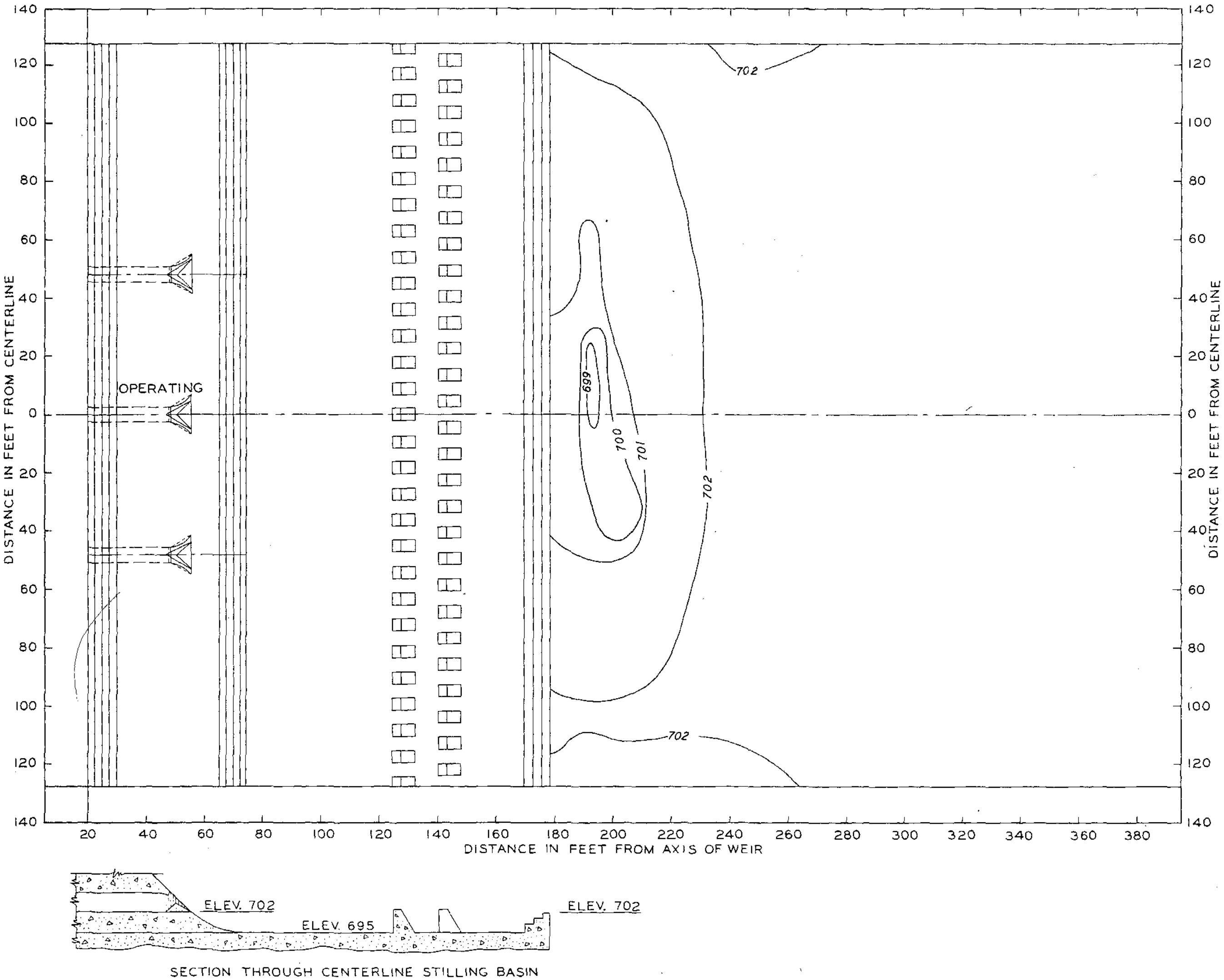


SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES

TYPE A



TEST CONDITIONS

DISCHARGE	1077 CFS
POOL ELEV	740.0
TAILWATER ELEV	703.4 *

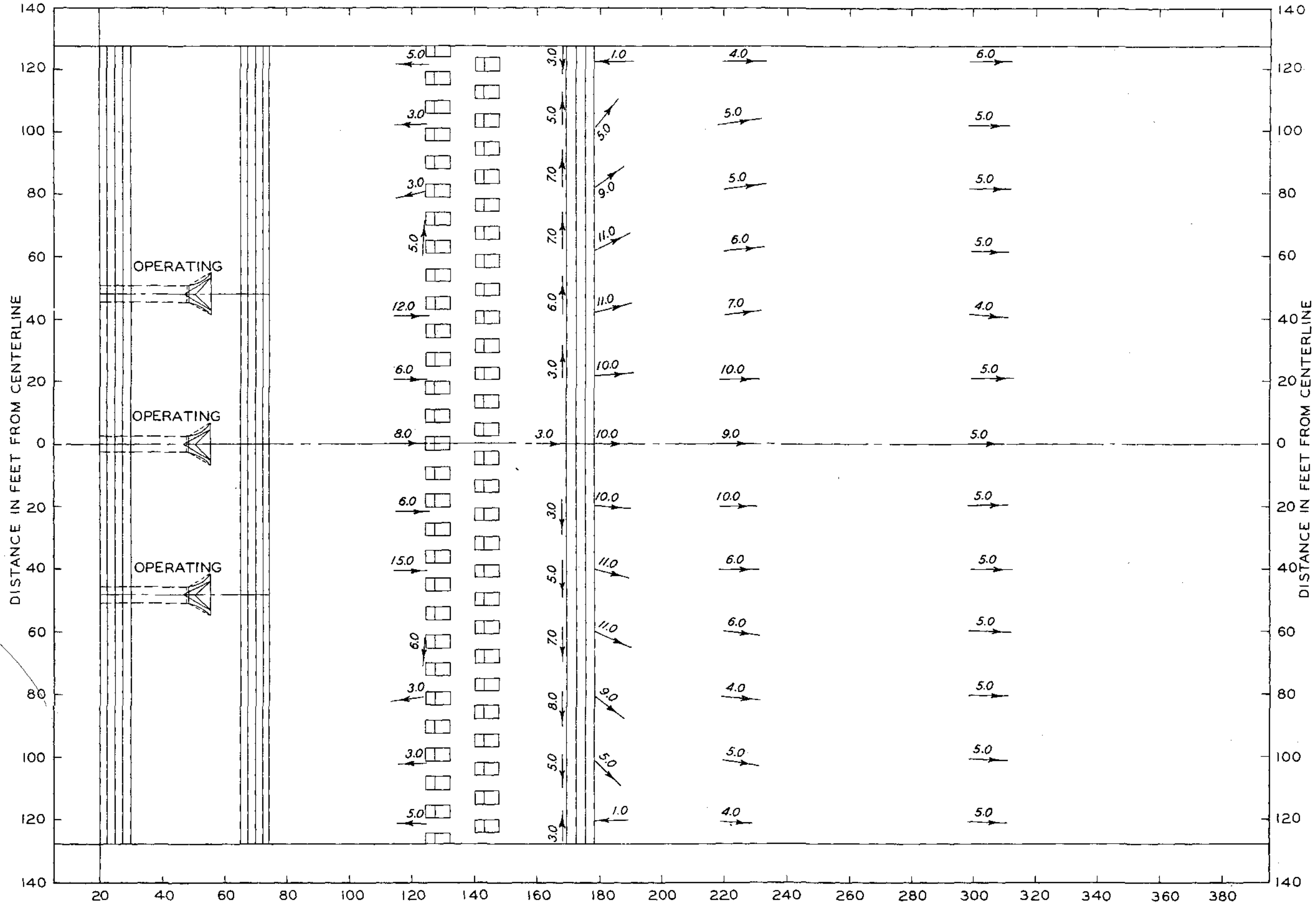
BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN

TYPE A



DISTANCE IN FEET FROM AXIS OF WEIR

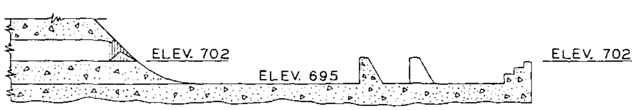
TEST CONDITIONS

DISCHARGE	3230 CFS
POOL ELEV	740.0
TAILWATER ELEV	704.6 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.



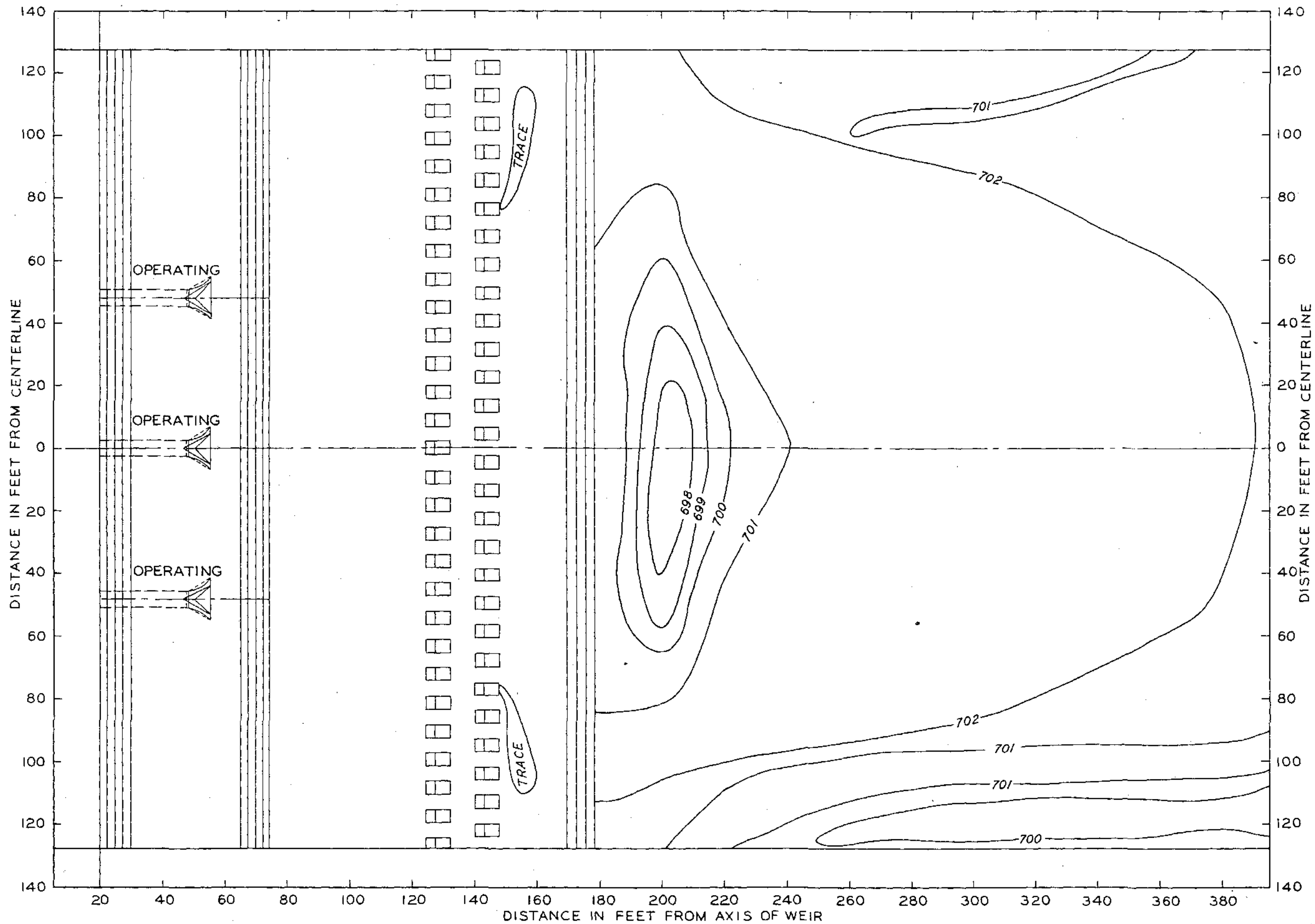
SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES

TYPE A

PLATE 11

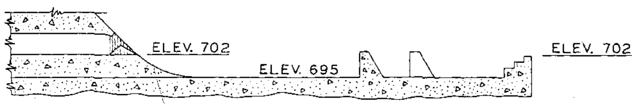


TEST CONDITIONS

DISCHARGE	3230 CFS
POOL ELEV	740.0
TAILWATER ELEV	704.6 *

BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.



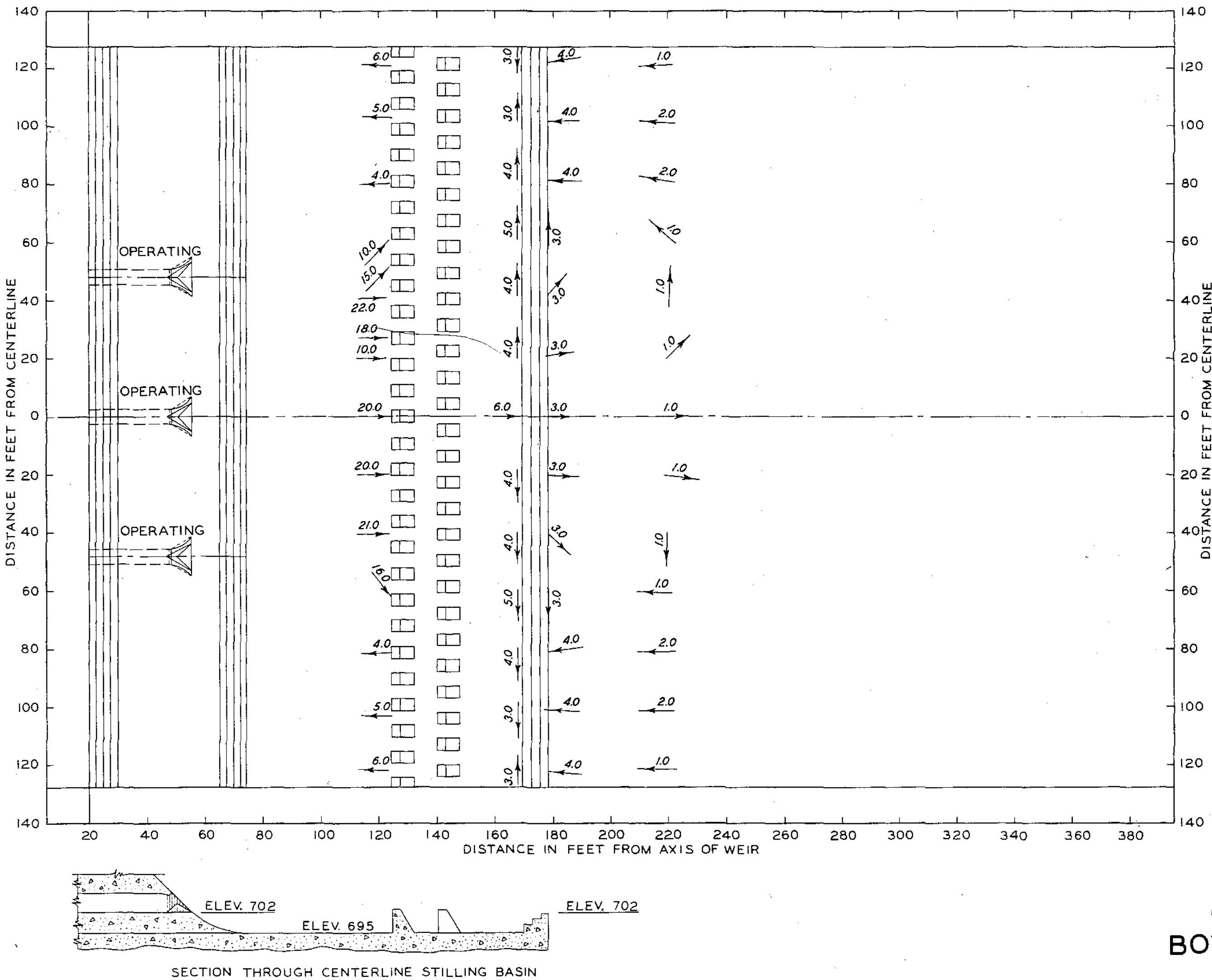
SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN

TYPE A

PLATE 12



TEST CONDITIONS

DISCHARGE 11820 CFS
POOL ELEV 765.0
TAILWATER ELEV 717.7 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

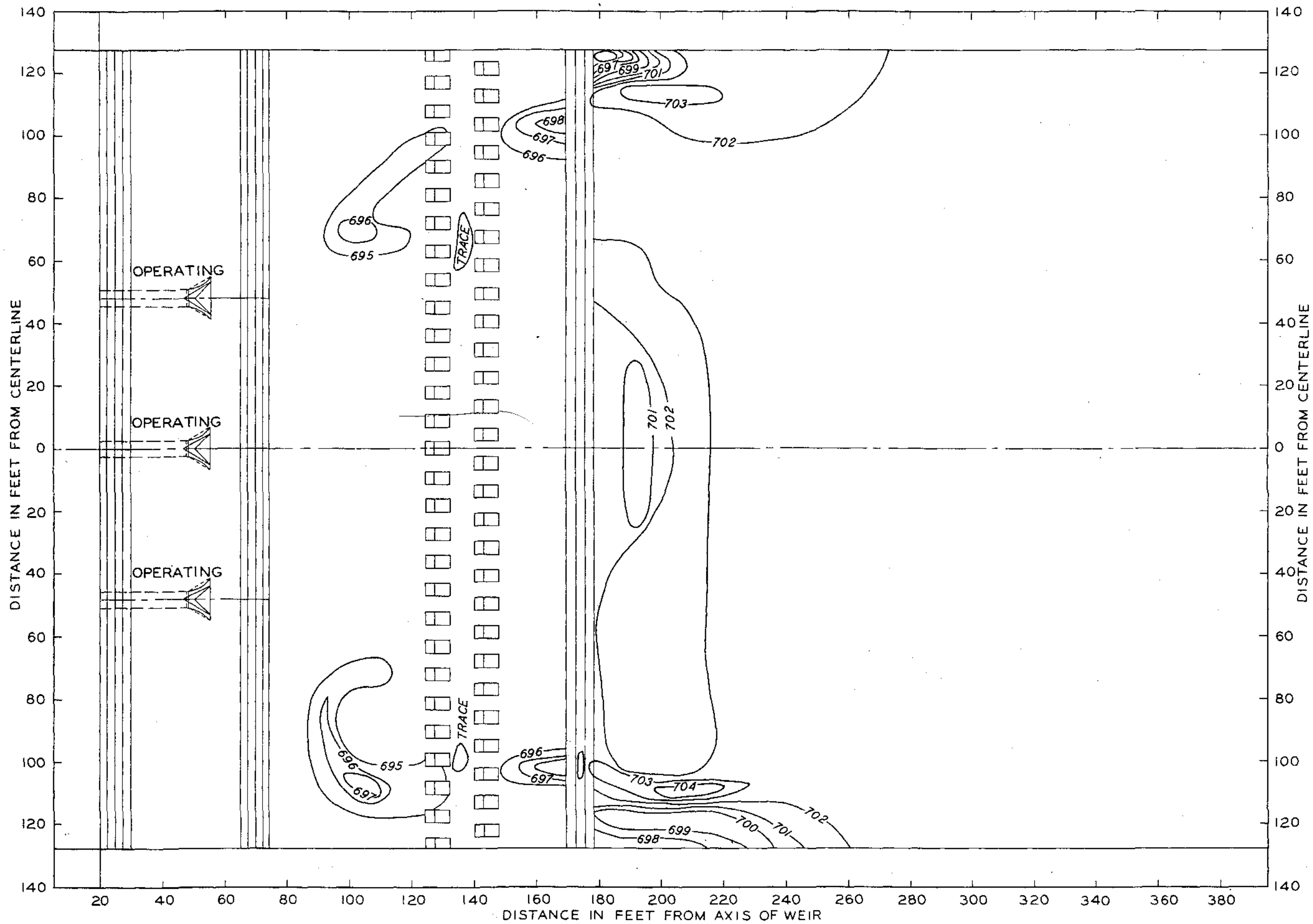
VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

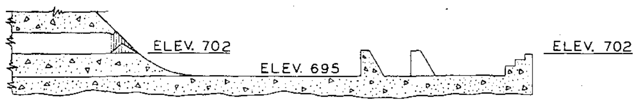
* TAILWATER ELEV SET 400' DOWNSTREAM FROM AXIS OF WEIR.

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES

TYPE A





SECTION THROUGH CENTERLINE STILLING BASIN

TEST CONDITIONS

DISCHARGE 11820 CFS
POOL ELEV 765.0
TAILWATER ELEV 717.7 *

BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

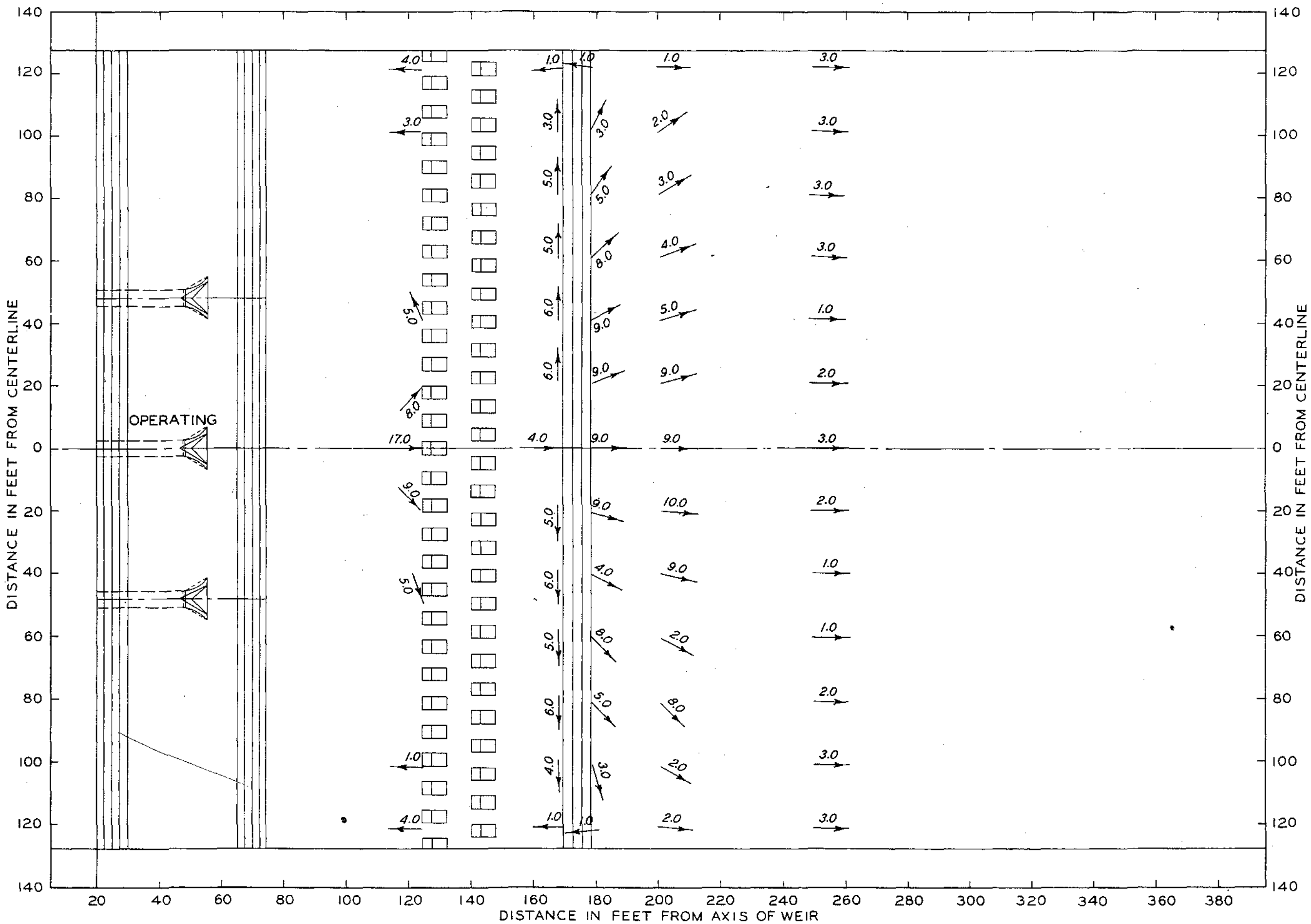
* TAILWATER ELEV SET 400' DOWNSTREAM FROM AXIS OF WEIR.

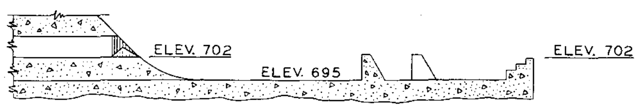
MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN

TYPE A

PLATE 14





SECTION THROUGH CENTERLINE STILLING BASIN

TEST CONDITIONS

DISCHARGE	1107 CFS
POOL ELEV	731.0
TAILWATER ELEV	703.5 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

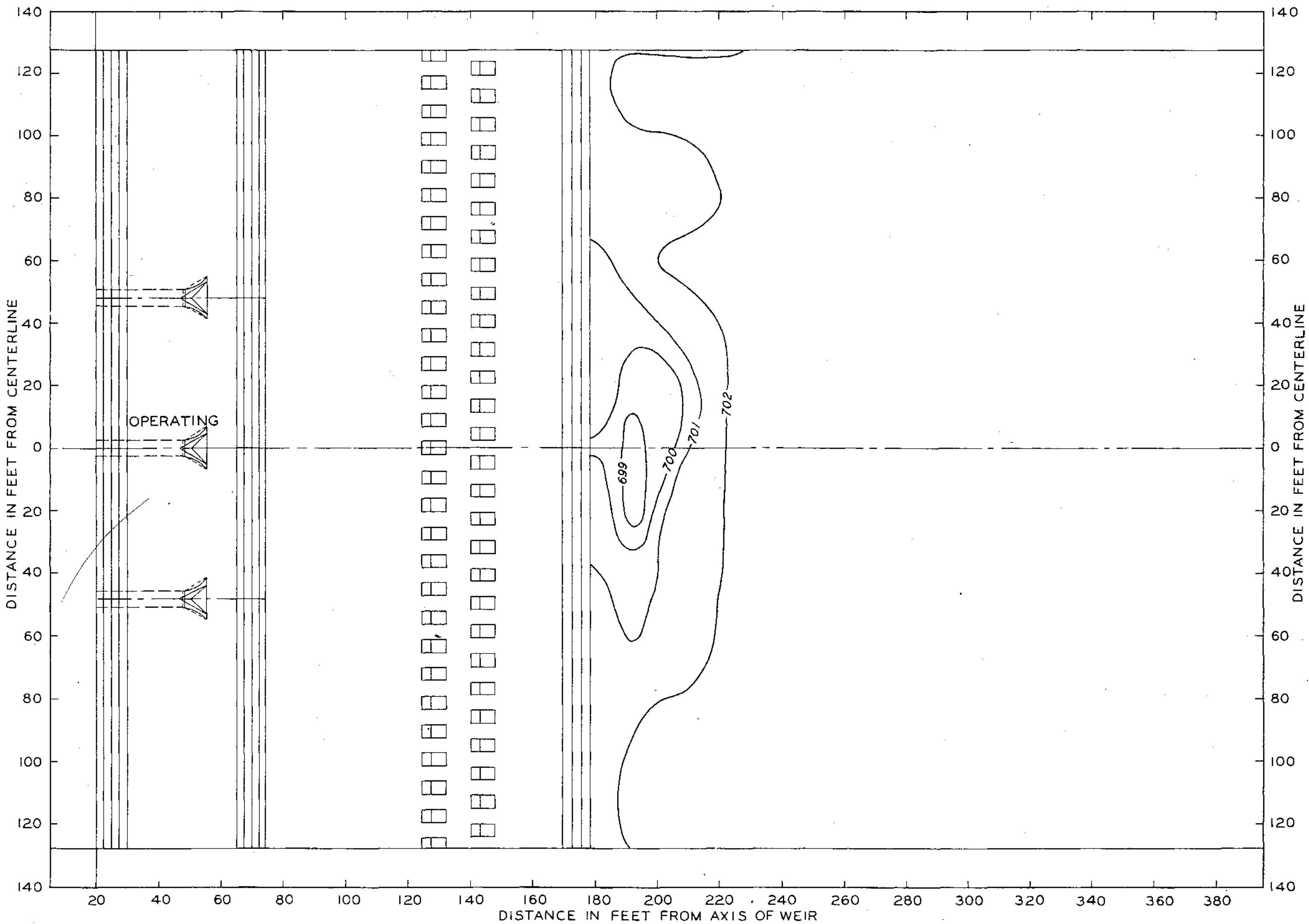
VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES

TYPE A-1

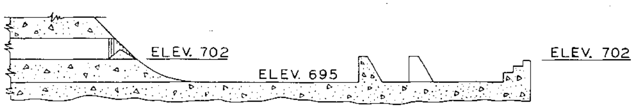


TEST CONDITIONS

DISCHARGE 1107 CFS
POOL ELEV 731.0
TAILWATER ELEV 703.5 *

BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

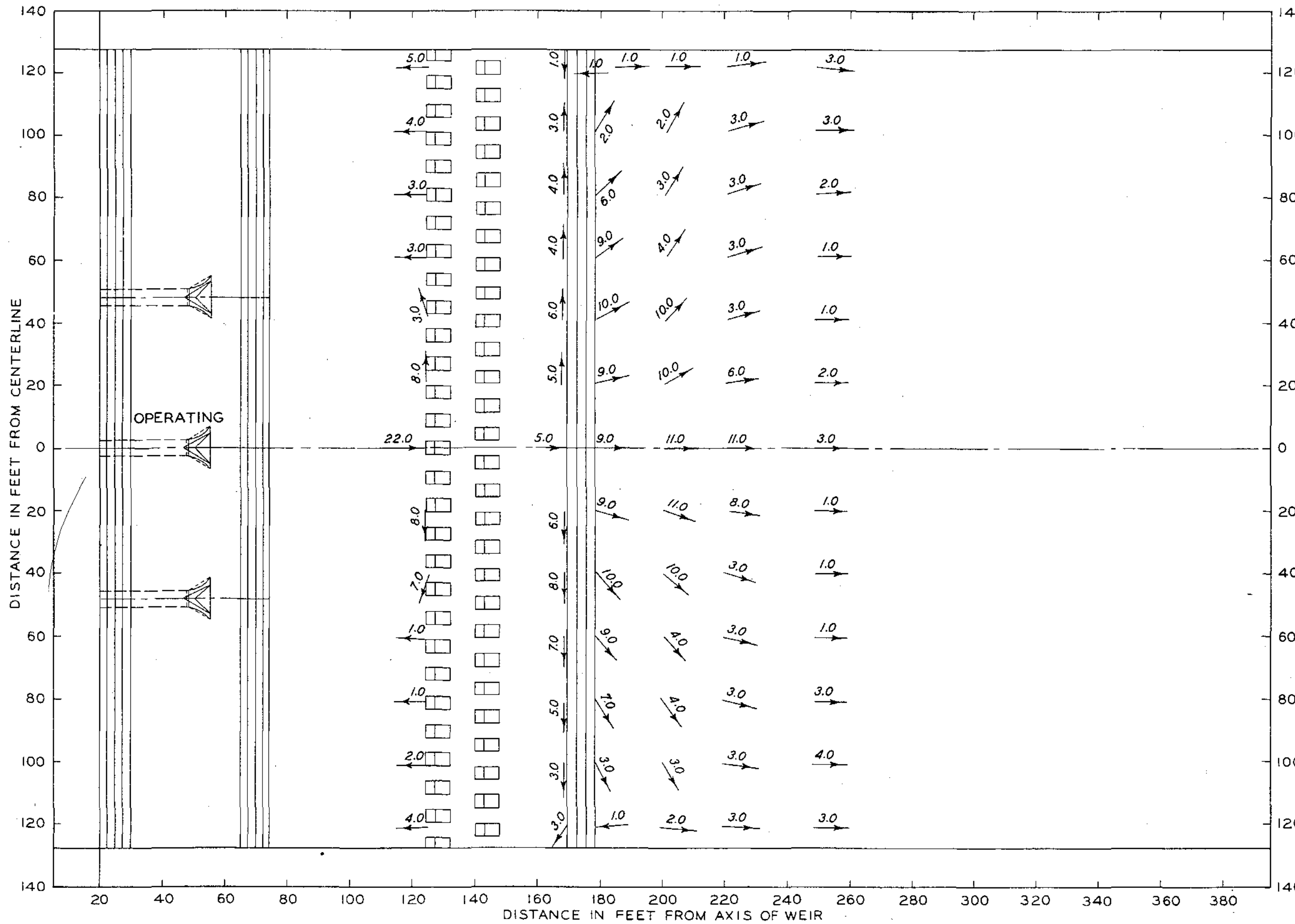


SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN

TYPE A-1



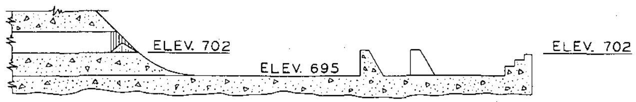
TEST CONDITIONS

DISCHARGE	1283 CFS
POOL ELEV	740.0
TAILWATER ELEV	703.7 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.



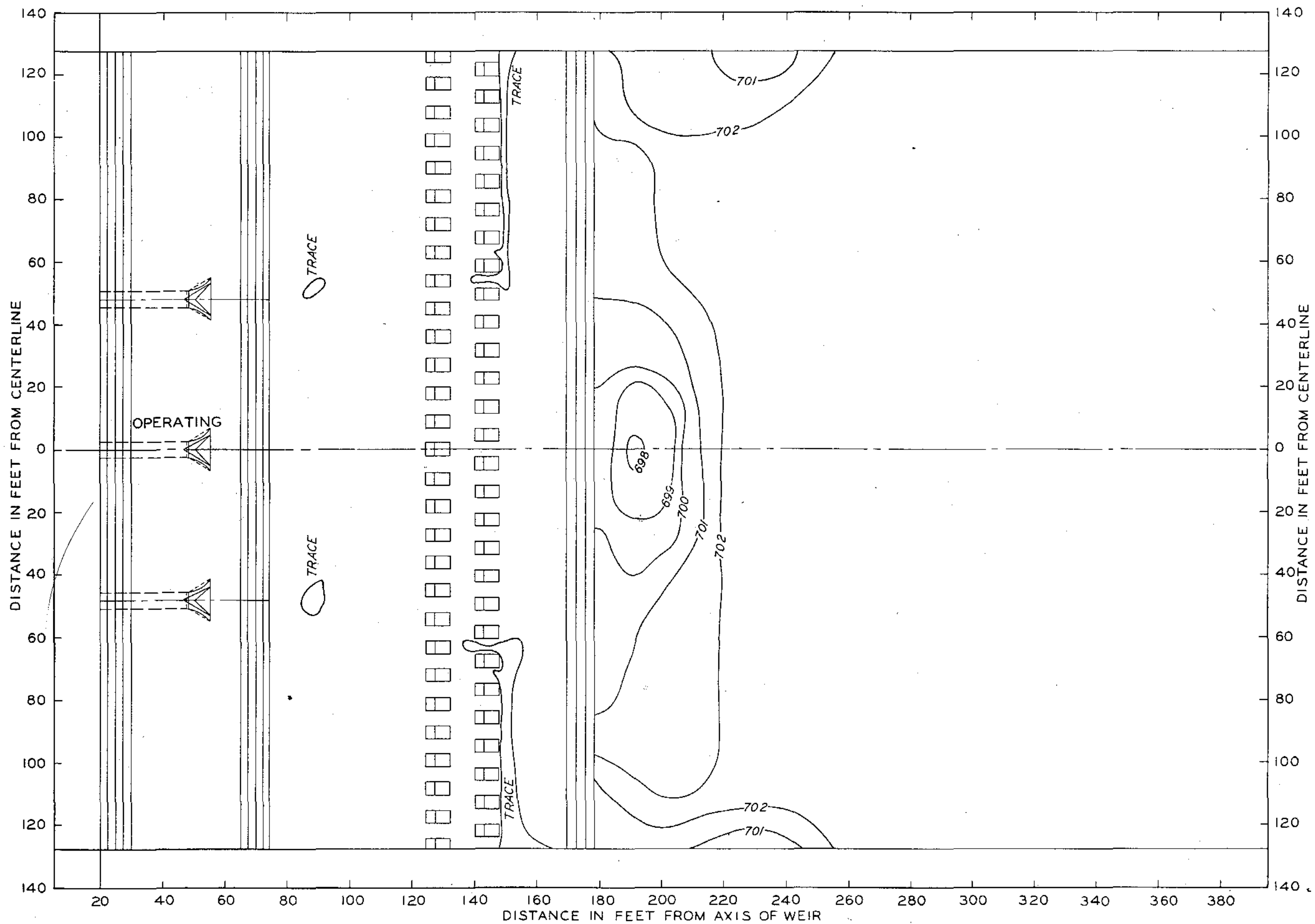
SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES

TYPE A-1

PLATE 17

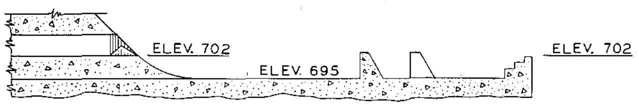


TEST CONDITIONS

DISCHARGE 1283 CFS
POOL ELEV 740.0
TAILWATER ELEV 703.7 *

BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.



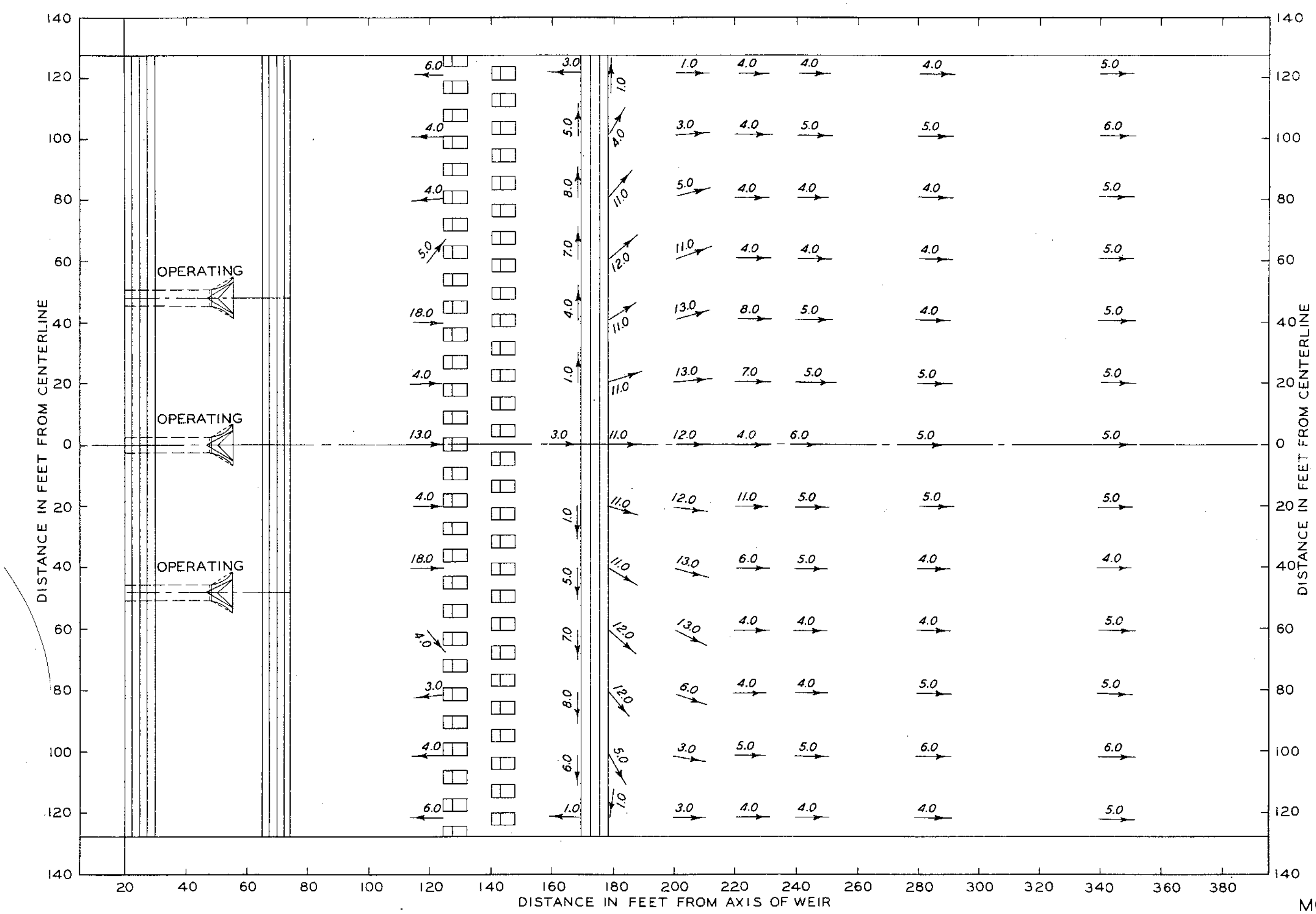
SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN

TYPE A-1

PLATE 18



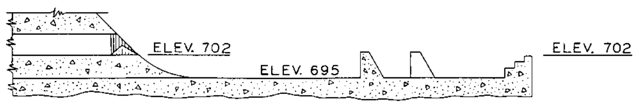
TEST CONDITIONS

DISCHARGE	3850 CFS
POOL ELEV	740.0
TAILWATER ELEV	705.0 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

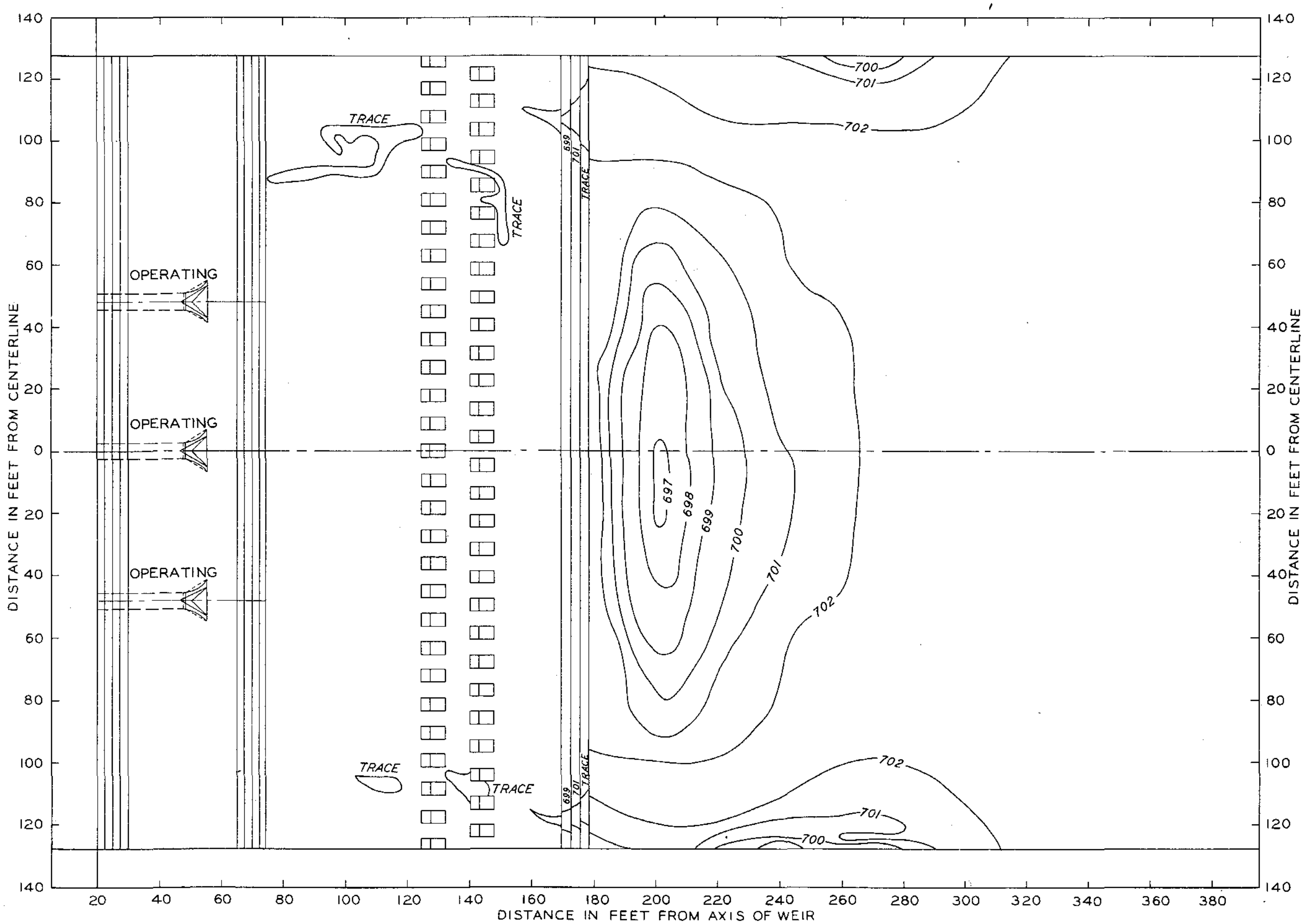


SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES

TYPE A-1

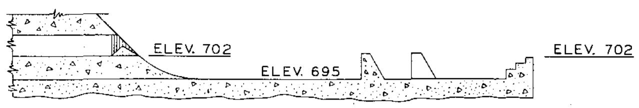


TEST CONDITIONS

DISCHARGE 3850 CFS
POOL ELEV 740.0
TAILWATER ELEV 705.0 *

BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

* TAILWATER ELEV READ 300' DOWNSTREAM FROM AXIS OF WEIR.

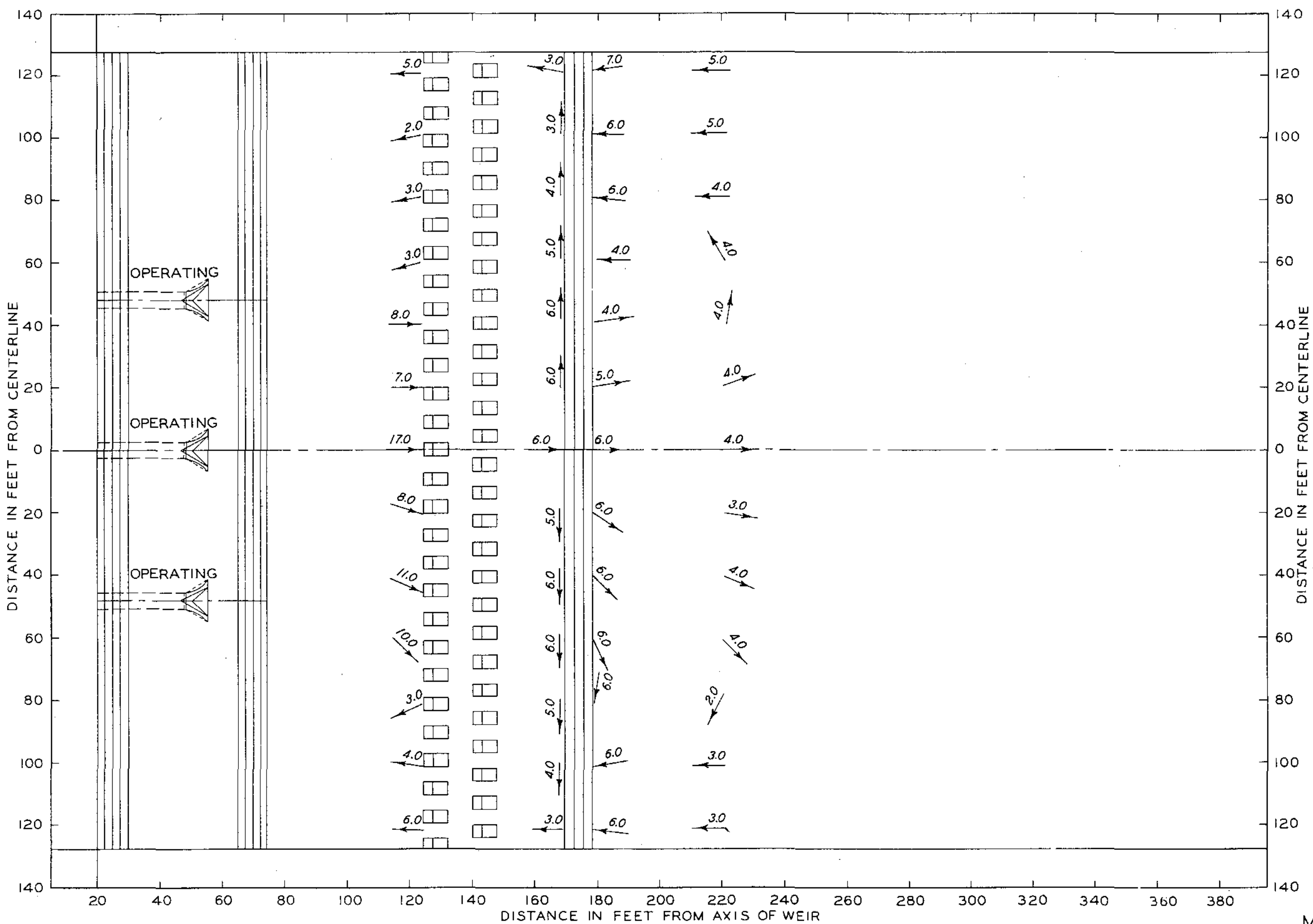


SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN

TYPE A-1



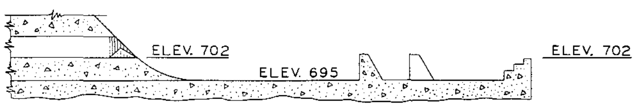
TEST CONDITIONS

DISCHARGE	14040 CFS
POOL ELEV	765.0
TAILWATER ELEV	718.9 *

BED OF EXIT CHANNEL MOLDED FLAT IN CEMENT MORTAR TO ELEV 702.0.

VELOCITIES ARE PROTOTYPE FEET PER SECOND, 1.0 ABOVE BOTTOM.

* TAILWATER ELEV SET 400' DOWNSTREAM FROM AXIS OF WEIR.

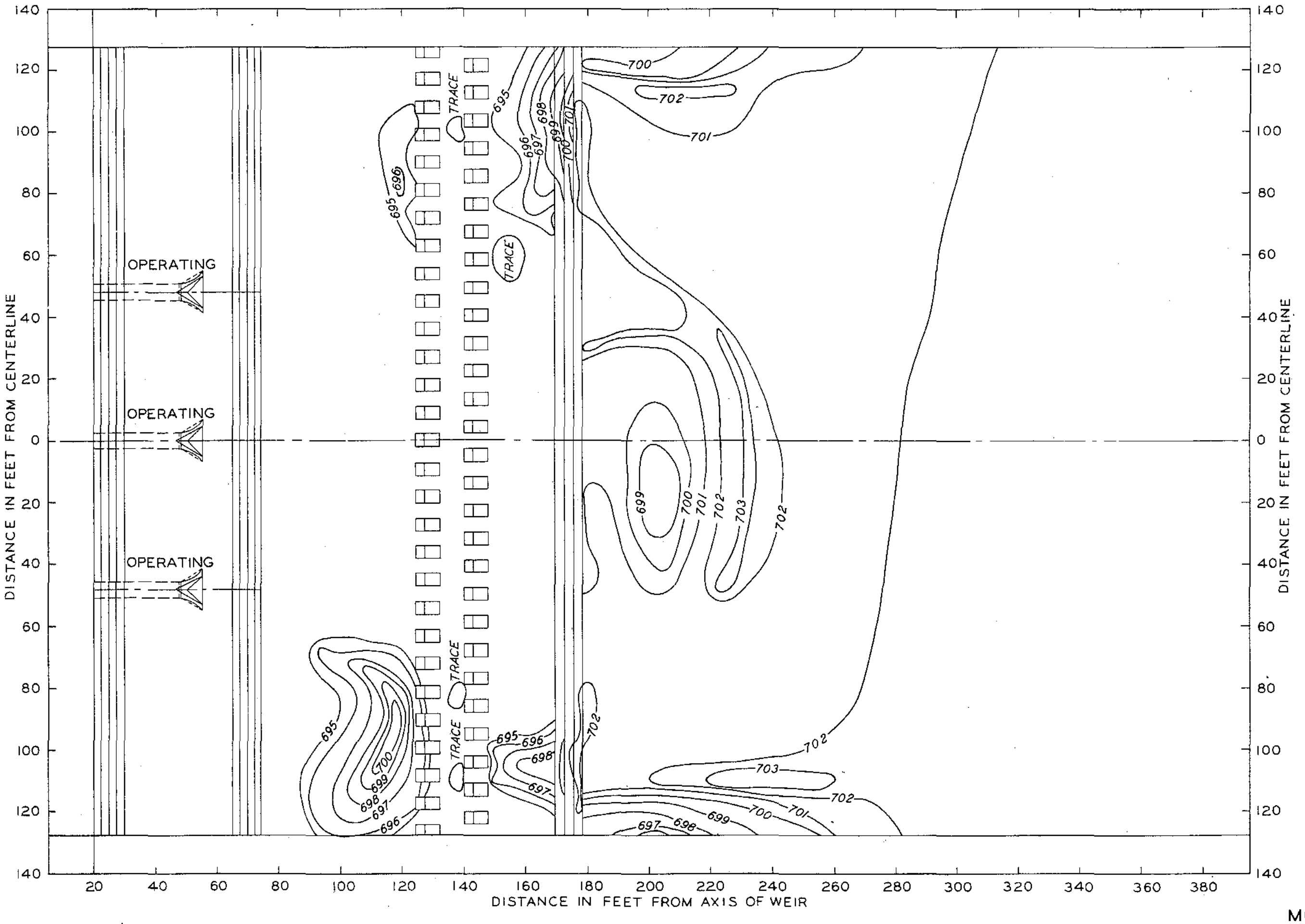


SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

BOTTOM VELOCITIES

TYPE A-1

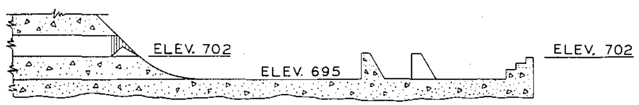


TEST CONDITIONS

DISCHARGE	14040 CFS
POOL ELEV	765.0
TAILWATER ELEV	718.9 *

BED OF EXIT CHANNEL MOLDED FLAT TO ELEV 702.0.

* TAILWATER ELEV SET 400' DOWNSTREAM FROM AXIS OF WEIR.



SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES
HULAH DAM
CANEY RIVER, OKLAHOMA

SCOUR PATTERN

TYPE A-1