TECHNICAL REPORT NO. 2-718

FILLING AND EMPTYING SYSTEMS MILLERS FERRY AND JONES BLUFF LOCKS ALABAMA RIVER, ALABAMA

Hydraulic Model Investigation

by

J. H. Ables, Jr.
M. B. Boyd

March 1966

Sponsored by

U. S. Army Engineer District
Mobile, Alabama

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

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FOREWORD

The model investigation reported herein was authorized by the Office, Chief of Engineers, in the second indorsement dated 31 July 1962, to a request by the U. S. Army Engineer District, Mobile, dated 23 July 1962. The study was conducted in the Hydraulics Division of the U. S. Army Engineer Waterways Experiment Station (WES) during the period September 1962 to August 1964 under the direction of Mr. E. P. Fortson, Jr., Chief of the Hydraulics Division, and Mr. T. E. Murphy, Chief of the Structures Branch. The tests were made by Messrs. J. H. Ables, Jr., N. R. Oswalt, H. H. Allen, and B. C. Parker. This report was prepared by Mr. Ables and Mr. M. B. Boyd, Chief of the Locks Section, and was reviewed by Mr. Murphy.

Directors of the WES during the conduct of the study and the preparation of this report were Col. Alex G. Sutton, Jr., CE, and Col. John R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

Mr. J. P. Davis of the Office, Chief of Engineers, Mr. L. T. Leach of the South Atlantic Division, and Messrs. A. M. Cronenberg, A. W. Kerr, and J. R. Couey of the Mobile District visited the WES during the course of the study to discuss test results and correlate these results with design work being accomplished concurrently.

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SUMMARY

Millers Ferry Lock will be located at mile 142.2 on the Alabama River in southwest Alabama and will be 84 ft wide by 655 ft long and will provide a maximum lift of 48 ft. Results of tests of the entire hydraulic system for this lock are presented in this report. Results of additional tests concerned with the Jones Bluff Lock also are included. This lock also will be 84 ft by 655 ft and will be located 105 miles upstream from the Millers Ferry Lock.

Single intake and outlet ports for each of the wall culverts will be provided on the river side of the riverward lock wall. Performance of the original design intakes and outlets was considered satisfactory.

A new type of lock filling and emptying system was investigated in this model study. The system herein called the longitudinal floor culvert system was designed to improve the balance of flow into the two ends of the chamber. Two satisfactory floor culvert systems were developed. The type 23 culvert arrangement is recommended for use at the Millers Ferry project where foundation conditions require the system to be confined within approximately the middle third of the lock chamber. The type 41 culvert arrangement is recommended for use at the Jones Bluff Lock where no space restrictions are placed on the system.

The Millers Ferry system (type 23) provided two longitudinal floor culverts extending into each end of the lock chamber from a lateral crossover culvert at the midpoint of the chamber. Lateral floor culverts extend across the lock in each end of the chamber to connect the longitudinal floor culverts. Ports are provided in both longitudinal and lateral floor culverts. The ratio of total port area to floor culvert area is 1.00. With this system the lock can be filled in 11.0 min and emptied in 14.2 min with maximum hawser stresses no higher than about 4.5 tons. Turbulence distribution in the chamber during filling is satisfactory.

The system recommended for Jones Bluff Lock (type 41) eliminated the lateral floor culverts and extended the longitudinal floor culverts over about 54 percent of the lock chamber length. The dividing walls in the lateral crossover culvert also were removed to retain a connection between the two sides of the system. A port-to-culvert area ratio of 0.91 was provided in this arrangement. At the expected 45-ft head, the lock can be filled in about 10.8 min and emptied in 13.6 min with maximum hawser stresses of about 3.9 tons. The distribution of turbulence in the lock chamber during filling operations is satisfactory.

With both recommended culvert arrangements, pressures conducive to cavitation were measured just downstream from the filling valves during the valve opening period. Admission of small quantities of air in this region is recommended to minimize possible cavitation damage.

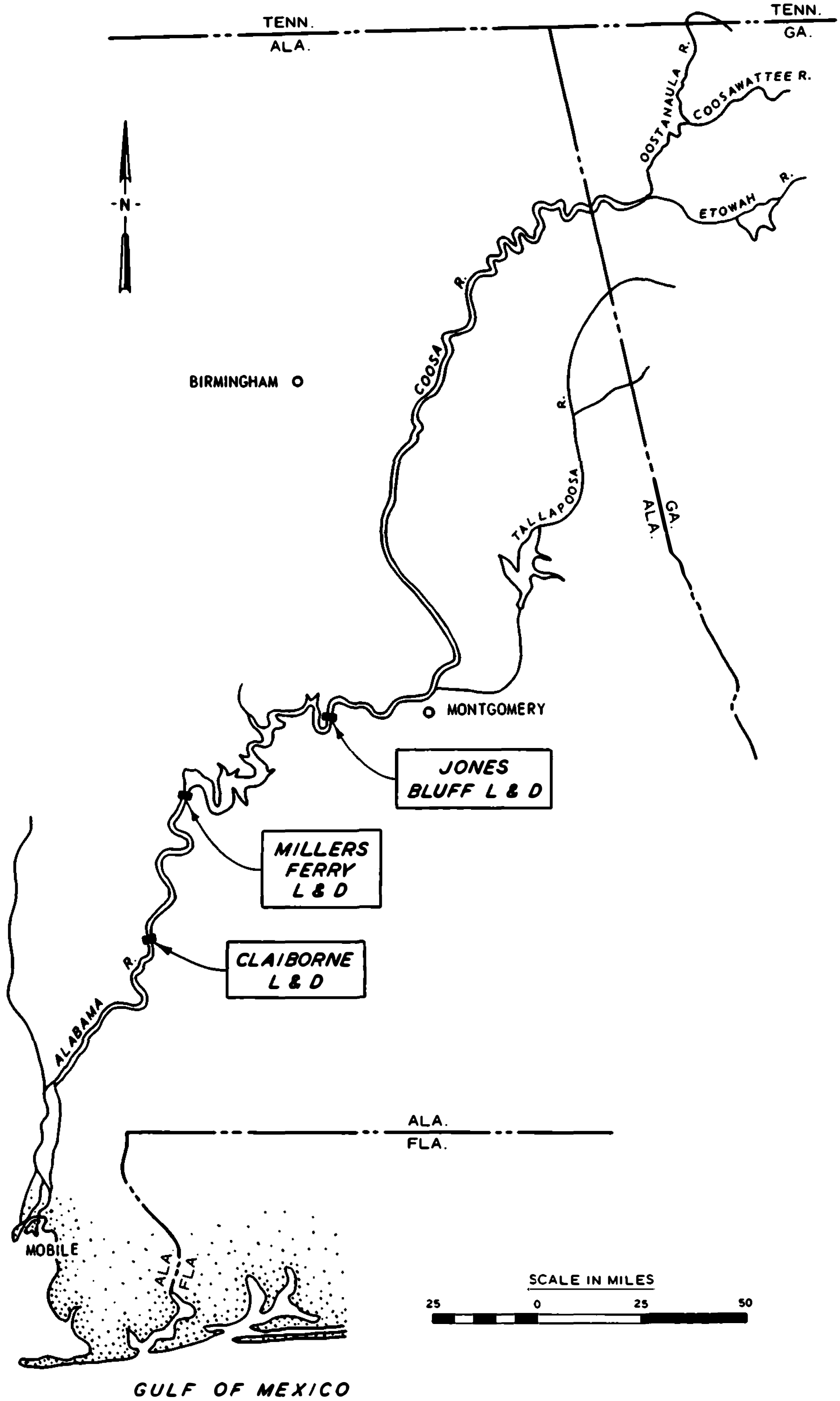

Fig. 1. Location map

FILLING AND EMPTYING SYSTEMS
MILLERS FERRY AND JONES BLUFF LOCKS
ALABAMA RIVER, ALABAMA

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

Location

1. Millers Ferry Lock and Dam will be located 142.2 miles above the mouth of the Alabama River in southwest Alabama and approximately 10 miles northwest of Camden and 30 miles southwest of Selma. This project, which will develop the middle reach of the 320-mile-long Alabama River waterway, will be 60 miles upstream from the proposed Claiborne Lock and Dam and 105 miles downstream from the proposed Jones Bluff Lock and Dam. The project locations are shown in fig. 1.

Project features

2. The Millers Ferry project will provide a lock and spillway at mile 142.2 with a power plant located in an earth dike 3100 ft downstream from the main dam (plate 1). The gated spillway will consist of a concrete gravity section having an overall length of 1012 ft with the crest at elevation 46.0.* Flow over the spillway will be regulated by 17 tainter gates, each 50 ft long and 35 ft high. An earth dike forms the damming surface between the gated spillway and high ground on the west. The navigation lock is adjacent to the spillway in the left bank. Earth dikes are provided on the left overbank to form the damming surface between the lock and the power plant and between the power plant and high ground to the east.

3. The lock will have a chamber width of 84 ft and length of 655 ft (pintle to pintle) to provide a usable length of 600 ft. The maximum lift of 48 ft will result when the upper pool is at normal elevation 80.0 and the tailwater at elevation 32.0, the minimum level of the proposed

* Elevations are in feet above mean sea level.

Claiborne Reservoir. The upstream miter gate sill will be at elevation 61.0 and the downstream sill at elevation 17.0. The tops of the lower approach walls will be at elevation 82.0 with the tops of all other lock walls and the upstream and downstream miter gates at elevation 87.0. The proposed lock filling and emptying system consisted of two intake ports located in the river side of the upper gate block, a 10-ft-square culvert in each of the chamber walls, a lateral crossover culvert leading to four longitudinal floor culverts which are positioned symmetrically about the midpoint of the lock, and culvert outlets which empty riverward of the lock in a common outlet basin. Flow in each of the wall culverts will be controlled by two reverse tainter valves.

Hydraulic Model Studies

4. The hydraulic structures and navigation conditions were investigated in three models. A 1:120-scale model which included the upper and lower river approaches, lock, spillway, earth dikes, and the powerhouse was used to study the effect of spillway and powerhouse releases on the maneuverability of tows in the natural river channel and lock approaches. A 1:50-scale section model of the gated spillway was used to study performance of the spillway and stilling basin. A 1:25-scale lock model was used to develop the design features of the filling and emptying system for Millers Ferry Lock and for tests of a second lock (Jones Bluff) on the Alabama River. The results of all lock model tests are included in this report. Separate reports on model investigations in the general* and section** models have been prepared.

Purpose of Lock Tests

5. Model studies were conducted to determine the adequacy of the proposed lock filling and emptying system and to develop, if possible,

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* U. S. Army Engineer Waterways Experiment Station, CE, General Studies of Millers Ferry Lock and Dam, Alabama River, Alabama; Hydraulic Model Investigation (Vicksburg, Miss.) (in preparation).

** U. S. Army Engineer Waterways Experiment Station, CE, Spillway and Stilling Basin for Millers Ferry Lock and Dam, Alabama River, Alabama; Hydraulic Model Investigation (Vicksburg, Miss.) (in preparation).

improvements in the system. Specific features to be studied included:

- a. Performance of the culvert intakes, including determination of the distribution of flow between the two intakes and evaluation of vortex tendencies at the intakes.
- b. The effect of minimum tailwater on culvert pressures immediately downstream from the filling valves.
- c. Culvert outlet performance.
- d. Performance of the longitudinal floor culvert system.

Special emphasis was given to development of an optimum arrangement for the longitudinal floor culvert system since this type of system had not been previously tested.

PART II: THE MODEL

Description

6. A model (fig. 2 and plate 2) of the Millers Ferry Lock was constructed to a scale of 1:25, and reproduced 670 ft of the upstream lock approach, all elements of the lock filling and emptying system, and 600 ft of downstream approach. The lock approaches were reproduced in concrete,

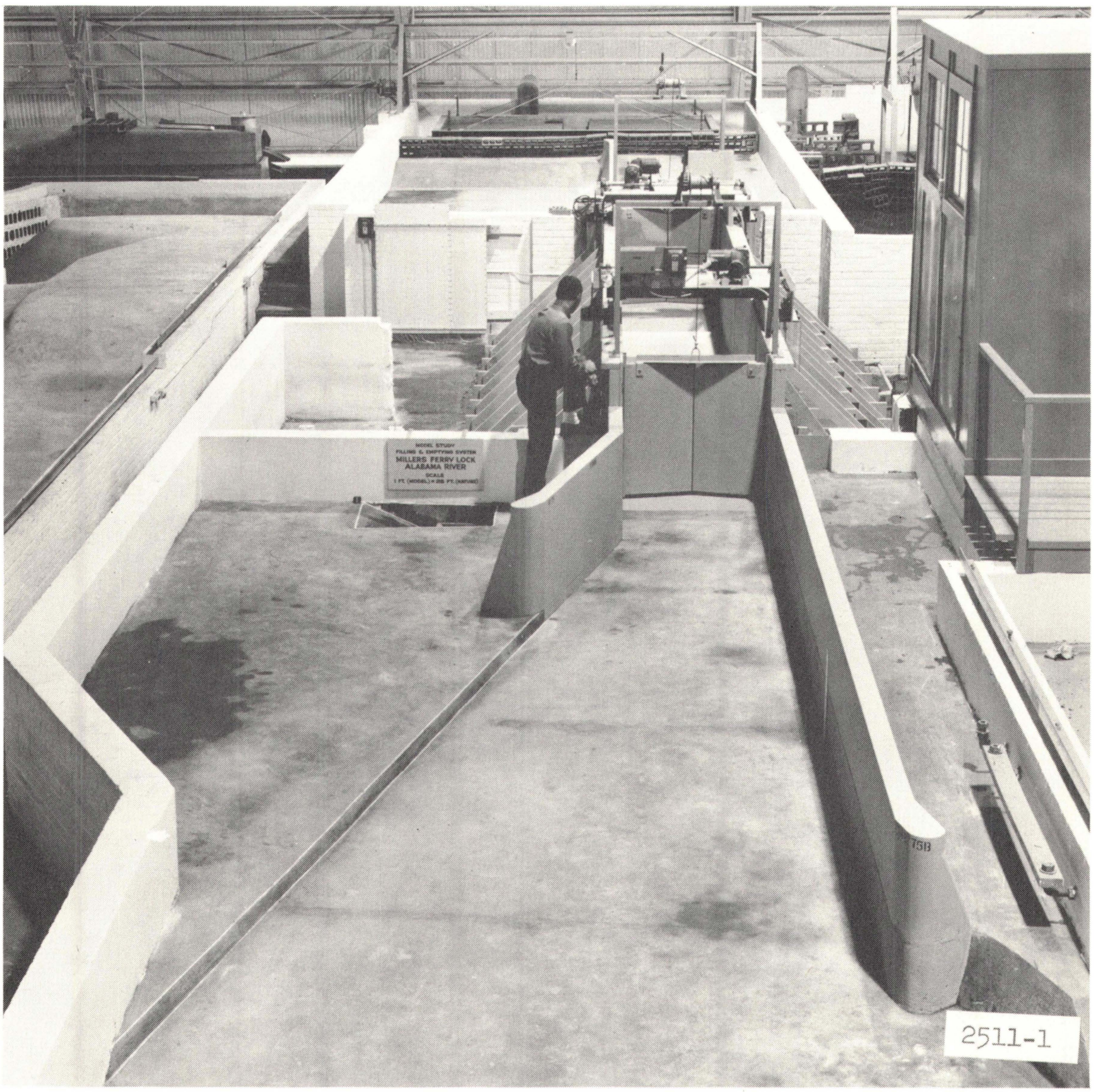


Fig. 2. General view of model

and the guide and guard walls were constructed of sheet metal. The lock chamber was reproduced in plywood, and the intakes, wall culverts, and outlets were constructed of plastic and sheet metal. The lateral crossover culvert and the longitudinal floor culverts were molded of a mixture of resin and sand. The culvert valves were constructed of brass and fitted with rubber seals to prevent leakage. Twelve sheet-metal barges (plate 3), each simulating a length of 140 ft, width of 25 ft, and depth of 15 ft, were arranged to form various size tows. Weights were added to produce the desired draft.

Appurtenances and Instrumentation

7. Water was supplied to the model through a circulating system. The headbay and tailbay of the model each contained a skimming weir that maintained constant upper and lower pools during filling and emptying operations. A vertical adjustment of the skimming weirs permitted simulation of any desired pool elevation. Pitot tubes were used to determine velocity and direction of flow. Dye and confetti were used to show subsurface and surface current directions. Pressures throughout the lock filling and emptying cycles were measured with piezometers. A pressure cell was used to record minimum culvert pressures immediately downstream of the filling valves. Other pressure cells were used to record the level of the water surface in the lock chamber and to measure water-surface differentials between selected points in the lock chamber.

8. By means of the linear motion of a gear-rack-driven cam plate, the culvert valve drive mechanism accurately controlled the rate at which the tainter valves opened. The gear drive was powered by a reversible motor. Limit switches mounted on the gear-rack guide automatically shut off the valve drivers when either the fully open or closed position was reached. The valve opening schedules used in the tests are shown in plate 4.

9. A hawser-pull (force links) device for determining the longitudinal and transverse forces acting on a tow in the lock chamber during filling and emptying operations is shown in fig. 3. Three such devices

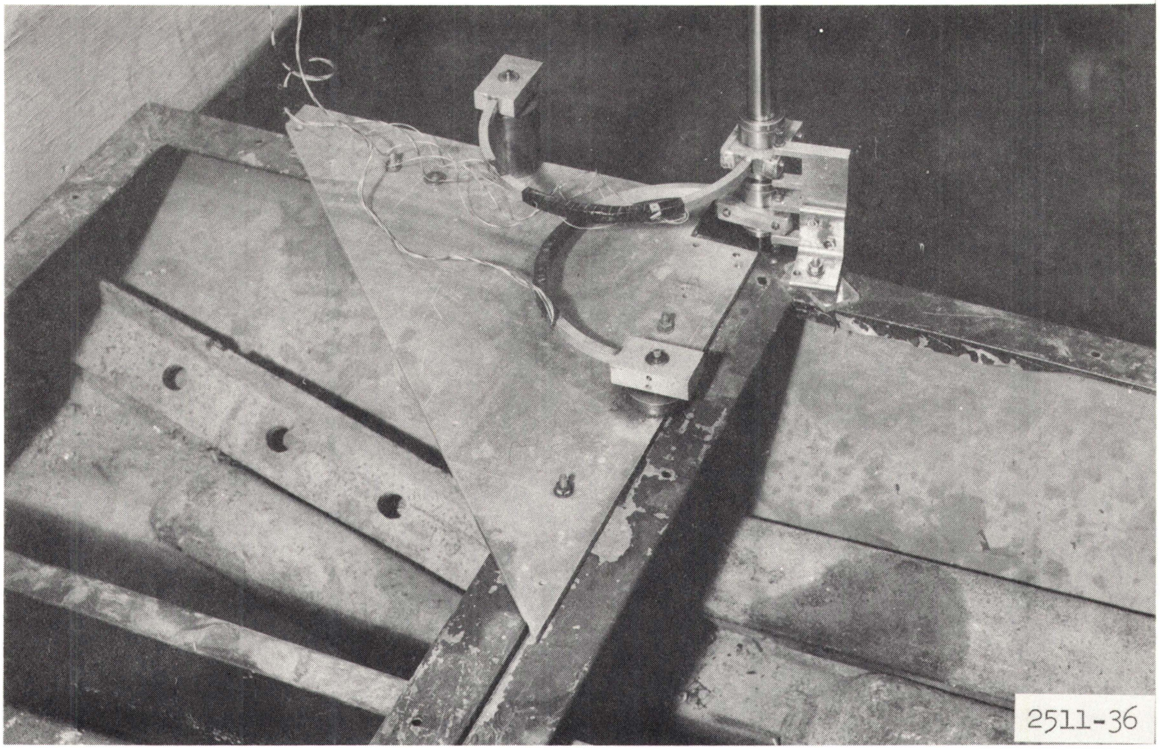


Fig. 3. Force links for measuring hawser stresses

were used: one to measure longitudinal stresses and the other two to measure transverse stresses on the upstream and downstream ends of the tow, respectively. These links were machined from aluminum, and had SR-4 strain gages cemented to the inner and outer edges. When the device was mounted on the model tow, one end of the link was pin-connected to the tow while the other end engaged a fixed vertical rod and was free to move up and down with changes in water-surface elevation in the lock. Any horizontal motion of the tow caused the links to deform and vary the signal to a recorder. The links were calibrated by inducing deflections of the links with known weights.

10. All data were recorded graphically on a commercial recorder. The sensing elements (mechanical-to-electrical conversion devices), located at various points on the model, were connected by shielded cables to amplifiers where the outputs were stepped up to the level required for graphical recording.

Scale Relations

11. The accepted equations of hydraulic similitude, based upon the Froudian relations, were used to express the mathematical relations between the dimensions and hydraulic quantities of the model and the prototype. General relations for transference of model data to prototype equivalents, or vice versa, are presented in the following tabulation:

Dimension	Ratio	Scale Relations
Length	$L_r = L$	1:25
Area	$A_r = L_r^2$	1:625
Velocity	$V_r = L_r^{1/2}$	1:5
Time	$T_r = L_r^{1/2}$	1:5
Discharge	$Q_r = L_r^{5/2}$	1:3125
Weight	$W_r = L_r^3$	1:15,625
Force	$F_r = L_r^3$	1:15,625

Test Procedure

12. Performance of the lock hydraulic system was evaluated primarily on the basis of conditions produced by typical filling and emptying tests. Characteristics used for evaluation included observed flow conditions at the culvert intakes and in the lock chamber and measured hawser stresses on barge tows. Steady-flow tests which represented a particular instant in a lockage also were used to determine flow distribution in the culvert intakes and along the port manifolds in the longitudinal floor culverts.

PART III: TESTS AND RESULTS, MILLERS FERRY LOCK

Test Program

13. Model tests were scheduled to evaluate performance of all elements of the hydraulic system for Millers Ferry Lock with particular attention being given to development of a new type filling and emptying system, herein called the longitudinal floor culvert system. During the course of the study, design personnel of the U. S. Army Engineer District, Mobile, determined from foundation conditions at the project site that the longitudinal floor culvert filling and emptying system would have to be confined within approximately the middle third of the lock chamber. At the time this decision was reached, 14 culvert arrangements had been tested and none were considered satisfactory. Culvert arrangements 15-24 were then investigated in an attempt to develop an arrangement which would provide satisfactory performance while conforming to the site restrictions. Results of tests on culvert arrangement types 1-24 are presented herein along with data obtained in tests of other features of the Millers Ferry hydraulic system.

14. Following completion of tests concerning the Millers Ferry Lock, additional culvert arrangements (25-56) were tested to develop an optimum floor culvert system which was not confined by the restrictions imposed at the Millers Ferry project. Plans called for use of this system at the Jones Bluff Lock on the Alabama River. Tests also were conducted to evaluate the effect of culvert intake submergence at the head conditions expected at the proposed Jones Bluff and Claiborne Locks. Model topography which simulated that at the Millers Ferry project was not changed during these tests. Results of the additional tests are presented in Part IV of this report.

Upstream Lock Approach and Intakes

15. Approximately 600 ft of the upstream approach channel was reproduced in the model to ensure proper simulation of flow conditions at the culvert intakes (plate 2). The original design included a single-port

intake for each wall culvert. The intakes were located side by side in the river side of the riverward approach wall as shown in plate 5 and fig. 4.

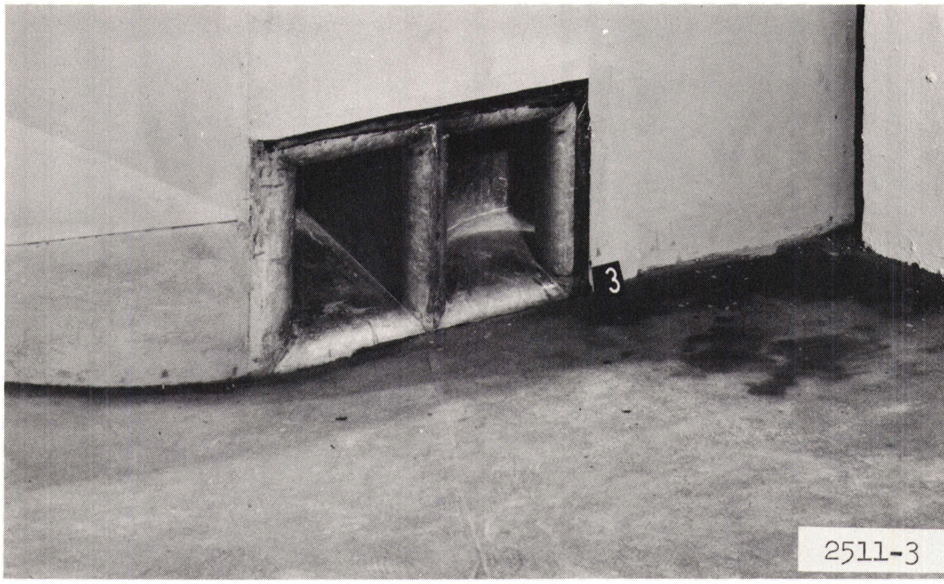


Fig. 4. Culvert intakes

The roof of the intakes (elevation 45.0) is 35 ft below the proposed normal pool elevation of 80.0.

16. Flow conditions in the upstream approach area were observed during filling operations at upper pool elevations of 70.0 and 80.0 to evaluate the tendency for vortex formation. The following terminology is used in describing vortex conditions:

a. Swirl. A vortex with only a slight concave depression in the water surface.

b. Vortex. A vortex with an air cavity or tail extending below the water surface.

c. Air-entraining vortex. A vortex with a tail extending into the culvert intake (none observed in model).

During operation at an upper pool elevation of 70.0, numerous swirls and an occasional vortex were observed. Photograph 1 shows flow patterns above the intakes 4.5 and 6.5 min after initiation of valve opening during a typical filling operation (4-min valve time) at this pool elevation. Operation at a pool elevation of 80.0 resulted in occasional swirls but no vortices. The additional 10 ft of submergence resulted in significant reduction in the tendency for vortex formation.

17. Steady-flow tests were conducted at three discharges to determine the distribution of flow between the two intakes. During these tests the upstream valves were fully open and the downstream valves closed. The desired lock chamber water-surface level was maintained by opening the lower miter gate. Velocities were measured at the wall face at 21 points in each intake (plate 6). Discharges through each intake were computed from these data. Distribution between the two intakes was reasonably good, as shown in the following tabulation:

Upper Pool El	Total Discharge cfs	Percent of Total Discharge: Land Wall Culvert Intake	Percent of Total Discharge: River Wall Culvert Intake
80.0	7200	47.5	52.5
80.0	6600	48.5	51.5
70.0	5500	49.0	51.0

18. Performance of the original design culvert intakes was considered satisfactory. These intakes were used in all tests concerned with the longitudinal floor culvert system.

Culvert Outlets

19. The two wall culverts discharge into a common outlet basin on the river side of the lower lock approach wall (plate 5). The stilling basin structure is designed to provide roller action. Model observations indicate that the basin should perform satisfactorily.

Longitudinal Floor Culvert System

Type 1 (original) culvert arrangement

20. Details of the original design culvert arrangement are given in table 1 and plate 7. The longitudinal culverts in each lock wall carry flow to the lateral crossover culvert located at the center of the lock (sta 323.0). The wall culverts were 10 by 10 ft at the valves with the culvert roof at elevation 26.0. The culvert floor sloped down to elevation

10.25 in the vicinity of the entrance to the crossover culvert (fig. 5).

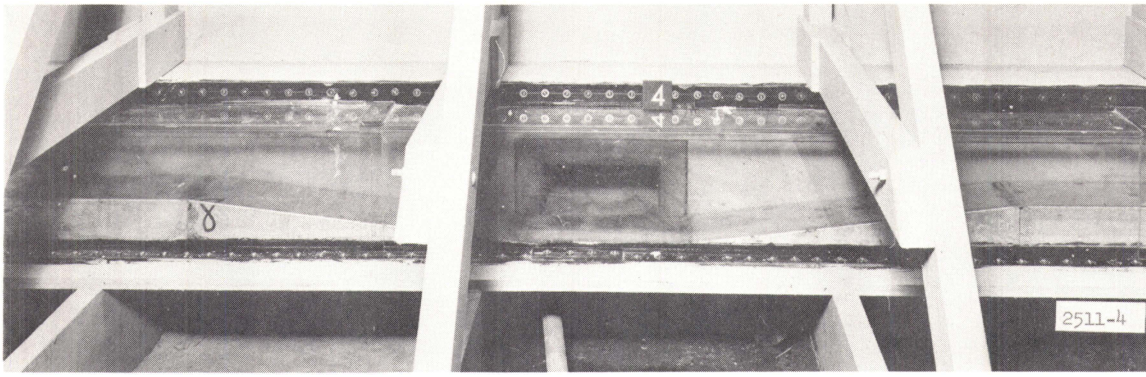


Fig. 5. Entrance to lateral crossover culvert

Four longitudinal floor culverts were used to distribute flow from the 17-ft-wide by 7-ft-high crossover culvert into the two ends of the lock chamber. These culverts were 8.5 ft wide and 7 ft high. Ten pairs of ports (1.25 ft wide by 4.0 ft high) were spaced 8 ft on centers in each floor culvert. A dividing wall was located between the two culverts in each end of the lock to prevent intersection of jets from opposing ports. The top of the floor culverts was at elevation 17.0 with the main lock floor at elevation 18.0. A submergence of 14 ft exists above the lock floor at minimum tailwater (elevation 32.0).

21. Filling and emptying characteristics were measured during operation at normal head-submergence conditions using valve schedule I (plate 4). Tests were run with a full tow (12 barges) in the lock chamber and with a half tow covering the upstream or downstream end of the chamber. Pertinent data are given in table 2. Maximum hawser stresses obtained during filling and emptying are plotted in plates 8 and 9, respectively. Filling operations with a full tow resulted in maximum longitudinal and transverse hawser stresses of about 9.6 and 13.0 tons, respectively. However, stresses recorded during operation with a half tow in the downstream end of the chamber were consistently higher than those measured with the full tow (plate 8). During emptying tests, hawser stresses were considerably lower, but again maximum stresses were obtained with a half tow in the downstream end of the lock (plate 9). Typical data obtained during filling and emptying tests with a full tow in the lock chamber are shown in plates

10 and 11, respectively. The full tow was selected for use in comparative tests of other arrangements, with half-tow data to be obtained on the more promising culvert arrangements.

22. Observations of lock chamber water-surface turbulence during filling operations showed excessive turbulence over the floor culverts. The water surface in the chamber during a filling operation with 4-min valve time is shown in photograph 2.

23. Flow distribution along the port manifold of one of the type A floor culverts used in the original design culvert arrangement was investigated under steady-flow conditions (plate 12). Numbering of the ports begins with the port nearest the crossover culvert. Data from these tests indicated a deficiency of flow through the first four ports. Approximately 22 percent of the total manifold flow was discharged through the first four ports while the remaining six ports carried about 78 percent. Two modified culverts (B and C) which included interior deflectors at the ports nearest the crossover culvert were tested in an attempt to improve flow distribution along the manifold. The size, position, and shape of the interior port deflectors are shown in plate 12. The modified culverts are described briefly in the following tabulation:

Culvert Type	Port No.	Interior Deflector Width, ft	Interior Deflector Height, ft
A	1-10	--	--
B	1-3	0.83	4.00
	4	0.50	4.00
	5-10	--	--
C	1 (closed)		
	2-4	1.00	4.00
	5-6	0.50	4.00
	7-10	--	--

Improved flow distribution was obtained with the type C culvert which moved the first open port an additional 8 ft from the junction of the crossover culvert and the floor culvert and added interior deflectors at the downstream face of the first five ports.

Culvert arrangement types 2-14

24. Culvert arrangements 2-14 represent a series of tests in which

the following modifications were tested in an attempt to develop a satisfactory arrangement.

- a. Varying the number, spacing, and location of ports in the longitudinal floor culverts.
- b. Installing interior and exterior deflectors at the downstream face of the ports.
- c. Removing the dividing wall between floor culverts and staggering ports in the two culverts.
- d. Adding a cutoff wall at the center of the crossover culvert.
- e. Adding a splitter wall at the entrance to the crossover culvert.

These arrangements are described in detail in table 1 and in plates 13 and 14. Developmental tests of the different arrangements were conducted with a full tow in the chamber. Data collected during filling tests are given in table 3. Valve opening schedule II, shown in plate 4, was used in tests of all culvert arrangements except the original design (type 1).

25. Culvert arrangement types 2-5 and 12-14 used ports spaced 8 ft on centers in the longitudinal floor culverts. Port manifolds in each end of the lock chamber covered a maximum of about 12 percent of the lock chamber length and were located near the crossover culvert. The upstream and downstream manifolds were both within the middle third of the lock chamber. Maximum hawser stresses measured with culvert arrangements 2-3 and 12-14 are compared in plate 15. The type 2 culvert arrangement, which used the type C culverts (paragraph 23), resulted in some improvement in both longitudinal and transverse hawser stresses. Addition of 3-ft-long by 4-ft-high exterior deflectors at the downstream face of all ports (culvert arrangement type 3) further reduced transverse stresses but increased longitudinal stresses. The dividing wall between the floor culverts was removed, and ports in the two culverts were staggered in culvert arrangements 4 and 5. Operation with these two arrangements resulted in higher hawser stresses (table 3). The dividing walls between the floor culverts were replaced, and port staggering was eliminated in culvert arrangements 12-14. The type 12 arrangement used the culvert layout of the type 3 arrangement but included a dividing wall in the crossover culvert and a 17-ft-long splitter wall at the entrance of the crossover culvert. These modifications reduced

the filling time by about 0.5 min and lowered the maximum hawser stress to about 5.9 tons. Removal of the exterior port deflectors (type 13) increased the longitudinal hawser stresses during operation with the 2-min valve but resulted in slightly lower maximum stresses at slower valve times. The type 14 arrangement, in which the dividing wall in the crossover culvert was removed, resulted in longer filling times and higher hawser stresses than either the type 12 or 13 culvert arrangements.

26. The port spacing was increased to 16 ft on centers in culvert arrangements 6-11, providing port manifolds in each end of the lock chamber which covered approximately 20 percent of the chamber length. In each of these arrangements the dividing wall between the floor culverts was removed and ports were staggered in the two culverts. Maximum hawser stresses measured during filling tests with arrangements 6 and 8-11 are compared in plate 16. These arrangements had 10 pairs of ports in each floor culvert, with exterior deflectors located at the downstream face of each port. The type 6 arrangement, which included interior deflectors at the first three ports, resulted in lower maximum hawser stresses than the type 8 arrangement in which these deflectors were removed. However, interior deflectors were not used in culvert arrangements 9-11, which were tested to determine the effect of adding a dividing wall in the crossover culvert and a splitter wall at the entrance to the crossover culvert. Arrangement type 10, which included both the dividing wall and splitter wall, resulted in lower hawser stresses than either the type 9 arrangement (dividing wall only) or the type 11 arrangement (splitter wall only). Maximum stresses measured with the type 10 arrangement were about 5.7 tons.

27. Data collected on culvert arrangements 1-14 revealed that performance was significantly improved by the addition of a dividing wall in the crossover culvert and a 17-ft-long splitter wall at the entrance to the crossover culvert. These modifications tended to stabilize and improve the distribution of flow between the upstream and downstream floor culverts. Test data also indicated that the use of interior deflectors at the ports nearest the crossover culvert improved flow distribution along the floor culvert port manifold and turbulence distribution in the lock chamber. The use of exterior deflectors at the downstream face of all ports improved

transverse hawser stresses but in some cases resulted in higher longitudinal stresses.

Section model of entrances to crossover culvert and longitudinal floor culverts

28. At this point in the study, a 1:36-scale model was constructed to study flow conditions in the entrances to the crossover culvert and the longitudinal floor culverts. One-half of the culvert system was reproduced in this model (fig. 6). The cap at the end of the crossover culvert in

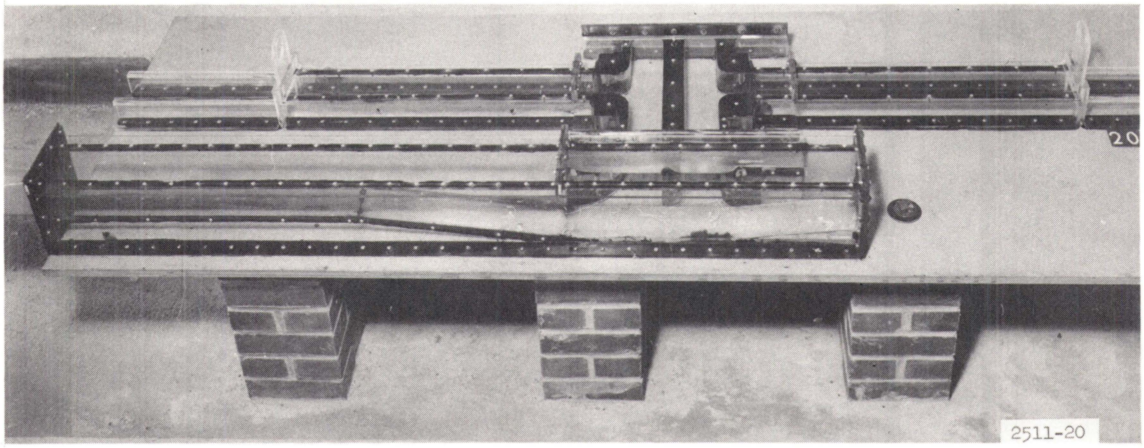


Fig. 6. Section model (scale 1:36) of entrances to crossover culvert and longitudinal floor culverts

effect simulated the dividing wall used in earlier culvert arrangements to separate the two sides of the system. Five different crossover culvert entrance arrangements (plate 17) were tested. Entrance types 2-5 contained a continuous splitter wall which divided the crossover culvert into upstream and downstream flow passages. Measurements were made during steady-flow tests to determine flow distribution between the upstream and downstream floor culverts and to evaluate the hydraulic losses through the entrance sections. The energy losses were measured from a point in the longitudinal wall culvert about 100 ft upstream from the center of the crossover culvert to points in the floor culverts which were about 60 ft from the center of the crossover culvert. The loss was expressed as a percentage of the velocity head in the wall culvert. Flow distribution and approximate energy losses measured during tests of the five entrances are tabulated below:

Entrance Type	Percent of Total Flow		Energy Loss in Percent of Velocity Head	
	Upstream Floor Culvert	Downstream Floor Culvert	Upstream Floor Culvert	Downstream Floor Culvert
1	47.5	52.5	84	64
2	51.0	49.0	68	73
3	51.0	49.0	57	64
4	51.0	49.0	63	70
5	50.0	50.0	53	53

The type 5 entrance, in which crossover culvert flow passages and the floor culverts were enlarged to 11 by 7 ft, provided the most satisfactory performance.

Culvert arrangement types 15-24

29. Prior to initiation of tests on culvert arrangement type 15, design personnel of the Mobile District advised that foundation conditions at the Millers Ferry Lock site made it necessary for the floor culverts to be confined within approximately the middle third of the lock chamber. Consequently, this series of tests (culvert arrangements 15-24) was oriented toward development of a satisfactory floor culvert system which conformed to the site restrictions. Details of culvert arrangement types 15-24 are given in table 4, and half plans of arrangements 15-18 and 19-22 are presented in plates 18 and 19, respectively. Data obtained during filling tests with arrangements 15-23 are given in table 5.

30. The type 15 culvert arrangement used the type 5 entrance developed in the section model except that there was no dividing wall in the crossover culvert. Nine pairs of ports were spaced 8 ft on centers in each floor culvert with ports staggered in the two culverts in each end of the lock. Interior deflectors were used at the first five port pairs. Operation with this arrangement resulted in reasonably satisfactory hawser stresses with only a 5.3-ton maximum when the lock was filled in 10.4 min. However, turbulence conditions above the floor culverts were very unsatisfactory.

31. In culvert arrangement type 16, the central crossover culvert

was closed by adding dividing walls formed on 15-ft radii to guide flow into the longitudinal floor culverts. Lateral floor culverts were installed to connect the two longitudinal floor culverts in each end of the lock chamber. Eight ports (1.27 ft wide by 4 ft high) were spaced 8 ft on centers in the lateral culverts. Flow from the lateral culvert ports was directed toward the ends of the chamber in an effort to improve turbulence distribution. A 4-ft-high end sill was located 6 ft from the lateral culvert wall ports with a 10-on-1 slope beginning at the rear edge of the end sill used to return the lock chamber floor to its normal elevation (18.0). In the longitudinal culverts, port spacing was increased to 14 ft on centers and the interior deflectors were removed. Dividing walls also were installed between the two culverts. Tests with the type 16 arrangement, which included only seven ports in each longitudinal floor culvert, resulted in filling times much longer than were considered desirable, but also showed improved turbulence distribution.

32. The number of ports in each longitudinal culvert was increased to 10 in the type 17 culvert arrangement, but otherwise this arrangement was identical with type 16. The type 18 arrangement was identical with type 17 except for removal of the dividing wall between the floor culverts. Maximum hawser stresses measured during tests of arrangements 15-18 are compared in plate 20. Based on these data and observation of turbulence conditions in the chamber during filling tests, the type 18 arrangement was considered the most promising arrangement for further refinement. Turbulence over the longitudinal floor culverts was satisfactory, but conditions above the lateral culverts and in the ends of the lock indicated the need for improvement by modifications to the lateral culvert port arrangement.

33. Culvert arrangements 19-23 represent tests in which the lateral culvert port arrangement and the sill and floor conditions in front of the lateral culverts were modified to determine the effect on hawser stresses and turbulence conditions in the ends of the lock chamber. The following tabulation shows how these arrangements differed from type 18.

Culvert Arrangement Type	Lateral Ports				Sill		Floor Slope from Rear of Sill
	Wall		Roof				
	Number	Size ft	Number	Diameter ft	Height ft	Width ft	
18	8	1.25 × 4.0	--	--	4.0	4.0	10 on 1
21	9	1.25 × 4.0	27	0.67	3.5	4.0	10 on 1
23	9	1.25 × 4.0	27	0.67	3.5	4.0	4 on 1
20	9	1.75 × 4.0	--	--	3.5	4.0	10 on 1
19	9	1.75 × 4.0	27	0.67	3.5	4.0	10 on 1
22	9	1.75 × 4.0	27	0.67	3.5	4.0	4 on 1

The roof ports used in arrangements 19 and 21-23 were arranged in three rows of nine ports each. One row was angled 45 deg upstream, another 45 deg downstream, and the third was normal to the roof.

34. Filling tests were conducted using the type 19 culvert arrangement with the sill height varied from 2.5 to 4.0 ft. Measured hawser stress data and visual observations of turbulence conditions indicated that a height of 3.5 ft was most satisfactory. Consequently, this height was used in culvert arrangement types 20-23.

35. Tests of culvert arrangements 19-23 were conducted with a half tow located in the downstream end of the lock chamber. Maximum hawser stresses measured during filling operations using a 2-min valve time are compared in plate 21. Arrangements which used the smaller wall port (1.25 ft wide by 4.0 ft high) caused slightly lower hawser stresses than those which used the larger port. Observations of the lock chamber water surface during filling tests indicated that addition of the 8-in.-diam roof ports improved the distribution of turbulence. A small reduction in hawser stresses also was evident with arrangements which included these ports. Culvert arrangements 22 and 23 were tested to determine the effect of increasing the slope of the chamber floor behind the sill to 4 on 1 since prototype site conditions make it desirable to return to the normal floor elevation (18.0) as rapidly as is practical. Operation with the steeper slope was very satisfactory with hawser stresses being slightly lower than those with the 10-on-1-sloping floor.

36. Consideration of both measured data and visual observations resulted in the selection of culvert arrangement type 23 as the most satisfactory arrangement. One additional culvert arrangement (type 24) was

tested to determine the effect of reopening the lateral crossover culvert at the center of the lock chamber. Other features of this arrangement were identical with those of the type 23 arrangement. Test data showed only minor differences in hawser stresses, but indicated a slightly longer filling time (plate 22) for the type 24 arrangement. Since the longitudinal floor culverts in each end of the lock chamber were connected by lateral floor culverts, there appeared to be no advantage to a crossover culvert at the center of the chamber.

Type 23 (recommended)
culvert arrangement

37. The type 23 culvert arrangement was recommended for adoption at the Millers Ferry project. This arrangement provided a floor culvert system which was symmetrical about the midpoint of the lock chamber and was confined within approximately the middle third of the chamber. The connections between the wall culverts and the floor culvert system were centered in the lock chamber (sta 323.0). At each of these connections the flow passage was divided by a 5-ft-wide splitter wall into upstream and downstream longitudinal floor culverts, each 11 ft wide by 7 ft high. The two longitudinal culverts in each end of the lock chamber were connected by a lateral floor culvert which also was 11 by 7 ft. Five pairs of 1.25-ft-wide by 4.0-ft-high ports were spaced 14 ft on centers in each longitudinal floor culvert. The two lateral floor culverts each contained nine wall ports of the same size spaced 8 ft on centers. Flow from these ports was directed toward the ends of the lock chamber. A 3.5-ft-high sill was located 6 ft from the lateral culvert face. A 4-on-1 slope beginning at the rear edge of the sill was used to return the lock chamber floor to its normal elevation (18.0). The lateral culverts also contained three rows of nine 8-in.-diam ports in the roof. The ratio of the combined port area to culvert area (floor culvert) was 1.00. Details of this culvert arrangement are given in table 4 and plate 23.

38. Filling and emptying data collected during operation at Millers Ferry design conditions (48-ft head and 14-ft submergence) with full and half tows are presented in table 6. Maximum hawser stresses measured during filling and emptying tests are plotted in plates 24 and 25, respectively.

Filling operations with a half tow in the downstream end of the lock chamber still resulted in the highest stresses. However, maximum hawser stresses were only about 4.5 tons when the lock was filled in 11.0 min (2-min valve). Hawser stresses measured during emptying tests did not exceed about 2.5 tons. Typical data obtained during filling and emptying tests using 2-min valve times are shown in plates 26 and 27, respectively.

39. Observations of the lock chamber water surface during filling operations indicated that turbulence was well distributed over the lock chamber with this culvert arrangement. The water surface during a filling test using a 2-min valve time is shown in photograph 3. Visual observations also were made of the movement of free tows in the lock chamber. Tests in which a full or half tow was centered in the chamber prior to initiation of filling or emptying showed no significant longitudinal movement of the tow. Filling tests with a half tow located in either end of the chamber indicated that the tow would move toward the near miter gate for a short period of time and then drift slowly toward the far gate for the remainder of the filling operation.

40. The effect of single-valve operation on filling characteristics was investigated with a full tow in the chamber (table 7). Filling time with a 2-min valve was increased from 11.0 min with normal operation (two valves) to 21.0 min. Maximum longitudinal hawser stresses were increased from about 3.7 tons (normal two-valve operation) to about 4.3 tons. Maximum transverse hawser stresses were about 2.5 tons. Stresses measured during emptying did not exceed 1 ton. The distribution of turbulence in the lock chamber during single-valve operation was excellent. The exceptional performance of this culvert arrangement during single-valve operation is attributed primarily to the inclusion of lateral floor culverts to connect the two longitudinal floor culverts in each end of the lock chamber. This allows the entire floor culvert system to be supplied by either wall culvert.

41. Filling and emptying tests were run at a range of head and submergence conditions to provide general design and operation data. The maximum head-submergence combination which could be tested in the model facility was 78 ft. This permitted testing of a 64-ft head with 14-ft

submergence. Maximum heads tested with submergences of 17 and 20 ft were slightly lower. Pertinent data collected during filling and emptying tests are presented in tables 8 and 9, respectively. The generalized hawser stress plot presented in plate 28 was developed from the tabulated filling data and can be used to determine permissible filling times for specific head-submergence conditions which should result in maximum hawser stresses within 3-, 4-, or 5-ton limits. Maximum hawser stresses measured during emptying tests did not exceed about 3.5 tons.

42. Filling and emptying times for heads from 38 to 64 ft are plotted against valve time in plate 29. Overall lock coefficients (C_L) were computed using these data and the formula

$$C_L = \frac{2A_L\left(\sqrt{H + d} - \sqrt{d}\right)}{A_c\ (T - Kt_v)\sqrt{2g}}$$

where

A_L = area of lock chamber, sq ft

H = initial head, ft

d = measured overtravel

A_c = area of culvert, sq ft

T = filling or emptying time, sec

K = a constant

t_v = valve time, sec

g = acceleration of gravity, ft/sec^2

The term $T - Kt_v$ is the lock filling time for the hypothetical case of instantaneous valve opening and is obtained directly from the curves plotted in plate 29. Computed coefficients for the type 23 culvert arrangement are given in the following tabulation:

Initial Head ft	Overall Lock Coefficient Filling	Overall Lock Coefficient Emptying
38	0.72	0.56
48	0.72	0.55
58	0.72	0.54
64	0.71	0.54

43. Normal filling tests were conducted with the bulkhead slots downstream from the filling valves sealed. Pressures in the area just downstream from the valve were recorded using a pressure cell at the location shown in plate 30. Plate 31 presents typical traces showing pressure variation with time during normal filling operations at the Millers Ferry design conditions (48-ft head and 14-ft submergence). Minimum pressures measured during tests with 2-, 4-, and 8-min valve times are shown below.

Valve time min	Filling time min	Drawdown from Tailwater ft	Pressure on Culvert Roof ft
2	11.0	18	-12
4	12.0	16	-10
8	14.0	11	-5

The limited data available indicate that these pressure conditions may result in cavitation damage. Admission of small quantities of air in this region should cushion the collapse of vapor pockets and minimize resulting damage. Consequently, tests in which air was admitted in this area were run to investigate the effect of this type of operation on filling characteristics and minimum pressures. Tests were conducted using vent sizes from 1-1/2-in. diameter to 12-in. diameter. Pertinent data are presented in table 10. These data indicate a small increase in filling time and progressive increases in maximum hawser stresses as the vent size is increased. Maximum stresses measured during 2-min valve operation varied from 4.5 tons with no venting to about 6.4 tons in tests with a 12-in.-diam vent. Minimum culvert pressures were raised from -12 ft to -7.3 ft during these tests.

44. Pressures throughout the hydraulic system were measured during filling and emptying tests using a 2-min valve time. Piezometer locations in the type 23 culvert arrangement are shown in plate 30. Sequence photographs of manometer boards were used to record average pressures at specified time intervals during the filling and emptying operations. Data collected during these tests are presented in tables 11 and 12. Pressure conditions were satisfactory throughout the system except in the region just downstream from the filling valves. Conditions at this location were discussed in the preceding paragraphs. Pressures measured downstream from the

emptying valves showed that the pressure gradient in this region dropped to approximately elevation 20 during the valve opening period. This results in a negative pressure of about -6 ft on the culvert roof. However, the bulkhead slots downstream from these valves can be open during emptying operation since the culverts discharge into a basin outside the riverward lock wall. Air supplied through these slots should essentially eliminate the possibility of cavitation damage in this area.

45. Additional tests were conducted to investigate head differentials across the filling valves during abnormal filling operations. Pressure cells were used to record pressure variations upstream and downstream from the valve. Data from tests in which the valves were opened at a 2-min valve speed to 1/2, 3/4, and fully open positions and immediately closed at the same speed are plotted in plate 32. The maximum differential recorded was about 1.35 times the initial head and was measured during the test in which the valve was raised to the 1/2 open position and then closed. Minimum pressure on the culvert roof downstream from the valve was about -19 ft of water during this test.

PART IV: TESTS AND RESULTS, JONES BLUFF LOCK

46. This segment of the report covers tests which were principally directed toward providing design information for the Jones Bluff Lock on the Alabama River. The Jones Bluff project site imposed no restrictions on the location of the longitudinal floor culvert system in the lock chamber. Consequently, the series of tests described in subsequent paragraphs (culvert arrangement types 25-56) was conducted to develop a floor culvert system in which the floor culvert port manifolds extended over the optimum percentage of the lock chamber length and were located at the most advantageous positions in the lock chamber. Developmental tests were run at the head-submergence conditions expected at the Jones Bluff project (45-ft head and 14-ft submergence). Visual observations also were made during filling tests at heads of 45 and 30 ft which were the heads expected at the Jones Bluff and Claiborne Locks, respectively, to evaluate the effect of culvert intake submergence on the tendency for vortices to form above the intakes.

Vortex Tendencies at Culvert Intakes

47. Observations of flow patterns above the culvert intakes were made at heads of 30 ft (Claiborne Lock) and 45 ft (Jones Bluff Lock) to determine the effect of intake submergence on the tendency for vortex formation. The original design (Millers Ferry) culvert intakes (plate 2 and fig. 4) were used in the tests. Model approach topography, which simulated that at the Millers Ferry project, was not changed. Observations were made with the intake roof submerged 15, 20, 25, and 30 ft. Terminology used in the following tabulation to describe observed flow patterns is defined in paragraph 16.

Lock	Test No.	Submergence of Roof of Intake*, ft	Head ft	Valve Time, min	Time from Beginning of Valve Opening, min: Swirl Begins	Vortex Begins	Vortex Ends	Swirl Ends
Claiborne	1	15	30	2	2.1	2.9	6.7	7.1
	2	20	30	2	2.1	2.7	3.5	4.8
	3	25	30	2	2.3	3.2	3.8	4.6
	4	30	30	2	2.5	--	--	4.2
Jones Bluff	5	15	45	2	2.7	4.3	10.0	11.5
	6	20	45	2	1.9	2.3	7.8	9.7
	7	25	45	2	[illegible]	2.3	4.2	5.8
	8	30	45	2	--	--	--	--

* Roof of intake at elevation 45.0.

Model tests at both the Jones Bluff and Claiborne design heads indicated that an intake roof submergence of approximately 30 ft was required to prevent formation of a vortex during filling tests with a 2-min valve time.

Longitudinal Floor Culvert System

48. The type 23 culvert arrangement (plate 23) developed for the Millers Ferry project at which foundation conditions confined the floor culverts within approximately the middle third of the lock chamber resulted in very satisfactory performance. However, when no chamber space restrictions were placed on the floor culvert system, it was believed that a simpler system could be developed which would provide equally satisfactory, if not improved, performance. Since the Jones Bluff Lock site necessitated no restrictions, the series of tests described in the following paragraphs was undertaken to develop a floor culvert system which would occupy as much of the lock chamber as was required to locate the floor culvert port manifolds at the optimum positions in the chamber. In these tests, modifications to the culvert system were confined within the lock chamber. Other features of the hydraulic system were identical with those used in the type 23 culvert arrangement.

Culvert arrangement types 25-40

49. Details of culvert arrangement types 25-40 are given in table 13 and plates 33 and 34. These arrangements included the basic culvert system used in the type 23 culvert arrangement except for the removal of the lateral floor culverts which connected the longitudinal floor culverts in each end of the lock chamber. The longitudinal floor culverts were lengthened to permit testing of various size port manifolds at different positions in the chamber. All arrangements in this group used the type A port (1.25 ft wide by 4.0 ft high). Filling characteristics obtained during tests with a 2-min valve time are given in table 14. Maximum hawser stresses measured on a half tow located in the downstream end of the lock chamber are compared in plate 35.

50. Consideration of the measured hawser data and visual observations of lock chamber turbulence indicated that the type 38 arrangement

resulted in the most satisfactory performance. This arrangement used seven port pairs spaced 14 ft on centers in each longitudinal floor culvert, resulting in a port-to-culvert area ratio of 0.91. The port manifolds in each end of the lock covered slightly less than 13 percent of the lock chamber length and were centered approximately 20 percent of the chamber length upstream and downstream from the midpoint of the chamber (sta 323.0). With this arrangement, the lock filled in about 10.8 min with a maximum hawser stress of 3.7 tons.

51. In all arrangements of this series except type 39, the lock chamber floor was raised to its normal elevation (18.0) by a vertical step located 7 ft beyond the last port in the floor culverts. In the type 39 arrangement, the floor was left at elevation 8.5 over the entire chamber. This arrangement, which otherwise was identical with the type 38 arrangement, resulted in a sharp increase in hawser stresses. All subsequent arrangements used the vertical step return to the normal floor elevation.

Culvert arrangement types 41-56

52. Details of the types 41-56 culvert arrangements are given in table 15 and plates 36-38. Filling data collected during tests using a 2-min valve time are presented in table 16. Maximum hawser stresses measured during tests of these arrangements are compared in plate 39. Culvert arrangement types 41-45 were tested to determine the effect of reopening the lateral crossover culvert at the center of the lock chamber. Port manifolds composed of seven pairs of type A ports were again tested at different locations in the longitudinal floor culverts. The type 41 culvert arrangement resulted in the most satisfactory hawser stresses and lock chamber turbulence. This arrangement was identical with the type 38 culvert arrangement except for the opening of the crossover culvert. Maximum hawser stress measured on the half tow was 3.8 tons with the filling time still about 10.8 min. Sequence photographs of the lock chamber water surface (photograph 4) give an indication of lock chamber turbulence during a filling operation with this arrangement.

53. Model test data and visual observations showed no significant difference in the performance of arrangements 38 and 41 even though it is apparent that hydraulic losses must be somewhat larger in the system with

the open crossover culvert. However, the advantages of the open crossover culvert during single-valve operation more than offset a relatively minor increase in losses during normal operation. Consequently, the additional arrangements tested in this series utilized the open crossover culvert.

54. Arrangement types 46-56 were tested to investigate the use of smaller ports to spread the manifolds over a greater portion of the lock chamber. The port-to-culvert area ratio remained at 0.91 in these arrangements. Manifolds composed of 14 type D ports (1.25 ft wide by 2.0 ft high) spaced 14 ft on centers were tested at various locations in culvert arrangement types 46-50. None of these arrangements performed as satisfactorily as the better arrangements with the larger type A port.

55. Culvert arrangement types 51-56 represent tests of manifolds composed of 10 type E ports (1.25 ft wide by 2.8 ft high) spaced 14 ft on centers. Performance of the type 53 culvert arrangement was comparable to that of the type 41 arrangement. With this arrangement, the port manifolds in each end of the lock chamber covered slightly more than 19 percent of the lock chamber length and, as in the types 38 and 41 arrangements, were centered approximately 20 percent of the chamber length upstream and downstream from the midpoint of the chamber. The lock filled in about 10.8 min with a maximum hawser stress of only 3.5 tons. Turbulence distribution in the lock chamber during filling operations was satisfactory. Sequence photographs of the lock chamber water surface are presented in photograph 5.

56. Additional tests were conducted with the types 41 and 53 culvert arrangements to provide more comparative data. Data collected during filling and emptying tests with full and half tows in the chamber are presented in table 17. Maximum hawser stresses measured during filling tests with the two arrangements are plotted in plates 40 and 41. The two arrangements resulted in approximately equal hawser stresses. Arrangement type 53, which used the smaller type E port, distributed flow over a greater percentage of the lock chamber, but no significant difference in turbulence conditions could be detected during filling operations with the two arrangements. The chamber water surface during filling operations with the types 41 and 53 arrangements is shown in photographs 4 and 5, respectively. Since no significant benefits were derived from the use of a larger number

of smaller ports, economic considerations dictated that the type 41 culvert arrangement be recommended. However, either arrangement should result in satisfactory prototype performance.

Type 41 (recommended) culvert arrangement

57. The type 41 culvert arrangement was recommended for adoption at the Jones Bluff project. This arrangement provided a floor culvert system which was symmetrical about the midpoint of the lock chamber and extended over approximately the middle 54 percent of the chamber. Longitudinal culverts in each lock wall carried flow to a lateral crossover culvert located at sta 323.0. A 5-ft-wide splitter wall divides the crossover culvert into upstream and downstream flow passages (each 11 ft wide by 7 ft high) which supply two longitudinal floor culverts in each end of the lock chamber. Seven pairs of 1.25-ft-wide by 4.0-ft-high ports were spaced 14 ft on centers in each floor culvert, resulting in a port-to-culvert area ratio of 0.91. The manifolds in each end of the lock covered slightly less than 13 percent of the chamber length and were centered approximately 20 percent of the chamber length upstream and downstream from the midpoint of the chamber. Details of this arrangement are given in table 15 and plate 42.

58. Filling and emptying data collected during tests of this arrangement at Jones Bluff design conditions (45-ft head and 14-ft submergence) are presented in table 17. Maximum hawser stresses measured during filling are plotted in plate 40. The maximum stress exerted on any tow arrangement was only about 4.7 tons when the lock was filled in 10.2 min (1-min valve). Emptying operations resulted in maximum stresses of about 2 tons. Typical data recorded during filling tests with a 1-min valve are shown in plate 43. Observations of lock chamber turbulence during filling tests indicated a satisfactory distribution of turbulence over the chamber (see photograph 4).

59. Data were collected at a range of head and submergence conditions to provide general design and operation information. Tests originally were run at 38-, 48-, and 58-ft heads with submergences of from 14 to 20 ft. A subsequent modification to the test facility permitted data to be obtained at a 69-ft head with a 14-ft submergence. Only filling characteristics were obtained at this head. These data are given in tables 18 and 19.

A generalized hawser stress plot based on the filling data from tests at heads of up to 58 ft is presented in plate 44. Filling and emptying times for heads from 38 to 69 ft are plotted against valve time in plate 45. Overall lock coefficients computed for the type 41 culvert arrangement are given below:

Initial Head ft	Overall Lock Coefficient Filling	Overall Lock Coefficient Emptying
38	0.71	0.54
45	0.69	0.53
58	0.70	0.53
69	0.69	--

60. The effect of single-valve operation on filling characteristics was investigated at the 45-ft head expected at the Jones Bluff Lock and at a 69-ft head (table 20). At the faster valve speeds filling times were increased by about 70 to 80 percent and maximum hawser stresses increased by about 1.5 tons. Operation with the 45-ft head using a 2-min valve time resulted in a filling time of 18.6 min with a maximum hawser stress of about 6.3 tons. Visual observations indicated a good distribution of turbulence in the chamber since the open crossover culvert in this arrangement permitted flow to be discharged through all four longitudinal culverts even though only one wall culvert was in use.

61. Pressures throughout the hydraulic system were measured during filling and emptying tests using a 2-min valve time. Piezometer and pressure cell locations in the type 41 culvert arrangement are shown in plate 46. Average pressures were recorded at specified time intervals during the filling and emptying cycles. Data collected during filling and emptying are given in tables 21 and 22, respectively. Pressure conditions were satisfactory throughout the system except in the area just downstream from the filling and emptying valves. Low pressures recorded downstream from the emptying valves should not present serious problems (see paragraph 44). Culvert pressures below the filling valves were recorded during normal and single-valve operation at heads of 45 and 69 ft using a pressure cell located as shown in plate 46. Minimum pressures measured during these tests of the type 41 culvert arrangement are given in the following tabulation.

		Normal Operation			Single-Valve Operation		
Initial Head ft	Valve Time min	Filling Time min	Drawdown from Tailwater ft	Pressure on Culvert Roof ft	Filling Time min	Drawdown from Tailwater ft	Pressure on Culvert Roof ft
45	1	10.2	12.7	-6.7	18.2	14.0	-8.0
	2	10.8	16.0	-10.0	18.6	18.5	-12.5
	4	11.8	14.8	-8.8	19.7	19.3	-13.3
	8	13.8	10.0	-4.0	21.8	17.0	-11.0
69	1	12.8	21.5	-15.5	21.8	30.5	-24.5
	2	13.4	26.0	-20.0	22.4	37.0	-31.0
	4	14.3	25.0	-19.0	23.4	38.0	-32.0
	8	16.3	17.5	-11.5	25.4	34.0	-28.0

Pressures conducive to cavitation were measured at both heads. The effect of admitting air in this region on filling characteristics and minimum pressures was investigated in earlier tests with the type 23 culvert arrangement (paragraph 43).

PART V: DISCUSSION OF RESULTS

62. The original design of the Millers Ferry Lock hydraulic system provided single-port intakes for each wall culvert with the intakes located side by side in the river side of the riverward approach wall. The roofs of the intakes were at elevation 45.0. Observation of filling operations with the normal upper pool elevation of 80.0 (48-ft lift) indicated that swirls (see paragraph 16 for definition) would form occasionally above the intakes. Similar tests with the upper pool lowered to elevation 70.0 (38-ft lift) resulted in numerous swirls and an occasional vortex. Observations also were made at the head conditions expected at Jones Bluff and Claiborne Locks (45 and 30 ft, respectively) to evaluate the effect of culvert intake submergence on the tendency for vortex formation. These tests indicated that a submergence of 30 ft was needed to eliminate vortex formation in the model. Data obtained during steady-flow tests at three discharges showed that the distribution of flow between the two intakes was reasonably good. Performance of the original design culvert intakes was considered satisfactory.

63. The two wall culverts discharge into a common outlet basin located on the river side of the lower approach wall. Model observations indicate that the stilling basin, which was designed to provide roller action, should perform satisfactorily.

64. The major portion of this model study was devoted to developmental tests of a new type of filling and emptying system, the longitudinal floor culvert system. This system, which had not been previously tested, was designed primarily to improve the balance of flow into the two ends of the lock chamber, thereby reducing the longitudinal surges in the chamber during filling. During the course of the study, design engineers of the Mobile District determined that foundation conditions at the Millers Ferry project site made it desirable to confine the floor culvert system within approximately the middle third of the lock chamber. Consequently, two satisfactory longitudinal floor culvert systems were developed in the study, i.e. one to conform to the site restrictions at the Millers Ferry project (plate 23), and a second for use at the Jones Bluff project (plate 42)

where no space limitations were placed on the system.

65. The culvert arrangement recommended for use at the Millers Ferry project (type 23) provides a floor culvert system which is symmetrical about the midpoint of the lock chamber and occupies slightly more than the middle third of the chamber. Longitudinal culverts in each lock wall carry flow to connections to the floor culvert system at the center of the chamber (sta 323.0). Here the flow passage is divided into upstream and downstream longitudinal floor culverts by a 5-ft-wide splitter wall. A lateral floor culvert connects the two longitudinal floor culverts in each end of the chamber. Five pairs of 1.25-ft-wide by 4.0-ft-high ports are spaced 14 ft on centers in each longitudinal culvert. The lateral floor culverts each contain nine ports of the same size spaced 8 ft on centers in the walls facing the ends of the chamber. Three rows of nine 8-in.-diam ports also are included in the roof of the lateral culverts. A 3.5-ft-high sill is located 6 ft from the lateral culvert. The lock chamber floor is returned to its normal elevation by a 4-on-1 slope which begins at the rear edge of the sill.

66. At the Millers Ferry design conditions (48-ft head and 14-ft submergence), this system permits the lock to be filled in 11.0 min (2-min valve time) with maximum hawser stresses of only about 4.5 tons. Emptying required 14.2 min with measured hawser stresses no higher than 2.5 tons. The distribution of turbulence in the chamber during filling is satisfactory. Observation of tests with a free tow centered in the chamber indicates no significant longitudinal movement of the tow as the lock is filled and emptied. A free tow located in either end of the chamber will move toward the near miter gate for a short period of time and then drift toward the far gate for the remainder of the filling cycle. Single-valve operation increased filling times to 21.0 min, but hawser stresses and turbulence distribution remained satisfactory.

67. The culvert arrangement recommended for use at the Jones Bluff project (type 41) differed from the Millers Ferry arrangement as follows:

- a. The lateral floor culverts were eliminated and the longitudinal culverts were extended to cover approximately the middle 54 percent of the lock chamber.

b. A lateral crossover culvert was provided at the center of the lock chamber (sta 323.0) to retain a connection between the two sides of the system. In this arrangement, each longitudinal floor culvert contained seven pairs of 1.25-ft-wide by 4.0-ft-high ports spaced 14 ft on centers. The resulting port manifolds in each end of the lock covered slightly less than 13 percent of the lock chamber length and were centered approximately 20 percent of the chamber length upstream and downstream from the midpoint of the chamber. A vertical step located 7 ft beyond the last port was used to return the chamber floor to its normal elevation.

68. With the type 41 culvert arrangement, filling and emptying times for the 45-ft head expected at Jones Bluff were 10.8 and 13.6 min, respectively (2-min valve time). Hawser stresses did not exceed 3.9 tons during filling tests and 1.9 tons during emptying. Turbulence distribution in the chamber during filling was very good. Single-valve operation with the same valve speed increased filling time to 18.6 min and increased the maximum hawser stress measured during the filling operation by about 1.5 tons.

69. Pressure conditions throughout the hydraulic system were investigated with both recommended culvert arrangements. Pressures were satisfactory in all areas except just downstream from the filling valves. Under normal operating conditions the pressure gradient in this region dropped 10 to 12 ft below the roof of the culvert during the period when the valves were about one-half to two-thirds open. Tests with the type 41 arrangement revealed that pressures in this region drop even lower during single-valve operation. The limited available data indicate that these pressure conditions may result in cavitation damage. Admission of small quantities of air just downstream from the valves should cushion the collapse of vapor pockets and minimize possible damage without adversely affecting the performance of the system. Admission of too much air will result in increased surging in the chamber when air pockets are discharged. Model tests of the type 23 arrangement with the air vent diameter varied from 1.5 to 12 in. showed a progressive increase in hawser stresses as the vent diameter increased. However, since laws for scaling air entrainment from model to prototype have not been established, it is suggested that the optimum amount of air venting be established in the prototype. A valve on the prototype vent should allow observers to determine the opening required to

quiet the crackling noise associated with cavitation without causing a significant adverse effect on filling characteristics.

70. The longitudinal floor culvert systems investigated in this study exhibited several favorable characteristics which suggest that this type of system may be used effectively in larger and higher-lift locks. These characteristics include the following:

- a. Performance of the system is relatively insensitive to valve speed or nonsynchronization of the valves.
- b. Operation over a range of lifts and submergences revealed quite small differences in maximum hawser stresses.
- c. Filling characteristics during single-valve operation were satisfactory.

However, much additional developmental work is needed prior to the use of a longitudinal floor culvert system at projects with larger locks or significantly higher lifts.

Table 1

Details of Culvert Arrangement Types 1-14, Millers Ferry Lock

Culvert Arrangement Type	No. of Port Pairs	Port Area/Culvert Area Ratio	Center-to-Center Port Spacing, ft	Stations of Ports in Culverts: Upstream Group: Upstream Port	Upstream Group: Downstream Port	Downstream Group: Upstream Port	Downstream Group: Downstream Port	Percent of Lock Chamber: Upstream: Without Ports	Upstream: With Ports	Center: Without Ports	Downstream: With Ports	Downstream: Without Ports	Dividing Wall Between Floor Culverts	Floor Culvert Ports: Staggered	Floor Culvert Ports: Interior Deflectors	Floor Culvert Ports: Exterior Deflectors	Crossover Culvert: Dividing Wall	Crossover Culvert: Entrance Splitter Wall
1	10	1.68	8	233.5	305.5	340.5	412.5	35.0	11.0	5.4	11.0	37.0	Yes	No	No	No	No	No
2	9	1.51	8	233.5	297.5	348.5	412.5	35.6	9.8	7.8	9.8	37.0	Yes	No	Yes	No	No	No
3	9	1.51	8	233.5	297.5	348.5	412.5	35.6	9.8	7.8	9.8	37.0	Yes	No	Yes	Yes	No	No
4	9	1.51	8	229.5	297.5	348.5	416.5	35.1	10.4	7.8	10.4	36.4	No	Yes	Yes	Yes	No	No
5	11	1.85	8	213.5	297.5	348.5	432.5	32.6	12.8	7.8	12.6	34.0	No	Yes	Yes	Yes	No	No
6	10	1.68	16	149.5	297.5	348.5	496.5	22.8	22.5	7.8	22.6	24.2	No	Yes	Yes	Yes	No	No
7	12	2.02	16 & 8	149.5	297.5	348.5	496.5	22.8	22.5	7.8	22.6	24.2	No	Yes	Yes	Yes	No	No
8	10	1.68	16	153.5	305.5	340.5	492.5	23.5	23.2	5.3	23.2	24.5	No	Yes	No	Yes	No	No
9	10	1.68	16	153.5	305.5	340.5	492.5	23.5	23.2	5.3	23.2	24.8	No	Yes	No	Yes	Yes	No
10	10	1.68	16	153.5	305.5	340.5	492.5	23.5	23.2	5.3	23.2	24.8	No	Yes	No	Yes	Yes	Yes
11	10	1.68	16	153.5	305.5	340.5	492.5	23.5	23.2	5.3	23.2	29.8	No	Yes	No	Yes	No	Yes
12	9	1.51	8	233.5	297.5	348.5	412.5	35.6	9.8	7.8	9.8	37.0	Yes	No	Yes	Yes	Yes	Yes
13	9	1.51	8	233.5	297.5	348.5	412.5	35.6	9.8	7.8	9.8	37.0	Yes	No	Yes	No	Yes	Yes
14	9	1.51	8	233.5	297.5	348.5	412.5	35.6	9.8	7.8	9.8	37.0	Yes	No	Yes	No	No	Yes

Note: The type A port (1.25 ft wide by 4.0 ft high) was used in arrangements 1-14.
The lock chamber is 84 ft wide by 655 ft long.
The stations in feet are measured from the upstream miter gate pintles.
The floor culverts are 8.5 ft wide by 7.0 ft high.

Table 2

Filling and Emptying Characteristics, Type 1 (Original) Culvert Arrangement, Millers Ferry Lock

Upper Pool El 80.0 and Lower Pool El 32.0

No. of Barges	Distance Between Tow and Upstream Miter Gate Pintles, ft	Valve Time min	Filling or Emptying Time min	Maximum Hawser Stresses															
				Longitudinal				Upstream Transverse				Downstream Transverse							
				Upstream		Downstream		Left		Right		Left		Right					
				Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min				
Filling Operation																			
12 (11,305 tons)	47	2	11.8	9.6	4.0	7.8	3.7	5.5	2.3	11.0	2.2	5.4	3.0	13.0	2.2				
		4	12.9	6.3	5.1	5.3	5.4	3.9	3.4	5.5	4.6	5.3	4.3	6.3	3.8				
		8	15.1	5.6	7.5	3.9	8.5	4.5	7.1	3.4	7.3	5.0	7.6	4.3	7.3				
6 (5410 tons)	47	2	11.8	6.3	1.4	8.4	2.5	3.4	2.4	4.1	1.7	4.3	3.7	5.2	2.2				
		4	12.9	5.5	5.3	5.9	4.8	3.7	3.6	2.9	3.9	3.5	3.7	5.0	4.7				
		8	15.1	4.8	7.3	5.3	7.6	2.2	7.2	2.2	7.3	2.4	7.7	2.7	8.9				
6 (5410 tons)	327	2	11.8	11.3	3.6	8.6	4.2	6.3	2.7	8.6	2.6	7.4	2.7	6.2	2.8				
		4	12.9	9.0	5.5	7.4	5.7	4.3	5.3	6.3	4.7	5.5	4.1	5.9	4.3				
		8	15.1	7.2	7.5	6.4	7.6	3.0	7.6	4.7	7.5	3.4	7.4	3.4	7.5				
Emptying Operation																			
12 (11,305 tons)	47	2	14.0	3.9	7.0	3.2	7.2	1.6	7.4	1.2	8.3	2.4	7.0	1.6	6.9				
		4	15.1	3.5	7.9	2.4	7.6	1.0	6.8	0.8	6.9	2.0	7.4	1.8	6.8				
		8	17.3	3.2	8.0	2.2	8.3	1.6	10.6	0.7	10.9	1.8	10.6	1.6	10.8				
6 (5410 tons)	47	2	14.0	4.7	7.5	3.6	7.6	1.5	7.3	1.2	7.4	1.5	7.3	1.6	7.2				
		4	15.1	4.3	7.3	3.6	7.8	1.5	10.9	1.2	10.8	1.5	8.1	1.6	10.1				
		8	17.3	3.1	10.3	2.8	9.9	1.0	12.8	0.8	12.9	1.5	13.6	1.2	13.5				
6 (5410 tons)	327	2	14.0	6.3	3.9	4.3	4.0	1.6	7.4	0.8	7.5	1.6	7.3	0.8	7.1				
		4	15.1	5.7	9.0	3.7	8.9	1.6	9.6	1.2	9.7	1.6	9.8	1.4	9.6				
		8	17.3	4.3	10.0	3.5	10.1	1.6	12.5	1.2	11.9	1.6	11.3	1.6	9.1				

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves. Valve opening schedule I was used.

Table 3

Filling Characteristics, Types 2-14 Culvert Arrangements, Millers Ferry Lock

Upper Pool El 80.0 and Lower Pool El 32.0

			Maximum Hawser Stresses															
			Longitudinal				Upstream Transverse				Downstream Transverse			
			Upstream		Downstream		Left		Right		Left		Right	
Culvert Arrangement Type	Valve Time min	Filling Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min
2	2	11.8	5.5	4.6	7.4	4.3	6.3	1.7	6.7	1.8	7.4	1.6	6.4	1.7
	4	12.8	4.8	6.1	5.4	6.2	3.3	3.0	4.0	2.9	4.3	3.9	4.7	4.2
	8	14.8	4.0	6.6	4.0	7.1	2.2	6.2	2.7	6.1	2.4	5.9	2.3	6.7
3	2	11.8	9.2	7.8	10.0	3.9	5.8	1.8	5.0	1.7	4.7	1.6	5.3	1.7
	4	12.8	5.9	7.3	6.8	4.6	3.2	2.9	3.0	3.2	3.9	4.7	4.1	3.6
	8	14.9	4.3	6.6	5.5	6.9	2.2	6.0	1.9	4.9	2.5	7.5	2.9	7.3
4	2	11.7	7.6	2.3	9.4	2.4	8.5	1.7	9.0	1.6	8.5	1.7	7.8	1.6
	4	12.7	6.7	3.6	8.0	3.3	4.4	3.8	4.4	3.4	4.5	3.8	3.7	3.4
	8	14.9	5.5	5.5	5.1	5.8	3.9	5.2	2.7	8.2	3.5	5.6	3.2	5.3
5	2	11.4	12.1	4.0	13.8	3.8	5.9	2.5	5.0	3.0	7.0	2.7	6.6	3.6
	4	12.5	8.6	4.9	8.4	5.1	4.7	3.4	3.7	3.3	6.2	3.2	5.5	3.5
	8	14.5	7.4	6.9	7.2	6.8	2.4	5.9	2.6	5.3	2.6	5.2	2.5	5.3
6	2	11.4	7.5	4.4	7.5	2.0	3.5	1.6	3.9	1.4	4.7	4.6	3.9	4.3
	4	12.5	7.1	4.8	6.1	6.4	2.4	3.7	2.9	5.3	3.7	5.0	4.6	4.7
	8	14.5	4.6	6.9	5.6	6.6	2.2	8.3	2.3	7.4	3.0	7.3	3.1	7.9
7	2	11.4	11.3	4.3	10.8	4.0	7.4	2.2	6.4	2.4	6.4	2.6	7.2	2.7
	4	12.5	6.8	4.8	7.0	4.9	4.5	3.6	4.3	3.7	4.6	3.6	3.9	3.5
	8	14.5	4.1	7.1	4.1	8.6	3.5	6.5	3.1	6.2	2.7	5.7	3.2	5.9
8	2	11.5	9.1	4.3	8.4	4.0	4.8	3.0	5.0	2.9	5.9	2.3	4.6	2.9
	4	12.5	8.3	4.5	7.6	5.0	2.3	3.6	1.7	3.5	3.0	3.6	2.6	3.7
	8	14.5	6.8	8.3	6.2	8.6	2.0	5.5	0.8	5.2	1.5	8.0	2.3	5.6
9	2	11.6	6.6	4.9	7.6	4.8	4.6	2.0	3.7	2.6	3.8	2.7	5.3	2.6
	4	12.5	5.4	3.8	6.7	3.3	2.4	2.8	2.2	4.7	3.0	3.1	3.3	3.7
	8	14.5	3.0	7.2	3.9	7.1	2.0	7.6	1.6	7.2	2.3	6.5	1.5	6.2
10	2	11.5	5.2	4.5	5.7	4.2	3.4	2.1	2.5	2.2	3.9	2.3	3.1	2.2
	4	12.5	4.7	6.2	5.3	6.5	2.4	4.4	2.3	3.9	3.1	3.8	2.9	3.7
	8	14.4	3.6	5.5	3.9	7.8	1.6	6.1	1.4	6.9	2.0	7.0	2.1	7.5
11	2	11.4	8.2	4.7	8.3	4.9	3.2	4.2	3.0	3.9	3.6	4.2	3.7	4.3
	4	12.4	5.9	5.0	6.1	3.6	3.4	3.6	2.2	3.3	3.2	3.6	2.8	3.5
	8	14.4	3.9	7.2	4.7	6.9	2.0	5.2	1.4	5.8	2.3	6.7	1.5	7.0
12	2	11.3	5.7	3.2	5.9	4.5	3.0	2.9	2.8	3.2	3.6	1.6	3.3	1.7
	4	12.3	4.7	5.7	5.3	6.6	2.5	3.3	2.3	3.6	2.6	3.1	2.5	3.2
	8	14.3	4.6	7.0	5.0	6.7	2.1	6.3	2.4	6.0	2.7	6.1	2.7	5.8
13	2	11.4	7.1	3.5	8.3	3.8	3.6	1.7	2.5	2.0	4.0	3.4	2.7	2.0
	4	12.4	4.3	5.6	4.8	4.3	2.4	3.4	1.5	3.8	3.1	3.3	2.3	4.0
	8	12.4	3.5	8.3	4.0	8.1	2.0	5.3	1.2	6.5	2.5	4.0	2.2	3.9
14	2	11.7	7.8	3.8	8.8	3.7	4.7	2.1	4.7	2.2	5.3	2.4	3.9	2.1
	4	12.7	5.7	4.7	5.5	4.8	3.0	2.9	2.9	2.8	3.6	3.6	3.2	2.8
	8	14.7	4.0	8.5	3.8	6.9	1.5	4.8	1.6	6.2	2.3	5.3	2.1	6.2

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II was used.
Full 12-barge tow (11,305-ton displacement at 9-ft draft) was positioned 47 ft from upstream miter gate pintles.

Table 4

Details of Culvert Arrangement Types 15-24, Millers Ferry Lock

Culvert Arrangement Type	Port Type and No. Longitudinal Culverts	Port Type and No. Lateral Culvert Wall	Port Type and No. Lateral Culvert Roof	Center-to-Center Port Spacing, ft Longitudinal Culverts	Center-to-Center Port Spacing, ft Lateral Culvert	Port Area/Culvert Area Ratio	Stations of Ports in Culverts: Upstream Group Upstream Port	Stations of Ports in Culverts: Upstream Group Downstream Port	Stations of Ports in Culverts: Downstream Group Upstream Port	Stations of Ports in Culverts: Downstream Group Downstream Port	Percent of Lock Chamber: Upstream Without Ports	Percent of Lock Chamber: Upstream With Ports	Percent of Lock Chamber: Center Without Ports	Percent of Lock Chamber: Downstream With Ports	Percent of Lock Chamber: Downstream Without Ports	Open Crossover Culvert (Sta 323.0)	Dimensions of Sill Opposite Lateral Culvert Ports Height ft	Dimensions of Sill Opposite Lateral Culvert Ports Width ft	Slope from Rear of Sill to Normal Floor El (18.0)
15*	A-36	--	--	8	--	1.23	228.5	292.5	353.5	417.5	34.9	9.8	9.3	9.8	36.2	Yes	4.0	4.0	10 on 1
16**	A-14	A-8	--	14	8	0.71	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	4.0	4.0	10 on 1
17**	A-20	A-8	--	14	8	0.91	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	4.0	4.0	10 on 1
18	A-20	A-8	--	14	8	0.91	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	4.0	4.0	10 on 1
19	A-20	B-9	C-27	14	8	1.12	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	3.5	4.0	10 on 1
20	A-20	B-9	--	14	8	1.06	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	3.5	4.0	10 on 1
21	A-20	A-9	C-27	14	8	1.00	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	3.5	4.0	10 on 1
22	A-20	B-9	C-27	14	8	1.12	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	3.5	4.0	4 on 1
23	A-20	A-9	C-27	14	8	1.00	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	No	3.5	4.0	4 on 1
24	A-20	A-9	C-27	14	8	1.00	208.0	292.5	353.5	438.0	31.8	12.9	9.3	12.9	33.1	Yes	3.5	4.0	4 on 1

Note: The type A port is 1.25 ft wide by 4.0 ft high.
The type B port is 1.75 ft wide by 4.0 ft high.
The type C port is 0.667 ft in diameter.
The lock chamber is 84 ft wide by 655 ft long.
The stations in feet are measured from the upstream miter gate pintles.

* The longitudinal floor culvert ports were staggered and had interior port deflectors.

** A dividing wall was installed between the two longitudinal floor culverts in each end of the lock chamber.

Table 5

Filling Characteristics, Types 15-23 Culvert Arrangements, Millers Ferry Lock

Upper Pool El 80.0 and Lower Pool El 32.0

Culvert Arrangement Type	No. of Barges	Distance Between Tow and Upstream Miter Gate Pintles, ft	Valve Time min	Filling Time min	Maximum Hawser Stresses: Longitudinal, Upstream, Pull tons	Longitudinal, Upstream, Time min	Longitudinal, Downstream, Pull tons	Longitudinal, Downstream, Time min	Upstream Transverse, Left, Pull tons	Upstream Transverse, Left, Time min	Upstream Transverse, Right, Pull tons	Upstream Transverse, Right, Time min	Downstream Transverse, Left, Pull tons	Downstream Transverse, Left, Time min	Downstream Transverse, Right, Pull tons	Downstream Transverse, Right, Time min
15	12 (11,305 tons)	47	2	10.4	5.1	3.1	5.3	2.8	1.2	2.7	3.8	1.9	2.9	2.5	1.1	3.5
			4	11.3	4.4	6.5	5.0	6.7	0.9	7.1	2.8	4.8	2.1	4.6	1.1	6.8
			8	13.2	1.9	11.5	1.7	10.2	0.8	6.4	1.2	5.1	1.2	7.1	1.0	7.2
16	12	47	2	11.5	4.7	2.1	3.9	6.7	3.0	2.2	2.3	2.3	2.8	2.7	2.4	2.1
			4	13.1	3.8	5.0	2.7	4.0	2.4	3.5	1.8	3.8	2.5	3.4	1.8	3.5
			8	19.3	2.7	6.5	2.3	6.9	2.0	7.2	2.1	7.3	1.7	7.4	1.9	7.5
17	12	47	2	10.9	6.3	3.9	6.2	3.6	2.0	2.1	2.7	2.7	2.3	4.6	2.8	2.2
			4	11.9	5.9	4.8	5.3	5.1	2.0	4.2	2.6	4.0	2.6	4.1	2.2	3.8
			8	13.9	3.3	6.6	3.7	6.3	1.9	7.4	1.8	7.5	2.0	7.0	2.3	7.3
18	12	47	2	11.2	5.7	2.3	4.5	2.6	2.4	2.4	2.4	2.3	2.0	2.6	2.6	2.3
			4	12.2	4.2	4.6	4.0	4.7	1.5	3.6	1.7	3.4	1.6	3.5	2.2	3.9
			8	14.2	3.1	6.9	3.0	6.7	1.5	7.8	1.6	6.7	1.6	7.4	1.6	8.0
19	6 (5410 tons)	327	2	10.7	5.4	2.8	4.5	1.3	2.2	3.2	2.1	3.3	2.1	3.9	2.7	3.8
20	6	327	2	10.8	6.8	1.9	5.2	5.5	1.6	2.1	1.9	2.8	1.8	3.6	1.6	2.8
21	6	327	2	11.0	5.1	3.0	3.9	5.0	2.8	3.3	2.1	3.1	2.6	3.5	2.3	3.9
22	6	327	2	10.8	5.4	2.7	3.8	1.4	2.1	2.0	2.3	2.1	1.7	2.0	2.1	2.2
23	6	327	2	11.0	4.5	2.3	4.0	1.7	2.1	3.3	2.7	3.1	2.2	3.2	2.9	3.0

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves. Valve opening schedule II was used.

Table 6

Filling and Emptying Characteristics, Type 23 (Recommended) Culvert Arrangement, Millers Ferry Lock

Upper Pool El 80.0 and Lower Pool El 32.0

No. of Barges	Distance Between Tow and Upstream Miter Gate Pintles, ft	Valve Time min	Filling or Emptying Time min	Maximum Hawser Stresses											
				Longitudinal				Upstream Transverse				Downstream Transverse			
				Upstream		Downstream		Left		Right		Left		Right	
				Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min
				Filling Operation											
12 (11,305 tons)	47	2	11.0	3.5	2.7	3.7	2.5	2.0	1.6	2.3	2.1	2.6	1.7	3.0	2.5
		4	12.0	2.8	3.9	3.2	3.6	2.4	3.6	2.3	5.8	2.2	5.7	2.4	5.6
		8	14.0	2.3	7.4	3.1	8.4	1.4	6.6	1.3	7.2	1.4	7.1	1.7	7.2
6 (5410 tons)	47	2	11.0	3.3	1.3	4.3	2.0	2.3	2.0	2.1	2.1	2.6	2.0	2.3	2.4
		4	12.0	3.1	6.0	3.9	4.9	1.4	4.3	1.2	3.4	1.4	3.5	1.2	3.3
		8	14.0	2.0	12.2	2.7	7.3	1.2	6.3	0.8	7.5	1.2	8.1	1.2	6.5
6	327	2	11.0	4.5	2.3	4.0	1.7	2.1	3.3	2.7	3.1	2.2	3.2	2.9	3.0
		4	12.0	3.5	4.4	3.3	6.4	1.4	4.1	1.4	3.3	1.5	4.6	1.8	5.0
		8	14.0	2.9	7.5	2.3	7.3	1.4	5.3	1.0	4.9	1.2	6.9	1.2	6.4
				Emptying Operation											
12 (11,305 tons)	47	2	14.2	1.3	6.1	1.2	6.4	0.9	2.7	0.9	3.0	1.1	6.0	0.9	2.8
		4	15.2	1.3	6.0	1.3	6.1	0.9	6.3	1.0	7.4	1.1	7.6	1.0	7.5
		8	17.2	1.3	9.2	1.2	9.9	0.8	13.1	0.7	9.5	1.0	9.6	0.7	9.5
6 (5410 tons)	47	2	14.2	2.5	2.5	1.8	2.3	0.6	2.9	0.8	2.8	0.8	2.9	0.8	3.3
		4	15.2	2.0	2.2	2.0	2.1	0.8	4.6	0.4	2.7	0.8	3.5	0.8	3.7
		8	17.2	1.2	5.1	1.6	5.5	0.4	6.9	0.6	4.5	0.8	7.3	0.8	7.4
6	327	2	14.2	2.0	0.6	1.5	3.2	0.8	8.4	0.6	8.3	1.0	2.7	0.9	2.6
		4	15.2	1.8	9.6	1.4	7.5	0.8	4.7	0.6	3.9	0.8	6.3	0.8	5.1
		8	17.2	1.8	5.6	1.4	4.1	0.8	8.9	0.6	9.0	0.8	2.6	1.0	2.5

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II was used.

Table 7

Effect of Single-Valve Operation on Filling Characteristics, Type 23 (Recommended) Culvert Arrangement, Millers Ferry Lock

Upper Pool El 80.0 and Lower Pool El 32.0

No. of Barges	Distance Between Tow and Upstream Miter Gate Pintles, ft	Valve Time min	Filling Time min	Maximum Hawser Stresses: Longitudinal: Upstream Pull tons	Longitudinal: Upstream Time min	Longitudinal: Downstream Pull tons	Longitudinal: Downstream Time min	Upstream Transverse: Left Pull tons	Upstream Transverse: Left Time min	Upstream Transverse: Right Pull tons	Upstream Transverse: Right Time min	Downstream Transverse: Left Pull tons	Downstream Transverse: Left Time min	Downstream Transverse: Right Pull tons	Downstream Transverse: Right Time min
12	47	2	21.0	4.3	3.5	4.2	2.6	2.0	5.7	2.1	5.4	2.5	5.5	2.5	5.2
(11,305		4	21.8	3.5	6.5	2.9	5.6	2.5	4.3	2.0	4.4	2.3	4.2	2.1	4.1
tons)		8	23.8	3.1	6.7	2.7	6.8	2.1	8.0	2.0	8.2	2.1	8.1	2.1	8.4

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II was used.
River-wall valves remained closed during filling and emptying operation.
Emptying hawser stresses were less than 1.0 ton.

Table 8

Filling Characteristics for Range of Operation Conditions, Type 23 (Recommended)

Culvert Arrangement, Millers Ferry Lock

					Maximum Hawser Stresses											
					Longitudinal				Upstream Transverse				Downstream Transverse			
	Lower	Upper	Valve	Filling	Upstream		Downstream		Left		Right		Left		Right	
Head ft	Pool El	Pool El	Time min	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min
					Submergence 14 ft											
38	32.0	70.0	2	10.0	3.9	3.0	3.8	1.3	1.7	2.9	2.5	2.5	1.9	2.6	2.3	2.1
			4	11.0	2.8	6.2	2.9	4.8	1.1	6.3	1.5	4.1	1.3	6.2	1.3	6.3
			8	13.0	2.7	6.2	2.0	11.0	0.8	6.7	0.9	7.4	0.8	8.0	1.2	7.1
48	32.0	80.0	2	11.0	4.5	2.3	4.0	1.7	2.1	3.3	2.7	3.1	2.2	3.2	2.9	3.0
			4	12.0	3.5	4.4	3.3	6.4	1.4	4.1	1.4	3.3	1.5	4.6	1.8	5.0
			8	14.0	2.9	7.5	2.3	7.3	1.4	5.3	1.0	4.9	1.2	6.9	1.2	6.4
58	32.0	90.0	2	12.0	5.8	1.8	5.0	1.3	1.7	4.3	2.0	2.1	2.1	3.2	2.5	3.3
			4	13.0	4.8	4.9	4.0	5.1	1.2	4.1	1.6	4.2	1.6	4.3	2.0	6.1
			8	15.0	3.5	7.3	2.7	9.0	1.1	6.7	1.2	6.6	1.2	6.7	1.4	6.8
64	32.0	96.0	2	12.4	6.2	3.2	5.4	4.0	2.5	4.1	2.4	4.0	2.3	3.9	2.3	3.8
			4	13.5	5.2	5.2	4.6	5.6	2.2	5.8	2.3	3.2	2.4	5.9	2.3	4.1
			8	15.6	3.3	10.0	2.9	10.6	1.4	8.1	0.8	7.7	1.2	7.3	1.6	7.2
					Submergence 17 ft											
38	35.0	73.0	2	10.0	3.5	3.6	3.6	1.3	1.6	3.1	2.1	3.0	1.5	2.9	1.7	2.8
			4	11.0	3.0	4.1	2.4	5.7	1.3	4.2	0.9	6.8	0.9	4.8	1.2	4.0
			8	13.0	2.3	8.2	1.5	6.8	0.7	6.4	0.9	6.5	1.1	6.8	1.1	6.6
48	35.0	83.0	2	11.0	4.5	4.3	3.9	1.2	1.6	2.5	1.6	2.9	1.6	2.6	1.6	2.3
			4	12.0	3.8	5.4	2.8	7.0	1.2	4.6	1.2	3.6	1.1	3.4	1.5	5.4
			8	14.0	2.7	8.5	2.3	8.4	1.2	5.9	1.1	7.8	1.2	7.7	1.2	7.6
58	35.0	93.0	2	12.0	5.7	2.6	4.5	4.3	1.4	1.8	2.4	2.3	1.6	2.0	2.0	2.2
			4	13.0	4.5	4.2	3.9	5.0	1.4	4.5	1.2	4.7	1.6	4.4	1.6	3.9
			8	15.0	3.0	8.4	2.5	9.4	0.9	5.3	0.8	5.8	1.0	5.7	1.2	5.9
61	35.0	96.0	2	12.2	5.9	2.7	5.0	2.9	1.6	3.2	1.5	3.3	2.1	3.6	2.0	3.5
			4	13.2	4.5	4.8	3.3	5.0	1.0	4.5	1.2	4.3	1.7	4.9	2.2	5.0
			8	15.2	3.1	7.1	2.8	7.9	0.6	7.6	0.7	5.7	1.0	5.8	1.1	6.0
					Submergence 20 ft											
38	38.0	76.0	2	10.0	3.4	2.8	3.2	4.0	1.4	2.9	1.4	3.0	1.4	4.9	1.6	5.0
			4	11.0	3.0	4.7	2.5	8.7	0.9	4.5	0.9	4.4	1.3	4.6	1.2	4.5
			8	13.0	2.0	6.7	2.0	8.1	1.2	7.6	1.0	7.5	1.1	7.6	1.2	7.5
48	38.0	86.0	2	11.0	4.2	3.1	3.7	3.9	1.6	1.8	1.6	3.7	1.8	5.0	2.0	1.8
			4	12.0	3.3	6.7	2.7	7.4	1.4	5.5	1.0	5.6	1.4	5.3	1.2	5.8
			8	14.0	2.6	9.3	2.3	9.0	1.4	7.3	1.0	6.3	1.4	7.5	1.3	6.4
58	38.0	96.0	2	12.0	5.1	3.1	4.2	1.5	2.0	1.9	2.0	2.0	2.1	2.1	2.1	4.1
			4	13.0	3.9	8.0	3.0	7.9	1.0	4.3	1.0	4.9	1.2	2.9	1.2	4.4
			8	15.0	3.1	9.2	2.8	9.8	1.1	7.6	1.0	7.4	1.1	7.1	1.3	7.0

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II was used.
Six-barge tow (5410 tons displacement at 9-ft draft) positioned 327 ft below upstream miter gate pintles.

Table 9

Emptying Characteristics for Range of Operation Conditions, Type 23 (Recommended) Culvert Arrangement, Millers Ferry Lock

					Maximum Hawser Stresses													
					Longitudinal				Upstream Transverse				Downstream Transverse			
					Upstream		Downstream		Left		Right		Left		Right	
Head ft	Lower Pool El	Upper Pool El	Valve Time min	Emptying Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min
					Submergence 14 ft											
38	32.0	70.0	2	12.6	3.3	1.2	2.6	1.3	0.7	8.4	0.8	8.3	0.7	1.0	0.7	2.3
			4	13.6	2.5	4.0	2.4	2.9	0.7	4.8	0.7	3.0	0.9	2.9	1.0	3.0
			8	15.6	1.8	3.1	1.9	3.0	0.6	6.8	0.6	5.0	0.8	4.9	0.9	4.2
48	32.0	80.0	2	14.2	2.0	0.6	1.5	3.2	0.8	8.4	0.6	8.3	1.0	2.7	0.9	2.6
			4	15.2	1.8	9.6	1.4	7.5	0.8	4.7	0.6	3.9	0.8	6.3	0.8	5.1
			8	17.2	1.8	5.6	1.4	4.1	0.8	8.9	0.6	9.0	0.8	2.6	1.0	2.5
58	32.0	90.0	2	15.6	3.5	2.4	3.5	2.5	0.9	5.4	0.8	4.1	1.1	4.0	1.1	3.0
			4	16.6	2.0	8.9	1.9	5.5	0.8	11.6	0.7	11.7	0.9	5.3	1.1	4.8
			8	18.7	1.8	3.0	1.7	3.2	0.6	5.4	0.5	4.3	0.6	4.3	0.9	4.4
64	32.0	96.0	2	16.0	2.0	3.6	1.8	3.5	0.8	2.4	0.7	2.5	1.2	1.7	0.9	1.8
			4	17.1	1.9	3.2	1.5	3.3	0.7	6.1	0.6	3.1	0.8	4.2	0.8	4.3
			8	19.3	1.7	2.3	1.5	2.4	0.8	2.5	0.4	3.1	0.8	3.9	0.9	4.0
					Submergence 17 ft											
38	35.0	73.0	2	12.6	2.0	1.7	1.6	2.4	0.9	2.0	0.5	3.1	0.7	2.6	0.8	2.1
			4	13.6	1.6	4.8	1.2	5.8	0.7	12.5	0.7	12.4	0.6	4.9	0.6	4.2
			8	15.6	1.2	9.2	1.0	9.3	0.7	4.3	0.7	4.2	0.8	4.3	0.7	4.2
48	35.0	83.0	2	14.2	1.9	5.6	2.0	5.8	0.9	2.2	0.9	2.3	1.0	6.4	1.1	6.3
			4	15.2	1.8	6.2	1.7	5.5	0.9	11.7	0.9	9.4	0.9	8.1	1.1	8.0
			8	17.2	1.7	9.0	1.5	11.4	1.2	4.0	0.9	3.9	1.2	5.0	1.2	5.1
58	35.[illegible]	93.0	2	15.6	2.8	2.8	2.9	2.6	0.7	3.9	0.7	3.8	1.1	4.1	0.9	4.3
			4	16.6	2.1	3.8	2.3	3.9	0.7	3.7	0.6	3.8	0.9	2.7	0.8	2.6
			8	18.7	2.1	8.7	1.9	8.8	0.8	7.8	0.7	11.3	0.8	6.7	0.9	11.3
61	35.0	96.0	2	15.8	2.5	4.1	2.0	4.2	1.2	7.[illegible]	0.8	7.3	1.1	4.1	1.1	10.7
			4	16.8	2.0	9.7	1.8	4.3	1.5	4.2	1.0	4.3	1.2	2.8	1.2	4.3
			8	18.9	1.7	2.8	1.5	2.2	0.8	3.2	0.9	4.2	1.1	5.8	1.3	9.9
					Submergence 20 ft											
38	38.0	76.0	2	12.5	1.5	1.5	1.8	5.0	0.4	1.7	0.4	2.5	0.4	2.6	0.4	3.8
			4	13.5	1.5	6.0	1.5	7.4	0.4	6.2	0.4	6.3	0.5	4.9	0.4	4.8
			8	15.5	1.4	4.8	1.3	3.5	0.4	3.2	0.4	2.9	0.5	8.9	0.4	7.5
48	38.0	86.0	2	14.2	2.0	3.3	2.0	4.1	0.8	6.5	0.8	6.4	1.3	6.6	1.1	6.5
			4	15.2	1.9	7.6	1.8	7.7	0.8	3.1	0.6	7.4	1.2	3.9	1.0	2.7
			8	17.2	1.8	7.3	1.8	8.6	0.6	7.3	0.6	3.4	1.0	5.9	1.2	6.0
58	38.0	96.0	2	15.5	2.7	2.9	2.4	2.5	1.0	3.1	1.1	2.8	1.1	2.8	1.6	2.7
			4	16.5	2.5	10.8	2.3	10.1	0.9	0.5	0.9	0.9	1.0	1.4	1.0	0.6
			8	18.6	2.3	2.0	2.6	1.9	0.8	1.5	0.5	4.5	0.9	6.1	0.8	5.6

NOTE: Time listed under hawser stresses is time of occurrence after beginning of movement of valves. Valve opening schedule II was used. Six-barge tow (5410 tons displacement at 9-ft draft) positioned 327 ft below upstream miter gate pintles.

Table 10

Effect of Air Vent Size on Filling Characteristics and Minimum Pressures Below Filling Valves

Type 23 (Recommended) Culvert Arrangement, Millers Ferry Lock

Upper Pool El 80.0 and Lower Pool El 32.0

	Minimum Pressure Below Filling Valve				Maximum Hawser Stresses											
					Longitudinal				Upstream Transverse				Downstream Transverse			
					Upstream		Downstream		Left		Right		Left		Right	
Vent Diam in.	Water ft	Time min	Valve Time min	Filling Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min
None	-12.0	1.3	2	11.0	4.5	2.3	4.0	1.7	2.1	3.3	2.7	3.1	2.2	3.2	2.9	3.0
None	-9.5	2.4	4	12.0	3.5	4.4	3.3	6.4	1.4	4.1	1.4	3.3	1.5	4.6	1.8	5.0
1-1/2	-10.5	1.2	2	11.2	5.2	2.0	4.0	1.3	1.9	2.3	2.8	2.2	2.1	2.1	2.6	2.4
1-1/2	-10.0	2.5	4	12.2	4.2	3.8	3.1	7.2	1.6	5.0	1.3	3.4	1.9	5.6	2.3	5.7
3	-9.0	1.3	2	11.2	5.4	5.1	4.2	1.4	1.9	1.7	2.0	1.9	1.8	1.8	2.6	2.6
6	-8.2	1.1	2	11.2	5.6	3.1	5.0	2.9	2.2	2.6	2.4	3.1	2.1	3.2	2.5	2.7
12	-7.3	1.1	2	11.2	6.0	4.0	6.4	4.2	2.3	2.1	2.3	2.2	2.7	5.3	2.9	2.1

Note: The six-barge tow positioned 327 ft from upstream miter gate pintles has a displacement of 5410 tons.
Bulkhead slots closed.
Time listed under hawser stresses and filling-valve pressure is time of occurrence after beginning of movement of valves.
Valve opening schedule II was used.
Minimum pressure below filling valve is related to the roof of the culvert at elevation 26.0

Table 11

Average Piezometer Readings During Filling Operation, Type 23 (Recommended) Culvert Arrangement, Millers Ferry Lock

Initial Head 48.0 ft (Upper Pool El 80.0 and Lower Pool El 32.0)

Piezometer Locations			Average Piezometer Reading, in Prototype Elevation																			
Piez No.	Station	El	T* = 0 LC** = 32.0	T = 30 LC = 32.6	T = 60 LC = 33.4	T = 90 LC = 35.0	T = 120 LC = 38.2	T = 150 LC = 42.2	T = 180 LC = 46.0	T = 210 LC = 50.0	T = 240 LC = 53.0	T = 270 LC = 56.3	T = 300 LC = 60.1	T = 330 LC = 62.5	T = 360 LC = 65.3	T = 390 LC = 67.9	T = 420 LC = 69.8	T = 450 LC = 72.5	T = 480 LC = 73.7	T = 540 LC = 76.9	T = 600 LC = 78.7	T = 660 LC = 80.0
Intake Piezometer Group A																						
1	0+54.00B	25.0	80.0	80.0	79.8	78.2	76.4	76.5	77.0	77.2	77.5	77.8	78.1	78.3	78.7	78.9	79.1	79.4	79.7	79.8	80.1	80.2
2	0+54.00B	25.0	80.0	79.7	78.1	73.8	67.6	68.0	69.3	70.5	71.5	72.5	73.8	74.5	75.3	76.2	77.0	77.6	78.2	78.8	79.8	80.1
3	0+34.50B	25.0	80.0	79.5	78.0	73.0	66.5	66.9	68.3	69.0	70.2	71.8	72.5	73.8	74.3	75.5	76.6	77.2	77.9	78.7	79.7	80.1
4	0+15.00A	22.5	80.0	79.3	77.3	71.0	62.7	63.1	65.0	66.3	68.0	69.4	71.8	72.0	73.1	74.2	75.8	76.5	77.3	78.2	79.6	80.2
5	0+34.50B	25.0	80.0	80.2	79.8	78.3	76.3	76.5	76.9	77.2	77.6	78.0	78.2	78.5	78.8	79.0	79.1	79.4	79.7	79.9	80.2	80.3
6	0+15.00A	22.5	80.0	79.9	78.0	72.8	64.3	64.2	65.8	67.3	69.0	70.5	71.8	72.8	73.8	74.9	75.9	76.6	77.4	78.1	79.4	80.0
Filling-Valve Piezometer Group B																						
1	0+85.00A	26.0	80.0	79.7	75.6	64.8	50.0	51.3	55.0	58.1	60.6	63.0	65.8	67.4	69.1	71.0	73.0	74.1	75.5	77.0	79.2	80.0
2	0+88.00A	16.0	80.0	79.5	75.5	64.9	50.7	52.0	55.6	58.5	61.0	63.5	66.0	67.6	69.3	71.1	73.0	74.1	75.6	77.0	77.0	79.9
3	1+08.00A	16.0	32.0	61.8	64.3	54.0	48.2	51.0	54.6	57.8	60.1	63.8	65.0	66.8	68.7	70.5	72.2	73.4	74.9	76.4	78.7	79.4
4	1+10.00A	16.0	32.0	32.8	50.0	47.8	47.2	50.2	53.8	57.0	59.3	62.0	64.3	66.0	68.0	69.7	71.7	72.9	74.2	75.8	78.2	78.9
5	1+12.00A	16.0	32.0	28.2	33.3	40.2	47.1	50.4	54.0	57.2	59.8	62.3	64.9	66.6	68.5	70.2	72.1	73.2	74.9	76.3	78.6	79.5
6	1+14.00A	16.0	32.0	28.1	24.0	32.5	46.6	50.0	53.9	56.8	59.5	62.1	64.5	66.2	68.2	70.1	72.0	73.2	74.8	76.2	78.5	79.4
7	1+14.00A	26.0	32.0	26.0	19.0	15.8	44.0	49.0	53.0	56.3	59.0	61.7	64.2	66.0	68.0	70.0	71.8	73.0	74.5	76.1	78.4	79.2
8	1+16.00A	16.0	32.0	28.0	21.8	26.7	46.3	50.0	53.8	57.0	59.5	62.1	64.7	66.3	68.3	70.2	72.0	73.3	74.8	76.2	78.7	79.5
9	1+18.00A	16.0	32.0	27.8	21.2	23.1	46.0	49.6	53.3	56.8	59.2	61.8	64.2	66.0	68.0	70.0	71.9	73.1	74.6	76.1	78.5	79.3
10	1+20.00A	16.0	32.0	27.0	20.2	20.8	46.0	49.3	53.1	56.2	59.0	61.5	64.0	65.8	67.9	69.8	71.8	73.0	74.4	76.0	78.4	79.2
11	1+19.00A	26.0	32.0	25.8	19.0	17.3	47.1	50.0	53.8	57.0	59.5	62.2	64.8	66.5	68.5	70.3	72.1	73.3	74.8	76.2	78.7	79.5
12	1+22.00A	16.0	32.0	27.2	20.8	20.5	46.2	49.5	53.3	56.5	59.0	61.8	64.3	66.0	68.2	70.0	71.9	73.0	74.6	76.0	78.5	79.4
13	1+24.00A	16.0	32.0	26.8	20.7	20.5	46.1	49.4	53.2	56.5	59.0	61.8	64.2	66.0	68.1	70.0	72.0	73.1	74.7	76.1	78.6	79.5
14	1+24.00A	26.0	32.0	26.5	20.3	20.2	46.8	49.3	53.2	56.5	59.0	61.8	64.2	66.0	68.1	70.0	72.0	73.2	74.8	76.2	78.7	79.5
15	1+26.00A	16.0	32.0	26.4	20.0	20.2	45.5	48.9	52.7	56.0	58.5	61.5	64.0	65.8	67.8	69.7	71.7	72.9	74.3	76.0	78.4	79.3
16	1+28.00A	16.0	32.0	27.0	20.7	21.3	45.7	49.0	52.8	56.2	58.8	61.7	64.0	66.0	68.0	70.0	71.9	73.1	74.6	76.1	78.7	79.5
17	1+30.00A	16.0	32.0	27.5	21.5	23.2	46.0	49.1	53.0	56.3	59.0	61.8	64.1	65.9	68.0	69.9	71.8	73.1	74.7	76.1	78.7	79.6
18	1+29.00A	26.0	32.0	27.8	21.3	23.8	46.3	49.2	53.0	56.3	58.8	61.7	64.0	65.8	67.9	70.0	71.8	73.0	74.5	75.5	78.4	79.4
19	1+32.00A	16.0	32.0	27.3	20.8	23.9	45.3	48.2	52.0	55.2	58.0	60.8	63.2	65.1	67.1	69.0	71.0	72.3	74.9	75.0	77.9	78.8
20	1+34.00A	16.0	32.0	27.8	21.5	25.5	44.7	47.9	51.8	55.0	57.5	60.4	63.0	64.8	66.8	68.7	70.8	71.9	73.4	75.2	77.4	78.3
21	1+36.00A	16.0	32.0	28.3	22.0	26.8	44.3	47.5	51.4	54.8	57.3	60.2	62.9	64.7	66.8	68.8	70.8	72.0	73.6	75.2	77.8	78.7
22	1+38.00A	16.0	32.0	28.5	22.1	28.0	43.8	47.0	51.0	54.3	57.0	60.0	62.7	64.5	66.6	68.5	70.7	71.9	73.5	75.3	77.7	78.7
Culvert Piezometer Group C																						
1	1+82.50A	21.0	32.0	33.2	34.7	38.8	42.5	45.7	50.0	53.5	56.3	59.3	62.3	64.2	66.4	68.5	70.7	72.0	73.6	75.3	78.0	79.0
3	2+32.50A	21.0	32.0	33.0	34.7	37.7	41.0	44.5	48.8	52.5	55.3	58.5	61.4	63.5	66.0	68.0	70.2	71.7	73.4	75.2	78.0	79.0
5	2+82.50A	21.0	32.0	32.8	34.9	40.3	48.0	51.5	54.8	57.8	60.0	61.4	64.9	66.5	68.3	70.1	72.0	72.9	74.2	75.8	78.0	79.0
7	3+32.50A	21.0	32.0	33.0	35.8	43.5	54.3	58.0	60.8	63.0	64.4	65.8	67.5	69.0	70.7	71.8	72.1	74.2	75.3	76.4	78.2	79.0
9	3+82.50A	21.0	32.0	33.0	35.7	44.2	58.0	60.3	62.7	65.5	66.6	68.3	69.8	71.0	72.3	73.0	74.2	75.2	76.0	77.1	78.8	79.3
11	4+32.50A	21.0	32.0	33.0	35.8	44.2	57.9	60.5	62.8	65.7	66.8	68.5	69.8	71.0	72.3	73.1	74.2	75.2	76.1	77.2	78.9	79.4
13	4+82.50A	21.0	32.0	32.7	35.0	43.0	56.7	60.0	62.5	65.0	66.2	68.0	69.2	70.7	71.8	72.8	73.8	74.8	75.6	76.8	78.3	79.0
Longitudinal Floor Culvert Piezometer Group D																						
Main																						
1	3+15.00A	8.5	32.0	32.7	34.3	39.5	47.0	51.0	53.8	56.7	59.2	61.5	63.8	65.8	68.0	69.7	71.5	73.0	74.3	75.8	78.1	79.0
2	3+31.00A	8.5	32.0	32.7	34.3	39.3	46.7	50.0	53.3	56.2	58.8	61.0	63.8	65.7	67.3	69.5	71.3	72.6	74.1	75.6	77.9	78.8
Upstream																						
1	3+08.25A	8.5	32.0	32.8	34.5	39.8	46.8	50.8	53.8	56.2	59.0	61.4	63.7	66.0	68.2	69.9	72.0	73.3	74.8	76.1	78.6	79.4
2	2+84.50A	8.5	32.0	32.1	33.5	37.0	43.8	48.0	51.3	54.2	57.0	59.5	62.2	64.5	66.8	68.5	71.0	72.3	73.8	75.3	77.9	78.9
3	2+60.50A	8.5	32.0	32.5	34.3	39.8	47.4	51.2	54.3	56.8	59.0	61.4	63.8	65.9	68.0	69.5	71.4	72.7	74.0	75.5	77.8	78.8
4	2+36.50A	8.5	32.0	32.7	34.8	41.1	50.0	54.0	57.0	59.0	61.0	63.0	65.2	67.3	69.3	70.9	72.5	73.8	75.0	76.3	78.5	79.2
Downstream																						
9	3+37.75A	8.5	32.0	32.8	34.3	38.4	44.8	48.4	52.0	55.0	57.8	60.4	63.2	65.0	61.0	69.3	71.4	72.8	74.3	75.8	78.4	79.4
10	3+61.50A	8.5	32.0	32.6	34.0	37.9	43.8	47.7	51.3	54.2	57.2	59.7	62.5	64.5	66.6	69.0	71.0	72.3	73.9	75.4	78.0	79.0
11	3+85.50A	8.5	32.0	32.5	34.1	38.9	46.3	50.2	53.8	56.8	59.2	61.7	64.2	66.0	67.9	69.9	71.8	73.0	74.4	75.9	78.2	79.1
12	4+09.50A	8.5	32.0	32.5	34.3	39.5	48.0	51.8	55.1	57.9	60.5	62.7	65.1	66.8	68.7	70.3	72.2	73.4	74.8	76.0	78.3	79.2

Note: Elevations are in feet referred to mean sea level.
Two-min valve schedule II fills lock in 11.0 min.
Bulkhead slots below filling valves closed.
* T is time (in prototype seconds) after beginning of filling operation.
** LC is elevation of water surface in lock chamber.

Table 12

Average Piezometer Readings During Emptying Operation, Type 23 (Recommended) Culvert Arrangement, Millers Ferry Lock

Initial Head 48.0 ft (Upper Pool El 80.0 and Lower Pool El 32.0)

Piezometer Locations			Average Piezometer Reading, in Prototype Elevation																			
Piez No.	Station	El	T* = 0 LC** = 80.0	T = 30 LC = 79.5	T = 60 LC = 78.5	T = 90 LC = 76.5	T = 120 LC = 73.6	T = 150 LC = 70.0	T = 180 LC = 67.3	T = 210 LC = 64.3	T = 240 LC = 61.5	T = 270 LC = 58.7	T = 300 LC = 56.0	T = 330 LC = 53.8	T = 360 LC = 51.5	T = 390 LC = 49.2	T = 420 LC = 47.2	T = 450 LC = 45.4	T = 480 LC = 43.5	T = 540 LC = 40.4	T = 600 LC = 37.9	T = 660 LC = 36.8	T = 720 LC = 34.2
Culvert Piezometer Group C																						
2	2+07.50A	21.0	80.0	78.0	75.5	69.7	61.1	57.8	55.8	53.5	51.7	50.0	48.1	46.6	45.0	43.4	47.1	40.9	39.7	37.3	35.8	34.2	33.1
4	2+57.50A	21.0	80.0	78.5	75.8	69.9	61.3	58.0	55.9	53.7	51.8	50.1	48.2	46.7	45.1	43.5	47.2	41.0	39.8	37.5	35.8	34.3	33.2
6	3+07.50A	21.0	80.0	78.5	75.8	69.8	61.0	57.5	55.5	53.3	51.4	49.8	48.0	46.4	44.8	43.2	47.0	40.8	39.7	37.3	35.7	34.2	33.1
8	3+57.50A	21.0	80.0	77.5	73.2	62.7	51.7	48.0	46.8	45.3	44.1	43.3	42.1	41.1	40.0	39.0	38.2	37.5	36.8	35.2	34.1	33.2	32.5
10	4+07.50A	21.0	80.0	77.0	71.3	58.0	44.0	40.7	39.7	38.7	38.2	38.0	37.6	36.8	36.2	35.4	35.1	34.8	34.2	33.5	33.0	32.3	32.0
12	4+57.50A	21.0	80.0	77.3	70.7	55.8	41.8	38.8	38.1	37.3	36.8	37.0	36.8	36.0	35.3	34.8	34.6	34.3	34.1	33.2	33.0	32.3	32.0
14	5+07.50A	21.0	80.0	77.2	69.5	53.0	39.0	36.5	36.0	35.1	35.3	35.6	35.3	34.6	34.3	33.9	33.8	33.7	33.4	32.8	32.5	32.1	32.0
Valve Piezometer Group E																						
1	5+41.00A	26.0	80.0	77.0	69.0	52.1	37.3	34.9	34.5	33.8	33.9	34.3	34.3	33.8	33.7	33.0	33.1	33.0	33.0	32.5	32.3	32.0	31.9
2	5+44.00A	16.0	80.0	77.5	69.6	52.7	38.0	35.7	35.1	34.4	34.6	34.9	34.8	34.1	33.9	33.4	33.4	33.3	33.0	32.7	32.5	32.1	32.0
3	5+49.00A	16.0	80.0	76.5	68.9	52.1	37.5	35.0	34.6	34.0	34.1	34.5	34.3	33.8	33.4	33.0	33.0	33.0	32.8	32.2	32.1	31.9	31.8
4	5+59.50A	16.0	80.0	75.3	66.0	48.3	36.5	34.3	34.0	33.3	33.5	33.9	33.8	33.2	33.0	32.8	32.7	32.6	32.2	32.0	32.0	31.8	31.8
5	5+63.50A	16.0	32.0	51.2	57.0	44.5	36.7	34.5	34.2	33.5	33.8	34.0	33.9	33.4	33.1	32.9	32.8	32.8	32.6	31.1	32.1	31.9	31.8
6	5+67.60A	16.0	32.0	27.8	28.0	35.2	36.0	33.8	33.6	32.9	33.1	33.5	33.4	33.0	32.8	32.4	32.4	32.4	32.4	32.0	32.0	31.8	31.7
7	5+73.50A	26.0	32.0	28.9	28.8	28.8	32.2	32.2	32.0	31.8	31.8	32.0	32.0	32.0	31.9	31.8	31.7	31.8	31.8	31.5	31.6	31.5	31.5
8	5+75.50A	16.0	32.0	26.0	20.3	22.0	35.3	33.0	33.0	32.1	32.6	33.0	33.0	32.8	32.4	32.1	32.1	32.2	32.1	31.9	31.9	31.7	31.7
9	5+79.50A	16.0	32.0	26.5	22.0	21.1	35.3	33.0	33.0	32.1	32.6	33.0	33.0	32.8	32.5	32.1	32.1	32.2	32.1	32.0	31.9	31.7	31.7
10	5+83.50A	16.0	32.0	26.3	22.1	20.3	34.9	32.9	32.8	32.0	32.2	32.8	32.8	32.6	32.3	32.0	32.0	32.1	32.0	31.9	31.8	31.5	31.5
11	5+87.50A	16.0	32.0	27.5	23.8	20.8	35.0	33.0	32.9	32.0	32.3	32.9	32.9	32.8	32.5	32.1	32.1	32.2	32.1	32.0	31.9	31.8	31.7
12	5+88.50A	26.0	32.0	28.0	26.4	26.4	32.3	32.0	32.0	31.3	31.7	32.0	32.0	31.8	31.7	31.4	31.3	31.4	31.3	31.0	31.1	31.0	31.0
13	5+91.50A	16.0	32.0	27.8	24.0	20.0	34.5	32.8	32.6	32.0	32.2	32.8	32.8	32.5	32.3	32.0	32.0	32.1	32.0	31.9	31.8	31.7	31.5
Outlet Piezometer Group F																						
1	7+06.00A	5.0	32.0	31.8	31.3	28.5	28.3	28.8	28.8	28.3	29.3	30.0	30.2	30.0	30.1	30.2	30.7	30.8	30.9	31.0	31.3	31.3	31.4
2	6+98.00A	5.0	32.0	33.0	34.0	36.0	36.0	33.6	33.3	32.8	33.1	33.4	33.2	32.9	32.8	32.2	32.5	32.2	32.2	32.0	32.0	31.7	31.6
3	7+23.00A	5.0	32.0	32.8	33.1	34.0	34.0	32.0	31.0	31.9	31.5	31.6	31.9	31.4	31.4	31.1	31.6	31.5	31.6	31.3	31.3	31.3	31.3
4	7+23.00A	5.0	32.0	32.0	31.7	32.0	30.0	28.8	28.7	28.7	29.1	30.0	29.9	30.0	30.0	30.0	30.5	30.7	30.9	31.0	31.0	31.2	31.3

Note: Elevations are in feet referred to mean sea level.
Two-min valve schedule II empties lock in 14.2 min.
* T is time (in prototype seconds) after beginning of emptying operation.
** LC is elevation of water surface in lock chamber.

Table 13

Details of Culvert Arrangement Types 25-40, Jones Bluff Lock

Culvert Arrangement Type	No. of Port Pairs	Center-to-Center Port Spacing ft	Port Area/ Culvert Area Ratio	Stations of Ports in Culverts				Percent of Lock Chamber				
				Upstream Group		Downstream Group		Upstream		Center	Downstream	
				Upstream Port	Downstream Port	Upstream Port	Downstream Port	Without Ports	With Ports	Without Ports	With Ports	Without Ports
25	10	14	1.30	166.5	292.5	353.5	479.5	25.4	19.3	9.3	19.3	26.7
26	8	14	1.04	194.5	292.5	353.5	451.5	29.7	15.0	9.3	15.0	31.0
27	8	14	1.04	180.5	276.5	367.5	465.5	27.5	15.0	13.6	15.0	28.9
28	8	14	1.04	166.5	264.5	381.5	479.5	25.4	15.0	17.8	15.0	26.8
29	8	14	1.04	152.5	250.5	395.5	493.5	23.3	15.0	22.0	15.0	24.7
30	8	14	1.04	138.5	236.5	409.5	507.5	21.1	15.0	26.4	15.0	22.5
31	8	14	1.04	124.5	222.5	423.5	521.5	19.0	15.0	30.6	15.0	20.4
32	8	14	1.04	110.5	208.5	437.5	535.5	16.9	15.0	35.0	15.0	18.1
33	8	14	1.04	96.5	194.5	451.5	549.5	14.7	15.0	39.2	15.0	16.1
34	8	28	1.04	96.5	292.5	353.5	549.5	14.7	29.9	9.4	29.9	16.1
35	7	28	0.91	110.5	278.5	367.5	535.5	16.9	25.6	13.6	25.6	18.3
36	7	28	0.91	124.5	292.5	353.5	521.5	19.1	25.6	9.3	25.6	20.4
37	7	14	0.91	152.5	250.5	409.5	493.5	23.3	12.8	26.4	12.8	24.7
38	7	14	0.91	152.5	236.5	409.5	493.5	23.3	12.8	26.4	12.8	24.7
39	7	14	0.91	152.5	236.5	409.5	493.5	23.3	12.8	26.4	12.8	24.7
40	7	14	0.91	138.5	222.5	423.5	507.5	21.1	12.8	30.7	12.8	22.5

Note: The type A port (1.25 ft wide by 4.0 ft high) was used in arrangement types 25-40.
The lock chamber is 84 ft wide by 655 ft long.
The stations in feet are measured from the upstream miter gate pintles.
The floor culverts are each 11.0 ft wide by 7.0 ft high.

Table 14

Filling Characteristics, Types 25-40 Culvert Arrangements

Jones Bluff Lock

Upper Pool El 77.0 and Lower Pool El 32.0

Culvert Arrangement Type	Filling Time min	Maximum Hawser Stresses: Longitudinal, Upstream, Pull tons	Longitudinal, Upstream, Time min	Longitudinal, Downstream, Pull tons	Longitudinal, Downstream, Time min	Upstream Transverse, Left, Pull tons	Upstream Transverse, Left, Time min	Upstream Transverse, Right, Pull tons	Upstream Transverse, Right, Time min	Downstream Transverse, Left, Pull tons	Downstream Transverse, Left, Time min	Downstream Transverse, Right, Pull tons	Downstream Transverse, Right, Time min
25	10.3	5.3	4.2	3.0	4.3	2.5	4.3	2.2	4.6	2.5	4.4	2.3	4.3
26	10.4	6.0	0.3	3.1	2.0	2.1	2.3	2.0	3.8	2.0	2.4	2.0	2.5
27	10.4	5.6	3.6	2.9	0.3	2.0	2.3	1.8	2.1	2.0	3.3	1.8	3.2
28	10.4	4.6	1.9	2.9	1.8	2.5	2.6	1.9	2.5	2.0	2.6	2.1	2.7
29	10.4	4.7	2.7	2.5	3.8	1.6	3.0	1.1	5.3	1.5	2.5	1.1	3.3
30	10.5	3.9	1.8	2.6	5.3	1.3	2.6	1.2	1.5	1.2	1.6	1.4	1.5
31	10.5	3.9	2.6	2.7	5.3	1.5	2.2	1.2	2.1	1.6	1.3	1.2	3.4
32	10.6	4.0	1.8	2.5	4.6	1.6	2.8	1.6	1.7	2.1	2.3	1.3	2.8
33	10.6	4.2	1.8	2.7	6.2	1.0	2.7	1.7	2.2	1.7	2.1	1.3	2.6
34	10.5	5.2	2.6	3.4	5.8	2.7	2.9	1.9	2.0	2.4	3.0	2.0	3.5
35	10.6	4.6	3.2	2.7	4.8	1.6	2.2	1.4	2.0	1.6	2.9	2.0	2.1
36	10.5	4.3	3.7	2.9	3.1	1.9	2.2	1.9	1.9	2.2	2.1	2.1	2.0
37	10.7	4.3	2.0	2.0	0.3	1.6	1.6	1.6	2.8	2.5	2.9	1.4	2.8
38	10.9	3.7	1.8	2.1	5.7	2.3	2.8	1.1	3.0	2.1	2.4	1.2	1.7
39	10.8	5.1	2.6	2.5	5.9	2.3	2.2	1.2	1.9	2.7	3.0	2.3	2.4
40	10.9	4.1	6.0	2.3	6.3	1.8	2.8	1.3	2.9	1.6	4.6	1.4	4.7

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II and 2-min valve time were used.
Six-barge tow (5410 tons displacement at 9-ft draft) positioned 327 ft downstream from upper miter gate pintles.

Table 15

Details of Culvert Arrangement Types 41-56, Jones Bluff Lock

Culvert Arrangement Type	Port Type	No. of Ports	Stations of Ports in Culverts				Percent of Lock Chamber				
			Upstream Group		Downstream Group		Upstream		Center	Downstream	
			Upstream Port	Downstream Port	Upstream Port	Downstream Port	Without Ports	With Ports	Without Ports	With Ports	Without Ports
41	A	7	152.5	236.5	409.5	493.5	23.3	12.8	26.4	12.8	24.7
42	A	7	166.5	250.5	395.5	479.5	25.4	12.8	22.1	12.8	26.9
43	A	7	138.5	222.5	423.5	507.5	21.1	12.8	30.6	12.8	22.7
44	A	7	124.5	208.5	437.5	521.5	19.0	12.8	34.9	12.8	20.5
45	A	7	110.5	194.5	451.5	535.5	16.9	12.8	39.1	12.8	18.4
46	D	14	110.5	292.5	353.5	535.5	16.9	27.8	9.1	27.8	18.4
47	D	14	96.5	278.5	367.5	549.5	14.7	27.8	13.4	27.8	16.3
48	D	14	82.5	264.5	381.5	563.5	12.6	27.8	17.7	27.8	14.1
49	D	14	68.5	250.5	395.5	577.5	10.5	27.8	21.9	27.8	12.0
50	D	14	54.5	236.5	409.5	591.5	8.3	27.8	26.3	27.8	9.8
51	E	10	152.5	278.5	367.5	493.5	23.3	19.2	13.6	19.2	24.7
51	E	10	138.5	264.5	381.5	507.5	21.1	19.2	17.7	19.2	22.7
53	E	10	124.5	250.5	395.5	521.5	19.0	19.2	22.1	19.2	20.5
54	E	10	110.5	236.5	409.5	535.5	16.9	19.2	26.3	19.2	18.4
55	E	10	96.5	222.5	423.5	549.5	14.7	19.2	30.6	19.2	16.3
56	E	10	82.5	208.5	437.5	563.5	12.6	19.2	34.9	19.2	14.1

Note: The type A port is 1.25 ft wide by 4.0 ft high.
The type D port is 1.25 ft wide by 2.0 ft high.
The type E port is 1.25 ft high by 2.8 ft high.
All ports are spaced 14 ft on centers.
The lock chamber is 84 ft wide by 655 ft long.
The stations in feet are measured from the upstream miter gate pintles.
The port-to-culvert area ratio = 0.91.

Table 16

Filling Characteristics, Types 41-56 Culvert Arrangements

Jones Bluff Lock

Upper Pool El 77.0 and Lower Pool El 32.0

Culvert Arrangement Type	Filling Time min	Maximum Hawser Stresses: Longitudinal: Upstream: Pull tons	Upstream: Time min	Downstream: Pull tons	Downstream: Time min	Upstream Transverse: Left: Pull tons	Left: Time min	Right: Pull tons	Right: Time min	Downstream Transverse: Left: Pull tons	Left: Time min	Right: Pull tons	Right: Time min
41	10.8	3.8	1.9	1.6	5.6	1.8	2.3	0.8	2.6	1.5	2.9	1.5	3.6
42	10.8	4.3	3.3	2.3	4.8	1.2	2.1	2.0	2.0	2.3	2.1	1.8	3.1
43	10.8	3.9	1.9	1.3	0.7	1.6	2.1	1.5	2.2	2.3	2.1	2.3	2.0
44	10.8	4.1	1.9	1.6	4.4	1.4	1.6	1.3	2.0	1.8	1.6	1.6	5.2
45	10.8	4.5	1.8	1.6	4.4	2.1	2.5	2.3	2.4	2.3	2.3	2.0	1.9
46	10.8	4.5	1.3	2.7	5.6	0.8	3.0	1.2	3.1	1.6	2.7	1.4	2.9
47	10.8	5.8	3.3	2.7	7.4	1.6	5.1	1.4	5.2	2.3	5.2	1.8	5.1
48	10.8	5.3	1.8	2.3	4.1	1.4	2.9	1.4	3.0	1.4	2.3	1.4	3.3
49	10.8	4.9	5.7	3.1	5.5	1.0	3.6	1.4	3.3	1.6	3.2	1.2	3.7
50	10.8	5.3	1.8	3.1	5.5	1.6	3.0	1.2	1.8	1.6	3.2	1.0	2.4
51	10.8	5.1	4.1	3.1	3.5	2.0	2.2	1.8	2.1	2.1	2.2	2.1	2.3
52	10.8	3.9	1.9	1.8	5.1	1.5	3.5	1.6	3.2	1.8	3.3	1.6	3.4
53	10.8	3.5	1.9	1.8	0.3	1.2	2.5	1.0	5.0	1.4	2.4	1.4	1.8
54	10.8	3.8	1.9	1.4	0.3	1.2	1.7	0.9	2.9	1.4	1.8	0.8	2.6
55	10.8	4.9	1.7	2.4	5.1	1.4	3.1	2.0	3.0	1.5	2.9	2.0	3.0
56	10.8	6.2	2.6	3.0	3.7	1.2	2.6	1.6	2.1	1.7	2.2	2.1	3.0

Note: Six-barge tow (5410-ton displacement at 9-ft draft) positioned 327 ft downstream from the upper miter gate pintles.
Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II and 2-min valve time were used.

Table 17

Filling and Emptying Characteristics, Types 41 (Recommended) and 53 Culvert Arrangements

Jones Bluff Lock

Upper Pool El 77.0 and Lower Pool El 32.0

Culvert Arrangement Type	No. of Barges	Distance Between Tow and Upstream Miter Gate Pintles ft	Valve Time min	Filling or Emptying Time min	Maximum Hawser Stresses: Longitudinal, Upstream, Pull tons	Longitudinal, Upstream, Time min	Longitudinal, Downstream, Pull tons	Longitudinal, Downstream, Time min	Upstream Transverse, Left, Pull tons	Upstream Transverse, Left, Time min	Upstream Transverse, Right, Pull tons	Upstream Transverse, Right, Time min	Downstream Transverse, Left, Pull tons	Downstream Transverse, Left, Time min	Downstream Transverse, Right, Pull tons	Downstream Transverse, Right, Time min
				Filling Operation												
41	12 (11,305 tons)	47	1	10.2	2.9	4.9	4.1	2.1	3.1	1.6	3.1	1.5	3.5	1.4	2.3	1.4
			2	10.8	3.3	4.1	3.5	3.0	2.7	2.3	2.7	2.4	2.1	2.2	2.8	2.8
			4	11.8	2.9	6.4	3.5	5.4	0.8	5.2	2.9	4.1	2.0	3.0	3.0	4.7
			8	13.8	2.0	8.1	3.1	8.4	0.8	4.3	2.9	6.6	1.4	6.7	1.6	8.1
41	6 (5410 tons)	47	1	10.2	2.1	6.9	4.7	1.4	1.8	1.5	2.0	1.6	1.2	1.1	3.5	1.6
			2	10.8	1.6	7.0	3.9	1.9	1.2	2.0	1.6	4.4	1.2	6.7	2.7	4.0
			4	11.8	1.2	10.5	3.1	6.0	1.6	3.8	1.2	3.7	1.2	3.8	2.0	3.9
			8	13.8	1.2	9.6	2.9	9.4	0.8	9.5	0.8	9.6	0.8	9.0	0.8	8.9
41	6 (5410 tons)	327	1	10.2	4.2	[illegible]	2.8	5.6	2.1	2.3	1.4	2.4	1.9	0.9	1.6	2.6
			2	10.8	3.8	1.9	1.6	5.6	1.8	2.3	0.8	2.6	1.5	2.9	1.5	3.6
			4	11.8	2.9	3.7	1.6	9.3	1.2	3.9	0.8	2.5	1.6	4.6	1.1	4.5
			8	13.8	2.7	9.0	1.5	8.9	1.0	7.2	0.8	5.8	1.6	7.4	1.0	7.2
				Emptying Operation												
41	12 (11,305 tons)	47	1	13.2	1.5	4.2	1.5	4.5	1.1	5.9	1.2	5.7	1.0	6.1	1.2	5.8
			2	13.6	1.4	5.3	1.4	5.1	1.0	5.3	1.0	5.7	0.8	7.1	0.8	7.4
			4	14.7	1.2	4.6	1.2	4.8	1.2	2.6	0.8	2.7	1.2	4.0	0.8	3.7
			8	16.7	1.2	8.7	1.2	7.2	1.6	11.5	1.0	6.7	0.6	8.7	0.6	8.5
41	6 (5410 tons)	47	1	13.2	1.6	2.0	1.6	1.6	0.8	5.1	0.8	2.4	0.8	1.3	0.8	2.4
			2	13.6	1.6	2.5	1.6	2.4	0.8	4.5	0.8	3.7	0.8	4.4	0.8	3.4
			4	14.7	1.6	3.0	1.6	3.4	0.8	6.7	0.8	1.2	0.8	4.4	0.8	4.3
			8	16.7	1.6	6.9	1.6	7.0	1.0	4.7	1.0	4.1	1.2	3.7	1.2	4.1
41	6 (5410 tons)	327	1	13.2	2.0	1.3	2.0	1.5	1.2	1.7	1.4	2.3	1.2	2.0	1.1	2.1
			2	13.6	1.9	0.9	1.8	2.2	1.0	1.5	0.9	1.6	0.8	2.8	1.1	2.9
			4	14.7	1.6	2.5	1.6	1.1	1.1	1.2	0.9	1.4	0.9	1.3	1.0	1.4
			8	16.7	1.5	1.6	1.6	1.9	1.0	2.7	1.0	2.6	1.2	2.7	1.0	2.3
				Filling Operation												
53	12 (11,305 tons)	47	1	10.3	4.0	4.0	4.2	4.4	4.2	1.5	1.8	1.6	3.8	1.5	2.9	1.6
			2	10.8	3.5	3.9	4.1	4.1	2.5	4.1	1.4	4.0	2.5	2.3	1.8	3.3
			4	11.8	2.5	6.4	3.5	4.3	1.6	5.2	1.6	3.1	2.0	3.0	1.2	2.9
			8	13.8	2.3	6.9	3.1	7.2	1.4	6.0	0.8	8.3	1.2	5.8	1.0	5.9
53	6 (5410 tons)	47	1	10.3	1.9	7.2	4.8	1.3	2.1	2.3	1.0	1.5	1.8	1.0	1.6	1.1
			2	10.8	1.2	7.4	4.3	1.8	2.0	2.1	1.2	1.7	1.6	1.6	1.6	1.7
			4	11.8	0.8	9.4	2.7	3.4	1.6	4.7	0.8	4.9	1.6	3.2	1.2	3.3
			8	13.8	0.4	7.0	2.3	6.7	0.8	5.5	0.4	6.1	0.8	7.1	0.8	7.0
53	6 (5410 tons)	327	1	10.3	4.6	0.9	2.4	0.2	1.5	1.4	1.2	1.6	2.3	1.4	1.2	0.8
			2	10.8	3.5	3.5	1.6	0.2	1.3	3.0	1.2	4.1	1.2	3.0	1.2	3.1
			4	11.8	2.7	3.6	1.2	6.6	1.6	3.2	0.8	3.3	1.6	3.4	1.2	5.0
			8	13.8	2.0	7.1	1.2	7.0	0.8	5.8	0.8	5.3	0.8	5.5	0.8	5.4
				Emptying Operation												
53	12 (11,305 tons)	47	1	13.2	1.8	1.4	1.9	1.1	1.6	5.4	1.1	5.6	1.6	6.4	1.6	5.2
			2	13.7	1.8	5.4	1.8	5.3	1.6	4.8	1.2	4.7	1.6	5.2	1.6	4.9
			4	14.7	1.6	5.4	1.8	5.2	1.0	5.5	0.8	8.6	1.2	8.3	1.2	8.2
			8	16.7	1.4	8.9	1.6	8.6	1.2	9.7	1.0	10.8	1.2	7.3	1.2	7.1
53	6 (5410 tons)	47	1	13.2	2.3	7.2	2.3	1.5	1.2	11.3	1.3	11.4	1.6	11.4	1.6	12.2
			2	13.7	2.3	2.8	2.3	2.9	1.2	7.1	1.2	7.0	1.5	6.1	1.6	3.7
			4	14.7	2.0	6.8	2.0	5.1	1.2	6.1	1.2	6.2	1.6	4.7	1.6	6.5
			8	16.7	2.0	7.9	2.0	8.0	1.2	7.9	0.8	6.5	1.6	6.0	1.2	7.6
53	6 (5410 tons)	327	1	13.2	2.2	0.8	2.3	5.6	1.1	5.3	1.1	0.8	1.2	3.2	1.2	4.7
			2	13.7	2.2	7.5	2.3	7.3	0.8	3.3	1.0	2.9	0.8	3.3	1.2	3.4
			4	14.7	2.3	1.5	2.3	1.4	1.0	1.2	0.8	3.2	1.2	2.5	1.2	3.6
			8	16.7	2.0	8.0	2.2	8.1	1.0	2.8	1.2	4.1	1.6	[illegible]	1.2	4.6

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves. Valve opening schedule II was used.

Table 18

Filling Characteristics for Range of Operation Conditions

Type 41 (Recommended) Culvert Arrangement

Jones Bluff Lock

					Maximum Hawser Stresses											
					Longitudinal				Upstream Transverse				Downstream Transverse			
					Upstream		Downstream		Left		Right		Left		Right	
Head ft	Lower Pool El	Upper Pool El	Valve Time min	Filling Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min
					Submergence 14 ft											
69	32.0	101.0	1	12.8	6.2	1.0	3.1	3.0	3.8	1.5	2.1	1.6	3.5	1.4	2.1	1.3
			2	13.4	5.3	1.9	2.0	4.4	2.0	2.0	2.6	1.8	2.6	1.8	2.0	1.6
			4	14.3	4.0	4.0	2.1	3.9	1.4	3.6	1.1	4.1	2.0	4.0	1.6	3.9
			8	16.3	3.1	7.0	1.7	7.2	0.8	7.1	0.8	4.9	1.1	7.3	1.2	7.2
58	32.0	90.0	1	11.6	5.9	2.1	2.7	0.2	2.7	1.1	2.8	1.3	3.1	1.2	2.6	1.7
			2	12.1	5.1	1.9	1.7	0.3	3.4	2.2	1.9	1.9	2.9	2.0	2.3	2.1
			4	13.1	3.2	6.1	1.6	6.9	1.8	3.8	1.5	3.6	2.1	3.7	1.5	6.3
			8	15.1	2.8	6.8	1.6	6.7	1.5	7.3	1.1	7.4	1.2	8.8	1.2	8.9
48	32.0	80.0	1	10.4	4.9	1.0	2.1	0.2	1.8	1.1	1.2	1.8	1.9	1.4	1.9	2.7
			2	10.9	4.1	1.8	1.4	0.3	1.8	2.2	1.7	2.3	2.0	2.6	1.4	1.5
			4	11.9	3.1	5.1	1.6	5.9	1.5	2.8	0.9	3.0	2.0	4.1	1.2	4.0
			8	13.9	2.5	6.3	1.5	12.1	1.1	7.1	0.6	8.2	1.2	6.3	1.4	6.8
38	32.0	70.0	1	9.3	3.7	1.4	2.9	5.0	2.3	1.6	2.0	1.8	2.3	1.8	2.1	1.7
			2	9.8	3.5	1.9	1.6	1.3	1.8	2.9	1.6	2.8	1.6	3.0	1.6	2.9
			4	10.9	3.1	4.0	1.6	6.5	1.2	3.3	1.2	2.7	1.2	5.0	1.0	2.6
			8	12.9	2.1	6.2	1.4	10.5	1.0	8.2	1.0	8.1	1.2	8.2	1.2	8.6
					Submergence 17 ft											
58	35.0	93.0	1	11.4	6.2	1.7	3.1	6.4	1.6	1.6	2.0	1.8	2.7	1.6	2.3	1.7
			2	11.9	4.7	2.5	2.6	6.1	1.4	1.8	1.6	4.4	1.8	1.8	1.4	4.5
			4	12.9	4.2	4.0	1.7	4.2	1.0	4.8	1.2	3.5	1.6	3.4	1.2	3.3
			8	15.0	3.1	7.3	1.6	7.6	0.8	7.4	0.9	7.5	1.1	5.0	0.8	10.0
48	35.0	83.0	1	10.4	5.1	1.7	2.3	0.6	1.8	1.1	1.4	1.3	1.5	1.2	1.6	1.1
			2	10.9	3.6	1.8	1.6	0.7	1.2	1.8	1.0	3.4	1.0	3.6	1.3	3.5
			4	11.9	3.0	3.4	1.4	6.1	1.2	5.5	1.1	4.8	1.2	5.6	1.5	5.5
			8	13.8	2.1	10.2	1.5	10.5	0.9	6.0	0.7	9.1	0.8	8.3	1.1	6.8
38	35.0	73.0	1	9.1	4.0	1.3	1.7	0.7	1.4	1.9	1.1	1.8	1.3	1.7	1.3	1.8
			2	9.6	2.9	2.2	1.2	0.3	1.3	2.1	0.9	2.2	2.0	2.1	1.3	2.0
			4	10.6	3.0	4.8	0.9	6.2	0.7	4.2	0.8	5.0	0.8	4.5	0.8	4.7
			8	12.6	1.9	7.7	0.7	6.4	0.6	7.2	0.5	5.1	0.7	5.3	0.7	7.4
					Submergence 20 ft											
58	38.0	96.0	1	11.5	5.0	1.3	2.0	0.2	1.8	1.0	1.4	1.6	1.8	1.0	1.5	1.7
			2	12.0	4.2	2.4	2.0	9.7	1.2	1.6	1.8	2.6	1.2	2.5	1.6	2.6
			4	13.1	3.2	7.1	1.9	6.5	1.1	8.2	0.9	3.8	1.3	4.1	1.1	3.9
			8	15.1	2.9	6.5	1.7	6.2	0.7	5.4	0.9	7.1	1.1	6.3	1.1	7.7
48	38.0	86.0	1	10.4	4.8	1.3	2.1	0.2	1.2	1.6	1.6	1.8	1.6	1.3	1.8	1.7
			2	10.9	3.9	2.1	2.5	6.0	1.1	2.1	1.1	4.9	1.2	4.5	2.0	4.6
			4	11.9	3.4	3.8	2.3	5.3	0.9	3.9	1.4	4.7	1.3	3.5	1.4	5.3
			8	13.8	2.1	7.8	1.3	9.5	0.9	5.6	1.0	5.7	0.9	5.1	1.3	5.0
38	38.0	76.0	1	9.3	4.0	1.2	2.2	4.8	1.2	3.8	1.4	2.7	1.4	1.4	1.6	2.8
			2	9.8	3.3	2.0	1.5	5.1	0.8	1.8	0.9	1.9	1.1	3.5	1.3	3.0
			4	10.9	3.1	4.1	1.2	9.3	0.8	7.6	1.1	4.7	0.9	3.8	0.9	4.8
			8	12.9	2.3	8.5	1.7	8.8	0.9	8.4	0.5	6.5	0.7	6.8	0.9	10.0

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II was used.
Six-barge tow positioned 327 ft below upstream miter gate pintles (5410 tons displacement).

Table 19

Emptying Characteristics for Range of Operation Conditions

Type 41 (Recommended) Culvert Arrangement

Jones Bluff Lock

					Maximum Hawser Stresses											
					Longitudinal				Upstream Transverse				Downstream Transverse			
	Lower	Upper	Valve	Emptying	Upstream		Downstream		Left		Right		Left		Right	
Head	Pool	Pool	Time	Time	Pull	Time	Pull	Time	Pull	Time	Pull	Time	Pull	Time	Pull	Time
ft	El	El	min	min	tons	min	tons	min	tons	min	tons	min	tons	min	tons	min
Submergence 14 ft																
58	32.0	90.0	1	14.9	2.3	0.7	1.8	1.6	1.5	3.5	1.5	3.4	1.4	3.4	1.5	3.2
			2	15.4	1.6	6.5	1.8	6.7	1.3	3.6	1.2	3.9	0.9	3.8	1.2	3.9
			4	16.4	1.6	0.9	1.9	1.0	1.3	4.9	1.2	5.9	1.1	4.8	0.9	4.9
			8	18.4	1.7	2.2	1.6	2.1	1.1	3.1	0.7	3.0	1.1	2.4	1.2	2.5
48	32.0	80.0	1	13.6	1.9	0.5	1.6	0.6	0.9	2.0	0.9	2.1	0.9	3.6	1.2	0.6
			2	14.1	2.0	2.0	1.6	1.9	1.0	2.6	0.9	2.2	0.9	2.7	1.4	2.2
			4	15.0	1.6	2.8	1.6	6.3	0.7	1.6	0.8	1.7	0.9	3.2	0.8	1.8
			8	17.1	2.0	5.0	1.5	4.9	0.9	6.6	0.8	5.7	1.1	4.2	1.2	4.1
38	32.0	70.0	1	11.8	2.3	5.6	2.3	5.7	0.8	4.7	0.8	4.8	0.8	4.8	0.8	4.9
			2	12.4	2.3	2.3	2.1	2.4	1.2	2.6	0.8	2.8	1.0	1.3	1.2	1.2
			4	13.4	1.8	3.9	1.6	3.0	1.2	7.2	0.8	7.4	1.0	2.7	1.0	7.3
			8	15.4	2.0	8.0	1.8	9.4	1.0	5.9	1.0	9.0	1.2	6.2	1.0	6.0
Submergence 17 ft																
58	35.0	93.0	1	15.1	2.3	8.1	2.6	1.3	1.2	2.7	1.2	2.6	1.3	8.3	1.2	7.4
			2	15.5	2.1	2.4	2.2	9.8	1.4	2.4	1.6	2.6	1.2	2.9	1.3	2.2
			4	16.5	2.2	2.1	1.9	2.0	1.6	5.0	1.2	4.9	1.4	4.7	1.0	4.8
			8	18.5	2.0	8.7	2.0	8.8	1.4	3.9	1.2	5.4	2.0	6.0	1.6	5.9
48	35.0	83.0	1	13.6	2.7	1.8	3.0	1.9	1.3	0.9	1.0	1.2	1.3	6.8	1.2	7.4
			2	14.0	2.6	2.2	2.6	1.3	1.6	1.5	1.2	1.6	1.5	1.5	1.3	1.6
			4	15.0	2.7	2.8	2.2	2.9	1.3	6.9	1.2	7.0	1.5	6.9	1.4	7.1
			8	17.1	2.0	7.2	1.8	7.9	1.2	2.4	1.0	2.5	1.1	2.5	1.0	2.6
38	35.0	73.0	1	11.9	3.0	0.8	2.3	1.2	1.2	1.2	1.3	4.5	1.4	4.7	1.4	4.6
			2	12.5	2.1	6.8	1.7	4.3	1.0	1.1	1.1	9.4	1.2	1.2	1.0	4.8
			4	13.6	1.6	7.8	1.6	3.2	1.0	2.4	1.1	7.2	1.2	1.5	0.9	7.7
			8	15.4	1.6	3.2	1.4	3.3	1.1	4.6	0.8	6.0	1.4	5.7	0.9	6.1
Submergence 20 ft																
58	38.0	96.0	1	15.0	2.3	2.1	2.0	2.0	0.8	1.0	1.0	1.3	0.9	2.4	0.9	7.0
			2	15.6	2.0	8.2	1.8	8.3	0.7	1.1	1.1	3.1	1.0	3.2	1.1	2.7
			4	16.4	2.1	1.6	2.0	1.7	1.1	2.1	1.1	2.2	0.9	2.3	1.1	4.0
			8	18.4	2.0	3.0	1.7	4.7	1.1	2.5	0.9	2.4	1.2	2.4	0.9	2.5
48	38.0	86.0	1	13.6	2.0	6.8	2.0	6.7	0.9	2.0	0.9	5.7	0.8	1.8	1.0	6.2
			2	14.1	1.9	8.2	1.8	6.9	0.9	2.8	0.7	6.2	0.7	7.3	0.8	7.9
			4	15.1	1.6	12.2	1.6	12.1	0.7	3.6	0.8	6.2	0.8	3.9	0.8	7.1
			8	17.1	1.6	1.5	1.3	1.4	0.8	6.3	0.9	6.6	1.1	6.0	1.0	5.6
38	38.0	76.0	1	12.1	2.0	6.2	2.0	6.6	0.7	6.1	0.7	9.7	0.9	3.6	0.8	3.5
			2	12.6	1.7	2.1	1.6	1.0	0.6	6.5	0.8	1.2	1.0	7.1	0.8	5.9
			4	13.6	2.0	3.2	1.8	3.3	0.7	2.0	0.6	7.7	0.8	4.1	0.8	3.6
			8	15.6	2.0	7.3	1.8	7.2	1.2	7.7	0.7	2.9	1.8	7.6	1.2	8.1

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valves.
Valve opening schedule II was used.
Six-barge tow positioned 327 ft below upstream miter gate pintles (5410 tons displacement).

Table 20

Effect of Single-Valve Operation on Filling Characteristics

Type 41 (Recommended) Culvert Arrangement

Jones Bluff Lock

No. of Barges	Distance Between Tow and Upstream Miter Gate Pintles ft	Valve Time min	Filling Time min	Maximum Hawser Stresses											
				Longitudinal				Upstream Transverse				Downstream Transverse			
				Upstream		Downstream		Left		Right		Left		Right	
				Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min	Pull tons	Time min
				45-ft Head, 14-ft Submergence											
12 (11,305 tons)	47	1	18.2	7.4	2.2	6.1	3.4	1.6	2.8	3.5	1.4	2.0	2.3	2.3	2.9
		2	18.6	6.3	4.3	4.6	3.6	1.8	2.4	2.7	2.5	1.6	3.2	3.0	2.5
		4	19.7	5.4	4.8	3.7	4.9	1.1	4.6	2.0	4.9	1.4	5.0	1.6	5.6
		8	21.8	4.8	9.1	3.8	9.9	1.2	8.8	1.8	8.6	1.6	7.1	1.3	9.8
				69-ft Head, 14-ft Submergence											
12 (11,305 tons)	47	1	21.8	7.6	1.3	6.6	6.8	1.0	4.2	2.4	0.9	2.9	1.9	2.1	2.8
		2	22.4	6.4	3.0	5.3	3.3	1.2	4.9	2.4	2.9	2.0	3.0	2.9	2.9
		4	23.4	4.8	7.6	4.2	7.4	0.8	4.8	2.0	3.8	2.3	4.4	2.3	4.5
		8	25.4	4.5	7.4	3.9	7.2	0.8	9.5	1.1	7.1	1.1	7.4	1.6	6.2
6 (5410 tons)	327	1	21.8	6.4	1.1	3.9	7.9	1.8	1.6	2.5	1.5	2.6	1.5	2.0	1.6
		2	22.4	4.7	3.6	3.1	3.7	1.7	4.2	1.8	2.2	1.9	4.1	1.9	2.4
		4	23.4	4.6	4.8	3.0	5.7	2.1	3.6	2.0	3.7	2.0	3.9	1.6	3.5
		8	25.4	3.9	7.3	3.2	10.4	1.0	8.3	0.8	7.5	1.2	8.4	1.3	7.2

Note: Time listed under hawser stresses is time of occurrence after beginning of movement of valve.
Valve schedule II was used.
The land-wall valves remained closed during both filling and emptying.
At 69-ft head, lock empties in 28.5 min using a 1-min valve with hawser stresses not exceeding 2.5 tons.
At 45-ft head, emptying hawser stresses did not exceed 1.5 tons.

Table 21

Average Piezometer Readings During Filling Operation, Type 41 (Recommended) Culvert Arrangement, Jones Bluff Lock

Initial Head 45.0 ft (Upper Pool El 77.0 and Lower Pool El 32.0)

Piezometer Locations			Average Piezometer Reading, in Prototype Elevation																				
Piez No.	Station	El	T* = 0 LC** = 32.0	T = 30 LC = 32.1	T = 60 LC = 33.1	T = 90 LC = 35.2	T = 120 LC = 39.0	T = 150 LC = 43.0	T = 180 LC = 46.4	T = 210 LC = 49.7	T = 240 LC = 52.8	T = 270 LC = 56.1	T = 300 LC = 59.1	T = 330 LC = 61.7	T = 360 LC = 64.2	T = 390 LC = 66.7	T = 420 LC = 68.3	T = 450 LC = 70.0	T = 510 LC = 73.1	T = 570 LC = 75.0	T = 630 LC = 76.0	T = 690 LC = 76.5	T = 750 LC = 77.1
Intake Piezometer Group A																							
1	0+54B	25.0	77.0	76.9	76.3	75.0	73.4	74.0	74.2	74.3	74.8	75.0	75.4	75.5	75.9	76.1	76.2	76.3	76.7	76.9	76.9	77.0	77.0
2	0+54B	25.0	77.0	76.3	74.6	70.1	64.9	66.8	67.5	68.1	69.2	70.1	71.5	72.1	73.0	73.7	74.0	74.9	75.8	76.4	76.8	76.9	77.0
3	0+34.5B	25.0	77.0	76.1	74.6	69.5	63.7	64.8	65.6	67.0	68.1	69.8	70.9	71.5	72.3	73.5	73.5	74.5	75.8	76.4	76.7	76.9	77.0
4	0+15A	22.5	77.0	76.0	73.9	67.5	60.1	62.0	63.2	64.4	66.0	67.7	69.1	70.0	71.3	72.4	73.0	73.9	75.3	76.2	76.5	76.9	77.0
5	0+34.5B	25.0	77.0	76.9	76.4	75.0	73.4	73.8	74.1	74.3	74.7	75.0	75.3	75.5	75.9	76.1	76.2	76.3	76.7	76.9	76.9	77.0	77.0
6	0+15A	22.5	77.0	76.6	74.8	69.0	61.5	62.3	64.0	65.3	66.1	67.9	69.2	70.7	71.4	73.0	73.2	74.0	75.4	76.4	76.4	76.9	77.1
Filling-Valve Piezometer Group B																							
1	0+85A	24.0	77.0	76.6	72.5	62.7	48.9	50.4	53.3	56.8	58.2	60.6	63.3	65.7	67.0	69.5	70.5	72.0	74.1	75.9	76.5	77.0	77.2
2	0+88A	14.0	77.0	76.6	72.4	62.8	49.7	51.0	53.9	57.1	58.7	61.0	63.7	65.9	67.1	69.6	70.5	72.0	74.1	75.9	76.4	76.9	77.1
3	1+08A	14.0	32.0	60.0	62.3	52.2	48.5	50.5	53.2	56.8	58.3	60.6	63.4	65.8	67.0	69.4	70.5	72.0	74.0	75.8	76.3	76.7	77.0
4	1+10A	14.0	32.0	32.8	50.7	47.3	48.3	50.4	53.0	56.7	58.1	60.4	63.2	65.7	67.0	69.3	70.5	72.0	74.0	75.8	76.3	76.8	77.1
5	1+12A	14.0	32.0	28.6	34.7	40.6	48.0	50.0	52.8	56.3	58.0	60.2	63.1	65.5	66.9	69.1	70.5	72.0	73.9	75.4	76.1	76.5	77.0
6	1+14A	14.0	32.0	27.9	25.6	33.8	47.9	49.8	52.5	56.1	57.8	60.0	63.0	65.4	66.8	69.1	70.5	72.0	74.0	75.8	76.3	76.9	77.1
7	1+14A	24.0	32.0	25.9	19.9	17.9	47.2	48.8	51.4	55.4	57.1	59.1	62.5	64.9	66.4	68.8	70.4	71.7	73.9	75.7	76.2	76.9	77.0
8	1+16A	14.0	32.0	27.7	23.0	28.8	47.8	49.6	52.2	56.0	57.7	59.9	62.9	65.2	66.7	69.0	70.4	71.7	74.0	75.7	76.2	76.9	77.0
9	1+18A	14.0	32.0	27.3	22.1	25.3	47.7	49.4	52.1	55.9	57.6	59.8	62.8	65.2	66.7	69.0	70.4	71.7	74.0	75.7	76.2	76.9	77.1
10	1+20A	14.0	32.0	26.7	21.1	22.9	47.3	49.0	51.9	55.7	57.3	59.5	62.7	65.0	66.6	68.9	70.4	71.5	74.0	75.7	76.1	76.9	77.0
11	1+19A	24.0	32.0	25.7	20.2	19.4	48.1	49.7	52.1	56.0	57.8	59.7	62.9	65.4	66.8	69.0	70.6	71.8	74.0	75.8	76.1	77.0	77.1
12	1+22A	14.0	32.0	27.0	21.9	23.0	47.3	49.1	51.9	55.8	57.4	59.6	62.7	65.0	66.5	68.9	70.5	71.5	73.9	75.7	76.0	76.8	77.0
13	1+24A	14.0	32.0	26.8	21.1	22.4	46.9	49.0	51.8	55.7	57.2	59.4	62.7	65.0	66.5	68.9	70.5	71.5	73.9	75.7	76.1	76.9	77.1
14	1+24A	24.0	32.0	26.2	21.8	20.9	47.0	49.1	51.8	55.8	57.2	59.4	62.8	65.0	66.5	68.9	70.5	71.7	74.0	75.7	76.1	76.9	77.1
15	1+26A	14.0	32.0	26.0	20.7	21.9	46.4	48.3	51.4	55.1	56.9	59.1	62.3	64.9	66.3	68.7	70.3	71.4	73.9	75.7	76.0	76.9	77.0
16	1+28A	14.0	32.0	26.1	21.2	23.0	46.4	48.3	51.4	55.1	56.9	59.1	62.3	64.9	66.3	68.8	70.3	71.4	73.9	75.7	76.0	76.9	77.0
17	1+30A	14.0	32.0	26.9	22.3	25.1	46.7	48.7	51.5	55.3	57.0	59.2	62.4	64.9	66.3	68.8	70.3	71.4	73.9	75.6	76.0	76.9	77.0
18	1+29A	24.0	32.0	27.1	22.2	24.6	46.9	48.8	51.5	55.3	57.0	59.2	62.4	64.9	66.2	68.8	70.3	71.2	73.8	75.5	76.0	76.8	77.0
19	1+32A	14.0	32.0	26.8	22.0	26.1	46.1	48.2	51.2	55.1	56.9	59.0	62.3	64.9	66.2	68.8	70.3	71.2	73.8	75.5	76.0	76.8	77.0
20	1+34A	14.0	32.0	27.3	22.9	27.9	46.0	48.1	51.1	55.0	56.8	59.0	62.2	64.7	66.1	68.7	70.3	71.2	73.8	75.5	76.0	76.8	77.1
21	1+36A	14.0	32.0	27.9	23.3	29.2	45.7	47.8	50.8	54.8	56.4	58.8	62.0	64.3	66.0	68.4	70.2	71.1	73.7	75.4	75.9	76.6	76.9
22	1+38A	14.0	32.0	28.4	23.2	30.7	45.0	47.2	50.4	54.2	56.0	58.4	61.8	64.2	65.9	68.3	70.2	71.1	73.7	75.5	76.0	76.7	77.0
Culvert Piezometer Group C																							
1	1+82.5A	19.0	32.0	33.3	35.1	39.7	43.1	45.8	48.9	53.1	55.0	57.6	61.0	63.4	65.2	68.0	70.0	70.9	73.5	75.4	76.0	76.8	77.0
3	2+32.5A	19.0	32.0	33.1	35.1	38.7	41.7	44.2	47.7	52.0	54.0	56.8	60.5	62.0	64.8	67.7	69.8	70.7	73.5	75.4	76.1	76.8	77.0
5	2+82.5A	19.0	32.0	33.1	35.8	41.7	48.5	51.0	53.8	57.5	58.9	61.0	64.0	65.9	67.3	69.7	71.0	72.0	74.1	75.9	76.4	76.9	77.1
7	3+32.5A	19.0	32.0	33.2	36.7	45.2	56.0	56.7	59.3	61.7	63.7	64.2	66.3	68.7	69.8	70.7	72.4	73.0	75.0	76.2	76.5	77.0	77.0
9	3+82.5A	19.0	32.0	33.3	36.6	46.1	57.9	58.9	60.5	63.1	64.8	65.1	68.2	69.2	70.7	72.0	73.6	73.6	75.1	76.5	76.8	77.0	77.1
11	4+32.5A	19.0	32.0	33.2	36.6	46.1	58.1	58.7	60.7	63.7	64.8	65.0	68.3	69.2	70.7	72.0	73.6	73.8	75.0	76.4	76.7	77.0	77.2
13	4+82.5A	19.0	32.0	33.2	36.1	45.0	57.9	58.1	60.6	64.0	64.5	65.0	68.0	69.1	70.6	72.0	73.4	73.4	74.9	76.4	76.6	76.9	77.0
Longitudinal Floor Culvert Piezometer Group D																							
Main																							
1	3+15.0A	8.5	32.0	33.0	35.2	41.1	48.9	47.2	53.2	57.1	56.4	59.1	61.5	64.5	67.0	68.5	70.5	71.1	73.9	75.6	76.1	76.9	77.1
2	3+31.0A	8.5	32.0	33.0	35.1	40.1	45.3	51.1	53.1	54.1	58.9	61.0	64.0	65.4	66.8	69.1	70.8	71.9	74.2	75.9	76.4	76.9	77.1
Upstream																							
1	3+08.25A	8.5	32.0	33.0	35.1	40.9	48.4	49.8	53.5	56.7	58.0	60.9	62.5	65.0	67.5	69.0	70.8	71.9	74.1	76.0	76.5	77.0	77.1
2	2+84.5A	8.5	32.0	32.9	34.2	38.2	43.1	45.7	49.6	52.7	54.8	58.0	60.8	63.1	65.9	67.9	69.3	71.0	73.6	75.7	76.4	77.0	77.1
3	2+60.5A	8.5	32.0	32.8	34.1	37.8	42.6	45.5	49.1	52.3	54.8	58.0	60.8	63.1	65.8	67.9	69.3	71.0	73.8	75.7	76.3	76.9	77.1
4	2+36.5A	8.5	32.0	32.8	34.1	38.2	43.8	46.8	50.0	53.1	55.5	58.8	61.4	63.7	66.1	68.1	69.6	71.2	73.9	75.8	76.3	77.0	77.1
5	2+25.75A	8.5	32.0	32.8	34.2	38.6	44.8	47.7	50.9	54.1	56.1	59.1	61.9	64.0	66.6	68.5	69.8	71.2	74.0	75.8	76.4	77.0	77.1
6	2+01.75A	8.5	32.0	32.7	34.3	39.5	46.9	49.4	52.4	55.9	57.8	60.4	62.8	64.9	67.2	69.0	70.3	71.6	74.1	75.9	76.4	77.0	77.1
7	1+77.75A	8.5	32.0	32.7	34.7	40.3	48.9	51.0	54.0	57.2	58.8	61.3	63.4	65.6	67.8	69.5	70.7	71.9	74.3	75.9	76.3	77.0	77.1
8	1+53.75A	8.5	32.0	32.7	34.8	40.8	49.8	57.6	54.5	58.0	59.2	61.8	63.7	65.9	67.9	69.5	70.9	71.9	74.2	75.9	76.3	76.9	77.0
Downstream																							
9	3+37.75A	8.5	32.0	33.0	35.1	39.9	46.0	49.2	52.3	54.7	57.8	60.3	62.4	65.0	66.8	68.7	70.6	71.7	74.0	75.9	76.3	76.9	77.0
10	3+61.50A	8.5	32.0	32.9	34.3	38.3	43.0	47.0	49.9	52.3	56.0	58.9	61.5	63.8	65.9	68.0	69.6	71.0	73.7	75.5	76.1	76.9	77.0
11	3+85.50A	8.5	32.0	32.8	34.0	37.9	42.7	46.3	49.5	52.2	55.5	58.4	61.0	63.3	65.8	67.7	69.3	71.0	73.6	75.4	76.1	76.8	77.0
12	4+09.50A	8.5	32.0	32.7	34.0	38.0	43.2	47.0	50.1	52.9	56.0	58.9	61.5	63.8	66.0	68.0	69.6	71.1	73.8	75.4	76.1	76.8	77.0
13	4+20.25A	8.5	32.0	32.5	34.0	38.0	43.7	47.1	50.4	53.1	56.1	59.1	61.8	63.9	66.1	68.0	69.8	71.1	73.8	75.4	76.1	76.8	77.0
14	4+44.25A	8.5	32.0	32.5	34.1	39.1	45.9	49.3	52.3	54.9	57.9	60.4	62.9	64.9	66.9	68.8	70.5	71.6	74.1	75.8	76.4	76.9	77.0
15	4+68.25A	8.5	32.0	32.3	34.1	39.4	46.9	50.6	53.3	55.7	58.5	61.0	63.5	65.4	67.2	69.0	70.7	71.9	74.2	75.9	76.4	76.9	77.0
16	4+92.25A	8.5	32.0	32.3	34.1	39.8	47.5	51.2	54.0	56.0	58.9	61.2	64.0	65.8	67.6	69.3	70.8	72.0	74.3	75.8	76.2	76.9	77.1

Note: Elevations are in feet referred to mean sea level.
2-min-valve schedule I fills lock in 10.8 min.
Bulkhead slots below filling valves closed.
* T is time (in prototype seconds) after beginning of filling operation.
** LC is elevation of water surface in lock chamber.

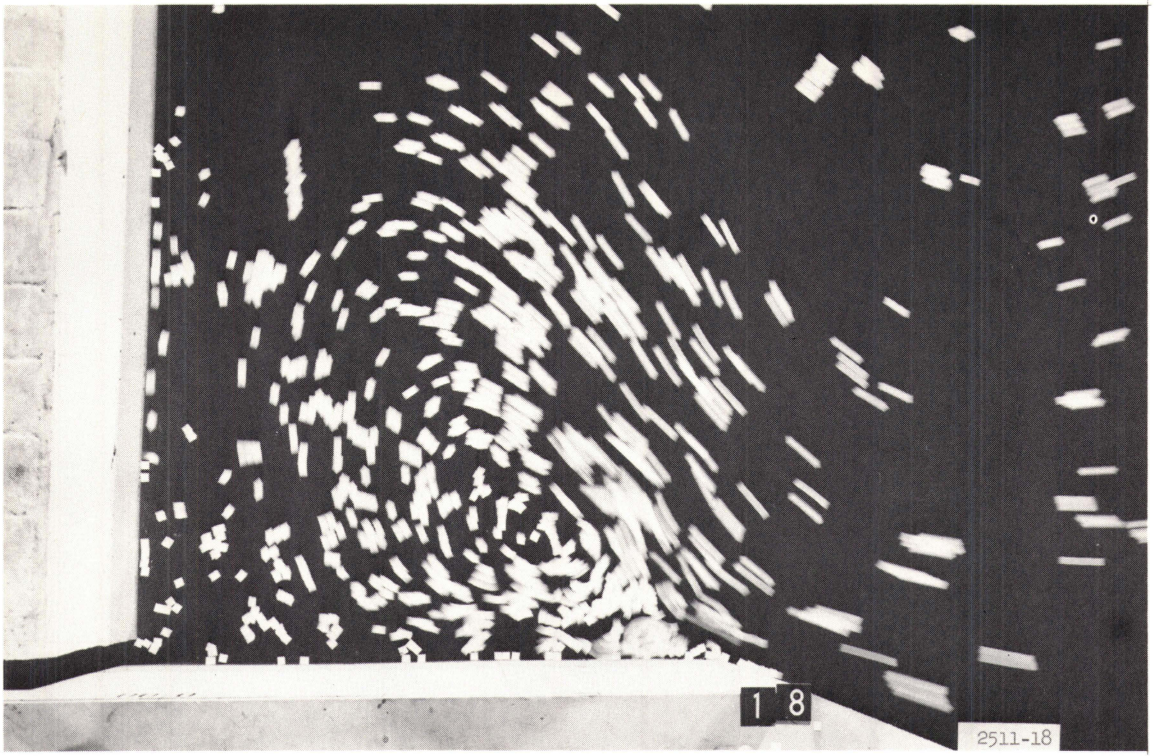
Table 22

Average Piezometer Readings During Emptying Operations, Type 41 (Recommended) Culvert Arrangement, Jones Bluff Lock

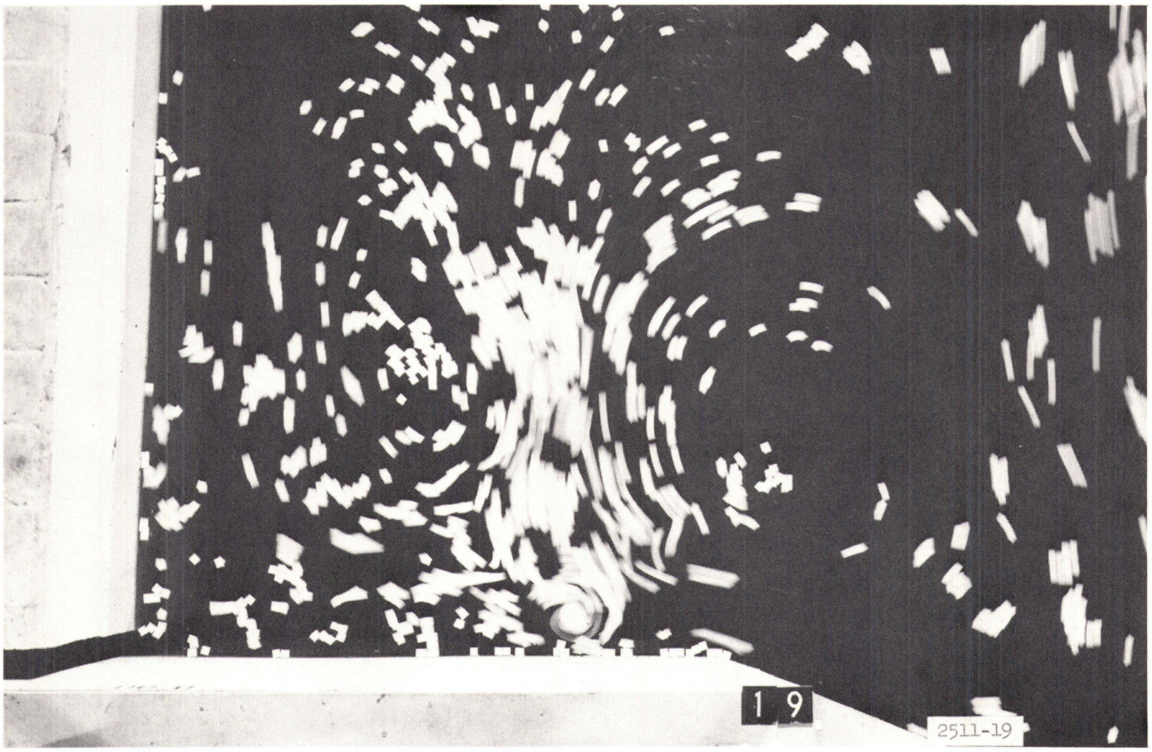
Initial Head 45.0 ft (Upper Pool El 77.0 and Lower Pool El 32.0)

Piezometer Locations			Average Piezometer Reading, in Prototype Elevation																				
Piez No.	Station	El	T* = 0 LC** = 77.0	T = 30 LC = 76.8	T = 60 LC = 75.5	T = 90 LC = 73.6	T = 120 LC = 71.0	T = 150 LC = 67.8	T = 180 LC = 64.8	T = 210 LC = 61.9	T = 240 LC = 59.3	T = 270 LC = 56.9	T = 300 LC = 54.4	T = 360 LC = 50.0	T = 420 LC = 46.1	T = 480 LC = 42.4	T = 540 LC = 39.5	T = 600 LC = 37.1	T = 660 LC = 35.1	T = 720 LC = 33.6	T = 780 LC = 32.3	T = 840 LC = 31.6	T = 900 LC = 31.4
Culvert Piezometer Group C																							
2	2+07.5A	19.0	77.0	75.7	72.7	67.0	59.3	56.0	54.0	51.9	50.0	48.7	47.0	45.1	43.9	42.6	41.1	40.0	36.0	33.4	32.0	31.9	32.1
4	2+57.5A	19.0	77.0	75.7	72.7	66.9	59.2	55.9	54.0	51.9	50.0	48.7	47.0	45.1	43.8	42.5	40.0	40.0	36.0	33.3	32.0	31.9	32.1
6	3+07.5A	19.0	77.0	75.8	72.7	66.9	59.7	55.8	54.0	52.0	50.0	48.7	47.0	45.1	43.8	42.4	40.0	40.0	36.0	32.2	32.0	31.8	32.1
8	3+57.5A	19.0	77.0	75.3	70.6	61.9	50.0	46.6	45.2	43.9	42.8	42.1	41.1	40.0	39.0	38.3	37.4	36.9	34.7	32.8	32.0	31.9	32.1
10	4+07.5A	19.0	77.0	74.9	68.8	57.9	43.2	39.8	39.0	38.2	37.5	37.8	37.0	36.2	35.7	35.2	34.9	34.7	33.3	32.2	31.9	31.9	32.0
12	4+57.5A	19.0	77.0	75.0	68.0	56.3	41.8	38.4	37.8	37.2	36.6	36.9	36.2	35.8	35.1	34.9	34.7	34.2	33.2	32.1	32.0	31.9	32.0
14	5+07.5A	19.0	77.0	74.9	66.5	53.6	38.8	35.5	35.4	34.8	34.6	35.0	34.8	34.3	33.9	33.9	33.5	33.5	32.8	32.0	32.0	31.9	32.0
Emptying-Valve Piezometer Group E																							
1	5+41A	24.0	77.0	74.9	66.1	53.0	37.0	34.0	34.0	33.6	33.3	34.0	33.8	33.7	33.1	33.1	33.0	33.0	32.7	32.0	31.9	31.9	32.0
2	5+44A	14.0	77.0	74.9	66.2	53.1	37.7	34.8	34.8	34.1	33.8	34.4	34.1	34.0	33.6	33.6	33.1	33.1	32.8	32.0	31.9	31.9	32.0
3	5+49A	14.0	77.0	74.7	66.3	53.0	37.3	34.5	34.5	33.9	33.7	34.2	34.0	33.9	33.4	33.4	33.0	33.0	32.7	32.0	31.9	31.9	32.0
4	5+59A	14.0	77.0	73.0	62.9	49.3	36.3	33.9	33.9	33.3	33.2	33.8	33.7	33.5	33.0	33.1	32.8	32.8	32.6	32.0	31.9	31.9	32.0
5	5+63.5A	14.0	31.6	53.7	55.1	45.3	36.7	34.2	34.1	33.8	33.5	34.0	33.9	33.8	33.3	33.3	32.9	32.9	32.7	32.0	31.9	31.9	32.0
6	5+67.5A	14.0	31.4	26.6	29.3	35.4	36.0	33.8	33.8	33.1	33.0	33.8	33.5	33.4	33.0	33.1	32.8	32.8	32.4	32.0	31.9	31.9	32.0
7	5+73.5A	24.0	32.0	29.3	29.1	29.4	33.8	33.0	33.0	32.9	33.0	33.1	33.0	33.0	33.0	33.0	32.9	32.9	32.8	32.7	32.6	32.6	32.6
8	5+75.5A	14.0	31.4	25.2	20.8	21.4	35.8	33.0	33.0	32.5	32.5	33.1	33.0	33.0	32.8	32.9	32.4	32.5	32.1	31.9	31.9	31.9	32.0
9	5+79.5A	14.0	31.5	26.0	22.6	20.9	36.0	33.0	33.0	32.5	32.5	33.1	33.0	33.0	32.8	32.9	32.4	32.6	32.1	31.9	31.9	31.9	32.0
10	5+83.5A	14.0	31.5	26.1	23.5	20.3	35.8	33.0	32.9	32.4	32.4	33.0	33.0	32.9	32.8	32.9	32.4	32.5	32.1	31.9	31.9	31.9	32.0
11	5+87.5A	14.0	31.8	27.3	25.0	20.8	35.8	33.0	32.9	32.4	32.5	33.1	33.0	33.0	32.8	32.9	32.4	32.6	32.1	31.9	31.9	31.9	32.0
12	5+88.5A	24.0	31.6	28.4	27.0	26.4	33.6	32.0	32.0	31.7	31.7	32.3	32.2	32.1	31.9	32.0	31.9	31.8	31.5	31.2	31.2	31.1	31.2
13	5+91.5A	14.0	31.8	27.6	25.2	25.1	35.3	32.9	32.8	32.2	32.4	33.0	33.0	32.9	32.8	32.9	32.4	32.5	32.1	31.9	31.9	31.9	32.0
Outlet Piezometer Group F																							
1	7+06A	5.0	32.0	32.6	33.5	24.1	33.5	32.0	32.0	31.7	31.8	32.5	32.3	32.3	32.2	32.4	32.0	32.1	32.0	31.9	31.9	31.9	32.0
2	6+98A	5.0	32.0	32.1	31.7	29.1	28.0	29.0	29.2	28.9	29.9	30.8	30.5	30.9	30.8	31.0	31.0	31.2	31.7	31.9	31.9	32.0	32.0
3	7+23A	5.0	32.0	33.3	34.2	34.5	36.8	33.9	33.2	32.2	32.8	33.1	33.0	32.9	32.8	32.9	32.7	32.6	32.2	32.0	31.9	31.9	32.0
4	7+23A	5.0	32.0	33.2	33.9	33.3	35.1	32.6	31.8	30.8	31.4	32.0	32.0	32.0	32.3	32.2	32.2	32.0	32.0	31.9	31.9	31.9	32.0
5	7+23A	5.0	32.0	32.2	31.9	30.2	31.7	28.0	28.8	28.1	29.4	30.0	30.1	30.8	30.7	30.9	30.9	31.0	31.6	31.8	31.9	32.0	32.0

Note: Elevations are in feet referred to mean sea level.
2-min-valve schedule I empties lock in 13.6 min.
Bulkhead slots below filling valves closed.
* T is time (in prototype seconds) after beginning of emptying operation.
** LC is elevation of water surface in lock chamber.

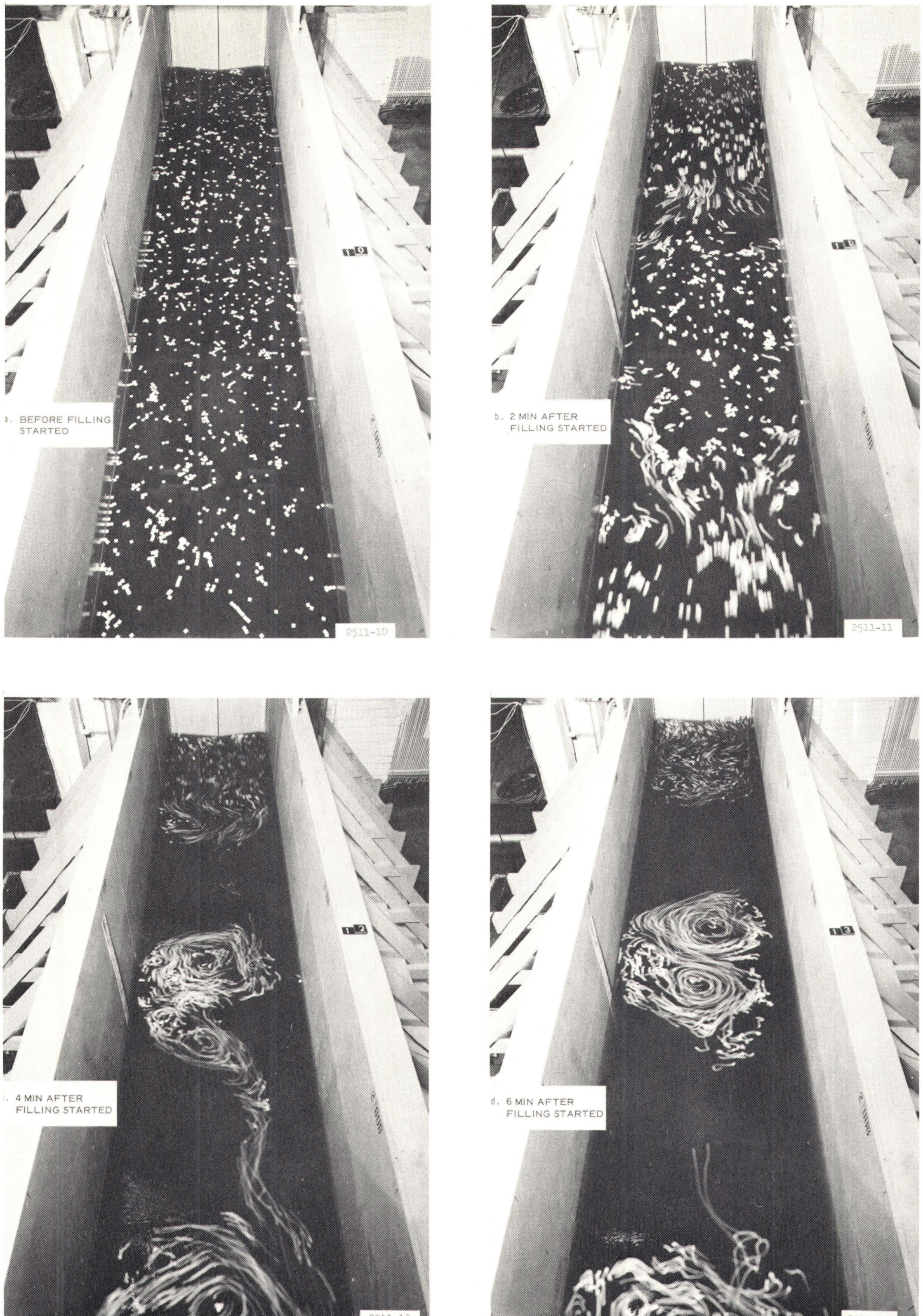


a. Flow pattern 4.5 min after beginning of filling operation

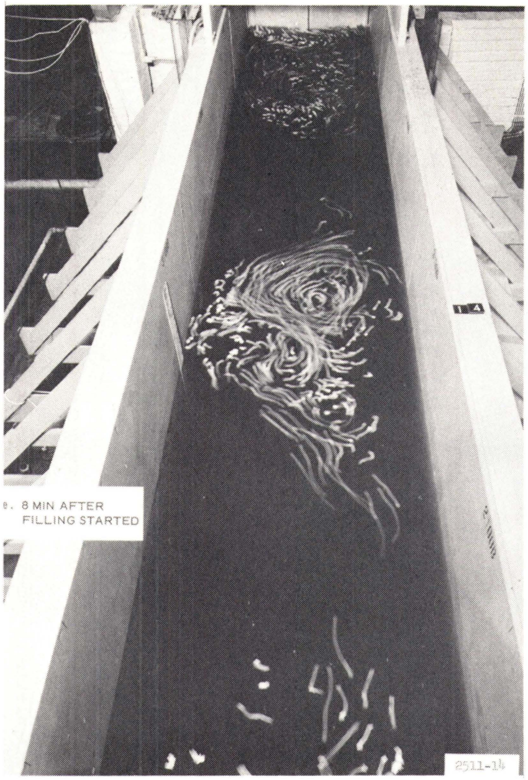


b. Flow pattern 6.5 min after beginning of filling operation

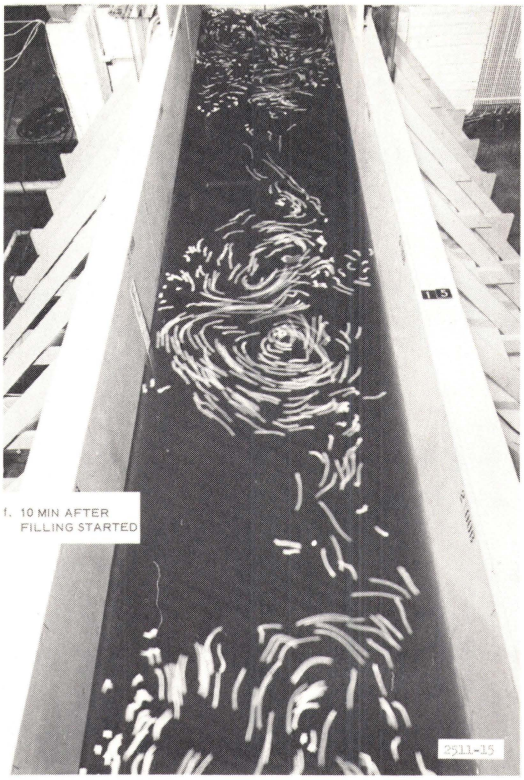
Photograph 1. Flow pattern above culvert intakes during filling operation with upper pool at elevation 70.0



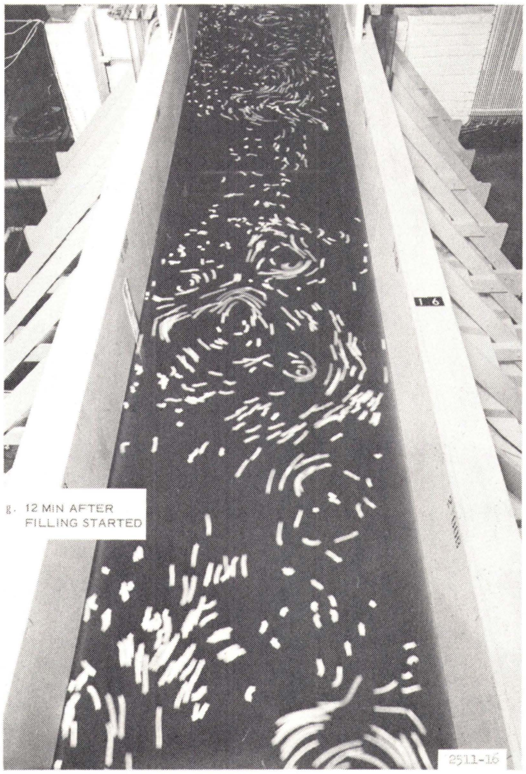
Photograph 2. Surface currents during filling operation with type 1 (original) culvert arrangement; 4-min valve time (sheet 1 of 2)



e. 8 MIN AFTER FILLING STARTED

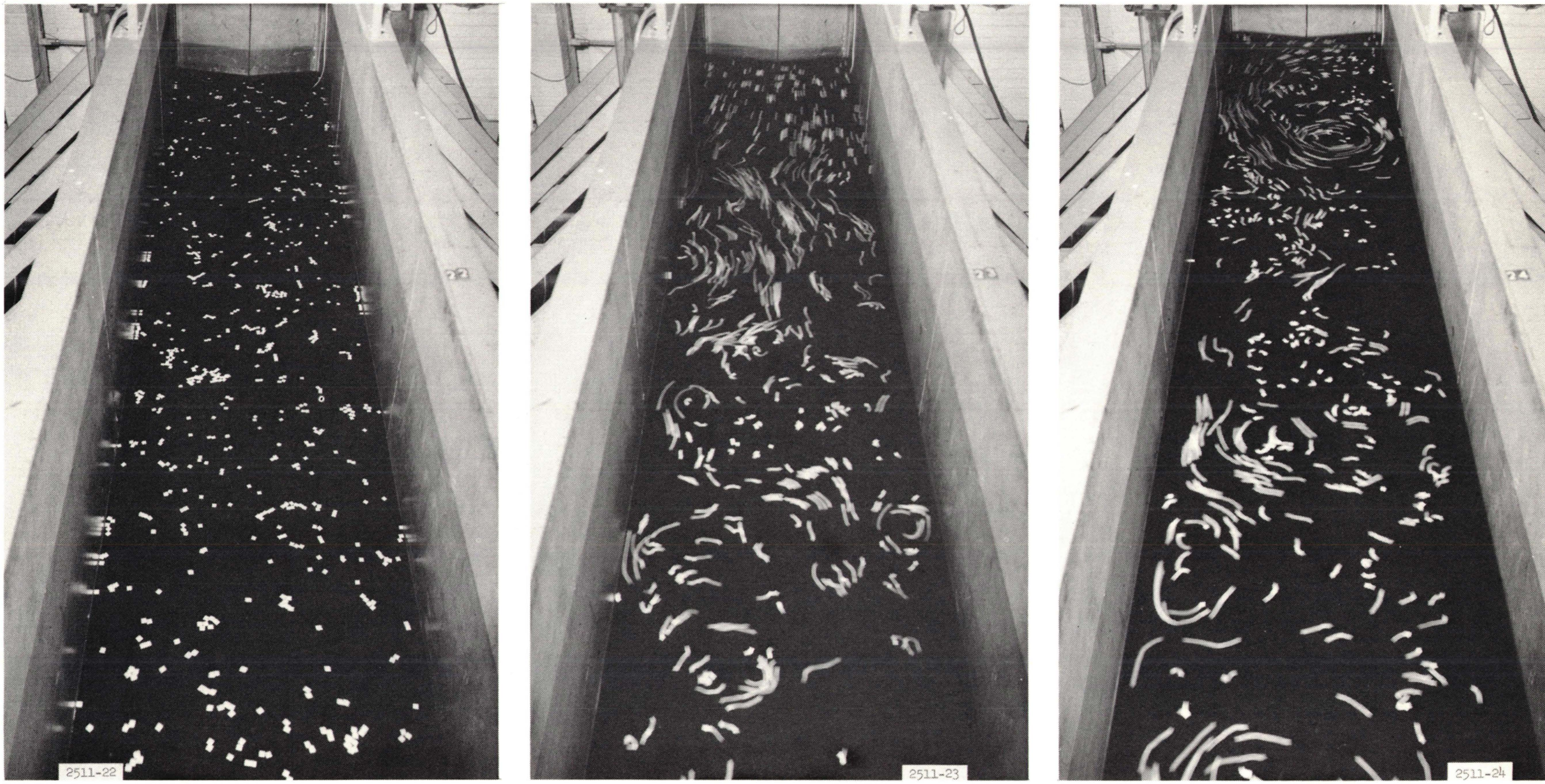


f. 10 MIN AFTER FILLING STARTED



g. 12 MIN AFTER FILLING STARTED

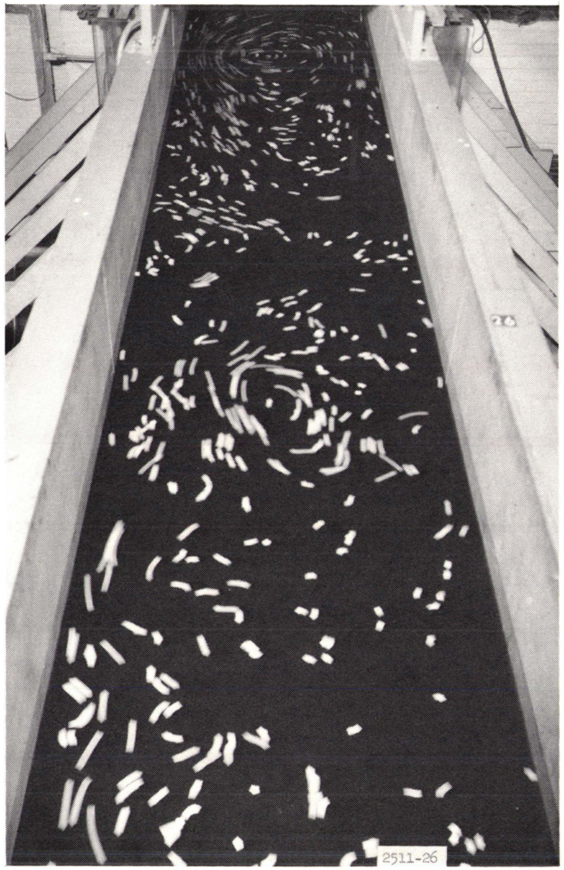
Photograph 2 (sheet 2 of 2)



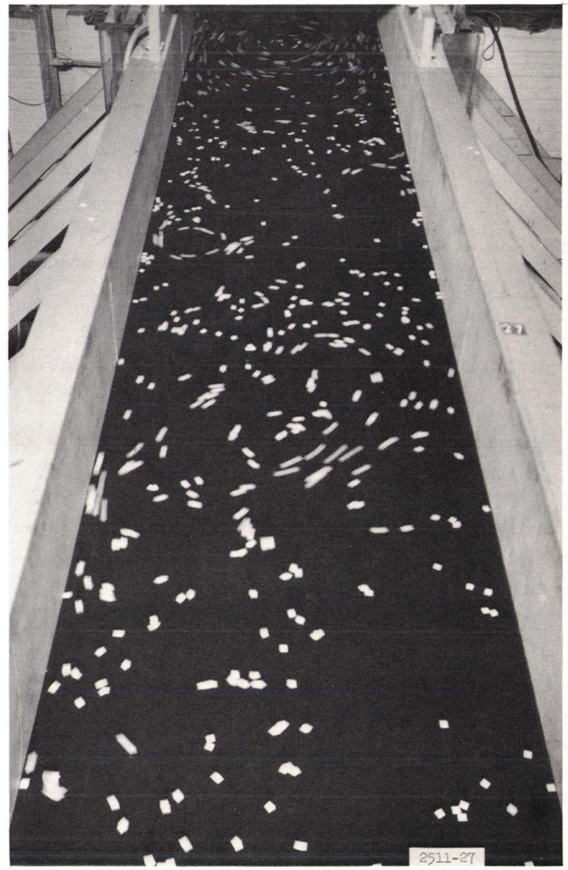
a. Before filling started b. 2 min after filling started c. 4 min after filling started

Photograph 3. Surface currents during filling operation with type 23 culvert arrangement; 2-min valve time (sheet 1 of 2)

d. 6 min after filling started

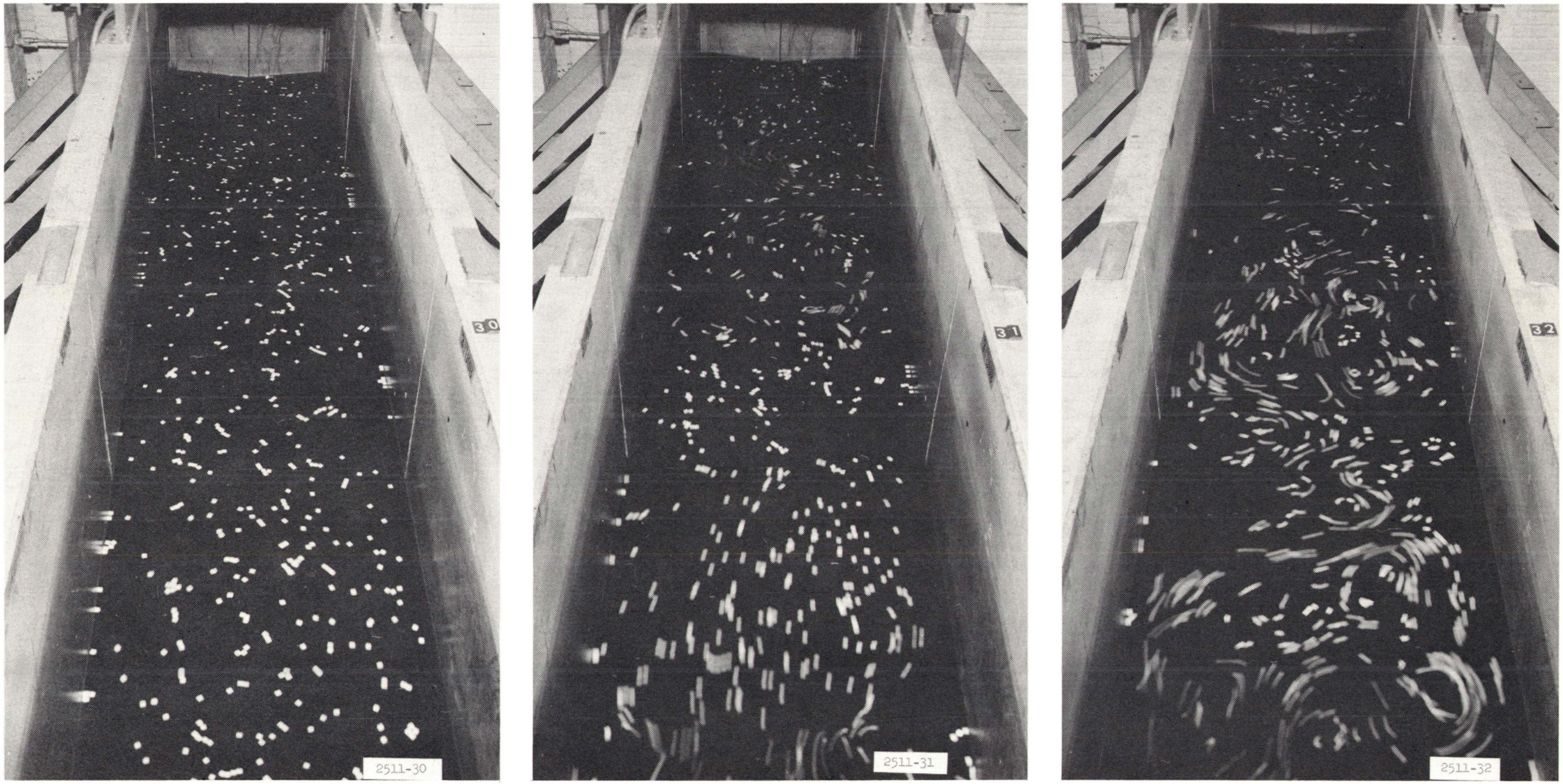


e. 8 min after filling started



f. 10 min after filling started

Photograph 3 (sheet 2 of 2)



a. Before filling started b. 2 min after filling started c. 4 min after filling started

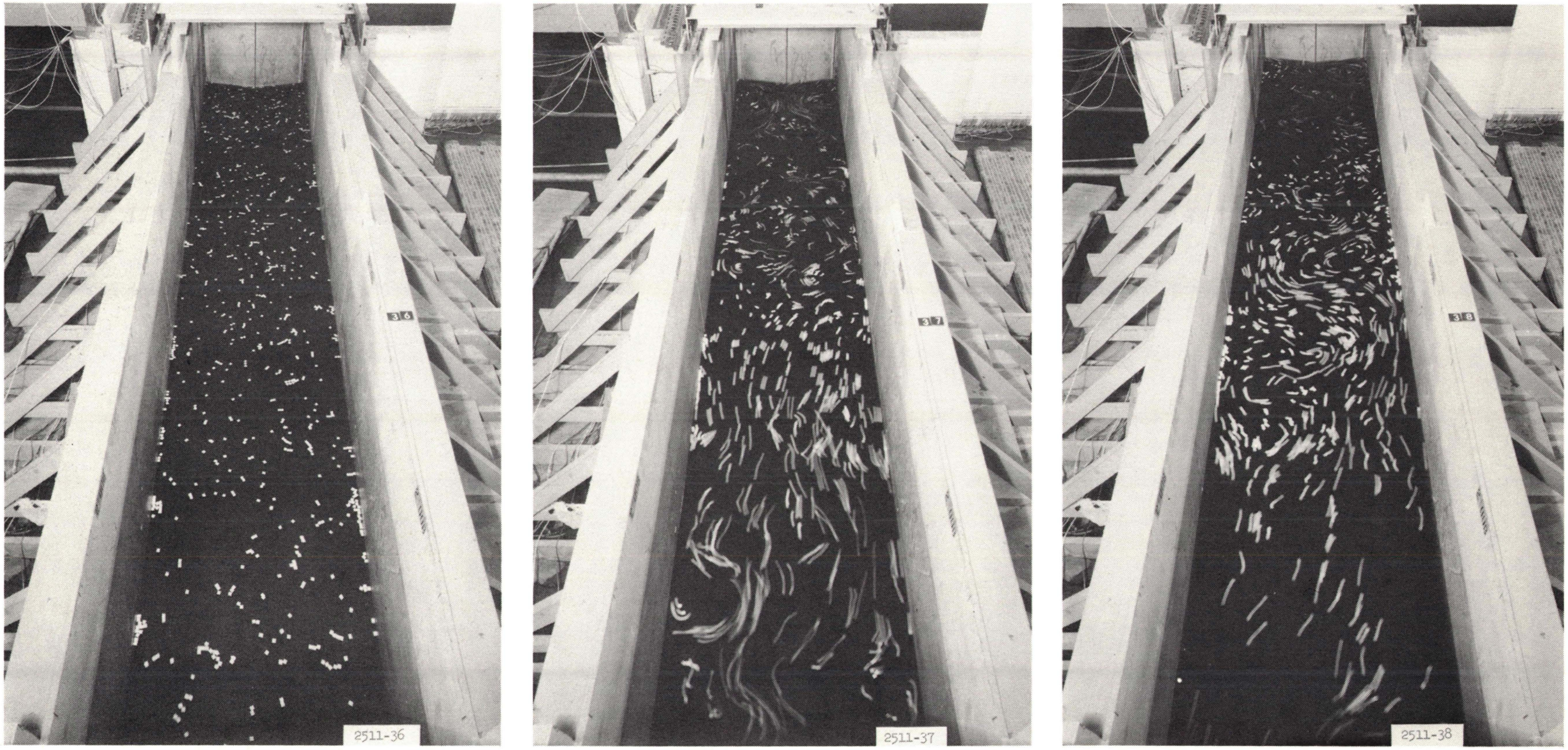
Photograph 4. Surface currents during filling operation with type 41 culvert arrangement; 2-min valve time (sheet 1 of 2)

d. 6 min after filling started

e. 8 min after filling started

f. 10 min after filling started

Photograph 4 (sheet 2 of 2)

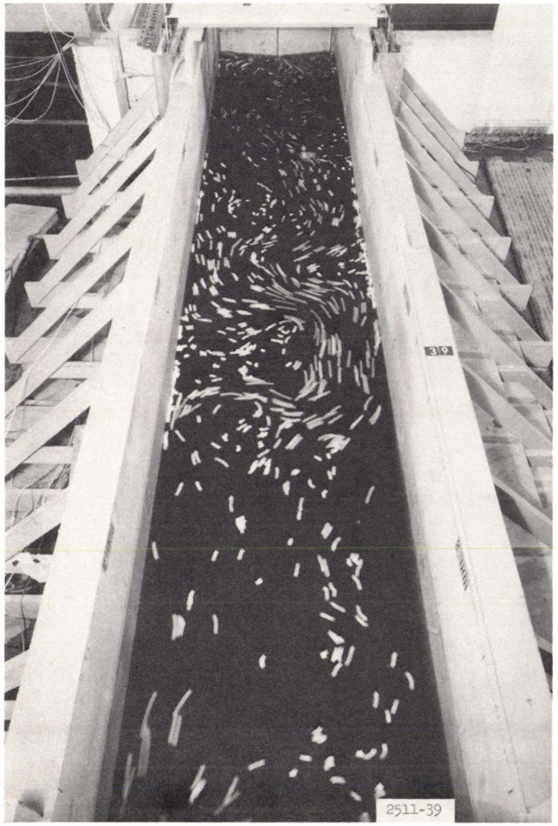


a. Before filling started

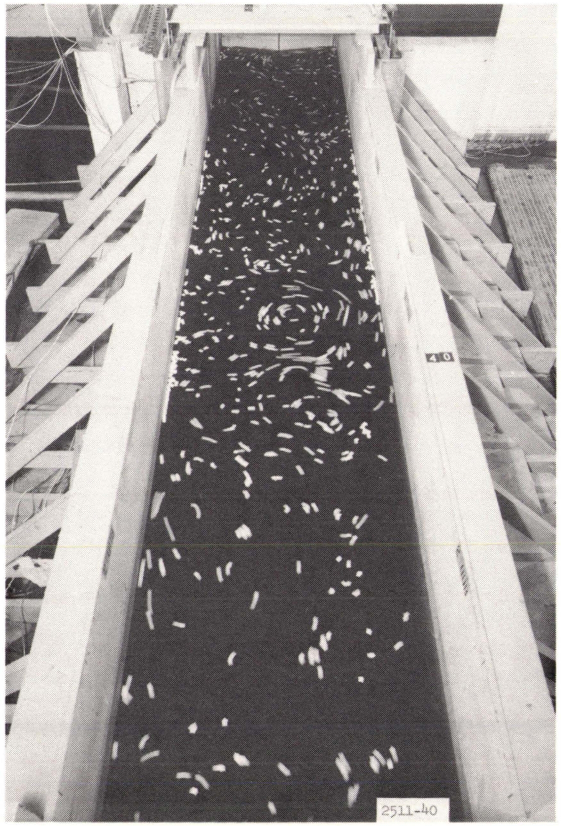
b. 2 min after filling started

c. 4 min after filling started

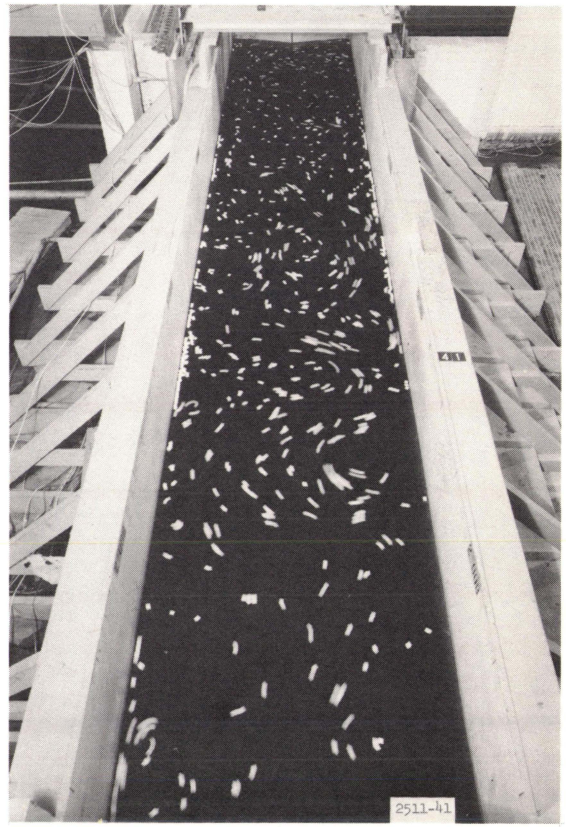
Photograph 5. Surface currents during filling operation with type 53 culvert arrangement; 2-min valve time (sheet 1 of 2)



d. 6 min after filling started

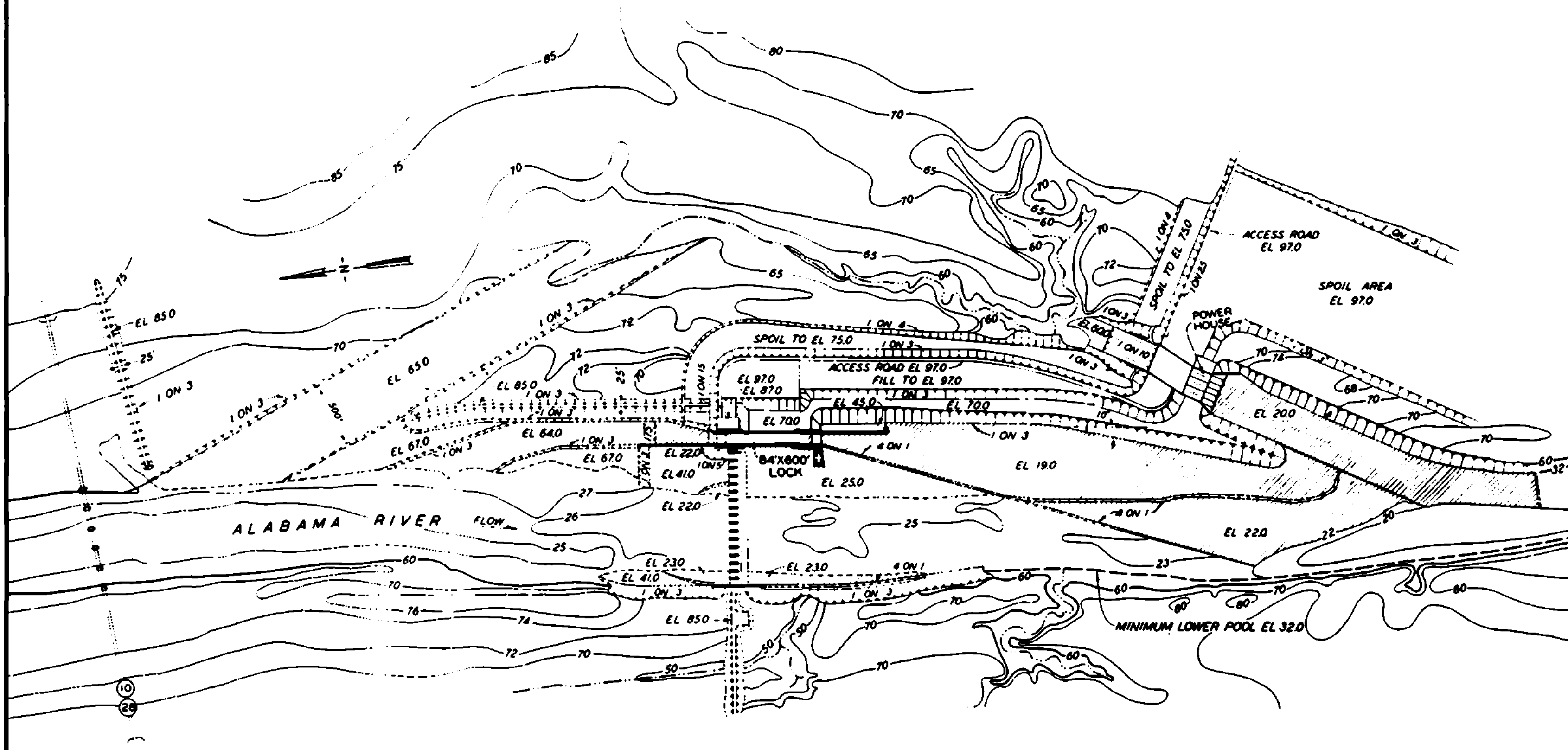


e. 8 min after filling started



f. 10 min after filling started

Photograph 5 (sheet 2 of 2)



NOTE: CONTOURS AND ELEVATIONS IN FEET
REFERRED TO MEAN SEA LEVEL.

LEGEND

DREDGED AREAS

MILLERS FERRY LOCK AND DAM

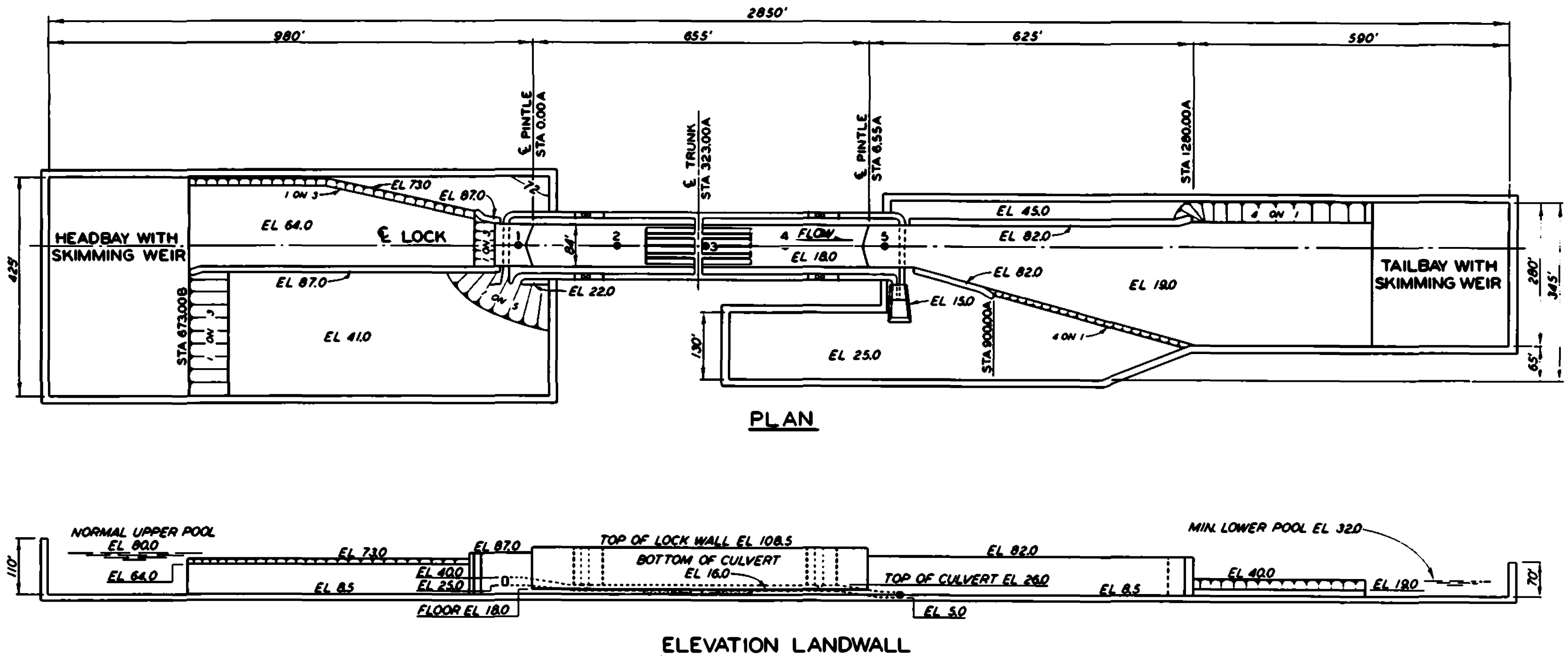
PROJECT LAYOUT

SCALE IN FEET

500 0 500 1000

PLATE 1

PLATE 2



GAGE IDENTIFICATION	
GAGE NO.	UNIT MEASURED
1	WATER SURFACE, UPPER POOL
2-4	WATER-SURFACE SLOPE, LOCK CHAMBER
3	WATER SURFACE, LOCK CHAMBER (FILLING OR EMPTYING CURVE)
5	WATER SURFACE, LOWER POOL

NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.

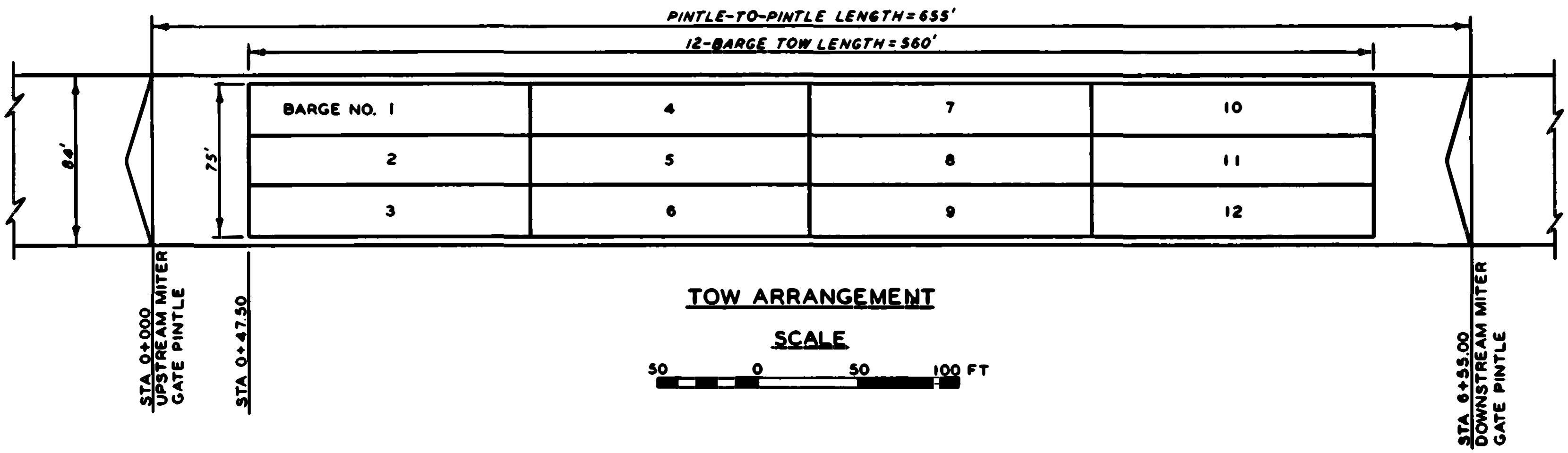
MILLERS FERRY LOCK

MODEL LAYOUT

SCALES

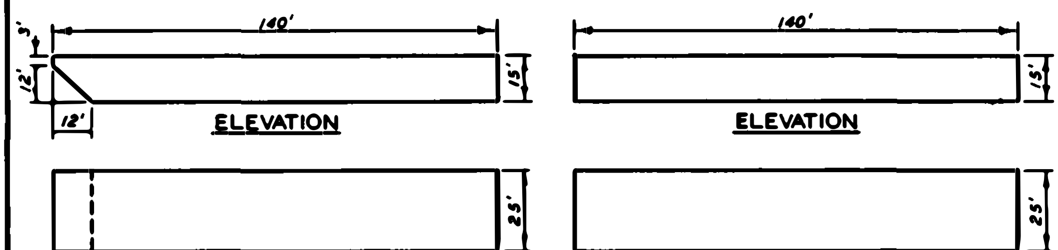
PROTOTYPE 100 0 100 200 300 400 FT

MODEL 4 0 4 8 12 16 FT



TOW ARRANGEMENT

SCALE



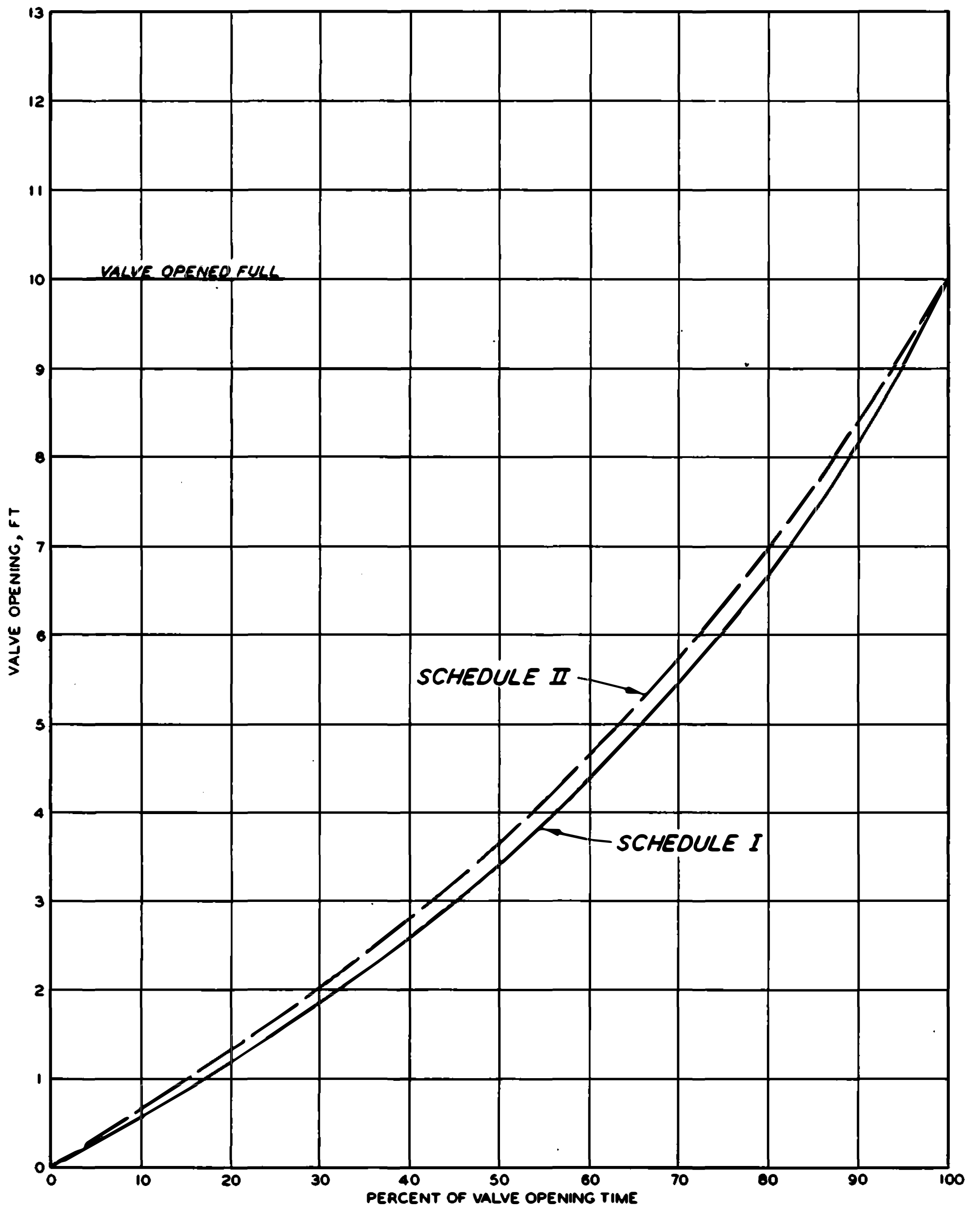
END BARGE

INTERIOR BARGE

NUMBER OF BARGES IN TOW	DISPLACEMENT IN TONS	
	9-FT DRAFT	12-FT DRAFT
3	2,705	3,611
6	5,410	7,222
9	8,358	11,151
12	11,306	15,085

MILLERS FERRY LOCK

TOW ARRANGEMENT AND BARGE DETAILS



NOTE: SCHEDULE I USED ONLY IN TESTS OF TYPE I (ORIGINAL) CULVERT ARRANGEMENT.

MILLERS FERRY LOCK

VALVE OPENING SCHEDULES I AND II

PLATE 4

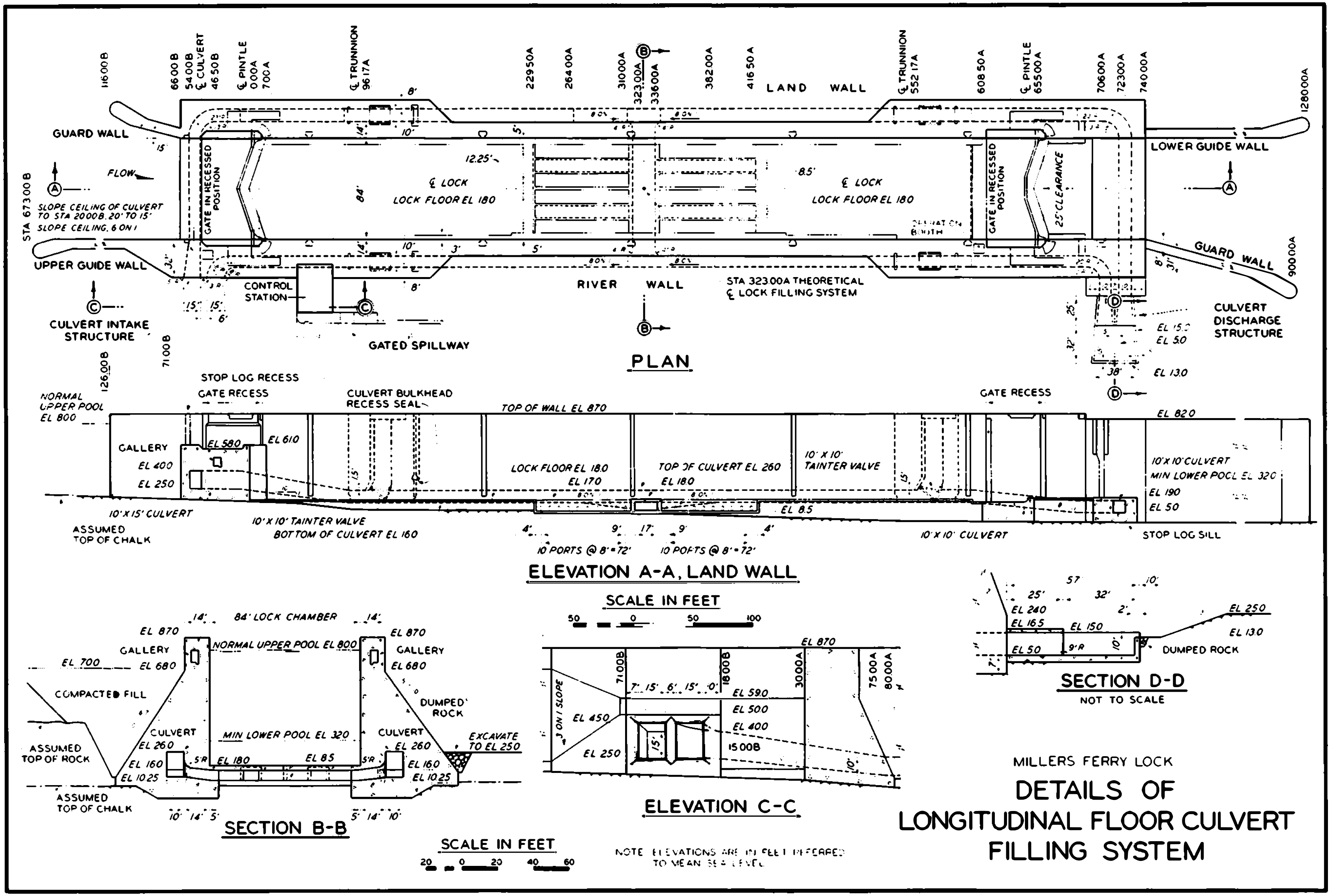

LAND WALL
RIVER WALL
GUARD WALL
UPPER GUIDE WALL
LOWER GUIDE WALL
FLOW
SLOPE CEILING OF CULVERT TO STA 200 0B, 20' TO 15'
SLOPE CEILING, 6 ON 1
GATE IN RECESSED POSITION
℄ LOCK
LOCK FLOOR EL 18.0
25' CLEARANCE
CONTROL STATION
CULVERT INTAKE STRUCTURE
GATED SPILLWAY
STA 323.00A THEORETICAL ℄ LOCK FILLING SYSTEM
CULVERT DISCHARGE STRUCTURE
PLAN
NORMAL UPPER POOL EL 80.0
STOP LOG RECESS
GATE RECESS
CULVERT BULKHEAD RECESS SEAL
TOP OF WALL EL 87.0
GALLERY
10' X 15' CULVERT
ASSUMED TOP OF CHALK
10' X 10' TAINTER VALVE
BOTTOM OF CULVERT EL 16.0
LOCK FLOOR EL 18.0
TOP OF CULVERT EL 26.0
10' X 10' TAINTER VALVE
10 PORTS @ 8' = 72'
10' X 10' CULVERT
10'X 10' CULVERT
MIN LOWER POOL EL 32.0
STOP LOG SILL
ELEVATION A-A, LAND WALL
SCALE IN FEET
84' LOCK CHAMBER
NORMAL UPPER POOL EL 80.0
COMPACTED FILL
ASSUMED TOP OF ROCK
CULVERT
MIN LOWER POOL EL 32.0
DUMPED ROCK
EXCAVATE TO EL 25.0
ASSUMED TOP OF CHALK
SECTION B-B
SCALE IN FEET
3 ON 1 SLOPE
ELEVATION C-C
SECTION D-D
NOT TO SCALE
DUMPED ROCK
NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MILLERS FERRY LOCK
DETAILS OF LONGITUDINAL FLOOR CULVERT FILLING SYSTEM

PLATE 5

5' 5.5' 5.5' 5' EL 48.0

3' 3' 3' 3' 3' 3' 3' 5' 26'

4.7	5.2	4.7
5.2	6.2	5.2
4.7	6.2	5.2
6.2	6.2	5.7
6.6	7.0	6.2
6.6	7.0	6.2
5.2	6.6	6.2

21'

EL 22.0

LAND WALL CULVERT INTAKE
48.5 PERCENT OF TOTAL DISCHARGE

4.7	5.2	3.9
5.2	6.2	5.7
5.2	6.2	6.6
5.7	6.6	7.3
6.2	7.0	7.7
6.2	7.0	8.0
5.7	6.6	8.0

RIVER WALL CULVERT INTAKE
51.5 PERCENT OF TOTAL DISCHARGE

VELOCITY DISTRIBUTION WITH UPPER POOL EL 80.0

TEST CONDITIONS: UPPER VALVES OPEN FULL — TOTAL DISCHARGE 6600 CFS
LOWER VALVES CLOSED — LOCK CHAMBER EL 48.8

3.9	5.2	4.7
4.7	5.2	5.2
5.7	5.7	5.2
5.7	6.2	5.2
6.2	6.6	5.2
6.6	6.6	5.7
5.2	6.2	5.7

LAND WALL CULVERT INTAKE
49.0 PERCENT OF TOTAL DISCHARGE

4.7	5.2	4.7
5.2	5.2	5.7
5.2	5.7	6.2
5.2	6.2	6.6
5.2	6.6	7.0
5.7	6.6	7.0
5.2	6.2	7.0

RIVER WALL CULVERT INTAKE
51.0 PERCENT OF TOTAL DISCHARGE

VELOCITY DISTRIBUTION WITH UPPER POOL EL 70.0

TEST CONDITIONS: UPPER VALVES OPEN FULL — TOTAL DISCHARGE 5500 CFS
LOWER VALVES CLOSED — LOCK CHAMBER EL 45.0

5.0	5.7	5.7
5.4	6.5	6.2
5.7	6.5	6.4
5.7	6.8	6.8
6.2	7.3	6.9
6.8	7.6	6.8
6.3	7.0	6.5

← UPSTREAM DOWNSTREAM →

LAND WALL CULVERT INTAKE
47.5 PERCENT OF TOTAL DISCHARGE

5.1	5.7	6.8
5.6	6.8	7.2
5.6	6.9	8.3
5.9	7.2	8.4
6.6	7.9	8.7
6.7	8.2	8.7
6.3	7.8	8.3

RIVER WALL CULVERT INTAKE
52.5 PERCENT OF TOTAL DISCHARGE

VELOCITY DISTRIBUTION WITH UPPER POOL EL 80.0

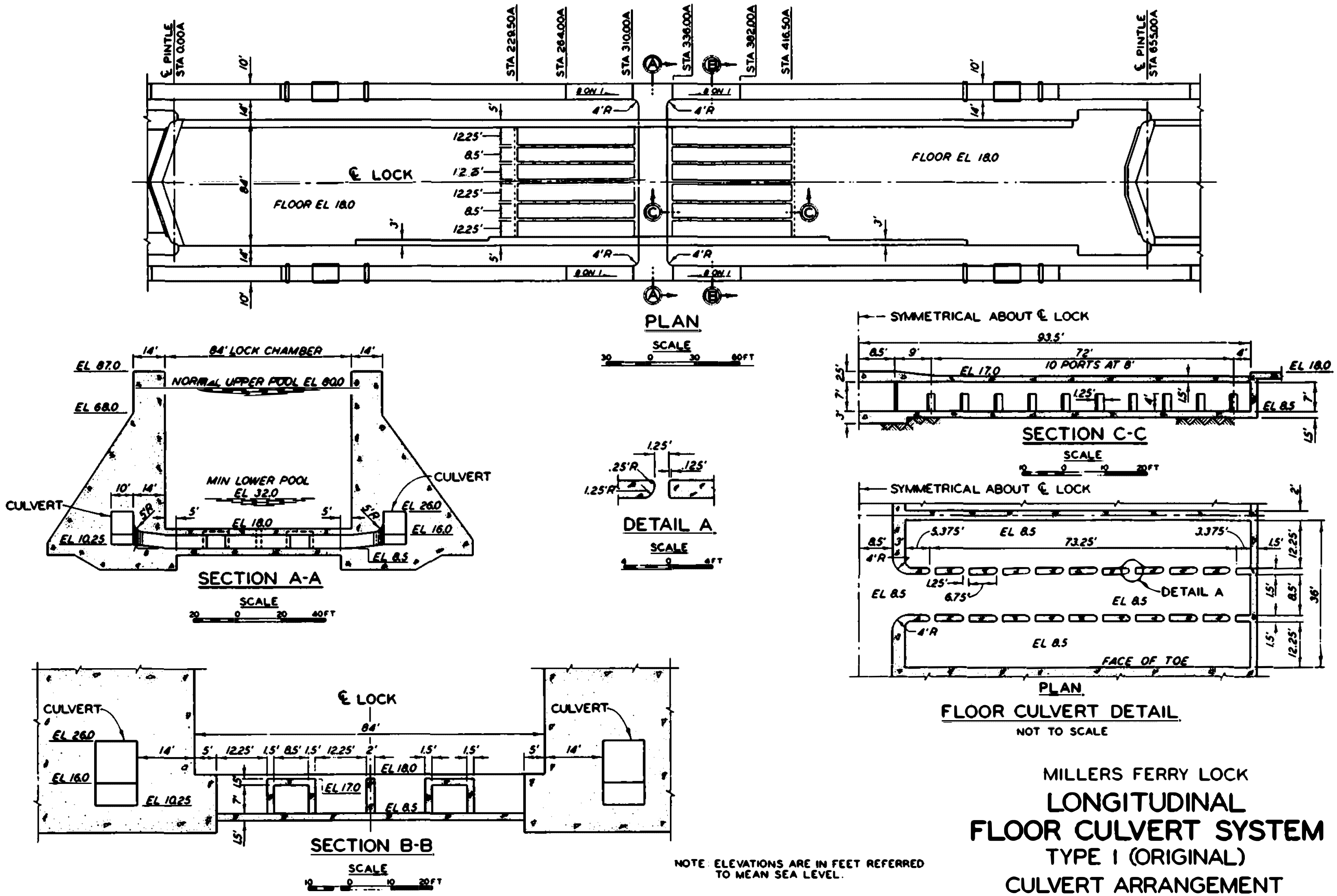
TEST CONDITIONS: UPPER VALVES OPEN FULL — TOTAL DISCHARGE 7200 CFS
LOWER VALVES CLOSED — LOCK CHAMBER EL 40.0

NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.
VELOCITIES ARE SHOWN IN PROTOTYPE FEET PER SECOND.

MILLERS FERRY LOCK

INTAKE FLOW DISTRIBUTION

TYPE 1 (ORIGINAL) DESIGN
CULVERT INTAKES



MILLERS FERRY LOCK

LONGITUDINAL

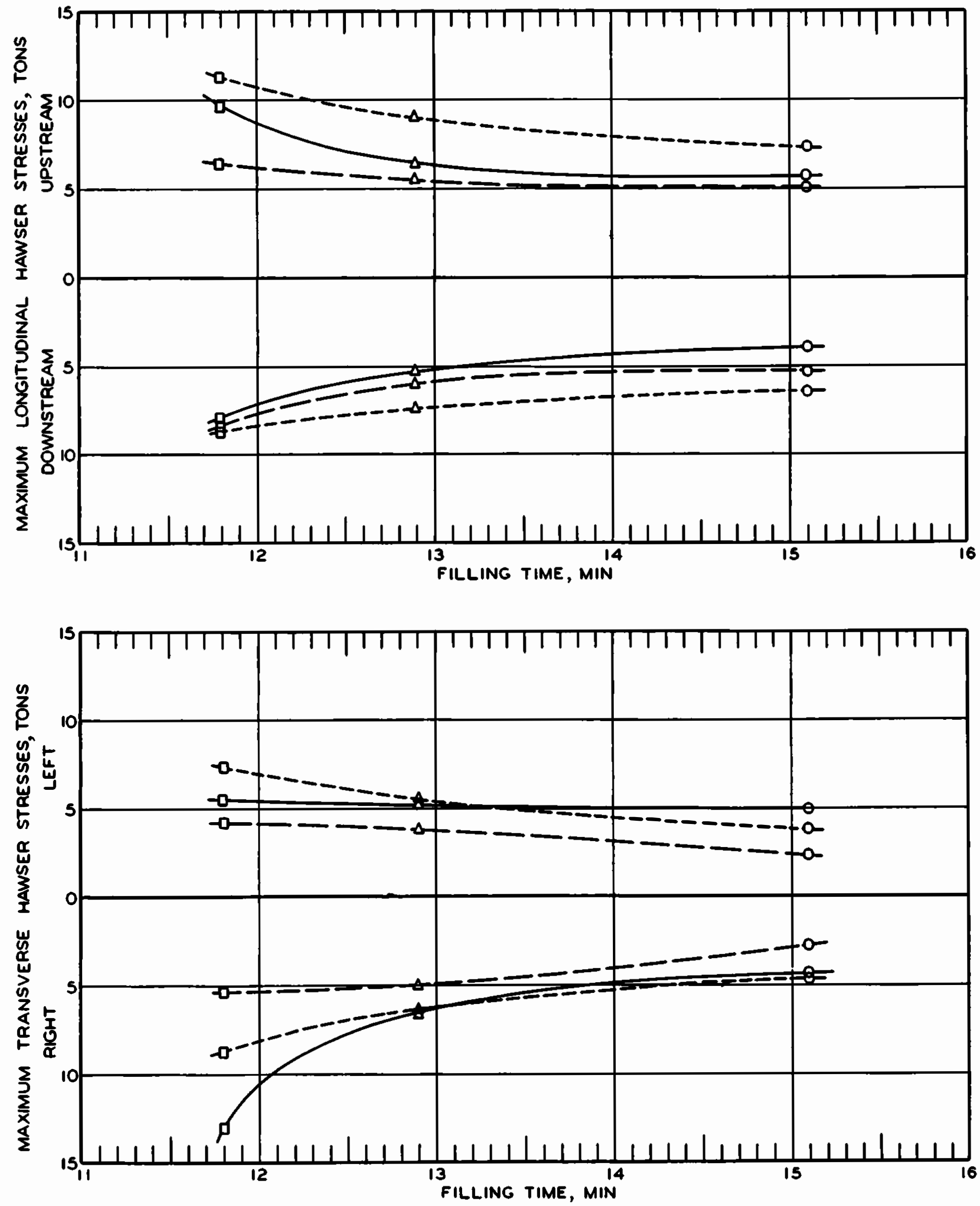
FLOOR CULVERT SYSTEM

TYPE 1 (ORIGINAL)

CULVERT ARRANGEMENT

NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.

PLATE 7



LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
□	2-I
△	4-I
○	8-I

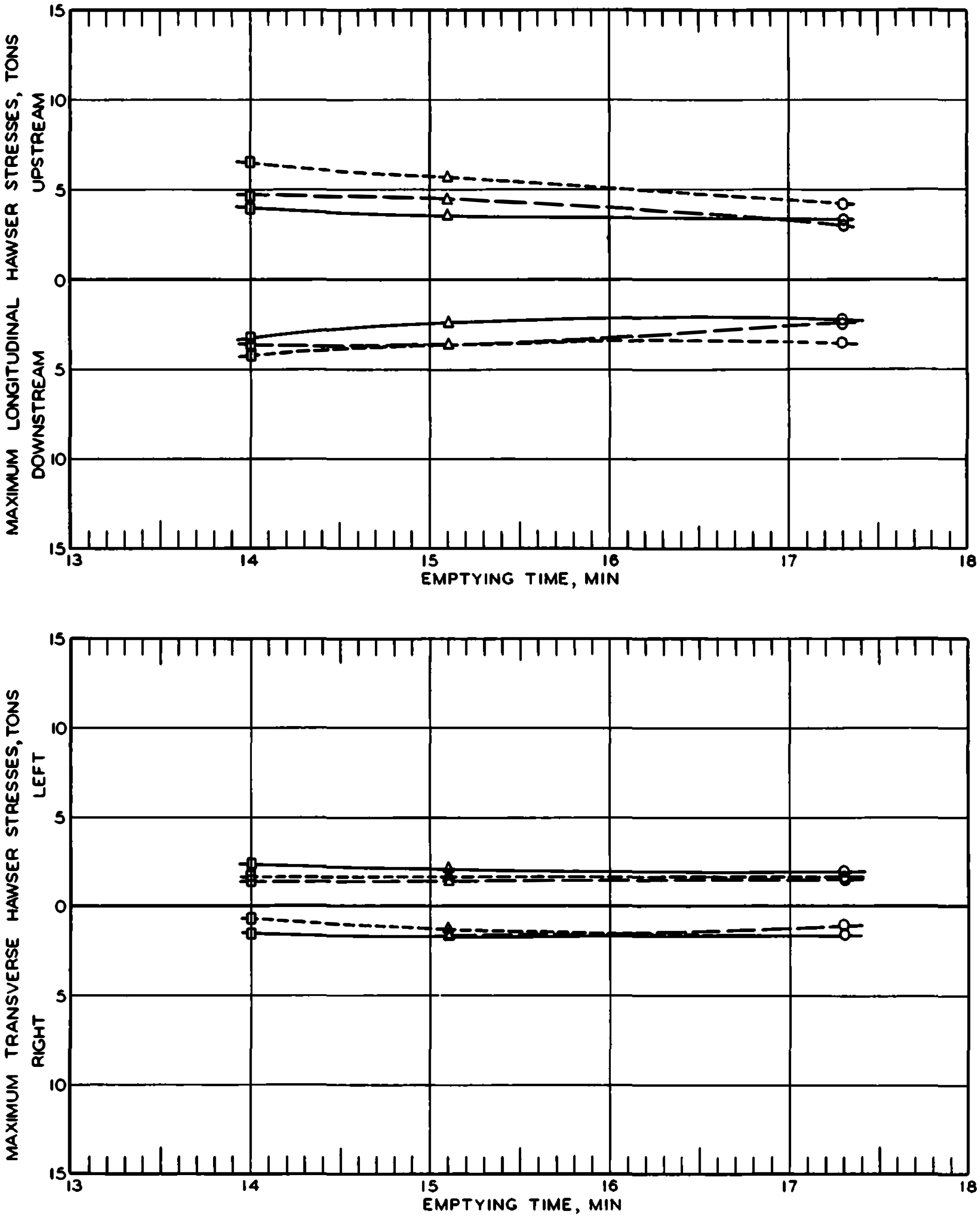
NOTE: 48-FT HEAD (UPPER POOL EL 80.0, LOWER POOL EL 32.0)

—— 12-BARGE TOW AT STA 0+47
— — 6-BARGE TOW AT STA 0+47
- - - - 6-BARGE TOW AT STA 3+27

MILLERS FERRY LOCK

EFFECT OF TOW SIZE AND POSITION ON MAXIMUM HAWSER STRESSES DURING FILLING

TYPE I (ORIGINAL) CULVERT ARRANGEMENT



LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
□	2-I
Δ	4-I
O	8-I

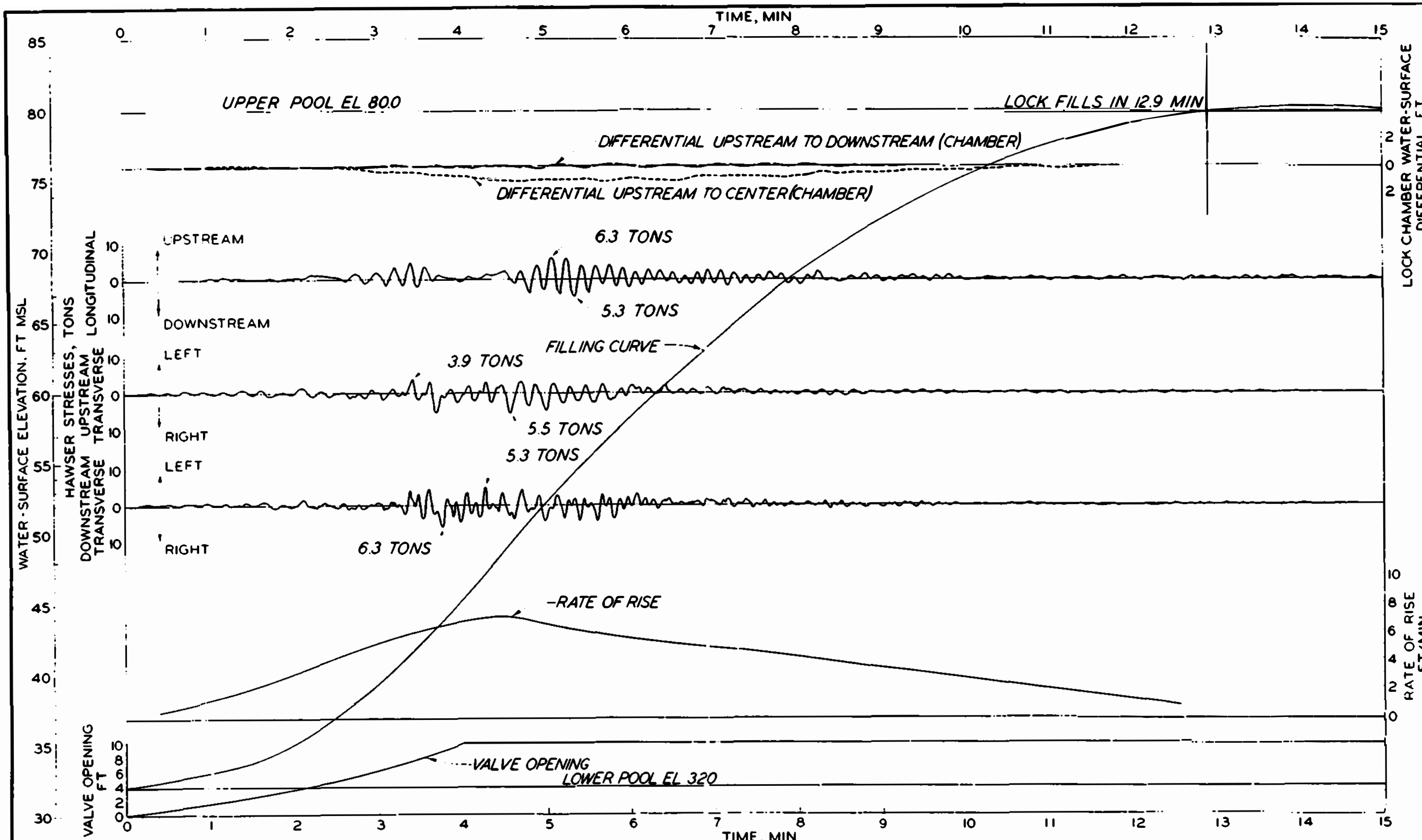
NOTE: 48-FT HEAD (UPPER POOL EL 80.0, LOWER POOL EL 32.0)

——— 12-BARGE TOW AT STA 0+47
— — 6-BARGE TOW AT STA 0+47
- - - - 6-BARGE TOW AT STA 3+27

MILLERS FERRY LOCK

EFFECT OF TOW SIZE AND POSITION ON MAXIMUM HAWSER STRESSES DURING EMPTYING

TYPE I (ORIGINAL) CULVERT ARRANGEMENT



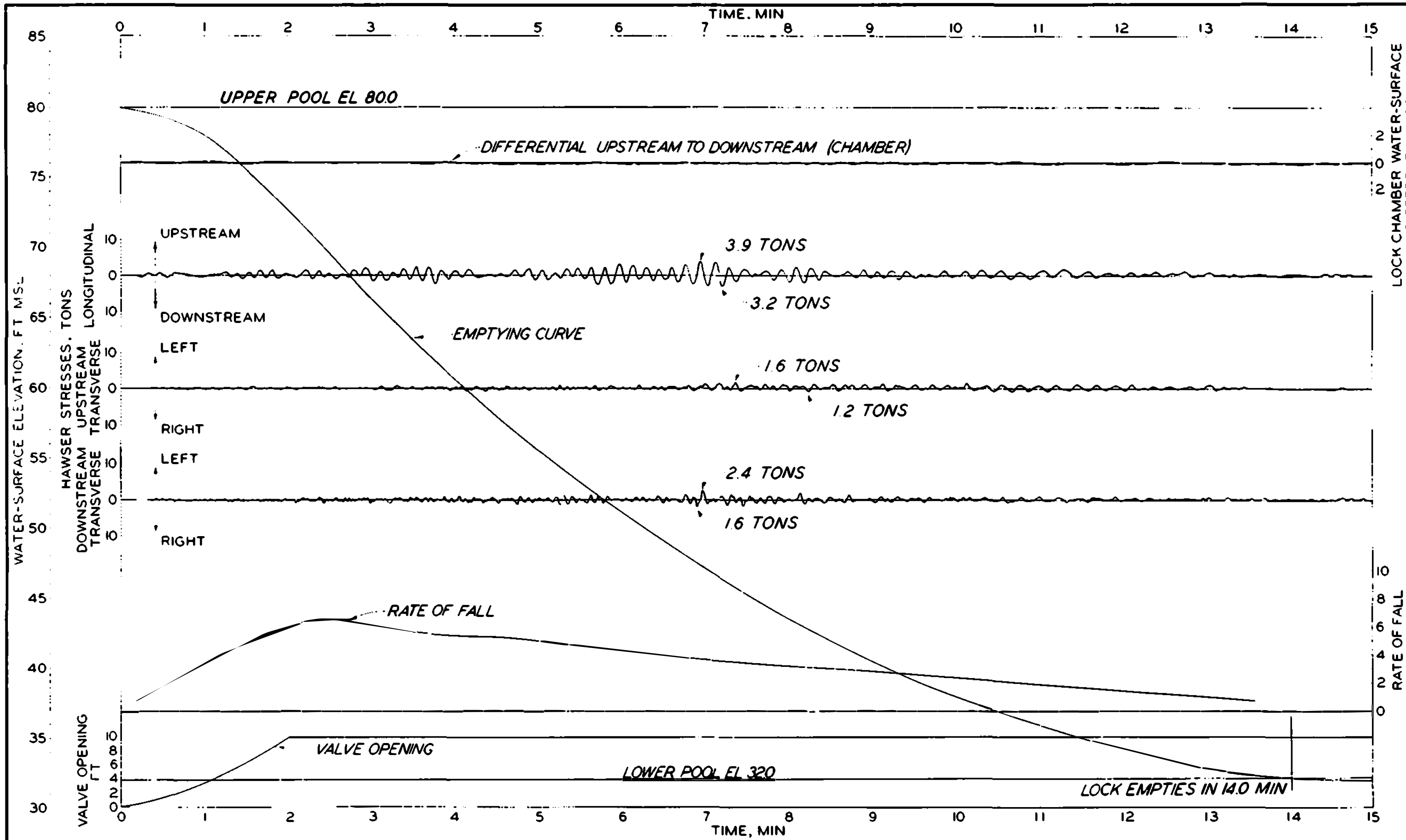
NOTE 12-BARGE TOW POSITIONED 47 FT FROM UPSTREAM MITER GATE PINTLES (11,305 TONS DISPLACEMENT)

MILLERS FERRY LOCK

FILLING CHARACTERISTICS

TYPE I CULVERT ARRANGEMENT

4-MIN VALVE, SCHEDULE I



NOTE: 12-BARGE TOW POSITIONED 47 FT FROM UPSTREAM MITER GATE PINTLES ([illegible] TONS DISPLACEMENT)

MILLERS FERRY LOCK

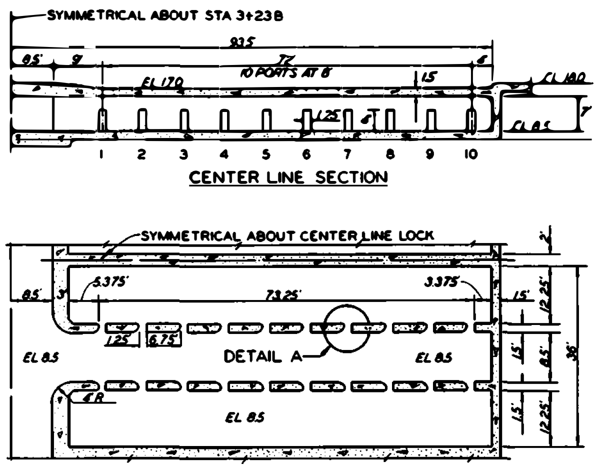
EMPTYING CHARACTERISTICS

TYPE I CULVERT ARRANGEMENT

2-MIN VALVE, SCHEDULE I

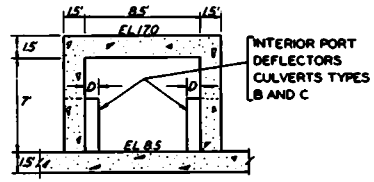
PLATE 11

PLATE 12

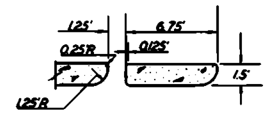


PLAN

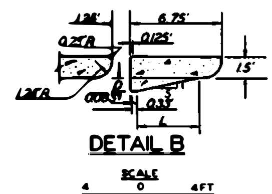
TYPE A (ORIGINAL) CULVERT



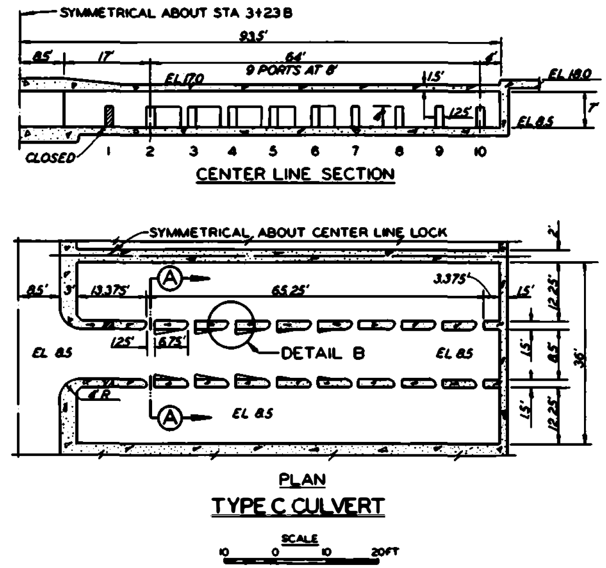
SECTION A-A



DETAIL A

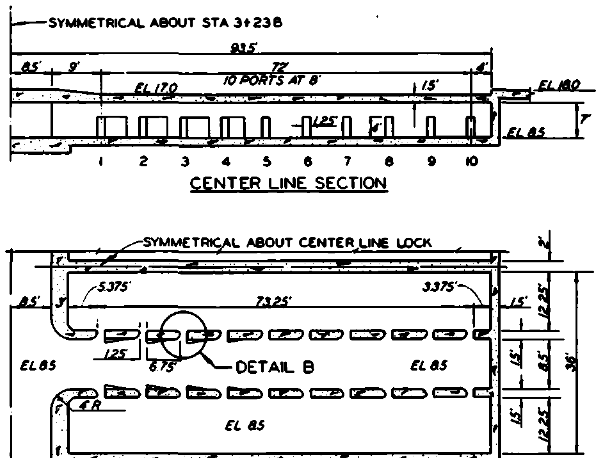


DETAIL B



PLAN

TYPE C CULVERT

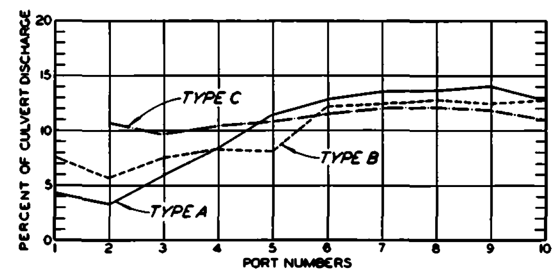


PLAN

TYPE B CULVERT

INTERIOR DEFLECTOR DETAILS FLOOR CULVERT PORTS			
CULVERT TYPE	PORT NO.	D OFFSET	L LENGTH
A	1-10	NONE	NONE
B	1-3 4 5-10	10" 6" NONE	50" 30" NONE
C	1 2-4 5-6 7-10	CLOSED 12" 6" NONE	CLOSED 60" 30" NONE

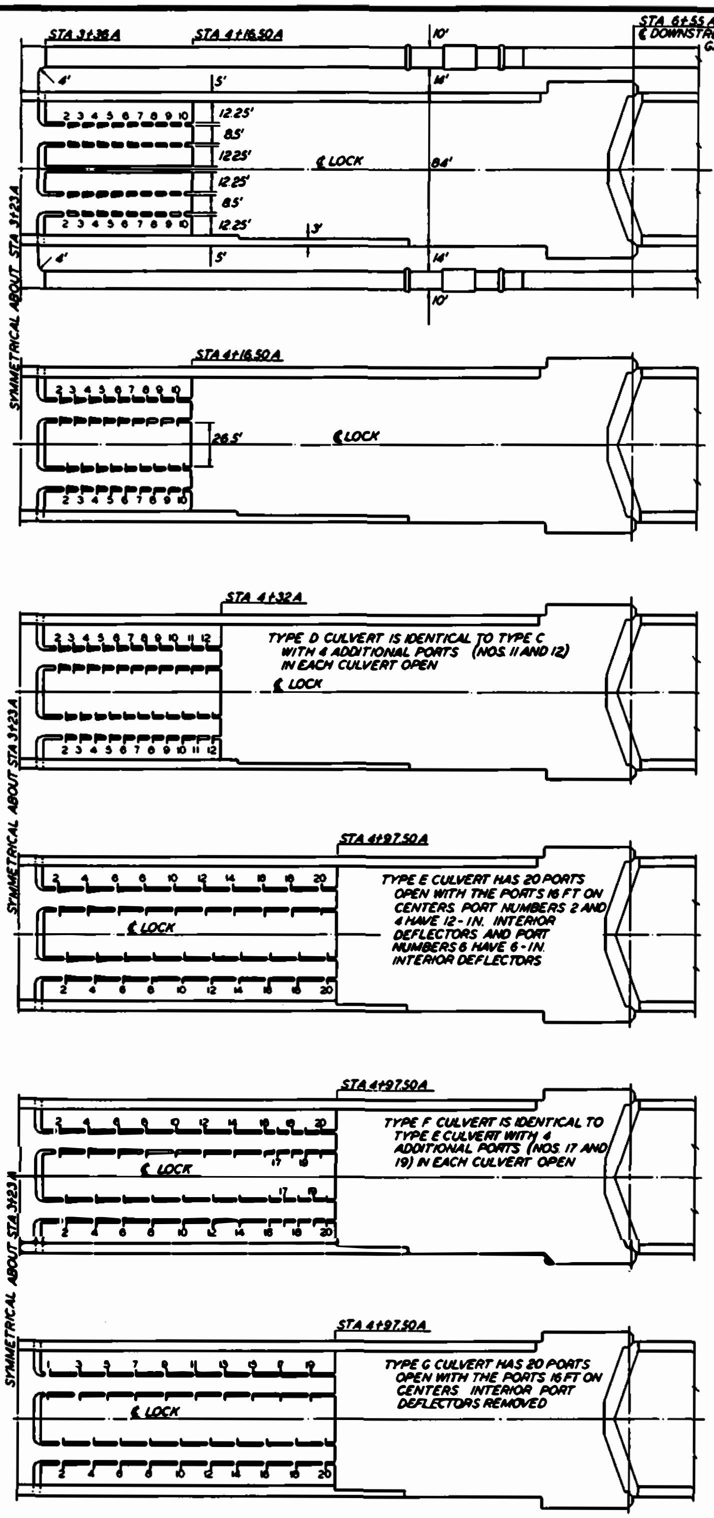
NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.



STEADY-FLOW CULVERT DISTRIBUTION

MILLERS FERRY LOCK

DETAILS OF AND FLOW DISTRIBUTION IN TYPES A,B,AND C FLOOR CULVERTS



TYPE 2

TYPE C CULVERTS.

TYPE 3

TYPE C CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS.

TYPE 4

TYPE C CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL REMOVED AND CULVERTS INSTALLED WITH CORRESPONDING PORTS STAGGERED.

TYPE 5

TYPE D CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL REMOVED AND CULVERTS INSTALLED WITH CORRESPONDING PORTS STAGGERED.

TYPE 6

TYPE E CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL REMOVED AND CULVERTS INSTALLED WITH CORRESPONDING PORTS STAGGERED.

TYPE 7

TYPE F CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL REMOVED AND CULVERTS INSTALLED WITH CORRESPONDING PORTS STAGGERED.

TYPE 8

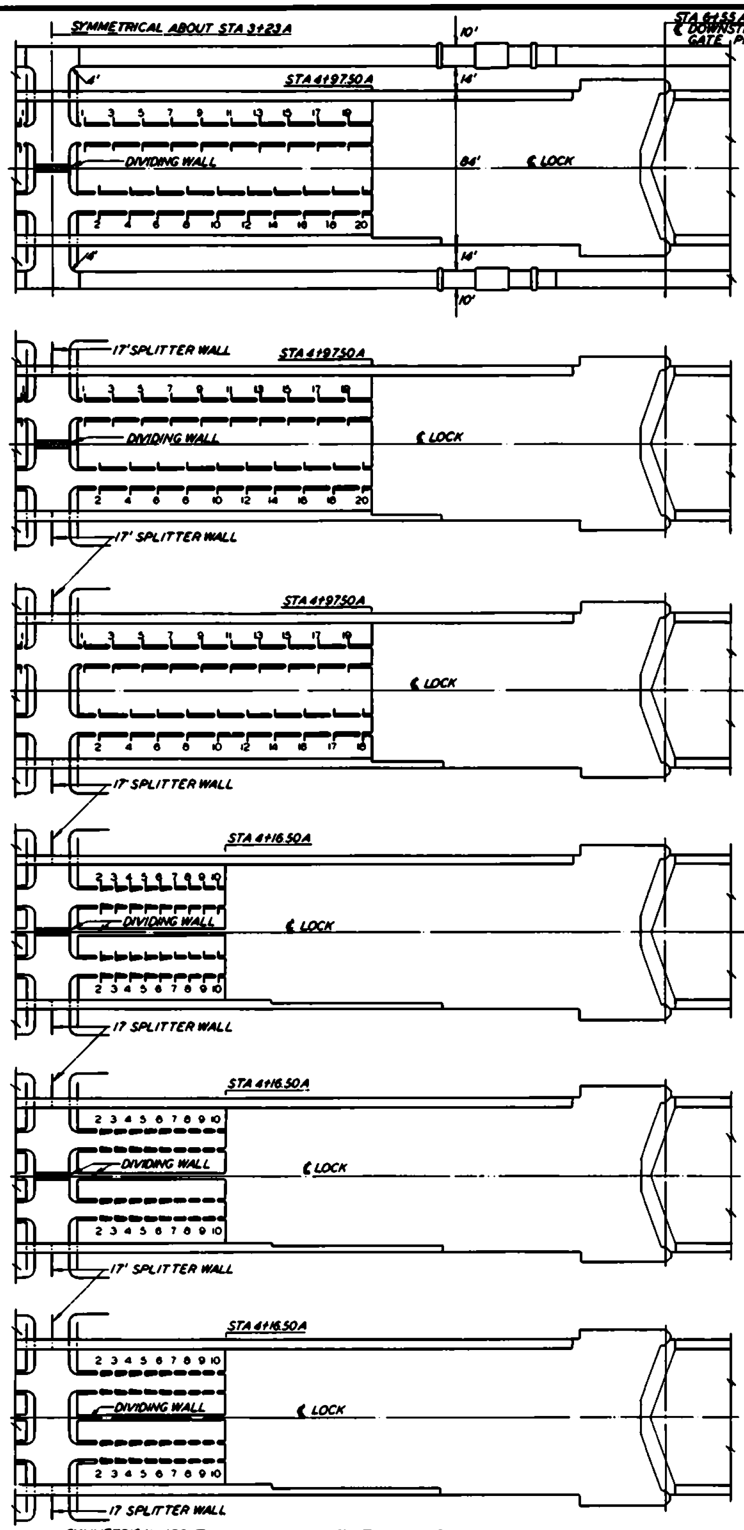
TYPE G CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING W LL REMOVED AND CULVERTS INSTALLED WITH PORTS STAGGERED.

HALF PLANS

MILLERS FERRY LOCK

CULVERT ARRANGEMENTS

TYPES 2-8



HALF PLANS

TYPE 9

TYPE G CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL REMOVED AND CULVERTS INSTALLED WITH CORRESPONDING PORTS STAGGERED. DIVIDING WALL INSTALLED IN CROSSOVER CULVERT ON CENTER LINE OF LOCK.

TYPE 10

TYPE G CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL REMOVED AND CULVERTS INSTALLED WITH CORRESPONDING PORTS STAGGERED. DIVIDING WALL INSTALLED IN CROSSOVER CULVERT ON CENTER LINE OF LOCK.

TYPE 11

TYPE G CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL REMOVED AND CULVERTS INSTALLED WITH CORRESPONDING PORTS STAGGERED.

TYPE 12

TYPE C CULVERTS WITH 3-FT-LONG BY 4-FT-HIGH EXTERIOR PORT DEFLECTORS. DIVIDING WALL INSTALLED IN CROSSOVER CULVERT AND ON CENTER LINE LOCK CHAMBER. SPLITTER WALL AT ENTRANCE TO CROSSOVER CULVERT.

TYPE 13

TYPE C CULVERTS WITH EXTERIOR PORT DEFLECTORS REMOVED. DIVIDING WALL INSTALLED IN CROSSOVER CULVERT ON CENTER LINE OF LOCK. SPLITTER WALL AT ENTRANCE TO CROSSOVER CULVERT.

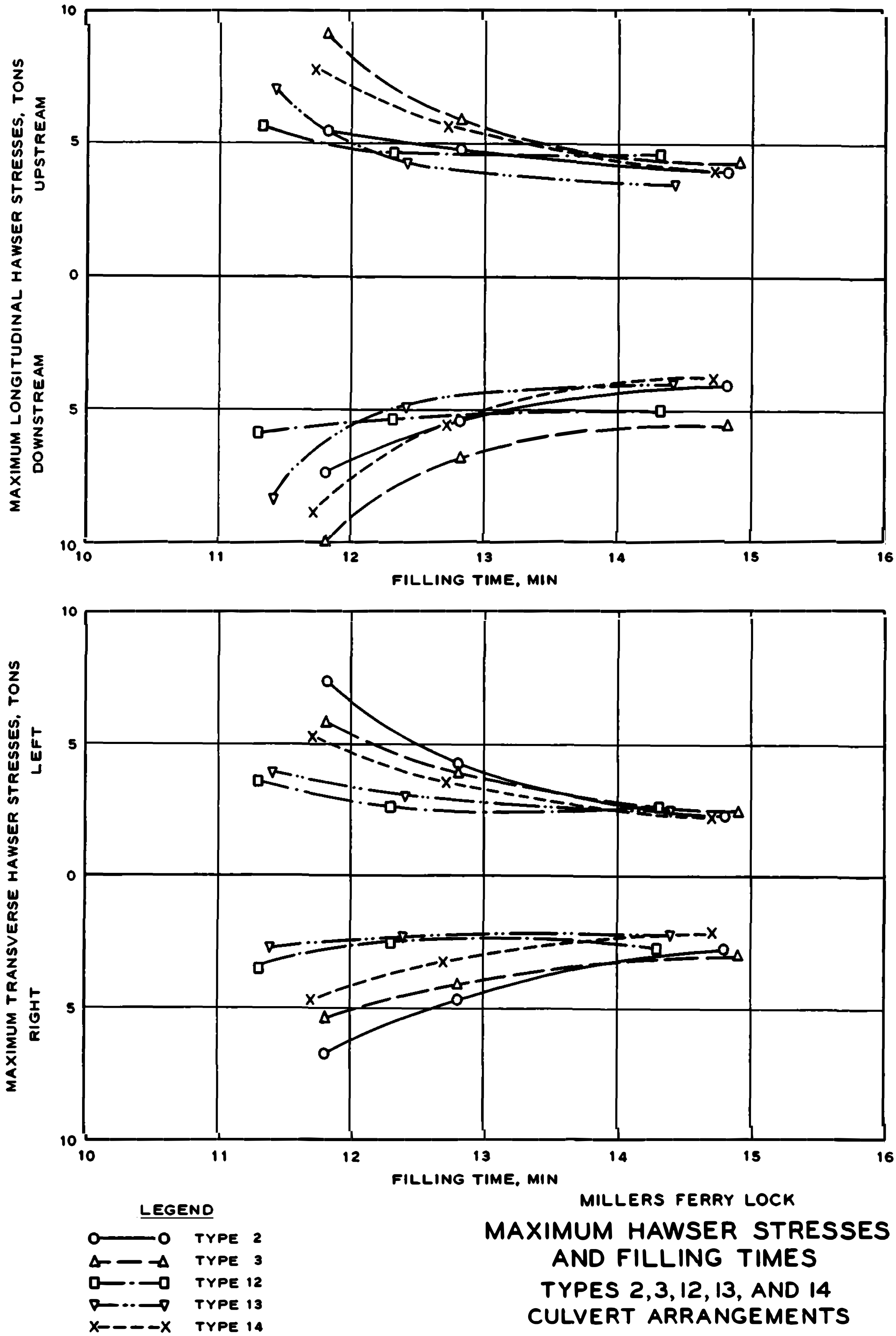
TYPE 14

TYPE C CULVERTS WITH SPLITTER WALL AT ENTRANCE TO CROSSOVER CULVERT. DIVIDING WALL REMOVED FROM CROSSOVER CULVERT ON CENTER LINE OF LOCK.

MILLERS FERRY LOCK

CULVERT ARRANGEMENTS

TYPES 9-14

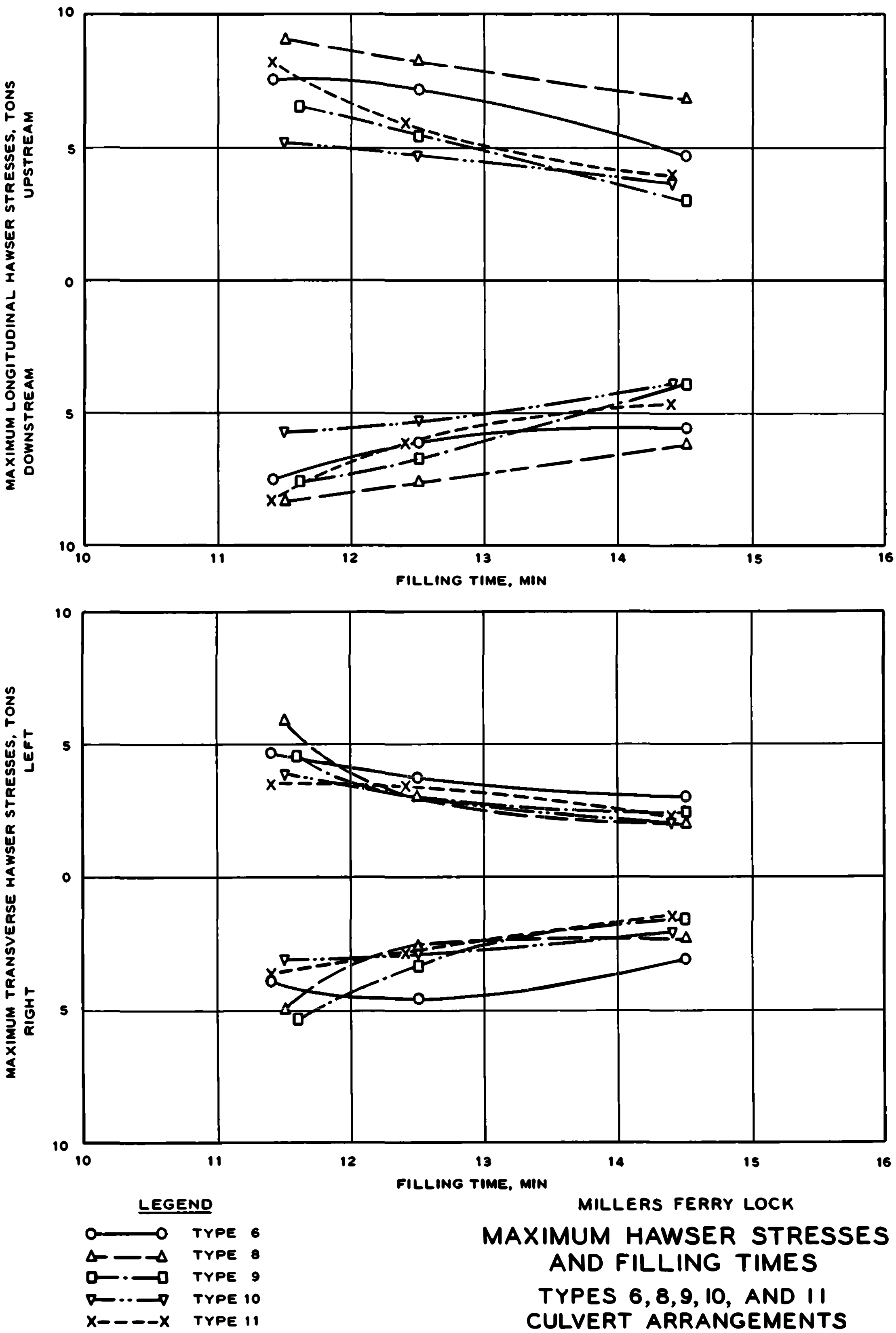


MILLERS FERRY LOCK

MAXIMUM HAWSER STRESSES AND FILLING TIMES

TYPES 2, 3, 12, 13, AND 14 CULVERT ARRANGEMENTS

8-FT PORT SPACING

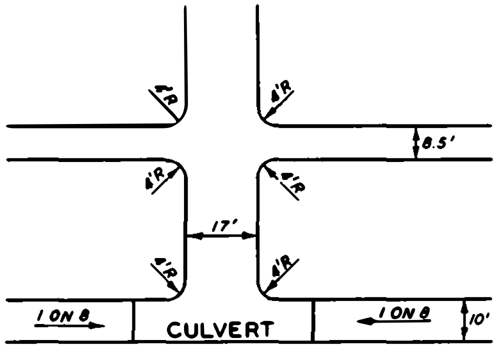


MILLERS FERRY LOCK

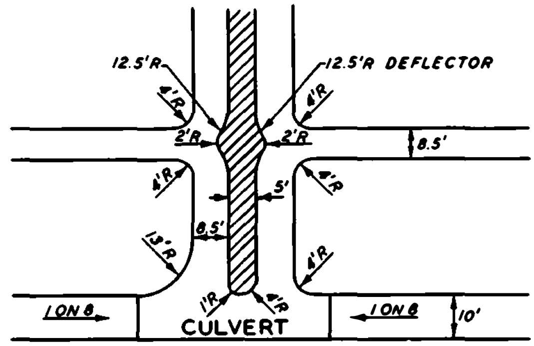
MAXIMUM HAWSER STRESSES AND FILLING TIMES

TYPES 6, 8, 9, 10, AND 11 CULVERT ARRANGEMENTS

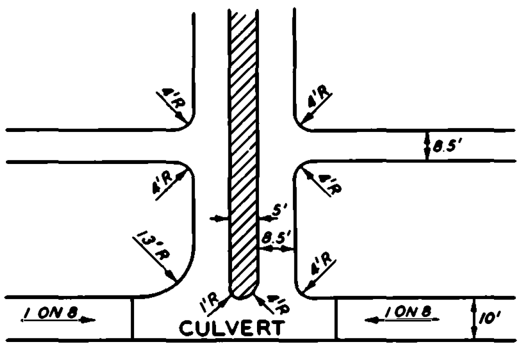
16-FT PORT SPACING



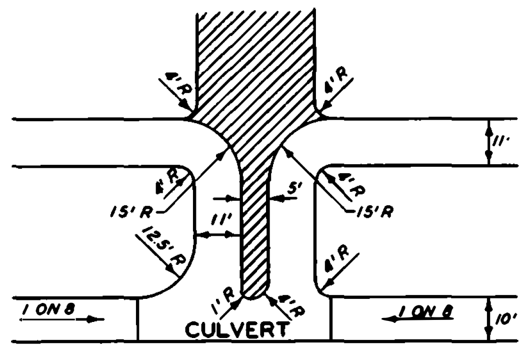
TYPE I (ORIGINAL)



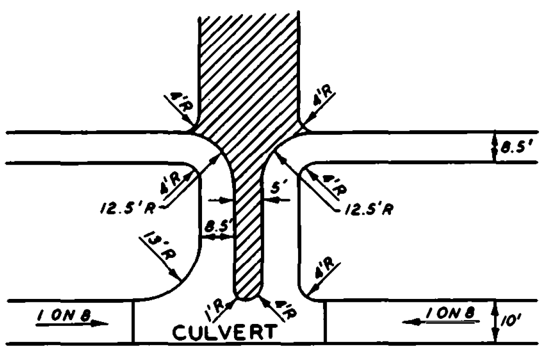
TYPE 4



TYPE 2



TYPE 5



TYPE 3

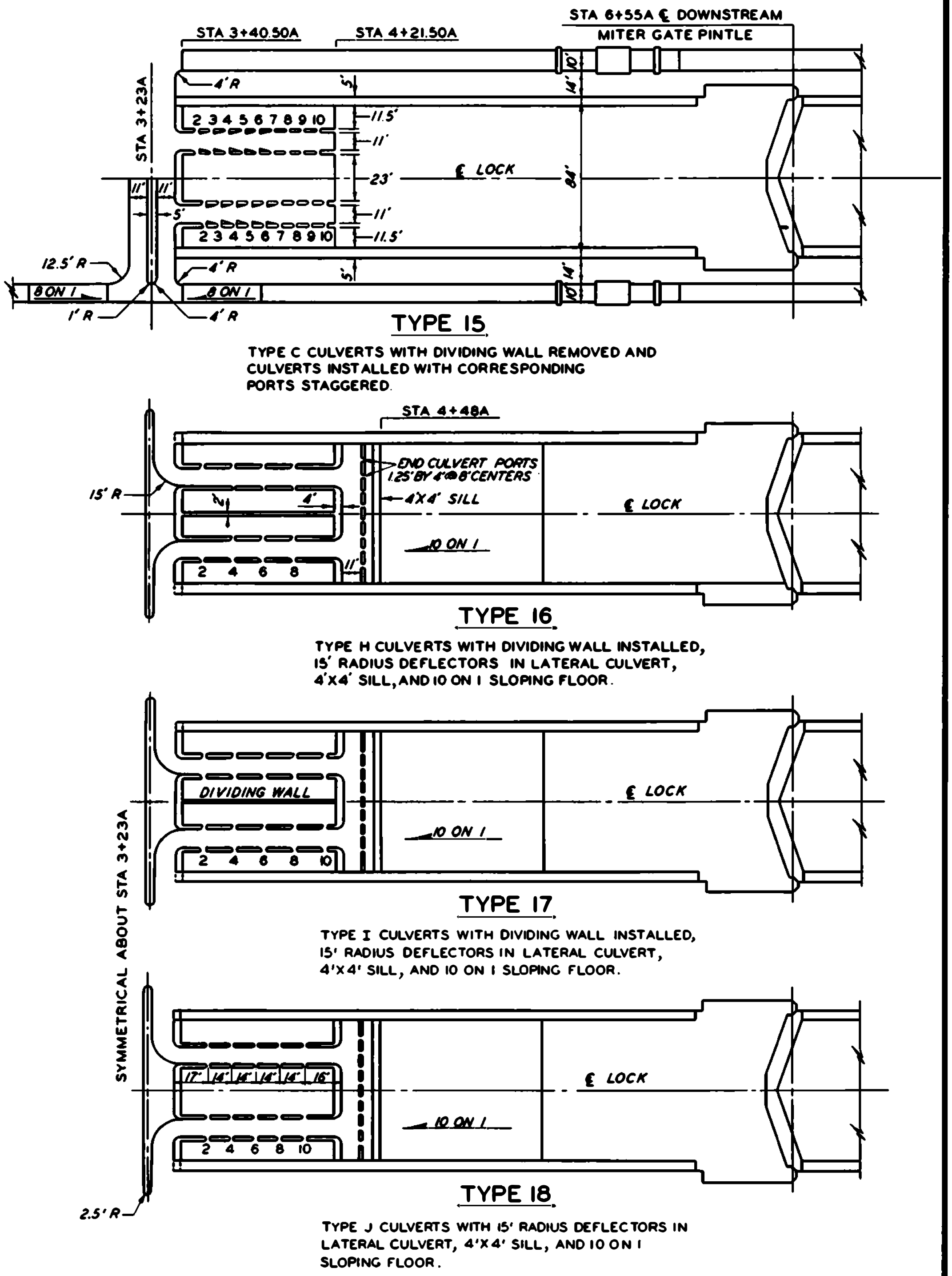
NOTE: ALL DIMENSIONS ARE IN PROTOTYPE UNITS.

MILLERS FERRY LOCK

CROSSOVER CULVERT ENTRANCES
TYPES 1-5

SCALE IN FEET

25 0 25 50 75



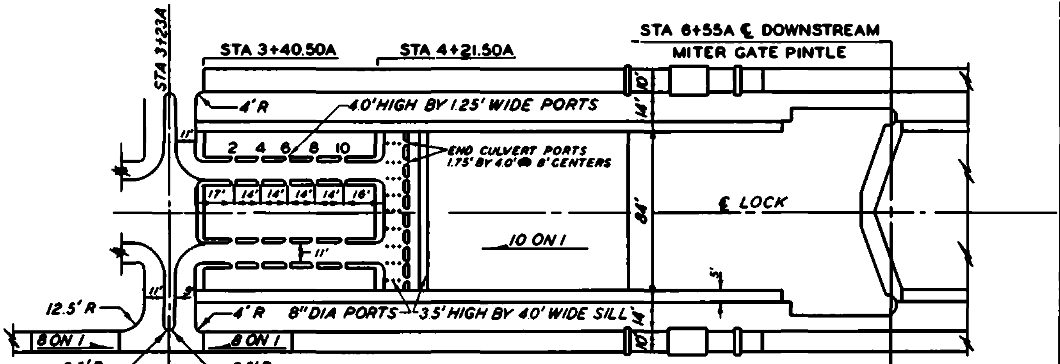
HALF PLANS

NOTE: ALL TYPES HAVE 11' WIDE CULVERTS, 5' SPLITTER WALL, AND 12.5' RADIUS ON UPSTREAM ENTRANCE TO LATERAL CULVERT (STA 3+23).

MILLERS FERRY LOCK

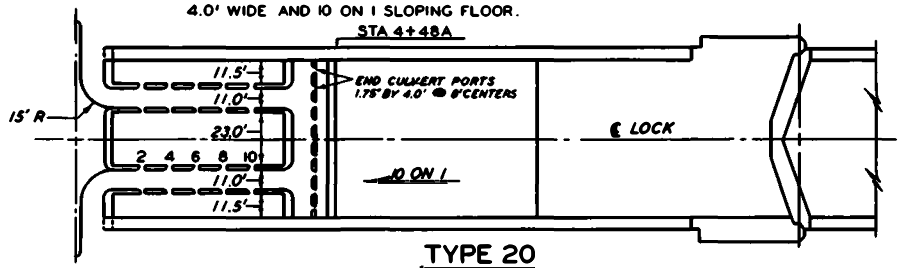
CULVERT ARRANGEMENTS

TYPES 15 – 18



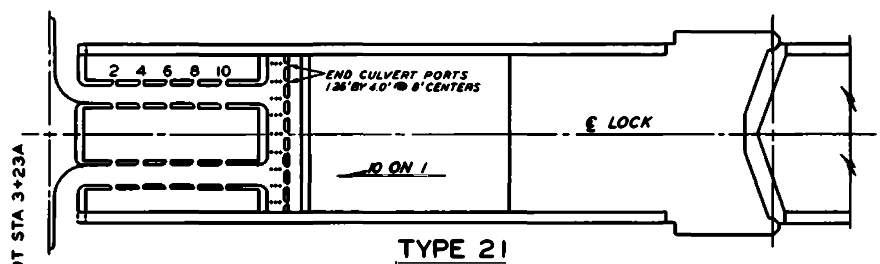
TYPE 19

TYPE K CULVERTS WITH ROOF PORTS IN END CULVERT ANGLED RESPECTIVELY, 45 DEG UPSTREAM, NORMAL, AND 45 DEG DOWNSTREAM. END SILL IS 3.5' HIGH BY 4.0' WIDE AND 10 ON 1 SLOPING FLOOR.



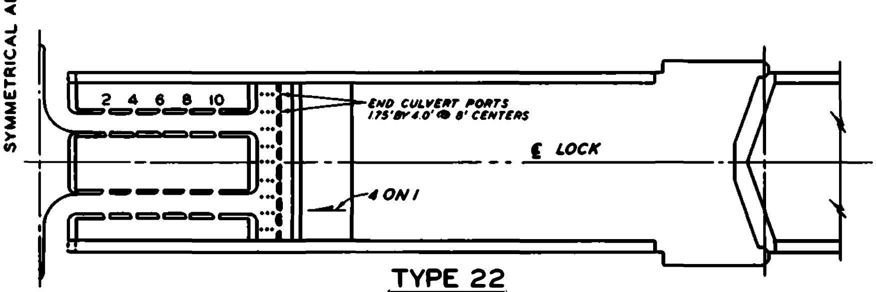
TYPE 20

TYPE L CULVERTS



TYPE 21

TYPE M CULVERTS



TYPE 22

TYPE K CULVERT WITH A 4 ON 1 SLOPING CHAMBER FLOOR.

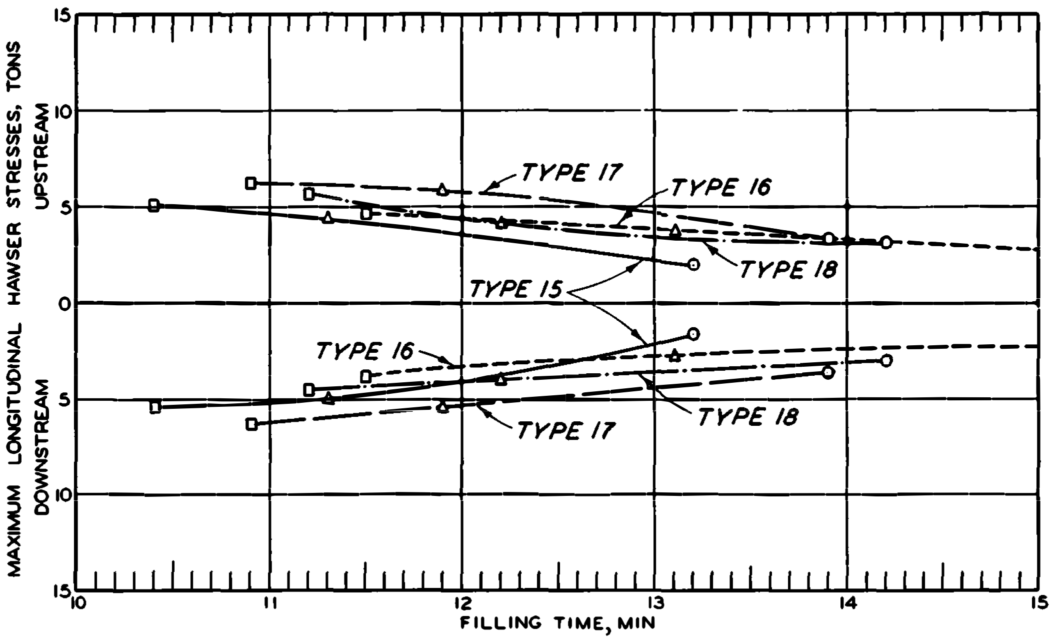
HALF PLANS

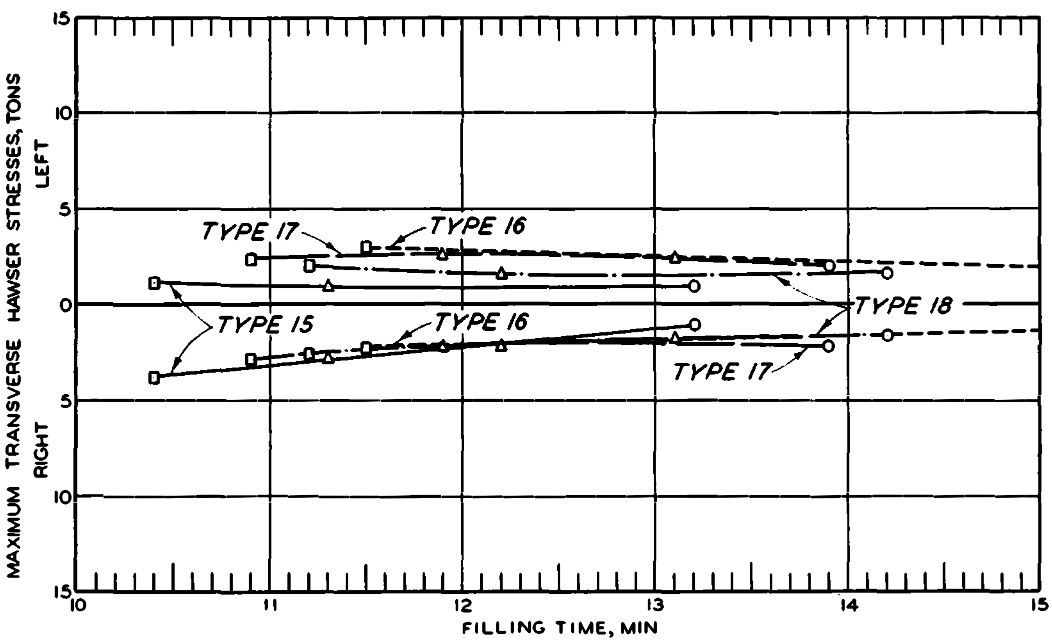
NOTE: ALL TYPES HAVE 11' WIDE CULVERTS, 5' SPLITTER WALL, AND 12.5' RADIUS ON UPSTREAM ENTRANCE TO LATERAL CULVERT (STA 3+23).

MILLERS FERRY LOCK

CULVERT ARRANGEMENTS

TYPES 19- 22





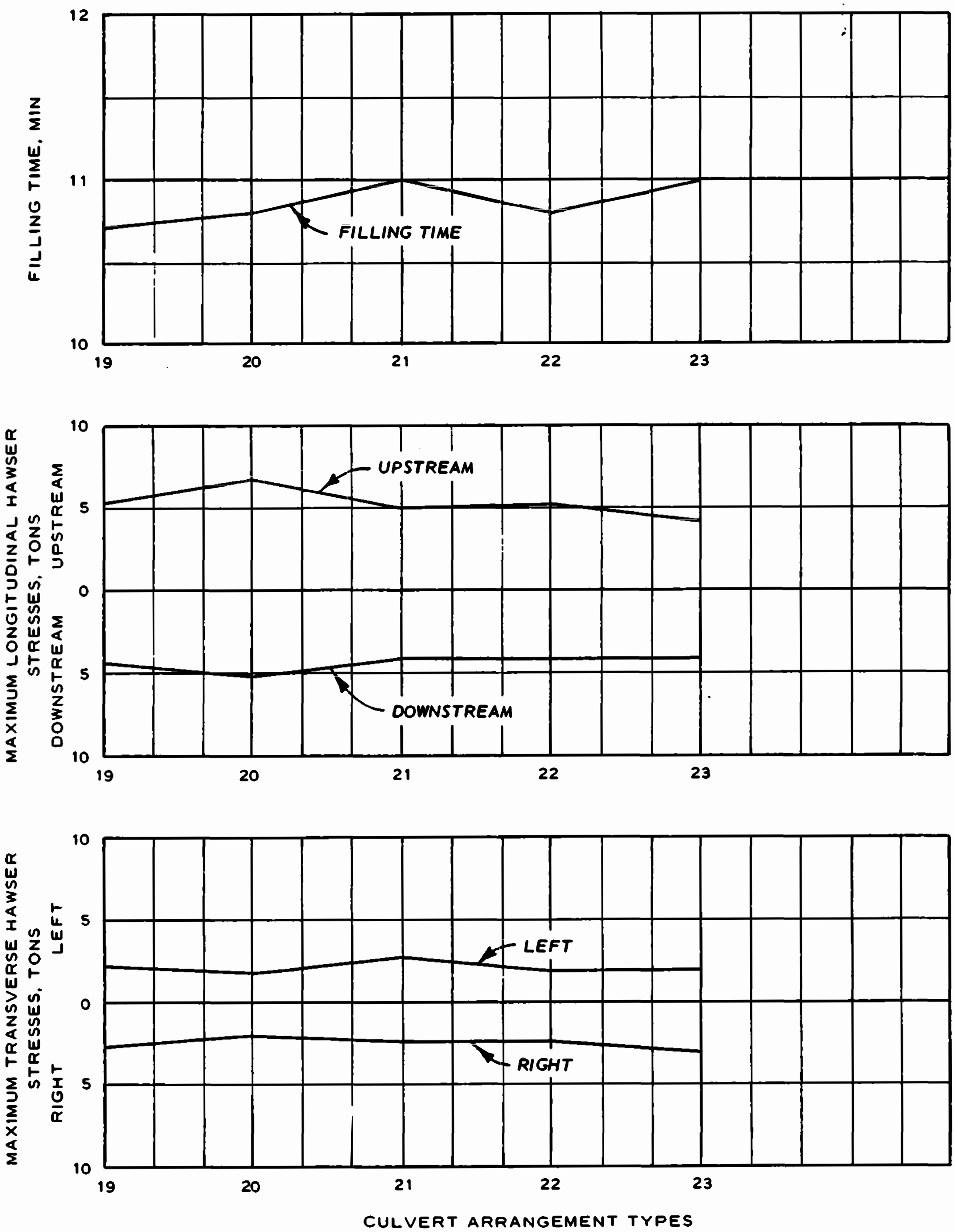
LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
□	2-I
Δ	4-I
O	8-I

NOTE: 48-FT HEAD (UPPER POOL EL 80.0, LOWER POOL EL 32.0).

MILLERS FERRY LOCK

MAXIMUM HAWSER STRESSES AND FILLING TIMES

TYPES 15-18 CULVERT ARRANGEMENTS
12-BARGE TOW



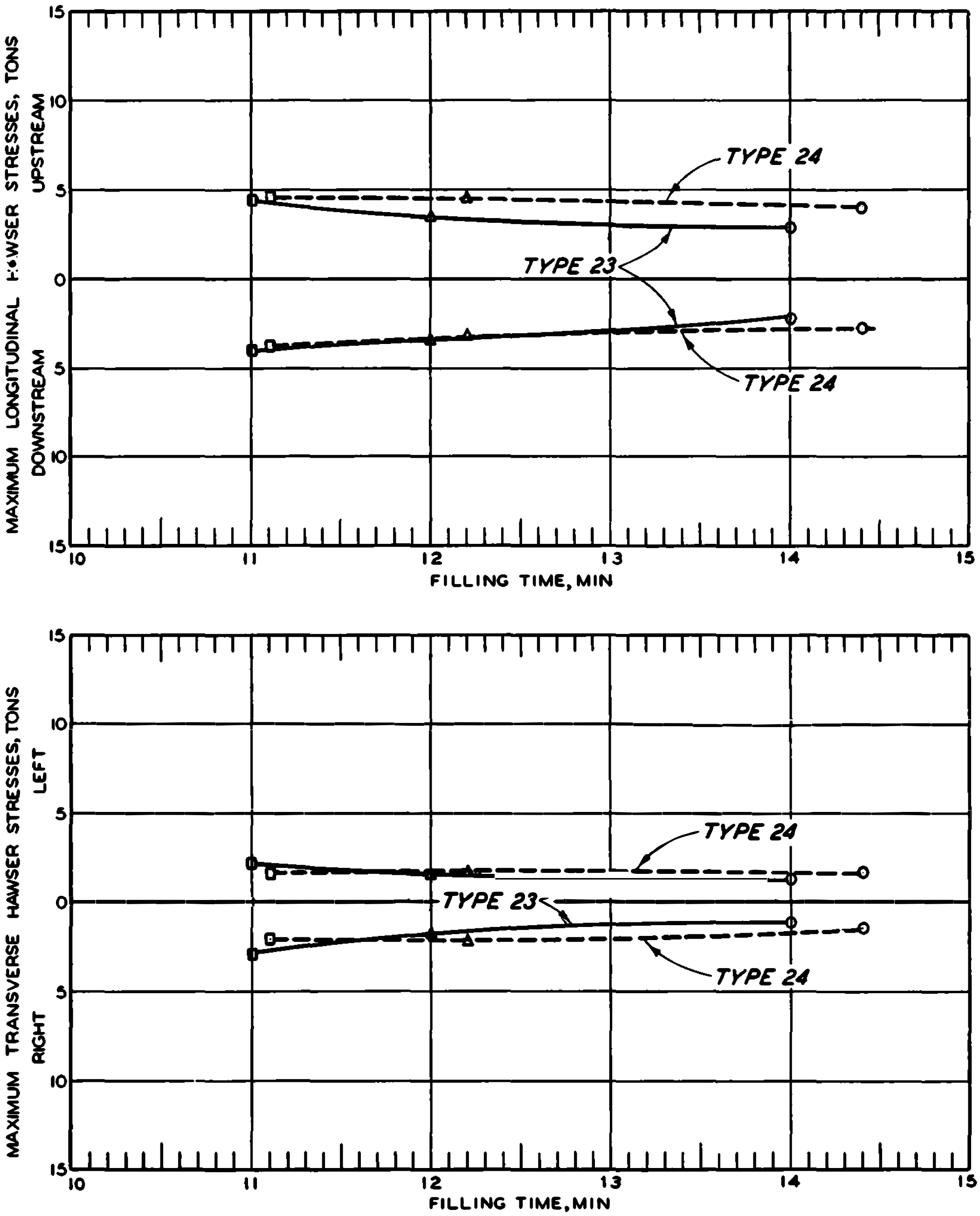
NOTE: 6-BARGE TOW POSITIONED 327 FT BELOW UPSTREAM MITER GATE PINTLES.

MAXIMUM HAWSER STRESSES AND FILLING TIMES

TYPES 19-23 CULVERT ARRANGEMENTS

48-FT HEAD

2-MIN VALVE, SCHEDULE II



LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
□	2-I
△	4-I
○	8-I

NOTE: 48-FT HEAD (UPPER POOL EL 80.0, LOWER POOL EL 32.0).

MILLERS FERRY LOCK

MAXIMUM HAWSER STRESSES AND FILLING TIMES

TYPES 23 AND 24 CULVERT ARRANGEMENTS
6-BARGE TOW

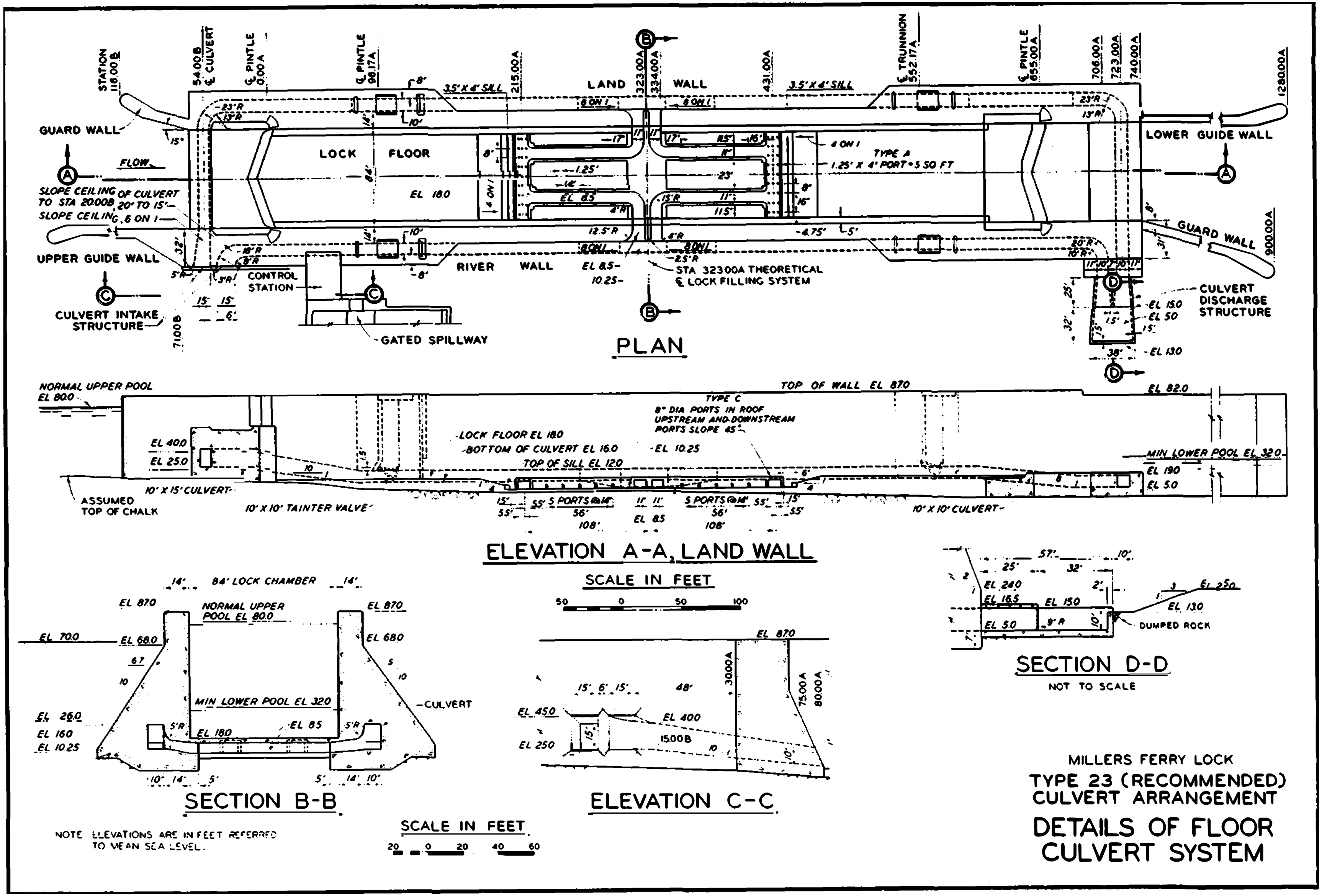
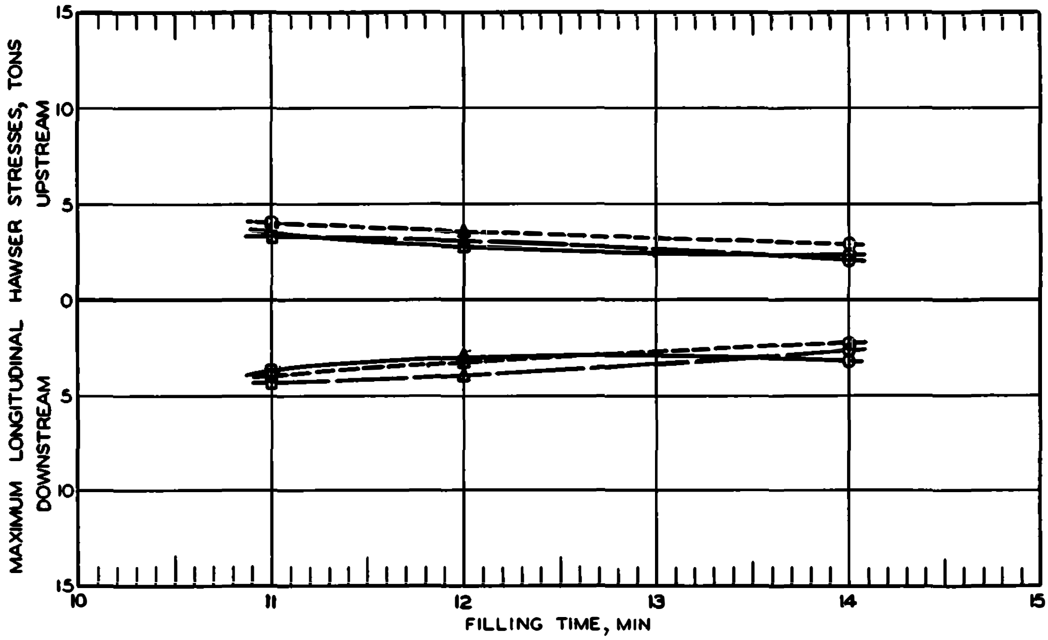
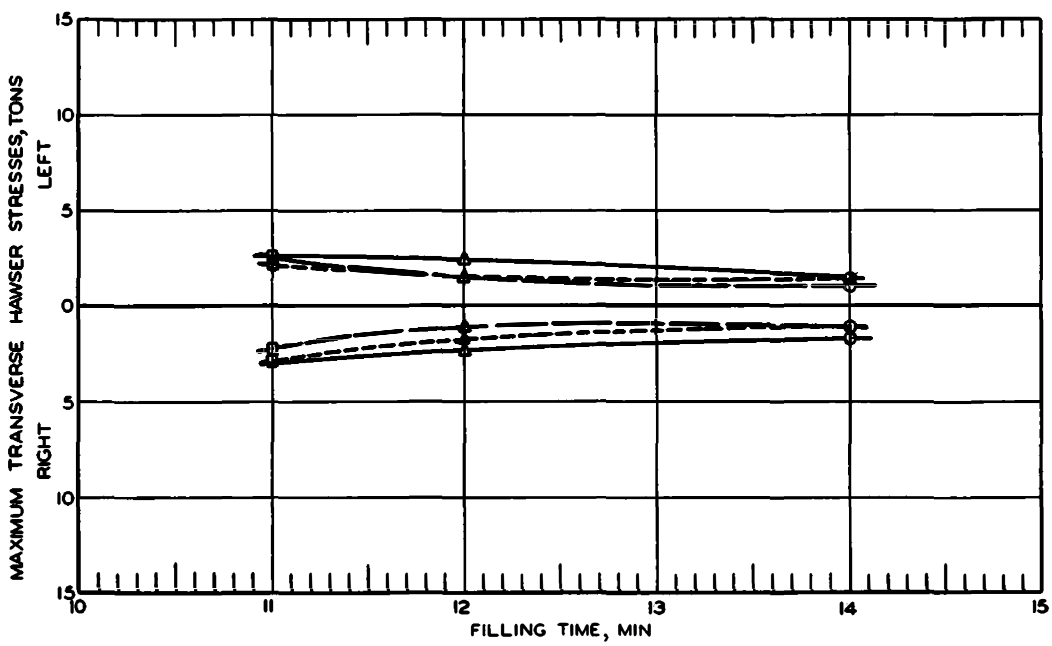

PLAN
LAND WALL
RIVER WALL
LOCK FLOOR
EL 180
GUARD WALL
FLOW
UPPER GUIDE WALL
LOWER GUIDE WALL
SLOPE CEILING OF CULVERT TO STA 20.00B 20' TO 15'
SLOPE CEILING, 6 ON 1
CULVERT INTAKE STRUCTURE
CONTROL STATION
GATED SPILLWAY
CULVERT DISCHARGE STRUCTURE
STA 323.00A THEORETICAL ℄ LOCK FILLING SYSTEM
TYPE A 1.25' X 4' PORT = 5 SQ FT
3.5' X 4' SILL
STATION 116.00B
54.00B ℄ CULVERT
℄ PINTLE 0.00A
℄ PINTLE 98.17A
215.00A
323.00A
334.00A
431.00A
℄ TRUNNION 552.17A
℄ PINTLE 655.00A
706.00A
723.00A
740.00A
1280.00A
900.00A
71.00B
ELEVATION A-A, LAND WALL
NORMAL UPPER POOL EL 80.0
TOP OF WALL EL 87.0
TYPE C 8" DIA PORTS IN ROOF UPSTREAM AND DOWNSTREAM PORTS SLOPE 45°
LOCK FLOOR EL 18.0
BOTTOM OF CULVERT EL 16.0
TOP OF SILL EL 12.0
EL 10.25
MIN LOWER POOL EL 32.0
10' X 15' CULVERT
ASSUMED TOP OF CHALK
10' X 10' TAINTER VALVE
5 PORTS @ 14'
10' X 10' CULVERT
SCALE IN FEET
SECTION B-B
84' LOCK CHAMBER
NORMAL UPPER POOL EL 80.0
MIN LOWER POOL EL 32.0
CULVERT
ELEVATION C-C
SECTION D-D
NOT TO SCALE
DUMPED ROCK
NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.
MILLERS FERRY LOCK
TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT
DETAILS OF FLOOR CULVERT SYSTEM

PLATE 23





LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
□	2-II
Δ	4-II
O	8-II

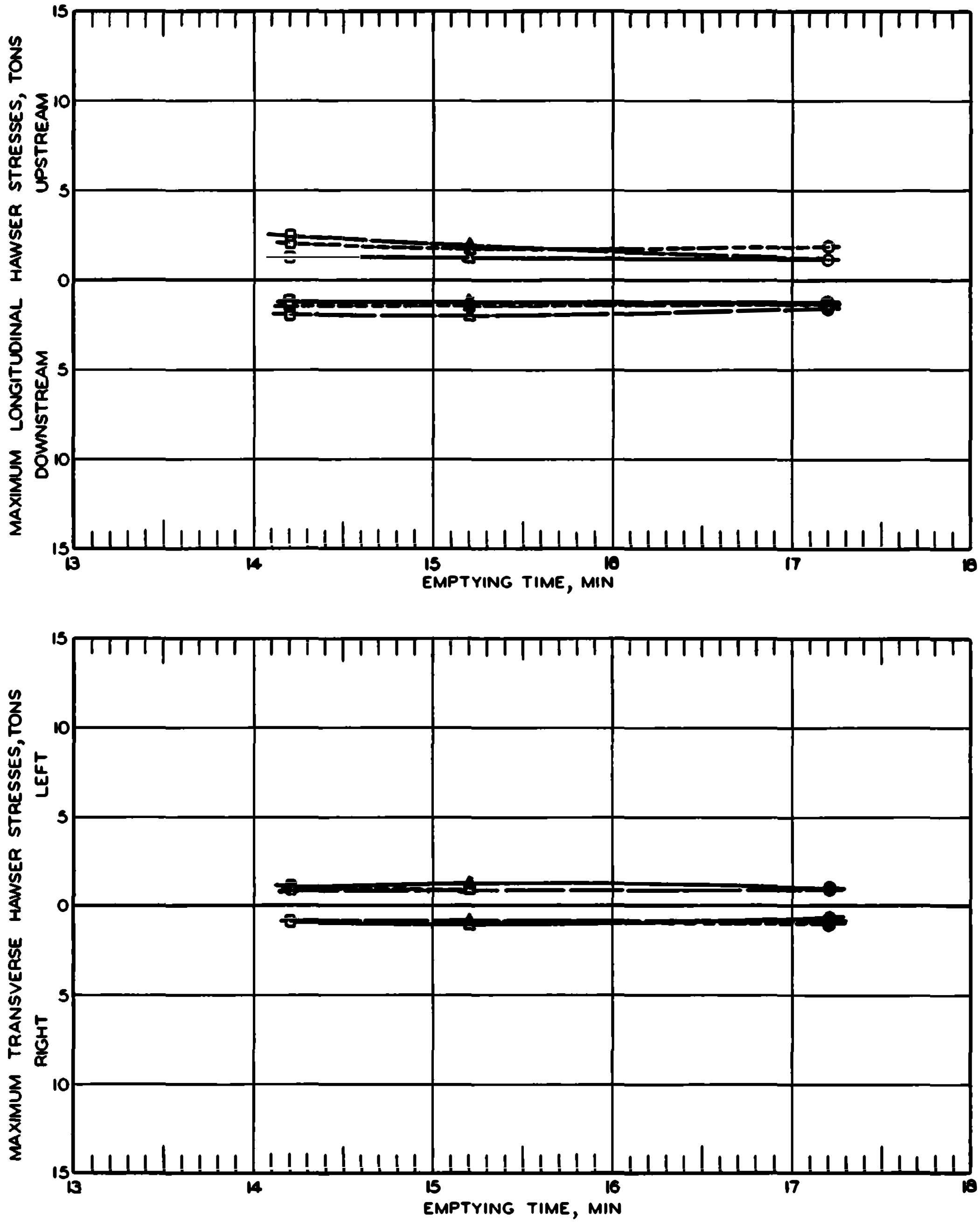
NOTE: 48-FT HEAD (UPPER POOL EL 80.0, LOWER POOL EL 32.0).

——— 12-BARGE TOW AT STA 0+47
— — 6-BARGE TOW AT STA 0+47
- - - - 6-BARGE TOW AT STA 3+27

MILLERS FERRY LOCK

EFFECT OF TOW SIZE AND POSITION ON MAXIMUM HAWSER STRESSES DURING FILLING

TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT



LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
□	2-II
△	4-II
○	8-II

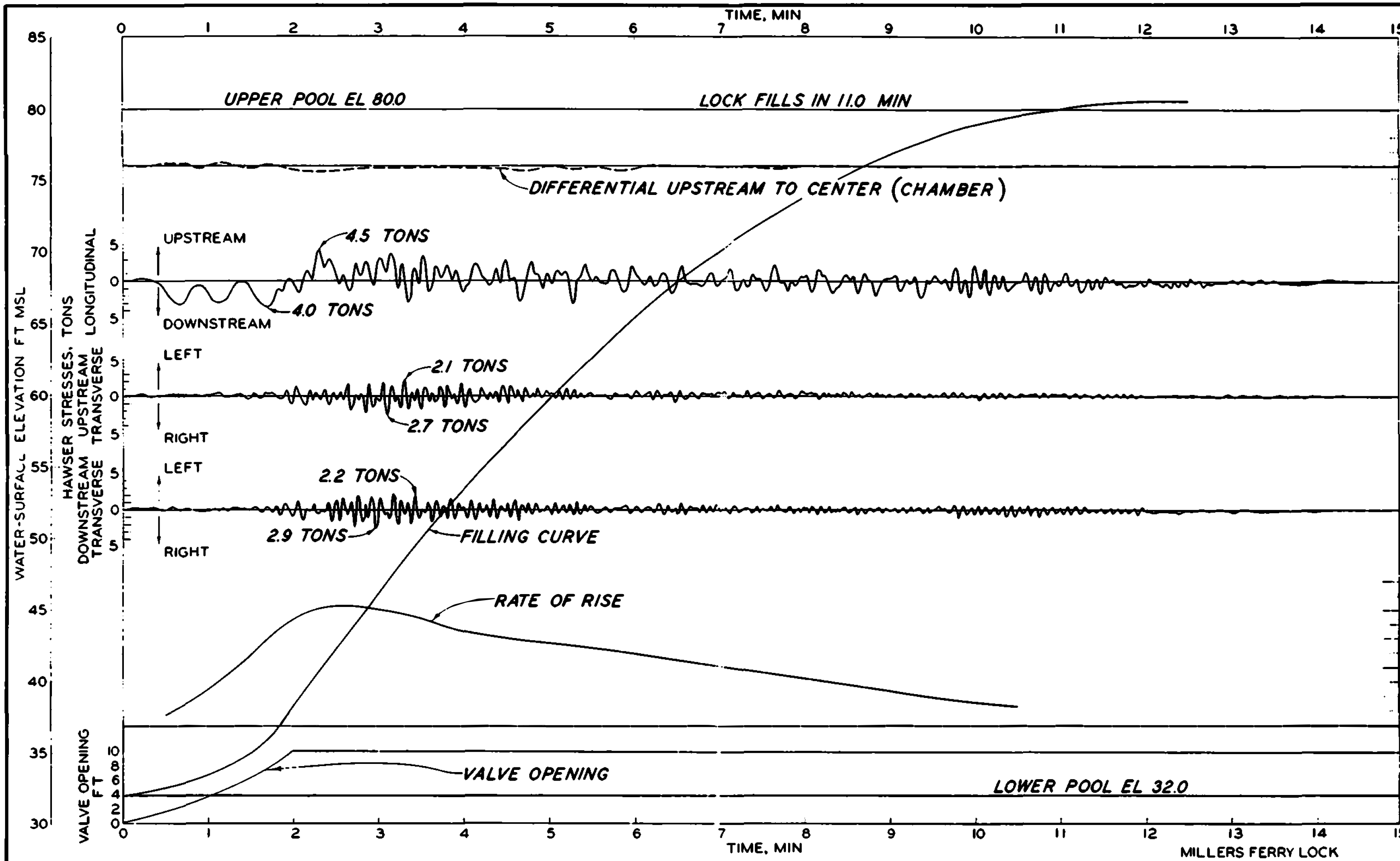
NOTE: 48-FT HEAD (UPPER POOL EL 80.0, LOWER POOL EL 32.0).

——— 12-BARGE TOW AT STA 0+47
— — 6-BARGE TOW AT STA 0+47
- - - - 6-BARGE TOW AT STA 3+27

MILLERS FERRY LOCK

EFFECT OF TOW SIZE AND POSITION ON MAXIMUM HAWSER STRESSES DURING EMPTYING

TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT



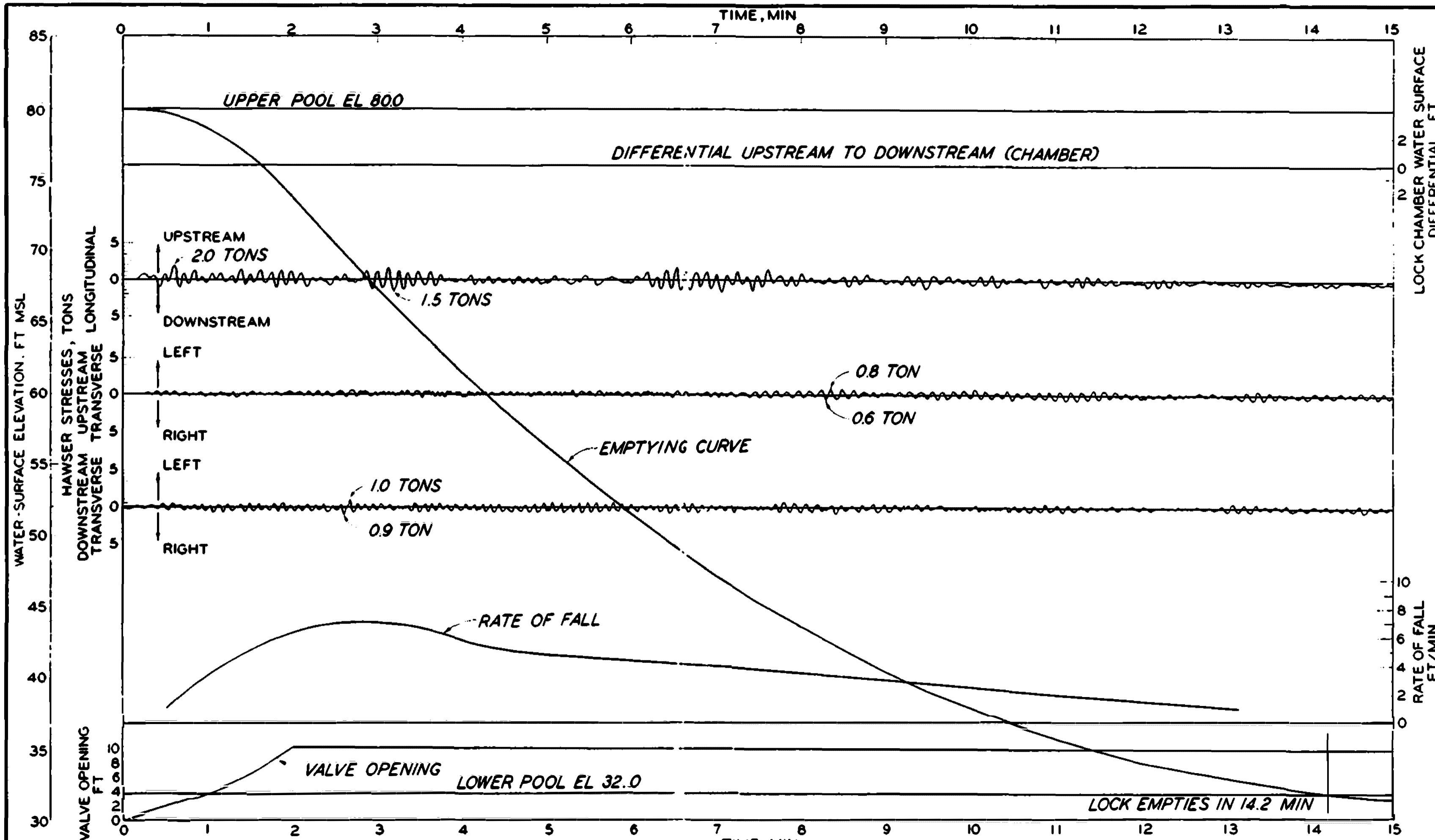
NOTE: 6-BARGE TOW POSITIONED 327 FT FROM UPSTREAM MITER GATE PINTLES (5410 TONS DISPLACEMENT)

MILLERS FERRY LOCK

FILLING CHARACTERISTICS

TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT

2-MIN VALVE. SCHEDULE II



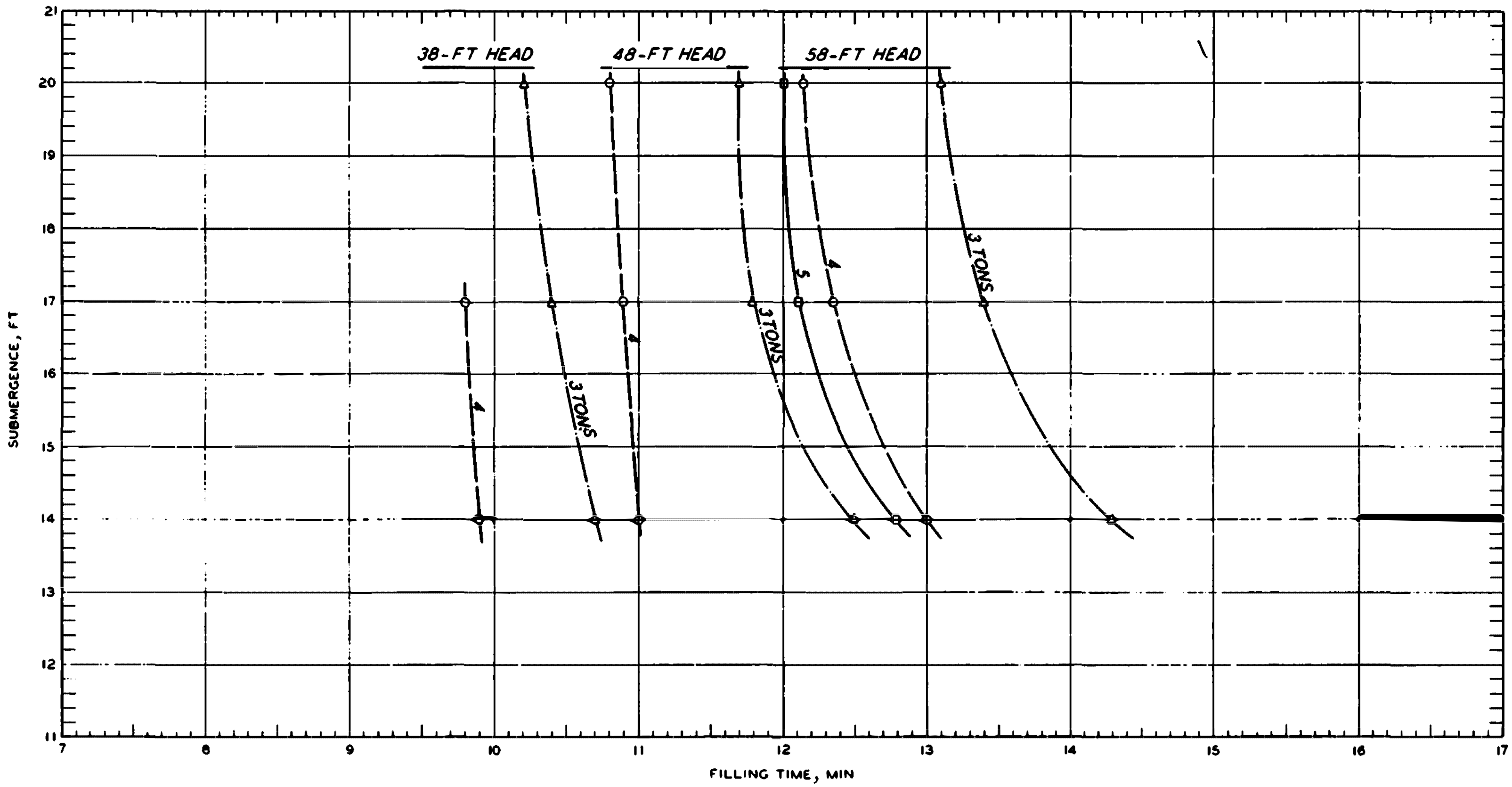
NOTE: 6-BARGE TOW POSITIONED 327 FT FROM UPSTREAM MITER GATE PINTLES (5410 TONS DISPLACEMENT).

MILLERS FERRY LOCK

EMPTYING CHARACTERISTICS

TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT

2-MIN VALVE, SCHEDULE II



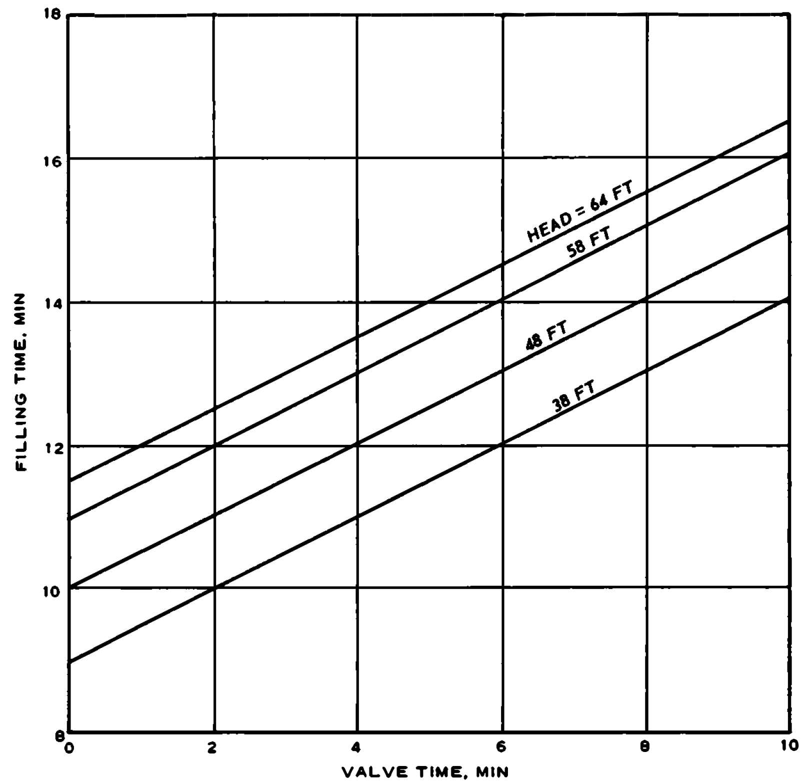
NOTE: HAWSER STRESSES WERE MEASURED ON 6-BARGE TOW (5410 TONS DISPLACEMENT) POSITIONED 327 FT FROM UPSTREAM MITER GATE PINTLES.

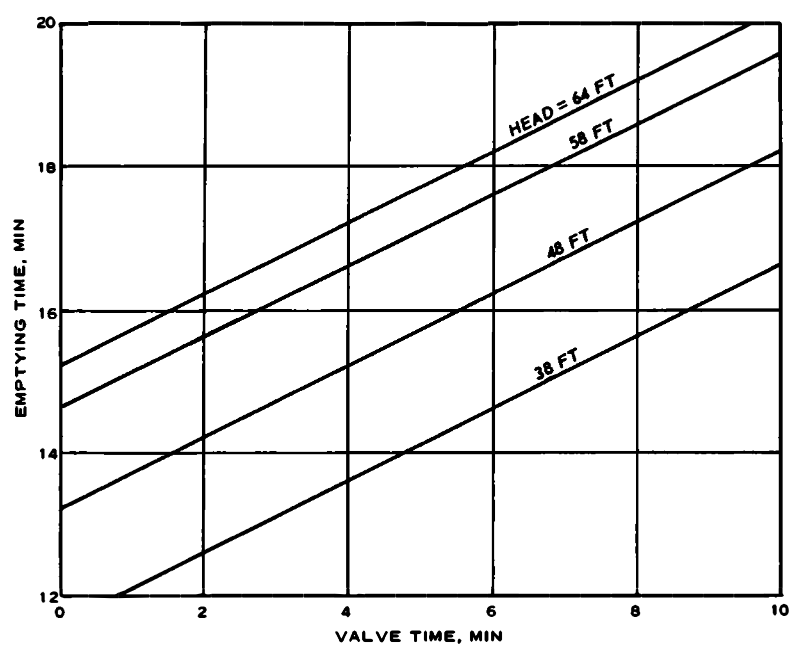
SUBMERGENCE IS THE DIFFERENCE IN ELEVATION BETWEEN LOWER POOL AND THE ROOF OF THE FLOOR CULVERT AT EL 18.0.

MILLERS FERRY LOCK

PERMISSIBLE FILLING TIMES TO KEEP HAWSER STRESSES WITHIN 3-, 4-, AND 5-TON LIMITS

TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT



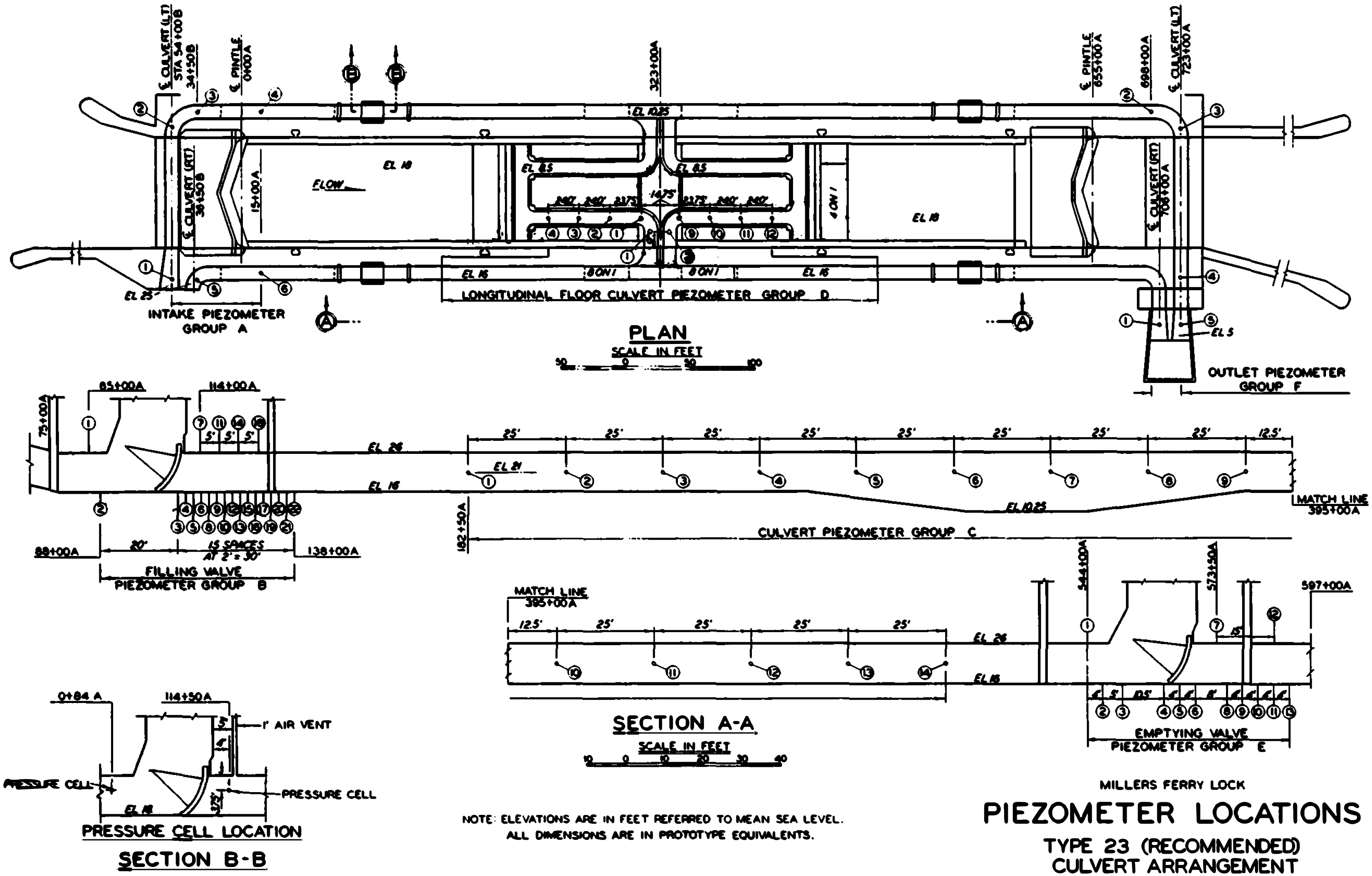


MILLERS FERRY LOCK

VARIATION OF FILLING AND EMPTYING TIMES WITH VALVE TIME

TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT

PLATE 30

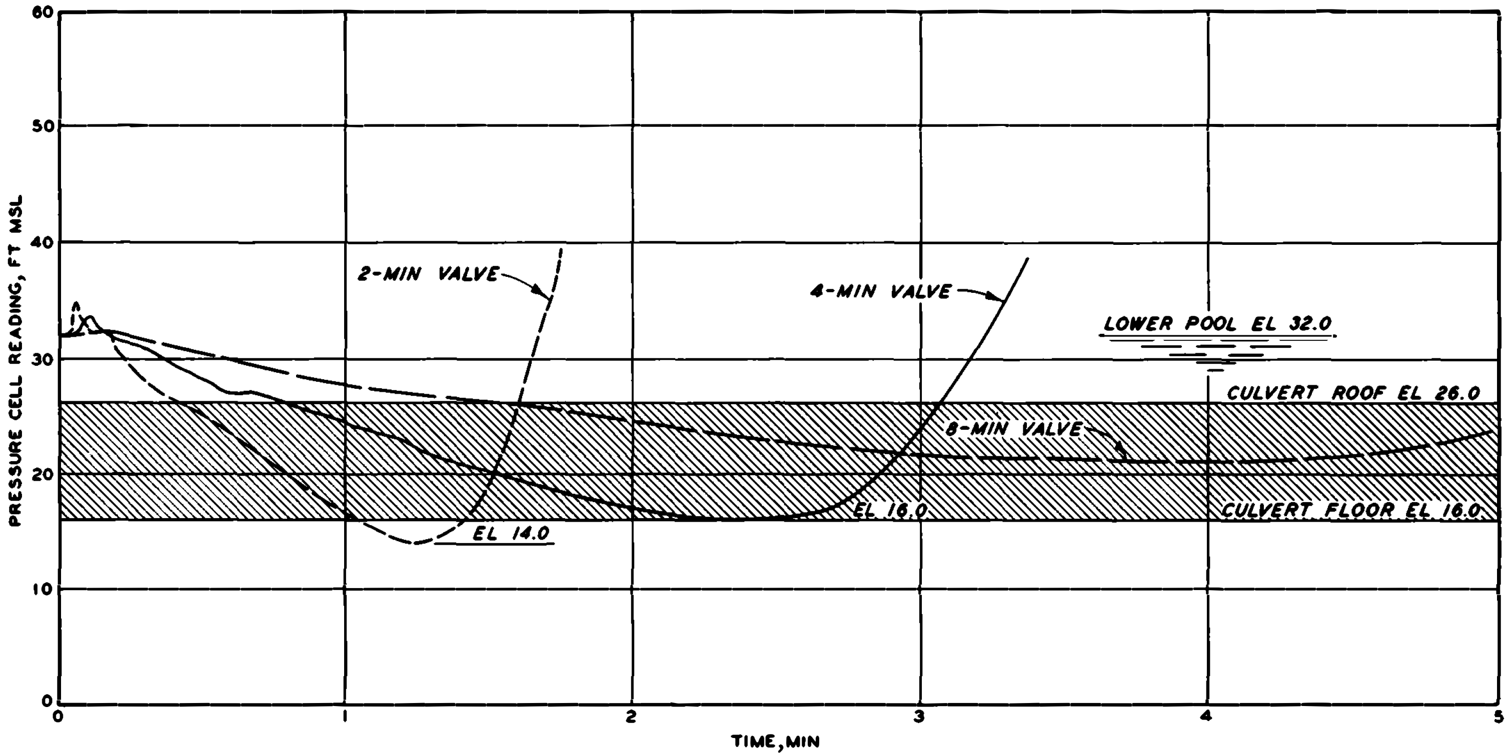


NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.
ALL DIMENSIONS ARE IN PROTOTYPE EQUIVALENTS.

MILLERS FERRY LOCK

PIEZOMETER LOCATIONS

TYPE 23 (RECOMMENDED)
CULVERT ARRANGEMENT



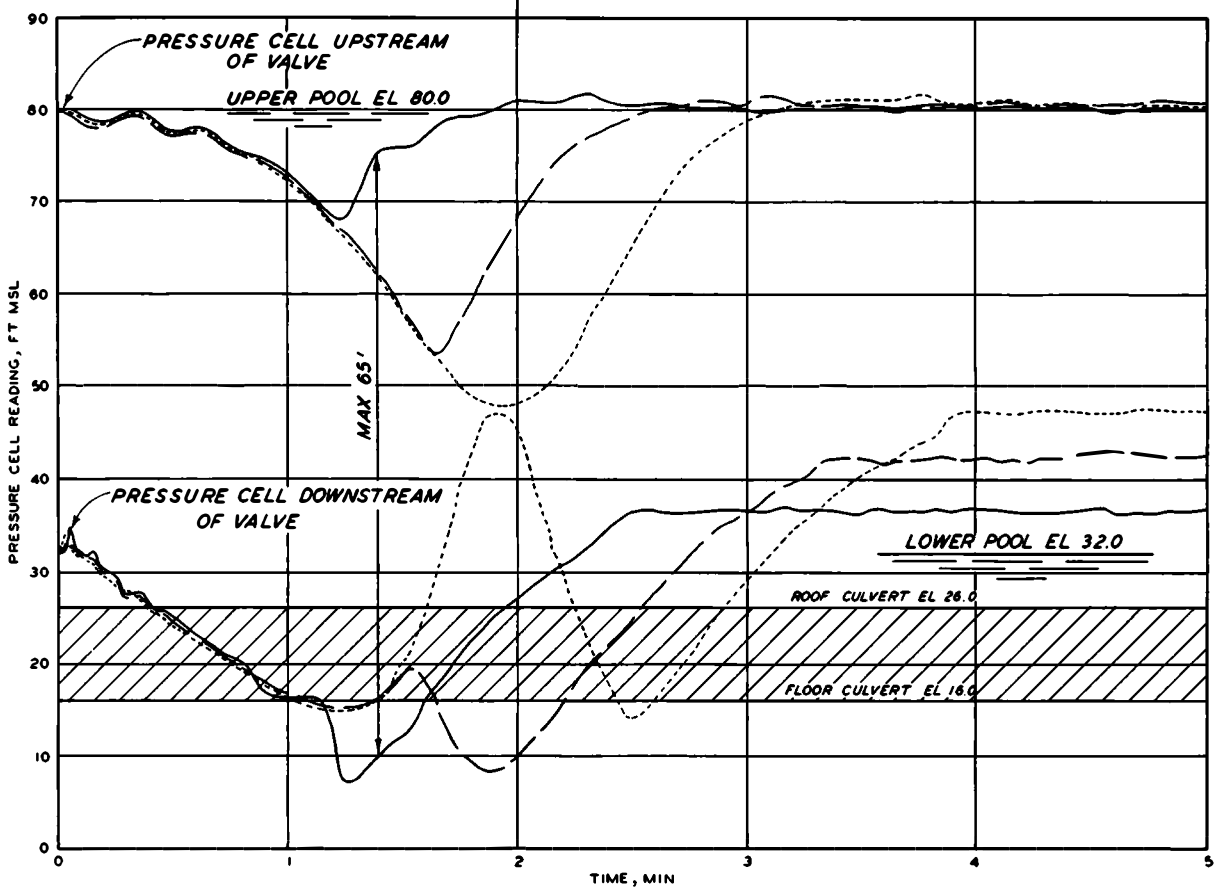
NOTE: LOWER POOL EL 32.0 AND UPPER POOL EL 80.0.
10-FT-WIDE BY 10-FT-HIGH CULVERT.
SUBMERGENCE IS MEASURED FROM LOCK FLOOR EL 18.0.
BULKHEAD SLOTS BELOW FILLING VALVES CLOSED.

MILLERS FERRY LOCK

AVERAGE PRESSURE CELL READING BELOW FILLING VALVE

TYPE 23 (RECOMMENDED) CULVERT ARRANGEMENT

14-FT SUBMERGENCE, 48-FT HEAD



LEGEND

PRESSURE READING	VALVE OPENED AND THEN CLOSED
————	1/2
— — —	3/4
--------	FULL

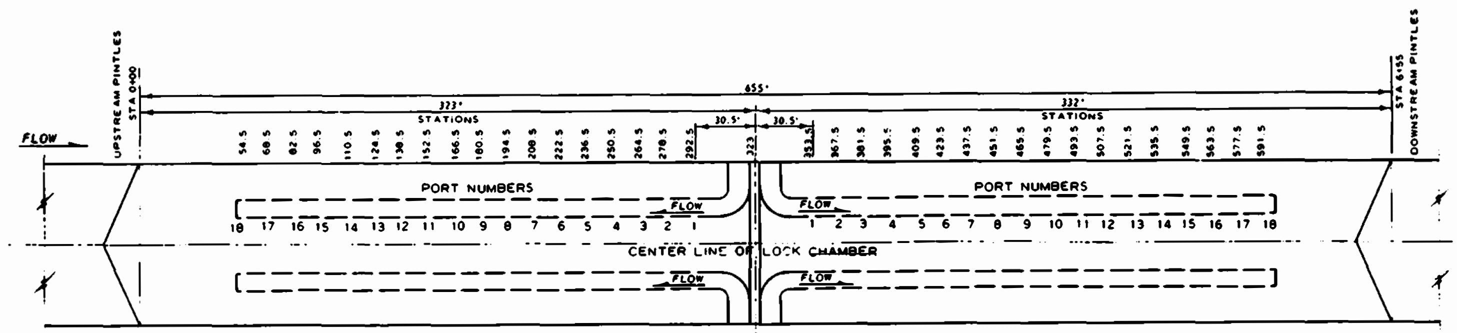
NOTE: LOWER POOL ELEVATION 32.0 AND UPPER POOL ELEVATION 80.0

10-FT-WIDE BY 10-FT-HIGH CULVERT WITH FLOOR AT ELEVATION 16.0

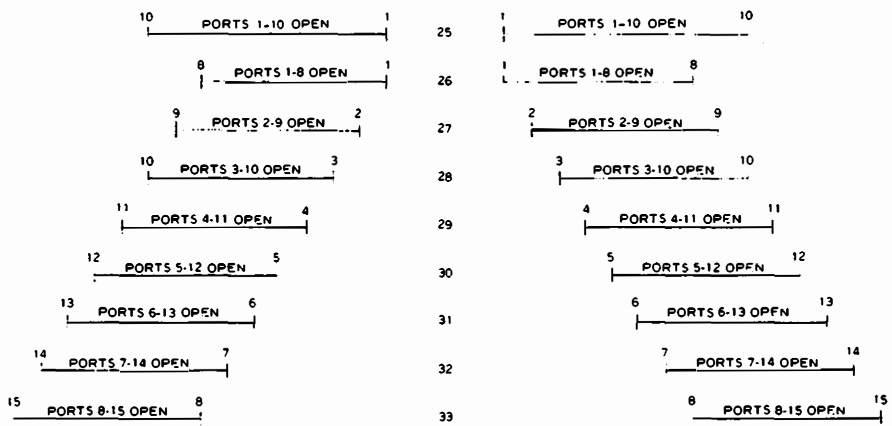
MILLERS FERRY LOCK

PRESSURE CELL READING ACROSS FILLING VALVE DURING ABNORMAL OPERATIONS

2-MIN VALVE OPENED 1/2, 3/4, AND FULL AND REVERSED TO CLOSED POSITION



PLAN



CULVERT ARRANGEMENT TYPES

SCALE IN FEET

50 0 50 100

NOTE: ALL DIMENSIONS ARE IN PROTOTYPE UNITS.
TYPE A PORT THROAT AREA = 1.25 FT BY 4.0 FT = 5.0 SQ FT.

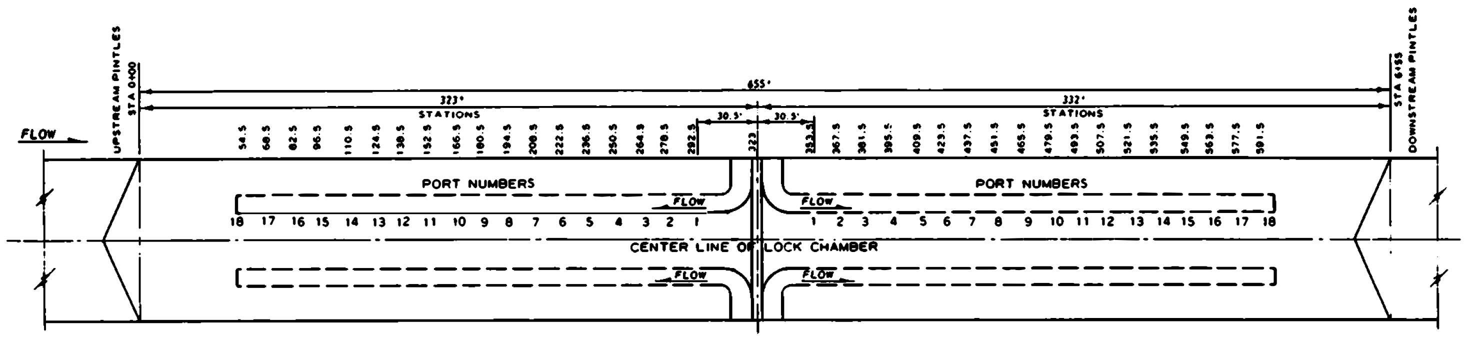
JONES BLUFF LOCK

CULVERT ARRANGEMENTS

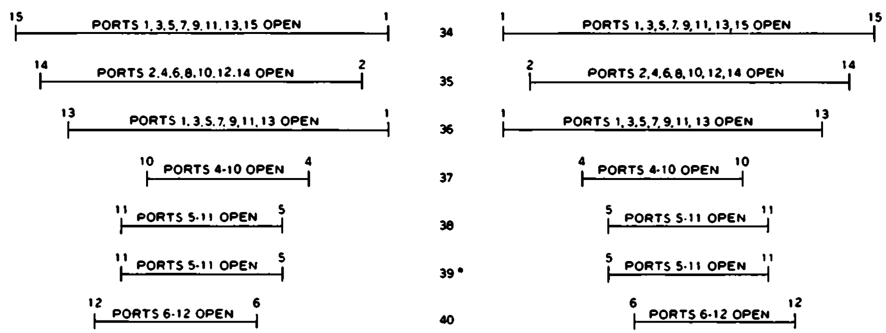
TYPES 25-33

PLATE E 33

PLATE 34



PLAN



CULVERT ARRANGEMENT TYPES

NOTE: ALL DIMENSIONS ARE IN PROTOTYPE UNITS.
PORT THROAT AREA = 1.25 FT BY 4.0 FT = 5 SQ FT (TYPE A).
* LOCK FLOOR REMAINS AT EL 8.5 BEYOND PORTS.

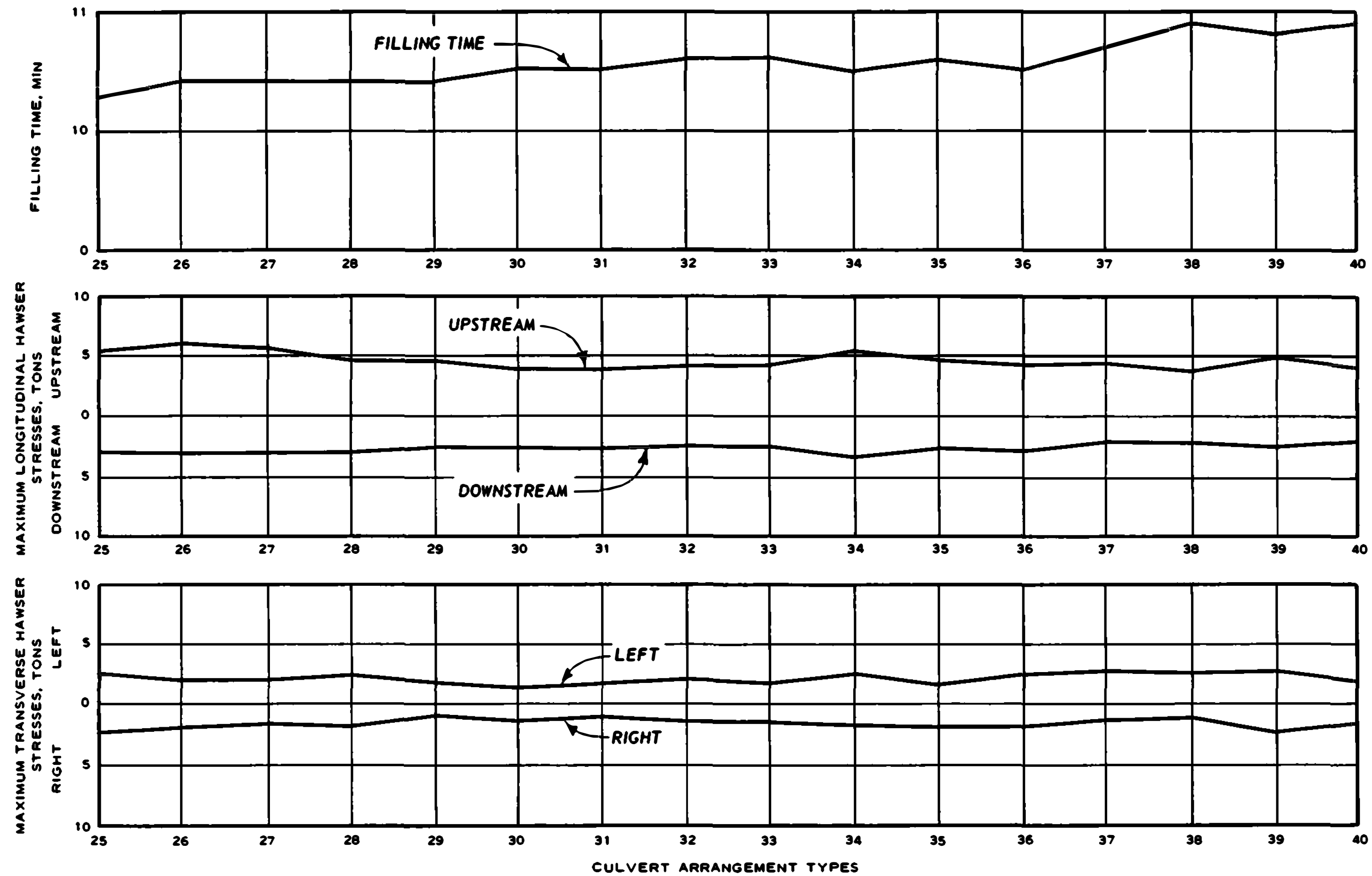
SCALE IN FEET

50 0 50 100

JONES BLUFF LOCK

CULVERT ARRANGEMENTS

TYPES 34-40



NOTE: 6-BARGE TOW POSITIONED 327 FT BELOW UPSTREAM MITER GATE PINTLES.

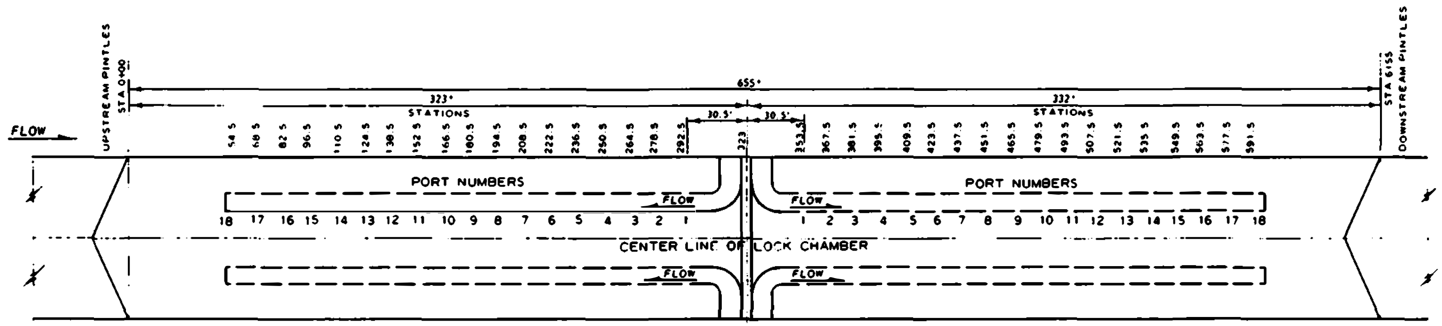
JONES BLUFF LOCK

COMPARISON OF MAXIMUM HAWSER STRESSES AND FILLING TIME

TYPES 25-40 CULVERT ARRANGEMENTS

45-FT HEAD

2-MIN VALVE, SCHEDULE II



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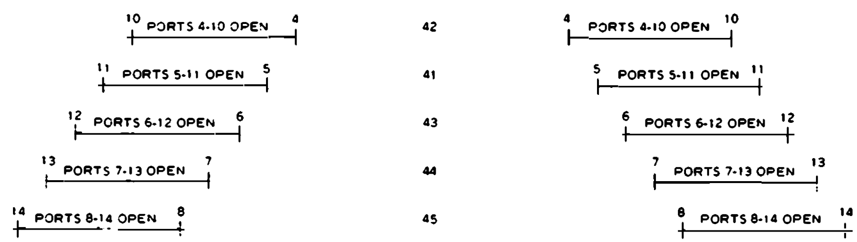


CULVERT ARRANGEMENT TYPES

NOTE: ALL DIMENSIONS ARE IN PROTOTYPE UNITS.

TYPE A PORT THROAT AREA = 1.25 FT BY 4.0 FT = 5.0 SQ FT.

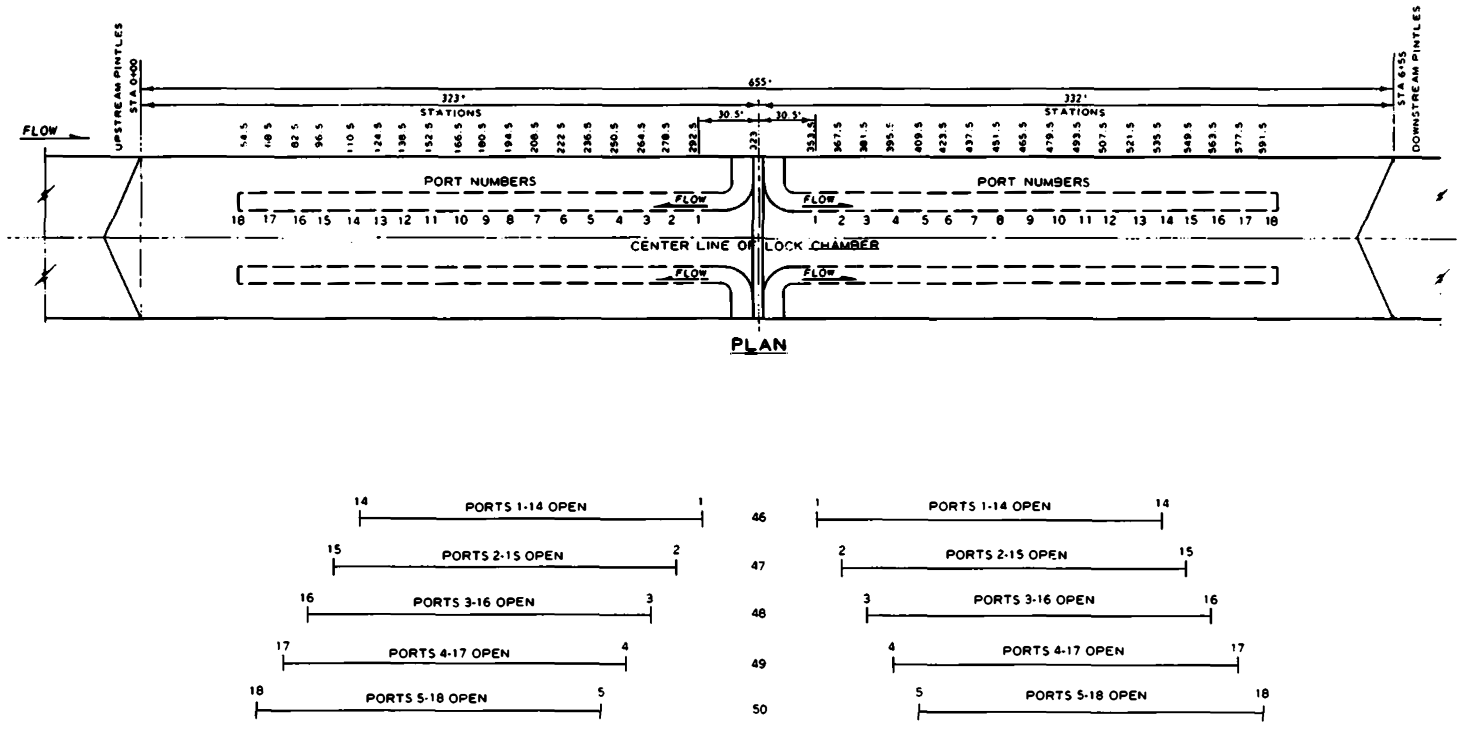
LOCK FLOOR RISES VERTICALLY TO ELEVATION 18.0, A DISTANCE OF 7 FT FROM THE EXTREME PORT IN EACH ARRANGEMENT.

SCALE IN FEET

JONES BLUFF LOCK

CULVERT ARRANGEMENTS

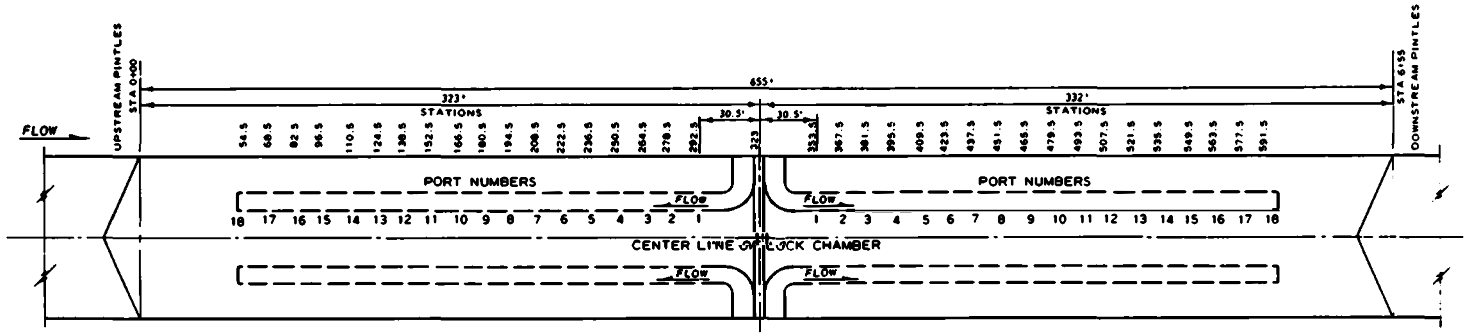
TYPES 41-45



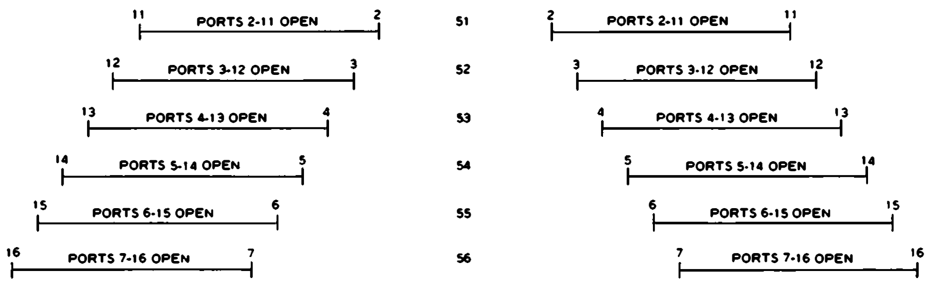
CULVERT ARRANGEMENT TYPES

NOTE: ALL DIMENSIONS ARE IN PROTOTYPE UNITS.
TYPE D PORT THROAT AREA = 1.25 FT BY 2.0 FT = 2.5 SQ FT.
LOCK FLOOR RISES VERTICALLY TO ELEVATION 18.0, A DISTANCE OF 7 FT FROM THE EXTREME PORT IN EACH ARRANGEMENT.

JONES BLUFF LOCK
CULVERT ARRANGEMENTS
TYPES 46-50



PLAN

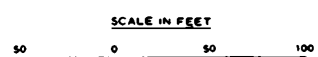


CULVERT ARRANGEMENT TYPES

NOTE: ALL DIMENSIONS ARE IN PROTOTYPE UNITS.

TYPE E PORT THROAT AREA = 1.25 FT BY 2.8 FT = 3.5 SQ FT.

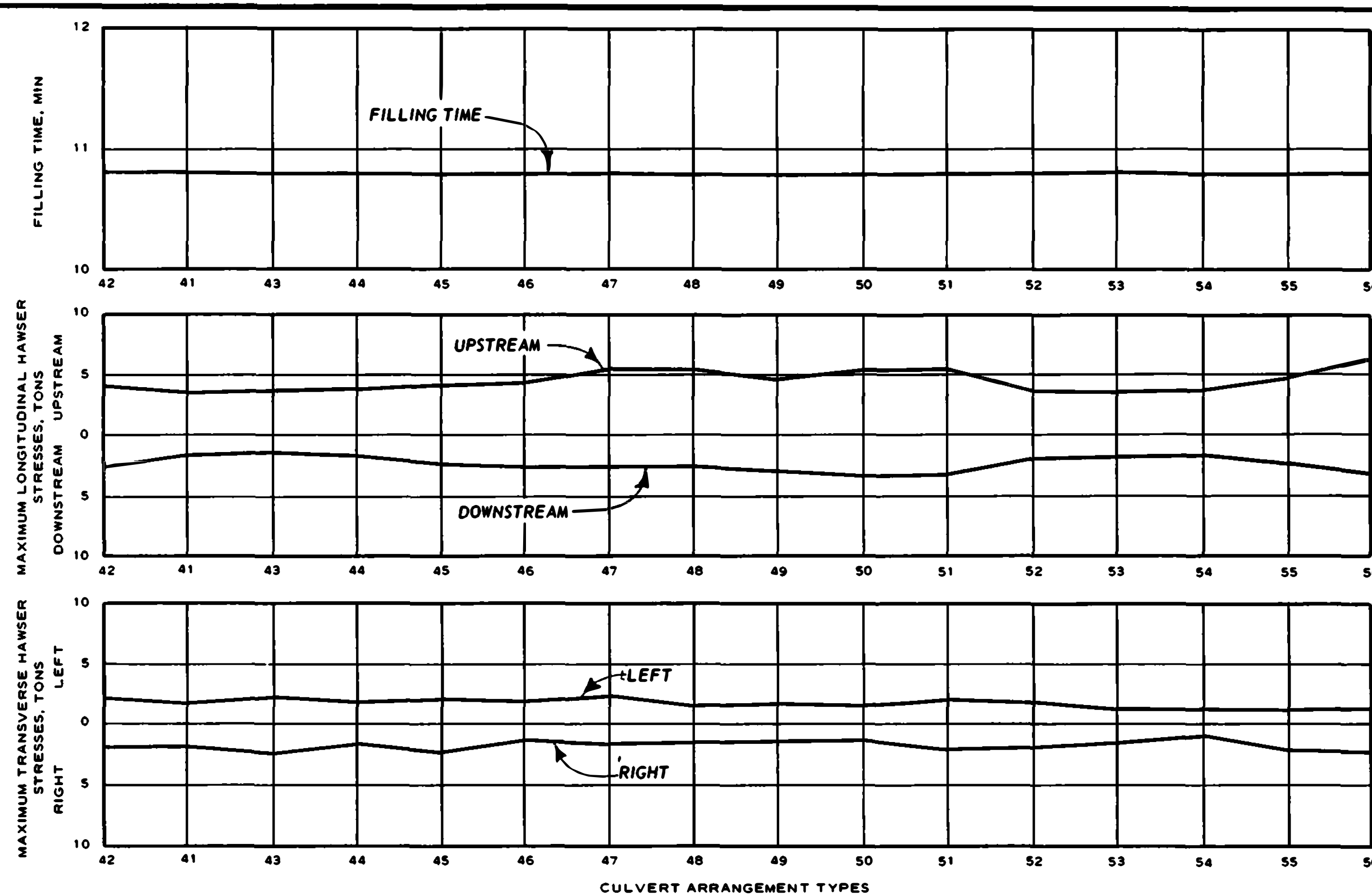
LOCK FLOOR RISES VERTICALLY TO ELEVATION 18.0, A DISTANCE OF 7 FT FROM THE EXTREME PORT IN EACH ARRANGEMENT.



JONES BLUFF LOCK

CULVERT ARRANGEMENTS

TYPES 51-56

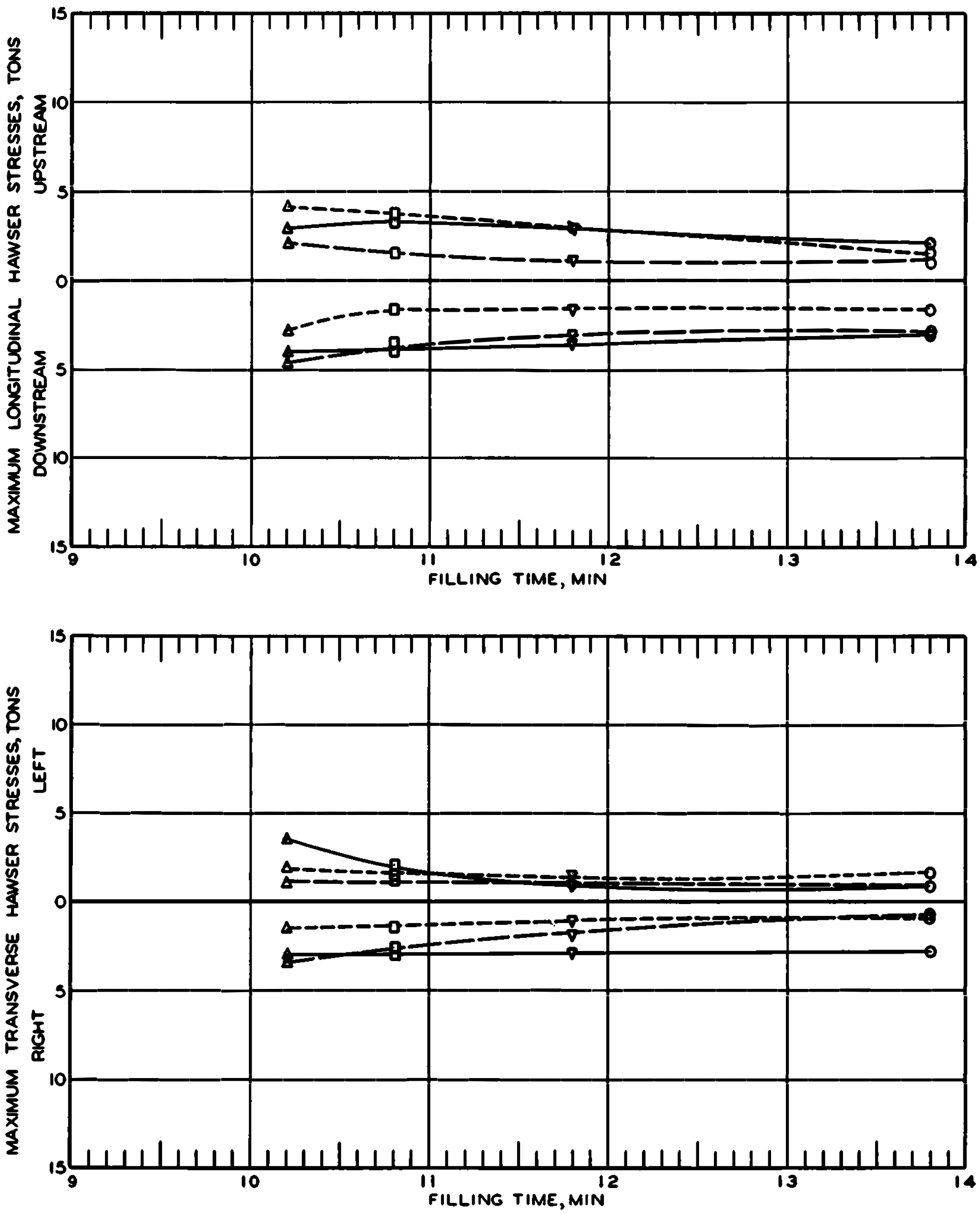


JONES BLUFF LOCK

COMPARISON OF MAXIMUM HAWSER STRESSES AND FILLING TIME

TYPES 41-56 CULVERT ARRANGEMENTS
45-FT HEAD
2-MIN VALVE, SCHEDULE II

NOTE: 6-BARGE TOW POSITIONED 327 FT BELOW UPSTREAM MITER GATE PINTLES.



LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
Δ	1 II
□	2 II
▽	4 II
O	8 II

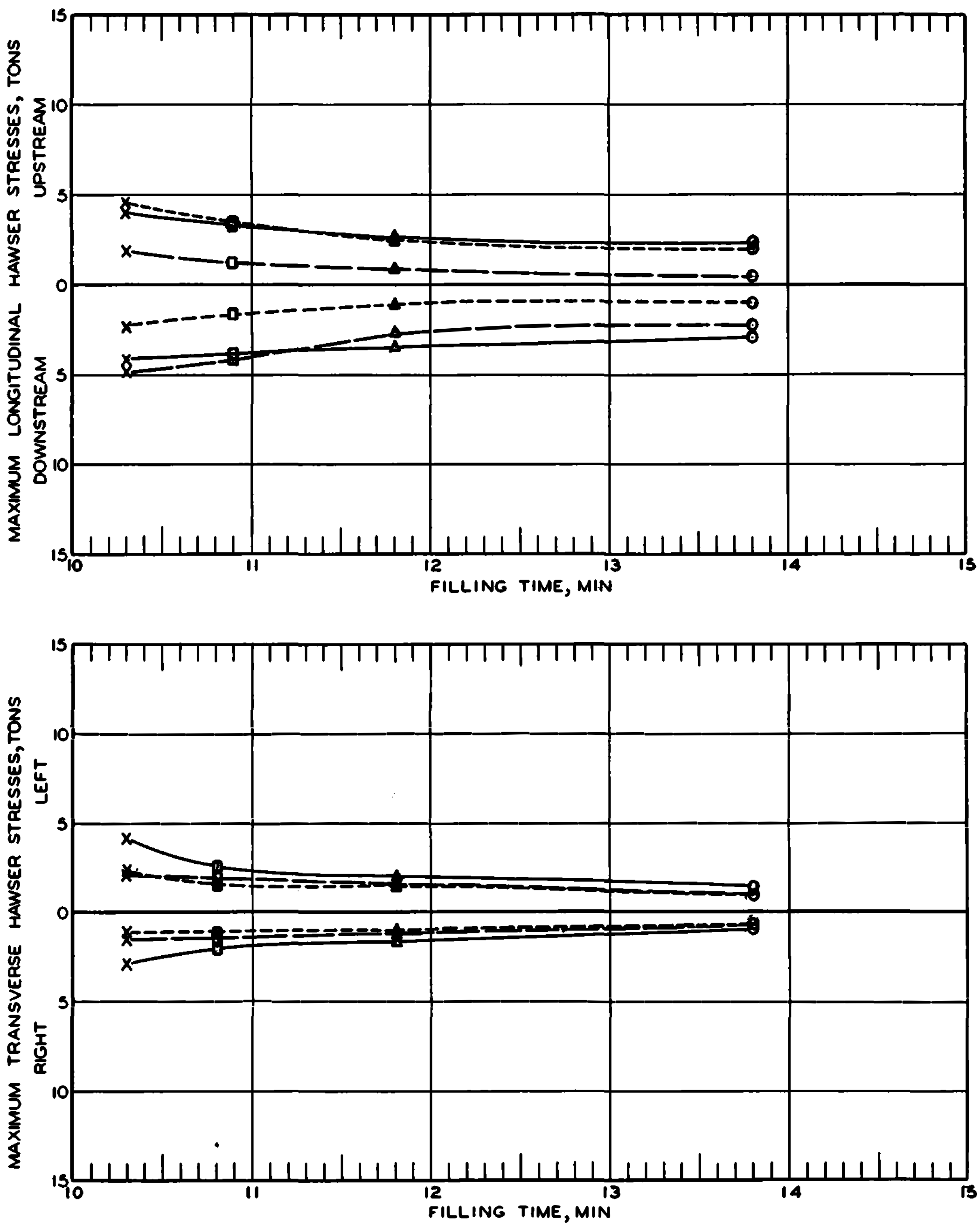
NOTE: 45-FT HEAD (UPPER POOL EL 77.0, LOWER POOL EL 32.0).

——— 12-BARGE TOW AT STA 0+47
— — 6-BARGE TOW AT STA 0+47
---- 6-BARGE TOW AT STA 3+27

JONES BLUFF LOCK

EFFECT OF TOW SIZE AND POSITION ON MAXIMUM HAWSER STRESSES DURING FILLING

TYPE 41 (RECOMMENDED) CULVERT ARRANGEMENT



LEGEND	
SYMBOL	VALVE SCHEDULE, MIN
X	1-II
□	2-II
Δ	4-II
O	8-II

NOTE: 45-FT HEAD (UPPER POOL EL 77.0, LOWER POOL EL 32.0).

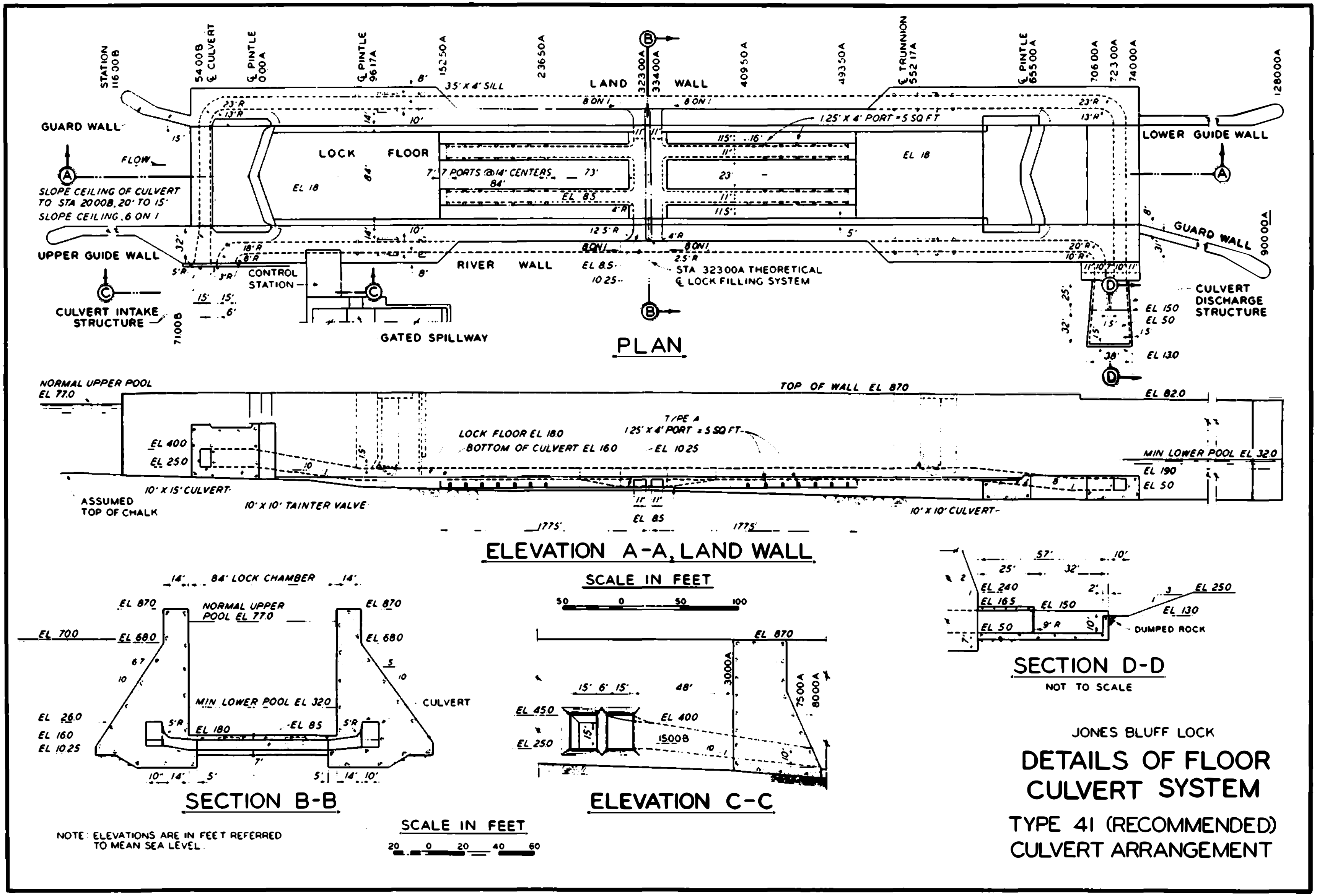
——— 12-BARGE TOW AT STA 0+47
— — 6-BARGE TOW AT STA 0+47
- - - - 6-BARGE TOW AT STA 3+27

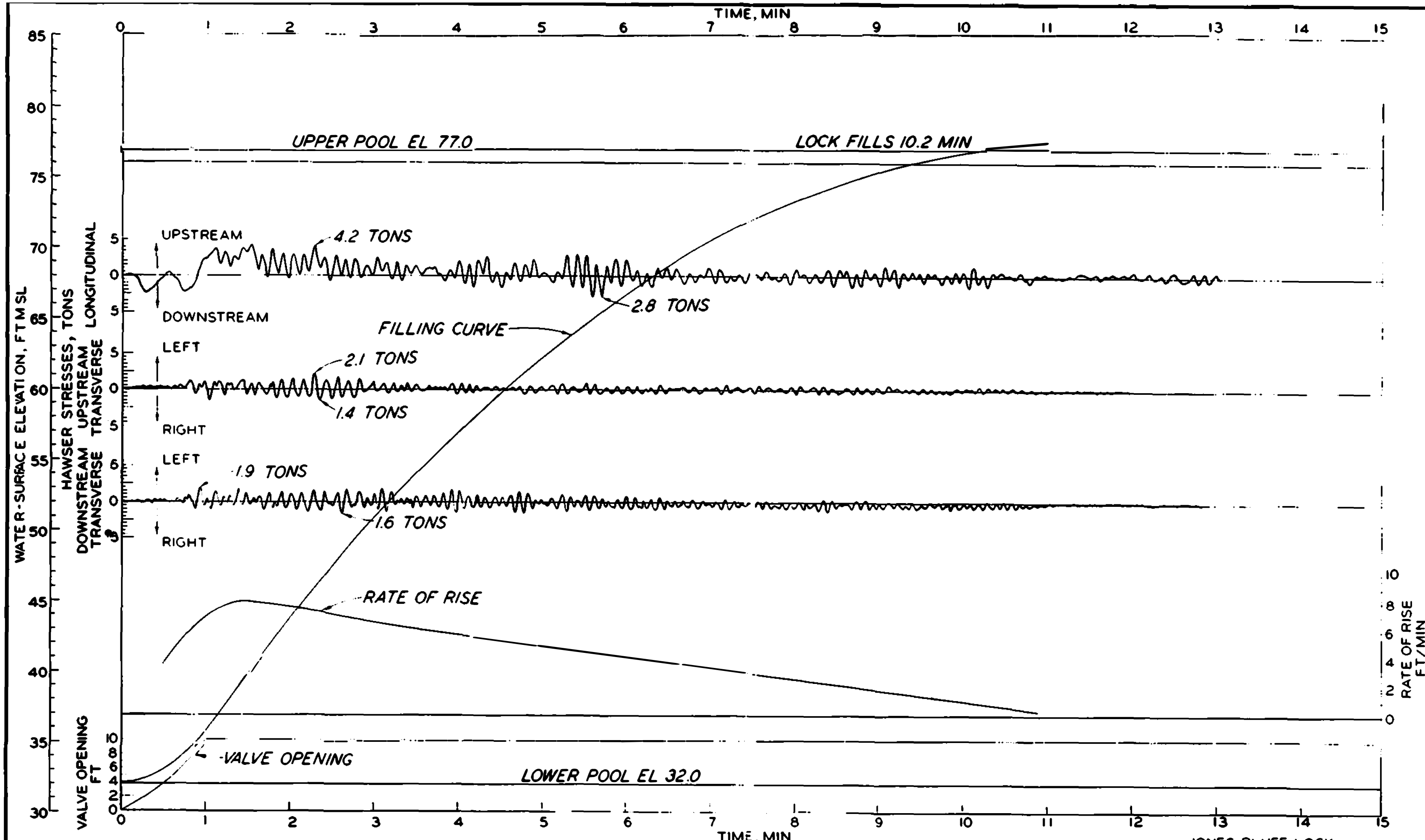
JONES BLUFF LOCK

EFFECT OF TOW SIZE AND POSITION ON MAXIMUM HAWSER STRESSES DURING FILLING

TYPE 53 CULVERT ARRANGEMENT

PLATE 42


PLAN
LAND WALL
RIVER WALL
LOCK FLOOR
GUARD WALL
UPPER GUIDE WALL
LOWER GUIDE WALL
FLOW
SLOPE CEILING OF CULVERT TO STA 2000B, 20' TO 15'
SLOPE CEILING, 6 ON 1
CONTROL STATION
GATED SPILLWAY
CULVERT INTAKE STRUCTURE
CULVERT DISCHARGE STRUCTURE
35' X 4' SILL
1.25' X 4' PORT = 5 SQ FT
7 PORTS @ 14' CENTERS
STA 32300A THEORETICAL ℄ LOCK FILLING SYSTEM
STATION 11600B
5400B ℄ CULVERT
℄ PINTLE 000A
℄ PINTLE 9617A
15250A
23650A
32300A
33400A
40950A
49350A
℄ TRUNNION 55217A
℄ PINTLE 65500A
70600A
72300A
74000A
128000A
90000A
7100B
ELEVATION A-A, LAND WALL
NORMAL UPPER POOL EL 77.0
TOP OF WALL EL 87.0
LOCK FLOOR EL 18.0
BOTTOM OF CULVERT EL 16.0
TYPE A 1.25' X 4' PORT = 5 SQ FT
MIN LOWER POOL EL 32.0
10' X 15' CULVERT
10' X 10' TAINTER VALVE
10' X 10' CULVERT
ASSUMED TOP OF CHALK
SCALE IN FEET
SECTION B-B
84' LOCK CHAMBER
NORMAL UPPER POOL EL 77.0
MIN LOWER POOL EL 32.0
CULVERT
NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.
ELEVATION C-C
SCALE IN FEET
SECTION D-D
NOT TO SCALE
DUMPED ROCK
JONES BLUFF LOCK
DETAILS OF FLOOR CULVERT SYSTEM
TYPE 41 (RECOMMENDED) CULVERT ARRANGEMENT



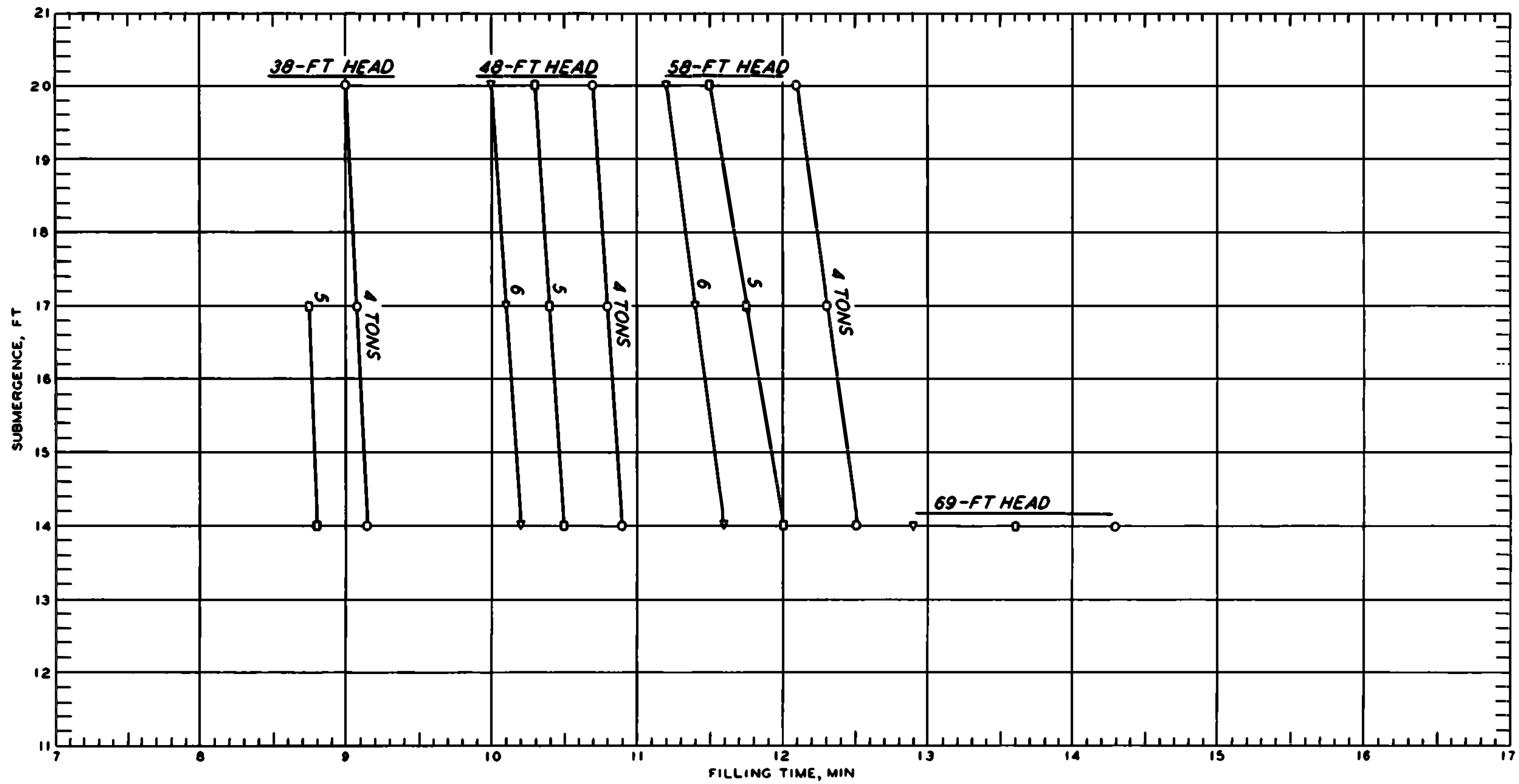
NOTE 6-BARGE TOW POSITIONED 327 FT FROM UPSTREAM MITER GATE PINTLES (5410 TONS DISPLACEMENT)

JONES BLUFF LOCK

FILLING CHARACTERISTICS

TYPE 41 (RECOMMENDED) CULVERT ARRANGEMENT

1-MIN VALVE SCHEDULE II



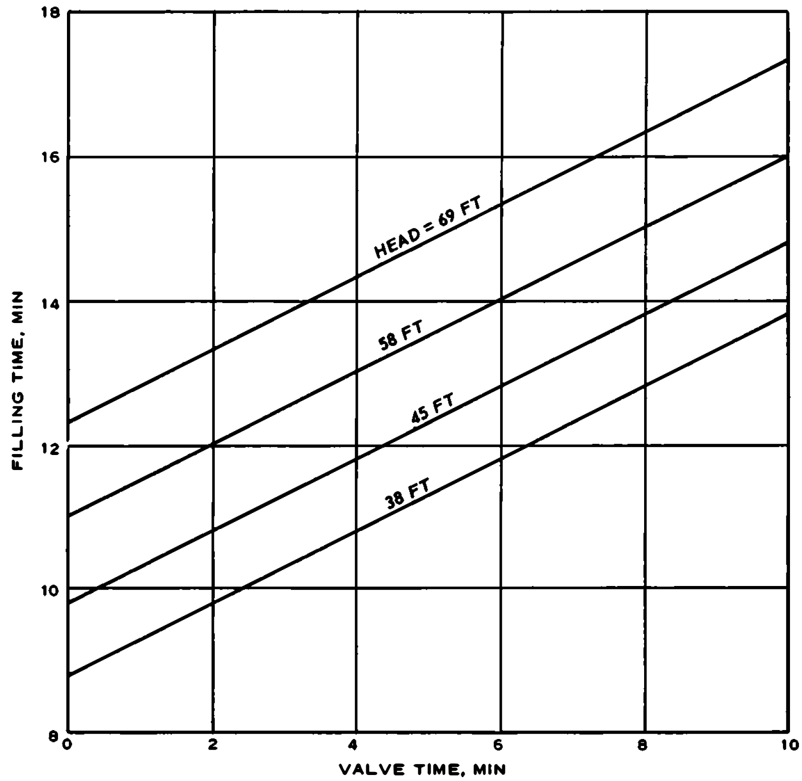
NOTE: HAWSER STRESSES WERE MEASURED ON 6-BARGE TOW (5410-TON DISPLACEMENT) POSITIONED 327 FT FROM UPSTREAM MITER GATE PINTLES.

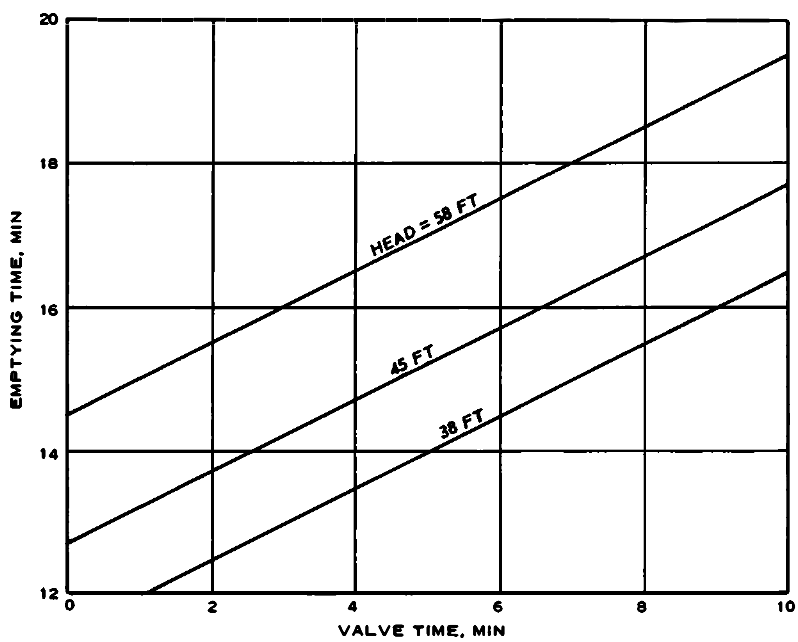
SUBMERGENCE IS THE DIFFERENCE IN ELEVATION BETWEEN LOWER POOL AND THE ROOF OF THE FLOOR CULVERT AT EL 18.0.

JONES BLUFF LOCK

PERMISSIBLE FILLING TIMES TO KEEP HAWSER STRESSES WITHIN 4-, 5-, AND 6-TON LIMITS

TYPE 41 (RECOMMENDED) CULVERT ARRANGEMENT

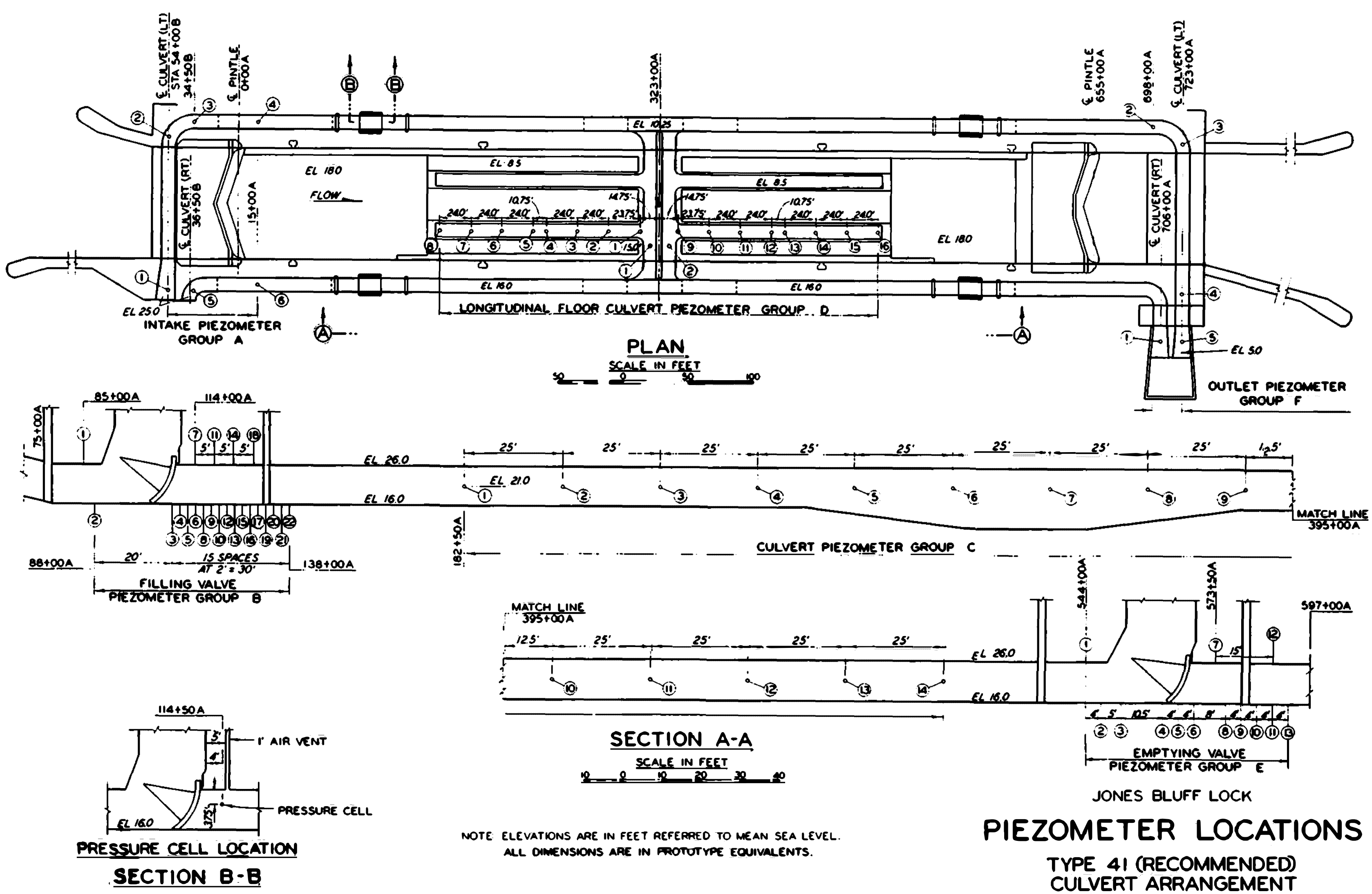




JONES BLUFF LOCK

VARIATION OF FILLING AND EMPTYING TIMES WITH VALVE TIME

TYPE 41 (RECOMMENDED) CULVERT ARRANGEMENT



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13. ABSTRACT Filling and emptying systems for the 600- by 84-ft Millers Ferry (48-ft lift) and Jones Bluff (45-ft lift) Locks will comprise two intake ports in the river side of the upper gate block, 10-ft-square culverts in each wall, a lateral crossover culvert at the midpoint of the lock leading to four longitudinal floor culverts with side ports, and culvert outlets which empty riverward of the lock in the common outlet basin. Reverse-mounted tainter valves control flow in the system. The hydraulic system was tested in a 1:25-scale model. Original design intakes and outlets performed satisfactorily. The major portion of the study was devoted to developmental tests of a new type of filling system, the longitudinal floor culvert system. Two systems were developed, one to conform to site restrictions at the Millers Ferry project and a second for use at the Jones Bluff project where no space limitations are placed on the system. Pressures were satisfactory except just downstream from the filling valves; pressures recorded in these areas may result in cavitation. Admission of small controlled quantities of air just downstream of the valves should cushion the collapse of vapor pockets and minimize possible damage without adversely affecting performance of the system. With the adopted hydraulic system installed in the model, hawser stresses on 6- and 12-barge tows were well within the 5-ton limit during operations with normal heads and 14-ft submergence. The longitudinal floor culvert systems investigated exhibited several favorable characteristics which suggest that these systems may be used effectively in larger and higher-lift locks. However, much additional developmental work is needed prior to the use of such a system at projects with larger locks or significantly higher lifts.

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
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Hydraulic systems						
Jones Bluff Lock						
Locks -- filling and emptying systems						
Millers Ferry Lock						

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