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CORPS OF ENGINEERS, U. S. ARMY

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**SLIDE GATE TESTS, NORFORK DAM  
NORTH FORK RIVER, ARKANSAS**

MODEL AND PROTOTYPE INVESTIGATIONS



TECHNICAL MEMORANDUM NO. 2-389

CONDUCTED FOR

**LITTLE ROCK DISTRICT, CORPS OF ENGINEERS**

BY

**WATERWAYS EXPERIMENT STATION  
VICKSBURG, MISSISSIPPI**

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FRONTISPIECE. Norfolk Dam, North Fork of the White River, Arkansas

## PREFACE

In a letter to the Division Engineer, Southwestern Division, dated 23 November 1945, subject: "Slide Gate Tests," the Office, Chief of Engineers, proposed a series of slide gate tests to be made at Norfolk Dam, Arkansas. Actual authorization of the tests was contained in the 4th indorsement to the initiating letter. Model tests, to form the basis for selection of the prototype test gates, were authorized in a letter, dated 14 January 1946, from the Chief of Engineers to the Waterways Experiment Station.

The model tests were conducted by the Waterways Experiment Station during the period May 1946-December 1946. The prototype tests, conducted during December 1947-May 1948, were supervised by the Little Rock District Office under the general direction of the Office, Chief of Engineers. The Experiment Station provided all measuring equipment and personnel for operation of equipment. This report was prepared by the Waterways Experiment Station in collaboration with the Little Rock District and the Office, Chief of Engineers.

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## SUMMARY

Results of full-scale tests at Norfork Dam of the two types of slide gates, selected on the basis of model tests, indicated that the performance of a gate with a 45-degree upstream bevel at the lower edge (type B) was superior to that of the Norfork-type gate (type A) which had a flat bottom with a slight slope to fit the sealing surface. High negative pressures on the gate bottom, considerable gate vibration, and crackling sounds characteristic of cavitation were noted for most gate openings of the Norfork gate. By contrast, high positive pressures occurred over the sloping bottom of the 45-degree gate, resulting in elimination of cavitation sounds and in a marked reduction in gate vibration. The high positive pressures also resulted in less air demand at partial gate openings.

Tests of long duration at partial gate openings with both test gates revealed some cavitation damages to the outer edge of the bronze seals on both sides of the gate frame and to the cast steel immediately downstream and just under the gate.

SLIDE GATE TESTS, NORFORK DAM  
NORTH FORK RIVER, ARKANSAS

Model and Prototype Investigation

PART I: INTRODUCTION

The Problem

1. The need for fine reservoir regulation, together with the economy of installing a few large reservoir outlets as opposed to a larger number of smaller outlets, makes it desirable to discharge under conditions of partial gate openings and high reservoir heads. Operating experience at existing structures has revealed undesirable downpull, chatter, and vibration of some control gates when subjected to long periods of operation under heads greater than 75 ft.\*

2. After studying available information on objectionable performance of control gates, the Office, Chief of Engineers, initiated a comprehensive gate testing program involving both model and prototype investigations to develop and test reservoir outlet gates for high-head operation. Slide and tainter gates\*\* were selected for detailed investigation because of their economy, superior hydraulic performance, and structural and mechanical simplicity. The main purpose of the test program reported herein was to develop a slide gate which could be operated continuously at partial gate openings and under heads of 200 ft or more without undesirable cavitation or vibration.

3. Model tests on a 1:6-scale model of a typical slide gate were first undertaken to determine the most satisfactory shape of the bottom edge of gate, which would later be tested under prototype conditions. The prototype tests were considered highly desirable because of the

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\* Missouri River Division, Corps of Engineers, Survey of Hydraulic Control Works, 25 April 1947.

\*\* Waterways Experiment Station, Corps of Engineers, Tainter Gate Tests, Norfork Dam, Technical Memorandum No. 2-387, June 1954.

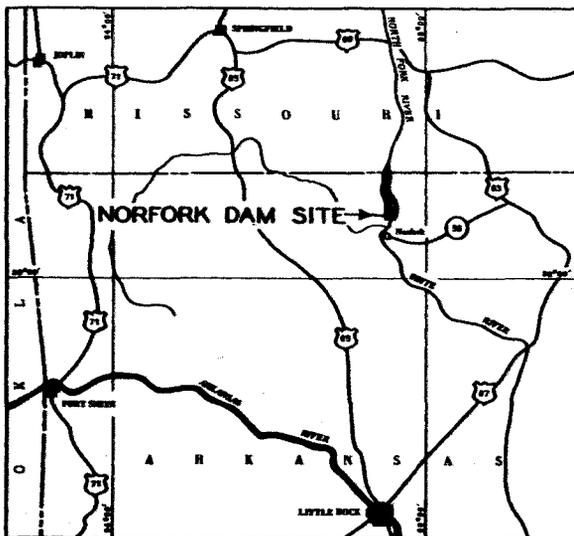
large number of slide gates planned for future installation in Corps of Engineers structures.

4. The model data obtained consist of pressure measurements on six shapes of gate lip obtained by means of 15 to 20 closely spaced piezometers. On the basis of the model tests, two gate-lip shapes were selected for further investigation under prototype conditions.

5. The purpose of the prototype tests was to verify and extend the experimental data obtained on the model for the two shapes of gate lip selected for prototype testing. In addition to observations of general hydraulic performance of the gates at several partial gate openings, measurements were made of pressures on the gate lip and in the conduit a small distance downstream of the test gate, vibration of the gate in vertical and horizontal (upstream and downstream) directions, strains developed near the gate lip, and air requirements.

#### Norfolk Dam

6. In view of the relatively high heads available, Norfolk Dam,



SCALE IN MILES  
0 25 50 75

Fig. 1. Vicinity map

located in northern Arkansas on the North Fork of the White River (fig. 1), was selected as the site for the prototype slide gate tests. This dam (frontispiece and plate 1) is a concrete gravity structure 2631 ft long and 233 ft high. The spillway, located near the left abutment, is 568 ft wide and has a crest elevation of 552.\* Twelve tainter gates, 40 ft wide and 28 ft high, are installed on the spillway crest. The stilling basin, 568 ft wide and 181.5 ft long, has a floor elevation of 362. Two

\* All elevations are in feet above mean sea level.

rows of baffle piers 8 ft high and a stepped end sill 6 ft in height are located on the basin floor to assist in dissipation of energy contained in spillway and sluice flows.

7. Eleven flood-control conduits, each 4 ft wide by 6 ft high, are provided through the base of the spillway section. The combined capacity of the conduits with the reservoir at spillway crest is 21,000 cfs. Each conduit has a bellmouth entrance with invert at elev 394.99. The conduits are inclined downward on a constant slope of about  $8\text{-}1/2$  degrees to an intersection with the stilling basin. Each conduit is controlled by two hydraulically operated flat-bottomed gates in tandem, the downstream gate being used for normal operation and the upstream gate being reserved for emergency operation. The axes of the gate frames and leaves are in a vertical plane (plate 2). The gate and air vent slots are bevelled as shown on plate 3. The gates are fully vented and are operated from control rooms just above each conduit, which are reached through an operating gallery with floor elev 404.4.

## PART II: MODEL TESTS

Description of Gate Designs Tested

8. The model consisted of five 1:6-scale slide gates and one 1:10-scale slide gate installed within an existing model conduit section of Bull Shoals Dam. Fig. 2 shows the test section with type A gate in place. The test section represented a conduit 6 ft high by 4 ft wide. The gate slots were 11 in. wide, 6-1/8 in. deep, and sloped downstream from top to bottom on a batter of 10 on 1.5.\* Details of the over-all model layout are shown on plate 4.

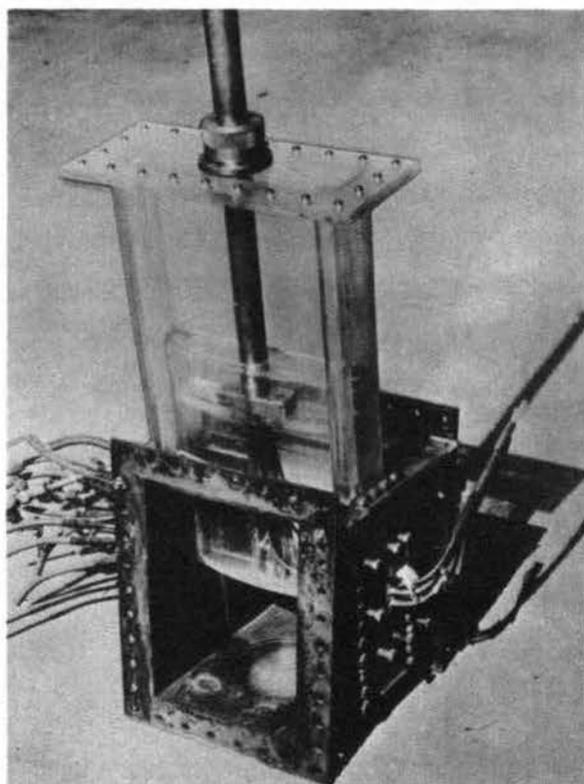


Fig. 2. Test section with bonnet installed and type A gate in place

9. The six gates tested were designed jointly by the Office, Chief of Engineers, and the Little Rock District. Gates were fabricated of plastic in

the model with gate lips shaped as follows:

- a. Type A. This shape was modeled from the prototype slide gates now in use at Norfolk Dam. It had a 1-in. lug on the downstream face which was included in a 7-1/2-in. bottom bearing surface. Then, after a 1/4-in. rise, a surface parallel with the bearing surface extended upstream to the tangent point of a 2-1/4-in. radius which connected it tangentially with the upstream face of the gate (plate 5).

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\* At Norfolk Dam the conduits slope, and the gate slots are in a vertical plane. The model tests were conducted with the conduit horizontal to insure symmetrical flow.

- b. Type B. This shape consisted of a 2-in. bearing surface measured from the downstream face of the gate. After a 1/2-in. rise at the upstream edge of the 2-in. bearing surface, a 45-degree slope extended to the tangent point of a 12-in. radius which connected tangentially to the upstream face of the gate (plate 6).
- c. Type C. The type C shape had a 4-in. bearing surface measured from the downstream face of the gate. Then, after a 1/2-in. rise at the upstream edge of the bearing surface, a 60-degree slope extended to the tangent point of a 12-in. radius which connected tangentially to the upstream face of the gate (plate 7).
- d. Type D. A 1-in. lug on the downstream face of the gate was included in a 2-in. bottom bearing surface. Then, after a 1/2-in. rise, a surface parallel with the bearing surface extended to the upstream face of the gate (plate 8).
- e. Type E. The type E lip shape was similar to that of type C described previously; the only variation being that type E had a 2-in. bearing surface instead of a 4-in. bearing surface as in type C (plate 9).
- f. Type F. The type F lip shape was identical to type B, the only difference being that it was fabricated to a 1:10 scale (plate 10).

#### Method of Operation

10. Water used in operation of the model was supplied by centrifugal pumps connected in such manner as to allow for flexibility of operation. The water was supplied from a large sump, passed through a surge tank, through the test section, and back to the sump through a conduit (plate 4). Average pressures were measured with large, open, water manometers constructed of transparent pyralin and a special mercury gaging device. Discharge was controlled by valves located between the pumps and test section, and was measured by venturi meters. Pressure on the system was controlled by a valve downstream from the test section. In order to prime the piezometers, after the desired gate opening was set, pressure was placed on the system forcing water into the air vent to a point above the piezometer tubing. After all piezometers were primed, the head was set by operating the control valve and downstream valve simultaneously. The

conduit immediately downstream from the gate flowed partially full for all but the 6-ft gate opening.

## Test Results

### Prefatory remarks

11. Investigation of the six types of gate lip designs involved observations of pressures at numerous critical points along the gate lips and at several points on the left side of the conduit below the gate slots. Pressure observations were made on the 1:6-scale gate lips at the following gate openings: 0.25, 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 ft. Pressure observations were made on the 1:10-scale model gate lip (type F) at gate openings of 0.5, 1.0, 3.0, 5.0, 7.0, and 9.0 ft. Attempts were made with the model gate lip of both scales to obtain measurements with the pressure at the control piezometer set at 100, 75, 50, and 25 ft of water. However, because of the limited capacity of the pumps, the larger pressures at the control piezometers could not be obtained at the 6.0-ft opening (1:6-scale model) and the 9.0-ft opening (1:10-scale model).

### 1:6-scale model gate lips

12. Tabulations of pressure data for the five different gate lips obtained at various openings and heads are included in appendix A to this report (tables A1-A40). Plates 11-20 show plots of average pressure coefficients obtained; plates 21-24 show the discharge curves for comparison of the four principal designs tested. Plate 25 is presented for the purpose of comparing the five gate shapes tested by means of pressure contours plotted on a horizontal projected area of each gate for the most critical combinations of heads and gate openings. A comparison of all data, both tables and plates, obtained for the types A through E lip designs indicates that types A and D had the lowest negative pressure areas, and that based on pressure contours the type A areas were lower than those of type D. The data further reveal that the steeper front lip designs of types B, C, and E produced, in general, similar results in that positive pressure existed under most conditions of operation. Type E (60-degree bevel) lip shape resulted in the highest uplift pressure recorded.

### 1:10-scale model gate lip

13. To determine the effect of conduit height on pressure conditions around slide gate lips a 1:10-scale model of the type B gate lip was constructed and designated, for identification purposes, type F gate lip. Pressure data obtained with this gate are also included in the appendix (tables A41-A46), and plates 26 and 27 show, in curve form, the average pressure coefficients. A comparison of plates 26 and 27 with plates 13 and 14 reveals that the average pressure coefficients are almost identical and that pressure behavior around the gate lip of a conduit 10 ft high is similar to that of a conduit 6 ft high.

### Conduit side pressures

14. Six 1/16-in. piezometers were used for the measurement of pressures on the side of the conduit, and were located at various points downstream from the gate and on the bevel of the gate slot. The location of these piezometers is shown on plate 28. Tables A47-A50 of the appendix summarize pressures observed on these piezometers at gate openings of 3.0, 4.0, and 5.0 ft on the types A, B, C, and D lip designs. It can be noted from these tabulated data that types B and C lip designs caused much higher positive pressures than types A and D. Also, as the gate opening was increased pressures on the gate lip were increased. Lowest pressures were observed during tests with the type D gate design installed.

### Discussion of Results

15. Pressure tests conducted on the six gate lip designs showed conclusively that the wide, flat-bottomed bearing surfaces of types A and D lips were not as desirable as the narrow-bottom bearing surfaces of types B, C, and E lip designs. The narrow-bottom bearing surface at the downstream edge of the gate permitted use of a steep bevel to an intersection with the upstream face of the gate which resulted in the elimination of almost all negative pressures on the gate lip. On the assumption that vibration and chattering of slide gates are the result of low pressures at the gate lip, the elimination of such pressures should

contribute to the stability of the gate at partial openings. Thus, the best gate lip shape of those investigated appears to be either type B or type E. Type B lip shape was selected for further investigation because lip pressures were not only positive but were of such magnitude as to prevent an excessive upward thrust. Type B gate lip also had certain structural advantages over type E. The one test conducted with the 1:10-scale model gate did not demonstrate that gate lip pressures were affected by the height of the conduit. Type A gate also was selected for tests in the prototype to provide comparative data.

16. Pressures measured on the side of the conduit downstream from the gate slot indicated that best conditions would obtain with the type B gate lip installed.

### PART III: PROTOTYPE TESTS

#### Test Site

17. Details of the dam and conduits have been described previously in paragraphs 6 and 7 and are presented on plates 1-3. The existing service gate of the conduit nearest the powerhouse was replaced by the test gates for the full-scale tests. With the test-gate sill at elev 390.13 and the reservoir water surface between elev 550.0 and 550.4, the head on the gates during the tests was approximately 160 ft.

#### Test Gates

18. The first gate lip tested, type A, had a flat bottom with a slight slope to fit the bottom sealing surface when closed and the roof of the conduit when fully open (existing Norfork-type slide gate). The second gate lip tested, type B, had a 45-degree inclined bottom with a 2-in. sealing surface on the downstream portion of the lip. The 2-in. sealing edge is required to keep bearing pressures on the gate seal within reasonable limits. A 1/2-in. vertical projection is provided to permit machining of the sealing edge without changing the width of bearing surface. The detailed dimensions of these gates are shown on plates 29-32. An airtight chamber in the gate body contained the necessary measuring equipment. The change from one test gate to the other involved only removal of the oil cylinder lifting mechanism and the gate bonnet cover (fig. 3). The embedded gate frame was not disturbed during the test program.

#### Instrument Installations and Test Procedures

19. Data obtained in the prototype tests included average and instantaneous pressures on the gates and in the downstream conduit, gate

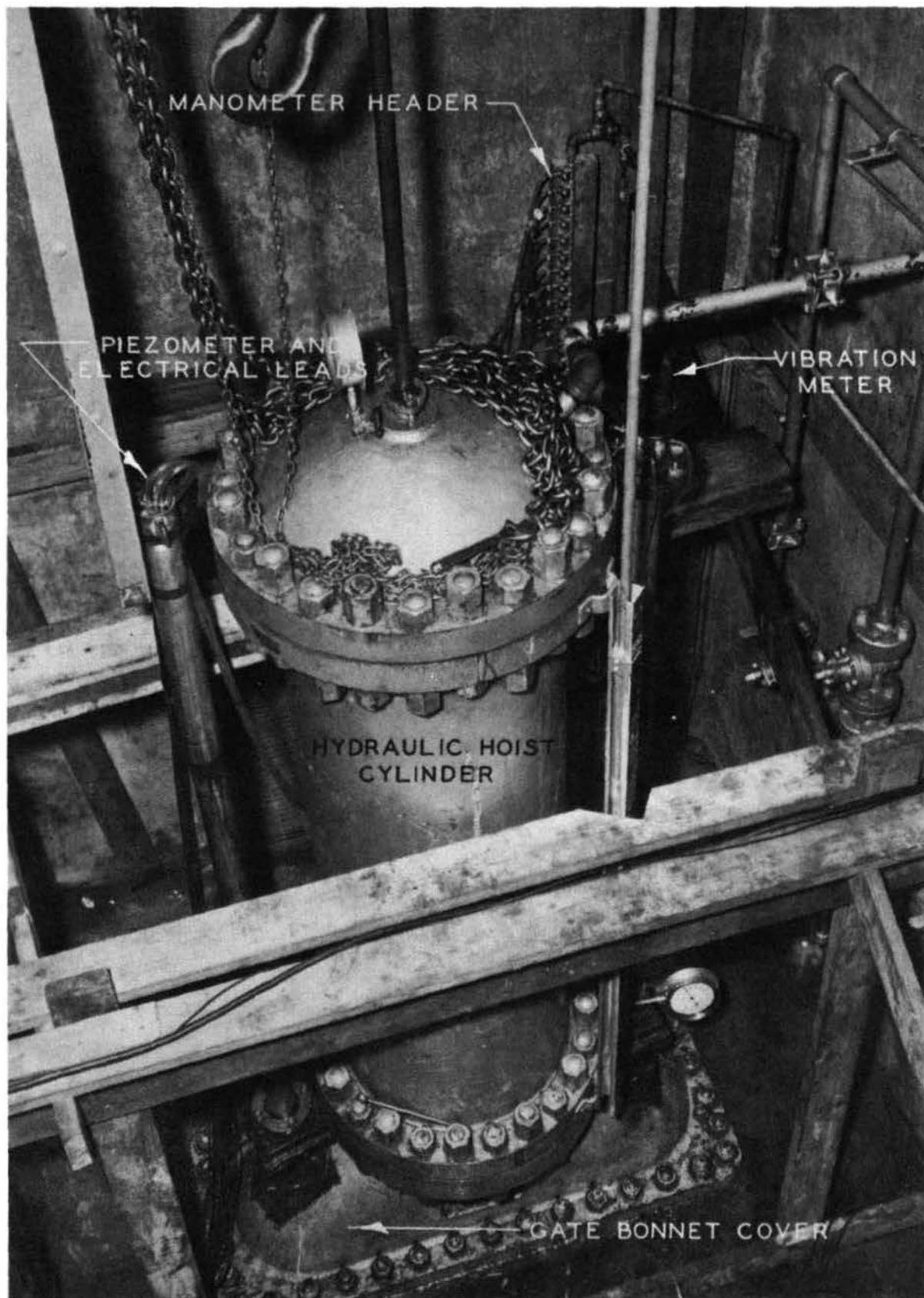


Fig. 3. Assembled gate for slide gate tests

vibration, strain measurements, and air demand. Apparatus for measuring and recording prototype data included SR-4 strain gages, six channel amplifiers, Westinghouse type P.A. recording oscillographs, Brush piezo-electric crystal vibration pickups, electric pressure cells, 24- and 100-in. mercury U-tubes, high-pressure dial gages, orifice plates, pitot tube, and a Velnor air-velocity meter.

20. Each gate leaf was equipped with facilities for determining the pressure distribution on the lip surface by means of piezometers and electrical pressure cells (fig. 4 and plates 29-34). Facilities were provided also for determining pressure conditions in the bonnet and on the conduit roof immediately downstream from the test gate. The 13 piezometers in type A gate leaf and the 11 piezometers in type B gate leaf, together with a pressure tap in the manhole cover downstream from the gate and a pressure tap on the gate bonnet, were read with the conventional 24-in., or 100-in., U-tube with mercury as the gage

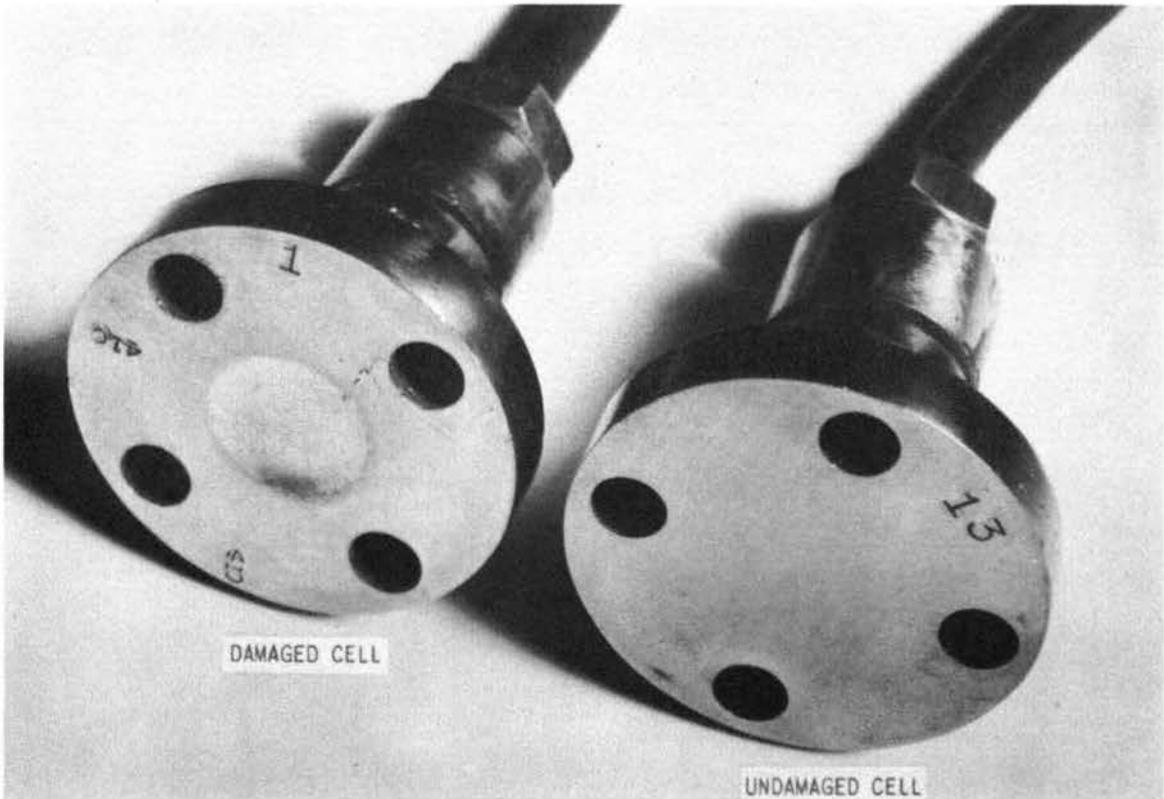


Fig. 4. Electrical pressure cells for measuring pressure fluctuations on gate lip

fluid (fig. 5). Pressures above the range of the 100-in. U-tube were recorded with a Bourdon-type dial gage. The electrical pressure cells for measurements of pressure fluctuations were located as shown on plates 33 and 34. These cells were designed and constructed by the Waterways Experiment Station especially for this series of tests. Each cell was about 1 in. in diameter, surrounded by a mounting plate approximately 2 in. in diameter. The face of each cell consisted of a thin diaphragm to the inner side of which were bonded two SR-4 strain gages. As the diaphragm was flexed under pressure or vacuum the electrical resistance varied in direct proportion to the amount of deflection. The cells were designed for use with pressures ranging from -15 to 75 psi and were calibrated prior to installation in the test gate. Recording equipment used is shown in fig. 6.

21. The horizontal and vertical vibrations of each test gate were measured with a Brush vibration pickup, a commercial product of the Brush Development Company. This instrument is of the inertia type which utilizes piezoelectric crystal elements as the generating members. The instruments were screwed to studs fastened to the test gates (plates 33 and 34). Movement of the crystal element in a direction normal to its face generated a small voltage that was approximately proportional to the acceleration the crystal received when applied to a vibrating body. To obtain a displacement record, this acceleration curve was integrated twice by an electrical circuit. A permanent record was obtained by using the camera attachment of the oscillograph. The camera, loaded with a sensitized recording paper 5 in. wide, could be driven at various speeds. This same camera attachment was used to record the pressure fluctuations with the pressure cells described in the preceding paragraph. Other apparatus used are shown in fig. 7.

22. The quantity of air required for each test gate at various openings was measured by circular orifice plates located on the inlet end of a 20-in. steel pipe specially constructed to extend the air vent to the top of dam thereby facilitating measurements (fig. 8 and plates 35 and 36). A pressure tap was located 1 in. below the orifice plate and the differential between atmospheric and tap pressures was recorded

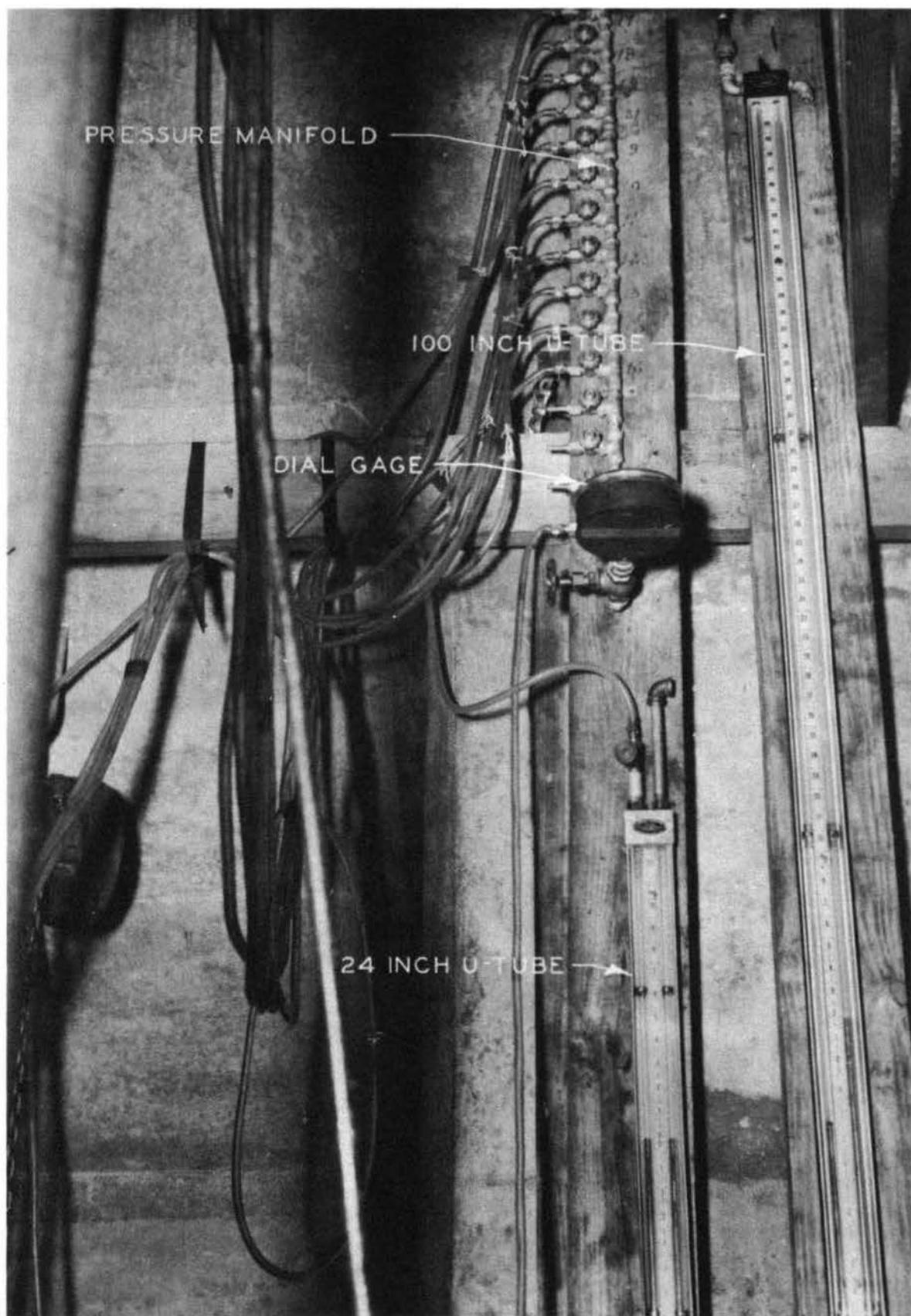


Fig. 5. Measuring equipment to obtain pressures on front face of slide gate by piezometric method

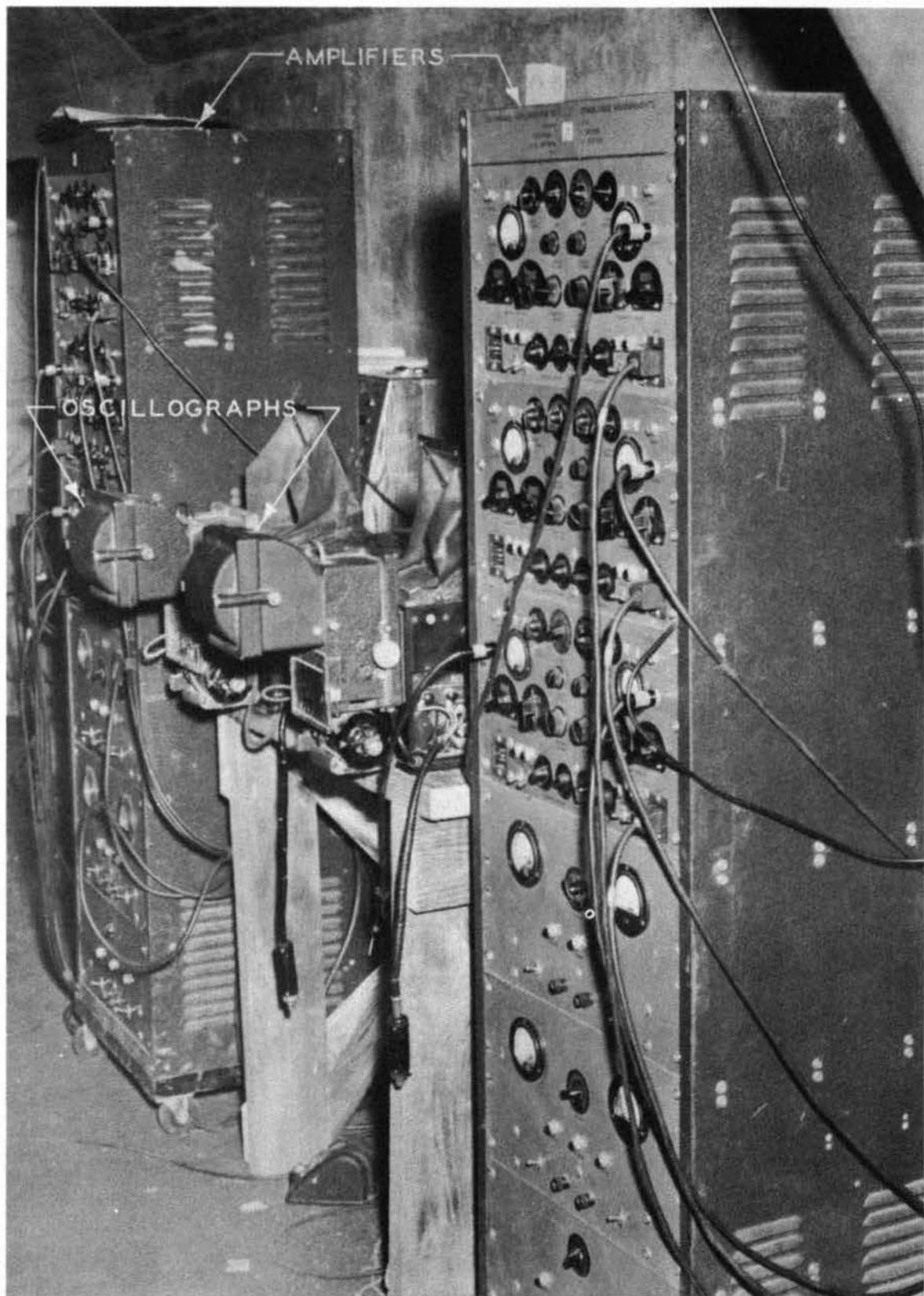


Fig. 6. Apparatus for measuring and recording resistance change in SR-4 strain gages (pressure cells). Shown are two 6-channel amplifiers and two Westinghouse type P.A. recording oscillographs

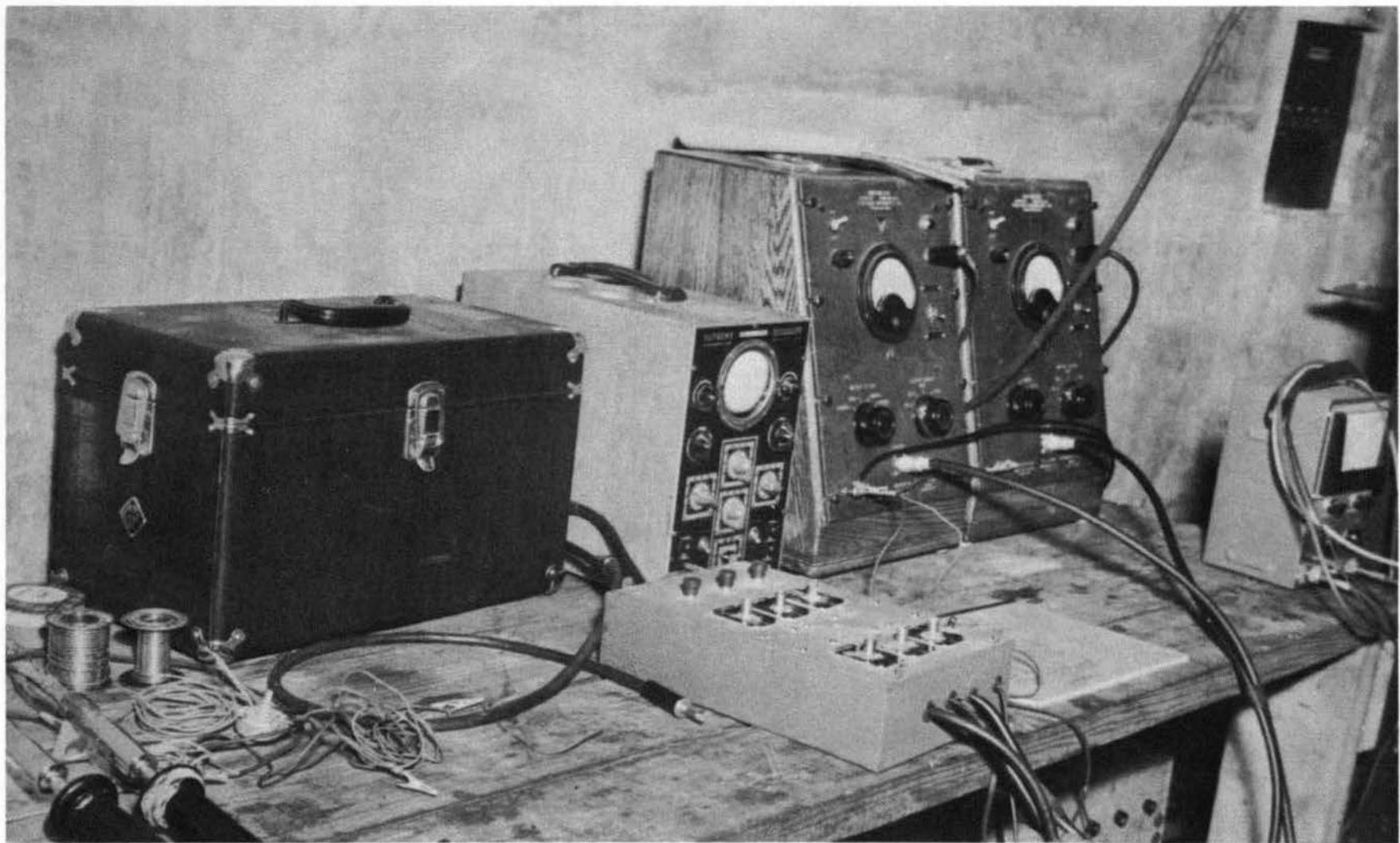


Fig. 7. Apparatus for recording vibration of the test gate. Reading from left to right: general radio vibration analyzer, cathode ray oscilloscope, two televiso's vibrometers. Front row: calibration device for vibrometers and vacuum tube voltmeter

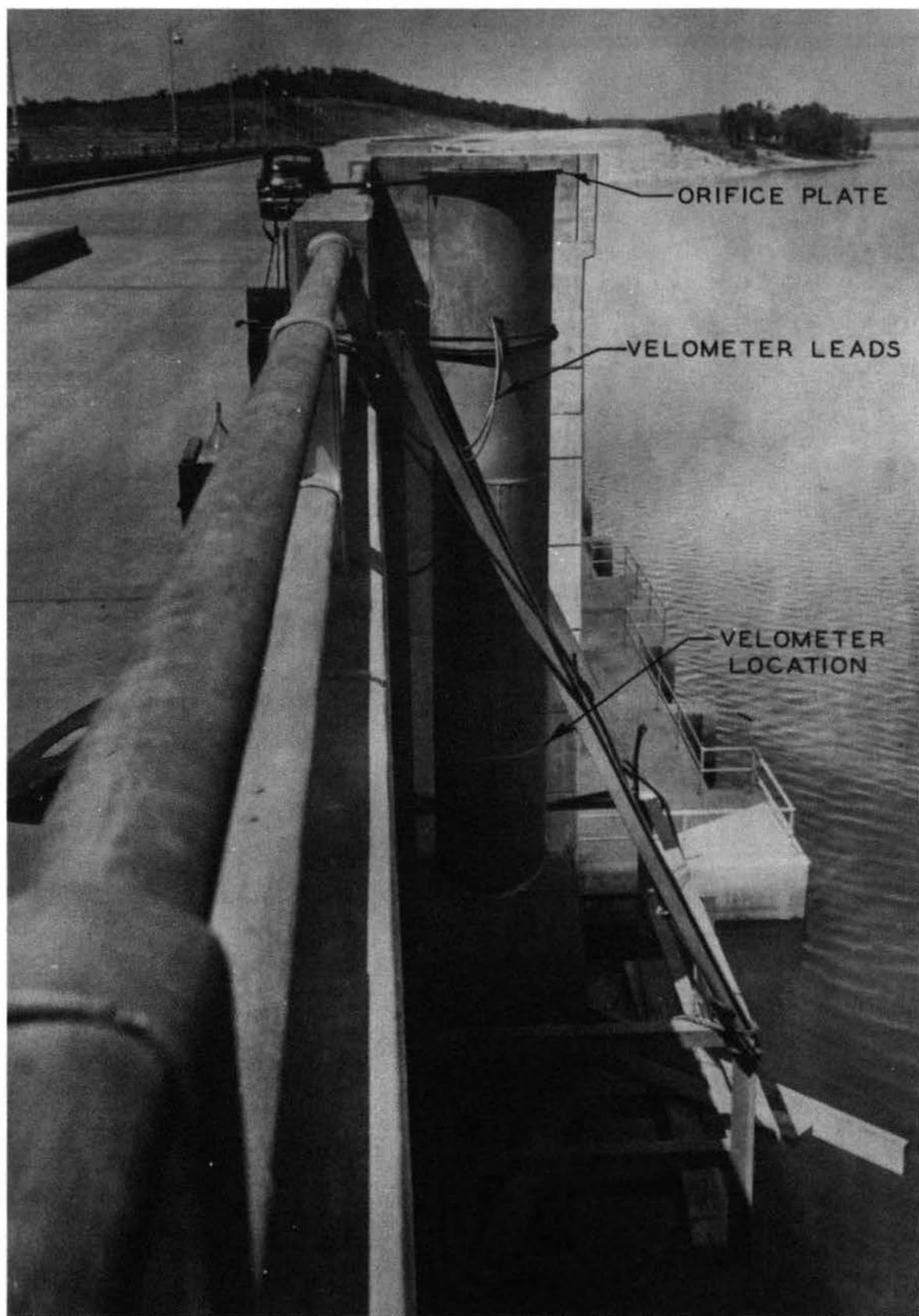


Fig. 8. 20-in. air vent extension pipe with circular orifice plate installed

by a U-tube manometer with water as the gage fluid. The orifice plates were of the square-edged type with diameters selected to give orifice areas equal to 75, 50, and 25 per cent of the area of the 20-in.-diameter air vent extension. The method recommended by the American Society of Mechanical Engineers in its publication entitled "Flow Measurement," dated 1940, was used in transforming manometer readings to rate of air flow. A constant coefficient of discharge of 0.6 was assumed. Attempts were also made to measure air quantities with a commercial-type air velometer and a pitot tube. Both methods were abandoned, however, in favor of the inlet-type orifice plate.

23. Strain measurements were attempted by SR-4 strain gages mounted at strategic points on the inside of the gate in a watertight compartment. Any bending movement of the gate on which the gage was mounted resulted in a corresponding deformation of the gage and a change in the electrical resistance of the gage. The change in electrical resistance was related to stress in the gate members and thus to bending forces.

24. The desired data were recorded for gate openings of 0.25, 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 ft. Air demand data were also recorded for various sizes of orifices located on top of the 20-in.-diameter extension to the air vents. These orifices had diameters of 20 in. (full vent area), 17.32 in. (75 per cent vent area), 14.4 in. (50 per cent vent area), and 10 in. (25 per cent vent area). Although the orifices resulted in a reduction in inlet area of the 20-in.-diameter riser pipe, they did not give results similar to those that would obtain had the entire air vent been reduced in the same proportion. However, as the diameter of the orifice was reduced it did result in increased losses at the entrance to the air vent, thereby throttling the vent to some extent. The effect of this throttling resulted in changed hydraulic performance of the slide gate. Piezometer readings were recorded for all conditions of vent opening, but pressure cell, strain, and vibration measurements were obtained only for the unrestricted vent and the smallest diameter orifice (25 per cent).

25. The general test procedure followed consisted in securing a set of pressure readings, both piezometric and electric, and measuring

vibration, strain, and air demand for the smallest gate opening and then proceeding to the next larger gate opening where the procedure was repeated. After the gate was completely opened, it was closed in 1-ft increments and similar measurements were obtained as a check on those obtained during the opening procedure. It was not possible to make discharge measurements for the various gate openings. However, a computed pool-discharge relation curve for one gate fully open is included (plate 37) for reference purposes.

### Test Results

#### General hydraulic performance

26. Observation of the general hydraulic performance of the test gates and of the emergency gate upstream revealed some interesting facts. As the emergency gate was raised or lowered the motion was made in a series of short jerks accompanied by sharp metallic pinging and hammering sounds. Based on an earlier inspection of the gate seals by the gate manufacturer, it was concluded that the irregular emergency gate movement was due to clamping action caused by a wavy surface finish on the gate seals. This action was minimized on the service and test gates by lubricating the sliding-contact surfaces with a heavy coat of waterproof grease. Corresponding surfaces for the emergency gate could not be lubricated, but the action could be minimized by operating the gate at a slow rate of movement. Even though seals of both test gates were greased, type B gate appeared to operate more smoothly with less sound effects than did type A, especially when the air vents were throttled. The greatest vertical vibration for each gate appeared to occur at a gate opening of 80 to 90 per cent of the conduit height. This same characteristic was observed in the model tests of other gate designs conducted at the Waterways Experiment Station.

27. The manhole cover in the roof of the conduit downstream from the gate (plate 2) was removed to observe flow conditions in the conduit downstream from the gates. It was observed that for small gate openings the flow was rough and concentrated in the center of the conduit with

considerable spray along the side walls. This is attributed to the curved upstream face of the gate. Excessive spray at the manhole and high-velocity air flow through the manhole into the conduit made observations impossible at openings in excess of 2 ft.

#### Average pressure measurements

28. Measurements of average pressures for various gate openings and air vent conditions, as determined on types A and B gates by means of piezometers, are presented in tables 1-10. In any analysis of these data, cognizance should be taken of the fact that for gate openings larger than about 5 ft some piezometers were located in the gate well above the conduit roof. For comparison with model results it will be necessary to convert the prototype data to pressure coefficients and compare with the plots presented on plates 11-14.

29. Plots of the pressure data presented in tables 2 and 7 are shown on plates 38-41. These plots reveal superior pressure conditions for type B gate, for which pressures were positive along the entire gate lip with the exception of the 2-in. sealing strip at the base. There, flow was deflected free from the 2-in. sealing strip by the 1/2-in. vertical projection at the base (plate 32) and small negative pressures occurred, being substantially equal in magnitude to the conduit pressures. Pressures were negative on the under side of type A gate for all gate openings except those less than 0.5 ft and full gate opening.

30. Pressures measured at the manhole cover on the roof of the conduit about 5 ft downstream from the test gate are shown on plate 42. These data also indicate the superiority of type B gate. In general, negative pressures in the conduit were more nearly constant and of smaller magnitude for type B gate. Throttling the air vent resulted in slightly increased negative pressures in the conduit. The low pressures at 0.75-ft gate opening for type A gate are attributed to the unfavorable shape of the gate bottom. Low pressures which occurred between 5.0- and 6.0-ft gate openings for both gates were due to the downstream conduit being nearly filled with water, resulting in maximum air requirement. The pressures recorded on the roof of the conduit were in each instance about the same as those observed on the bottom of type A gate and on the

2-in. sealing edge of type B gate. Maximum negative pressures on the two test gates occurred at these locations.

31. Pressures recorded in the bonnet for type A and B gates are presented on plate 43. The low bonnet pressures, as compared to the head on the gate, for openings in excess of 0.5 ft were caused by the clearance in the gate well on the downstream side of the gate being considerably larger than on the upstream side, resulting in low water levels in the gate well. The high pressure for a gate opening of 0.25 ft was caused by the top of the gate being in contact with the downstream seal when gate openings were small.

#### Instantaneous pressure measurements

32. Results of instantaneous pressure measurements recorded with electrical pressure cells in type B gate are shown in tables 11-19 and on plate 44. Maximum, minimum, and observed average pressures are presented as taken from oscillograph records. All pressures were positive except on the base of the 2-in. sealing strip where a pressure of -21 ft was recorded at a 0.25-ft gate opening (table 11). Comparisons of observed average pressures as determined by pressure cells in type B gate with those recorded by piezometers for several gate openings and two air vent conditions are shown in tables 11-19 and on plate 44. These data reveal reasonable agreement between the two methods.

33. Pressure cell data are not presented for type A gate. While two attempts were made to measure pressure fluctuations for type A gate, in each attempt all cells on the underside of the gate (plate 33) were damaged. The diaphragm of the cell failed by being forced inward (fig. 4). Tests on a similar type cell in the laboratory revealed that the cell could be subjected to a steady pressure of about 490 psi before failure. Since this is about 7.5 times the head of water at Norfolk Dam, it was concluded that the cell failures were caused by extremely high instantaneous pressures resulting from collapse of cavitation pockets, or from high-frequency pressure changes set up by vibration of the gate. Thus, further attempts to record pressure fluctuations on type A gate were abandoned.

#### Vibration of test gates

34. Vibrations, both in horizontal (upstream and downstream) and

vertical planes for each test gate were constant, for the most part, throughout the full range of gate openings (plates 45 and 46). The vibration data represent only relative vibration; that is, the relative vibration scale of each plot is based on percentages of the maximum amplitude of recorded vibration, which occurred in the horizontal plane for type A gate. The determination of vibration amplitude in terms of dimensional quantities was beyond the capabilities of the test equipment. Vibration in the vertical plane was somewhat less pronounced for type B gate. In the horizontal plane, vibration of type B gate was considerably less than that of type A gate. The vibration measurements provide additional evidence of the superiority of type B gate.

35. Frequency of vibration of the types A and B gates varied as the gate opening and vent opening was altered. In general, however, frequency of vibration in a vertical direction was about 20 and 70 cps for types A and B gates, respectively; the natural period of vibration of each gate was about 100 cps.

#### Air demand

36. The equipment and methods for measuring air demand have been previously described in paragraph 22. For type A gate, maximum points of air demand occurred at gate openings of 0.75 ft and 5 ft (plate 47). These gate openings correspond to those for which pressures on the roof of the downstream conduit were most critical (plate 42). For type B gate, air demand gradually increased as the gate was opened, reaching a maximum at a 5-ft opening (plate 48). Maximum air demands were 323 and 290 cfs for types A and B gates, respectively. For both gates, air demand gradually reduced to zero between gate openings of 5 and 6 ft as conduit flow changed from partly full to full. Also, for both gates, large air demands occurred at a gate opening of 0.25 ft, which probably results from a combination of spray filling the downstream conduit at small gate openings and submergence of the conduit exit by high tailwater during small conduit flows. The spray action caused maximum air entrainment and the submerged exit prevented part of the air demand from being supplied at the conduit exit.

37. In analysis of the air demand data, it should be noted, as

stated in paragraph 24, that a reduction in orifice size does not result in a similar reduction in air vent size. Air demand data would be most useful if the quantity of air could be related to a vent of uniform size.

#### Effect of air demand on gate performance

38. The effect of throttling the air supply downstream from the gate is shown by the pressure and vibration data referred to previously. Reduction in air supply, within the limits tested, resulted in only small reductions in pressures on the two gates tested and in the downstream conduit. In general, vibration of both gates in the vertical and horizontal planes increased with reduced air supply, the effect being more pronounced for type A gate. Vibration of type A gate with the 25 per cent orifice installed indicated that further reduction in air demand would be undesirable, if not unsafe.

#### Strain measurements

39. An attempt was made by the Structural Branch, Little Rock District, to analyze the strain gage measurements to evaluate stresses in the structural members near the bottom of type A gate. Strain gage measurements were not obtained for type B gate and only a limited number of measurements were obtained for type A gate because of trouble experienced with condensation inside the watertight chamber and consequent shorting of the electrical strain gages. The initial data procured at location A in the type A gate (plate 33) indicated comparative stresses about as expected. They were 50 per cent higher than the stress calculated for the static water load, which indicates a considerable impact factor. Data procured during a check run, however, indicated compressive stresses nearly twice as large as for the initial test. Pressure data for location B were erratic and did not give definite results. Since no strain gage results were obtained for type B gate nor for the lower part of type A gate (locations C and D), and the results obtained could not be analyzed to present dependable data, none of the results have been included in this report.

#### Cavitation

40. All measurements and observations pointed to the presence of cavitation phenomena with the type A gate installed and the elimination

or reduction of such phenomena by use of the type B gate. Following tests of the two gates, both gates were operated at partial opening for an extended period of time to investigate possible cavitation effects. Operation of the gates was in accordance with the following schedule.

<u>Gate Opening, ft</u>	<u>Time of Operation in Hours</u>	
	<u>Type A Gate</u>	<u>Type B Gate</u>
1.5	202	345
3.0	---	163
5.0	191	96

41. Examination of the conduit after flow at the 1.5-ft gate opening revealed that, with the type A gate, considerable cavitation occurred on both sides of the gate frame seals and immediately downstream from the seals at the 1.5-ft mark (fig. 9). The entire bottom babbitt seal was removed and cavitation occurred approximately 1.5 ft downstream in the conduit lining. For the 5-ft gate opening only slight cavitation pitting along the sides of the gate frame at the 5-ft mark was noted.



Fig. 9. Considerable cavitation effects can be seen on both sides of and downstream from gate frame seals of type A gate after 202 hours of flow at 1.5-ft gate opening

42. With the type B gate set at an opening of 1.5 ft, slight cavitation pitting was noted along the outer edge of the bronze seals on both sides of the gate frame with slightly more pitting in the cast steel immediately downstream and just under the gate. Several other areas showed evidence of paint having been removed and the shiny metal exposed (fig. 10). There was no apparent wear or pitting of the gate leaf. At gate openings of 3 and 5 ft only slight polishing of the bronze seal was noted.



Fig. 10. Slight cavitation effects are apparent in cast steel under type B gate and immediately downstream after 345 hours of flow at 1.5-ft gate opening

#### Conclusions

43. On the basis of the test results presented in previous paragraphs, the following conclusions appear justified:

- a. The over-all hydraulic performance of type B gate (45-degree lip shape) was far superior to type A gate (flat-bottomed, existing Norfork gate) at partial gate openings.
- b. Based on the pressure data, hydraulic downpull of considerable magnitude occurred on the bottom of type A gate and hydraulic uplift occurred on the bottom of type B gate.

(Total gate loads are increased and decreased by hydraulic downpull and uplift, respectively.)

- c. Instantaneous pressure fluctuations were considerably smaller in magnitude for type B gate.
- d. Vibrations in the vertical direction were comparatively small for both gates, being somewhat smaller for type B gate. Vibration magnitudes in the horizontal direction (upstream and downstream) for type A gate were approximately five times the corresponding magnitudes for type B gate. (The large horizontal vibration of type A gate is attributed to the unstable pressures on the bottom of the gate.)
- e. Air demand was greater for type A gate, probably as a result of low pressures on the gate bottom and rougher flow conditions under the gate. Although air demand varied considerably with gate opening for both gates, in general type B gate required less air and the air demand varied more uniformly with gate opening.
- f. In general, negative pressures in the conduit downstream of the gate were increased when the air supply was reduced.
- g. Downward hydraulic loads on top of type A gate, as indicated by bonnet pressures, were small (7 to 21 per cent of the head on the gate) for gate openings of 0.5 ft or greater, when the top of gate was not in contact with the downstream seal. Downward hydraulic loads on top of type B gate were slightly higher (25 to 35 per cent of the head on the gate) for gate openings in excess of 2 ft.
- h. Cavitation probably occurred 100 per cent of the time on the bottom of type A gate for most gate openings, whereas cavitation did not occur on the bottom of type B gate. Cavitation pitting of the seals and the steel liner downstream occurred with both type gates installed although to a lesser degree with the type B gate. The smaller openings appeared to cause more pitting than the larger openings.

Table 1

PIEZOMETER ELEVATIONS -- TYPE A GATE

Pie- zometer Number	Gate Opening in Feet							
	0.25	0.50	1.0	2.0	3.0	4.0	5.0	6.0
1	390.6	390.8	391.3	392.3	393.3	394.3	395.3	396.3*
2	390.5	390.7	391.2	392.2	393.2	394.2	395.2	396.2
3	390.1	390.7	391.2	392.2	393.2	394.2	395.2	396.2
4	390.4	390.7	391.2	392.2	393.2	394.2	395.2	396.2
5	390.4	390.7	391.2	392.2	393.2	394.2	395.2	396.2
6	390.4	390.6	391.1	392.1	393.1	394.1	395.1	396.1
7	390.4	390.6	391.1	392.1	393.1	394.1	395.1	396.1
8	390.4	390.6	391.1	392.1	393.1	394.1	395.1	396.1
9	390.6	390.8	391.3	392.3	393.3	394.3	395.3	396.3*
10	390.4	390.7	391.2	392.2	393.2	394.2	395.2	396.2
11	390.4	390.7	391.2	392.2	393.2	394.2	395.2	396.2
12	390.4	390.6	391.1	392.1	393.1	394.1	395.1	396.1
13	390.4	390.6	391.1	392.1	393.1	394.1	395.1	396.1

NOTES: Piezometer locations are shown on plate 29.  
 All piezometers marked by asterisk (\*) are located in the gate well for particular opening indicated.

Table 2

PRESSURE DATA -- TYPE A GATE  
Air Vent Unrestricted

Piez Number	Gate Opening in Feet							
	0.25	0.50	1.0	2.0	3.0	4.0	5.0	6.0
1	130.6 -----	95.8 97.4	71.3 71.1	53.1 53.1	48.1 48.5	61.7 59.3	80.3 75.5	21.4* -----
2	58.7 -----	-6.0 -10.5	-7.2 -10.5	-7.7 -9.1	-9.2 -12.0	-10.3 -3.9	-12.4 0.8	76.7 -----
3	40.5 -----	-9.2 -10.6	-7.8 -10.6	-8.9 -9.7	-10.1 -11.9	-8.2 -10.7	-9.5 -11.0	19.6 -----
4	75.8 -----	-10.7 -10.1	-7.1 -10.2	-7.8 -10.2	-8.7 -11.7	-6.3 -7.6	-7.3 -8.0	29.6 -----
5	100.3 -----	51.5 63.3	-5.4 -10.5	-8.4 -9.0	-7.4 -9.2	-5.2 -6.3	-7.3 -8.2	50.8 -----
6	-9.9 -----	-3.9 -8.6	0.0 -3.3	-2.0 -2.1	-2.4 -3.9	3.9 0.9	0.1 0.7	-8.3 -----
7	-9.9 -----	9.4 19.4	-2.4 -8.9	-7.0 -7.3	-7.5 -8.9	-3.7 -6.3	-6.5 -7.2	-12.2 -----
8	14.1 -----	1.0 11.3	-0.1 -1.6	-4.3 -4.7	-5.4 -5.8	-2.9 4.2	-5.2 -5.5	17.4 -----
9	122.2 -----	69.1 48.1	42.0 42.5	20.6 24.0	19.2 20.5	28.3 30.6	46.0 45.8	14.2* -----
10	29.9 -----	-9.7 -10.4	-8.3 -10.2	-10.8 -11.1	-11.2 -12.3	-11.4 -11.8	-13.5 -14.3	53.0 -----
11	82.9 -----	-10.1 -10.2	-8.3 -10.7	-8.8 -11.6	-9.8 -12.3	-9.7 -11.1	-11.5 -14.0	50.8 -----
12	34.2 -----	-10.1 -10.2	30.6 44.2	-7.7 -11.6	-9.0 -12.4	-8.5 -9.4	8.6 6.9	-12.8 -----
13	40.2 -----	6.6 11.4	-6.7 -5.6	3.0 2.5	-1.4 -0.9	2.4 -2.5	-5.0 -5.1	18.2 -----

NOTES: Piezometer locations are shown on plate 29. Piezometer zeros are shown in table 1. Pressures are recorded in feet of water. Reservoir elevations 550.2 msl. All piezometers marked by asterisk (\*) are located in gate well for particular opening indicated.

Table 3

PRESSURE DATA -- TYPE A GATE  
Air Vent Restricted By 75 Per Cent Orifice

Piez Number	Gate Opening in Feet						
	<u>0.25</u>	<u>0.50</u>	<u>1.0</u>	<u>2.0</u>	<u>3.0</u>	<u>4.0</u>	<u>5.0</u>
1	131.5	96.3	70.8	52.6	48.9	60.6	84.4
2	55.6	-8.8	-7.9	-9.2	-10.8	-11.1	-12.5
3	37.7	-9.4	-8.4	-9.9	-12.3	-8.5	-10.6
4	73.1	-8.5	-7.6	-8.1	-10.7	-5.7	-8.7
5	98.7	55.0	-4.6	-7.2	-8.4	-5.7	-8.5
6	-8.2	-4.5	-2.9	-2.6	-3.6	4.3	1.2
7	-8.2	18.7	-3.0	-6.5	-8.4	-3.8	-6.6
8	12.0	10.2	-0.3	-4.8	-6.7	-3.0	-6.6
9	119.2	67.2	42.1	22.5	20.0	26.7	45.1
10	26.0	-7.9	-8.5	-9.4	-10.4	-10.9	-11.9
11	79.4	-8.8	-9.9	-10.4	-10.5	-11.4	-12.0
12	36.0	-7.8	37.2	-9.0	-9.2	-9.5	-8.2
13	41.0	3.6	-7.7	0.2	-2.7	-0.9	-5.3

NOTES: Piezometer locations are shown on plate 29. Piezometer zeros are shown in table 1. Pressures are recorded in feet of water. Reservoir elevation 550.0 msl.

Table 4

PRESSURE DATA -- TYPE A GATE  
Air Vent Restricted By 50 Per Cent Orifice

Piez Number	Gate Opening in Feet						
	0.25	0.50	1.0	2.0	3.0	4.0	5.0
1	131.5	96.1	71.5	54.2	48.8	61.1	79.4
	-----	97.0	70.8	52.5	48.8	61.6	80.0
2	58.1	-7.9	-8.6	-9.8	-11.9	-13.4	-13.2
	-----	-10.0	-10.7	-10.6	-12.5	-10.9	-12.8
3	39.3	-9.2	-9.8	-11.2	-12.1	-6.1	-12.6
	-----	-10.4	-10.6	-11.3	-12.5	-9.3	-9.3
4	73.6	-10.1	-9.2	-10.0	-12.2	-5.2	-10.2
	-----	-10.4	-10.5	-10.8	-12.1	-7.6	-9.7
5	99.4	59.3	-4.3	-9.0	-11.9	-4.3	-9.1
	-----	64.0	-7.2	-10.0	-9.5	-6.9	-8.5
6	-9.3	-8.2	0.0	-3.1	-3.1	3.9	-0.3
	-----	-9.2	-5.1	-2.0	-2.4	3.9	0.3
7	-9.5	19.7	-3.6	-6.5	-9.2	-3.2	-6.9
	-----	13.3	-5.9	-7.0	-8.7	-3.8	-7.2
8	12.5	10.9	-1.1	-5.1	-7.1	-3.2	-6.9
	-----	11.5	-2.1	-4.8	-6.2	-3.3	-7.2
9	121.4	68.8	41.4	24.0	19.6	26.2	44.4
	-----	70.1	41.6	23.2	20.2	28.0	46.6
10	29.3	-10.0	-9.0	-10.8	-11.7	-13.6	-9.3
	-----	-10.5	-10.0	-11.5	-11.4	-12.8	-12.7
11	81.5	-10.2	-10.2	-11.2	-11.7	-12.8	-13.6
	-----	-10.4	-10.3	-11.9	-12.4	-11.7	-13.6
12	37.9	-10.2	37.9	-10.4	-11.0	-9.9	11.5
	-----	-10.4	39.7	-11.7	-11.1	-9.4	-10.9
13	40.9	5.5	-5.8	-0.3	-2.7	-0.6	-6.6
	-----	11.1	-5.5	3.2	-2.9	-1.4	-6.6

NOTES: Piezometer locations are shown on plate 29. Piezometer zeros are shown in table 1. Pressures are recorded in feet of water. Reservoir elevation 550.0 msl.

Table 5

PRESSURE DATA -- TYPE A GATE  
Air Vent Restricted By 25 Per Cent Orifice

Piez Number	Gate Opening in Feet							
	0.25	0.50	1.0	2.0	3.0	4.0	5.0	6.0
1	131.0 -----	96.6 97.7	71.3 70.7	53.7 52.4	48.7 47.2	61.7 56.8	80.1 84.7	21.7* -----
2	58.3 -----	-10.4 -10.0	-10.7 -10.6	-11.8 -11.2	-12.6 -12.5	-11.1 -11.4	-10.5 -10.7	78.4 -----
3	39.9 -----	-10.6 -10.5	-10.9 -11.0	-11.7 -11.7	-12.7 -12.6	-11.0 -11.6	-12.4 -12.4	18.7 -----
4	73.9 -----	-10.6 -10.5	-10.6 -10.7	-11.8 -11.6	-12.4 -12.6	-9.9 -11.9	-10.7 -10.2	30.3 -----
5	99.5 -----	56.6 63.6	-8.6 -10.5	-10.7 -10.8	-11.3 -11.7	-8.5 -10.0	-8.9 -10.4	55.0 -----
6	-9.9 -----	-8.3 -8.6	-2.1 -5.1	-2.5 -3.9	-2.9 -2.9	-3.7 -0.8	-2.7 -1.5	-10.0 -----
7	-10.0 -----	19.5 13.7	-5.9 -7.2	-7.9 -8.3	-8.9 -9.1	-7.4 -6.5	-8.7 -9.2	-8.4 -----
8	12.2 -----	10.5 11.3	-0.3 -0.8	-4.1 -4.6	-7.1 -6.5	-5.7 -5.2	-8.7 -9.2	14.8 -----
9	120.2 -----	67.8 69.5	41.4 42.0	23.1 24.2	21.0 20.9	28.5 28.2	42.7 46.7	14.0* -----
10	28.1 -----	-10.5 -10.2	-10.6 -10.6	-11.7 -11.2	-12.7 -12.6	-11.9 -12.7	-12.7 -13.5	52.9 -----
11	81.0 -----	-11.1 -10.4	-10.6 -10.9	-11.7 -11.7	-12.7 -12.6	-11.9 -12.7	-11.6 -14.1	51.7 -----
12	37.4 -----	-10.3 -10.3	42.2 39.7	-11.9 -11.7	-12.7 -12.6	-9.7 -11.5	4.6 -11.8	-6.0 -----
13	41.1 -----	4.0 -10.6	-4.7 -3.5	-0.1 2.3	-2.2 -2.1	-1.2 -2.0	-8.4 -8.7	18.1 -----

NOTES: Piezometer locations are shown on plate 29. Piezometer zeros are shown in table 1. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl. All piezometers marked by asterisk (\*) are located in the gate well for particular opening indicated.

Table 6

PIEZOMETER ELEVATIONS -- TYPE B GATE

Pie- zometer Number	Gate Opening in Feet							
	0.25	0.50	1.0	2.0	3.0	4.0	5.0	6.0
1	391.8	392.0	392.5	393.5	394.5	395.5	396.5*	397.5*
2	391.4	391.6	392.1	393.1	394.1	395.1	396.1	397.1*
3	391.0	391.3	391.8	392.8	393.8	394.8	395.8	396.8*
4	390.9	391.1	391.6	392.6	393.6	394.6	395.6	396.6*
5	390.7	390.9	391.4	392.4	393.4	394.4	395.4	396.4*
6	390.5	390.8	391.3	392.3	393.3	394.3	395.3	396.3*
7	390.4	390.7	391.2	392.2	393.2	394.2	395.2	396.2
8	391.7	392.0	392.5	393.5	394.5	395.5	396.5*	397.5*
9	391.3	391.5	392.0	393.0	394.0	395.0	396.0	397.0*
10	390.9	391.1	391.6	392.6	393.6	394.6	395.6	396.6*
11	390.4	390.7	391.2	392.2	393.2	394.2	395.2	396.2

NOTES: Piezometer locations shown on plate 32.

All piezometers marked by asterisk (\*) are located in the gate well for particular opening indicated.

Table 7

PRESSURE DATA -- TYPE B GATE  
Air Vent Unrestricted

Piez Number	Gate Opening in Feet							
	0.25	0.50	1.0	2.0	3.0	4.0	5.0	6.0
1	158.0	152.9	143.4	130.8	124.1	131.2	34.4*	14.9*
	156.4	152.5	142.7	132.2	130.1	140.6	39.8	0.1
2	153.8	143.8	123.2	101.5	88.6	101.9	123.7	27.6*
	153.6	142.2	123.0	101.3	93.4	105.2	129.2	8.5*
3	153.9	139.8	111.4	94.8	83.0	84.7	103.6	9.9*
	151.6	137.2	120.9	95.0	83.6	86.4	103.3	-1.0*
4	148.3	134.6	119.5	97.7	85.9	85.8	95.3	11.5*
	148.1	133.7	119.0	96.5	86.2	85.8	94.8	0.8*
5	142.5	127.0	114.2	96.8	87.4	85.3	88.9	52.1*
	142.3	126.5	113.8	95.6	87.2	85.1	88.2	25.7*
6	138.9	128.1	121.9	111.2	107.4	105.6	97.8	89.7*
	138.5	127.2	121.9	109.9	105.6	103.6	99.3	40.1*
7	-2.7	-0.2	-1.1	-1.8	-1.7	0.4	-3.0	-12.8
	-2.6	0.2	-1.2	-2.1	-2.2	-1.8	-3.3	-13.7
8	153.9	146.3	129.6	115.2	112.6	117.8	107.9*	19.0*
	153.9	145.4	129.8	115.4	114.0	119.9	109.0*	4.9*
9	147.0	126.2	98.2	60.1	53.4	59.2	85.9	15.4*
	147.0	125.9	98.2	59.8	51.8	61.8	88.5	0.8*
10	141.6	120.9	92.5	64.1	54.8	48.9	50.8	13.0*
	141.4	117.3	93.7	63.0	55.0	50.2	52.7	1.3*
11	-8.3	17.9	10.6	-7.1	-11.0	27.7	20.9*	-7.2
	-----	11.3	0.1	1.3	-1.7	30.5	22.3*	-11.9

NOTES: Piezometer locations shown on plate 32. Piezometer zeros are shown in table 6. Pressures are recorded in feet of water. Reservoir elevation 550.4 msl. All piezometers marked by asterisk (\*) are located in the gate well for particular opening indicated.

Table 8

PRESSURE DATA -- TYPE B GATE  
Air Vent Restricted By 75 Per Cent Orifice

Piez Number	Gate Opening in Feet						
	0.25	0.50	1.0	2.0	3.0	4.0	5.0
1	136.5	151.1	142.0	131.1	129.9	137.4	27.5*
	-----	150.8	142.9	130.2	-----	136.2	31.6*
2	133.1	142.2	139.0	101.5	94.2	106.1	129.4
	-----	142.2	128.1	101.3	-----	107.9	116.7
3	129.6	137.2	120.8	94.5	84.2	85.5	105.6
	-----	137.0	120.9	94.5	-----	87.2	103.8
4	127.1	133.5	118.8	96.4	86.2	85.6	96.9
	-----	133.3	119.0	96.5	-----	85.8	105.4
5	120.1	130.8	113.4	95.6	87.1	84.7	89.6
	-----	131.2	113.7	95.4	-----	84.5	88.2
6	117.3	127.4	121.6	110.2	105.6	103.8	101.2
	-----	127.4	121.7	111.4	-----	103.8	97.5
7	-3.1	-1.1	-1.4	-3.8	-1.8	-2.0	-3.3
	-----	-0.8	-1.4	-3.9	-----	-2.0	-3.7
8	134.2	144.2	129.1	115.3	111.6	114.9	102.9*
	-----	146.0	130.8	115.6	-----	117.3	105.9*
9	126.4	129.9	98.3	58.7	49.7	61.4	84.6
	-----	130.4	99.8	60.5	-----	61.3	86.8
10	120.6	121.0	92.8	62.5	51.9	49.2	50.7
	-----	121.8	94.8	64.2	-----	49.3	50.5

NOTES: Piezometer locations shown on plate 32. Piezometer zeros are shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.1 msl. All piezometers marked by asterisk (\*) are located in the gate well for particular opening indicated.

Table 9

PRESSURE DATA -- TYPE B GATE  
Air Vent Restricted By 50 Per Cent Orifice

Piez Number	Gate Opening in Feet						
	0.25	0.50	1.0	2.0	3.0	4.0	5.0
1	156.2	152.5	143.4	129.0	128.9	135.7	40.5*
	-----	152.7	143.2	130.6	129.9	132.1	35.7*
2	153.6	142.5	123.7	103.0	93.4	104.0	115.9
	-----	143.3	128.2	101.9	95.3	107.2	121.1
3	150.2	137.0	121.2	95.2	83.7	86.0	100.2
	-----	137.7	121.2	94.8	84.2	87.3	101.6
4	147.6	133.5	119.1	96.1	86.1	85.7	93.0
	-----	135.6	119.2	96.6	86.2	85.9	93.6
5	141.6	126.3	113.6	95.1	86.5	85.5	87.5
	-----	126.5	113.8	95.3	86.9	84.9	88.2
6	143.1	127.1	121.6	110.3	105.2	104.6	98.7
	-----	127.1	126.5	110.8	105.8	103.8	100.3
7	-3.1	-0.3	-1.4	-1.6	-2.0	-2.3	-4.2
	-----	-0.3	-1.4	-1.5	-1.5	-1.9	-4.2
8	153.9	145.4	129.8	117.9	112.8	119.1	106.8*
	-----	145.8	131.2	115.9	113.5	121.1	104.8*
9	146.8	125.7	97.7	60.5	54.9	60.1	85.4
	-----	125.7	99.1	60.9	52.3	61.8	87.3
10	140.3	120.7	93.0	64.1	53.0	49.2	50.7
	-----	121.7	94.4	63.8	54.1	49.5	50.8
11	10.3	11.4	1.1	8.5	-9.7	23.6	114.2
	-----	12.4	6.2	-0.8	-3.5	24.0	11.9

NOTES: Piezometer locations are shown on plate 32. Piezometer zeros are shown in table 6. Pressures are recorded in feet of water. Reservoir elevation 550.1 msl. All piezometers marked by asterisk (\*) are located in gate well for particular opening indicated.

Table 10

PRESSURE DATA -- TYPE B GATE  
Air Vent Restricted By 25 Per Cent Orifice

Piez Number	Gate Opening in Feet						
	0.25	0.50	1.0	2.0	3.0	4.0	5.0
1	156.2	151.8	143.2	130.2	130.3	138.3	32.1*
	-----	151.6	142.9	130.4	129.9	135.6	27.9*
2	153.3	142.5	128.2	101.1	92.8	110.5	121.0
	-----	142.5	128.4	101.5	94.2	106.5	124.3
3	150.2	137.0	121.0	94.4	83.0	86.3	102.6
	-----	137.2	121.3	94.7	83.4	86.7	103.0
4	147.6	133.5	119.1	96.4	85.9	85.6	94.2
	-----	133.3	119.1	96.5	86.1	85.8	94.2
5	141.3	131.0	113.7	95.4	86.5	84.6	89.9
	-----	131.2	114.0	95.4	87.0	84.7	86.6
6	142.9	127.4	122.0	110.5	105.9	104.7	97.5
	-----	127.1	121.9	110.8	105.7	103.5	98.2
7	-3.5	-0.4	-1.4	-2.7	-2.5	-2.5	-6.5
	-----	-0.6	-1.4	-1.3	-1.9	-2.4	-6.4
8	153.5	145.4	129.6	115.4	112.1	117.7	105.3*
	-----	145.8	131.0	115.4	112.8	116.9	106.7*
9	147.2	130.2	97.4	61.0	50.9	61.7	85.4
	-----	130.6	99.4	60.3	51.1	62.4	84.2
10	142.3	120.7	93.6	62.6	52.1	49.5	49.2
	-----	121.8	94.5	63.3	52.9	50.1	49.0
11	-9.8	11.0	11.7	-1.6	-1.6	24.5	12.7
	-----	15.0	22.9	-6.8	-2.4	27.6	12.9

NOTES: Piezometer locations shown on plate 32. Piezometer zeros are shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.1 msl. All piezometers marked by asterisk (\*) are located in gate well for particular opening indicated.

Table 11

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 0.25 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1	166.5	144.3	155.5	157.2
2	175.5	151.5	164.0	153.7
3	-----	-----	-----	152.8
4	142.6	133.0	138.0	148.2
5	-----	-----	-----	142.4
6	133.4	126.9	129.9	138.7
7	-12.3	-21.1	-15.9	-2.7
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1	157.1	136.8	146.5	156.2
2	170.3	146.7	156.7	153.3
3	149.3	130.1	139.5	150.2
4	146.7	139.4	143.7	147.6
5	149.2	126.4	137.6	141.3
6	127.3	119.9	123.3	142.9
7	-4.3	-9.5	-6.9	-3.5

NOTE: Pressure cell locations shown on plate 34. Piezometer locations are shown on plate 32. Piezometer zeros shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.

Table 12

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 0.5 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1	160.1	137.9	150.0	152.7
2	136.9	118.4	125.2	143.0
3	-----	-----	-----	138.5
4	128.2	117.0	123.0	134.2
5	-----	-----	-----	126.8
6	132.8	124.9	128.9	127.7
7	2.9	-8.3	-2.8	0.0
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1	150.7	131.5	141.0	151.7
2	157.9	136.9	146.7	142.5
3	134.9	114.4	125.3	137.1
4	135.0	121.5	128.5	133.4
5	139.1	111.3	123.3	131.1
6	123.7	114.9	119.3	127.3
7	1.0	-8.1	-4.3	-0.5

NOTE: Pressure cell locations shown on plate 34. Piezometer locations are shown on plate 32. Piezometer zeros are shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.

Table 13

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 1.0 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1	149.2	133.8	139.0	143.1
2	134.7	117.4	121.7	123.1
3	-----	-----	-----	116.2
4	-----	-----	101.4	119.3
5	100.6	90.0	102.1	114.0
6	112.5	102.9	107.8	121.9
7	0.9	-6.6	-2.8	-1.2
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1	142.1	122.9	132.4	143.1
2	140.3	119.4	129.3	128.3
3	110.1	97.9	103.8	121.2
4	118.0	101.6	110.0	119.1
5	119.3	93.2	106.0	113.9
6	113.5	103.9	108.4	122.0
7	-1.6	-6.6	-4.7	-1.4

NOTE: Pressure cell locations shown on plate 34. Piezometer locations shown on plate 32. Piezometer zeros are shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.

Table 14

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 2.0 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1	136.6	116.3	127.0	131.5
2	118.6	112.4	115.5	101.4
3	90.9	77.9	84.5	94.9
4	75.9	66.1	71.0	97.1
5	133.5	107.2	119.9	96.2
6	114.9	98.3	106.5	110.6
7	-2.4	-6.9	-4.9	-2.0
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1	133.4	112.4	122.9	130.3
2	107.2	101.0	104.2	101.3
3	86.3	74.4	80.3	94.6
4	90.7	80.0	85.6	96.5
5	97.7	75.2	86.4	95.4
6	110.1	95.3	103.5	110.7
7	-4.0	-7.8	-5.6	-2.0

NOTE: Pressure cell locations shown on plate 34. Piezometer locations shown on plate 32. Piezometer zeros are shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.

Table 15

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 3.0 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1	141.7	107.9	125.0	127.1
2	105.0	82.2	100.5	91.0
3	87.9	55.3	71.0	83.3
4	91.5	75.9	83.0	86.1
5	94.7	65.1	79.9	87.3
6	119.9	88.6	104.0	106.5
7	-1.7	-6.4	-4.0	-2.0
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1	132.3	108.1	120.2	130.1
2	101.8	82.6	94.9	93.5
3	74.3	59.1	68.2	83.2
4	86.0	69.6	77.1	86.0
5	94.4	59.2	76.4	86.8
6	122.1	93.8	104.9	105.8
7	-----	-----	-5.6	-2.2

NOTE: Pressure cell locations shown on plate 34. Piezometer locations shown on plate 32. Piezometer zeros shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.

Table 16

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 4.0 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1	147.5	109.9	129.0	135.9
2	115.4	103.6	110.2	103.6
3	86.5	60.1	71.0	85.6
4	97.9	74.3	83.0	85.8
5	97.7	72.2	84.4	85.2
6	108.5	85.0	97.0	104.6
7	-5.9	-11.8	-9.5	-0.7
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1	136.4	106.9	120.8	137.0
2	111.4	92.2	104.4	108.5
3	87.1	57.9	72.7	86.5
4	86.8	66.3	76.2	85.7
5	90.6	59.2	75.2	84.7
6	109.3	79.8	93.2	104.1
7	-4.2	-8.0	-6.2	-2.5

NOTE: Pressure cell locations shown on plate 34. Piezometer locations shown on plate 32. Piezometer zeros are shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.

Table 17

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 5.0 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1*	46.6	15.6	30.4	37.1
2	133.5	115.0	119.2	126.5
3	117.2	88.8	102.5	103.5
4	97.3	79.0	88.0	95.1
5	94.7	72.2	82.9	88.6
6	110.5	83.4	97.0	98.6
7	-6.6	-13.0	-10.1	-3.2
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1*	36.8	7.1	19.8	30.0
2	116.2	102.6	110.0	122.7
3	105.5	77.9	90.3	102.8
4	87.4	73.5	82.8	94.2
5	91.8	58.0	75.6	88.3
6	101.3	71.2	85.5	97.9
7	-6.1	-11.8	-9.4	-6.5

NOTE: Pressure cell locations shown on plate 34. Piezometer locations shown on plate 32. Piezometer zeros shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.  
\* Cell located in gate well.

Table 18

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open 5.5 Ft

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1*	-----	-----	-----	-----
2*	-----	-----	-----	-----
3*	-----	-----	-----	-----
4	-----	-----	-----	-----
5	-----	-----	-----	-----
6	-----	-----	-----	-----
7	-----	-----	-----	-----
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1*	44.9	-26.3	33.8	-----
2*	78.2	39.3	61.1	-----
3*	97.7	51.8	75.3	-----
4	119.3	74.1	92.4	-----
5	98.3	59.2	78.6	-----
6	103.5	69.0	85.5	-----
7	-5.9	-11.8	-9.5	-----

NOTE: Pressure cell locations shown on plate 34. Piezometer locations shown on plate 32. Piezometer zeros shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.  
\* Cell located in gate well.

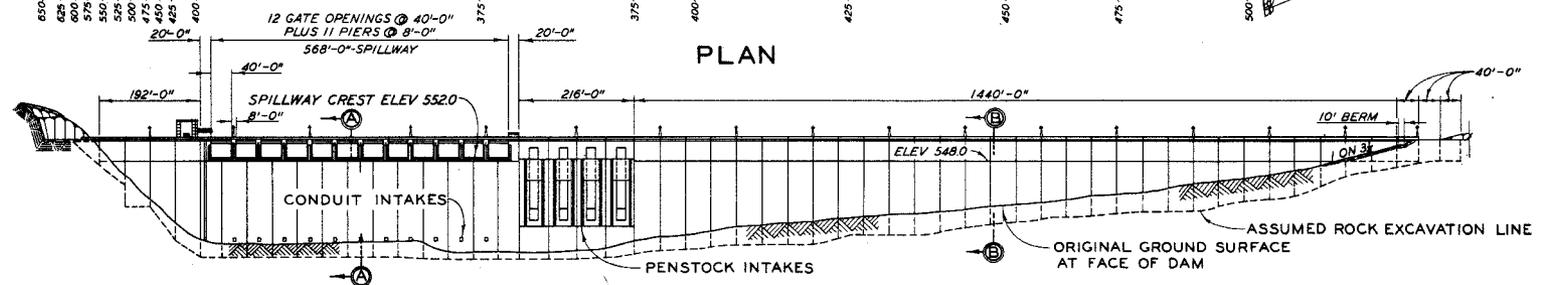
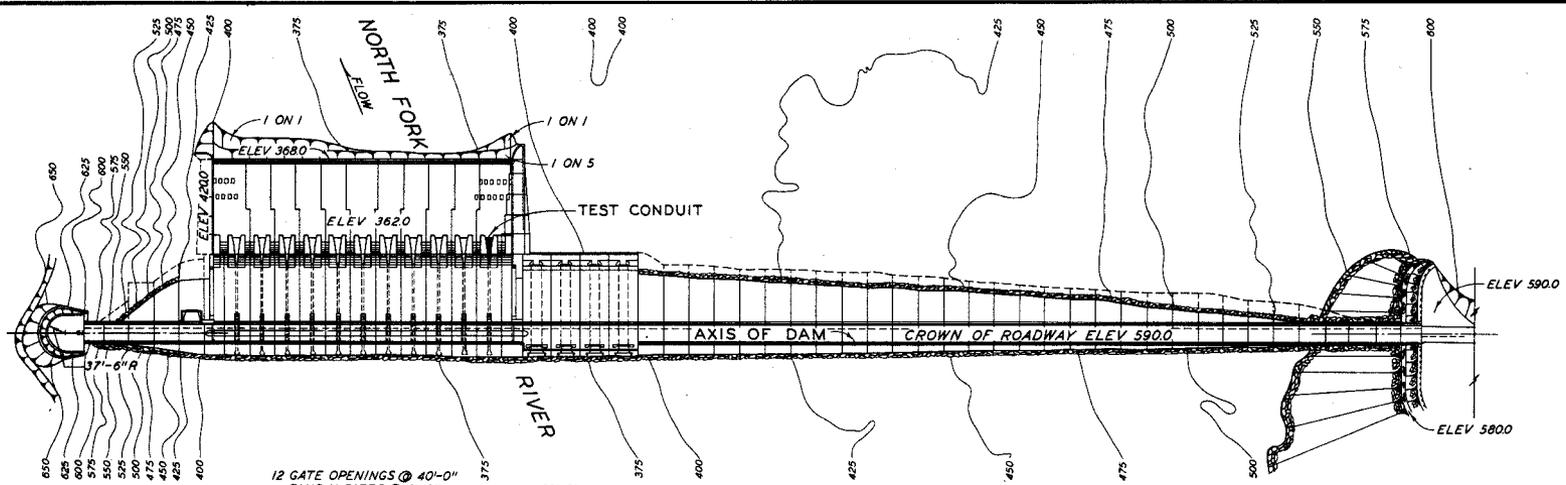
Table 19

PRESSURE CELL DATA -- TYPE B GATE  
Gate Open Full

<u>Pressure Cell No.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Piezometric Pressure</u>
<u>Air Vent Unrestricted</u>				
1*	16.9	-1.9	8.2	7.5
2*	36.5	12.2	24.0	18.1
3*	90.9	42.6	67.1	4.5
4*	----	----	22.5	6.2
5*	62.2	13.3	38.5	38.9
6*	109.7	47.9	77.7	64.9
7	----	----	----	-13.3
<u>Air Vent Restricted By 25 Per Cent Orifice</u>				
1*	----	----	-20.0	----
2*	60.9	6.8	30.0	----
3*	----	----	-5.4	----
4*	----	----	5.8	----
5*	----	----	60.5	----
6*	----	----	75.4	----
7	12.5	-25.6	-6.3	----

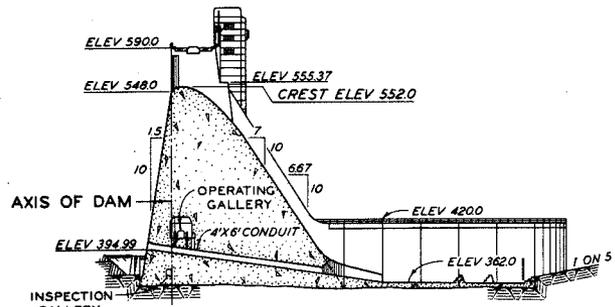
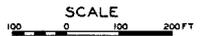
NOTE: Pressure cell locations shown on plate 34. Piezometer locations shown on plate 32. Piezometer zeros are shown on table 6. Pressures are recorded in feet of water. Reservoir elevation 550.2 msl.

\* Cell located in gate well.

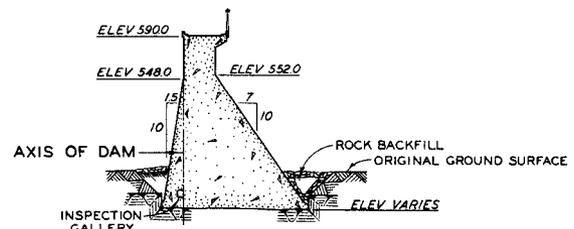
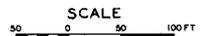


PLAN

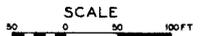
UPSTREAM ELEVATION



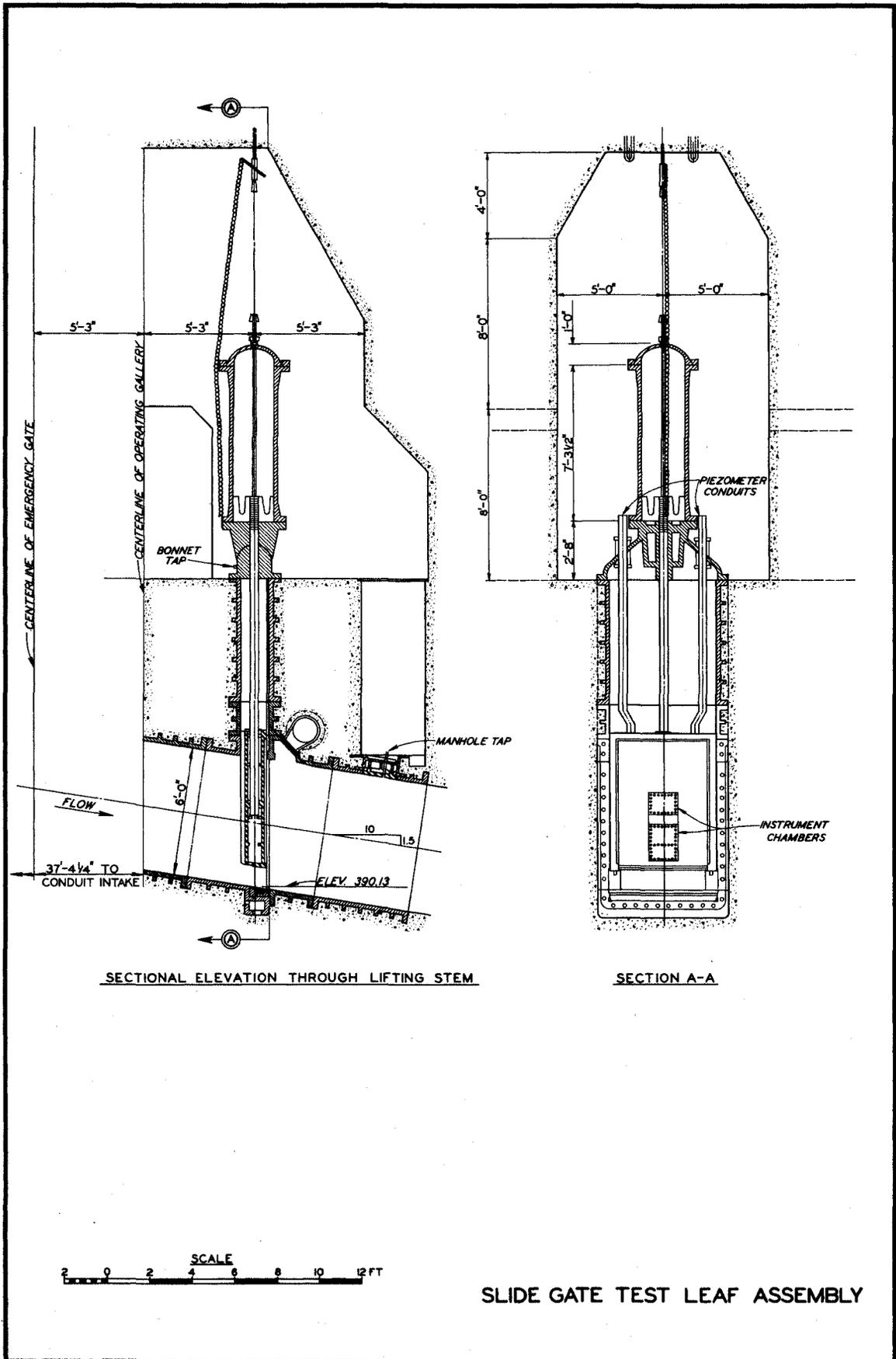
SECTION A-A



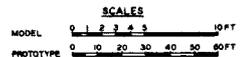
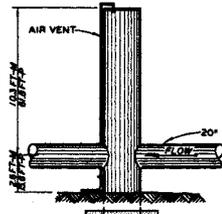
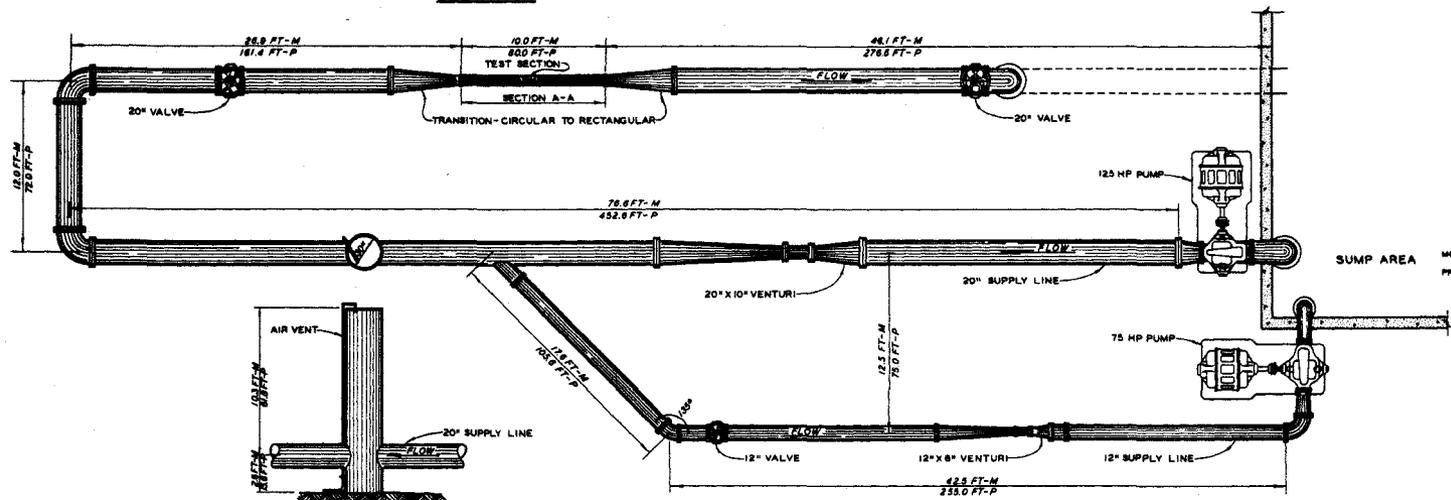
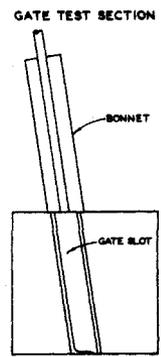
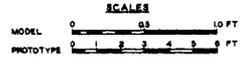
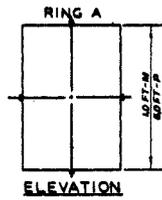
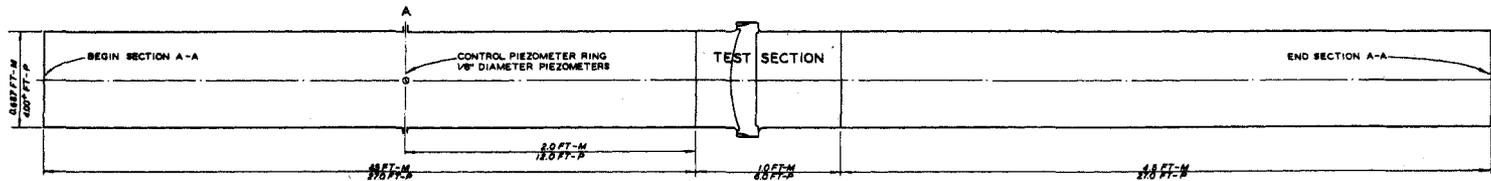
SECTION B-B



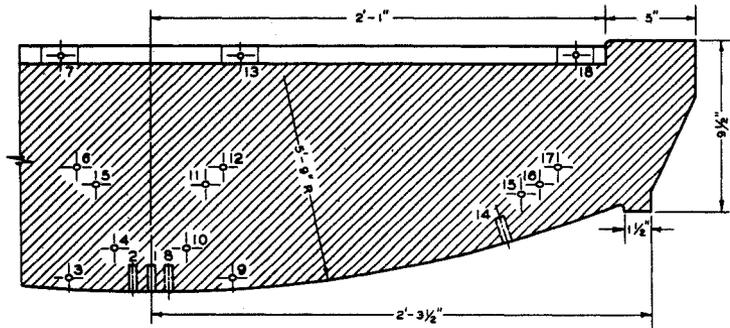
GENERAL DETAILS OF DAM



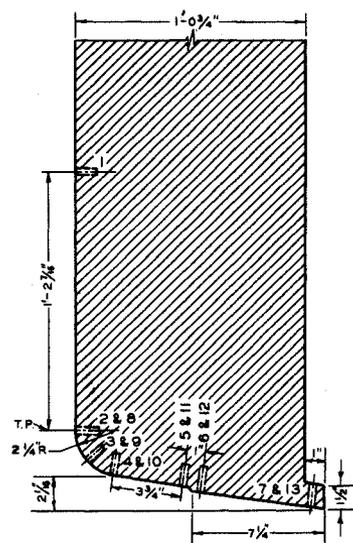




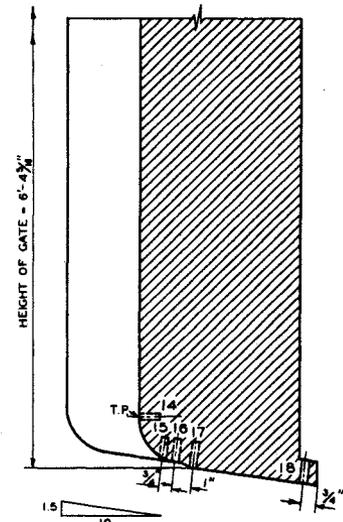
GENERAL MODEL LAYOUT



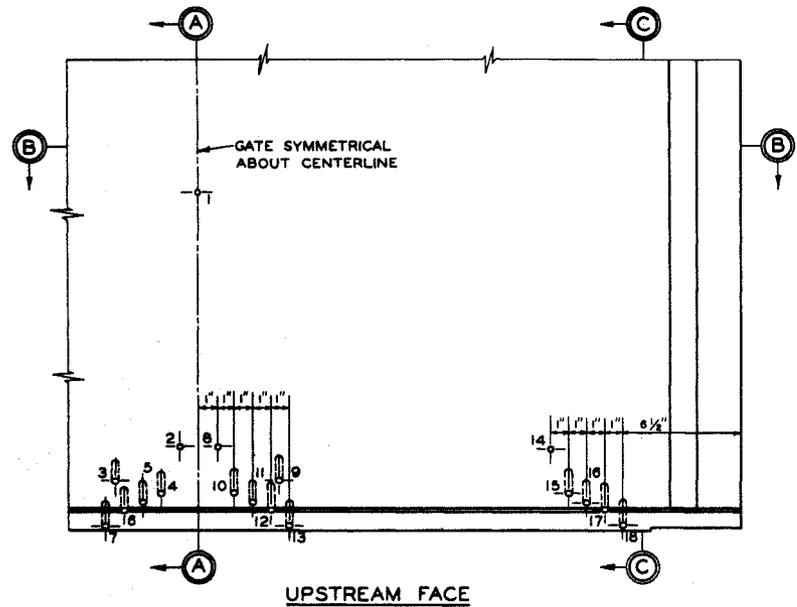
SECTION B-B



SECTION A-A



SECTION C-C

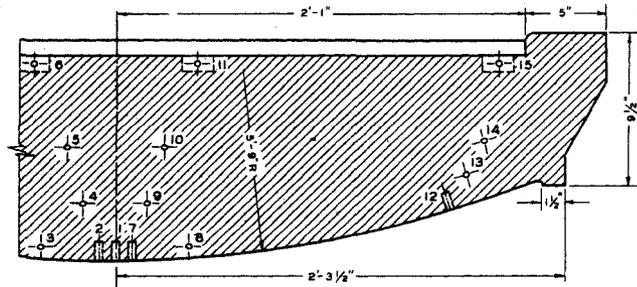


UPSTREAM FACE

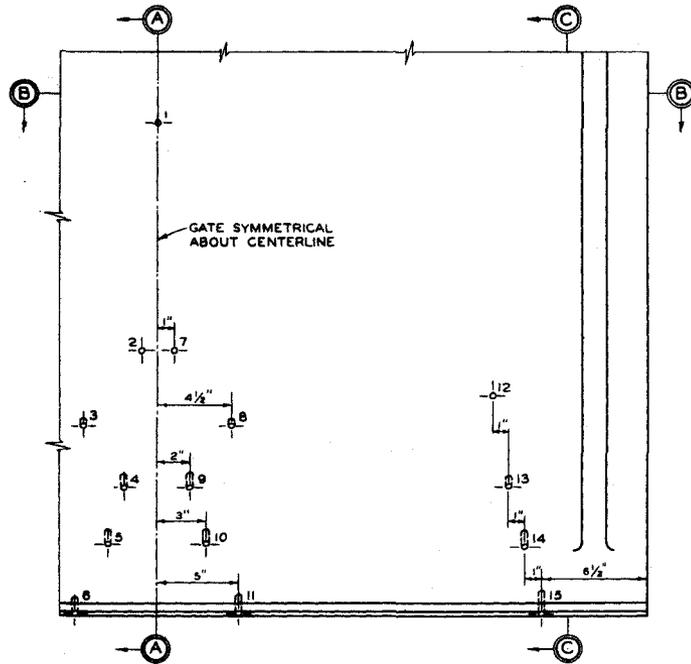
NOTE: PIEZOMETERS LOCATED ON RIGHT SIDE OF GATE ONLY. ALL PIEZOMETERS 1/8" IN DIAM. EXCEPT THOSE ON DOWNSTREAM EDGE OF BOTTOM BEARING SURFACE WHICH ARE 1/16" IN DIAM.

DETAILS OF TYPE A GATE LIP  
PIEZOMETER LOCATIONS

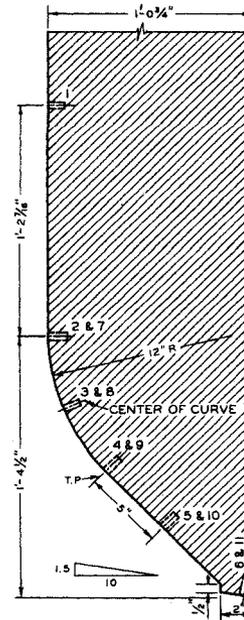




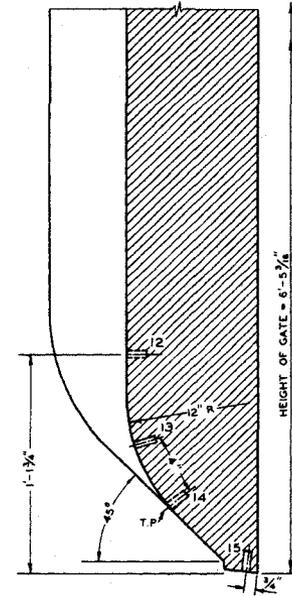
SECTION B-B



UPSTREAM FACE



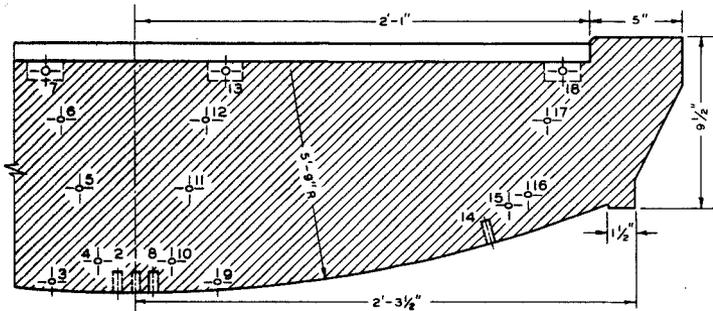
SECTION A-A



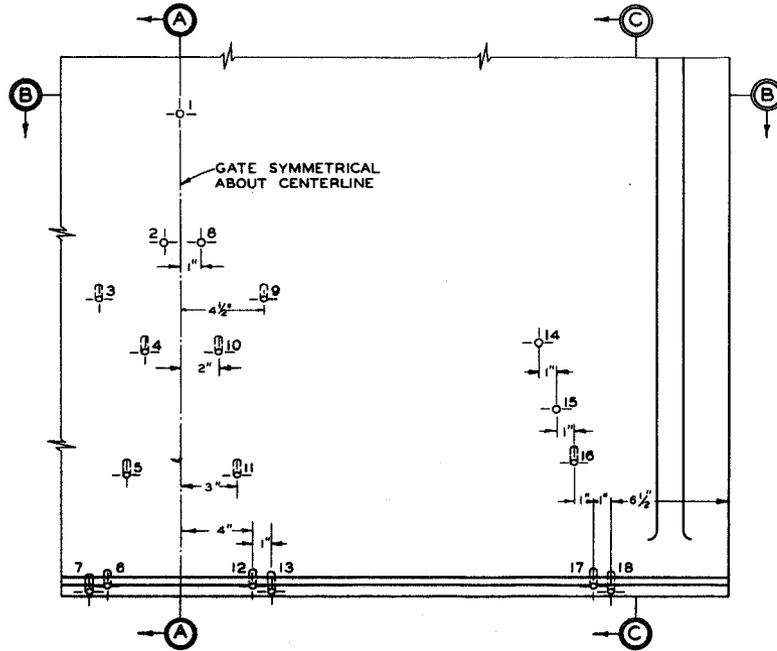
SECTION C-C

DETAILS OF TYPE B GATE LIP  
PIEZOMETER LOCATIONS

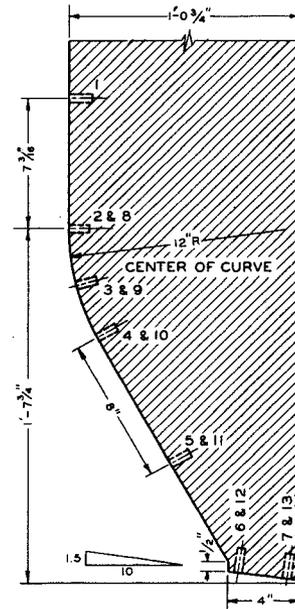




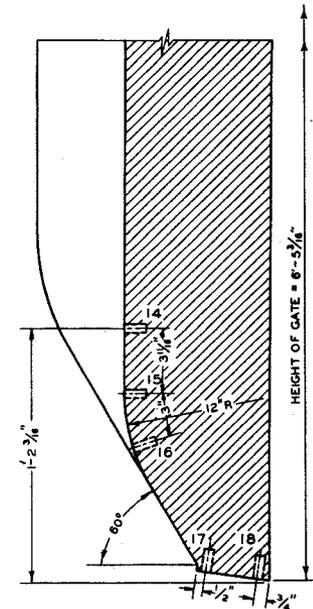
SECTION B-B



UPSTREAM FACE



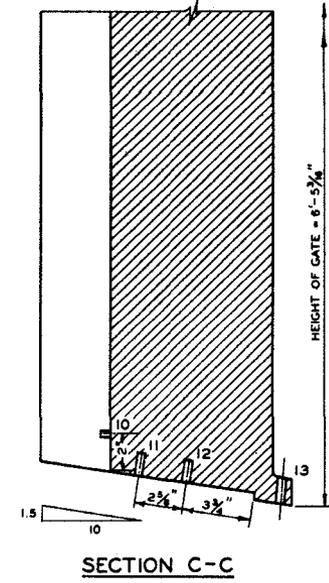
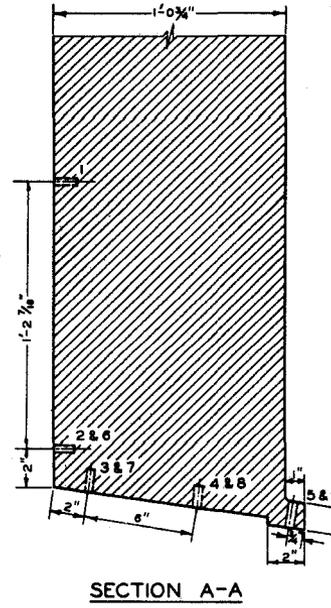
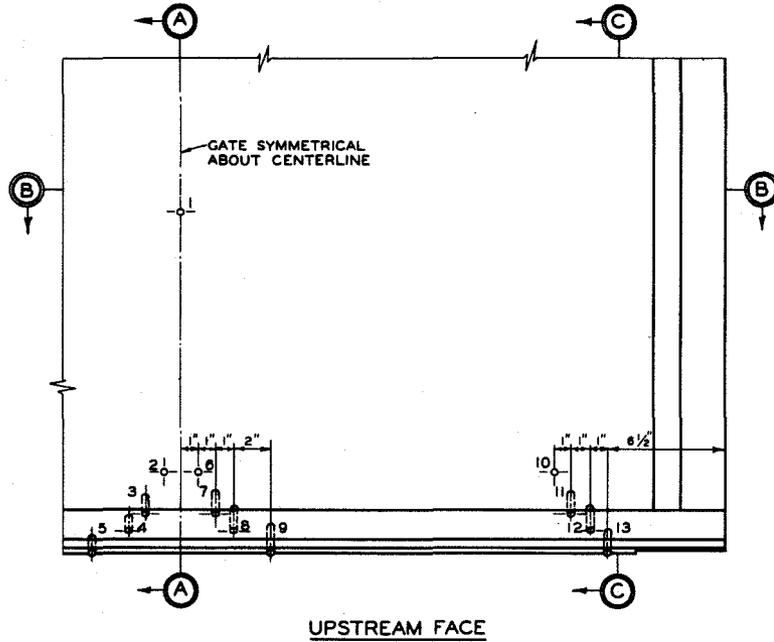
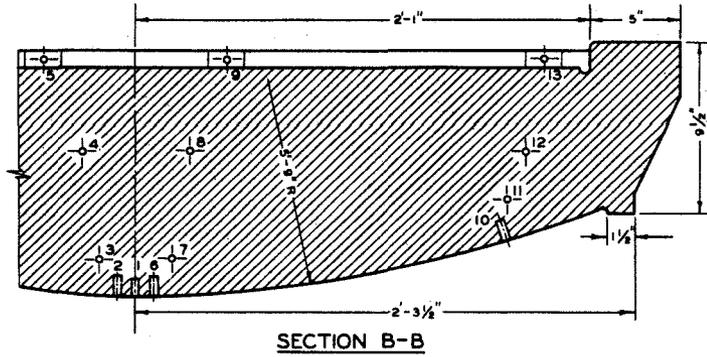
SECTION A-A



SECTION C-C

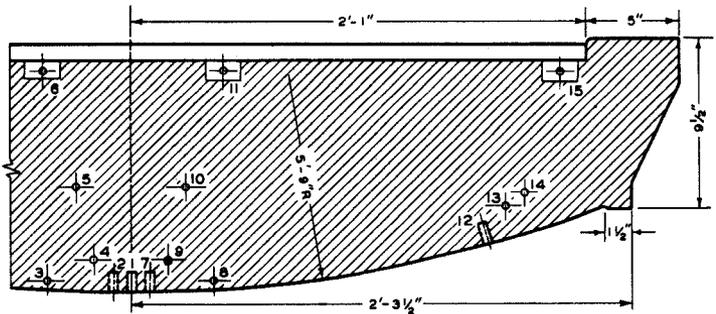
DETAILS OF TYPE C GATE LIP  
PIEZOMETER LOCATIONS



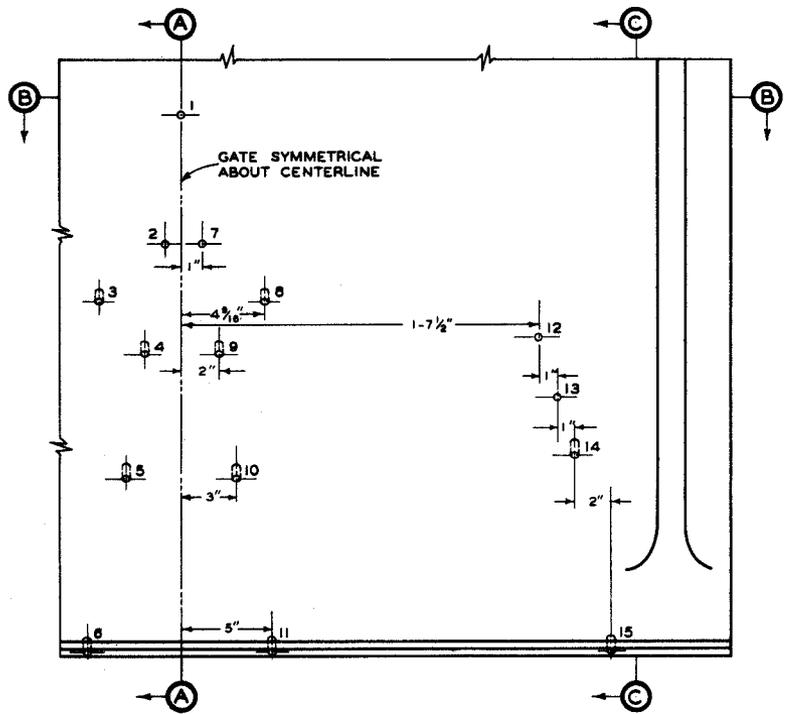


DETAILS OF TYPE D GATE LIP  
PIEZOMETER LOCATIONS

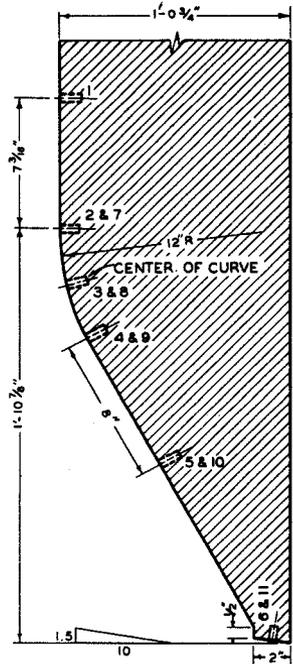




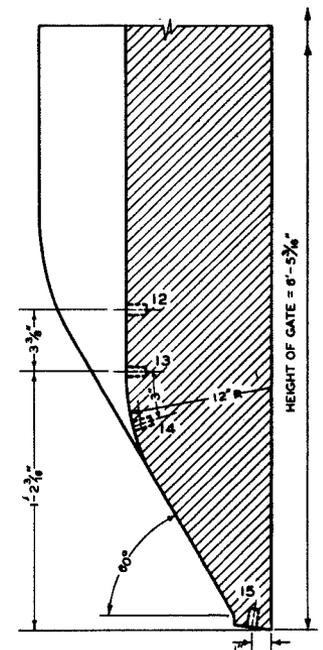
**SECTION B-B**



**UPSTREAM FACE**



**SECTION A-A**

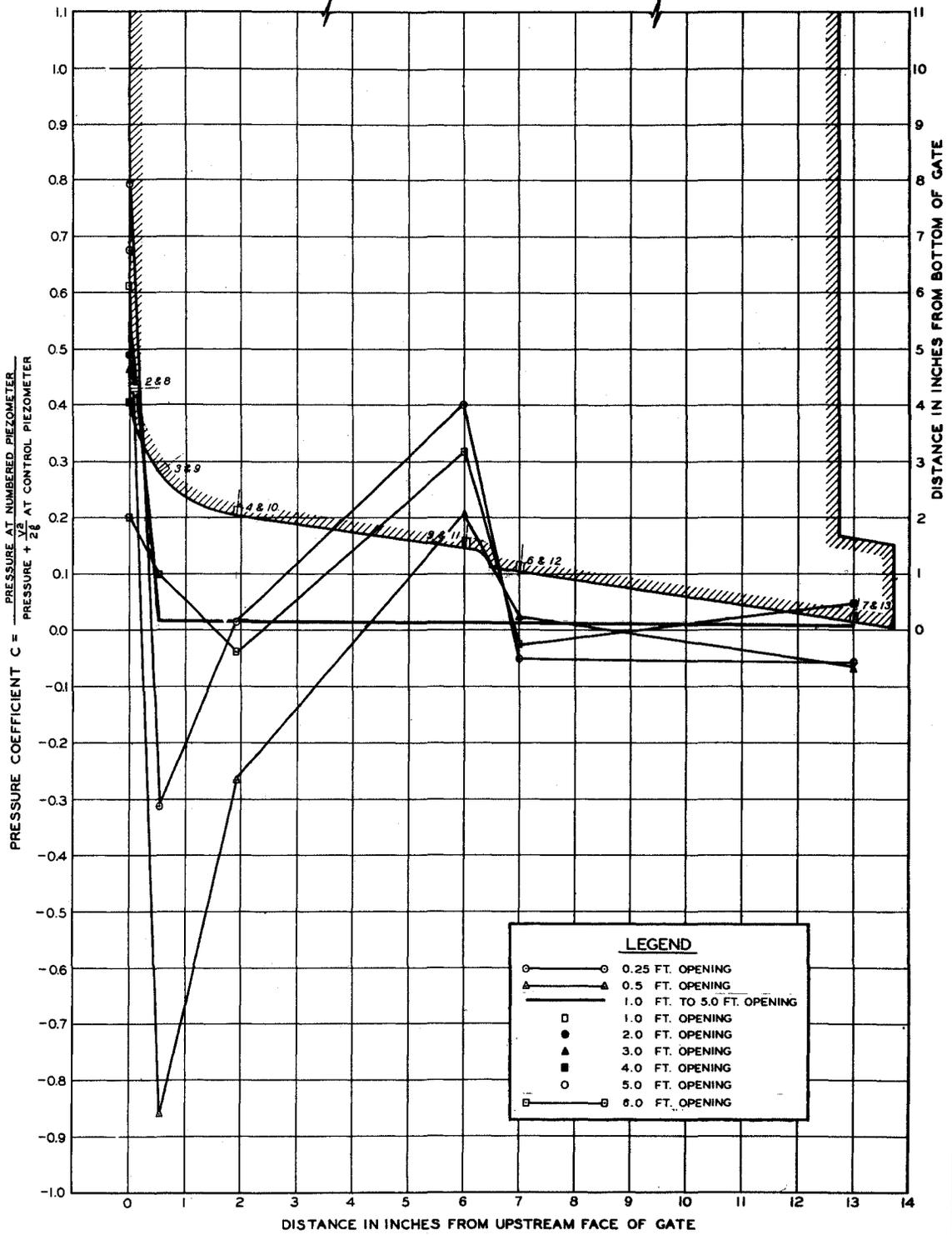


**SECTION C-C**

DETAILS OF TYPE E GATE LIP  
PIEZOMETER LOCATIONS

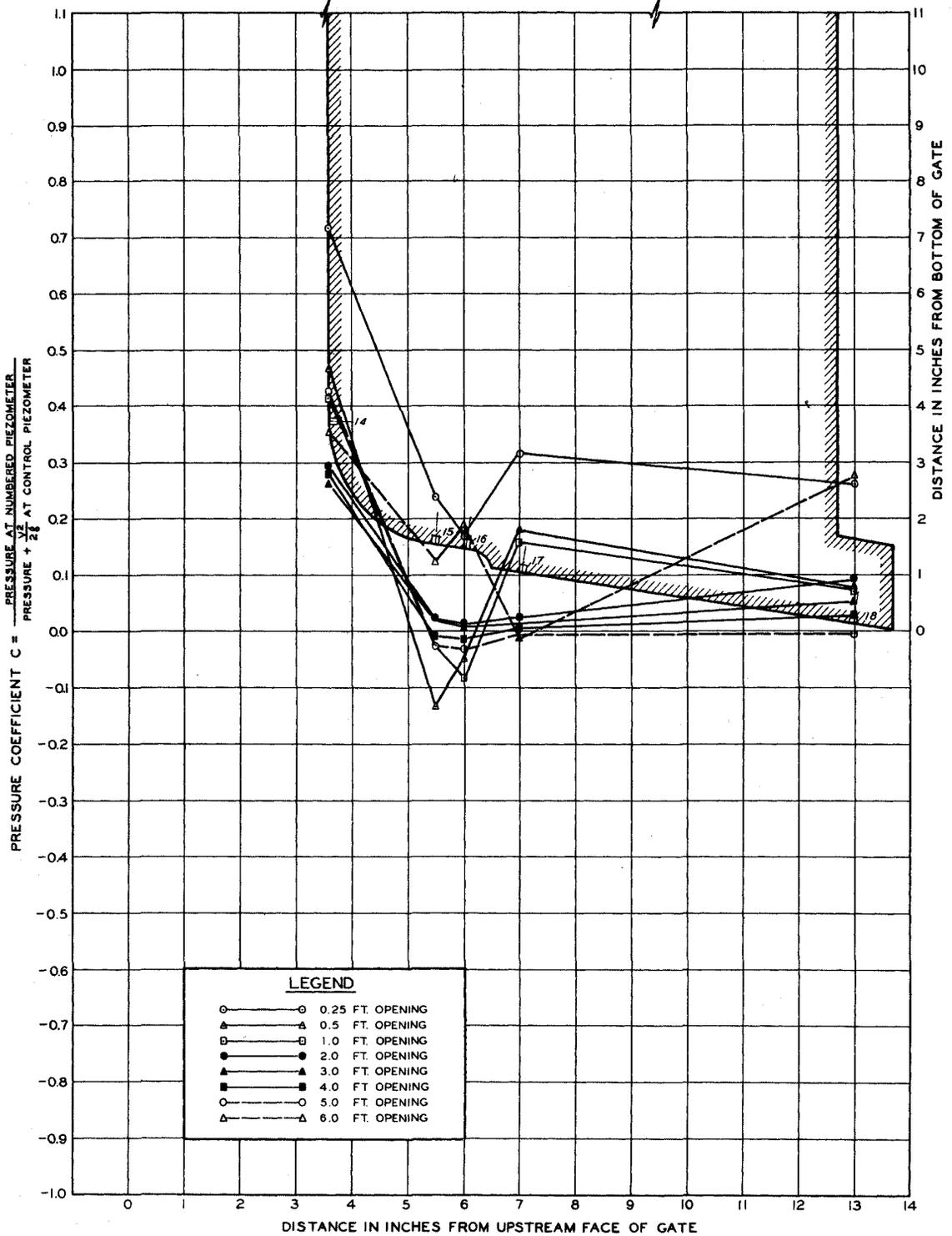




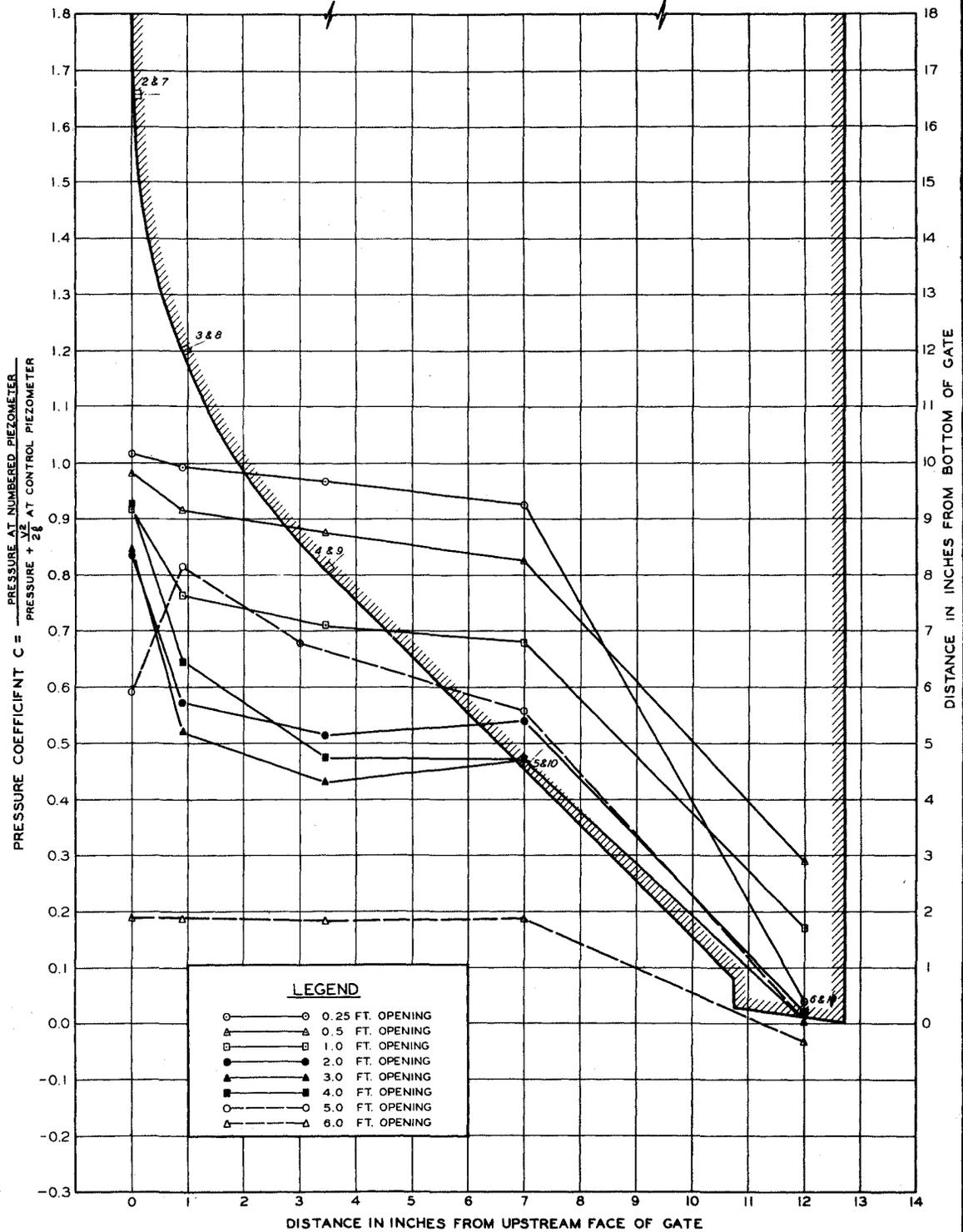


NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

**PRESSURE COEFFICIENTS**  
 TYPE A GATE LIP  
 CENTER PIEZOMETERS

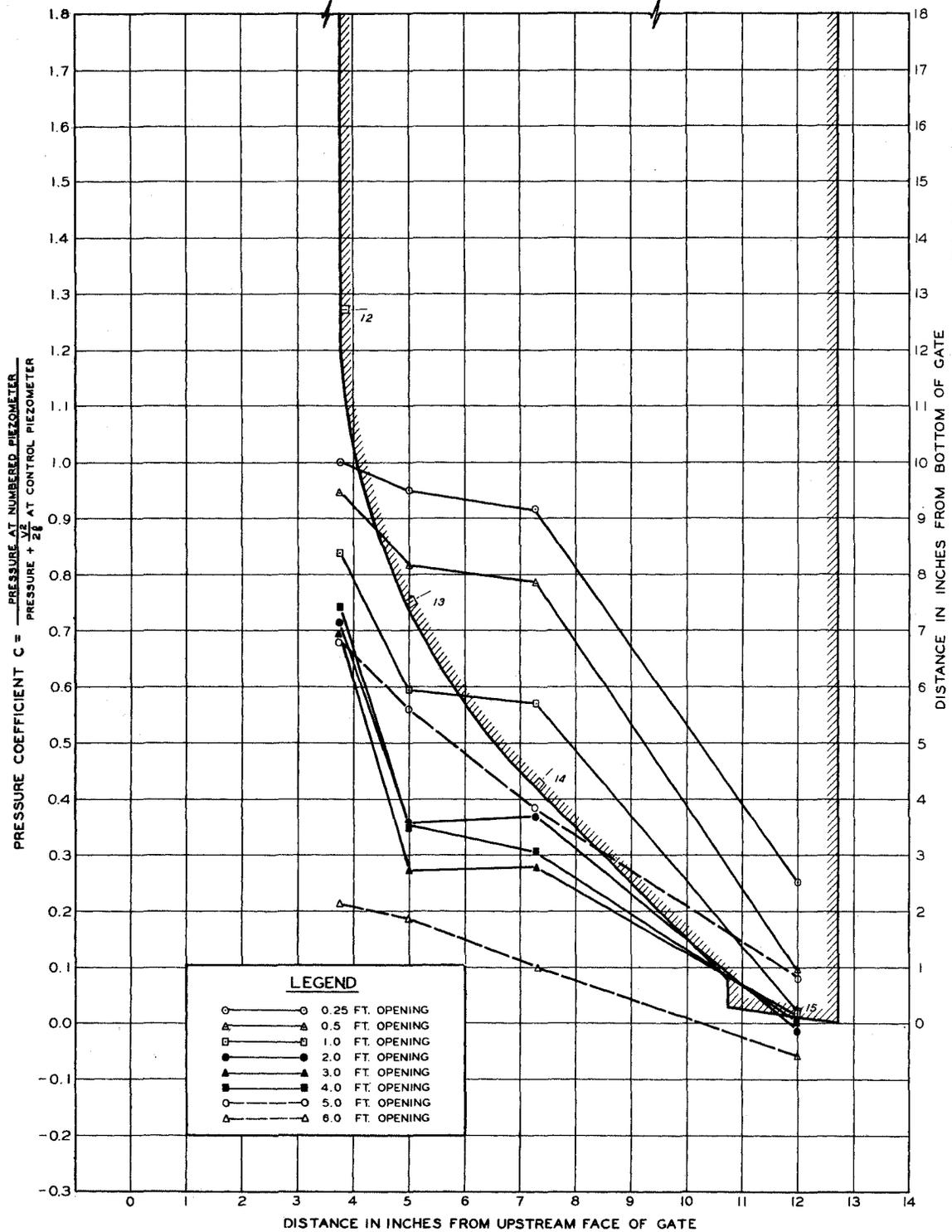


**PRESSURE COEFFICIENTS**  
 TYPE A GATE LIP  
 SIDE PIEZOMETERS



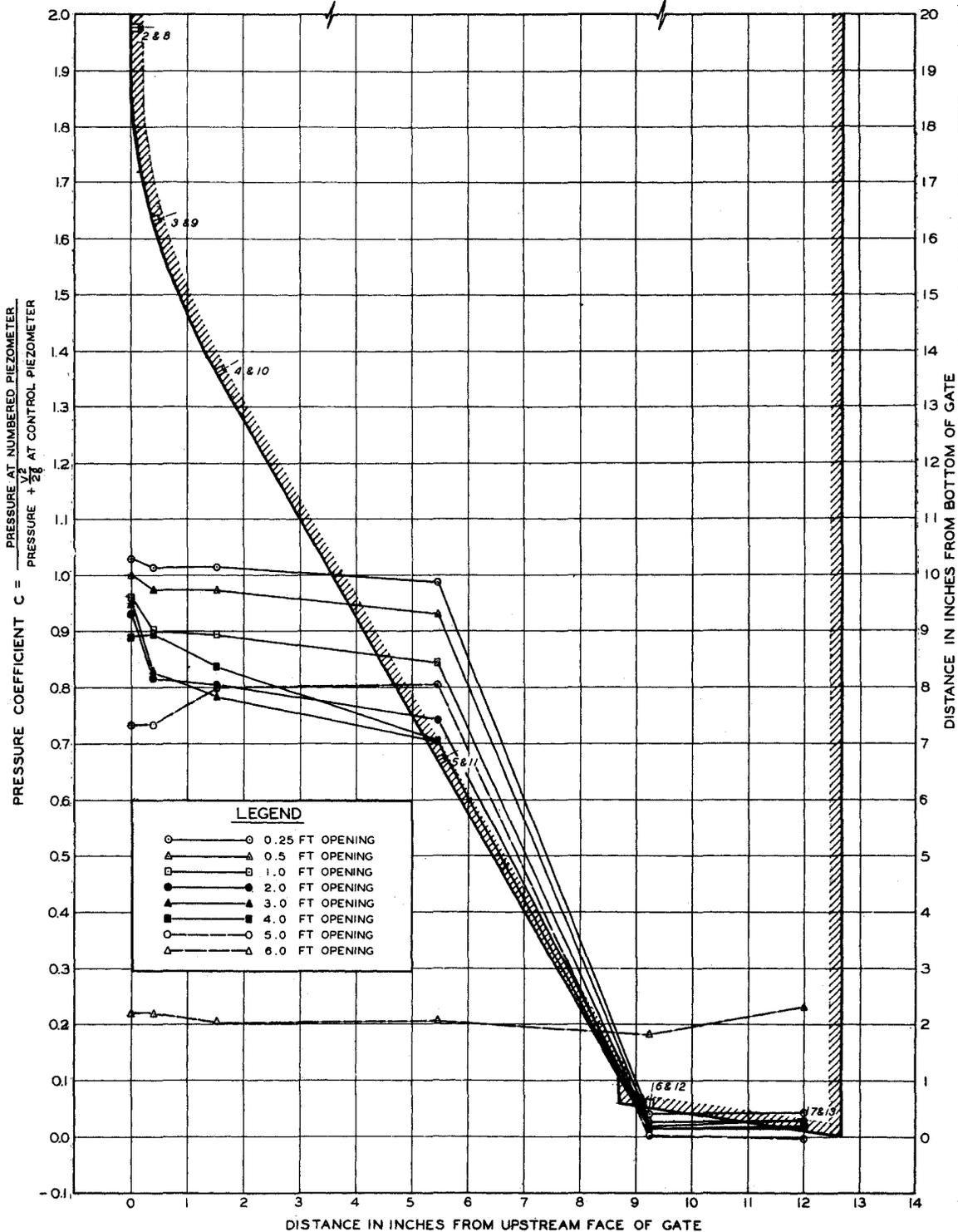
NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

**PRESSURE COEFFICIENTS**  
TYPE B GATE LIP  
CENTER PIEZOMETERS



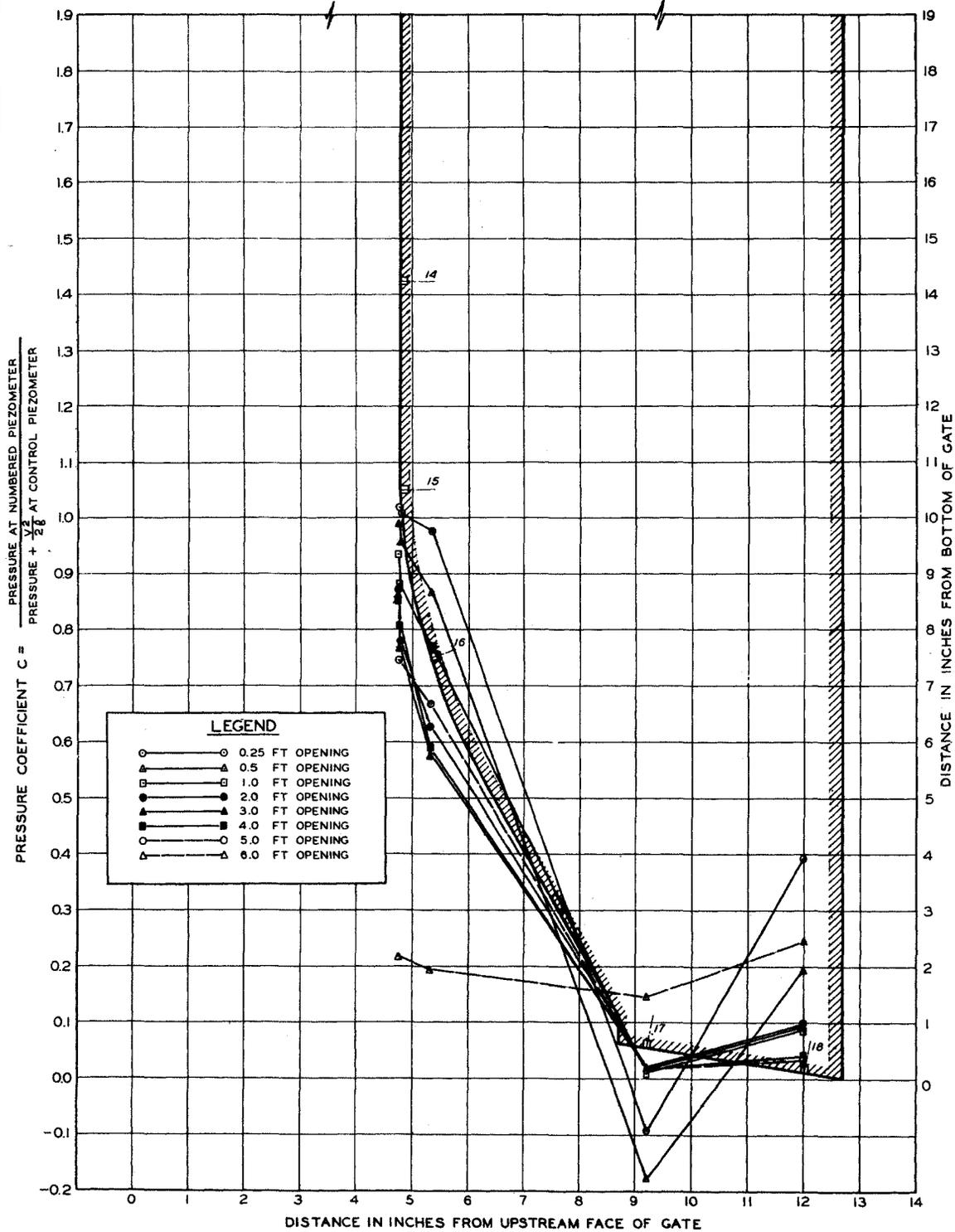
NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

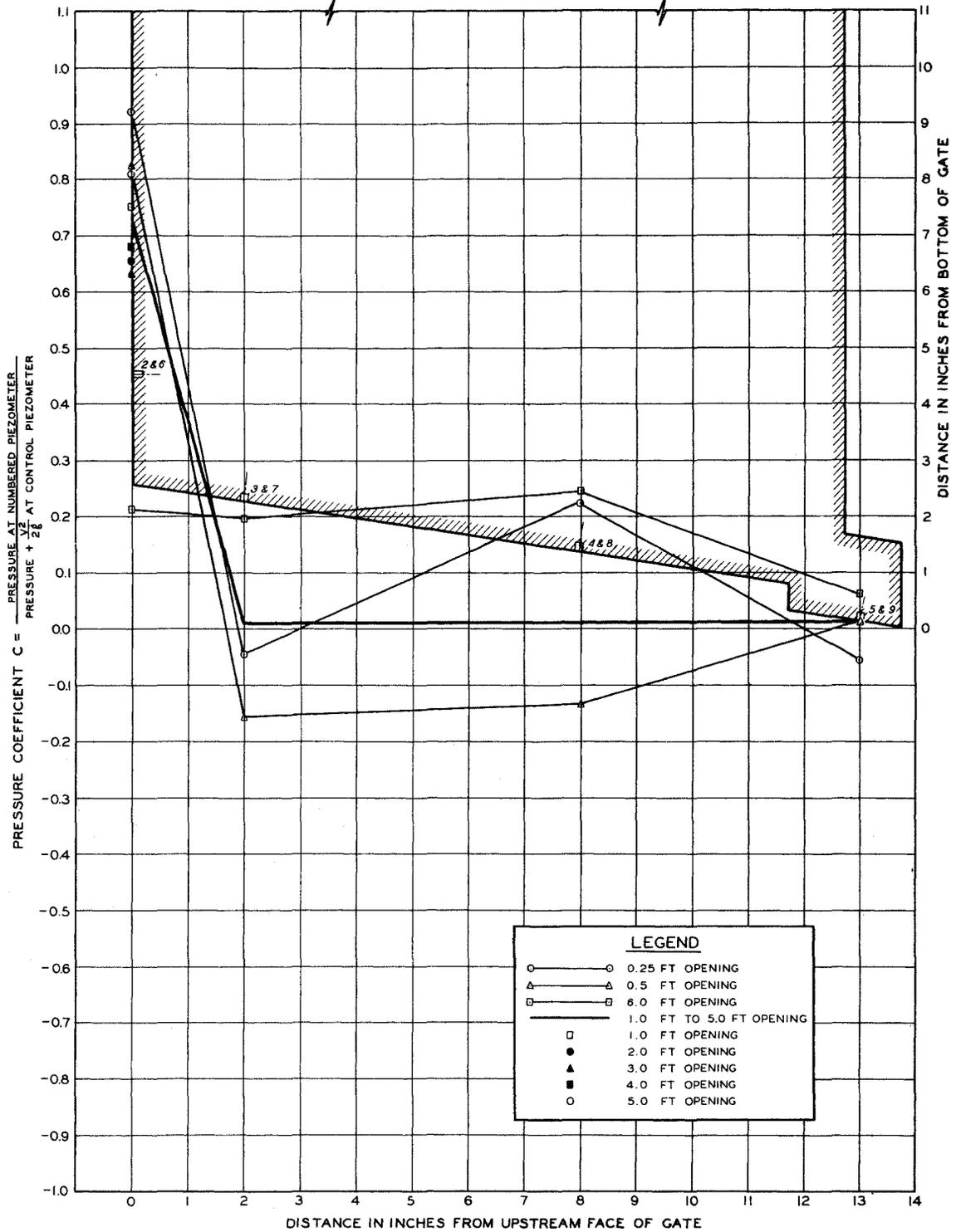
**PRESSURE COEFFICIENTS**  
TYPE B GATE LIP  
SIDE PIEZOMETERS



NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

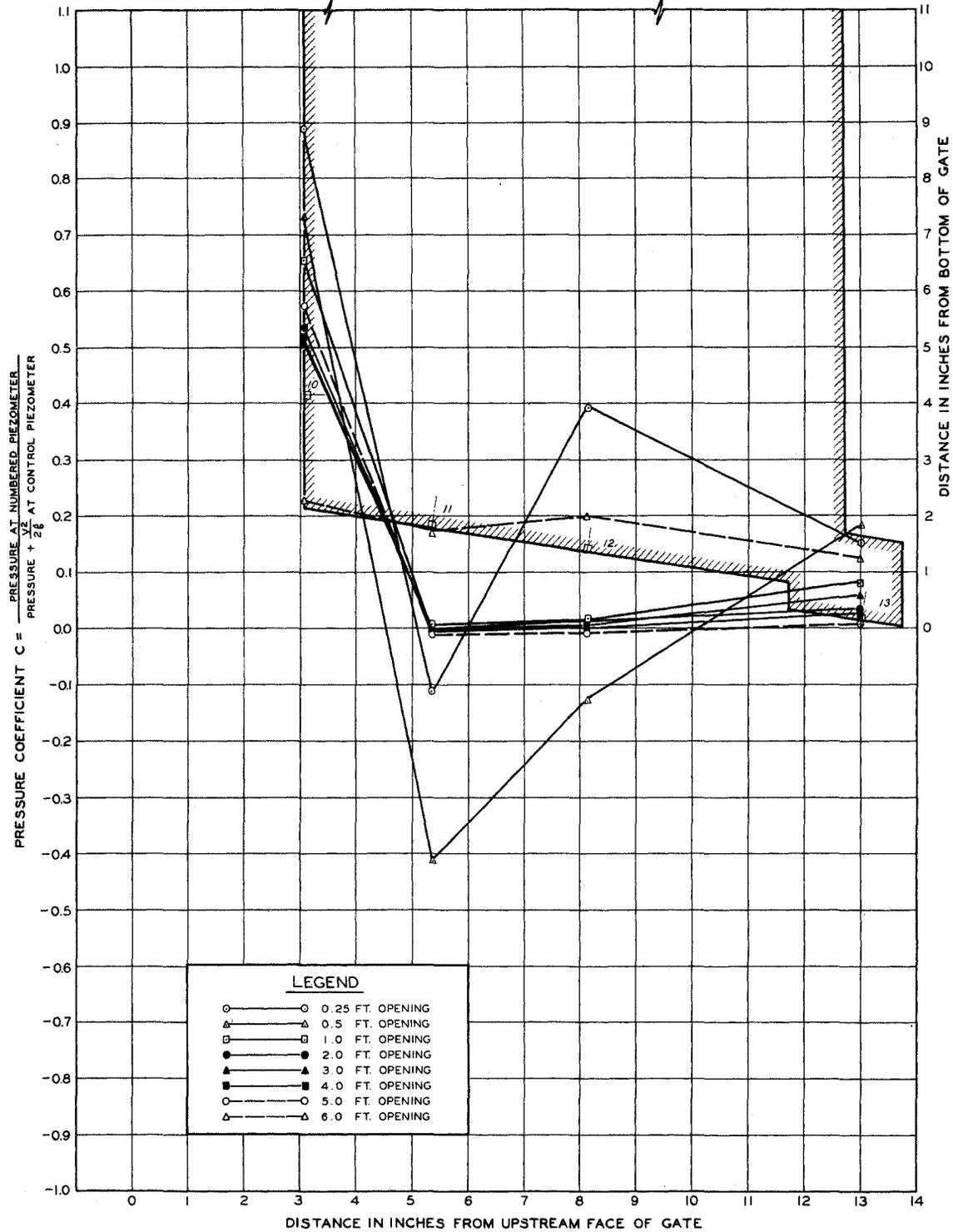
**PRESSURE COEFFICIENTS**  
 TYPE C GATE LIP  
 CENTER PIEZOMETERS





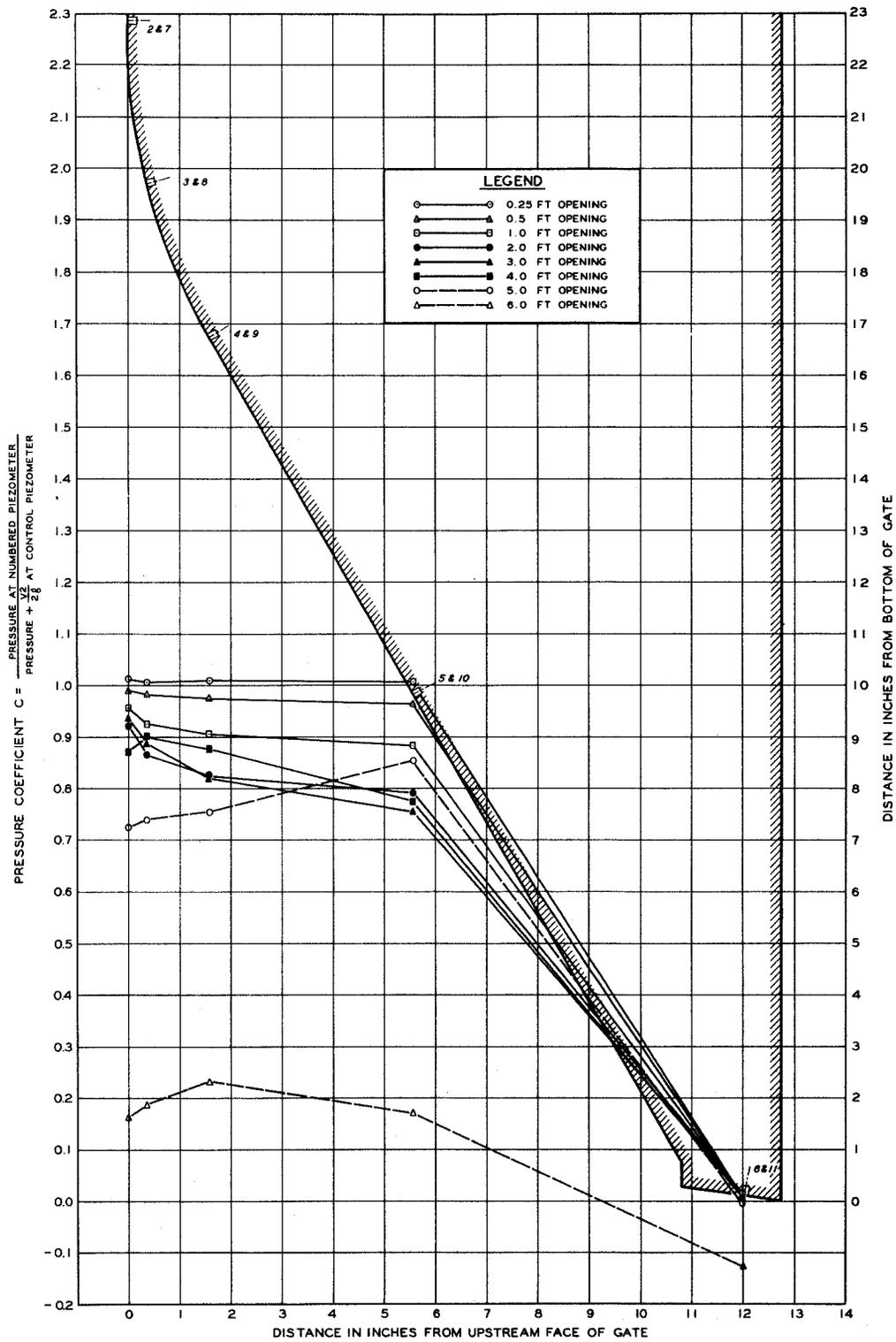
NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

**PRESSURE COEFFICIENTS**  
 TYPE D GATE LIP  
 CENTER PIEZOMETERS

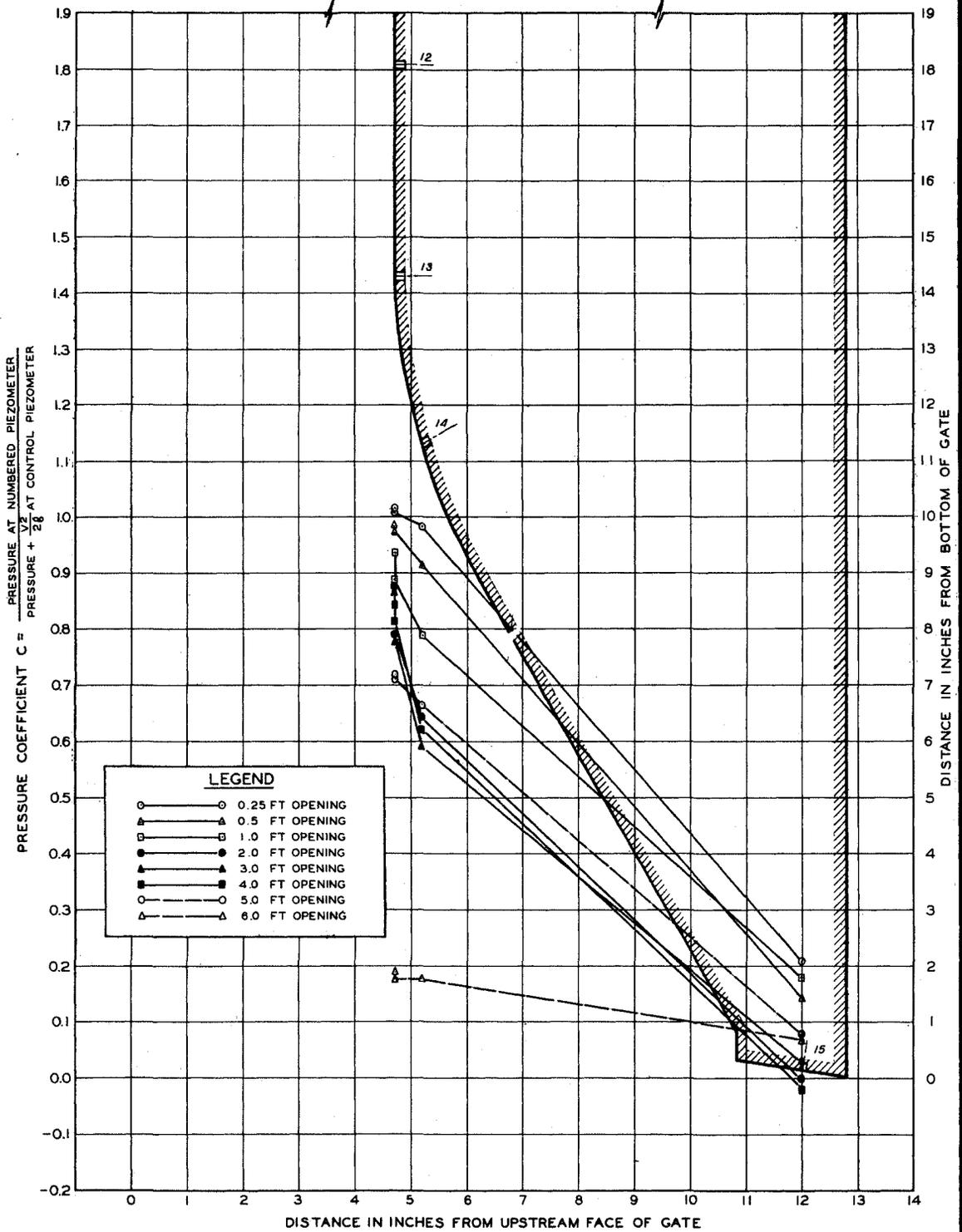


NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

**PRESSURE COEFFICIENTS**  
 TYPE D GATE LIP  
 SIDE PIEZOMETERS

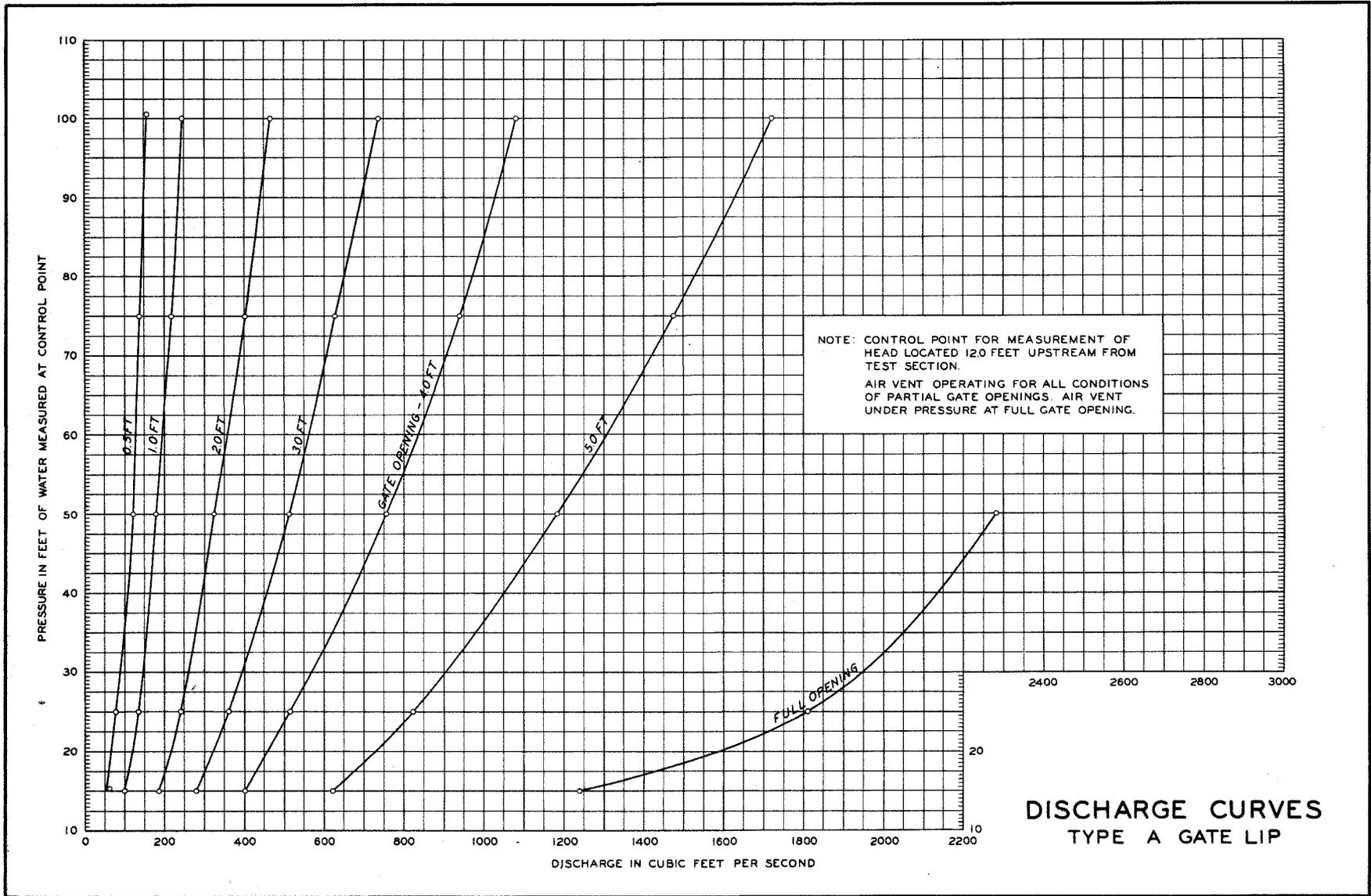


**PRESSURE COEFFICIENTS**  
 TYPE E GATE LIP  
 CENTER PIEZOMETERS

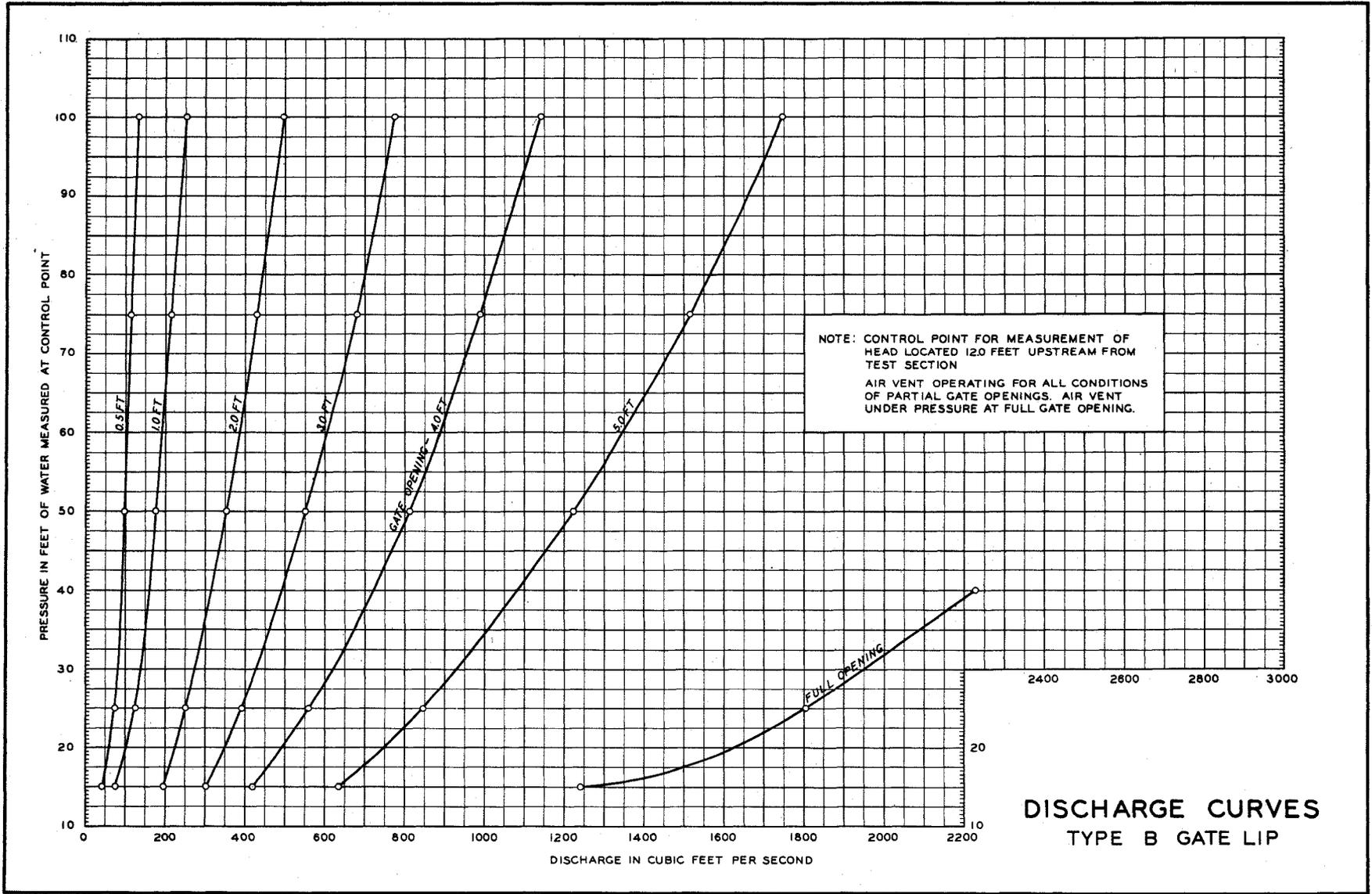


NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

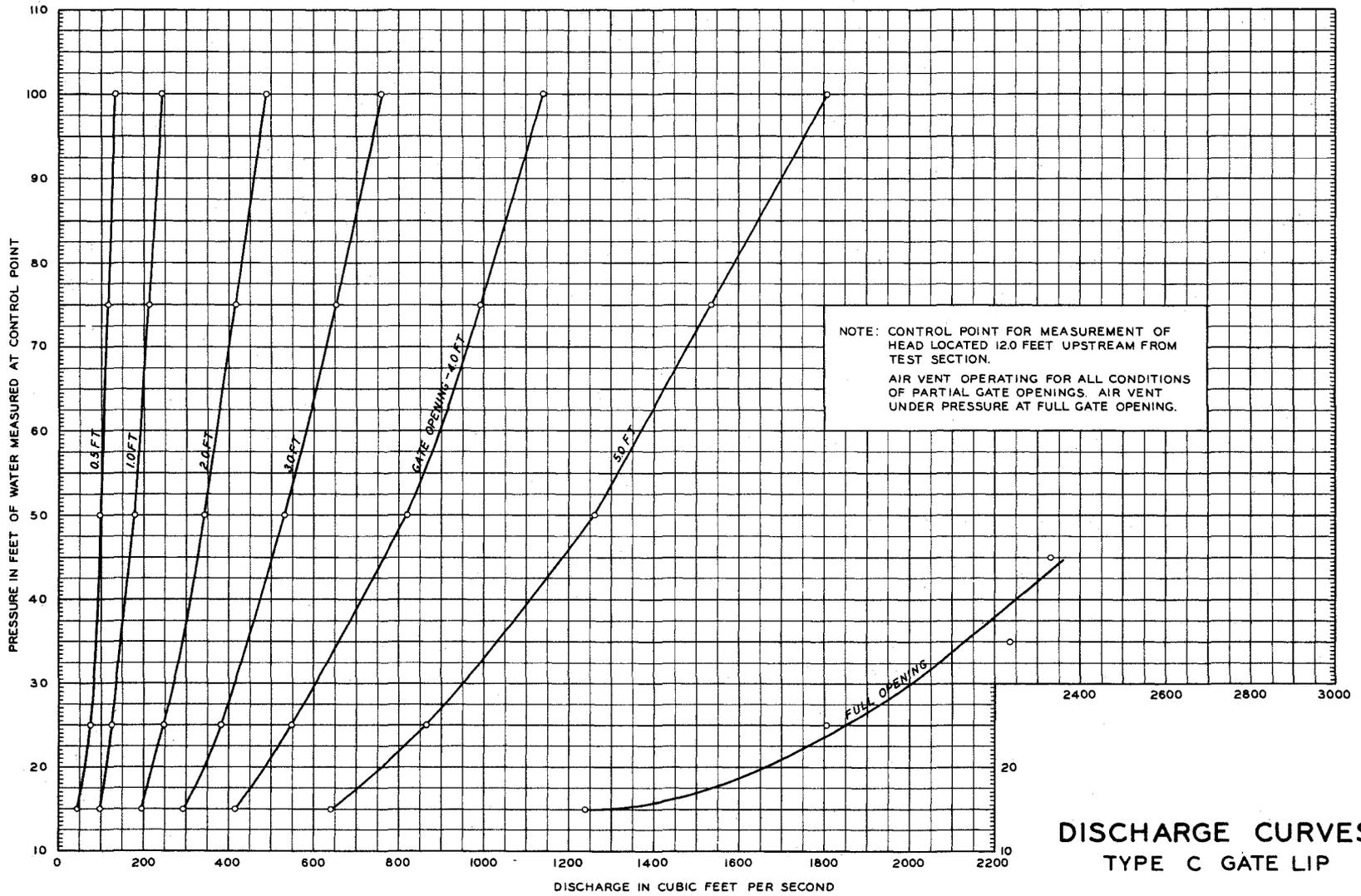
**PRESSURE COEFFICIENTS**  
TYPE E GATE LIP  
SIDE PIEZOMETERS



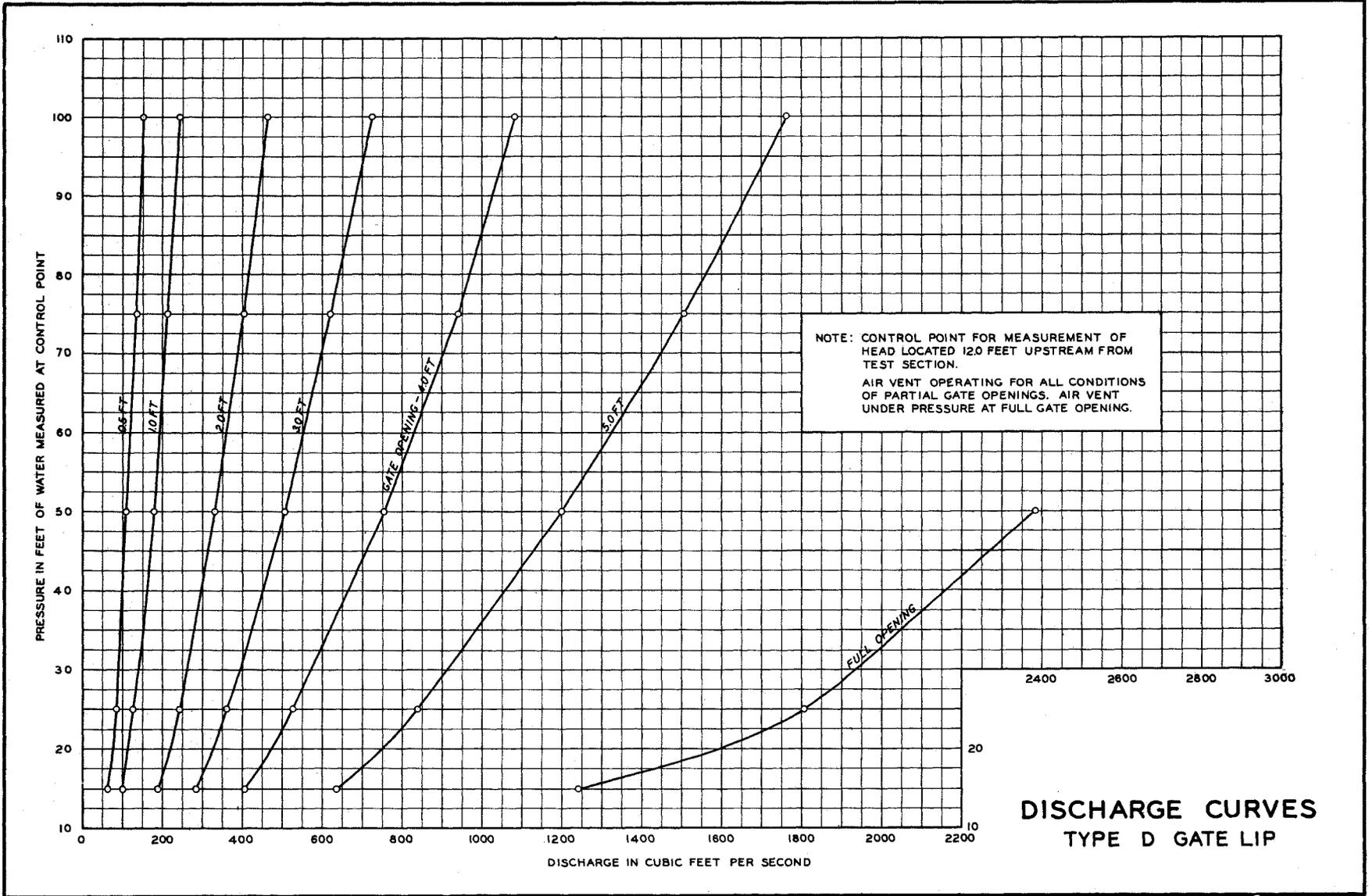
DISCHARGE CURVES  
 TYPE A GATE LIP



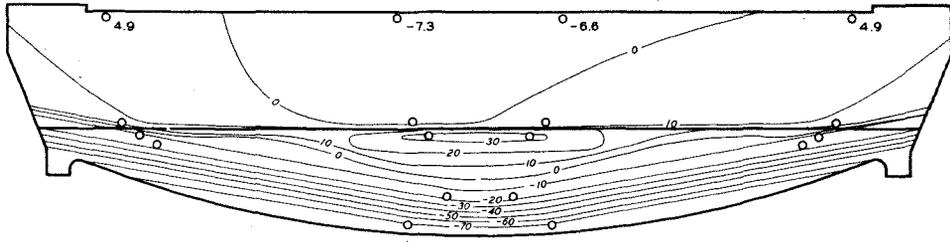
DISCHARGE CURVES  
 TYPE B GATE LIP



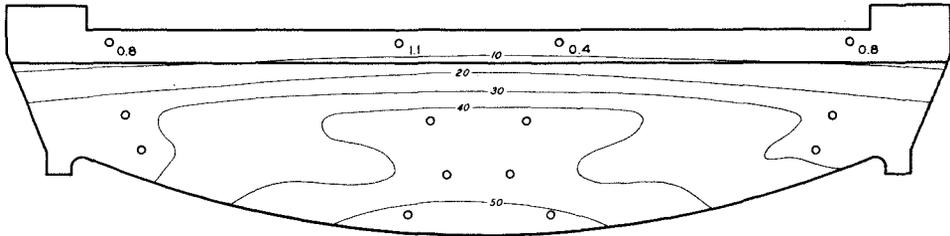
DISCHARGE CURVES  
TYPE C GATE LIP



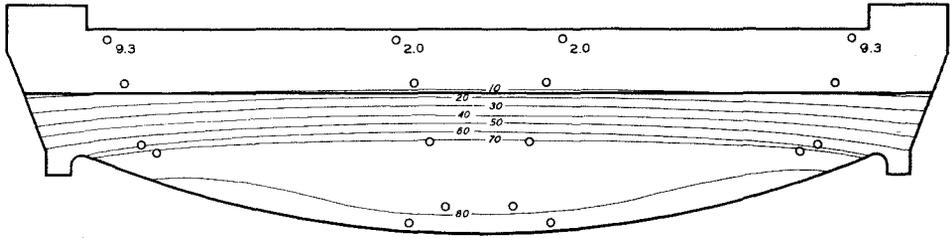
DISCHARGE CURVES  
TYPE D GATE LIP



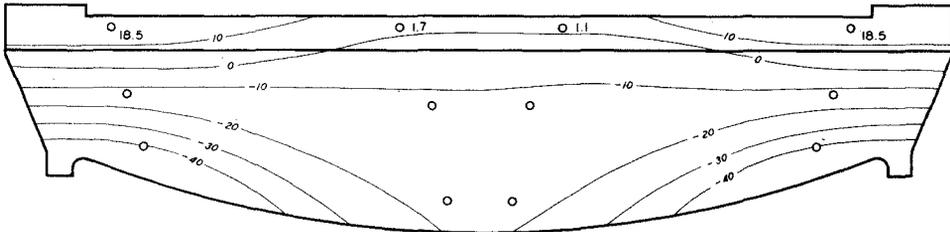
TYPE A  
0.5 FT GATE OPENING



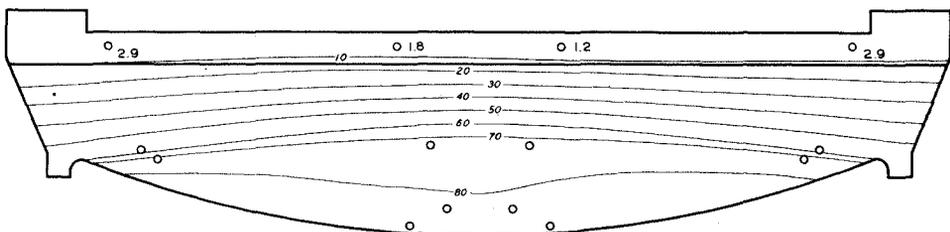
TYPE B  
3.0 FT GATE OPENING



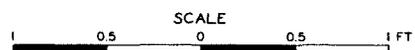
TYPE C  
3.0 FT GATE OPENING



TYPE D  
0.5 FT GATE OPENING

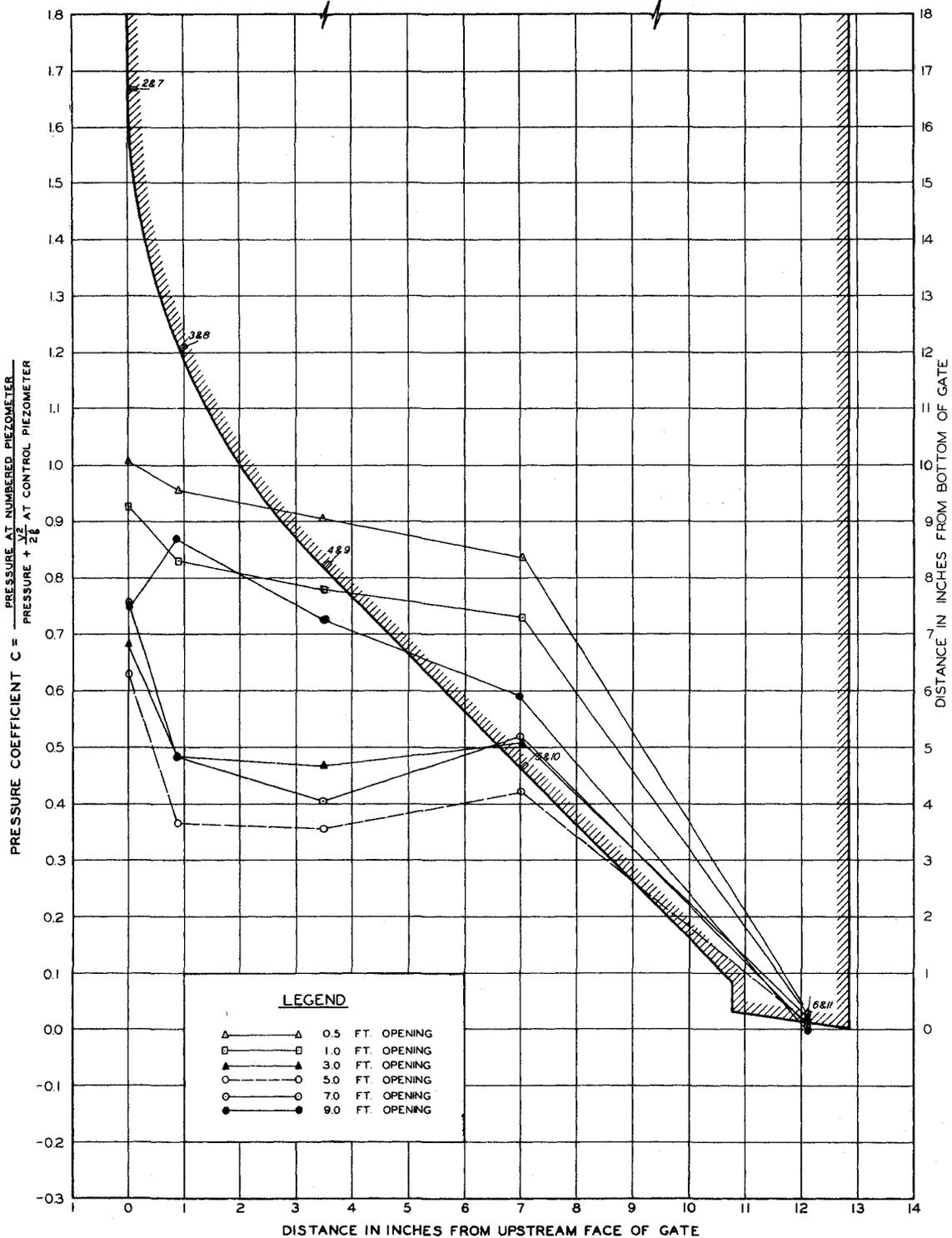


TYPE E  
3.0 FT GATE OPENING



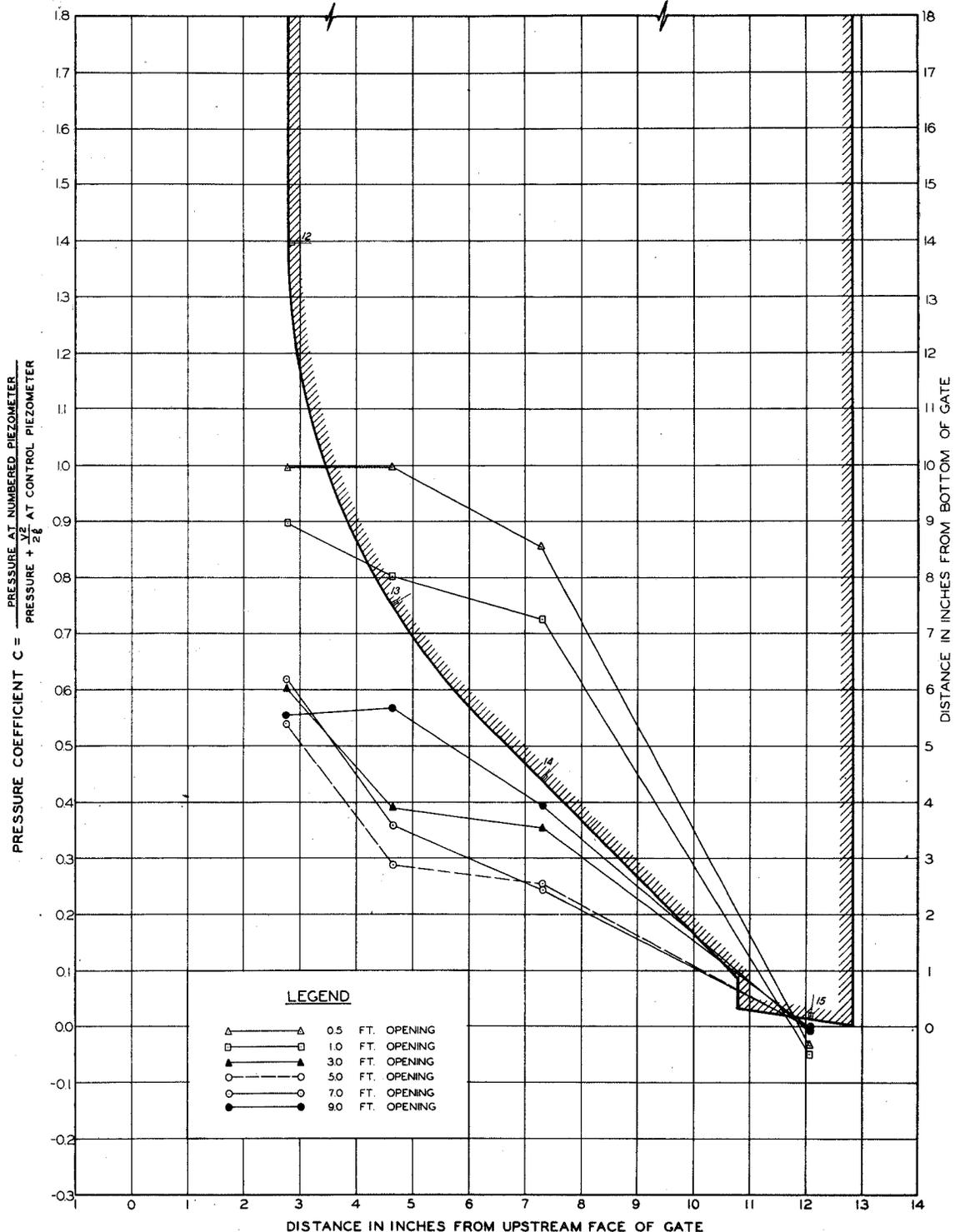
NOTES:  
VIEWS SHOWN ARE HORIZONTAL PROJECTIONS OF GATE LIP BOTTOMS. CONTOURS REPRESENT PRESSURES IN PROTOTYPE FEET OF WATER. HEAD ON SLUICE = 100 FT. GATE OPENINGS ARE THOSE AT WHICH MINIMUM PRESSURES WERE MEASURED.

GATE LIP PRESSURE CONTOURS

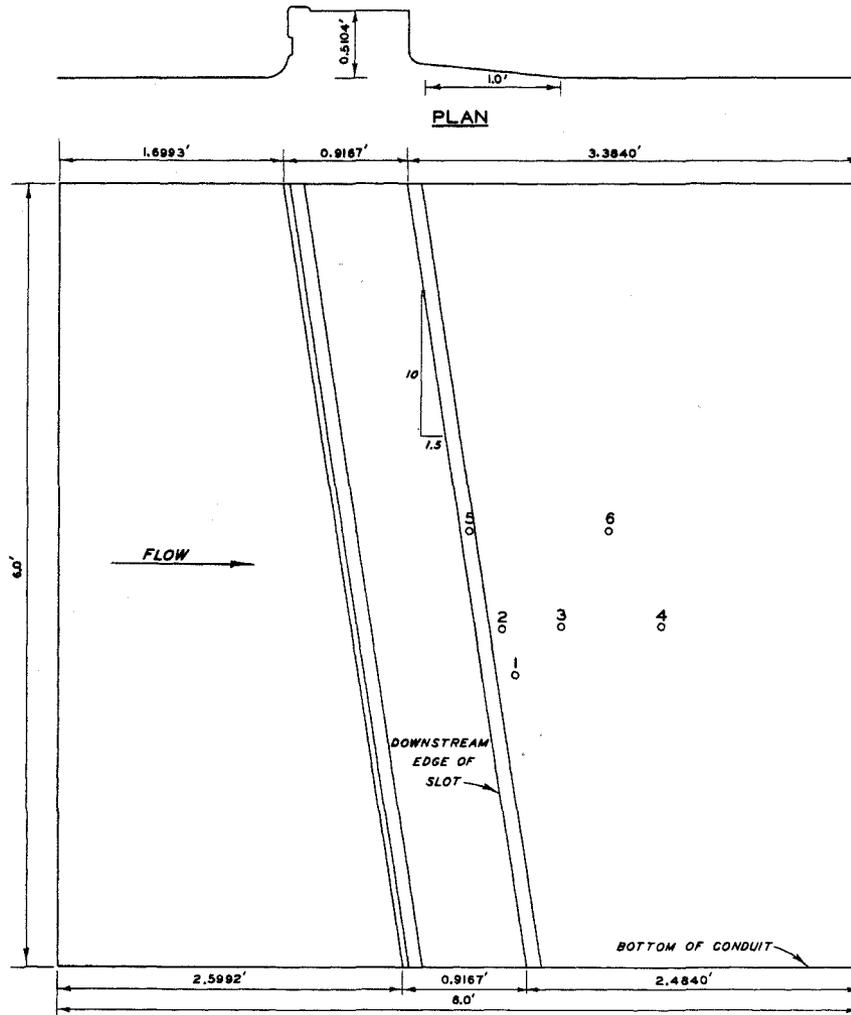


NOTE: GATE LIP PROFILE AND LOCATION OF PIEZOMETERS SHOWN FOR REFERENCE PURPOSES.

**PRESSURE COEFFICIENTS**  
 TYPE F GATE LIP  
 CENTER PIEZOMETERS



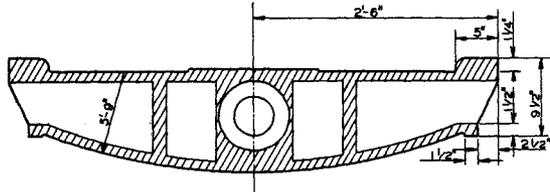
**PRESSURE COEFFICIENTS**  
 TYPE F GATE LIP  
 SIDE PIEZOMETERS



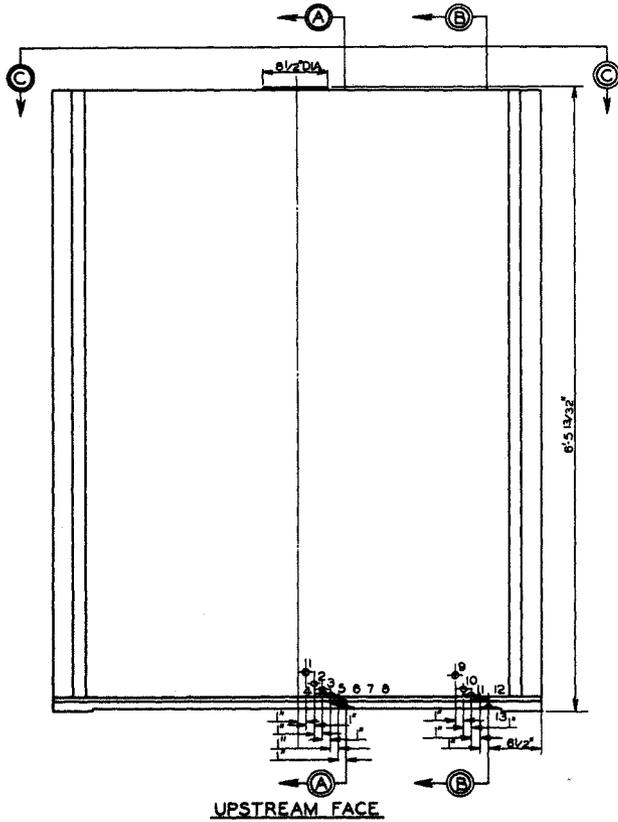
PIEZOMETER NUMBER	HORIZONTAL DISTANCE FROM DOWNSTREAM EDGE OF SLOT PROTOTYPE FT	VERTICAL DISTANCE FROM BOTTOM OF CONDUIT PROTOTYPE FT
1	0.256	2.232
2	0.198	2.604
3	0.642	2.610
4	1.398	2.610
5	0.066	3.348
6	1.128	3.348

CONDUIT SIDE  
PIEZOMETER LOCATIONS

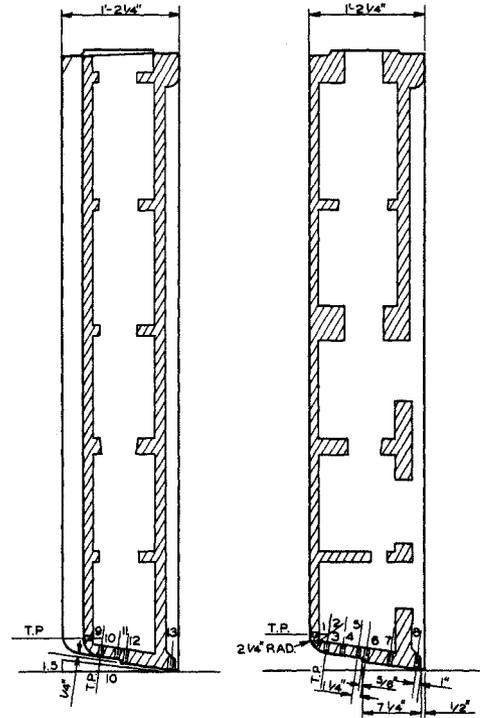




SECTION C-C

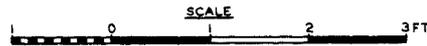


UPSTREAM FACE



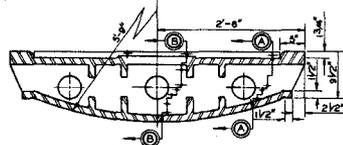
SECTION B-B

SECTION A-A

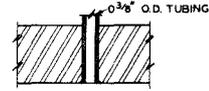


PROTOTYPE STUDY OF SLIDE GATES

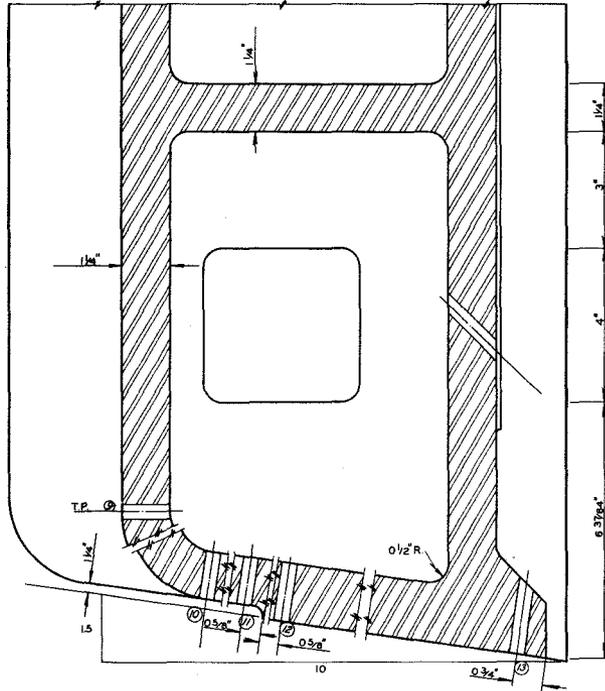
DETAILS OF TYPE A GATE  
AND PIEZOMETER LOCATIONS



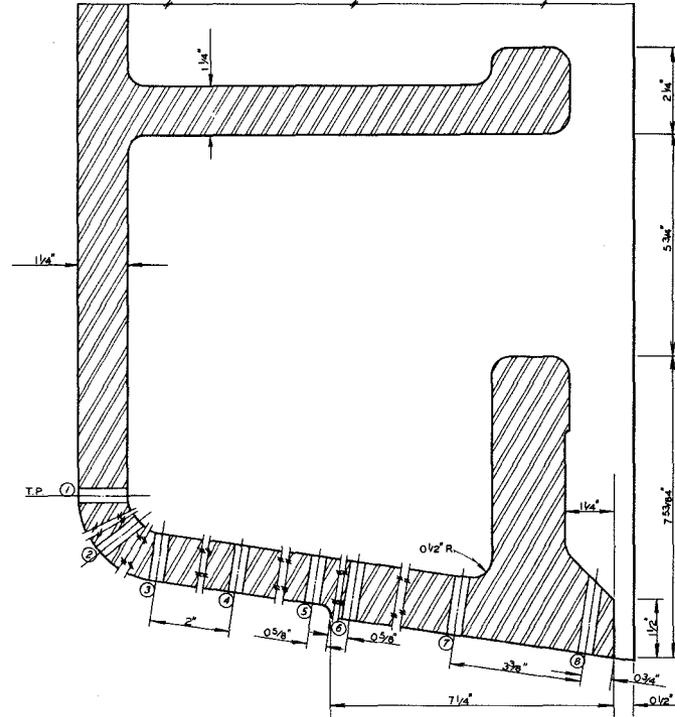
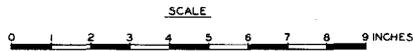
SECTION THROUGH GATE



DETAILS AT PIEZOMETER ORFICE



SECTION A-A



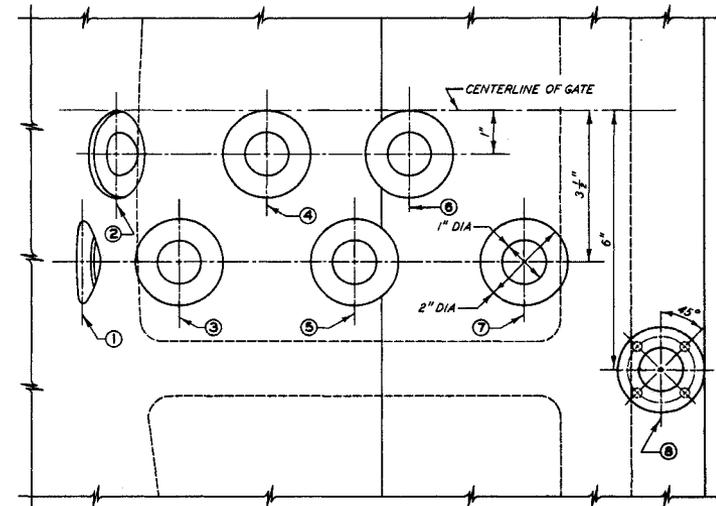
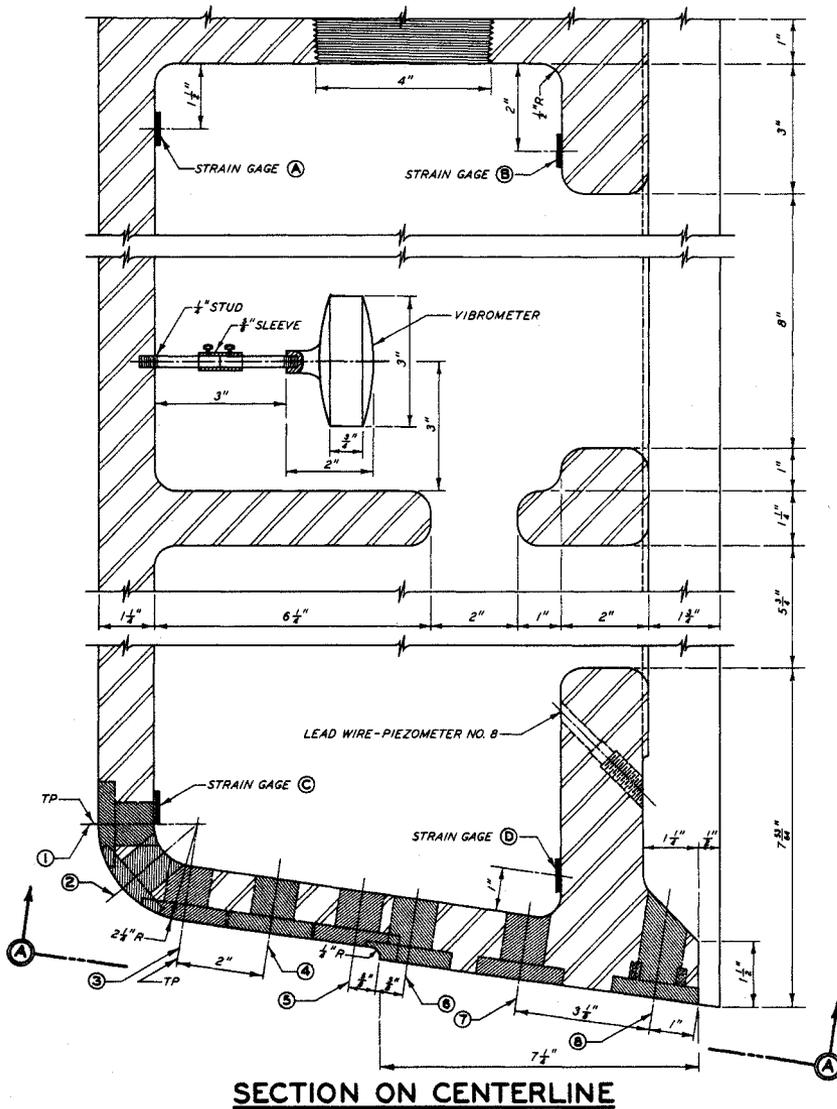
SECTION B-B

PROTOTYPE STUDY OF SLIDE GATES

PIEZOMETER LOCATIONS  
TYPE A GATE



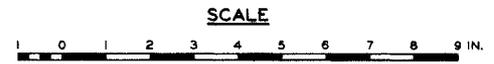


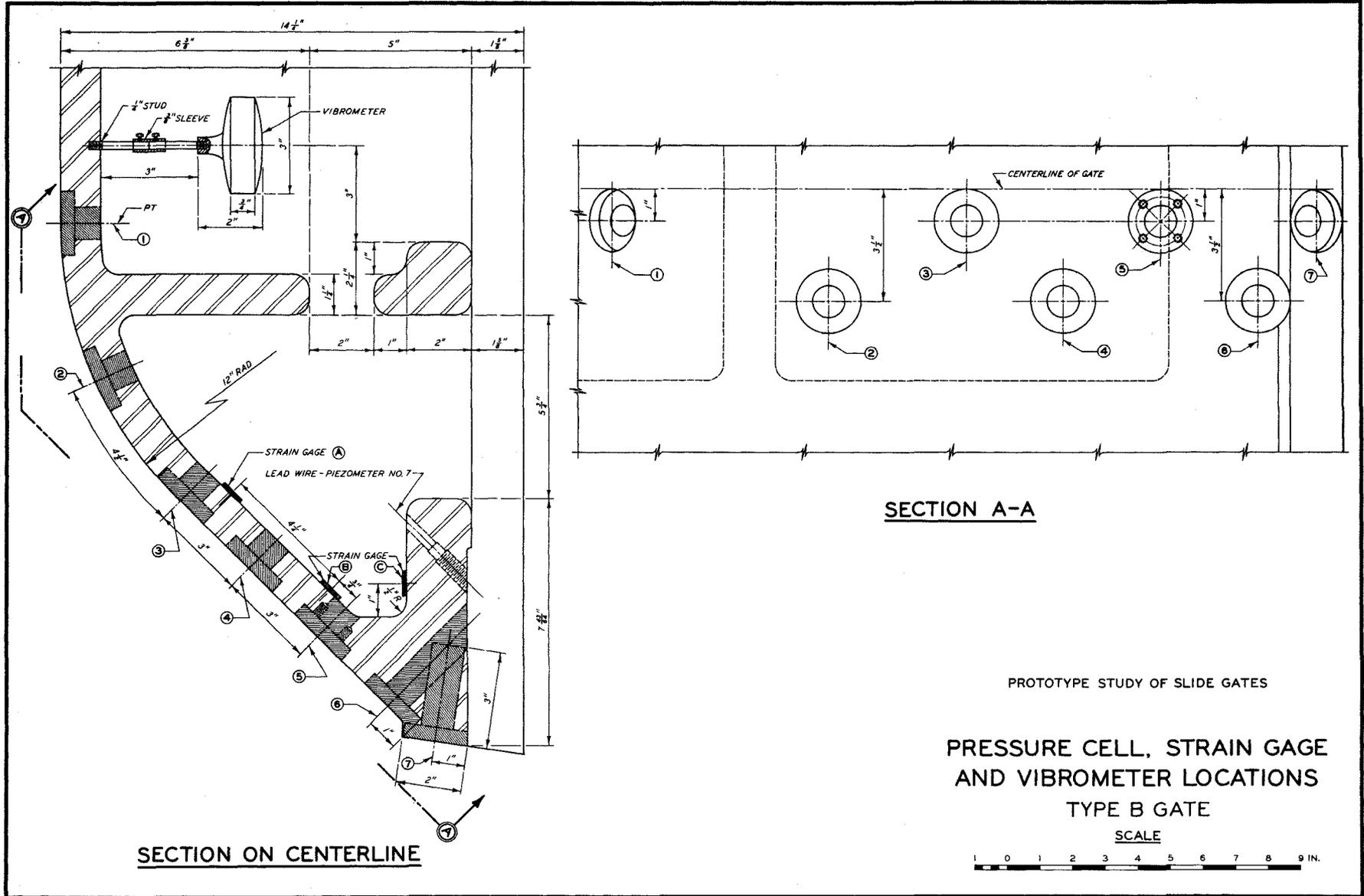


**SECTION A-A**

PROTOTYPE STUDY OF SLIDE GATES

**PRESSURE CELL, STRAIN GAGE  
AND VIBROMETER LOCATIONS  
TYPE A GATE**





SECTION ON CENTERLINE

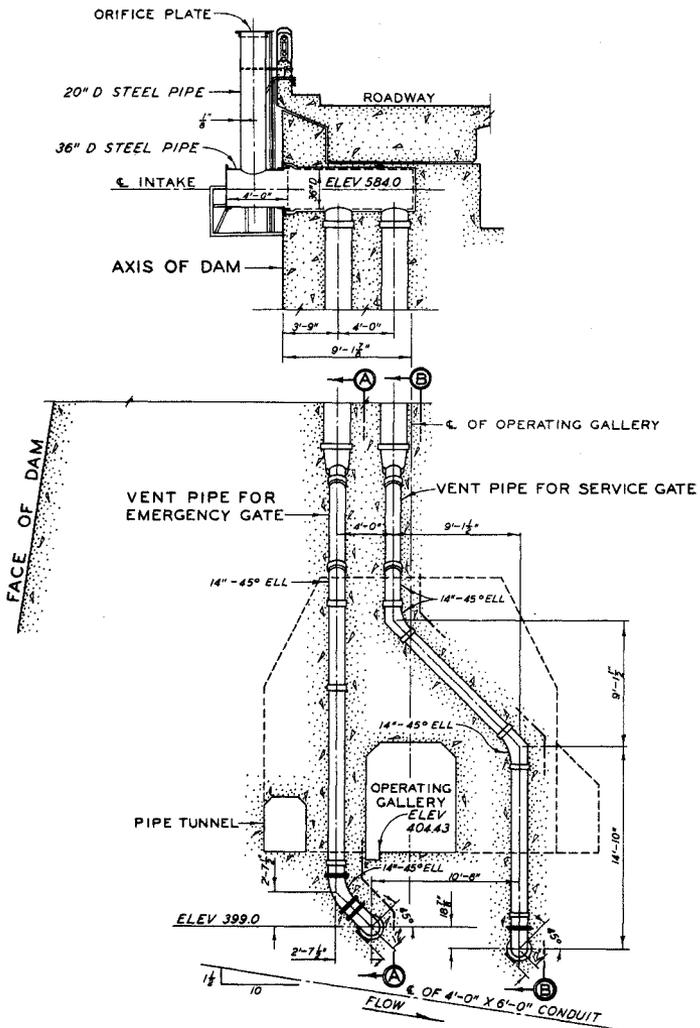
SECTION A-A

PROTOTYPE STUDY OF SLIDE GATES

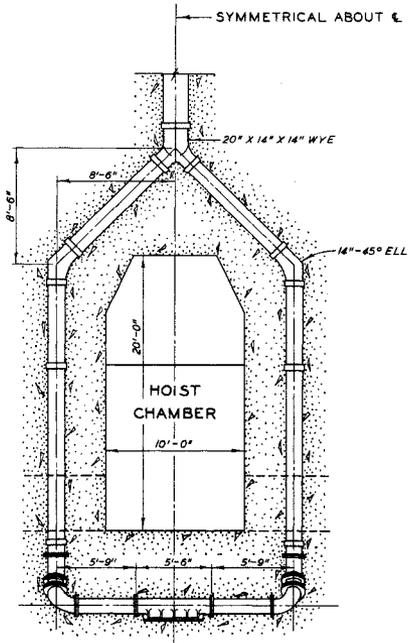
PRESSURE CELL, STRAIN GAGE  
AND VIBROMETER LOCATIONS  
TYPE B GATE

SCALE

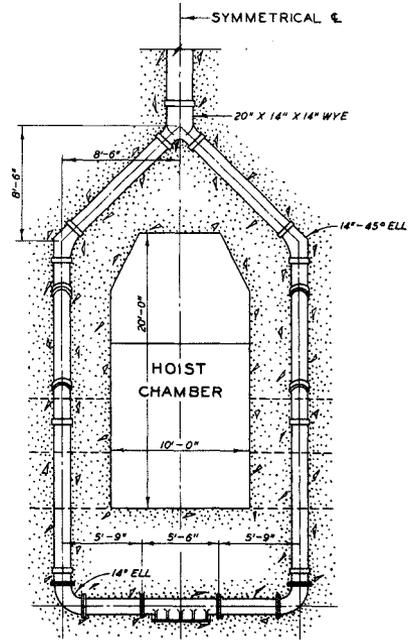




SECTIONAL ELEVATION



SECTION A-A

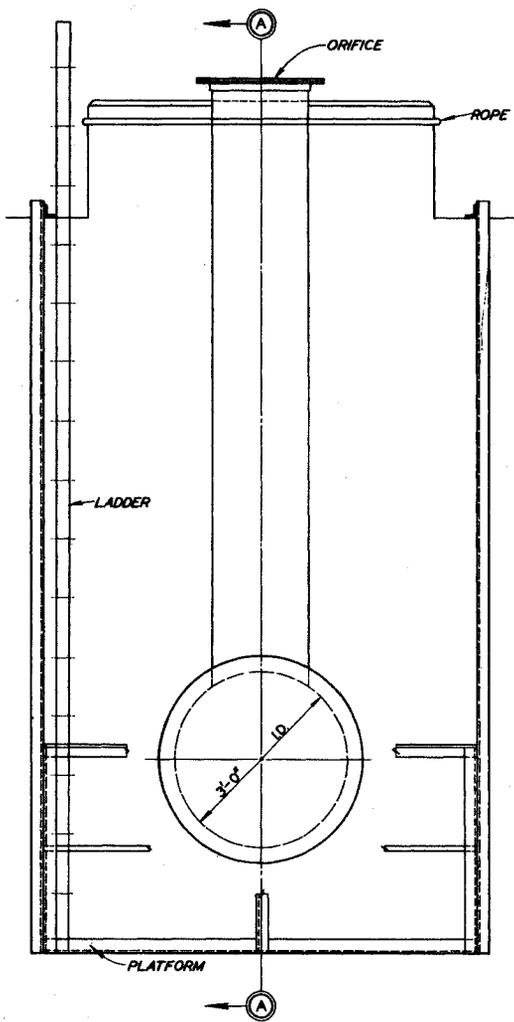


SECTION B-B

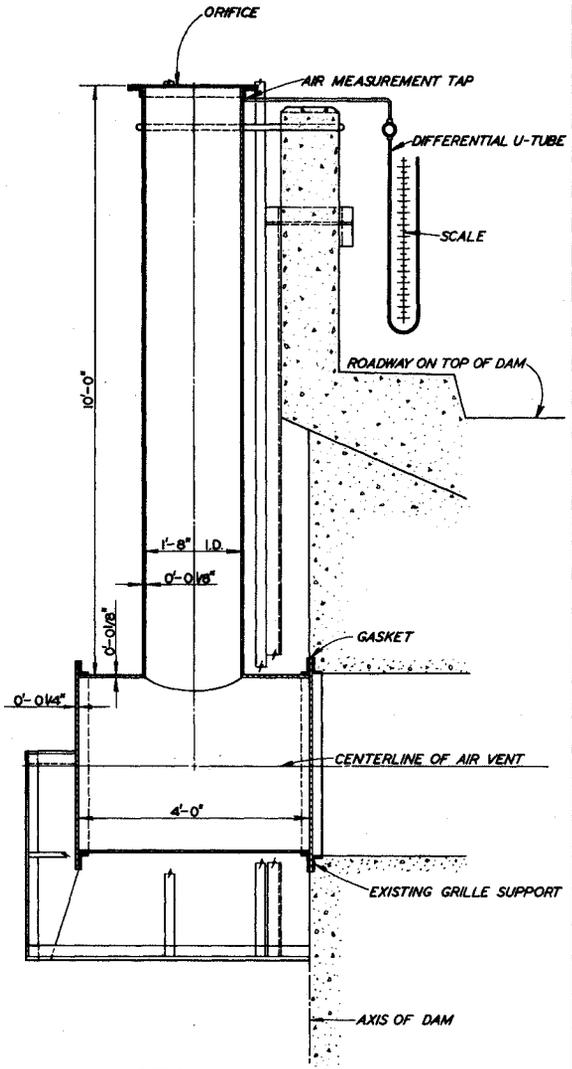


PROTOTYPE STUDY OF SLIDE GATES

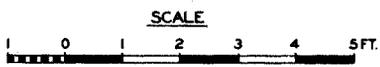
DETAILS OF AIR VENT



UPSTREAM ELEVATION

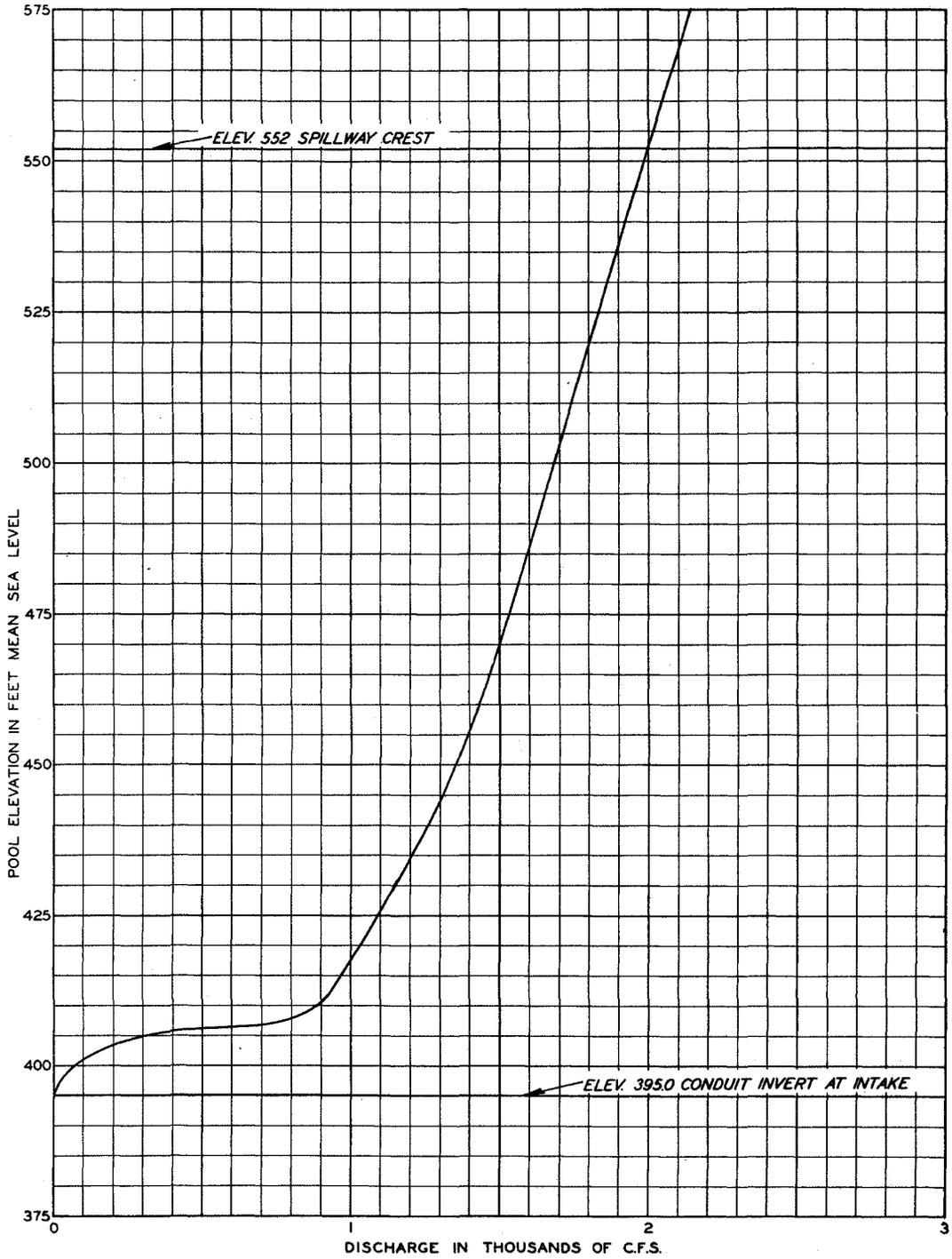


SECTION A-A



PROTOTYPE STUDY OF SLIDE GATES

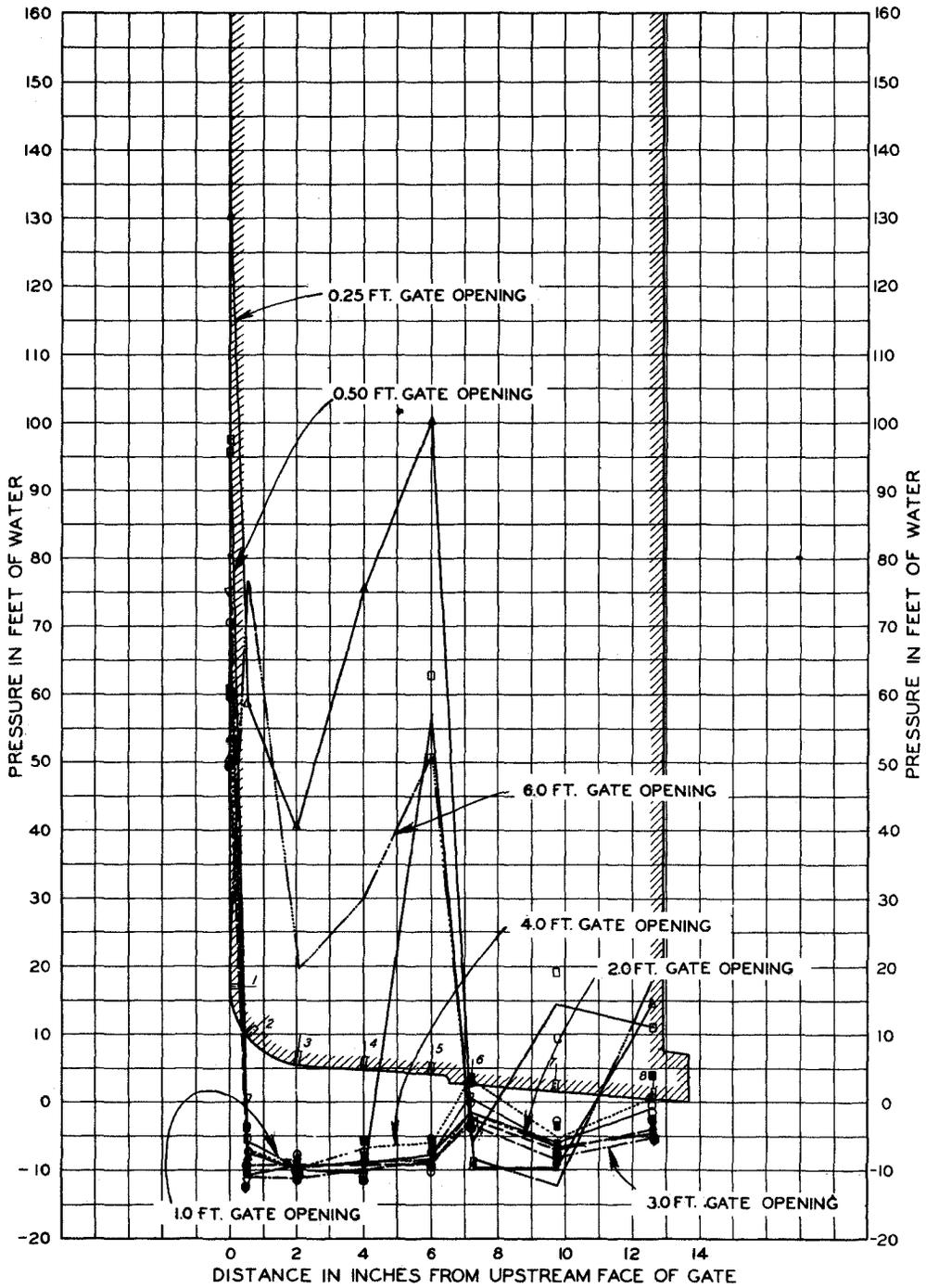
DETAILS OF AIR VENT EXTENSION



NOTE: DISCHARGE CURVE AS SHOWN  
 COMPUTED FOR ONE 4 X 6 FT. CONDUIT.

PROTOTYPE STUDY OF SLIDE GATES

**DISCHARGE CURVE  
 GATE FULL OPEN**

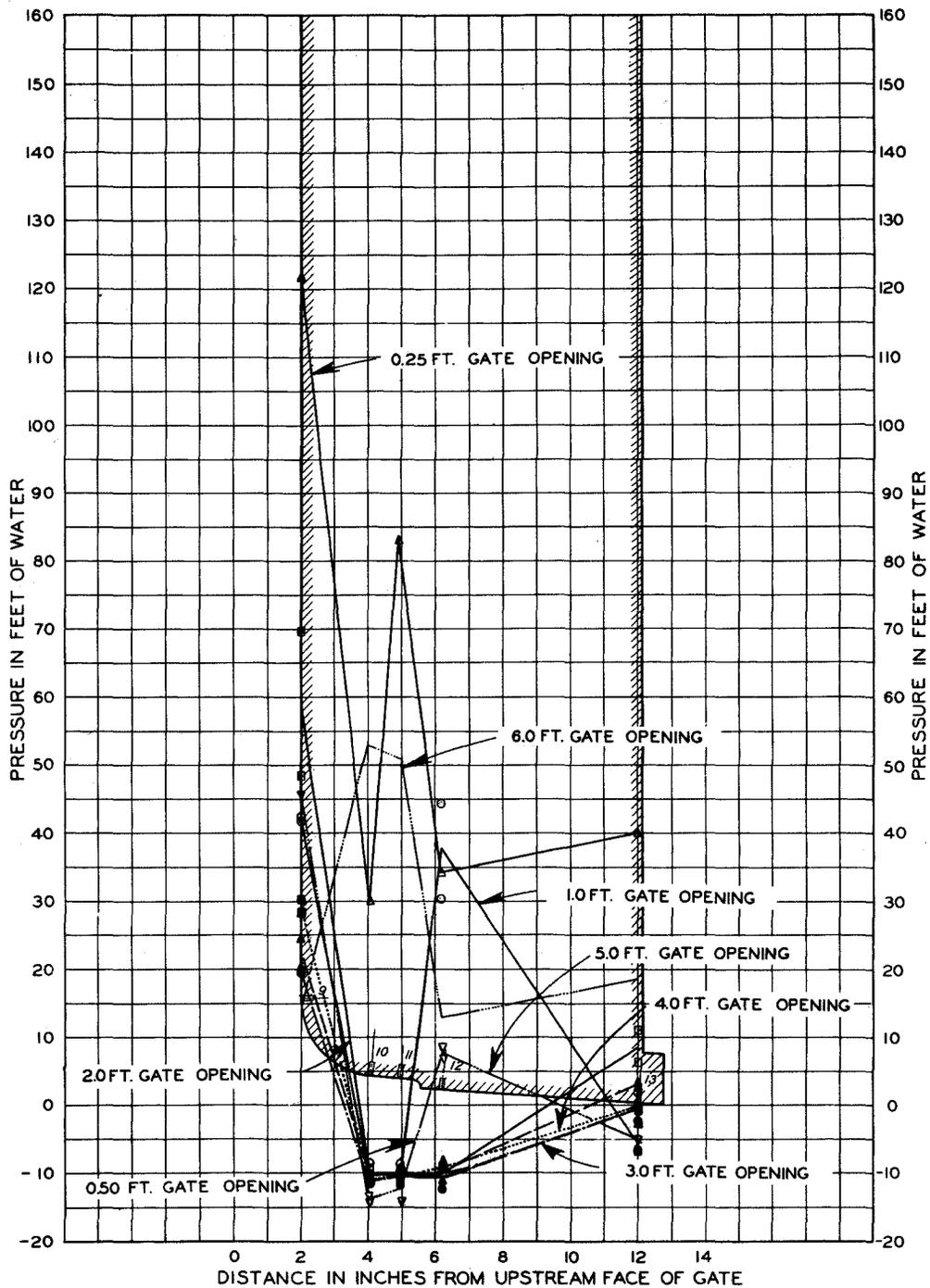


NOTE: OUTLINE OF GATE SHOWN FOR REFERENCE PURPOSES ONLY.

AIR VENT OPEN FULL.

PROTOTYPE STUDY OF SLIDE GATES

**PRESSURES ON CENTERLINE OF GATE LIP  
TYPE A GATE**

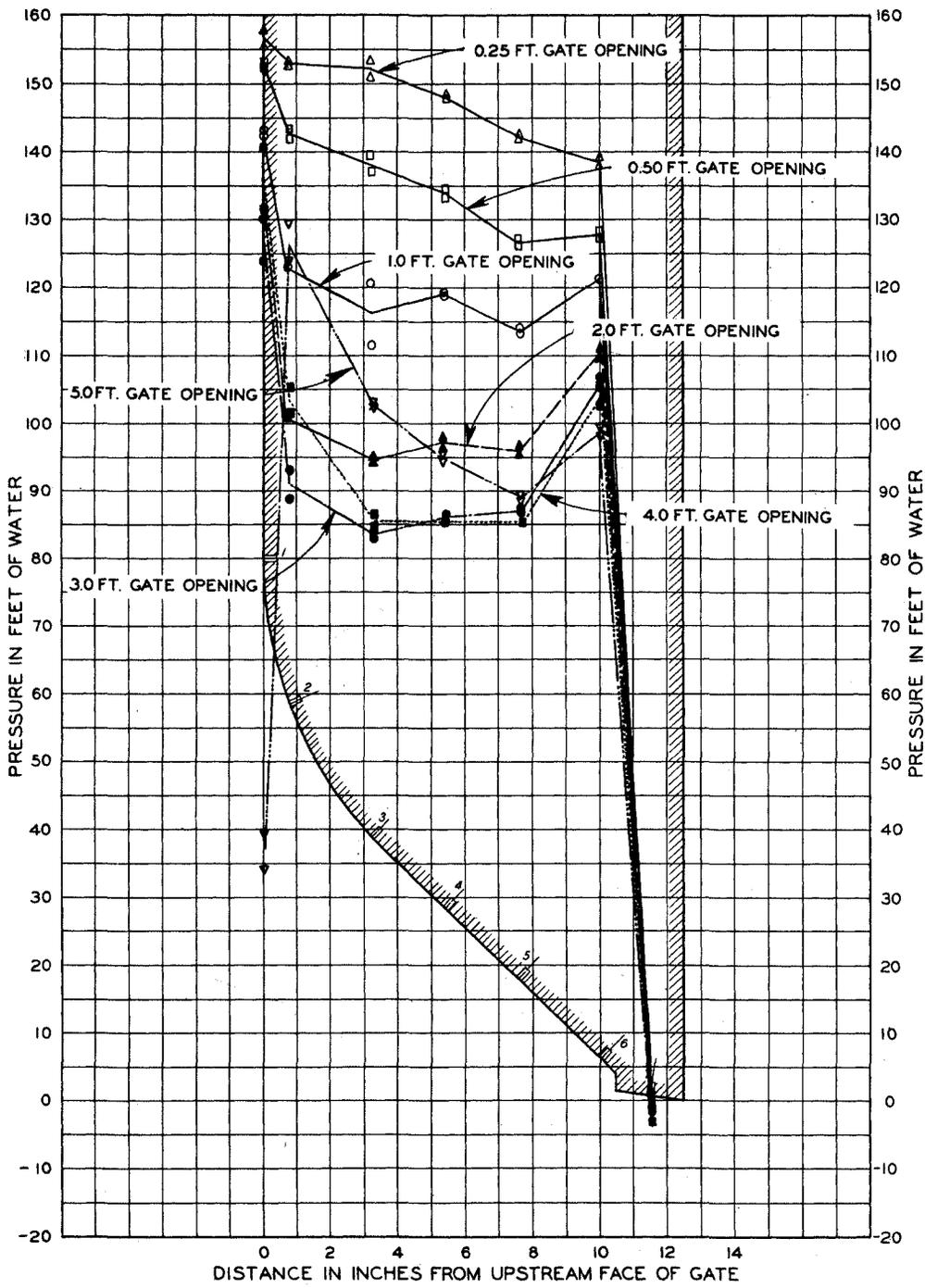


NOTE: OUTLINE OF GATE SHOWN FOR REFERENCE PURPOSES ONLY.

AIR VENT OPEN FULL

PROTOTYPE STUDY OF SLIDE GATES

**PRESSURES ON SIDE OF GATE LIP  
TYPE A GATE**

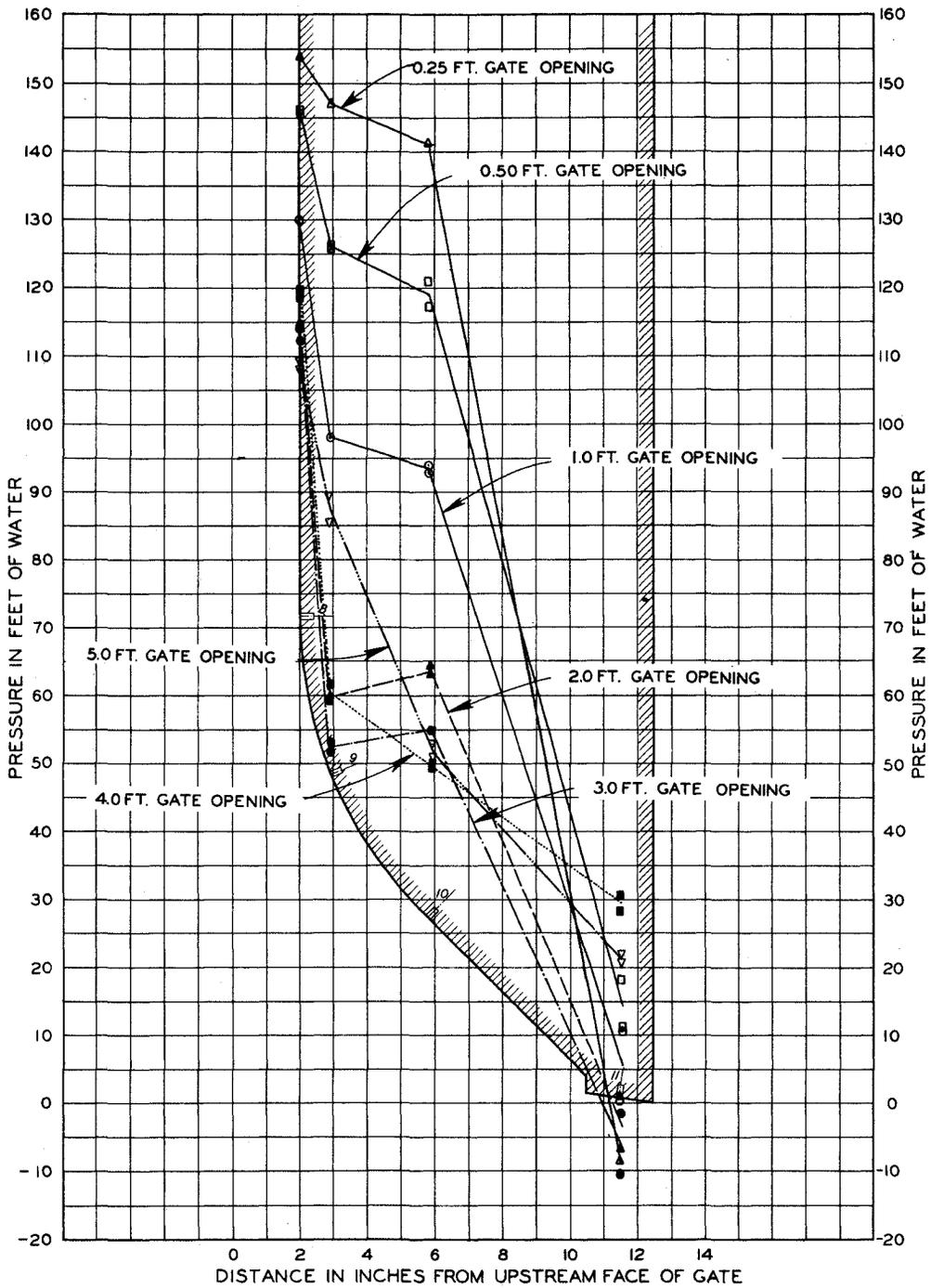


NOTE: OUTLINE OF GATE SHOWN FOR REFERENCE PURPOSES ONLY.

AIR VENT OPEN FULL.

PROTOTYPE STUDY OF SLIDE GATES

**PRESSURES ON CENTERLINE OF GATE LIP  
TYPE B GATE**

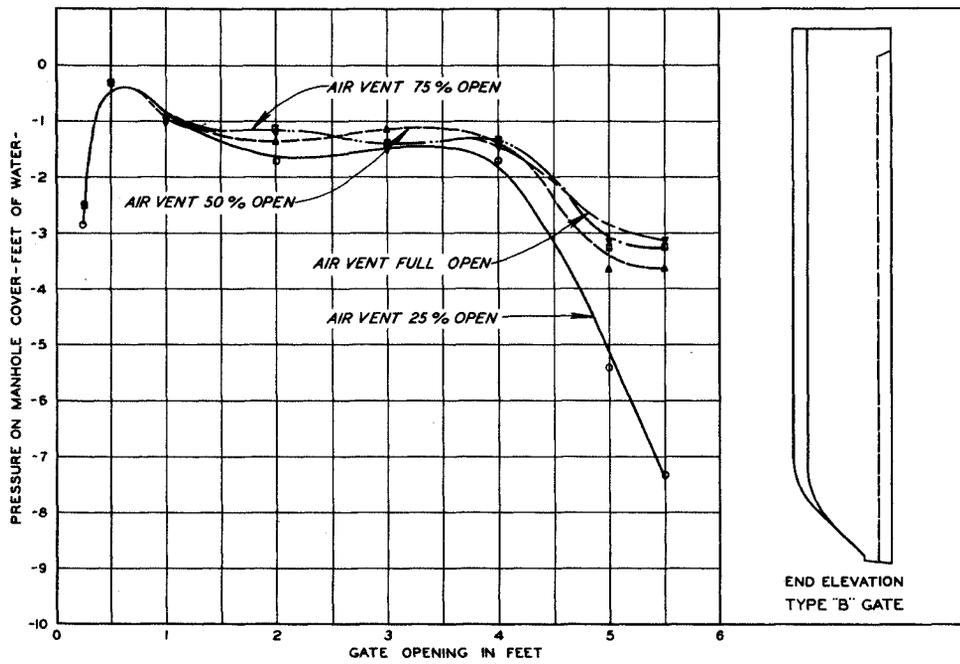
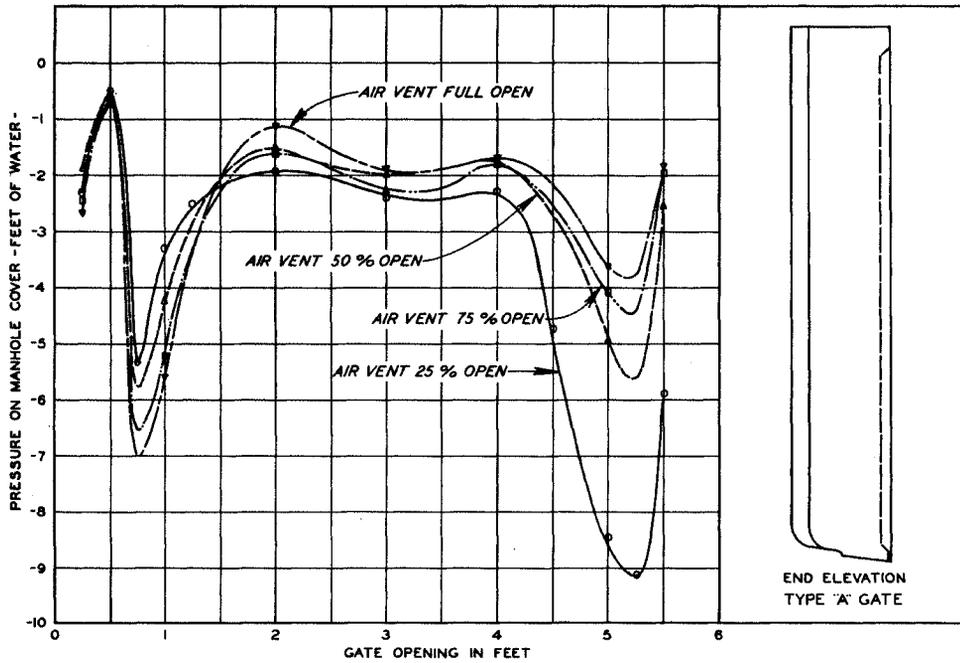


NOTE: OUTLINE OF GATE SHOWN FOR REFERENCE PURPOSES ONLY.

AIR VENT OPEN FULL.

PROTOTYPE STUDY OF SLIDE GATES

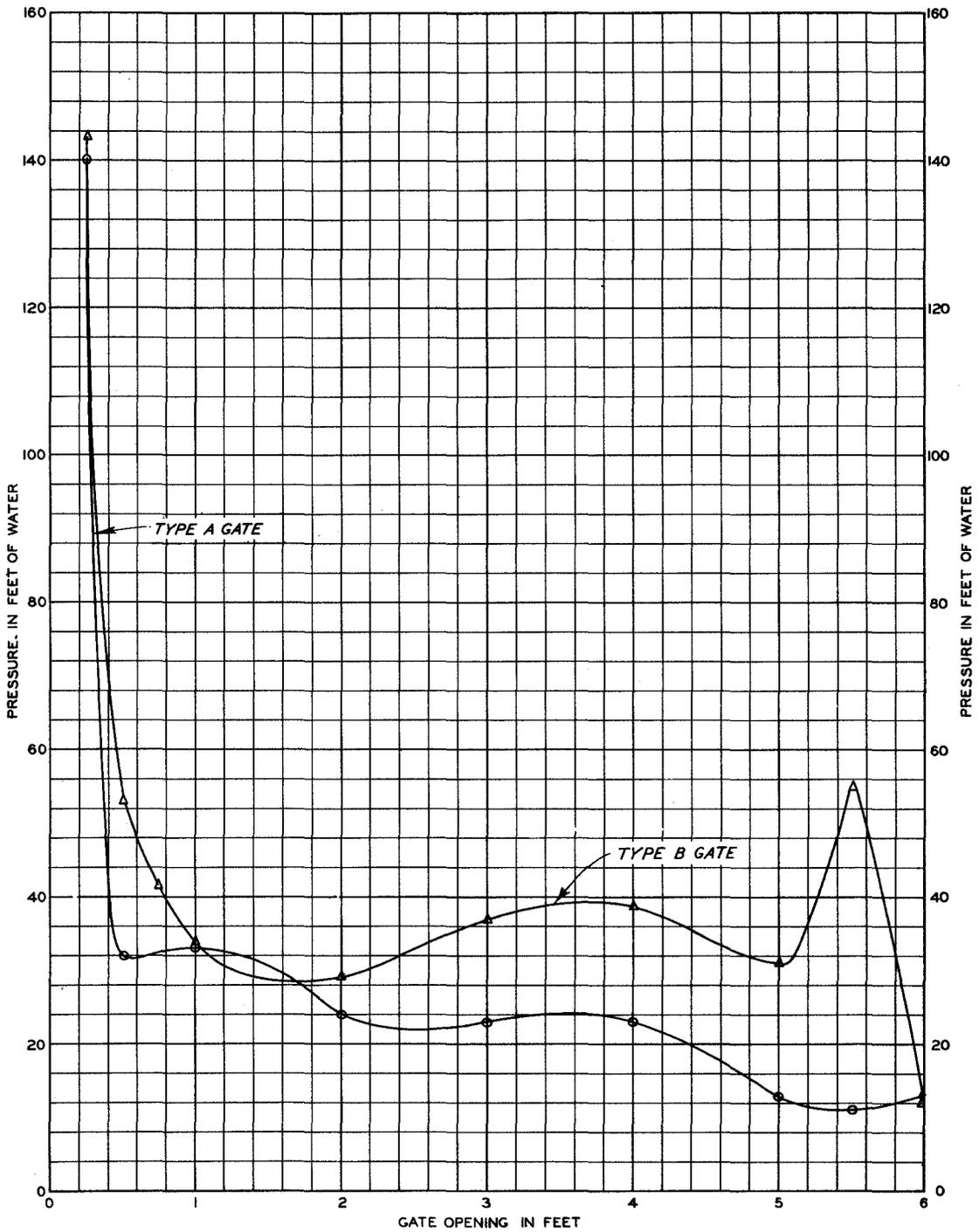
**PRESSURES ON SIDE OF GATE LIP  
TYPE B GATE**



NOTE: LOCATION OF PIEZOMETER WHERE MANHOLE PRESSURES WERE MEASURED SHOWN ON PLATE 2.

PROTOTYPE STUDY OF SLIDE GATES

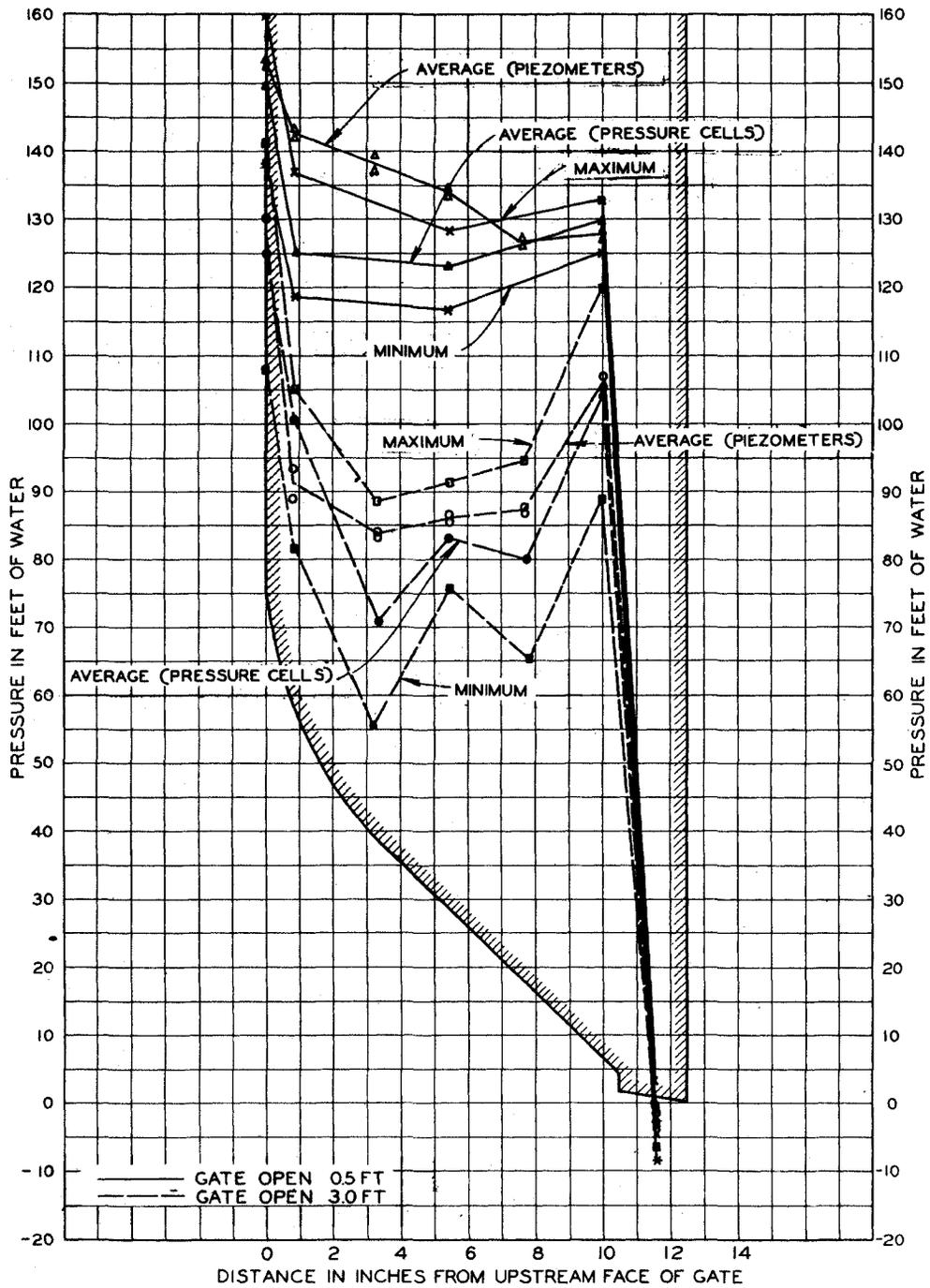
EFFECT OF AIR VENT OPENING ON PRESSURES IN CONDUIT



NOTE: AIR VENT UNRESTRICTED.

PROTOTYPE STUDY OF SLIDE GATES

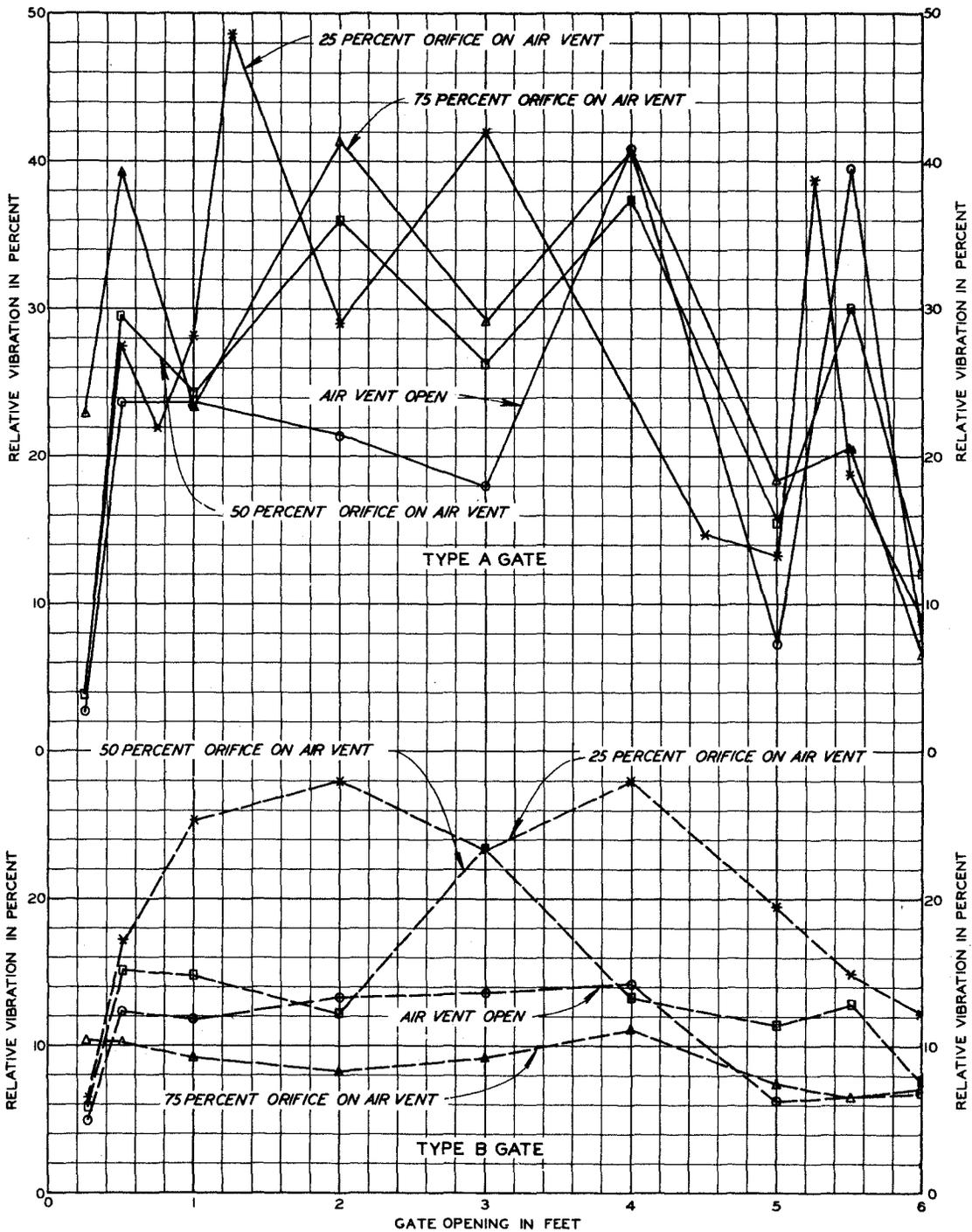
**BONNET PRESSURES**  
 TYPES A AND B GATES



NOTE: OUTLINE OF GATE SHOWN FOR REFERENCE PURPOSES ONLY.  
AIR VENT OPEN FULL.

PROTOTYPE STUDY OF SLIDE GATES

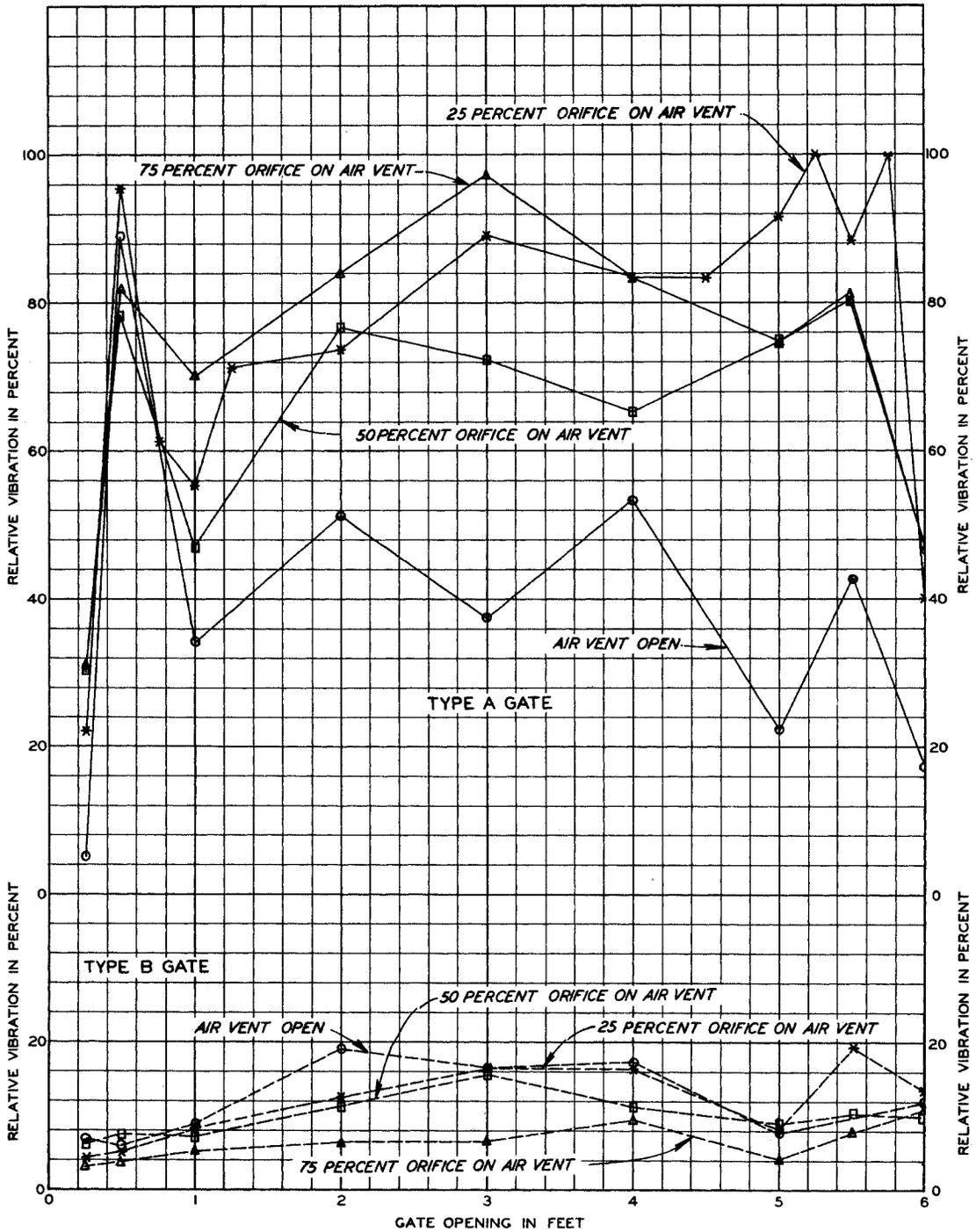
PRESSURE FLUCTUATIONS  
ON CENTERLINE OF GATE LIP  
TYPE B DESIGN



NOTE: RELATIVE VIBRATION IS IN PERCENT OF MAXIMUM VIBRATION IN HORIZONTAL PLANE FOR TYPE A GATE.

PROTOTYPE STUDY OF SLIDE GATES

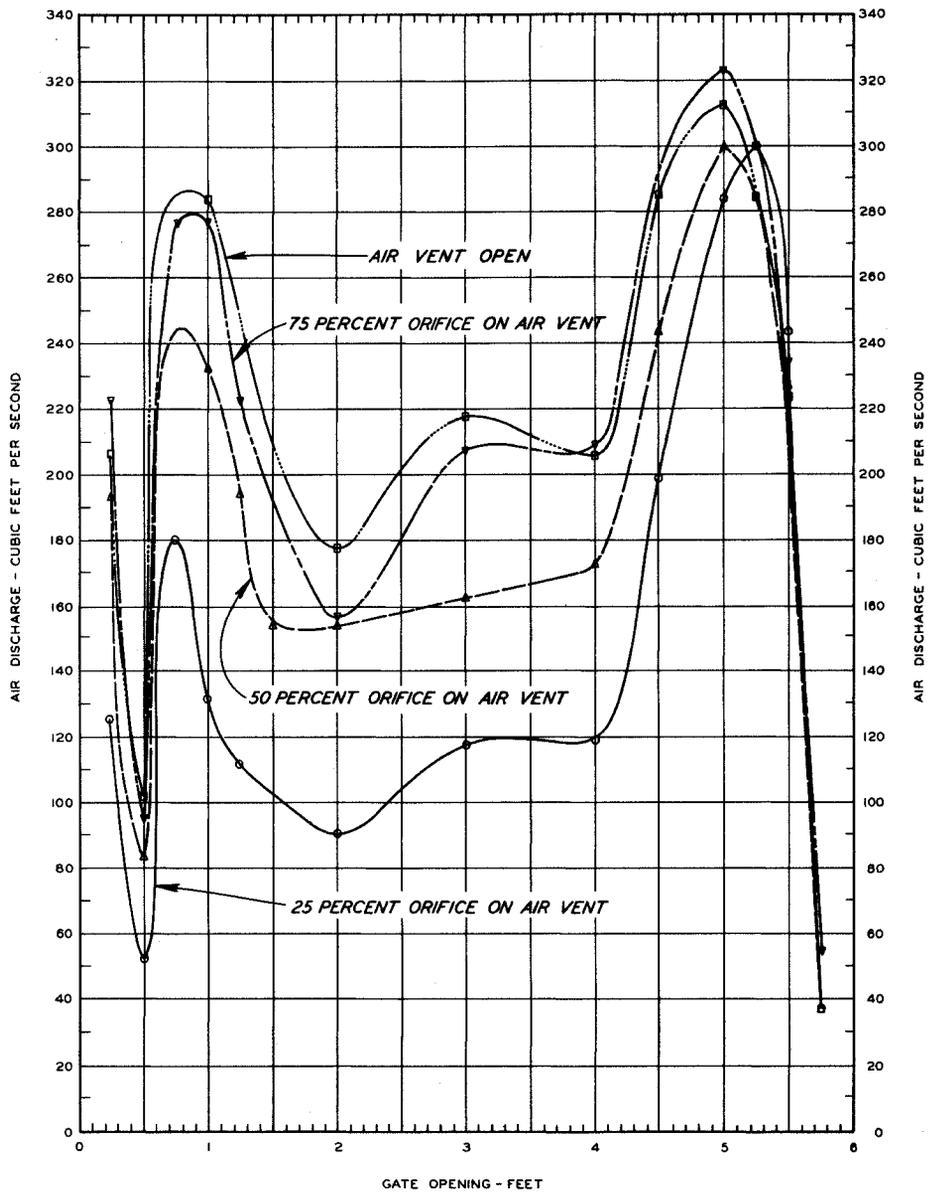
VIBRATION AMPLITUDE  
VERTICAL PLANE  
TYPE A AND B GATES



NOTE: RELATIVE VIBRATION IS IN PERCENT OF MAXIMUM VIBRATION IN HORIZONTAL PLANE FOR TYPE A GATE.

PROTOTYPE STUDY OF SLIDE GATES

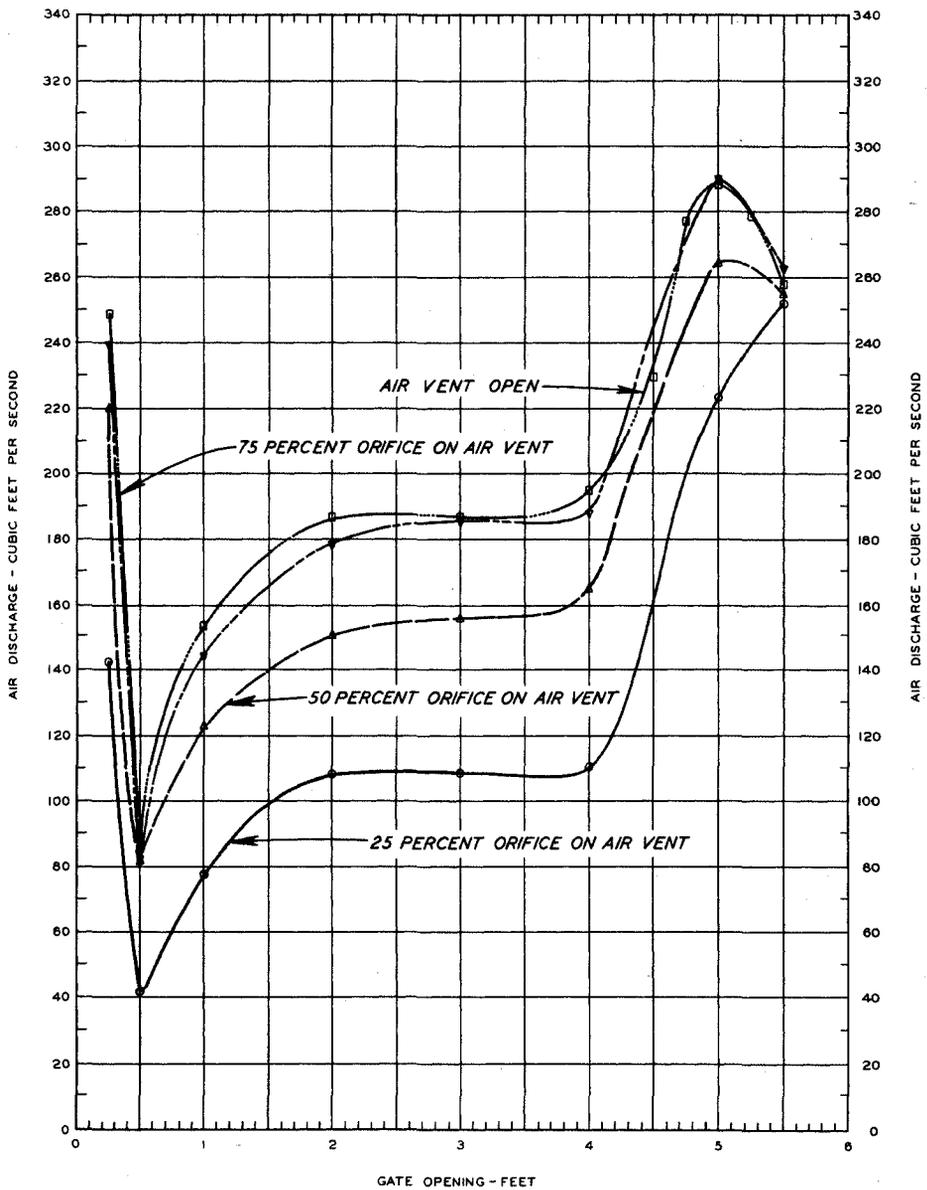
VIBRATION AMPLITUDE  
HORIZONTAL PLANE  
TYPE A AND B GATES



NOTE: ORIGINAL VENT 20 INCHES IN DIAMETER.

PROTOTYPE STUDY OF SLIDE GATES

**AIR DEMAND  
TYPE A GATE**



NOTE: ORIGINAL VENT 20 INCHES IN DIAMETER.

PROTOTYPE STUDY OF SLIDE GATES

**AIR DEMAND  
TYPE B GATE**

APPENDIX A: MODEL PRESSURE DATA FOR TYPES A-F GATE  
LIP SHAPES AND CONDUIT

TABLE A1  
 PRESSURE DATA - TYPE A GATE LIP  
 GATE OPEN 0.25 FT

Piez. No.	Discharge - 118.0 cfs		Discharge - 98.0 cfs		Discharge - 75.0 cfs		Discharge - 60.0 cfs		Average C
	Pressure - 100.0 ft	$v^2/2g - 0.4$ ft	Pressure - 75.0 ft	$v^2/2g - 0.3$ ft	Pressure - 50.0 ft	$v^2/2g - 0.1$ ft	Pressure - 25.0 ft	$v^2/2g - 0.1$ ft	
	Head - 100.4 ft		Head - 75.3 ft		Head - 50.1 ft		Head - 25.1 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	100.9	1.005	75.3	1.000	50.8	1.014	26.1	1.040	1.015
2	79.7	0.794	59.7	0.793	40.6	0.810	21.6	0.861	0.814
3	-16.7	-0.166	-12.4	-0.165	-8.8	-0.176	-5.0	-0.199	0.176
4	10.2	0.102	8.6	0.114	6.1	0.122	1.3	0.052	0.098
5	45.0	0.448	34.0	0.452	22.9	0.457	12.1	0.482	0.459
6	5.1	0.051	4.1	0.054	2.7	0.054	2.6	0.104	0.066
7	-7.8	-0.077	-5.1	-0.068	-3.5	-0.070	-1.3	-0.052	-0.067
8	81.2	0.809	60.5	0.803	41.2	0.822	21.9	0.873	0.827
9	-36.3	0.362	-27.2	-0.361	-18.9	-0.377	-9.9	-0.394	-0.373
10	9.9	0.099	7.4	0.098	2.8	0.056	-0.5	-0.020	0.058
11	45.7	0.455	34.4	0.457	23.2	0.463	12.4	0.494	0.467
12	-1.8	-0.018	-1.1	-0.015	-0.6	-0.012	0.0	0.000	-0.011
13	-8.6	-0.086	-6.4	-0.085	-3.7	-0.074	-1.4	-0.056	-0.075
14	73.7	0.734	55.4	0.736	37.8	0.755	19.9	0.793	0.754
15	29.9	0.298	21.6	0.287	14.2	0.283	-0.6	-0.024	0.289
16	25.7	0.256	15.6	0.207	9.1	0.182	4.0	0.159	0.201
17	33.9	0.338	25.4	0.337	16.9	0.337	9.4	0.375	0.347
18	14.4	0.143	10.0	0.133	6.5	0.130	4.0	0.159	0.141

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 5.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A2

PRESSURE DATA - TYPE A GATE LIP

GATE OPEN 0.5 FT

Piez. No.	Discharge - 185.0 cfs		Discharge - 162.0 cfs		Discharge - 135.0 cfs		Discharge - 98.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	99.6	0.989	75.0	0.993	50.0	1.000	25.0	1.012	0.999
	$V^2/2g$ - 0.9 ft		$V^2/2g$ - 0.7 ft		$V^2/2g$ - 0.5 ft		$V^2/2g$ - 0.3 ft		
	Head - 100.5 ft		Head - 75.7 ft		Head - 50.5 ft		Head - 25.3 ft		
1	99.4	0.989	75.2	0.993	50.5	1.000	25.6	1.012	0.999
2	58.9	0.586	45.3	0.598	30.3	0.600	16.8	0.664	0.612
3	-72.2	-0.718	-54.3	-0.717	-37.3	-0.738	-21.8	-0.861	-0.724
4	-14.6	-0.145	-10.3	-0.136	-6.7	-0.133	-3.8	-0.150	-0.141
5	32.6	0.324	24.6	0.325	16.7	0.331	8.7	0.344	0.331
6	-4.2	0.042	1.6	0.021	1.7	0.034	1.0	0.039	0.034
7	-6.8	-0.068	-5.1	-0.067	-3.2	-0.063	-0.7	-0.028	-0.066
8	60.4	0.601	46.5	0.614	31.3	0.620	16.5	0.652	0.622
9	-100.7	-1.002	-76.3	-1.008	-50.7	-1.004	-25.7	-1.016	-1.008
10	-18.2	-0.181	-13.3	-0.176	-8.7	-0.172	-4.7	-0.186	-0.179
11	34.7	0.345	26.4	0.349	17.5	0.347	8.9	0.352	0.348
12	-3.9	-0.039	-3.2	-0.042	-2.2	-0.044	-0.7	-0.028	-0.038
13	-7.7	-0.077	-6.0	-0.079	-3.7	-0.073	-1.6	-0.063	-0.073
14	47.6	0.474	37.5	0.495	25.5	0.505	14.3	0.565	0.509
15	1.1	0.011	-5.9	-0.078	-11.5	-0.228	-7.0	-0.277	-0.143
16	-9.9	-0.099	-16.0	-0.211	-13.6	-0.269	4.2	-0.166	-0.186
17	8.9	0.089	3.8	0.050	-1.6	-0.032	8.2	0.324	0.108
18	5.1	0.051	4.0	0.053	3.0	0.059	0.8	0.032	0.049

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 5.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A3  
PRESSURE DATA - TYPE A GATE LIP  
GATE OPEN 1.0 FT

Piez. No.	Discharge - 268.0 cfs		Discharge - 232.0 cfs		Discharge - 192.0 cfs		Discharge - 135.0 cfs		Average C
	Pressure - 100.0 ft	$V^2/2g$ - 1.9 ft	Pressure - 75.0 ft	$V^2/2g$ - 1.4 ft	Pressure - 50.0 ft	$V^2/2g$ - 1.0 ft	Pressure - 25.0 ft	$V^2/2g$ - 0.5 ft	
	Head - 101.9 ft		Head - 76.4 ft		Head - 51.0 ft		Head - 25.5 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	98.9	0.972	74.2	0.974	49.6	0.974	24.6	0.965	0.971
2	61.5	0.605	46.6	0.611	31.1	0.610	15.5	0.608	0.608
3	0.1	0.001	0.9	0.012	1.9	0.037	2.7	0.106	0.039
4	0.4	0.004	1.0	0.013	1.0	0.019	1.3	0.051	0.022
5	0.8	0.008	0.8	0.010	0.9	0.018	1.2	0.047	0.021
6	1.0	0.010	1.2	0.016	1.0	0.019	1.3	0.051	0.024
7	0.7	0.007	0.5	0.006	0.5	0.010	0.5	0.020	0.011
8	61.9	0.607	46.8	0.614	31.1	0.610	15.9	0.624	0.614
9	0.5	0.005	0.9	0.012	1.2	0.024	2.6	0.102	0.036
10	1.0	0.010	0.6	0.008	0.7	0.014	0.9	0.035	0.017
11	0.7	0.007	0.9	0.012	0.6	0.012	1.3	0.051	0.021
12	3.7	0.036	2.4	0.031	1.9	0.037	1.9	0.075	0.045
13	1.0	0.010	0.6	0.008	0.5	0.010	0.4	0.016	0.011
14	41.3	0.406	31.7	0.415	21.6	0.423	10.7	0.420	0.416
15	-2.7	-0.027	-3.4	-0.045	-1.9	-0.037	0.2	0.008	-0.025
16	-7.1	-0.070	-7.2	-0.094	-4.3	-0.084	-2.4	-0.094	-0.086
17	19.6	0.193	13.2	0.173	8.0	0.157	2.9	0.114	0.159
18	8.1	0.080	5.0	0.066	3.5	0.069	1.9	0.075	0.073

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 5.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A4  
PRESSURE DATA - TYPE A GATE LIP  
GATE OPEN 2.0 FT

Piez. No.	Discharge - 481.0 cfs		Discharge - 420.0 cfs		Discharge - 345.0 cfs		Discharge - 245.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	99.8 ft		75.0 ft		50.1 ft		25.0 ft		
	$V^2/2g$ - 6.3 ft		$V^2/2g$ - 4.8 ft		$V^2/2g$ - 3.2 ft		$V^2/2g$ - 1.6 ft		
	Head - 106.1 ft		Head - 79.8 ft		Head - 53.3 ft		Head - 26.6 ft		
1	101.4	0.956	75.8	0.950	50.8	0.953	24.4	0.917	0.944
2	51.0	0.480	38.6	0.484	26.2	0.492	13.0	0.489	0.489
3	-0.2	-0.002	-0.2	-0.002	-0.2	-0.004	0.2	0.008	0.000
4	0.8	0.008	0.9	0.011	0.8	0.015	0.7	0.026	0.015
5	1.2	0.013	1.9	0.024	0.8	0.015	0.9	0.034	0.021
6	1.2	0.013	1.2	0.015	1.0	0.019	0.9	0.034	0.020
7	1.2	0.013	0.5	0.006	0.5	0.009	0.4	0.015	0.011
8	51.6	0.486	39.2	0.492	26.4	0.495	13.2	0.497	0.493
9	0.7	0.007	0.4	0.005	0.6	0.011	1.4	0.053	0.019
10	1.7	0.016	1.2	0.015	0.8	0.015	1.2	0.045	0.023
11	1.6	0.015	2.0	0.025	0.8	0.015	0.8	0.030	0.021
12	1.6	0.015	0.5	0.006	1.0	0.019	0.9	0.034	0.018
13	2.6	0.024	1.2	0.015	0.8	0.015	0.4	0.015	0.017
14	30.4	0.286	23.4	0.294	16.2	0.304	8.1	0.304	0.297
15	1.7	0.016	1.5	0.019	0.8	0.015	0.9	0.034	0.021
16	-0.1	-0.001	0.0	0.000	0.8	0.015	0.9	0.034	0.012
17	1.8	0.017	1.4	0.018	0.8	0.015	1.1	0.041	0.023
18	10.3	0.097	7.3	0.092	5.0	0.094	2.1	0.079	0.090

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 5.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A5  
PRESSURE DATA - TYPE A GATE LIP  
GATE OPEN 3.0 FT

Pies. No.	Discharge - 745.0 cfs		Discharge - 650.0 cfs		Discharge - 509.0 cfs		Discharge - 368.0 cfs		Average C
	Pressure - 100.0 ft	$V^2/2g$ - 15.0 ft	Pressure - 75.0 ft	$V^2/2g$ - 11.4 ft	Pressure - 50.0 ft	$V^2/2g$ - 7.0 ft	Pressure - 24.9 ft	$V^2/2g$ - 3.7 ft	
	Head - 115.0 ft		Head - 86.4 ft		Head - 57.0 ft		Head - 28.6 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	111.2	0.967	85.6	0.991	71.5	1.254	26.4	0.923	1.034
2	52.1	0.453	40.6	0.470	26.5	0.465	13.1	0.458	0.462
3	-1.3	-0.011	-0.5	-0.006	-0.2	0.004	0.1	0.003	-0.005
4	0.8	0.007	0.5	0.006	0.9	0.016	1.4	0.049	0.019
5	1.1	0.009	1.0	0.012	1.2	0.021	2.5	0.087	0.032
6	0.2	0.002	0.3	0.003	1.7	0.030	0.9	0.031	0.016
7	0.2	0.002	0.2	0.002	0.6	0.011	0.9	0.031	0.012
8	52.4	0.456	40.3	0.466	26.4	0.463	13.1	0.458	0.461
9	0.6	0.005	0.5	0.006	0.8	0.014	0.6	0.021	0.012
10	0.9	0.008	0.7	0.008	1.0	0.018	1.0	0.035	0.017
11	0.8	0.007	0.5	0.006	0.8	0.014	1.0	0.035	0.015
12	1.2	0.010	0.4	0.005	1.1	0.019	1.1	0.038	0.018
13	0.4	0.003	-0.2	0.002	0.5	0.009	0.7	0.024	0.008
14	28.4	0.247	22.9	0.263	15.6	0.274	7.8	0.273	0.264
15	0.7	0.006	0.4	0.005	1.1	0.019	1.2	0.042	0.018
16	0.1	0.001	0.2	0.002	0.4	0.007	0.6	0.021	0.008
17	1.2	0.010	0.5	0.006	0.7	0.012	1.5	0.052	0.020
18	5.2	0.045	4.5	0.052	2.7	0.047	1.8	0.063	0.052

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 5.  
Figures in heading refer to control piezometer located in the conduit ... upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A6

## PRESSURE DATA - TYPE A GATE LIP

GATE OPEN 4.0 FT

Piez. No.	Discharge - 1070 cfs		Discharge - 960.0 cfs		Discharge - 770.0 cfs		Discharge - 530.0 cfs		Average C
	Pressure - 100.0 ft	$V^2/2g$ - 30.9 ft	Pressure - 75.0 ft	$V^2/2g$ - 24.9 ft	Pressure - 50.0 ft	$V^2/2g$ - 16.0 ft	Pressure - 25.0 ft	$V^2/2g$ - 7.6 ft	
	Head - 130.9 ft		Head - 99.9 ft		Head - 66.0 ft		Head - 32.6 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	128.1	0.979	95.0	0.951	62.3	0.944	29.9	0.917	0.948
2	65.8	0.503	48.7	0.487	33.8	0.512	16.6	0.509	0.503
3	-2.2	-0.017	-1.3	-0.013	-0.1	-0.002	0.4	0.012	-0.005
4	-0.3	-0.002	0.0	0.000	0.5	0.008	0.7	0.021	0.008
5	0.0	0.000	0.2	0.002	0.6	0.009	0.2	0.006	0.004
6	-0.3	-0.002	0.1	0.001	0.9	0.014	0.6	0.018	0.008
7	-0.5	-0.004	-0.3	-0.003	0.1	0.002	0.4	0.012	0.002
8	66.0	0.504	48.8	0.488	34.0	0.515	16.8	0.515	0.505
9	-0.8	-0.006	0.0	0.000	0.4	0.006	0.6	0.018	0.004
10	-0.3	-0.002	-0.1	-0.001	0.1	0.002	0.5	0.015	0.004
11	0.1	0.001	0.2	0.002	0.7	0.011	1.0	0.032	0.012
12	-0.3	-0.002	0.1	0.001	0.9	0.014	1.0	0.032	0.011
13	-0.4	-0.003	-0.1	-0.001	0.1	0.002	0.5	0.015	0.003
14	35.6	0.272	27.1	0.271	18.9	0.286	9.8	0.301	0.282
15	-2.5	-0.019	-2.0	-0.020	0.1	0.002	0.2	0.006	-0.008
16	-2.6	-0.020	-2.2	-0.022	-0.8	-0.012	0.1	0.003	-0.013
17	0.5	0.004	0.2	0.002	0.1	0.002	0.3	0.009	0.004
18	5.3	0.040	0.1	0.001	1.5	0.023	1.2	0.037	0.025

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 5.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A7  
PRESSURE DATA - TYPE A GATE LIP  
GATE OPEN 5.0 FT

Piez. No.	Discharge - 1790 cfs		Discharge - 1520 cfs		Discharge - 1234 cfs		Discharge - 857.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	100.0		75.0		50.0		25.0		
	86.5		62.4		41.2		19.7		
	186.5		137.4		91.2		44.7		
1	135.8	0.728	93.7	0.682	61.2	0.671	25.9	0.579	0.665
2	131.9	0.707	92.2	0.671	61.9	0.679	28.5	0.638	0.674
3	1.1	0.006	1.2	0.009	1.1	0.012	1.2	0.027	0.013
4	-2.7	-0.014	-1.6	-0.012	-0.6	-0.007	0.9	0.020	-0.003
5	-2.2	-0.012	-1.3	-0.009	-1.0	-0.011	0.4	0.009	-0.006
6	-2.4	-0.013	-0.5	-0.004	-0.5	-0.005	0.2	0.005	-0.004
7	-2.5	-0.013	-0.8	-0.006	-0.8	-0.009	-0.1	-0.002	-0.008
8	132.3	0.709	92.5	0.673	61.9	0.679	28.7	0.642	0.676
9	-1.8	-0.010	-1.1	-0.008	-0.6	-0.007	0.9	0.020	-0.001
10	-3.0	-0.016	-2.0	-0.015	-0.9	-0.010	0.8	0.018	-0.006
11	-2.1	-0.011	-1.3	-0.009	-1.1	-0.012	0.3	0.007	-0.006
12	-1.7	-0.009	-0.5	-0.004	-0.5	-0.005	0.2	0.005	-0.003
13	-1.6	-0.009	-1.0	-0.007	-0.8	-0.009	-0.2	-0.005	-0.003
14	78.9	0.423	58.7	0.427	39.3	0.431	18.2	0.407	0.422
15	-4.6	-0.025	-4.4	-0.032	-2.7	-0.030	-0.2	-0.005	-0.023
16	-6.6	-0.035	-4.6	-0.033	-3.7	-0.041	-0.8	-0.018	-0.032
17	0.0	0.000	0.6	-0.004	-0.7	-0.008	-0.3	-0.007	-0.005
18	2.3	0.012	-1.4	-0.010	-1.3	-0.014	0.0	0.000	-0.003

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 5.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A8

PRESSURE DATA - TYPE A GATE LIP

GATE OPEN 6.0 FT

Piez. No.	Discharge - 2360 cfs		Discharge - 1795 cfs		Average C
	Pressure - 40.3 ft	$v^2/2g$ - 150.0 ft	Pressure - 25.1 ft	$v^2/2g$ - 86.9 ft	
	Head - 190.3 ft		Head - 112.0 ft		
	Pressure	C	Pressure	C	
1					
1	57.3	0.301	31.1	0.278	0.290
2	40.9	0.215	24.4	0.218	0.216
3	32.2	0.169	18.1	0.162	0.165
4	-14.1	-0.074	-8.4	-0.075	-0.075
5	60.8	0.319	34.3	0.307	0.313
6	-3.5	-0.018	-2.3	-0.021	-0.019
7	4.7	0.025	2.8	0.025	0.025
8	33.4	0.176	20.9	0.187	0.182
9	6.0	0.031	3.9	0.035	0.033
10	0.0	0.000	-0.3	-0.003	-0.002
11	63.4	0.333	34.8	0.311	0.322
12	-4.7	-0.025	-4.7	-0.042	-0.033
13	17.1	0.090	5.0	0.045	0.068
14	67.0	0.352	39.8	0.355	0.354
15	25.9	0.136	12.8	0.115	0.125
16	36.8	0.193	20.4	0.182	0.188
17	-2.0	-0.011	-1.2	-0.011	-0.011
18	43.3	0.228	35.1	0.313	0.272

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 5.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A9

## PRESSURE DATA - TYPE B GATE LIP

GATE OPEN 0.25 FT

Piez. No.	Discharge - 93.0 cfs		Discharge - 80.0 cfs		Discharge - 67.0 cfs		Discharge - 45.0 cfs		Average C
	Pressure - 100.0 ft		Pressure - 75.0 ft		Pressure - 50.0 ft		Pressure - 25.0 ft		
	$V^2/2g$ - 0.2 ft		$V^2/2g$ - 0.2 ft		$V^2/2g$ - 0.1 ft		$V^2/2g$ - 0.0 ft		
	Head - 100.2 ft		Head - 75.2 ft		Head - 50.1 ft		Head - 25.0 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	100.3	1.000	75.0	0.997	49.4	0.986	25.0	1.000	0.996
2	100.2	1.000	75.2	1.000	50.7	1.012	26.3	1.052	1.016
3	97.8	0.976	73.2	0.973	49.4	0.986	25.8	1.032	0.992
4	95.5	0.953	71.4	0.949	48.2	0.962	24.9	0.996	0.965
5	90.8	0.906	68.2	0.907	46.2	0.922	24.4	0.976	0.928
6	0.3	0.003	5.8	0.077	1.1	0.022	0.0	0.000	0.025
7	100.2	1.000	75.0	0.997	50.6	1.010	26.3	1.052	1.015
8	98.4	0.982	73.6	0.979	49.5	0.988	25.6	1.024	0.993
9	95.5	0.953	71.3	0.948	48.3	0.964	25.2	1.008	0.968
10	90.3	0.901	68.2	0.907	45.8	0.914	24.1	0.964	0.922
11	2.2	0.022	3.8	0.050	0.9	0.018	3.1	0.124	0.053
12	98.3	0.981	73.9	0.983	49.9	0.996	26.1	1.044	1.001
13	93.8	0.936	70.2	0.934	47.4	0.946	24.7	0.988	0.951
14	90.2	0.900	67.6	0.899	45.5	0.908	23.8	0.952	0.915
15	23.3	0.233	16.8	0.223	10.7	0.214	8.6	0.344	0.253

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 6.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A10  
PRESSURE DATA - TYPE B GATE LIP  
GATE OPEN 0.5 FT

Piez. No.	Discharge - 155.0 cfs		Discharge - 135.0 cfs		Discharge - 110.0 cfs		Discharge - 75.0 cfs		Average C
	Pressure	Head	Pressure	Head	Pressure	Head	Pressure	Head	
	100.0 ft	100.7 ft	75.0 ft	75.5 ft	50.0 ft	50.3 ft	25.0 ft	25.1 ft	
	$V^2/2g = 0.7$		$V^2/2g = 0.5$		$V^2/2g = 0.3$		$V^2/2g = 0.1$		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	100.9	1.002	75.2	0.996	49.9	0.992	24.2	0.964	0.988
2	98.8	0.981	73.7	0.976	49.4	0.982	24.7	0.984	0.981
3	91.6	0.910	68.6	0.909	45.8	0.910	23.1	0.920	0.912
4	87.2	0.866	65.4	0.866	43.9	0.873	22.3	0.888	0.873
5	82.1	0.815	61.7	0.817	41.5	0.825	21.4	0.852	0.827
6	0.6	0.006	0.8	0.010	1.6	0.032	0.9	0.036	0.021
7	99.1	0.984	73.9	0.979	49.5	0.984	24.7	0.984	0.983
8	91.9	0.913	68.8	0.911	46.1	0.916	23.2	0.924	0.916
9	87.3	0.867	65.3	0.865	43.9	0.873	22.5	0.896	0.875
10	81.6	0.810	61.3	0.812	41.3	0.821	21.4	0.852	0.824
11	2.1	0.021	1.3	0.017	1.4	0.027	2.0	0.080	0.036
12	95.6	0.949	71.1	0.942	47.8	0.950	23.9	0.952	0.948
13	81.7	0.811	61.3	0.812	41.2	0.819	20.9	0.833	0.819
14	78.3	0.778	58.5	0.775	39.7	0.789	20.2	0.805	0.787
15	9.8	0.097	7.7	0.102	5.3	0.105	2.1	0.084	0.097

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 6.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A11

PRESSURE DATA - TYPE B GATE LIP

GATE OPEN 1.0 FT

Piez. No.	Discharge - 283.0 cfs		Discharge - 245.0 cfs		Discharge - 200.0 cfs		Discharge - 142.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	101.0	0.988	74.7	0.975	49.5	0.969	24.1	0.945	0.969
	93.7	0.917	69.9	0.913	46.9	0.918	23.4	0.918	0.916
	78.0	0.763	58.0	0.757	38.7	0.757	19.4	0.761	0.759
	72.2	0.706	54.1	0.706	36.1	0.706	18.4	0.722	0.710
	69.2	0.677	51.6	0.674	34.8	0.681	17.9	0.701	0.683
	0.8	0.008	0.9	0.011	0.9	0.017	0.9	0.035	0.018
	93.7	0.917	69.9	0.913	46.7	0.914	23.4	0.918	0.915
	78.3	0.766	58.3	0.761	39.0	0.763	19.6	0.769	0.765
	71.4	0.699	53.7	0.701	35.9	0.703	18.4	0.722	0.706
	68.6	0.671	51.4	0.671	34.4	0.673	17.8	0.698	0.678
	0.6	0.006	0.9	0.011	0.8	0.016	0.9	0.035	0.017
	86.3	0.844	64.1	0.837	42.8	0.838	21.4	0.839	0.839
	60.7	0.594	45.6	0.595	30.1	0.589	15.4	0.604	0.595
	58.0	0.568	43.6	0.569	28.8	0.564	14.9	0.584	0.571
	-4.1	-0.040	-2.3	-0.031	-2.1	-0.041	0.9	0.035	-0.019

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 6.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A12

## PRESSURE DATA - TYPE B GATE LIP

GATE OPEN 2.0 FT

Piez. No.	Discharge - 532.0 cfs		Discharge - 470.0 cfs		Discharge - 375.0 cfs		Discharge - 268.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	106.8	0.992	79.4	0.980	51.7	0.961	24.9	0.926	0.965
2	91.5	0.850	68.1	0.841	44.7	0.831	22.0	0.818	0.835
3	62.0	0.576	46.5	0.574	30.5	0.567	15.0	0.558	0.569
4	55.9	0.519	42.1	0.520	27.8	0.517	13.6	0.506	0.515
5	58.9	0.544	44.3	0.547	29.3	0.545	14.5	0.539	0.544
6	1.0	0.009	1.0	0.012	1.1	0.020	0.8	0.030	0.018
7	91.3	0.848	68.0	0.840	44.8	0.833	22.0	0.818	0.835
8	62.5	0.580	47.1	0.581	31.1	0.578	15.3	0.569	0.577
9	55.4	0.514	41.9	0.517	27.5	0.511	13.6	0.506	0.512
10	57.9	0.538	43.6	0.538	28.9	0.537	14.4	0.535	0.537
11	1.1	0.010	1.0	0.012	1.0	0.019	1.1	0.041	0.021
12	77.8	0.722	58.4	0.721	38.6	0.717	18.9	0.703	0.716
13	38.4	0.357	29.0	0.358	19.3	0.359	9.7	0.361	0.359
14	39.1	0.363	29.6	0.365	20.1	0.374	10.2	0.379	0.370
15	-1.4	-0.013	-1.3	-0.016	-1.0	-0.019	0.3	0.011	-0.009

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 6.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A13

## PRESSURE DATA - TYPE B GATE LIP

GATE OPEN 3.0 FT

Piez. No.	Discharge - 840.0 cfs		Discharge - 750.0 cfs		Discharge - 585.0 cfs		Discharge - 403.0 cfs		Average C
	Pressure - 100.0 ft		Pressure - 75.0 ft		Pressure - 50.0 ft		Pressure - 25.0 ft		
	$V^2/2g$ - 19.1 ft		$V^2/2g$ - 15.2 ft		$V^2/2g$ - 9.2 ft		$V^2/2g$ - 4.4 ft		
	Head - 119.1 ft		Head - 90.2 ft		Head - 59.2 ft		Head - 29.4 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	114.8	0.964	85.4	0.947	55.6	0.939	26.0	0.884	0.933
2	101.0	0.848	75.1	0.833	51.1	0.863	24.5	0.833	0.844
3	61.5	0.516	46.0	0.510	30.9	0.522	14.8	0.503	0.513
4	52.5	0.441	39.2	0.435	26.1	0.441	12.5	0.425	0.435
5	56.9	0.478	42.4	0.470	28.1	0.475	14.0	0.476	0.475
6	-0.8	-0.007	0.0	0.000	0.6	0.010	0.4	0.014	0.004
7	100.9	0.847	75.0	0.831	51.0	0.861	24.6	0.837	0.844
8	63.5	0.533	47.1	0.522	31.5	0.532	15.2	0.517	0.526
9	51.3	0.431	38.5	0.427	25.7	0.434	12.2	0.415	0.427
10	55.9	0.467	41.6	0.461	27.8	0.469	13.7	0.466	0.466
11	0.9	0.008	0.7	0.009	0.7	0.012	0.5	0.017	0.011
12	83.8	0.704	62.1	0.689	41.2	0.696	20.2	0.687	0.694
13	31.7	0.266	23.7	0.263	16.7	0.282	8.2	0.279	0.272
14	33.3	0.279	24.6	0.273	16.9	0.285	8.3	0.282	0.279
15	2.4	0.020	1.5	0.017	0.8	0.014	-0.6	-0.020	0.008

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 6.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A14  
 PRESSURE DATA - TYPE B GATE LIP  
 GATE OPEN 4.0 FT

Piez. No.	Discharge - 1210 cfs		Discharge - 1065 cfs		Discharge - 810.0 cfs		Discharge - 585.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	92.2	0.661	64.8	0.615	40.2	0.595	17.2	0.503	0.593
2	130.2	0.934	97.4	0.924	63.6	0.941	30.4	0.889	0.922
3	89.4	0.641	66.4	0.630	43.2	0.639	21.3	0.623	0.633
4	67.4	0.483	49.9	0.474	32.7	0.484	16.0	0.468	0.477
5	66.5	0.477	49.6	0.471	32.4	0.479	15.9	0.465	0.473
6	-0.3	-0.002	-0.3	-0.003	0.7	0.010	0.8	0.023	0.007
7	130.1	0.933	97.4	0.924	63.6	0.941	30.3	0.886	0.921
8	92.6	0.664	68.0	0.645	44.7	0.661	22.1	0.646	0.654
9	66.4	0.476	49.0	0.465	32.2	0.476	15.9	0.465	0.471
10	65.4	0.469	48.6	0.461	32.2	0.476	15.8	0.462	0.467
11	-0.3	-0.002	-0.3	-0.003	0.0	0.000	0.5	0.015	0.002
12	106.1	0.761	79.2	0.751	50.9	0.753	24.2	0.708	0.743
13	49.5	0.355	36.4	0.345	24.3	0.359	12.0	0.351	0.353
14	47.5	0.341	35.0	0.332	22.8	0.337	7.1	0.208	0.304
15	0.5	0.004	0.1	0.001	0.1	0.001	0.5	0.015	0.005

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 6.  
 Figures in heading refer to control piezometer located in the control 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A15

## PRESSURE DATA - TYPE B GATE LIP

GATE OPEN 5.0 FT

Pies. No.	Discharge - 1868 cfs		Discharge - 1613 cfs		Discharge - 1315 cfs		Discharge - 900.0 cfs		Average C
	Pressure - 100.0 ft	$v^2/2g$ - 94.0 ft	Pressure - 75.0 ft	$v^2/2g$ - 70.1 ft	Pressure - 50.0 ft	$v^2/2g$ - 46.6 ft	Pressure - 25.0 ft	$v^2/2g$ - 21.8 ft	
	Head - 194.0 ft		Head - 145.1 ft		Head - 96.6 ft		Head - 46.8 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	117.7	0.607	82.6	0.569	51.0	0.528	20.6	0.440	0.536
2	121.4	0.626	89.0	0.613	57.7	0.597	25.1	0.536	0.593
3	159.9	0.824	120.8	0.833	79.5	0.823	36.2	0.774	0.813
4	135.0	0.696	99.9	0.688	66.0	0.683	30.2	0.645	0.678
5	111.3	0.574	81.8	0.564	54.3	0.562	25.3	0.541	0.560
6	-2.0	-0.010	-1.2	-0.008	0.3	0.003	0.8	0.017	0.000
7	121.8	0.628	88.9	0.613	57.7	0.597	25.1	0.536	0.593
8	161.5	0.832	121.7	0.839	79.7	0.825	36.0	0.769	0.816
9	135.0	0.696	99.9	0.688	65.9	0.682	30.1	0.643	0.677
10	110.9	0.572	81.2	0.560	52.9	0.548	25.1	0.536	0.554
11	1.0	0.005	-0.1	-0.001	1.3	0.014	1.4	0.030	0.012
12	136.3	0.703	101.6	0.700	66.7	0.690	30.3	0.648	0.685
13	111.6	0.575	82.5	0.569	54.2	0.561	25.1	0.536	0.560
14	77.3	0.398	57.5	0.396	36.5	0.378	16.5	0.353	0.381
15	9.8	0.051	6.1	0.042	11.3	0.117	6.2	0.132	0.085

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 6.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A16

PRESSURE DATA - TYPE B GATE LIP

GATE OPEN 6.0 FT

Piez. No.	Discharge - 2416 cfs		Discharge - 2118 cfs		Average C
	Pressure	G	Pressure	G	
	48.5 ft		25.0 ft		
	$V^2/2g - 157.1$ ft		$V^2/2g - 120.9$ ft		
	Head - 205.6 ft		Head - 145.9 ft		
	Pressure	G	Pressure	G	
1	44.8	0.218	27.0	0.185	0.201
2	42.0	0.204	25.5	0.175	0.189
3	41.4	0.201	26.3	0.180	0.190
4	40.2	0.196	25.7	0.176	0.186
5	43.6	0.212	25.4	0.174	0.193
6	-2.7	-0.013	-8.9	-0.061	-0.037
7	41.9	0.204	25.5	0.175	0.189
8	41.5	0.202	25.4	0.174	0.188
9	38.9	0.189	24.6	0.169	0.179
10	40.8	0.198	24.0	0.164	0.181
11	2.2	0.011	-7.9	-0.054	-0.022
12	47.3	0.230	28.7	0.197	0.213
13	43.6	0.212	26.4	0.181	0.186
14	25.2	0.123	11.2	0.077	0.100
15	-5.4	-0.026	-11.9	-0.082	-0.054

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 6.  
 Figures in heading refer to control piezometer located in the conduit  
 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A17

## PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 0.25 FT

Piez. No.	Discharge - 98.0 cfs		Discharge - 80.0 cfs		Discharge - 68.0 cfs		Discharge - 47.0 cfs		Average C
	Pressure - 100.0 ft	Head - 100.3 ft	Pressure - 75.0 ft	Head - 75.2 ft	Pressure - 50.0 ft	Head - 50.1 ft	Pressure - 25.0 ft	Head - 25.1 ft	
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	102.3	1.020	75.9	1.009	51.3	1.024	25.5	1.016	1.017
2	102.1	1.018	76.5	1.017	52.2	1.042	26.4	1.052	1.032
3	100.9	1.006	75.3	1.000	50.8	1.014	25.6	1.020	1.010
4	101.3	1.010	75.5	1.004	51.0	1.018	25.9	1.030	1.015
5	98.3	0.980	73.5	0.977	49.7	0.992	25.2	1.000	0.987
6	0.8	0.008	2.2	0.029	1.7	0.034	2.0	0.079	0.037
7	0.9	0.009	2.9	0.038	3.4	0.068	1.4	0.056	0.043
8	101.9	1.016	76.3	1.015	51.9	1.036	26.2	1.044	1.028
9	101.6	1.013	75.4	1.003	51.0	1.018	25.9	1.032	1.017
10	101.4	1.011	76.1	1.012	50.5	1.008	25.7	1.024	1.016
11	98.1	0.978	73.4	0.976	49.6	0.990	25.4	1.012	0.989
12	0.6	0.006	1.7	0.022	1.3	0.026	3.0	0.119	0.043
13	13.7	0.136	7.4	0.098	4.4	0.088	3.8	0.151	0.118
14	101.4	1.010	75.9	1.009	50.7	1.012	26.2	1.044	1.018
15	99.3	0.990	75.2	1.000	50.5	1.008	26.0	1.036	1.008
16	96.7	0.964	72.3	0.961	48.6	0.971	25.4	1.012	0.977
17	-7.9	-0.079	-6.2	-0.082	-3.8	-0.076	-3.5	-0.139	-0.094
18	38.6	0.385	28.9	0.384	18.5	0.369	10.7	0.426	0.391

NOTE: Pressures are in prototype ft of water  
 Piezometer locations shown on plate 7.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A18

## PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 0.5 FT

Piez. No.	Discharge - 168.0 cfs		Discharge - 135.0 cfs		Discharge - 108.0 cfs		Discharge - 82.0 cfs		Average C
	Pressure - 100.0 ft	$v^2/2g$ - 0.8 ft	Pressure - 75.0 ft	$v^2/2g$ - 0.5 ft	Pressure - 50.0 ft	$v^2/2g$ - 0.3 ft	Pressure - 25.0 ft	$v^2/2g$ - 0.2 ft	
	Head - 100.8 ft		Head - 75.5 ft		Head - 50.3 ft		Head - 25.2 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	101.0	1.002	74.9	0.992	50.5	1.004	25.3	1.004	1.001
2	100.7	0.999	74.8	0.991	50.4	1.002	25.6	1.016	1.002
3	97.8	0.970	72.7	0.963	49.0	0.974	25.1	0.997	0.976
4	97.0	0.962	72.5	0.960	48.6	0.966	24.9	0.988	0.969
5	92.2	0.915	68.9	0.912	46.9	0.932	24.1	0.956	0.929
6	1.0	0.010	1.5	0.020	1.4	0.028	1.3	0.052	0.027
7	1.1	0.011	1.4	0.019	1.6	0.032	1.4	0.056	0.030
8	100.4	0.996	74.5	0.987	50.3	1.000	25.5	1.012	0.999
9	97.5	0.967	72.6	0.962	48.7	0.968	24.9	0.988	0.971
10	97.2	0.964	72.7	0.963	48.9	0.972	25.0	0.992	0.973
11	92.5	0.918	69.1	0.915	46.9	0.932	24.1	0.956	0.930
12	0.6	0.006	1.2	0.016	1.2	0.024	1.0	0.040	0.021
13	1.0	0.010	1.0	0.013	1.4	0.028	1.3	0.052	0.026
14	97.6	0.968	74.1	0.982	49.9	0.992	25.2	1.000	0.986
15	94.6	0.938	71.9	0.952	48.4	0.962	24.6	0.976	0.957
16	87.2	0.865	65.8	0.872	43.8	0.871	21.6	0.857	0.866
17	-9.5	-0.094	-13.4	-0.177	-10.3	-0.205	-6.0	-0.238	-0.178
18	24.0	0.238	18.4	0.244	11.0	0.219	1.8	0.071	0.193

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 7.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A19

PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 1.0 FT

Piez. No.	Discharge - 276.0 cfs		Discharge - 236.0 cfs		Discharge - 194.0 cfs		Discharge - 145.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	100.0		75.0		50.0		25.0		
	$v^2/2g$ - 2.1 ft		$v^2/2g$ - 1.5 ft		$v^2/2g$ - 1.0 ft		$v^2/2g$ - 0.6 ft		
	Head - 102.1 ft		Head - 76.5 ft		Head - 51.0 ft		Head - 25.6 ft		
1	100.9	0.988	75.7	0.990	49.7	0.975	24.5	0.957	0.978
2	98.7	0.967	73.9	0.966	48.9	0.959	24.4	0.953	0.961
3	92.5	0.906	69.4	0.907	46.0	0.902	23.0	0.898	0.903
4	91.5	0.896	68.6	0.897	45.5	0.892	22.9	0.895	0.895
5	85.3	0.835	64.2	0.839	42.7	0.837	22.2	0.867	0.844
6	1.1	0.011	0.9	0.012	0.8	0.016	0.9	0.035	0.018
7	1.4	0.014	1.7	0.022	1.2	0.024	1.3	0.051	0.028
8	98.6	0.966	73.7	0.963	48.7	0.955	24.4	0.953	0.959
9	91.7	0.898	69.1	0.903	45.8	0.898	22.6	0.883	0.896
10	91.5	0.896	68.6	0.897	45.6	0.894	22.8	0.891	0.895
11	85.1	0.833	64.2	0.839	42.7	0.837	22.2	0.867	0.844
12	1.1	0.011	0.9	0.012	0.8	0.016	0.8	0.031	0.018
13	1.4	0.014	2.1	0.027	1.5	0.029	1.1	0.043	0.028
14	94.8	0.929	71.4	0.933	47.7	0.935	24.0	0.938	0.934
15	88.5	0.867	67.0	0.876	44.7	0.876	22.9	0.895	0.879
16	77.9	0.763	58.5	0.765	39.2	0.769	20.0	0.781	0.769
17	1.3	0.013	1.0	0.013	1.0	0.020	0.0	0.000	0.011
18	8.3	0.081	6.7	0.088	4.8	0.094	2.3	0.090	0.088

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 7.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A20

## PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 2.0 FT

Piez. No.	Discharge - 520.0 cfs		Discharge - 435.0 cfs		Discharge - 360.0 cfs		Discharge - 257.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	106.0	0.988	77.8	0.971	51.5	0.963	26.0	0.970	0.973
2	99.9	0.931	74.2	0.926	49.8	0.931	25.1	0.936	0.931
3	88.3	0.823	65.4	0.816	44.2	0.826	22.4	0.836	0.825
4	86.1	0.802	64.0	0.799	43.3	0.809	21.8	0.813	0.806
5	78.9	0.735	58.6	0.732	39.8	0.744	20.6	0.769	0.745
6	0.9	0.008	1.1	0.014	1.0	0.019	1.2	0.045	0.021
7	1.1	0.010	0.9	0.011	0.9	0.017	1.0	0.037	0.019
8	99.8	0.930	74.0	0.924	49.7	0.930	25.0	0.933	0.929
9	86.3	0.804	64.0	0.800	43.3	0.809	21.7	0.810	0.806
10	85.8	0.800	63.6	0.794	43.3	0.809	21.8	0.813	0.804
11	78.9	0.735	58.5	0.730	39.7	0.742	20.5	0.765	0.743
12	0.4	0.004	0.9	0.011	0.8	0.015	1.2	0.045	0.019
13	1.8	0.017	1.6	0.020	1.7	0.032	1.6	0.060	0.032
14	93.9	0.875	70.0	0.874	46.5	0.870	23.6	0.881	0.875
15	82.9	0.773	62.1	0.775	41.5	0.776	21.2	0.791	0.779
16	67.6	0.630	50.4	0.630	33.6	0.628	16.7	0.623	0.628
17	-0.1	-0.001	0.8	0.010	0.5	0.009	1.7	0.063	0.020
18	12.0	0.112	6.6	0.082	4.7	0.088	2.9	0.108	0.097

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 7.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A21

## PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 3.0 FT

Piez. No.	Discharge - 778.0 cfs		Discharge - 691.0 cfs		Discharge - 525.0 cfs		Discharge - 391.0 cfs		Average C
	Pressure - 100.0 ft	$V^2/2g$ - 16.3 ft	Pressure - 75.0 ft	$V^2/2g$ - 12.9 ft	Pressure - 50.0 ft	$V^2/2g$ - 7.5 ft	Pressure - 25.0 ft	$V^2/2g$ - 4.1 ft	
	Head - 116.3 ft		Head - 87.9 ft		Head - 57.5 ft		Head - 29.1 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	112.8	0.970	84.6	0.962	55.1	0.958	26.6	0.914	0.951
2	111.7	0.960	83.8	0.953	55.1	0.958	26.9	0.924	0.949
3	97.9	0.842	73.5	0.836	48.4	0.842	23.6	0.811	0.833
4	91.4	0.786	69.0	0.785	45.5	0.791	22.5	0.773	0.784
5	82.3	0.708	61.9	0.704	41.1	0.715	20.1	0.691	0.704
6	0.7	0.006	0.8	0.009	0.9	0.016	0.7	0.024	0.014
7	0.7	0.006	1.1	0.012	1.4	0.024	1.1	0.038	0.020
8	111.7	0.960	83.7	0.952	55.1	0.958	26.8	0.921	0.948
9	96.4	0.829	72.4	0.824	47.8	0.831	23.2	0.797	0.820
10	91.2	0.784	68.9	0.784	45.3	0.788	22.3	0.766	0.780
11	82.2	0.707	61.8	0.703	40.9	0.711	20.0	0.687	0.702
12	0.6	0.005	0.7	0.008	1.0	0.017	0.7	0.024	0.013
13	0.7	0.006	1.1	0.012	1.3	0.023	1.1	0.038	0.020
14	101.1	0.869	76.4	0.869	50.4	0.876	23.7	0.814	0.857
15	89.3	0.768	67.1	0.763	44.6	0.776	22.0	0.756	0.766
16	67.2	0.578	50.6	0.576	33.8	0.588	16.6	0.570	0.578
17	1.0	0.009	1.2	0.013	1.1	0.019	0.7	0.024	0.016
18	9.1	0.078	8.7	0.099	5.6	0.097	2.8	0.096	0.093

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 7.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A22

## PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 4.0 FT

Piez. No.	Discharge - 1160 cfs		Discharge - 1010 cfs		Discharge - 820.0 cfs		Discharge - 570.0 cfs		Average C
	Pressure	Head	Pressure	Head	Pressure	Head	Pressure	Head	
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	102.4	0.751	75.1	0.732	49.9	0.732	21.8	0.645	0.715
2	124.7	0.914	94.1	0.917	61.1	0.896	28.2	0.834	0.890
3	124.6	0.914	94.2	0.918	61.2	0.896	29.4	0.870	0.899
4	114.6	0.837	85.6	0.834	59.9	0.878	27.2	0.805	0.838
5	97.8	0.717	73.2	0.713	48.2	0.707	23.2	0.686	0.706
6	-0.1	-0.001	0.5	0.005	0.9	0.013	1.0	0.030	0.012
7	-0.2	-0.002	0.2	0.002	0.8	0.012	1.2	0.036	0.012
8	124.6	0.914	94.1	0.917	61.1	0.896	28.2	0.834	0.890
9	124.0	0.909	92.7	0.904	60.3	0.884	29.2	0.864	0.890
10	113.9	0.835	85.6	0.834	59.8	0.877	27.2	0.805	0.838
11	97.8	0.717	73.2	0.713	48.2	0.707	23.2	0.686	0.706
12	-0.1	-0.001	0.1	0.001	0.9	0.013	1.2	0.036	0.012
13	-0.3	-0.003	0.2	0.002	0.8	0.012	1.2	0.036	0.012
14	118.5	0.869	88.0	0.858	58.5	0.858	27.8	0.822	0.852
15	111.4	0.817	83.6	0.815	54.9	0.805	26.7	0.790	0.807
16	81.9	0.600	59.7	0.582	40.2	0.589	19.4	0.575	0.586
17	0.1	0.001	0.9	0.009	0.9	0.013	1.4	0.041	0.016
18	4.3	0.031	3.7	0.036	2.1	0.031	2.1	0.062	0.040

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 7.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A23

PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 5.0 FT

Piez. No.	Discharge - 1780 cfs		Discharge - 1545 cfs		Discharge - 1250 cfs		Discharge - 855.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	100.0 ft		75.0 ft		50.0 ft		25.0 ft		
	85.4 ft		64.4 ft		42.1 ft		19.7 ft		
	185.4 ft		139.4 ft		92.1 ft		44.7 ft		
1	142.3	0.768	105.4	0.756	67.2	0.730	29.9	0.669	0.731
2	140.5	0.758	104.3	0.748	67.7	0.735	30.5	0.682	0.731
3	140.5	0.758	104.2	0.747	68.0	0.738	31.1	0.696	0.735
4	152.8	0.824	113.8	0.816	73.6	0.799	33.8	0.756	0.799
5	153.3	0.827	114.3	0.820	74.1	0.805	34.3	0.767	0.805
6	-1.7	-0.009	-0.4	-0.003	-0.3	-0.003	0.8	0.018	0.001
7	-1.9	-0.010	-0.4	-0.003	0.1	0.001	0.2	0.004	-0.002
8	140.6	0.758	104.4	0.749	68.0	0.738	30.6	0.685	0.733
9	140.7	0.759	104.3	0.748	68.1	0.739	31.0	0.694	0.735
10	152.8	0.824	113.8	0.816	73.6	0.799	33.8	0.756	0.799
11	153.3	0.827	114.2	0.819	74.1	0.805	34.3	0.767	0.805
12	-1.7	-0.009	-0.4	-0.003	-0.3	-0.003	0.8	0.018	0.001
13	-2.0	-0.011	-0.3	-0.003	0.3	0.003	0.4	0.010	0.000
14	143.2	0.772	106.6	0.765	69.1	0.750	31.2	0.698	0.746
15	139.0	0.750	103.9	0.745	67.8	0.736	31.3	0.700	0.744
16	126.2	0.681	94.4	0.677	61.8	0.671	28.5	0.638	0.667
17	2.1	0.011	2.2	0.015	-0.6	-0.007	1.9	0.043	0.017
18	4.5	0.024	3.4	0.024	2.7	0.029	2.7	0.060	0.034

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 7.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A24

PRESSURE DATA - TYPE C GATE LIP

GATE OPEN 6.0 FT

Piez. No.	Discharge - 2382 cfs		Discharge - 2015 cfs		Average C
	Pressure	Head	Pressure	Head	
	Pressure	C	Pressure	C	
1	42.8	0.213	29.7	0.221	0.217
2	43.2	0.215	30.2	0.225	0.220
3	43.1	0.215	30.1	0.224	0.220
4	40.8	0.203	27.4	0.204	0.204
5	40.3	0.201	27.7	0.206	0.203
6	35.4	0.176	24.8	0.184	0.180
7	45.5	0.227	31.6	0.235	0.231
8	42.9	0.214	29.9	0.222	0.218
9	42.5	0.212	29.3	0.218	0.215
10	39.8	0.198	27.2	0.202	0.200
11	41.4	0.206	27.8	0.207	0.206
12	35.9	0.179	24.4	0.181	0.180
13	45.6	0.227	31.8	0.236	0.231
14	44.7	0.223	28.5	0.212	0.217
15	45.0	0.224	28.8	0.214	0.219
16	37.0	0.184	27.1	0.201	0.193
17	29.5	0.147	19.1	0.142	0.144
18	48.0	0.239	33.6	0.250	0.245

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 7.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A25

PRESSURE DATA - TYPE D GATE LIP

GATE OPEN 0.25 FT

Piez. No.	Discharge - 92.0 cfs		Discharge - 80.0 cfs		Discharge - 67.0 cfs		Discharge - 51.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	99.0 ft		75.0 ft		49.6 ft		24.7 ft		
	$v^2/2g - 0.2$ ft		$v^2/2g - 0.2$ ft		$v^2/2g - 0.1$ ft		$v^2/2g - 0.1$ ft		
	Head - 99.2 ft		Head - 75.2 ft		Head - 49.7 ft		Head - 24.8 ft		
1	99.1	0.998	75.5	1.004	50.5	1.016	25.7	1.036	1.013
2	89.7	0.905	68.2	0.906	46.2	0.930	23.8	0.960	0.925
3	-4.1	-0.041	-3.2	-0.042	-2.0	-0.040	-1.2	-0.48	-0.043
4	21.6	0.218	15.5	0.206	10.3	0.208	5.4	0.218	0.213
5	-4.8	-0.048	-3.3	-0.044	-2.0	-0.040	-0.3	-0.012	-0.044
6	89.0	0.897	67.8	0.900	45.8	0.922	23.5	0.947	0.917
7	-4.9	-0.49	-3.6	-0.048	-2.0	-0.040	1.3	-0.052	-0.047
8	24.3	0.245	17.7	0.235	11.7	0.236	6.0	0.242	0.239
9	-7.1	-0.072	-5.0	-0.067	-3.4	-0.068	-1.3	-0.052	-0.065
10	86.5	0.872	65.7	0.873	44.3	0.891	22.8	0.919	0.889
11	-8.1	-0.082	-7.5	-0.100	-6.2	-0.125	-3.4	-0.137	-0.111
12	48.5	0.489	36.4	0.484	25.0	0.503	12.8	0.516	0.498
13	13.0	0.131	11.1	0.148	7.8	0.157	4.2	0.169	0.151

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 8.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A26

PRESSURE DATA - TYPE D GATE LIP

GATE OPEN 0.5 FT

Piez. No.	Discharge - 155.0 cfs		Discharge - 135.0 cfs		Discharge - 109.0 cfs		Discharge - 85.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	99.5 ft		74.8 ft		50.3 ft		25.0 ft		
	$V^2/2g - 0.6$ ft		$V^2/2g - 0.5$ ft		$V^2/2g - 0.4$ ft		$V^2/2g - 0.2$ ft		
	Head - 100.1 ft		Head - 75.3 ft		Head - 50.7 ft		Head - 25.2 ft		
1	98.2	0.981	75.3	1.000	50.6	1.000	25.3	1.000	0.995
2	81.8	0.816	62.3	0.827	42.1	0.831	21.5	0.855	0.832
3	-17.1	-0.171	-10.9	-0.144	-8.0	-0.158	-3.7	-0.147	-0.155
4	-14.1	-0.141	-9.5	-0.126	-7.0	-0.138	-3.3	-0.131	-0.134
5	0.6	-0.006	0.4	0.005	0.5	0.009	0.6	0.024	0.011
6	80.0	0.798	61.3	0.813	41.4	0.817	21.1	0.837	0.816
7	-17.3	-0.172	-10.9	-0.144	-8.0	-0.158	-3.7	-0.147	-0.155
8	-13.7	-0.137	-9.5	-0.126	-6.8	-0.134	-3.3	-0.131	-0.132
9	0.5	0.005	0.7	0.009	0.7	0.014	1.0	0.040	0.017
10	70.9	0.707	55.0	0.728	37.3	0.737	19.1	0.759	0.733
11	-41.7	-0.416	-29.7	0.394	-21.4	-0.423	-10.0	-0.397	-0.408
12	-12.0	-0.120	-8.7	-0.115	-8.0	-0.158	-2.9	-0.115	-0.127
13	18.2	0.182	13.5	17.9	9.3	0.183	5.0	0.197	0.185

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 8.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A27

PRESSURE DATA - TYPE D GATE LIP

GATE OPEN 1.0 FT

Piez. No.	Discharge - 254.0 cfs		Discharge - 220.0 cfs		Discharge - 182.0 cfs		Discharge - 130.0 cfs		Average C
	Pressure	$V^2/2g$	Pressure	$V^2/2g$	Pressure	$V^2/2g$	Pressure	$V^2/2g$	
	99.6 ft	1.7 ft	74.6 ft	1.3 ft	49.8 ft	.9 ft	24.8 ft	.5 ft	
	Head - 101.3 ft		Head - 75.9 ft		Head - 50.7 ft		Head - 25.3 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	98.7	0.974	74.3	0.980	49.5	0.978	24.4	0.964	0.974
2	75.9	0.749	57.3	0.756	38.4	0.758	19.3	0.763	0.758
3	0.5	0.005	0.3	0.004	2.3	0.045	3.1	0.123	0.044
4	0.1	0.001	0.1	0.001	0.4	0.008	0.2	0.008	0.004
5	0.9	0.009	0.5	0.007	3.2	0.063	0.5	0.019	0.024
6	74.3	0.734	56.5	0.745	37.8	0.746	18.9	0.749	0.743
7	0.4	0.004	0.1	0.001	0.3	0.006	0.2	0.008	0.005
8	0.3	0.003	5.1	0.067	0.4	0.008	0.7	0.028	0.026
9	0.1	0.001	0.1	0.001	0.4	0.008	0.4	0.016	0.006
10	65.6	0.648	50.0	0.660	33.1	0.655	16.7	0.660	0.656
11	-0.4	-0.004	-0.4	-0.005	0.0	0.000	0.3	-0.012	-0.005
12	-0.7	-0.007	-0.2	-0.003	0.4	0.008	0.2	0.008	0.001
13	2.6	0.025	1.3	0.017	1.2	0.024	0.9	0.036	0.025

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 8.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A28

PRESSURE DATA - TYPE D GATE LIP

GATE OPEN 2.0 FT

Piez. No.	Discharge - 475.0 cfs		Discharge - 410.0 cfs		Discharge - 338.0 cfs		Discharge - 240.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	103.4	0.970	75.7	0.955	51.4	0.965	25.3	0.941	0.958
	70.3	0.658	52.3	0.658	35.4	0.665	18.0	0.670	0.663
	0.4	0.004	0.3	0.004	0.3	0.006	0.3	0.011	0.006
	0.9	0.008	0.5	0.006	0.3	0.006	0.7	0.026	0.011
	0.8	0.007	-0.3	-0.004	1.6	0.030	1.1	0.041	0.019
	68.9	0.646	51.0	0.642	34.8	0.652	17.5	0.650	0.648
	1.7	0.016	0.3	0.004	0.8	0.015	0.5	0.019	0.013
	0.8	0.007	0.8	0.010	0.5	0.009	0.7	0.026	0.013
	2.8	0.026	0.3	0.004	2.4	0.045	0.5	0.019	0.023
	57.0	0.534	42.5	0.535	28.7	0.538	14.5	0.540	0.537
	0.0	0.000	0.3	0.004	-0.1	-0.002	0.2	0.007	0.003
	0.2	0.002	1.9	0.024	0.8	0.015	0.4	0.015	0.014
	8.2	0.077	6.7	0.084	4.2	0.080	2.3	0.086	0.082

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 8.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A29  
PRESSURE DATA - TYPE D GATE LIP  
GATE OPEN 3.0 FT

Piez. No.	Discharge - 732.0 cfs		Discharge - 625.0 cfs		Discharge - 512.0 cfs		Discharge - 358.0 cfs		Average C
	Pressure - 100.0 ft	$v^2/2g$ - 14.5 ft	Pressure - 74.9 ft	$v^2/2g$ - 10.6 ft	Pressure - 49.9 ft	$v^2/2g$ - 7.1 ft	Pressure - 24.4 ft	$v^2/2g$ - 3.5 ft	
	Head - 114.5 ft		Head - 85.5 ft		Head - 57.0 ft		Head - 27.9 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	112.5	0.983	86.1	1.010	56.4	0.990	26.4	0.946	0.982
2	73.3	0.640	55.9	0.654	36.6	0.643	17.6	0.631	0.642
3	0.1	0.001	-0.1	-0.001	0.8	0.014	0.2	0.007	0.005
4	0.2	0.002	-0.3	-0.004	1.1	0.019	0.6	0.022	0.010
5	1.1	0.010	0.8	0.009	0.6	0.010	0.3	0.011	0.010
6	71.4	0.623	54.4	0.636	36.0	0.632	17.0	0.610	0.625
7	0.1	0.001	-0.1	-0.001	0.7	0.012	0.2	0.007	0.005
8	0.2	0.002	-0.2	-0.002	1.1	0.019	0.3	0.011	0.007
9	2.4	0.021	1.3	0.015	0.6	0.010	1.6	0.057	0.026
10	58.4	0.510	44.0	0.515	29.4	0.516	13.7	0.492	0.508
11	-0.2	-0.002	-0.6	-0.007	0.2	0.004	0.0	0.000	-0.001
12	0.2	0.002	0.0	0.000	0.6	0.010	0.2	0.007	0.005
13	7.0	0.061	4.7	0.055	3.4	0.059	1.6	0.057	0.058

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 8.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A30

## PRESSURE DATA - TYPE D GATE LIP

GATE OPEN 4.0 FT

Piez. No.	Discharge - 1085 cfs		Discharge - 945.0 cfs		Discharge - 758.0 cfs		Discharge - 526.0 cfs		Average C
	Pressure - 100.0 ft	$V^2/2g$ - 31.8 ft	Pressure - 75.0 ft	$V^2/2g$ - 24.1 ft	Pressure - 50.0 ft	$V^2/2g$ - 15.5 ft	Pressure - 25.0 ft	$V^2/2g$ - 7.5 ft	
	Head - 131.8 ft		Head - 99.1 ft		Head - 65.5 ft		Head - 32.5 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	125.3	0.951	95.6	0.965	62.1	0.948	30.0	0.923	0.947
2	90.5	0.687	67.6	0.682	45.7	0.698	22.4	0.689	0.689
3	0.8	0.006	0.5	0.005	0.2	0.003	0.7	0.022	0.009
4	0.0	0.000	0.3	0.003	0.4	0.006	0.8	0.025	0.008
5	0.1	0.001	0.3	0.003	2.3	0.035	0.6	0.018	0.014
6	87.4	0.663	66.2	0.668	44.7	0.682	21.9	0.674	0.672
7	1.9	0.014	1.0	0.010	0.3	0.005	0.5	0.015	0.011
8	0.3	0.002	0.6	0.006	0.5	0.008	1.0	0.031	0.012
9	0.7	0.005	0.9	0.009	1.9	0.029	1.1	0.034	0.019
10	67.6	0.513	50.9	0.514	34.1	0.521	16.8	0.517	0.516
11	0.2	0.002	-0.6	-0.006	0.1	0.001	0.3	0.009	0.001
12	0.1	0.001	0.6	0.006	0.5	0.008	0.9	0.028	0.011
13	4.1	0.031	2.9	0.030	2.2	0.033	1.4	0.043	0.034

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 8.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A31

PRESSURE DATA - TYPE D GATE LIP

GATE OPEN 5.0 FT

Piez. No.	Discharge - 1772 cfs		Discharge - 1520 cfs		Discharge - 1220 cfs		Discharge - 840.0 cfs		Average C
	Pressure - 100.0 ft	Pressure - 75.0 ft	Pressure - 50.0 ft	Pressure - 25.0 ft	$V^2/2g$ - 84.8 ft	$V^2/2g$ - 62.2 ft	$V^2/2g$ - 40.1 ft	$V^2/2g$ - 19.1 ft	
	Head - 184.8 ft	Head - 137.2 ft	Head - 90.1 ft	Head - 44.1 ft	Pressure : C	Pressure : C	Pressure : C	Pressure : C	
1	141.9	0.768	104.0	0.758	65.0	0.721	30.1	0.683	0.733
2	154.7	0.837	115.2	0.840	73.6	0.817	33.7	0.765	0.815
3	0.3	0.002	-0.9	-0.007	-0.5	-0.006	0.4	0.009	-0.001
4	0.4	0.003	-1.1	-0.008	-0.5	-0.006	0.2	0.005	-0.002
5	0.4	0.003	-0.4	-0.003	-0.2	-0.002	0.8	0.018	0.004
6	152.2	0.824	112.4	0.819	73.0	0.810	33.2	0.753	0.805
7	0.5	0.003	-0.9	-0.007	-0.5	-0.006	0.1	0.002	-0.002
8	0.4	0.003	-1.1	-0.008	-0.4	-0.004	0.2	0.005	-0.001
9	1.0	0.005	-0.5	-0.004	-0.6	-0.007	0.8	0.018	0.003
10	104.8	0.567	81.1	0.591	53.0	0.588	25.2	0.571	0.579
11	-1.3	-0.007	-2.8	-0.020	-1.0	-0.011	-0.1	-0.002	-0.010
12	-0.6	-0.003	-2.2	-0.016	-0.7	-0.008	-0.1	-0.002	-0.007
13	3.0	0.016	0.3	0.002	-0.2	-0.002	0.4	0.009	0.006

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 8.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

Pressure coefficient C = 
$$\frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A32

PRESSURE DATA - TYPE D GATE LIP

GATE OPEN 6.0 FT

Piez. No.	Discharge - 2360 cfs		Discharge - 1795 cfs		Average C
	Pressure	$v^2/2g$	Pressure	$v^2/2g$	
	42.5 ft	150.1 ft	25.0 ft	87.0 ft	
	192.6 ft		112.0 ft		
	C		C		
1	42.1	0.219	21.8	0.194	0.207
2	43.3	0.225	23.0	0.205	0.215
3	38.3	0.199	20.5	0.183	0.191
4	49.1	0.255	26.6	0.238	0.247
5	12.8	0.066	6.8	0.061	0.064
6	43.3	0.225	23.0	0.205	0.215
7	41.0	0.213	21.8	0.194	0.204
8	49.1	0.255	26.6	0.238	0.247
9	12.8	0.066	6.8	0.061	0.064
10	45.5	0.236	24.6	0.220	0.228
11	35.1	0.182	18.4	0.164	0.173
12	40.4	0.210	20.8	0.186	0.198
13	24.7	0.128	13.3	0.119	0.124

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 8.  
 Figures in heading refer to control piezometer located in the conduit  
 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A33

## PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 0.25 FT

Piez. No.	Discharge - 98.0 cfs		Discharge - 80.0 cfs		Discharge - 67.0 cfs		Discharge - 53.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	101.6	1.013	77.2	1.027	49.9	0.996	24.8	0.988	1.006
	101.7	1.014	77.0	1.024	50.4	1.006	25.2	1.004	1.012
	101.2	1.009	76.8	1.021	50.3	1.004	25.2	1.004	1.009
	100.7	1.004	76.5	1.017	50.1	1.000	25.2	1.004	1.006
	100.2	0.999	76.1	1.012	50.2	1.002	25.5	1.016	1.007
	0.3	0.003	0.3	0.004	0.3	0.006	0.4	0.016	0.007
	101.9	1.016	77.4	1.029	50.2	1.002	25.3	1.008	1.014
	100.5	1.002	76.3	1.015	49.9	0.996	25.0	0.996	1.002
	101.1	1.008	76.8	1.021	50.2	1.002	25.4	1.012	1.011
	100.2	0.999	76.1	1.012	50.2	1.002	25.4	1.012	1.006
	0.4	0.004	0.3	0.004	0.3	0.006	0.3	0.012	0.006
	100.7	1.004	76.7	1.020	50.3	1.004	25.9	1.032	1.015
	100.1	0.998	76.0	1.011	50.1	1.000	25.7	1.024	1.008
	97.6	0.973	74.2	0.987	49.1	0.980	25.1	1.000	0.985
	23.8	0.237	15.5	0.206	12.5	0.249	3.8	0.151	0.211

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 9.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A34

## PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 0.5 FT

Piez. No.	Discharge - 163.0 cfs		Discharge - 135.0 cfs		Discharge - 108.0 cfs		Discharge - 75.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	101.1	1.004	75.0	0.993	50.1	0.996	24.5	0.976	0.992
1	100.3	0.996	74.6	0.988	49.8	0.990	24.8	0.988	0.990
2	98.9	0.982	73.7	0.976	49.4	0.982	24.8	0.988	0.982
3	97.9	0.972	73.1	0.968	49.0	0.974	24.6	0.980	0.973
4	96.1	0.954	71.9	0.952	48.4	0.962	24.6	0.980	0.962
5	0.4	0.004	0.2	0.003	0.2	0.004	0.3	0.012	0.006
6	100.3	0.996	74.6	0.988	49.8	0.990	24.8	0.988	0.990
7	98.9	0.982	73.6	0.975	49.4	0.982	24.8	0.988	0.982
8	98.3	0.976	73.1	0.968	49.1	0.976	24.7	0.984	0.976
9	95.8	0.951	72.9	0.966	48.4	0.962	24.6	0.980	0.965
10	0.2	0.002	0.2	0.003	0.1	0.002	0.5	0.020	0.007
11	100.0	0.993	73.9	0.979	49.9	0.992	24.5	0.976	0.985
12	97.8	0.971	72.6	0.962	49.0	0.974	24.6	0.980	0.972
13	92.4	0.918	68.6	0.909	46.1	0.917	23.0	0.916	0.915
14	17.9	0.178	12.8	0.170	7.2	0.143	1.8	0.072	0.141

NOTE: Pressures are in prototype ft of water.  
Piezometer locations shown on plate 9.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A35

## PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 1.0 FT

Pies. No.	Discharge - 272.0 cfs		Discharge - 235.0 cfs		Discharge - 194.0 cfs		Discharge - 140.0 cfs		Average C
	Pressure - 100.0 ft		Pressure - 75.0 ft		Pressure - 50.0 ft		Pressure - 25.0 ft		
	$v^2/2g$ - 2.0 ft	Head - 102.0 ft	$v^2/2g$ - 1.5 ft	Head - 76.5 ft	$v^2/2g$ - 1.0 ft	Head - 51.0 ft	$v^2/2g$ - 0.5 ft	Head - 25.5 ft	
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	100.6	0.986	74.8	0.978	49.7	0.975	24.3	0.953	0.973
2	98.1	0.962	73.2	0.957	48.9	0.959	24.2	0.949	0.957
3	94.8	0.929	70.8	0.925	47.6	0.933	23.5	0.922	0.927
4	92.6	0.908	69.0	0.902	46.5	0.912	23.0	0.902	0.906
5	89.7	0.879	67.2	0.878	45.2	0.886	22.8	0.894	0.884
6	0.4	0.004	0.2	0.003	0.5	0.010	0.5	0.020	0.009
7	98.2	0.963	73.2	0.957	48.9	0.959	24.2	0.949	0.957
8	94.8	0.928	70.8	0.925	47.6	0.933	23.5	0.922	0.927
9	92.6	0.908	69.0	0.902	46.4	0.910	23.0	0.902	0.905
10	89.7	0.879	67.1	0.877	45.2	0.886	22.8	0.894	0.884
11	0.4	0.004	0.2	0.003	0.5	0.010	0.3	0.012	0.007
12	95.5	0.936	71.4	0.933	47.8	0.937	24.0	0.941	0.937
13	90.2	0.884	67.4	0.881	45.4	0.890	22.8	0.894	0.887
14	79.9	0.783	60.1	0.786	40.3	0.790	20.3	0.796	0.789
15	18.7	0.183	15.7	0.205	9.8	0.192	3.5	0.137	0.179

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 9.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A36

PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 2.0 FT

Pies. No.	Discharge - 503.0 cfs		Discharge - 428.0 cfs		Discharge - 360.0 cfs		Discharge - 260.0 cfs		Average C
	Pressure - 100.0 ft	$v^2/2g$ - 6.8 ft	Pressure - 75.0 ft	$v^2/2g$ - 4.9 ft	Pressure - 50.0 ft	$v^2/2g$ - 3.5 ft	Pressure - 25.0 ft	$v^2/2g$ - 1.8 ft	
	Head - 106.8 ft		Head - 79.9 ft		Head - 53.5 ft		Head - 26.8 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	104.9	0.982	77.6	0.971	51.6	0.964	25.1	0.937	0.963
2	99.8	0.934	74.6	0.934	49.7	0.929	24.4	0.910	0.927
3	93.5	0.875	69.3	0.867	46.3	0.865	22.8	0.851	0.865
4	89.1	0.834	65.8	0.824	44.2	0.826	21.9	0.817	0.825
5	85.0	0.796	62.7	0.785	42.4	0.793	21.3	0.795	0.792
6	0.4	0.004	0.7	0.009	0.9	0.017	0.8	0.030	0.015
7	99.7	0.934	74.5	0.932	49.6	0.927	23.5	0.877	0.918
8	93.7	0.877	69.6	0.871	46.6	0.871	23.0	0.858	0.869
9	89.1	0.834	65.8	0.824	44.2	0.826	21.9	0.817	0.825
10	85.3	0.799	62.9	0.787	42.5	0.794	21.3	0.795	0.794
11	0.3	0.003	0.5	0.006	0.8	0.015	0.7	0.26	0.012
12	94.8	0.888	69.8	0.874	47.0	0.879	23.3	0.869	0.878
13	85.0	0.796	62.9	0.787	42.3	0.791	21.3	0.795	0.792
14	69.0	0.646	51.5	0.645	34.7	0.649	17.1	0.638	0.645
15	-2.2	-0.021	-2.2	-0.028	0.8	0.015	0.9	0.034	0.000

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 9.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A37

PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 3.0 FT

Piez. No.	Discharge - 778.0 cfs		Discharge - 665.0 cfs		Discharge - 542.0 cfs		Discharge - 376.0 cfs		Average C
	Pressure - 100.0 ft		Pressure - 75.0 ft		Pressure - 50.0 ft		Pressure - 25.0 ft		
	$V^2/2g$ - 16.3 ft		$V^2/2g$ - 11.9 ft		$V^2/2g$ - 7.9 ft		$V^2/2g$ - 3.8 ft		
	Head - 116.3 ft		Head - 86.9 ft		Head - 57.9 ft		Head - 28.8 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	112.4	0.966	82.4	0.948	54.6	0.943	25.0	0.868	0.931
2	111.1	0.955	82.6	0.954	54.9	0.948	25.6	0.889	0.936
3	104.7	0.900	78.6	0.904	52.0	0.898	24.3	0.844	0.887
4	96.7	0.831	72.3	0.831	48.0	0.829	22.6	0.785	0.819
5	88.5	0.761	66.0	0.759	44.7	0.772	21.2	0.736	0.757
6	0.7	0.006	0.7	0.008	0.7	0.012	0.7	0.024	0.012
7	111.0	0.954	82.5	0.949	54.8	0.946	25.5	0.885	0.934
8	104.8	0.901	78.7	0.906	52.1	0.900	24.3	0.844	0.888
9	96.7	0.831	72.3	0.831	48.0	0.829	22.6	0.785	0.819
10	88.4	0.760	65.8	0.757	44.6	0.770	21.0	0.729	0.754
11	0.6	0.005	1.9	0.022	1.9	0.033	0.3	0.010	0.018
12	101.4	0.872	75.8	0.872	51.4	0.888	24.2	0.840	0.868
13	91.1	0.783	67.6	0.778	46.1	0.796	21.7	0.753	0.778
14	70.1	0.603	51.9	0.597	35.1	0.606	16.3	0.566	0.593
15	3.3	0.028	2.8	0.032	2.4	0.041	0.4	0.014	0.029

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 9.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A38

PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 4.0 FT

Piez. No.	Discharge - 1125.0 cfs		Discharge - 968.0 cfs		Discharge - 802.0 cfs		Discharge - 548.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	113.3	0.845	83.5	0.832	53.6	0.795	25.2	0.761	0.808
2	121.7	0.908	91.2	0.909	57.0	0.846	27.3	0.825	0.872
3	124.4	0.928	92.9	0.926	59.8	0.887	28.7	0.867	0.902
4	120.2	0.896	89.0	0.887	59.1	0.877	28.2	0.852	0.878
5	105.5	0.787	78.5	0.783	51.9	0.770	25.3	0.764	0.776
6	-0.3	-0.002	-0.3	-0.003	0.5	0.007	0.5	0.015	0.004
7	121.7	0.908	91.2	0.909	57.0	0.846	27.3	0.825	0.872
8	123.7	0.922	92.0	0.917	59.8	0.887	28.5	0.861	0.897
9	120.2	0.896	89.1	0.888	59.2	0.878	28.2	0.852	0.878
10	105.5	0.787	78.5	0.783	51.9	0.770	25.3	0.764	0.776
11	-0.4	-0.003	-0.3	-0.003	0.4	0.006	0.5	0.015	0.004
12	117.4	0.875	86.9	0.866	56.2	0.834	26.8	0.810	0.846
13	111.6	0.832	82.6	0.824	54.9	0.815	26.1	0.789	0.815
14	85.7	0.639	63.5	0.633	41.4	0.614	20.1	0.607	0.623
15	-4.0	-0.030	-2.2	-0.022	0.1	0.001	-0.2	-0.006	-0.014

NOTE: Pressures are in prototype ft of water.  
 Piezometer locations shown on plate 9.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A39

PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 5.0 FT

Piez. No.	Discharge - 1715.0 cfs		Discharge - 1475.0 cfs		Discharge - 1200.0 cfs		Discharge - 830.0 cfs		Average C
	Pressure	Head	Pressure	Head	Pressure	Head	Pressure	Head	
1	136.7	0.765	101.4	0.758	66.0	0.743	29.7	0.681	0.738
2	132.1	0.740	98.3	0.735	64.8	0.730	29.4	0.674	0.720
3	134.3	0.752	100.8	0.753	66.6	0.750	30.7	0.704	0.740
4	138.3	0.774	103.0	0.770	67.4	0.760	31.2	0.716	0.755
5	156.0	0.874	116.9	0.874	75.7	0.852	35.6	0.817	0.854
6	-2.0	-0.011	-0.6	-0.004	-0.4	-0.005	0.3	0.007	-0.003
7	132.7	0.743	100.0	0.747	64.8	0.730	30.3	0.695	0.729
8	135.0	0.756	100.8	0.753	66.6	0.750	30.5	0.700	0.740
9	138.3	0.774	103.0	0.770	67.4	0.760	31.2	0.716	0.755
10	157.1	0.880	116.9	0.874	75.7	0.852	35.6	0.817	0.856
11	-2.0	-0.011	-0.6	-0.004	-0.4	-0.005	0.3	0.007	-0.003
12	133.1	0.745	98.8	0.738	63.4	0.714	29.8	0.683	0.720
13	129.5	0.725	96.2	0.720	62.8	0.707	29.8	0.683	0.709
14	120.6	0.675	90.8	0.679	59.8	0.673	27.8	0.638	0.666
15	9.1	0.051	12.1	0.091	8.0	0.090	3.7	0.085	0.079

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 9.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A40

PRESSURE DATA - TYPE E GATE LIP

GATE OPEN 6.0 FT

Piez. No.	Discharge - 2395 cfs		Discharge - 2087 cfs		Average C
	Pressure - 38.9 ft	$V^2/2g$ - 154.6 ft	Pressure - 25.0 ft	$V^2/2g$ - 117.4 ft	
	Head - 193.5 ft		Head - 142.4 ft		
	Pressure	C	Pressure	C	
1	42.0	0.217	26.5	0.186	0.201
2	34.1	0.176	21.1	0.148	0.162
3	39.7	0.205	25.6	0.180	0.192
4	47.6	0.246	30.6	0.215	0.231
5	35.3	0.182	22.6	0.159	0.171
6	17.8	-0.092	-16.7	0.117	0.104
7	34.7	0.179	27.8	0.153	0.166
8	38.4	0.198	24.0	0.168	0.183
9	47.6	0.246	30.9	0.217	0.232
10	35.3	0.182	22.6	0.159	0.171
11	-24.9	-0.129	-24.2	-0.170	-0.150
12	39.1	0.202	25.2	0.177	0.190
13	37.0	0.191	23.3	0.163	0.177
14	36.3	0.188	23.0	0.161	0.174
15	16.6	0.086	8.2	0.057	0.071

NOTE: Pressures are in prototype ft of water.

Piezometer locations shown on plate 9.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{Pressure at numbered piezometer}}{\text{Pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A41

PRESSURE DATA - TYPE F GATE LIE

GATE OPEN 0.5 FT

Piez. No.	Discharge - 334.0 cfs		Discharge - 287.0 cfs		Discharge - 240.0 cfs		Discharge - 190.0 cfs		Average G
	Pressure - 100.0 ft	$v^2/2g$ - 0.4 ft	Pressure - 75.0 ft	$v^2/2g$ - 0.3 ft	Pressure - 50.0 ft	$v^2/2g$ - 0.2 ft	Pressure - 25.0 ft	$v^2/2g$ - 0.1 ft	
	Head - 100.4 ft		Head - 75.3 ft		Head - 75.3 ft		Head - 25.1 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	102.7	1.023	76.4	1.015	52.0	1.036	26.7	1.064	1.035
2	98.7	0.983	73.7	0.979	50.3	1.002	26.4	1.052	1.004
3	93.5	0.931	69.8	0.927	47.9	0.954	25.0	0.996	0.952
4	88.3	0.879	66.4	0.882	45.5	0.906	24.0	0.956	0.906
5	81.2	0.809	61.1	0.811	42.0	0.837	22.4	0.892	0.837
6	1.4	0.014	1.4	0.019	1.4	0.028	1.5	0.060	0.030
7	99.8	0.994	74.4	0.988	50.8	1.012	26.5	1.056	1.012
8	93.5	0.931	70.0	0.930	47.9	0.954	25.0	0.996	0.953
9	88.3	0.879	66.4	0.882	45.5	0.906	24.0	0.956	0.906
10	81.2	0.809	61.1	0.811	42.0	0.837	22.4	0.892	0.837
11	1.3	0.013	1.4	0.019	1.4	0.028	1.3	0.052	0.028
12	97.7	0.973	72.8	0.967	50.2	1.000	26.1	1.040	0.995
13	91.3	0.909	68.3	0.907	47.0	0.936	24.9	0.992	0.936
14	82.8	0.825	62.5	0.830	43.0	0.857	22.8	0.908	0.855
15	-3.9	-0.039	-2.7	-0.036	-1.7	0.034	-0.6	-0.024	-0.033

NOTES: Pressures are in prototype feet of water.  
 Piezometer locations shown on plate 10.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{pressure at numbered piezometer}}{\text{pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A42

PRESSURE DATA - TYPE F GATE LIP

GATE OPEN 1.0 FT

Pies. No.	Discharge - 510.0 cfs		Discharge - 441.0 cfs		Discharge - 352.0 cfs		Discharge - 269.0 cfs		Average C
	Pressure - 100.0 ft	$v^2/2g$ - 0.9 ft	Pressure - 75.0 ft	$v^2/2g$ - 0.7 ft	Pressure - 50.0 ft	$v^2/2g$ - 0.4 ft	Pressure - 25.0 ft	$v^2/2g$ - 0.3 ft	
	Head - 100.9 ft		Head - 75.7 ft		Head - 50.4 ft		Head - 25.3 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	98.2	0.973	76.2	1.007	50.7	1.006	26.4	1.043	1.007
2	88.9	0.881	69.1	0.913	46.4	0.921	24.5	0.968	0.921
3	79.8	0.791	62.1	0.820	41.9	0.831	22.1	0.874	0.829
4	75.0	0.743	58.3	0.770	39.1	0.776	20.9	0.826	0.779
5	70.3	0.697	54.3	0.717	36.8	0.730	20.0	0.791	0.734
6	1.2	0.012	1.2	0.016	1.2	0.024	1.2	0.047	0.025
7	90.1	0.893	70.2	0.927	47.0	0.933	25.0	0.988	0.935
8	80.1	0.794	62.3	0.823	41.8	0.829	22.4	0.885	0.833
9	75.0	0.743	58.3	0.770	39.1	0.776	20.9	0.826	0.779
10	70.1	0.695	54.0	0.713	36.4	0.722	19.7	0.779	0.727
11	1.7	0.017	1.3	0.017	1.4	0.028	1.3	0.051	0.028
12	88.7	0.879	66.8	0.882	44.8	0.888	23.7	0.937	0.897
13	78.0	0.773	59.7	0.789	40.2	0.798	21.5	0.850	0.803
14	70.0	0.694	53.7	0.709	36.2	0.718	19.7	0.779	0.725
15	3.9	0.039	2.6	0.034	2.9	0.058	1.7	0.067	0.050

NOTES: Pressures are in prototype feet of water.  
 Piezometer locations shown on plate 10.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{pressure at numbered piezometer}}{\text{pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A43

## PRESSURE DATA - TYPE F GATE LIP

GATE OPEN 3.0 FT

Piez. No.	Discharge - 1328.0 cfs		Discharge - 1163.0 cfs		Discharge - 951.0 cfs		Discharge - 700.0 cfs		Average C
	Pressure - 100.0 ft		Pressure - 75.0 ft		Pressure - 50.0 ft		Pressure - 25.0 ft		
	$V^2/2g - 6.2$ ft		$V^2/2g - 4.7$ ft		$V^2/2g - 3.1$ ft		$V^2/2g - 1.7$ ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	99.1	0.933	74.3	0.932	49.2	0.927	24.7	0.925	0.929
2	70.4	0.663	53.6	0.672	35.3	0.665	17.7	0.663	0.666
3	51.5	0.485	38.7	0.485	25.1	0.473	12.9	0.483	0.481
4	49.8	0.469	37.6	0.472	24.7	0.465	13.0	0.487	0.473
5	54.0	0.508	40.5	0.508	26.7	0.507	14.2	0.532	0.514
6	1.1	0.010	0.9	0.011	0.9	0.017	1.1	0.041	0.020
7	75.0	0.707	56.3	0.706	37.0	0.697	19.0	0.712	0.705
8	52.2	0.492	39.0	0.489	25.8	0.486	13.2	0.494	0.490
9	49.1	0.462	36.8	0.462	24.3	0.458	12.6	0.472	0.463
10	53.2	0.501	39.8	0.499	26.4	0.497	13.8	0.517	0.504
11	1.1	0.010	0.9	0.011	1.2	0.022	1.1	0.041	0.021
12	66.2	0.623	48.4	0.607	32.2	0.607	15.2	0.569	0.602
13	40.9	0.385	30.7	0.385	20.5	0.386	10.6	0.398	0.388
14	37.1	0.349	28.0	0.351	18.6	0.350	10.0	0.374	0.356
15	-1.1	-0.010	-1.0	-0.012	-0.4	-0.008	0.4	0.015	-0.004

NOTES: Pressures are in prototype feet of water.

Piezometer locations shown on plate 10.

Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{pressure at numbered piezometer}}{\text{pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A44

PRESSURE DATA - TYPE F GATE LIP

GATE OPEN 5.0 FT

Piez. No.	Discharge - 2225.0 cfs			Discharge - 1849.0 cfs			Discharge - 1569.0 cfs			Discharge - 1127.0 cfs			Average C
	Pressure	$V^2/2g$	Head	Pressure	$V^2/2g$	Head	Pressure	$V^2/2g$	Head	Pressure	$V^2/2g$	Head	
	Pressure	C		Pressure	C		Pressure	C		Pressure	C		
1	111.9	0.954	84.5	0.970	54.8	0.934	26.4	0.898	0.939				
2	72.0	0.614	53.9	0.619	35.7	0.608	17.2	0.585	0.607				
3	44.7	0.381	32.5	0.373	20.7	0.353	9.4	0.320	0.357				
4	43.5	0.371	32.2	0.370	21.2	0.361	10.2	0.347	0.362				
5	51.1	0.436	38.3	0.440	25.1	0.428	12.6	0.429	0.433				
6	0.4	0.003	0.8	0.009	0.8	0.013	1.1	0.037	0.015				
7	78.0	0.665	58.1	0.667	38.3	0.652	18.5	0.629	0.653				
8	45.5	0.388	33.4	0.383	21.9	0.373	10.5	0.357	0.375				
9	42.1	0.359	31.0	0.356	20.2	0.344	9.9	0.337	0.349				
10	49.7	0.424	37.3	0.428	24.3	0.414	12.2	0.415	0.420				
11	0.4	0.003	0.8	0.009	1.3	0.022	1.1	0.037	0.018				
12	66.6	0.568	49.1	0.564	31.7	0.540	14.1	0.480	0.538				
13	34.0	0.290	25.5	0.293	16.6	0.283	8.2	0.279	0.286				
14	30.2	0.257	22.2	0.255	15.0	0.255	7.5	0.255	0.256				
15	-1.1	-0.009	-0.8	-0.009	-0.1	-0.002	0.5	0.017	-0.001				

NOTES: Pressures are in prototype feet of water.  
 Piezometer locations shown on plate 10.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient C} = \frac{\text{pressure at numbered piezometer}}{\text{pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A45

## PRESSURE DATA - TYPE F GATE LIP

GATE OPEN 7.0 FT

Piez. No.	Discharge - 3545.0 cfs		Discharge - 3096.0 cfs		Discharge - 2496.0 cfs		Discharge - 1738.0 cfs		Average C
	Pressure	Head	Pressure	Head	Pressure	Head	Pressure	Head	
	100.0 ft	143.9 ft	75.0 ft	108.4 ft	50.0 ft	71.8 ft	25.0 ft	35.5 ft	
	$v^2/2g$ - 43.9 ft		$v^2/2g$ - 33.4 ft		$v^2/2g$ - 21.8 ft		$v^2/2g$ - 10.5 ft		
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
1	131.8	0.916	98.9	0.912	63.8	0.889	29.6	0.834	0.888
2	109.5	0.761	82.0	0.756	52.7	0.734	25.1	0.707	0.739
3	71.8	0.499	54.2	0.500	34.9	0.487	15.6	0.439	0.481
4	59.4	0.413	44.5	0.411	28.9	0.403	13.7	0.386	0.403
5	63.0	0.438	47.3	0.436	30.9	0.430	14.5	0.408	0.428
6	-0.2	-0.001	0.4	0.004	0.6	0.008	1.0	0.028	0.010
7	114.9	0.798	85.8	0.792	55.8	0.777	26.3	0.741	0.777
8	71.5	0.497	53.9	0.497	35.6	0.496	16.6	0.468	0.489
9	58.5	0.407	43.9	0.405	29.7	0.414	13.3	0.375	0.400
10	61.3	0.426	46.1	0.425	29.6	0.412	13.9	0.392	0.414
11	0.0	0.000	0.4	0.004	0.6	0.008	1.0	0.028	0.010
12	91.7	0.637	68.5	0.632	44.4	0.618	20.9	0.589	0.619
13	52.6	0.366	39.2	0.362	26.0	0.362	12.1	0.341	0.358
14	37.8	0.263	27.5	0.254	18.3	0.255	8.7	0.245	0.254
15	-1.9	-0.013	-0.9	-0.008	-0.1	-0.001	0.6	0.017	0.001

NOTES: Pressures are in prototype feet of water.  
Piezometer locations shown on plate 10.  
Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{pressure at numbered piezometer}}{\text{pressure} + \frac{v^2}{2g} \text{ at control piezometer}}$$

TABLE A46

PRESSURE DATA - TYPE F GATE LIP

GATE OPEN 9.0 FT

Piez. No.	Discharge - 6237.0 cfs		Discharge - 5356.0 cfs		Discharge - 4307.0 cfs		Discharge - 2844.0 cfs		Average C
	Pressure	C	Pressure	C	Pressure	C	Pressure	C	
	100.0 ft		75.0 ft		50.0 ft		25.0 ft		
	$v^2/2g - 135.8$ ft		$v^2/2g - 100.1$ ft		$v^2/2g - 64.7$ ft		$v^2/2g - 28.2$ ft		
	Head - 235.8 ft		Head - 175.1 ft		Head - 114.7 ft		Head - 53.2 ft		
1	132.0	0.560	97.6	0.557	62.7	0.547	26.0	0.489	0.538
2	174.5	0.740	129.3	0.738	83.2	0.725	36.3	0.682	0.721
3	209.2	0.887	158.7	0.906	91.7	0.799	44.9	0.844	0.859
4	175.0	0.742	130.0	0.742	84.2	0.734	35.8	0.673	0.723
5	143.7	0.609	107.0	0.611	68.8	0.600	29.1	0.547	0.592
6	-2.5	-0.011	-2.1	-0.012	-0.3	-0.003	1.1	0.021	-0.001
7	187.8	0.796	138.8	0.793	89.0	0.776	39.6	0.744	0.777
8	212.9	0.903	158.7	0.906	102.2	0.891	43.6	0.820	0.880
9	175.9	0.746	132.2	0.755	85.8	0.748	35.8	0.673	0.731
10	143.7	0.609	106.6	0.609	68.6	0.598	29.1	0.547	0.591
11	-2.5	-0.011	-2.1	-0.012	-0.3	-0.003	1.1	0.021	-0.001
12	135.4	0.574	99.9	0.571	64.3	0.561	27.6	0.519	0.556
13	134.7	0.571	101.8	0.581	64.8	0.565	29.4	0.553	0.568
14	93.6	0.397	69.9	0.399	45.7	0.398	20.3	0.382	0.394
15	-4.8	-0.020	-3.1	-0.018	-1.4	-0.012	0.7	0.013	-0.009

NOTES: Pressures are in prototype feet of water.  
 Piezometer locations shown on plate 10.  
 Figures in heading refer to control piezometer located in the conduit 12 ft upstream from the test section.

$$\text{Pressure coefficient } C = \frac{\text{pressure at numbered piezometer}}{\text{pressure} + \frac{V^2}{2g} \text{ at control piezometer}}$$

TABLE A-47

## PRESSURES DOWNSTREAM FROM GATE SLOT

Type A Gate Lip

Piez. Number	Pressure Head, 100 Ft		Pressure Head, 75 Ft		Pressure Head, 50 Ft		Pressure Head, 25 Ft		Pressure Head, 15 Ft	
	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure
3.0-Ft Gate Opening										
1	18.3	19.1	10.1	10.9	4.5	5.3	1.6	2.4	0.6	1.4
2	-1.7	-1.3	-1.9	-1.5	-1.1	-0.7	-0.9	-0.5	-0.8	-0.4
3	-0.5	-0.1	-1.2	-0.8	-0.7	-0.3	-0.5	-0.1	-0.4	0.0
4	2.2	2.6	1.1	1.5	0.8	1.2	0.2	0.6	0.1	0.5
5	-0.6	-1.0	-0.7	-1.1	-0.3	-0.7	-0.2	-0.6	-0.2	-0.6
6	-0.7	-1.1	-0.8	-1.2	-0.2	-0.6	0.0	-0.4	0.1	-0.3
4.0-Ft Gate Opening										
1	30.4	31.2	22.1	22.9	14.2	15.0	7.0	7.8	4.3	5.1
2	30.0	30.4	22.7	23.1	15.2	15.6	8.0	8.4	5.0	5.4
3	19.9	20.3	15.2	15.6	10.0	10.4	5.4	5.8	3.4	3.8
4	7.7	8.1	5.6	6.0	3.4	3.8	1.7	2.1	1.1	1.5
5	1.8	1.4	0.5	0.1	1.0	0.6	0.3	-0.1	0.2	-0.2
6	-4.8	-5.2	-4.4	-4.8	-3.8	-4.2	-2.0	-2.4	-1.3	-1.7
5.0-Ft Gate Opening										
1	48.3	49.1	37.0	37.8	24.7	25.5	12.9	13.7	8.1	8.9
2	53.7	54.1	40.7	41.1	27.3	27.7	14.1	14.5	8.8	9.2
3	33.3	33.7	26.1	26.5	17.5	17.9	9.5	9.9	6.0	6.4
4	15.2	15.6	12.1	12.5	8.3	8.7	5.0	5.4	3.4	3.8
5	26.7	26.3	21.0	20.6	13.6	13.2	7.7	7.3	5.0	4.6
6	-3.7	-4.1	-2.0	-2.4	-1.0	-1.4	0.5	0.1	0.9	0.5

NOTES: Piezometer locations shown on plate 28.

All piezometer readings referred to centerline of conduit.

Head refers to pressure at control piezometer located in the conduit 12 ft upstream from the test section.

TABLE A-48

PRESSURES DOWNSTREAM FROM GATE SLOT

Type B Gate Lip

Piez. Number	Pressure Head, 100 Ft		Pressure Head, 75 Ft		Pressure Head, 50 Ft		Pressure Head, 25 Ft		Pressure Head, 15 Ft	
	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure
3.0-Ft Gate Opening										
1	32.8	33.6	24.4	25.2	15.9	16.7	7.7	8.5	4.6	5.4
2	27.5	27.9	19.2	19.6	11.7	12.1	5.2	5.6	3.0	3.4
3	12.5	12.9	9.5	9.9	6.2	6.6	2.6	3.0	1.4	1.8
4	3.5	3.9	3.0	3.4	2.0	2.4	0.6	1.0	0.4	0.8
5	11.2	10.8	6.8	6.4	2.9	2.5	0.8	0.4	0.6	0.2
6	----	----	----	----	----	----	---	---	---	---
4.0-Ft Gate Opening										
1	45.9	46.7	34.9	35.7	23.5	24.3	12.1	12.9	7.3	8.1
2	45.4	45.8	33.9	34.3	22.8	23.2	11.7	12.1	7.1	7.5
3	30.0	30.4	22.4	22.8	15.3	15.7	7.9	8.3	4.9	5.3
4	11.8	12.2	8.7	9.1	6.3	6.7	3.3	3.7	2.1	2.5
5	11.3	10.9	8.9	8.5	6.8	6.4	3.7	3.3	2.8	2.4
6	-7.7	-8.1	-5.7	-6.1	-3.5	-3.9	-1.3	-1.7	-0.7	-1.1
5.0-Ft Gate Opening										
1	53.6	54.4	41.0	41.8	27.5	28.3	14.1	14.9	9.0	9.8
2	71.0	71.4	55.1	55.5	36.7	37.1	18.8	19.2	11.4	11.8
3	48.5	48.9	36.7	37.1	24.5	24.9	13.0	13.4	8.1	8.5
4	23.8	24.2	18.6	19.0	12.1	12.5	6.9	7.3	4.5	4.9
5	75.9	75.5	58.0	57.6	38.4	38.0	20.3	19.9	12.0	11.6
6	6.6	6.2	5.5	5.1	3.3	2.9	2.6	2.2	2.1	1.7

NOTES: Piezometer locations shown on plate 28.

All piezometer readings referred to centerline of conduit.

Head refers to pressure at control piezometer located in the conduit 12 ft upstream from the test section.

TABLE A-49

## PRESSURES DOWNSTREAM FROM GATE SLOT

Type C Gate Lip

Piez. Number	Pressure Head, 100 Ft		Pressure Head, 75 Ft		Pressure Head, 50 Ft		Pressure Head, 25 Ft		Pressure Head, 15 Ft	
	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure
3.0-Ft Gate Opening										
1	28.7	29.5	21.6	22.4	14.3	15.1	7.0	7.8	4.2	5.0
2	19.3	19.7	14.5	14.9	9.9	10.3	4.8	5.2	2.6	3.0
3	6.9	7.3	5.3	5.7	3.5	3.9	1.7	2.1	0.9	1.3
4	2.1	2.5	1.7	2.1	1.0	1.4	0.3	0.7	0.1	0.5
5	----	----	----	----	----	----	0.3	-0.1	0.4	0.0
6	----	----	----	----	----	----	0.3	-0.1	0.3	-0.1
4.0-Ft Gate Opening										
1	48.5	49.3	36.5	37.3	25.0	25.8	13.1	13.9	8.0	8.8
2	43.4	43.8	32.3	32.7	22.2	22.6	12.0	12.4	7.4	7.8
3	27.7	28.1	20.7	21.1	14.2	14.6	7.4	7.8	4.7	5.1
4	8.8	9.2	6.4	6.8	4.7	5.1	3.2	3.6	2.1	2.5
5	0.0	-0.4	0.0	-0.4	0.0	-0.4	-0.3	-0.7	0.2	-0.2
6	-7.8	-8.2	-5.9	-6.3	-3.3	-3.7	-1.1	-1.5	-0.4	-0.8
5.0-Ft Gate Opening										
1	57.9	58.7	44.0	44.8	27.5	28.3	14.3	15.1	9.1	9.9
2	69.0	69.4	52.2	52.6	34.5	34.9	17.7	18.1	11.0	11.4
3	44.8	45.2	34.0	34.4	23.0	23.4	12.1	12.5	7.8	8.2
4	18.7	19.1	14.8	15.2	10.9	11.3	6.1	6.5	4.2	4.6
5	94.0	93.6	69.3	68.9	47.0	46.6	23.9	23.5	14.3	13.9
6	5.5	5.1	5.3	4.9	3.8	3.4	3.1	2.7	2.7	2.3

NOTES: Piezometer locations shown on plate 28.

All piezometer readings referred to centerline of conduit.

Head refers to pressure at control piezometer located in the conduit 12 ft upstream from the test section.

TABLE A-50

PRESSURES DOWNSTREAM FROM GATE SLOT

Type D Gate Lip

Piez. Number	Pressure Head, 100 Ft		Pressure Head, 75 Ft		Pressure Head, 50 Ft		Pressure Head, 25 Ft		Pressure Head, 15 Ft	
	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure	Piezometer Reading	Pressure
3.0-Ft Gate Opening										
2	-1.3	-0.9	-1.1	-0.7	-1.0	-0.6	-0.7	-0.3	-0.5	-0.1
3	-0.3	0.1	-0.3	0.1	-0.2	0.2	-0.4	0.0	-0.4	0.0
4	-0.7	-0.3	-0.5	-0.1	-0.4	0.0	-0.5	-0.1	-0.4	0.0
5	0.5	0.1	0.6	0.2	0.6	0.2	0.4	0.0	0.5	0.1
6	0.0	-0.4	0.1	-0.3	0.4	0.0	0.4	0.0	0.5	0.1
4.0-Ft Gate Opening										
2	27.5	27.9	21.4	21.8	15.0	15.4	7.8	8.2	4.8	5.2
3	18.4	18.8	14.1	14.5	9.7	10.1	5.1	5.5	3.2	3.6
4	0.9	1.3	1.0	1.4	1.2	1.6	0.8	1.2	0.6	1.0
5	----	----	----	----	----	----	----	----	----	----
6	-1.8	-2.2	-1.2	-1.6	-0.6	-1.0	-0.1	-0.5	0.1	-0.3
5.0-Ft Gate Opening										
2	49.6	50.0	39.1	39.5	26.8	27.2	14.1	14.5	8.8	9.2
3	33.2	33.6	26.1	26.5	17.8	18.2	9.6	10.0	6.2	6.6
4	9.0	9.4	8.0	8.4	5.8	6.2	3.7	4.1	2.8	3.2
5	53.9	53.5	39.2	38.8	26.5	26.1	13.9	13.5	8.5	8.1
6	-0.6	-1.0	1.0	0.6	1.3	0.9	1.5	1.1	1.7	1.3

NOTES: Piezometer locations shown on plate 28.  
 All piezometer readings referred to centerline of conduit.  
 No readings taken on number 1 piezometer.  
 Head refers to pressure at control piezometer located in the conduit 12 ft upstream from the test section.