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Rating Flow Regulation Structures in the Bear River Canal System

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RATING FLOW REGULATION STRUCTURES IN THE BEAR RIVER CANAL SYSTEM

Prepared for

Utah-Idaho Sugar Company

Prepared by

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The fabrication of the gates used in the laboratory was under the supervision of Mr. Kenneth Steele with Messrs. Gilbert Peterson, Mark Nilson, Verl Bindrup, and Keith Miller assisting. Messrs. Keith Eggleston and Ross Anderson performed part of the laboratory data collection. The cover design was prepared by Mrs. Carolyn Davis and the graphs are the efforts of Mr. Howard Smith. The editing of this report was accomplished by Miss Donna Higgins and the typing by Mrs. Linda Williams.

Gaylord V. Skogerboe
Winford M. Barrus
Lloyd H. Austin

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INTRODUCTION

The Bear River Canal System (Fig. 1) is located below Cutler Reservoir in Box Elder County, Utah. The average annual quantity of water conveyed through the canal system is approximately 230,000 acre-feet. Any water not consumptively used in this area eventually flows into Great Salt Lake.

Utah Power and Light Company has the rights to the waters stored in Cutler Reservoir for operating a hydroelectric plant. The irrigation distribution system below the reservoir is operated and maintained by the Utah-Idaho Sugar Company. The water is delivered to the water users through the distribution system and a nominal maintenance charge is assessed each user.

PURPOSE OF STUDY

Proper distribution of water to users in the Bear River Canal System requires accurate flow measurement by the personnel of the Utah-Idaho Sugar Company. Accuracy has been achieved by using a current meter to periodically check the discharge rates being turned out at each flow regulation structure. The primary difficulty of this method is the time involved in making the measurements. Consequently, a program for rating the flow regulation, or turnout, structures in the distribution system was deemed desirable.

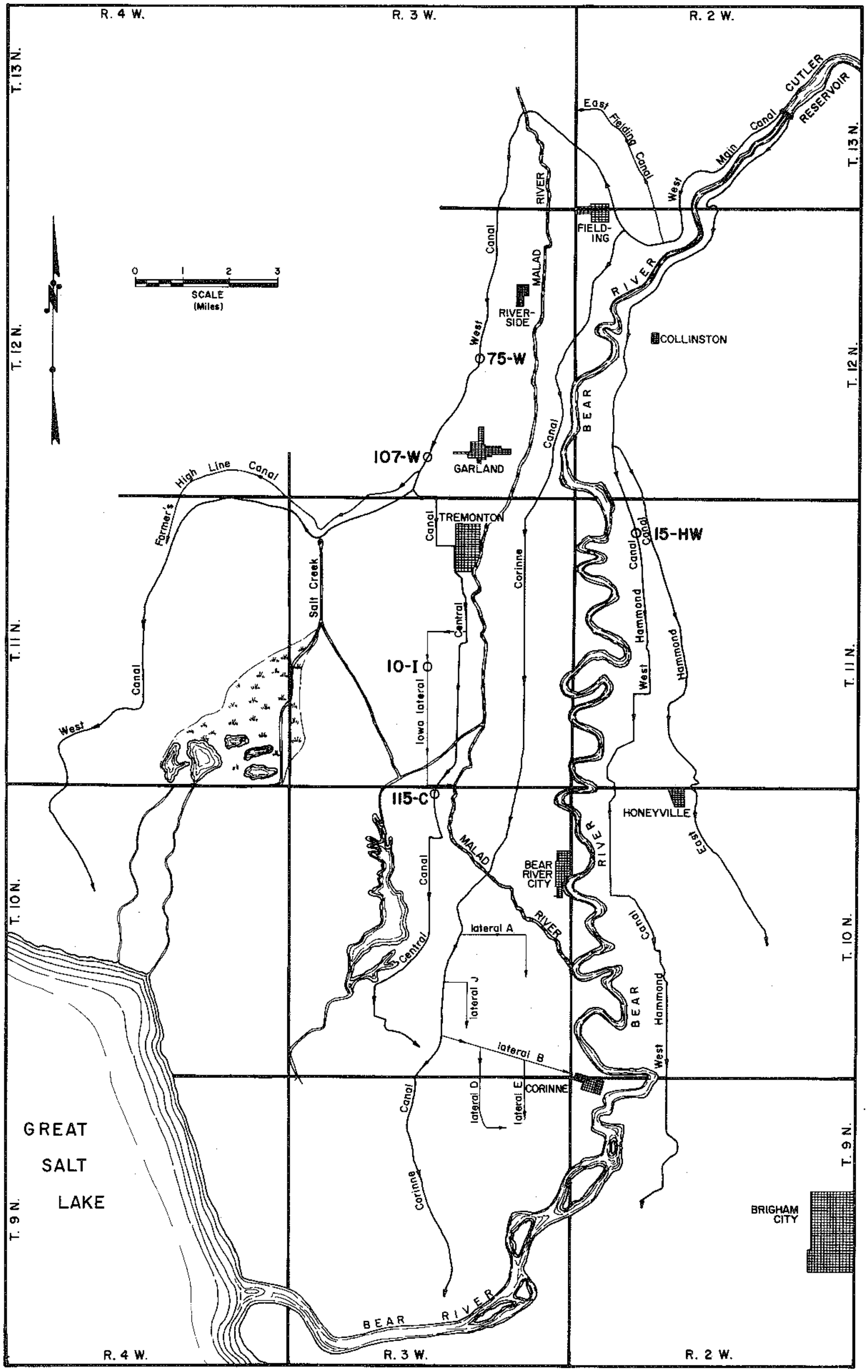

FIG. 1.- BEAR RIVER CANAL SYSTEM, Box Elder County, Utah.

Rating the hundreds of gate structures in the Bear River Canal System would be costly if accomplished in a short time. Therefore, an initial research effort delineating the proper measurements necessary for developing a rating for any structure appeared advisable, followed by a long range program of field measurements collected over many years.

Testing some typical flow regulation structures was considered essential for establishing the accuracy of any proposed measuring system. Through laboratory testing, a large quantity of data could be generated in a short period of time. The information collected in the laboratory could then be checked in the field using similar structures.

The verification between field and laboratory data would provide the basis for the long range program of developing field ratings. The field data could be collected as a part of the normal work load of the water masters and hydrographers. The accumulation of measurements over the years would provide enough data to base a rating. The development of the ratings would not only reduce the work load of the hydrographers, but would materially assist the water masters in accurately delivering the water to each irrigator.

LABORATORY FACILITIES

Fluid Mechanics Laboratory

A large share of the data was collected in the Fluid Mechanics Laboratory (Fig. 2) located in the Engineering and Physical Science Building. A flume recessed in the floor having a width of 5 feet and a depth of 5 feet was employed. Water was pumped from a tank located in the basement of the laboratory into a 12-inch diameter pipeline which discharges into the flume. The depth of flow in the flume was controlled by a tailgate located near the downstream end of the flume. The flow rate was determined by discharging the water into a weighing tank and measuring the length of time required to accumulate a particular weight of water. After obtaining a flow rate measurement, the water was discharged into the sump (tank), where it was recirculated through the system.

Water Research Laboratory

The large flume, 8 feet wide and 6 feet deep (Fig. 3), located in the Utah Water Research Laboratory was used for testing the largest of the three flow regulation structures. Water was delivered from the small reservoir behind the First Dam located on the Logan River immediately upstream from the laboratory. Then, the water was conveyed to the large flume by a 4-foot diameter pipeline. The flow in the flume was measured with a Parshall flume having a throat width of 3 feet. The depth of flow in the flume was controlled by a slide gate 6 feet wide located downstream from the structure under study. The flow passing through the flume was then discharged into the Logan River below the laboratory.

LABORATORY STRUCTURES

The principal type of flow regulation structure used in the Bear River Canal System consists of a slide gate for regulating the quantity of flow followed by a semicircular corrugated culvert to convey the water through the canal bank. Three different slide gates were selected for the laboratory tests.

The first gate structure tested in the Fluid Mechanics Laboratory consisted of a 2-foot wide cast iron gate with supporting ribs (Fig. 4). The gate opening was rectangular in shape. The semicircular corrugated culvert had a base width of 22.8 inches and a height of 12 inches, with all dimensions being the clear distance between the inside extremities of the corrugations. The length of the corrugated pipe was 9 feet.

A flow regulation structure having a gate 2 feet wide constructed of 1/4-inch steel plate (Fig. 5) was next tested in the Fluid Mechanics Laboratory. Again, the gate opening was rectangular in shape. The semicircular corrugated culvert had a base width of 22.3 inches, height of 12.8 inches, and length of 9 feet.

A structure having a 3-foot wide steel plate gate with structural steel angles (Fig. 6) was tested both in the Utah Water Research

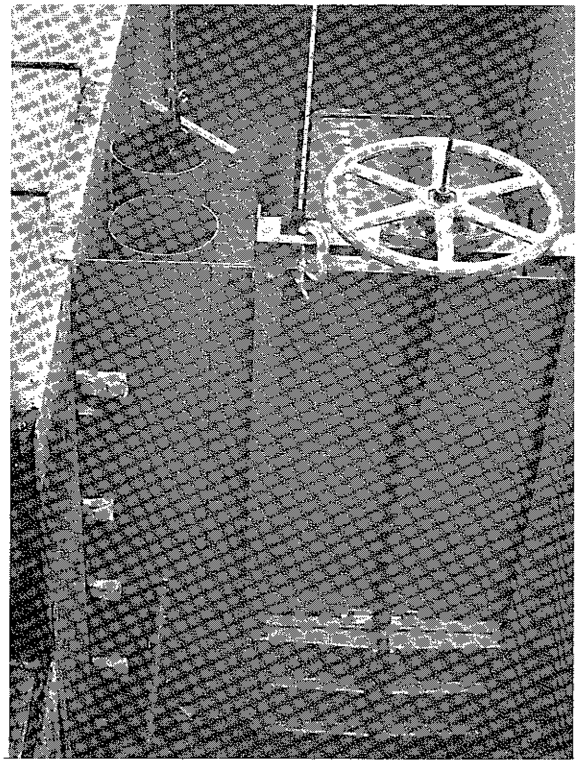

Fig. 4. Two-foot cast iron gate.

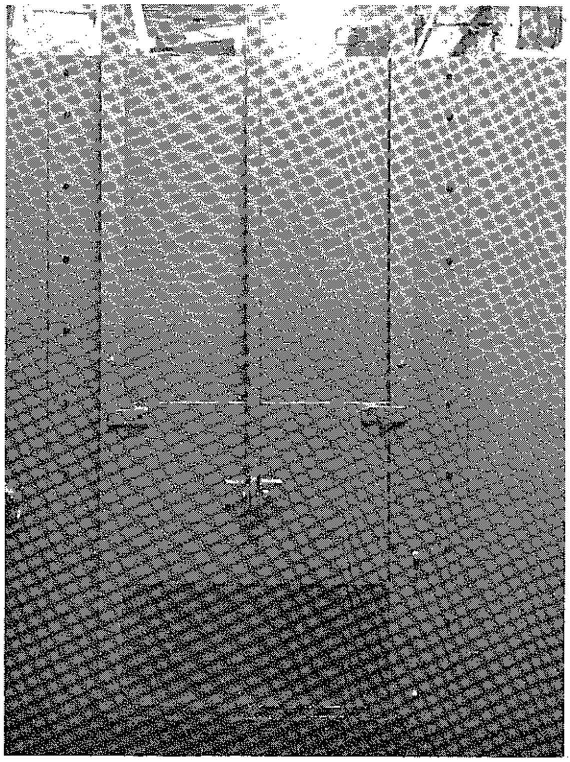

Fig. 5. Two-foot steel gate.

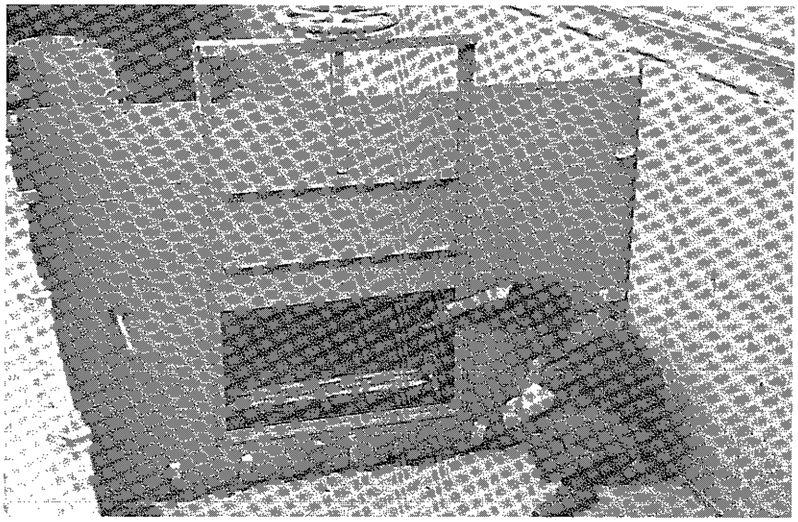

Fig. 6. Three-foot steel gate.

Laboratory and the Fluid Mechanics Laboratory. The gate opening was semicircular with a base width of 36 inches and a height of 19.75 inches. The semicircular corrugated culvert had a base width of 35.75 inches, height of 19.5 inches, and length of 10 feet. Flow rates in excess of 5 cfs (second-feet) were employed during the tests at the Utah Water Research Laboratory, while flow rates less than this amount were used in the tests conducted at the Fluid Mechanics Laboratory.

RATING SYSTEM

Discharge Equation

The flow regulation structures in the Bear River Canal System are used for diverting water from the large canals constituting the conveyance system into the small distribution channels which convey the water to the irrigated fields. Most of the gates in these structures are submerged. A gate is submerged when the downstream depth of flow becomes great enough to back the water up against the downstream face of the gate (Fig. 7). For the flow regulation structures to be used both for the diversion of water and flow rate measurement, a suitable submerged flow discharge equation must be developed.

The equation used for determining the flow rate through a submerged orifice, or gate, is

$$Q = C_d A \sqrt{2g(\Delta H)} \quad \ldots\ldots\ldots\ldots \quad 1$$

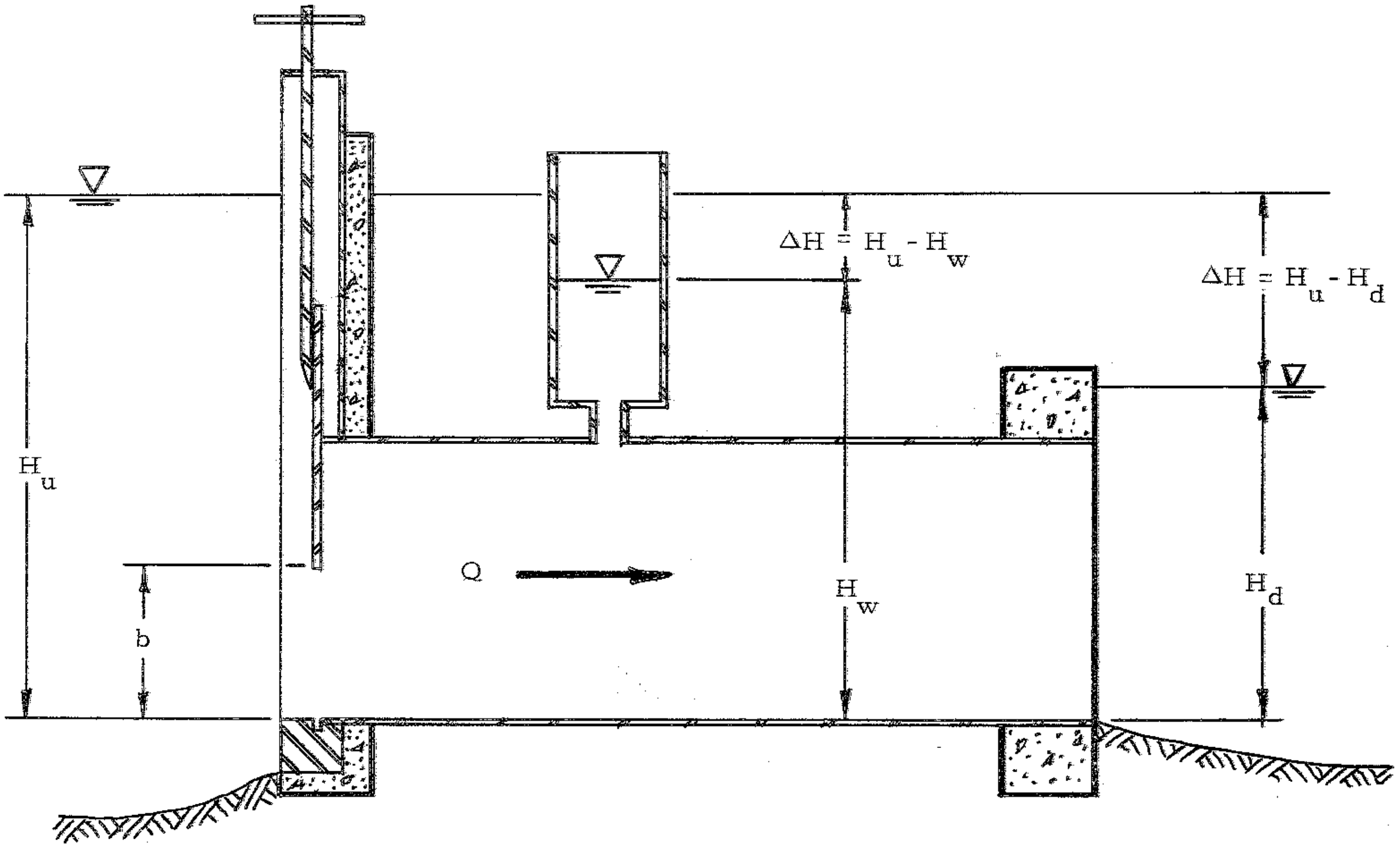

Fig. 7. Definition sketch of submerged gate.

where

Q = discharge, in cubic feet per second (cfs)

C_d = coefficient of discharge of system, dimensionless

A = area of gate opening, square feet

g = acceleration due to gravity, feet per second per second

ΔH = difference between water surface elevation upstream from the gate and a water surface elevation downstream from the gate, feet

The area of the gate opening, A, is a function of the height of gate opening, b. The functional relationship between A and b can be mathematically expressed by

$$A = f(b) \qquad \ldots \qquad 2$$

where f denotes "a function of." The relationship between A and b is not simple because of the irregular shape of the corrugated culverts.

The coefficient of discharge must be developed for each flow regulation structure. To accomplish the experimental development of a unique rating, the general submerged orifice discharge equation (Eq. 1) can be written in functional form.

$$Q = f(A, \Delta H) \qquad \ldots \qquad 3$$

Substituting Eq. 2 into Eq. 3

$$Q = f(b, \Delta H) \qquad \ldots \qquad 4$$

The functional form of the submerged orifice discharge equation shows that a rating can be developed for any particular gate structure provided the relationship between the discharge, height of gate opening, and change in water surface elevation can be established. The purpose of the laboratory experimental work, then, was to generate the data required for establishing the required relationship.

Measuring System

The height of gate opening, b, was measured by a pointer attached to the gate rod (Fig. 8) The elevation of the pointer was read by a steel tape attached to a structural steel angle and mounted on the gate frame (Figs. 8 and 9). Raising or lowering the gate resulted in an equal movement of the gate rod, and consequently, the pointer. The datum on the steel tape corresponding to a zero gate opening was established prior to running any tests.

The depth of flow upstream from the gate, H_u, was measured by using a perforated pipe (Figs. 9 and 11) which was connected to a stilling well placed immediately downstream from the bulkhead (Figs. 9 and 12). The depth of flow downstream from the gate, H_w, was measured by means of a tap located on the top of the corrugated culvert and 3 feet downstream from the gate frame (Figs. 9 and 12). The depth of water in the stilling wells was measured with a point gage reading to 0.001 feet (Fig. 10). The corrections to be applied to the point gage readings in order to obtain H_u and H_w were determined with an engineer's level.

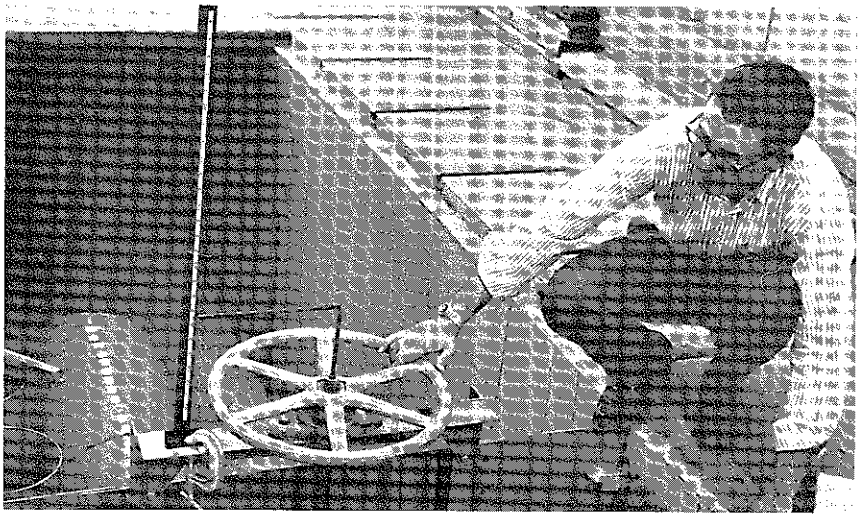

Fig. 8. Gate opening indicator with gage.

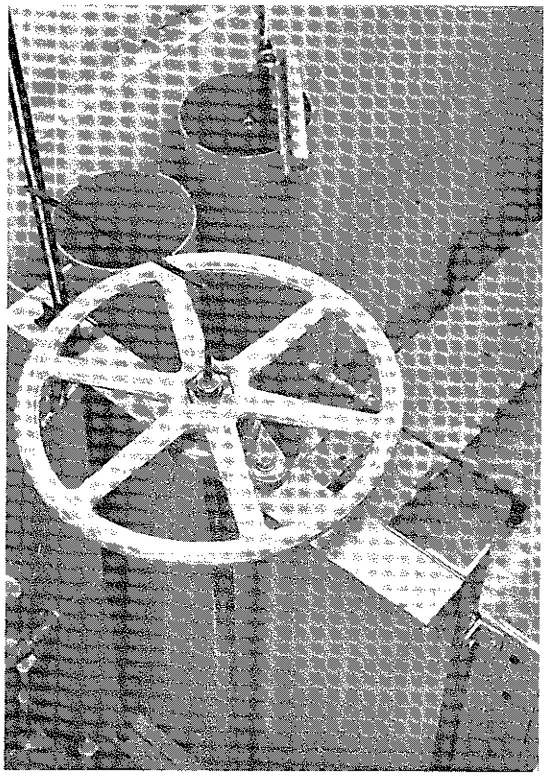

Fig. 9. Piping to stilling wells for measuring H_u and H_w.

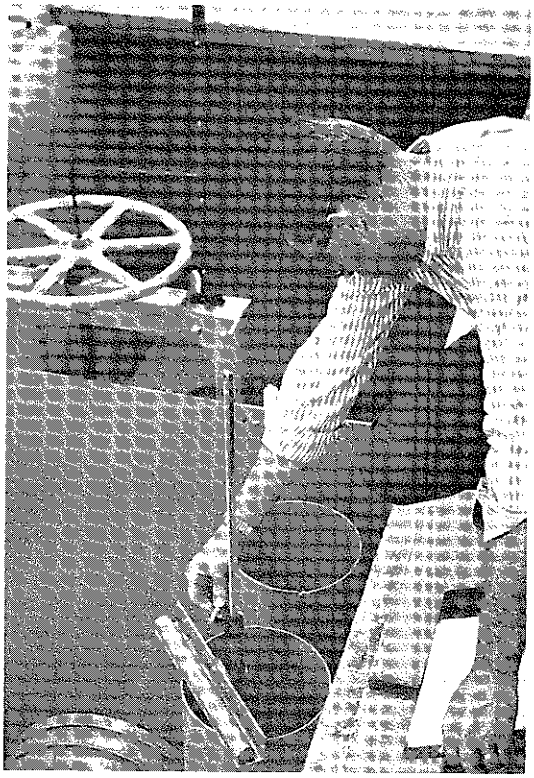

Fig. 10. Point gage for measuring water surface level in stilling wells.

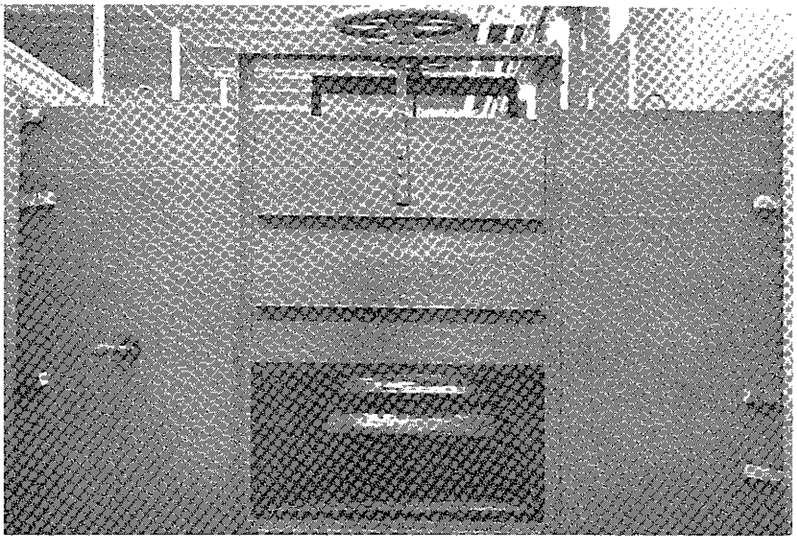

Fig. 11. Three-foot steel gate showing pipe for measuring upstream flow depth, H_u.

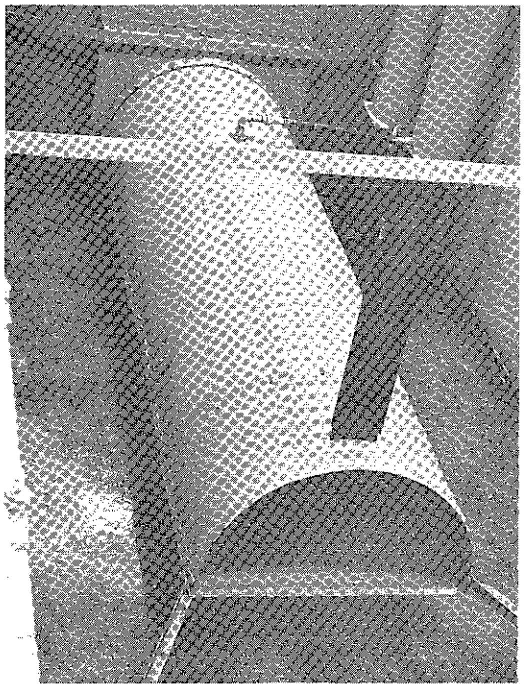

Fig. 12. Piping from semicircular corrugated culvert to stilling well for measuring H_w.

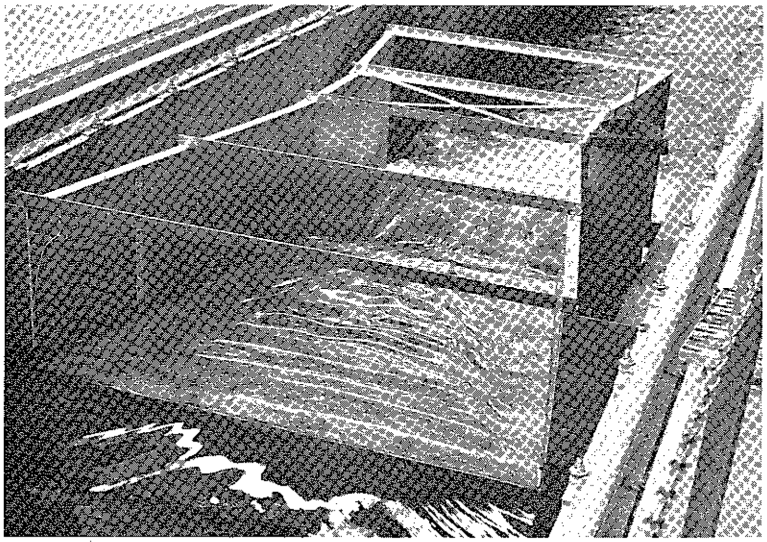

Fig. 13. Parshall flume used for measuring discharge located in Utah Water Research Laboratory.

The discharge was determined with a Parshall flume (Fig. 13) for the tests conducted in the Utah Water Research Laboratory. In the Fluid Mechanics Laboratory, weighing tanks were used for measuring the flow rate during the tests.

LABORATORY DATA ANALYSIS

For any particular gate structure, if the height of gate opening, b, is held constant, thereby resulting in a constant area of gate opening, A, the discharge becomes a function only of the change in water surface elevation, ΔH. The relationship between Q and ΔH, derived from Eq. 1, can be simply written as

$$Q = C_q (\Delta H)^{1/2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad 5$$

If Eq. 5 is correct, then the data generated for any flow regulation structure with the gate opening held constant should plot as a straight line on log-log paper. The slope of the straight line should be 1/2. Collecting data for a number of gate openings should provide a family of straight lines on log-log paper, with each line corresponding to a finite value of b.

The laboratory data collected from the 2-foot cast iron gate has been plotted in Fig. 14. Lines of constant gate opening, b, have been drawn with a slope of 1/2 to best fit the data. As can be seen from Fig. 14, the lines fit the data very well. Consequently, Eq. 5 describes the lines drawn in Fig. 14.

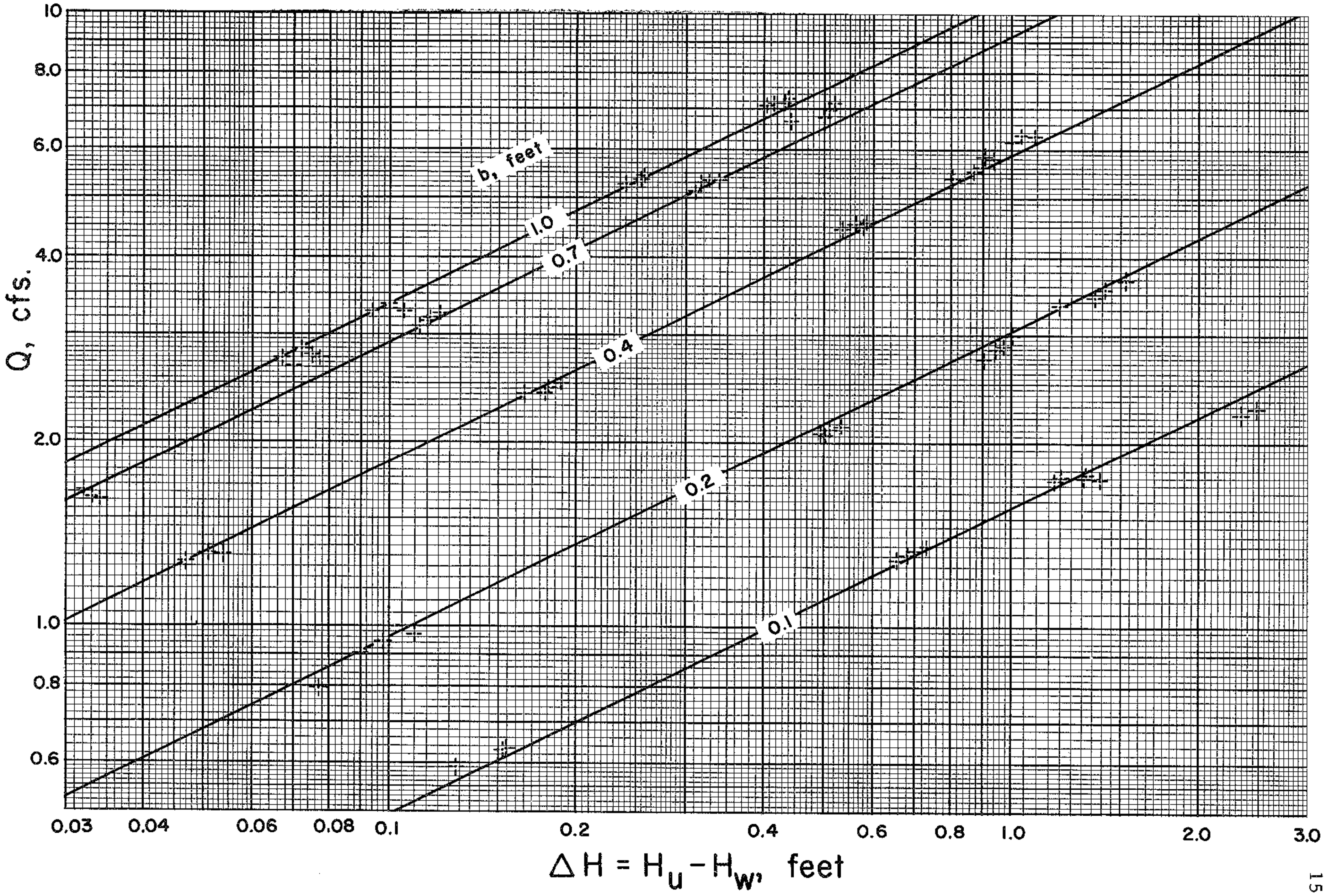

Fig. 14. Laboratory rating for 2-foot cast iron gate.

The coefficient, C_q, in Eq. 5, which is the value of Q when $\Delta H = 1.0$, has a different value for each line of constant b (Fig. 14). The relationship between C_q and b for the 2-foot cast iron gate has been plotted on log-log paper in Fig. 15. A straight line relationship between b and C_q on log-log paper can be expressed by the general equation

$$b = C_b C_q^{s} \quad \ldots\ldots\ldots\ldots\ldots \quad 6$$

where s is the slope of the line and C_b is the value of b when C_q is equal to one. The equation for the straight line portion of Fig. 15 is

$$b = 0.062\ C_q^{1.05} \quad \ldots\ldots\ldots\ldots\ldots \quad 7$$

The empirical discharge equation for the 2-foot cast iron gate can be developed using Eqs. 5 and 7. The primary restriction of such an empirical equation is that the gate opening must be less than 0.5 feet. Most of the flow regulation structures in the Bear River Canal System are operated with gate openings less than half the culvert height.

Before proceeding with the determination of the empirical discharge equation for the 2-foot cast iron gate, a more general empirical equation will be developed using Eqs. 5 and 6. Solving for C_q in Eq. 6

$$C_q = (b/C_b)^{1/s} \quad \ldots\ldots\ldots\ldots\ldots \quad 8$$

Substituting Eq. 8 into Eq. 5

$$Q = (b/C_b)^{1/s} (\Delta H)^{1/2} \quad \ldots\ldots\ldots\ldots\ldots \quad 9$$

Define a constant, C, by the equation

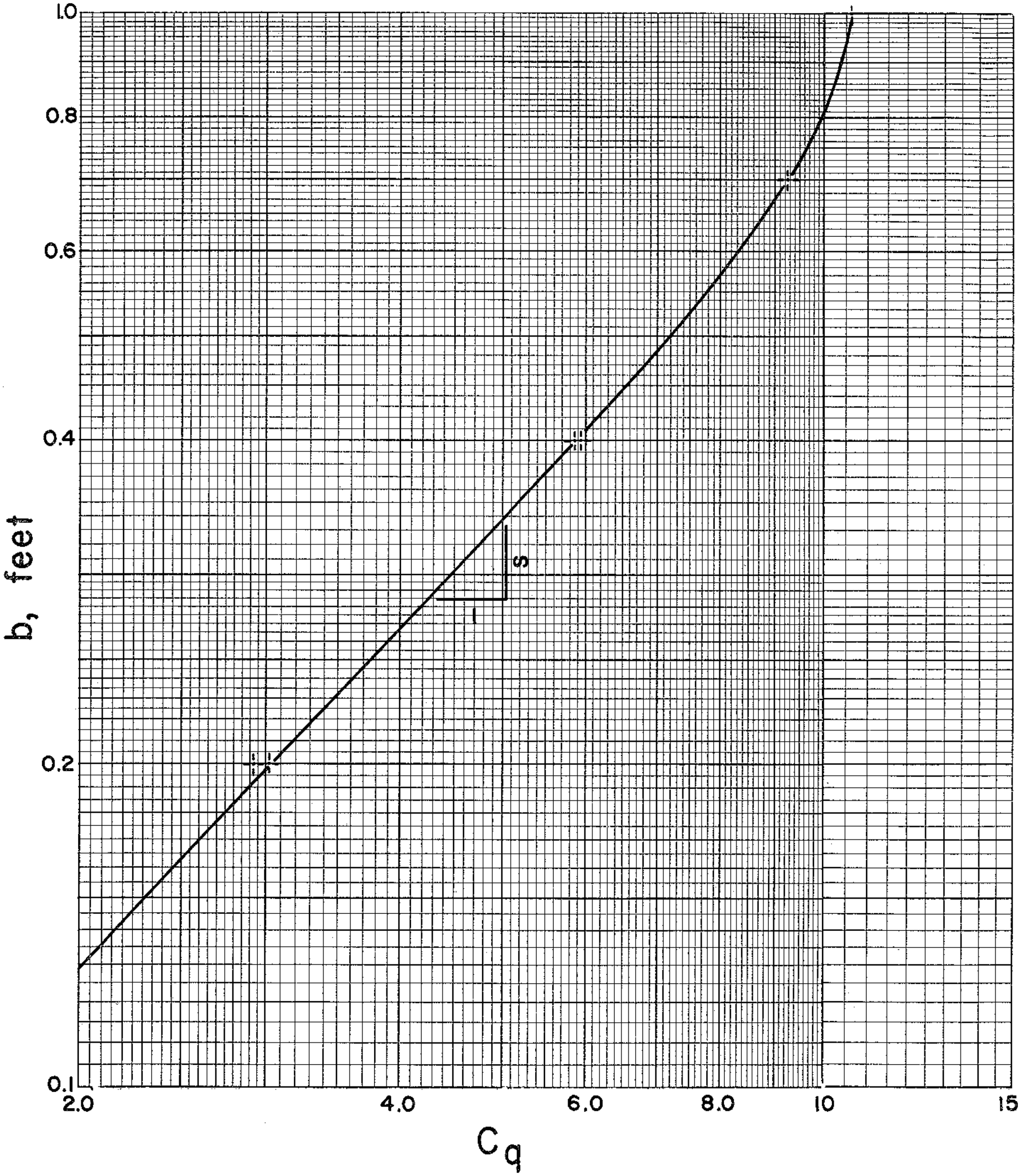

Fig. 15. Relationship between b and C_q for 2-foot cast iron gate.

$$C = (1/C_b)^{1/s} \quad \ldots \ldots \quad 10$$

Substituting Eq. 10 into Eq. 9

$$Q = C\, b^{1/s} (\Delta H)^{1/2} \quad \ldots \ldots \quad 11$$

For the 2-foot cast iron gate, the equation (Eq. 6) describing the straight line portion of Fig. 15 can be written as

$$b = 0.062\, C_q^{1.05} \quad \ldots \ldots \quad 12$$

Since C_b is equal to 0.062 and s is equal to 1.05, the constant C can be solved from Eq. 10.

$$C = (1/0.062)^{1/1.05} = 14.2 \quad \ldots \ldots \quad 13$$

Consequently, the empirical submerged flow discharge equation for the 2-foot cast iron gate can be written as

$$Q = 14.2\, b^{1/1.05} (\Delta H)^{1/2} \quad \ldots \ldots \quad 14$$

where

$$\Delta H = H_u - H_w \quad \ldots \ldots \quad 15$$

The laboratory data for the 2-foot steel gate has been plotted in Fig. 16. Again, the lines of constant gate opening, b, have been drawn with a slope of 1/2. A straight line relationship between b and C_q is obtained on log-log paper (Fig. 17) for gate openings less than 0.75 feet. The equation for the straight line portion of the curve in Fig. 17 can be written as

$$b = 0.092\, C_q^{0.95} \quad \ldots \ldots \quad 16$$

Eq. 10 can be used to solve for C.

$$C = (1/0.092)^{1/0.95} = 12.4 \quad \ldots \ldots \quad 17$$

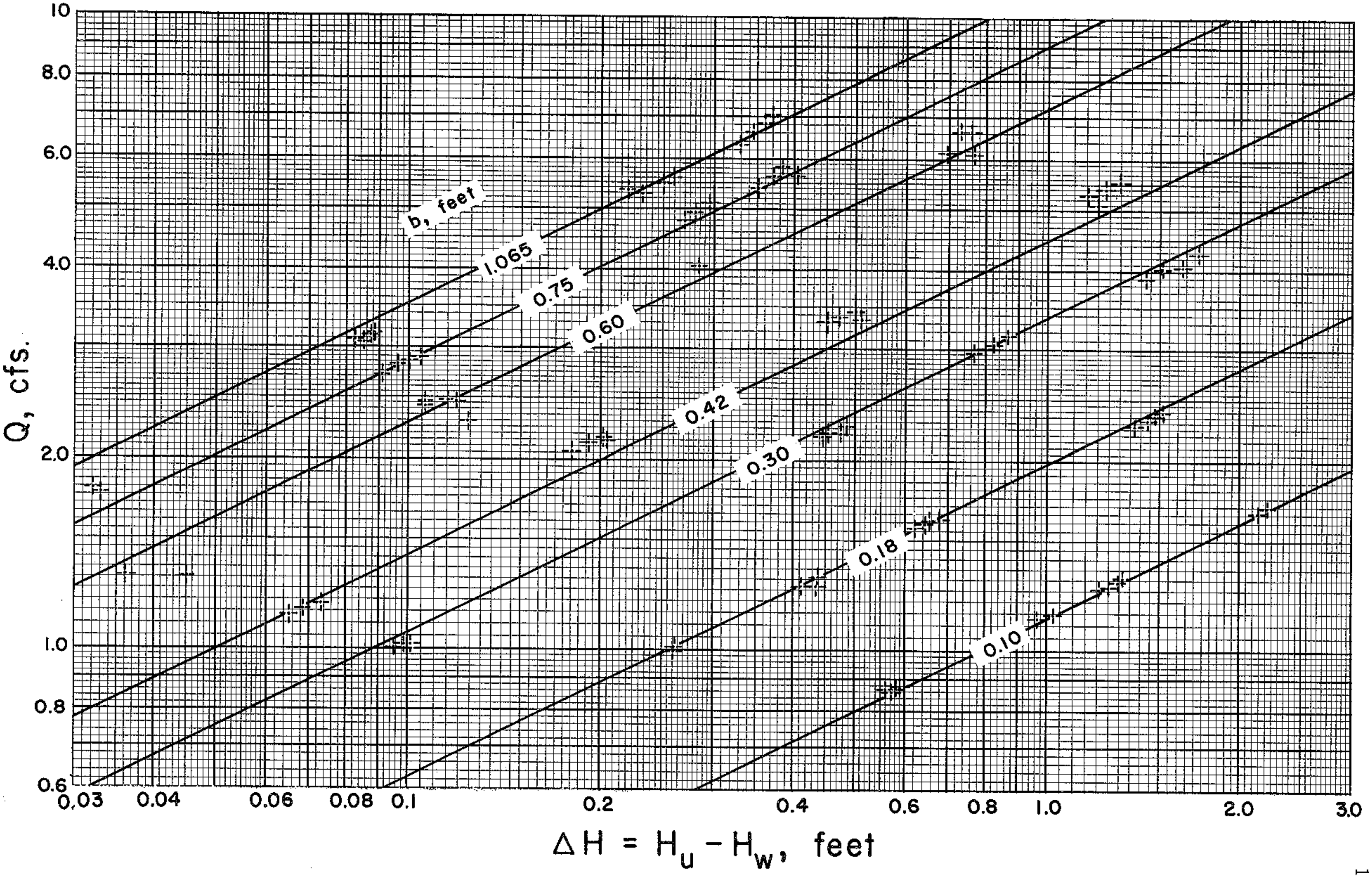

Fig. 16. Laboratory rating for 2-foot steel gate.

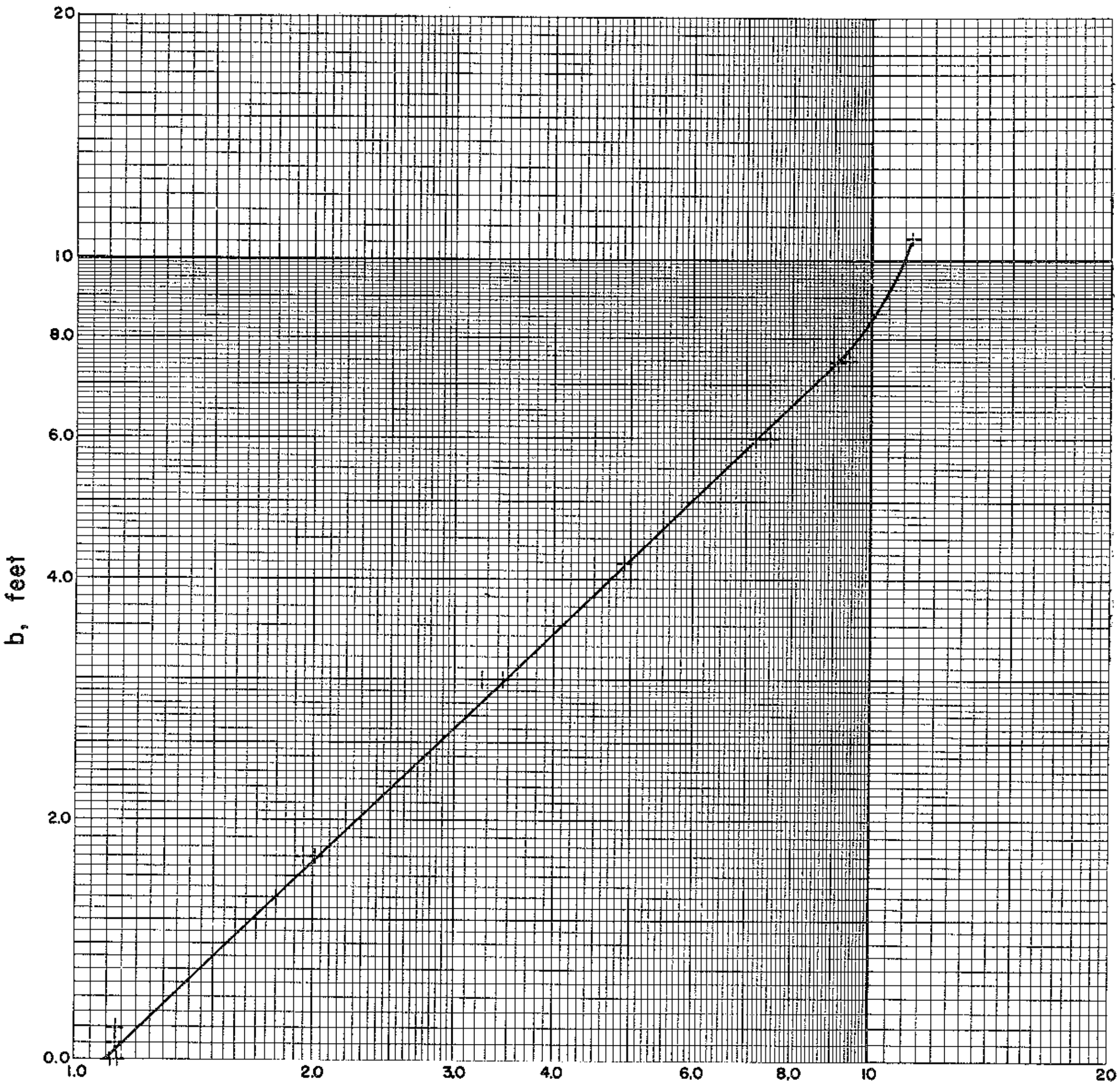

Fig. 17. Relationship between b and C_q for 2-foot steel gate.

The empirical submerged flow discharge equation for the 2-foot steel gate becomes

$$Q = 12.4\, b^{1/0.95} (\Delta H)^{1/2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad 18$$

The data collected both in the Fluid Mechanics Laboratory and the Utah Water Research Laboratory for the 3-foot steel gate are shown in Fig. 18. The plot of b against C_q on log-log paper in Fig. 19 yields a straight line relationship. The equation of the line in Fig. 19 is

$$b = 0.0625\, C_q^{1.0} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad 19$$

Solving for C from Eq. 10

$$C = 1/0.0625 = 16 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad 20$$

The empirical submerged flow discharge equation for the 3-foot steel gate can be written as

$$Q = 16\, b\, (\Delta H)^{1/2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad 21$$

The relationships between b and C_q for the three gates (Figs. 15, 17, and 19) show some striking differences. The relationship for the 3-foot steel gate was as expected, with the slope of the line being 1.0. For the other two gates, the slope, s, was 1.05 for the 2-foot cast iron gate and 0.95 for the 2-foot steel gate. Also, a straight line relationship does not exist between b and C_q at large gate openings for the 2-foot gates. The discrepancy between the 2-foot and 3-foot gates can be primarily attributed to the manner in which the gate and culvert were coupled to form a flow regulation structure. The 3-foot gate consisted of a metal frame placed between the gate frame and culvert with the opening in the metal frame corresponding to the

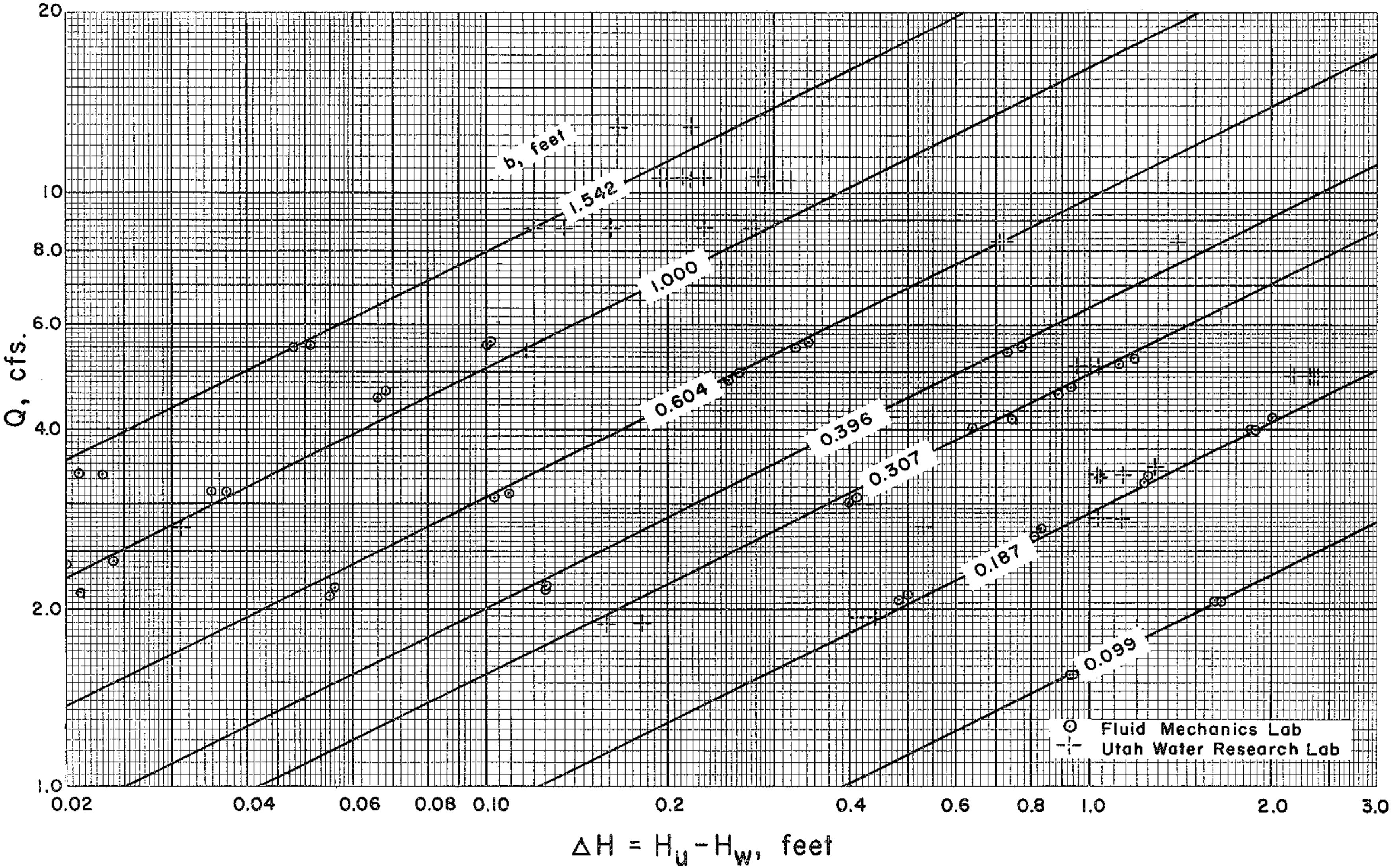

Fig. 18. Laboratory rating for 3-foot steel gate.

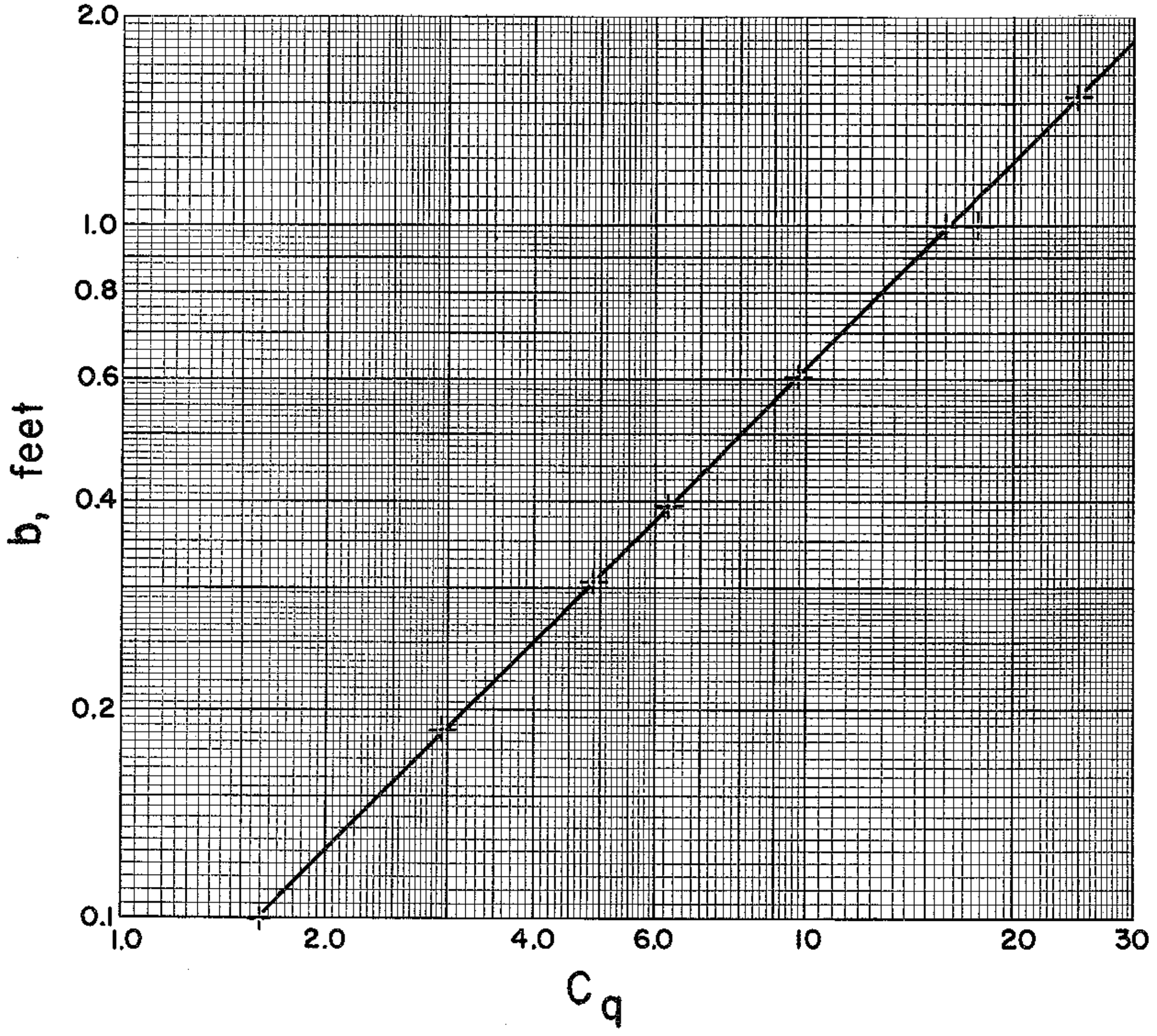

Fig. 19. Relationship between b and C_q for 3-foot steel gate.

dimensions of the semicircular corrugated culvert. Thus, as the gate was raised, the area of gate opening increased as a simple linear function of the height of gate opening, b. For the 2-foot gates, the semicircular corrugated culvert was attached directly to the gate frame. The opening in the gate frame was rectangular, but at large gate openings, the shape of the semicircular culvert restricted the area of opening, thus complicating the relationship between b and A (Eq. 2).

FIELD STRUCTURES

A total of five submerged flow regulation structures were selected for field calibration. Field structures selected were similar to the structures tested in the laboratory. Another important consideration was the availability of a simple, accurate flow measuring device to determine the discharge. For this reason, structures were selected which had Parshall flumes located immediately downstream. Each Parshall flume was checked for proper inlet conditions, geometry, and the level of the inlet floor. A stilling well was placed over each culvert at a distance of 3 feet downstream from the gate frame. The location of the stilling wells for the field structures corresponded with the location utilized in the laboratory tests. Because of the difficulty encountered installing a few of the stilling wells, the depths of flow beyond the exit of the culvert, H_d (Fig. 7), were measured in order to compare the rating curves employing H_u and H_d with those resulting from H_u and H_w.

Flow regulation structure 107W (Fig. 20) consisted of a 2-foot steel gate with a semicircular corrugated culvert. The exit of the culvert was submerged during all of the tests (Fig. 21). A 9-inch concrete Parshall flume (Fig. 21) was located immediately downstream from the culvert exit. The flume operated both in the submerged flow range (Fig. 22) and as a free flow critical-depth measuring structure.

Structure 75W (Fig. 23) consisted of a 3-foot steel gate followed by a semicircular corrugated culvert, whose exit was submerged. A 12-inch concrete Parshall flume (Fig. 24), which operated under free flow (Fig. 25), was located a short distance downstream from the flow regulation structure.

Gate structure 10I (Fig. 26) was also a 3-foot steel gate. A 12-inch concrete Parshall flume (Figs. 27 and 28) was located downstream from the structure.

Flow regulation structure 115C consisted of a 3-foot cast iron gate followed by a semicircular corrugated culvert. This structure was selected in order that the rating for a 3-foot cast iron gate could be checked with a 3-foot steel gate. A concrete Parshall flume (Figs. 30 and 31) having a throat width of 2 feet was located downstream from the culvert exit.

The structure shown in Figs. 32 and 33 was number 15HW, and had a 2-foot cast iron gate. A steel Parshall flume (Fig. 34) having a throat width of 9 inches was located a short distance downstream from the structure.

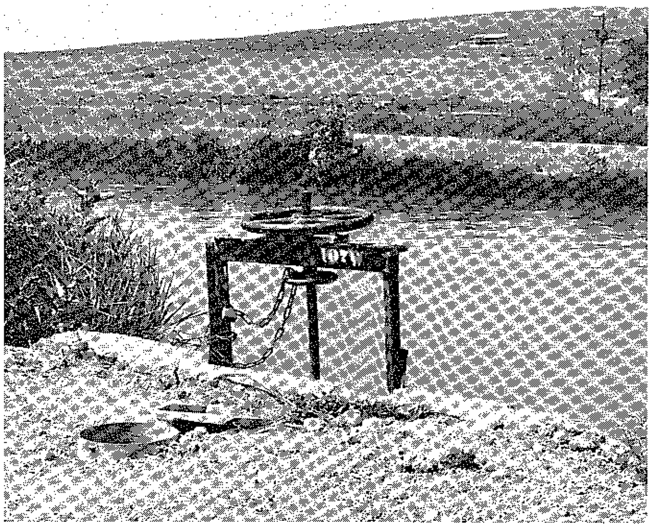

Fig. 20. Flow Regulation Structure 107W showing West Canal with stilling well in foreground.

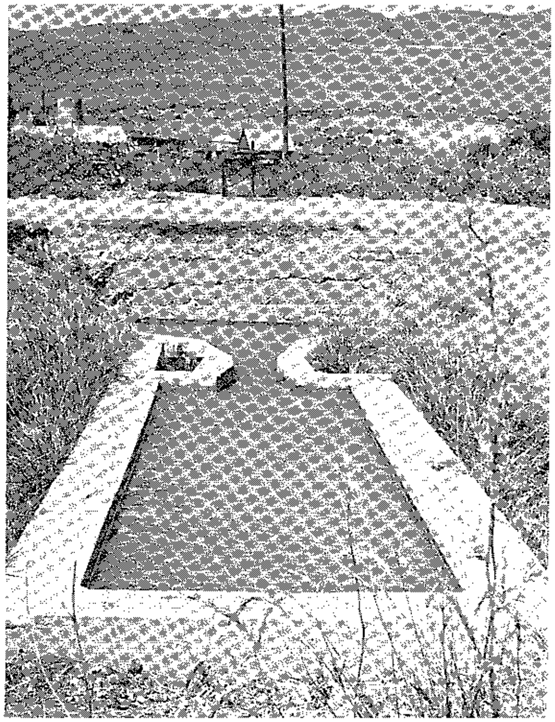

Fig. 21. Parshall flume followed by turnout box below structure 107W.

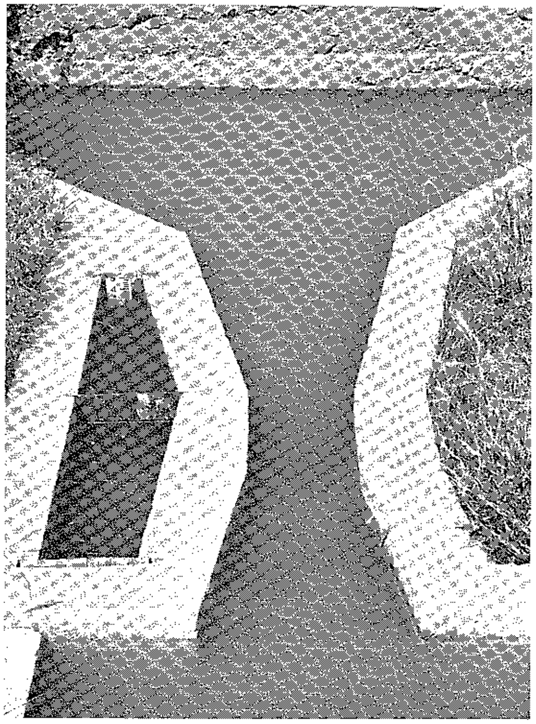

Fig. 22. Submerged exit of structure 107W followed by submerged Parshall flume.

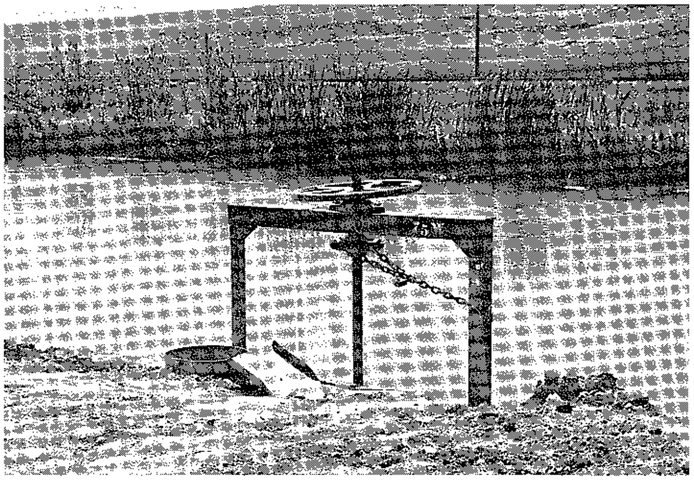

Fig. 23. Flow Regulation Structure 75W showing West Canal and stilling well.

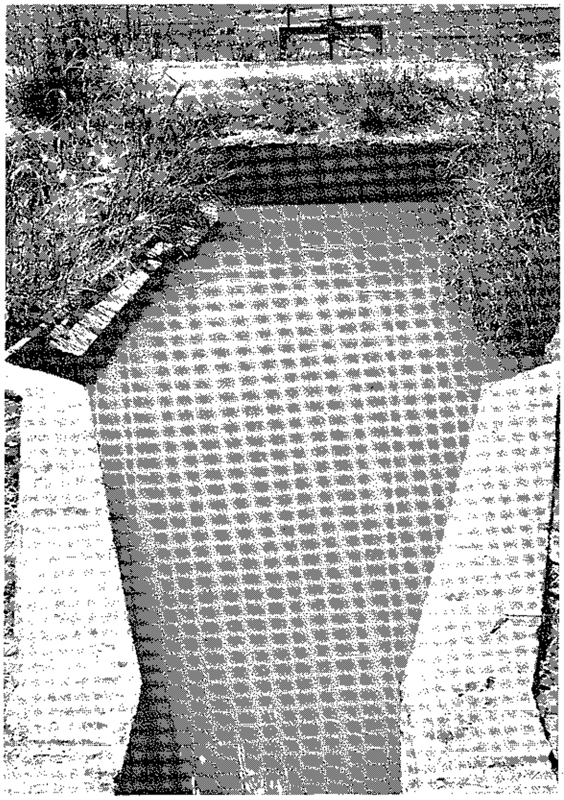

Fig. 24. Submerged exit at structure 75W.

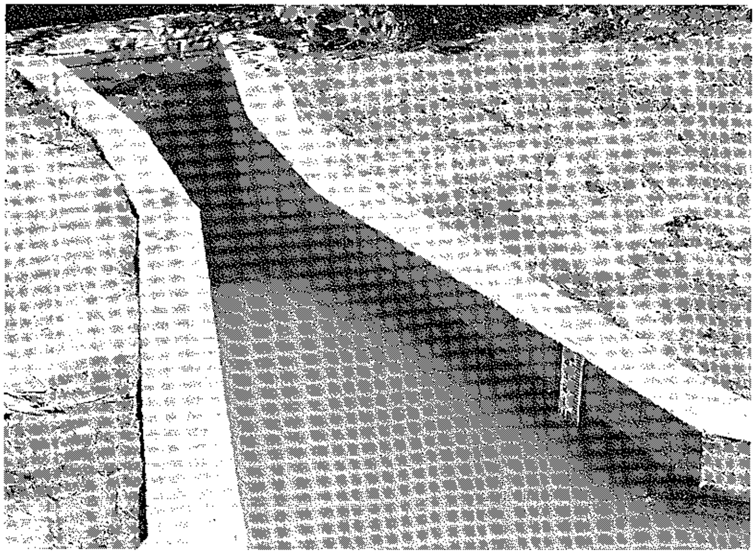

Fig. 25. Free flow occurring in Parshall flume located downstream from structure 75W.

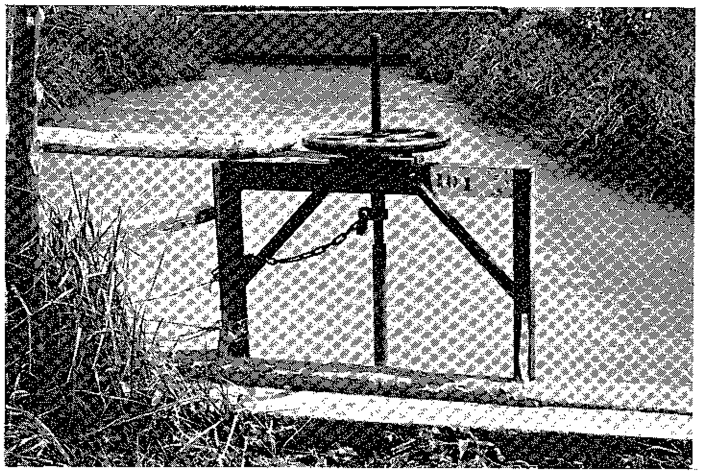

Fig. 26. Flow Regulation Structure 10I showing Iowa Lateral and stilling well for measuring H_w.

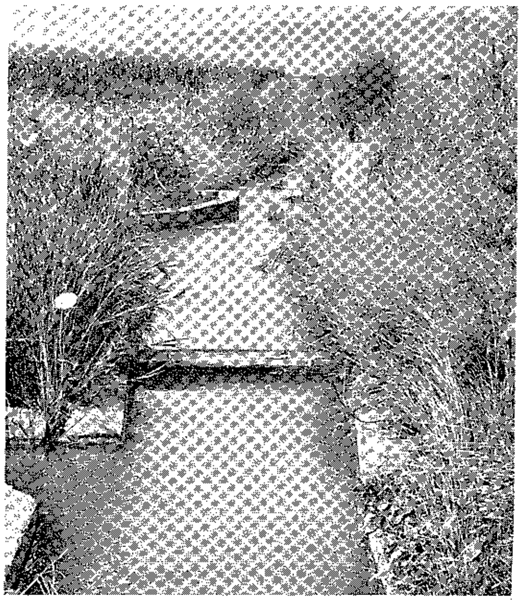

Fig. 27. Division structure located below structure 10I.

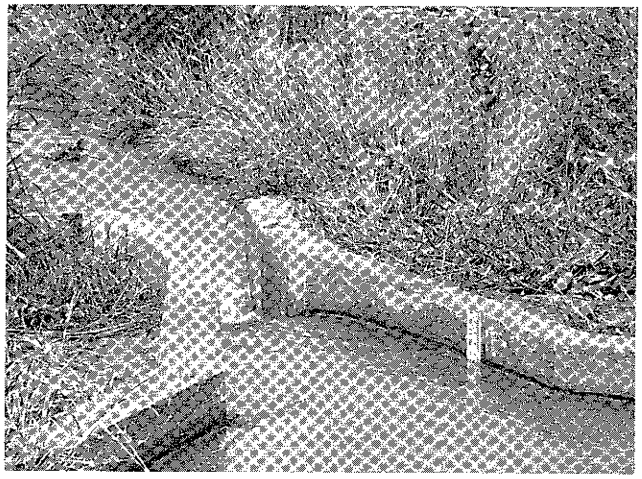

Fig. 28. Parshall flume below structure 10I operating under free flow conditions.

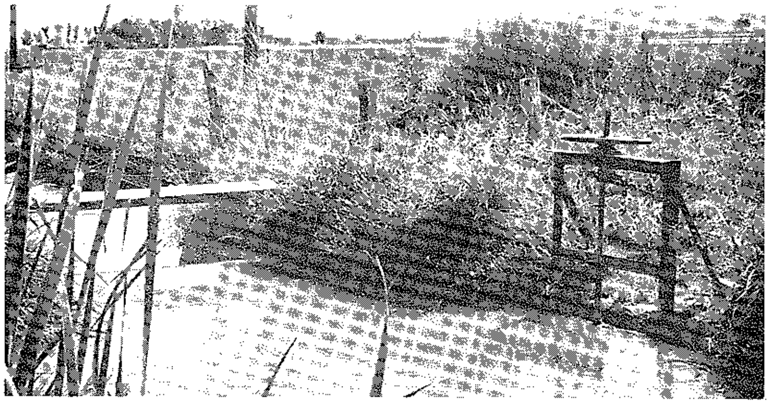

Fig. 29. Flow Regulation Structure 115C which diverts water from the Central Canal.

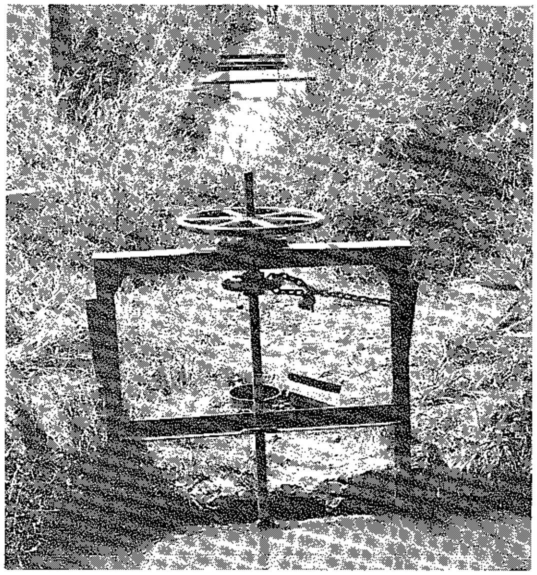

Fig. 30. Structure 115C showing stilling well.

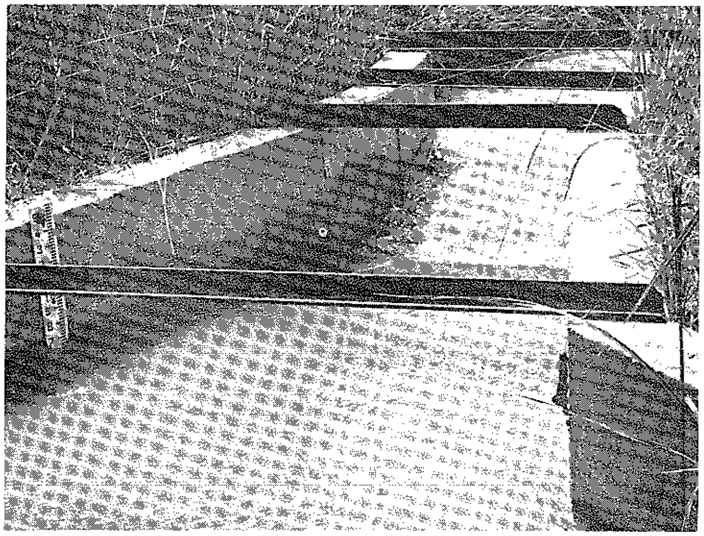

Fig. 31. Parshall flume located downstream from exit of structure 115C.

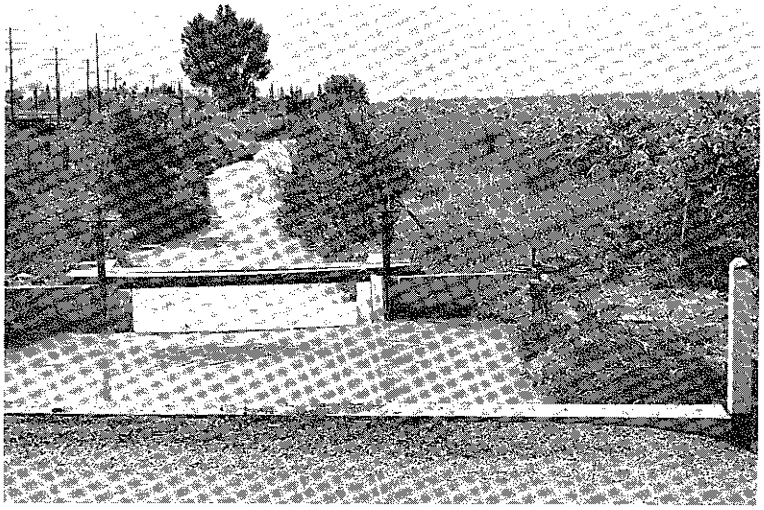

Fig. 32. West Hammond Canal with Flow Regulation Structure 14HW located on right bank.

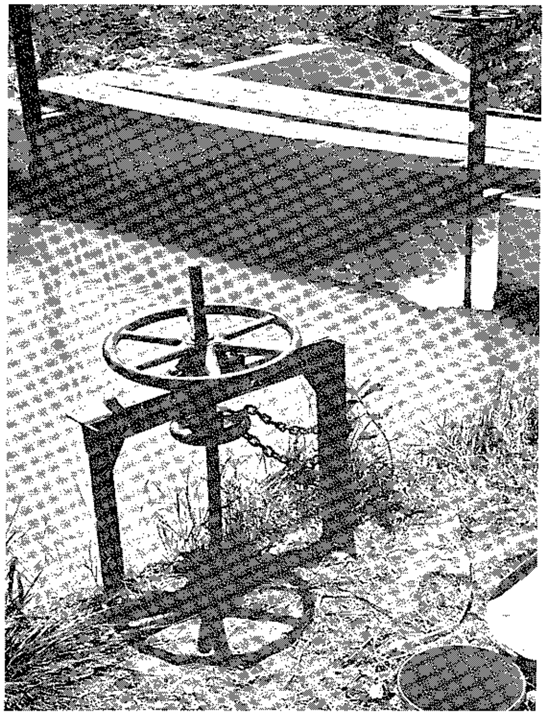

Fig. 33. Structure 15HW with stilling well.

Fig. 34. Parshall flume located below structure 14HW.

ANALYSIS OF FIELD DATA

Typical field ratings are illustrated by Figs. 35 and 36 which were developed for structure 107W. The lines of constant gate opening, b, in both figures were developed from the data in conjunction with the plots of b against C_q shown in Fig. 37. As can be seen from Fig. 37, the agreement between the field and laboratory data for this particular structure is good.

Most of the flow regulation structures in the Bear River Canal System are operated to provide a constant flow rate to the water user. The magnitude of this constant discharge varies from one structure to another. An alternative method of presenting the rating information for use by the water masters is illustrated in Fig. 38 using structure 107W for an example. Here, a rating curve for a constant discharge, Q, of 3.00 cfs is presented using H_u and H_d as the flow depths. Whenever the flow is being regulated through structure 107W, the gate opening, b, and change in water surface elevation, ΔH, would be measured by the water master. The information would be plotted on Fig. 38, and if the point falls below the rating curve, the discharge passing through the culvert would be less than 3.00 cfs, thus requiring the gate to be raised. If b and ΔH should plot above the rating curve, the discharge would be greater than 3.00 cfs and would require that the gate be lowered until b and ΔH fall on the rating curve.

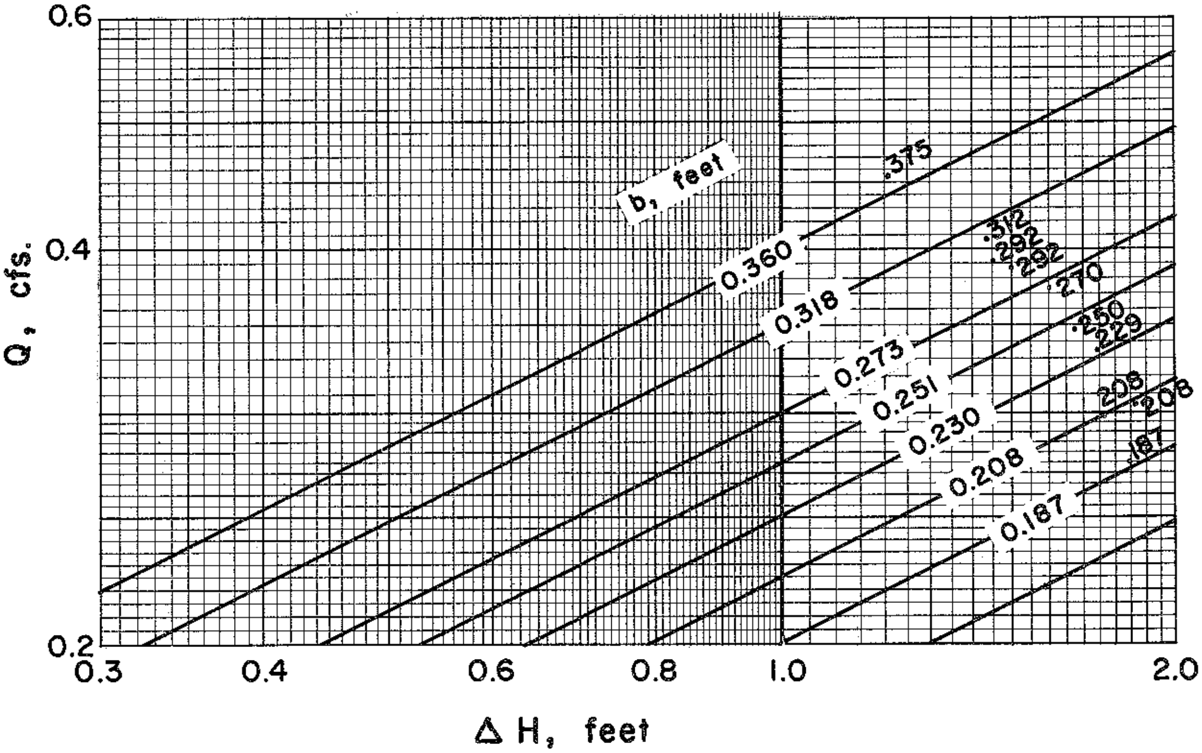

Fig. 35. Rating for field structure 107W using stilling well.

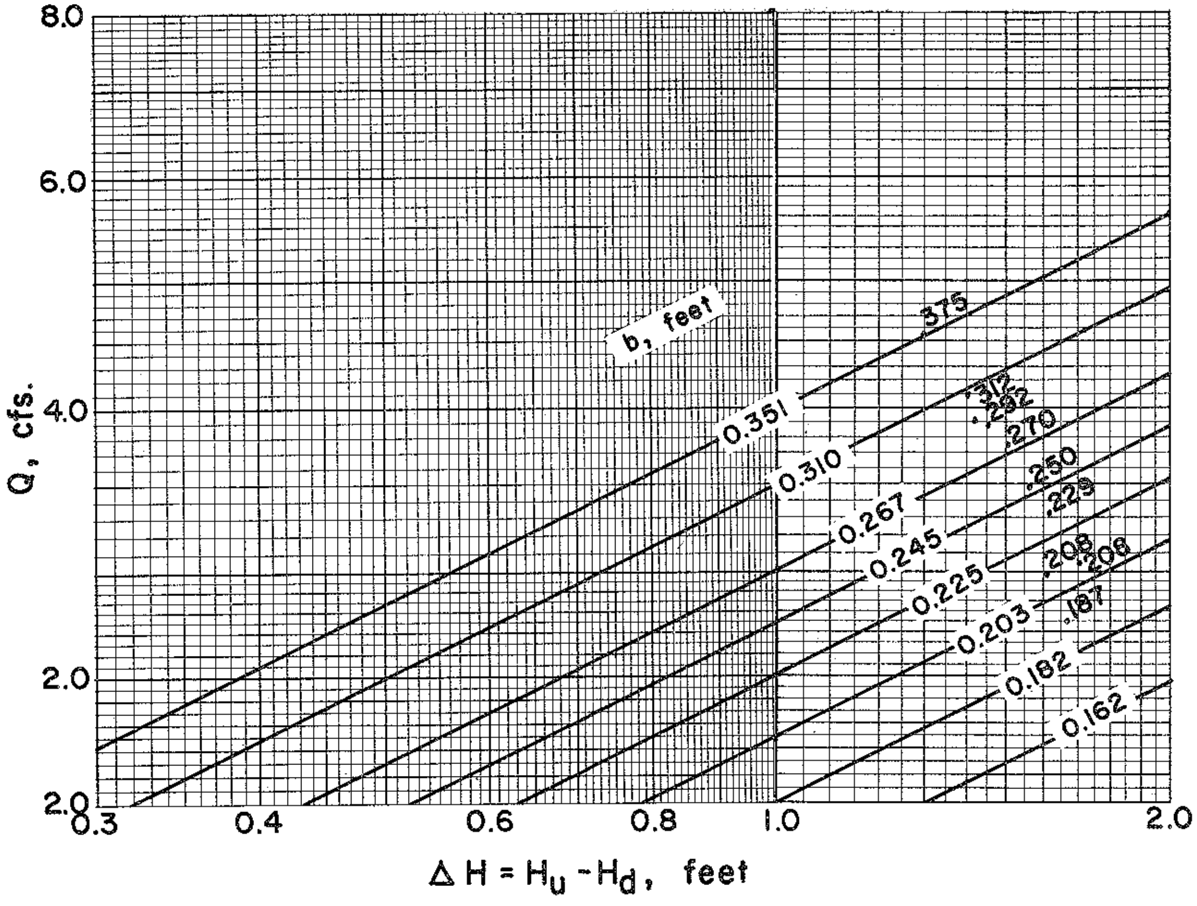

Fig. 36. Rating for field structure 107W using flow depth beyond culvert exit.

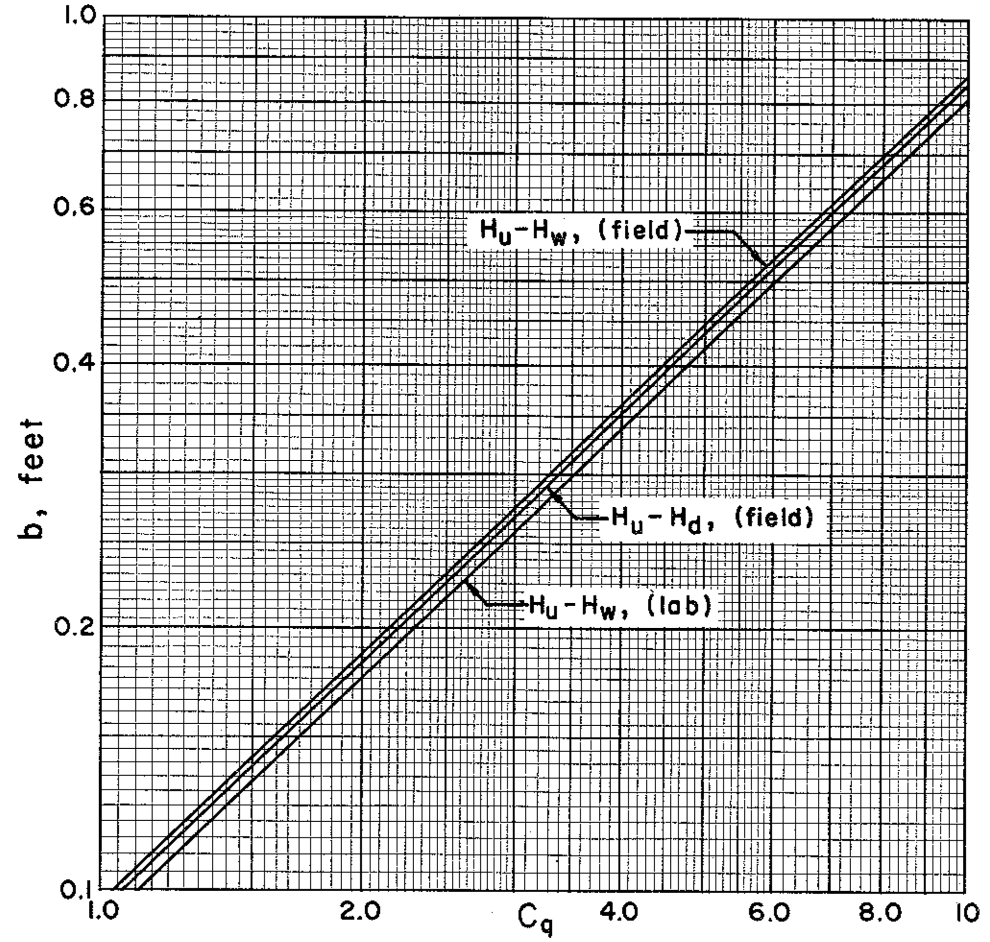

Fig. 37. Relationships between b and C_q for structure 107W.

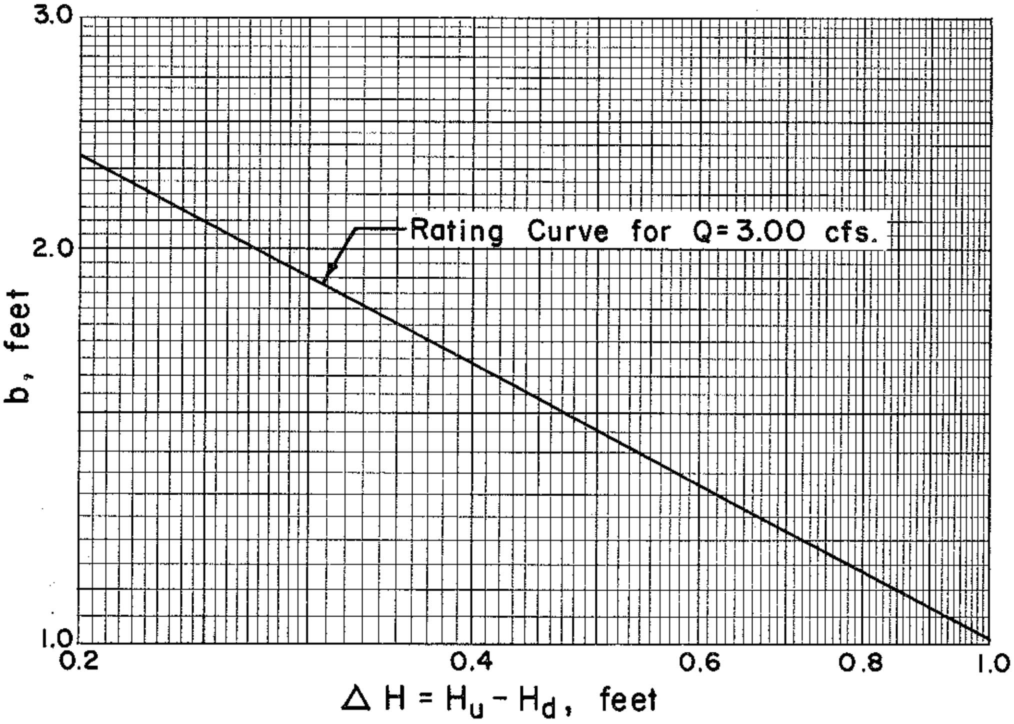

Fig. 38. Constant discharge rating for structure 107W.

The comparison of the relationship between b and C_q for the 2-foot cast iron gate tested in the laboratory with field structure 15HW is shown in Fig. 39. The field data for the 2-foot cast iron gate plotted above the laboratory data in Fig. 39, which was also the case for the 2-foot steel gate (Fig. 37).

The relationships between b and C_q for the three field structures having 3-foot gates, along with the relationship developed in the laboratory for a 3-foot steel gate, are shown in Fig. 40. The wide variations in the ratings for the three field structures point out the necessity of developing individual field ratings for each flow regulation structure.

During the field ratings conducted as a part of this study, the discharge, Q, depth of flow in the main canal, H_u, depth of flow in the stilling well, H_w, depth of flow beyond the exit of the culvert, H_d, and the height of gate opening, b, were measured. Rating curves were developed for each field structure utilizing both $H_u - H_w$ and $H_u - H_d$ for ΔH. Both rating curves were comparably accurate. Consequently, the use of H_d rather than H_w in developing the rating for a structure would be advantageous because the construction and installation of a stilling well would not be necessary. The primary purpose of including H_w in the rating program was to obtain consistent ratings between similar structures. As indicated by Fig. 40, a wide variation can exist in the ratings for similar structures, thus negating any apparent advantages in using H_w.

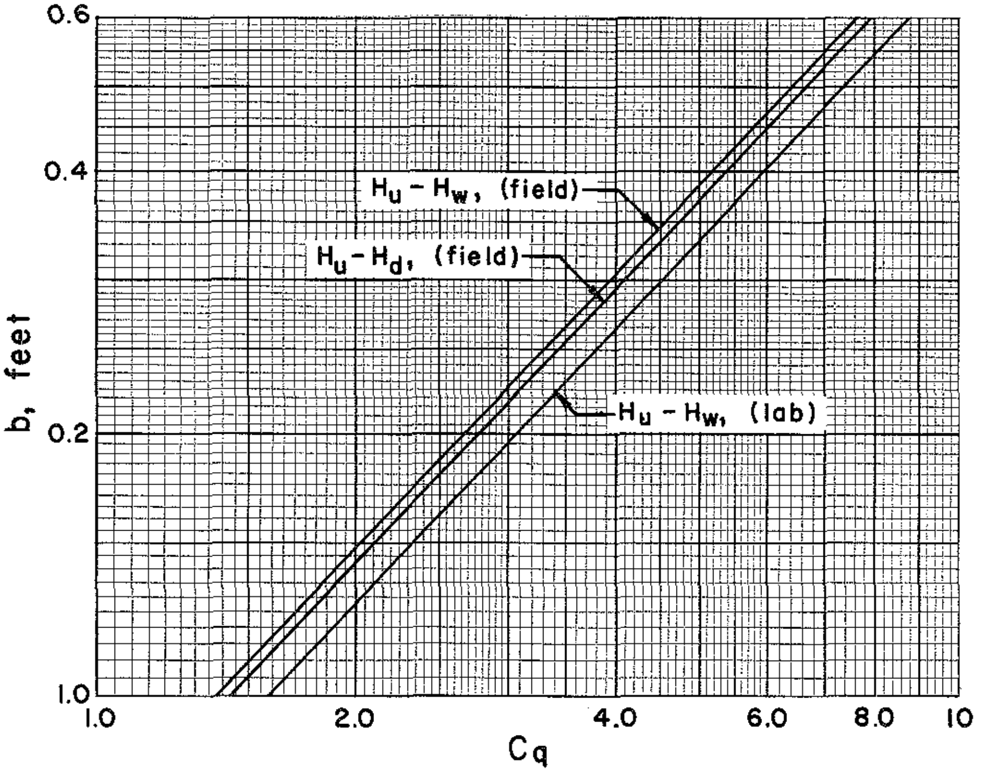

Fig. 39. Relationships between b and C_q for structure 15HW.

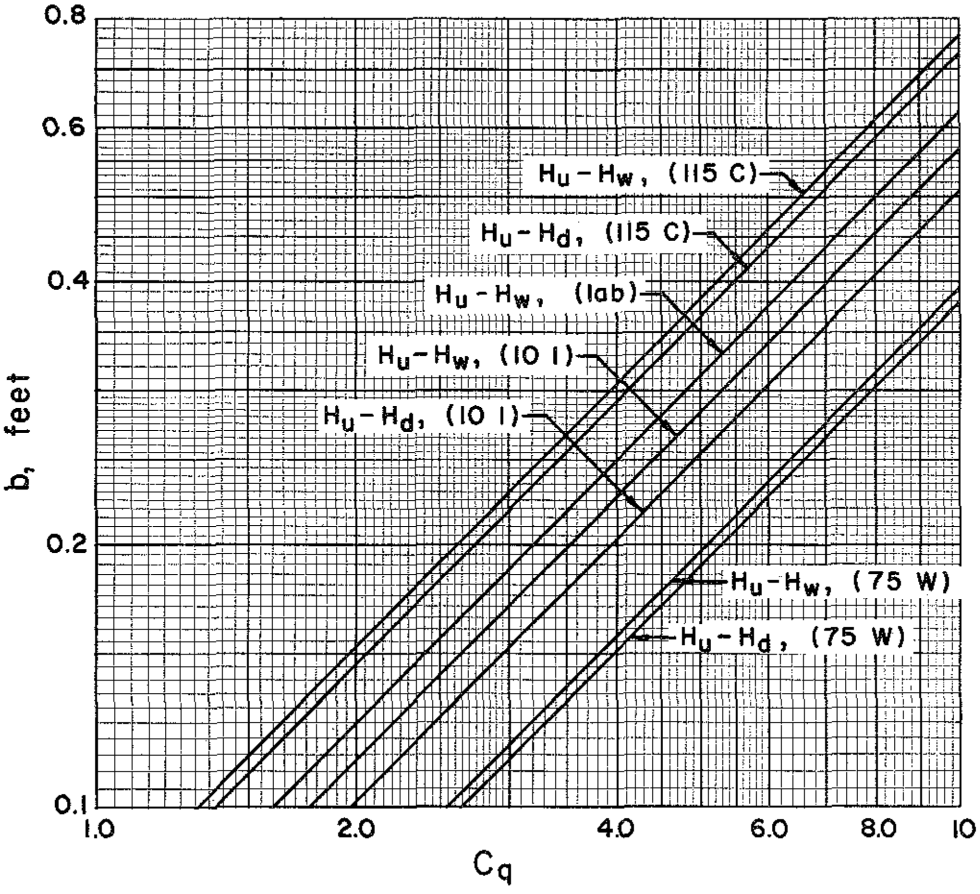

Fig. 40. Relationships between b and C_q for structures 75W, 10I, and 115C.

PROCEDURE FOR FIELD RATING

The results from the analysis of the laboratory and field data can now be utilized in developing the procedure for rating individual structures in place. The development of field data will require the measurement of discharge, Q, height of gate opening, b, and change in water surface elevation between the main canal and the culvert exit, $H_u - H_d$. Most of the discharge measurements will be collected over a period of years with a current meter. The use of a few portable steel Parshall flumes would allow a more rapid development of field ratings. Techniques for measuring the height of gate opening, b, have already been developed by the personnel operating the canal system. Measuring the change in water surface elevation requires only the establishment of reference points from which H_u and H_d can be determined.

To illustrate the procedure for developing the rating for any individual flow regulation structure, a hypothetical example is presented. Suppose, the field data listed in Table 1 have been collected for a particular structure. The first step in analyzing this data is to compute C_q from Eq. 5.

$$Q = C_q (\Delta H)^{1/2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 5$$

$$C_q = Q/(\Delta H)^{1/2}$$

The computations for C_q are listed in Table 2. Now, C_q can be plotted against b on log-log paper as shown in Fig. 41. The line of best fit is

Table 1. Field data for hypothetical flow regulation structure.

Run No.	Q cfs	b feet	H_u feet	H_d feet	ΔH feet
1	2.69	0.24	3.06	2.17	0.89
2	2.96	0.27	3.03	2.23	0.80
3	3.22	0.30	3.09	2.25	0.84
4	3.63	0.35	3.04	2.29	0.75
5	3.97	0.40	3.00	2.34	0.66
6	4.59	0.45	3.09	2.37	0.72
7	4.83	0.50	3.06	2.39	0.67
8	5.13	0.53	3.04	2.42	0.62

Table 2. Computation of C_q for hypothetical structure.

Run No.	Q cfs	b feet	ΔH feet	C_q
1	2.69	0.24	0.89	2.85
2	2.96	0.27	0.80	3.30
3	3.22	0.30	0.84	3.51
4	3.63	0.35	0.75	4.19
5	3.97	0.40	0.66	4.90
6	4.59	0.45	0.72	5.42
7	4.83	0.50	0.67	5.89
8	5.13	0.53	0.62	6.50

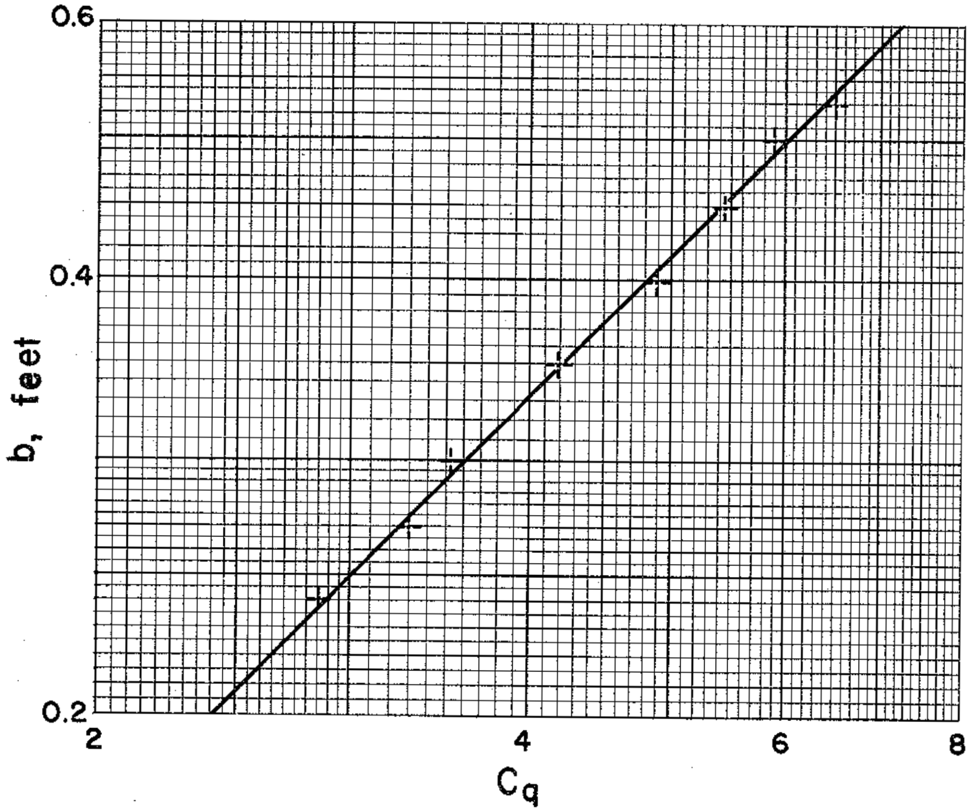

Fig. 41. Relationship between b and C_q for hypothetical structure.

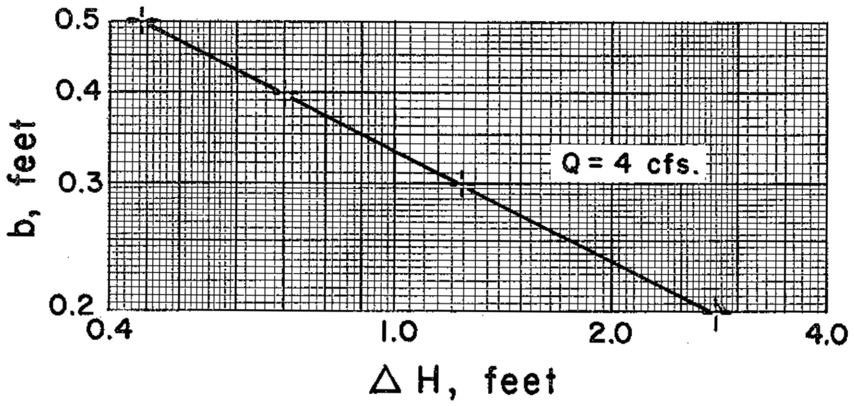

Fig. 42. Constant discharge rating for hypothetical structure.

drawn through the data. Although a straight line should generally be used, there will be cases when the data will dictate a curved line, particularly for the larger gate openings.

The relationship between b and C_q (Fig. 41) is the rating for the hypothetical flow regulation structure. All that remains is to present the rating in a more usable manner.

In most cases, a particular structure in the Bear River Canal System is operated (not always continuously) at a constant discharge during the irrigation season. For such cases, a constant discharge rating curve is sufficient. For the hypothetical example being used, a rating for a constant discharge of 4.0 cfs will be developed. By entering Fig. 41 with values of b, the corresponding values of C_q can be obtained from the line of best fit. The values of C_q, along with the constant discharge of 4.0 cfs, are substituted into Eq. 5 and ΔH is calculated. The selection of data from Fig. 41 and the corresponding computations to determine ΔH are listed in Table 3. With this information, b can be plotted against ΔH as shown in Fig. 42, with the line which fits the points being the constant discharge (4.0 cfs) rating. Thereafter, when operating the structure, if a measurement of b and ΔH should plot below the rating curve, the discharge would be less than 4.0 cfs, and the gate would have to be raised until the measurement of b and ΔH would plot on the rating curve (Fig. 42).

A general rating for the hypothetical flow regulation structure can also be obtained from Fig. 41. The general rating would be

Table 3. Data from Fig. 41 for constant discharge rating (Q = 4 cfs).

b feet	C_q	ΔH feet
0.2	2.4	2.78
0.3	3.6	1.24
0.4	4.8	0.70
0.5	6.0	0.44

Table 4. Data from Fig. 41 for general discharge rating.

b feet	C_q
0.20	2.4
0.25	3.0
0.30	3.6
0.35	4.2
0.40	4.8
0.45	5.4
0.50	6.0

prepared over the range of gate openings the structure might be operated. The general rating (Fig. 43) would be obtained by entering Fig. 41 with values of b and obtaining the corresponding values of C_q from the line of best fit. The data from Fig. 41 is listed in Table 4. The value of C_q for each gate opening, b, is actually the value of Q when $\Delta H = 1.0$. Thus, C_q has been plotted in Fig. 43 on the vertical corresponding to $\Delta H = 1.0$. From the plotted points, straight lines are drawn having a slope of 1/2. Each straight line is labeled with the corresponding value of gate opening, b. Thus, Fig. 43 becomes the general rating for the hypothetical flow regulation structure. Rather than presenting the general rating in graphical form, the same information can be placed in a table, as water masters may find the employment of tables more satisfactory than graphs.

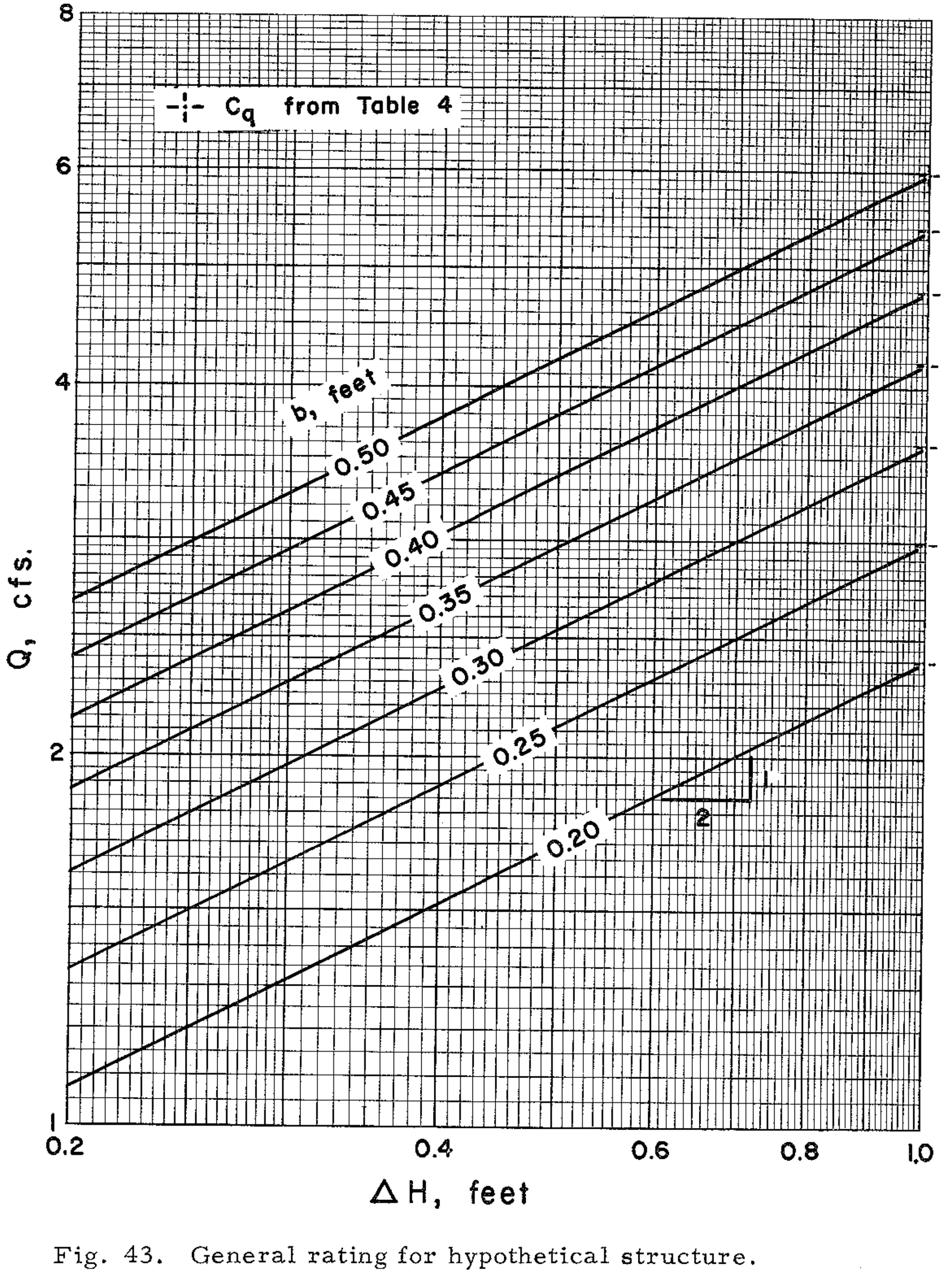

Fig. 43. General rating for hypothetical structure.

Table 5. Discharge rating for hypothetical flow regulation structure. (Discharge is listed in cubic feet per second.)

ΔH feet	Gate Opening, b, feet						
	0.20	0.25	0.30	0.35	0.40	0.45	0.50
0.40	1.52	1.90	2.28	2.66	3.04	3.41	3.79
0.42	1.56	1.94	2.33	2.72	3.11	3.50	3.89
0.44	1.59	1.99	2.39	2.79	3.18	3.58	3.98
0.46	1.63	2.03	2.44	2.85	3.26	3.66	4.07
0.48	1.66	2.08	2.49	2.91	3.33	3.74	4.16
0.50	1.70	2.12	2.55	2.97	3.39	3.82	4.24
0.52	1.73	2.16	2.60	3.03	3.46	3.89	4.33
0.54	1.76	2.20	2.65	3.09	3.53	3.97	4.41
0.56	1.80	2.24	2.69	3.14	3.59	4.04	4.49
0.58	1.83	2.28	2.74	3.20	3.66	4.11	4.57
0.60	1.85	2.32	2.79	3.25	3.72	4.18	4.65
0.62	1.89	2.36	2.83	3.31	3.78	4.25	4.72
0.64	1.92	2.40	2.88	3.36	3.84	4.32	4.80
0.66	1.95	2.44	2.92	3.41	3.90	4.39	4.87
0.68	1.98	2.47	2.97	3.46	3.96	4.45	4.95
0.70	2.01	2.51	3.01	3.51	4.02	4.52	5.02
0.72	2.04	2.55	3.05	3.56	4.07	4.58	5.09
0.74	2.06	2.58	3.10	3.61	4.13	4.65	5.16
0.76	2.09	2.62	3.14	3.66	4.18	4.71	5.23
0.78	2.12	2.65	3.18	3.71	4.24	4.77	5.30
0.80	2.15	2.68	3.22	3.76	4.29	4.83	5.37
0.82	2.17	2.72	3.26	3.80	4.35	4.89	5.43
0.84	2.20	2.75	3.30	3.85	4.40	4.95	5.50
0.86	2.23	2.78	3.34	3.89	4.45	5.01	5.56
0.88	2.25	2.81	3.38	3.94	4.50	5.07	5.63
0.90	2.28	2.85	3.42	3.98	4.55	5.12	5.69
0.92	2.30	2.88	3.45	4.03	4.60	5.18	5.75
0.94	2.33	2.91	3.49	4.07	4.65	5.24	5.82
0.96	2.35	2.94	3.53	4.11	4.70	5.29	5.88
0.98	2.38	2.97	3.56	4.16	4.75	5.35	5.94
1.00	2.40	3.00	3.60	4.20	4.80	5.40	6.00

CONCLUSIONS

The generation of data from flow regulation structures constructed in the laboratory has provided the necessary information regarding the general flow characteristics of such structures. The collection of field data from a number of gate structures has shown the necessity of rating each individual structure because of the variation that occurred from one rating to another for apparently similar structures. The testing program clearly showed that a water surface elevation beyond the exit of the culvert, H_d, was as satisfactory as measuring the water surface in a stilling well, H_w. The collection and analysis of both laboratory and field data have been fruitful in establishing the procedure for developing field ratings. The conduct of a field program in collecting the proper measurements at each flow regulation structure over a period of years will yield the desired ratings. Once the ratings have been developed, a more adequate and equitable distribution of the waters in the Bear River Canal System will be possible.

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APPENDIX

LABORATORY AND FIELD DATA

Table 6. Laboratory data for 2-foot cast iron gate.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
1	2.28	0.10	3.941	1.460	2.481
2	2.24	0.10	4.221	1.881	2.340
3	1.78	0.10	2.822	1.494	1.328
4	1.74	0.10	3.276	1.988	1.388
5	1.76	0.10	3.647	2.448	1.199
6	1.73	0.10	4.034	2.860	1.174
7	1.77	0.10	2.800	1.450	1.350
8	1.75	0.10	3.074	1.761	1.313
9	1.35	0.10	2.178	1.452	0.726
10	1.33	0.10	2.641	1.943	0.698
11	1.31	0.10	3.070	2.389	0.681
12	1.29	0.10	3.471	2.817	0.654
13	1.27	0.10	3.845	3.205	0.640
14	0.59	0.10	1.512	1.384	0.128
15	0.63	0.10	2.013	1.860	0.153
16	0.63	0.10	2.409	2.255	0.154
17	3.34	0.20	4.128	2.933	1.195
18	3.48	0.20	3.832	2.485	1.347
19	3.58	0.20	3.474	2.046	1.428
20	3.69	0.20	3.076	1.551	1.525
21	2.74	0.20	3.788	2.889	0.899
22	2.85	0.20	3.408	2.466	0.942
23	2.88	0.20	2.977	2.008	0.969
24	3.01	0.20	2.520	1.518	1.002
25	2.07	0.20	3.343	2.841	0.502
26	2.07	0.20	2.932	2.439	0.493
27	2.11	0.20	2.495	1.985	0.510
28	2.14	0.20	2.016	1.484	0.532
29	0.90	0.20	2.764	2.674	0.090
30	0.94	0.20	2.439	2.341	0.098
31	0.97	0.20	1.994	1.884	0.110
32	0.79	0.20	1.502	1.435	0.077
33	5.85	0.40	4.069	3.166	0.903
34	6.21	0.40	3.723	2.714	1.009
35	6.36	0.40	3.308	2.264	1.044
36	6.36	0.40	2.870	1.777	1.093
37	5.41	0.40	3.951	3.145	0.806

Table 6. Continued.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
38	5.56	0.40	3.569	2.699	0.870
39	5.64	0.40	3.140	2.243	0.897
40	5.81	0.40	2.687	1.751	0.936
41	4.43	0.40	3.620	3.085	0.535
42	4.50	0.40	3.204	2.624	0.580
43	4.55	0.40	2.758	2.192	0.566
44	4.58	0.40	2.275	1.690	0.585
45	2.41	0.40	3.101	2.936	0.165
46	2.41	0.40	2.684	2.506	0.178
47	2.45	0.40	2.230	2.049	0.181
48	2.50	0.40	1.748	1.560	0.188
49	1.27	0.40	2.860	2.813	0.047
50	1.32	0.40	2.445	2.394	0.051
51	1.32	0.40	1.994	1.944	0.054
52	1.05	0.40	1.458	1.429	0.029
53	6.68	0.70	3.667	3.224	0.443
54	6.79	0.70	3.294	2.794	0.500
55	6.97	0.70	2.862	2.354	0.508
56	7.15	0.70	2.380	1.861	0.519
57	5.14	0.70	3.498	3.188	0.310
58	5.31	0.70	3.082	2.766	0.316
59	5.34	0.70	2.639	2.313	0.326
60	5.34	0.70	2.160	1.820	0.340
61	3.11	0.70	3.062	2.950	0.112
62	3.16	0.70	2.638	2.523	0.115
63	3.21	0.70	2.191	2.075	0.116
64	3.23	0.70	1.715	1.594	0.121
65	1.60	0.70	2.837	2.808	0.029
66	1.61	0.70	2.419	2.385	0.034
67	1.63	0.70	1.973	1.940	0.033
68	1.66	0.70	1.488	1.456	0.032
69	7.03	1.00	3.655	3.249	0.406
70	7.15	1.00	3.232	2.818	0.414
71	7.15	1.00	2.782	2.350	0.432
72	7.28	1.00	2.286	1.848	0.438
73	5.20	1.00	3.366	3.118	0.148
74	5.27	1.00	2.930	2.691	0.239
75	5.34	1.00	2.485	2.232	0.253

Table 6. Continued.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
76	5.41	1.00	1.987	1.730	0.257
77	3.27	1.00	3.055	2.961	0.094
78	3.27	1.00	2.626	2.520	0.106
79	3.30	1.00	2.177	2.077	0.100
80	3.37	1.00	1.700	1.600	0.100
81	2.70	1.00	2.984	2.914	0.070
82	2.74	1.00	2.564	2.497	0.067
83	2.78	1.00	2.011	1.936	0.075
84	2.84	1.00	1.630	1.558	0.072

Table 7. Laboratory data for 2-foot steel gate.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
1	1.26	0.10	3.922	2.708	1.214
2	1.27	0.10	3.541	2.292	1.249
3	1.29	0.10	3.137	1.846	1.291
4	1.31	0.10	2.763	1.442	1.321
5	0.86	0.10	2.630	2.057	0.573
6	0.87	0.10	2.567	1.984	0.563
7	0.87	0.10	2.410	1.826	0.584
8	0.87	0.10	1.984	1.396	0.588
9	1.13	0.10	3.043	2.072	0.971
10	1.15	0.10	2.643	1.618	1.025
11	1.67	0.10	3.982	1.846	2.136
12	1.70	0.10	3.588	1.375	2.213
13	2.28	0.18	4.138	2.764	1.374
14	2.32	0.18	3.768	2.332	1.436
15	2.36	0.18	3.358	1.883	1.475
16	2.39	0.18	2.919	1.386	1.533
17	1.57	0.18	3.360	2.738	0.622
18	1.60	0.18	2.969	2.324	0.645
19	1.60	0.18	2.546	1.890	0.656
20	1.63	0.18	2.088	1.408	0.680
21	1.27	0.18	3.001	2.587	0.414
22	1.27	0.18	2.725	2.289	0.436
23	1.32	0.18	2.322	1.883	0.439
24	1.63	0.18	2.088	1.408	0.680
25	1.00	0.18	2.313	2.053	0.260
26	1.01	0.18	2.095	1.834	0.261
27	3.89	0.30	4.134	2.702	1.432
28	4.03	0.30	3.864	2.348	1.516
29	4.05	0.30	3.503	1.877	1.626
30	4.26	0.30	3.125	1.402	1.723
31	2.97	0.30	3.579	2.808	0.771
32	3.02	0.30	3.185	2.387	0.798
33	3.06	0.30	2.771	1.944	0.827
34	3.17	0.30	2.321	1.444	0.877
35	2.20	0.30	3.220	2.775	0.445

Table 7. Continued.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
36	2.21	0.30	2.822	2.370	0.452
37	2.21	0.30	2.408	1.933	0.475
38	2.28	0.30	1.934	1.450	0.484
39	1.01	0.30	2.279	2.184	0.095
40	1.02	0.30	2.202	2.101	0.101
41	1.03	0.30	1.964	1.865	0.099
42	6.07	0.60	3.808	3.171	0.777
43	6.16	0.60	3.430	2.735	0.695
44	6.46	0.60	3.008	2.274	0.734
45	6.68	0.60	2.549	1.790	0.759
46	4.05	0.60	3.291	3.007	0.284
47	4.15	0.60	2.888	2.574	0.314
48	4.29	0.60	2.460	2.132	0.328
49	4.38	0.60	2.008	1.669	0.339
50	2.43	0.60	2.965	2.858	0.107
51	2.47	0.60	2.564	2.457	0.107
52	2.47	0.60	2.128	2.010	0.118
53	2.48	0.60	1.643	1.528	0.115
54	1.29	0.60	2.557	2.434	0.123
55	1.31	0.60	2.354	2.319	0.045
56	1.32	0.60	1.940	1.904	0.036
57	1.03	0.60	1.414	1.396	0.018
58	5.41	0.75	3.515	3.164	0.351
59	5.64	0.75	3.168	2.760	0.408
60	5.68	0.75	2.682	2.311	0.371
61	5.85	0.75	2.201	1.820	0.381
62	4.80	0.75	3.380	3.111	0.269
63	4.95	0.75	2.987	2.708	0.279
64	5.14	0.75	2.557	2.262	0.295
65	5.24	0.75	-----	-----	-----
66	2.77	0.75	3.027	2.936	0.091
67	2.83	0.75	2.634	2.538	0.096
68	2.86	0.75	2.189	2.089	0.100
69	2.90	0.75	1.719	1.615	0.104
70	2.15	0.75	2.881	2.827	0.054

Table 7. Continued.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
71	2.17	0.75	2.481	2.427	0.054
72	2.18	0.75	2.047	1.990	0.057
73	2.18	0.75	1.568	1.511	0.057
74	6.36	1.07	3.518	3.189	0.329
75	6.62	1.07	3.118	2.772	0.346
76	6.85	1.07	2.681	2.321	0.360
77	7.03	1.07	2.194	1.825	0.369
78	5.31	1.07	3.340	3.109	0.231
79	5.38	1.07	2.909	2.690	0.219
80	5.49	1.07	2.490	2.240	0.250
81	5.60	1.07	2.011	1.753	0.258
82	3.07	1.07	3.008	2.923	0.085
83	3.14	1.07	2.596	2.509	0.087
84	3.09	1.07	2.178	2.096	0.082
85	3.17	1.07	1.701	1.613	0.088
86	1.74	1.07	2.847	2.818	0.029
87	1.75	1.07	2.446	2.417	0.029
88	1.77	1.07	2.001	1.968	0.033
89	1.80	1.07	1.547	1.515	0.032
90	5.07	0.42	4.042	2.845	1.197
91	5.31	0.42	3.694	2.531	1.163
92	5.41	0.42	3.308	2.077	1.231
93	5.56	0.42	2.873	1.573	1.300
94	3.31	0.42	3.360	2.908	0.452
95	3.38	0.42	2.969	2.497	0.472
96	3.44	0.42	2.537	2.036	0.501
97	3.35	0.42	2.102	1.593	0.509
98	2.06	0.42	3.024	2.844	0.180
99	2.13	0.42	2.615	2.423	0.192
100	2.15	0.42	2.174	1.970	0.204
101	2.17	0.42	1.712	1.510	0.202
102	1.24	0.42	2.248	2.183	0.065
103	1.26	0.42	2.353	2.285	0.068
104	1.28	0.42	1.973	1.900	0.073
105	0.99	0.42	1.425	1.385	0.040

Table 8. Laboratory data for 3-foot steel gate.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
1	4.91	0.19	4.008	1.739	2.269
2	4.91	0.19	4.145	1.748	2.397
3	4.91	0.19	4.233	1.909	2.324
4	4.91	0.19	4.128	1.739	2.389
5	2.85	0.19	3.700	2.723	0.977
6	2.85	0.19	3.091	1.968	1.123
7	2.85	0.19	2.820	1.793	1.027
8	2.85	0.19	3.470	3.069	0.401
9	3.46	0.19	4.073	2.791	1.282
10	3.37	0.19	3.693	2.580	1.113
11	3.37	0.19	3.638	2.591	1.047
12	3.37	0.19	3.302	2.265	1.037
13	3.37	0.19	3.014	1.999	1.037
14	1.94	0.19	3.901	3.461	0.440
15	1.94	0.19	4.183	3.771	0.409
16	1.94	0.19	2.966	2.784	0.182
17	1.89	0.19	2.474	2.316	0.158
18	5.12	0.31	3.828	2.737	1.091
19	5.12	0.31	3.282	2.255	1.027
20	5.12	0.31	2.860	1.862	0.998
21	5.10	0.31	2.731	1.778	0.953
22	4.12	0.31	3.090	2.341	0.749
23	4.12	0.31	2.690	2.024	0.666
24	4.12	0.31	3.501	2.892	0.609
25	4.09	0.31	3.947	3.263	0.684
26	12.88	1.54	3.822	3.657	0.165
27	12.88	1.54	3.356	3.138	0.218
28	8.76	1.54	4.232	3.957	0.275
29	8.76	1.54	2.956	1.836	0.120
30	8.76	1.54	2.557	2.422	0.135
31	8.76	1.00	2.566	2.404	0.162
32	8.76	1.00	2.815	2.584	0.231
33	8.76	1.00	3.131	2.898	0.233
34	10.68	1.00	4.040	3.757	0.283
35	10.68	1.00	3.603	3.391	0.212

Table 8. Continued.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
36	10.68	1.00	3.297	3.069	0.228
37	10.60	0.60	3.656	2.561	1.095
38	10.60	0.60	3.436	2.253	1.183
39	10.60	0.60	3.771	2.573	1.198
40	8.30	0.60	3.625	2.949	1.398
41	8.30	0.60	2.931	2.218	0.713
42	8.30	0.60	3.071	2.355	0.716
43	5.44	0.60	3.390	3.062	0.328
44	5.44	1.00	3.362	3.245	0.117
45	5.44	1.54	3.310	3.274	0.036
46	2.74	0.31	4.011	3.746	0.265
47	2.74	0.19	4.195	3.668	0.527
48	2.74	0.60	3.972	3.941	0.031
49	2.74	1.00	3.938	3.936	0.002
50	4.01	0.19	4.855	2.975	1.880
51	4.20	0.19	4.540	2.522	2.012
52	3.26	0.19	4.179	2.951	1.228
53	3.35	0.19	3.764	2.521	1.243
54	2.66	0.19	4.050	3.237	0.813
55	2.73	0.19	3.663	2.931	0.832
56	2.09	0.19	3.705	3.221	0.484
57	2.13	0.19	3.310	2.810	0.500
58	3.99	0.19	4.855	3.021	1.834
59	5.17	0.31	4.404	3.282	1.122
60	5.31	0.31	4.049	2.862	1.187
61	4.61	0.31	4.179	3.290	0.889
62	4.71	0.31	3.820	2.880	0.930
63	4.03	0.31	3.939	3.295	0.644
64	4.17	0.31	3.605	2.862	0.743
65	3.04	0.31	3.677	3.278	0.399
66	3.09	0.31	3.286	2.877	0.409
67	5.49	0.60	3.738	3.413	0.325
68	5.64	0.60	3.343	3.001	0.342
69	5.01	0.60	3.253	2.991	0.262
70	4.86	0.60	3.647	3.392	0.255

Table 8. Continued.

Run No.	Q cfs	b feet	H_u feet	H_w feet	ΔH feet
71	3.08	0.60	3.427	3.324	0.103
72	3.13	0.60	3.025	2.916	0.109
73	2.18	0.60	2.912	2.856	0.056
74	2.12	0.60	3.313	3.258	0.055
75	5.60	1.00	3.601	3.500	0.101
76	5.68	1.00	3.208	3.106	0.102
77	4.63	1.00	3.120	3.025	0.068
78	4.55	1.00	3.511	3.445	0.066
79	3.16	1.00	3.390	3.353	0.037
80	3.16	1.00	2.992	2.957	0.035
81	2.17	1.00	2.897	2.878	0.019
82	2.14	1.00	3.295	3.274	0.021
83	5.53	1.54	3.583	3.535	0.048
84	5.56	1.54	3.174	3.123	0.051
85	3.38	1.54	3.013	2.990	0.023
86	3.40	1.54	3.417	3.396	0.021
87	2.39	1.00	3.330	3.310	0.020
88	2.42	1.00	2.927	2.903	0.024
89	2.06	0.10	4.845	3.185	1.660
90	2.07	0.10	4.419	2.793	1.626
91	1.56	0.10	4.078	3.138	0.940
92	1.55	0.10	4.168	3.237	0.931
93	5.41	0.40	4.070	3.343	0.727
94	5.53	0.40	3.692	2.929	0.763
95	2.20	0.40	2.978	2.857	0.121
96	2.17	0.40	3.377	3.256	0.121

Table 9. Field data for structure 107W.

Run No.	b feet	Q cfs	$H_u - H_w$ feet	$H_u - H_d$ feet
1	0.208	3.050	1.703	1.865
2	0.229	3.330	1.620	1.750
3	0.250	3.480	1.568	1.682
4	0.270	3.755	1.511	1.610
5	0.292	3.880	1.452	1.511
6	0.312	4.090	1.401	1.443
7	0.187	2.752	1.677	1.854
8	0.208	2.992	1.614	1.771
9	0.375	4.560	1.292	1.214
10	0.292	3.905	1.422	1.463

Table 10. Field data for structure 75W.

Run No.	b feet	Q cfs	$H_u - H_w$ feet	$H_u - H_d$ feet
1	0.193	4.182	-----	0.911
2	0.219	4.717	0.784	0.823
3	0.057	1.912	1.264	1.349
4	0.078	2.427	1.139	1.219
5	0.099	2.790	1.056	1.109
6	0.141	3.608	0.910	0.990
7	0.188	4.337	0.713	0.859
8	0.234	4.337	0.660	0.724
9	0.260	5.241	0.607	0.635

Table 11. Field data for structure 10I.

Run No.	b feet	Q cfs	$H_u - H_w$ feet	$H_u - H_d$ feet
1	0.500	3.859	0.155	0.198
2	0.542	3.949	0.134	0.178
3	0.583	3.949	0.123	0.145
4	0.625	3.979	0.102	0.124
5	0.667	3.979	0.092	0.114
6	0.708	4.069	0.070	0.093
7	0.750	4.129	0.081	0.103
8	0.792	4.129	0.061	0.083

Table 12. Field data for structure 115C.

Run No.	b feet	Q cfs	$H_u - H_w$ feet	$H_u - H_d$ feet
1	0.458	4.150	0.412	0.423
2	0.396	3.435	0.480	0.506
3	0.417	3.619	0.359	0.475
4	0.438	3.856	0.436	0.459
5	0.458	4.101	0.428	0.459
6	0.479	4.345	0.417	0.449
7	0.500	4.545	0.351	0.412

Table 13. Field data for structure 15HW.

Run No.	b feet	Q cfs	$H_u - H_w$ feet	$H_u - H_d$ feet
1	0.427	2.535	0.206	0.226
2	0.344	2.364	0.246	0.258
3	0.365	2.405	0.236	0.252
4	0.385	2.421	0.232	0.237
5	0.406	2.458	0.223	0.232
6	0.427	2.822	0.230	0.252
7	0.427	3.085	0.075	0.254