Measurement of Irrigation Water

On the Farm

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Measurement of Irrigation Water On the Farm

By Floyd E. Brown, Specialist in Irrigation Practice

Water is the most valuable asset of irrigated agriculture. It's intelligent and economical use depends largely upon a knowledge of the amount used. Unless the water is measured, the farmer has no idea how much water the crops actually use or the amount they will need the following year. What do we mean by a "light" or a "heavy" irrigation? We don't know unless the water is accurately measured.

There are many ways of expressing different quantities of water, such as "rights," "shares," "heads," "Farmer's Inches," "Miner's Inches," and other terms. These units are not the same for every ditch or for every farm, and their use leads to a great deal of confusion. It would be best if the farmer would "unlearn" to use such terms where he has been in the habit of using them, and learn to use two or three terms which are definite, and which do not vary from one farm to another. These terms are **cubic feet per second,** (which is also called second-feet) **acre-inches, and acre-feet.**

Units of Measurement of Water

Cubic foot per second (Second-foot).—A flow of water equivalent to a stream 1 foot wide and 1 foot deep flowing at the rate of 1 foot per second.

Acre-Inch.—The volume of water necessary to cover an acre 1 inch deep, or the amount of water falling on an acre in a 1-inch rain.

Acre-Foot.—Twelve acre-inches. The volume of water necessary to cover an acre 1 foot deep.

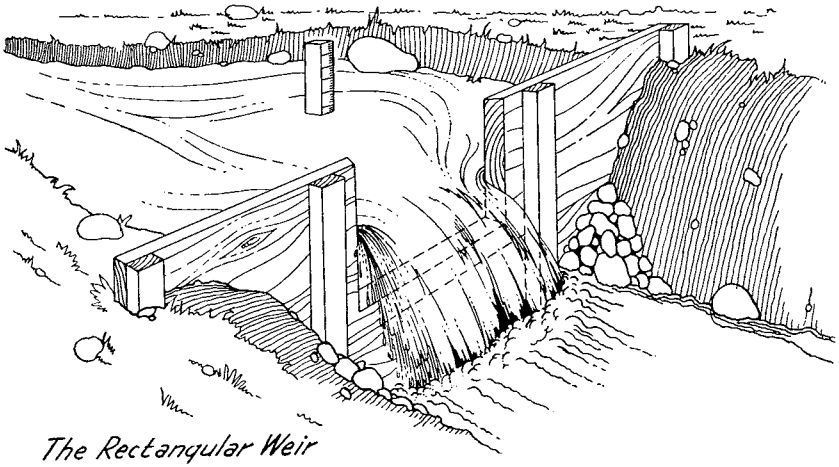
One cubic foot per second flowing for 1 hour is equal to approximately 1 acre-inch. To determine the number of acre-inches applied to a field—multiply the number of second-feet by the number of hours the water flows on the field. By dividing the number of acre-inches applied to the field by the number of acres in the field, the number of acre-inches per acre may be determined.

It is seldom necessary and is often a waste of water to apply more than 6 acre-inches per acre in a single irrigation. Six acre-inches should penetrate the soil to a depth of from 4 to 6 feet.

The Measuring Weir

A weir consists of a dam or bulkhead made of lumber, concrete, or metal, with a notch cut in the top edge and placed across a stream through which the water pours.

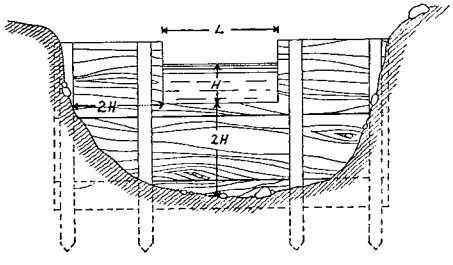
Weirs can only be used where there is sufficient slope in the ditch to permit the water to be partially held back and allowed to spill over the weir, as shown in the figure. In some ditches the banks of the



The Rectangular Weir

ditch above the weir must be raised to hold the water. The bottom of the notch over which the water flows is called the **crest** of the weir.

The crest of the rectangular or Cipolletti weir should be level so that water passing over it will be the same depth at all points.



The crest should be high enough so the water will fall freely below the weir, leaving an air space under the over-falling sheet of water.

Set the weir so the sides are vertical. Do not allow the weir to lean upstream or downstream.

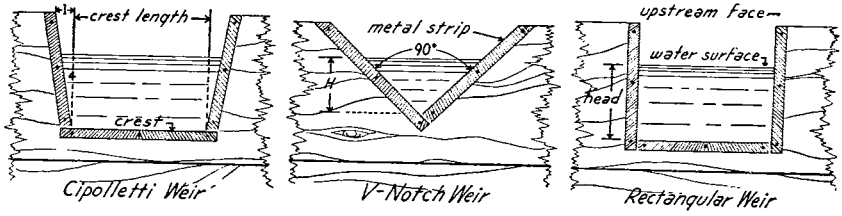
Do not let the ditch above the weir fill with silt or sand.

The depth of the water flowing over the weir should be measured far enough from the notch so that it will not be affected by the downward curve of the water as it flows toward the weir.

The measurement may be done by placing a weir gage or rule on the upstream face of the weir and far enough to one side of the notch so that it will be in still water. A simple way is to drive a nail into the upstream face of the weir at the same level of the weir crest. The depth of the water is then found by measuring with a rule, the distance between the top of the nail and the surface of the water. Be sure the zero point of the gage or rule is level with the edge of

the crest. An accurate measurement cannot be made by placing the rule on the crest over which the water is flowing.

Three types of weirs are shown below:



The bottom of the ditch on the upstream side of the weir should be about twice as far below the weir crest as the depth of the water flowing over the weir.

The length of the crest of the rectangular weir or the Cipolletti weir may be 12 inches, 18 inches, 24 inches, or 36 inches, depending on the amount of water usually flowing in the ditch. The V-notch weir is the best for small streams.

After the depth of the water flowing over the weir has been determined; the number of cubic feet per second (second-feet) flowing in the ditch is found by using the table on the back page.

The first two columns on the right show the depth of water. If the depth of the water is measured in feet, use the first column, or if the depth is measured in inches, use the second column.

Note that the table is for rectangular weirs, Cipolletti weirs, the V-notch weir, and for the Parshall flume. Also, note that for the rectangular weir, the Cipolletti weir, and the Parshall flume, there are columns provided for the different sizes of these structures. The figures shown in these columns are the number of cubic feet of water flowing per second for the depth shown at the left of the table.

For example, suppose the depth of the water measures 6-5/8 inches or .55 foot over a Cipolletti weir and the length of the crest is 1.5 feet. Enter the column marked "inches" under "Depth of Water" and follow downward to 6-5/8. Then move to the right, to the column marked "1-1/2 feet" under "Cipolletti Weir." The figure at this point is 2.07, which indicates that the amount of water flowing is 2.07 cubic feet per second.

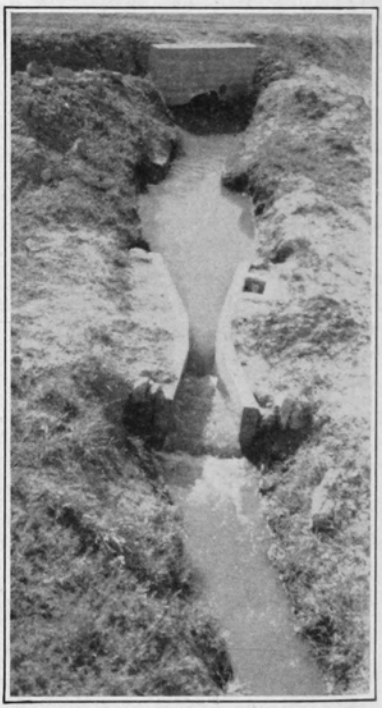
If a 2-foot rectangular weir were being used the flow would be 2.60 cubic feet per second, or if a V-notch weir were being used, then the flow would be .564 cubic foot per second. The figures used in this example are in bold-face type in the table.

The Parshall flume is one of the best measuring devices and is widely used in the measurement of water. Since the Parshall flume is more difficult to construct, it is not described in this circular. The rates of discharge, however, are shown for different sizes on the right of the table.

When a permanent measuring device is to be installed it is recommended that a concrete Parshall flume be constructed. Portable wooden forms may be used where canal companies build more than one flume and concrete is used. The use of portable forms greatly reduces the cost of construction when several flumes are made with the same set of forms.

The advantages of the Parshall flume are:

1. It is accurate for practical purposes.
2. Sand or silt in the water is carried through the flume and does not affect its operation or the accuracy of its record.
3. It operates successfully with small loss of head or ditch grade, being about one-fourth that for weirs.
4. Its operation is affected very little by the velocity or rate of flow of the water as it approaches the weir.
5. The flume has a range of capacity extending over wide limits — a one-foot Parshall flume will measure from one-third of a cubic foot per second to more than 10 cubic feet per second.



A Parshall flume in operation.

6. It may be readily constructed of wood, metal, or concrete.
7. It maintains a constancy of conditions and is unlikely to become inaccurate after extended use.
8. The flume is simple to operate.
9. Soil erosion on the bottom and sides of the ditch below the flume is not severe.

Some ditches are so nearly level, that it is impossible to use either a weir or a Parshall flume. In this case a measuring device known as the Submerged Orifice may be used.

Information regarding both the Parshall flume and the Submerged Orifice may be secured from the local County Extension Agent, or by writing to the Extension Service, Colorado State College.

Irrigation Equivalents

The following figures may be used for changing one unit of water to another, and in computing the volume of water delivered by different rates of flow.

1. **One cubic foot per second (Second-Foot) equals:**

   38.4 Colorado Miner's Inches
   448.8 gallons per minute
   Approximately 1 acre-inch per hour
   Approximately 1 acre-foot in 12 hours
   Approximately 2 acre-feet per day (24 hours)

2. **One Acre-Inch equals:**

   3,630 cubic feet
   27,154 gallons

3. **One Acre-Foot equals:**

   43,560 cubic feet
   325,851 gallons
   12 acre-inches

4. **One Cubic Foot equals:**

   1,728 cubic inches
   7.48 gallons
   and weighs approximately 62.4 pounds

Discharge Table Showing Rate of Flow in Second-Feet

Depth of Water		Rectangular Weirs				Cipolletti Weirs				V Notch Weir	Parshall Flume Throat Widths			
Feet	Inches	1 foot	1½ feet	2 feet	3 feet	1 foot	1½ feet	2 feet	3 feet		6 In.	9 In.	12 In.	24 In.
.10	1-3/16	.11	.16	.22	.33	.11	.16	.23	.33	....	.05	.09	....	....
.12	1-7/16	.14	.20	.29	.42	.14	.21	.29	.43	....	.07	.12	....	....
.15	1-13/16	.19	.28	.39	.58	.19	.29	.39	.59	....	.10	.17	....	....
.17	2-1/16	.23	.34	.47	.70	.23	.36	.47	.71	....	.12	.20	....	....
.20	2-3/8	.29	.44	.59	.89	.30	.45	.60	.90	.046	.16	.26	.35	.66
.22	2-5/8	.34	.50	.68	1.02	.35	.52	.69	1.04	.058	.19	.30	.40	.77
.25	3	.40	.61	.82	1.23	.42	.63	.84	1.25	.080	.23	.37	.49	.93
.27	3-1/4	.45	.68	.91	1.38	.47	.70	.94	1.40	.096	.26	.41	.54	1.05
.30	3-5/8	.53	.80	1.07	1.61	.56	.83	1.10	1.64	.125	.31	.49	.64	1.24
.32	3-13/16	.58	.88	1.18	1.77	.61	.91	1.21	1.80	.147	.34	.54	.71	1.37
.35	4-3/16	.66	1.00	1.34	2.02	.70	1.04	1.38	2.07	.184	.39	.62	.80	1.57
.37	4-7/16	.72	1.09	1.45	2.20	.77	1.13	1.50	2.25	.211	.43	.67	.88	1.72
.40	4-13/16	.80	1.21	1.63	2.46	.87	1.28	1.69	2.53	.256	.48	.76	.99	1.93
.42	5-1/16	.86	1.30	1.75	2.65	.93	1.37	1.82	2.72	.289	.52	.81	1.07	2.09
.45	5-3/8	.96	1.44	1.94	2.93	1.04	1.53	2.02	3.01	.343	.58	.90	1.19	2.32
.47	5-5/8	1.02	1.54	2.07	3.12	1.11	1.63	2.16	3.21	.382	.63	.97	1.27	2.48
.50	6	1.11	1.68	2.26	3.42	1.22	1.79	2.37	3.53	.445	.69	1.06	1.39	2.73
.52	6-1/4	1.18	1.78	2.40	3.62	1.30	1.90	2.51	3.74	.491	.73	1.13	1.48	2.90
.55	6-5/8	1.28	1.94	2.60	3.94	1.42	2.07	2.74	4.07	.564	.80	1.23	1.62	3.17
.57	6-13/16	1.35	2.04	2.74	4.15	1.50	2.19	2.89	4.30	.617	.85	1.30	1.70	3.35
.60	7-3/16	1.45	2.20	2.96	4.47	1.62	2.37	3.13	4.64	.700	.92	1.40	1.84	3.62
.62	7-7/16	1.52	2.31	3.10	4.69	1.71	2.49	3.28	4.88	.760	.97	1.48	1.93	3.81
.65	7-13/16	1.63	2.47	3.32	5.03	1.84	2.68	3.53	5.24	.854	1.04	1.59	2.08	4.11
.67	8-1/8	1.71	2.59	3.47	5.25	1.93	2.81	3.70	5.48	.921	1.10	1.66	2.18	4.30
.70	8-3/8	1.82	2.76	3.71	5.61	2.07	3.01	3.95	5.86	1.03	1.17	1.78	2.33	4.60
.72	8-5/8	1.90	2.87	3.86	5.85	2.16	3.14	4.13	6.12	1.10	1.23	1.86	2.43	4.81
.75	9	2.01	3.05	4.10	6.21	2.31	3.35	4.40	6.51	1.22	1.31	1.98	2.58	5.12
.77	9-1/4	2.09	3.17	4.26	6.45	2.41	3.49	4.58	6.77	1.30	1.36	2.06	2.68	5.34
.80	9-5/8	2.21	3.35	4.51	6.83	2.56	3.70	4.85	7.18	1.43	1.45	2.18	2.85	5.66
.82	9-13/16	2.29	3.47	4.67	7.08	2.66	3.84	5.04	7.45	1.52	1.50	2.27	2.96	5.88
.85	10-3/16	2.41	3.66	4.92	7.46	2.82	4.07	5.33	7.87	1.66	1.59	2.39	3.12	6.22
.87	10-7/16	2.50	3.79	5.10	7.72	2.93	4.22	5.52	8.15	1.76	1.65	2.48	3.24	6.44