

Terms and Tables for Water Measurement and Management

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Introduction

Dramatic land development of agriculture operations has resulted in the development of small acreage parcels of 1 to 10 acres across Utah. Often, small acreage owners are faced with water management and water technical terms that they are unfamiliar with. The goal of this publication is to help the reader become familiar with the most common water measurement and management terms. Additionally, four tables provide water measurement conversions, water elevation conversions to pressure head, maximum flow rates in PVC pipe, and the volume of water delivered to a field.

Irrigation Terms

Acre foot – the volume of water to cover 1 acre to a 1 foot depth. It is approximately equal to 43,560 cubic feet or 325,851 gallons.

Acre inch – the volume of water to cover 1 acre to a 1 inch depth. It is approximately equal to 3,630 cubic feet or 27,154 gallons.

Cubic foot – 7.48 gallons.

Cubic feet per second (CFS) – is a stream 1 foot wide and 1 foot deep, traveling at the rate of 1 foot per second. For example, 1 CFS is 448.8 (450) gallons per minute. This is sometimes referred to as “second feet.”

Evapotranspiration (Et) – Evapotranspiration is the combination of transpiration from plant leaves (plant water use) and evaporation from adjacent soil surfaces. The Et function is $Et = Kc E_{tr} + E_{ws}$, whereas Kc is the crop coefficient, and E_{tr} is the reference evapotranspiration estimate to which the value of Kc is correlated. Reference E_{tr} values are obtained, for example, from grass or alfalfa covered areas, open pan water loss measurements, or estimates from mathematical models using local weather data.

Flumes – Flow-through devices for measuring open channel water flow. These devices create uniform flow through control sections of the device by narrowing, but not damming, the channel. Common flume types include Parshall and Trapezoidal flumes.

Friction loss – the loss of pressure resulting from water moving against the walls of a pipe.

Gallons per minute (GPM) – A standard rate unit representing the volume (in gallons) of water flowing through a channel or pipe, per minute.

Head – Depth of water above a reference point or datum, as in “there is 10.1 feet of head on that pipe.” In other words, the end of the pipe is 10.1 feet below the free surface of water at the entry to the pipe.

Irrigation efficiency – This is the ratio of the target amount of water needed by the crop (usually represented by accrued crop Et preceding the irrigation) divided by the total amount pumped or supplied from the water source to the field. If runoff is not captured for reuse, then the amount delivered to the field includes runoff. If runoff is captured and re-diverted to the same or another field, then runoff is subtracted from the water delivered to the field.

Irrigation uniformity – Refers to the uniformity of irrigation water applied to a field. Poor irrigation uniformity would be the application of 1 inch in one area of the field and application of 3 inches in another area. Irrigation uniformity should not be confused or interchanged with “irrigation efficiency,” although uniformity influences efficiency significantly. For example, a sprinkler applies more water near the sprinkler head than around its outer reach. Thus, uniformity is poor for one sprinkler nozzle. By moving the sprinklers or overlapping coverage uniformity improves substantially.

Miner’s inch – A rate of flow. It is a variable unit having different meanings in different states. A Utah miner’s inch is the rate of water flowing freely

through an opening 1 inch square, the center of which is 4 inches below the free surface of the water standing above the opening. It is equivalent to a flow of 9 gallons per minute. The miner’s inch is used for measuring small streamflow where the total flow is less than 1 CFS.

Staff gage – A measuring device used with flumes and weirs. It is a “ruler” used for measuring water depth or head and is usually a porcelain-coated, flat steel strip with gradations marking feet, tenths, and hundredths.

Velocity meter – A device used to measure the speed of the water. Meters are mechanical, such as propellers, paddle wheels, and turbines, or they are electronic, such as electromagnetic or ultrasonic.

Weirs – Like flumes, these are devices used to measure open channel water flow. They are different than flumes in that they directly dam water flow in the channel to create uniform flow over a shaped opening. The shape of the flow opening gives them their names. The most commonly used weirs are the rectangular, trapezoidal (or Cipolletti), and 90-degree triangular or V-notch, weir.

Tables

Table 1. Convenient water measurement conversions.					
Cubic Feet per Second	Gallons per Minute	Million Gallons per Day	Miner’s Inches (Utah)	Acre Inches per Hour	Acre Feet per Day
1	448.8 (450)	0.646	50	0.992	1.983
0.00223	1	0.00144	0.1114	0.0022	0.00442
1.547	694.4	1	77.36	1.535	3.07
0.020	9	0.0129	1	0.0198	0.0397
1.01	452.42	0.651	50.40	1	2
0.504	226.3	0.3258	25.21	0.5	1

Example: 1 cfs = 450 gpm (approximately) = 1 acre inch per hour (approximately)

Table 2. Water elevation conversion to pressure (or head) in a pipe.

Elevation	Pressure
25	10.8
50	21.7
75	32.5
100	43.3
125	54.1
150	65.0

Note: 1 foot head = 0.433 pounds per square inch (PSI)

Table 3. Maximum flow rates in PVC pipe (based on 5 ft/sec velocity).

PVC Pipe Size	GPM	CFS
3/4	8	0.02
1	14	0.03
1 1/2	32	0.07
2	50	0.11
3	130	0.29
4	220	0.49
6	500	1.11
8	800	1.78
10	1,200	2.67
12	1,800	4.00
15	2,600	5.78
18	4,000	8.89
21	5,400	12.00
24	7,000	15.56
27	9,000	20.00
30	11,000	24.44

Table 4. Approximate acre-feet of water delivered when flow and length of time are known.

Flow Rate		Time in Hours							
GPM	CFS	1	2	6	12	24	48	60	72
224	0.5	0.0	0.1	0.2	0.5	1.0	2.0	2.5	3.0
448	1.0	0.1	0.2	0.5	1.0	2.0	4.0	5.0	5.9
896	2.0	0.2	0.3	1.0	2.0	4.0	7.9	9.9	11.9
1345	3.0	0.2	0.5	1.5	3.0	5.9	11.9	14.9	17.8
1793	4.0	0.3	0.7	2.0	4.0	7.9	15.8	19.8	23.8
2241	5.0	0.4	0.8	2.5	5.0	9.9	19.8	24.8	29.7
2689	6.0	0.5	1.0	3.0	5.9	11.9	23.8	29.7	35.6
3137	7.0	0.6	1.2	3.5	6.9	13.9	27.7	34.7	41.6
3586	8.0	0.7	1.3	4.0	7.9	15.8	31.7	39.6	47.5
4034	9.0	0.7	1.5	4.5	8.9	17.8	35.6	44.6	53.5
4482	10.0	0.8	1.7	5.0	9.9	19.8	39.6	49.5	59.4

References

Utah Water Measurement Pocket Reference. Utah Association of Conservation Districts, Salt Lake City, Utah.

Irrigation Water Measurement – Irrigation Ditches and Pipelines. University of Wyoming Agriculture Extension Service. Bulletin 583R. Laramie, Wyoming.

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