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G78-393 Water Measurement Calculations (Revised November 1984)

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Water Measurement Calculations

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Water measurement is an important tool for checking irrigation management skills. Irrigators can use one of several methods to measure water. To take advantage of water management data, a knowledge of water measurement calculations is important.

Units of Water Measurement

There are two conditions under which water is measured--at rest and in motion. Volume units are used for water at rest. Water in motion is described in units of flow.

Volume

Volume units describe how much space a given amount of water will occupy. Water in tanks and ponds is an example of water at rest. Common units of volume are gallons, acre-inches, acre-feet, and cubic feet. These units are defined as:

Acre-inch--the volume of water that would cover an acre one inch deep.

Acre-foot--the volume of water that would cover an acre one foot deep.

Cubic foot--the amount of water that would fill a container one foot wide by one foot long by one foot deep.

Flow

Flow units tell how fast a given volume of water is moving past a fixed point. They can be used to describe the discharge of a pump, flow in a canal or river, and discharge of a sprinkler, gate, or siphon

tube. Flow units frequently used in irrigation are gallons per minute (gpm) and cubic feet per second (cfs).

Gallons per minute--the rate of flow necessary to fill a gallon container in one minute.

Cubic foot per second--the amount of water that would flow in a stream one foot wide by one foot deep and moving at a rate of one foot every second.

Table I shows a list of equivalents of water measurement units.

By knowing the rate of flow, the volume of water used over a period of time can be calculated using the equivalents in *Table I.* As an example, a system that delivers 900 gpm can apply two inches to one acre in one hour (900 gpm ÷ 450 gpm per acre-inch per hour = 2 acre inches). *Table II* can be used to determine the volume of water applied for different time periods and various flow rates.

Table I. List of Equivalents
Volume Units
1 gallon = 8.33 pounds
1 cubic foot = 7.48 gallons
1 acre-inch = 3,630 cubic feet
1 acre-inch = 27,154 gallons
1 acre-foot = 43,560 cubic feet
1 acre-foot = 325,851 gallons
Units of Flow
1 cubic foot per second = 449 gallons per minutes (450 for practical purposes)
1 cubic foot per second for 1 hour = 1 acre-inch
452 gallons per minute for 1 hour = 1 acre-inch
1 gallon per minute = 0.00223 cubic feet per second
1 gallon per minute = 0.00221 acre-inches per hour
Length Units
1 mile = 5280 feet
1 mile = 320 rods
1 rod = 16.5 feet
Area Units
1 acre = 43,560 square feet
1 acre = 160 square rods

Table II. Volume of water applied for various flow rates and time periods.

Flow Rate	Volume Applied			
	1 Hr.	8 Hrs.	12 Hrs.	1 Day
gpm	ac-in	ac-in	ac-in	ac-in
100	0.22	1.77	2.65	5.3
200	0.44	3.54	5.31	10.6
300	0.66	5.31	7.96	15.9
400	0.88	7.08	10.6	21.2
500	1.11	8.85	13.3	26.5
600	1.33	10.6	15.9	31.9
700	1.55	12.4	18.6	37.2
800	1.77	14.2	21.2	42.5
900	1.99	15.9	23.9	47.8
1000	2.21	17.7	26.5	53.1
1100	2.43	19.5	29.2	58.4
1200	2.65	21.2	31.8	63.7
1300	2.87	23.0	34.5	69.0
1400	3.10	24.8	37.2	74.3
1500	3.32	26.5	39.8	79.6
2000	4.42	35.4	53.1	106

To calculate the depth of water applied, both the volume applied and the acres covered must be known. There are 43,560 square feet in an acre. *Table III*, *Table IV*, and *Table V* can be used as a guide in calculating the acreage of total fields or an irrigation set.

Example Calculations

Most water meters have a volume totalizer that registers either acre-feet, acre-inches, cubic feet, or gallons.

Example 1. Calculation of depth applied to a field with meter registration in *acre-feet*.

Given: Assume the field just irrigationd is 1,815 feet long and 1,320 feet wide.
Meter reading before irrigation = 162.8 acre feet.
Meter reading after irrigation = 182.5 acre feet.

Calculations:

Acre-feet applied = 19.7 acre-feet.
Acres in field = 55 acres (*Table III*).
Depth applied = 19.7 acre-feet ÷ 55 acres = 0.358
feet = 0.358 x 12 inches/foot = 4.3 inches.

Example 2. Calculation of depth applied to field with meter registration in *gallons*.

Given: Same field--55 acres.
Meter reading before irrigation = 53,984,000 gal.
Meter reading after irrigation = 58,924,000 gal.

Calculations:

Gallons applied = 4,940,000 gal.
Acre-inches applied = 4,940,000 ÷ 27,154 (*Table I*) = 181.9 ac.-in.
Depth applied = 181.9 ac.-in. ÷ 55 acres = 3.3 in.

Example 3. Calculation of depth applied to field with meter that measures rate of flow only.

Given: Same field-55 acres.
Assume pump discharge = 800 gpm.
Days of irrigation = 7 days.

Calculations:

Acre-inches applied = 42.4 ac-in/day (*Table IV*) x 7 days= 296.8 acre-inches.
Depth applied = 296.8 ac-in ÷ 55 acres = 5.4 inches.

Example 4. Calculations of depth applied to an irrigation set.

Given:
-- Number of rows = 80
-- Length of rows 1320 feet
-- Width of rows = 36 inches
-- 1000 gpm system
-- 12 hour set

Calculations:

Area of set = 6.1 acres x 1.2 (*Table IV*) = 7.3 acres.
Water applied = 26.5 ac-in (*Table II*).
Depth applied = 26.5 acre-inches ÷ 7.3 acres = 3.6 inches.

Application Formula

$$\text{Application depth (inches)} = \frac{\text{flow rate (gpm) x application period (hours) x 96.3}}{\text{irrigationd area (square feet)}}$$

Example 5. Same problem as *Example 3* above.

Flow rate = 800 gpm
Application period =- 7 days x 24 hrs/day = 168 hours

irrigationd area = 1815 x 1320 = 2,395,800 square feet.

$$\text{Depth applied} = \frac{800 \times 168 \times 96.3}{2{,}395{,}800} = 5.4 \text{ inches}$$

Table III. Acres in a rectangular field.									
			----------Width of Field----------						
		Feet	660	990	1320	1650	1980	2310	2640
Length of Field		Rods	40	60	80	100	120	140	160
Feet	Rods								
660	40		10.0	15.0	20.0	25.0	30.0	35.0	40
825	50		12.5	18.8	25.0	31.2	37.5	43.8	50
990	60		15.0	22.5	30.0	37.5	45.0	52.5	60
1155	70		17.5	26.2	35.0	43.8	52.5	61.2	70
1320	80		20.0	30.0	40.0	50.0	60.0	70.0	80
1485	90		22.5	33.8	45.0	56.2	67.5	78.8	90
1650	100		25.0	37.5	50.0	62.5	75.0	87.5	100
1815	110		27.5	41.2	55.0	68.8	82.5	96.2	110
1980	120		30.0	45.0	60.0	75.0	90.0	105	120
2145	130		32.5	48.8	65.0	81.2	97.5	114	130
2310	140		35.0	52.5	70.0	87.5	105.0	122	140
2475	150		37.5	56.2	75.0	93.8	112.5	131	150
2640	160		40.0	60.0	80.0	100	120	140	160

Table IV. Acres in an irrigation set.											
Length of Rows		Number of Rows per Set-30-inch* rows									
Feet	Rods	10	20	30	40	50	60	70	80	90	100
660	40	0.38	0.76	1.1	1.5	1.9	2.3	2.7	3.0	3.4	3.8
825	50	0.47	0.95	1.4	1.9	2.4	2.8	3.3	3.8	4.3	4.7
990	60	0.57	1.1	1.7	2.3	2.8	3.4	4.0	4.5	5.1	5.7
1155	70	0.66	1.3	2.0	2.7	3.3	4.0	4.6	5.3	6.0	6.6
1320	80	0.76	1.5	2.3	3.0	3.8	4.5	5.3	6.1	6.8	7.6
1485	90	0.85	1.7	2.6	3.4	4.3	5.1	6.0	6.8	7.7	8.5
1650	100	0.95	1.9	2.8	3.8	4.7	5.7	6.6	7.6	8.5	9.5
1815	110	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	9.4	10.4
1980	120	1.1	2.3	3.4	4.5	5.7	6.8	8.0	9.1	10.2	11.4

2145	130	1.2	2.5	3.7	4.9	6.2	7.4	8.6	9.8	11.1	12.3
2310	140	1.3	2.7	4.0	5.3	6.6	8.0	9.3	10.6	11.9	13.3
2475	150	1.4	2.8	4.3	5.7	7.1	8.5	9.9	11.4	12.8	14.2
2640	160	1.5	3.0	4.5	6.1	7.6	9.1	10.6	12.1	13.6	15.2

*For 36-inch rows, multiply the values in the table by 1-20; for 38-inch rows, multiply by 1.27; for 40-inch rows, multiply by 1.33.

Table V. Acres irrigationd with a center pivot.

	Acres irrigationd		
System Length (feet)	**No End Gun or Sprinkler**	**End Gun on Continuously**	**End Gun on in Corners Only**
660	31	41	36
785	44	56	50
915	60	74	67
1040	78	94	86
1170	98	116	107
1300	121	140	131
1425	146	167	157
1550	173	196	185
1680	200	227	214
1810	235	262	249
1935	269	298	284

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