USDA

United States Department of Agriculture

Irrigation Scheduling Recordbook

Montana
Natural Resources Conservation Service

mt.nrcs.usda.gov/

IRRIGATION SCHEDULING RECORDBOOK

- This recordbook is a tool used to assist in scheduling irrigations and maintain useful records by recording crop water use, irrigation applications, and soil water levels.
- The recordbook assumes the irrigator has access to crop water use data such as AgriMet, AgWeatherNet, CIMIS, an atmometer, or crop water use information based on historic data.
- Use an irrigation guide for reference as needed.
- NRCS can assist you in developing an Irrigation Water Management (IWM) Plan that is tailored for your field and crop.

The Irrigation Scheduling Recordbook includes four tables:

Table 1: Basic Information
contains information about your crop, soil, and irrigation system.

Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling
is used for recording crop water use, water applied, and soil water status.

Table 3: Record of Irrigation Water Application
is used for determining the amount of water applied during an irrigation.

Table 4: Soil Water Observations and Measurements
is used for recording details of soil water status.

Available Water Capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil depth for each soil layer in your field. This information is available from the NRCS "Web Soil Survey" website (http://websoilsurvey.nrcs.usda.gov/app/) or by contactingyour local NRCS office. Enter this information in Table l.

Total Available Water Capacity (TAWC) is the total water available for use by plants in the root zone in inches. TAWC = AWC x Root Zone Depth

Management Allowed Depletion (MAD) is the percent of the available water holding capacity allowed to be depleted before irrigation is initiated.

Application Efficiency is the percentage of applied water that is stored in the crop root zone. Enter this number in Table 1.

Design Gross Irrigation Use Table 3 to determine your design gross irrigation for each irrigation. If your gross irrigation depth does not change during the season, enter this number in Table 1.

Example Data **for Table 1: Basic Information**				p. 6
Tract/Field	SW Qtr	**Soil & Water Information**	Initial Period	At Full Root Zone
Field Area (acres)	130			
Crop:	Alfalfa	Rooting Depth (in)	Use this column if your crop has an early limited root zone.	48"
Soil Type:	Silt Loam	Available Water Capacity (in/in)		0.18 in/in
Soil Depth (in.)	60 inches	Total Available Water Capacity (in)		8.6"
Irrigation System Information		MAD (%)		50%
System Type:	Center Pivot	MAD (in)		4.3"
Application Efficiency (%)	80%	Minimum Balance (TAWC - MAD) (in)		4.3"
Design Gross Irrigation (in)	1.5"	Source of Crop Water Use (Evapotranspiration) Data:	Agrimet	
Design Net Irrigation (in)	1.2"	Design Net Irrigation must be less than MAD in inches		

Table 1: Basic Information				p. 7
Tract/Field		**Soil & Water Information**	Initial Period	At Full Root Zone
Field Area (acres)				
Crop:		Rooting Depth (in)		
Soil Type:		Available Water Capacity (in/in)		
Soil Depth (in.)		Total Available Water Capacity (in)		
Irrigation System Information		MAD (%)		
System Type:		Mad (in)		
Application Efficiency (%)		Minimum Balance (TAWC - MAD) (in)		
Design Gross Irrigation (in)		Source of Crop Water Use (Evapotranspiration) Data:		
Design Net Irrigation (in)		Design Net Irrigation must be less than MAD in inches		

CROP WATER USE (EVAPOTRANSPIRATION)

Evapotranspiration (ET) is the sum of the evaporative losses by the transpiration of plants, evaporation of water from wetted foliage, and evaporation from the soil. The amount of daily evaporation that your irrigated crop uses can be estimated using data obtained from an ET network, an atmometer, and/or historic data.

IRRIGATION SCHEDULING USING DAILY EVAPOTRANSPIRATION

Irrigation Scheduling is the process of determining **when** to irrigate, **how much** water to apply, and **recording the amount applied**. This recordbook will help you utilize the "checkbook" method of irrigation scheduling.

However, no successful irrigation manager relies on only one method to determine an irrigation schedule. **Frequent field checks of soil water and crop health should be made to ensure that the numbers in this book correspond to the reality in the field**.

THE CHECKBOOK METHOD

Monitoring the available soil water in your field can be tracked in the same manner as a checkbook balance. Through evapotranspiration, water is removed from the field (withdrawals) and the available soil water (account balance) is reduced. When the available soil water approaches the minimum balance (account balance approaches a minimum allowable amount), water should be applied either by rain or irrigation (make a deposit to the account). The penalty for overdraft below a minimum balance of soil water is crop stress and reduced yield (overdraft charge for bank account). Repeated or excessive water stress (overdraft) may lead to severely reduced yields or crop death (pick your own negative term!). Also, the upper limit of water that can be stored in the soil is the Total Available Water Capacity (only so much can be held in the account).

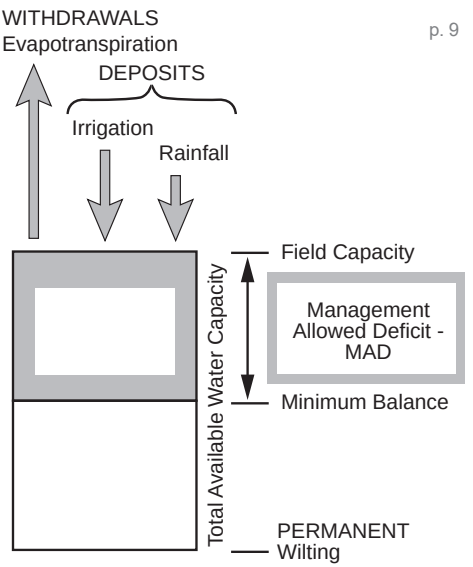

Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling

- **Make an entry for each irrigation.**

Column B values from current or historic crop water use data as specified in an IWM Plan.

Column C values from Table 3 Record of Irrigation Water Application.

Column E values should not be greater than Total Available Water Capacity nor less than the Minimum Balance (from Table 1). Adjust Column E values as needed based on soil water observations (Table 4).

Column F includes notes on soil water observations, irrigation applications, etc.

Irrigation should be scheduled when the available soil water reaches the Minimum Balance found in Table 1: "Soil Water Remaining at Irrigation".

Field:	Withdrawals	Deposits		Balance	Notes
A	B	C	D	E	F
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance 4.3 in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

Example Data Entry

Need to schedule irrigation when the Balance (Available Soil Water Column E) is 4.3 inches

	----- Example entries for daily values -----				
7/1	-	-	-	5.42	measured Soil Water
7/2	0.18	0	0	5.24	
7/3	0.20	0	0.45	5.34	
7/4	0.17	0	0	5.17	
7/5	0.22	0	0	4.95	
7/6	0.24	0	0	4.71	
7/7	0.26	0	0	4.45	irrigate 1.2" (net) on 7/8
7/8	0.22	1.2	0	5.43	
7/9	0.17	0	0	5.26	

Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling

Note: Entries for this table may be daily values or multiple-day cumulative values.

- If an entry is for multiple-days, values entered for crop water use and rainfall are cumulative values since the previous entry.
- **Make an entry for each irrigation.**

Column B values from current or historic crop water use data as specified in an IWM Plan.

Column C values from Table 3 Record of Irrigation Water Application.

Column E values should not be greater than Total Available Water Capacity nor less than the Minimum Balance (from Table 1). Adjust Column E values as needed based on soil water observations (Table 4).

Column F includes notes on soil water observations, irrigation applications, etc.

Irrigation should be scheduled when the available soil water reaches the Minimum Balance found in Table 1: "Soil Water Remaining at Irrigation".

Field:	Withdrawals	Deposits		Balance	Notes
A	B	C	D	E	F
Date	Crop Water Use (ET)	Net Irrigation	Effective Rainfall	Available Soil Water	Minimum Balance 4.3 in.

(mo/day)	(inches)	(inches)	(subtract 0.15" from measured rainfall) (inches)	Previous E - B + C + D (inches)	Observed/measured soil moisture level or depletion Data and amount of next irrigation
Example Data Entry Need to schedule irrigation when the Available Soil Water (Column E) is 4.3 inches					
	----- Example entries for multiple day cumulative values -----				
7/1	-	-	-	5.42	measured Soil Water
7/4	0.55	0	0.45	5.17	
7/8	0.94	1.2	0	5.43	1.2" irrigation on 7/8
7/12	0.65	0	0	4.78	will irrigate1.2" (net) on 7/14

Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					p. 14
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

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Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					p. 16
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

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Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					p. 18
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

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Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					p. 22
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

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Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					p. 24
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

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Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					p. 26
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

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Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

Table 2: Crop Water Use and Checkbook Method for Irrigation Scheduling					p. 30
Field:	**Withdrawals**	**Deposits**		**Balance**	**Notes**
A	**B**	**C**	**D**	**E**	**F**
Date (mo/day)	Crop Water Use (ET) (inches)	Net Irrigation (inches)	Effective Rainfall (subtract 0.15" from measured rainfall) (inches)	Available Soil Water (Previous E - B + C + D) (inches)	Minimum Balance _____ in. Observed/measured soil moisture level or depletion Data and amount of next irrigation

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Using Table 3: Record of Irrigation Water Application

Use Table 3 and the formula below to determine the gross and net depth of your irrigation application.

$$\text{Gross depth (inches)} = \frac{\textit{Flowrate (cfs)} \times \textit{Irrigation Duration (hours)}}{\textit{Area of Field (acres)}}$$

OR

$$\text{Gross depth (inches)} = \frac{\textit{Flowrate (gpm)} \times \textit{Irrigation Duration (hours)}}{\textit{453 x Area of Field (acres)}}$$

Using a center-pivot sprinkler as an example:

Irrigation duration: 84 hours
Flow rate: 1,050 gpm
Acres: 130 acres

$$\text{Gross depth (inches)} = \frac{1050\ (\textit{gpm}) \times 84\ (\textit{hours})}{453 \times 130\ (\textit{acres})} = 1.5 \text{ inches}$$

Multiply the gross depth by the application efficiency (from Table 1) to obtain the net irrigation depth.

Example: **Gross irrigation depth** (1.5 inches) x **irrigation efficiency** (80%) = 1.2 inch **net irrigation depth**

Table 3: Record of Irrigation Water Application

$$\text{Gross Depth of Irrigation} = \frac{\textit{Flowrate}\ (\textit{gpm}) \times \textit{Irrigation Duration}\ (\textit{hours})}{453 \times \textit{Area of Field}\ (\textit{acres})}$$

Example Data Entry

$$\text{Gross Depth of Irrigation} = \frac{1050\ (\textit{gpm}) \times 84\ (\textit{hours})}{453 \times 130\ (\textit{acres})} = 1.5 \text{ inches (Col. C)}$$

Net Depth of Irrigation = 1.5 inches x 80% (Application Efficiency) =
1.2 inches (Col. E)

Example Data Entry

Date		**Water Applied**			**Notes**
A	**B**	**C**	**D**	**E** **C x D/100**	Include Comments
Start of Irrigation (mo/day)	Irrigation Duration (days or hours)	Gross Irrigation Depth Applied (inches)	Application Efficiency (%)	Net Irrigation in Root Zone (inches)	
7/8	84 hours	1.5 inches	85%	1.2 inches	Enter the value from Column E into Column B of Table 2

Table 3: Record of Irrigation Water Application

Typical Gross Depth of Irrigation

$$\frac{\text{\_\_\_\_\_ (}gpm\text{) x \_\_\_\_\_ (}hours\text{)}}{\text{453 x \_\_\_\_\_ (}acres\text{)}} = \text{\_\_\_\_\_ inches}$$

Net Depth of Irrigation =
_____ inches (gross depth of irrigation) x _____ (application efficiency) =
_____ inches (to Column E)

Date and Time		Water Applied			Notes
A	**B**	**C**	**D**	**E** **C x D/100**	Include Comments
Start of Irrigation (mo/day)	Irrigation Duration (days or hours)	Gross Irrigation Depth Applied (inches)	Application Efficiency (%)	Net Irrigation in Root Zone (inches)	

Table 3: Record of Irrigation Water Application

Typical Gross Depth of Irrigation

$$\frac{\text{\_\_\_\_\_ (}gpm\text{) x \_\_\_\_\_ (}hours\text{)}}{\text{453 x \_\_\_\_\_ (}acres\text{)}} = \text{\_\_\_\_\_ inches}$$

Net Depth of Irrigation =
_____ inches (gross depth of irrigation) x _____ (application efficiency) =
_____ inches (to Column E)

Date and Time		Water Applied			Notes
A	**B**	**C**	**D**	**E** **C x D/100**	Include Comments
Start of Irrigation (mo/day)	Irrigation Duration (days or hours)	Gross Irrigation Depth Applied (inches)	Application Efficiency (%)	Net Irrigation in Root Zone (inches)	

Table 3: Record of Irrigation Water Application

Typical Gross Depth of Irrigation

$$\frac{\text{\_\_\_\_\_ (}gpm\text{) x \_\_\_\_\_ (}hours\text{)}}{\text{453 x \_\_\_\_\_ (}acres\text{)}} = \text{\_\_\_\_\_ inches}$$

Net Depth of Irrigation =
_____ inches (gross depth of irrigation) x _____ (application efficiency) =
_____ inches (to Column E)

Date and Time		Water Applied			Notes
A	**B**	**C**	**D**	**E** **C x D/100**	Include Comments
Start of Irrigation (mo/day)	Irrigation Duration (days or hours)	Gross Irrigation Depth Applied (inches)	Application Efficiency (%)	Net Irrigation in Root Zone (inches)	

Available Soil Water (%)	Coarse texture fine sand, loamy find sand	Moderately coarse texture sandy loam, fine sandy loam	Medium texture sandy clay loam, silt loam	Fine texture clay loam, silty clay loam
	Available Water Capacity (in/ft)			
	0.6-1.2	1.3 - 1.7	1.5-2.1	1.6-2.4
Field Capacity (100%)	Wet, forms a weak ball, light to heavy soil water coating on fingers, wet outline of soft ball remains on hand	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil water coating on fingers	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil water coating on fingers	Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil water coating on fingers, slick and sticky
75%-100%	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon	Wet, forms a ball with wet outline left on hand, light to medium water staining on fingers, makes a weak ribbon between thumb and forefinger	Wet, forms a ball with well-defined finger marks, light to heavy soil water coating on fingers, ribbons between thumb and forefinger	Wet, forms a ball, uneven medium to heavy soil water coating on fingers, ribbons easily between thumb and forefinger

50%-75%	Moist, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon [2/]	Moist, forms a ball with defined finger marks, very light soil water staining on fingers, darkened color, will not slick	Moist, forms a ball, very light water staining on fingers, darkened color, pliable, forms a weak ribbon between thumb and forefinger	Moist, forms a smooth ball with defined finger marks, light soil water staining on fingers, ribbons between thumb and forefinger
25%-50%	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remains on fingers	Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers, grains break away	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains	Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure
0%-25%	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure	Dry, forms a very weak ball [1/], aggregated soil grains break away easily from ball	Dry, soil aggregations break away easily, no moisture staining on fingers, clods crumble	Dry, soil aggregations easily separate, clods are hard to crumble with applied pressure

1/ Ball is formed by squeezing a handful of soil very firmly with one hand.
2/ Ribbon is formed when soil is squeezed out of hand between thumb and forefinger.
Reference: Estimating Soil Moisture by Feel and Appearance, NRCS Program Aid No. 1619

Table 4: Soil Water Observations and Measurements					p. 44
Tract/Field ID:				Field Area (acres)	
Crop:				Total Available Water Capacity in Soil (inches)	
Note the instrumentation used:					
	Observations or Readings at Depth			Total soil water in root zone	Comments
Date	Upper Sensor	Middle Sensor	Lower Sensor		Note whether values are water available OR water depletion
(mo/day)	Observation Depths			Indicate whether (in) (%) (centibars)	
	____(in)	____(in)	____(in)		

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Table 4: Soil Water Observations and Measurements					
Tract/Field ID:				Field Area (acres)	
Crop:				Total Available Water Capacity in Soil (inches)	
Note the instrumentation used:					
	Observations or Readings at Depth			Total soil water in root zone	Comments
Date	Upper Sensor	Middle Sensor	Lower Sensor		Note whether values are water available OR water depletion
(mo/day)	Observation Depths			Indicate whether (in) (%) (centibars)	
	____(in)	____(in)	____(in)		

Table 4: Soil Water Observations and Measurements					p. 48
Tract/Field ID:				Field Area (acres)	
Crop:				Total Available Water Capacity in Soil (inches)	
Note the instrumentation used:					
	Observations or Readings at Depth			Total soil water in root zone	Comments Note whether values are water available OR water depletion
Date	Upper Sensor	Middle Sensor	Lower Sensor		
(mo/day)	Observation Depths			Indicate whether (in) (%) (centibars)	
	____(in)	____(in)	____(in)		

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Table 4: Soil Water Observations and Measurements					
Tract/Field ID:				Field Area (acres)	
Crop:				Total Available Water Capacity in Soil (inches)	
Note the instrumentation used:					
	Observations or Readings at Depth			Total soil water in root zone	Comments
Date	Upper Sensor	Middle Sensor	Lower Sensor		Note whether values are water available OR water depletion
(mo/day)	Observation Depths			Indicate whether (in) (%) (centibars)	
	____(in)	____(in)	____(in)		

CONVERSIONS AND FORMULAS

Water Flow Rates

1 cubic foot per second (cfs) = 448.8 gallons per minute

1 cfs for 1 hour = 0.99 acre-inch

1 cfs for 24 hour = 1.98 acre-ft

1,000 gpm = 2.23 cfs

1,000 gpm for 24 hr = 4.42 acre-ft

1 gpm/ac = 0.053 ac-in/ac/day

1 cfs = 40 miner's inches in OR, MT, Northern CA

1 cfs = 50 miner's inches in ID, WA

1 miner's inch = 11.22 gpm in OR, MT, Northern CA

1 miner's inch = 9 gpm in ID, WA

1 cfs = 28.32 liters/sec

1 cubic meter/sec = 35.3 cfs

1 liter/sec = 15.85 gpm

Q x T = D x A

Where Q=cfs, T=hr, D=inches depth, A=acres

Gpm for 5ft/s velocity in PVC pipe

6"	8"	10"	12"	14"
480	800	1250	1750	2150

CONVERSIONS AND FORMULAS

Water Volumes and Weights:

1 cubic foot = 7.48 gallons

1 cubic foot = 62.4 lb = 28.3 liters

1 acre-foot = 43,560 cubic feet (1 acre covered 1 foot deep)

12 acre-in = 1 acre-ft = 325,829 gal

1 million gallons = 3.07 acre-ft

1 acre-ft = 1,234 cubic meters

1 cu meter = 1,000 liters = 35.3 cu ft

Pressure and Preassure Head:

1 psi = 2.31 ft of pressure head

1 atmosphere (sea level) = 14.7 psi = 33.9 ft of head

Lengths and Areas:

1 mile = 5,280 ft = 1.61 km

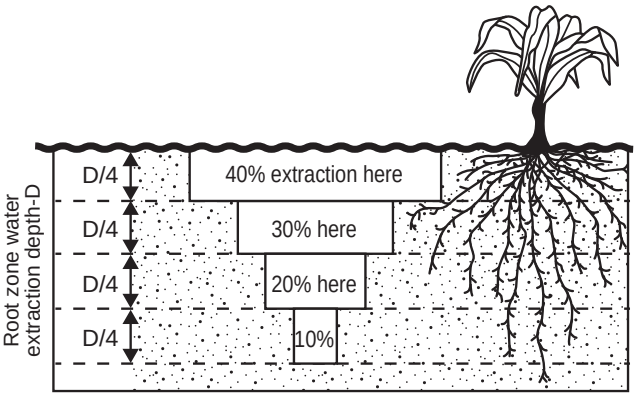
1 meter = 3.28 ft = 39.37 inches

1 acre = 43,560 square ft

1 hectare = 2.47 acres

TYPICAL WATER EXTRACTION PATTERN IN UNIFORM SOIL PROFILE

- Approximately 70 percent of water used by plants comes from the upper half of the plant root zone.
- Very thin tillage pans can restrict root development in an otherwise homogeneous soil.
- Never assume a plant root zone.
- Observe the root development of resent or former crops.



Notes and Calculations