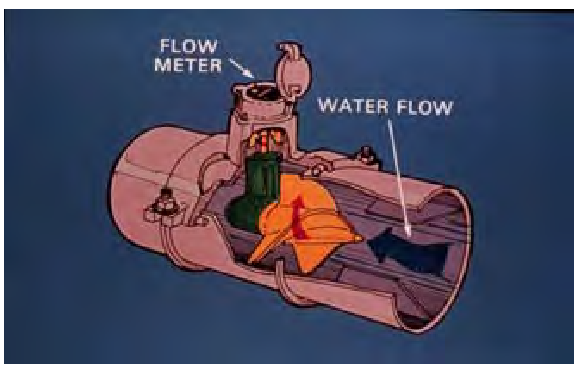
IRRIGATION WATER MANAGEMENT (Code 449)

Irrigation Water Management (IWM) is the practice of monitoring and managing the rate, volume, and timing of water application according to the seasonal crop needs, giving consideration to the soil intake and water holding capacities. Soil moisture should be managed to obtain optimum yields, without deep percolation losses or runoff.

Irrigation water management will help irrigators determine the effectiveness of irrigation practices, make good water management decisions, and justify making irrigation adjustment in existing systems.

Tools are available to assist the irrigator with irrigation water management:

- "Checkbook" method to monitor and balance soil moisture in irrigated cropland.
- Flow meters to record instantaneous flow rates and total volume usage.
- Soil moisture meters and sensors to monitor soil water deficit.
- Soil moisture data loggers to record soil moisture history throughout the growing season.



Propeller Type Flow Meter

Irrigation Water Management levels

The producer can contract one of three IWM levels.

Basic – Producer would monitor and report irrigation and precipitation amounts to a checkbook accountant on a weekly basis during the growing season. The checkbook accountant would track the daily balance of soil moisture in the field. The producer would participate in a year-end feedback session with NRCS staff and checkbook accountant (via phone) to review the effective management of soil moisture through the growing season, and discuss the potential for water and energy savings.

Intermediate – Same as Basic. In addition, the producer would install 1 set of soil moisture sensors per 20 acres, maximum 3 sets. The producer would monitor and report soil moisture deficit readings to the checkbook accountant on a weekly basis, along with irrigation and precipitation amounts. These readings would allow the checkbook accountant to reconcile the balance of soil moisture on a weekly basis for more accurate feedback.

Advanced – Same as Intermediate. However, the soil moisture sensors would include wireless transmitters. The producer would monitor and record the daily soil moisture deficit using a wireless data logger. In addition to the year-end feedback session, the producer would participate in weekly feedback sessions with the checkbook accountant to assess the timing of irrigations. The producer would actively manage soil moisture between field capacity and the Maximum Allowable Depletion (MAD) level for specific soils and crops.

Checkbook Method

The "checkbook method" is a tool to record the daily withdrawals and deposits of soil moisture in order to properly schedule irrigations.

The electronic version of the checkbook method can be run in Excel® 2007 or earlier version.

The checkbook program tracks the consumptive use of the crop and soil moisture deficit. The soil moisture deficit (created by evapotranspiration) is based on crop growth stage and maximum daily temperature. Depending on the contracted IWM Level, the producer will monitor and report their irrigations, flow meter readings, precipitation amounts, and soil moisture deficits to the checkbook accountant. Daily temperatures can be accessed from the internet for different locations in Montana. A typical internet site is located at this web address: http://www.accuweather.com/us-city-list.asp?zipcode=&state=MT

The checkbook balance is used to determine if soil moisture is properly managed between field capacity and the MAD level (see Figures 1-3).

At the end of the irrigation season, the checkbook accountant will print out the soil moisture balance sheet, recommended irrigation schedule, graphed presentation of water use, potential energy savings, and technical certification sheet. The technical certification sheet will be signed by the landowner and accountant and given to the NRCS for release of contractual payments.

Tensiometers and Gypsum Blocks and Soil Moisture Meter

Tensiometer

Gypsum Block

The producer can install tensiometer or gypsum blocks to measure soil moisture deficit levels in the field.

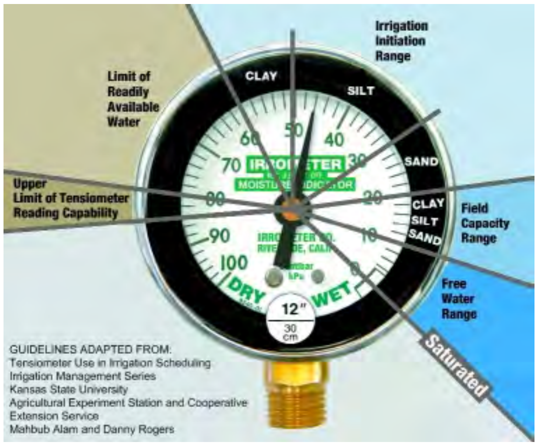
A tensiometer is a hollow plastic tube with a ceramic tip at one end and a vacuum gauge at the other. The tube is filled with distilled water, and then placed in the ground at various depths.

A tensiometer reads water tension (vacuum) in the soil-plant matrix. A tensiometer acts like a dummy root, allowing the soil moisture to interact with the instrument through a ceramic tip. Soil water tension in the soil tries to remove water from the instrument and creates a measurable tension inside the instrument column. This tension is read with a mechanical gauge attached to the instrument. The volume of water removal is not as important as the applied tension (vacuum) by the soil-plant matrix. Soil water tension has to be overcome before the plant can pull water into its root system. Different soil types will have different tensions even at the same moisture levels.

Periodic maintenance is required to keep tensiometers full of water. It must be removed from the field during winter months to avoid freezing.

Tensiometers should be nested at a depth of 12 inches and at the mid-point of mature fibrous roots. Variation in sensor depth is particularly important when the water requirement of the crop is highest and crop yields are most sensitive to water shortage. Tensiometers should be read daily to monitor how hard the crop is working to extract moisture.

Following irrigation, the reading on the tensiometer will be reduced. A pattern of daily readings should be used to determine when irrigation is required.



Tensiometer Dial

Subsequent irrigations are determined by the amount of water applied and stored in the root zone by the last irrigation. If only a light irrigation was applied, or a small section of the root zone wetted, then the soil will dry faster. A higher tensiometer reading is reached sooner than if a heavy irrigation was applied and the entire root zone wetted. Climatic conditions and crop growth stage will also affect the rate of soil drying.

Tensiometers can also be used to determine the effectiveness of rainfall, the need for fall irrigation, and the location of poor water distribution.

Gypsum blocks sensors are used similar to tensiometers but they use an indirect method of measuring soil water tension. A soil moisture meter electronically reads the amount of moisture absorbed through a granular matrix unit. The resistance across a pair of electrodes imbedded within the granular matrix varies with moisture content. This varied resistance is calibrated against known values and reported as soil water tension. Internally installed gypsum is used as a buffering agent to compensate for the effects of varying salinity.

Use the following readings as a general guideline:

- 0-10 centibars = Saturated soil
- 10-30 centibars = Soil is adequately wet (except coarse sands, which are beginning to lose water)
- 30-60 centibars = Usual range for irrigation (most soils)
- 60-100 centibars = Usual range for irrigation in heavy clay and is the upper limit for a tensiometer.
- 100-200 centibars = Soil is becoming dangerously dry for maximum production. Proceed with caution! **Note:** *Tensiometer scales cannot read this high, but soil moisture meters can*.

Gypsum block sensors are calibrated to reflect the same values that would be generated by a tensiometer. The sensors are maintenance free and can be left in the ground permanently. They require very little power to read and integrate with electronic systems for data logging or telemetry.

Soil Moisture Meter

A soil moisture meter is a solid state alternating current resistance bridge meter for reading gypsum block sensors. The meter can be calibrated for soil temperature variations. One meter can be used to read an unlimited number of sensors, one at a time. Meter readings can be acquired by connecting two leads to the gypsum block and selecting the "read" button. The meter reads units in centibars and range from 0 cb (wet) to 199 cb (very dry).

Wireless Soil Moisture Transmitter and Data Logger

A wireless soil moisture data logger/receiver is similar to the soil moisture meter described above, but it allows for a wireless connection to transmitters at soil moisture sensor locations. A transmitter will measure and transmit data from 4 sensors. The data logger records the soil moisture data from as many as 16 transmitters, or 64 sensors. Data is stored on the logger and can be downloaded using a laptop, PDA, or with 900 MHz radio telemetry.

Soil Moisture Transmitter

Wireless Soil Moisture Data Logger

Data Logger Downloading to a Laptop

A wireless soil moisture data logger features:

- 1,500 ft. line of site range between receiver and each transmitter.
- 4 sensors on each transmitter.
- In field display of current readings used to adjust irrigation applications.
- Download history to computer for graphical display.
- Tipping rain bucket gauge also can be read by the data logger.

Installation

For producers who are in Intermediate and Advanced levels, there shall be a maximum of 6 tensiometers or gypsum blocks (soil moisture sensors) installed per irrigation system. Three locations shall each have two sensors nested together at different depths within the root zone. Shallow sensors are set at approximately 25% of the crop rooting depth. Deep sensors are set at approximately 75% of the crop rooting depth.

Placement of Soil Moisture Sensors in Furrow Irrigation

Place soil moisture sensors approximately two-thirds of the way down the run and 3 or 4 rows in from the field edge. Install sensors at root zone, and in the crop row.

Placement of Soil Moisture Sensors in Flood or Border Irrigation

In flood or border method of irrigation, soil moisture sensors are normally placed approximately two-thirds of the way down the run and midway between the borders. If purchasing tensiometers, make sure of sufficient length to keep gauges out of the flood water.

Placement of Soil Moisture Sensors in Sprinkler Irrigation

Soil moisture sensors should be located in areas receiving consistent application rates. On pivot irrigation, install sensors between the first and second tower, between the last two towers, and at the midpoint of the entire machine length. Alternative placements can be made in "hot spots", lightest soil, quickest to dry, or a point that represents the best production area in the field.

Special care should be exercised in taller crops to insure that leafs and stocks do not obstruct the sprinkler pattern to the moisture sensor location or that they are not located beyond the normal pattern of the sprinkler.

Placement of Soil Moisture Sensors in Drip or Trickle Irrigation

In drip (trickle) irrigation, soil moisture sensors are normally located at the drip line of the crop. Each unit should be placed 12 to 18 inches away from the emitter (24 to 36 inches from the micro sprinkler or spray) to ensure that they are in the wetted area. In newly planted crops, the shallow instruments should be placed in the root ball of the crop regardless of emitter location. In row crops, the units should be placed in the row. Additional instruments may be used to measure water movement away from the emitter but controlling instruments should be placed in representative locations 12 to 18 inches from the water source and in the root mass area.

SOIL MOISTURE BALANCE SHEET

Producer: John Smith
Phone: 1-406-285-3560
Crop: alfalfa
Field: 1-2
Emergence Date: 4/15
Acres: 140
Gross Irrigation by system: 4.20 inches
Pump Capacity: 580 total gpm
Net Irrigation: 2.7 inches
Root Zone Depth: 5 Feet
Designed Peak Consumptive Use: 0.32 inches
Water Holding Capacity: 7.1 inches
Management allowed depletion: 50 %
Starting Available soil moisture: 4 inches
Beginning Flow meter reading 100 Ac/Ft.
Ending Flow Meter reading: 717.2 Ac/Ft.
Maintain deficit less than: 3.55 inches - otherwise the crop will try to use water that is not available

Pick system Type

- ☐ Center Pivot
- ☐ Linear Pivot
- ☑ Wheel Line
- ☐ Hand/K Line
- ☐ Graded Border
- ☐ Furrow
- ☐ Contour ditches
- ☑ Other List:

Potential Efficiency

efficiency = 70%

64%

			ADD	SUBTRACT		TOTAL
Week After Emergence	Start of Emergence	Maximum Temperature	Crop Water Use	Rainfall	Net Irrigation	Total Available Moisture
WEEK 1	4/15	70	0.04		2.7	4.00
	4/16	71	0.04			3.96
	4/17	65	0.04			3.92
	4/18	72	0.04			3.88
	4/19	72	0.04			3.84
	4/20	75	0.04			3.80
	4/21	74	0.04			3.76
WEEK 2	4/22	73	0.09			3.67
	4/23	59	0.06			3.61
	4/24	63	0.08			3.53
	4/25	51	0.06			3.47
	4/26	58	0.06			3.41
	4/27	70	0.09			3.32
	4/28	48	0.05	0.1		3.37
WEEK 3	4/29	40	0.05			3.32
	4/30	47	0.05			3.27
	5/1	52	0.06			3.21
	5/2	54	0.06	0.1		3.25
	5/3	61	0.08	0.05		3.22
	5/4	46	0.05			3.17
	5/5	44	0.05			3.12
WEEK 4	5/6	43	0.08			3.04
	5/7	49	0.08			2.96
	5/8	59	0.12			2.84
	5/9	56	0.12			2.72
	5/10	59	0.12		2.7	5.30
	5/11	54	0.12			5.18
	5/12	55	0.12			5.06

Figure 1. Tabulated Soil Moisture Balance Sheet (Checkbook)

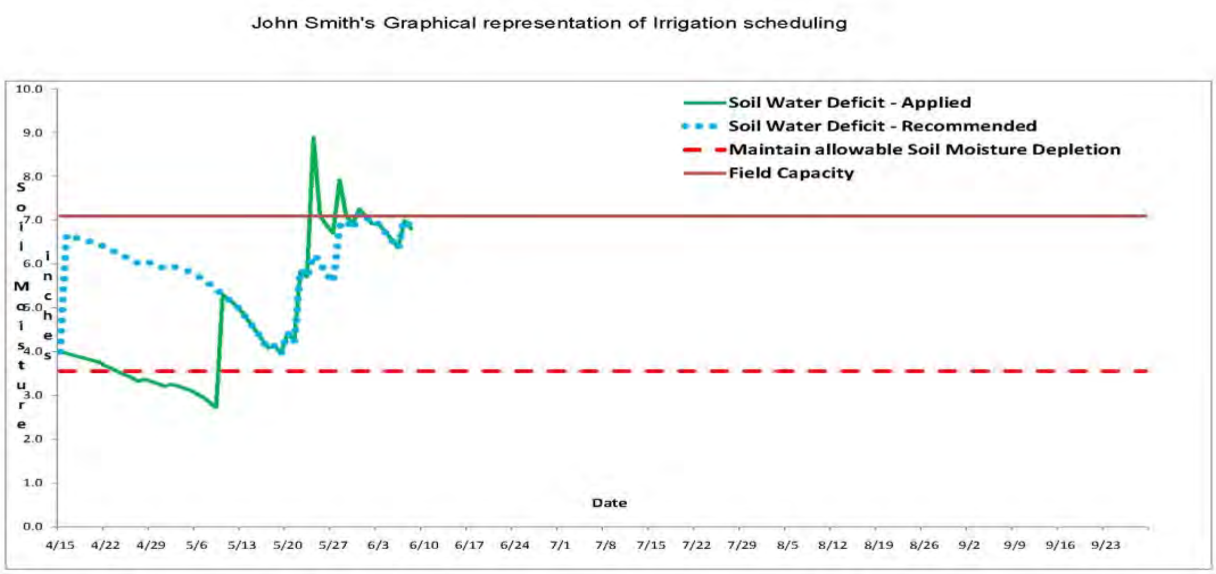


Figure 2. Graphical Presentation of Water Use

CERTIFICATION OF AN IRRIGATION WATER MANAGEMENT PLAN

Producer: John Smith Phone: 1-406-285-3560 Contract Number: EQIP56-345
Crop: alfalfa
Acres: 140 Net irrigation needed (CU-P)= 27.2 inches
Net irrigation applied= 32.8

Beginning Flow meter reading 100 Ac/Ft. Ending Flow Meter reading: 542 Ac/Ft.

Total gross water applied= 442 Ac/ft. 3.16 Per acre 37.9 inches

Efficiency — net/applied water = 71.8% Compare this to the Potential Efficiency from page 1

Any "Caution" flags from page 1, indicate the crop was trying to get water from the lower half of the soil's water holding capacity. This causes some stress to the plant, and will lead to productivity losses. See the Recommended irrigation schedule.

A proper Irrigation Water Management Plan will reduce irrigation runoff and deep percolation, improve crop productivity and conserve water, and energy costs.

I Certify that the irrigation records which include pages 1,2, 3 reflect proper irrigation water management applied.
And this is record to certify payment

Producer:____________________ Date: ________

Assistance by: ____________________ Date: ________

Approved by NRCS: ____________________ Date: ________

Other items used in irrigation water management to achieve a more advanced level include: Soil Probe, Tensiometers, Gypsum Blocks, Soil Moisture Meter, Data Logger, Agrimet Site, Atmometer, Improved pivot panel.
Ask NRCS about any or all of these IWM tools.

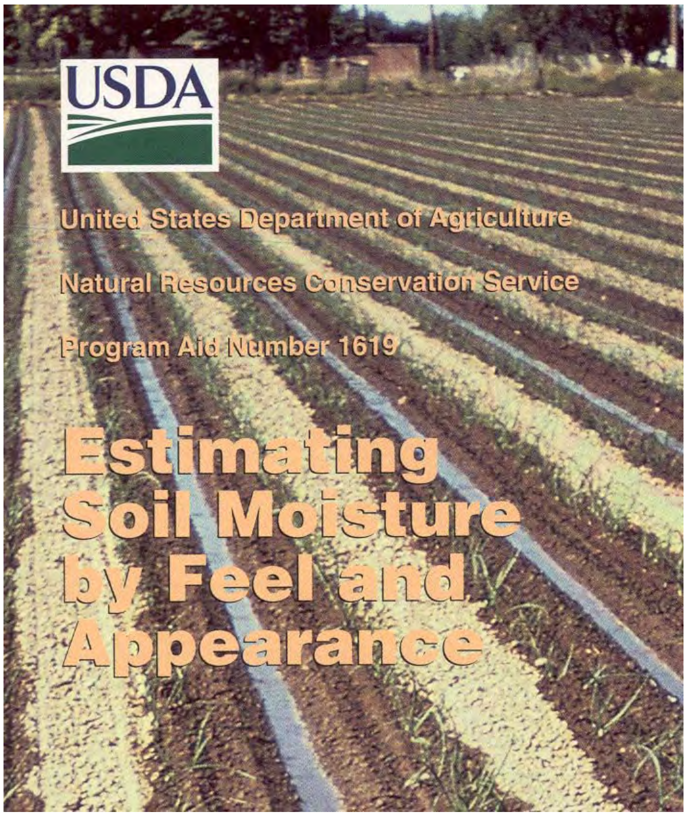
If following the "Recommended Irrigation Schedule, this system would have applied a net irrigation of:	29	inches
That's a net saving of;	3.8	inches.
This saving would have resulting in pumping less water and only applying:	150.67	Ac/ft..
difference from applied water is:	44.33	Ac/ft..
The Irrigation pump is stated as pumping:	580	gpm
Converting to Acre Feet:	2.56	Ac/ft. per day.
Total days the pump could have be shut down:	17.3	days
Pump horse power:	40	Hp
Total Kilowatts based on HP:	29.8	KW
So the pumped saving would be:	516.22	KW-days
Charge per KW:	0.11	$/kw/hr
Savings for following the "Recommended Irrigation Schedule" and on running a pump:	1363	$-Season

If the pump is not running, then the irrigation system may not be running, this would increase savings from electricity if, not to mention less work the pump and irrigation system will be subjected too.

Figure 3. Certification Sheet with Potential Pump Savings Cost

Estimating Soil Moisture by Feel and Appearance

Irrigation Water Management (IWM) is applying water according to crop needs in an amount that can be stored in the plant root zone of the soil.



The "feel and appearance method" is one of several irrigation scheduling methods used in IWM. It is a way of monitoring soil moisture to determine when to irrigate and how much water to apply. Applying too much water causes excessive runoff and/or deep percolation. As a result, valuable water is lost along with nutrients and chemicals, which may leach into the ground water.

The feel and appearance of soil vary with texture and moisture content. Soil moisture conditions can be estimated, with experience, to an accuracy of about 5 percent. Soil moisture is typically sampled in I-foot increments to the root depth of the crop at three or more sites per field. It is best to vary the number of sample sites and depths according to crop, field size, soil texture, and soil stratification. For each sample the "feel and appearance method" involves:

1. Obtaining a soil sample at the selected depth using a probe, auger, or shovel;
2. Squeezing the soil sample firmly in your hand several times to form an irregularly shaped "ball";
3. Squeezing the soil sample out of your hand between thumb and forefinger to form a ribbon;
4. Observing soil texture, ability to ribbon, firmness and surface roughness of ball, water glistening, loose soil particles, soil/water staining on fingers, and soil color. [Note: A very weak ball will disintegrate with one bounce of the hand. A weak ball disintegrates with two to three bounces;
5. Comparing observations with photographs and/or charts to estimate percent water available and the inches depleted below field capacity.

Example:

Sample Depth	Zone	USDA Texture	AWC*for Zone	Soil Moisture Delpetion**	Percent Depletion
6”	0-12"	sandy loam	1.4"	1.0"	70
18"	12-24"	sandy loam	1.4"	.8"	55
30"	24-36"	loam	2.0"	.8"	40
42"	36-48"	loam	2.0"	.5"	25
			6.8"	3.1"	

Result: A 3.1" net irrigation will refill the root zone.
** Available Water Capacity*
*** Determined by “feel and appearance method”*

Available Water Capacity (AWC) is the portion of water in a soil that can be readily absorbed by plant roots of most crops.

Soil Moisture Deficit (SMD) or Depletion is the amount of water required to raise the soil-water content of the crop root zone to field capacity.

Appearance of fine sand and loamy fine sand soils at various soil moisture conditions.

Available Water Capacity 0.6-1.2 inches/foot

Percent Available: Currently available soil moisture as a percent of available water capacity.

In/ft. Depleted: Inches of water currently needed to refill a foot of soil to field capacity.

0-25 percent available
1.2-0.5 in./ft. depleted

Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure. (Not pictured)

25-50 percent available
0.9-0.3 in./ft. depleted

Slightly moist, forms a very weak ball with well-defined finger mark

50-75 percent available
0.6-0.2 in./ft. depleted

Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.

75-100 percent available
0.3-0.0 in./ft. depleted

Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon

100 percent available
0.0 in./ft. depleted (field capacity)

Wet, forms a weak ball, moderate to heavy soil/ water coating on fingers, wet outline of soft ball remains on hand. (Not pictured)

Appearance of sandy loam and fine sandy loam soils at various soil moisture conditions.

Available WaterCapacity 1.3-1.7 inches/foot

Percent Available: Currently available soil moisture as a percent of available water capacity.

In/ft. Depleted: Inches of water currently needed to refill a foot of soil to field capacity.

0-25 percent available 1 7-1.0 in/ft. depleted

Dry, forms a very weak ball, aggregated soil grains break away easily from ball. (Not pictured)

25-50 percent available 1.3-0.7 in/ft. depleted

Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers, grains break away.

50-75 percent available 0.9-0.3 in./ft. depleted

Moist, forms a ball with defined finger marks, very light soil/water staining on fmgers, darkened color, will not slick.

75-100 percent available 0.4-0.0 in./ft. depleted

Wet, forms a ball with wet outline left on hand, light to medium staining on fingers, makes a weak ribbon between the thumb and forefinger.

100 percent available 0.0 in./ft. depleted (field capacity)

Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers. (Not pictured)

Appearance of sandy clay loam, loam, and silt loam soils at various soil moisture conditions.

Available WaterCapacity 1.5-2.1 inches/foot

Percent Available: Currently available soil moisture as a percent of available water capacity.

In/ft. Depleted: Inches of water currently needed to refill a foot of soil to field capacity.

0-25 percent available 2.1-1.1 in./ft. depleted

Dry, soil aggregations break away easily, no staining on fingers, clods crumble with applied pressure. (Not pictured)

25-50 percent available 1.6-0.8 in./ft. depleted

Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.

50-75 percent available 1.1-0.4 in./ft. depleted

Moist, forms a ball, very light staining on fingers, darkened color, pliable, forms a weak ribbon between the thumb and forefinger.

75-100 percent available 0.5-0.0 in/ft. depleted

Wet, forms a ball with well-defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.

100 percent available 0.0 in/ft. depleted (field capacity)

Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers. (Not pictured)

Appearance of clay, clay loam, and silt clay loam soils at various soil moisture conditions.

Available WaterCapacity 1.6-2.4 inches/foot

Percent Available: Currently available soil moisture as a percent of available water capacity.

In/ft. Depleted: Inches of water currently needed to refill a foot of soil to field capacity.

0-25 percent available
2.4-1.2 in/ft. depleted

Dry, soil aggregations separate easily, clods are hard to crumble with applied pressure. (Not pictured)

25-50 percent available
1.8-0.8 in/ft. depleted

Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.

50 - 75 percent available
1.2-0.4 in./ft. depleted

Moist, forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger.

75-100 percent available
0.6-0.0 in./ft. depleted

Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger.

100 percent available
0.0 in./ft. depleted (field capacity)

Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil/water coating on fingers, slick and sticky. (Not pictured)

Guidelines for Estimating Soil Moisture Conditions

	Coarse Texture- Fine Sand and Loamy Fine Sand	Moderately Coarse Texture Sandy Loam and Fine Sandy Loam	Medium Texture - Sandy Clay Loam, Loam, and Silt Loam	Fine Texture- Clay, Clay Loam, or Silty Clay Loam
	Available Water Capacity (Inches/Foot)			
	0.6-1.2	1.3-1.7	1.5-2.1	1.6-2.4
Available Soil Moisture Percent	Soil Moisture Deficit (SMD) in inches per foot when the feel and appearance of the soil are as described.			
0-25	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure. SMD 1.2-0.5	Dry, forms a very weak ball, aggregated soil grains break away easily from ball. SMD 1.7 -1.0	Dry. Soil aggregations break away easily. no moisture staining on fingers, clods crumble with applied pressure. SMD 2.1-1.1	Dry, soil aggregations easily separate, clods are hard to crumble with applied pressure SMD 2.4-1.2
25-50	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remain on fingers. SMD O.9-0.3	Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers, grains break away. SMD 1.3-0.7	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away. SMD1.6-0.8	Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure SMD 1.8-0.8
50-75	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon. SMD O.6-0.2	Moist, forms a ball with defined finger marks. very light soil/water staining on fingers. darkened color, will not slick. SMD O.9-0.3	Moist, forms a ball, very light water staining on fingers, darkened color, pliable, forms a weak ribbon between thumb and forefinger. SMD 1.1- 0.4	Moist. forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger. SMD I.2-0.4
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. SMD O.3-0.0	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. SMD O.4-0.0	Wet, forms a ball with well defined finger marks, light to heavy soil/water coating on fingers, ribbons between , thumb and forefinger. SMD O.5 -0.0	Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger. SMD O.6-0.0
Field Capacity (100 %)	Wet, forms a weak ball, moderate to heavy soil/ water coating on fingers, wet outline of soft ball remains on hand. SMD 0.0	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking,medium to heavy soil/water coating on fingers. SMD 0.0	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers. SMD 0.0	Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil/water coating on fingers, slick and sticky. SMD 0.0

April 1998