The Irrigator

A crop water use information project of Solano Irrigation District, Reclamation District 2068, Maine Prairie Water District, Solano County Water Agency, Natural Resources Conservation Service, and the Dixon and Solano Resource Conservation Districts

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- Be a Four Tool Irrigator:
  1. Utilize ET rates
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New for 2019

Remote Soil Moisture Monitoring Program

Improved Weather Website:

sid.westernweathergroup.com

Read your flow meter

How Much Water is Being Applied to the Crop?

Flow definitions: GPM = gallons per minute
CFS = cubic feet per second

Growers of all crops should record the amount of water applied to their crops and compare it to the crop water demand from evapotranspiration rates and soil moisture monitoring. The purpose is to irrigate more efficiently and with greater precision. An accurate flow meter is required, or check monthly billing records from the irrigation district. Depending on the type of flow meter, here are some important formulas:

1. **Calculate the Application Rate (inches/hr.)**

GPM meter: GPM/area irrigated (acres) x 0.0022 = inches/hour

CFS meter: CFS/area irrigated (acres) x 0.992 = inches/hour

Gallons meter: Gallons/time period over which measured (min)/acres irrigated x 0.0165= in/hr

Acre-Feet meter: Acre-ft/time period over which measured (min)/acres irrigated x 720 = in/hr

Flow meter with Instantaneous Rate, Readout in GPM: $\frac{\text{GPM x irrigation time (hrs)}}{\text{449 x acres irrigated}}$ = CFS

2. **Calculate the applied water volume for the entire season**

Seasonal Water Application (inches) = Application rate (in./hr.) x Irrigation time (hrs.)

SeaMetrics Mag Meter

McCrometer Propeller Meter

When to Apply the First Irrigation?

Orchards

The heavy rainfall from this past winter will make irrigations decisions challenging for optimal orchard production. Irrigating too early may harm tree health by promoting root/crown Phytophthora infection or oxygen-starved roots. However, irrigating too late may stress trees and result in reduced spur and shoot growth along with current and future yields. The best way to calculate timing for the first irrigation is to know:

1. **How much Plant Available Water will your soil hold after rainfall or irrigation ?**

Sandy Loams, Fine Sandy Loams	1.5"/ft.	(approximate)
Loams, Silt Loams, Very fine Sandy Loams	1.8"/ft.	"
Clay Loams, Silty Clay Loams	2.1"/ft.	"
Clays	2.0"/ft..	"

2. **What are the approximate "active" rooting depths?**

Almonds	(mature)	3'
Prunes	(mature)	3'
Walnuts	(mature)	4'

For younger trees, an estimation of decreased rooting depth is required.

3. **Calculate Total Plant Available Water = plant available water /ft. x "Active" root zone in feet**

4. **How much water are the trees using?**

Determine acre inches of crop Evapotranspiration (ETo) for trees from websites or weather stations (see page 3 for a list of websites). Water use by young tress can be estimated by observing canopy volume.

5. **How much water are you applying per hour or per set?**

Refer to the system design, available from the installer, or

Measure the flow output from drip emitters, micro-sprinklers or impact sprinklers

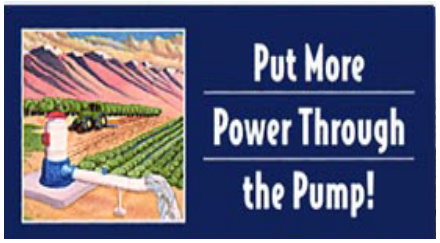
EXAMPLE: - Your soil holds 1.7"/ft. of water in the root zone, with a 3' rooting depth= 5" Plant Avail. Water.

- Your irrigation system puts 2" of water in the soil per set.

- It rained 0.5" after the trees used 1" of moisture from the soil .

In this example, the first irrigation should occur when the orchard used 2.5 acre-inches of moisture, according to ETc rates, starting from the last date of Field Capacity conditions (typically early spring after heavy rains have ended). Be sure to probe the soil for moisture levels to confirm soil conditions, and adjust your schedule accordingly.

For more information regarding orchard irrigation and management, go to "Sacramento Valley Orchard Source" at ***www.sacvalleyorchards.com.*** The site was developed by the U.C. Agriculture and Natural Resources Division and covers all aspects of orchard production.



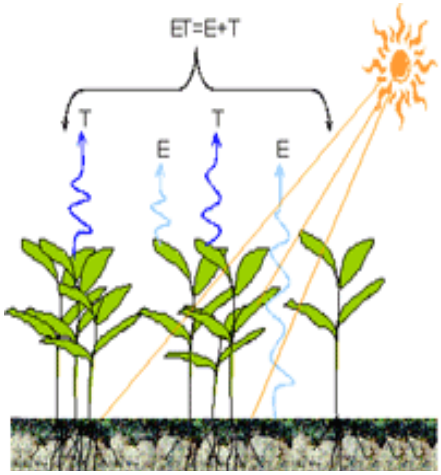
Pump Efficiency Tests are available for any grower or landowner in Solano County, free-of-charge. A pump test measures pump performance and efficiency, and can indicate whether repairs are needed. Annual testing can point out trends that might help plan future retrofits. Pumps must be deep well or low-lift, and PG&E powered. For information, contact Paul Lum at (707) 455-4024, or email LumP@sidwater.org.

The Four Tool Approach to Irrigation Management

Combining several methods and techniques is recommended for precise, efficient irrigation scheduling. We advocate utilizing the following approaches in order to meet crop water demand, maintain plant health and vigor, and avoid wasting water.

1. Track Evapotranspiration Rates (determine the crop water requirement)
2. Monitor soil moisture (use soil sensors)
3. Monitor plant water stress (for orchard growers, measure Stem Water Potential with the "Pressure Bomb")
4. Track water use (flow meter or district records)

1. Evapotranspiration Rates Explained



ETo = "Reference ET" = the amount of water use by a well irrigated, mowed field of alfalfa, pasture, or grass. The factors that affect ETo are temperature, relative humidity, solar radiation, and wind.

ETo rates for areas in Solano County are available on the following websites: ***sid.westerweathergroup.com***

The ET for a specific crop is ETc, or Crop Evapotranspiration. ETc is determined by factoring a "Crop Coefficient" or Kc. Thus, **ETc = ETo x Kc**

There are ETc rates for almost every crop grown in our area, since each crop transpires water differently, and at different growth stages. Kc coefficients factors are available online at:

www.Wateright.org. Search for "References" and then find "Crop Coefficients for Ag Crops".

Or, use historical ETc rates, available online. Search ITRC Report RT03-001 and go to ***www.itrc.org/reports/pdf/californiadcrop.pdf/californiacrop.pdf***

Basic ET Scheduler

To the right is a basic ET scheduler that applies to all crops. In this example, a walnut grower with a micro-irrigation system has set a *target date* when cumulative ETc reaches 1.0". The grower starts tracking ETc after an early season rain or irrigation event fills the soil profile to Field Capacity (maximum soil moisture content after ponding and drainage cease) on 3/31. Daily ETo rates can be found on the weather websites listed above. On 4/1 ETo was 0.18". Multiply by the Kc factor to find the ETc. The grower adds the ETc values daily until it reaches his target date for an irrigation. The target is a growers' decision for Management Allowed Depletion (MAD) whereby the grower decides how much soil moisture depletion he will allow before irrigating, usually 50% depletion. As ETc accumulated daily, the soil depletion level increases, and when it reached 1.1" the grower applied 1.0" to restore ETc losses. The goal is to restore ETc while avoiding plant stress or over-irrigation. Scheduling should take into account soil moisture conditions by regular monitoring with a hand auger or shovel, and sensors. Other considerations are plant maturity, canopy cover, field operations, and weather forecasts.

Date	Irrigation or Rain	ETo (inches)	Kc	ETc	Cumulative ETc minus water applied
4/1	0	0.18	0.53	0.10	0.10
4/2	0	0.12	0.53	0.06	0.16
4/3	0	0.13	0.53	0.07	0.23
4/4	0	0.13	0.53	0.07	0.30
4/5	0	0.13	0.53	0.07	0.37
4/6	0	0.14	0.53	0.07	0.44
4/7	0	0.14	0.53	0.07	0.51
4/8	0	0.14	0.53	0.07	0.58
4/9	0	0.17	0.53	0.09	0.67
4/10	0	0.22	0.53	0.14	0.81
4/11	0	0.17	0.53	0.09	0.90
4/12	0	0.17	0.53	0.09	0.99
4/13	0	0.17	0.53	0.09	1.08
4/14	1.0"				0.08

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Scheduling worksheets are available that are helpful and save time. Calculations are made for when and how much water to apply. For grape, and orchard growers the Excel tables post recommended start dates, irrigation frequency, run-time hours and application amounts. A grape spreadsheet can be found online; search for *Excel Irrigation Scheduling Worksheet UCANR*. For other crops, contact Paul Lum at (707) 455-4024, or LumP@sidwater.org .

2. Monitor Soil Moisture

Free Watermark Sensors Available

Watermark soil sensors are among the most popular sensors throughout California. Manufactured by Irrometer, Inc., the sensors consist of electrodes embedded within a granular matrix— similar to the gypsum block sensor but enclosed within a stainless steel housing. Moisture is measured in the form of electrical resistance in centibars. As the soil dries, the tension between the soil-to-sensor contact increases. A hand meter or data-logger reads the resistance in centibars pressure. Watermarks are inexpensive ($32/ea.), are easily installed, and can be easily removed before harvest in annual crops. For tomatoes, they are practical for single season usage due to it's low cost. ($32/each) . When readings are monitored regularly, the grower can determine drying trends, moisture content through the soil profile, and the depth of water applied after an irrigation. With experience, the readings can be a guide for determining when and how much to irrigate. The sensors are usually installed at 1', 2', 3' & 4' depths depending on the crop. To sign up for free sensors on a first come first served basis contact Paul Lum at (707) 455-4024 or at LumP@Sidwater.Org.

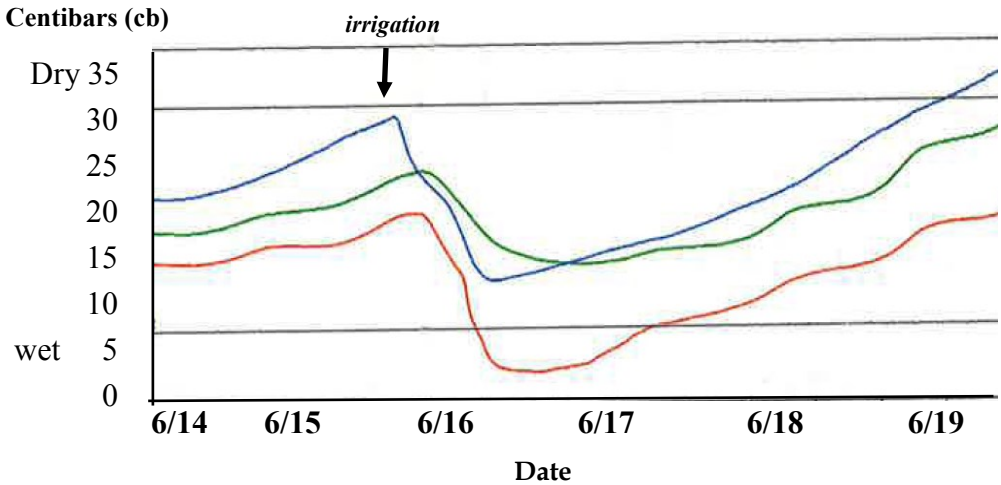
Watermark soil sensor & meter

Sensor installation in tomatoes

Sensor installation in orchards

New for 2019: Remote Soil Monitoring Project

The Solano Ag Water Conservation Committee is partnering with Dellevalle Labs in Davis to install the Wildeye soil monitoring system on six orchards or vineyards in Solano County. Wildeye's system provides remote monitoring of soil moisture levels on a 24/7 basis. The program involves a grower Agreement with Dellevalle Labs to provide equipment, installation, maintenance, support, and an internet subscription. The equipment consists of a capacitance probe, datalogger, antenna, and solar panel. The Committee will contribute $1,200 towards the first year of the system implementation. The costs for the 2nd year and subsequent years would be covered by the grower.



Example Wildeye Soil Moisture Graph in Tomatoes

Watermark Sensors—Interpreting the Readings

The sensor number corresponds with the depth of the sensor placement.

Sensor #1 (S1) is 1' deep
Sensor #2 (S2) is 2' deep
Sensor #3 (S3) is 3' deep
Sensor #4 (S4) is 4' deep

The centibar (cb) value represents the amount of soil water tension to extract moisture from the soil. The greater the centibar number, the drier the soil conditions are. Here is a general guideline for the centibar readings:

0 – 10 cb	**Fully saturated soil to field capacity (wet but not ponding)**
10 – 30 cb	**Adequately moist soils; plenty to adequate available moisture**
30 – 60 cb	**Range for irrigation in sandy or loamy soils; limited available moisture**
40 – 80 cb	**Range for irrigation in clay soils; limited available moisture**
80 - 100 cb	**Limited available moisture**
100 - 200 cb	**Dry soils**

It is more important to note the **moisture trends over time** as opposed to the actual centibar number. Centibar readings have a range of variance from sensor-to-sensor but the trends are an important indicator of soil conditions over time. A slow downward trend generally means a slow drying of soil, but a steep downward trend indicates a rapid moisture loss.

3. Measure Stem Water Potential

For orchard and winegrape growers, monitoring Stem Water Potential, or plant moisture stress can be measured with a portable Pressure Chamber.

Commonly called the "Pressure Bomb" it has become a popular tool for irrigation scheduling. U.C. Extension Farm Advisors and UCD faculty have published guidelines for interpreting the readings and providing general recommendations. It can be especially valuable in the Spring, when deciding when to start irrigating.

The Pressure Bomb works by taking a representative leaf sample and measuring the amount of pressure it takes to force water out of the leaf. A high pressure means a high value of water tension and a high degree of water stress. Mid-day is the best time to measure leaf pressure, when plant water movement is greatest. It is our goal to use the pressure bomb as a tool, along with soil monitoring and evapotranspiration data to assist farmers with efficient irrigation scheduling. The Pressure Bomb is available to growers on loan. For information, contact Paul Lum at (707) 455-4024 or LumP@Sidwater.Org.

Pressure Bomb

New Weather Website

Check out our new weather website provided by Western Weather Group at ***sid.westernweathergroup.com.*** The site provides near-real-time weather information from (7) stations owned by SID. The website features satellite imagery, river and reservoir levels, a Crop Water Use Report, and ETo data for irrigation scheduling. Historical weather data is archived, and there are links to the California Irrigation Management Information System (CIMIS), and the California Data Exchange Center (CDEC). Below is a partial, example view of the website homepage from 8:30am, February 14 2019, after a night of heavy rainfall.

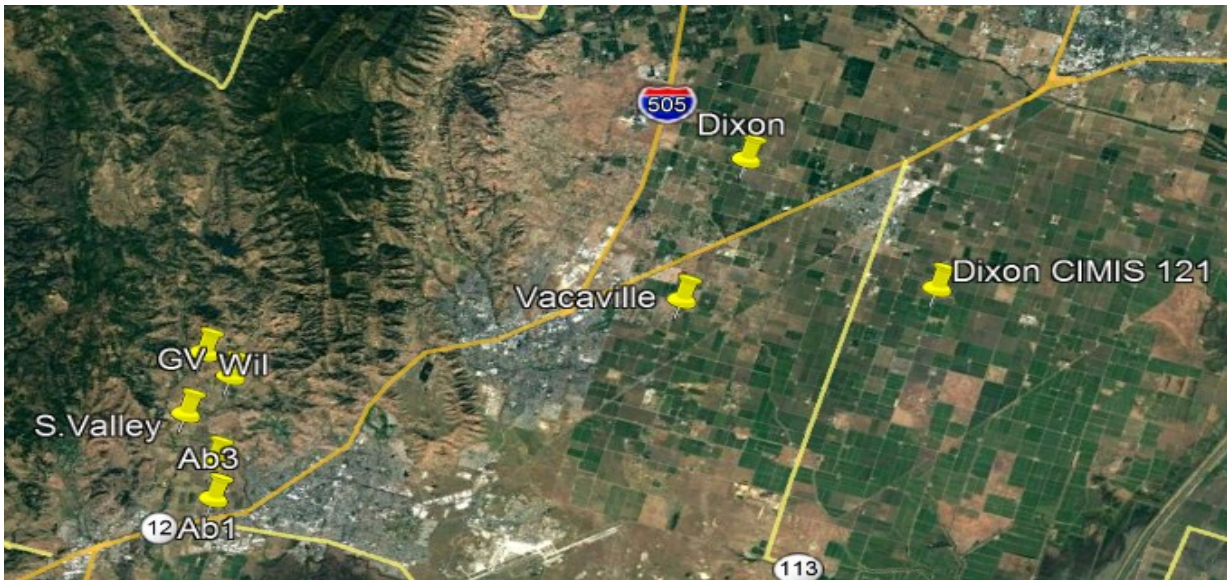
Station	Date	Time	Temp (F)		RH%		Dew Pt (F)		Wind Spd (mpg)	Wind Dir (degrees)		Wind Gust (mph)		Rain 1 hr	Rain 24 hr
Williams 2	2/14/19	7am	46.0	+3.7	89	-7	42.9	+1.7	7.9	WSW	250	24.0	+12.9	0.03	1.13
Gord Valley 3	2/14/19	7am	51.9	+8.0	100	+0	52.0	+8.0	10.6	WSW	243	22.2	+16.4	0.02	0.78
Suisun Valley	2/14/19	7am	56.4	+10.4	90	-4	34.8	+2.6	9.0	WSW	237	20.7	+10.9	0.02	0.83
Abernathy 3	2/14/19	7am	55.9	+9.9	90	-1	37.5	+3.7	13.7	WSW	258	25.9	+11.1	0.02	0.48
Abernathy 1	2/14/19	7am	54.2	+9.9	91	-1	33.0	+3.1	11.1	WSW	243	21.7	+10.9	0.02	0.48
Dixon West	2/14/19	7am	56.3	+13.1	76	-18	36.7	+1.0	12.7	S	90	24.7	-2.5	0.05	1.19
Vacaville East	2/14/19	7am	55.7	+12.1	82	-17	35.9	+0.1	12.3	SW	215	26.2	-1.0	0.15	0.79

Station Access—Online and Phone

Dixon West	sid.westernweathergroup.com.
Vacaville East	sid.westernweathergroup.com.
Suisun Valley	(707) 863-8978 & website (above)
Abernathy 1	(707) 426-4896 & website (above)
Abernathy 3	sid.westernweathergroup.com
Williams 2	(707) 426-4063 & website
Gordon Valley 3	sid.westernweathergroup.com
Dixon CIMIS #121	www.CIMIS.water.ca.gov
Hastings CIMIS#212	www.CIMIS.water.ca.gov

Frost Alert Program

A frost alert system is available, pending enough grower interest. Farmers can designate which weather station or stations to use as the provider of alerts by text, phone call, or email. Wind and rain-fall alerts can also be set. For information contact Paul Lum at LumP@sidwater.org.



Solano Weather Station Map

4. Scheduling Formulas

Furrow & Flood Irrigated Crops:

Calculate # inches applied to the crop: (Assume DU=1.0)

Inches = $\frac{96.3 \times \text{gpm} \times \text{set time (hrs.)}}{\text{Area irrigated (sq. ft.)}}$ Example: $\frac{\mathbf{96.3 \times 1800\ gpm \times 12\ hrs.}}{\mathbf{522{,}720\ sq.\ ft.}}$ = **4.0 inches**

Calculate # hours to apply:

Hours = $\frac{\text{Area (sq. ft.)} \times \text{inches}}{96.3 \times \text{gpm} \times .8\ \text{DU}}$ Example: $\frac{\mathbf{522{,}720\ sq.\ ft. \times 4.0\ inches}}{\mathbf{138{,}672}}$ = **15.0 hours**

Note: 1 cubic ft./second = 450 gallons per minute

DU = Distribution Uniformity. Assume 0.8 for this example

Trees & Grapes:

Convert Daily Crop Evapotranspiration rates to Gallons per Day per Tree or Vine:

ETc Water Use (gals/day) = crop spacing (sq. ft.) x ETc (in/day) x 0.623

Example: ETc is 0.20 inch per day as posted on ***sid.westernweathergroup.com*** or ***www.CIMIS.com***

Plant spacing is 15 feet x 15 feet = 225 square feet

Water use per plant = 225 x 0.20 x 0.623 = 28.0 gallons

Measure the Application Rates of Drip/Micro-sprinklers

Use a graduated a cylinder to collect flow from emitters or micro sprinklers.

A 100 ml cylinder is used for drip systems and a 1000 ml cylinder for micro sprinkler systems.

1. Calculate the flow rate for an emitter or micro sprinkler

   _____ ml water collected in 30 seconds x 0.317 = _____discharge rate (gallons per hour)

   (for drip you may need to collect flow for 3-4 minutes and convert # minutes to 30 seconds)

2. Find the average flow rate per emitter or micro-sprinkler in gallons per hour by measuring Numerous emitters or micro-sprinklers.

Calculate the application rate in inches per hour:

Avg. flow (gph) x # devices per plant / area per plant x 1.6 = Application rate in inches per hour

collecting flow from sprinklers

drip emitter measurement

The Irrigator

Solano County Agricultural
Water Conservation Committee
810 Vaca Valley Parkway, Suite 201
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Free Services:

Irrigation Evaluations
Soil Sensor installations
Pump Tests
Weather forecast 2 week trial

If you have input or suggestions for the Solano County Agricultural Water Conservation Committee or would like previous issues or information, please email Paul Lum at LumP@sidwater.org. or call (707) 455-4024.

Paul Lum
Chairman, Solano County
Agricultural Water Conservation Committee

Published by the Solano County Agricultural Water Conservation Committee: Reclamation District 2068, Solano Irrigation District, Maine Prairie Water District, Solano County Water Agency, Natural Resources Conservation Service, and the Dixon & Solano Resource Conservation Districts.