Principles of Irrigation Scheduling and Soil Moisture Monitoring

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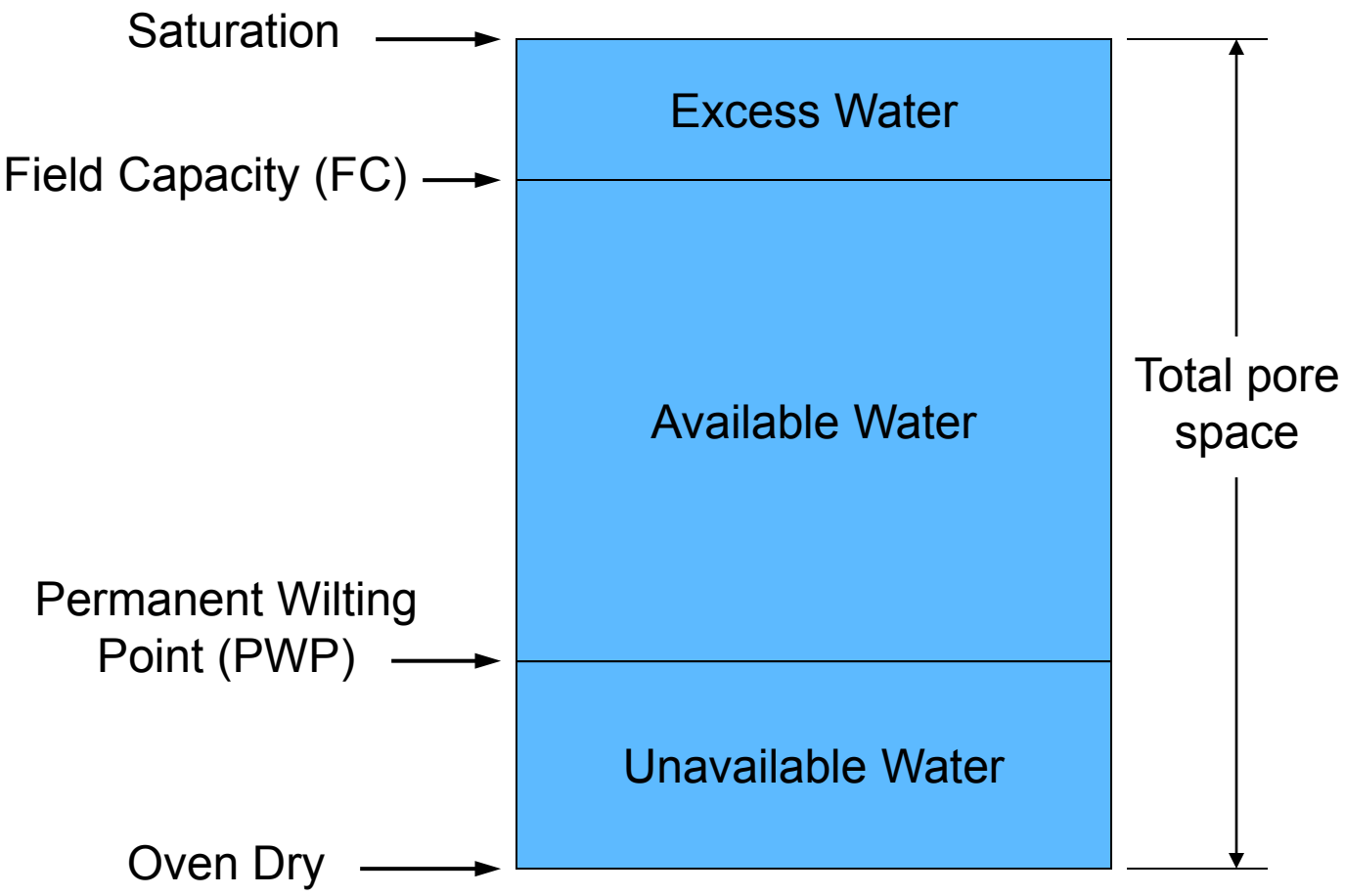
Basic Soil Water Relations

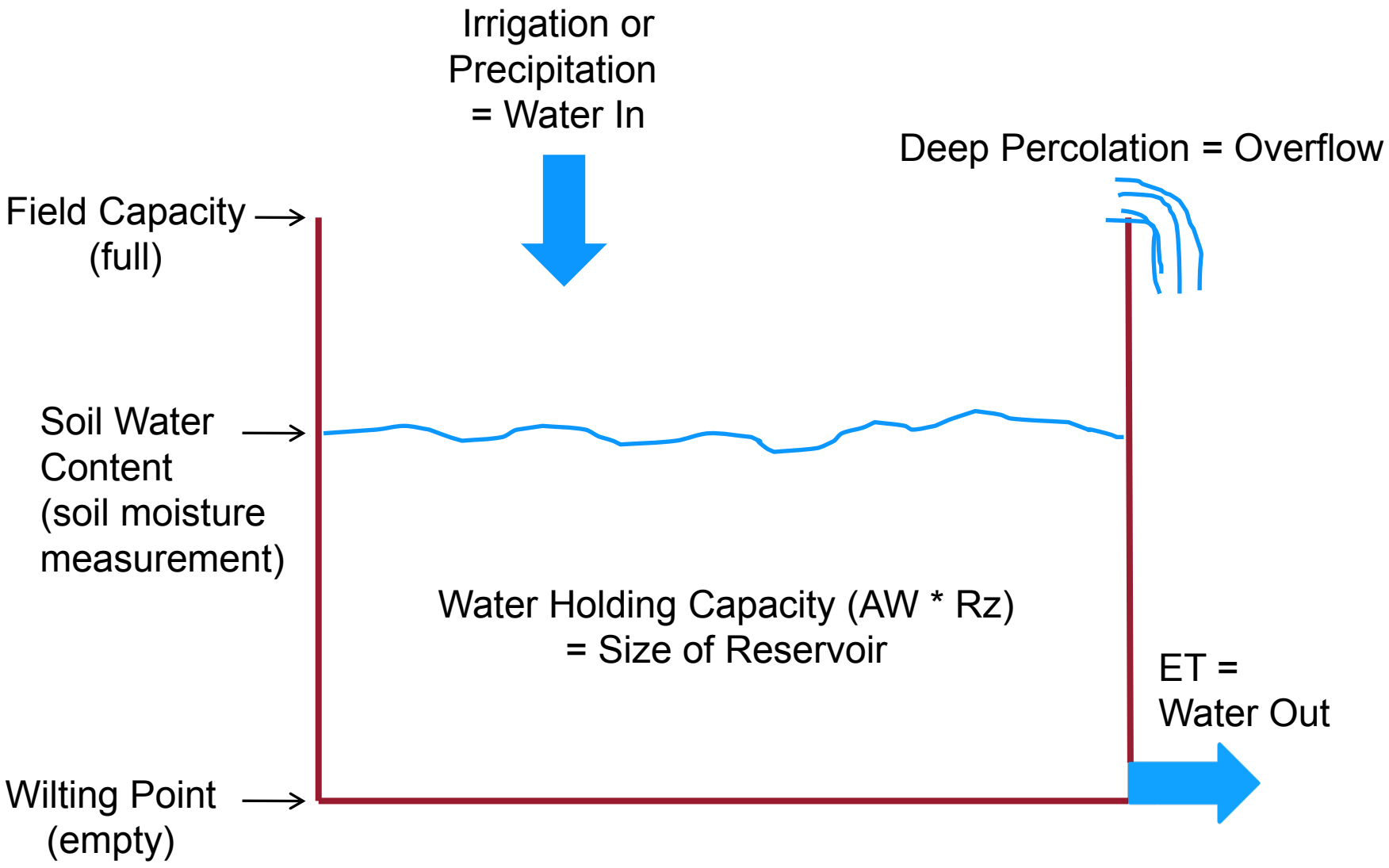
When can I safely turn it off? For how long?
Don't guess! Get data!

- Soil-based
  - Soil moisture sensors
- Weather-based
  - ET and crop coefficients (mathematical model)
- Plant-Based
  - Sap flow gauges and stem/leaf water potential
  - Canopy temperature

Soil Water


Saturation
Field Capacity (FC)
Permanent Wilting Point (PWP)
Oven Dry
Excess Water
Available Water
Unavailable Water
Total pore space

Soil is a Water & Nutrient Reservoir



Soil Texture and Available Water

Soil Texture	Available Water (AW) in/ft
Coarse Sand	0.2 - 0.8
Fine Sand	0.7 - 1.0
Loamy Sandy	0.8 - 1.3
Sandy Loam	1.1 - 1.6
Fine Sandy Loam	1.2 - 2.0
Silt Loam	1.8 - 2.8
Silty Clay Loam	1.6 - 1.9
Silty Clay	1.5 - 2.0
Clay	1.3 - 1.8
Peat Mucks	1.9 - 2.9

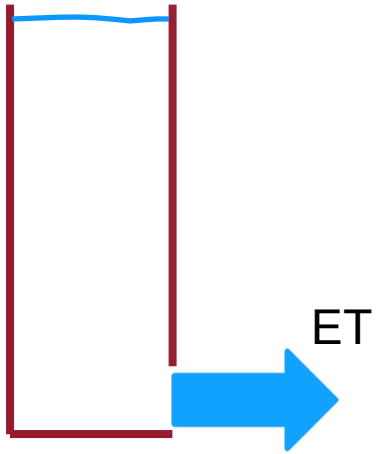
Find your soil at web soil survey:
http://websoilsurvey.nrcs.usda.gov/

How Big is Your Reservoir?

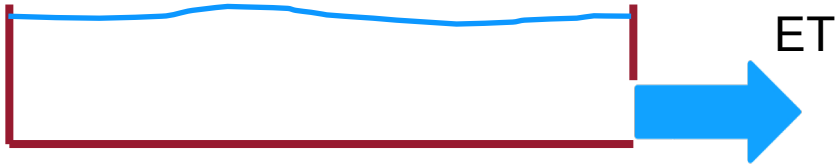
How much water can it hold? When will it be empty?

Deep Silt

Deep Sand

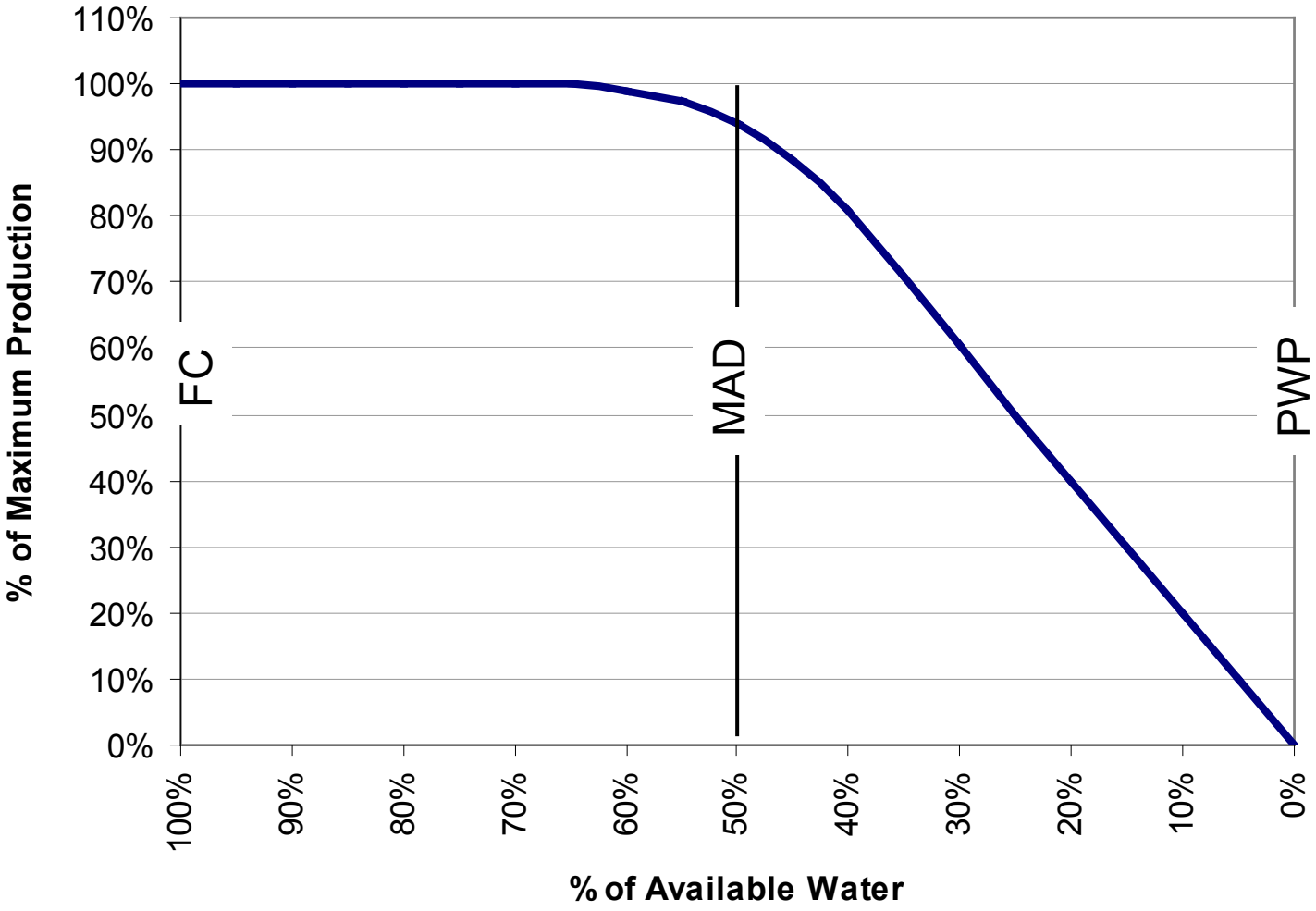


Shallow Silt



Shallow Sand

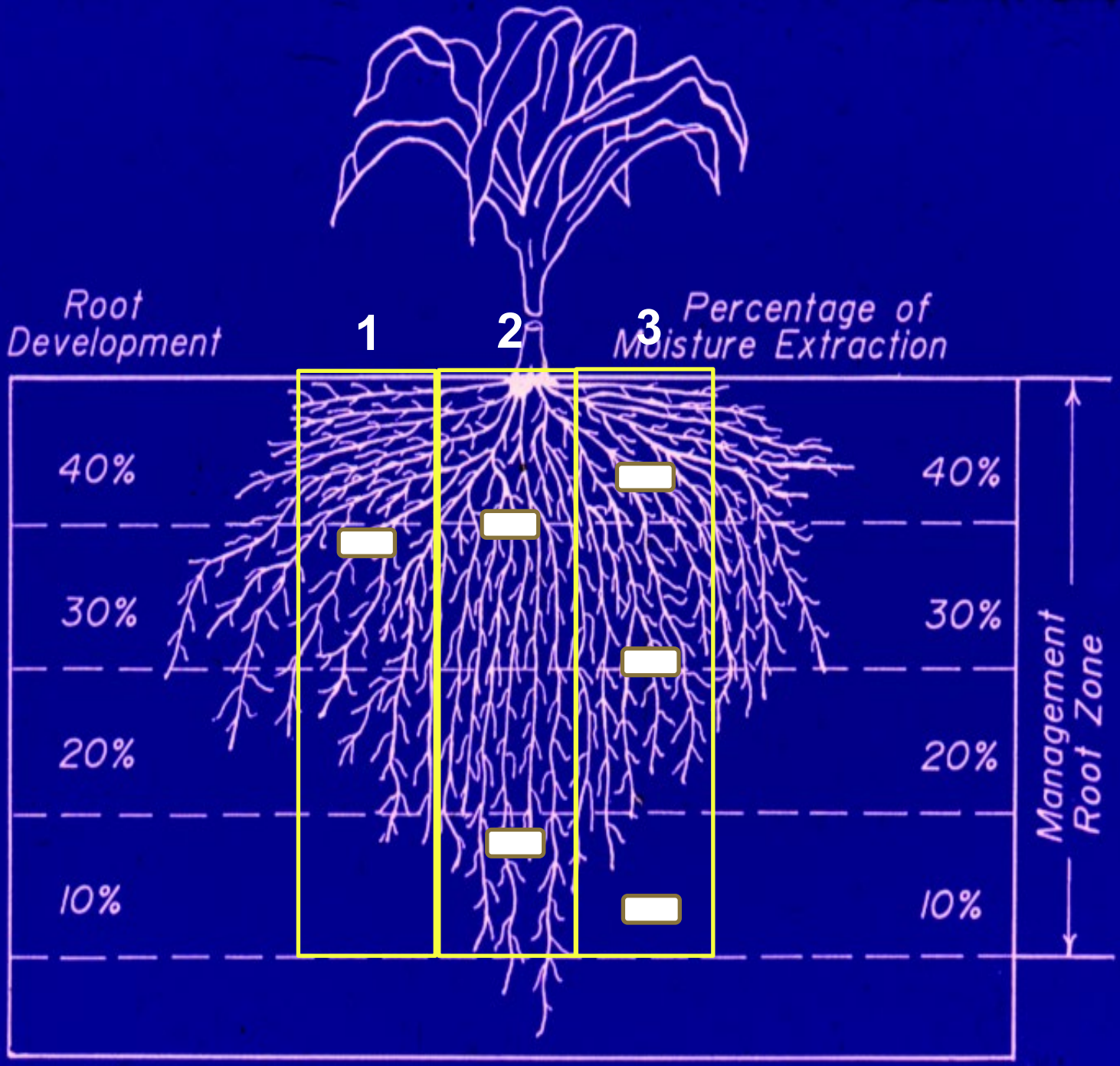
Production Reduction Function



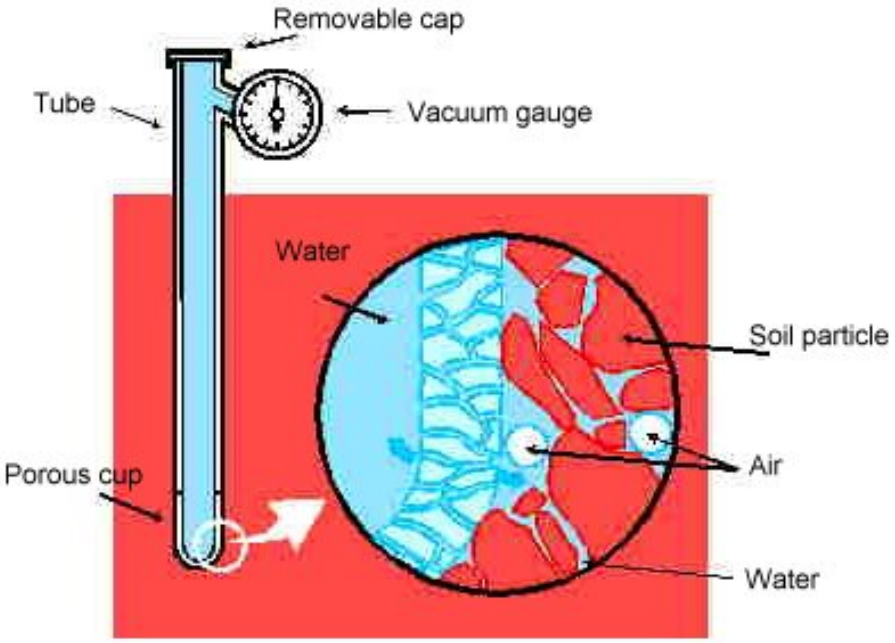
Soil Moisture Sensors

Where to put them?

- Field location
  - *Not* right on the edge of the field.
  - Average soil condition?
  - Lowest water holding capacity (sandy).
- Depths
  - (1) Middle of root zone.
  - (2) 1/3 – middle, and bottom of root zone.
  - (3) Top, middle, and bottom of root zone.
  - Top sensors tell you *when* to water, bottom shows more severe stress, and shows water holding capacity of soil… *how much.*


Root Development
1
2
3
Percentage of Moisture Extraction
40%
30%
20%
10%
40%
30%
20%
10%
Management Root Zone

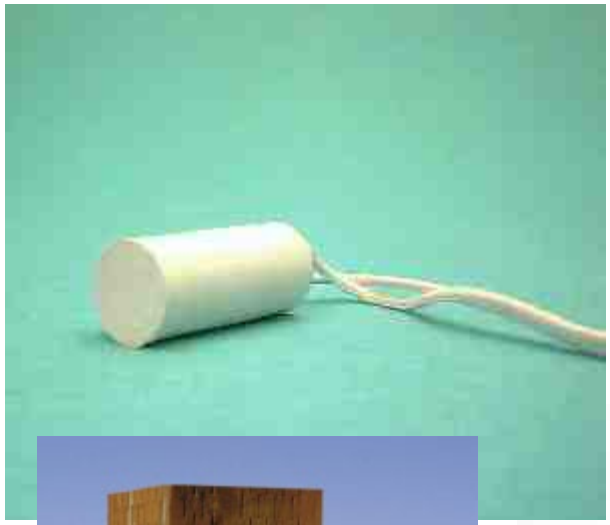
Tensiometers



Tensiometers

- Strengths
  - Soil water tension (same as plant sees)
  - Less expensive
  - Widely used, studied and accepted
  - Not affected by salinity
- Weaknesses
  - Small sample area
  - Indicates “when” to irrigate, not “how much”

Resistance



Resistance type

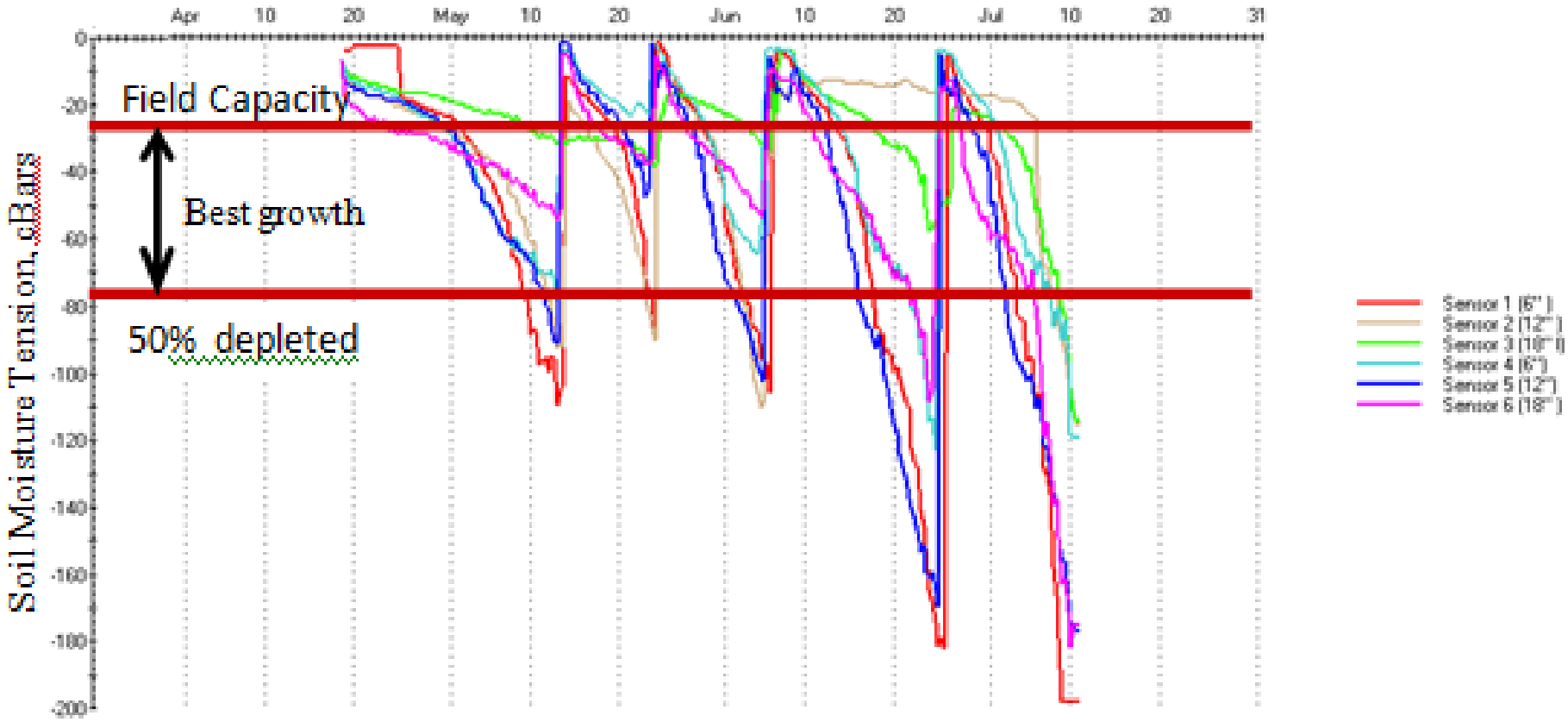
- Strengths
  - Inexpensive
  - Usable trends
  - Give soil water potential (same as plant sees)
  - Easy to log data

- Weaknesses
  - Affected by salinity
  - Imperfect accuracy
  - Samples small area


WATERMARK
25

Practical use of Tension- Based Soil Moisture Sensors

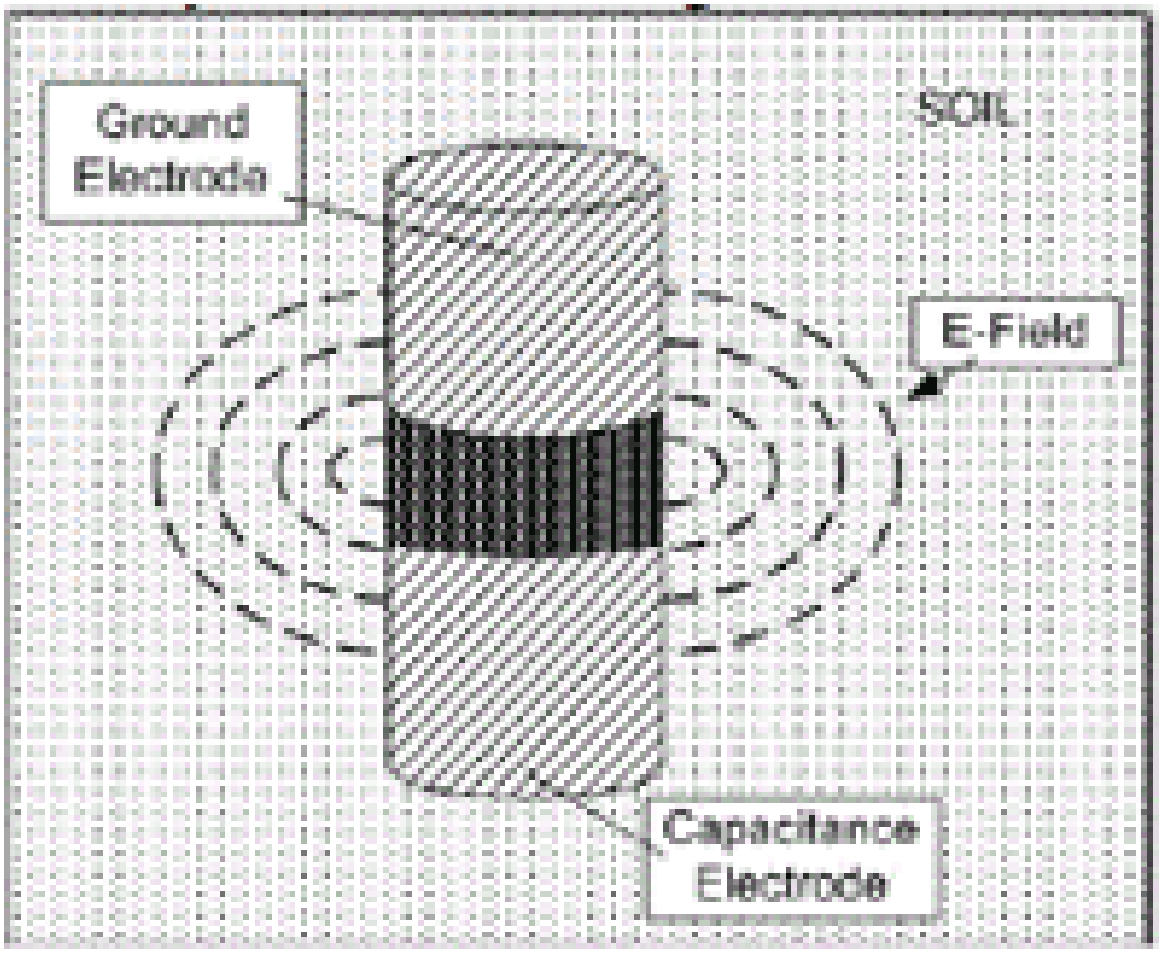
- Start with 30-50 centibars as irrigation point for no stress.
- Increase to 80-100 centibars or higher for imposed stress.
- Correlate numbers to crop condition, then use numbers in future to indicate degree of soil dryness.
- Watch deep sensor after an irrigation to indicate depth of penetration.


Apr
10
20
May
10
20
Jun
10
20
Jul
10
20
31
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
Soil Moisture Tension, cBars
Field Capacity
Best growth
50% depleted
Sensor 1 (6")
Sensor 2 (12")
Sensor 3 (18")
Sensor 4 (6")
Sensor 5 (12")
Sensor 6 (18")

Capacitance Probes


Courtesy Rick Hamman, Mercer Estate Winery

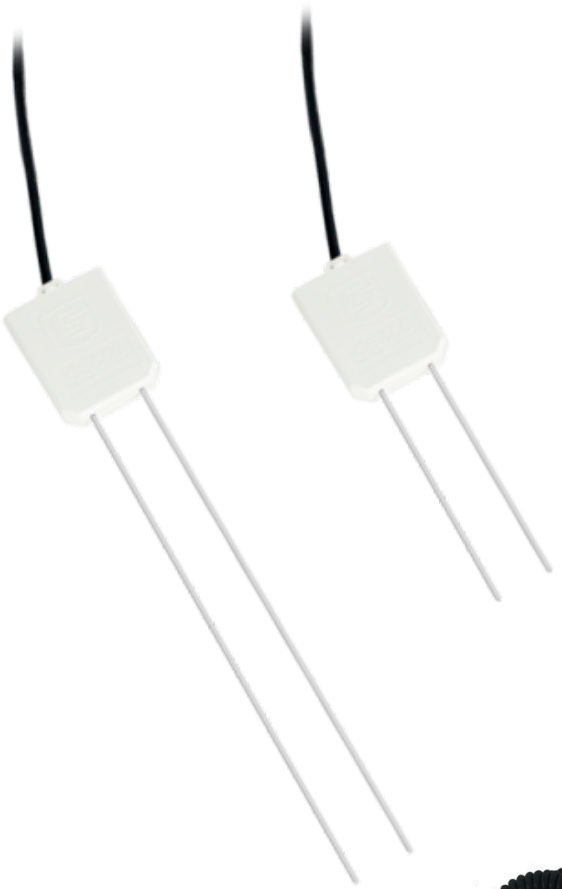
Capacitance Sensors

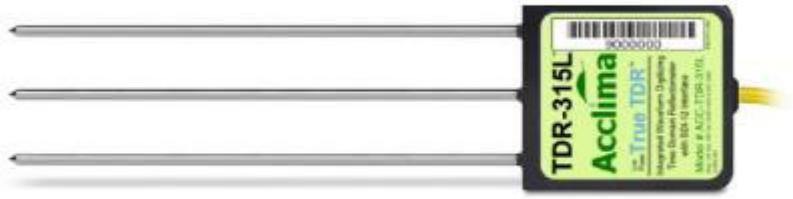


Capacitance Sensors

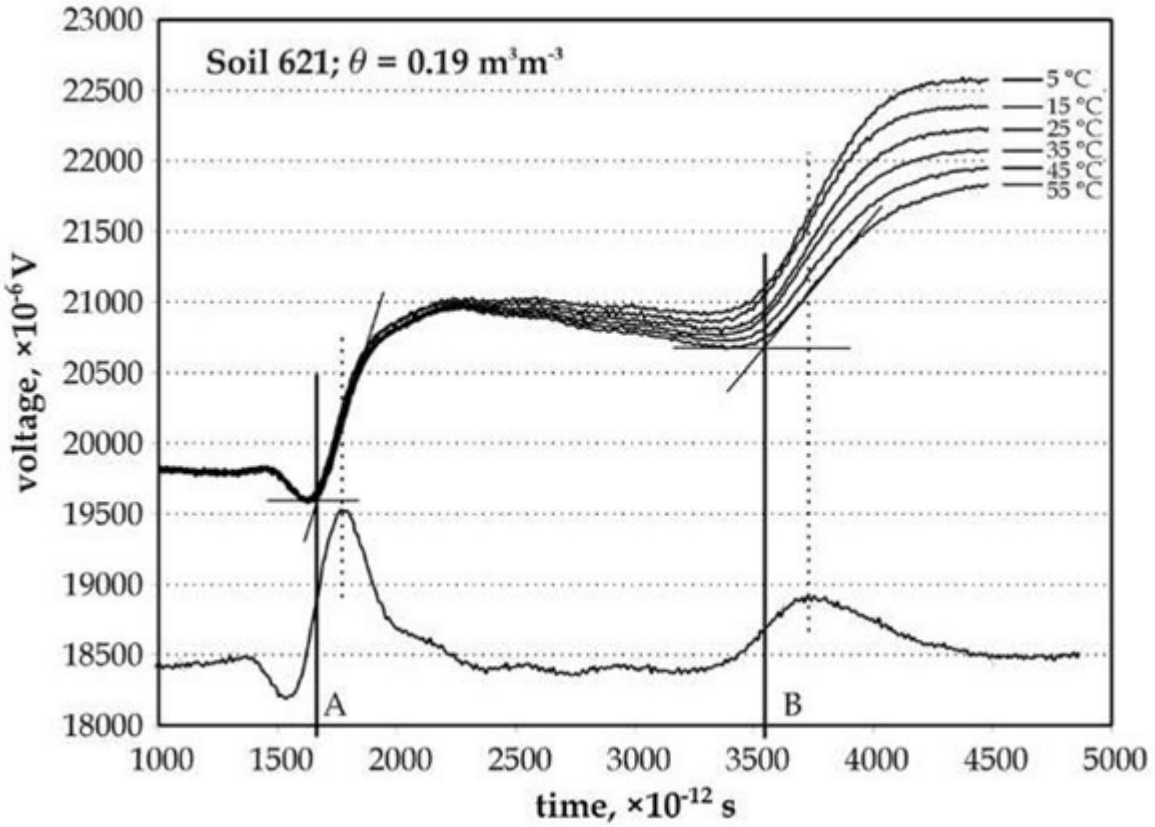
- Strengths
  - Gives soil water content
  - Easy to log data (real-time)
- Weaknesses
  - Small sample area
  - Highly dependant on very local soil structure
  - Inconsistent (high variability)
  - Can be expensive
  - Proper installation is critical, and not always easy
  - Affected by salinity and temperature

Time Domain Reflectometry (TDR)





Time Domain Reflectometry (TDR)



Measures bulk dielectric permittivity which is a function of soil moisture.

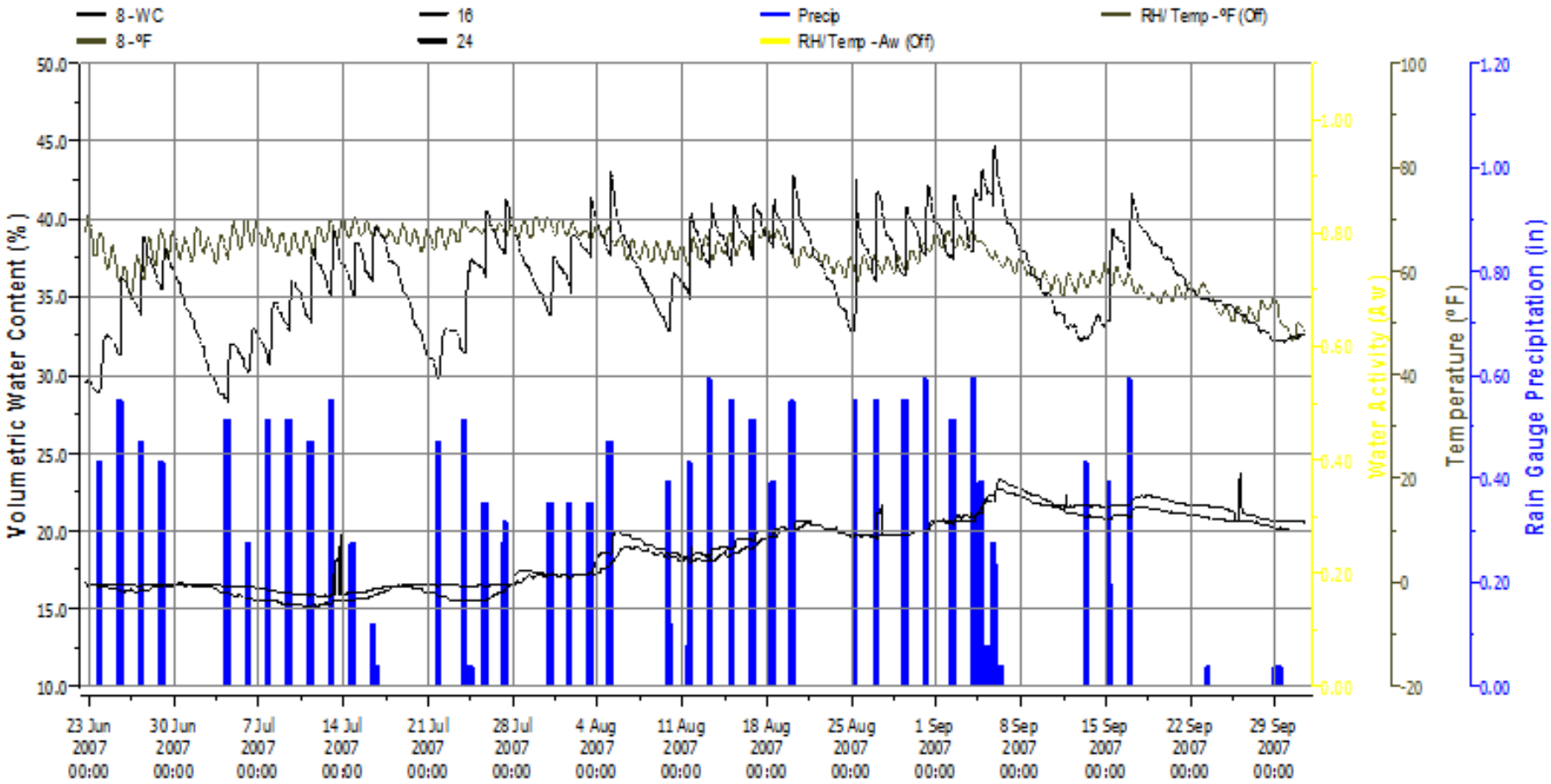
Practical use of soil content sensors (capacitance, neutron probe)

- Find field capacity (full) point: Measure as soon as soil thaws, or 24 hrs after heavy irrigation.
  - Less important whether it is right.
- Then use AWC by soil texture and start with 30-40% MAD for most vegetables. Refine this using feedback from plants and experience.

Analyze your data through graphical display

Graphical display

The John Deere Field Connect solution provides a robust graphing capability to allow producers to view and analyze soil moisture information. Graphs are available showing total moisture as well as individual moisture readings by sensor. Producers can choose different time ranges, filters, and viewing options to customize the graph for their needs.


8 - WC
8 - °F
16
24
Precip
RH/Temp - Aw (Off)
RH/Temp - °F (Off)
Volumetric Water Content (%)
Water Activity (Aw)
Temperature (°F)
Rain Gauge Precipitation (in)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
1.00
0.80
0.60
0.40
0.20
0.00
100
80
60
40
20
0
-20
1.20
1.00
0.80
0.60
0.40
0.20
0.00
23 Jun 2007 00:00
30 Jun 2007 00:00
7 Jul 2007 00:00
14 Jul 2007 00:00
21 Jul 2007 00:00
28 Jul 2007 00:00
4 Aug 2007 00:00
11 Aug 2007 00:00
18 Aug 2007 00:00
25 Aug 2007 00:00
1 Sep 2007 00:00
8 Sep 2007 00:00
15 Sep 2007 00:00
22 Sep 2007 00:00
29 Sep 2007 00:00

Soil Moisture Sensors
The "Look and Feel Method"

- Advantages
  - Cheap
  - Easy
- Weaknesses
  - Subjective - especially w/ dry soil.

Look and Feel

- May take time and experience to train yourself to do this correctly.
- Start with the NRCS pamphlet recommendations
- Refine your techniques for your particular soil by condition of soil at particular crop stress points, or correlated with a soil sensor.
- Go deep!
- Gets you out in the field, which is good!

Soil Moisture Sensors

- Neutron Probe will give the “most correct” answer.
- Most sensors will give a trend that is usable for irrigation scheduling.
- Proper installation of sensors is critical and must be done right for good data
- Actually using the sensor is most important!
- Keep records… calibrate yourself using numbers, crop response and experience
- Hire a consultant, watch them and ask lots of questions.

Weather-Based Methods

Evapotranspiration

Consumptive use

Transpiration is very closely correlated with yield

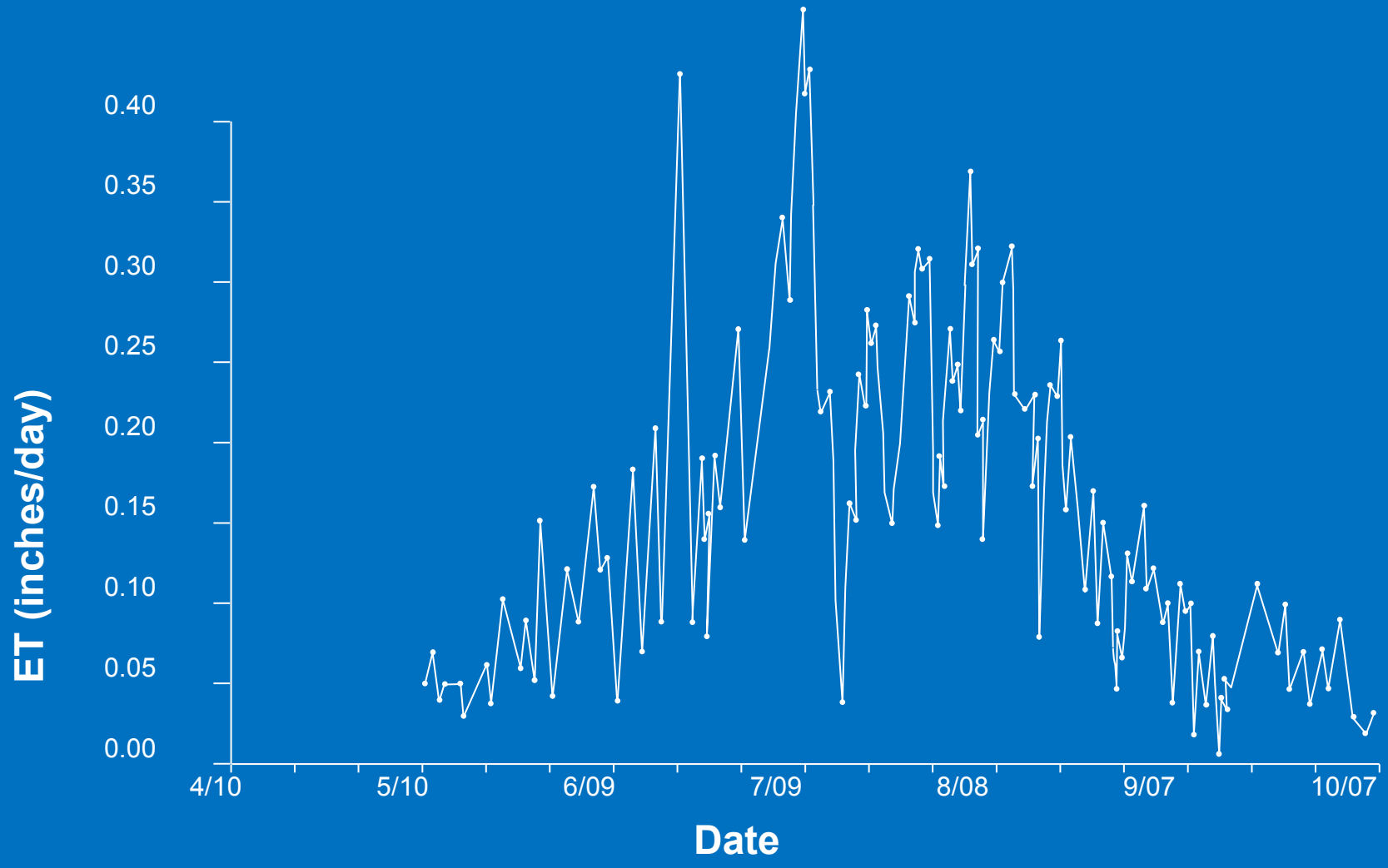
Calculated as:

$$ET = K_c \cdot ET_r$$

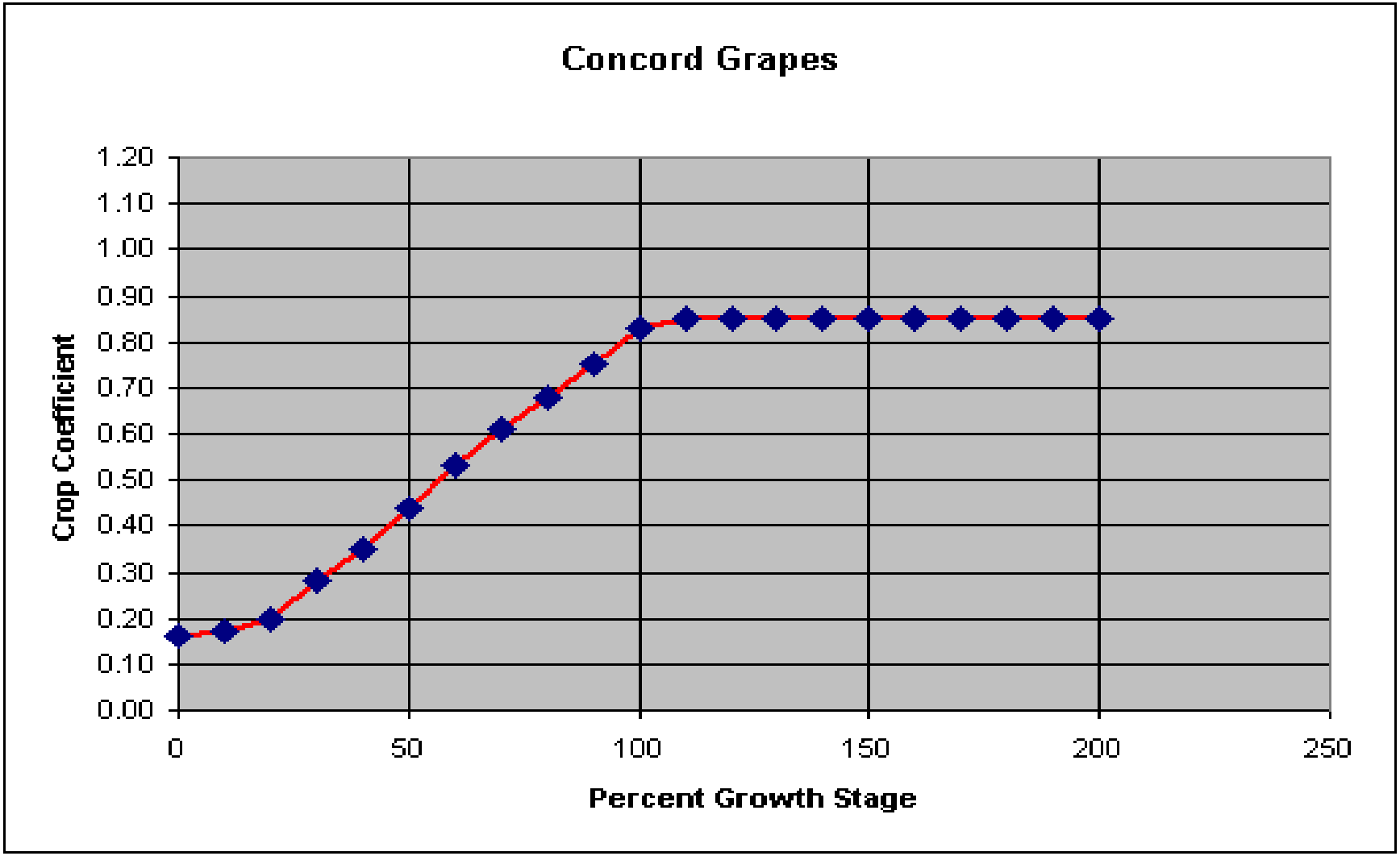
Where K_c is a crop coefficient (crop and growth stage) and ET_r is calculated from weather data

Available online from the Ag. Weather Net

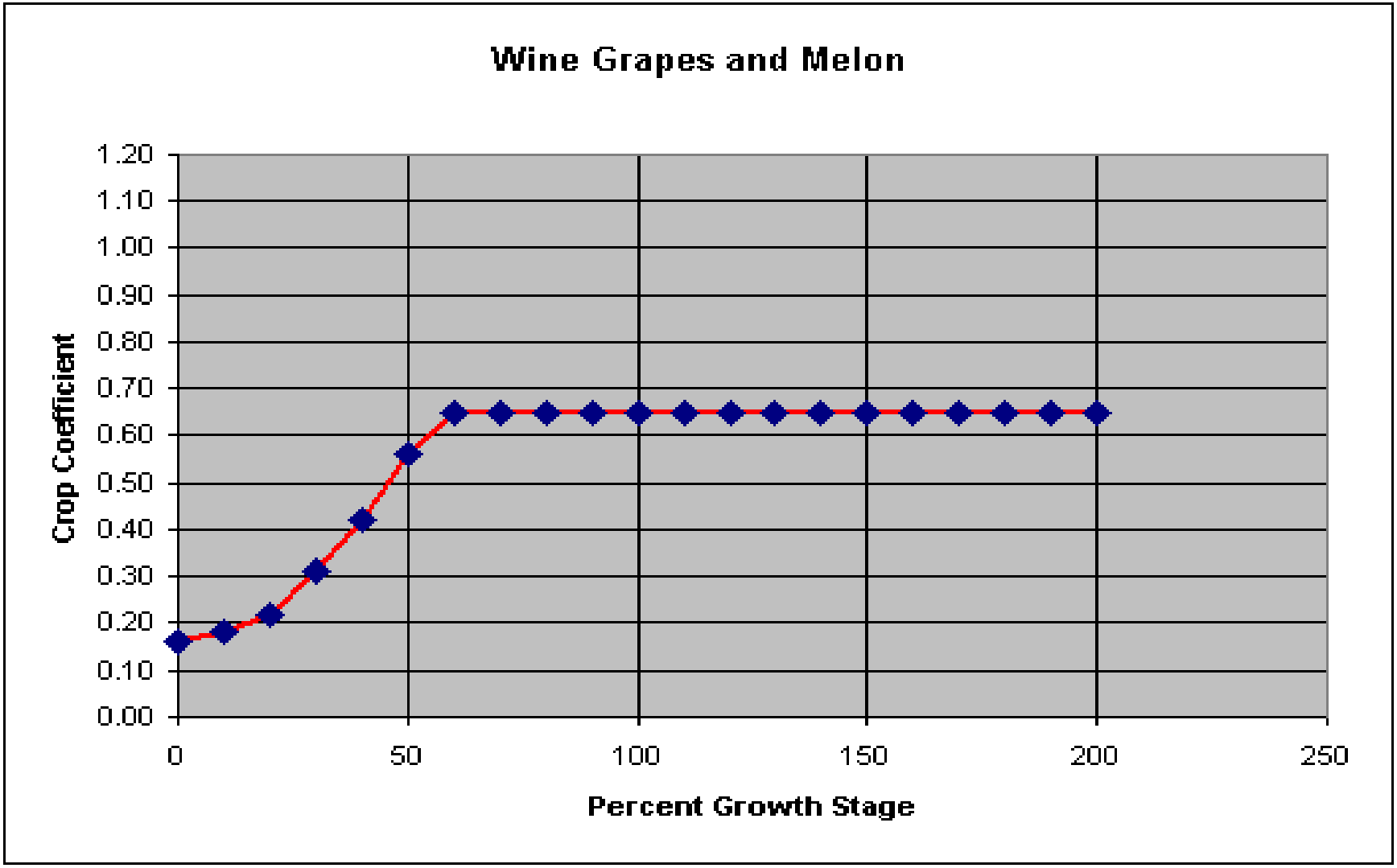
ET_r and Weather



Crop Coefficients

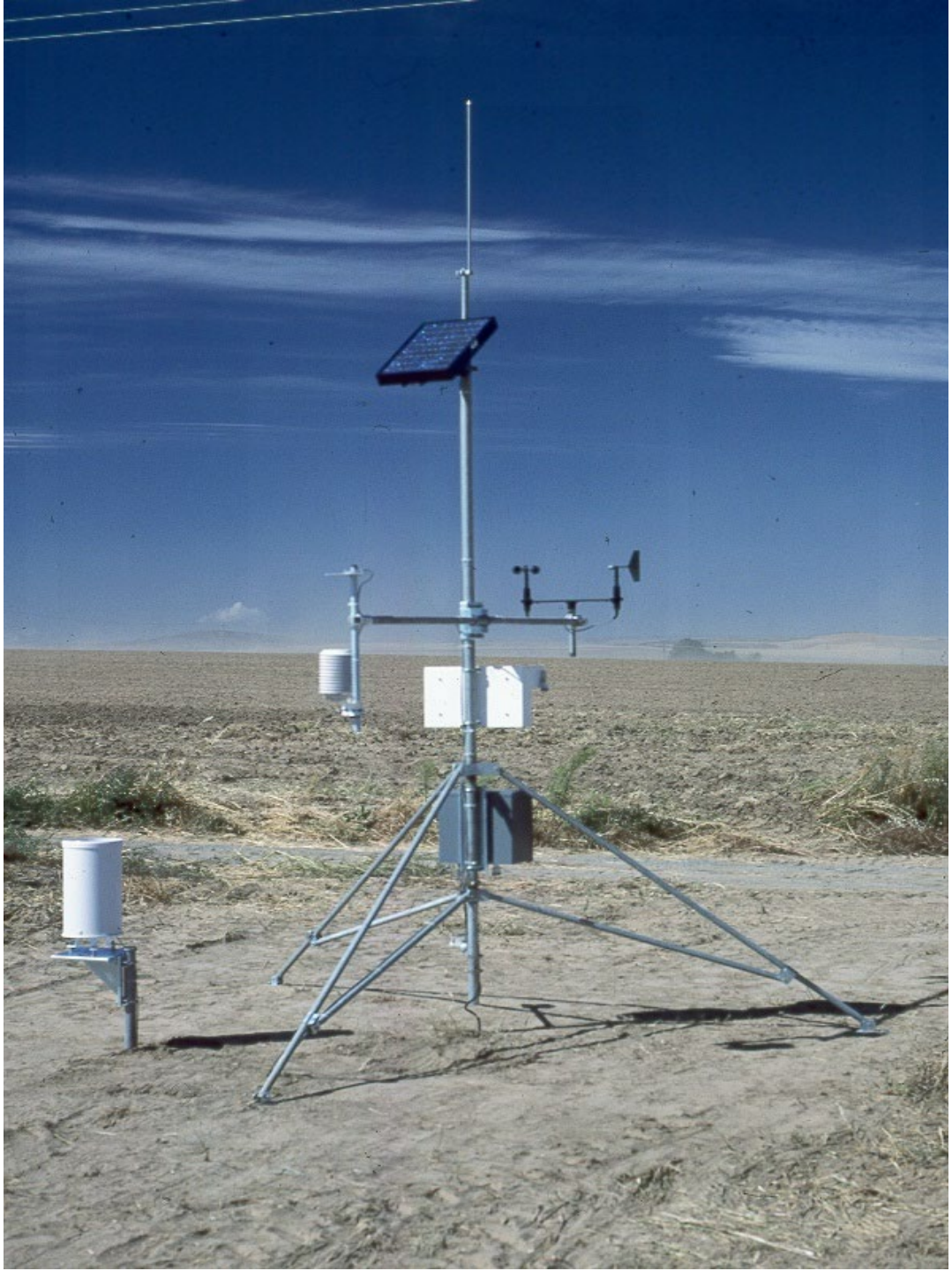


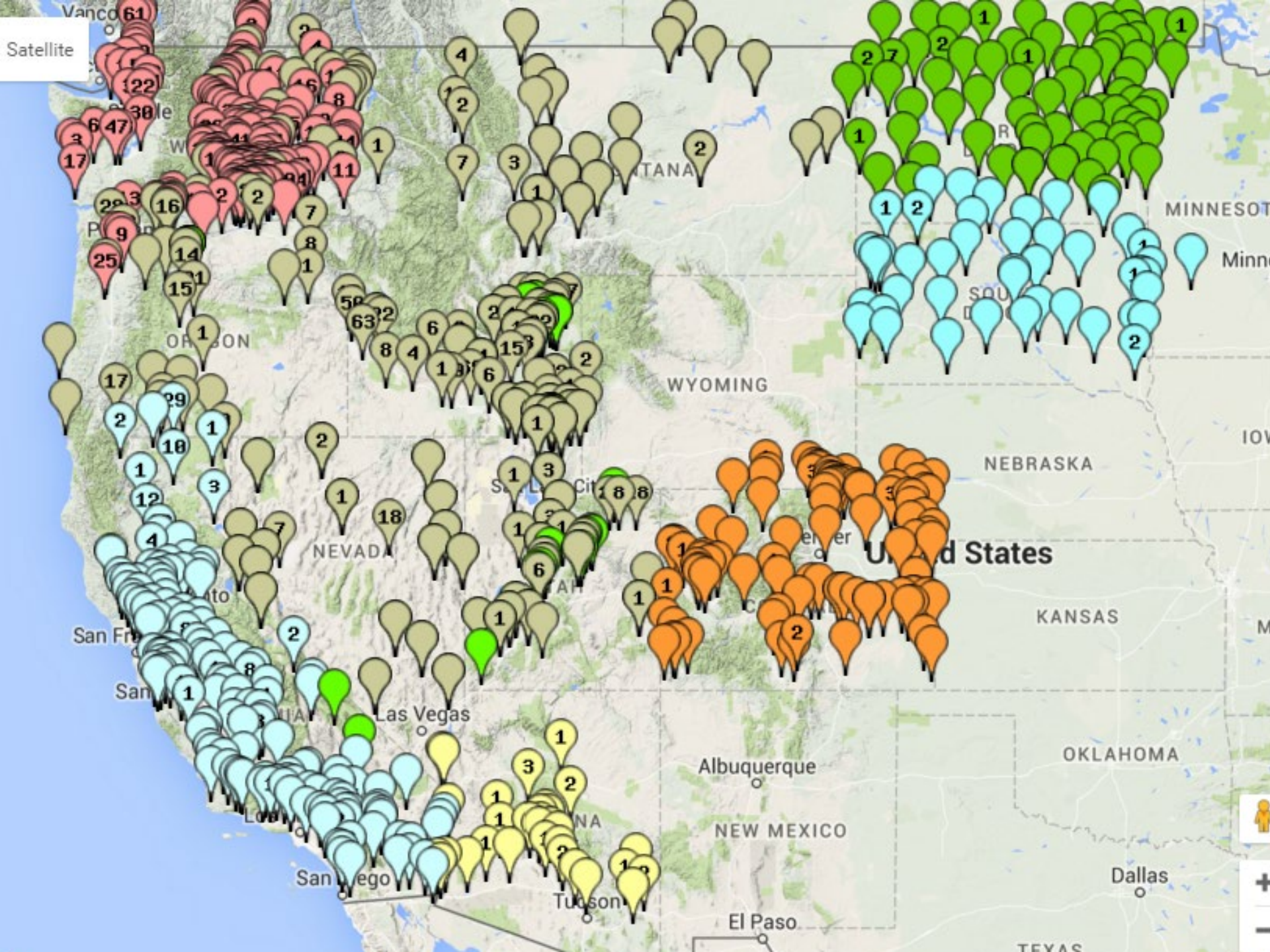
Crop Coefficients



Agricultural Weather Networks

- Why?
- What sensors?
- Which ones would you recommend?
- What problems do you foresee?
- How to take care of these?
- How will you get the data onto the web?
- How will you check that the data is good?
- Where should we put the stations?



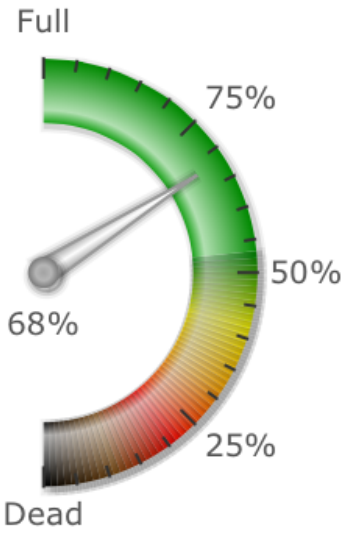

Satellite
WYOMING
NEBRASKA
NEVADA
KANSAS
OKLAHOMA
NEW MEXICO
Albuquerque
Las Vegas
El Paso
Dallas
Tucson
San Diego
MINNESOTA
United States

irrigation scheduler mobile

Soil Water Dashboard

Field:

N Pod Pasture, 2014; Grass (Pasture)



This Morning's Soil Water Deficit:	0.9 in. or 5.4 hrs
Today's Irrigation:	0.00 hrs

I Irrigated Today: ☐ hrs

Save

Green is good. Crops increasingly stressed below green.

Dashboard

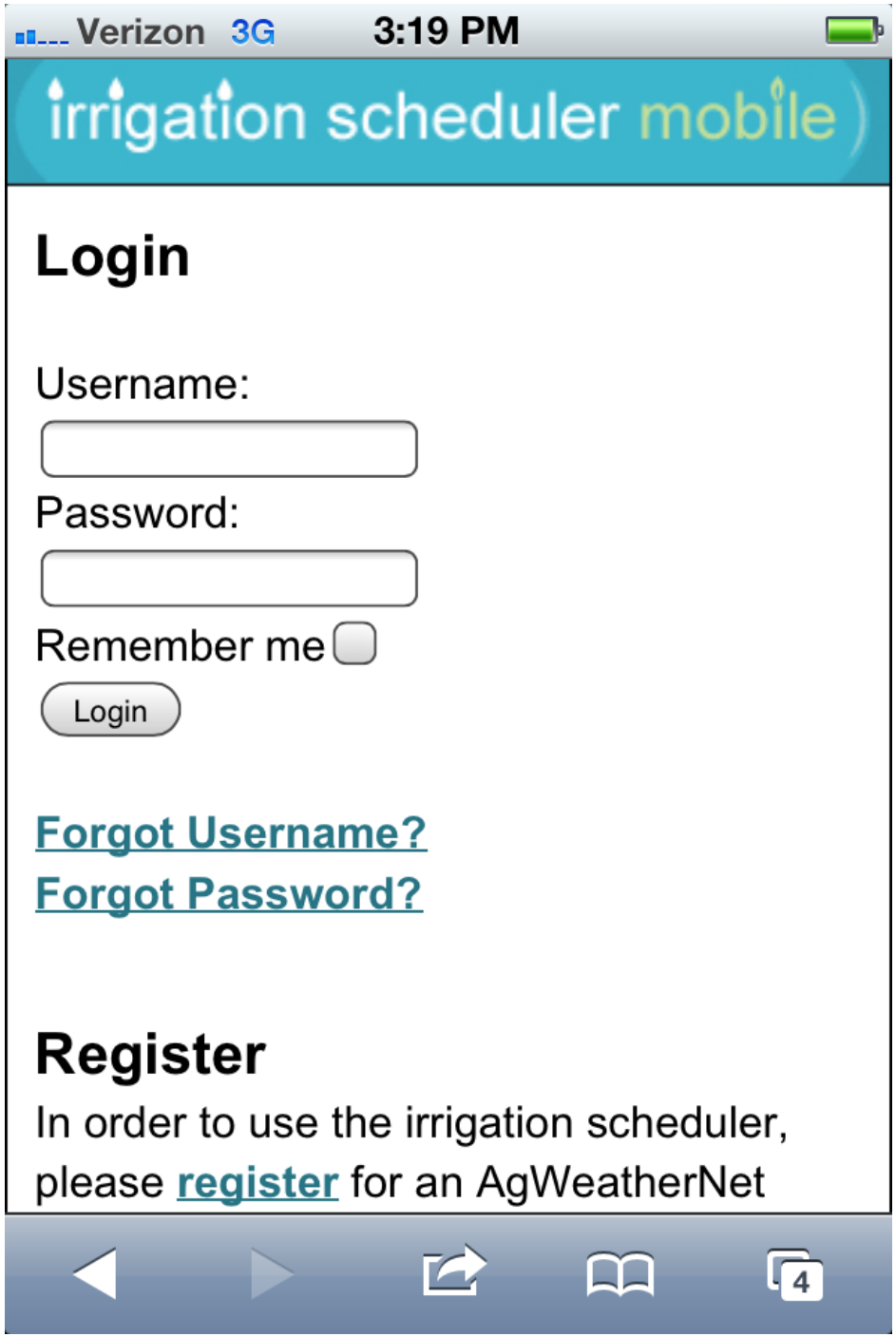
Daily Budget Table

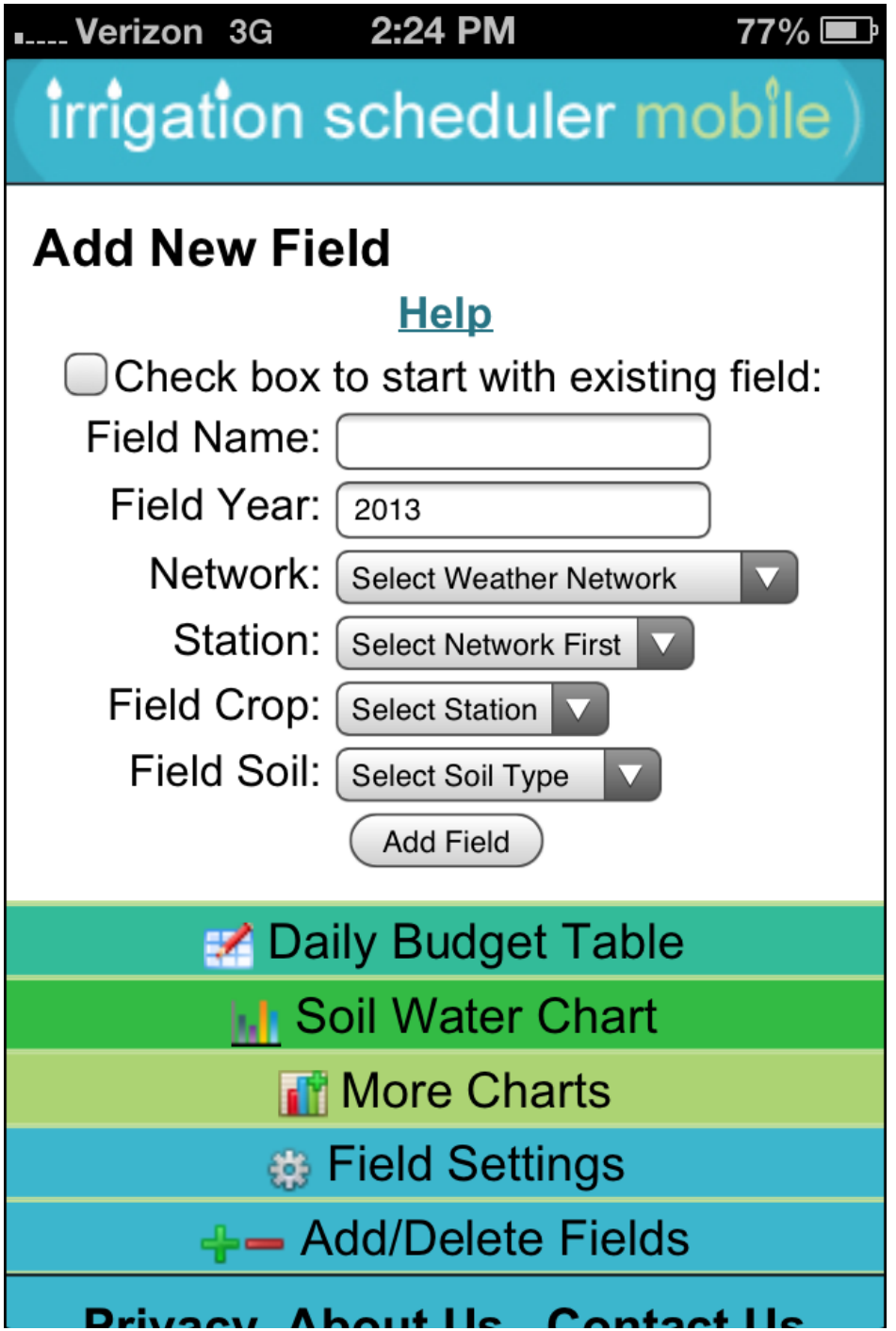
Soil Water Chart

More Charts

irrigation scheduler mobile

- Simple soil water balance based on ET.
- Designed for use on a smart phone, but usable on any desktop web browser.
- Quick & easy to set up.
- Automatically pulls ET data from selected weather stations.


Verizon 3G 3:19 PM
irrigation scheduler mobile
Login
Username:
Password:
Remember me
Login
Forgot Username?
Forgot Password?
Register
In order to use the irrigation scheduler, please register for an AgWeatherNet


Verizon 3G 2:24 PM 77%
irrigation scheduler mobile
Add New Field
Help
Check box to start with existing field:
Field Name:
Field Year: 2013
Network: Select Weather Network
Station: Select Network First
Field Crop: Select Station
Field Soil: Select Soil Type
Add Field
Daily Budget Table
Soil Water Chart
More Charts
Field Settings
Add/Delete Fields

Verizon 3G 11:13 AM 100%

irrigation scheduler mobile

7-Day Daily Budget Table

Field: Potatoes, 2011; Potatoes

Help

Date	Water Use (in)	Rain& Irrig. (in)	Available Water (%)	Water Deficit (in)	Edit Data
07/12	0.22	0	80.9	0.88	Edit
07/13	0.25	0	75.5	1.13	Edit
07/14	0.22	0	70.7	1.35	Edit
07/15	0.24	0	65.4	1.59	Edit
07/16	0.23	0	60.4	1.82	Edit
07/17	0.22	1	77.5	1.04	Edit
07/18	0.2	0	73.1	1.24	Edit

|<< <<< Jul 12, 2011 >>> >>|

Verizon 3G 4:30 PM 88%

irrigation scheduler mobile

Field: Potatoes, 2011; Potatoes

Help