Irrigation Scheduling in Orchards

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Irrigation Scheduling

- When to apply irrigation water
- How Much to apply

When and How Much?

- Different crops
- Different orchard development stage
- Different stage of growth
- Presence of an orchard vegetative cover

- Climate

- Irrigation system

Orchard water use

- Determined by:
  - Climate
  - Stage of Growth (Canopy size)
  - Presence of ground cover

Climate

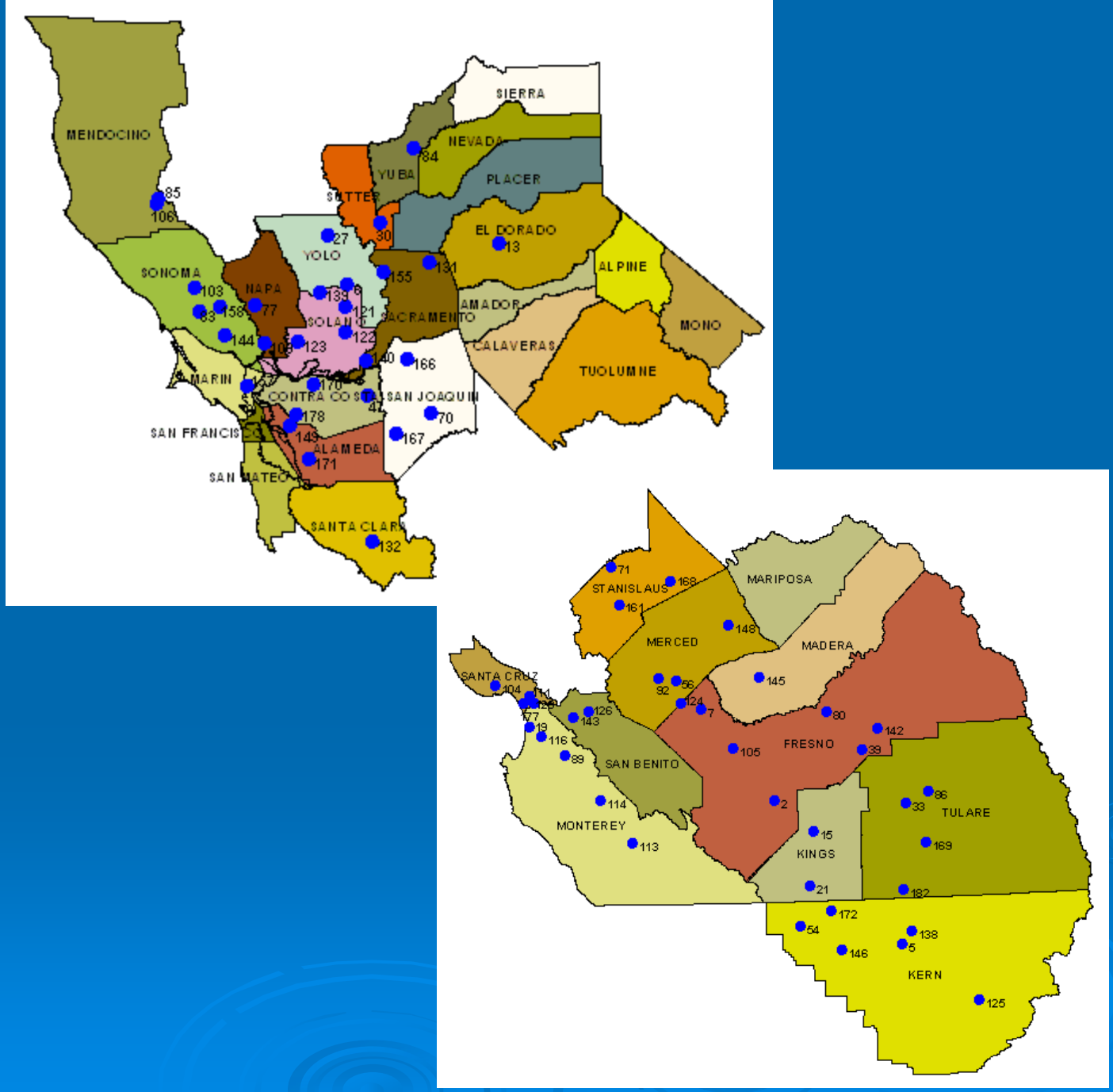
- Evapotranspiration
  - ETo

CIMIS

CALIFORNIA IRRIGATION MANAGEMENT INFORMATION SYSTEM
DEPARTMENT OF WATER RESOURCES
OFFICE OF WATER USE EFFICIENCY

www.cimis.water.ca.gov

www.ipm.ucdavis.edu/


MENDOCINO
SIERRA
NEVADA
YUBA
PLACER
SUTTER
EL DORADO
YOLO
ALPINE
SONOMA
NAPA
AMADOR
SACRAMENTO
MONO
CALAVERAS
TUOLUMNE
MARIN
CONTRA COSTA
SAN JOAQUIN
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
STANISLAUS
MARIPOSA
MERCED
MADERA
SANTA CRUZ
FRESNO
SAN BENITO
TULARE
MONTEREY
KINGS
KERN

Stn Id	Station	Date	Precip (in)	CIMIS ETo (in)	PPT	Eto	
70	Manteca	7/1/2009	0	0.26			
70	Manteca	7/2/2009	0	0.26			
70	Manteca	7/3/2009	0	0.26			
70	Manteca	7/4/2009	0	0.25			
70	Manteca	7/5/2009	0	0.25			
70	Manteca	7/6/2009	0	0.27			
70	Manteca	7/7/2009	0	0.27			
70	Manteca	7/8/2009	0.08	0.27			
70	Manteca	7/9/2009	0	0.27			
70	Manteca	7/10/2009	0	0.26			
70	Manteca	7/11/2009	0	0.2			
70	Manteca	7/12/2009	0	0.21			
70	Manteca	7/13/2009	0	0.27			
70	Manteca	7/14/2009	0	0.29			
70	Manteca	7/15/2009	0	0.27	0.08	3.9	1-15
70	Manteca	7/16/2009	0	0.27			
70	Manteca	7/17/2009	0	0.28			
70	Manteca	7/18/2009	0	0.27			
70	Manteca	7/19/2009	0	0.28			
70	Manteca	7/20/2009	0	0.29			
70	Manteca	7/21/2009	0	0.26			
70	Manteca	7/22/2009	0	0.26			
70	Manteca	7/23/2009	0	0.25			
70	Manteca	7/24/2009	0	0.24			
70	Manteca	7/25/2009	0	0.24			
70	Manteca	7/26/2009	0	0.25			
70	Manteca	7/27/2009	0	0.26			
70	Manteca	7/28/2009	0	0.25			
70	Manteca	7/29/2009	0	0.23			
70	Manteca	7/30/2009	0	0.23			
70	Manteca	7/31/2009	0	0.24	0	4.1	16-31

ETo = Kc x ETo

Where:

- ETc = crop evapotranspiration
- Kc = crop coefficient
- ETo = evapotranspiration of the reference crop (station Information)

Canopy

- Coverage
- Mature -- more than 62% Shading
  - Use established crop coefficients
- Less than 62% Shading
  - Use a 2:1 ratio
    - 20% shade = 40% use of mature orchard


Cover increases water use by 25-30%

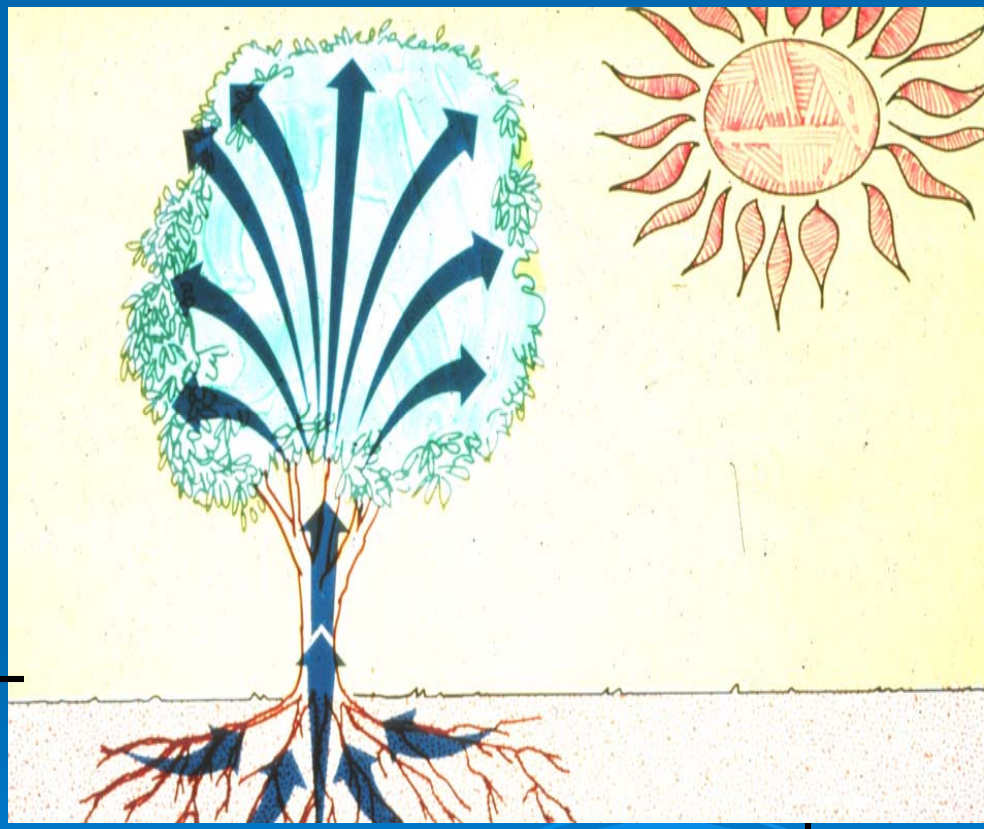
Kc	Peach	Almond	Walnut	Pistachio
period				
Mar 16-31	0.35	0.54	0.12	
Apr 1-15	0.42	0.6	0.53	0.07
Apr 16-30	0.56	0.66	0.68	0.43
May 1-15	0.62	0.73	0.79	0.68
May 16-31	0.76	0.79	0.86	0.93
June 1-15	0.82	0.84	0.93	1.09
June 16-30	0.96	0.87	1	1.17
July 1-15	1.01	0.92	1.14	1.19
July 16-31	1.06	0.97	1.14	1.19
Aug 1-15	1.1	1.06	1.14	1.19
Aug 16-31	1.15	1	1.14	1.12
Sept 1-15	1.15	0.94	1.08	0.99
Sept 16-30	1.12	0.91	0.97	0.87
Oct 1-15	1.1	0.85	0.88	0.67
Oct 16-31	1.01	0.79	0.51	0.50
Nov 1-15	0.82	0.7	0.28	0.35

Irrigation scheduling using ETo values based on a 20-year average
Manteca, CIMIS Station 70
Leaf out: 3/15 Leaf drop: 11/15
Walnut No cover crop

Date	Evapotranspiration Reference ET_o	Crop Coefficient k_c	Water Use (inches) ET_c	Cumulative Inches ET_c
Mar 16-31	2.3	0.12	0.28	0.3
Apr 1-15	2.5	0.53	1.34	1.6
Apr 16-30	2.9	0.68	1.96	3.6
May 1-15	3.3	0.79	2.59	6.2
May 16-31	3.6	0.86	3.14	9.3
Jun 1-15	3.8	0.93	3.53	12.8
Jun 16-30	4.0	1.00	3.98	16.8
Jul 1-15	4.1	1.14	4.66	21.5
Jul 16-31	3.9	1.14	4.49	26.0
Aug 1-15	3.7	1.14	4.16	30.1
Aug 16-31	3.5	1.14	3.98	34.1
Sep 1-15	2.9	1.08	3.12	37.2
Sep 16-30	2.4	0.97	2.30	39.5
Oct 1-15	2.0	0.88	1.73	41.3
Oct 16-31	1.6	0.51	0.79	42.1
Nov 1-15	1.1	0.28	0.30	42.4

Water Use / Losses

- Evapotranspiration
  - Transpiration
  - Evaporation
- Runoff
- Non Uniformity

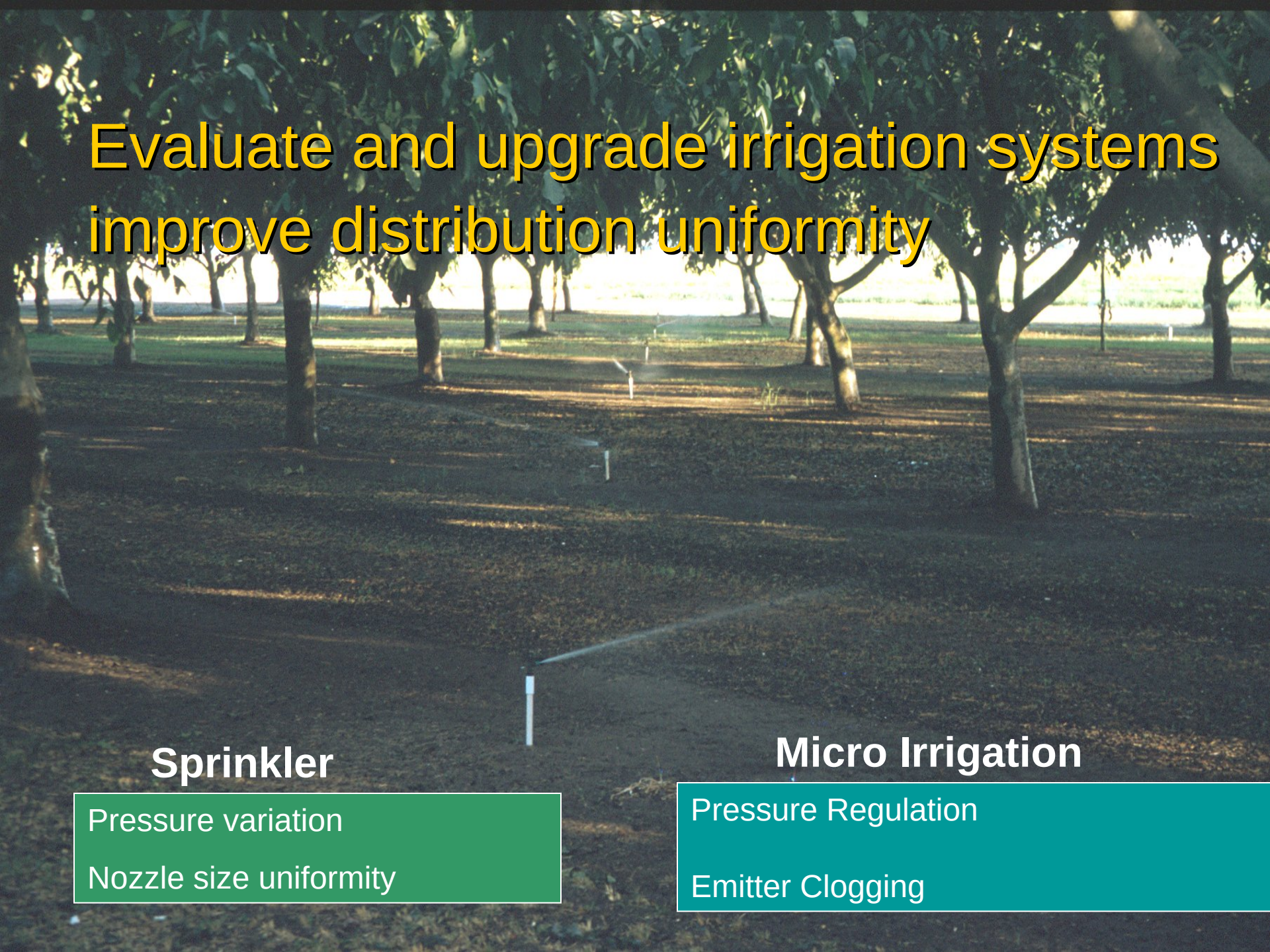


Deep percolation


Irrigation Management
Sprinkler

Pressurized systems

- Engineered Distribution Uniformity
  - Not perfect
    - Sprinkler
    - Micro irrigation


Evaluate and upgrade irrigation systems improve distribution uniformity
Sprinkler
Pressure variation
Nozzle size uniformity
Micro Irrigation
Pressure Regulation
Emitter Clogging

Irrigation

1. Determine Net Irrigation Requirement

2. Determine Application Rate
   - Determine Average application rate
   - Uniformity of applied water

3. Measure Applied Water

Evaluate (Measure) Irrigation System

- Average Application rate
- Distribution uniformity

Quantifying Irrigation System Performance

- Distribution Uniformity (DU 1/4)
  - An indication of how evenly the water is distributed across the system

- DU =

$$\frac{\text{Average of the } \textit{low quarter} \text{ of volume measurements}}{\text{Average of all volume measurements}} \times 100$$

- 85-95% well designed and maintained system

ETo x Kc = ET / DU = Gross Irrigation

	Sta 21	no cover	Biweekly	Biweekly
Period	Kettelman	Kc	Net irr	Gross
Date	ETo		(in.)	
1/1-1/15	0.7		0.00	0.00
1/16-1/31	0.99		0.00	0.00
2/1-2/15	1.09		0.00	0.00
2/16-2/28	0.9		0.00	0.00
3/1-3/15	1.48		0.00	0.00
3/16-3/31	2.8	0.25	0.70	0.82
4/1-4/15	2.26	0.54	1.22	1.44
4/16-4/30	3.28	0.6	1.97	2.32
5/1-5/15	4.42	0.66	2.92	3.43
5/16/5/31	5.08	0.73	3.71	4.36
6/1-6/15	4.85	0.79	3.83	4.51
6/16-6/30	4.75	0.84	3.99	4.69
7/1-7/15	4.15	0.87	3.61	4.25
7/16-7/31	4.64	0.92	4.27	5.02
8/1-8/15	4.39	0.97	4.26	5.01
8/16-8/31	4.29	1.06	4.55	5.35
9/1-9/15	3.49	1	3.49	4.11
9/16-9/30	3.15	0.94	2.96	3.48
10/1-10/15	2.65	0.91	2.41	2.84
10/16-10/31	1.85	0.85	1.57	1.85
11/1-11/15	1.24	0.79	0.98	1.15
11/16-11/30	0.63	0.7	0.44	0.52
12/1-12/15	0.74	0	0.00	0.00
12/16-12/31	0.498		0.00	0.00
			47	55

Distribution Uniformity
85%

DU Low Quarter

100
87.5
75
62.5
50
37.5
25
12.5
0

Applying the Correct Amount

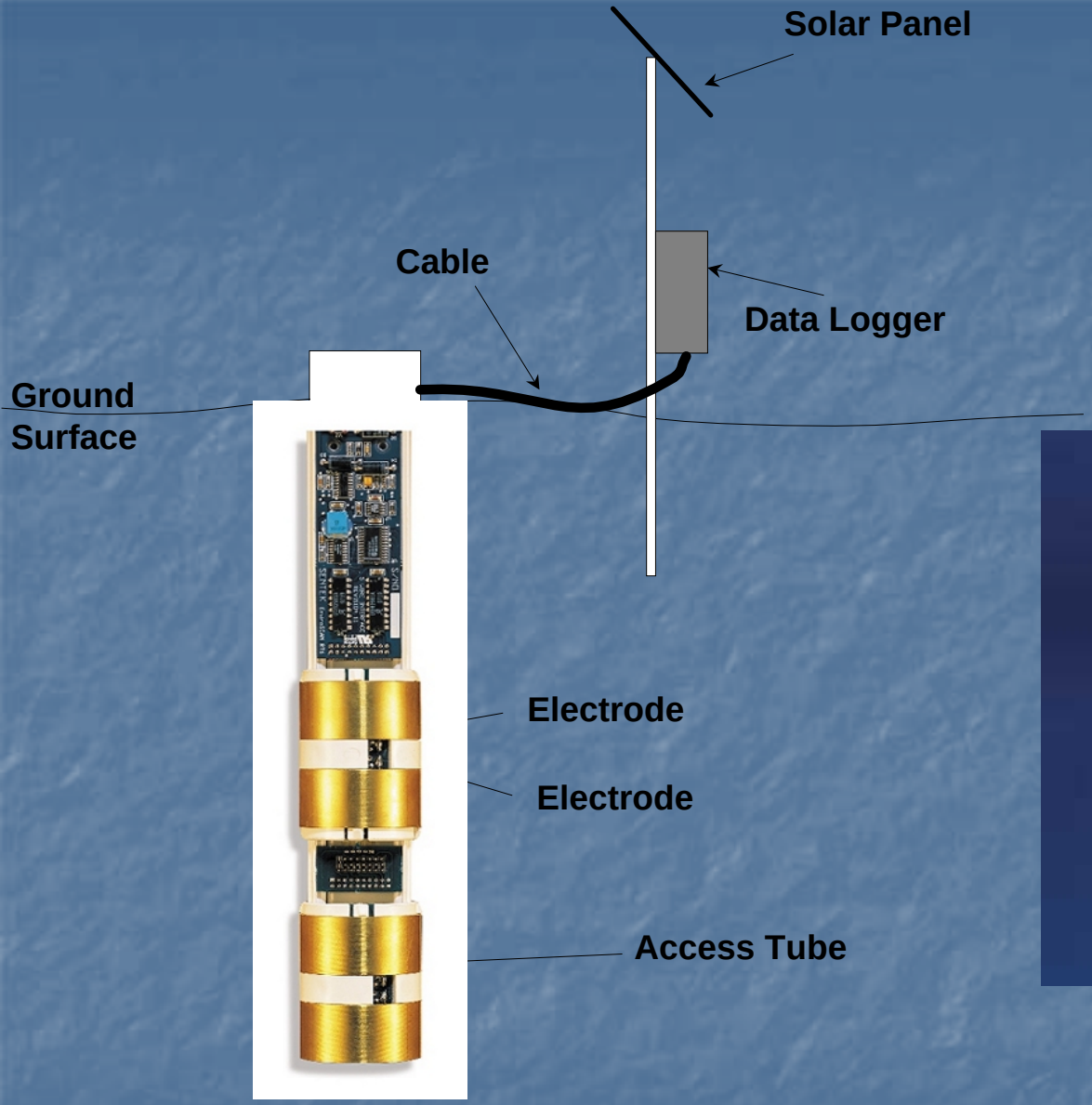
- Water meter

Measuring Micro Irrigation Discharge Rate

Soil Based Irrigation Scheduling

- Devices that measure moisture
  - Status
  - Content

WaterMark Sensor

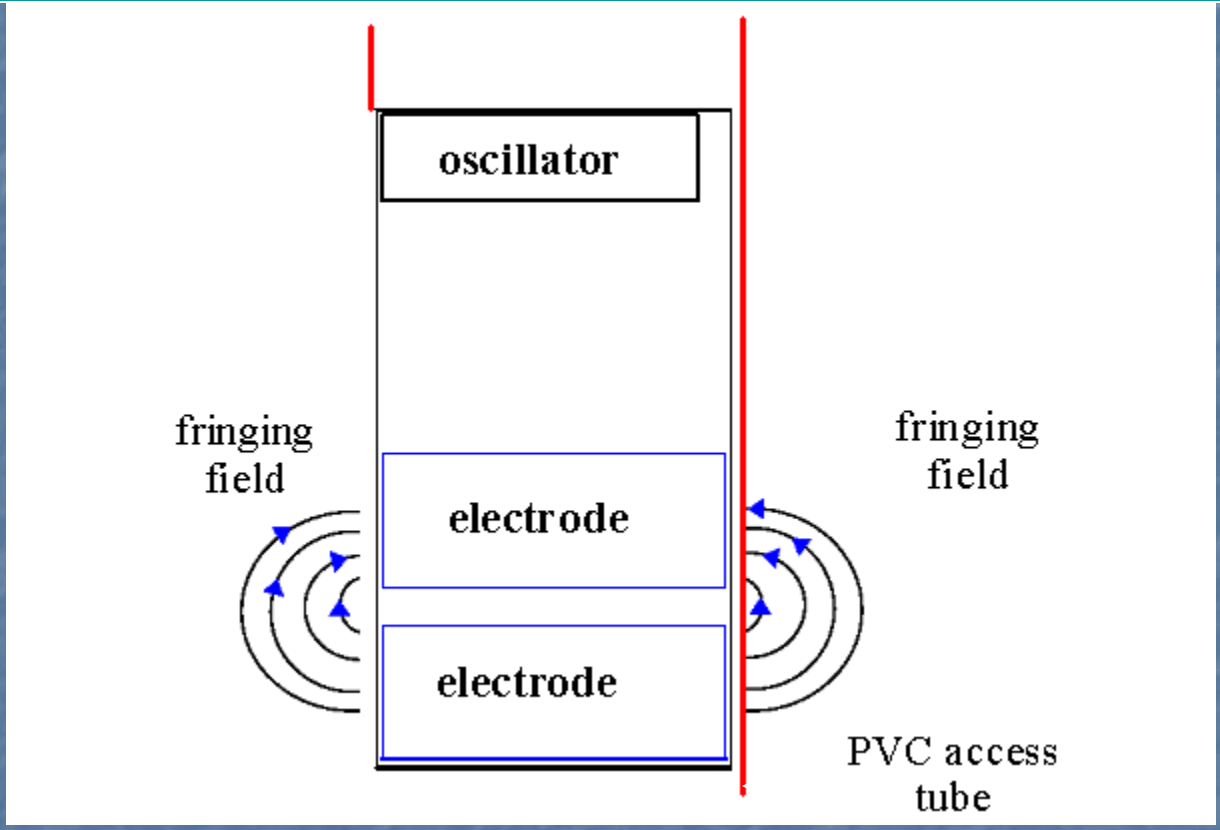


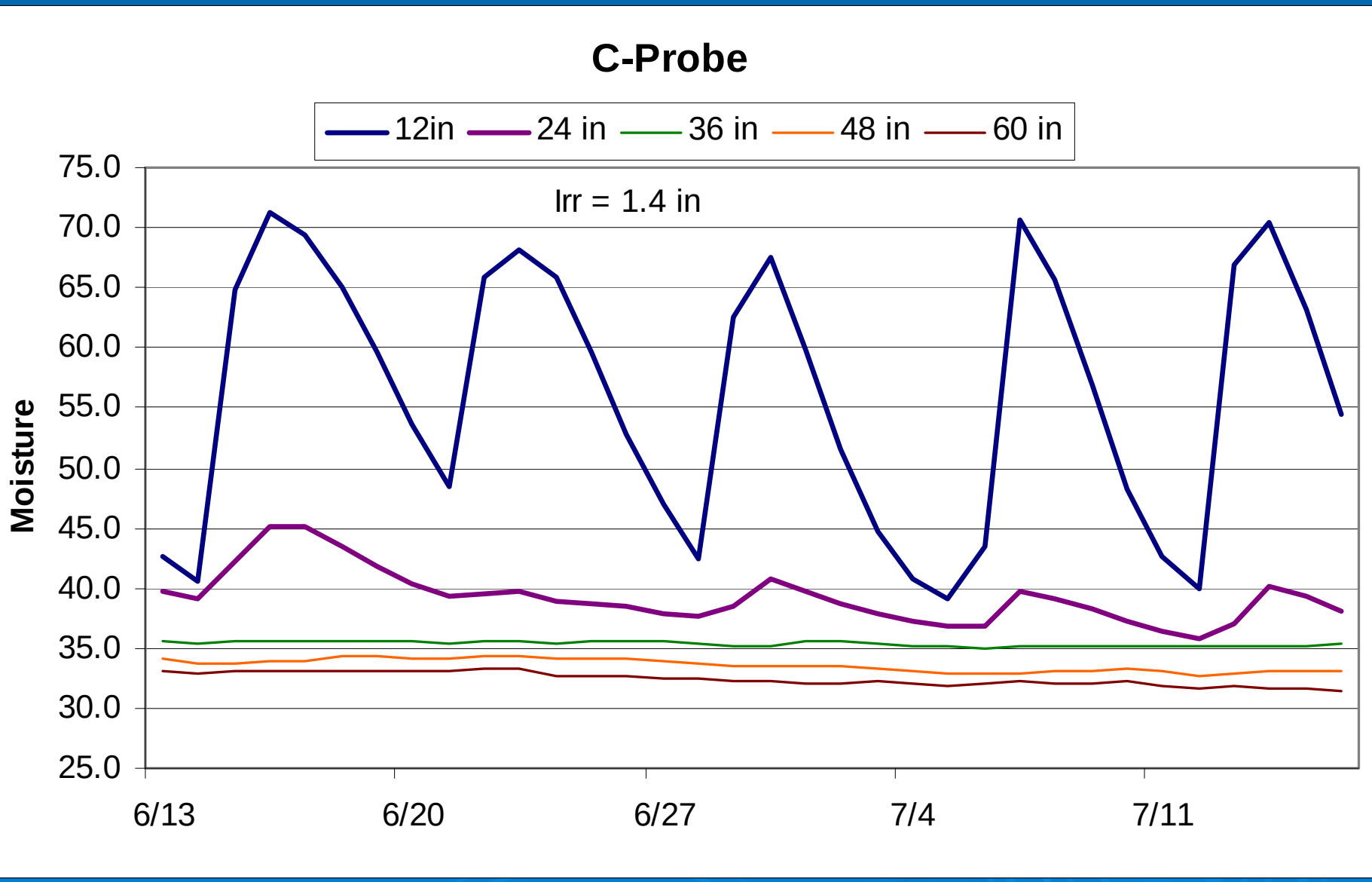
Permanent/logging
Multi depth

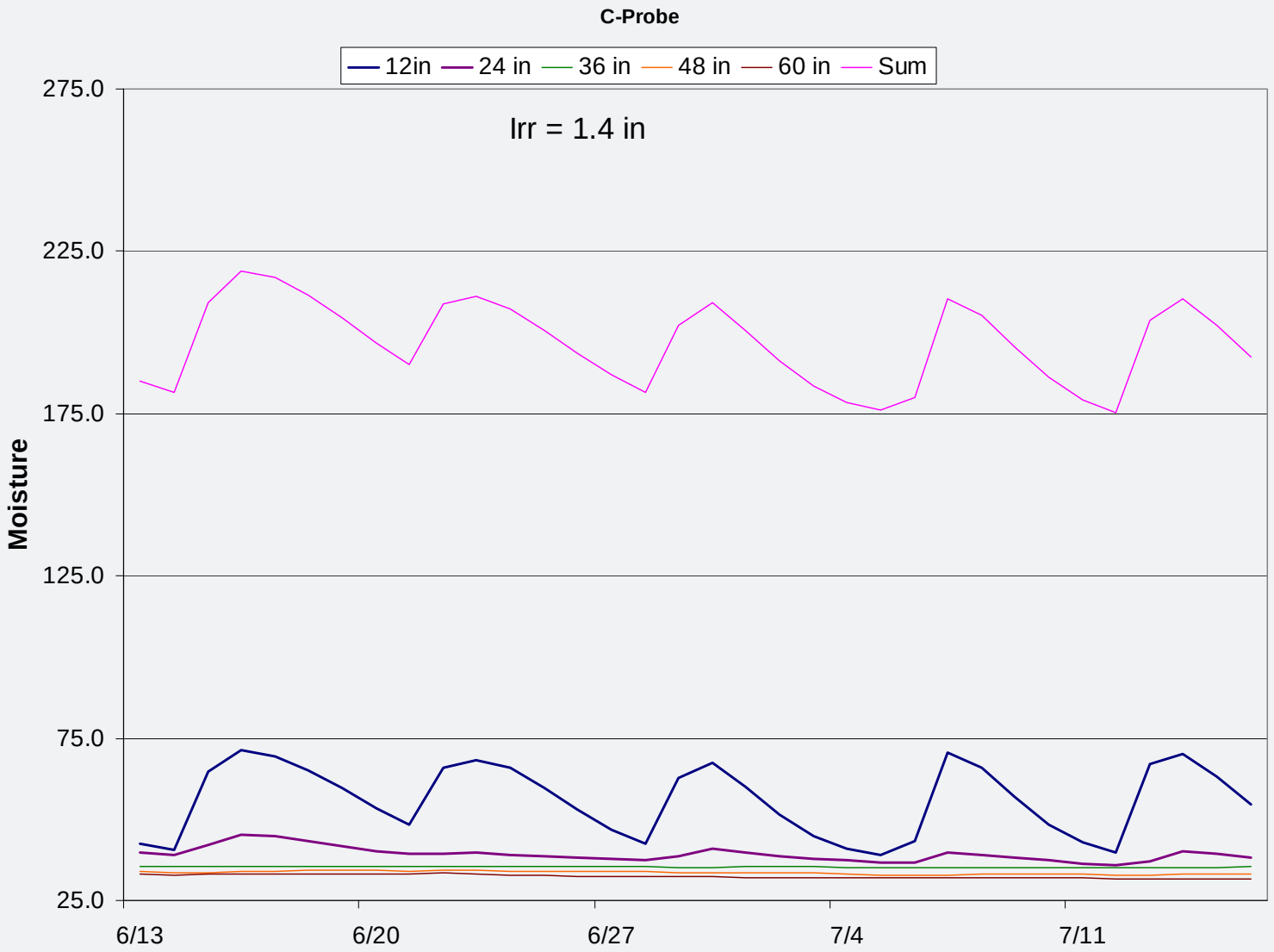
Portable

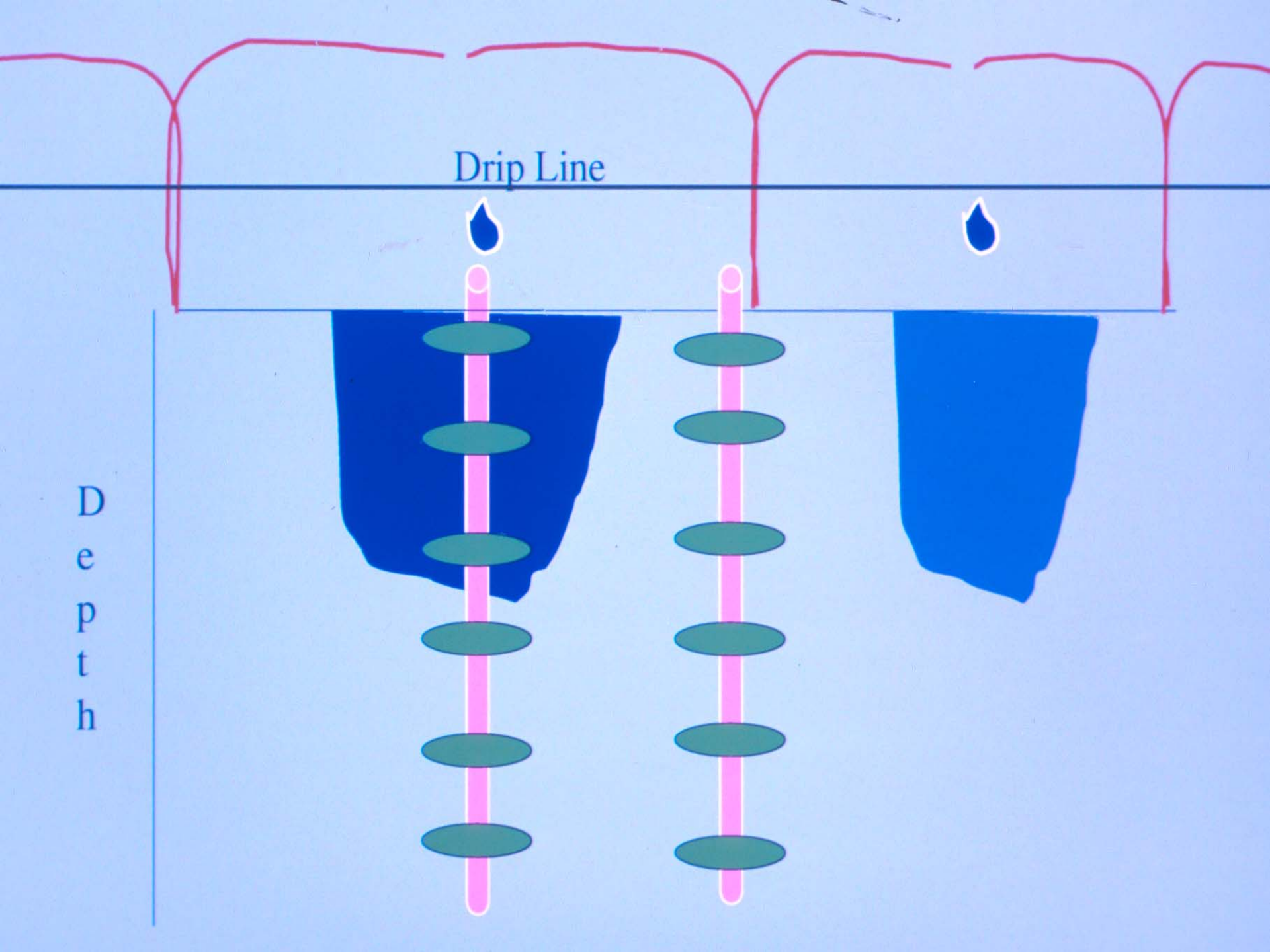
Single point measure

Capacitance Probe




C-Probe
12in
24 in
36 in
48 in
60 in
Irr = 1.4 in
Moisture
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
6/13
6/20
6/27
7/4
7/11


C-Probe
12in
24 in
36 in
48 in
60 in
Sum
Irr = 1.4 in
Moisture
275.0
225.0
175.0
125.0
75.0
25.0
6/13
6/20
6/27
7/4
7/11

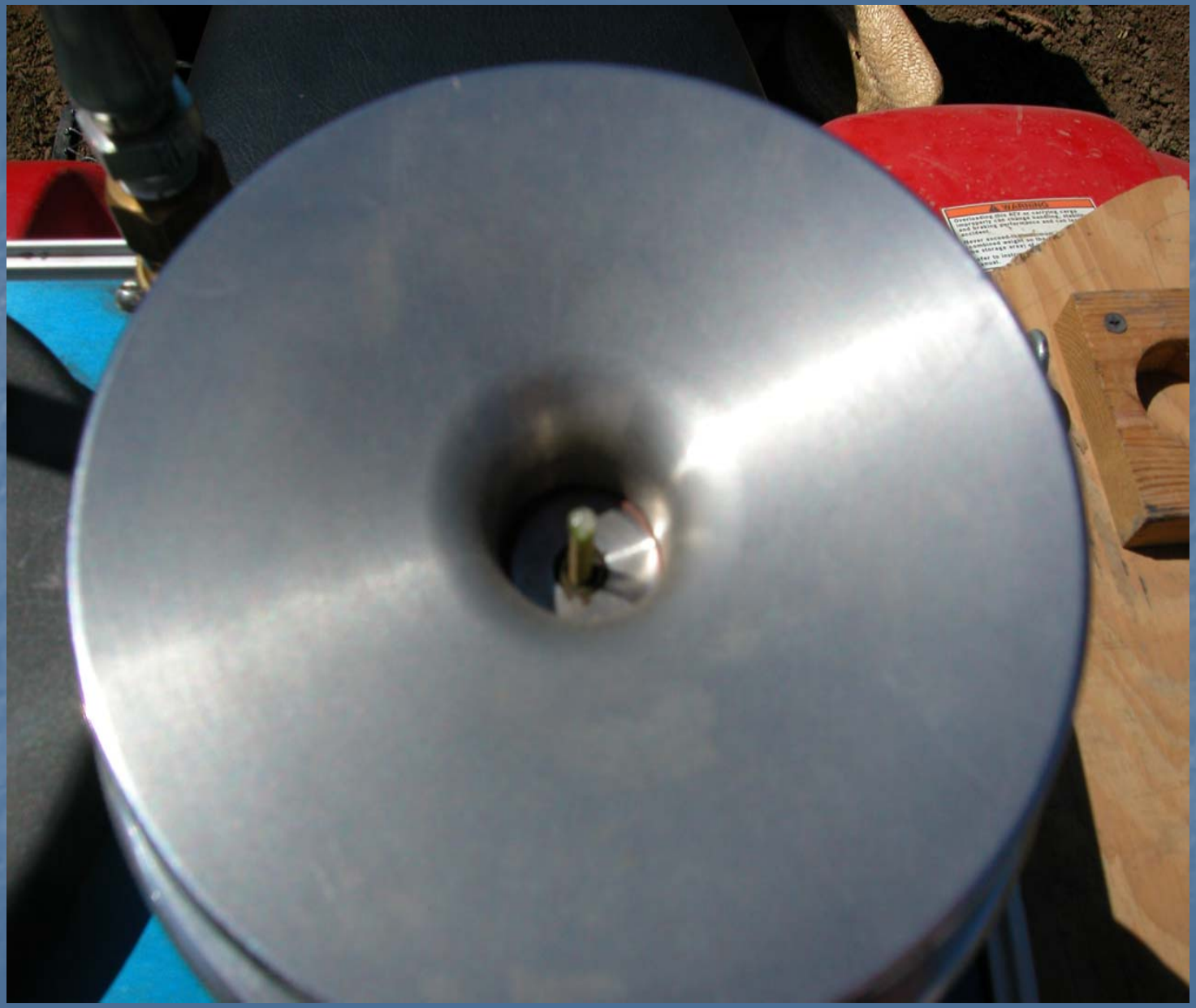

Drip Line
D
e
p
t
h

Plant Based Irrigation Scheduling

- Stem Water Potential

Plant Based Tree Water Status

- Use midday stem water potential
- to assure that you are not over or under-irrigating




pms
150
200
100
250
50
300
psi
BAR
BAR

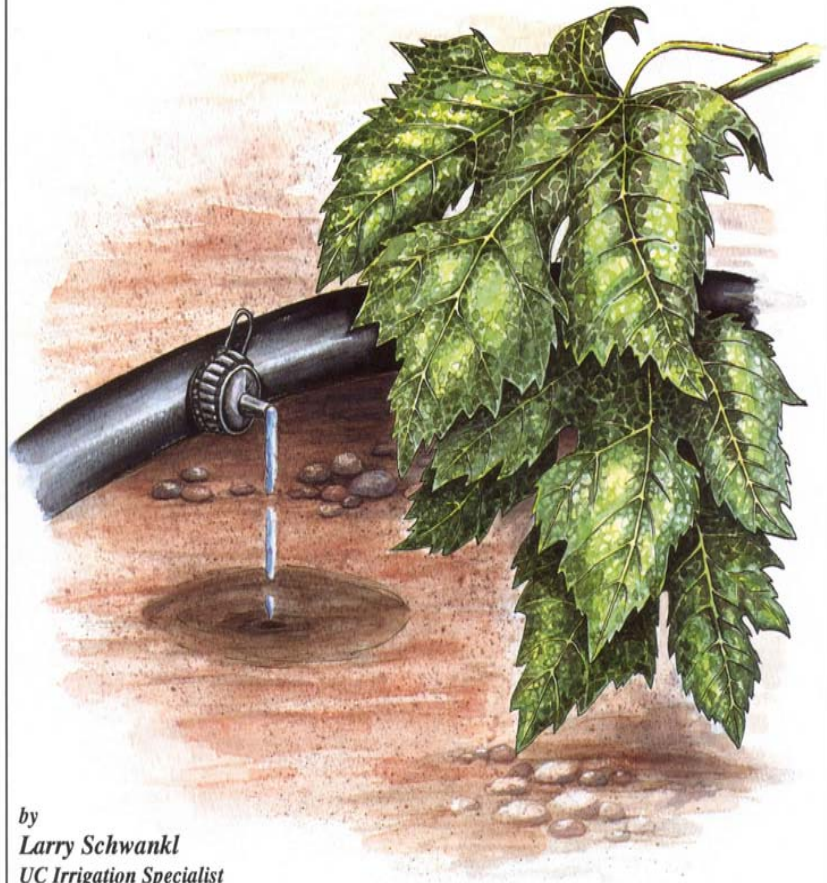
Walnut Stem Water Potential

- 0 to –2.0 — Not commonly observed
- -2.0 to –4.0 — Fully irrigated, low stress, commonly observed when orchards are irrigated according to estimates of real time evapotranspiration (ETc), long term root and tree health may be a concern
- -4.0 to –6.0 — Low to mild stress, high rate of shoot growth visible, suggested level from leaf-out until mid June when nut sizing is completed
- -6.0 to –8.0 — Mild to moderate stress, shoot declines especially with Black Walnut Rootstock. These levels do not appear to affect kernel development

Walnut Stem Water Potential

- -8.0 to –10.0 Moderate to high stress,
  shoot growth in non-bearing trees may stop,
  nut sizing may be reduced in bearing trees
- -10.0 to –12.0 High stress,
  temporary wilting of leaves has been observed. New shoot growth may be sparse or absent and some defoliation may be evident. Nut size likely to be reduced.
- -12.0 to –14.0 Relative high levels of stress,
  moderate to severe defoliation, should be avoided
- -14.0 to –18.0 Severe defoliation

Micro-irrigation of Trees and Vines



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Web Site URL:

- http://lawr.ucdavis.edu/faculty/prichard/
- Click on: Educational Materials