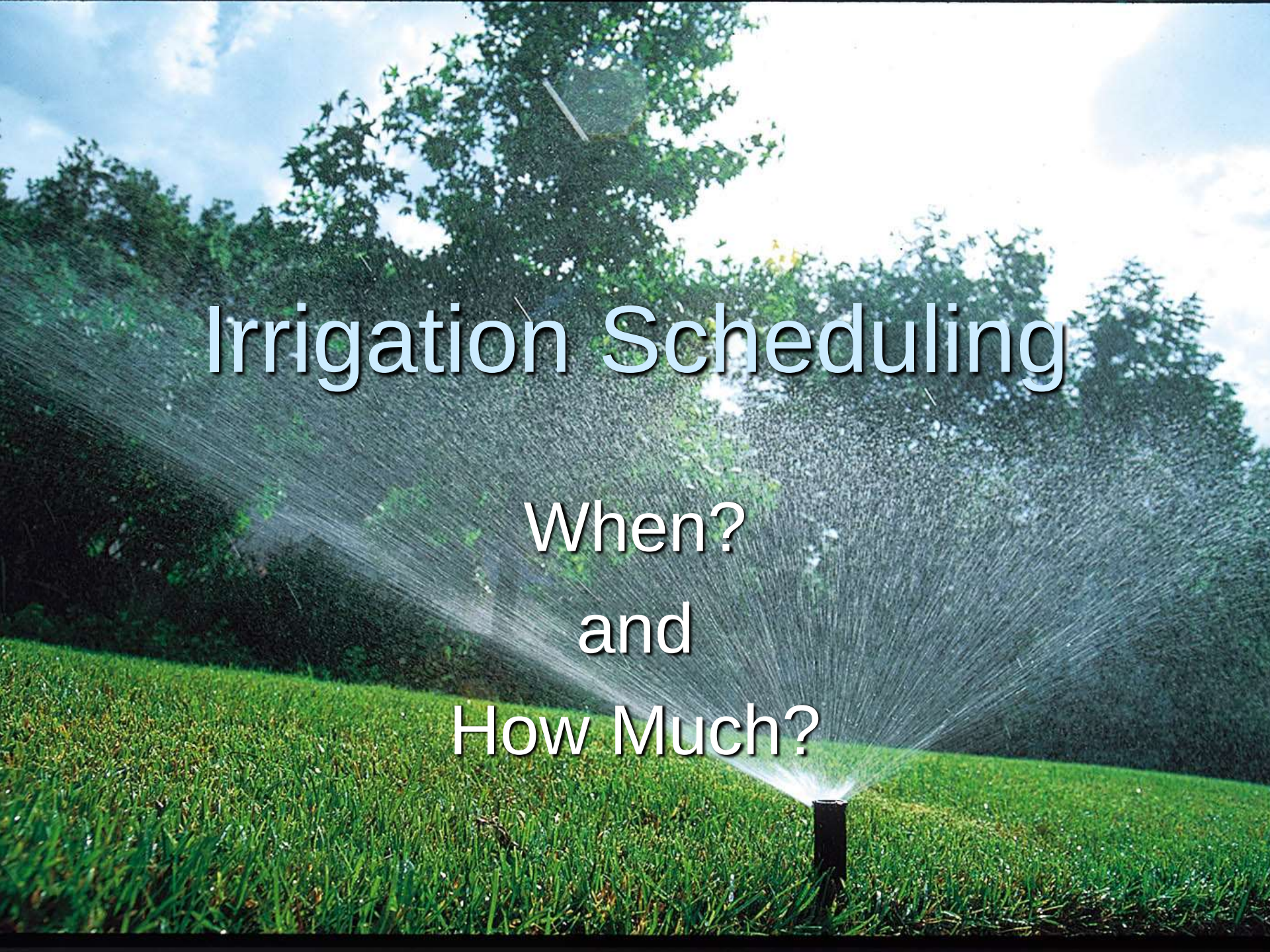
Irrigation Management and Irrigation Technology for Fresh Market Vegetable Production

R. Troy Peters, Ph.D., P.E.

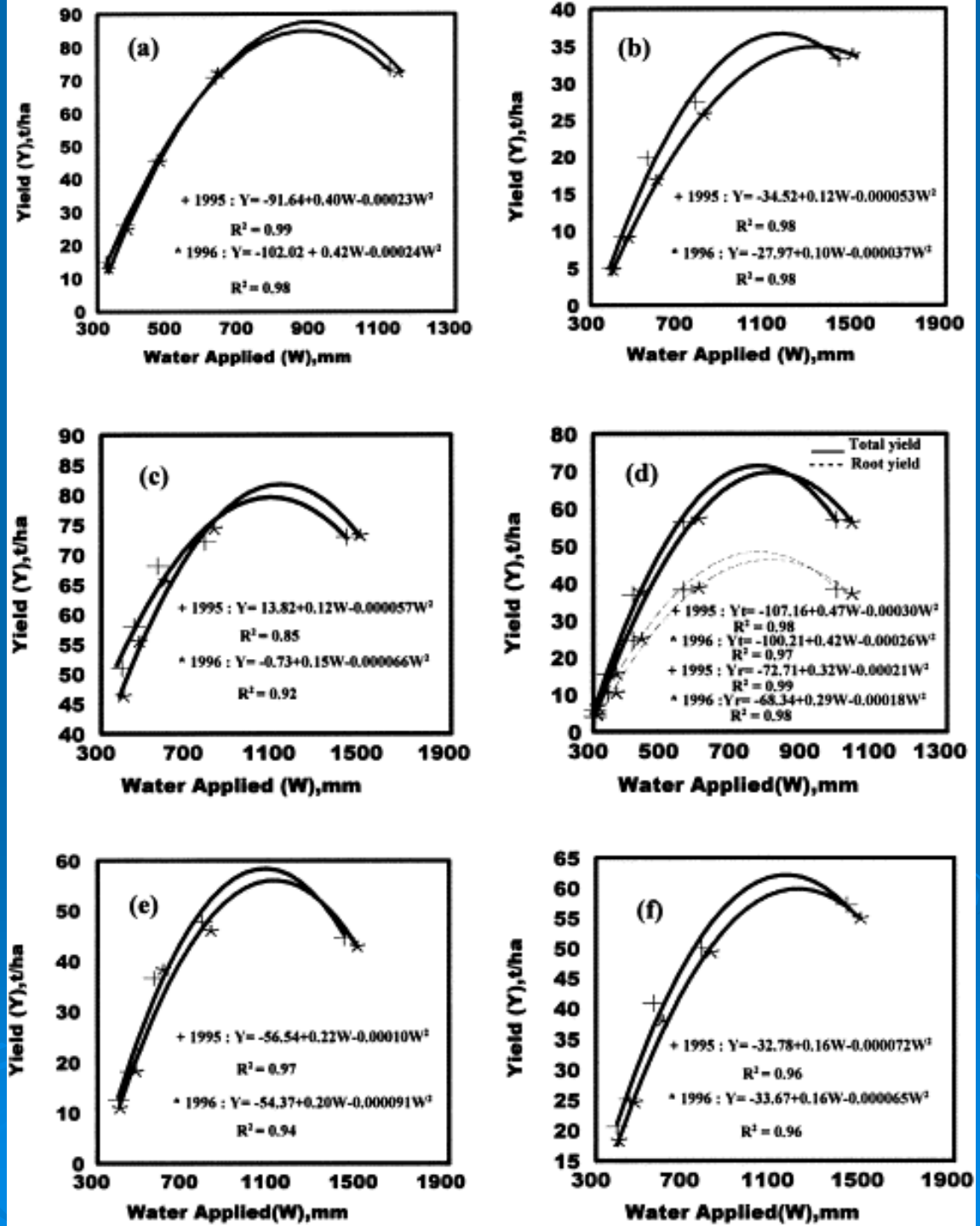
WSU Extension Irrigation Engineer


Irrigation Scheduling
When?
and
How Much?

Irrigation Scheduling
Why Should I Care?

- Better Yields!
- Better Quality!
- Use Less Water!
- Lower Pumping Bills!
- Lower Labor Costs!
- Lower Fertilizer Costs!
- Help keep the environment clean!

Marketable Yields for Various Vegetable Crops



Imtiyaz, M., N.P. Mgadla, B. Chepete, and S.K. Manase. 2000. Response of six vegetable crops to irrigation schedules. Agricultural Water Management. 45(3):331-342

Over-Irrigating

- Increased incidence of plant diseases
  - Blights, molds, rots, wilts
- Less oxygen in root zone = yield loss
- Reduced storability for many vegetables
- Additional labor, pumping, fertilizer costs, wear and tear on irrigation equipment.
- Difficulty with harvesting and cultural operations

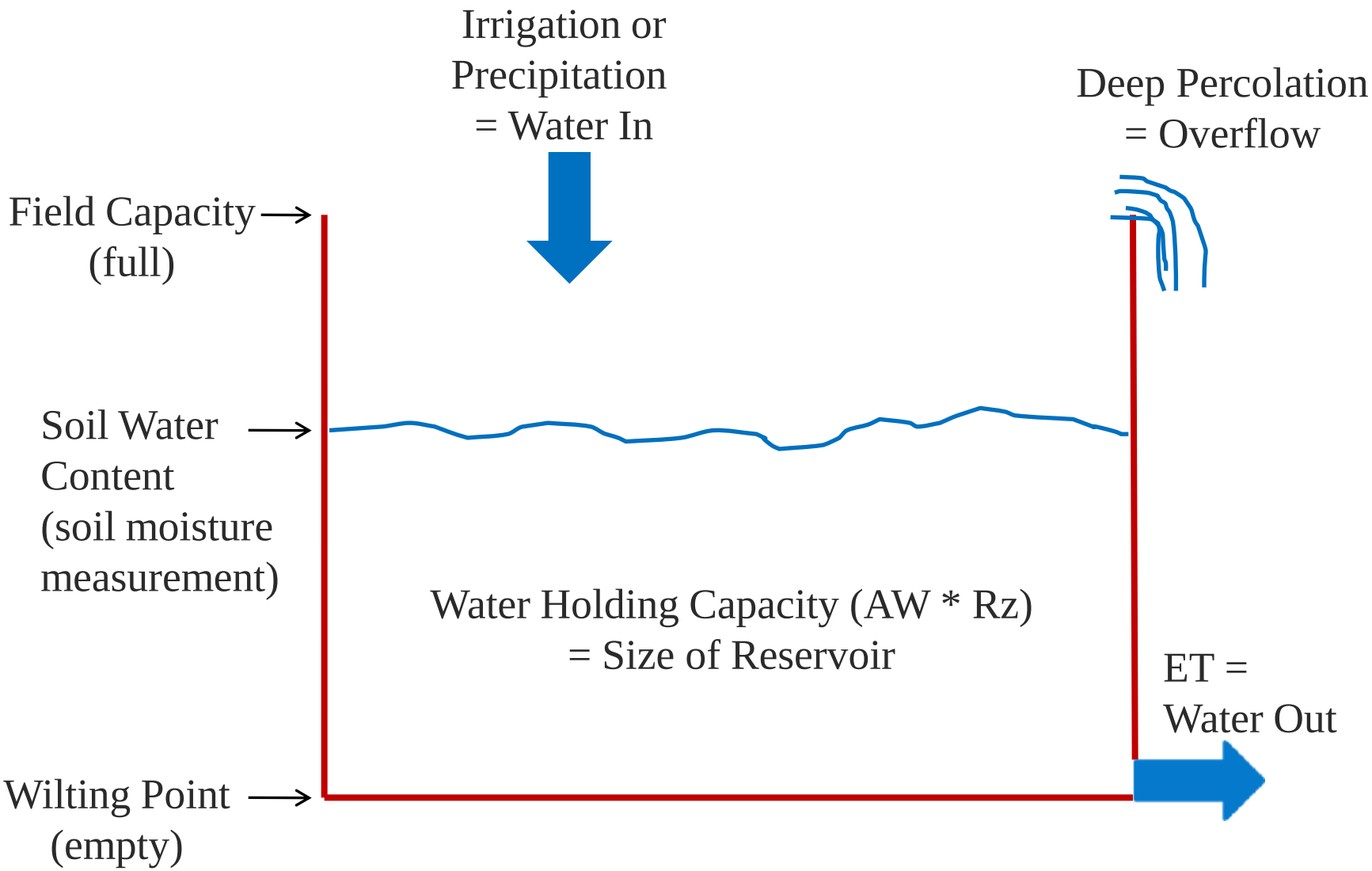
Levels of Irrigation Scheduling

- Same schedule all season / Guessing
- Kicking the dirt / Looking at the plants

- Look and feel method using shovel or soil probe
- Checkbook method / ET (AgWeatherNet)
- Soil moisture monitoring
- Soil sensor + Checkbook/ET monitoring

Best

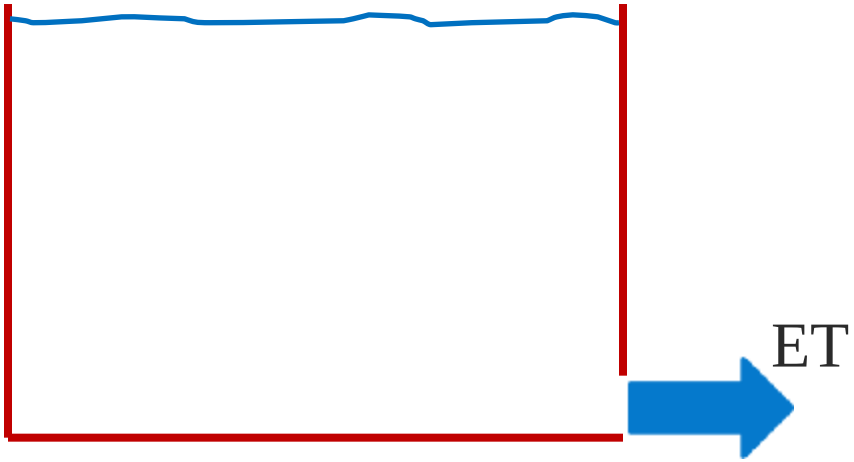
Soil is a Water & Nutrient Reservoir



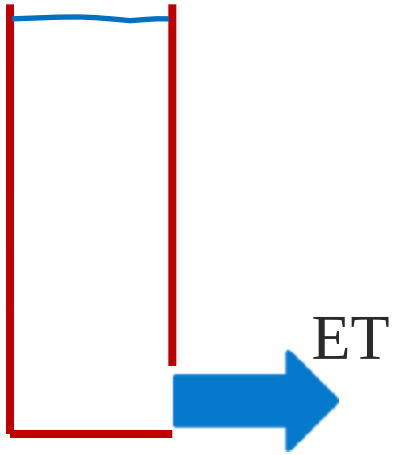
How Big is Your Reservoir?

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

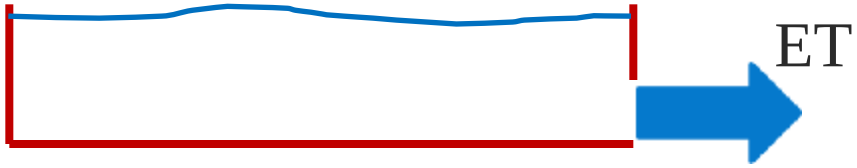
Deep Silt



Deep Sand

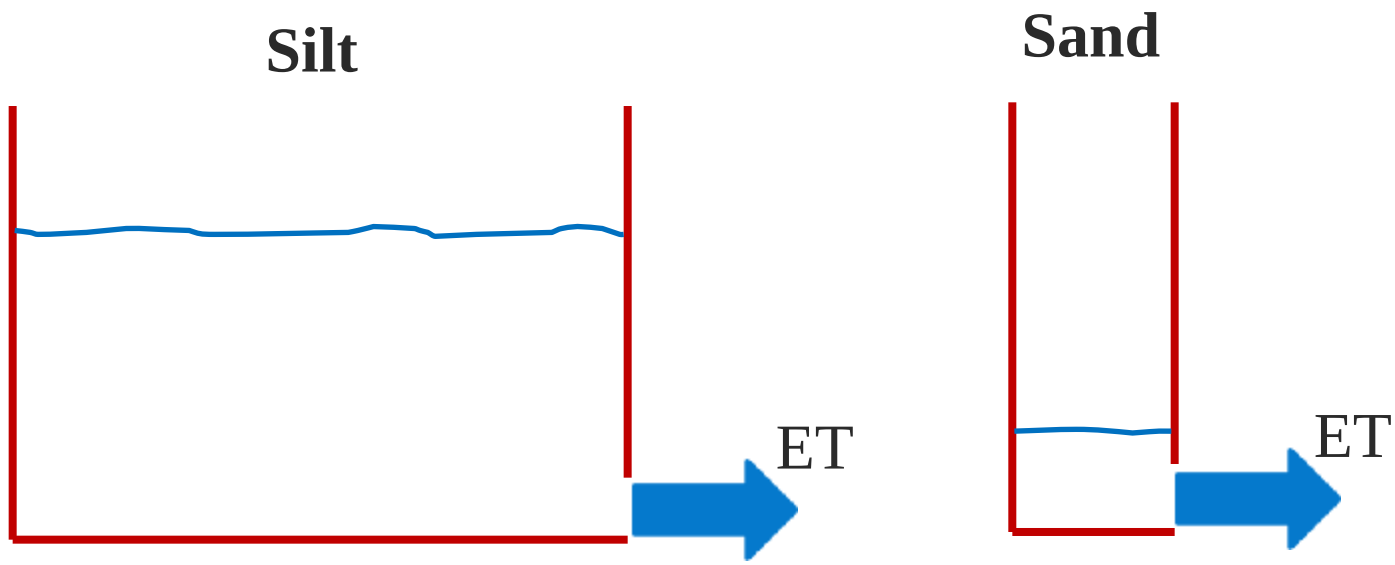


Shallow Silt

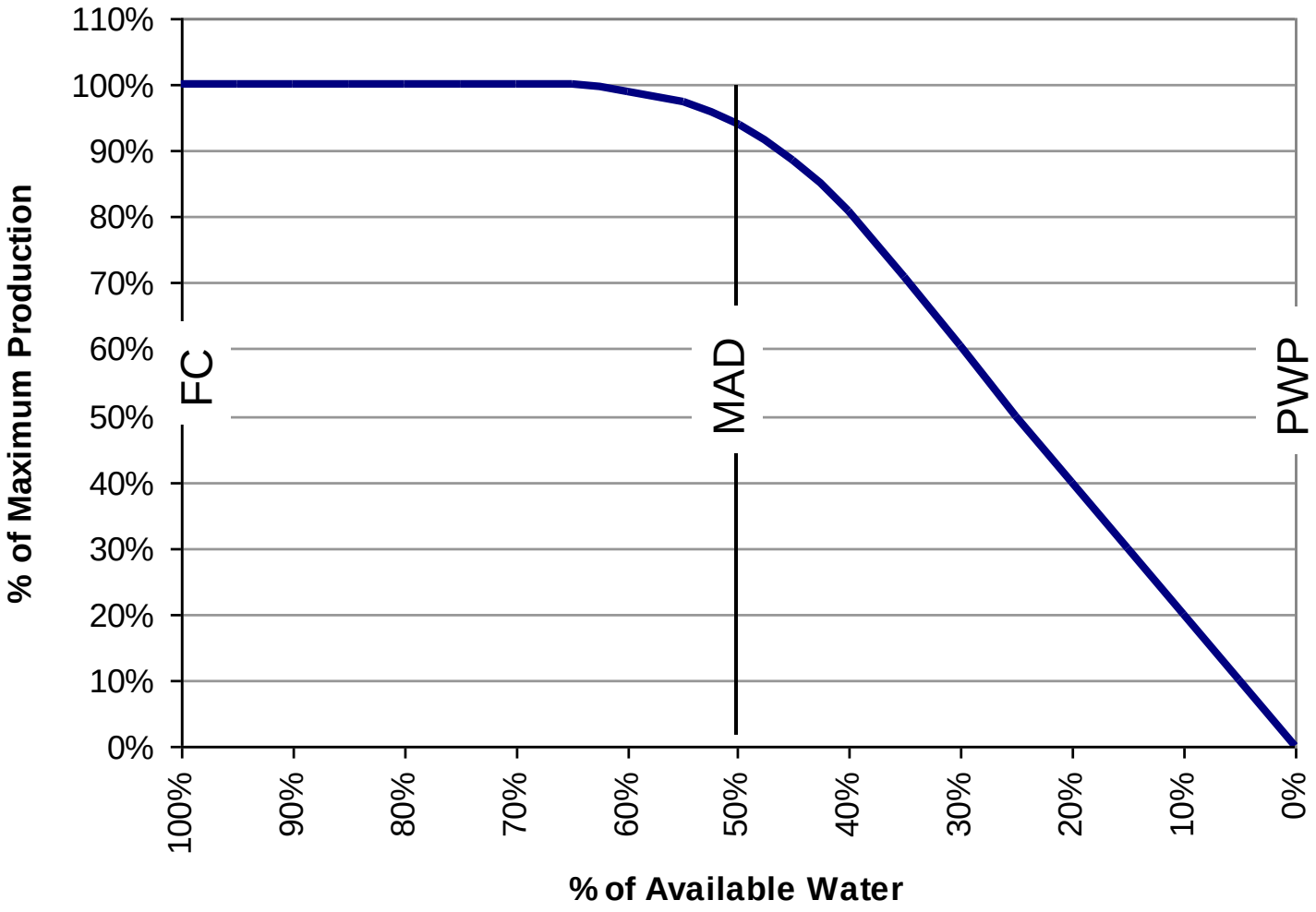


Shallow Sand

Starting from full, after a few days of water use.



Production Reduction Function



Example Soil Water Budget

- Silt Loam: AW = 2 in/ft
- Effective rooting depth: 1.5 ft
- Total water holding capacity:

  $2\ {}^{in}/_{ft} \times 1.5\ ft = 3\ in$
- MAD: 50%
- Soil water deficit at MAD:

  3 in * 50% = 1.5 in

Example Soil Water Budget cont..

- Daily ET rate: 0.1 in/day (or use actuals from web site)
- Time to dewater full profile to MAD:

  1.5 in / 0.1 in/day = 15 days
- Once/2 weeks = 14 * 0.1 = 1.4 in
- If measuring flow…
  - Irrigation Efficiency: 70%
  - Irrigation Amount: 1.4 in / 70% = 2 in
  - How long does it take to put on 2 inches?

Estimate ET

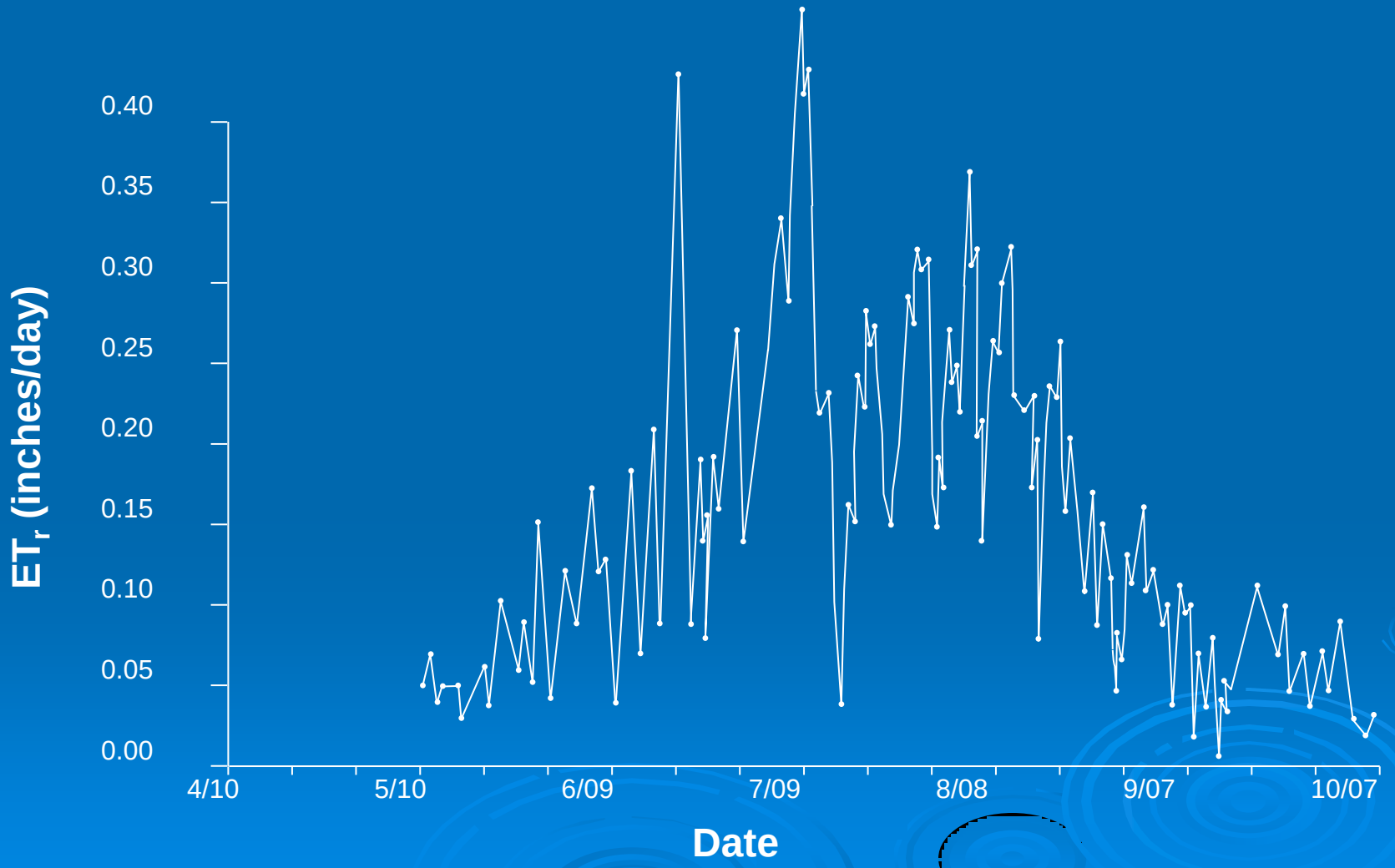
$$ET_c = ET_r \times K_c$$

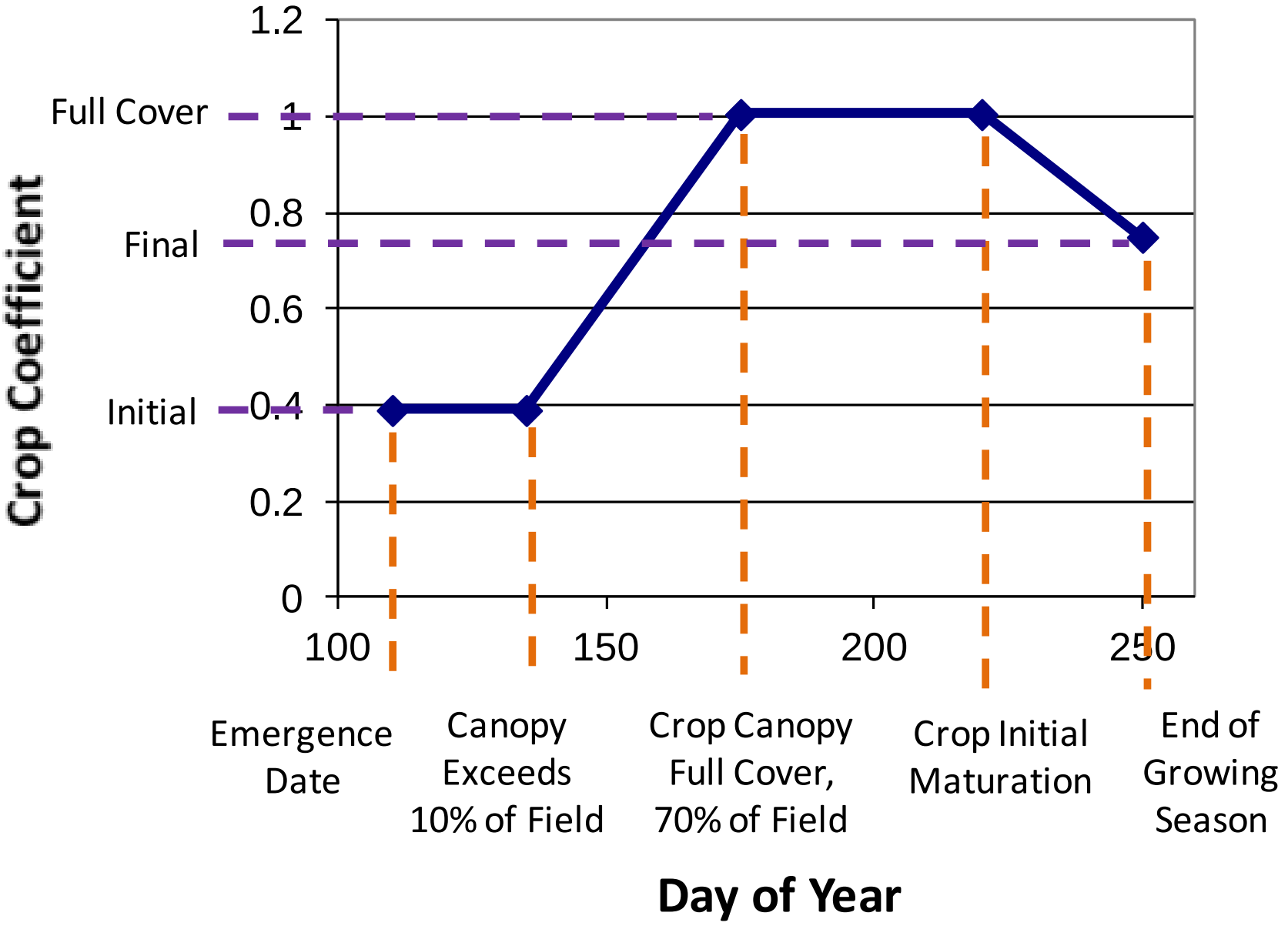
ET_c = crop evapotranspiration

ET_r = evapotranspiration rate of a reference crop (alfalfa). Function of the weather.

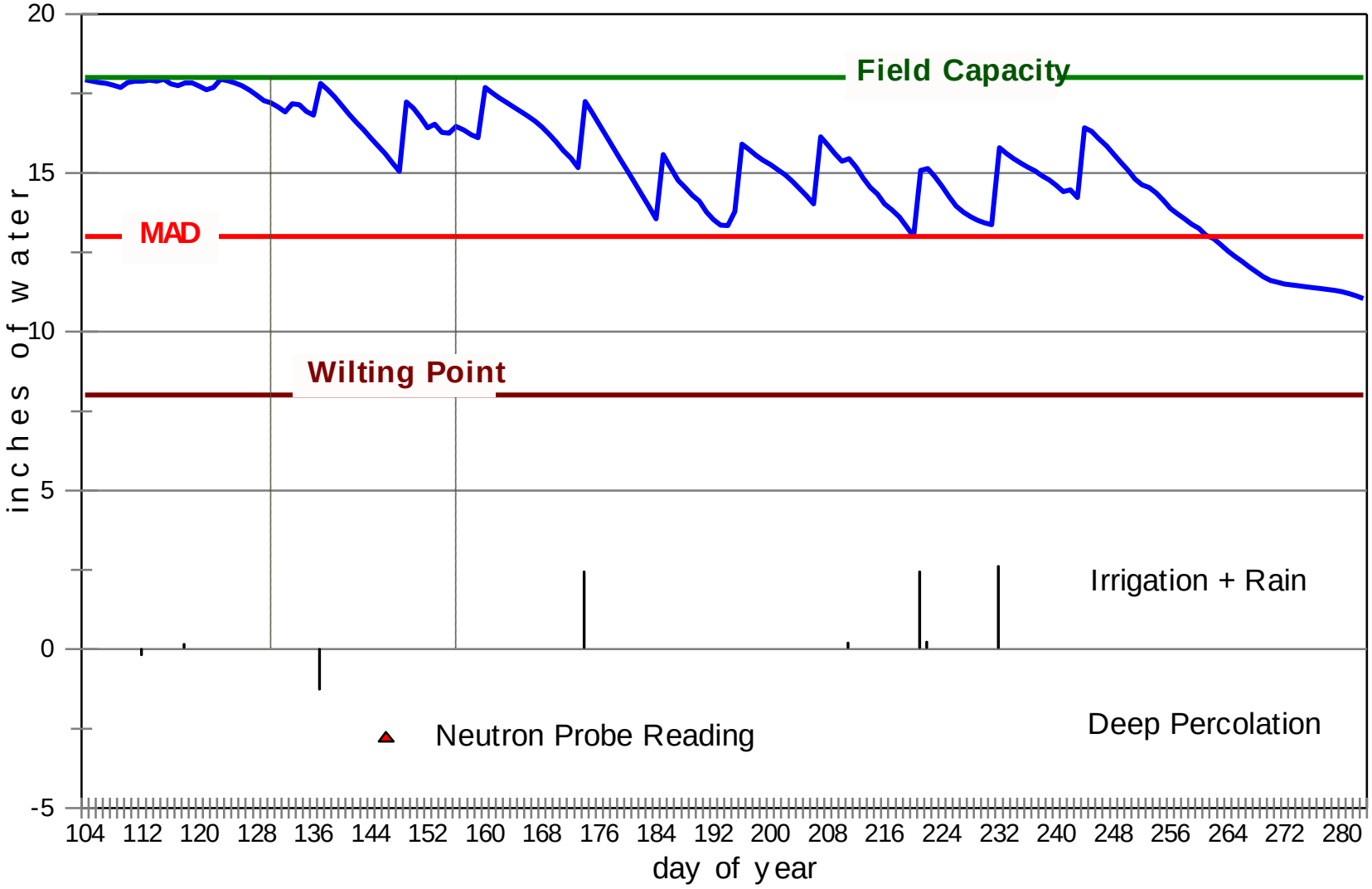
K_c = crop coefficient. Function of the plants.

ET_r and Weather

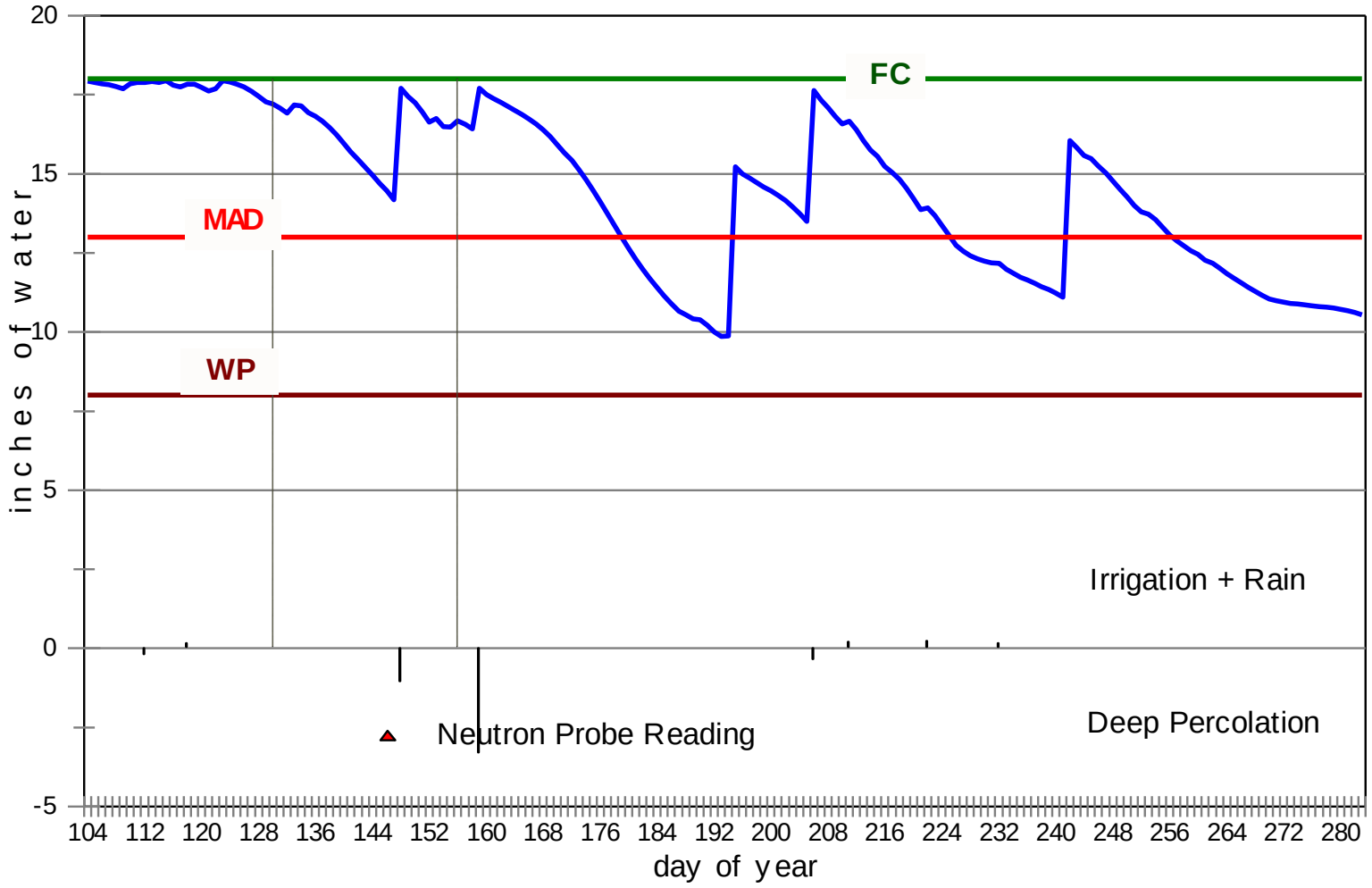



Crop Coefficient
1.2
1
0.8
0.6
0.4
0.2
0
Full Cover
Final
Initial
100
150
200
250
Emergence Date
Canopy Exceeds 10% of Field
Crop Canopy Full Cover, 70% of Field
Crop Initial Maturation
End of Growing Season
Day of Year

Managing to Minimize Stress



Poor Irrigation Scheduling



irrigation scheduler mobile

http://weather.wsu.edu/ism

irrigation scheduler mobile

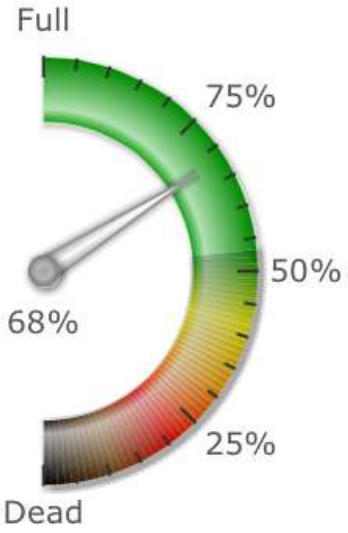
- Simple soil water balance based on ET.
- Designed for use on a smart phone, but usable on any desktop web browser.
- Designed for usability #1.
- Quick & easy to set up.
- Automatically pulls ET data from selected weather stations.
- Can run on any weather network who's data can be automatically accessed.

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

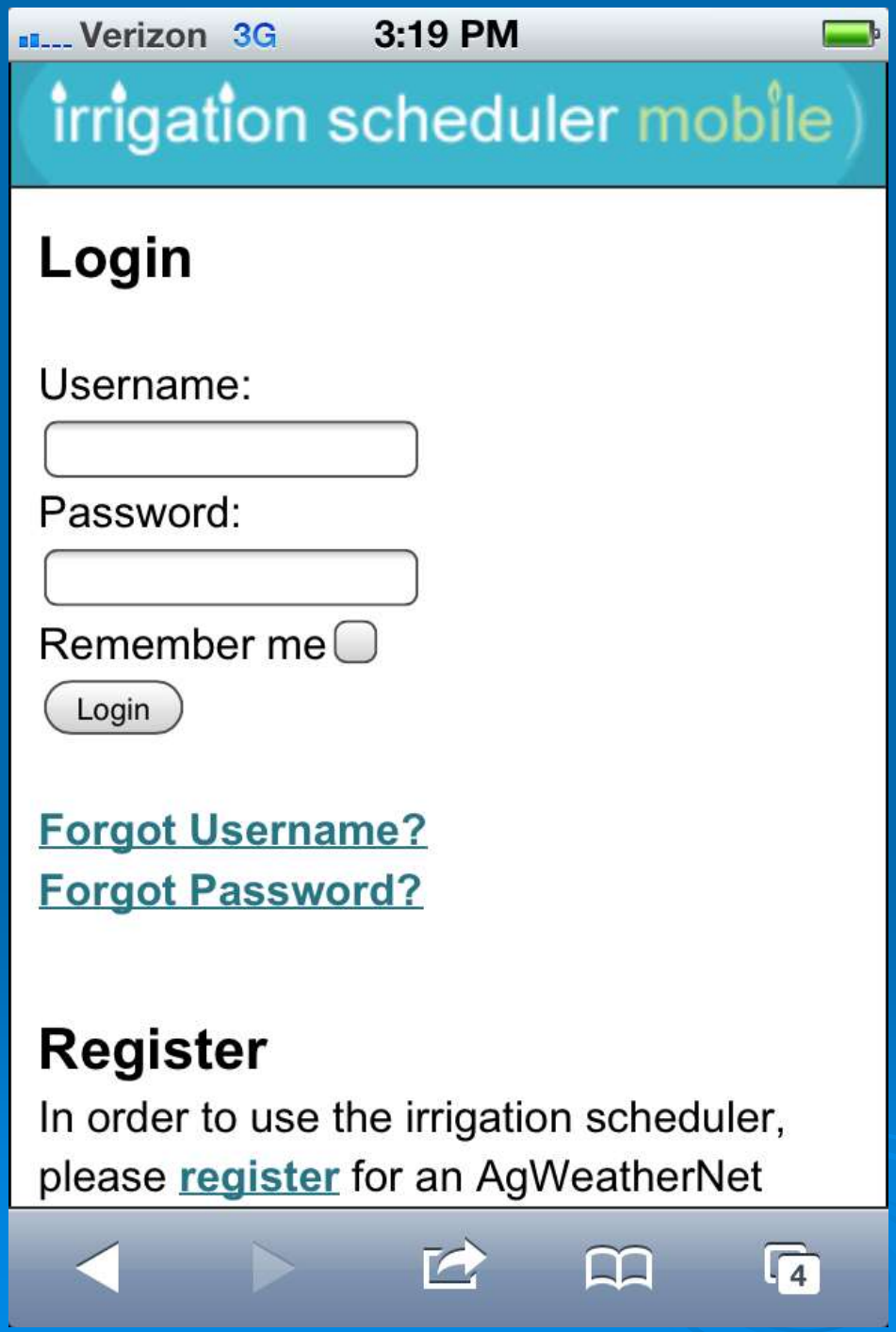
Green is good. Crops increasingly stressed below green.

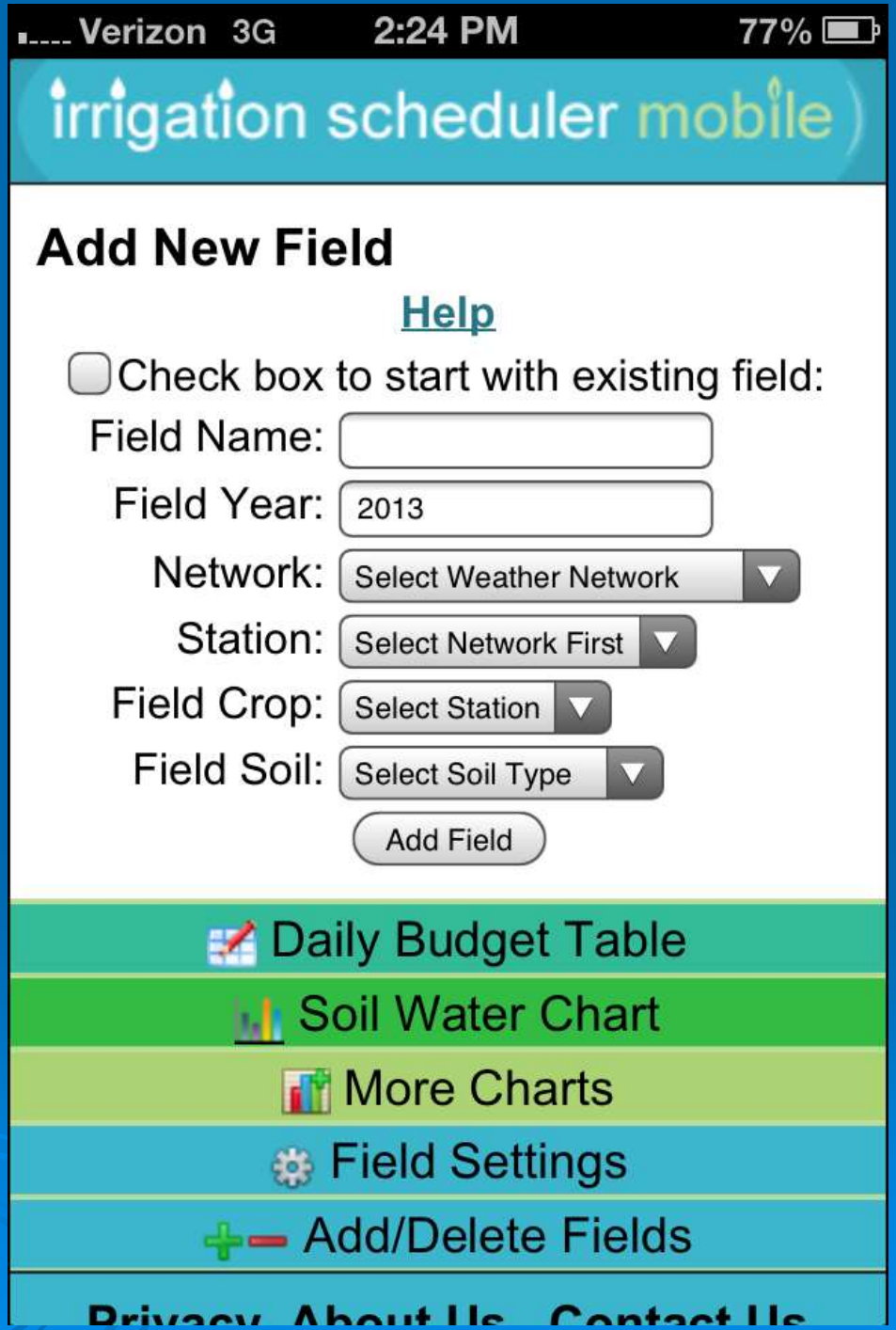
Dashboard

Daily Budget Table

Soil Water Chart

More Charts


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%

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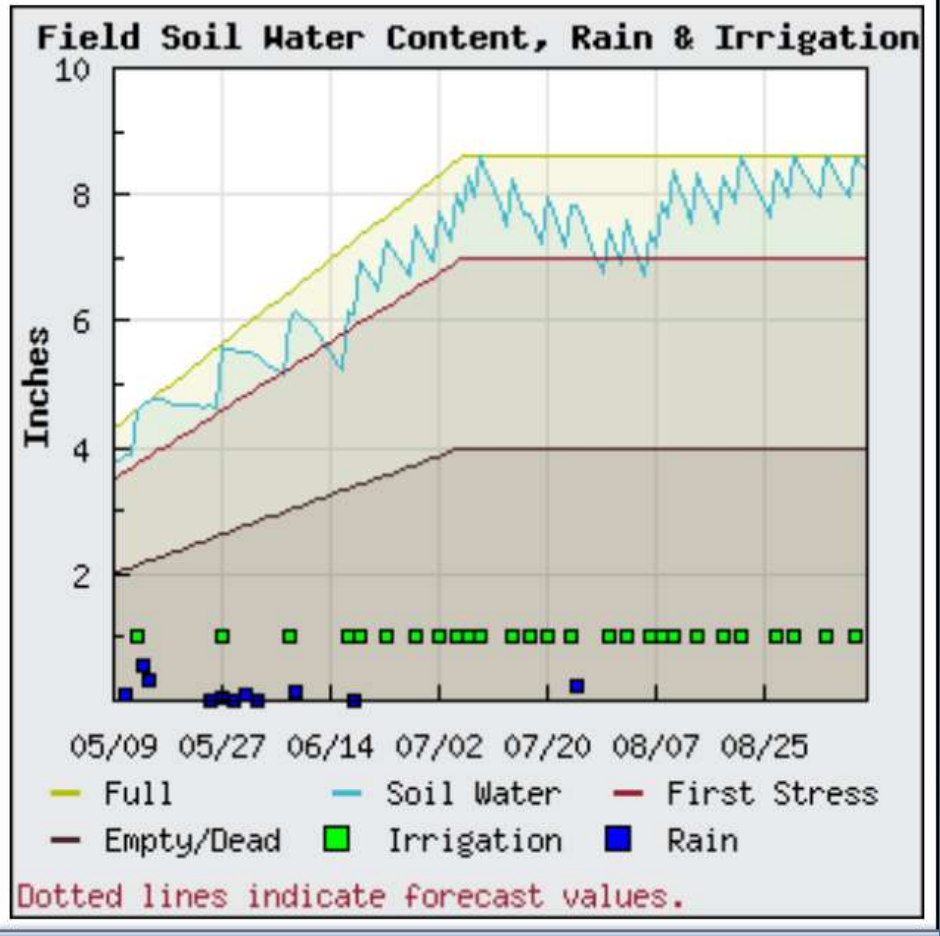
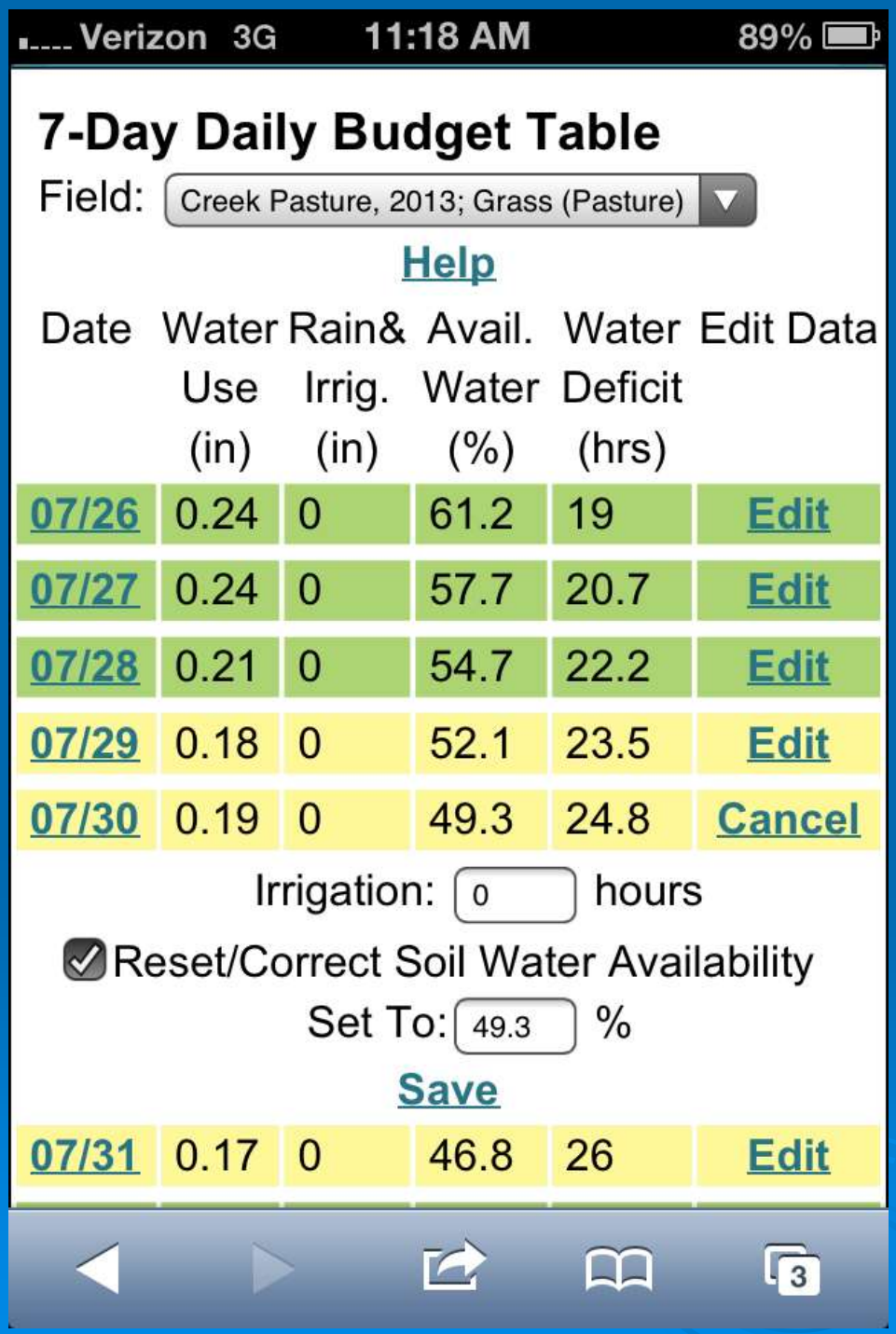
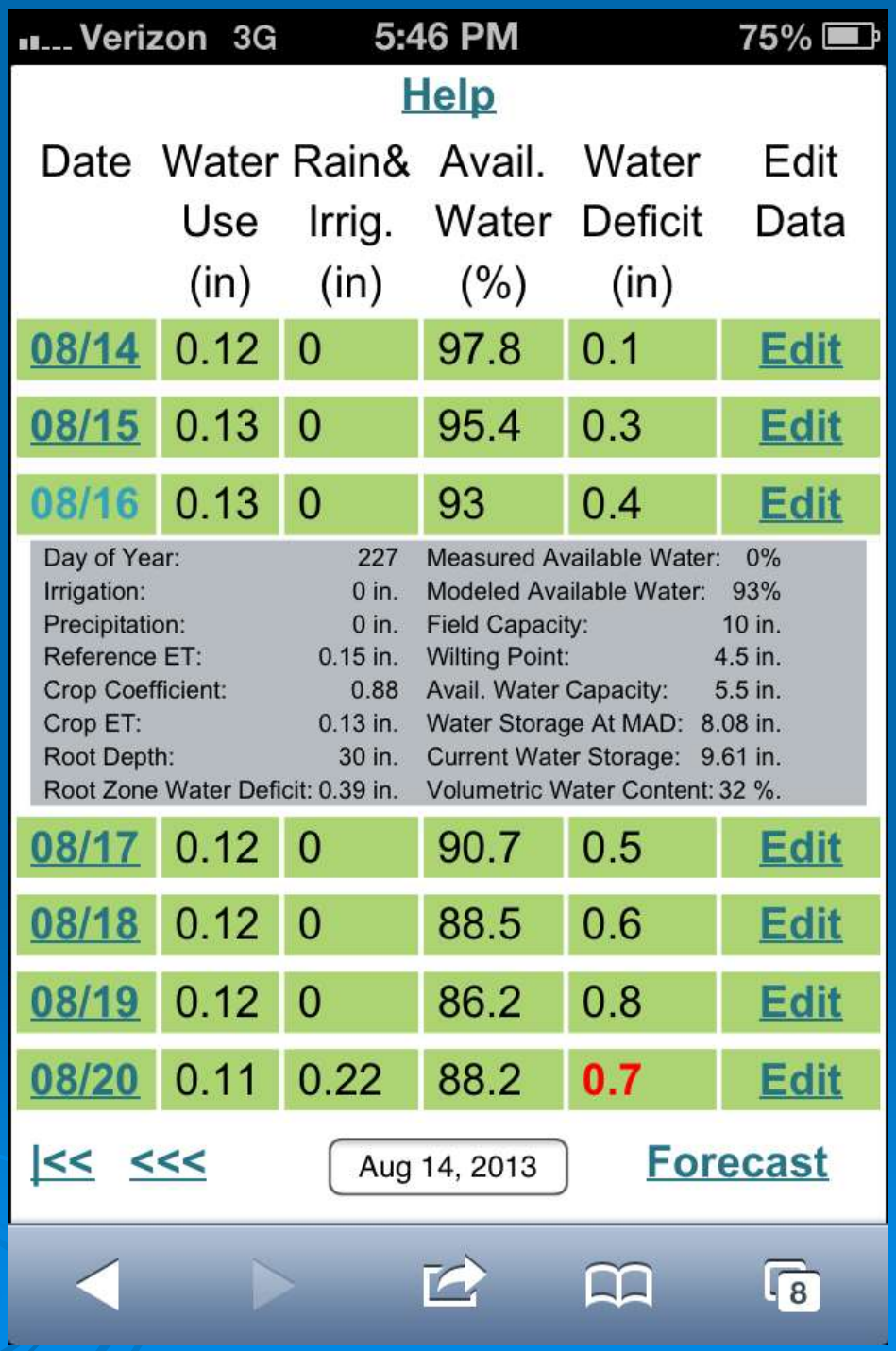
Field: Potatoes, 2011; Potatoes

Help




Verizon 3G 11:18 AM 89%
7-Day Daily Budget Table
Field: Creek Pasture, 2013; Grass (Pasture)
Help
Date | Water Use (in) | Rain& Irrig. (in) | Avail. Water (%) | Water Deficit (hrs) | Edit Data
07/26 | 0.24 | 0 | 61.2 | 19 | Edit
07/27 | 0.24 | 0 | 57.7 | 20.7 | Edit
07/28 | 0.21 | 0 | 54.7 | 22.2 | Edit
07/29 | 0.18 | 0 | 52.1 | 23.5 | Edit
07/30 | 0.19 | 0 | 49.3 | 24.8 | Cancel
Irrigation: 0 hours
Reset/Correct Soil Water Availability
Set To: 49.3 %
Save
07/31 | 0.17 | 0 | 46.8 | 26 | Edit
3


Verizon 3G 5:46 PM 75%
Help
Date | Water Use (in) | Rain& Irrig. (in) | Avail. Water (%) | Water Deficit (in) | Edit Data
08/14 | 0.12 | 0 | 97.8 | 0.1 | Edit
08/15 | 0.13 | 0 | 95.4 | 0.3 | Edit
08/16 | 0.13 | 0 | 93 | 0.4 | Edit
Day of Year: 227
Irrigation: 0 in.
Precipitation: 0 in.
Reference ET: 0.15 in.
Crop Coefficient: 0.88
Crop ET: 0.13 in.
Root Depth: 30 in.
Root Zone Water Deficit: 0.39 in.
Measured Available Water: 0%
Modeled Available Water: 93%
Field Capacity: 10 in.
Wilting Point: 4.5 in.
Avail. Water Capacity: 5.5 in.
Water Storage At MAD: 8.08 in.
Current Water Storage: 9.61 in.
Volumetric Water Content: 32 %.
08/17 | 0.12 | 0 | 90.7 | 0.5 | Edit
08/18 | 0.12 | 0 | 88.5 | 0.6 | Edit
08/19 | 0.12 | 0 | 86.2 | 0.8 | Edit
08/20 | 0.11 | 0.22 | 88.2 | 0.7 | Edit
|<< <<< Aug 14, 2013 Forecast
8

Verizon 3G 11:20 AM 88%

08/08	0.3	0	91.4	0.5	Edit

|<< <<< Aug 02, 2013 Forecast

- Daily Budget Table
- Soil Water Chart
- Less Charts
- Daily Water Use Chart
- Cumulative Water Chart
- Crop Coefficient Chart
- Deep Water Loss Chart
- Water Stress Chart
- Field Settings
- Add/Delete Fields

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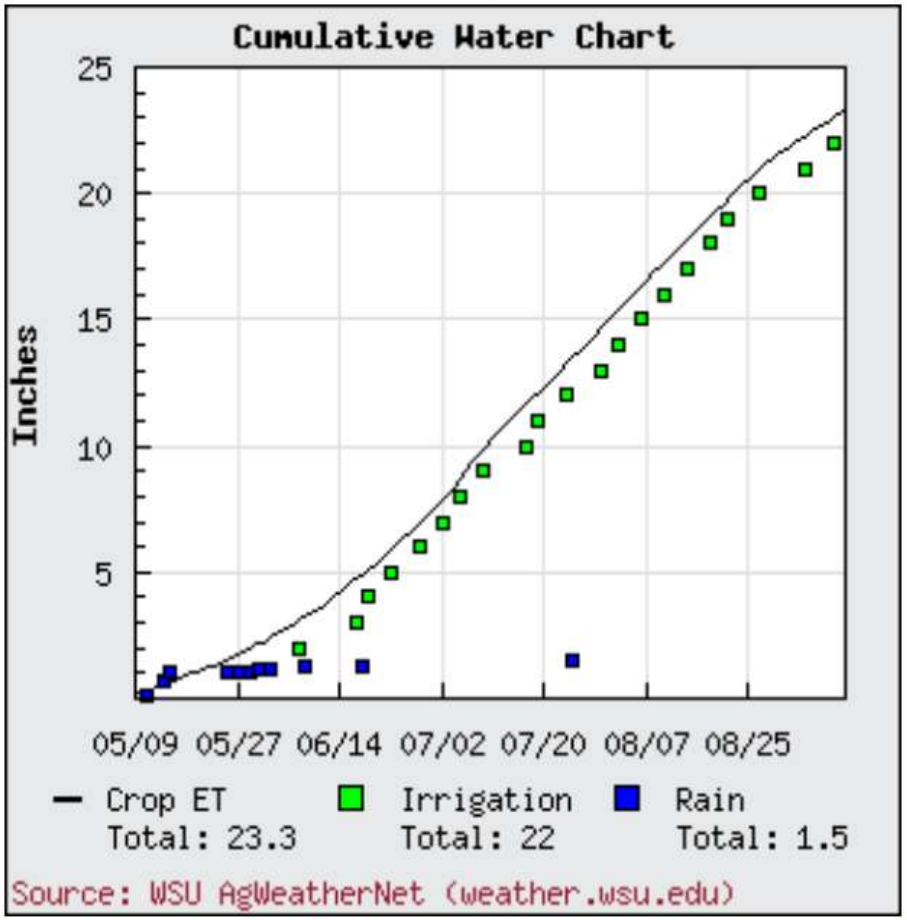
Verizon 3G 11:26 AM 100%

irrigation scheduler mobile

Field: Potatoes, 2011; Potatoes

Help

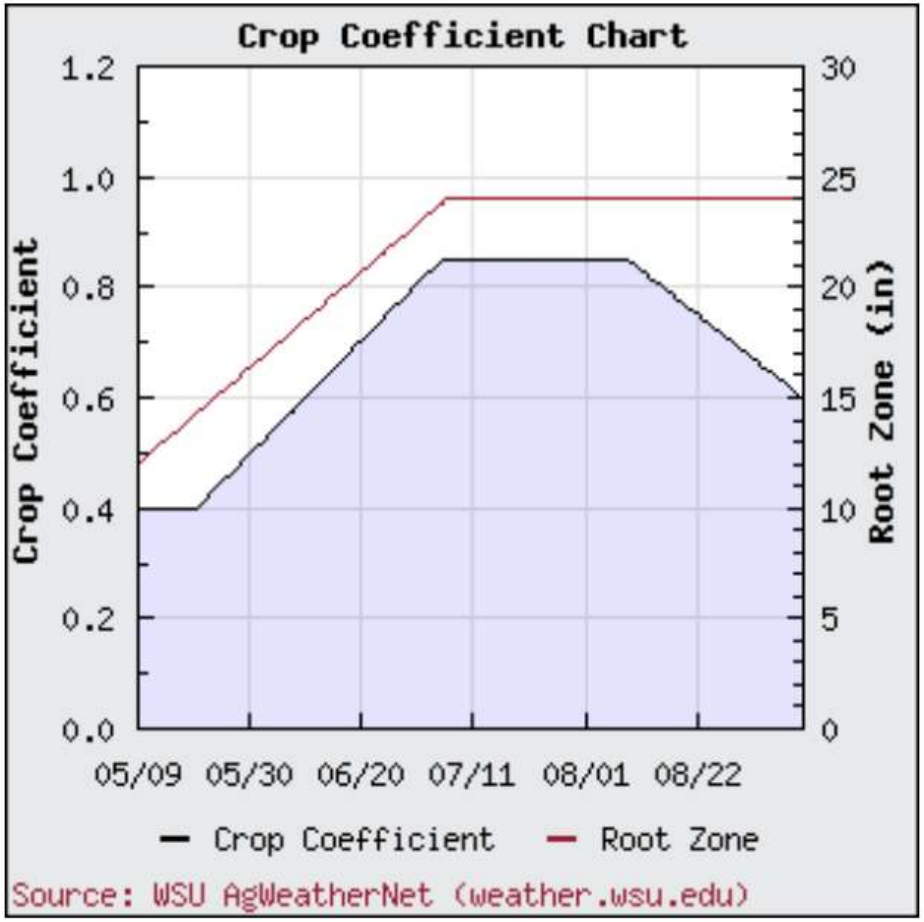


Verizon 3G 11:26 AM 100%

irrigation scheduler mobile

Field: Potatoes, 2011; Potatoes

Help



Verizon 3G 11:25 AM 100%

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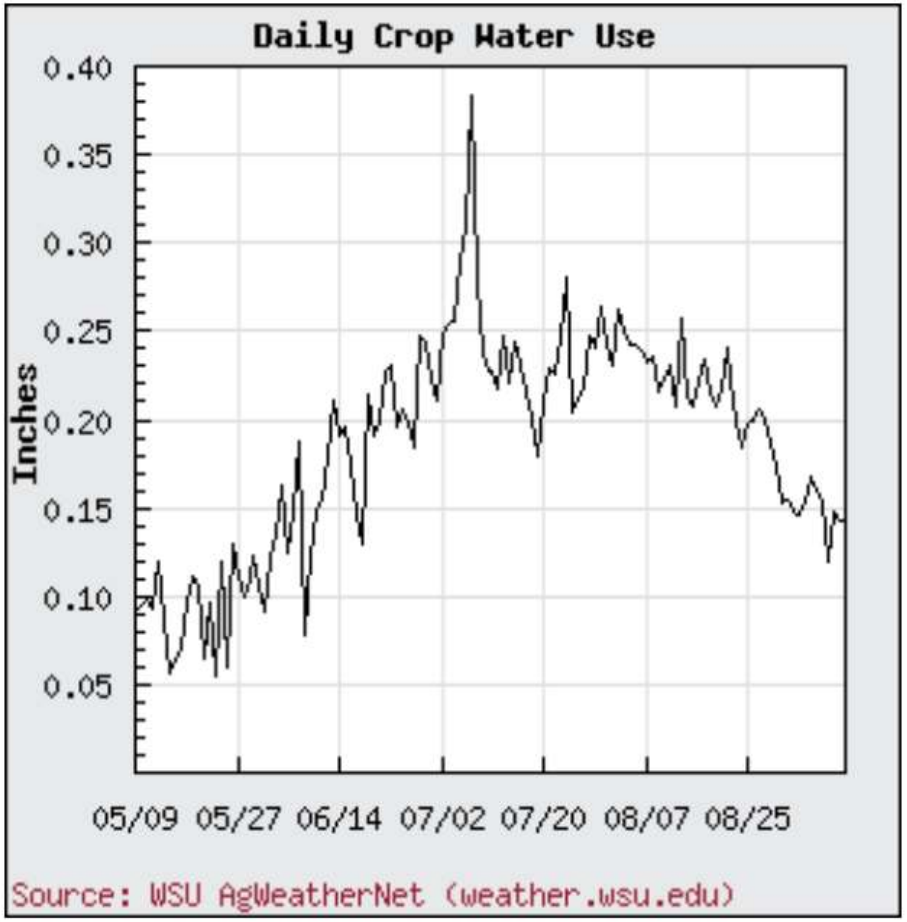
Field: Potatoes, 2011; Potatoes

Help

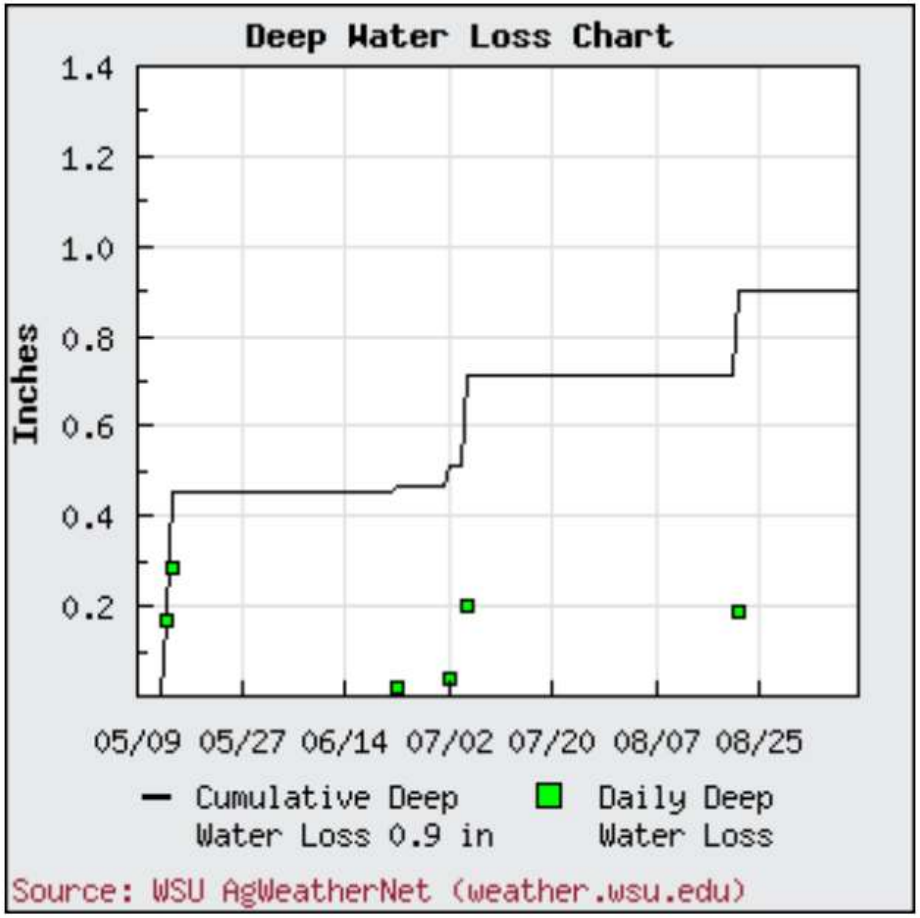


Verizon 3G 11:26 AM 100%

irrigation scheduler mobile

Field: Potatoes, 2011; Potatoes

Help



Verizon 3G 10:23 AM

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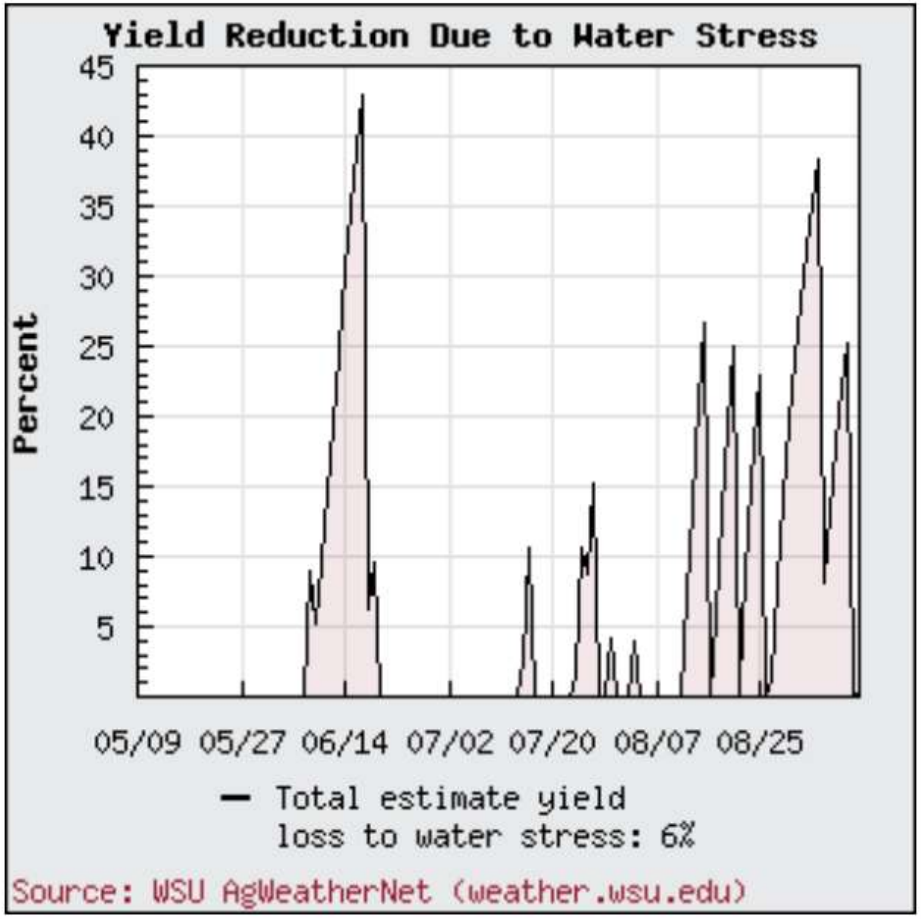
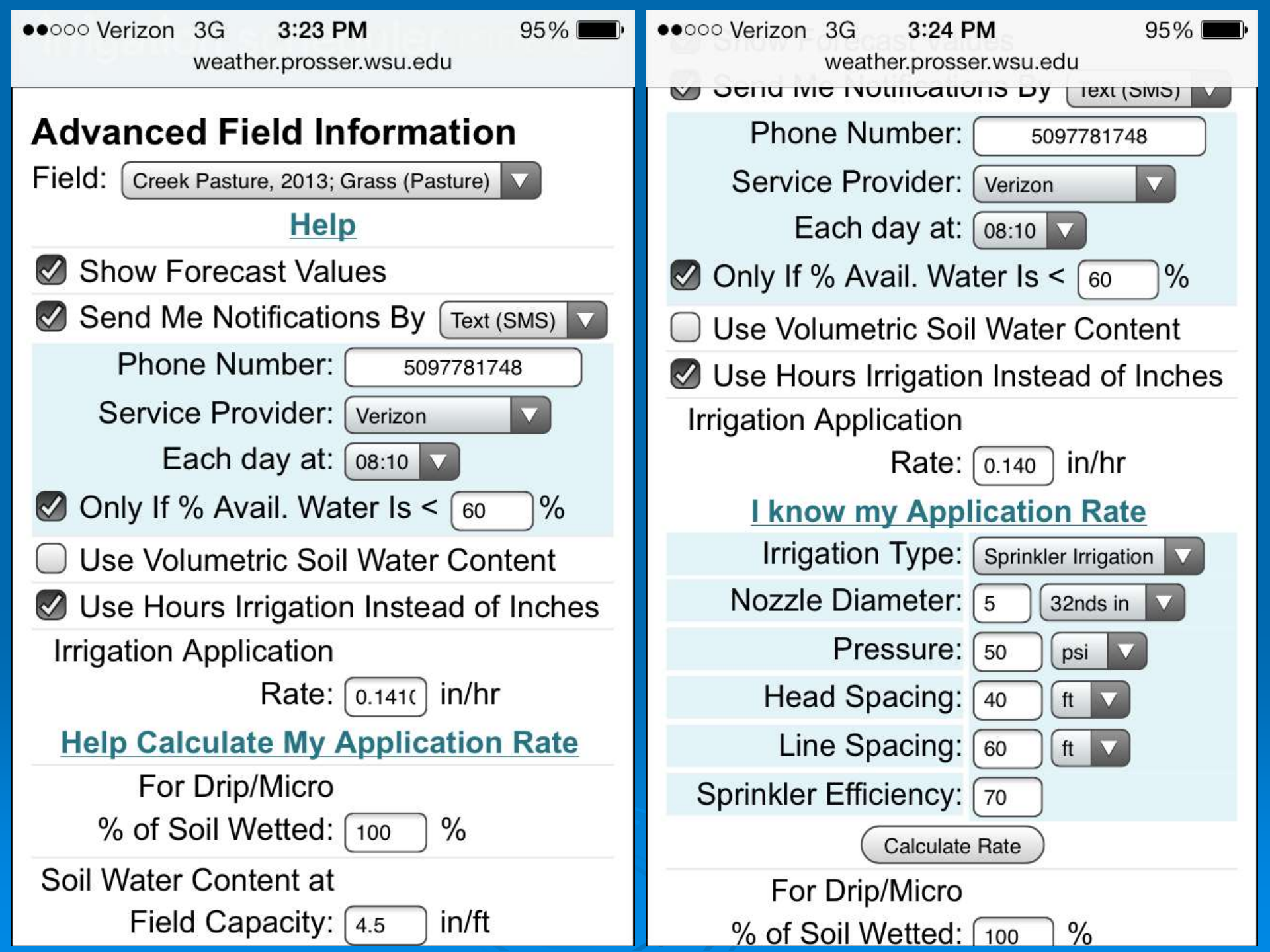
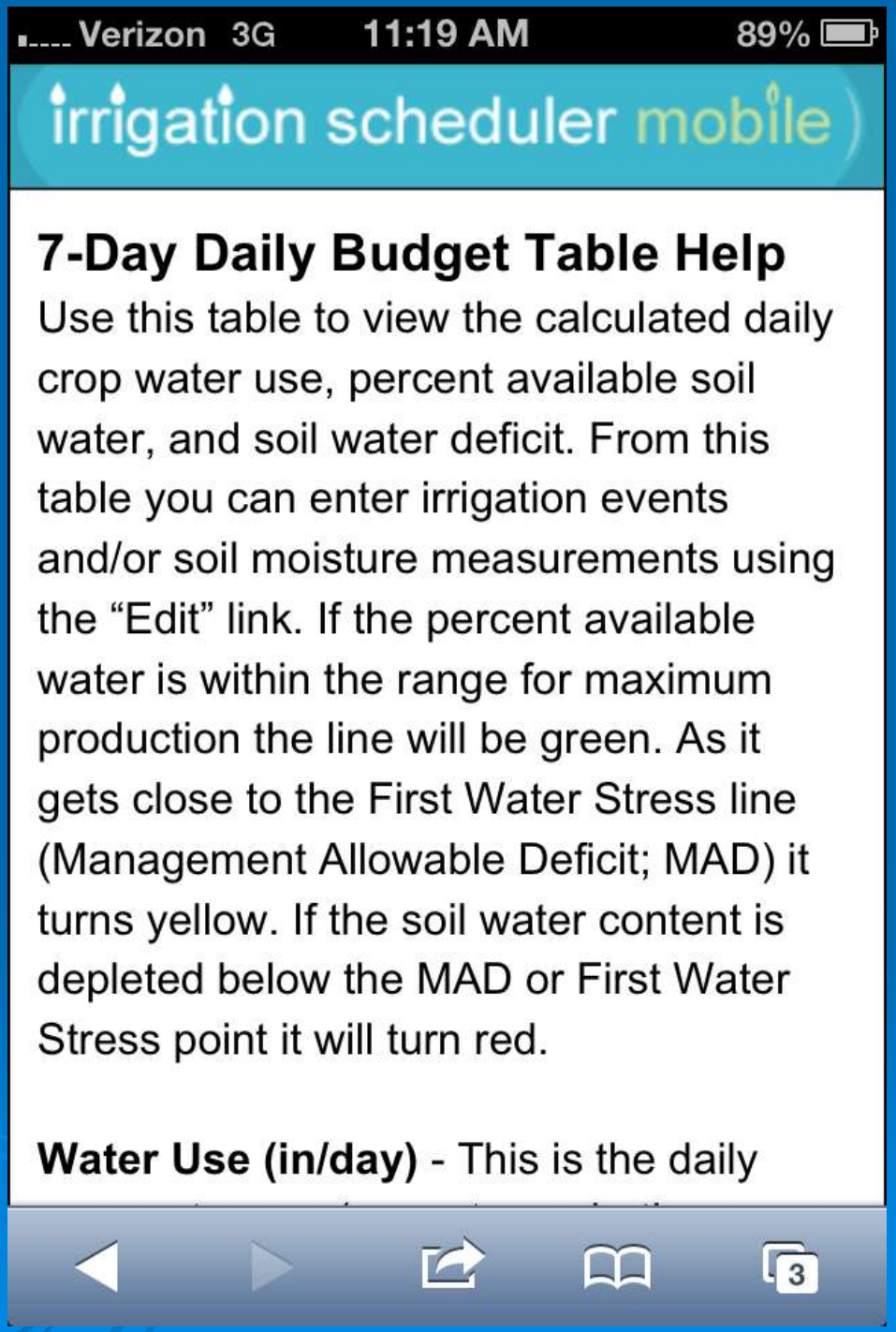
Field: Potatoes, 2011; Potatoes

Help




●●○○○ Verizon 3G 3:23 PM 95%
weather.prosser.wsu.edu
Advanced Field Information
Field: Creek Pasture, 2013; Grass (Pasture)
Help
Show Forecast Values
Send Me Notifications By Text (SMS)
Phone Number: 5097781748
Service Provider: Verizon
Each day at: 08:10
Only If % Avail. Water Is < 60 %
Use Volumetric Soil Water Content
Use Hours Irrigation Instead of Inches
Irrigation Application
Rate: 0.141(in/hr
Help Calculate My Application Rate
For Drip/Micro
% of Soil Wetted: 100 %
Soil Water Content at
Field Capacity: 4.5 in/ft
●●○○○ Verizon 3G 3:24 PM 95%
weather.prosser.wsu.edu
Send Me Notifications By Text (SMS)
Phone Number: 5097781748
Service Provider: Verizon
Each day at: 08:10
Only If % Avail. Water Is < 60 %
Use Volumetric Soil Water Content
Use Hours Irrigation Instead of Inches
Irrigation Application
Rate: 0.140 in/hr
I know my Application Rate
Irrigation Type: Sprinkler Irrigation
Nozzle Diameter: 5 32nds in
Pressure: 50 psi
Head Spacing: 40 ft
Line Spacing: 60 ft
Sprinkler Efficiency: 70
Calculate Rate
For Drip/Micro
% of Soil Wetted: 100 %

Specific help link on every screen



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World Class. Face to Face.

The Washington Agricultural Weather Network Version 2.0, WSU Prosser

AgWeatherNet

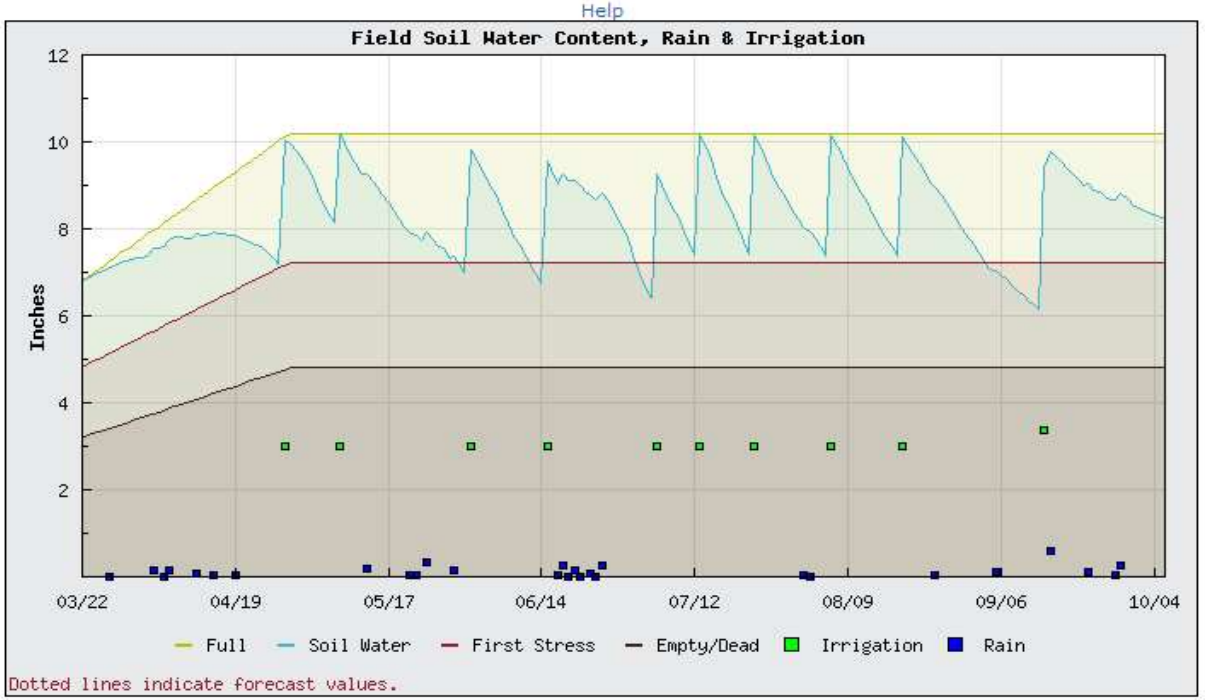
Some Crops Migrate North with Warmer Temperatures

Home
AWN Mobile
AWN News
AWN Outlook
AWN Frost Risk
AWN Warnings
Pictures
Station Details
Weather Widget
Current Conditions
Yesterday's Weather
I Want to Give
Contact AWN
Help
Temp & Wind Alerts
Favorites
AWN Reports
AWN Data
AWN Models
Chilling Hours
Cold Hardiness
GDD Calculator
Irrigation Scheduler Mobile
Irrigation Scheduler
Tree Fruit IPM Models
Current Maps
Yesterday Maps
Month-To-Date Maps
Year-To-Date Maps

Field: Block C3, 2013; Grass (Pasture)

Daily Budget Table | Soil Water Chart | Daily Water Use Chart | Cumulative Water Chart
Crop Coefficient Chart | Deep Water Loss Chart | Water Stress Chart | Field Settings
Add A Field | Field Activity

Help



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iPad
iPod

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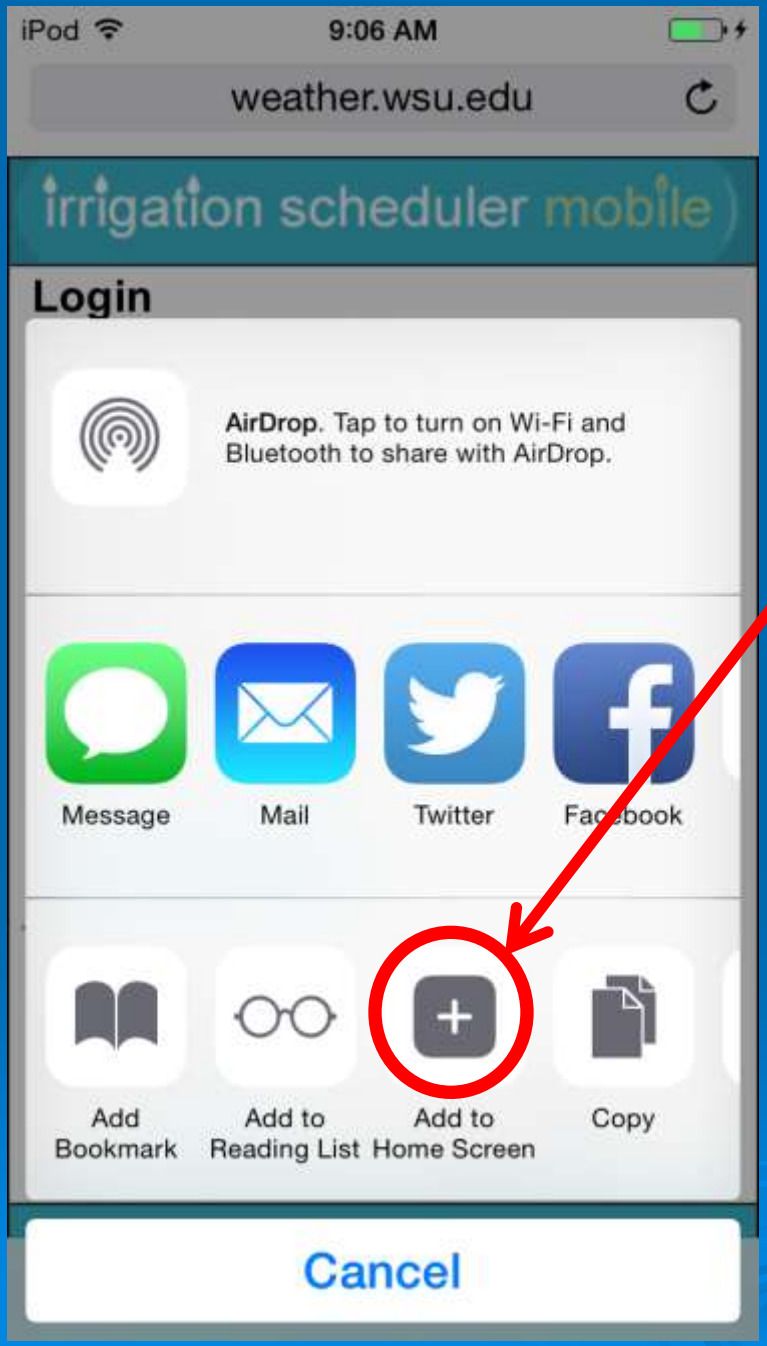
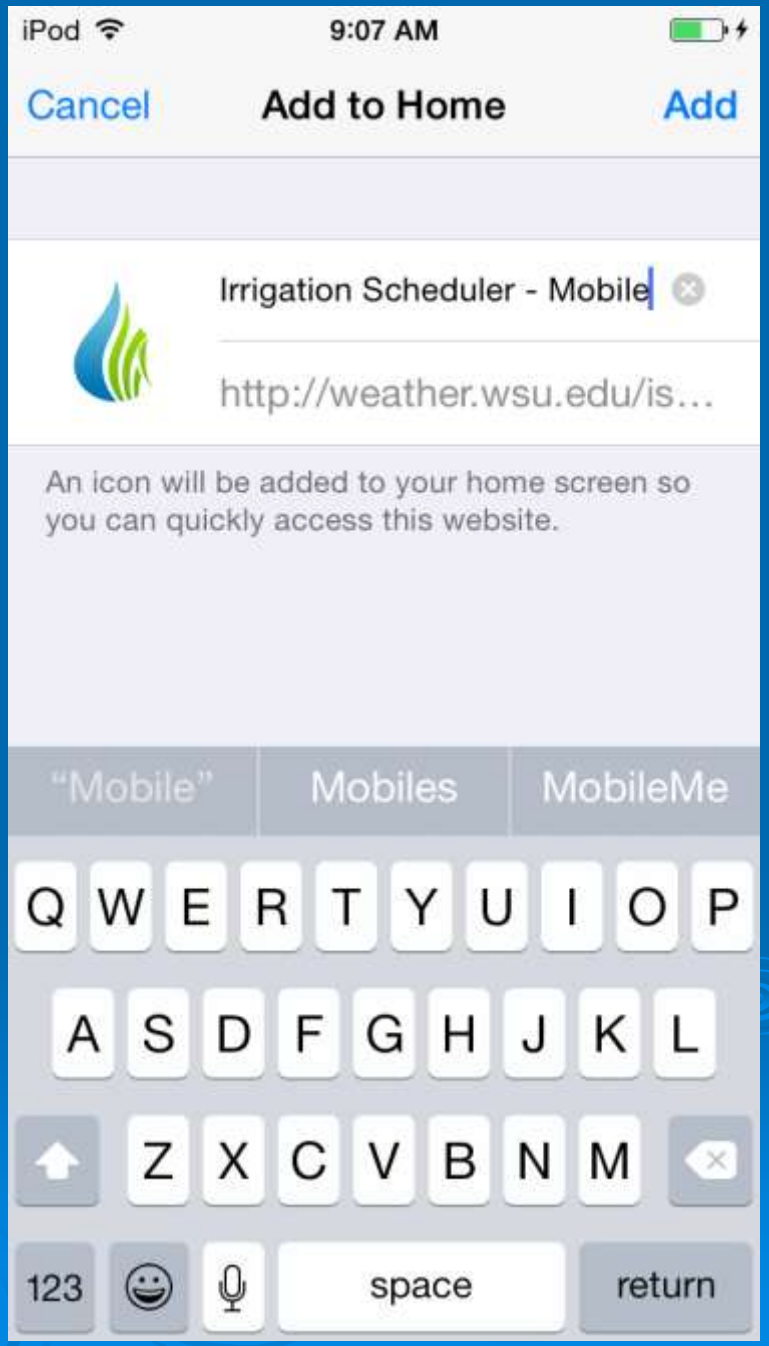
in Safari

Then…

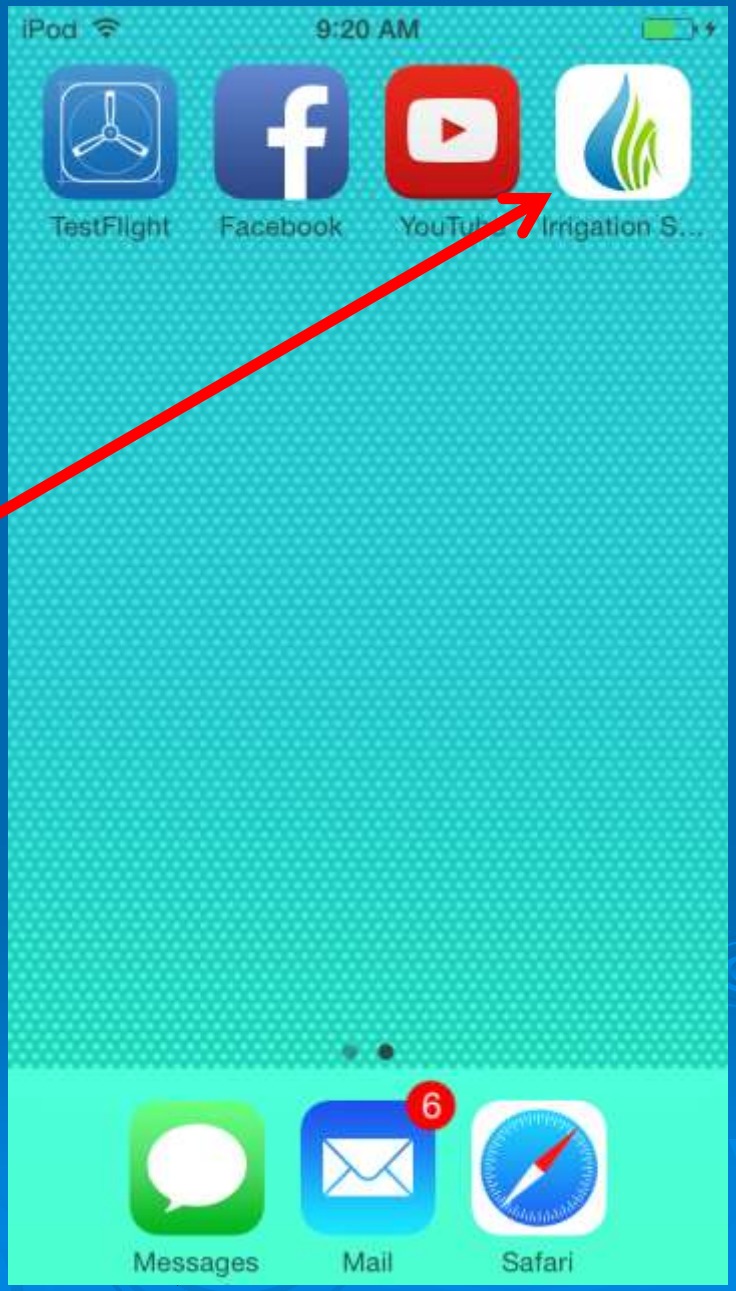

iPod
9:06 AM
weather.wsu.edu
irrigation scheduler mobile
Login
AirDrop. Tap to turn on Wi-Fi and Bluetooth to share with AirDrop.
Message
Mail
Twitter
Facebook
Add Bookmark
Add to Reading List
Add to Home Screen
Copy
Cancel

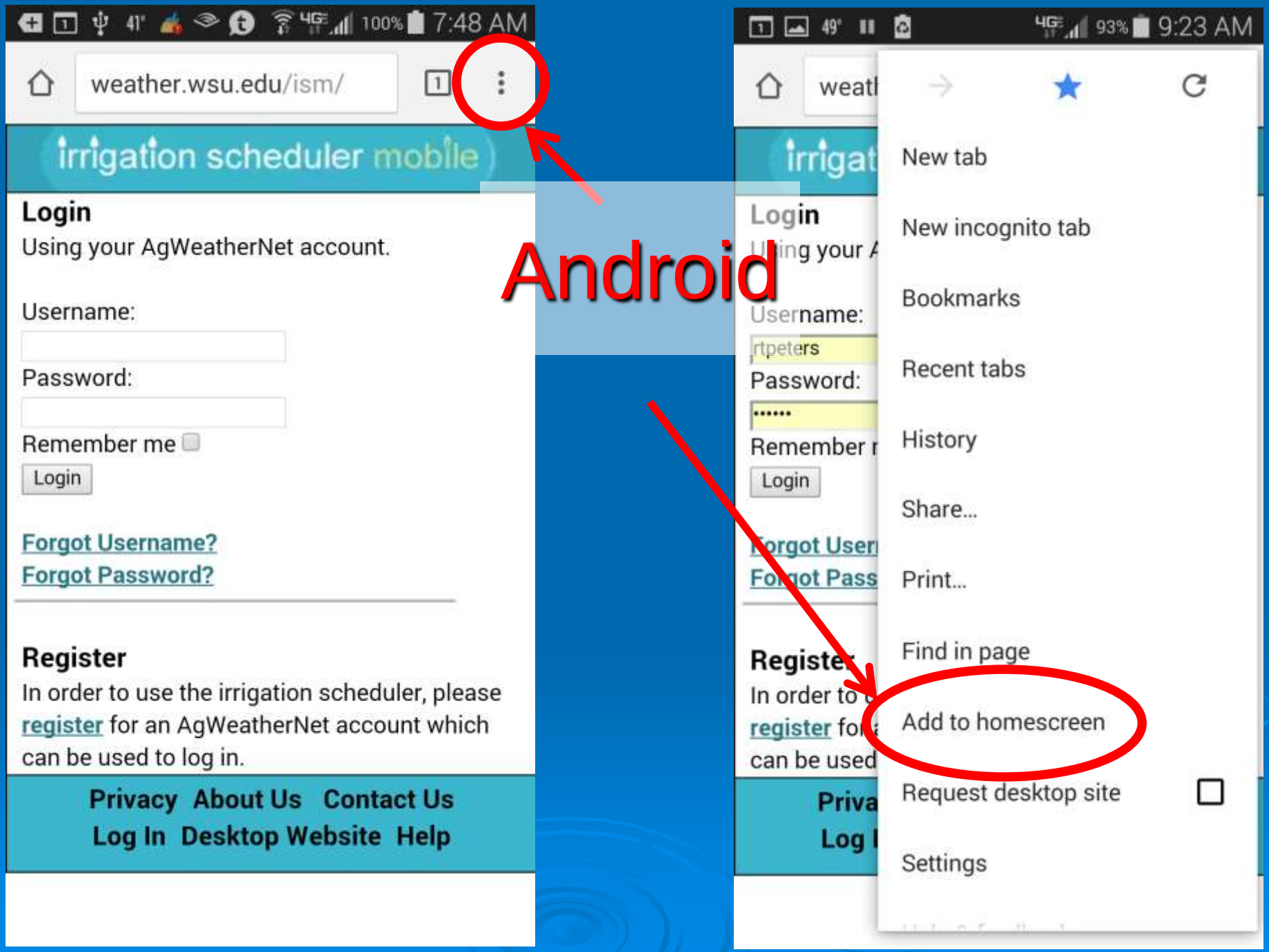
Then


iPod
9:07 AM
Cancel
Add to Home
Add
Irrigation Scheduler - Mobile
http://weather.wsu.edu/is…
An icon will be added to your home screen so you can quickly access this website.
"Mobile"
Mobiles
MobileMe
Q W E R T Y U I O P
A S D F G H J K L
Z X C V B N M
123
space
return

Looks and behaves like an app!

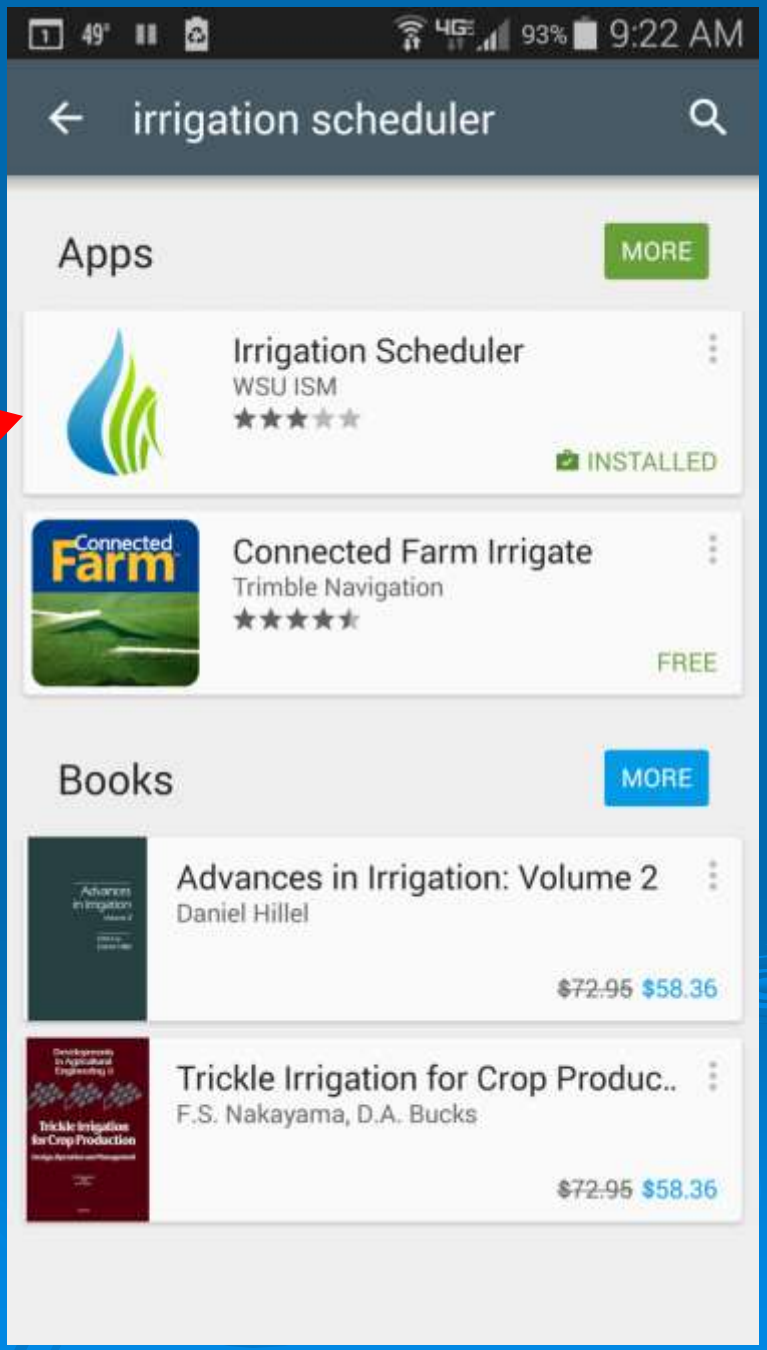
runs in Safari




7:48 AM
weather.wsu.edu/ism/
irrigation scheduler mobile
Login
Using your AgWeatherNet account.
Username:
Password:
Remember me
Login
Forgot Username?
Forgot Password?
Register
In order to use the irrigation scheduler, please register for an AgWeatherNet account which can be used to log in.
Privacy About Us Contact Us
Log In Desktop Website Help
Android
9:23 AM
New tab
New incognito tab
Bookmarks
Recent tabs
History
Share...
Print...
Find in page
Add to homescreen
Request desktop site
Settings

Android

Google Play Store



Additional Features

- Copy settings from an existing field for quick setup/reset for new year.
- One-week ETc forecast
  - NWS max & min forecast & Hargreaves eqtn.
- Can use hrs of irrigation run time instead of inches of applied water.
  - Integrated calculators to help calc app. rate.
- Correction for dry, un-irrigated inter-rows (adjustment to water holding capacity)

Additional Features

- Option for notifications via email or text.
- Download all data to a .csv from full-page.
- Use reporting.
  - Shows what users do and when.
- Can set up different crop defaults for different states, or climatological regions.
  - i.e. can make it state-specific.
    - Crop Kc, growth dates, MAD,
- Free and Open source. (PHP, MySQL)

irrigation scheduler mobile

http://weather.wsu.edu/ism

Drip Irrigation

Rainbird Corp.

Drip/Micro Irrigation

- High cost
- Very clean water required (filtration)
- Operates at low pressures
- Most efficient. Very little loss to evaporation
- High uniformity.
- Easily automated
- Most control over timing and amounts
- Suitable to all soil types
- Foliage stays dry

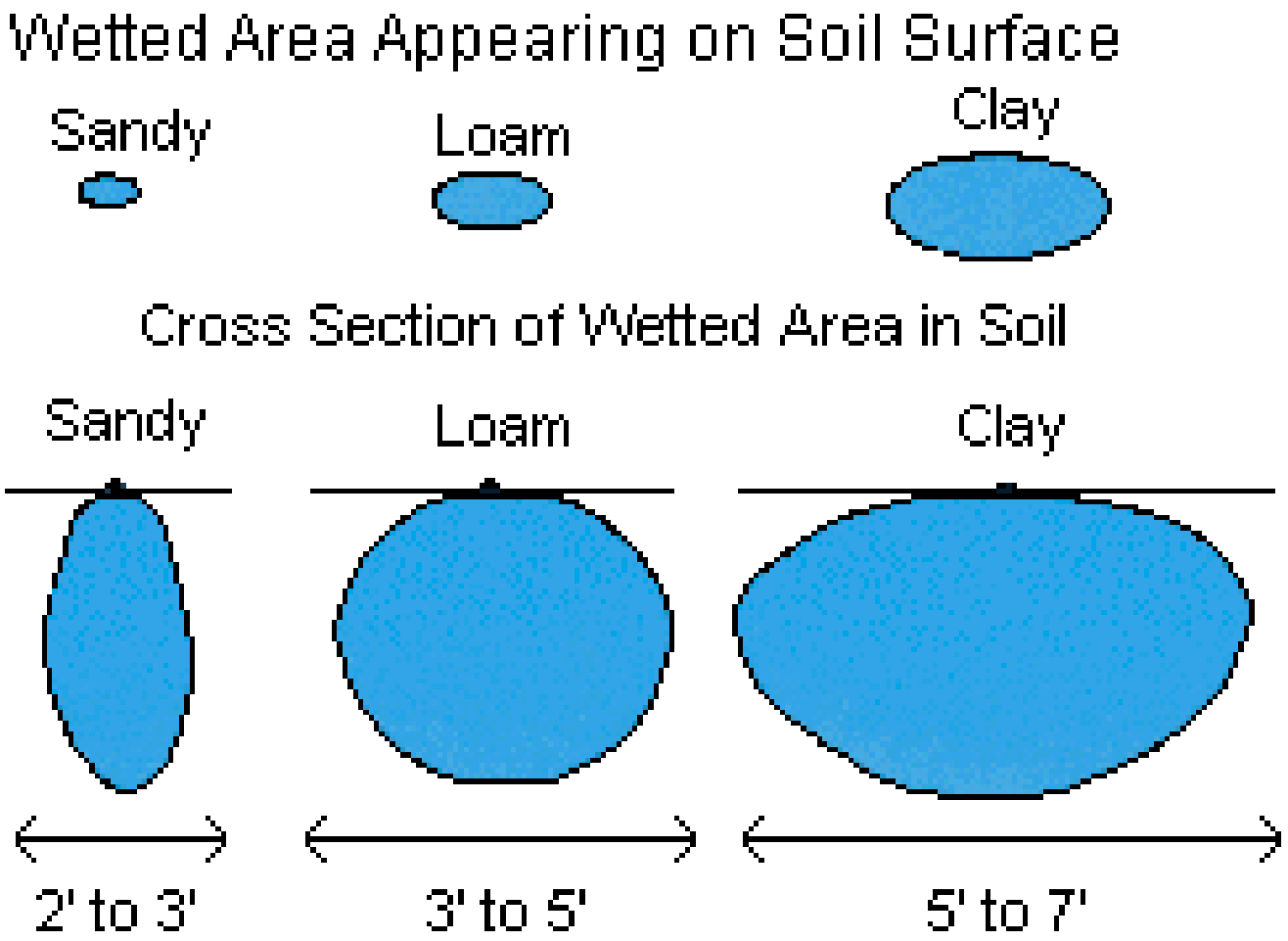
Drip Irrigation

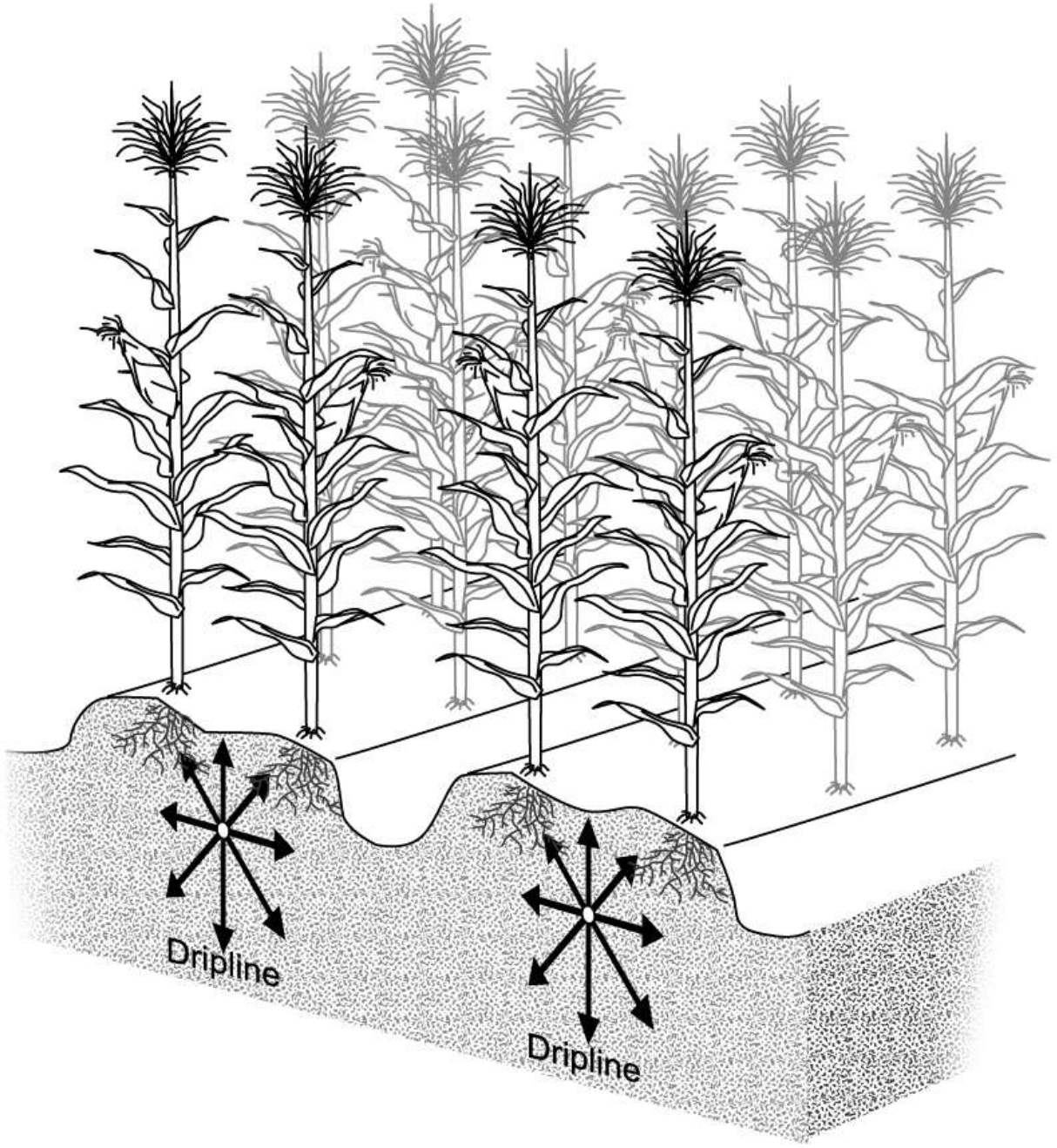
- Highest cost
- Very clean water required (filtration)
- Operates at low pressures
- Most efficient. Very little loss to evaporation
- Easily automated
- Most control over timing and amounts
  - short burst of small amount means small wetted area
- Suitable to all soil types
- Foliage stays dry (less disease)
- Inter-rows stay dry (fewer weeds)

Efficiency Comparison

- Surface =~ 50%
- Sprinklers =~ 70%
- Drip =~ 90%

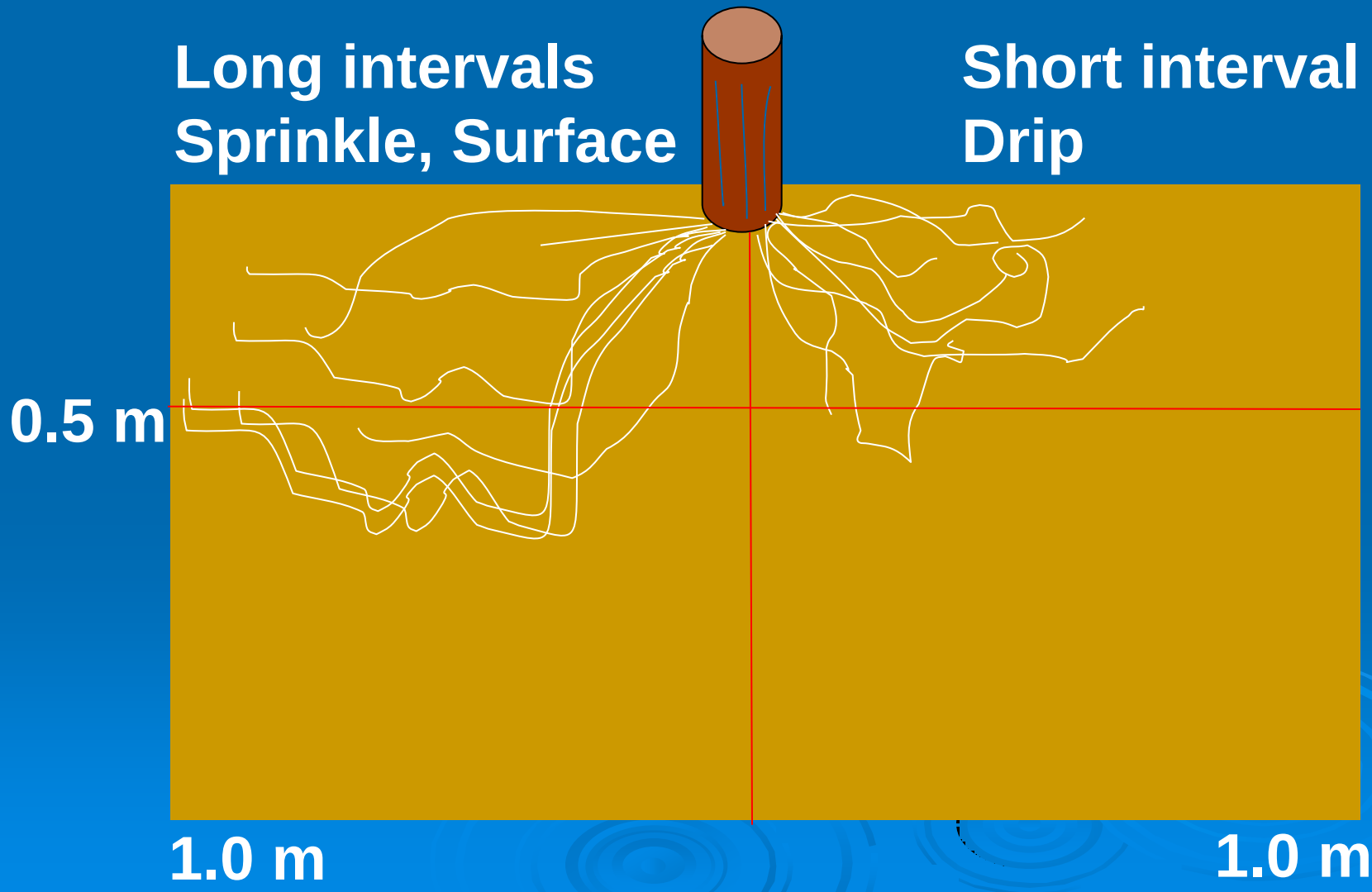
Drip


Wetted Area Appearing on Soil Surface
Sandy
Loam
Clay
Cross Section of Wetted Area in Soil
Sandy
Loam
Clay
2' to 3'
3' to 5'
5' to 7'

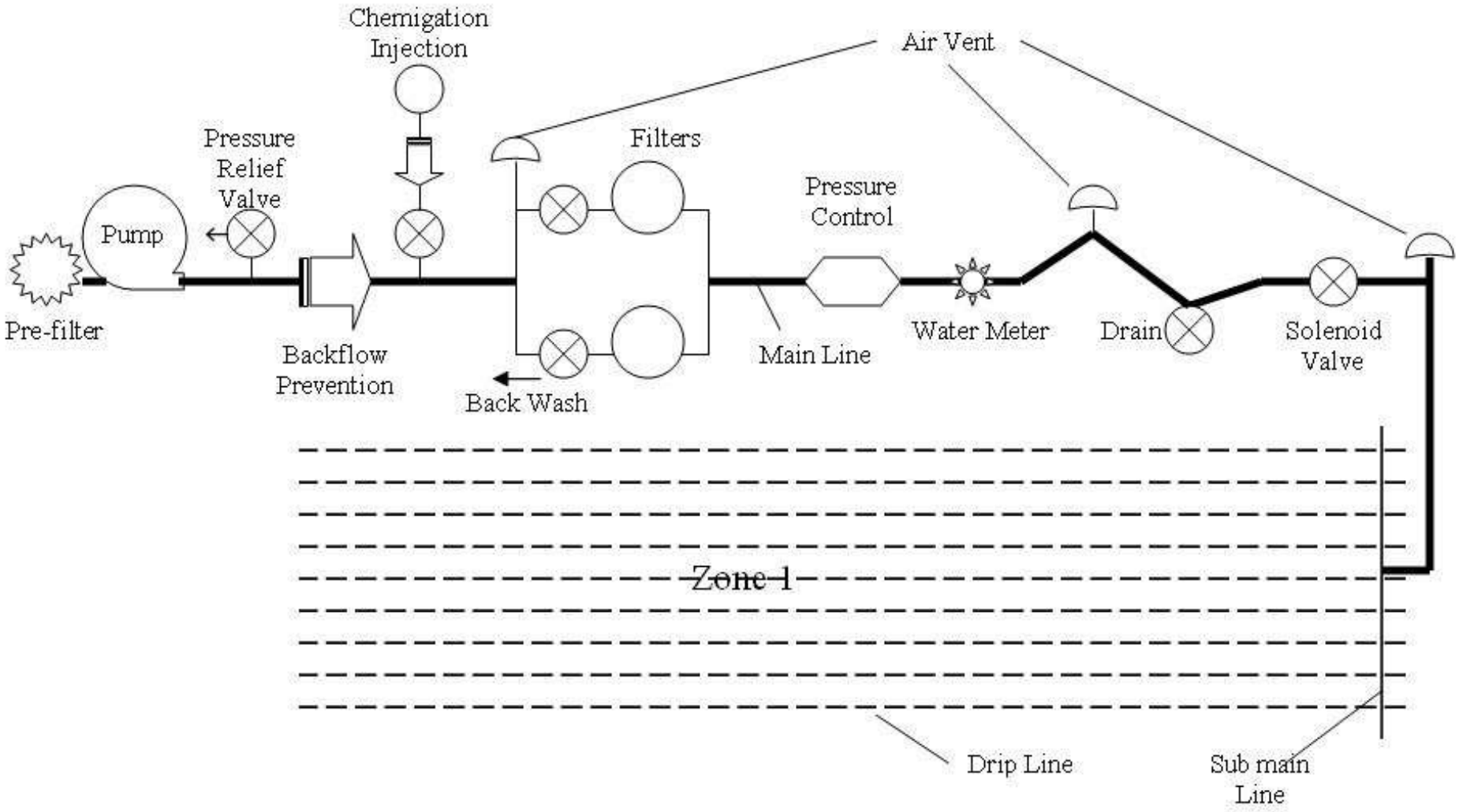


Drawing from KSU Irrigation Extension Education

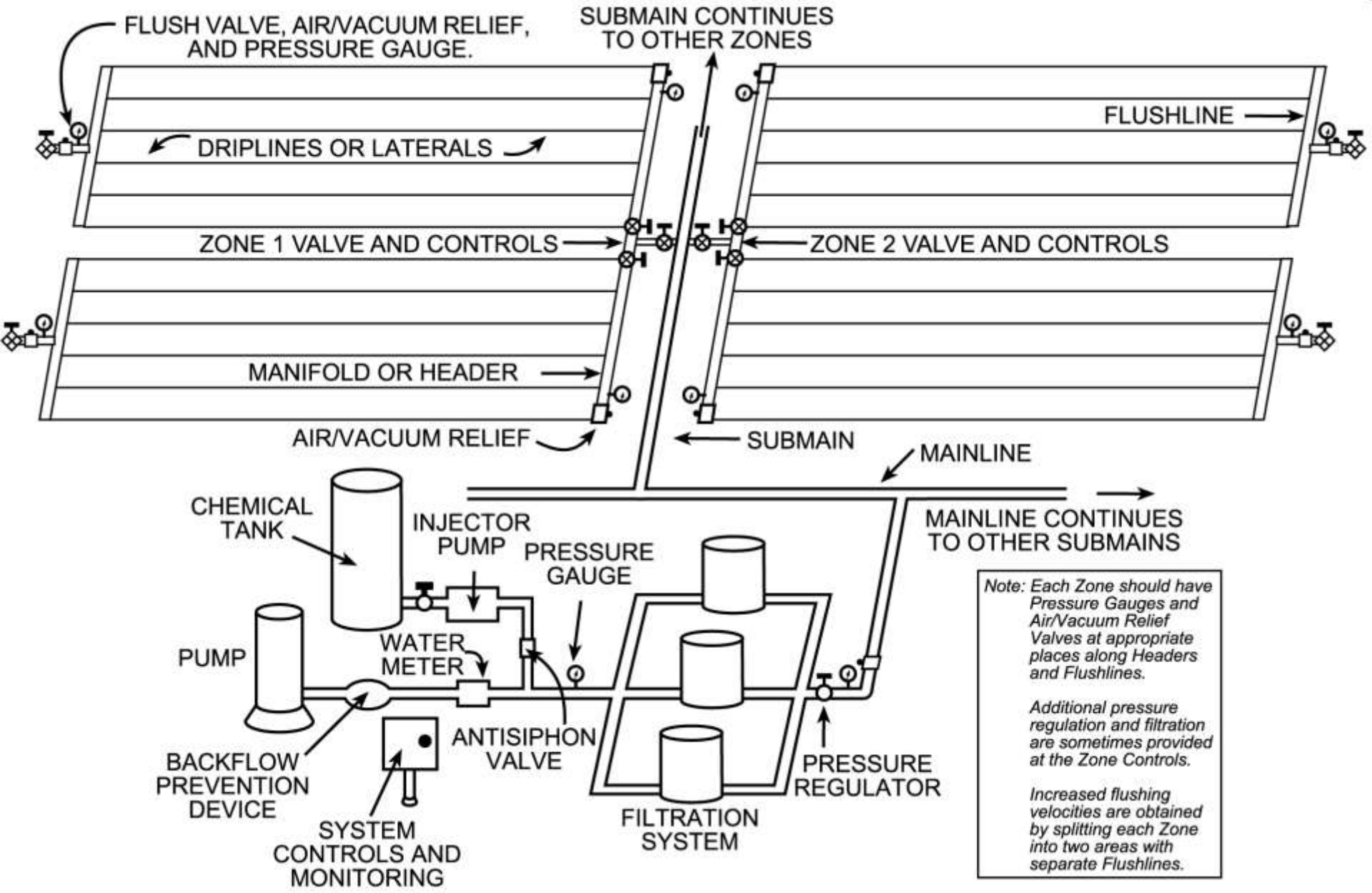
Root Distribution



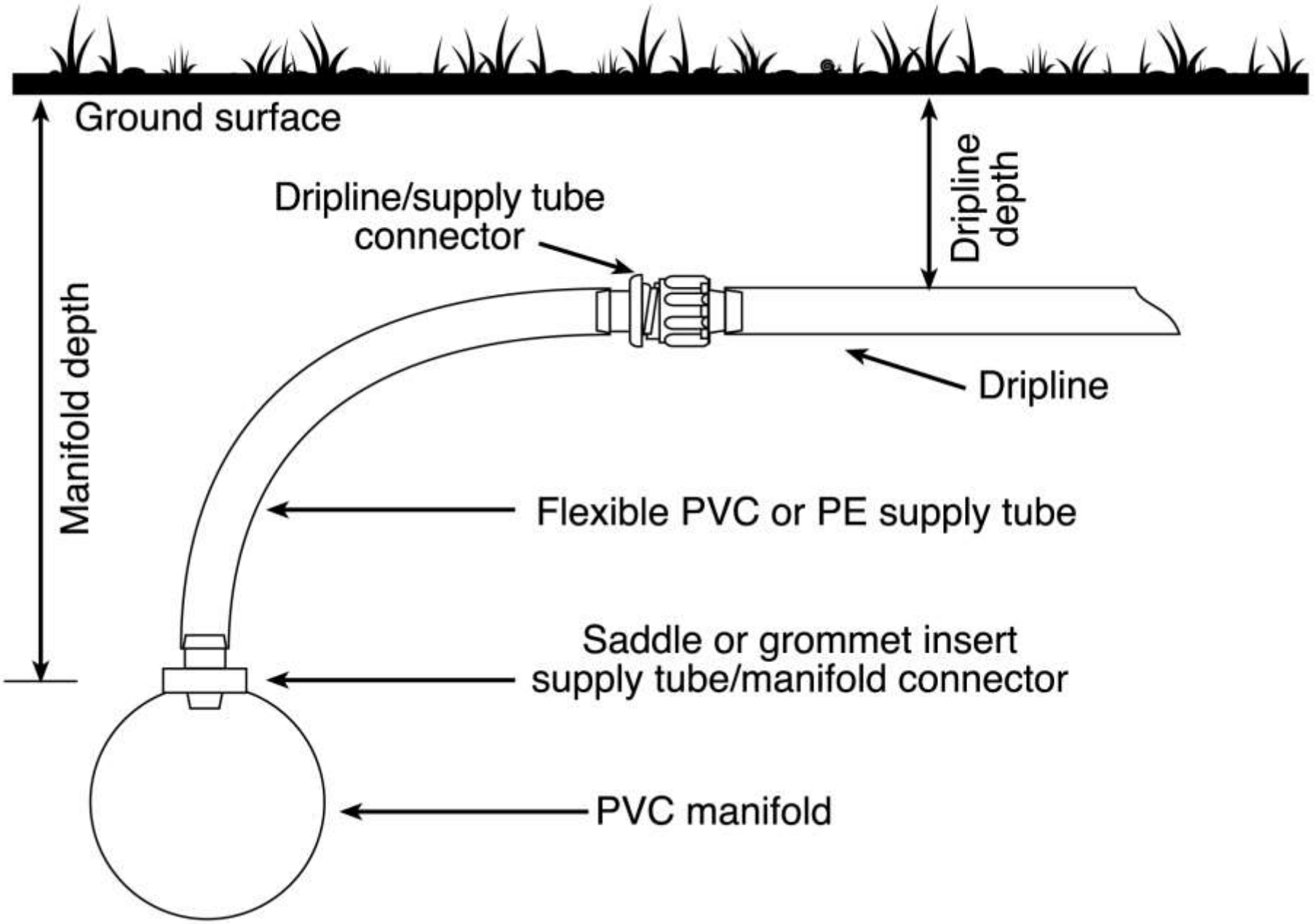
Drip System Components



Oregon State University. cropinfo.net



Drawing from KSU Irrigation Extension Education



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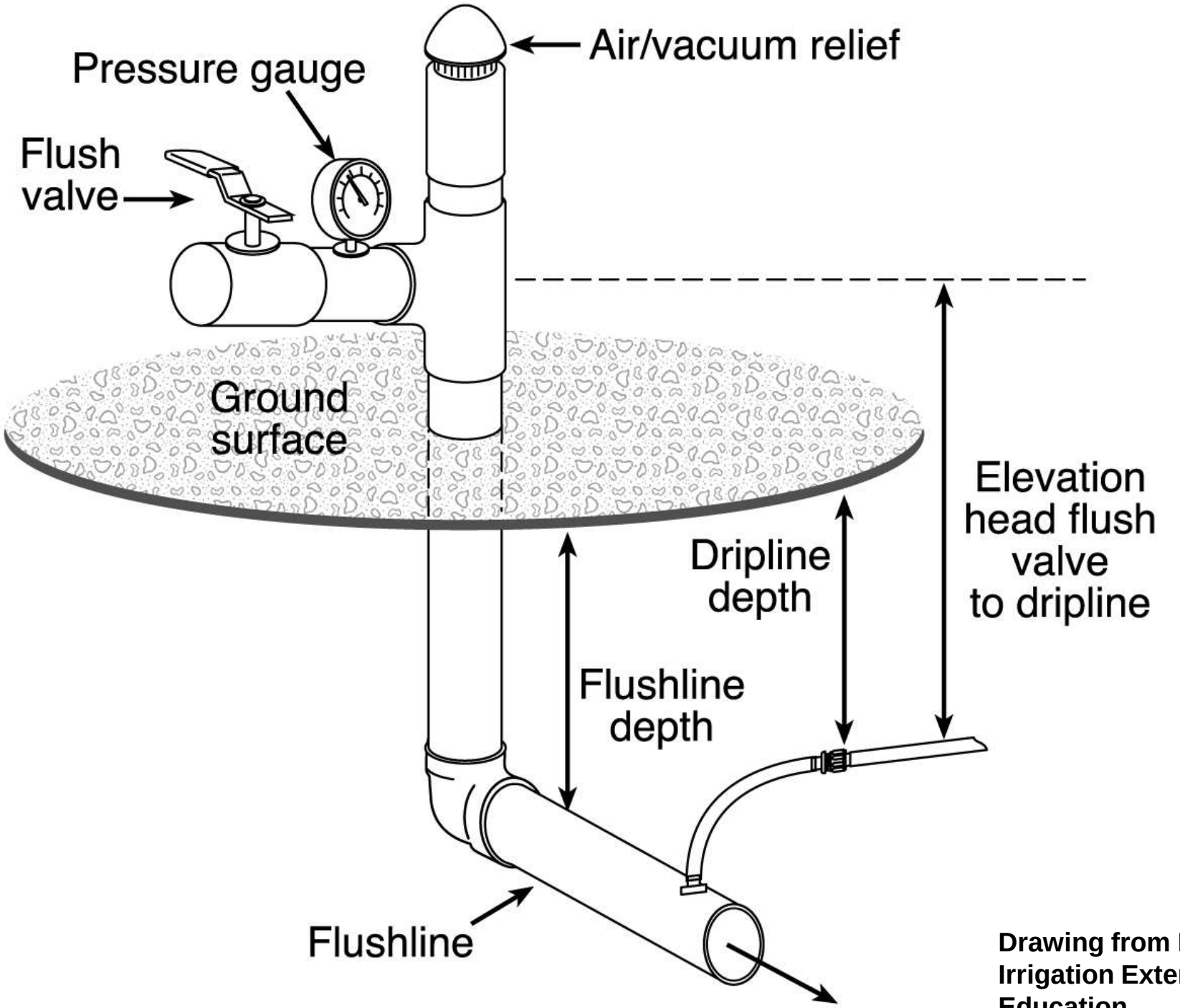


Drawing from KSU Irrigation Extension Education

The anatomy of a dripper

Figure 1-10: Orifice flow emitter

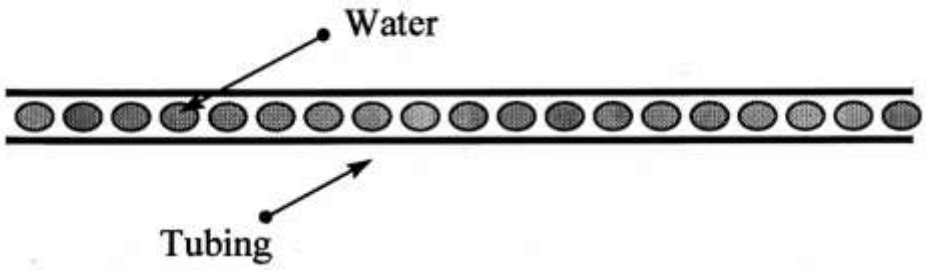


Figure 1-11: Laminar flow emitter

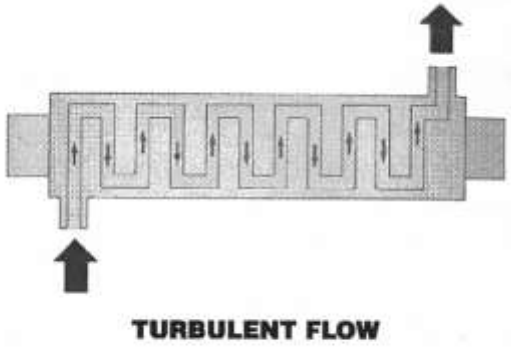
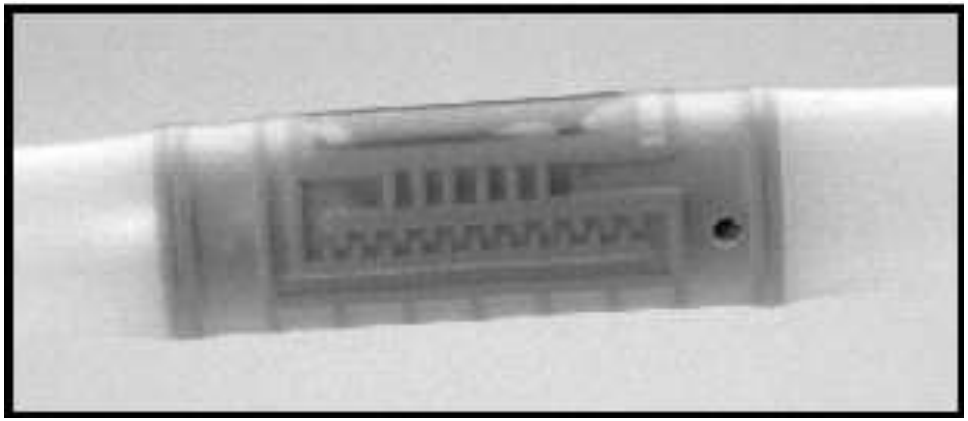


Figure 1-12: Turbulent flow

In-line turbulent flow emitters



Pressure Compensating Emitters

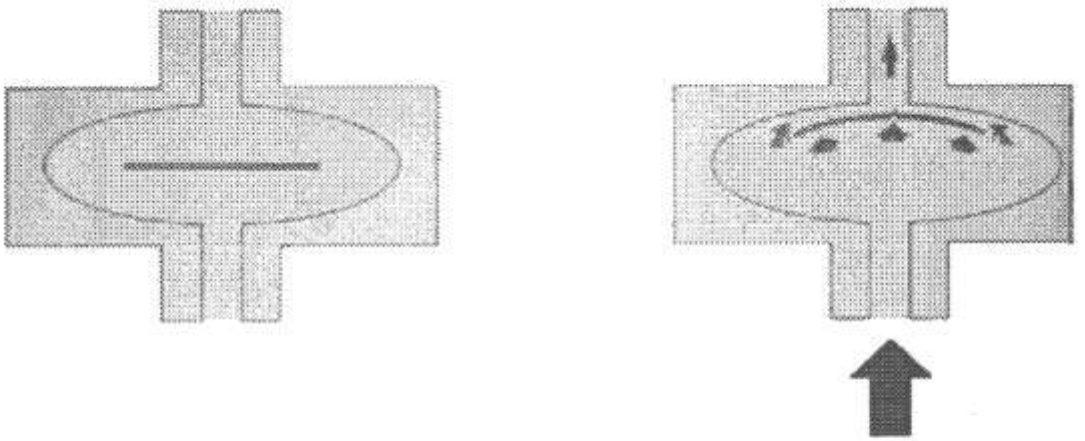
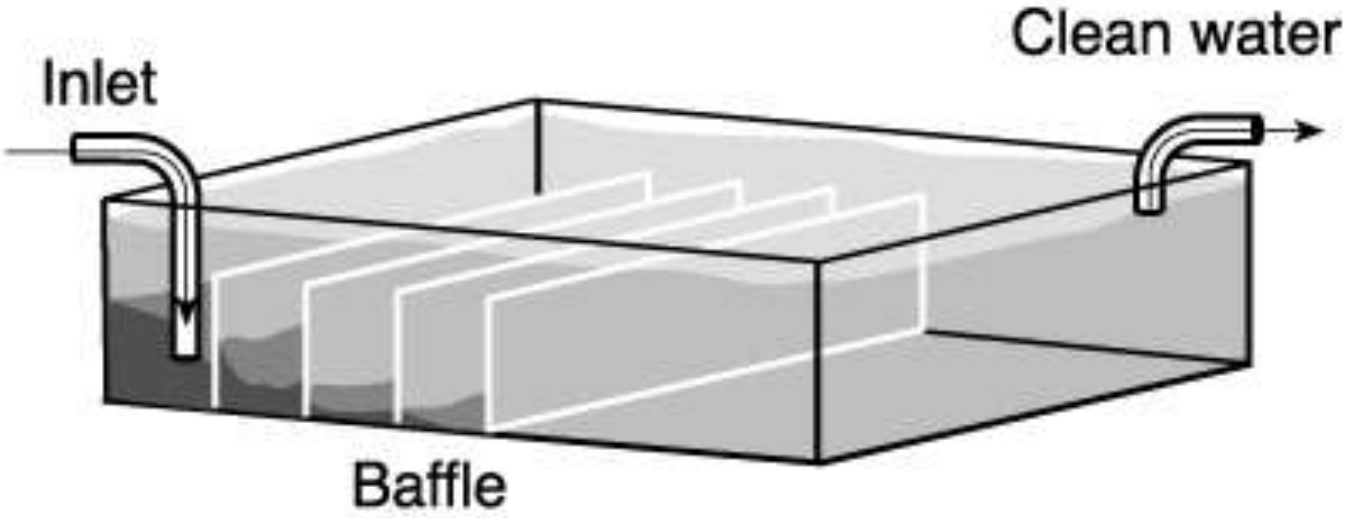


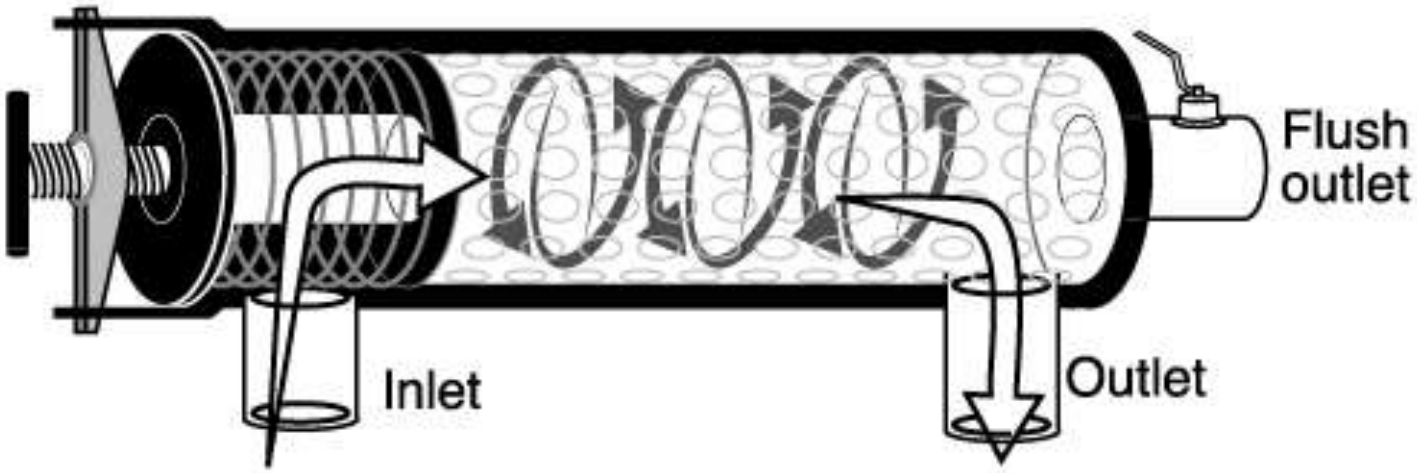
Figure 1-14: Flexible diaphragm/compensating

Filtration.
It’s a must!



Settling Basin

Drawing from KSU Irrigation Extension Education



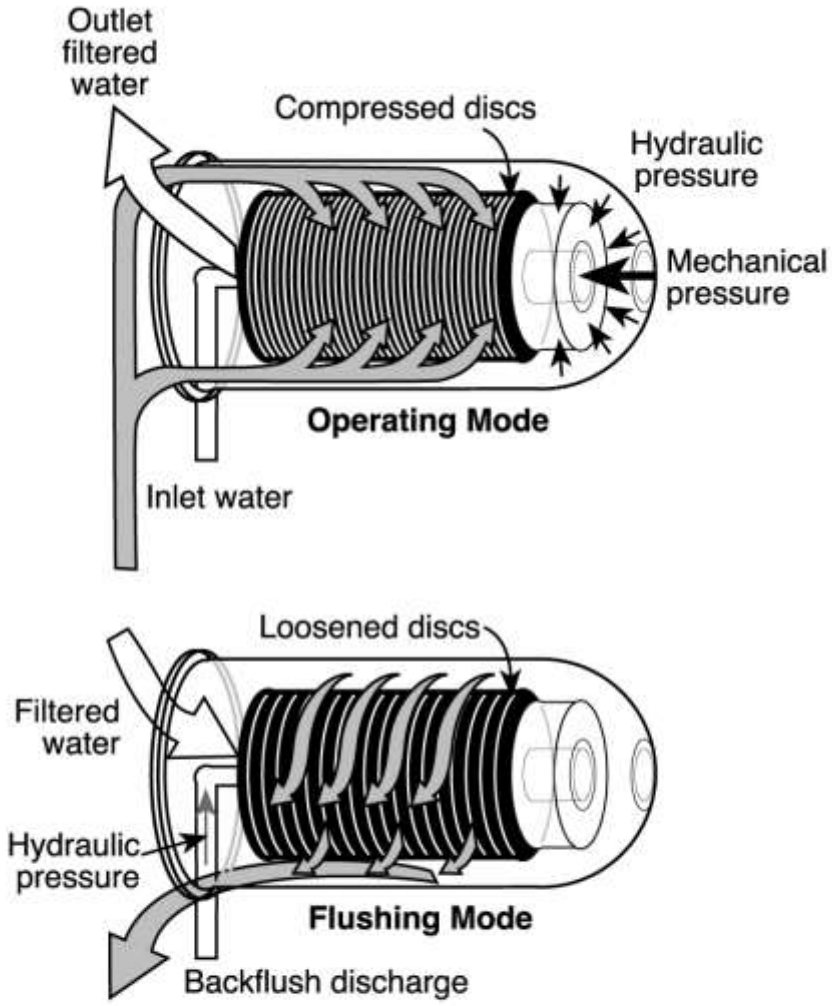
Screen Filter

Drawing from KSU Irrigation Extension Education

Screen Filters

Disk Filters

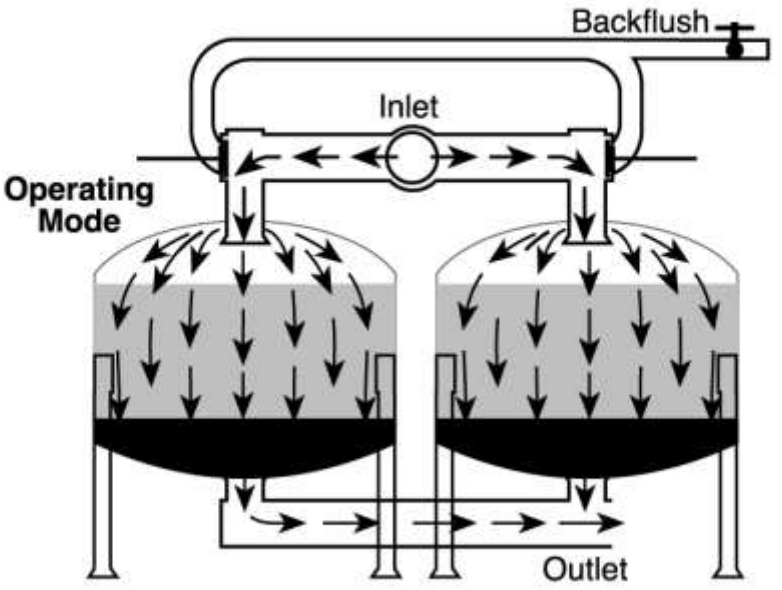
The disks used in disk filtration.

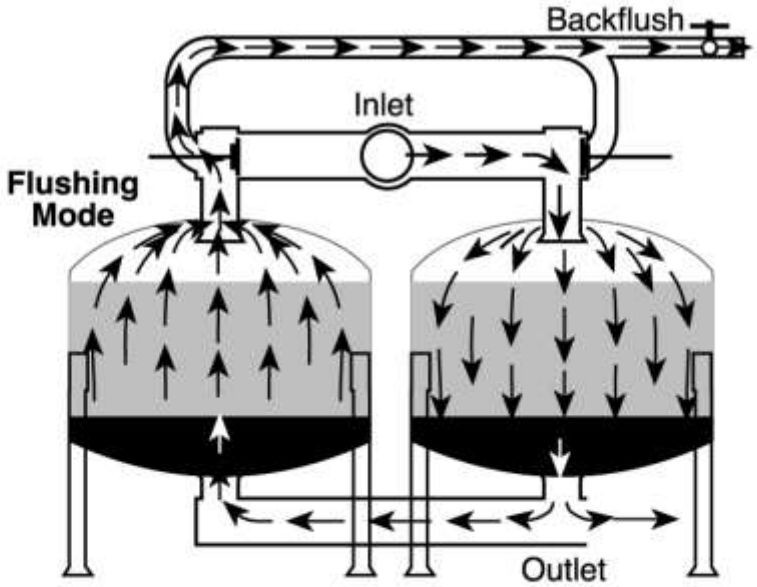


Disk Filter

Drawing from KSU Irrigation Extension Education

Sand Media Filters





Sand Media Filter

Drawing from KSU Irrigation Extension Education

FLOW-GUARD
6 3:35PM

Flushing

6 3:06PM

Hoses

Polyethylene

PVC

Lay-Flat Tubing

Lay-Flat Header Hose

Polyethylene
Header Hose

AMFT
6 3:13PM

Drip Tubing

Pressure Regulators

6 4:13PM

Air Vents/Vacuum Relief

Air Release/ Vacuum Breaker

6 4:28PM

Line Placement

Suspended Drip Lines

6 3:10PM

Surface Drip

6 3:07PM

10 4:35PM

- Drip irrigating under plastic is *very* efficient, i.e. very little water lost to evaporation
- Use less water when dripping under plastic
- “Out of site, out of mind”
- Check soil water status frequently
- Use information based irrigation scheduling
- Saturated soil conditions promote root rot.

Buried Drip

Buried Drip

- Good
  - Tubing lasts longer
  - Out of the way
  - Less risk of damage
- Bad
  - Root Intrusion
  - Can’t see plugged emitters

Drip Line Application Rate

$$ApRt = 231.1 \frac{EmitterFlow}{RowSpc \cdot EmitterSpc}$$

ApRt = Application Rate (inches per hour)
EmitterFlow = Emitter flow rate (gallons per hour)
RowSpc = Spacing between rows (inches)
EmitterSpc = Spacing between emitters (inches)

Drip Rate Calculator - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dns1.prosser.wsu.edu/irrigation/drip.php?calcs=1&drip=1

Google

http://irrigation.wsu.edu

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Drip Rate

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  - -Drip
    - -Drip Line
  - -Sprinklers
  - -Center Pivot
  - -General
  - -Residential
  - -Unit Conversions
  - -Water Measurements
  - -Washington Data
  - -All Calculators
- FAQs & Tutorials
- WSU Irrigation Research
- Irrigation Fact Sheets
- Irrigation Glossary
- Useful Irrigation Links
- Contact

Use to calculate the water application rate of drip irrigation lines(tape,tubing) given the flow rate from individual emitters, the spacing of the emitters along the drip line, and the spacing beween the drip lines.

Unit Descriptions

Emitter Flow: [ ] gph

Distance beween drip lines: [ ] in

Emitter Spacing along the line: [ ] in

calculate

Application Rate: [ ] in/hr

Contact an equipment dealer for help with your design

Done | Now: Cloudy, 43° F | Mon: 52° F | Tue: 52° F | Wed: 58° F | Thu: 57° F

Drip Rate Calculator - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dns1.prosser.wsu.edu/irrigation/drip.php?calcs=1&drip=1

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Drip Rate

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Distance beween drip lines: [ ] in

Emitter Spacing along the line: [ ] in

calculate

Application Rate: [ ] in/hr

Done

Now: Cloudy, 43° F | Mon: 52° F | Tue: 52° F | Wed: 58° F | Thu: 57° F

Chemigation/Fertigation

- Using irrigation water to apply pesticides, herbicides (chemigation) or fertilizers (fertigation).

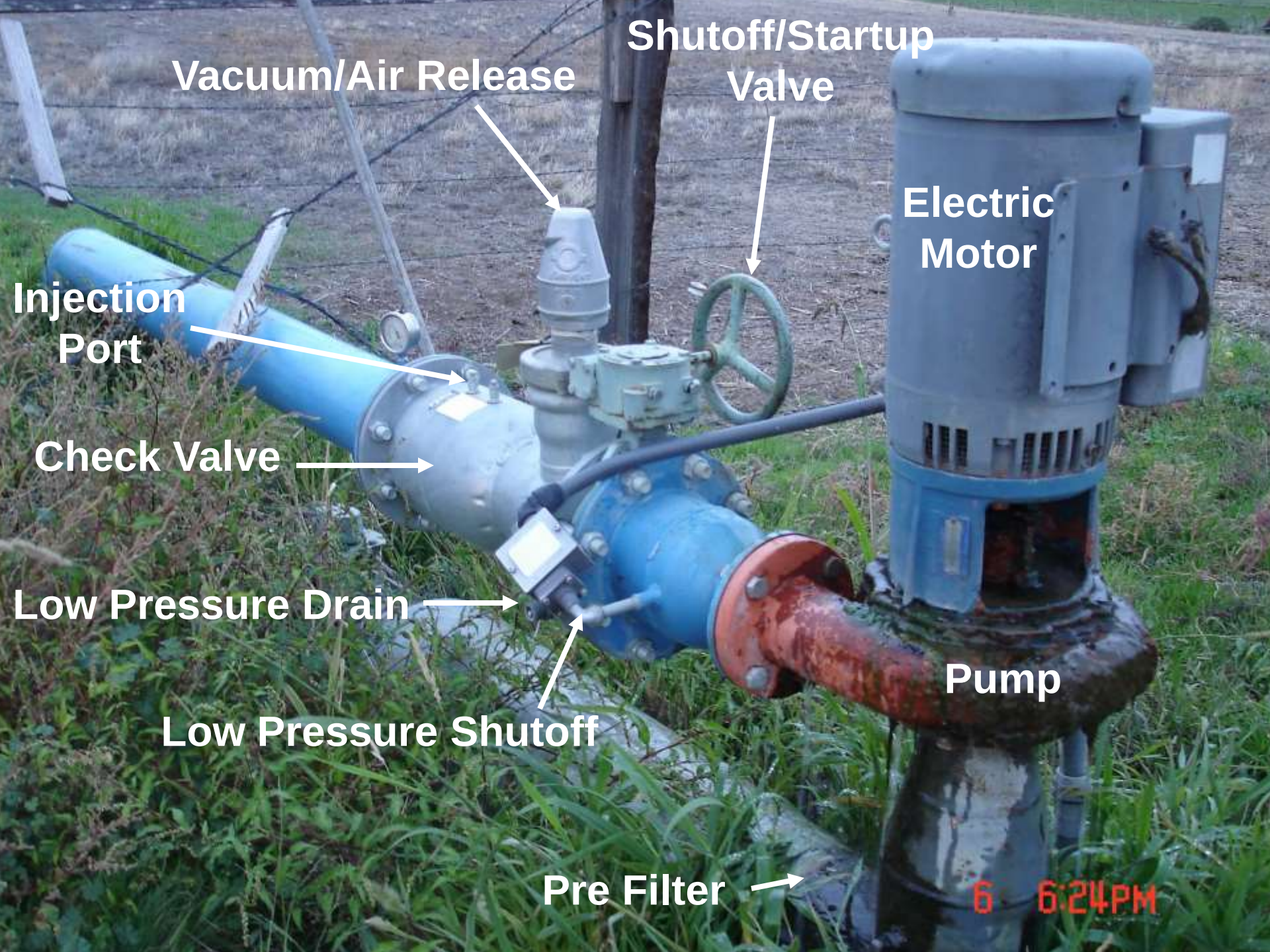
Follow the Label

Chemigation

- Water must be applied in a “uniform and controlled” manner (Pivots, drip OK. Surface, no)
- Scientifically based water management system should be in place
- Minimize deep percolation and runoff
- Calm (non windy conditions)
- System calibrated and operated by knowledgeable person
- Follow EPA guidelines

Required on Water Line
in order from water pump

1. Vacuum relief
2. Low pressure drain
3. Low pressure switch (shuts off chemical injection pump if water pump stops)
4. Functional check valve (backflow prevention device)
5. Injection port


Vacuum/Air Release
Shutoff/Startup Valve
Electric Motor
Injection Port
Check Valve
Low Pressure Drain
Low Pressure Shutoff
Pump
Pre Filter
6 6:24PM

Req'd on Chemical Injection Line
In order from Chemical Tank

1. Interlocked (with water pump) normally closed solenoid operated valve
2. "Metering" chemical injection pump
3. Normally closed injection line check valve
4. Injection port

Simplot
GUARD
6 3:27PM

INHALATION HAZARD
6 3:37PM

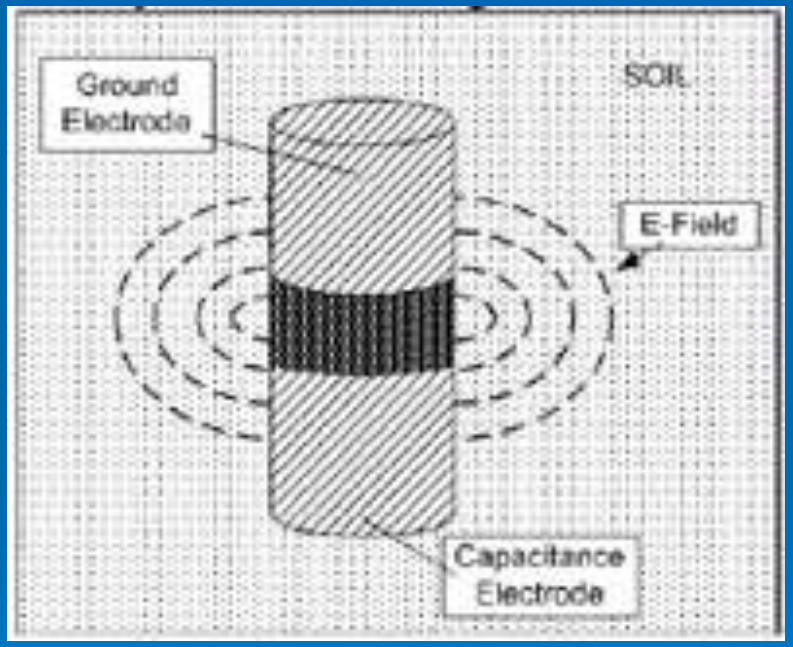
Evaporative Cooling?

- Works! But only when the canopy is wet.
- On hot days, a wet canopy dries quickly.
- Requires fast pivots, or rapid cycling of sprinklers with small amounts / irrigation
  - Might get behind in irrigation.
- Solid set – low flow, sprinklers must stay on during the hot part of day.
- Requires lots of water!
  - Saturated soils,
  - Root rot problems,
  - Leached nitrates, etc

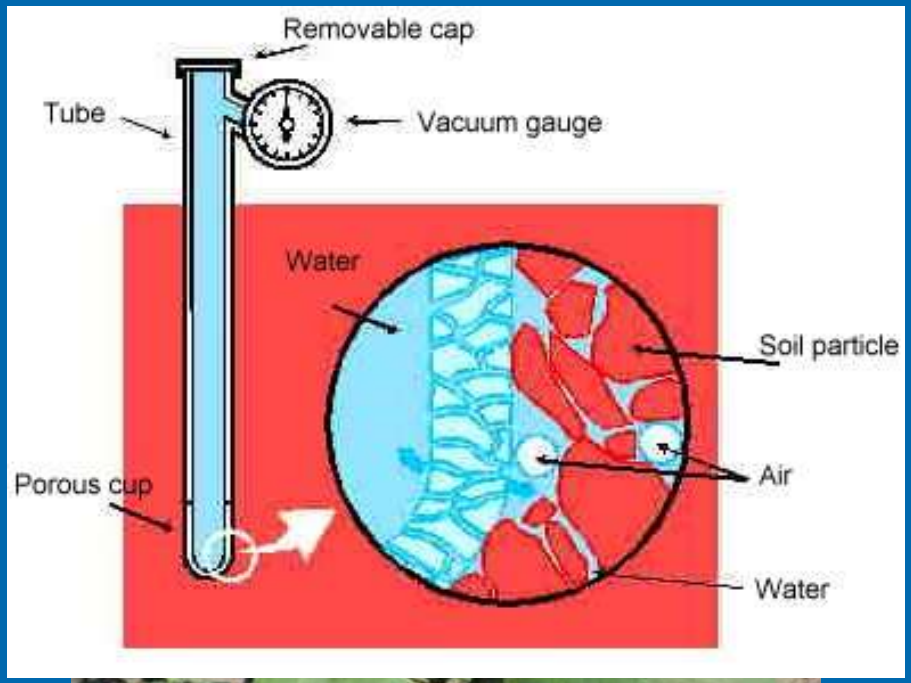
Soil Moisture Sensors

Capacitance Probes

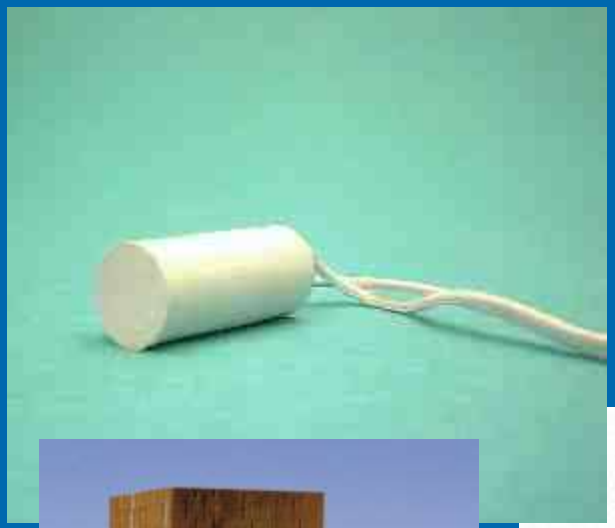
Capacitance Sensors



Tensiometers



Resistance



Soil Moisture Sensors
The “Look and Feel Method”

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