Walnut Orchard Irrigation Systems

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Walnut Short course Davis Nov. 2018

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Outline

- Irrigation systems in walnut orchards
- Operation and maintenance of irrigation systems
- Quantifying irrigation system performance
- Applying the correct amount of water and fertilizer through Fertigation
- Heading off Problems
- Concluding Remarks

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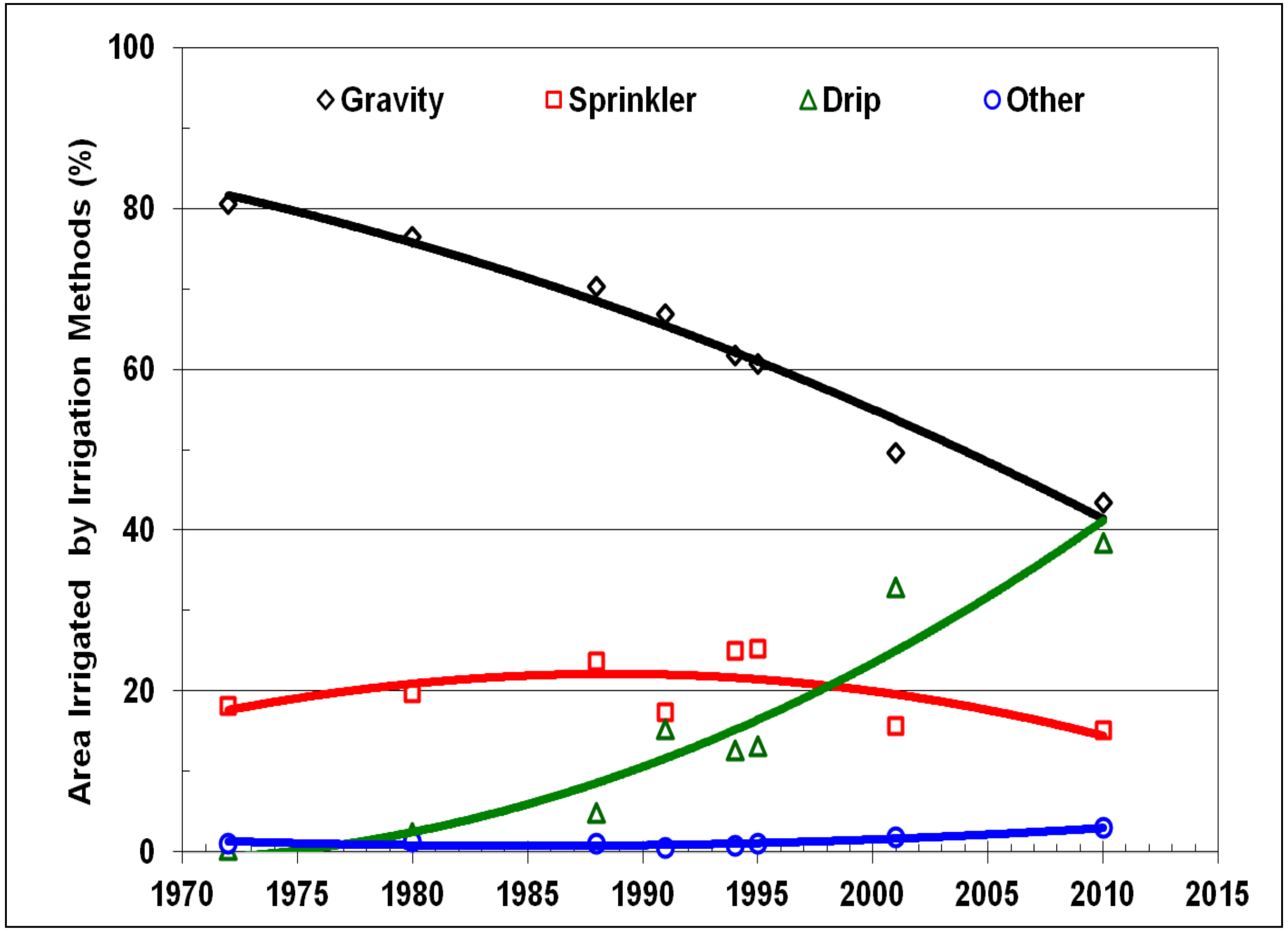
Snapshot of Trends in Irrigation Systems in California

- Water Agencies and regulators provide financial incentives to growers to shift to micro-irrigation systems (SWEEP, EQIP, CEC)



Approximately 30% decline in field crops between 2006 and 2015 and increase in permanent crops

Irrigation Survey 2010

(Tindula, Orang & Snyder, 2013)

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Irrigation Systems in Walnut Orchards

- Goals
  - Apply water to meet walnut orchard demand
    - Seasonal demand
    - Peak demand
    - Frost protection (in some areas)
    - Without tree/crop damage
    - Without runoff or excessive deep percolation

  - Apply water uniformly across orchard (conventional approach) or use variable rate irrigation that accounts for spatial and temporal variability.

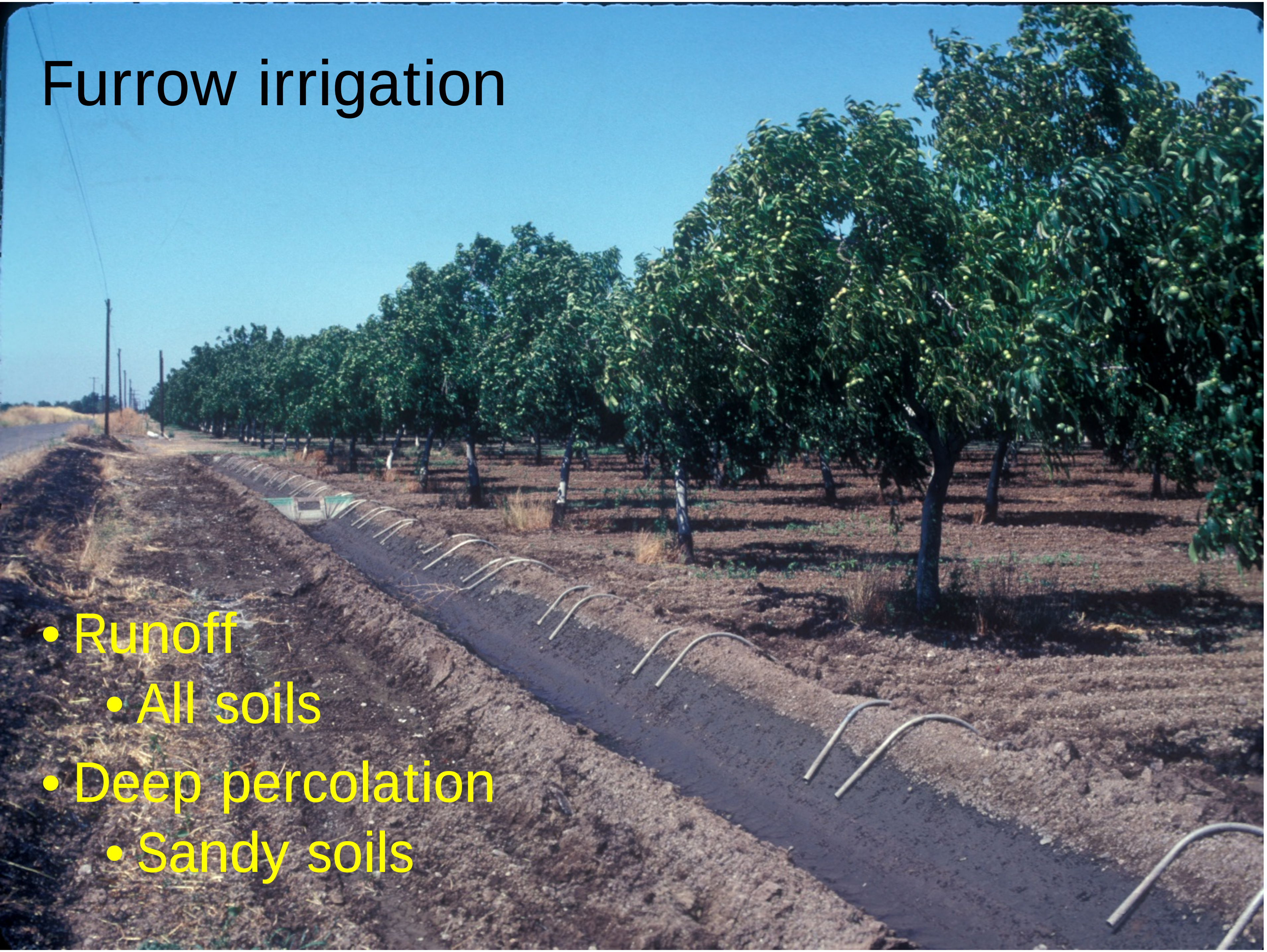
  - Apply water with consistent reliability.

Irrigation systems in walnut orchards

- **Surface irrigation systems (Gravity)**
  - Furrow irrigation
  - Border check irrigation

- **Pressurized systems**
  - Permanent set sprinklers
  - Microsprinklers
  - Drip (surface and subsurface)

Furrow irrigation



- Runoff
  - All soils
- Deep percolation
  - Sandy soils

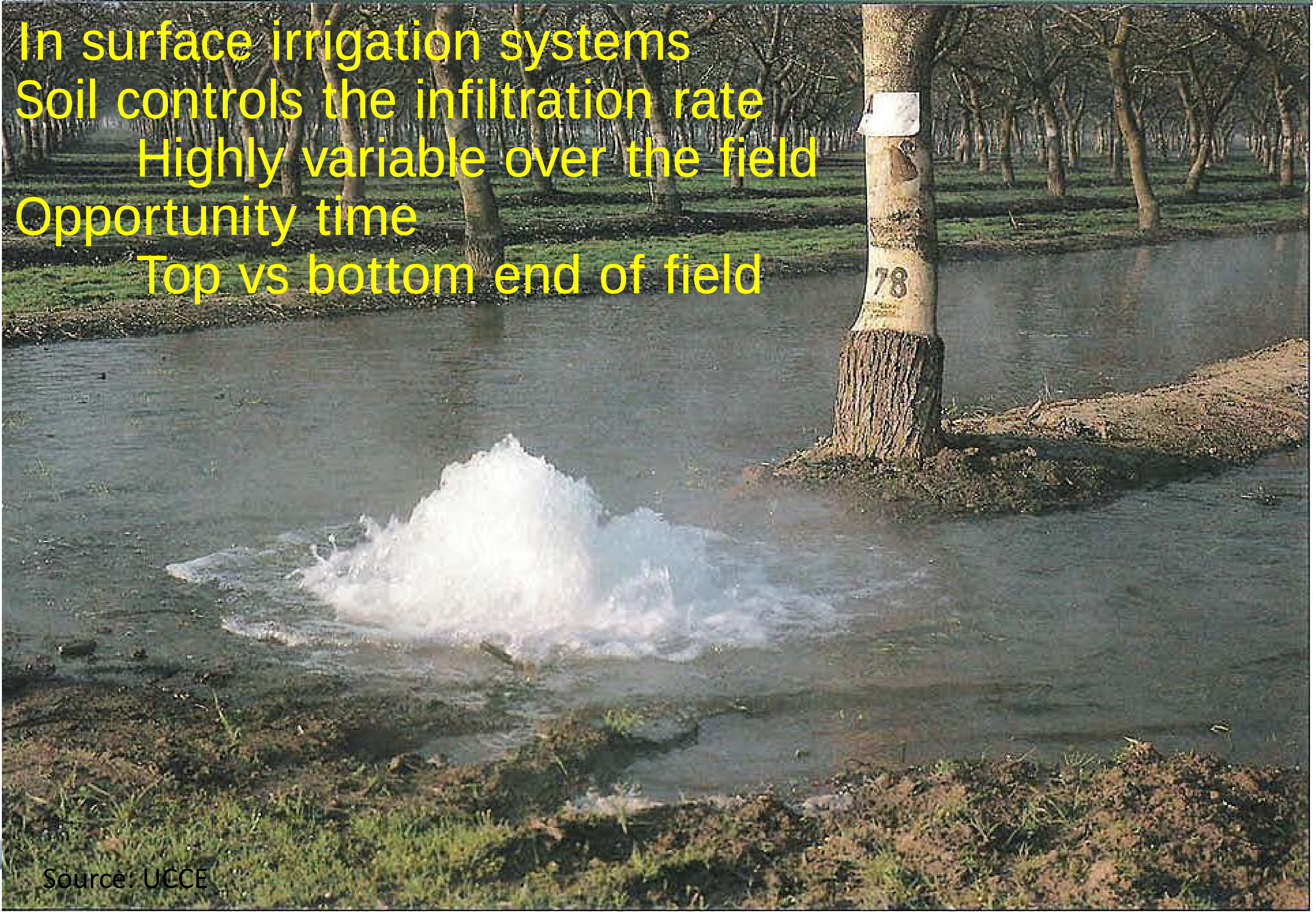
In surface irrigation systems

Soil controls the infiltration rate

- Highly variable over the field

Opportunity time

- Top vs bottom end of field



Source: UCCE

Permanent set sprinklers in a Walnut Orchard in Tehama CA

Designed to be able to meet irrigation and frost protection needs

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- In young orchards, microsprinkler can increase potential for soil water evaporation compared to drip.
- Can encourage bigger root volume.
- Better for frost protection compared to drip.

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In a young walnut orchard drip irrigation reduces soil water evaporation.
Need to add another drip line when the tree fully develops in order to meet ET demand.

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Subsurface drip irrigation in a Walnut orchard in Yolo County CA.
Minimizes soil water evaporation.

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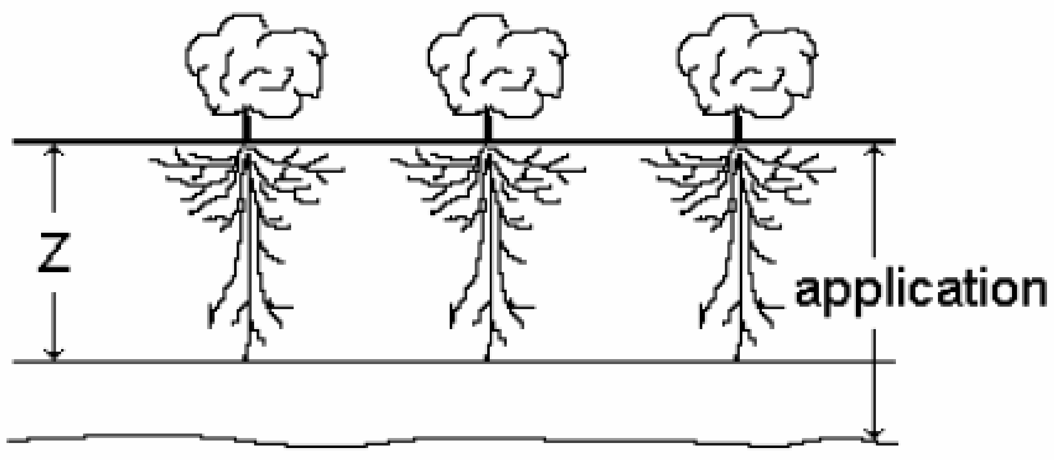
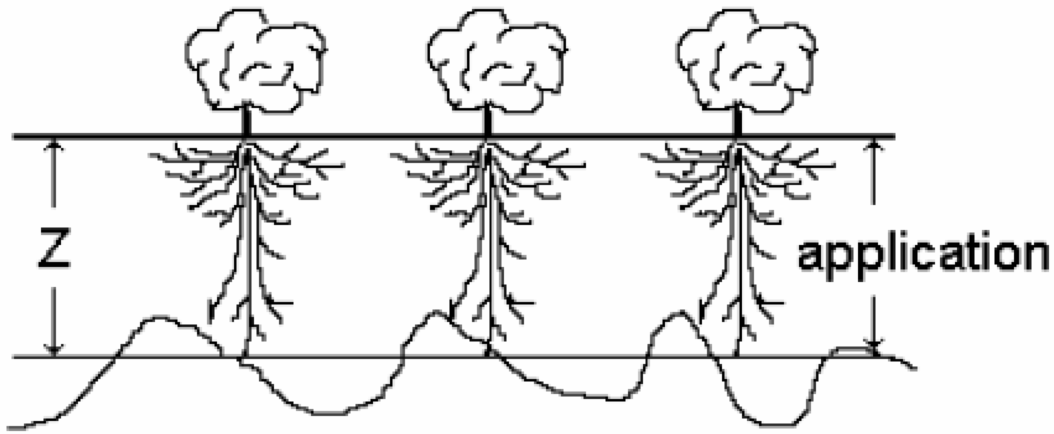
Uniformity and efficiency



Uniform but average applied soil water depth exceeds soil water deficit.

Deep percolation.



Average applied depth is correct but non uniform.

Under irrigation and deep percolation.

Uniformity a function of system design and maintenance | Application depth influenced by runtime.

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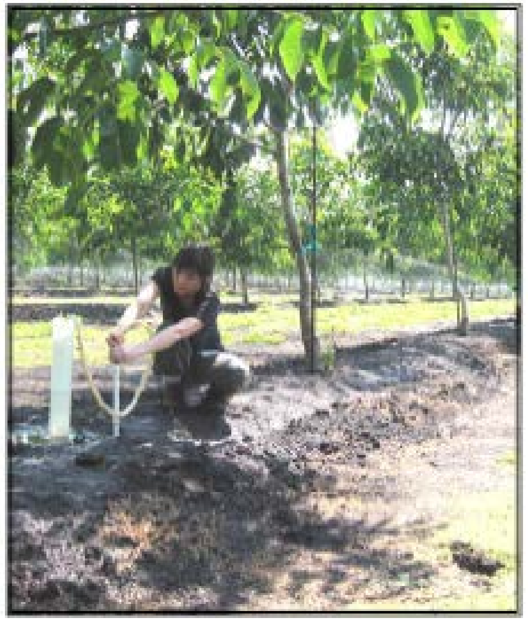
Distribution Uniformity

- Distribution Uniformity (DU lq)
  - 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 pressurized system



Source: Resource Conservation District of Tehama

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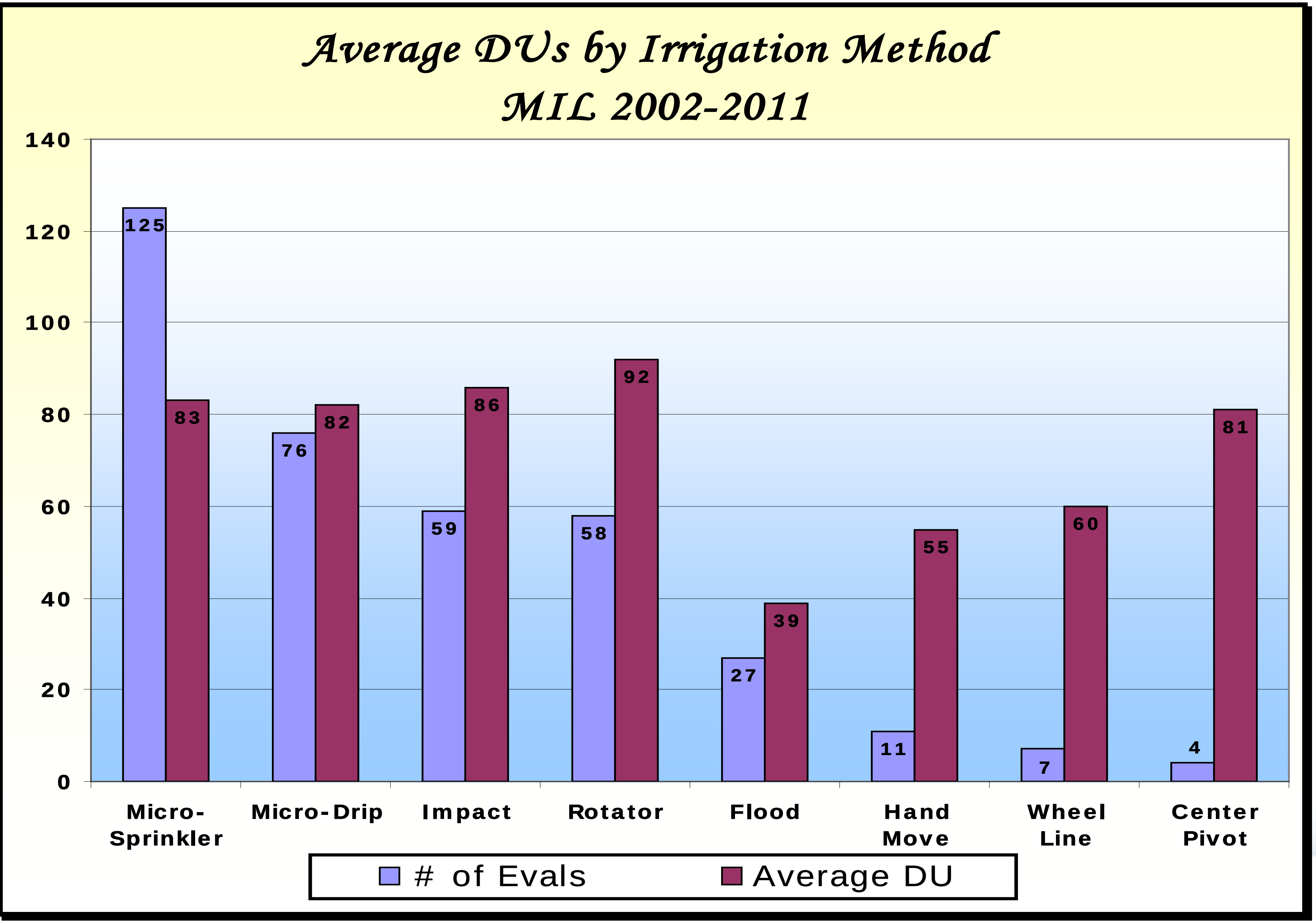
Irrigation Uniformities of Various Irrigation Systems

Data from mobile irrigation lab run by the Tehama County Resource Conservation District



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of Systems Tested

System	Time Span		
	(88–96)	(97-05)	(06-14)
Drip	109	210	545
Micro Sprinkler	128	252	362
Percent Micro	44%	73%	96%

Irrigation System Uniformities

System	County Average		
	(88–96)	(97-05)	(06-14)
Drip	77	84	91
Micro Sprinkler	80	82	86

Source: Brian Hockett, North West Kern RCD, Mobile Irrigation Laboratory

Distribution Uniformity not Perfect

Engineered Distribution Uniformity

DU not perfect

Manufacturing variability
Pressure differences
Emitter clogging

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Sprinkler
Irrigation management affects application depth.

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Irrigation scheduling using ETo values based on a 20-year average.

Manteca, CIMIS Station 70.

Leaf out: 3/15 Leaf drop: 11/15

Mature Walnut Orchard -- 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


Cover increases water use by 25-30%
Source: T. Prichard

How long should you run your irrigation system?

Example 1: Assuming drip irrigation system

Step 1: Convert crop water use from in/day to gal/day

Water use by Walnut tree (gal/day) = Tree Spacing (ft^2) X Crop Water Use (in/day) X 0.623

Water use by Walnut tree (gal/day) = 20 * 20 (ft^2) X 4.66/15 (in/day) X 0.623 ~ 75 gal/day

Step 2: Determine application rate of irrigation system (gal/hr)

Application Rate (gal/hr) = Number of emitters per tree X Emitter discharge rate (gal/hr)

Application Rate (gal/hr) = 4 X 1 (gal/hr) = 4.0 gal/hr

Step 3: Determine irrigation system runtime (hr/day)

$$\text{Runtime (hour/day)} = \frac{\text{Water use by Walnut tree }(\frac{\text{gal}}{\text{day}})}{\text{Application rate }(\frac{\text{hr}}{\text{day}})} = \frac{75}{4} = \mathbf{18.8\ hr/day}$$

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How long should you run your irrigation system?

Example 2: Assuming microsprinkler irrigation system

Step 1: Convert crop water use from in/day to gal/day

Water use by Walnut tree (gal/day) = Tree Spacing (ft^2) X Crop Water Use (in/day) X 0.623

Water use by Walnut tree (gal/day) = 20 * 20 (ft^2) X 4.66/15 (in/day) X 0.623 ~ 75 gal/day

Step 2: Determine application rate of irrigation system (gal/hr)

Application Rate (gal/hr) = Number of emitters per tree X Emitter discharge rate (gal/hr)

Application Rate (gal/hr) = 1 X 12 (gal/hr) = 12.0 gal/hr

Step 3: Determine irrigation system runtime (hr/day)

$$\text{Runtime (hour/day)} = \frac{\text{Water use by Walnut tree } (\frac{\text{gal}}{\text{day}})}{\text{Application rate } (\frac{\text{hr}}{\text{day}})} = \frac{75}{12} = \mathbf{6.3\ hr/day}$$

Fertigation: Injection Time

- To ensure proper mixing, injection of fertilizers should not be done in short high conc. applications.

- It takes 15 to 20 minutes for water to travel 500 ft to the end of a drip tube lateral with emitters of 1 gph spaced 4 feet.

- It takes 30 to 40 minutes for water to travel 800 ft to the end of a drip tape lateral with 0.22 gpm/100 ft discharge rate.

- For good fertilizer distribution constant long injection times recommended.

How can I estimate fertigation injection rate?

- Injection Amount (gallons) = $\dfrac{\left(Desired\ lbs\ of \dfrac{N}{acre}\right) * acres * 100}{\left(Fertilizer\ density\left(\dfrac{lbs}{gal}\right)\right) * (\%of\ N\ in\ fertilizer)}$

- Injection Rate (gal/hr) = $\dfrac{\left(Desired\ lbs\ of \dfrac{N}{acre}\right) * acres * 100}{\left(Fertilizer\ density\left(\dfrac{lbs}{gal}\right)\right) * (\%of\ N\ in\ fertilizer) * injection\ time\ (hrs)}$

How can I estimate fertigation injection rate?

Example : Fertigation injection rate

A Walnut grower wants to apply 50 lbs per acre of nitrogen by injecting UN 32 in to microsprinkler irrigation system. The microsprinkler irrigation system serves 120 trees planted on a spacing of 28 * 28 ft. At what rate should the grower inject the fertilizer? Assume UN32 has a density of 11.1 lbs/gal.

Estimated area served by micro sprinkler irrigation system: 120 * (28 *28) = 94,080 ft2 = 2.16 acres

Assuming a injection time of 2 hours

- Injection Rate (gal/hr) = $\frac{(50) * 2.16 * 100}{(11.1) * (32) * 2} = \mathbf{15.2\ \mathit{gph}}$

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The pump is the heart of a pressurized irrigation system and needs to be well maintained.

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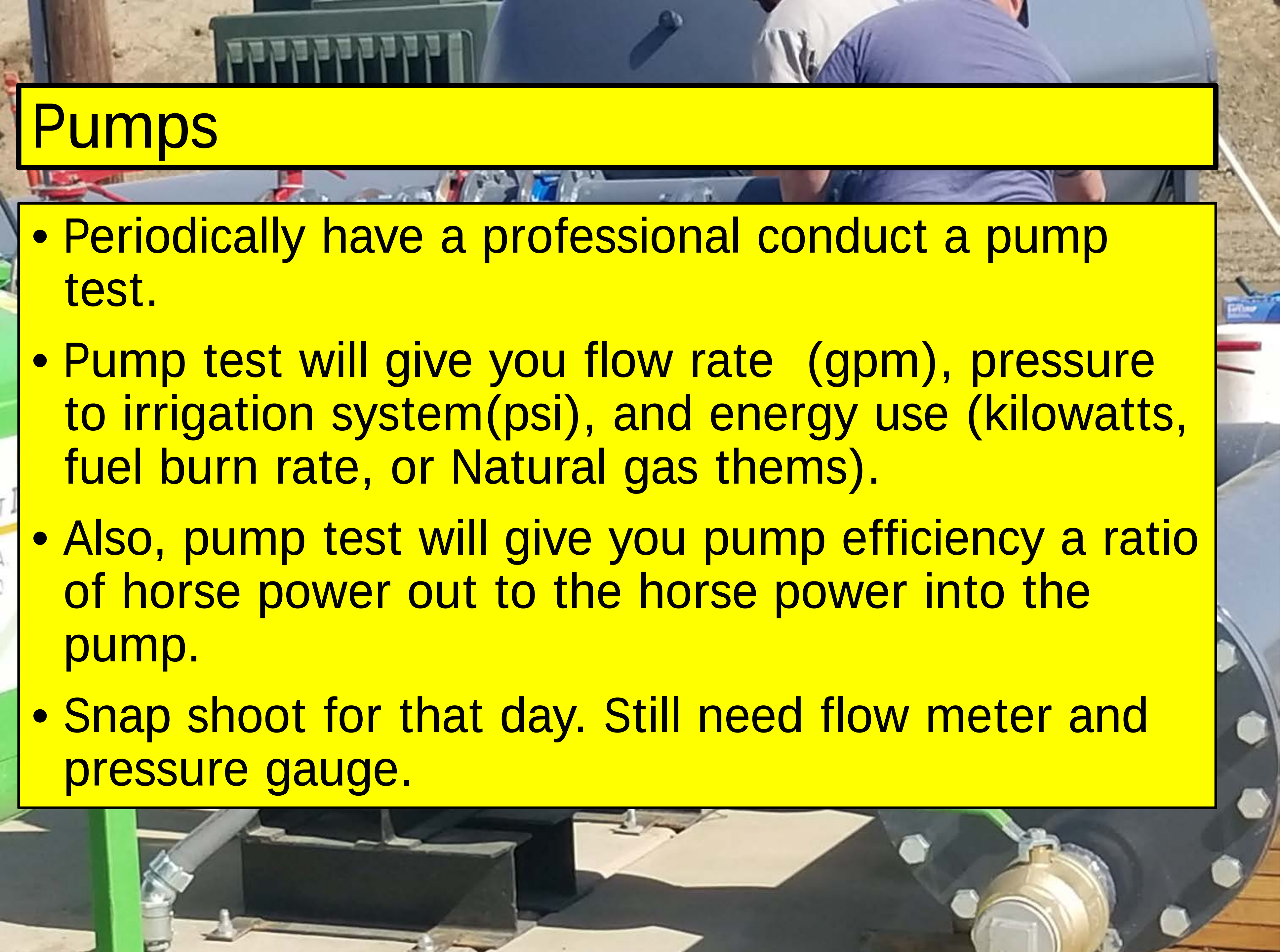

Pumps

- Periodically have a professional conduct a pump test.
- Pump test will give you flow rate (gpm), pressure to irrigation system(psi), and energy use (kilowatts, fuel burn rate, or Natural gas thems).
- Also, pump test will give you pump efficiency a ratio of horse power out to the horse power into the pump.
- Snap shoot for that day. Still need flow meter and pressure gauge.

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Variable Frequency Drives (VFDs)

- A VFD allows the pump to speed up or slow down to meet the needs of an irrigation system.
- If less flow or pressure is demanded e.g., when irrigating a few blocks the VFD will slow the pump down.
- Reducing electricity/energy the pump is using results in savings in pumping costs.
- This technology is particularly useful for variable rate irrigation management.
- SWEEP, Utility companies or NRCS might offer rebates for VFDs.

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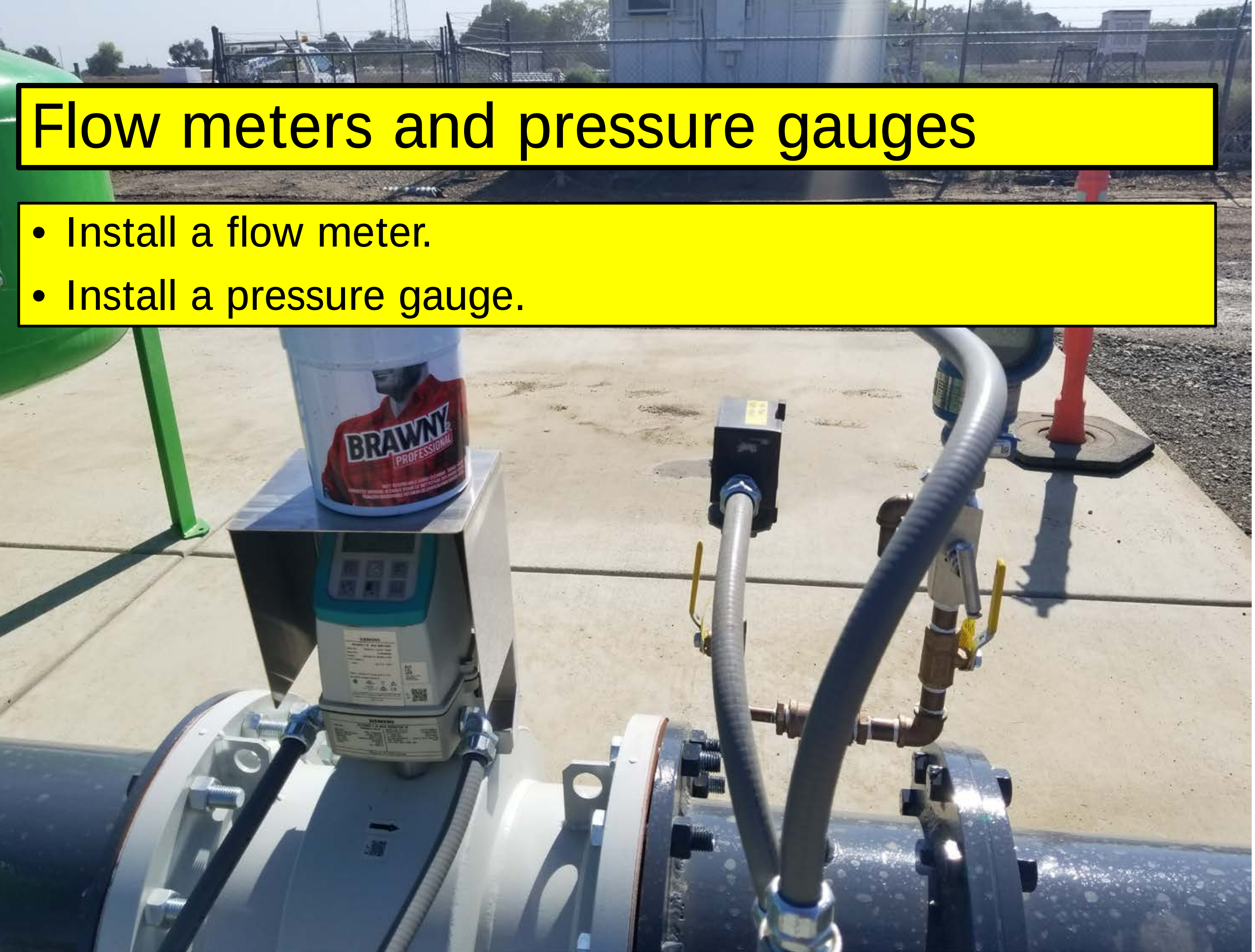
Flow meters and pressure gauges

- Install a flow meter.
- Install a pressure gauge.



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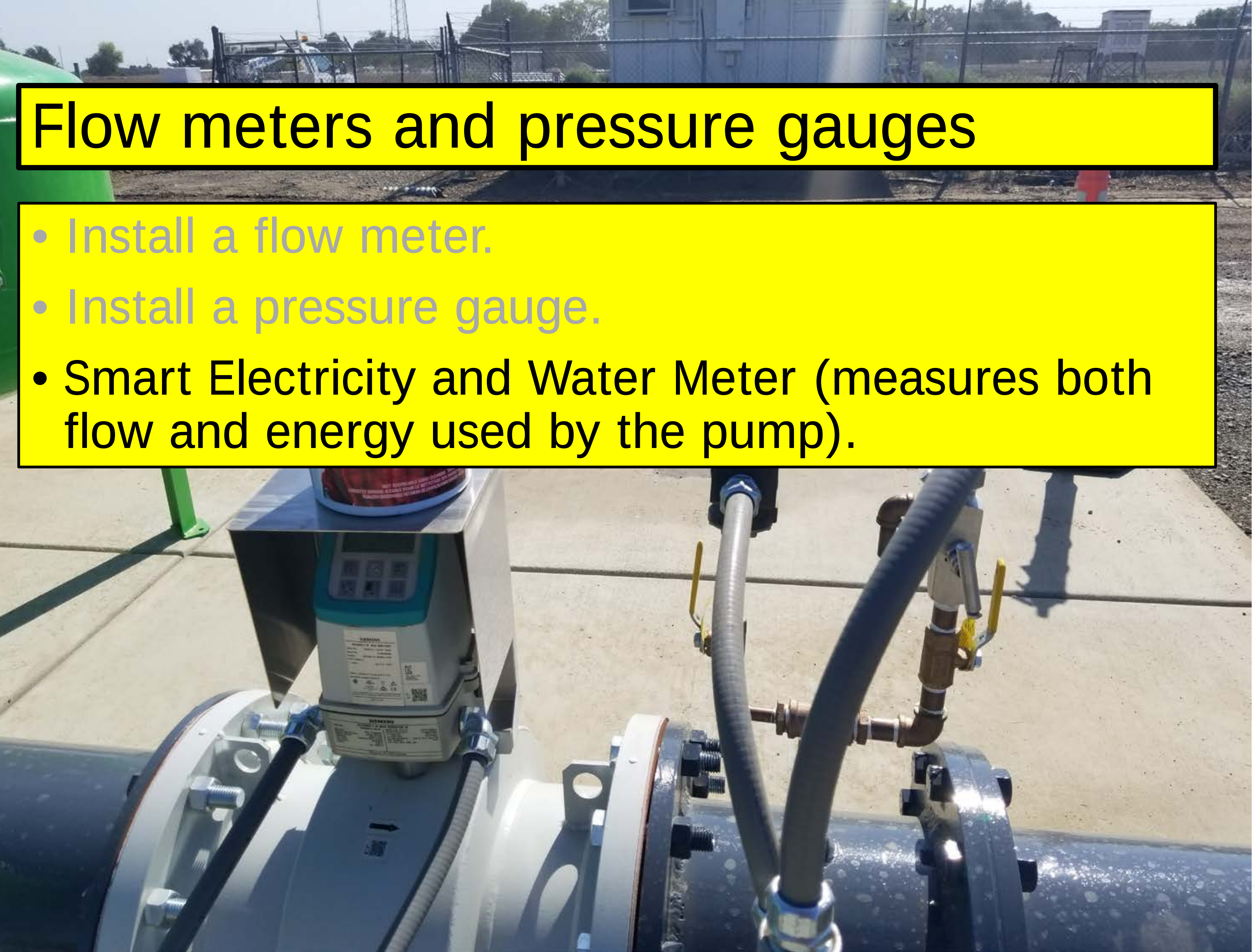
Flow meters and pressure gauges

- Install a flow meter.
- Install a pressure gauge.
- Smart Electricity and Water Meter (measures both flow and energy used by the pump).



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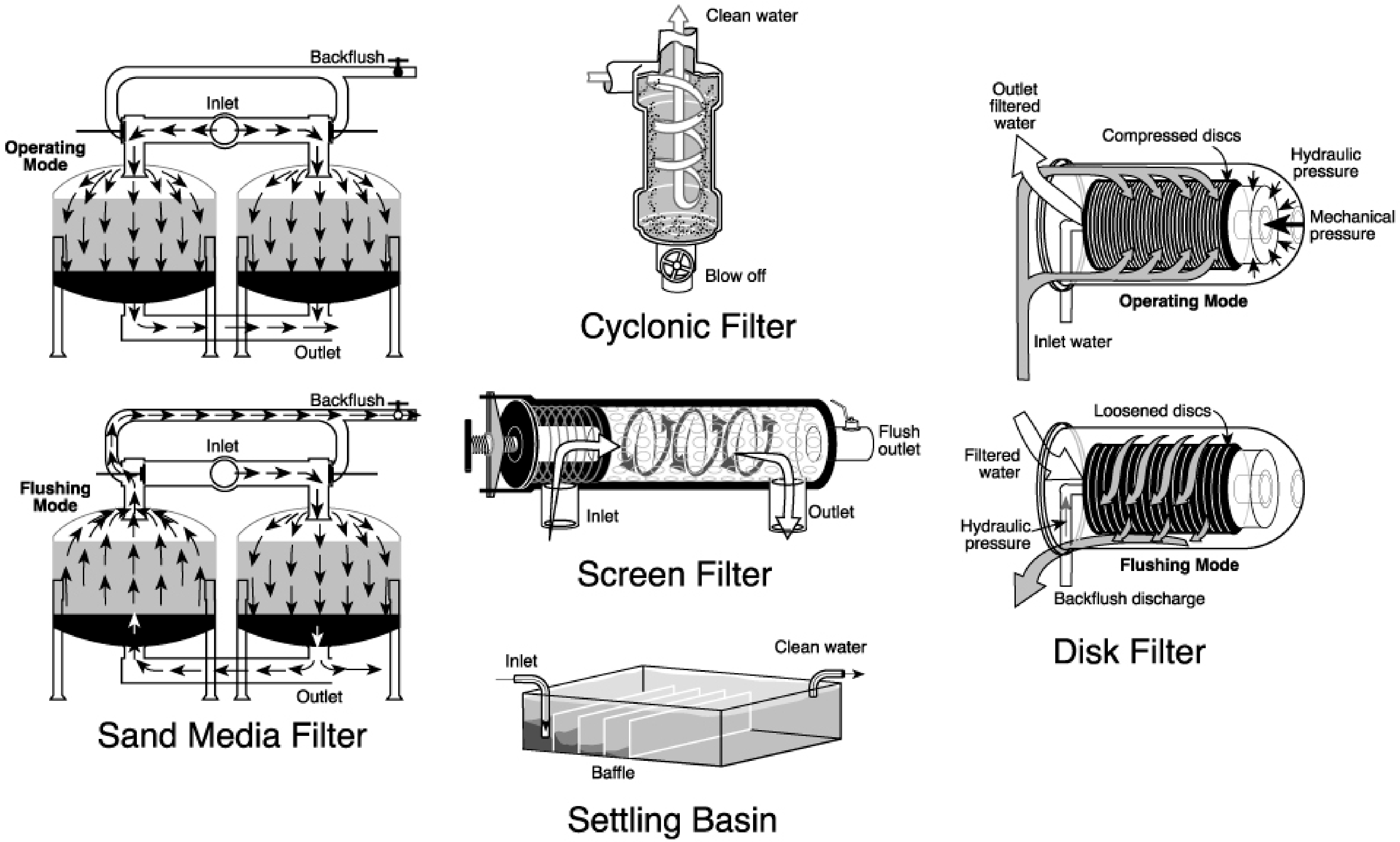
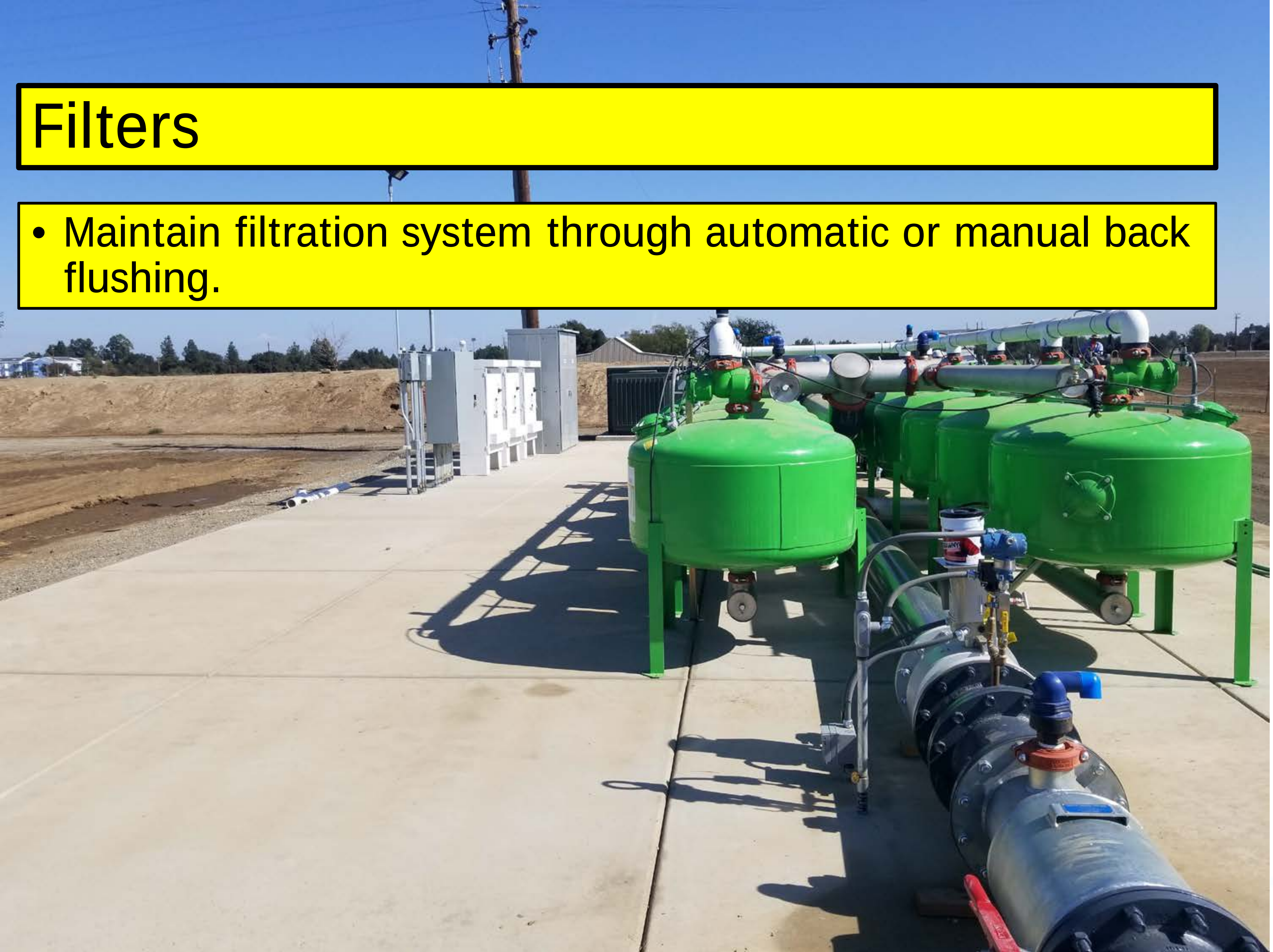
Filters



Backflush
Inlet
Operating Mode
Outlet
Backflush
Inlet
Flushing Mode
Outlet
Sand Media Filter
Clean water
Blow off
Cyclonic Filter
Flush outlet
Inlet
Outlet
Screen Filter
Inlet
Clean water
Baffle
Settling Basin
Outlet filtered water
Compressed discs
Hydraulic pressure
Mechanical pressure
Operating Mode
Inlet water
Loosened discs
Filtered water
Hydraulic pressure
Flushing Mode
Backflush discharge
Disk Filter

Filters

- Maintain filtration system through automatic or manual back flushing.



Screen Filters

Flushing

Need to flush the system - mainlines, submains, and laterals (in that order).

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Potential problems

- Chemical precipitate clogging.
- Root intrusion.
- Salt accumulation.
- Non uniform crop growth.

Assess water quality

Water Characteristics	Minor	Moderate	Severe
Maximum suspended solids (ppm)	<50	50-100	>100
pH	<7.0	7.0-8.0	>8.0
Maximum dissolved solids (ppm)	<500	500-2000	>2000
Maximum manganese conc. (ppm)	<0.1	0.1-1.5	>1.5
Maximum iron conc. (ppm)	<0.2	0.1-1.5	>1.5
Maximum hydrogen sulfide conc. (ppm)	<0.2	0.2-2.0	2.0
Bacterial population (maximum number per ml)	<10,000	10,000-50,000	>50,000
Chloride (meq/l)	<5.0	5.0-15.0	>15.0
Boron (ppm)	<0.5	0.5-3	>3.0
Sodium (adj. Rna value)	<5.0	5.0-8.0	
ECw (dS/m)	<1.1	1.1-3.2	>3.2

Source: Bucks et al. 1979; Doll 2016

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Clogging is the greatest “threat” to microirrigation systems.

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Clogging of Microirrigation Systems

Source: Physical Clogging - Particulates

Solution: Filtration

Clogging of Microirrigation Systems

Source: Chemical Precipitates

- Lime (calcium carbonate) and iron are the most common problems.

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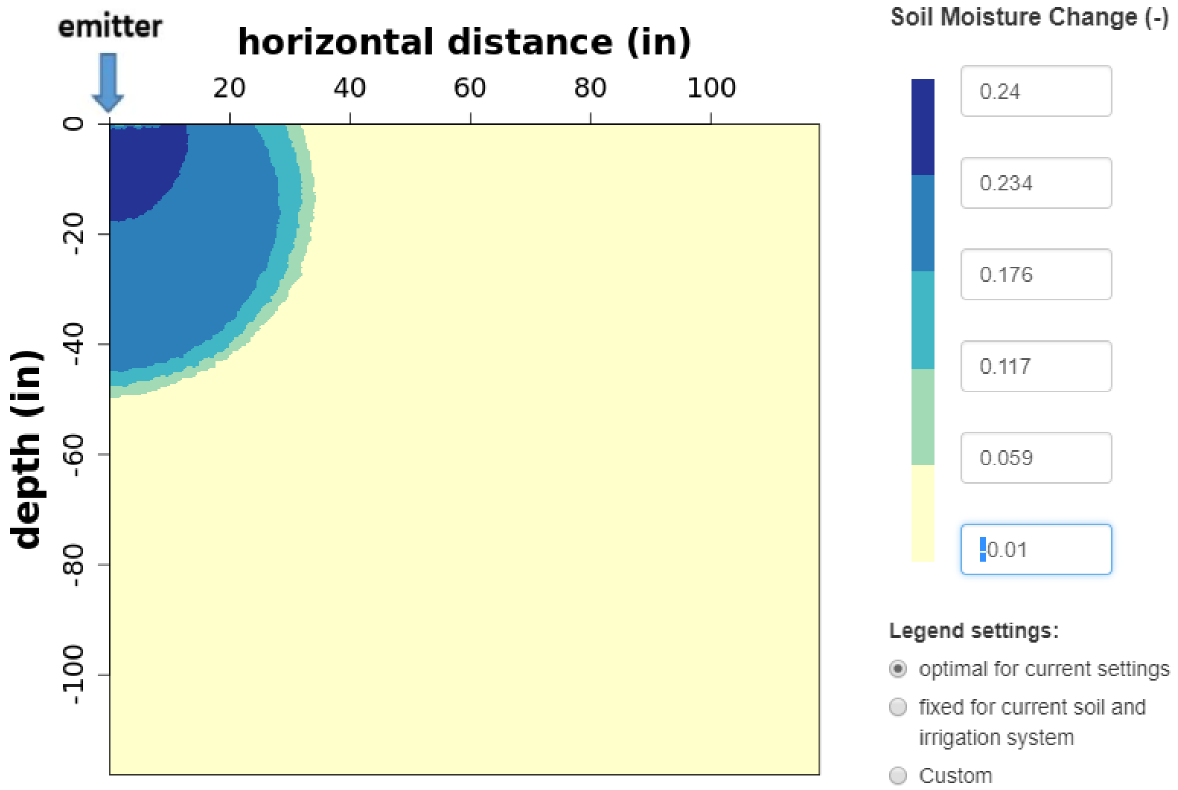
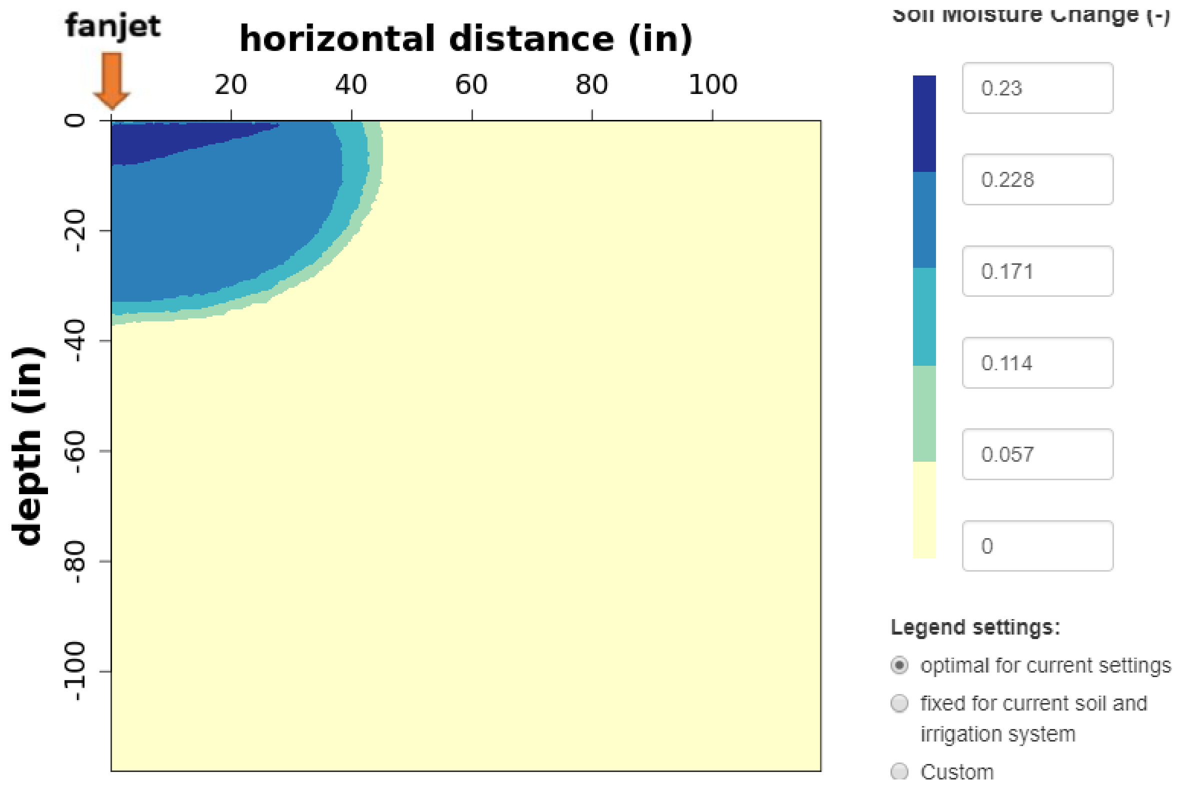
High salinity can reduce root water uptake and harm your trees.

Drip



Microsprinkler



For irrigation water with high salinity (Ecw) salts will accumulate on the fringes of the wetted bulb.

Chemical Precipitate Clogging of Microirrigation Systems

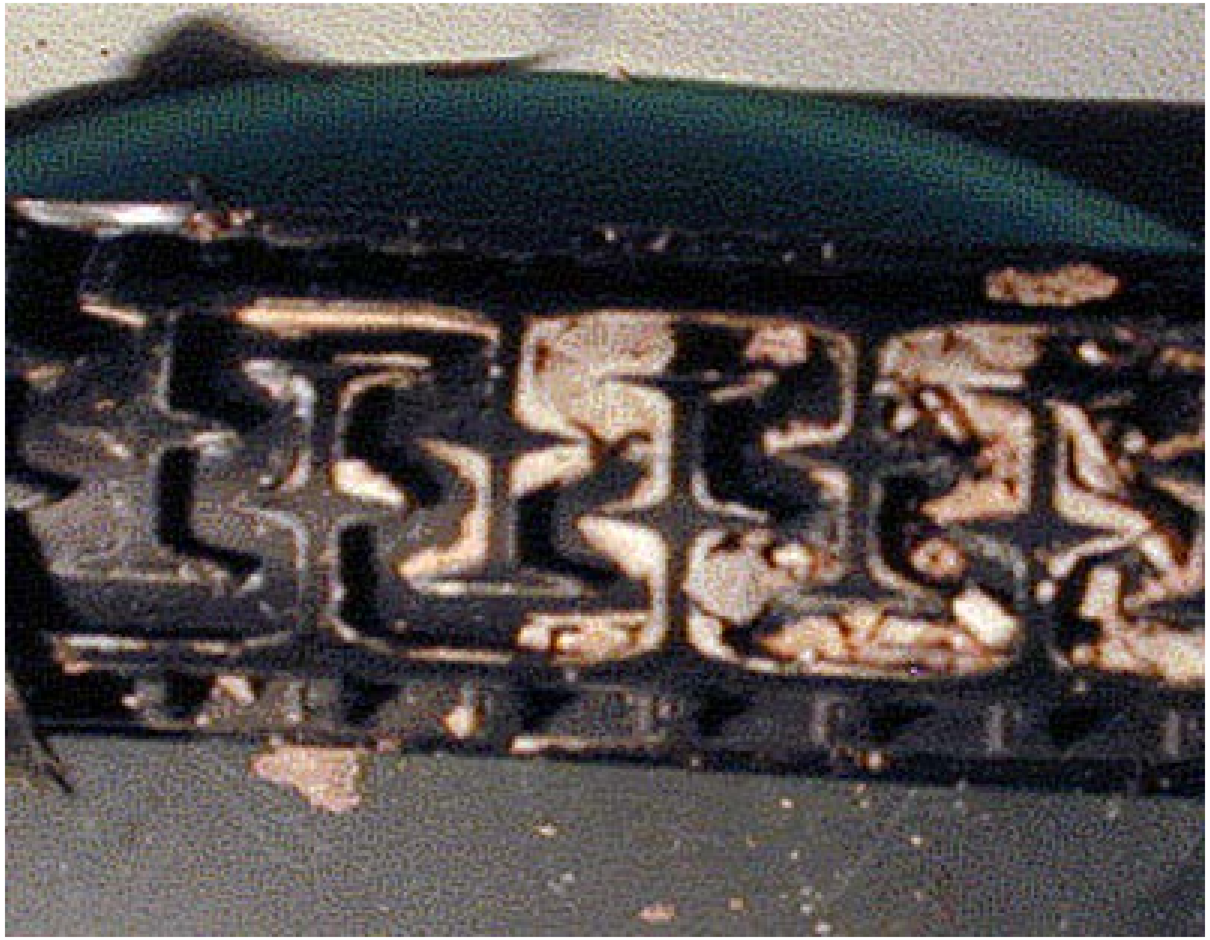
Water quality levels of concern:

- Calcium: pH > 7.5 and 2.0 meq/l (120 ppm) of bicarbonate
- Iron: pH > 4.0 and 0.5 ppm iron

Source: Lime

Solution: pH Control (Acidification) + filtration

Emitter clogged by calcium carbonate



Credits: metzer

Emitters are small and are clogged easily by chemical precipitation of minerals, and nonfiltered particulate. Filtration, chemical treatment and flushing can solve problem.

Biological clogging of microirrigation systems

Chlorine

- Sources:
  - Liquid - sodium hypochlorite.
  - Solid - calcium hypochlorite.
  - Gas chlorine.

Free Chlorine
End of line

Continuous injection
1-2 ppm

Periodic injection
10-20 ppm

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Potential for root intrusion for SDI

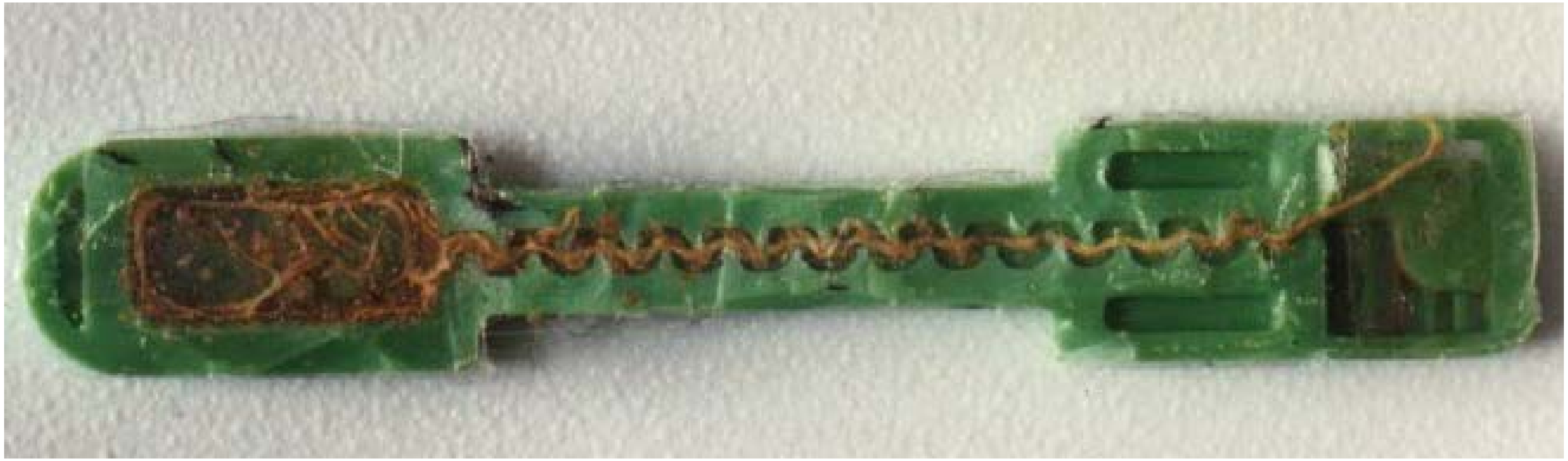

Photo Credits: Plastro Irrigation

Occurs when plants are stressed and are looking for water and nutrients. Problem can be managed by injection of approved herbicides or injection of acid to lower pH.

Root pinching for SDI in Orchards

Can be minimized by installing the dripline far from the trunk as optimally possible, avoiding installing SDI in mature orchards.

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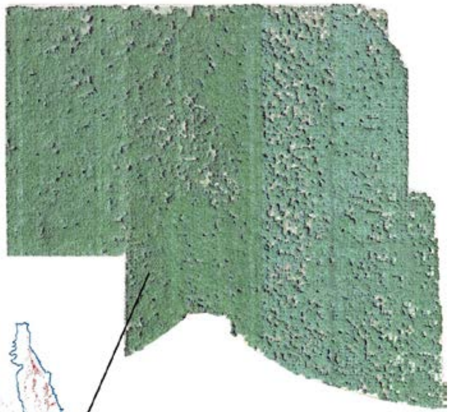
Spatial variability in canopy growth can be assessed at 30 m spatial resolution using free images from Landsat Satellite.



Uniform canopy in Walnut orchard in the San Joaquin Valley

Images can be accessed here: https://earthexplorer.usgs.gov/

Spatially variable canopy in a Walnut orchard in the San Joaquin Valley

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Take homes

- A uniform irrigation system is more likely to use water and N efficiently.
- Level of irrigation efficiency achieved and yield reached will depend on management (irrigation scheduling).
- Irrigation system maintenance is key:
  - ✓Monitor flow and pressure
  - ✓Check filtration
  - ✓Check water quality
  - ✓Flush mains, submains and laterals
  - ✓Monitor distribution uniformity
- Systems should be professionally designed.
- Manage system to attain production goals while minimize environmental impact.

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Thank you!

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