Irrigation Systems and Salinity Management in Alfalfa

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Irrigation Methods in California:

1- Surface irrigation (flood):

- Border strip (flat) irrigation (slope 0.1-0.2%)
- Furrow irrigation (slope)
- Basin irrigation (zero slope)

2- Sprinkler Irrigation (various types, mostly hand move systems, little use of center pivots and linear move systems)

3- Drip Irrigation (various types)

- Surface drip
- Subsurface drip

Surface irrigation:

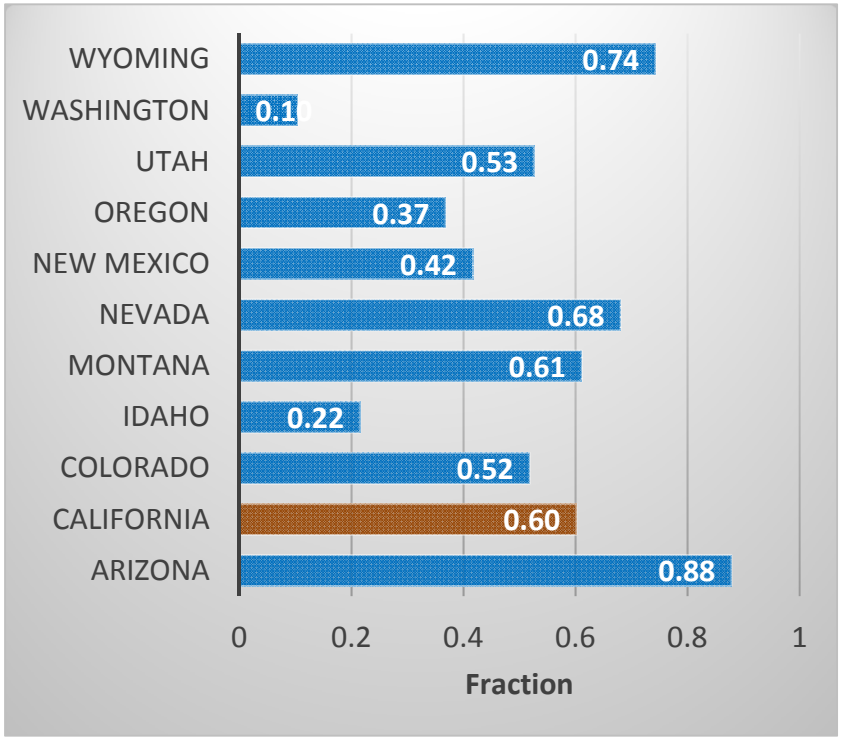
- Water application methods where water is applied over the soil surface by gravity (no energy is needed).

- Most common irrigation system throughout the world

- Has been used for thousands of years

- Land leveling practices over the past century made it more efficient

- High efficiency possible on medium and heavy soils

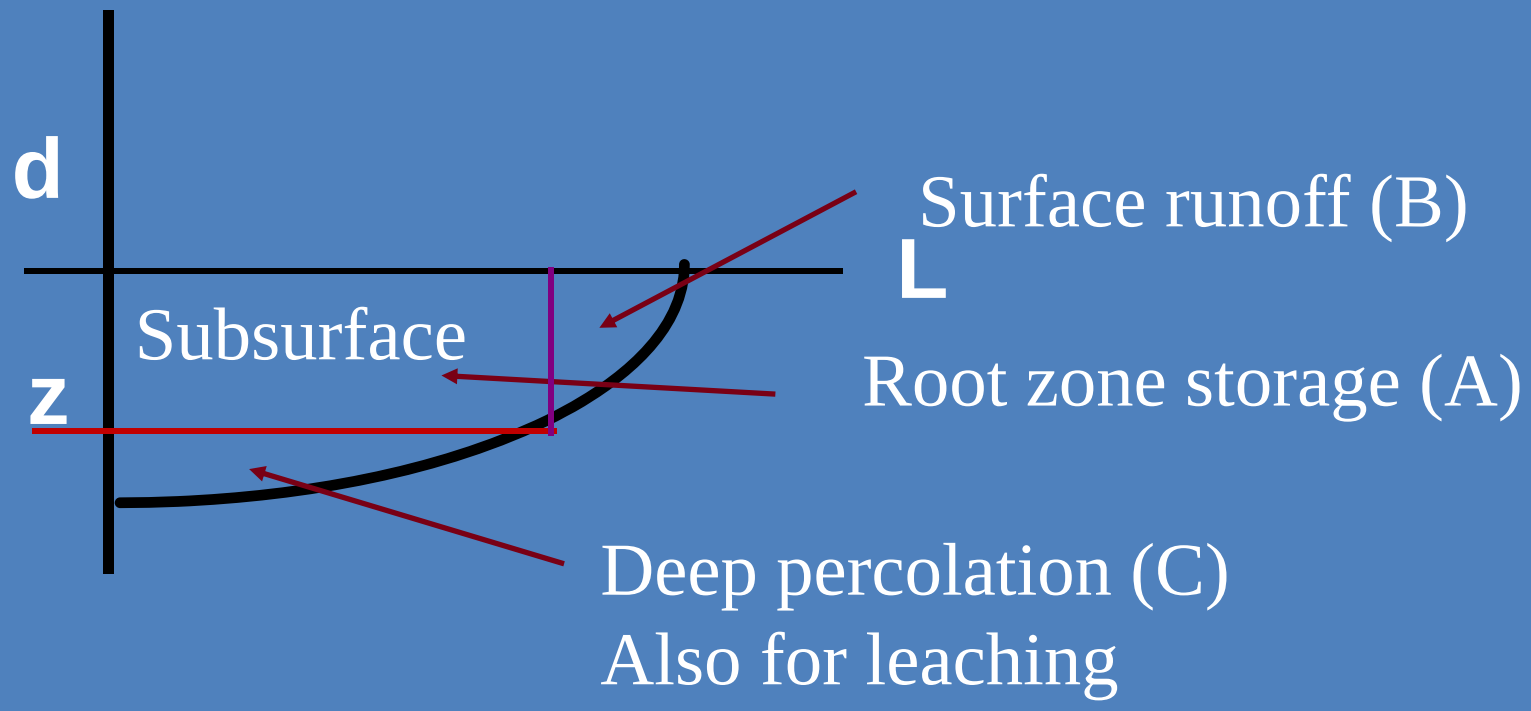


2013 Fraction of irrigated land totally or partially irrigated with gravity methods in western states.

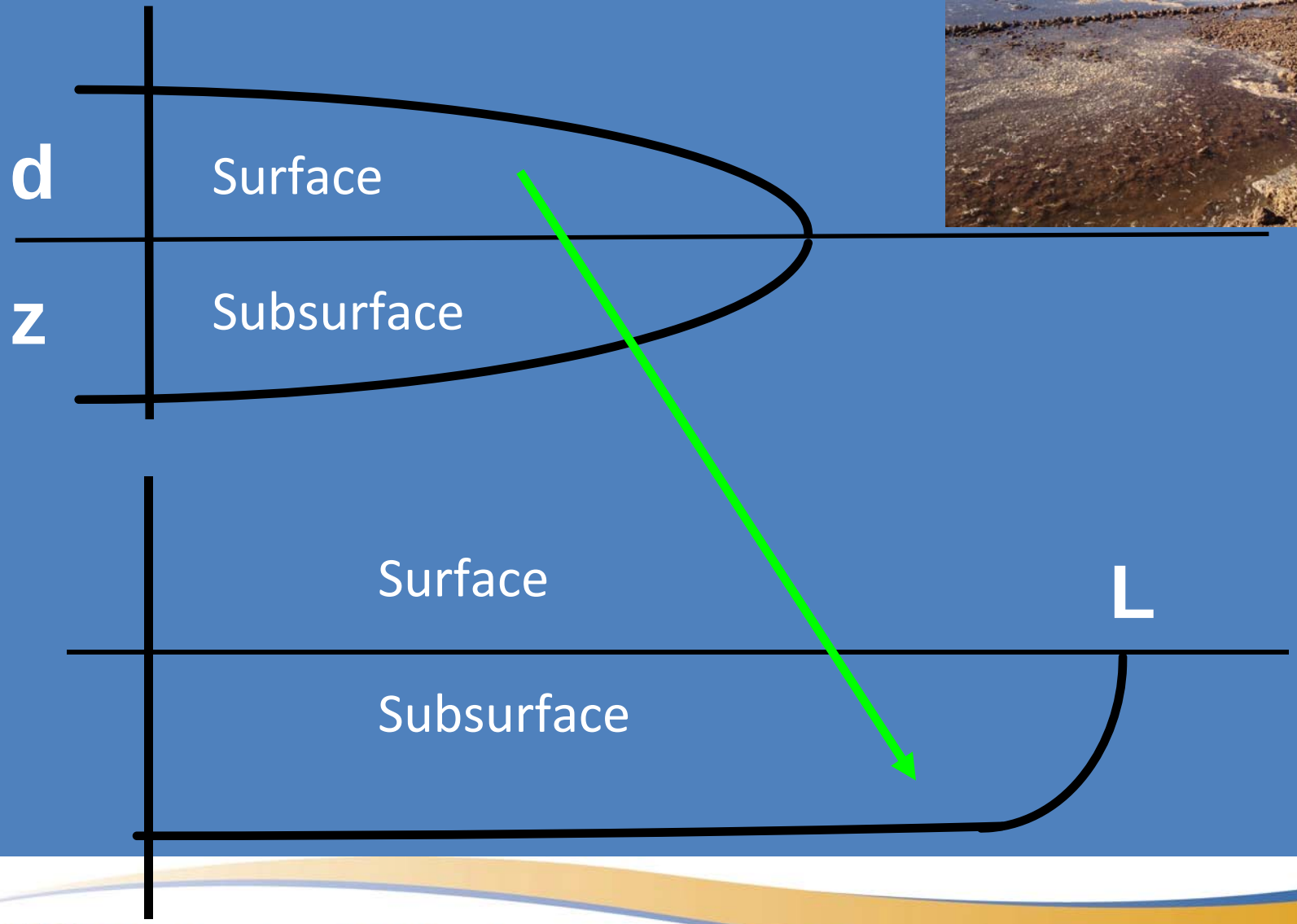
Source: USDA Farm and Ranch Irrigation Survey -FRIS, 2013

Alfalfa Surface Irrigation vs SDI (subsurface drip)

Applied water = Root zone storage + runoff + deep percolation



Irrigation management – applying the right amount of water

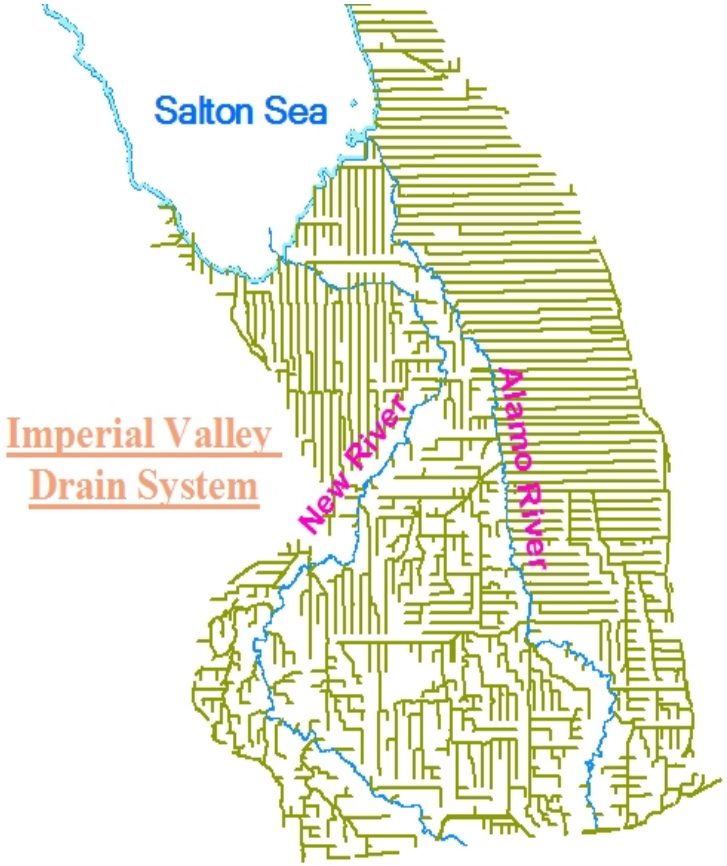


Irrigation system and salinity

~1,400 miles of irrigation canals

~1400 miles of open drainage channels

~ 4 million tons of salts/year



On-Farm Water Conservation
=Higher Application Efficiency (AE)

IRRIGATION = Evapotranspiration (ET)+ DEEP PERCOLATION + Runoff

A + B + C

Application Efficiency (AE)= A/(A+B+C)

To achieve higher efficiency, reduce B and/or C

BUT

Need to have a balance,

Deep Percolation sometimes is needed for salinity control

(650 ppm ~ 0.9 tons of salt/ac-ft)

Runoff is needed for Uniformity (100% AE means under irrigation)

ETo and Water Use

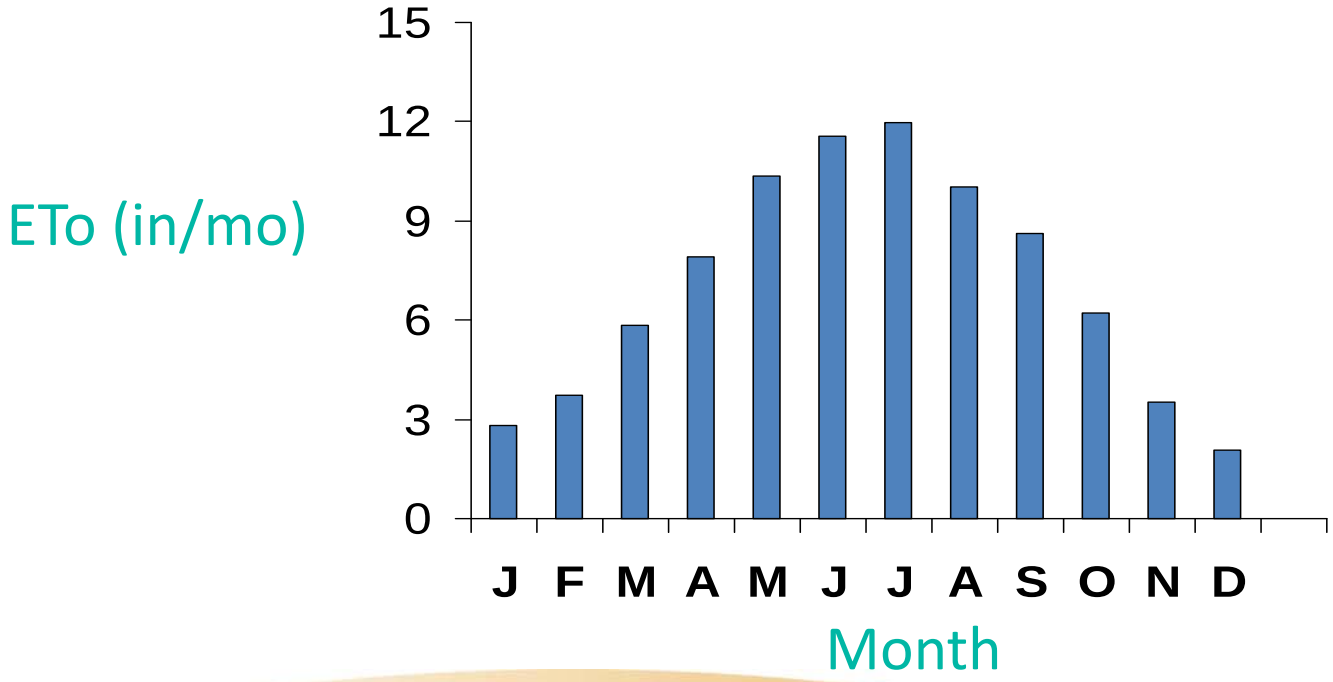
Field crops 3-7 ac-ft/ac

Tree and Vegetable Crops 2-4 ac-ft/ac

Salt accumulation: concentration and volume of applied water

Flood and Sprinkler: Clear understanding of leaching

Surface and subsurface: leaching, how often, how much water to apply??



Salinity of Irrigation and Drainage Waters

Salinity units (electrical conductivity):

1 dS/m= 1 mmho/cm

1 dS/m is about 640 mg/l (ppm) for EC values less than 5 dS/m

1 dS/m is about 800 mg/l for EC values above 8 dS/m

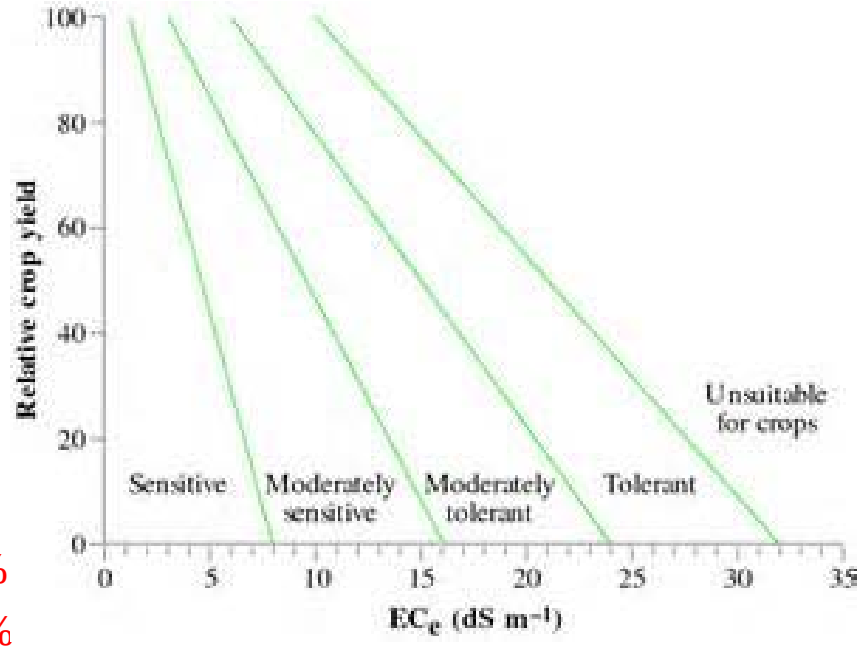
1 ac-ft of water at EC of 1.2 dS/m contains about 1 ton of salts

Crop Salt Tolerance

Crop salt tolerance

- Ability of crop to maintain yield and quality with increases salinity

- Sensitive crops: strawberry
- Moderately sensitive: alfalfa?
- Moderately tolerant: wheat
- Tolerant: Bermudagrass



Alfalfa (literature)

- ECe of 2 dS/m or less: no yield loss
- For every unit increase in salinity above 2 dS/m, 10% reduction in yield

If ECe is 3 dS/m, then yield loss would be 10%

If ECe is 6 dS/m, then yield loss would be 40%

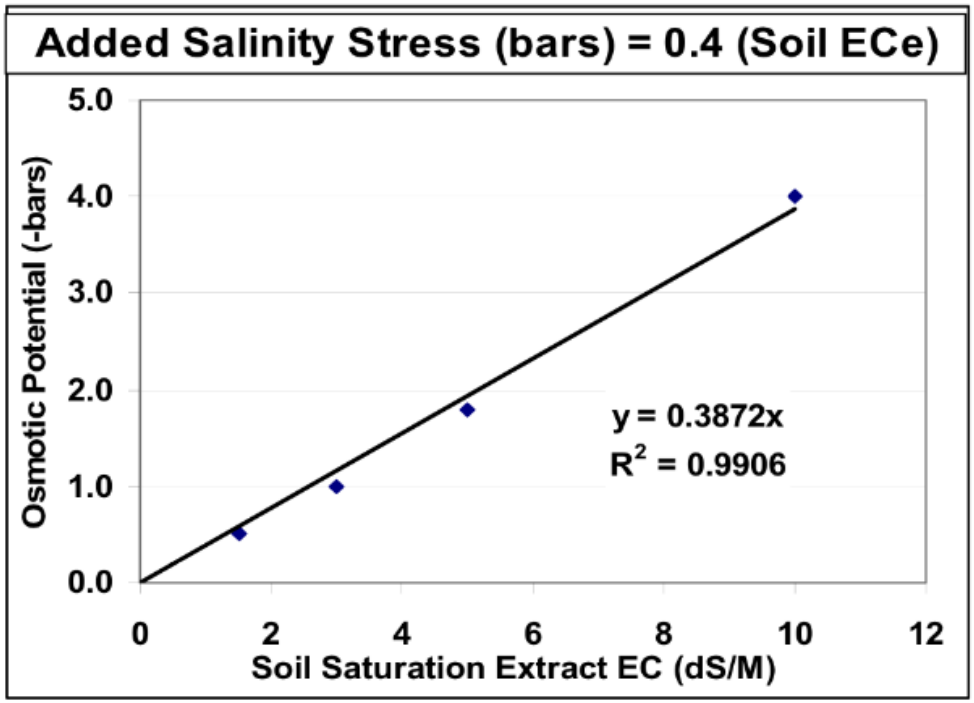


Fig. 1. Soil solution osmotic potential as a function of soil saturation extract salinity. Adapted from, USDA. 1954. "Diagnosis and Improvement of Saline and Alkali Soils. Agricultural Handbook 60.

creased when the soil water potential (matric or capillary potential) dropped to -1 bar, -100 centibars, or just about the time a tensiometer breaks suction. Figure 1 shows that for every 1 dS/m (or mmho/cm) unit increase in the soil ECe as measured in the lab you add an extra -0.4 bars of osmotic water stress t potential root uptake. **As a rule of thumb, for every 2 point increase in soil EC above 2 dS/m you can expect about a 10% decrease in normal ET and tonnage.**

So the first best step in managing salinity in alfalfa is to review forage ET in the SJV to understand the "normal year", unstressed water requiremen to be supplied by irrigation.

Source: Sanden and Sheesley, 2007. Salt Tolerance and Management for Alfalfa

Crop Salt Tolerance

Crop salt tolerance

- Ability of crop to maintain yield and quality with increases salinity

Alfalfa (experience and recent work (Putnam et al.)

- No significant decline in yield for ECe at or below 6 dS/m for most varieties

Salinity of Irrigation and Drainage Waters

Leaching fraction (LF): depth of drainage water/depth of applied water

Example: irrigation water 6 ac-ft/ac and drainage water of 1 ac-ft/ac

LF=1/6 or 17%

17% of applied water is used for leaching.

LF ~ salinity of drainage water/salinity of irrigation water (steady state- salts coming in with irrigation water are leaving the rootzone)

Salinity of Irrigation and Drainage Waters

Crop salt tolerance

- Most common: stunning of growth when EC at above threshold level (osmotic, total salt concentration is excessive)
- Specific ions (regardless of concentration, example; Na, Cl, B)

- Management strategies:
- Minimize water stress (combination of osmotic and water stress, SDI)
- Theoretical vs actual crop tolerance (alfalfa is a good example)
- Monitor soil salinity
- Leach soil if salinity is approaching threshold levels (crop salt tolerance)
- In general field crops are more tolerant to salinity than vegetable crops

Flood and Sprinkler Irrigation

-Leaching with every irrigation or at the end of season (vegetable and field crops)

Very little or no leaching with drip or SDI systems

Major issues with SDI: salt accumulation above drip tape (summer rain?)

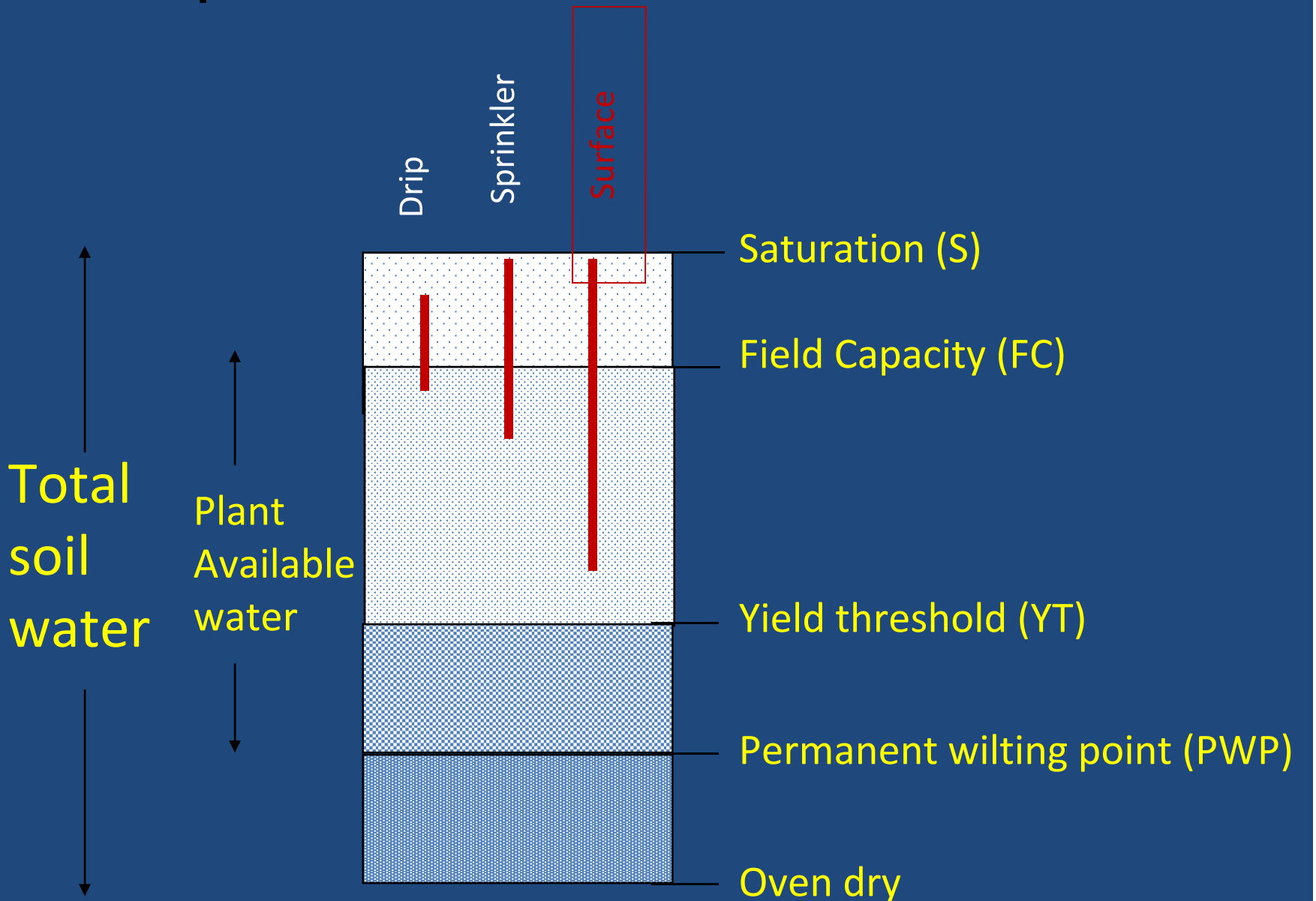
Management practices:

- **Another irrigation system for leaching (flood or sprinkler irrigation)**
- **Calculate LF and monitor salinity**
- **Monitor tile drain (volume and concentration)**
- **check soil salinity**

Subsurface Drip Irrigation on Alfalfa

		DRIP		FLOOD	
		Total	Per Acre	Total	Per Acre
Water Use Efficiency (Crop per Drop)					
	Acre Feet water used	2,464	6.50	3,608	9.52
	Gallons water used	802,733,939	2,118,032	1,175,696,476	3,102,102
Tons hay per acre foot water		**2.38**		**1.21**	

Crop Water use: Soil moisture



Salinity Management- Alfalfa

Leaching: winter or spring time when ET is not high
System design (design for sprinkler demand or keep the flood system)

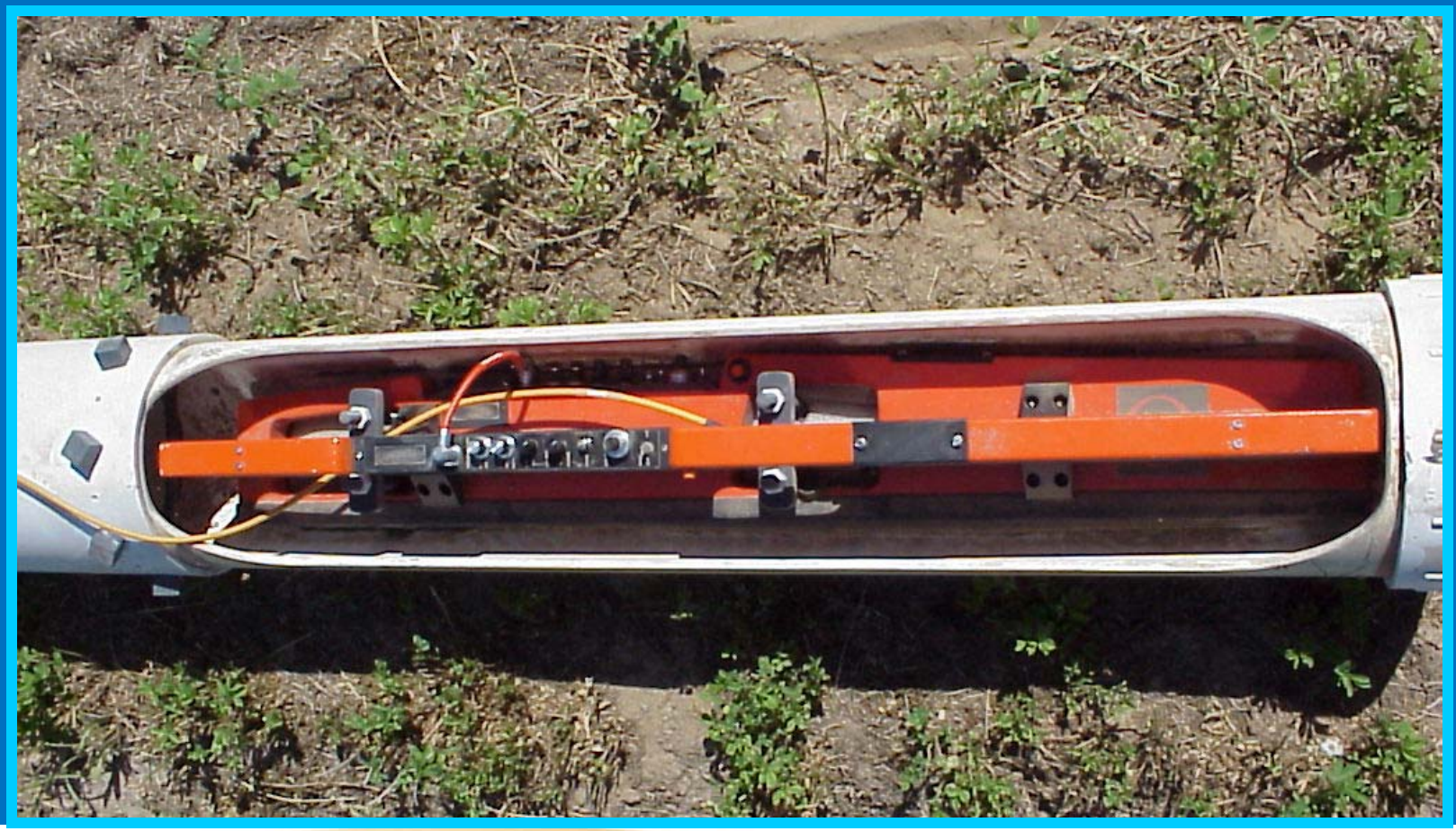
IID Salinity Assessment Vehicle

IID Salinity Assessment Vehicle

Electronic Components

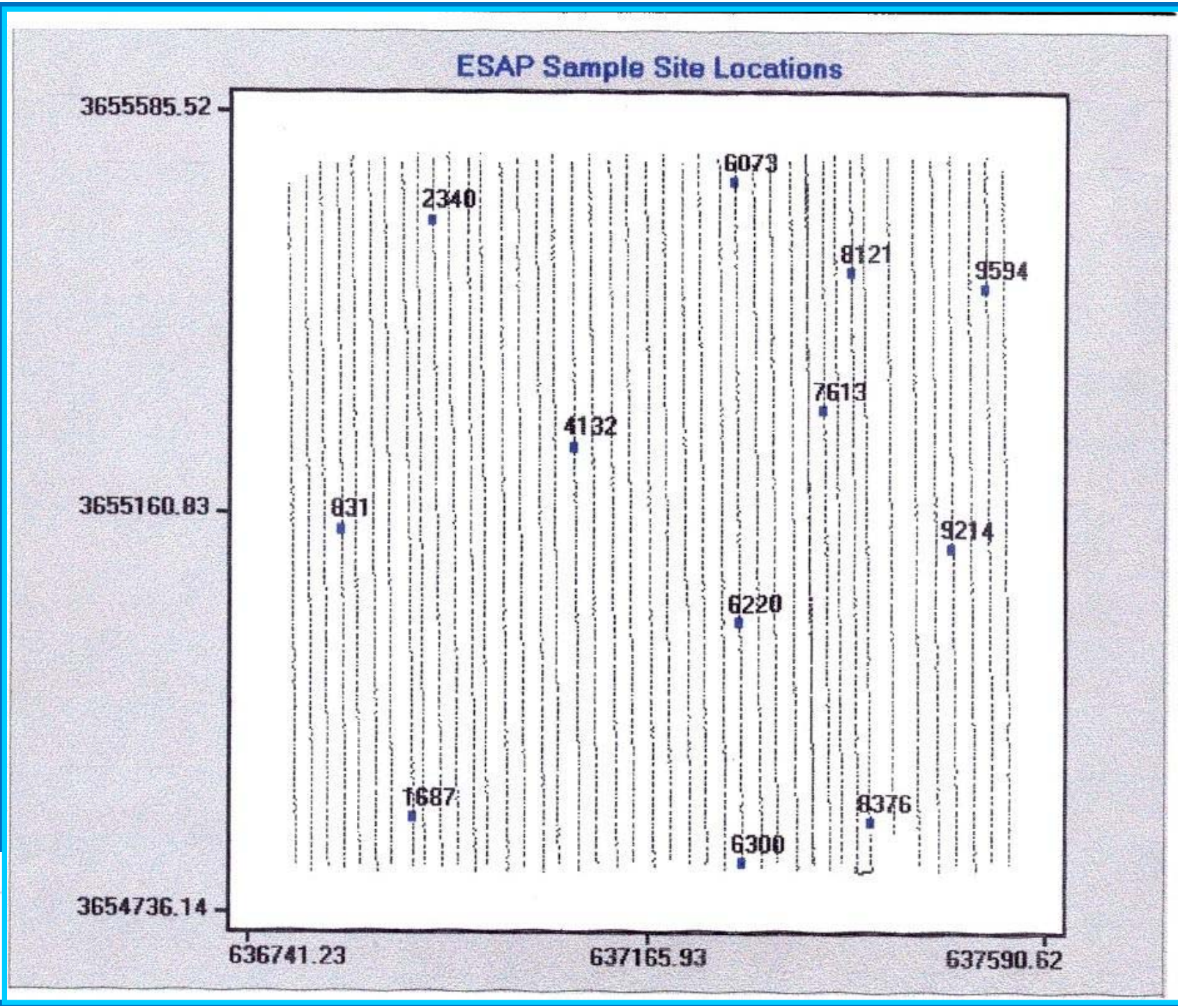
- Global Positioning System (DGPS)
- Geonics EM-38-DD Salinity Sensor
- Laptop Computer

Salinity Assessment Vehicle



Salinity Assessment Vehicle

- Perform electronic field survey
- Develop sample plan based on statistical distribution of collected data
- Collect 'ground truthing' soil samples analyze for EC & SP
- Correlate electronic data with soil analysis
- Generate field maps


ESAP Sample Site Locations
3655585.52
3655160.83
3654736.14
636741.23
637165.93
637590.62
6073
2340
8121
9594
7613
4132
831
9214
6220
1687
8376
6300

Salinity Assessment Vehicle

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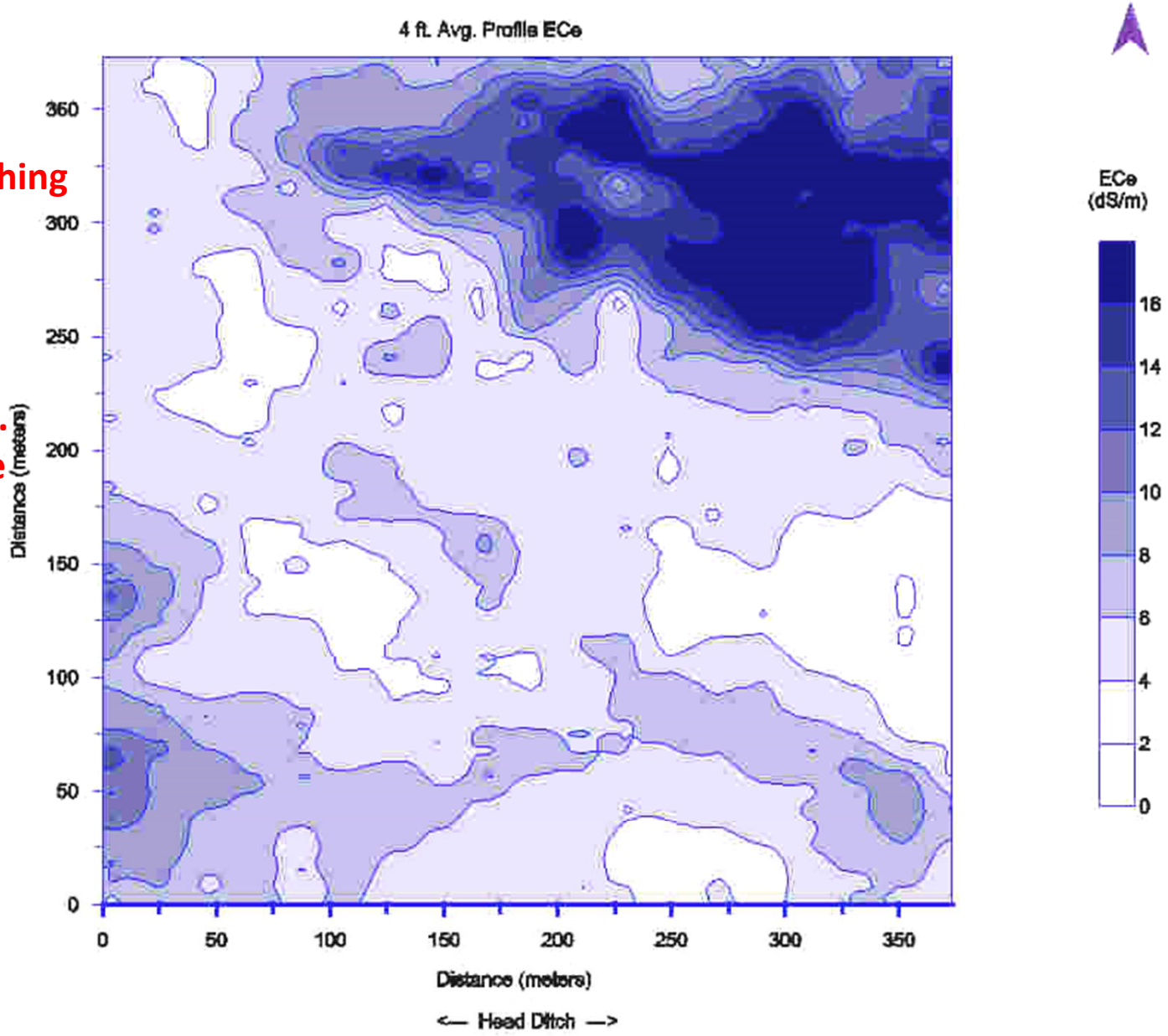
Selective leaching With flood irrigation is Not practical

Sprinkler irrig. is much more effective



Prepared by Steve Burch - Imperial Irrigation District - Salinity Assessment Vehicle Project

Expected Sugarbeet Yield Loss Map

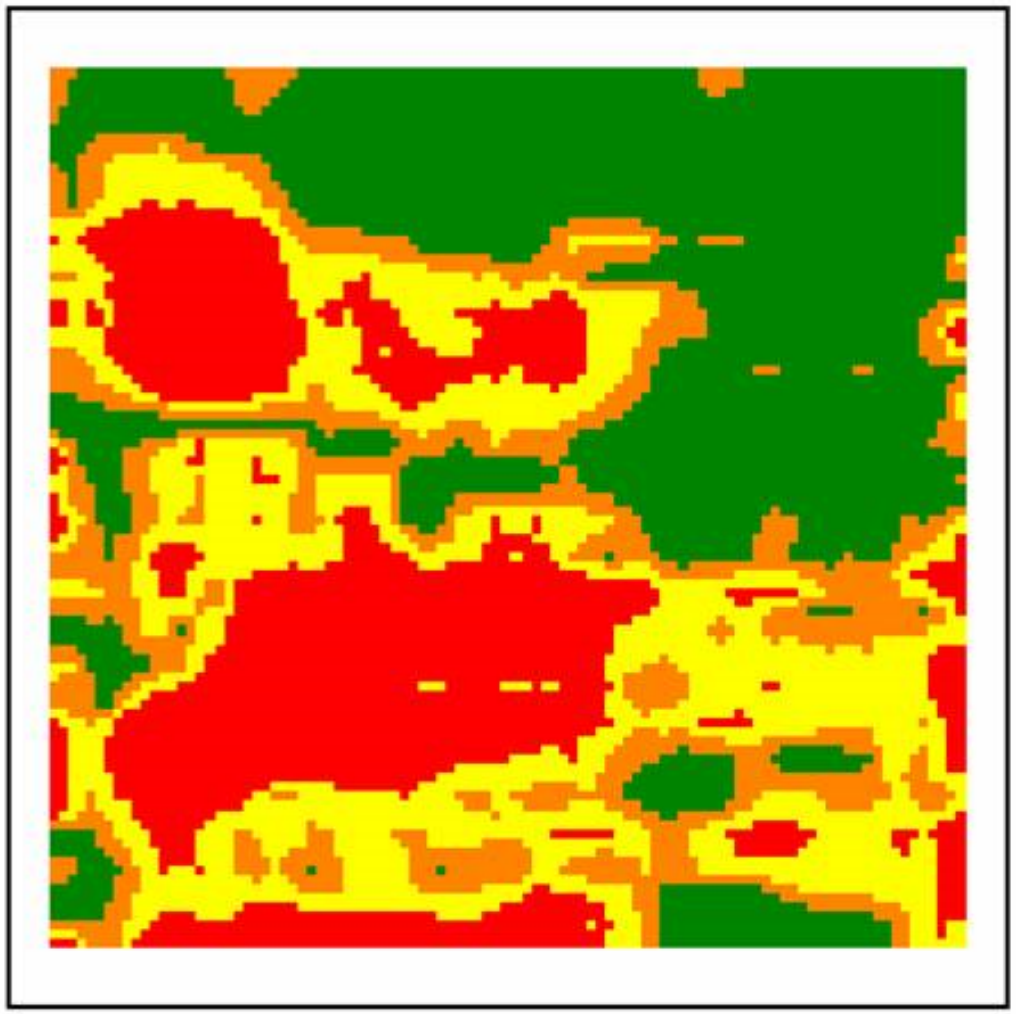
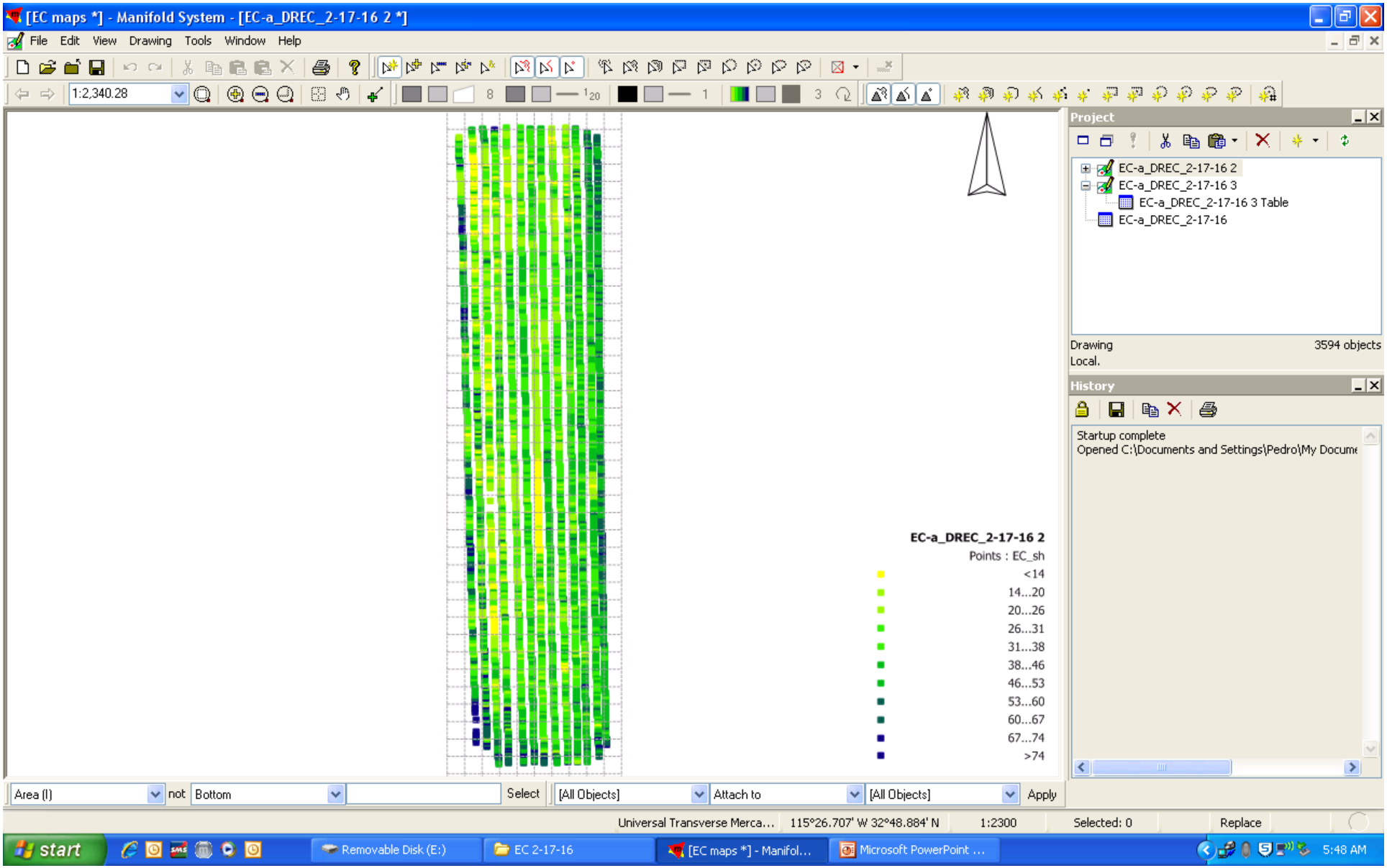


Image courtesy of
Stephen Kaffka
University of California – Davis
Extension *Agronomist*

Predicted sugarbeet yield loss = 22.5 % Actual yield loss = 18.5%

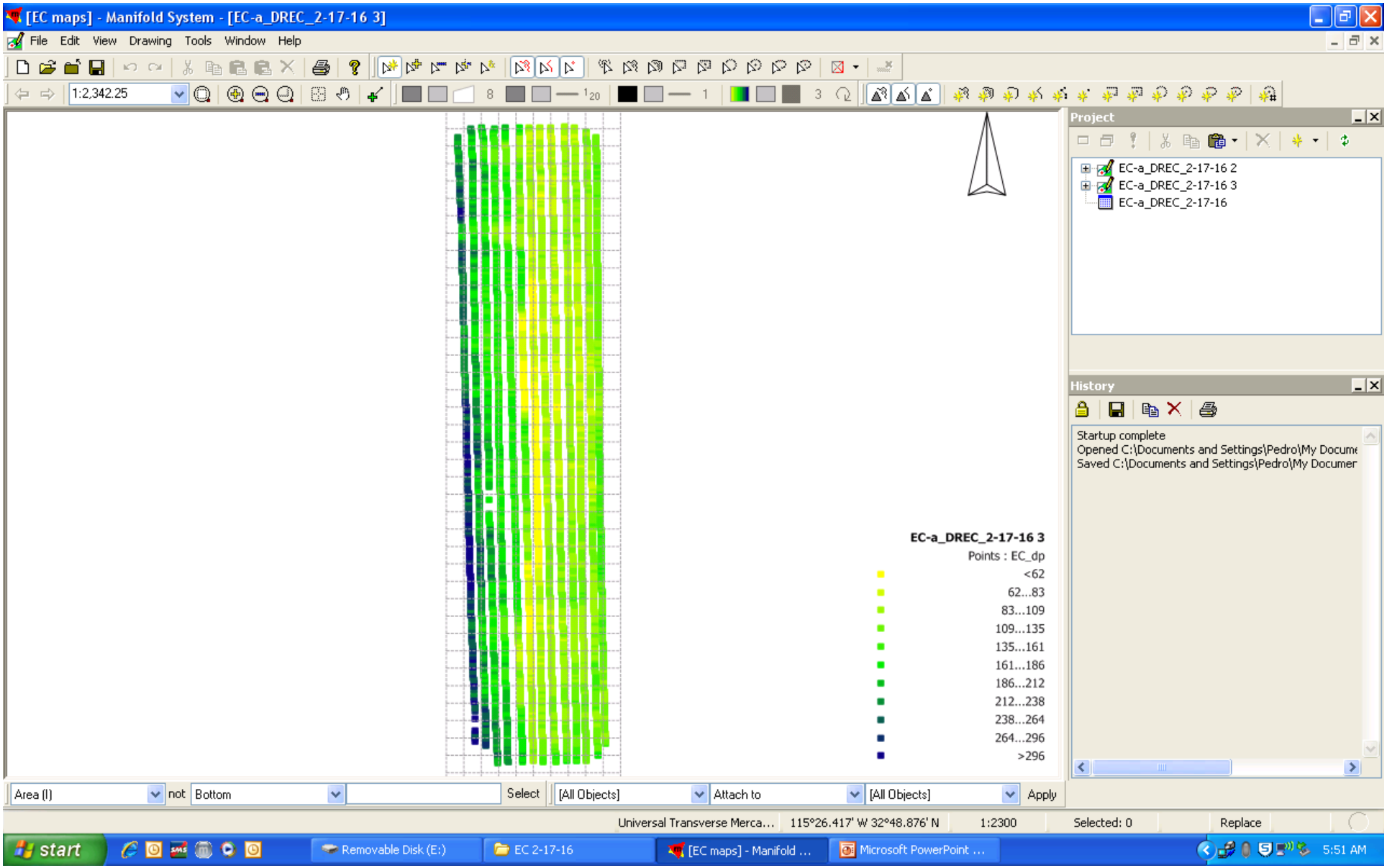
UCDREC- Sunflower

Soil apparent electrical conductivity (EC_a) of 0-0.3m depth, 10m grid on true North



UCDREC Sunflower

Soil apparent electrical conductivity (EC_a) of 0-1m depth, 10m grid on true North



Resources

UC ANR publications:

Drought Tip 8562	Crop Salt Tolerance
Drought Tip 8554	Use of Saline Water for Crop Production
Drought Tip 8550	Managing Salts by Leaching

Thank you

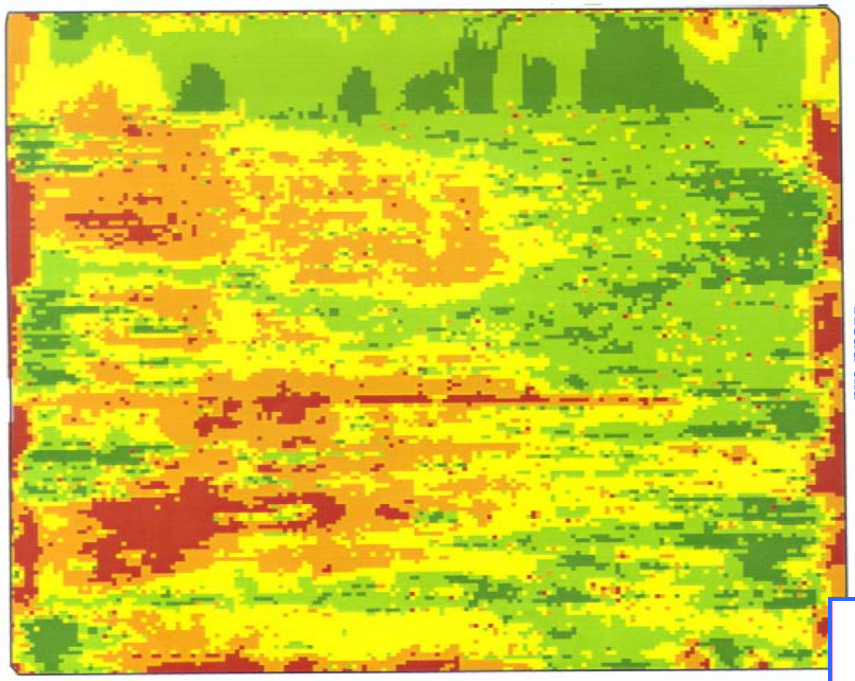
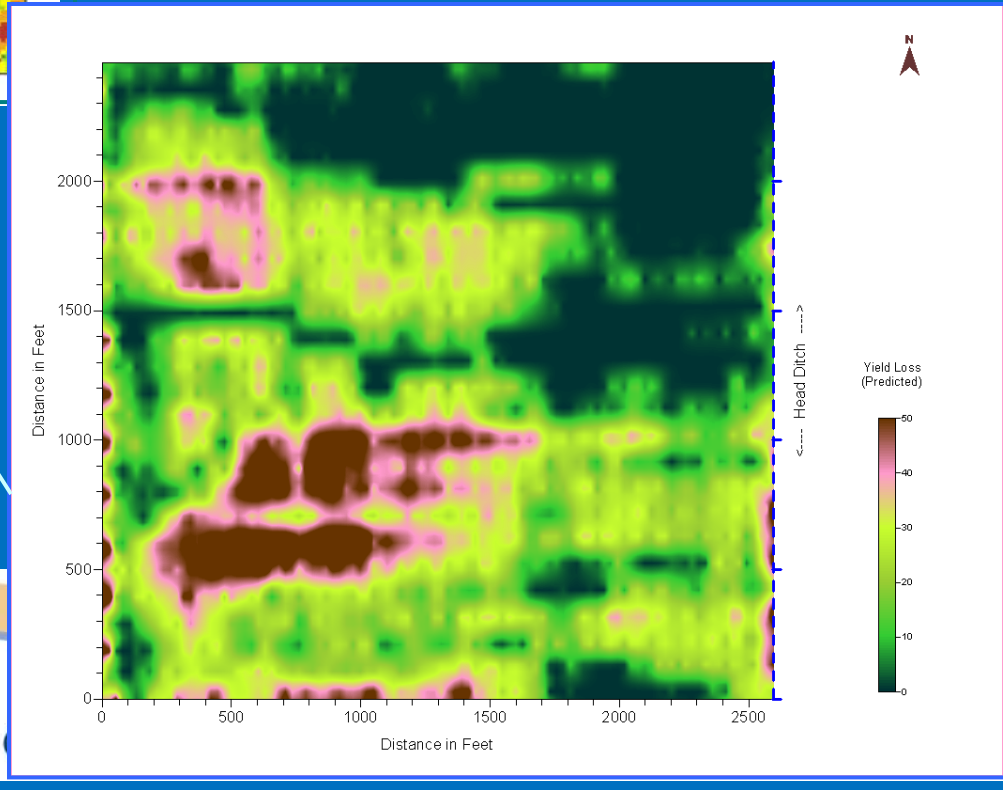


Image courtesy of **Stephen Kaffka**
University of California – Davis
Extension Agronomist

Actual Yield data

IID Salinity Assessment Vehicle
Predicted Yield Loss Image Map



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