Variable Rate Irrigation (VRI) with Overhead Systems

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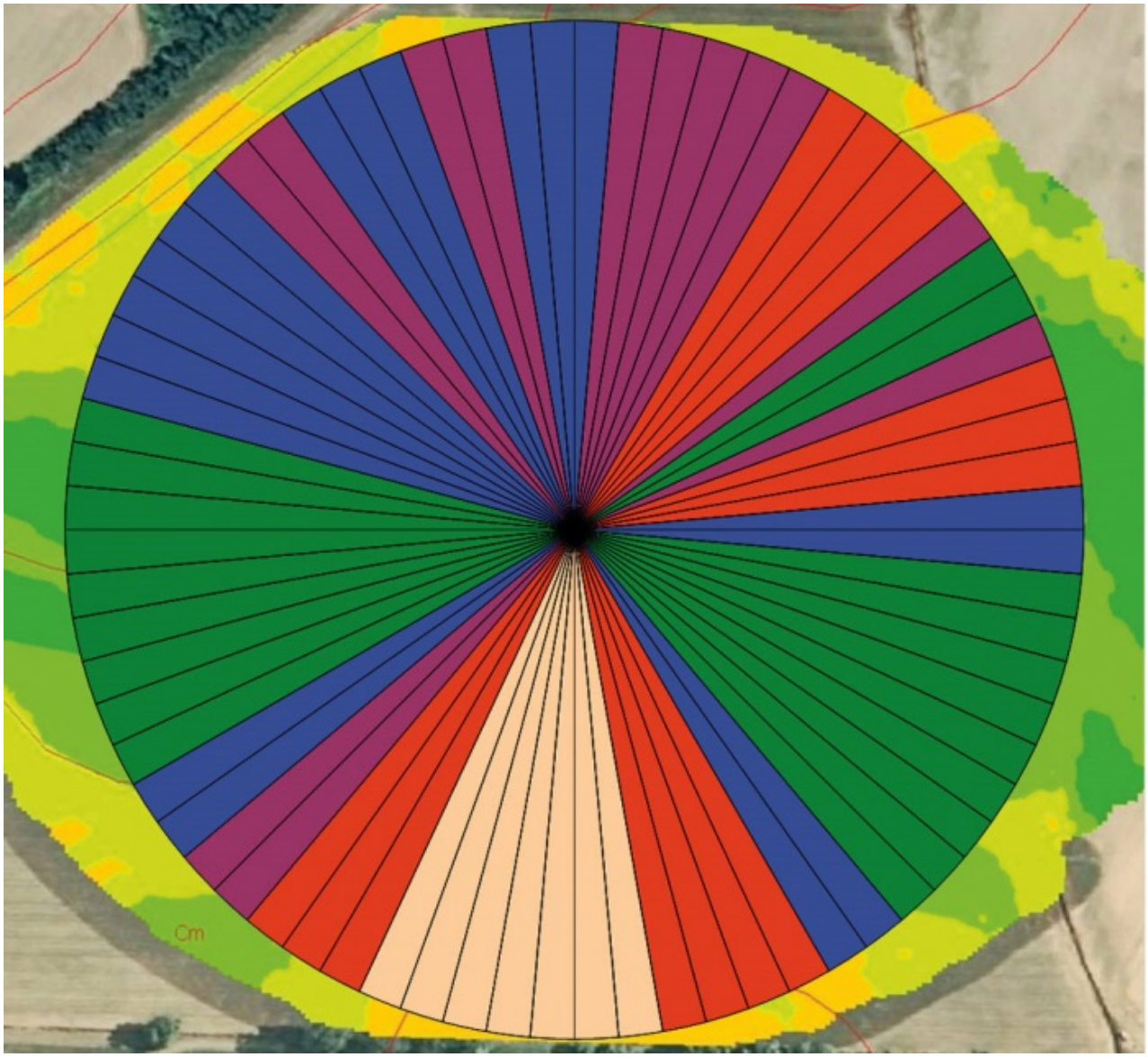
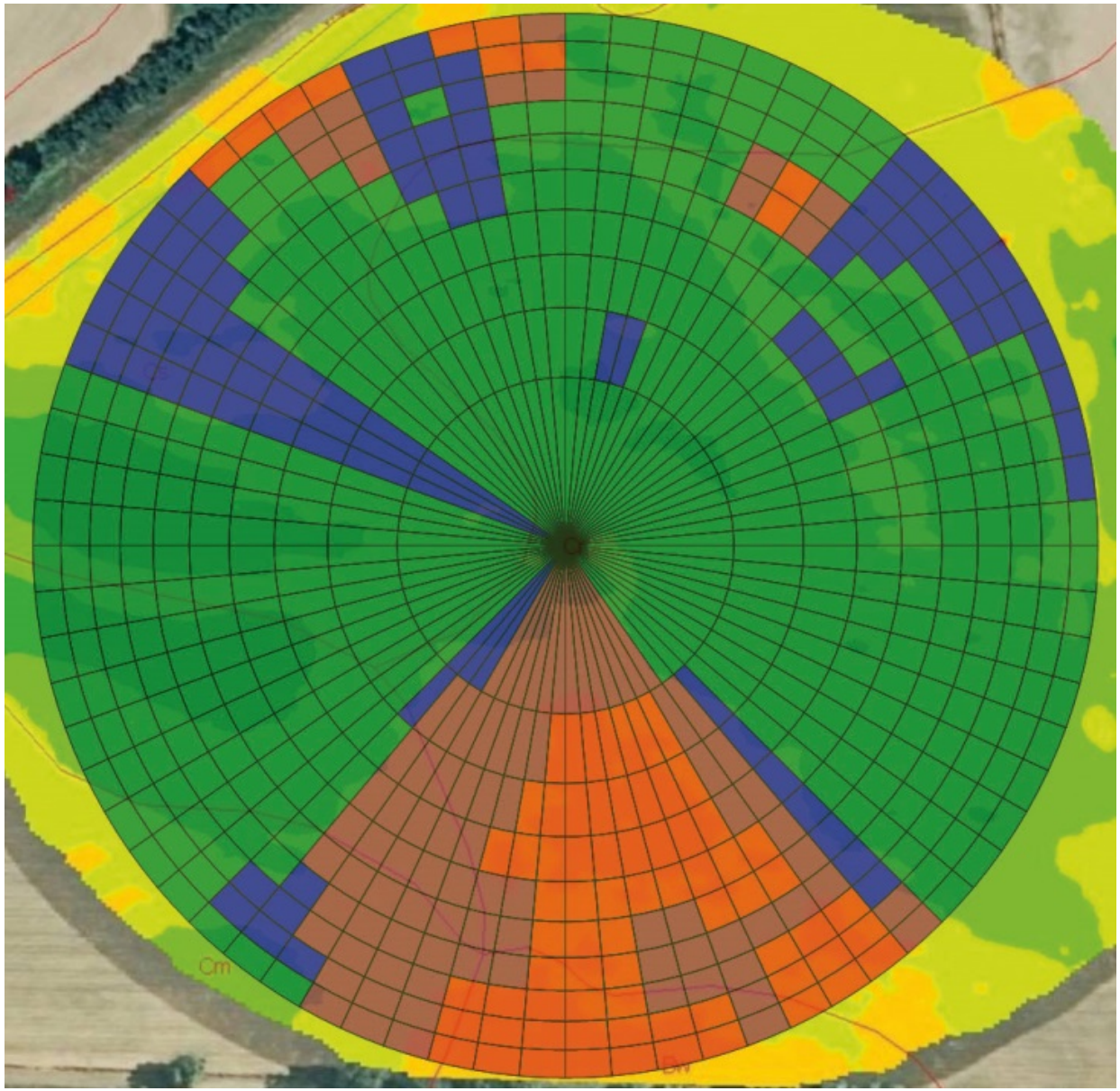
Variable Rate Irrigation on Center Pivots

- Different amounts of water to different areas of the field.
- Most vendors have VRI control systems.
  - Zimmatic
  - Reinke
  - Valley

Variable Speed Irrigation



Variable Zone Irrigation



They perform as expected

- Center Pivot VRI systems currently being sold have been shown to accurately implement the uploaded VRI prescriptions.
- Reasonable uniformity within the zone.
- Pulsing (switching the nozzles on and off to vary the rate) did not negatively affect the uniformity

Studies on VRI

- Many studies couldn't find water savings with VRI.
  - Does not always conserve water
  - Ambiguous water saving, or yield improvement
  - Increasing the number of management units in a field did not necessarily result in more optimal water use
  - Not guarantee savings & in many cases yield the opposite result

Some Simulation Studies DID find water savings with VRI

- Simulation studies In New Zealand and Missouri
  - Large in-season rainfall events and large differences in WHC allow
  - To "mine" the soil water
  - Reduced deep percolation
  - Saved 4-7%, 9-19%, and 22-26% in different studies.
  - Reduction in drainage losses of 45%.

Nebraska Study (Lo, 2016)

- GIS study using soil from the entire state.
- Using historical weather data
- 1.3% total savings if everybody used VRI
- 13% of fields could save 1 inch or more
- 2% of fields could save 2 inches or more
- Large in-season rainfall events would allow them to “mine” the soil water again to increase savings.

Field Studies of Water Savings from VRI

- No significant water savings (Stone et al. 2011)
- Some popular press articles with farmer-stated, or sales-man-stated water savings (12 – 28 %)

<u>Areas with high rainfall</u>

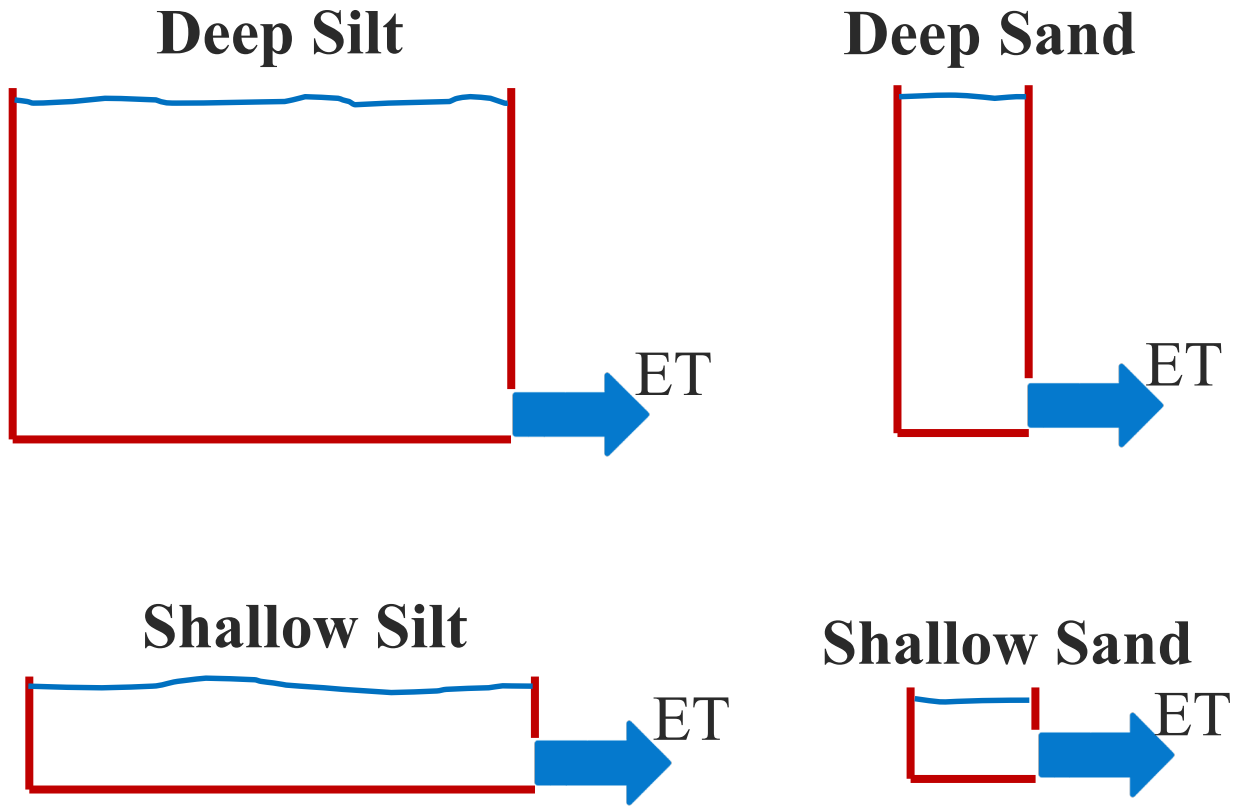
- 25% less water in Mississippi (Sui and Haijun, 2017)
- 85% reduced leaching in New Zealand (McDowell, 2017)
- Reduction in leaching ≠ reduction in water applied.
- Low total irrigation water requirements/season => smaller savings create larger % savings (smaller denominator).

Variable Rate Irrigation in Response to Variable Soils

- "*The sandy/rocky soils need more water.*"
  - Sandy/rocky soils need water more ***frequently***.
  - Hay growing there doesn't *use* more water. The soil can't *hold* very much water.
  - Good management (no stress *OR* excess water) in these areas, and the rest of the field will be fine.

Variable Rate Irrigation?

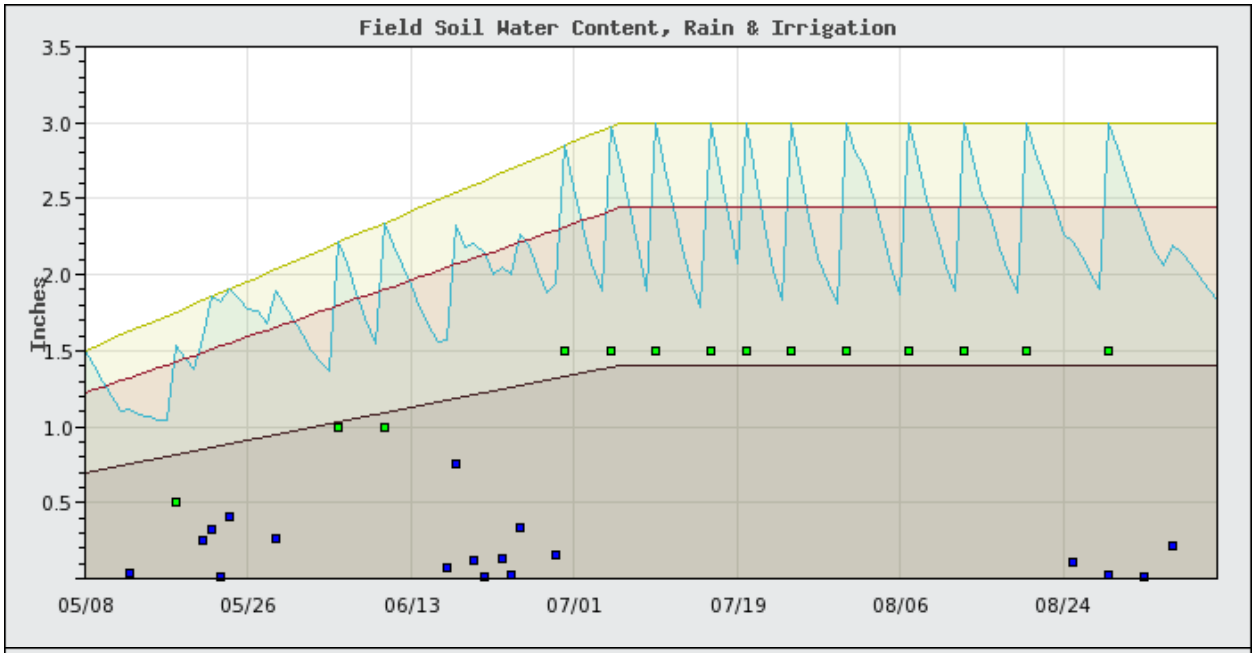
Different Amounts of Water to Different Areas



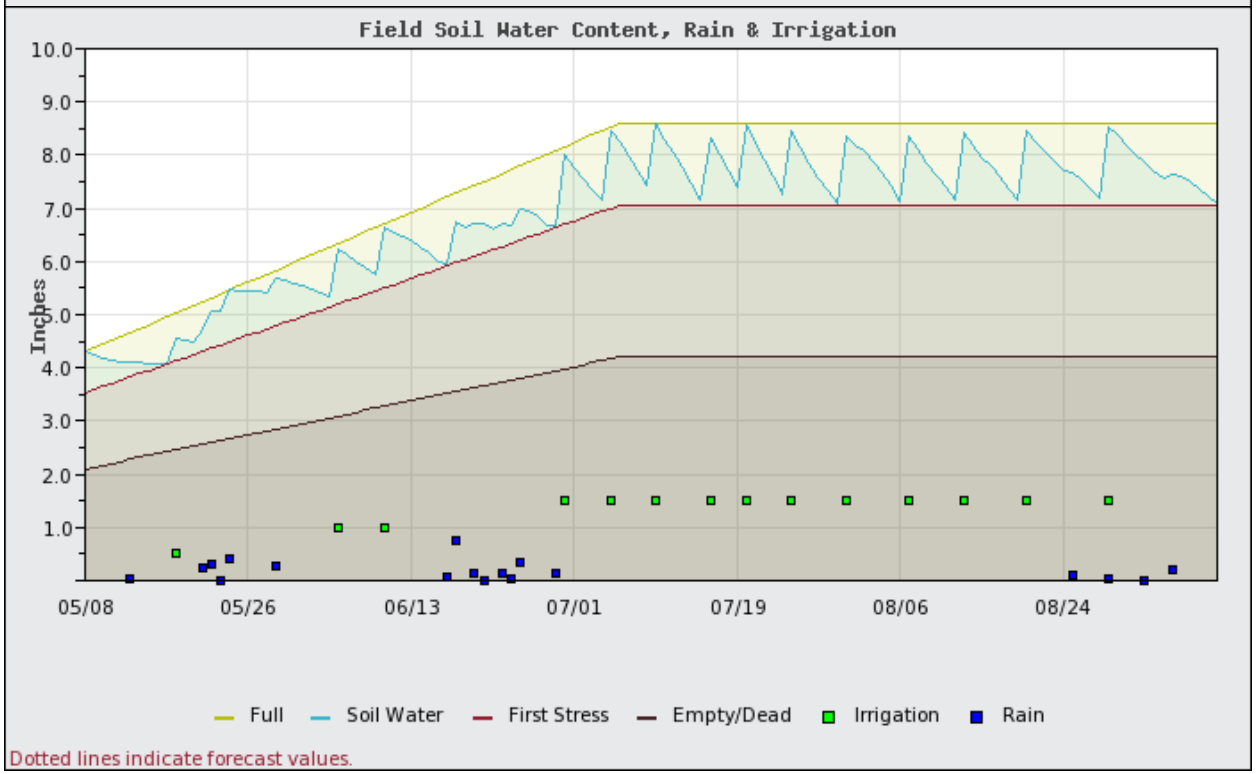
Most soil variability problems can be fixed through uniform irrigation management for the problem soils

Managed for Silt Soils

Shallow Sandy/Rocky Soils



Deep Silt Soils



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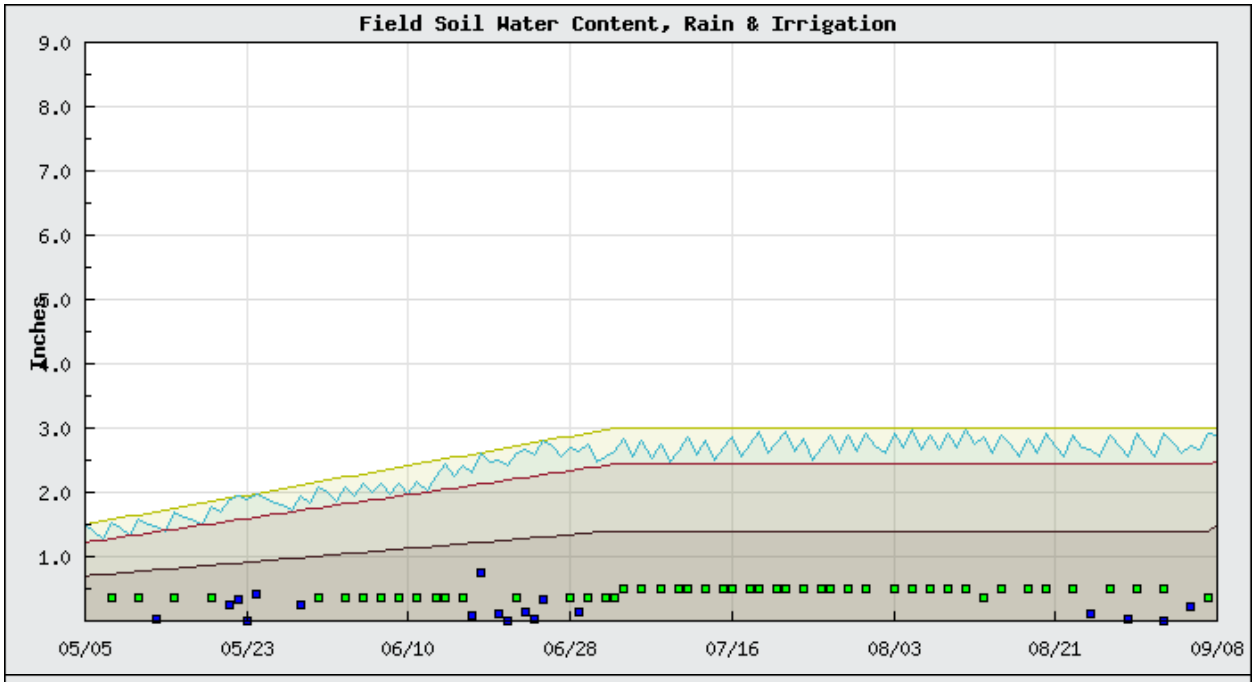

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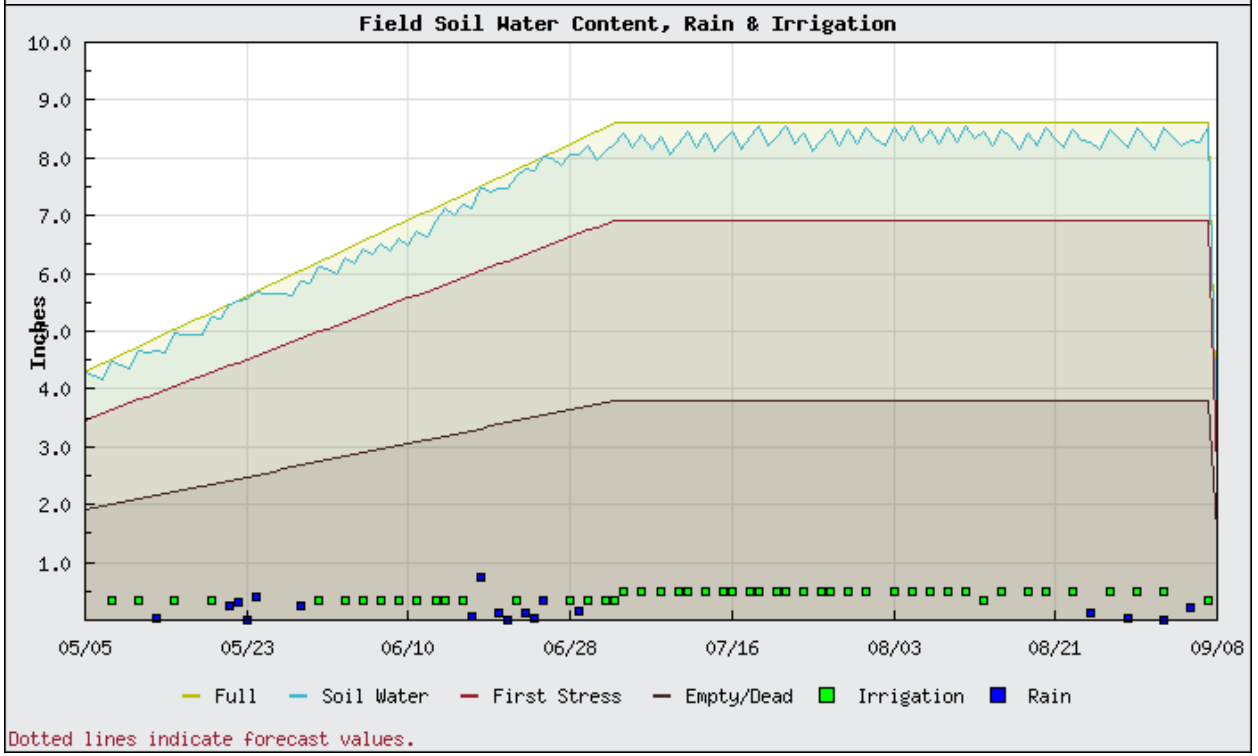


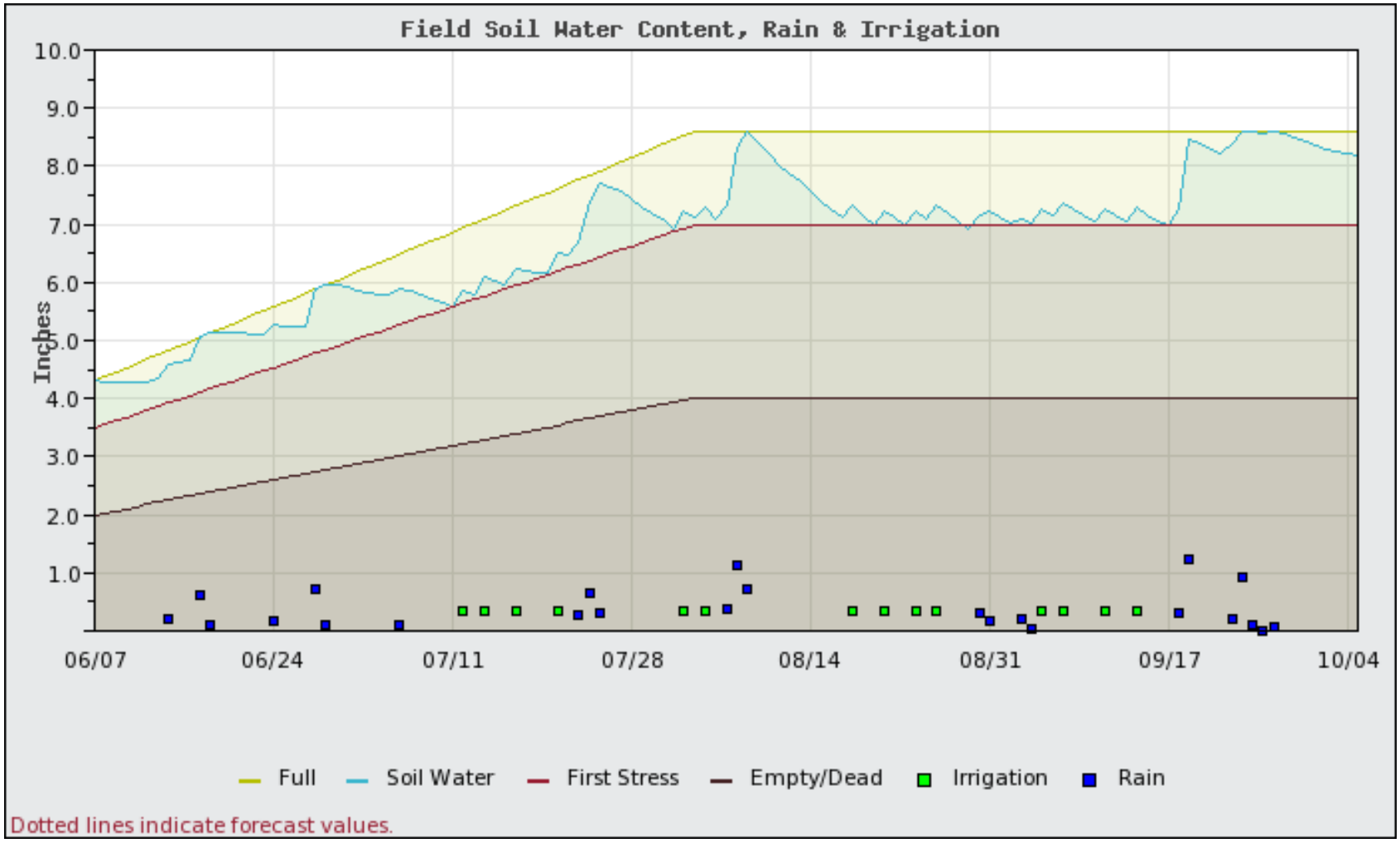
Variable Rate Irrigation in Response to Variable Soils

- *"Water is ponding in some areas."*
  - Irrigation > ET
  - Excess water drains through in most places
  - Poor drainage in some areas.
    - Cut back on water everywhere.
- *"I have Runoff"*
  - More water to areas with runoff won't help
    - Increase infiltration in problem areas using alternative tillage, sprinklers with a larger wetted diameter, or use boombacks.

When VRI can Save Water

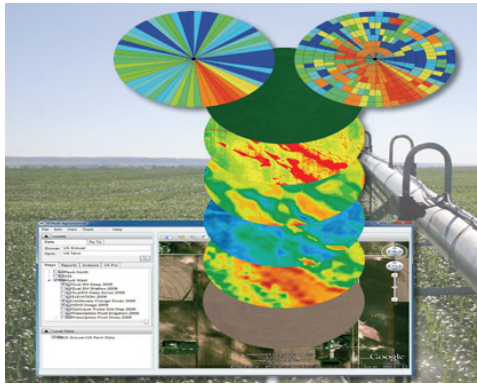
- Areas of the field getting water from other sources. (high water table)
- Different areas *using* different amounts of water. ET is not constant.
  - May be due to disease or pest pressure.
  - South facing vs. north facing slopes.
  - To save water, irrigate areas doing poorly *less*, not *more*. Counterintuitive.

Managing to Maintain Space for Significant in-season rainfall.



Requires very close water management in time *and* space.

Creating and modifying VRI Prescriptions. Not Trivial!

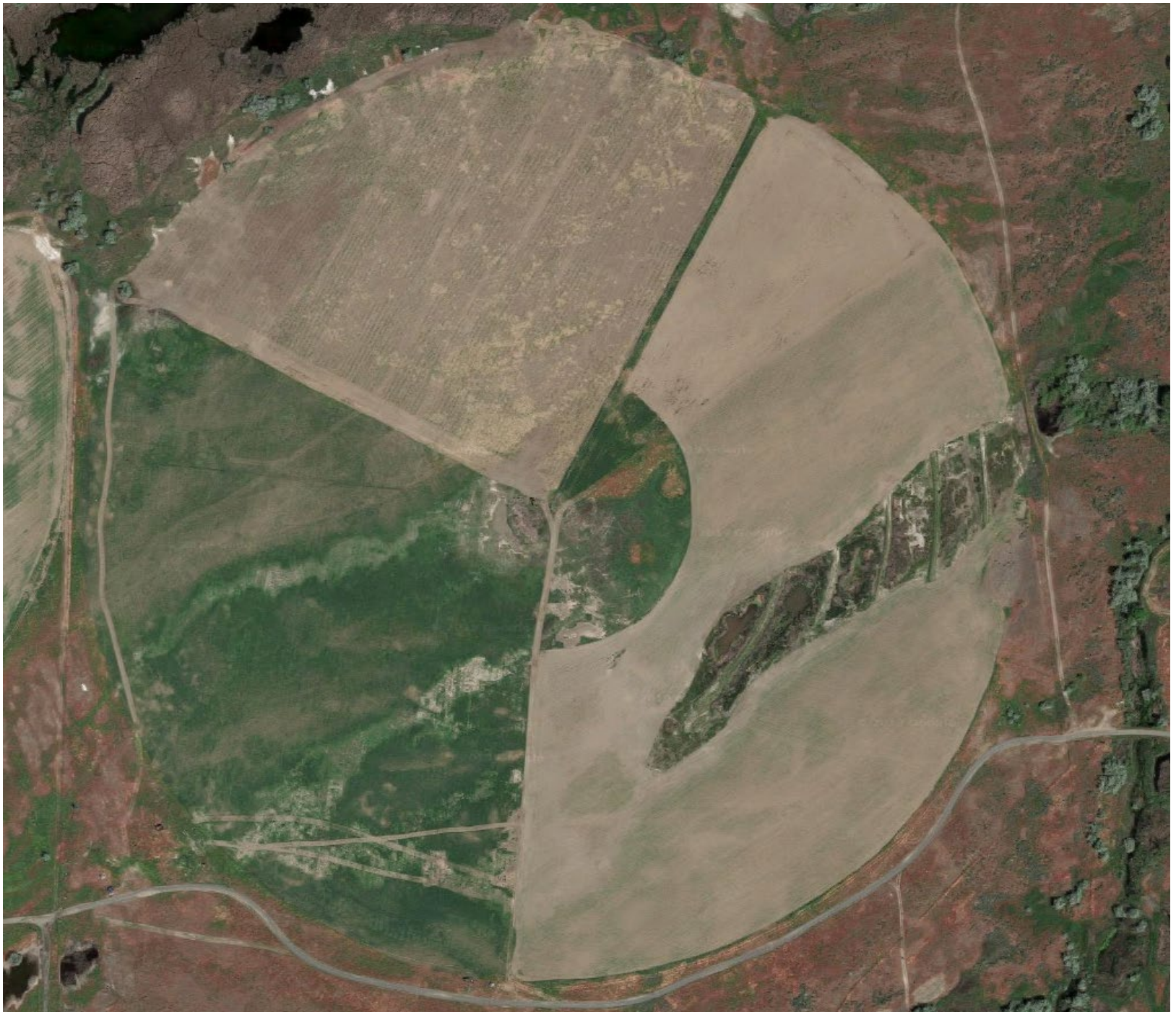


- Can be time consuming, expensive, and plagued by high degrees of uncertainty.
- Requires educated and skilled personnel.
- Depending on objectives, prescriptions must be reevaluated many times during the season (change in time *and* space).
  - This can be especially challenging due to continuously variable soils.

Greatest Profit Potential for VRI

- Consistent prescription maps.
  1. No irrigation to non-cropped surfaces
  2. Crops getting consistent amounts of water from alternative sources.
- May be required if injecting chemicals that can't legally be applied to non-cropped areas.
- Variable *speed* irrigation likely profitable more often than variable *zone* due to the high costs of variable zone.


Falcon Rd




E 400 S
E 400 S
S 500 E
S 500 E
K Can


N Rd
N Rd
W 700 N
W 700 N
W 700 N

Summary: VRI Benefits

- Potential to save significant amounts of water and energy is certain situations!
- Simple water and energy conservation opportunities when using VRI to avoid irrigating non-cropped areas of the field
- % savings = % of field that is non-cropped.
- Can save water when crops are getting water from other sources

Summary: Barriers

- Not as many opportunities to save water in arid areas with low in-season rainfall.
- Prescription map management is complicated
- Many of the problems that VRI can rectify were caused by poor irrigation management:
  - Irrigation > ET.
  - Runoff.
  - Using VRI to fix these is complicated (vary in time and space).

Summary: Crop, Soil, Topography, Climate Specifics

- Large variations in WHC in the field => Savings
- Climates with significant in-season rainfall helps => greater savings
- Differences in in-field drainage (depth to confining layer)
- Deep rooted crops have greater potential for savings if soils are variable
- Fields with non-cropped surfaces

Summary

- VRI can be relied upon to save water and energy to avoid irrigating non-cropped surfaces. Uses a static prescription map.
- VRI can save water in other instances, but currently it is so complicated to manage that these savings likely cannot be relied upon.
- Growers may choose to use VRI to increase yields in high-value crops and to alleviate water-logging that can theoretically be avoided using “precision uniform irrigation”.


E 200 S
E 200 S
S 800 E
K Canal
S 800 E
25