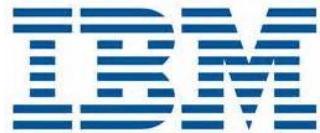


Pixel watering of wine grapes in California: Proof-of-concept testing of a modular variable rate irrigation prototype



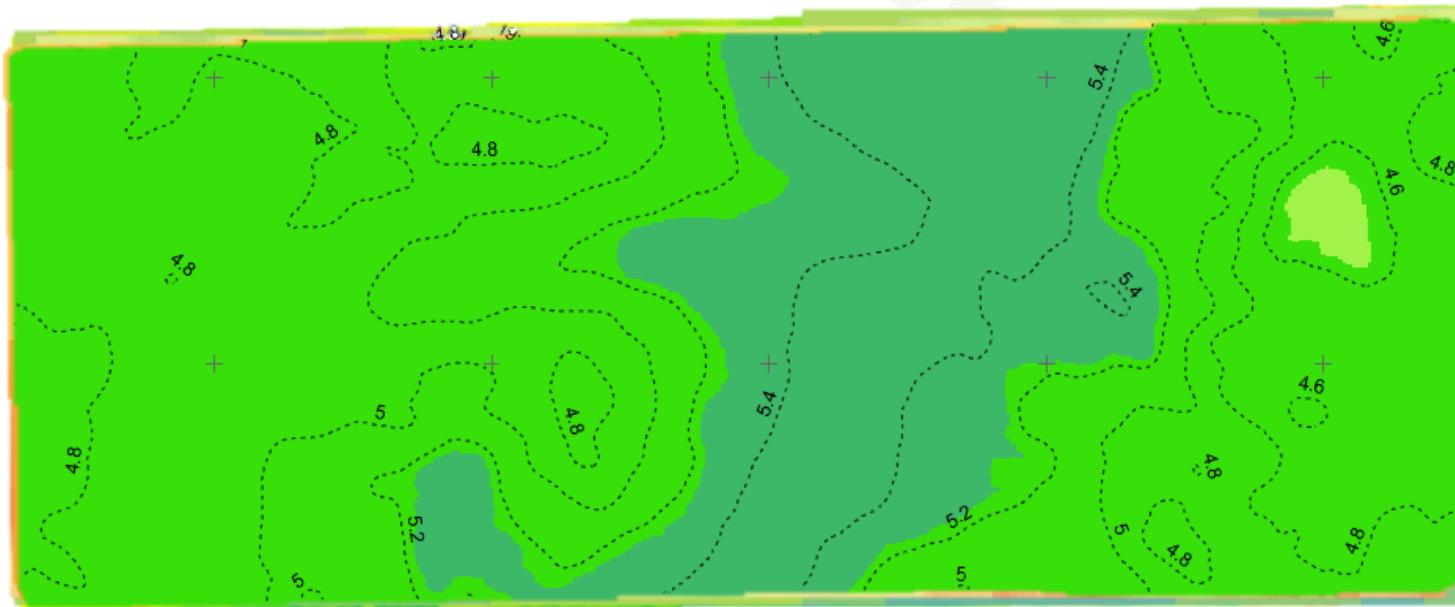
E&J Gallo Winery

Luis Sanchez, InfoAg – July 28, 2015



E&J Gallo Winery

Variable vineyards



Colony 13 – Petite Sirah



E&J Gallo Winery

How can we manage vineyard variability?

Through Precision Viticulture:

- Management to optimize vineyard performance
 - Responding to field variability
 - Maximizing grape yield and quality
 - Minimizing environmental footprint

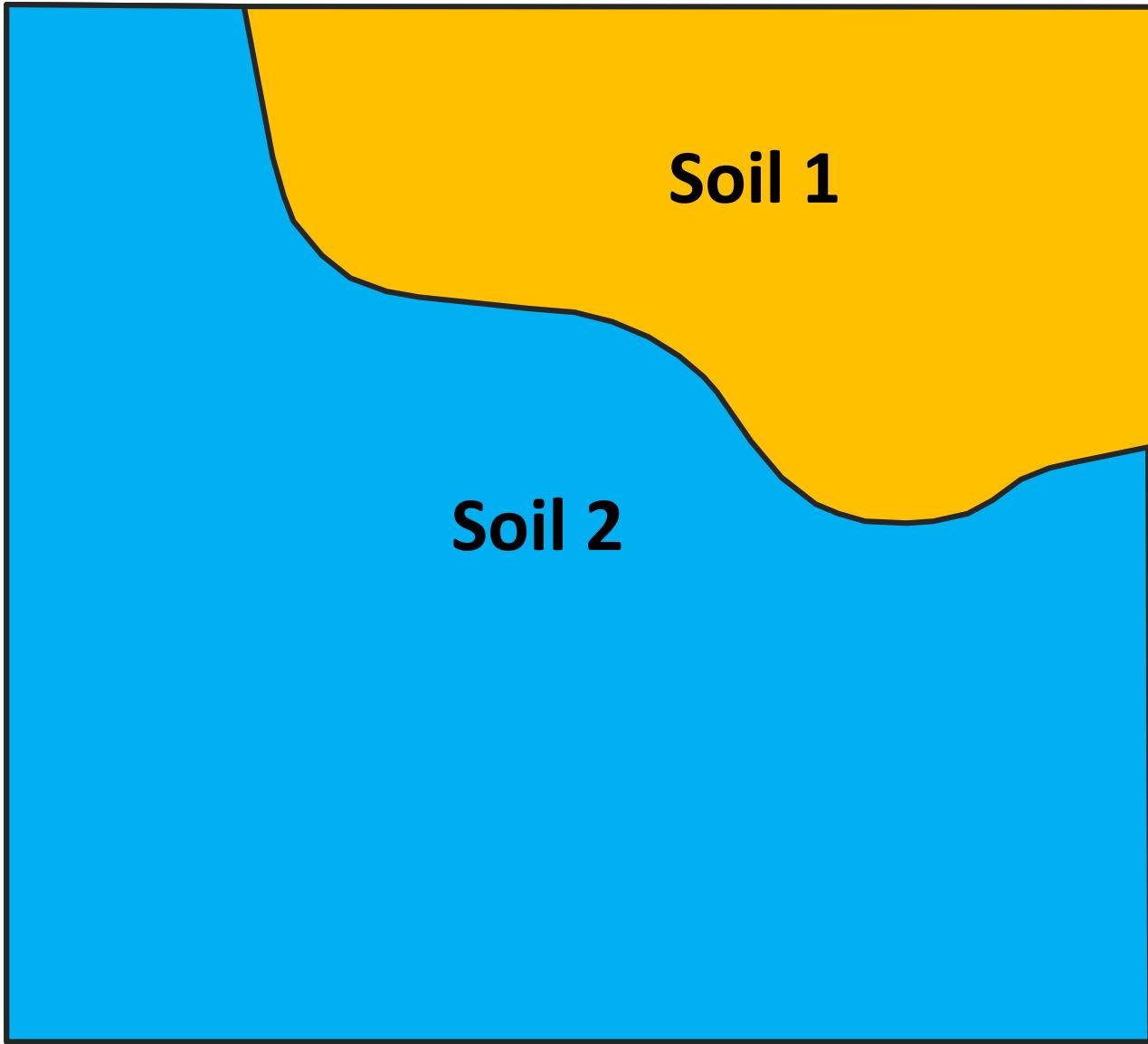


Precision Viticulture

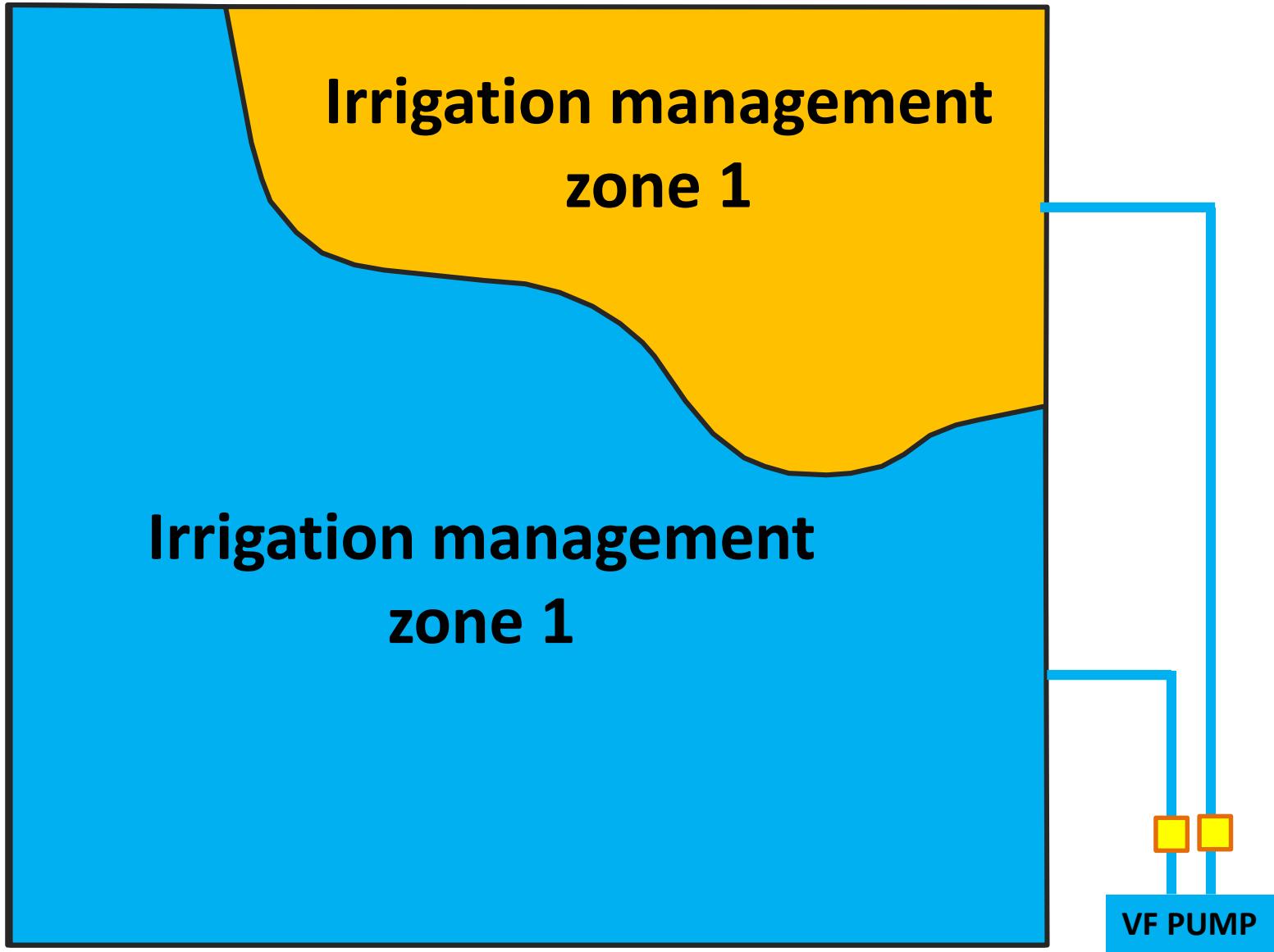
- Variable rate irrigation
 - Sensor-driven systems in potted plants (*and vines?*)
 - Center pivot systems in grain crops
 - Management zones in wine grapes
 - Australia (*McClymont et al. 2012; Proffitt and Pearce 2004*)
 - Spain (*Bellvert et al. 2012; Martínez-Casasnovas et al. 2009*)
 - California



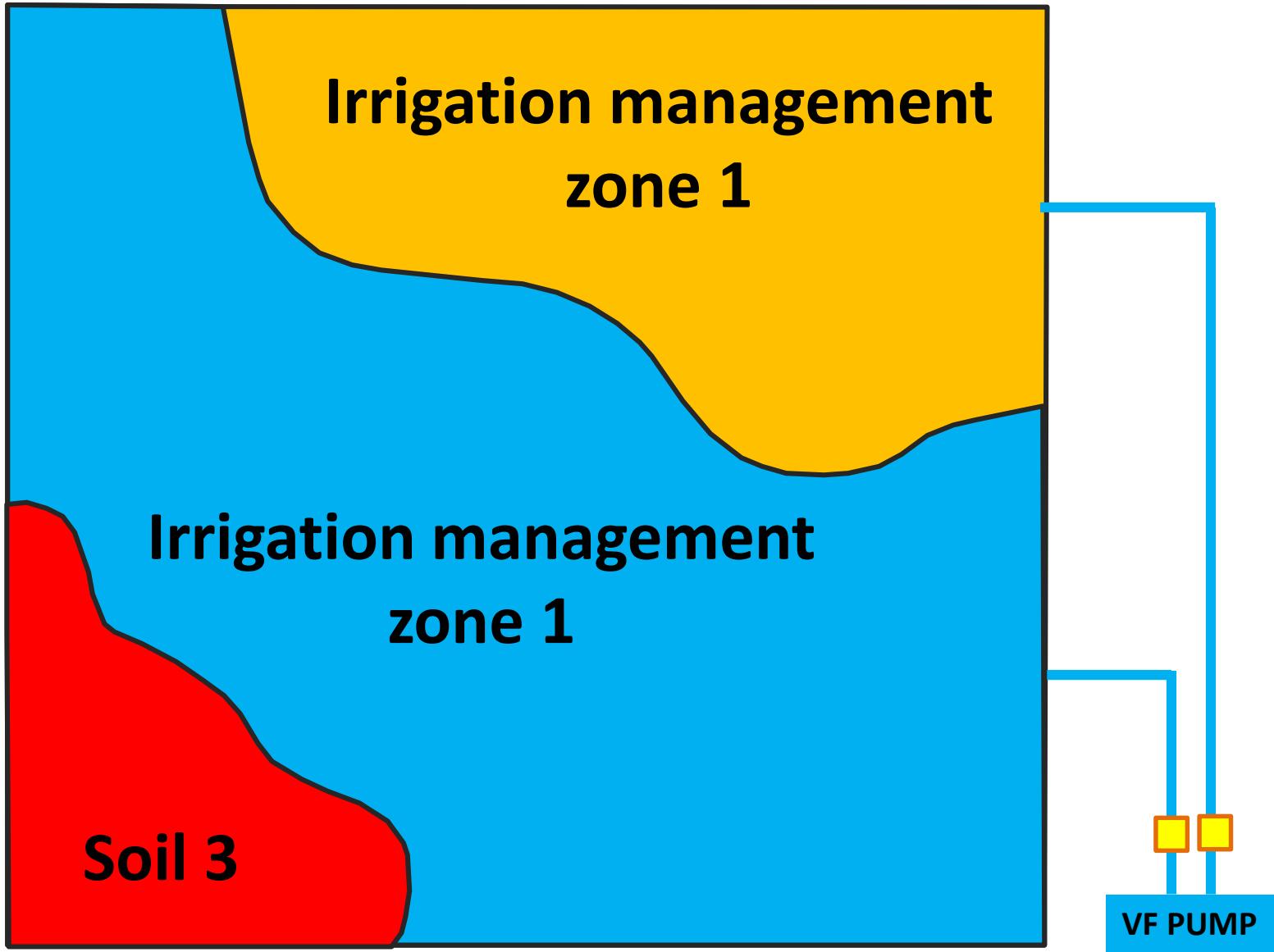
Zonal Irrigation



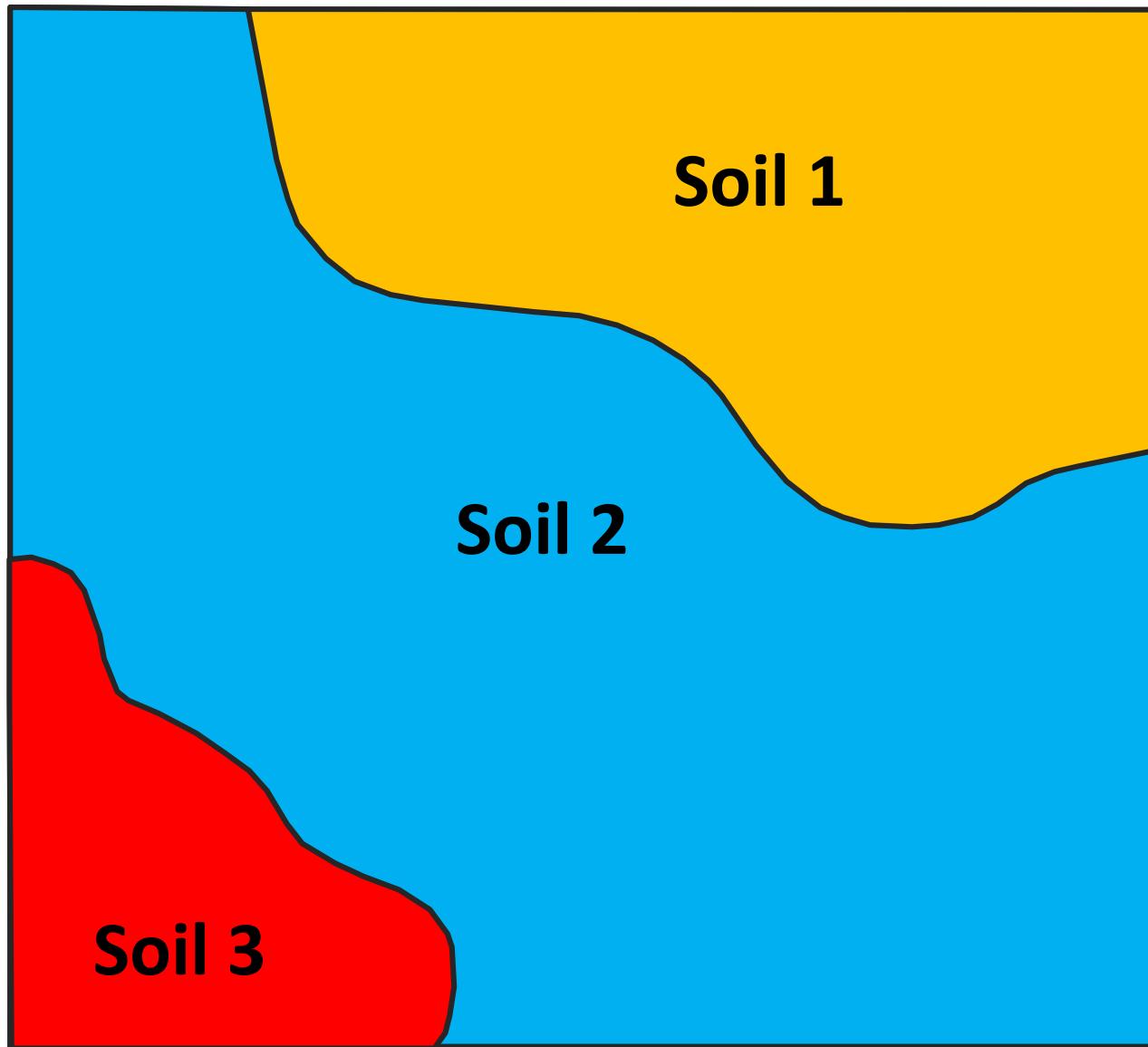
Zonal irrigation



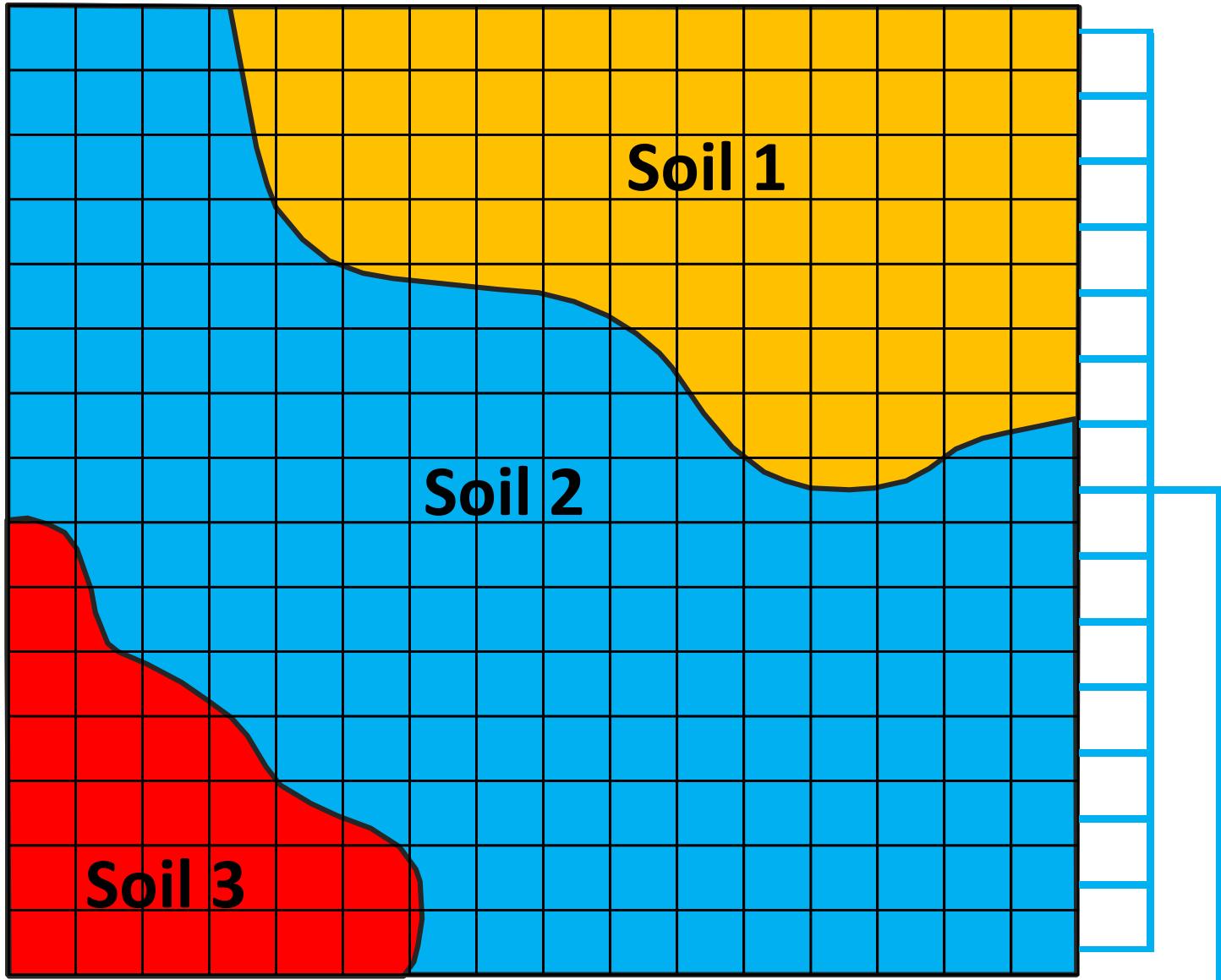
Zonal irrigation



Modular Irrigation

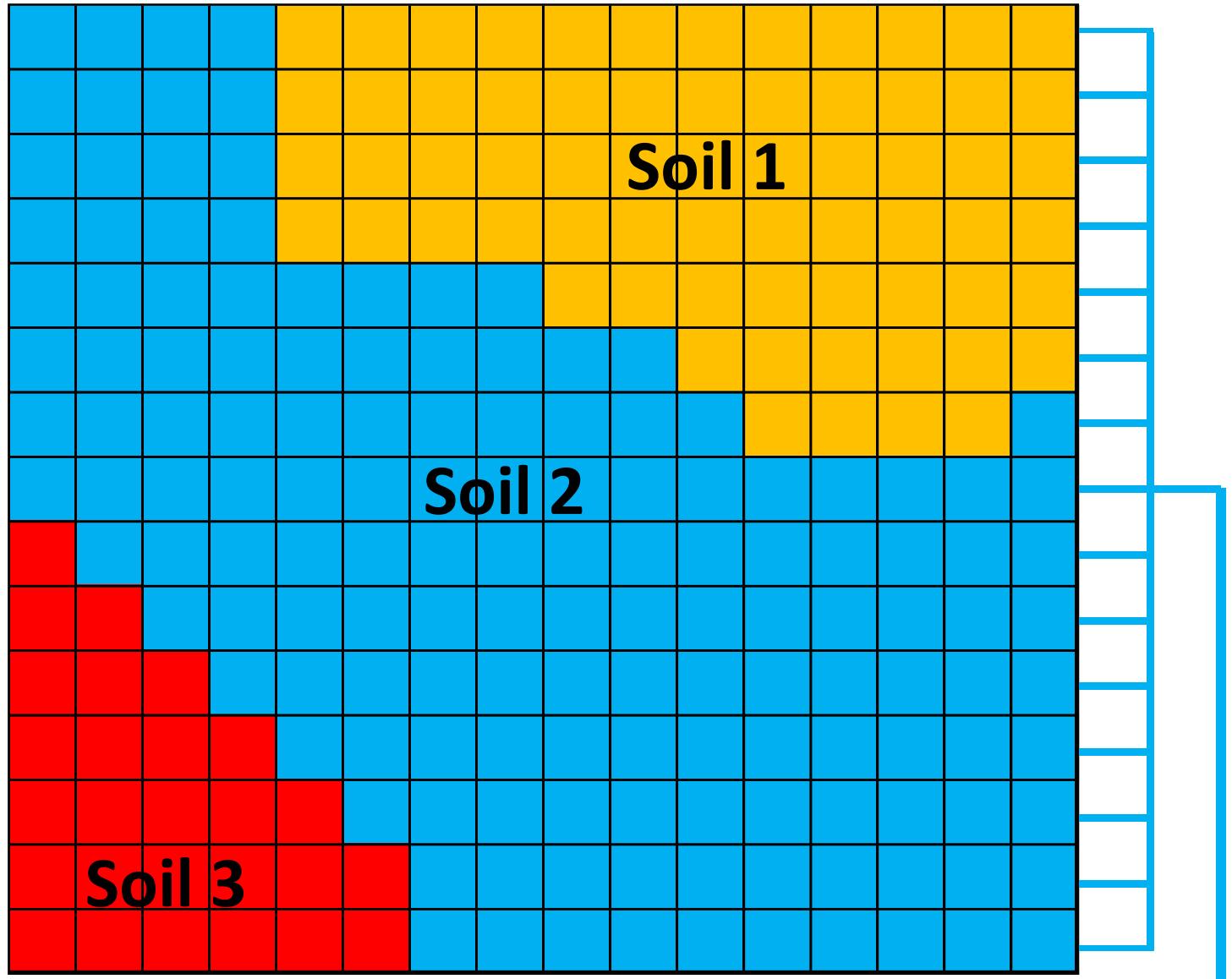


Modular Irrigation



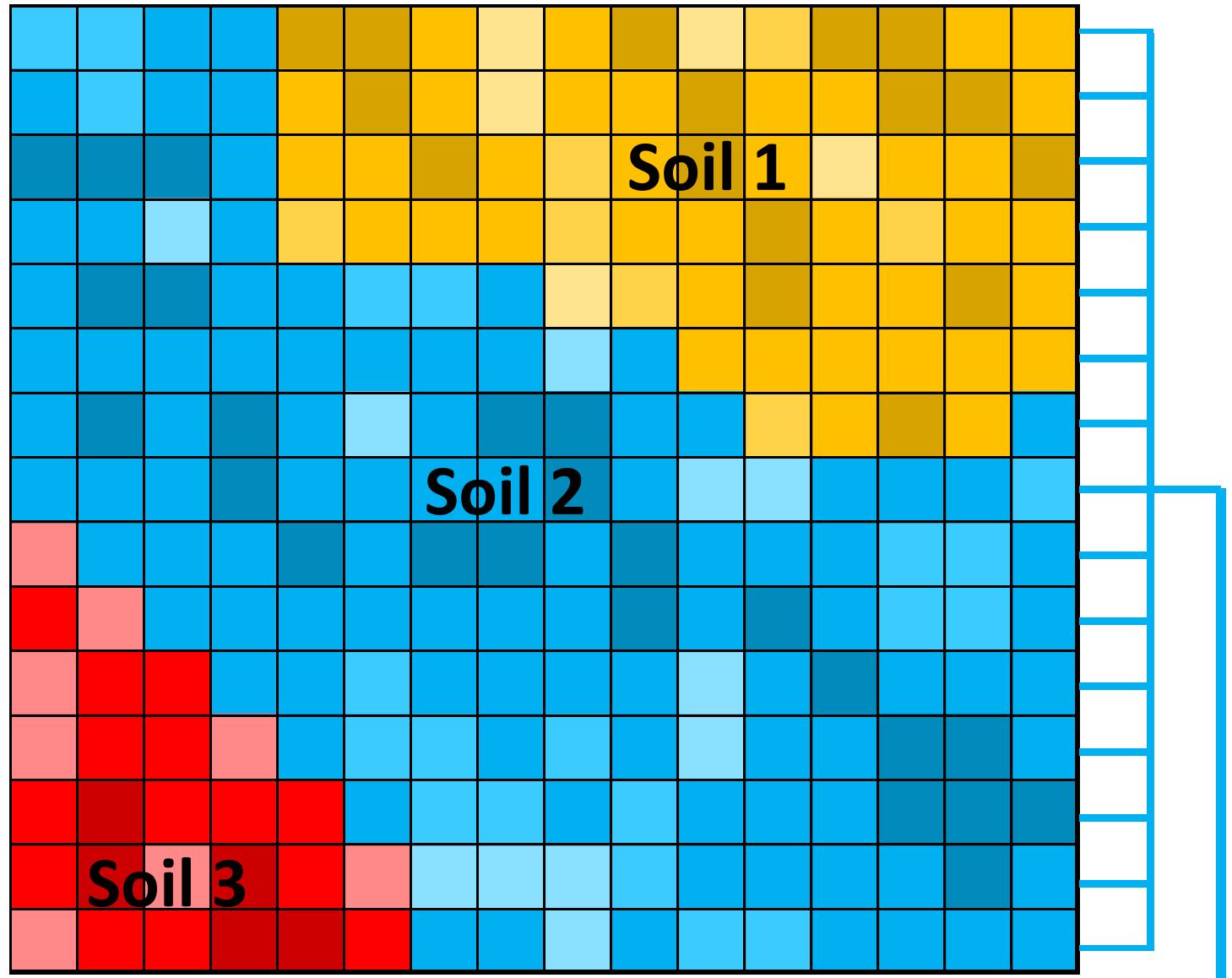
VF PUMP

Modular Irrigation



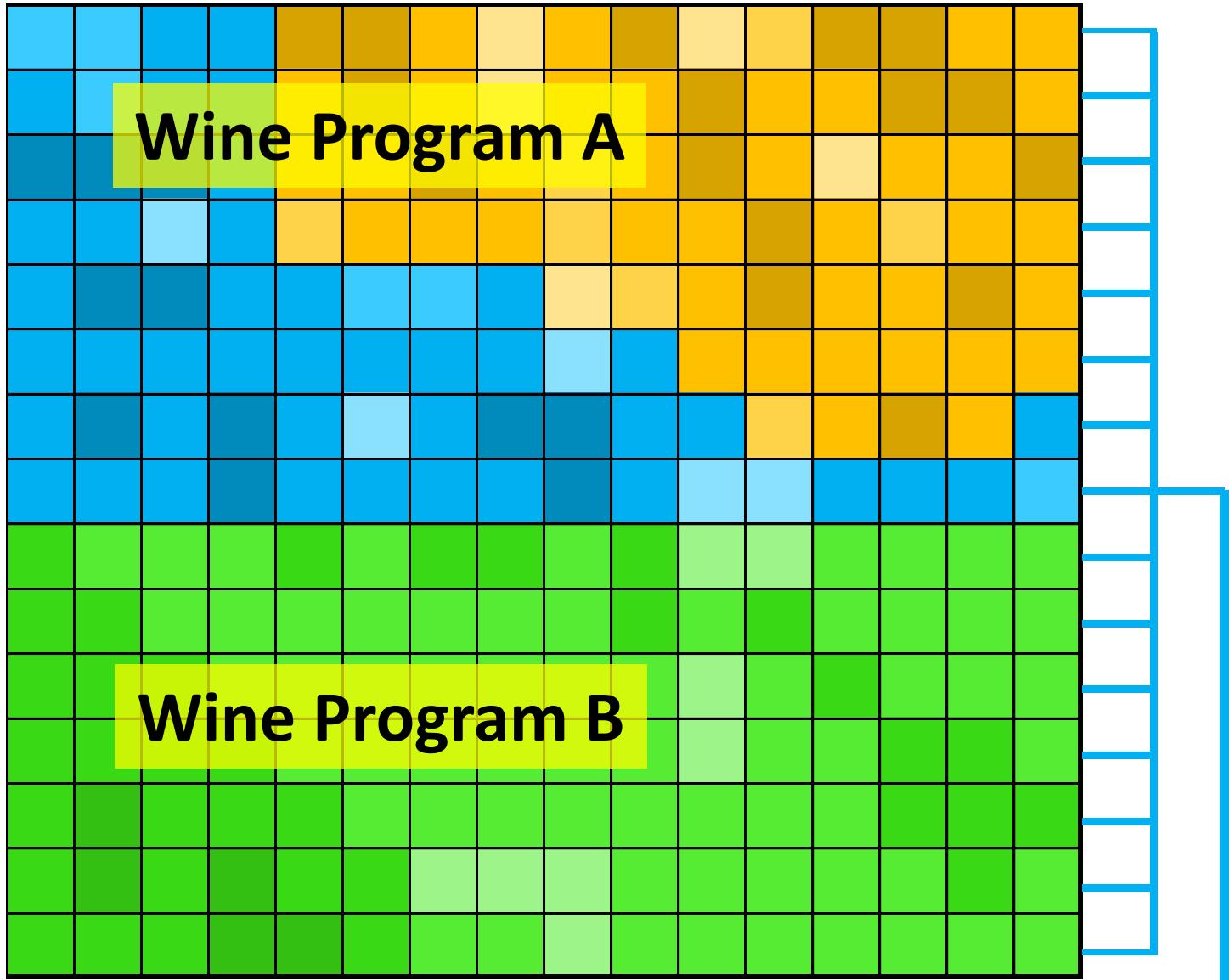
VF PUMP

Modular Irrigation



VF PUMP

Modular Irrigation



Variable Rate Irrigation Study

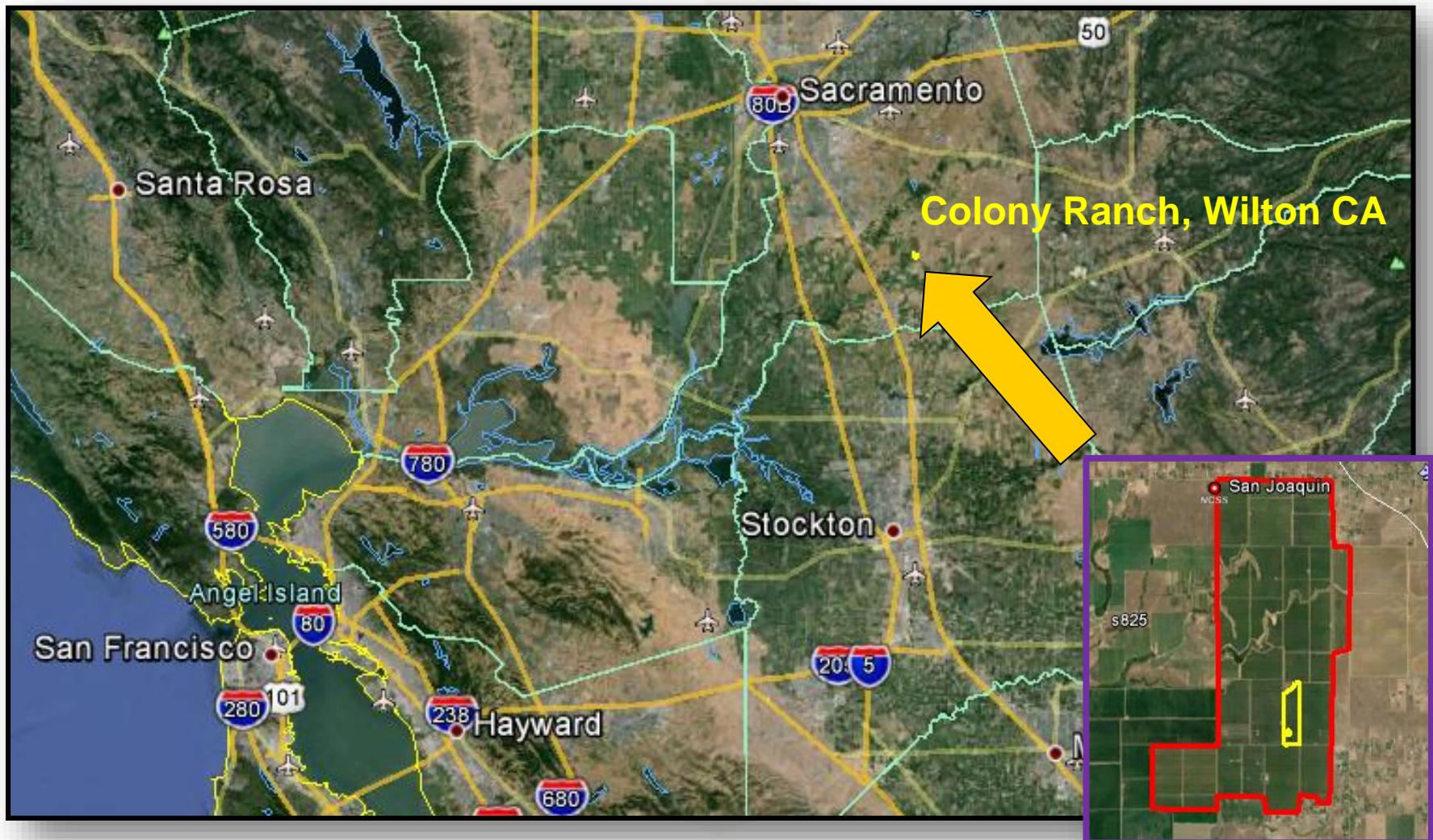
Objective:

Develop and operate a proof-of-concept VRI system prototype and validate it by:

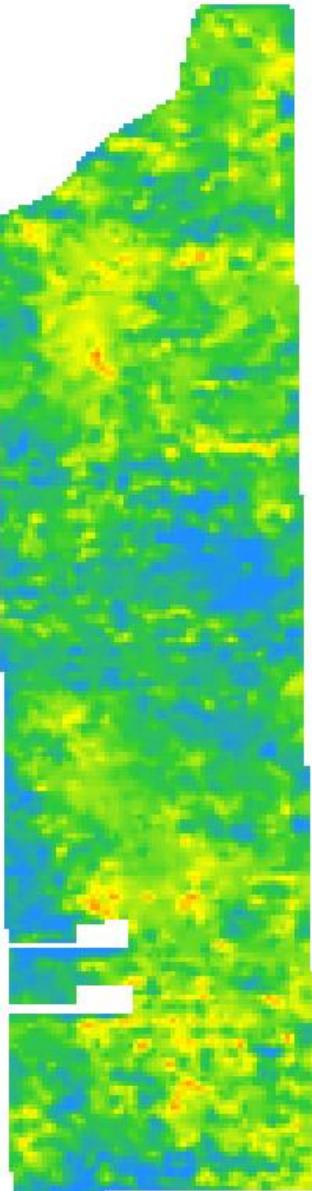
- Decreasing vineyard variability
- Optimizing fruit yield and quality
- Increasing water use efficiency



Experiment location



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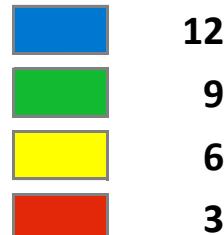


2012 yield map

Colony 2A Cabernet Sauvignon

- Wilton, California
- 31.5 acres
- 5 x 11 feet
- 17-year old
- Teleki 5C
- Hand-pruned
- Drip-irrigated
- San Joaquin silt loam (~ 75%)
- San Joaquin-Galt complex (~ 25%)
- 500 mm (20") annual rainfall
- Highly variable

2012 Yield
tons per acre



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Field layout

2012 Yield tons per acre

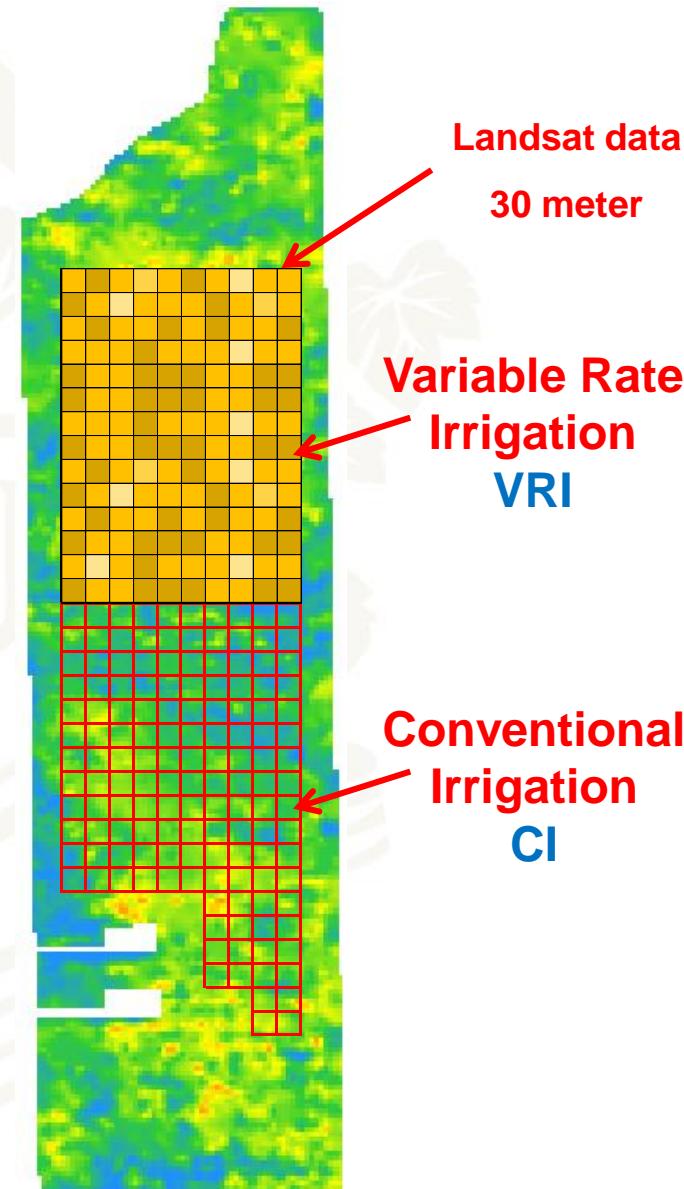


Block area: 31.5 acres

VRI & CI: 10.0 acres

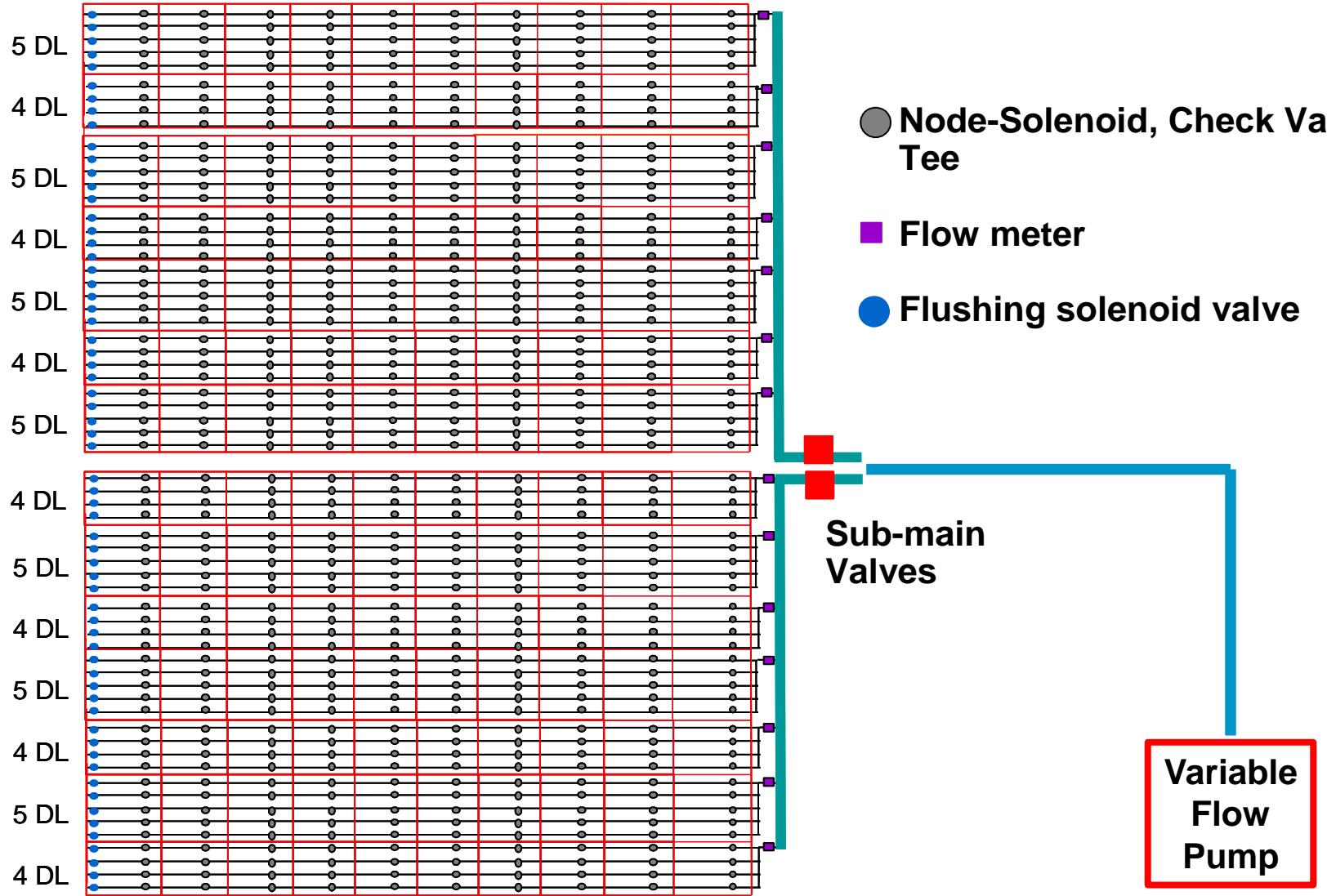
Field average: 9.17 tons/acre

140 Irrigation Zones



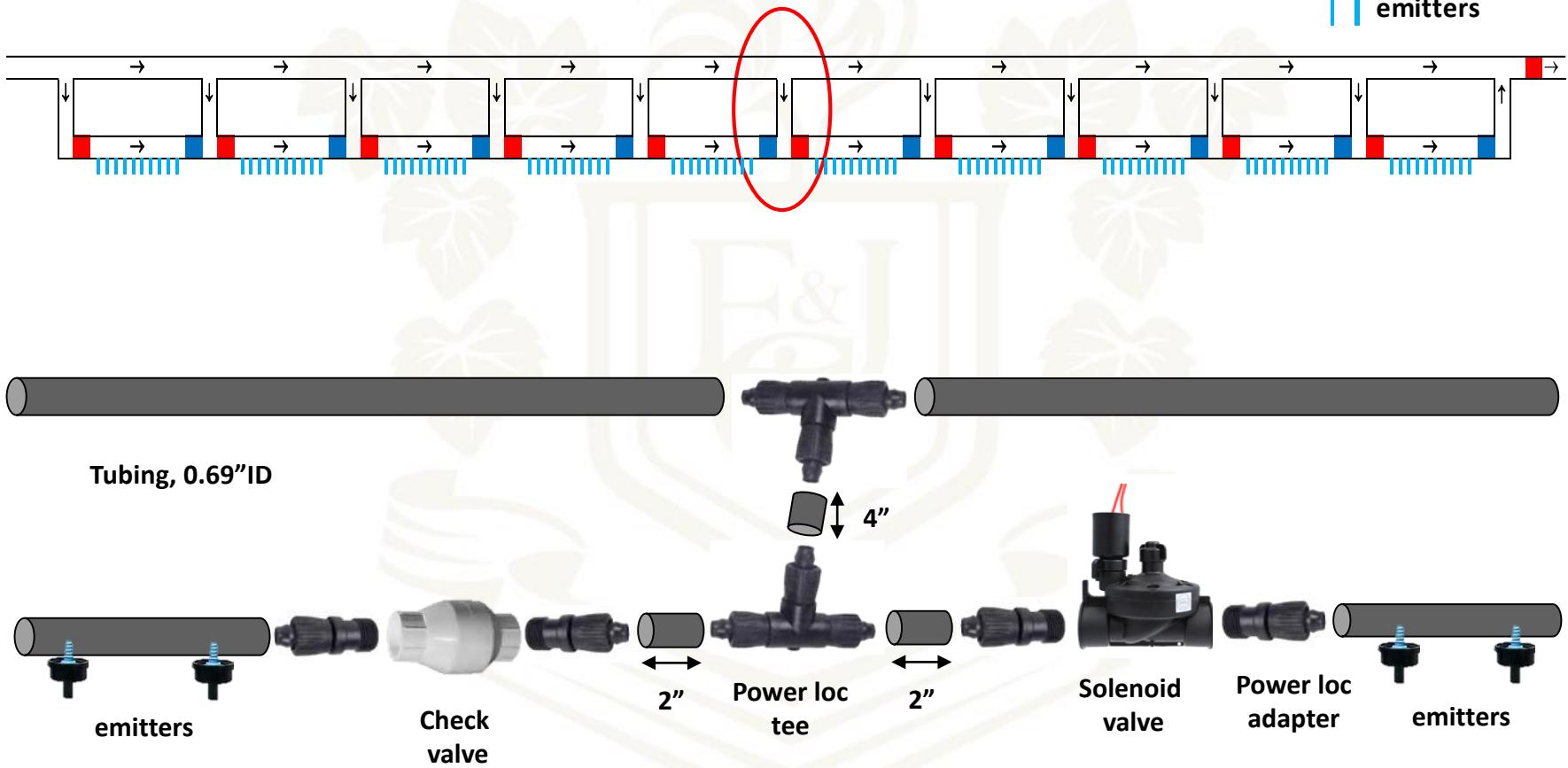
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General layout



System design

- solenoid valve
- check valve
- emitters



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System design



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Control board

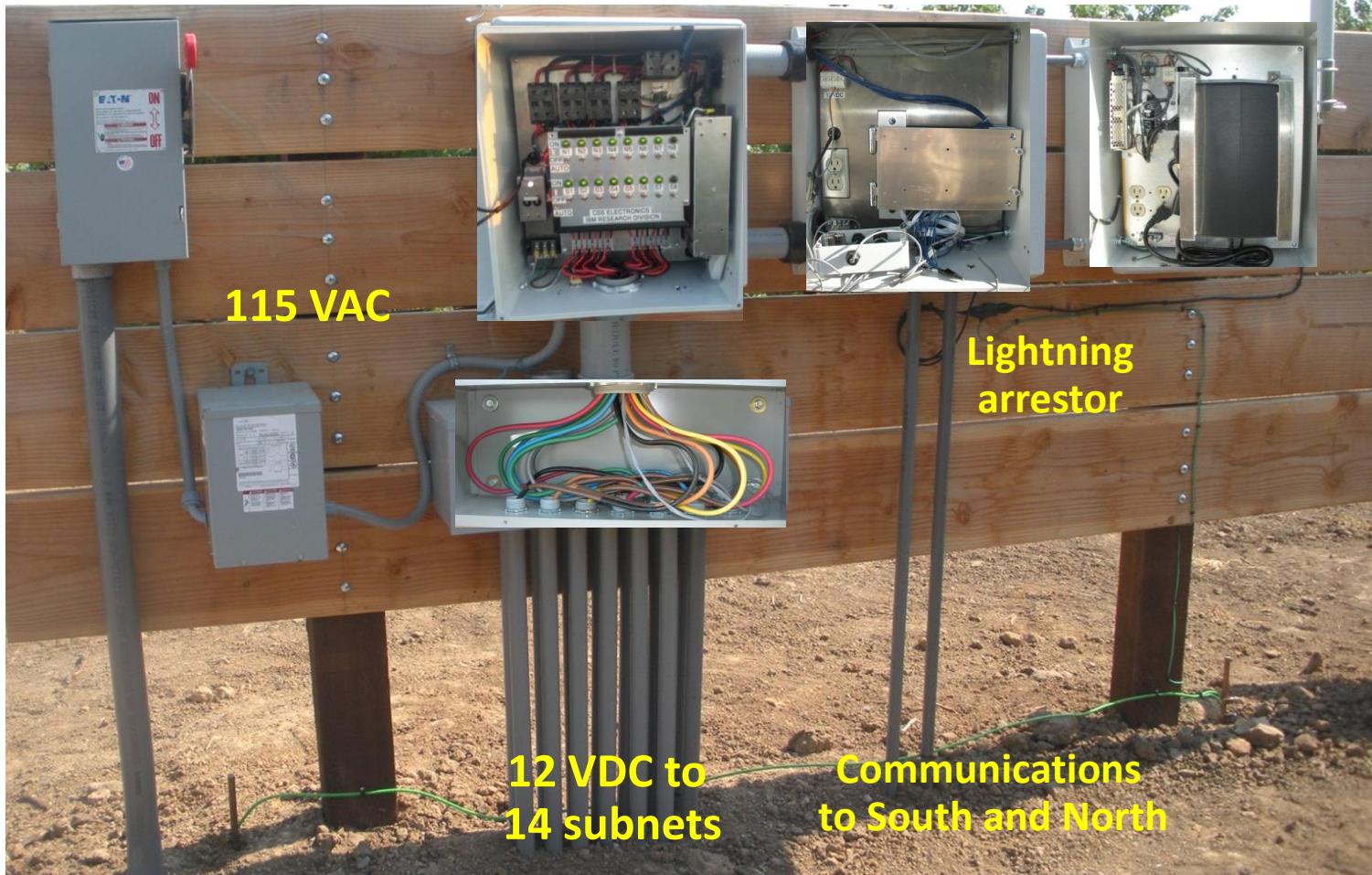
480 VAC

Power
distribution
box

Control
box

UPS
box

Cell
Antenna



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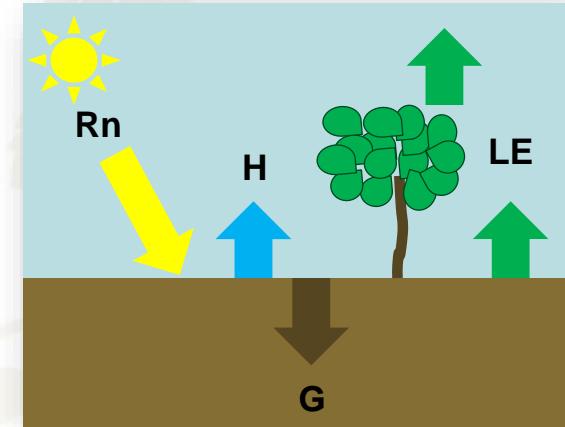
Irrigation scheduling

- METRIC (Mapping evapotranspiration at high resolution and internalized calibration)
- ET residual of surface energy balance

$$Rn + LE + G + H = 0$$

- Inputs
 - Landsat (visible & infrared)
 - CIMIS weather data
- Outputs
 - ETc
 - Kc (f/NDVI)
- Watering of each zone:

$$ETc = ETref * Kc * Km$$



2013 irrigation management

2012 yield tons/acre <i>(average = 8.9)</i>	# of irrigation zones	Irrigation management factor		
		May 4 weeks	June 4 weeks	July - Oct 16 weeks
< 8.9	76	1.2	0.5	0.7
> 8.9	64	no irrigation	0.5	0.7

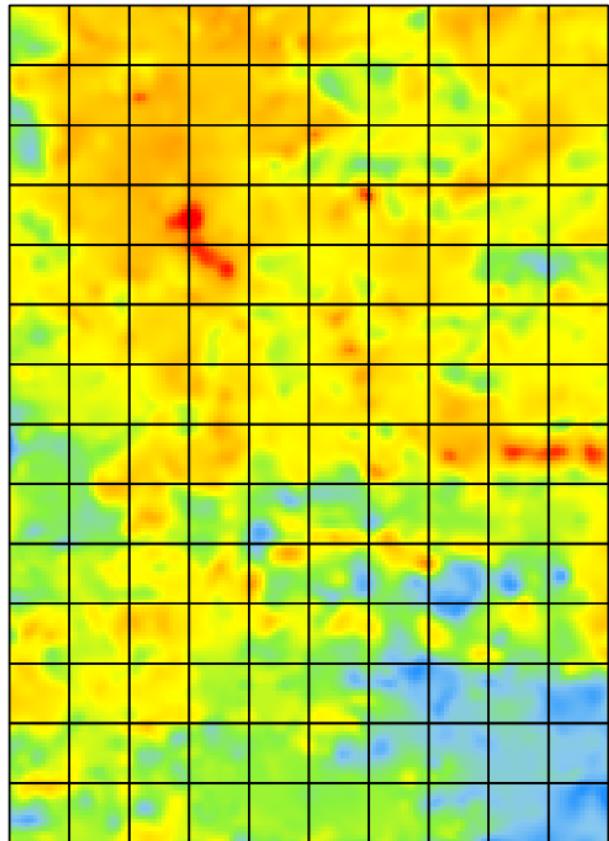


2014 irrigation management

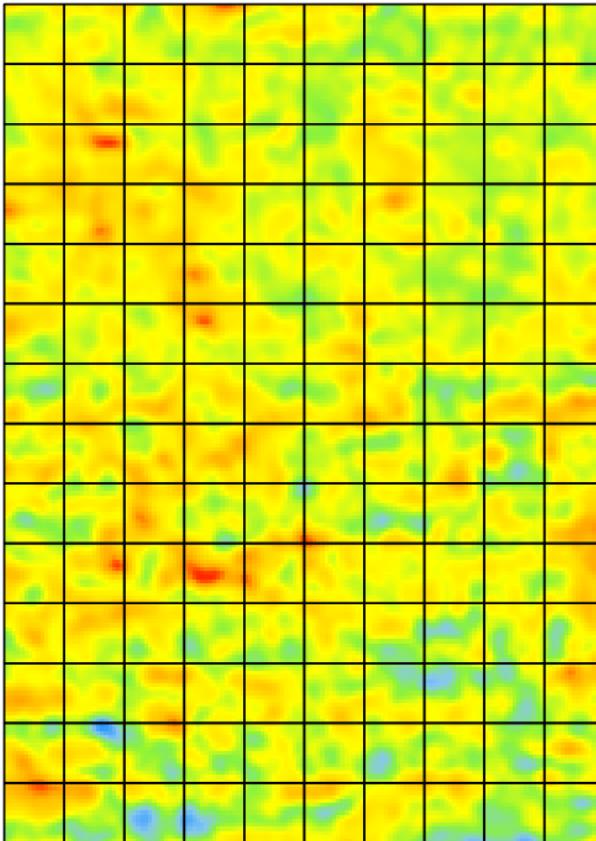
# of irrigation zones	Irrigation management factor		
	May 4 weeks	June 4 weeks	July - Oct 16 weeks
140	0.0 - 0.7	0.5 – 0.8	0.6 – 1.0



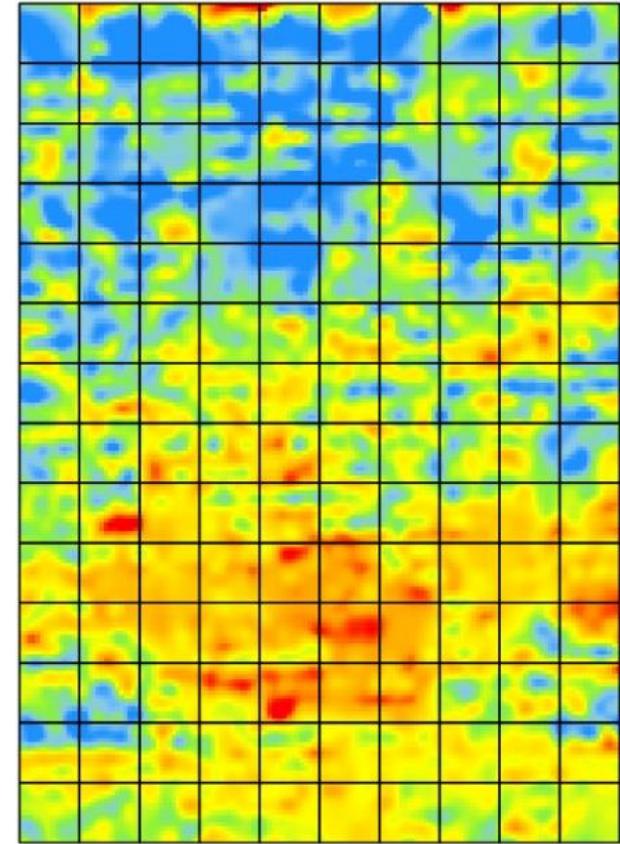
VRI Yield - Normalized



2012 Yield:
Mean = 8.9 t/ac
6.1 – 12.4 t/ac
Range = 6.3

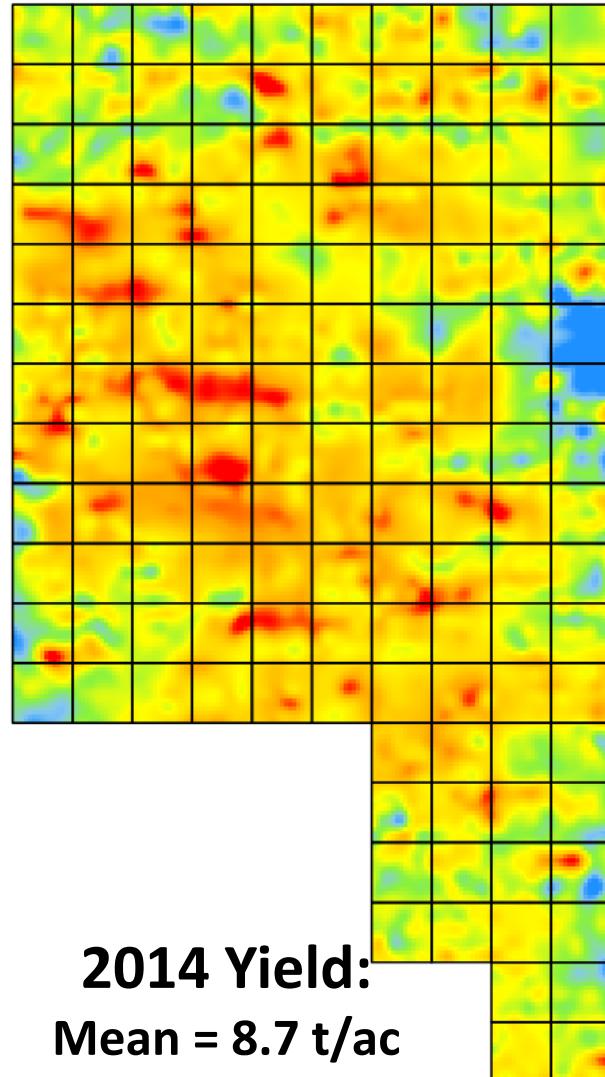
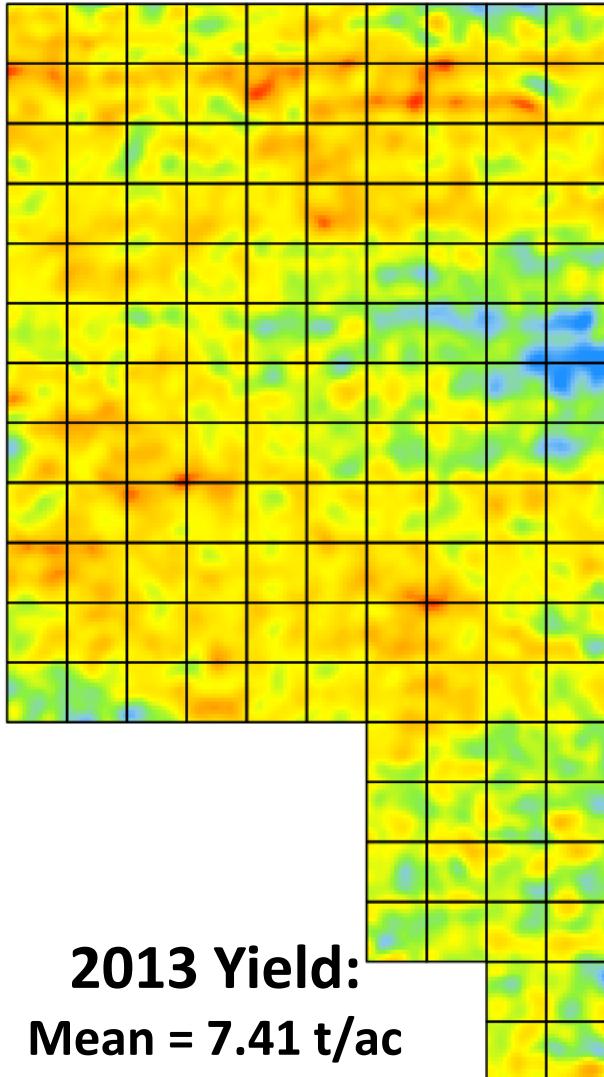
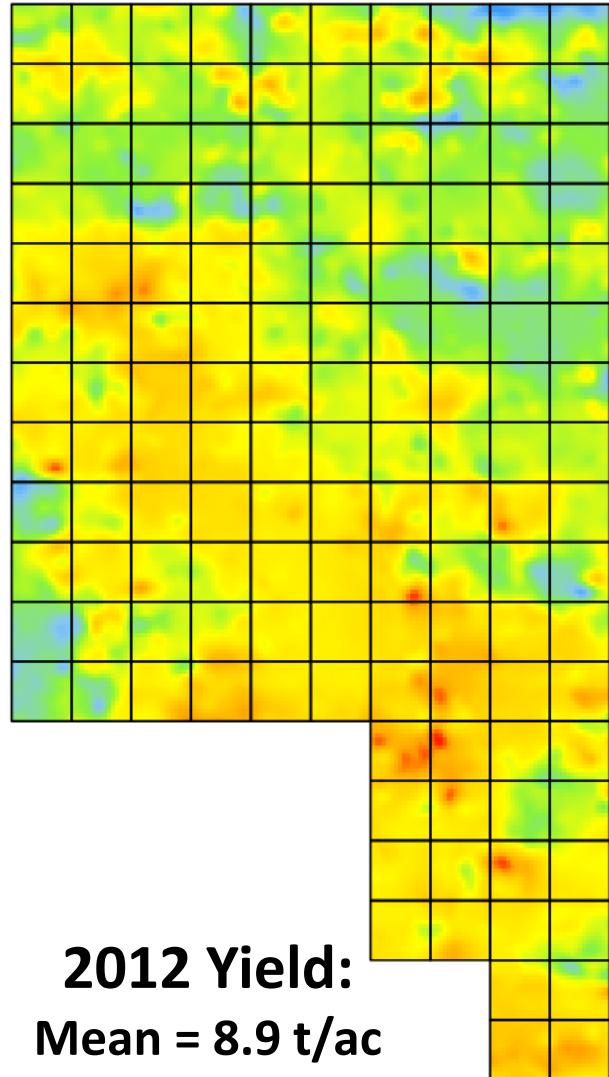


2013 Yield:
Mean = 7.7 t/ac
6.3 – 8.9 t/ac
Range = 2.6

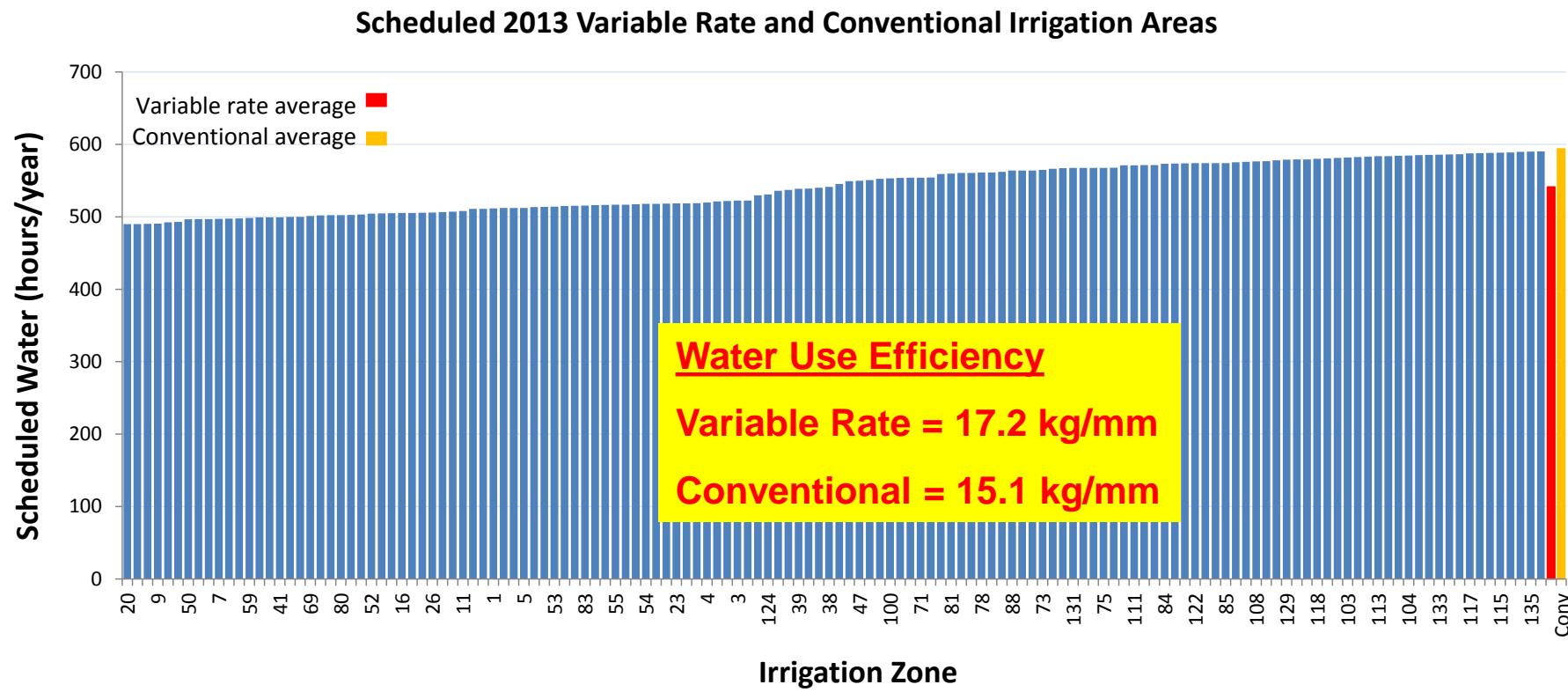


2014 Yield:
Mean = 10.2 t/ac
6.2 – 14.0 t/ac
Range = 7.8

CI Yield - Normalized

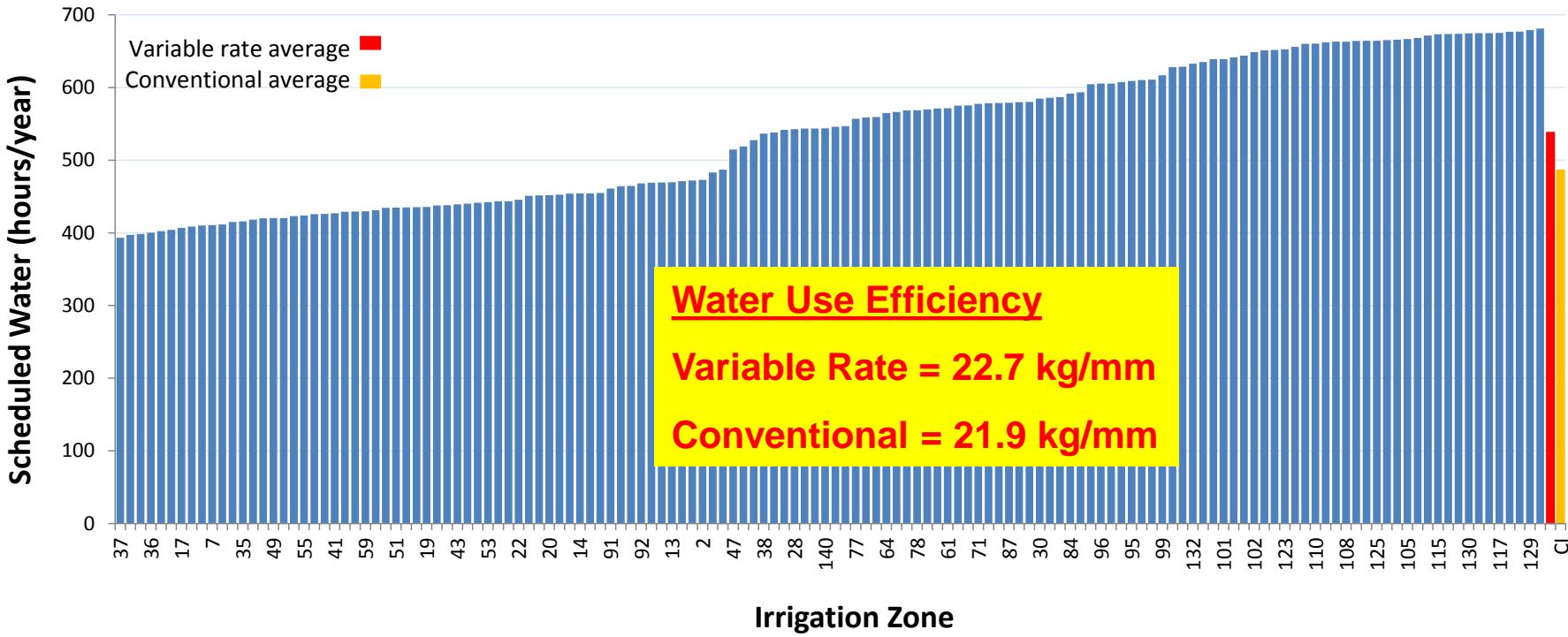


2013 applied water



2014 applied water

Scheduled 2014 Variable Rate and Conventional Irrigation Areas



Non-spatial statistics

Irrigation	Yield class	Leaf Area Index	clusters per vine	cluster weight (g)	berry weight (g)
Variable rate	high	6.0 a	147.7 a	76.0 a	0.9 ab
	medium	5.3 a	127.7 a	84.7 a	0.8 b
	low	5.2 a	127.7 a	71.6 a	0.7 c
Conventional	high	6.1 a	151.6 a	81.9 a	1.0 a
	medium	6.1 a	155.6 a	75.7 a	0.8 b
	low	6.1 a	130.2 a	66.1 a	0.7 bc

Different letters are significantly different at p<0.05



Conclusions

- Successful modular variable rate irrigation system prototype implementation
- Precise manipulation of vineyard variability
- Maintaining high water use efficiency

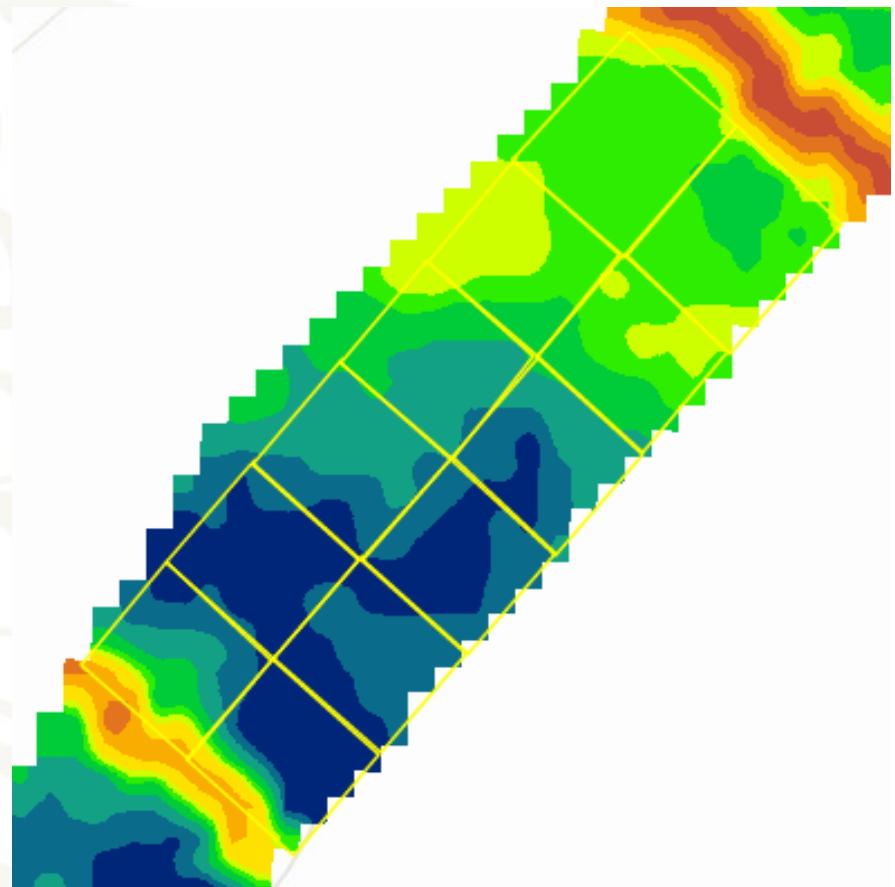


Next steps

- Continue testing prototype until year 5
- Second generation system underway
 - Multiple vineyards
 - Other permanent crops
- Commercial level system
 - Cost effectiveness



Next steps



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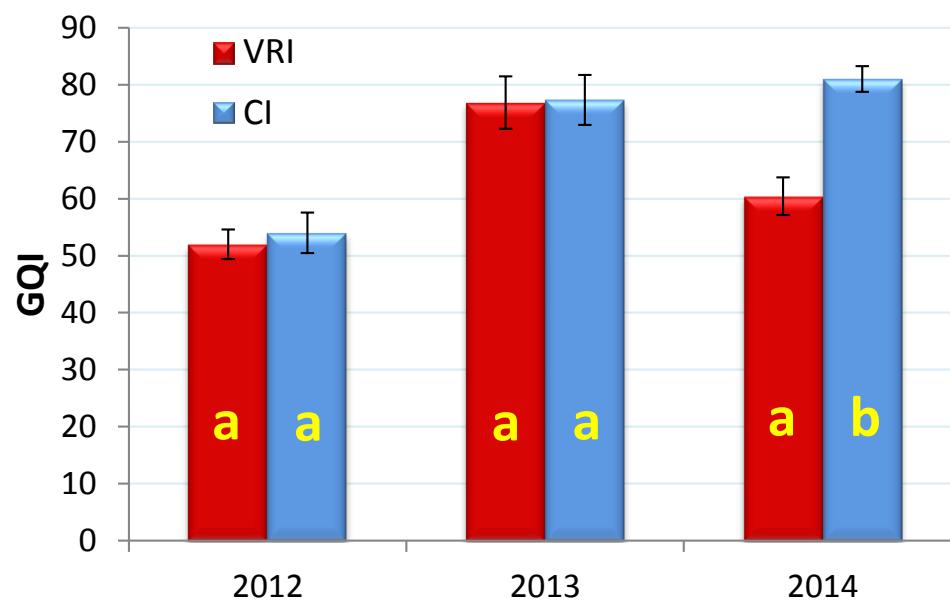
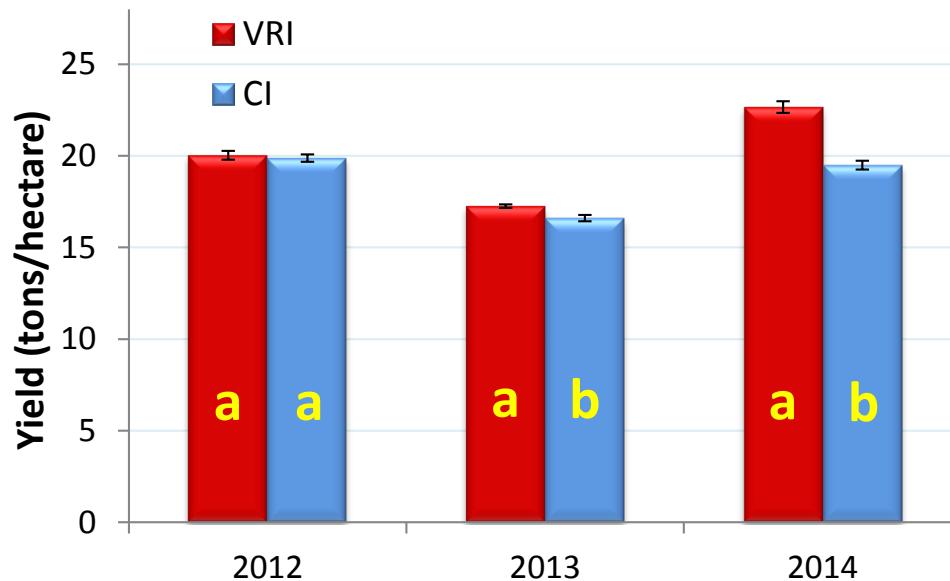
Acknowledgments

- E&J Gallo Winery
 - Viticulture Lab: Brent Sams, Maegan Salinas, Erin Troxell, Shijian Zhuang, Nona Ebisuda
 - Chemistry: Hui Chong, Bruce Pan, Natalia Loscos
 - Research Winery: David Santino, Bianca Wiens, Steven Kukesh
 - GIS-CE: Martin Mendez, Andrew Morgan
 - Nick Dokoozlian
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 - TJ Watson Lab, NY: Levente Klein, Nigel Hinds, Hendrik Hamann
 - Data Services, CA: Alan Claassen, David Lew
- James Taylor, New Castle University, UK
- Ernie and Jeff Dosio, Pacific Agrilands
- Scott Britten and Associates, Bennett & Bennett

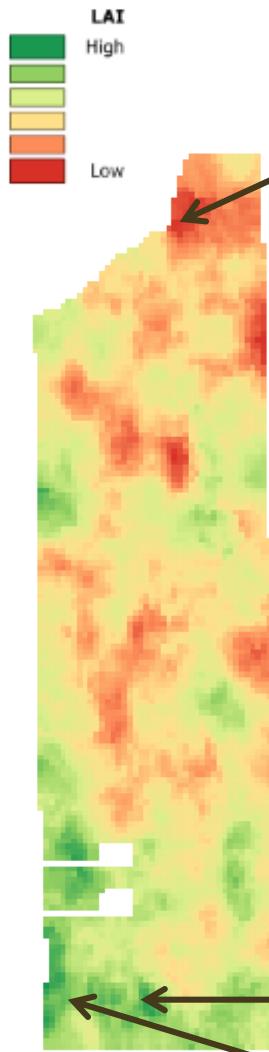


Thank you!

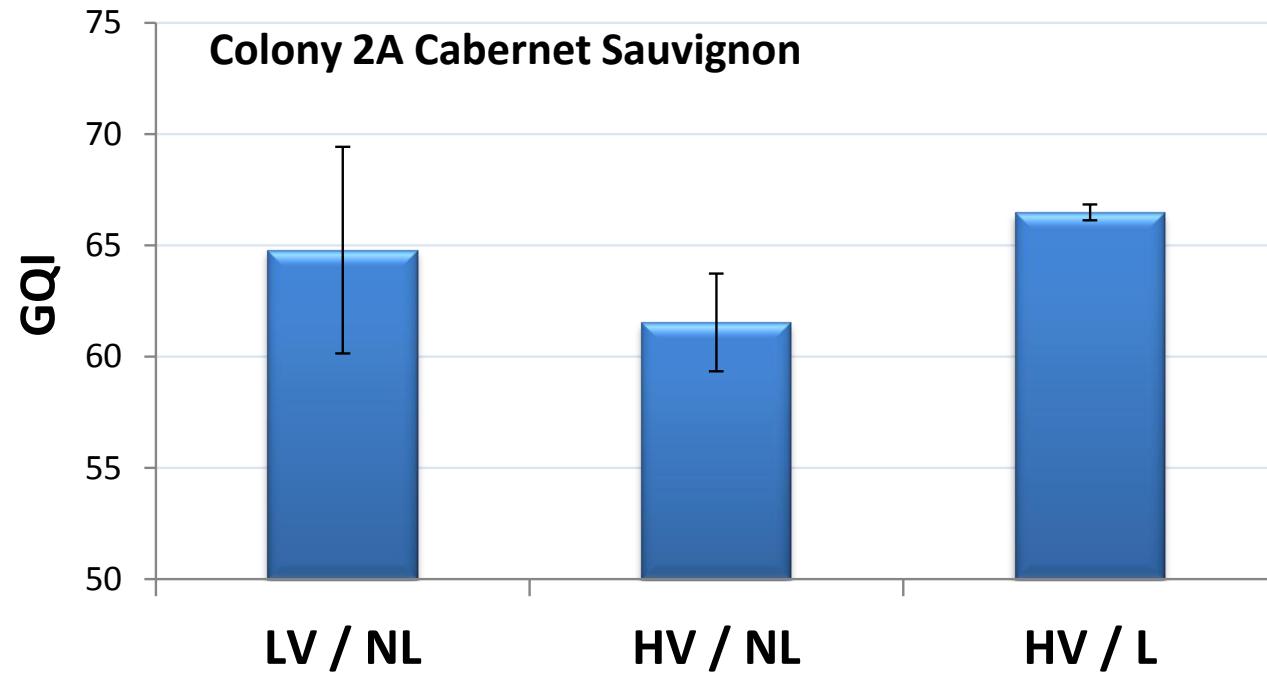
Fruit Yield and Quality



2014 Leafing study



LV / NL = Low vigor, No Leafing



HV / L = High vigor, Leafing

LAI

HV / NL = High vigor, No Leafing



E&J Gallo Winery

Non-spatial statistics

	VRI		CI	
	CV	Spread	CV	Spread
2012	0.14	0.71	0.12	0.50
2013	0.07	0.33	0.12	0.68
2014	0.17	0.76	0.15	0.93

CV = STDEV/MEAN

SPREAD = RANGE/MEDIAN



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Spatial statistics

1. MCD, Mean Correlation Distance
2. Cambardella Index

Measures of spatial dependence and structure

Variable Rate Irrigation:

- Decreased spatial structure in 2013
- Increased spatial structure in 2014



Statistics

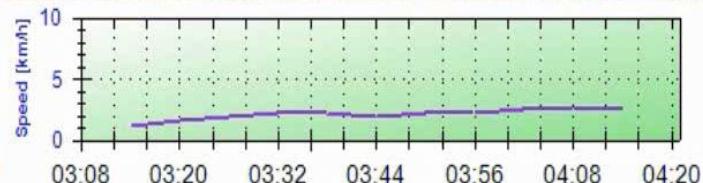
21-Oct-201

17:04:14

0.33

0.241

Lon: 121 15' 0.24" W, Lat: 38 21' 14.69" N



Hectares Mapped

2012	320
2013	1,600
2014	4,800

