Surface Irrigation Strategies on Alfalfa for Groundwater Recharge

Alfalfa and Forage Virtual Field Day

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Irrigation: Controlled amount of water is applied to plants at specific intervals

Irrigation Methods in California:

1- Surface irrigation (flood or gravity):

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

2- Sprinkler Irrigation (various types)

3- Low volume/Drip Irrigation (various types)

- **Surface drip and Subsurface drip**




CALIFORNIA DEPARTMENT OF
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SGMA Groundwater Management

On September 16, 2014, Governor Jerry Brown signed into law a three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA). For the first time in its history, California has a framework for sustainable, groundwater management - "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results."

SGMA requires governments and water agencies of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge. Under SGMA, these basins should reach sustainability within 20 years of implementing their sustainability plans. For critically over-drafted basins, that will be 2040. For the remaining high and medium priority basins, 2042 is the deadline.

Source: California Department of Water Resources

Top field crops in California

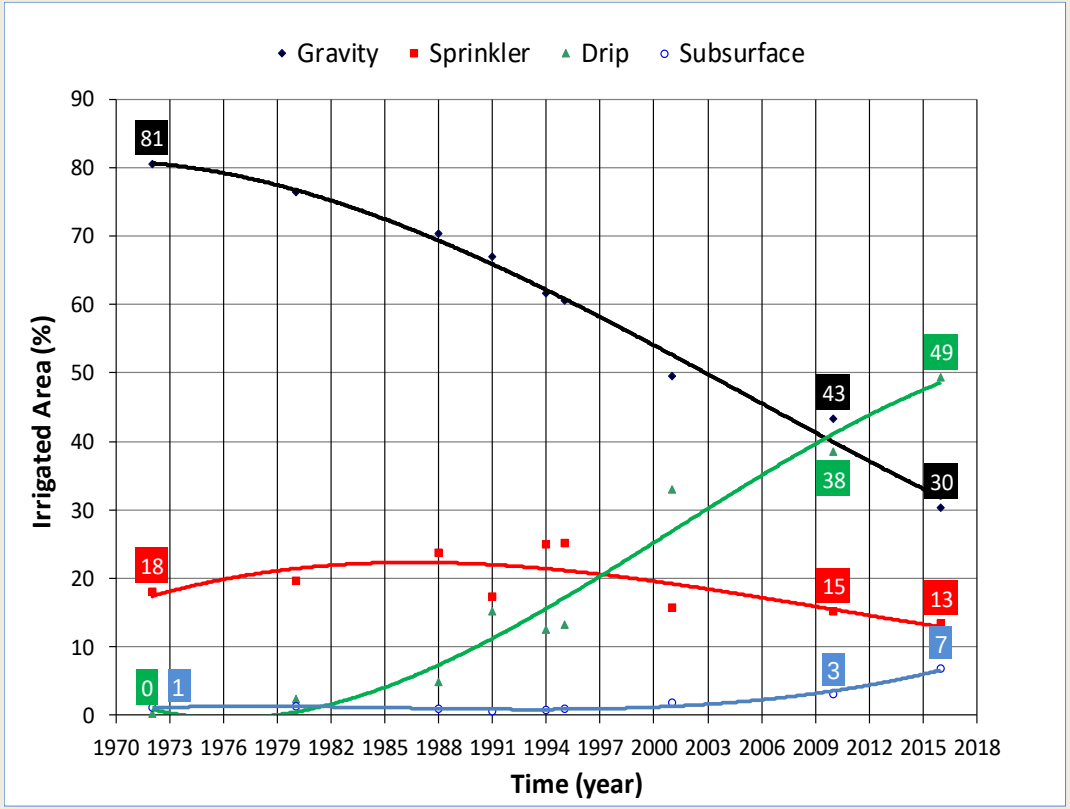
Commodity Rank, Acreage, Production, and Value, 2018

Commodity	U.S. Rank[1]	CA Share of U.S. Receipts[2]	Area Harvested	Production	Total Value[2]	California Rank[3]	
						2017	2018
	Number	*Percent*	*1,000 Acres*	*1,000 Tons*	*$1,000*	*Number*	
FIELD AND SEED CROPS TOTAL VALUE							
Barley	8	1.5	26.0	43.1	8,578	64	56
Beans, Dry	8	7.1	47.7	59.6	68,885	50	43
Cotton Lint, All	3	7.6	302.0	216.5	548,816	17	17
Cottonseed	2	8.8	NA	339.0	78,725	46	40
Grain, Corn	32	0.1	65.0	314.9	52,570	48	47
Peppermint	NA	NA	1.6	7.6	3,739	66	NA
Hay, Alfalfa and Other	1	11.1	980.0	5,682.0	769,826	12	11
Oats	19	1.6	6.0	6.7	1,448	67	59
Potatoes (Excl. Sweet)	4	7.0	38.3	772.9	258,625	31	25
Potatoes, Sweet	2	30.4	21.0	435.1	198,912	36	27
Rice	2	30.0	504.0	2,431.8	755,763	13	12
Sugar Beets	7	3.4	24.6	1,092.0	52,761	53	46
Wheat, All	21	0.8	143.0	348.2	68,167	51	44
Oil Crops[4]	30	0.1	117.5	121.5	37,797	54	51
Other Seed Crops	NA	NA	NA	NA	NA	NA	NA
Other Field Crops	NA	NA	NA	NA	NA	NA	NA
Floriculture	1	25.5	NA	NA	1,215,997	NA	7
Miscellaneous Crops[5]	1	22.5	NA	NA	4,725,764	NA	3

Alfalfa
1,020,000 acres in 2009
670,000 acres in 2018
About 34% decline

Source: CDFA : California Agricultural Statistics Review 2018-2019

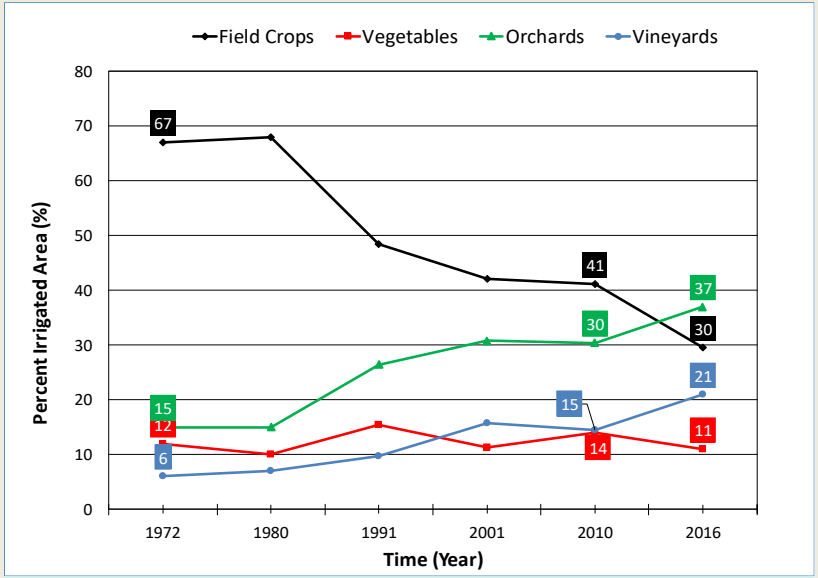
TRENDS IN CALIFORNIA IRRIGATED AGRICULTURE



California Agriculture Challenges

Regulations, water, labor, high production costs, etc

Approximately 30% decline in field crops between 2009 and 2018 and increase in permanent crops



Source: Irrigation Survey 2018, *(DWR-UCD)*

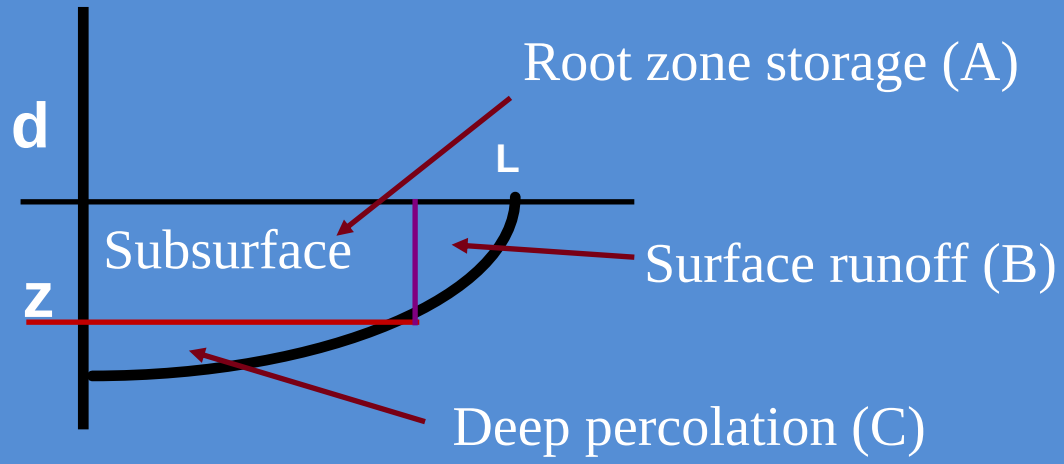
Typical 80-160 acre alfalfa field in CA

- Flow rate, Q: 4- 20 cfs (1cfs ~449 gpm)
- Border length: 1,200-2,500 ft
- **Border width:** 60-**300 ft**
- Slope: ~ 1-2 ft/1000 ft
- Average depth applied per irrigation 3-6 in

- **Goal with surface irrigation: refill soil profile**
- **Minimize losses (runoff and deep percolation)**

Surface Irrigation Efficiency

Applied water = Root zone storage + runoff + deep percolation



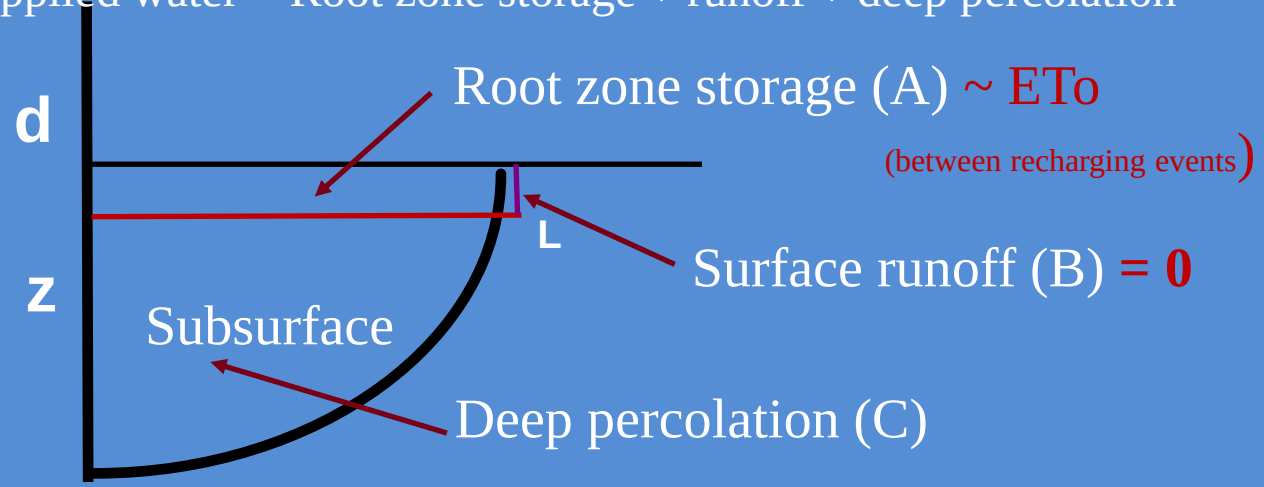
Application Efficiency (AE)= A/(A+B+C)

To achieve higher efficiency, reduce B and/or C

Intermittent Groundwater Recharge on Alfalfa

One low flow (Q) and long (T) surface irrigation event per week (Jan- April)

Applied water = Root zone storage + runoff + deep percolation



Groundwater Recharge Efficiency = C/(A+B+C)

To achieve high GW recharge efficiency, eliminate B and minimize A

Intermittent Groundwater Recharge on Alfalfa

UC Kearney Agricultural Research and Extension Center, Parlier, CA

2019 feasibility study on selected borders
3rd year alfalfa stand

2020 replicated study on 24 borders
2nd year alfalfa stand

Soil: Hanford sandy loam

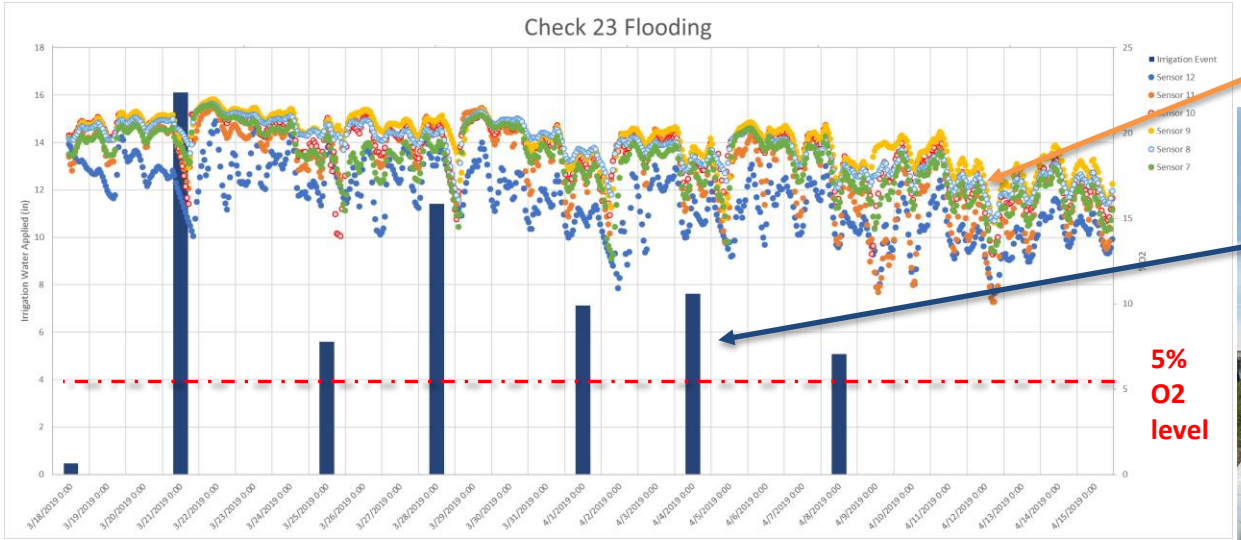
Drainage class: Well drained
Capacity of the most limiting layer to transmit water
K_{sat}: High (1.98 to 5.95 in/hr)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Hc	Hanford sandy loam	5.9	70.2%
Hg	Hanford sandy loam, silty substratum	1.3	15.2%
Hm	Hanford fine sandy loam	1.2	14.6%
Totals for Area of Interest		8.4	100.0%

Surface Irrigation and Groundwater Recharge on alfalfa (2019- 3rd year stand)

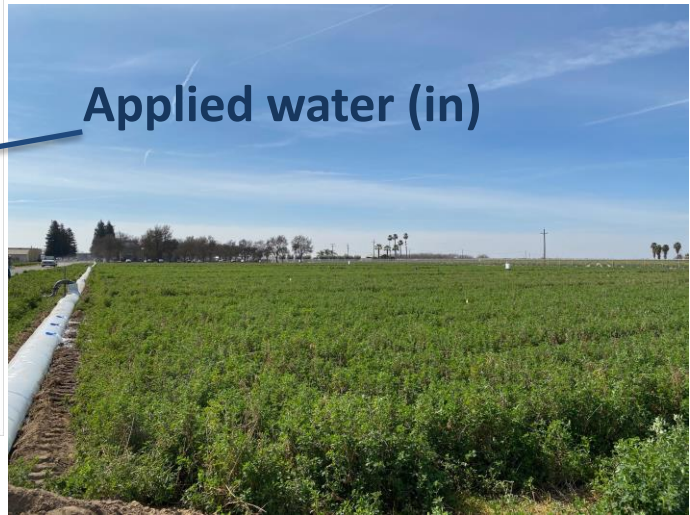
- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 16”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- O_2 levels in rootzone above the critical 5% needed to maintain healthy root system

Data from UC Kearney Research and Extension Center (2019; **~53 inches** of recharge in 6 irrigation events)



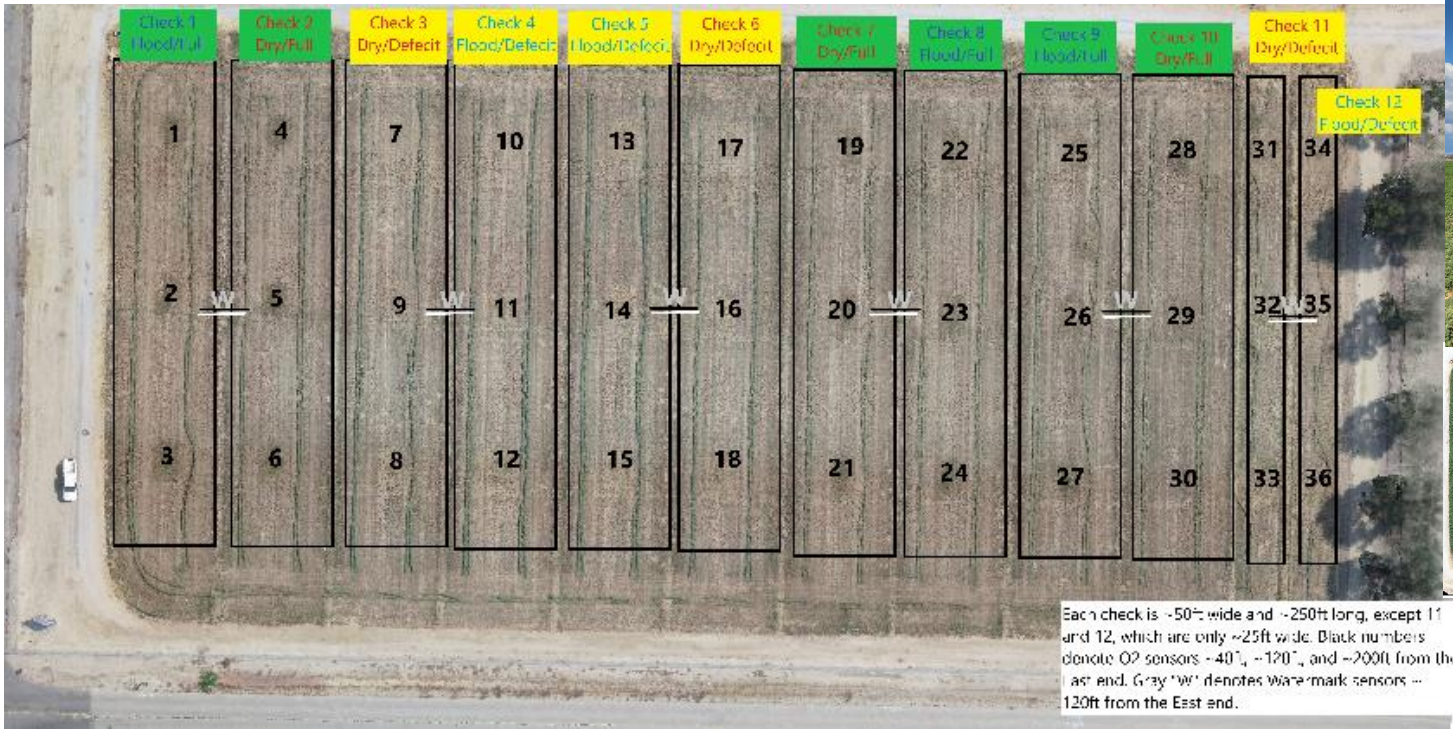
%O_2 level

Applied water (in)

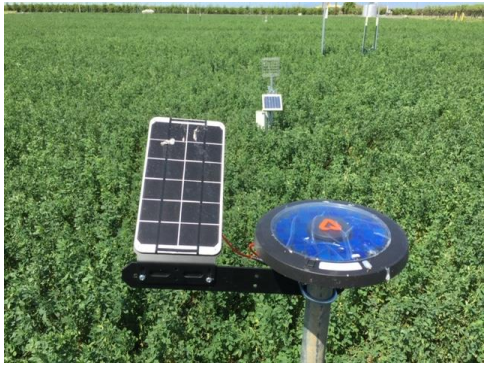


Surface Irrigation and Groundwater Recharge on alfalfa (2020- 2nd year stand)

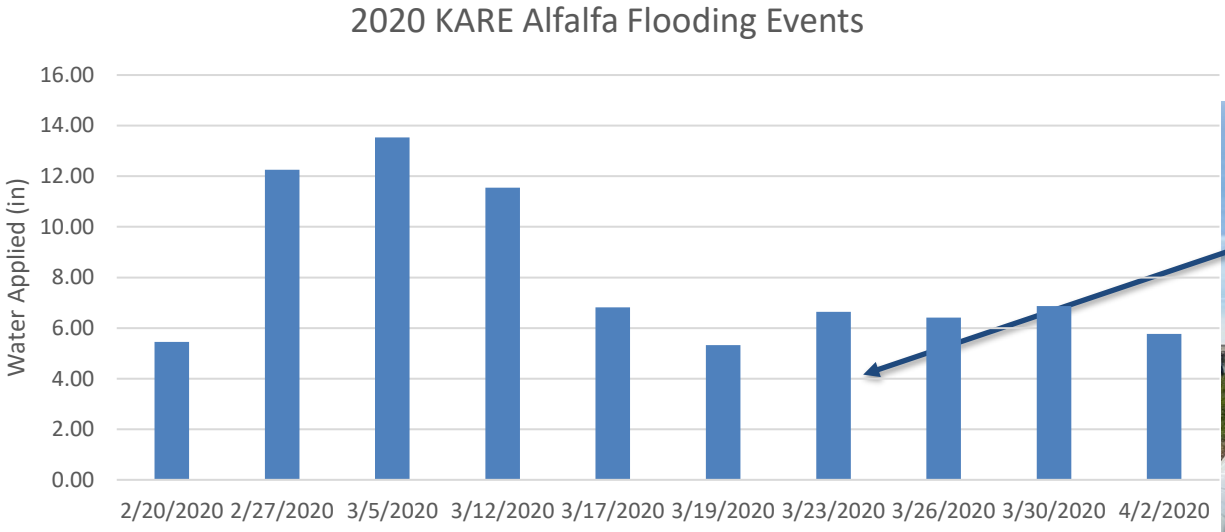
- Irrigation treatments during the growing season (April-November):
  - Full irrigation and Deficit irrigation after August cutting
- GW recharge treatment: Intermittent winter flooding and no flooding
- Replicated three times (yield, O_2 level in soil, moisture content, ETa, etc)

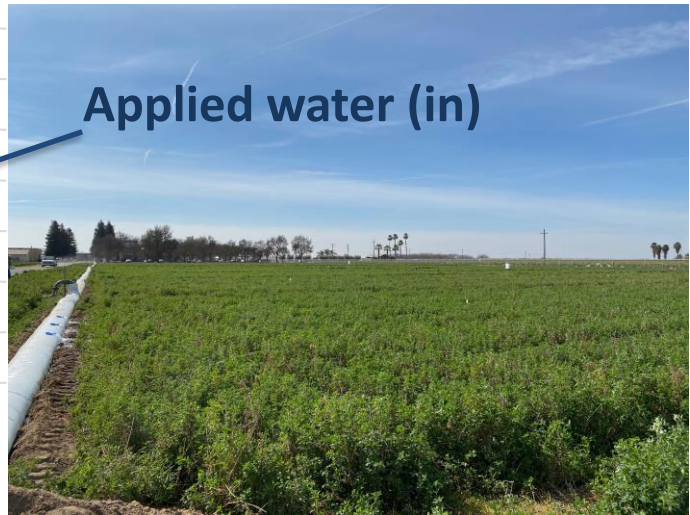


Surface Irrigation and Groundwater Recharge on alfalfa (2020- 2nd year stand)



- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 14”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- Data from UC Kearney Research and Extension Center (2020; **~80 inches** of recharge in 10 irrigation events)





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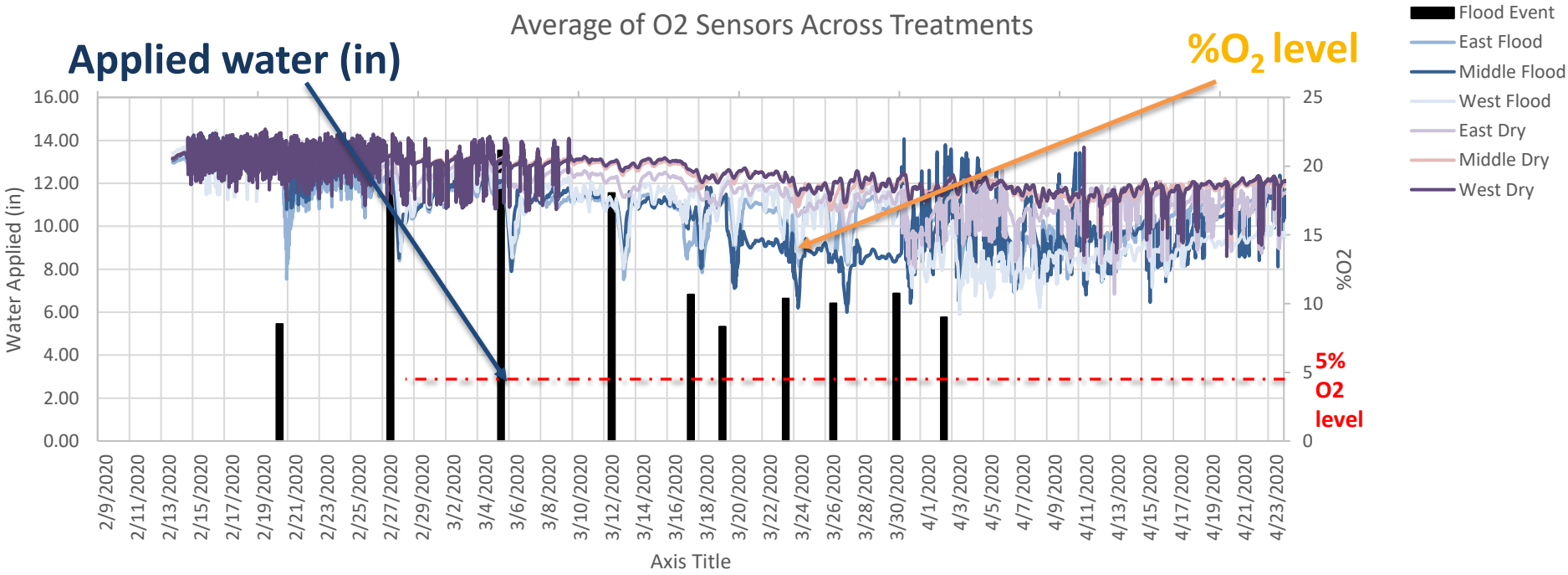
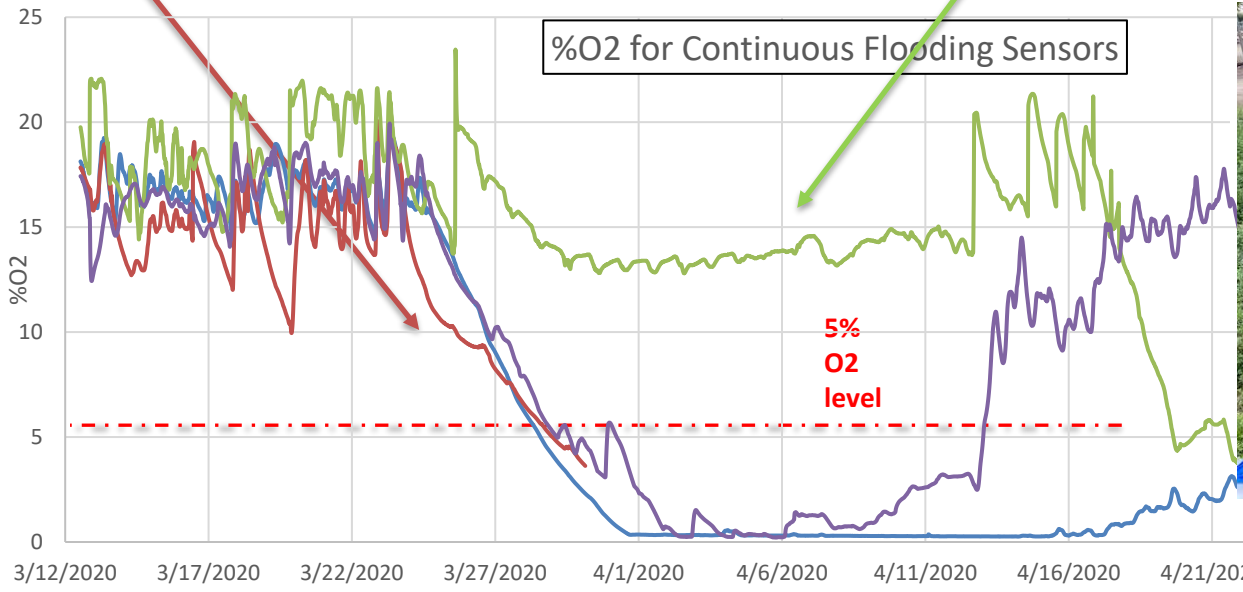


Surface Irrigation and Groundwater Recharge on alfalfa (2020- 2nd year stand)

- Continuous flooding: reached 5% O_2 level in 5-7 days

%O_2 level continuous flooding

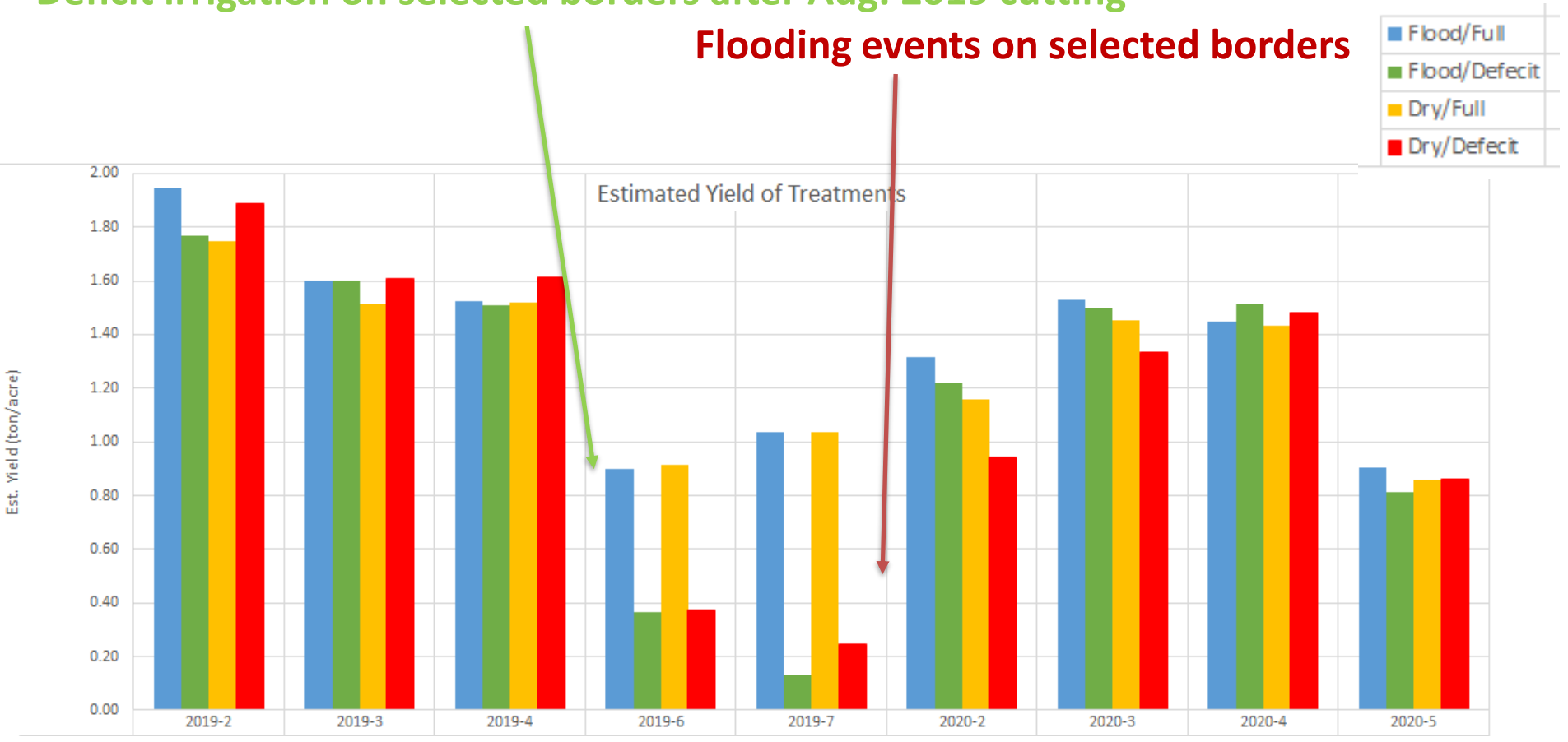
%O_2 level control (no flooding)



Surface Irrigation and Groundwater Recharge on alfalfa (2020- 2nd year stand)

Deficit irrigation on selected borders after Aug. 2019 cutting

Flooding events on selected borders



Summary

Practical options for groundwater recharge (alfalfa)

- Deficit irrigation on alfalfa to address water shortages is feasible (Water transfer, drought, SGMA, and limited water supplies, etc) with minimal impact on alfalfa stand KARE

- Great potential for utilizing existing surface irrigation infrastructure for groundwater recharge (to address SGMA) on alfalfa

- Alfalfa fields with the proper soil type (medium to high infiltration rates) are ideal locations for GW recharge in California (less potential issues with nitrate leaching as compared to other crops)

- Very little modification is needed to the existing surface irrigation system and no need for dual irrigation systems (for irrigation and surface system for GW recharge)

- Modernization of irrigation districts or flood water delivery to farms is needed (SSJID- Pressurized, Turlock ID- Active control, Oakdale ID- Storage and automated control, CVWD- GW recharge)

Thank You