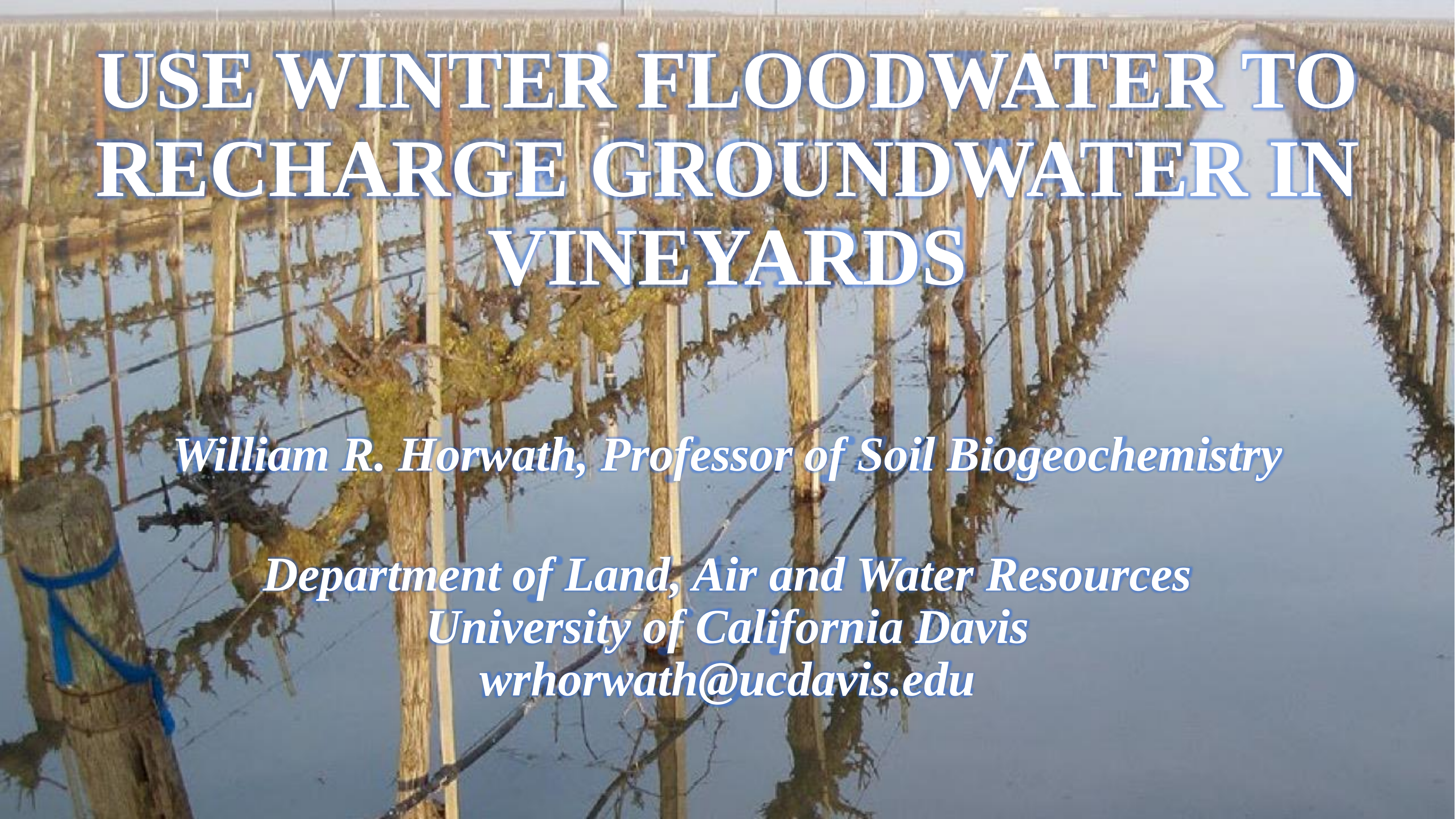

USE WINTER FLOODWATER TO RECHARGE GROUNDWATER IN VINEYARDS

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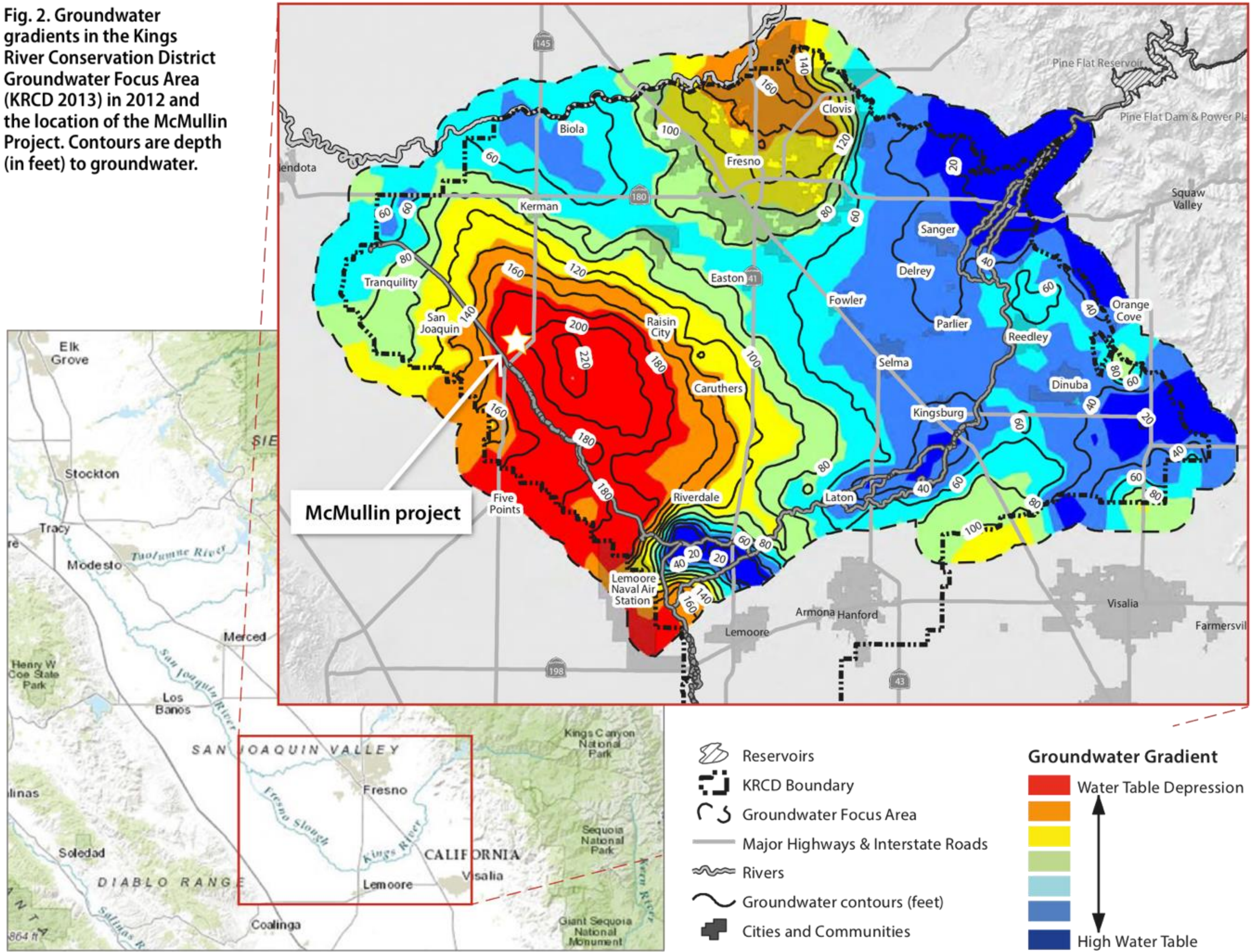
Introduction

- The San Joaquin Valley (SJV) is a productive agricultural area that faces two severe hydrologic issues: persistent ground-water overdraft and flooding risks.
- Groundwater makes up 30%, 38% and 54% of total water demand in the Sacramento River, San Joaquin River and Tulare Lake hydrologic regions, respectively (DWR 2013).
- From 2005 to 2010, between 5.5 and 13 million acre-feet of storage was lost in the Central Valley aquifer (DWR 2013), and SJV groundwater levels are more than 100 feet below previous historic lows (DWR 2014).

Changes in groundwater over time

Fig. 2. Groundwater gradients in the Kings River Conservation District Groundwater Focus Area (KRCD 2013) in 2012 and the location of the McMullin Project. Contours are depth (in feet) to groundwater.



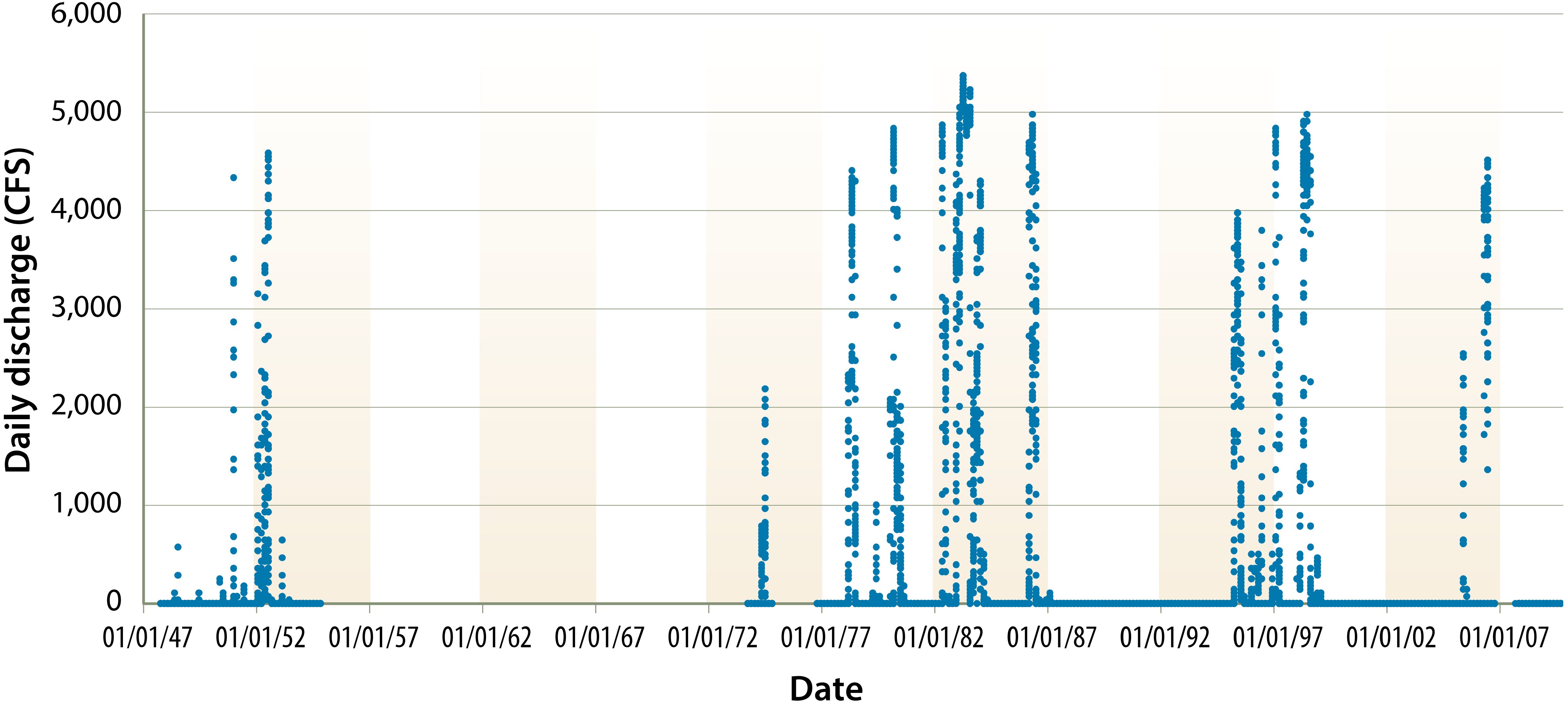
The future

- The hedge against future droughts can be accomplished by groundwater recharge on agricultural land
- Perennial crops, such as grapes are excellent candidates for groundwater recharge during the dormant winter rainy season.
  - Also very tolerant
- Though grapes are very water use efficient, the expanded acreage now means that a sustainable water supply is needed to maintain future production.
- Droughts are a reoccurring climate event, with return intervals becoming more variable.

Addressing the issue

- Capturing flood flows for groundwater recharge could help address issues of water supply and to mitigate downstream urban flood damage.
- However, flood flow frequency, duration, and magnitude vary greatly depending on snowpack.
- This variability makes dedicated, engineered recharge approaches expensive.
- However, existing infrastructure could be modified to reverse flows from existing irrigation infrastructure during the winter period when abundant water is available

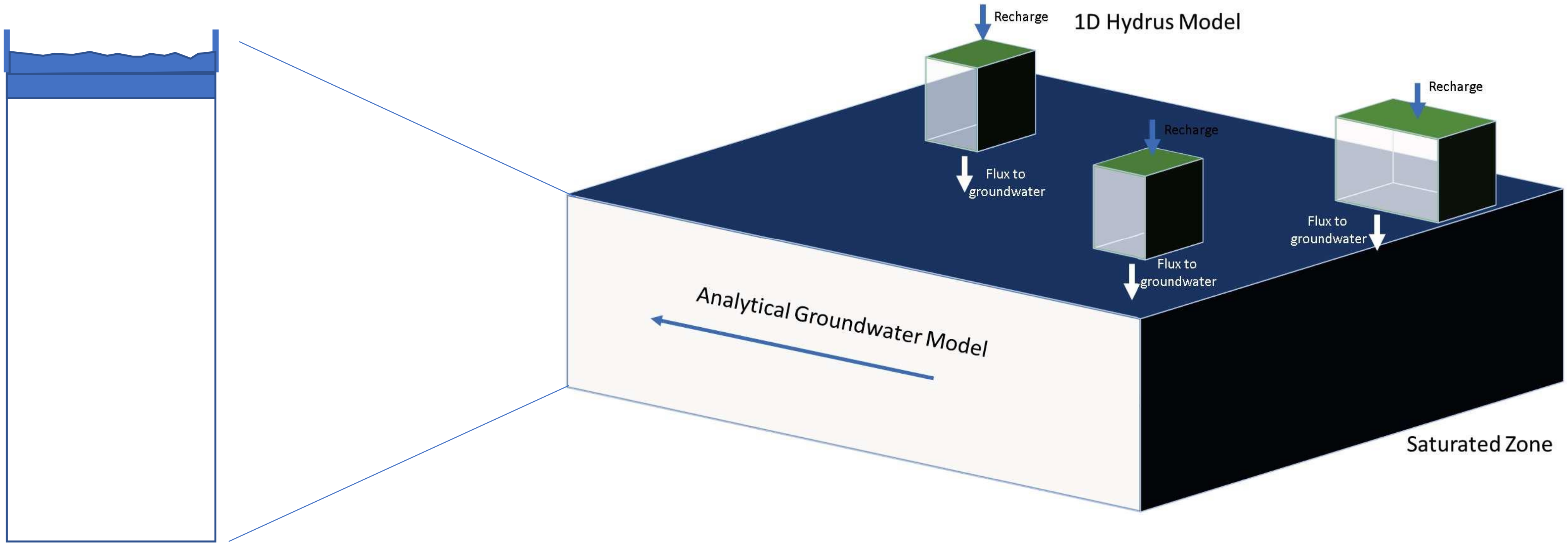
Flows in excess of 100 CFS generally only occur in the James Bypass



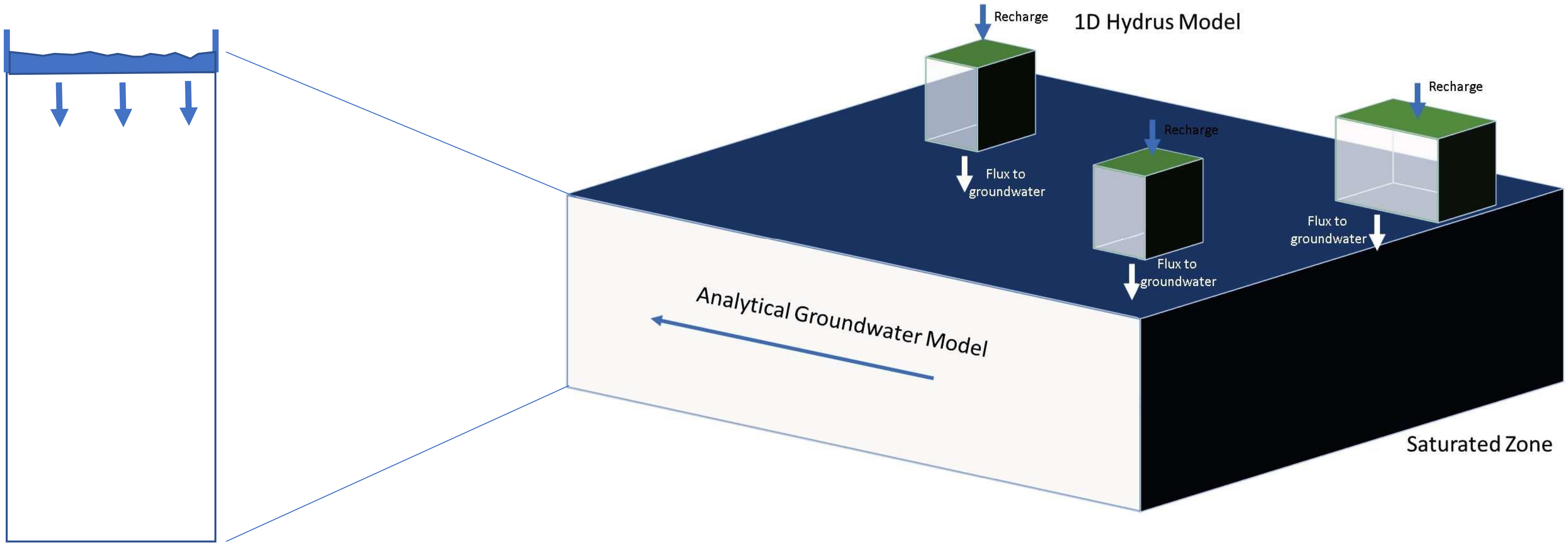
Moving water for recharge

Since water movement was originally engineered to leave fields, some modification is likely necessary to reverse flow from main ditches and slews back onto fields during flood flows or when water is available.

How recharge works



How recharge works



Concerns

- Concerns with groundwater recharge include leaching of salts and nitrates to groundwater.
- Nitrate, primarily from fertilizers, septic tanks, dairies, and soil salts, locally occurring but also exacerbated by farming practices, irrigation waters, and wastes, are water quality issues affecting SJV groundwater sustainability.

Study area:

Fresno County

<u>Two studies</u>

Crops:

Grapes, Almonds

and tomatoes

Source: Department of Water Resources, CWP 2013

Field methods

Field
methods:

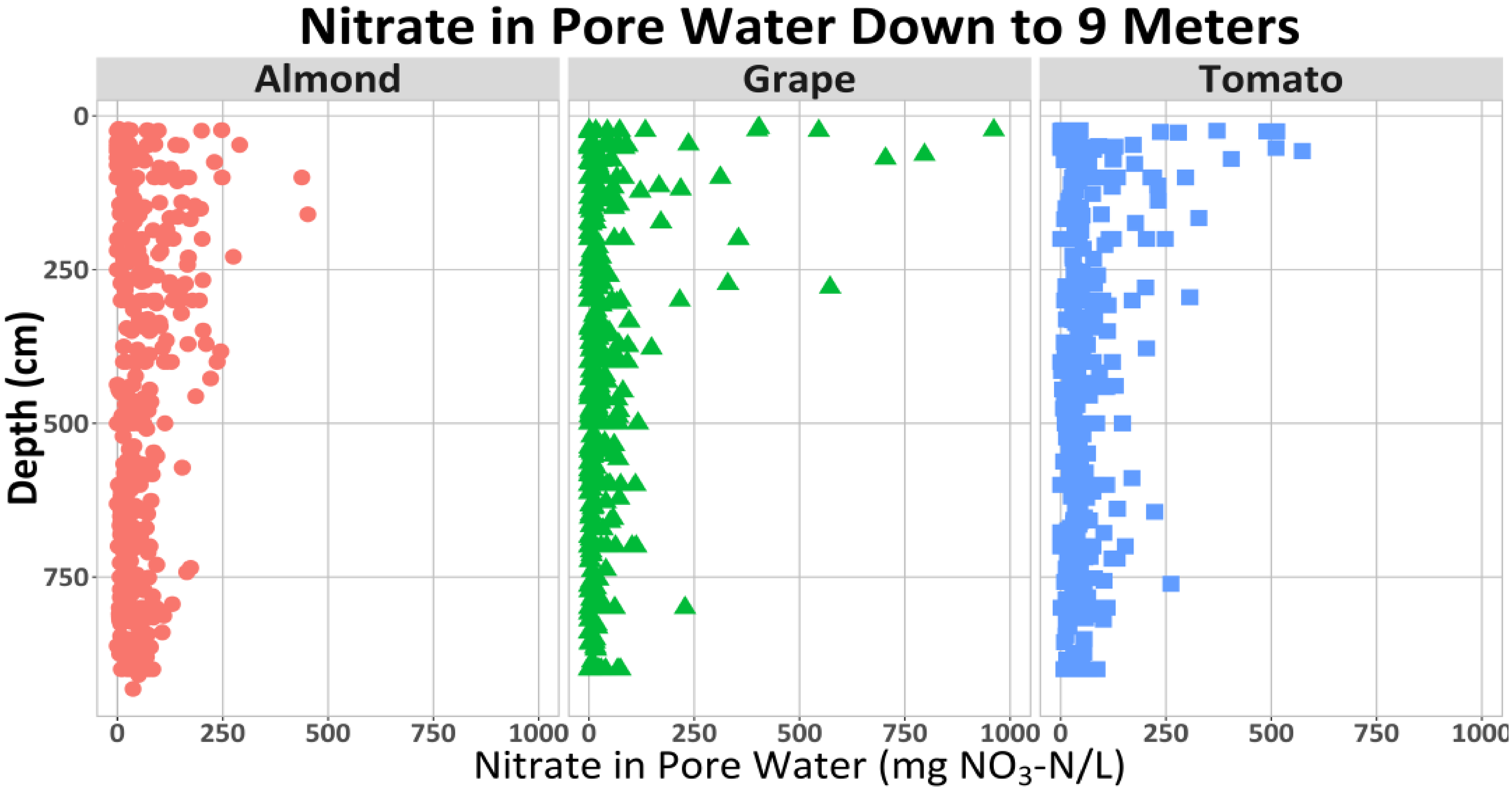
coring to 50ft

Lab studies:

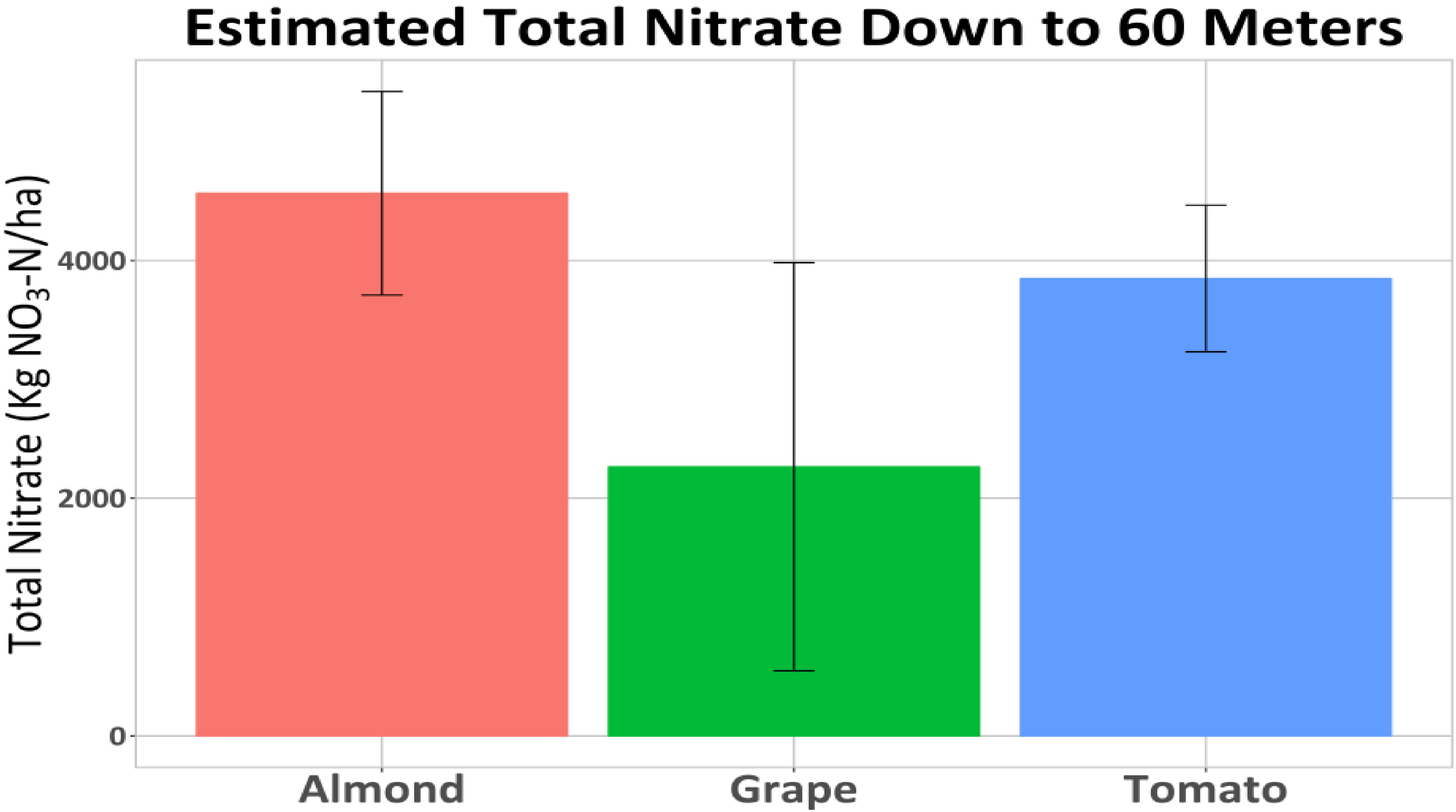
Processing cores

Analysis for salts, nitrates, dissolved carbon

Comparison of different crops
Study 1

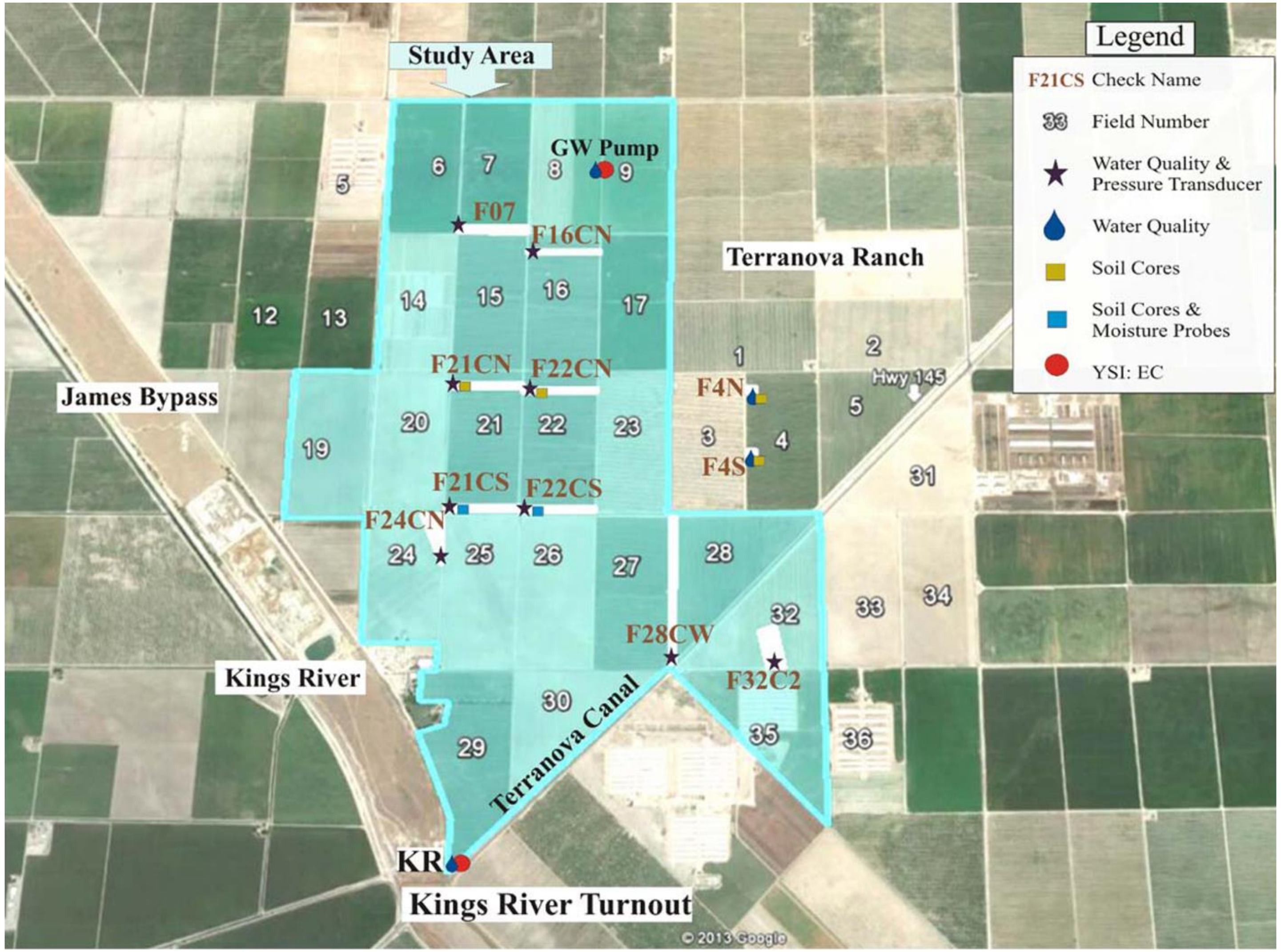


Total nitrate in cores
Study 1



Terranova Ranch (Study 2)

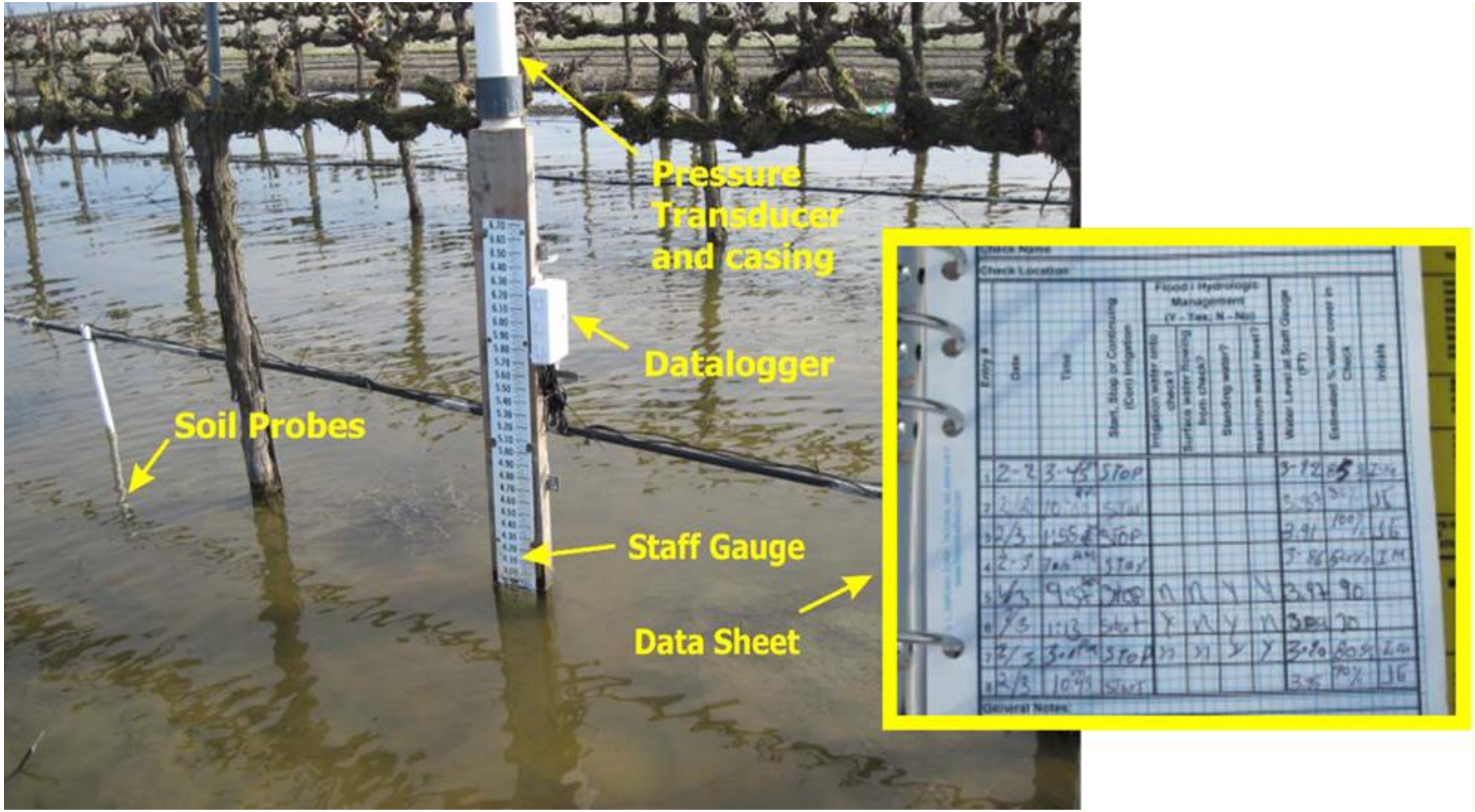
Looked at wine grapes, tomatoes and almonds



Panoramic picture of the James Bypass from the Terranova Ranch in October 2010 (top) and early February 2011 (below) from the Highway 145 overpass.

Flood flows occur approximately on a 2-year interval.

Monitoring

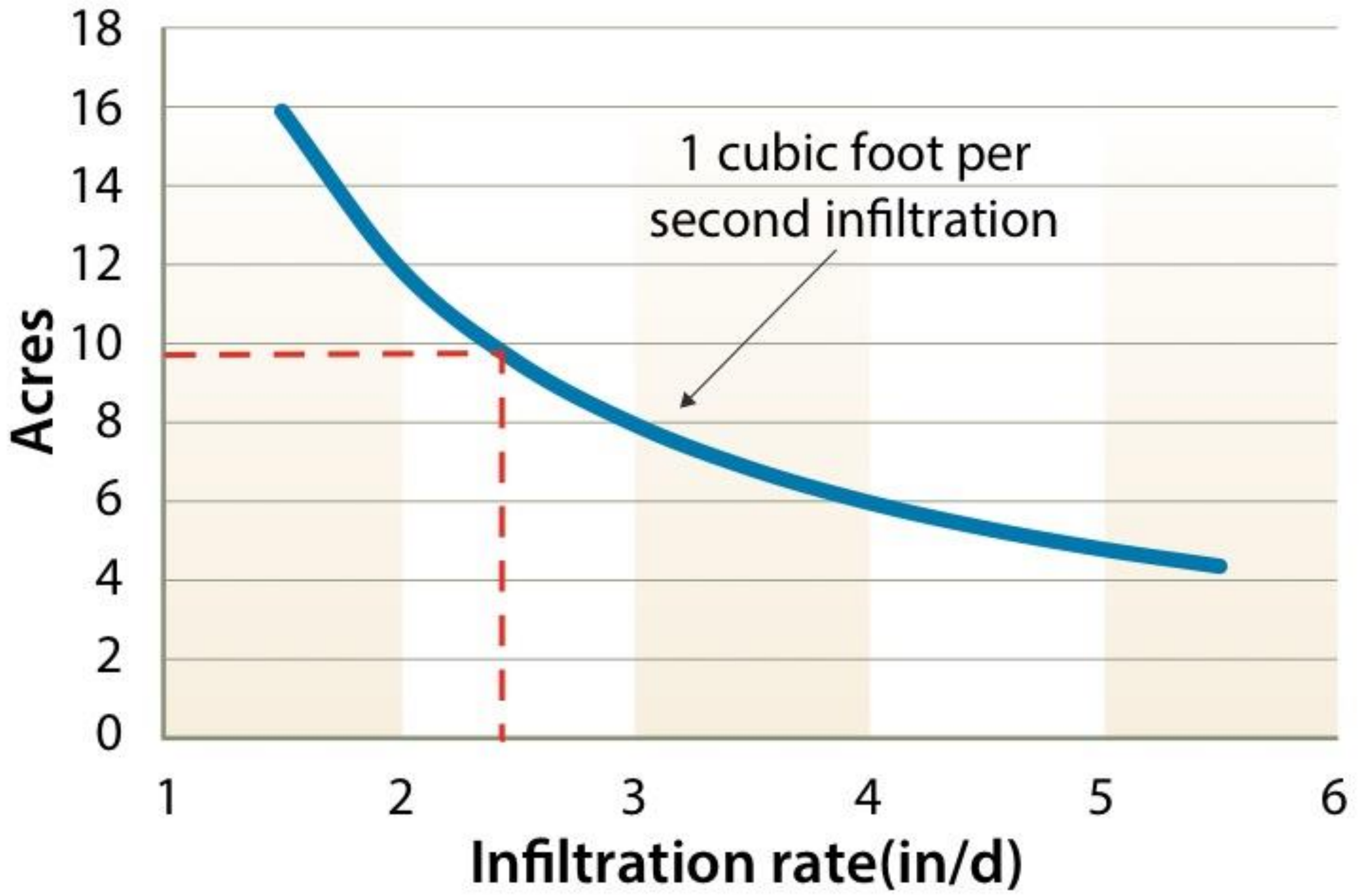

Pressure Transducer and casing
Datalogger
Soil Probes
Staff Gauge
Data Sheet

Infiltration rates

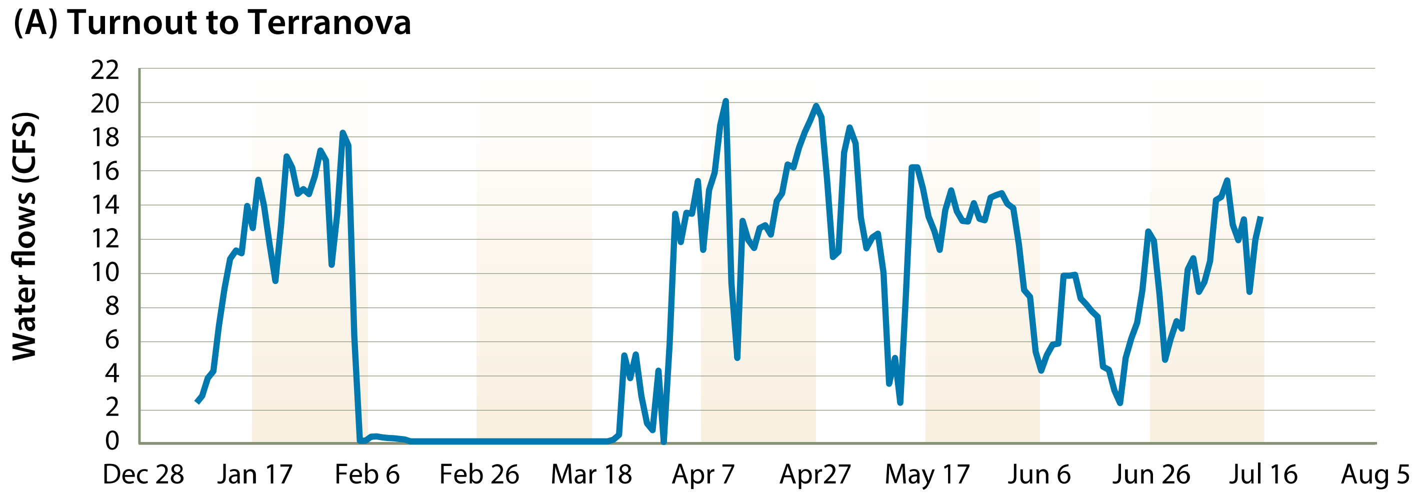
check	date range	N^a	infiltration rates in/day	daily total ft	season total ft
F16CN	1/27/11–7/30/11	30	3.8	0.26	7.8
F21CN	4/30/11–7/31/11	7	15.8	0.41	2.8
F21CS	5/6/11–8/3/11	5	14.2	0.51	2.6
F22CN	1/29/11–7/9/11	34	3.3	0.28	9.5
F22CS	1/29/11–7/10/11	31	2.7	0.20	6.2
F24CN	1/15/11–2/4/11	23	2.7	0.11	2.6
F28CW	4/12/11–7/11/11	5	3.5	0.57	2.9
F32C2	1/29/11–2/4/11	10	3.5	0.16	1.6
F07	4/19/11–7/28/11	6	6.0	0.34	2.1

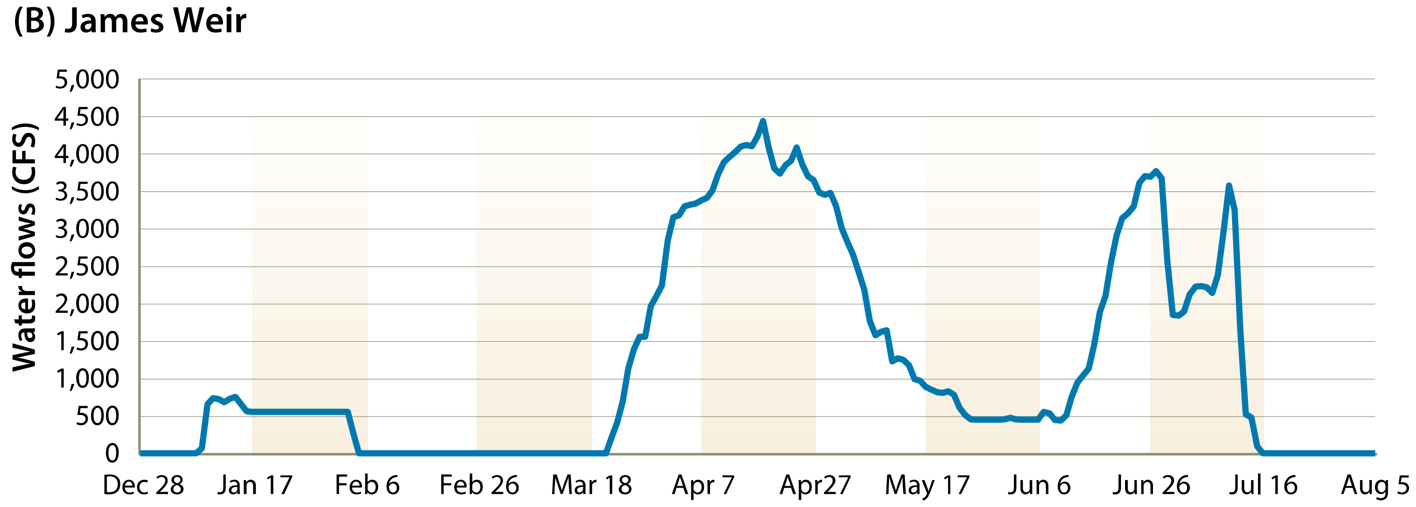
Infiltration potential

At a measured infiltration rate of 2.5 inches per day in wine grape checks approximately on 10 acres is required to capture 1 CFS. That relationship corresponds to pumping water at 3,500 gpm onto a 70-acre field.



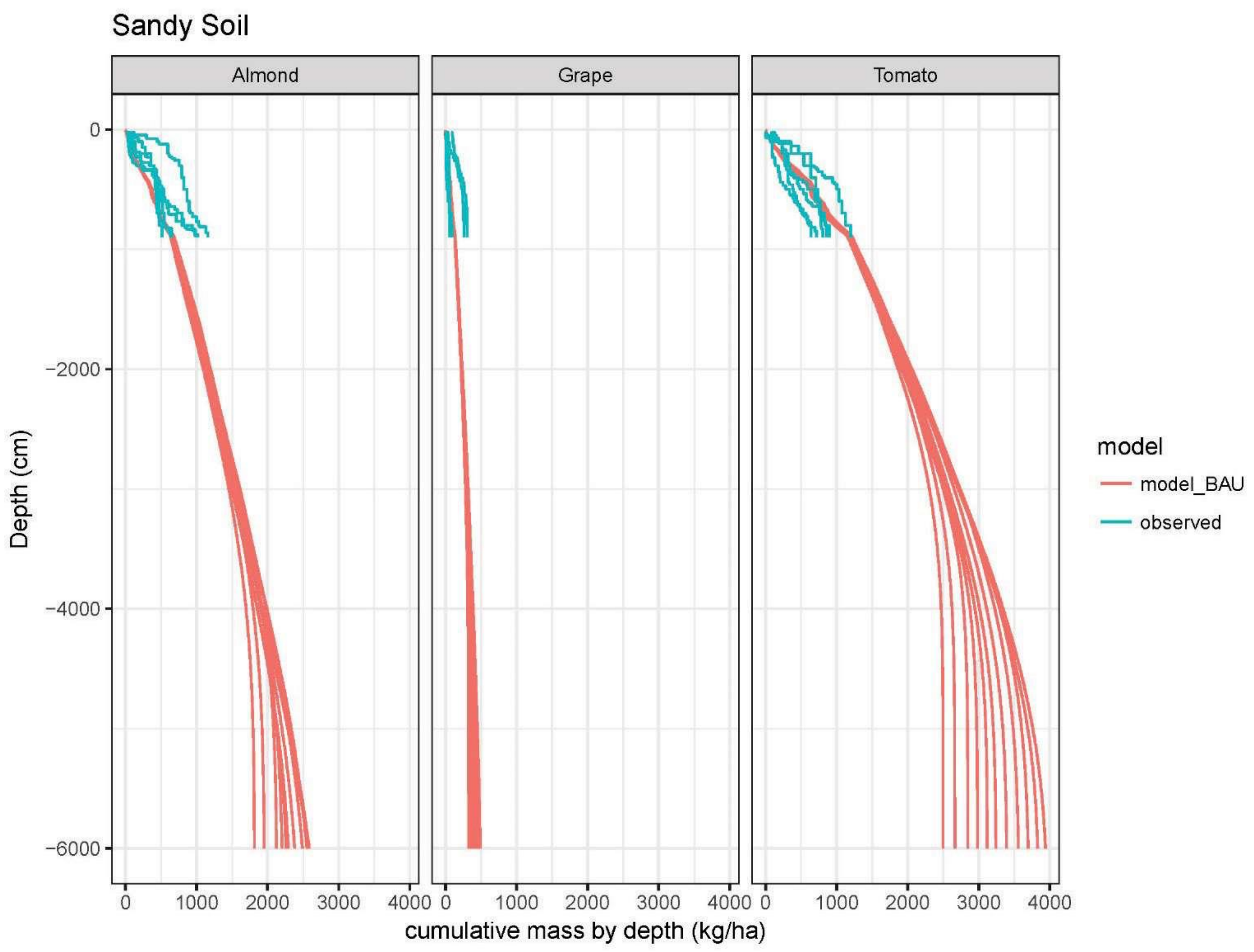
Flows diverted past the James Weir (A) into the James Bypass (B). Diverted flows ranged up to 22 CFS. The total volume diverted to the ranch was 3,116 acre-ft





Modeled Cumulative N Profile for different crops.

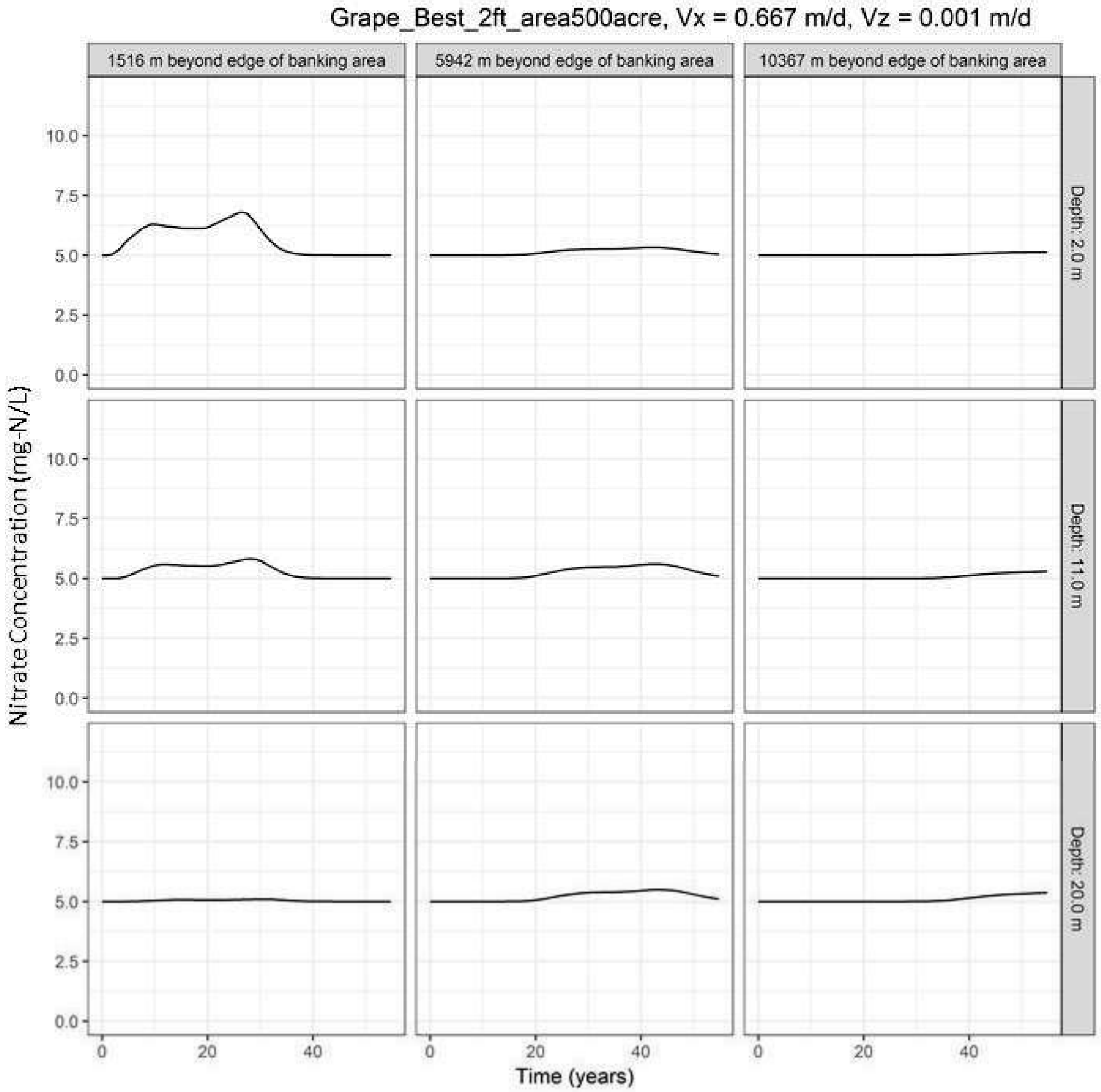
Soil profiles were developed over a 25-year run under BAU fertilization and irrigation practices. Nitrogen profiles are shown for a 200-foot unsaturated (vadose) zone showing cumulative N mass by depth. The profiles show increasing N with depth over the 25-year period and compares those profiles with the first 30-feet of data from collected soil cores.



Changes in groundwater nitrate concentrations under low recharge rates.

This example is representative of lower recharge rates (2-ft recharge per recharge year) across 500 acres for groundwater velocities in the range typical for the Tulare Lake Hydrologic Region (Vx = 2 ft/d, Vz = 0.003 ft/d).

Locations represent observation points downstream of the recharge area (1, 4 and 6 miles) at depths (6.5, 36 and 66 ft) below the groundwater/ vadose zone interface.



Estimating costs of groundwater recharge

- Groundwater recharge is economical for sustainable groundwater and profit.
- Over a 25-year period groundwater recharge costs were est. to be $36/ac-ft.
- Recharge costs using an engineered basin system has been estimated to range from $5–97/ac-ft., with a median cost of $51/ac-ft.
- James Irrigation District charges consumers $88–91/ac-ft. for irrigation water and relies primarily on groundwater.
- Because some captured flood flows are utilized for in lieu recharge, the costs of pumping groundwater are avoided.
- Pumping groundwater is estimated to cost about $95/ac-ft but may be as high as $120/ac-ft.

Estimating costs of groundwater recharge (cont.)

- When flood flows are captured but not utilized for in lieu recharge purposes, the cost to capture and irrigate is $131/ac-ft: the cost of recharge ($36/ac-ft) plus the cost of groundwater pumping ($95/ac-ft).
- When 100% flood flows are used for in lieu recharge, the total cost decreases to only the cost of recharge since groundwater is not used.
- For this project irrigation costs drop when 25% or more of the captured flood flows are utilized for irrigation.
- The avoided costs form a basis for investing in and saving money with groundwater recharge practices.

Benefits

- Not included in this farm-scale cost assessment are regional benefits. Besides slowing regional groundwater declines, these practices also reduce flood damage risks.
  - Large floods in 1983, 1995, and 1997 along the Kings River and the San Joaquin River caused $1.2 billion dollars (2012 dollars) in damages.
- A Hydrologic and Hydraulic assessment found implementing a 500 cfs diversion to divert flood flows from the Kings River had a benefit:cost ratio near 2 over 50 years, with $800,000 annual savings from avoided flood damages along the Kings and San Joaquin rivers.

Additional benefits

Implementing recharge to full build-out capacity (capable of diverting 500 CFS) in the KR irrigation district since 1980, would have been able to capture nearly 20% (1.47 MAF) of the total available surplus flood flows (7.35 MAF).

We estimate that four equivalent projects (capable of diverting 2,000 CFS total), would have the capacity to capture 60% (4.41 MAF) of flood flows.

Conclusions

- Recharge quantity can be small relative to the groundwater volume underlying the recharge site, so the groundwater NO_3^- concentration may remain within an acceptable level,
  - particularly for wine grapes with less residual soil nitrate.
- From an economic perspective, quicker groundwater recharge will result in a higher net present benefit.
- How do you incentivize groundwater recharge.
  - Down stream urban areas may want to avoid flood damage
  - Or do you need to?