Characterizing Stream-Aquifer Exchanges: From Models to Measurements

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October 02, 2024

DAVIDS ENGINEERING, INC

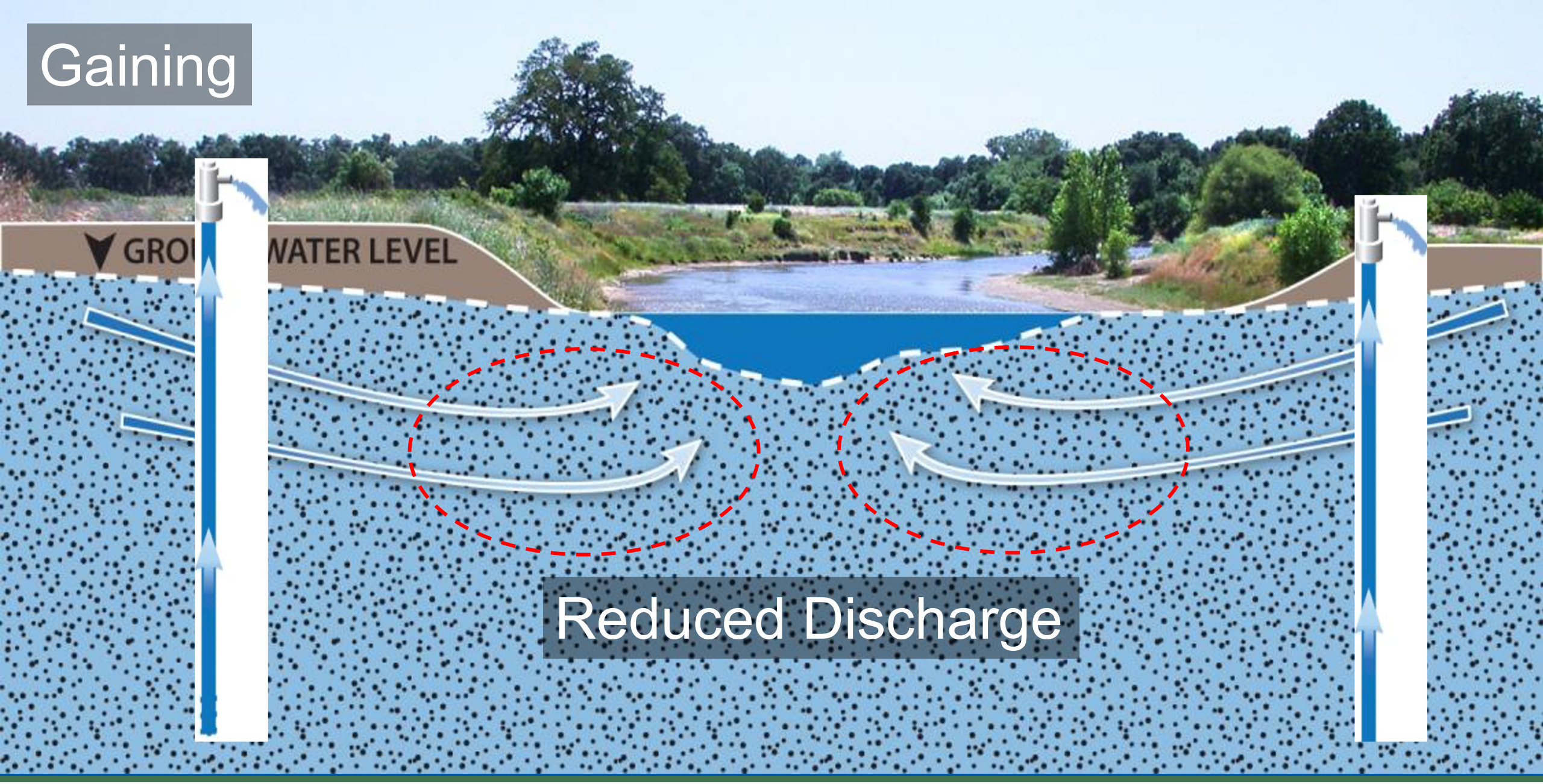
Serving Stewards of Western Water Since 1993

Sustainable Groundwater Management Act Sustainability Indicators

Sustainability Indicators	 Lowering GW Levels	 Reduction of Storage	 Seawater Intrusion	 Degraded Quality	 Land Subsidence	 Surface Water Depletion
Metric(s) Defined in GSP Regulations	• Groundwater Elevation	• Extraction Volume	• Chloride concentration isocontour	• Migration of Plumes • Number of supply wells • Volume • Location of isocontour	• Rate and Extent of Land Subsidence	• Volume or rate of surface water depletion

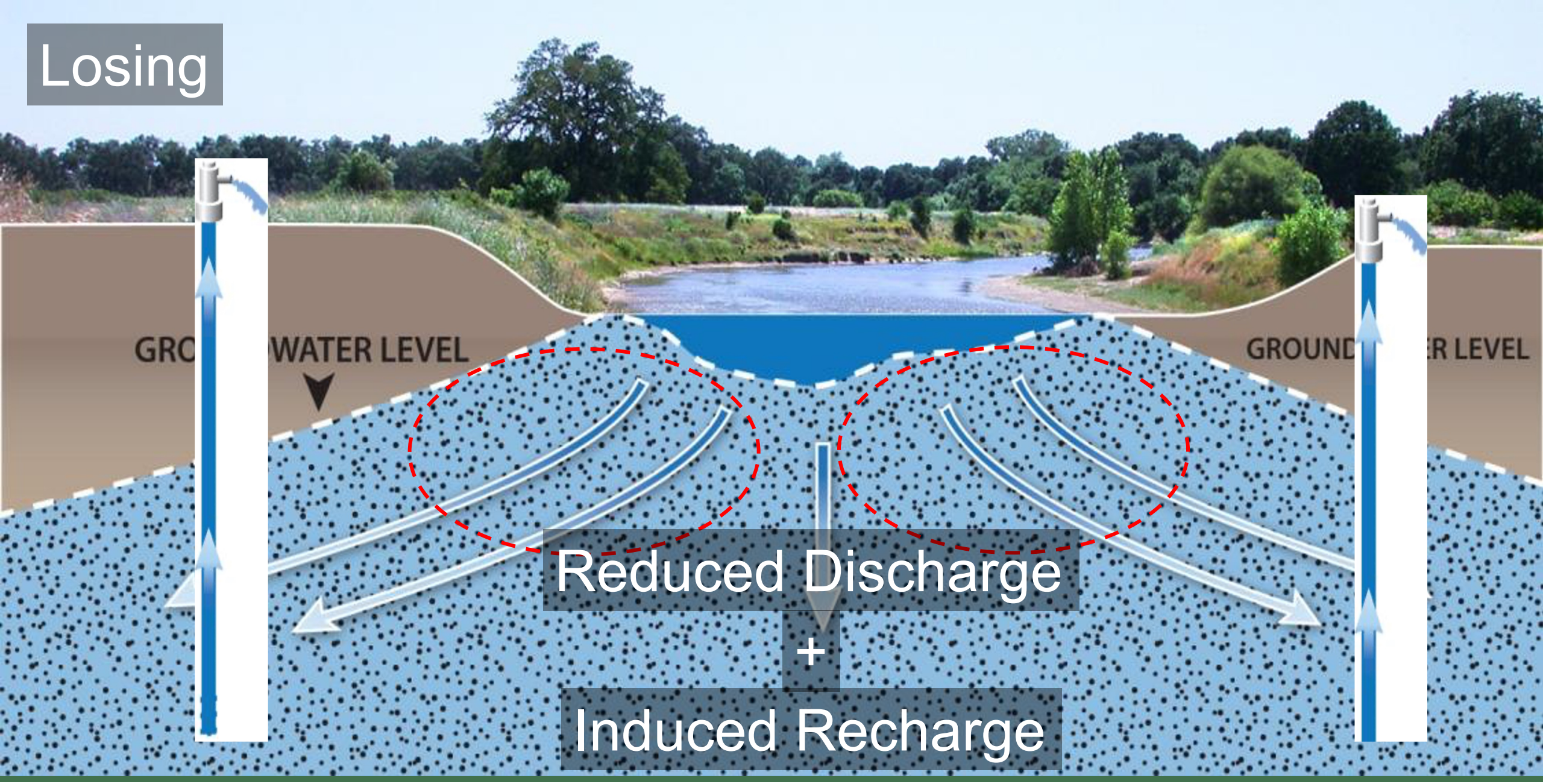
Source: https://mavensnotebook.com/2019/07/31/sgma-implementation-developing-sustainable-management-criteria/

Gaining



Source: The Nature Conservancy (Maurice Hall)

Losing



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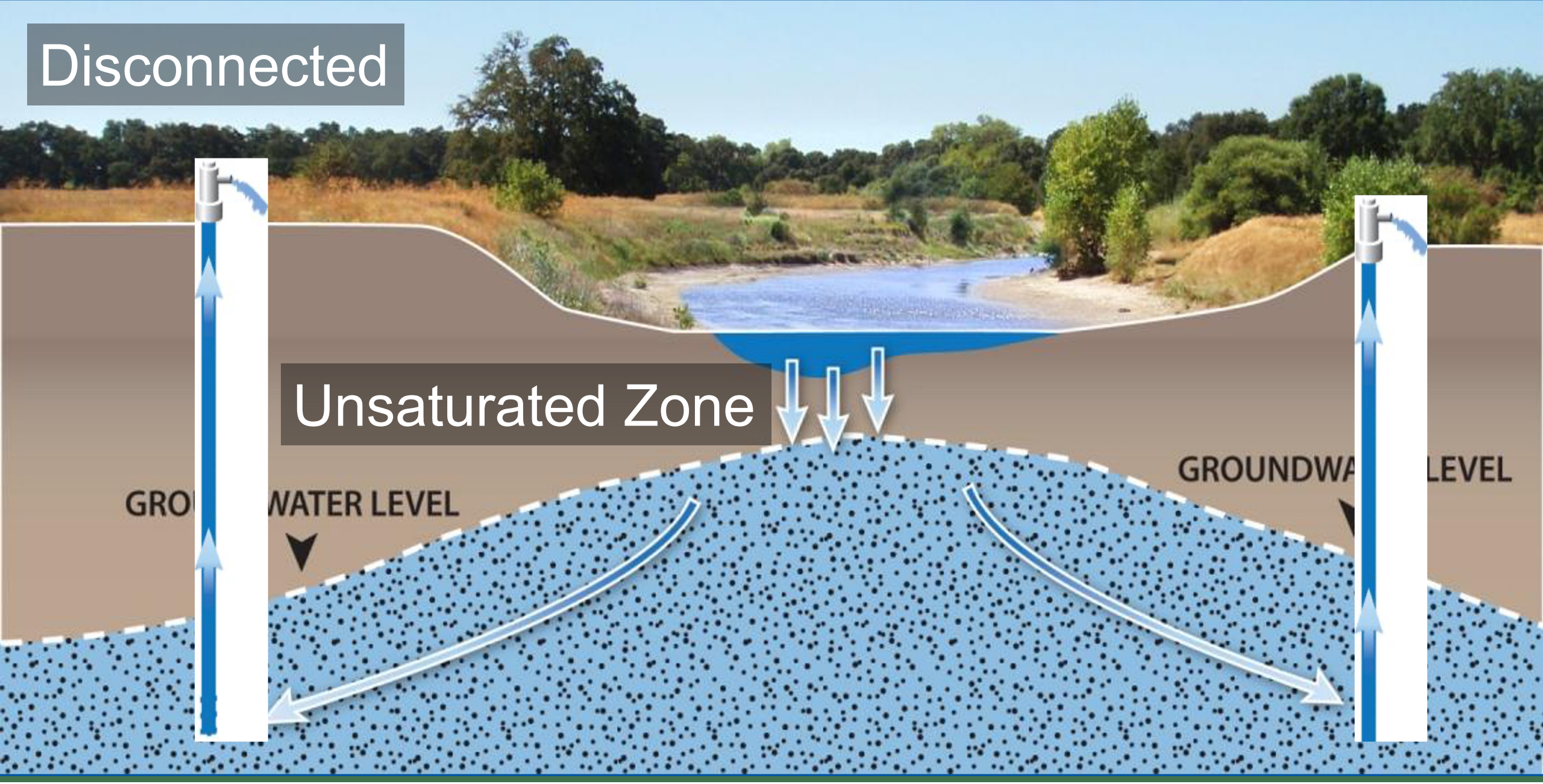

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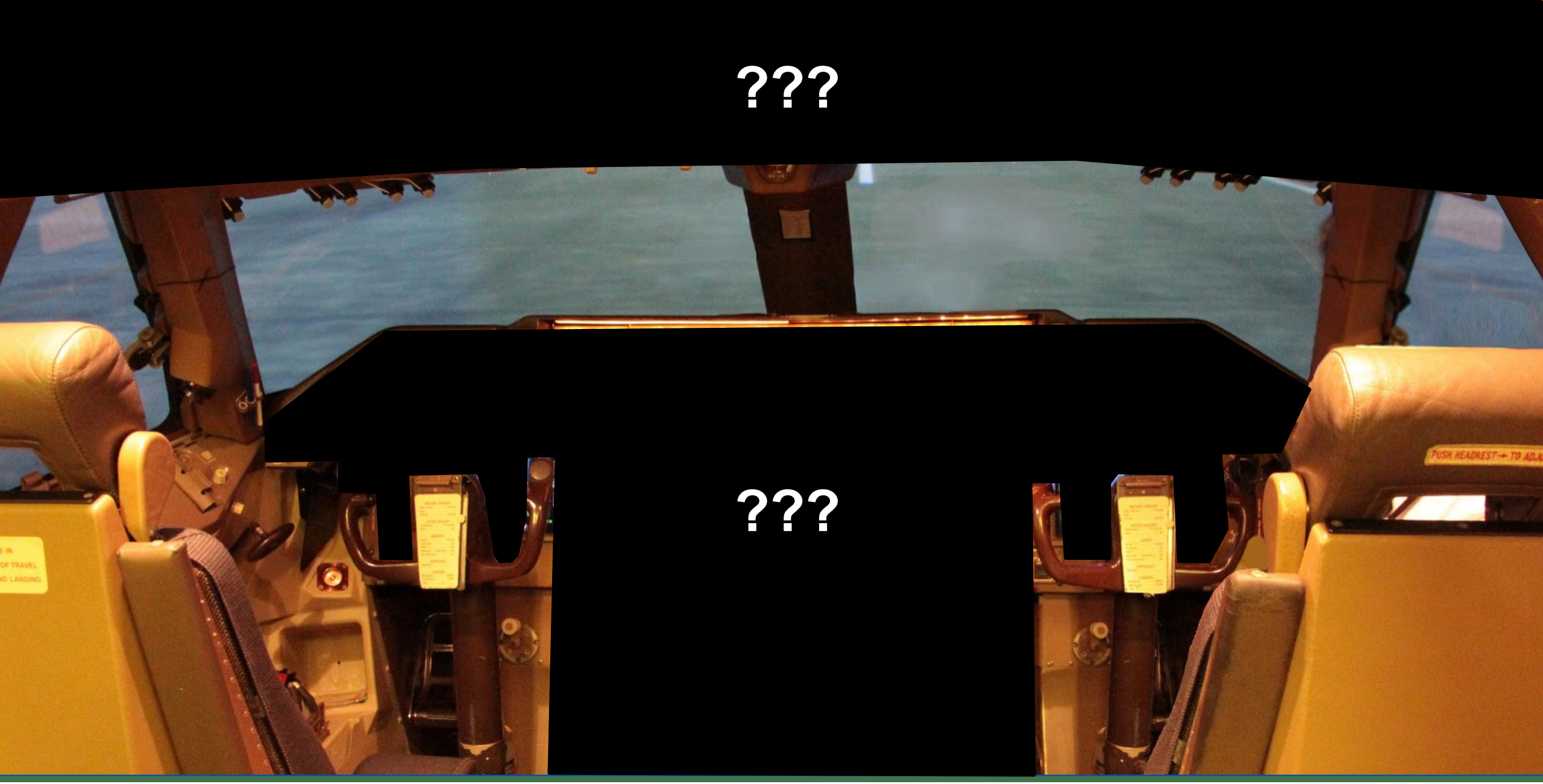
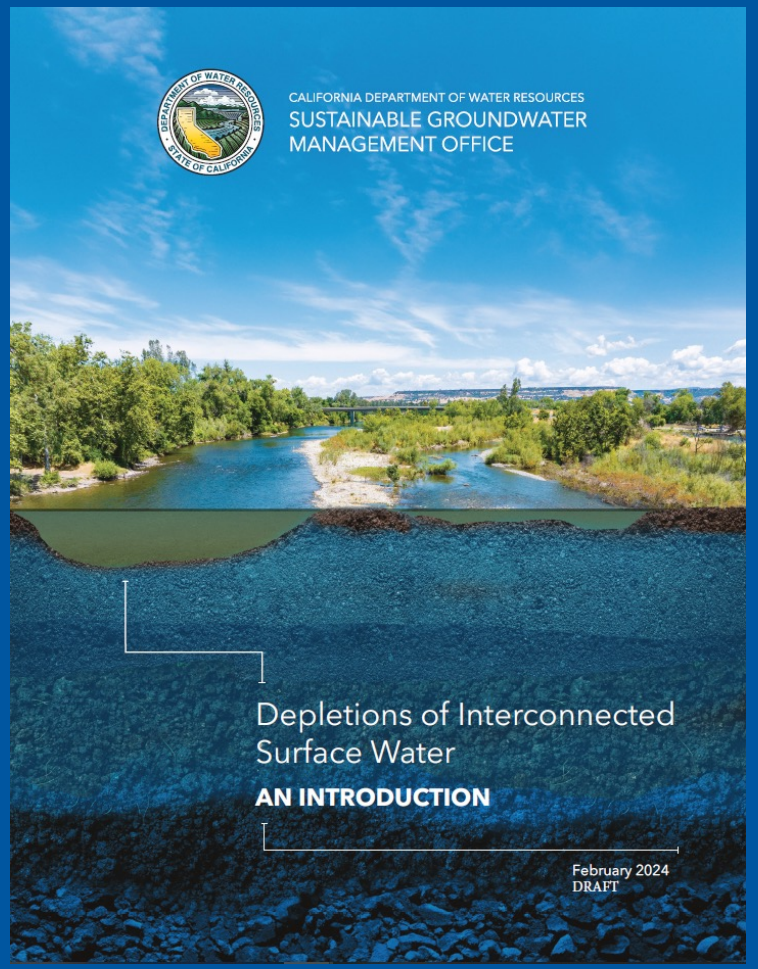
BOEING
747
INTERCONTINENTAL



DWR Interconnected Surface Water Depletion (Undesirable Result 6) Guidance Documents

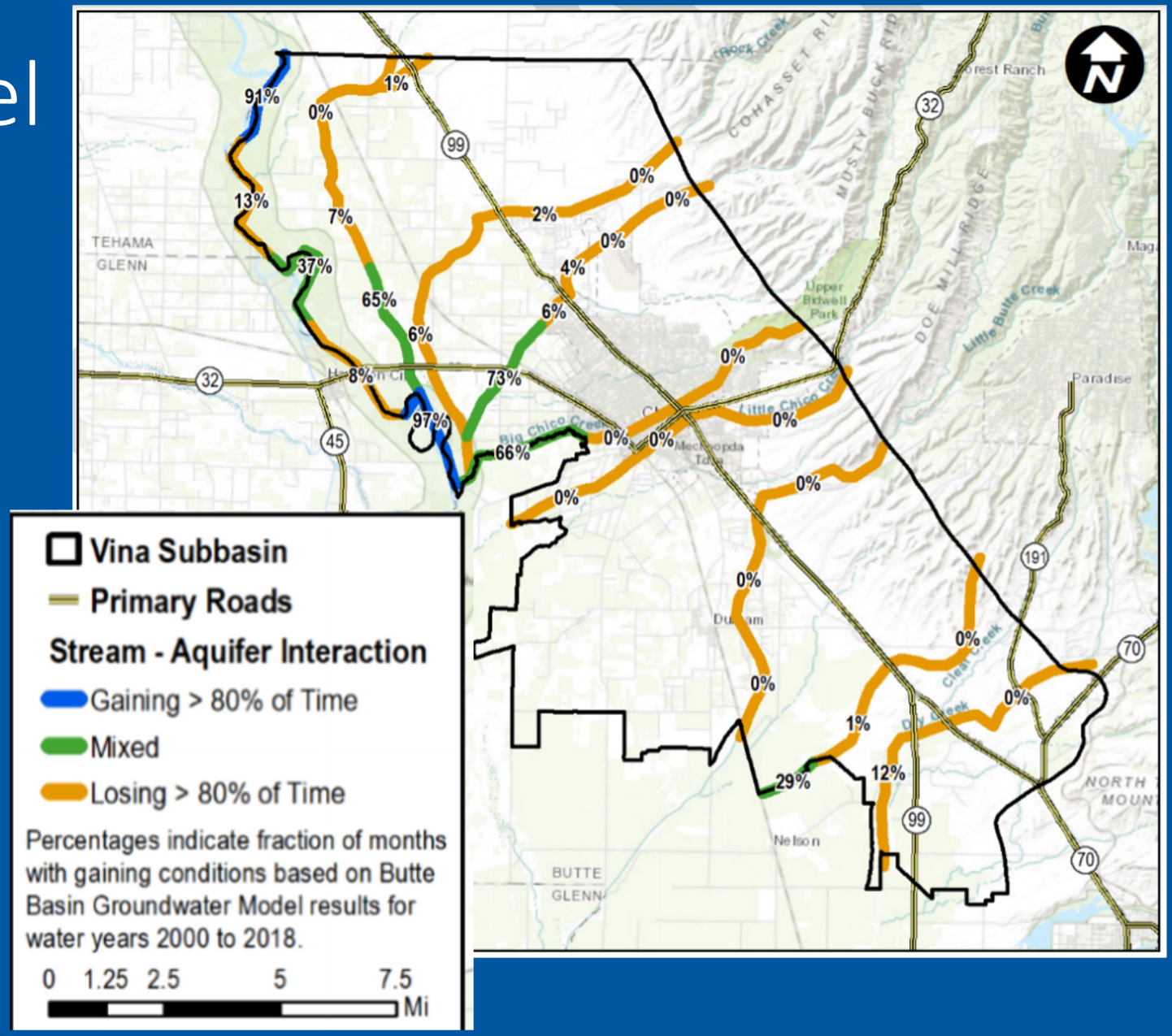
- Paper 1: Introduction
- Paper 2: Techniques for Estimating Interconnected Surface Water Depletion Caused by Groundwater Use
- Paper 3: Examples for Estimating Interconnected Surface Water Depletion Caused by Groundwater Use



Case Study I - Big Chico Creek

Butte Basin GW Model Vina Subbasin

- Groundwater Sustainability Plan Regulations require:
  - Identification of interconnected surface water systems within the basin
  - An estimate of the quantity and timing of depletions of those systems,
- …"utilizing data available from the Department, as specified in Section 353.2, or the best available information."

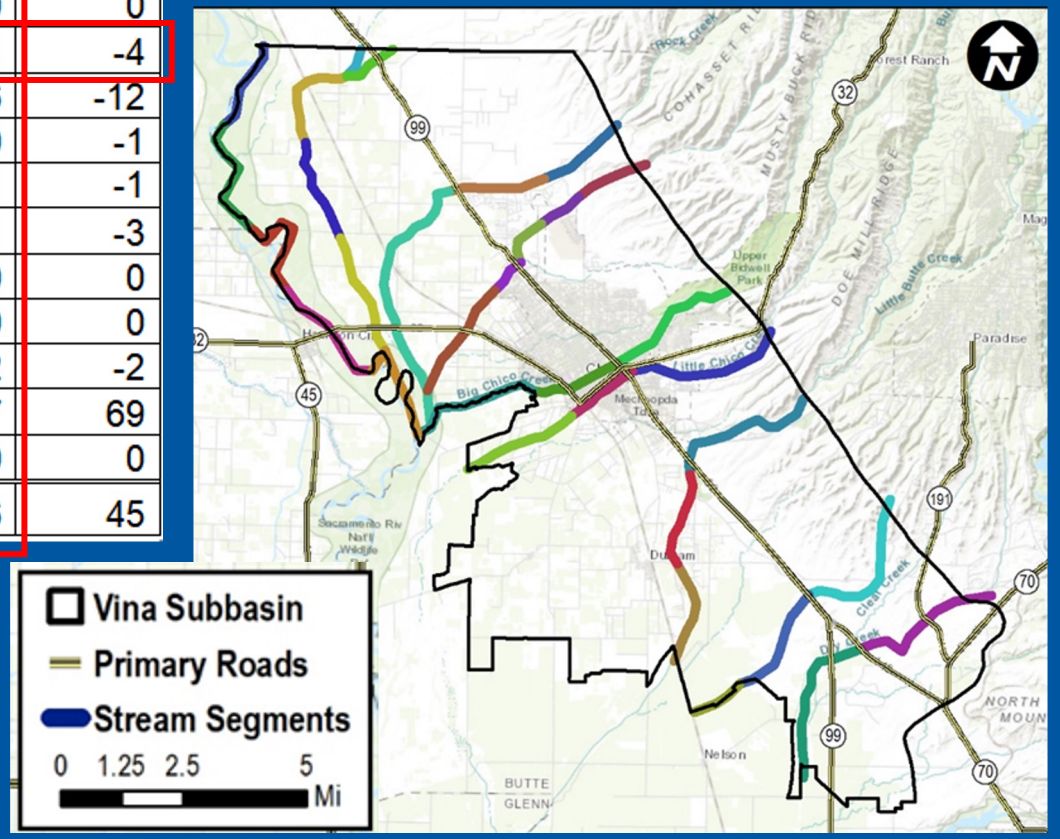


Source: Vina Subbasin Gaining and Losing Stream Reaches based on BBGM, Water Year 2000 to 2018

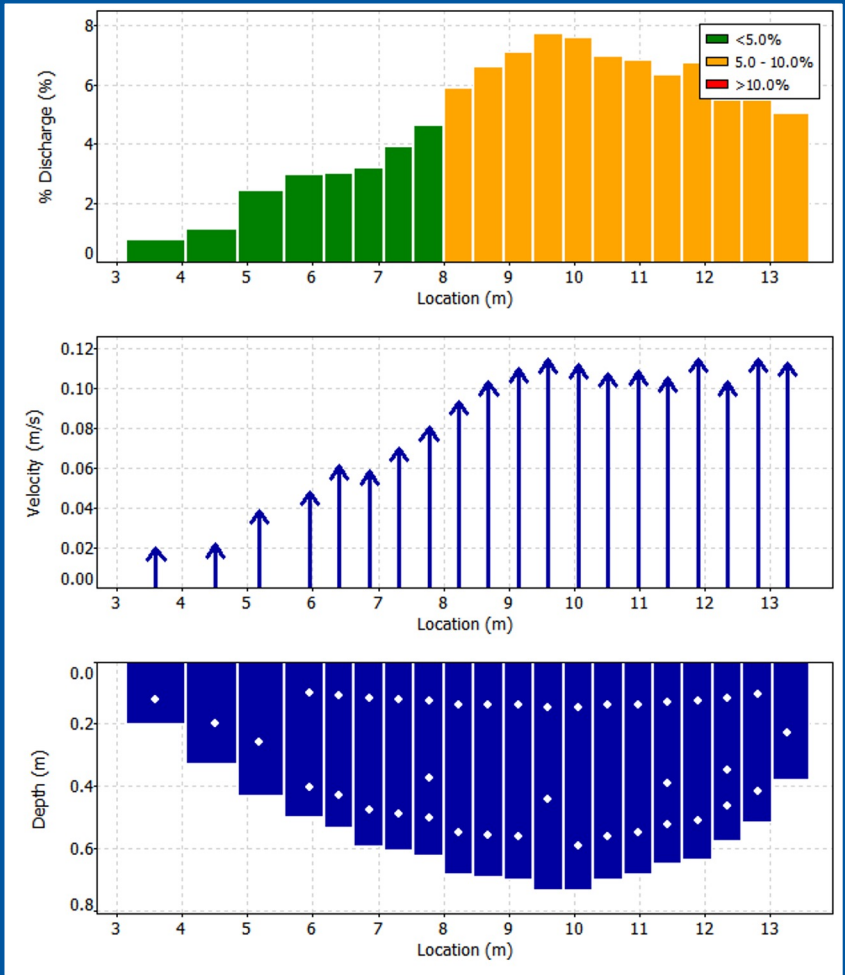
Vina Subasin Butte Basin Groundwater Model - Stream-Aquifer Interaction Estimates

Stream	Monthly Gains from Groundwater (cfs)												Average (cfs)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Angel Slough	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Chico Creek	-2	-3	-6	-7	-7	-8	-5	-3	-2	-2	-2	-1	-4
Butte Creek	-7	-10	-15	-15	-18	-20	-18	-14	-10	-7	-6	-6	-12
Dry Creek	-1	-1	-3	-2	-2	-2	-1	0	0	0	0	0	-1
Little Chico Creek	-1	-1	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1
Little Dry Creek	-2	-3	-6	-6	-6	-5	-4	-2	-2	-1	-1	-1	-3
Mud Creek	0	0	-1	1	1	2	2	1	1	0	0	0	0
Pine Creek	-1	-2	-4	-1	0	2	3	3	2	1	1	0	0
Rock Creek	-3	-3	-4	-3	-3	-2	-2	-2	-2	-2	-2	-2	-2
Sac River	109	151	24	-44	20	50	181	142	91	13	33	57	69
Singer Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	92	129	-17	-79	-18	15	154	123	76	1	22	46	45

Average Monthly Gains to Streamflow from Groundwater, Water Years 2000 to 2018 (cfs)



Big Chico Creek Field Data Collection



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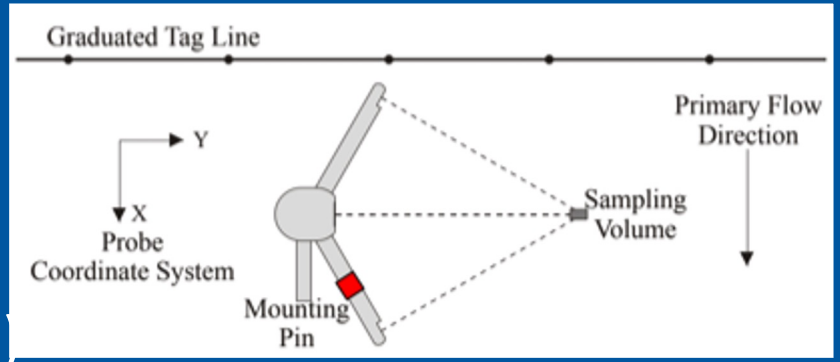
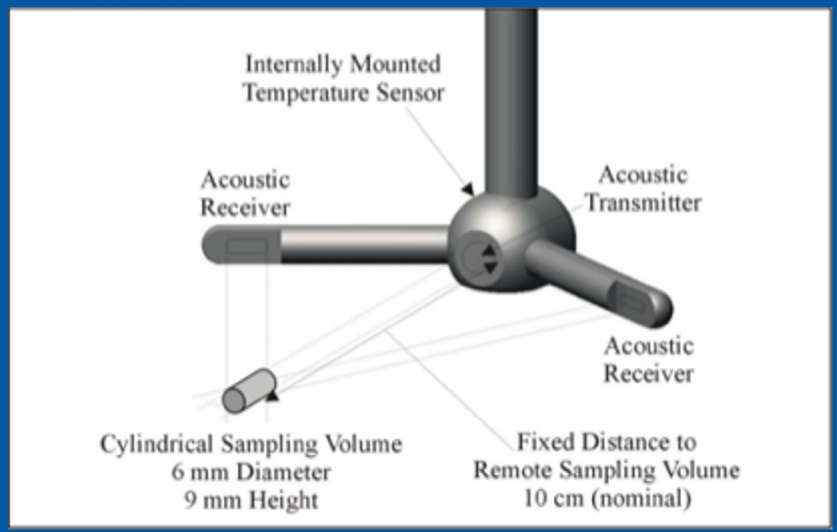
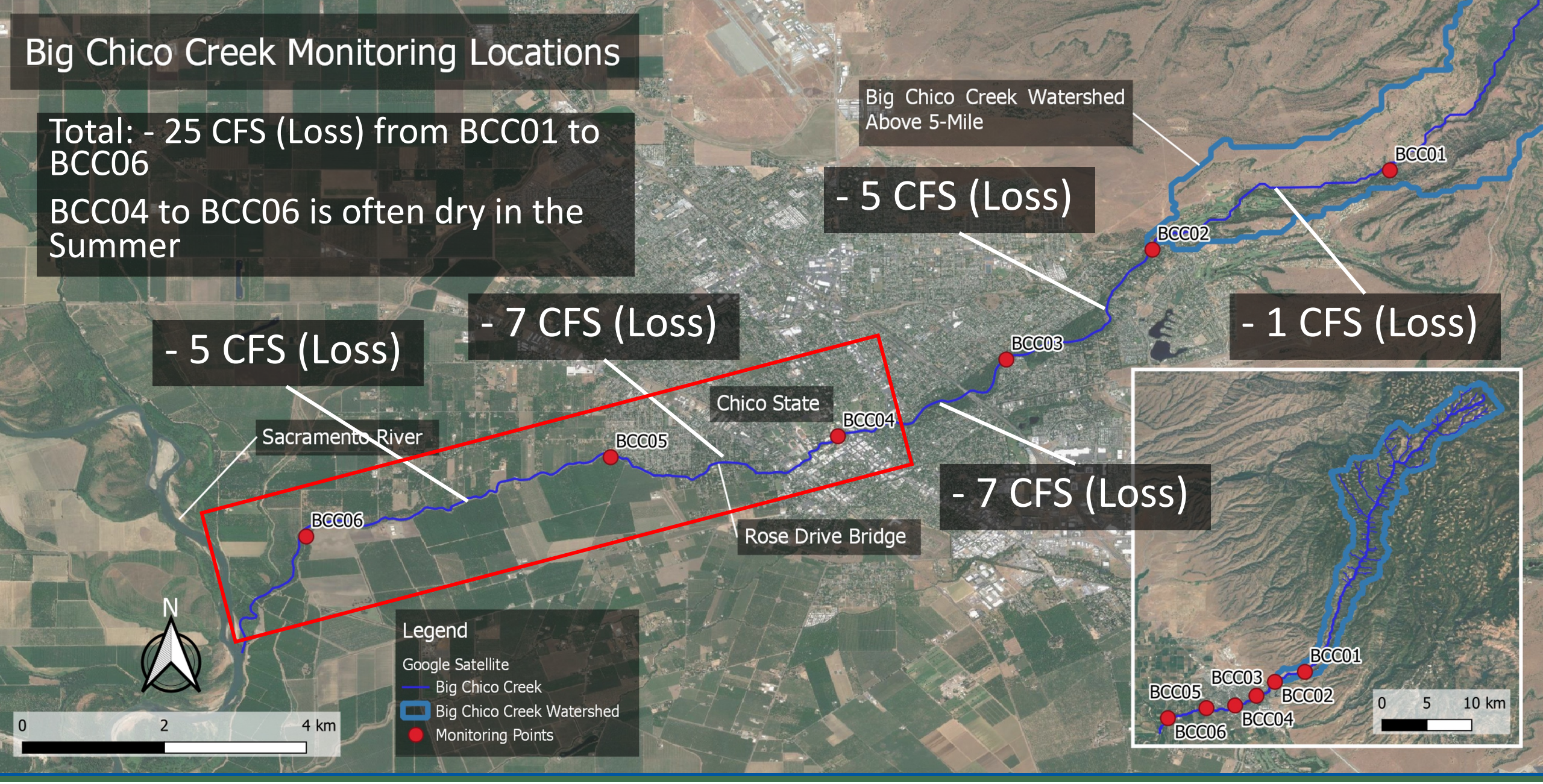


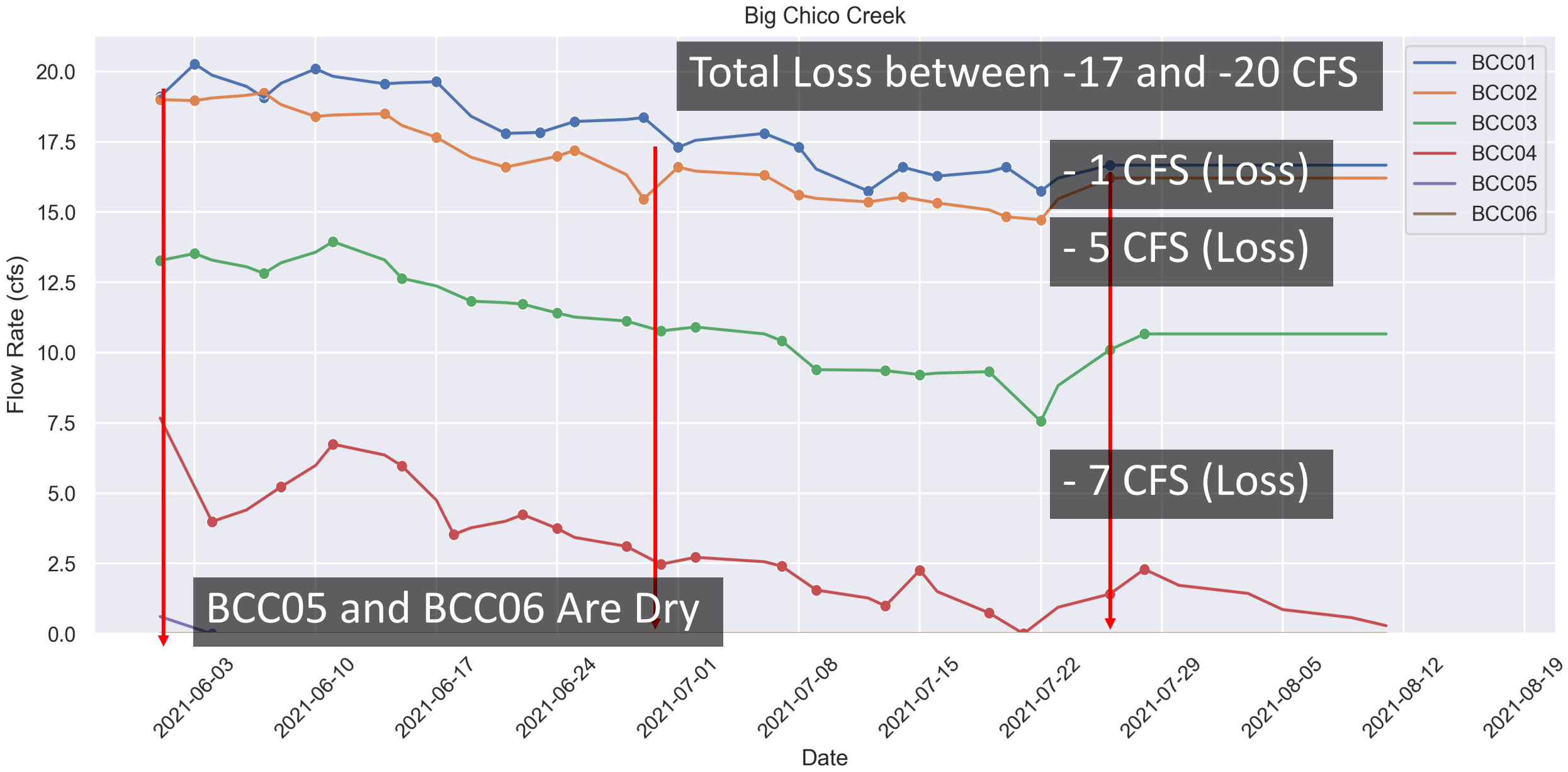


Big Chico Creek Monitoring Locations

Total: - 25 CFS (Loss) from BCC01 to BCC06

BCC04 to BCC06 is often dry in the Summer




Big Chico Creek
Total Loss between -17 and -20 CFS
- 1 CFS (Loss)
- 5 CFS (Loss)
- 7 CFS (Loss)
BCC05 and BCC06 Are Dry
BCC01
BCC02
BCC03
BCC04
BCC05
BCC06
Flow Rate (cfs)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2021-06-03
2021-06-10
2021-06-17
2021-06-24
2021-07-01
2021-07-08
2021-07-15
2021-07-22
2021-07-29
2021-08-05
2021-08-12
2021-08-19
Date

Case Study II - Butte Creek

Vina Subasin Butte Basin Groundwater Model - Stream-Aquifer Interaction Estimates

Stream	Monthly Gains from Groundwater (cfs)												Average (cfs)
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Angel Slough	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Chico Creek	-2	-3	-6	-7	-7	-8	-5	-3	-2	-2	-2	-1	-4
Butte Creek	-7	-10	-15	-15	-18	-20	-18	-14	-10	-7	-6	-6	-12
Dry Creek	-1	-1	-3	-2	-2	-2	-1	0	0	0	0	0	-1
Little Chico Creek	-1	-1	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1
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Mud Creek	0	0	-1	1	1	2	2	1	1	0	0	0	0
Pine Creek	-1	-2	-4	-1	0	2	3	3	2	1	1	0	0
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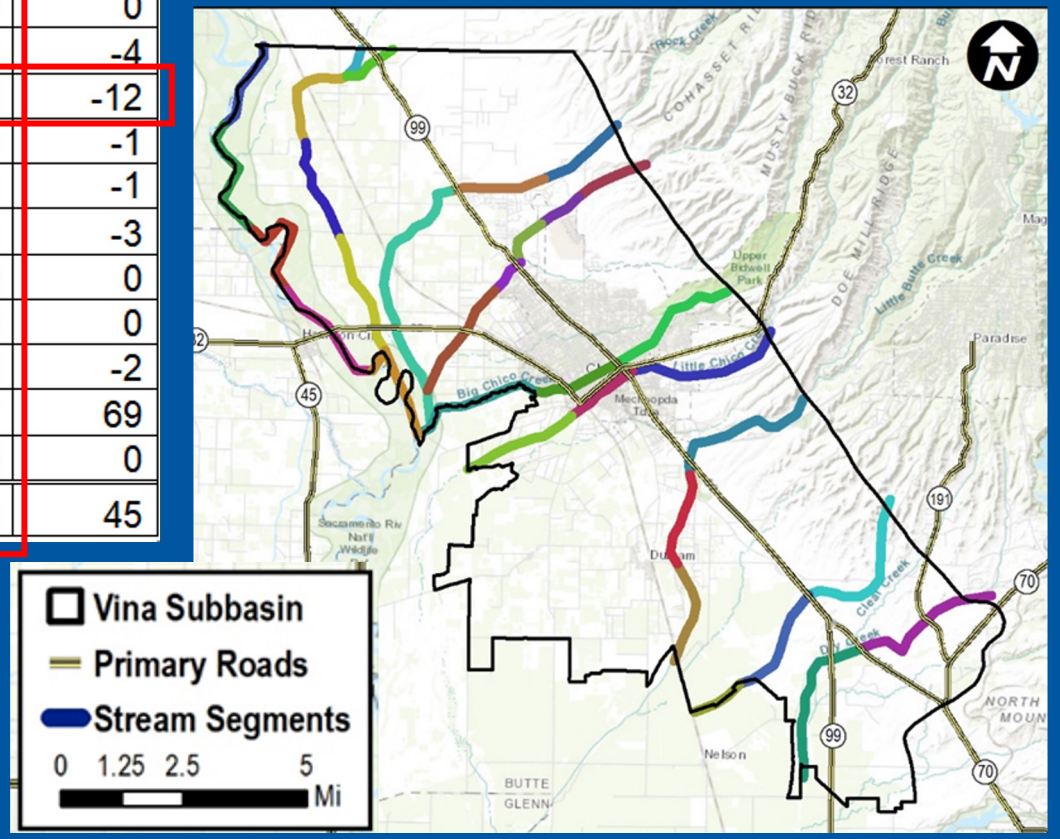
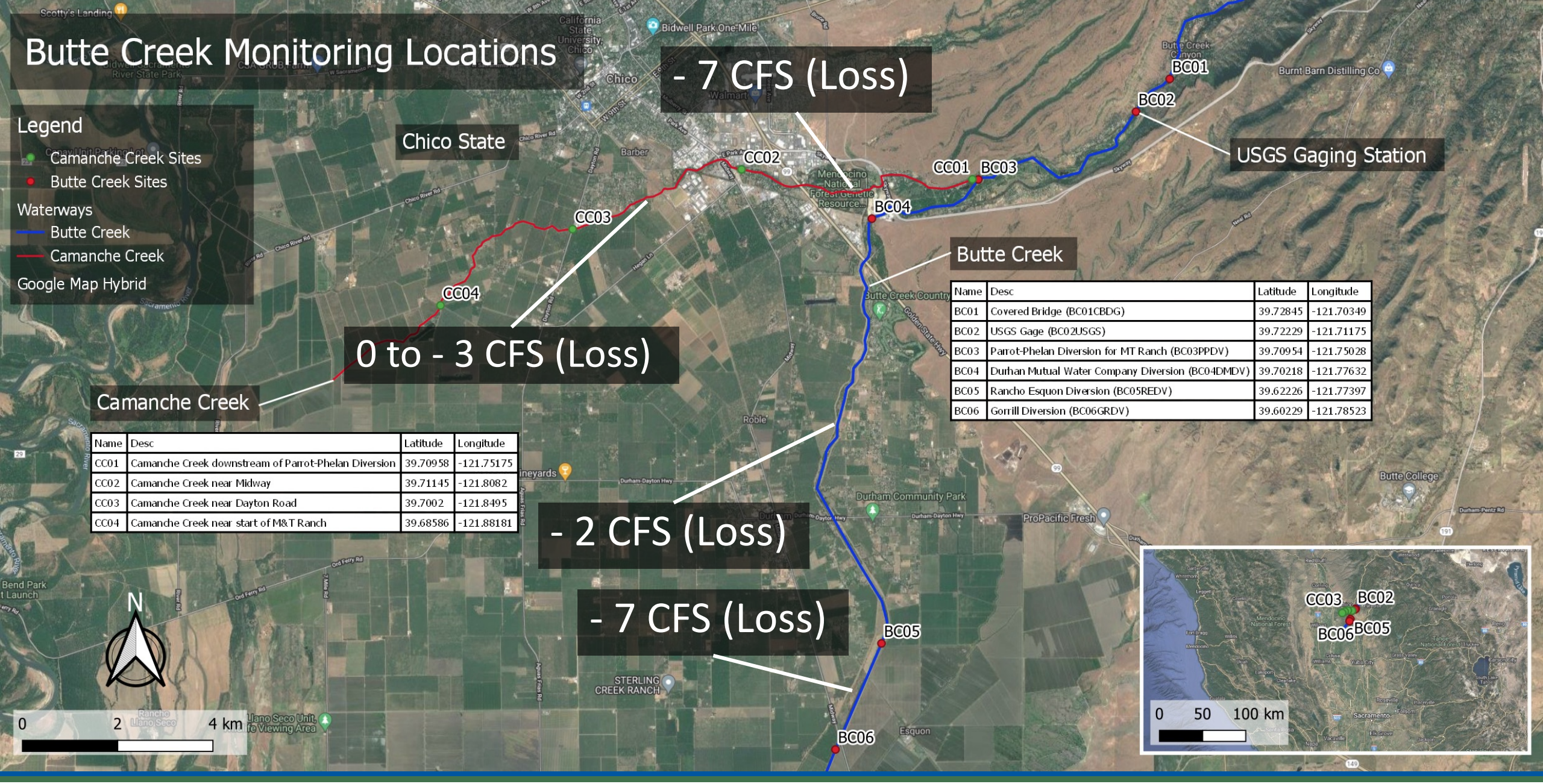
Sac River	109	151	24	-44	20	50	181	142	91	13	33	57	69
Singer Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	92	129	-17	-79	-18	15	154	123	76	1	22	46	45

Average Monthly Gains to Streamflow from Groundwater, Water Years 2000 to 2018 (cfs)



Butte Creek Monitoring Locations



Name	Desc	Latitude	Longitude
CC01	Camanche Creek downstream of Parrot-Phelan Diversion	39.70958	-121.75175
CC02	Camanche Creek near Midway	39.71145	-121.8082
CC03	Camanche Creek near Dayton Road	39.7002	-121.8495
CC04	Camanche Creek near start of M&T Ranch	39.68586	-121.88181

Name	Desc	Latitude	Longitude
BC01	Covered Bridge (BC01CBDG)	39.72845	-121.70349
BC02	USGS Gage (BC02USGS)	39.72229	-121.71175
BC03	Parrot-Phelan Diversion for MT Ranch (BC03PPDV)	39.70954	-121.75028
BC04	Durhan Mutual Water Company Diversion (BC04DMDV)	39.70218	-121.77632
BC05	Rancho Esquon Diversion (BC05REDV)	39.62226	-121.77397
BC06	Gorrill Diversion (BC06GRDV)	39.60229	-121.78523

Case Study III - Feather and Yuba River Bathymetry and Stream-Reach Water Budgets

Feather and Yuba Rivers - Overview

- Focused on improvements to Yuba Groundwater Model (YGM)
  - Improved stage-discharge relationships
  - Improved stage-wetted perimeter relationships
  - Improved streambed conductance characterizations
- Intensive field data collection
  - 18 bathymetry sites
  - Over 100 Acoustic Doppler Current Profiler (ADCP) measurements transects performed
- Fully digital data collection including essential meta data (GPS, images, notes, etc.)

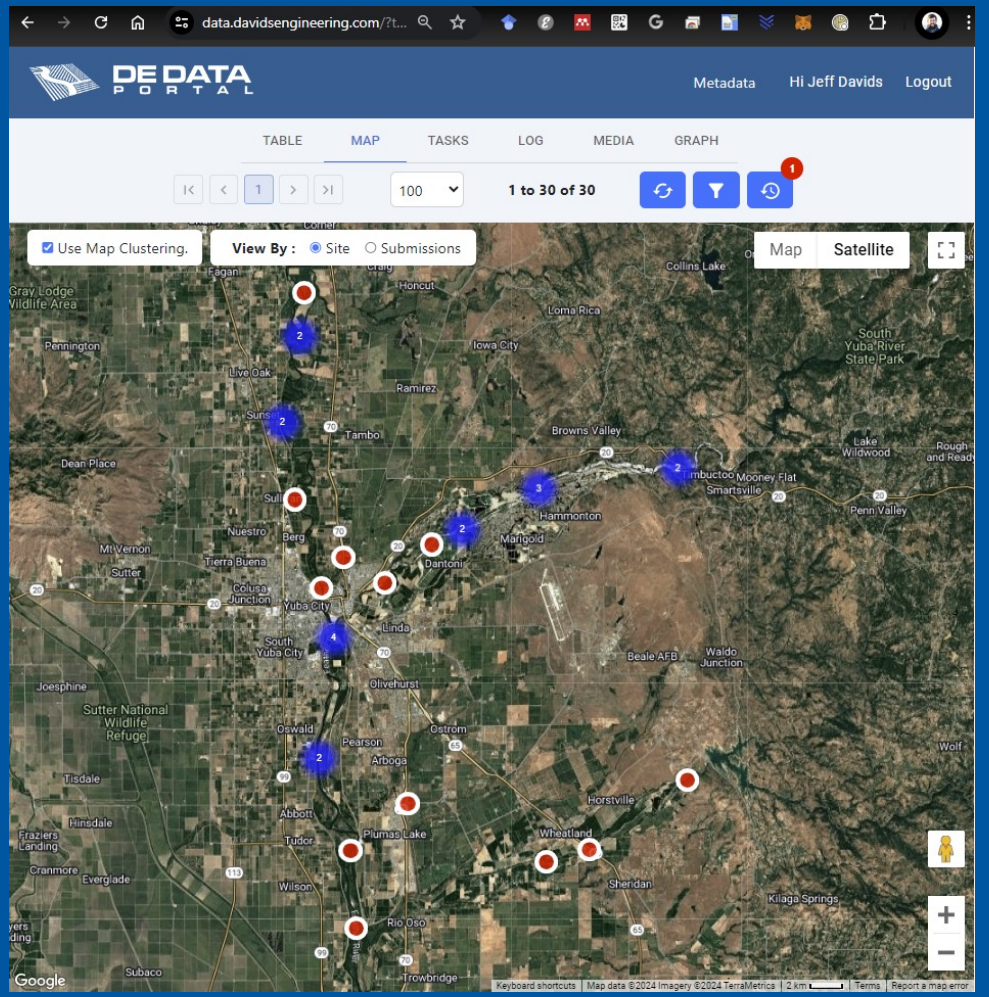


TABLE MAP TASKS LOG MEDIA GRAPH

1 to 30 of 30

YRUSDP_Yuba River Upstream of Daguerre Point

Summary Table Tasks Log Media Graph

Earliest Submission Date	2024-07-24 09:27:00
Latest Submission Date	2024-09-25 08:26:00
Number of Submissions	5
Monitors	DE_MON_00005_Jeff_Davids, DE_MON_00007_Erika_Sos, DE_MON_00009_Christopher_Sortor
Coordinates	39.2118936, -121.4405347


2024-07-24 09:27:00

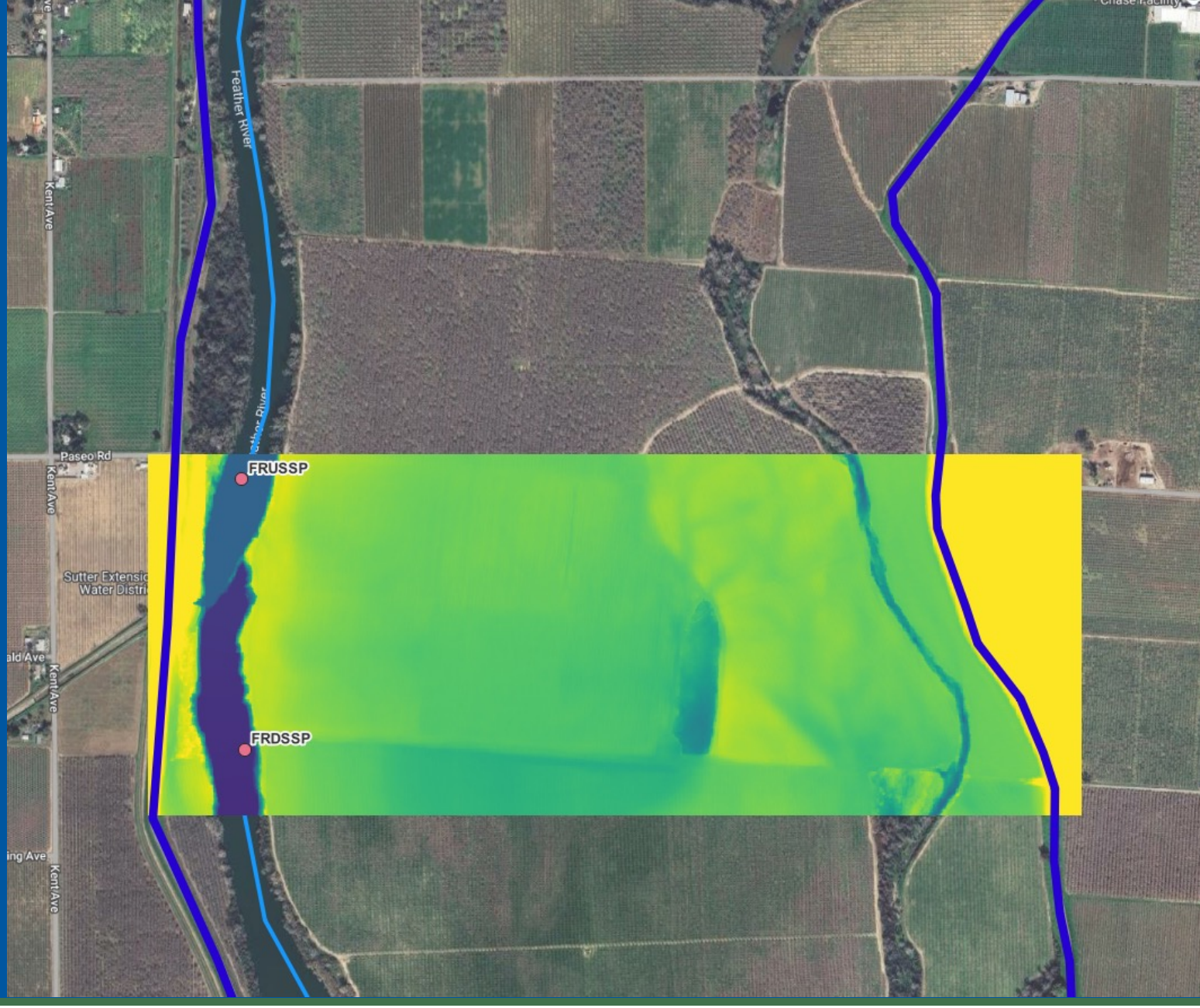

2024-07-24 09:32:00


2024-09-25 08:26:00


2024-09-25 08:26:00

Feather and Yuba Rivers - Bathymetry

Feather and Yuba Rivers - Bathymetry



Feather and Yuba Rivers - Bathymetry

- Below water bathymetry from *butterfly* ADCP measurements
- Kriging to create streambed surface
- Stitched together with 1M 3DEP DEM
- Levee-to-levee cross section created perpendicular to flow direction
- Stage-wetted perimeter created from crawling algorithm

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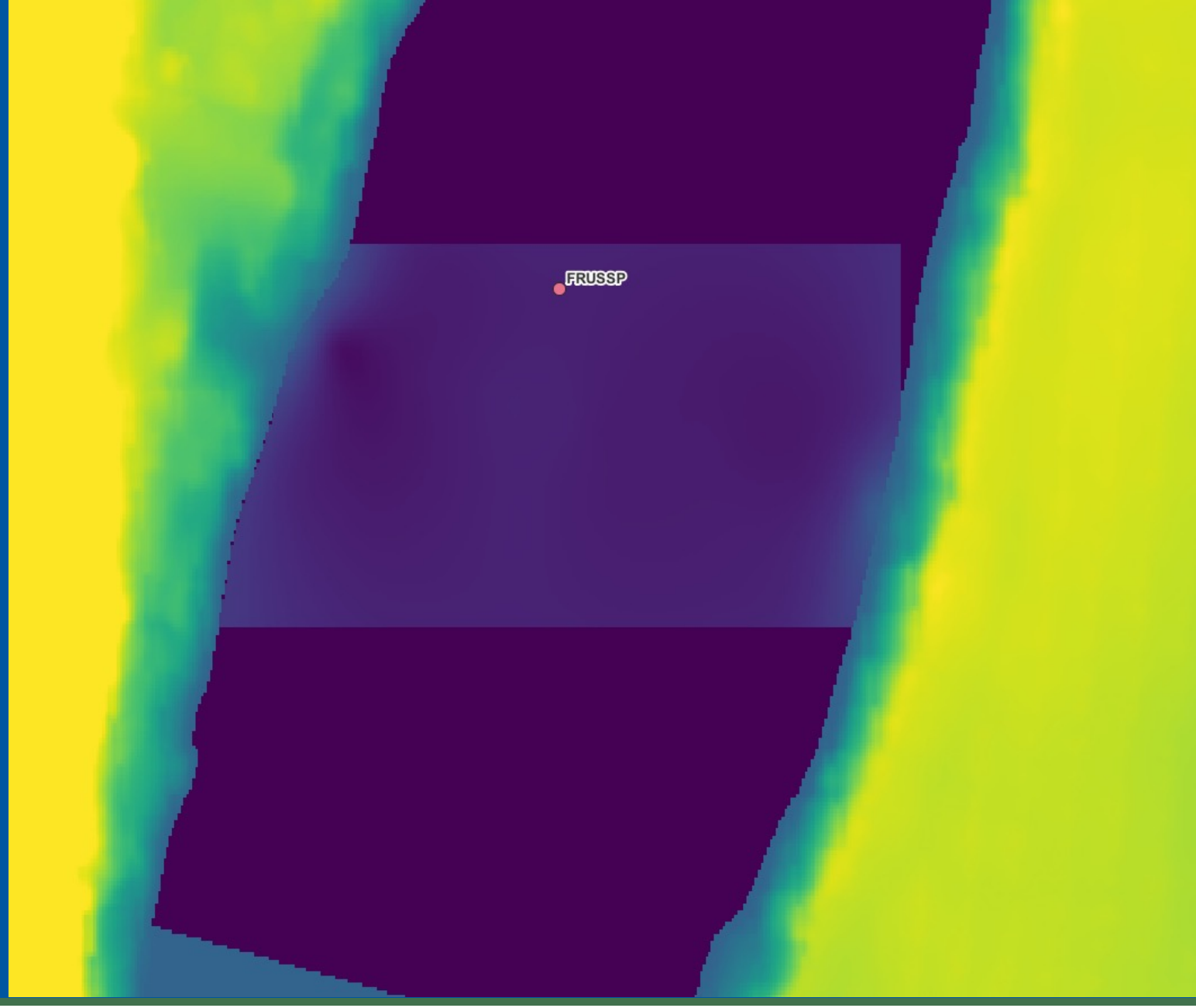

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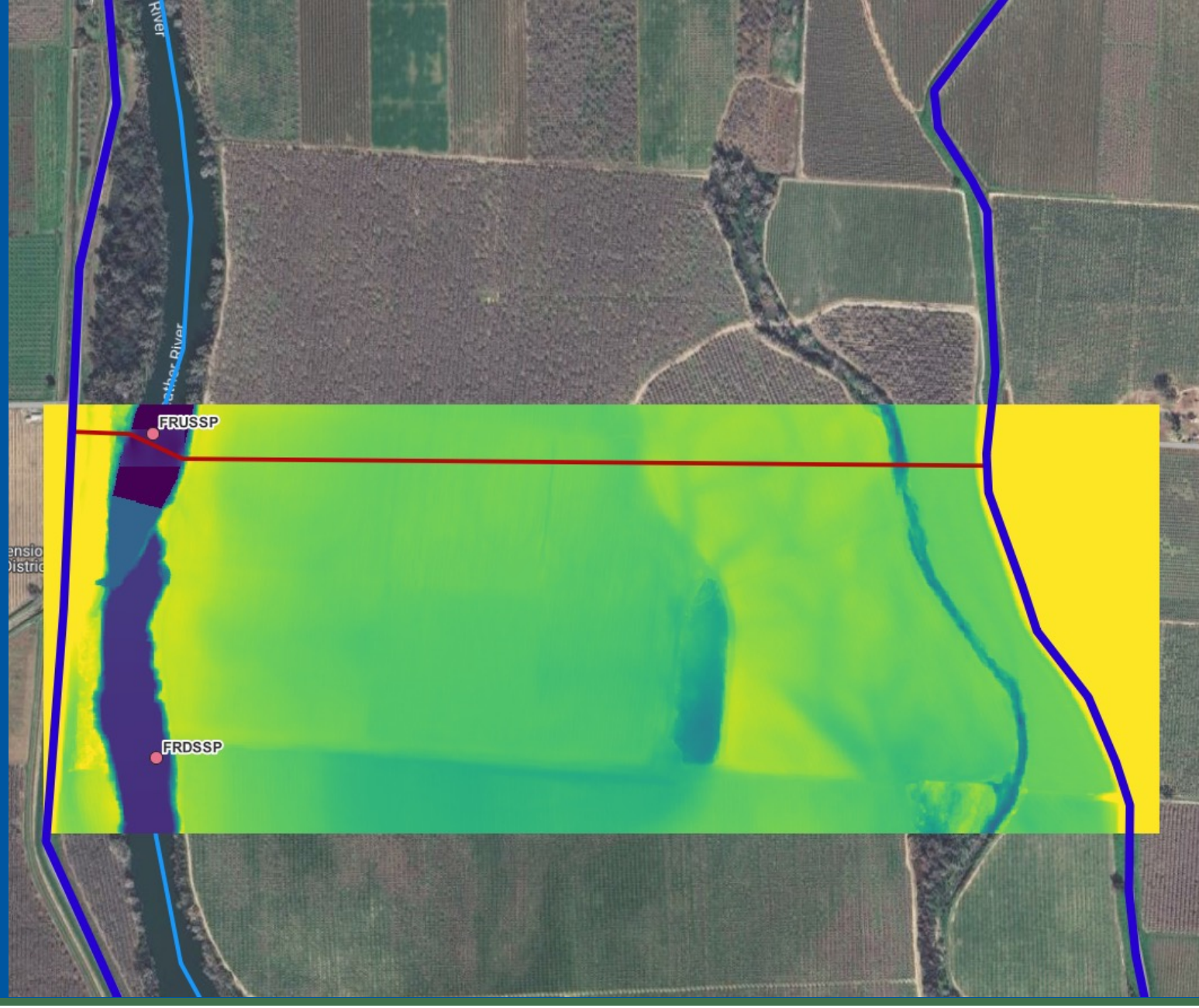
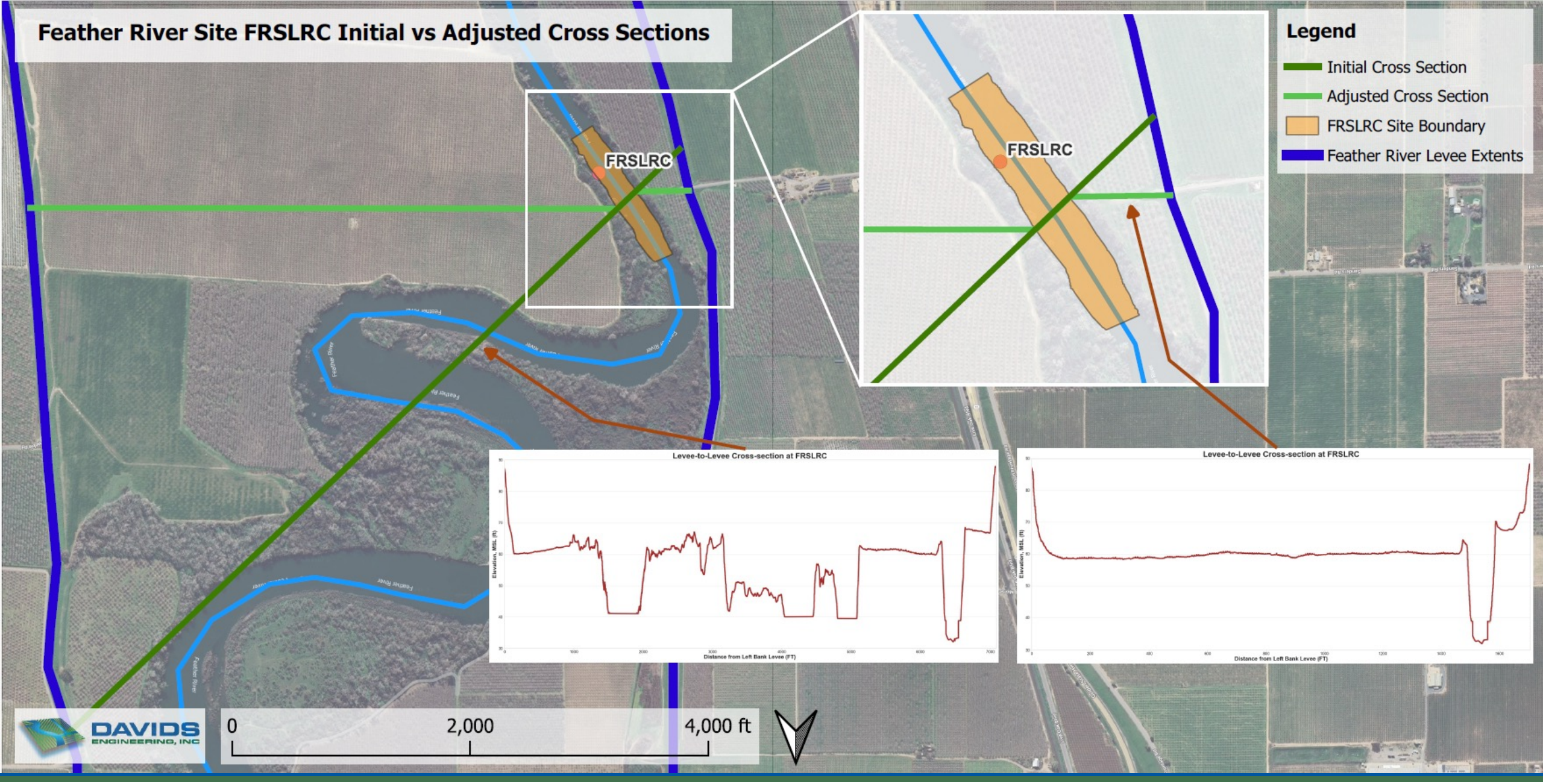
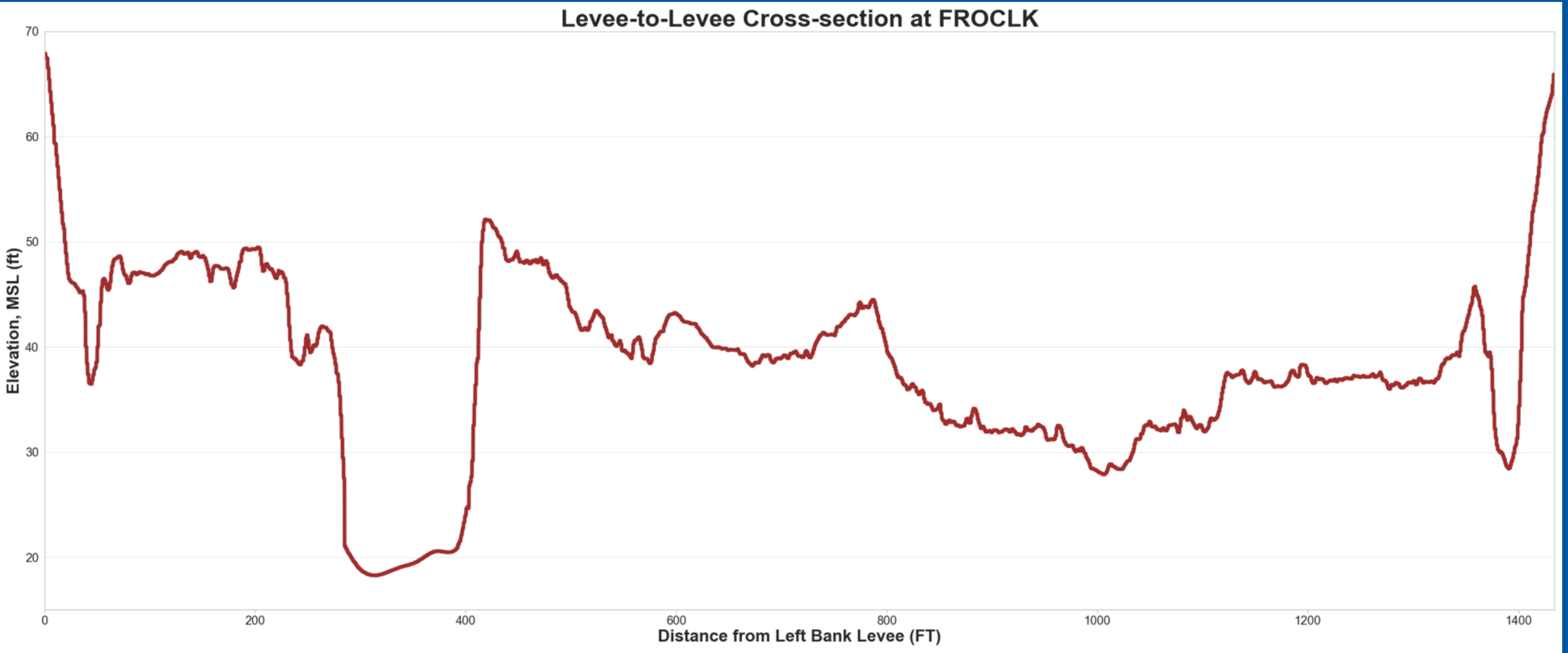


Feather River Site FRSLRC Initial vs Adjusted Cross Sections



Feather and Yuba Rivers - Bathymetry



Feather and Yuba Rivers - Stream-Reach Water Budgets

Conclusions and Next Steps

- Models are important for characterizing depletions of interconnected surface water (DWR guidance documents).
- However, models must be grounded in data to the greatest extent possible.
- Improvements to how models characterize stream-aquifer interactions can be improved by:
  - Refining stage-discharge relationships for stream nodes
  - Refining stage-wetted perimeter relationships for stream nodes
  - Refining understanding of stream-aquifer fluxes with stream-reach water budgets
- We are busy collecting stream reach water budget data as miscellaneous inflows/outflow, ET, and P are all reducing in the fall.