From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success
Morning Session

A Concurrent Session at the 42nd Annual Salmonid Restoration Conference
Santa Cruz, California, April 29 - May 2, 2025

Session Coordinators: David Dralle, *US Forest Service Pacific Southwest Research Station*, and Monty Schmitt, *The Nature Conservancy*

Groundwater plays a vital role in keeping streams flowing during the dry season, especially in watersheds that support salmon. With growing pressures from land use changes, groundwater pumping, and climate variability, it's more important than ever to manage the connection between groundwater and surface water to protect these critical flows.

This session will focus on practical tools and strategies for managing groundwater to maintain streamflows that salmon rely on. We'll cover the latest advancements in large-scale groundwater models that can help predict and address streamflow depletion. We'll also look at regional groundwater management plans that are successfully safeguarding water resources through thoughtful planning and regulation. In addition, we'll explore new research on why some streams dry up and how this affects fish, alongside a discussion on the global issue of aquifer decline and what it means for local water management.

By sharing case studies, management approaches, and the latest research, this session aims to provide practitioners, researchers, and policymakers with actionable insights and tools to support salmon restoration efforts through effective groundwater and surface water management.

Presentations

Marshall Ranch Flow Enhancement Project: the benefits of incorporating hyporheic processes into flow augmentation projects

2025 Salmonid Restoration Federation Conference

Concurrent Session: From Groundwater to Streamflow: Scaling up Strategies, Models and Datasets for Salmonid Success

Author/Presenter: Joel Monschke, Engineer/Geomorphologist, Stillwater Sciences

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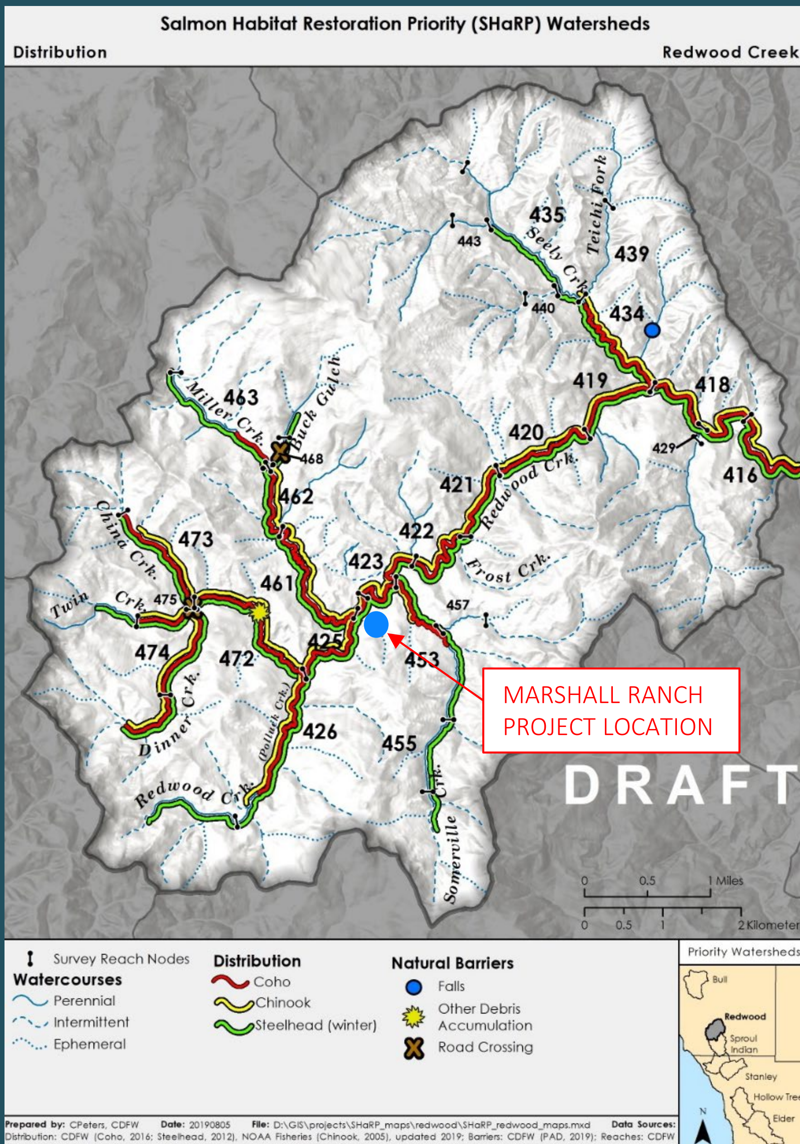
Tom Hicks, Hicks Law

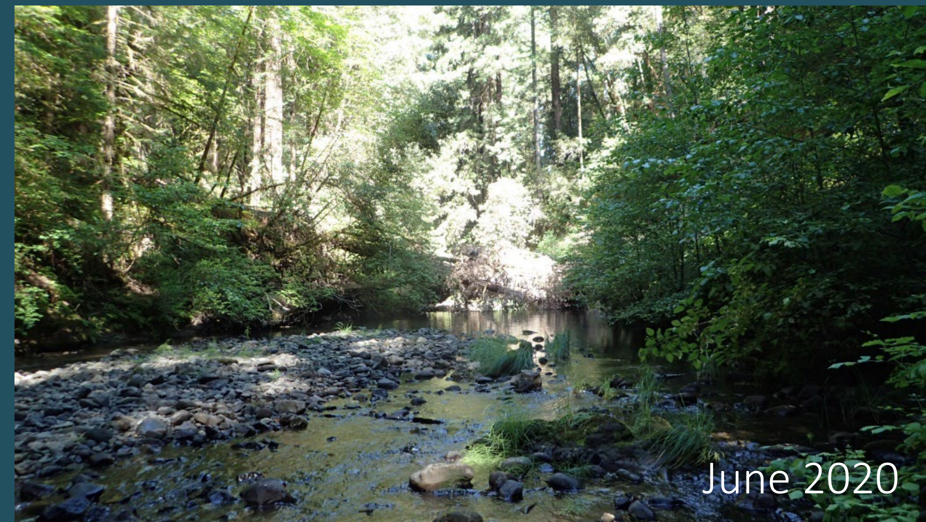
Stillwater Sciences

Presentation Outline

I. Background & Setting
II. Project Design & Construction
III. Operations, Monitoring and Adaptive Management
IV. Lessons Learned and Next Steps

Project Location and fish distribution

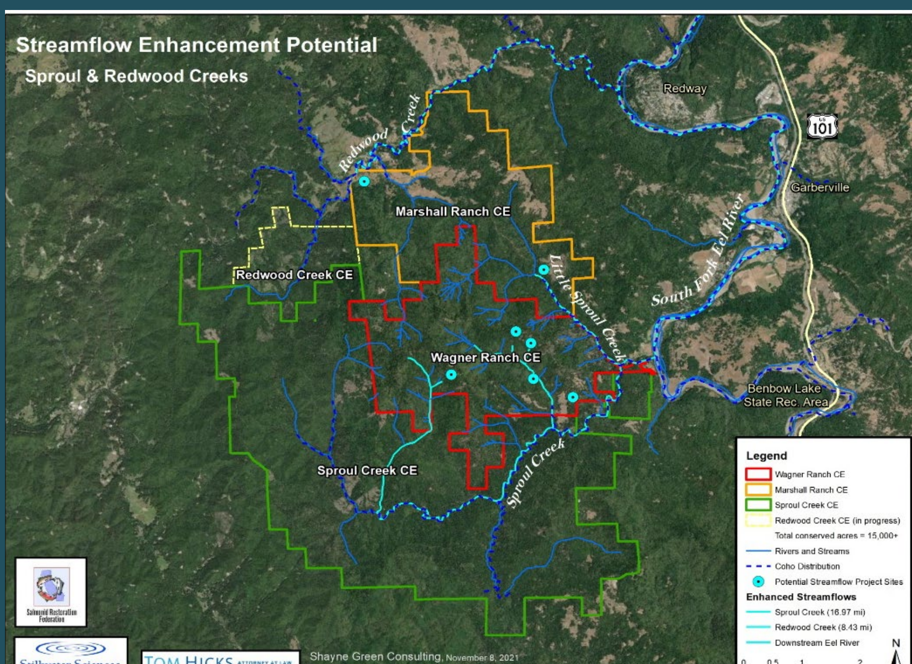




Redwood Creek near confluence with South Fork Eel

The Marshall Ranch

The Marshall family of mixed indigenous and European ancestry has inhabited their Wailaki Ancestral Land from time immemorial to the present and has been actively involved in all stages of this project through development, construction, and operations



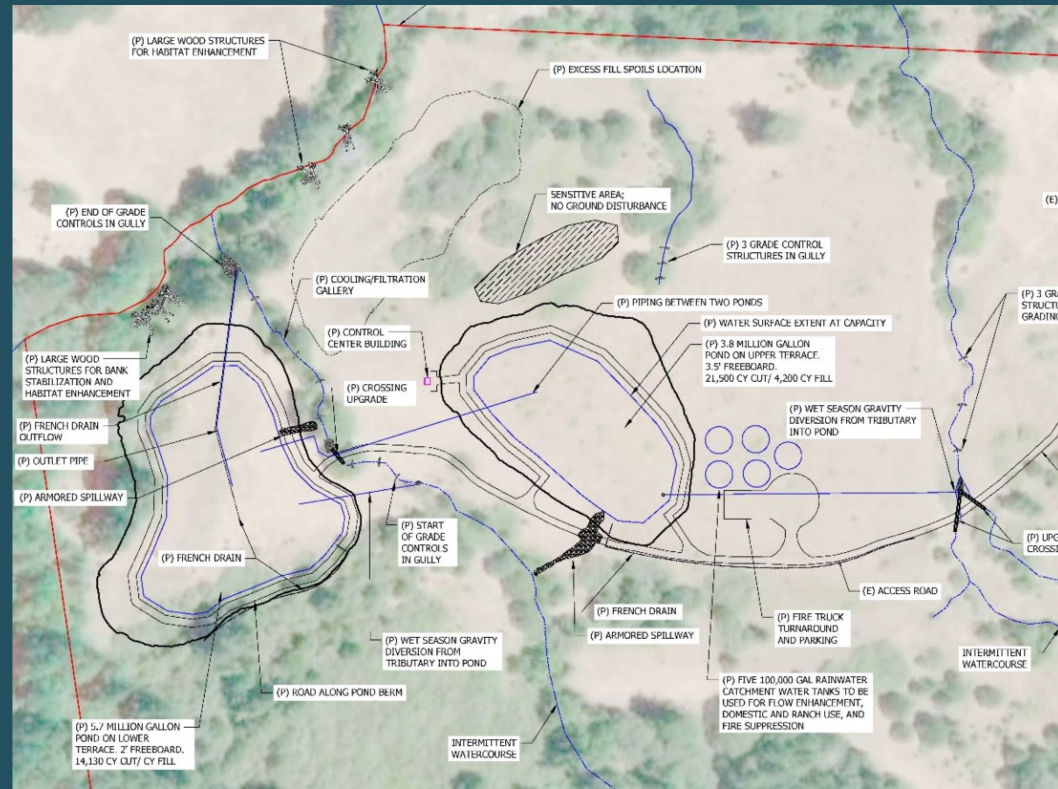
Conservation Easement

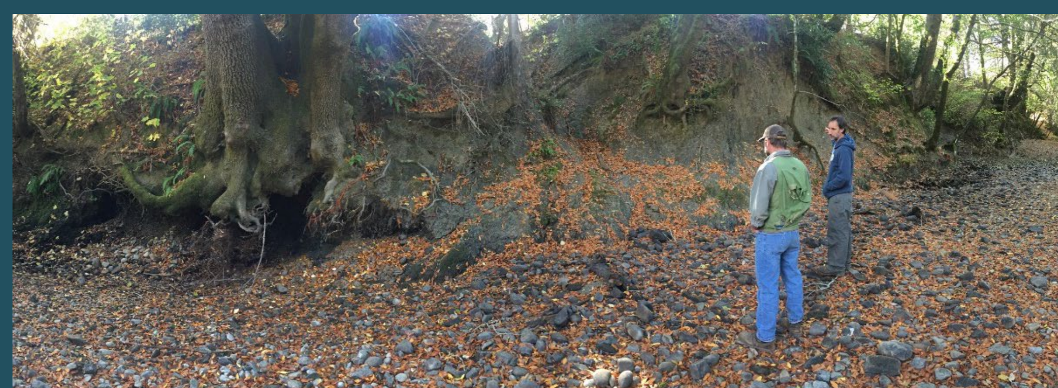
- CDFW: $5,012,125
- Department of Conservation, Strategic Growth Council Sustainable Agricultural Lands Conservation Program: $2,523,225
- California Department of Forestry and Fire Protection (CALFIRE), California Climate Investments - Forest Health Grant Program: $3,500,000

Shayne Green, Consultant
Noah Levy, Consultant

Marshall Ranch Flow Enhancement Project

- 10 million gal lined off-stream storage in two ponds
- Two surface water diversions with Appropriative Water Right
- Managed flow release to Redwood Creek – via direct release or cooling/filtration gallery
- Construction mostly completed in 2023
- ~$4 M implementation phase funded by WCB.

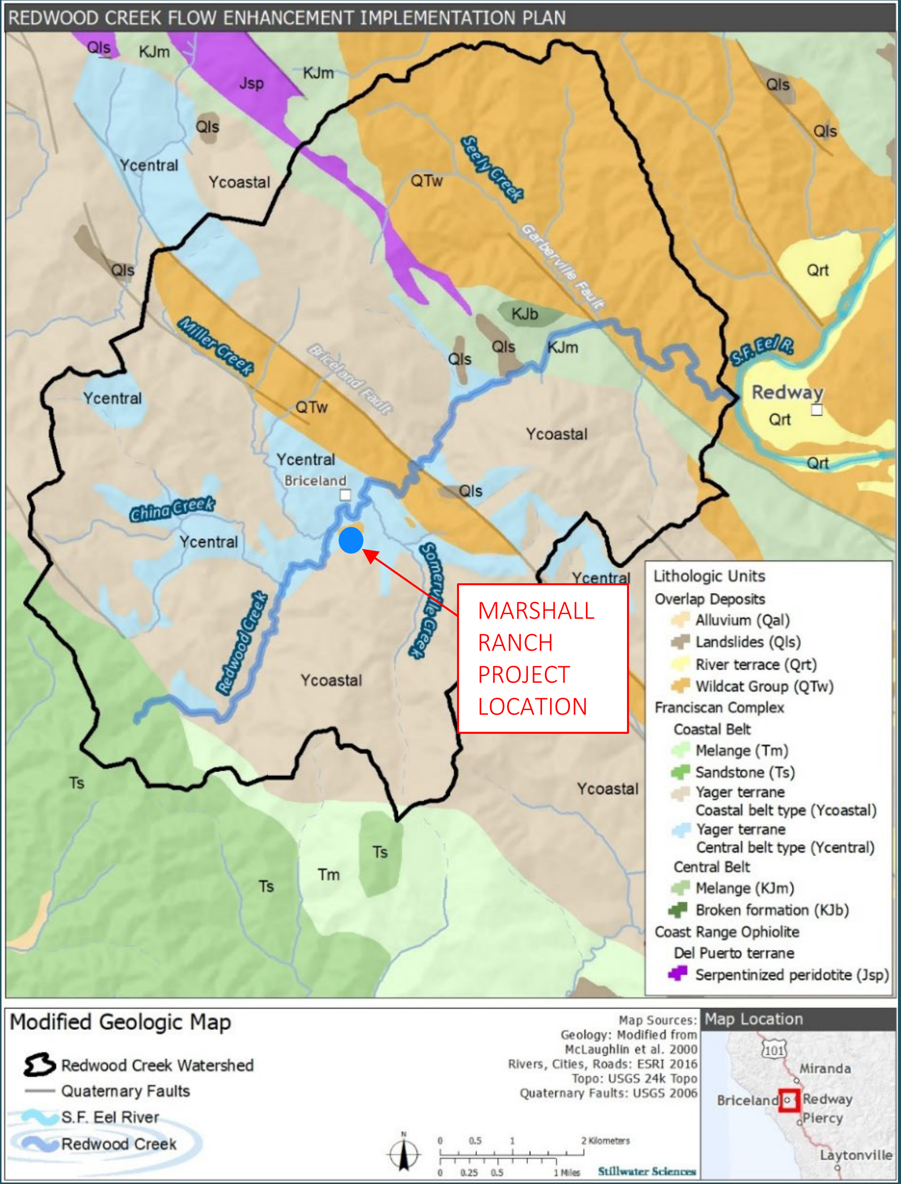




Marshall Ranch during construction September 2023

Geology and Soil Stratigraphy

- Project lies within the messy intersection of Coastal and Central Belt Franciscan terranes
- Immediate project vicinity underlaid by mudstone shale bedrock
- No major loosing reaches in Redwood Creek downstream from the project site



Marshall Ranch ponds at full capacity

East Pond

West Pond

- Ponds have HDPE liners topped with gravel to increase longevity
- Designed to fill with 40” of rain which is drought conditions

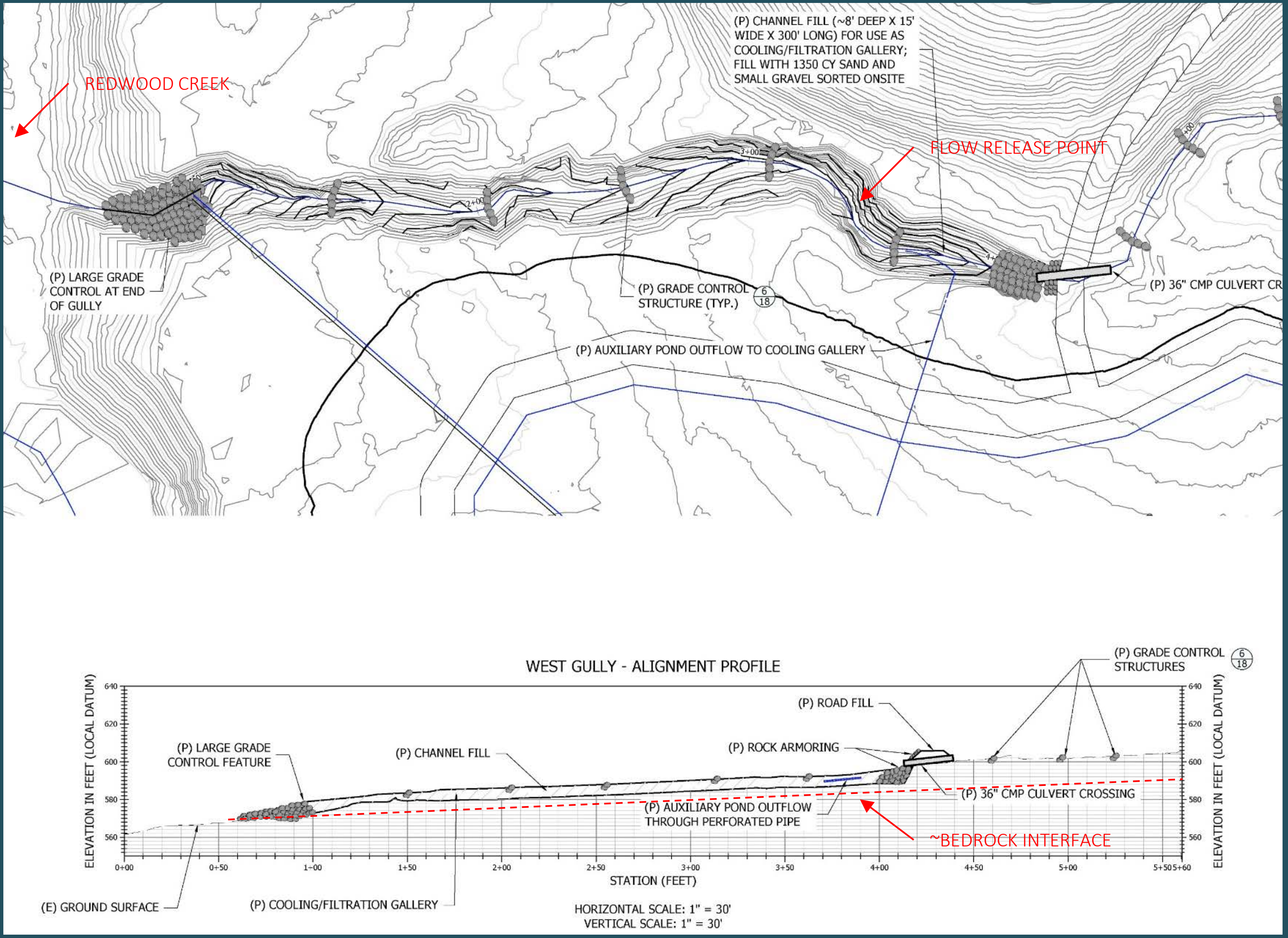
Onsite monitoring setup

In-Situ telemetry system

Data logger locations

2024 early operational challenge

- Pond water temperatures higher than anticipated at start of summer 2024 so immediate need for use of cooling/filtration gallery



Cooling/Filtration Gallery

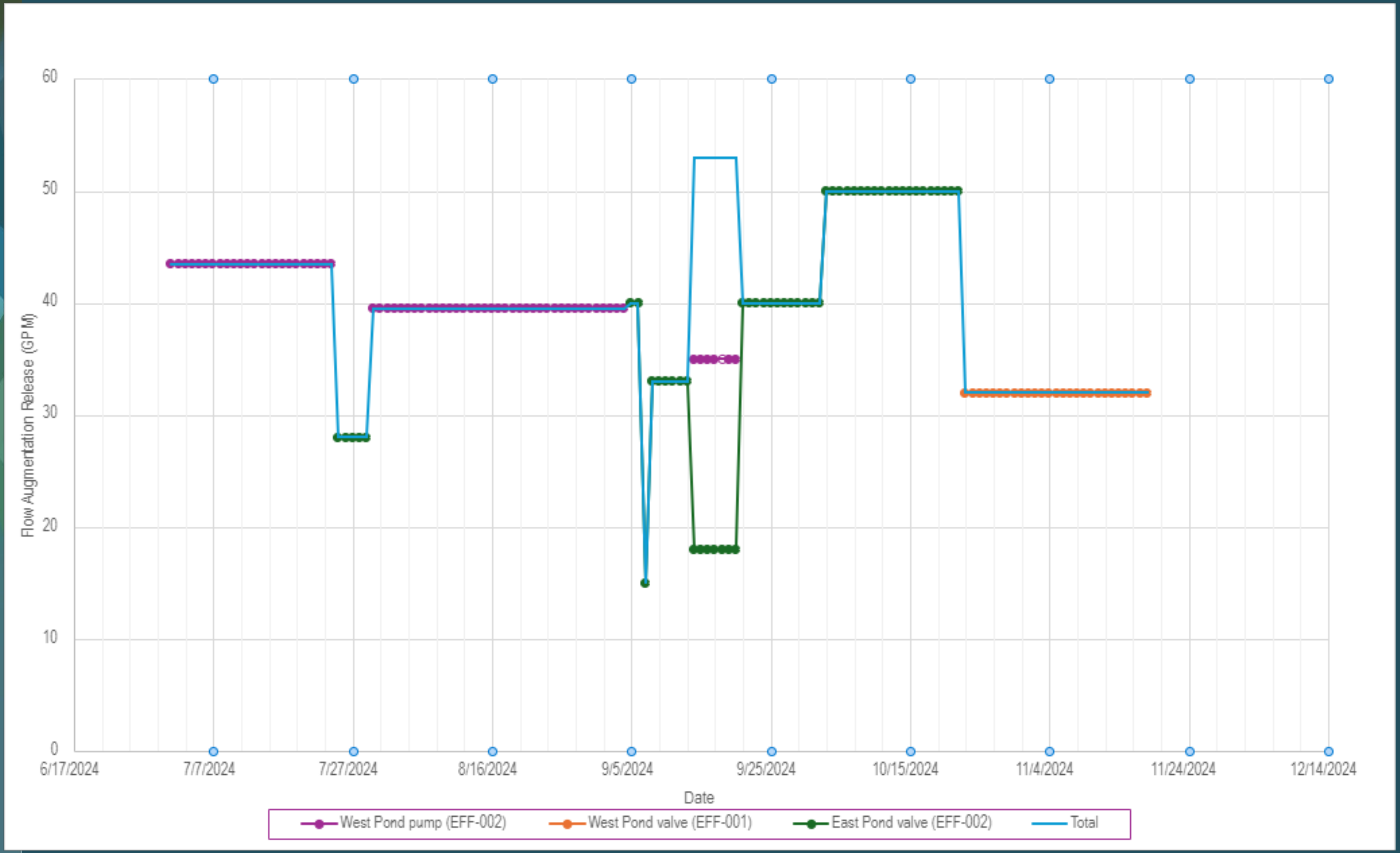
Pre-project

Post-project

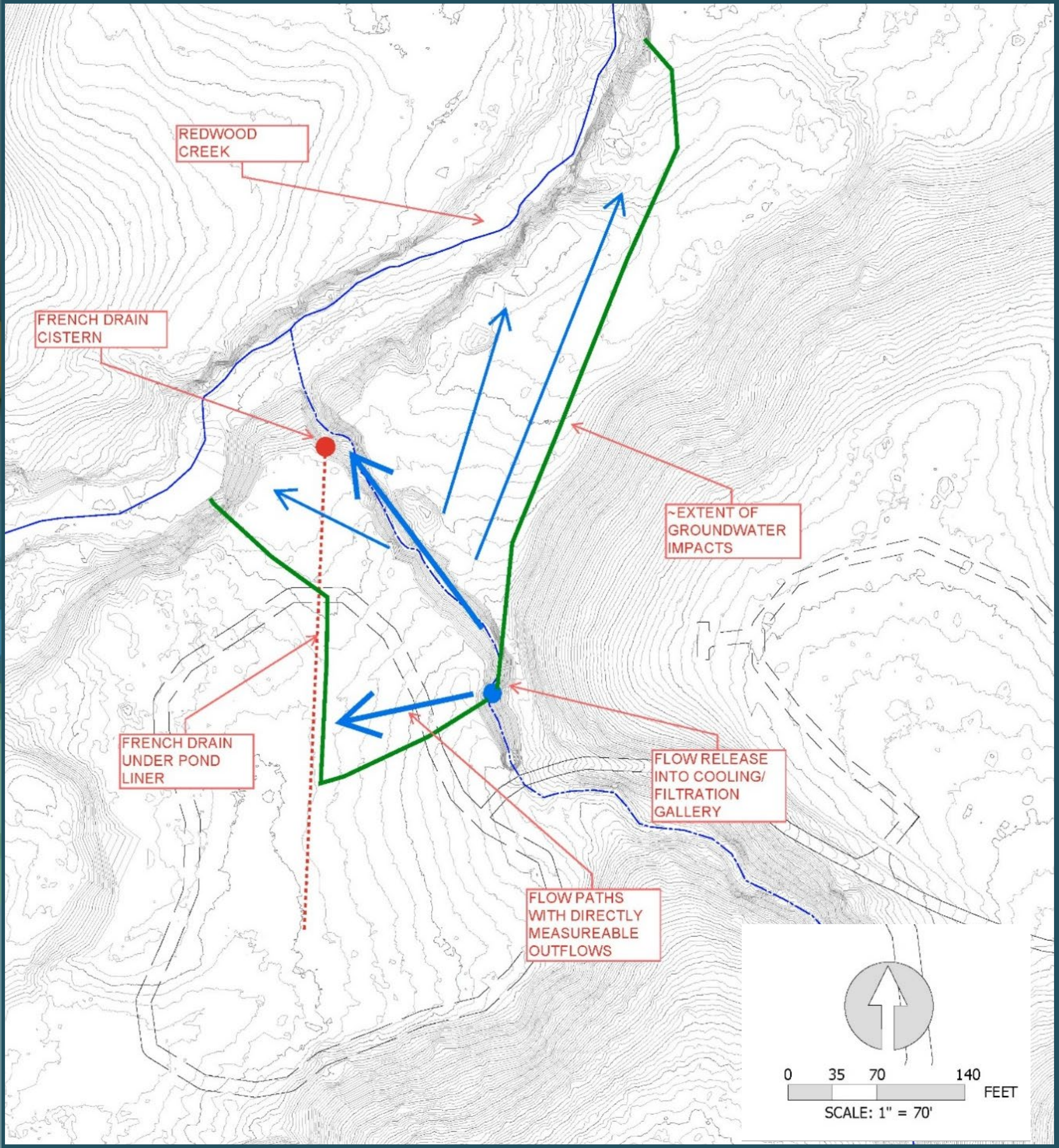
2024 flow release

Cooling/
Filtration
Gallery input

8M gal augmentation over 4.5 months; ~40 gpm average



Cooling/Filtration Gallery Functionality

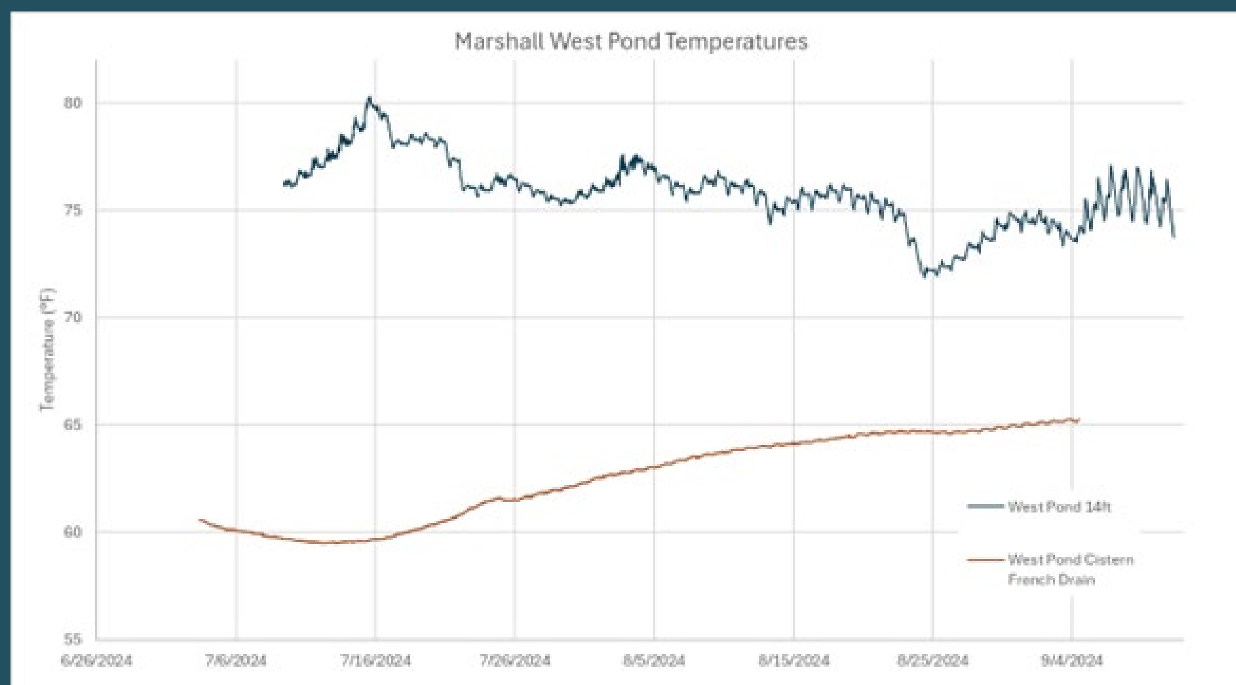


- Two primary flow paths with measurable outflows (bold blue arrows) representing ~50% of input flow
- Dispersed flow paths with seepage evident along soil-bedrock interface

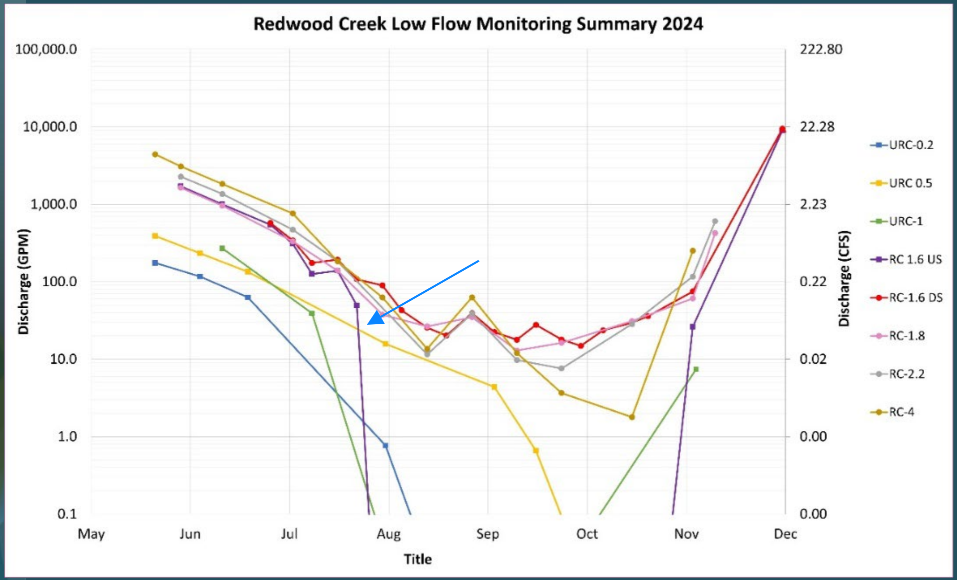
Temperature benefits of cooling gallery

Cooling gallery outflow to Redwood Creek

- Initial cooling benefits of 15 deg F, decreasing to ~10 deg F
- Measured in French drain cistern (shortest flow path)

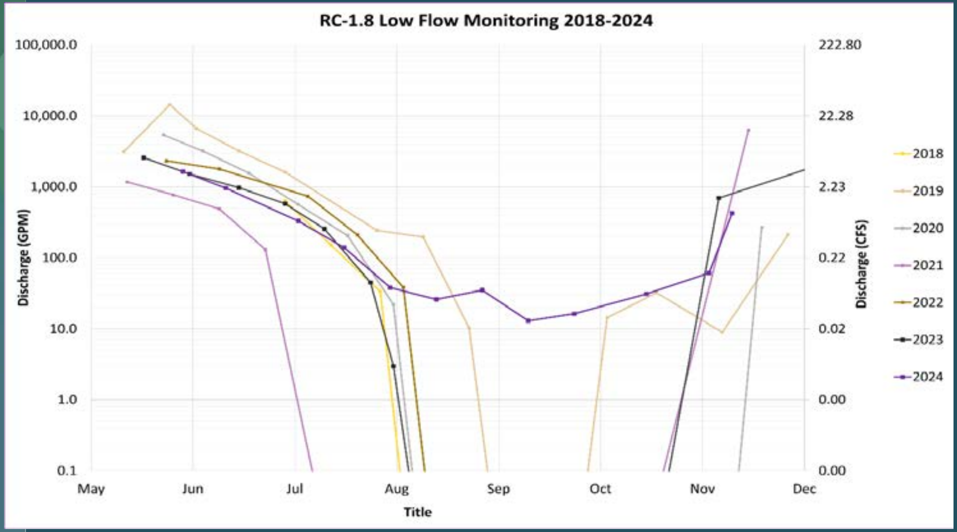


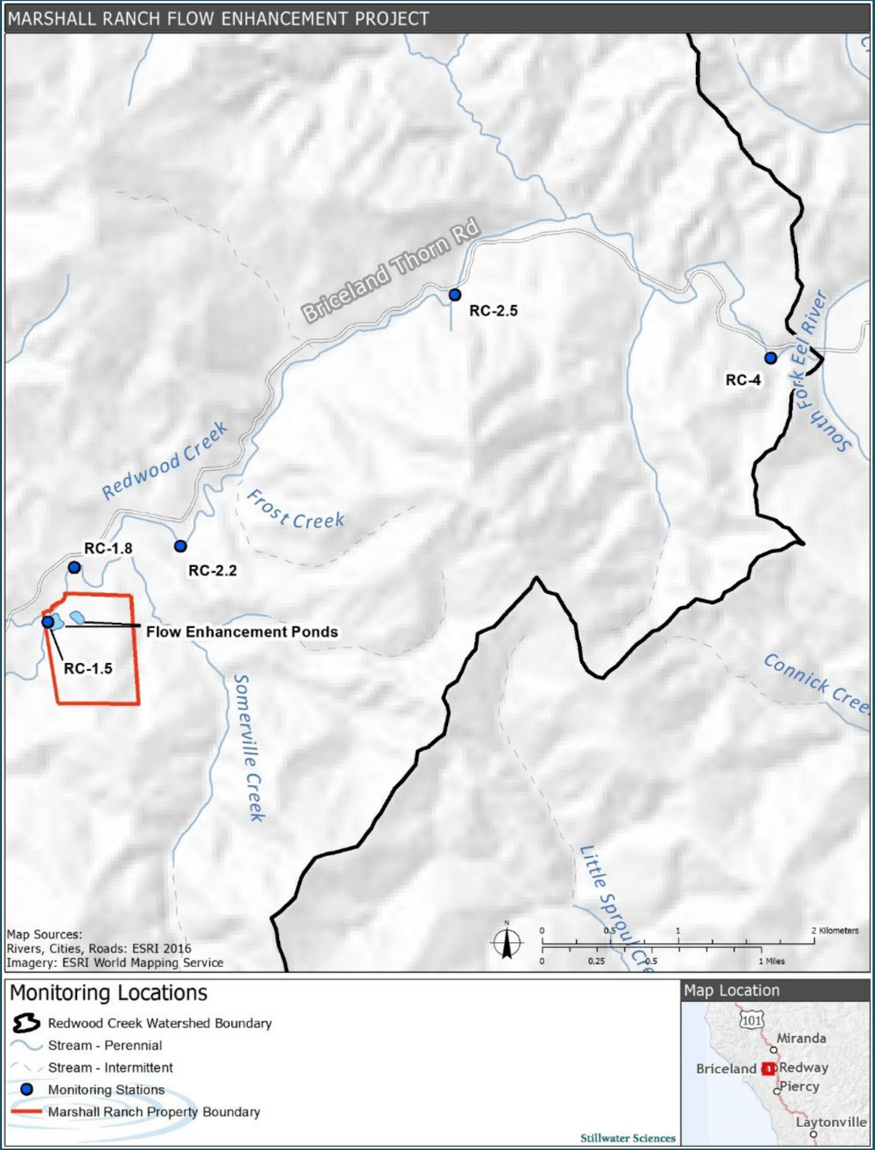
Watershed monitoring - discharge



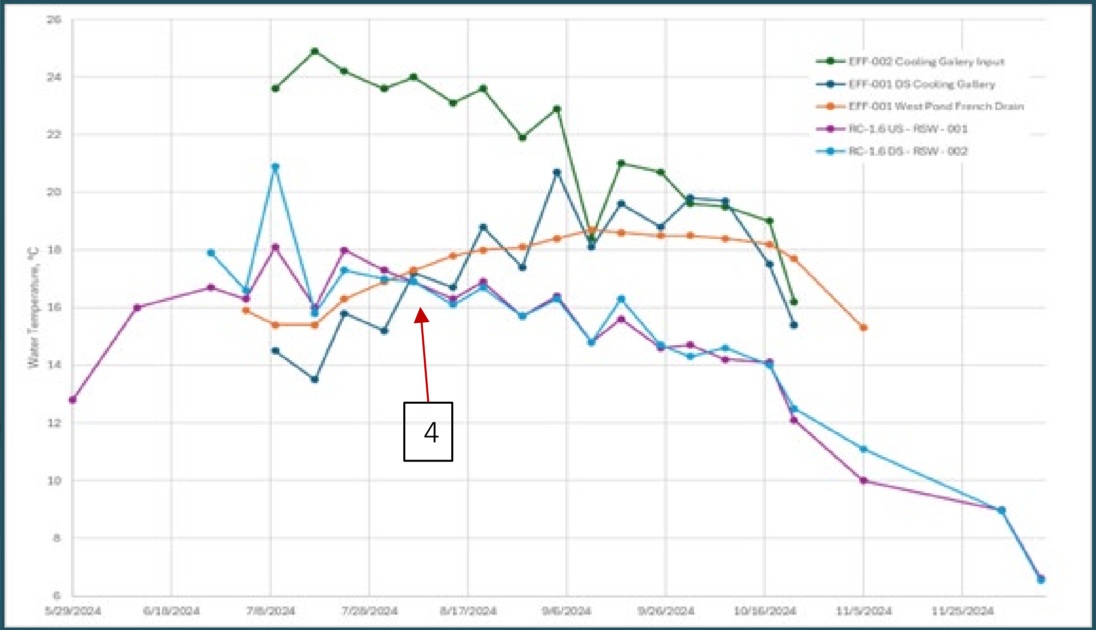
Flow at upstream gage ceases in mid July

First year with continuous flow at downstream gage since 2018 (including 1 very wet year)





Additional Project Site Monitoring Data - Temperature

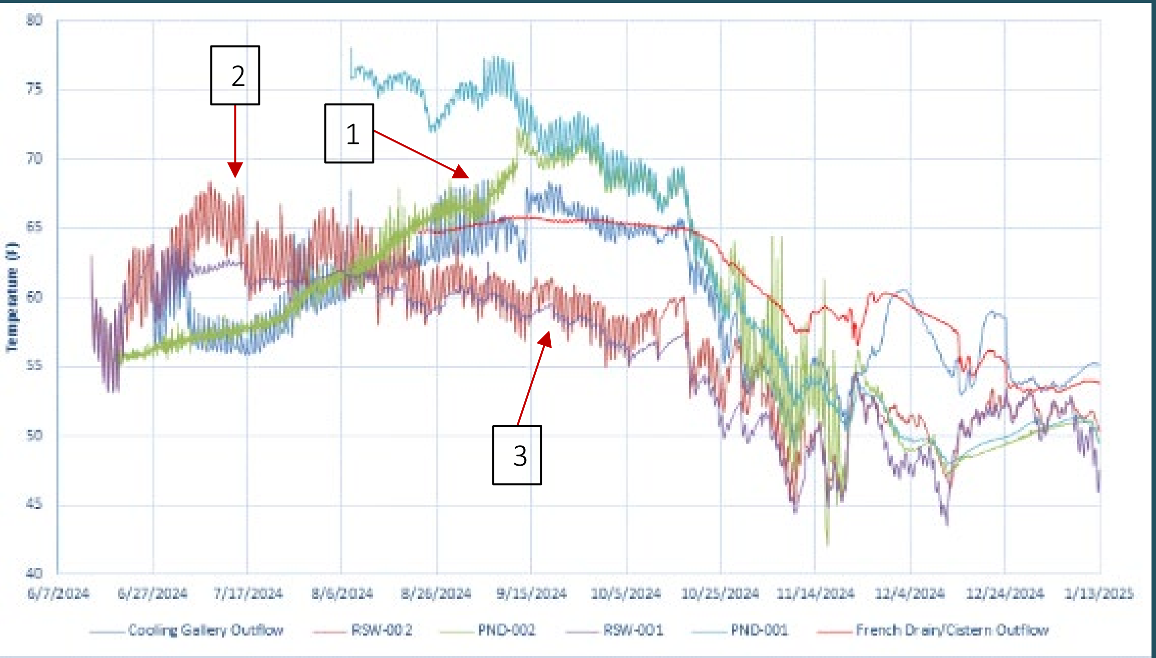


SRF spot measurements

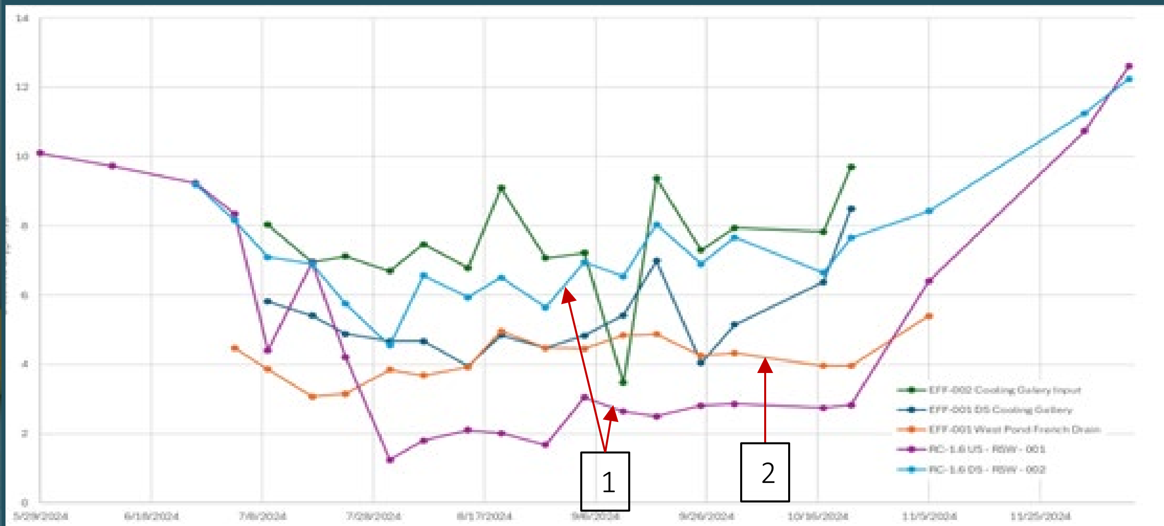
In-Situ Logger Data

Strong consistency between datasets:

1. East pond stayed stratified until late August
2. Early season high water temps driven by surface flow connectivity
3. Late season suitable downstream water temperatures maintained for Coho
4. Warming water outflow from cooling gallery offset by seasonal cooling and increased dominance of hyporheic flow dynamics



Additional Project Site Monitoring Data – DO

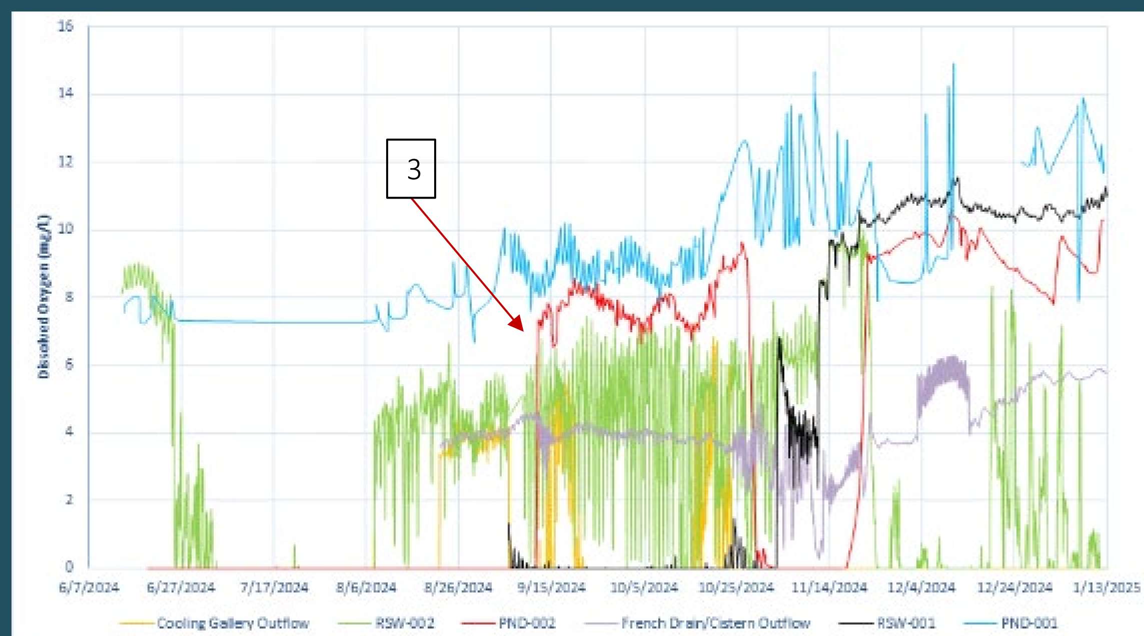


SRF spot measurements

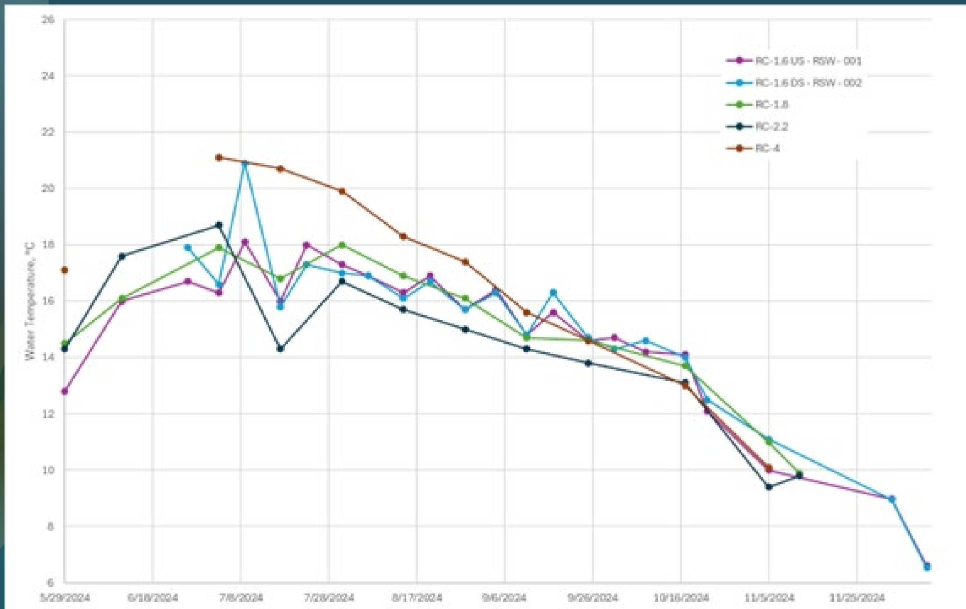
In-Situ Logger Data

General consistency between datasets, buggy In-Situ DO logger communication to be updated in 2025 and calibrated

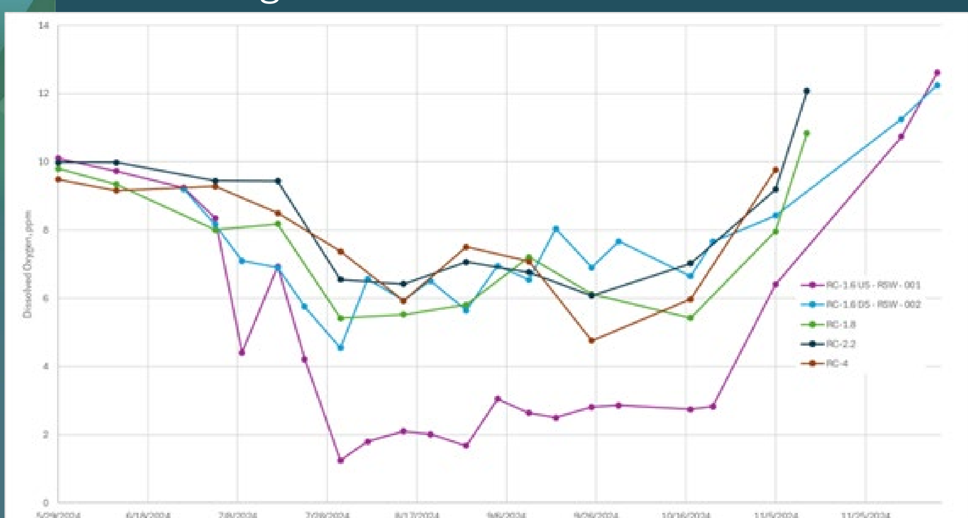
1. Significant improvement in DO levels in Redwood Creek upstream to downstream from augmentation
2. Cooling gallery output fairly steady at 4 mg/L.
3. Aeration system in ponds provided instant benefit

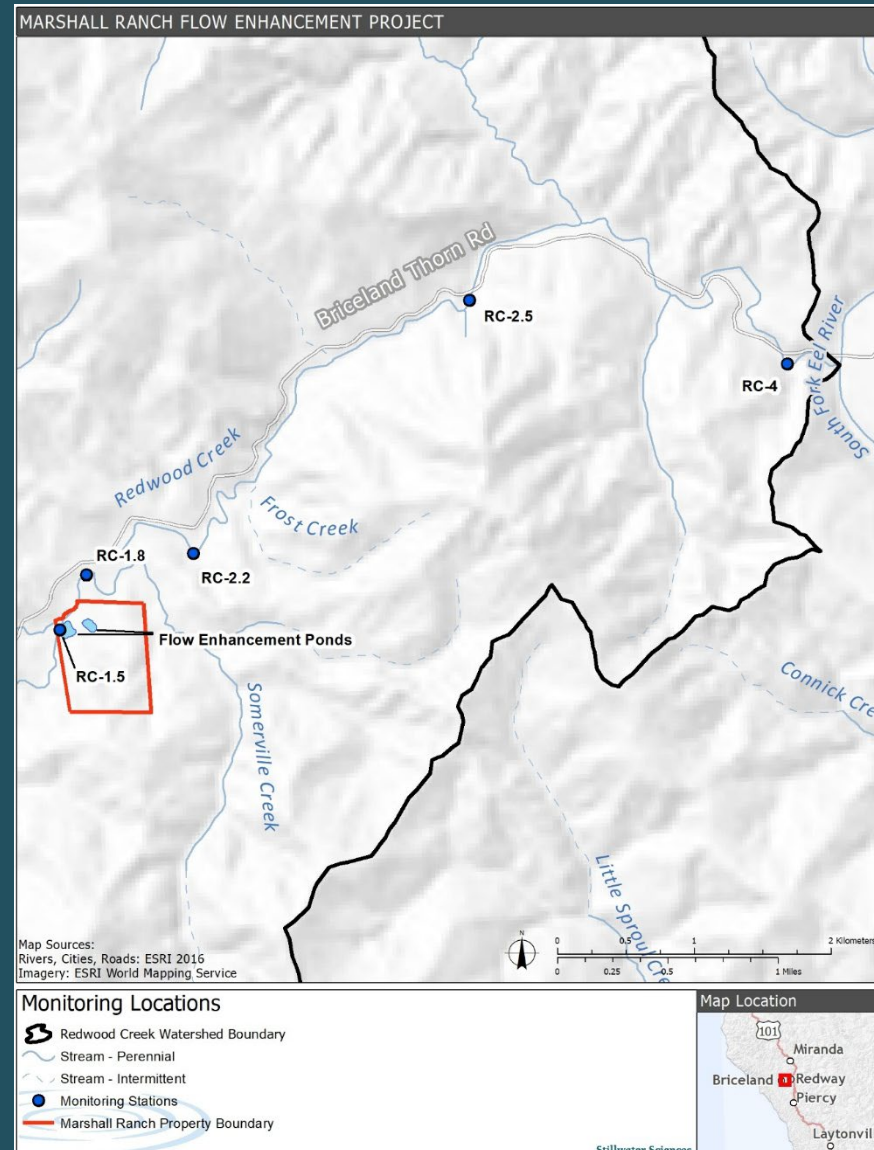


Watershed Monitoring – Temperature and DO

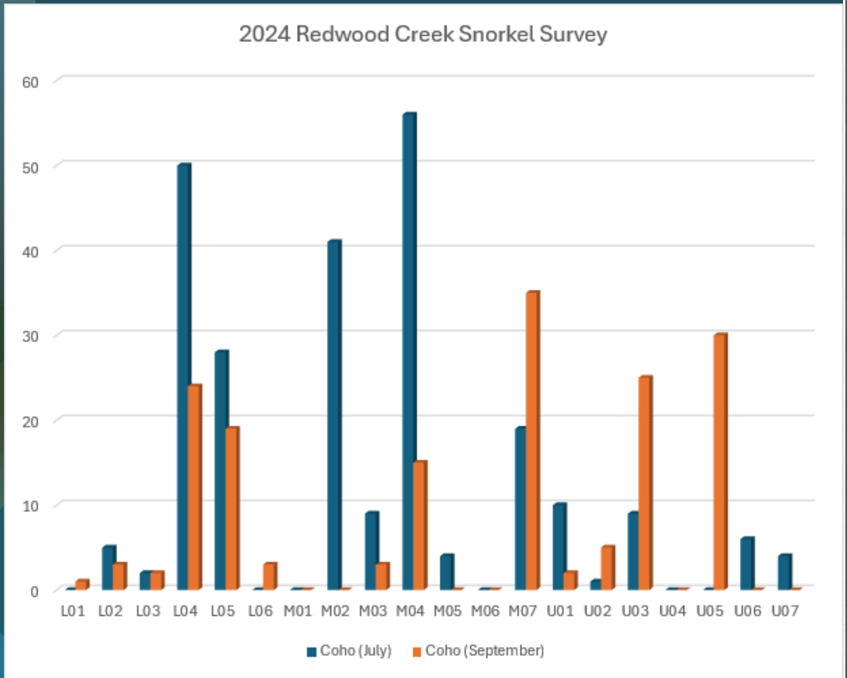


Downstream water temperature (above) and DO (below) consistent with project site monitoring.



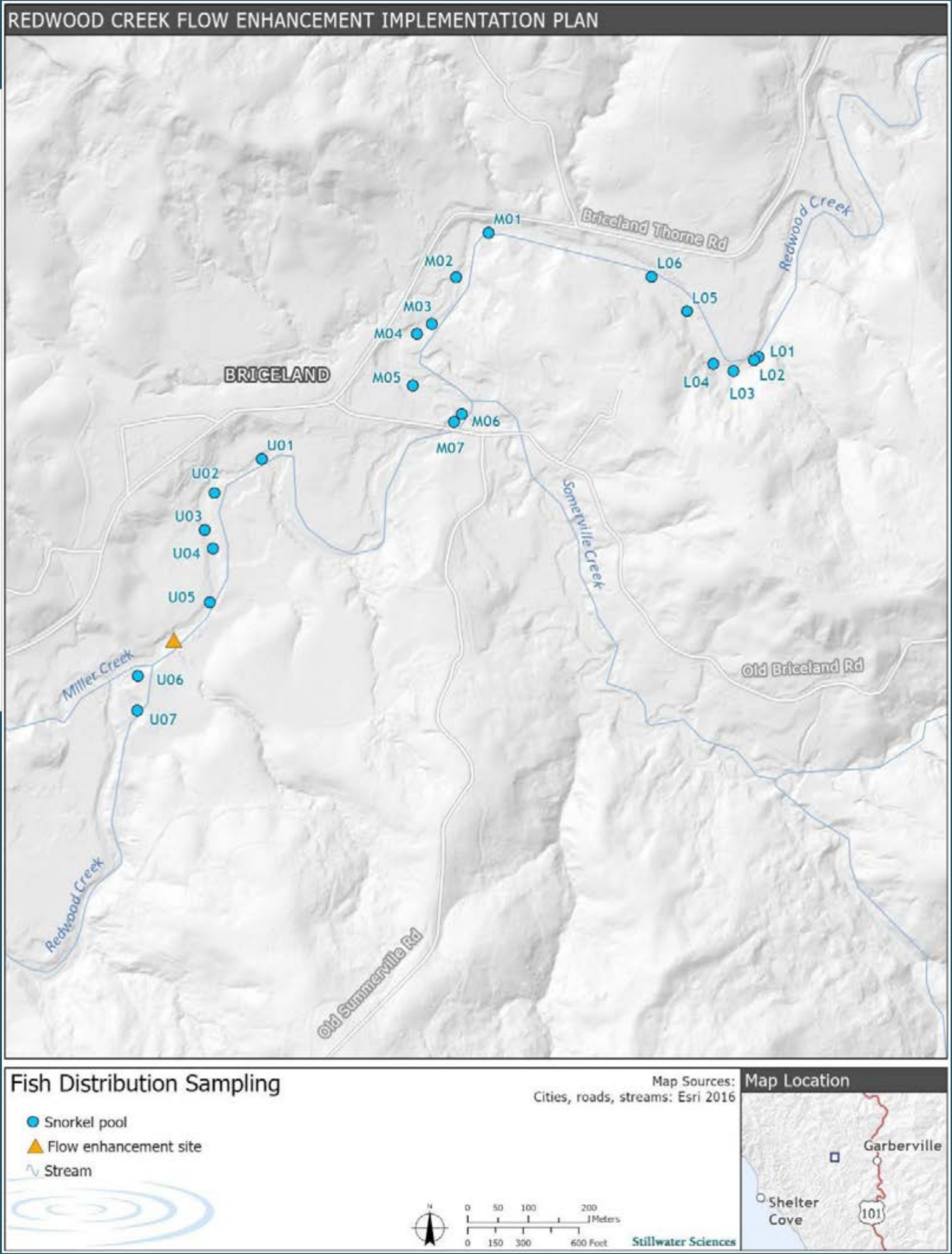


2024 Fish snorkel surveys



Comparison of July and September snorkel survey provides overall positive results:

1. No coho in disconnected pools upstream of augmentation in September (Pools U06, U07)
2. Coho moved into pools downstream from site between July and September (Pools U02, U03, U05)
3. Reasonable survival through the rest of the study reach



Summary & Lessons Learned

- Project successfully achieving objectives during first year of flow augmentation
- Coupling flow augmentation with hyporheic exchange provides significant temperature benefit, although variable over time
- Challenge of balancing water temperature and DO conditions to optimize habitat – higher flow release rates increases DO (good for coho) but can also increase water temperature (bad for coho)

Next Steps:

- System upgrades to improve operations May/June 2025
- Flow augmentation releases starting in July
- 2025 monitoring plans:
    - Standard temp, DO, and discharge
    - More detailed fish abundance surveys
    - Funded by final WCB grant funding and Stillwater Sciences strategic science initiative
- 2026 additional monitoring:
    - Tracer dye studies for cooling/filtration gallery
    - Fish growth/movement analysis

Oct 24, 2024 Upstream (left) and down-stream (right

Long Term Operations from Ranch Management Perspective

- Liability, regulatory hurdles, and post-construction long-term operations are major concerns for landowner
- Project made possible by grant from local private foundation funding long-term operations and management
- Use of the cooling/filtration gallery significantly simplifies long-term operations because it provides water quality buffer

Marshall Ranch's Vision:

Multi-generational stewardship to protect and enhance ancestral lands in collaboration with good faith conservation partners

Questions?

Support provided by:

Salmonid Restoration Federation

WCB
State of California
Wildlife Conservation Board

THE MARSHALL RANCH

TOM HICKS ATTORNEY AT LAW

TROUT UNLIMITED

NOAA FISHERIES

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

CALIFORNIA Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Coastal Conservancy

Setting Protective Flows for Diversions to Enhance Dry-Season Baseflows in Scott River

Salmonid Restoration Federation – 42nd Annual Salmonid Restoration Conference
Santa Cruz, CA

May 2, 2025

Eric Ginney
Jason Wiener, PhD
Environmental Science Associates

Acknowledgments

- Co-Author – Dr. Jason Wiener
- California Department of Water Resources
- Scott Valley Irrigation District
- Larry Walker & Associates

Before non-indigenous settlers, the Scott Valley was inhabited by Native Americans known as the Iruaitsu, a band of the Shasta Indian Nation Tribe, for millennia (Kroeber, 1976).

These lands are also territories of the Modoc and Confederated Tribe of the Siletz.

Overview

- Scott River (CA)
  - Fish & Limiting Factors to Recovery
- Flood-Managed Aquifer Recharge (Flood-MAR or FMAR)
  - What is it and what are the challenges?
  - Scott Valley Irrigation District FMAR Project
- Ecohydrologic Assessment (60 pages…~20 minutes…)
  - Two methods
  - Results
- 2024 Recharge Results
- Recommendations for a Methodology to Set FMAR Diversion Criteria

Bottom Line, Up Front (BLUF)

- **Planning-level models/hydrologic statistics are not suitable as Diversion Criteria for FMAR projects.**
- **Ecohydraulic modeling and/or bioverification are protective tools that can us optimize diversions for recharge.**
- **Ongoing: Applying the CEFF (lexicon; some code) and these tools may form a new methodology.**

Scott River (CA)

- Key Klamath River tributary
- No major dams
- Critical Habitat for:
  - Chinook salmon (ESA Candidate spp.)
  - Southern Oregon Northern California Coast (SONCC) ESU Coho salmon (ESA threatened)
  - Steelhead

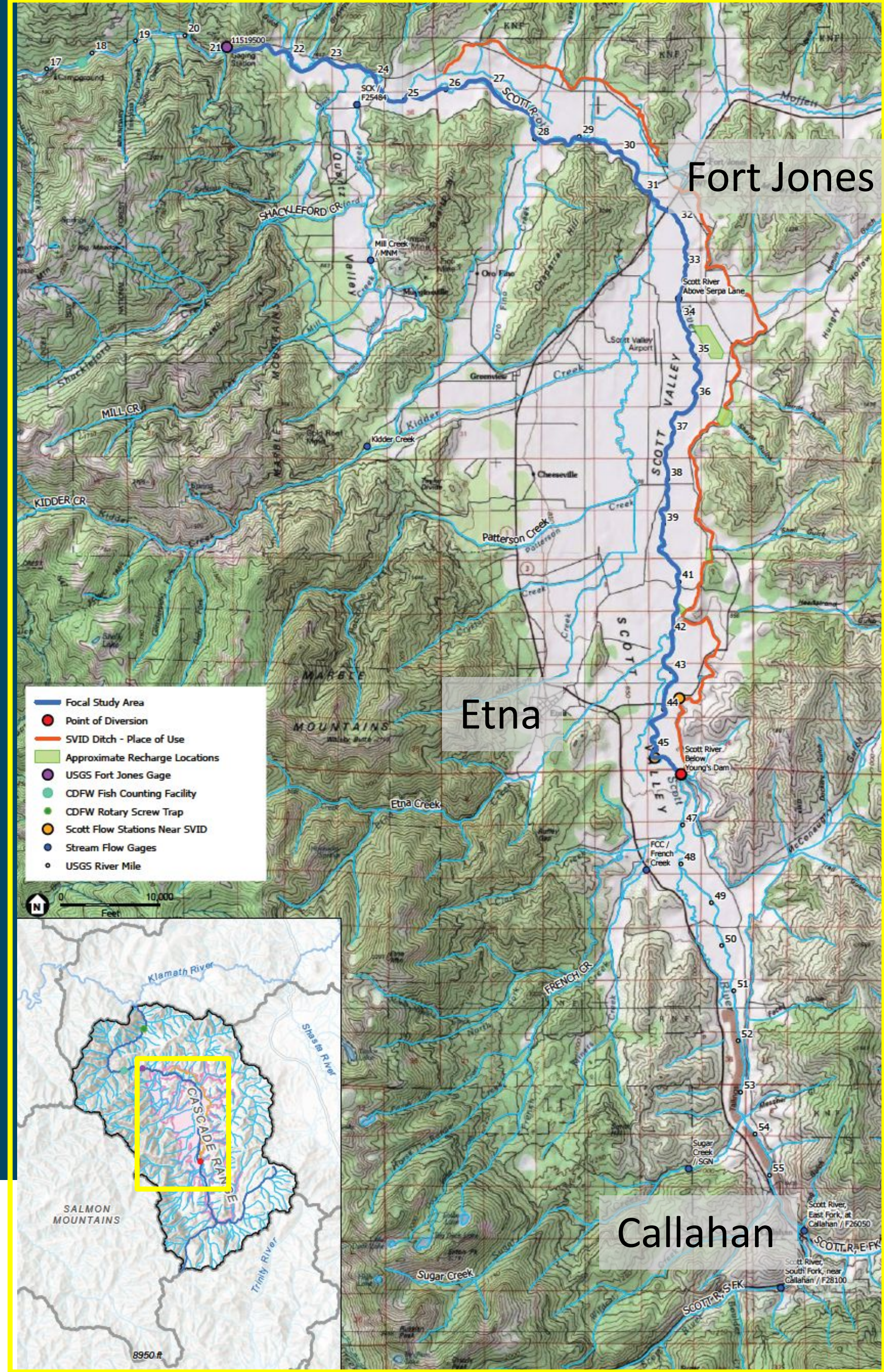
Scott River (CA)

- Anomalous valley morphology (Scott Valley)
- Important watershed for Coho salmon

Scott Valley

- ~30 miles of river in the valley
- Channels and floodplains = simplified and drained
- Mostly in pasture and alfalfa
- SVID canal in orange
- USGS Fort Jones gage in purple

study area



Scott River - the Past (Beaver Valley)

- Initially named "Beaver Valley" by EuroAmericans because of the abundant presence of beavers (Guddle and Bright, 2004).

- High groundwater; ample streamflow; good Coho salmon habitat.

- In the 1830s, fur trappers initiated the near eradication of *Castor canadensis—marking the beginning of the decline of the river ecosystem.*

Scott River in Scott Valley Today

Cumulative impacts:

- beaver removal
- mining
- flood control
- channel straightening
- timber harvest
- surface water diversion for agriculture
- increased groundwater pumping
- decreasing winter snowpack

= Salmonid habitat degraded & in-stream and floodplain ecosystem functions critically threatened

Scott River in Scott Valley Today

- Simplified and incised channel
- Floodplain disconnected from channel and converted to agriculture
- Degraded groundwater levels

Scott River in Scott Valley Today

- Low late summer / autumn flows can limit:
  - upstream migration of Chinook and Coho salmon for spawning
  - out-migration success of juveniles (low flows and/or high temperatures)

Theoretically, higher flows are necessary to support these species.

Yes…low flows are bad for juvenile Coho

Final SONCC Coho Recovery Plan - 2014

36.5 Stresses

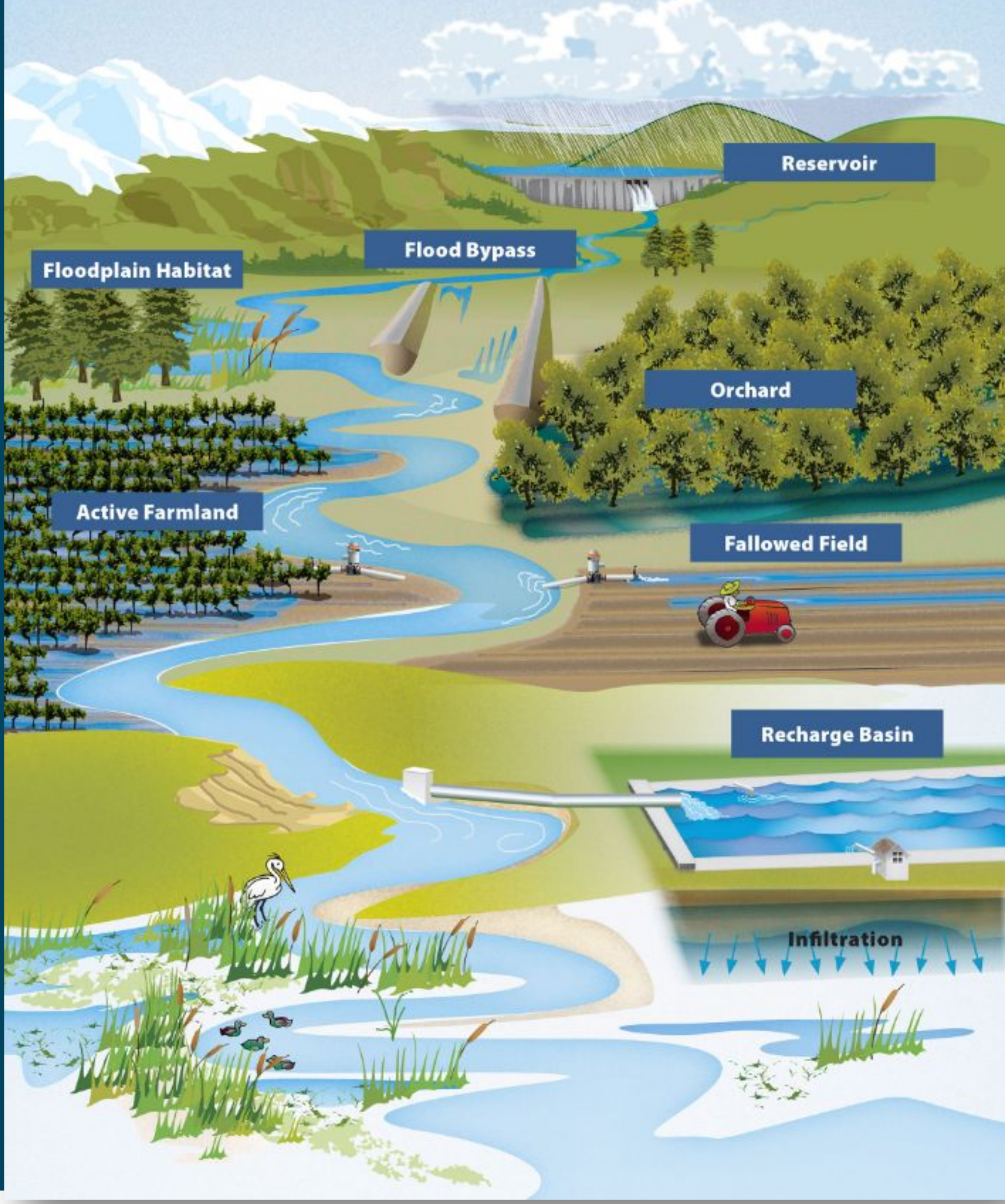
Table 36-4. Severity of stresses affecting each life stage of coho salmon in the Scott River. Stress rank categories, assessment methods, and data used to assess stresses are described in Appendix B.

	Stresses	Egg	Fry	Juvenile[1]	Smolt	Adult	Overall Stress Rank
1	Altered Hydrologic Function[1]	High	Very High	Very High[1]	Very High	Medium	Very High
2	Degraded Riparian Forest Conditions[1]	-	Very High	Very High[1]	Very High	Medium	Very High
3	Impaired Water Quality	Very High	High	High	High	Very High	Very High
4	Impaired Estuary/Mainstem Function	-	Low	High	High	Low	High
5	Lack of Floodplain and Channel Structure	Medium	High	Very High	High	High	Very High
6	Altered Sediment Supply	Very High	Very High	Medium	Medium	High	Very High
7	Adverse Hatchery-Related Effects	Medium	Medium	Medium	Medium	Medium	Medium
8	Increased Disease/Predation/Competition	Low	Medium	High	High	Medium	High
9	Barriers	-	Low	High	Low	Low	Low
10	Adverse Fishery- and Collection-Related Effects	-	-	Low	Low	Medium	Low

[1] Key limiting stresses and limited life stage.

What is Flood-MAR?

Diverting and spreading high flood flows onto agricultural land, working landscapes, and managed natural areas to recharge aquifers, sustain riverine and groundwater-dependent ecosystems, and achieve other wide ranging benefits.



And for salmonids, what are we really trying to do?

- Increase GW levels to increase river base flows and support the groundwater dependent riparian ecosystem.
- Provide an anthropogenic means of groundwater recharge that is a surrogate for “natural” overbank flooding (floodplain inundation).
- Buy time until process-based restoration activities can increase floodplain connectivity and increase the duration of floodplain inundation.
- Get a jump-start on increasing GW levels to bolster future river-focused actions that will negate or decrease the need for Flood-MAR.

So…What's so difficult about all of this?

- *We are diverting water from a river.*

- Most regulatory thinking and experience for diversions is for summer/irrigation season diversions (a time of scarcity).

- SWRCB default guidance (90/20 predetermined threshold) is to "protect critical ecosystem functions associated with high flows by applying a conservative cap on the amount of water that can be diverted." <u>And, it's too conservative.</u>

- To divert, flow must be above the 90% exceedance level for that day and no more than 20% of flow can be diverted.
  - 90/20 is from Richter et al (2011) and isn't specific to CA or our rivers.
  - Most diversion facilities cannot take 20% of the 90% exceedance during winter!

- Collective understanding of flow in relation to key habitat variables and geomorphic processes can get muddled (at best).

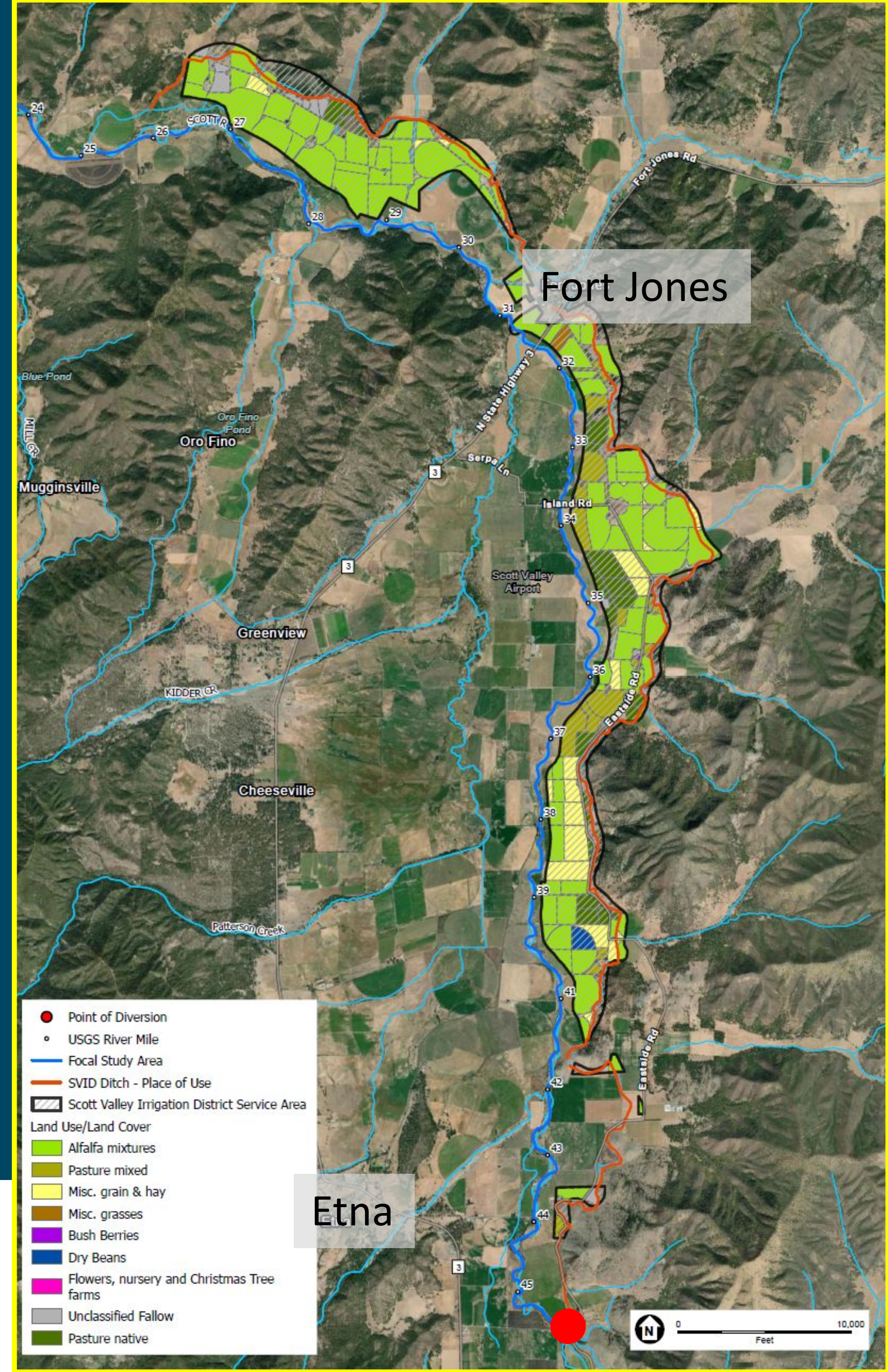
Scott Valley Irrigation District (SVID) FMAR Project

- First permitted FMAR project in CA (2016); annual 'pilot' projects
- Point of Diversion (POD) is Young's Dam (laddered and screened)
- Annual permit to divert up to 5,400 acre-feet (af), maximum
- Diversion rate = 30 cubic feet per second (cfs);
- January 1 to March 31
- *Flow conditions under which diversion may occur were the focus of our study*

study area

SVID FMAR Project

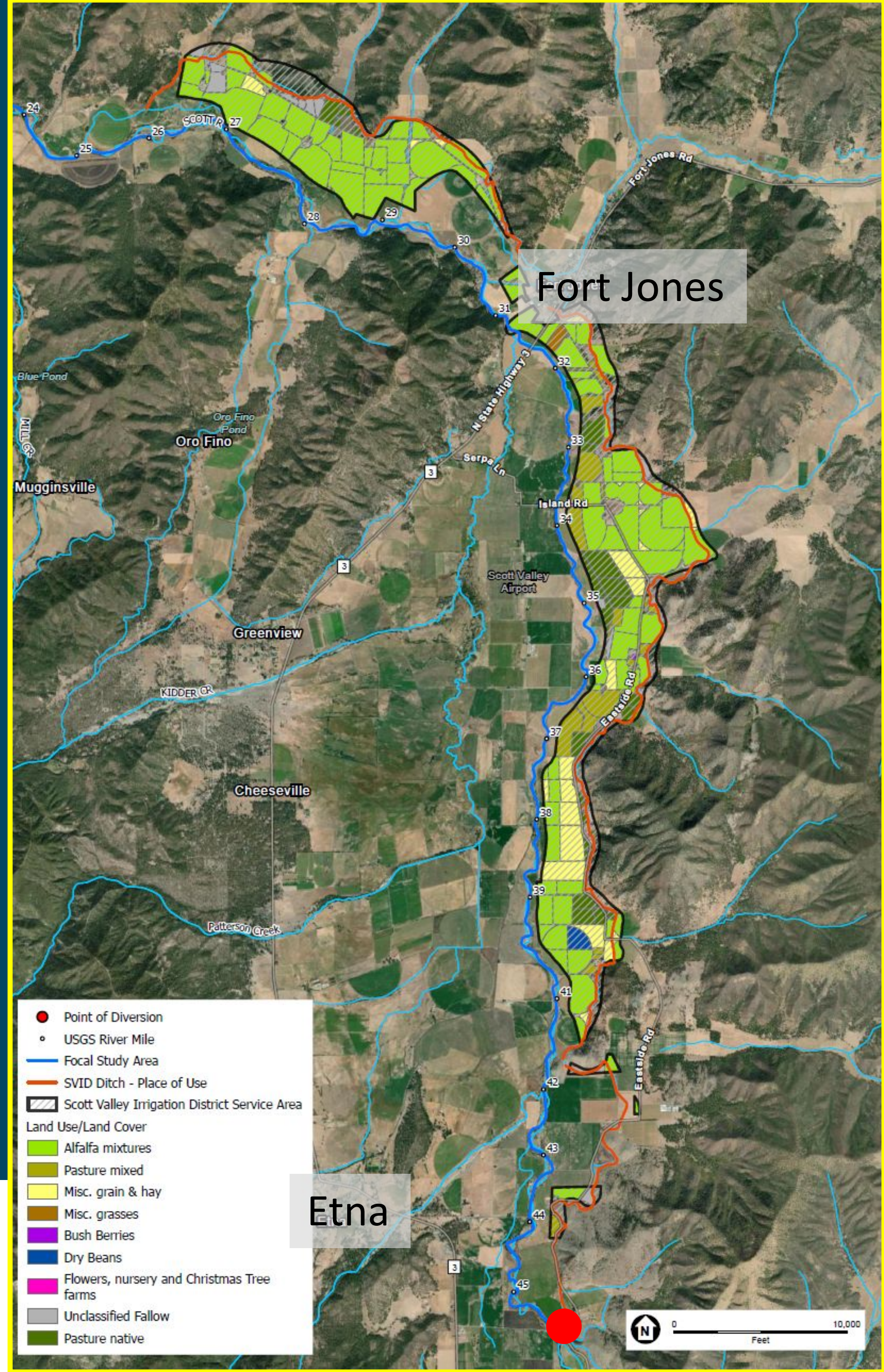
- POD at RM 46.7
- 13.2-mile canal system for diverting and conveying water to its service area.
- The unlined earthen canal system and 1,400 acres of dormant agricultural fields (mostly in pasture and alfalfa) as potential infiltration areas.



study area

SVID FMAR Project

- **Project to date wasn't using 90/20 for diversion criteria.**
- Instead, the permitted minimum flow threshold for diversion is keyed to existing winter water rights (USFS – 440cfs for instream beneficial use).



Habitat Benefits

Scott Valley Integrated Hydrologic Model (SVIHM) and water budget estimates that:

--most of the recharged water returns to the river for habitat enhancement during the first spring and summer

--remainder reaching the river in the autumn and into the following years.

New Information Available

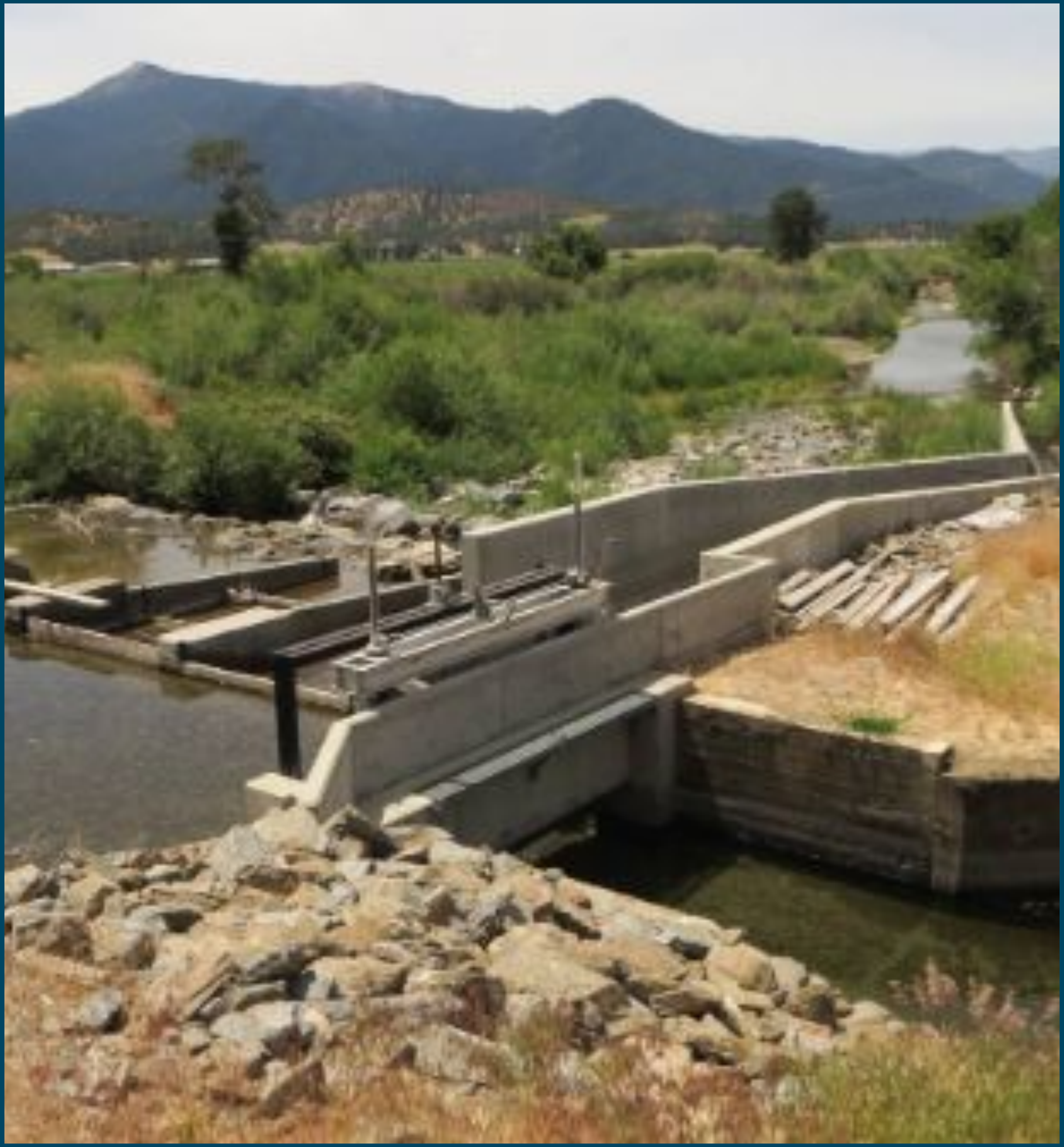
CDFW report (2017*) suggests maintaining 362 cfs in the Scott River between January 1 and March 31 is protective of coho salmon life stage requirements.

Interim Instream Flow Criteria for the Protection of Fishery Resources in the Scott River Watershed, Siskiyou County. Prepared by California Department of Fish and Wildlife, February 6, 2017

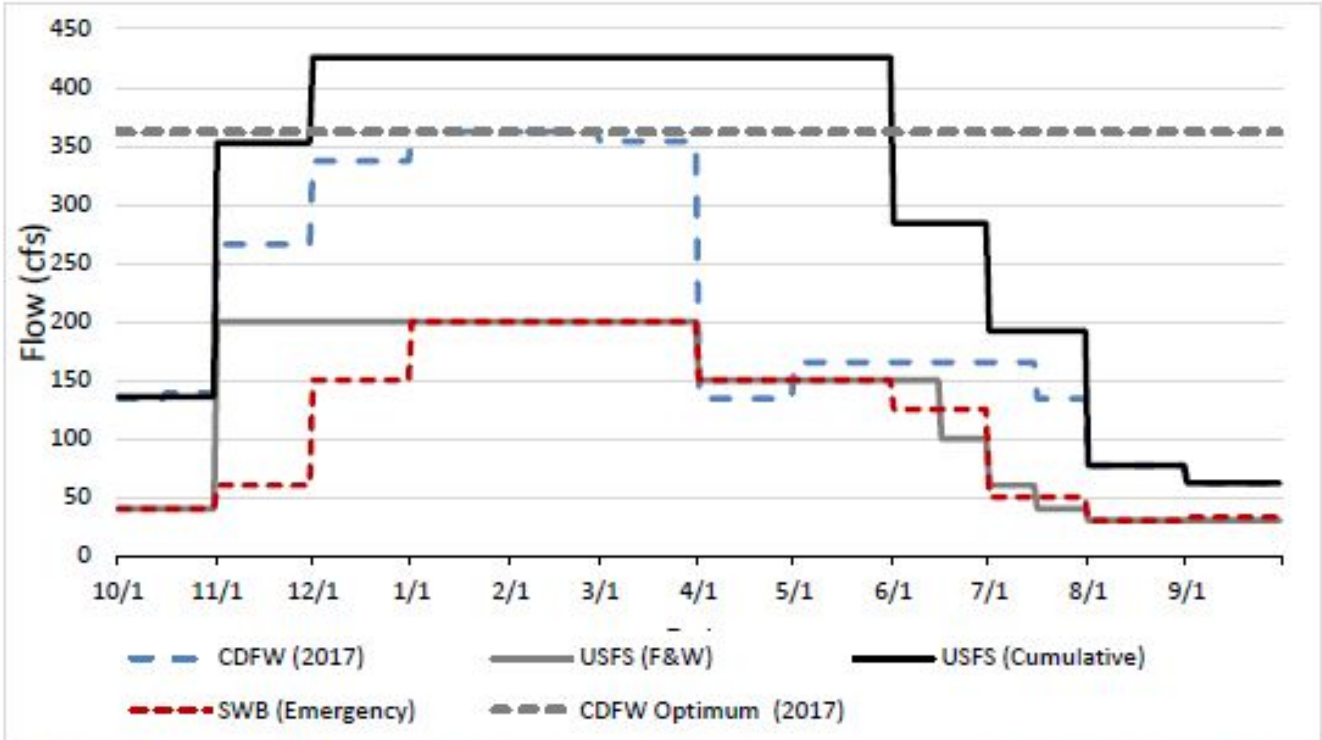
New Information Available

ESA (2024) water availability analysis found a substantial recharge benefit to reducing the diversion threshold from 440 cfs to 362 cfs.

- But, btw…going lower than ~230 cfs yields no additional recharge benefits.



SVID proposal: lower the diversion initiation threshold from 440 cfs to 362 cfs at Fort Jones (*even though still not maximizing recharge*).



NOTE: U.S. Forest Service (USFS) flow requirements are from the Scott River Adjudication Decree (State Water Resources Control Board 1980) and include those flows allocated for fish and wildlife ("USFS [F&W]") and the total USFS allocation flows ("USFS [Cumulative]"). "SWB (Emergency)" flows are those established by the Scott and Shasta River Watersheds Drought Emergency Requirements (State Water Resources Control Board 2024). The CDFW Optimum (2017) is the theoretical optimal flow for steelhead spawning in the Scott River based on the statistical model of Hatfield and Bruce (2000).

Figure 1.
Annual hydrograph of compiled monthly instream flow requirements and recommendations as measured at the Fort Jones gage.

Our Charge

Provide material support to justify a reduction of the flow threshold (under which diversion can occur) -
from: 440 cfs
- to: 362 cfs

CDFW Analysis (362 cfs)

A theoretical (empirical) *optimal* flow based on the statistical model of Hatfield and Bruce (2000).

Intended for planning and research purposes.

Not intended for prescriptive use without validation

e.g., through ecohydraulic modeling and/or bioverification (Wheaton et al. 2004; Brown and Pasternack 2008; Kammel et al. 2016; Moniz et al. 2019), which is currently lacking for the Scott River.

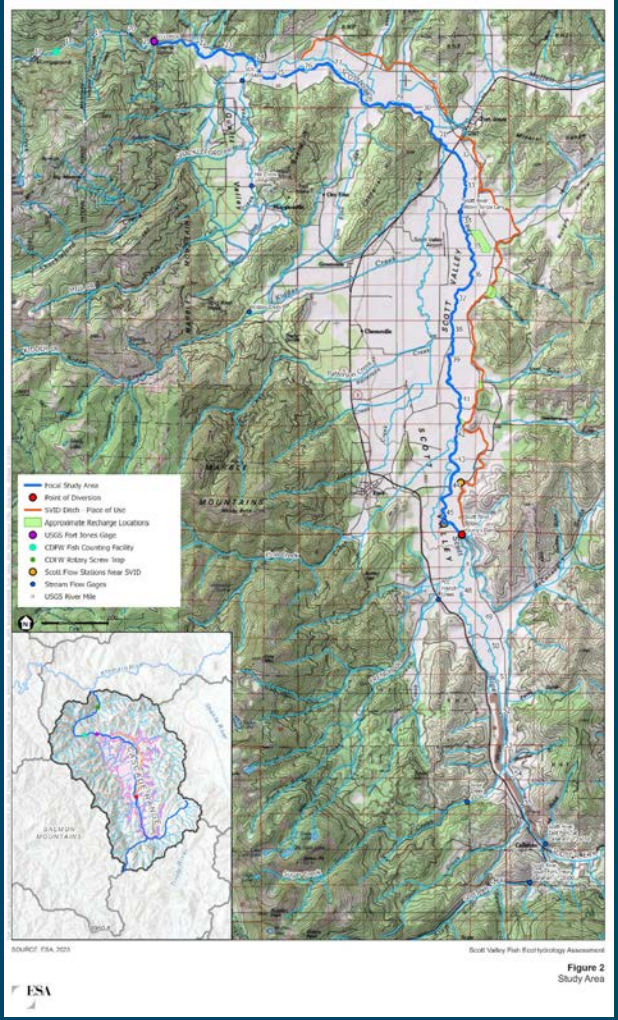
CDFW Analysis (362 cfs)

Does not consider:
- bioenergetics, or
- site-specific hydraulics influencing the ecological functions performed by salmon and steelhead (e.g., upstream migration).

Calculated for the most limiting species (steelhead) and life stage; <u>not a minimum-flow criterion</u>.

Our Analysis: EcoHydrology Assessment

- *Spatial focus*:
  - Portion of Scott River between Young's Dam and the Fort Jones Gage (RM 46.7 to RM 21).
- *Fish Species of Primary Interest:*
  - Chinook salmon, coho salmon, and steelhead trout.
  - Based on analytical approach and spatial and temporal focus, life stage most relevant to study was <u>adult migration</u>

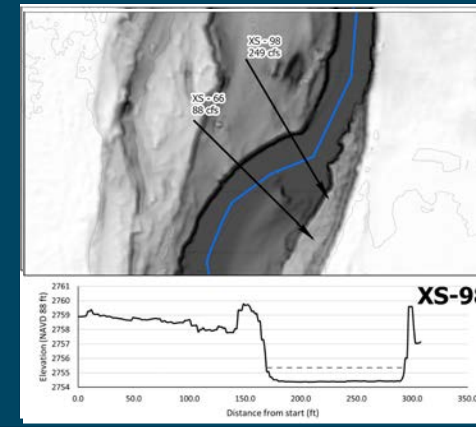


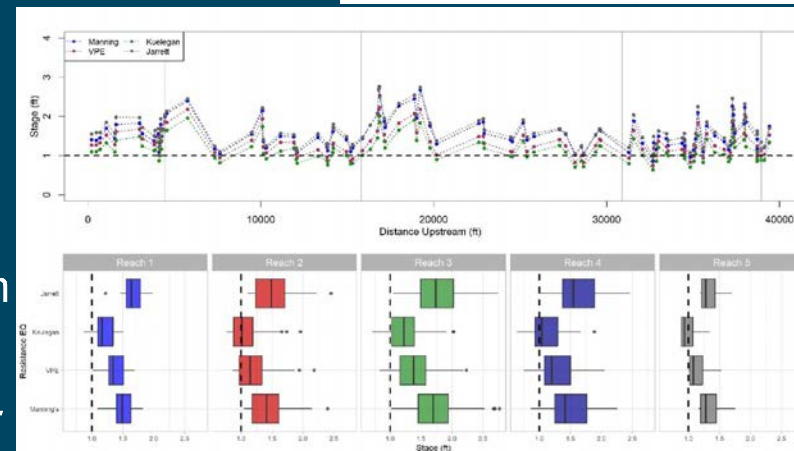
EcoHydrology Assessment

Two-pronged Analytical Approach

1 - A physically based hydraulics approach:

- Identify low-flow conditions that provide passage for anadromous salmonids.
- Based on CDFW critical riffle analysis procedures.
- LiDAR basis; multiple resistance equations; 1-foot conservative passage depth; accounts for decreasing flow accretion with distance upstream





2 - A data-driven biological observation approach:

- Coupled decades of biological observation data (escapement monitoring; video; spawner surveys) with flow data to document and provide inferences into flow conditions that enable adult salmonids to migrate and spawn in various portions of the Scott Valley.

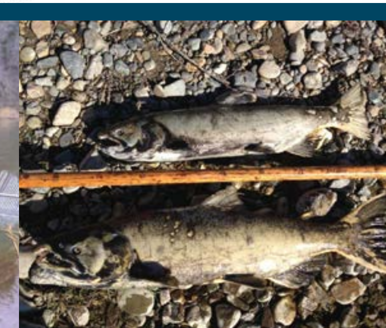


Photo credits: CDFW and Lindsay Magranet

EcoHydrology Assessment - Results

- *Fish Passage Assessment:*
  - **Flows even lower than 362 cfs provide nearly unimpeded passage** for adult and juvenile salmonids along the Scott River from RM 21.5 to just upstream of Young's Dam (RM 46.5).
- *Coupled Observation Assessment:*
  - **Flows at Fort Jones between 100 and 200 cfs consistently enabled Coho salmon to migrate** through the Scott River Canyon, through the valley, and into most west-side tributaries (e.g., 2001, 2002, 2004, 2005, 2008, 2009, 2011, 2012, 2013, and 2019)

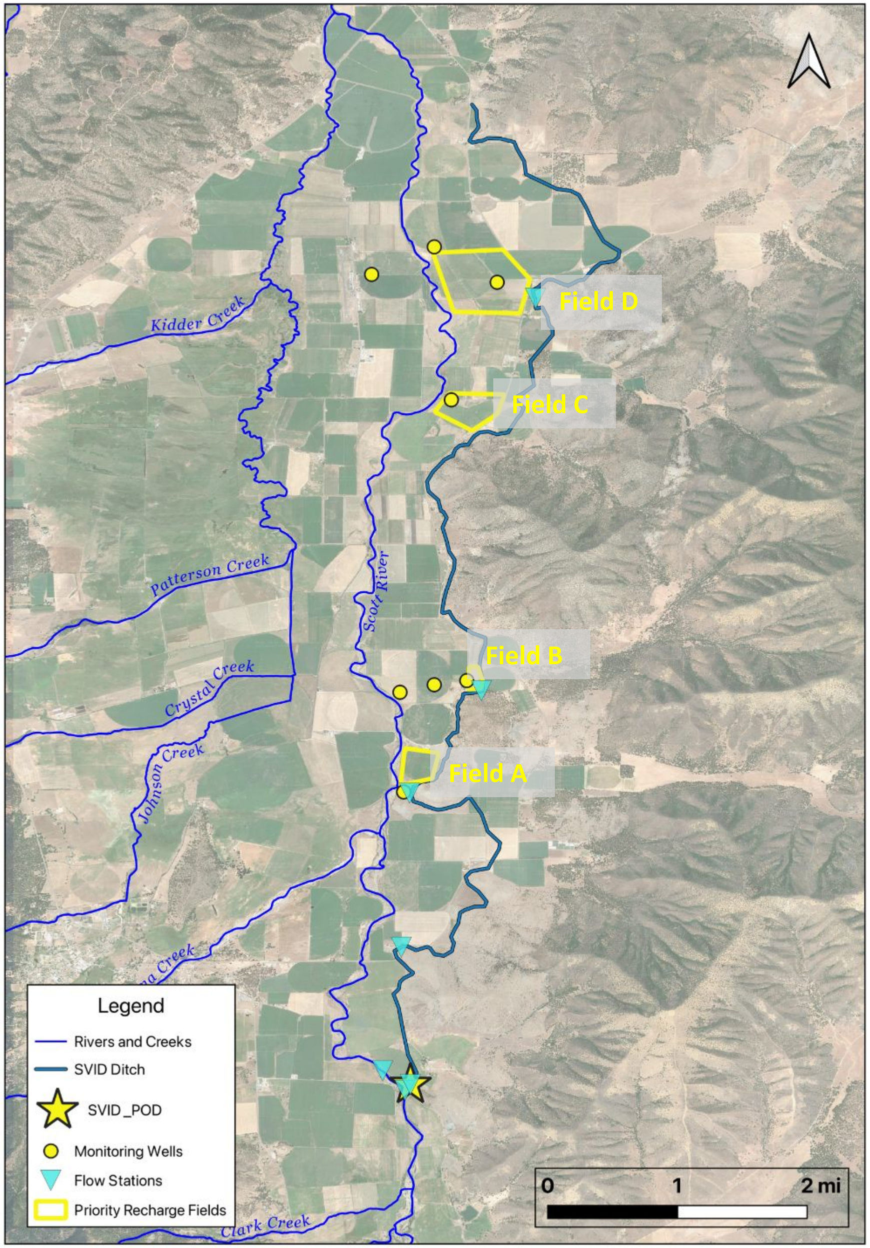
Photo credit Sari Sommarstrom

2024 Recharge

- Total of **2,783 AF** diverted from Young's Dam
- 10 different locations used in SVID service area to apply water (Fields A through J)
- Total area ~ 260 acres

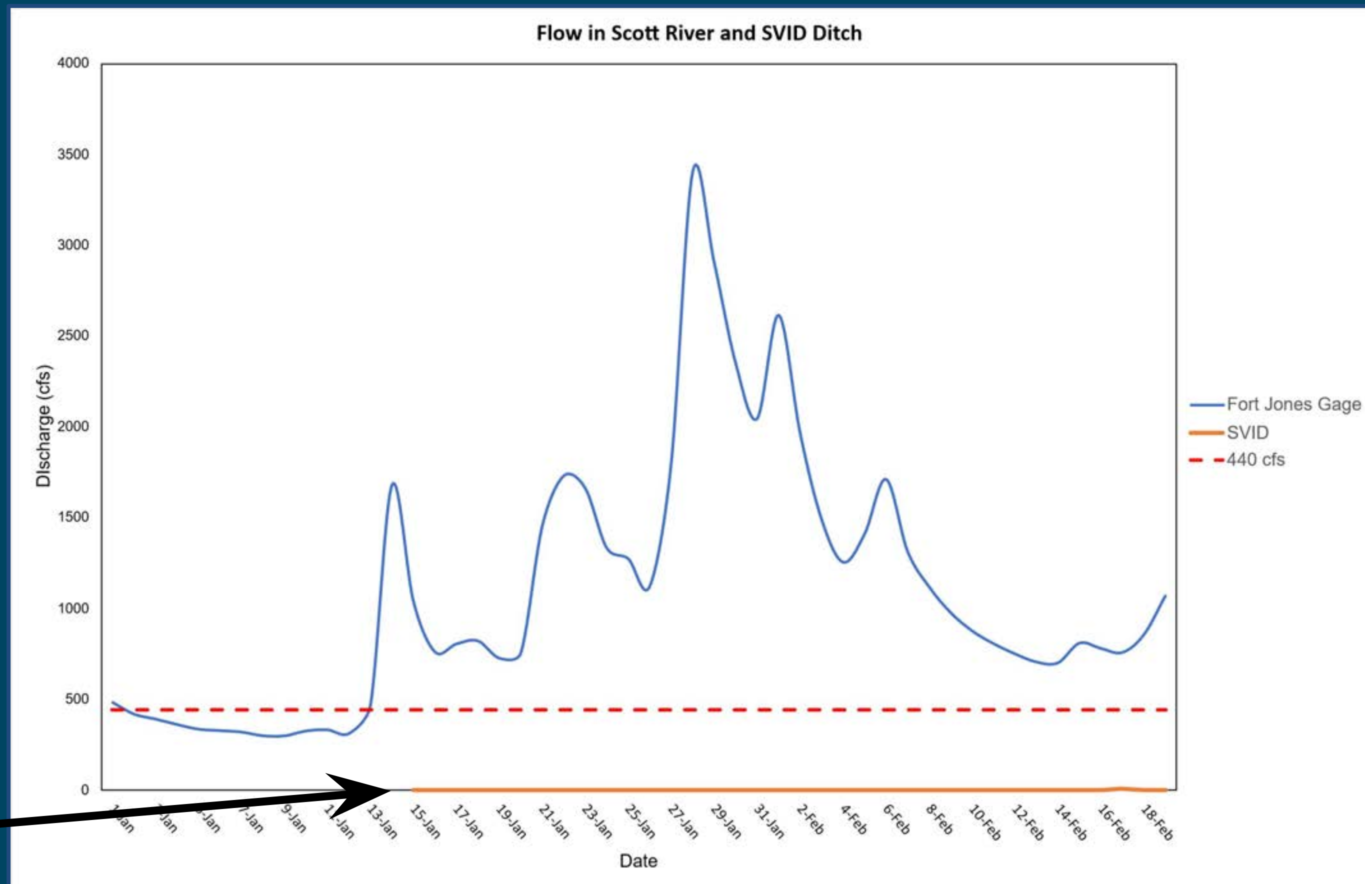
2024 Monitoring

- 8 Groundwater wells in recharge project area
- Temperature sensors
- **2** Flow stations in Scott River
- **5** Flow stations along the ditch
- Biological Monitoring (throughout recharge period)



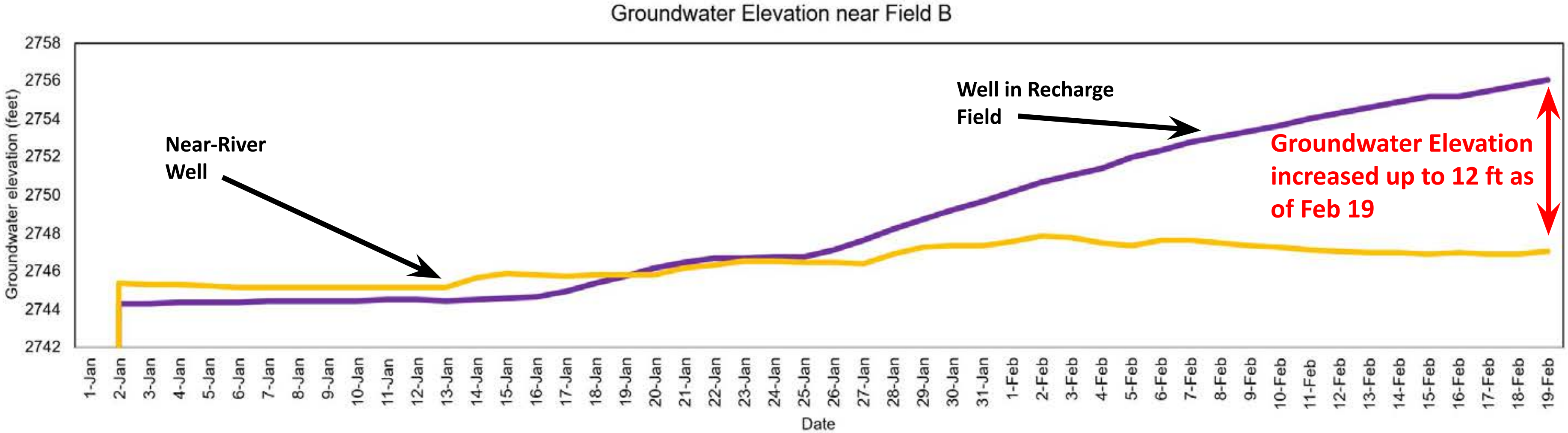
2024 Flow Monitoring

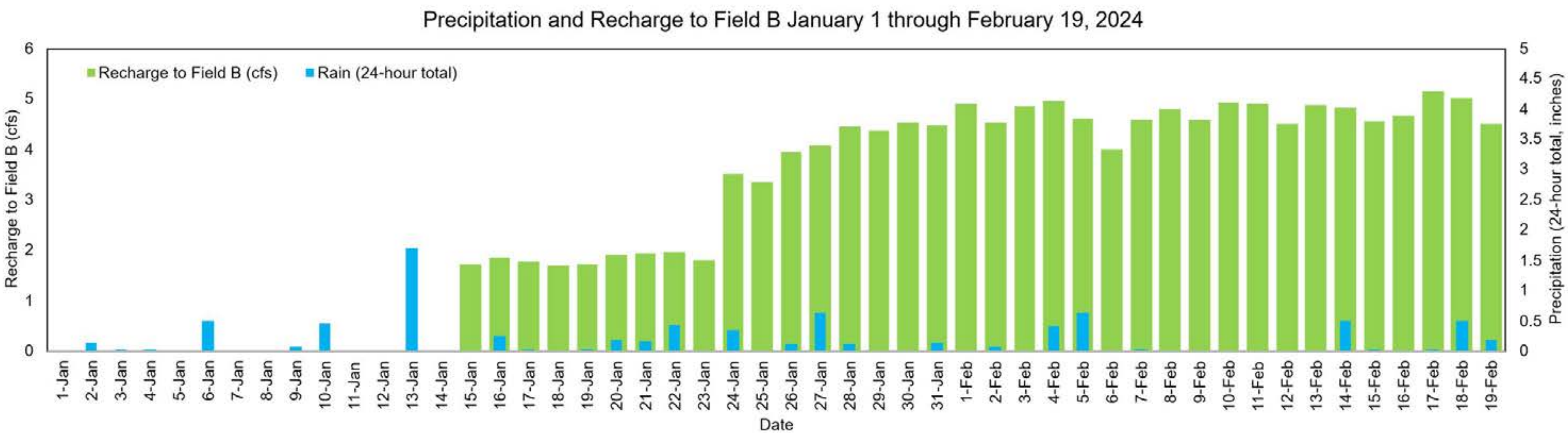
Flow diverted to SVID ditch at the point of diversion (POD), Young's Dam is a fraction of flow measured at the Fort Jones USGS gage.



Diversion started January 15, 2024

2024 – Example: Recharge in Field B

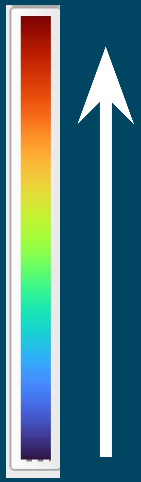




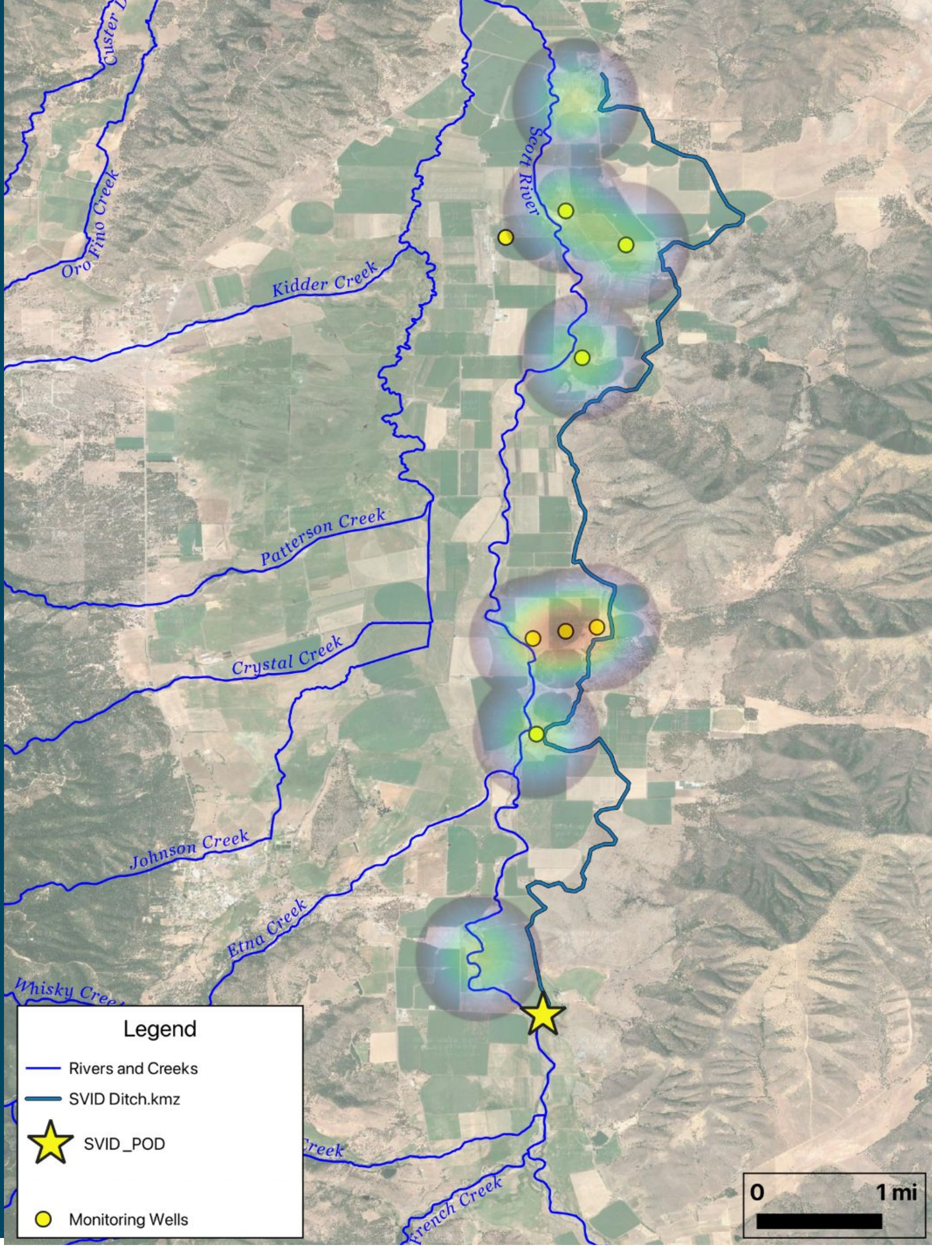
2024 Recharge Results

- Modeled change in groundwater elevation from **January 1st to February 19th**
- All wells showed an increase in groundwater elevation
- Elevation increased from **1.26 ft to 12 ft** as of February 19th

Greater increase in groundwater elevation



Less increase in groundwater elevation



Recommendations

- Develop a new method for setting diversion thresholds
- Don’t assume that statistical hydrologic approaches will optimize for both species protection and maximizing recharge
- Focus on ecohydraulic conditions and/or bioverification
- Leverage existing methods, tools, frameworks (e.g. CEFF)

Recommendations

- Consider the application: Facilitate diversion simulation and optimization modeling
- Scope the method in a collaborative with regulatory agencies.
- Focus on key species and processes in the FMAR watershed & guide development of diversion criteria that are protective <u>and also maximize recharge opportunity</u> (because in the long-term, that can help recover flows!)

ESA

Preliminary Method

1. Identify key species and processes *(as locally and quantitatively as possible!)*
2. Model a series of post-diversion hydrologic scenarios.
3. Use the eFlows Functional Flows Calculator (FFC) to quantify relevant wet season functional flow metrics for pre- and post-diversion hydrologic scenarios.
4. Compare pre- and post-diversion wet season functional flow metrics to determine if functional flows are altered (CEFF Appendix J. *Assessing flow alteration).*
5. Compare expected annual diversion volumes and probability of zero diversion that result from diversion simulation models.
6. Identify thresholds in diversion criteria that result in the alteration of functional flows.
7. Explore Pareto optimal diversion criteria fronts based on multi-objectives of maximizing diversion volume and probability and minimizing alteration of functional flows.

Thank You

Male coho salmon found in the Scott River during 2001 spawning surveys.
Photo credit Sue Maurer

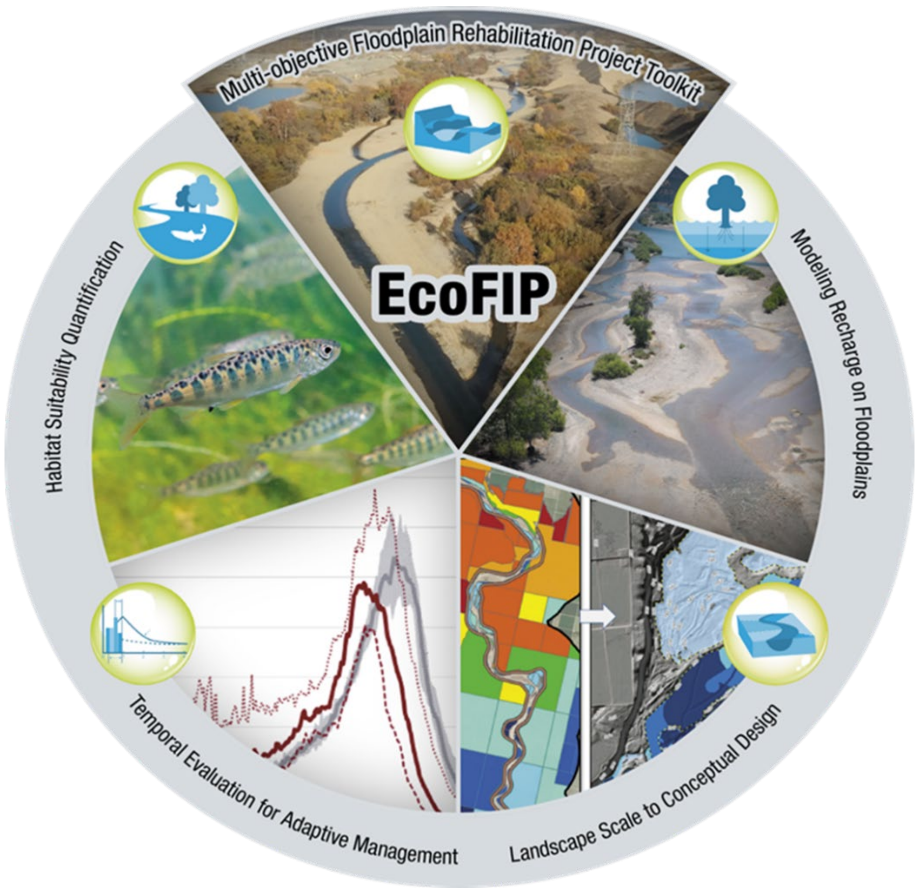
SRF 2025 | May 2, 2025

Ecological Floodplain Inundation Potential

A Toolbox for Assessing Multi -Benefit Floodplain Restoration Opportunities

Chris Hammersmark

and many many others at cbec …



Overview

Background (10 min)

- Rehabilitating Degraded Landscapes
- Example Projects
- The Planning Problem

The EcoFIP Methodology (10 min)

- Large-Scale Inundation Potential
- Benefit Quantification
- Conceptual Design

EcoFIP Applications, Questions (5 min)


San Joaquin River, Great Valley Grasslands State Park, CA (Photo: American Rivers)

Rehabilitating Degraded Landscapes

Humans & Rivers

- Confined, Dammed, Diverted
- Deforested, Mined
- Aging infrastructure, changing climate
- Disadvantaged communities

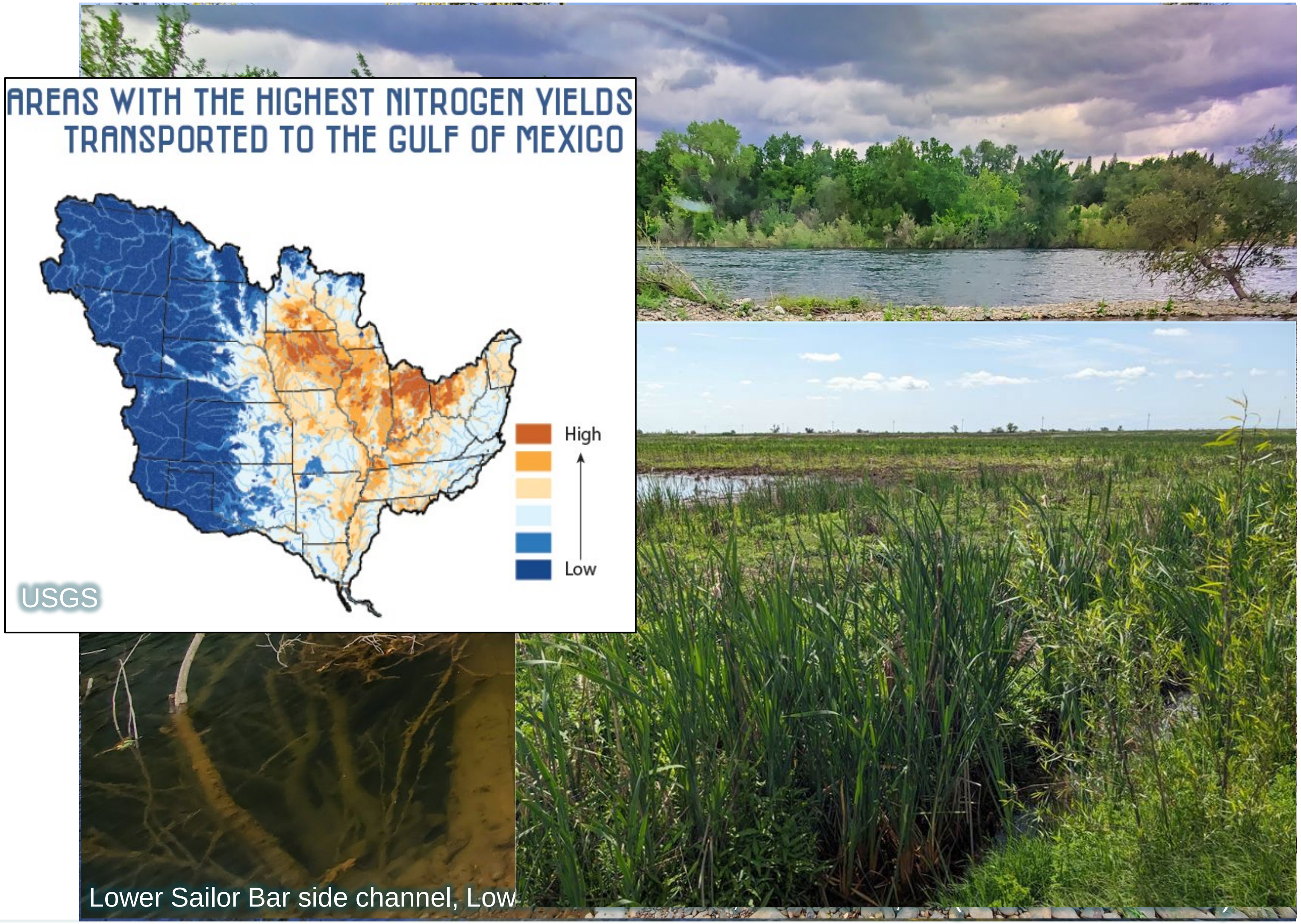
Sacramento – San Joaquin River Delta (Photo: NOAA)

Levee repair, CA, 2023 (Photo: SF Chronicle)

Rehabilitating Degraded Landscapes

Multi-Benefit Objectives & Solutions

- Habitat uplift
- Flood risk reduction
- Water storage, aquifer recharge
- Nutrient reduction



Rehabilitating Degraded Landscapes

Lower American & Yuba Rivers, CA

Salmonid Habitat Enhancement

- Excavate side channels, alcoves, floodplains to create rearing habitat
- Sort excavated gravel to build riffles for spawning salmonids

WATER FORUM

SYRCL SOUTH YUBA RIVER CITIZENS LEAGUE

YUBA WATER AGENCY

U.S. FISH & WILDLIFE SERVICE

TEICHERT

CRAMER FISH SCIENCES An Employee Owned Consulting Company

Nimbus Basin spawning riffle, Lower American River, Sacramento, CA (Photo: Erica Bishop, Sacramento Water Forum)

Rehabilitating Degraded Landscapes

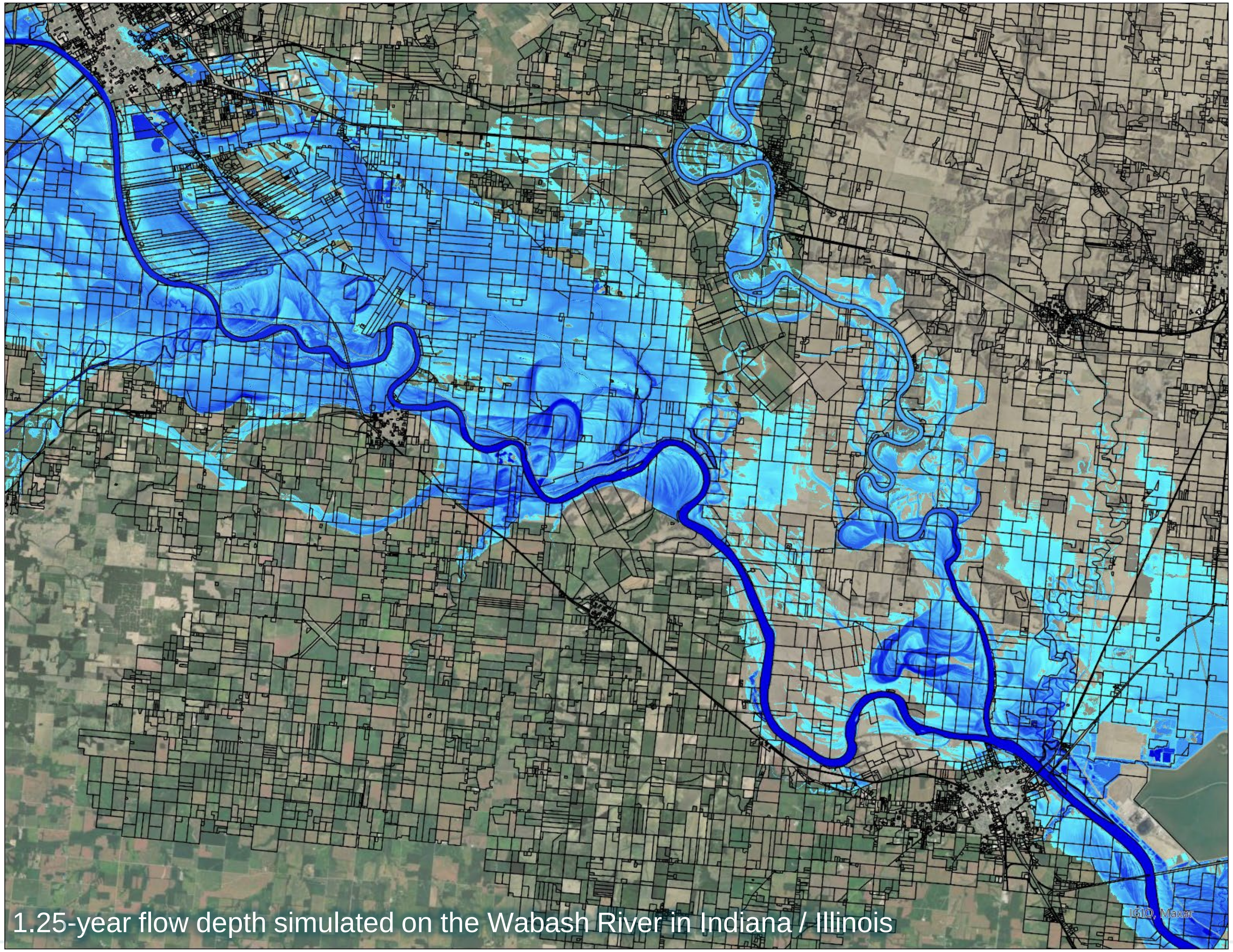
So many sites to choose from

- Optimizing multiple objectives
- Maximize uplift, minimize cost
- Many potential stakeholders
- Landowner willingness

The Planning Problem

Hydraulic Modeling

- Large-scale 1D models like HEC-RAS
- Simulate flows on the river to understand existing conditions
- Leveed, incised systems show little inundation with raw model outputs
- Difficult to identify areas that are dry now, but could potentially inundate with some grading
- Project in-channel water surface elevations through barriers, onto the floodplains, to make comparisons

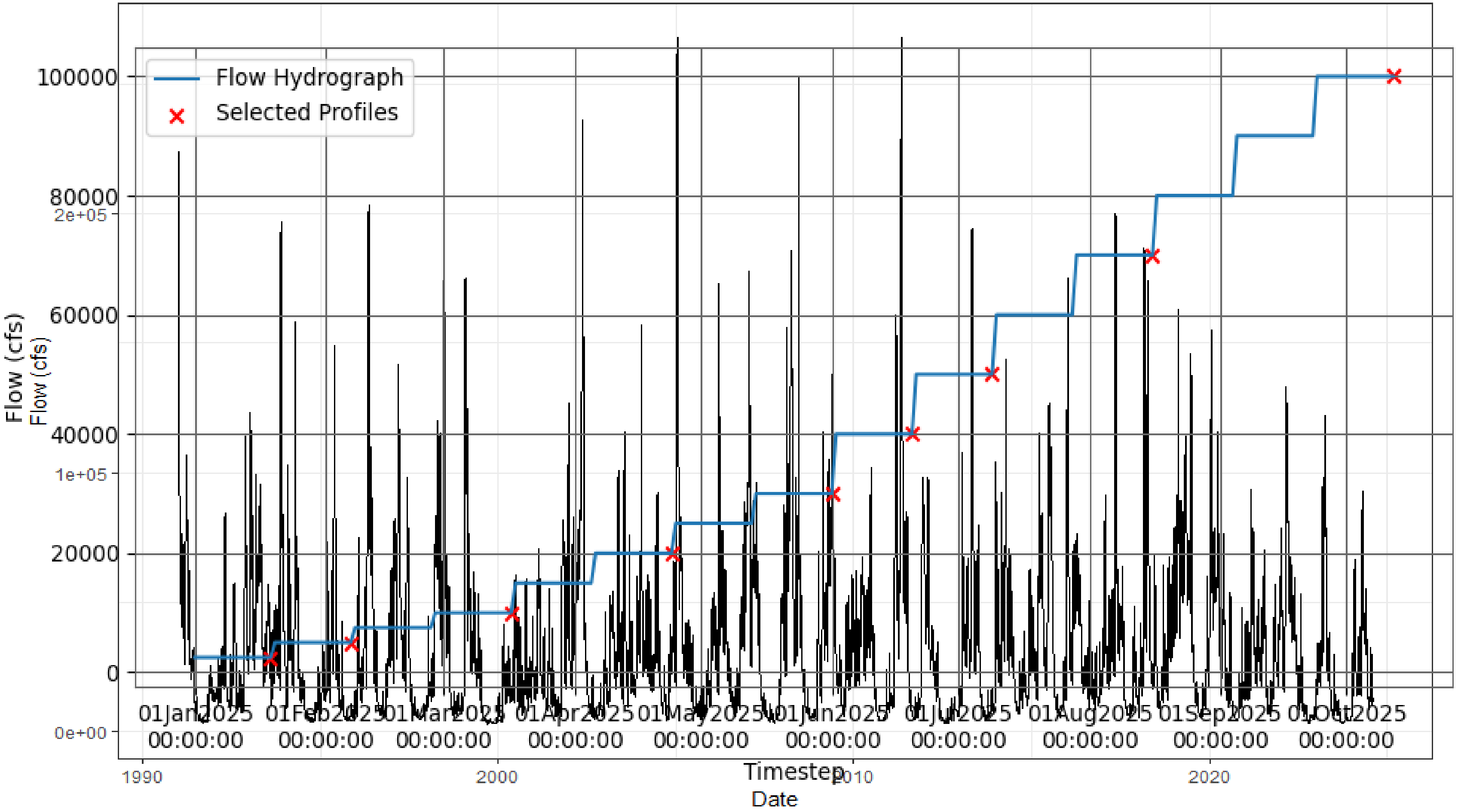


1.25-year flow depth simulated on the Wabash River in Indiana / Illinois

The Planning Problem

Hydraulic Modeling

- Would like to examine many water years, 30 years or further back in the hydrologic record
- Simulating such long time periods is restrictively time consuming due to computational limitations
- Use a single set of model results that cover a range of flows to estimate inundation over long periods



The EcoFIP Methodology

Tier 1:

Large-scale

inundation potential

Tier 2:

Multi-objective

Site Identification and Prioritization

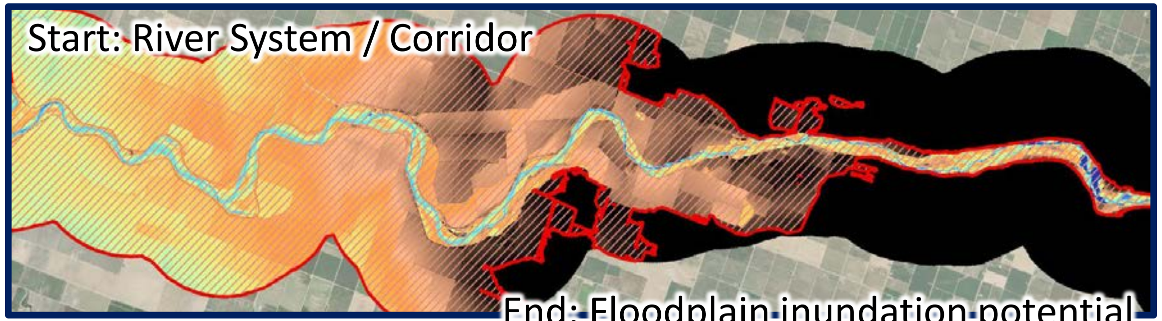
Tier 3:

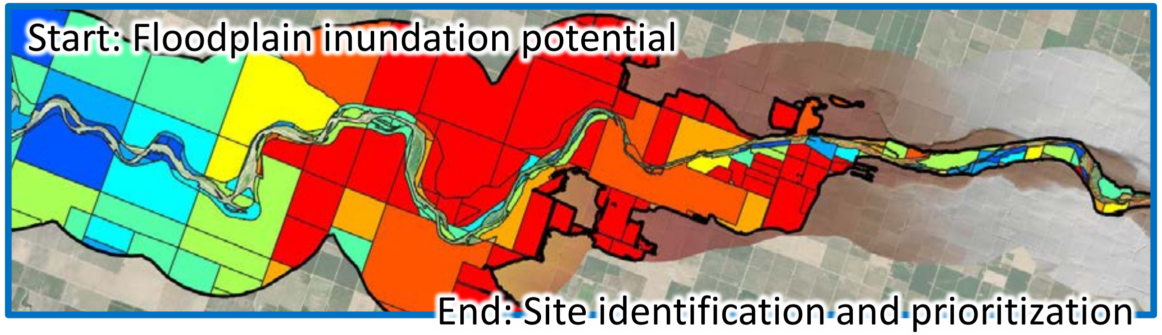
Conceptual

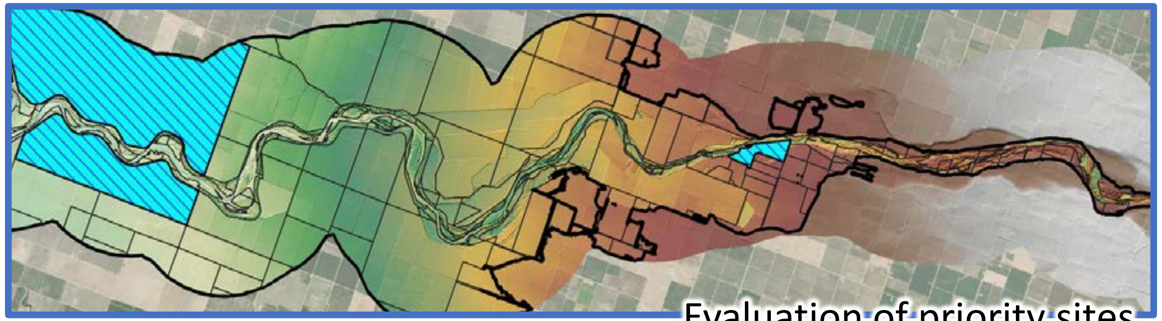
Designs

Analysis Dimensions

Temporal	*Spatial*
Individual flows	*River reach*
	Boundaries
	(parcels, river miles, grid)
WY-based accumulated stats	
	Site-level

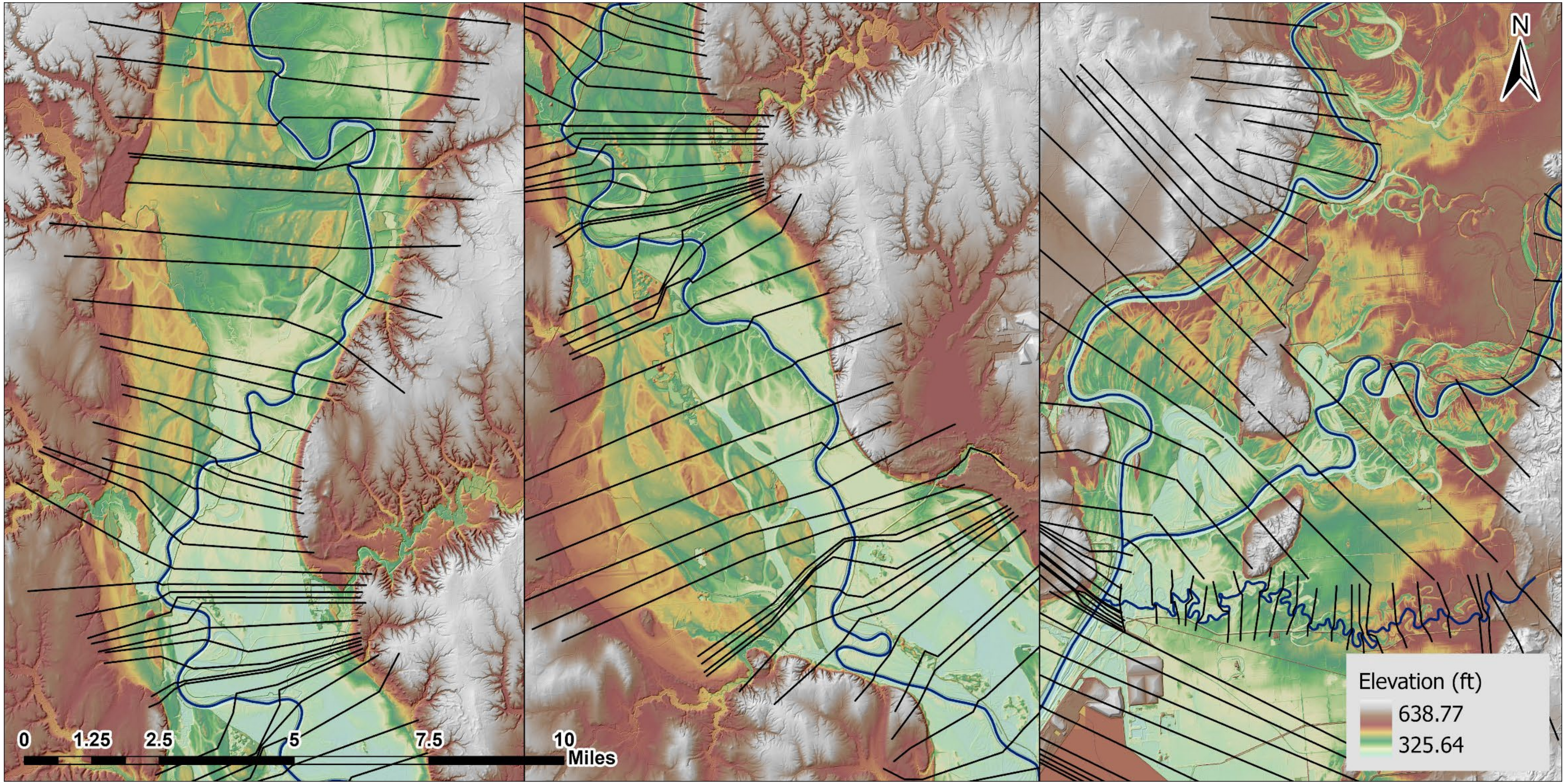






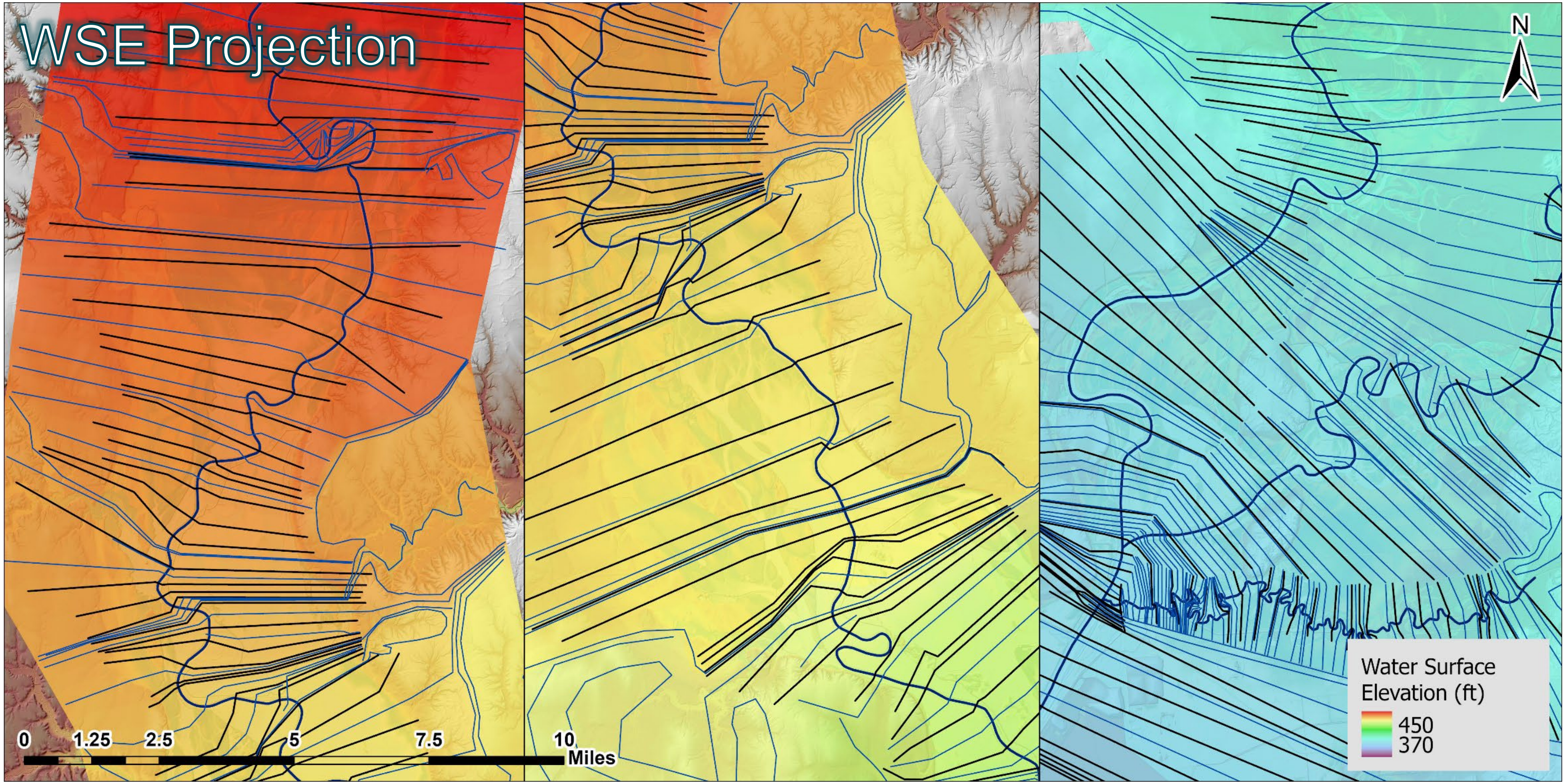
The EcoFIP Methodology

Tier 1

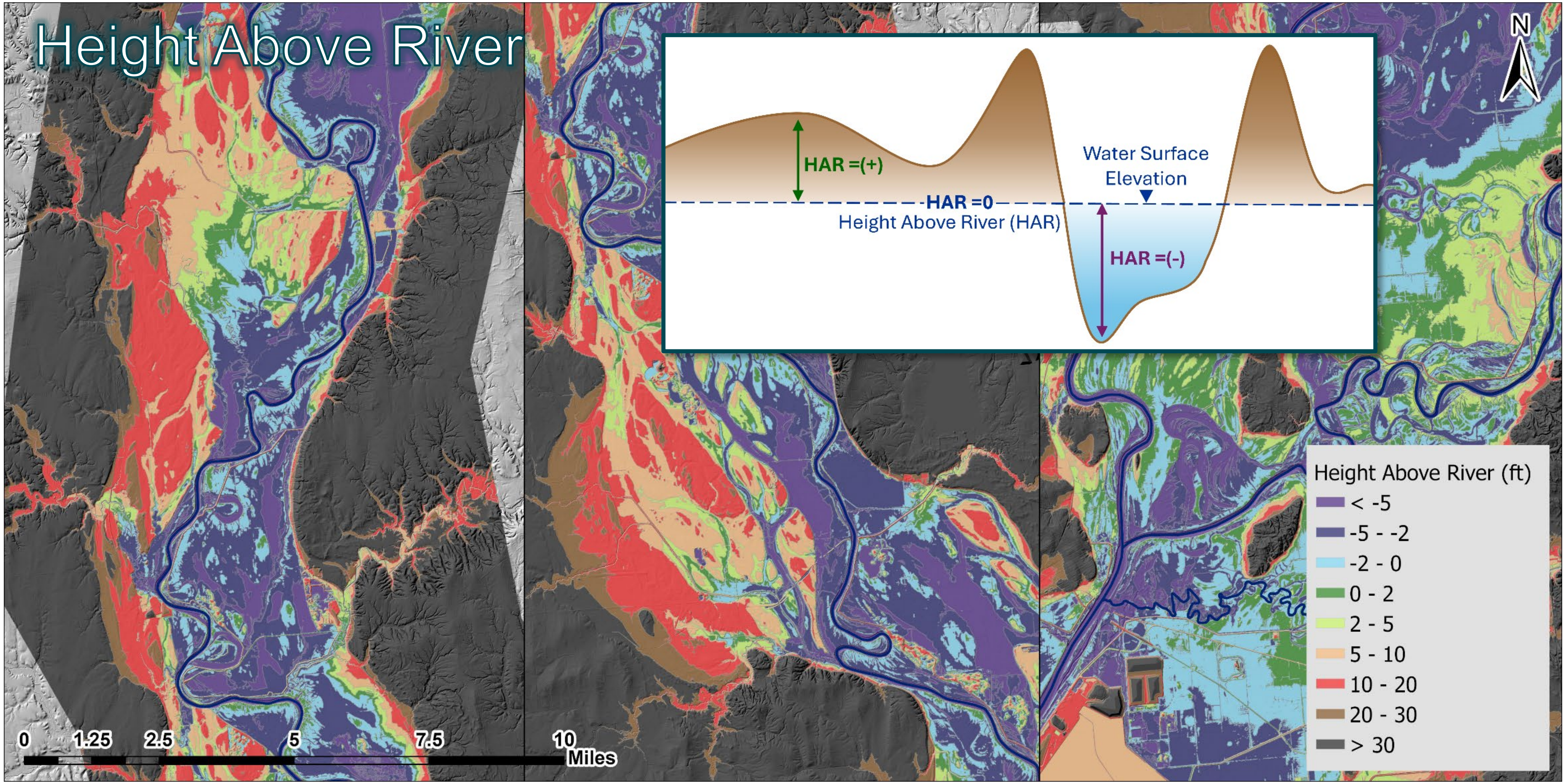


The EcoFIP Methodology

Tier 1

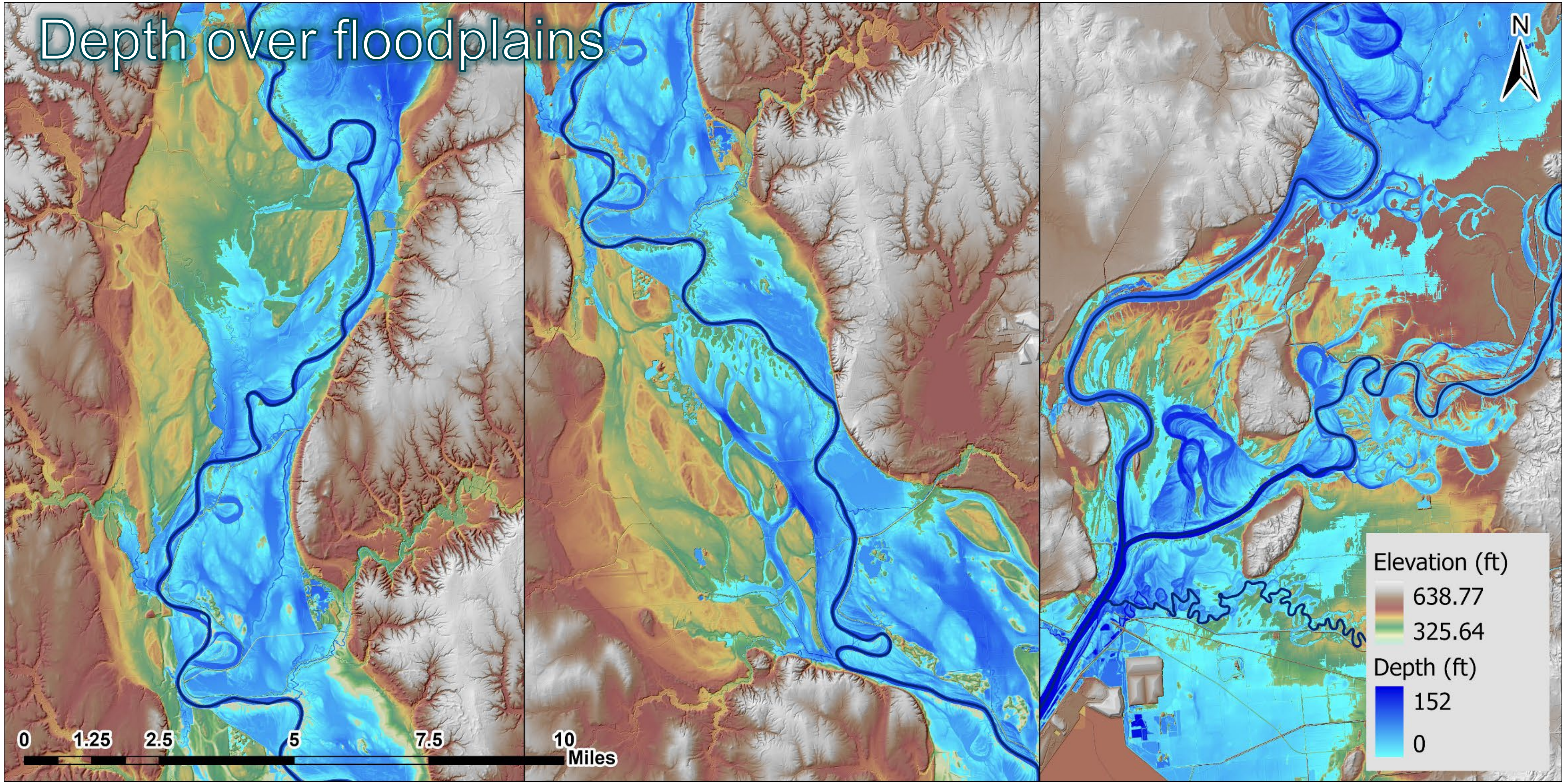


The EcoFIP Methodology



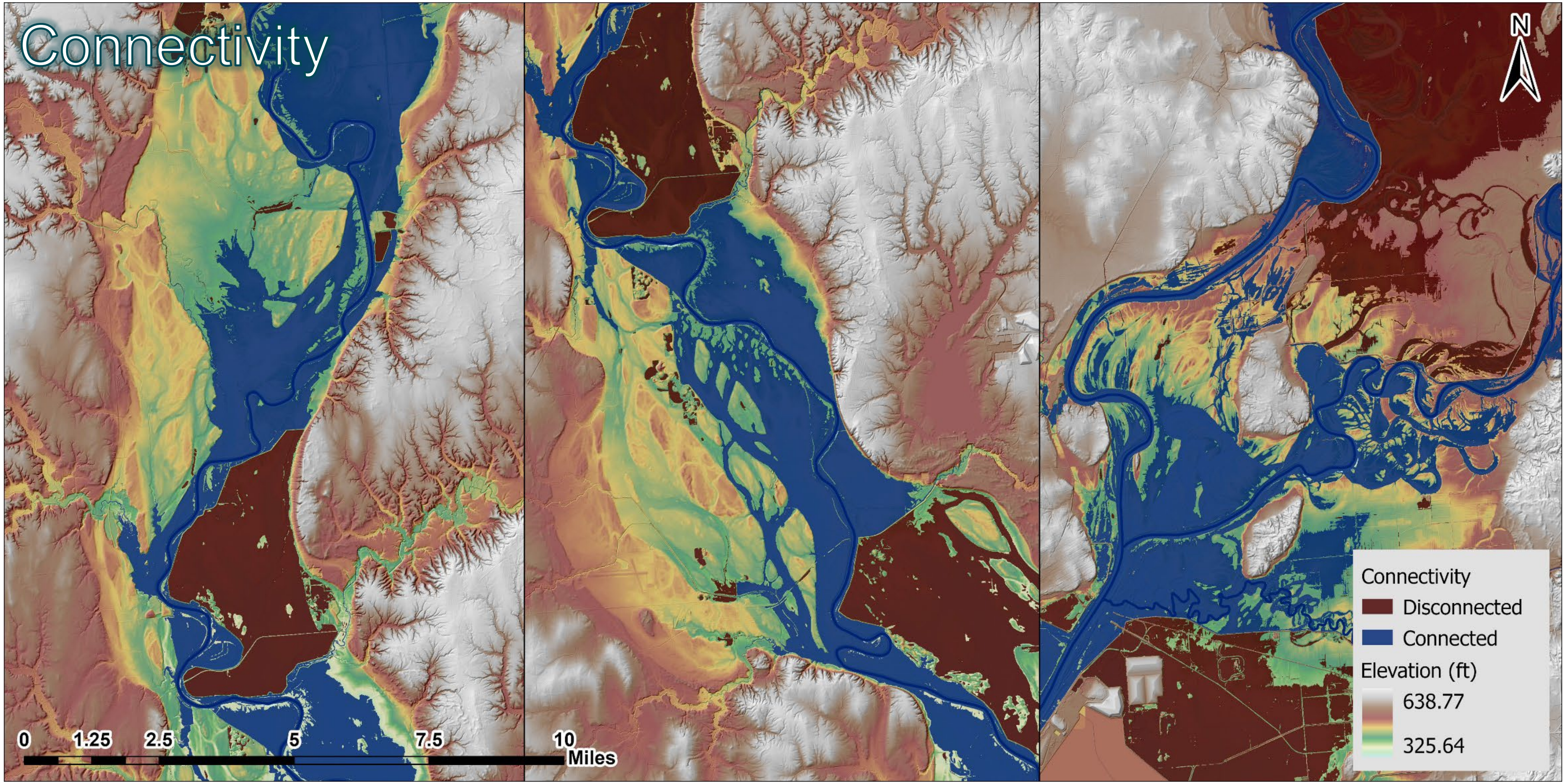
The EcoFIP Methodology

Tier 1



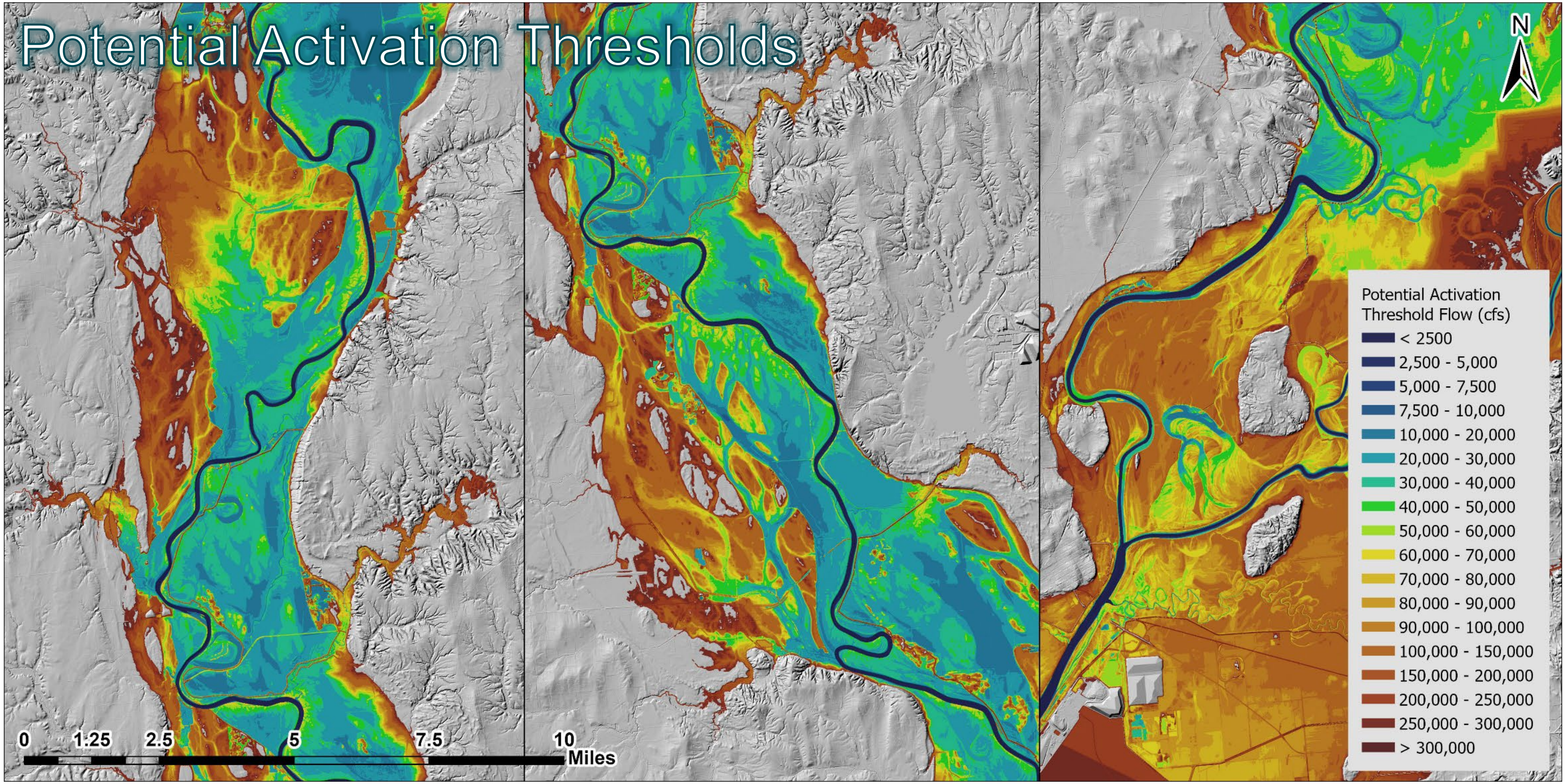
The EcoFIP Methodology

Tier 1



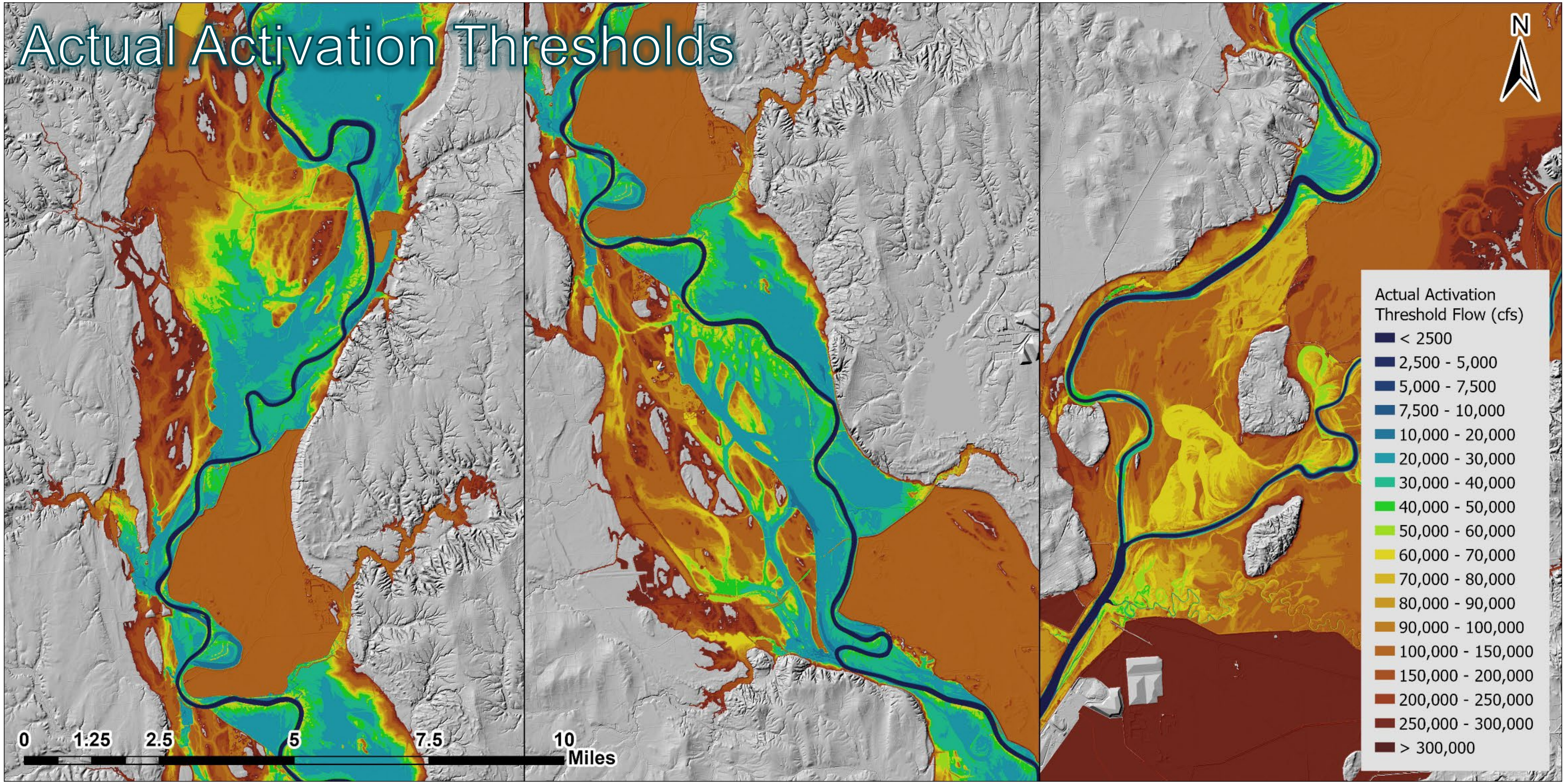
The EcoFIP Methodology

Tier 1



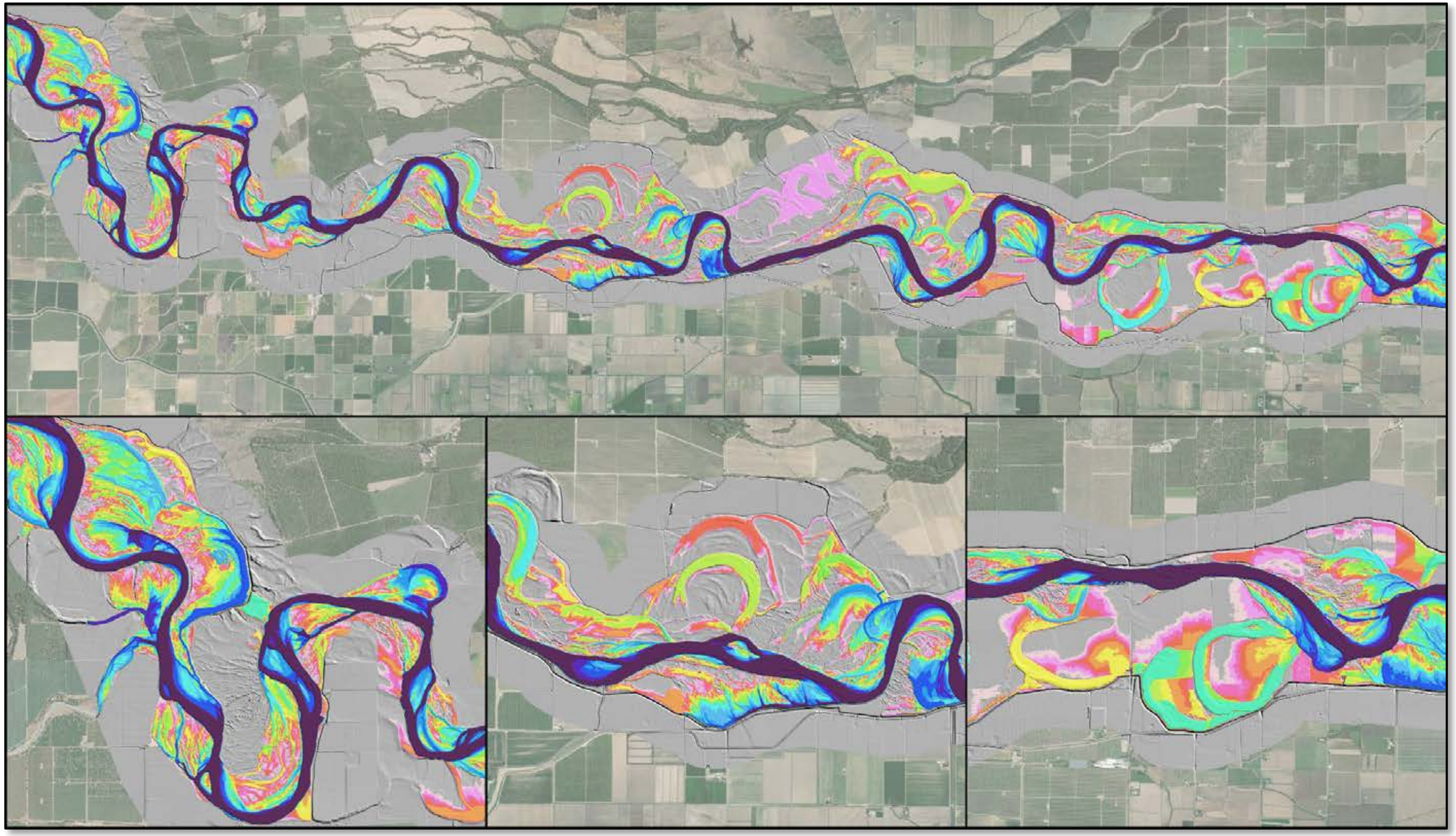
The EcoFIP Methodology

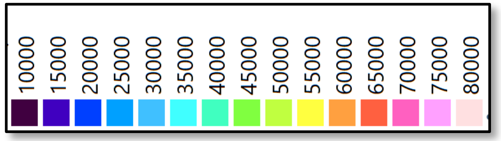
Tier 1



The EcoFIP Methodology

Tier 1





Flow (cfs)

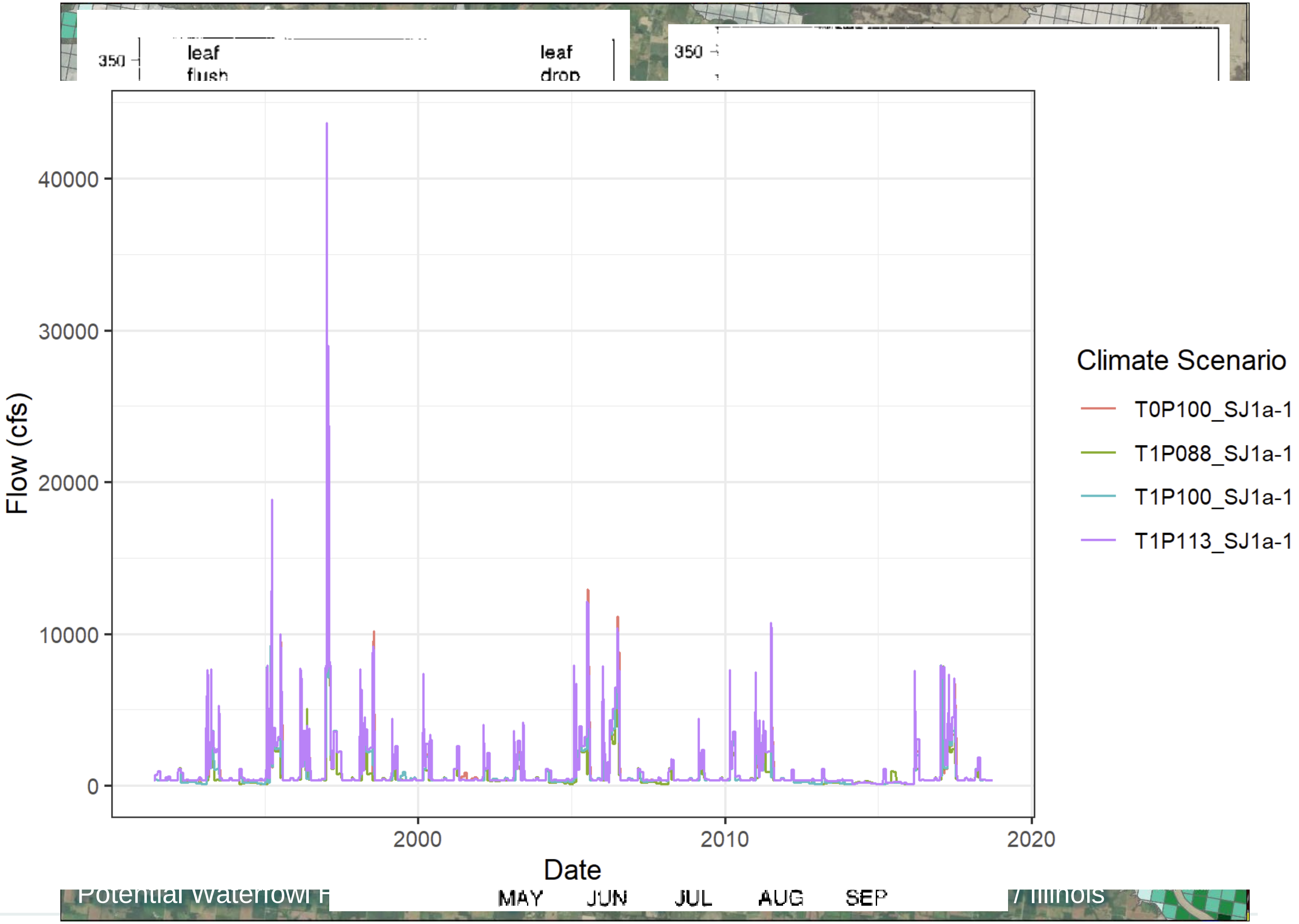
The EcoFIP Methodology

Tier 2

Benefit Quantification

- Discretization of floodplain selected
- Gage record plugged into flow-area curve for each unit
- Area – duration of inundation, habitat, recharge, etc. summed over each WY
- Acre-days of habitat in an average WY based on the record
- Highlight most restorable units
- Analyze many different metrics (depth criteria, recharge, nutrients, riparian recruitment, etc.)
- Various hydrologic timeseries

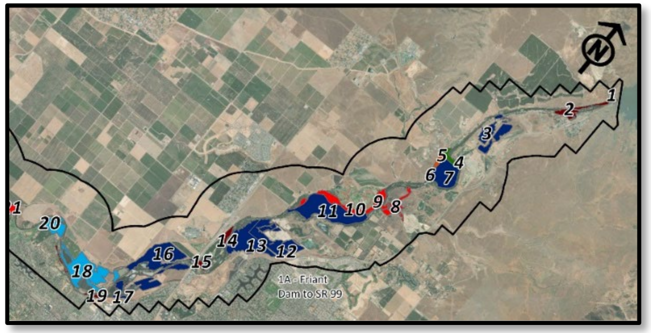
  (historic, climate models)



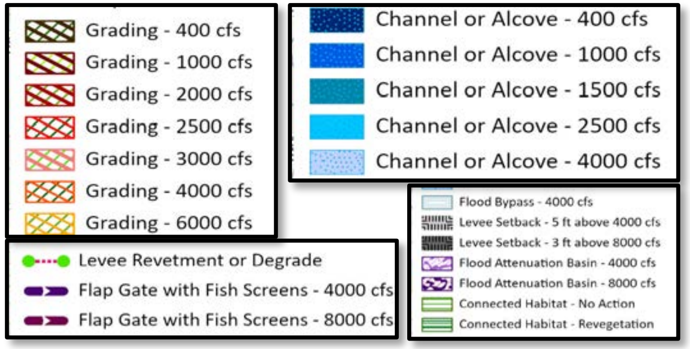
The EcoFIP Methodology

Tier 3

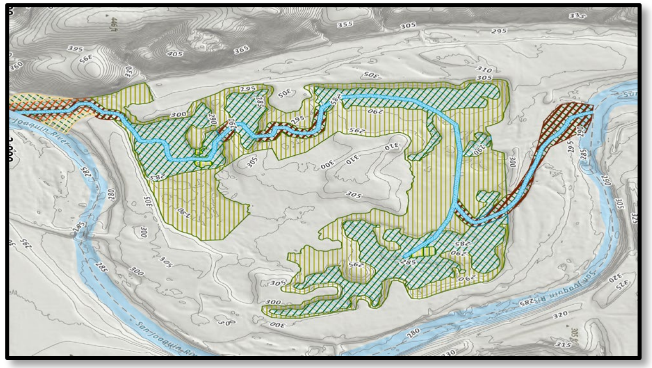
Select Areas to Prioritize Restoration Concepts

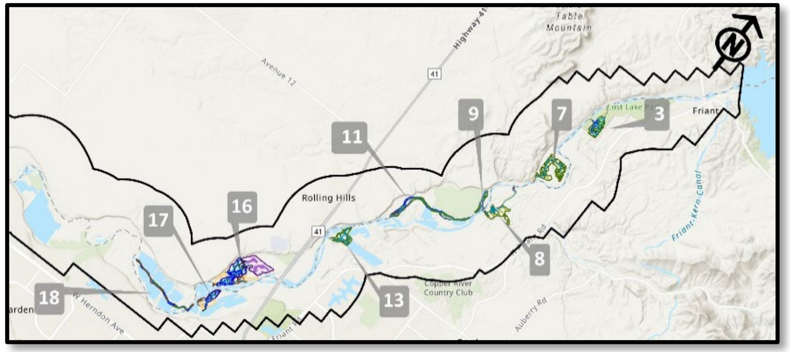


Floodplain Rehabilitation Actions Library

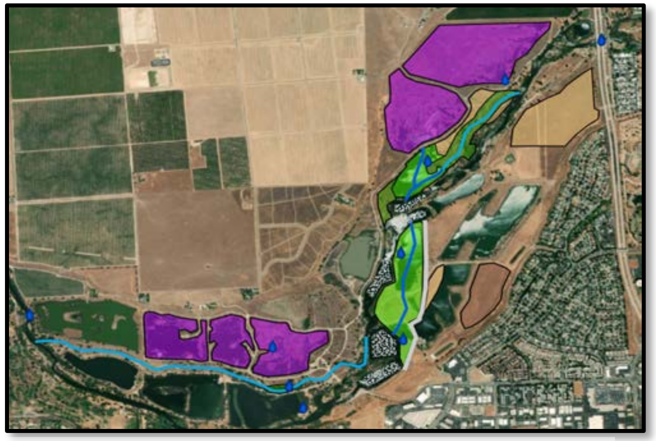


Develop and Evaluate Initial Concepts





Concept Refinement with Project Partners

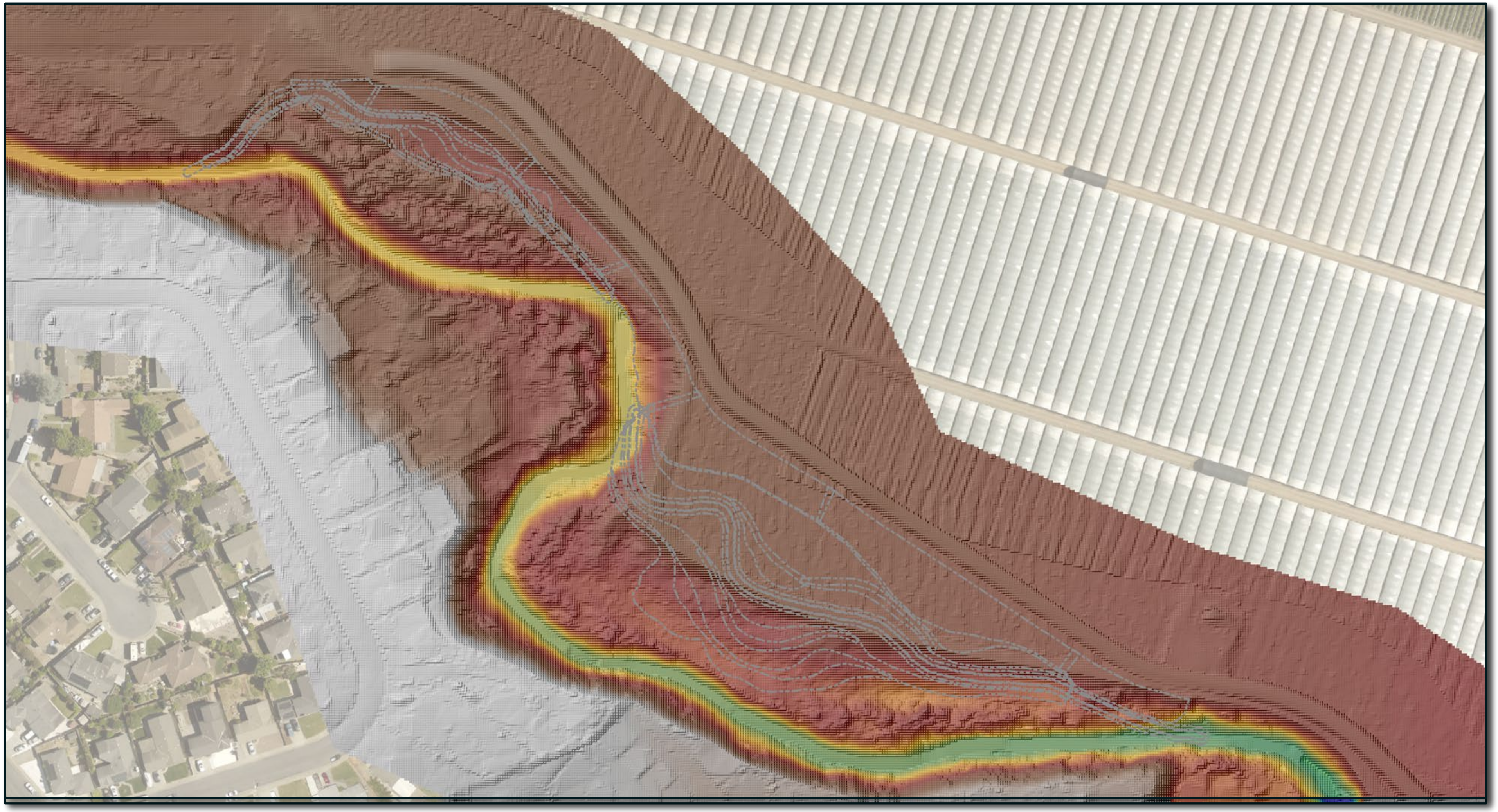


Project Costs and Benefit Comparisons

Select Sites to Advance to 30% Design

The EcoFIP Methodology

Tier 3



EcoFIP Applications

Total: 1,330 River Miles

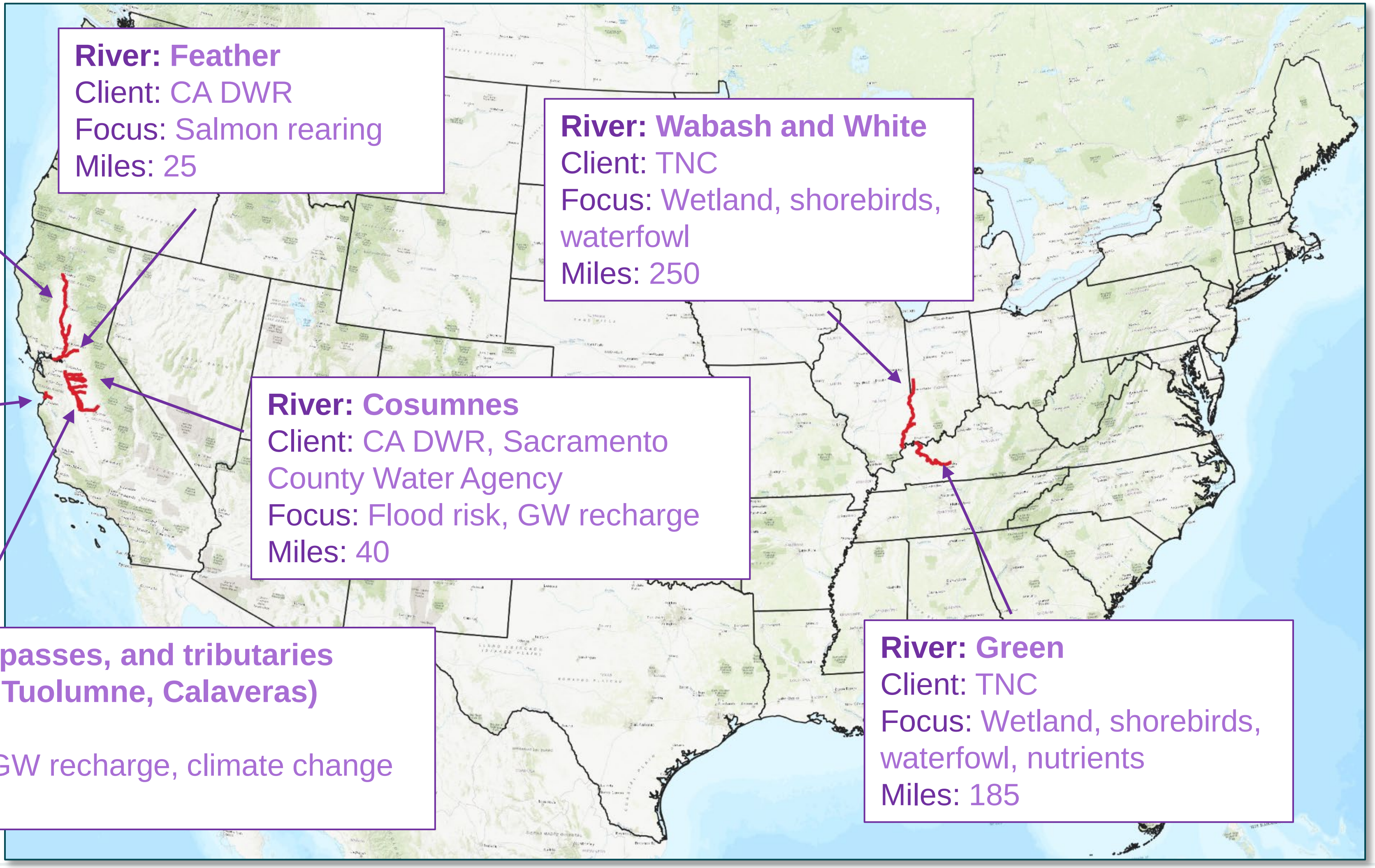
GUI

River: Sacramento
Client: Cal Trout
Focus: Salmon rearing
Miles: 300

River: Feather
Client: CA DWR
Focus: Salmon rearing
Miles: 25

River: Wabash and White
Client: TNC
Focus: Wetland, shorebirds, waterfowl
Miles: 250

River: Pajaro
Client: CA DWR, USACE
Focus: Flood risk, steelhead, GW recharge
Miles: 30



River: Cosumnes
Client: CA DWR, Sacramento County Water Agency
Focus: Flood risk, GW recharge
Miles: 40

River: San Joaquin mainstem, bypasses, and tributaries (Bear Creek, Merced, Stanislaus, Tuolumne, Calaveras)
Client: CA DWR
Focus: Flood risk, salmon rearing, GW recharge, climate change
Miles: 500

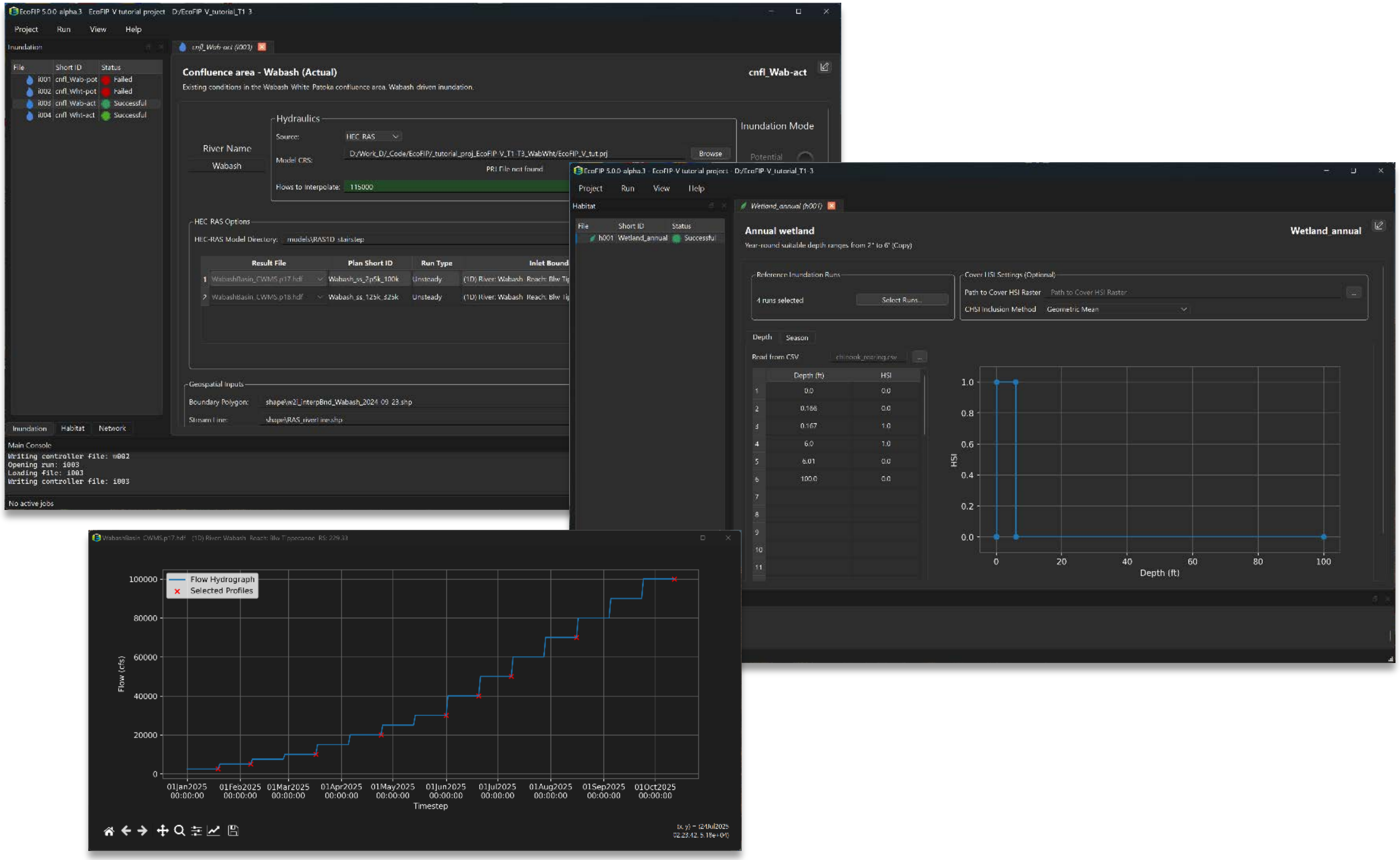
River: Green
Client: TNC
Focus: Wetland, shorebirds, waterfowl, nutrients
Miles: 185

The EcoFIP Methodology

GUI

User-Friendly Architecture

- Graphical user interface enables many staff to use
- Taking on many more projects… scaling up!
- Expanding capabilities in metrics and processing



Questions?

Chris Hammersmark

Director, Ecohydrologist

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916-668-5236

verdantas
eco engineering

Fish and Flow in the Scott River Watershed

Betsy Stapleton,
Charnna Gilmore,
Erich Yokel ,
Harrison Morrow.
Scott River Watershed Council

Landowners

Water Quantity: a (the?) major limiting factor for fish populations in streams and rivers

- Increasing competition for limited water resources
  - Drought
  - Tribes, Ag
  - Regulation: curtailment- belly scraping flows, long term in-stream flows for “recovery”.

Scott River Watershed Council

Maintain Fish “in good condition,” per California Fish & Game Code 5937. Mono Lake Decision. Recent Court of Appeals Decision.

- Moyles 1998 defines “Fish in good Condition
  - Individual condition, which refers to body condition and growth opportunities: typical restoration effectiveness monitoring.
  - Population condition, which refers to resilient populations that have all life history stages present. Assessment of Instream Flow Needs for the Upper Shasta River: McBain, TU, UNR
  - Community: definition reflects recent ecological thinking and recognizes that a fish community is a complex, dynamic entity whose persistence through time requires a complex, dynamic habitat. For streams, in particular, a healthy fish community requires flows and habitats that have attributes of those that existed historically. Few to no studies.

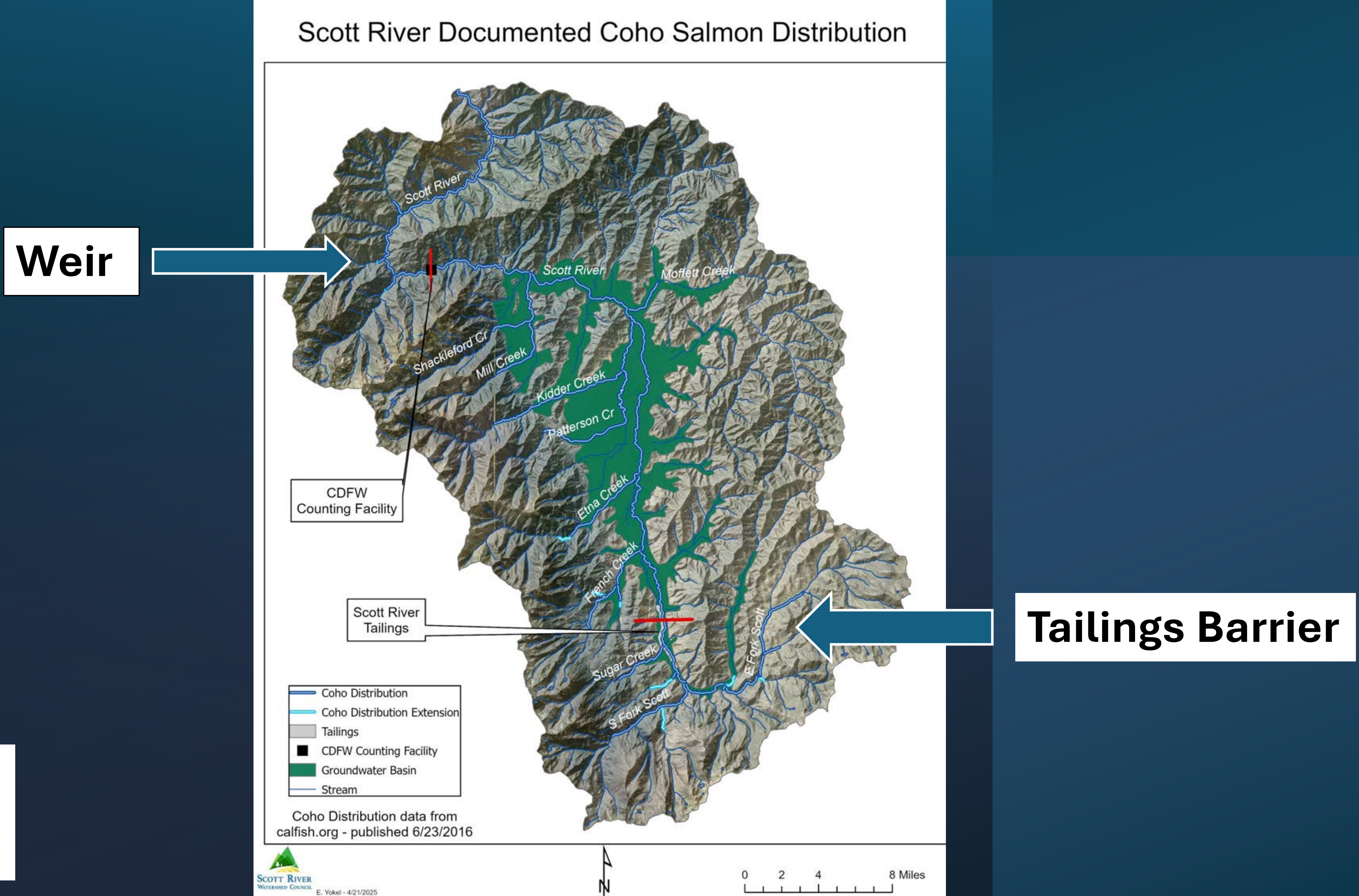
Observations from the Scott

- High Value Anadromous Fish Rearing
  - Source population of wild fish for the Klamath upper basin repopulation
  - Fish and Farms in the same locations
  - Increasing regulatory and political interest in understanding “how much water do fish need?”

Observations from the Scott

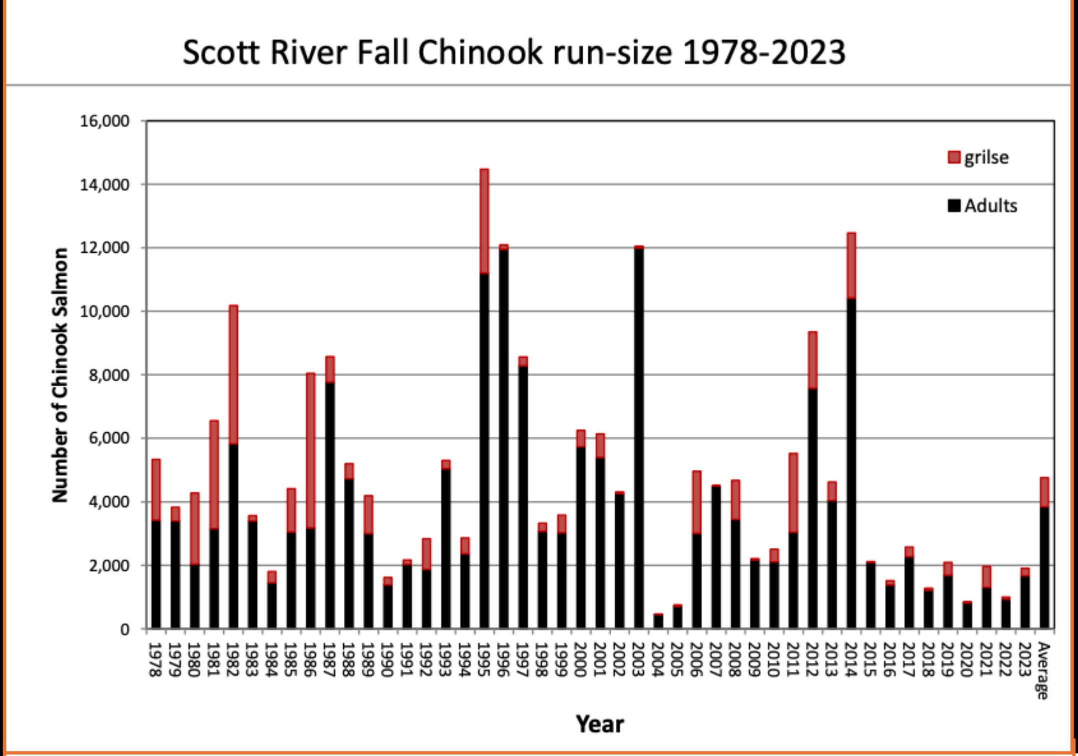
- Observational science from a variety of sources (no claim for statistical significance)
  - USGS Gauge, Stream Gauges
  - SVIHM- connection and disconnection dates per model
  - CDFW Connectivity survey
  - Correlation between USGS and Tributary connections not well established
  - Spawning Surveys- not randomized, access limited by landowner willingness.
  - Juvenile Direct Observation Dives- not randomized, access limited by landowner willingness

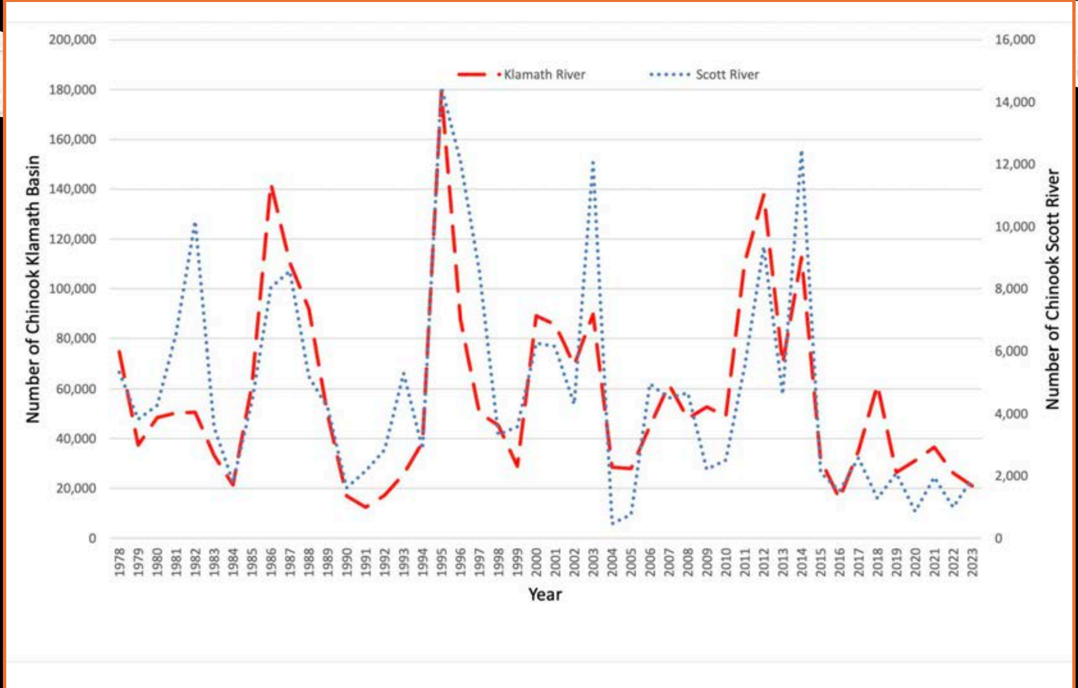
What this talk does not address: Why flows are declining.

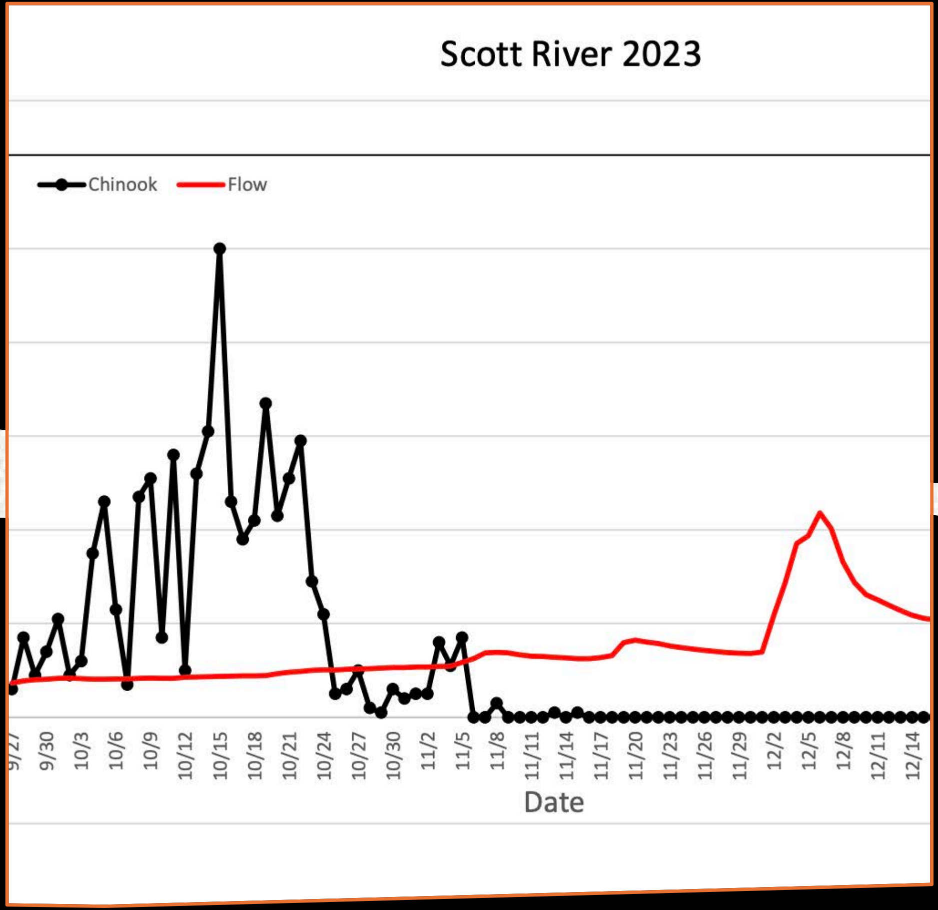


Scott River Watershed Council

Scott Chinook

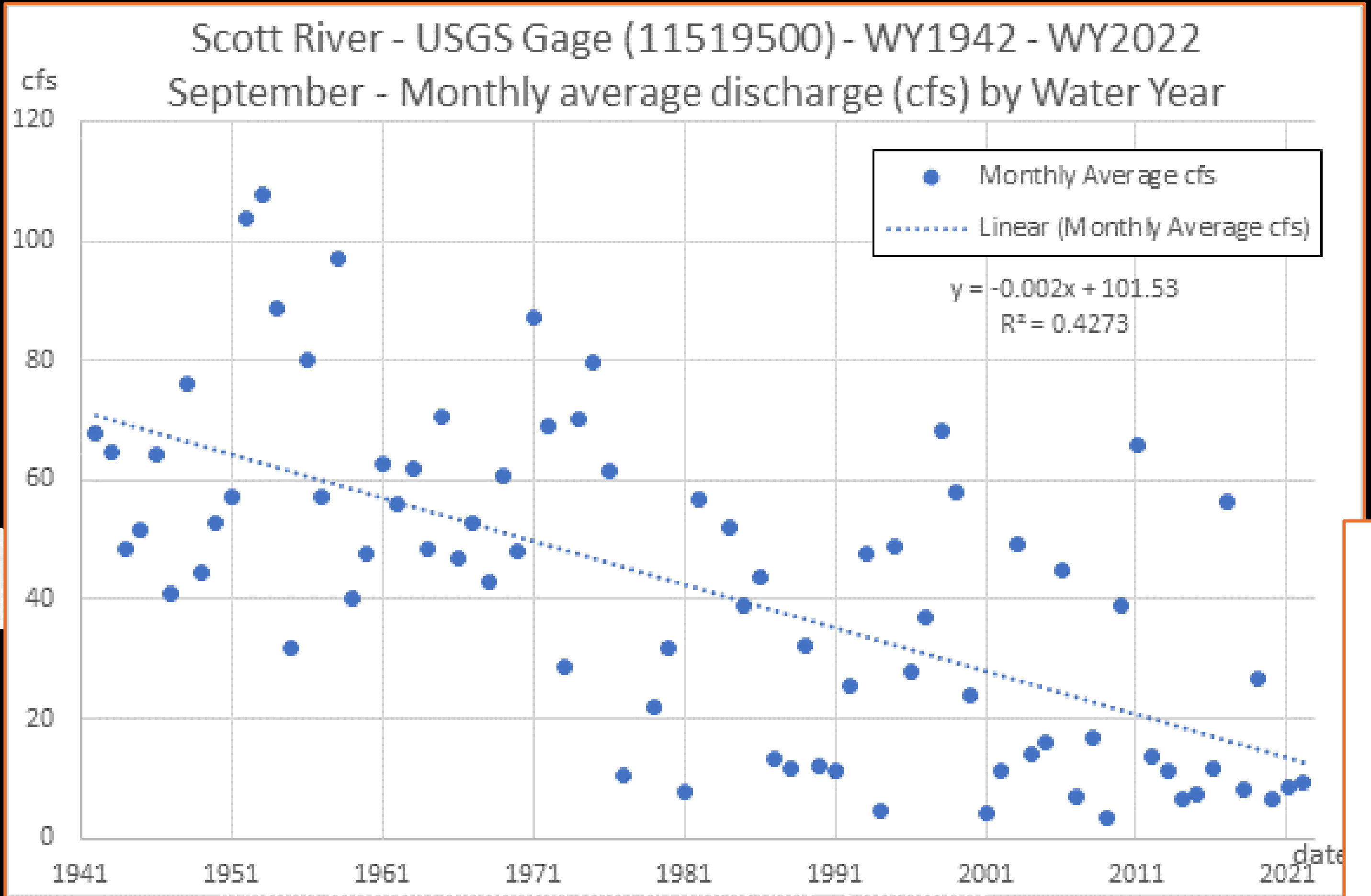




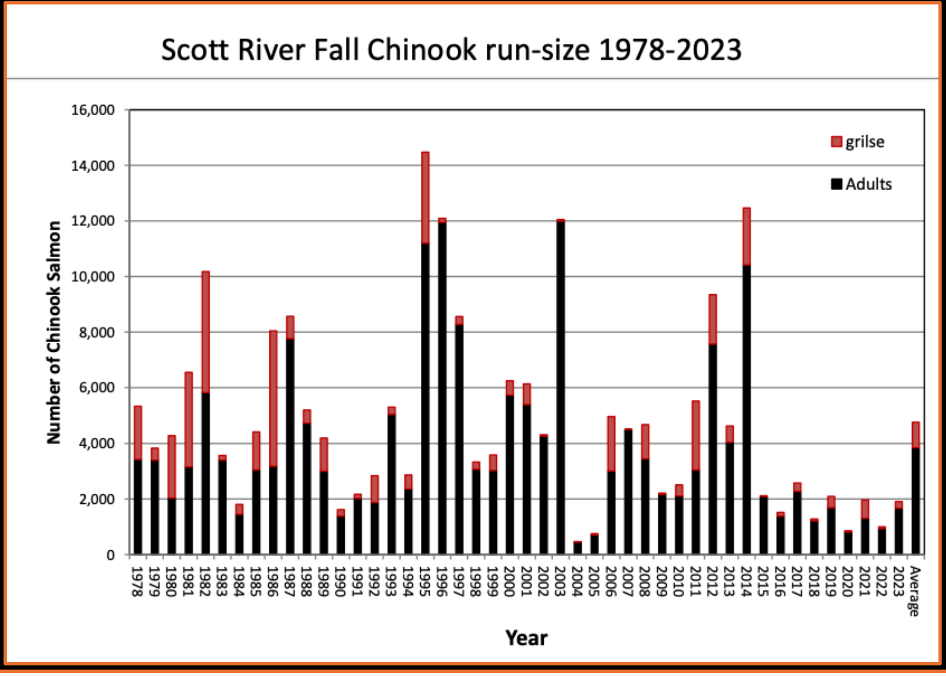


2023 SCOTT RIVER SALMON RESEARCH
California Department of Fish and Wildlife
Northern Region Klamath River Initiative

Scott Chinook



Average monthly discharge (cfs) by water year – September

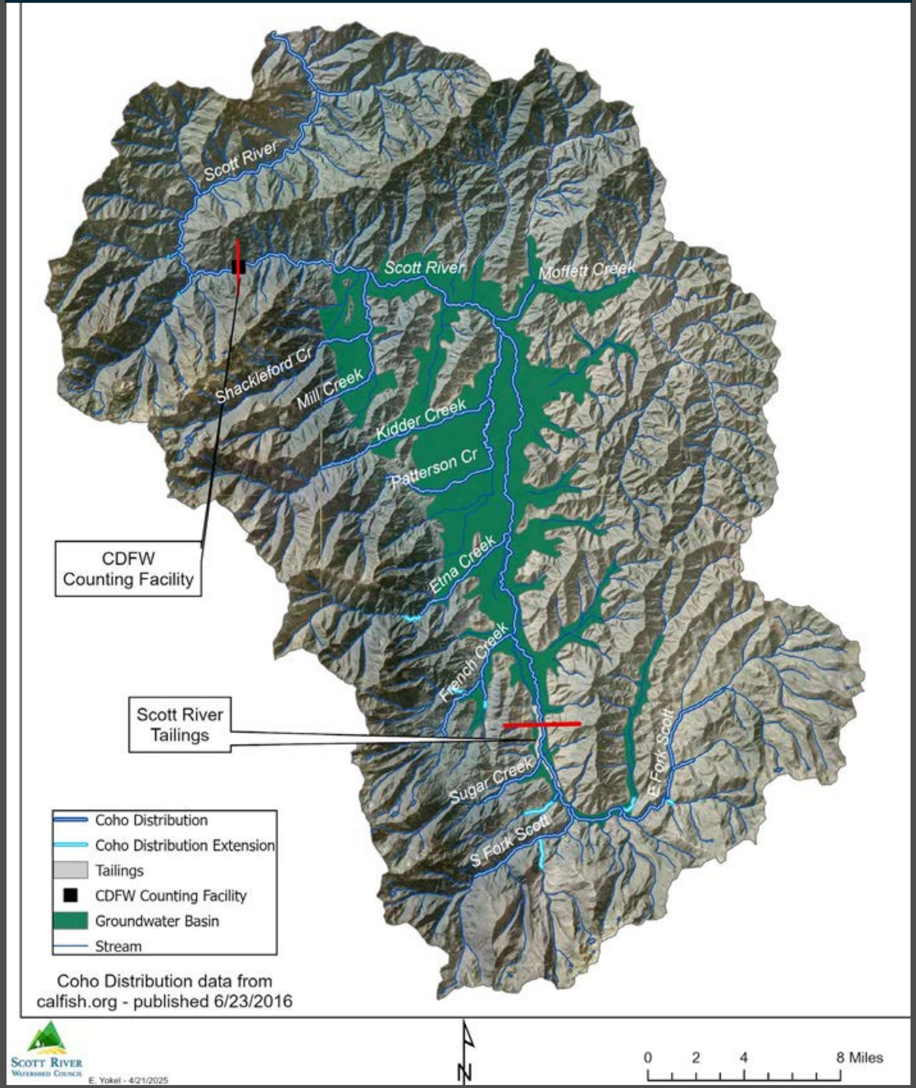


	cfs
Average (WY1942 - WY2022)	45
Average (WY1942 - WY1975)	62
Average (WY1976 - WY2000)	45
Average (WY2001 - WY2022)	20
Average (WY2013 - WY2022)	15

Average of Average monthly discharge (cfs) for different periods - September

Scott River Watershed Council

September - Initiate Chinook Return



Monthly Average Discharge (cfs) at Scott River USGS Gage

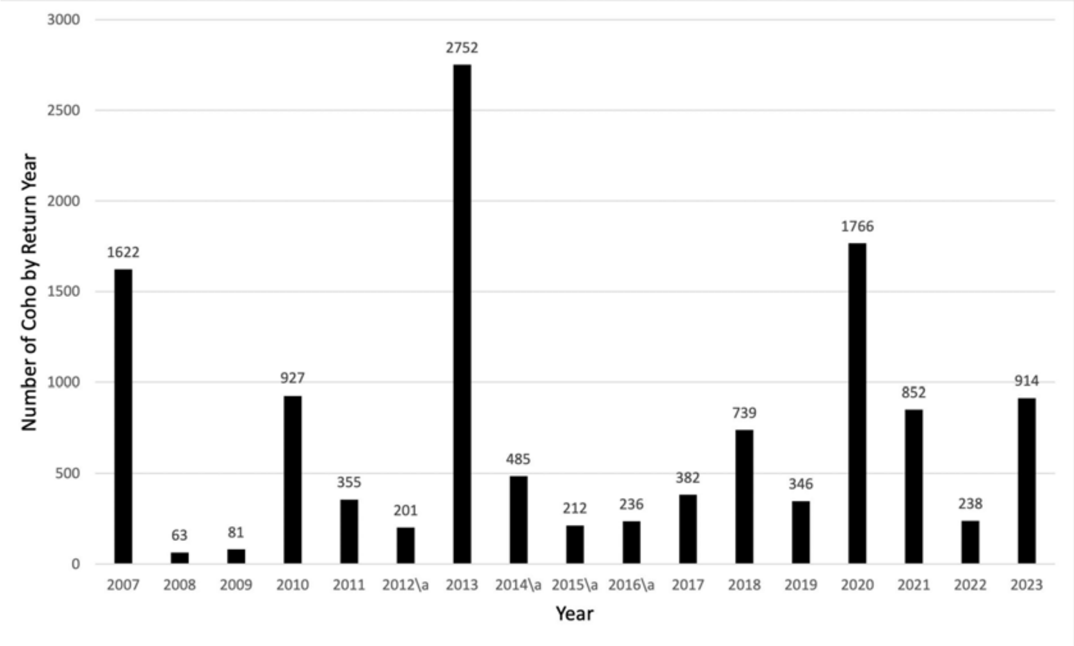
Year	September	October	November
2008	17	35	138
2009	3	19	54
2010	39	112	285
2011	66	84	100
2012	14	25	127
2013	11	45	50
2014	7	29	152
2015	7	7	8
2016	12	294	525
2017	56	74	333
2018	8	11	28
2019	27	44	55
2020	7	8	13
2021	9	73	206
2022	9	8	16
Average	19	58	139

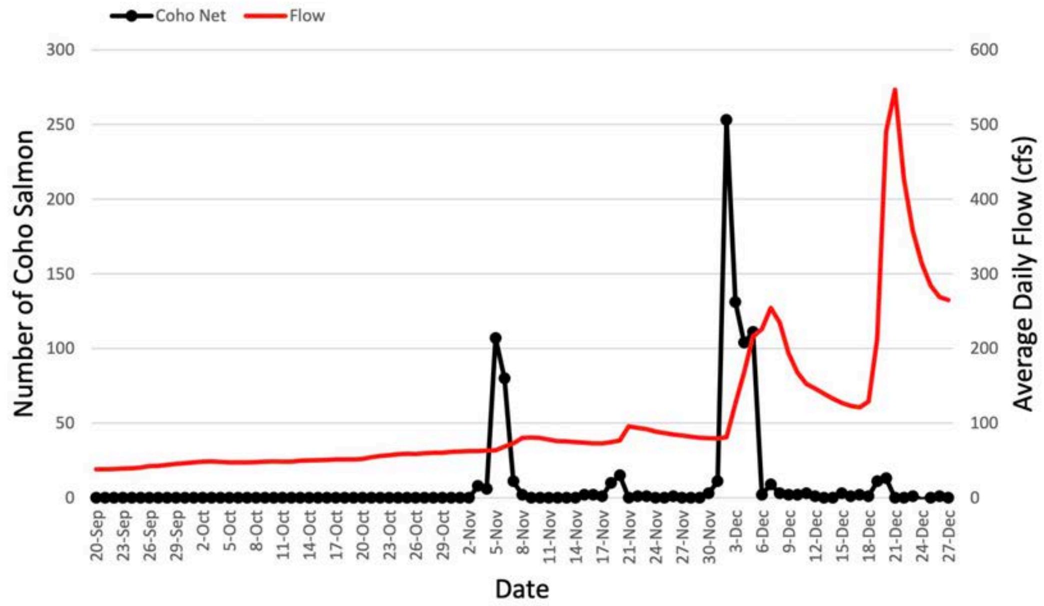
Chinook Salmon Abundance Estimates - CDFW

% Upstream of Counting Station	Total Basin Estimate
69%	4,673
54%	2,211
89%	2,508
82%	5,521
87%	9,352
73%	4,624
76%	12,471
18%	2,113
76%	1,515
88%	2,576
32%	1,279
74%	2,090
31%	855
71%	1,961
7%	994
62%	3,650

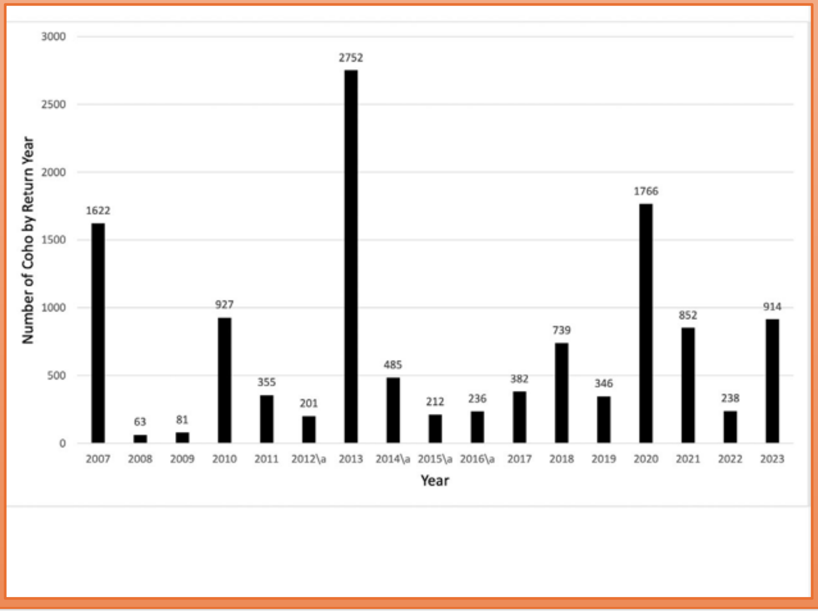
Scott River Watershed Council

Scott Coho

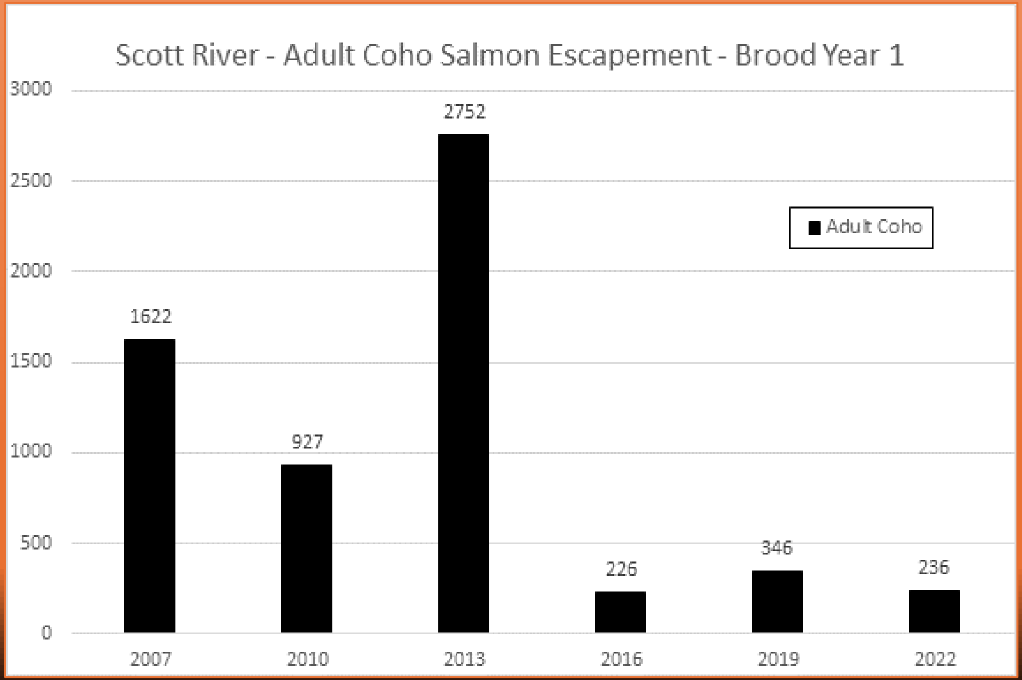


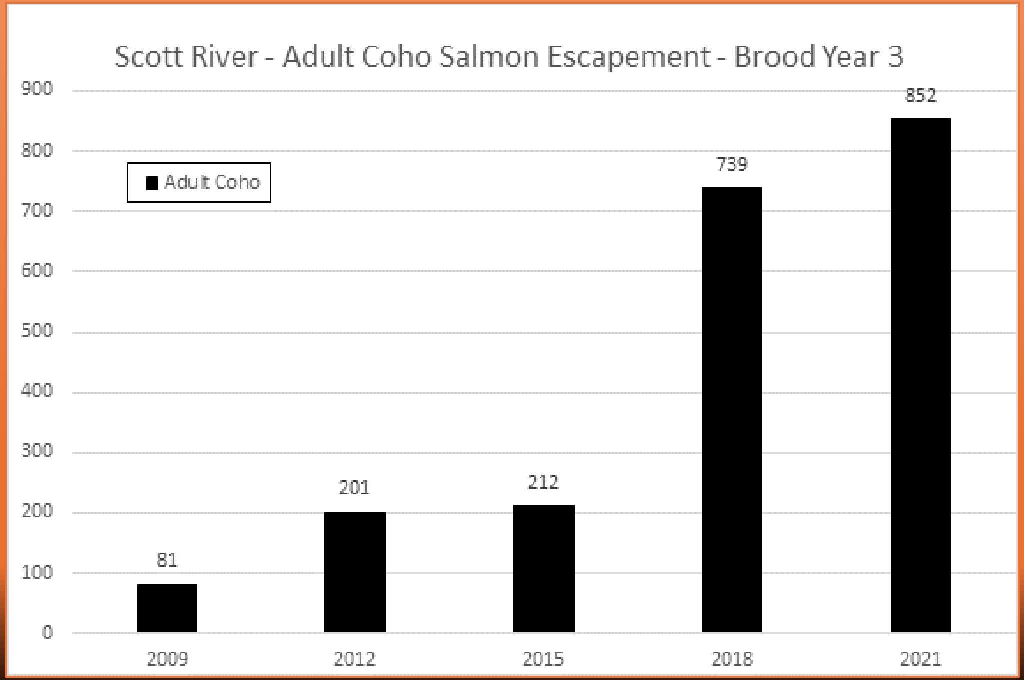


2023 SCOTT RIVER SALMON RESEARCH
California Department of Fish and Wildlife
Northern Region Klamath River Initiative



- In the early 2000's there was one relatively strong brood year of coho salmon and two very week broods of coho salmon.
- The Drought of 2013 – 2014 led to the demise of the strong brood year while the two weak brood years have shown significant increases over the last five (5) generations.

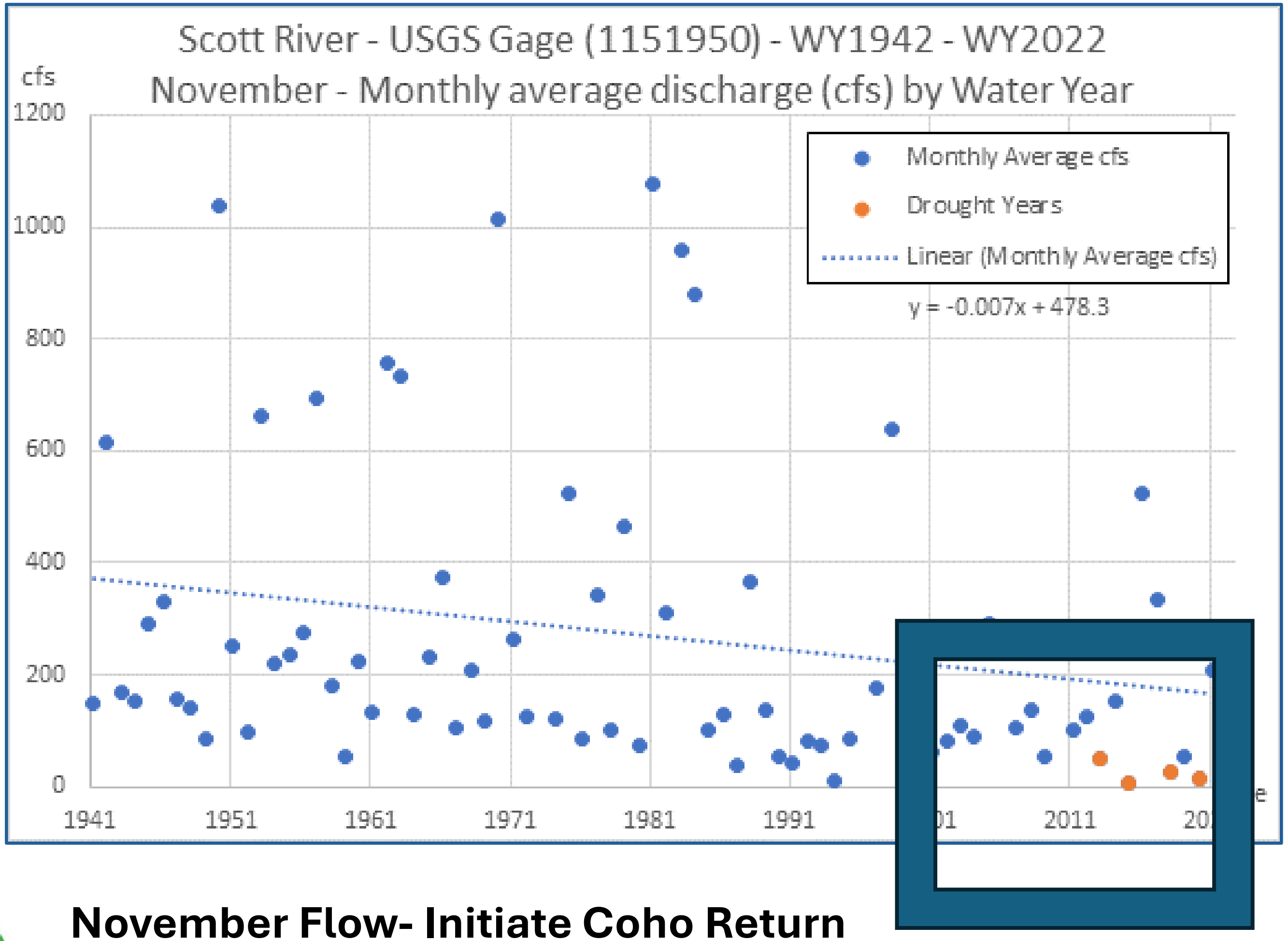




Scott Coho

SCOTT RIVER WATERSHED COUNCIL

Scott Coho



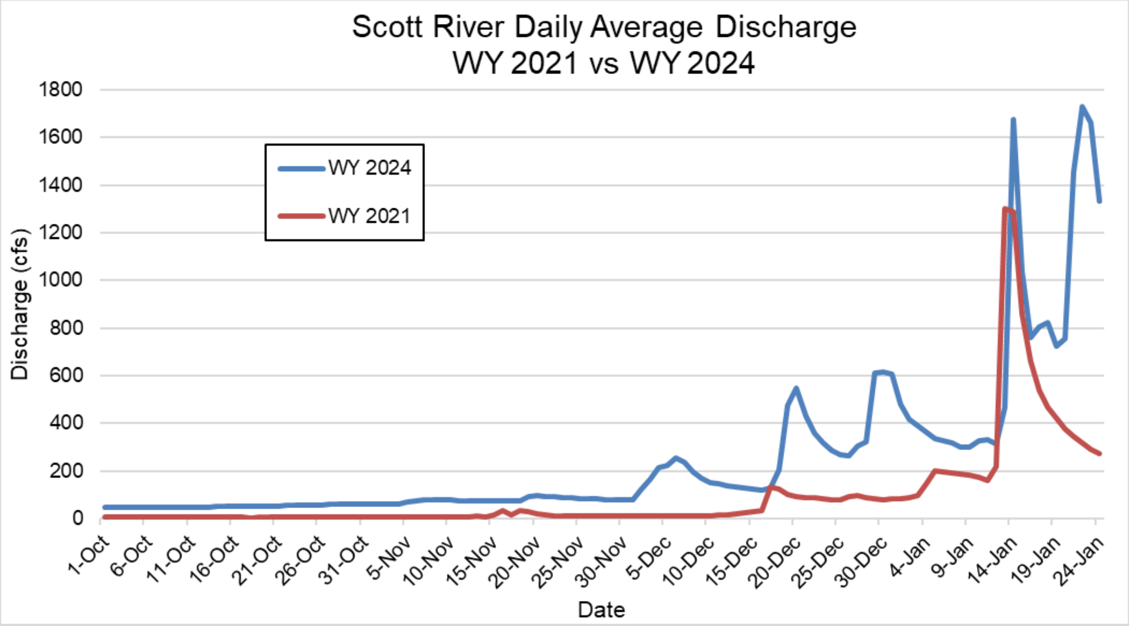
November - Average of Average Monthly Discharge (cfs)

	cfs
Average (WY1942 - WY2022)	287
Average (WY1942 - WY1975)	352
Average (WY1976 - WY2000)	324
Average (WY2001 - WY2022)	143
Average (WY2013 - WY2022)	150

Scott River Watershed Council

November Flow- Initiate Coho Return

26% of the coho spawning occurred in the mainstem Scott River during 2020-2021
9% occurred in the mainstem in 2023-2024



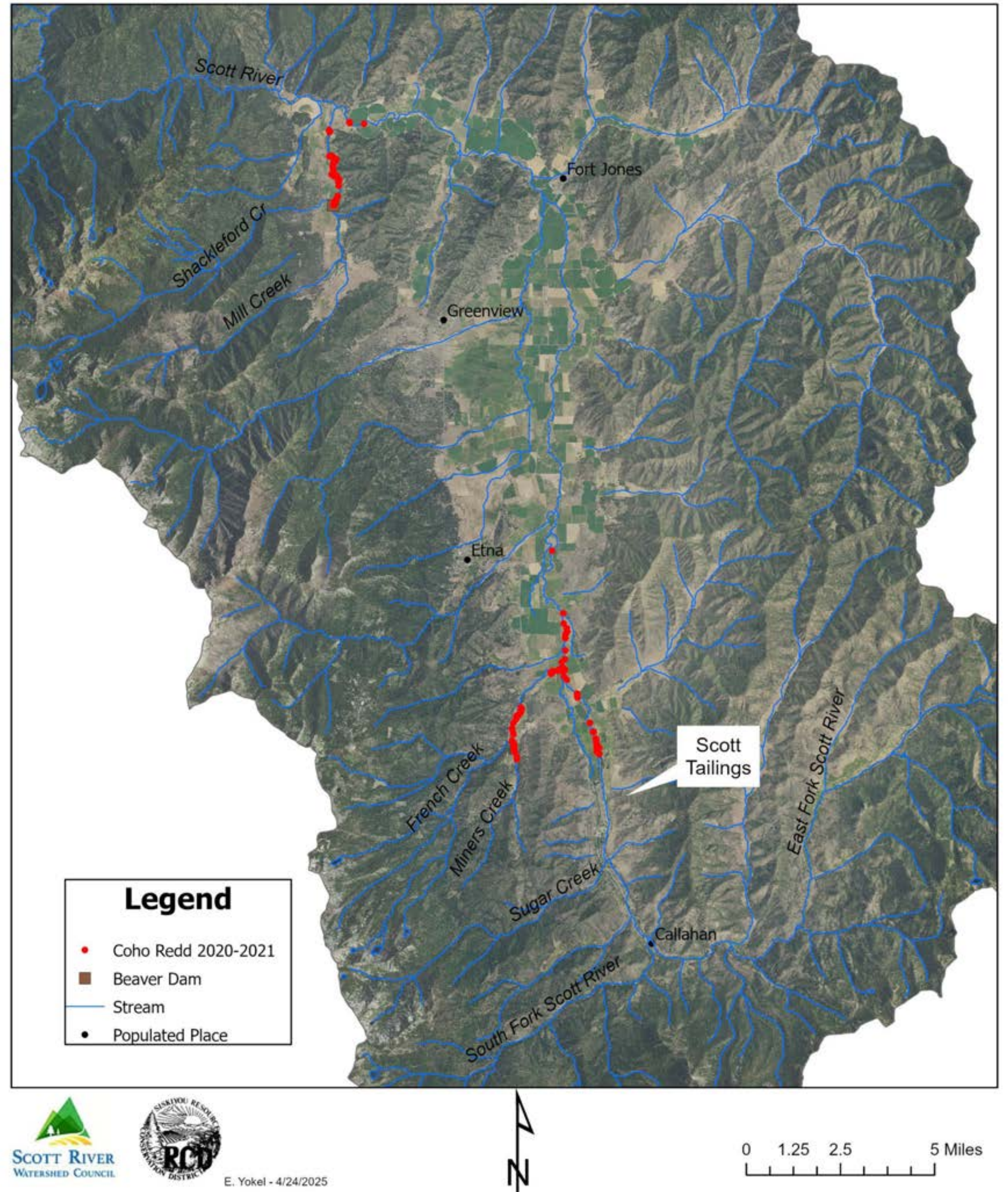
Stream	2020-21 Redds (1,766 Spawners)		2023-24 Redds (912 Spawners**)	
Scott River Mainstem	**Number**	**Percentage**	**Number**	**Percentage**
Reach 16 Partial (RKM 87.4-87.7)	ND	NA	15	6.0%
Reach 16 Partial (RKM 80.8-82.5)	30	10.6%	3	1.2%
Reach 15 (RKM 75.1-80.8)	33	11.7%	4	1.6%
Reach 13 Partial (RKM 68.6-70.6)	1	0.4%	0	0.0%
Reach 9	5	1.7%	ND	NA
Scott River Mainstem Total	**72**	**26.0%**	**22**	**8.8%**
Tributaries (North to South)				
Mill Creek	55	20.0%	2	0.8%
Shackleford Creek	67	24.0%	20	8.0%
Kidder Creek	ND	NA	5	2.0%
Etna Creek	ND	NA	28	11.2%
Miners Creek**	30	10.0%	1	0.4%
French Creek	56	20.0%	88	35.1%
Sugar Creek	0	0.0%	43	17.1%
Wildcat Creek	ND	NA	2	0.8%
East Fork	ND	NA	39	15.5%
South Fork	0	0.0%	1	0.4%
Tributary Total	**208**	**74.0%**	**229**	**91.2%**

**Coho salmon abundance data from the CDFW SRFCF in 2023-2024 is preliminary.

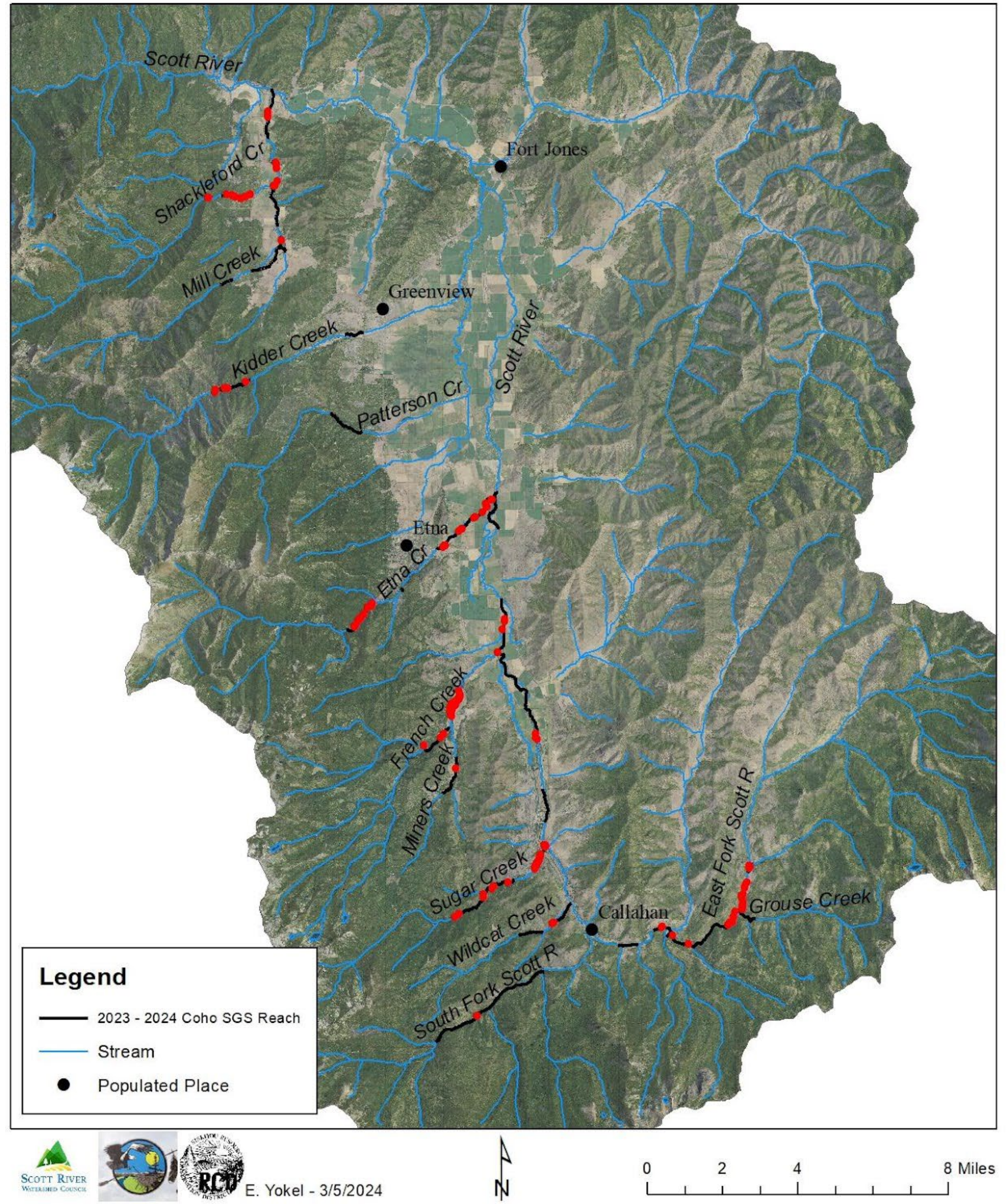
Timing of early fall precipitation and runoff effects connectivity and migration timing with drought years having a significant effect on documented distribution.

Scott River Watershed Council

Scott River Coho Spawning Ground Surveys
Coho Redds - 2020 - 2021

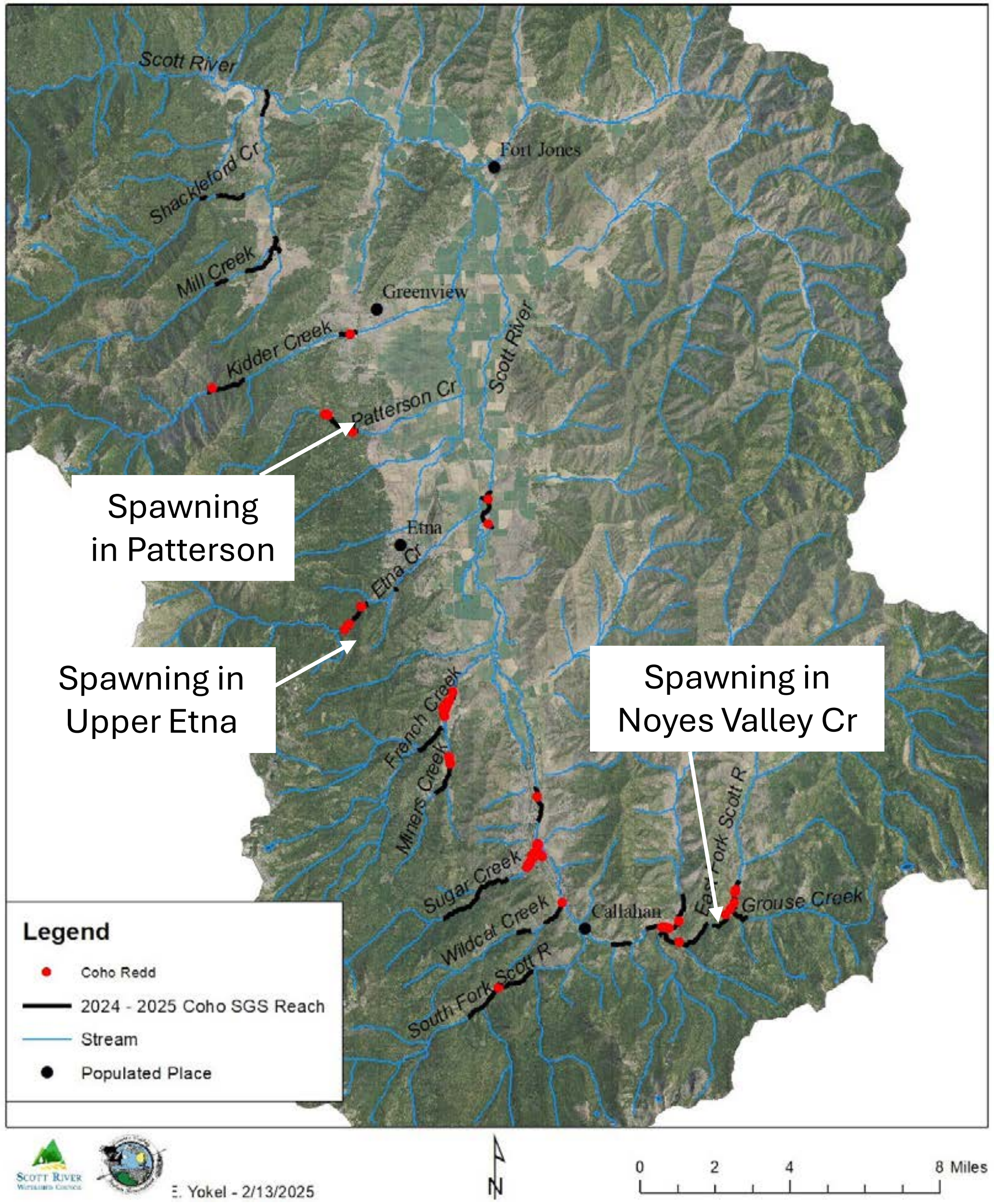


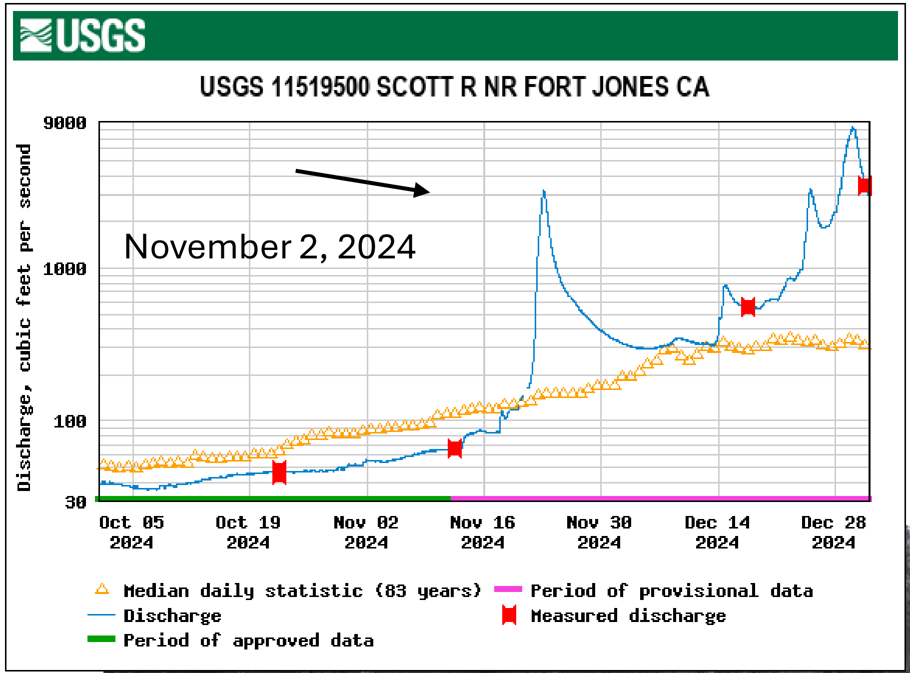
2023 - 2024 Scott River Coho Spawning Ground Surveys
Observed Coho Salmon Redds

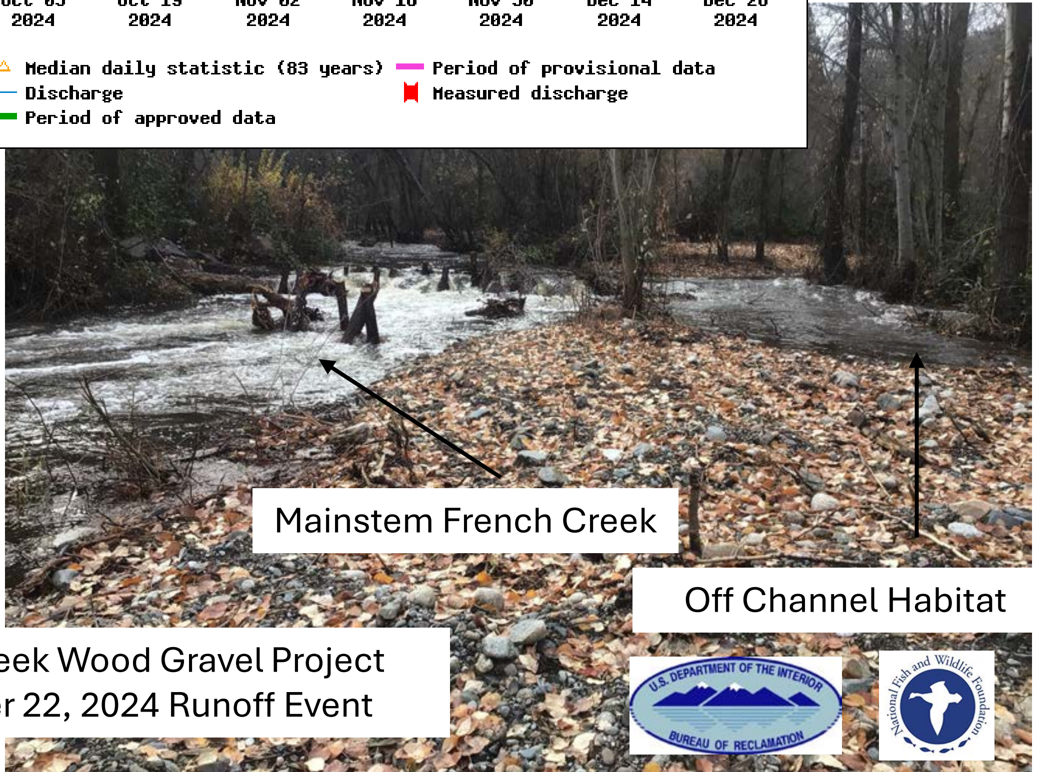


Coho Spawning 2024 – 2025
Brood Year 2021 Returns as Adults

2024 - 2025 Scott River Coho Spawning Ground Survey Reaches
Observed Coho Salmon Redds

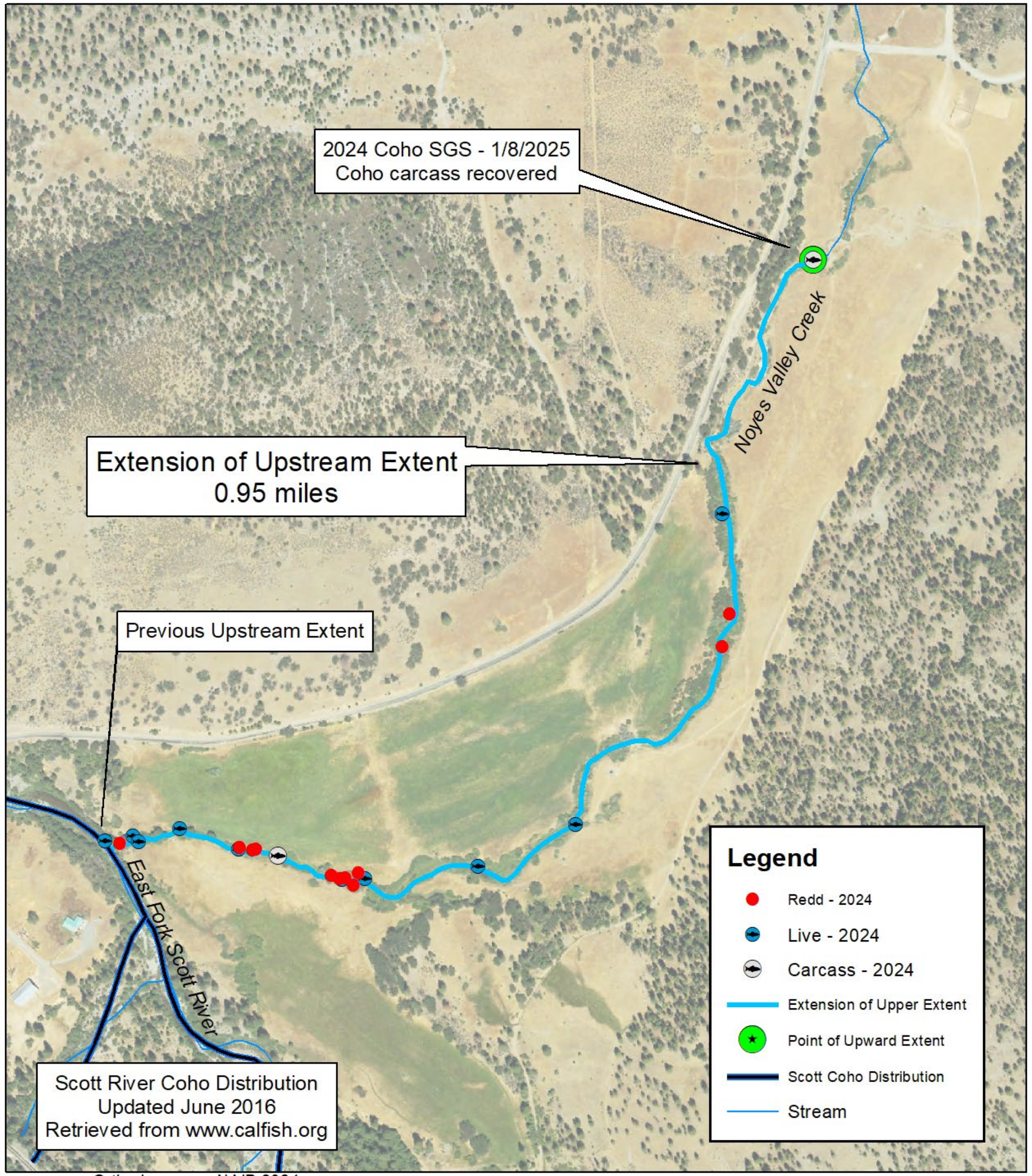






French Creek Wood Gravel Project
November 22, 2024 Runoff Event

Noyes Valley Creek
Upstream Extent of Observed Coho Salmon
Area of Extension of Coho Salmon Distribution



Ortho Imagery - NAIP 2024

E. Yokel - 2/13/2025

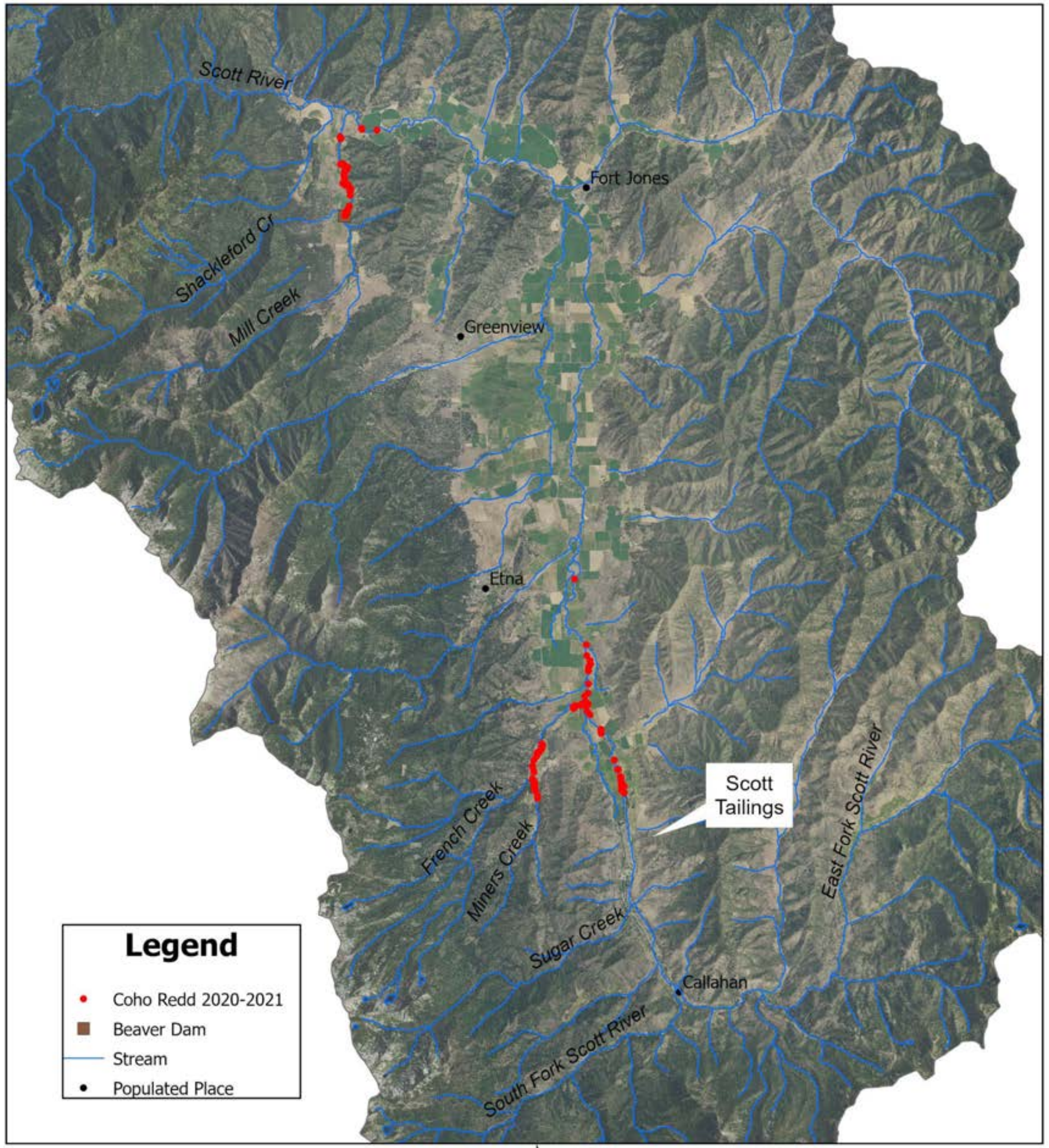
N

0 250 500 1,000 Feet

Extension of Upper Extent of Coho Salmon Distribution

THE WILDLANDS CONSERVANCY

Scott River Coho Spawning Ground Surveys
Coho Redds - 2020 - 2021



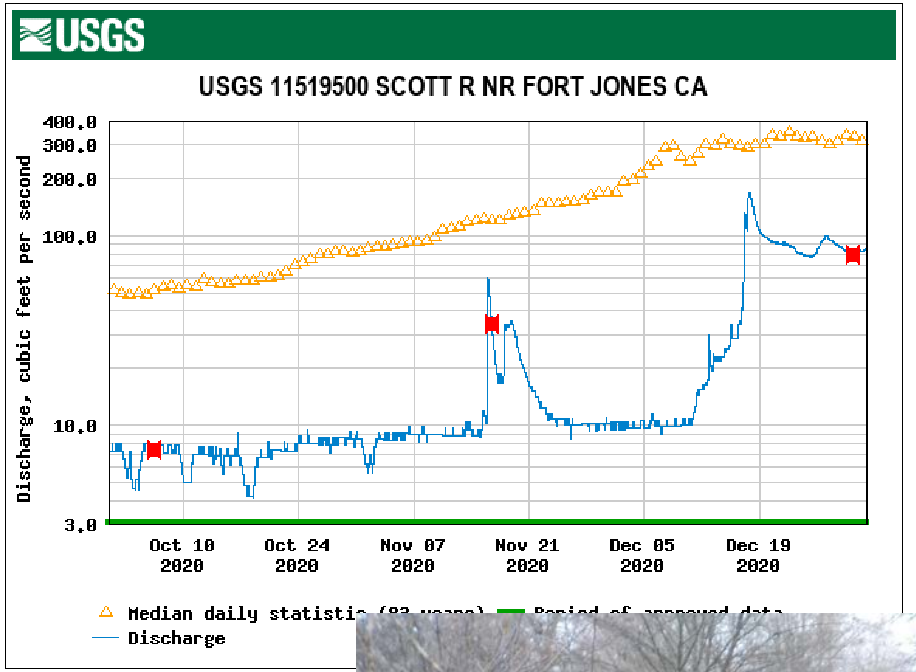
Scott River Watershed Council

E. Yokel - 4/24/2025

N

0 1.25 2.5 5 Miles

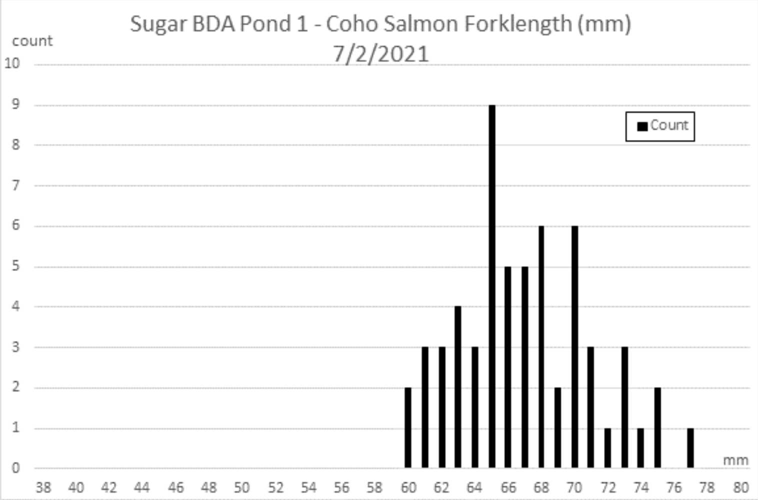
Coho Spawning 2020 – 2021 - Brood Year 2017 Returns as Adults

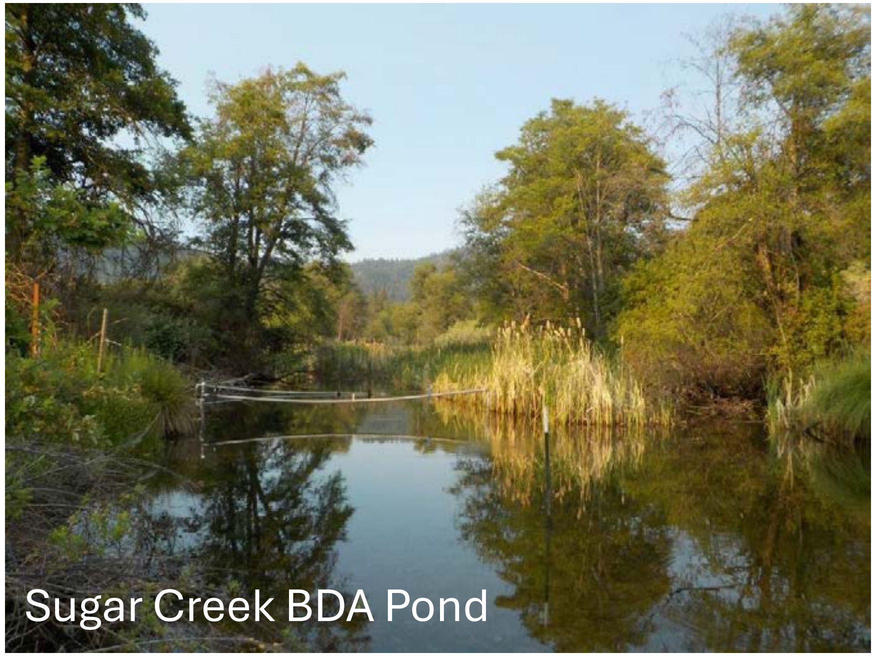


French Creek
1/11/2021

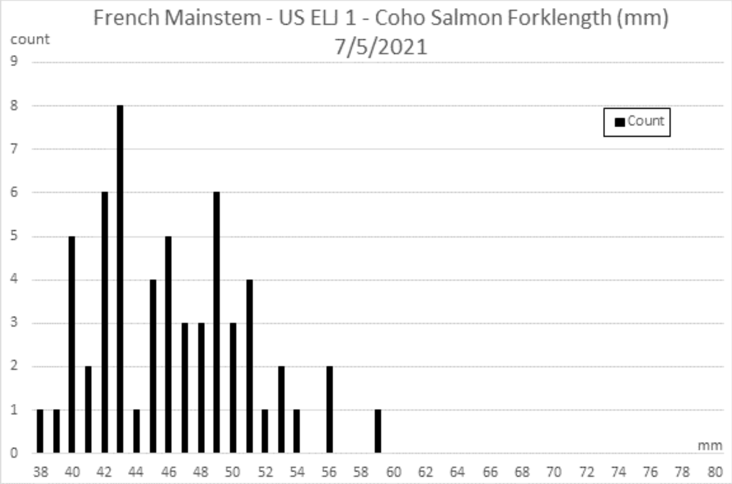
Brood Year 2020 Juvenile Sampling
July 2021 Fish Sampling

YOY Coho Salmon – Sugar Creek BDA Pond 1 – July 2, 2021

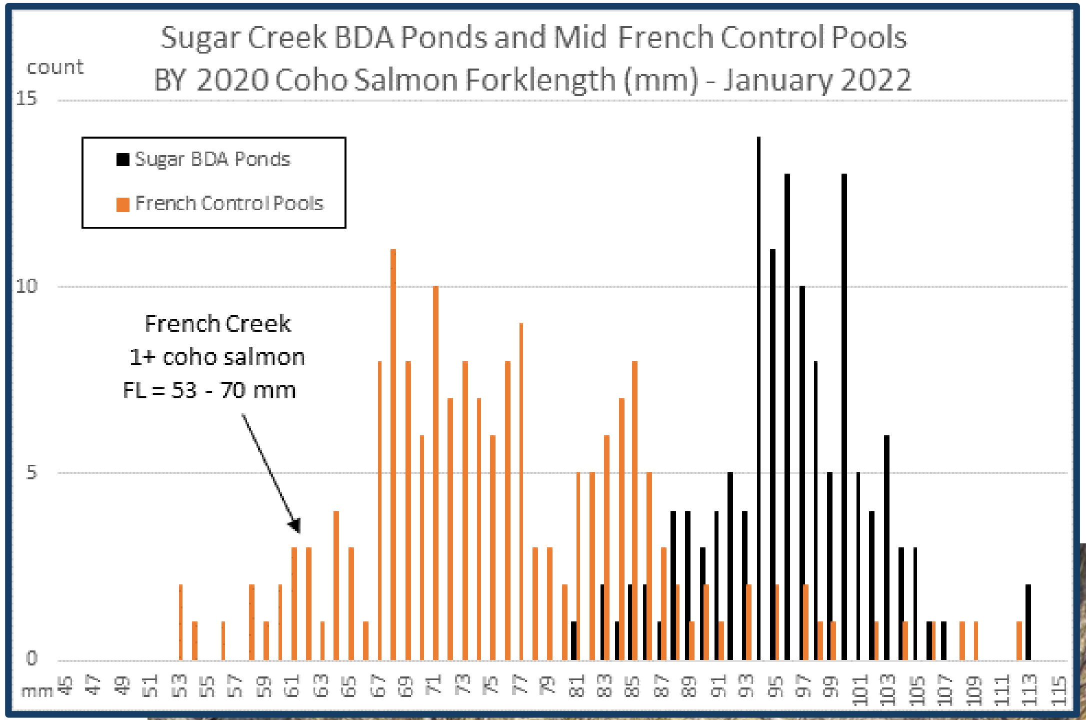




YOY Coho Salmon – French Creek Mainstem – Upstream ELJ1 – July 5, 2021



Brood Year 2020 Juvenile Sampling
January 2022 Fish Sampling

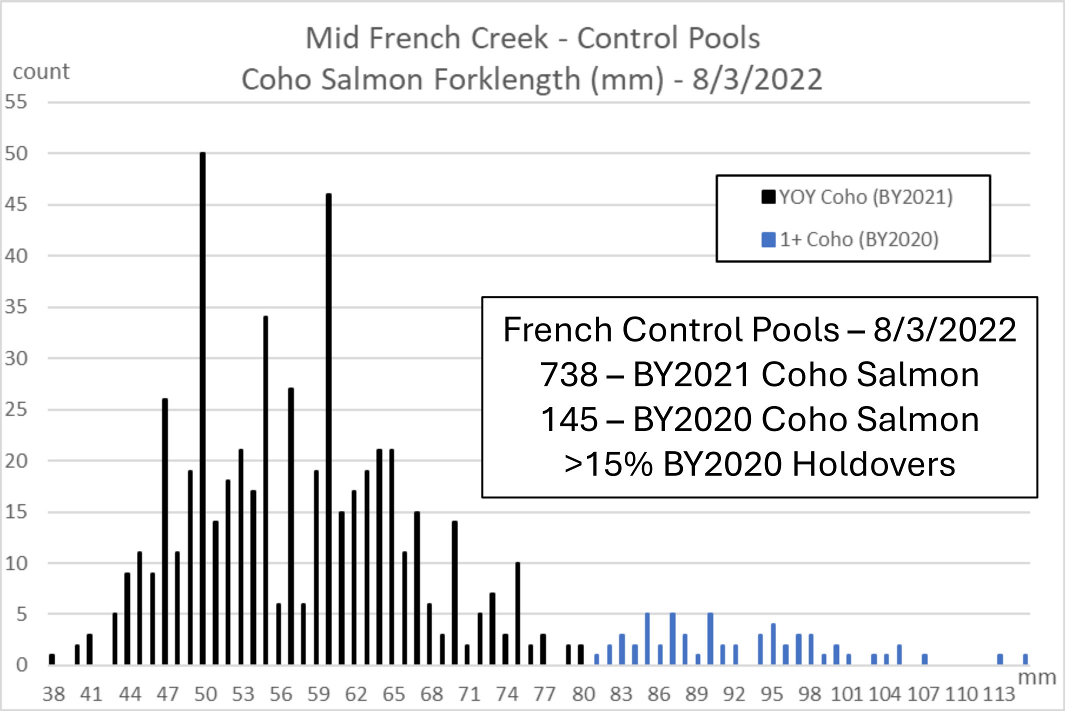


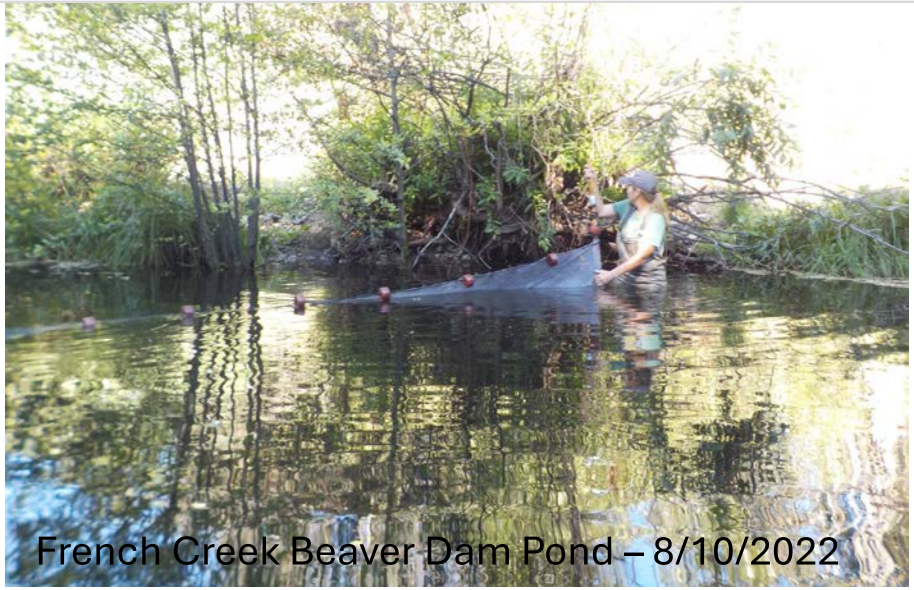

French Creek Control Pools – January 20, 2022


Sugar Creek BDA Pond – January 18, 2022


French Creek Control Pools – January 20, 2022

BY2021 Juvenile Sampling w/ BY2020 Holdovers
French Creek – August 2022

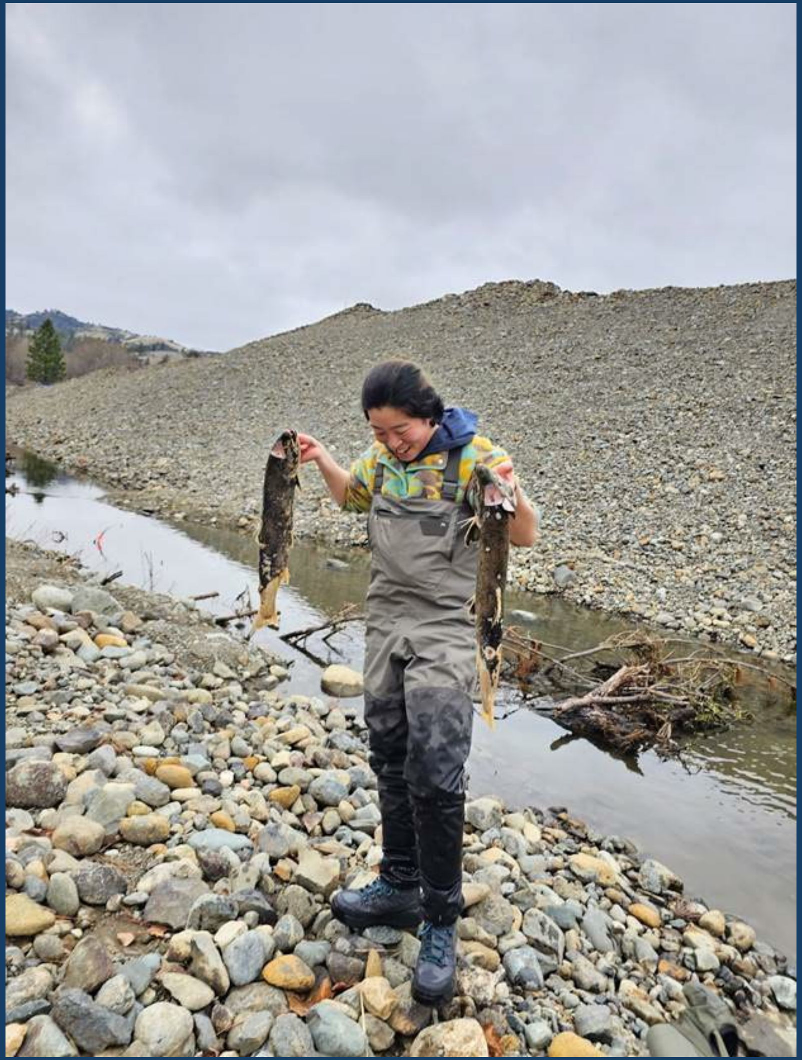



French Creek Beaver Dam Pond – 8/10/2022


8/3/2022 – BY2020 Coho Salmon
French Creek Control Pools


8/10/2022 – BY2021Coho Salmon
& BY2020 Coho Salmon
French Creek Beaver Dam Pond

Sugar Creek Coho Salmon Refugia Project

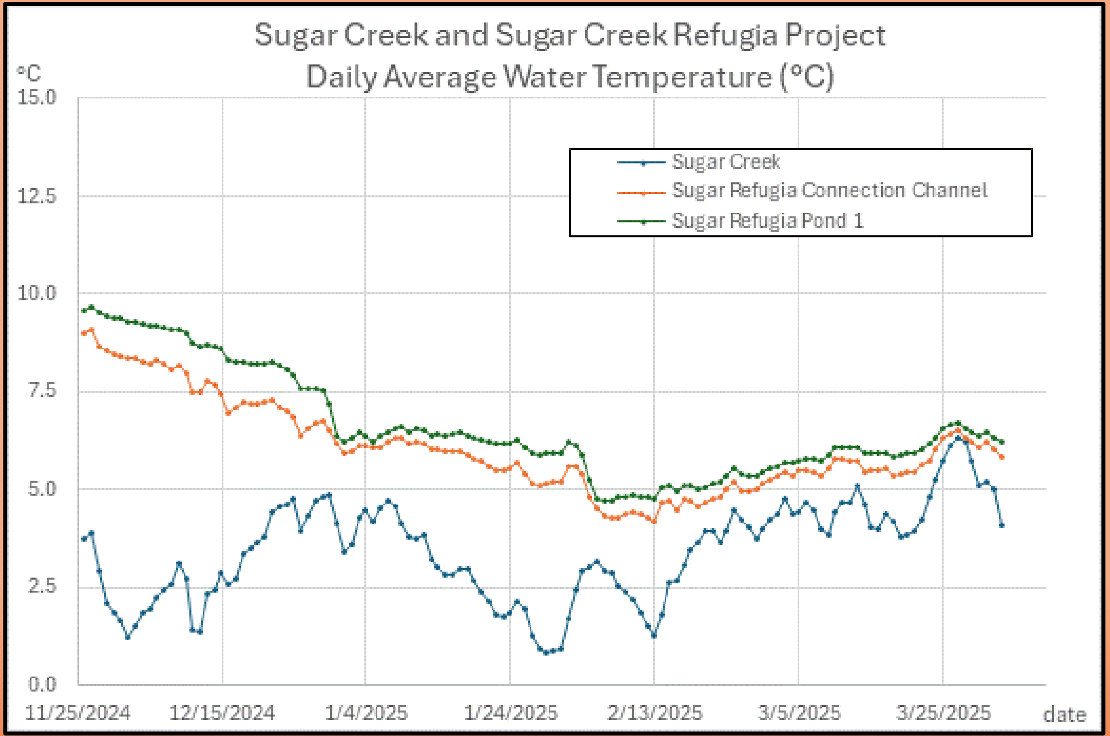


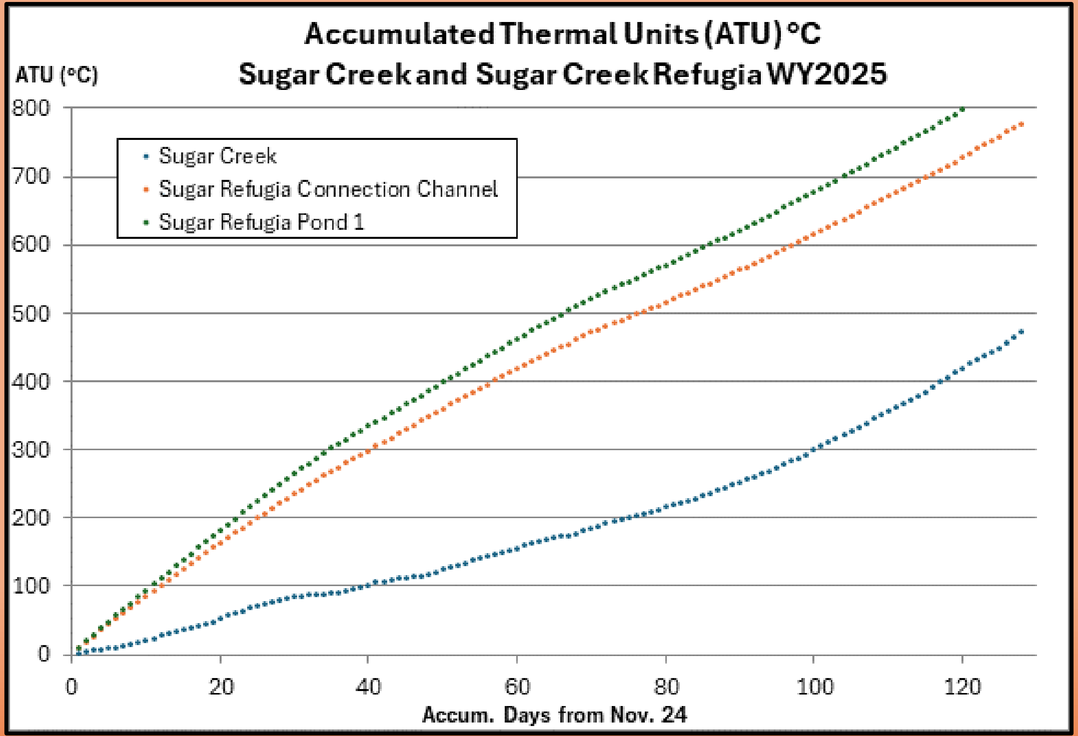
NORTH COAST RESOURCE PARTNERSHIP

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

National Fish and Wildlife Foundation

Access + Habitat Means Population Success





Date of ATU Achievement - 11/25/2024 Fertilization

Stage	ATU (°C)	Sugar Creek Mainstem	Sugar Refugia Connection Channel	Sugar Refugia Pond 1
To Eyed	220	2/6/2025	12/22/2024	12/19/2024
To Hatch	400	3/24/2025	1/19/2025	1/13/2025
	500	--	2/8/2025	1/29/2025
To Emergence	700	--	3/19/2025	3/8/2025
	800	--	--	3/24/2025

2024 PIT Tagged Adult Returns				Juvenile Tagging Event					
Detection Information				**Tag Origin**					
Stream	Array	Date	PIT Code	Tag date	Species	Location	FL	Weight	Brood Year
Sugar Creek	1A	11/18/2024	989001039966031	8/1/2022	Cohsal	Sugar - BDA Pond 1 - Alder Hole	72	4.3	BY2021
Sugar Creek	1A	11/23/2024	989001041194314	9/19/2022	Cohsal	Sugar - BDA Pond 1	75	4.5	BY2021
Sugar Creek	1A	12/16/2024	989001041194828	9/20/2022	Cohsal	Sugar - Jensen Control - Pool 3 (Big Pool)	67	3.6	BY2021
Sugar Creek	1A	12/7/2024	989001041195076	9/22/2022	Cohsal	French - Control Pool 3	70	3.7	BY2021
Sugar Creek	1A	11/24/2024	989001041195189	10/24/2022	Cohsal	French - Control Pool 4	70	3.4	BY2021
Sugar Creek	1A	11/26/2024	989001044295191	10/28/2022	Cohsal	Sugar - BDA Pond 1 - Alder Hole	68	3.7	BY2021
Sugar Creek	1A	11/28/2024	989001044295694	2/1/2023	Cohsal	Sugar - BDA 1 - Alder Hole	78	4.7	BY2021
Sugar Creek	1A	11/23/2024	989001044295700	2/2/2023	Cohsal	Sugar - Below Natural Beaver Dam	79	5	BY2021
Sugar Creek	1A	11/19/2024	989001045427633	11/7/2023	Cohsal	Sugar - Below Natural Beaver Dam	91	8.1	BY2022
French Creek	F2	11/22/2024	989001039966514	8/2/2022	Cohsal	French - Beaver Dam Pond	94	10.1	BY2020
French Creek	F1	11/22/2024	989001039966522	8/2/2022	Cohsal	French - Beaver Dam Pond	93	10.4	BY2020
French Creek	F2	11/21/2024	989001041194417	8/10/2022	Cohsal	French - Beaver Dam Pond	102	11.1	BY2020
French Creek	F1	11/22/2024	989001041194464	8/10/2022	Cohsal	French - Beaver Dam Pond	68	3.3	BY2021
French Creek	F1	12/14/2024	989001041195189	10/24/2022	Cohsal	French - Control Pool 4	70	3.4	BY2021
French Creek	F1	11/22/2024	989001044295670	2/2/2023	Cohsal	Sugar Creek - OCP	93	8.7	BY2021

Fish and humans need habitat and water.

Drivers of Surface Water Response and Persistence in a Non-Perennial Stream Network

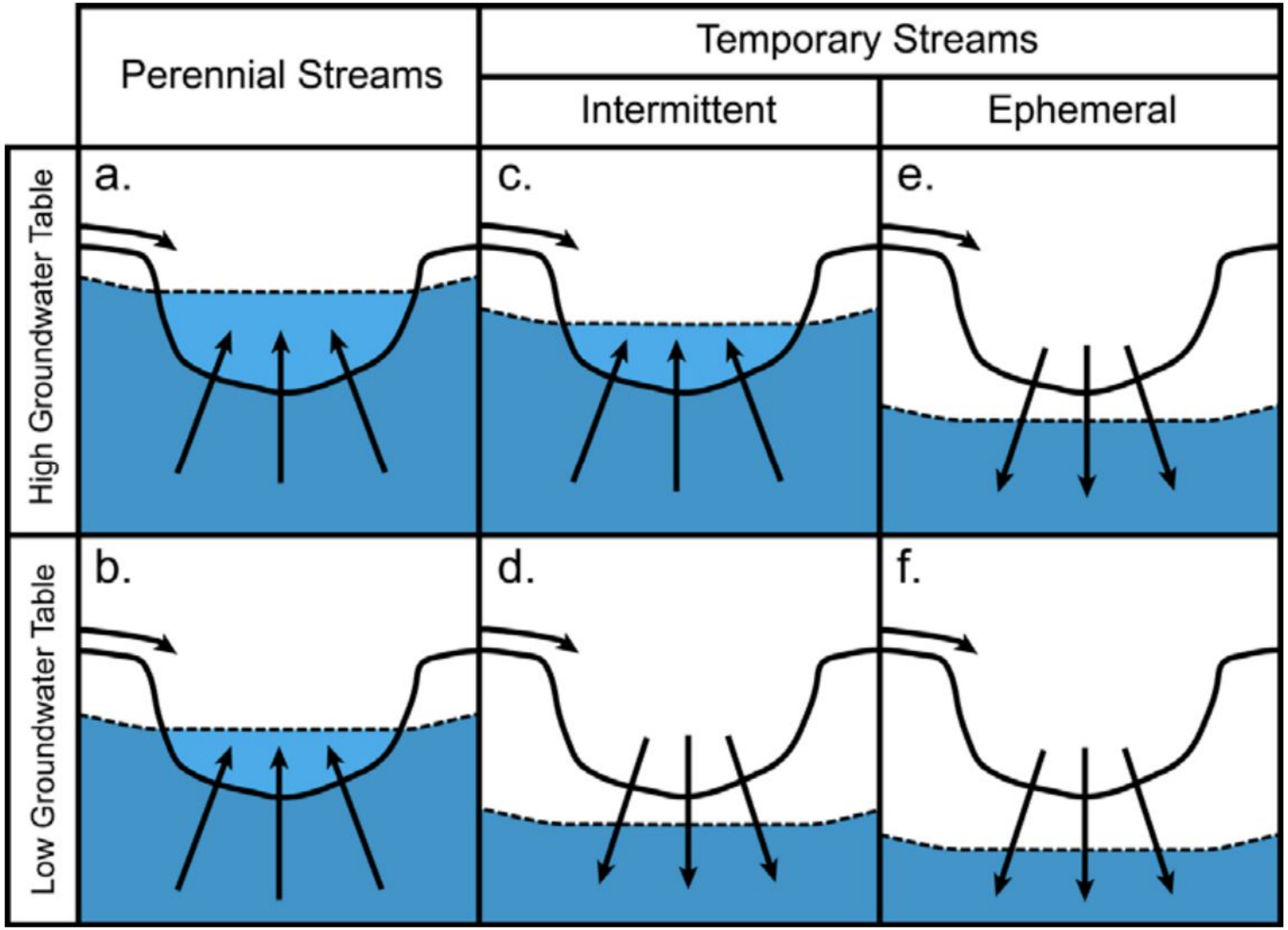
Lauren Giggy,
Dept. of Earth and Planetary Sciences, University of California, Santa Cruz

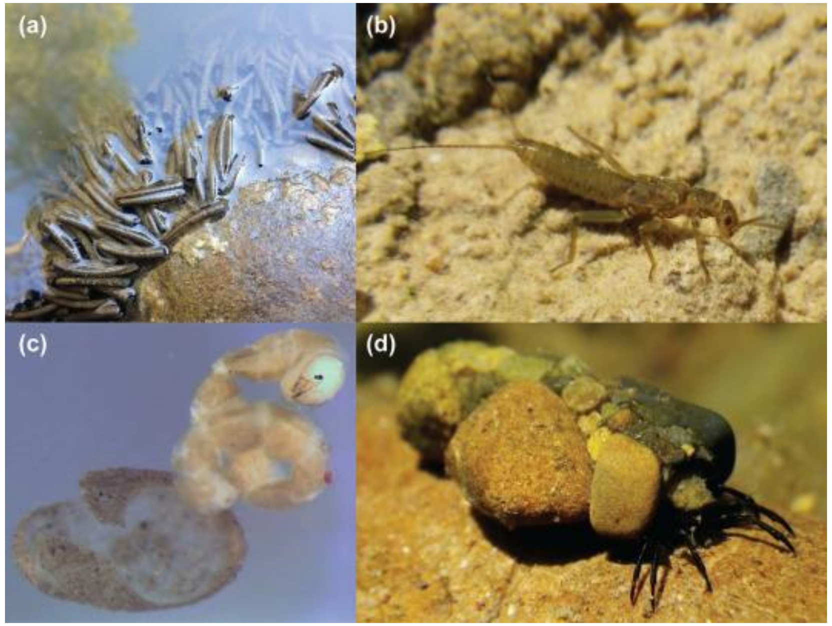
Adam Price - Research Hydrologist, USFS
Margaret Zimmer – Associate Professor, University of Wisconsin, Madison

Non-perennial streams - Alternate between flowing and dry states

Intro

Types of non-perennial streams





79% of U.S. streams lengths have non-perennial streamflow (Jaeger et al., 2021)

In the western U.S., >50% of all streamflow is sourced from non-perennial streams
(Brinkerhoff et al., 2024)

Critical aquatic, riparian, and terrestrial habitat

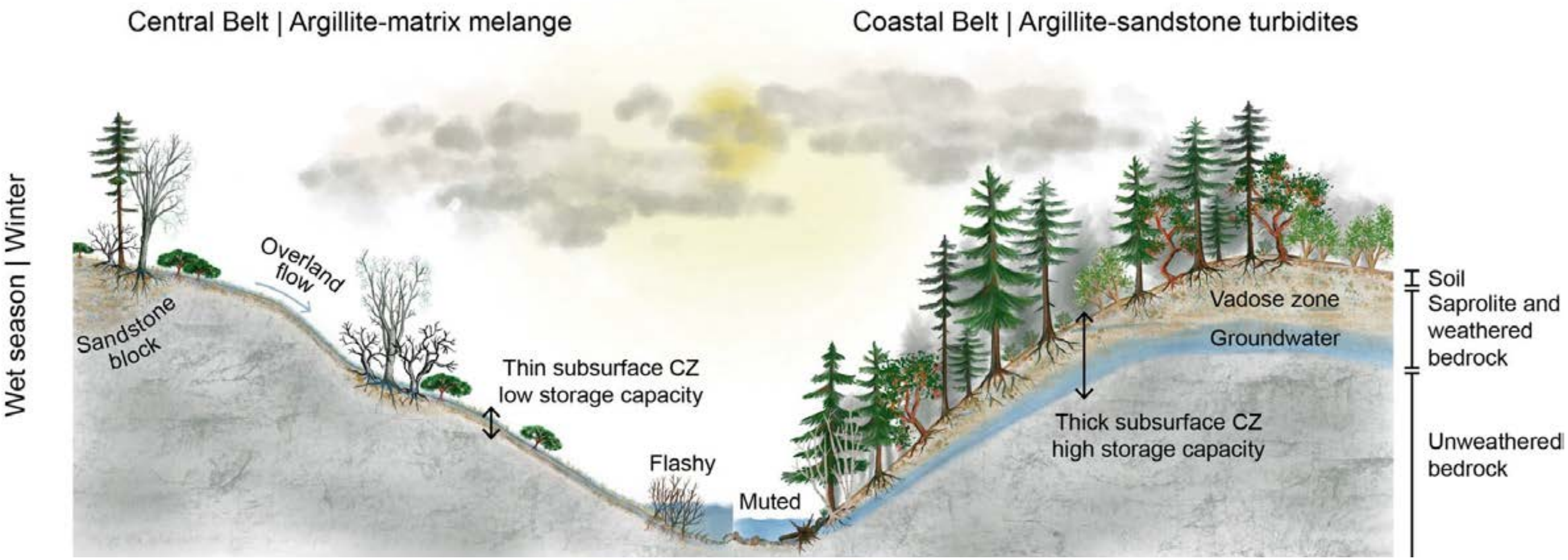
It is critical that we understand how non-perennial streams function

Non-perennial streams have **complex patterns of surface water**

Basic principle:
Surface water emerges when it can no longer be accommodated by the subsurface

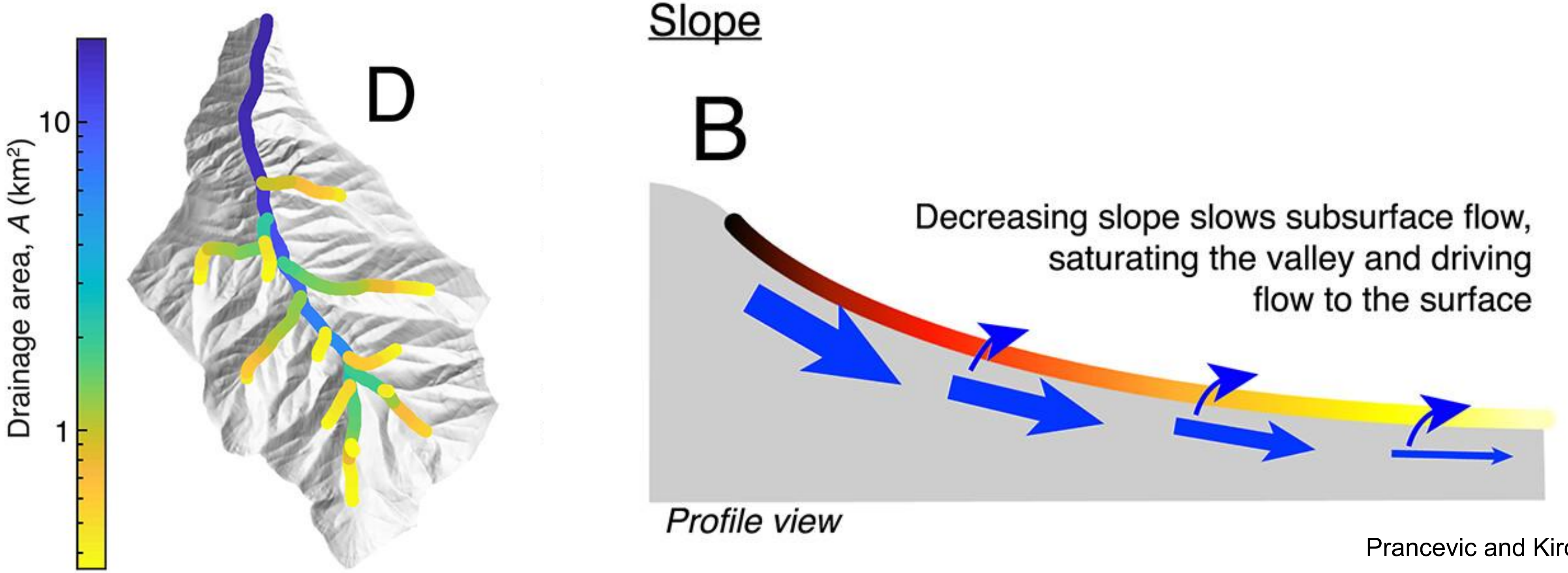
Basic principle:
Surface water emerges when it can no longer be accommodated by the subsurface

1) **Subsurface properties** should strongly influence surface water response and persistence



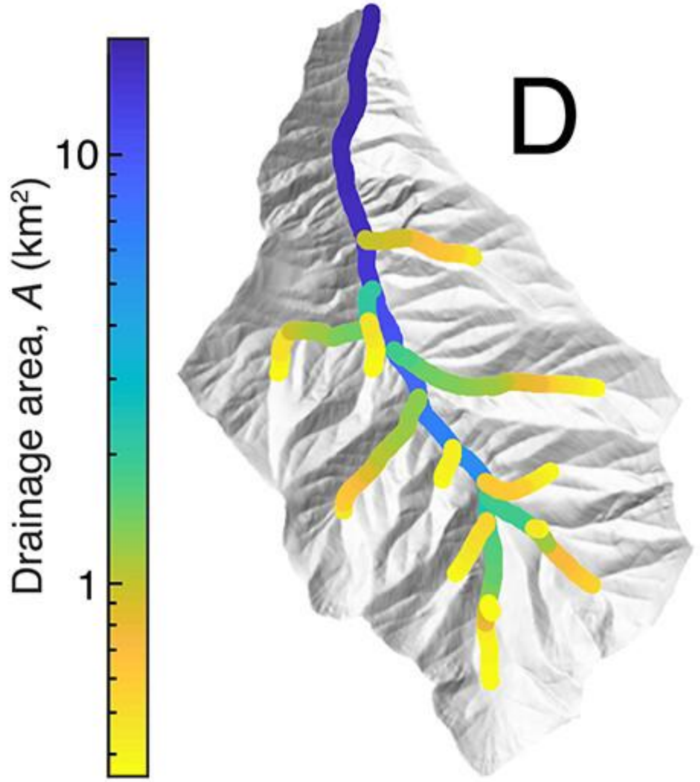
Dralle et al., 2023; Lovill et al., 2018; Hahm et al., 2019

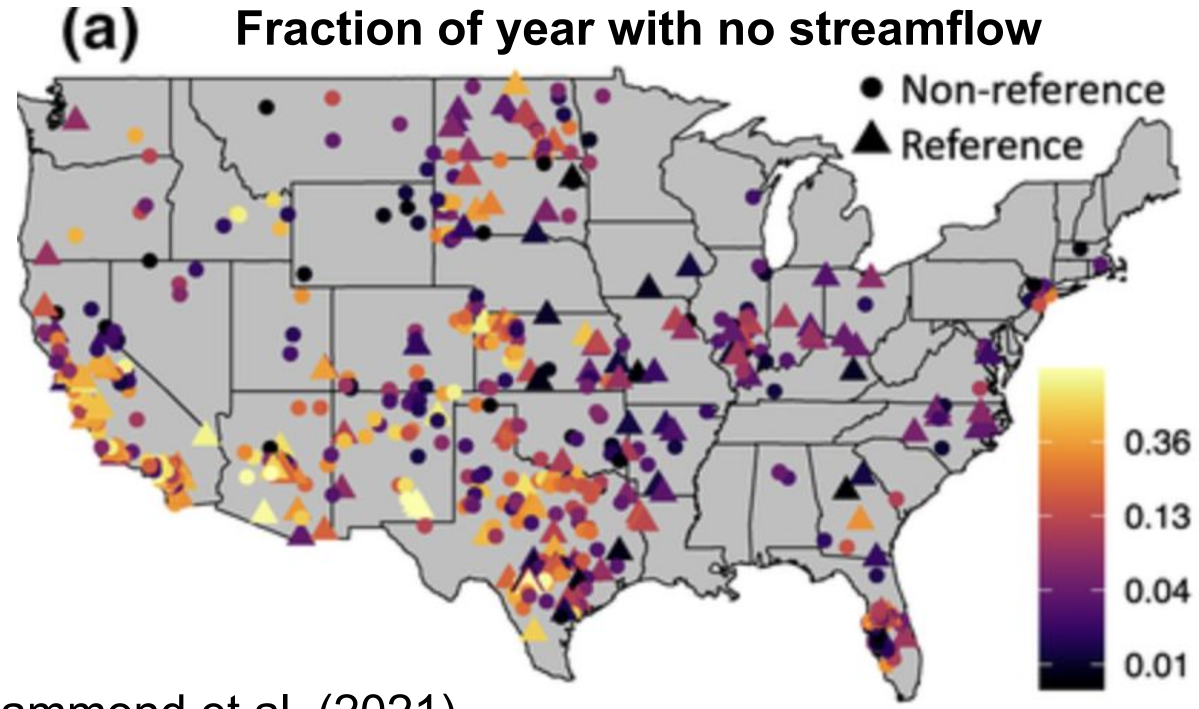
2) Numerous other studies have shown **links between topography and surface water response and persistence** (Prancevic and Kirchner, 2019; Warix et al., 2021)



Prancevic and Kirchner, 2019

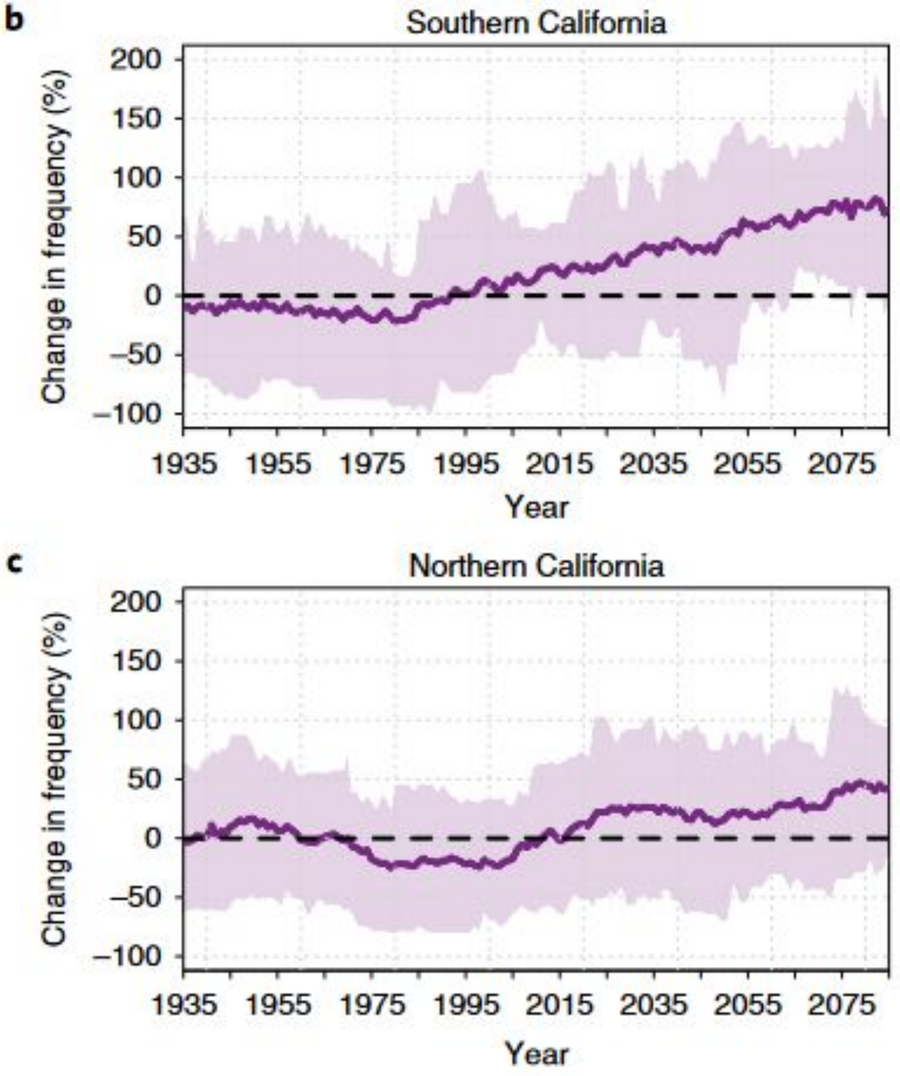
3) The rate and volume of incoming water strongly influence non-perennial streamflow response and persistence - from upstream, from groundwater, from precipitation..





Hammond et al. (2021)

3) The rate and volume of incoming water strongly influence non-perennial streamflow response and persistence

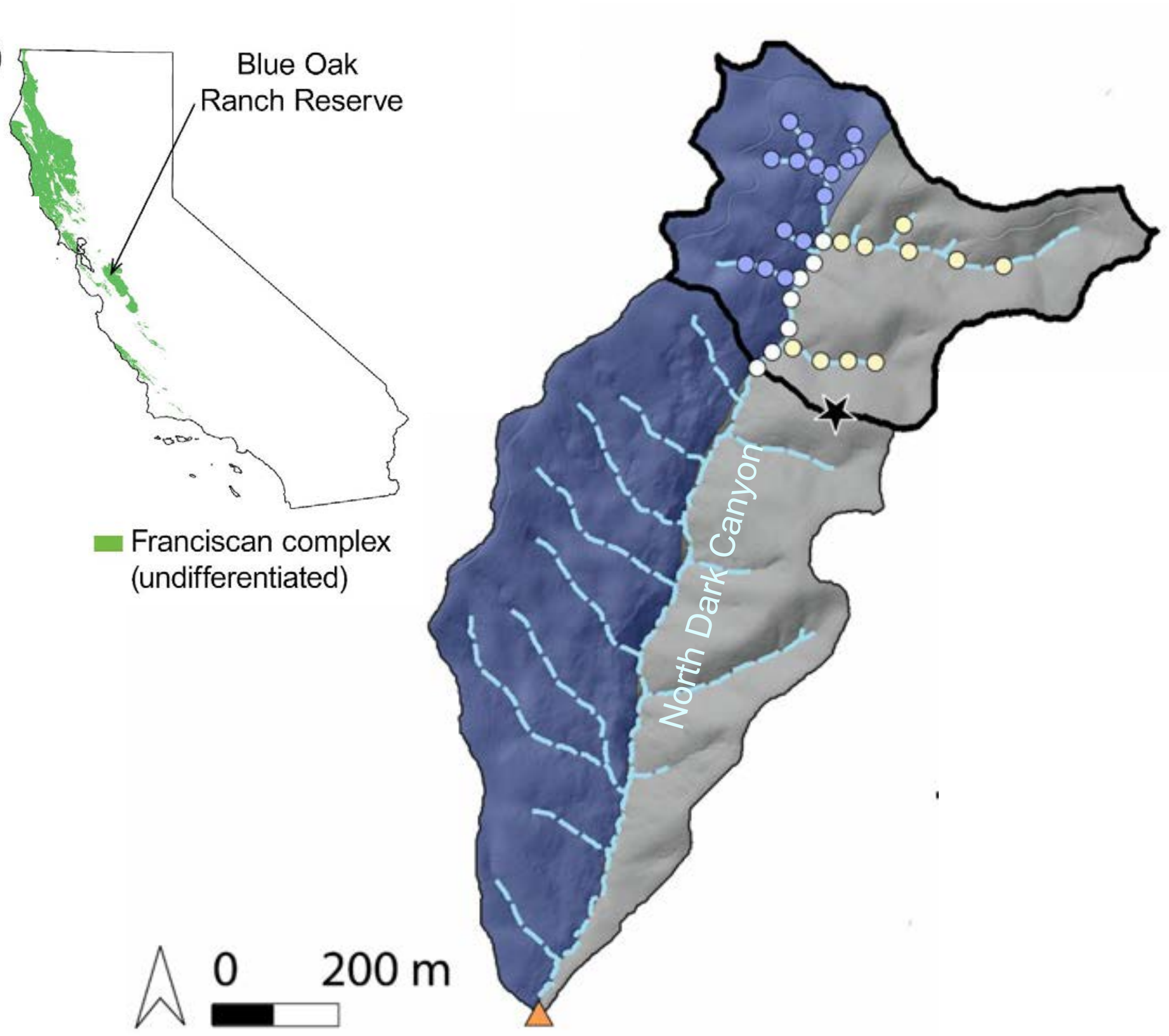


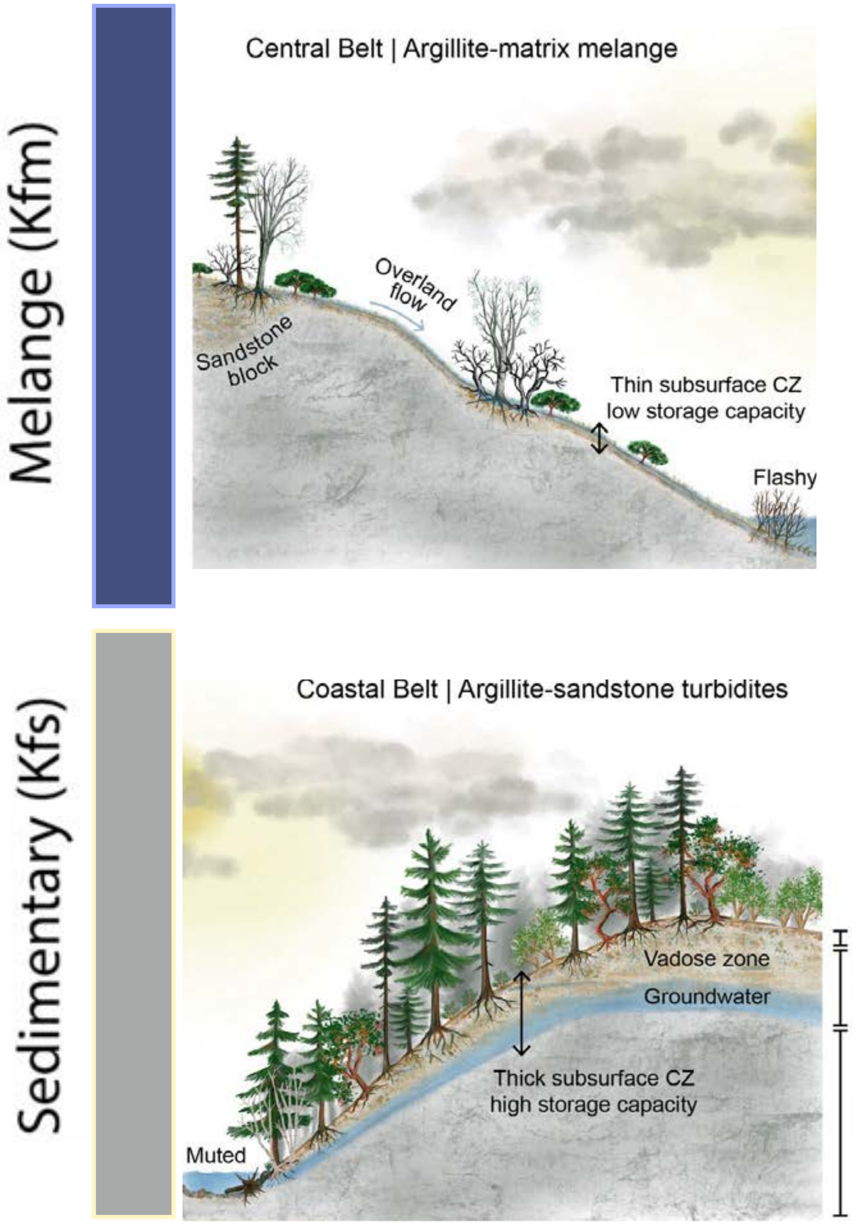
- Shifts in climate, including **extended drought AND extremely wet conditions,** are expected in future climate scenarios for CA

Swain et al. (2018)

(Photos by
Justin Sullivan/Getty Image; Josh Edelson/ Getty Images)

Role of **lithology, topography, and precipitation characteristics** on surface water activation and persistence across a **multi-year drought**

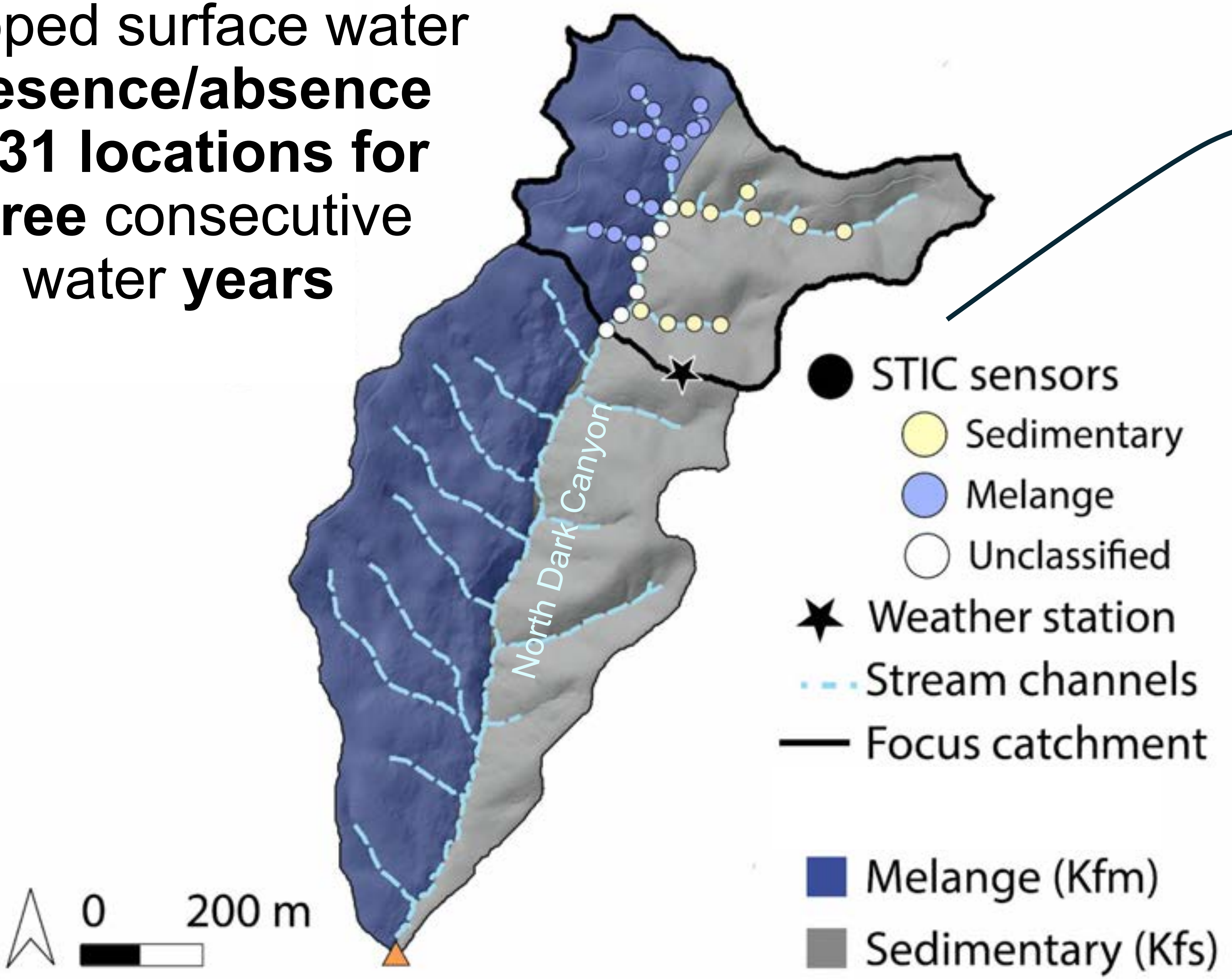




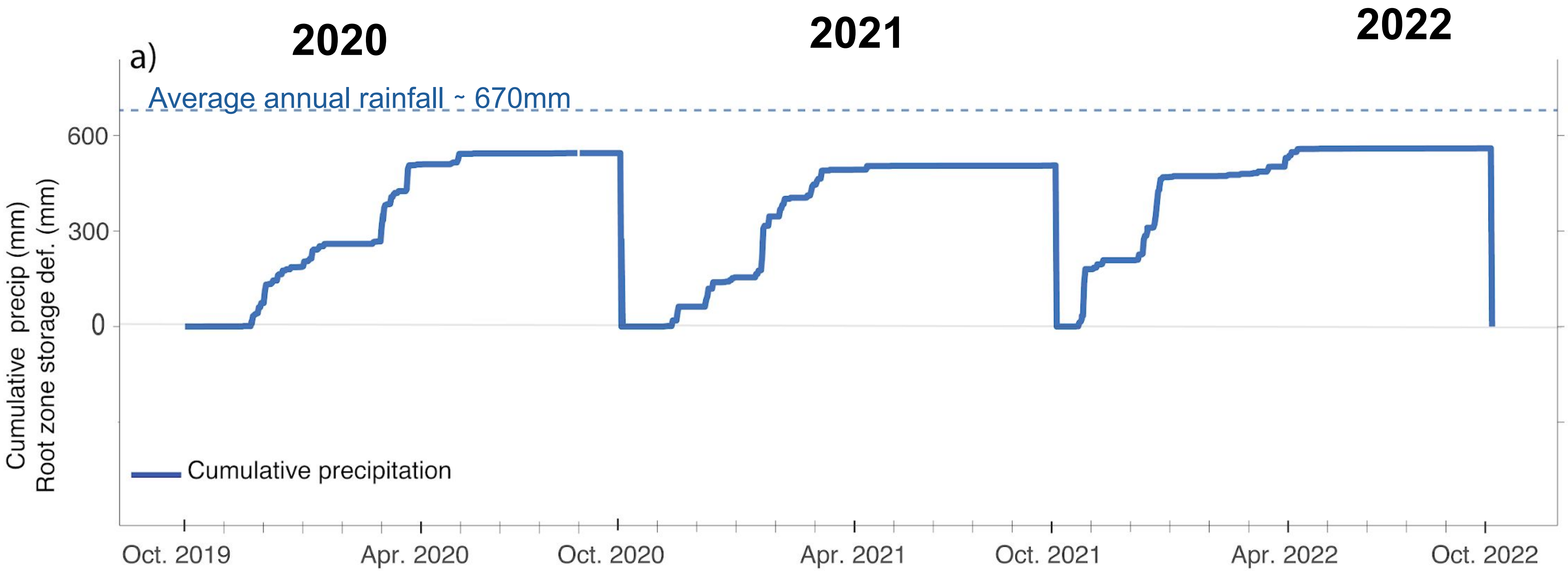
(Dralle et al, 2023)

Methods

Mapped surface water **presence/absence at 31 locations for three** consecutive water **years**

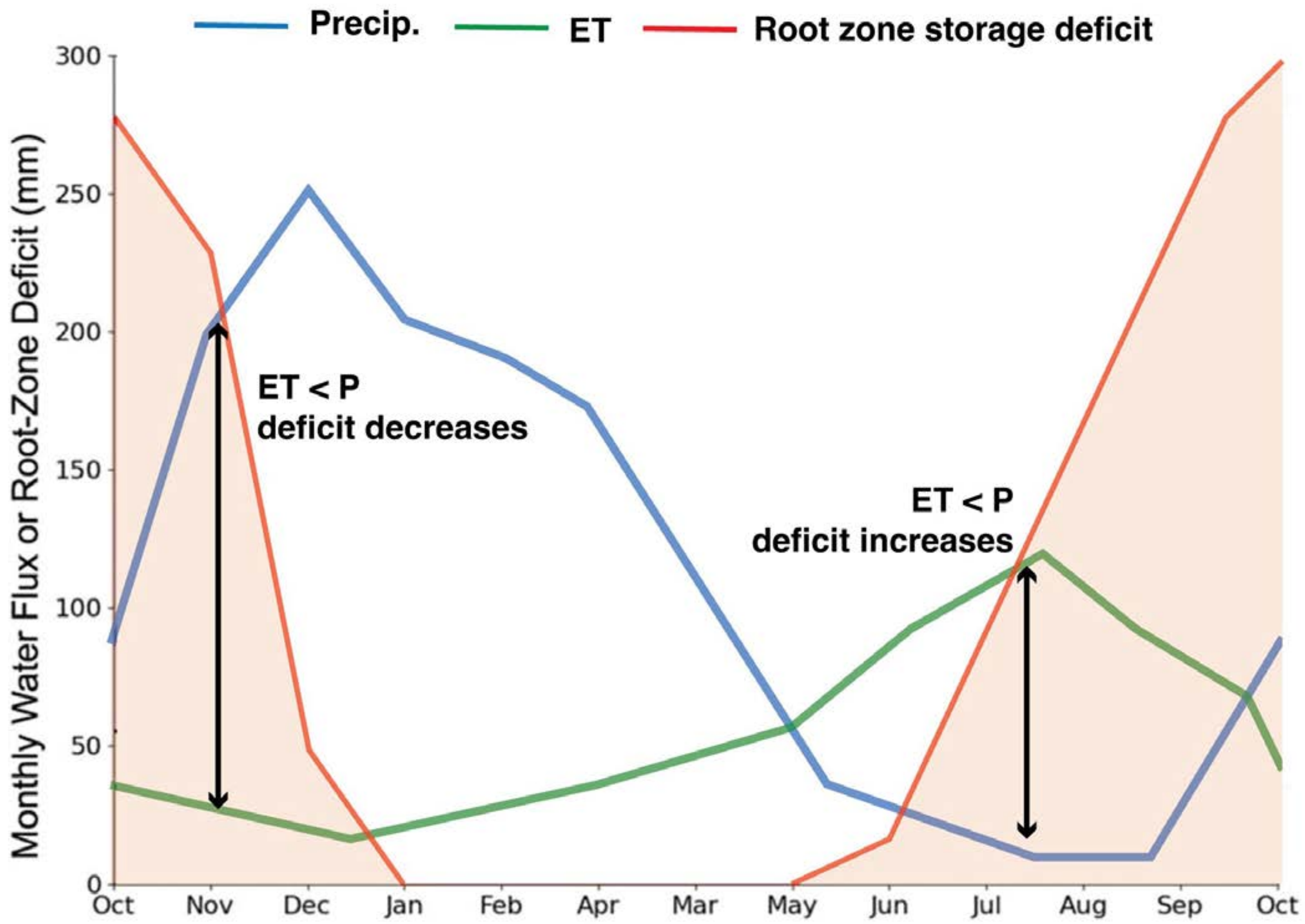


Low rainfall across the three study years



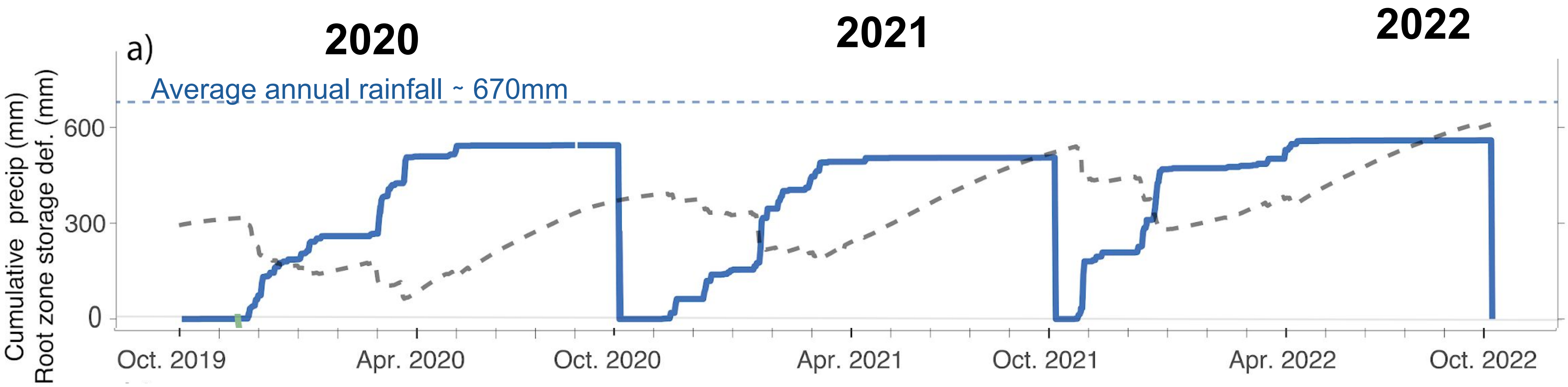
Methods

Cumulative storage deficit / Root zone storage deficit

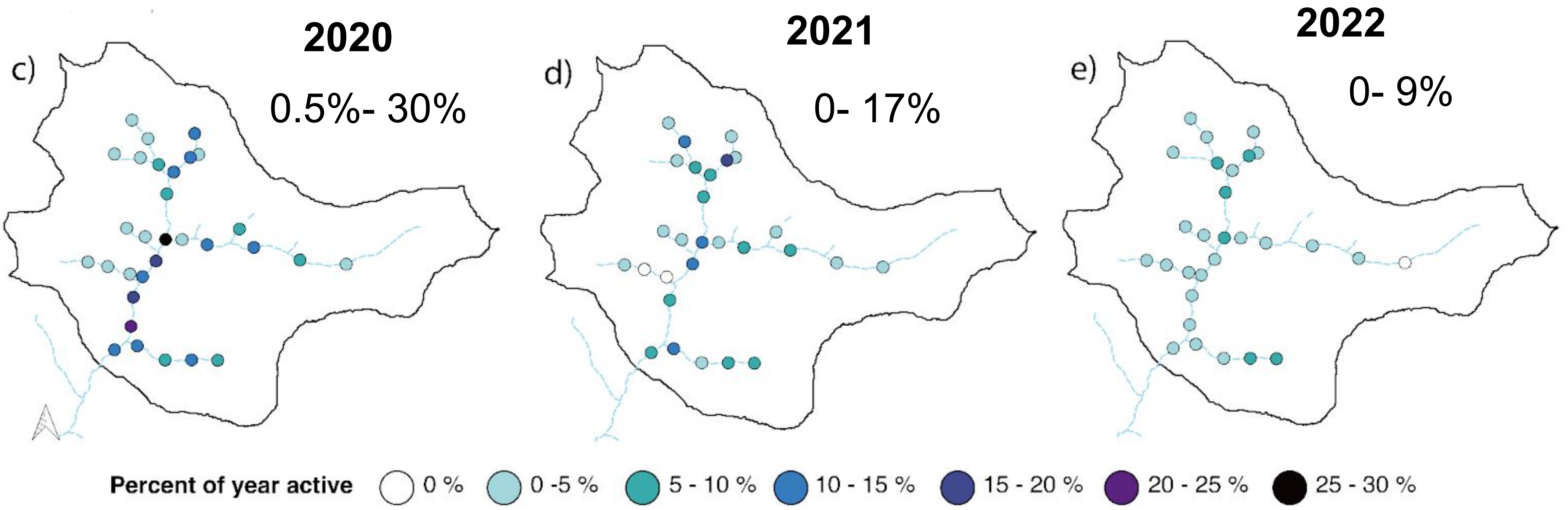


Modified from Ehlert et al., 2024

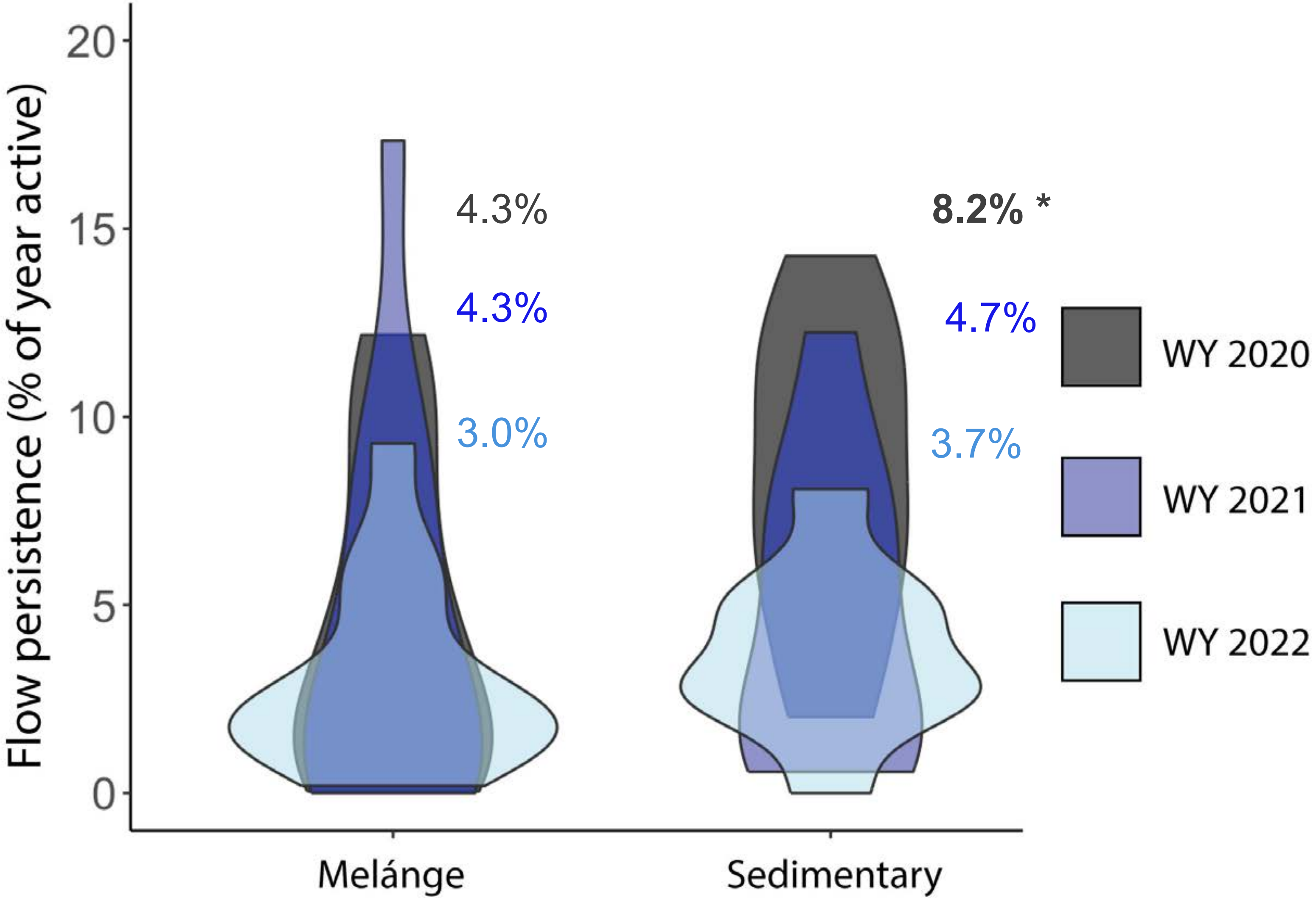
Low rainfall, drought, and **high storage deficits** across the three study years

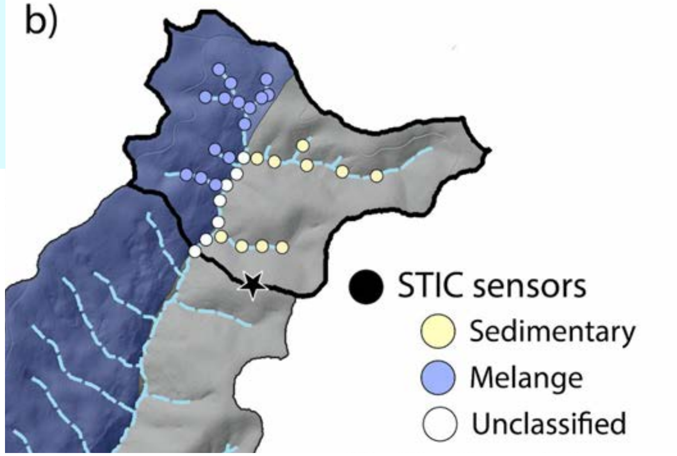


Declining annual **surface water persistence** with each year of ongoing drought



1) Lithology and surface water persistence

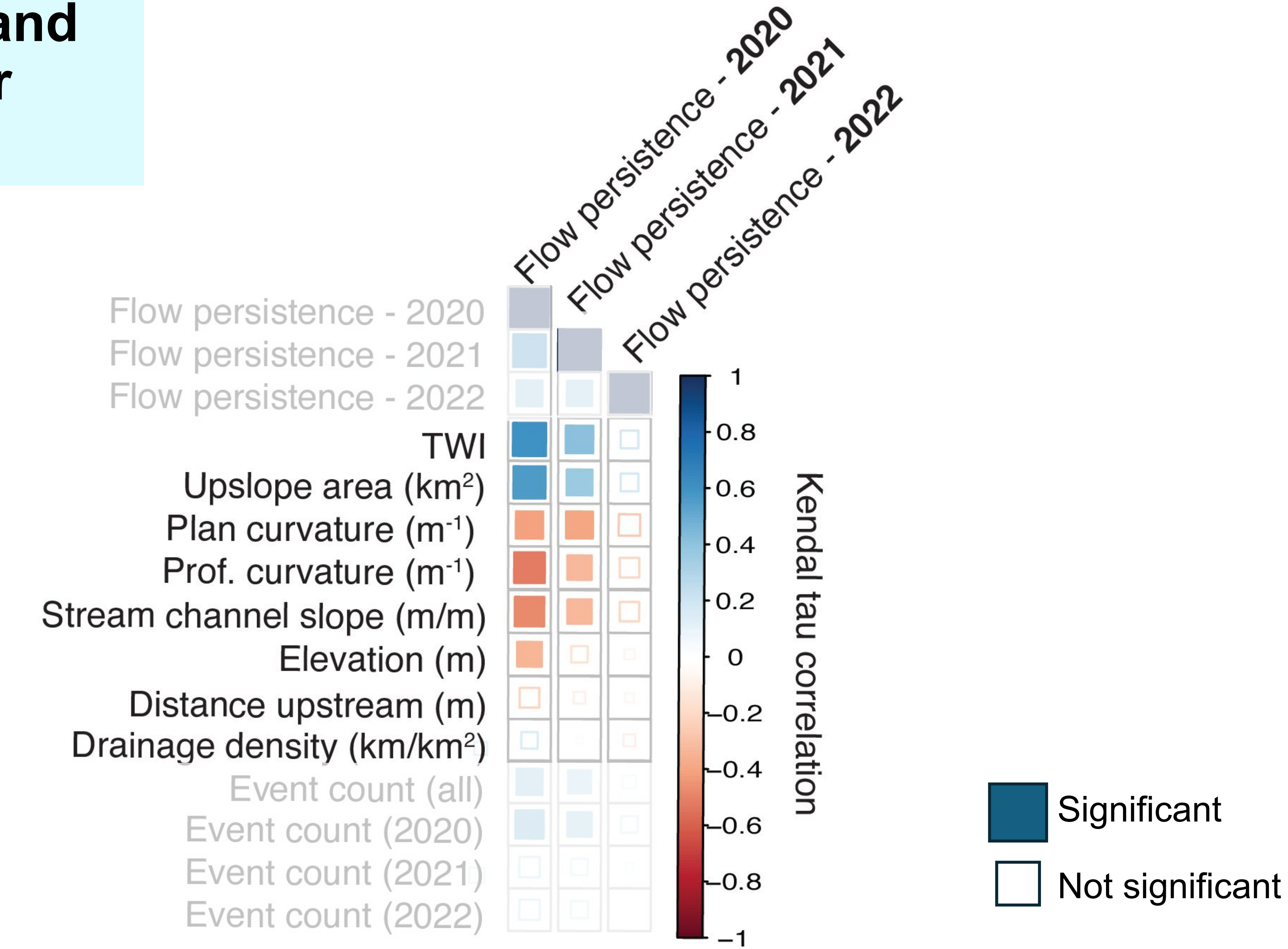




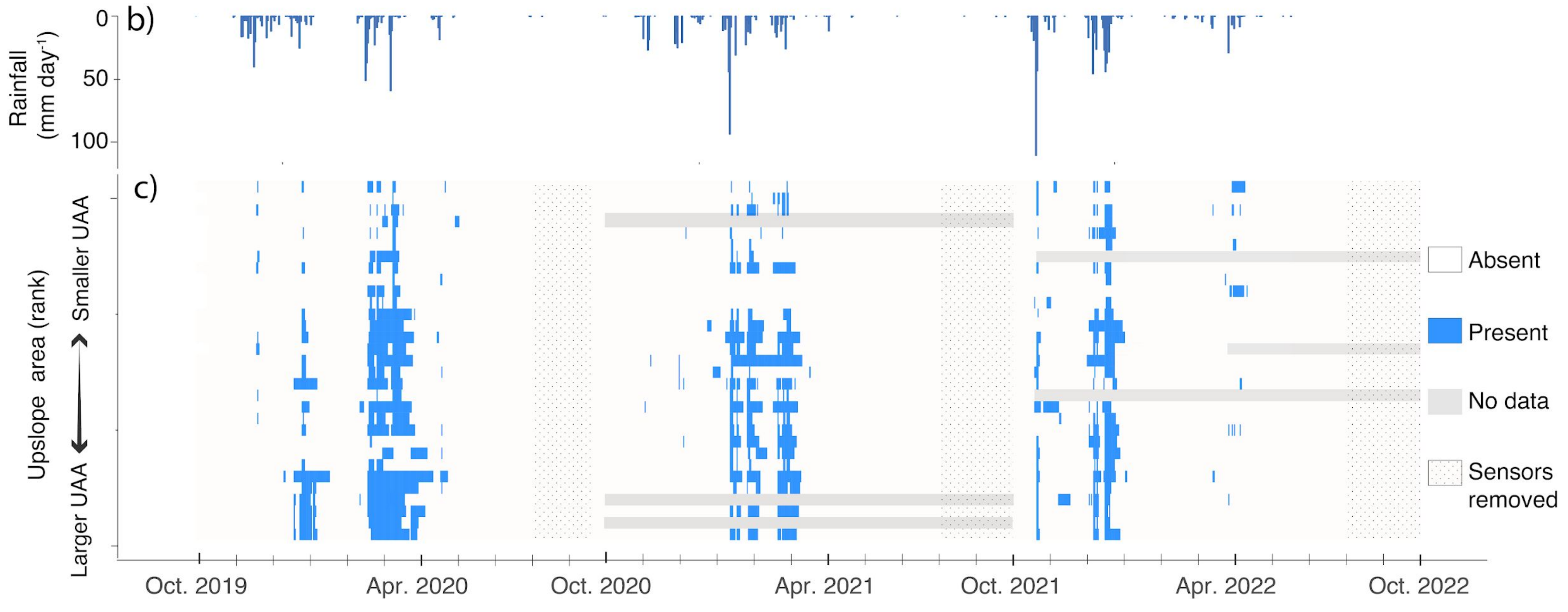
Sedimentary regions have slightly elevated surface water persistence, likely driven by differences in water storage

2) Topography and surface water persistence

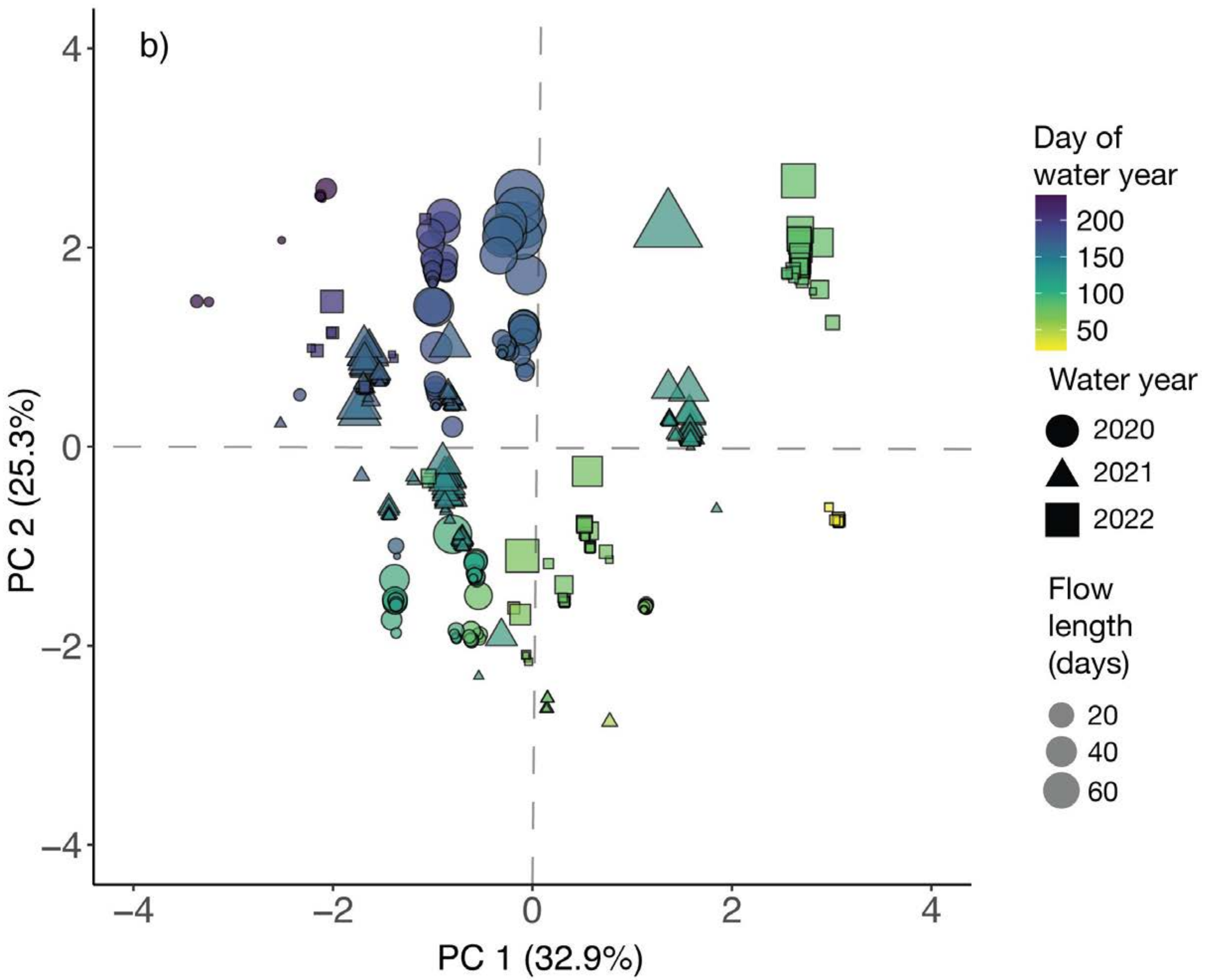
Declining relationships between topography and surface water persistence



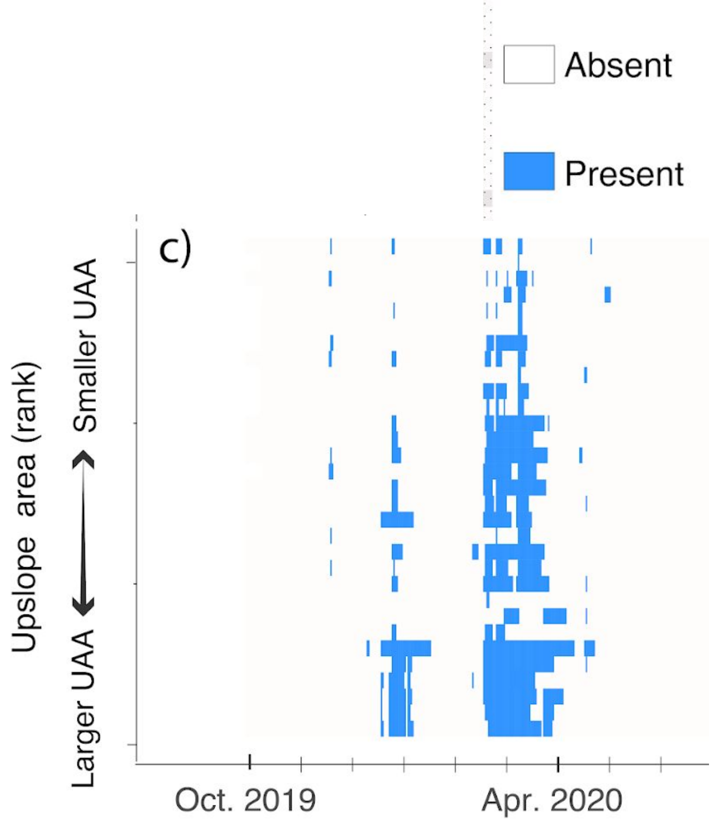
3) Influence of precipitation event characteristics

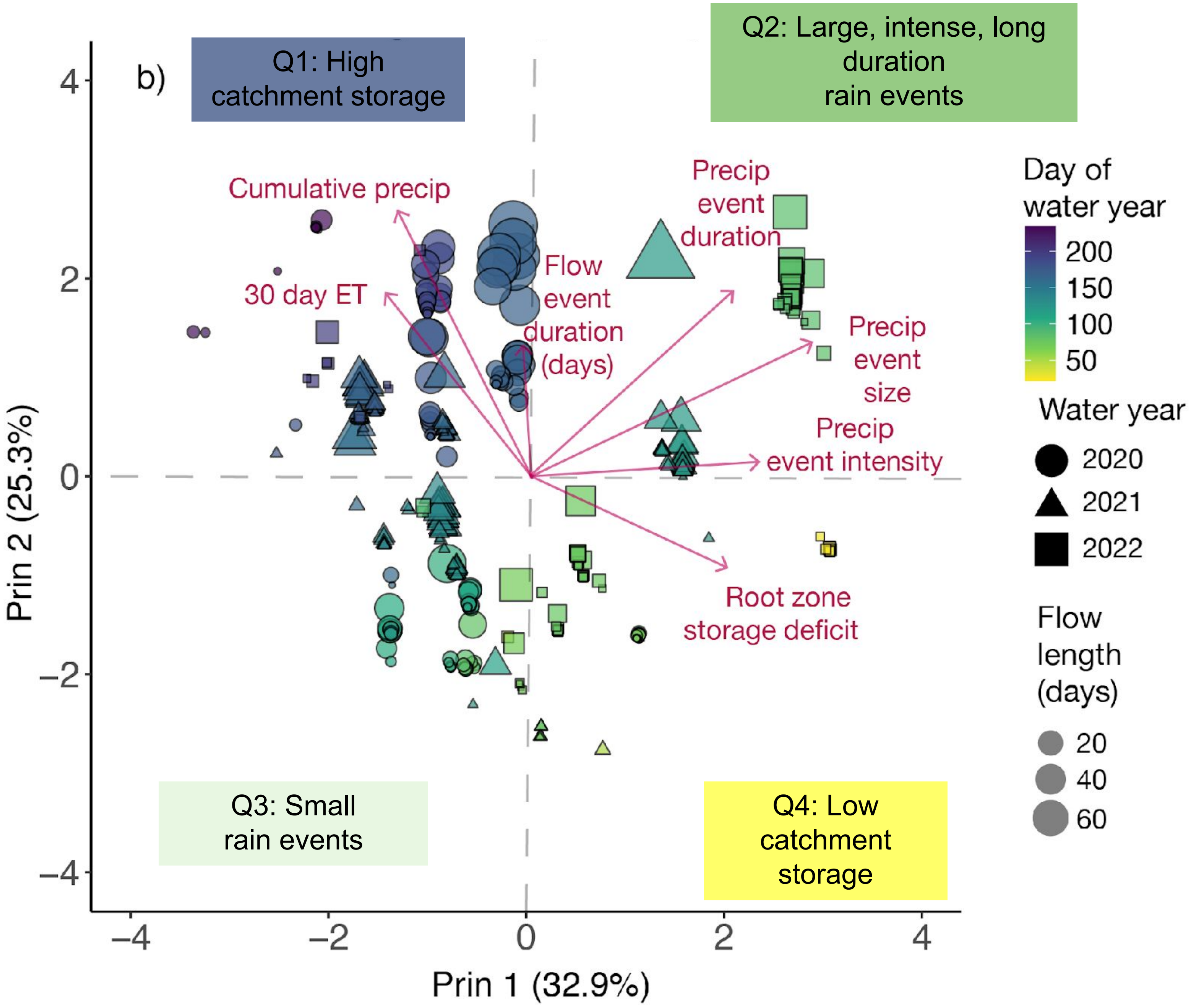


Calculated the **length and timing of each flow event** at each sensor and **characteristics of the associated precipitation event**



- Principal component analyses reduce complex data sets
- Emphasize variation in the data to reveal patterns

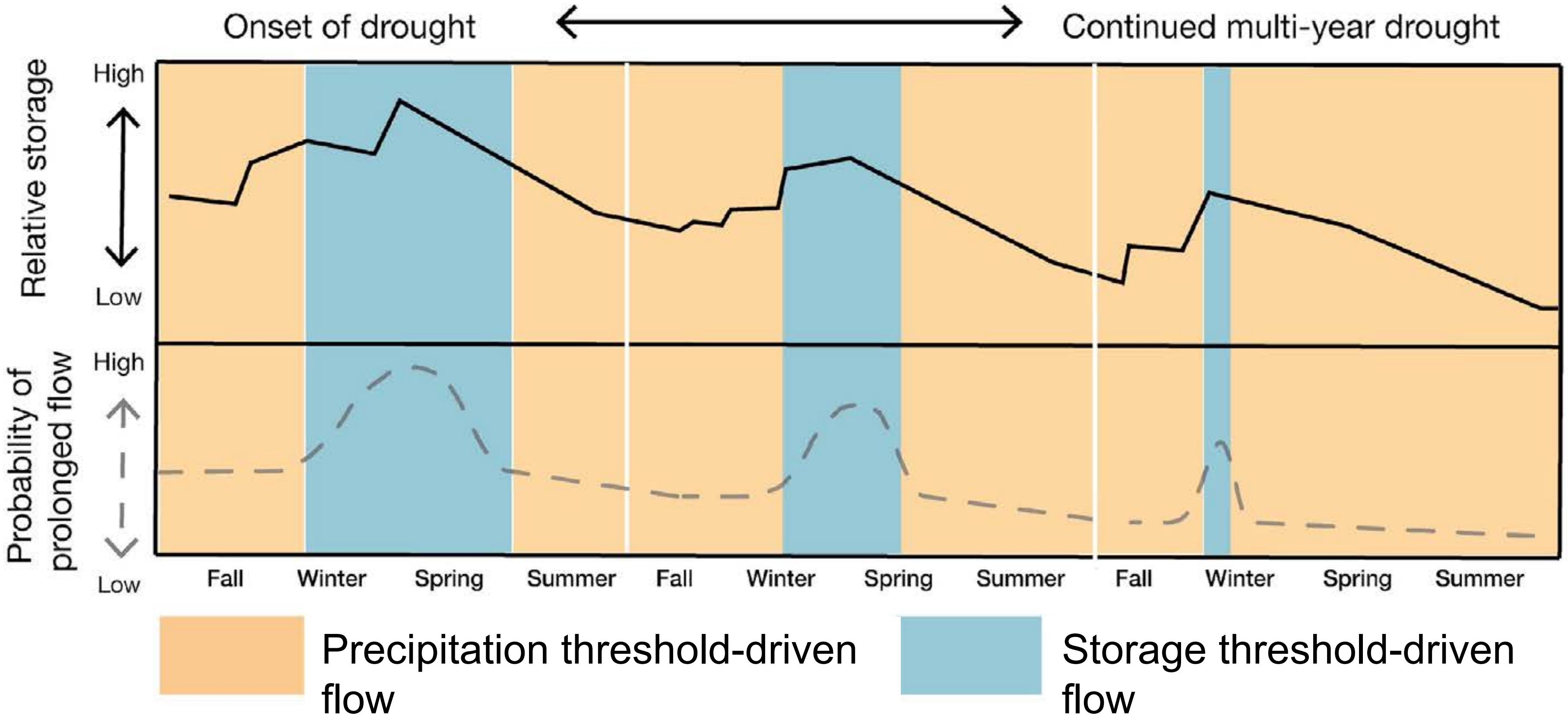




- Principal component analyses reduce complex data sets
- Emphasize variation in the data to reveal patterns
- **Flow is driven by high storage states in 2020 and 2021**
- **Flow is driven by precipitation event characteristics in 2022**

Results

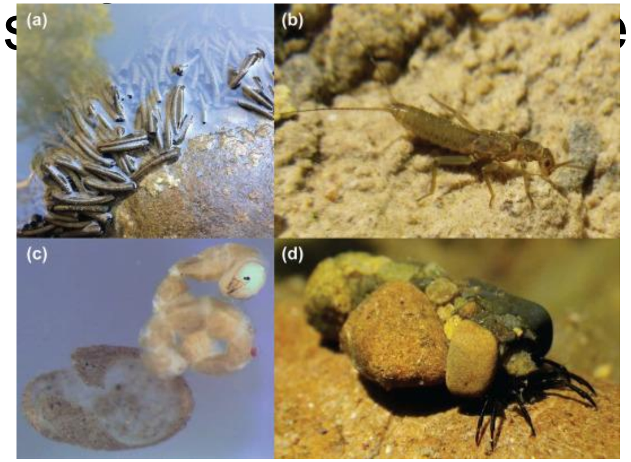
With ongoing drought, the drivers of surface water response and persistence **shifted from storage threshold responses to precipitation intensity threshold responses**



- This non-perennial system is very susceptible to drought conditions

- Sedimentary, low-slope, higher drainage area regions were not able to overcome the ongoing dry conditions and suggests a shifts in the dominant runoff mechanisms

- Not all precipitation is equal. Sporadic large, high intensity rainfall may not
  ontribute to s ence for strea



Intermittent Rivers and Ephemeral Streams, *Ecology and Management*

Conclusions

Acknowledgments

Adam Price - Research Hydrologist, USFS

Margaret Zimmer – Associate Professor, University of Wisconsin, Madison

Zac Tuthill and Zac Harlow– Blue Oak Ranch Reserve

Zimmer Hydrology Lab

Questions?

Groundwater Recharge and Flow Augmentation: Two Pond Projects in a Mattole Headwaters Trib

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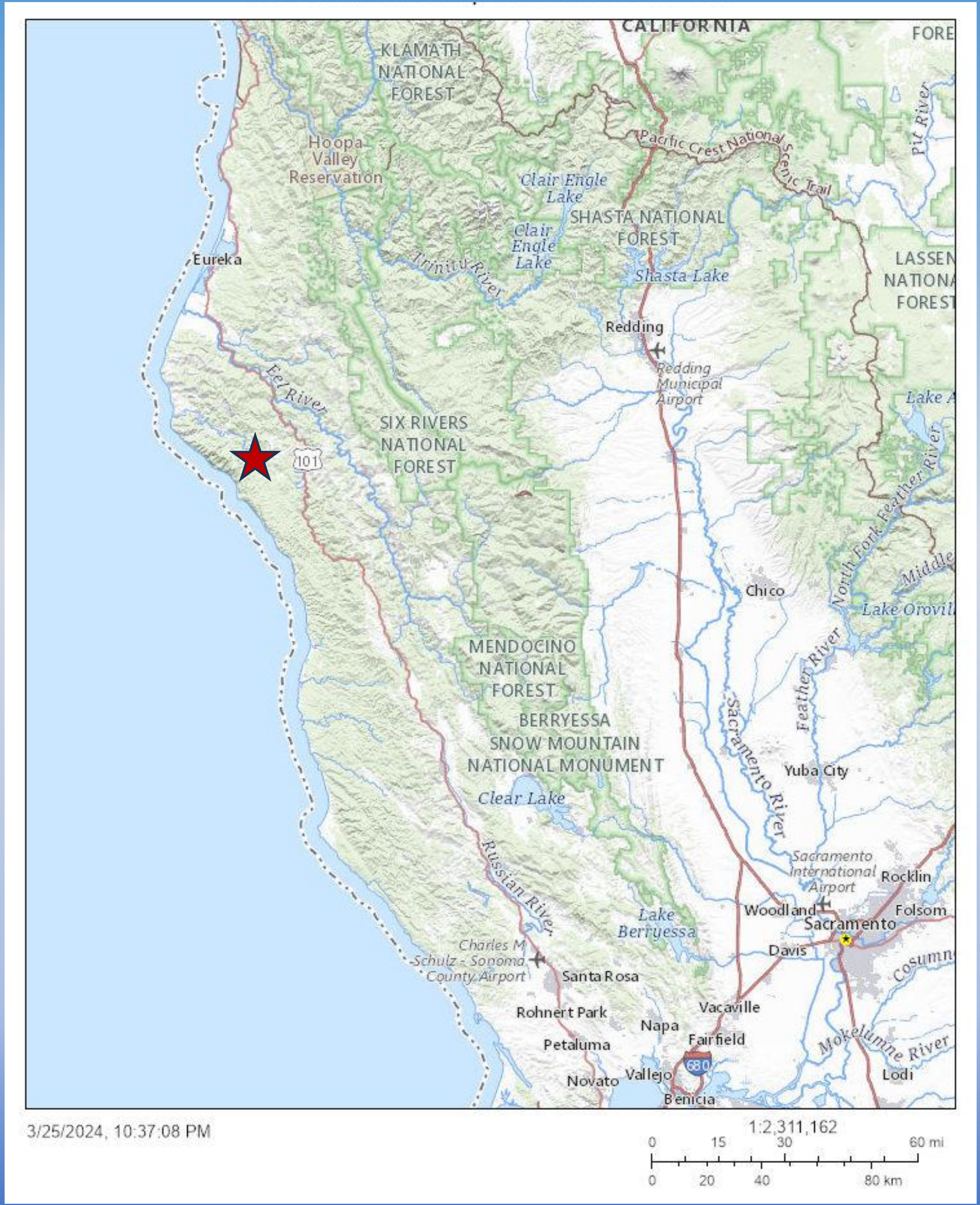
Sanctuary Forest


CALIFORNIA
KLAMATH NATIONAL FOREST
Hoopa Valley Reservation
Clair Engle Lake
SHASTA NATIONAL FOREST
Pacific Crest National Scenic Trail
Eureka
Trinity River
Shasta Lake
Redding
Redding Municipal Airport
LASSEN NATIONAL FOREST
Eel River
SIX RIVERS NATIONAL FOREST
101
Chico
MENDOCINO NATIONAL FOREST
BERRYESSA SNOW MOUNTAIN NATIONAL MONUMENT
Clear Lake
Sacramento River
Feather River
Yuba City
Lake Oroville
Sacramento International Airport
Rocklin
Woodland
Sacramento
Folsom
Davis
Russian River
Lake Berryessa
Charles M Schulz - Sonoma County Airport
Santa Rosa
Rohnert Park
Napa
Vacaville
Fairfield
Petaluma
Novato
Vallejo
Benicia
Lodi
Mokelumne River
3/25/2024, 10:37:08 PM
1:2,311,162
0 15 30 60 mi
0 20 40 80 km


The Mattole Watershed
101
Rainbow Ridge
Taylor Peak
Lower North Fork Mattole
Petrolia
Mattole River
Prosper Ridge
Squaw Cr.
Mattole River
Upper North Fork Mattole
Honeydew
Gilham Butte
Wilder Ridge
Mattole Canyon Cr.
King Peak
Ettersburg
Bear Cr.
Telegraph Ridge
Garberville
Briceland
King Range National Conservation Area
Eubank Cr.
Thorn Junction
Shelter Cove
Whitethorn
Chemise Mountain
Humboldt Co.
Mendocino Co.
Elevation in feet
> 2500
1501 - 2500
1001 - 1500
501 - 1000
251 - 500
< 250
Peaks
Critical Coastal Areas
Mattole Watershed Boundary
Humboldt State Redwoods Park
King Range National Conservation Area
Punta Gorda Marine Potection Area
Area of Special Biological Significance
0 2.5 5
Miles

Comparing Flow Enhancement Approaches Using Ponds

- Groundwater recharge – ponds with “passive” streamflow benefits.
- Direct Flow Augmentation- ponds with “active” metered flow to the stream.

Goals of Flow Enhancement Strategies

Primary goal: enhancing rearing habitat for juvenile salmon and steelhead during the dry season.

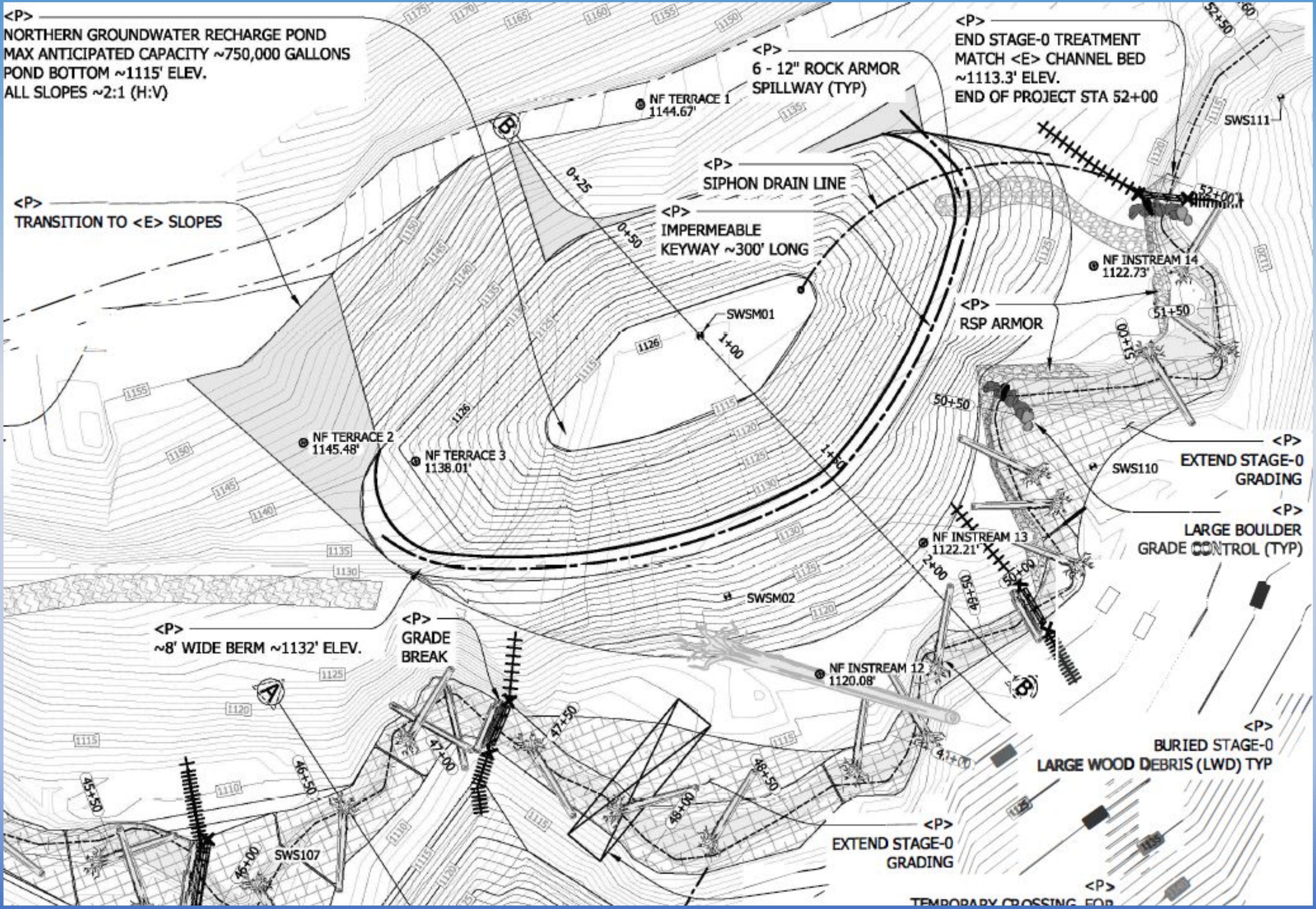
Additional benefits: improving forest health and fire resiliency of riparian corridor, habitat for other species, and water security for downstream human communities.

North Fork Lost River Ponds

Groundwater Recharge Ponds

(1 million gallons of surface water and groundwater combined)

- Cutoff wall in berm
- Impacts near-pond groundwater levels
- Releases groundwater passively
- Off-channel

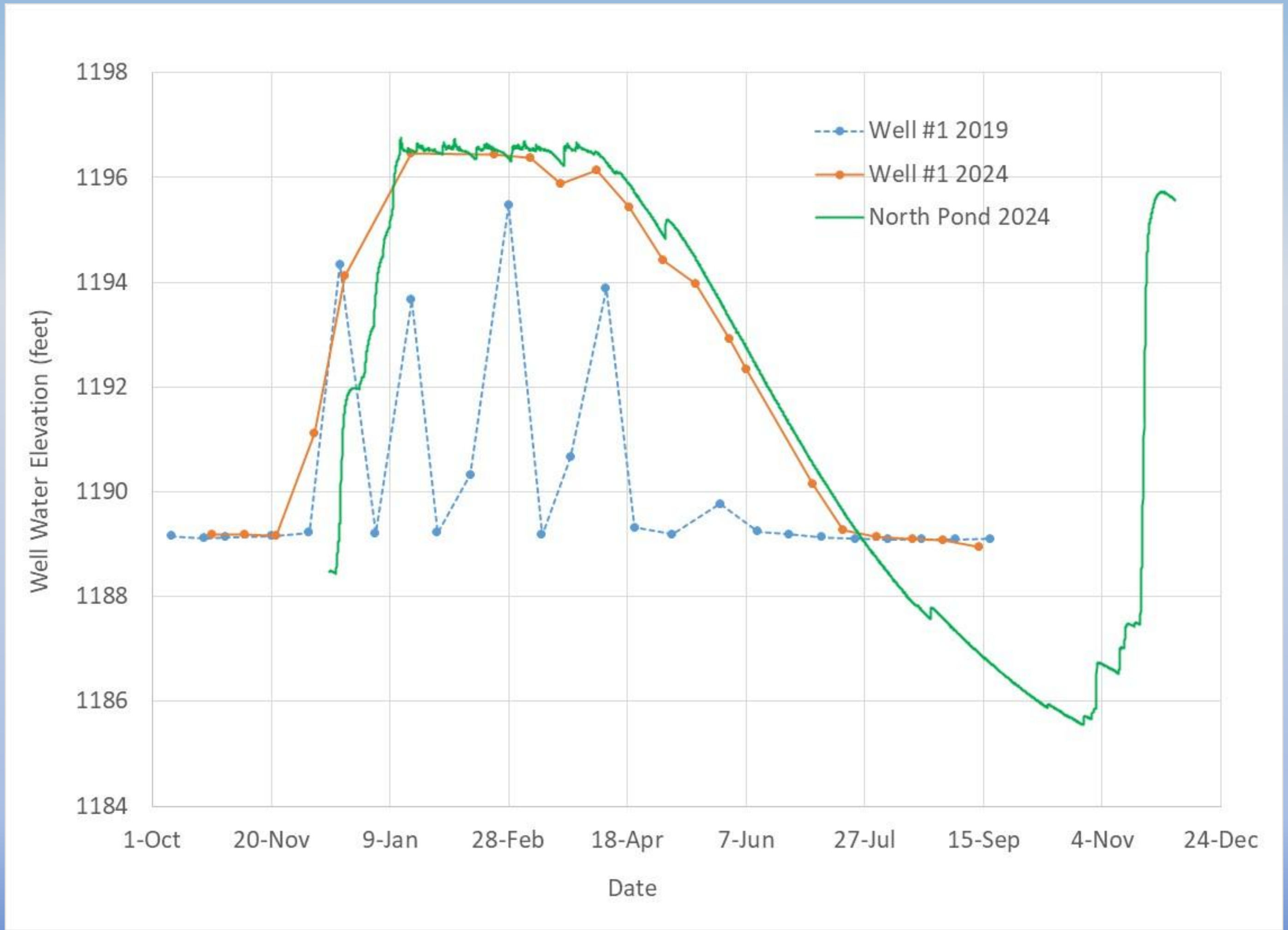

<P>
NORTHERN GROUNDWATER RECHARGE POND
MAX ANTICIPATED CAPACITY ~750,000 GALLONS
POND BOTTOM ~1115' ELEV.
ALL SLOPES ~2:1 (H:V)
<P>
6 - 12" ROCK ARMOR
SPILLWAY (TYP)
<P>
END STAGE-0 TREATMENT
MATCH <E> CHANNEL BED
~1113.3' ELEV.
END OF PROJECT STA 52+00
NF TERRACE 1
1144.67'
SWS111
<P>
SIPHON DRAIN LINE
<P>
TRANSITION TO <E> SLOPES
<P>
IMPERMEABLE
KEYWAY ~300' LONG
NF INSTREAM 14
1122.73'
SWSM01
<P>
RSP ARMOR
NF TERRACE 2
1145.48'
NF TERRACE 3
1138.01'
SWS110
<P>
EXTEND STAGE-0
GRADING
<P>
LARGE BOULDER
GRADE CONTROL (TYP)
NF INSTREAM 13
1122.21'
SWSM02
<P>
~8' WIDE BERM ~1132' ELEV.
<P>
GRADE
BREAK
NF INSTREAM 12
1120.08'
<P>
BURIED STAGE-0
LARGE WOOD DEBRIS (LWD) TYP
SWS107
<P>
EXTEND STAGE-0
GRADING
<P>

North Fork Lost River Ponds

Terrace Well #1 water elevations in 2019 and 2024 and North Pond levels.

Well Monitoring

- Pre Project (blue): water level rapidly rises and falls with rain events
- Post Project (orange): water level rises and falls in tandem with pond level



Analysis by consulting hydrologist Randy Klein. Flow monitoring by Sanctuary Forest.

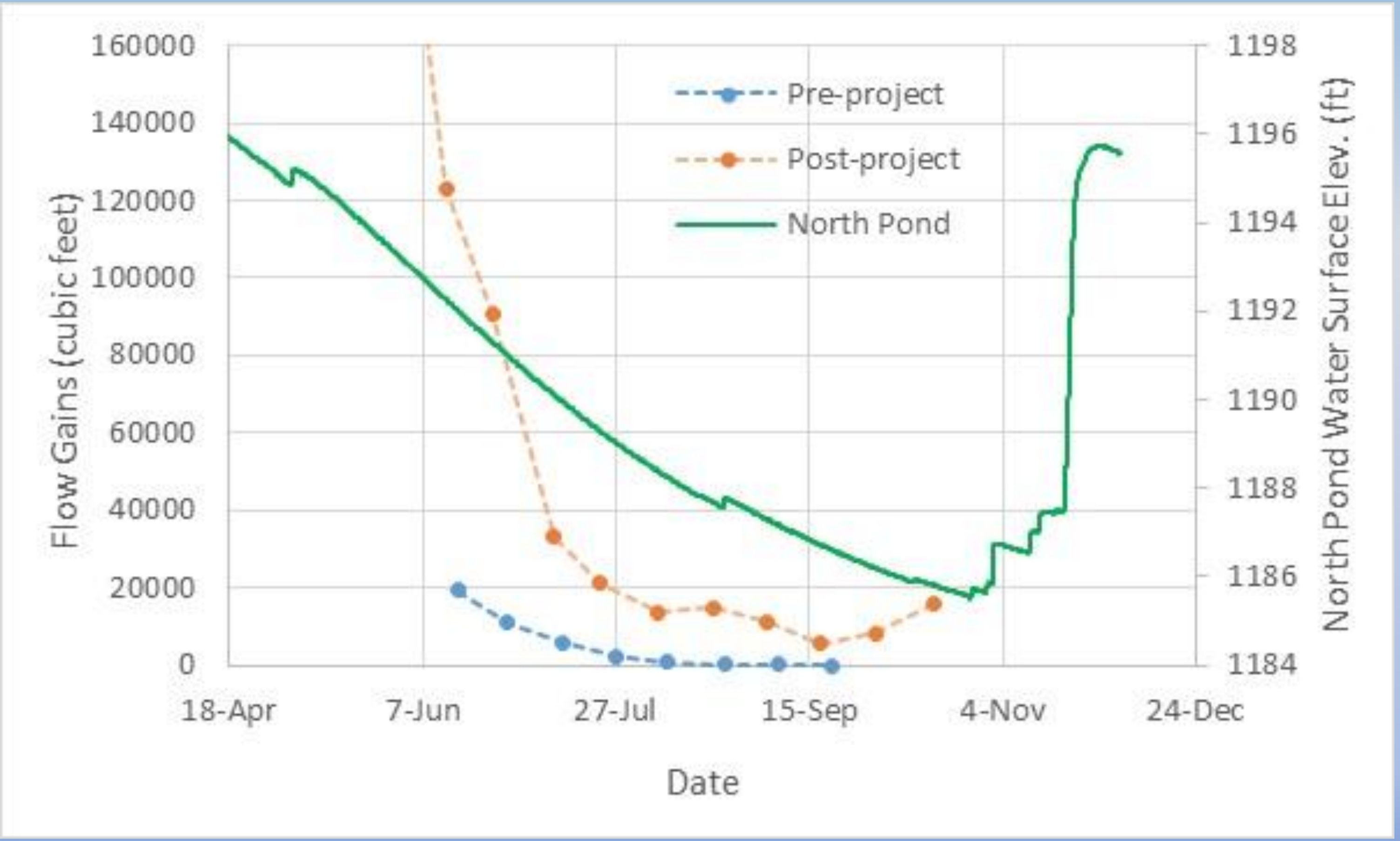
North Fork Lost River Ponds

Making the most of passive releases

- Streamflow enhancement structures (sealed log weirs) in the 3000 ft reach downstream of ponds
- Channel grading raised streambed approximately 3 feet
- Stacking of strategies to try to make a measurable difference

North Fork Lost River Ponds & Instream

Pre- and post-project cumulative flow volumes at the NFLR downstream flow monitoring site, and post-project recession of North Pond water level.



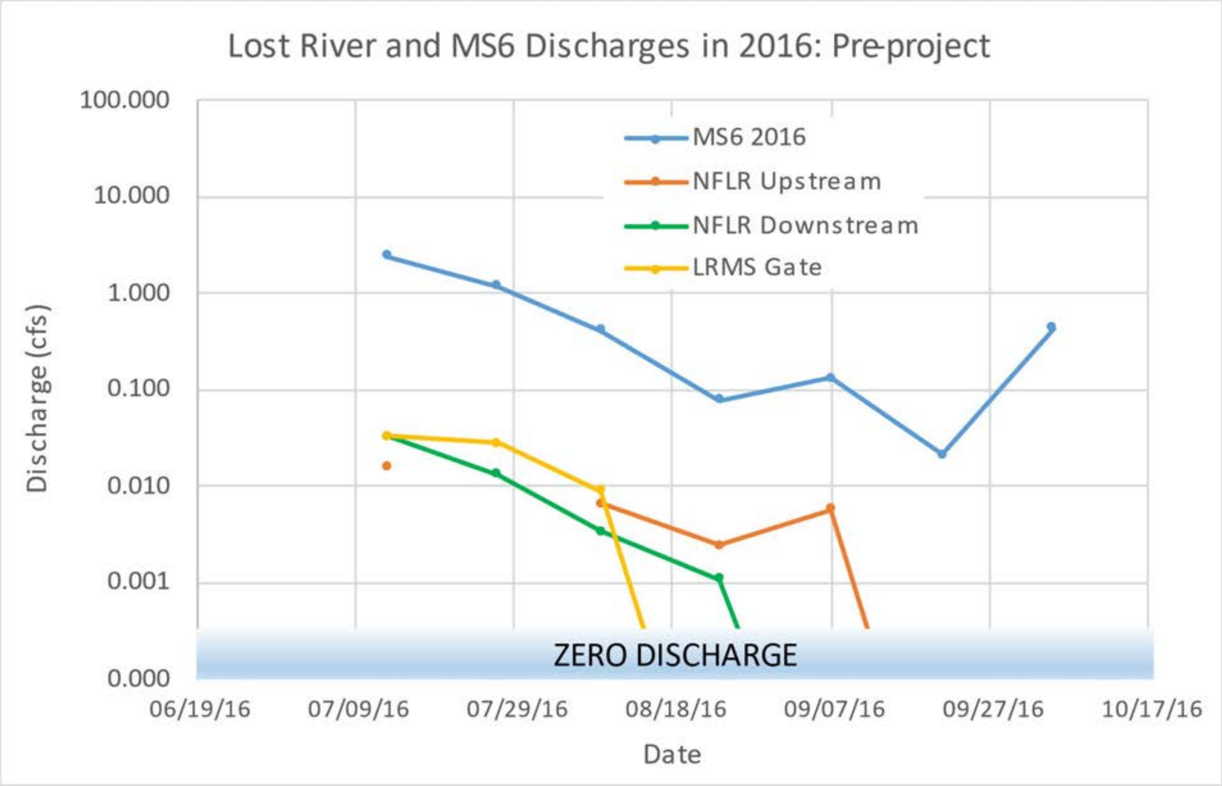
Analysis by consulting hydrologist Randy Klein. Flow monitoring by Sanctuary Forest.

Did the project improve summer streamflow?

- Pre project flow gain (DS – US) ranged from 19,000 gallons on June 16, 2016
- Approximately xxxx in flow gains between June 13 and Nov xxxx, but flow gains concentrated in late spring/early summer.
- Flow increase of approximately xxxx gpm in dryest part of summer

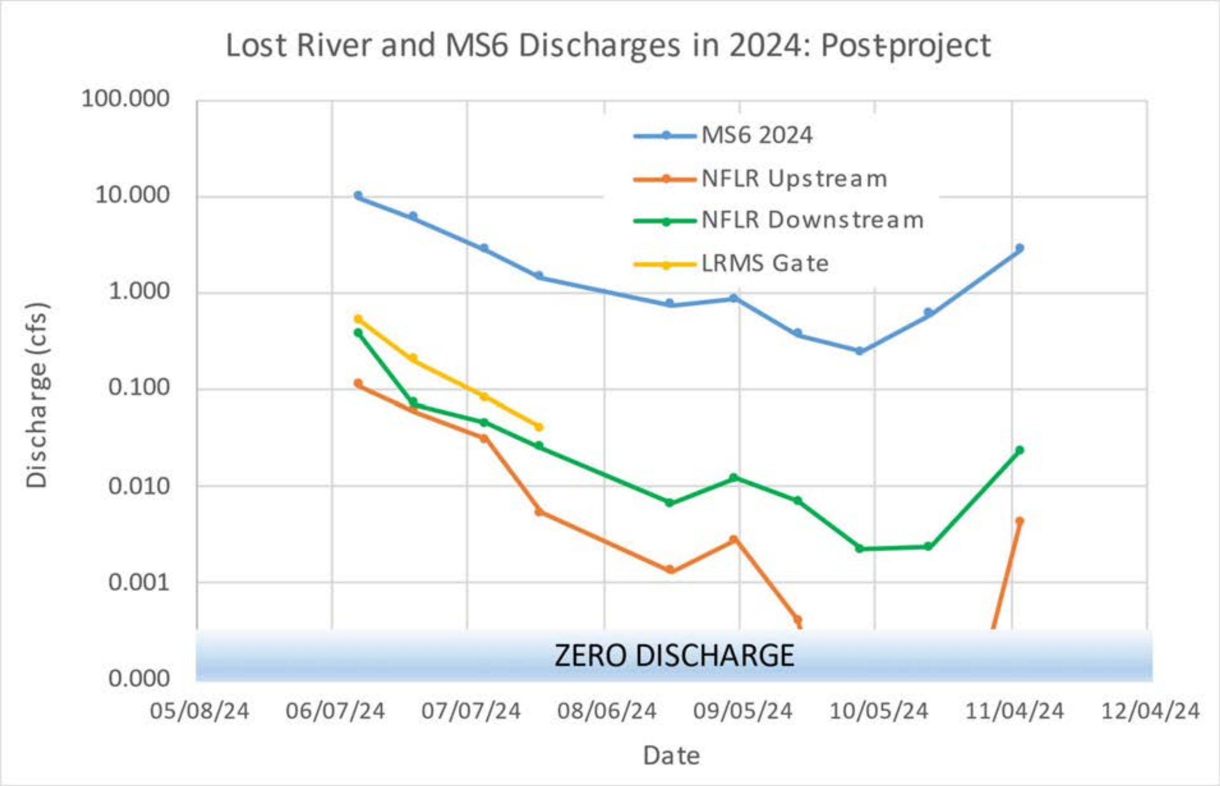
North Fork Lost River Ponds & Instream

Pre-Project



Upstream flows = zero 9/21/16 through 10/05/16
Downstream flows = zero 9/07/16 through 10/05/16

Post-Project



Upstream flows = zero 9/18/24 through 10/17/24
Downstream flows = low of 1.0 GPM on 10/02/24
More water in early dry season
Declining limb less steep and flow persisting throughout

Analysis by consulting hydrologist Randy Klein. Flow monitoring by Sanctuary Forest.

North Fork Lost River Ponds

Benefits to Groundwater Recharge Ponds

- Potential for large increases in groundwater storage capacity
- No liner
- Less infrastructure and maintenance
- Passive release means less long-term management

Challenges to Groundwater Recharge Ponds

- Little control over timing of flow benefit
- Rate of release diminishes with head pressure = less water in late summer
- Project impact/effectiveness varies in every geologic setting.
- Can be difficult to measure/quantify impacts

South Fork Lost River Pond

Metered Flow Augmentation Pond

(800,000 gallon capacity)

- Lined with HDPE pond liner
- Metered flow release into cooling/infiltration gallery
- Off channel

South Fork Lost River Pond

- Flow release through siphon and simple valving system
- Release controlled by opening ball valve to desired rate between 0 and 7.5 gpm

South Fork Lost River Pond

Benefits to Direct Flow Augmentation/Lined Pond

- Timing of flow benefit can be targeted
- Smaller project can make bigger difference on late dry season flows
- More predictable outcome through project planning, implementation, and operation

Challenges to Direct Flow Augmentation/Lined Pond

- Need to purchase and install plastic liner – liner has a life span
- More infrastructure - **infiltration gallery**, pumps or siphons, water meters
- More management – water quality monitoring and adaptive management, operation of flow release indefinitely, equipment maintenance

Combined Flow Benefits

NFLR Projects ~ 1 GPM, SFLR Lined Pond ~ 2.5 GPM

Pre project: 10/5/2016.
No measurable flow for previous six weeks.
USGS ETT Gauge 11.6 CFS

Post Project: 10/2/2024.
Instantaneous flow of 3.5 GPM (lowest of 2024)
USGS ETT Gauge 5.2 CFS

Key Takeaways and Additional Thoughts

- Groundwater recharge ponds: In Mattole headwaters, primary flow benefit occurs in early summer and not during highest stress period for juvenile fish.
- Direct flow augmentation/lined ponds: provide a measurable and predictable benefit when fish need it most.
- Both methods are not mutually exclusive.
- You don’t necessarily need surface water for groundwater recharge project

Sanctuary Forest

Thank You to Our Partners!

With acknowledgement to our partners including (but not limited to!):

- Joel Monschke, Stillwater Sciences
- Campbell Thompson, Mattole Salmon Group
- Macky McCullough, McCullough Construction
- California Conservation Corps
- Lost Coast Forestlands LLC
- Randy Klein, Consulting Hydrologist
- Wyeth Wunderlich, EBA Engineering
- Community volunteers and working group/technical advisory committees, 2010 – present
- Regional & State Water Quality Control Boards and CDFW Staff

Sanctuary Forest

Thank You to Our Funders!

- California Wildlife Conservation Board
- California Department of Water Resources
- Bella Vista Foundation
- Firedoll Foundation
- Weeden Foundation
- Grace Us Foundation

Dual strategy – groundwater and metered flow

Lost River Watershed – Example of Dry Season Flow Augmentation

Dry season June 15 - Oct 15 (2-week periods)	June 15 –30	July 1 - 15	July 16-31	Aug 1-15	Aug 16-31	Sept 1-15	Sept 16-30	Oct 1-15	Total Gallons Jun 15 – Oct 15
Measured pre-project flows (gpm)	162	94	40	10	2.6	0.2	0	0	~6.7 million gallons
Estimated flow (gpm) resulting from increased groundwater	131	65	32	15	7	3.5	1.8	0.9	~5.6 million gallons
Metered flow (gpm) from NFLR & SFLR proposed ponds	0	0	0	15.8	15.8	15.8	15.8	15.8	~ 1.8 million gallons
Total estimated post-project flows (gpm)	293	159	72	40.8	25.4	19.5	17.6	16.7	~14 million gallons

SANTA CRUZ COUNTY
ENVIRONMENTAL HEALTH

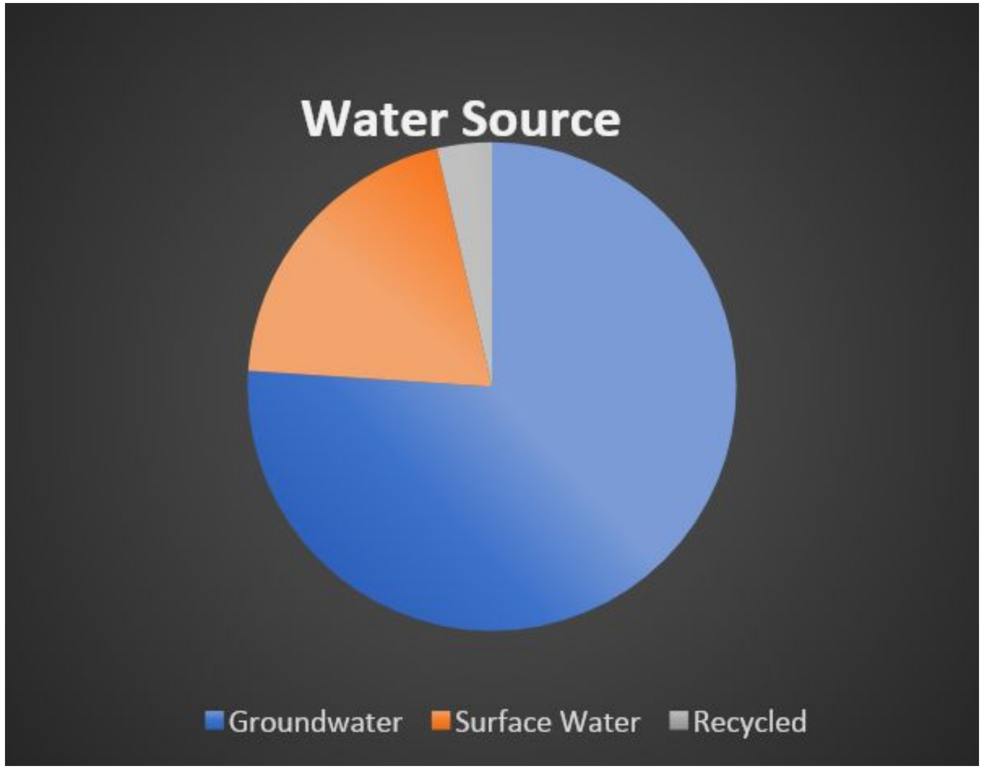
Santa Cruz County Well and Water Systems Ordinance Update

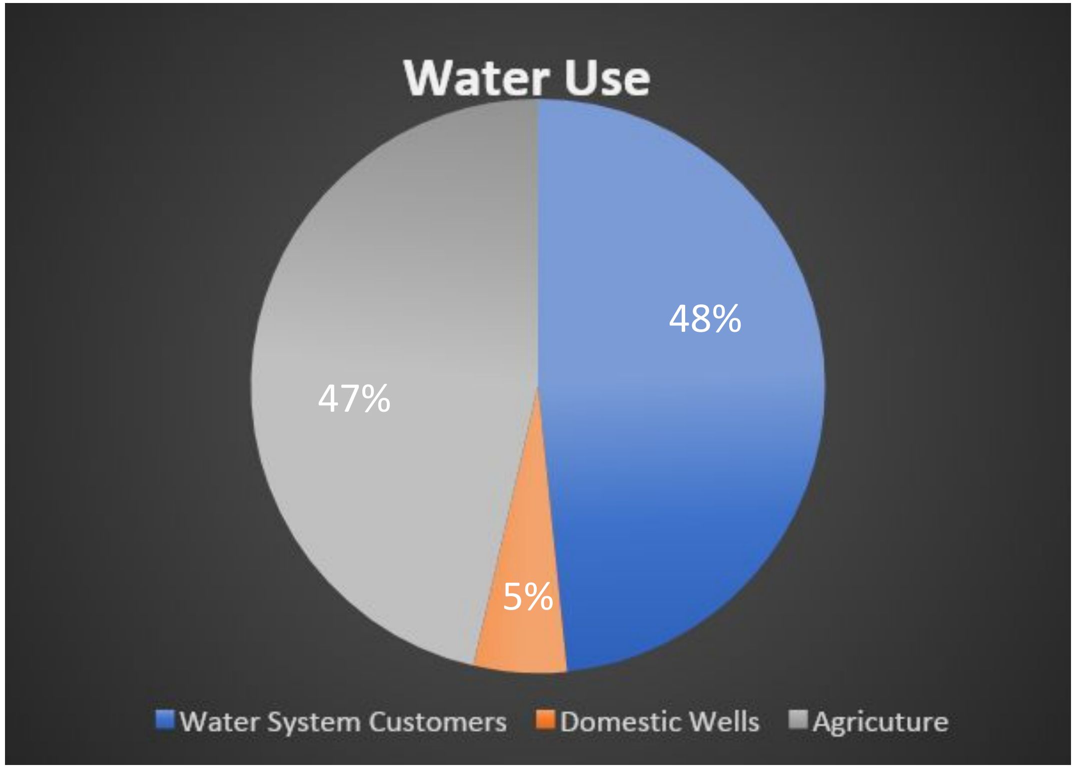
Salmonid Restoration Federation Conference

Sierra Ryan, Water Resources Program Manager

Current Water Supplies in Santa Cruz County

- Local surface water and groundwater basins
- Limited recycled water (currently irrigation only)
- Santa Cruz is not on state or federal water projects, we must solve our problems locally

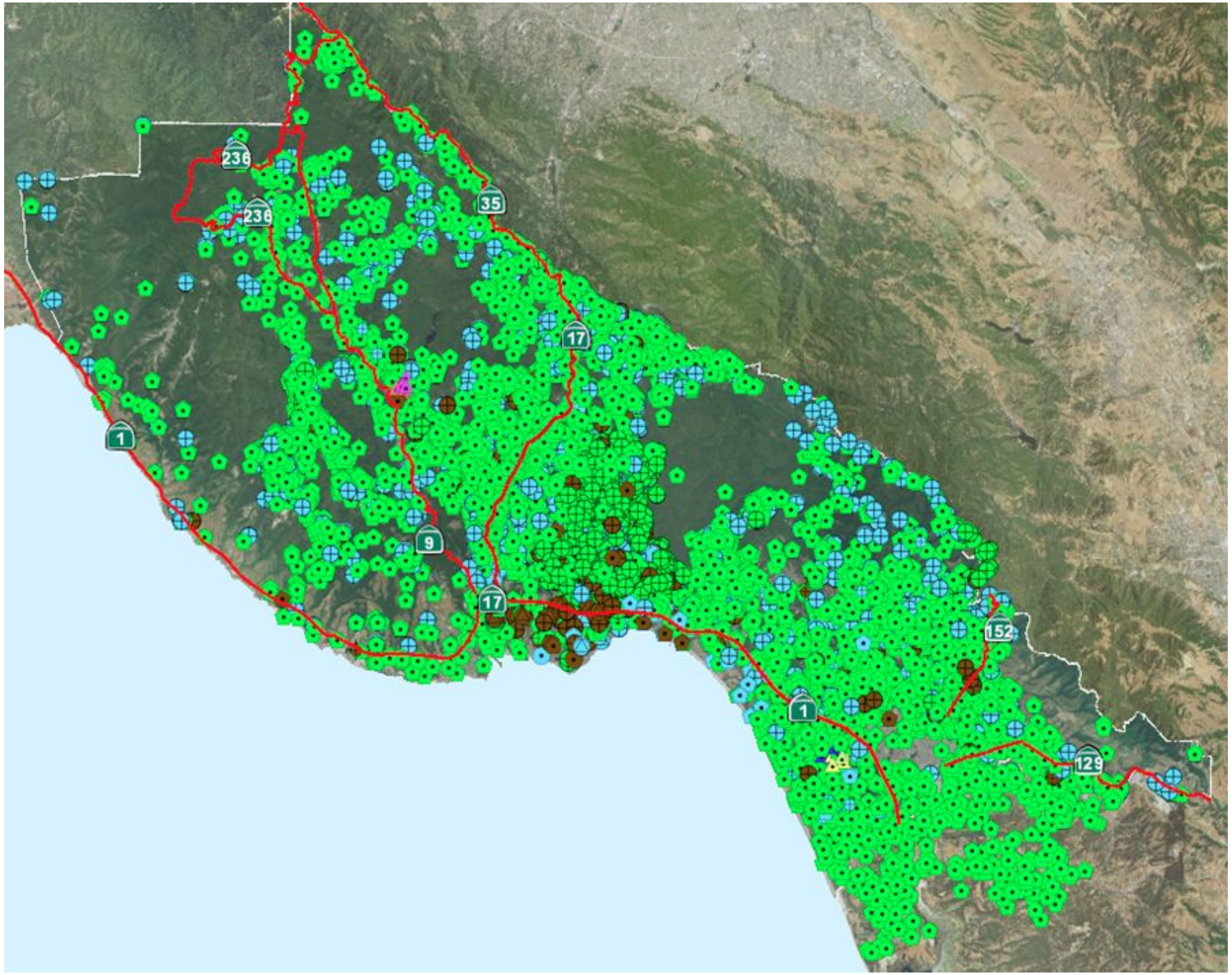




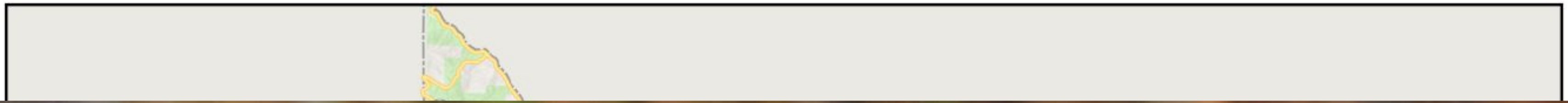
County's Role in Protecting Groundwater

- Develop/enforce ordinances:
  - Well Construction/Destruction
  - Individual Water Systems
  - Larger Water Systems
  - Water waste prohibitions
- Issue well permits within jurisdiction
  - Excludes cities without formal agreements
- Water Quality Protection
  - Local Agency Management Program
  - Hazardous Materials/Site Mitigation
- Sustainability
  - Member of two Groundwater Sustainability Agencies

9,100+ Wells in County:



Salmonid Bearing Streams



January 8, 2024

1:276,300

0 2.25 4.5 9 mi

0 3.75 7.5 15 km

County of Santa Cruz

Street Labels

Street Labels

Streams Fish Bearing

Steelhead and Limited Coho

Steelhead and Coho

Steelhead High Flow

Steelhead

Resident Rainbow

Purpose of Well Ordinance:

Water Wells (Chapter 7.70)

1. Provide well construction and destruction standards to protect water quality and minimize environmental impacts.
2. Implement policies of the County General Plan and the Local Coastal Plan (LCP)
3. Update to include Sustainable Groundwater Management Act (SGMA), and protection of public trust resources

Individual Water System (IWS) Ordinance (Chapter 7.73)

Ensure adequate water availability and water quality for homes and other uses dependent on private wells for water supply.

Current Well Permits:

		Totals	Percent	Average/ year
Total Water Wells in Database		**9,100**		
Well Construction Applications 2018-2024		**326**		**47**
	NEW WELL DOMESTIC	66	20%	9
	REPLACEMENT WELL - DOMESTIC	26	8%	4
	SUPPLEMENTAL WELL - DOMESTIC	162	50%	23
Subtotal Domestic/De Minimis			**78%**	**36**
	REPLACEMENT WELL - IRRIGATION	12	4%	2
	SUPPLEMENTAL WELL - IRRIGATION	25	8%	4
	REPLACEMENT WELL - NON-DOMESTIC	6	2%	1
	SUPPLEMENTAL WELL - NON-DOMESTIC	19	6%	2
Subtotal Non-De Minimis Replace/Supplmntl			**19%**	**8**
	NEW WELL IRRIGATION	3	1%	0.4
	NEW WELL NON-DOMESTIC	7	2%	1
Subtotal Non-De Minimis New			**3%**	**2**

Local Context:

1. Growth potential in rural areas is low.
2. There is limited potential for development of new agricultural use in the county.
3. Actual water use by de minimis users is less than 0.5 af/y mitigated by water use efficiency, stormwater infiltration, and return flow from onsite sewage disposal.
4. Groundwater levels in the county are recovering due to reduced pumping and Groundwater Sustainability Plan implementation.
5. Very complex geology, heterogeneous stacked aquifers with faults, lots of hills.

Reasons for Update:

Since the last update in 2009, policy changes at the State and local level, have occurred:

- Passage of Sustainable Groundwater Management Act
- Senate Bill 552 looks to counties to take more responsibility for deficiencies of private wells.
- State concern with well interference
- Ongoing case law regarding CEQA review and public trust
- County has adopted the Climate Action and Adaptation Plan, the Drought Response and Outreach Plan
- National Marine Fisheries Service has raised concerns about interconnected surface waters in the County
- Required oversite of soil borings

Technical Advisory Committee Members

Technical Expertise	Person
Small farmers	Alma Fernandez
Large working lands/Agriculture	Dennis Lebow
Large working lands/Agriculture alternate	Robert Wall
Well driller	Aaron Lingemann, CA C-57
Well driller	Dave Landino, CA C-57
Water Advisory Commission	Bryan Largay
Water Advisory Commission	Nate Gillespie
Santa Cruz Mid-County and Santa Margarita Groundwater Agencies	Rob Swartz, PG, CHG
Pajaro Valley Water Management Agency	Brian Lockwood, PG, CHG
Biotic resources -National Marine Fisheries Service	Rick Rogers
Biotic resources -California Department of Fish and Wildlife	Jessie Maxfield
Public utilities/Soquel Creek	Brice Dalhmeier, PE
Department of Water Resources	Benjamin Brezing, PE

SCIENCE

Streamfl

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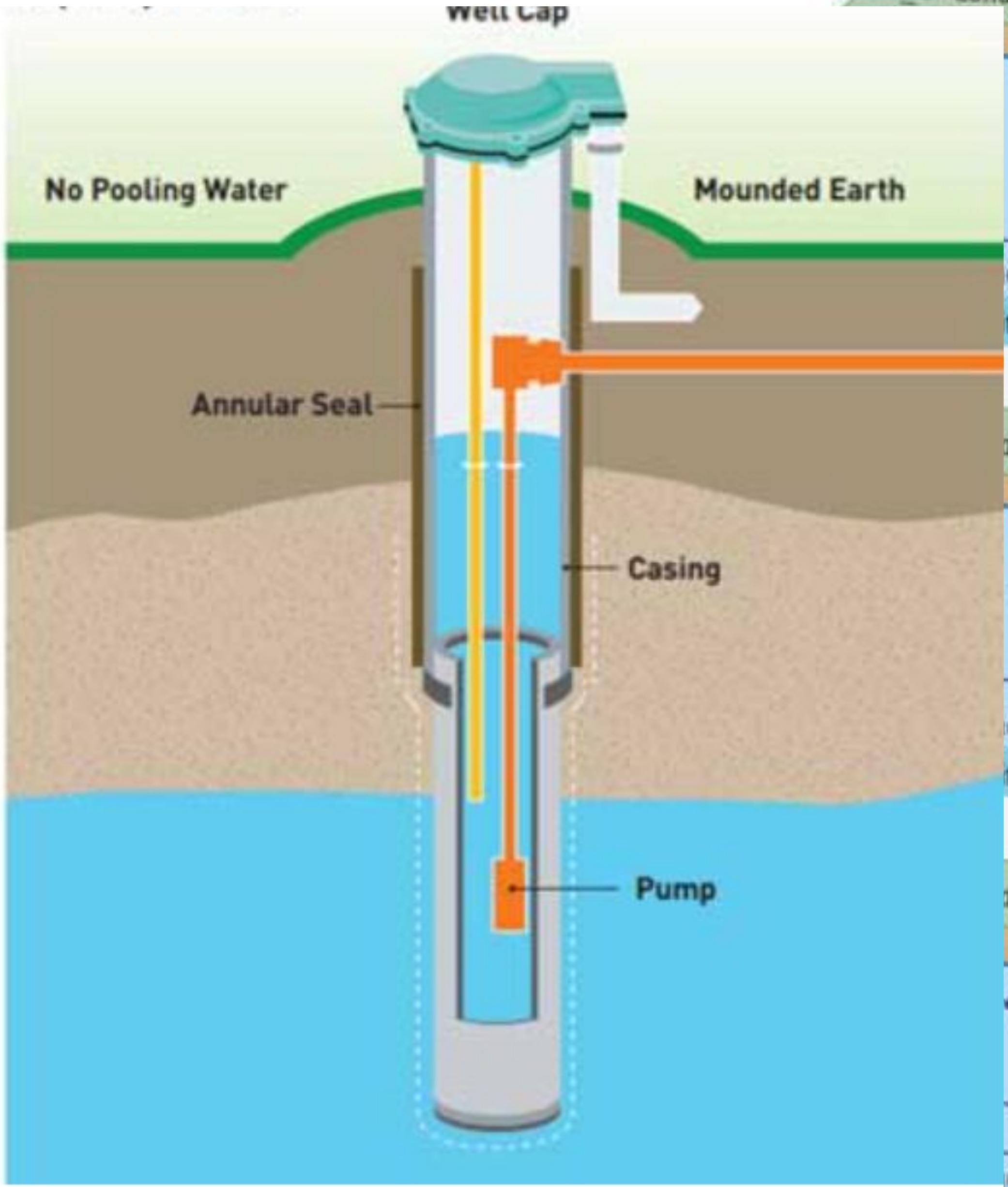
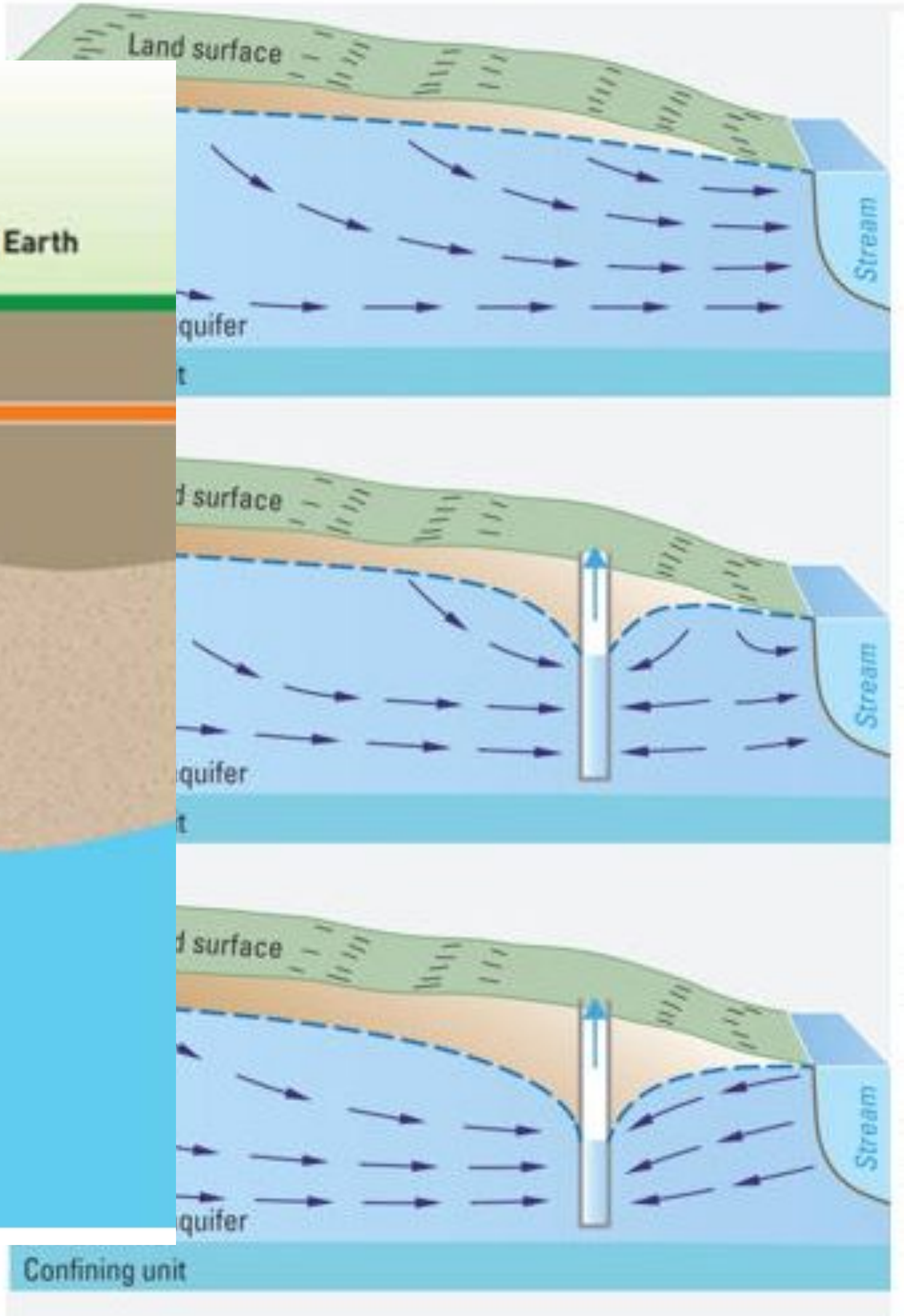


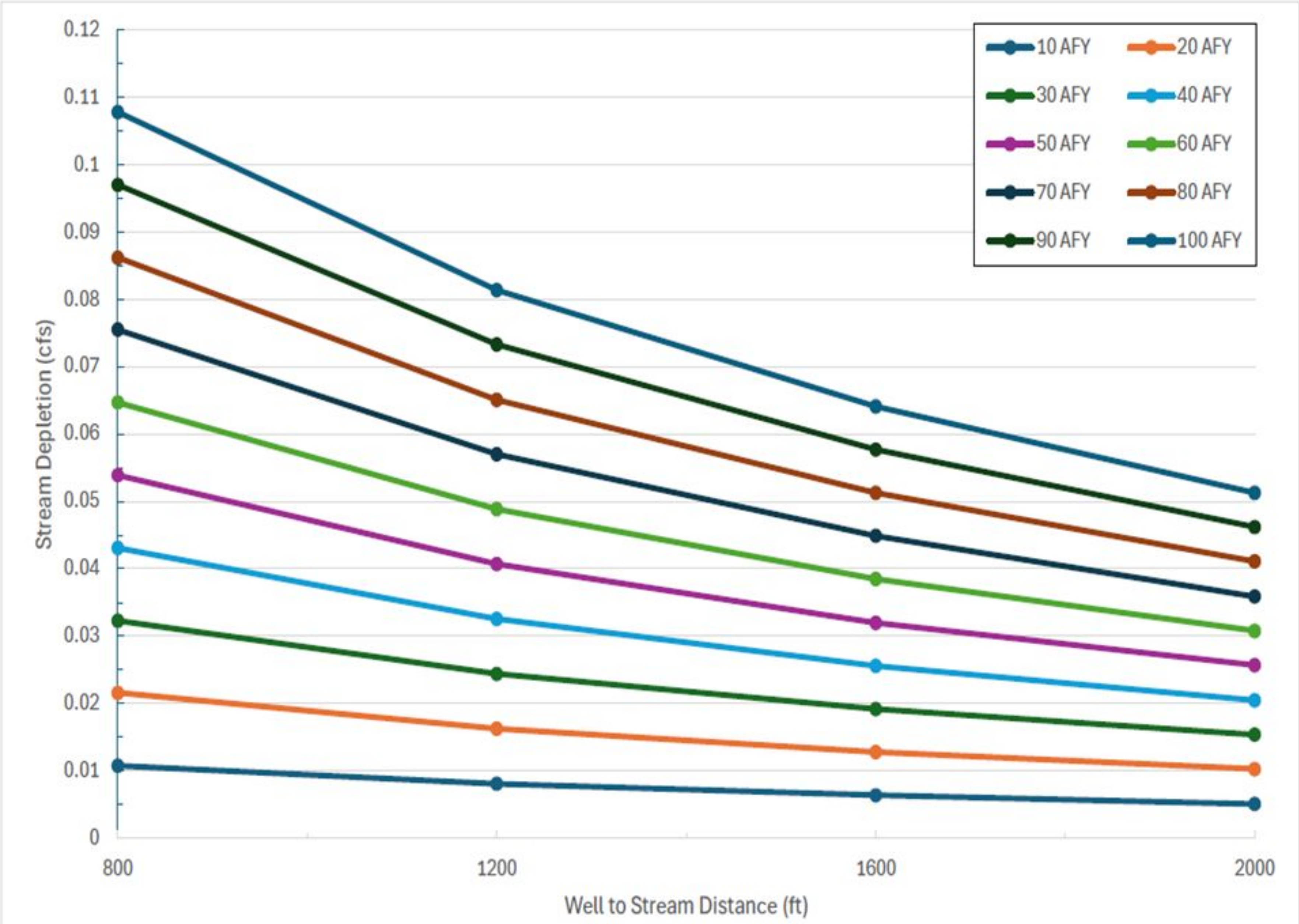


https://books.gw-project.org/groundwater-resource-development/chapter/streamflow-depletion/
https://www.canada.ca/en/health-canada/services/environment/drinking-water/well/protect-maintain.html

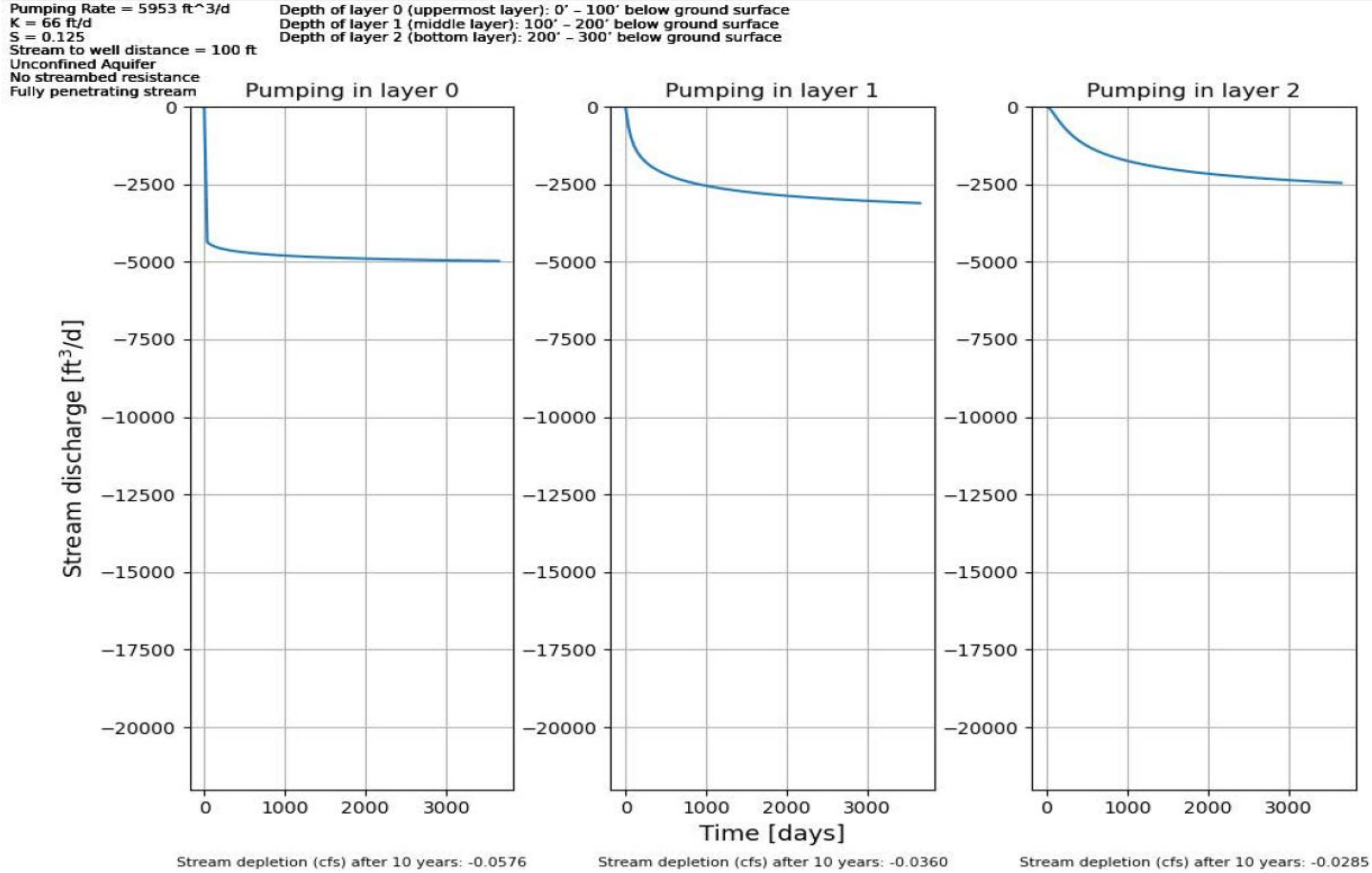
Stream Depletion Calculations:

1. Various models were used to assess relative impacts of wells on streamflow and nearby wells based on pumped amounts, setback, seal depth, and geologic conditions.
2. Assumed all annual pumping was in 180-day dry season. Also assessed impacts at same rate of pumping over extended periods of 2 years and 10 years.
   a. Wells pumping 10 af/y had minimal impact (0.01-0.02 cfs)
   b. Increasing seal depth to 100 ft reduced depletion by 20-70%. Significant further reductions occurred with a seal depth of 200 ft. The effect was more pronounced at distance less than 1000 ft from the creek.
   c. Pumping from below an aquitard reduced depletion by 50-97%
   d. Increasing stream setback had moderate effect on depletion: increasing setback from 50 ft to 1000 ft reduced the amount of depletion by 25-30%. However, going from 800 to 2000 ft reduced the depletion by 50%.
   e. Modified Theis Non-Equilibrium Equation was used to determine amount of setback needed to prevent more than 5 feet of drawdown in nearby well: 25-1400 ft for a 100 gpm well, depending on aquifer properties.

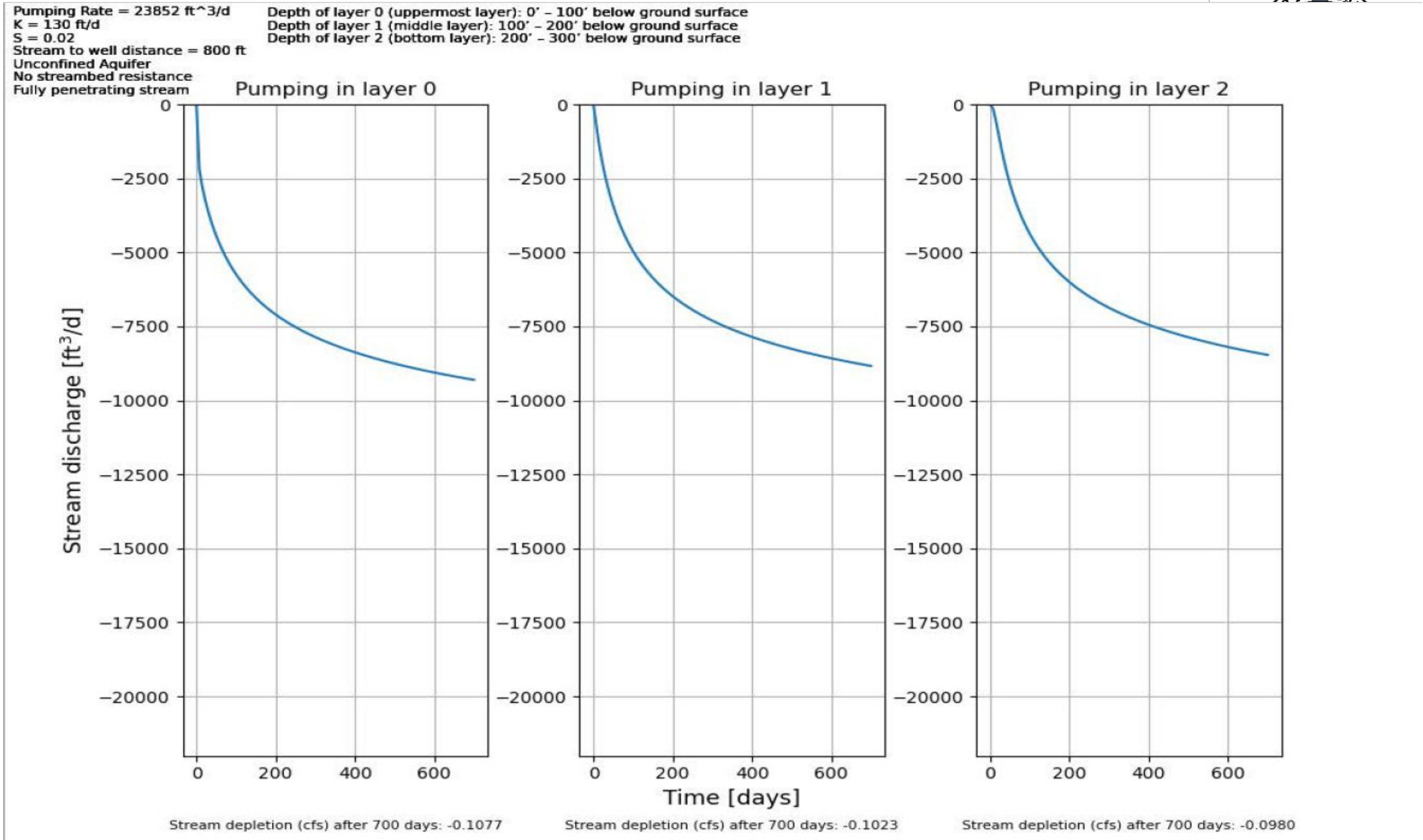
Depletion with setback, no seal:



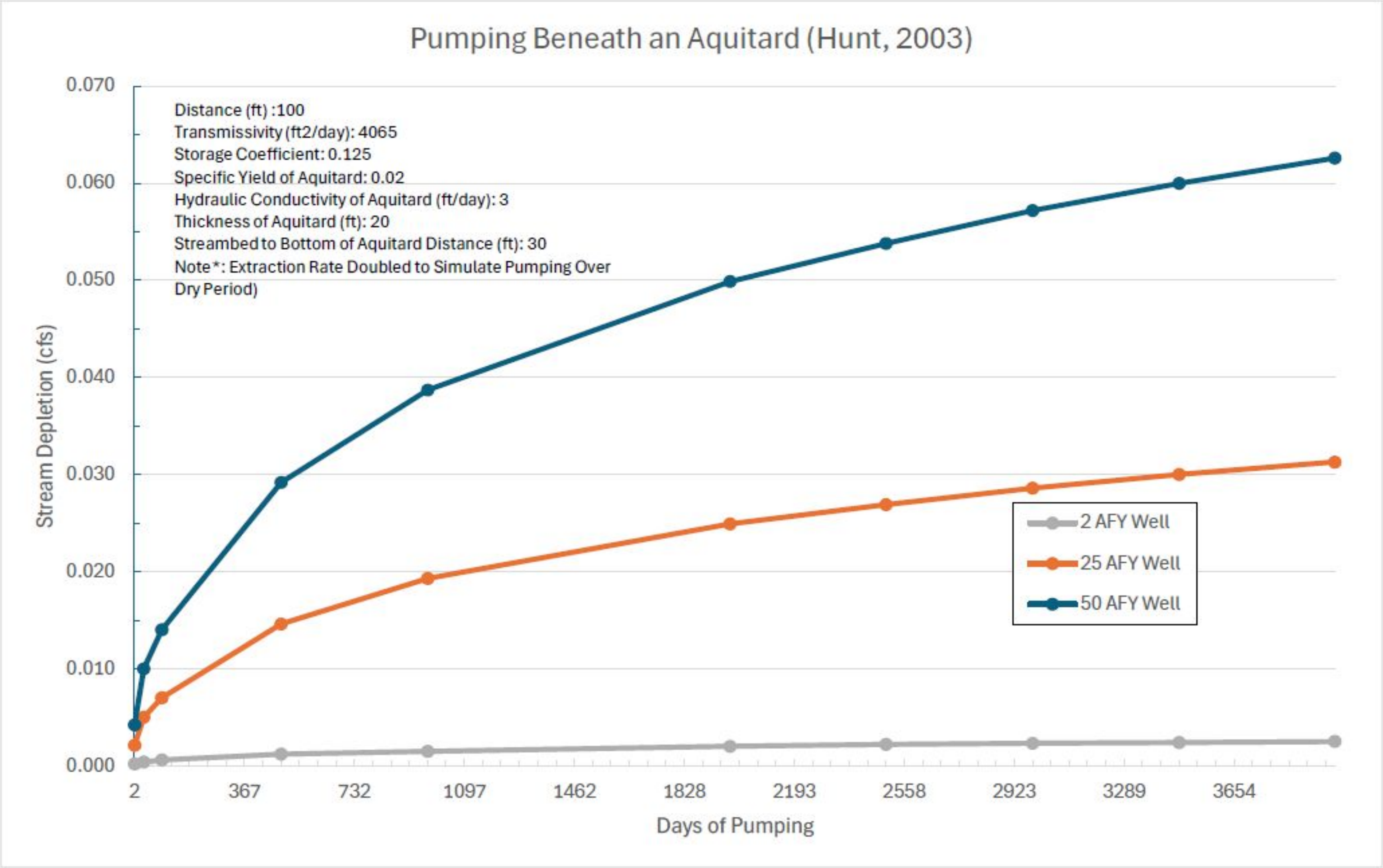
Effect of seal depth at short distances:



Effect of seal depth at long distances:



Stream depletion beneath an aquitard:



POLICY

Permitting Approach:

1. Tiered (Tier 1 through 4) approach to well permits.
   a. Tier 1 wells are similar to current requirements.
   b. Tier 4 wells are discretionary, require significant analysis, CEQA, and can be denied.
2. All tiers have water conservation requirements
3. More extensive water quality testing will be required for new wells
4. Water quality and yield testing will be required at time of sale.
5. Metering and reporting required on new and replacement wells used for non-domestic purposes or pumping 2+ AFY.
6. The Code relies on a Resource Protection Policy.

Resource Protection Policy:

To be adopted by Board resolution but can be modified by Board as needed. Provides detailed requirements for code implementation:

1. Minimize impacts on streams,
   a. Requirements for well tiers
   b. Critical Streams
2. Minimizing Influence on groundwater levels
3. Karst;
4. Environmental review requirements;
5. Metering and reporting for non-de minimis wells;
6. Water use efficiency measures
7. Additional requirements in groundwater extraction concern areas.
   a. Limited Yield Areas: more stringent yield testing
   b. Elevated Water Quality Concern Areas: water quality testing
   c. Seawater Intrusion Areas: Additional evaluation

Proposed Level of Review and Mitigation Required for Various Types of Well permit Applications					
Tier	Criteria	Average Number of Permits/year	CEQA Review Required?*	Connected Stream Setback	Nearby Well Setback
Tier 1	De Minimis, domestic < 5 connections; Non-de minimis <2 AFY	44	Ministerial	>50 ft and 100 ft deep seal within 1000 ft of stream**	>50 ft
Tier 2	Non-De minimis Replace/Supplemental	11	Ministerial	>100 ft or not less than existing, and 200 ft deep seal within 2000 ft of stream**	>50 ft, or not less than existing
	Public Water system replace/supplemental	1			
Tier 3	New Non-De minimis wells that are consistent with GSPs, meet Tier 3 calculated setbacks, and will pump less than 50 afy/100gpm	1	Ministerial	If within 2000 ft of stream, Using depletion model, 10th percentile dry season flow shall not be reduced by more than allowed % after 10 years of pumping ***	Calculated minimum setback so that drawdown at nearby well is less than 5 feet****
	Wells that do not meet Tier 1 or 2 minimum setbacks, but do meet Tier 3 calculated setbacks	?			
Tier 4	Wells that do not meet Tier 1,2,or 3 requirements; or located in a control zone or Tier 4 gw concern area	?	Yes	Analysis, including cumulative effect on streamflow in overall basin	Analysis and mitigation
	New Public Water System Serves > 199 connections	<1			

Stream	Resource Value	All years 10th Percentile Dry Season Unimpaired Flow (A)	All Years 10th Percentile Dry Seas. Observed Flow	Data Sources Observed Flow	Current Estimated Depletion	Data Sources Estimated Depletion	Allowed Additional Depletion*	Allowed Depletion cfs*
Lower Soquel @USGS	2	2.44	0.84	A	65%	B,G,H,G	1%	0.008
E. Branch Soquel @ W. Branch	1	1.23	0.1	B,D,E,G	60%	B,D,E,G	1%	0.001
W. Branch Soquel @ E. Branch	2	0.63	0.81	B,D,E,F	15%	B,D,E,F	5%	0.041
Moore Gulch	4	0.05	0.15	E,F	17%	E,I	5%	0.008
Other Soquel Tribs	4				10-20%	E	5%	
Aptos ab Valencia	2	0.46	0.66	D,E,G	<=5%	D,E	10%	0.046
Valencia	4	0.11	0.02	D,E,G	82%	D,E	1%	0.001
Upper Corraltios	4	0.63	0.3	D, E	50%	D,E	1%	0.006
Browns Valley Cr.	4	0.22	0.2	D, E	>20%	D,E	1%	0.002
SLR @ Big Trees (Felton, mainstem)	2	15.2	12	A,C,G,H	30%	C,D,E,G,H	1%	0.120
Branciforte	2	0.34	0.46	C,D,E,F	5-10%	C,D,E	5%	0.017
Bean	1	0.5	2.3	C,D,F,G	21%	F,G,H	1%	0.023
Zayente ab Bean	1	1.19	1.53	A,D,E,G,H	5-10%	C,D,E,G	5%	0.077
Bear	2	1.12	0.63	C,D,E,F	<=5%	C,D,E	10%	0.063
Kings	2	0.58	0.2	A,C,E,F	<=5%	C,E	10%	0.058
Boulder Creek	3	0.89	1.1	A,C,D,E,F	25%	C,D,E	1%	0.011
SLR Other Tribs	4			C,E	5-10%	C,E	10%	
Laguna	1	0.5		A,G	>10%	E,G	1%	0.005
Majors	2	0.22		A,G	>10%	E,G	5%	0.011
San Vicente	1	0.85		A	>10%	E	1%	0.009
Scott	1	1.99		A	>10%	E	1%	0.020
Other County Streams	4			E	5-10%	E	10%	

Well Ordinance Update

scceh.com/NewHome/Programs/WaterResources/WellOrdinanceUpdate.aspx

Well Ordinance Update

Final Adopted Language, February 11, 2025

Ordinance Amending Santa Cruz County Code Chapter 7.70

Ordinance Amending Santa Cruz County Code Chapter 7.73

Well Ordinance Update Materials December 4, 2024

Well Ordinance Update Context

Updates to 7.70 (Clean)

Updates to 7.73 (clean)

Resource Protection Policy

Updates to SCCC 7.73 (redline)

Updates to SCCC 7.70 (redline)

Groundwater Concern Areas Map

Critical Stream Depletion Background

Stream Depletion Analysis

The Board of Supervisors has adopted updates to Chapters 7.70 and 7.73 of the County Code. These updated chapters modernize well construction and individual water system management to take into account groundwater sustainability, public trust impacts, drought risk for domestic wells, and drinking water quality concerns. The updated codes need to go to the Coastal Commission for approval before they go into effect, anticipated on July 1, 2025.

Goal and Objectives

The goal of the update is to provide protection against adverse impacts of well construction and use, while not creating an undue burden to applicants.

The updated code meets the following objectives, which were set at the beginning of the update process:

1. Follows all applicable laws and regulations.
2. Honors the core tenants of the County General Plan which includes recognition of agricultural land as an essential and irreplaceable resource for future generations.
3. Is equitable in its consideration of impacts to groundwater users, including the public trust.
4. Facilitates communications with Groundwater Sustainability Agencies and recognizes their mandate to sustainably manage their groundwater basins.
5. Acknowledges the impact that climate change is having on water resources.

Representative Groups in Code Update Development

In order to ensure that County staff adequately considered the impact to various uses and users of groundwater, the following representatives from various interested parties participated in a Technical Advisory Committee:

Technical Expertise	Person
Small farmers	Alma Fernandez
Large working lands/Agriculture (Meetings 1 and 2)	Dennis Lebow

SANTA CRUZ COUNTY
ENVIRONMENTAL HEALTH

Discussion

Sierra.Ryan@SantaCruzCountyca.gov