Defining Environmental Flow Needs for California's Central Valley Rivers

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CWEMF CALIFORNIA Water & Environmental Modeling Forum

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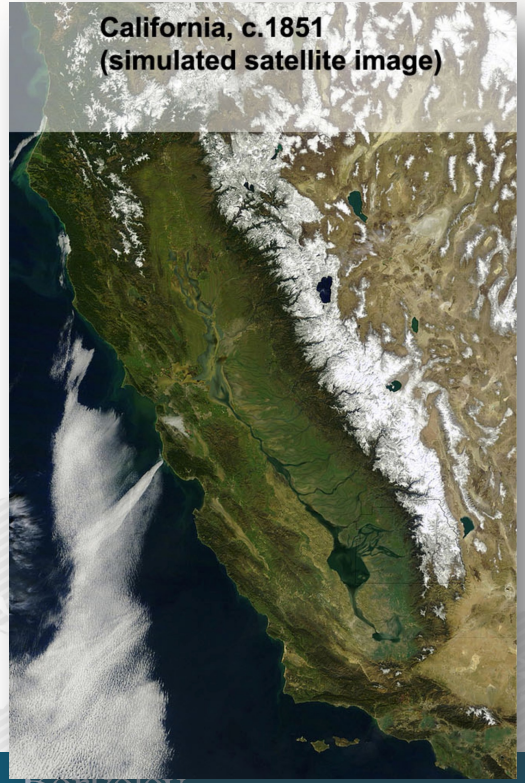
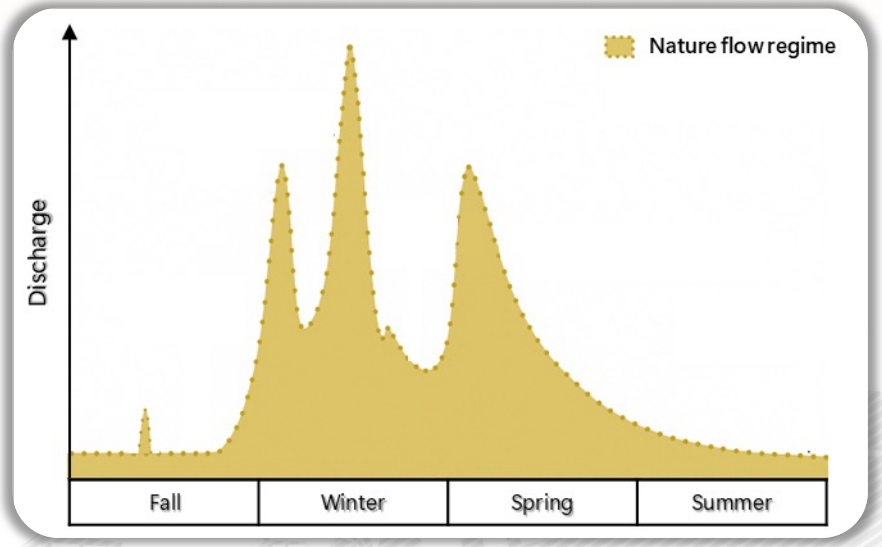
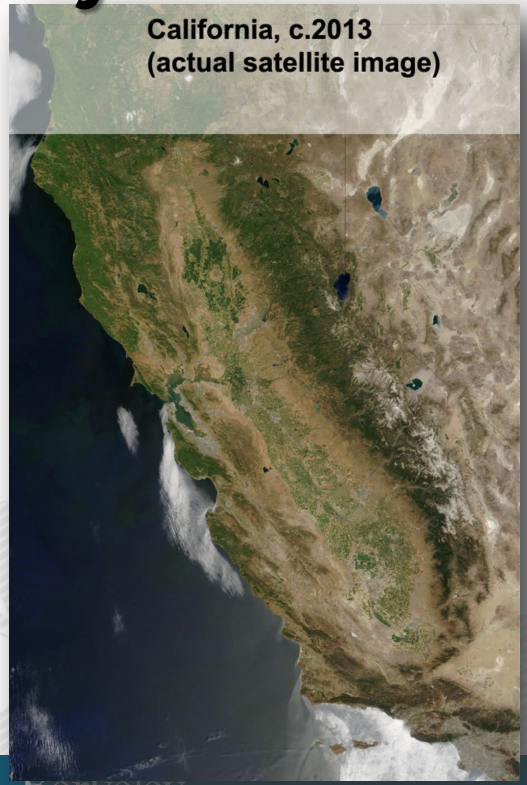
What did the Central Valley look like in the 1850s?





- High flows in winter – natural pattern supporting ecosystem processes
- Low flows in summer – critical for habitat stability and native species

What big changes were made in the Central Valley since 1850s?



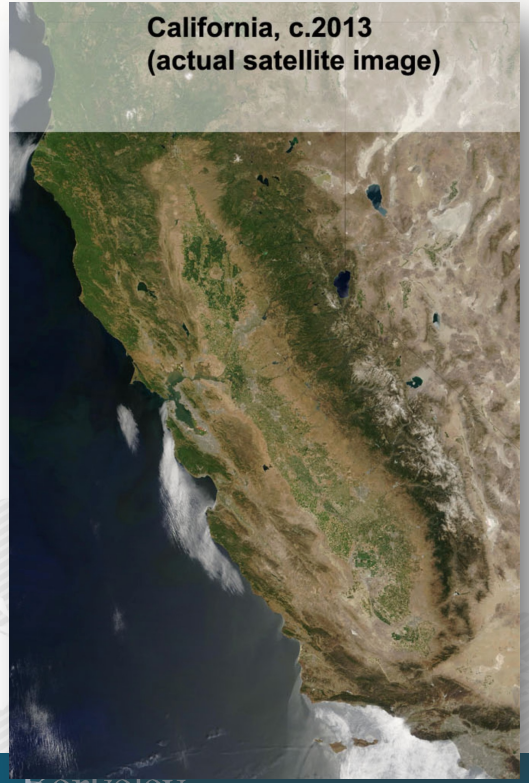
Related Image

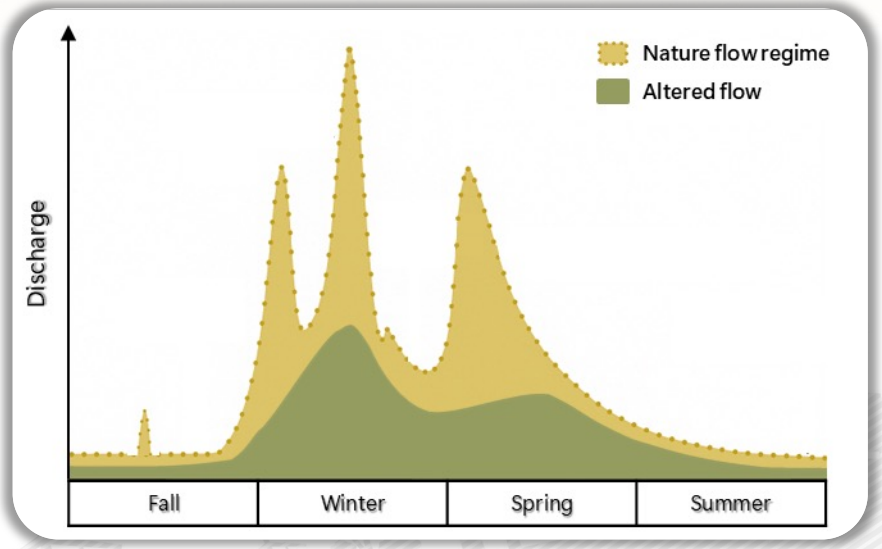
Central Valley Project (1937 – 1980s)

Trinity Dam (1963)

Shasta Dam (1945)

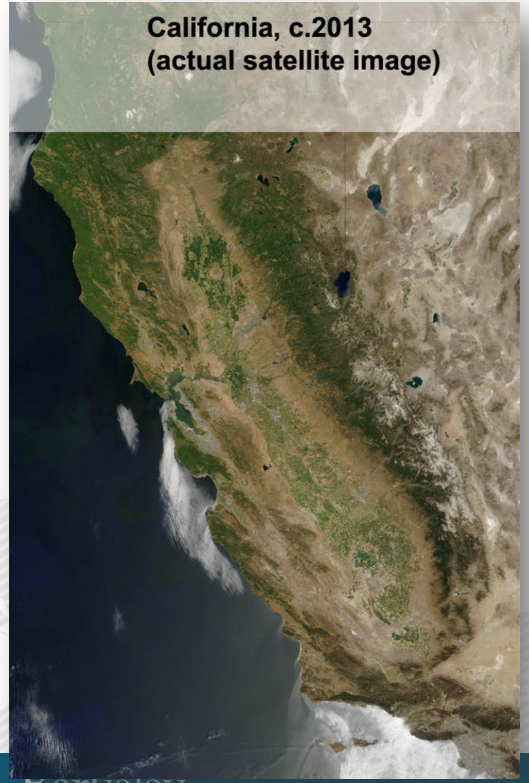
How did these water infrastructures alter flows?

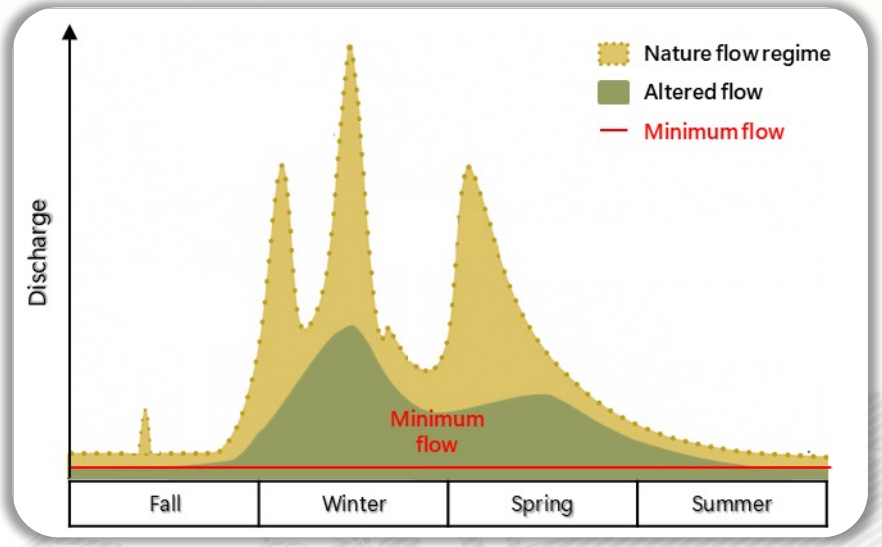




- Major changes to natural flow regimes
- Loss of seasonal peak flows
- Reduced flow variability and more uniform patterns

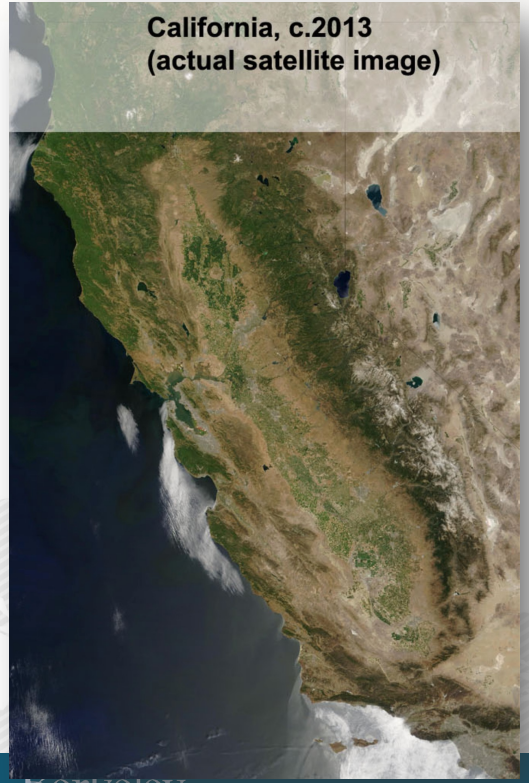
How did we try to restore flow conditions?

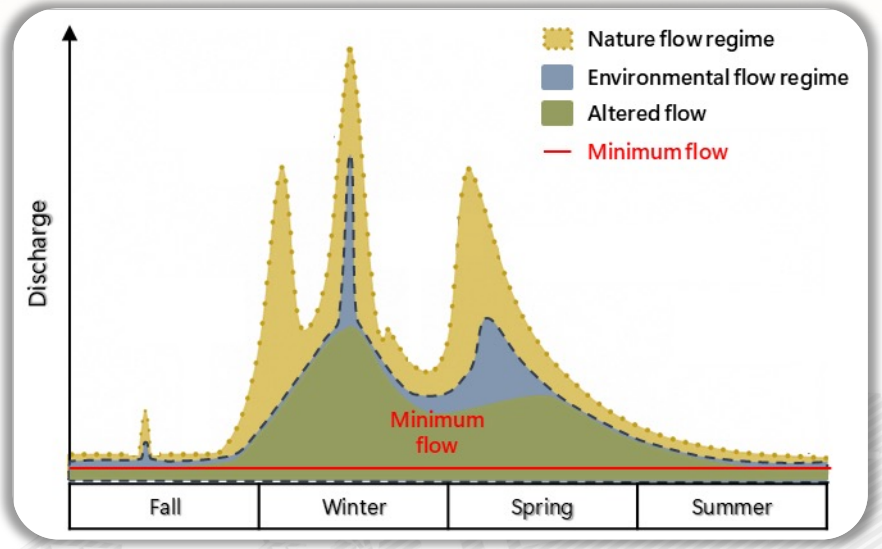




- What is ***minimum flow***?
- The baseline amount of water that should always be in the river

What is the alternative to minimum flows?





- What is ***environmental flow***?
- A flow regime to sustain natural river functions and services while meeting human water demands

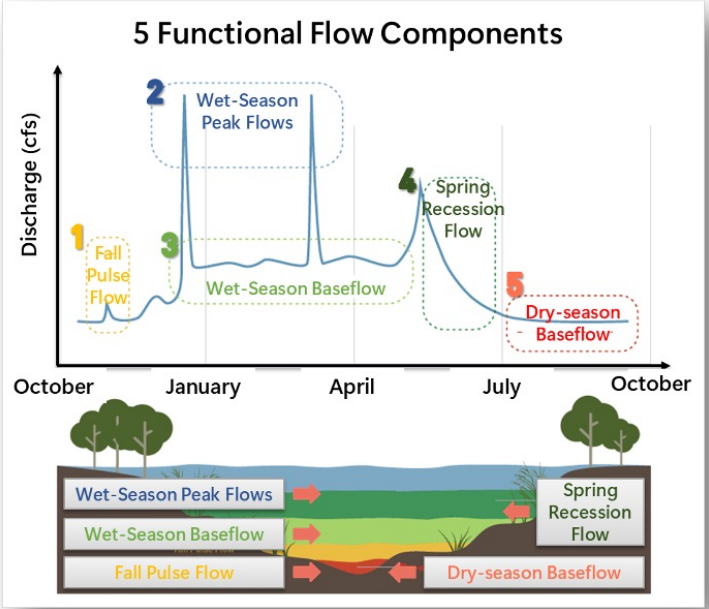
How did we quantify environmental flows?

Functional flows mimic key components of a river's flow that support critical biological, chemical and physical functions

Sacramento River

What do functional flows aim to achieve?

- Functional flows focus on hydrograph flow components that:
  - ✔ Support natural disturbances
  - ✔ Promote physical dynamics
  - ✔ Drive ecosystem functions
  - ✔ Support high biodiversity



What was the research gap?

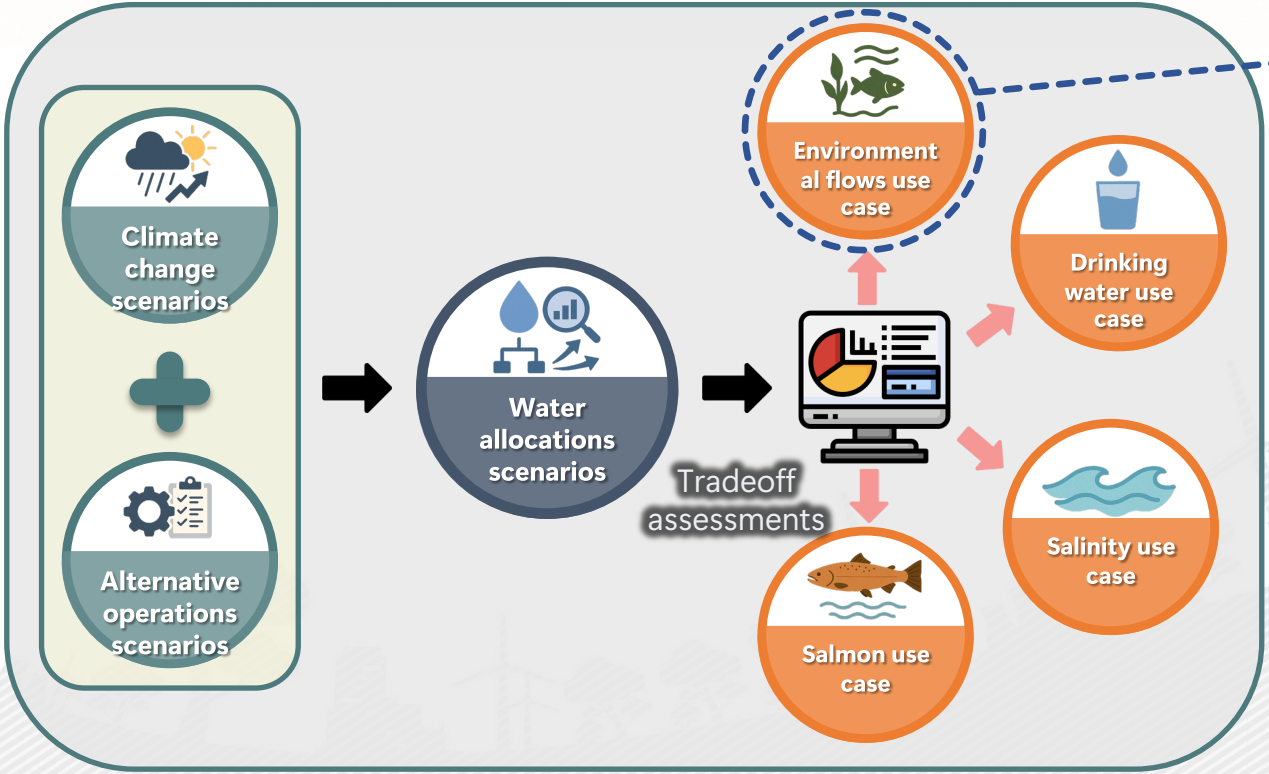
We don't yet know how much water rivers in the Central Valley need to meet functional flow goals.

It's unclear how these flows would affect different water use cases–like drinking water, salmon habitat, or salinity control.

What are the study objectives?

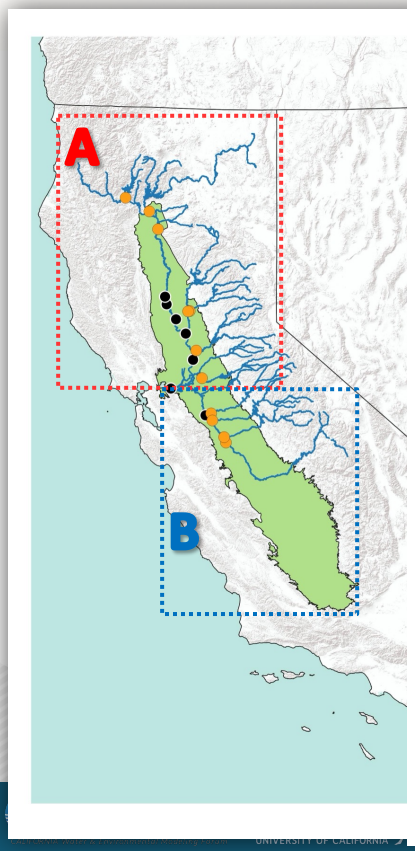
1. Quantify functional flows for Central Valley rivers.
2. Estimate monthly water budget required to maintain functional flows.
3. (Forthcoming) Evaluate functional flow water budget under alternative water management and climate scenarios

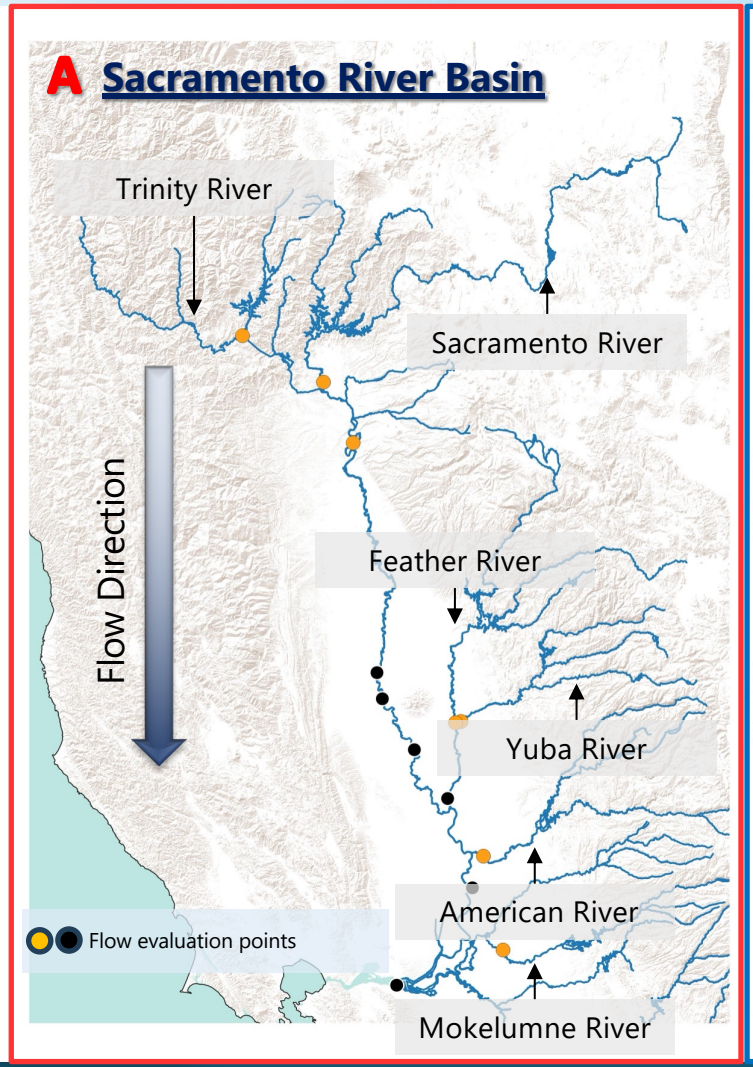
What is COEQWAL?

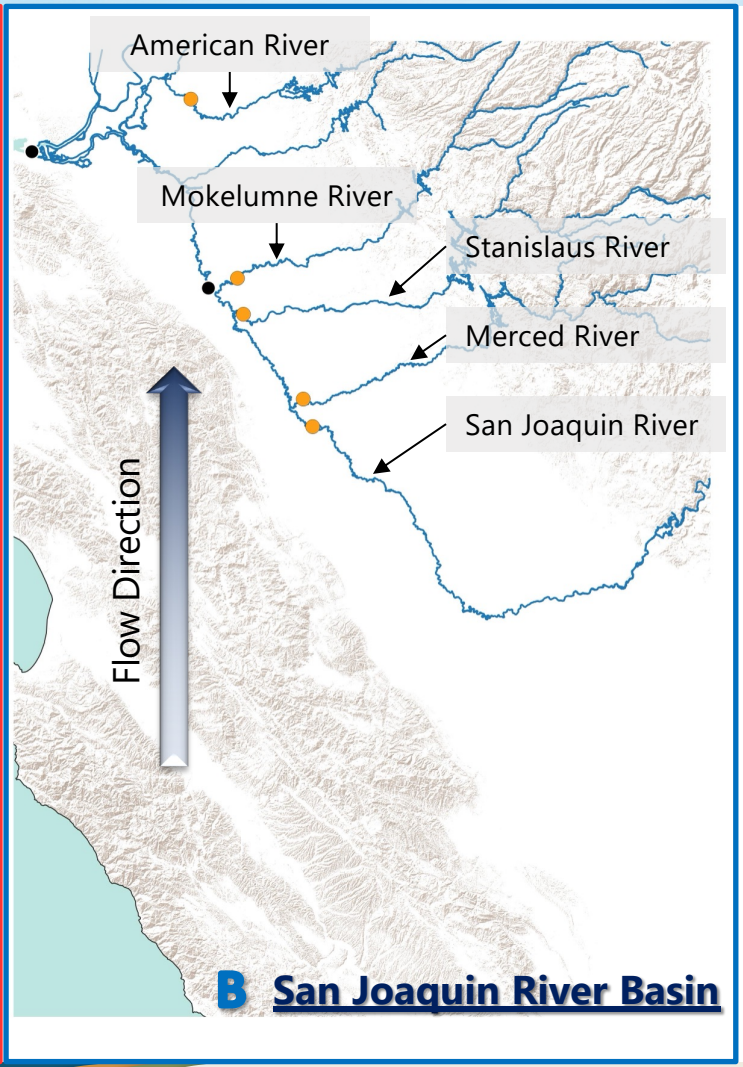


"A flow regime (quantity, quality and timing) to sustain natural river functions and services while meeting human water demands" (Poff et al. 1997)

Multi-community engagement

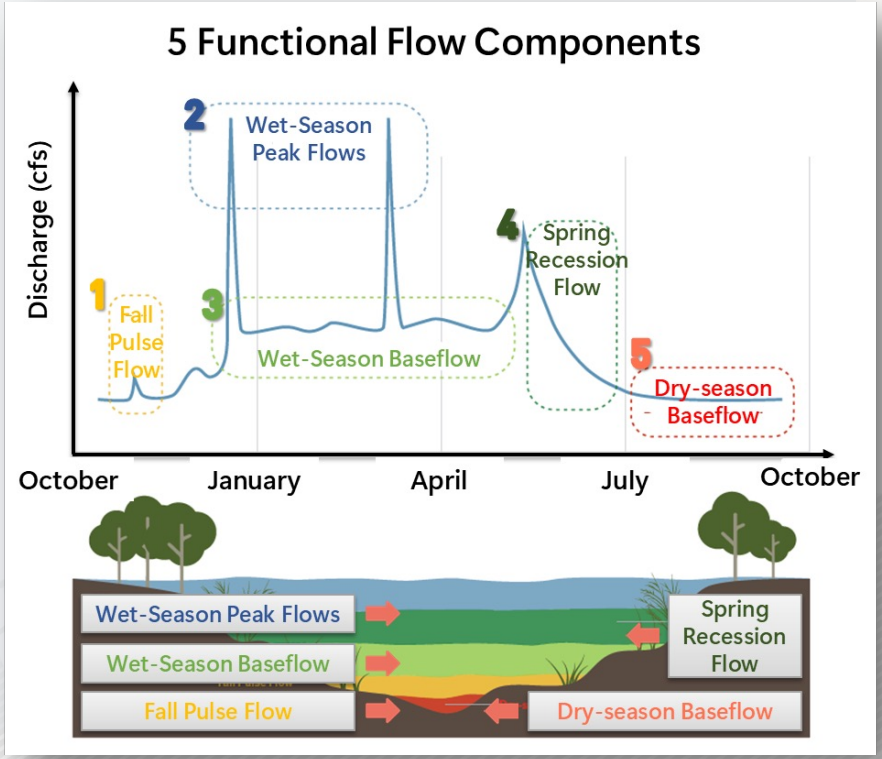

A
B


A Sacramento River Basin
Trinity River
Sacramento River
Flow Direction
Feather River
Yuba River
American River
Flow evaluation points
Mokelumne River


American River
Mokelumne River
Stanislaus River
Merced River
San Joaquin River
Flow Direction
B San Joaquin River Basin

What is functional flow?

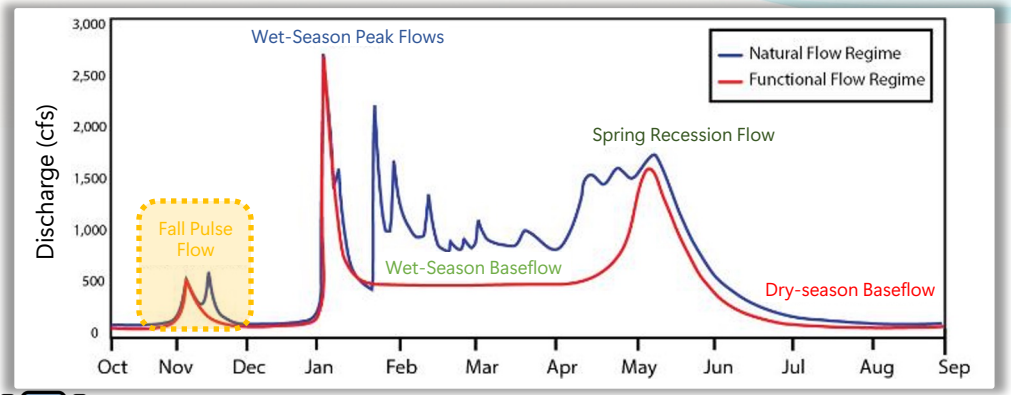
Functional Flow Component	Functional Flow Metrics
Fall Pulse Flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
	Frequency
Wet-season peak flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
	Frequency
Wet-season baseflow	Magnitude (cfs)
	Timing
Spring recession flow	Magnitude (cfs)
	Timing (date)
	Rate of change (%)
Dry-season base flow	Magnitude (cfs)



What is Fall Pulse Flow?

Fall Pulse Flow

- First wet season storms
- Trigger ecosystem processes
  - Kick-start nutrient cycling
  - Clear channel beds of organics and fine sediments
- Reconnect aquatic habitats
  - Link channel, riparian zones, and floodplains
- Provide ecological cues
  - Simulate upstream migration of native species



Related Image

Salmon, Shasta River, CA

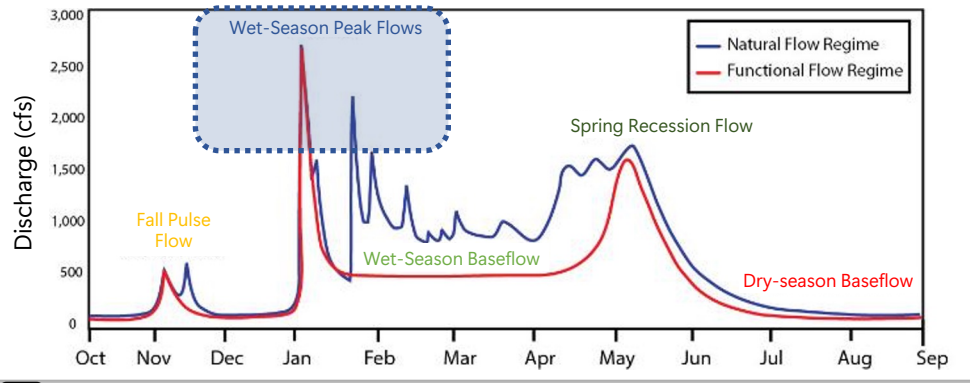
Delta Smelt

Cosumnes River, CA

What is Wet-Season Peak Flows?

Wet-Season Peak Flow

- Act as natural disturbances
  - Resets ecological succession
  - Redistributes large volumes of sediment
  - Prevents vegetation encroachment
  - Limit invasive species by mimicking natural flood regimes
- Enhance geomorphic diversity
- Inundate floodplain habitat
- Trigger bed mobilization, bank erosion, and bar formation



Related Image

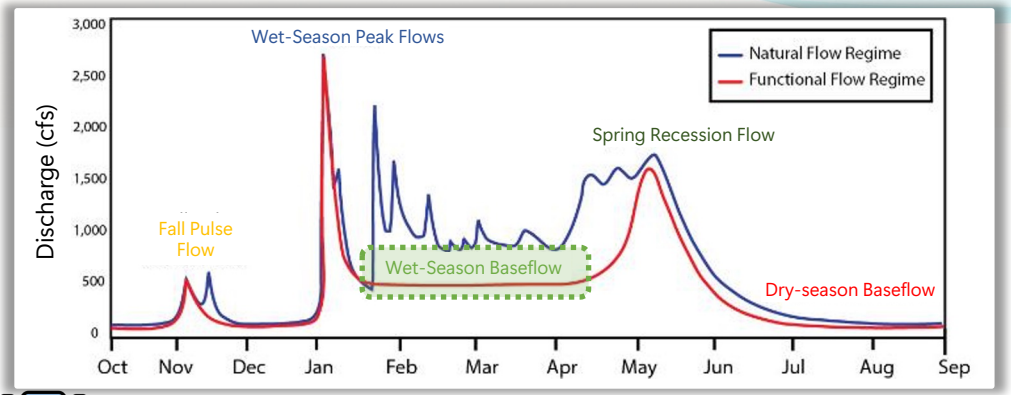
Cosumnes River, CA levee breaches

Sacramento River, CA

What is Wet-Season Baseflow?

Wet-Season Baseflow

- Maintain stream network during winter
- Support fish passage and movement across the watershed
  - Especially coastal salmonids
- Provide greater hydraulic habitat compared to dry season baseflows
- Reflect seasonal rhythm of California rivers



Related Image

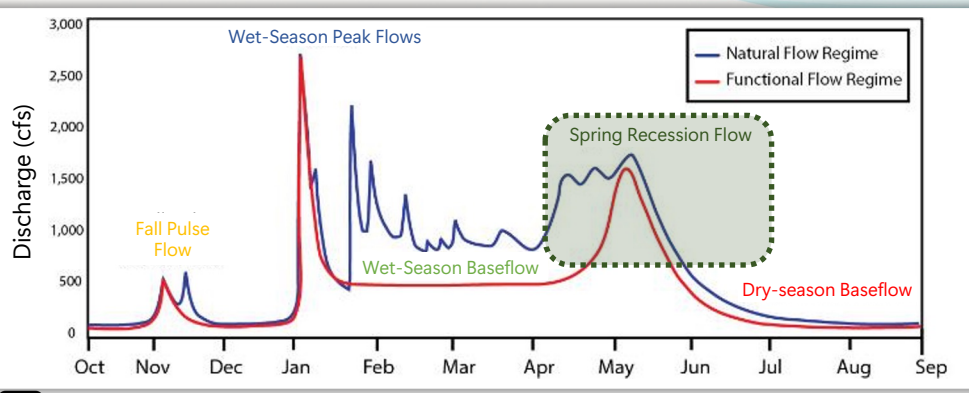
Cosumnes River, CA levee breaches

Sacramento River, CA

What is Spring Recession Flow?

Spring Recession Flow

- Provide seasonal cues for native species' reproduction and migration
- Redistributes sediments
  - Gradual flow allow finer particles to settle naturally
- Maintain habitat diversity
  - Spawning areas
- Extends cold water and floodplain inundation



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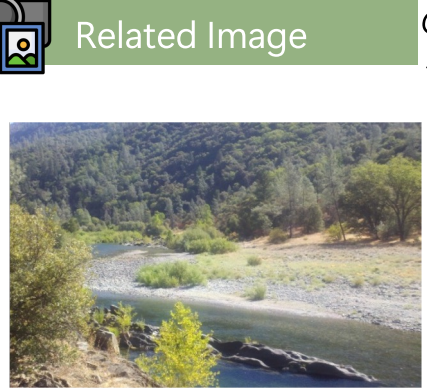


North Fork American River, CA

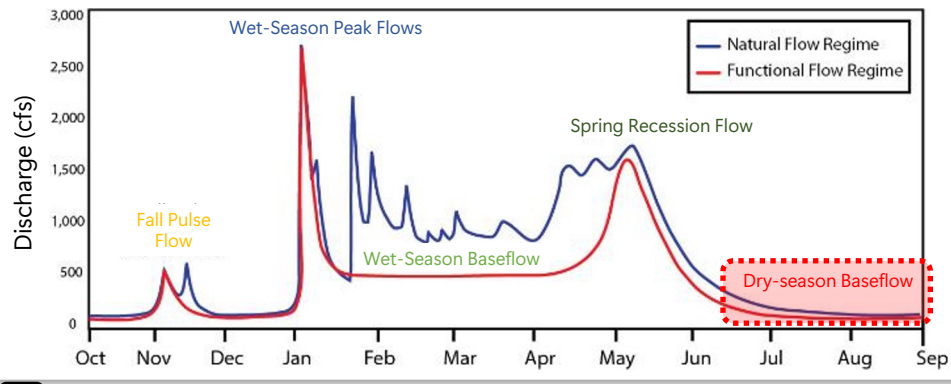
Chinook Salmon

Foothill yellow-legged frog

What is Dry-Season Baseflow?

Dry Season Baseflow

- Set critical habitat limits
  - Low flow magnitude and duration shape physical habitat quality
- Native species have adapted to survive stressful low-flow conditions
- Reduces extent of exotic species not adapted to limiting conditions
- Encourage different species to use the environment in different ways



Related Image

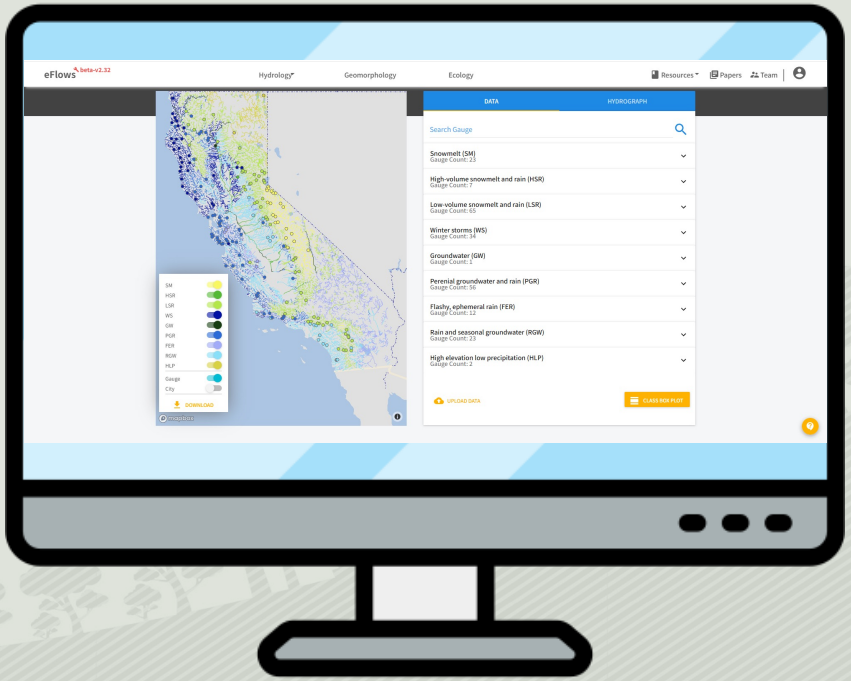
Santa Clara River, CA

Step 1: Calculate the functional flow components and metrics

Daily natural flow

Functional Flow Calculator

Generate daily hydrograph



Step 2: Establish relationships between metrics and water year percentile

Daily natural flow

Functional Flow Calculator

Generate daily hydrograph

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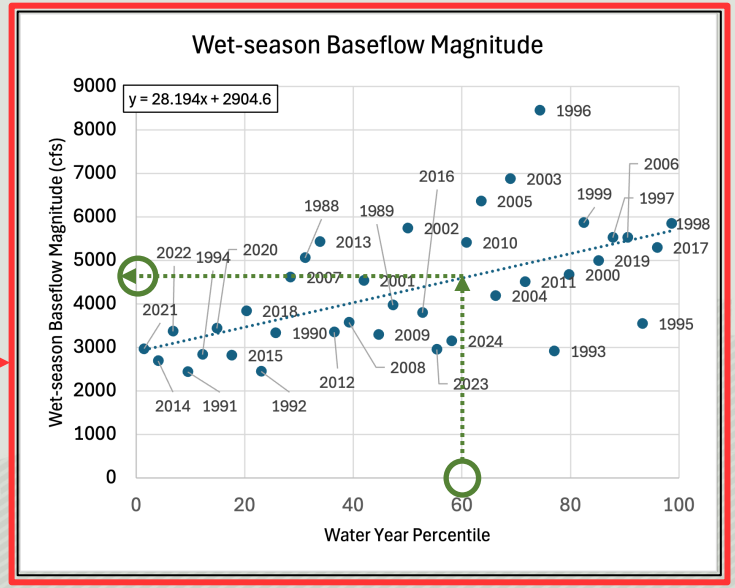

Step 3: Generate daily hydrograph (representing the functional flow targets)

Daily natural flow

↓

Functional Flow Calculator

↓

Generate daily hydrograph

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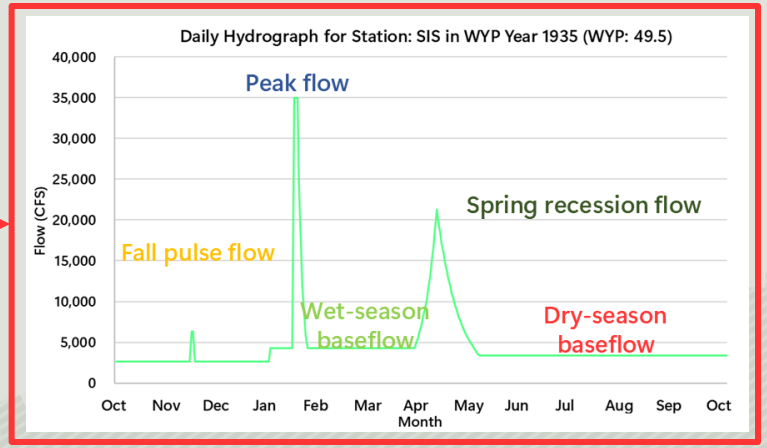

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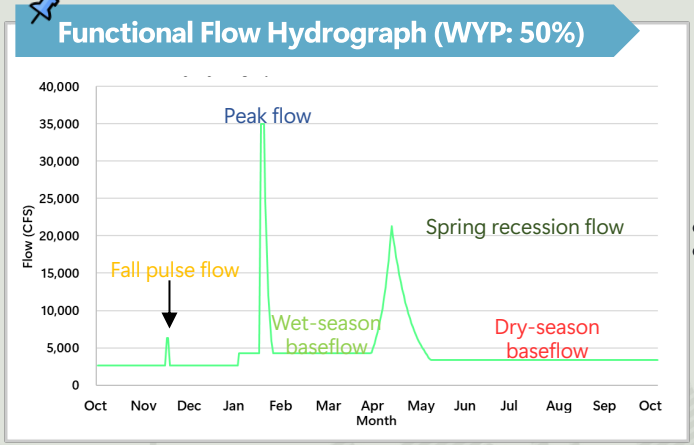
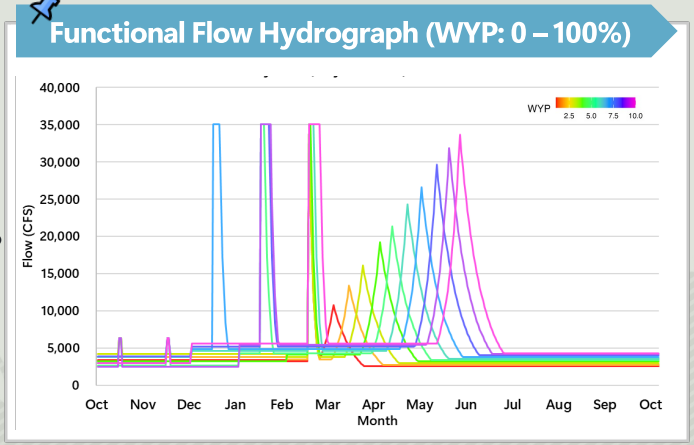
Functional Flow Calculator

Generate daily hydrograph

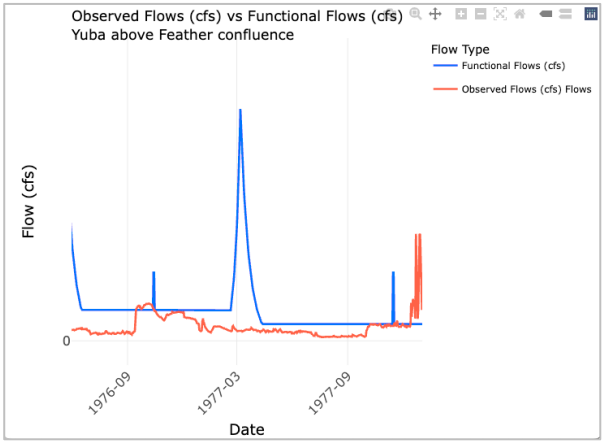




How does functional flow look in dry vs. wet years?

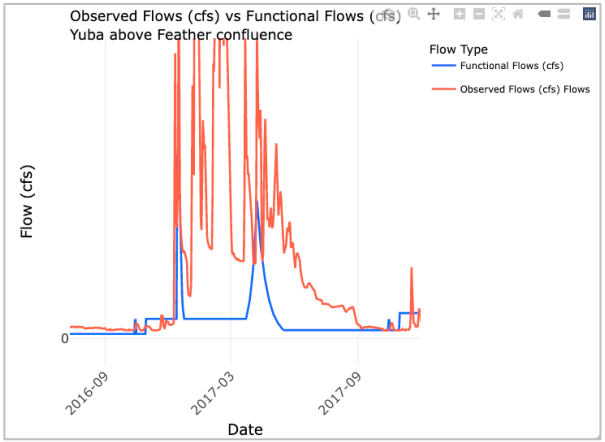
Yuba above Feather Confluence

Dry Year (1977)



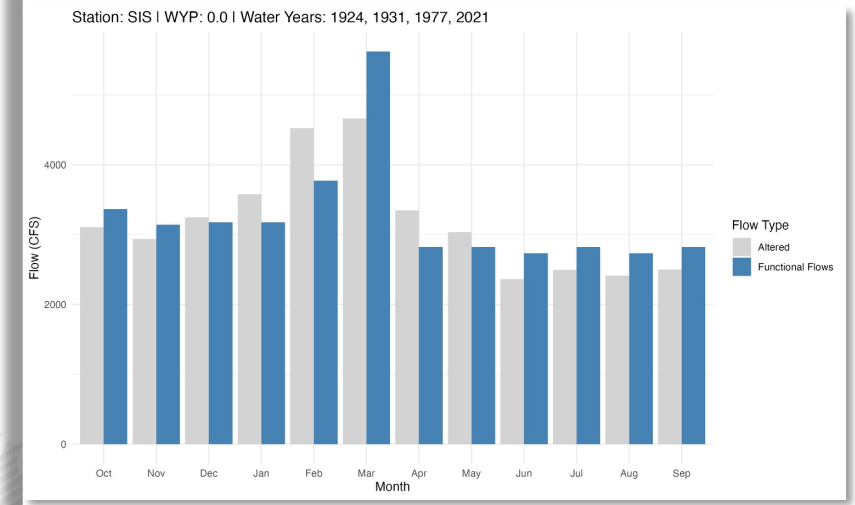
VS

Wet Year (2017)

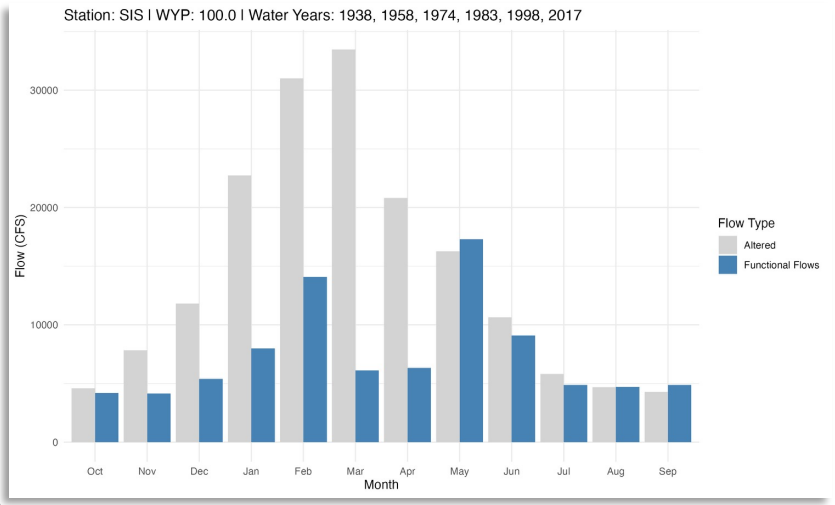


How much of the altered flow is captured by functional flow requirements?

Sacramento River (Dry Year)



Sacramento River (Wet Year)



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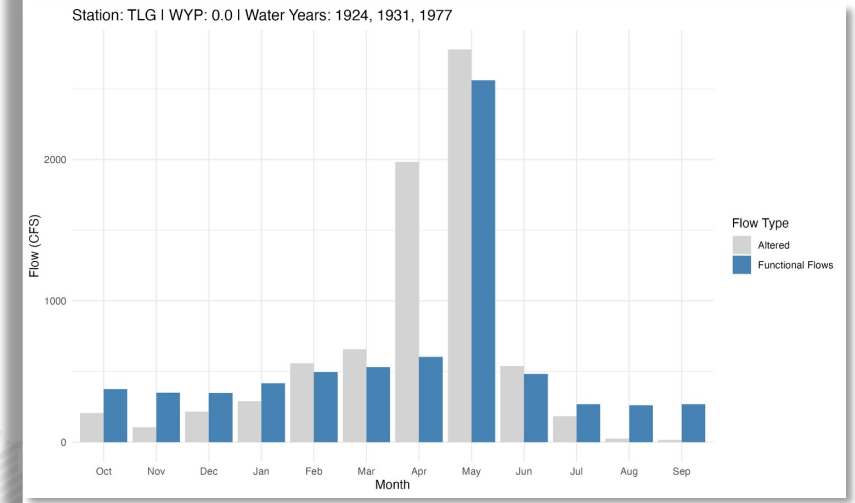
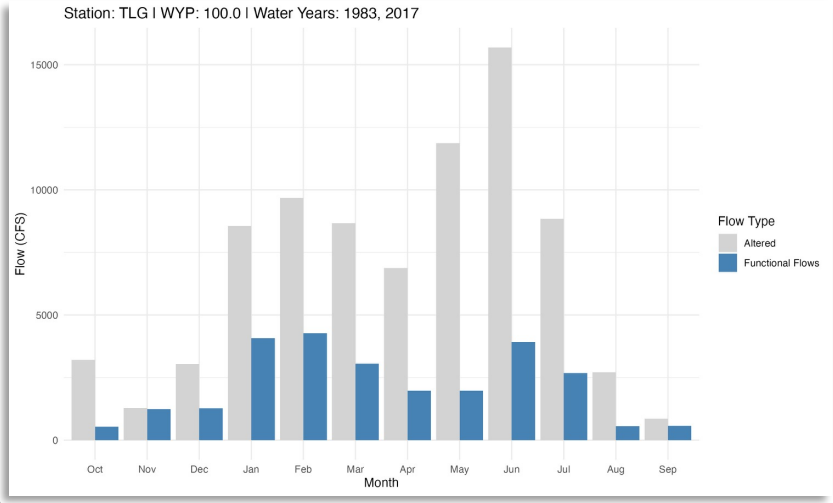
Tuolumne River (Dry Year)



Tuolumne River (Wet Year)

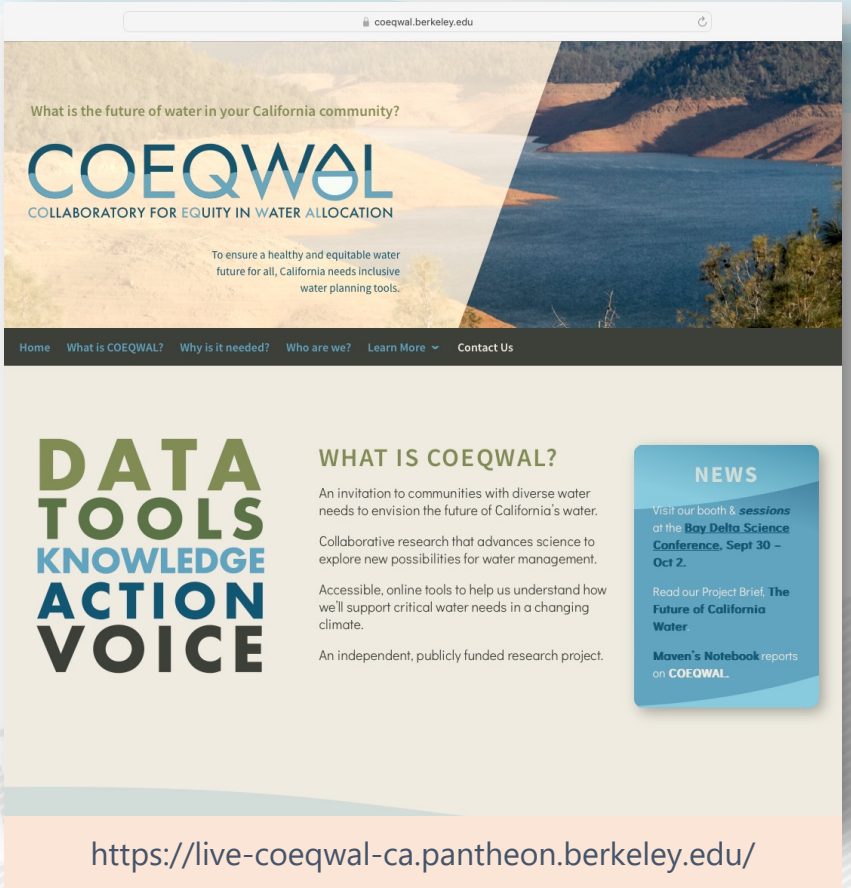


What are the key takeaways from this study?

- Developed an approach to define and quantify environmental flow requirements
- Designed a framework to guide the quantification and allocation of environmental water budgets
- Recognized the importance of seasonal, interannual, and geographic variability in flow regimes

Yuba River

Thank you



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