California Environmental Flows Framework

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University of California
Agriculture and Natural Resources

The Nature Conservancy

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CALIFORNIA
WATER QUALITY
MONITORING COUNCIL

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DEPARTMENT OF
FISH & WILDLIFE

UtahStateUniversity

SCCWRP
Established 1969

CALIFORNIA TROUT
FISH · WATER · PEOPLE

California Environmental Flows Framework

Prepared by:

California Environmental Flow Working Group, a committee of the California Water Quality Monitoring Council

Funded by:

State Water Resources Control Board, Division of Water Rights

November XX 2020

CEFF TECHNICAL TEAM

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- Bronwen Stanford - CA Department of Fish and Wildlife
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- Eric Stein – Southern CA Coastal Water Research Project
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- Kris Taniguchi-Quan – S. CA Coastal Water Research Project
- Robert Holmes – CA Department of Fish and Wildlife
- Rob Lusardi - CalTrout
- Sam Sandoval-Solis – University of California, Davis
- Samuel Cole – State Water Resources Control Board
- Sarah Yarnell – University of California, Davis
- Ted Grantham – University of California, Berkeley

CA Environmental Flows Framework (CEFF)

Provides technical guidance for managers to efficiently develop scientifically defensible environmental flow recommendations following a functional flows approach.

Multi-step process to define:

- **Ecological flow criteria:** metrics that describe the range of flows that must be maintained within a stream and its margins to support the natural functions of healthy ecosystems
- **Environmental flow recommendations:** metrics that consider human uses and other management objectives along with ecological flow criteria

Guidance document now available: *ceff.ucdavis.edu*

Environmental Flow Methodologies

By 2002, Over 200 methods and broader frameworks existed to assess water requirements and support flow management (Tharme 2003)

- **Hydrologic (flow)**
- **Hydraulic (flow + stage & velocity)**
- **Habitat-based (physical + biological)**
- **Holistic (entire ecosystem)**

DeSabla powerhouse
Butte Creek, CA

So what's the Problem?

Flow-ecology relationships are:

- described for a limited set of flow metrics
- averaged over the flow record
- often single species focused
- static, not time variable
- not process-based
- don't account for shifting baselines

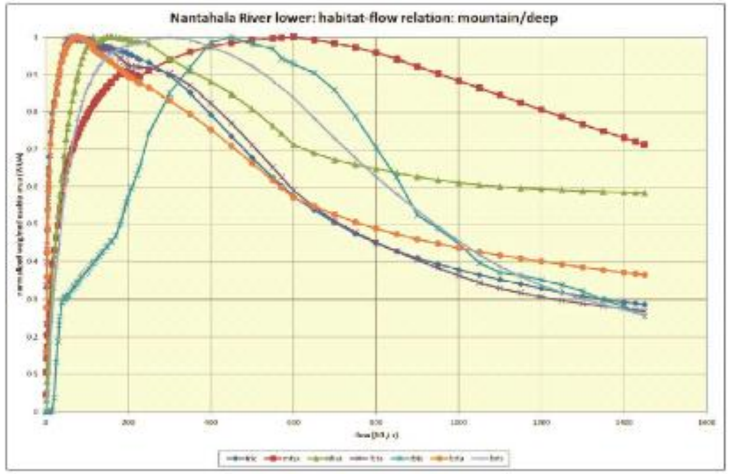
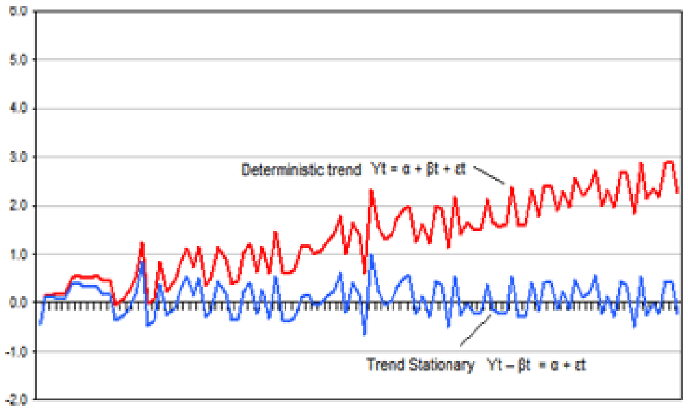
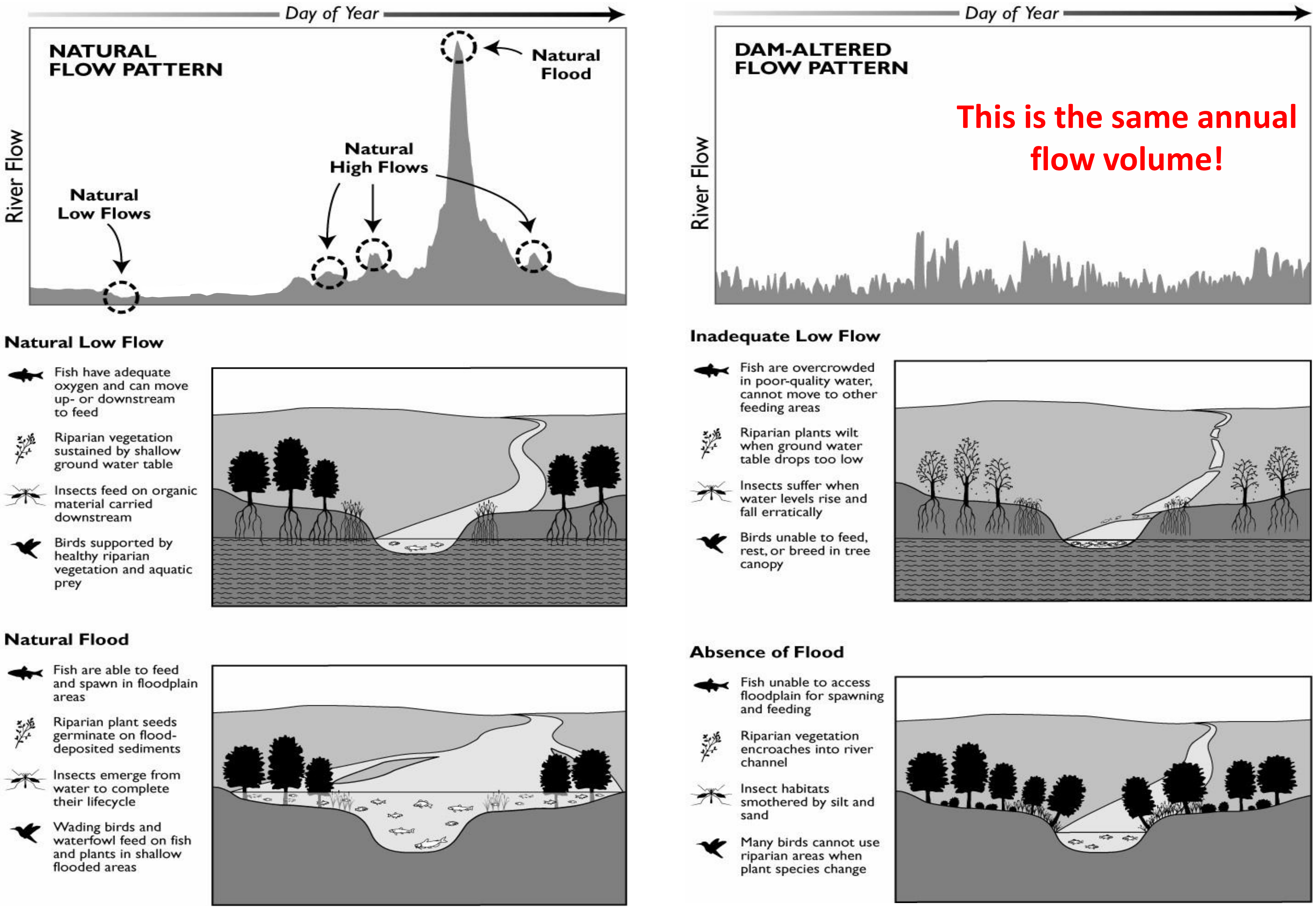


Figure 3. Example of WUA habitat-discharge relation (mountain-deep species/life stages) output from PHABSIM modeling.



It's not just a matter of Flow Volume



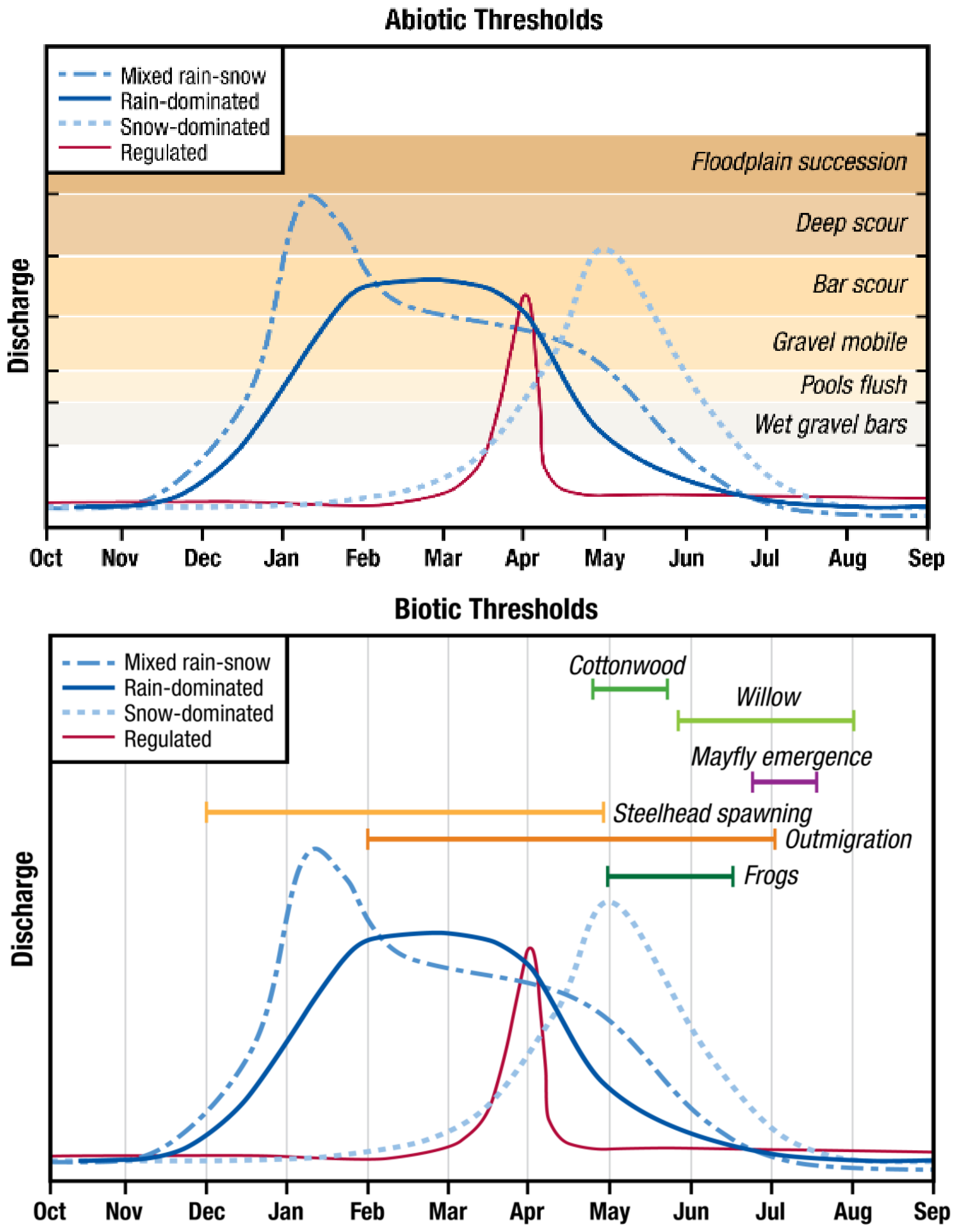
Postel & Richter 2003

Functional Flows Approach

Environmental Flows - focus on hydrograph flow components that:

- Support natural disturbances
- Promote physical dynamics
- Drive ecosystem functions
- Support high biodiversity

Consideration of geomorphic setting and channel-floodplain dynamics

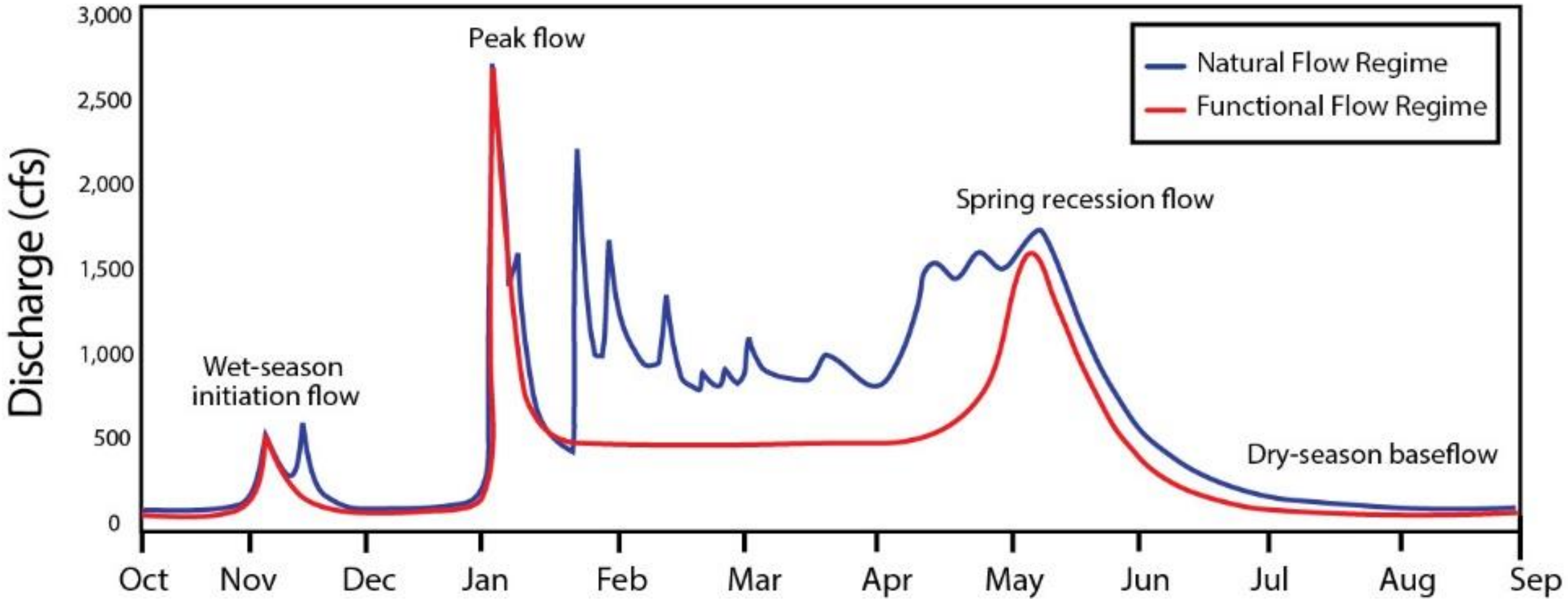


Yarnell et al. 2010

Functional Flows Approach

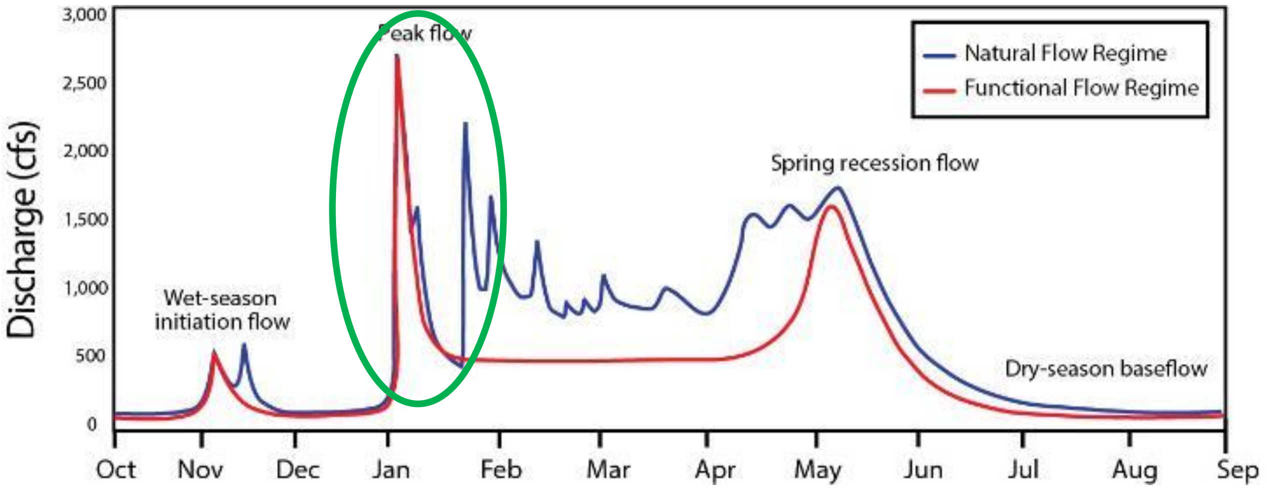
- "Functional Flow" = hydrograph component that provides a distinct geomorphic, ecologic, or biogeochemical function
- Reflective of natural patterns that occur in space & time

Yarnell et al. 2015



Peak Magnitude Flow

- Primary geomorphic disturbance
- Resets natural processes such as succession
- Redistributes large volumes of sediment
- Prevents vegetation encroachment
- Reduces extent of exotic species not adapted to disturbance regime
- Most effective when given SPACE – levee setbacks, levee breaches to floodplain, tributary junctions



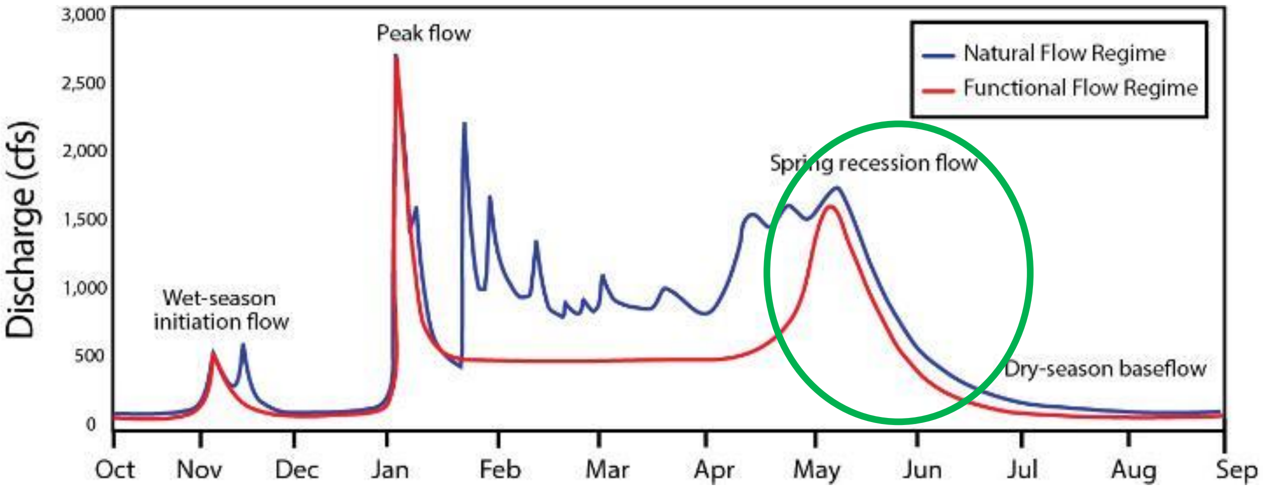
Sacramento River, CA

Cosumnes River, CA levee breaches

Spring Recession Flow

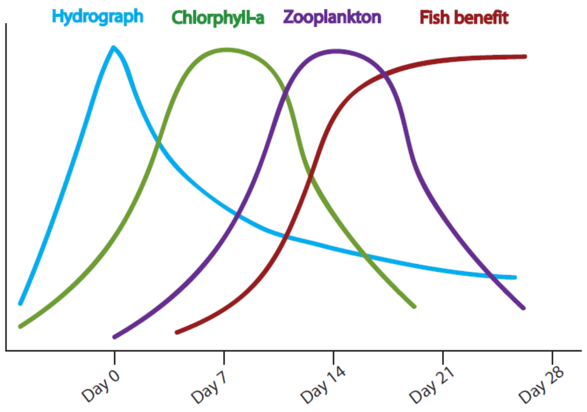
High to Low Flow Transition

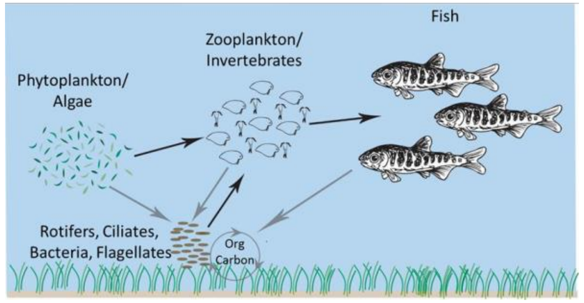
- Redistributes and sorts sediment mobilized by high flows
- Limits riparian vegetation encroachment
- Provides distinct annual cues for native species to reproduce and outmigrate
- Extended cold water and floodplain inundation



Foothill yellow-legged frog

Chinook Salmon



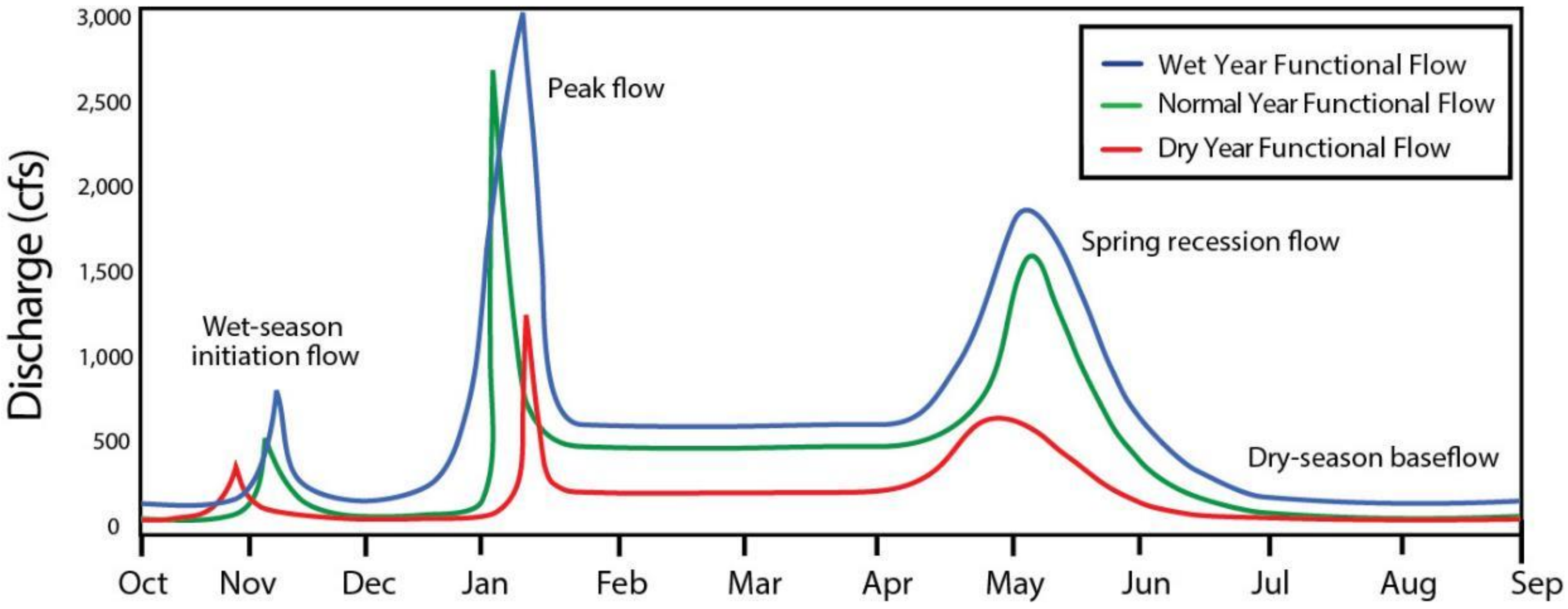


(Jeffres et al 2008)

Interannual Flow Variability

Magnitude, timing and duration of specific flow events vary:

within their associated season depending on regional climatic conditions, and *between* years depending on global climate conditions

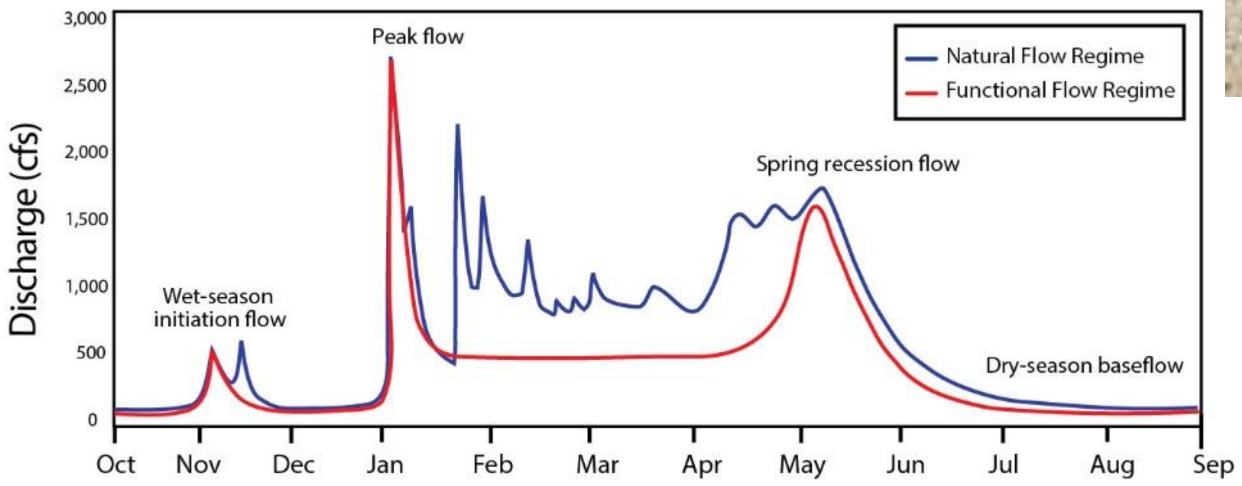


Supports diversity in geomorphic habitat and subsequent diversity in native species over the long-term

Functional Flows need to "Function"

Restoring Geomorphic Complexity

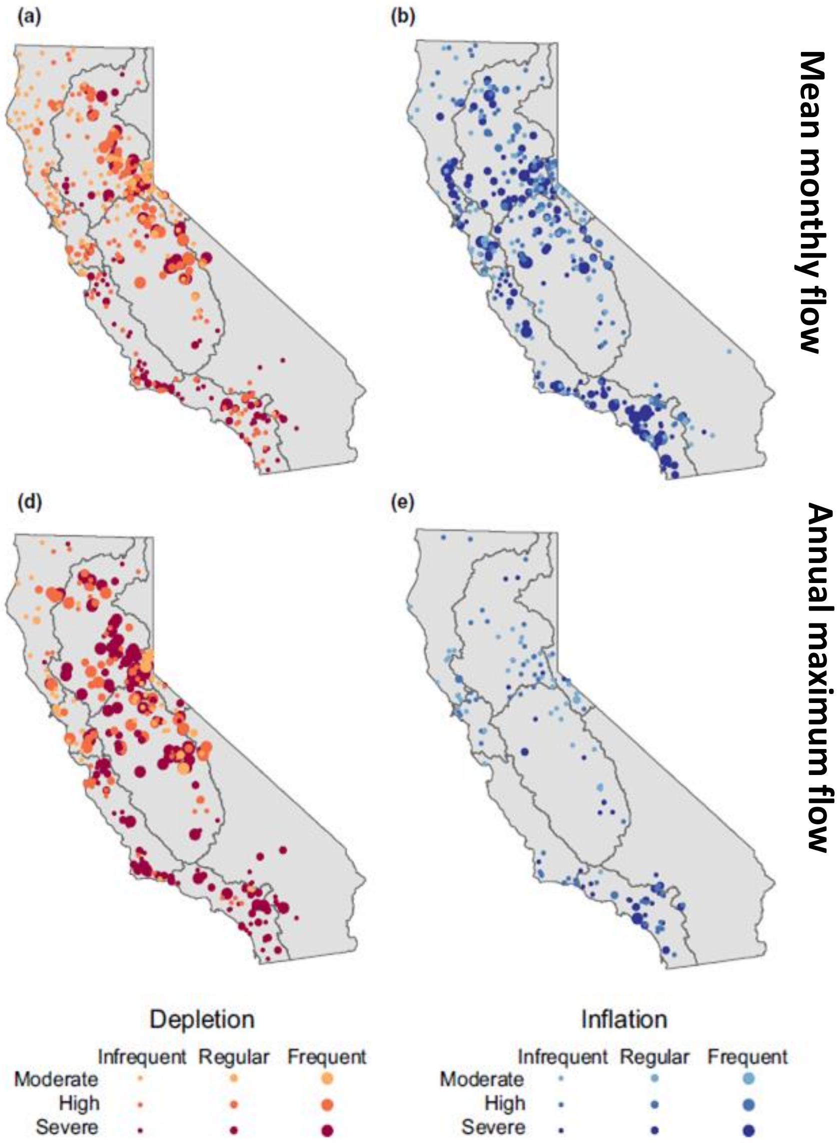
- Physical Habitat Restoration
- Floodplain Connectivity



Yarnell et al. 2015; Yarnell and Thoms, In review

Challenges to Implementation in California

- California is a very complex/diverse state
- Hard to balance environmental flow needs with a broad range of other demands
- 95% of gauged locations have at least some altered flows; 11% have pervasive alteration



Zimmerman et al 2018

Need for a Coordinated Framework

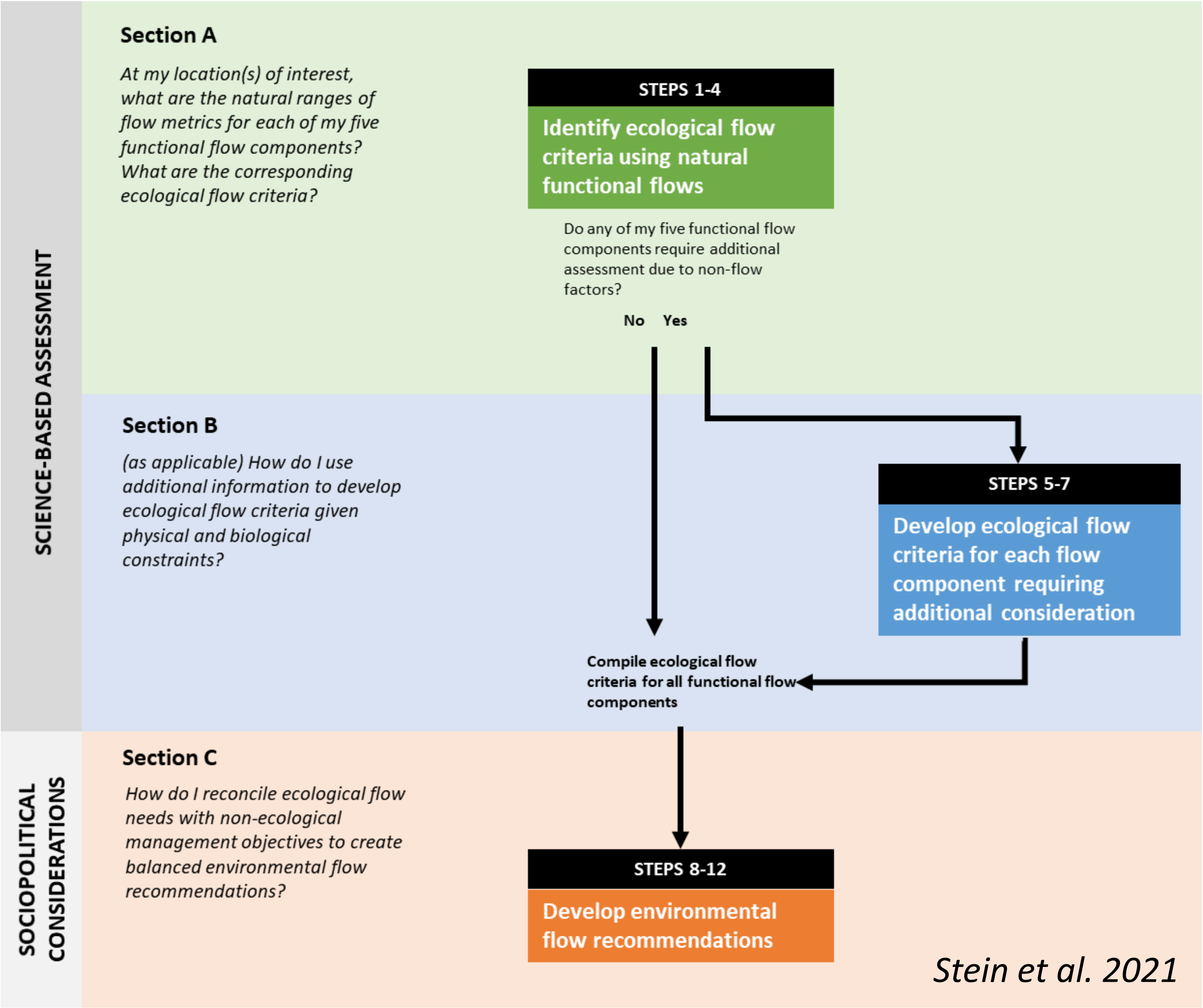
Many programs are attempting to set environmental flows

- Different systems
- Different endpoints
- Different management needs
- Different stakeholder priorities

- Poor coordination
- Challenge in sharing data
- Uncertainty in which methods are most appropriate
- Inefficiencies/redundancy in developing requirements
- Difficulty in communicating to stakeholders and the public

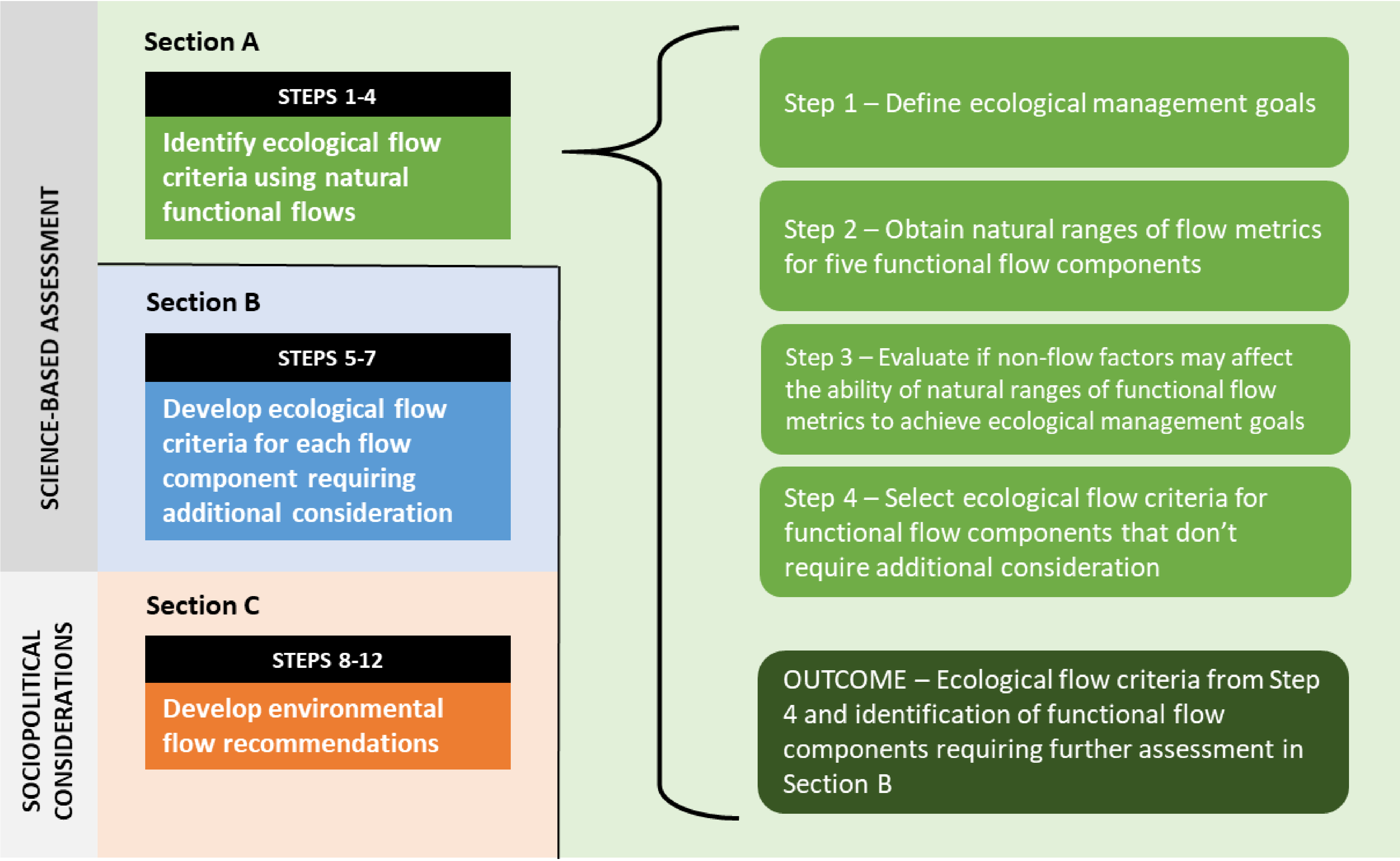
CEFF Steps Overview

ceff.ucdavis.edu

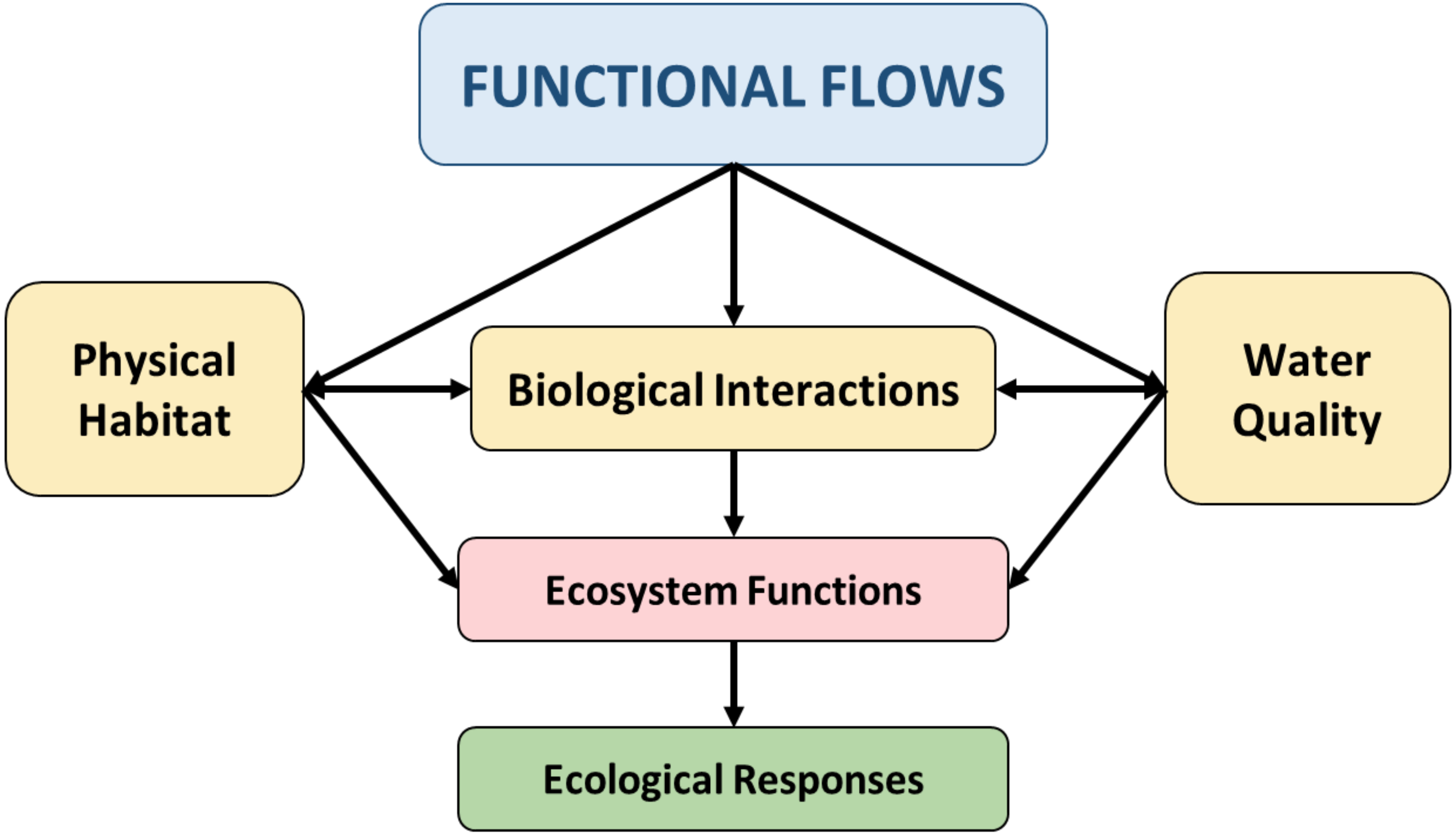


Stein et al. 2021

CEFF Section A

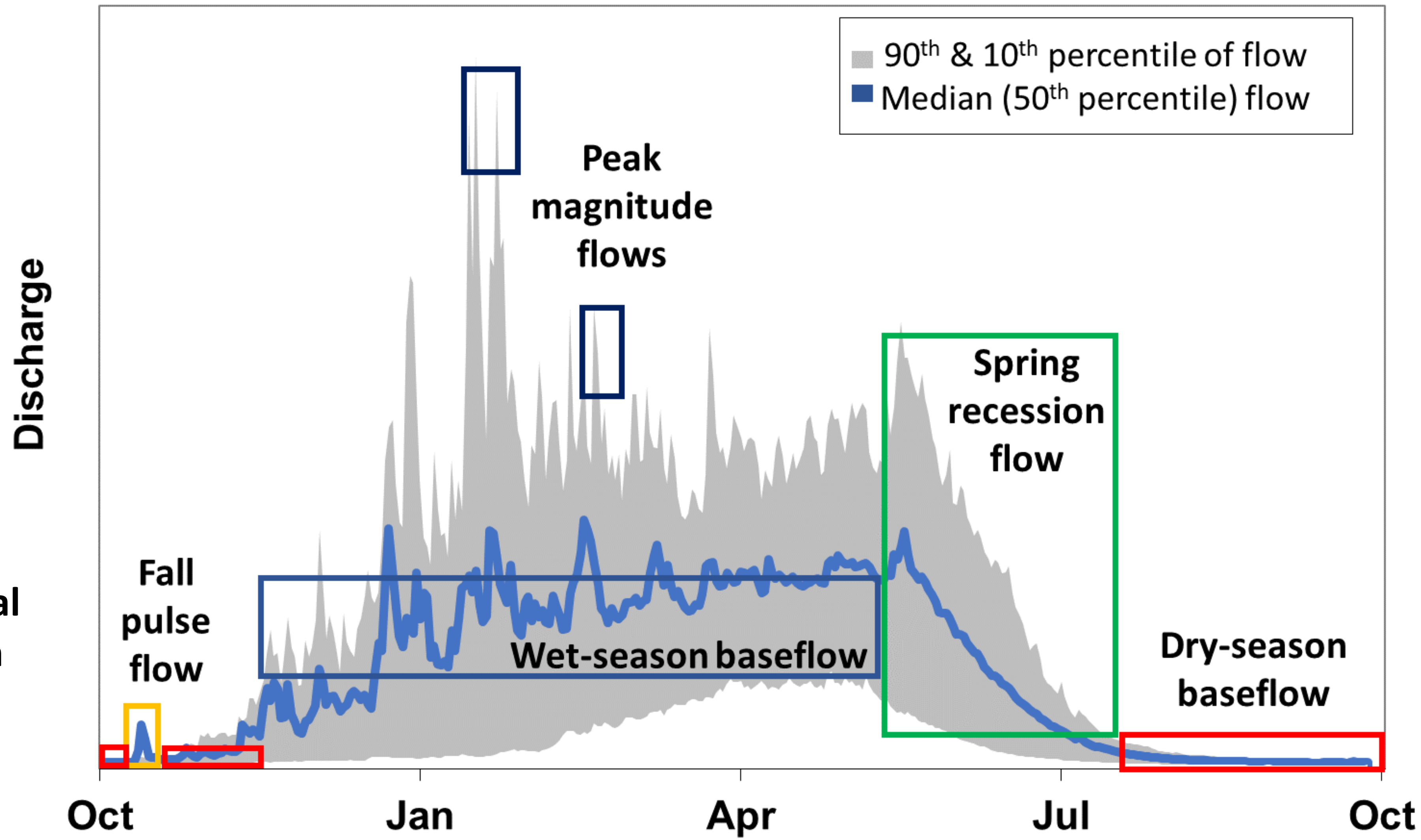


Using Natural Flows to Set Ecological Flow Criteria in Section A



Functional Flows in California

Metrics relate to general stream health based on *natural flow conditions*

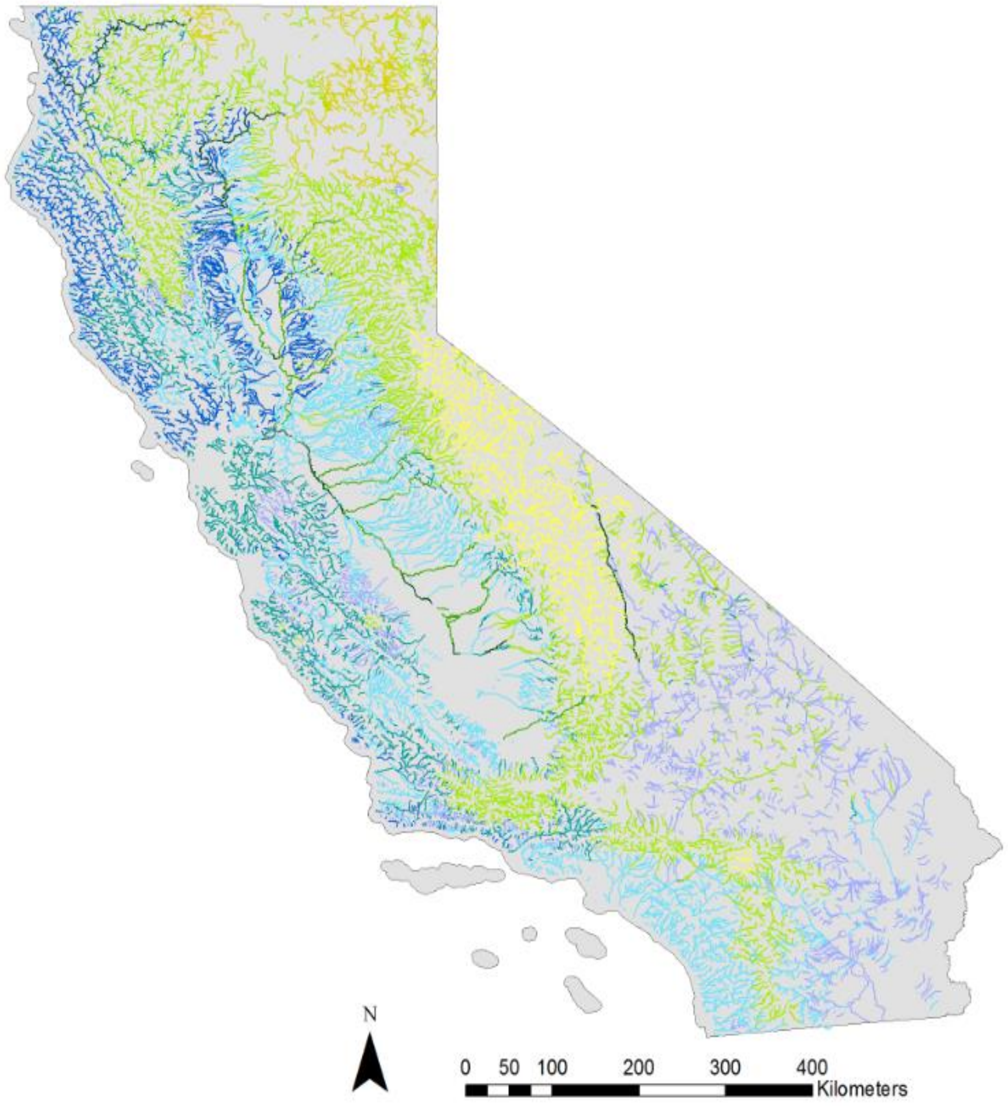


Yarnell et al. 2020 RRA

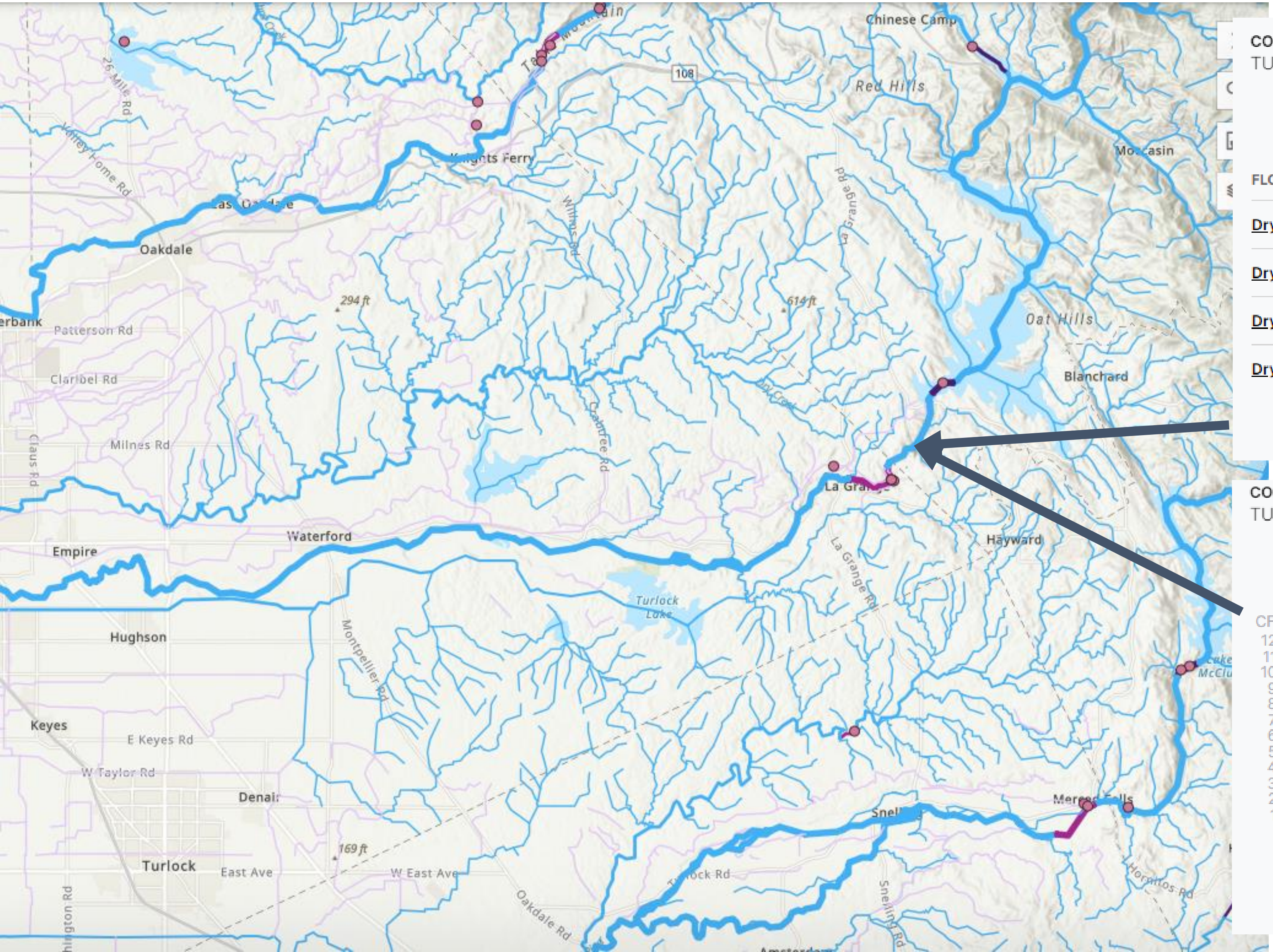
Modeled Natural Functional Flows

- Predictions of natural functional flow metric ranges at every stream in the state
- Hydrologic model predictions used for 16 metrics and observed, reference-gage data used for 8 metrics
- Ranges reported by water-year type for most metrics

Grantham et al. 2022 FES



Natural Flows Web Tool: rivers.codefornature.org



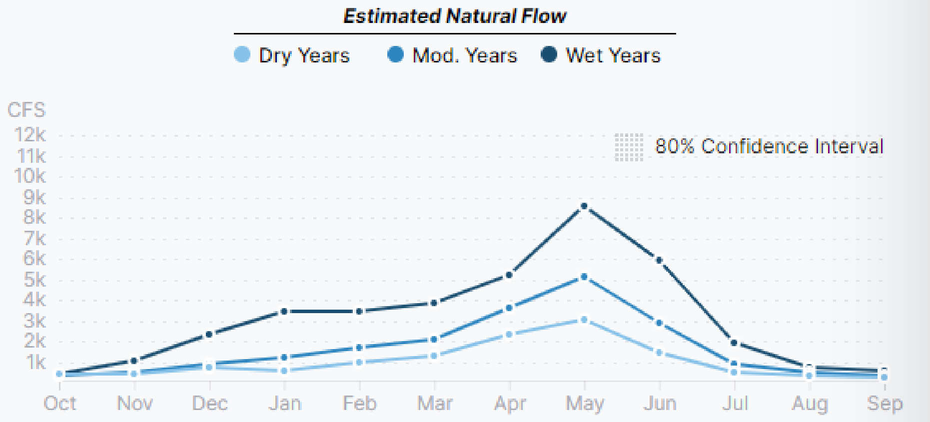
COMID: 17080381
TUOLUMNE RIVER

Flow Component	Year Type	Recurrence Interval
Dry-season base flow	All Years	2-year

FLOW METRIC	10th pctl	50th pctl	90th pctl	Observed Med.
Dry-season baseflow	189 CFS	526 CFS	862 CFS	-
Dry-season high baseflow	383 CFS	901 CFS	1,690 CFS	-
Dry-season start	Jul. 10	Jul. 29	Aug. 29	-
Dry-season duration	108 DAYS	160 DAYS	215 DAYS	-

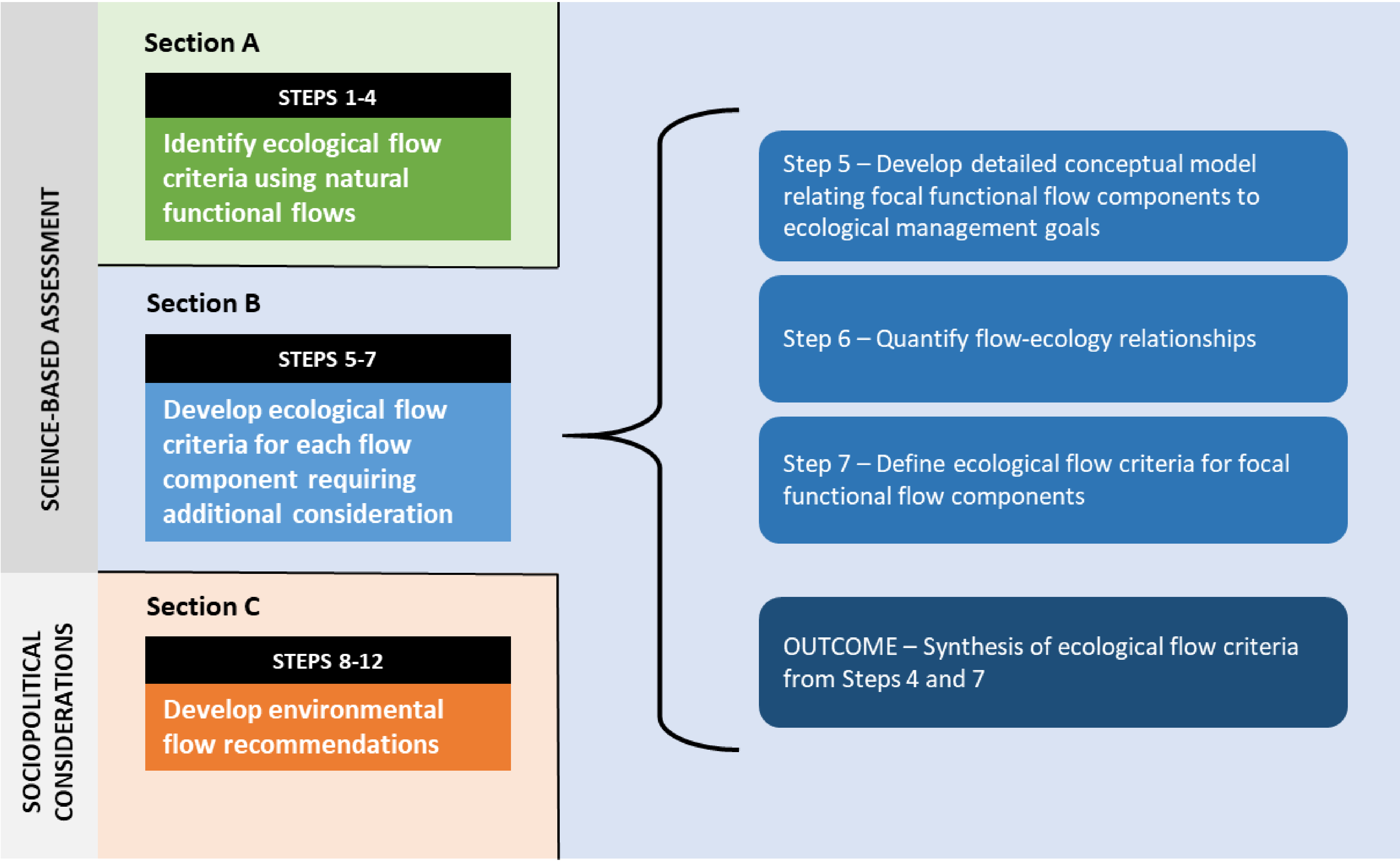
Functional Flow Metrics

COMID: 17080381
TUOLUMNE RIVER

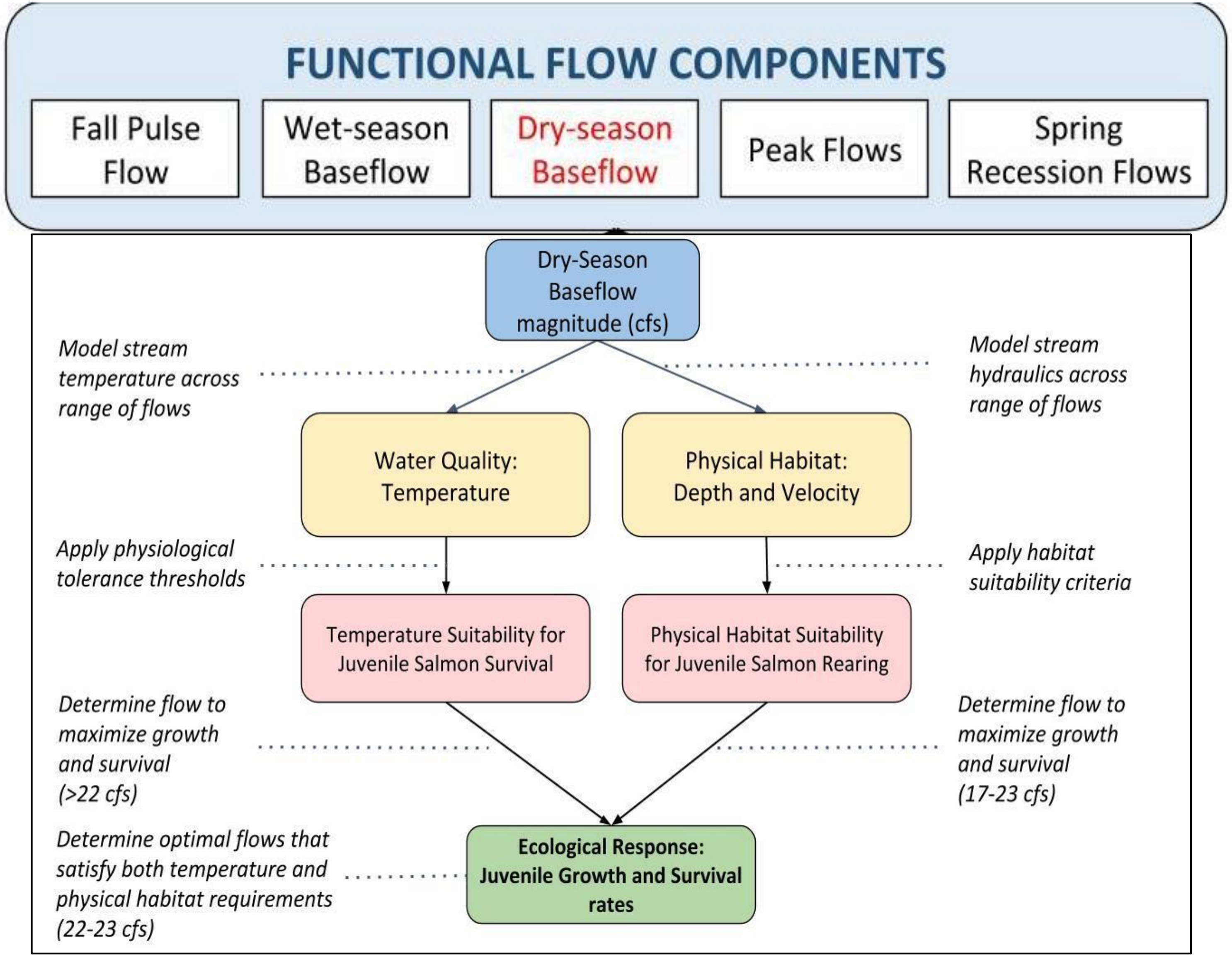


Line Hydrograph

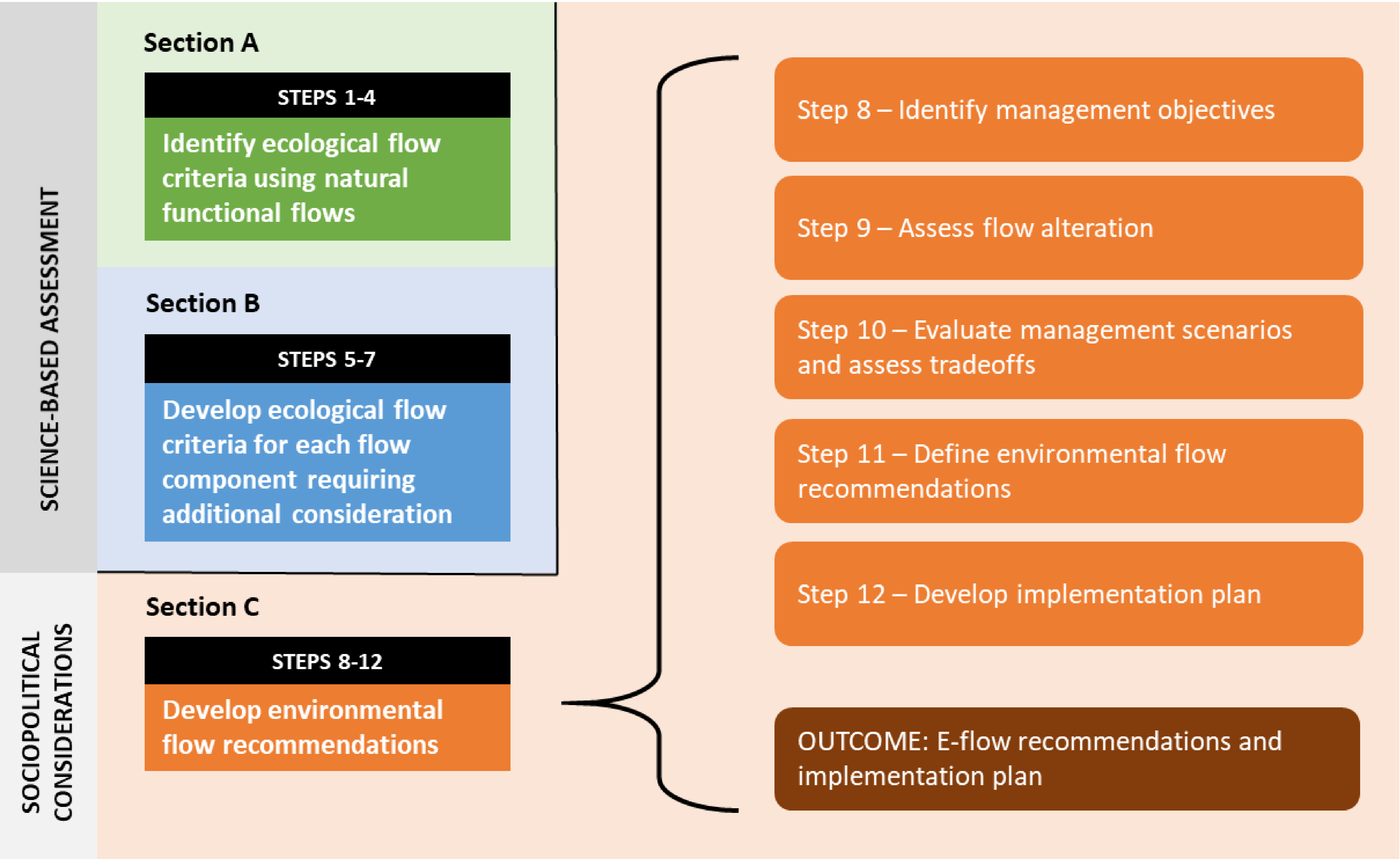
CEFF Section B



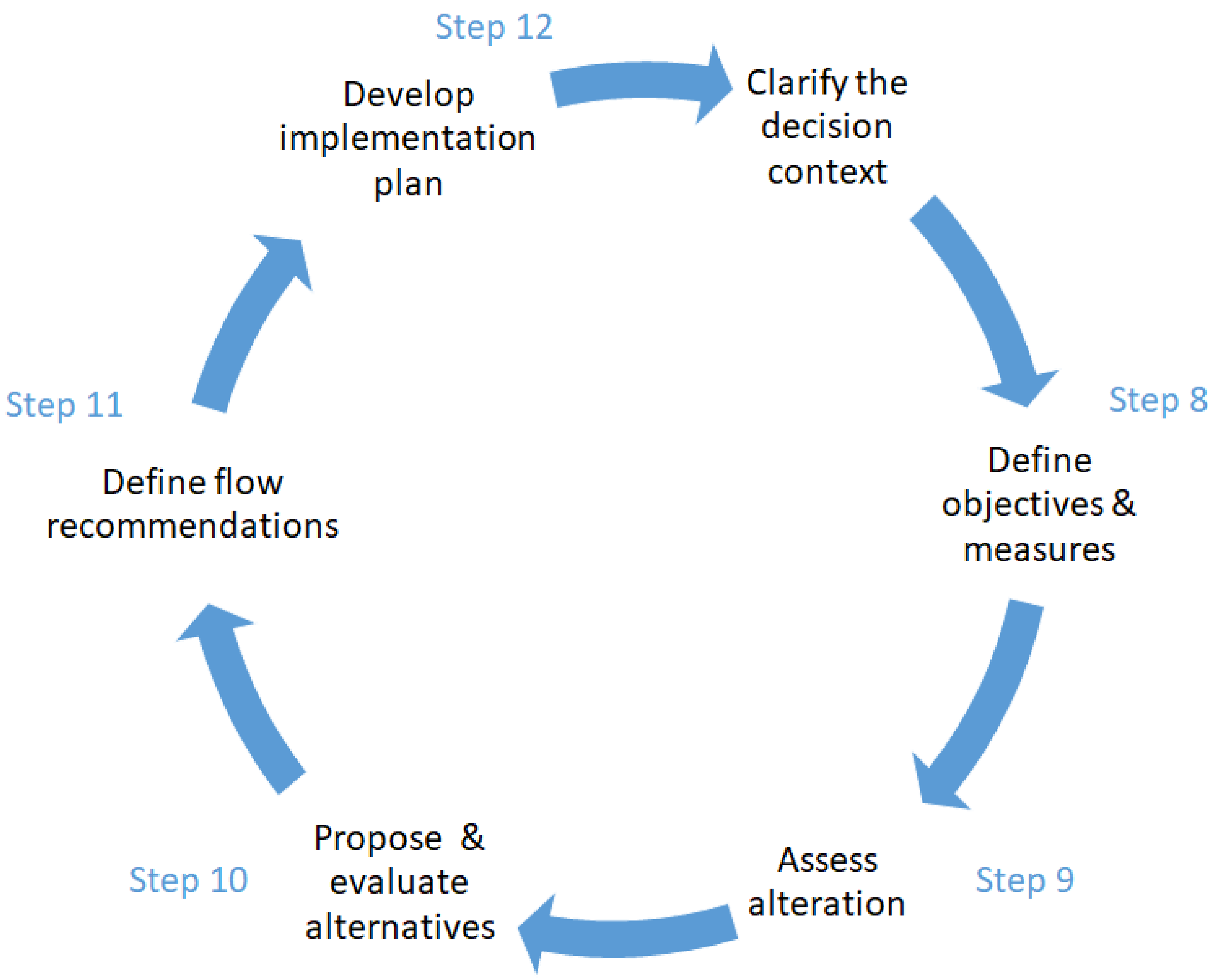
Section B: Investigating Specific Flow-Ecology Relationships



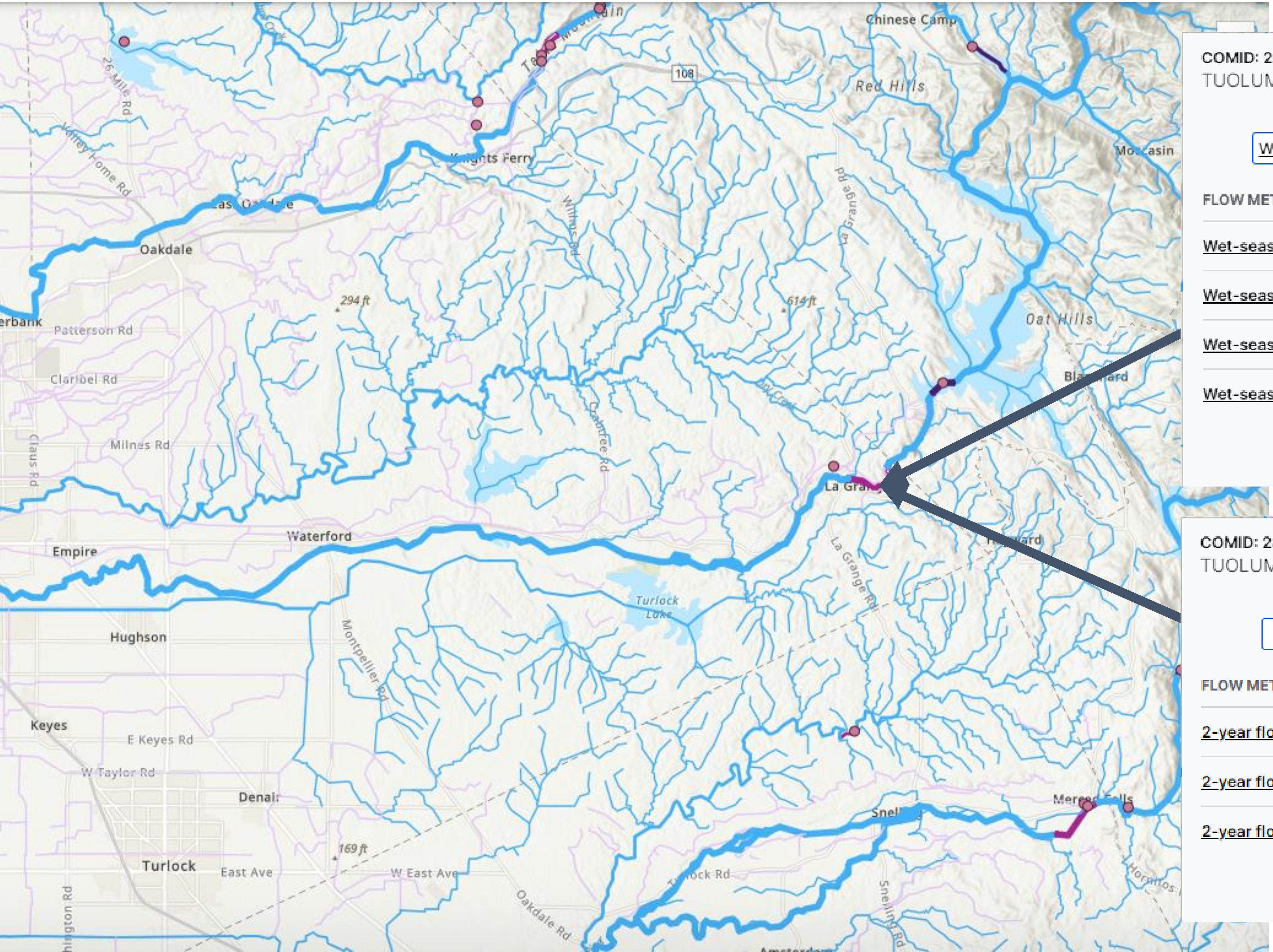
CEFF Section C



Section C
Develop Environmental Flow Recommendations



Section C: Alteration analysis - Tuolumne



COMID: 2823750
TUOLUMNE RIVER

Flow Component: Wet-season base flow | **Year Type:** All Years | **Recurrence Interval:** 2-year

FLOW METRIC	10th pctl	50th pctl	90th pctl	Observed Med.
Wet-season baseflow	652 CFS	1,100 CFS	1,760 CFS	226 CFS
Wet-season median baseflow	1,810 CFS	3,130 CFS	5,110 CFS	1,290 CFS
Wet-season start	Nov. 17	Jan. 2	Feb. 14	Jan. 18*
Wet-season duration	71.4 DAYS	127 DAYS	185 DAYS	80.5* DAYS

Functional Flow Metrics

COMID: 2823750
TUOLUMNE RIVER

Flow Component: Peak flow | **Year Type:** All Years | **Recurrence Interval:** 2-year

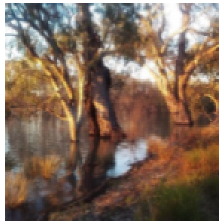
FLOW METRIC	10th pctl	50th pctl	90th pctl	Observed Med.
2-year flood magnitude	9,380 CFS	17.2 KCFS	24.4 KCFS	2,980 CFS
2-year flood duration	2 DAYS	5 DAYS	19 DAYS	88.5 DAYS
2-year flood frequency	1 OCCUR.	2 OCCUR.	4 OCCUR.	2.5 OCCUR.

Functional Flow Metrics

Outcomes of CEFF

- Ecological flow criteria for areas of interest
  - Required by multiple regulatory processes (FERC, SGMA, ESA, WQcerts, etc)
- Environmental flow recommendations (via stakeholder process)
- Recommended mitigation measures (via stakeholder process)
- Implementation, monitoring and adaptive management plan
- Online tools:
  - natural flows database/web tool (rivers.codefornature.org)
  - functional flow calculator in python (eflows.ucdavis.edu)
  - information repository (ceff.ucdavis.edu)

Special Issue Journal – Frontiers in Freshwater Science



Research Topic

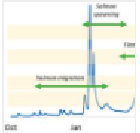
Environmental Flows in an Uncertain Future

Manage topic | Submit your abstract | Submit your manuscript | Participate

Overview | 13 Articles | 71 Authors | Impact

Articles

By Views | By Type | By Date



The California Environmental Flows Framework: Meeting the Challenges of Developing a Large-Scale Environmental Flows Program

Eric D. Stein , Julie Zimmerman , Sarah M. Yarnell , Bronwen Stanford, Belize Lane , Kristine T. Taniguchi-Quan , Alyssa Obester , Theodore E. Grantham , Robert A. Lusardi and Samuel Sandoval-Solis

Original Research Environmental flow programs aim to protect aquatic habitats and species while recognizing competing water demands. Often this is done at the local or watershed level because it is relatively easier to address technical and implementation challenges ...

Published on 28 October 2021
Front. Environ. Sci. doi: 10.3389/fenvs.2021.769943

2,543 total views Altmetric 22

Environmental Flow Requirements of Estuaries: Providing Resilience to Current and Future Climate and Direct Anthropogenic Changes

Daniel Chilton , David P. Hamilton , Ivan Nagelkerken , Perran Cook , Matthew R. Hipsey , Robert Reid , Marcus Sheaves , Nathan J. Waltham and Justin Brookes

Review Estuaries host unique biodiversity and deliver a range of ecosystem services at the interface between catchment and the ocean. They are also among the most degraded ecosystems on Earth. Freshwater flow regimes drive ecological processes contributing ...

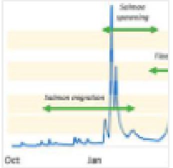
Published on 17 November 2021
Front. Environ. Sci. doi: 10.3389/fenvs.2021.764218

2,287 total views Altmetric 19

Open Access to all articles

https://www.frontiersin.org/research-topics/16816/environmental-flows-in-an-uncertain-future#articles

- Special issue provides additional external peer review of CEFF products
  - ✓ 20 total articles, 6 related to CEFF
- Highlights CEFF in the context of international efforts



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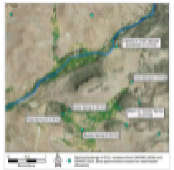
Application of flow ecology analysis to inform prioritization for stream restoration and management actions

Katie Irving , Kristine Taniguchi-Quan , Amanda Aprahamian , Cindy Rivers, Grant Sharp , Raphael D Mazor , Susanna Theroux , Ryan Peek and Eric D. Stein

Original Research A key challenge in managing flow alteration is determining the severity and pattern of alteration associated with the degradation of biological communities. Understanding these patterns helps managers prioritize locations for restoration and flow ...



Functional Flows in Groundwater-Influenced Streams: Application of the California Environmental Flows Framework to Determine Ecological Flow Needs

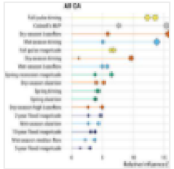
Sarah M. Yarnell , Ann Willis , Alyssa Obester , Ryan A. Peek , Robert A. Lusardi, Julie Zimmerman , Theodore E. Grantham and Eric D. Stein

Original Research Environmental flows, or the practice of allocating water in river systems for ecological purposes, is a leading strategy for conserving aquatic species and improving river health. However, consideration of surface-groundwater connectivity is seldom ...

Developing ecological flow needs in a highly altered region: Application of California Environmental Flows Framework in southern California, USA

Kristine T. Taniguchi-Quan , Katie Irving , Eric D. Stein , Aaron Poresky , Richard A. Wildman, Jr., Amanda Aprahamian , Cindy Rivers, Grant Sharp , Sarah Yarnell and Jamie Feldman

Original Research Flow alteration is a pervasive issue across highly urbanized watersheds that can impact the physical and biological condition of streams. In highly altered systems, flows may support novel ecosystems that may not have been found under natural ...



Identifying Functional Flow Linkages Between Stream Alteration and Biological Stream Condition Indices Across California

Ryan Peek , Katie Irving , Sarah M. Yarnell , Rob Lusardi, Eric D. Stein and Raphael Mazor

Original Research Large state or regional environmental flow programs, such as the one based on the California Environmental Flows Framework, rely on broadly applicable relationships between flow and ecology to inform management decisions. California, despite having ...

Modeling Functional Flows in California's Rivers

Theodore Grantham , Daren M. Carlisle , Jeanette Howard , Belize Lane , Robert Lusardi, Alyssa Obester , Samuel Sandoval-Solis, Bronwen Stanford, Eric D. Stein , Kristine T. Taniguchi-Quan , Sarah M. Yarnell and Julie K. H. Zimmerman

Original Research Environmental flows are critical to the recovery and conservation of freshwater ecosystems worldwide. However, estimating the flows needed to sustain ecosystem health across large, diverse landscapes is challenging. To advance protections of ...

Tools

California Environmental Flows Framework

Home | The Framework › | Resources › | About

Fact Sheet and FAQs

California Environmental Flows Framework • Resources • Fact Sheet and FAQs

In response to comments received throughout the development of the Framework, the CEFF Technical Team has developed resources to help users understand the Framework and answer common questions.

A fact sheet describing the Framework is available for download here.

The FAQs provided below detail responses to questions that arose during public review of the California Environmental Flows Framework version 1.0. They have been grouped into the following categories based on sim... analy...

Fac... Pre... Art...

Explore and visualize California's unimpaired streamflow patterns, including natural stream classes and functional flow metrics

EXPLORE HYDROLOGY | HOW DOES IT WORK?

Stream | Dimensionless Observed | Functional Flow ...rics

...v metrics quantify ...aspects of the ...ural flow regime ...ed to critical ...system functions.

R Package for Obtaining Functional Flow Metrics

An R package has been developed that allows users to access the Functional Flows Calculator directly via an API. The package allows users to:

- Retrieve streamflow data automatically from USGS or transform user-uploaded streamflow timeseries and run them through the functional flow calculator online,
- Obtain modeled functional flow ...
- Create plots of dimensionless hy...
- Compare observed and natural f...

The package is available on GitHub.

California Natural Flows Database

Water is essential for California's people, economy, and environment. Centuries of water diversion have altered the flows in many streams and rivers, which can harm the freshw... Conservancy and the United States Geological Survey (USGS), and other partners have ... (expected streamflow in the absence of human modification) in all the streams and river... present.

Explore the Data

Science

Understanding natural flows and patterns of flow alteration is an important first step in improving the management of California's rivers and streams for human and ecosystem ...

Map

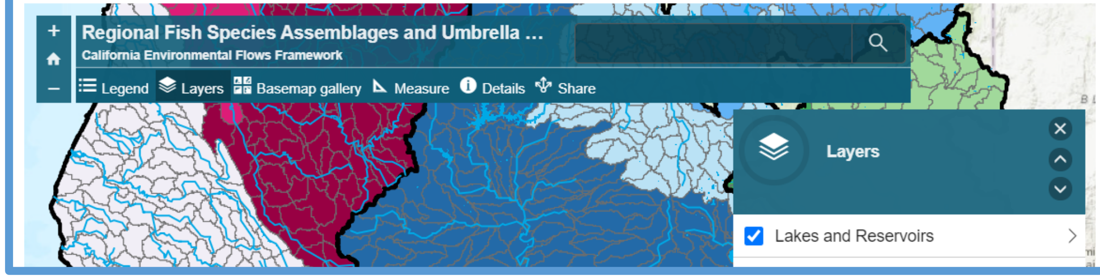
Explore, visualize, and download the natural flows data with a map-based application. Search for stream segments, visualize estimated flow rates, and download flow data ...

Data download and API

Feel more comfortable at the command line? Query the data directly using a REST API. Follow the link below for detailed documentation and code samples in R, ...

Umbrella Species and Functional Flow Needs

Umbrella fish species and their functional flow requirements were identified for California. Access the map here, or begin using the map below by clicking "OK". The map displays the umbrella species for California; users may click on a watershed to view regional fish species assemblages (where each assemblage is represented by a different color), the umbrella species associated with each assemblage, and the HUC 12 distributions that comprise these assemblages outlined in gray. Functional flow needs for each umbrella species are available in the attached Excel workbook. For further details on how umbrella species were identified, see Obester et al. 2021.



Next Steps

CEFF is a "living document"

- Reviewed by the WQMC eflows workgroup
- Revised technical report is available, considered "draft final"
- FAQs available: https://ceff.ucdavis.edu/fact-sheets-and-faqs
- Overview paper available: https://www.frontiersin.org/articles/10.3389/fenvs.2021.769943/full

Multiple case studies under development

- Little Shasta and Cosumnes – groundwater-surface water interactions (paper available)
- Eel River – dam relicensing and reoperation
- Southern California – flow requirements for water quality (paper available)

Workplan to guide and prioritize new efforts

- Improvements in technical tools
- Track and document case studies
- Mechanisms for ongoing data and information sharing
- Available on CEFF website: https://ceff.sf.ucdavis.edu/sites/g/files/dgvnsk5566/files/media/documents/CEFF%20Implementation%20workplan_Aug2021%20Draft.pdf