Napa Valley and River, 1885, by Manuel Valencia. Collection of the Hearst Gallery, Saint Mary's College of California

CA Environmental Flows Framework: Importance of Groundwater and Nexus with SGMA

Sarah Yarnell, UC Davis

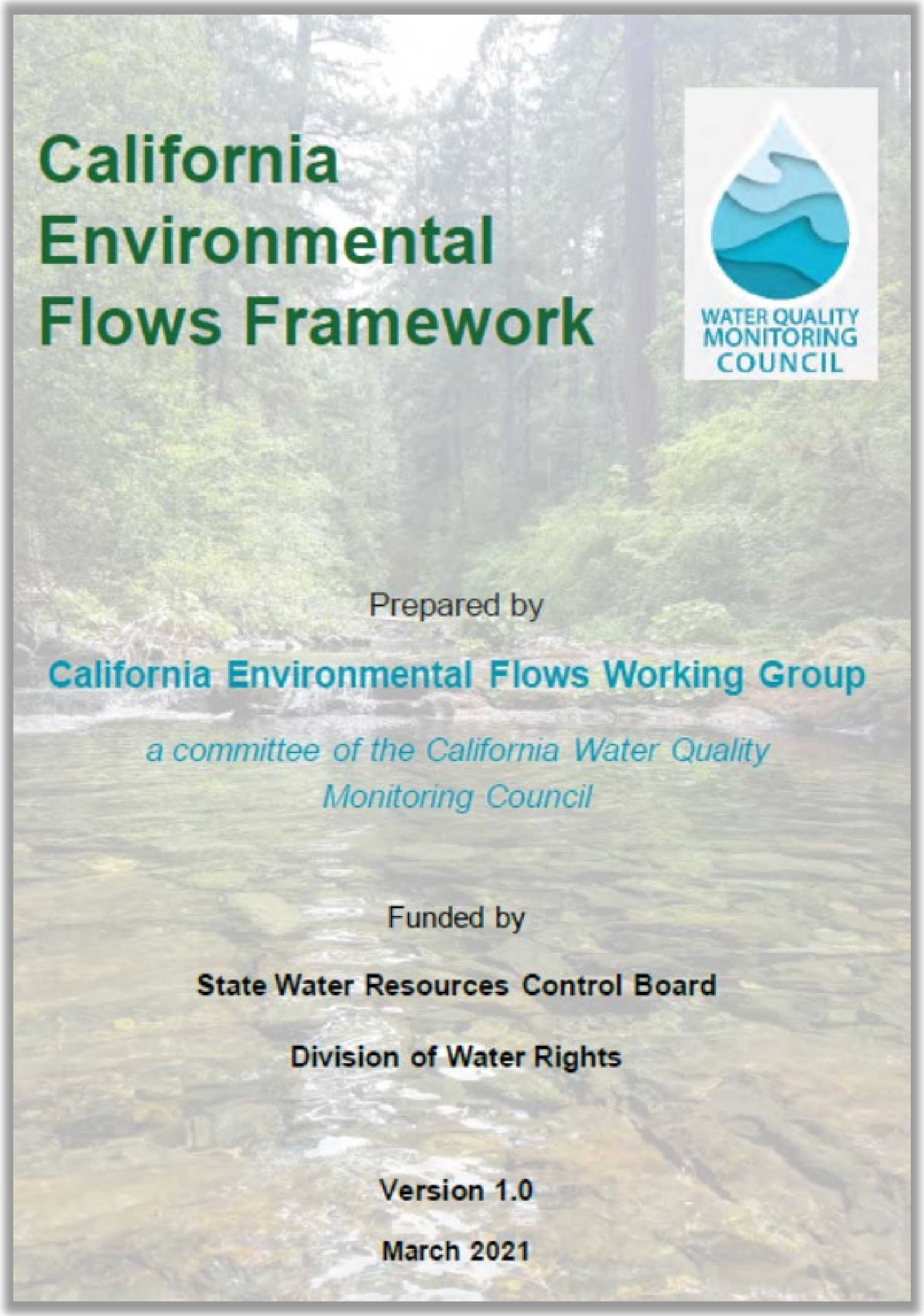
May 9, 2024

Napa County GSA TAG

Topics

- Overview of California Environmental Flows Framework (CEFF)
- Nexus of CEFF with SGMA
- CEFF case studies
    - Aliso Creek (south Orange County)
    - Little Shasta & Cosumnes River
- Implementation and Adaptive Management

Napa River Napa River Ecological Preserve
Photo by Robin Grossinger


California Environmental Flows Framework

WATER QUALITY MONITORING COUNCIL

Prepared by

California Environmental Flows Working Group

a committee of the California Water Quality Monitoring Council

Funded by

State Water Resources Control Board

Division of Water Rights

Version 1.0

March 2021

CEFF TECHNICAL TEAM

- CA Department of Fish and Wildlife
- State Water Resources Control Board
- Southern CA Coastal Water Research Project
- The Nature Conservancy
- Utah State University
- CalTrout
- University of California, Davis
- University of California, Berkeley

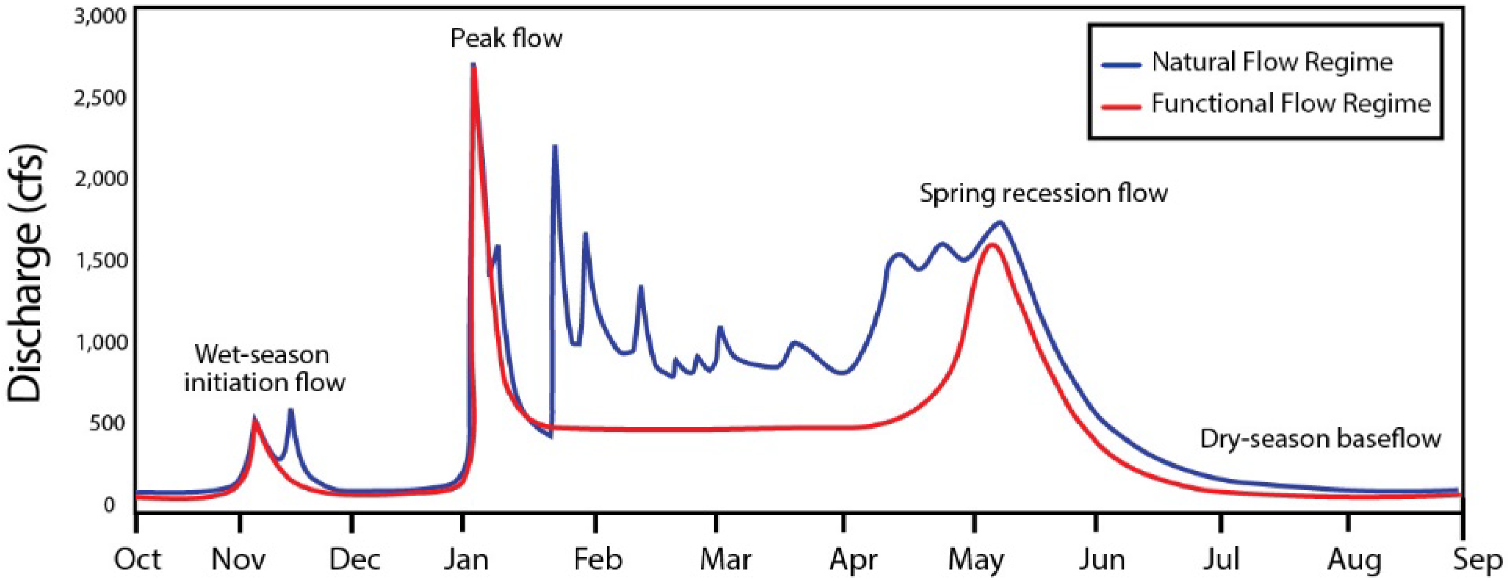
ceff.ucdavis.edu

Functional Flows Approach

Environmental Flows - focus on hydrograph flow components that:

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

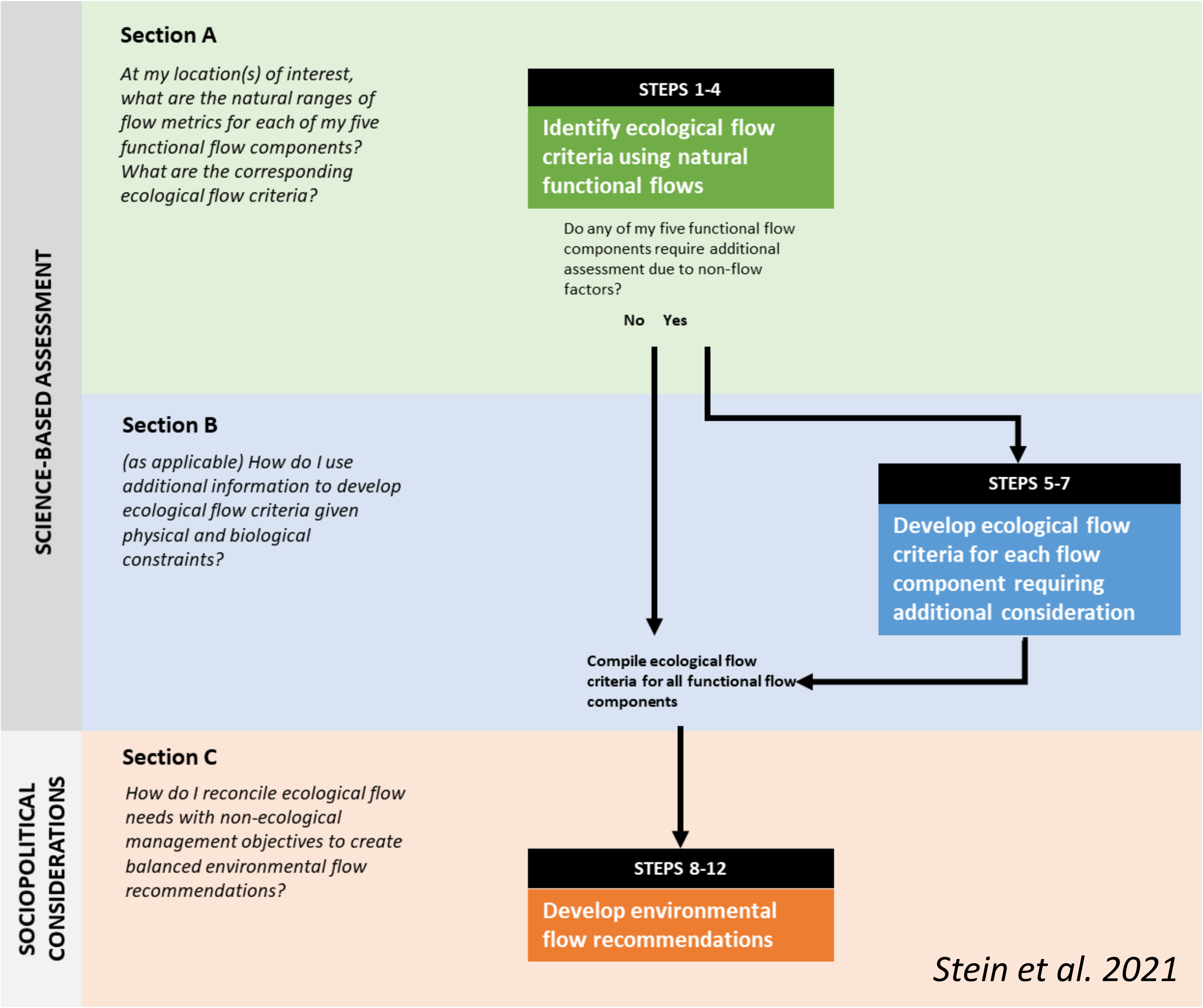
Consideration of geomorphic setting and channel-floodplain dynamics



Yarnell et al. 2015

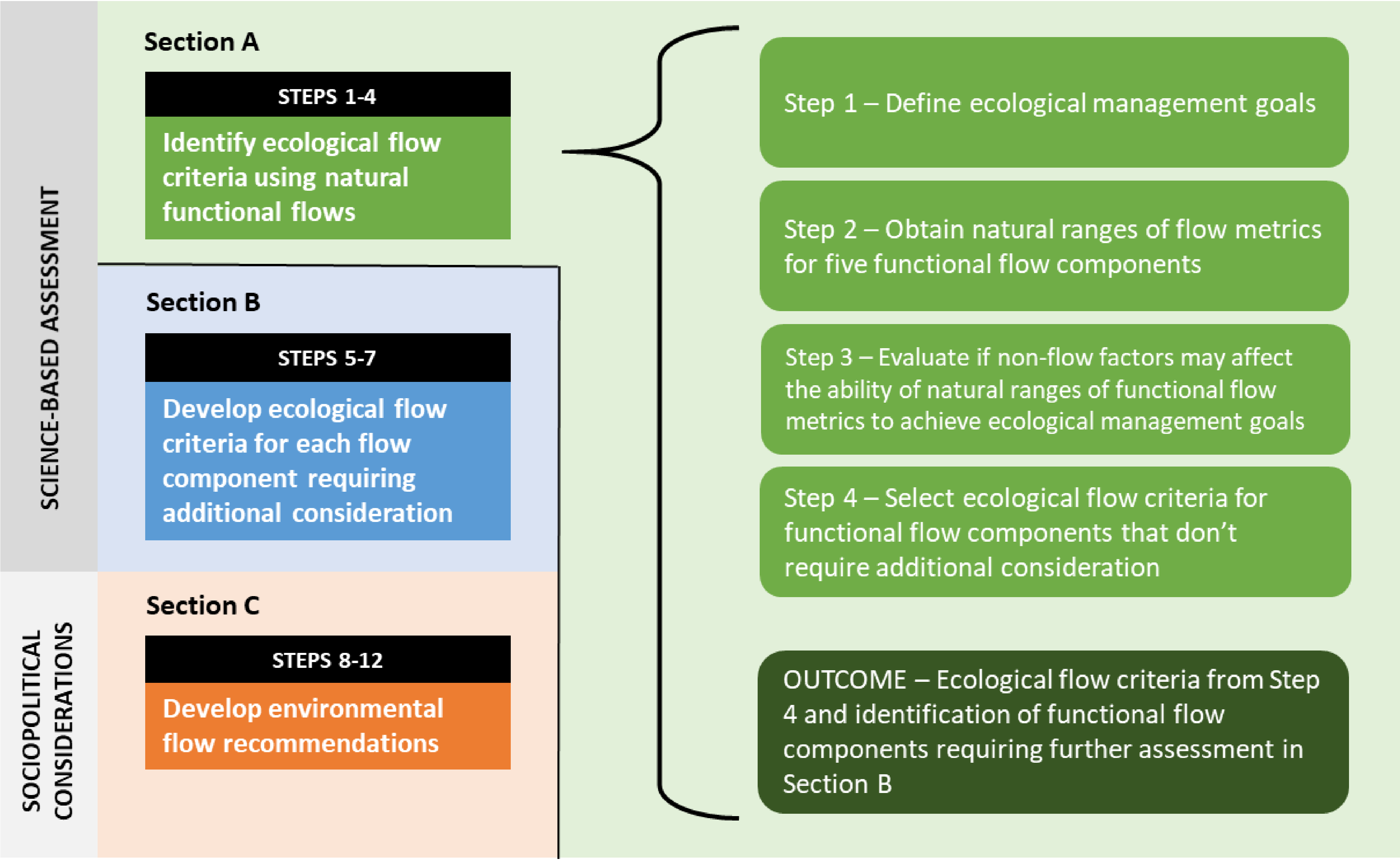
CEFF Steps Overview

ceff.ucdavis.edu

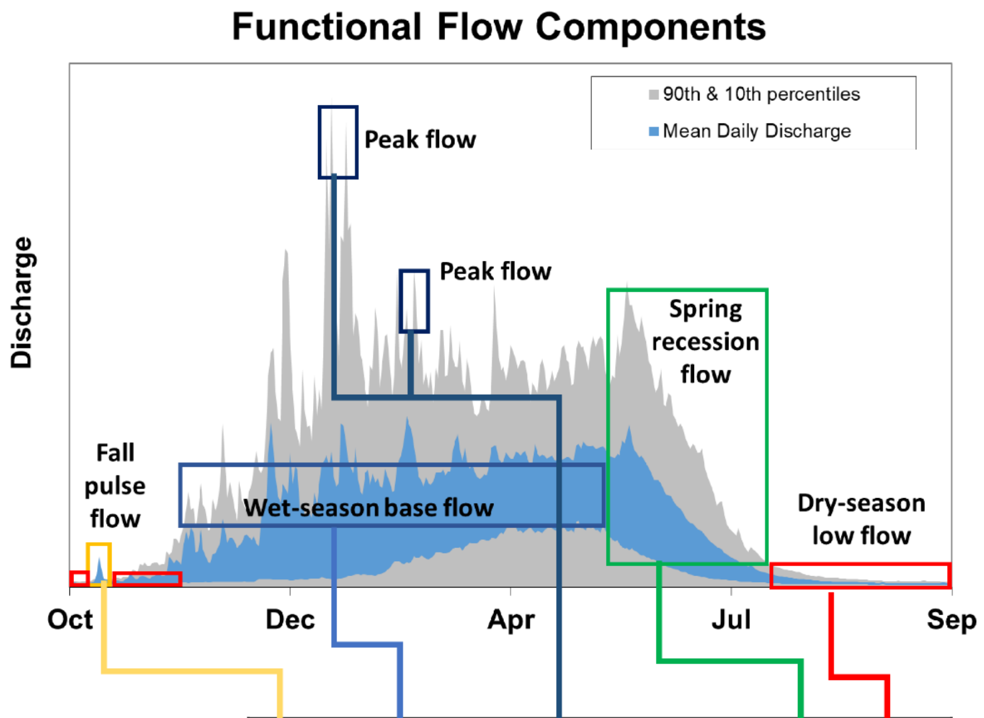


Stein et al. 2021

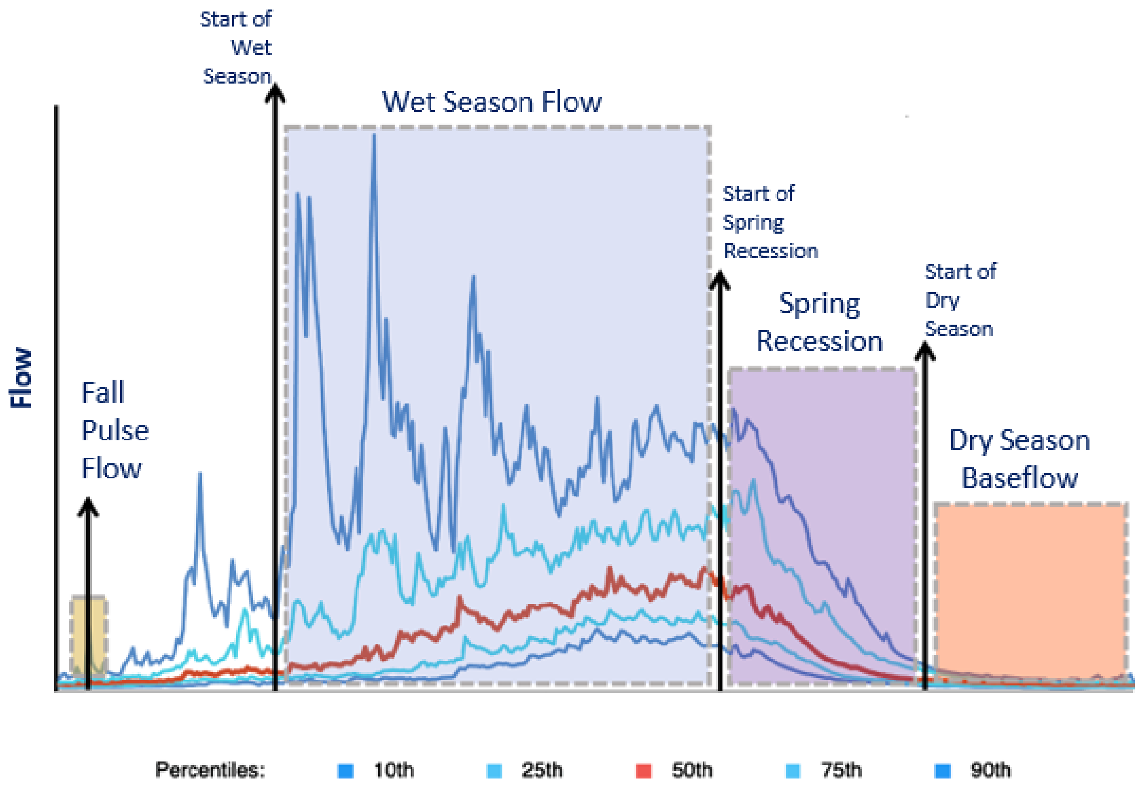
CEFF Section A



Functional Flows Approach



	Functional Flow Components				
Flow Characteristics	Fall Pulse	Wet Baseflow	Peak Flow	Spring Recession	Dry Low Flow
Magnitude	X	X	X	X	X
Timing	X	X	X	X	X
Duration		X	X	X	X
Frequency			X		
Rate of Change				X	X

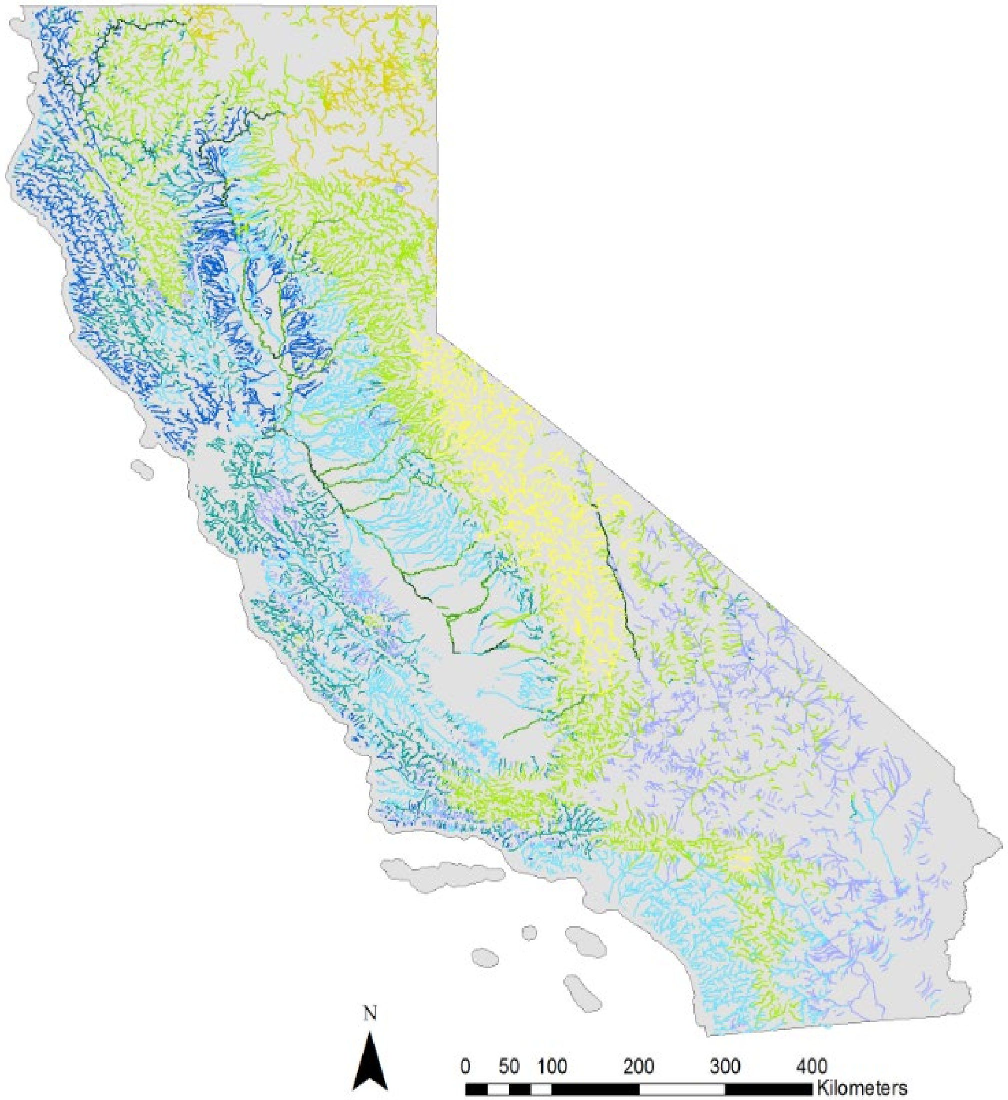


- 24 functional flow metrics quantify 5 flow components
- Metrics calculated from daily flow timeseries using signal processing techniques at all reference gages in California

Yarnell et al. 2020; Patterson et al. 2020

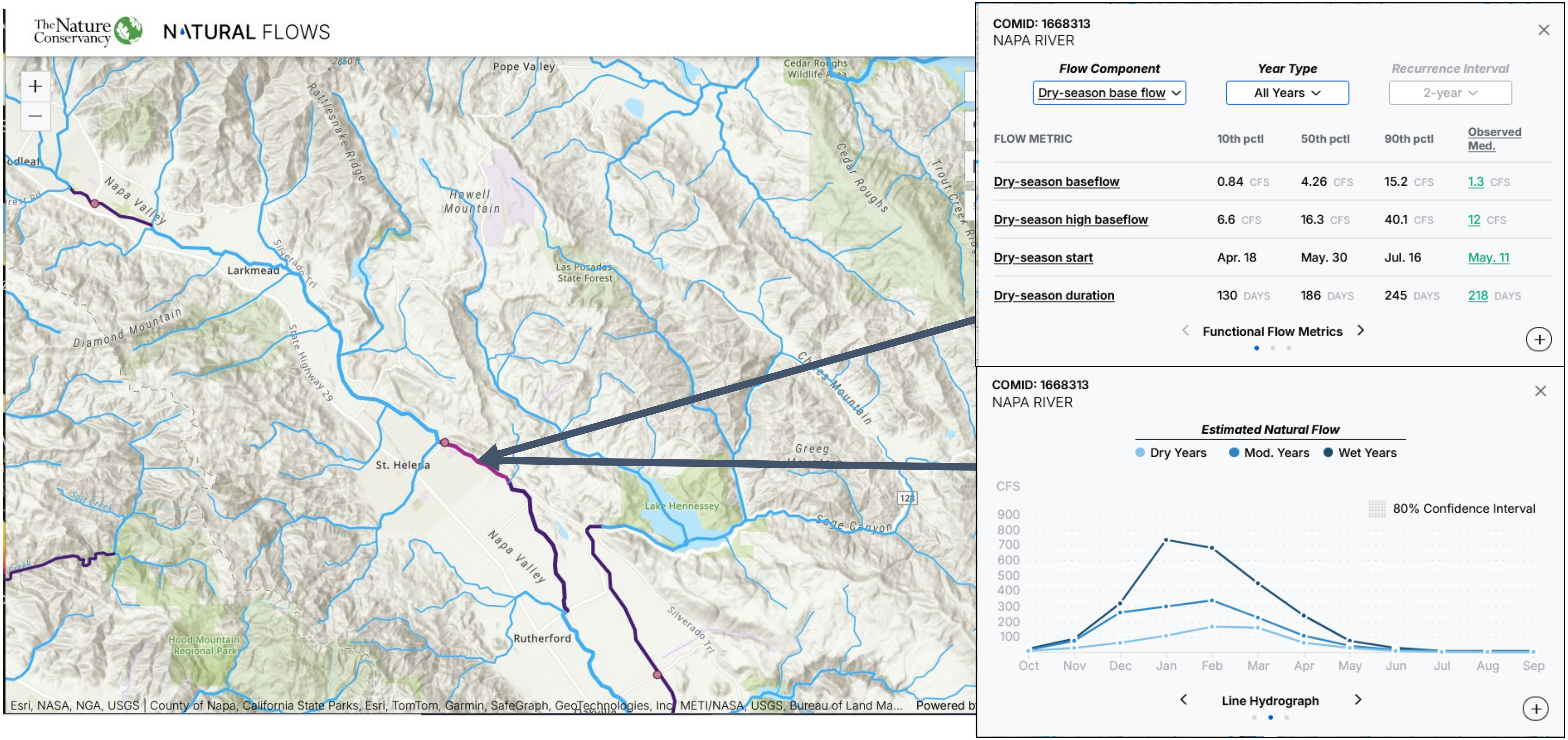
Modeled Natural Functional Flows

- Predictions of natural functional flow metric ranges at every stream in the state
- Modeled predictions based on physical and climate characteristics of basin
- 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



Outcomes of Section A

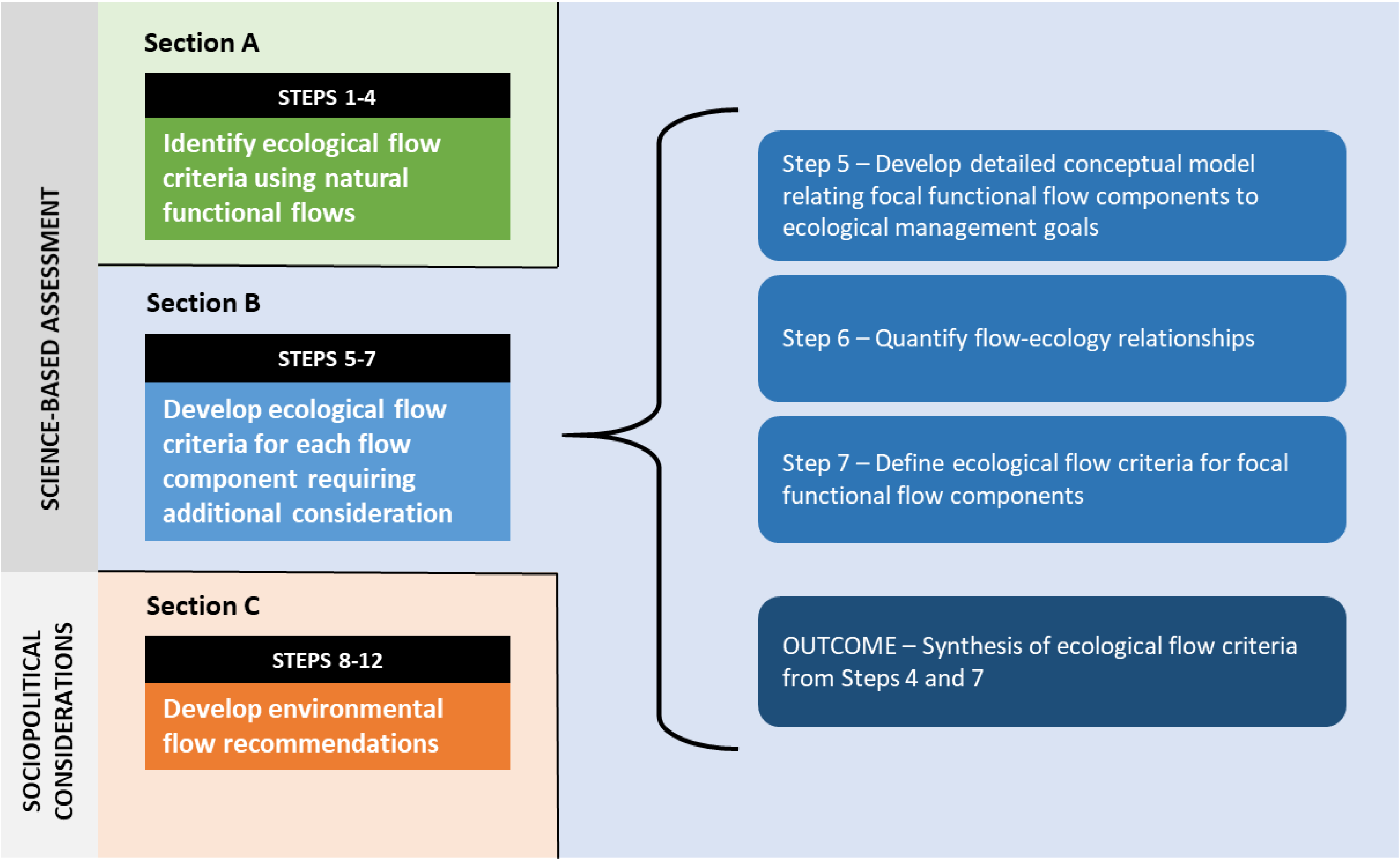
Natural Range of Functional Flow Metrics as Ecological Flow Criteria

- Download from Natural Flows database *-OR-*
- Assess local hydrologic data for potential additions/subtractions due to groundwater inputs/losses *-OR-*
- Develop local hydrologic model accounting for groundwater and use functional flow calculator to determine ranges of natural functional flow metrics

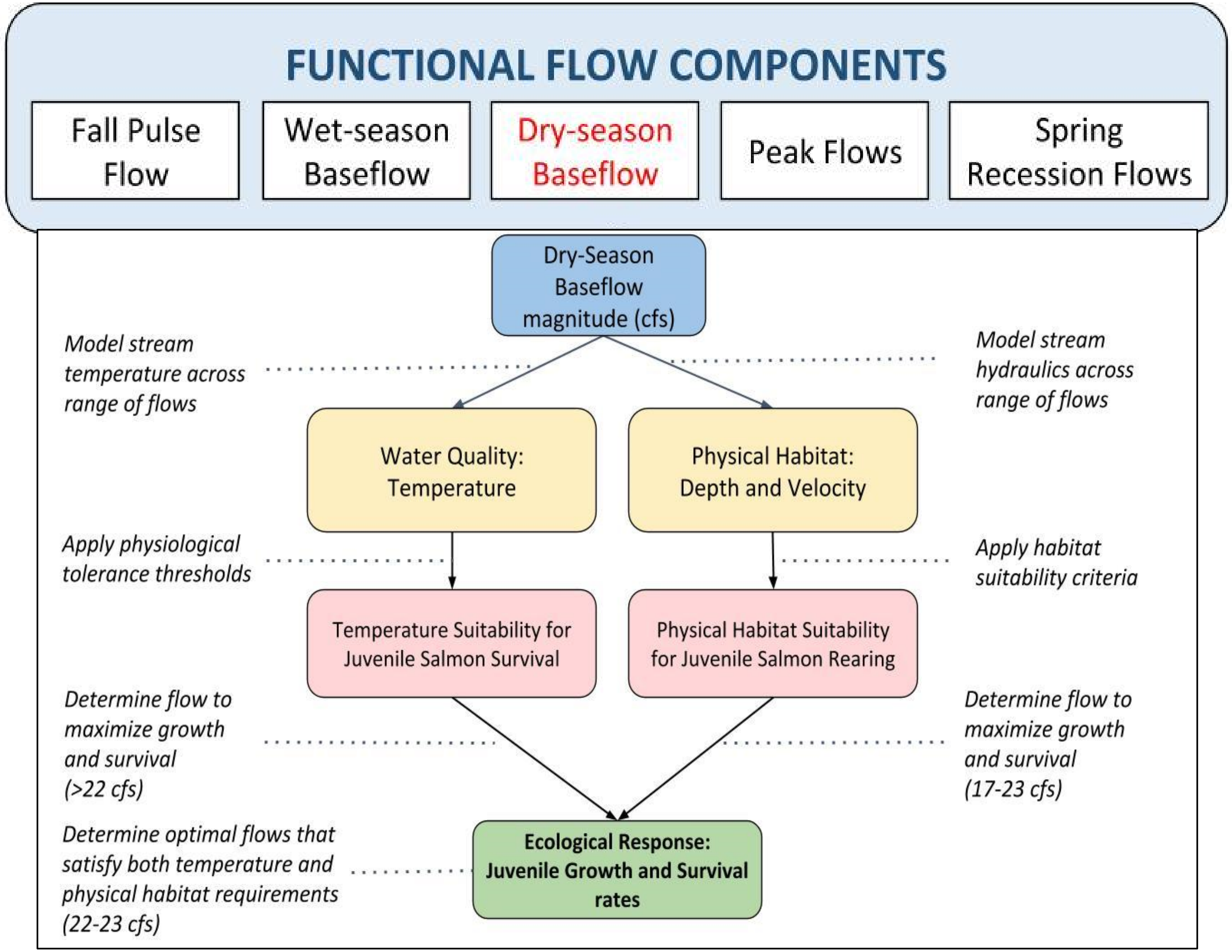
ID of Functional Flow Components that need more evaluation

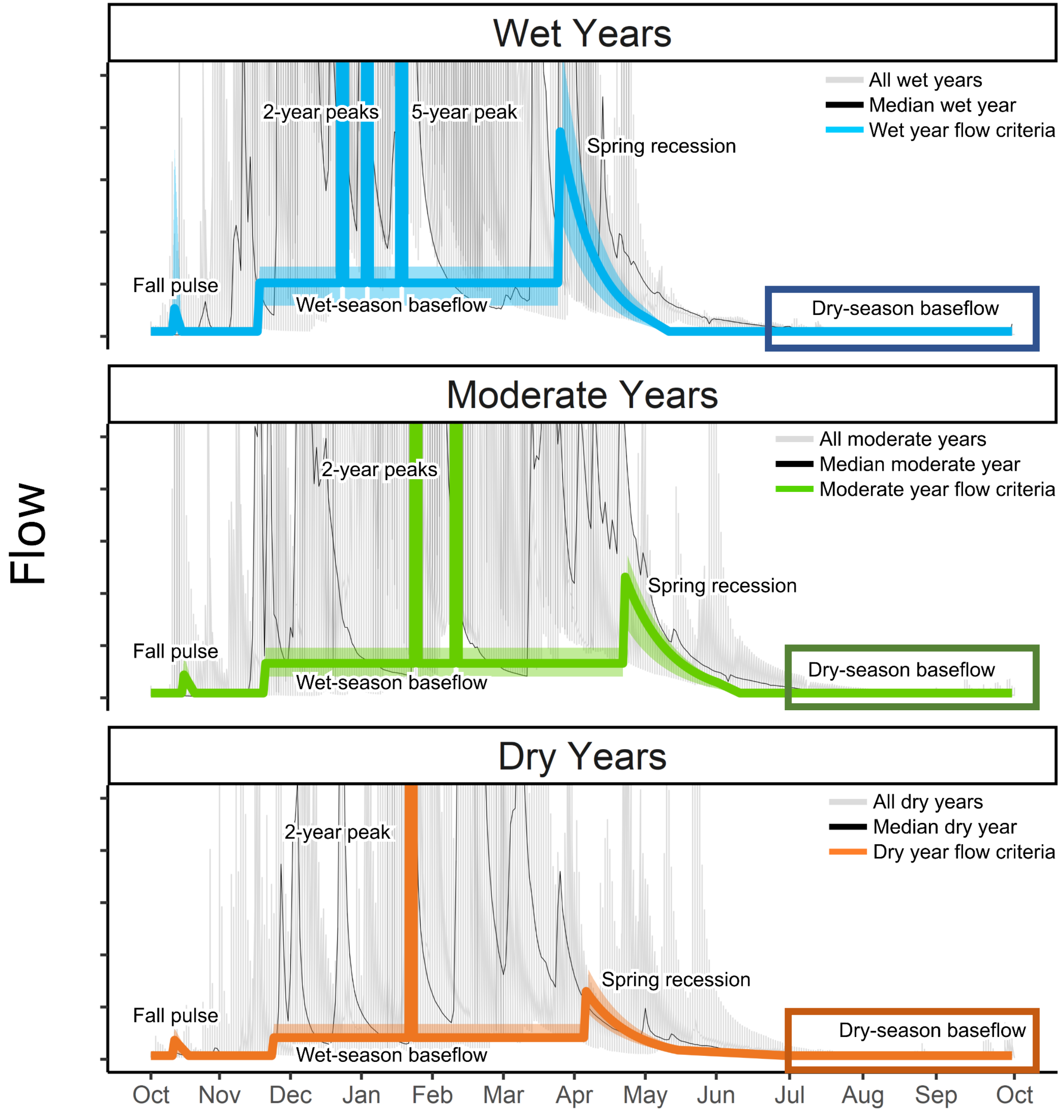
- Is there a reason section A criteria might *not* meet desired functions?
- Presume section A criteria will provide functionality unless evidence otherwise
- If needed for some components, assess further in section B

CEFF Section B



Section B: Investigating Specific Flow-Ecology Relationships

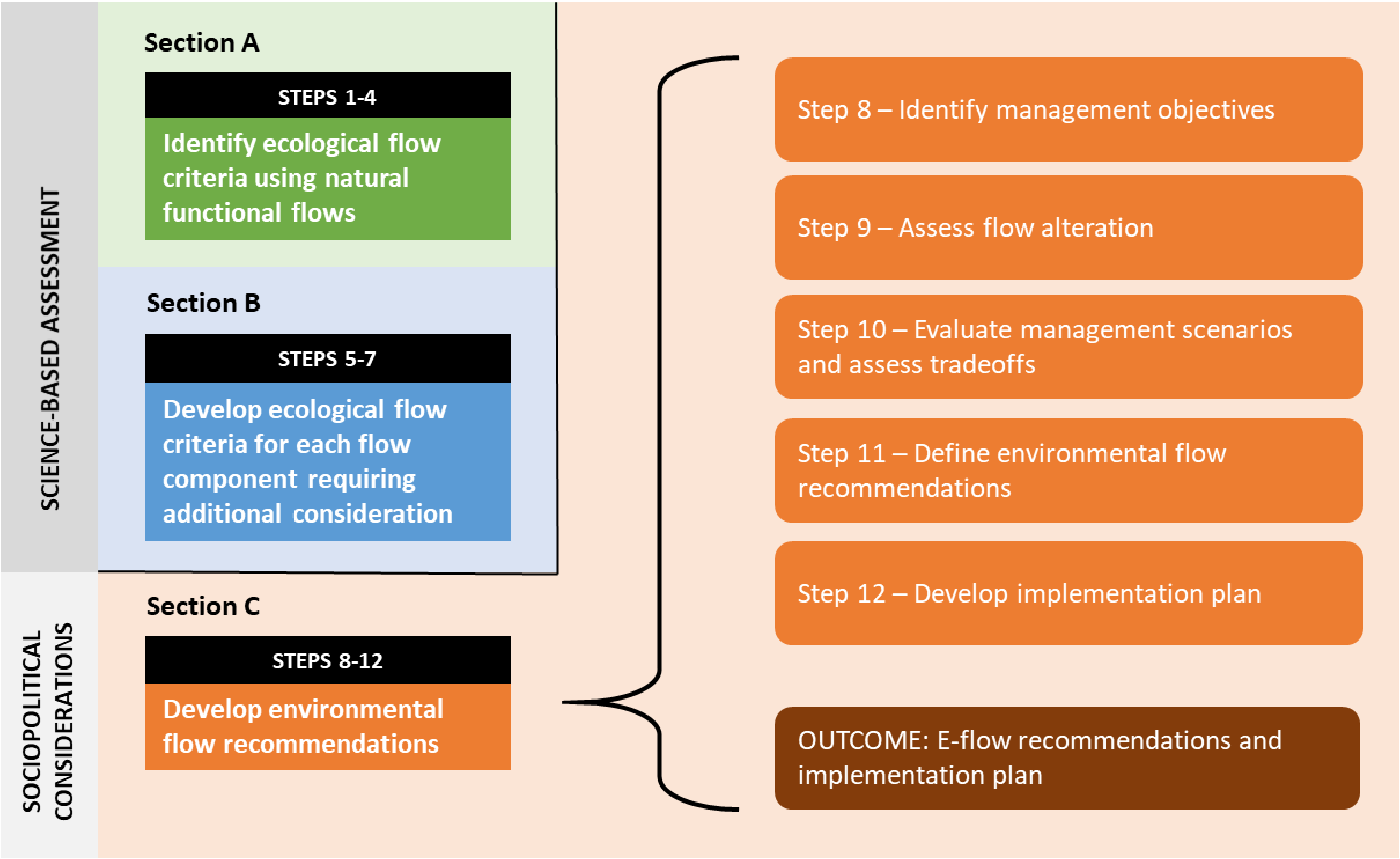




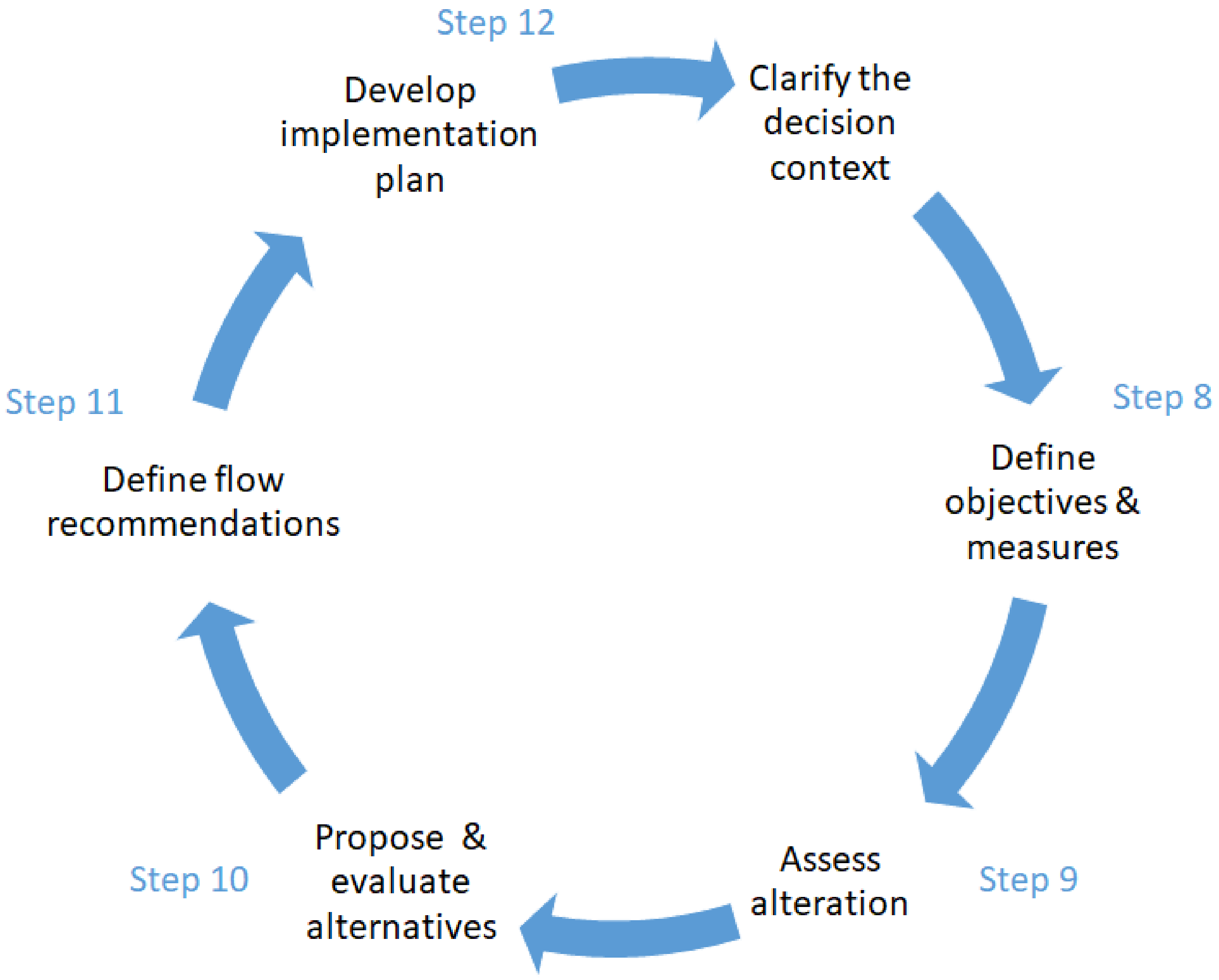
Outcomes from Section B

Ecological flow criteria can serve as measurable objectives that can vary by water year type

CEFF Section C

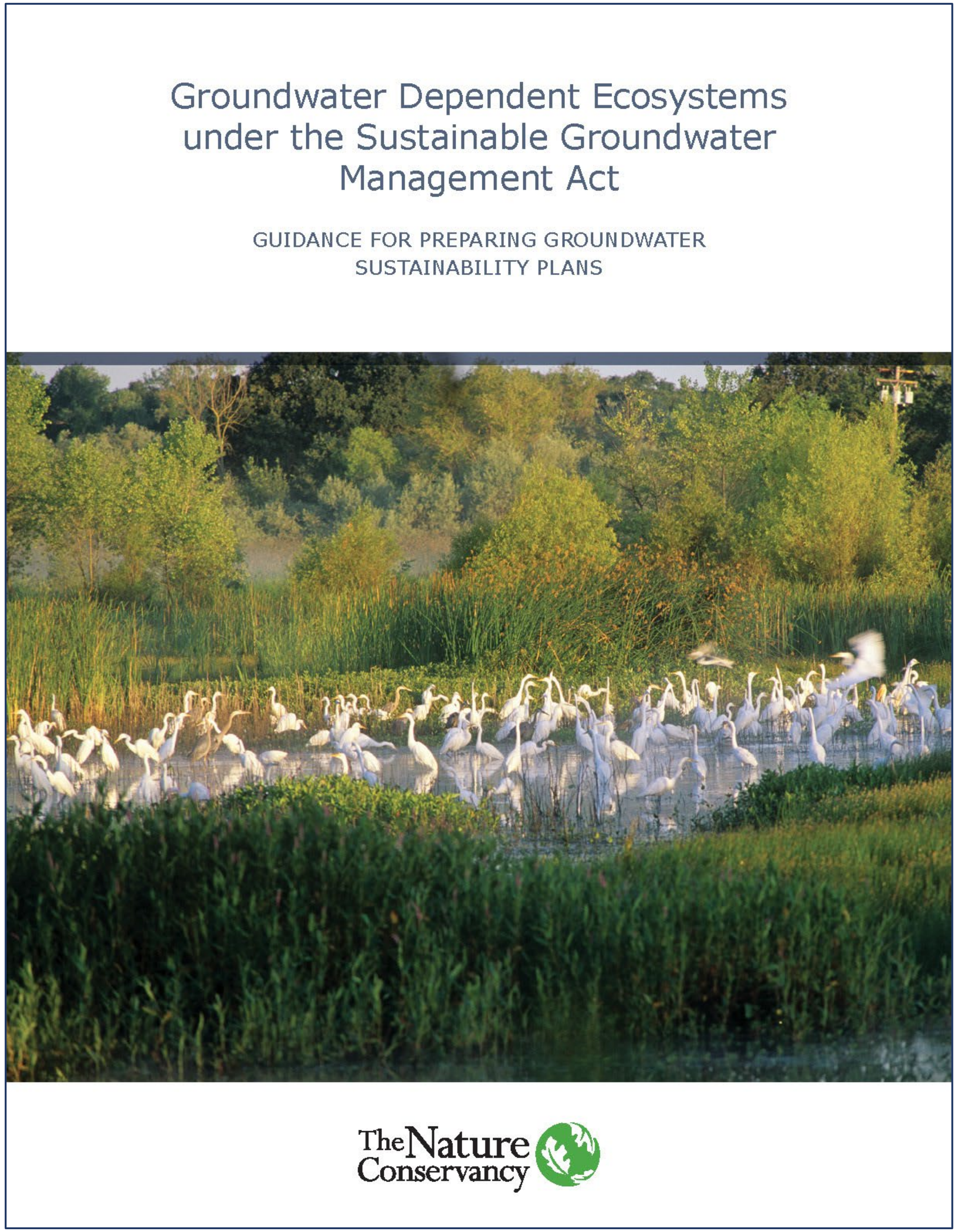


Section C:
Develop Environmental Flow Recommendations

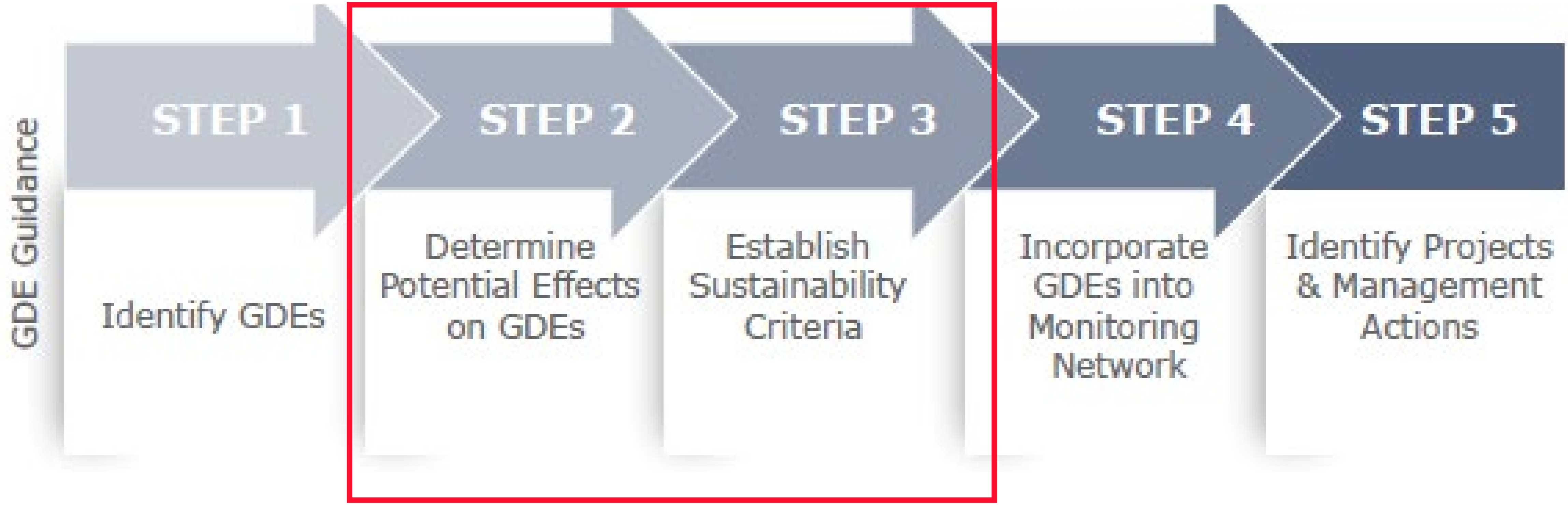


Groundwater-Dependent Ecosystems

SGMA does not explicitly consider environmental flow needs, but adverse effects to groundwater-dependent ecosystems (GDE) must be avoided

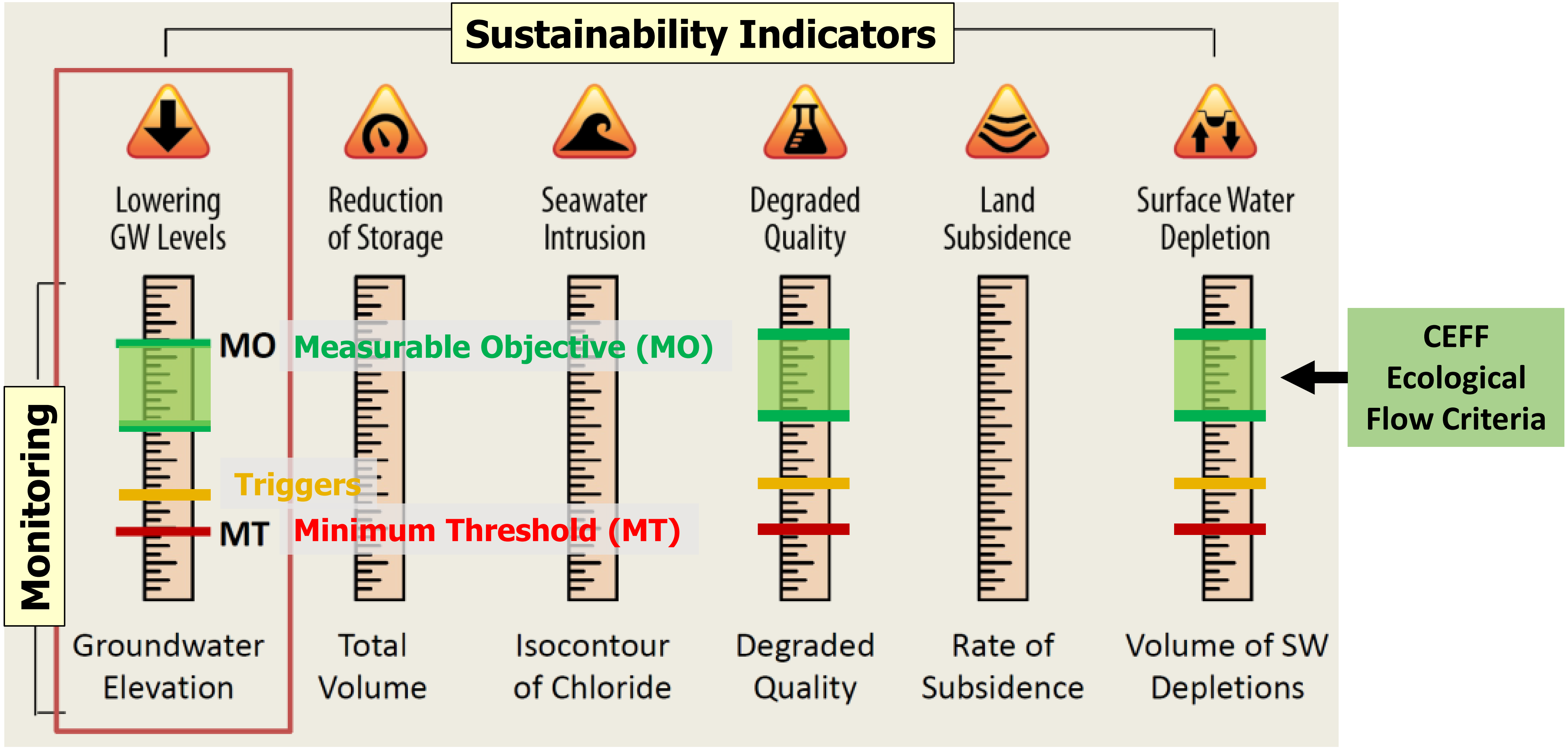


CEFF and SGMA



The Nature Conservancy 2018

GSP: CEFF can Inform Monitoring and Managing Sustainability



modified from CADWR 2016

Case Studies Implementing CEFF

- South OC Flow Ecology Study
- LA River Environmental Flows Study
- Cosumnes River
- Little Shasta River
- South Fork Eel
- Mill Creek
- Others

Photo: TNC

Photo: Ann Willis

https://www.frontiersin.org/articles/10.3389/fenvs.2022.787631/full

ORIGINAL RESEARCH article

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

Provisionally accepted
The final version of the article will be published here soon pending final quality checks

Notify me

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[3]Orange County Public Works, United States
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COUNTY OF ORANGE CALIFORNIA

H2OC STORMWATER PROGRAM

OC Public Works

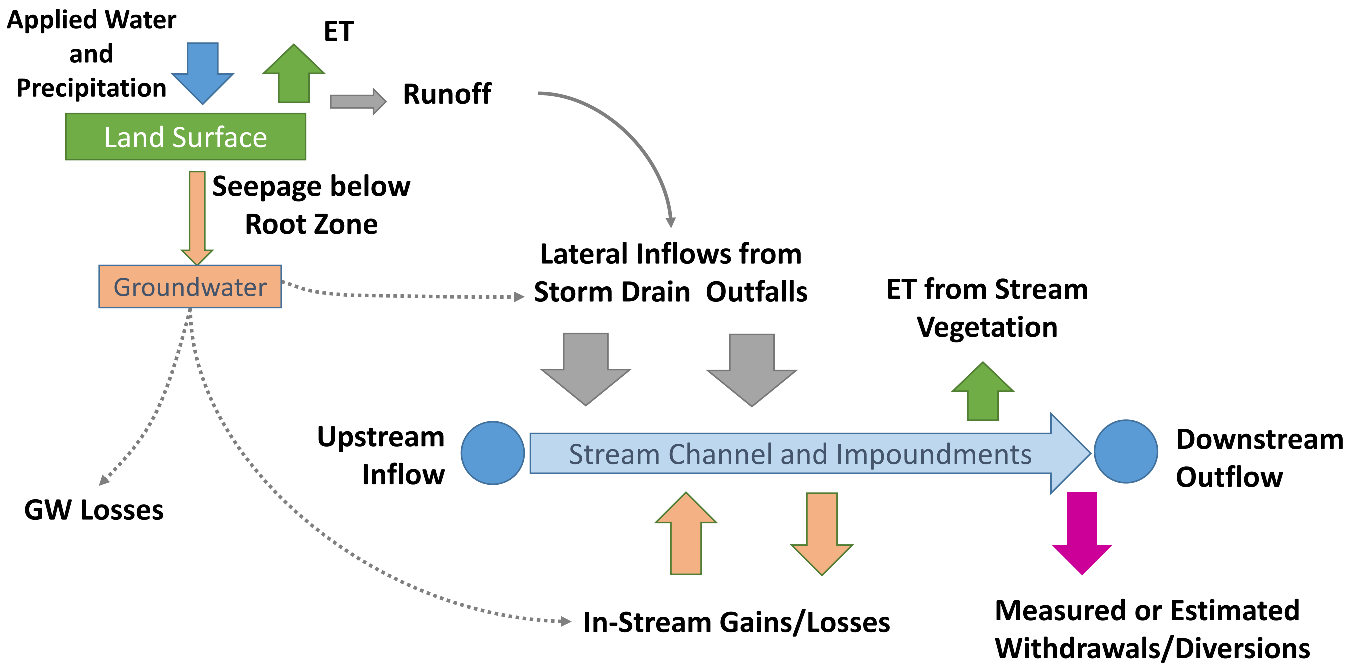
WCB State of California Wildlife Conservation Board

CEFF Application – South Orange County, Aliso Creek

- Highly modified watershed where establishing reference-based flows may be challenging
- Flow modifications are from diffuse non-point sources
- Groundwater may be a significant contributor to summer baseflows

Hydrologic Modeling – Section A

- Utilized isotope analysis to quantify groundwater contribution to summer baseflows
- Developed watershed model that accounts for groundwater inputs



Used Loading Simulation Program in C++

Current condition

- Current land use and flow management measures
- Recent climate: 1990-2019; Recent irrigation patterns: 2010-2019
- Calibrated to streamflow gages, outfall monitoring, and water isotope data

Reference condition

- Remove urban land, irrigated agriculture, diversions, and impoundments
- Same time period

Future scenarios

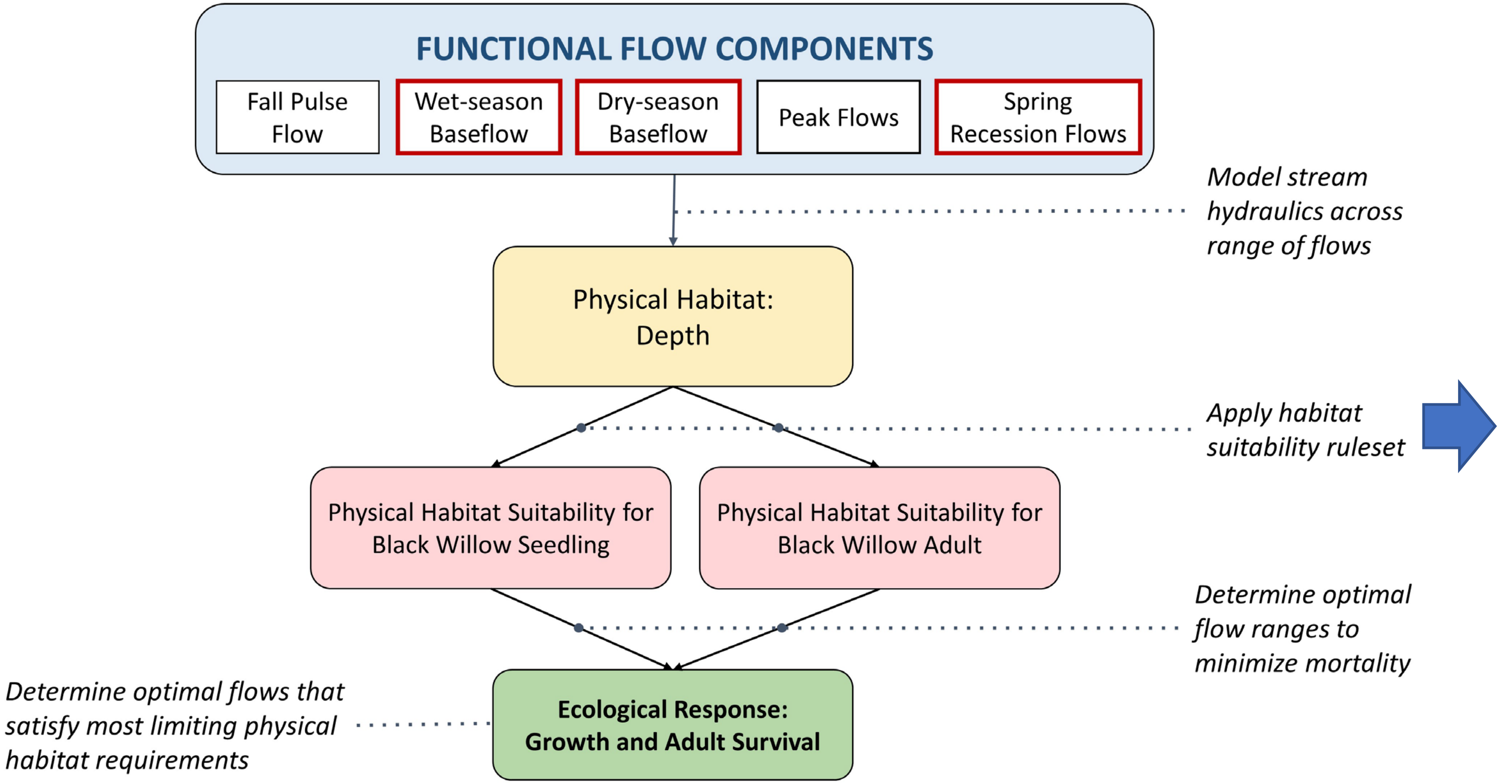
- Climate change at mid-century
- Increased water conservation progress

Non-Flow Limiting Factors – Section B

Functional Flow Component	**Potential Limiting Factor**	**Affected Ecosystem Function(s)**
Fall pulse flow	None identified	None
Peak flows	None identified	None
Wet-season baseflow	**Altered channel morphology**	Potential limited habitat availability to support migration, spawning, and residency of aquatic organisms; Potential limited access to shallow groundwater (riparian)
Spring flow recession	**Altered channel morphology**	Potential limited floodplain inundation and hydrologic conditions for riparian species recruitment and seed dispersal
Dry-season baseflow	**Altered channel morphology**	Potential limited habitat availability (i.e., depth) for native aquatic species; Potential limited riparian soil moisture

Section B: Willow

Conceptual Model



Suitability Ruleset

Life Stage	Functional Flow Metric	Lower Limit	Upper limit
Adult	Wet-Season Baseflow Magnitude Dry-Season Baseflow Magnitude	Discharge necessary to maintain at least 3 cm depth of flow in the river, under the assumption that roots can reach water table	Maximum flow that would not inundate the overbank area to limit oversaturated soils in the overbanks
Adult & Seedling	Spring Recession Start Magnitude	Discharge necessary to inundate 10 cm depth in the overbank areas for seed dispersal and to provide soil moisture in the overbanks prior to the start of the dry-season	No upper limit, used the reference 90^{th} percentile if > lower limit (only refined the lower limit to ensure overbank inundation at the start of spring recession)

Ecological Flow Criteria

[a] High baseflow criteria due to enlarged channel morphology. Channel modifications needed for suitable baseflow depths

Flow Component	Flow Metric	Natural Range of Flow Metrics median (10th - 90th)	Ecological Flow Criteria: Black Willow
Fall pulse flow	Fall pulse magnitude	2.4 (1.7 - 5) cfs	Same as natural range
	Fall pulse timing	Nov 29 (Oct 24 - Dec 3)	Same as natural range
	Fall pulse duration	11 (3 - 16) days	Same as natural range
Wet-season baseflow	Wet-season baseflow magnitude	3 (2 – 5) cfs	**0.1 – 12 cfs**
	Wet-season timing	Dec 15 (Oct 10 – Jan 25)	Same as natural range
	Wet-season duration	67 (30 - 133) days	Same as natural range
Peak flows	2-year peak flow magnitude	31 cfs	Same as natural range
	2-year peak flow duration	4 (1 – 25) days	Same as natural range
	2-year peak flow frequency	2 (1 – 8)	Same as natural range
	5-year peak flow magnitude	423 cfs	Same as natural range
	5-year peak flow duration	3 (1 - 6) days	Same as natural range
	5-year peak flow frequency	3 (1 - 4) event(s)	Same as natural range
Spring recession flows	Spring recession start magnitude	15 (3 - 528) cfs	**33** - 528 cfs
	Spring timing	Mar 3 (Feb 22 - Mar 18)	Same as natural range
	Spring duration	109 (76 - 125) days	Same as natural range
	Spring rate of change	1.4 (0.9 – 1.9) % decline per day	Same as natural range
Dry-season baseflow	Dry-season baseflow magnitude	2 (0.5 – 4) cfs	**0.1 – 12 cfs**
	Dry-season timing	June 20 (May 9 - Jul 10)	Same as natural range
	Dry-season duration	198 (116 - 220) days	Same as natural range

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

Funded by Wildlife Conservation Board Streamflow Enhancement Program, American River Conservancy, and The Nature Conservancy

Photo: Carson Jeffres

https://www.frontiersin.org/articles/10.3389/fenvs.2021.788295/full

Application of CEFF in Groundwater-Influenced Streams

1) Evaluation of groundwater sources contributing to streamflow (section A)
2) Consideration of channel morphology controls on surface-groundwater interactions (section B)
3) Discussion of management actions that could be expected to sustain surface-groundwater interactions that are critical to stream ecosystem health

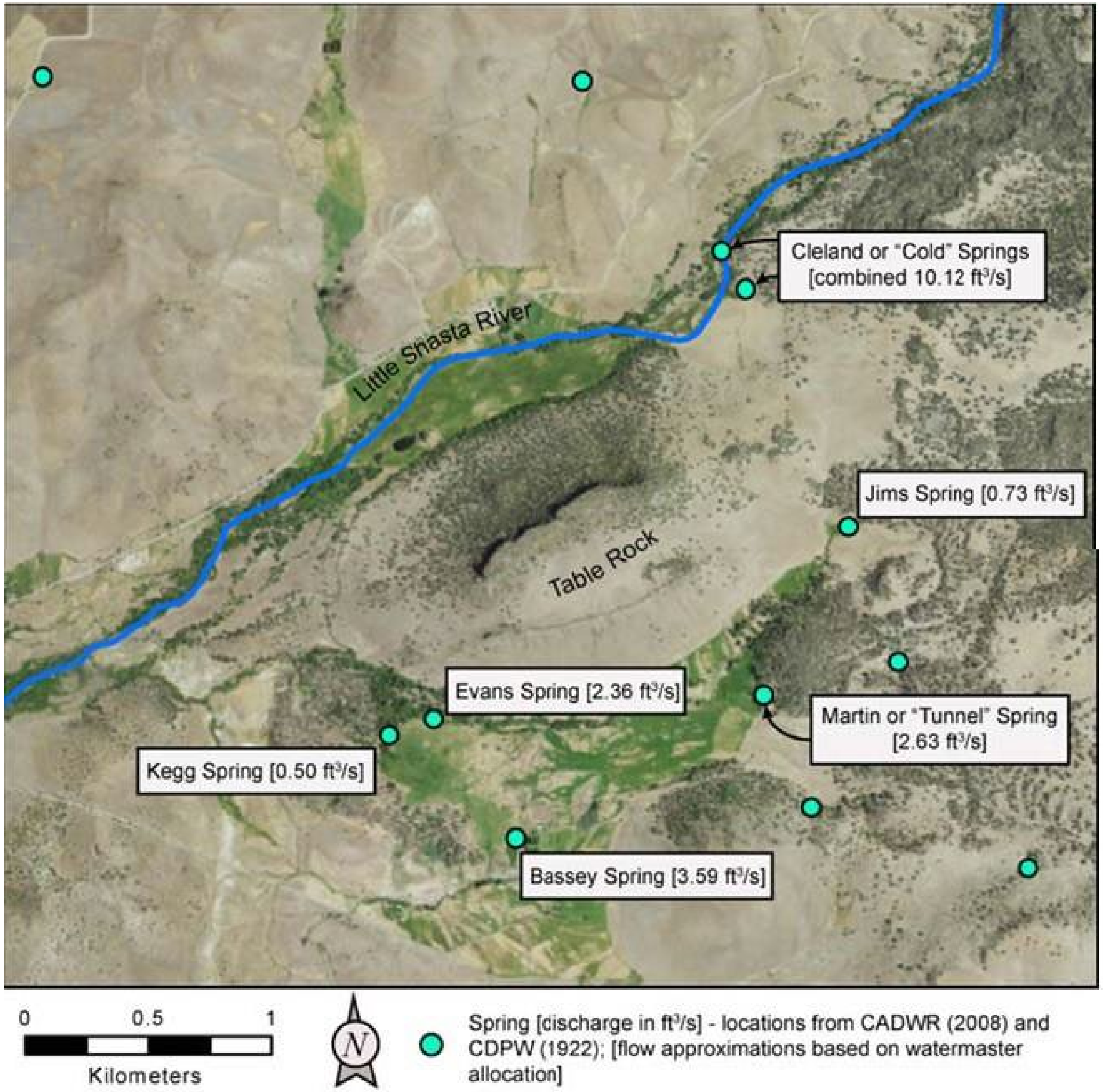
Section A - Groundwater

Little Shasta River

- Discrete springs historically contributed to Little Shasta River
- All diverted since early 20th century
- Not accounted for in natural functional flow metric predictions
- Added 10 cfs to baseflow

Lower Cosumnes River

- Potential baseflow contributions from perched aquifers – more study needed



Section B - Channel Incision

Little Shasta River

- No impacts at foothills
- Modest incision in bottomlands but not limiting to 2-year flood lateral connectivity
- No adjustments to metrics
- Monitor potential grazing impacts

Photo: Ann Willis

Lower Cosumnes River

- Moderately incised in upper reaches
- Heavily incised in middle reaches
- Increased 2-year peak magnitude
- Increased fall pulse minimum magnitude for fish passage in modified channel conditions

Photo: David Marson

Section C - Potential Management Actions

Maintain direct spring/groundwater contributions to support high water quality

- Support funding for supplemental water sources for agriculture
- Restore riparian habitat

Increase groundwater levels

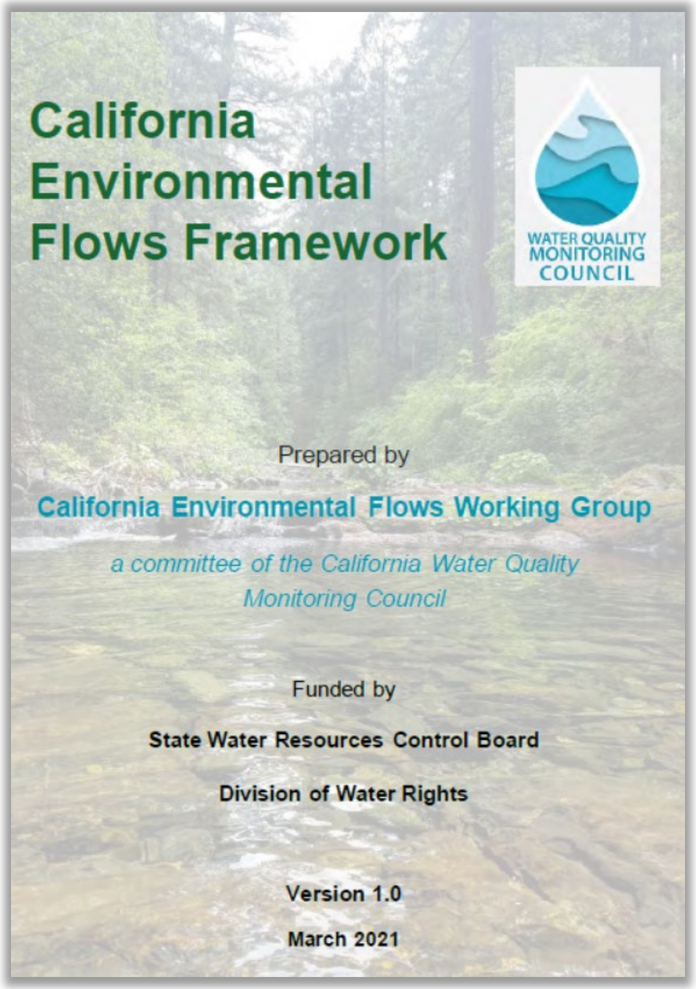
- Floodplain reconnection
- Managed riparian recharge
- Relocation of shallow wells adjacent to riparian/GDEs




Photos: Carson Jeffres, Andrew Nichols

Lessons Learned to Date

- CEFF provides flexible guidance
  - ➢Multiple approaches can be implemented in Section B
- When determining ecological flow criteria, important to:
  - ➢Evaluate groundwater contributions to instream flow
  - ➢Consider impact of mediating factors (i.e., channel alteration) on instream flow
- CEFF can be used to inform groundwater sustainability plans
  - ➢Ecological flow criteria can serve as measurable objectives
  - ➢Inform design of channel restoration that benefits instream flows, groundwater dependent ecosystems, and groundwater sustainability



Implementation and Adaptative Management

- Integration of CEFF with SGMA requires good monitoring
  - ➢Monitor link between groundwater and surface water levels
  - ➢Monitor ecological and water quality objectives
- Interannual flow variability key
  - ➢Maximize geomorphic diversity with flow diversity to build resilience
  - ➢Maintain natural ranges of flow exceedances, limit ‘managed drought’
- Flexible adaptive management
  - ➢Take advantage of real-time data to adjust with changing water conditions
  - ➢Assess, revaluate, and adjust if needed (learn from actions)