

# Overview of Tier 1 and Tier 2 Process and Products



# California E-Flows Framework

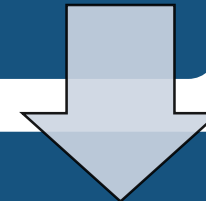
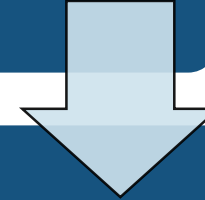
**Tier 1**

Statewide approach for setting reference-based flow targets

**Tier 2**

Regional or Site-specific eflows where necessary

Data sharing and information dissemination to the public



# CEFF Overview

Databases, Guidelines, Tools, and Information  
Accessible to the Public

## Tier 1: Statewide ecological flow criteria *based on reference hydrology*

- Identify reference stream class from statewide classification
- Determine reference hydrology patterns
- Assess reference functional flow metrics for stream class
- Assess functional flow metrics for local stream reach
- Set functional flow metric ranges at locations of interest

## Tier 2: Regional, local or site-specific ecological flow criteria *Considers specific species/habitats and management needs*

- Define hydrologic context and ecological objectives
- Characterize physical, biological and infrastructure data
- Select environmental flow method
- Incorporate policy and management needs
- Consider implementation needs and management plans

Ecological  
Flow Criteria

# Outline of CEFF Guidance Document

- Background and overview
  - ✓ Comparison of Tier 1 vs. Tier 2
- Tier 1 process
  - ✓ General steps and process
  - ✓ How to use Tier 1 products
  - ✓ Focus on use of tools to calculate Tier 1 criteria
- Tier 2 guidance
  - ✓ How to decide when Tier 2 is necessary
  - ✓ Checklist of features that are consistent with CEFF approach
  - ✓ General approach
- Case study examples

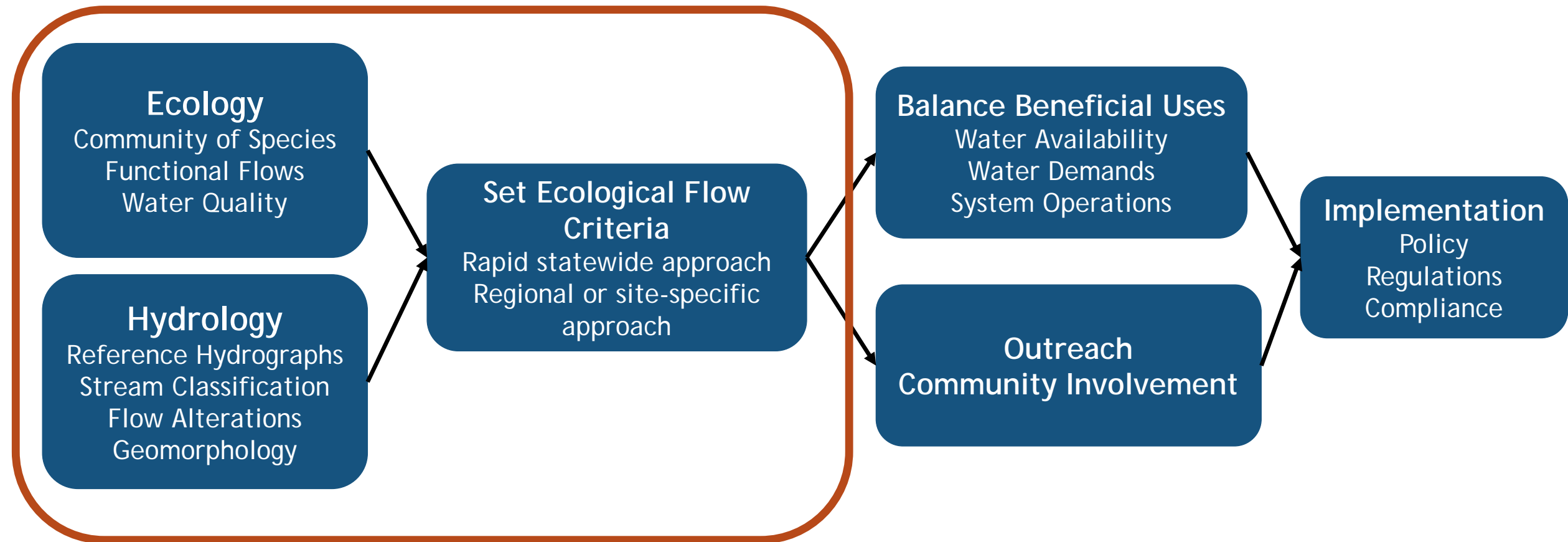


# CEFF Background and Conceptual Approach

*Target audience = practitioners who will estimate ecological flow criteria*

- What are functional flows and why do we base CEFF on a functional flows approach
  - ✓ Consideration of all aspects of the annual hydrograph
  - ✓ Quantifiable links to ecological function
- Importance of Tiered approach
  - ✓ Tier 1 → based on reference hydrology, statewide, **prescriptive**
  - ✓ Tier 2 → Regional, local or site specific, **more detailed, more guidance**
- Supporting resources
  - ✓ Websites
  - ✓ Guidance document
  - ✓ Glossary
  - ✓ Case studies

# California Environmental Flows Framework (CEFF)



# Comparison of Tier 1 and Tier 2

	Tier 1	Tier 2
<b>Spatial scale of application</b>	Statewide	Region or watershed or stream segment
<b>Type of criteria</b>	Ecological flow criteria	Environmental flow recommendations
<b>Basis for setting criteria</b>	Comparison of functional flow metrics to reference ranges	Establishment of functional flow criteria relative to specific habitat and/or species needs
<b>Resolution</b>	Broad ranges	Narrower, more prescriptive
<b>General analytical approach</b>	Statistical analysis and modeling of reference conditions	Combination of statistical and mechanistic models
<b>Physical basis</b>	Functional flow metrics	Includes consideration of geomorphic forms and infrastructure with hydrology
<b>Biological basis</b>	Functional flow components	Includes consideration of local or regional aquatic communities or species of interest

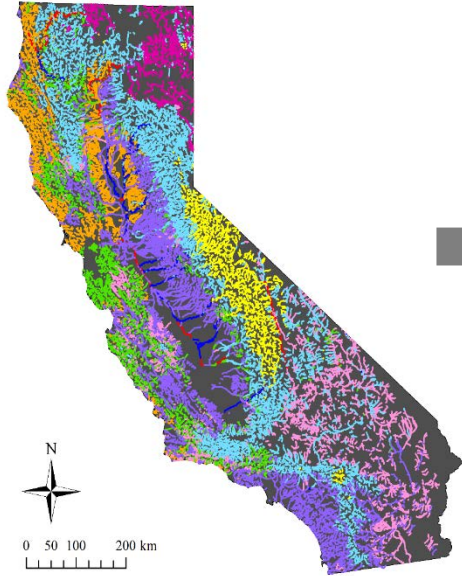
# Tier 1

*A prescribed approach for statewide ecological flow criteria*

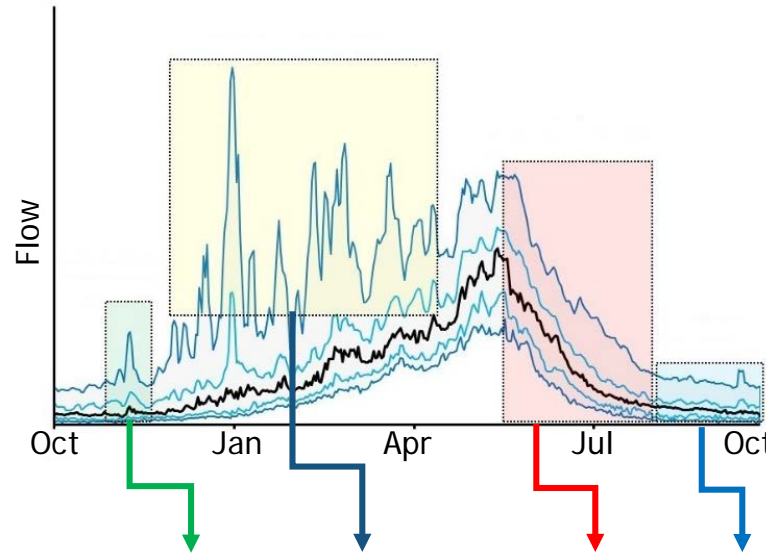


# Tier 1 Approach

Natural Streamflow Classification



Dimensionless Reference Hydrographs for Each Reference Gage



Flow Characteristics	Wet Season Initiation	Peak Magnitude Flows	Spring Recession Flow	Dry Season Low Flows
Magnitude	X	X	X	X
Timing	X	X	X	X
Duration	X	X	X	X
Frequency		X		
Rate of Change			X	X

Functional Flows Components and Metrics for *reference conditions/gauges*

Functional Flow Metrics  
**Modeled natural predictions for all stream reaches**

**Tier 1 Ecological Flow Criteria**

# Tier 1 Steps

- Regional reference hydrology and FF metric calculation code at:  
***[eflows.ucdavis.edu](http://eflows.ucdavis.edu)***
- Modeled monthly natural flows and FF metrics at:  
***[flowline.codeofnature.org](http://flowline.codeofnature.org)***
- Stream reach specific Tier 1 targets can be produced using:
  - a. Measured data (i.e. gauge data)
  - b. Local modeled data
  - c. Statewide model predictions

## Step 1 :

Determine stream class

## Step 2 :

Explore reference hydrology

## Step 3 :

Evaluate reference functional flow metrics

## Step 4:

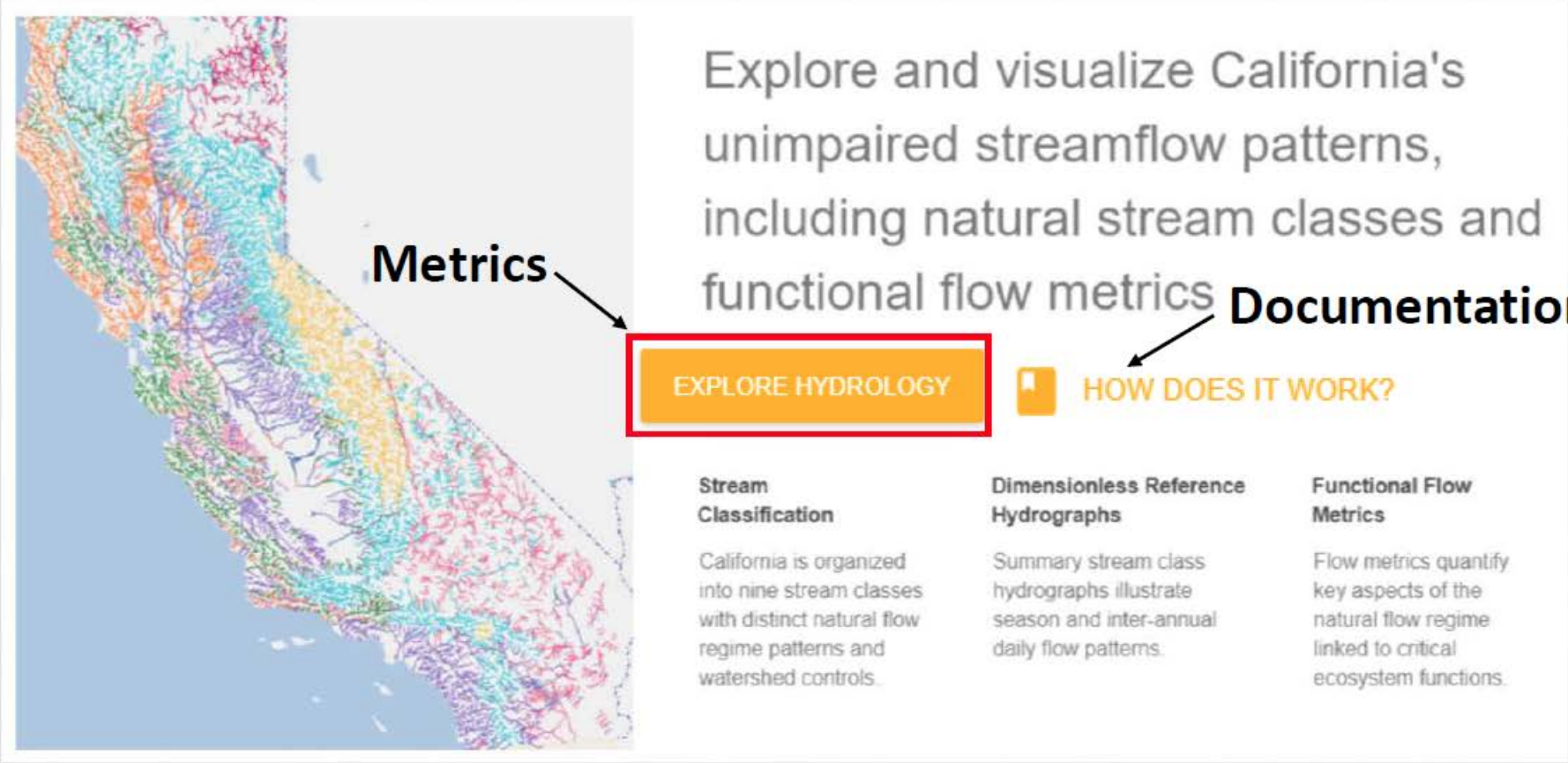
Assess modeled natural functional flow metrics at local stream reaches

## Step 5:

Determine ecological flow criteria based on functional flow metrics

# Classification and Reference Hydrology

Ultimately to be hosted through CWQMC Portal



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

**Metrics** → **EXPLORE HYDROLOGY**

**Documentation** → **HOW DOES IT WORK?**

Stream Classification	Dimensionless Reference Hydrographs	Functional Flow Metrics
California is organized into nine stream classes with distinct natural flow regime patterns and watershed controls.	Summary stream class hydrographs illustrate season and inter-annual daily flow patterns.	Flow metrics quantify key aspects of the natural flow regime linked to critical ecosystem functions.

# Steps 1 and 2: Explore Regional and Local Reference Hydrology

**WHAT:** Identify which regional hydrologic class you are in and identify relevant reference gauges for your location of interest

**WHY:** Provides context for your location of interest and allows for direct comparison to appropriate reference condition (some functional flow metrics may not apply for certain stream classes)

**WHERE:** [eflows.ucdavis.edu](http://eflows.ucdavis.edu)

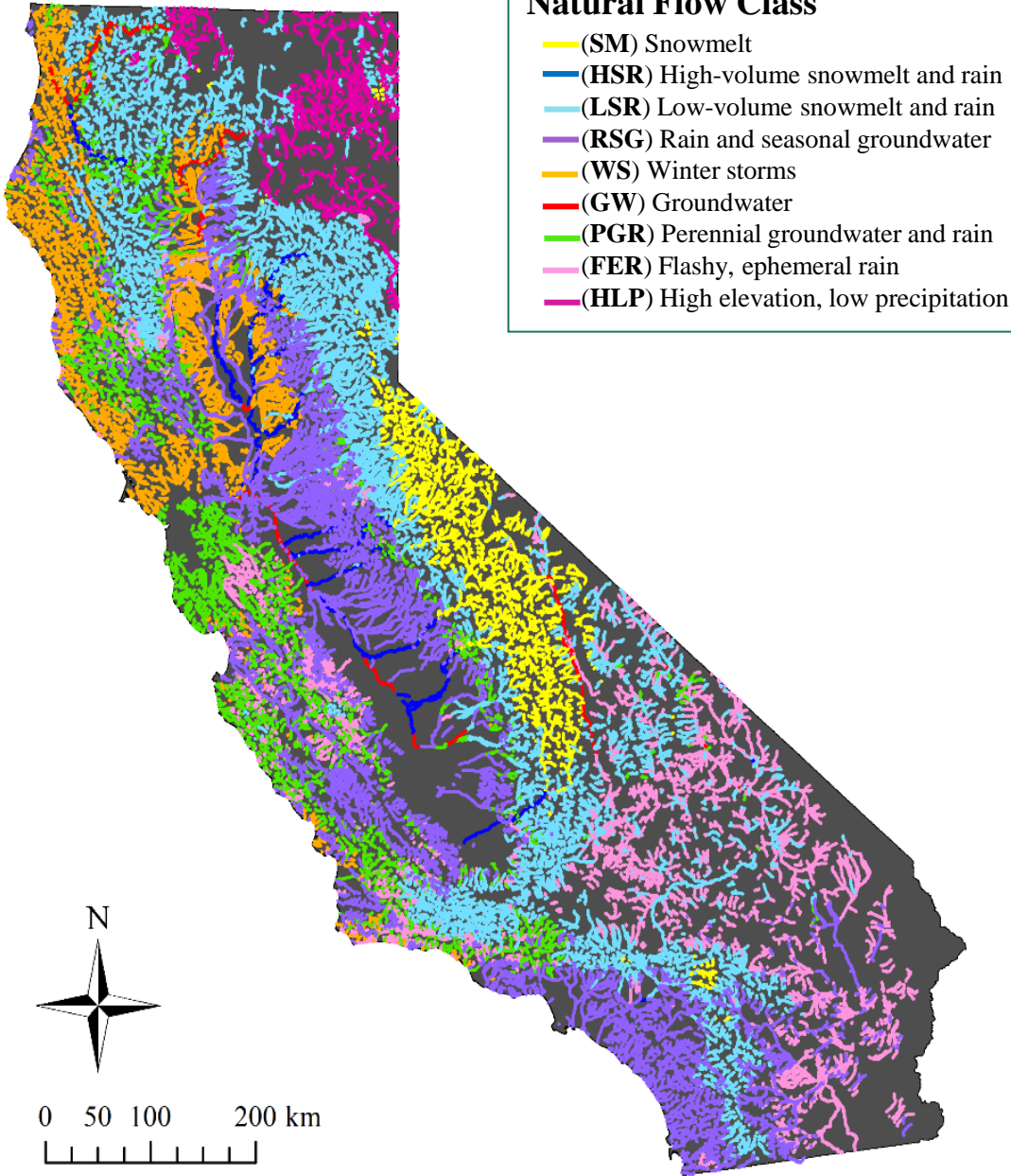
# Stream Classification

Catchment Properties

Rainfall Patterns

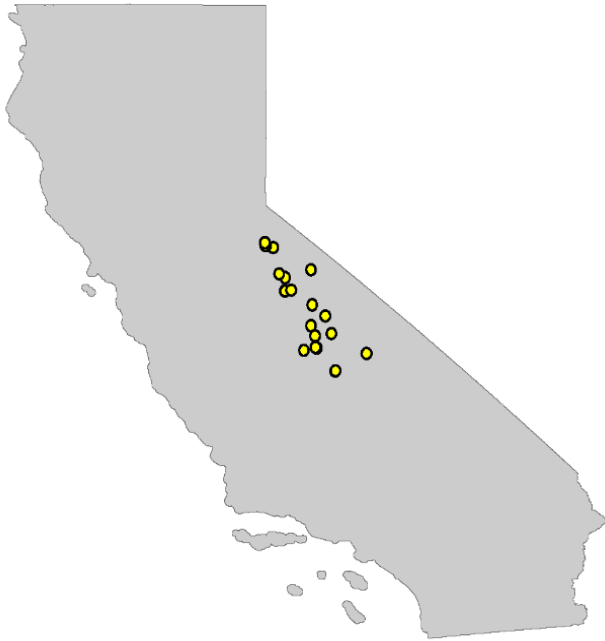
Geology

Soil Properties

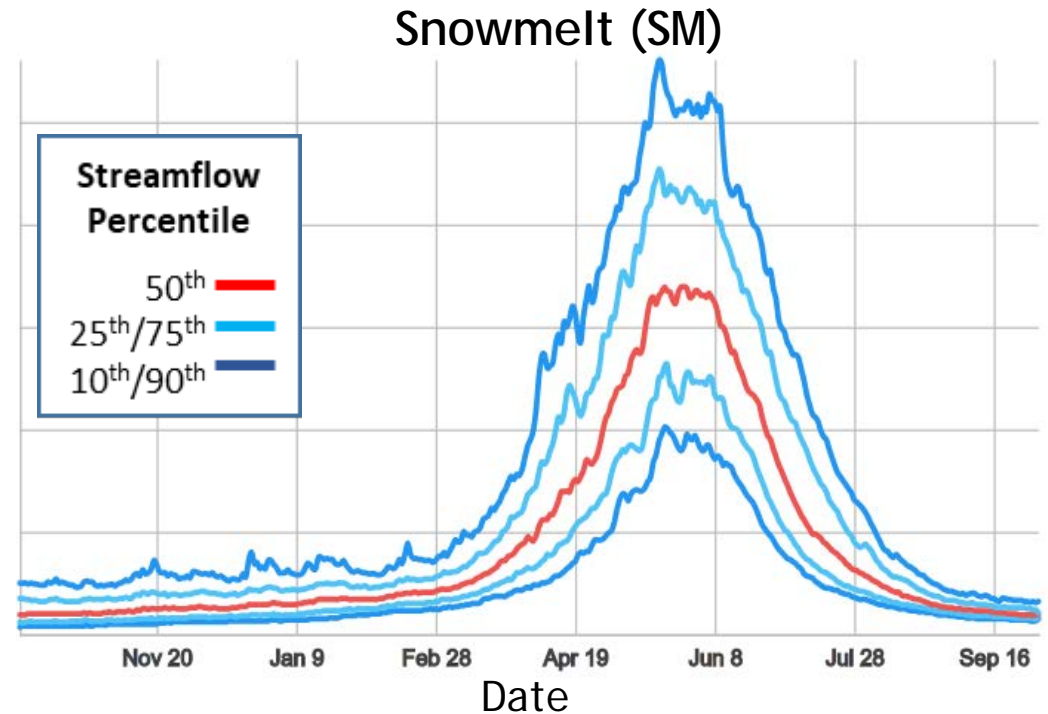


Lane et al., 2018

# Dimensionless Reference Hydrographs



Daily flow / Average annual flow

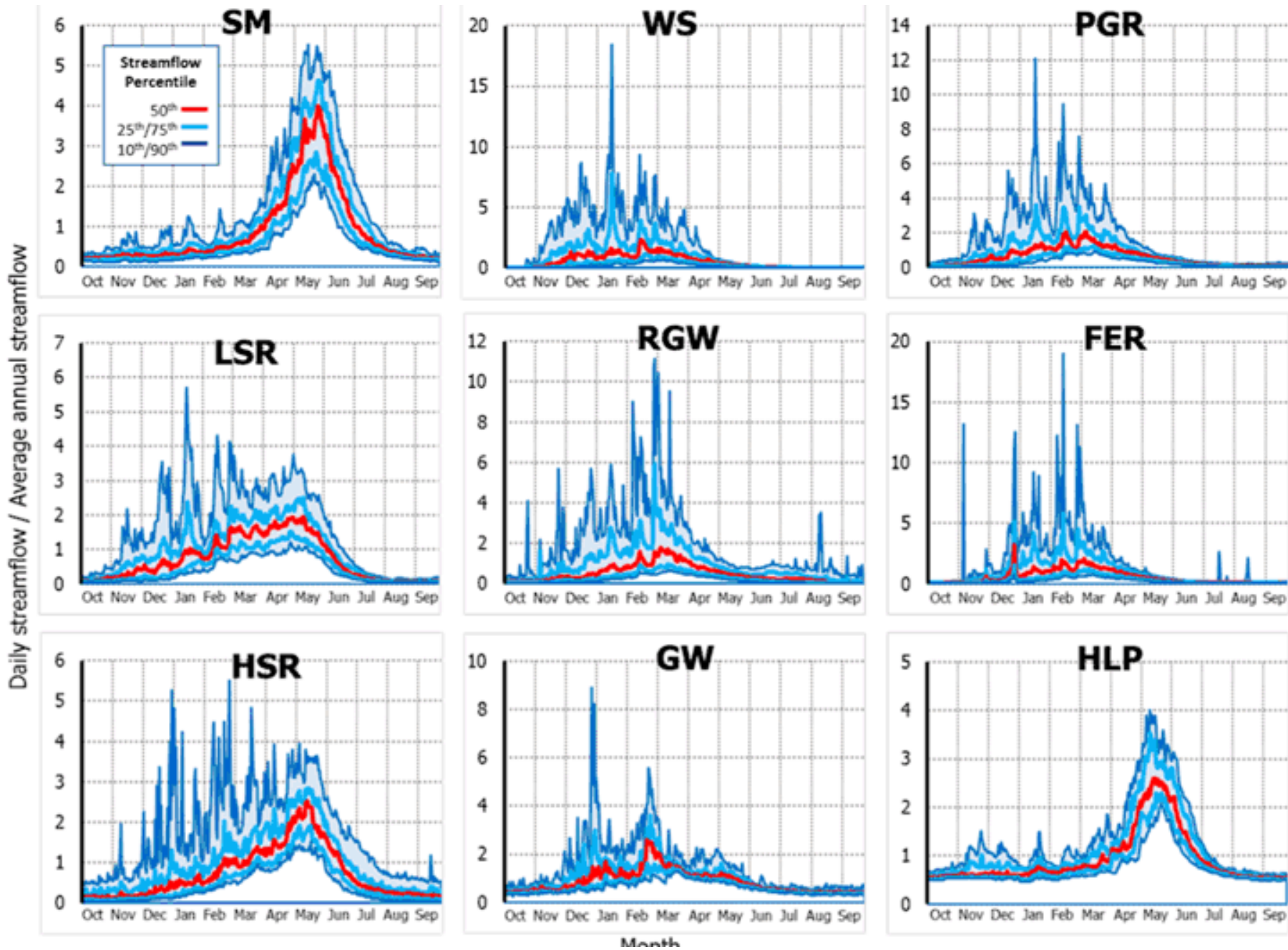


## Purpose:

To characterize comparable seasonal and inter-annual flow patterns for each stream class.

## Methods:

For each reference gage in a stream class, divide daily flow values by water year average annual flow. Calculate nondimensional flow percentiles for each date across all gauges and years.



- (SM) Snowmelt
- (HSR) High-volume snowmelt and rain
- (LSR) Low-volume snowmelt and rain
- (RSG) Rain and seasonal groundwater
- (WS) Winter storms
- (GW) Groundwater
- (PGR) Perennial groundwater and rain
- (FER) Flashy, ephemeral rain
- (HLP) High elevation, low precipitation

# Step 3: Evaluate Reference Functional Flow Metrics

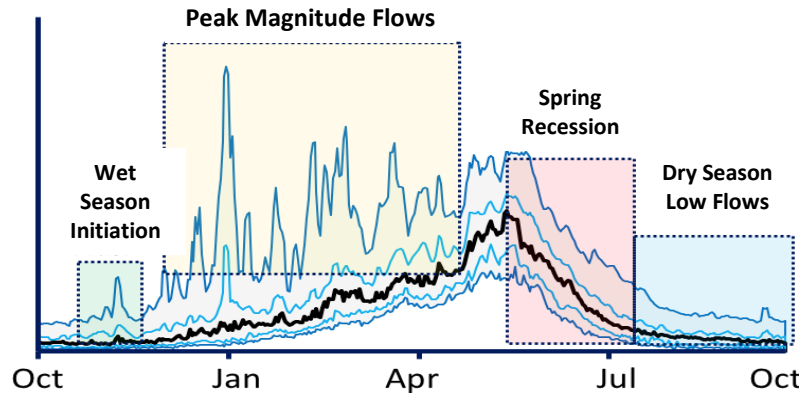
**WHAT:** Characterize reference hydrology for your location of interest using a series of *hydrologically representative and ecologically relevant* metrics

**WHY:** Functional flow metrics provide a way to quantify ranges of reference condition for each functional flow component. Hydrology at your location of interest can then be compared to relevant reference expectations.

**WHERE:** [eflows.ucdavis.edu](http://eflows.ucdavis.edu) (reference gauges) and [flowline.codeofnature.org](http://flowline.codeofnature.org) (stream reach in development)



# Functional Flow Metrics



Flow Component	Flow Characteristic	Metric
Annual	Rate of change (%)	coeff. of variation of daily flow
	Average (cfs)	average annual daily flow
Wet Season Initiation	Magnitude (cfs)	magnitude
	Timing (date)	start date
	Duration (days)	# days (start-end)
Peak Magnitude Flows	Timing (date)	start of wet season
	Magnitude (cfs)	wet season average baseflow
	Magnitude (cfs)	peak magnitude: 2%, 5%, 10%, 20%, 50% exceedances
	Timing (date)	start date: 2%, 5%, 10%, 20%, 50% exceedances
	Duration (days)	# days: 2%, 5%, 10%, 20%, 50% exceedances
	Frequency (#)	# of events in record: 2%, 5%, 10%, 20%, 50%
	Spring Recession	Magnitude (cfs)
	Rate of change (%)	percent decrease per day
	Timing (date)	start date
	Duration (days)	# days (start-end)
Dry Season Low Flow	Magnitude (cfs)	baseflow magnitude
	Timing (date)	start date of summer
	Duration (days)	# days (start-wet) and (start to first wet season event)
	Frequency (#)	# of no flow days

Metrics not related to any specific organism.

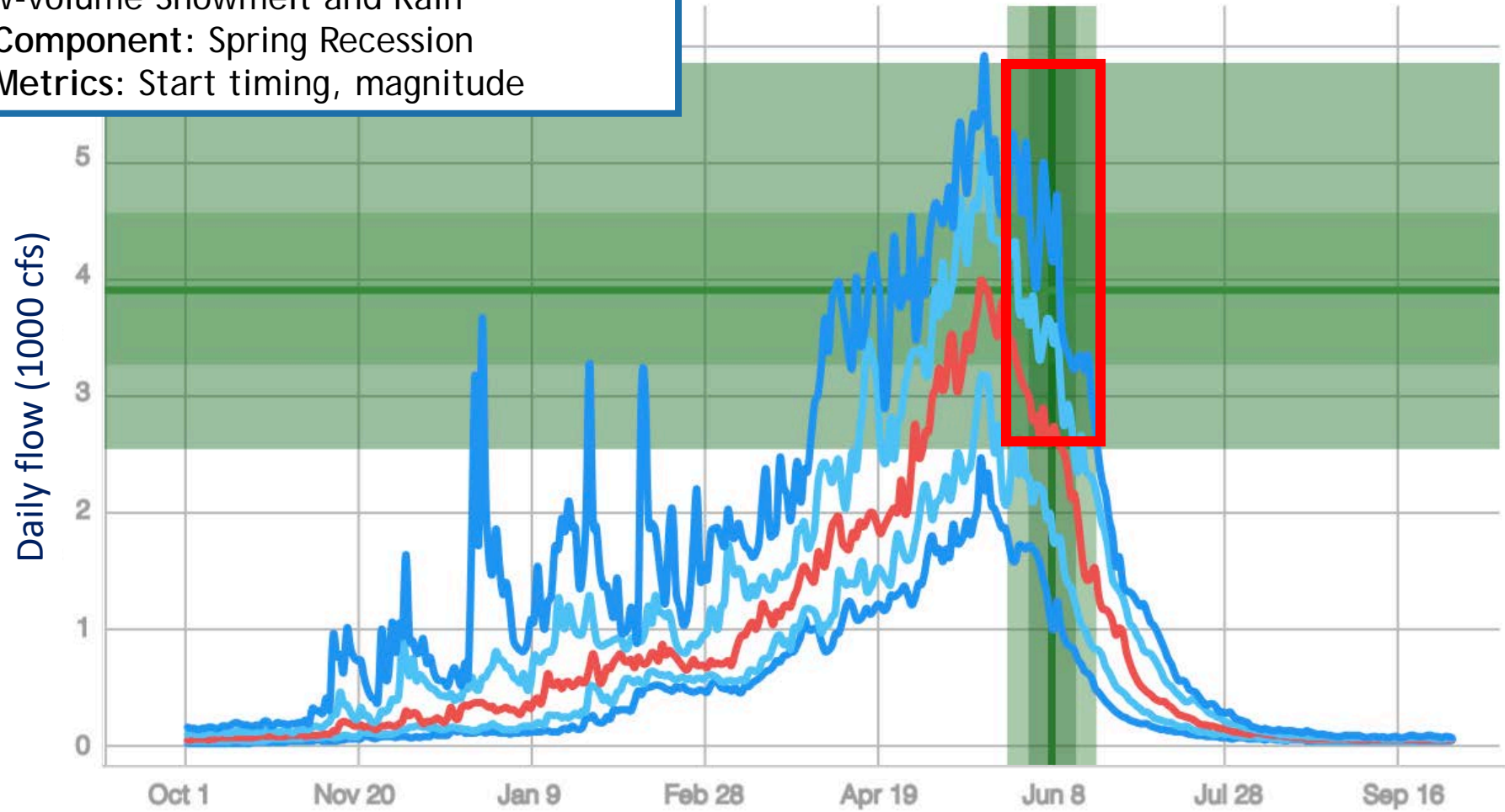
Metrics relate to general health based on *reference conditions*

# Ways to Determine Functional Flow Expectations

- Scaling the dimensionless reference hydrograph for local conditions
- Based on local reference gauge(s)
- Locally calibrated and validated model → flow time series → metrics
- Statewide natural flows model → functional flow metrics

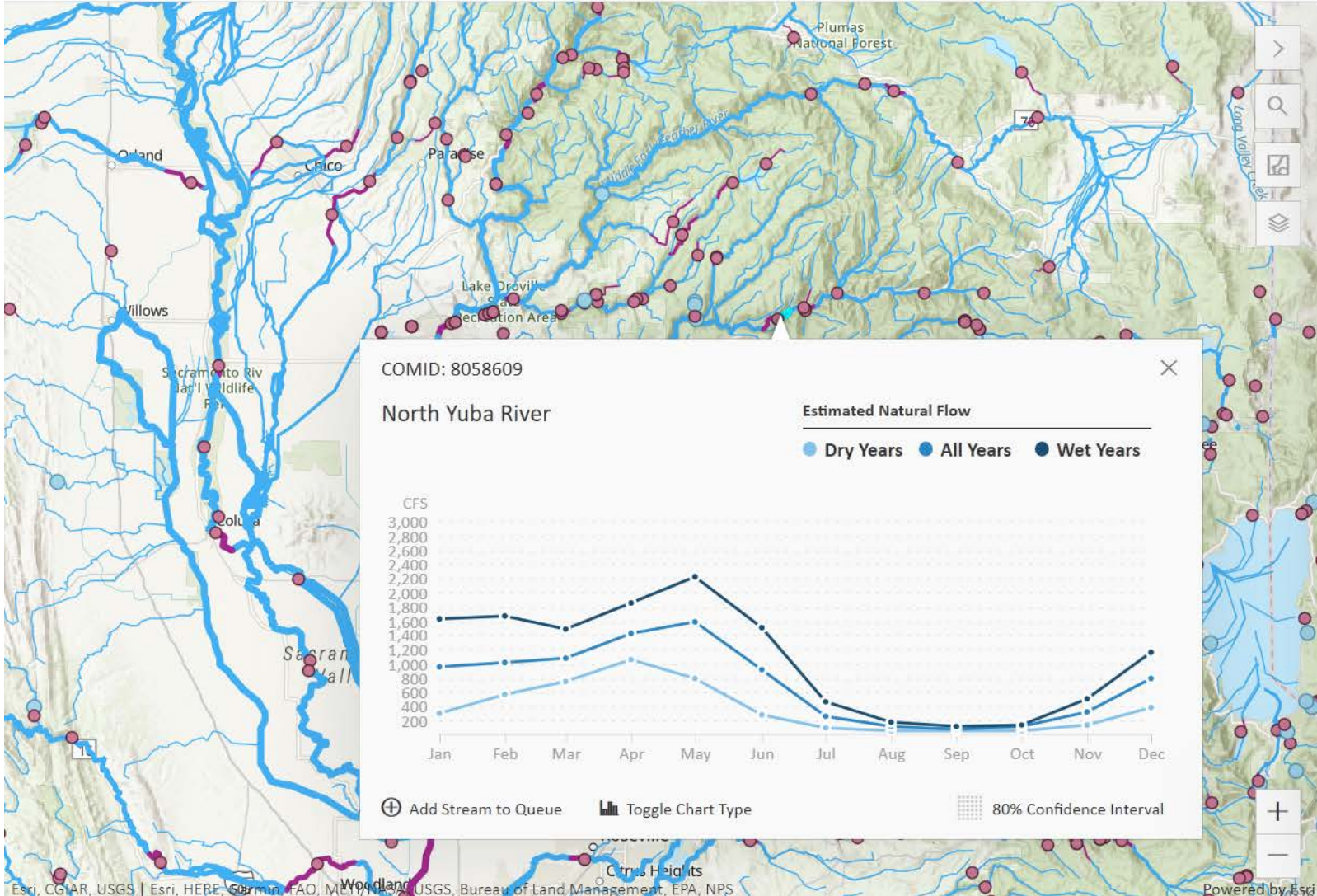
# Functional Flow Metric Ranges

Stream Class: Low-volume Snowmelt and Rain  
Functional Flow Component: Spring Recession  
Functional Flow Metrics: Start timing, magnitude



Percentiles:    ■ 10th    ■ 25th    ■ 50th    ■ 75th    ■ 90th

# Modeled Monthly Natural Flows



## Streams

Clear all

Select a stream segment on the map and click 'Add to Queue' to add stream to download queue.

## Statistics

- Min
- Mean
- Median
- Max

## Variables

- Estimated
- Observed
- p10
- p90

## Years

From: 1950 To: 2015

## Months

- January
- May
- September
- October
- November
- December
- April
- August

Download Data

# Functional Flows Calculator (eflows.ucdavis.edu)

The interface is divided into several sections:

- Map:** Shows the Yuba River basin with various gauging stations marked by colored dots. A legend at the bottom left lists categories: SM, HSR, LSR, WS, GW, PGR, FER, RGW, HLP, Gauge, and City.
- Control Panels:**
  - Spring Recession:** Includes sliders for Recession Timing and Recession Magnitude.
  - Dry Season:** Includes sliders for Dry Season Start Timing and Low Flow Magnitude.
  - Wet Season Initiation:** Includes sliders for Event Timing and Event Magnitude.
  - Peak Magnitude:** Includes sliders for Wet Season Start Timing and Baseflow Magnitude.
  - Peak Magnitude High Flows:** A dropdown menu.
  - Min/Max:** A toggle switch.
- Data Panel:** Shows the selected station: "N YUBA R AB SLATE C NR STRAWBERRY CA" with ID: 11413100 and Class: Low-volume snowmelt and rain. A "DISPLAY" button is present.
- Dimensionless Reference Hydrograph:** A line graph showing "Daily flow / Average annual flow" over time. A black box highlights a specific period. Percentiles are set to the 10th.
- Water year hydrograph for 1975:** A line graph showing "Flow Value (cfs)" over time for the year 1975. Vertical lines mark specific dates: Oct 1, Nov 20, Jan 9, Feb 28, Apr 19, Jun 6, Jul 28, and Sep 15.
- Navigation:** A "CLOSE" button is at the bottom left, and a "Slide the bar to change the water year!" slider is at the bottom right, ranging from 1968 to 1986.

Select by water year type:  
Wet, moderate, dry

Annual Flow Matrix  
Annual Metric Result

# Water Year Typing

- Determined water year type for all stream segments with monthly modeled flow in TNC Natural Flow database
- Calculated mean annual flow for each stream segment based on modeled monthly flows
- Calculated tercile cutoffs to define wet, dry, and moderate for each segment for entire period of record (1950-2016)
- Categorized each mean annual flow into a water year type

COMID	STATION_	Water_Year	Mean_Annual_Flow	WYT
22684930	BIG ROCK	1951	2.583333333	Dry
22684930	BIG ROCK	1952	24.5	Wet
22684930	BIG ROCK	1953	6.583333333	Dry
22684930	BIG ROCK	1954	10.66666667	Moderate
22684930	BIG ROCK	1955	8.083333333	Moderate

# Steps 4 and 5: – Estimate Reach-scale Functional Flow Metrics Relative to Tier 1 Criteria

**WHAT:** Quantitatively characterize current hydrologic conditions at your location of interest using the functional flow metrics.

- Measured data (i.e. gauge data)
- Local modeled data

**WHY:** Determine whether your location of interest meets Tier 1 Ecological Flow Criteria

**WHERE:** calculated from code at [eflows.ucdavis.edu](http://eflows.ucdavis.edu) or downloaded from [flowline.codeofnature.org](http://flowline.codeofnature.org)

# Calculating Tier 1 Functional Flow Metric Ranges

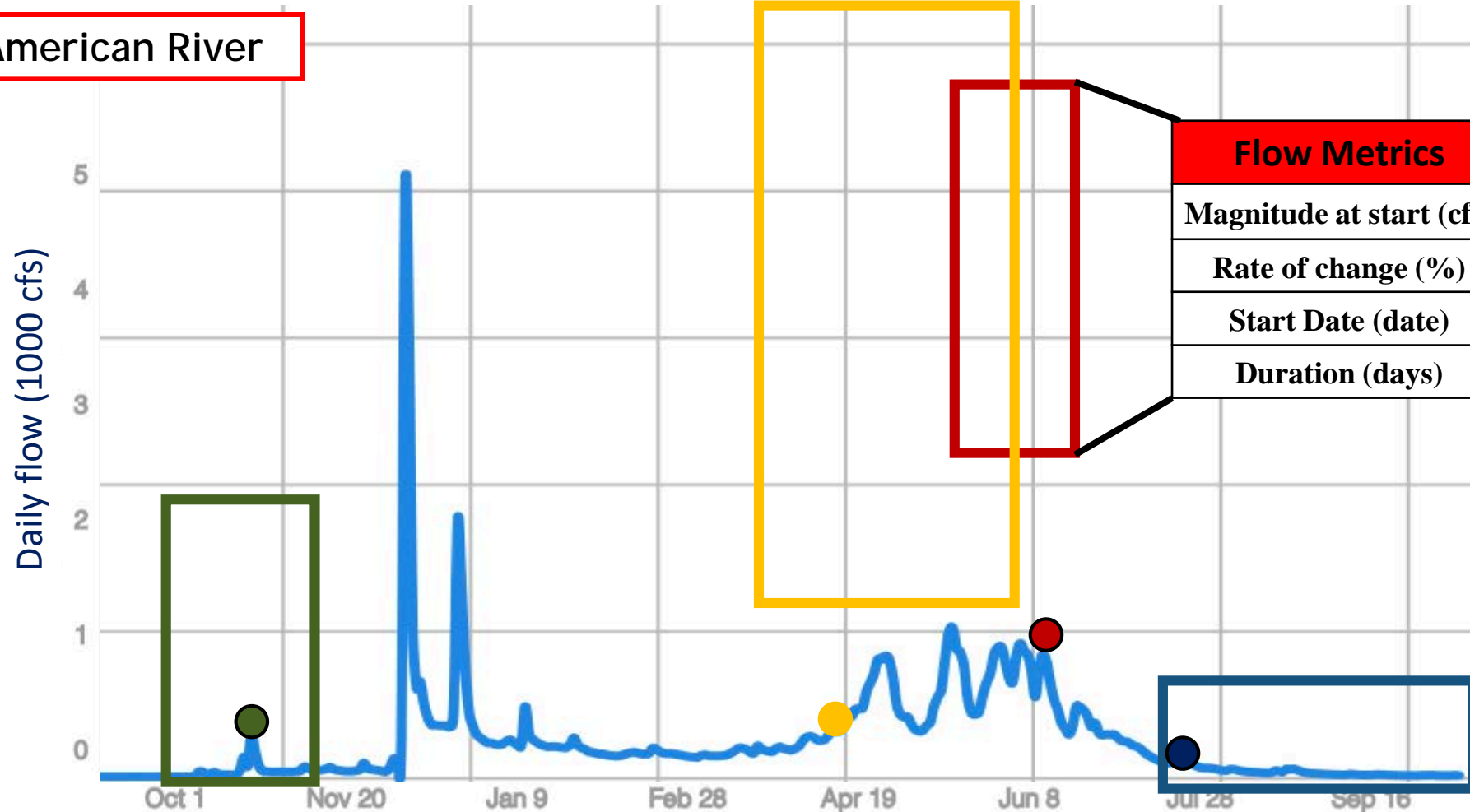
Flow Characteristics	Wet Season Initiation	Peak Magnitude Flows	Spring Recession Flow	Dry Season Low Flows
Magnitude	X	X	X	X
Timing	X	X	X	X
Duration	X	X	X	X
Frequency		X		
Rate of Change			X	X

Flow Metrics	Values
Magnitude at start (cfs)	2028 – 4880 cfs
Rate of change (%)	5 – 8%
Start Date (date)	May 11 – May 27
Duration (days)	36 to 50 days



# Do I Meet Tier 1 Criteria?

South Fork American River

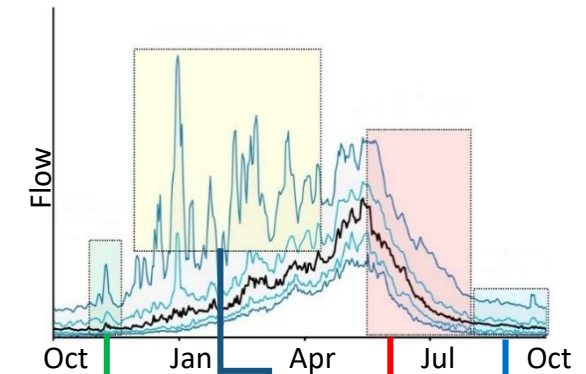
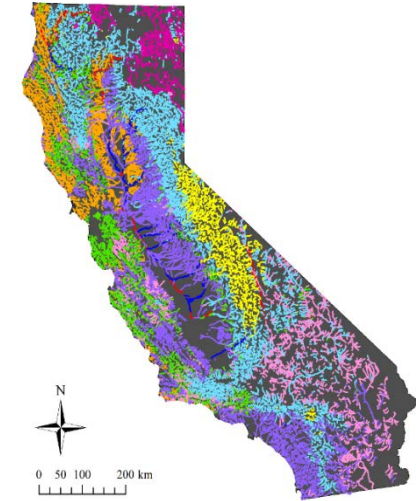


Flow Metrics	Values
Magnitude at start (cfs)	2028 – 4880 cfs
Rate of change (%)	5 – 8%
Start Date (date)	May 11 – May 27
Duration (days)	36 to 50 days

Percentiles: ■ 10th ■ 25th ■ 50th ■ 75th ■ 90th

# Tier 1 Products

- Hydrologic classification
- Dimensionless reference hydrographs
- List of priority functional flow metrics
  - ✓ **Functional flows calculator**
- Functional flow metric predictions for all stream reaches in the state
- Sample applications



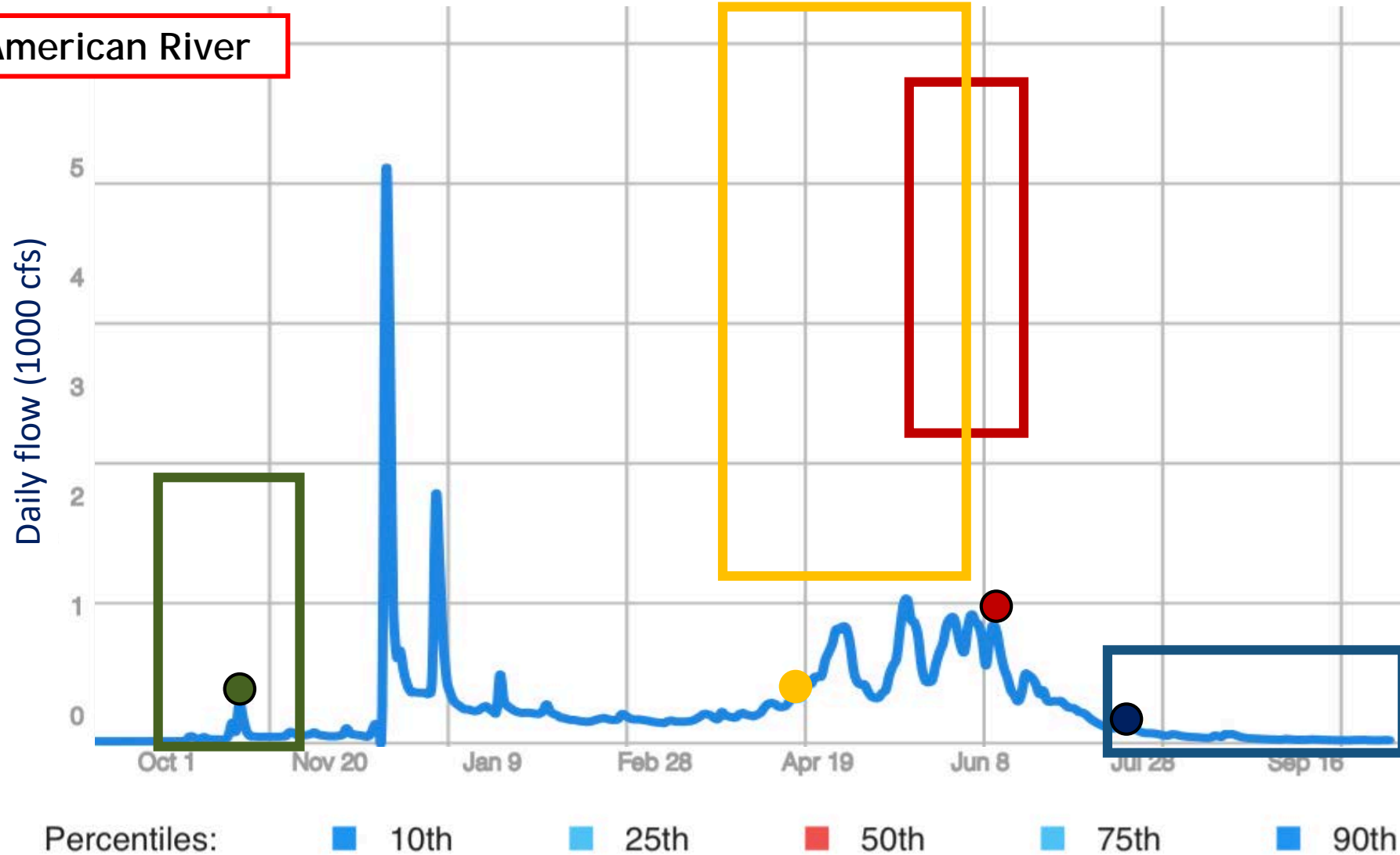
Flow Characteristics	Wet Season Initiation	Peak Magnitude Flows	Spring Recession Flow	Dry Season Low Flows
Magnitude	X	X	X	X
Timing	X	X	X	X
Duration	X	X	X	X
Frequency		X		
Rate of Change			X	X

# Uses of Tier 1 Products

- Reference-based ecological flow criteria
- Assessing regional hydrologic condition
  - ✓ Status and trends assessments
- Planning study to prepare for Tier 2

# Reference Based Ecological Flow Criteria

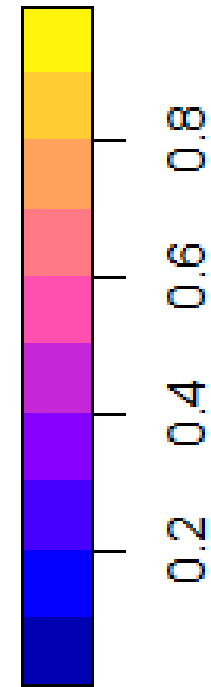
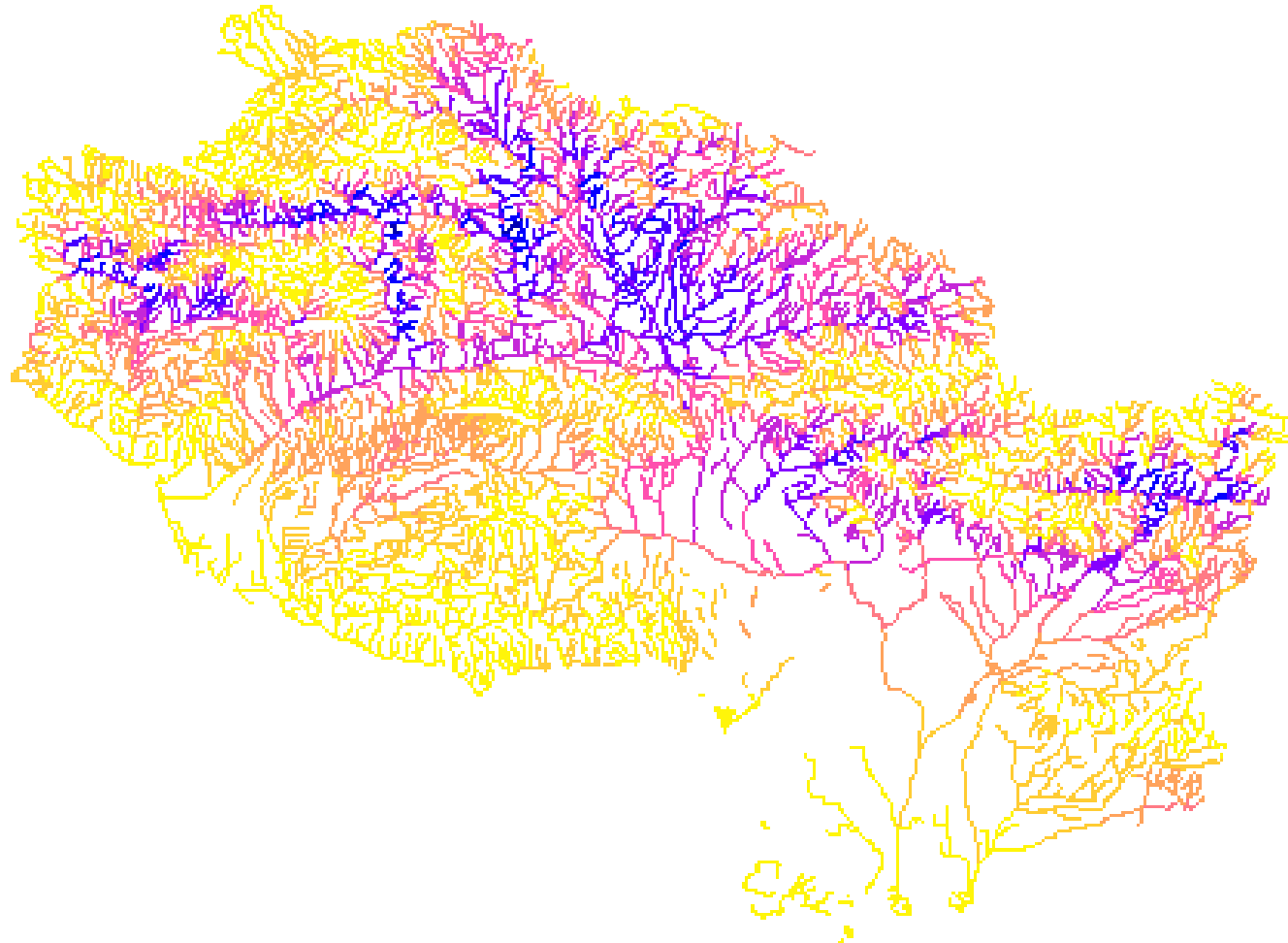
South Fork American River



# Assessing Regional Hydrologic Condition

Proportion of functional flow metric ranges met under current conditions

**HYPOTHETICAL DATA BASED ON PRELIMINARY MODELLING**







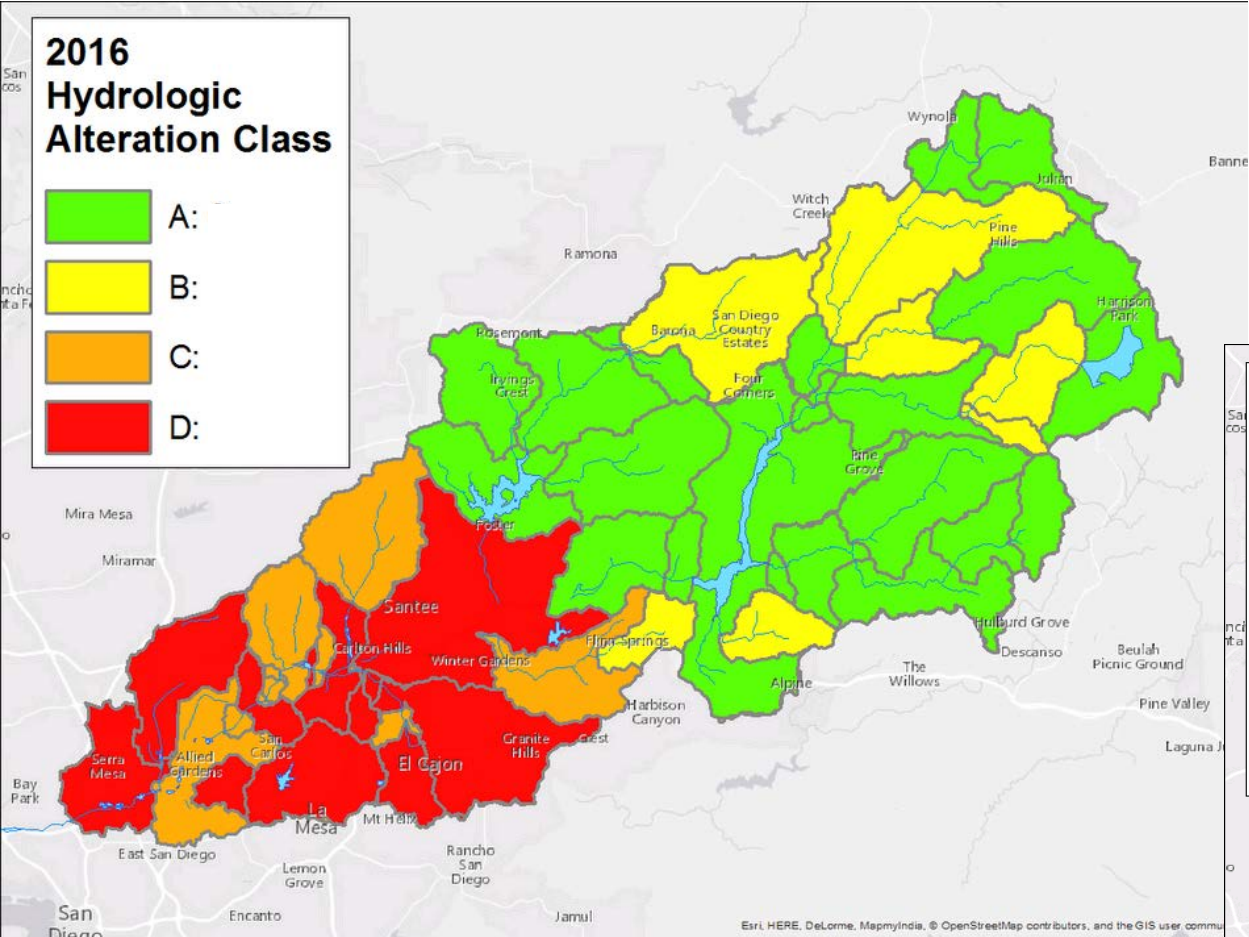
Similar maps could be produced for individual functional flow metrics by water year type

# Planning for Tier 2 Analysis





San Diego River Watershed

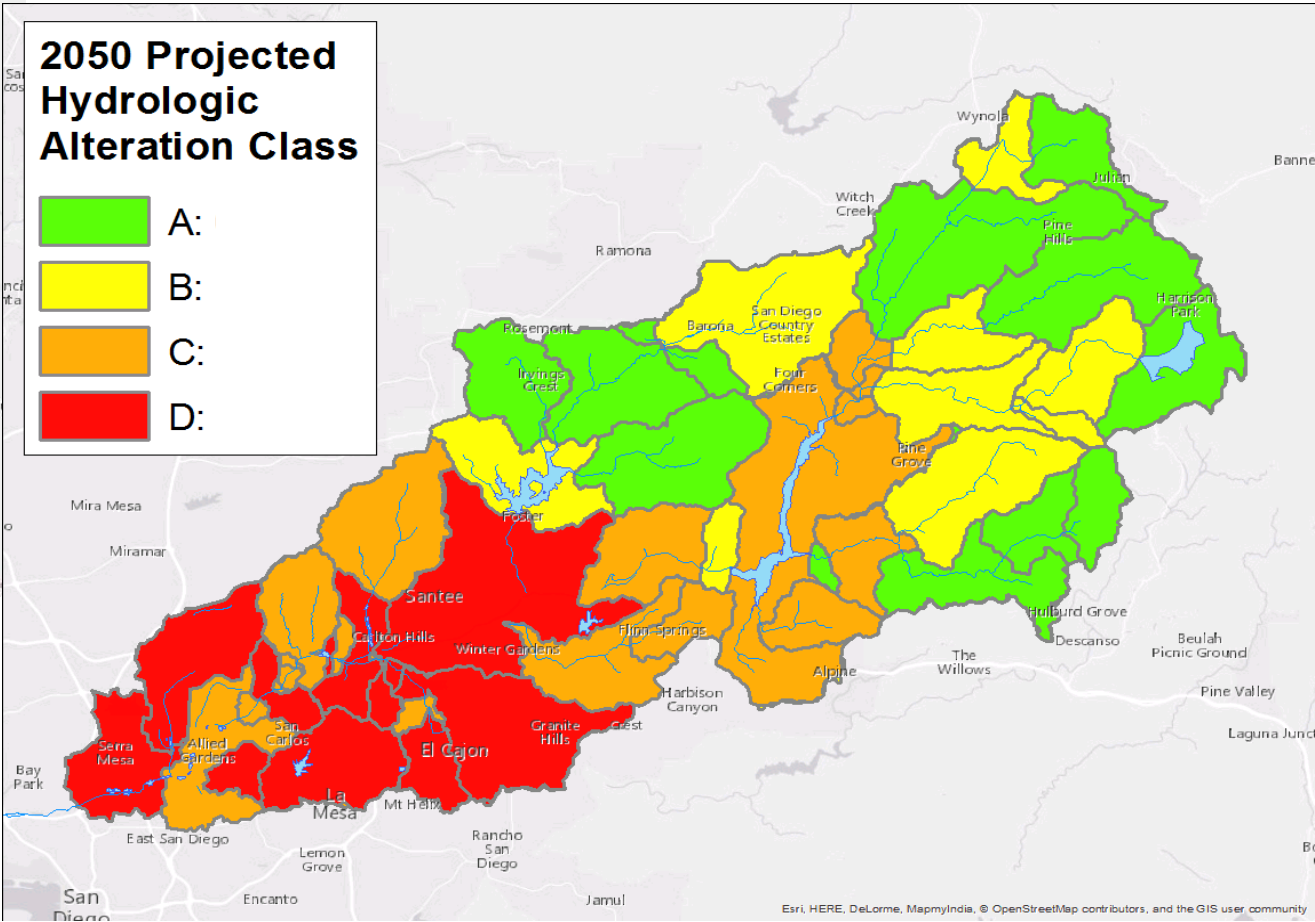
**2016  
Hydrologic  
Alteration Class**

-  A:
-  B:
-  C:
-  D:



**2050 Projected  
Hydrologic  
Alteration Class**

-  A:
-  B:
-  C:
-  D:



**Inform land and conservation  
planning processes**

# Implementation Questions for Agencies to Consider

- How good is good enough?
  - ✓ What level of confidence do you want in Tier 1 criteria (e.g. how big of a “box” do we want to draw)?
- How do you want to spatially aggregate results?
  - ✓ If one reach “fails” what does that mean? How many “failures” indicate that there is a problem?
- How often do you need to meet criteria?
  - ✓ Focus on certain water year types?
  - ✓ Do you need to “pass” during a minimum number of years or % of years?

# Tier 2

*Guidelines and information for developing finer scale environmental flow recommendations*



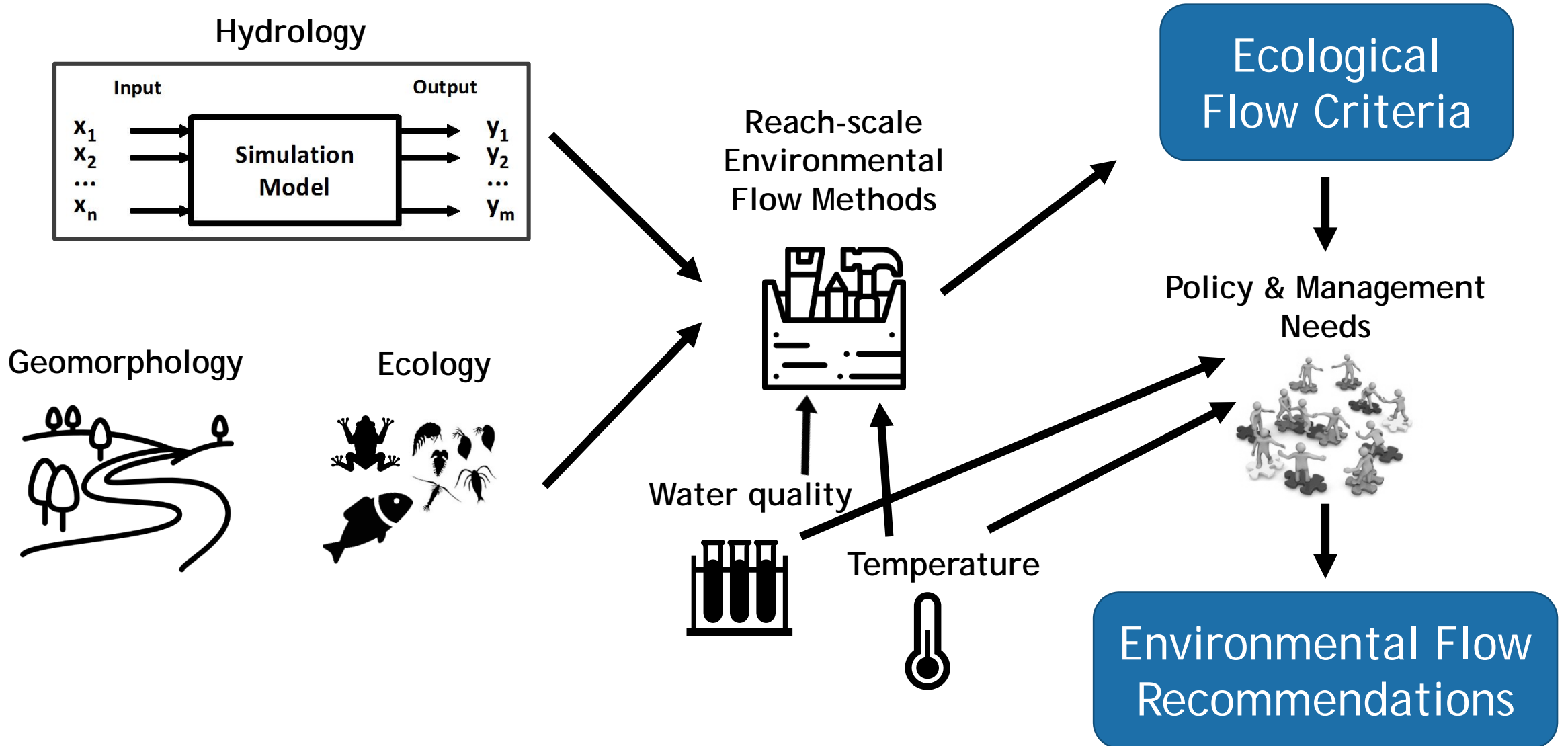
# Comparison of Tier 1 and Tier 2

	Tier 1	Tier 2
<b>Spatial scale of application</b>	Statewide	Region or watershed or stream segment
<b>Type of criteria</b>	Ecological flow criteria	Environmental flow recommendations
<b>Basis for setting criteria</b>	Comparison of functional flow metrics to reference ranges	Establishment of functional flow criteria relative to specific habitat and/or species needs
<b>Resolution</b>	Broad ranges	Narrower, more prescriptive
<b>General analytical approach</b>	Statistical models and relationships	Combination of statistical and mechanistic models
<b>Physical basis</b>	Hydrologic metrics	Includes consideration of geomorphic forms and infrastructure with hydrology
<b>Biological basis</b>	Functional flow components	Includes consideration of local or regional aquatic communities or species of interest

# When is Tier 2 Necessary?

- Tier 1 criteria are too coarse
- Desire to focus on flow effects on specific ecological conditions (e.g. particular species, communities, or habitats)
- Need to consider specific physical settings or constraints
- Need to address specific management issues
- Desire to balance ecological flow needs with other (human use) demands

# Tier 2 Approach



# What are the Features of a Tier 2 Approach

*Not all environmental flow projects are consistent with the CEFF framework . . . and that is OK . . . But CEFF provides important elements that ensure comprehensive consideration of hydrology in an ecologically relevant way*

## *CEFF Tier 2 approach:*

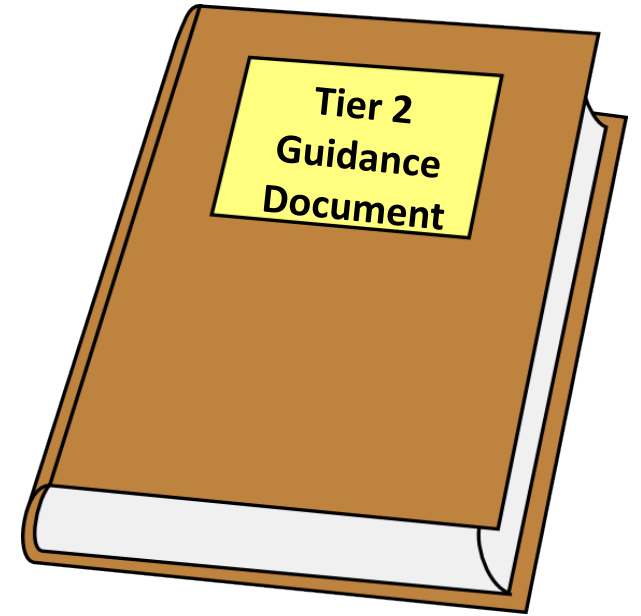
- Addresses specific questions or management needs
- Includes consideration of relevant reference conditions
- Employs a functional flows approach
- Includes consideration of balancing multiple objectives
- Provides guidance on monitoring and adaptive management

# General Tier 2 Process

- Start with Tier 1 Functional Flow Metrics
- Consider specific management targets, species, habitats
- Consider constraints of the system you are working in.
- Prioritize functional flow metrics based on issues/constraints and justify choice of priorities
- Establish flow-ecology relationships, provided they are consistent with functional flow metrics
- Assess functional flows using locally relevant models/tools
- Optimize flows to account for other demands and management actions
  - ✓ balance objectives, implementation, monitoring, adaptive management

# Tier 2 Tools and Products

- Key data sets
  - ✓ Geomorphic classification
  - ✓ Regional species assemblages
  - ✓ Impaired flows classification
- Models and tools
  - ✓ List of hydrologic models and decision support for model selection
  - ✓ Hydrologic/hydraulic needs of key species
  - ✓ Flow-ecology tools and relationships and decision support for tool selection
- Summary of programs and policies that involve environmental flow considerations
- Implementation considerations
  - ✓ General design for monitoring effect of environmental flow management
  - ✓ Recommended indicators and monitoring approaches
  - ✓ Recommendations for adaptive management
  - ✓ Data management considerations → possible future data repository/clearing house



# Case Studies

*Examples of how Tier 1 and Tier 2 is being implemented.  
Templates to guide future implementation*

# Regional Case Study Examples

- South Fork of the Eel River – balancing new water rights (cannabis growers) with instream habitat needs
- Southern California – flow requirements for water quality criteria based on benthic invertebrates
- Los Angeles River – balancing recycled water use with instream habitat needs
- Central and Northern California – dam relicensing for salmonid protection
- North Coast – water withdrawals for fish passage



# Next Steps and Future Topics

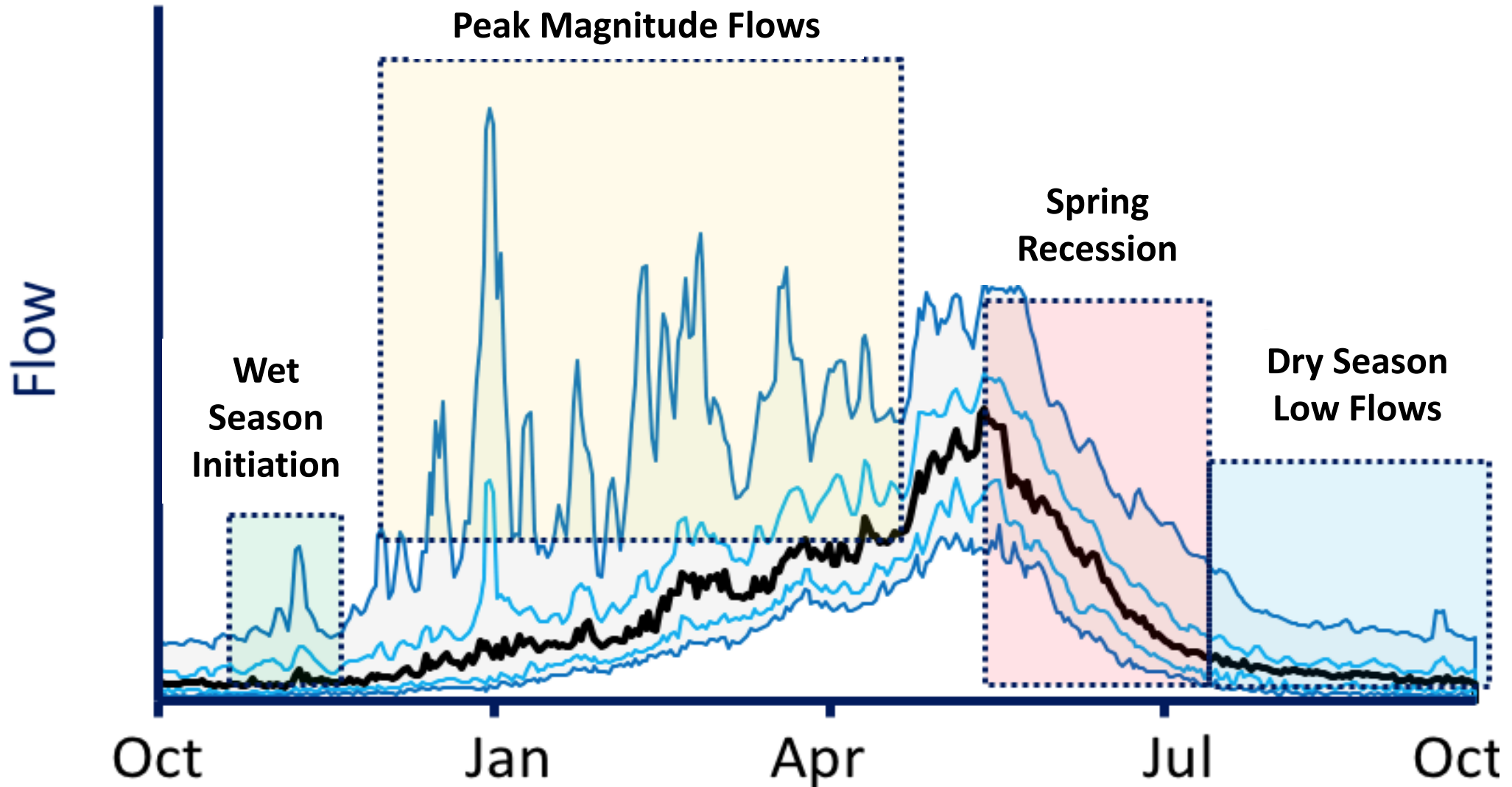
- Additional discussion on application of Tier 1 products.
- Hydrologic modeling and model selection process
- Mapping and prioritization of habitats and species
- How to deal with highly modified landscapes
- Other?



**Welcome to the California Environmental  
Flows Framework website**

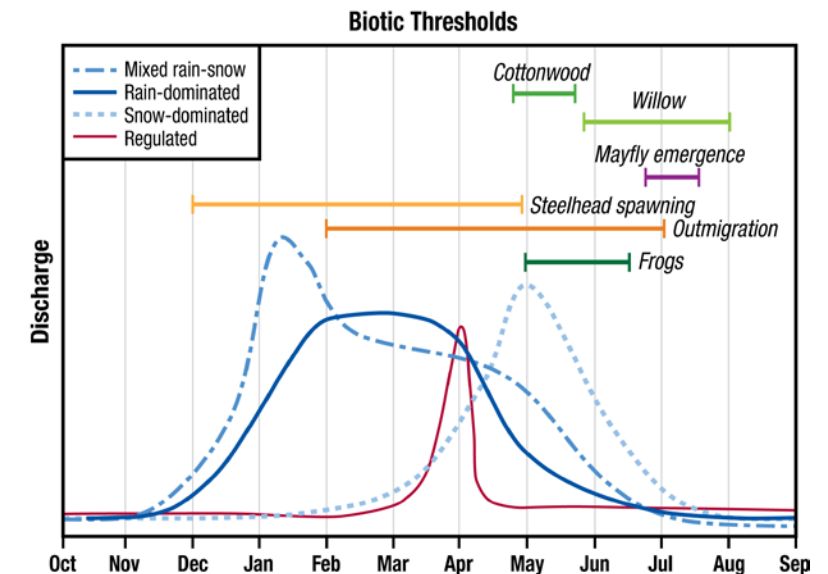
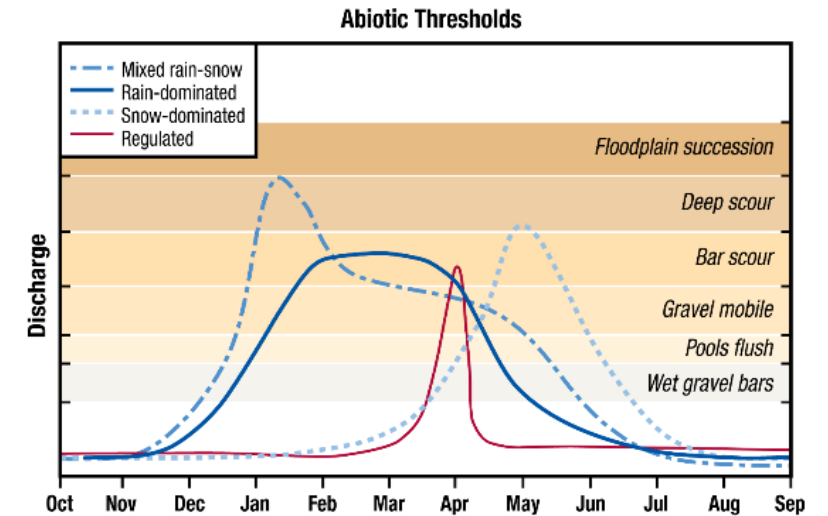


# Functional Flow Components



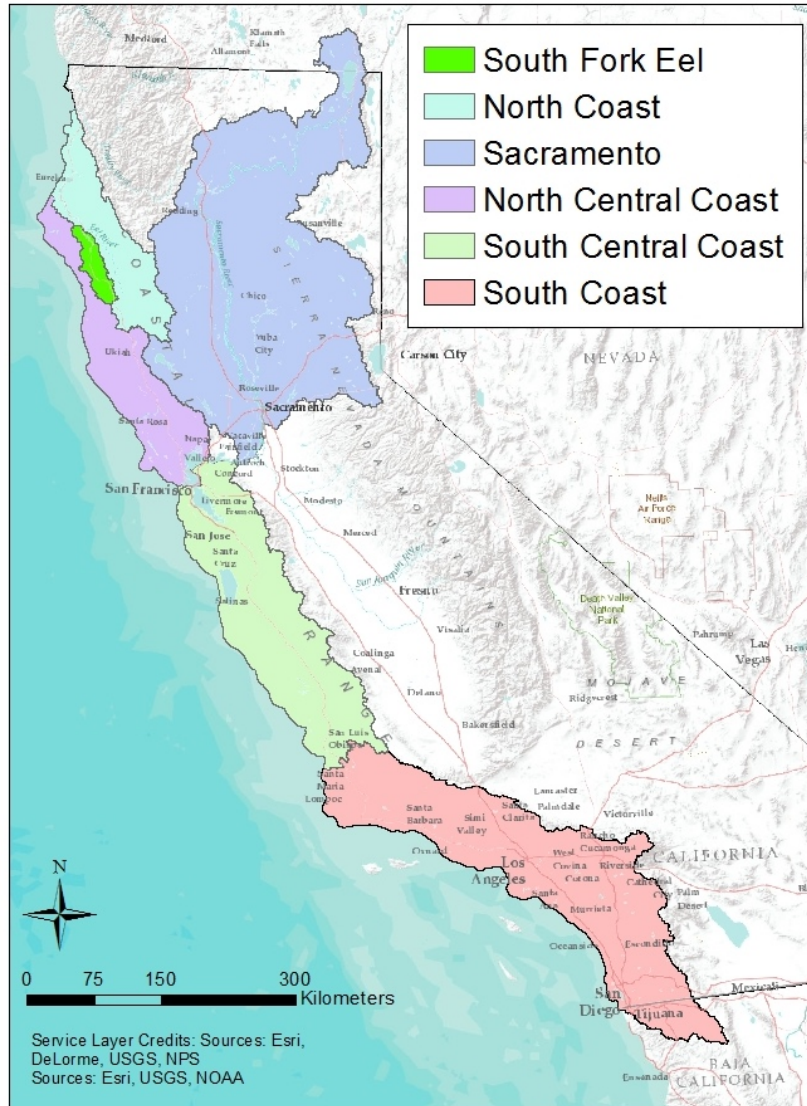
# Functional Flow Metrics

- Focus on quantifying hydrograph flow components that:
  - ✓ Support natural disturbances
  - ✓ Promote physical dynamics
  - ✓ Drive ecosystem functions
  - ✓ Support high biodiversity
- Consideration of geomorphic setting and channel-floodplain dynamics
- Quantification of functional flow components provides a way to link ecological theory with discrete quantifiable measures of flow



# Regional Geomorphic Classification

Refine flow criteria based on geomorphic setting and specific species needs



Headwater, constricted, cobble

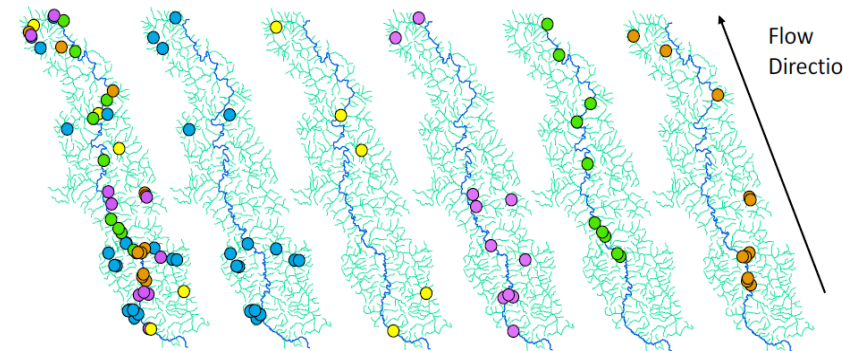
Upland, confined with floodplain pockets

Headwater, steep, confined, boulder

Lower main-stem South Fork Eel, confined with floodplain pockets, large cobble-gravel

Upper main-stem South Fork Eel and tributary, constricted, bedrock

## South Fork Eel River



- Headwater, constricted, cobble
- Upland, confined with floodplain pockets
- Headwater, steep, confined, boulder
- Lower main-stem South Fork Eel, confined with floodplain pockets, large cobble-gravel
- Upper main-stem South Fork Eel and tributary, constricted, bedrock

# Flow Sensitive Fish Assemblages

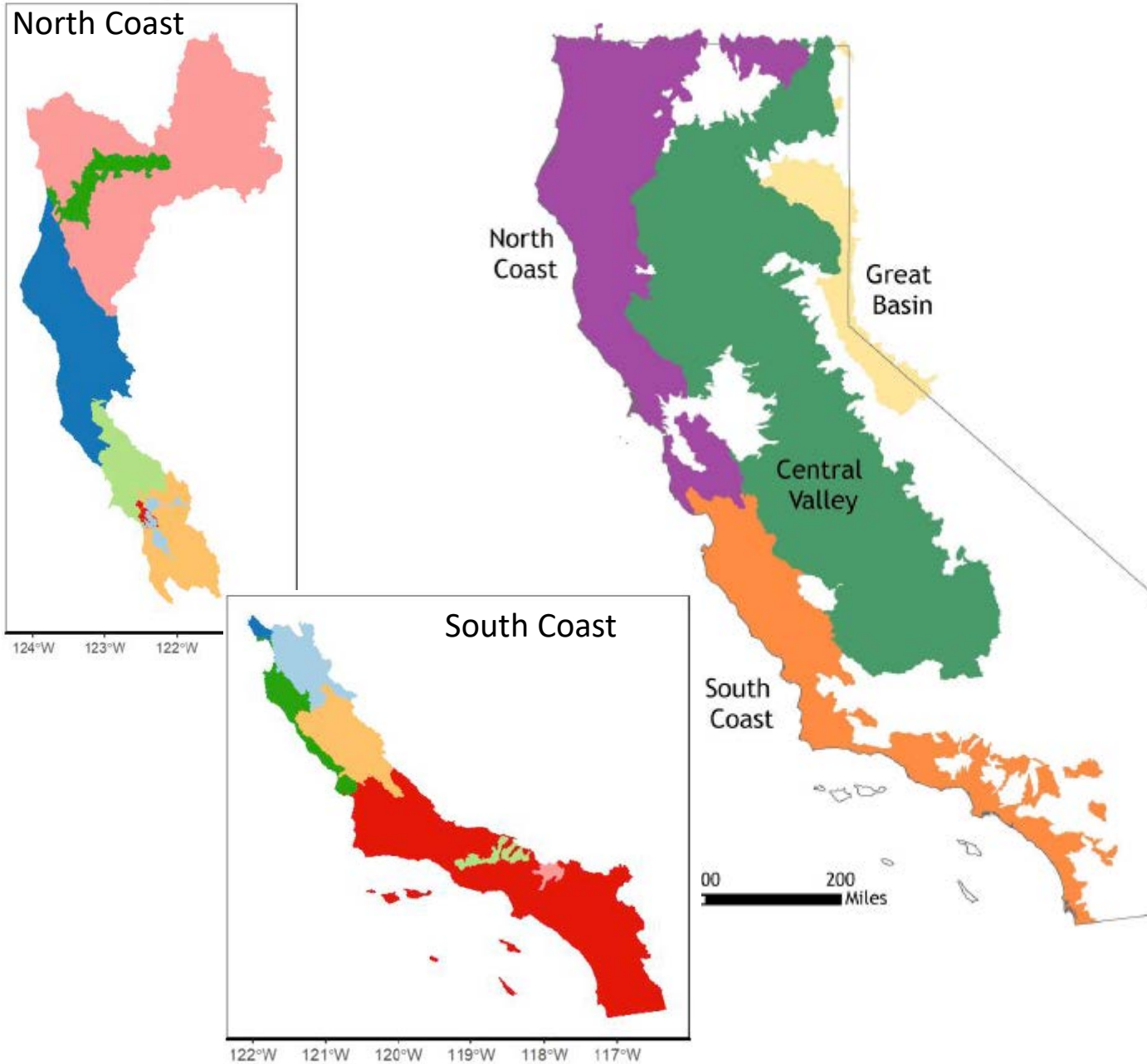


Table 1. Flow sensitive species in each of the five hydrogeographic assemblages in the North Coast region.

Taxon	Group 1	Group 2	Group 3	Group 4	Group 5
Blue chub					+
California Coast fall Chinook salmon		+	+		
California roach			+		
Central California coast winter steelhead	+		+		
Central Coast coho salmon		+	+		
Central Valley fall Chinook salmon	+				
Central Valley late fall Chinook salmon	+				
Central Valley spring Chinook salmon	+		+		
Central Valley winter Chinook salmon	+				
Delta smelt	+		+		

Table 5. Flow sensitive species in each of the five hydrogeographic assemblages in the South Coast region.

Taxon	Group 1	Group 2	Group 3	Group 4	Group 5
Arroyo chub					+
Central California coast winter steelhead		+			
Inland threespine stickleback	+	+		+	+
Monterey hitch	+			+	
Monterey sucker	+			+	
Pacific lamprey	+	+	+	+	+
Riffle sculpin	+				
Sacramento pikeminnow	+			+	+
Sacramento speckled dace	+	+		+	
Santa Ana speckled dace					+
Santa Ana sucker					+

# Tier 2: Incorporate local data, define objectives, refine recommendations

