California Environmental Flows Framework

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 Diversity of California Agriculture and Natural Resources
 The Nature (to be california)
 University of California

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Statewide Hydrologic Impairment



95% of gauged locations have at least some altered flows; 11% have pervasive alteration

- What is the biological effect of these impairments?
- What elements of the flow regime are most important to manage?
- How much water needs to stay in river to adequately protect ecosystems?

Zimmerman et al. 2018 Freshwater Biology

How do we answer those questions?

- Develop quantitative flow-ecology and flow-habitat relationships
- But flow-ecology relationships have limitations, including that they are:
 - only described for a limited set of flow metrics
 - averaged over the flow record
 - static, not time variable
 - often single species focused
 - not process-based
 - don't help assess tradeoffs with other water uses
 - do not comprehensively capture the ecological functionality of natural or prescribed flow regimes



California Environmental Flows Framework

Prepared by:

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

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State Water Resources Control Board, Division of Water Rights

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Functional Flows in California



Yarnell et al. 2020 RRA

Natural flows database

- Partnership between USGS, TNC and UC Berkeley
- Machine learning approach to predict natural monthly flows for every stream reach in CA
- Model was trained with flow data from 250 reference gages in CA, as well as precipitation, air temp, and many physical habitat variables; extensively validated
- Outputs: mean, max, min monthly unimpaired flow estimates, 1950-2015

Functional flow metrics

- Developed by the CEFF partnership
- Uses similar machine learning approach to predict FFMs for every stream reach in CA
- Outputs: predictions of functional flow metrics for each stream segment; provided as a range (p10, p90, p50) to reflect model uncertainty and interannual variation
- Also, reported in bins: wet, moderate and dry years

Functional flow metrics



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

Natural Flows Web Tool: rivers.codefornature.org



Esri, NASA, NGA, USGS | Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA

*Functional flows alone do not provide ecosystem function (water quality and physical habitat)



CEFF Definitions

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 criteria: metrics that consider human uses and other management objectives along with ecological flow criteria

CEFF Steps Overview (Nov 2020)

SCIENCE-BASED ASSESSMENT

SOCIOPOLITICAL CONSIDERATIONS

Section A

At my location(s) of interest, what are the natural ranges of flow metrics for each of my five functional flow components? What are the corresponding ecological flow criteria?

Section B

Section C

(as applicable) How do I use additional information to develop ecological flow criteria given physical and biological constraints?

How do I reconcile ecological flow

management objectives to create balanced environmental flow

needs with non-ecological

recommendations?

STEPS 1-4 Identify ecological flow criteria using natural functional flows Do any of my five functional flow components require additional assessment due to non-flow factors? No Yes STEPS 5-7 **Develop ecological flow** criteria for each flow component requiring additional consideration Compile ecological flow criteria for all functional flow components **STEPS 8-12 Develop environmental** flow recommendations

CEFF Section A

Section A

STEPS 1-4

Identify ecological flow criteria using natural functional flows

Section B

STEPS 5-7

Develop ecological flow criteria for each flow component requiring additional consideration

Section C

STEPS 8-12

Develop environmental flow recommendations

Step 1 – Define ecological management goals

Step 2 – Obtain natural ranges of flow metrics for five functional flow components

Step 3 – Evaluate if non-flow factors may affect the ability of natural ranges of functional flow metrics to achieve ecological management goals

Step 4 – Select ecological flow criteria for functional flow components that don't require additional consideration

OUTCOME – Ecological flow criteria from Step 4 and identification of functional flow components requiring further assessment in Section B

SOCIOPOLITICAL

SCIENCE-BASED ASSESSMENT

CEFF Section B

SCIENCE-BASED ASSESSMENT

Section A

STEPS 1-4

Identify ecological flow criteria using natural functional flows

Section B

STEPS 5-7

Develop ecological flow criteria for each flow component requiring additional consideration

Section C

STEPS 8-12

Develop environmental flow recommendations Step 5 – Develop detailed conceptual model relating focal functional flow components to ecological management goals

Step 6 – Quantify flow-ecology relationships

Step 7 – Define ecological flow criteria for focal functional flow components

OUTCOME – Synthesis of ecological flow criteria from Steps 4 and 7

SOCIOPOLITICAL CONSIDERATIONS

CEFF Section C

SCIENCE-BASED ASSESSMENT

SOCIOPOLITICAL CONSIDERATIONS

Section A

STEPS 1-4

Identify ecological flow criteria using natural functional flows

Section B

STEPS 5-7

Develop ecological flow criteria for each flow component requiring additional consideration

Section C

STEPS 8-12

Develop environmental flow recommendations

Step 8 – Identify management objectives

Step 9 – Assess flow alteration

Step 10 – Evaluate management scenarios and assess tradeoffs

Step 11 – Define environmental flow recommendations

Step 12 – Develop implementation plan

OUTCOME: E-flow recommendations and implementation plan

Outcomes of CEFF

- Ecological flow criteria for areas of interest
- 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)
 - information repository (ceff.ucdavis.edu)

				Predicted Range at			
		Predicted Range at Lower	Predicted Range at Mid	Upper Mill - Na11	Predicted Range at	Predicted Range at	
		Mill-Na02 and Na13	Mill - Na12 (COMID	(COMID 2664723);	Little Mill (COMID	Meyer Gulch (COMID	
		(COMID 2664783); median	2664737); median (10th -	median (10th - 90th	2664675); median (10th -	2664715); median (10th -	
Flow Component	Flow Metric	(10th - 90th percentile)	90th percentile)	percentile)	90th percentile)	90th percentile)	
Fall pulse flow	Fall pulse magnitude	5.44 (1.78-33) cfs	4.59 (1.69-18.2) cfs	2.87 (1.08-10.5) cfs	0.77 (0.26-3.08) cfs	0.72 (0.21-5.19) cfs	
	Fall pulse timing	Oct. 27 (Oct. 9-Nov. 14)	Oct. 27 (Oct. 9-Nov. 14)	Oct. 27 (Oct. 9-Nov. 13)	Oct. 29 (Oct. 8-Nov. 19)	Oct. 29 (Oct. 8-Nov. 20)	
	Fall pulse duration	3 (2-6.5) days	3 (2-6.5) days	3 (2-6.5) days	No data	No data	
	Wet season baseflow						
Wet season	(median magnitude)	16.9 (8.38-34) cfs	15.4 (7.88-30.8) cfs	10.8 (5.3-19.2) cfs	2.11 (1.06-3.79) cfs	1.78 (0.86-3.47) cfs	
baseflow	Wet season start date	Dec. 3 (Nov. 20-Dec. 22)	Dec. 3 (Nov. 19-Dec. 21)	Dec. 2 (Nov. 21-Dec. 18)	Dec. 5 (Nov. 15-Dec. 30)	Dec. 5 (Nov. 13-Dec. 31)	
	Wet season duration	117 (74-155) days	116 (75-154) days	117 (78-152) days	113 (69-159) days	111 (67-159) days	
Peak flows	5-year flood magnitude	893 (488-1300) cfs	818 (447-1340) cfs	482 (263-984) cfs	104 (56-171) cfs	91 (45-149) cfs	
	5-year flood duration	2.5 (1-6) days	2.5 (1-6) days	2.5 (1-6) days	No data	No data	
	5-year flood frequency						
	(number of 5-year						
	floods/year)	1 (1-3) occurrences	1 (1-3) occurrences	1 (1-3) occurrences	No data	No data	
Carries respective	Spring recession						
	magnitude	88 (22-276) cfs	78.9 (20.5-239) cfs	47.5 (13.2-132) cfs	10.7 (2.99-41.1) cfs	9.75 (2.55-39.5) cfs	
	Spring recession timing	Apr. 2 (Mar. 12-Apr. 28)	Apr. 2 (Mar. 13-Apr. 27)	Apr. 4 (Mar. 15-Apr.26)	Apr. 2 (Mar.8-May 1)	Mar. 31 (Mar. 8-May 1)	
flows							
nows	Spring recession duration	40 (25-77) days	40 (25-76) days	39 (26-74) days	42 (24-102) days	43 (24-105) days	
	Spring recession rate of						
	change	6 (3-10) %	6 (3-10) %	6 (3-10) %	No data	No data	
	Dry season (median)						
Dry season	baseflow	0.75 (0.34-1.4) cfs	0.71 (0.32-1.33) cfs	0.43 (0.2-0.92) cfs	0.11 (0.05-0.26) cfs	0.09 (0.03-0.23) cfs	
baseflow	Dry season start date	May 24 (Apr. 26-Jun. 22)	May 24 (Apr. 28-Jun. 22)	May 24 (May 3-Jun. 20)	May 28 (Apr. 25-Jul. 5)	May 26 (Apr. 23-Jul. 6)	
	Dry season duration	193 (147-239) days	192 (148-235) days	192 (149-234) days	190 (133-241) days	190 (135-242) days	

				Predicted Range at			
		Predicted Range at Lower	Predicted Range at Mid	Upper Mill - Na11	Predicted Range at Little	Predicted Range at	
		Mill - Na02 and Na13	Mill - Na12 (COMID	(COMID 2664723);	Mill (COMID 2664675);	Meyer Gulch (COMID	
		(COMID 2664783); median	2664737); median (10th -	median (10th - 90th	median (10th - 90th	2664715); median (10th -	
Flow Component	Flow Metric	(10th - 90th percentile)	90th percentile)	percentile)	percentile)	90th percentile)	
Fall pulse flow	Fall pulse magnitude	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered	
	Fall pulse timing	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered	
	Fall pulse duration	likely unaltered	likely unaltered	likely unaltered	No data	No data	
	Wet season baseflow						
Wet season	(median magnitude)	unclear if altered*	unclear if altered*	likely altered (low)*	unclear if altered*	likely unaltered*	
baseflow	Wet season start date	unclear if altered	likely unaltered	unsure if altered	likely unaltered	likely unaltered	
	Wet season duration	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered	
	5-year flood magnitude	likely altered (low)*	likely altered (low)*	likely altered (low)*	likely altered (low)*	likely altered (low)*	
	5-year flood duration	likely unaltered	likely unaltered	likely unaltered	No data	No data	
Peak flows	5-year flood frequency						
	(number of 5-year						
	floods/year)	likely unaltered	likely unaltered	likely unaltered	No data	No data	
Spring recession flows	Spring recession						
	magnitude	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered	
	Spring recession timing	unclear if altered	unclear if altered	unclear if altered	likely altered (early)	likely altered (early)	
	Spring recession duration	likely unaltered	likely unaltered	likely unaltered	unclear if altered	likely unaltered	
	Spring recession rate of						
	change	likely unaltered	likely unaltered	likely unaltered	No data	No data	
Dry season baseflow	Dry season (median)						
	baseflow	likely altered (low)	likely altered (low)	likely unaltered	likely altered (low)	likely altered (low)	
	Dry season start date	likely unaltered	likely unaltered	unclear if altered	likely unaltered	likely unaltered	
	Dry season duration	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered	

	July mean	Natural Flows Database mean monthly				August mean	Natural Flows Database mean monthly			
	monthly flow	10th		Mod.	Wet	monthly flow	10th		Mod.	Wet
	observed (cfs)	percentile	Dry years	Years	years	observed (cfs)	percentile	Dry years	Years	years
Little Mill	no data	0.03	0.14	0.18	0.24	no data	0.00	0.05	0.09	0.15
Meyer Gulch	no data	0.01	0.1	0.13	0.2	no data	0.00	0.00	0.04	0.09
Upper Mill (Na13)	0.29	0.31	0.59	0.77	1.12	0.16	0.13	0.42	0.51	0.67
Middle Mill (Na12)	0.31	0.48	0.92	1.28	1.71	0.12	0.20	0.59	0.74	0.92
Lower Mill (Na02 &										
Na13)	0.29	0.52	1	1.39	1.86	0.10	0.23	0.65	0.81	1.02
	Sept. mean	Natural Flows Database mean monthly			October mean	Natural Flows Database mean monthly				
	monthly flow	10th		Mod.	Wet	monthly flow	10th		Mod.	Wet
	observed (cfs)	percentile	Drv vears	Years	vears	observed (cfs)	percentile	Dry years	Years	years
Little Mill	no data	0.00	0.01	0.00	0.03	n <mark>o data</mark>	0.03	0.13	0.18	0.2
Meyer Gulch	no data	0.00	0.00	0.00	0.00	n <mark>o data</mark>	0.02	0.11	0.15	0.17
Upper Mill (Na13)	0.09	0.03	0.24	0.26	0.35	0.23	0.31	0.60	0.88	1.13
Middle Mill (Na12)	0.09	0.06	0.33	0.38	0.51	0.25	0.49	1.01	1.94	1.30
Lower Mill (Na02 &										
Na13)	0.06	0.07	0.36	0.41	0.55	0.24	0.52	1.12	2.07	1.41

Next Steps

CEFF is a "living document"

- Reviewed by the WQMC eflows workgroup
- Revised technical report should be available soon
- FAQs available: https://ceff.ucdavis.edu/fact-sheets-and-faqs

Multiple case studies under development

- North Coast water diversions
- Eel River dam relicensing and reoperation
- Southern California flow requirements for water quality
- Workplan to guide and prioritize new efforts
 - Improvements in technical tools
 - Track and document case studies
 - Mechanisms for ongoing data and information sharing