

# Ecological Flows Tool

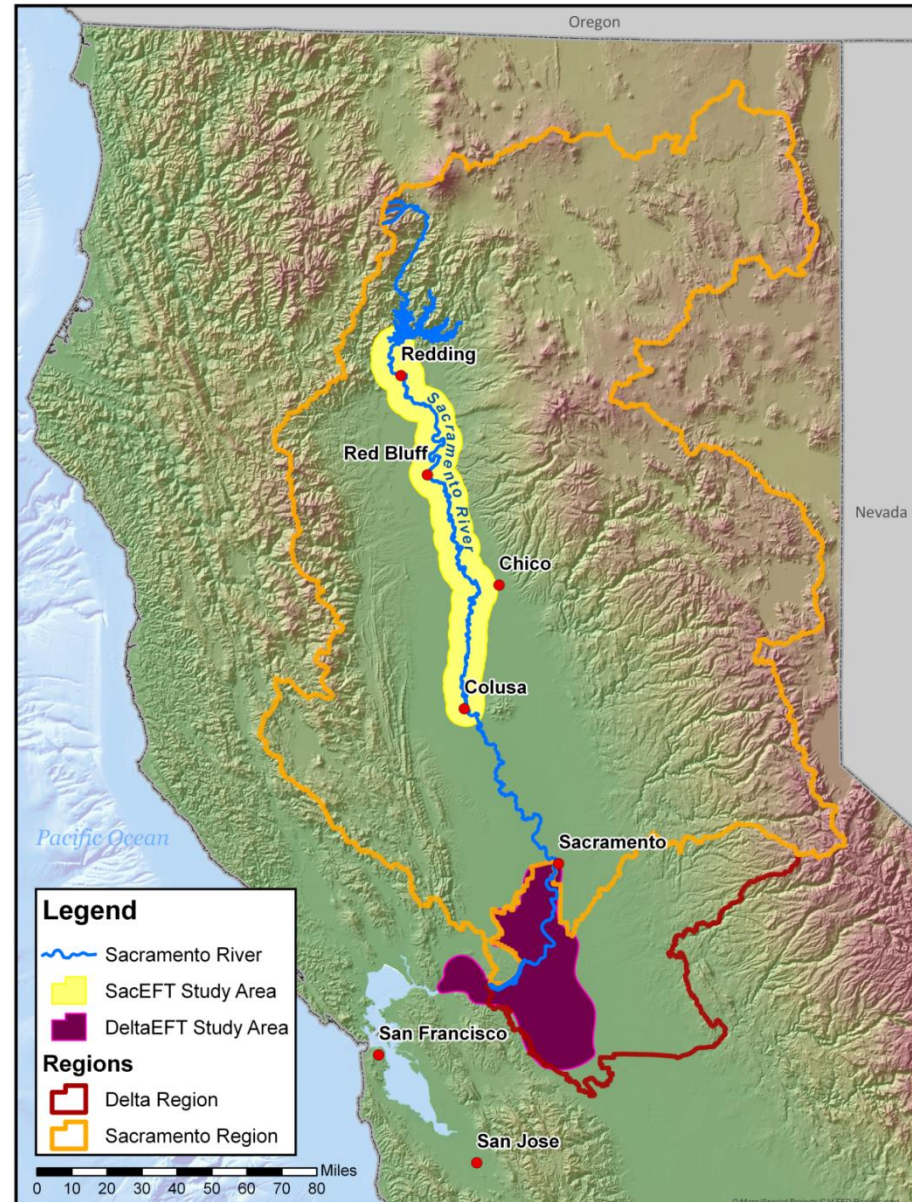
## for the Sacramento River and Delta



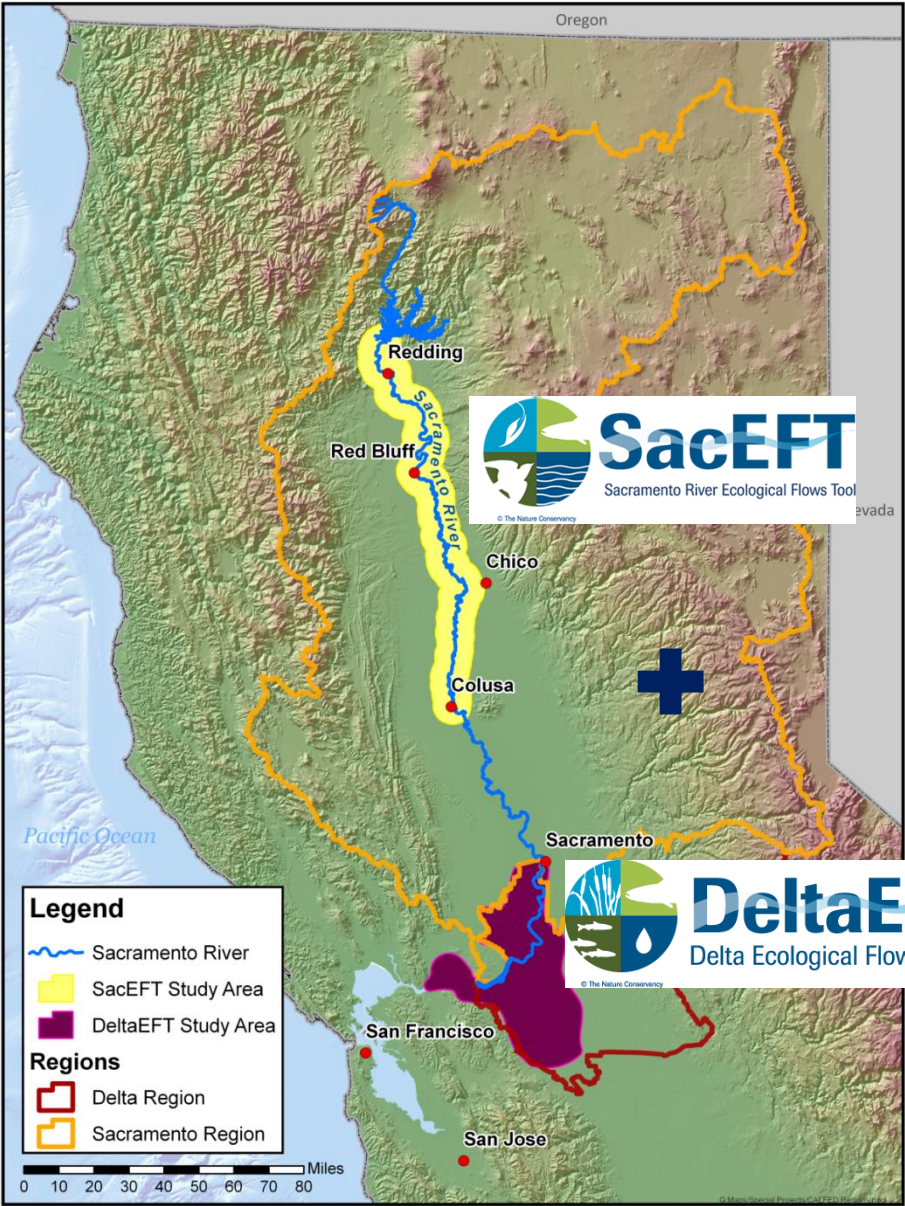


# Why TNC developed EFT

1. Evaluate ecological trade-offs of water projects and water project operations.
2. Develop a broader set of functional ecological flow guidelines.



# EFT links the Sacramento and Delta ecosystems



**Legend**

- Sacramento River
- SacEFT Study Area
- DeltaEFT Study Area

**Regions**

- Delta Region
- Sacramento Region

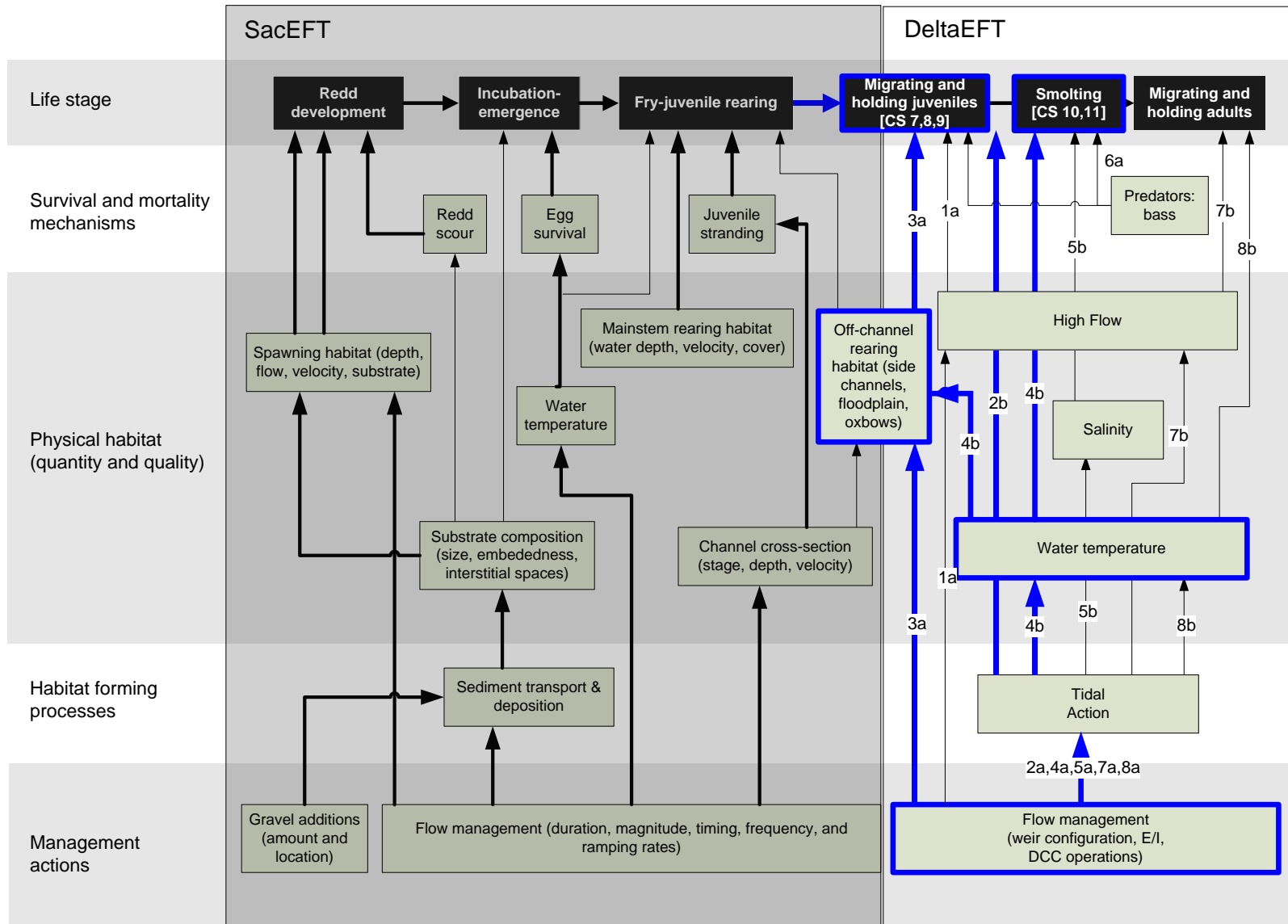
## What it does

- Links Sacramento & Delta ecoregions
- Multiple focal species & habitats
- Evaluates multiple actions
- Links with existing models
- Develops new ecological flow guidelines

## What it doesn't do

- Not a population model
- Does not consider effects on other beneficial uses (water deliveries, power, etc.) -- but designed to be paired with models that assess these objectives

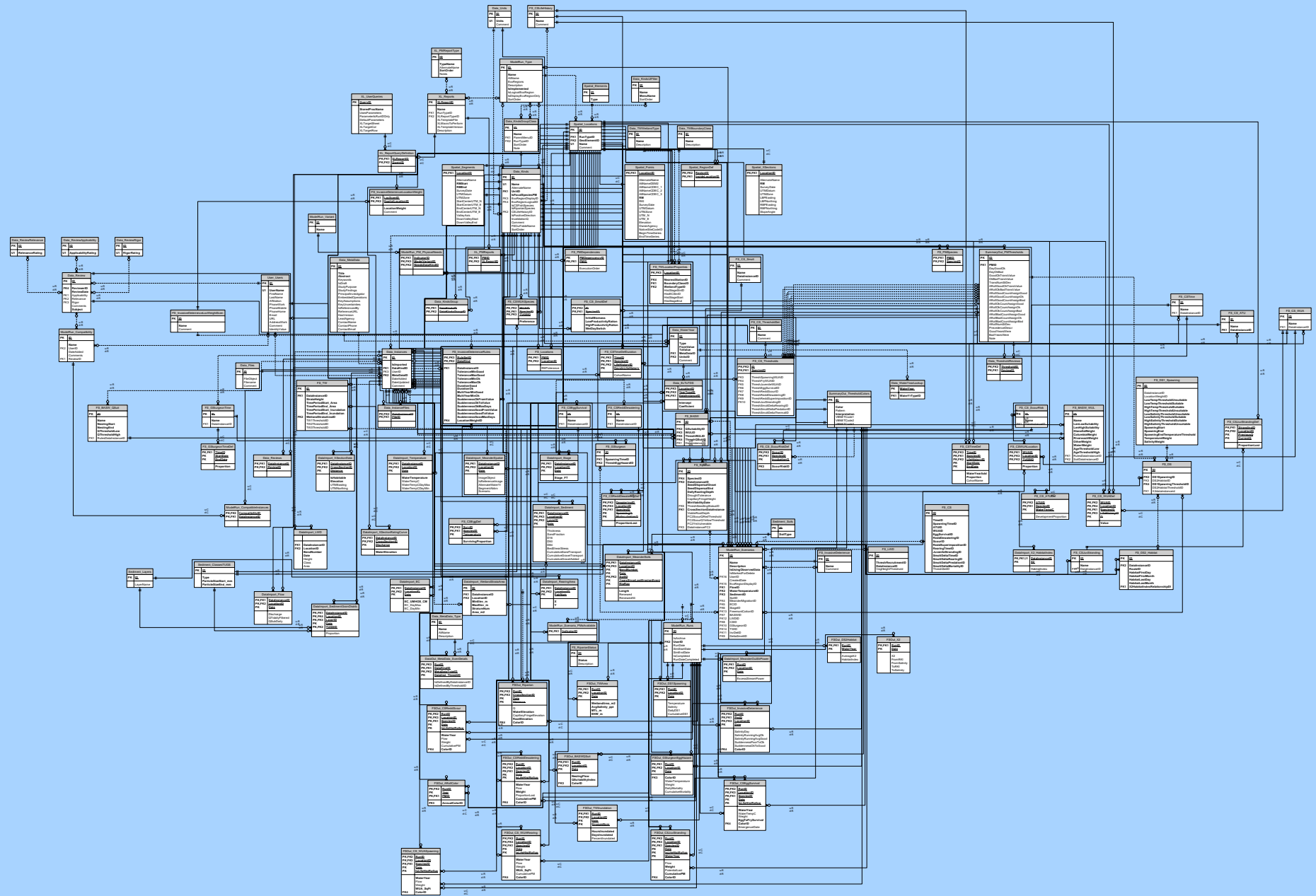
# Functional relationships



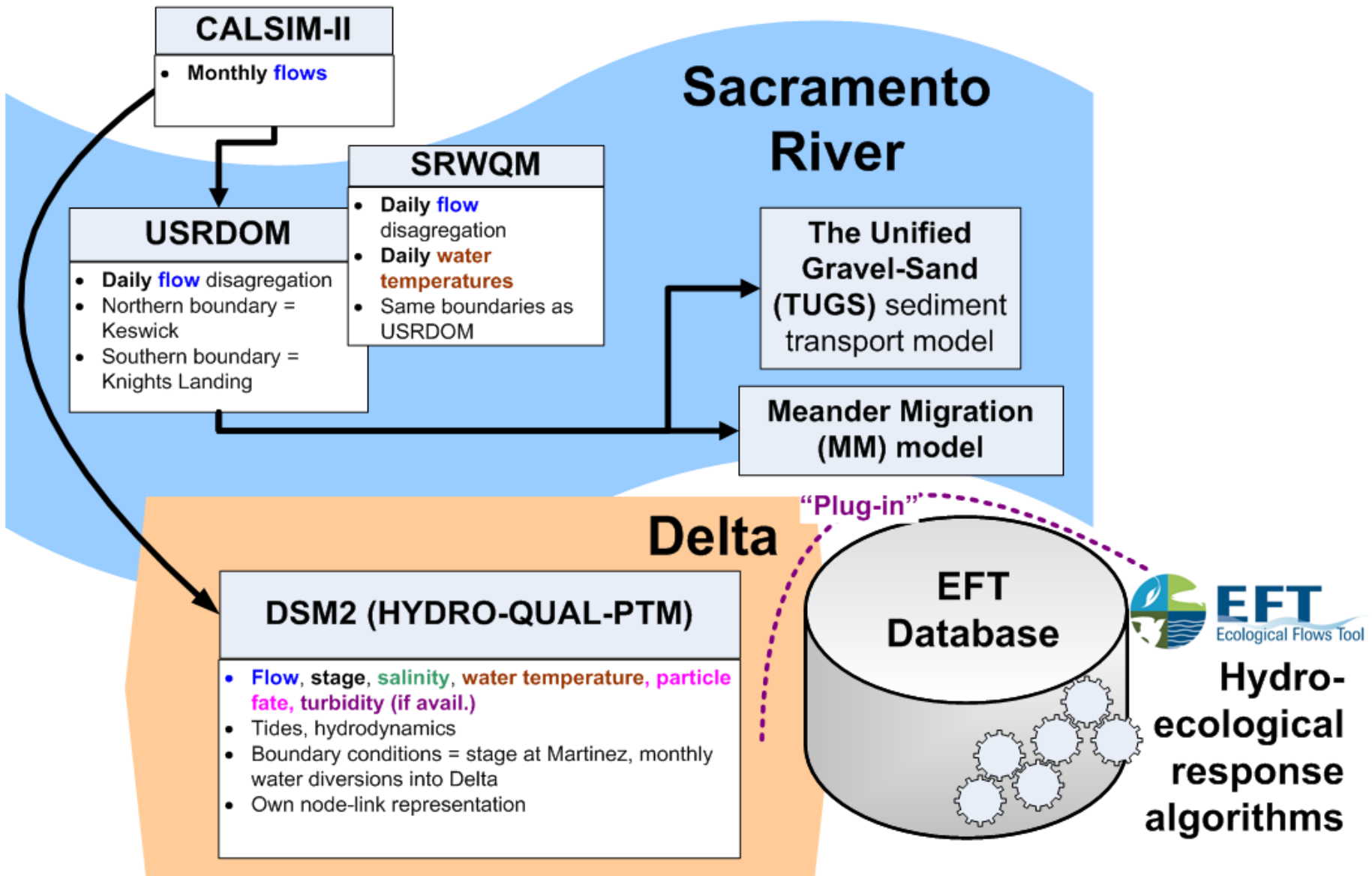
Important relationships discussed at workshop
  Important relationships not discussed at workshop
  Out of scope relationships



# EFT relational database



# EFT hydrologic foundation





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# SacEFT

Sacramento River Ecological Flows Tool



## *Sacramento River*



Steelhead trout



Chinook salmon



Green sturgeon



Bank swallow



Western pond turtle



Fremont cottonwood

# SacEFT physical inputs

Focal Species Performance Measures	Physical datasets and submodels				
	Flow	Stage - Discharge	Temperature	Sediment Transport	Meander Migration
Fremont cottonwood (FC)	●	●			
Bank swallow (BASW)	●				●
Green sturgeon (GS)			●		
Chinook, steelhead (CS)	●		●	● <sup>1</sup>	
Large Woody Debris (LWD) recruitment	●				●

<sup>1</sup> Certain indicators only. The linkage between channel bed conditions and Chinook and steelhead is restricted to weighted useable area for spawning. According to source data from Mark Gard (USFWS), rearing habitat is unaffected by substrate conditions. We relate substrate suitability curves taken from *River-2D* with substrate conditions predicted by the TUGS sediment transport model.

# Multiple focal species performance indicators

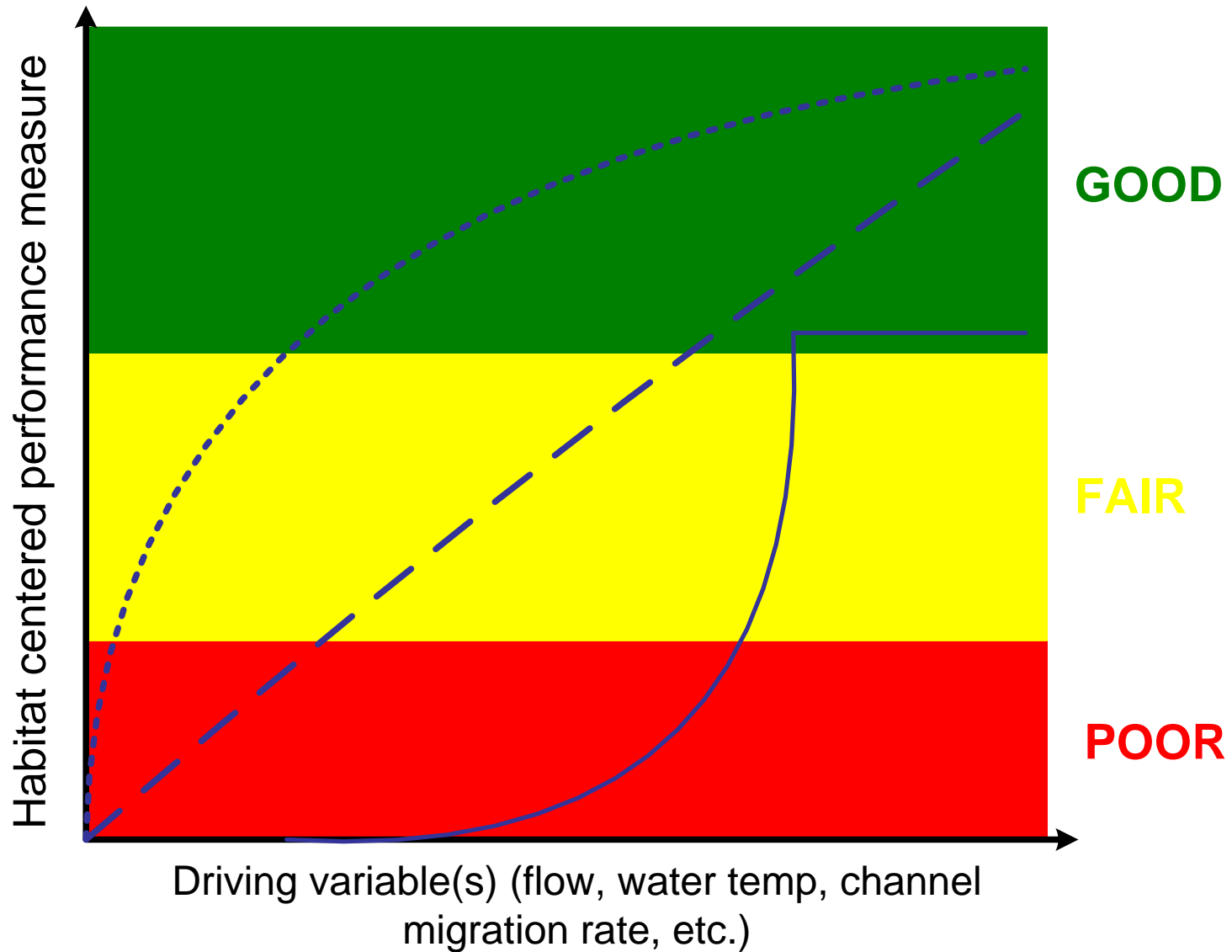
Focal Species	Ecological Objectives	Performance Measures
Fremont cottonwood (FC)	Maximize areas available for riparian initiation, and rates of initiation success at individual index sites.	<p><u>FC1</u> – Successful Fremont cottonwood initiation (incidence of cottonwoods initiated along a given cross section, at end of seed dispersal period)</p> <p><u>FC2</u> – Cottonwood seedling scour. Following years that have fair to good initiation success, evaluate the risk of seedling scour during the first year following successful initiation.</p>
Bank swallow (BASW)	Maximize availability of suitable nesting habitats	<p><u>BASW1</u> – Habitat potential/suitability.</p> <p><u>BASW2</u> – Risk of nest inundation and bank sloughing during nesting</p>
Western pond turtle (WPT)	Maximize availability of habitats for foraging, basking, and predator avoidance	<u>LWD1</u> – Index of old vegetation recruited to the Sacramento River mainstem.
Green sturgeon (GS)	Maximize quality of habitats for egg incubation	<u>GS1</u> – Egg-to-larvae survival
Chinook salmon, Steelhead trout (CS)	<p>Maximize quality of habitats for adult spawning</p> <p>Maximize quality of habitats for egg incubation</p> <p>Maximize availability and quality of habitats for juvenile rearing</p>	<p><u>CS1</u> – Area of suitable spawning habitat (ft<sup>2</sup>)</p> <p><u>CS3</u> – Egg-to-fry survival (proportion)</p> <p><u>CS5</u> – Redd scour (Red/Yellow/Green hazard zones)</p> <p><u>CS6</u> – Redd dewatering (proportion)</p> <p><u>CS2</u> – Area of suitable rearing habitat (ft<sup>2</sup>)</p> <p><u>CS4</u> – Juvenile stranding (index)</p>

# EFT: multiple analysis products

<b>Question</b>	<b>Analysis supporting answers</b>
<p>1. What water operation alternative has preferable environmental performance?</p>	<ul style="list-style-type: none"> <li>• Multi-year roll-up of indicator performance (% change in number of simulation years having a favorable rating).</li> </ul>
<p>2. What explains why a particular ecosystem function is/isn't being achieved?</p>	<ul style="list-style-type: none"> <li>• Graphs and daily output data by index location</li> </ul>
<p>3. What is the spatial pattern of performance for a particular ecosystem function?</p>	<ul style="list-style-type: none"> <li>• Spatial visualizations with data features.</li> </ul>
<p>4. What water operation criteria/guidelines would improve conditions for a given species?</p>	<ul style="list-style-type: none"> <li>• Use “good year” flow/water temperature traces to inform target ranges and specific flow rules.</li> </ul>



# Indicator ratings



# Completed NODOS analysis August 2011



## Analysis of the North-of-the-Delta Offstream Storage Investigation



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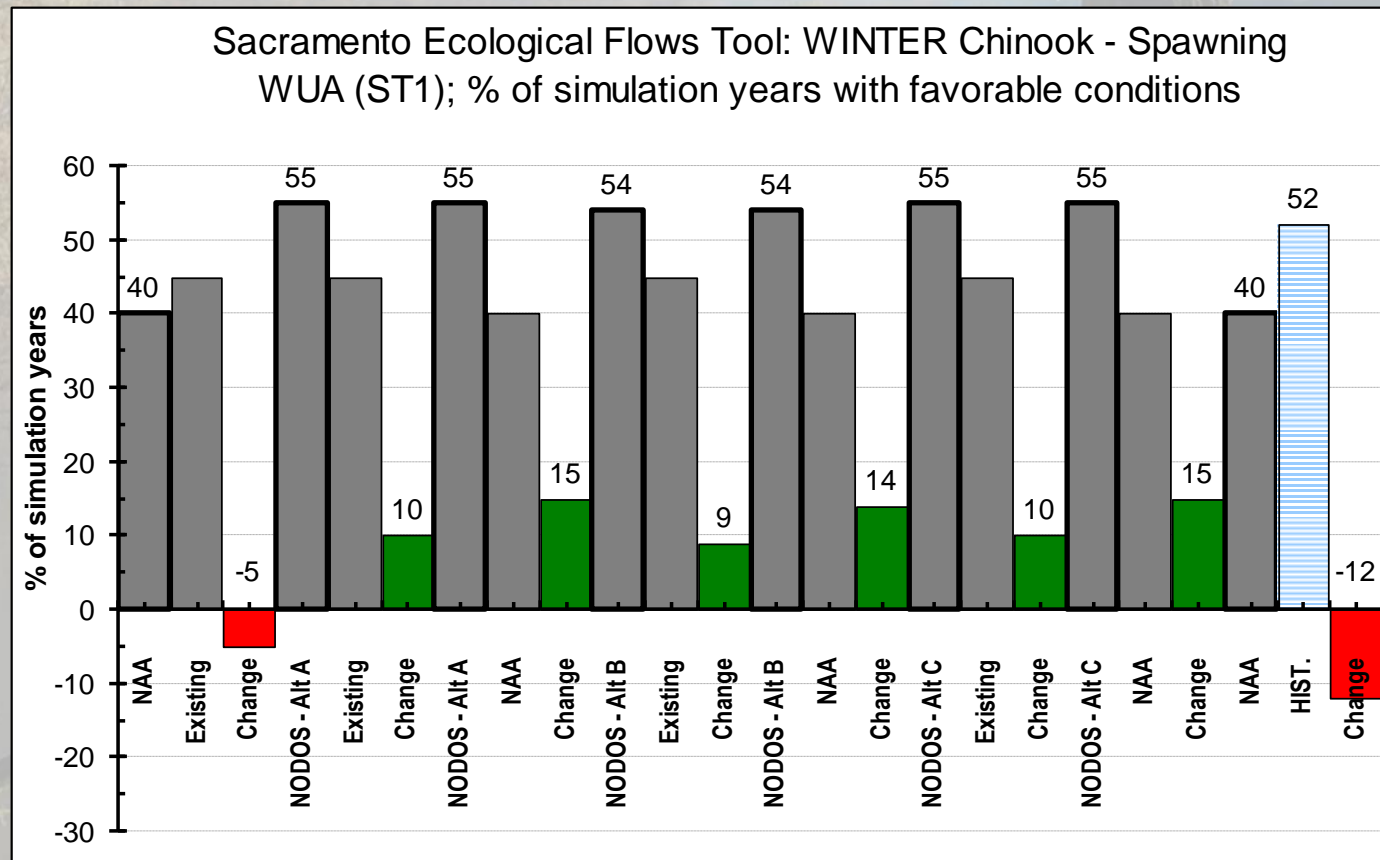
August 5, 2011

# SacEFT NODOS EIS/R Report - Results

Fremont Cottonwood - Initiation Success (FC1) - Roll-Up									
ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good		
<b>NODOS - Alternative A, NoRipRapRemoval</b>									
136	FC1 - initiation	Fremont Cottonwood - relative initiation success	<input checked="" type="checkbox"/>		85	15	0		
<b>NODOS - Alternative B, NoRipRapRemoval</b>									
139	FC1 - initiation	Fremont Cottonwood - relative initiation success	<input type="checkbox"/>		91	9	0		
<b>NODOS - Alternative C, NoRipRapRemoval</b>									
140	FC1 - initiation	Fremont Cottonwood - relative initiation success	<input type="checkbox"/>		88	12	0		
<b>NODOS - Existing, NoRipRapRemoval</b>									
132	FC1 - initiation	Fremont Cottonwood - relative initiation success	<input type="checkbox"/>		87	13	0		
<b>NODOS - No Action, NoRipRapRemoval</b>									
134	FC1 - initiation	Fremont Cottonwood - relative initiation success	<input type="checkbox"/>		83	17	0		
<b>VERSION 2 CALIBRATION RUN (HISTORICAL)</b>									
118	FC1 - initiation	Fremont Cottonwood - relative initiation success	<input type="checkbox"/>		63	20	17		

# SacEFT NODOS EIS/R Report - Results

Percentage of years in the simulation having favorable (green), fair (yellow), and poor (red) conditions.





# SacEFT NODOS EIS/R Report - Results

Focal species	Performance measure	Alternatives (below) vs. Existing Conditions				NAA vs.
		NAA {#1}	NODOS - Alt A {#2}	NODOS - Alt B {#4}	NODOS - Alt C {#6}	Historic Conditions {#8}
Fremont Cottonwood	Initiation success (FC1)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)	-- (-17)
	Post-initiation scour risk (FC2)	+	++	ni (+2)	++	++ (+10)
Bank Swallows	Habitat potential/suitability (BASW1)**	ni (+/-0)	-	-	ni (-3)	ni (+1)
	Peak flow during nesting period (BASW2)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)	+
Western Pond Turtles	Large Woody Debris Recruitment (LWD)**	ni (-3)	ni (-3)	ni (-3)	ni (-3)	-- (-29)
Green Sturgeon	Egg temperature preferences (GS1)	ni (+1)	+	+	+	n/a
Steelhead	Spawning WUA (ST1)	ni (+/-0)	ni (+2)	ni (+2)	ni (+2)	++ (+14)
	Thermal egg mortality (ST3)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Redd Dewatering (ST6)	ni (+/-0)	+	+	+	+
	Redd Scour (ST5)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)	-- (-16)



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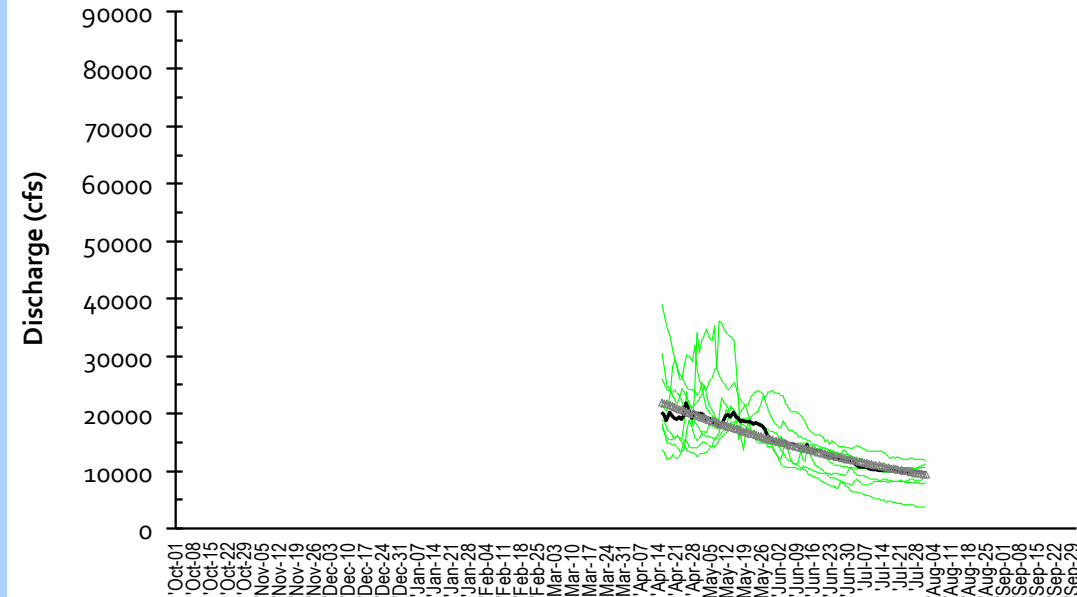
# EFT

Ecological Flows Tool

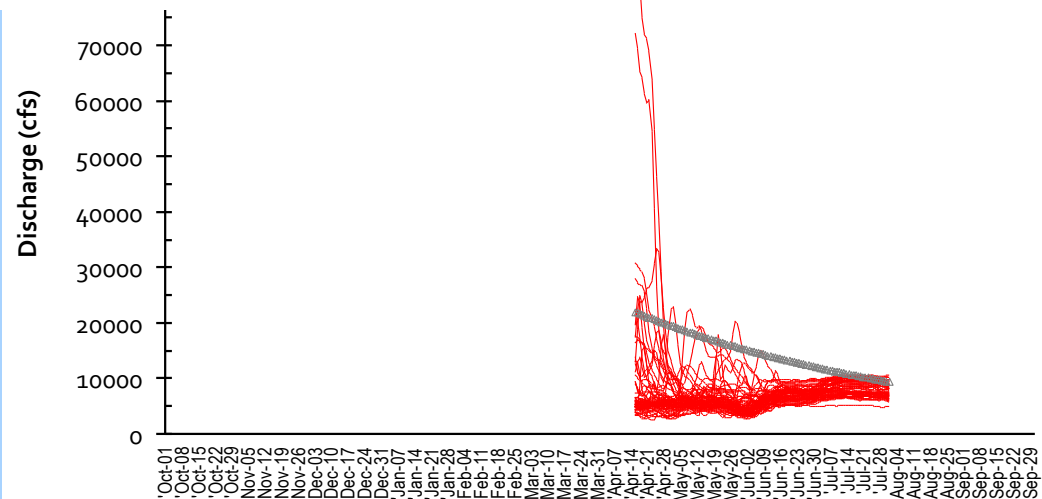
## **Development of new ecological flow guidelines**

# Ecological flow recommendations

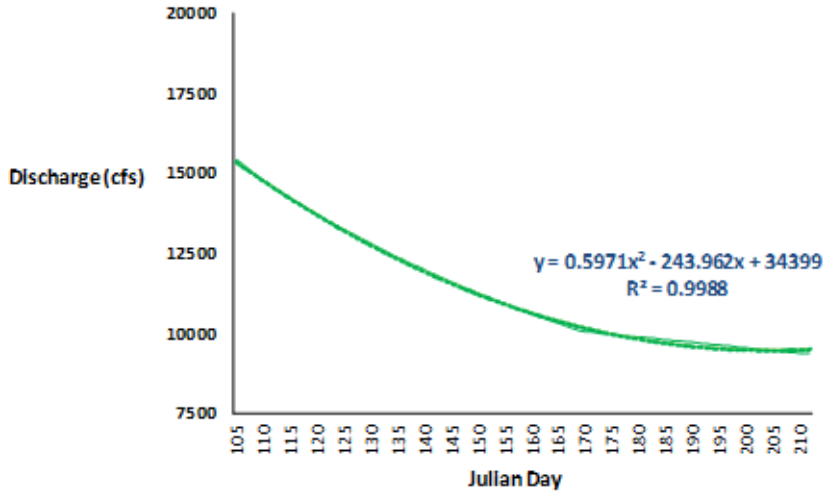
SacEFT: Target/Favourable Flow Profiles (Sacramento River nr Butte City; ~RM168) during Critical Period for Cottonwood Initiation (Apr-15 to Jul-31)



SacEFT: Example Avoidance Flow Profiles (Sacramento River nr Butte City; ~RM168) during Critical Period for Cottonwood Initiation (Apr-15 to Jul-31)



# Ecological flow recommendations

Sacramento River												
Fremont Cottonwood												
Indicator	FC1		Relative initiation success									
Objective & Rationale	Periodically provide recession flows that support areas for riparian initiation (as indexed by Fremont cottonwoods) <i>in the target zone for initiation</i> (i.e., riparian channel bank areas above <u>8,500 cfs elevation + 3ft</u> ). (SacEFT Design Document Section 4.3.4, pp. 96-100).											
Timing	O	N	D	J	F	M	A	M	J	J	A	S
Location	Hamilton City (RM199, SACRAMENTO R NR HAMILTON CITY CA, 11383800)											
Variable & Condition	<p>76 out of 108 days of flows (70%) at Hamilton City (RM199) between Apr-15 (105) and July-31 (212) equal or exceed flows predicted by the following equation:</p> <p><b>Min. target Q (cfs) = <math>0.5971x^2 - 243.962x + 34399</math> (where x = Julian day)</b></p> <p>Fremont Cottonwood initiation – min. flows Hamilton City index point (RM199, Sacramento NR Hamilton City, 11383800)</p>  <p>Discharge (cfs)</p> <p>Julian Day</p> <p><math>y = 0.5971x^2 - 243.962x + 34399</math> <math>R^2 = 0.9988</math></p>											
Recurrence	At least once every 8 years.											
References	Mahoney and Rood 1998; Roberts et al. 2002; Roberts 2003; HEC-RAS supplemented stage-discharge relations; Alexander 2004											



# Ecological flow recommendations

Sacramento River												
Bank Swallow												
Indicator	BASW1		Habitat potential									
Objective & Rationale	Maximize availability of suitable nesting habitat (SacEFT Design Document Section 4.3.3, pp. 86-92).											
Timing	O	N	D	J	F	M	A	M	J	J	A	S
Location	Hamilton City (RM199, SACRAMENTO R NR HAMILTON CITY CA, 11383800)											
Variable & Condition	<N WYT: Release a volume of 0.28 MAF above 18,000 cfs if target not met in preceding two years ≥N WYT: Release a volume of 2.8 MAF above 18,000 cfs if target not met in preceding two years											
Other Triggers	Attempt for WYT < N if target not met in preceding two years											
Recurrence	At least every 3 years											
Potential conflicts & trade-offs	Avoid during Bank Swallow nesting period (BASW2).											
References	Meander Migration modelling references, as cited in Stillwater Sciences (2007)											

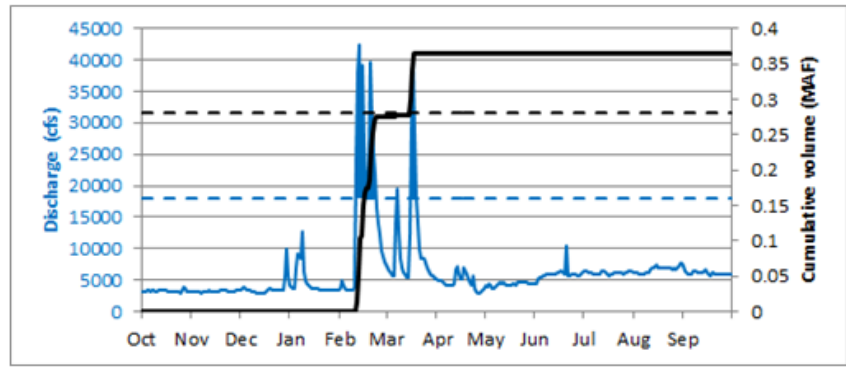
## Additional Details

The daily volume in cubic feet is calculated as the volume released above the 18,000cfs threshold:

$$DailyVolume = \begin{cases} 0 & \text{if } Q < 18,000cfs \\ (Q - 18,000cfs) \times 86,400s & \end{cases}$$

The Cumulative Volume over the water year is the sum of all Daily Volumes converted to MAF.

$$CumulativeVolume = \sum_{i=1}^{365} DailyVolume_i \times 2.3 \times 10^{-11} \frac{ft^3}{MAF}$$



Example: The continuous blue line shows daily flow, the stippled blue line marks the threshold and the filled blue areas show the daily volume released above the threshold. The continuous black line shows the cumulative volume of water released once the threshold has been reached; which in this year exceeds the threshold of 0.28 MAF for dry and critical years, shown by the stippled black line.