Interoperable Flows Project:

Identifying Flow Data Gaps and Creating Alternative Future Daily Flow Scenarios for California Central Valley Salmonid Restoration

California Environmental Flows Workgroup
13 August 2024

Background / Problem Statement

Habitat restoration and multi-benefit programs require flow and habitat time series under alternative scenarios.

However:

- Flow models are cumbersome
- Available flow predictions for alternative future operations are limited and poorly documented
- Available flow predictions are typically at a monthly time step

Problem Statement:

Current data and tools are not sufficient to generate usable future flow scenarios to drive habitat, temperature, and related analyses for aquatic ecosystem restoration projects in California (primarily in the Central Valley)

Interoperable Flows Project Goals and Objectives

Goals

Expand surface water flow and temperature modeling capabilities to support salmonid restoration planning in California's Central Valley through data collection, data management, and model development.

Leverage existing frameworks, hydrological models, and statistical techniques to develop a new suite of tools to support flow/temperature scenario development by:

(1) **improving flow data resolution** and

(2) **making data accessible and reusable**.

Objectives

✓ **Document data gaps and limitations** of current flow data sources and water resources planning models

✓ **Generate interoperable, modeled daily time-step flow and temperature datasets** to reflect alternative operations and management scenarios

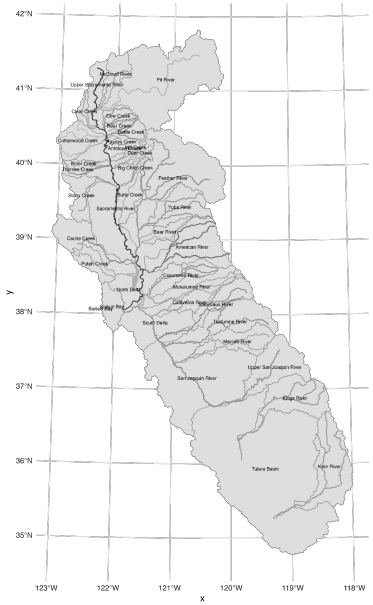
✓ **Publish flow data** in formats that are both:

(1) optimized for integration into existing salmonid life cycle and scenario planning models, and

(2) publicly accessible and intuitive to work with.

Geographical Scope

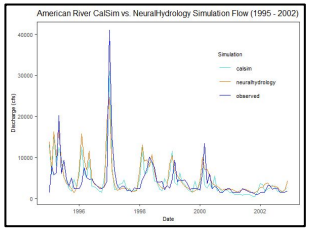
- Present and historical Chinook salmon and steelhead habitat streams in the Central Valley (Sacramento, San Joaquin, Tulare basins)



Project Components: Work To Date

streamFlowExplorer R package

- ✓ Data gap analysis of existing empirical and modelled flow data sources
- ✓ Guidance for selecting a flow data source for salmonid habitat modeling
- ✓ Guidance for flow modeling and data gap interpolation



Daily Flow Model Pilot Project

- ✓ Pilot of in-depth modeling methods to produce daily flow data for a watershed: Deer Creek and American River case studies

Work to date: streamFlowExplorer

streamFlowExplorer R package

Data package developed by FlowWest and Metropolitan Water District to explore existing California empirical and modeled flow datasets.

Provides summaries describing the following California flow datasets, highlights limitations for various use cases, and explores the utility of these flow data for use in Salmonid population modeling.

Empirical Data Sources:

- United States Geological Survey (USGS)
- California Data Exchange Center (CDEC)

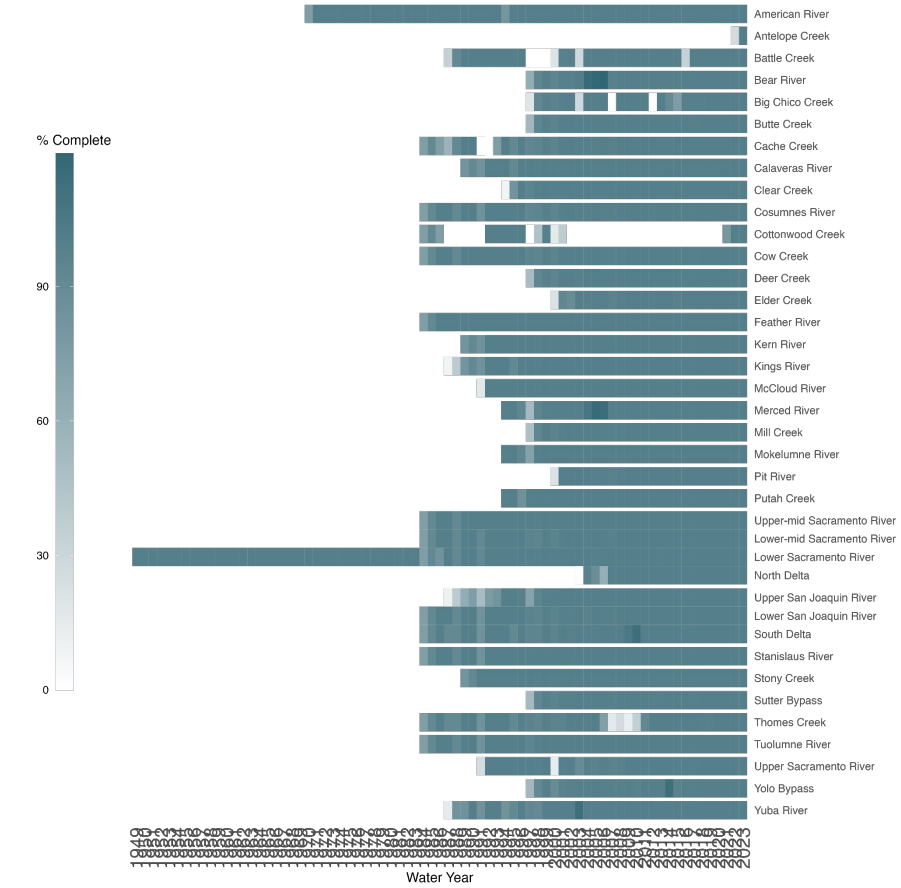
Modeled Datasets:

- CalSim
- SacWAM
- Natural Flows Database

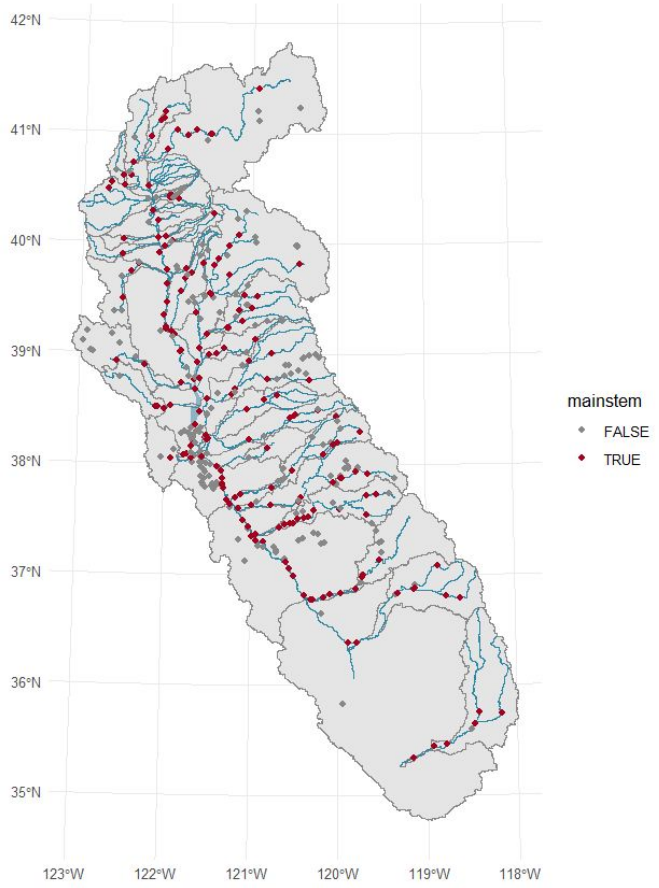
flowwest.github.io/streamFlowExplorer

Overview and Gap Analysis of Existing Data Sources

Temporal Coverage



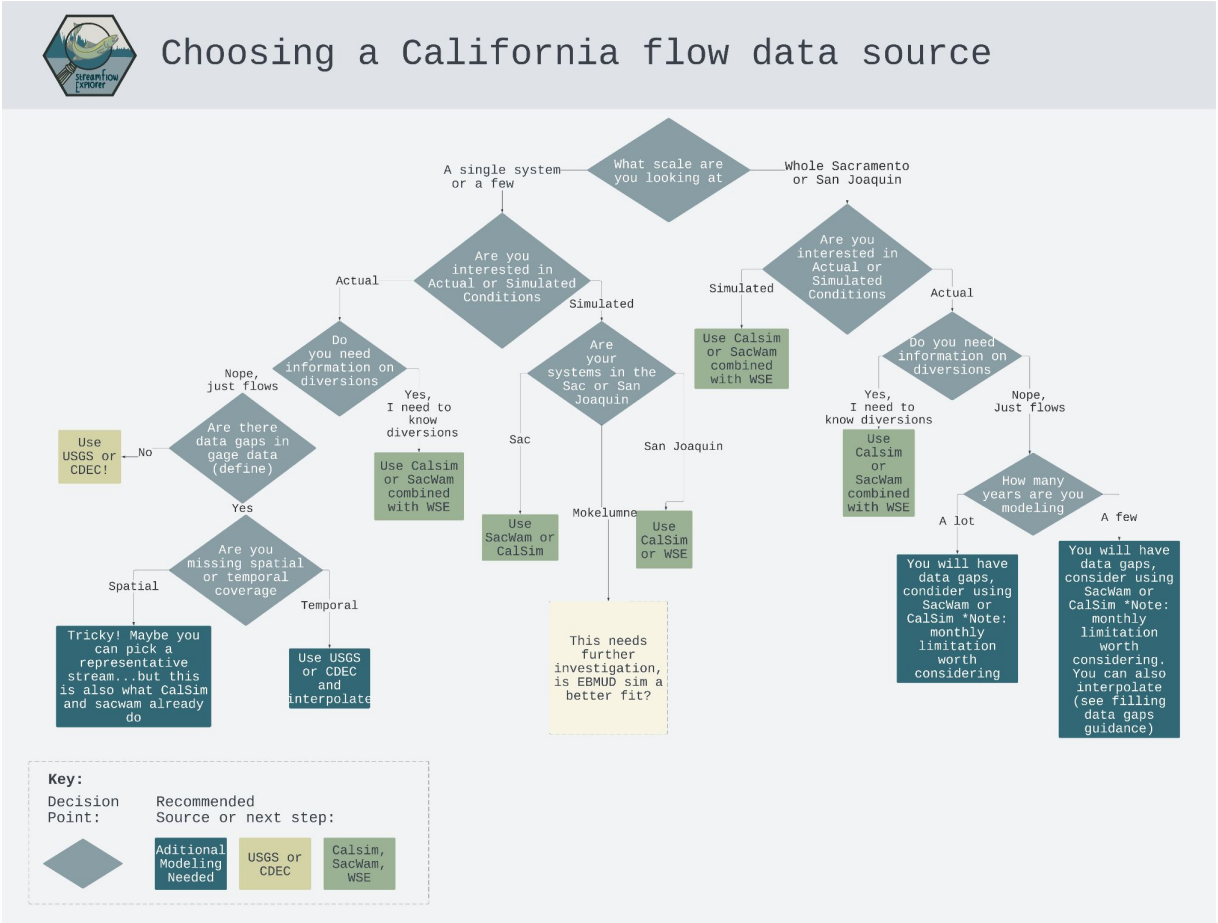
Spatial Coverage



Guidance for Selecting a Flow Data Source

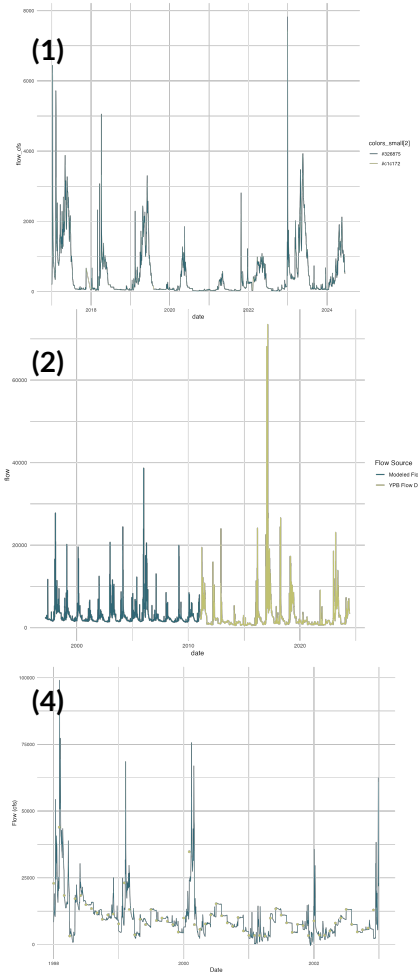
Use Category	Scale	Use Case	Data Type	Limitations
Ecological Modeling	*Single system/ regional analysis*	Studying the effects of streamflow changes on aquatic ecosystems	Empirical Flow Data (USGS or CDEC)	Availability and coverage vary by system. Data gaps on some systems making regional analysis challenging
		Analyzing long term trends on in streamflow data to understand the effect of climate change on aquatic ecosystems	Empirical Flow Data (USGS or CDEC)	Availability and coverage vary by system. Data gaps on some systems making regional analysis challenging
	Regional analysis	Analyzing long term trends on in streamflow data to understand the effect of climate change on aquatic ecosystems	CalSim and SacWAM	Monthly timestep is limiting. Summarized flows can miss critical flow events that may have ecological effects.
	Single system	Hydraulic modeling for planning a restoration project	Empirical Flow Data (USGS or CDEC)	Availability and coverage vary by system, with some systems entirely without data.
			CalSim and SacWAM	Monthly timestep is limiting. Summarized flows can miss critical flow events that may have ecological effects.
Water Resource Management	*Regional analysis*	Assessing water availability for agriculture, urban use, and ecosystems.	Empirical Flow Data (USGS or CDEC)	Does not allow for testing alternatives; only provides empirical data on the system
			CalSim and SacWAM	Only available for certain scenarios. High level of effort and experience needed to model additional operations scenarios.

Guidance for Selecting a Flow Data Source



Guidance for Flow Modeling to Fill Empirical Data Gaps

Approach	Benefit	Limitations
(1) Time series interpolation to fill longer gaps	Quick and easy Performs relatively well for flow data that follows seasonal patterns. Good for data that is fairly complete with some shorter gaps.	May miss abnormal extreme flow events May have more uncertainty than other approaches
(2) Linear Regression between stream gages to fill longer temporal gaps	Fairly quick and straightforward Linear regression typically does a fairly good job	Need at least some gage overlap across different conditions: if you do not have good coverage across different conditions you may lose some of the extreme flow events
(3) Utilizing existing modeled flow data	CalSim or SacWAM already modeled it for you—no need to repeat the process	Monthly flow granularity may be limiting for your use case
(4) Expanding / downscaling existing modeled flow data	Provides daily timestep data	Uncertainty in daily flows Lots of different time series could produce the same monthly mean flow Daily predictions are smoothed version of what an actual daily flow time series may look like

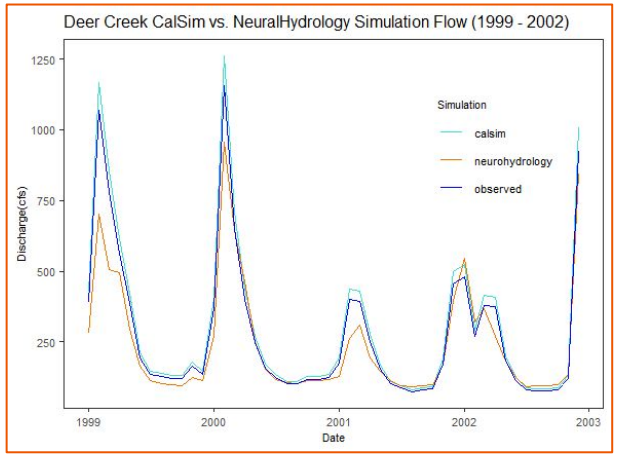


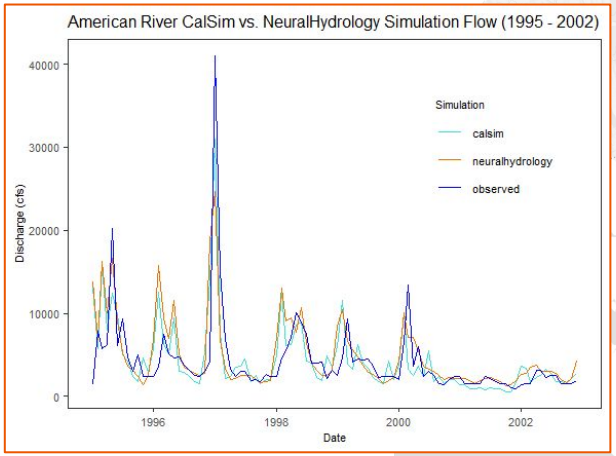
Work to date:
Daily Flow Model Pilot Project

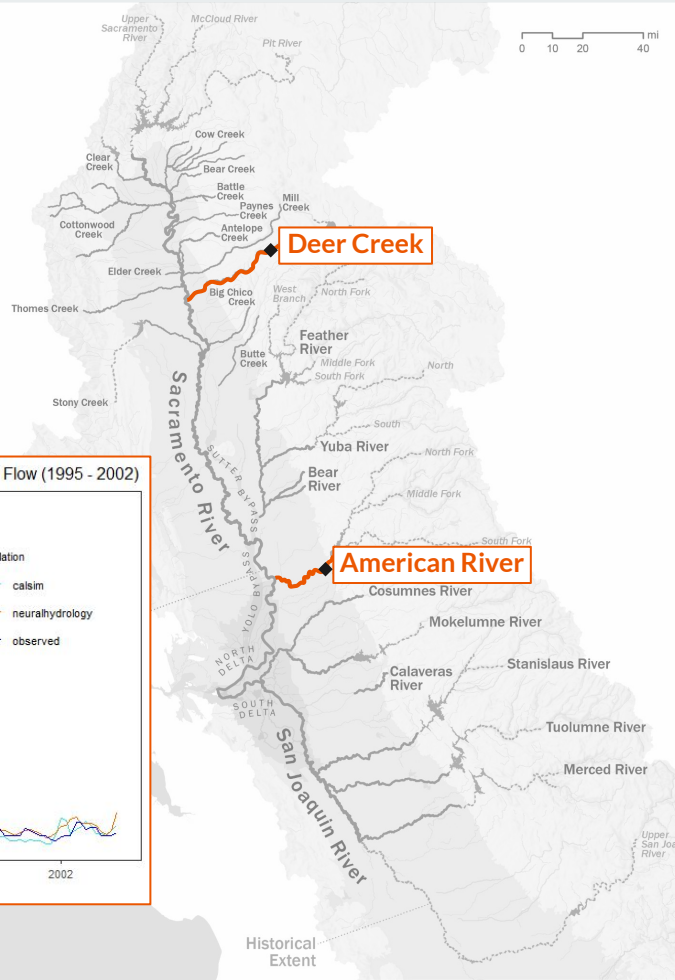
Daily Flow Model Pilot Project

Developed 2 LSTM deep learning models for predicting daily streamflow using NeuralHydro:

- **Deer Creek near Vina**: Natural unregulated streamflow
- **American River at Fair Oaks:** Highly regulated streamflow managed by diversions and dam operations





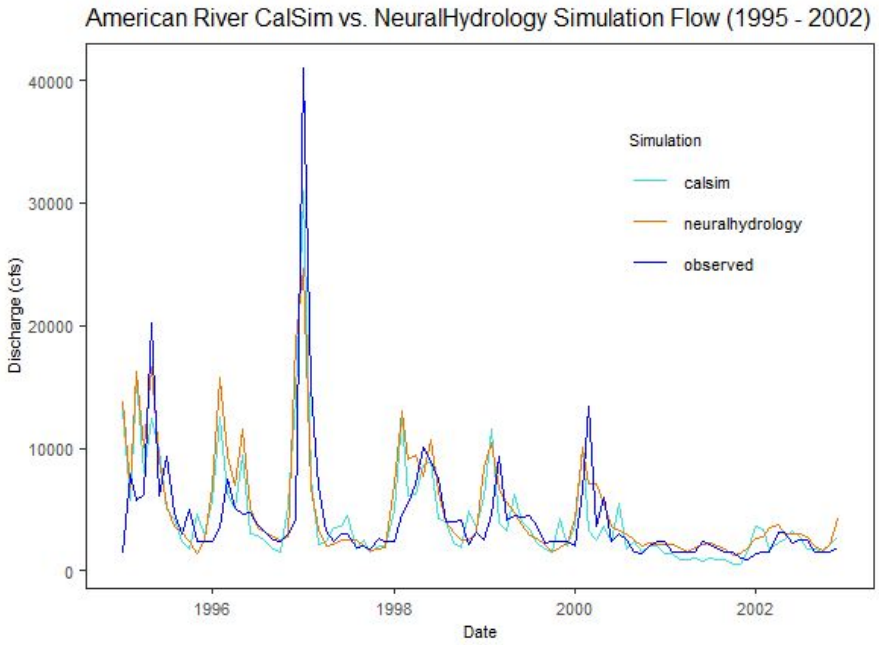


Daily Flow Model Pilot Project: American River Case Study

- Highly Regulated
- USGS gauge: American River at Fair Oaks CA - 11446500
- Training period: 1950-1986,
  Validation: 1987-1994,
  Testing: 1995-2002
- Used custom-generated CAMELS hydrometeorological data

Results:

- Correlation with CalSim: 92.69%
- Overestimation of high and middle flows, underestimation of low flows
- Peak timing off by about 1.75 days



Daily Flow Model Pilot Project: Next Steps

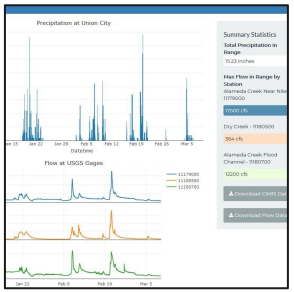
- Extract data from CALSIM WRESL files
    - Construct dataset with known operational constraints for watersheds of interest
- Focus on periods with extreme events to improve peak flow prediction
    - Develop custom loss functions emphasizing peak flows or high-flow events
    - Utilize additional training data to better capture variability across flow regimes

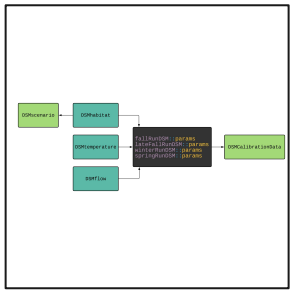
Next Steps

Next Steps via WaterSMART Grant

- Refinement of flow modeling methods, incl. adding operational constraints (dam operations, diversions)
- Addition of temperature data/models to gap analysis and prediction
- Development of platform for data access and integration into life-cycle/scenario models





Potential Applications

- **Integration with Salmonid Habitat Modeling**
  - Interoperability with life cycle models e.g. CVPIA SIT, R2R
  - Combining with habitat suitability models (flow-to-suitability curves) to estimate habitat area under historical and projected scenarios
- **Supporting Regional Decision-Making Processes for Salmonid Conservation/Restoration**
  - Central Valley Project Improvement Act (CVPIA)
  - Spring Run Juvenile Production Estimate
  - Voluntary Agreements
- **Conservation Practice Development**
  (e.g. fish food production and juvenile rearing on rice fields)
  - Forecasting the effects of management practice under different climate change and reservoir management scenarios
- **Water Resource Management**
  - Community Water Supply & Demand
  - Agriculture Water Supply & Demand
  - Ecosystem Water Needs

Integration with Other Efforts

- **COEQWAL Project**
  - Modeling Central Valley water supply (via Calsim3/CalLite) under multiple scenarios with variable operational/legal/infrastructure parameters and climate change projections
  - Collaboration potential around developing rules to reflect potential future operations
  - Interoperable Flows project team members on COEQWAL advisory panel

- **habistat**
  - Parallel effort by Trout Unlimited and FlowWest to deal with habitat data gaps
  - Prediction of flow-to-habitat relationships for unmodelled streams

Questions?