From Reservoir to Riffle: A Multi-Model Approach to Assess Water Supply and Environmental Benefits of the Pacheco Reservoir Expansion Project

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Introduction

The Pacheco Reservoir Expansion Project (PREP or Project) is a multi-agency strategic and long-term investment to provide environmental benefits and ensure a more reliable supply of safe, clean drinking water in the face of climate change. The Project, located in Santa Clara County, California, would increase the storage capacity of the existing Pacheco Reservoir from 5,500 acre-feet to approximately 140,000 acre-feet through construction of a new dam, conveyance facilities, and appurtenant infrastructure. The expanded reservoir would be operated primarily to increase water supply reliability and system operational flexibility, and to increase suitable spawning and rearing habitat for South-Central California Coast (SCCC) steelhead in Pacheco Creek.

Evaluation of Project operations requires simulation of three major interrelated systems: (1) the statewide Central Valley Project (CVP) and California State Water Project (SWP), (2) local water supply and distribution systems, and (3) the Pacheco Creek watershed, including the expanded reservoir, Pacheco Creek, and major tributaries. Project operations include capture and storage of natural inflows, environmental releases, and the input, storage, and withdrawal of imported CVP water from Pacheco Conduit. This paper describes the multi-model framework developed to evaluate Project operations and assess water supply and environmental benefits.

Multi-Model Framework

Nine separate models are available, or were developed as part of the Project, for simulating water supply operations, reservoir and riverine physical processes, and fisheries habitat. Figure 1 shows the primary modeling domains for five numerical models: 1) a water system model (CalSim II) to produce monthly imported contract water available to Valley Water, 2) a water supply operations model (WEAP) to simulate monthly integrated operations of Valley Water, 3) a water quality model (CE-QUAL-W2) to simulate water temperatures in the expanded reservoir, 4) a stream flow, temperature, and habitat suitability model (PCSHSM) to quantify the amount of suitable habitat in Pacheco Creek, and 5) a hydraulic model (HEC-RAS) to simulate depth and velocity under various discharges in Pacheco Creek. Models were structured to produce outputs on a monthly basis based on a simulated time period of 1922 – 2003. Models were linked through a database so outputs from one model could be used as inputs to the adjacent model.

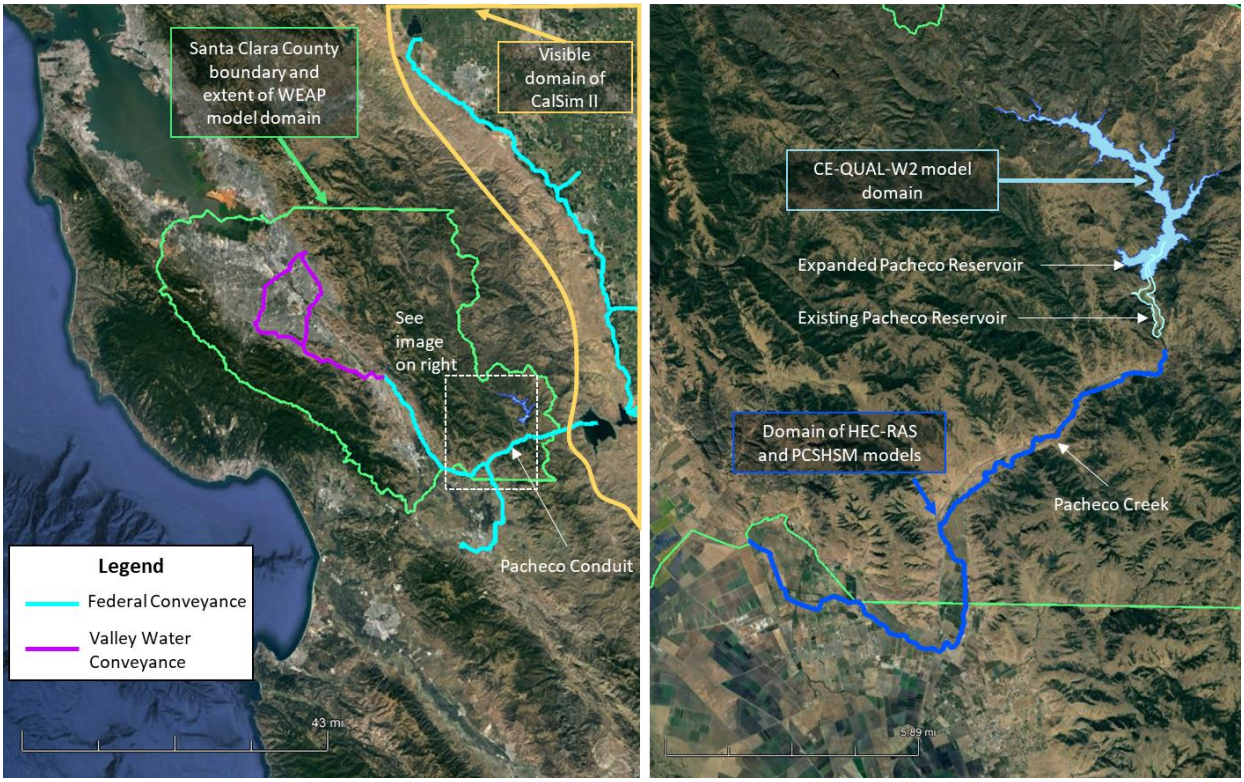

Figure 1. Model domain for water supply models (left) and physical process models (right).

CalSim II

An existing software jointly developed by Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) for performing planning studies related to Central Valley Project (CVP) and State Water Project (SWP) operations. The primary purpose of CalSim-II is to simulate the integrated operation of the CVP and SWP over a historical time period and calculate the amount of annual contract water available to Valley Water. CalSim II outputs are provided to WEAP.

Water Evaluation and Planning (WEAP)

An existing software used to simulate the integrated water supply operations of Valley Water, comprised of facilities to recharge the county's groundwater subbasins, local water supply systems, including the operation of reservoirs and creeks, treatment and distribution facilities, and raw water conveyance systems. The model also accounts for non-Valley Water sources and distribution of water in the county, such as imported water supplies from the CVP, SWP, and San Francisco Public Utilities Commission, recycled water, and local water developed by other agencies. WEAP outputs are used to estimate monthly storage levels in and releases from the expanded reservoir, which are provided as outputs to CE-QUAL-W2 and PCSHSM, respectively.

CE-QUAL-W2

An existing water quality and hydrodynamic model used to simulate water temperature within the expanded reservoir. Outputs of release water temperature are provided to PCSHSM.

HEC-RAS 2D

An existing software used to model flow and velocity in Pacheco Creek under a range of discharges. Outputs of velocity and depth for a given discharge at a given cross-section are provided to PCSHSM.

Pacheco Creek Steelhead Habitat Suitability Model (PCSHSM)

An existing watershed, water supply system, and South-Central California Coast (SCCC) steelhead habitat suitability model owned and maintained by Valley Water. PCSHSM integrates reservoir operations strategies with models of reservoir and stream physical conditions, including reservoir temperature, stream temperature, stream surface-groundwater interactions, and habitat-discharge relationships to estimate habitat suitability in Pacheco Creek. PCSHSM produces an annual cohort score, a quantitative metric of steelhead production potential, calculated based on habitat-appropriate flow and temperature associated with the spawning, rearing, and outmigrating life stages that occur during a 14-month freshwater life cycle in Pacheco Creek.

Reservoir Operations and Water Supply Benefits

Inflows to the expanded reservoir would include a combination of natural inflows from the surrounding watershed, which have historically ranged 50,000 acre-feet in wetter years to less than 50 acre-feet in the driest years on an annual basis, and contract CVP supplies transferred from San Luis Reservoir via the Pacheco Conduit, which are anticipated to range from 40,000 acre-feet or greater in wetter years to zero in the driest years. Under the Project, Valley Water would modify their CVP delivery pattern from San Luis Reservoir to better coordinate water supplies and more fully utilize CVP allocations by integrating the expanded reservoir into their local and imported water supply portfolio, providing improved operational flexibility and reliability Valley Water would also use the expanded reservoir to modify the timing of CVP deliveries to avoid water supply interruptions that occur due to algae blooms in San Luis Reservoir.

Within the modeling framework, both CalSim II and WEAP were used to assess different reservoir operations and quantify water supply benefits. Over 150 different reservoir operations were assessed that modified the timing of CVP inflows and withdrawals based on different coordination strategies with other Valley Water water supplies. Water supply benefits were quantified and relatively compared across scenarios using several metrics, including 1) long-term expanded reservoir storage values, 2) quantity of annual water supply withdrawals, 3) number of months of avoided water supply interruptions, and 4) overall change in Valley Water baseline supplies with and without the project.

Environmental Flows and Environmental Benefits

An integral component of Project operations is reservoir releases to support the freshwater life stages of SCCC steelhead in Pacheco Creek. Over a dozen workshops were held with interested parties, including federal and state resource agencies and local landowners, to develop potential flow release schedules. The release schedule converged upon by interested parties included three components that varied in magnitude by water year type: continuous monthly baseflows, adult steelhead attraction pulse flows from January through March, and juvenile steelhead outmigration pulse flows in April and May. In years when adult migration most likely would not

occur, and other steelhead life stages within Pacheco Creek would not likely be present, reservoir releases for summer/fall baseflows may be reduced to retain water supplies to create later environmental pulse flows.

The benefits of each reservoir release schedule were evaluated in PCSHSM for the 8-mile stretch below the expanded reservoir. Using an 82-year timeseries of monthly flow volume, suitable habitat in each creek mile in each month was quantified using a reach-specific habitat suitability curve that provided an estimate of weighted usable area for feeding juvenile steelhead as a function of mean monthly flow velocity, flow depth, and water temperature in five habitat unit types: pools, head-of-pools, glides, riffles, and runs. A graphic depicting the monthly habitat suitability calculation process is shown in Figure 2. An annual cohort score metric was calculated as the product of the annual habitat suitability, a coefficient that reflected how frequently adult passage was provided during the spawning window, and a coefficient that reflected how frequently juvenile passage was provided during the outmigration window. Environmental benefits were quantified and relatively compared across scenarios using the cohort score metric and its individual components.

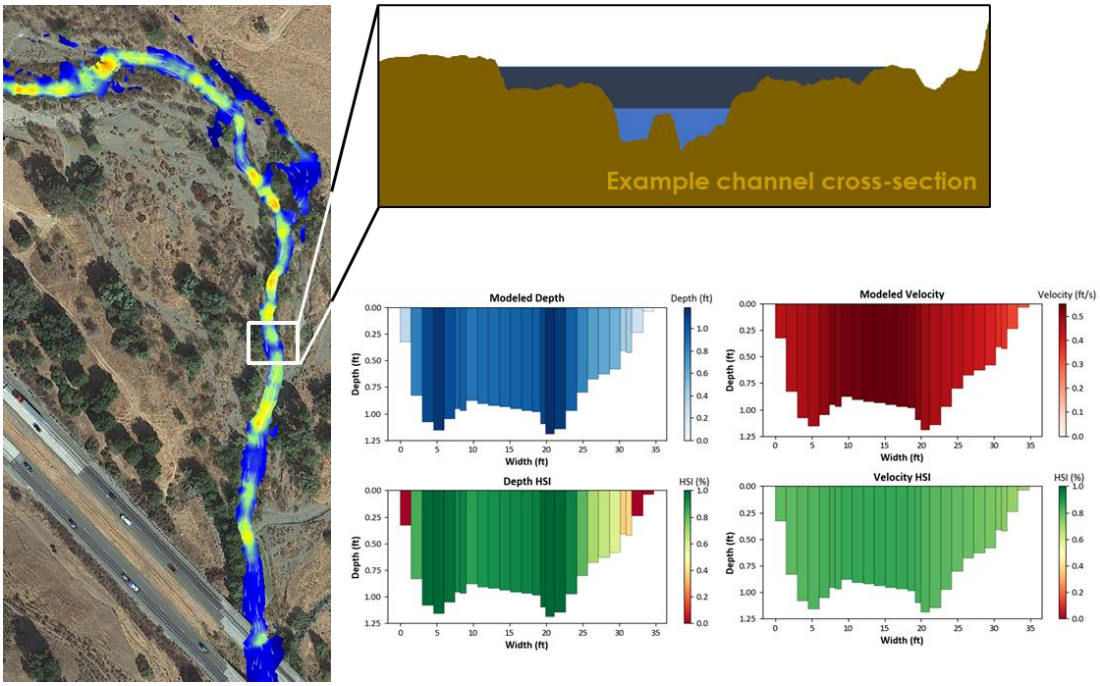

Figure 2. The simulated velocity of Pacheco Creek from HEC-RAS (left) were used to evaluate the suitability of depth and velocity for steelhead at multiple cross sections in PCSHSM (right).

Conclusions

A comprehensive multi-model framework was developed and applied to support an operations and benefits assessment of the Pacheco Reservoir Expansion Project. These water supply and physical process models were essential to assess Project benefits and effects.

References

Valley Water. 2022. Draft Environmental Impact Report. Pacheco Reservoir Expansion Project.