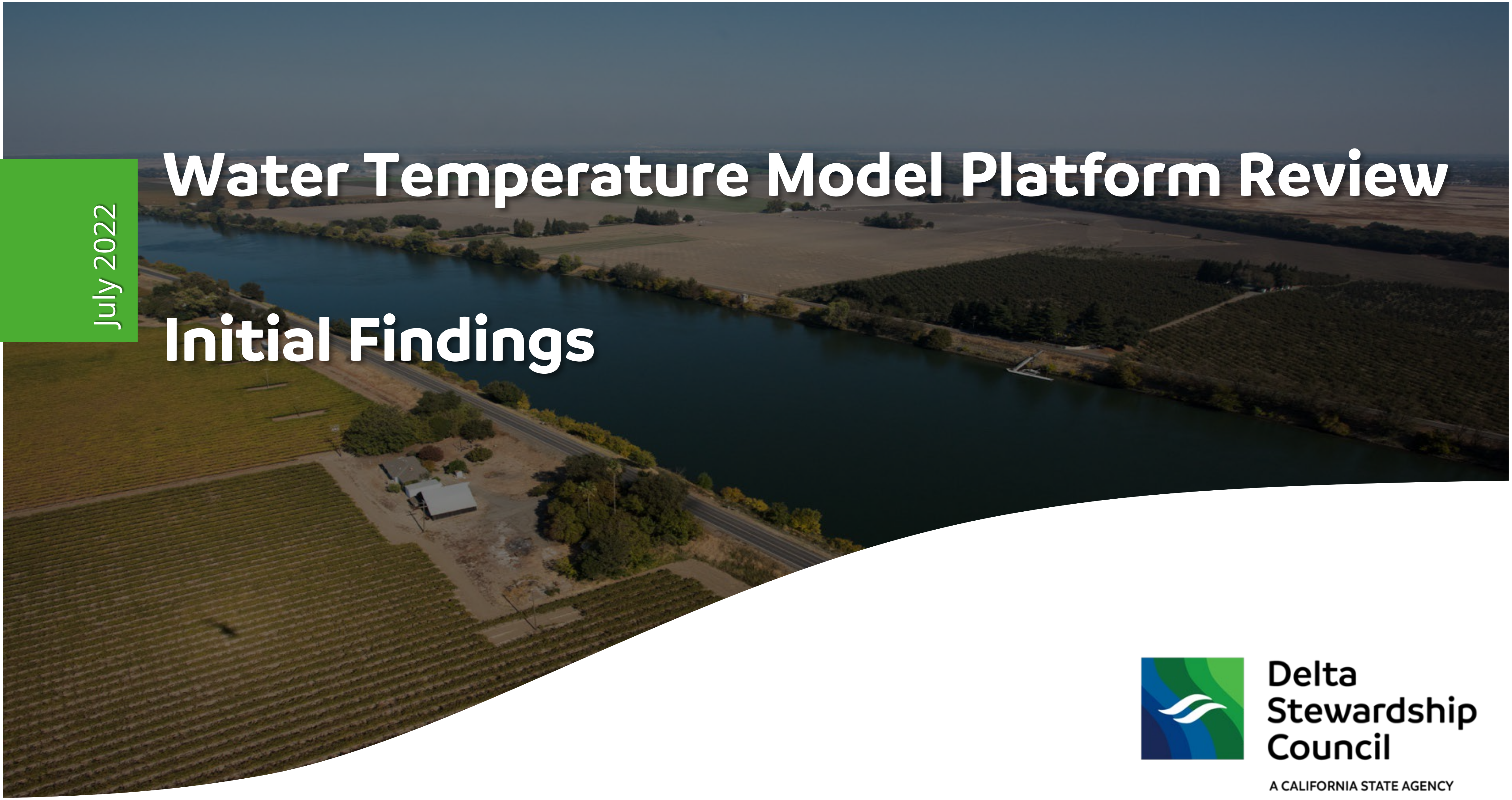

July 2022

Water Temperature Model Platform Review

Initial Findings

Delta Stewardship Council

A CALIFORNIA STATE AGENCY

Water Temperature Model Platform Review

Initial Findings

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WTMP Meeting
July 19-20, 2022

Features to Commend

The project highlighted several important features:

- Transparency along with open software, data and meta data (RISE)
- Stakeholder engagement through open science
- Dissemination of models and data to build community capability both in house and within the stakeholder
- System framework with data flow through the modeling elements, automation
- Vision for a framework which would accommodate running the systems at different spatial-temporal scales and for different purposes.
- Analysis of model behavior at the element scale

General Questions, Clarifications, Suggestions

Suggest that USBR starts with a high-level overview

- What are the Model Features (show a conceptual model)?
- What are the Model Events (show the dynamic conditions that affect the model)?
- What are the Model Processes (show the physical, chemical, and biological relationships that describe model operations)?
- What is the regulatory and operational context for the model framework and how will it be used by USBR?
- What temporal, geographic, and biologic metrics are critical to understand and target accurately?
- Need improved maps with overlay of locations, times, and thresholds that determine system operation

Suggest that USBR provide a Risk-Informed Performance Assessment

- What are the Performance Measures (regulatory and operational)?
- What scenarios are expected to cause the inability to meet Performance Measures?
- What are the consequences of failure to meet Performance Measures?
- What metrics are suggested by the US NMFS and US FWS

General Questions, Clarifications, Suggestions

Questions regarding Model Evaluation and Performance ("validation")

- Code Verification: Determine whether the code is functioning as desired using analytic solutions or by comparing results between multiple modeling systems
- Model Accuracy: Distinguish between parameter calibration errors and model prediction errors considering parameter covariance and equifinality.
- Model Resiliency: Identify the limits of model utility considering uncertainties in future conditions

While USBR is limited to existing operational constraints, we suggest identifying additional tools that would provide greater operational flexibility

- What resources (e.g., infrastructure, monitoring, modeling) would help improve meeting Performance Measures?
- How could other Federal Agencies provide greater help in meeting Performance Measures (e.g., having the USFS manage their lands to increase water yield and reduce water temperatures through improved silvicultural practices)?

General Questions, Clarifications, Suggestions

- Clearly document the three different model modes (real-time operations, seasonal forecasting, and long-term planning) and the associated data and model workflows.
- For example, for each mode, document:
  - Source (or anticipated source) of model initial conditions and time-varying boundary conditions such as inflows and meteorological data.
  - Update frequencies and whether these updates are automated or manually triggered.
  - Which sources of uncertainty are important?
  - These may differ for the different model modes, e.g., uncertainty in initial conditions will dominate the operational forecast and will be important for the seasonal forecast but will be less important for long-term planning.

General Questions, Clarifications, Suggestions

Don't leave a consideration of uncertainty until the end of the project.

- The sources of uncertainty will vary for the different model modes and how to address, represent, and communicate uncertainty will dictate how the model framework will be used.
- For example, deterministic versus ensemble forecast approaches, parameter uncertainty propagation, etc.
- At this time, the goal is not to implement any of these workflows, but to make sure the model framework and the data workflows are sufficiently flexible to address the anticipated needs.

Panel Charge

1. Does the modeling design (e.g., model selection, framework) include the necessary processes and resolution (spatial and temporal) to represent the short-term and long-term temperature dynamics expected in the reservoir and river environments throughout the CVP project area?
2. Are the models adequate for describing water temperature during extreme hydrologic/storage conditions (e.g., droughts/low storage)?
3. Are unique features (i.e., selective withdrawal devices, thermal curtains, and submerged structures) adequately represented?
4. Are available data sufficient for the development of the selected models and intended uses?
   a. Where data gaps have been identified, are the assumptions and methodologies used to address them suitable?
5. Are testing methods (calibration and validation) adequate to demonstrate confidence in model performance for the historic period?
6. Does the modeling documentation include adequate information, assumptions, and detail to allow for transparency and replication of model results?

1. Does the modeling design (e.g., model selection, framework) include the necessary processes and resolution (spatial and temporal) to represent the short-term and long-term temperature dynamics expected in the reservoir and river environments throughout the CVP project area?

The model selection is well described. Description of how the role of uncertainties on meeting the goals should be added. For instance, uncertainties on TCD on water temperature releases has been handled by parametrizing its behavior under different water levels.

Questions:

- Are the following hydrologic components important, and if so, can they be incorporated in the model?
  - Groundwater inflows, hyporheic exchanges
  - Point and nonpoint source inflows
  - Riparian zone exchanges (e.g., Turtle Bay)
  - Solar insolation and riparian/topographic shading
- What is long-term planning (one year or multiple years to predict dry-wet-average year?)

1. Does the modeling design (e.g., model selection, framework) include the necessary processes and resolution (spatial and temporal) to represent the short-term and long-term temperature dynamics expected in the reservoir and river environments throughout the CVP project area?

Questions (cont.):

- In the report, it states that the ResSim model has been made comparable to the corresponding CE-QUAL-W2 configurations to facilitate driving both models with the same set of boundary conditions. We need more details on the steps that were performed.
    - Were the storage-elevation curves for the ResSim models developed to match the per-elevation reservoir volumes in the CE-QUAL-W2 models?
    - Do the ResSim outflows match the CE-QUAL-W2 outflows?
- Are the rivers downstream well-represented by a 1D model or is stratification a concern in low-gradient reaches?
- Is the water balance of the CE-QUAL-W2 models being recomputed and adjusted for each 1-year simulation period

2. Are the models adequate for describing water temperature during extreme hydrologic/storage conditions (e.g., droughts/low storage)?

- Without a better understanding of key metrics, it is difficult for the panel to determine adequate performance
    - Indexes and metrics could be better focused on key components such as: position of the thermocline (which provides information on the pool-water volume), performance at specific control points, individual biological thresholds, etc.
- Model performance under drought and other low-pool conditions could be more thoroughly evaluated. How does low-pool drought performance compare to other hydroclimatic conditions? If model performance degrades under low-flow or low-pool conditions, does it still meet key performance metrics for relevant management questions at key locations?
- How will the use of average wind sheltering coefficients for the CE-QUAL-W2 models affect their ability to forecast extreme events, which will have a significant impact on reservoir stratification?

2. Are the models adequate for describing water temperature during extreme hydrologic/storage conditions (e.g., droughts/low storage)?

- Under low-flow conditions, do the models perform adequately when processes such as groundwater inflow and hyporheic flow become more important?
- How will carryover storage be modeled and is there a plan to manage fall-winter water in the reservoir to increase cold water pool for next year, especially when a long-term prediction suggests drought or low-water year?
- How will monitored data will be used to improve model predictions at short and long terms and under extreme hydrologic conditions?

3. Are unique features (i.e., selective withdrawal devices, thermal curtains, and submerged structures) adequately represented?

- The unique features presented and described in the documents were the TCD in Shasta and the Water Control System in Folsom Reservoir.
- Thermal curtains and submerged structures have been mentioned but not described.
- The trans-basin water exchange from Trinty and Sacramento is included.
- The representation of TCD (e.g., leakage) on water release has been parametrized based on observations on water temperature at the dam outlet. This creates a set of rules, which may mask also hydrodynamics and thermal mixing processes within the reservoir. This should be explained for transparency.

Questions

- How are the thermal curtains and submerged structures modeled in the 2D and in the 1D models?

4. Are available data sufficient for the development of the selected models and intended uses?

- Difficult for the panel to assess data sufficiency with materials currently available

a. Where data gaps have been identified, are the assumptions and methodologies used to address them suitable?

- Gap filling in the time-domain may not be as accurate or efficient as using frequency-domain methods (e.g., Fourier, HALS)
- Cross-correlations between stations (e.g., Sq___ Creek) using zero-lag correlations may not be as accurate or efficient as using transfer functions (i.e., convolution)
- Could existing watershed models be integrated to provide inflows from ungaged streams?
- How are long-term (decadal) data (e.g., snowpack, precipitation) considered for forecasting?

5. Are testing methods (calibration and validation) adequate to demonstrate confidence in model performance for the historic period?

- Testing methods need to relate more strongly to the quantities that you care about, such as
  - the temporal evolution of the cold pool
  - the depth of the thermocline
  - temperature of the outflow
  - the water temperature during extreme events at specific locations
  - exceedance of threshold flows and temperatures during extreme periods (intensity, duration, severity)
- Different characteristics of the modeling system matter for the different model modes (real-time, seasonal, long-term).
- Use the performance characteristics of the system to learn about the strengths and weaknesses of the modeling system and communicate both to support transparency and build trust.

5. Are testing methods (calibration and validation) adequate to demonstrate confidence in model performance for the historic period?

- Make sure that the "validation" (evaluation) period includes the types of events that are relevant for your decision-making (extreme events)
- Calibration and "validation" (evaluation) has been done at the element scale but not at the modeling framework scale. We did not see a full prediction of temperature in the river system accounting for all operations upstream (Shasta, Trinity, Whiskeytown, Lewiston, and Keswick).
  - This should be shown to see if the model framework will work.
  - This may highlight the problem of uncertainty and error propagation.
- Not all observations have the same value in evaluating model performance. This needs to be reflected in aggregate performance statistics.

5. Are testing methods (calibration and validation) adequate to demonstrate confidence in model performance for the historic period?

- Method of calibration is different for CE-QUAL-W2 (year-by-year) and HEC-ResSim (continuous period). How does that affect validation and use of the model for the three different model modes?
- How will the performance of the model be assessed when run as a system (as opposed to individual elements)?
- How will model performance be assessed using forecast data series as opposed to the historic period?
- Because the water balance in CE-QUAL-W2 is manually calibrated using a distributed tributary, the water surface elevation fit in the reservoir models is not an adequate metric to evaluate model performance. Suggest discussing the size of the distributed tributary and how does it vary temporally?

6. Does the modeling documentation include adequate information, assumptions, and detail to allow for transparency and replication of model results?

- Suggest development of clear maps and model diagrams, including:
- Individual model elements (e.g., a diagram of the Lake Shasta CE-QUAL-W2 model)
- System-wide (e.g., illustrating connection between different model elements, key control points, etc.)
- Map of all data sources, potentially linked to a table providing the period of record for each source
- Suggest replacing use of the word "Sq___" for all references to Branch 2 in the Shasta CE-QUAL-W2 model or other usage https://public-inspection.federalregister.gov/2022-03748.pdf
- Is documentation available for other model elements beyond what has been provided (e.g., Trinity Basin models, etc.)?
- Will documentation of the model system be produced?
- How does the Keswick W2 model perform using modeled inflow and temperature?