BUREAU OF RECLAMATION

# CVP Water Temperature Modeling Platform

## Pre-Final Peer Review Presentation

August 2, 2023

# Agenda

- Phase I and II Overview
- Mid-Term Peer Review Responses
- Review Final Peer Review Charge/Questions

# Pre-Final Peer Review Presentation: Goal

- Prepare for an efficient Final Peer Review to provide useful feedback to enhance and improve the WTMP project and its products for anticipated application by the LTO Watershed Monitoring Workgroups

Photo credit: John Hannon, Reclamation

# WTMP Goals and Phase I & II Activities for the Current Project

Randi Field, Hydrologic Engineer, CVO, Reclamation

# Vision for the WTMP Project (Part I)

- Goal: Deliver quality products to support Reclamation's mission – predict water temperature to support CVP operations
  - Modernize systemwide water temperature modeling and analytics
  - Develop to professional standards and foster transparency
  - Consistent use: real-time, seasonal, and long-term planning
  - Address modeling uncertainty
  - Design for flexibility to accommodate technical advancement
  - Build expertise in Reclamation

# Vision for the WTMP Project (II)

- Tool: The WTMP project is the technical tool development effort to build the model and supporting mechanisms for water temperature management analysis
- Use: The long-term operation (LTO) teams establish how to apply tools and analysis for water temperature management

# Vision for the WTMP Project (III)

- Outcome: A living modeling platform to support long-term CVP operations by addressing water temperature modeling needs and challenges.
- Major products:
  - Complete model and platform documentation based on the current installation
  - Water Temperature Modeling Platform
    - Implemented models/model framework with built-in functions to support modeling needs
    - Data Management System and associated data (raw and processed)
  - Outcomes from independent scientific peer review (mid-term and final)
  - Outcomes from the MTC collaboration (communications and participations in product review)

# WTMP Phase I

- Establish project needs and selection criteria
- Engage with MTC community (on-going basis)
- Research available tools
- Model evaluation and selection
- Framework model setup
- Complete model development
  - Trinity/Whiskeytown/Shasta, American, and Stanislaus
  - Unique feature development
- Initial documentation of Shasta/Keswick
- Mid-Term Peer Review

# WTMP Phase II

- Continued documentation and enhancement with Peer Review and MTC feedback
- WTMP Data Management System enhancements
- Continued framework development
- Uncertainty: Definition and evaluation
- Final Peer Review

# WTMP Post Final Review: Response and Roll Out

- Response to Final Peer Review
  - Enhanced documentation
- Deploying/hosting:
  - Database management internal to Reclamation
  - Software repository (GitHub)
  - Public facing data and studies to Reclamation Information Sharing Environment (RISE)

# Agenda Topics for the 2021-2022 MTC Meetings

| Topic | 7/1/2021 | 10/7/2021 | 1/6/2022 | 4/7/2022 | 7/7/2022 | 10/6/2022 |
|---|---|---|---|---|---|---|
| MTC Orientation | 1/2/3 | - | - | - | - | - |
| Project Purposes, Goals, Anticipated Outcomes | 1/2/3 | 3 | - | - | - | - |
| Modeling Framework Selection | 1 | 2 | 3 | - | - | - |
| Water Temperature Model Selection | 1 | 2 | 3 | - | - | - |
| Consistency between System Model and Detailed Models | - | 1 | 2 | 3 | - | - |
| Common Model Preparation and Considerations | - | 1 | 2/3 | - | - | - |
| Sacramento/Trinity River Water Temperature Model | - | - | 1 | 2 | 2/3 | 3 |
| American River Water Temperature Model | - | - | - | 1 | 2 | 2/3 |
| Stanislaus River Water Temperature Model | - | - | - | - | 1 | 1/2 |
| Modeling Framework Implementation | 1 | - | 2 | - | - | - |
| Mid-term Peer Review Outcomes | - | - | - | - | - | 1/2/3 |
| Phase II Activities (Introduction only) | - | - | - | - | 1/2/3 | - |

Key: 1 – Introductory Presentation; 2 – Comments and Discussion; 3 – Closure Discussion

# Agenda Topics for the 2022-2023 MTC Meetings

| Topic | 7/7/2022 | 10/6/2022 | 1/5/2023 | 4/6/2023 | 7/6/2023 | 10/5/2023 |
|---|---|---|---|---|---|---|
| Sacramento/Trinity River Water Temperature Model | 2/3 | 3 | - | - | - | - |
| American River Water Temperature Model | 2 | 2/3 | - | - | - | - |
| Stanislaus River Water Temperature Model | 1 | 1/2 | 2/3 | 3 | - | - |
| Modeling Framework Implementation | - | - | 2/3 | - | 3 | - |
| Mid-term Peer Review Outcomes | - | 1/2/3 | - | - | - | - |
| Phase II Activities (introduction only) | 1/2/3 | - | - | - | - | - |
| Follow-up Model Discussions (as needed) | - | - | - | 1/2 | 2/3 | - |
| Characterization of Model Uncertainty | - | - | 1 | 2 | 3 | - |
| Communication of Model Uncertainty | - | - | 1 | 1/2 | 2/3 | 3 |
| Output and Visualization | - | - | 1 | 1/2 | 2/3 | 3 |
| Final Peer Review Outcomes | - | - | - | - | - | 1/2/3 |
| Celebration | - | - | - | - | - | 1/2/3 |

Key: 1 – Introductory Presentation; 2 – Comments and Discussion; 3 – Closure Discussion

# Essence of WTMP Project Goals

- The viability of the WTMP project rests in a credible, comprehensive data set and management system, a well-documented functional and flexible set of modeling tools/framework with adaptable and tested elements.
- The WTMP team is aware there is great potential, although not part of the WTMP tasks, to explore a wide array of questions after the tools are established.  WTMP team is cognizant of this potential and at every opportunity, in consultation with the MTC, have attempted to incorporate flexibility for future applications.

Photo credit: John Hannon, Reclamation

# Mid-Term Peer Review Responses

Randi Field, Hydrologic Engineer, CVO, Reclamation

# General Response to Peer Review Findings

- Effective critique
  - The level of technical detail in the review exceeds previous review feedback and the WTMP is grateful for a rigorous and complete critique.
  - The team has not overlooked the value of thoughtful feedback and comments to address topics from a stakeholder perspective.
  - WTMP team appreciates the tone which supports the goal to seek opportunities and suggest ways to enhance or improve this project and its products.

# General Response

- Comments, suggested edits, and recommendations have been addressed to the best of the team's abilities and within the confines of the project scope and budget.  Responses were offered in the spirit to improve and enhance the project and products with the anticipation of use/application by the Long-Term Operations (LTO) Water Monitoring Workgroups.
- Some items were outside of the scope of the project; these key topics are identified in this presentation.  WTMP team prioritized completing the foundational tools first which can subsequently support a wide breadth of future evaluations.

# Response to Features to Commend

- The WTMP team is appreciative the Peer Review Panel recognized several outstanding elements:
  - Transparency, stakeholder engagement, model and data dissemination, and building expertise
  - Systems Framework approach for applying different spatial-temporal scales
  - Ability to analyze model behavior at the element scale
- This information helps the WTMP Modeling Technical Committee (MTC)/stakeholder community confirm the strengths of the project.

# Response to Conceptual Recommendations

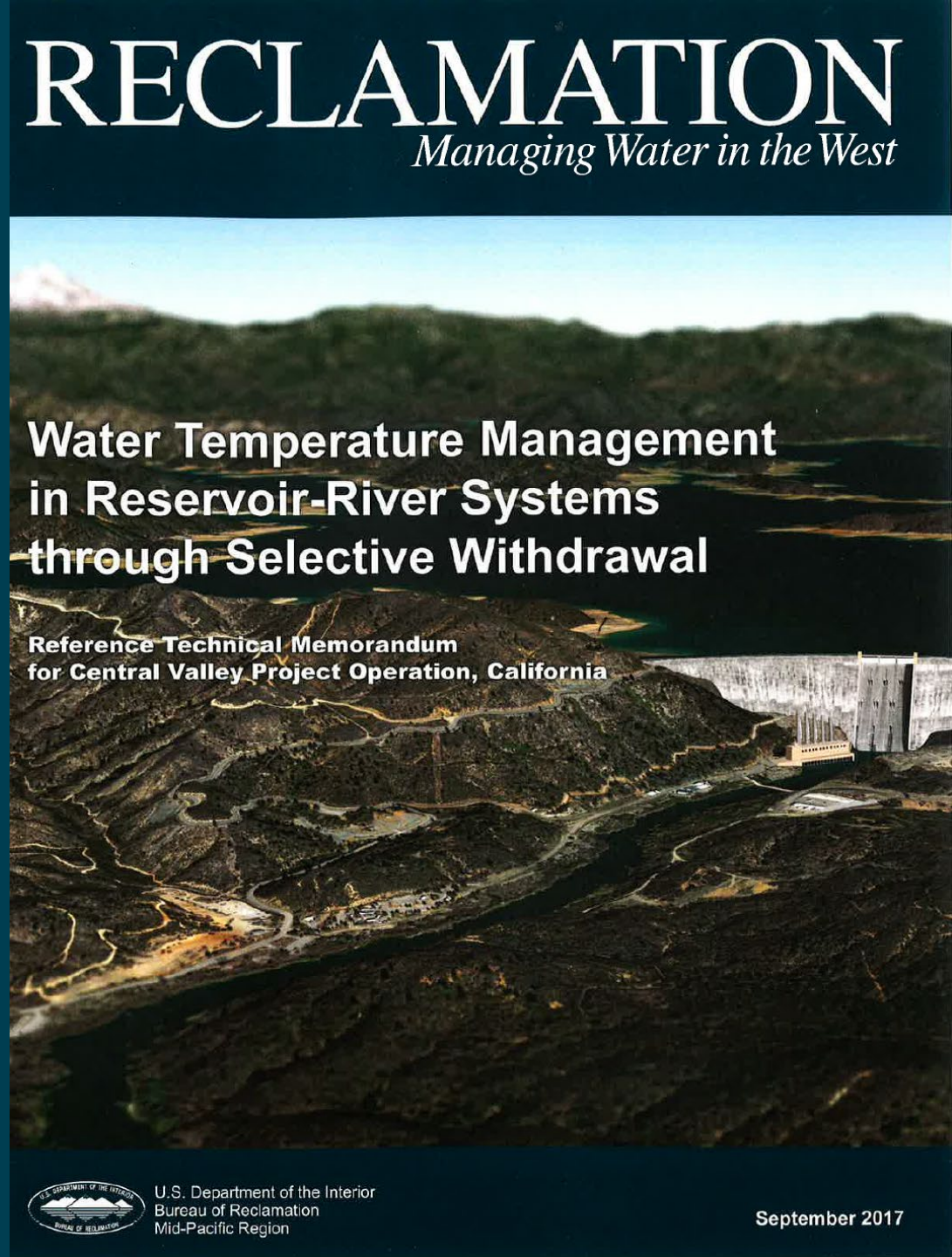
- WTMP resources were prioritized to address model development over general/conceptual suggestions of temperature dynamics.
- Reclamation has already invested in a rigorous and practical document on Water Temperature Management in Reservoir-River Systems through Selective Withdrawal, with specific examples on the Sacramento and American River systems.  The reader is pointed to this reference for more information.

# Temperature Management

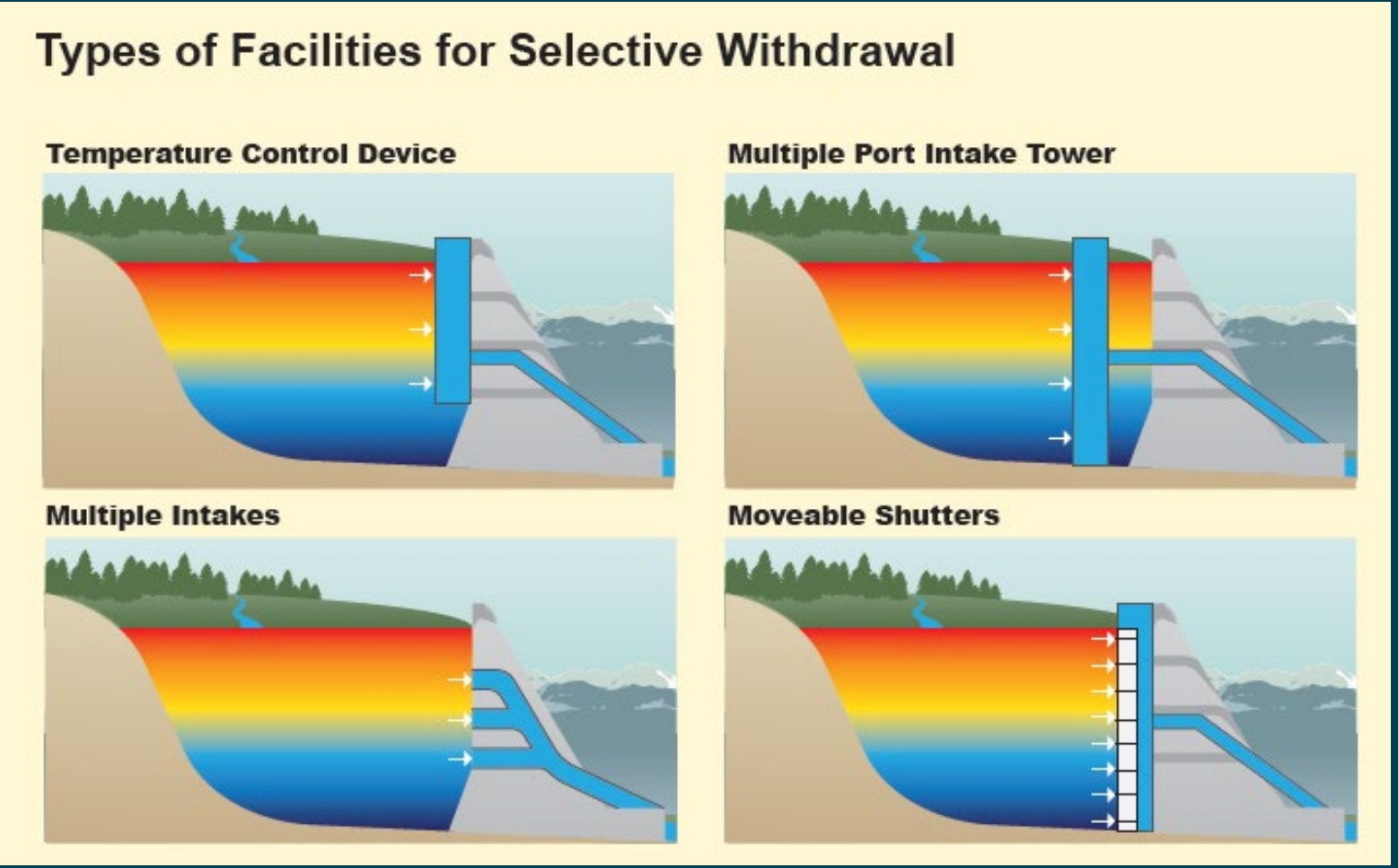
## Reference Technical Memorandum 2017

Web Link - See Additional References:

https://www.usbr.gov/mp/bdo/cvp-wtmp.html

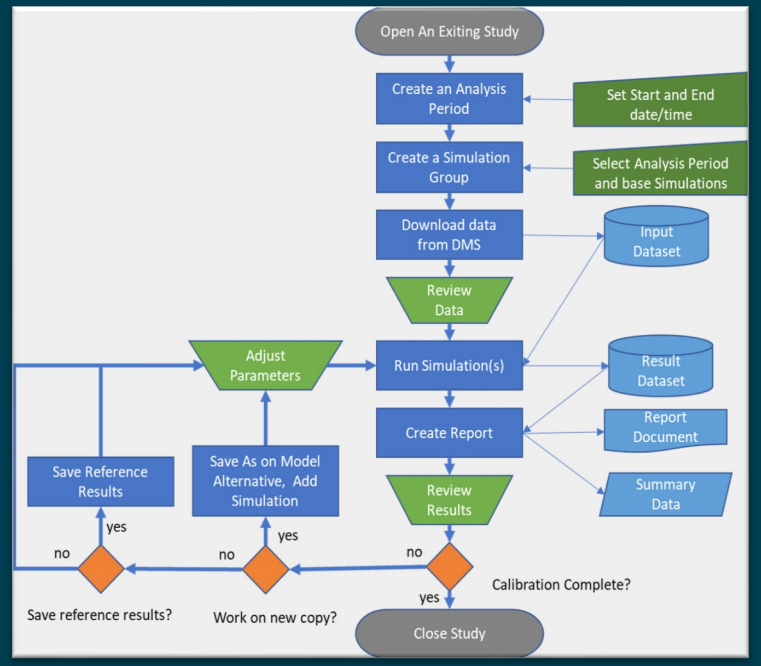


# Example: Temperature Management Fundamentals



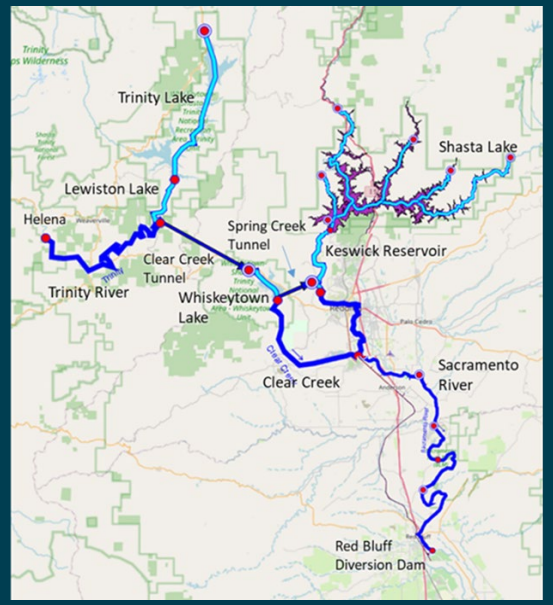
# Response to Modeling Design – High Level Overview (Introductory overview)

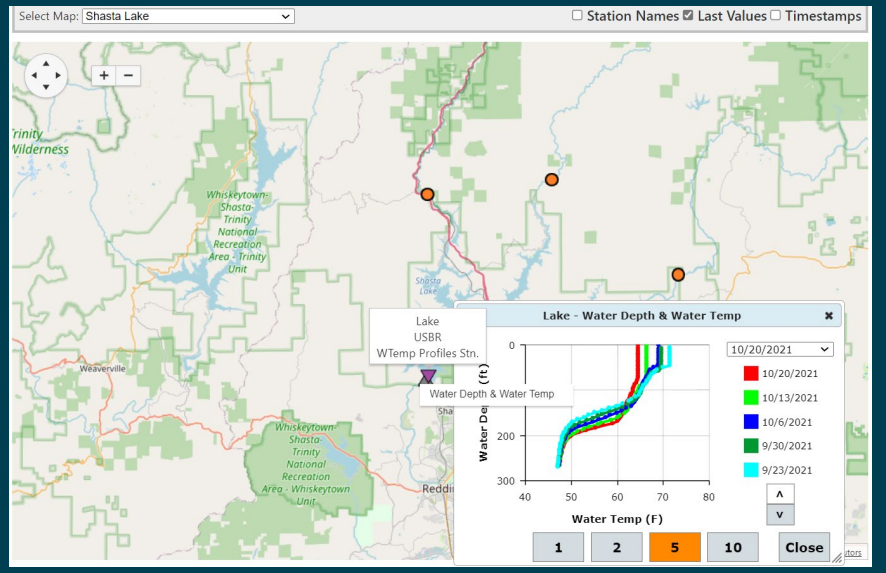
- Documentation has been enhanced based on the Panel feedback as part of the Phase II activity.  Additional detail has been added in the introductory sections:
  - High-level overviews
  - Model features, events, and processes
  - Testing processes:
    - Calibration, validation, and sensitivity



# Response to Modeling Design – High Level Overview (Visualization)

- Documentation contains enhanced maps/diagrams/model elements/control points
- Names replaced per DOI guidance 9/8/22
- Documentation enhanced to include importance of hydrologic events



# Response to Modeling Design – Biologic Metrics

- The MTC hosted two sub-committee meetings (2/9/22 and 3/8/22) on the topic of Habitat Data.
- The request of attendees was to communicate the biological importance of river reaches in the context of temperature significance, and review the accuracy, characterization, and applicability to water temperature model development.
- Meeting agenda, participants, handouts, and meeting summary are posted on the WTMP web page.

# Response to Modeling Design – Hydrologic Components

- Groundwater exchange, i.e., hyporheic flow, is not modeled explicitly in the river models. Considerable, site-specific information is required to quantify location, magnitude, and thermal impacts on stream temperature.
- The WTMP project did not include implementing new field monitoring effort, although new field data can be incorporated in the future.

# Response to Modeling Design – Leakage and Thermal Curtains

- Documentation has been enhanced based on the Panel feedback as part of the Phase II activity.
- Selective Withdrawal leakage assumptions are explained in the Model Development documentation
  - Shasta Temperature Control Device (TCD)
  - Folsom Temperature Shutters
- Thermal curtains are explained in the Model Development documentation
  - Lewiston
  - Whiskeytown

# Response to Model Design – Risk-Informed Analysis

- Several comments/questions fall outside the scope of the WTMP project; however, WTMP team is aware of the potential new resource tools will have and recommend the Long-Term Operations (LTO) Watershed Monitoring Workgroups use these tools appropriately as suggested by the Panel:
- What are the performance measures? NMFS 2019 Biological Opinion
- How is decision making performed? Real-Time Water Operations Charter
- What are the actions to meet performance measures? 2019 LTO Proposed Action

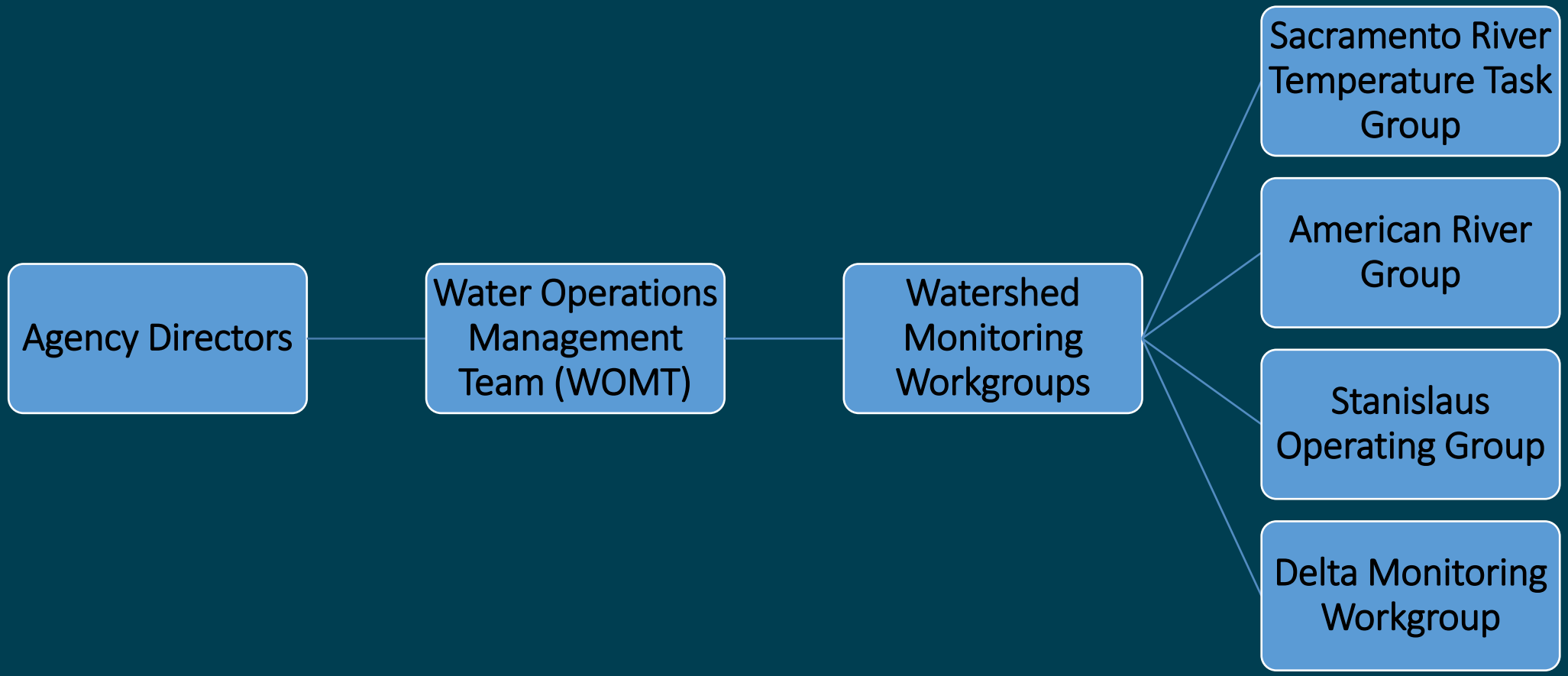
# What type of problem is this?

"If the problem were just about allocating freshwater flows, it might be solvable.  Add in the complexity of moving water through a hydrologically and hydro-dynamically complex Delta and it becomes complicated.  Add the uncertainty of ecological responses and the institutional complexity of many actors with many visions and the problem becomes wicked.  Then add the ever-changing water supply and ecological and economic contexts within which decisions must be made, and the problem becomes devilishly wicked."

Challenges Facing the Sacramento-San Joaquin Delta (9/28/15)

Delta Science Program, Delta Stewardship Council Brochure

# Decision-Making Organizational Chart



# Current Risk-Informed Analysis

- LTO Watershed Monitoring Workgroups assess risk:
  - Temperature thresholds at various locations
  - Uncertainty using different runoff and meteorological exceedances
  - Alternatives/tradeoff analysis
  - Performance measures
    - Dates/duration of lowest selective withdrawal configuration
    - Cold water pool volume at select months
    - Biological considerations
- Updated WTMP tools are expected to complement exploring risk-informed performance
- Many topics are supported by the WTMP workflow structure and reporting.

# Response to Model Adequacy: Outflow and Reservoir Elevation

- A first check in testing if the conservation of mass is preserved and a valuable first step in the modeling process is confirming outflow and storage elevations.

# Response to Model Adequacy: Extreme Hydrologic/Storage Conditions (Part I)

- Tables detailing historical water year types, reservoir release, and storage conditions have been enhanced in the Data Development documentation.
- Consideration of the full range of model applications was an important project objective.
- The WTMP team does not see any consistent or obvious calibration bias for different year types to suggest a need for multiple models.

# Response to Model Adequacy: Extreme Hydrologic/Storage Conditions (II)

- The 2000 - 2021 calibration period covers a broad spectrum of water year types and extreme conditions (i.e., wet and critically dry) and storage conditions, and individual year type assessment (e.g., critical, dry, below normal, above normal, wet) is challenging due to the small sample size of each year type.
- The WTMP team suggests examining the performance for years 2008, 2014, and 2015 (all critically dry water year types based on the Sacramento Valley Index); annual and monthly detailed information is provided in the documentation and appendices.

# Response to Model Adequacy: Extreme Hydrologic/Storage Conditions (III)

- There are a wide range of hydrologic conditions, operations, initial spring storage, cold water pool, meteorology, demands, and other factors when temperature management challenges benefit from the use of a model, with no particular storage condition (e.g., low, medium, or high) that is markedly “more” important than another.
- During extreme low storage periods, a model can inform trade-off conditions (i.e., season-long temperature control is unattainable and information when and where this occurs can help resource managers seek to limit negative environmental impacts and quantify water supply impacts). Further, emergency response actions and regulatory changes were taken in these years (but not in a consistent manner) that included, reduced flows, changes in temperature compliance point, operating to higher water temperatures, de-ganging shutt power bypass, temperature control curtain, variable power hydropower operations, and other actions.

# Response to Model Adequacy: Extreme Hydrologic/Storage Conditions (IV)

- Enhanced discussion and model limitations are presented in the Model Development documentation.
- Testing model robustness should consider model uncertainty (Phase II) and model application use (intended to be updated monthly or more frequently as necessary).  This could be considered as a future "use application" evaluation.

# Response to Data Sufficiency

- Sensitivity analysis is a Phase I & II activity and is scheduled for the Final Peer Review and highlighted in Model Development documentation.
- Complete details of meteorological and vertical reservoir temperature profiles are described in Data Development documentation.
- Systematic sensitivity analysis described in Model Implementation for ongoing review of input parameters.
- Gap filling suggestions for future data gathering are considered in the Data Quality Control plan documentation (not yet available, but an on-going development).

# Response to Model Testing: Validation

- It was not intended that model validation be given unequal weight to model performance metricies.  WTMP team perceive calibration and testing in the form of "validation" or evaluating/testing analysis as all equally important information to understanding model performance.
- The documentation has been significantly enhanced to address the topic of “validation” and we are sensitive to the Panel’s concern that the term may have different definitions in the industry.
- The term “validation” and its definition, consistent with CWEMF (2021), is retained in the documentation as we find balance between the stakeholder and academic/professional communities.

# Response to Model Testing: Calibration (Part I)

- The calibration section documentation was enhanced based on Panel feedback.
- A manual model calibration was performed for the models (described with further detail in the following slides).

# Response to Model Testing: Calibration (II)

- Calibration was completed based on multiple model performance metrics of bias, squared error, and goodness of fit and considered regulatory temperature targets or objectives (described in detail in the following slides).

# Response to Model Testing: Calibration (III)

- Professional experience in applying models and the measurement accuracy of typical instrumentation used to collect stage, flow, water temperature data, and meteorological data was considered, as well as the spatial and temporal representativeness of available data.
- The process also included consideration of model geometric representations and the spatial resolution for one-dimensional reservoirs and rivers (ResSim) and two-dimensional reservoirs (CE-QUAL-W2) over multiple basins; and overall CE-QUAL-W2 and ResSim model structure and process representations (e.g., governing equations, numerical solutions, withdrawal logic representations, wind forcing approximations, etc.).

# Response to Model Testing: Calibration (IV)

- Using these as guidelines, coupled with pre-identified specific temperature signatures for reservoirs (large, medium, small) and rivers, analysts aimed to complete a graphical and statistical calibration within the identified metrics and document deviations (outside performance metric ranges).

# Response to Model Testing: Calibration (V)

- A notable challenge in a large system with multiple models is the calibrating end-point.
- All analysts in this project recommend continual refinement as model application continues and new data and information (see recommendations) become available.
- An automated calibration process is challenging for this large set of system models, data difficulties/complexities, and unique operations capabilities.  However, as these methods improve, the potential to employ such an approach may be appropriate.

# Response to Model Testing: Plots

- “Data rich/high frequency” plots were retained; however, complementary component plots were added to better examine details.
- Plots containing the differences between simulated and observed values were not included for every comparison, this was a strategic project management decision, these can easily be incorporated in the future (i.e., non-complex, but time-consuming task).

# Response to Model Testing: Model Performance at the Framework scale

- This topic is a Phase II activity and is scheduled for the Final Peer Review, see Uncertainty documentation.
- Additional feedback has been requested from the Panel for clarification and level of analysis.

# Response to Model Testing: Performance Statistics

- Model performance parameters were investigated, selected, and vetted through the Modeling Technical Committee (MTC) and the WTMP has implemented recommendations based on the MTC discussions.

# Response to Model Testing: Model Modes

- This topic is a Phase II activity and is scheduled for the Final Peer Review, see Implementation documentation.

# Response to Model Documentation

- Reclamation is interested in pursuing a more rigorous and formal method for documenting modeling for future projects.  It appears this may be an emerging area of development particularly for this sub discipline.
- Documentation and formatting was decided early in the project and there was not sufficient flexibility for significant modifications, this was a strategic project management decision.
- Project team resources were expended on managing updated and evolving 508/ADA and Visual Identity requirements.

Photo credit: John Hannon, Reclamation

# Final Peer Review Overview

Randi Field, Hydrologic Engineer, CVO, Reclamation

# Final Peer Review: Overview

- The Final Review is envisioned to capture the same components of the Mid-term review, but instead of focusing on the Shasta/Keswick and Upper Sacramento River, also to address elements developed in the Trinity, Whiskeytown, American, and Stanislaus watersheds.
- The Final Review is intended to constructively evaluate the full development of the temperature models. This review includes: (1) model selection, (2) data development, (3) model structure, (4) testing, and treatment of selective withdrawal components, and (5) documentation.

# Final Peer Review: Overview (Part I)

- The Final Review will include the representation of system features within the temperature models, including
  - the unique physical components of Lewiston and Whiskeytown Lakes temperature curtains
  - Folsom Dam temperature shutters
  - submerged Old Melones Dam
- This review will constructively evaluate the application of the models for the intended uses, including abilities to utilize real-time/seasonal tools in a forecast mode and to incorporate and address uncertainty. The Independent Review Panel's findings and recommendations will influence the final phase of the temperature model application effort.

# Final Peer Review: Overview (II)

- The Final Review will focus priority on real-time/seasonal tool (in a forecasting mode) application and a "proof of concept" long-term planning application is offered for consideration.

# Final Peer Review: Overview (III)

- Are the model framework linkages adequate between models?
- Are the models, in forecast mode, adequate for the intended real-time and seasonal planning purposes (i.e., forecast period ranges from 3- to 5-days to six months into the future), based on performance measures, uncertainty, and the fidelity with which the models represent physical processes?

# Final Peer Review: Overview (IV)

- Is the proposed plan to manage the range of expected variability (e.g., hydrology and meteorology) from future climate projections adequate?
- Are the metrics and methodology for describing and incorporating uncertainty in input data adequate and is model uncertainty described and quantified appropriately?
- Are the modeling processes and approaches associated with model application appropriately documented?
- What should be included in the models in the future to improve their accuracy, resolution, or other features?

# WTMP Request of Final Peer Review

- Questions or comments within the scope of the WTMP technical development effort to target overall product improvement and credibility.
- Expand discussion of features where the MTC/stakeholder community can confirm WTMP project strengths.
- Recommendation priority would be helpful (e.g., "essential" to "complementary")
- How does the WTMP project compare to other similar development efforts?

# Post Final Peer Review Activity

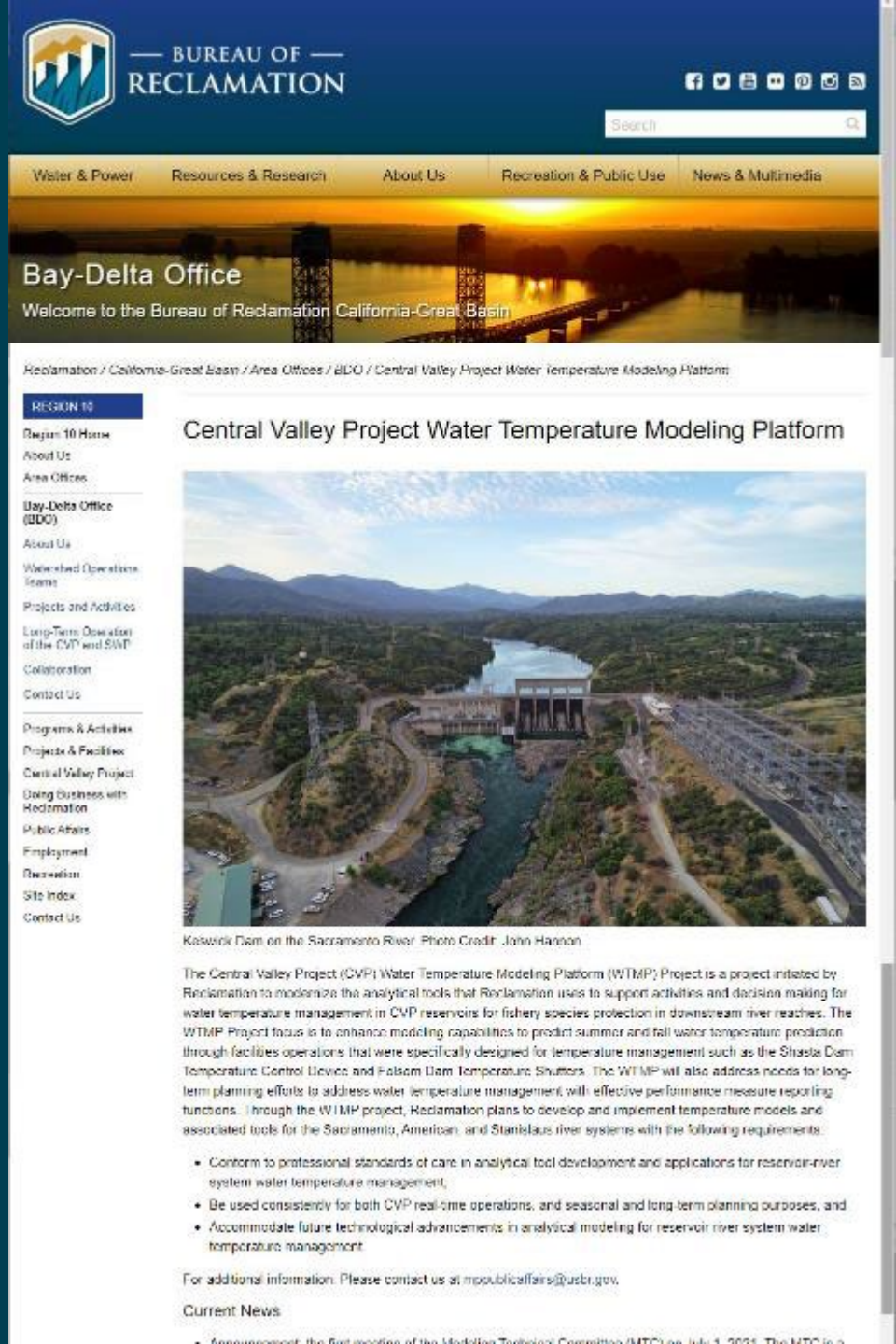
- Documentation enhancement, within scope, by WTMP team based on Final Peer Review feedback

# Final Independent Scientific Peer Review

- Host: Delta Stewardship Council
- Review materials available to the panel by August 11, 2023
- Peer Review Panel convening, and deliberation scheduled: 9/12/23 – 9/14/23
- Anticipated final report in early November 2023

# Communication Channels

- Project website with continued updates: https://www.usbr.gov/mp/bdo/cvp-wtmp.html
  - Meeting information/Fact sheets/Deliverables
- Project contact: mppublicaffairs@usbr.gov
- Interim deliverable comments and suggestions: RField@usbr.gov
- MTC: sun.yunghsin@sunziconsulting.com



# Information Sharing and Contacts

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- Project Information:
  - Contact: mppublicaffairs@usbr.gov
  - Website link - https://www.usbr.gov/mp/bdo/cvp-wtmp.html

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