

## **Review of the Sacramento Water Allocation Model (SacWAM) Charge to the Independent Review Panel**

### **Background/Purpose**

Sacramento Water Allocation Model (SacWAM) is a hydrology/system operations model developed by the Stockholm Environment Institute (SEI) and State Water Resources Control Board (State Water Board) to assess potential revisions to instream flow and other requirements in the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (2006 Bay-Delta Plan). SacWAM was developed using the Water Evaluation And Planning (WEAP) system, and is intended to be user-friendly and to easily accept various scenarios. The Delta Science Program is conducting an independent peer review of SacWAM to assure transparency and confirm the robustness of SacWAM for applications related to updates of the Bay-Delta Plan, and as part of the Delta Science Program's mission to provide the best possible unbiased scientific information to inform water and environmental decision-making in the Bay-Delta system.

The WEAP system uses water balance accounting, where both the engineered and biophysical components of a water system are represented, to facilitate multi-stakeholder water management dialogue on a broad range of topics, including sectoral demand analysis, water conservation, water rights and allocation priorities, reservoir operations, hydropower generation, pollution tracking, ecosystem requirements, and project benefit-cost analysis. WEAP informs management strategies through scenario-driven analyses of possible water futures where the influences of climate, land use management, demand, regulation, and planning objectives can be explored. These analyses can be conducted at any number of scales, from municipal water systems and the local watersheds to regional, transboundary river systems.

The State Water Board's periodic review of the 2006 Bay-Delta Plan was initiated with the 2008 Strategic Plan, which prioritized Bay-Delta planning activities, and the 2009 Periodic Review Staff Report (2009 Staff Report), which recommended further review of the following: (1) Delta outflow objectives; (2) export/inflow objectives; (3) Delta Cross Channel Gate closure objectives; (4) Suisun Marsh objectives; (5) potential new reverse flow objectives for Old and Middle Rivers; (6) potential new floodplain habitat flow objectives; (7) potential changes to the monitoring and special studies program; and (8) other potential changes to the program of implementation.

The State Water Board's water quality control planning process for approving amendments to the Bay-Delta Plan must ensure the reasonable protection of beneficial uses, which requires balancing competing beneficial uses of water, including municipal and industrial uses, agricultural uses, fish and wildlife, and other environmental uses. The State Water Board's process will include an analysis of the effects of any changed flow objectives on the environment in the watersheds in which Delta flows originate, in the Delta, and in the areas in which Delta water is used. It will also include an analysis of the economic impacts that could result from changed flow objectives. Computer modeling will assist in these analyses and decision-making.

The California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation) have developed and extensively used the CalSim II model for planning, managing, and operating the State Water Project (SWP) and Central Valley Project (CVP). Potential modifications to the 2006 Bay-Delta Plan may affect Central Valley and Delta operations that are included in the CalSim II model, such as inflow, Delta outflow, export/inflow ratio, Delta Cross Channel Gate closure, and Old and Middle River reverse flows. However, for its review of the Bay-Delta Plan, the State Water Board will need the following additional modeling capabilities that are not part of CalSim II's functionality: (1) the ability to predict flows at the mouths of tributaries to the Delta; (2) ability to simulate water diversions on non-mainstem tributaries and creeks; and (3) ability to simulate the operation of local agency reservoirs that are not part of the SWP or CVP. The State Water Board also needs a flexible, user-friendly simulation tool to rapidly assess the impacts of various regulatory scenarios on flows into the Delta, within the Delta, and flows exported from the Delta. The WEAP system allows for rapid assessment of alternative water development and management strategies. As a policy analysis tool, WEAP can evaluate a wide range of water development and management options, and it takes into account multiple and competing uses of water.

SacWAM was designed to estimate stream flows at Sacramento River tributary mouths, locations on the Sacramento River, Delta Eastside tributaries and key channels within the Delta. To achieve this, it was designed to include most of the CVP and SWP operations logic found in CalSim II. It was designed to run on a monthly time step in order to estimate seasonal variation in water demands, supplies, and stream flow important to aquatic species of interest. Its temporal and spatial discretization are meant to provide a tool useful for assessing all of the Sacramento River Hydrologic Region within a continuous hydrological and system operations model. Impacts on processes that occur on a sub-monthly time scale will need additional study using more refined models.

Stream flows estimated by SacWAM may be used to inform the following types of analyses as part of the State Water Board's assessment of potential alternative regulatory requirements:

- Estimates of flow conditions under a range of alternative regulatory requirements.
- Estimates of changes in water diversions for use in an evaluation of the impacts of alternative regulatory requirements on agricultural resources, water suppliers, and groundwater.
- Estimates of changes in reservoir storage for use in an analysis of the impacts of alternative regulatory requirements on hydropower generation, recreation, and fisheries.
- To inform other analyses or models, such as delta hydrodynamics, temperature, economic, and fisheries benefits models.

SacWAM will be used in a comparative manner in which a model scenario is compared to a model base condition and the difference in model outputs is used to assess potential impacts of proposed regulatory actions. Additionally, conclusions may be derived from broad statistical measures of model output and not particular model output for in a single month or single year.

### **Charge to Independent Review Panel**

The overall purpose of this review is to answer the question “is SacWAM an appropriate tool to assist the State Water Board with the analyses associated with the Bay-Delta Plan update?” The model will be reviewed by an Independent Review Panel in a public forum in order to assure transparency and confirm the adequacy of SacWAM to simulate water balance for comparative purposes for applications related to updates to the Bay-Delta Plan.

### **Specific Questions**

1. Is the SacWAM model a suitable tool to assist in the analyses being undertaken by the State Water Board as it updates the Bay-Delta Plan?
2. What are the limitations, uncertainties, and impediments associated with the use of the SacWAM model? Can you suggest ways to improve SacWAM to address those concerns?
3. Under what circumstance(s) would SacWAM or CALSIM II be more scientifically justified?
4. What additional information or capabilities could be added to the SacWAM model, post-run processing, or documentation to improve its usefulness to State Water Board?
5. Is SacWAM’s calibration and/or validation appropriate and sufficient for the intended use to evaluate potential changes in flows, and environmental and economic impacts under different regulatory requirements?
6. What, if any, additional sensitivity analysis, calibration and/or validation is recommended for SacWAM?
7. Are SacWAM’s temporal and geographic scales and resolutions appropriate for the intended use?

### **Review Materials**

REPORTS:

SacWAM model documentation and calibration report

Hydrological and Operations Modeling Considerations for the Phase 2 Update of the 2006 Bay-Delta Plan

### **ADDITIONAL RECOMMENDED MATERIALS:**

WEAP Water Evaluation and Planning System Tutorial, August 2015.

[http://www.weap21.org/downloads/WEAP\\_Tutorial.pdf](http://www.weap21.org/downloads/WEAP_Tutorial.pdf)

2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

[http://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/wq\\_control\\_plans/2006wq\\_cp/](http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/2006wq_cp/)

2009 State Water Board Staff Report - Periodic Review of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

[http://www.swrcb.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/periodic\\_review/docs/periodicreview2009.pdf](http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/periodic_review/docs/periodicreview2009.pdf)

State Water Board Supplemental Notice of Preparation and Notice of Scoping Meeting for Environmental Documentation for the Update and Implementation of the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: Comprehensive Review, January 24, 2012.

[http://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/bay\\_delta\\_plan/environmental\\_review/docs/notice\\_baydeltaplancompreview.pdf](http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/environmental_review/docs/notice_baydeltaplancompreview.pdf)

State Water Board Informational Workshop on Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects held on November 13 & 14, 2012

Revised Public Notice for 2012 Informational Workshops

[http://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/docs/pubnot\\_phs2wrkshps.pdf](http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/pubnot_phs2wrkshps.pdf)

Public Comments Received

[http://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/comments111312.shtml](http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/comments111312.shtml)

Final Workshops Summary Report

[http://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/bay\\_delta\\_plan/docs/bdwrkshprpt070813.pdf](http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/docs/bdwrkshprpt070813.pdf)

State Water Board San Joaquin River Flows and Southern Delta Water Quality Draft Substitute Environmental Document Chapter 4 – the end of this chapter provides a short example of how hydrologic modeling results are used to evaluate impacts.

[http://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/bay\\_delta\\_plan/water\\_quality\\_control\\_planning/2012\\_sed/docs/2012ch\\_04.pdf](http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2012_sed/docs/2012ch_04.pdf)

#### SUPPLEMENTAL DOCUMENTS

Peer-reviewed Publications on WEAP model:

Joyce, B., Purkey, D., Yates, D., Groves, D., and Draper, A., 2010, Integrated scenario analysis for the 2009 California Water Plan update: California Department of Water Resources technical memorandum, 97 p.

Mehta, V.K., D.E. Rheinheimer, D. Yates, D.R. Purkey, J.H. Viers, C.A. Young and J.F. Mount, "Potential impacts on hydrology and hydropower production under climate warming of the Sierra Nevada," Journal of Water and Climate Change, Vol. 2, No. 1, pp. 29–43, doi:10.2166/wcc.2011.054, 2011.

Thompson, L.C., M.I. Escobar, C.M. Mosser, D.R. Purkey, D. Yates and P.B. Moyle, "Water Management Adaptations to Prevent Loss of Spring-Run Chinook Salmon in California under Climate Change," *Journal of Water Resources Planning and Management*, doi:10.1061/(ASCE)WR.1943-5452.0000194, August 2011.

Yates, D., Purkey, D., Sieber, J., Huber-Lee, A., Galbraith, H., West, J., Herrod-Julius, S., Young, C., Joyce, B., and Raye, M., 2009, Climate driven water resources model of Sacramento Basin, California: *Journal of Water Resources Planning and Management*, v. 135, no. 5, p. 303–313.

Yates, D., J. Sieber, D.R. Purkey and A. Huber-Lee, "WEAP21--A Demand-, Priority-, and Preference-Driven Water Planning Model: Part 1, Model Characteristics," *Water International*, 30 (2005), pp. 487-500.

Yates, D., D.R. Purkey, J. Sieber, A. Huber-Lee and H. Galbraith, "WEAP21--A Demand-, Priority-, and Preference-Driven Water Planning Model: Part 2, Aiding Freshwater Ecosystem Service Evaluation," *Water International*, 30 (2005), pp. 501-512.