Appendix 2 – Improved Modeling Capabilities Needed for the Bay-Delta Planning Effort (2009)

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From: CALFED Hydrodynamics Modeling Community Members

RE: Improved Modeling Capabilities Needed for the Bay-Delta Planning Effort

The Bay-Delta is in transition. Sea level rise, additional flooded islands, more aquatic habitat, and significant changes in water flow and quality will make the Bay-Delta very different in the coming years. Without sufficient modeling capability to predict how water flow and water quality will respond to these changes, we face the likelihood of a less-than-adequate scientific basis for management, planning, and policy decisions. California's water community needs to invest in expanding and updating our hydrodynamic and water quality modeling capabilities and to improve Bay-Delta field measurements. With these objectives in mind, a subset of our group wishes to meet with you and/or your staff to discuss how a targeted work proposal can best be developed for your consideration.

A wide variety of models are currently being used or are under development in the Bay-Delta, including one-dimensional (1-D) models (DSM2, FDM), 1-D/2-D hybrid models (RMA, REALM), 2-D (only) models (TRIM2D), and a suite of 3-D models (TRIM3D, UnTRIM, Si3D, SUNTANS, Delft3d, ROMS). These models provide users a toolbox for solving a variety of problems under a range of conditions. Although significant model improvement has been made recently, not all modeling needs are currently being met, and many expected future conditions will require enhancements to existing tools to ensure proper analysis. Because hydrodynamic and water quality modeling is at the heart of any scientifically-based policy, planning, and management for a changing Bay-Delta, enhanced modeling capability is a high priority. An expanded list of modeling needs is provided in Appendix 1. Given the controversial nature of policy-making in the Bay-Delta, these needs must be met with a high level of scientific transparency, proper verification and validation, adequate documentation, and rigorous peer review.

Two urgent needs should be addressed immediately. We recommend:

- Semi-formal **comparison of model performance** for the DSM2, RMA, TRIM3D, and UnTRIM hydrodynamic models should be performed as soon as possible using general procedures outlined in previous calibration reports (CDWR 2005, 2008). Performance of each model should then be described and discussed when confronting hydrodynamics data collected in 2007 and 2008. The aim of this performance evaluation is not to establish primacy of an individual model, but rather to identify which attributes of each model make it more or less suitable for given applications, and to help document how best to use our suite of models and our community of modeling expertise.

- Immediate investment in a formal program to update, evaluate, and maintain a widely-available **bathymetric and topographic digital elevation dataset** for use regardless of platform or program code. All Delta models and all applications for these models require the most accurate and most recently updated bathymetry with which to resolve system dynamics. Accurate, current bathymetry will benefit not only modeling but also other emergency response, operation, planning, and conservation applications. The updated, maintained grid will also provide the starting point for any evaluation of levee breaks, shoreline protection decisions, island floods, and restoration trajectories within the sub-tidal to supra-tidal Bay-Delta basin under conditions that include seal level rise and flooded Delta islands.

As a necessary follow-on, and to realize a substantial improvement in California's Bay-Delta modeling capabilities, we also propose enhancing future investment in model and data collection and analysis to provide new modeling capabilities and to develop more informed insight into the Delta's problems and potential solutions. A nomination of elements essential for an effective modeling program is listed in Appendix 2.

We share in your enthusiasm for revitalizing the community of Bay-Delta modelers, and we are ready and willing to meet with you to discuss ways for moving support for our efforts forward, particularly in light of pressing proposals included in the development of BDCP.

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Appendix 1: Model Needs

Near-term

- Updated and maintained bathymetric and topographic (land surface elevation) data bases for the Delta and Bay, and expansion of these data bases to allow for improved ability to model water levels, flows, and salinities under conditions of sea-level rise and island flooding
- Continued improvement of 1-D models, especially to develop more accurate methods to parameterize 3-D dispersive processes in these models. This process will include integration and comparison of large-scale observations and numerical studies
- Better connection of Delta hydrodynamic models with upstream water management models
- Guidance for project managers on the roles, insights, and limitations of each of the available models for policy, planning, and management purposes
- Collection of 3-D tracer datasets (field data) for the establishment and validation of transport mechanisms for various scalars important within the Delta

Intermediate

- More accurate simulations of salinity for the entire Bay-Delta estuary that include better parameterization of dispersive mixing processes
- Improved accounting for the effects of in-Delta agricultural water use and drainage on salinity and other aspects of Delta water quality
- Expanded development of the capacity to model additional variables such as temperature, turbidity, residence time, nutrients, sediment, disinfection by-product precursors, toxics, phytoplankton and particles, including particles with behavior to better represent fish in Delta modeling and management
- Continued development of visualization tools for displaying modeling outputs that assist in communicating the results from modeling studies, and the development of pre- and post-processing tools that make models easier to use

Long-term

- Greater computational efficiency of multi-dimensional (hybrid) modeling systems to support ambitious Delta planning efforts requiring many runs in relatively short spans of time
- Improved methods to represent shoreline irregularities in multi-dimensional models, including underwater boundary representations in layered 3-D models
- New model features that make it easy to change the scales of numerical grid resolution within the Delta from coarse to fine scales, and that allow change in the dimensionality of a code as needed from 1-D, to 2-D, or to 3-D (so-called hybrid models)
- Improved real-time modeling capabilities to assist in real-time decision making

Appendix 2: Effective Long-term Modeling Program Needs

Longer-term responsibilities for the CALFED Science Program and the community of Bay-Delta modelers include elements of education, evaluation, development, licensing, research, and regular peer-review as part of a commitment to establishing and maintaining a state-of-the-art group of model developers, users, and interpreters. These elements are often discussed within the Bay-Delta modeling community, and there is broad-based support for collaboration and coordination for longer-term model and modeler improvement. Commonly, however, shorter-term priorities consume available expertise and money, and coordination among efforts between agencies with competing mandates is difficult without dedicated effort and funding. For these reasons, we recommend development of a collaborative, integrated program dedicated to advancing Delta modeling capabilities. We welcome management input and are ready to respond to calls for real progress and real work given real management and fiscal support.

By agreeing on the most appropriate directions for expanding existing modeling capabilities, our proposed program will permit the development of intermediate products while working toward longer-term objectives. We recommend that the proposed program include the following:

- Use of the diverse model and data development talents and capabilities already existing in California's agencies, universities, and consulting firms
- Establish community-wide 2-year, 5-year, and 10-year goals for strategic model development
- Leadership that maintains a consistent application-oriented scientific perspective and maintains focus on achieving strategic modeling goals (2-yr, 5-yr, 10-yr)
- Requirement of product completion according to 2-, 5-, and 10-year schedules to satisfy near-term modeling needs
- Proper mathematical verification of model codes and calculations, field testing of models, and peer-review of model algorithms and documentation
- An external review committee to provide outside scientific advice, oversight, and quality assurance, drawing on expertise from other estuaries
- Model codes and documentation made freely available in the public domain
- Identification of a caretaker of model codes and documentation
- Programmatic investment of $3 million/year for 5 years to support these recommendations

This modeling program would generate tools and products useful for a variety of applications: long term policy, planning, and regulatory decisions for the Management and Resources Agencies (CDWR, USBR, CDFG, USFWS, and NMFS), the State Water Resources Control Board, local agencies (particularly CCWD and Delta water districts), and other Federal agencies (USACE, USGS, and USEPA); real-time operations (by CDWR, USBR, CCWD, and local Delta water agencies); support for improved ecological modeling; support for operations and planning models; and support for improved understanding of Delta water quality, transport, flooding, and flows. The State Water Resources Control Board, through its mandated data collection for the IEP, can mandate changes in data collection to support this effort without undue increase in data collection budgets.

Appendix 3. Background on common operation and hydropower models

Operation Modeling

Almost all major rivers flowing into the Delta are controlled by large reservoirs in the foothills where the rivers enter the Central Valley. Traditionally the responsibility for meeting Delta requirements has been assigned to the major foothill reservoirs of the CVP (Trinity, Shasta, Folsom, New Melones) and SWP (Oroville), with lesser requirements from other major foothill reservoirs.

The CalSim II operations planning model for the CVP and SWP includes these reservoirs as well as the CVP/SWP project Delta export facilities and some other, smaller projects throughout the Central Valley and the Delta (except the Tulare basin). While having known limitations the CalSim II model is currently the large scale operations model being used in almost every major water supply project affects the Delta.

The CalLite model is a model of the CalSim II model. It is designed to be easier to use with a user interface, to run faster that CalSim, and to produce results similar to CalSim. Because CalLite's user interface, it can only simulate changes to specific operational parameters included in the model. Incorporation of these changes often requires CalSim simulations be performed which can then be used to guide modification of the CalLite interface.

Without knowing the specific questions to be addressed, the CalSim II model is typically more appropriate for modeling highly modified or new parameters, facilities, regulatory requirements, or operational rules. CalLite, after appropriate modifications if required, is used for repetitive, simulations with parameter modifications that can be made through the user interface. Several external reviews have been completed of CalSim II (Ford et al. 2006; Ferierra et al 2004, 2005; Close et al. 2003).

A variety of other system operations models have been developed for planning purposes. These include various applications of WEAP simulation, which emphasizes integration of hydrology and water demands. Several local agencies have stand-alone simulation models using various software platforms. Spreadsheet models also are common for operations planning simulation, even for large projects, both as stand-along models and for examination of small changes to the system perturbing base CalSim model results. Optimization modeling is widespread for hydropower operations above the foothill reservoirs, such as PG&E's SOCRATES model. For water supply, optimization models have so far remained largely restricted to academic studies, particularly CALVIN, although some of these have significantly informed policy discussions of climate change, the Delta, and infrastructure options.

Hydropower Modeling

Hydropower modeling has traditionally included the CVP/SWP system as they are the major focus of the CalSim II based operational modeling, and because they are major generators and users of hydroelectric power in California. The CVP is a net generator of power and the SWP is a net user of power.

Hydropower modeling of the CVP/SWP projects is done with two Excel spreadsheet based CalSim II post-processors, LongTermGen for the CVP and SWP Power for the SWP. The spreadsheets read monthly water operation data from CalSim II output and compute the energy production and usage of the project at their reservoirs, Delta export facilities, and throughout their distribution systems based on the unique generation or pumping characteristics at each facility. The computation simulates on and off peak operations by maximizing generation during peaking hours and pumping during off peak hours to maximize revenue and minimize costs.

Plexus is not technically a hydropower model, but a power market modeling tool. Hydropower facilities can provide several benefits other than energy generation (ancillary services) because of hydropower's unique characteristics to respond very quickly to changes in power market or grid conditions. There are implementations of Plexus, and other similar tools, to the power market in California. This type of model is useful in adjusting operations to maximize the overall value of hydropower facilities including any ancillary services. The major CVP/SWP facilities are operated for water supply and regulatory requirements first and hydropower second. This lack of flexibility limits the ability of the projects to re-operate to maximize ancillary services, and limits, but not eliminates the utility of this type of analysis.

Most of the many hydropower projects above the foothill reservoirs are operated by various proprietary optimization models, with additional software being used for hydrologic and power marketing. The effects of Delta regulations on these higher-elevation reservoirs are usually dampened considerably by the effects of usually much larger primarily water supply reservoirs downstream.

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