**California Water and Environmental Modeling Forum**

# 2013
# ANNUAL MEETING
# SESSION ABSTRACTS

## With Links to Speaker Presentations

Lake Natoma Inn
702 Gold Lake Drive
Folsom, California

# Session 1. Developments and Applications of CalSim and CalLite Part I

## *WRIMS2 – Development and Updates* – Kevin Kao-Cheng (DWR)

**0.4 MB**

WRIMS2 has updated the WRESL+ language, added connections to several external solvers, and developed a new tool for detecting non-unique solutions. Notable new features in WRESL+ include future array syntax and conditional file inclusion syntax. Future array syntax can simplify coding for multi-period optimizations by using arrays and an iterator to define variables and constraints efficiently. Conditional file inclusion syntax provides flexibility for scenario management by preprocessing file inclusions based on user specified conditions. Regarding external solver connections, WRIMS2 has added interfaces to three mixed-integer programming solvers, including two open-source solvers LpSolve and Coin-OR CBC, and one proprietary solver Gurobi. A tool that can detect non-unique solutions in a linear programming problem is also developed for improving model robustness and consistency.

## *WRIMS Integrated Development Environment and its Applications* – Hao Xie (DWR)

An integrated development environment (IDE) is a software application that provides comprehensive facilities to computer programmers for software developments. WRIMS IDE consists of a source code editor, a launcher, and a debugger. The introductions of WRIMS IDE demonstrate its ability of assisting WRESL code developments and run time debugging. WRIMS is being applied to variable time step optimization, multi-step optimization, Window 64 bit, and Linux system.

## *CalLite Model Development and New Features* – Tom FitzHugh (Reclamation)

**5.1 MB**

The Department of Water Resources and United States Bureau of Reclamation have implemented a number of updates and improvements to the CalLite 2.0 screening model. These improvements include (1) Isolated Facility implementation; (2) Shasta Reservoir enlargement options; (3) D-1485 Regulation options; (4) a dynamic San Joaquin module; and (5) climate change hydrology options. This release will also include new capabilities for designing CVP/SWP allocations, such as (1) an automated script for WSI-DI curve generation; (2) a Forecast Allocation Module for SWP; and (3) the capability to enter user-specified fixed project allocations. As with other CalLite features, all of these options can be turned on or off through the CalLite interface. Addition of these new features improves the capability of the CalLite 2.0 screening model to analyze the impacts of regulations and proposed projects on system operations, river flows, Delta hydrology, and water deliveries.

## *CalLite Comparison of Water Supply and Delta Outflow under Three Regulatory Environments: D-1485, D-1641, and Biological Opinions* – Holly Canada (DWR)

**2.8 MB**

CalLite is used to evaluate the impact of Delta regulations on water supply and Delta outflow by modeling three different Delta regulatory environments: (1) the State Water Board Decision D-1485 (issued August 1978), (2) the State Water Board Decision D-1641 (issued December 1999), and (3) the Biological Opinion Reasonable and Prudent Alternatives (BO RPAs) (issued December 2008 and June 2009). Results are reported for both current land use (with SWP variable export demands) and for future land use (with full Table A SWP export demands). In general, D-1485 regulations led to lower required delta outflow, lower total delta outflow, higher exports, and higher south of delta deliveries. During drought years, D-1485 requirements allow the highest percent of south of delta demands to be met. Deliveries are lowest with the BO RPA scenario. The CalLite results are comparable to results from a corresponding CalSim II study. Functionality is also added to the GUI for users to turn on or off several D-1485 regulations and for “quick-selecting” either a D-1485, D-1641, or BO RPA regulatory environment for a model run.

## Session 2. Technical Analysis in Support of California Water Plan Update 2013

### *New Developments in the Water Portfolios: What to Expect in Update 2013 and Beyond*

**Todd Hillaire (DWR)** **4 MB**

The Water Portfolios are an essential component of the California Water Plan process that characterizes current water management in California. A broad wealth of annual water supply and use information form the basis of the Water Portfolios. Water Plan Update 2013 extends the analysis and reporting of annual water portfolio data through 2010. The California Department of Water Resources is striving for greater flexibility in managing these data to meet the requests for information and work cooperatively with modeling efforts throughout the State. These efforts include incorporating database management tools and working on pilot studies with agencies to leverage efforts in better representing all uses of water. As funding becomes a challenge for developing these detailed annual water portfolios, one approach to the Water Plan Update 2018 could include focusing on water suppliers by planning area as the small unit of water budget analysis. This presentation will highlight these developments and results for the Water Plan Update 2013.

Additional contributor: Tito Cervantes (DWR).

### *California's Future Water Demand Modeling Using WEAP* – Mohammad Rayej (DWR) **10 MB**

As a part of the California Water Plan Update 2013, a physically-based water resources model called Water Evaluation and Planning (WEAP) has been used to project California's future urban and agricultural water demands under different demographic and socio-economic factors, and climate change scenarios. WEAP integrates water demands from all sectors with water supply elements such as rivers, reservoirs, canals, groundwater, desalination and hydropower projects. It allocates supplies based on a set of user-defined demand priorities, supply preferences and other constraints with the goal of maximizing the demand coverage. In the current application, only the demand side is modeled for the 10 hydrologic regions of the State. WEAP uses a monthly time-step, from base year 2006 to planning horizon 2050, to give a monthly trajectory of water demand. Impacts of three population growths coupled with three housing density scenarios (a total of nine scenarios) are used to project the future demand under 12 climate change scenarios. A future demand scenario with repeat of historical climate is also modeled as "no climate change scenario" for the purpose of comparison. As work in progress, preliminary results from the analysis are presented.

### *Groundwater Enhancement for the California Water Plan Update 2013* **5 MB**

**Abdul Khan (DWR)**

In the California Water Plan Update 2013, the California Department of Water Resources has initiated a process to enhance groundwater content in a major way. The effort is intended to bring all the available information together from a statewide and regional perspective. The information content on groundwater built through this initiative is anticipated to set the stage for future Water Plan Updates and related activities to provide on a long-term basis additional data, information, and analyses as well as policy needs for California's groundwater planning and management. The major deliverables planned for Update 2013 include the following - consolidated groundwater information from various State, federal, regional, and local water resource planning initiatives; status of regional groundwater conditions, management activities, and problem areas; data gaps to better inform future groundwater monitoring needs and activities; estimates of regional annual change in groundwater storage; Case Studies of successes and challenges of local and regional groundwater management; inventory and potential for conjunctive management of groundwater with other supplies; inventory and potential for groundwater banking and integrated flood management; and preliminary indicators to assess sustainability. Progress to date on the groundwater content enhancement is presented.

Additional contributor: Dan McManus (DWR).

***Water Sustainability Indicators for the California Water Plan*** **– Fraser Shilling (UC Davis)** **1 MB**

The California Water Sustainability Indicators Framework (hereafter "Framework"), brings together water sustainability indicators to inform assessments of water system conditions and their relationships to ecosystems, social systems, and economic systems. The Framework was developed with extensive feedback through the California Water Plan public advisory process and national water sustainability organizations like the Sustainable Water Resources Roundtable. The Framework is built around both statements of intent (e.g., objectives) and domains (e.g., water quality) that collectively cover natural and human water systems. Indicators were chosen that allow measurement of progress toward meeting goals and objectives and to represent different domains. Reporting indicator condition is based upon the principle of measuring how far a current condition is from both a desired condition and an undesirable condition. The measurement of distance is based on linear or non-linear relationships between a condition and its impact. Indicator scores may be presented as aggregated or disaggregated, depending on need. The Framework is intended to support reporting of indicators to a wide array of water and environmental stakeholders, the public, and decision makers to build knowledge and to enhance adaptive decision-making and policy change.

Additional contributors: Lara Lacher, Susana Cardenas, David Waetjen, Caitlin Cornwall (UC Davis).

## Session 3. Achieving Scientific Advancements by Exploring Dimensional Enhancements

***2D Modeling and Ecohydraulic Analysis*** **– Greg Pasternack (UC Davis)** **16 MB**

Process-based fluvial geomorphology is undergoing a paradigm shift in which new scientific discoveries increasingly stem from "near-census" maps of rivers and river change along with comparably detailed and expansive predictive models of hydrodynamics and/or morphodynamics. "Near-census" analysis involves the use of densely gridded data at ~1-m resolution over long river segments (~10-100 km) as opposed to the traditional standard of limited statistical sampling with transects or intensive reference-site analysis. Near-census, sub-meter physical data that are rapidly emerging at low cost include color aerial imagery, airborne LiDAR of terrestrial bare earth, water surfaces, and plant-canopy tops, survey-grade bathymetric echosounding, boat-based surface velocity tracking, image-based extraction of bed material particle size distributions on terrestrial land and through clear water, and image-based extraction of streamwood deposits. Near-census data may be used to drive 2D and 3D hydrodynamic models that yield near-census predictions of flow patterns with reasonable accuracy. Together, data and model results can be analyzed using emerging methods to map and uncover the complex patterns of river-corridor landforms at different spatial scales. Then, geomorphic processes and ecological functions (including habitats for specific species' lifestages) can be analyzed relative to the landforms at each scale. The end result is a comprehensive assessment of the status of the flow-dependent aspects of a river with tools in hand to answer specific management questions and guide engineering design of technical solutions to identified problems. These topics will be illustrated with examples. To support academic and professional training in near-census analysis, a new textbook titled "2D Modeling and Ecohydraulic Analysis" is now available.

### *SELFE 3D Application to the Sacramento-San Joaquin Bay Delta* – Eli Ateljevich (DWR)

The Bay-Delta SELFE project is an application of the Semi-Implicit Eulerian-Lagrangian Finite Element model to the Bay-Delta and near coastal shelf. The talk will discuss the expansion of the model this year from the Bay to the full Bay-Delta. We will discuss Delta-specific code enhancements (e.g. hydraulic structures), data development, and calibration results. We will discuss a cross-scale ROMS-SELFE application to fisheries as well as a comparison to DSM2 describing the flow field on a flooded island. We also list some of the challenges imposed by the algorithm and domain.

### *Development of the SUNTANS Model for the Sacramento-San Joaquin Delta* **1.9 MB**
### Nancy Monsen (Stanford University)

We are developing the SUNTANS hydrodynamic model for the Sacramento-San Joaquin Delta region. We will discuss the current calibration and the next steps planned for the model. In addition to the SUNTANS specific issues, we will also discuss overarching, long-standing issues that every hydrodynamic model of the Delta needs to address including the quality and availability of bathymetric data, stage benchmarks throughout the region, and the quality of information about gate and pump operations. We will present modeling results from SUNTANS to demonstrate why these long standing issues are important for representing transport and mixing in the Delta.

Additional contributors: Phillip Wolfram, Karla Gleichauf, Oliver Fringer, and Stephen G. Monismith (Stanford University)

### *Computing Secondary Flows in the Delta: The Problem of Noise on Unstructured C-grids*

### Phil Wolfram (Stanford University) **4.3 MB**

Hydrodynamic solutions of tidal river flows on unstructured, Finite-Volume C-grid solvers, such as SUNTANS and UnTRIM, are generally well accepted. However, recent results by Wolfram and Fringer (2013, in revision) have demonstrated the inability of the unstructured triangular C-grid to accurately reproduce secondary flows. This is due to feedback of errors in computing the horizontal divergence, which is intrinsic to the triangular C-grid (Danilov, 2010; Gassmann, 2011). Consequently, application of existing triangular C-grid hydrodynamic solvers to tidal river junctions, where small-scale processes such as mixing layers may dominate mixing, is suspect.

We assess filtering needs to reproduce secondary flow features on triangular and hexagonal C-grids for the case of a curved channel. The results are extended to Georgiana Slough (GS), a representative field site due to relative geometric simplicity and ease of access for field measurements. GS is comprised of four channels characterizing confluence and diffluence behavior that exhibits flow separation, secondary circulation, and mixing zones. Accurate computation of horizontal divergence and corresponding vertical velocities are consequently key. These results suggest that existing hydrodynamic solvers are unable to reproduce secondary flows and may ignore important effects of junction-scale flow features on network dispersion unless a filter is employed. Understanding how junction mixing affects network dispersion is vital towards improvement of modeling efforts to simulate and analyze the effects of Delta management operations.


Danilov, S., 2010. On utility of triangular C-grid type discretization for numerical modeling of large-scale ocean flows. Ocean Dynamics 60, 1361-1369.

Gassmann, A., 2011. Inspection of hexagonal and triangular C-grid discretizations of the shallow water equations. Journal of Computational Physics 230, 2706-2721.

Wolfram, P., Fringer, O.B., 2013, in revision. Mitigating horizontal divergence 'checkerboard' oscillations on unstructured triangular cgrids for nonlinear hydrostatic and nonhydrostatic flows. Ocean Modelling X, Z.


Additional contributors: Oliver Fringer, Nancy Monsen, Karla Gleichauf, and Stephen G. Monismith (Stanford University)

## Session 4. Linking Delta Water Quality Modeling to Regulations and Monitoring

***U.S. Geological Survey SPARROW Model: Integrating Monitoring Data with Landscape Information to Understand Nitrogen and Phosphorus Sources, Transport and Fate in California Streams*** **– Dina Saleh (USGS)** **8.4 MB**

Sources and factors affecting the transport of nitrogen and phosphorus are being evaluated for most of California and some areas in Oregon, using the SPARROW model (SPAtially Referenced Regression On Watershed attributes). Nitrogen and total phosphorus loads calculated at monitoring sites are regressed against landscape factors that affect environmental occurrence and fate (point sources, land use or cover, fertilizer use, recharge, atmospheric deposition, soil and stream characteristics, and others). This calibration is completed for a base year. The calibration is then used to predict loads at un-monitored reaches, which are the majority of stream segments.

SPARROW models are being used in other parts of the country as a management tool for nutrient control. A new version of the model, Dynamic SPARROW, is being developed for the Chesapeake Bay. This version will likely have utility for understanding nutrient transport to the Delta and San Francisco Bay, as it incorporates seasonality in the transport equations, and can be used to predict watershed loads based on changes in land use, streamflow, or climate. This presentation will describe how both versions can provide useful modeling tools for regulating nutrient sources to the Delta and designing regional monitoring programs in the Delta and its watershed.

Additional contributor: Joseph Domagalski (USGS)

***Mercury and Dissolved Oxygen Processes in Suisun Marsh*** **– Philip Bachand (Tetra Tech)** **2 MB**

Habitat restoration in Suisun Marsh, west of the Delta, is presented in the Bay Delta Conservation Plan alternatives. The Marsh exhibits low dissolved oxygen (DO) in its sloughs and elevated methylmercury (MeHg) concentrations in fish. Restoring managed wetlands to fully tidal wetlands will likely affect water quality; more information is needed for informed restoration strategies, regulation and monitoring. The 70-acre Blacklock Wetland, breached in 2006 to convert it from muted to fully tidal marsh, provides such information. Pre- and post-breach data collected include soil, biota, fish and water MeHg samples, hydrology and ancillary field measurements. The breach increased high tide marsh water volumes by 25%; increased tidal exchange by 25 times; and lowered MeHg concentrations 90% in the wetland and about 60-80% in the adjacent slough. Hydrology rather than biogeochemistry appear to be the primary factor resulting in lower MeHg concentrations. Net MeHg loads were slightly higher for the full tidal marsh than for the muted tidal marsh, though the differences were not statistically significant. MeHg loads were highest during the transition from muted to fully tidal system. Because the fully tidal marsh greatly decreases MeHg concentrations, it potentially has benefits for fish by decreasing spatial and temporal MeHg hotspots.

Additional contributors: Dan Gillenwater and Stuart Siegel (Wetlands and Water Resources)

***Dye Studies and Modeling to Characterize the Fate of Effluent from the City of Vacaville in the Delta*** **– Susan Paulsen (Flow Science)** **6 MB**

The City of Vacaville's Easterly Wastewater Treatment Plant (EWWTP) discharges treated effluent to Old Alamo Creek, which flows into New Alamo Creek, Ulatis Creek, and Cache Slough. Five dye studies conducted in 2011 characterized the transport and dilution of EWWTP effluent in the creeks and Delta in various seasons. The studies will be used to support the EWWTP NPDES permit renewal application.
In March and July 2011 studies, dye was released with the EWWTP discharge to the creek system for several days. Dye concentrations and flow data collected in the creek system showed that dilution of the EWWTP effluent at Ulatis Creek (downstream of Brown Road) was approximately 20:1 to 50:1 in the March study and 11:1 in the July study, and showed the impact of agricultural diversions.

In April, August, and November 2011, dye was released into Ulatis Creek at Cache Slough for twelve hours. Dye concentrations were measured using both boat-mounted and fixed instruments in Cache, Lindsey, and Barker Sloughs. Dye concentrations were consistently at background levels (<1 ppb) at French Island and at Lindsey and

Barker Sloughs. Results were used to validate the DSM2 model, which simulated the fate of the discharge over longer time periods.

Additional contributors: Gang Zhao, Al Preston, and Aaron Mead (Flow Science); Tony Pirondini (City of Vacaville); Rhys McDonald (Brown and Caldwell)

***Delta Water Quality Modeling and Development of a Numeric Nutrient Endpoint Framework for San Francisco Bay*** **– Andy Stoddard (Dynamic Solutions)** **6 MB**

As part of an effort to develop Numeric Nutrient Endpoints (NNE), the San Francisco Bay Regional Water Quality Control Board is working with the State Water Resources Control Board to develop a NNE framework for San Francisco Bay. The framework will include numerical models to describe cause-effect interactions between nutrient inputs, regulatory controls, and numeric endpoints.

With support from DWR and the Corps of Engineers Sacramento District, 3D models of the Sacramento-San Joaquin Delta have been developed with the Environmental Fluid Dynamics Code (EFDC). The Delta water quality model includes Suisun Bay, the Delta, the Sacramento River (Verona) and the San Joaquin River at Vernalis. The Bay-Delta hydrodynamic model extended the Delta domain to San Pablo Bay, San Francisco Bay and the ocean for sea level rise analyses.

A Bay-Delta water quality model is needed to evaluate the effects of regulatory controls. The investment in the EFDC models can be leveraged to develop a Bay-Delta water quality model to support the NNE framework. Data sources and model results will be presented to show validation to data collected in 2003-2004. To inform monitoring programs, additional data sources needed for development of a Bay-Delta water quality model to support the NNE framework will also be presented.

Additional contributors: Silong Lu, Paul Craig, Christopher Wallen, Zhijun Liu, and William McAnally (Dynamic Solutions); Eugene Maak (US Army Corps of Engineers)

## Session 5. Keynote Speaker

***History of Great Lakes Modeling in Support of Resource Management Decisions*** **4 MB**
**Joseph DePinto (LimnoTech)**

The International Association for Great Lakes Research (IAGLR) (www.iaglr.org) is a scientific organization with about 1000 members from academia, government, and the private sector with the goal of studying the Laurentian Great Lakes, other large lakes of the world, and their watersheds. IAGLR members encompass all scientific disciplines with a common interest in the management of large lake ecosystems on many levels. I will by giving a brief introduction of how IAGLR functions (membership, meetings, structure) to give CWEMF members information to consider during their strategic planning. I will then focus on how models developed by the Great Lakes research and management community have supported policy and management decisions relative to various issues through the years following the initial signing of the Great Lakes Water Quality Agreement in 1972. These would include: eutrophication models for establishment of phosphorus target loads in the late 1970s; toxics models in the 1980's and 1990's; fishery management models in the 1980's and 1990's; models for establishment of water level and flow regulation in the 2000's; and fine-scale integrated models to address the re-eutrophication of the Great Lakes beginning in the mid-1990’s due to invasive species, changes in phosphorus loads, and changes in nearshore ecosystem functioning.

## Session 6. Developments and Applications of CalSim and CalLite – Part II

***San Joaquin Basin Model Resolution - CalSim3 and CalLite*** **– Nancy Parker (Reclamation)**

**0.4 MB**

The San Joaquin River was first integrated dynamically in CVP/SWP planning modeling with the development of CalSim. An initial implementation was a port of the SANJASM and StanMod codes, a 2003 update introduced land-use-based demand representation on the Eastside, and a 2005 effort migrated from the Kratzer equation to a mass-balance approach for determining Vernalis water quality. Recent efforts have addressed modeling the San Joaquin at the coarser resolution of CalLite and the finer resolution of CalSim3. Progress on this model development will be presented.

***Los Vaqueros Enlargement – CalSim Application*** **– Dan Easton (MBK)**

A WRIMS based model of Contra Costa Water District's diversion, storage, and conveyance system was developed for the Los Vaqueros Reservoir Expansion Final EIR/EIS operations analysis. The model was developed to run in stand-alone mode or as an integrated part of CalSim. Diversion and storage operational decisions are based on service area demand, service area and storage salinity targets, and Delta salinity conditions. The presentation will describe key infrastructure, operating rules, and regulatory constraints and outline the CCWD system operations algorithm. Results from the Los Vaqueros Reservoir Expansion Final EIR/EIS operations analysis will be discussed.

***Temperature Model Development for CalSim and CalLite*** **– En-Ching Hsu (DWR)** **1 MB**

The purpose of this study is to integrate a temperature model into CalSim and CalLite. The temperature model adopted here is SRWQM (Sacramento River Water Quality Model), which is a daily model with TCD (temperature control device) operation. A simple reservoir system around Lake Shasta is designed for testing. The reservoir itself is divided into four layers and temperature is estimated based on given inputs: air temperature, solar radiation, storage, and inflow. An Artificial neural network (ANN) is utilized to capture the behavior of SRWQM. The estimated temperature from CalLite matches the results from SRWQM well. This new module adds the capability to evaluate the impacts on water temperature while varying water system operation.

***Development of CalLite Hydrology Based on CalSimHydro*** **– Richard Chen (DWR)** **0.4 MB**

A methodology is being developed to generate hydrology inputs to CalLite based CalSimHydro outputs directly. The current hydrology inputs to CalLite are based the CalSim II inputs and outputs. However, any change in hydrology requires a rerun of CalSim II in order to update the CalLite hydrology input file. CalSimHydro was originally designed to automate the various steps in the computation of hydrologic inputs for CalSim 3.0. CalSimHydro is capable of generating rainfall runoff, deep percolation, irrigation demands, and irrigation return flow under various land use conditions and various climate scenarios. By using CalSimHydro outputs directly, more hydrologic scenarios can be simulated by CalLite efficiently. The methodology, preliminary testing results, and technique issues will be discussed in the presentation.

## Session 7. Sediment Transport and Channel Morphology with Spatially Resolved Models, Approaches, Applications, and Analysis

***Suspended Sediment Transport and Geomorphic Processes at a Breached Delta Island***

**Edward Divita (ESA PWA)** **3.6 MB**

Long-term planning for the Delta has identified habitat restoration as a key element for reconciling human impacts with ecosystem function in the Delta. However, the linkages between physical processes and the resulting habitat evolution are not well understood. As part of the BREACH III project team, we have developed hydrodynamic, wind-wave, and sediment transport models for Liberty Island, a former diked area now breached to restore flow, to understand these linkages. We have represented the northwest portion of the Delta, encompassing Liberty Island and surrounding channels, with a two-dimensional hydrodynamic model (Delft3D) coupled with a wind-wave model (SWAN). These two models are used to predict the re-suspension, transport, and deposition of suspended sediment. The models are forced with a range of inputs, including tides, wind, and river discharge, including the Yolo Bypass. By analyzing the predicted response to different forcing conditions and ambient sediment conditions, we assess the relative role of different forcing mechanisms (wind-waves, channel-mudflat connectivity, and the Yolo Bypass) to creating the elevated suspended sediment conditions in the region and the trends in geomorphic change.

Additional contributors: Matt Brennan and Steve Crooks (ESA PWA)

***Investigating Sediment Routing during the 2011 First Flush Using the UnTRIM Bay-Delta Hydrodynamic, Wave, and Sediment Transport Modeling System***
**Aaron Bever (Delta Modeling Associates)**

The UnTRIM San Francisco Bay-Delta model has been coupled to the SWAN wave model and the SediMorph seabed morphology model to create a fully three-dimensional hydrodynamic, wave, and sediment transport modeling system. Sediment is initialized using a spatially varying initial sediment bed and input through nine Bay and Delta tributaries. The time period of December 2010 through July 2011 is simulated, such that the 2011 "first flush" from the Delta and another larger discharge period in March-April 2011 are modeled. A mass balance approach is used to investigate sediment routing in the Delta to identify regions that may be net depositional or erosional during the simulated time period. The modeled sediment flux past Mallard Island is used to estimate the percentage of the tributary sediment input deposited within the Delta.

Additional contributor: Michael L. MacWilliams

***Creation of Salmon Habitat on the Sacramento River: How Multidimensional Modeling and Sediment Transport Data Aid the Design Process*** **– Paul Frank (New Fields)** **7 MB**

Removal of a large seasonal agricultural diversion dam on the Sacramento River and replacement with a fish screened-pump station was recently completed at Red Bluff, California. Mitigation for construction impacts included creation of a new three-quarter mile long perennial channel adjacent to the river in a floodplain slough historically used for boating and other recreation. We developed 2-D hydrodynamic and sediment transport models of 4 miles of the Sacramento River and its floodplain system to aid design of the new channel. Multiple iterations of modeling and channel designs were performed to satisfy project objectives including timing and quantity of hydraulic interaction with the Sacramento River, inlets and channel geometry that would provide a range of suitable habitat types, and sediment transport characteristics that would promote desired bed substrates and minimize maintenance needs. This presentation will describe the modeling approach, design process, and lessons learned.

Additional contributor: Mark Tompkins

# Session 8. Central Valley Project Integrated Resource Plan - Integrating Socioeconomic and Climate Uncertainties in Long Range Planning

***Central Valley Project Integrated Resource Plan - Project Overview*** **0.4 MB**
**Mike Tansey (Reclamation)**

The Central Valley Project Integrated Resource Plan (CVP IRP) study continues the long-range planning activities of the Central Valley Project Yield Feasibility Investigation by addressing future uncertainties in climate as well as changing socioeconomic conditions. To better understand future challenges, the CVP IRP study focuses on providing more comprehensive assessments of potential climatic and socioeconomic uncertainties for the entire CVP Service Area and each of the CVP Divisions. The CVP IRP study employed a scenario-based analytical approach. Future socioeconomic-climate uncertainties were characterized by combining three potential socioeconomic and six representative climate futures to form 18 future scenarios. Each scenario was simulated with conditions continuously changing from present day to the end of the 21st century. Existing operational, hydrologic, water quality, hydropower, urban and agricultural economic models were integrated into a suite of decision support tools for assessing the effects of future socioeconomic-climate uncertainties on the coordinated operations of the CVP and State Water Project (SWP) system as well as other Central Valley non-project water management systems under current regulatory requirements. The study also explored various portfolios of system wide and local water management actions that might be employed to adapt to potential twenty-first century challenges. These strategies were evaluated against key CVP performance criteria to compare their potential effectiveness under a broad range of future socioeconomic-climate uncertainties, and to identify tradeoffs among various delivery reliability, water quality, environmental, hydropower, and urban and agricultural economic performance characteristics.

***Development of the Socioeconomic and Climate Scenarios*** **3.1 MB**
**Tapash Das (CH2M Hill) and Mike Tansey (Reclamation)**

To account for a range of uncertainty in future conditions, the CVP IRP characterized three potential socioeconomic futures and six representative climate futures for a total of 18 future scenarios. Each scenario was simulated using a transient approach for the period from 2011-2099. The CVP IRP used slow growth, current trends, and expansive growth socioeconomic future scenarios developed as part of the California Water Plan Update 2009 and extended the population and land use projections for these scenarios through the end of the century. One historical and five statistically representative future climate projections were developed from an ensemble of 112 bias corrected spatially downscaled global climate model (GCM) simulations to characterize the central tendency and the range of the ensemble uncertainty including projections representing drier, less warming; drier, more warming; wetter, more warming; and wetter, less warming conditions than the median projection. The observed natural variability in the historic climate between 1915 and 2003 was used to create the same inter-annual variability in the projected climates. Transient sea level rise projections corresponding with projected climate changes were also developed for the Sacramento-San Joaquin Delta. Finally, the effects of climate changes on water demands were analyzed using projections of changes in temperature, precipitation to estimate corresponding changes in solar radiation, atmospheric humidity, and wind speed to evaluate changes in evapotranspiration (ET) of major crops grown in the Central Valley.

***Development and Application of the CVP IRP CalLite Model*** **3.1 MB**
**Brian Van Lienden and Derya Sumer (CH2M Hill)**

CVP IRP CalLite is an interactive screening model that allows for rapid evaluation of different water management alternatives. CalLite simulates the hydrology of the Central Valley, reservoir operations, SWP and CVP project operations and delivery allocation decisions, Delta salinity responses using ANN's to river flow and export changes, and habitat-ecosystem indices. For the CVP IRP, the model has been expanded to include the San Joaquin River and Tulare Lake regions and to incorporate climate-based surface water and groundwater hydrology and local agricultural and urban demand estimates developed by the Central Valley WEAP model. The CVP IRP used the CVP IRP CalLite model to perform simulations of 18 socioeconomic-climate scenarios for a Baseline condition and for portfolios of potential systemwide and local water management actions. For each action, the model produces a supply-demand balance within each CVP Division and systemwide outputs relating to flow, storage, and salinity in the SWP, CVP, and the Delta. These results were used to perform trade-off analyses between the potential actions.

***Development and Application of Other CVP IRP Performance Assessment Models***

**Chandra Chilmakuri, Lucas Bair, and Brian Van Lienden (CH2M Hill)** **2 MB**

The portfolios of water management actions were evaluated for water temperature, agricultural and urban economics, hydropower, and GHGs impacts over the range of future socioeconomic climate scenarios. This presentation describes the development and application of this suite of additional modeling tools as part of the CVP IRP's integrated model package. The economics models include the Least Cost Planning Simulation Model (LCPSIM), Statewide Agricultural Production Model (SWAP), Other Municipal Water Economics Model (OMWEM), and the South Bay Water Quality Model (SBWQM). Each economics model was developed and simulated for 3 socioeconomic scenarios (Strategic Growth, Current Trends, and Expansive Growth) at 3 points in time (2025, 2055 and 2085). In addition, the effects of climate change on agricultural production were incorporated into the SWAP analysis. Reservoir and river temperatures under each scenario were simulated using the HEC5Q models developed for the Sacramento River (2002) and San Joaquin River systems (2007), which were modified by the CVP IRP to simulate temperatures using CALLITE reservoir operations and river flows as inputs and to allow simulation of water temperatures over an 88-year period under varying meteorological conditions. LTGen and SWP_Power were used to perform power generation and use analysis for the CVP and SWP systems. These models were enhanced by the CVP IRP to estimate the GHG emissions changes related to CVP and SWP power and pumping facilities.

***Project Summary and Next Steps*** **– Armin Munevar (CH2M Hill) and Arlan Nickel (Reclamation)**

**1 MB**

The CVP IRP study demonstrated how the combined effects of socioeconomic and climate uncertainties can be effectively incorporated into long range planning using a suite of integrated models to assess impacts and evaluate adaptation strategies. However, additional improvements in the modeling approach and tools can be accomplished in future studies. The Sacramento-San Joaquin Basins Study is one such opportunity. A brief description of the purpose, objectives, and opportunities this new partnership between Reclamation and Central Valley stakeholders will be described.

## Session 9. Rising Above and Seeing from Afar: Remote Sensing and Modeling

***Data as a Resource – Automated Monitoring and Data Libraries Create Rich Data Sets***

**Jeffrey N. Schuyler (Eyasco)** **2.6 MB**

In 2006 Solano County Water Agency began to install automated monitoring systems and a telemetry network to monitor environmental conditions and operational parameters throughout the County in a "real-time" mode. Since then the number of automated monitoring stations has grown to over 60 and includes monitoring applications in flood warning, canal and dam operations, river and groundwater conditions, and water quality information. The data collected from such a diverse range of sensors and wide ranging applications has been inventoried and managed by a relational database tool called Merlin Resource Manager (MRM), which also includes QA/QC, web visualization, and reporting tools. The commitment to building an "end-to-end" data monitoring and inventory solution from the beginning has saved SCWA personnel countless hours in data manipulation, annotation and management, allowing them to focus on resource management rather than data 'crunching.' Currently other data sources such as government (CDEC and USGS), hand-entered operational data, laboratory test results, water usage reported by customers, biological data and field notes are being integrated into MRM with the monitoring data to create a rich data resource for managers and analysts. This "data library" allows a user to rapidly visualize large data sets, to collect them into an aggregate form, then filter and process the data to normalize date ranges and time steps for graphical reports, data analysis, and modeling.

Additional contributors: Thomas Pate and Jay Cuetara (Solano County Water Agency)

**[*Improvement of DETAW and its Application to the DSM2 Historical Simulation*]** 1.6 MB

**Lan Liang (DWR)**

Delta Evapotranspiration of Applied Water (DETAW) version 1.0 crop coefficients were calibrated and validated using 2007 and 2009 data from the Surface Energy Balance Algorithm for Land (SEBAL), which quantified the actual ET by the water balance modeling with multispectral satellite imagery. DETAW generates total consumptive use and water supplied by irrigation, rainfall and seepage on each of 168 regions in the Delta using both daily and monthly time steps.

Diversion and return flows are assigned to DSM2 nodes taking into account a Delta-wide irrigation efficiency and using allocation factors found in the Delta Island Consumptive Use model (DICU). DETAW-generated diversions and returns were then used by DSM2 to simulate historical Delta hydrodynamics and water quality. Results were compared to observed and DSM2-DICU simulated data. Implications for a recalibration of DSM2 and daily versus monthly consumptive use values are discussed.

***Multiple Uses for Aerial LiDAR Data Sets throughout All Stages of Floodplain Restoration Projects*** **– Andrew Nichols (UC Davis)** 5 MB

Landscape-scale ecological patterns on floodplains largely depend on small topographic and hydrologic gradients. For example micro-topography generated through floodplain deposition processes can determine where riparian forests grow, while small differences in flood inundation timing and duration govern the regeneration success of individual tree species. With floodplain restoration projects often extending over large areas, remotely-sensed, high-resolution topographic data are critical for accurately characterizing floodplain topography, identifying restoration objectives, and monitoring change. On the Cosumnes River floodplain of central California, aerial Light Detection and Ranging (LiDAR) data have been critical throughout the restoration planning and monitoring processes. During planning periods, the detailed topographic data set has enabled the development of hydraulic models for flood routing, while also allowing a landscape-scale view of topographic gradients critical to understanding historical trends in floodplain form and process. During periods of project monitoring, LiDAR data have provided a baseline data set from which to monitor changes in floodplain topography and vegetation growth. The multiple uses of aerial LiDAR data make it a valuable tool for floodplain researchers across many disciplines, and should be considered early in the planning stages of any floodplain restoration project.

***Physically Based Modeling of Delta Island Consumptive Use: A Case Study of Fabian Tract and Staten Island*** **– Lucas Siegfried (UC Davis)** 10 MB

Continuous water diversions, water operations, and land-use changes in the Delta have affected Delta water flows, quality, and suitability for native fish species. Knowledge and understanding of the flows in Delta rivers, channels, and streams is crucial to solve the Delta's many problems. In an on-going effort to better understand and manage the Delta, a collaborative, integrated approach was used to predict internal Delta Island Consumptive Use of water (DICU) values and water quality variables on a higher resolution and base diversion and return locations on current high-resolution topography rather than past approximations. The Delta islands known as Fabian Tract and Staten Island were selected for this study based on available data and island accessibility. A combination of historical diversion and return location data, water rights claims, and LIDAR digital elevation model data were used to predict island diversion and return locations.

Predicted diversion and return location accuracy was analyzed and improved through ground-truthing. Soil and land-use characteristics as well as weather data were incorporated with the IWFM Demand Calculator (IDC) to calculate water requirements and runoff returns from agricultural land-use. IDC was selected because of model capabilities, ease of use, applicability, and recommendations. As input to the IDC model, Fabian Tract and Staten Island were divided into grid cells forming subregions, representing fields, levees, ditches, and roads.

The subregions were joined to form diversion and return watersheds representing the total area supplied by, or returning to, a given water source. Diversion and return volumes were limited to physical abilities of the systems. Model results provide daily estimates of the volume of water diverted and returned from actual diversion and return locations, providing insights into daily agricultural diversion and return operations within the Delta that are missed in DICU models and supporting sustainable solutions for the problems of the Delta.

***Field-scale Modeling of the Yolo Bypass*** **– William Fleenor (UC Davis)** **5.6 MB**

To examine possibilities of managing flooding on the Yolo Bypass, a detailed 2-dimenisonal model was produced with RMA2. The resulting model is used to examine various scenarios of how different areas of the bypass could be flooded to enhance habitat without unduly compromising agricultural production

***The Hobbes Project*** **– Josué Medellín-Azuara (UC Davis)** **2.4 MB**

The Hobbes Project for water resources modeling in California is to develop an open, organized, and documented repository for the state's intertied water supply system. Features for Hobbes include a standardized geocoded database, a multi-tiered database set of elements to create higher and lower resolution networks and sub-networks, and a streamlined migration to other simulation and optimization frameworks with a focus on database structure, organization, and documentation. Modeling inputs and outputs will be visualized in commonly used mapping applications and in conventional tabular and compressed formats.

## Session 11. Highlights from the Modeling Trenches

***San Joaquin River Restoration Program Use of Modeling Tools and Real-time Monitoring to Guide Restoration Flow Management*** **– Scott McBain (McBain & Trush)** **1.4 MB**

The San Joaquin River Settlement Agreement, signed in 2006, directs the Restoration Administrator to recommend to the Secretary of Interior annual Restoration Flows to achieve the Restoration Goal in the Settlement Agreement. The Restoration Flows are intended to satisfy a range of ecological objectives, including spring-run and fall-run Chinook salmon restoration, riparian habitat restoration, geomorphic processes, and others. The Restoration Administrator, in consultation with a Technical Advisory Committee, develops annual Restoration Flow recommendations, and adjusts flows during “flexible flow” periods to accommodate changing hydrologic, meteorological, and biological conditions along the river. The SJRRP has developed a number of modeling tools and real-time monitoring activities to help develop these flow recommendations, and planning is underway to expand the real-time monitoring activities to include biological objectives. This presentation will provide an overview of modeling tools, analytical tools, and monitoring information currently being used, and discuss how these tools are being used to inform flow management recommendations.

## *Hydraulic Modeling to Support Floodplain Habitat Assessment for the SJRRP* 4 MB

**Blair Greimann (Reclamation)**

Meeting the Restoration Goal for the San Joaquin River Restoration Program (SJRRP) includes development of channel and structural improvements, release of flows, and reintroduction of Chinook salmon. Two of the identified channel and structural improvements in the Settlement include floodplain habitat. Fish need floodplain habitat in order to grow and develop (rear) as they move downstream (emigrate) from the Restoration area. To quantify the amount of required additional floodplain habitat within the Restoration area, it was first necessary to quantify the amount of floodplain habitat needed to accomplish the Restoration Goal and the amount of existing habitat. This talk will present the quantification of the existing floodplain habitat for the SJRRP and the analysis methods that will be used to estimate the changes to the hydraulic and sediment transport conditions resulting from creating additional floodplain habitat. A two-dimensional hydraulic and sediment transport model (SRH-2D) was used to estimate the depth and velocity over approximately 100 miles of the San Joaquin River. The reach was divided into several separate models to decrease computational time and make the terrain datasets more manageable. Habitat Suitability Indices (HSI) were applied to depth and velocity output from the model, and then cover suitability was estimated using vegetation mapping of the river corridor.

Once the amount of required additional habitat is quantified, it will be necessary to then develop projects to create new habitat and/or improve the quality of the existing habitat. One of the primary means by which fish habitat may be improved is the establishment or alteration of the floodplain vegetation. However, vegetation changes could significantly alter the hydraulic roughness and change the sediment transport characteristics. Measured water surfaces profiles and vegetation characteristics in reaches of dense and sparse vegetation will be used to determine the best methodology for representing vegetation roughness. The effect of vegetation on sediment transport processes is less understood and few data specific to this process exist. Strategies for incorporating the effect of vegetation on sediment transport are reviewed and potential implementation strategies are suggested for use in SRH-2D.

Additional contributors: Daniel Dombroski and Elaina Gordon (Reclamation)

## *Virtuous Data Management for Decision Support Tools: Examples from IOOS and CUAHSI*

**Tad Slaweki (LimnoTech)** 3.4 MB

Resource management decisions generally are better when more data are available and used. A frequent barrier to effective use in decision support of today's wide array of research and monitoring data is the difficulty of discovery. Many agencies and research programs hold extensive collections of potentially useful data whose existence is not widely appreciated. One approach to increasing the discoverability (and transparency) of datasets is to develop and publish descriptive metadata that document the who, what, when, where, why, and how of data collection for each study. Publication of standards-compliant metadata through portals like the Global Earth Observation System of Systems (GEOSS) provides stakeholders everywhere with the opportunity to find datasets and evaluate their utility. Interoperability - furnishing the data as well in a standards-compliant fashion for direct access - is an additional best practice that makes use of the data that much easier. Examples of standards-based discoverability, transparency, and interoperability will be presented from NOAA's Integrated Ocean Observing System (IOOS) and from the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) program. The examples will lay out a vision for effective data management that, although not inexpensive, can be the right approach for supporting complex decisions.

## *Bathymetry for Bay-Delta Modeling* – Rueen-Fang Wang (DWR) 13 MB

Bed elevation is an important input to any hydrodynamic model, and the DWR Delta Modeling Section has maintained a database of bathymetry information for decades. In recent years, we have developed a special bathymetry product to support our multidimensional modeling effort. This product is a set of mutually consistent 10m and 2m integrated elevation maps (DEM), developed by synthesizing LiDAR, single- and multibeam-sonar soundings and surveys and integrating them with existing integrated maps that themselves were collated from multiple sources. We just released an updated version, available for download at http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/modelingdata/DEM.cfm.

In this presentation, we will introduce our product, focusing on the important role of the newly available multibeam bathymetry datasets. We will discuss the strength and weakness of these high-quality and high-resolution datasets with respect to traditional sparse data. We will talk about the techniques and methodologies we used to resolve the associated difficulties. We also will mention the data sources used and other similar bathymetry products. Finally, we will talk about collaboration with similar efforts and future plans.

Additional contributor: Eli Ateljevich (DWR)

***Groundwater Overdraft in California's Central Valley: Updated CALVIN Modeling Using Recent CVHM and C2VSIM Representations (UC Davis)*** **– Heidi Chou (CH2MHill)** **5 MB**

Updates have been made to the California Value Integrated Network (CALVIN) hydro-economic optimization model of California's integrated water supply and delivery system. These updates better reflect water demands, groundwater availability, and local water management opportunities. This update project focused on improving groundwater representation in CALVIN, which included updating CALVIN groundwater parameters to reflect inputs and results from the California Department of Water Resources' (DWR) California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the United States Geological Survey (USGS) Central Valley Hydrologic Model (CVHM) model. Using these models, a CALVIN model with updated groundwater representation now exists. In addition, the updated CALVIN model was used to study the effects of different cases of overdraft on Central Valley groundwater basins. The background, methods, and results associated with this analysis are summarized in this presentation.

## Session 12. Reconciling Flood Risk and Improved Ecosystems: Consideration of Plant Structure in Flood Modeling

***Introduction*** **– Stefan Lorenzato (DWR)**

***Making the Connections between Riparian Vegetation and Flow Conveyance in Reconciliation Design*** **– Chris Bowles (cbec)** **9 MB**

Hydraulic (steady state) models have historically been used to analyze the impacts of vegetation to flood flow conveyance. Increasingly, hydrodynamic (unsteady state) models have been used in recent years to not only analyze the potentially restrictive nature of vegetation, but also to optimize the use of vegetation for ecosystem enhancement and to minimize erosion and other detrimental effects of flood flows through the full hydrograph. The use of conceptual models and habitat evaluation criteria are linked to hydrodynamic modeling results in order to create linkages between physical conditions and ecological response. 2- and 3-dimensional hydrodynamic models are rapidly superseding 1-dimensional models in multi-objective floodplain management and planning. In addition, improvements in computational power has meant that sediment transport modeling is now becoming more frequently linked to hydrodynamic modeling in order to assess the effect of vegetation on sedimentation patterns. Case studies are provided on the Feather, Yuba, and Sacramento Rivers to demonstrate how physical predictions with linkages to ecological response can be made using the latest tools at our disposal.

Additional contributors: Chris Hammersmark and Chris Campbell (cbec)

***Floodplain Vegetation Structure: Important Considerations for Multi-benefit Projects***

**Tom Griggs (River Partners)** **10 MB**

Given rich soil, a soil water-table within the reach of plant roots, and the warm, dry, bright climate of the Central Valley, plants of all kinds can grow in the Floodway. This riparian vegetation in the floodway creates flow resistance, and is described in flood models as roughness or Manning's n. Historically vegetation's Manning's n values have been averaged across transects in floodways and calculated for high flow events. This approach has limited our ability to manage vegetation within the floodway. From the perspective of hydraulic roughness all vegetation is not created equal – plants exhibit low, medium, and high flow resistance for both native and non-native species. Working with MBK River Partners has developed Manning's n values for native plant communities in the Central Valley. What we learned is roughness is only an issue in high velocity areas of the floodplain. A high density of rigid stems creates turbulence in the water column, increasing roughness and slowing velocity. A low density of rigid stems does not create enough turbulence to slow velocity. Flexible stems at high densities can reduce turbulence and improve conveyance. Results from a study in a large flume showed that four species of flexible-stemmed plants – Sandbar willow, blackberry, rose, mulefat – modified the velocity profile of the flow such that velocity slowed under the plants' canopies, and increased over the top of the canopy. There was no reduction in conveyance capacity in the flume study with flexible stem plants.

From a management perspective, riparian vegetation is quantifiable and predictable because it is successional. Stem density decreases over time and stem rigidity (basal area) can increase over time. Soils can "lock in" plant communities – trees will not grow everywhere in the floodplain. Flood model performance can be improved if these plant characteristics are taken into account. Ultimately flood risk can be reduced by better understanding and use of plants.

***Central Valley Flood Operations*** **– Nate Burley and Christy Jones (UC Davis)** **0.6 MB**

This presentation covers an update to a linear program model of the Sacramento Valley flood system originally developed by David Ford. It includes five flood control reservoirs and the river and bypass network downstream. Piece-wise linear flood damage functions, Muskingum routing and weir functions are used to optimize system operations for very large runoff events. The linear programming formulation has limitations such as perfect foresight and interaction of economic penalties with physical penalties (both represented with dollar values), but it does provide insights. The value of expanding capacity for river reaches and bypasses is accessible as well as flood damage reduction benefits of joint reservoir operations.

## Session 14. Poster Session

***DSM2 Version 8.1 Calibration with NAVD88 Datum*** **– Lianwu Liu (DWR)**

Version 8.1 incorporates latest improvements to DSM2 code. The main updates in this new version include: DSM2-Qual model formulation change to improve model convergence, documented in Chapter 1 of the 2011 Annual Progress Report: modifications to the DSM2-Hydro program source code that improve channel geometry calculation, documented in Chapter 2 of the 2012 Annual Progress Report; datum conversion to NAVD88. The new Hydro has also been improved to run 3 times faster as compared to the previous version.

A new calibration effort was undertaken as a result of these changes. It was based on the 2009 BDCP calibration grid which has been converted to NAVD88 datum. Data errors in Clifton Court Gate operation data, Martinez stage and EC data were corrected. This calibration was done mainly by adjusting Manning's coefficient values in Hydro and dispersion coefficients in Qual. The new calibrated model results are generally very close to the 2009 BDCP calibration results, with improvements at a few locations. The model predicted EC at key stations in Central Delta fairly well (Collinsville, Emmaton, Antioch, Jersey Point). Further improvements involving other changes, e.g. new bathymetry and grid changes, may come in future releases.

Additional contributor: Prabhjot Sandhu (DWR)

## *Rain-On-Snow Study in Upper Feather River Basins under PMP Conditions* – Leiji Liu (DWR)

The California Department of Water Resources (DWR) Division of Flood Management (DFM) performed the studies on the Probable Maximum Flood (PMF) for three dams in the Upper Feather River – Antelope Dam, Grizzly Valley Dam, and Frenchman Dam. Historically the most severe storms/floods in the area occurred in winter and it is very likely that the Probable Maximum Precipitation (PMP) would occur as general storm in winter when there is snow accumulated. Therefore a Rain-On-Snow computation is necessary for a PMF study.

A Rain-On-Snow program (SNOW4) developed by USACE Sacramento District was used for the computation. The meteorological conditions, such as wind speed and temperature, were determined according to HMR 58/59. Total depths from October through April were determined and arranged to have various temporal patterns, and the time series of wind speed and temperature were rearranged following the temporal patterns of PMP. Reasonable range of initial snow conditions for each month was statistically determined. Rain-On-Snow computation was performed with wind speed, temperature, and PMP as the inputs and the response of PMF to differing initial snow conditions were analyzed.

This poster summarizes the framework of Rain-On-Snow computation, starting from the delineation of the basins into different elevation zones due to the different conditions of snow packs and meteorological variables, and then discusses the challenges of data processing, and finally presents the results of the computation.

Additional contributors: Hyun-Min Shin and Sudhakar Talanki (DWR)

## *A Tool for Irrigation Water Management Planning (CUP Plus)* – Morteza Orang (DWR)

A user-friendly Microsoft Excel application program “Consumptive Use Program +” or “CUP+” was developed to help growers and water agencies determine reference evapotranspiration ($ET_o$), crop coefficient ($K_c$) values, crop evapotranspiration ($ET_c$), and evapotranspiration of applied water ($ET_{aw}$), which provides an estimate of the net irrigation water diversion needed to produce a crop. The application also can be used to study the impact of climate change on evapotranspiration and irrigation water needs.

CUP+ computes reference evapotranspiration ($ET_o$) from daily solar radiation, maximum and minimum temperature, dew point temperature, and wind speed using the daily Penman-Monteith equation. In addition, the program uses a curve fitting technique to derive one year of daily weather data from the monthly data and to estimate daily $ET_o$. It also uses daily rainfall data to estimate bare soil evaporation as a function of mean of $ET_o$ and wetting frequency in days. A bare soil $K_c$ value is calculated to estimate the off-season evapotranspiration and as a baseline for in-season $K_c$ calculations. CUP+ accounts for the influence of orchard cover crops on $K_c$ values and it accounts for immaturity effects on $K_c$ values for tree and vine crops. Further, the program computes and applies all $ET_o$ and $K_c$ values on a daily basis to determine crop water requirements by month, by season, by year. The soil water balance model is similar to that used in the Simulation of ET of Applied Water (SIMETAW) application program, which was also developed as a cooperative effort between the California Department of Water Resources (DWR) and the University of California (UC). The application outputs a wide range of tables and charts that are useful for irrigation planning.

Additional contributor: Richard Snyder (UC Davis)

### ***Assessment of Climate Change Impacts on Agricultural Water Demands and Crop Yields in California's Central Valley* – Mike Tansey (Reclamation)**

Long term planning for the management of California's water resources requires assessment of the effects of future climate changes on both water supply and demand. Considerable progress has been made on the evaluation of the effects of future climate changes on water supplies but less information is available with regard to water demands. Uncertainty in future climate projections increases the difficulty of assessing climate impacts and evaluating long range adaptation strategies. Compounding the uncertainty in the future climate projections is the fact that most readily available downscaled climate projections lack sufficient meteorological information to compute evapotranspiration (ET) by the widely accepted ASCE Penman-Monteith (PM) method.

This study addresses potential changes in future Central Valley water demands and crop yields by examining the effects of climate change on soil evaporation, plant transpiration, growth and yield for major types of crops grown in the Central Valley of California. Five representative climate scenarios based on 112 bias corrected spatially downscaled CMIP 3 GCM climate simulations were developed using the hybrid delta ensemble method to span a wide range future climate uncertainty. Analysis of historical California Irrigation Management Information System meteorological data was combined with several meteorological estimation methods to compute future solar radiation, wind speed and dew point temperatures corresponding to the GCM projected temperatures and precipitation. Future atmospheric CO2 concentrations corresponding to the 5 representative climate scenarios were developed based on weighting IPCC SRES emissions scenarios.

The Land, Atmosphere, and Water Simulator (LAWS) model was used to compute ET and yield changes in the early, middle, and late $21^{st}$ century for 24 representative agricultural crops grown in the Sacramento, San Joaquin, and Tulare Lake basins. Study results indicate that changes in ET and yield vary between crops due to plant specific sensitivities to temperature, solar radiation and the vapor pressure deficits. Shifts in the growth period to earlier in the year as well as extended fall growth can also exert important influences. Projected increases in $CO_2$ concentrations in the late $21^{st}$ century exert very significant influences on ET and yield for many crops. To characterize potential impacts and the range of uncertainty, changes in total crop water demands and yields were computed assuming that current crop types and acreages in 21 Central Valley regional planning areas remained constant throughout the $21^{st}$ century for each of the 5 representative future climate scenarios.

Additional contributors: Francisco Flores and Chuck Young, Stockholm Environment Institute; Justin Huntington, Desert Research Institute

### ***Building Models from the Data Up: From Calvin to Hobbes* – Wei Chu (UC Davis)** 1 MB

Water resource management in California is often extensive and complex and deserves a comprehensive data and modeling approach. The Hobbes Project is a new effort to provide a venue for modelers in California and elsewhere to create an open, organized, and documented quantitative representation of the state's intertied water resources system. Geocoded elements in this database can be interactively converted into tiered networks which can be solved by multiple modeling platforms depending on user preferences, with the appropriate translators. Many Hobbes tools will be web-based with exporting capabilities to the most common analytical and modeling software.

The Hobbes Project will include: 1) Database standardization and data documentation; 2) Geocoded data element representations; 3) Open platform with web access; 4) Ability to transform database elements into documented model inputs via co-development; 5) Focus on data and database structure, organization, documentation, not specific models

Users of the Hobbes Project will be able to visualize different documented elements in a common web-based mapping application, run specific modeling networks using either the Hobbes basic database, network managers scenario manager software pieces and visualize model outputs in tabular form, chart templates, maps or simply exporting the modeling network, its input data and/or its modeling output to be used in other platforms.

Additional contributors: Jay Lund, Josué Medellín Azuara, Samuel Sandoval, Alvar Escriva-Bou, Ashley Vincent, Erik Porse, Prudentia Zikalala, Timothy Nelson, and Rui Hui (UC Davis)

***Hydrodynamic and Water Temperature Application of CE-QUAL-W2 to Lewiston Reservoir – Trinity River, California* – Mike Deas (Watercourse Engineering)**

Lewiston Reservoir is the re-regulating reservoir below Trinity Dam. Reclamation uses the reservoir to manage releases to the Trinity River, the Trinity River fish hatchery, Lewiston Dam PH, and deliveries to Whiskeytown Reservoir via the Clear Creek tunnel. Unique to Lewiston operations is the dual role of temperature control for anadromous fish in the Trinity River downstream of Lewiston Dam, as well as water supply to the upper Sacramento River and Clear Creek (both via Whiskeytown Reservoir deliveries). The reservoir has installed thermal curtains at two locations: approximately 0.5 miles upstream from the dam to encourage cooler waters to remain at depth; and at the fish hatchery intake to regulate hatchery water temperature. Additionally, the morphology of the reservoir has complexities, largely due to the extensive gold mine tailings that remained after construction of Trinity and Lewiston Dams. These relic tailings created side channels and other features that may lead to undesirable heating as waters are conveyed through Lewiston Reservoir for release to the Trinity River or export to the Sacramento River basin. To address these various geomorphology and operational features for future temperature modeling applications, a W2 model was implemented and calibrated for Lewiston Reservoir.

Additional contributors: Rod Whittler (Reclamation) and Nimal Jayasundara (Watercourse Engineering)

***Numerical Experiments on the Optimal Inefficiencies of Agricultural Water Use* – Ashlee Vincent (UC Davis)**

Abstract not available.

***Residential Water-Energy Use in California: The Impacts of Spatial, Behavioral, and Household Heterogeneity* – Alvar Escriva-Bou (UC Davis)** **1.1 MB**

Abstract not available.

## Session 16. Advances in Climate Change Assessment

***Tracking Change – Existing and New Monitoring Systems to Document Climate Change and its Impact on Water Resources Management* – Michael Anderson (DWR)** **2.5MB**

Climate change is expected to significantly alter California's hydrologic cycle from higher temperatures, more precipitation falling as rain rather than snow, higher snow lines, a decreasing snow pack, earlier snow melt, and rising sea levels. California's current hydroclimate monitoring network was built through a variety of programs with different goals and monitoring expectations. How well can these networks function charting the change in the hydrologic cycle due to climate change? This talk will review existing monitoring networks and highlight some new monitoring networks that together may be able to provide the needed information to track climate change for mitigation and adaptation planning efforts.

***Subsidence Monitoring in the Sacramento Delta Using Space- and Near-Ground Platforms***

**Ben Brooks (USGS)** **7.4 MB**

Abstract not available.

## ***Balancing Relevance, Reliability, and Uncertainty in the Face of Evolving Climate Projections: Incorporating CMIP5 into Reclamation's West-Wide Climate Risk Assessments***

**Kirk Nelson (Reclamation)** **2 MB**

Assessing the vulnerability of water resource systems under potential climate change requires the ability to judge the applicability of climate projection information to the given systems and management questions at hand. Applicability depends on information reliability and relevance. This question of information applicability is particularly important at a time when new global climate projections are being released through the World Climate Research Programme Coupled Model Intercomparison Project phase 5 (CMIP5). The recent CMIP5 release introduces new information opportunities and interpretation challenges.

In response to these new challenges, Reclamation, USACE, CIRES and NOAA have initiated a collaborative demonstration project to evaluate the applicability of CMIP5 projections for use in water and environmental resources planning. The framework involves dual evaluations of relevance and reliability to inform the judgment of applicability, which is expected to vary with decision-making context. The framework is being developed and demonstrated within the context of reservoir systems management in California's Sacramento and San Joaquin River basins. This presentation will discuss the project framework and preliminary results.

Additional contributors: Ian Ferguson and Levi Brekke

## ***Sensitivity of Integrated California Forecast and Reservoir Management to Projected Climatic Change*** **– Kosta Georgakakos (Hydrologic Research Center and Scripps Institution of Oceanography)** **2 MB**

The INFORM (Integrated Forecast and Reservoir Management) Demonstration Project was created to demonstrate the utility of climate, weather and hydrologic predictions for water resources management in Northern California (includes Trinity River, the Sacramento River, the Feather River, the American River, the San Joaquin River, and the Sacramento-San Joaquin Delta). The INFORM system integrates climate-weather-hydrology forecasting and adaptive reservoir management methods, explicitly accounting for system input and model uncertainties. The numerical system has been used in detailed simulations to examine the sensitivity of the Northern California reservoir system to projected climatic change. The experiment design reproduces important elements of the real-time operation of INFORM, including the incorporation of forecast uncertainty in the decision components both for the present and the future climate. Future-climate reservoir inflow simulations indicate an early shift in monthly average flow volume and higher inflow variability as compared to present climate inflows. Comparisons of the results of the adaptive INFORM decision methodology with a numerical representation of the current reservoir operations and under present and projected future climate, indicate that adaptive management (as implemented in INFORM) yields significantly lower impacts from climatic change on reservoir system performance objectives (annual average spillage, minimum water supply, firm energy and violation of Delta X2 constraint).

References:
Georgakakos, A. P., Yao, H., and M. Kistenmacher, Georgakakos, K.P., Graham, N. E., Cheng, F.-Y., Spencer, C., Shamir, E., "Value of Adaptive Water Resources Management in Northern California under Climatic Variability and Change: Reservoir management." J. of Hydrology, 412-413, 34-46, doi:10.1016/j.jhydrol.2011.04.038, 2012
Georgakakos, K.P., Graham, N. E., Cheng, F.-Y., Spencer, C., Shamir, E., Georgakakos, A. P., Yao, H., and M. Kistenmacher, "Value of Adaptive Water Resources Management in Northern California under Climatic Variability and Change: Dynamic Hydroclimatology." J. of Hydrology, 412-413, 47-65, doi:10.1016/j.jhydrol.2011.04.032, 2012

Additional contributors: Aris Georgakakos (Georgia Tech) and Nicholas Graham (Hydrologic Research Center)

## Session 17. Sensor Networks and Real-time Decision Support

***Moving Towards a Decision Support System for the San Joaquin River Restoration Program***

***Katrina Harrison* (Reclamation) and Tom Heinzer (Reclamation)** **3 MB**

The San Joaquin River Restoration Program has installed several hundred monitoring stations including stage, flow, temperature, groundwater level, and water quality parameters. These monitoring stations are part of the Interim Flows program, an experimental program to determine the effects of flows prior to release of full Restoration Flows. The SJRRP includes many interdisciplinary agencies and stakeholders working to implement an aggressive schedule. Data sharing is especially important in this context to enable resources to be effectively and quickly utilized by all parties. In addition to publishing data, program efforts require frequent decision-making based on real time data. Program decisions include frequent evaluations of seepage and flow target compliance, and periodic flow scheduling changes based on water quality. In addition, water districts negotiate water transfers based on weekly recapture estimates. The SJRRP hopes to build a publicly accessible database with a web-based graphical user interface for visualization of monitoring data, data download, and reporting. This enables the program to increase response times to stakeholder data requests and minimize user error in reporting, supporting decisions. This presentation will discuss the SJRRP monitoring network, database, current status and plans for the interface tool.

***Three-dimensional Hydrodynamic and Water Quality Model for Lake Mead*** **16 MB**

**Al Preston (Flow Science)** YouTube **Video Link** **(13 minutes)**

With funding and support of SNWA, CWC, and NPS, Flow Science developed a three-dimensional hydrodynamic and water quality model for Lake Mead. The model is calibrated for nine years, including temperature, salinity (i.e., conductivity), bromide, perchlorate, nutrients, total organic carbon, algae, dissolved oxygen, and pH. Data used as input to the model or for model calibration include extensive sensor data for river inflow flow rate, temperature, and salinity; in-lake temperature, salinity, depth, and water quality measurements; Landsat data describing lake surface temperature; and meteorological data. Accurately predicting the hydrodynamic behavior of a lake as geometrically complex as Lake Mead requires extensive data on water density (i.e., temperature and salinity) and meteorological input, particularly to describe wind-induced mixing. Collection of high-frequency data (i.e., 10-minute to hourly data) in recent years has improved model accuracy significantly. For example, automated in-reservoir profile measurements and Landsat images were used to validate the model's ability to capture sub-daily seiching and upwelling. The Lake Mead model has been used to assess the potential effects of climate change (e.g., warmer temperatures, lower inflows, and lower lake volumes), storms, and changes in operations on hydrodynamics and water quality within the lake, and impacts to drinking water treatment processes. Moving forward, there may be opportunities to further utilize the model in real-time storm forecasting applications, through automated linking to sensor measurements and weather and flow forecasts.

Additional contributor: Susan Paulsen (Flow Science)

***Bridging the Data Gaps in Real Time for Situational Awareness and Decision Support***

**Matt Ables (KISTERS North America)** **4 MB**

During floods in Central Texas, precipitation, streamflow, and flood water elevation data are collected by a number of observation systems, including the US Geological Survey's National Water Information System, the City of Austin's Flood Early Warning System, and the HydroMet system of the Lower Colorado River Authority. Each system has its own web page where data can be accessed one gage at a time, and in a unique way, and some gages are reported on more than one web site. Following the severe flooding that occurred during Tropical Storm Hermine in September 2010, emergency managers asked for "one view" of this information to make understanding storm and flood conditions quicker and easier. The Central Texas Hub was developed to meet this need by KISTERS, ESRI, and the Center for Research in Water Resources (CRWR) of the University of Texas at Austin. This presentation will discuss the challenges faced and technologies used to bring the Central Texas Hub into existence, as well as the power of this "network of networks" approach for water data management.

***Sensor Web Technologies for Real-Time Scheduling of Salt Loading from Seasonally Managed Wetlands*** **– Nigel Quinn (Berkeley National Laboratory/Reclamation)** **3.3 MB**

The Central Valley Regional Water Quality Control Board has made provision in the 2002 salinity TMDL for the San Joaquin Basin to allow additional salt load export beyond that allowed under Waste Discharge requirements conditional on the development of a Real-Time Water Quality Management Program. Real-time water quality management requires the synthesis of monitoring, data management, simulation modeling and forecasting and data visualization capabilities to continuously meet salinity objectives at the downstream compliance monitoring point at Vernalis while maximizing salt export. This talk provides an overview of the system developed in cooperation with Grassland Water District which provides decision support for the District in future attempts to match their salt export with their assigned portion of San Joaquin River salt assimilative capacity.

## Session 18. DSM2 Applications and Developments

***How good is my model? Assessing Model Skill in a Regulatory Environment*** **3 MB**
**Marianne Guerin (RMA)**

When numerical model output is used in decision support, an assessment of model accuracy is important so decision-makers can weigh the importance attached to forecasting results and the outcome of alternative actions. This talk illustrates an application of a QUAL turbidity model skill assessment - loosely defined as “fidelity to the truth”. The objective was maximizing model skill as defined by a set of skill assessment metrics with a focus on decision support. The motivation behind the work is the potential for the turbidity model to be used to support decisions on Delta operations during first flush turbidity conditions which are believed to act as a cue for delta smelt to swim toward higher turbidity. QUAL’s turbidity model may be used in real-time forecast modeling or in establishing operations to prevent the establishment of a turbidity bridge between the central and south Delta with the intent of minimizing the jeopardy to delta smelt.

***Adding Route Decision Behavior to the Particle Tracking Model*** **– Xiaochun Wang (DWR)** **1 MB**

Based on the data from the 2012 field acoustic telemetry salmon tag study at the junction of Georgiana Slough and Sacramento River, Russ Perry and his team established a general linear model (GLM) to predict salmon route selection probability. The model relates the fish route selection behavior to various environmental variables, including 1) operation of the non-physical barrier; 2) time of day; 3) discharge entering the river junction; 4) the cross-stream position of each individual fish; and 5) the location of the critical streakline in the channel cross section. The GLM has been implemented in DSM2 Particle Tracking Model (PTM). The presentation will discuss the implementation and the improvement of the PTM simulation by implementing the GLM. The PTM Model design change for adding behaviors will also be presented.

***Recent Developments and New Features of DSM2-PTM*** **– Yu Zhou (DWR)** **0.9 MB**

Several new features have been developed for Delta Simulation Model II – Particle Tracking Modeling (DSM2-PTM). They will be included in the new release of DSM2 (version 8.1) and are going to improve the module’s performance:

- The particle filter can simulate facilities’ function of directing/blocking particles without interrupting hydrodynamic conditions. One of the major applications of this particle filter is to simulate fish screens or non-physical barriers, which could block fish entering some water areas. Another application is to provide an option of keeping fish from entering into agricultural diversions and seepage.
- A standard PTM test suite has been designed. It includes several basic test grids and enables users to conduct their tests’ control and comparison among different module versions, with the help of automation.
- A debugging process corrected several PTM algorithm mistakes and improved the module’s performance, e.g. missing advection/dispersion, inconsistence of time interpolation, in-convergence among different user input time steps.

PTM Animations – Filter and No Filter at the Head of Old River .mp4; 8.9 MB

PTM Animations – Filter and No Filter at Georgiana Slough .mp4; 23 MB

***General Transport Module* (DSM2-GTM) – Nicky Sandhu (DWR)** 0.3 MB

Delta Modeling, in coordination with other staff in DWR and other agencies, is in the process of developing a new transport module. This module will, in time, replace DSM2-Qual, and will incorporate additional functionality not currently available in DSM2. This includes expanded capability to model various water quality parameters, the addition of sediment transport modeling, and mercury modeling. This presentation will be a summary of the current design plan.

## Session 19. Flood Modeling

### *Modeling Complex Flow Splits in the Lower Sacramento River System Using One-dimensional HEC-RAS and Two-dimensional TUFLOW Models for the Central Valley Floodplain Evaluation and Delineation Program (CVFED)* – Shyamal Chowdhury (Wood Rodgers)

Accurate evaluation of the flood hydraulics in the Lower Sacramento River System is critical for assessing regional flood risk reduction to protect the urbanized areas in and around Sacramento. Projects recommended for implementing the Central Valley Flood Protection Plan include expansion and/ or modification to the Lower Sacramento River system, especially the Fremont Weir complex. Past modeling efforts in the Sacramento River System with one-dimensional HEC-RAS models include large uncertainty in determining the flow splits at the Fremont Weir Complex for large floods particularly those rarer than the 1-percent- chance of being equaled or exceeded in a given year.

To reduce the uncertainty in flow split and to have a geometry setup that could be used for a wide variety of flows, Wood Rodgers developed a two-dimensional model utilizing TUFLOW software. The Presentation will demonstrate how the two-dimensional model informed the one-dimensional HEC-RAS Model for the Lower Sacramento River System. This presentation will demonstrate 1) flow split determination for several frequency storm events, and 2) impact of vegetation maintenance on flow split in the Yolo Bypass. Wood Rodgers will also present the flow patterns from the TUFLOW model as compared to the one-dimensional HEC-RAS model for the Lower Sacramento River system, developed under the Central Valley Floodplain Evaluation and Delineation Program.

Other contributors: Chris Ferrari and Ashok Bathulla (Wood Rodgers)

### *Towards Understanding the Flood Protection Function of the Yuba Goldfields* – Don Trieu (MBK) and Paul Brunner (TRLIA)

Over the past several years, the Three Rivers Levee Improvement Authority (TRLIA) has been improving the flood protection system for South Yuba County with a variety of levee improvement projects. The Yuba Goldfields provides a flood protection function for South Yuba County, but that function has historically been poorly understood. An analysis has been performed to further the understanding of the hydraulics and flood protection function of the Yuba Goldfields. The initial hydraulic assessment showed that particular areas of the Goldfields represented higher than expected flood risk. In response, interim actions were taken in 2011 to reduce the flood risk in South Yuba County. TRLIA is currently pursuing long-term flood risk reduction solutions that will meet FEMA 100-year and State 200-year certification standards. This presentation will explain the challenges in the formulation and execution of the preliminary analysis and explore how the hydraulic evaluations for the long-term solutions are being carried out.

## *CVFPP Life Risk Analysis: An Update* – Steve Cowdin (David Ford Consulting)

A life risk calculation (LRC) method was developed and applied for the 2012 CVFPP which incorporated commonly used procedures for assessing life risk, as influenced by flood hazard, system performance, and vulnerability and exposure of people. The method was tied closely to the economic risk calculations described in Attachment 8F: Flood Damage Analysis, using common numerical descriptions of flood hazard and levee system performance. Exposure of people was tied to exposure of property. With this analysis strategy, computations for both economic and life risk were accomplished with the USACE HEC-FDA software application.

The CVFPP HEC-FDA models were modified to estimate expected annual life risk for the No Project and with-project (CVFPP approaches) conditions. Modifications included: (1) replacing residential structures' economic values with persons/structure estimates based on 2000 U.S. Census population data, adjusted for likely evacuation prior to a flood event; and (2) replacing depth-% damage functions with depth-% mortality functions, based on Jonkman's (2009) research of life loss in New Orleans during Hurricane Katrina. The HEC-FDA models were then run to estimate changes in life risk attributable to the approaches, compared to the No Project condition. Life risk was defined as the long-term average annual number of lives potentially lost in an identified area, considering a given climate and land use condition, with a specified plan of flood control protection in place.

The resulting life risk values are *conditional*: they represent consequences for a given area with a specified set of hydrologic and hydraulic conditions of the system, with best representation of performance of system levees and other features, and with stated assumptions regarding public warning and response. As such, the results are informative *indices* of life risk, and the estimated values provide a reliable metric for comparing the life-risk reduction attributable to the proposed 2012 CVFPP approaches.
For the 2017 CVFPP, we will modify the 2012 CVFPP HEC-FDA life risk models to better account for key parameters that affect a flood loss of life analysis, including:

- Population age (under and over 65).
- Population distribution by structure type
- Revised mortality functions that reflect:
    - Population age.
    - Type of structure and number of stories.
    - Structure collapse during a flood.
    - Loss of life during evacuation.

In addition, the 2012 CVFPP HEC-FDA life risk models will also incorporate 2010 US Census data and updated hydrology and hydraulics information developed for the 2017 CVFPP.

Additional contributors: Natalie King, David Ford (David Ford Consulting)

## *Quantifying Ecologic Benefits of Floodplain Reconnection on the Lower San Joaquin River* – Katie Jagt (American Rivers)

To evaluate the potential ecological benefits of floodplain reconnection projects, we developed ecosystem benefit metrics that quantify the potential floodplain habitat in the reach as a function of season, duration, and frequency in Area-Duration-Frequency (ADF) curves. These curves show the characteristics of the system across many timeframes, flood durations, and inter-annual frequencies which allow them to be used to examine potential benefits across species as well as across a single species' life history. In addition to ADF curves, we developed the concept of expected annual habitat (EAH) for each season and flood duration. This single value is the average quantity of floodplain habitat that can be expected to be wet for a specific duration in any given year. The calculation and usage of EAH is analogous to expected annualized damage (EAD) that is one of the most common metrics used to analyze flood risk.

This study examined two physical configurations: the existing system with levees that that closely follow the mainstem channel alignment and a hypothetical levee setbacks that would reconnect approximately 20,000 acres of historic floodplain. We also looked at three hydrologic scenarios: the post-dam record (1970-2011), a hot and dry climate change scenario (2001-2099), and an augmented flow scenario (60% unimpaired 1929-2011 flows). Results show that there are nominal increases in frequently inundated floodplain habitat (two year to four year events) in this reach of the Lower San Joaquin River, even with a levee set back, within the existing reservoir operations scenario; major habitat benefits only start to emerge within an augmented flow scenario for these ecologically significant, frequent flood events. We also show that with a no-action project scenario (the physical layout of the system remains unchanged) we can produce noticeable habitat benefits simply by changing the upstream reservoir operations in one month per year. In the examined climate change scenarios, we see substantial floodplain habitat loss in a no-action scenario and that in order to maintain the current amounts of floodplain habitat significant corridor expansion is necessary.

Additional contributor: Mary Matella (UC Berkeley)

## Session 21. Ecological Engineering

### *The Challenges of Eco Engineering: Making the Connections between Engineering and Ecology*

**Chris Bowles (cbec)** **13 MB**

Ecological engineering, or eco engineering, is an emerging field in the study of integrating ecology and engineering, concerned with the design, monitoring, and construction of ecosystems. According to Mitsch (1996) "the design of sustainable ecosystems intends to integrate human society with its natural environment for the benefit of both".

Eco engineering emerged as a new idea in the early 1960s, and has been developing ever since and is still undergoing adjustment. As a commonly practiced field of engineering it is relatively new. Howard Odum (1963) and others first introduced it as "utilizing natural energy sources as the predominant input to manipulate and control environmental systems". Mtisch and Jorgensen (1989) were the first to define ecological engineering and provide ecological engineering principles. Later they refined the definition and increased the number of principles. They suggested that the goals of ecological engineering are:

a) the restoration of ecosystems that have been substantially disturbed by human activities such as environmental pollution or land disturbance, and
b) the development of new sustainable ecosystems that have both human and ecological values.

Here a more detailed overview of eco engineering is provided, more specifically how engineers and ecologists can utilize multi-dimensional computational models to create the linkages required for successful project implementation, a discussion of conceptual models developed to aid the in the construction of these linkages is provided, and finally an overview of how eco engineering principles are referenced through several case studies is provided. This presentation provides an introduction to three additional case studies by others, providing a variety of perspectives and applications in eco engineering.

## [*Validation of Two-dimensional Hydrodynamic Models for Assessing Meso-scale Hydraulics of Ecological Importance*] – Brian Wardman (Northwest Hydraulic Consultants) 3 MB

Two-dimensional depth-averaged hydrodynamic models are commonly used tools for evaluation of hydraulic properties related to ecological functions in fluvial systems. These models utilize numerical algorithms to solve the Saint-Venant equations across a computational grid, which produces a depth-averaged velocity vector and an average flow depth at each grid point. The application of these tools typically ranges from evaluation of large-scale ecological functions to meso-scale ecological functions, which exist at stream lengths equal 1 to 10 channel widths. The ability of the model to accurately predict the hydraulics of interest is strongly dependent on both the layout of the computational grid and user inputs: bed roughness and eddy viscosity. Model accuracy is also inherently limited by the assumptions of the numerical schemes. This research focuses on the application of two-dimensional models for evaluating meso-scale ecological functions in steep streams with emergent boulders. Accurate modeling of the hydraulics in these reaches is valuable when evaluating passage and habitat value for various types of aquatic organisms. The overall objective was to identify the ability of the model to accurately predict the length of the wake region behind and flow acceleration around emergent boulders. In situ stream conditions are being utilized to fulfill this objective. These data comes from measured velocity and depth data which were collected at three separate project sites. The project sites are representative of different meso-scale ecologic features and include a constructed riffle, a natural bed rock chute, and a natural riffle entrance. Velocity data was collected using Large Scale Particle Image Velocimetry (LSPIV) and Acoustic Doppler Velocimeters (ADV) and depth was measured with topographic surveying equipment. Each project site was modeled with the publically available River2D and ADH two-dimensional models. Results of the study demonstrate the sensitivity of the model output to user input values for bed roughness, eddy viscosity, and grid resolution relative to observed values. The effect of uncertainty in model input and output is qualitatively discussed as it applies to ecological applications.

Additional contributors: Brady McDaniel and Joey Howard (Northwest Hydraulic Consultants)

## [*Impacts of Beach Management on Salmonid Habitat Conditions in the Russian River Estuary*] Dane Behrens (ESA PWA) 8 MB

During dry conditions, bar-built estuaries in California rarely have full communication with the ocean, often having an inlet channel that is fully choked with sediment (“closure”) or a small supratidal spill channel (“perched overflow”). Under both conditions, saltwater remaining in the estuary from previous tidal action typically forms vertically-stratified conditions in the water column, characterized by a freshwater layer overlaying layers of denser saltwater generally having lower dissolved oxygen. The extent of the upper fresh layer is an important constraint on the habitat of juvenile salmonids, which use the estuary as a rearing ground in the summer. At present, it is unclear whether managing the beach to allow closure or to enforce perched overflow would produce different estuarine conditions. We address this knowledge gap with a two-dimensional (laterally averaged) numerical model of the Russian River Estuary, which we validate against several years of boat-based field data in the estuary. Using this model, we explore the response of the estuary to several beach states, and also examine the influence of variable forcing from wind, river inflow and beach seepage.

Additional contributors: Matt Brennan (ESA PWA); Fabián Bombardelli, John Largier, Shreya Hegde, and Kathryn Hewett (UC Davis)

## [*Evaluating Productivity Potential for Prospect Island Restoration Alternatives Using Particle Tracking Methods*] – Stephen Andrews (RMA) 13 MB

A major goal of the Prospect Island Tidal Restoration Project is to restore the natural processes of the island which promote primary production and tidal transport to the regional pelagic food web. Fifteen different island configurations were considered, varying in the placement and extent of connectivity between the island interior and adjacent channels. In order to assess the potential of each restoration alternative to produce and export phytoplankton, particle tracking runs were performed, using island exposure time as a proxy for phytoplankton production.

Particle exposure times within a certain range (e.g., 1 to 3 days) were considered beneficial. This time range was chosen to be long enough to support sufficient phytoplankton community growth, but short enough to prevent

Cyanobacteria production. Simulations were performed for June and July of 2010, the time of year when juvenile pelagic fish are growing rapidly in the Delta. Particle tracking simulations consisted of dropping 1,000 particles in Prospect every two hours over a two week spring neap tidal cycle and tracking both their time spent in the island and their regional fate. Results were summarized using exposure time histograms and spatial maps of average exposure time.

Particles having beneficial exposure times were maximized in alternatives with significant island through-flow, either between Miner Slough to the island's east and the Sacramento Deep Water Ship Channel (DWSC) to the west, or between the northern and southern parts of the island with Miner Slough. Single breach alternatives and many of the 2 breach cases did not result in significant island through-flow and generally had long exposure times. The majority of particles with beneficial island exposure times were transported to the lower Sacramento River, the DWSC, Liberty Island, and Cache Slough after 1 week. Modeling efforts for Phase II of the alternatives analysis will focus on adding the effects of emergent vegetation and improved wind mixing to the analysis.

Additional contributors: Richard Rachiele and John DeGeorge (RMA)

## Session 22. Recent Advances in Estimating X2 Position

***Nine Decades of Salinity Observations in Suisun Bay & Western Delta*** **1.6 MB**

***A New Empirical Bay-Delta Salinity Model*** **– Paul Hutton (MWDSC)** **2.2 MB**

This presentation summarizes work being conducted to assemble and evaluate over nine decades of salinity data collected in Suisun Bay and the western Delta. Over this period there were some well-established differences in sampling frequency and analytical methodology. The assembled data were systematically cleaned, filled, and converted to monthly EC time series using best available information on unit conversion and tidal effects. These monthly salinity records were used to develop a long-term time series of X2 values, as well as several surface isohalines ranging from 1-6 ppt.

The resulting long-term data record serves as a foundation for the continuing analysis of spatial and temporal trends in the low salinity zone of Suisun Bay and the western Delta. Future work may consider additional strategies to improve the cleaning methodologies and reexamine findings based on this initial work.

Additional contributors: Sujoy Roy and Limin Chen (Tetra Tech)

***Evaluating the Approaches and Assumptions Used to Calculate X2 Using Field Observations and Numerical Simulations*** **– Michael MacWilliams (Delta Modeling)** **2.2 MB**

By definition, X2 is the distance in kilometers from the Golden Gate to the tidally-averaged near-bed 2-psu isohaline. However, measuring the exact location of X2 directly is very difficult since this would require continuous near-bed salinity monitoring over the length of the tidal excursion each day. As a result, a range of approaches have been used to estimate X2. These approaches rely either on continuous monitoring of surface salinity at fixed stations, developing regression relationships that relate X2 to delta outflow and antecedent conditions, or numerical simulations. Each of these approaches requires specific assumptions that can result in systematic biases in the estimate of X2 under certain conditions. This talk provides an overview of some of the most common approaches for estimating X2 and compares estimates of X2 from multiple approaches over the same time period to evaluate how the assumptions used in each approach influence the resulting estimates of X2. The goal of these comparisons is to provide insight into how different assumptions used in the approaches to estimate X2 can bias the resulting estimate of X2 under specific conditions, and to identify how these approaches could be improved to produce more reliable estimates of X2 under a wider range of conditions.

## *A New Regression Relationship of X2 with Delta Outflow* – Edward Gross (RMA) 2 MB

An autoregressive relationship between X2 predicted by the UnTRIM Bay-Delta model and Delta outflow has been developed. This autoregressive relationship follows the power-law form proposed by Monismith and others (2002), $X2(t) = \alpha X2(t-1) + (1-\alpha)\beta Q^{\gamma}$ , where *t* is the time in days, *Q* is Delta outflow, □ is the weighting between the autoregressive term and the flow term, and □ and □ are fitting parameters relating steady flow and X2. A regression of this form was previously developed by Gross et al. (2009) using output of the TRIM San Francisco Estuary model. The X2 dataset used in this analysis is improved because the UnTRIM Bay-Delta model predicts X2 more accurately than the previous TRIM model published by Gross et al. (2009). For this reason, even with the same form of regression equation as in the previous analyses, substantially different parameter values were found. The regression equation was then extended to allow the weighting between the autoregressive term and the flow term to vary with Delta outflow. In addition, the uncertainty in both the parameters of the regression equation and the X2 predictions of the equation were estimated using Bayesian inference. Last, a related concept of antecedent flow, the equivalent steady state flow derived by a weighted time average of a portion of the preceding hydrograph, is introduced. A regression which accurately predicts X2 with a quantified level of uncertainty is useful to improve the confidence of correlations and other relationships of ecological properties to X2.

Additional contributors: Wim Kimmerer (San Francisco State), Michael MacWilliams (Delta Modeling), and Gerard Ketefian

## *Western Delta Salinity Modeling Using Artificial Neural Networks* – *Sujoy Roy (Tetra Tech)* 2 MB

The four-decade-long record of observed daily salinity in the Western Delta was used to develop predictive artificial neural network (ANN) models for salinity as a function of distance using various boundary inputs. A major focus of the work was the testing of different input combinations to identify suitable models for predicting salinity as a function of distance. Major inputs that were examined included the following: flows past Rio Vista on the Sacramento River and past Jersey Point on the San Joaquin River (identified as Qwest in the DAYFLOW model); tidal terms at different locations and astronomical tide at Golden Gate; and channel depth in the Western Delta. For each combination, two models were developed, one for the Sacramento River and one for the San Joaquin River. This approach differs from prior salinity ANN development in the Delta region, where the training has been performed on synthetic data generated from the DSM2 model. This presentation provides an overview of the ANN development approach, the comparative performance of specific models, and potential applications in the Delta.

Additional contributor: Paul Hutton (MWDSC)

# Session 23. Joint CWEMF and IEP – Models of Ecosystem Dynamics

## *We Need to Do the Modeling: Imagining How Models and Modelers Advance Understanding of the SFE* – Chris Enright (Delta Stewardship Council) 3.3 MB

Abstract not available.

***Physical Processes Influencing Habitat at a Breached Delta Island: Implications for Restoration Management and Planning*** **– Matt Brennan (ESA PWA)** **2.7 MB**

Long-term planning for the Delta has identified habitat restoration as a key element for reconciling human impacts with ecosystem function in the Delta. However, the linkages between physical processes and the resulting habitat evolution are not well understood. As part of the BREACH III project team, we have developed hydrodynamic, wind-wave, and sediment transport models for Liberty Island, a former diked area now breached to restore flow, to understand these linkages. We have represented the northwest portion of the Delta, encompassing Liberty Island and surrounding channels, with a two-dimensional hydrodynamic model (Delft3D) coupled with a wind-wave model (SWAN). These two models are used to predict the re-suspension, transport, and deposition of suspended sediment. The models are forced with a range of inputs, including tides, wind, and river discharge, including the Yolo Bypass. By analyzing the predicted response to different forcing conditions and ambient sediment conditions, we assess the implications for restoration management and planning. Applications include: circulation, residence time & export; waves and levee erosion; sediment budget and pathways; the proposed Yolo Bypass conservation measure; and vegetation expansion and habitat evolution.

Additional contributors: Edward Divita, Michelle Orr, and Steve Crooks (ESA PWA)

***Bay-Delta EDT: A Tool for Restoration Planning*** **– Chip McConnaha (ICF)** **1.1 MB**

The Bay-Delta has been greatly altered by human activity over the past 150 years, including substantial loss of tidal marsh and other habitats that supported delta smelt and other native fish species in the past. Restoration of these habitats is a high priority in recovery plans for delta smelt and other species and large-scale restoration planning is underway. The scale of proposed restoration and the novelty of habitat restoration in the Delta call for a strategic approach that effectively blends existing scientific knowledge with legal and social constraints. The Bay-Delta Ecosystem Diagnosis & Treatment model (BDEDT) provides a framework for organizing available information to develop effective strategies and priorities for restoration of habitats across the Delta. BDEDT provides a comprehensive structure for assembling information from other models, scientific studies, and expert knowledge to create an overall working hypothesis regarding delta smelt habitat constraints. The model is based on the Ecosystem Diagnosis & Treatment (EDT) system that has been successfully applied to stream environments and salmonid fishes throughout Washington, Oregon, and California. It is being adapted to the complex hydrologic network and unique environment of the Delta and to the habitat needs of delta smelt. BDEDT evaluates the environment along multiple life history pathways plotted across the DSM2 hydrologic network. The quantity and quality of habitat along these pathways is expressed as potential carrying capacity, productivity (density-independent survival), and equilibrium abundance of delta smelt; integration across multiple pathways estimates potential population performance of delta smelt in the modeled environment. The model is scalable spatially (Delta-geographic subregions-DSM2 reaches), biologically (by life stage), and environmentally (by habitat characteristics) providing assessment of limiting factors and habitat potential at local and delta-wide scales. EDT evaluates habitat based on the potential exposure of fish to conditions for specific periods and locations along the life history pathways. Exposure can be controlled by shaping life history patterns within the model. This permits the evaluation of alternative life history strategies and creates testable hypotheses of delta smelt response to environmental conditions. Evaluation of habitat condition is based on a knowledge base of relationships that captures prevailing knowledge of delta smelt habitat requirements; the model thus provides an avenue for synthesizing existing knowledge for application to management questions. Conditions can be compared between scenarios (alternative strategies or points in time) to identify restoration priorities (locations and habitat characteristics) or to compare the effectiveness of restoration alternatives. BDEDT is being developed to evaluate habitat constraints on delta smelt and to prioritize restoration actions leading to an informed strategy for restoration. Development of BDEDT to date has provided a workable model that is being parameterized to evaluate model behavior. The greatest value of BDEDT will be realized if it becomes the collective product of scientific and management communities to reflect the currently best available science and relevant management questions. The model is now at a point where the scientific community can enter the development process by providing knowledge and review, leading to a useful framework for habitat restoration in the Delta.

Additional contributors: Rick Wilder, Jesse Schwartz, Patrick Crain, Marin Greenwood and Karl Dickman (ICF)

***Are Shallower, Slower Habitats Necessarily "Greener"? How Clams Upend Conceptual Models Guiding Ecosystem Management in the Delta* – Lisa Lucas (USGS)**

As "food for the fish-food", phytoplankton is the dominant energy source to the food web of the Sacramento-San Joaquin Delta. However, Delta phytoplankton biomass is low and its long-term downward trend has been mirrored by declines in fish and zooplankton (fish-food). Low phytoplankton biomass and productivity are therefore implicated as factors contributing to the multi-decadal declines in fish species. For that reason, plans for managing the future Delta include actions aimed at enhancing phytoplankton productivity. Two common conceptual models shape those plans and expectations of the ultimate outcomes. The first holds that shallower aquatic habitats promote higher phytoplankton biomass and productivity than deeper habitats because they provide more sunlight energy for phytoplankton photosynthesis (the "Shallower is greener" model). The second holds that more slowly moving water is associated with higher phytoplankton biomass and productivity because longer retention time can allow for greater phytoplankton biomass accumulation (the "Slower is greener" model).

Although these conceptual models seem intuitive and reasonable, they aren't always correct. Using mathematical models and field observations, we show that where bivalve grazing is significant (as in much of the Delta), shallower and slower habitats: 1) are not necessarily characterized by higher phytoplankton biomass or productivity; 2) may be characterized by *lower* phytoplankton biomass and productivity than deeper, faster habitats; and 3) are associated with much greater uncertainty regarding ultimate algal biomass and productivity than deeper, faster habitats. These lessons all suggest that habitat depth and transport time should not be used as indicators of phytoplankton biomass and production. Further, phytoplankton growth and loss (e.g. grazing) rates must be considered together in estimates and expectations of algal biomass or production. Consideration of only one part of the mass balance can lead to substantial error. Practical implications of these lessons for management of the Delta will be discussed.

Additional contributor: Janet Thompson

***Enhancing Salmonid Habitat on the Lower American River* – Chris Bowles (cbec)** **16.5 MB**

Abstract not available.

## Session 24. Joint CWEMF and IEP – Models of Ecosystem Dynamics

***Yolo Bypass Ecosystem Reconciliation – Insights from Many Models and Lots of Field Work* - Robyn Suddeth (UC Davis)**

The Yolo Bypass is often cited as one of the more promising locations for habitat restoration in the Bay Delta system due to its large size and the benefits it already provides for many fish and waterfowl species. The Yolo Bypass also serves economic and social functions in Yolo County for farmers, duck hunters, and visitors to the state wildlife area. Finally, the Yolo Bypass is important for Sacramento Valley's flood control, able to carry many times the flow of the Sacramento River during floods. This talk presents an overview of past and present efforts to understand the many ecologic, hydraulic, and economic components of Yolo Bypass functioning, and suggests ways to translate this knowledge into promising management alternatives for future reconciliation efforts on the floodplain. A relatively formal method is used to explore promising environmental reconciliation solutions for Yolo Bypass.

### *Mathematical Models in Support of Restoration: Examples from the Klamath Basin and Beyond*

**Mike Deas (Watercourse Engineering)** **1.3 MB**

Mathematical models used to support restoration planning and implementation has been occurring for decades. However, the role of models in restoration has different meanings in different settings and to different people/groups. Examples from the Klamath River basin and other locations are used to identify successes and challenges at a range of scales from local reach restoration to watershed scale efforts. These examples focus on flow or water quality to support restoration of aquatic ecosystem functions (e.g., salmon recovery efforts).

### *San Joaquin River Restoration Program Use of Modeling Tools to Guide Floodplain Restoration*

**Katrina Harrison (Reclamation)** **2.6 MB**

The San Joaquin River Settlement Agreement, signed in 2006, requires channel and structural improvements in several reaches of the San Joaquin River to contribute towards the restoration goal of restoring and maintaining fish populations in good condition, with emphasis on Chinook salmon. Floodplain rearing habitat is an important habitat need for juvenile Chinook salmon, and implementation of channel improvements in two reaches will be focusing on increasing floodplain rearing habitat. However, there is uncertainty on: 1) defining floodplain rearing habitat suitable for juvenile Chinook salmon rearing, 2) how much rearing habitat is currently available, and 3) how much floodplain rearing habitat is needed to achieve the Restoration Goal. The SJRRP has developed a number of modeling and analytical tools to inform floodplain management decisions, both at specific channel improvement sites, as well as river-wide. This presentation will provide an overview of those modeling and analytical tools, with focus on how these tools were used to develop minimum rearing habitat area requirements.

### *Applying Modeling Results to Tidal Restoration Project Alternatives Development and Selection: Prospect Island* – Stuart Siegel (Wetlands and Water Resources) **7.3 MB**

Prospect Island is proposed for tidal restoration by the Department of Water Resources as partial fulfillment of the 8,000 acres of tidal restoration required in the 2008 USFWS delta smelt biological opinion and referenced in the 2009 NMFS salmonid biological opinion on the long-term operations of the State Water Project and Central Valley Project. The restoration purposes are, among others, to enhance primary and secondary aquatic food web productivity within Prospect Island and to transport that productivity into surrounding Delta waterways. The 1,600-acre Prospect Island is located at the confluence of Cache Slough, Miner Slough, and the Sacramento Deep Water Ship Channel.

We applied hydrodynamic modeling as a key tool for developing restoration alternatives and identifying which alternatives to carry forward into detailed restoration planning, and modeling will continue to be used to refine alternatives and support effects assessment. Prospect Island has the potential for tidal connections to be located on Miner Slough and/or the DWSC, with the specific breach configuration expected to exert a major influence over aquatic productivity within the site and the transport of that productivity off site. Breach configuration could also influence whether and to what extent a variety of other project effects may occur, both beneficial and adverse. Thirty conceptual alternatives were identified initially and grouped into 15 alternatives for screening-level modeling analysis. This initial modeling examined internal residence time as a proxy for phytoplankton production and particle tracking as a proxy for productivity transport. It also examined flood stage effects, tide stage effects, velocities in Miner Slough and the DWSC, and DOC transport to the Barker Slough Pump Plant. Restoration planners then convened an expert panel two-day workshop that drew extensively upon the modeling results to recommend five alternatives to advance and to recommend modeling approaches for the next phase of analysis. That modeling will soon be initiated.

*Note: Collaborative Effort of the Fish Restoration Program Agreement at the Department of Water Resources and California Department of Fish and Wildlife, Wetlands and Water Resources, Stillwater Sciences, cbec eco engineering, and Resource Management Associates with guidance from the Delta Science Program.*

***Habitat Restoration in the Delta: The Delta Independent Science Board Review*** **5.7 MB**
**John Wiens (ISB)**

The 2009 Sacramento-San Joaquin Delta Reform Act created the Delta Independent Science Board (DISB) to provide oversight of science in the Delta in order to achieve the co-equal goals of providing a reliable water supply and restoring and enhancing the Delta ecosystem. The DISB is charged with reviewing scientific research, monitoring, and assessment programs in the Delta that support adaptive management. The reviews focus on broad thematic areas of science applications in the Delta. The first review dealt with habitat restoration, emphasizing how restorations will be managed adaptively in the face of climate change.

Between summer 2012 and February 2013, the DISB drew on a variety of sources of information, including interviews with representatives of 25 federal and state agencies, water districts, consultants, non-profit organizations, and universities. The major findings from this review are: (1) There is a high level of dedication and knowledge among those directly involved with habitat restoration in the Delta; (2) Individual restoration projects are generally well-planned and have a strong science foundation; (3) Despite this, there is little coordination and integration among existing or planned restoration projects. Project goals are not interrelated, potential effects of one project or management activity on other projects are not considered, and there is little evidence of planning for long-term changes in the Delta ecosystem. Based on these findings, the DISB recommends:

(1) Establish a mechanism to coordinate planning and implementation of habitat-restoration projects to capitalize on potential synergies and complementarities.
(2) Incorporate uncertainty and potential climate-change effects in the design and implementation of habitat-restoration projects, using modeling tools where appropriate.
(3) Prioritize restoration projects in strategically designed networks to make the best use of limited funds.
(4) Strengthen and integrate scientific information and expertise to support monitoring and adaptive management.