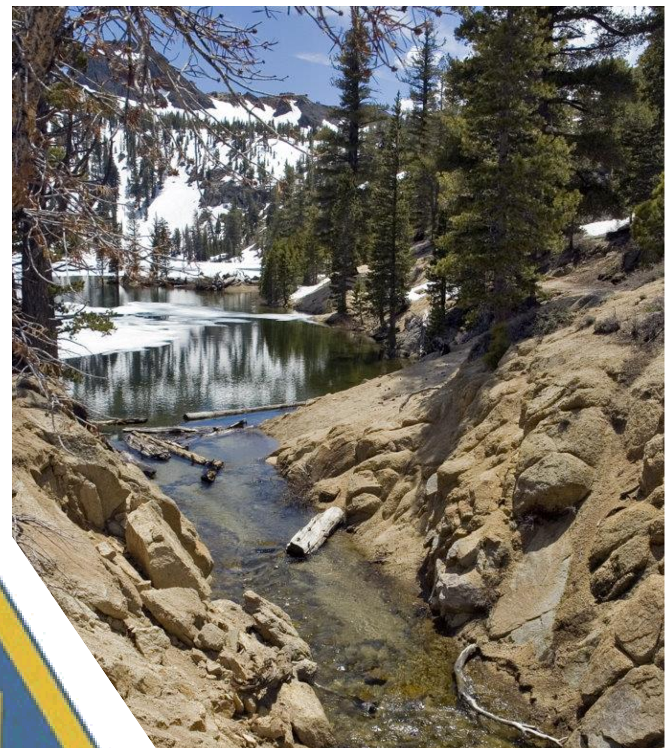
California Water and Environmental Modeling Forum

2015

ANNUAL MEETING SESSION ABSTRACTS

With Links to Speaker Presentations



ABSTRACTS[1]

Session 1. One-Water Hydrologic Model

Analysis of Pajaro Valley Water Supply and Demand using MF-OWHM – Randy Hanson (USGS)
Collaborator: Brian Lockwood (Pajaro Valley Water Management Agency) **7.6 MB**

Pajaro Valley is one of the most productive agricultural regions in the world. Increasing population, agricultural development, including shifts to more water-intensive crops, and climate variability are placing larger demands on available groundwater resources in the valley. Groundwater depletion and related seawater intrusion, especially during drought years, has resulted in decades of overdraft. Continued growth in demand required the Pajaro Valley Water Management Agency to build a 4,000 ac-ft/yr recycled water facility and managed aquifer recharge and recovery facility for supplemental irrigation supply for coastal ranches where groundwater is contaminated by seawater intrusion. These facilities have delivered over 25,500 acre-feet since 2002 and reduced seawater intrusion. While those facilities have helped, the problem persists. Thus, the Agency explored additional projects in a recent Basin Management Plan (BMP) Update (2014) to provide additional supplemental supply as a reliable and good quality alternative to coastal groundwater and pumping in excess of recharge.

Analysis of conjunctive use for historical conditions, and projections of existing and explored projects, was completed with an integrated hydrologic model that guided the evaluation of the adequacy and potential consequences of these alternative projects for the new BMP. Simulations indicate that while the current projects help reduce coastal pumping, they are not adequate to stop overdraft and seawater intrusion. This analysis has helped to develop a new BMP to further reduce groundwater pumpage and increase recharge throughout the valley to mitigate overdraft.

Simulation of Agricultural and Hydrologic Processes in the Modesto Region, California, using OWHM
Steve Phillips (USGS) **6.1 MB**
Collaborator: Jonathan Traum (USGS)

Strategies for managing groundwater in the Modesto region, California, are being formulated by the Stanislaus and Tuolumne Rivers Groundwater Basin Association (STRGBA). To aid in evaluating management strategies, the USGS and STRGBA developed a hydrologic model that simulates monthly groundwater and surface-water flow from 1960–2004 using MODFLOW-OWHM. Private groundwater pumpage and recharge associated with irrigated agriculture were estimated using the Farm Process, which simulates landscape processes associated with various land uses. The distribution of hydraulic conductivity was constrained using data from about 3,500 drillers' logs. The model was calibrated to 4,061 measured groundwater levels in 109 wells and 2,739 mean monthly surface-water flows at 6 stream gages. Simulated groundwater levels have an absolute mean residual of 0.8 ft; 74 percent of simulated heads were within 10 ft of observed. Simulated streamflow was biased low, but reasonable; the absolute mean residual was 780 cubic feet per second (cfs), and 68 percent of simulated streamflows were within 500 cfs of observed. Simulated private agricultural pumpage averaged about 1,000,000 acre-ft/yr; deep percolation of precipitation and irrigation averaged about 1,360,000 acre-

[1] Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

ft/yr. Key limitations to estimating the water budget are uncertainty associated with irrigation deliveries and efficiencies, and no available data for private agricultural pumpage.

Evaluating Potential Seepage Projects along the San Joaquin River Using Multiple Scale Groundwater Models – Brian Heywood (CDM Smith) **1.9 MB**
Collaborators: William Fernandez and Anusha Kashyap (CDM Smith); Katrina Harrison (USBR)

The San Joaquin River Restoration Program (SJRRP) is utilizing groundwater models of varying spatial and temporal resolutions to simulate regional and local surface water/groundwater interaction and to evaluate potential changes to groundwater levels under agricultural lands adjacent to the San Joaquin River and bypass system due to the increased and more frequent flows released by the SJRRP. The need for and effectiveness of seepage control measures (e.g., ditches, slurry walls, interceptor lines, and shallow pumping) to control groundwater levels are also being evaluated. The San Joaquin River Restoration Program groundwater model, based on the USGS's Central Valley Hydrologic Model, features a study area extending five miles from the river and bypass system, finer grid discretization, and more refined geologic representation. Local-scale models with finer grid spacing and reduced stress period lengths have been developed based on the structure of the SJRRPGW and are being used in the assessment of individual properties.

Conjunctive Use of Water in the Central Valley as Simulated using the Central Valley Hydrologic Model
Claudia Faunt (USGS) **9 MB**
Collaborators: Jonathan Traum, Michelle Sneed, and Randy Hanson (USGS)

California's Central Valley is one of the most productive agricultural regions in the world. However, recent drought conditions, land-use changes, and restrictions in surface-water flows have caused increased need for the conjunctive use of water. Increased demand for groundwater in the Central Valley has resulted in groundwater-level declines and associated land subsidence. Depending on local conditions, the declines and subsidence have occurred either only during droughts or during both drought and non-drought periods. Land subsidence has received increased attention during recent droughts, which have triggered high rates of groundwater withdrawal and historically high rates of land subsidence. The U.S. Geological Survey (USGS) developed the Central Valley hydrologic model (CVHM) to quantitatively assess aquifer-system responses to climatic variation, land-use changes, surface-water deliveries, artificial recharge, and groundwater pumping. Results from recent updates to the CVHM show the simulated spatial distribution, timing, and magnitudes of groundwater-level changes and land subsidence resulting from changes in these stresses. The updated CVHM provides an analysis of the spatial and temporal variability of changes in surface water and groundwater availability and subsidence. These results can be used to assist in making water management decisions necessary to achieve effective conjunctive use throughout the Central Valley.

Session 2. Flood Modeling

Flood System Optimization for the Central Valley – Jay Lund (UC Davis) **2.4 MB**

This talk summarizes two recent studies of the Sacramento Valley flood management system. 1) the results of an optimization modeling for flood operations, focusing on by-pass capacities in the system. This linear-programming based optimization found that the Yolo Bypass is probably the most important flood management bottle-neck in the system for large floods, and gives some insights into the interaction of flood infrastructure elements under optimized operations. 2) results of a multi-objective optimization of water and land management for the Yolo Bypass. This study shows potential for improving conditions for fish and birds with relatively little damage to agricultural production in the bypass and without substantially changing capacity for flood conveyance.

Effect of Hydrology Change on Computed Design Water Surface Elevations – Mike Archer (MBK Engineers) **0.9 MB**

The California Urban Levee Design Criteria specifies that the design water surface elevation for providing an "urban level of protection" is that produced by the flood that has a 1-in-200 chance of occurring in any given year (200-year flood). Generally, hydraulic routing models are used to compute the 200-year water surface with hydrologic input designed to represent a 200-year flood event at the location of interest. Until recently, the best available hydrologic data was that developed in 2002 for the Sacramento and San Joaquin River Basins Comprehensive Study (Comp Study). The State of California has recently undertaken the Central Valley Hydrologic Study (CVHS) with the purpose of developing a new hydrologic data set to replace the Comp Study data set. This presentation provides a case study of how the change in hydrology data can affect a computed design water surface elevation.

Sutter Bypass Two-Dimensional Hydraulic Model Development and Application – Kyle Winslow (CH2M Hill) **4.9 MB**
Collaborator: Sungho Lee (CVFPB)

On behalf of the Central Valley Flood Protection Board, CH2M HILL developed a 2D hydrodynamic model of the Sutter Bypass to investigate channel capacity under existing conditions and projected water levels under defined storm events such as the 100-year and 200-year events. The model was developed with a dense network of 47,000 grid cells representing the underlying surface with a unique elevation and 1 of 23 vegetative cover or land use conditions. Much of the land within the study reach has been retained as agricultural land but the Sutter Bypass National Wildlife Refuge occupies more than 2000 acres within the Bypass. The model was calibrated for the 2006 flood event with predicted water levels at 6 gauges matching observations with an error of 0.27 feet.

The calibrated model was used to investigate changes in peak flood elevations for potential management actions in the Bypass such as vegetation removal, sediment removal, land use alterations, and levee set-backs. Simulations were conducted to bound future water levels assuming either complete vegetation removal or continued growth of vegetation (no future maintenance activities). In general, results indicate that local management actions have a localized, minor effect on water level. The scale of vegetation removal necessary to impart significant changes in predicted water levels was on the order of several thousand acres.

Developing a 2D HEC-RAS Model of the Lower Sacramento River – William Fleenor (UC Davis) **14 MB**
Collaborators: Alessia Siclari and Lily Tomkovic (UC Davis)

Conservation measure 2 (CM2) of the Bay Delta Conservation Plan (BDCP) involves increasing flooding frequency on the Yolo Bypass and providing adequate fish passage. The approach to CM2 the formation of the Yolo Bypass Fisheries Enhancement Plan. The National Oceanographic and Atmospheric Administration (NOAA) Fisheries released a biological opinion (BO) requiring the U.S. Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) to restore salmon habitat on the lower Sacramento River Basin (possibly on the Yolo Bypass) and modify the Fremont Weir on the Yolo Bypass and other structures to provide passage of fish through the bypass. Yolo Bypass is a crucial agricultural portion of Yolo County and funded the Center for Watershed Sciences at UC Davis to create a public domain model of the lower Sacramento River to provide all stakeholders with a model to investigate proposed and alternate changes. The work presented is the development of the HEC-RAS model using 2D floodplains to represent the tidal and potentially flooded areas of the lower Sacramento River. Presentation will include boundary condition, roughness approaches, digital elevation model development, sub-grid bathymetry advantages, solution schemes, grid convergence, calibration and validation, and uncertainty metrics of the HEC-RAS 2D lower Sacramento River model.

Yolo Bypass Floodplain Analyses: Multi-Objective Modeling – Jeremy Thomas (CH2M Hill) and Mark Tompkins (Newfields) **0.8 MB**
Collaborator: Rummy Shivcharan (DWR)

As part of the Central Valley Flood Protection Plan (CVFPP) formulation, our team performed a screening level analysis of expected annual habitat (EAH) in the Yolo Bypass associated with different flood management configurations, including modifications to the Fremont Weir and levee setbacks. EAH is used to quantify the potential benefits of floodplain rearing habitat for native fish species by linking the spatial and temporal characteristics of floodplains to define the functional habitat they create. EAH generates area-duration-frequency (ADF) curves to quantify the area of floodplain inundated for a specified duration, timing, and frequency and can thus be useful in determining the suitability of a floodplain as habitat for fish, wildlife, or ecosystem processes. We coordinated with the DWR and US Bureau of Reclamation Biological Opinion (BiOps) teams for the Yolo Bypass to develop consistent daily hydrology with the addition of a notch on Fremont weir and implemented EAH using Python scripts to generate two types of modeling output. First, general flow-inundation area output including ADF curves, and then more refined inundation areas for specific timing, duration, and frequency requirements of target species. The modeling output will be used to inform the development of ecosystem restoration concepts in the Yolo Bypass and the formulation of multi-benefit projects for the 2017 CVFPP.

Session 3. CalSim and WRIMS Development

Modeling to Support CVP Cost Allocation: Flow Tracking and Multiple Regulatory Environments
Nancy Parker (Reclamation) **6.1 MB**

The Bureau of Reclamation is conducting analysis to support a new cost allocation for the Central Valley Project, which will apportion project costs among the project's seven Congressionally-authorized purposes (water supply, power, flood control, fish and wildlife, recreation, navigation, and water quality). New and revisited CalSim and WRIMS applications have been developed to support this analysis, including a suite of models depicting past regulatory environments, a flow-tracking module and a single purpose facility sizing tool. Although the final results of the Cost Allocation Study analysis are not yet available, details on the development of the CalSim studies and WRIMS applications can be shared with the broader modeling community.

The New California Groundwater Sustainability Legislation from a CalSim Perspective – David O'Connor (Reclamation) **8.9 MB**

The passage of the Sustainable Groundwater Management Act (SGMA) imposes a new regulatory landscape for groundwater use. Water supply reliability modeling for the CVP/SWP systems will soon need to account for groundwater extraction limits in greater detail. The presentation will summarize some commonly used models that simulate groundwater pumping and surface water-groundwater interaction in the Central Valley (C2VSIM, CVHM, CalSim) and will discuss plans and challenges in updating CalSim 3.0 to incorporate new groundwater extraction limits. The presentation will also show some preliminary results of groundwater pumping and surface water interaction simulated by CalSim 3.0 for the San Joaquin Basin.

CalSim 3.0 and the San Joaquin River: Where is the Model Now? – Travis Yonts (Reclamation) **1.2 MB**

Recent work has been completed to update the San Joaquin River CalSim 3.0 model representation. This work has involved the collection and comparison of CalSim 3.0 output to observed data and CalSim II output. Ultimately, these comparisons assist with the determination of the CalSim 3.0 loss factors, as well as understanding and describing differences between CalSim II and CalSim 3.0 results. This presentation will summarize how each model (CalSim II and CalSim 3.0) simulates demand units, provide an example of the abovementioned comparison analysis, and discuss how the analysis is being utilized to assist with CalSim 3.0 San Joaquin River model development.

WRIMS 2 GUI/IDE Development – Hao Xie (DWR) **1.1 MB**

The new WRIMS 2 Graphic User Interface (GUI) consists of an Integrated Development Environment (IDE), which provides comprehensive facilities, such as a Run Time Debugger, a Code Editor, and a Model Launcher, to modelers for programming CalSim/CalLite applications in Water Resources Simulation Language (WRESL). Four perspectives: WRIMS IDE, DSS Operator, Schematic Viewer, and Schematic Editor, are integrated and presented in WRIMS 2 GUI/IDE. Position Analysis Runner, Multi-Study Runner, and Batch Runner, etc, have been developed to facilitate complicated CalSim/CalLite applications. Collaborations between WRIMS 2 and other Water Resources Modeling software packages are being conducted.

Session 4. Sustainable Groundwater Management

The State's Role in Implementing the Sustainable Groundwater Management Act – Rich Juricich (DWR) and Erik Ekdahl (SWRCB) **1.4 MB**

On September 16, 2014, California Governor Jerry Brown signed into law a three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act. The Governor's signing message states "a central feature of these bills is the recognition that groundwater management in California is best accomplished locally." This new legislation defines sustainable groundwater management as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." This presentation will highlight the implementation roles of the Department of Water Resources and the State Water Resources Control Board for this new legislation.

Methods and Examples of Sustainability Analysis – Randy Hanson (USGS) **11.3 MB**
Collaborator: Scott Boyce (USGS)

An analysis of the sustainability of water resources starts with a physically-based approach to simulating supply and demand components of the hydrosphere. Additional factors may constrain the conceptual framework of sustainability of water resources, including climate, the biosphere, urban and agricultural supply and demand, limits to secondary effects of overexploitation, imports and exports of water, and the level of mitigation of historical conditions. These factors contribute to the dynamic framework necessary for water-resource management, and may also affect water and food security within a watershed. Using a physically-based, demand-driven and supply-constrained integrated hydrologic model, such as MODFLOW-OWHM (One Water Hydrologic Model), provides a basis for this analysis and a tool for exploration of the effects of changing supply and demand on sustainability. Examples from the Pajaro, Cuyama, and Rio Grande Valleys will be used to demonstrate the utility of this approach to sustainability analysis. Applying the quantitative approach shown in these examples demonstrate how temporal and process-based information yields the more holistic analysis that is necessary for understanding sustainability under changing conditions. This integrated hydrologic model embodies the dynamic framework needed for future sustainability analysis and creates an impartial pathway for mediation.

Using Groundwater Models for Successful Groundwater Sustainability Planning – Thomas Harter (UC Davis) **1.6 MB**

Groundwater models for basin management first and foremost represent a physically consistent conceptual framework of a basin groundwater flow system that reflects a) the scientifically accepted physics of groundwater flow; b) the known (however limited or simplified) geologic understanding of the hydrogeological structure of a groundwater basin; c) an expert system of the known or hypothesized water fluxes into and out of the groundwater basin; d) an optimized (fine-tuned) approximation of the real system that also honors measured data about groundwater flow, groundwater levels, and other components of the groundwater system subject to the constraints imposed by a)-c). As part of groundwater management planning and implementation, a groundwater model represents aggregated "expert opinion" that may serve multiple purposes. The presentation will discuss the overall framework within which such modeling occurs, the strengths and potential pitfalls of current approaches.

Habitat Considerations in Sustainable Groundwater Management – Daniel Wendell (The Nature Conservancy) **2 MB**

Since Theis' seminal 1940 paper, *"The Source of Water Derived from Wells, Essential Factors Controlling the Response of an Aquifer to Development,"* we have known that there are only two sources of sustainable water supply for a pumped well: 1) induced infiltration; and 2) decreased discharge to surface water systems. In California's arid landscapes the second factor is, by far, dominant. Accordingly, *groundwater pumping is only sustainable to the degree we are willing to accept like amounts of stream depletion and associated impacts to surface water rights and the environment.* Identification of a sustainable yield must, therefore, explicitly acknowledge these tradeoffs and be arrived at through an open, stakeholder-driven process. This process not only needs to account for economic benefits of land cultivation and development, but also economic and cultural benefits of in-stream flows, maintenance of important riparian habitat in select streams, and protection of existing surface water rights. Strategies to maximize sustainable yield revolve around deliberately increasing recharge, proactively managing the timing and location of pumping and, as needed to meet stakeholder goals, limiting the total amount of groundwater pumping from the basin.

Session 6. Pop-Up Talks

Conjunctive Use Strategy Optimization: Simple User Friendly Excel Tool – Eric Mork (UC Davis)

Ecosystem Management Under Uncertain Hydrologic Condition – Karandev Singh (UC Davis) **5 MB**

CALVIN and HOBBES Updates – Josue Medellin (UC Davis) **0.6 MB**

Watershed Modeling of the Santa Clara River Watershed –Tony Donigian (Aqua Terra Consultants)

Maximizing Fish Survival via Optimized Reservoir Operations – Lauren Adams (UC Davis) **1.2 MB**

Situational Analysis of Riverine Temperatures Below CVP Reservoirs – Tom Fitzhugh (USBR) **0.3 MB**

Sustainable Capture – Steffen Mehl (CSU Chico) **0.5 MB**

Quasi-decadal Oscillation in the CMIP5 and CMIP3 Climate Model Simulations: California case Jianzhong Wang (DWR) **0.7 MB**

Towards a USEPA Strategy for Sharing Continuous Water Quality Monitoring Data – Tad Slawecki (LimnoTech) **0.5 MB**

Project Updates: Characterizing and Quantifying Nutrient Sources, Sinks and Transformations in the Delta – Marianne Guerin (RMA) **1 MB**

DSM2 User Group Updates – Min Yu (DWR) **0.5 MB**

Flood Warning System Improvements – Holly Canada (David Ford Consulting Engineers) **97 KB**

Session 7. 2014 DSM2 Development and Applications

Modifying Delta Channel Depletions to Improve DSM2 EC Modeling – Lan Liang (DWR) **5.2 MB**

This presentation covers the work done to incorporate groundwater into the total consumptive use of Delta islands and to show how the new estimates of consumptive use and net channel depletions affect DSM2 EC modeling. DICU and DETAW are Delta consumptive use (CU) models. Their output is used as input by DSM2 to represent water diverted from and drained back to channels due to agricultural practices in the Delta. The models use evapotranspiration calculations based on crop type to determine the amount of applied water. When using either model, DSM2 overestimates EC in the summers of most drought years. In drought conditions, when net delta outflow is less, small changes in the estimate of net delta outflow can result in large differences in salinity transport within the Delta. Better estimates of net channel depletions have been targeted as a possible reason for the differences between DSM2 model results and observed data. By incorporating groundwater into the consumptive use estimates, DSM2 models better salinity transport in Drought years without negatively impacting salinity transport results in other year types.

Water Cost of Compliance: A Robust Decision Tool for Drought Alternatives – Eli Ateljevich (DWR) **1 MB**

When water supply is critically low, sensitivities and uncertainties emerge that stress models beyond the norm in operational planning. Agricultural water use is a dominant and uncertain component of outflow and the salinity field is positioned precariously close to the north-south passageway into the Central Delta. This talk juxtaposes two approaches to modeling under these circumstances. In the first, hydrology scenarios are fixed a priori and used to generate salinity results under two scenarios (e.g. with and without emergency barriers). In the second, salinity compliance is assumed and an inverse problem is solved to generate the water cost and schedule discretionary flow for each alternative. The approaches create very different impressions about the scenarios under investigation.

Thousands of Releases: Characterizing Lagrangian Transport and Comparing to Eulerian Metrics
Deanna Sereno (CCWD) **3 MB**

Abstract not available.

DSM2 Particle Tracking Model Development and Collaboration – Xiaochun Wang (DWR) **0.4 MB**
Collaborators: Doug Jackson (NOAA) and Russell Perry (USGS)

In order to evaluate possible impacts of project operations and new construction on fish migration and survival through the Delta, NMFS and DWR have been developing fish behavior particle tracking models with USGS providing expertise on developing methodologies for calibration and fish behavior sub-models. Although the scope of the development differs between NMFS and DWR, it is agreed that the two agencies will merge the development efforts and produce a single set of behavior sub-models for Chinook smolts. Three behavior sub-models (swimming, survival, and route selection) are under development. The parameters of these behavior sub-models are calibrated using acoustic telemetry tag data and optimization techniques. This presentation will provide an overview of the project background, the modeling methodologies, the current status of the development, and the collaboration plan between NMFS and DWR.

Session 8. Sacramento and San Joaquin Basins Study – 2015 Update

Overview of the Sacramento and San Joaquin Basins Study – Michael Tansey (Reclamation) **1.8 MB**

An overview of the Sacramento and San Joaquin Basins Study will be presented including a discussion of Reclamation’s climate change program and recent activities in the Mid Pacific Region. The presentation will also include background information on the methods and models used in the study.

Updates to Climate Change Scenarios and Impacts on Central Valley Water Supplies – Tapash Das (CH2M Hill) **2.2 MB**
Collaborators: Armin Munévar and Brian Van Lienden (CH2M Hill); Charles Young and Michael Tansey (Reclamation)

The amount of water available throughout the Sacramento and San Joaquin basins over the twenty-first century are highly uncertain and dependent upon several factors, including the potential impacts of future climate variability. Phase 1 of the Basins Study has been completed using a suite of climate scenarios to reflect a range of future conditions. The climate scenarios used in the Phase I relied on Coupled Model Intercomparison Project, Phase 3 (CMIP3). Currently newer climate projections available from CMIP5 climate model simulations are consistent with the most recent Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR5). The climate scenarios for Phase 2 are being updated based on CMIP5 climate model simulations to perform assessments of current and future water supplies in the Central Valley. The water supply assessment characterizes and quantifies the probable magnitude and variability of historical and future natural flows in the basins to evaluate the potential effects of future climate variability and climate change and to estimate quantified projections of future hydrology.

Assessing the Impacts of Socioeconomic-Climate Scenarios on Central Valley System Risk and Reliability – Brian Van Lienden (CH2M Hill) **2.3 MB**
Collaborators: Heidi Chou and Armin Munévar (CH2M Hill)

A system risk and reliability assessment is being performed on water dependent resources in California's Central Valley through a broad scenario planning approach combined with integrated systems analysis. To account for a range of uncertainty in future conditions through 2100, a suite of scenarios reflecting a combination of socioeconomic-climate futures has been developed. The performance of the Central Valley water system is being evaluated for water delivery, water quality, recreation, flood control, hydroelectric power, and ecological resource areas using an integrated model package that simulates CVP, SWP and local system operations and regulatory requirements using the CVP IRP CalLite Model and other performance assessment tools. Performance metrics for each resource area have been developed to articulate existing and future system vulnerabilities under the range of potential future conditions. The results from the suite of models will be used to guide the development of water management actions to address system risks.

Development and Evaluation of Adaptation Actions to Address Central Valley Water Management Risks – Armin Munévar (CH2M Hill) **1.3 MB**
Collaborators: Arlan Nickel (Reclamation) and Brain Van Lienden (CH2M Hill)

The Sacramento-San Joaquin Basins Study seeks to explore a range of water management actions that can help reduce or manage future risks posed by potential changes in climate and socioeconomic conditions. The Basins Study will include a range of water management actions including demand management, supply augmentation, reuse, desalination, watershed management, storage and conveyance, and adaptive system operations. Each of these measures has the potential to create a more resilient water management system to respond to future changes and threats. In addition, exploration of combinations of such actions, or portfolios, may suggest robust sets of actions or pathways to manage risk while achieving differing levels of economic, environmental, and social benefits. This presentation will outline the approach and initial results for the development and evaluation of adaptation actions in the Basins Study.

Next Steps in the Sacramento-San Joaquin Basins Study – Arlan Nickel (Reclamation) **0.2 MB**

The status of tasks and schedule of completion for the Sacramento and San Joaquin Basins Study will be presented.

Session 10. CalLite

CalLite 3.00 Updates – Raymond Hoang (DWR) **2.9 MB**
Collaborators: Nazrul Islam, Erik Reyes, Francis Chung, Richard Chen, Hao Xie, Kevin Kao, and Ali Abrishamchi (DWR); Nancy Parker, Tom FitzHugh, and Travis Yonts (Reclamation); Dan Easton (MBK Engineers); Tad Slawecki (LimnoTech); Holly Canada (David Ford Consulting)

The California Department of Water Resources and the U.S. Bureau of Reclamation Mid-Pacific Region have developed CalLite as an interactive screening model for evaluating various Central Valley water management alternatives. CalLite simulates the hydrology of the Central Valley, reservoir operations, delivery allocation decisions, delta salinity, and habitat-ecosystem flow indices over an 82 year planning period. The model achieves this with a short run time (<10 minutes) and maintains the hydrologic and operational integrity of its parent model, CalSim.

CalLite 3.00 is the latest version of the model and was released to the public in November 2014. Major updates from CalLite 2.01 include: (1) utilization of the latest WRIMS 2 engine, (2) expanded simulation capabilities for exploring water management alternatives, climate change and regulatory options, (3) improved allocation methods, (4) dynamic San Joaquin River simulation and (5) an updated graphical user interface (GUI). The updated GUI includes new post-processing tools and batch run capability to further assist in the screening of a broad range of water management options in California.

Drought Impact Analysis on Storage, Salinity, and Flow Using Position Analysis – Ali Abrishamchi (DWR) **2 MB**
Collaborators: Nazrul Islam, Raymond Hoang, and Erik Reyes (DWR)

CalLite, an interactive screening model to evaluate Central Valley water management alternatives, is used to examine the impact of the potential future drought sequences. CalLite model uses the existing conditions with Biological Opinions (BO) in a position analysis. Position analysis is a simulation method in which varying hydrologic input sequences are run from a fixed starting condition. CalLite simulations were performed for historical critical water years of 1924, 1929, 1931, 1933, 1934, 1976, 1977, 1988, 1990, 1991, 1992, and 1994. Forecasted end-of-September 2014 storage and X2 Positions were used as initial conditions when running the model for the abovementioned critical water years and BO Reasonable and Prudent Alternative (RPA) base simulation data for drought years was used as initial conditions for all other variables. The impact of the drought on storage, salinity, and flow was analyzed by using the Position Analysis technique.

Decision Scaling with CalLite to Identify Climate Change Vulnerabilities to the State Water Project
Andrew Schwarz (DWR) **0.3 MB**
Collaborators: Matt Correa (DWR); Patrick Ray and Sungwook Wi (University of Massachusetts-Amherst)

The California Department of Water Resources – Climate Change Program in cooperation with the University of Massachusetts-Amherst Hydrosystems Research Group are using CalLite and the Decision Scaling approach to explore the State Water Project's operational vulnerabilities to climate change. Decision Scaling links bottom-up vulnerability assessment with multiple sources of climate information. The Decision Scaling approach is particularly well suited to exploration of California's unique internal and external variability and can provide decision relevant metrics of change. CalLite's ability to rapidly simulate water system response to an array of hydrologic changes allows for the exploration of a wide range of internal/natural variability and external variability/imposed climate shifts (long-term changes in precipitation and temperature).

In this study, the CalLite inputs have been systematically reconfigured so that new hydrologies (beyond what has previously been explored) can be analyzed by the model. All input time series are synthetically generated to be consistent with the hydrologic and climatological inputs. After identifying specific areas of vulnerability the same analysis process will be used to explore potential adaptation strategies that reduce identified vulnerabilities.

Interfacing CalLite with DHI's Integrated Modeling Platform – Steve Blake (DHI US Water Resources)
Collaborators: Arnold Engelmann, Jesper Overgaard, Sunny Mittal (DHI US Water Resources) **2 MB**

DHI develops and uses technology for decision support and water resources information management around the world. This presentation will demonstrate the application of a model and information management platform to expand and extend the capabilities of DWR's CalLite v.3 towards enhanced spatial and temporal scales and included processes. These capabilities can be used to localize specific studies, verify inputs and build connections to real time observations and forecasts, and represent phenomena of importance to decision makers and stakeholders in California's water environments.
Using DHI's Platform for real-time data management and visualization, we will demonstrate an application connecting and extending CalLite for information management, modeling and decision support using a specifically tailored, extensible interface. Steps to implement database connectivity, model interoperability and results presentation will be reviewed.

Using this approach and the ECOLab interface, DHI's open equation editor and solver, a typical WQ process can be described, modeled and displayed to build consensus on model formulation and parameterization. This development will extend CalLite's inherent capabilities to provide scenario development, situational context and boundaries. The approach can be used to implement solutions for in-stream temperature modeling, salinity modeling, or simulation of fish behaviors and management impacts to select species.

Session 11. A Simulation Tool for the Bay-Delta Water Quality Control Plan

The Bay-Delta Water Quality Control Plan: What is it, and How are we Modeling it? – Eleanor Bartolomeo (SWRCB) **0.3 MB**

The current Bay-Delta Water Quality Control Plan, more commonly known as D-1641, sets instream flow requirements, salinity limits, and export restrictions for the Sacramento – San Joaquin River Delta and its tributaries. The State Water Resources Control Board (Board) is in the process of revising these standards to protect beneficial uses in the Bay-Delta watershed, including fish and wildlife, agricultural, and municipal and industrial uses. To evaluate the water supply impacts of alternative levels of beneficial protection, the Board is developing a combined hydrology / system operations model of the Sacramento River Basin called the Sacramento Valley Water Allocation Model (SacWAM). The goal is to develop a flexible, user friendly model that allows for efficient analysis of multiple scenarios. This talk presents an overview of the Bay-Delta Water Quality Control planning process as well as the goals and motivation in the development of SacWAM.

SacWAM – The Best of Both Worlds – Charles Young (SEI) **0.7 MB**

The State Water Resources Control Board, Stockholm Environment Institute, and MWH have developed the Sacramento Valley Water Allocation Model (SacWAM) to support water allocation analyses for the Board's Bay-Delta Water Quality Control Plan. The model, developed in the WEAP software, draws features from both the Central Valley Planning Area (CVPA) model used in the Water Plan and CalSim. The upper watersheds of the Sacramento Hydrologic Region are represented using a refined hydrology representation based on the CVPA model. The valley floor demands are simulated at a spatial scale similar to that found in the CalSim model. In this presentation the approach taken in the development of the model will be discussed.

SacWAM – A Climate Driven Model of Sacramento Valley Rim Watersheds with Layered Infrastructure and Operations – Charles Young (SEI) **0.8 MB**

The representation of the Sacramento Valley Rim watersheds in the Sacramento Valley Water Allocation Model (SacWAM) is based on a refined version of the Central Valley Planning Area model developed for the State Water Plan. The refinements include representation of storage reservoirs and inter-basin transfers. In this presentation the approach taken in developing the upper watershed hydrology, infrastructure, and operations will be discussed. Model performance will also be presented.

SacWAM – Valley Floor Hydrology and a Nested Daily FAO 56 Crop Water Demand Model in a Monthly Simulation Model – Andy Draper (MWH) **1.5 MB**

Irrigated agriculture in the Sacramento Valley covers approximately 2 million acres and consumes about 5 million acre-feet of water each year. Accurate representation of crop water use is a critical part of modeling the water resources of this region. The WEAP software allows the model user to directly simulate agricultural water demands based on land use, soil, and agronomic inputs. The direct embedding of a crop water model within a river-reservoir simulation model facilitates model calibration and provides greater flexibility in modeling different land-use and climate scenarios. The "MABIA" module of the WEAP software is a daily accounting of soil moisture in the root zone through simulation of crop transpiration, soil evaporation, and irrigation scheduling. MABIA uses the standard dual-crop coefficient method established by Richard Allen et al. (1998) in FAO Irrigation and Drainage Paper No. 56. The dual-crop approach better represents ET in the non-growing season and during the initial stages of plant growth. The MABIA module also offers various options for simulating the timing of irrigation events. Routines have been added for rice cultivation, including daily schedules of flood-up, maintenance, and drawdown. Effective precipitation is estimated using the Soil Conservation Service (SCS) Curve Number method.

SacWAM – Managing Water for Fish, Farms, Floods, and Faucets – Brian Joyce (SEI) **0.7 MB**

The Sacramento Valley Water Allocation Model (SacWAM) has been developed to account for the competing demands for water that exist in the Sacramento Valley and the Delta. Operations rules have been developed to account for flow requirements for fishery protection, water allocation for agricultural users, flood control, Delta water quality, and urban water demands. In this presentation a summary of the operations rules included in the model will be discussed as well as a presentation of model performance.

Session 12. Integrated Water Resources Models

Status Update on IWFM Activities – Emin Can Dogrul (DWR) **1.5 MB**

The IWFM numerical engine undergoes constant improvements to allow the users address complex questions in an efficient way. In the past year, new simulation features such as stream flow routing using kinematic wave approach and root water uptake from groundwater have been implemented, and used in modeling studies. A new version of IWFM, IWFM-2015, was made available to the public last year. IWFM-2015 is based on a new modeling framework that is fully modular and extensible, and is designed to improve linkage to other water resources planning tools such as CalSim, Statewide Agricultural Model (SWAP) and groundwater transport models. IWFM pre- and post-processor tools are also going through enhancements to improve user experience and workflow efficiency. Recently, a new mixed triangular-quadrilateral mesh generator was developed and integrated into the ArcGIS platform. This presentation will give a detailed explanation of the IWFM improvements and activities with examples from several modeling studies.

Assessment of Surface Water – Groundwater Interactions in the Central Valley – Mesut Cayar (RMC)
Collaborators: Ali Taghavi and Jim Blanke (RMC); Dan Wendell and Maurice Hall (The Nature Conservancy) **2.9 MB**

The California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) is a leading Central Valley-wide integrated hydrologic model adopted by California DWR and many other regional and state-wide agencies, as well as non-governmental organizations (NGOs) to evaluate various water management scenarios throughout the Valley. In an effort to evaluate and quantify the interaction between the groundwater and surface water system, C2VSim was employed. Three potential future management scenarios were developed and simulated: (i) Groundwater Substitution Scenario; (ii) Increased Agricultural Water Demand Scenario, (iii) Increased Irrigation Efficiency Scenario.

The results of this study contribute significantly to the understanding of how management of groundwater and surface water are interrelated and will inform the development of more effective integrated water management in the Central Valley and throughout California.

Simulation of Groundwater and Surface Water Resources in the Santa Rosa Plain Watershed using GSFLOW – Linda Woolfenden (USGS) **9.3 MB**
Collaborators: Joseph Hevesi and Tracy Nishikawa (USGS)

Water managers in the Santa Rosa Plain (SRP) face the challenge of meeting increasing water demand with a combination of surface water (which has uncertainties in future availability), local groundwater resources, ongoing and expanding recycled water, and water from other conservation programs. To better understand and to help manage the hydrologic resources in the SRP watershed, GSFLOW (a coupled groundwater and surface-water model) was developed. The GSFLOW model was used to analyze selected components of water budgets and to determine the effects of specified pumping and future-climate on the hydrologic system. Selected results indicated that despite the variation in stream-flow discharge from the SRP watershed, the relative average contributions of surface runoff and interflow to streamflow were similar for most years. Pumping resulted in an average reduction of streamflow of about 8 percent. This quantity contributed 53 percent of the total groundwater pumped in the SRP watershed. Increased recharge during wet years was insufficient for groundwater storage to recover from increased pumping and reduced recharge during dry periods, resulting in an overall decline in groundwater storage. In the future-climate scenarios, water levels generally declined from historical conditions, resulting in reduced baseflows, increased losing-stream reaches, and reduced riparian evapotranspiration.

Coping with the Hydrologic Complexity of Surface-Groundwater Interaction – Hubert Morel-Seytoux (Hydroprose) **0.3 MB**

Flow exchange between surface and ground water is of great importance for beneficial allocation and use of the water resources or for the proper exercise of water rights in large-scale regional studies. That exchange can take place under a saturated or unsaturated flow regime. Which regimes occur depend on conditions right in the interactive area (e.g. case of irrigation) or in its near vicinity (seepage from a river). In large-scale regional studies to simulate the complex hydrological processes it is necessary, for practical reasons, to simplify them. The difficulty is to do so without affecting greatly the accuracy of the results. This presentation suggests a few methods to identify which processes are actually taking place and to describe them in an efficient and accurate way. It also shows that Numerical (i.e. Finite differences or elements) Integrated Hydrologic Models currently in use can lead to significant errors if grid sizes are too coarse. Much of the discussion has to do with a condition of steady-state. It is meant as a first step toward a simple, yet accurate and physically based treatment of the transient situations.

Session 13. Historical Delta Modeling Project

Unimpaired Flows vs. Natural Flows to the Sacramento-San Joaquin Delta: What's the Difference?
Tariq Kadir (DWR) **1.1 MB**
Collaborator: Guobiao Huang (DWR)

CA DWR is in process of finalizing estimates of daily natural flows in the Sacramento – San Joaquin Valley for WY 1922-2013. In the California water community, the terms "unimpaired flows" and "natural flows" have often been used interchangeably to reflect stream flows prior to agricultural and urban land use development. However, the two physical processes are quite different and, depending how they are interpreted and used, may lead to erroneous conclusions on availability of water supply in the Central

Valley. This presentation will summarize the key differences between the two concepts and also compare results between natural flows and unimpaired flows (as estimated by CA DWR) into the Sacramento–San Joaquin Delta.

Historical Delta Elevation Model – Logic and Methods – Andy Bell (UC Davis) **4.1 MB**
Collaborator: William Fleenor (UC Davis)

Since the mid-19th century, the landscape of the Sacramento–San Joaquin River Delta has been heavily altered through human modifications. Artificial levees for flood control, debris from hydraulic mining, deepwater shipping channels, and water exports have all fundamentally altered the form and function of the Delta. To characterize the hydrodynamics of the Delta under natural conditions (prior to modifications of the Delta's geometry and hydrology), a bathymetric-topographic digital elevation model (DEM) was created to represent the Delta circa the early 1800s. Primary inputs to the elevation model include 2D historical Delta channels and land cover data from previous historical ecology mapping efforts (Whipple et al. 2012), along with data from historical sources, including the US Coast Survey hydrographic sheets and early rivers surveys. Novel techniques were developed to work with historical data, including methods to interpolate between sparse historical soundings, infer the depths of non-navigable channels from channel width, and convert historical tidal datums to modern fixed datums. The resulting 2-meter resolution digital elevation model covers the Delta's historical channels, tidal and non-tidal wetlands, ponds, and natural levees (800,000 acres total).

3D Modeling Comparison of Salinity in the Historical and Contemporary Delta – Steve Andrews (RMA)
Collaborators: Ed Gross and John DeGeorge (RMA) **3.2 MB**

Many changes have taken place in the Delta between the early 1800s and today, including channel deepening and straightening, levee construction, marsh removal, and inflow alterations in magnitude and timing, among others. In order to examine how these changes affected characteristics of the low salinity zone, we constructed and calibrated three-dimensional models of the Delta as it was in the early 1800s (the "natural" condition) and its current condition. Inflow boundary conditions, developed using the C2VSim model, and early 1800s bathymetry, developed from historical maps and sounding data, were used to recreate conditions for the natural Delta. Earlier presentations in this session discuss this development in detail. Yearly flow and salinity simulations were performed for both an above average precipitation year and a below average one. The character of the effects of inflow changes versus changes in Delta geometry was assessed by simulating both natural and contemporary inflow hydrologies on each Delta grid.

Ecological Implications of Modeled Hydrodynamic Changes in the Sacramento-San Joaquin Delta since 1800 AD – Sam Safran (SFEI) **13 MB**
Collaborator: Robin Grossinger (SFEI)

A broad team has recently developed a pair of three dimensional, stratified flow hydrodynamic models of the Sacramento-San Joaquin Delta: one representing conditions circa 1800 (the "historical" Delta model), the other representing conditions circa 2012 (the "modern" Delta model). To assess how alterations to Delta geometry since 1800 AD have affected Delta hydrodynamics, we used these models to evaluate a series of hydrodynamic metrics under historical and modern conditions. To isolate the effects of altered geometry, both the natural and modern models were run under conditions of identical Delta inflow. Hydrodynamic metrics—including residence time, tidal prism, tidal excursion, average cross-sectional velocity, and tracer distributions—were chosen based on their known or assumed relationship to the provision of key ecological functions (e.g., fish rearing and migration, food supply and nutrient cycling). Accordingly, in addition to presenting model results, we discuss the implications of the modeled changes through a review of the available literature tying hydrodynamics to ecological function. By providing an improved regional-scale understanding of changes in physical drivers/gradients over time and the implications for wildlife, this work supports the development of management and restoration guidelines grounded in a deeper understanding of system characteristics.

Session 15. Selected PEST Applications in California

Calibrating the Soquel-Aptos PRMS Model to Streamflow Data Using PEST – Cameron Tana (Hydrometrics, Inc.) **13 MB**
Collaborator: Georgina King (Hydrometrics, Inc.)

A model was developed using the U.S. Geological Survey's (USGS) Precipitation-Runoff Modeling System (PRMS) to estimate deep recharge from watersheds overlying the Soquel-Aptos groundwater basin. The model is a distributed-parameter, physically based hydrologic model that uses precipitation and temperature data to calculate runoff, evapotranspiration, and deep groundwater recharge.

Following guidance from the USGS, we calibrated PRMS parameters using a step-wise approach. The first step was to manually calibrate solar radiation and potential evapotranspiration. The second step is to use PEST to calibrate soil-zone parameters to achieve the best match between measured and simulated streamflow at ten gages throughout the model area. We used the PestGui, a Java-based graphical user interface developed by the USGS to create files for PEST.

Calibration accuracy was first estimated by visually comparing measured streamflow with simulated streamflow at each of the ten gages. Calibration was also assessed by calculating the Nash-Sutcliffe goodness of fit statistics. The visual and statistical assessments showed that the model was well calibrated.

Using PEST to Calibrate the G Model and Inverting it to Estimate Net Delta Outflow – Nicky Sandhu (DWR) **1 MB**
Collaborator: Yu Zhou (DWR)

Salinity is estimated at Martinez with flow and stage inputs using a combination of G-model and its convolution with a linear model. PEST was used to calibrate this non-linear model that involves about 14 parameters with the objective of meeting observation salinity. PEST allowed ease of model exploration of additional complexity and parameter analysis helped to identify correlated parameters. In addition, PEST was used to estimate the Delta outflow using the salinity model by specifying daily flow as parameters. This approach results in an ill-posed problem with large amount of parameters, which PEST can solve for by using Tikhonov regularization or truncated SVD without over-fitting.

[**Using Pareto Optimization to Determine Model Predictive Uncertainty of Groundwater and Surface Water Interactions for the San Joaquin River**]() – Jonathan Traum (USGS) **1.8 MB**

Through the software PEST, Pareto optimization was used to estimate the predicative uncertainty of average stream seepage simulated by the San Joaquin River Restoration Program Groundwater Model (SJRRPGW). The SJRRPGW is an integrated hydrologic model developed to support the SJRRP by estimating the groundwater and surface-water interaction along a 150-mile reach of the San Joaquin River below Friant Dam. The average annual net stream seepage to groundwater simulated by the model is 370,000 acre-feet per year (AFY) (510 cfs) within the 1,300-square-mile model domain during the model's calibration period from 1962 to 2003. The median seepage rate is 280,000 AFY, with a range from 900,000 AFY in 1983 to 170,000 AFY in 1985. The average stream seepage can range from 230,000 acre-feet per year to 520,000 AFY with less than a 10% rise in the calibration objective function. In addition, the results define confidence levels of predicted model parameter values and were used to reveal which observation data sets provide information in reducing seepage estimate uncertainty. This additional knowledge was useful for identifying model parameters that were critical to the simulation of groundwater and surface-water interaction and were used to inform management decisions regarding SJRRP flow targets.

[**Comparing Cloud Computing Resources for Model Calibration with PEST**]() – Charlie Brush (DWR) **2.6 MB**

The computational resources required to calibrate hydrologic models increases with their scale and complexity. We tested the performance of Parallel PEST on four computer systems: multiple linked Office PC computers, the USDOE NERSC Carver system, the Amazon Web Services Elastic Compute Cloud (AWS EC2), and Windstream Hosted Solutions (WHS). Metrics were developed to compare the four systems based on technical assistance, ease of use, system performance, and costs. The four systems were tested with an example Parallel PEST calibration run using the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) coarse-grid model. The Office PC and Carver systems do not have the capacity to calibrate complex models within a reasonable time frame, and the AWS EC2 and Windstream HS systems can both scale nearly infinitely. The performance of Parallel PEST appears to be inversely proportional to network latency and contention. AWS EC2 is more flexible than Windstream HS, has lower base pricing, is more difficult to set up and operate, has high network latency and contention, and has limited technical assistance. Windstream HS has a limited number of configurations, is very easy to set up and operate, has excellent performance and technical assistance, and has significantly lower life-time costs.

Session 16. Kaleidoscope of Modeling from Shasta, the Sacramento River, and the Delta

Development of a Mercury Model for the Delta and Yolo Bypass – [Carol DiGiorgio]() (DWR)
Collaborators: Jamie Anderson, David Bosworth, En-Ching Hsu, Hari Rajbhandari, Nicky Sandhu, and Tara Smith (DWR); Cody Beals, Reed Harris, and David Hutchinson (Reed Harris Environmental, Ltd.)

A modeling team, consisting of Department of Water Resources' modelers and outside consultants, are creating a mercury model for the Delta and applying an existing mercury model to the Yolo Bypass. These models support the open water workgroup's regulatory compliance with the Central Valley

Regional Water Quality Control Board's Delta Mercury Control Program. As part of this regulation, the workgroup must examine the methylmercury impacts associated with operation of the State and Federal Water Projects and conveyance of flood waters in the Yolo Bypass. This presentation provides an overview of the group's efforts to date. For the Delta, a mercury module is being developed that will be used in conjunction with upgrades to DSM2. For the Yolo Bypass, the Dynamic Mercury Cycling Model is being used in conjunction with the Tuflow hydrodynamics model. Currently Department modelers are working on the General Transport Model of DSM2 and mercury related processes, while consultants are assembling mercury algorithms including mercury reactions and partitioning. In the Yolo Bypass, consultants have created base layer maps and, by the time of this talk, may have begun calibration of the model using currently available data.

CE-QUAL-W2 Modeling of Head-of-Reservoir Conditions at Shasta Reservoir, California – Katherine Clancey (UN Reno)
Collaborators: Laurel Saito (UN Reno); C. Svoboda, M. Bender, and J. Hannon (Reclamation)

Restoration of Chinook salmon and steelhead is a priority in the Sacramento River Basin since they were listed under the Endangered Species Act in 1989 and 1998, respectively. Construction of Shasta Dam and Reservoir obstructed fish migration, resulting in severe population declines. Efforts have been undertaken to restore the fisheries, including evaluation of opportunities for reintroducing Chinook salmon upstream of the dam and providing juvenile fish passage downstream past Shasta Dam. Shasta Reservoir and the Sacramento River and McCloud River tributaries have been modeled with CE-QUAL-W2 (W2) to assess hydrodynamic and temperature conditions with and without surface curtains to be deployed in the tributaries. Expected head-of-reservoir tributary conditions of temperature and water depth are being simulated under dry, median, and wet year conditions. Model output is analyzed during months of downstream migration of fish from upstream Sacramento and McCloud River tributaries. W2 will be used to determine presence of favorable conditions for juvenile rearing with proposed surface temperature curtains. Evaluation of favorable conditions for fish includes assessment of water temperature, velocities, and depth. Preliminary results for head-of-reservoir conditions and the influence of temperature curtains modeled with W2 will be presented. Study findings may assist in formulation of juvenile fish passage alternatives for Shasta Lake.

Modeling Reservoir Operations to Address Extreme Climate Impacts on the Downstream Fishery at Shasta Lake – Laurel Saito (UN Reno)
Collaborators: Joseph Sapin and Derek Kauneckis (UN Reno); Balaji Rajagopalan (University of Colorado at Boulder); Arthur Dai (University of Arizona)

Dams can have large impacts on freshwater ecosystems, changing natural river systems into fragmented networks of regulated flows and artificial reservoirs. However, dam operations and management can be adjusted to lessen impacts to aquatic ecosystems while still maintaining multi-purpose reservoir needs. We have been using a two-dimensional hydrodynamic model (CE-QUAL-W2) to examine downstream impacts of reservoir operations at Shasta Lake in northern California. Shasta Dam has a unique operations tool, the temperature control device (TCD) that became operational in 1997. The TCD enables releases from multiple levels of the dam to generate hydropower and control downstream temperatures. We have coupled CE-QUAL-W2 with stochastic input generation techniques to examine impacts of extreme flow scenarios on meeting downstream temperature guidelines for salmon. We modeled different reservoir operation options under these flow conditions to evaluate trade-offs of temperature deviations from targets and cold pool accumulation. As part of the project, we interacted with reservoir managers to create scenarios that would help them to make decisions about operations at Shasta. Results indicate that extreme climate conditions coupled with management constraints limit options for managing downstream temperatures and in-reservoir cold pool volumes, but the TCD does enhance the ability to address these targets.

Three-Dimensional Numerical Modeling of Periodicity and Spatial Variability in Secondary Circulation in the Tidal Sacramento River – Aaron Bever (Delta Modeling Associates)

Using the three-dimensional UnTRIM Bay-Delta model we examined the spatial and temporal variability in the secondary circulation near the junctions of the Sacramento River with the Delta Cross Channel and Georgiana Slough. The strength of the secondary circulation was shown to vary strongly on the tidal time scale, and generally increased with increasing flow and broke down near slack water. The location of strong secondary circulation was also shown to vary with the tidal cycle, as locations in the bends near the junctions were either on the up-flow side (strong secondary circulation) or the down-flow side (weak secondary circulation) of the bend dependent on the water flow direction. This temporal and spatial variability caused the along-channel pattern in the secondary circulation to be markedly different on ebb than on flood tide.

Session 17. A Deluge of Drought Modeling

Economic Analysis of the 2014 California Drought on Agriculture. Post-Assessment and Prospects for 2015 – Josué Medellín-Azuara (UC Davis) **2.8 MB**
Collaborators: Richard Howitt and Duncan MacEwan (ERA Economics); Jay Lund (UC Davis)

California faced in 2014 one of the worst droughts in more than a 100 years of records, at a time when agricultural water use and population are the highest environmental concerns have a prominent role in water management. Groundwater, the once abundant swing resource during drought makes over most surface water losses once again. We present methods and results in conducting an economic assessment of the 2014 drought. Emphasis is placed on the Central Valley, which hosts over 7 million acres of irrigated land and has been more severely affected by drought. Study results highlight the role of groundwater for coping with drought, the region-wide effects of fallowing on employment and income and the vulnerabilities of the water supply system in agriculture. The early estimates of the drought impacts predicted more than 410 thousand acres of land fallowed in the Central Valley costing $800 million in crop revenue, $200 million for dairies and livestock and nearly $450 million in increased pumping costs to partially offset surface water shortage. Remote sensing using Landsat imagery was employed to compare overall idle land patterns. Estimates coincide for the most part, with some discrepancies in the Sacramento Valley where additional rice fallowing occurred due to water trading and other factors. Research in progress includes an economic assessment of the 2015 drought, and use of energy balance approaches to estimate water consumptive use in high idle land areas.

Hydrology Forecasting using SWAT Hydrologic Models for the 2014 California Drought – Guobiao Huang (DWR) **2.7 MB**
Collaborator: Francis Chung (DWR)

During the prolonged drought in Water Year 2014, we made use of the in-house calibrated physically-based SWAT watershed models for the Sacramento River basin, and performed the forecast of simulated daily unimpaired streamflow for remaining of the WY2014 to assist DWR drought operation and planning. Weekly update of model input of climate data was made using the 4 km grid PRISM daily data. Historical climate data from 1915 to 2013 were then used for remaining of the WY2014 to make probabilistic forecasts. The modeled streamflow frequency and probability plots were then used to inform current drought situation/position in comparison to historical critical dry years (1976, 1977, 1924, and 1931). It was good added information for drought decision making such as the installation and timing of the delta emergency temporary barriers.

Delta Coordinated Operations Model – Tracy Pettit (DWR) **0.6 MB**

The DCO, developed in house in 1995, is a spreadsheet model used to model SWP operations on a monthly time-step. It is used in the decision-making process to determine how much water the State Water Project can allocate to its 29 State Water Contractors on an annual basis under various hydrologic exceedances and contractor demands, and includes the contractual and regulatory requirements applicable to the State Water Project. The DCO is updated monthly incorporating existing conditions for the current month and projections for the remainder of the year.

2014 was a challenging year for the State Water Project. The State Water Contractors received its lowest allocation on record at 5% following the driest calendar year (2013) on record. The Department of Water Resources (DWR) jointly with the U.S. Bureau of Reclamation (Reclamation) requested modification to the State Water Resources Control Board's Water Rights Decision 1641. In order to evaluate 2014 operations, the State Water Project (SWP) used the Delta Coordinated Operations (DCO) model. Modifications to the hydrology and demand assumptions were made within the DCO due to the extremely dry conditions. An overview of the DCO and how it was used will be presented.

2014 Drought Forecast Modeling in 1-, 2-, and 3-D – John DeGeorge (RMA) **3.2 MB**

With very little precipitation in California through December 2013 and January 2014, water supply forecasts included very dire conditions that could warrant placement of temporary barriers in the Sacramento-San Joaquin Delta for salinity control. With support from the State and Federal Water Contractors and the Metropolitan Water District of Southern California, RMA conducted an analysis of potential barrier placement strategies using both a 1-D tidally averaged model and the 2D RMA Bay-Delta Model for several forecast conditions. Simulations were performed on a very tight time schedule, and in parallel with DSM2 modeling performed by the DWR Delta Modeling Section. Later, RMA performed additional analysis with a 3-D model to further examine potential salinity impacts with extremely low net Delta outflow. This talk will present some of the results of the analysis with focus on the importance of the location and timing of barrier placement. The challenges of modeling extreme conditions in an open collaborative environment will also be discussed.

Session 18. Marriage of Data and Water Quality Model Output Visualization for Stakeholder Involvement and Real-time Decision Support

Advanced Real-time Decision Support and Visualization – Jesper Kjelds (DHI) **4.4 MB**

Balancing the needs for managing water supply, flood risk and protection, ecosystem management, and water quality in receiving waters underlie many of the challenges in coastal and inland environments. Fundamental to these conversations are the issues of accountability and credibility to stakeholders and the ability to share, disseminate and visualize information more rapidly and dynamically than traditional methods provide. Recent advances in capabilities for real time water management, including flood warning, water supply, and information management have been extended to data visualization and scenario comparison in a series of projects in California and Florida.

We will briefly explore the technical implementation of model integration and data workflows, and the various strategies for connecting and interfacing models, getting more analysis than a typical process model inherently provides, and the various overlay capabilities that make these workflows more efficient. The key steps include:

- Data acquisition and quality control
- Model preparation, automation and optimization
- Provision for real time results mapping and scenario development
- Improved visualization and dissemination of forecast and warnings

Stakeholder involvement and visualization are also fundamental components of advanced decision support systems. Expanding the access to data observations, remote sensing, model results and scenario comparison is a common feature of modern decision support systems. The ability to achieve this objective in a robust manner for any model, and any platform across the client, web and mobile environments is a common requirement. By exposing these capabilities and providing programmatic access to these features, agencies and communities can help to foster involvement, collaborative discussion, and eventual decision-making.

Integration of Real-time Data Management Systems and Runoff Models in Reservoir Operations
Timothy Lee (Kisters International Inc.) **4 MB**

KISTERS North America completed a recent project with TransAlta in Calgary where the RAVEN precipitation and snow runoff model was integrated with Water Information System KISTERS (WISKI) software. Using publicly available GRIB2 forecast data, the end product has an integrated GUI and is a good example of gathering data from multiple sources, processing the data in WISKI, running the model, and analyzing the results back in WISKI. The data is used to help operate a series of cascading hydroelectric reservoirs and will eventually be an input to the KISTERS Resource Optimization (ResOpt) software which TransAlta also uses.

Silver Creek Watershed – Dynamic Stream Temperature Modeling and Visualization – Stephen Blake (DHI) **4.1 MB**

The incorporation of water quality data collection with modeling and visualization is an emerging opportunity to advance the analysis and stakeholder engagement process. These capabilities can be built on automated and real time data connections, processing and advanced modeling and analysis linking traditionally separate fields of study. An integrated hydrologic and water quality tool has been developed for the Silver Creek Watershed in south-central Idaho to simulate hydrologic processes, stream temperature and fish life-cycles. The approach is used to analyze anthropogenic impacts to stream temperature and salmonid habitat helping watershed managers demonstrate links between development and water management scenarios and the effect on the stream and watershed thermal regime.

Gauging the impacts on salmonids requires the ability to synthesize intensive data collection and data management techniques with an understanding of processes that control seasonal and spatially varying temperature dynamics. Temperature dynamics are in turn influenced by surface water-groundwater interaction. Hence the need has arisen to consider groundwater, surface water, and water quality as an integrated system, and to provide the ability to encapsulate these techniques within an integrated framework. Data connections of sensors and remote sensing to modeling platforms are enabling rapid improvements in the delivery of environmental modeling and decision support. Improvements in sensor capabilities, cellular telemetry, and remote sensing provide new data streams that are growing in availability, resolution, and overall utility. This affords the means to acquire and process data in real-time, to guide awareness and decision support, and to run models that provide a coherent spatial picture, as well as the ability to predict future conditions and compare scenarios. DHI's MIKE Customised Platform has been implemented to address operational decision support, data dissemination, and visualization of models results and scenario comparisons in a variety of water environments.

We will show an applied approach to data acquisition and processing, scenario development and planning, model development and post-processing, and visualization and dissemination of results. These capabilities are applied in example projects focused on stream temperature modeling, with impacts from agricultural withdrawals climate change and riparian restoration. Integrated models are used to represent surface and groundwater dynamics, constituent transport, and agent based modeling to represent impacts on salmonid habitat and sustainability.

Real-time Decision Support and Visualization for Salinity Management in the San Joaquin River – WARMF Online – Nigel Quinn (Berkeley National Laboratory/Reclamation), Amye Osti and Nathan Hemenway (34 North, Inc.) **10.3 MB**

Collaborative, real time water quality management is best facilitated when all stakeholders have a forum and toolset for aggregating and accessing the data and information used to inform management decisions and operations. These data include reports, GIS data, DEMs, telemetered data (real time, discrete and historic), model inputs and results, graphs, visualizations and much more. The SJR real time management program has developed a comprehensive online resource to support collaborative efforts to provide a salt assimilative capacity forecasting model and supplemental decision support tools to improve salinity management in the lower San Joaquin River. The online decision support platform combines WARMF model output visualizations alongside customizable data dashboards with the supplemental data visualizations for understanding the bigger picture. The tools provide collaborators with timely information and a transparent process for estimating their salt load contributions to the River in relation to other dischargers in the Basin. The collaborative forum creates opportunity to coordinate west-side Basin salt loading schedules with reservoir releases of high quality flows from the East-side of the Basin. The talk will provide information on the long-term goals of the project, demonstrate accomplishments to date and details of the various GIS-based visualization techniques being deployed on a publicly accessible web server to support real-time salinity management.

The SJR real time salinity management program in developed is a four-way collaboration between the US Bureau of Reclamation, Systech Water Resources, 34-North Inc. and Berkeley National Laboratory.

Session 19. Poster Session

Impact of Aquifer Desaturation on River Seepage – Hubert Morel-Seytoux (Hydroprose)

There are two parts to this investigation.

(1) A simple, analytically derived, criterion is presented to determine the initiation of the loss of saturated hydraulic connection at the interface between a river bottom and the aquifer below. Desaturation below a clogging layer happens usually due to a significant lowering of the water table in the vicinity of the river (recharge area). Most groundwater models use incorrect criteria for this estimation of incipient desaturation and of the associated resulting flow exchange. Does it have a strong importance in practice?

(2) A simple procedure is developed to estimate the recharge rate to the aquifer under transient conditions of the supply rate to the recharge area. The capillary barrier phenomenon at the interface between a clogging layer and the aquifer below has a very strong effect on the amount of recharge taking place, particularly when the ponded depth in the recharge area is small (and maintained small). How large must the ponded depth be so that the capillary barrier effect can be neglected? Most saturated-unsaturated numerical models do not account for the capillary barrier effect at the interface between highly contrasted soil layers.

Quasi-decadal Oscillation in the CMIP5 and CMIP3 Climate Model Simulations: California Case – Jay Wang (DWR)
Collaborators: Hongbing Yin, Erik Reyes, and Francis Chung (DWR)

The ongoing three drought years in California are reminding us of two other historical long drought periods: 1987-1992 and 1928-1934. This kind of interannual variability is corresponding to the dominating 7-15 yr quasi-decadal oscillation (QDO) in precipitation and streamflow in California. When using global climate model projections to assess the climate change impact on water resources planning in California, it is natural to ask if global climate models are able to reproduce the observed interannual variability like 7-15 yr quasi-decadal oscillation.

Further spectral analysis to tree ring chronicles and historical precipitation records proves the existence of 14 yr quasi-decadal oscillation in California in modern climate. But while implementing spectral analysis to all the CMIP5 and CMIP3 global climate model historical simulations using wavelet analysis approach, it was found that only CESM1-WACCM, have statistically significant 14 quasi-decadal oscillations in California.

Modeling the Establishment of Riparian Habitat Vegetation with Applications to Populus Fremonti on the Sacramento River, California – Michael Tansey (Reclamation)
Collaborator: Chuck Young (SEI)

The existence of healthy riparian forests in the Sacramento, San Joaquin and other tributaries of the Bay-Delta is important for successfully managing the estuary for both human and ecosystem benefits. These riparian forests provide important ecological services including stream bank stabilization, shade, nutrient inputs, and physical habitat for terrestrial and aquatic species. The survival and renewal of riparian forests requires the periodic establishment of cottonwood and other riparian vegetation seedlings in near-river sediments in order to replace trees lost to natural mortality and other causes. Determining under what conditions riparian vegetation seedlings will survive is an important consideration in managing river flows for both human and ecological objectives.

To address this need, a hydro-biological conceptual model describing the growth and survival of riparian vegetation from germination through the first year of seedling growth was developed. This Riparian Habitat Establishment Model (RHEM) was developed by integrating the conceptual model into the well-known HYDRUS-2D numerical model. RHEM dynamically simulates seedling root and shoot growth and plant survival as the combined effects of sediment texture, meteorological conditions, and water table depth. Using the RHEM model, an analysis based on water table controlled cottonwood (Populus Fremonti) growth experiments revealed that the seedlings do not experience significant water stress until a critical water table depth is reached. This depth depends on sediment texture with finer textured sediments having greater critical depths. Additional analyses showed that, for the conditions simulated in this study, sediment texture has a larger effect on seedling survival than meteorological conditions. The RHEM model was also used to derive and evaluate a simple cottonwood seedling density and survival model which was applied to observed seedling growth and survival conditions on the Sacramento River, CA. The density model was able to successfully replicate the decline in seedling density observed as river stage declined.

Five Years of Change: The Hidden Story of the Sacramento River at Georgiana Slough – Shawn Mayr (DWR)
Collaborators: Amy Zuber and Scott Flory (DWR)

The saga continues with our annual multibeam bathymetric data sets at Georgiana Slough. Highly detailed bathymetric measurements have been made of this important intersection since 2010. What might changes in the topography mean to hydrodynamics, and fish migration?

Color Your Delta – Shawn Mayr (DWR)

Colored pencils and crayons will be provided with this interactive poster to share locations of good fishing areas, lunch spots, and unexplained phenomena. We can also show locations of bathymetric datasets to share and a wish list of data needs. Existing data extents in our library will be shown as well as a (live?) link to our updated online bathymetry catalog map.

Using Measured Bottom X2 to Estimate Effective Delta Outflow and Electrical Conductivity during Water Year 2014 – Anne Huber (ICF)
Collaborator: Russ Brown (ICF)

Daily average bottom EC measured in the western Delta during water year 2014 was used to interpolate the daily average X2 where bottom EC was 3,830 µS/cm (2 ppt). This measured X2 position varied with the variation in the daily mean tide (spring-neap tidal cycle) by a distance generally between ±3 km. This tidal variation in X2 can be estimated as a function of daily mean tide (minus the 2-week average tide). Effective Delta outflow was estimated from the measured X2 values by first removing the tidal effect from the measured X2 values and then back-calculating effective outflow from the steady-outflow form of the daily X2-log outflow equation. The magnitude of the resulting effective outflow was generally between the effective outflow calculated from the DAYFLOW estimates of daily outflow and the effective outflow calculated from USGS tidally-filtered daily outflow based on flow measurements at Rio Vista, Jersey Point, Threemile Slough, and Dutch Slough. If tidal effects are retained in the measured X2 values, the back-calculation of effective outflow includes the flow-equivalent effect of the tidal variation, representing the "equivalent" outflow. This "equivalent" outflow was used in G-model negative exponential formulas to produce estimates of daily average surface EC. These estimates showed good agreement with daily average surface EC measurements at multiple locations, including good agreement with the variations due to the spring-neap tidal cycle.

Mapping Decadal Change of Rice Field Extent and Phenology in the Sacramento Valley using Landsat Imagery – Liheng Zhong (DWR)

As the largest water consumer in the Sacramento Valley, rice plantation is one of the most significant sources of variability in water management and planning. Historical changes have been observed in the extent and growing season of rice due to annual variation of weather and water availability, the use of early-mature varieties, etc. It is essential to precisely detect rice growing extent and phenology to improve the hydrological simulation using models like CalSim 3.0. In this project, several years since 1989 were selected based on the availability of high-quality Landsat images. Rice fields were identified based on the unique temporal profiles of vegetation indices derived from series of segmented images. Validation using field survey data and other land use maps shows a promising accuracy for further change analysis. The start and the end of the growing season and other phenological metrics were extracted from object-level temporal profiles of vegetation index by a curve-fitting method. Historical change and spatial distribution of rice growing period were compared to site observations and district-level water delivery data.

Trailing Non-Aqueous Phase Liquids (NAPL) in the Groundwater: Modeling and Application – Pavithra Prakash (Indian Institute of Technology)
Collaborator: Indumathi Nambi (Indian Institute of Technology)

The distribution of NAPL in multiple forms and configurations is a likely phenomenon in a layered heterogeneous subsurface system due to variations in capillary pressure in each of its layer. The unique feature of a NAPL contaminated heterogeneous subsurface system is the spatio-temporal variation in fluids and porous media properties. The variable porous media properties includes reversible permeability fields, changing flow hydrodynamics such as flow bypassing and preferential flow, while variable fluid property includes changing NAPL saturation. An improvised contaminant transport model was formulated to account for the spatio-temporal while predicting concentration profile in downstream end of the NAPL source. The key features in the model were the inclusion of new relative permeability correlations; NAPL-water mass transfer correlations, and a non-Gaussian dispersion equation. The robustness of the predictive model was assessed through comparative analysis of the predicted concentration with experimentally observed concentrations.

Predicting Effect of Reservoir Expansion with Three-Dimensional Modeling: Case Study of Los Vaqueros Reservoir – Gang Zhao (Flow Science)
Collaborators: Benjamin Martin, Li Ding, and E. John List (Flow Science)

The use of three-dimensional (3D) models to simulate the hydrodynamics and water quality of reservoirs and lakes can be a powerful tool to aid in the development of management strategies. Models can be used proactively to predict how reservoirs will react to changes, either physical or operational. 3-D modeling aided in the management decisions of the Los Vaqueros Reservoir (LVR), managed by Contra Costa Water District (CCWD), during a recent expansion via dam raise. A well calibrated and validated hydrodynamic and water quality model was used to evaluate the adequacy of the existing oxygenation system for the expanded reservoir and the potential water quality effects. Available data from LVR was analyzed and used to construct a 3D computational fluid dynamics (CFD) model of the reservoir. Two predictive scenarios were run: 1) Drawdown, where LVR storage was ~ half the original volume during construction, and 2) Expanded Reservoir, where LVR storage reached the full 160TAF capacity. Predictions were used to support design decisions for the oxygenation system and evaluate potential changes in water quality within the reservoir.

Cloud Cover Variability and its Relation to Springtime Snowmelt and Runoff – Edwin Sumargo (UC San Diego)
Collaborator: Daniel Cayan (UC San Diego)

The uncertainties in water supply forecast are largely produced by the variability in solar insolation, which in turn is modulated by cloud cover. Here we investigate the space/time variability of cloud and incoming radiation and its influence on snow and streamflow. We employ NASA/NOAA Geostationary Operational Environmental Satellite (GOES 9-11 and 15) albedo product spanning from 1996 to 2012 during the daytime (8-16 PST) over the westernmost U.S. (25-50 °N, 113-130 °W) with 4-km spatial and 30-minute temporal resolutions. Pixels with elevations below 800m are masked to avoid contaminations from coastal marine and low stratus clouds. A translation of cloud albedo (α_cloud) to incoming surface radiation yields results that are well correlated with a scattered set of time series from surface radiometers in Sierra Nevada locations. To describe prominent patterns and temporal variability of α_cloud over the western U.S., we conduct a Rotated Empirical Orthogonal Function/Principal Component (REOF/PC) analysis. The 5 leading REOF modes account for ~65% of the total variance of α_cloud. The leading mode (~19%) covers portions of the Sierra Nevada and the Cascades and has a high variance during the springtime, suggesting its pertinence during the snowmelt season. During spring and early summer, correlation maps reveal sizeable PC/α_cloud influence on snowmelt/runoff (R2 > 30%), with anomalously high α_cloud producing lower snowmelt/runoff and vice versa. Correlations indicate a strong change in the response to incoming radiation of snowmelt and streamflow over the seasonal transition from winter-to-spring-to-summer. Dry years and wet years exhibit considerable difference in cloud amount and pattern, with lower overall springtime cloudiness in drier years, which leads to higher surface radiation available for snowmelt.

Planning for Sustainable Management of Groundwater Resources – Ahmad Abrishamchi (Sharif University)

Groundwater as a major source of water in arid and semiarid regions is the key source for development in many developing countries. Therefore, sustainable management of groundwater resources is vital for sustainable development. Nevertheless, groundwater is not managed sustainably so far and groundwater depletion and contamination is increasing in Iran. Groundwater sustainability should be defined in an integrated hydrological, agronomic, social, economic, and environmental system. So in order to be sustainable, groundwater systems should be designed and managed to be effective, efficient and robust- balancing changes in demands and supplies over time and space and to ensure that there are no negative long-term irreversible or cumulative impacts on ecosystems.

In Iran, due to its climatic conditions and limitations of dry farming, groundwater management has an essential role in food production. Over the years, the increasing population and therefore the greater demand for water has resulted in over-exploitation of groundwater resources in almost the whole country of Iran. Groundwater depletion has caused many problems such as land subsidence, reduction in base flow of the rivers, destruction of wetlands, increasing the cost of pumping, decreasing drainage capacity of the aquifer, and salt water intrusion in coastal areas. Studies show that in Iran only 10 percent of the groundwater basins are still in equilibrium state; the rest are over-exploited and facing ever increasing depletion. Khorasan Province in north east of Iran where groundwater is the main source of water supply is in a critical condition. Uncontrolled withdrawal of groundwater resources has caused continuous water table decline. All these problems show the importance and necessity of planning for sustainable groundwater management in this province.

Planning for sustainable management of groundwater resources is a complex task due to its long-term nature faced with many uncertainties and the need for coordinated use of surface and groundwater and water allocation between competitive uses and users. WEAP software will be used for simulation of the system of sources and uses. This software has the ability to connect to MODFLOW groundwater model and thus provide an integrated model of surface and groundwater resources and uses. Several management scenarios will be examined to determine sustainable groundwater discharge using the integrated model and the concept of "capture". Having determined the sustainable aquifer discharge in each scenario, Game Theory will be used to determine the optimal groundwater resources allocation to different consumers. To consider the effect of uncertainty and participation of stakeholders in the sustainable management of groundwater resources, Bayesian Belief Network (BBN) will be used. Hugin software will be used for the development of BBN network structure based on the conceptual model of the study area. A conceptual model of the region determines various components of the system and their interrelationships. Available information and data and the results of the integrated model of water resources and uses will provide the input data to the network.

Real-time Forecasting of Salt Assimilative Capacity in the San Joaquin River – Reginald Dones (Reclamation)
Collaborators: Nigel Quinn, Michael Mosley, and Laura Condon (Reclamation)

Real-time forecasting of salt assimilative capacity in the San Joaquin River is a key component of Basin-scale real-time salinity management. The WARMF-SJR model has been under development for more than a decade. The new WARMF Manager module has been designed to automate easy importation of web-accessible real-time flow and electrical conductivity data and the substitution of model-derived watershed forecasts with data obtained from interaction with local stakeholders. The poster shows the capability of the current WARMF-SJR model and examines forecast "skill" by comparing model forecasts to observed data at key monitoring sites.

2D Modeling of the Salinas River to Facilitate Consensus Based Flood Protection and Conservation – Paul Frank (Newfields)

The Salinas Valley is one of the world's most productive agricultural areas with some farming occurring within the 5-year floodplain of the River. In decades past, private landowners removed vegetation from the riverbed in an attempt to increase flood conveyance but in recent years such activities have not been accepted by regulatory agencies. Additionally, the flood-reducing benefits of vegetation removal had not been quantified. After several years of being unable to remove vegetation from the channel, competing interests of farmers, environmentalists, regulators, and other stakeholders reached a boiling point.

In 2013 The Nature Conservancy (TNC) invested in a program to improve the physical understanding of the River's hydraulics and geomorphology, build consensus amongst stakeholders, and engage regulators to develop a solution to the problem. At the core of this program, NewFields created a 2D hydraulic model of approximately 25 miles of the Salinas River that helped explain flooding mechanisms within the complex private levee system along the River. Based on the new understanding of river hydraulics and flooding this model provided, NewFields and others designed a geomorphically-based vegetation clearing approach that minimized impacts on sensitive riparian habitat. In 2014, TNC spearheaded an effort to work with landowners in a pilot reach of approximately 12 miles that successfully permitted and implemented this geomorphically-based approach. In 2015 TNC as well as the Monterey County Water Resources Agency, the Central Coast Grower-Shipper Association and the Salinas River Channel Coalition, are working towards implementing similar programs throughout the approximately 100 river miles of the Salinas in Monterey County, including expansion of the 2D model.

Climates Change. That's What They Do – Om Prakash (West Consultants)
Collaborator: David Curtis (West Consultants)

Climates change. That's what they do. It is a natural and dynamic process. With all of the discussion about anthropogenic (i.e. man-made) climate change, it is easy to overlook just how variable our natural climate is. California's climate is uniquely variable. It can and does vary by significant amounts within one human lifetime and well within the design lifetime of our water infrastructure. Sometimes this fact gets lost in the noise of climate change debate. Part of the reason is our relatively short meteorologic and hydrologic records. The few long records available provide some interesting insights.

This presentation explores and presents findings regarding rapid variation of "climate averages" in central and northern California using long term rainfall records and tree ring measurements. The results suggest that not only is stationarity dead, it likely wasn't really alive in the first place. We simply assumed it was.

Flood Warning with HEC-RTS (Real Time Simulation) – Kayson Shurtz (West Consultants)
Collaborator: Jeff Harris (West Consultants)

The US Army Corps of Engineers has developed the Corps Water Management System (CWMS) for managing forecasts for Corps of Engineers reservoirs. For security reasons, this is proprietary software for use by the Corps of Engineers on. However, many agencies have expressed interest in being able to use the capabilities of CWMS for managing their own forecasts. The US Army Corps of Engineers, Hydrologic Engineering Center responded to this need by providing these capabilities in the HEC-RTS software. WEST Consultants is working with San Diego County and applying HEC-RTS to the San Diego River. This poster will show the flow of HEC-RTS and how it is being applied to the San Diego River.

Linking Operations, Watershed, and Water Quality Models to Support Third-Party Nutrient TMDL Review and Revision for the Truckee River, Nevada – John Wolfe (LimnoTech)
Collaborators: Laura Weintraub and Dave Dilks (LimnoTech)

Dissolved oxygen (DO) concentrations in the Truckee River had historically violated water quality standards due to nutrients that foster growth of periphyton, i.e. attached algae, especially at low flow and in shallow water. A 1994 TMDL developed by the Nevada DEP set maximum nitrogen and phosphorus loads to comply with standards for DO, and communities built state-of-the-art treatment facilities to meet those limits, while non-point sources were left unchanged.

Faced with population growth since 1994, along with an expected increase in summer river flows in response to the Truckee River Operating Agreement, the Cities of Reno and Sparks, Washoe County, and the Truckee Meadows Water Authority wanted to revisit the TMDL. They engaged LimnoTech to develop a more refined representation of the system, including improved representation of nonpoint-source loadings, nutrient speciation, and the effects of periphyton on water quality. The parties have conducted a series of monitoring events to support calibration and confirmation of a linked suite of models, consisting of the Truckee River Operations Model, a WARMF (Watershed Analysis Risk Management Framework) model of the watershed, and an upgraded HSPF water quality model of the Truckee River. Based on results from this integrative model of the watershed, new water quality standards for phosphorus have been proposed as a necessary precursor to a revised nutrient TMDL. The enhanced model is also helping to support understanding of scientific issues, communication, and decision-making by multiple stakeholders with diverse interests.

Coarse Resolution Planning Tools for Prioritizing Central Valley Improvement Act Fisheries Activities – Rodney Wittler (Reclamation)
Collaborators: Jim Peterson (USGS); David Mooney (Reclamation); Cesar Blanco and Julie Zimmerman (USFWS)

Central Valley Project Improvement Act (CVPIA) Fisheries Program used a structured decision making (SDM) approach to develop a framework to allowed decision-makers to identify Program objectives and guide planning of broad scale fisheries activities. Participants in the process included representatives from various Federal and California State resource management agencies. The participants used a rapid prototyping approach to identify and quantify Program objectives and develop dynamic coarse resolution decision models to evaluate the relative benefit of candidate CVPIA Fisheries actions. The structure of the models was determined by the participants and acknowledged subject matter experts and represented their beliefs regarding the dynamics of the managed system. When two or more experts could not agree, alternative representations of system dynamics were developed. The models were parameterized using a combination of expert judgment and empirical data. Model performance was evaluated using stochastic simulation of alternative Program actions and via sensitivity analyses. The models were able to capture the coarse dynamics of the system and estimated escapement of fall run Chinook salmon reasonably well. Sensitivity analysis provided insight into the important or influential unknowns and assumptions that can be targeted for monitoring in an adaptive management framework. The entire process was completed in one year. The Program is currently developing a transparent decision making process that will revise and incorporate these models.

Use of UAVs in the Design, Construction Observation, and Post-Project Monitoring of Rehabilitation Projects – Jesse Barker (cbec eco-engineering)
Collaborators: Chris Bowles and Chris Hammersmark (cbec eco-engineering); John Hannon (Reclamation)

The accessibility of unmanned aerial vehicles (UAVs or Drones) to the general public has grown in recent years, and with it has the opportunity to apply these relatively inexpensive, yet sophisticated devices in natural resource management. One application is the use of UAVs to collect low altitude aerial imagery for river rehabilitation projects. The aerial images can be used: to develop site maps and topographic data; to inform hydraulic modeling and design; to track progress on land and within aquatic areas, and to perform post-project physical and biological monitoring. To demonstrate the potential for this type of technology, a recently design and constructed salmonid rehabilitation project consisting of gravel augmentation and side channel creation within the Nimbus Basin, along the Lower American River in Fair Oaks, CA is used. Aerial imagery was collected before, during and after construction. Imagery was used to develop topographic datasets and digital elevations models (DEMs) that were geo-referenced using RTK-GPS surveyed points. The DEM, as modified with additional bathymetric survey data, was used for hydraulic modeling to inform the rehabilitation design. During construction, the site was monitored regularly with the UAV to ensure proper construction techniques were being implemented as well as track overall progress. The site was surveyed after construction to document the as-built topographic conditions. In addition, post-project imagery was used to document the utilization of the constructed site by spawning salmonids.

Numerical Modeling of Sea Strait's Flow: Case Study of the Bosphorus Strait in Turkey - Mehmet Ozturk (Yildiz Technical University)

A sea strait is a channel connecting two basins of different properties. The difference may arise owing to difference in density (salinity, temperature, and/or sediment concentration) and water level difference. As a result of these differences a two-layer flow structure often is found. A proper understanding of the dynamics of sea strait flow is very important for navigation, environmental pollution, waste water discharge and fishing interests.

A typical example of the stratified flows occurs at the Bosphorus Strait. The Bosphorus is a long and narrow strait with a length of 31 km, connecting the Marmara Sea and the Black Sea. The stratified structure is largely controlled by two predominant mechanisms, namely the density and the water level differences between the Marmara Sea and the Black Sea. The exchange occurs between denser Mediterranean water and the less saline Black Sea water.

In this study, a three-dimensional hydrodynamic model of the Bosphorus is performed by using the Mike 3 Flow Model. The model was calibrated selecting the drag coefficient (cf), the buoyancy parameter (cε3) and the turbulence Prandtl number (σT) as calibration parameters. The numerical model was also validated both temporally and spatially. For temporal validation, the results of the model were compared to the results of the current measurement station which was used at calibration for four different periods in 2005. As to spatial validation the model results were compared to different current measurement stations. Model results are in good agreement with the measurements. The RMS (root mean square) errors of the calibrated and validated models vary only in the range of of 10 cm/s.

Building Foundational Tools for Flood Management in the next Decade, Central Valley Floodplain Evaluation and Delineation Program - Yiguo Liang (Department of Water Resources)

As an integral part of the FloodSAFE California Initiative (FloodSAFE), the Central Valley Floodplain Evaluation and Delineation (CVFED) program has been developing new foundational information and tools since February 2008 to help the Department of Water Resources (DWR) better understand the risk of flooding in the Central Valley – specifically as related to the existing State Plan of Flood Control (SPFC).

The study area for the CVFED program exists within the drainage areas of the Sacramento River and the San Joaquin River in the Central Valley. A portion of the Kings River system is included so evaluations to better understand impacts to the SPFC due to Kings River discharges split between the San Joaquin River Basin and the Tulare Lake Basin.

Comprised of three (3) projects, the $110 million CVFED program has developed new topography for 9,000 square miles area in the Central Valley, 57 riverine reach-based and system-wide HEC-RAS hydraulic models and 24 overland FLO-2D hydraulic models, and floodplain mapping to meet legislative mandates. These products are foundational tools for supporting on-going and future flood management activities performed by DWR, U.S. Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), as well as local communities, universities, research institutions, and non-governmental organizations. To date, 270 data requests for topographic data and 42 requests for hydraulic models have been processed.

CALifornia Value Integrated Network: Model Updates - Mustafa Dogan, Karandev Singh, Josue Medellin-Azuara, and Jay Lund (University of California Davis)

CALVIN, a hydro-economic engineering optimization model for California's entire inter-tied water system, has been recently updated. These updates include finer representation of agricultural demand areas within the Central Valley, standardized agricultural and urban demand areas and adding 10 more years to all CALVIN datasets. Furthermore, agricultural consumptive use, groundwater pumping cost, agricultural target demand and shortage penalties are updated. California Aqueduct-Delta Mendota Canal intertie completed in 2012 is added to the network. It is aimed to better represent California's water system with these updates.

Drought Water Rights Allocation Tool (DWRAT) - Ben Lord, Jay Lund, Bonnie Magnuson, Reed Thayer, Andy Tweet, Chad Whittington, Lauren Adams, Bill Fleenor, Quinn Hart (University of California Davis)

Within California's water rights system, water users have different priorities to available water during drought. Higher priority users are less likely to face shortage due to the demands of other users but may be limited by reduced availability of water. An integrated set of water right allocation models was developed to determine optimal allocation of shortage for riparian and appropriative water right holders, which also allows for including required flows for the environment, public health and safety and operational reliability for senior water right-holders. Riparian water right holders have equal priority with water shortage allocated as an equal proportion of normal diversions for all riparian users within each sub-basin. These proportions are determined by water availability with downstream users likely to receive higher proportions due to downstream accumulations of streamflow. Appropriative users as a class have a lower priority than riparian users. Shortages allocated among appropriative water right holders are made strictly by water right seniority.

The HOBBES Project Update - Quinn Hart, Josué Medellín-Azuara, Samuel Sandoval, Jay Lund, Alvar Escriba-Bou, Rui Hui, Mustafa Dogan, Karandev Singh, and Nicholas Santos (University of California, Davis)

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 can be interactively converted into tiered networks able to be solved by multiple modeling platforms, with the appropriate translators. This poster provides an update of the HOBBES project including visualization and editing tool for the California's water supply system, geocoded elements such as storage and conveyance and service areas and metadata capabilities. User interface, database schema and details on the platform employed and future development in the following months will be presented.

Session 21. California Water Rights Analyses and Modeling

2014 Water Right Curtailment Analyses in the Sacramento-San Joaquin, Russian River, and Eel River Watersheds – Brian Coats (SWRCB) **2.4 MB**

The right to divert surface water in California is based on the type of right being claimed and the priority date. Water right permits specify the season of use, purpose of use and place of use for the quantity of water authorized under the permit or license. In times of drought and limited supply, the most recent ("junior") right holder must be the first to discontinue use. Even more senior water right holders, such as some riparian and pre-1914 water right holders may also receive a notice to stop diverting water if their diversions are downstream of reservoirs releasing stored water and there is no natural flow available for diversion.

In 2014, due to severe drought conditions, water availability analyses were performed to determine allocations to water right holders in the Sacramento-San Joaquin, Russian River, and Eel River watersheds. State Water Board staff evaluated both tributary and basin-wide variations prior to issuing water right curtailments in May and June of 2014. Later in the year, a post-curtailment analysis was initiated to monitor conditions in each of the affected watersheds to determine if and when to lift curtailments. The State Water Board lifted water right curtailments in November 2014.

Drought Water Rights Allocation Tool (DWRAT) - Ben Lord (UC Davis) **1.5 MB**

The 2014 drought has focused and renewed discussion about how California curtails water rights when water availability is insufficient. Prior to the 2013-14 water year, the most recent curtailment effort dates back almost 40 years to 1976-77. Since then, many changes and advances have occurred in water use, policies, and technology. New complicating issues include the growth of environmental and water quality requirements. Given the likely growing frequency of the need for water right curtailments and the centrality of curtailments to overall drought management, the State Water Resources Control Board needs a comprehensive, quantitative water rights curtailment program. Preliminary phases of such a program have already been developed and applied in the Eel and Russian River basins, including a

Drought Water Right Allocation Tool (DWRAT) that estimates ideal curtailments given data sets on water rights and water availability. Extending this program to other basins, including the Sacramento-San Joaquin Delta watershed, will require decisions on water rights and water availability quantification and resolution of several ambiguous or conflicting policies. Supporting the development of DWRAT as the basis for water rights curtailment decisions will provide a long-term approach that brings structure, quantification, and transparency to a complex and difficult administrative process.

WRIMS-based Sacramento Valley Water Right Model – Liheng Zhong and Richard Chen (DWR) **1.5 MB**

A WRIMS-based model is being developed in order to incorporate water right information for water allocation under drought conditions and to support decision-making of water management in the Sacramento Valley. Detailed and timely information on individual water rights is essential to estimate water demand and consumption, especially under drought conditions. However, such information is rarely fully implemented by simulation models due to the complexity of the water right system. As an early attempt in this study, detailed water right records were obtained from SWRCB database with major water rights identified based on actual diversions during previous years, which account for over 90% of the total diversion for consumptive use in the Sacramento Valley. These major water rights were analyzed and were associated with the demand units of CalSim 3.0 based on spatial overlay in GIS.

In this model, information of individual water rights are explicitly incorporated in the model based on the detailed CalSim 3.0 schematic. Model constraints such as seasonal diversion limit and diversion priority are applied to each demand unit by reviewing all relevant water rights. Water right categories including riparian, pre-1914, and post-1914 appropriative water rights are treated differently according to existing regulations. Riparian and pre-1914 water right holders are assumed to divert the amount of reasonable beneficiary use from natural flow prior to project construction with equal priority. CalSimHydro is used to estimate the upper limit of beneficiary water use at each demand unit based on its existing land use information. Among post-1914 water rights the priority of each water right applicant is assigned based on seniority when water shortage occurs. Then the total diversion to each demand unit under water right is estimated. Modeling conceptualization, model structure, and preliminary findings of the study will be presented.

Session 22. Modeling an Unstructured Environment: Recent Developments and Applications of Multi-Dimensional Bay-Delta Models

Open Software, Open Source, Open Data, and Open Models: San Francisco Community Model Initiative – Edwin Elias (Deltares USA Inc.)

The San Francisco Bay-Delta system is complex in its physical and environmental dynamics. Modeling tools that integrate hydrodynamics and water quality dynamics are essential to unravel the governing processes on various spatial and temporal scales and assess potential developments due to climate change and adapting management strategies. There is a need for open access, publicly available, integrated modelling platforms to facilitate and enhance interdisciplinary and interagency scientific communication, collaboration, and understanding.

Sediment Transport Modeling in a San Francisco Bay Salt Marsh – Yun Zhang (Stanford University)
Collaborators: Oliver Fringer, Ivy Huang, Derek Fong, and Stephen Monismith (Stanford University) **1.7 MB**

We apply the 3D SUNTANS model to a salt marsh in San Pablo Bay to study sediment transport. Subgrid bathymetry is incorporated into the SUNTANS model to study the system with a hierarchy of 3D, 2D, and 1D discretizations to understand tradeoffs between model complexity and accuracy. Effects of marsh drag and culverts are also studied to understand how they affect sediment transport. Results show that the culverts act to retain sediment in the system, while marsh drag acts to restrict the flow to the main channels and encourage landward sediment transport due to the tides. Comparison of the 3D, 2D, and 1D models shows that the 1D model predicts flow and stage reasonably well, although the 2D model is needed to predict sediment transport as accurately as the 3D model.

SCHISM Salinity Modeling 2013-2014 and Recent Developments – Eli Ateljevich (DWR)

The talk will begin with a few slides describing recent model developments, workshops and the recent independent release of the Virginia Institute of Marine Science (VIMS) version of SELFE as SCHISM. Then we will focus on our own DWR modeling in 2013-2014 including some relatively new introspection concerning mechanisms of salinity transport in the corridor of the Sacramento above the confluence region. We describe recent calibration decisions we've made in this region and how they were influenced by salinity observations near the peak of intrusion in 2014.

Salinity, Waves, Sediment, and X2: Recent Applications Using the UnTRIM Bay-Delta Model – Michael MacWilliams (Delta Modeling Associates) **7.1 MB**
Collaborator: Aaron Bever (Delta Modeling Associates)

The UnTRIM Bay-Delta model is a three-dimensional hydrodynamic and salinity model of San Francisco Bay and the Sacramento-San Joaquin Delta, which extends from the Pacific Ocean through the entire Sacramento-San Joaquin Delta. The UnTRIM Bay-Delta model has been coupled with the Simulating WAves Nearshore (SWAN) wave model and the SediMorph morphological model and used in studies of San Francisco Bay and the Sacramento-San Joaquin Delta for California DWR, USBR, USGS, US EPA, and the US Army Corps of Engineers. The model calibration and validation conducted as part of these studies demonstrate that the UnTRIM Bay-Delta model is accurately predicting flow, stage, and salinity, wind waves, and sediment transport in San Francisco Bay and the Sacramento-San Joaquin Delta under a wide range of hydrologic conditions. This presentation will give an overview of some of the recent applications of the UnTRIM Bay-Delta model, which include simulation of sediment transport in the Sacramento-San Joaquin Delta, some recent high resolution model applications in South San Francisco Bay, and a 34 year three-dimensional hydrodynamic and salinity simulation competed for the US EPA.

Session 24. California Water Plan Update 2013: Key Contents

California Water Plan Update 2013: Investing in Innovation and Infrastructure – Paul Massera (DWR)

For almost 60 years, the California Water Plan has served as the long-term strategic plan for informing and guiding the sound management and development of water resources in our state. With updates every five years, it remains the single most complete and relevant body of knowledge about statewide water resources. Update 2013 reaffirms the State's commitment to integrated water management. It recognizes and reflects these basic facts about today's water situation:

- Water is California's Life Blood.
- California's Complex Water Resources System is in Crisis.
- A Diverse Portfolio Approach is Required to Address the Challenges.
- The Solution Requires Integration, Alignment, and Investment.
- We All Have a Role to Play in Securing Our Future.

Consistent with State law, the 2013 update of the California Water Plan lays out recommendations, rather than mandates. Based on decades of scientific data and analyses, nearly 40 State agency plans, and the voices of hundreds of stakeholders, it is a tool to guide investment priorities and legislative action to ensure resilient and sustainable water resources. Update 2013 applies at statewide, regional, and local scales, and serves to advise a diverse audience, including elected officials, planners and resource managers, tribal governments, academia, and the general public.

California Water Plan Update 2013 Water Portfolios, WYs 2001-2010 – Jennifer Kofoid (DWR) **7.3 MB**

The water portfolios are an essential component of the California Water Plan. "The primary reason for the water portfolio tables and flow diagrams is to provide an accounting of all water that enters and leaves the state and how it is used and exchanged between the regions for each water year. This is important to all water planning activities". –excerpt from *California Water Plan Update 2013*

The water portfolios provide an abundance of water supply and use information. Update 2013 presents annual water portfolio data in Volumes 1, 3, and 5 at varying levels of detail and at different spatial scales, including statewide and California's 10 hydrologic regions. The presentation will provide an overview of Update 2013's water portfolio content for water years 2001-2010, including where and how to access the technical content.

California Water Plan Update 2013 Future Scenarios: Results and Analysis – Mohammad Rayej (DWR)

Planning scenarios were developed for California Water Plan Update 2013 to illustrate how key uncertainties such as future population growth, land use patterns, and climate affect future water demands. Future urban and agricultural water demands were computed for 10 hydrologic regions of the State under nine growth scenarios as well as under twelve Climate Action Team (CAT) future climate scenarios and a thirteenth scenario representing a repeat of historical climate (1962-2006). Future water demands were calculated utilizing the Water Evaluation and Planning (WEAP) modeling framework that simulates catchment hydrology under various climate and land use scenarios. Results show that future urban water demands under the three growth scenarios are heavily influenced by the assumptions related to future population growth and to a lesser extent by future climate. Future agricultural water demands, however, are observed to be heavily influenced by both assumptions about future climate and urbanization of agricultural lands.

Enhanced Groundwater Contents for California Water Plan Update 2013 – Abdul Khan and Mark Nordberg (DWR) **6.7 MB**

California's Groundwater Update 2013: A Compilation of Enhanced Content for California Water Plan Update 2013 compiles and analyzes readily-available groundwater information to characterize California's groundwater basins, aquifers, and well infrastructure. It also presents data and analysis related to groundwater monitoring efforts, aquifer conditions in response to extraction, groundwater management practices, and conjunctive management programs. Statewide and regional findings, data gaps, and recommendations to improve groundwater management are also included. It expands and enhances baseline groundwater information on a regional scale, identifies challenges associated with sustainable groundwater management, and helps guide implementation of diverse resource management strategies. The set of data, information, and analysis developed can help local and regional groundwater managers, as well as individual well owners, better understand California's hidden and commonly misunderstood resource.

Session 25. Meet the Students and More

Moderator: Josué Medellín-Azuara (UC Davis)
Location: Sierra 1

The HOBBES Project Update – Josué Medellín-Azuara (UC Davis) **0.5 MB**
Collaborators: Quinn Hart, Jay Lund, Samuel Sandoval, Alvar Escriba-Bou, Rui Hui, Mustafa Dogan, Karandev Singh, and Nicholas Santos (UC Davis)

The HOBBES project offers a bottom-up approach and a venue for modelers in California and elsewhere to create an open, organized and documented quantitative representation of the an intertied water system. This presentation provides an update of the HOBBES project including visualization and editing tool for the California's water supply system, geocoded elements such as storage and conveyance and service areas and metadata capabilities. User interface, database schema and details on the platform employed and future development in the following months will be presented.

California Water Management with Upgraded Hydropower and Reservoir Operations Representation with CALVIN – Mustafa Dogan (UC Davis) **1.9 MB**
Collaborators: Karandev Singh, Josué Medellín-Azuara, and Jay Lund (UC Davis); Joshua Viers (UC Merced)

Management of water resources is essential in California since it is a place where water is scarce. Allocation of limited resources, therefore, needs careful planning. Computer models have been useful tools to help optimally manage water and to study different management scenarios and alternatives.

CALVIN, an economic-engineering optimization model for California's entire intertied water system, is used to exercise California water management. CALVIN has been recently updated to have better representation of hydropower and reservoir operations, as well as urban and agricultural demand areas and wildlife refuges. Water resources models generally use average energy prices. This can underestimate revenue of energy production. With updated hydropower representation of low-elevation hydropower plants in CALVIN, the effect of releasing water during peak hours are tried to be captured. In addition, the effect of a warm-dry climate scenario on California water supply management is studied, and results are compared with the historical case.

Optimal Conjuctive Use of Surface Water and Groundwater Resources: A Tale of Two Cities in the Delta – Robert Gailey (UC Davis)

The results of a planning study that considers coordinating municipal use of surface water and groundwater are presented. Operations research, or optimization, methods were used to streamline the exploration of conjunctive use options. Seasonal groundwater pumping schedules were developed considering well production capacities, pumping interferences from wells in a neighboring city, and facility management policies. Another constraint on pumping was the potential to draw waters of undesirable quality (naturally occurring high TDS and VOC contamination) into the wellfield. A limited supply of surface water was available to supplement groundwater production in meeting the total demand. The tradeoff between quantity and quality was also addressed by examining the effects of various groundwater quality protection policies on total production capability. It was found that the magnitude of this tradeoff could be reduced through selection of a seasonal allocation of surface water use that was appropriate for the particular set of circumstances in this study.

Optimal Flood Hedging Pre-releases for a Single Reservoir – Rui Hui (UC Davis) **1 MB**

Hedging for flood reservoir operations involves making releases in advance of a storm to make additional storage capacity available in the reservoir, as a way of reducing the probability of more severe flooding. Such pre-releases can involve the likely loss of water supply value and might also involve too large pre-releases to create small floods or increase downstream levee failures under some conditions. This study explores some theoretical conditions for flood hedging to be optimal. A necessary condition for flood hedging in all cases is that damages from flood releases are convex. The convexity in flood damages can arise from convex increasing probabilities of levee failure with flow, convex flood damage functions, or uncertainty in intermediate downstream inflows. Small storms, which are handled relatively easily, and extremely large storms, which overwhelm flood management systems, do not encourage flood hedging operations. The likelihood of intermediate storms that are large but not overwhelming, where the additional flood storage capacity from pre-releases is likely to reduce overall flood damage, drives the optimality of flood hedging pre-releases operations.

Impact of Climate Change on Ecosystem Management in the Central Valley of California – Karandev Singh (UC Davis) **4.3 MB**
Collaborators: Mustafa Dogan, Josué Medellín-Azuara, and Jay Lund (UC Davis); Rachel Esralew (USFWS); Joshua Viers (UC Merced)

Water is non-optimally distributed across time and space in California. Vast engineering networks were constructed in 1940s and 1960s to move water from places of abundance to places of scarcity; however, at a cost to the State's aquatic ecosystems and freshwater dependent species in terms of reduced environmental flows. The water supply network heavily dependents on sociopolitical and economic constraints that often limit efficiency and discourage equity. Global warming and regional hydroclimatic alteration are likely to exacerbate the water scarcity problem. This research examines the impact of a warm-dry climate scenario, changes in water infrastructure and competing environmental flow demands on water deliveries to eleven National Wildlife Refuges (NWRs) in California's Central Valley. Alternate water management schemes are evaluated to enhance resiliency of NWRs to face uncertainties in water supplies. The study is conducted within a statewide framework to capture the physical, environmental and policy constraints present in the existing water management system. This is achieved by employing CALVIN, a hydro-economic optimization model of the State of California. Historical and a warm-dry form of climate change are explored. Region of Hydrologic Influence (RHI) is determined for each refuge which includes inflows from topographically generated surface water runoff and water delivered through engineered conveyances. Lastly, the NWRs are integrated into the statewide CALVIN model. Several simulation runs are set-up to examine the hydrologic, economic, and ecological consequences of alternative management schemes and climatic scenarios on the NWR water deliveries. Results highlight vulnerabilities in the water supply system, especially competing demand for water earmarked for environmental use and the potential of water markets, water banking and other water management tools to cope with water scarce conditions.

PEST WORKSHOP

John Doherty (Watermark Numeric Computing)

Calibration, Uncertainty Analysis and Model-Based Decision-Making

Many important decisions are made using a "calibrated environmental model"; this may be a groundwater model, surface water model, or a model which integrates both systems. Expensive contracts are signed for the production, review, and use of such models. Implied in many of these contracts, and in the proposals that win these contracts, is that good models are complex models, that better models are even more complex models, and that a model's ability to replicate historical system behaviour ensures its ability to predict future system behaviour. Is this indeed the right recipe for model-based decision-making? If not, then how should models be best developed and deployed to inform decisions and resolve conflicts?

This workshop has two purposes. First it explains and demonstrates the capabilities of the PEST suite of software in model calibration and in calibration-constrained uncertainty analysis. In a basic and easily-understood way, it introduces the theory behind PEST and demonstrates application of this theory, with numerous examples from the real world.

The discussion is then broadened to explore issues that calibration and uncertainty analysis expose. In particular, it investigates how an environmental model can provide receptacles for the two types of information on which decisions pertaining to environmental management are necessarily based, namely expert knowledge and the historical behaviour of that system. The issues of appropriate complexity and the need for "good calibration" are discussed. Particular attention is focussed on the fact that even the most complex model is a grossly imperfect replicator of real-world environmental system behaviour. Conclusions are drawn which question some long-established beliefs of what constitutes "a good model". Suggestions are made of what should be asked of an environmental model when used to support the making of important management decisions.

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