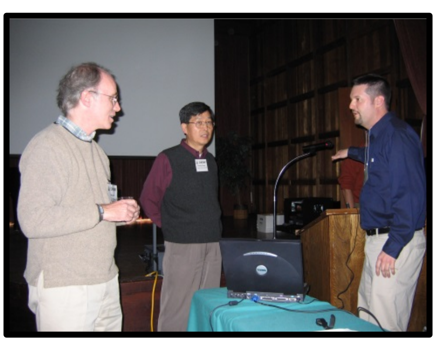
California Water and Environmental Modeling Forum

2014
ANNUAL MEETING
SESSION ABSTRACTS

With Links to Speaker Presentations



ABSTRACTS

Session 1. Delta Simulation Model 2 (DSM2) Model Development and Applications

DSM2 Version 8.1 Calibration – Lianwu Liu and Prabhjot Sandhu (DWR) **3.6 MB**

Version 8.1 incorporates the latest improvements to the DSM2 code. The main differences in DSM2 version 8.1 include: DSM2-Qual model formulation change to improve model convergence (presented at CWEMF 2011 conference and discussed in (Liu & Ateljevich, Improvements to DSM2-Qual: Part 1,2011)); modifications to the DSM2-Hydro program source code that improve channel geometry calculation (presented at CWEMF 2012 conference and documented in (Liu & Ateljevich, Improved Geometry Interpolation in DSM2-Hydro, 2012)); datum conversion to NAVD88; and Martinez EC boundary correction. Since these changes affect results both in DSM2 Hydro and Qual, a new calibration has been performed for Version 8.1 of DSM2. This calibration is done by adjusting Manning's coefficient values in Hydro and dispersion coefficients in Qual. The new calibrated model results are generally very close to the 2009 calibration results. Improvements were seen in a few places in Hydro and Qual. Further improvements involving other changes, e.g. new bathymetry and grid change, may come in future releases. DSM2-Hydro has also been improved to run 2 times faster than the previous version.

Using DSM2 in Support of Delta Smelt Lifecycle Modeling – Chandra Chilmakuri (CH2MHill) **0.9 MB**

US Fish and Wildlife Service is in the process of developing a delta smelt life cycle model to help evaluate the potential effects of various water management actions on the delta smelt populations. Estimating potential larval smelt movement within the Delta under the influence of historical flow and tidal conditions is necessary for the life cycle model development to help explain larval/post-larval movement dynamics across the regions. Delta Simulation Model (DSM2) was used to represent the effects of hydrodynamics on the larval Delta Smelt movement within the Delta channels in the delta smelt life cycle model development. For this analysis, the Delta was divided into four (4) regions and 25 sub-regions. DSM2 Particle Tracking Model (PTM) was used to estimate the movement of neutrally buoyant particles among the sub-regions. The DSM2 model was driven using the historical flow and tide data at the boundaries for the 1990 – 2010 period. The PTM was used to simulate particle movement during Mar, Apr, May and June months of the 21 years. A database of the percentage of particles that moved from one sub-region to other during each of the 84 months was developed for use in the Delta Smelt life cycle model. Recently, to extend this database to past historic flow conditions, the DSM2 model was used to simulate Delta hydrodynamics over the 1962 – 1989 period. DSM2 was extended to 1962 for use in the delta smelt life cycle model development. Results from the extended DSM2 model were compared to the observed data to validate the model performance over the extended period.

Modeling Seasonal Nutrient Transformations and Losses in the Delta: Project Findings on the Effects of Time-varying DICU Concentrations Using DSM2 V8.1.2 – Marianne Guerin (RMA) **2.2 MB**
Collaborators: David Senn (SFEI) and Carol Kendall (USGS)

In this IEP-funded project, our task is to combine the analysis of long-term nutrient-related DWR-EMP monitoring data and existing stable isotope data with output from the DSM2 hydrodynamic and water quality models to characterize the role the Delta plays in transforming, assimilating, and removing various nutrients. The Sacramento and San Joaquin Rivers carry substantial loads of nutrients into the Delta, while within the Delta nutrient loads from agricultural return flows, wetland drainage, and stormwater flows are added and nutrient transformations and losses occur. In this talk, the focus is on the contributions from agricultural return flows as time-and-space-varying DICU nutrient concentrations are added to the v8.1.2 QUAL nutrient model. Model scenario comparisons for the years 1990 – 2008 are made. These findings move us to our eventual goal of identifying the factors that contribute to spatial and temporal trends and variability in nutrient concentrations and ratios.

Delta Barriers Study – Subir Saha (DWR) **2 MB**

The purpose of this study is to block particles entering into the interior and southern delta, and into the SWP and CVP export facilities from the Sacramento and San Joaquin Rivers when water flows towards the ocean. Tidally operated gates at four key junctions in delta are simulated using the DSM2-Hydro and the DSM2-Qual model. Individual gates and a combination of gates are modeled for monthly flow reductions of 100% and 50% at those junctions using gates. The modeling results are analyzed to determine impacts to flow, stage and water quality in various locations throughout the delta. The impact due to the flow reduction is summarized in this presentation.

Session 2. IWFM & IDC 2012-2013 Enhancements and Applications

2013 Enhancements to IWFM and IDC – Emin Can Dogrul (DWR) **1 MB**

Several new features have been implemented in IWFM and IDC numerical engines in the past year. Most prominent of these is the root water uptake from groundwater to simulate the effect of shallow groundwater table on evapotranspiration and irrigation water demand. Other enhancements made include access of riparian vegetation to stream flows, ability to define stream wetted perimeter as a function of stream flow and routing of stream flows using the kinematic-wave approach. Additionally, several software products that were developed to aid users in pre-processing and post-processing the IWFM/IDC input data and simulation results will be showcased. A look at the planned IWFM/IDC improvements for the near future will also be presented.

Yolo County IWFM Demand Calculator (IDC) Parameter Development **0.5 MB**
Bryan Thoreson (Davids Engineering)
Collaborators: Byron Clark, Lindsay Hall, and Grant Davids (Davids Engineering)

Groundwater provides a significant storage reservoir for California that can be drawn on in times of limited surface supplies. Computer groundwater models have been developed to improve the understanding and management of this important resource. The Integrated Water Flow Model (IWFM) is one such model developed by the California Department of Water Resources (DWR). The IWFM features a land use based approach of calculating water demand that tracks water budgets for individual crops through a root zone water balance model, known as the IWFM Demand Calculator (IDC). Accurate portrayal of crop season water balances is a complex modeling exercise. This presentation will review the process of developing parameters to obtain accurate crop season root zone water balances through review of an IWFM model developed for Yolo County. Selection of soil and irrigation management parameters will be described and annual graphs depicting the resulting crop season root zone water balance of major soil-crop groups will be reviewed and discussed.

Yolo County IWFM: Calibration and Model Application for Developing Conjunctive Use Framework in an Aquifer-Floodplain Recharge Operation – Carlos Flores (UC Davis) **6.1 MB**
Collaborators: Graham Fogg (UC Davis), Ken Loy (West Yost Associates), Bryan Thoreson (Davids Engineering) and Emin Can Dogrul (DWR)

Conjunctive water use is of high interest today. The use of groundwater storage during dry periods of time, when the lack of surface water constrains the diverse water uses, is an alternative to increase the water availability to meet water demand. Full benefits of conjunctive use can be achieved when excess surface water during wet years can be recharged into the groundwater. This is done normally in upgradient areas, but in many other cases, the water for recharge is only available in downgradient zones, such as the Yolo Bypass, a floodplain area where the hydrogeology is semi-confined with a shallow water table. The Integrated Water Flow Model (IWFM) was used to explore aquifer-floodplain recharge operations for conjunctive use in Yolo County as a study case. For that purpose, the model was updated and calibrated to recent data. Modeling suggest that a promising conjunctive use framework could be developed in the Yolo Bypass with countywide benefits, by storing excess water from the Sacramento River during flooding seasons, and a pumping scheme in the bypass that would reverse the ambient groundwater flow creating space for recharge. Increased groundwater storage could then be recovered for extraction during dry periods.

Using PEST to Calibrate IWFM Models – Charles Brush (DWR) **2.3 MB**
Collaborators: Tariq Kadir and Emin Can Dogrul (DWR)

IWFM simulates water movement through the land surface, surface water, and groundwater flow systems. The many types of parameters in an IWFM model pose unique problems for automated calibration, which relies on the construction of a single mathematical expression expressing how well the model matches the observations. The PEST software suite is a powerful and flexible collection of computer programs that facilitate model calibration. PEST includes many features that simplify and speed up the calibration of complex and highly parameterized models. Parallel versions of PEST that run on multi-processor computers can significantly reduce model calibration time when this involves a large number of parameters. DWR recently published software tools that link PEST with the IWFM application. PEST and the PEST-IWFM software tools were used to calibrate DWR's California Central Valley Groundwater-Surface Water Simulation Model (C2VSim). The initial calibration steps were performed on desktop computers, and as the number of calibration parameters increased, the calibration was moved to a Linux cluster at UC Davis and the Carver computer cluster at Lawrence Berkeley National Laboratory. PEST and the PEST-IWFM tools can also be used to rapidly calibrate complex IWFM models on commercial computing clusters such as Amazon Cloud and Google Compute Engine.

Session 3. Sacramento and San Joaquin Basins Study: Modeling Climate Change Impacts and Adaptation Strategies

Sacramento and San Joaquin Basins Study Overview – Michael Tansey (Reclamation) **2.4 MB**

The Sacramento and San Joaquin Basins Study is a collaborative long range planning study being conducted by Reclamation and partner agencies to assess the impacts of future changes in climate and socioeconomic conditions on the water resource management in Central Valley of California. The study goals also include the development and evaluation of the effectiveness and tradeoffs between potential adaptation strategies. To accomplish these objectives, a scenario based planning approach is being employed to characterize a broad range of future climate and socioeconomic uncertainties. Existing hydrologic, CVP/SWP operations, water quality, hydropower, GHG and economic models were modified and integrated into a loosely coupled decision support system. This suite of models is being used to simulate how transient changes in projected climate and socioeconomic conditions may impact key performance characteristics of the CVP, SWP and other non-project water management systems in the Central Valley. The results of these simulations are currently being used by Reclamation and the partners to develop portfolios of water management actions to effectively adapt to the 21st century challenges.

Assessments of Climate Change Impacts on Central Valley Supplies and Demands **2.7 MB**
Brian Van Lienden (CH2MHill)

The amount of water available and changes in the demand for water 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. To account for a range of uncertainty in future conditions, a suite of scenarios reflecting a combination of socioeconomic and climate futures has been developed to reflect a range of future conditions. These scenarios are used to perform assessments of current and future water supplies and demands 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. The water demand assessment characterizes the potential effects of changes in population, land use, water use efficiency, and climate variability on agricultural and urban demands in the Central Valley.

Analyzing and Presenting Central Valley System Risk and Reliability through the 21st Century **2 MB**
Armin Munevar (CH2MHill)

The reliability of water dependent resources in the Central Valley has been evaluated through a broad scenario planning approach, combined with integrated systems analysis, and vulnerability assessments. The performance of the Central Valley water system was evaluated for water delivery, water quality, recreation, flood control, hydroelectric power, and ecological resource areas under a range of potential socioeconomic and climatic future conditions through 2100. In multi-resource evaluations such as the Basins Study, performance measures for each resource must be developed to articulate existing and future vulnerability and to link potential adaptation strategies to consequences associated with the resources. Quantitative evaluations of system performance utilizing the CVP IRP CalLite model for water operations analysis and companion tools to derive metrics for all major resources was performed. The results from the suite of models were used to analyze and present near-term and long-term reliability of the system and will be used to guide future adaptation strategy development for the Study.

Next Steps – Arlan Nickel (Reclamation) **0.4 MB**

The Sacramento and San Joaquin Basins Study is a collaborative 2 year cost shared study involving Reclamation and 7 partner agencies. The study officially began in the October of 2012 with meetings between Reclamation, partner agencies and the consultant team. It is scheduled to be completed by October 2014. At present, Task A (Project Initiation), Tasks B & C (Supply and Demand Assessments), and Task D (System Risk and Reliability) are essentially complete. Technical reports describing the methods, modeling and results associated with these tasks are currently being completed. The project team is nearing completion of Task E (Evaluation of Actions) and work on Task F (Evaluation of Adaptive Responses) is scheduled to begin next month. Public participation has been on-going throughout the study. The final study reports should be publically available in early to mid-October 2014. In the future, Reclamation plans to build upon the results of this study by seeking partners interested in performing feasibility level investigations to evaluate in more detail one or more of the most promising adaptation strategies with the intent to obtain funding for implementation.

Session 4. Integrated Water Resources Modeling

Integrated Water Resources Modeling for the California Water Plan: WEAP Applications **4.2 MB**
Mohammad Rayej (DWR)

An integrated water resources model called WEAP has been used in recent years in several updates of California Water Plans; namely Updates 2009 and 2013 to quantify future water conditions under different population growth, socioeconomic factors, and climate change scenarios. WEAP (Water Evaluation And Planning) is a physically-based, demand driven water supply allocation model which integrates various sources of supply and demand in a region. It steps through time to give a trajectory of regional water supply and demand as it evolves over time helping water managers and planners evaluate system vulnerabilities and future shortages. It can incorporate various sources of supply (rivers, on-stream and off-stream reservoirs, groundwater, desalination, recycling) and demand sites (agricultural, urban indoor and outdoor and environmental flow requirements). It is highly scalable in space (local, regional) and time (daily, monthly, and yearly time-step). Through its hydrologic catchments, WEAP can directly translate climate signals into snowpack accumulation and/or snowmelt runoff flowing into upstream reaches of the reservoirs without a need for an outside hydrologic model. It has a very powerful scenario-building capability enabling water managers and planners evaluate an extensive sets of water management options like demand reductions and/or supply augmentations projects. It has been widely used as a long term planning tool in many countries and international water projects.

Updates to the USGS Central Valley Hydrologic Model – Jonathan Traum (USGS) **12 MB**
Collaborators: Claudia Faunt), Michelle Sneed, and Randall Hanson (USGS); and Nigel Quinn (Berkeley National Laboratory/Reclamation)

California's Central Valley has been one of the most productive agricultural regions in the world; however, groundwater pumping for irrigation has caused groundwater-level declines and associated land subsidence. Recent drought conditions caused increased demand for groundwater, resulting in land subsidence. The potential damages in surface infrastructure from subsidence may cause managers to limit groundwater withdrawals both spatially and temporally. The U.S. Geological Survey (USGS) recently developed the Central Valley hydrologic model (CVHM) to quantitatively assess aquifer-system responses to climatic variation, surface-water deliveries, and groundwater pumping. To more accurately simulate the recent groundwater levels and the spatial distribution, timing, and magnitudes of subsidence, the CVHM has been updated. MODFLOW-FMP has been enhanced to more accurately simulate the timing of subsidence by incorporating effects layers that delay deformation, changes in altitudes caused by subsidence (grid deforms), and separation of the inelastic and elastic portions of subsidence. More recent data were added to extend the simulation through 2009 and recalibrate CVHM to recent groundwater-level and subsidence data. The updated CVHM provides a detailed analysis of changes in groundwater availability and subsidence and can be used to assist decision makers in making water management decisions necessary to achieve effective conjunctive use.

C2VSim Refined Grid Version Development and Applications **5.2 MB**
Mesut Cayar (RMC Water & Environment)
Collaborators: Ali Taghavi, Reza Namvar, and Jim Blanke (RMC Water & Environment)

The C2VSim has been developed by the California DWR to analyze the surface water and groundwater conditions in the Central Valley for both historical and future conditions. Recently, a fine grid C2VSim (C2VSim-FG) has been developed to assist water supply and groundwater management in Central Valley and to support Integrated Regional Water Management (IRWM) activities at regional scale with more accuracy. The C2VSim-FG grid conforms the Bulletin 118 Groundwater Basin Boundaries, Depletion Study Areas (DSAs), Hydrologic Study Areas (HSAs), Detailed Analysis Units (DAUs), and DWR Hydrologic Regions. The C2VSim-FG model has more than 30,000 groundwater nodes and around 4,500 stream nodes.

Since its development, C2VSim-FG has been used for the following applications: (i) evaluation of the impacts of a groundwater substitution program on interaction of rivers and aquifers and their impacts on the hydrological system; (ii) assessment of impacts of increased agricultural acreage in parts of Central Valley; (iii) evaluation of increased irrigation efficiency on groundwater recharge conditions; (iv) quantification of potential recharge through flooding agricultural lands using excess winter time flows; and (v) evaluation of the hydrologic and economic conditions resulting in sustainable groundwater conditions.

Model Development to Support a Growing Understanding and Management of Local Groundwater in Butte County – Christina Buck (Butte County Dept of Water and Resource Conservation) **1.4 MB**

The Butte Basin Water Users Association funded the initial development of the Butte Basin Groundwater Model (BBGM) in 1992 to support water management activities in the region. In its early years, the model program was *FLOW3D* with a simulation period of 1972-1999. As part of a later model update beginning in the early 2000s, the model was migrated to IWFM and the hydrogeological representation updated to be based on geologic cross-sections developed by the Department of Water Resources Northern Region Office. A historical model (WYs 1971-1999) was calibrated and a base case and scenario run developed and results documented. The BBGM is currently being updated to extend the simulation timeframe to 2012 to support an evaluation of Butte County's water supply and demand picture for the last decade. An overview of model development and motivation, what's been learned, and potential future analyses will be presented and discussed.

Session 6. Advances in Climate Change Assessment

Detection of a 12-15 year Hydrologic Cycle in Streamflow and Precipitation Data Using Wavelet Analysis – Guobiao Huang (DWR) **2.4 MB**

In developing and calibrating precipitation-runoff SWAT models for the upper watersheds flowing into California's Central Valley, wavelet analysis was performed on observed precipitation and streamflow time series data to detect dominant cyclic patterns and frequencies. A common 12-15 year cyclic pattern (a wavelet power peak at the 13.9-year scale) was detected in observed monthly unimpaired streamflow data (1910-2010 period) in 24 major upper watersheds and two representative precipitation indices, Northern Sierra 8 Station index and San Joaquin 5-Station Precipitation index. Further testing showed that USGS long-term measured/computed unimpaired watershed streamflow data for Merced, Eel and the Arroyo Seco rivers, Lake Tahoe water level data, and Golden Gate sea level data also show a similar cyclic pattern. Strong wavelet coherence (localized correlation in frequency domain) between streamflow and precipitation reinforces the premise that precipitation is the cause of the quasi-decadal cyclic pattern in streamflow. On the other hand, causality between precipitation and major climate indices (ENSO, Arctic oscillation, PDO and others) needs further investigation. SWAT models simulated streamflow data preserve well the wavelet cyclic patterns found in observed streamflow data. However, tested raw precipitation gridded data in California from selected global climate models (GCM) did not show the 12-15 cyclic patterns seen in the observed historical data.

Comparison of CMIP5 and CMIP3 Climate Model Precipitation Projections in California **1.4 MB**
Jianzhong Wang (DWR)
Collaborators: Hongbing Yin and Francis Chung (DWR)

Climate projections for the fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) were based on scenarios from the Special Report on Emissions Scenarios (SRES) and simulations of the third phase of the Coupled Model Intercomparison Project (CMIP3). Since then, a new set of four scenarios (the representative concentration pathways or RCPs) was designed. Climate projections in the IPCC fifth assessment report (AR5) will be based on the fifth phase of the Coupled Model Intercomparison Project (CMIP5), which incorporates the latest versions of climate models and focuses on RCPs.

It is in urgent need to see how these new versions of climate models and new emission scenarios (RCPs) change precipitation projections in California through comparison of CMIP5 and CMP3 since future precipitation scenarios would impact evaluation of water supply security in California. The preliminary comparison of CMP3 and CMIP5 by Levi et al (2013) reveals that projections in CMIP5 showing wetter portions of California and the Upper Colorado Basin are notable because they challenge previous projections from CMIP3 that suggested these regions will become drier, resulting in reduced runoff.

Although the RCPs were not developed to mimic specific SRES scenarios, pairs with equivalent CO2 concentration and then similar temperature projections over the twenty-first century can be found between RCP 4.5 and SRES B1.Thus, CMIP5 climate model projections under the RCP4.6 concentration scenarios are compared to CMIP3 climate model projections under the SRES B1 scenario in this work to see if new features in new versions of climate models including finer resolution and more complex physics, rather than these representative concentration paths (RCPs) in CMIP5, change projected precipitation trend (wetter or dried) in California.

Do New Climate Change Predictions Demand New Impact Studies? 3.6 MB
Ed Maurer (Santa Clara University)

Global climate models (GCMs) have seen considerable improvements in their simulation of the processes driving the Earth's climate. The spatial resolution at which they operate is finer than earlier generations of models, and continued testing against new observational data sets has revealed greater insights into their performance. The 2007 report of the Intergovernmental Panel on Climate Change (IPCC) featured climate projections based on GCM output from simulations based on experiments performed as part of the Coupled Model Intercomparison Project phase 3 (CMIP3), and many impacts studies have been based on CMIP3 output. The new IPCC report includes projections by a new set of GCMs using new future greenhouse gas concentration scenarios, based on CMIP5. Those interested in the impacts of future climate disruption on water resources are faced with a decision as to whether the new projections require a revisiting of past work on climate impacts. In this talk, a brief summary will be presented of how the CMIP5 projections differ from CMIP3, and what the implications are for climate impacts on water resources.

Perspectives on Extremes and Improving Infrastructure Resiliency in a Changing Climate 4 MB
Armin Munevar and Tapash Das (CH2MHill)

Hydro-meteorological extremes have an unavoidable impact on human activities, water resources, agricultural activities, urban infrastructure, and ecosystems' responses. Climate influences many aspects of infrastructure planning, design, and operations. Growing scientific consensus suggests that climate change will be inevitable as the result of increased concentrations of greenhouse gases and related changes in temperature and precipitation. Meanwhile water demands are increasing due to demographic and climate pressures. In addition to mean changes in climate state, frequency, and severity of many hydro-meteorological extremes, including heat waves, floods, and droughts are expected to increase in future. Moving beyond climate stationary assumptions requires new methodologies to incorporate climate change for planning and shifts toward risk-based decision-making. This paper will present several case studies incorporating climate extremes information in planning through a systems approach to achieve long-term resiliency.

Session 7. Reservoir Water Quality Modeling – Applications for Better Management

Comprehensive Water Quality Modeling – The Value of Continued Model Development: Keno Reservoir, Klamath River, Oregon – Mike Deas (Watercourse Engineering) 2 MB
Collaborators: I.E. Sogutlugil (Watercourse Engineering); Annett Sullivan and Stewart Rounds (USGS)

Water quality models are invaluable tools for the assessment of aquatic system response to various forcing functions and within-system interactions. Such models can be helpful for decision-makers to manage flow, water quality, and fisheries, as well as to guide monitoring. Water quality models require representation of hydrodynamics to simulate basic physical transport processes for water quality variables. Extensive data are required to effectively develop, calibrate, and apply such models. Our quantitative understanding of complex, dynamic aquatic systems – that level of data-supported knowledge to represent an aquatic system in a numerical model – is typically limited. The application of a model, however, helps to identify and quantify dominant processes, and often provides the invaluable "analytical service" of identifying model and/or data limitations. The common practice of using models for a single assessment (development, calibration, application, final report) often fails to capitalize on this analytical service. The value of continued model development for systems that exhibit complex, incompletely understood processes is illustrated with a case study of Keno Reservoir (Klamath River), which has a 20-year history of CE-QUAL-W2 modeling. Keno Reservoir is a shallow, hypereutrophic impoundment that undergoes a complex set of water quality conditions leading to remarkable impairment. Continued model development and use has allowed additional state variables (macrophytes) and processes (advanced simulation of pH buffering) to be simulated, and anomalous time periods outside the original calibration period to be examined; all such uses have made the model more robust and useful.

Three-dimensional Hydro-thermal Modeling of the Lower Stanislaus River and its Three Reservoirs

Andrew Parker (Tetra Tech) **2.5 MB**
Collaborators: Li-Ming He (NOAA NMFS); Sen Bai and Mustafa Faizullabhoy (Tetra Tech)

Water temperature in the Lower Stanislaus River (LSR) is strongly influenced by its three upstream reservoirs – Goodwin, Tulloch, and New Melones. Increased residence times in the reservoirs and the release regime from Goodwin Reservoir have led to elevated temperatures in the river, particularly during periods critical to salmonids. Previous hydro-thermal modeling of the river and reservoirs provided limited insight into the influence of reservoir operations on high resolution temporal and spatial variability of temperature in the river. Therefore, we developed hydro-thermal models of the three reservoirs and LSR using the Environmental Fluid Dynamics Code (EFDC). Curvilinear grids were generated for the three reservoirs using data collected by multi-beam sonar during recent bathymetric surveys. The reservoir models simulate water temperature in three dimensions at a sub-hourly time step. They are linked to one another in series and to a downstream EFDC one-dimensional model of the LSR. The fully calibrated, linked modeling framework enables the impacts of reservoir operations and meteorological inputs on the temperature regime to be readily evaluated. Should the need arise, the EFDC-based modeling system could be readily enhanced to simulate nutrients, dissolved oxygen, and other critical water quality parameters.

Mokelumne System Temperature Management: Integrating Modeling Tools and Monitoring Programs into Planning and Operations – Benjamin Bray (EBMUD) **6.4 MB**

A critical component of lower Mokelumne River fisheries management is the adaptive operation of the East Bay Municipal Utility District's EBMUD's) Mokelumne Reservoir System to minimize Camanche Reservoir release temperatures in the fall coincident with fall-run adult Chinook escapement. An adaptive management framework is essential for operational flexibility responsive to natural variability. EBMUD's coordinated operations account for many factors in the development and execution of the temperature management strategy in any given year, including: timing and magnitude of watershed runoff, meteorological conditions, aspects affecting cold water pool transfer efficiency, and hypolimnetic characteristics of the System's reservoirs. This presentation gives an overview of the extensive monitoring program and array of modeling tools developed to inform adaptive operations of the System to maximize its beneficial uses. The historical motivation of the temperature management program and the framework developed to support and inform reservoir management actions are described, concluding with a look forward to future plans for expanding and improving upon components of the program. Recent drought operations as well as key insights gained from the monitoring program are also highlighted.

Enhancement of the Coldwater Pool Management Model for the Purpose of Identifying the Coolest Thermal Regime Possible in the Lower American River – Chris Hammersmark (cbec eco-engineering) **2.7 MB**

Supporting Chinook salmon and Steelhead habitat in the lower American River requires thoughtful balancing of a very limited resource--coldwater--between two species of salmonids. Rearing juvenile Steelhead require cool water during summer, while adult Chinook returning to spawn require cool water conditions during late summer and fall. The Coldwater Pool Management Model (CPMM) which simulates temperature conditions in Folsom Reservoir, Lake Natoma, and the lower American River, is used by the US Bureau of Reclamation in its annual temperature management planning for the lower American River. This presentation shares several CPMM updates and enhancements. The updated model utilizes an iterative Automated Temperature Selection Procedure to determine the coolest temperature schedule that is achievable with the initial reservoir conditions and the anticipated release hydrograph for the spring, summer, and fall. The updated model also can iteratively manipulate the release hydrograph to determine the coolest thermal regime achievable with the same overall release volume and initial conditions. A number of other improvements to the model will be discussed.

Session 8. CalSim II / CalLite2 / WRIMS 2 Updates and Applications

CalSim II Logic Updates – Nancy Parker (Reclamation) **1.9 MB**

CalSim II undergoes constant testing through new applications, corroboration studies, and scrutiny of model output. Investigation of specific controls in the model can often shed new light on aspects of the CVP/SWP system representation and highlight needs for improvement. In other cases, system operation changes or newly available data can require or support implementation changes. Numerous updates have been made to CalSim II since August 2011, when the BDCP baseline studies were updated for QA-QC purposes. These updates are now fully functional in DWR's Delivery Reliability Report studies and BOR's Remand studies. This presentation will discuss the changes that have been made and highlight their individual and collective impacts on model results.

Using CalSim II to Analyze the Impact of Climate Change on California's Water Systems under Varying Delta Regulatory Environments – Holly Canada (DWR) **1.3 MB**

CalSim II, a water resource system model developed by the California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation), is used to evaluate the impact of climate change on California's water systems: the State Water Project (SWP) and the Central Valley Project (CVP). Climate change impacts are compared across three regulatory environments: (1) the State Water Board Decision D-1485 (issued August 1978), (2) the State Water Board Decision D-1641 (issued December 1999), and (3) the Biological Opinion Reasonable and Prudent Alternatives (BO RPAs) of the U.S. Fish and Wildlife Service Operational Criteria and Plan (OCAP) Delta Smelt BO (issued December 2008) and the National Marine Fisheries Service OCAP Salmonids BO (issued June 2009).

The SWP and CVP systems are assessed under two individual components of climate change: sea level rise and climate change hydrology, and under the combined impact of both components. Changes in delta outflow, south of delta exports, and north of delta storage are compared across regulatory environments. As flexibility of the system increases from BO RPAs to D-1641 to D-1485, the ability of the system to respond to climate change improves.

Developments and Applications of WRIMS New Timestep Features – Hao Xie (DWR) 0.7 MB

New timestep features have been developed in the WRIMS 2 engine including the modules for multi-timestep optimization and monthly-daily mixed timestep simulation. The new features in WRIMS 2 have been utilized in new model applications and exercises. A Forecast Allocation Model (FAM) has been developed based on the California Allocation Model (CAM) by utilizing the multi-timestep optimization module. A Daily Delta model has been developed inside a regular monthly CalLite model with the support from the monthly-daily mixed timestep simulation module in WRIMS 2. The mechanisms and model applications for these new timestep features will be presented and discussed under this topic.

Visualization of CalSim Results Using the Palantir Software 4.2 MB
Mike Urkov (NewFields) and Tom FitzHugh (Reclamation)
Collaborator: Carolina Zuri (NewFields)

Review of CalSim results can be challenging because of the complexity of the model, the large number of variables involved, and the need to analyze inputs and results from multiple cycles in order to fully understand model behavior. Because of its capabilities for management, analysis, and visualization of large datasets, the Palantir software provides a powerful tool for making CalSim results easier to analyze, both on their own and in conjunction with other datasets. This presentation will show two example analyses which use Palantir for this purpose. The first analysis is a review of BDCP CalSim results in conjunction with other empirical data such as salvage and measured flow, which shows how Palantir can improve the speed of analysis. The second analysis uses Palantir to analyze factors which control CVP and SWP operations in CalSim, such as Delta regulatory standards, minimum instream flow requirements, Delta export operations, and flood control requirements. The impact of these factors varies depending on month and water year type, and being able to visualize the interaction of these various controlling factors can be very useful in understanding model results and especially why results shift when moving from one model to another.

Session 9. Technical Analysis in Support of the California Water Plan

Overview of the California Water Plan Update 2013 – Paul Massera (DWR) 7.6 MB
Collaborator: Lew Moeller (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.

Evaluating Central Valley Water Vulnerabilities and Management Responses for the California Water Plan – David Groves (RAND Corporation) **1.7 MB**
Collaborators: Evan Bloom and Edmundo Molina-Perez (RAND Corporation); and Rich Juricich (DWR)

California faces significant challenges in ensuring that its water resources successfully meet diverse needs across the state in the coming decades. The California Water Plan has been developing new data and tools to evaluate management conditions and new strategies under climate change. This talk describes a technical analysis of the Central Valley water management approach performed for the California Water Plan Update 2013. The analysis uses Robust Decision Making to identify key future vulnerabilities of the current management approach to urban and agricultural reliability, groundwater storage, and environmental flows in the Central Valley. It next evaluates how response packages, comprising different management strategies, might reduce these vulnerabilities. Lastly, it presents key trade-offs among the different response packages in terms of their cost and their ability to reduce vulnerabilities. The agricultural sector in the San Joaquin River hydrologic region and the urban and agricultural sectors in the Tulare Lake hydrologic region are found to be particularly vulnerable to many plausible future climate and growth projections. Groundwater levels and environmental flows are also vulnerable. Increases in efficiency, conjunctive use, and reuse can reduce these vulnerabilities. The implementation of new environmental flow and groundwater targets improves outcomes relative to flows and groundwater, but decreases the reliability of water supplies for urban and agricultural use.

Groundwater Findings and Recommendations for the California Water Plan and Status of CASGEM Program – Dan McManus and Mary Scruggs (DWR) **8.2 MB**
Collaborator: Abdul Khan (DWR)

As part of the California Water Plan Update 2013, additional groundwater information was developed. Groundwater information compiled and analyzed by hydrologic region include well infrastructure, supply and use, groundwater quality, change in aquifer storage, land subsidence, groundwater management, and conjunctive use. Findings and recommendations from the California Water Plan groundwater efforts are presented, along with an update of the California Groundwater Elevation Monitoring (CASGEM) Program. Recent CASGEM efforts include the prioritization of California's 515 alluvial groundwater basins with the goal to have designated groundwater monitoring entities in all high and medium priority basins in the state. An overview of the CASGEM basin prioritization results and update on groundwater monitoring entities are also presented.

Indicators for Evaluating and Reporting Water Sustainability in the California Water Plan 3.9 MB
Fraser Shilling (UC Davis)
Collaborators : Dave Waetjen Lara Lacher and Susana Cardenas (UC Davis); Julian Fulton and Heather Cooley (Pacific Institute)

The California Water Sustainability Indicators Framework (hereafter "Framework") was developed as part of the California Water Plan Update 2013. The Framework was developed with stakeholder input and brought together water sustainability indicators to inform assessments of water system conditions and their relationships to natural, social, and economic systems. Indicators were organized by sustainability goal and by system domains (e.g., water quality). Evaluating indicators was based upon the principle of measuring how far a current condition is from both a desired condition and an undesirable condition. The process was tested at both the regional and state scales, including stakeholder involvement, indicators selection, and indicator evaluation and reporting. One critical indicator of water use was the water footprint, which is the sum of water use and impacts to provide goods and services that individuals or regions consume. The water footprint was usually up to ten-fold higher than the amount of water managed through delivery systems and in exceptionally dry years rivals the flow of all river systems in California. The entire system is published at http://indicators.ucdavis.edu.

Session 12. Recent Innovations in Numerical Modeling Techniques and Model Data Management

Integrated Water Resources Modeling and Data Management Tools: Automated Sharing of Model Data on the Web – Mesut Cayar (RMC Water and Environment) 5.7 MB
Collaborators: Jeanna Long, Ali Taghavi, Saquib Najmus, Yamin Noor, and Farhad Navaei (RMC Water and Environment)

Increased attention to integrated water resources management in the last decade has resulted in advancement of integrated groundwater and surface water models as well as a need for transparency of data sharing and analysis due to intensive involvement of multiple stakeholders with multiple perspectives. RMC has developed an Integrated Water Resources Modeling and Data Management framework that provides an integrated set of web-based and desktop applications that support the collaborative efforts to manage and share data and models.

The Integrated Water Resources Modeling System (IWRM) is a comprehensive GIS-based modeling environment for the IGSM and IWFM. The IWRM is a state-of-the-art system that allows users to develop model input files from existing groundwater datasets, generate and store completed simulations, map results, report water budgets, analyze time/non-time series and 3-D data, and compare model scenarios.

The HydroDMS is a comprehensive data management tool that stores water resources and hydrologic data for use in the IWRM environment. The HydroDMS allows data storage, data sharing, data analysis, and reporting in a cost effective manner among all stakeholders. The HydroDMS can also store and display input and output of hydrologic models such as IGSM and IWFM. The HydroDMS is integrated with RMC's OPTI system for centralized, web-based project and data management.

Visualizing Hydrologic Data and Simulation Results with Python and ArcGIS – Donald Martin (USGS) 1.8 MB

Hydrologic flow models, such as MODFLOW, produce large amounts of output, such as large cumbersome ASCII or binary files, which is often difficult to analyze and visualize. Python and ArcGIS can be used together to create custom tools to parse, extract, and visualize the relevant data from the MODFLOW output files. The data are stored in binary arrays by using the Python package NumPy, allowing for quick read/write access. The Python package ArcPy is used to link Python and ArcGIS tools together to automate the generation of maps, figures, and animations. Examples are Animate Heads and C-Flow. Animate Heads extracts head values from MODFLOW output files and calculates the groundwater-level change and the depth to water. These results are animated through time. C-Flow is a toolbox developed to analyze and visualize the flow terms in the MODFLOW Cell-By-Cell flow file by producing maps that display the flow direction across model layers. Although these tools were developed specifically for MODFLOW output files, Python, ArcGIS, and the methods used to create these tools can be applied to any model output.

POD Model Reduction: A Method for Reducing the Computational Burden of Solving Systems of Equations from Numerical Models – Scott E. Boyce (UCLA) .ppsx (PowerPoint Slideshow); 13 MB
Collaborator: William W.G. Yeh (UCLA)

Effective water resource management is aided by the development and implementation of mathematical models to evaluate the hydrologic effects of various management actions. However, these studies often require a large number of simulations to conduct advanced analyses and are intractable when using complex, highly-discretized, or regional-scale models with large computational requirements. Therefore, reducing the computational burden associated with these models will provide opportunities to apply them to a wider spectrum of water resource management problems.

One effective technique to reduce the computational burden of large-scale simulations is projection-based model reduction, which involves construction of a projection matrix (basis) that is used to reduce the dimensionality of the state variable (i.e. number of equations) of a model. To construct the projection matrix, a set of solutions (i.e. results from the original model) are transformed to an orthonormal basis and analyzed through principal component analysis (PCA). PCA identifies the components of the original model that have the largest impact on its output and truncates components with little influence. In hydrology, this model reduction technique is called Proper Orthogonal Decomposition (POD). While the terminology and mathematics behind POD are complex, the methodology is simple in its implementation.

PEST – Beyond Basic Model Calibration – Jonathan A. Traum (USGS) 1.3 MB

PEST is a model-independent suite of software tools used throughout the environmental, hydraulic, and hydrologic modeling fields for parameter estimation in complex numerical models. PEST has many capabilities, beyond those used for basic parameter estimation, for finding optimal parameter values and for performing additional analysis. By using a version called BeoPEST, runtime can be greatly improved by executing parallel model runs on one or more computers. PEST's features, such as regularization through prior information and singular value decomposition, can improve runtime, reduce numerical instability and non-uniqueness of parameter estimates, and ensure that parameter estimates make physical sense. PEST uses the Gauss-Marquardt-Levenberg optimization method by default; however, it can be used to find optimal parameter values in highly nonlinear models and/or models with local minima in the calibration objective function with two global optimization methods: CMAES_P and SCEUA_P. PEST facilitates automation of a traditional sensitivity analysis and can perform more complex linear or non-linear predictive uncertainty analyses. A "Pareto" mode can be implemented to analyze the tradeoff between two optimization objective functions. PEST can be used with a calibrated model for decision analysis by replacing model parameters with decision variables and reformulating an objective function that minimizes negative effects and/or maximizes benefits.

Session 13. Modeling Floodplain Hydraulics and Habitat

Hydraulic Modeling of Floodplain Inundation and Gravel Movement on the Stanislaus River to Support Better River Management Decisions – Paul Frank (NewFields) **4.7 MB**

Like many major rivers in California, the Stanislaus both irrigates farmland and provides rearing and spawning habitat for salmonids. These important uses are often at odds with each other, particularly when river managers and decision makers seek to allocate dam releases to satisfy habitat targets. In this environment, sophisticated river modeling tools can aid decision makers by helping them understand the physical processes that create the conditions required for survival of salmon fisheries.
We have built a new 2-D model of 55 river miles of the Stanislaus, from downstream of Goodwin Dam to the confluence with the San Joaquin. Unlike any models yet constructed of the Stanislaus, this model is capable of producing extremely accurate water surface and flooding extent predictions over a wide range of flow regimes, and of doing so on time frames that facilitate rapid decision making. It can also determine spatial patterns of sediment mobility. This model is therefore capable of identifying where and when important physical processes occur that create or maintain salmonid spawning and rearing habitat.

The model is currently being used in a collaborative process between federal resource agencies and irrigation districts to answer important management questions about the way the Stanislaus River behaves so that management decisions about actions such as controlled releases and siting of restoration projects can be done with a high level of confidence not possible before.

Large Scale Hydrodynamic Modeling for Multi-Objective Floodplain Management
Chris Bowles (cbec eco-engineering)
Collaborators: Chris Campbell (cbec); Rob Lamb, Rob Berry, and Matthew Tancock (JBA Consulting)

Floodplain management planning efforts in the Central Valley of California are moving at an accelerated pace. In the next few years, critical decisions will be made regarding how to modify the current complex flood management system that protects major urban and agricultural areas in the Central Valley, based on holistic and multi-objective criteria aimed not solely for flood management, but also for ecosystem enhancement and agricultural sustainability.

To help inform these critical decisions, an innovative new tool is being developed and tested that will facilitate prediction of floodplain flows over vast areas of the Central Valley under existing conditions and a range of different potential management scenarios. This tool is a new, rapid 2-dimensional hydrodynamic model that is based on novel approaches to approximating the equations of water flow using latest computational hardware. The tool is ideal for testing multiple large-scale planning scenarios in a computationally efficient manner, and is being calibrated and validated for the Sacramento Valley from Ord Ferry to Sacramento, including the major tributaries to the Sacramento River. Preliminary modeling results for this project are presented and other current and potential future uses of the planning are discussed.

2-D Floodplain Modeling of Yolo Bypass – William Fleenor (UC Davis) **7.8 MB**
Collaborators: Robyn Suddeth and Fabián Bombardelli (UC Davis)

The Yolo Bypass is a very important agricultural, wildlife and recreational asset in Yolo County. The benefits of these three uses of the bypass bring significant monetary and social gain to the area. The Bay-Delta Conservation Plan visualizes the bypass as a major mitigation for the plan through the Yolo Bypass Fish Enhancement Plan. The Center for Watershed Sciences (CWS) of UC Davis has been researching various benefits and beneficial uses of the bypass. Two different 2-dimensional hydrodynamic models have been developed to support the field work and the optimization work being done by CWS researchers. Both a 2-D RMA2 finite element model and an HEC-RAS model using the newly developed 2-D floodplain implementation, with 1-D channels, have been developed to examine different possible flooding scenarios, both flows and timing, that would benefit fish and waterfowl and minimizing agricultural losses.

CWS has also been working with FEMA and DWR to produce guidelines for 2-D floodplain modeling. The major findings of these investigations will be presented.

Analyses Supporting Quantification of Rearing Habitat Targets in the Central Valley **3.9 MB**
Mary Matella (American Rivers/California Coastal Commission)
Collaborators: Mark Tompkins (NewFields) and Joe Merz (Cramer Fish Sciences)

Review of CalSim results can be challenging because of the complexity of the model, the large number of variables involved, and the need to analyze inputs and results from multiple cycles in order to fully understand model behavior. Because of its capabilities for management, analysis, and visualization of large datasets, the Palantir software provides a powerful tool for making CalSim results easier to analyze, both on their own and in conjunction with other datasets. This presentation will show two example analyses which use Palantir for this purpose. The first analysis is a review of BDCP CalSim results in conjunction with other empirical data such as salvage and measured flow and how it can improve speed of analysis. The second analysis uses Palantir to analyze factors which control CVP and SWP operations in CalSim, such as Delta regulatory standards, minimum instream flow requirements, Delta export operations, and flood control requirements. The impact of these factors varies depending on month and water year type, and being able to visualize the interaction of these various controlling factors can be very useful in understanding model results and especially why results shift when moving from one model to another.

Session 15. Poster Session

The Hydrology of Joe DeVries – William Fleenor (UC Davis)

Abstract not available.

Insufficient Validation of Integrated Hydrologic Models Applied at a Regional Scale Undermines their Credibility – Hubert Morel-Seytoux (Hydroprose)

Prediction of impacts of various management strategies in water systems can be in error for many reasons. One is due to the "inaccuracy" of the components of the numerical model supposed to represent the physical behavior of the system. Our investigations have shown that the use of a coarse grid size can lead to significant errors. Two examples will illustrate that point. One is the case of the estimation of the flow exchange between a stream and a hydraulically connected aquifer. Another involves the estimation of the reduction of outflow from a stream and the amount of seepage from the stream under transient conditions of inflow into the stream and pumping from a well in the vicinity of the river. These investigations provide criteria to estimate the coarsest grid size that can still produce an acceptable error. In addition the derived analytical techniques (the basis for the comparisons with results from a range of very fine to very coarse grids) provide an alternative to using only purely numerical components.

Using ArcGIS to Process PRISM Climate Data: Application to DETAW as an Example – Jane Schafer-Kramer (DWR)

The PRISM Climate Group at Oregon State University has been producing spatially-reference grids of historical climate data that are recognized as the highest-quality spatial climate data sets currently available. In this poster, a non-programmer presents a workflow for automating the pre-processing of long-term PRISM precipitation data into monthly time-series for input specified boundaries using ArcGIS ModelBuilder. Results for application to DETAW (Delta Evapotranspiration of Applied Water) boundaries are shown. The approach can be easily extended to other areas.

What Does the Water Year 2011 Data Show Us about Salinity Intrusion? – Russ Brown and Anne Huber (ICF)

There is a wealth of available data for evaluating salinity in the San Francisco Estuary. Data collected by the USGS, DWR, and USBR in the Delta and San Francisco Bay during water year 2011 were evaluated to better understand the effects of outflow on seawater intrusion. Water year 2011 was selected because Delta outflow varied widely from approximately 2,500 cfs to 225,000 cfs. Electrical conductivity (EC), flow, elevation, and velocity data collected every 15 minutes at multiple locations, as well as USGS boat survey data were integrated and evaluated. The data show how salinity varies longitudinally and vertically through the SF Estuary as well as how the salinity gradients vary in response to tidal flow and net outflow. At any given location, the daily range of EC values (caused by tidal excursion) is much greater than vertical stratification. Delta outflow is the primary control for seawater intrusion. Other factors such as tidal strength and gravitational circulation play a secondary role. Effective outflow (described as the G-model by CCWD) was used to estimate the daily EC at each monitoring location and to estimate the daily X2 position more accurately than the daily X2 equation. Adding a term representing the high tides of the spring-neap tidal cycle improved the daily EC estimates. Although outflow, X2, and daily average EC values provide an accurate summary of the SF Estuary salinity gradients, the 15-minute data reveal many more interesting hydrodynamic events.

Modeling for Floodplain Inundation: Applications of HEC-RAS2D to the Yolo Bypass – Laila Kasuri (UC Davis)

At 59,000 acres, the Yolo Bypass is the Central Valley's largest contiguous floodplain that has integrated waterfowl and bird habitat into an area with flood control and agricultural uses. The Bay Delta Conservation Plan (BDCP) has proposed more extensive ecological restoration projects adding native fish as an additional purpose for the Yolo Bypass. Ecological reconciliation might become a larger part of the landscape of the Bay-Delta over the next fifty years requiring better tools to simulate proposed changes. The aim of this research is to develop a hydraulic model for evaluating and demonstrating the flood conveyance and water management impacts of proposed land-use changes in the Yolo Bypass. The application of the newly developed flood simulation software (HEC-RAS-2D) to the Yolo Bypass will help assess whether proposed solutions are realistic and their possible effects on the floodplain. This type of decision-making application is likely relevant for other floodplain restoration efforts in California and elsewhere.

Flood Storage Allocation Rules for Parallel Reservoirs – Rui Hui (UC Davis)

Optimal operating policies have been derived for reservoirs in series and in parallel for various purposes, but little formal analysis has been done for flood operations of parallel reservoirs. For flood management in a parallel reservoir system, reservoir releases should be managed together to reduce downstream peak flow and minimize flood damage. The optimal allocation of available flood storage among parallel reservoirs should be allocated so each reservoir's flood storage allocation provides the same incremental reduction to downstream flood flows. This approach is developed mathematically and applied for deterministic and probabilistic inflow cases. The applicability and effectiveness of these derived flood storage allocation rules are demonstrated by the case study of Oroville Reservoir and New Bullards Bar Reservoir in California's Sacramento River Basin with a single historical 1997 flood and an uncertain storm.

Optimization Storage Balancing in the Sacramento Valley – Timothy Nelson and Jay Lund (UC Davis)

Reservoirs serve as vital elements of California's water resource infrastructure, serving to moderate the temporal variability in water supply and reduce the severity of floods. Managing the system effectively requires well defined operating rules that will guide reservoir operators in making decisions with limited knowledge of water availability in the future. In this study the CALVIN model, an economic optimization model, is used to produce monthly operating rules for the major reservoirs of the Central Valley, optimized to minimize the total cost of the system. The rules are divided into two classes: 1) release rules used to define release based on the current and past state of the system and 2) storage allocation rules to balance the storage of water between multiple reservoirs. Operating rules will also be developed from CALSIM II results to represent more realistic operations. Finally, the optimized rules will be compared with the CALSIM II rules to determine where optimizations could be applied in the actual system.

Sacramento Basin Flood Control Linear Program – James Connaughton and Benjamin Lord (UC Davis)

A flood control linear program (FCLP) was developed to optimize releases from five reservoirs in the Sacramento Basin based on input hydrographs and penalty functions for excessive downstream flows, reservoir storage, and ramping. The FCLP program is applied using inflow hydrograph data from the 1986, 1995, and 1997 flood events to produce optimal reservoir releases. Shasta, Black Butte, Oroville, and New Bullard's bar reservoirs synchronize and alternate releases to minimize the combined peak flow downstream at the Fremont Weir for all three events. Folsom reservoir acts more independently and makes releases before and after peak upstream flows to avoid exceeding the channel capacity. Releases depend on the travel time to river convergences and the flows accumulated from local runoff in addition to the penalty functions. The FCLP will be further developed to explore optimal reservoir operation for additional hydrograph shapes, changes in weir geometry and an updated economic penalty curve.

Better Redd than Dead: Optimizing Chinook Salmon Survival through Dam-release Manipulation at Folsom Dam (American River, CA) – Rebecca M. Quiñones (UC Davis)
Collaborators: Lauren Adams, Ted Grantham, Josué Medellín-Azuara, Jay Lund, and Peter Moyle

Low precipitation levels in winter 2014 have resulted in unprecedented drought conditions in many California rivers. Flows in Central Valley streams have dropped so low as to threaten the survival of fall Chinook salmon (*Oncorhynchus tshawytscha*) embryos already incubating in redds. Regulated rivers, however, may offer an opportunity to increase embryo survival through optimal dam operation. Here, we use historical streamflow data to create probability curves of dam releases from Folsom Dam in the American River. This data is used to assess water-level scenarios that result in varying degrees of redd stranding. Redd stranding occurs when adult salmon build redds in areas that dry once water levels drop and results in complete embryo mortality. Our goal is to identify dam releases that optimize embryo survival by evaluating the relationship between release level and duration, and stream volume. Although we assume uniform channel configuration and redd distribution, our analysis can help elucidate the relative viability of salmon redds resulting from different release decisions. Consequently, our analysis can be viewed as analogous with a redd risk assessment.

The HOBBES Project at Year One: Adventures in Organizing, Documenting, and Displaying California's Water System Information – Josué Medellín-Azuara (UC Davis)
Collaborators: Andrew Bell, Alvar Escriva-Bou, Quinn Hart, Rui Hui Jay R. Lund, Erik Porse, Samuel Sandoval-Solis, Nicholas Santos, and David Waetjen (UC Davis)

The HOBBES project is a bottom-up approach for organizing, documenting, and making water information available to support water modeling efforts in California. The database schema of the HOBBES project accommodates a wide range of elements from the California water system and allows geocoding for displaying information. The HOBBES database management and documentation system emphasizes data organization and documentation standards, fosters local involvement in data management, allows flexibility in the modeling algorithms and may decrease the startup cost of water modeling projects. After a year of work, the HOBBES development team has drafted a database schema, use cases and started web-based interface to display information. This has been done in collaboration with agencies, non-government organizations, consultants, and academic institutions. Next steps include implementing the use cases with the web user interphase and hold a late spring workshop to present our progress to the water community.

Effectiveness and Tradeoffs between Portfolios of Adaptation Strategies Addressing Future Climate and Socioeconomic Uncertainties in California's Central Valley – Mike Tansey (Reclamation)

Abstract not available.

Ninety Years of Salinity Monitoring in the Suisun Bay and Western Delta – Sujoy Roy (TetraTech)
Collaborators: John Rath and Limin Chen (Tetra Tech); Paul Hutton (MWDSC)

The location of the low salinity zone in San Francisco Bay where the bottom salinity is 2 parts per thousand (ppt) (termed as X2 and reported as the distance in kilometers from Golden Gate), has been used as the basis for outflow management in the estuary. There is great interest in understanding how the low salinity zone in general, and the X2 position in particular, has changed over time under different conditions of hydrology, exports, and development. The present work supports such an effort through the compilation and analysis of data over a nine-decade period, with additional screening and cleaning to better characterize salinity trends in the Delta. Data incorporated in this work include historical grab sample data and modern conductivity sensor data from and were compiled into a master database containing surface salinity data from October 1921–September 2012, i.e. water years 1922–2012. The data were largely collected by the state Department of Public Works/ Department of Water Resources and federal agencies. The original data were subjected to an extensive cleaning effort, and then used to calculate the daily and monthly X2 position along the Sacramento and San Joaquin Rivers. Various statistical analyses were performed on the X2 and other isohalines to characterize behavior over time and in response to different hydrologic conditions and are discussed in this poster. This work is supported by a report and electronic appendices detailing the data compilation and analysis steps, and can serve as the basis for future studies of salinity in Suisun Bay and the western Delta.

Comparing Consumptive Agricultural Water Use in the Sacramento-San Joaquin Delta: A Proof of Concept using Remote Sensing – Josué Medellín-Azuara (UC Davis)
Collaborators: Nadya Alexander and Richard E. Howitt (UC Davis)

This study explored the potential of using three different methods to estimate consumptive use of water in crop production on five islands in the Sacramento-San Joaquin Delta (Delta). The authors used the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen et al., 1998a) on actual evapotranspiration for year 2007 and compared it to evapotranspiration (ET) estimates using methods from the Irrigation Training and Research Center (ITRC) of California Polytechnic State University-San Luis Obispo, and the method used by DWR, Simulation of Evapotranspiration of Applied Water (SIMETAW) model (Snyder et al., 2012) in its California version Cal-SIMETAW (Orang et al., 2013). Initial results from our comparison show strong correlation between the three methods for many of the eight crop types compared and indicate that remote sensing is a promising tool that can be of practical, cost-effective service in managing water while reducing the need for detailed field information. The next phase of this project will examine the individual reference evapotranspiration, crop coefficients, and crop area parameters to determine the sources of inter-model variability in the seasonal ET. This phase will also include additional comparisons with DWR's DETAW model and the METRIC model from the University of Idaho at Kimberly.

Using Real-time in situ Water Quality Sensors to Detect Wastewater Effluent in the Sacramento River to Help Understand Controls on Nutrient and Phytoplankton Dynamics – Thi Pham (CSU Sacramento)

Abstract not available.

Economic Analysis in the Department of Water Resources – Emmanuel Asinas (DWR)

The Economic Analysis Section of the California Department of Water Resources develops and maintains in-house expertise to provide high quality, timely, and cost-effective responses to meet DWR program managers' needs. The section provides technical assistance and policy guidance for economic, demographic, and mathematical analysis to improve the management of California's natural resources.

California Water Sustainability Indicators Framework – Abdul Khan and Rich Juricich (DWR)

A California Water Sustainability Framework was developed for Update 2013 of the California Water Plan to help monitor progress to meeting water sustainability objectives through the development and application of an analytical framework. The framework also includes the development and valuation of a water footprint for California. The framework was developed in collaboration with experts from UC Davis and U.S. EPA Region 9, and a wide array of stakeholders.

Water Planning Information Exchange (Water PIE) – Greg Smith and Rich Juricich (DWR)

Sound decisions require good information. Too often, the lack of access to water resource information constrains our ability to craft innovative solutions to regional issues and integrate these projects into a statewide water management framework. The purpose of the Water Planning Information Exchange is to make access to water resource data easier for everyone.

The goal is to use Water Planning Information Exchange to share any information that would inform the California Water Plan, and other strategic planning efforts at the local and regional levels. The subject material can range from basic hydrologic information, such as surface water, groundwater, water quality and climate information, to information about water use, demographics, water rates, service areas, environmental mitigation, and water projects. Organizations could share all of this water resource information and more through Water Planning Information Exchange.

Session 16. Natural Delta Outflow: Part 1

Evapotranspiration from Natural Vegetation in the Central Valley of California: Monthly Grass Reference Based Vegetation Coefficients and the Dual Crop Coefficient Approach 1.4 MB
Dan Howes (CSU San Luis Obispo)
Collaborators: J. Phyllis Fox (Fox Consulting) and Paul Hutton (MWDSC)

Accurate evapotranspiration estimates are required for a wide variety of surface and subsurface hydrologic evaluations. Establishing dedicated water supplies for ongoing and future restoration activities in the Central Valley of California require accurate evapotranspiration information for different types of vegetation. Directly measuring evapotranspiration can be difficult or impossible depending on the evaluation timeframe. Transferability of measured evapotranspiration in time and space is necessary but typically requires a weather-based reference. For non-agricultural vegetation, there is no standard reference, which makes evaluating a variety of vegetation types from different sources difficult and time-consuming. This paper uses several methods to estimate evapotranspiration from native vegetation, including the use of vegetation coefficients (Kv). Vegetation coefficients are based on a standardized reference and are computed as the ratio of vegetation evapotranspiration (ETv) to the grass reference evapotranspiration (ETo). These monthly Kv values are used to compute the long-term (1922-2009) average ETv for vegetation types documented to exist in the California's Central Valley prior to development. For vegetation that relies on precipitation and soil moisture storage, a calibrated daily soil water balance with a dual crop coefficient approach was used to compute evapotranspiration regionally over the timeframe.

Natural Delta Outflow Water Balance – Paul Hutton (MWDSC) **0.9 MB**
Collaborators: J. Phyllis Fox (Fox Consulting), Dan Howes (CSU San Luis Obispo), and Andy Draper (MWH Americas)

We estimated long-term, annual average Delta outflow under natural conditions. Natural conditions are defined as those that existed before European settlement in the Central Valley (circa 1769). The natural outflow calculation is neither an estimate of paleo conditions nor an estimate of conditions that were realized in particular individual years. Rather, the calculation is analogous to a CalSim "level of development" analysis, assuming the contemporary 88-year (water years 1922 to 2009) precipitation pattern and flows to San Francisco Bay with the Central Valley Floor in a natural or undeveloped state, before flood control, levies, reclamation, irrigation, etc. The resulting natural Delta outflow estimate is compared with current level Delta outflow and theoretical "unimpaired" Delta outflow erroneously used by some to assess ecosystem changes.

The pristine Central Valley was home to five million acres of freshwater marshes, including over one million acres in the area draining into San Francisco Bay. The major rivers were flanked by natural levees along their entire lengths as well as their major tributaries and most Delta channels. These levees rose some 10 to 30 feet above the normal water level and extended several miles back from the river's edge in places. These levees were home to vast riparian jungles of trees, shrubs, and vines. Vast swaths of grasslands dotted with vernal pools and oak savannahs stretched from the flood basins to the oak- and pine-covered foothills. This vegetation used much of the water supply that was subsequently harvested for other uses.

Calculation of the amount of water used by natural vegetation in the Central Valley requires estimates of (1) area associated with each type of natural vegetation and (2) evapotranspiration rates associated with each type of natural vegetation. Methods used to arrive at these estimates are presented.

Natural Flow Monthly Routing Model – Andy Draper (MWH Americas) **6 MB**

Human activities in the Sacramento and San Joaquin valleys have significantly changed the natural inflow to the Sacramento-San Joaquin Delta. Direct impacts to streamflows include storage regulation and diversions for irrigation and municipal and industrial purposes. Changes in land use have affected the amount and timing of surface runoff. Groundwater pumping and deep percolation associated with irrigated agricultural have impacted groundwater elevations and groundwater inflows to streams and rivers. Additionally, flood control measures and an extensive network of levees have ended the natural cycle of bank overflows and detention storage.

The Natural Flow Monthly Routing Model (NF Model) was developed under contracts with the State Water Contractors, the San Luis and Delta-Mendota Water Agency, and the Metropolitan Water District of Southern California (MWDSC). The model estimates the natural inflows to the Delta and the net Delta outflows that would have occurred in the absence of human activity from 1922 through 2009. Natural conditions are defined as those that existed before European settlement in the Central Valley (circa 1769).

The NF Model is a spreadsheet-based monthly water balance that accounts for both surface water and groundwater flows within the Sacramento River and San Joaquin River hydrologic regions and accounts for land-based evaporative depletions. At high flows, water spills over the natural river levees and flows through a parallel network of sloughs. Flood water is stored in natural basins and slowly returns to the rivers at low river stage. Flood water recharges the soil profile and underlying aquifer. Groundwater, represented as a series of lumped parameter groundwater basins, sustains river flows during the summer and fall, and supports surface vegetation ET under conditions of a high watertable. Through a sensitivity analysis, the NF Model identifies the key input parameters that determine natural inflows to the Delta.

Session 17. Real-time Modeling

A Real Time Salinity Visualization and Management Tool – Jun Wang (Reclamation) **2.7 MB**

5½-minute demonstration video **15.5 MB (.mp4 format)**

A real time salinity visualization and management tool was developed for the Grassland Water District near Los Banos, *CA* to improve access to real time and recent salinity and flow data. This GIS-based desktop visualization tool, developed using the MapObjects library, can provide graphical output of hourly/daily salt concentration, salt load, flow, and stage of all canals. The tool will enhance the district's decision support capability – improving ability to schedule and manage salt export to Mud Slough and the San Joaquin River. This tool can be extended to other District to improve Basin-wide compliance with salinity concentration objectives.

Manager Module for the WARMF Water Quality Simulation and Forecasting Model **1.1 MB**
Joel Herr (Systech)

The Watershed Analysis Risk Management Framework (WARMF) is being upgraded to facilitate its use for real-time salinity management of the San Joaquin River. A Manager Module is being developed within WARMF to provide a simplified user interface and provide input and output visualization. Real-time inputs can be viewed and edited, data can be extrapolated, and simulations run through simple controls. Output can be viewed as time series of flow overlayed with TDS/EC concentration, load, and assimilative capacity. Modified Gowdy Output identifies the sources of salt reaching Vernalis on each day overlayed with assimilative capacity to identify opportunities to reduce loading or increase salt exports as conditions permit.

Web-based Services in Support of Water Quality Forecasting Model Visualization 3.3 MB
Amye Osti (34-North)

Real-time water quality management relies on real-time forecasting of conditions and the use of a calibrated watershed model that provides predictions of flow and salinity resulting from watershed activities. 34 North, in cooperation with USBR and Systech, is developing a web-based toolset to support the WARMF model in the following ways: Real time aggregation and assembly of disparate data sources to run WARMF in near real time, Spatial Visualization of model results, Collaboration Tools for stakeholder participation in watershed management activities and the centralization of model operations by virtualization of model online. Our presentation will outline efforts and demonstrate prototype examples.

Data Quality Assurance for Basin-scale Real-time Water Quality Management 4 MB
Nigel Quinn (Berkeley National Laboratory/Reclamation)

The concept of real-time water quality management is being applied within the San Joaquin basin and relies on a level of cooperation and coordination between basin stakeholders that discharge to the San Joaquin River that hitherto has not occurred. One of the major constraints to public data sharing is the fear that preliminary and potentially inaccurate data may be used against individual stakeholders. A commercial software package WISKI has been used for the past 4 years to attempt to automate the data QA process so as to reduce the risk of data sharing and encourage this activity as part of real-time water quality management. This talk will provide an overview of the capabilities of this software tool and how it is currently being deployed within the Grassland Water District.

Session 18. Natural Delta Outflow: Part 2

Simulated 1922-2009 Daily Inflows to the Sacramento – San Joaquin Delta under Predevelopment Conditions Using Precipitation-Runoff Models and C2VSIM: Preliminary Results –Tariq Kadir (DWR)
Collaborator: Guobiao Huang (DWR) 2.8 MB

Daily inflows to the Sacramento – San Joaquin Delta under pre-development conditions were simulated using precipitation-runoff models for the upper watersheds and then routing the water through the Central Valley floor area using C2VSIM for water years 1922 through 2009. Daily stream inflows from all major upper watersheds for the Central Valley accounting for >95% of Delta inflow were simulated using 20 developed and calibrated Soil Water Assessment Tool (SWAT) models. Historical precipitation and evapotranspiration data were extracted from the SIMATAW-2 model 4km gridded data. Distributions of natural and riparian vegetation were obtained from a pre-1900 historical vegetation map of the Central Valley. A new version of C2VSIM was used with daily time steps and based on IWFM v4.1 with new features including root zone uptake from groundwater and riparian access to stream water. Wetlands were dynamically simulated using a series of interconnected lakes. Flows overtopping natural levees were simulated using flow rating curves. Sensitivity analyses were performed with different levels of vegetative potential evapotranspiration. Simulations show that evapotranspiration estimates and surface-groundwater interactions play a key role in the magnitude and attenuation of upstream flows to the Delta.

Generating a Historical Delta Bathymetric-Topographic Digital Elevation Model (Part I): Data Collection and Development – Robin Grossinger and San Safran (San Francisco Estuary Institute)
Collaborators: Julie Beagle (San Francisco Estuary Institute); John DeGeorge (RMA); William Fleenor, Alison Whipple, Andy Bell, and Mui Lay (UC Davis) **9.1 MB**

There is substantial interest in better understanding the hydrodynamics of the San Francisco Bay-Delta under "natural" conditions (those prior to major modification of Bay-Delta geometry and hydrology beginning in the mid-19th century). To serve this need, an effort is underway among multiple partners to generate a 3D model mesh of the early 1800s San Francisco Estuary. One component of this effort--the creation of a bathymetric-topographic digital elevation model (DEM) for the historical Sacramento-San Joaquin Delta--is presented here in two parts. Part I covers data collection and development. Plan-form data of historical Delta channels were adapted from Whipple et al.'s 2012 Sacramento-San Joaquin Delta Historical Ecology Study. Bathymetric data were obtained from mid-19th century sources, including US Coast Survey hydrographic sheets and early surveys of the Sacramento and San Joaquin rivers. The historical topographic data collection effort focused on the elevations of natural levees and the marsh plain, which were generally obtained from early 1900s USGS topographic quads and Debris Commission transects. Different areas and system components had to be addressed separately, given data availability. Since historical soundings obtained from early sources were generally constrained to large, navigable channels, we fit a power function to estimate the depths of small channels based on their widths. Historical bathymetric and topographic data were processed into a form that could be adapted to conventional surface generation techniques (presented in Part II). Additionally, written historical accounts of tidal range, marsh plain inundation depth, tidal extent, and salinity were georeferenced for use as model calibration data. The first application of the Delta historical DEM will be modeling salinity transport associated with "natural" Bay-Delta hydrology.

Generating a Historical Delta Bathymetric-Topographic Digital Elevation Model (Part II) Data Interpolation – William Fleenor (UC Davis)
Collaborators: Alison Whipple, Andy Bell, and Mui Lay (UC Davis); Robin Grossinger, Sam Safran, and Julie Beagle (San Francisco Estuary Institute); John DeGeorge (RMA)

There is substantial interest in better understanding the hydrodynamics of the San Francisco Bay-Delta under "natural" conditions (those prior to major modification of Bay-Delta geometry and hydrology beginning in the mid-19th century). To serve this need, an effort is underway among multiple partners to generate a 3D model mesh of the early 1800s San Francisco Estuary. One component of this effort--the creation of a bathymetric-topographic digital elevation model (DEM) for the historical Sacramento-San Joaquin Delta--is presented here in two parts. Part II covers the development of various methods to adapt the historical bathymetric and topographic data (presented in Part I) for use with conventional surface generation techniques. Methods varied depending on the data type and density. In places, sparse historical surface bathymetric and topographic data required developing methods to interpolate for needed information. This was performed within ESRI ArcGIS and ENVI environments. Subsequent modeling will be required to 'tune' the conveyance of major channels and the overflow of tidal marsh. Additionally, a technique used to analyze uncertainty associated with the grid resolution of the model is demonstrated. The first application of the Delta historical DEM will be modeling salinity transport associated with "natural" Bay-Delta hydrology.

Development of a Three-Dimensional, Stratified Flow Model of the Natural Delta 3.5 MB
John DeGeorge (RMA)
Collaborators: Edward Gross, Stephen Andrews, and Stacie Grinbergs (RMA)

In an effort to better understand the hydrodynamic and salinity regime of the Sacramento-San Joaquin Delta prior to agricultural development of the 1800's, a new three dimensional, stratified flow model is being created based on the San Francisco Estuary Institute (SFEI) Sacramento-San Joaquin Delta Historical Ecology Study. The first use of this model will be to establish a draft relationship between isohaline positions and Bay-Delta outflow under "natural" and current conditions. This work is being performed with support of the Metropolitan Water District of Southern California and in collaboration with the UC Davis Watershed Science Center (UCD) and SFEI. UCD and SFEI are developing detailed plan view channel networks and a digital elevation model to serve as the bathymetric data set for the flow model.

Utilizing a three dimensional, stratified flow model for this study is essential because it is not known at the outset how different the level of salinity stratification might be under the historic condition relative to today, and so there is no way to calibrate empirical mixing coefficients required by lower dimensional models. Representing the complex natural Delta channel network in a 3D model that must also represent the San Francisco Bay is a significant challenge. The UnTRIM3D engine was selected for this application because it is computationally very efficient and because it supports the use of sub-grid scale bathymetry in determining the volumetric and conveyance attributes of computational elements. Using sub-grid bathymetry it is possible to perform reasonably accurate hydrodynamic calculations for detailed tidal marsh channel networks without the extreme grid resolution and very long run times.

Session 19. From the Sierra to the Sea: Snowmelt, Floodplains, Stormwater, Faucets, and More

Optimization Storage Balancing in the Sacramento Valley – Timothy Nelson (UC Davis) 1.5 MB

Reservoirs serve as vital elements of California's water resource infrastructure, serving to moderate the temporal variability in water supply and reduce the severity of floods. Managing the system effectively requires well defined operating rules that will guide reservoir operators in making decisions with limited knowledge of water availability in the future. In this study the CALVIN model, an economic optimization model, is used to produce monthly operating rules for the major reservoirs of the Central Valley, optimized to minimize the total cost of the system. The rules are divided into two classes: 1) release rules used to define release based on the current and past state of the system and 2) storage allocation rules to balance the storage of water between multiple reservoirs. Operating rules will also be developed from CALSIM II results to represent more realistic operations. Finally, the optimized rules will be compared with the CALSIM II rules to determine where optimizations could be applied in the actual system.

Flood Optimization and Bypass Expansion Value for the Sacramento Valley 0.7 MB
James Connaughton (UC Davis)

A flood control linear program optimizes the releases from five reservoirs in the Sacramento Basin based on input hydrographs and penalty functions for excessive downstream flows, reservoir storage, and ramping. The formulation and constraints of the hydrodynamic model are outlined. The flood control linear program is applied using inflow hydrograph data from the 1986, 1995, and 1997 floods to produce optimal reservoir releases. The Shasta, Black Butte, Oroville, and New Bullard's Bar reservoirs synchronize and alternate releases to minimize the combined peak flow downstream at the Fremont Weir. The Folsom reservoir acts more independently and makes releases before and after peak upstream flows to efficiently use the channel capacity. Releases depend on the travel time to river convergences and the flows accumulated from local runoff in addition to the penalty functions. Later when weir diversions are optimized, the flood control linear program improves performance by routing flood waves through the bypass systems more efficiently, which allows for greater releases and shifts the locations where flow penalties are accumulated. The analysis suggests that increased channel and diversion capacities at the Fremont Weir would most effectively improve the system.

Flood Storage Allocation Rules for Parallel Reservoirs – Rui Hui (UC Davis) **1.4 MB**

Optimal operating policies have been derived for reservoirs in series and in parallel for various purposes, but little formal analysis has been done for flood operations of parallel reservoirs. For flood management in a parallel reservoir system, reservoir releases should be managed together to reduce downstream peak flow and minimize flood damage. The optimal allocation of available flood storage among parallel reservoirs should be allocated so each reservoir's flood storage allocation provides the same incremental reduction to downstream flood flows. This approach is developed mathematically and applied for deterministic and probabilistic inflow cases. The applicability and effectiveness of these derived flood storage allocation rules are demonstrated by the case study of Oroville Reservoir and New Bullards Bar Reservoir in California's Sacramento River Basin with a single historical 1997 flood and an uncertain storm.

Connectivity in California Water Resources Infrastructure – Erik Porse (UC Davis) **1.3 MB**

Connectivity between components of a water resource distribution system determines flow patterns and operational flexibility. Typical visualization techniques for water resource networks include schematics and geospatial overlays. Network analysis and visualization methods can provide additional tools to view and assess connectivity in networks. We analyzed the structure and function of the California water infrastructure network as modeled in CALVIN using network theory visualizations and metrics. The analysis identified important nodes and links in the whole network, as well as the San Francisco Bay Area sub-network, using measures of centrality. We also assessed network-wide centralization and connectivity using measures of spacing, linkage, and central dominance. A node degree distribution, which quantifies the incoming and outgoing links for all nodes in the entire CALVIN network, follows a power-law relationship, indicating the network has small world and scale-free properties. We analyzed effects of network degradation through piecewise and cumulative removal of important components, revealing the complex relationships between connectivity, efficiency, and central dominance. The results provide insights for network structure and new tools to understand resilience in the California water system.

Modeling Residential Water, Energy, Carbon Footprint and Costs in California **1.6 MB**
Alvar Escriva-Bou (UC Davis)

Water-related residential end-uses are responsible of 5.4% of all electricity and 15.1% of all natural gas used in California (CEC, 2005). Most of this energy is used heating water. As a consequence, tons of greenhouse gases emitted daily to the atmosphere are directly related with our household water use. Accounting for these sources of variability, we develop a model of household water end-uses, water-related energy and greenhouse emissions, including water and energy costs paid by customers, to estimate overall values for the state of California, and to evaluate the feasibility of potential water and energy conservation actions for different objectives and locations. Results show high variability in outdoor use, but indoor uses are quite similar. Water and energy rate structures imply variability in costs for households that mean a different willingness to implement conservation strategies. Household water-related CO_2 emissions are 6.4% of total per capita California emissions, and simulation results show that managing water and energy jointly is a way to reduce significantly greenhouse emissions in the state.

Value of Reuse and Groundwater Conjunctive Use in the Bay Area – Michelle Lent (UC Davis) **1.3 MB**

The San Francisco Bay Area obtains two-thirds of its water supply from imported surface water and only 5% from groundwater. In part due to limited surface water storage, the supply is vulnerable to fluctuations in runoff, as well as reductions and disruptions in imports. This study investigated the potential for local groundwater banking and artificial recharge using recycled water to decrease supply vulnerability and system costs. Groundwater banking with surface water and recycled water was modeled in CALVIN, a hydro-economic model of the California water system. The model results showed that groundwater banking and indirect potable reuse could reduce water supply vulnerability in the San Francisco Bay Area. Although there is an increase in operational cost due to groundwater banking and indirect potable reuse, the savings from reduced scarcity (measured in economic loss) offset the increase in operational costs. Groundwater banking was shown to be most effective for reducing short-term scarcity, while indirect potable reuse was effective for reducing the severity of intense, longer-term scarcity. Additionally, the increased operational flexibility from groundwater banking could allow the Bay Area to expand conjunctive use, potentially reducing scarcity elsewhere in the state.

Session 21. Applying Models to San Joaquin River Restoration Program Decision Making

Water Supply Forecasting Effects on the SJRRP – Todd Vandegrift (Reclamation) **0.6 MB**

The San Joaquin River Restoration Program releases Restoration Flows into the San Joaquin River from Millerton Lake with overall goals of restoring and maintaining fish populations while reducing or avoiding water supply impacts to water users supplied from Millerton Lake. The flow volume allocated and released for restoration purposes is dependent on water supply conditions; specifically the forecasted unimpaired runoff into Millerton Lake. January through April 90th percentile forecasts, appropriately conservative for water supply, result in potential allocation shortages to the Restoration Program due to the spring flow releases.

Multiple forecast sources are available and each must be used appropriately and prudently to manage the restoration program as efficiently as possible. The California Department of Water Resources publishes water supply forecasts during spring runoff in Bulletin 120 reports containing multiple forecast values representing differing probabilities of occurrence, largely using snow depth monitoring, overall basin water conditions, and historical data. The California Nevada River Forecast Center of NOAA produces seasonal and shorter-term water supply and river flow forecasts incorporating various observed data, meteorological and streamflow models, climate information, and historical data, utilizing ensemble streamflow predictions. Additionally, Southern California Edison is developing near-real time short-term flow forecasting tools for hydropower management. The SJRRP is developing tools to evaluate these various water supply forecasts and integrate the information provided for decision making, planning, reservoir operations, and flow scheduling to best meet the overall project goals.

Modeling Subsidence Impacts on Channel Capacity along the San Joaquin River and Eastside Bypass
Alexis Phillips-Dowell (DWR) **1.8 MB**

From 1926 to 1970, groundwater pumping caused land subsidence up to 28 feet near the town of Mendota in Fresno County. Recently it has been determined that extreme subsidence rates up to nearly 1 foot per year are occurring in a new area centered near the town of El Nido and including areas of the San Joaquin River and flood bypass channels within Madera and Merced Counties. With the potential impact on channel conveyance and improvements of the San Joaquin River Restoration Program (SJRRP), the Department of Water Resources (DWR), Reclamation, and other agencies have performed surveys to understand the limit and rate of the subsidence.

Hydraulic models developed to support the SJRRP incorporate 2008 LiDAR survey data and use water surface profile data collected from 2009 to 2011 for model calibration. Some of the model reaches, specifically in those areas that have experienced a great amount of subsidence, were unable to calibrate because of the subsidence that had occurred between the model topography collected in 2008 and the calibration data collected a few years later. To investigate this issue, DWR completed a study to accomplish two objectives 1) provide calibrated hydraulic models to support the SJRRP, and 2) evaluate the effects of ground subsidence on flow capacity.

Using Multiple Scale Groundwater Models to Assess the Impacts of Restoration Flows in the San Joaquin River – Brian Heywood (CDM Smith) **2.7 MB**

To better understand the link between flows in the San Joaquin River and groundwater levels under adjacent lands, the San Joaquin River Restoration Program (SJRRP) is utilizing groundwater models of varying scales to simulate regional and local surface water/groundwater interaction. The San Joaquin River Restoration Program Groundwater model (SJRRPGW) is based on the USGS's Central Valley Hydrologic Model (CVHM). The SJRRPGW includes a more limited study area extending five miles from the river and bypass system, finer grid discretization (i.e., 1/4 mile vs. one mile cells), and more refined geologic representation. The SJRRPGW model is used to assess the extent of groundwater impacts due to SJRRP flows for the entire SJRRP program area. In addition, the SJRRP requires assessment of potential groundwater impacts on a more localized (i.e., individual property) basis. To accommodate this requirement, local models have been developed based on the SJRRPGW which use finer grid spacing (i.e., 1/16 mile cells) and reduced stress period lengths. The SJRRP utilizes models from both scales to assess changes in groundwater impacts due to increased SJRRP flows and the potential effectiveness of implementing various seepage control measures (e.g., ditches, slurry walls, interceptor lines, and shallow pumping) on controlling groundwater levels.

Comparing Fisheries Benefits of the Reach 2B and Mendota Pool Bypass Project **1.7 MB**
Chip McConnaha (ICF)

The San Joaquin River Restoration Program (SJRRP) prescribes flow from Friant Dam as well as a number of specific restoration projects to restore spring-run Chinook salmon. Reclamation, working with the fishery agencies, has used the Ecosystem Diagnosis & Treatment model (EDT) to evaluate restoration actions in regard to their enhancement value for spring run Chinook. Analysis of actions related to restoration of floodplain and construction of bypass channels in the 12 mile Reach 2B will be discussed. The model evaluated restoration benefits for four potential spring Chinook life histories. The base condition assumed SJRRP settlement flow and full fish passage at all existing barriers. Under these conditions, the existing habitat supported a spring Chinook population that was highly dependent on wetter water year conditions. The rapid downstream increase in water temperature affected the value of restoration and significant fish benefits were limited to actions when water temperature was favorable. Floodplain restoration and bypass actions increased habitat potential but their values were limited by water temperature and the assumed timing of juvenile life stages. The analysis shows the close coupling of restoration benefits to the presumed fish life history and the synergisms of temperature and other in-stream conditions.

Session 22. Modeling from Over the Mountains and Across the Pond

Assessing Ecological Responses to Alternative Flow Regulation Plans in the Great Lakes **5.8 MB**

Tad Slawecki (LimnoTech)
Collaborators: Todd Redder, Joe DePinto, Dan Rucinski, and Hua Tao (LimnoTech)

The Laurentian Great Lakes, which contain 21% of the world's surface fresh water, supply a wide range of economic and ecological services that directly or indirectly benefit the 30 million people within the Great Lakes basin. The quality and value of these services is tightly linked to water levels within the lakes, which are regulated at control structures near the outlets of Lake Superior, Lake Erie, and Lake Ontario. The International Joint Commission, an international organization created under the 1909 Boundary Waters Treaty, has worked to evaluate options for improved regulation of levels and flows in the Lake Ontario-St. Lawrence River system (2000-2006) and in the Upper Great Lakes (2007-2012).

In support of the evaluation process, LimnoTech led the development of the "Integrated Ecological Response Model" (IERM) framework to assess the potential ecological impacts of plausible future basin climate, supply scenarios, and regulation. The framework, which synthesizes the research of scientists in Ecosystems Technical Working Groups for Lake Ontario and for the Upper Great Lakes, quantifies the cause-effect relationship between hydrologic conditions and ecosystem "performance indicators". The suites of performance indicators represent a range of coastal ecosystem components, including wetland vegetation, macroinvertebrates, fish, and wetland birds.

The IERM framework encompasses visualization tools that allow the user to review summary comparisons for the entire set of indicators and to drill down into detailed results for individual indicators. A supplemental "Coping Zone" analysis is also available to evaluate the potential for significant harm to the nearshore ecosystem to occur as a result of extreme hydrologic conditions. The results of these evaluations are integrated into a Shared Vision Model to support selection of regulation plans for Lake Ontario and for the Upper Great Lakes that considers tradeoffs between environmental and economic interests.

To Dredge or Not To Dredge? Local Versus Systematic Approaches to Critical Floodplain Habitat Management – F. Douglas Shields (cbec eco-engineering) 17 MB
Collaborators: John M. Stoflet and Chris Bowles (cbec eco-engineering)

The Apalachicola River, a large, rapidly migrating sand-bed stream, is a major ecological resource in the Southeastern U.S. Much of the river corridor remains under forested wetland cover, and is comprised of a rich complex of side channels, sloughs, distributaries, floodplain lakes, and wetlands that provide critical habitat for a diverse assemblage of plants and animals. Since cessation of main channel navigation channel maintenance about 10 years ago, the State of Florida has considered various management strategies for protecting and preserving the floodplain habitats under pressure from drought and reservoir regulation. The reach of concern for this study includes the Chipola Cutoff, a major distributary that captures about 30% of the mainstem discharge and Swift Slough, a smaller floodplain channel that exits the river downstream from Chipola Cutoff and provides endangered mussel habitat that has experienced dewatering at low river stage in recent years. Various strategies to improve the hydrologic connectivity between the Apalachicola River and Swift Slough during low-flow periods have been considered. A two-dimensional sediment transport computer model of the reach in question, supported by an extensive field data collection was developed and used to evaluate restoration design alternatives. Field data collection included water level monitoring, velocity/discharge measurements, characterization of the sediment regime, and a bathymetric survey of the study reach. Simulated alternatives included two dredging schemes and use of training structures to modify the geometry of the mainstem-Swift Slough confluence. Simulation results indicate local measures are likely to have short-lived effects; resource management must be based on strategies that work at a larger spatial scale.

Parallelized Modeling for 2D Flood Prediction with Links to Watershed Management and Floodplain Hydro-morphology – Rob Lamb (JBA Trust, UK) 6 MB
Collaborators: Rob Berry, Matthew Tancock and Barry Hankin (JBA Consulting); Nigel Wright and Mingfu Guan (Leeds University)

Beginning with JBA's research and development in 2006, graphics processing units (GPUs) have been used to achieve substantial performance gains in 2D flood modeling software. This work opened new possibilities for detailed and large-scale flood models, and several vendors of 2D hydrodynamic models have since followed with similar parallelization technology. This paper will briefly review progress in parallelized models for 2D flood flow solving the Shallow Water Equations. With outputs from the JFlow model we will illustrate how the approach can help with floodplain delineation and scenario analysis and to deliver robust predictions for channel/floodplain systems and for urban flooding. We will also discuss prospects for linking fast reach-scale and catchment-scale 2D modelling into wider watershed management issues, including diffuse pollution and reach morphology.

Simple Models and Realistic Expectations for Stream Restoration – Martin Doyle (Duke University) 1.7 MB

Stream restoration design has been based in engineering design and associated models, particularly hydraulics models. Many of these same models also provide ready estimates on the potential efficacy of stream restoration for oft-cited purposes of the project, yet are surprisingly under-used for this type of reality checking exercise. Here, simple modeling along with even simpler back-of-the-envelope calculations are used to illustrate realistic constraints to possible purposes of stream restoration.

Session 23. CWEMF/IEP Joint Session – Modeling Ecosystem Responses to Management Actions

Overview of Work on Natural Delta Outflow – Paul Hutton and Curt Schmutte (MWDSC) **2.7 MB**

A significant effort is underway to characterize the hydrology and hydrodynamics of the Delta and its upstream watersheds under "natural" or pre-development conditions. Two sessions will be devoted to this effort during CWEMF's 2014 Annual Meeting. This talk, which will provide an overview of the work that will be presented in these sessions, will summarize findings and the methods used to estimate:

- water use associated with natural vegetation in the Delta and its watersheds,
- annual Delta outflow under natural conditions through simple water balance given the area and water use associated with each type of natural vegetation,
- intra- and inter-annual variability of Delta inflow and outflow under natural conditions,
- topography and bathymetry associated with the natural Delta, and
- Delta hydrodynamics under natural conditions.

A supporting effort is underway to develop a visual "flyover" display of the Delta landscape under natural conditions. This display will be presented at the end of the talk assuming availability.

Landscape Change in the Delta, 1850-2000: Implications for Ecological Functions **3.1 MB**
Robin Grossinger (SFEI)

Recent research has characterized the historical ecology of the Delta (Whipple et al. 2012). Currently, in the Delta Landscapes project, we are analyzing landscape change between the historical and contemporary Delta landscape. This presentation will show mid-project findings from the first detailed landscape ecological analysis of Delta habitat change. Based on input from the project Landscape Interpretation Team and contemporary literature, we have synthesized historical and contemporary data sets and analyzed the Delta's transformation from the perspective of a number of key ecological functions. These data provide a new level of specificity for considering lost habitat functions and landscape-scale restoration priorities.

Managing Finite Supplies for Environmental Goals – Walter Bourez (MBK Engineers) **2.3 MB**

Managing water supplies to achieve environmental goals often requires changes in reservoir operations and involves tradeoffs among various beneficial uses of finite water supplies. Management of available water supply requires both seasonal and multiyear considerations. Management of seasonal reservoir releases within each water year may improve conditions for many species; however, these benefits may have consequences to other species and beneficial uses of finite water supplies. Managing water supplies to protect environmental conditions also requires balancing use of water supplies in wetter years with need to preserve water needed in dryer years. Both seasonal and multiyear management of supplies involves a degree of risk to various species and beneficial uses of water and increasing water use for one goal may result in water supply reduction for other goals. Analysis have been performed to learn more about balancing supply for environmental goals, these analyses help define risk and tradeoffs among various management strategies.

Evaluation of the Effects of Prospect Island Restoration on Sediment Transport and Turbidity **3.9 MB**

Michael MacWilliams (Delta Modeling Associates)

Collaborators: Aaron Bever (Delta Modeling Associates), Noah Hume (Stillwater Sciences), Erik Loboschefsky (DWR), and Stuart Siegel (Wetlands and Water Resources)

The Prospect Island Tidal Habitat Restoration Project (Project) is a joint effort by the California Department of Water Resources (DWR) and the California Department of Fish & Wildlife (CDFW) to restore the approximately 1,600 acres in Prospect Island to freshwater tidal wetland and open water (subtidal) habitats to benefit native fish and improve aquatic ecosystem functions. The UnTRIM Bay-Delta model was applied together with the SWAN wave model and the SediMorph sediment transport and seabed morphology model to evaluate Project effects on turbidity. This approach allows for a direct method to evaluate the potential changes in sediment dynamics in the Project vicinity, since sediment transport, deposition and resuspension, the effect of wind waves, and the potential for deposition within Prospect Island to influence regional sediment dynamics are all explicitly simulated. The model was validated using observations of water level, flow, suspended sediment concentration, and turbidity. The model was successfully used to evaluate the effects of different breach locations upon suspended sediment transport during periods with both high and low Delta outflow through the comparison of potential Project alternatives to baseline conditions. The effects of marsh vegetation extent upon particle trapping and re-suspension, the rate of sediment accumulation inside Prospect Island, and the effects on turbidity on a relative basis between potential Project alternatives in the Project vicinity were evaluated. These model results demonstrate the usefulness of three-dimensional sediment transport modeling for evaluating and comparing the potential effects of large-scale restoration projects on sediment dynamics in the San Francisco Estuary.

Collaborative Science Informing Mokelumne River Fisheries Management – Jose Setka (EBMUD) **6.9 MB**

Effective use of adaptive management on the lower Mokelumne River is dependent on good multidisciplinary science in order to make decisions. As a result of the 2008 Central Valley salmon stock collapse, the Lower Mokelumne River Partnership (Partnership) initiated a number of management actions to expedite the recovery of Mokelumne stocks. These actions were dependent on evaluating data from fisheries monitoring, reservoir hydrology, delta and ocean conditions, in order to best use the suite of tools available. Management actions implemented based on the available science has resulted in a rapid recovery of Mokelumne salmon populations. Over the period 2009-2013 the return has included three of the top four escapements documented since 1940 and a record escapement of over 18,000 fish in 2011. However, a disproportionate number of the returns are hatchery versus natural origin fish. Future challenges include identifying collaborative scientific approaches to improving the natural contribution to the Mokelumne salmon population.