California Water and Environmental Modeling Forum

2022 ANNUAL MEETING PROGRAM

Building a Water-Resilient California

ORGANIZATIONAL MEMBERS

California Department of Water Resources

California State Water Resources Control Board

Contra Costa Water District

Delta Stewardship Council

East Bay Municipal Utility District

ICF

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Metropolitan Water District of Southern California

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OFFICERS

Tariq Kadir, Convener

Jesse Jankowski, Vice-Convener

Stacy Tanaka, Treasurer

Ben Bray, Secretary

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Paul Hutton, Executive Director

KEYNOTE ADDRESS

Mark Arax, Author and Journalist

Mark Arax is an author and journalist whose writings on California have been compared to the great social portraits by Steinbeck, Didion and Saroyan. The Atlantic Monthly called Mark's last book, *West of the West*, a masterpiece of literary nonfiction. His books include a memoir of his father's murder and the bestselling *The King of California*, which won a California Book Award and was named a top book of 2004 by the Los Angeles Times and the San Francisco Chronicle. His newest book, *The Dreamt Land: Chasing Water and Dust Across California,* is being hailed by critics as one of the most important books ever written about the West. It, too, has become a national bestseller.

Mark is from a family of Central Valley farmers, a writer with deep ties to the land who has watched the battles over water intensify even as California lurches from drought to flood and back again. In *The Dreamt Land*, he travels the state to explore the one-of-a-kind distribution system, built in the 1940s, 50s and 60s, that is straining to keep up with California's relentless growth. A heartfelt, beautifully written book, *The Dreamt Land* weaves reportage, history and memoir to confront the "Golden State" myth in riveting fashion. No other chronicler of the West has so deeply delved into the empires of agriculture that drink so much of the water. The nation's biggest farmers—the nut king, grape king and citrus queen—tell their story here for the first time. It's a tale of politics and hubris in the arid West, where drought turns to flood once again and all is forgotten as the farmers plant more nuts and the developers build more houses.

Mark's book will be available for purchase on Monday and Tuesday. He will be available for book signing on Tuesday afternoon following Sessions 15 & 16.

SUMMARY OF SESSIONS

Monday, April 4

Time	Session	Moderator	Room
8:00 – 8:30	Registration		Sierra Hallway
8:30 – 10:15	1. California Water Plan Update 2023: Building the State's Water Resilience	Abdul Khan	Pavilion
	2. SGMA in Action: Knowledge Gaps and Lessons Learned from the First 5 Years	Steffen Mehl	Sierra 1
10:15 - 10:30	Break		
10:30 - 12:15	3. CalSim and CalLite Development and Application	Yiwei Cheng	Pavilion
	4. C2VSim Coarse Grid Updates	Tariq Kadir	Sierra 1
12:15 – 1:00	Lunch - Included in registration fee		Restaurant
1:00 – 1:45	5. CWEMF Awards Ceremony	Shyamal Chowdhury	Pavilion
1:45 – 1:50	Break		
1:50 – 3:15	6. CalSim Input Development, Tiered Analysis & Computational Aspects	Derya Sumer	Pavilion
	7. Fine Grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG): Calibration, Baseline, Local Applications & Lessons Learned	Mesut Cayar	Sierra 1
3:15 – 3:30	Break		
3:30 – 5:15	8. Reclamation Model Development & Application	Derya Sumer	Pavilion
	9. C2VSimFG Data and Tool Refinements for the Next Phase of Development	Tyler Hatch	Sierra 1
5:30 - 8:00	10. Business Meeting and Social	Tariq Kadir	Cliff House of Folsom

SUMMARY OF SESSIONS

Tuesday, April 5

Time	Session	Moderator	Room
7:30 - 8:00	Registration		Sierra Hallway
8:00 - 9:45	11. Water Resilience, Sustainability & Multi-Benefit Projects: Role of Data, Water Accounting and Modeling	Abdul Khan	Pavilion
	12. CVP Water Temperature Modeling Platform	Yung-Hsin Sun	Sierra 1
9:45 - 10:00	Break		
10:00 - 11:45	13. Pop-Up Talks	Stacy Tanka & Nigel Quinn	Pavilion
11:45 - 12:30	Lunch - Included in registration fee		Restaurant
12:30 - 1:10	14. Keynote Address – Mark Arax	Tariq Kadir	Pavilion
1:10 - 1:15	Break		
1:15 – 3:00	15. Drought Assessment for Agriculture, Communities and the Environment: Panel Discussion	Alvar Escriva-Bou	Pavilion
	16. Merced River Flood-MAR Study	Francisco Flores-Lopez	Sierra 1
3:00 - 3:15	Break		
3:15 - 5:00	17. Coastal Flooding & Sea Level Rise in California	Samson Haile-Selassie	Pavilion
	18. CVSOM Development: Phase 1	Tariq Kadir	Sierra 1
5:00 - 7:00	19. Social		Sierra 1

SUMMARY OF SESSIONS

Wednesday, April 6

Time	Session	Moderator	Room
7:30 - 8:00	Registration		Sierra Hallway
8:00 - 9:45	20. Regional Groundwater Desalination and Contaminant Remediation	Reza Namvar	Pavilion
	21. Assessing the Impact of Potential Instream Flow Targets on Human Supply and Aquatic Habitat in the South Fork Eel River	Doug Chalmers	Sierra 1
9:45 - 10:00	Break		
10:00 - 11:45	22. Groundwater and Large Dams and Reservoirs – Impact and Safety Analysis	Reza Namvar	Pavilion
	23. Innovations in Integrated Water Resources Modeling	Mesut Cayar	Sierra 1
11:45 - 1:15	Lunch at area restaurants		
1:15 - 3:00	24. Grab Bag	Rich Satkowski	Pavilion
	25. Delta Modeling	Eli Ateljevich	Sierra 1
3:00 - 3:15	Break		
3:15 – 5:00	26. Habitats & Fish	Jeremy Thomas	Pavilion
	27. Watershed Modeling & Management Issues	David Curtis	Sierra 1

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LUNCHES

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California Water and Environmental Modeling Forum
Promoting Excellence and Consensus in Water and Environmental Modeling
P.O. Box 5051, Vacaville, CA 95696-5051 (916) 850-3110 cwemf@cwemf.org

Dear CWEMF Membership:

Welcome and thank you for participating in CWEMF's 27th Annual Meeting on April 4-6, 2022. After a two-year pandemic that has touched many of us, our loved ones, families, and friends, I hope you are all safe and healthy. The last two years have altered not only our personal lives, but our work lives as well. To its credit, CWEMF has maintained its Annual Meeting tradition through the pandemic by hosting virtual meetings in 2020 and 2021. Kudos to those who participated, including facilitators, moderators, and presenters. Along with a return to an in-person Annual Meeting, we hope to resume hosting technical workshops that are popular with our members and stakeholders.

This year's CWEMF Annual Meeting theme is "Building a Water-Resilient California." In 2020, California Governor Gavin Newsom released the Water Resilience Portfolio**,** the state's blueprint for equipping California to cope with more extreme droughts, floods, and rising temperatures while addressing long-standing challenges that include declining fish populations, over-reliance on groundwater, and lack of safe drinking water in many communities. The focus of this year's Annual Meeting is on how state, federal, local and private entities are developing and using models across watersheds to carry out the actions described in the Portfolio.

The CWEMF Annual Meeting includes 20 technical sessions over two tracks, an annual business meeting, two socials, an awards session, and a keynote address. The annual business meeting and social, held on Monday evening, gives our officers and Executive Director an opportunity to update members on the organization's activities over the previous year. The Tuesday evening social, a good venue to interact with other members, will feature *in memoriam* posters honoring noted CWEMF members who passed away in the last year. During the awards session (held on Monday afternoon), CWEMF officers will present the 2022 winners for our Career Achievement and Distinguished Life Membership awards. This year, our keynote speaker will be Mr. Mark Arax, a noted journalist and award-winning author whose latest published book – *The Dreamt Land: Chasing Water and Dust Across California* – has won critical acclaim. Mr. Arax will also participate in a panel discussion following his keynote address on Tuesday afternoon.

I would like to thank our sponsors for their generous contributions towards this year's Annual Meeting's refreshments, lunches, and social events. Following this event, I encourage you to join and participate in CWEMF's Steering Committee meetings, subcommittees, activities, workshops, and facilitated peer reviews. Finally, please participate in the Annual Meeting follow-up survey to help us improve and better prepare for next year.

Sincerely,

Tariq Kadir, Ph.D., P.E.
CWEMF Convener

CONTENTS

AGENDA

Monday, April 4

8:00 – 8:30 a.m. – Registration in Sierra Hallway

Refreshments sponsored by Limno Tech

8:30 – 10:15 a.m.

Session 1. California Water Plan Update 2023: Building the State's Water Resilience

Moderator: Abdul Khan & Lew Moeller (DWR)
Location: Pavilion

1. What is California Water Plan Update 2023 and How Does it Relate to the Water Resilience Portfolio? – Lew Moeller & Paul Massera (DWR)

2. Watershed Resilience – Eric Tsai (DWR)

3. Future Scenarios: Does California Have Enough Water to Survive to 2070? – Paul Shipman & Mohammad Rayej (DWR)

4. Performance Tracking – How Do We Know We are Achieving a More Resilient and Sustainable Future? – Jason Sidley & Eric Tsai (DWR)

Session 2. SGMA in Action: Knowledge Gaps and Lessons Learned from the First 5 Years

Moderator: Steffen Mehl (CSU Chico)
Location: Sierra 1

1. Higher-order Observations for Assessing Undesirable Results with SGMA Models – Randy Hanson (One-Water Hydrologic)

2. SGMA and Groundwater Modeling Myths - Graham Fogg (UC Davis)

3. Reassessing SGMA Models Built for Both Public and Regulatory Acceptance - Derrik Williams (Montgomery & Associates)

4. Panel Discussion (all presenters)

10:30 a.m. – 12:15 p.m.

Session 3. CalSim and CalLite Development and Application

Moderator: Yiwei Cheng (DWR)
Location: Pavillion

1. Klamath Basin Planning Model – Dan Easton (MBK)

2. CalSim3: 2021 Delivery Capability Report – Nazrul Islam (DWR)

3. CalLite Daily D-1641 Operations – Nicole Osorio (UC Davis, DWR)

4. CalSim 3 Miscellaneous Model Updates – Yiwei Cheng (DWR)

Session 4. C2VSim Coarse Grid Updates

Moderator: Tariq Kadir (DWR)
Location: Sierra 1

1. Vision for Development and Use of the C2VSimCG Model – Tariq Kadir (DWR)

2. C2VSimCG Data Updates, Calibration & Baseline Development – Ali Taghavi & Sara Miller (Woodard & Curran)

3. Updates to the Delta Area – Charles Brush (Hydrolytics, LLC)

4. The Daily Version of C2VSim-CG – Norman Johns (DWR)

12:15 – 1:00 p.m.

Lunch

Pick up a box lunch and then join us for the CWEMF Awards Ceremony in Pavilion.

Lunch sponsored by Larry Walker & Associates (LWA)

1:00 – 1:45 p.m.

Session 5. CWEMF Awards Ceremony

Moderator: Shyamal Chowdhury (CWEMF/USACE)
Location: Pavilion

Presentation of the Career Achievement and Distinguished Life Membership awards.

1:50 – 3:15 p.m.

Session 6. CalSim Input Development, Tiered Analysis & Computational Aspects

Moderators: Derya Sumer (USBR)
Location: Pavilion

1. The CalSim Flow Tracker – Cameron Koizumi (USBR)

2. Updating CalSim-III Groundwater Linkage from IWFMv3 to IWFM-2015 – Scott Boyce (USGS)

3. Demand Determination for CalSim3 – Drew Loney, Mark Spears & Lauren Thatch (USBR)

4. ICAR-VIC Basis for CalSim3 Climate Scenarios – Mike Wright (USBR)

5. Modeling Shasta Reservoir Temperature Operations in Planning and Operations Contexts – Mike Wright & Drew Loney (USBR)

Session 7. Fine Grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG): Calibration, Baseline, Local Applications & Lessons Learned

Moderator: Mesut Cayar (Woodard & Curran)
Location: Sierra 1

1. Historical Calibration of C2VSim-FG – Mesut Cayar (Woodard & Curran), Sercan Ceyhan (Woodard & Curran), and Vivek Bedekar (SSPA) & Andres Diaz (Woodard & Curran)

2. C2VSim-FG Baseline Development – Liz DaBramo (Woodard & Curran) and Guobiao Huang (DWR)

3. Use of C2VSim-FG for Local GSPs in the Central Valley – Sara Miller & Dominick Amador (Woodard & Curran)

4. Use of C2VSimFG: Applications and Lessons Learned – Ali Taghavi (Woodard & Curran) & Tyler Hatch (DWR)

3:30 – 5:15 p.m.

Session 8. Reclamation Model Development & Application

Moderators: Derya Sumer (USBR)
Location: Pavilion

1. The Exploratory Modeling Suite – Derya Sumer, Nancy Parker & Amanda Becker (USBR)

2. Position Analysis for Reservoir Operations Projection – Cameron Koizumi (USBR)

3. CVP/SWP Interim Operations Modeling Using CalSim II – Derya Sumer, Nancy Parker & Drew Loney (USBR)

4. Evaluation of FIRO at Folsom Reservoir – Drew Loney (USBR)

Session 9. C2VSimFG Data and Tool Refinements for the Next Phase of Development

Moderator: Tyler Hatch (DWR)
Location: Sierra 1

1. Model Data Development and Tools – Guobiao Huang (DWR) and Liz DaBramo (Woodard & Curran)

2. Estimate the Historical Evapotranspiration of the Central Valley – Lan Liang (DWR)

3. The Importance of a Well-Developed Stratigraphy for Improving the C2VSimFG Numerical Model – Behrooz Etebari (DWR)

4. Regional Cluster Analysis of Groundwater Quality to Determine Aquifer Sources of Wells Lacking Construction Data – Kyle Hardage (DWR)

5:30 – 8:00 p.m.

Session 10. Business Meeting and Social

Moderator: Tariq Kadir (CWEMF/DWR)
Location: Cliff House of Folsom

Social sponsored by Jacobs, MBK, Resource Management Associates (RMA), Stantec, and Tetra Tech

PLEASE RETURN YOUR NAME BADGE TO THE REGISTRATION TABLE IF YOU WILL NOT BE COMING BACK TO THE ANNUAL MEETING.

AGENDA

Tuesday, April 5

7:30 – 8:00 a.m. – Registration in Sierra Hallway

Refreshments sponsored by Watercourse Engineering

8:00 – 9:45 a.m.

Session 11. Water Resilience, Sustainability & Multi-Benefit Projects: Role of Data, Water Accounting and Modeling

Moderator: Abdul Khan (DWR) & Saquib Najmus (Woodard & Curran)
Location: Pavilion

1. Putting Data to Work – What We Have and What We Need – Christina McCready and Mahesh Gautam (DWR)

2. Climate Changed: Adjusting Historical Data for Climate Changes That Have Already Occurred – Andrew Schwarz (DWR)

3. Exploring Water Accounting Use Cases for Decision Making – Paul Shipman (DWR) and Frank Qian (Woodard & Curran)

4. A Water Accounting Tool for California: Initial Implementation – Abdul Khan (DWR) and Saquib Najmus (Woodard & Curran)

Session 12. CVP Water Temperature Modeling Platform

Moderator: Yung-Hsin Sun (Stantec)
Location: Sierra 1

1. Purposes and Goals for the CVP Water Temperature Modeling Platform – Randi Field (USBR)

2. Design of the CVP Water Temperature Modeling Platform – John DeGeorge (RMA)

3. Approach to Development of CVP Water Temperature Modeling Platform – Mike Deas (Watercourse Engineering)

4. The Development of CVP Water Temperature Modeling Platform: Accomplishments to Date – Mike Deas (Watercourse Engineering) and Jeff Schuyler (Eyasco)

5. Stakeholder Engagement for the Development of the CVP Water Temperature Modeling Platform – Yung-Hsin Sun (Stantec)

10:00 – 11:45 a.m.

Session 13. Pop-up Talks

Moderators: Stacy Tanaka (Watercourse Engineering) and Nigel Quinn (USBR/Berkeley National Lab)
Location: Pavilion

Five-minute overviews summarizing modeling work using a maximum of five PowerPoint slides per speaker.

11:45 a.m. – 12:30 p.m. – Lunch

Pick up a box lunch and then join us for the keynote address in Pavilion.

Lunch sponsored by Pacific Agroecology, LLC and Stantec

12:30 – 1:15 p.m.

Session 14. Keynote Address: Mark Arax (author and journalist)

Moderator: Tariq Kadir (CWEMF/DWR)
Location: Pavilion

1:15 – 3:00 p.m.

Session 15. Drought Assessment for Agriculture, Communities and the Environment: Panel Discussion

Moderator: Alvar Escriva-Bou (PPIC)
Location: Pavilion

Panel Members: Mark Arax, Jeanine Jones (DWR), Helen Dahlke (UC Davis) & Erik Ekdahl (SWRCB)

Droughts stress our water systems furthering existing gaps between water available and water needs. The scientific community broadly agrees on higher temperatures and whiplash climate for California in which more intense and frequent multi-year droughts can be follow by wet periods. Droughts also provide opportunities to learn about vulnerabilities in agriculture, communities, ecosystems and water supply systems. Promising strategies such as water demand management, use of natural infrastructure through recharge, coordinated surface and groundwater use, changes in cropping patterns and repurposing of land to buffer communities and ecosystems from competing uses and non-point source pollution have been examined in the literature. In this session we present research on economic and water supply impacts of recent droughts in California on agriculture, ecosystems and communities with a panel covering various disciplines including communications, planning, policy and infrastructure. Insights for managing future droughts on various sectors will be discussed.

Session 16. Merced River Flood-MAR Study

Moderator: Francisco Flores-Lopez (DWR)
Location: Sierra 1

1. Merced River Watershed Study: Overview – David Arrate (DWR)

2. Merced River Watershed Study: Water Available for Replenishment and Water Supply and Flood Risk Benefits – David Arrate (DWR)

3. Merced River Watershed Study: In-depth Discussion of Ecosystem Effects – Karandev Singh (DWR)

4. Merced River Watershed Study: Multi-sector Performance Using Risk-based Analytics – Karandev Singh (DWR)

3:15 – 5:00 p.m.

Session 17. Coastal Flooding & Sea Level Rise in California

Moderator: Samson Haile-Selassie (DWR)
Location: Pavilion

1. California Coastal Flood Modeling & Effects of Sea Level Rise – Nick Garrity & Yashar Rafati (ESA)

2. The Next Generation of the San Francisco Bay-Delta Community Model: Public Domain Modeling in Support of Compound Flood Protection and Forecasting – Kees Nederhoff (Deltares USA)

3. Using the Coastal Storm Modeling System (CoSMoS) to Assess Climate-driven Coastal Hazards Across California – Patrick Barnard (USGS)

4. Developing an Advisory Coastal Flood Hazard Maps Accounting for Sea Level Rise and the Fluvial Flooding – Om Prakash (DWR)

Session 18. CVSOM Development: Phase 1

Moderator: Tariq Kadir (DWR)
Location: Sierra 1

1. CVSOM Development Vision and Goals – Tariq Kadir (DWR)

2. IWFM-OPS: Innovative Approaches to Linking Integrated Hydrologic and Reservoir Systems Analysis Models – Can Dogrul (DWR)

3. CVSOM: Reservoir Operations Model – Puneet Khatavkar (Stantec)

4. Hydrology and Surface Water – Groundwater Interaction Formulation – Ali Taghavi (Woodard & Curran)

5:00 – 7:00 p.m.

Session 19. Social

Location: Sierra 1

Social sponsored by CBEC Eco Engineering, ICF, Papadopulos & Associates, Stockholm Environment Institute (SEI), and Woodard & Curran

PLEASE RETURN YOUR NAME BADGE TO THE REGISTRATION TABLE IF YOU WILL NOT BE COMING BACK TOMORROW.

AGENDA

Wednesday, April 6

7:30 – 8:00 a.m. – Registration in Sierra Hallway

Refreshments sponsored by Stantec

8:00 – 9:45 a.m.

Session 20. Regional Groundwater Desalination and Contaminant Remediation

Moderator: Reza Namvar (Woodard & Curran)
Location: Pavillion

1. San Jacinto Groundwater Basin Water Quality Management Projects (Perris North & South Subbasins) – Tom Henderson (Eastern Municipal Water District)

2. Groundwater Model Development: Automated Calibration, PEST and Cloud Computation – Zach Roy (Woodard & Curran)

3. Groundwater Flow MODFLOW Model Use for Regional Groundwater Contamination Remediation – Jingnan Zhou (Woodard & Curran)

Session 21. Assessing the Impact of Potential Instream Flow Targets on Human Supply and Aquatic Habitat in the South Fork Eel River

Moderator: Doug Chalmers (SEI)
Location: Sierra 1

1. Estimating Environmental Demands – Sam Sandoval (UC Davis) & Belize Lane (Utah State U.)

2. Investigating the Complexities of Instream Flows and Water Availability in the South Fork Eel River Watershed – John Riverson (Paradigm Environmental)

3. Demands: Legal or Not? Estimating Demands from Water Rights and Unpermitted Cannabis Grows – Doug Chalmers (SEI)

4. Simulating Allocations in the South Fork of the Eel River Water Allocation Model – Chuck Young (SEI)

5. Developing a Decision Support Tool to Evaluate Strategies and Results – Laura Forni (SEI)

10:00 – 11:45 a.m.

Session 22. Groundwater and Large Dams and Reservoirs – Impact and Safety Analysis

Moderator: Reza Namvar (Woodard & Curran)
Location: Pavillion

1. Lake Perris Seepage Recovery - Instrumentation and Data Collection for Groundwater Modeling – Holly Nichols (DWR)

2. 3D Modeling of Lithology and Aquifer Temperature for Development of MODFLOW Models – Ralph Simon (Woodard & Curran)

3. Groundwater Modeling for Lake Perris Seepage Recovery Project Design – Reza Namvar (Woodard & Curran)

4. Groundwater Modeling for Dam Safety Analysis – Breanna Clabourne (Woodard & Curran)

Session 23. Innovations in Integrated Water Resources Modeling

Moderator: Mesut Cayar (Woodard & Curran)
Location: Sierra 1

1. Artificial Intelligence 101 for Water Resources Engineers and Planners – Sercan Ceyhan (Woodard & Curran)

2. Integrated Water Flow Model (IWFM): A Hydrologic Modeling Toolset for Today's Water Resources Management Challenges – Emin Can Dogrul (DWR)

3. Using Machine Learning to Predict Recovery Strategies for Delta Levee Failure Events – Laurence Sanati (DWR) & Ryan Ripken (RMA)

4. Cloud Computing in Water Management Modeling – Xiaochun Wang (DWR)

5. Microsoft Azure Cloud Computing Practice in DSM2 Simulation Applications – Yu Zho (DWR)

11:45 a.m. – 1:15 p.m. - Lunch

Lunch at area restaurants

1:15 – 3:00 p.m.

Session 24. Grab Bag

Moderator: Rich Satkowski (Public Member – SWRCB Retired)
Location: Pavillion

1. Interannual Variability Analysis to CMIP6 Climate Model Historical Simulation and Future Projection for California Region – Jianzhong Wang (DWR)

2. California Urban Water Management Economic Tool – Kensey Daly (Jacobs)

3. Protocols for Water and Environmental Modeling – Rich Satkowski (Public Member) & John DeGeorge (RMA)

4. Simplified Approach for Estimating Salinity Constituents in the San Francisco Estuary & Delta – Paul Hutton (Tetra Tech)

Session 25. Delta Modeling

Moderator: Eli Ateljevich (DWR)
Location: Sierra 1

1. Modeling the Emergency Drought Barrier ... Again – Eli Ateljevich (DWR)

2. Hydrodynamic, Water Quality, and Ecological Impacts of Levee Breaches in Suisun Marsh – Scott Burdick (RMA)

3. Sediment Supply from Local Tributaries to the San Francisco Bay – Tan Zi (SFEI)

4. Progress in Cloud Computing for Bay-Delta SCHISM – Kijin Nam (DWR)

3:15 – 5:00 p.m.

Session 26. Habitats & Fish

Moderator: Jeremy Thomas (Jacobs)
Location: Pavillion

1. Challenges in Classifying Habitats with Model Predictions using Hard Suitability Thresholds – Benjamin Abban (USBR)

2. Floodplain Rearing Habitat Analysis of the Sacramento River, Sutter Bypass, and Yolo Bypass Associated with Sites Reservoir Feasibility Studies – Jeremy Thomas (Jacobs)

3. Transport Pathways and Processes in the Northern Delta – Stephen Andrews (RMA)

4. A Numerical Model for Juvenile Salmon Entrainment at River Junctures – Benjamin Abban (USBR)

Session 27. Watershed Modeling & Management Issues

Moderator: David Curtis (WEST Consultants)
Location: Sierra 1

1. Water Right Curtailments and Unavailability Methodology for the Sacramento-San Joaquin Delta Watershed – Jesse Jankowski (SWRCB)

2. Real Time Forecast Modeling for the San Joaquin Basin – Marco Bell (WEST Consultants)

3. Updates of Unimpaired and Natural Flows for Central Valley of California by Bay-Delta Office (BDO) Extended Through Water Year 2020 – Shalamu Abudu (DWR)

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ABSTRACTS

Session 1. California Water Plan Update 2023: Building the State's Water Resilience

Moderators: Abdul Khan & Lew Moeller [DWR]

Principal Contact: Abdul.Khan@water.ca.gov

1. What is California Water Plan Update 2023 and how does it relate to the Water Resilience Portfolio?

Presenter(s): Lew Moeller & Paul Massera [DWR]

Presenter(s) email(s): lewis.moeller@water.ca.gov; paul.massera@water.ca.gov

Permission for CWEMF to post pdf of presentation: yes

The California Water Plan (CWP), updated every five years, is the State's strategic plan for sustainably and equitably managing and developing water resources for current and future generations. Required by Water Code, it presents the status and trends of California's water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios. The CWP Update 2023 will provide a statewide vision, resilience planning framework and toolkit, and a progress tracking framework for advancing climate resilience in water-related sectors. This Update will also promote climate resilience across regions and water sectors with a statewide vision, clear goals, watershed planning framework and toolkit, and progress-tracking dashboard of indicators. The final Water Resilience Portfolio (WRP) was released in July 2020 and represents the Administration's blueprint for California water management to cope with more extreme droughts and floods, rising temperatures, declining fish populations, over-reliance on groundwater, and other challenges. The CWP Update 2023 planning process provides an ongoing platform for supporting State agencies tasked with implementing WRP actions as well as jointly tracking and sharing progress and outcomes.

2. Watershed Resilience

Presenter: Eric Tsai [DWR]

Presenter email: eric.tsai@water.ca.gov

Permission for CWEMF to post pdf of presentation: yes

Climate change is already impacting California more acutely than ever from increasing extremes related to floods, drought, and wildfires. To respond to current and future climate risks, California should focus on increasing our resilience by better understanding climate risks/vulnerabilities and developing proactive adaptation strategies. The Watershed Resilience Program seeks to promote sustainability and resiliency through watershed-scale partnerships and resilience planning guidance, data, and tools.

3. Future Scenarios: Does California Have Enough Water to Survive to 2070?

Presenter(s): Paul Shipman & Mohammad Rayej [DWR]

Presenter(s) email(s): paul.shipman@water.ca.gov; mohammad.rayej@water.ca.gov

Collaborator(s): Francisco Flores-Lopez & Romain Maendly [DWR]

Permission for CWEMF to post pdf of presentation: yes

The future scenarios project for California Water Plan 2023 will include updated model inputs as well as adaptation of the decision scaling approach to analysis of climate change impacts. Presentation will include results of a pilot study on incorporation of paleo climate data and decision scaling approach into Water Evaluation And Planning (WEAP) model, vision and scope of the future scenario analysis including geographical expansion and model updates, and overview of proposed metrics to identify future water-related vulnerabilities that will be faced by regions of California.

4. Performance Tracking – How do we know we are achieving a more resilient and sustainable future?

Presenter(s): Jason Sidley & Eric Tsai [DWR]

Presenter(s) email(s): jason.sidley@water.ca.gov; eric.tsai@water.ca.gov

Collaborator(s): Lori Clamurro-chew, David Martasian & Lewis Moeller [DWR]; Jeanna Long [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

This presentation will provide an overview of the past and future direction of Performance Tracking in the California Water Plan (CWP) and Central Valley Flood Protection Plan (CVFPP). For years now, the CWP and CVFPP have been advancing a framework to establish a single comprehensive and practical method for tracking and reporting progress toward and effectiveness of implementing water management actions and policies that provide shared agreement and consistency among State and local governments across California's diverse regions. A Flood Performance Tracking System has been developed to monitor flood project implementation progress to date and compares them to flood risk reduction and ecosystem objectives. CWP has been also advancing a web-based atlas summarizing the makeup of various water agencies across the state, and their water management challenges and successes as well as proposed projects that are envisioned to meet these challenges. Identified metrics will help track climate risk and the effectiveness of management responses. Tracking will be conducted by local and regional agencies, which will be rolled up to assess resilience statewide through a web-based dashboard.

Session 2. SGMA in Action: Knowledge Gaps and Lessons Learned from the First 5 Years

Moderator(s): Steffen Mehl [CSU Chico], Tyler Hatch [DWR], Scott Boyce [USGS] & Laura Foglia [Larry Walker Associates, UC Davis]

Principal Contact: smehl@csuchico.edu

1. Higher-order Observations for Assessing Undesirable Results with SGMA Models

Presenter: Randy Hanson [One-Water Hydrologic]

Presenter email: randythanson@gmail.com

Permission for CWEMF to post pdf of presentation: no

Many GSPs primarily rely on monitoring networks to assess the changes and related thresholds of the six undesirable results under SGMA, but integrated models also need to replicate some or all of these features. The use of higher-order observations to train integrated hydrologic models (IHMs) through calibration and conceptual confirmation can supplement the monitoring networks and help confirm other estimates made with these models that are difficult to provide from monitoring networks. Higher-order observations that could be considered when designing SGMA monitoring networks can become additional model observations. This includes subsidence and changes in subsidence, streamflow gains and losses, climate variability, irrigation diversions, changes in salinity, vertical-head differences, agricultural pumpage and changes in pumpage between wet and dry periods, changes in actual ET between wet and dry periods, changes in soil moisture, drain returnflows, and groundwater/surface-water rights. These are examples that are commonly not used or even available in commercial GUIs but can further inform IHMs for SGMA uses. Since many of these attributes are estimated during simulation and not specified inputs within IHMs, they can be used to further inform SGMA applications provided the observations are available. Higher-order observations can also give insight into structural errors. Selected examples of observations from regional-scale IHMs models are used to demonstrate their use.

2. SGMA and Groundwater Modeling Myths

Presenter: Graham Fogg [UC Davis]

Presenter email: gefogg@ucdavis.edu

Permission for CWEMF to post pdf of presentation: yes

The two largest, dominant groundwater budget terms in most irrigated groundwater basins of California are pumpage and recharge (including that from surface water). Both these terms are seldom measured, and to make matters even more challenging, recharge is basically unobservable. To the casual observer, this predicament would seem to make groundwater modeling unreliable or impractical. To the contrary, it is through groundwater models, including those coupled with surface water, that we are able to produce useful estimates of groundwater budgets. This is especially true in the SGMA context where ongoing groundwater monitoring and periodic review and updating of model performance will force progressive improvements to the models and resulting groundwater budgets. At the root of the above-described paradox are several groundwater modeling myths that I will elucidate in my part of the panel discussion. Furthermore, I will suggest a pathway forward for development of better data and models in support of SGMA.

3. Reassessing SGMA Models Built for Both Public and Regulatory Acceptance

Presenter: Derrik Williams [Montgomery & Associates]

Presenter email: Dwilliams@ELMontgomery.com

Permission for CWEMF to post pdf of presentation: yes

Public interest in SGMA and the stakeholder requirements of SGMA resulted in significant public scrutiny of groundwater models. Groundwater models were often reviewed by stakeholders with little formal groundwater training, yet who often expected a level of certainty that is generally in regional groundwater modeling. Simultaneously, DWR had little time to review groundwater models, and the concern of regulatory acceptance was generally unfounded. Recognizing the balance between public demands and regulatory requirements could have led to different decisions on how SGMA modeling was conducted. The perceived pressures of developing accurate models with limited data, developing models that can address up to up to six sustainable management criteria, and achieving DWR acceptance resulted in modeling decisions that could have been simplified. GSAs that developed multiple model tools to address the various SMCs seemed more successful at developing accurate SMCs than GSAs that worked with only one model. Additionally, some models did not put enough focus on inter-basin coordination. Finally, coordinating stakeholder expectations of models with the fact that GSPs will be modified in the future, potentially significantly, is fundamental for stakeholder acceptance. Because modeling is an ongoing process, GSAs have an opportunity to address these issues during implementation.

Session 3. CalSim and CalLite Development and Application

Moderator: Yiwei Cheng [DWR]

Principal Contact: Yiwei.Cheng@water.ca.gov

1. Klamath Basin Planning Model

Presenter: Daniel Easton [MBK]

Presenter email: Easton@mbkengineers.com

Permission for CWEMF to post pdf of presentation: no

Reclamation's Klamath Project irrigates approximately 230,000 acres of farmland in southern Oregon and northern California. Subject to the ESA, the Klamath Project must operate in accordance with biological opinions protecting the listed species coho salmon and Shortnose and Lost River suckers. Coho run the Klamath River and tributaries downstream of the Klamath Project and the suckers populate Upper Klamath Lake. The WRIMS based Klamath Basin Planning Model (KBPM) was created to simulate Klamath Project operations and support the development of a Proposed Action to protect the listed species. This presentation will describe the conflict between the water needs of the salmon, suckers, and farmers on the Klamath River and the use of the KBPM in an attempt to solve an intractable problem.

2. CalSim3: 2021 Delivery Capability Report

Presenter: Nazrul Islam [DWR]

Presenter email: Nazrul.Islam@water.ca.gov

Collaborator(s): Nicole Osorio, Shima Shamkhali Chenar & Yiwei Cheng [DWR]

Permission for CWEMF to post pdf of presentation: no

Department of Water Resources (DWR) has released the 2021 Delivery Capability Report (DCR) and its companion CalSim 3 study. The 2021 DCR study is an updated model compared to 2019 DCR. Updates include the transition from the CalSim II to CalSim 3 which extends the simulation period from 2003 to 2015, refinement of Incidental Take Permit (ITP) operations, Dudley Ridge and Mojave Water Agency Max Table A contracts, San Joaquin River Restoration recapture, SWP San Luis rule curve refinements, and other miscellaneous code improvements.

3. CalLite Daily D-1641 Operations

Presenter: Nicole Osorio (UC Davis, DWR)

Presenter email: nsosorio@ucdavis.edu

Collaborator(s): Jay Lund (UC Davis)

Permission for CWEMF to post pdf of presentation: no

A daily timestep version of the CalLite screening model is in development. The mainstream CalLite model evaluates various Central Valley water management scenarios in monthly timestep mode, which is usually sufficient for long-term planning. However, a daily timestep CalLite model offers a more refined temporal representation of several key operational components, including, but not limited to 1) Reservoir operations for flood control and minimum-instream flow requirements, 2) Weir spills, and 3) State Water Project (SWP) and Central Valley Project (CVP) Delta operations and regulations. This presentation will explain how the D-1641 CalLite code was updated from the monthly version to a daily version, compare the simulated and historical Water Year 1997 flows and storages, evaluate the compliance of D-1641 requirements, and share current limitations and areas of improvement.

4. CalSim 3 Miscellaneous Model Updates

Presenter: Yiwei Cheng [DWR]

Presenter email: Yiwei.Cheng@water.ca.gov

Collaborator(s): Nazrul Islam, Shima Shamkhali Chenar & Nicole Osorio [DWR]; Daniel Easton [MBK]

Permission for CWEMF to post pdf of presentation: yes

In CalSim3 (CS3), in order to improve model stability when utilizing the CBC solver, the ratio of the maximum weight/penalty to the minimum weight/penalty resolution is recommended to be within the range of $10^7 – 10^9$. Investigation into a recent CS3 study revealed the ratio to be the order of 10^{14}. Updates were made to the weights/penalties to reduce the ratio to 10^9. To further improve model efficiency, some integers were fixed and assigned as state variables in later cycles, reducing the complexity of the problem sent to the CBC solver.

Old and Middle River (OMR) flows have significant impacts on water project operations, water quality and Delta smelt population. As such, simulation models of OMR flows are important, with a water balance type model incorporated into CalSim. Work is underway to explore the use of different machine learning models in forecasting OMR flows.

Session 4. C2VSim Coarse Grid Updates

Moderator: Tariq Kadir [DWR]

Principal Contact: kadir@water.ca.gov

1. Vision for Development and Use of the C2VSimCG Model

Presenter: Tariq Kadir [DWR]

Presenter email: kadir@water.ca.gov

Permission for CWEMF to post pdf of presentation: yes

Work by consultants to DWR was recently completed for a new version of the C2VSimCG model, both for a historical simulation, and a current level baseline simulation. Enhancements to the historical simulation include modifications/corrections to the representation of the physical system, input data, mapping the simulation to the IWFM-2015 engine, improvements to modeling the Delta, and recalibration. Also, a baseline model was developed using fixed 2018 land use, and historical trace of precipitation and crop evapotranspiration (but current level diversions/ground water pumping). This presentation will summarize these enhancements, as well as potential use of the model in the future for planning studies. The follow up presentations in this session will provide more details.

2. C2VSimCG Data Updates, Calibration & Baseline Development

Presenter(s): Ali Taghavi & Sara Miller [Woodard & Curran]

Presenter email: ataghavi@woodardcurran.com

Collaborator(s): Tariq Kadir & Norman Johns [DWR]

Permission for CWEMF to post pdf of presentation: yes

The C2VSimCG model was updated using the latest data from various sources, including C2VSimFG, Calsim, and local data sources. The updated model was recalibrated for the period WY1974-2015. This presentation will cover the mapping techniques used to generate data for the C2VSimCG model and the data review and analysis to ensure the accuracy of the model files and consistency with C2VSimFG. The calibration process included both manual and PEST-assisted methods with confirmation and additional analysis of agricultural demands, streamflow hydrographs, subregional water budgets, and groundwater level hydrographs. Subsequent to the model calibration, a Baseline model was developed which covers the hydrologic period WY 1922-2015. The baseline model assumes a level of development based on the 2018 land and water use conditions and includes evaluation of agricultural and urban water demands over 94 years of historical hydrology, beginning with either a pre-drought or a post-drought groundwater level to address drought condition effects on the projected conditions.

3. Updates to the Delta Area

Presenter: Charles Brush [Hydrolytics, LLC]

Presenter email: Charles.Brush@Hydrolytics-LLC.com

Permission for CWEMF to post pdf of presentation: yes

The Sacramento-San Joaquin Delta component of the C2VSim Coarse-Grid model (C2VSimCG) was refined to more accurately simulate Delta water demands, water flows and groundwater levels. Detailed hydrologic information for the Sacramento-San Joaquin Delta area was compiled from existing studies and models. This information was used to modify the Delta portion of the C2VSimCG model to more accurately represent the groundwater hydrology, stream network, stream and canal seepage, diversions and return flows, land use, boundary conditions, subsurface flows and groundwater usage. Accurate simulation of Delta hydrology was somewhat limited by the coarseness of the C2VSimCG grid and the available simulation features within the IWFM application. These modifications significantly improved model performance with regards to Delta demands, groundwater flows, and stream-groundwater interactions. These modifications are an important step toward development of a representative integrated hydrologic simulation of the Sacramento-San Joaquin Delta.

4. The Daily Version of C2VSIM-CG

Presenter: Norman Johns [DWR]

Presenter email: norman.johns@water.ca.gov

Collaborator: Tariq Kadir [DWR]

Permission for CWEMF to post pdf of presentation: yes

A daily time-step version of CDWR's monthly C2VSIM-CG integrated surface water/ groundwater model has been developed. The long-term goals of the daily approach are to improve hydrological performance and to better address certain regulatory and environmental modeling needs. Four key hydrological time series (precipitation, evapotranspiration, stream flows, and surface water diversions) for the period WY1922 through WY2015 were developed. These time series were based on either a direct utilization of daily data or a distribution of monthly data via a polynomial fitting / mass balance maintenance procedure. This presentation will summarize the development efforts and examine some key hydrologic performance results to-date.

Session 6. CalSim Input Development, Tiered Analysis & Computational Aspects

Moderator: Derya Sumer [USBR]

Principal Contact: dsumer@usbr.gov

1. The CalSim Flow Tracker

Presenter: Cameron Koizumi [USBR]

Presenter email: ckoizumi@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

The CalSim Flow Tracker now has the ability to track releases from individual reservoirs as passthrough inflow or release of stored water, and to include flood control in each of these components. The LP solution algorithm which drives where each "color" of water is distributed allows the user to implement perspectives unique to study needs. Examples will illustrate the value of multiple perspectives and highlight recent uses of flow tracker analysis.

2. Updating CalSim-III Groundwater Linkage from IWFMv3 to IWFM-2015

Presenter: Scott Boyce [USGS]

Presenter email: seboyce@usgs.gov

Collaborator(s): Emin Can Dogrul [DWR]; Nancy Parker & Derya Sumer [USBR]

Permission for CWEMF to post pdf of presentation: yes

The Bureau of Reclamation and the Department of Water Resources have jointly developed a new version of the California Simulation model of the Central Valley Project and State Water Project operations, known as CalSim-III. Part of this project incorporated a spatially discrete groundwater module based on Integrated Water Flow Model version 3 (IWFMv3) source code to simulate the use of groundwater and its associated interaction with streamflow. The groundwater module's input datasets are based on the California Central Valley SIMulation model (C2VSIM). The current release version of IWFM is version 5, referred to as IWFM-2015. This presentation will detail the steps taken in updating the CalSim-III groundwater model from IWFMv3 to IWFM-2015 and the benefits and shortfalls of this linkage.

3. Demand Determination for CalSim3

Presenter(s): Drew Loney, Mark Spears & Lauren Thatch [USBR]

Presenter(s) email(s): dloney@usbr.gov; JSpears@usbr.gov; lthatch@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

CalSimHydro enables calculation of applied water demands for irrigated lands and refuges, based on ET, land use, planting dates, and local operational parameters. Reclamation will present efforts and opportunities to leverage data sources, streamline calculation processes, and incorporate water user feedback to improve upon representation of demands and facilitate validation of results.

4. ICAR-VIC Basis for CalSim3 Climate Scenarios

Presenter: Mike Wright [USBR]

Presenter(s) email(s): mwright@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

A research collaboration among Reclamation, NCAR, and NOAA is working towards use of the Intermediate Complexity Atmospheric Research (ICAR) platform, with the Variable Infiltration Capacity (VIC) runoff model as an intermediary, as a basis for development of climate scenarios to be used by CalSim3. Previous work produced ensembles of future climate simulations featuring new methods of orographic precipitation and snowpack estimation. The current effort directs these and improved microphysics schemes toward creation of new CalSim3 input datasets. This research will evaluate the implications of these new datasets to California water supply operations under future climate stresses.

5. Modeling Shasta Reservoir Temperature Operations in Planning and Operations Contexts

Presenter(s): Mike Wright & Drew Loney [USBR]

Presenter(s) email(s): mwright@usbr.gov; dloney@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

Water temperature modeling in the HEC-5Q platform is used by Reclamation to yield information about the range of operations that are feasible for addressing Sacramento River temperature needs. HEC-5Q modeling is performed using operations forecasts as inputs to inform operators' needs on an in-season basis and using the CalSim water supply model as inputs for planning studies in the longer term. Decisions on shutter settings in the Shasta Temperature Control Device and the influence of initial conditions and adjacent operations can have a significant effect on results. Non-intuitive outcomes and operational perspectives on carryover storage vs releases for temperature are challenges met in recent analyses.

Session 7. Fine Grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG): Calibration, Baseline, Local Applications & Lessons Learned

Moderator: Mesut Cayar [Woodard & Curran]

Principal Contact: mcayar@woodardcurran.com

1. Historical Calibration of C2VSimFG

Presenter(s): Mesut Cayar, Sercan Ceyhan & Andres Diaz (Woodard & Curran); Vivek Bedekar (SSPA)

Presenter(s) email(s): mcayar@woodardcurran.com ; mceyhan@woodardcurran.com; vivekb@sspa.com; adiaz@woodardcurran.com

Collaborator(s): Tyler Hatch & Guobiao Huang (DWR); Ali Taghavi (Woodard & Curran); Matt Tonkin (SSPA)

Permission for CWEMF to post pdf of presentation: yes

Calibrating the Central Valley-wide integrated surface water-groundwater model was a significant undertaking that integrated and validated recent data, developed tools for evaluation and calibration, and estimated model sensitivity. The presentation will highlight three components of the calibration process: (1) overall calibration approach and data, (2) sensitivity analysis of input parameters, and (3) calibration of aquifer parameters facilated using PEST. Through visualization of key steps and calibration results, audience members will leave the presentation with a better understanding of the C2VSimFG calibration process and strengths, calibration tools, and future refinements.

2. C2VSimFG Baseline Development

Presenter(s): Liz DaBramo (Woodard & Curran); Guobiao Huang (DWR)

Presenter(s) email(s): LDaBramo@woodardcurran.com; guobiao.huang@water.ca.gov

Collaborator(s): Tyler Hatch (DWR); Ali Taghavi & Mesut Cayar (Woodard & Curran)

Permission for CWEMF to post pdf of presentation: yes

In addition to the historical C2VSimFG model, a 94-year baseline model was developed for the Central Valley. Development of baseline models requires significant assumptions and predictions for future hydrologic, land, and water use conditions in each basin. This presentation will share the assumptions and approach for developing model files of the C2VSimFG baseline model. The presentation will also highlight the estimated land and water use and groundwater conditions projected into the future to support local scenario and project development.

3. Use of C2VSimFG for Local GSPs in the Central Valley

Presenter(s): Sara Miller & Dominick Amador (Woodard & Curran)

Presenter(s) email(s): smiller@woodardcurran.com; damador@woodardcurran.com

Collaborator: Ali Taghavi (Woodard & Curran)

Permission for CWEMF to post pdf of presentation: yes

C2VSimFG has been developed based on regional and local data from basins in Central Valley and has sufficient resolution to capture details of the local basins. These characteristics make C2VSimFG a model of choice for many groundwater basins to develop their SGMA related water budgets and project evaluations. Application of C2VSimFG to basins in Central Valley for development of their GSPs will be presented. Lessons learned from use of C2VSimFG in these basins will be shared for use of the model in other basins.

4. Use of C2VSimFG – Applications and Lessons Learned

Presenter(s): Ali Taghavi (Woodard & Curran); Tyler Hatch (DWR)

Presenter(s) email(s): ataghavi@woodardcurran.com; tyler.hatch@water.ca.gov

Permission for CWEMF to post pdf of presentation: yes

The Fine-Grid California Central Valley Groundwater-Surface Water Simulation (C2VSimFG) model is a regional integrated hydrologic model. The Department of Water Resources developed Version 1.01 of C2VSimFG as part of its commitment to provide technical assistance for Groundwater Sustainability Agencies developing GSPs. The particular focus of this version of the model was to provide a historical model for developing water budgets and perform aquifer parameter calibration. Due to data limitations, this version also provided a valuable way to scrutinize the observation datasets and the model conceptualization to identify future data needs and refinements. This presentation will also discuss how C2VSimFG v1.01 has been used and can be used in the future.

Session 8. Reclamation Model Development & Application

Moderator: Derya Sumer [USBR]

Principal Contact: dsumer@usbr.gov

1. The Exploratory Modeling Suite

Presenter(s): Derya Sumer, Nancy Parker & Amanda Becker [USBR]

Presenter(s) email(s): dsumer@usbr.gov; nparker@usbr.gov; abecker@usbr.gov

Collaborator(s): Cameron Koizumi [USBR]; Robert Leaf, Steve Micko & Solmaz Rasoulzadeh [Jacobs]

Permission for CWEMF to post pdf of presentation: yes

Reclamation has developed a suite of CalSim model runs which start with "run-of-river" and end with current operations. Scenarios with layers of storage operations, delivery priorities, and regulatory criteria yield a fresh perspective on system capabilities and CVP/SWP operational flexibility. The studies are expected to lay a foundation for Long Term Operations consultation. Model construction required consideration of each layer of system operation and obligation within the context of the linear programming solution algorithm. The effort will also serve a longer-term purpose as the basis for an anticipated CalSim training tool - the CalSim Builder.

2. Position Analysis for Reservoir Operations Projection

Presenter: Cameron Koizumi [USBR]

Presenter email: ckoizumi@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

Use of the Position Analysis (Monte Carlo simulation) feature of the WRIMS software has enabled use of CalSim with actual forecast data as well as historical data to project CVP operations under a range of seasonal conditions. Model performance and sensitivity will be presented for 2021 and 2022.

3. CVP/SWP Interim Operations Modeling Using CalSim II

Presenter(s): Derya Sumer, Nancy Parker & Drew Loney [USBR]

Presenter(s) email(s): dsumer@usbr.gov; nparker@usbr.gov; dloney@usbr.gov

Collaborator(s): Drew Loney, Michael Wright, Cameron Koizumi, Amanda Becker, Mechele Pacheco, Suzanne Manugian & Victor Huang [USBR]; Ian Uecker, Vadim Demchuk, Devinder Dhillon & Aaron Miller [DWR]; Steve Micko & Robert Leaf [Jacobs]

Permission for CWEMF to post pdf of presentation: yes

Reclamation, in collaboration with DWR, developed a modeling framework to evaluate effects of the Interim Operations Plan for the Water Year 2022. Modeling included operational outlook using CalSim II position analysis and subsequent Sacramento River temperature, Delta hydrodynamics (PTM), temperature dependent mortality, and through-Delta migration model for salmonids. The IOP modeling effort was the first of its kind in looking at a single - year with operational outcomes and effects of potential operations on species.

5. Evaluation of FIRO at Folsom Reservoir

Presenter: Drew Loney [USBR]

Presenter email: dloney@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

Reclamation water management is increasingly influenced by multiple factors which intensify the requirements on water resources infrastructure and the scrutiny regarding how those resources are managed. Forecast Informed Reservoir Operations (FIRO) can improve Reclamation water management and help it adapt to these factors. FIRO pilot studies have demonstrated the feasibility of utilizing improved meteorological/hydrological forecasts combined with better management techniques to simultaneously improve dam safety and water availability.

A FIRO pilot study has been initiated at Folsom Reservoir to determine alternatives to increase water availability, improve environmental compliance, and adapt to a changing climate. Folsom is of particular interest due to its buffering role in managing the Central Valley Project and its significant environmental demands. The project will implement the three core components of FIRO – meteorological ensemble forecasts, hydrologic/hydraulic modeling with optimization, and quantitative management objectives – to create a prototype FIRO management system which will allow Reclamation to evaluate the potential benefit of improved forecasts, incorporation of quantitative uncertainty into management models, and dynamic trade-off of competing water objectives in a risk-informed framework.

Session 9. C2VSimFG Data and Tool Refinements for the Next Phase of Development

Moderator: Tyler Hatch [DWR]

Principal Contact: tyler.hatch@water.ca.gov

1. Model Data Development and Tools

Presenter(s): Guobiao Huang (DWR); Liz DaBramo (Woodard & Curran)

Presenter(s) email(s): guobiao.huang@water.ca.gov; LDaBramo@woodardcurran.com

Collaborator(s): Tyler Hatch [DWR]; Mesut Cayar [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

Through the development and calibration of the Fine-Grid California Central Valley Groundwater-Surface Water Simulation (C2VSimFG) model, numerous datasets were developed to simulate historical conditions. Due to the size of the datasets, numerous scripts and utility programs were developed to visualize, review, check the data. In this presentation, we discuss some of these tools and how they were used to review and update the model input files.

2. Estimate the historical evapotranspiration of the Central Valley

Presenter: Lan Liang [DWR]

Presenter email: lan.liang@water.ca.gov

Collaborator(s): Andres Guillen & Morteza Sadeghi [DWR]

Permission for CWEMF to post pdf of presentation: yes

The actual evapotranspiration (ETa) on the ground surface is one major factor affecting both groundwater and surface water balances. To understand the spatial-temporal interactions between groundwater and surface water in the Central Valley more realistically, a python tool was developed to calculate the historical daily and monthly reference ET (ETo) and ETa with the inputs, such as historical PRISM climate, land use, and crop coefficients. It was built on ArcGIS. Given the feature layers of the land use, C2VSimFG elements, and subregions, the tool could provide the output layers of the ETa spatial averages at the land use parcel, element, and subregion levels. Additionally, it converts the layers into timeseries files in the DSS and text formats and directly links to C2VSimFG. The historical ETo has been validated with the ETo of most CIMIS weather stations in the Central Valley. This tool could reproduce the latest C2VSimFG v1.01 potential ET very closely with the related crop coefficients. It also estimated the ET for the C2VSimFG baseline model with consideration of the historical v1.01 ET and 2018 multi-cropping land use. The historical land use layers are under development. After they are completed, the crop coefficients and ETa could be calibrated according to the observed and remote-sensing ET data, and it will benefit of recalibrating C2VSimFG and simulate more accurate groundwater-surface water interactions.

3. The importance of a well-developed stratigraphy for improving the C2VSimFG numerical model

Presenter: Behrooz Etebari [DWR]

Presenter email: behrooz.etebari@water.ca.gov

Collaborator(s): Kyle Hardage & Thi Pham [DWR]

Permission for CWEMF to post pdf of presentation: yes

The Fine-Grid California Central Valley Groundwater Surface Water Simulation model (C2VSimFG) was developed to simulate regional scale groundwater occurrence and movement. Model stratigraphy included 4 layers and focused on shallow and deep groundwater production zones as the top two layers. Given the needs for more refined analysis of groundwater occurrence and movement at the regional scale, the Department of Water Resources has undertaken a detailed review of Central Valley geologic data with the goal of improving and adjusting the C2VSimFG stratigraphy in areas where pinch outs, faults, facies change, interfingering, and buried channels occur. Datasets being evaluated as part of this effort include cross-sections from Groundwater Sustainability Plans (GSPs), well completion reports, geophysical logs, water quality data, and AEM surveys. For the analysis, numerous datasets were synthesized using a combination of GMS and ArcGIS to refine the hydrogeologic conceptual model of the Central Valley. C2VSimFG stratigraphy datasets were compared with the geologic datasets to determine where refinements were needed most. In addition, C2VSimFG stratigraphy was also compared to the stratigraphy of the USGS Central Valley Hydrologic Model. This work will be an ongoing effort to help improve the ability of the model to represent groundwater level observations, vertical and horizontal gradients as new data become available.

4. Regional cluster analysis of groundwater quality to determine aquifer sources of wells lacking construction data

Presenter: Kyle Hardage [DWR]

Presenter email: kyle.hardage@water.ca.gov

Collaborator(s): Uditha Bandara & Tyler Hatch [DWR]

Permission for CWEMF to post pdf of presentation: yes

Conceptualization and calibration of the Fine-Grid California Central Valley Groundwater Surface Water Simulation model (C2VSimFG) using groundwater elevation requires well-known construction datasets from wells such as depth and screening interval. However, in the northern Central Valley, relatively few (~700 of ~4,000) wells possess the necessary information, thus omitting otherwise usable groundwater hydrographs. We use cluster analysis of water quality data (natural trace metal geochemistry) from the Groundwater Ambient Monitoring Program (GAMA) to constrain aquifer sources for wells of unknown construction data. Due to the sparse temporal nature of GAMA data, water quality cannot be used to analyze temporal trends, but suites of conservative metals may be used in multivariate techniques such as ordination and hierarchical clustering on a subregional scale. Alkali and alkaline earth metals (Na, Mg, K, Ca) and chloride provide the greatest geographic coverage (multi-county level), while specific hazardous metals (Cr, Ni, Hg, Pb) provide greater utility on sub-county scales. The multi-variate geochemical constraints on aquifer source complement single-variate groundwater elevation data that respond to regional precipitation but may not distinguish the recharge response of discrete aquifers. Future work will use water quality of multi-level monitoring wells with construction data to establish type-chemistry of specific aquifer depths to refine cluster analysis results.

Session 11. Water Resilience, Sustainability & Multi-Benefit Projects: Role of Data, Water Accounting and Modeling

Moderator(s): Abdul Khan [DWR] & Saquib Najmus [Woodard and Curran]

Principal Contact: Abdul.Khan@water.ca.gov

1. Putting Data to Work – What we have and what we need

Presenter(s): Christina McCready & Mahesh Gautam [DWR]

Presenter(s) email(s): christina.mccready@water.ca.gov; mahesh.gautam@water.ca.gov

Collaborator(s): David Harris [Cal Natural Resources Agency]; Tara Moran [Cal Water Data Consortium]

Permission for CWEMF to post pdf of presentation: yes

California has made substantial progress toward publishing State- and federally held California water and ecological data as required by the Open and Transparent Water Data Act of 2016 (AB 1755, Dodd). Presenters will share recent developments, describe longer-term goals and objectives, and solicit audience feedback.

2. Climate Changed: Adjusting historical data for climate changes that have already occurred

Presenter: Andrew Schwarz [DWR]

Presenter email: andrew.schwarz@water.ca.gov

Collaborator(s): Erik Reyes, Romain Maendly, Tariq Kadir, Hongbing Yin, Richard Chen, Aaron Miller, Tara Smith & Nicky Sandhu [DWR]

Permission for CWEMF to post pdf of presentation: yes

Models are indispensable tools in seeking solutions to California's complex water and environmental problems and providing reliable feedback to DWR management. Hydrological data -observed, measured, or estimated- over the last 100-years, have been the basis for developing model input. A prime example is the current baseline CalSim run, which uses a historical trace of hydrology, and provides information about operations and performance of the SWP and CVP systems under current demands, regulations, and operations. The current scientific consensus has raised questions on whether the historical trace of natural hydrology by itself, and without modifications, is adequate for the reliability of modeling results moving forward. Using CalSim again as the example, the performance of the SWP and CVP systems under current level water demands and constrained by regulatory and operations requirements must be driven by a reliable input hydrology reflecting current conditions, to ensure reliability in modeling results. To address hydrologic inputs for modeling a multi-agency workgroup has developed a "Climate change adjusted Current Conditions Hydrology" timeseries. This presentation will discuss the data and evaluation conducted and the methods used for developing this new timeseries, its intended uses, and differences in system performance resulting from the climate changes that have already occurred.

3. Exploring Water Accounting Use Cases for Decision Making

Presenter(s): Paul Shipman [DWR] & Frank Qian [Woodard & Curran]

Presenter(s) email(s): paul.shipman@water.ca.gov; fqian@woodardcurran.com

Collaborator(s): Abdul Khan [DWR]; Saquib Najmus & Jeanna Long [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

Many decisions in water management, from day-to-day management activities to planning for climate change and future projects, are rooted in water accounting. Examination of water accounting use cases highlights underlying themes in water management, complexities associated with creating comprehensive water budgets, and the challenge of transforming water budget data into information needed to inform water management decisions. This presentation will explore preliminary ideas on how developing and organizing water accounting use cases can address myriad decision-making challenges in water management.

4. A Water Accounting Tool for California: Initial Implementation

Presenter(s): Abdul Khan [DWR]; Saquib Najmus [Woodard & Curran]

Presenter(s) email(s): Abdul.Khan@water.ca.gov; snajmus@woodardcurran.com

Collaborator(s): Paul Shipman [DWR]; Frank Qian & Jeanna Long [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

California Department of Water Resources is envisioning a Water Accounting System, a suite of tools to help modernize the State's water management and tracking by facilitating accurate and efficient accounting of California's water. This suite of tools includes the Handbook for Water Budget Development: With or Without Models (Water Budget Handbook); supplemental guides on component indexing, zone selection, zone aggregation, and estimation of uncertainty; and the Water Accounting Tool. The Water Budget Handbook and the supplemental guides provide the methods, templates, data sources, and guidance for developing water budgets for any water budget zone(s). The Water Accounting Tool ingests, organizes, and synthesizes the water budget numbers to help us understand what those numbers mean; it facilitates communication and sharing of water budgets and enables rapid evaluation of management actions and adaptation strategies for improved resource management. This presentation will discuss the initial implementation of the Water Accounting Tool.

Session 12. CVP Water Temperature Modeling Platform

Moderator: Yung-Hsin Sun [Stantec]

Principal Contact: hsin.sun@stantec.com

1. Purposes and Goals for the CVP Water Temperature Modeling Platform

Presenter: Randi Field [USBR]

Presenter email: rfield@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

The Central Valley Project (CVP) Water Temperature Modeling Platform (WTMP) Project is an important undertaking by Reclamation supported by the Bay Delta Office, the Central Valley Project Operations Office, and the Planning Office of the California-Great Basin Region. Reclamation's goal for this project is to addresses the need to modernize water temperature models for continued CVP operation in the Sacramento-Trinity, American, and Stanislaus River systems, and associated fishery species protection. The WTMP will also provide significant opportunities for organization capacity building at Reclamation. The anticipated outcome of the WTMP is the improved capacity to provide water temperature predictions in CVP reservoirs and downstream river reaches with sufficient confidence to complete the necessary planning for real-time, seasonal, and long-term applications while also describing risk and uncertainty.

2. Design of the CVP Water Temperature Modeling Platform

Presenter: John DeGeorge [RMA]

Presenter email: jfdegeorge@rmanet.com

Permission for CWEMF to post pdf of presentation: yes

The Central Valley Project (CVP) Water Temperature Modeling Platform (WTMP) is suite of software tools that will facilitate Reclamation's temperature modeling activities for the Sacramento, American, and Stanislaus River systems. Primary design objectives for the WTMP are to (1) conform to professional standards of care in analytical tool development and applications for reservoir-river system water temperature management, (2) be used consistently for both CVP real-time operations, seasonal and long-term planning purposes, and (3) be flexible to accommodate future technologic advancements in analytical modeling for reservoir-river system water temperature management. This presentation will discuss the design of the WTMP to meet the above requirements including modeling framework structure, and supporting database management and reporting functions, standardize workflows to improve efficiency reduce human errors, user experience and interface for users with different levels of modeling expertise and needs, and embedded flexibilities for accommodate future expansion and other workflow needs. Initial development of the WTMP is scheduled to be completed by the end of 2023.

3. Approach to Development of CVP Water Temperature Modeling Platform

Presenter: Mike Deas [Watercourse Engineering]

Presenter email: mike.deas@watercourseinc.com

Permission for CWEMF to post pdf of presentation: yes

The Central Valley Project (CVP) Water Temperature Modeling Platform (WTMP) will update or refine existing model technologies and develop new models to assist Reclamation and resource agencies in water temperature management. The geographic scope includes the (1) northern system: Shasta Lake, Keswick Reservoir, and Sacramento River from Keswick Dam to Red Bluff; Trinity Lake, Lewiston Lake, and Trinity River to North Fork Trinity River; and Whiskeytown Reservoir and Clear Creek from Whiskeytown Dam to Sacramento River; (2) American River system: Folsom Reservoir, Lake Natoma, and American River downstream from Nimbus Dam to Sacramento River; and (3) Stanislaus River system: New Melones Lake, Tulloch Lake, Goodwin Dam, and Stanislaus River from Tulloch Dam to San Joaquin River. Taking advantages of improved technology, the WTMP will provide an efficient and reliable tool to assess strategies for managing CVP facilities for authorized purposes, while addressing water temperature management with a finite cold-water resource. This presentation will discuss the strategy, workplan and schedule for a two-phased approach to complete the project and major tasks including model and framework selections, data collection and database management, and mode calibration and validation, modeling framework development and model integration, and description of uncertainty associated with water temperature predictions.

4. The Development of CVP Water Temperature Modeling Platform: Accomplishments to Date

Presenter(s): Mike Deas [Watercourse Engineering]; Jeff Schuyler [Eyasco]

Presenter(s) email(s): mike.deas@watercourseinc.com, jeff@eyasco.com

Permission for CWEMF to post pdf of presentation: yes

The development of the Central Valley Project (CVP) Water Temperature Modeling Platform (WTMP) is scheduled to complete by the end of 2023. The early work products focus on the foundational components of the WTMP including the modeling framework selection, model selection, and database management. Based on the identified goals and objectives, intended applications, and the river-reservoir system characteristics, criteria were identified for selecting appropriate framework and models among a wide range of candidate frameworks and models for implementation. The database management is essential for the WTMP functions and integration of models and user interface facilitated by the framework. As data collection continues, different types of modeling data, including time series data, physical data, and operational data, are prepared and assessed for completeness and quality. This presentation will address identified selection criteria to meet project needs for these components, evaluations of existing available tools, and recommendations for implementation. Ongoing progress in implementation of selected models, modeling framework and database management structure will be summarized with lessons learned that will be incorporated in continued project execution.

5. Stakeholder Engagement for the Development of the CVP Water Temperature Modeling Platform

Presenter(s): Yung-Hsin Sun [Stantec]; Randi Field [USBR]

Presenter(s) email(s): yung-hsin.sun@stantec.com; RField@usbr.gov

Permission for CWEMF to post pdf of presentation: yes

For the development of the Central Valley Project (CVP) Water Temperature Modeling Platform (WTMP), Reclamation has identified the following principles including (1) focusing on technical improvement to advance water temperature modeling tools and analytical methods; (2) using a collaborative model development approach with stakeholders and interested parties; and (3) maintaining an open and transparent environment for information sharing and cooperation. This presentation will summarize the strategy for stakeholder involvement and outreach to support the WTMP development, including the cornerstone activities of a Modeling Technical Committee (MTC). The MTC is a technically focused collaborative venue for all modeling specialists, model users, and other interested parties to contribute their expertise and experience to assist Reclamation in developing the WTMP. When necessary, a topic-specific or river system-specific subgroup can be organized for a deep dive for identified subjects. The overall strategy for stakeholder involvement and outreach is to establish common understanding and expectations of the resulting tools. The presentation also includes a summary of planned peer reviews for further enhancing the transparency and robustness of the products to reinforce the above project development principles and stakeholder engagement strategy.

Session 16. Merced River Flood-MAR Study

Moderator: Francisco Flores-Lopez [DWR]

Principal Contact: Francisco.FloresLopez@water.ca.gov

1. Merced River Watershed Study: Overview

Presenter: David Arrate [DWR]

Presenter email: David.Arrate@water.ca.gov

Collaborator(s): Karandev Singh, Francisco Flores-Lopez, Alex Vdovichenko, Iman Mallakpour, Clark Churchill, James Wieking, Jennifer Marr, Ajay Goyal, Romain Maendly, & Alejandro Perez (DWR); Lee Bergfeld & Wesley Walker (MBK); Ali Taghavi, Liz DaBramo & Sercan Ceyhan (Woodard & Curran), Daniel Mountjoy, Taylor Broadhead & Aysha Massell (Sust. Conserv.); Paul Bergman & Travis Hinkelman (ESA); Glen Low (Earth Genome)

Permission for CWEMF to post pdf of presentation: yes

The Merced Watershed uses a headwater-to-groundwater integrated toolset to evaluate the multi-sector effects and opportunities using a common 100-year hydrologic dataset resulting from implementing Flood-MAR at the watershed scale. This is achieved by integrating nine different models simulating watershed's physical and management processes. This presentation will take a deeper dive into how the nine models communicate results, describe how climate change is studied, and provide an overview the progressive levels of Flood-MAR implementation included in the Merced Study.

2. Merced River Watershed Study: Water Available for Replenishment and Water Supply and Flood Risk Benefits

Presenter: David Arrate [DWR]

Presenter email: David.Arrate@water.ca.gov

Collaborator(s): Karandev Singh, Francisco Flores-Lopez, Alex Vdovichenko, Iman Mallakpour, Clark Churchill, James Wieking, Jennifer Marr, Ajay Goyal, Romain Maendly, & Alejandro Perez (DWR); Lee Bergfeld & Wesley Walker (MBK); Ali Taghavi, Liz DaBramo & Sercan Ceyhan (Woodard & Curran), Daniel Mountjoy, Taylor Broadhead & Aysha Massell (Sust. Conserv.); Paul Bergman & Travis Hinkelman (ESA); Glen Low (Earth Genome)

Permission for CWEMF to post pdf of presentation: yes

The Merced River Watershed Study has been highlighted as an important approach to contribute achieving resiliency and sustainability of California's watersheds. The Merced River Watershed Study takes an innovative approach through deploying nine different models to simulate the watershed's physical and management processes from headwaters to groundwater. While each tool can provide insightful results on its own, together they provide decision makers with the larger picture and ability to evaluate the benefits of water supply and flood risk reduction.

To provide this type of information, these tools must be seamlessly integrated to communicate information. The reservoir operations model estimates the Water Available for Replenishment (WAFR) using the operation rules, conveyance capacity, and flow required at a downstream location. Focusing on the groundwater system, the groundwater model simulates the groundwater supply and flow, the interactions between surface water and groundwater, and the replenishment of the aquifer. Hydraulic and flood economic models are used to calculate the flood risk consequences and potential flood risk reduction benefits. The study quantifies the benefits from multiple levels of Flood-MAR, from recharging excess flows, recharge plus reservoir reoperations, and recharge plus reservoir reoperation plus infrastructure improvements through 30 potential climate change futures.

3. Merced River Watershed Study: In-depth Discussion of Ecosystem Effects

Presenter: Karandev Singh [DWR]

Presenter email: Karandev.Singh@water.ca.gov

Collaborator(s): David Arrate, Francisco Flores-Lopez, Alex Vdovichenko, Iman Mallakpour, Clark Churchill, James Wieking, Jennifer Marr, Ajay Goyal, Romain Maendly, & Alejandro Perez (DWR); Lee Bergfeld & Wesley Walker (MBK); Ali Taghavi, Liz DaBramo & Sercan Ceyhan (Woodard & Curran), Daniel Mountjoy, Taylor Broadhead & Aysha Massell (Sust. Conserv.); Paul Bergman & Travis Hinkelman (ESA); Glen Low (Earth Genome)

Permission for CWEMF to post pdf of presentation: yes

The implementation of managed aquifer recharge projects presents the opportunity to provide ecosystem enhancements by carefully coordinating the timing and location of water deliveries to minimize impacts and maximize benefits to aquatic and terrestrial species of concern. This presentation will define ecosystem indicators that were used to evaluate the environmental effects of Flood-MAR and help refine water management actions to maximize project benefits to key indicator species. Ecosystem indicators were developed to capture effects to all key indicator species, including groundwater-dependent vegetation, anadromous fish, and shorebird species. The findings include the effects of progressive levels of Flood-MAR implementation on each ecosystem indicator compared to baseline conditions. In addition to presenting the results, this presentation will describe how baseline analyses for each ecosystem indicator were used to refine reservoir reoperations and identify water infrastructure changes to minimize impacts and maximize benefits to key indicator species.

4. Merced River Watershed Study: Multi-sector Performance Using Risk-based Analytics

Presenter: Karandev Singh [DWR]

Presenter email: Karandev.Singh@water.ca.gov

Collaborator(s): David Arrate, Francisco Flores-Lopez, Alex Vdovichenko, Iman Mallakpour, Clark Churchill, James Wieking, Jennifer Marr, Ajay Goyal, Romain Maendly, & Alejandro Perez (DWR); Lee Bergfeld & Wesley Walker (MBK); Ali Taghavi, Liz DaBramo & Sercan Ceyhan (Woodard & Curran), Daniel Mountjoy, Taylor Broadhead & Aysha Massell (Sust. Conserv.); Paul Bergman & Travis Hinkelman (ESA); Glen Low (Earth Genome)

Permission for CWEMF to post pdf of presentation: yes

The frameworks for making water resource investment decisions in the face of growing climate and regulatory uncertainty are undergoing rapid evolution. Decision Scaling is specifically designed to make the best and most efficient use of uncertain but potentially useful climate change projections to inform and support decision making. This presentation will describe the approach and results from the integrated analytical toolset used to assess the vulnerability of the Merced River watershed to climate change and the potential resilience provided by Flood-MAR. The results will be presented using the decision scaling approach for select indicators that collectively track performance across the three primary water management sectors – flood, water supply, and ecosystem.

Session 17. Coastal Flooding & Sea Level Rise in California

Moderator: Samson Haile-Selassie [DWR]

Principal Contact: samson.haile-selassie@water.ca.gov

1. California Coastal Flood Modeling & Effects of Sea Level Rise

Presenter(s): Nick Garrity & Yashar Rafati [ESA]

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Collaborator(s): Robert Battalio [ESA]

Permission for CWEMF to post pdf of presentation: yes

Coastal flooding and erosion hazards put our natural and built assets at risk of damage and loss. Much of the damage along the California coast has occurred during intermittent extreme storm events, during which large swells coincide with elevated tidal water levels and result in major erosion and flooding. With sea-level rise, the extents of wave runup will be amplified to extend higher and farther inland than indicated by adding the amount of sea-level rise to the existing flood elevation.

ESA, in collaboration with DWR, developed the Technical Methods Manual for Adjusting FEMA Coastal Flood Maps to Account for Future Sea Level Rise (Technical Methods Manual or TMM) in 2016 to assist planners and engineers with planning for sea level rise by extension of FEMA coastal flood hazard maps typically used by municipalities. ESA has subsequently tested the TMM by comparison with results from more detailed methods at several California locations. The presentation will summarize our findings and address uncertainties associated with calculation of wave runup. These uncertainties are largely driven by data uncertainty (inputs to calculations such as surfzone wave characteristics, profile geometry and responses to storms and sea-level rise), method uncertainty (there are several wave runup methods and extreme value equations used by FEMA and others) and inherent uncertainty (the magnitude of dynamic setup and profile response to sea-level rise are uncertain).

2. The Next Generation of the San Francisco Bay-Delta Community Model: Public Domain Modeling in Support of Compound Flood Protection and Forecasting

Presenter: Kees Nederhoff [Deltares USA]

Presenter email: kees.nederhoff@deltares-usa.us

Collaborator(s): Mick van der Wegen [DELTARES]; Rohin Saleh [Alameda FCD]

Permission for CWEMF to post pdf of presentation: yes

The San Francisco Bay and Delta is the largest estuary on the U.S. West Coast. Over the last few decades, a range of numerical models using different software platforms have been developed to study this complex area. However, most of the previous models have limitations related to proprietary software, access for the research community for further development, limited support/maintenance, model extent, extreme value analysis methodology, and model schematizations. Considering the need of the San Francisco Bay Community for a regional, public domain model that can be used with a high level of consistency around the Bay, the vision for the development of this model was initiated by U.S. Geological Survey, Alameda Flood Control District, and Deltares.

The 1D-2D hydrodynamics model (SFBD-SWL) is used to compute compound flooding in San Francisco Bay and the Sacramento-San Joaquin Delta. The model has a relatively high grid resolution in the Bay (~100 m) and is designed for water level computations for hindcasting (Nederhoff et al., 2021) or forecasting purposes (Tehranirad et al, 2020). In particular, extreme impact events resulting from multiple physical drivers (e.g. marine, fluvial and pluvial) can be taken into account. In this presentation, we will present this new model schematization including several applications of it for the Bay and Delta. All the data and science can be accessed via www.d3d-baydelta.org.

3. Using the Coastal Storm Modeling System (CoSMoS) to assess climate-driven coastal hazards across California

Presenter: Patrick Barnard [USGS]

Presenter email: pbarnard@usgs.gov

Collaborator(s): Patrick Barnard, Li Erikson, Amy Foxgrover, Juliette Hart, Patrick Limber, Andrea O'Neill, Sean Vitousek, Nathan Wood, & Jeanne Jones [USGS]; Maya Hayden [Point Blue Conservation Science]; Kevin Befus [Univ. of Arkansas]; Maarten van Ormondt [Deltares]

Permission for CWEMF to post pdf of presentation: yes

Over 26 million people living in California coastal counties will be directly or indirectly affected by sea-level rise and associated coastal climate hazards. But coastal hazards investigations are often limited to SLR inundation, and do not account for the dynamic response of the coast, flooding during extreme events, or groundwater hazards. Here we present a comprehensive modeling approach that has been developed with support from state agencies over the last decade to address all these hazards, the Coastal Storm Modeling System (CoSMoS), and translates those hazards into socioeconomic exposure. In building this system, a series of new models and supporting techniques have been developed to integrate the effects of SLR, tides, waves, storms, river discharge, vertical land motion, and short and long-term coastal

change (i.e., beach erosion and cliff retreat), as well as a complementary assessment of groundwater inundation.

We apply CoSMoS to one of the world's wealthiest economic and most developed coastal environments, the urbanized coast of the state of California, USA, where over 99% of the population in the world's 5th largest economy reside. We show that over $200 billion of property, equating to more than 6% of the state's GDP, and 600,000 people in California could be impacted by dynamic flooding by 2100; this is a three-fold increase in exposed population than if only SLR and a static coastline are considered. Therefore, to better assess the true risk of climate change to global coastal communities, a dynamic approach should be applied that projects long-term beach and cliff evolution and integrates those changes with a plausible range of SLR and storm scenarios.

4. Developing an Advisory Coastal Flood Hazard Maps accounting for Sea Level Rise and the Fluvial Flooding

Presenter: Om Prakash [DWR]

Presenter email: oprakash@water.ca.gov

Collaborator: Samson Haile-Selassie [DWR]

Permission for CWEMF to post pdf of presentation: Yes

Coastal flooding can be one of the greatest threats to life and property during storms. Storms introduce risks to coastal communities in California in the form of flooding, erosion, and shoreline retreat. Rising sea levels and altered seasonal wave conditions due to climate change will continue to alter California's shorelines over the upcoming decades and beyond. Adaptation to these rising sea levels rise will require existing and future coastal planning and policies to be adaptive and flexible.

FEMA Mapping Master Plan (2013) identified five coastal watersheds as high priority mapping watersheds based on their high population and on the age of the FEMA maps. DWR's Technical team in collaboration with stakeholders has selected Santa Margarita coastal watershed to conduct a pilot study in developing an advisory coastal flood hazard maps accounting for the joint hazards of the Sea Level Rise and Fluvial Flooding using two-dimensional hydrodynamic modeling.

This hydrodynamic model aims to account for the details of local development outlines, characteristics of waves and future shoreline changes or erosion for the Santa Margarita watershed coastal area along with considering local factors that alter the flooding and inundation patterns such as roadways, flood barriers, buildings, wave conditions and linear features that tend to channelize water flows or block/divert the flows. This presentation will focus on the DWR's role in providing comprehensive technical assistance to understand the sea level rise dynamics in coastal flooding and, engage and coordinate with the stakeholders to reduce the flood risks for population living in coastal floodplains against future climate change impacts.

Session 18. CVSOM Development: Phase 1

Moderator: Tariq Kadir [DWR]

Principal Contact: kadir@water.ca.gov

1. CVSOM Development Vision and Goals

Presenter: Tariq Kadir [DWR]

Presenter email: kadir@water.ca.gov

Permission for CWEMF to post pdf of presentation: yes

A new draft version of CVSOM (Central Valley System Operations Model) was recently completed by consultants for DWR. In development during 2021, it builds on prior presenter's academic research, and follow-up work by DWR staff. CVSOM uses C2VSM-CG as the template for: representation of the physical system, dynamically (during simulation), computing land-used based consumptive water demands, and simulating the physical processes such runoff, ground water, and surface water – groundwater interactions. Reservoir operations and water allocations of the Central Valley CVP/SWP systems are computed on a monthly time step for the period WY1922-2015. The engine driving CVSOM is IWFM-OPS which that acts as a wrapper for both the generic software IWFM (for integrated hydrological models) and WRIMS2 (for reservoir operations). A key feature of CVSOM is the modeling of all main surface reservoirs in the Tulare Basin, in addition to those of Sacramento Valley and San Joaquin Valley. CVSOM builds on, and includes many features of, CalSim-3. While still only a robust proof of concept, It is envisioned that CVSOM could serve as the next generation CalSim, and the basis for developing an enhanced CalLite-like model for quicker simulations. Key features and planned enhancements for CVSOM will be shared in the presentation. The remainder presentations in this session will cover the development of CVSOM in more detail.

2. IWFM-OPS: Innovative Approaches to Linking Integrated Hydrologic and Reservoir Systems Analysis Models

Presenter: Can Dogrul [DWR]

Presenter email: can.dogrul@water.ca.gov

Permission for CWEMF to post pdf of presentation: yes

Realistic planning of surface and subsurface water resources management for future climate and regulatory settings requires simulation models to incorporate reservoir system analysis into hydrologic modeling. This is particularly true in California's Central Valley where almost all stream boundary inflows are regulated via reservoirs. Over the past several years, staff from California DWR has been developing the IWFM-OPS, a generic simulation engine that links an integrated hydrologic model, IWFM, and a reservoir systems analysis model, WRIMS. IWFM-OPS strives to make the combined simulations of water demands, reservoir and surface water system operations to meet these demands and resulting surface and subsurface flow routing as simple as possible for the model user by utilizing several innovative approaches. These approaches include 1) the ability to develop the representation of the surface water operations in a step-by-step fashion, 2) use of keywords to guide IWFM-OPS in determining the linkage between the IWFM and WRIMS models, 3) automatic generation of stream continuity equations to be used as constraints for the WRIMS model, and 4) forecasting future water demands to guide reservoir operations. In this presentation, these approaches will be detailed, and they will be compared to the currently existing methods used in reservoir systems analysis models.

3. CVSOM: Reservoir Operations Model

Presenter: Puneet Khatavkar [Stantec]

Presenter email: puneet.khatavkar@stantec.com

Collaborator: Andy Draper [Stantec]

Permission for CWEMF to post pdf of presentation: yes

CVSOM is the Central Valley application of IWFM-OPS combining IWFM and WRIMS software capabilities: IWFM simulates the surface water and groundwater hydrology along with the land-use based water demands, WRIMS adds water management decision capabilities. Reservoir operations, including reservoir releases, surface water diversions and bypasses, are performed using WRESL code in WRIMS, while the routing of the flow and simulation of surface-groundwater interactions as well as computation of water demands and delivery requirements are performed in IWFM.

For this initial application, reservoir operations in CVSOM are performed using a simplified simulation of the surface water operations in the Sacramento Valley, San Joaquin Valley (including the Tulare Basin), and Delta. The four-cycle CalSim setup for simulation of the San Joaquin Valley was condensed to one cycle in the current version of CVSOM. Similarly, the eleven cycle CalSim setup for simulation of the Sacramento Valley was condensed to one cycle in the current version of CVSOM. This was achieved by eliminating some aspects of SWP and CVP operations, including wheeling, transfers, joint point of diversion, and SWP Incidental Take Permit (ITP) requirements. Comparison of simulated reservoir operations with historical data and with results from a “limited” version of CalSim show that the current version of CVSOM provides a robust proof-of-concept for simulating the water resources of the Central Valley.

4. Hydrology and Surface Water-Groundwater Interaction Formulation

Presenter: Ali Taghavi [Woodard & Curran]

Presenter email: ataghavi@woodardcurran.com

Collaborator: Sercan Ceyhan [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

CVSOM, which is based on the IWFM-OPS platform, combines the capabilities of the Integrated Water Flow Model (IWFM) and Water Resources Integrated Management System (WRIMS) to simulate the land use, surface water, and groundwater systems under dynamic water management decision capabilities for the Central Valley. The CVSOM integrated hydrology development is based on the Coarse Grid version of the C2VSim (C2VSim-CG), which calculates the hydrologic, water demand and water supply information for the WRIMS engine in CVSOM, which drives the reservoir operations decisions. This presentation will discuss the hydrologic datasets and assumptions used for the development of CVSOM, computation of delivery requirements, and stream accretions in light of the similarities and differences to C2VSim-CG. It will also discuss the information flow through the reservoir operations, surface water, and groundwater system based on the formulation of surface water - groundwater interaction under dynamic water management capabilities.

Session 20. Regional Groundwater Desalination and Contamination Remediation

Moderator: Reza Namvar [Woodard & Curran]

Principal Contact: rnamvar@woodardcurran.com

1. San Jacinto Groundwater Basin Water Quality Management Projects (Perris North & South Subbasins)

Presenter: Tom Henderson [Eastern Municipal Water District]

Presenter email: hendersont@emwd.org

Collaborator(s): Rachel Gray, Leighanne Kirk & Daniel Thomas [Eastern Municipal Water District]; Zach Roy, Jingnan Zhou, Ali Taghavi & Reza Namvar [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

This presentation will cover the process that Eastern Municipal Water District (EMWD) uses to develop groundwater quality management projects. The role of models in defining the projects, project design, stakeholders' involvement, and project implementation will be described. The Twenty-year history EMWD's use of MODFLOW for groundwater basin management will be presented. Recent desalination and contamination remediation projects will be presented as case studies.

2. Groundwater Model Development - Automated Calibration, PEST and Cloud Computation

Presenter: Zach Roy [Woodard & Curran]

Presenter email: zroy@woodardcurran.com

Collaborator(s): Jingnan Zhou, Breanna Clabourne, Ali Taghavi & Reza Namvar [Woodard & Curran]; Tom Henderson, Rachel Gray, Leighanne Kirk & Daniel Thomas [Eastern Municipal Water District]

Permission for CWEMF to post pdf of presentation: yes

Groundwater within the San Jacinto Groundwater Basin (SJGB) is utilized by Eastern Municipal Water District as a source of local municipal water supply. Portions of the SJGB contain groundwater that has high concentrations of total dissolved solids and other chemicals including nitrate and perchlorate. This presentation will cover the recent update, calibration, and application of a MODFLOW-based groundwater flow model for the San Jacinto Groundwater Basin. For model update, the presentation will include a review of available data, aquifer test information, basin geology, recharge tools and other tools developed by the modeling team to build the updated model. For model calibration, the presentation will cover the manual and automated PEST calibration process and results and how CLOUD computation was used to calibrate the model. A brief overview of model application for the Perris South Desalination project will be presented.

3. Groundwater Flow MODFLOW Model Use for Regional Groundwater Contamination Remediation

Presenter: Jingnan Zhou [Woodard & Curran]

Presenter email: jzhou@woodardcurran.com

Collaborator(s): Zach Roy, Breanna Clabourne, Reza Namvar & Ali Taghavi [Woodard & Curran]; Tom Henderson, Rachel Gray, Leighanne Kirk & Daniel Thomas [Eastern Municipal Water District]

Permission for CWEMF to post pdf of presentation: yes

Groundwater contaminants including tetrachloroethylene (PCE), perchlorate, and nitrate have been detected in the northwestern areas of the San Jacinto Groundwater Basin (SJGB). Groundwater contaminants have been migrating from north to south as groundwater generally flows in a southerly direction and could potentially impact additional water supply wells. Eastern Municipal Water District is conducting a groundwater contamination prevention and remediation program to prevent the spread of these contaminants and protect the unimpacted portions of the aquifer that serves as a source of drinking water.

This presentation will cover the use of the San Jacinto Groundwater Flow Model (SJFM) for design and implementation of a regional groundwater contamination remediation project. The development of baseline and various scenario models will be presented. Use of the model to simulate the ability of the project to capture the contaminants of concern will be presented. Model use for selecting the extraction well locations, assigning preliminary extraction rates, and evaluating the project impact on local plumes including the active plumes and remediation activities of the March Air Reserve Base (MARB) superfund site will be presented. The presentation will also include the use of SJFM for evaluating the interaction of the project extraction wells with local per- and polyfluoroalkyl substances (PFAS) plume and optimizing the locations and extraction rates of the Project extraction wells.

Session 21. Assessing the Impact of Potential Instream Flow Targets on Human Supply and Aquatic Habitat in the South Fork Eel River

Moderator: Doug Chalmers [Stockholm Environment Institute]

Principal Contact: doug.chalmers@sei.org

1. Estimating Environmental Demands

Presenter(s): Sam Sandoval [UC Davis]; Belize Lane (Utah State U.)

Presenter(s) email(s): samsandoval@ucdavis.edu; belize.lane@usu.edu

Collaborator: Jesse Rowles [Utah State U./cbec eco engineering]

Permission for CWEMF to post pdf of presentation: yes

This presentation will describe the estimation and comparison of environmental water demands using hydrologic and habitat response methods, as well as a thorough description of the regional method for determining ecological response at every 200-m reach in the State of California. The regional method for estimating ecological response consists of: (1) a geomorphic classification that have determined the channel archetypes in a given basin, (2) the hydraulic modeling of the different channel archetypes to determine the flow and velocity response at different discharges, (3) the evaluation of ecological response using habitat suitability curves. The regional method is intended to be available at every 200 meter (600 feet) reach in the State of California.

2. Investigating the Complexities of Instream Flows & Water Availability in the South Fork Eel River Watershed

Presenter: John Riverson [Paradigm Environmental]

Presenter email: john.riverson@paradigmh2o.com

Permission for CWEMF to post pdf of presentation: yes

The State Water Resources Control Board, through collaboration with Paradigm Environmental, the California Department of Fish and Wildlife, and the North Coast Regional Water Quality Control Board, is leading the development of a hydrologic characterization model for the South Fork Eel River watershed. The project is one of five that support Action 4 of the California Action Plan, to "Protect and Restore Important Ecosystems," specifically to implement a suite of individual and coordinated administrative efforts to enhance flows that support critical habitat for anadromous fish. The modeling system was based on two separate models representing surface and groundwater hydrology, including: (1) the Loading Simulation Program C++ (LSPC) for simulation of hourly streamflows and surface infiltration, and (2) MODFLOW for simulation of groundwater and the impacts of water demands on baseflows. Various data sources were incorporated to develop a comprehensive and detailed understanding of the factors that are believed to have the most influence on instream flows, including climate conditions, watershed physical properties, geology, groundwater supplies, and consumptive use of water in various forms. Once configured, the modeling system was calibrated based through comparison of model-simulated and measured flows throughout the watershed. The modeling system provides a robust platform for investigating the interactions and complexities associated with water management scenarios.

3. Demands- legal or not? Estimating demands from water rights and unpermitted cannabis grows.

Presenter: Doug Chalmers [SEI]

Presenter email: doug.chalmers@sei.org

Collaborator: Rajaa Hassan [SWRCB]

Permission for CWEMF to post pdf of presentation: yes

Estimating demands in the remote forested watershed of the South Fork Eel River required the use of novel techniques. Few large water service providers exist. Instead, demand sites largely consist of individual homesteads and unpermitted cannabis cultivation sites, which lack reliable water use data. These demands are distributed throughout the watershed, with many located in headwater areas sensitive even to small demands. Although often unreliable and incomplete, water rights data from the publicly available eWRIMS database represented the best available source of water use records. A new tool, the eWRIMS Analyzer, was developed to extract demand estimates from water rights data with improved reliability. However, within this Emerald Triangle region, demands are prominent for unpermitted cannabis cultivation which lack legal water rights. For these unpermitted cannabis demands, several extraction and storage patterns explore a range of uncertainty and management options in the watershed. Finally, illegal domestic use was considered for existing buildings outside of any municipal service or current water right areas.

4. Simulating allocations in the South Fork of the Eel River Water Allocation Model

Presenter: Chuck Young [SEI]

Presenter email: chuck.young@sei.org

Permission for CWEMF to post pdf of presentation: yes

Several technical challenges had to be overcome to successfully simulate human and environmental water demands and performance at high temporal and spatial resolution across the study watershed. The South Fork Eel River watershed water allocation model (SE-WAM) was developed using the WEAP software, which can apply complex operating rules and constraints to water allocation across diverse demands. The model had to solve a daily allocation problem over a 20-year simulation period that consisted of streamflow in 395 sub-catchments, over 900 human demands, and over 300 environmental flow locations. This complex model was then run for 141 scenarios aimed to capture uncertainty in current and future water demands and storage. This level of model detail required a level of computational power beyond that provided by a desktop computer. To solve this, the WEAP software was modified to work with cloud computing services, allowing the parallel computation of all 141 scenarios to occur simultaneously. This modeling and data management effort ultimately enabled precise representation of the effects of uncertainty and changes in water supplies and demands.

5. Developing a decision support tool to evaluate strategies and results

Presenter: Laura Forni [SEI]

Presenter email: laura.forni@sei.org

Permission for CWEMF to post pdf of presentation: yes

Evaluating policies to address the trade-offs between diverting water to different uses and maintaining river flows for fish requires to navigate the complexity of water resources systems. That complexity involves the evaluation of temporal trends and seasonality as well as spatially determined points of interests in creeks and rivers. This information needs to be informed and validated by a Decision Support System (DDS) interphase that includes management objectives, facilitates a participatory process to ensure its utility, and addresses the complexity in evaluating trade-offs. In this study, a DSS visualization platforms to evaluating trade-offs between environmental flows and agricultural was designed. A series of graphical dashboards that incorporates spatiotemporal data from different domains contained a set of interactive filters to evaluate ecological and management scenarios that leads to a trade-offs analysis and the evaluation of future management challenges. The design of the DSS also took in consideration the logical sequence progression of the graphics to allow the effective use and understanding of scientific information. Scenario development that arises from a collaborative process can informs the design of the visualization platforms to facilitate participation, discussion, and meaningful exploration of the data facilitating the interaction of stakeholders in a multidisciplinary setting.

Session 22. Groundwater and Large Dams and Reservoirs – Impact and Safety Analysis

Moderator: Reza Namvar [Woodard & Curran]

Principal Contact: rnamvar@woodardcurran.com

1. Lake Perris Seepage Recovery - Instrumentation and Data Collection for Groundwater Modeling

Presenter: Holly Nichols [DWR]

Presenter email: Holly.Nichols@water.ca.gov

Collaborator: Grace Chen [DWR]

Permission for CWEMF to post pdf of presentation: yes

This presentation will cover the history and background of the seepage recovery project and how the project was designed, project benefits, users of the recovered seepage and what project questions were answered by the groundwater and geotechnical models. A review of instrumentation, data collection (including lithology and thermal data), and data analysis at the project site will be presented.

2. 3D Modeling of Lithology and Aquifer Temperature for Development of MODFLOW Models

Presenter: Ralph Simon [Woodard & Curran]

Presenter email: rsimon@woodardcurran.com

Collaborator(s): Breanna Clabourne & Reza Namvar [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

Earth Volumetric Studio (EVS) 3D modeling software was used to discretize a MODFLOW ground water flow model to predict ground water head beneath a dam with increased resolution and accuracy. High resolution 3D models were generated in EVS representing the distribution of lithology types from 479 borehole logs and aquifer temperature data for 88 wells in a localized area where the MODFLOW model required discretization. The modeled data were then appended to MODFLOW cells based on their 3D location and results were classified to create model calibration zones, assign initial hydraulic parameters, and determine ranges for sensitivity analysis. Following MODFLOW model calibration, EVS was used to generate cross-sections depicting the MODFLOW grid, boundary conditions, calibrated conductivities, predicted head, head changes over time, drawdown, velocity, and various other features.

3. Groundwater Modeling for Lake Perris Seepage Recovery Project Design

Presenter: Reza Namvar [Woodard & Curran]

Presenter email: rnamvar@woodardcurran.com

Collaborator(s): Jingnan Zhou, Breanna Clabourne & Emily Honn [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

This presentation will cover the development of a locally refined groundwater model to estimate the Lake Perris seepage rates, seepage volumes that could be recovered. The groundwater modeling work for selecting the number and location of the seepage recovery wells and operation rates and schedule will be presented.

4. Groundwater Modeling for Dam Safety Analysis

Presenter: Breanna Clabourne [Woodard & Curran]

Presenter email: bclabourne@woodardcurran.com

Collaborator(s): Ralph Simon, Jingnan Zhou & Reza Namvar [Woodard & Curran]

Permission for CWEMF to post pdf of presentation: yes

This presentation will cover the development of a very refined groundwater model for the Perris Dam area. Development of lithology and thermal models based on collected data will be presented. Use of lithology model in development and refinement of groundwater model will also be presented. Model calibration and analysis of seepage rates and groundwater heads with and without seepage recovery projects will be discussed. Finally, development of the groundwater model output needed for the geotechnical analysis will be presented.

Session 23. Innovations in Integrated Water Resources Modeling

Moderator: Mesut Cayar [Woodard & Curran]

Principal Contact: mcayar@woodardcurran.com

1. Artificial Intelligence 101 for Water Resources Engineers and Planners

Presenter: Sercan Ceyhan [Woodard & Curran]

Presenter email: mceyhan@woodardcurran.com

Permission for CWEMF to post pdf of presentation: yes

The rise of artificial intelligence applications in the recent years transformed many areas in our lives. From manufacturing to business intelligence, e-commerce to space exploration we come across many examples each and every day. Water resources is one of those areas in which artificial intelligence have a lot to promise in California. Increasing data collection efforts and complex management problems make California a playground for innovative solutions utilizing the latest technology. This presentation will offer an introduction to artificial intelligence concepts and tools, and present examples of artificial intelligence applications related to water resources management from both academia and industry.

2. Integrated Water Flow Model (IWFM): A Hydrologic Modeling Toolset for Today's Water Resources Management Challenges

Presenter: Can Dogrul [DWR]

Presenter email: Can.Dogrul@water.ca.gov

Permission for CWEMF to post pdf of presentation: yes

The climate is changing, basins are being developed beyond the ability of the local water resources to meet new water demands, and water management restrictions are being imposed to guarantee sustainability and to protect the environment and water quality. In response, the questions water managers are seeking answers to are getting more complex along with the modeling needs. To provide meaningful answers to these challenging water management questions, California DWR's Integrated Water Flow Model (IWFM), an integrated hydrologic model, has adopted several innovative approaches. These include adoption of new and improved hydrologic simulation techniques, efficient file formats to store and process vast amounts of modeling results, development of an application programming interface (API) that allow modelers create their own processing and analysis tools as well as to efficiently link IWFM to other types of models (e.g. reservoir systems analysis models, agricultural economics models). This presentation will describe some of these innovations and their benefits.

3. Using machine learning to predict recovery strategies for Delta levee failure events

Presenter(s): Laurence Sanati [DWR]; Ryan Ripken [RMA]

Presenter(s) email(s): Laurence.Sanati@water.ca.gov; ryan@rmanet.com

Collaborator(s): John DeGeorge & Stephen Andrews (RMA)

Permission for CWEMF to post pdf of presentation: yes

Much of the land surface in the Sacramento-San Joaquin Delta has subsided below sea level and is protected from inundation by hundreds of miles of levees. When a levee failure occurs, highly saline water from Suisun Bay and San Pablo Bay can be drawn into the Delta as the Delta "island" floods. Historically, there have only been a few events where levees on individual islands have abruptly breached (e.g., the Jones Tract failure of 2004). There is concern that, with increasing sea level and continued island subsidence, there is an increasing chance of multiple simultaneous levee failures occurring. This type of event would cause significant disruption of the water supply operations in the Delta. The California Department of Water Resources Delta Emergency Response Tool (Delta-ERT) is a software application developed to provide rapid evaluation of salinity intrusion associated with levee failure events and support reconnaissance level planning of recovery operations to minimize water supply disruption. A new machine learning component has been added to the Delta-ERT to suggest optimum strategies for temporary barrier placement, given the location of levee breaches, system state at the time of the event, and estimates of future inflows. The machine learning algorithm has been trained using hundreds of thousands of hypothetical levee breach events simulated with the Delta-ERT on DWR's AWS cloud computing infrastructure.

4. Cloud Computing in Water Management Modeling

Presenter: Xiaochun Wang [DWR]

Presenter email: Xiaochun.Wang@water.ca.gov

Collaborator: Nicky Sandhu [DWR]

Permission for CWEMF to post pdf of presentation: yes

With modeling work becoming more and more computationally intensive, cloud computing shows its strengths and benefits, such as scalability, flexibility, efficiency, and security. In this talk, we will provide an overview about cloud computing services that currently available. We will then share our experiences in using the services for our particle tracking modeling (PTM) studies. For a PTM study, it usually needs to perform large number of simulations because of the stochasticity nature of PTM models and the need of particles to be inserted at different locations and with different simulation periods. Without a cloud service, it is difficult, if not impossible, to conduct such large number of simulations. For this reason, we have been extensively using cloud services for our studies and gained experiences in cloud service setup, data storage and cost management. We will also share the lessons learned in our presentation.

5. Microsoft Azure cloud computing practice in DSM2 simulation applications

Presenter: Yu Zhou [DWR]

Presenter email: yu.zhou@water.ca.gov

Collaborator(s): Nicky Sandhu & Raymond Hoang [DWR]

Permission for CWEMF to post pdf of presentation: yes

The Bay-Delta Office is leveraging Microsoft Azure, a popular cloud computing platform, to improve the efficiency, scalability and flexibility of Delta Simulation Model II (DSM2) modeling tasks. DSM2 is a mathematical model for dynamic simulation of one-dimensional hydrodynamics, water quality and particle tracking in a network of riverine or estuarine channels. The computational resources offered by Microsoft Azure can facilitate DSM2 modeling works by reducing run times while maintaining budgetary and time requirements. This presentation will provide an overview of our practice on building, deploying and scaling Microsoft Azure for high-volume DSM2 applications, including batch simulation, model calibration and processing. The services of Microsoft Azure can be accessed through web portal, Windows application and Python API, which will also be demonstrated.

Session 24. Grab Bag

Moderator: Rich Satkowski [Public Member, SWRCB - Retired]

Principal Contact: rsatkowski@aol.com

1. Interannual Variability Analysis to CMIP6 Climate Model Historical Simulation and Future Projection for California region

Presenter: Jianzhong Wang [DWR]

Presenter email: Jianzhong.wang@water.ca.gov

Collaborator(s): Hongbing Yin, Erik Reyes & Tara Smith [DWR]

Permission for CWEMF to post pdf of presentation: yes

CMIP6, as a new set of global climate model projections, is becoming available for public use. In this work, Interannual variability of CMIP6 model historical simulations from 1850 to 2014 will be analyzed using the wavelet spectrum analysis method to check if these models can capture the observed historical interannual variability oscillations in California hydroclimate like the occurrence of QBO, ENSO, QDO and PDO oscillations. These observed interannual variability oscillations regulate sequencing of drought periods and wet years and are thus important to California water management. Furthermore, interannual variability in the future projected by CMIP6 climate model projections from 2015 to 2100 will be investigated using the same wavelet method to see how climate change affects the occurrence of these historical interannual variability in the future. Although only a few climate models replicate the observed interannual variability oscillation to a reasonable extent, the ensemble mean of 27 climate models simulate these oscillations of QBO, ENSO, QDO, and PDO well in terms of their occurrence and significance. Because of this, future projections from these few indicative climate models and the ensemble of the 27 climate models are investigated further for possible shift of interannual variability associated with these oscillations in the future (2015 to 2100).

2. California Urban Water Management Economic Tool

Presenter(s): Kensey Daly & Liz Stryjewski [Jacobs]

Presenter(s) email(s): kensey.daly@jacobs.com; Liz.Stryjewski@jacobs.com

Collaborator: Daya Muralidharan, Tariq Kadir, Ray Hoagland & Tara Smith [DWR]

Permission for CWEMF to post pdf of presentation: yes

The California Urban Water Management Economic Tool (CaUWMET) builds upon the legacy water economic models Least-Cost Planning Simulation Model (LCPSIM) and California Water Economics Spreadsheet Tool (CWEST) to provide urban water suppliers with a more flexible framework for assessing economic costs and benefits of changes in water supply reliability. CaUWMET is a CALSIM-compatible local water system simulation tool that uses an annual hydrologic sequence to compare water user demands with existing or projected local and imported supplies. This comparison is made the context of available shortage management measures and the ability to add economically justified long-term water supply and demand management measures. The tool optimizes the total cost of managing urban water system reliability—which includes the cost of unreliability—to provide water suppliers an estimate of the costs and benefits of the least-cost management strategy. CaUWMET will be released in 2022 as an open-source python tool so the public has full access to contribute to or modify the tool for a wide range of applications. The tool will be released with a default input dataset largely based on demand and supply projections provided by the 2020 Urban Water Management Plans for over 40 urban water suppliers statewide.

3. Protocols for Water and Environmental Modeling

Presenter(s): Rich Satkowski [Public Member]; John DeGeorge [RMA]

Presenter(s) email(s): rsatkowski@aol.com; jfdegeorge@rmanet.com

Collaborator(s): This work was guided by the Modeling Protocols Committee of the California Water and Environmental Modeling Forum (CWEMF). Committee members are: Rich Satkowski (California State Water Resources Control Board, Retired; Committee Chair), Jamie Anderson (California Department of Water Resources), Will Anderson (Contra Costa Water District), Mike Deas (Watercourse Engineering), John DeGeorge (Resource Management Associates), Ben Geske (Delta Stewardship Council), Tariq Kadir (California Department of Water Resources), Josué Medellín-Azuara (University of California, Merced), George Nichol (California State Water Resources Control Board, Retired), Nicky Sandhu (California Department of Water Resources), Tad Slawecki (LimnoTech), Ali Taghavi (Woodard & Curran), and Chuching Wang (Metropolitan Water District of Southern California). The consultant team at Tetra Tech consisted of Sujoy Roy, Paul Hutton, Katherine Heidel, John Rath, and Arushi Sinha.

Permission for CWEMF to post pdf of presentation: yes

Modeling has become indispensable for managing water in California. It is used for a variety of essential tasks, including supporting compliance with regulations, managing water rights, planning for future changes due to growth and climate change, designing of new infrastructure and planning for environmental restoration. Major water-related projects are rarely undertaken in California without the support of some model-based analyses. This dependence on models raises important questions about quality control among stakeholders and decision-makers. To provide guidance on this complex activity, CWEMF developed a set of modeling protocols, first published in 2000. These were updated in 2021, reflecting changes in the practice of modeling, key technological developments, and applications addressing problems relevant today. These protocols are intended to serve modelers as well as the broader community of model sponsors and stakeholders, who have an interest in the quality and reliability of a modeling study. The protocols describe the following modeling approaches used to address water resources problems: analytical/numerical models that simulate individual and/or integrated physical processes over a defined domain; statistical/empirical models based on relationships among observed data but with little to no process representation; optimization-based models that seek to meet key objectives subject to defined constraints; machine learning-based models, a sub-class of statistical/empirical models with a wider range of algorithms and capacity to handle disparate data sets; and agent-based models that represent behavior of organisms or populations (animal or human) in response to external factors. This presentation provides an overview and recommended use of the 2021 version of the modeling protocols.

4. Simplified Approach for Estimating Salinity Constituents in the SF Estuary & Delta

Presenter: Paul Hutton [Tetra Tech]

Presenter email: paul.hutton@tetratech.com

Collaborator(s): Arushi Sinha & Sujoy Roy [Tetra Tech]

Permission for CWEMF to post pdf of presentation: yes

This work presents a simplified approach for estimating ionic concentrations from specific electrical conductance (EC) data in the Sacramento-San Joaquin River Delta (Delta) and San Francisco Estuary. Monitoring the EC of water through electrodes is simple and inexpensive. As a result, a wealth of high-resolution time series data is available to indirectly estimate salinity concentrations and, by extension, seawater intrusion throughout the study domain. However, scientists and managers are also interested in quantifying ionic (e.g. bromide, chloride) and total dissolved solids concentrations for meeting water quality regulations, protecting beneficial uses, supporting environmental analyses, and tracking source water dominance. These constituent concentrations, reported with lower spatial and temporal resolution than EC, are typically measured in the laboratory from discrete (grab) water samples. We divide the study domain into four unique regions for estimating concentrations of major ions and total dissolved solids as functions of measured or model-simulated EC; these mathematical relationships are generally expressed as polynomial (quadratic) equations where constant terms are determined through ordinary least squares regression of available grab sample data. Salinity relationships in three of the four regions – regions that represent Delta inflow and seawater-dominated boundaries – reflect quasi single- or dual-source water dominance that are independent of season and hydrologic condition and are highly correlated with EC. The fourth region – within the interior Delta – exhibits salinity characteristics associated with complex boundary source water mixing that varies by season and hydrologic condition. We introduce a novel method for estimating ionic and dissolved solids concentrations within this fourth region given month, water year type, and (optionally) X2 isohaline position which allows for more accurate EC-based estimates than previously available. The resulting approach, while not a substitute for Delta hydrodynamic modeling, can provide useful information under constrained schedules and budgets. A user guide has been developed to summarize this work.

Session 25. Delta Modeling

Moderator: Eli Ateljevich [DWR]

Principal Contact: Eli.Ateljevich@water.ca.gov

1. Modeling the Emergency Drought Barrier ... Again

Presenter: Eli Ateljevich [DWR]

Presenter email: Eli.Ateljevich@water.ca.gov

Collaborator(s): Kijin Nam & Qiang Shu [DWR]

Permission for CWEMF to post pdf of presentation: yes

In 2021, the Department of Water Resources installed an emergency hydraulic structure at West False River for the second time. The hydrological context was somewhat different than in 2015 and the barrier remained in place longer in anticipation of further drought. This talk recaps the local flow changes induced by the barrier, changes in salinity and temperature and differences in water age (a surrogate for residence time). The barrier is seen to efficiently reduce salinity intrusion; the barrier changes the spatial pattern of water age leading to areas of increased and reduced age from west to east. More modest changes in temperature patters are also discussed, as well as impacts from a 2017 level storm. We also describe aspects of the action that are hardest to model and some very fine scale modeling around the breach.

2. Hydrodynamic, Water Quality, and Ecological Impacts of Levee Breaches in Suisun Marsh

Presenter: Scott Burdick [RMA]

Presenter email: scott@rmanet.com

Collaborator(s): John Takekawa [Suisun Resources Conservation Dist.]; Richelle Tanner [Chapman U.]

Permission for CWEMF to post pdf of presentation: yes

Suisun Marsh is the largest contiguous brackish wetland in the western US, and it comprises rangelands, open water areas, and managed and tidal wetlands. Its location at the interface between San Francisco Bay and the Sacramento-San Joaquin Delta contributes to its unique hydrodynamics and water quality and makes it an important area for aquatic productivity and native fishes. The levees protecting much of the managed wetlands in Suisun Marsh are maintained by individual landowners and are susceptible to breaching and overtopping. In this talk, we look at the impact of levee breaches in Suisun Marsh on hydrodynamics and water quality both locally and into the Delta. Levee breach scenarios are modeled using a two-dimensional hydrodynamic and water quality model. The impacts of a breach are shown by changes from a base condition in tidal range, net flow, tidal excursion, salinity intrusion, and water temperatures. Impacts are shown to be dependent on the geographical location of the breach, whether the breach occurs off Grizzly or Honker Bay or Montezuma Slough, and the time of year. The ecological and water supply impacts of breaches are discussed within the context of projected future changes in climate and sea levels.

3. Sediment Supply from Local Tributaries to the San Francisco Bay

Presenter: Tan Zi [SFEI]

Presenter email: tanz@sfei.org

Collaborator(s): Lester McKee & Melissa Foley [SFEI]

Permission for CWEMF to post pdf of presentation: yes

Sediment is a critical resource that is essential for sustaining San Francisco Bay tidal marshes and mudflats under a changing climate. Sediment also serves as a contaminant carrier, transporting sediment-associated pollutants to the Bay. Previous estimates are thought to be reasonably reliable for total annual and regional sediment load, but are poorly resolved finer spatial and temporal scales. A new dynamic regional watershed model for analysing contaminant loads and trends is being developed to support the priority management questions (sediment and contaminants) of the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). This regional scale process-based dynamic watershed model will help to understand sediment transport dynamics at the watershed scale and during individual floods when the majority of sediment and pollutant mass enters the Bay, and the scale at which management intervention can be resolved. Specifically, the model simulates rainfall-runoff processes and sediment dynamics for specific sediment classes at an hourly scale while taking into account different geological characteristics, soil types, land use and land covers, and slopes. Efforts have been invested in quantifying the sources, sediment delivery on land surface, and sediment transport processes within channels. This watershed dynamic model is expected to provide a basis for contaminant load estimation and a linkage to the bay models and RMP management questions in the future.

4. Progress in cloud computing for Bay-Delta SCHISM

Presenter: Kijin Nam [DWR]

Presenter email: knam@water.ca.gov

Collaborator: Nicky Sandhu [DWR]

Permission for CWEMF to post pdf of presentation: yes

The Delta Modeling Section of Bay-Delta Office, DWR, has adopted cloud computing for Bay-Delta SCHISM, multi-dimensional hydrodynamics and water quality model for the Bay-Delta a couple of years ago, and it has already been used for various projects, for example, Emergency Drought Barrier evaluation for 2021. From our experience, the cloud computing has been proven to be a very effective tool in many regards, especially under a tight timeline that requires a large amount of computational capacity. At the same time, cloud computing has introduced new technologies continuously and become more affordable as well. For instance, new types of virtual machines reduced computational cost significantly, and new storage technology can improve workflow as well. We are adopting a batch method that can simplify the cloud computing infrastructure while reducing cost. This presentation will report such progresses and comparisons of different approaches, e.g. CycleCloud, Batch, on-premise, from our real-world applications.

Session 26. Habitats & Fish

Moderator: Jeremy Thomas [Jacobs Engineering]

Principal Contact: jeremy.thomas@jacobs.com

1. Challenges in Classifying Habitats with Model Predictions using Hard Suitability Thresholds

Presenter: Benjamin Abban [USBR]

Presenter email: babban@usbr.gov

Collaborator(s): Eli Ateljevich, Seshadri Rajagopal & Jon Shu [DWR]; Blair Greimann [USBR]

Permission for CWEMF to post pdf of presentation: yes

Current approaches for classifying suitable habitat for Delta Smelt adopt hard thresholds for common parameters known to affect Smelt habitat suitability (i.e., temperature, salinity, and turbidity). Spatiotemporal trends in habitat suitability are normally determined using hydrodynamic models, which predict parameter distributions in space and time. The model predictions are compared against the hard thresholds to determine whether habitat is suitable or not. This "black and white" approach of classifying suitable habitat presents several challenges related to model prediction uncertainties and smelt tolerance of near-threshold stream conditions. Even when model prediction bias is small, there is an increased likelihood of classification errors when stream conditions hover around suitable thresholds, thereby increasing uncertainty in suitable habitat identified. We are exploring several options to address this issue, including approaches that either correct for bias or adopt a "softer" thresholding approach based on the likelihood of habitat being suitable near stream threshold conditions and quantifying uncertainties. The options are being examined for both hindcasting and forecasting efforts.

2. Floodplain Rearing Habitat Analysis of the Sacramento River, Sutter Bypass, and Yolo Bypass Associated with Sites Reservoir Feasibility Studies

Presenter: Jeremy Thomas [Jacobs]

Presenter email: jeremy.thomas@jacobs.com

Collaborator: Chad Whittington [Jacobs]

Permission for CWEMF to post pdf of presentation: yes

Sites Reservoir is a proposed off-channel reservoir in the Sacramento Valley, capable of diverting and storing up to 1.5 million acre-feet of excess winter runoff from the Sacramento River and using it to improve water reliability in drier periods. The operations of Sites Reservoir will influence the quantity and quality of off-channel rearing habitat for juvenile salmonids. We performed hydrologic, hydraulic, and ecological modeling to determine the relationships between flows in the Sacramento River and the total area of potentially suitable habitats in the Sacramento River channel, Sutter Bypass, and Yolo Bypass, considering various hydrologic conditions and Sites Reservoir operational scenarios. Existing conditions were evaluated against potential Sites Project diversion scenarios by evaluating changes in the frequency of potential inundation events for different flows that satisfied requisite duration criteria, and changes in average monthly inundated areas that satisfied physical criteria. Depending on reservoir operations and

hydrologic conditions, Sites Reservoir had variable effects on rearing habitat acreage within the study area; for some scenarios Sites improved the frequencies of floodplain rearing habitat inundation, and for some scenarios, it slightly decreased the frequencies of inundation.

3. Transport pathways and processes in the Northern Delta

Presenter: Stephen Andrews [RMA]

Presenter email: steve@rmanet.com

Collaborator(s): Paul Stumpner & Jon Burau [USGS]

Permission for CWEMF to post pdf of presentation: yes

The majority of freshwater flow and sediment, and a large proportion of nutrients and outmigrating juvenile fish enter the Delta from the Sacramento River. This water is transported through a series of transitional reaches – the Sacramento River, Steamboat, Sutter, Georgiana and Miner Sloughs, and the Mokelumne River – to the Central Delta and Suisun Bay. These sloughs are transitional in that they vary between more riverine character (unidirectional flow) and tidal character within a narrow range of Freeport flows. In this study, we characterize conditions in these reaches and how they change based on flow magnitude, spring-neap tidal conditions, gate operations, and potential modifications to the landscape (e.g., tidal wetland restorations). Hydrodynamic and particle tracking models are used to simulate flow and transport through the North Delta. Simple metrics such as travel time, travel distance, entrainment ratios, and tidal to net flow ratios are used to characterize conditions in the reaches. Implications for survival of outmigrating juvenile salmon are discussed, as well as what impacts of landscape and operational changes may have on them.

4. A numerical model for juvenile salmon entrainment at river junctures

Presenter: Benjamin Abban [USBR]

Presenter email: babban@usbr.gov

Collaborator(s): D.L. Smith [USACE]; J. Israel [USBR]

Permission for CWEMF to post pdf of presentation: yes

Flow features are complex at river junctures and it has been studied extensively in the past. The juvenile salmon entrainment into the side channel at river junctures, however, is less investigated; previous studies relied mostly on empirical approaches. In this talk, we present a numerical modeling approach in which a 3D flow solver is used for flows and a numerical fish track model is developed to assess the implications of the fish entrainment at junctures. First, the flow model is validated with the available experimental data, key flow structures are discussed, and the implications for fish entrainment are discussed. Next, the numerical model is used to show that the cross-sectional fish distribution upstream of a juncture is an important factor for fish entrainment efficiency. Fish entrainment efficiency curves are developed and they are compared with the field measured fish tracking data. Further, the model is used to show that the secondary flow in a river bend may have a significant impact on fish entrainment at flow junctures. Finally, a submerged vane is demonstrated to be a potential management option to locally generate secondary flows upstream of a juncture to achieve the desired fish entrainment property.

Session 27. Watershed Modeling & Management Issues

Moderator: David Curtis [West Consultants]

Principal Contact: dcurtis@westconsultants.com

1. Water Right Curtailments and Unavailability Methodology for the Sacramento-San Joaquin Delta Watershed

Presenter: Jesse Jankowski [SWRCB]

Presenter email: jesse.jankowski@waterboards.ca.gov

Collaborator(s): Lisa Hong, Mara Irby, Riley Nolan, Alyssa Campbell, Jeff Laird, Andrew Hill, Robert McCarthy, Scott Ligare, Nicole Williamson, Matt Holland, Conny Mitterhofer, & Diane Riddle (SWRCB)

Permission for CWEMF to post pdf of presentation: yes

As a result of ongoing dry conditions in the Sacramento-San Joaquin Delta Watershed, in August 2021 the State Water Resources Control Board adopted an emergency regulation which authorized the Board's Division of Water Rights to issue orders curtailing surface water diversions when water is unavailable. The Delta Water Unavailability Methodology is a water accounting model developed to implement this regulation, evaluating water supply and demand across the watershed to determine which water rights or claims of right may be under curtailment at a given time. It incorporates the interconnected hydrology of the watershed and the Delta, reported water right diversion data, water right priority dates, water supply forecasts, instream flow releases, and agricultural and municipal return flows. The Division uses the Methodology on a regular basis to evaluate water unavailability and determine the curtailment status of nearly 17,000 water rights and claims in the watershed based on evolving conditions.

2. Real Time Forecast Modeling for the San Joaquin Basin

Presenter: Marco Bell [WEST Consultants]

Presenter email: mbell@WESTconsultants.com

Collaborator: Stephen Ho [Merced Irrigation District]

Permission for CWEMF to post pdf of presentation: yes

The Merced Irrigation District (MID) has developed a real time systems (RTS) model of the Merced River Basin in collaboration with Airborne Snow Observatories, Inc. (ASO), the California Department of Water Resources (CADWR), the United States Army Corps of Engineers (USACE), the California Nevada River Forecast Center (CNRFC), The United States Bureau of Reclamation (USBR), The Yosemite National Park, and others. The model is referred to as Merced Irrigation District Hydrologic and Hydraulic Optimization (MIDH2O). MIDH2O is a hydrologic, hydraulic, and reservoir operational decision-making support tool to provide MID with information for optimizing operations including hydropower, regulatory compliance, flood risk reduction, irrigation water supply, and groundwater management. The three major model components of MIDH2O are HEC-HMS, HEC-ResSIM, and HEC-RAS. The models use gridded hourly forecasts to simulate the snow accumulation and runoff into New Exchequer. The goal is to expand the HEC-HMS to the entire San Joaquin Basin. MIDH2O has been used for climate change studies, Flood-MAR pilot studies, snow research, water supply studies and April-July snowmelt runoff forecast.

3. Updates of Unimpaired and Natural Flows for Central Valley of California by Bay-Delta Office (BDO) Extended Through Water Year 2020

Presenter: Shalamu Abudu [DWR]

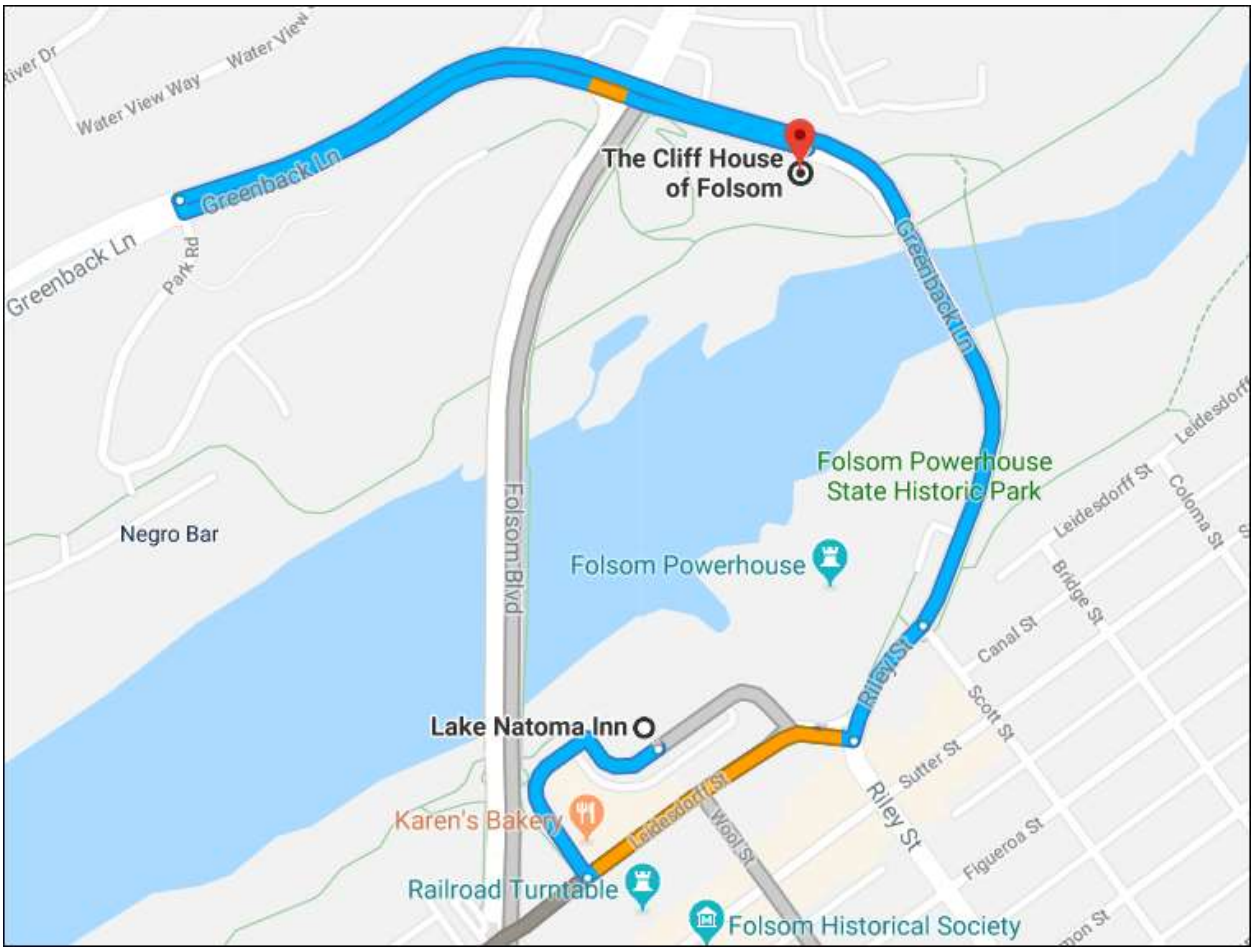
Presenter email: shalamu.abudu@water.ca.gov

Collaborator(s): Tariq Kadir & Guobiao Huang [DWR]

Permission for CWEMF to post pdf of presentation: yes

Stream flows into California's Sacramento - San Joaquin Delta (Delta) under pre-development vegetative conditions provide scientific support and guidance to establish minimum stream flows, restoration targets, and a basis for assessing impacts of global warming in the Bay-Delta system. California Department of Water Resources (DWR)'s Bay-Delta Office (BDO) has been estimating and publishing estimates of natural and unimpaired flows for all areas in the Central Valley tributary to the Delta since 1980. BDO's most recent published natural and unimpaired estimates cover the period Water Years (WY) 1922-2015. This presentation will cover recent work by BDO extending the estimates of both natural flows and unimpaired flows through WY2020. The unimpaired flows are extended using existing unimpaired flow calculation equations for removing upstream diversions, storage, or export of water to or import of water from other basins. The natural flows are extended previously developed Soil Water Assessment Tool (SWAT) models for the rim watersheds and a version of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim). Comparative analysis highlighting the differences between the estimated natural and unimpaired flows will also be presented. The digital data and associated documentation will be made available to the public in the first quarter of 2022.

DIRECTIONS TO BUSINESS MEETING
(CLIFF HOUSE OF FOLSOM)



DIRECTIONS:

- Depart Lake Natoma Inn
- Head southwest on Gold Lake Dr toward Leidesdorff St for 0.2 mi
- Turn left onto Leidesdorff St, travel 0.2 mi
- Turn left onto Riley St, travel 450 ft
- Continue onto Greenback Ln, travel 0.8 mi
- Make a U-turn at Park Rd, travel 0.4 mi
- Destination will be on the right:
  The Cliff House of Folsom, 9900 Greenback Ln, Folsom, CA 95630

LIST OF LOCAL RESTAURANTS

1. J Wild's Livery & Feed – 614 Sutter St.
2. Plank Craft Kitchen + Bar – 608 Sutter St.
3. Sutter Smokehouse – 703 Sutter St.
4. Q'Bole! Mexican Cocina & Cantina – 718 Sutter St #201
5. Gaslight Co. – 718 Sutter St. #200
6. Hacienda Del Rio Mexican Restaurant – 702 Sutter St
7. Hop Sing Palace – 805 Sutter St
8. Pizzeria Classico – 702 Sutter St
9. Scott's Seafood Roundhouse – 824 Sutter St.
10. Sociology Coffee Bar – 705 Gold Lake Dr. #390
11. Sutter Street Taqueria – 727 Sutter St
12. Naan Tikka – 915 Sutter St.
13. Cliff House – 9900 Greenback Lane
14. Fat Rabbit Public House – 825 Sutter St.
15. Escape Folsom – 727 Traders Lane
16. Mystique Dining – 611 Sutter St.
17. Samuel Horne's Tavern – 719 Sutter St.

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