GROUNDWATER RESOURCES ASSOCIATION OF CALIFORNIA

HYDRO VISIONS

VOLUME 18, NO. 2 SUMMER 2009

Groundwater Salinity:

A Groundwater Dilemma

Highlights and Summary by:
Jean E. Moran, California State University, East Bay; Michael Steiger, Erler & Kalinowski, Inc.;
Vicki Kretsinger, Luhdorff & Scalmanini, Consulting Engineers; Karl Longley, Chair,
Central Valley Regional Water Quality Control Board; Sargeant Green, California Water Institute;
Ray Tremblay, Los Angeles County Sanitation Districts; Ted Johnson, Water Replenishment District of Southern California;
Rudy Schnagl, Central Valley Regional Water Quality Control Board; Jose Faria, Department of Water Resources;
Andrew Chang, UC Center for Water Resources

GRA and the UC Center for Water Resources held a joint conference "Groundwater Salinity: A Groundwater Dilemma" on March 24 and 25, 2009 at the Radisson Hotel in Sacramento. As one conference attendee stated on the conference evaluation form, "Salt is THE issue." In California, the impacts of salinity include increasing concentrations of many salts in groundwater used for municipal and agricultural supplies, retirement of hundreds of thousands of acres of agricultural land due to saline-sodic soils, and drainage problems from highly saline shallow groundwater. Meanwhile, more and more resources are directed toward monitoring, treatment, and management of salinity by agricultural, industrial, and municipal dischargers. Many of the 164 conference attendees expressed a desire to stay current on research, management practices, and regulations; this conference addressed those needs by bringing together scientists, water managers, regulators, and

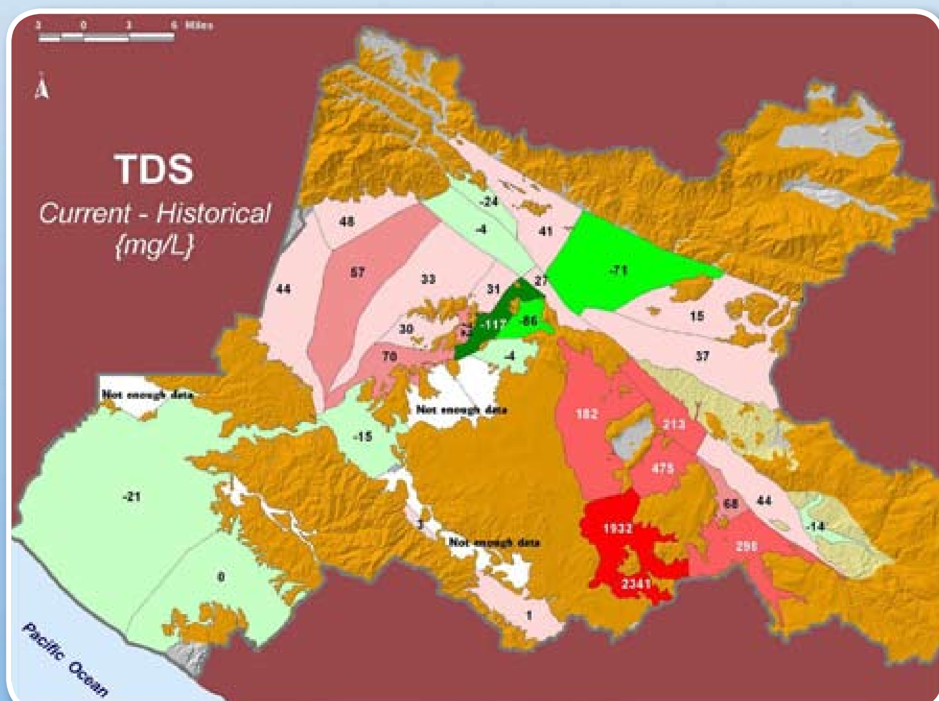


Figure 1. Salinity management in the Santa Ana watershed is examined by highlighting changes in TDS in newly defined management zones (Andrew Malone of Wildermuth Environmental, Inc.).

Continued on page 4…

The Groundwater Resources Association of California is dedicated to resource management that protects and improves groundwater through education and technical leadership.

Rock core sampling in southern California.

Inside this Issue

Features

Columns & Corners

HYDROVISIONS is the official publication of the Groundwater Resources Association of California (GRA). GRA's mailing address is 915 L Street, Suite 1000, Sacramento, CA 95814. Any questions or comments concerning this publication should be directed to the newsletter editor at editor@grac.org or faxed to (916) 442-0382.

Focus on Value

By James Strandberg

As California's economy, our environmental industry and GRA members face challenging times, GRA's Directors are searching for ways to build upon the Association's role as California's leading authority on groundwater resources through professional education, and to provide membership value. Some members have been unable to renew their memberships, and GRA events are drawing fewer attendees. We continue to receive excellent reviews for our events, but recognize that fewer professionals have been able to attend.

To support our membership and the needs of our industry, we will continue to offer high-quality events while carefully managing expenses to maintain GRA's strong financial standing. We continue to search for topics that will be of greatest interest to GRA members and rely on the dedication and passion of volunteers to make the events successful.

We have reached out to students by offsetting registration fees to statewide events, and several of GRA's Branches have active scholarship programs. For Micropol & Ecohazard 2009 (June 8-10, San Francisco), a world-class event held annually by the International Water Association and co-sponsored this year by GRA due to its focus on emerging contaminants, GRA offset the registration fees for four California college students, and the San Francisco Bay Area Branch elected to do the same for two more. This event is a microcosm of the challenges GRA has faced. During the early planning stages, the economy was much stronger and event planners targeted an audience of 350-400 participants; we now are hoping to attract 250 participants.

Our Directors and Committee Chairs have begun to prepare for our Annual Strategic Planning Meeting to be held in Berkeley on August 16, 2009 immediately following our quarterly Board meeting on August 15. We hold this important planning session mid-year so activities we adopt or potentially discontinue can be incorporated into the following year's budget. We will consider the challenges faced by the Association and focus on enhancing member benefits while maintaining GRA's vitality. Topics will include holding membership dues and registration fees steady for another year, website improvements, a statewide online event registration system, and potential use of recent online communication methods.

A recent member benefit that has received high acclaim is the newly designed online version of *HydroVisions* (HV). Our Communications Committee, chaired by Bill Pipes, and HV Editor, Steve Phillips, received numerous compliments and helpful suggestions. This edition revives an old feature at the suggestion of GRA's Founding President and Director, Vicki Kretsinger, titled "Student/Research Corner." This column provides a forum for college students to present their research to a large audience and offers HV readers a glimpse of current research on groundwater-related topics.

Another valuable member benefit is access to speaker PowerPoint presentations from all GRA events. Only event attendees may download the presentations; however, non-attending members may view the presentations, which helps offset the inability to attend an event.

GRA recently held three very successful statewide events, all covered in this issue. I thank Co-Chairs Brian Wagner and Eric Reichard of the U.S. Geological Survey, and the rest of their planning committee, for organizing "*Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making,*" held in February. I also thank Co-Chairs Michael Steiger of Erler & Kalinowski, Inc., Jean Moran of CSU East Bay, Vicki Kretsinger of Luhdorff & Scalmanini Consulting Engineers, and the rest of their planning committee for organizing "*Groundwater Salinity: A Groundwater Dilemma,*" held in March in collaboration with the UC Center for Water Resources. Finally, I thank GRA's legislative advocates, Chris Frahm and Paul Bauer of Brownstein Hyatt Farber and Schreck LLP and the Legislative Committee Chair, Tim Parker, for organizing another very successful Legislative Symposium and Lobby Day at the Capital in April.

As the drought continues and our economic challenges persist, I wish you all the best and thank you for your support of GRA.

Groundwater Salinity: A Groundwater Dilemma *– Continued from Page 1*

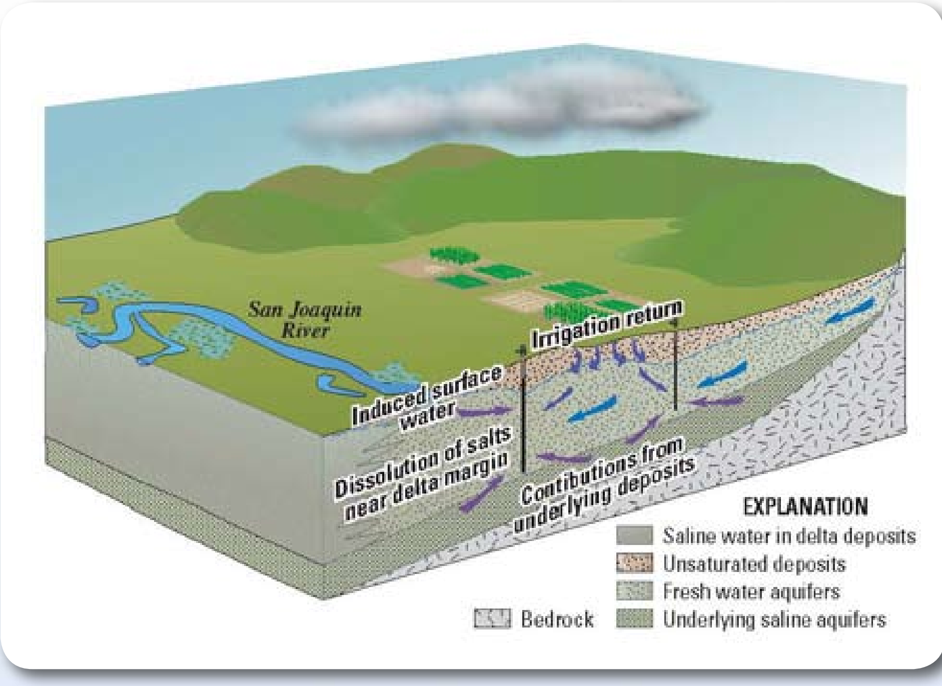


Figure 2. This schematic representation of the groundwater basins of San Joaquin County shows the major sources of salinity (Brandon Nakagawa of San Joaquin County and the Northeastern San Joaquin County Groundwater Banking Authority).

practitioners focused on various aspects of groundwater salinity.

The conference was especially timely because of a new State Water Resources Control Board policy that will require all groundwater basins and sub-basins in the state to develop salt and nutrient management plans within the next 5 years. The policy was shaped by the cooperative efforts of the Central Valley Salinity Coalition CV-SALTS (Salinity Alternatives for Long-Term Sustainability) initiative. One speaker described the new state policy as the 'full employment for hydrogeologists act of 2009.' Urgency in addressing salinity issues is also warranted because of the pressing challenges that will arise with a new paradigm for managing the Sacramento-San Joaquin delta. These challenges will be met, in part, by finding new ways to increase alternative water sources, including recycled water and storm water. Although the state is encouraging and supporting the increased reuse of discharge water and storm water, there are concerns about salt and nutrient loading of groundwater basins as a result of these activities.

Daniel M. Dooley, Vice President of the University of California (UC) Division of Agriculture and Natural Resources, opened the conference with his presentation on "Groundwater in the Broader Context of California Water Policy." Mr. Dooley described the major groundwater challenges facing California as population increases from 34 million in 2000 to 59 million in 2050. Understanding the role of groundwater and maintaining its quality are critical to California's future water policy. He explained that while some basins have adopted voluntary management plans, and many basins in southern California have been adjudicated, California does not have a statewide groundwater management program. Future issues facing California are likely to include continued water quality degradation. Compounding the challenges is the fact that institutional and regulatory structures are not geared to present or future complexities. Furthermore, state policies and regulations are focused on specific issues rather than system management, and fragmented water right and delivery systems make efficient management of quantity and quality difficult.

The next speaker in the opening session was Fred Phillips, Professor of Hydrology and Director of the Hydrology Program at New Mexico Tech. His talk "Salt in the Rio Grande: Where Does It Come From, Where Does It Go?" described research being conducted to assess the causes of increased salinity in the river of almost two orders of magnitude from its headwaters to where remaining flow is entirely diverted for irrigation. Topics that the research addressed included: 1) source(s) of the salt; 2) the salt budget of the river; 3) the relationship between groundwater and river salinity; and 4) the response of the river to prolonged drought. Dr. Phillips explained that traditional approaches to quantifying salinization include measuring the discharge and salt concentrations at gauging stations and computing the salt burden. Alternative approaches include measuring environmental tracers at high spatial resolution and employing dynamic simulation tools to interpret the results. The research shows that a large proportion of the salinity observed over time is the result of slow migration of connate brines into the Rio Grande River. Two other significant influences on salinity include solute concentration from evapotranspiration and geochemical reactions of solutes in irrigation water with the minerals and gases present in the soil. Understanding the salinity sources and dynamics are key to the development and evaluation of measures to mitigate the river salinity.

John Letey, Emeritus Professor of Soil Physics and Soil Physicist at UC Riverside, concluded the opening session with his talk "The Dilemma of Conflicting Laws." Agriculture plays a substantial role in California's economy and livelihood. A dilemma exists in the dual goal of sustaining high agricultural

Continued on the following page…

Groundwater Salinity: A Groundwater Dilemma – *Continued*

productivity and protecting groundwater quality. Dr. Letey summarized several scientific laws that play a role in the dilemma, including:

- It is physically impossible to irrigate without some water and nitrogen passing below the root zone;
- The salt concentration leaving the root zone is more concentrated than the irrigation water; and
- Chemicals in the soil strata below the root zone will be mobilized by flowing water.

He explained that additional factors arise due to the soil depositional environment. For example, on the west side of the San Joaquin Valley, soils that were originally beneath the ocean are high in salts and other constituents associated with a marine environment. Given the above physical laws, it is technically impossible to eliminate the migration of all constituents from agricultural lands to groundwater. However, irrigation management helps control constituent migration.

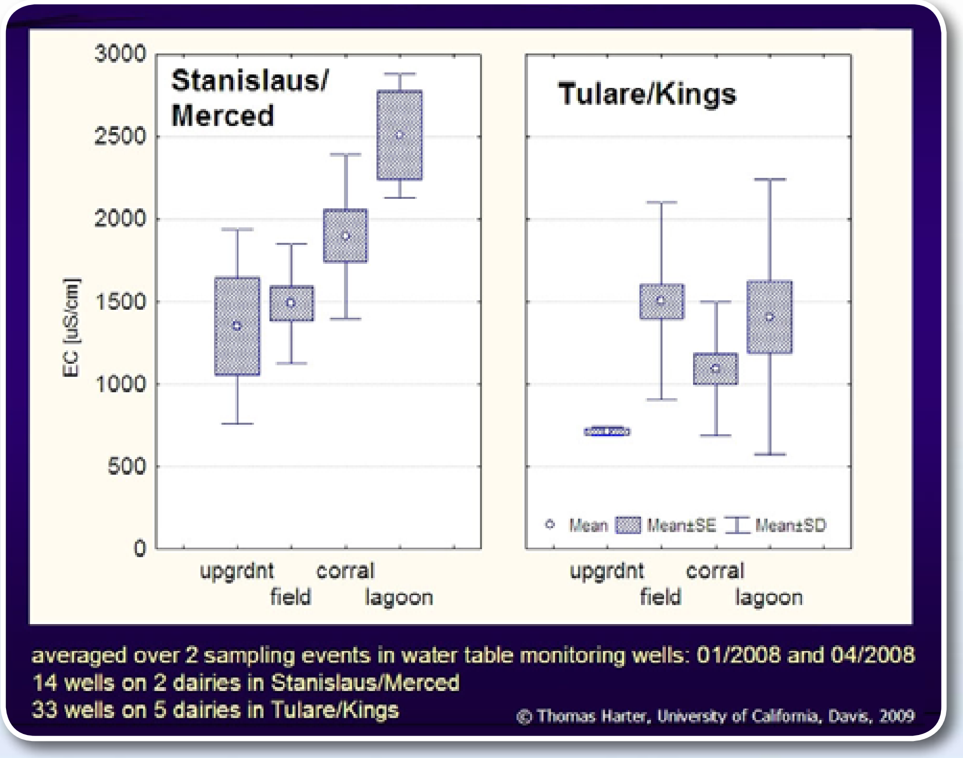


Figure 3. Salinity impacts to groundwater underlying various dairy operations are compared for dairies from the central and southern Central Valley (Thomas Harter of UC Davis).

Joe Grindstaff, of CALFED, opened the first general session with an overview of salinity impacts on industry, domestic use and the environment, and he provided an overview of actions undertaken by the Santa Ana Watershed Project Authority to develop an effective salinity management plan. Richard Howitt, of UC Davis, reported on the economic impact of "no action" to mitigate and adapt to the increasing salinization of the Central Valley's soils and waters. This study reported significant adverse economic consequences resulting from the lack of progress in addressing salinity impacts. Graham Fogg, of UC Davis, reported on the impacts of climate change on groundwater sustainability and salinity. He pointed out that the new timing of runoff will require different mechanisms for storing water. To develop sufficient subsurface storage, Dr. Fogg suggested that we identify the best locations for infiltration, implement local enhancements, and allow at least portions of floodplains to periodically flood. Overall, this session highlighted the impacts of increasing levels of salinity in water supplies and the technological and institutional challenges that must be addressed.

In the first concurrent session of the day on characterization methods, Nigel Quinn of Lawrence Berkeley National Laboratory discussed the use of adaptive fluid logging to determine the depth and distribution of salt beneath seasonally flooded wetlands. Using introduced deionized water and flowing fluid electrical conductivity logging, a detailed picture emerges for each borehole beneath a wetlands site near Los Banos, showing ribbons of permeable areas and a high resolution depth profile of salinity concentrations. John Jansen, of Aquifer Science and Technology, presented "Geophysical methods to map brackish and saline water in aquifers," an example of large-scale mapping of seawater intrusion to a depth of 350 feet in the Los Angeles West Coast Basin using geoelectrical methods. Thomas Butler, of ECO:LOGIC Engineering, presented a study in which analyses of stable isotopes and major cations and anions were applied to differentiate salinity impacts at wastewater treatment and disposal facilities. Stable isotopes of the water molecule were used to identify groundwater that had been evaporated in disposal ponds, or affected only by transpiration (surrounding groundwater); ion exchange processes that take place in disposal pond sediments further differentiated salinity sources. These three presentations showed the wide range of techniques available to provide data for informed decision making in areas where salinity is a key regulatory driver.

Continued on the following page…

Groundwater Salinity: A Groundwater Dilemma – *Continued*

Charles Kratzer, of the U.S. Geological Survey (USGS) began the concurrent "regional salinity sources" session with a discussion of salinity "hot spots," investigating the vertical and horizontal extent of shallow saline groundwater beneath and near the main stem of the San Joaquin River. The data indicate that the vertical extent of salinity impacts is limited, but that the horizontal extent is quite variable. Hot spots were found east of the River that could not be explained by groundwater gradients. Salt-laden groundwater west of the River appeared to have migrated eastward beneath the River. Bryant Jurgens, of the USGS, presented data from the Groundwater Ambient Monitoring and Assessment (GAMA) program for the eastern San Joaquin Valley, where significant levels of bicarbonate, calcium, nitrate, and sulfate have increased in different proportions since the turn of the 20th century as a result of irrigated agriculture. Associated soil-zone processes generate concentrations of bicarbonate high enough to make it the primary component of salinity in 458 shallow wells sampled in eastern San Joaquin Valley. In turn, bicarbonate is postulated to complex with uranium and cause uranium mobilization, which is responsible for the loss of many public supply wells on the east side. John Izbicki, of the USGS, described the groundwater flow and geologic conditions that have caused significant changes in chloride concentrations in wells in eastern San Joaquin County. Deltaic sediments have stored chloride and pumping depressions east of the chloride source areas have increased and expanded, allowing substantial migration of chloride into wells in the Stockton area.

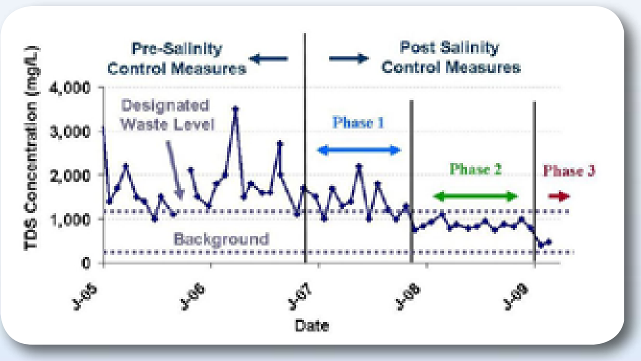


Figure 4. Graphical results from a project aimed at salinity discharge compliance at a rendering facility showing improvement after implementation of source control measures (Michael Steiger, Erler & Kalinowski).

Pascual Benito, of Northgate Environmental, led off a concurrent session about fate and transport with a presentation about regional groundwater degradation from the food processing industry. To model waste attenuation with a wide range of waste types and site conditions, he developed "transfer functions" for categories of food processors. The transfer functions were used with a regional groundwater flow model, showing substantial attenuation of nitrogen compounds, and limited attenuation of salinity. The groundwater impacts were shown to be fairly localized due to vertical gradients from pumping below the Corcoran Clay. Donald Suarez, with the U.S. Salinity Laboratory, discussed computer simulation models to evaluate the effects of agricultural best management practices on groundwater quality. The modeling results suggested that due to geochemical reactions, reduced leaching volume would not result in a proportional decrease in salt load. Chris Heppner, with Erler & Kalinowski, Inc., examined shallow groundwater salinity near a wastewater treatment facility. He used available data upgradient of the wastewater treatment plant to show that salinity increased in the direction of groundwater flow and discussed possible mechanisms for this pattern, including evapoconcentration. A monitoring well network was designed to evaluate "background" conditions. Brian Heywood, of Camp Dresser McKee Inc., presented two case studies of modeling saline impacts on groundwater. The first was a highway salt mixing and storage facility with a dense salt plume at the base of the aquifer, 1,700 feet from a municipal well field. The modeling helped to evaluate multiple combinations of remedial pumping options to protect the municipal well field. The second study was a regional-scale model to evaluate impacts on water quality from dredging of the Savannah harbor. The model was used to show that increases in concentration in the aquifer resulted more from changes in concentration at the bottom of the river than from dredging.

Sometimes the best technical and most cost-effective solutions are only as good as their implementation; a concurrent session on regional/political solutions to salinity focused on the policy and politics involved with controlling salinity in groundwater. Andrew Malone, of Wildermuth Environmental Inc., discussed the watershed approach to basin planning implemented in the Santa Ana River region; this approach has become a model for cooperation that other agencies in the state hope to emulate. Francisco Guerrero, of the Los Angeles County Sanitation Districts, described efforts to control salinity discharges to local POTWs through legislative action and local elections. Daniel Cozad, of Integrated Planning and Management, Inc., described the stakeholder-driven process being developed for the Central Valley Regional Board to institute regional salinity and nutrient management plans. Brandon Nakagawa, of San Joaquin County, closed the evening with a discussion of the Northeastern San Joaquin County Groundwater Banking Authority's efforts to identify sources of salinity and adopt a regional water management plan.

On the second day, Dr. Thomas Harter, of UC Davis, opened a concurrent session titled "Source Impacts and

Continued on the following page…

Groundwater Salinity: A Groundwater Dilemma *– Continued*

Source Control" with a talk answering the question "How much salt is added to groundwater by a dairy operation relative to other agricultural operations, and what are the long term implications for groundwater salinity in the major dairy regions in California?" He answered these questions by (1) investigating various dairy-derived salt sources; (2) providing estimates on salt loading to groundwater; (3) performing computer modeling on heterogeneous alluvial aquifer systems; and (4) comparing four regional dairy areas in the state, including San Joaquin Valley, eastern Tulare Lake Basin, Eel River Valley, and Chino Basin. Michael Steiger, of Erler & Kalinowski, Inc., discussed controlling saline discharges from a rendering facility. The goal of the project was to bring salinity and nutrient wastewater management practices into compliance with the State Anti-Degradation Policy. Extensive source control treatment alternatives were evaluated and a salinity mass balance performed. The selected source control measures are now being implemented with onsite monitoring indicating positive results, which saved up to $15 million in penalties and compliance costs. Joseph DiGiorgio, of Eco:Logic Engineering, discussed a 10-year effort by the City of Dixon to characterize and regulate municipal wastewater salinity impacts to protect the groundwater resources of this agriculturally-dominated area. Difficulties arose when the "background" water quality was found to be so variable in salinity concentrations that it was very difficult to determine if the source of the salts was the local wastewater treatment plant or the extensive agricultural activities in the area. Stable isotopes and boron were used to assist in the analysis as well as pharmaceuticals and other anthropogenic compounds. The City is now relying on wastewater source control, better groundwater characterization, and effluent discharge limitations to achieve regulatory compliance.

A session on Regulatory and Policy Issues comprised four presentations. Les Grober, of the State Water Resources Control Board (State Water Board), described the process that agency is following to review the salinity standards for channels at the south end of the Sacramento-San Joaquin Delta. Ken Landau, of the Central Valley Regional Water Quality Control Board, described the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) initiative, which is developing a salinity management plan and Basin Plan amendments addressing surface water and groundwater in the Central Valley. He also described the regulatory approach being used to address salinity when waste discharge requirements are updated. Steve Bayley, of the City of Tracy, discussed the steps the City is taking to reduce salt levels in wastewater being discharged to the Delta. Gary Carlton, of Kennedy/Jenks Consultants, and former member of the State Water Board, discussed the State Water Board's Statement of Policy with Respect to Maintaining High Quality of Waters in California. Mr. Carlton explained how this policy, commonly referred to as the anti-degradation policy, affects the regulation of discharges containing salt.

For the concurrent session about technologies, John Diener, with Red Rock Ranch, opened with a presentation titled "Integrated on-Farm Drainage Management: A Salt and Shallow Water Table Management Technique for Irrigated Lands." The IFDM project at Red Rock Ranch manages irrigation water on salt sensitive, high value crops and reuses drainage water to irrigate salt tolerant crops, trees and halophyte plants. A solar concentrator process receives the final volume of drainage water; salts are accumulated and used to produce marketable products. There is no disposal of salts and other trace elements from subsurface drainage water outside the farm. Michael Garrod of Sweetwater Authority presented "One Water District: Three Desalination Projects." Mr. Garrod discussed three projects that desalt brackish water and seawater to supplement their district's water needs. The main project is the just-approved Carlsbad Desalination Project, which consists of a 50 million gallon per day (56,000 acre-feet per year) seawater desalination plant and associated water delivery pipelines. The project is located at the Encina Power Station in the City of Carlsbad. Sweetwater Authority uses desalination technologies to provide a local source of potable water to supplement imported water supplies, improve water supply reliability, improve water quality, and complement local and regional water conservation and recycling programs. Abraham Migemi, of Israel's national water company (Mekorot) discussed saline water in Israel. In addition to producing and supplying water from natural sources, Mekorot, which sup-

Continued on the following page…

Groundwater Salinity: A Groundwater Dilemma *– Continued*

plies about 70% of Israel's water supply, has increased deliveries by reclaiming 190 million cubic meters of wastewater annually, and operating 31 desalination facilities of brackish water and seawater. In view of Israel's climatic conditions, Mekorot developed and integrated dozens of brackish-water desalination plants that enable towns and cities far from the regional water systems to obtain reliable potable water.

Kate Huckelbridge, with UC Berkeley, opened a concurrent session about wetland and river salt measurement and management with a presentation about salt dynamics in seasonal freshwater wetlands. The research focused on examining the mixing and transport of dissolved salts in the water column, the exchange of salt at the soil-water interface, and the effects of management activities on salt dynamics. Field and modeling studies indicate that high winds have the potential to drive internal mixing on short timescales, but that vegetation provides a much more consistent influence on mixing. At the soil-water interface, the largest mass of salt was released to the water column during long periods of flooding, although overall, the inflow acts as the primary source of salt. The best management strategy for minimizing salts loads discharged to the water column was found to be rapid flood-up and drawdown. Patrick Rahilly, with UC Merced and Grasslands Water District, gave a presentation about utilizing an electromagnetic device to produce soil salinity maps. Wetland managers are concerned that limiting salt and boron discharges to the San Joaquin River to certain times of the year will alter the hydrology in managed wetlands and adversely impact the productivity of the wetlands by increasing soil salinity. In one study, the device was found to produce good correlation to the lab-tested electrical conductivity. Andrew Tinka, with UC Berkeley, discussed the use of Lagrangian sensing technology to address issues in monitoring flow and transport in estuarial environments. They developed a drifting sensor network leveraging existing cell phone networks that can carry modular sensors for application-specific investigation and monitoring.

Researchers from the University of California system gave presentations in a session on seawater intrusion and saline drainage. Hugo Loáiciga, a professor at UC Santa Barbara, discussed methods for simulating the effects of projected sea-level rise due to human-induced climate change in a talk titled "Assessment of Seawater Intrusion Potential from Sea Level Rise and Pumping in Coastal Aquifers of California." He stressed the importance of including variable-density flow and the effects of pumping in a 3-D finite element numerical model, and showed examples from the Oxnard Plain and the Salinas Valley. Blake Sanden, a UC Cooperative Extension Advisor for Kern County, gave a lively presentation on "Large Scale Utilization of Saline Groundwater for Development and Irrigation of Pistachios Interplanted with Cotton." His presentation included extensive results of a multi-year trial designed to examine the sustainability of using saline water for commercial development of pistachios. A significant conclusion of the study is that the trial system may require 6 to 10 inches of annual effective rainfall or freshwater winter irrigation to be sustainable.

The final session of the day was a panel discussion, providing an excellent wrap-up for the conference. This session brought together the water-supply, water-quality, energy, and policy considerations that are tightly linked and must be addressed to ensure a sustainable future. Michael Hightower, of Sandia National Laboratory, provided an important discussion on the nexus between water and energy. He discussed data showing the large amount of water required for the various forms of alternative energy sources being considered and/or developed. He also discussed the energy requirements for desalination. Kamyar Guivetchi, Manager of Statewide Integrated Water Management, DWR, reported on the 2009 Update to the California Water Plan and pointed out that water quality is receiving increased focus in this update as evidenced by the new Water Plan Strategy "Salt and Salinity Management." Elizabeth Haven, Chief, Regulation Unit, State Water Resources Control Board, reported on the Waterboard's efforts towards salinity management and discussed implications of the water recycling policy approved by the State Water Resources Control Board on February 3, 2009. Bobbi Larson, Central Valley Salinity Coalition, reported on the efforts of the Central Valley Alternatives for Long Term Sustainability (CV-SALTS) and the formation of the Central Valley Salinity Coalition (CVSC), and the expected role for CVSC.

Figure 5. Blake Sanden discusses the use of saline groundwater for irrigation of pistachios (photo credit Joe DiGiorgio).

Figure 6. Panelists Elizabeth Haven (State Water Resources Control Board), Michael Hightower (Sandia National Laboratory, and Bobbi Larson (Central Valley Salinity Coalition) discuss the future for salinity management in California (photo credit Joe DiGiorgio).

Dates & Details

GRA EVENTS & KEY DATES

(Please visit www.grac.org for detailed information, updates, and registration unless noted)

GRA/IWA Conference Micropol & Ecohazard 2009
Assessment & Control of Micropollutants/Hazardous Substances in Water
Jun. 8-10, 2009 | Burlingame, CA

GRA Board & Planning Meetings
Aug. 15-16, 2009 | Berkeley, CA

27th Biennial Groundwater Conference/GRA 18th Annual Meeting
Oct. 6-7, 2009 | Sacramento, CA

GRA Nanotechnology Symposium
Call for abstracts:
www.grac.org/nanotech.asp
Nov. 3, 2009 | Northern CA

Toward Sustainable Groundwater in Agriculture – An International Conference Linking Science and Policy

JUNE 15-17, 2010 – SAN FRANCISCO, CA

Organized by Water Education Foundation
and the University of California Davis
Co-Sponsored by GRA

Groundwater is the lifeline for many rural and agricultural regions and their associated cultures and populations around the globe and a cornerstone of global food production. Groundwater constitutes nearly half the world's drinking water and much of the world's irrigation water supply. Population growth, overexploitation, salinization, nonpoint source pollution from agricultural activities (including animal farming, ranching, and forestry activities), impacts to surface water, and groundwater quality and quantity conflicts at the urban-rural interface have reached global dimensions and threaten the health and livelihood of this planet.

As we enter the second decade of the 21st millennium, this international conference brings together leading scientists, policy analysts, policy and decision makers, and agricultural and environmental stakeholder groups to define and highlight the science, challenges, and potential policy solutions in agricultural groundwater resources management and groundwater quality protection that will provide a sustainable future at regional, national, and global scales.

Conference speakers will be featured in general assemblies and also concurrent sessions that include the following issues and topics:

Socio-Economic Aspects of Agricultural Groundwater

- Agricultural groundwater and livelihoods: socioeconomics, policy issues, and adaptation
- Environmental justice and human health related to groundwater use in rural areas
- Groundwater's role in global food production

Climate, Energy, and Agricultural Groundwater

- Groundwater and climate change, including land use issues, groundwater recharge, and farming security
- Groundwater and energy, including biofuels, energy efficiency, carbon footprint of agriculture, and the role of energy subsidies

Agricultural Groundwater Quality and Contamination

- Groundwater salinity, including intrusion, drainage issues, and secondary salinization

Continued on the following page…

Toward Sustainable Groundwater in Agriculture – An International Conference Linking Science and Policy – *Continued*

- Impacts, monitoring, regulation, best management practices (BMPs), policy, economics regarding specific agricultural contaminants:
  - Nutrients (nitrogen and phosphorus)
  - Pesticides
  - Pharmaceuticals in animal farming
  - Pathogens and food safety
  - Farm petroleum-product management and groundwater contamination

Conjunctive Use, Agricultural Water Use, and Groundwater Management, Policy, and Regulation

- Conjunctive use of groundwater and surface water
- Irrigation water delivery and use efficiency: groundwater impacts, sustainability of irrigated agriculture, soil salinization due to increased water use efficiency, and conservation
- Groundwater management approaches, including community/collective approaches, instrumental approaches (laws, regulations, prices), demand management, and indirect approaches (energy policy, agricultural policies, adaptation)
- Management of the groundwater-agriculture nexus around the globe
- Groundwater recharge, including managed aquifer recharge (MAR), aquifer replenishment in crop production areas, increased recharge under land conversion to crop land, policies for aquifer recharge
- Policies related to economics of shifting agricultural management to control groundwater depletion/contamination, etc.
- Source water protection (groundwater) in agricultural regions, including policies, management, and economics
- Regulatory compliance related to nonpoint source impacts to groundwater, ambient groundwater monitoring for groundwater protection, including vadose zone monitoring, nutrient balance monitoring, and groundwater monitoring
- Modeling and assessment tools for evaluating agricultural groundwater quality and quantity trends and forecasting future conditions

Groundwater at the Agriculture-Urban Interface

- Groundwater use, management, and quality at the agriculture-urban interface, including agricultural legacy contamination
- Reuse of wastewater and biosolids in agriculture, including water quality impacts, economic incentives, and sustainable management
- Groundwater quality and management issues in forestry

Groundwater Linkages to Surface Water and Estuaries

- Surface water–groundwater interactions: impacts to and from agriculture, farm-groundwater-stream ecology linkage
- Agricultural groundwater and estuary ecosystems

Abstracts

Abstract submittal is open from September through December 31, 2009. For updates, please check: http://www.ag-groundwater.org (after June 2009)

Sponsors and Exhibitors

WEF and GRA are pleased to invite participants to sponsor Conference functions or to exhibit at the Conference. Exhibitors, please contact Mary Megarry at mmegarry@nossaman.com or 916-446-3626 for more information. Sponsors, please contact Rita Schmidt-Sudman at rsudmann@watereducation.org or 916-444-6240 for more information.

More Information

Please reserve the Conference dates and join us to hear the latest scientific, management, legal, and policy advances for sustaining our groundwater resources in agricultural regions. For more information, contact Rita Schmidt-Sudman at rsudmann@watereducation.org or 916-444-6240. Check the University of California Groundwater Cooperative Extension Program website at http://groundwater.ucdavis.edu/calendar.htm or http://www.ag-groundwater.org for conference updates.

mark your calendar

27th Biennial Groundwater Conference & 18th Groundwater Resources Association Annual Meeting

"Water Crisis and Uncertainty: Shaping Groundwater's Future"

October 6-7, 2009

Sacramento Convention Center, Sacramento, CA

California is facing an unprecedented water crisis spawned by climate change, drought, legal decisions, a failing Delta ecosystem, and a faltering economy. Groundwater will necessarily play an important role in dealing with this crisis, and decisions during this time may cause groundwater policies to change in dramatic ways.

Featuring topics such as:

- **Optimizing Water Storage: Dams and Subsurface**
- **Groundwater Salinity and Nutrient Management**
- **Planning for Times of Drought**
- **Water and Energy: Optimizing Groundwater Pumping**
- **Exploring Options of Groundwater Management**

A Call for Posters will be forthcoming.

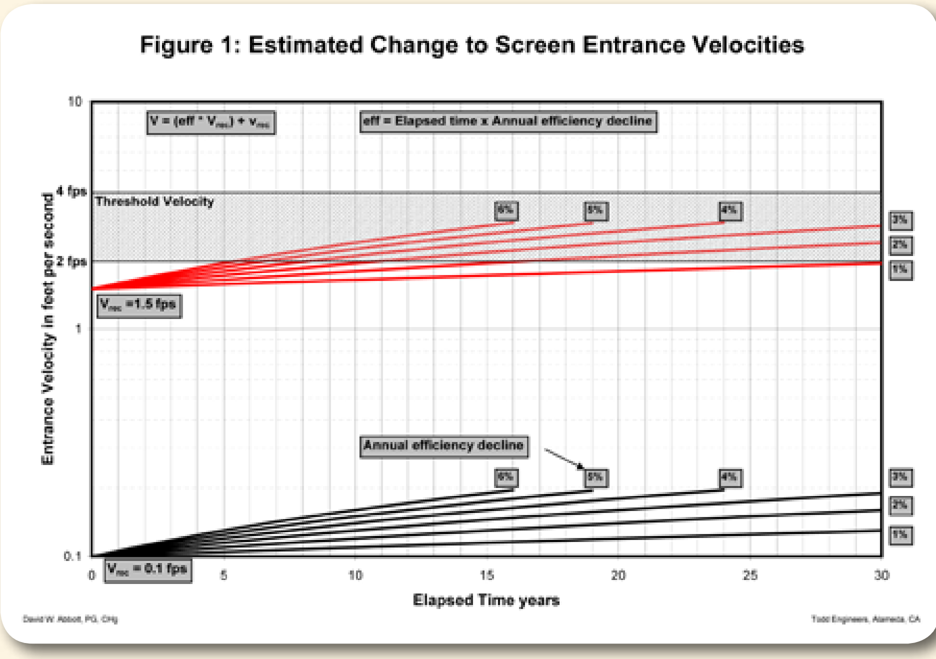
More details will be available on the UC Center for Water Resources website, www.waterresources.ucr.edu, as they develop.

Conference Sponsors:

- **University of California Center for Water Resources**
- **California Department of Water Resources**
- **Groundwater Resources Association of California**
- **Water Education Foundation**
- **U.S. Geological Survey**

Wells and Words

By David W. Abbott, P.G., C.Hg., Todd Engineers



A Missing Link in the Groundwater Industry Dispute on Well Screen Entrance Velocities

A long-standing, unresolved, but interesting discussion in the groundwater industry has focused on the recommended entrance velocity (V_{rec}) through the well screen (AWWA Standard for Water Wells; AWWA A100-06, 2006). The designed geometry of the well screen (diameter, length, aperture size, and percent open area) is based on the planned discharge, purpose of the well, aquifer parameters, and the V_{rec}. Note that the V_{rec} is the optimum design parameter to minimize encrustation, corrosion, and abrasion from sand at the inlet areas at the time of well construction and is *not* the operating screen entrance velocity at some future date, a detail that is *not* often cited in the literature.

Some prefer that the V_{rec} be less than or about 0.1 feet per second (fps) (Driscoll, 1986, Groundwater and Wells), while others suggest that the acceptable upper limit of the V_{rec} can exceed 1.5 fps (Roscoe Moss, 1990, Handbook of Ground Water Development); note that these guidelines vary by greater than one order of magnitude. It is of particular interest (and probably not a coincidence) that the percent open area of continuous-slot screens is about an order of magnitude greater than louvered, bridge-slot, or perforated-casing screens; this may be one reason for these differences in opinions. Also, it should be recognized that the entrance velocity will vary throughout the length of the well screen during pumping and therefore will vary about the average entrance velocity (V_{avg}) or V_{rec}.

There seems to be some agreement on the threshold velocity (V_{upper}) ranging between 2 and 4 fps. High entrance velocities begin to approach turbulent flow regimes and increase hydraulic pressures at screen inlet areas promoting thermodynamic changes to groundwater and well screen environments. Encrustation, corrosion, and abrasion negatively impact well longevity and successful well operation; these changes occur eventually in all wells. As a well ages, V_{avg} increases due to wear and tear, and the specific capacity decreases resulting in either deeper pumping water levels or lower well discharges. It is precisely this well deterioration and aging process which favors the lowest possible designed V_{rec}.

Well life-spans vary from 1 to 100 years (EPA Manual of Water Well Technology and Rehabilitation Technology, undated) depending on aquifer properties (geologic formation, water quality, and permeability), operating parameters, and preventative well maintenance. For example, municipal high-yield wells installed in alluvium can be expected to last between 2 and 10 years *without* maintenance, while such wells can be expected to last 30 to 40 years *with* maintenance. Well longevity is difficult to predict because of the large number of variables and the unknown synergy between variables.

> "Well designs using the lowest possible entrance velocity will optimize well longevity and maximize well efficiencies for a longer period of time."

Figure 1 shows the elapsed time in years (age of well) versus the entrance velocity (V) in fps caused by changes in the well efficiency, which was assumed to decrease as a linear function and was varied from 1% to 6% per year for each scenario; hence, a family of six curves. Well efficiency declines are

Continued on the following page...

Wells and Words – *Continued*

probably more complicated than a linear function and may more realistically be modeled as a logarithmic function. The entrance velocity at the well screen is directly related to the V_{rec} (a constant for each family of curves).

$$V = [(eff * V_{rec}) + V_{rec}]$$

where [eff = Elapsed time x Annual efficiency decline]

Therefore, a 10% decrease in the well efficiency results in a 10% increase in the entrance velocity provided the well yield has not changed. The 10% decrease could occur over 10 years at 1% per year or over 5 years at 2% per year.

The model provided two sets of curves, one based on the V_{rec} of 0.1 fps and the other for the V_{rec} of 1.5 fps. These sets of curves are essentially identical except they are displaced vertically on the graph because of the initial V_{rec} or y-intercept. Figure 1 also shows the threshold or upper limit (V_{upper}, 2 to 4 fps) of the entrance velocity. Comparing the age (x-axis) at which these curves intersect 2 fps suggests that the V_{upper} is reached far sooner (i.e., elapsed time) with a V_{rec} of 1.5 fps than with V_{rec} of 0.1 fps.

For example, a well with a V_{rec} of 0.1 fps and a rapid 6% annual efficiency decline, the lower threshold velocity (2 fps) will be reached in much more than 30 years; in contrast, a well with a V_{rec} of 1.5 fps reaches the threshold velocity in only 16 years with a much lower 2% annual efficiency decline. A logarithmic function would accelerate the well deterioration rate for both V_{rec} curve families.

In summary, well designs using the lowest possible entrance velocity will optimize well longevity and maximize well efficiencies for a longer period of time. This linear well deterioration model suggests that large designed entrance velocities (>1.5 fps) will reach any threshold velocity sooner than smaller designed entrance velocities (0.1 fps).

Legislative Update

By Chris Frahm and Paul Bauer, Brownstein Hyatt Farber Schreck and Tim Parker, Parker Groundwater

The 2009-10 Legislative Session is off to an interesting start. So far this year we have witnessed the longest Senate Floor Session in history (over 40 consecutive hours); a budget plan passed in February, 2009 for the fiscal year started July 1, 2008; the Republican leaders in the Assembly and Senate have been replaced; and, a historic Special Election appears all but certain to send the Legislature and Governor Schwarzenegger back to the drawing board on the budget crisis. We have truly entered uncharted territory.

GRA had another highly successful Legislative Symposium on Tax Day, April 15th. Working in partnership with the California Groundwater Coalition, our members met with several high-ranking legislators and key staff in the Capitol while "Tea Party" demonstrations raged outside the Capitol. Morning highlights included a panel presentation on Water Rights with Scott Slater, shareholder with Brownstein Hyatt Farber Schreck, Catherine Freeman of the Legislative Analyst's Office and Antonio ("Tony") Rossmann, law professor at Boalt Hall as guest speakers. The lively discussion set the tone for the Legislators who followed, including Senator Dave Cogdill, Assembly Member Mike Duvall, Alf Brandt, Principal Consultant to the Assembly Water Parks and Wildlife Committee, and Senator Joe Simitian's Principal Consultant Alan Gordon.

Jeff Kightlinger, General Manager of the Metropolitan Water District of Southern California, was our luncheon Keynote Speaker, after which a series of meetings with legislators in the Capitol were held. This allowed Legislators and their staff to discuss pending legislation, and gave GRA members the opportunity to discuss their concerns as well as continue to raise the profile of GRA in the Capitol. The annual Legislative Symposium is a key event that puts GRA on the map in Sacramento and establishes GRA as a leading voice with policy makers in the water arena.

With the current global economic crisis and the state's own growing budget deficit, water bond discussions have largely taken place out of the public eye. It is uncertain whether the Legislature and Governor will continue to push for a $10 billion-plus water bond in the current fiscal climate. The Delta Vision Report has been submitted to the Legislature, and has been the basis for much of the dialogue relating to restoring the Delta's ecosystem and providing water south of the Delta. However, the costs associated with implementation, and governance issues, continue to slow progress.

GRA is supporting the following bills moving through the legislative process:

- **AB 410** by Assembly Member Hector De La Torre authorizes using Prop 84 dollars to support salt management plans.
- **AB 1100** by Assembly Member Mike Duvall allows the transport of limited amounts of recycled water for the purpose of educating the public on the uses and safety of recycled potable water.
- **AB 1366** by Assembly Member Mike Feuer is the reintroduction of legislation from last year relating to the regulation of water softeners to combat salinity caused by the use of water softeners.
- **SB 122** by Senator Fran Pavley would establish a statewide groundwater monitoring program. The legislation is modeled after prior legislation SB 820 (2006) and SB 1640 (2007), both by Senator Kuehl, and SB 178 (2008) by Senator Steinberg.

As events unfold over the next two months relating to the state budget and water bond, we will continue to keep GRA at the forefront of the dialogue relating to groundwater. It is clear that the Legislature is aware of the value of groundwater and recognizes the important role groundwater will play in meeting the state's water needs.

The Federal Corner

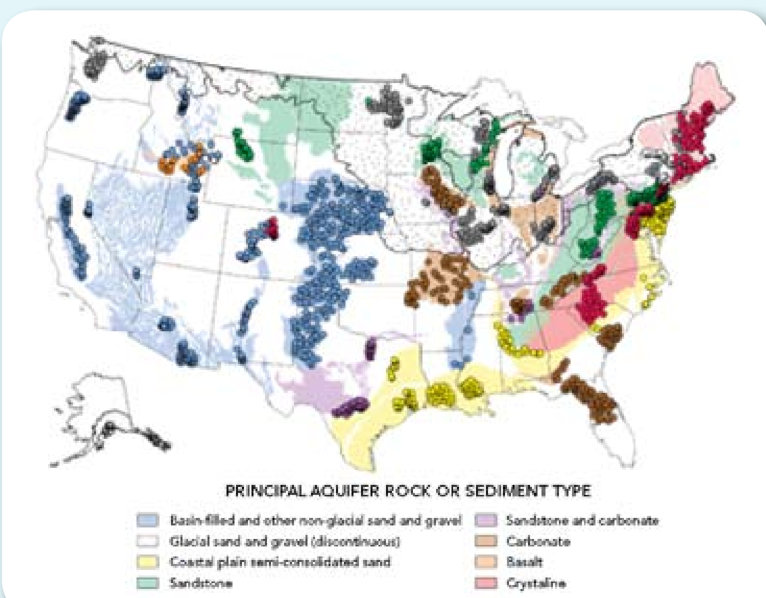
By John Ungvarsky

Quality of Water from Domestic Wells in the United States

A U.S. Geological Survey (USGS) study from the National Water-Quality Assessment Program summarizes the assessment of water-quality conditions for about 2,100 domestic wells across the United States. As many as 219 properties and contaminants, including pH, major ions, nutrients, trace elements, radon, pesticides, and volatile organic compounds, were measured. The large number of contaminants assessed and the broad geographic coverage of the present study provides a foundation for an improved understanding of the quality of water from the major aquifers tapped by domestic supply wells in the United States. The report is available at: http://water.usgs.gov/nawqa/studies/domestic_wells/.

Domestic wells sampled in this study (colored circles) are located in 48 states and within 30 regionally extensive aquifers used for water supply in the United States. The aquifers represented by wells in the study are shown, with aquifers and symbols for well locations color-shaded to indicate aquifer rock or sediment type.

2,167 Wells Sampled in 30 Regionally Extensive Aquifers



Climate Change and Water Resources Management: A Federal Perspective

Climate change may have a large impact on water resources and water resources managers. An interagency report prepared by the USGS, U.S. Army Corps of Engineers (USACE), Bureau of Reclamation (Reclamation), and National Oceanic and Atmospheric Administration (NOAA) explores strategies to improve water management by tracking, anticipating, and responding to climate change. For more information, go to: http://pubs.usgs.gov/circ/1331/Circ1331.pdf.

SECURE Water Act

In late March, President Obama signed into law the Omnibus Public Land Management Act of 2009 (H.R. 146), which included the SECURE *(Science and Engineering to Comprehensively Understand and Responsibly Enhance)* Water Act of 2009. This Act directs the USGS to develop a national ground water monitoring network in cooperation with state and local water resource agencies, although details of how this works and might be funded remain unclear at this time.

Safe Drinking Water Needs Assessed

The Drinking Water Infrastructure Needs Survey and Assessment was recently completed and indicates the nation's water utilities will need to invest an estimated $334.8 billion over the next 20 years to deal with aging infrastructure. The Needs Assessment is done every four years and assesses the anticipated costs for repairs and replacement of transmission and distribution pipes, storage and treatment equipment, and projects necessary to deliver safe supplies of drinking water. The Needs Assessment is available at: http://www.epa.gov/safewater/needsurvey.

Permits Issued for Carbon Sequestration Injection Project

The Arizona Department of Environmental Quality and U.S. Environmental Protection Agency (EPA) have issued permits authorizing the West Coast Regional Carbon Sequestration Partnership to inject 2,000 tons of carbon dioxide into an underground saline formation in Joseph City. The

Continued on the following page…

The Federal Corner *– Continued*

carbon dioxide injection will occur at a depth of about 3,500 feet. The project is sponsored by the Arizona Public Service Company and Lawrence Berkeley National Laboratory, with funding from the Department of Energy. The short-term pilot project includes requirements to protect underground sources of drinking water while allowing researchers to evaluate sequestration of greenhouse gases. For more information, go to: http://www.epa.gov/region09/water/groundwater/uic-permits.html#apsVep.

Aquifer Storage and Recovery National Meeting

EPA's Underground Injection Control Program held an Aquifer Storage & Recovery (ASR) Experts Meeting in Chicago on May 5-6. A Federal Register notice announcing the meeting was published on March 31 (74 FR 14553).

> "The short-term pilot project includes requirements to protect underground sources of drinking water while allowing researchers to evaluate sequestration of greenhouse gases."

EPA recognizes ASR as a beneficial tool in water resource management, but some ASR activities can endanger underground sources of drinking water. EPA assembled the interdisciplinary group of experts to discuss ASR issues. The meeting structure included facilitated discussions to stimulate ideas from individuals concerning protective strategies of operating and regulating ASR. For more information, contact Jill Dean at 202-564-8241.

John Ungvarsky is an Environmental Scientist at the U.S. Environmental Protection Agency, Region 9. He works in the Water Division's Ground Water Office and oversees source water protection efforts in CA, HI, and NV. For information on any of the above topics, please contact John at 415-972-3963 or ungvarsky.john@epa.gov.

Data Uncertainty

By Bart Simmons

John Taylor, formerly with the National Bureau of Standards (now NIST – the National Institute of Standards and Technology) identified three sources of uncertainty in environmental measurement: 1) random error; 2) systematic error, or bias; and 3) blunders. To his list I would add fraud, based on decades of experience with laboratory investigations, mostly by U.S. EPA and U.S. Department of Defense.

Random Error: The solution to random error is usually obtaining more measurements (e.g., field testing, more samples, composite sampling and/or more measurements per sample). For decades, U.S. EPA has been implementing a quality system which depends on project-specific Data Quality Objectives (DQOs). The evolution of the EPA system has moved from traditional PARCC "data quality indicators" – i.e., precision, accuracy, reproducibility, comparability and completeness – to the DQO system. The newer guidance takes a broader look at the project objectives and the statistical power needed to achieve the objectives. DQOs often come down to how many measurements are needed to reduce decision errors to acceptable levels. Since the DQO process takes an overtly statistical approach, its implementation demands some statistical comfort from project managers.

Systematic Error (Bias): Avoiding systematic error is more difficult, and requires a sensible sampling strategy – is the objective to find the highest concentration or to estimate an average? Grab sampling can introduce systematic error, which may or may not be appropriate, depending on the objective. Test methods may have some inherent bias; for example, GC-MS methods for extractable organics do not extract 100% of some compounds, e.g., phenols, and the results are not necessarily adjusted for low recovery. Matrix spike-matrix spike duplicate testing is done routinely to assess random error and systematic error, but it is standard practice to ignore the results if they are off and depend instead on Laboratory Control Samples (which are free of sample "matrix" effects).

Blunders: The DQO process does not directly address blunders, except to increase sample size to ensure against the effects of container breakage or equipment failure. Some blunders are avoidable: don't tell a lab to analyze groundwater samples with maximum sensitivity if the samples are highly contaminated; this can lead to equipment contamination and cross-contamination with other samples. Quality control procedures in the field and lab can help to detect blunders, but it is hard to prevent them. Composite sampling, which has a lot of value for controlling random error, does have the effect of producing fewer, more valuable samples. Blunders involving composite samples may have greater consequences.

Fraud: Labs have been associated with the bulk of recent environmental fraud cases, but sampling fraud has also raised its ugly head (heard of salting the mine?). Laboratory fraud is more subtle than sampling fraud, and its consequences could range from insignificant to catastrophic. The incentives for lab fraud are often unrealistic demands placed on the lab, e.g., high number of samples with short required holding times.

Modern quality management, including the DQO process, provides an improved system for dealing with random error and systematic error. To control for blunders and fraud requires a more human approach to ensure that people are working together with realistic expectations.

Bart Simmons can be reached at bartonps@aol.com.

Water Supply Adaptation to Climate Warming in California

By Christina R. Connell, University of California-Davis, Hydrologic Sciences Graduate Group

Research support and contributions by: Dr. Jay Lund and Dr. Josue Medellin-Azuara, University of California-Davis, Department of Civil and Environmental Engineering

Introduction

A changing climate, in terms of precipitation and temperature, affects several components of the hydrologic cycle and the availability and timing of water supplies. Downscaled global climate models applied to California and the western United States are used to explore and demonstrate changes in streamflow, snowmelt, snow water equivalent, evapotranspiration, and changes in magnitude of annual peak flows (Cayan et al., 2008; Hamlet et al., 2007; Miller et al., 2003). Early studies indicate a change in spring runoff since the 1940s as warming temperatures shift the timing of mean annual runoff to earlier in the year (Dettinger and Cayan, 1995). In a state dependent on developed water supplies to support agricultural, urban, and environmental demands, these changes have implications for California's economy.

Modeling Methods

As part of the Climate Change Assessment Report Update 2008, this study explored the independent effects of precipitation and temperature on California's hydrology as it relates to water supply and potential water management adaptations. The CALVIN (California value integrated network) economic-engineering optimization model of California's statewide water supply system is used for this analysis. Using the U.S. Army Corps of Engineers (HEC-PRM) optimization software, CALVIN simulates optimal operation of surface and groundwater resources and allocation of water over the historical hydrologic record (1921-1993) to maximize net statewide economic values of agricultural and urban uses, including selected hydropower benefits, within physical and environmental constraints (Draper et al., 2003). These constraints include reservoir and conveyance capacities and some minimum in-stream flows, but the model is not constrained by water rights or other policy regulations, including reservoir release rules. These 72 years of hydrology capture the variability of water supply experienced in California; they include wet, normal, and dry periods. For this entire period, agricultural and urban water demands are specified on the basis of estimated 2050 demands, population, and land use. Economically driven, CALVIN water allocations minimize total statewide water scarcity and operation costs. Scarcity is defined as the amount of water the user is willing to pay for above the volume of water delivered to that user. Whenever a user's target use is not met, scarcity occurs and incurs a cost. Each agricultural and urban demand area has a penalty function that describes the relationship between its scarcity and scarcity cost.

Three scenarios were developed to represent historical, warm-only, and warm-dry hydrologic conditions. The warm-dry hydrology was developed using downscaled results from the GFDL CM2.1 global climate model (A2 emissions scenario) for a 30-year period centered at 2085 to perturb the 72-year historical time series. The warm-only scenario was developed from the warm-dry hydrology, preserving the timing of early snowmelt from the warm-dry scenario while maintaining mean annual flows from historical hydrology. This separates the runoff volume and temperature effects of climate change on water availability and management adaptations. The new time series for each climate change scenario is a perturbation of the monthly historical hydrology. The historical scenario uses historical hydrology for rim inflows, reservoir evaporation, groundwater inflows and local accretions and depletions within the valley floor. Rim inflows are surface-water flows (streamflows) at the model boundary, many representing rivers entering the valley from the Sierras. Groundwater inflows represent additions to groundwater storage from changes in deep percolation, derived from the Central Valley Groundwater-Surface Water Model (CVGSM), and local accretions and depletions connect aquifer gains and losses with surface-water runoff.

Results

Hydrology

Compared to the historical climate scenario, rim inflows decrease by 28% in a warm-dry climate. Rim flows in the warm-only scenario keep the same average annual flow as in the historical climate. An increase of net reservoir evaporation statewide of 37% in a warm-dry climate is driven by increasing temperatures and decreased precipitation rates in the last third of the century. For the warm-only scenario, net evaporation increases 15% statewide. For the warm-dry hydrology, groundwater inflows decrease moderately with a 10% reduction from historical conditions statewide and net local accretions also decrease significantly regionally and statewide, leading to a large loss of available water to

Continued on the following page…

Water Supply Adaptation to Climate Warming in California – *Continued*

the system. Although not accounted for in this study, the warm-only condition would probably have some reduction in annual streamflow from increased evapotranspiration in each watershed.

Water Supply & Scarcity

When the whole system is economically optimized, agriculture is most vulnerable to water shortages under all climate scenarios. Shortages of more than 20% of agricultural target demands are expected for warm-dry conditions, decreasing agricultural production by over \$800 million/year. Water scarcity and its cost as well as storage volumes and releases are more sensitive to reductions in streamflow and precipitation than to temperature increases alone. Temperature rise alone does not greatly increase water shortages if system operations adapt, as allowed in CALVIN. This is in line with classical reservoir operation theory for a system with over-year water storage capacity (Hazen, 1914).

Optimized water transfers from agricultural to urban uses support the 2050 population; this counteracts some effects of reduced water supply, but exacerbates agricultural shortages. This assumes transaction costs are small and institutional infrastructure can support such water transfers (Pulido-Velazquez et al., 2004). Under the less severe climate conditions, historical and warm-only, climate-change effects on water supply play a lesser role than population growth. With increased competition for limited water resources, agricultural water shortages increase primarily as a result of rising urban water demands (demands estimated for year 2050).

Surface Storage

Analysis of percent of years filled for surface water reservoirs for warm-only and warm-dry scenarios suggests that surface storage capacity expansion may not alleviate climate induced water scarcity. Figure 1 plots the relative percent of years each reservoir fills versus the ratio of storage capacity to mean annual inflow (MAI), indicating relative storage availability for each basin. In most cases the frequency of years the reservoir fills decreases significantly for warm-dry (WD) hydrology compared to historical. In contrast, warm-only hydrology increases the frequency of filling for some reservoirs (Figure 1, ratio of % years filled exceeds 1 for warm-only/historical). Millerton Lake, New Bullards Bar, Pardee Reservoir, New Don Pedro, Hetch Hetchy, Lake Isabella, and Turlock Reservoir fill more frequently with warm-only hydrology than historical, due to earlier and higher spring and winter flows. The nature of climate change is crucial in estimating whether additional storage would relieve water scarcity and add flexibility to operating the system or would go unused because existing reservoirs would rarely be filled.

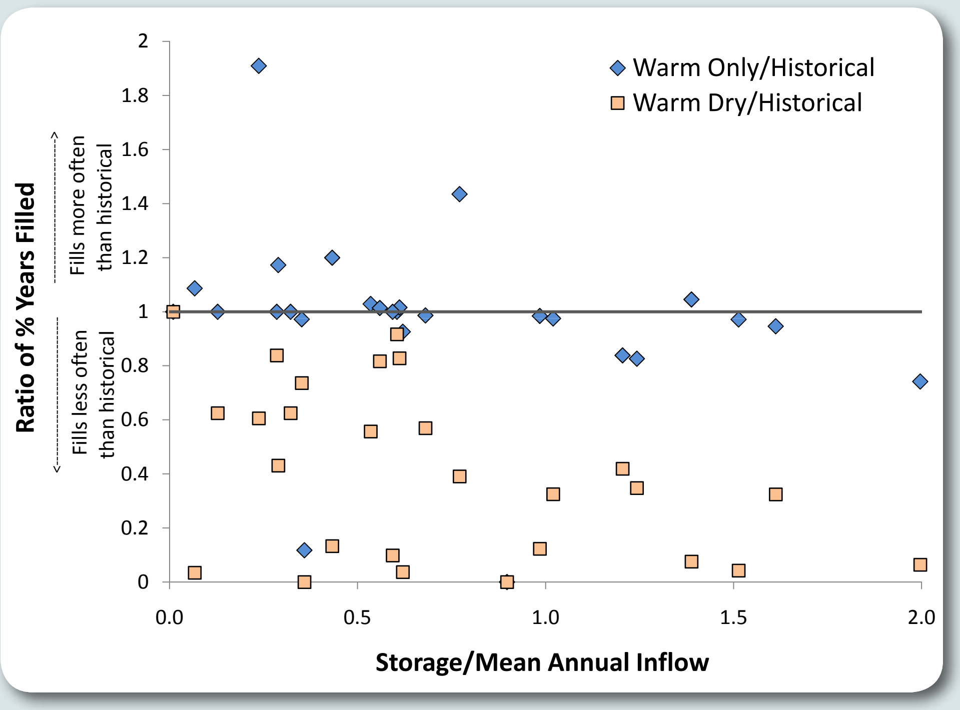


Figure 1. Ratio of percent of years filled versus storage/mean annual inflow (MAI) ratio for select surface water reservoirs.

Groundwater and Supply Portfolio

Model outputs suggest that groundwater, which has always been a key water supply during droughts, becomes even more important during drought conditions under climate change scenarios. CALVIN optimally uses groundwater and surface water resources conjunctively to meet urban and agricultural demands. As with scarcity, percent of groundwater use for each region's supply portfolio is comparable between historical and warm-only climate scenarios (Figure 2). Only the Sacramento Valley incurs scarcity (about 1%) under historical and warm-only conditions, because water tends to fetch a higher price in the San Joaquin Valley and Tulare Basin. Under simulated warm-dry conditions, when surface water is less available, the Sacramento Valley pumps additional groundwater, decreases its surface-water use, exports water southward, and consequently has a greater percentage of scarcity than the San Joaquin Valley or Tulare Basin (Figure 2). In all cases,

Continued on the following page…

Water Supply Adaptation to Climate Warming in California – *Continued*

groundwater deliveries increase during droughts. This highlights the economic value of switching supply sources during wet and dry periods.

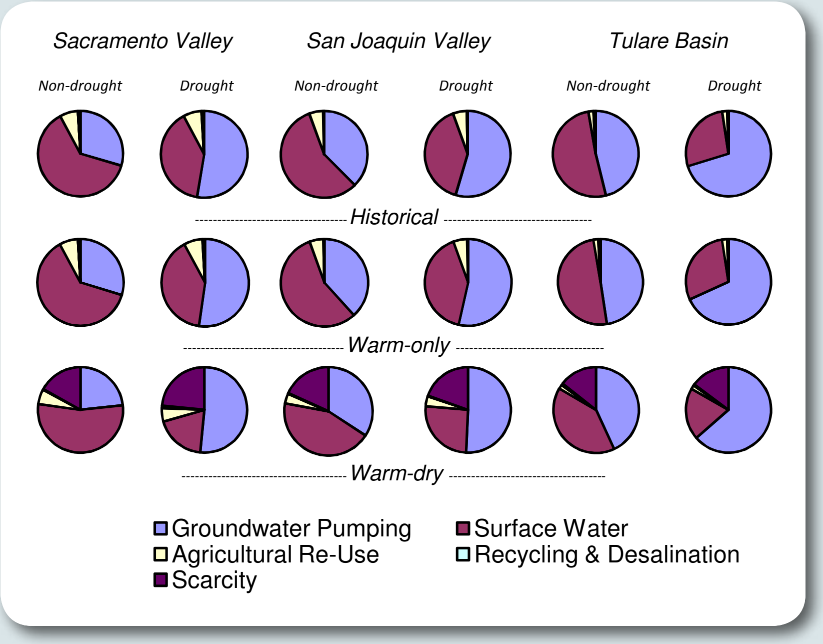


Figure 2. Supply portfolio for each region, climate scenario, and year type. Drought years include 1929-1934, 1976-1977, 1987-1992. Non-drought years are all others in the historical record (1921-1993).

water pumping costs do not reflect dynamic groundwater levels because CALVIN has a simple representation of groundwater. There is also uncertainty

Limitations

Limitations inherent to large-scale optimization models and CALVIN have been explored and discussed elsewhere (Jenkins et al., 2001; Jenkins et al., 2004). For this particular study, some specific limitations should be mentioned. First, urban water use and scarcity cost is assumed constant for all three hydrologic scenarios and does not account for conservation measures that may be employed if the climate were indeed to become warmer and drier as simulated. Also, because CALVIN economically optimizes water deliveries based on scarcity cost curves, water allocations are driven by the water demand targets and willingness to pay, as assigned to agricultural and urban regions. Uncertainty in estimates for these target levels for 2050 introduces uncertainty into CALVIN water supply results. Furthermore, ground-in how groundwater will be affected by a changing climate, and the warm-only scenario in this study assumes historical conditions for groundwater.

Conclusions

California has many options for adapting and mitigating costs associated with climate induced changes in water supply. Conjunctive use, adapted surface-water operations, and water markets all help mitigate higher economic costs driven by warmer and warmer-drier climates. Reoperation adaptations are aided by conjunctive use, thereby shifting some supply demands during droughts from surface reservoirs to groundwater.

Under warm-dry conditions, surface storage capacity is often unused, simply because the water is not available to store. In contrast, for the warm-only scenario, increased storage capacity in wet months may help capture increased peak flows in winter months. Under either scenario, changing reservoir operations in conjunction with a suite of management adaptations (i.e. conjunctive use, water recycling, water markets, etc.) serves well to reduce water scarcity and economic cost of climate change.

References

Cayan, D. R., Maurer, E. P., Dettinger, M. D., Tyree, M., and Hayhoe, K. (2008). "Climate change scenarios for the California region." Climatic Change, 87, S21-S42.

Dettinger, M. D., and Cayan, D. R. (1995). "Large-scale Atmospheric Forcing of Recent Trends Toward Early Snowmelt Runoff in California." Journal of Climate, 8(3), 606-623.

Draper, A. J., Jenkins, M. W., Kirby, K. W., Lund, J. R., and Howitt, R. E. (2003). "Economic-engineering optimization for California water management." Journal Of Water Resources Planning And Management, 129(3), 155-164.

Hamlet, A. F., Mote, P. W., Clark, M. P., and Lettenmaier, D. P. (2007). "Twentieth-century trends in runoff, evapotranspiration, and soil moisture in the western United States." Journal of Climate, 20(8), 1468-1486.

Hazen, A. (1914). "Storage to be provided in impounding reservoirs for municpal water supply." Transactions American Society of Civil Engineers, 77, 1539-1640.

Jenkins, M. W., A.J. Draper, J.R. Lund, R.E. Howitt, S.K. Tanaka, R. Ritzema, G.F. Marques, S.M. Msangi, B.D. Newlin, B.J. Van Lienden, M.D. Davis, and Ward, a. K. B. (2001). "Improving California Water Management: Optimizing Value and Flexibility." University of California Davis, Davis, California.

Jenkins, M. W., Lund, J. R., Howitt, R. E., Draper, A. J., Msangi, S. M., Tanaka, S. K., Ritzema, R. S., and Marques, G. F. (2004). "Optimization of California's water supply system: Results and insights." Journal of Water Resources Planning and Management-Asce, 130(4), 271-280.

Miller, N. L., Bashford, K. E., and Strem, E. (2003). "Potential Impacts of Climate Change on California Hydrology." Journal Of Water Resources Planning And Management, 39(4), 771-784.

Pulido-Velazquez, M., Jenkins, M. W., and Lund, J. R. (2004). "Economic values for conjunctive use and water banking in southern California." Water Resources Research, 40(3), 15.

California Groundwater Association Notes

By Mike Mortensson, CGA Executive Director

CGA & GRA Members Attend NGWA Fly-In

CGA and GRA members again participated in the NGWA Fly-In in Washington DC in late March. This year, there were 12 persons in the California delegation that visited Congressional offices. Past efforts have paid benefits for groundwater industry members ranging from tax credits for geothermal heat exchange systems to support for groundwater sustainability programs. This year, the focus was on air emissions funding through the DERA, inclusion of geothermal heat pump systems in a Federal Renewable Portfolio Standard on energy, adoption of the SECURE water act, funding for a one-time pilot project to determine the framework of a groundwater monitoring network, support for tax credits for voluntary testing of private wells, and a request to contact NGWA on any follow-up on an as-needed basis after the USGS Congressional briefing on the quality of private domestic well water.

CGA Continues Effort on Unlicensed Drilling

CGA's case against the Semitropic Water Storage District for drilling wells without the required C-57 license that was dismissed by the Superior Court of Kern County in late 2008 has been appealed. CGA has filed its opening brief with the Appellate Court in Fresno. Subsequent briefs are pending; it is expected the Court will set a hearing date later this year.

Carb Regulations

CGA continues to work with California Air Resources Board (CARB) officials to develop regulations for the groundwater industry that will offer some relief to the newly adopted In-Use On-Road Diesel Vehicle regulation. Other regulations are also being addressed. There is concern that the new regulations could impact groundwater availability due to downsizing of water well contracting firms as a result of the CARB regulations.

GSHP Standards

With increasing expansion of geothermal heat exchange wells (GHEW) and concerns being voiced by environmental health agencies and contractors alike about GHEW construction standards, CGA has contacted the Department of Water Resources to finalize the adoption of GHEW construction standards previously developed as required by AB 2334, passed in1996.

CGA Convention Expands Educational Options

CGA will hold its 61st Annual Convention and Trade Show on November 5-7, 2009 at the Silver Legacy Resort Casino and Reno Events Center. This year, the educational options have been expanded; the current schedule calls for all-day Thursday workshops on well disinfection and ground source heat pump installation. On Friday, there will be two separate sessions comprising four seminars. This change will allow participants to attend two seminars, instead of only one. Tentative seminar topics include VFD Analysis (separate seminars by Goulds and Grundfos), water treatment and safety programs. Saturday will have two-hour sessions on drilling fluids and air emission fleet calculators. There will also be a separate 3-hour leadership workshop. The ever-popular McEllhiney Lecture has been scheduled for Saturday morning; W. Richard Laton, Ph.D., PG, CPG, of Cal State Fullerton, will present the lecture on "Boring Logs – What's Important and What's Not; A Scientific Perspective."

For more information on any of these programs/activities, contact CGA at 707-578-4408; Fax: 707-546-4906 or email wellguy@ groundh2o.org.

NGWA Conference to Focus on Water Management Issues

The NGWA Ground Water Management Issues Forum takes place in Tahoe City, California, October 14-16, 2009 and will focus on the most critical ground water management issues facing all governments and strategies to address them.

The conference takes place among a myriad of complicated issues. Groundwater resources are under increasing stress in various parts of the world due to growth and changing weather patterns. Transboundary concerns between countries, states or provinces and municipalities have impacted their ability to provide adequate water supplies. Historical tensions embodied by the debates among agricultural, development, and environmental entities continue to raise the stakes in meeting the demands made on aquifers by growing populations.

Policymakers and regulators are faced with increasing challenges to providing adequate ground-water supplies to water-challenged areas experiencing growing populations. Industry, agriculture, and ground-water professionals are primary stakeholders in how ground-water resources are sustained, used, and maintained.

The conference will provide a forum for policymakers, regulators, industry, and ground-water professionals to assess the state of ground-water management on local, national, and international levels, and share tools and information to ensure adequate supplies for all.

An interactive format is being designed to accommodate both individual platform presentations and panel discussions, and to facilitate intense discussions among participants.

Attendees will learn:
- How the same doctrine can facilitate different outcomes
- The impact of legal challenges and resulting unintended consequences
- What tools are currently available and how to use them in managing ground water effectively
- Skills in working with stakeholders
- Strategies that worked and those that didn't.

NGWA is seeking submissions that accommodate platform or panel participation for this conference. Submissions must include a statement of experience/interest. Submitters should provide a description of their relevant background with respect to the conference topic, and what they feel they could contribute/gain by attending. Following the review process, accepted submissions will be scheduled to present in the program. Submissions are due by 11:59 p.m. ET, June 9, 2009 and are limited to 300 words in length.

Submissions will be accepted for these topic areas:
- Riparian and prior appropriation doctrines: Impact to water management
- Legal challenges: How did the rulings affect the ultimate outcome?
- Governmental challenges: International, state or provincial, and municipal/local entities
- Success stories and plans gone awry
- Working with stakeholders
- The best tools: Advantages and limitations.

For information, contact NGWA at 800-551-7379 or visit www.ngwa.org.

Groundwater Monitoring:
Design, Analysis, Communication, and Integration with Decision Making

February 25-26, 2009 – Orange, California

Highlights and Summary by Brian Wagner, U.S. Geological Survey; David Jordan, INTERA Incorporated; Thomas Harter, University of California, Davis; John Sankey, True Blue Technologies, Inc.; John McHugh, Santa Clara Valley Water District; Vicki Kretsinger, Luhdorff & Scalmanini, Consulting Engineers; Tim Parker, Parker Groundwater; Eric Reichard, U.S. Geological Survey

On February 25-26, 2009 GRA held a multidisciplinary symposium on "Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making." The goal of the conference was to showcase recent developments in all phases of groundwater monitoring. Sessions included Monitoring at Multiple Scales, Methods for Data Collection and Interpretation, California's Groundwater Ambient Monitoring and Assessment (GAMA) Program, Use of Modeling and Statistics for Monitoring Design and Assessment, Communication with the Public and Policy Makers, and Water Agency Case Studies. Highlights from these sessions are described below.

Rock core sampling to delineate DNAPL contamination in a fractured sandstone, southern California. Photo courtesy of Beth Parker, University of Guelph.

Monitoring at Multiple Scales: From Site Specific to National

Dico Fraters, National Institute for Public Health and the Environment, The Netherlands, opened the conference with the presentation "Nationwide, Ambient Groundwater Monitoring Approaches in Europe for Monitoring the Effectiveness of the Nitrates Directive Action Program." Dico discussed the European Union's Nitrates Directive, which was adopted in 1991 and directed the member states to institute programs to reduce the impact of agricultural nitrates on groundwater and surface water. Dico described two approaches to groundwater monitoring -- upscaling and interpolation. The upscaling approach uses groundwater monitoring at the plot scale to describe changes in nitrate leaching. These results are extrapolated to the national scale using process models and data on national-scale changes in agricultural nitrates usage. The interpolation approach uses random sampling of farms and wells, combined with statistical models to

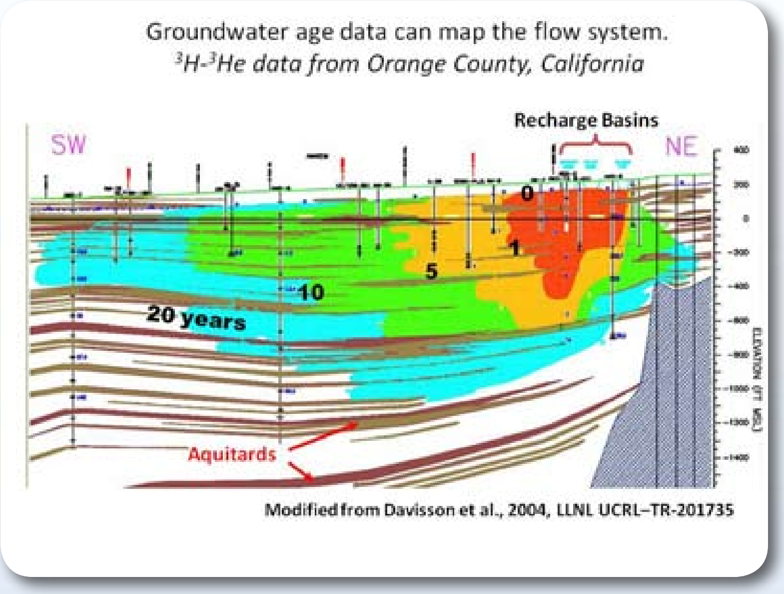
Continued on the following page…

Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making – *Continued*

define nitrate leaching and changes in leaching, at the national level. The effect of the Nitrates Directive has been to reduce nitrate leaching by 50 percent.

William Cunningham, U.S. Geological Survey, presented "Progress Toward a National Groundwater Monitoring Network." The effort to develop a national groundwater monitoring framework, undertaken by the Subcommittee on Ground Water of the federal Advisory Committee on Water Information, involves more than 70 scientists and managers representing state and federal agencies, academia, interstate organizations, and the private sector. A framework report to be issued this year will describe existing state, multicounty and national monitoring programs, and provide recommendations for expanding and integrating these efforts toward creating an effective national monitoring network. An example was presented that demonstrated the use of the USGS NWIS database to define three networks of monitoring wells: a real-time network, a climate-response network, and an active water-level network.

Kenneth Belitz, U.S. Geological Survey, continued the session with his presentation "Regional-Scale Monitoring of Ground-Water Quality: Perspectives from GAMA's Priority Basin Project." This presentation described the collaborative effort of the U.S. Geological Survey, the California State Water Resources Control Board, and Lawrence Livermore National Laboratory to monitor and assess the quality of groundwater in California. Ken provided an overview of the GAMA program and the methods used to obtain a groundwater quality assessment at the state scale. He discussed the program's focus on "priority" groundwater basins that account for 76% of the public supply wells in the state, and presented an overview of the grid-based sampling approach used in the GAMA program. This approach can provide a spatially unbiased estimate of regional-scale groundwater quality and allows for synthesis of results at multiple scales. Finally, he discussed the importance of effectively communicating the GAMA program and its products to a wide range of interested parties that include laymen, scientists, and water managers.



Sampling groundwater age can improve our understanding of groundwater travel times and flow paths. Slide courtesy of Steven Carle, Lawrence Livermore National Laboratory.

Thomas Harter, University of California, Davis presented an overview of "Compliance Monitoring of Nonpoint Sources." He contrasted Nonpoint Source (NPS) contamination with plume scale contamination, and presented examples of NPS monitoring in existing programs, including the California Dept. of Pesticide Regulation and the California Regional Water Quality Control Board Dairy Program. Thomas provided an assessment of how well current monitoring programs are meeting key objectives and noted several key factors associated with NPS monitoring in agricultural areas, including the large areas affected, the importance of regular recharge, and the fact that sampling the first-encountered groundwater may not be meaningful. Site-specific monitoring of NPSs will not be representative or cost-effective; a regional, statistically based approach is needed.

Murray Einarson, AMEC-Geomatrix, described the use of "Sampling Transects for Better and More Cost-effective Remedial Investigations." Murray noted that, although contaminant plumes are inherently three dimensional, they have traditionally been characterized two-dimensionally. It is more appropriate to employ transects of closely-spaced Direct-Push samples or multilevel wells. Murray presented several case studies to illustrate the method, and showed how the transect approach can be applied to the existing data at a site. He concluded that sampling transects provides more accurate plume delineation, improved risk assessments, and better verification of remediation strategies.

Continued on the following page…

Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making *– Continued*

Daniel Stephens, Daniel B. Stephens & Associates, concluded the opening session with his presentation “Vadose Zone Monitoring Strategies for Contaminant Detection and Recharge.” He provided an overview of the instrumentation used to monitor different vadose zone properties at different scales, including neutron probes, tensiometers, psychrometers, heat dissipation sensors, thermistors, and lysimeters. Daniel described the fundamental physics of water and solute movement in the vadose zone. He then presented strategies for vadose zone monitoring for different objectives, including detecting contaminants, assessing processes, and assessing hazards.

Methods for Data Collection and Interpretation

David Kaminski, QED Environmental Systems, discussed the proper application and use of low-flow groundwater sampling. He noted that: 1) low-flow purging and sampling can overcome many of the problems associated with traditional purging approaches, hand bailing and high-rate pumping; 2) purge methods will provide flow-weighted average samples in wells when used correctly, while multi-level systems provide the best opportunity for depth-discrete samples at high spatial resolution; 3) proper application of low-flow sampling requires attention to pumping rate, drawdown and indicator parameter stabilization; and 4) pumping rate, drawdown and screen length should not be based on arbitrary limits.

Adam Gilmore, University of Guelph, presented a case study on the application of the “Membrane Interface Probe (MIP) as a Tool for Rapidly Characterizing Sites with Low Permeability Zones.” MIP technology is especially valuable in settings where diffusion from low-permeability layers may cause plume tailing. Adam stressed the importance of using multiple detectors in the MIP logging, and calibrating the MIP results using continuous-core data.

Laura Zimmerman, University of Guelph, shared the results of a groundwater sampling study in the turbidite sandstone at the Santa Susana Field Laboratory in California. The goals were to: 1) compare the Snap Sampler (passive groundwater sampling device whereby sample bottles are sealed in-situ by a trigger used at the surface) to conventional sampling; 2) improve analysis accuracy for TCE degradation products; 3) examine variability with depth in un-pumped wells; and 4) develop better information concerning redox conditions relevant to degradation. The sampling provided accurate, depth dependent measurements of compound-specific isotopes, VOCs, dissolved gases, and redox indicators.

Renger Smidt, Schlumberger Water Services, focused on a cost-benefit analysis of automated groundwater data collection and management in the Netherlands. The need for new data is driven by legislation, regulation, the desire for reduction in uncertainty and risk, and recent advances in technology. He concluded that automated data collection (in this case, short-range radio using Diver NETZ) has a high capital cost, but provides higher-frequency data collection for the same or less total investment.

Ned Clayton, Schlumberger Water Services, described the use of advanced borehole geophysical logging to opti-

Continued on the following page…

Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making – *Continued*

mize the design of a deep multi-level monitoring well, which will be used for an aquifer artificial recharge pilot project in Mojave Desert, California. To provide nearly continuous-in-depth hydrogeologic, geologic and geochemical characterization across the vadose and saturated zones, the logging suite included: 1) magnetic resonance, 2) non-source epithermal neutron porosity, 3) array induction, 4) electrical imaging, 5) natural GR spectroscopy, and 6) non-source pulsed neutron-gamma spectroscopy.

Jessica Meyer, University of Guelph, presented results from a "Hydrogeologic Characterization in Fractured Sedimentary Rock using Detailed Head Profiles and an Outside-In Approach." She discussed the hydraulic and geologic controls of hydrogeologic units, which can be major drivers in contaminant distribution and remediation. Using continuous cores, geophysical logs, and multi-level wells, they were able to locate the lithologic and hydraulic boundaries. Jessica noted that sharp inflections in the logs were not necessarily indicative of classic aquitards, vertical hydraulic connections were poor, and units correlated across the site.

Beth Parker, University of Guelph, described the "Application of an Advanced Version of Contaminant Rock Core Analyses to Delineate and Understand TCE Plumes in Sandstone, Southern California." She described how conventional monitoring wells are not effective in characterizing contamination at sedimentary rock sites. The preferred alternative is to use a combination of multi-level monitoring systems in conjunction with rock core contaminant analyses. In the 1990s, initial VOC rock core analyses at a site in southern California indicated that most contamination occurred in the rock matrix. More recently, the methodology has been greatly improved, and has been applied to multiple sites at the study area. The core analyses yield detailed contaminant profiles and, along with other data, are being used to develop numerical models of the TCE transport at the study area.

Jonathan Kennel, University of Guelph, presented "Hydraulic Conductivity and Flow Comparisons Based on Borehole Measurements Using Flexible Liners in a Water Supply Dolostone Aquifer." He described the results of a study in the City of Guelph, Ontario where flexible liners were used to acquire hydraulic conductivity profiles, seal boreholes, and conduct high-resolution temperature profiling. The new data have provided valuable information on the three-dimensional conductivity field, and pathways of hydraulic connectivity.

California's Groundwater Ambient Monitoring and Assessment (GAMA) Program

This session featured speakers from the California State Water Resources Control Board (SWRCB), the U.S. Geological Survey (USGS), and Lawrence Livermore National Laboratory (LLNL). John Borkovich (SWRCB) began the afternoon with an overview of the GAMA program and an introduction to the beta version of the GeoTracker GAMA database. Once tested, the database will be publicly accessible. The GIS-linked database contains not only thousands of analyses of samples collected under the GAMA program since 2000, but also groundwater quality data shared by CDPH, USGS, LLNL, DWR, DPR

Continued on the following page…

Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making – *Continued*

and RWQCBs. New sources of data continue to be added. By accessing the database through a web-based map interface, the public, planning agencies, decision makers, and consultants will be able to easily obtain current and historic information on groundwater chemistry and at specific locations. Erik Ekdahl (SWRCB) demonstrated use of the GeoTracker GAMA database to map nitrate concentrations in California groundwater from 1980 to 2008. Data prior to 2000 include only CDPH public supply well records. After 2000, records are also available from GAMA wells, DWR wells, and environmental sites. Erik's talk also highlighted some of the challenges in interpreting long-term trends from these datasets.

> "The objective of the priority basin studies is two-fold: to provide an assessment of the current water-quality status, and to provide an assessment of the relationship between groundwater quality and potential explanatory factors."

Can we anticipate where groundwater nitrate contamination may show up next? Brad Esser (LLNL) addressed this question in his talk on the use of groundwater age and volatile organic carbons as groundwater tracers to assess groundwater vulnerability to nitrate contamination in California agricultural and urban areas. Brad suggested that the combination of VOC measurements, age data, and isotopic data provides a powerful tool to assess nitrate sources, to match nitrate contamination with historic land-use data, and to assess time-scales of nitrate contamination.

Michael Land (USGS) presented the rich diversity of data collected in one of the regional GAMA studies ("priority basin study"). A large array of water quality data are collected as part of these GAMA studies. Michael used the San Fernando, Raymond, and San Gabriel Basins study as a case study to demonstrate the type of data collected and the approach taken to select wells from which water samples are collected. He also discussed the development of a consistent approach for identifying, assessing, and reporting important water-quality results to a diverse audience. The objective of the priority basin studies is two-fold: to provide an assessment of the current water-quality status, and to provide an assessment of the relationship between groundwater quality and potential explanatory factors (e.g., land use).

Carmen Burton (USGS) focused on a groundwater quality investigation of part of the southeastern San Joaquin Valley. Samples were collected to provide an overall assessment of groundwater quality ("grid wells"), and to evaluate changes along identified groundwater flow paths ("understanding wells"). Samples were analyzed for organic constituents, constituents of special interest, inorganic constituents, and isotopes. Sample results were compared to US EPA maximum contaminant levels (MCLs) and California Department of Public Health (CDPH) aesthetic thresholds. Both DBCP and benzene were detected in several grid wells and understanding wells. Pesticide detections in all wells were below health-based thresholds. Perchlorate was detected in one grid well. Nitrate was detected in six understanding wells, one of which is a public supply well.

Michael Wright (USGS) focused on evaluating the occurrence of vanadium in groundwater throughout California. Evaluation of over 8,400 analyses indicated that 125 (1.5 percent) had vanadium levels equal to or above the California notification level (NL) of 50 µg/L. Potential sources for vanadium in groundwater include both natural and anthropogenic sources, including dissolution of vanadium-rich rocks, disposal of industrial waste, and burning fossil fuels. In this study, moderate to high vanadium concentrations in groundwater appear to be primarily associated with deposits derived from basaltic and gabbroic rocks.

Use of Modeling and Statistics for Monitoring Design and Assessment

Brian Wagner, USGS, discussed the relationship between actual and modeled results for the Upper Klamath Basin in northern California and southern Oregon. He provided examples of linear uncertainty analysis to test the value of new data for improving the numerical groundwater flow model. Through his analysis he found which data sets provide more certainty to the model. The uncertainty analysis was also used to identify hydrogeologic data and groundwater sampling designs that will

> "Can we anticipate where groundwater nitrate contamination may show up next?"

Continued on the following page…

Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making – *Continued*

most efficiently reduce the uncertainty in important model parameters.

Professor Patrick M. Reed, Pennsylvania State University, presented results from his research group's work in many-objective groundwater monitoring design under uncertainty. They developed a tool that provides decision makers and technical staff the trade-offs between certainty and uncertainty in different parameters. The tool learns as it computes, and graphical software allows presentation of the multiple solutions to the many-objective-problem to be understood by stakeholders and decision makers so that they may select one or more desirable solutions which embody their preferences.

Ben McAlexander, Trihydro Corporation, shared his use of partition and transport models of LNAPL for source delineation of MTBE and benzene at a petroleum terminal, where access for subsurface investigation was limited. A Rapid Optical Screening Tool (ROST) Laser-Induced Fluorescence (LIF) System was used for screening MTBE and benzene in the subsurface. This information, coupled with depth-discrete water sample results, provided input to the models to deduce the sources bodies. The entire process was aided by 3-D visualization software.

Kathy Yager, U.S. Environmental Protection Agency, illustrated several tools for optimizing long-term groundwater monitoring, focusing on the software package MAROs. The benefits of the optimization processes include cost savings due to reduction in sampling from elimination of temporal and spatial redundancy. MAROs takes input from databases, is modular, free, has user support, and has been used at over 100 sites. MAROs provides simple statistical and heuristic tools such as trend analysis, stability analysis, total plume mass, center of mass, and plume spread.

Steve Carle, Lawrence Livermore National Laboratory, described the use of tritium/helium (3H-3He) age dating. Age-dating can help predict contamination vulnerability. However three non-idealities in the percent "pre-modern" estimation complicate the calculated age: 1) 3H decays in the vadose zone, 2) mixing affects 3H-3He transport from source to sample, and 3) tritium source concentration before ~1962 is highly variable. Modeling results indicate: 1) recharge passing through the vadose zone will reduce the impact of dispersion and source variability, 2) 3H-3He age and noble gas recharge-

Continued on the following page…

Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making *– Continued*

temperature data constrain the physics of the groundwater system, and 3) gas-liquid phase (vadose zone) flow and transport processes are important.

David Ostendorf, University of Massachusetts, presented examples of cascade calibration of the hydraulic properties of soil. The calibration examples used data from a range of temporal and spatial scales. Data included aquifer-test results, water-level measurements, tracer studies, and isotope samples. From the large dataset collected, values were estimated for bulk parameters (transmissivity and storativity) and intrinsic properties, including soil permeability, porosity, compressibility, fluid characteristics (density, viscosity, compressibility), and aquifer thickness.

"Monitoring program adequacy depends primarily on whether the program provides timely answers to appropriate questions."

The Role of Monitoring in Protecting and Managing Groundwater Resources – Communication with the Public and Policy Makers

Lucy Eidam, President of LucyCo Communications, began the session with "Groundwater: Out of Sight, Out of Mind…Unless there's a Problem – How to Effectively Communicate with the Public and Policymakers about Groundwater Monitoring." Her research indicates that, of all water sources, the public is least familiar with groundwater; correspondingly, it is more challenging to engage public interest in groundwater monitoring. It is important to conduct research that builds a solid foundation for the development of public outreach strategies, prepare a plan that addresses outreach objectives, target audiences, key messages, tactics, and evaluation tools, and to evaluate the plan as it is implemented and modify as necessary.

Alan Fulton, University of California Cooperative Extension, presented "A Bird's Eye View of Groundwater Management in the Northern Sacramento Valley." Annual water demands of about 4.2 million acre-feet in the northern Sacramento Valley are met using surface and groundwater supplies. Reliance on groundwater supplies is expected to increase, and a groundwater monitoring network of 450 wells allows ongoing assessment of groundwater conditions. Although local governments and water agencies have developed groundwater management plans, concerns exist about future conjunctive management of surface and groundwater supplies. Prior to the pursuit of significant water transfer programs, it will be important to provide assurance to all stakeholders that their interests are equitably and adequately protected.

Keith Roberson, San Francisco Bay Regional Water Quality Control Board, closed the session with his presentation "The Evolving Role of Groundwater Monitoring in Regulatory Decision Making." He noted that many sites have outdated monitoring programs that no longer provide the data necessary for regulatory decision-making. Monitoring program adequacy depends primarily on whether the program provides timely answers to appropriate questions. It is important that monitoring programs be periodically reviewed and optimized so that key trends can be detected.

Panel Discussion: Water Agency Case Studies

The last session of the symposium was a panel discussion on developing, maintaining and utilizing groundwater monitoring networks. The session opened with excellent, contrasting presentations, followed by animated discussions covering issues of scale, authority, political will, economics, primary drivers, and technical approach. Session panelists included Roy Herndon, Orange County Water District (OCWD), Nancy Matsumoto, Water Replenishment District of Southern California (WRD), Dan Detmer, United Water Conservation District (UWCD), and Marcus Trotta, Sonoma County Water Agency (SCWA). Bill Cunningham (USGS) and Tim Parker (Parker Groundwater; formerly of Schlumberger Water Services) served as moderators.

The OCWD was created in 1933 with regulatory powers for the purpose of protecting the groundwater basin; their authority was subsequently increased to include rights to the Santa Ana River, and authority to assess a pump tax. OCWD's service area covers more than 350 square miles and includes Orange County's groundwater basin, which provides a water supply to more than 2.3 million people. OCWD has been recharging the groundwater basin for over fifty years, utilizing extensive infiltration basins and the Groundwater Replenishment System water recycling and injection facility. OCWD's monitoring network includes more than 1,000 monitoring points, which are measured at various frequencies.

The WRD was formed by popular vote in 1959 for the purpose of protecting the groundwater resources of the Central and West Coast groundwater basins in southern Los Angeles County, and to replenish the basin to

Continued on the following page…

Groundwater Monitoring: Design, Analysis, Communication, and Integration with Decision Making *– Continued*

address declining groundwater levels and seawater intrusion. Groundwater pumping in the Central and West Coast basins is managed and controlled under a court-ruled adjudication. WRD is responsible for obtaining replenishment water and has the authority to levy fees on pumpers. WRD has been recharging the groundwater basin for 50 years, and their groundwater management activities include providing the water for seawater intrusion barrier wells, contamination monitoring and mitigation, and groundwater flow modeling. Approximately 500 production and monitoring wells are measured on varying time scales.

UWCD, formed in 1927, focuses on maintaining water quality and conserving critical supplies. UWCD has invested in increased storage and protection of water resources in the 335 square-mile area of UWCD jurisdiction. Major capital projects have included Lake Piru, El Rio Spreading Grounds and Wells, Oxnard-Hueneme delivery system, and the Freeman Diversion. Major drivers in the UWCD area include seawater intrusion, nitrate impacts, salt management and overdraft, which form the basis for the voluntary groundwater monitoring program in the Valley. Of the more than 900 active wells in the basin, water levels are measured in approximately 300 production and monitoring wells on a continuous (pressure transducers) to monthly or annual basis.

In 2002, SCWA first began developing the scientific basis for development of the first groundwater management plan (GMP) in the county for the 166 square-mile Sonoma Valley through a USGS cooperative basin study and preparation of a groundwater flow model. The GMP, implemented in 2008, identified salinity intrusion, increasing demands and declining supplies as the major drivers, and forms the basis for the voluntary, cooperative groundwater monitoring program in the Valley. Of the more than 2,000 wells in the basin, approximately 100, including residential, agricultural, and municipal supply wells are monitored on a biannual basis for water levels.

Posters, Exhibitors, and Luncheon Speakers,

In addition to the oral sessions described above, the symposium featured a large group of excellent poster presentations, displays by 11 exhibitors, and two excellent luncheon speakers. Michael Barcelona, Western Michigan University, provided a compelling keynote luncheon talk titled "Serious Water Resources Issues in a Rebuilding Economy (Coupled with Climate Change)." Michael identified three key monitoring challenges – funding, data coverage, and communication – and highlighted the role of climate change. Tim Parker's (Parker Groundwater; formerly of Schlumberger Water Services) delivered the second-day luncheon presentation on "Geologic Carbon Sequestration – Characterization and Monitoring Tools and Technologies." Approaching the monitoring challenges for pilot-scale and full-scale carbon sequestration projects will require application of monitoring tools and techniques from both the groundwater and oil industries. Technologies will need to be adapted for application in the intense pressures and temperatures associated with most sequestration projects.

GRA Extends Sincere Appreciation to its Chair and Sponsors for its April 2009 *Legislative Symposium and Lobby Day*

CHAIR
Tim Parker

LEGISLATIVE ADVOCATES
Chris Frahm, Brownstein Hyatt Farber Schreck
Paul Bauer, Brownstein Hyatt Farber Schreck

TITLE SPONSOR
Metropolitan Water District of Southern California

LUNCHEON SPONSOR
Water Replenishment District of Southern California

LEADERSHIP SPONSOR
Golden State Water Company

GRA Welcomes the Following New Members

February 22, 2009 – May 15, 2009

Akers, Randy	Pressure Systems
Boyd, Jesse	Stevens, Drummond & Gifford
Boyer, Jennifer	LFR, Inc.
Byerrum, Jim	California Domestic Water Co.
Chapman, Steven	University of Guelph, School of Engineering
Coan, Sean	Camp Dresser & McKee, Inc.
Constantinescu, Valentin	
D'Anna, Michael	CSUS Geological Dept.
Dean, Robert	Calaveras County Water District
Diamond, Larry	Calaveras County Water District
Dickenson, Gary	State Water Resources Control Board
Gagan, Michael	Rose & Kindel
Gehlhausen, Andie	Worley Parsons
Holland, Pete	Vector Engineering
Jani, Mukesh	Torrent Laboratory, Inc.
Jones, William	Blaine Tech Services, Inc.
Kulla, Jean	K2 Enviro, Inc.
Pattison, Edwin	Calaveras County Water District
Patton, Kenneth	AECOM Environmental
Patton, Kent	Pace Analytical Services, Inc.
Pearl, Mike	Curtis & Tompkins Laboratories
Peterson, Justin	MWH Americas, Inc.
Rogan, Sheila	Trihydro
Rosenfeld, Paul	Soil Water Air Protection Enterprise
Seech, Alan	Adventus Group Inc.
Simon, Jason	
Swimley, Charlie	City of Lodi
Webb, David	Blaine Tech Services, Inc.
Wilson, Ed	MWH Labs

2009 Contributors to GRA – Thank You

FOUNDER *($1,000 and up)*
Brownstein Hyatt Farber Schreck

PATRON *($500-$999)*
DrawingBoard Studios
Roscoe Moss Company
Bob Van Valer

CORPORATE *($250-$499)*
David Abbott
Geomatrix
Luhdorff & Scalmanini Consulting Engineers
Malcolm Pirnie

CHARTER *($100-$249)*
Kate Burger
Martin Feeney
Stanley Feenstra
EMAX Laboratories, Inc.

SPONSOR *($25-$99)*
Megan Abadie
Charles Almestad
Richard Amano
Thomas Ballard
Jenifer Beatty
Timothy Boyd
Jennifer Boyer
BSK Associates
Teresa Butler
Calcon Systems, Inc.
Steve Campbell
Bob Cleary
Nova Clite
Condor Earth Technologies, Inc.
Thomas Cooper
Crawford Consulting, Inc.
Zafer Demir
Glenn Dombeck
Jessica Donovan
David Dunbar
Patrick Dunn
Earth Tech
EQUIPCO
Brad Esser
Fred Flint
Avram Frankel
Laura Frost
Jacob Gallagher
Gary Halbert
Thomas Harder
H2O Engineering, Inc.
Hydrometrics LLC
Ted Johnson
Gail Jones
Tammy Jones
Carol Kendall
Mark King
Taras Kruk
Jean Kulia
James Lehrman
LFR Inc.
Martha Maier
Robert Martin
Garry Maurath
John McAssey
Sally McCraven
Peter Mesard
Jean Moran
MWH Americas, Inc.
Alec Naugle
Aaron O'Brien
Kent O'Brien
Larry Ofiaro
Oliver Page
PES Environmental, Inc.
Steven Phillips
John Reay
Eric Reichard
Pawan Sharma
Shaw Environmental
William Sedlak
Alan Seech
Linda Spencer
Phyllis Stanin
Susan Trager
Treadwell & Rollo, Inc.
Brian Wagner
Ed Wallick
Weiss Associates
Gus Yates
Anthony Zampiello
William Zavora
Greg Zekoff

SUPPORTER
Angela Carmi
John Farr
Lauren Steely
Frank Yeamans

GRA Requests Nominations for the 2009 "Lifetime Achievement" and "Kevin J. Neese" Awards

The purpose of the GRA Awards Program is to recognize noteworthy projects and unique individual contributions related to the understanding, protection and management of groundwater. The objectives of the annual Awards Program are:

1. To provide recognition to individuals who have demonstrated leadership and continuous dedication in the field of groundwater;
2. To provide recognition for unique contributions to the field of groundwater in 2008-2009.

All nominations for the Lifetime Achievement and Kevin Neese Awards must be received by Stephanie Hastings at shastings@bhfs.com no later than **Friday, June 26, 2009**.

Nominations should be completed using the nomination forms available on the GRA's website at http://www.grac.org/awards.asp. Nominations should: not exceed one page, identify the award for which the nomination is made, and include justification for the award based on the criteria listed below.

The GRA Awards will be presented to the recipients selected by the GRA's Board of Directors at GRA's Annual Meeting in Sacramento, October 6-7, 2009.

Awards

Lifetime Achievement: presented to individuals for their exemplary contributions to the groundwater industry, and contributions that have been in the spirit of GRA's mission and organization objectives. Individuals that receive the Lifetime Achievement Award have dedicated their lives to the groundwater industry and have been pioneers in their field of expertise.

Previous Lifetime Achievement Award winners include:

- 2008 - Dr. Perry L. McCarty
- 2007 - Herman Bouwer
- 2006 - Glenn Brown
- 2005 - Dr. Luna P. Leopold
- 2004 - Dr. John Bredehoeft
- 2003 - Rita Schmidt Sudman
- 2002 - Tom Dibblee
- 2001 - Carl Hauge
- 2000 - Joseph H. Birman
- 1999 - David Keith Todd
- 1998 - Eugene E. Luhdorff, Jr.

Kevin J. Neese: recognizes significant accomplishment by a person or entity within the most recent 12-month period that fosters the understanding, development, protection or management of groundwater.

Previous Kevin J. Neese Award winners include:

- 2008 – Orange County Water District for its Groundwater Replenishment System (GRS), a new water purification plant that produces 70 MGD of near-distilled-quality water each day.
- 2006 – Senator Sheila Kuehl for her work to improve the production and availability of information about the state of our groundwater resources, information on which reasonable and sensible groundwater management may be developed.
- 2004 – California Department of Water Resources for publication in 2003 of its updated Bulletin 118: "California's Groundwater."
- 2002 – Glenn County Water Advisory Committee for formulating a significant groundwater management ordinance that was adopted by the Glenn County Board of Supervisors.
- 2001 – American River Basin Cooperating Agencies and Sacramento Groundwater Authority Partnership for fostering the understanding and development of a cooperative approach to regional planning, protection and management of groundwater.
- 2000 – Board of Directors of the Chino Basin Watermaster for delivering a remarkable OBMP that created a consensus-based approach for making water supplies in the Chino Basin more reliable and cost effective.
- 1999 – Governor Gray Davis for his work and leadership in addressing MTBE.

Sacramento

By John W. Ayres,
Branch Secretary

February Meeting

Steven T. Springhorn of the California Department of Water Resources, Central District, presented "Stratigraphic Analysis and Hydrogeologic Characterization of Cenozoic Strata in the Sacramento Valley near the Sutter Buttes." The presentation featured research, exploration, and establishment of a conceptual model of Cenozoic strata near the Sutter Buttes. Steven's research utilized existing datasets, including deep gas well logs and shallower groundwater well logs, to map the extent of the Sutter Buttes Rampart and evaluate a hypothesized connection between elevated arsenic levels and the presence of Rampart volcaniclastic materials. Arsenic concentrations in groundwater are generally less than 10 µg/l; however, arsenic concentrations in Rampart materials are considerably higher (10-370 µg/l).

March Meeting

The Sacramento Branch held a meeting featuring the beauty and diversity of California's landscapes as photographed by John Karachewski, of the California Department of Toxic Substances Control. John's presentation coupled excellent photographs of Southern California, the Sierra Nevada, Great Valley, Coast Ranges, and Cascade provinces with insightful descriptions of associated geologic and hydrologic histories. John collaborated on a popular book titled *"Geology of the San Francisco bay Region."*

April Meeting

The Sacramento Branch held a meeting at the Alumni center of California State University Sacramento, featuring Lorrie Flint, of the United States Geological Survey, and two student guest speakers. Lorrie's presentation entitled "Evaluating Future Hydrologic Changes in Western Watersheds" focused on the potential effects of climate change on western water resources. She discussed the timing of springtime snowmelt, basin runoff, and groundwater recharge. Lorrie's work involves 'downscaling' global climate model (GCM) information to drive models of water supply and ecology in the western United States. Downscaling derives regional climate values from GCM values and other data, and applies it to smaller discrete areas utilizing information on local weather, topography, slope, and vegetation cover.

The excellent student presentations were given by the 2008 recipients of funds donated through GRA Sacramento Branch Scholastic Program, with matching funds from statewide GRA.

The first student presenter, Mandy Plaskett, gave a presentation entitled "Heat Flow Measurements and Groundwater Surface Water Interaction." This presentation focused on temperatures of groundwater measured at various depths in wells throughout the CSUS campus. Temperatures in wells closest to the American River were higher, showing a connection to the surface water body.

The second student presenter, Katherine Waring, gave a presentation titled "Compression of Aquifers by Passing Trains." This presentation discussed the short-term increase in groundwater levels near railroad tracks that occurs when a train passes over the tracks. Her work included continuous monitoring of groundwater levels in wells near the railroad tracks, and analysis of these head perturbations. The monitoring indicated that groundwater levels increased slightly in the vicinity of the railroad during a train's passing. Her work included a mathematical description of this phenomenon using a line function and estimation of aquifer parameters.

San Francisco

By JohnKarachewski,
Branch Secretary


Photo by John Karachewski

On January 21, 2009, over 120 participants attended the "Annual Regulatory Update" provided by Stephen Hill, Elizabeth Allen, and Chuck Headlee from the San Francisco Bay Regional Water Quality Control Board (RWQCB). Stephen Hill discussed Board news, brownfields, and the GeoTracker database, whereas Elizabeth Allen provided an update on revisions to screening levels. Given the current economic downturn, Stephen Hill indicated that over 80% of the RWQCB budget is derived from special funds; however, the UST and cleanup programs will probably experience cuts in their allocations. Stephen Hill also discussed the increasing emphasis placed by Governor Arnold Schwarzenegger and the legislature on tracking and measuring the performance of site cleanups. Another important goal is to improve inter-agency coordination and develop uniform site assessment tools between the Water Boards and DTSC to facilitate cleanup and re-use of brownfields and to promote urban infill development. Stephen Hill also provided an update on GeoTracker 2.0 and the collaboration with EcoInteractive Inc. to use Google maps as a GIS interface and provide customized screens and management tools for UST, Site Cleanup, Department of Defense, and Land Disposal programs. Stephen Hill also discussed the agency and discharger responsibilities with respect to uploading e-data and reports and the important role that labs and consultants play in this process. Elizabeth Allen provided an update regarding the EPA PRGs, the Active Soil Gas Advisory, and Environmental Screening Levels (ESLs). The Active Soil Gas Advisory will be issued this spring by the Cal EPA and some of the anticipated changes include: the installation of semi-permanent and permanent probes, longer equilibration times, gas as well as liquid leak detection, a waiting period after rainfall events, no LDPE tubing, and analysis for naphthalene using method TO-17. Elizabeth Allen also noted impacts to indoor air quality have been correlated with groundwater contamination at concentrations in the low microgram per liter (μg/L) range. Of special interest, the new residential ESLs for BTEX, PCE, TCE, and vinyl chloride will be significantly lower than previous levels, which may require more site-specific risk assessments.

On March 17, 2009, over 80 participants attended the "UST Cleanup Fund Update" provided by manager Ron Duff. His presentation provided an overview of the program background, recent legislation, program status, cash flow issues, and current activities. The fund revenues are generated by a storage fee (1.4 cents) for every gallon of petroleum products placed into USTs. The fee currently generates about $230 - $250 million per year. Mr. Duff also described the 4-class priority system from Class A – residential tank owners, to Class D – other claimants such as major oil companies and government agencies. Interestingly, the current system is based on ability to pay for cleanups and is not related to risk or threat to the environment. Recent legislation (SB 1161, Lowenthal) extended the UST fund to January 1, 2016. Mr. Duff also provided a detailed summary of claim trends, status, and payments through time. Class B and C small and medium-sized businesses receive the bulk of the funds. The cash flow issue was of special interest to the large number of consultants in the audience. The long-term cash surplus in the UST fund is gone and the program must now operate within the annual income. The program is currently experiencing a major backlog of payments with a $240 million demand versus an available $150 million in funds. Class C medium-sized businesses will experience a major impact with many suspensions and a longer wait for reimbursement. Ron Duff also indicated that over 78% of sites have been active for 5 or more years. The reduced cash flow will require long-term changes to the UST program including a move to risk-based corrective action, implementation of uniform and cost-effective cleanup activities, consideration of future land use, and closure of sites.

Southern California

By Geniece Higgins,
Branch Secretary

February 25, 2009 Meeting: Regulatory Update

The Southern California Branch held its first meeting of the new year at the Double Tree Club Hotel in Santa Ana. Presenters at this year's annual regulatory update meeting spoke on several hot topics including the UST Cleanup Fund (USTCF), revisions to the California LUFT manual, and upcoming drinking water regulations.

The Southern California branch of the GRA also tried its hand at a remote web presentation by Bob Pallarino, with EPA Region 9's Underground Storage Tank Program, who discussed the upcoming revised LUFT manual and the processes through which input is obtained from all sectors of the UST community including regulators, inspectors, consultants, industry, etc. Bob introduced the LUFT Manual WIKI, which enables every stakeholder the opportunity to provide insight and comments during the formulation of the new manual.

Ms. Geniece Higgins, with the Orange County Health Care Agency – Local Oversight Program, then gave an update focusing on issues facing tank clean-up sites in Orange County. One of the main issues facing tank clean-ups this year is the moratorium on the issuance of permits from the South Coast Air Quality Management District. This moratorium has created obstacles for operation of new, and some existing, remediation systems. However, exemptions to the moratorium are available if sites meet qualifying criteria. For more information on the moratorium, please visit: http://www.aqmd.gov/permit/docspdf/PermitMoratoriumLetterandFAQ.pdf.

An additional issue facing clean-up at tank sites is related to the USTCF reimbursement delays (see details below); however, RPs were cautioned that the delay of USTCF payment should not jeopardize deadlines set by regulatory agencies.

Ms. Lori Casias, with the State UST Cleanup Fund, although not the bearer of optimistic news regarding the status of claims reimbursements, provided up-to-date information and graciously stayed well after the meeting's end to answer the many questions from RPs, consultants, and regulatory agencies. Based on the decline in revenues for the approximately 250 million dollars annual UST Cleanup Fund, the following information was presented pertaining to reimbursement for each of the four classes in the priority system:

Class A (Residential Claimants): 90 active claimants; payments and Letters of Commitment (LOCs) are being processed.


Photo by John Karachewski

Class B (Less than 100 Employees): 2,000+ active Priority claimants; payments will be delayed 6 to 18 months; some active LOCs may be suspended in the near future; 40 on Priority List will not be issued LOCs; approximately 150 appeals in-house to switch Priority Class C to B.

Class C (Less than 500 Employees): most affected by the Fund's revenue and cash flow issues; payment requests will be processed and the payments placed on hold pending the availability of funds; payments may be delayed as long as 30 months; 440 currently active (application filing date prior to January 1, 1995); 612 suspended on November 7, 2008; 617 suspended on January 7, 2009; 40 on Priority List will not be issued LOCs.

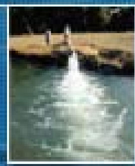
Class D (Other Claimants, Major Businesses): payment requests will be processed to meet 14% minimum; 370 currently active; 127 suspended on January 5, 2009; 4,500 on Priority List will not be issued LOCs.

Ms. Casias emphasized that the RPs should continue to work with each regulatory agency, submit complete reimbursement request packages (including electronic spreadsheets), be responsive to requests from the Fund, pay vendors promptly and provide proof of payment within 60 days of receipt, keep consultants notified of Fund communications and maintain Geotracker uploads.

The meeting concluded with a presentation by Dr. David Chang, of the Golden State Water Company, who talked about the Federal Groundwater Rule (FGR). The FGR aims to provide for increased protection against microbial pathogens in public water systems that use groundwater sources. The final rule was promulgated on November 22, 2006 with a compliance date, unless otherwise noted, of December 1, 2009. The FGR will apply to public water systems that serve groundwater. The FGR requires 1) periodic sanitary surveys of groundwater systems; 2) source water monitoring to test for the presence of E. coli, enterococci, or coliphage; 3) corrective action for any system with a significant deficiency or source water fecal contamination; and 4) compliance monitoring to ensure that treatment technology installed to treat drinking water reliably achieves at least 99.99 percent (4-log) inactivation or removal of viruses. For more information regarding the FGR, please visit: http://www.epa.gov/safewater/disinfection/gwr/index.html.

Plans for future Southern California Branch meetings tentatively include: presentations on the Great Shake Out scheduled for April 28, a visit to Roscoe Moss well material fabrication facility, and two Saturday summer Field Trips in conjunction with a UCI Extension class.

GROUNDWATER RESOURCES ASSOCIATION
of California



Dedicated to resource management that protects and improves groundwater through education and technical leadership

Groundwater Resources Association Symposium

Nanotechnology for Environmental Cleanup and Pollution Control

November 3, 2009, Northern California

Call for Abstracts, due August 1 – see www.grac.org/nanotech.asp

GRA seeks to provide a forum for leading nano researchers, practitioners, and nano policy and regulatory experts to share and express the latest research findings, case studies, and regulatory issues of nanotechnology. The focus of this symposium will be on the application of nanotechnology for groundwater remediation, surface water treatment and pollution control.

Featuring topics such as:

- Nanotechnology for Groundwater Remediation
- Nanotechnology for Surface Water Treatment and Pollution Control
- Delivery/Application Methods of Nanomaterials for Water Treatment
- Regulatory Issues with Nanomaterials and Nanotechnology
- Case Studies

Conference Sponsors:
California EPA / Department of Toxics Substances Control
AMEC Geomatrix, Inc.

For more information,
please visit the GRA website at: http://www.grac.org/

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

AMEC Geomatrix

Central Coast

e-mail: cc.branch@grac.org

President: Brad Herrema
Brownstein Hyatt Farber Schreck
(805) 882-1493
bherrema@bhfs.com

Vice President: Louie Hengehold
Hopkins Groundwater Consultants
(805) 653-5306
lhengehold.hgc@sbcglobal.net

Secretary: VACANT

Treasurer: Sam Schaefer
GEI Consultants, Bookman-Edmonston Division
(805) 729-4677
sschaefer@geiconsultants.com

Sacramento

e-mail: dvajet@aol.com

President: David Von Aspern
Sacramento County EMD
(916) 875-8467
dvajet@aol.com

Vice President: Steve Lofholm
Golder Associates
(916) 786-2424
slofholm@golder.com

Secretary: John Ayres
Brown + Caldwell
(916) 444-1023
jayres@brwncald.com

Treasurer: Rodney Fricke
Aerojet
(916) 355-5161
Rodney.fricke@aerojet.com

Technical Advisory Member, Operations: Pat Dunn
Dunn Environmental
(916) 941-3851
pfdunn@dunnenviro.com

Technical Advisory Member, Scholastic: Julie Friedman
City of Sacramento
(916) 798-5074
jlfriedman1@aol.com

Technical Advisory Member: Kent Parrish
URS
(916) 679-2000
kent_parris@urscorp.com

Technical Advisory Member: Kevin Brown
Geocon
(916) 852-9118
brown@geoconinc.com

San Francisco Bay

e-mail: sf.branch@grac.org

President: Jim Jacobs
Environmental Bio-Systems, Inc.
(415) 381-5195
jimjacobs@ebsinfo.com

Vice President: Jennifer Nyman
Malcolm Pirnie, Inc.
(510) 735-3012
jnyman@pirnie.com

Secretary: John Karachewski
Department of Toxic Substances Control
(510) 540-4121
Jkarache@dtsc.ca.gov

Treasurer: David W. Abbott
Todd Engineers
(510) 747-6920
dabbott@toddengineers.com

South Bay Coordinator: Mark Wheeler
Crawford Consulting, Inc.
mark@crawfordconsulting.com

Technical Advisor: James S. Ulrick
Ulrick & Associates
(925) 376-3721
julrick@ulrick.com

Technical Advisor: Carol Kendall
U.S. Geological Survey
(650) 329-4576
ckendall@usgs.gov

Past President: William E. Motzer
Todd Engineers
(510) 747-6920
bmotzer@toddengineers.com

San Joaquin Valley

e-mail: lisa.massie@amec.com

President: Bill Pipes
AMEC Geomatrix
(559) 264-2535
bill.pipes@amec.com

Vice President: Tom Haslebacher
Kern County Water Agency
(661) 871-5244
thaslebacher@bak.rr.com

Secretary: Mary McClanahan
California Water Institute
(559) 278-8468
mmcclana@csufresno.edu

Treasurer: Christopher Campbell
Baker Manock & Jensen
(559) 432-5400
clc@bmj-law.com

Technical Advisory Member: Barbara Houghton
Houghton HydroGeolgic, Inc.
(661) 398-2222
barbara@houghtonhydro.com

Technical Advisory Member: Gres Issinghoff
RWQCB, Central Valley Region
(559) 488-4390
issinghoffg@r5f.swrcb.ca.gov

Technical Advisory Member: Bruce Myers
RWQCB, Central Valley Region
(559) 488-4397
myersb@r5f.swrcb.ca.gov

Southern California

President: Emily Vavricka
emily.vavricka@dpra.com

Vice President: Bill Sedlak
Tetra Tech EC
(949) 756-7530
Bill.Sedlak@tteci.com

Secretary: Geniece Higgins
Orange County Health Care Agency
(714) 433-6263
ghiggins@ochca.com

Treasurer & Past President: Peter J. Murphy
Kennedy/Jenks Consultants
(949) 261-1577
PeterMurphy@kennedyjenks.com

Technical Advisor: Toby Moore
Golden State Water Company
(714) 535-7711
TobyMoore@gswater.com

Technical Advisor: Sheila Rogan
Tri Hydro
(714) 399-1560
srogan@trihydro.com

Technical Advisor: Paul Parmentier
Locus Technologies
(714) 333-1752
parmentierp@locustec.com

Mugu Lagoon, Southern California

The US Navy manages Mugu Lagoon and adjacent tidal flats, which together represent the largest remaining coastal wetlands in southern California. Waves and longshore currents transported sand into the area and built the beach and dunes that separate the brackish water of the lagoon from the open ocean. Construction of coastal breakwaters and dams across the major rivers has significantly reduced the supply of sand transported into this area. As a result, the shoreline has retreated by hundreds of feet during the past several decades. A submarine canyon also approaches within a few hundred feet of the beach, near the inlet of the lagoon (center).

Groundwater is the primary resource for agricultural irrigation and urban supply within the Oxnard Plain. Overdraft of groundwater has resulted in seawater intrusion, inter-aquifer flow, land subsidence, and groundwater contamination. The aquifers extend offshore into the marine environment where they crop out along the continental shelf and submarine canyons. Extensive groundwater pumping has caused a reversal in the direction of groundwater flow from the ocean towards the land and resulted in seawater intrusion and impacts to multiple aquifers.

Native Americans favored the Point Mugu area as a place of residence because of the abundant shellfish, fish, and birds living in the biologically rich environments. Mugu Lagoon is also an important resting and breeding ground for birds along the Pacific Flyway.

Photograph by John Karachewski, Ph.D. (DTSC)