Groundwater Resources Association of California

HYDRO VISIONS

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GRA 2010 Annual Meeting – A Broad View of Water and Groundwater Resources Management Challenges and Practices

By Tim Parker (co-Chair), Parker Groundwater, with David Abbott;
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John McHugh, Santa Clara Valley Water District; Jean Moran, California State University East Bay;
Vera Nelson, of Erler & Kalinowski, Inc.; Bill Pipes (co-Chair), Amec Geomatrix, Inc.;
and Sarah Raker, MACTEC Engineering Consulting

GRA would like to take this opportunity to thank the GRA Annual Meeting Planning Committee, Moderators, Speakers, Poster Presenters, Sponsors, GRA Members and Attendees for your support of the GRA 2010 Annual Meeting. Without your significant efforts and outstanding support, the 2010 Annual Meeting would not have been a success.

Opening Plenary Session: Expanding Local Portfolios, with Increasing Reliance on Groundwater Resources and Groundwater Protection – Panel Briefings

Moderated by **Tim Parker**, Layne Christensen Company, this session featured a number of distinguished speakers from federal and state agencies. **John Tubbs**, Deputy Assistant Secretary for Water and Science, Department of the Interior, kicked off the session demonstrating his depth of knowledge in western water gained in his former years in Montana, discussing overall challenges related to western water supplies and issues unique to California. Interior supports efforts to address the future of America's and the Southwest's water supply, and established a program called WaterSMART (Sustain and Manage America's Resources for Tomorrow). WaterSMART's purpose is to provide federal leadership and assistance to help secure and stretch water supplies for use by existing and future generations. The WaterSMART Program is already at work on a study of the existing water and power infrastructure in the Colorado River Basin, and how it will perform in response to projected future water supplies and demands. John added that Interior is focused on implementing the SECURE Water Act, which includes a Water Census inventory and development of the National Groundwater Monitoring Network.

David Albright, Manager, Groundwater Office, US Environmental Protection Agency (EPA) Region 9, described EPA's federal role under the Safe Drinking Water Act (SDWA) to encourage implementation of source water protection measures, set drinking water standards, oversee state implementation of the Drinking Water State Revolving Fund (SRF), and to implement the Underground Injection Control (UIC) regulations. Key EPA funding sources include the SRF (CA awarded $200M in 2009/2010 and $160M in 2009 ARRA), SDWA grants under the UIC, and grants to national organizations. EPA encourages development of source water protection and groundwater management plans, and is working to establish an SRF set-aside for wellhead and groundwater protection. UIC regulations are a Pollution Prevention provision of the SDWA; 95% of injection wells are < 100 feet deep; most are not subject to permits. Almost all deep injection wells (Class I – industrial/municipal disposal, Class II – oil and gas, and Class V – misc.) are permitted by EPA or the state. In CA,

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

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GRA's Finances

By Bill Pipes

Until I becoming involved in GRA at the Board of Directors level, I gave little thought to the organization's finances. Since becoming President, that increased awareness has become an obsession as I work closely with our Vice President, Treasurer, and Executive Director to ensure that GRA fulfills its mission while remaining financially viable. Like other non-profits we all get involved in—church groups, neighborhood associations, service clubs—GRA accomplishes a great deal on not very much money. Like these other groups, we rely heavily on the goodwill and commitment of volunteers. GRA is blessed to have many hard working volunteers.

Since its founding in 1992, GRA has been on a sure and steady growth curve and has generally stayed in the black, though some years have been better than others. GRA's financial health is tied directly to that of its members and their employers. The weak economy has posed financial challenges for GRA, and has caused us to question previous assumptions about growth and related financial projections. GRA's annual cash flow is about $350,000. Our revenues (see chart) come primarily from the events we put on and membership dues. GRA also receives unrestricted donations from companies and individuals, and donations restricted to certain items such as scholarships and lobbying.

GRA's largest expense (see chart) is for events, primarily for venues and meals. Our next expense is for our Executive Director, Kathy Snelson; she and her staff play an important role in supporting the events and other aspects of GRA. Lobbying comes next, then website expenses and *HydroVisions*. In the "other" category are insurance, accounting and legal, telephone, and travel. We aim not to spend all of the annual revenues so that we can maintain a rainy-day fund and have money to invest in worthwhile initiatives.

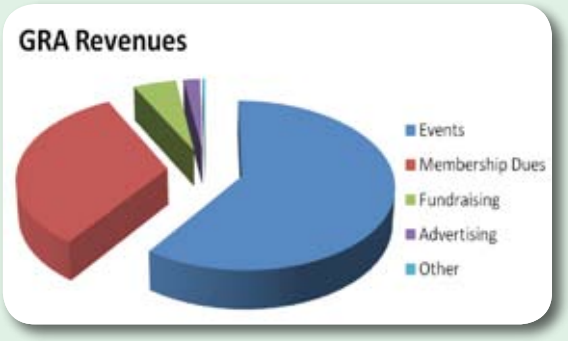
As a member of GRA, a reader of *HydroVisions*, and a participant in our events, I can assure you that you are receiving a lot of bang for your buck. Most importantly, our mission of protecting California's groundwater resources through education and advocacy is being realized.

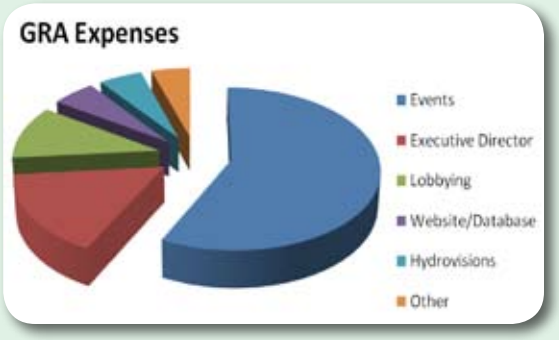
Speaking of the hard work and commitment of volunteers, I would like to recognize two GRA Directors who are finishing their terms this year and will not be renewing: Tom Johnson and Tom Mohr. The two Toms have donated much time and effort to GRA, and both have been instrumental in our success and growth during the last decade. Tom Mohr is a Senior Hydrogeologist with the Santa Clara Valley Water District, has served as a Director since 2001, and was the President in 2006-2007. Tom Johnson is Executive Vice President, Chief Technical Officer and Principal Hydrogeologist at ARCADIS. Tom has served as a Director since 2001 and was the President in 2004-2005. Both gentlemen brought to the GRA Board experience and insight into the important groundwater issues in California, and were a source of wisdom in helping to govern the organization. On behalf of the entire membership, thank you Tom and Tom, for your hard work and dedication to GRA.

And thank you for reading *HydroVisions*! Until next time,

Bill Pipes

Bill Pipes, *GRA President*





GUEST EDITORIAL

Water Policy Implications of California's Green Chemistry Initiative

By Edward L. Quevedo, Esq. and Bret A. Stone, Esq.

Introduction and Overview

California has long been viewed as a leader in the development of policies and regulations that create economic development opportunities while enhancing protection of human health and the environment. The new Green Chemistry legislation—supported by industry—was signed into law last year and is a prime example of this kind of leadership. The legislation will ultimately lead to safer and more healthful consumer products of all kinds, and will simultaneously create significant opportunity for entrepreneurs to develop alternatives to some of the most toxic industrial chemicals now in use.

Enacted as AB 1879 and SB 509, the Green Chemistry legislation aims to implement a new approach to the management of chemicals and other hazardous materials used across industry. Rather than address toxicity and risks to human health and the environment from these substances after they are produced and in the stream of commerce, Green Chemistry takes the preventative approach and requires that these issues be addressed at the product design stage.

The idea is to design-in environmentally friendly attributes and substances at the front-end of product development; "benign by design." California's Green Chemistry legislation represents part of a global trend toward such regulatory models. The states of Massachusetts and Michigan, among others, are considering using Green Chemistry as part of their regulatory tool kit. Likewise, the European Union and Canada have already adopted means to regulate the use of hazardous chemicals in products through regulatory tools such as the European REACH Directive. However, unlike these approaches which focus on the chemicals, California's legislation and regulations are focused on consumer products.

The term green chemistry, coined in 1991, is defined as "the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances." This approach to the protection of human health and the environment represents a significant departure from the traditional methods previously used. Although historically societies have tried to minimize exposure to chemicals, Green Chemistry emphasizes the design and creation of chemicals that are not hazardous to people or the environment. It has been applied to a wide range of industrial and consumer goods, including paints, dyes, fertilizers, pesticides, plastics, medicines, electronics, dry cleaning, energy generation, and water purification.

At the heart of Green Chemistry is the recognition that hazard is simply another property of a chemical substance. Properties of chemicals are caused by their molecular structure; they can be modified by changing that structure. The types of hazards that can be addressed by Green Chemistry vary. They include physical hazards (being explosive or flammable), toxicity (being carcinogenic or cancer causing, or lethal), and global hazards (climate change or stratospheric ozone depletion). Therefore, in the same way that a substance can be designed to be a certain color or texture, it may also be designed to be nontoxic.

Potential Water Policy Opportunities and Challenges

There is no question that a law as sweeping as Green Chemistry will present a challenge to industry, but this approach also portends many benefits to industry, society, and future generations:

- By mandating substitution of alternative, less harmful chemicals and substances in manufacturing, Green Chemistry will draw attention to the need to keep end-of-life chemicals out of the water supply. Whether through municipal collection, landfill disposition, or other legal or extra-legal disposal practices, the chemical content of consumer goods poses a substantial risk to habitat, drinking water supplies, and aesthetically valuable waterways. Although the Green Chemistry legislation does not include water resource protection as a legislative objective, the collateral impacts of Green Chemistry will very likely benefit our water resources.
- Through the means of design-based analysis, Green Chemistry will reduce the risks of exposure of employees to harmful chemicals in manufacturing environments, driving down manufacturing costs and elevating the level of worker protection and well-being.
- Eliminating the most toxic and harmful chemicals from use in manufacturing will also drive down the heavy regulatory and financial burden on industry resulting from storage, disposal, and long-term liability for management of hazardous wastes resulting from manufacturing activities. The alternatives analysis required as the foundation of substi-

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Water Policy Implications of California's Green Chemistry Initiative – Continued

tution of chemicals or reduction of their toxicity might also lead to water use reduction and greater operational efficiencies, with collateral benefits to water supply and water quality.

Origins of Green Chemistry

The foundations of Green Chemistry are rooted in principles of industrial process and product design. Before consumer products ever reach retail stores, hundreds of product and industrial designers, process and chemical engineers, research scientists, and many others in the development chain have their say in how the products will look, feel, perform, and operate. The legislative agenda set by Green Chemistry puts in place ambitious goals for manufacturers which are currently on an expedited time frame. Green Chemistry aims to jump-start this process in the interest of improving the safety of products and reducing the risks of use of chemicals in making consumer products to be used, sold, or leased in California. The opportunities embedded in each of these elements of Green Chemistry, however, should not be overlooked. Industries and companies that develop strategies to rework the way they design, manufacture, and develop consumer products—or at least the use of chemicals of concern in their processes—will obtain a commercial advantage over those who slowly or reluctantly engage in the Green Chemistry process, as consumer products which do not provide the information may be banned from the California market.

Adverse impacts to water supplies can be greatly minimized through effective Green Chemistry practices in industry. The methods used to make chemical materials, called synthetic methods, have often employed toxic chemicals such as cyanide or chlorine. In addition, these methods have at times generated large quantities of hazardous wastes. Green Chemistry research is developing new ways to make these synthetic methods more efficient and to minimize wastes while also ensuring that the chemicals used and generated by these methods are as nonhazardous as possible. For example, a number of industries, such as the pulp and paper industry, use chlorine compounds in processes that generate toxic chlorinated organic waste. Green chemists have developed a new technology that converts wood pulp into paper using oxygen, water and polyoxometalate salts, while producing only water and carbon dioxide as by-products.

Protection of water supplies can also be enhanced through designing safer chemicals. Once it is certain that the feedstocks and methods needed to make a substance are environmentally benign, it is important to ensure that the end product is as nontoxic as possible. By understanding what makes something harmful (the field of molecular toxicology), scientists are able to design the molecular structure so that it is not dangerous. The alternatives analysis process within the draft Green Chemistry regulations is intended to lead to more responsible chemical design.

The Legislative Details

The first of the two Green Chemistry statutes, AB 1879, establishes a process for California to systematically identify chemicals of concern to human health or the environment, and gives the Department of Toxic Substances Control (DTSC) authority to regulate such chemicals in consumer products. It creates a Green Ribbon Science Panel of experts to provide advice on scientific matters, chemical policy recommendations and implementation strategies, to ensure that implementation efforts are based on a strong scientific foundation. The bill expands the role of the Environmental Policy Council, composed of heads of all California EPA boards and departments, to oversee critical activities related to the implementation of the Green Chemistry program.

The second statute, SB 509, establishes a clearinghouse to provide access to vital information needed by citizens, consumers, workers, institutions, and businesses to make sound decisions about chemicals and chemical products they make, use, buy or sell. SB 509 authorizes DTSC to establish this clearinghouse for the collection, maintenance, and distribution of specific chemical hazard traits and environmental and toxicological end-point data. Finally, the legislation requires the California Office of Environmental Health Hazard Assessment (OEHHA), by January 1, 2011, to evaluate and specify the hazard traits and environmental and toxicological end-points and any other relevant data that are to be included in the clearinghouse.

The legislation targets "chemicals or chemical ingredients in consumer products." The chemicals that will receive attention are called "chemicals of concern." The regulations adopted under this legislation, which are currently in development at DTSC, will define these key terms and set the scope of the products and substances regulated by the Green Chemistry initiative.

The tasks mandated by this legislation are enormous. The vast number of consumer products produced, leased, used, and sold in California, and the hundreds of chemicals used in their manufacture, constitute a huge listing of potentially regulated goods and substances. DTSC is actively seeking public input, which commenced during 2007 and 2008 as the initial regulatory development process began. It will be critical for potentially affected companies and industries to engage actively in the regulatory development process.

Regulatory Development, Public Involvement, and Other Key Planning Steps

Use of Green Chemistry principles has proven effective in reducing the impact of chemicals on human health and the environment. In addition, many companies have found that it can be cheaper and even profitable to meet environmental goals. Profits de-

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rive from higher efficiency, less waste, better product quality, and reduced liability. Many environmental laws and regulations target hazardous chemicals, and following all these requirements can be complicated, but Green Chemistry allows companies to comply with the law in much simpler and cheaper ways. Finally, Green Chemistry is a fundamental science-based approach. Addressing the problem of hazard at the molecular level, it can be applied to all kinds of environmental issues.

Since 1991, there have been many advances in Green Chemistry, in both academic research and industrial implementation. For example, Spinosad, an insecticide manufactured by fermenting a naturally occurring soil organism, was registered by the EPA as a reduced-risk insecticide in 1997. Spinosad does not leach, bioaccumulate, volatilize, or persist in the environment, and in field tests left 70 to 90 percent of beneficial insects unharmed. It has a relatively low toxicity to mammals and birds and is slightly to moderately toxic to aquatic organisms, but is toxic to bees until it dries. This kind of scientific advance, however, represents an extremely small fraction of the potential applications of Green Chemistry.

The emergence of Green Chemistry will unquestionably present challenges to industry. Businesses will have to develop strategies that analyze the impact of their entire supply chain and the chemicals used in their products, from building materials to baby bottles and almost everything in between. However, many opportunities for commercial and social benefits will arise as well, especially as the processes of supply chain collaboration proceed in anticipation of meeting the demands of this new legislation.

Edward L. Quevedo is a partner at Paladin Law Group® LLP and chair of the firm's Sustainability Practice Group. He has over 25 years of experience advising clients on domestic and international environmental and health & safety (EHS) law compliance and litigation matters, sustainability planning and program development, and strategic EHS program development and performance counseling, both as an attorney and consulting advisor. Since 2004, Ed has served on the faculty of the Dominican University School of Business & Leadership MBA Program in Sustainable Enterprise (the Green MBA®) (www.greenmba.com). Bret A. Stone is a partner of the firm. His practice ranges from addressing issues resulting in environmental liabilities, including litigation concerning contaminated sites, to assisting companies and public entities on sustainability agendas.

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EPA has registered > 19,000 Class V shallow injection wells at > 3,000 sites since 1987, 138 Class V aquifer storage and recovery wells, > 25,000 Class II brine disposal wells, and 52 Class I injection wells.

Highlights of the California Water Plan Update 2009 were presented by **Kamyar Guivetchi**, Manager Statewide Integrated Water Management, California Department of Water Resources. First published in 1957 as Bulletin 3, the Water Plan has been updated nine times as Bulletin 160; the most recent is Update 2009, and the next is due in 2013. Update 2009 reinforces the need to follow the principles of statewide and regional integrated water management, and to use water efficiently, improve water quality and reliability, and integrate environmental stewardship into water management. The 27 Resource Management Strategies in Update 2009 build upon the historic water legislation signed into law in 2009, which included urban water conservation targets, creation of a Sacramento-San Joaquin Delta governance framework, water rights enforcement, funding for water supply reliability, and requiring statewide groundwater monitoring. New to this Update is an integration of water resource management and flood management to increase resiliency in hydrologic systems and yield benefits for public safety, habitat protection and water supply reliability. Climate change and increasing demand have reduced the flexibility and resilience of existing infrastructure; statewide improvements are critically needed, along with local resource strategies including conservation, water recycling, conjunctive use, and urban runoff management. Update 2013 is just getting started, and has an increased emphasis on integrating groundwater. For more information, visit www.waterplan.water.ca.gov.

Clay Rodgers, Assistant Executive Officer, State of California Regional Water Quality Control Board – Central Valley (RWQCB-CV), provided an overview of the "Groundwater Quality Protection Strategy for the Central Valley, A Roadmap" (Roadmap). The Central Valley is the largest groundwater basin in the state, contains the second largest aquifer in the nation, and provides > 50% of the drinking water in the basin. In December 2008, the RWQCB-CV adopted a Resolution to develop a stakeholder-driven process to plan a Groundwater Strategy for the Central Valley in order to protect beneficial uses of groundwater and ensure a sustainable, high quality water supply for the 5–25 year planning horizon. The Roadmap is an overarching framework for long range planning, defines the regulatory programs to be enhanced, and identifies ways to build upon existing partnerships. The Roadmap describes primary constituents of concern and includes current groundwater quality protection programs. Stakeholder's concerns and issues were considered in the evaluation of existing groundwater quality protection programs and identification of future actions. The August 2010 Roadmap was recently approved by the RWQCB-CV – for more information visit http://www.waterboards.ca.gov/centralvalley/water_issues/groundwater_quality/2010aug_gwq_protect_strat_approved.pdf.

Opening Plenary Panel Members (left to right) David Albright, EPA; Clay Rodgers, RWQCB-CV; Kamyar Guivetchi, DWR; John Tubbs, Dept. of the Interior; and Moderator Tim Parker, Parker Groundwater.

Session 1A – New Sources of Water

This session provided several examples where innovative solutions are being used to increase available water supplies through conservation and reuse. Vera Nelson of Erler & Kalinowski, Inc. presented a "Zero-Impact Water Footprint Plan for a new Sustainable Development in California." The focus was on conservation as a source of supply, and Vera discussed a large-scale sustainable development in a supply-constrained area of California. The objective was to incorporate aggressive conservation into the Project design and to identify opportunities within the water suppliers' service area to offset the Project's demand. The latter approach has been formalized by several water suppliers. The Project should be able to (1) reduce indoor potable water use by 50 percent by using non-potable supplies for toilet flushing, cooling, etc.; and (2) eliminate the use of potable water for irrigation.

Anona Dutton of the Bay Area Water Supply and Conservation Agency ("BASCWA") discussed BAWSCA's Long-Term Reliability Water Supply Strategy (Strategy). BASCWA represents the interests of 26 cities, water districts and private utilities that purchase water for 1.7 million people, and 30,000 businesses and community organizations from the San Francisco regional water system. After accounting for savings from existing and planned water conservation activities, BAWSCA demands are projected to equal available supplies by 2018 and exceed them by up to 30 million gallons per day (mgd) by 2035. Therefore, BAWSCA is developing a Strategy to identify projects that can be cost-effectively implemented by single or multiple member agencies in an appropriate timeframe to help meet demand. This Strategy has a near-term focus on conservation, as larger projects

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will take longer to implement. Larger projects include desalination, surface water imports and transfers. BAWSCA is also evaluating local projects, including recycled water, groundwater, stormwater capture and reuse, greywater, and rainwater harvesting.

Tess Byler of Weiss Associates focused on reuse of groundwater being treated for environmental site remediation in the San Francisco Bay Area. An estimated 1.4 billion gallons per year of groundwater is extracted as part of such remediation projects; however, only a small portion of the water extracted and treated is reused or returned to the subsurface. Tess discussed RWQCB resolution No. 88-160, which urges dischargers of extracted groundwater from site cleanup projects to reclaim their effluent, and policies implemented by Santa Clara Valley Water District to regulate reuse of such groundwater. She explored the barriers to reuse and potential regulatory options for increasing reuse of such water.

Session 1B: Protecting Groundwater While Slowing, Spreading, and Sinking Stormwater

Moderated by **Bill Pipes**, Amec Geomatrix, Inc., the session began with **Greg Gearheart**, Senior Water Resource Control Engineer at the CA SWRCB in Sacramento, who presented "Pimples to Dimples," a regulatory perspective on efforts to control stormwater runoff from new construction in California. As stormwater outfalls are considered point sources of pollutants into water bodies with water quality standards, local entities must ensure that pollutant concentrations in effluent are reduced to the maximum extent practicable through permitting and implementation of Low Impact Development (LID) elements at the project site. The concept is to reduce uncontrolled runoff from high areas ("pimples") and increase the amount of catchment, storage, and controlled release through the design of lower areas ("dimples").

Daniel Rourke, Environmental Resources Manager for the Fresno Metropolitan Flood Control District (FMFCD), discussed their stormwater and snowmelt recharge program. 154 basins and 500 miles of pipeline over a 200 square mile area are designed to capture and infiltrate urban stormwater flows and snow melt from the Sierra Nevada. Average capture amounts are 45,000 acre-feet per year, which is all recharged to groundwater, the sole-source supply in the Fresno area. Daniel described the multi-use aspect of the basins, which function as parks, ball fields, playgrounds, wildlife habitats, etc., and the year-round work needed to maintain basin integrity and infiltration rates.

Gus Yates, P.G., C.H., and consulting hydrologist, discussed enhancing groundwater recharge and yield through downspout disconnection in San Francisco. Gus evaluated the benefits of disconnecting building downspouts from the sanitary sewer to allow the infiltration of stormwater through western San Francisco's sandy soils into the aquifer to be captured by the City's water supply wells. He found that this program would be financially beneficial as it would increase the water supply at little cost and decrease wastewater treatment costs. Also, there would be fewer sewer overflows.

Session 2A: Conservation and Water Use Efficiency

Moderated by **David Abbott**, this session began with **Tyler Johnson** from the U.S. Geological Survey describing the use of readily available data to estimate the rate and distribution of urban or residential irrigation. Satellite imagery was calibrated using climatic records and geospatial land-use data to estimate the seasonal irrigation patterns in the San Fernando Valley. Geospatial data included two primary end-members: hardscaped areas such as airport buildings and pavement, and fully irrigated areas such as golf courses and parks; vegetated areas that were not irrigated (such as areas between airport runways) were a third category. Maps of residential irrigation rates developed using potential evapotranspiration and this method were comparable to maps using water use and this method.

Anona Dutton, PG, CHg, from Bay Area Water Supply and Conservation Agency (BAWSCA), and **Michelle Maddaus**, PE, talked about the methodology and results of a comprehensive water demand and conservation study conducted by BAWSCA for the SF Bay Area. The objectives of the study were to update demand projections and models, evaluate the water-savings potential of new conservation measures, and to develop a regional financing and implementations plan. The collaboration between stakeholders to develop a comprehensive water conservation program was a large-scale effort that will benefit the SF Bay Area and could be used as a model for other urban areas.

Hossein Ashtorab, Ph.D., from the Santa Clara Valley Water District, described the benefits of the Water Use Efficiency Unit programs on energy savings and air quality in Santa Clara Valley, and their impact on global climate change. Since FY 92-93 the District has reduced or saved through these programs 547,000 acre-feet of potable water, 2.67 kWh of energy (representing about $347M or enough electricity to supply 412,000 households for one year). The programs also have eliminated the emission of 625M kg of carbon dioxide (equivalent of removing 115,000 cars from the roads for one year), and reduced emissions of other air pollutants including reactive organic gases, carbon monoxide, nitrogen oxides, sulfur oxides, and particulate matter.

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Session 2B: Emerging Contaminants – From the Source to Groundwater.

Moderated by **Brian Lewis**, Department of Toxic Substances Control, this session commenced with "Drinking Water Contaminants of Possible Regulatory Interest," in which **Bruce Macler**, Ph.D., US Environmental Protection Agency, reviewed the US EPA's activities and expected outcomes. Among these, proposed revisions to the Total Coliform Rule include discontinuation of the Maximum Contaminant Level for total coliform bacteria. Instead, triggers based on positive coliform bacteria and E. coli monitoring would require utilities to determine the cause of contamination and to correct it. USEPA also will revise regulations for acrylamide, epichlorohydrin, trichloroethylene and tetrachloroethylene. USEPA is currently evaluating the Contaminant Candidate List 3 for possible regulations, though current health effects and occurrence data are needed. Of the 116 listed contaminants, the majority lack one or the other; a list of about 30 contaminants remain under consideration. To provide occurrence data, the Unregulated Contaminant Monitoring Rule 3 will soon appear. These methods will address some metals, chlorate, 1,4-dioxane, some volatile organic compounds, perfluro-organic compounds, estrogens and androgens, and a few pesticides.

Thomas Mohr, Santa Clara Valley Water District, presented a review of the origin and nature of 1,4-dioxane releases to groundwater. Based on historic association with TCA and its breakdown products, 1,1-DCE and 1,1-DCA, Mohr presented a forecast of the likely rates of detection of 1,4-dioxane in drinking water systems. Beginning in 2012, the 3rd Unregulated Contaminant Monitoring Requirements will require 1,4-dioxane testing using EPA Method 522 in ~40,000 water sources in the U.S. Recently, US EPA finalized the draft toxicity review for 1,4-dioxane, which recommends a steeper cancer slope factor and a correspondingly lower threshold for drinking water. If EPA's toxicity values for 1,4-doxane are adopted, the new drinking water advisory levels for this Class IIB probable human carcinogen could be as low as 0.38 µg/L, which has implications for recycled water treatment requirements and cleanup levels at solvent release sites.

William E. Motzer, Ph.D., P.G., Todd Engineers, presented "Old" and "New" Emerging Contaminants. In investigations and research for water districts, wastewater treatment plants, landfills, and foundations, emerging chemical contaminants (ECCs) with the potential for impacting groundwater have occupied our consideration for the past decade. These included both inorganic compounds such as arsenic, "hexavalent" chromium [Cr(VI)], and perchlorate (ClO4–), and organic compounds such as methyl-tertiary butyl ether (MTBE), N-Nitrosodimethylamine (NDMA), and the solvent stabilizer 1,4-dioxane. Such earlier investigated ECCs are now referred to as "post" emergent or "old" ECCs. "New" emergent EECs are those that are being researched by academia and regulatory agencies such as the U.S. EPA and DTSC; we are seeing more of these compounds being analyzed as test methods are being developed. These include:

- Pharmaceuticals and personal care products that include hundreds if not thousands of complex chemicals
- Nanomaterials including those derived from geogenic (natural) and anthropogenic sources
- Platinum group metals, which are being emitted by automobile catalytic converters and may be impacting groundwater in urban and suburban areas
- Prions (misfolded proteins) that are environmentally persistent, recalcitrant, and responsible for amyloidal diseases including bovine spongiform encephalopathy.

Session 3A – Collegiate Colloquium

Four students gave oral presentations during Session 3A, the third annual Collegiate Groundwater Colloquium, moderated by **Jean Moran**, California State University East Bay. This Colloquium, one of the highlights of the annual meeting, provides an opportunity for students to present their research to an audience of groundwater professionals. Submissions were solicited from undergraduate and graduate students through their faculty advisors. This year, four graduate students from four of California's public universities gave engaging presentations on a wide range of topics.

Jeannette Sager of UC Davis, advised by Graham Fogg, is developing a flow and transport model aimed at examining the potential for compensating for loss of surface storage (due to expected climate change effects) through floodplain recharge projects. Jeannette applies transition probability statistics (TPROGS) and the variably saturated parallel numerical model ParFlow to estimate the timing and volume of floodplain recharge into a heterogeneous aquifer along a well-studied reach of the Cosumnes River (Figure 1). The results will be useful for estimating the value of floodplain recharge to mitigate the water storage losses and to restore groundwater in overdrafted basins.

Amber Kuss, a graduate student of Jason Gurdak's at San Francisco State University, discussed the results of a numerical analysis of periodicity in climate forcings and the potential influence on

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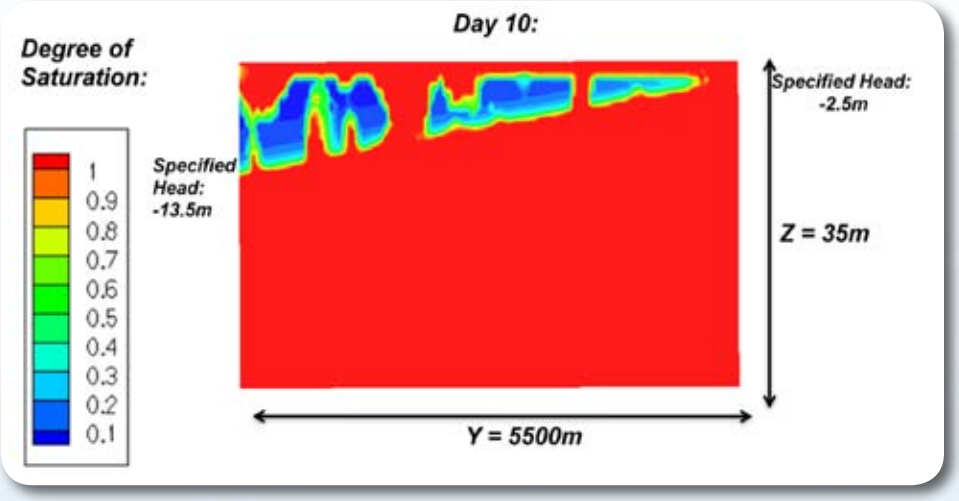

Figure 1. *Preliminary results from a modeling study of floodplain recharge along a reach of the Cosumnes River by Jeannette Sager.*

recharge to aquifers in the Central Valley of California. Amber first described climate forcings and their cycles, including the El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). She used singular spectrum analysis to identify the principal components of groundwater-level time series that contribute to variance in the record, and identified the PDO as the most significant contributor to groundwater-level fluctuations (Figure 2). Amber concluded by stressing the need to include multidecadal climate variability as a component of groundwater management.

Pamela Beitz, who is working with Jean Moran of CSU East Bay, presented a multi-tiered catchment analysis of surface water-groundwater interaction in Redwood Park, in the East Bay hills (Figure 3). Pamela used traditional hydrological methods such as rating curve development and water balance, along with GIS analysis and natural tracers to examine runoff patterns, delineate recharge areas, and perform event hydrograph separations. For example, she used stable isotopes of the water molecule to show that approximately 40% of the total streamflow is comprised of groundwater inflow during a late season event. This multi-tiered approach will be the basis for establishing a conceptual model of Redwood Creek's hydrologic regime, and will provide fundamental information for future habitat restoration efforts in this park refuge for Redwoods, spawning rainbow trout, and the California newt.

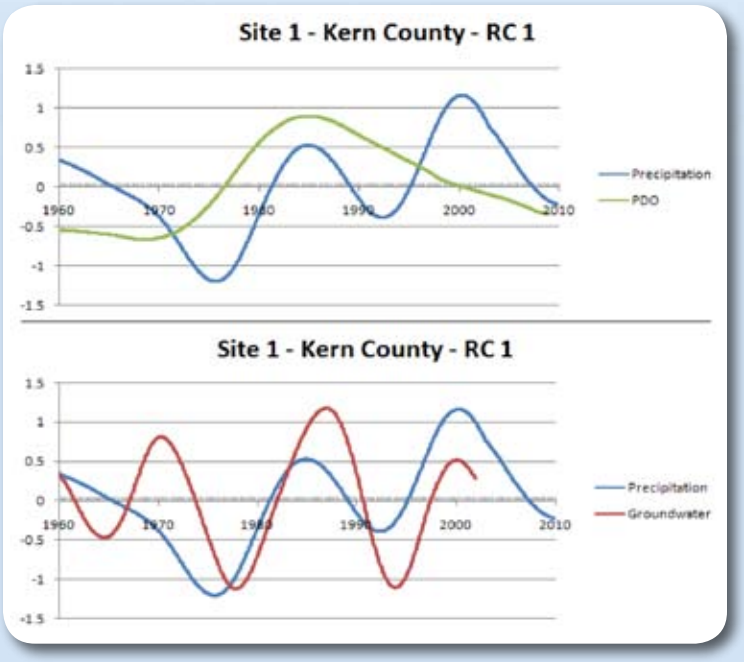

Figure 2. *Results of singular spectrum analysis for a well site in Kern County, showing the influence of the Pacific Decadal Oscillation (PDO) on the time lag between precipitation and the response in water level.*

Figure 3. *Redwood Creek in Redwood Park, near Oakland, the site of a quantitative analysis of groundwater inflow to the creek by Pamela Beitz.*

Stephanie Diaz, a PhD student at UC Santa Barbara working under the direction of Jordan Clark, presented research on a new tracer of managed aquifer recharge, ^{35}Sulfur. This cosmogenic isotope has a half-life of 87 days, and could be used to investigate transit times of a few months, which is an important time frame for indirect potable reuse projects (Figure 4). Stephanie described the advantages and limi-

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GRA 2010 Annual Meeting – A Broad View of Water and Groundwater Resources Management Challenges and Practices – *Continued*

tations of using ^{35}S as a tracer of recent recharge, then outlined the analytical methods used to extract and measure ^{35}S from sulfate in surface water and groundwater. Preliminary results from the Rio Hondo and Alameda County Water District artificial recharge facilities show higher ^{35}S activity in surface water than in groundwater and tracer travel times in the range of a few hundred days. Stephanie indicated that future interpretive work will address more complete ^{35}S source characterization and the effects of mixing during transport and in the wellbore.

Session 3B: Groundwater Monitoring – State-of-the-Industry and State-of-the-State

During this session, moderated by **John McHugh**, Santa Clara Valley Water District, several approaches to monitoring were presented. **Daniel Craig** of Todd Engineers gave an update on the City of San Jose's South Bay Water Recycling Groundwater Monitoring and Mitigation Program (Program). This talk provided a perspective on using existing wells and chemical results to determine the influence of recycled water on groundwater. The Program was evaluated by way of chemical analyses and statistical techniques to observe any signs of impact from the applied recycled water on underlying groundwater at six sites. The results showed some trends in chemical parameters, but the trends were mixed and those chemicals with trends were not unique to recycled water; mixing with other water sources could explain the observed trends.

Charles Kratzer, Department of Water Resources, provided an update and overview on Implementation of SBX7-6, California's Statewide Groundwater

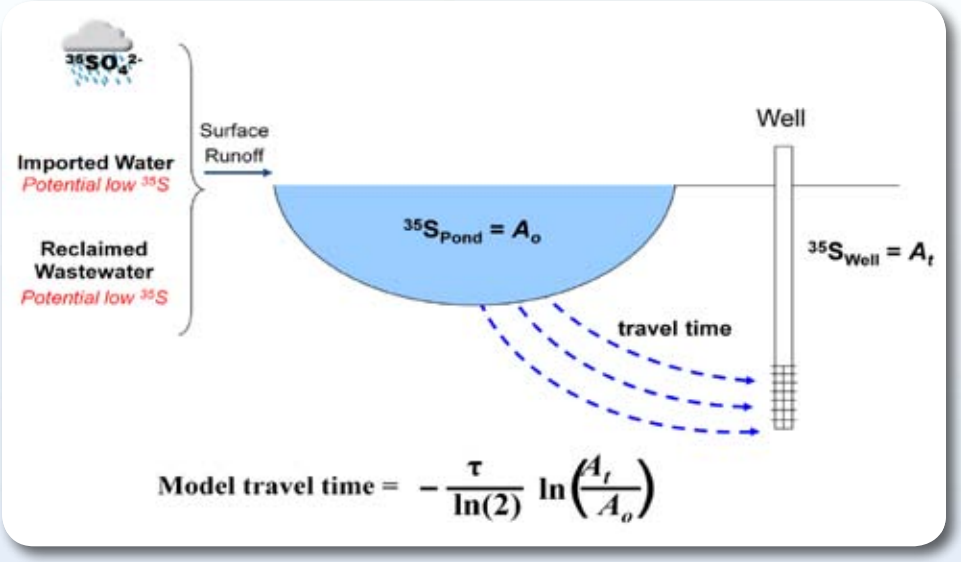

Figure 4. *Schematic model of the application of ^{35}Sulfur as a tracer of managed aquifer recharge on the time scale of a few months.*

Level Monitoring Program. SBX7-6 provides that:

- Local parties, or Monitoring Entities (ME) may assume responsibility for monitoring and reporting groundwater elevations
- DWR work cooperatively with local MEs to achieve monitoring programs that detect seasonal and long-term trends in groundwater elevations
- DWR accept and review prospective ME submittals, determine and notify the designated ME, and inform public
- DWR perform groundwater elevation monitoring in basins where no local party has agreed to perform the monitoring functions
- If local parties do not volunteer to perform the groundwater monitoring functions, and DWR assumes those functions, then those parties become ineligible for water grants or loans from the state.

Several questions arose from the audience indicating further communication will be needed as DWR and the responsible parties work out the details.

Andrew Eaton of MWH Laboratories presented a study "On the Use of Multiple Indicators to Assess Impaired Waters." The study took a novel approach to determine which chemicals are best used to verify recycled water. Such tests typically are conducted based on a preconceived set of expected chemicals, and therefore can lead to uncertainty. Aspects of ideal tracer chemicals include being chemically persistent (conservative) and readily available in measurable quantities in groundwater. Simultaneous extraction and analysis using LC/MS/MS allowed significantly faster analysis and increased accuracy. In conclusion, it appears that an overall good tracer for recycled water is the artificial sweetener sucralose, in part due to its conservative nature.

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Session 4A – Impaired Water Management

Moderated by **Roy Herndon** of Orange County Water District, the session began with **Meredith Durant**, Vice President of Kennedy Jenks Consultants, presenting "The Saugus Perchlorate Removal Project: Leaping Hurdles to Implementation." Ms. Durant explained that Castaic Lake Water Agency relies heavily on groundwater, and that perchlorate was detected in the Santa Clarita Valley in 1997. Four high-capacity wells were shut down due to perchlorate, which emanated from a former munitions facility. Hydrogeologic studies indicated that the perchlorate plume reached a depth of 2,000 feet. Treatability studies identified ion exchange as the preferred wellhead treatment technology. Litigation, obtaining a state operating permit, seeking stakeholder support, and evaluating endangered species impacts have been time consuming. The project has thus far recovered half of the lost well capacity using wellhead treatment.

Ralph Phraner, Director of Water Resources Management at Eastern Municipal Water District, presented "The Challenges and Rewards of Brackish Groundwater Desalination in West Riverside County California." Ralph summarized EMWD's goal of reducing its dependence on imported water from the Colorado River and northern California by increasing its use of recycled water and brackish groundwater. EMWD's plans for brackish groundwater desalination include design and construction of three facilities totaling about 18,000 acre-feet in annual production. Cost per acre-foot ranges from $660 to $950, which is competitive, particularly considering the added reliability. Challenges of implementing brackish groundwater projects include well and pipeline site acquisition, well blow-off surface water discharge regulatory compliance, and reverse osmosis brine concentrate disposal. He emphasized how EMWD's hydrogeologic understanding grew with each new well constructed and tested, and concluded that the rewards of increased water reliability, reduced dependence on imports, and improved salt management in have more than justified EMWD's efforts to develop its brackish groundwater resources.

Michael Steiger, a civil engineer with Erler & Kalinowski, Inc., presented "Evaluating Salinity Sources: A Critical Step to Effective Salt Management." Michael's study was in the Turlock Sub-Basin of the Central Valley where extraction for agricultural irrigation is the primary groundwater demand, and increasing salinity in surface and groundwater is a continuing problem. He used a relatively simple mass balance approach involving working with the stakeholders to identify and quantify salt sources. Benefits included direct stakeholder input, directly useable results, and scalable methodology. Salt balances were developed for each source, including confined animal feeding operations (CAFOs), irrigated food crops, municipalities, food processors, septic tanks, and mineral dissolution. The largest salt contributor (41% of the total) to groundwater was from CAFOs, with irrigated food crops contributing 30%. The major salt sources to surface water were municipalities (38%), irrigated food crops (24%),

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and CAFOs (21%). These findings provide a basis to prioritize potential salt management programs.

Session 4B – Recycled Water Groundwater Recharge

Moderated by **Ted Johnson** of the Water Replenishment District of Southern California, the session began with **David Smith,** Managing Director of WateReuse California, who discussed the implications of the State Water Board's recycled water advisory panel on constituents of emerging concern (CECs). In February 2009, the Board approved a recycled water policy to promote the use of recycled and storm water for groundwater recharge. The policy also required the Board to convene an expert panel to recommend an approach for monitoring CECs associated with the use of recycled water for agricultural and indirect potable reuse (i.e. recharge). For potable reuse projects, the panel recommended monitoring four potential human health CECs: 17 beta-estradiol, caffeine, triclosan, and NDMA. For treatment plant performance indicators, the constituents are gemfibrozil, DEET, caffeine, iopromide, sucralose, and NH3, NO3, and DOC. The panel also recommended further development of bioanalytical screening methods. The State Water Board is expected to make modifications to the recycled water policy to include CEC monitoring in November 2010.

Ed Lin, Senior Hydrogeologist at Todd Engineers, presented an intrinsic tracer study at the West Coast Basin seawater intrusion barrier project in Los Angeles County. Since 1964, the barrier has been using imported potable water for injection, but in July 1995 also began using highly treated recycled water as part of the injection stream. The intent of the project is to reach 100% recycled water for injection, but one of the permit requirements from the RWQCB is to verify travel time and concentration of the recycled water in the aquifers. Since 2008, Todd Engineers has been conducting an intrinsic tracer study at the barrier using baseline groundwater, blended barrier water, and seawater in an attempt to quantify travel time and relative content of each water type in compliance wells. Of multiple geochemical analysis techniques, the Brine Differentiation Plot (BDP) method was determined to be the most suitable. By plotting molar concentrations of calcium divided by calcium plus sulfate on the vertical axis versus sodium divided by sodium plus chloride, the relative amount of the three dominant end members over time in groundwater was determined.

Wes Hawthorne, Vice President of Locus Technologies, presented a multiphase evaluation of recycled water impact on groundwater in the Santa Clara Valley and Llagas groundwater basins. Since recycled water is becoming an increasingly important resource for groundwater recharge, its environmental impact on groundwater must be closely evaluated. Using modeling, laboratory-scale testing, and a field-scale pilot test, the study evaluated which recycled water constituents have the greatest potential to impact groundwater. Preliminary findings on over 40 constituents included: treatment-plant sources vary with upstream dischargs and treatment technologies; NDMA is a key concern as concentrations can be high and its unique characteristics increase the potential to impact groundwater; Perfluorochemicals (PFCs) can be formed after application of recycled water; and significant clay swelling was observed, indicating that application of recycled water may decrease permeability of soils.

Session 5A – Green Approaches to Managing Water in Urban Environments

Moderated by **Thomas Harter**, Ph.D., University of California Davis, this session began with **Jeff Loux**, University of California Davis, who gave an overview of the concept of Low Impact Development (LID). Urban stormwater runoff issues include impervious surfaces that lead to steeper hydrographs and higher and more rapid flood peaks, incised stream channels, and unattenuated pollutant transport. Conventionally routing runoff into pipes and retention basins provides stream protection, aesthetics, groundwater recharge, and recreation, but also carries the liabilities of increased mosquito populations, safety issues, and lack of treatment prior to recharge. LID blends the experience of hydrologists, engineers, ecologists, and landscape architects to achieve improved water quality, reduced runoff, increased groundwater recharge, and an aesthetically pleasing landscape. Recently, political and regulatory pressure from the California Regional Boards, city general plans, and LEED certification have provided impetus for use of LID.

Robert Siegfried of the Santa Clara Valley Water District focused on identifying and characterizing problems rather than solutions in urban water management. In his talk "Plant and Soil Limitations to Sustainable Use of Recycled Water for Irrigation," Robert reported the results of two University of California Davis studies on plant salinity tolerance and soil hydraulic conductivity changes that result from recycling of urban wastewater on urban landscapes. Typical recycled water has an electrical conductivity (EC) of 1 mS/cm and a Sodium Adsorption

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Ratio (SAR) of 3.7. Depending on the leaching fraction (irrigation efficiency), salinity of the leachate increases to as much as 10 mS/cm, with a SAR of 13.5. High salinity and sodium concentration affect landscape plants, such as the redwood (leaf-burn). In addition, hydraulic conductivities of the soils are sensitive to changes in salinity (higher salinity, higher permeability).

Amy Boulton of Sonoma County Water Agency introduced the Sonoma County Energy Independence Program (SCEIP), a loan program run by the county for its citizens. Through SCEIP, homeowners can apply for home improvements that increase energy efficiency, including various forms of energy- and water-saving construction. The county initially pays for the improvement, and is reimbursed by the homeowner through a long-term property assessment. The goal of the program is to reduce green-house gas emissions, save money, stimulate the economy, and provide incentives for the local labor market. SCEIP has been very popular in Sonoma County, with over 1,000 completed projects and nearly $50 million in loan applications. The most popular improvements include installation of solar photovoltaics, improved windows and doors, and energy-efficient heating and air conditioning.

Session 5B – Sustainable Groundwater Management

Moderator by **Sarah Raker**, MACTEC Engineering Consulting, this session began with **Kenneth Minn**, of the East Bay Municipal Utilities District, presenting an overview of EBMUD's recently completed Water Supply Management Plan 2040 (WSMP 2040), including its ongoing Bayside Groundwater Project. This aquifer storage and recovery project will be used to inject and later extract treated drinking water. Among the project's sustainable features, the potential for land subsidence due to future pumping is being monitored using multi-stage extensometers installed to depths over 1,000 feet.

John Ayres of Brown & Caldwell presented a Tehama County groundwater recharge study. The purpose of the study was to identify specific areas within the county where groundwater recharge may be enhanced now and in the future. A technical advisory committee determined the approach and GIS data to be evaluated. Criteria for selection included geology, soil type, proximity to surface water, drawdown in local wells, and depth to water. Five areas were selected. The next step is to identify the appropriate recharge methods and conduct feasibility studies with interested landowners.

Jeffrey Gilman of the San Francisco Public Utilities Commission discussed the status of groundwater production in the San Francisco Basin. San Francisco, like many major cities in California, has developed a water-supply diversification program that includes expanding its existing groundwater supply. San Francisco's goal is to establish 2.5 mgd of "new" groundwater and replace 1.5 mgd currently used for irrigation and other non-potable uses. To meet San Francisco's project goals, six new water supply wells are proposed in the Westside Basin Aquifer. Mr. Gillman also presented rarely seen historical records for water supply wells in San Francisco dating back to 1872.

Final General Session – What's in Store for Protection and Management of Future Supplies and Resources?

Duncan McFetridge, an attorney with Brownstein Hyatt Farber Schreck and Legislative Advocate for GRA, provided lunchtime remarks and a summary of the 2010 Legislative session. Mr. McFetridge discussed GRA's sponsored legislation and a number of bills being tracked on behalf of GRA, updated members on the status of the state budget (which had yet to be passed at the time), and gave a preview of the upcoming 2010 statewide election.

Final Plenary Session Panel Members (left to right) Tom Glover, Westlands Water District; Rob Roscoe, Sacramento Suburban Water District; David Aladjem, Downey Brand; Catherine Freeman, Legislative Analyst's Office; and Maurice Hall, The Nature Conservancy

2010 Sponsored Legislation

AB 2304(Huffman) – Vetoed

GRA partnered with the California Groundwater Coalition (CGC) to co-sponsor legislation that would have required the mapping and identification of recharge areas in groundwater management plans. The bill would have also required water supply agencies to provide these maps to local land-use planning agencies and expand public notification when preparing and approving groundwater management plans. The bill represented a modest but important step in groundwater management and policy. Despite passing the Assembly and Senate by comfortable margins, the Governor

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GRA 2010 Annual Meeting – A Broad View of Water and Groundwater Resources Management Challenges and Practices – *Continued*

During an evening break (clockwise from left) Roy Herndon, Tom Francis, Andrew Eaton, Tim Parker, Ted Johnson, David Jordan, Vicki Kretsinger, Emily Vavricka, Chris Petersen.

vetoed the bill, stating that it would negatively impact private property. Given the election of Governor-elect Brown, the author has indicated interest in reintroducing this measure in the coming legislative session.

2010 Tracked Legislation

SB 918(Pavley) (Water Recycling)

Requires the State Department of Public Health to develop and adopt uniform water recycling criteria for indirect potable water reuse for groundwater recharge, and develop and adopt uniform water recycling criteria for surface water augmentation under certain conditions. *Status: Chaptered into Law*

SB 1173 (Wolk) (Recycled Water)

Declares the use of raw or potable water for non-potable municipal or industrial uses, irrigational of landscaping, floor trap priming, cooling towers, and air conditioning devices a waste or unreasonable use of water if recycled water is available. The bill would prohibit a person or public agency from using raw or potable water that is suitable for non-potable municipal or industrial uses if suitable recycled water is available. *Status: Vetoed*

AB 1834(Solorio) (Rainwater Capture)

Enacting the Rainwater Capture Act of 2010, the bill authorizes a landowner to install, maintain, and operate a rainwater capture system meeting specified requirements. Requires the State Water Resources Control Board to initiate a process to develop recommendations for state and local agencies to encourage and facilitate the installation and use of such systems for non-potable uses and place them on its internet website. *Status: Vetoed*

GRA would like to thank the vendors for their support and exhibits, which added to the information sharing at the meeting.

Field Trip – Projects at the Forefront of Water Supply in the San Francisco Bay Area

By Greg Bartow, San Francisco Public Utilities Commission

This field trip was included as part of GRA's 2010 Annual Meeting. Over 50 participants had great weather while touring a range of water projects around San Francisco Bay.

East Bay Municipal Utility District's (EBMUD) Bayside Aquifer Storage and Recovery Facility in San Lorenzo – The Bayside facility is the first phase of a dry-year water supply project. EBMUD injects imported surface water during wet and normal years for recovery during dry years. During the field trip, EBMUD was conducting an extraction-cycle test of the Phase 1 portion (1 mgd) of the project. We also toured an extensometer that was installed in partnership with the USGS to investigate and monitor potential subsidence as a result of the project. After successfully operating Phase 1, EBMUD will consider a larger Phase 2 Bayside Project that would store 2 to 10 MGD, providing even greater drought protection. Before moving forward, EBMUD will review results from the groundwater monitoring system and extensometer, which measures minute changes (if any) in ground surface elevation during Phase 1 operation.

Joint EBMUD, San Francisco Public Utilities Commission (SFPUC) and City of Hayward water supply inter-tie in Hayward – The purpose of the inter-tie project is to provide a connection between the SFPUC and the EBMUD. The connection uses existing water system piping in the City of Hayward with connections to EBMUD and SFPUC systems on each end. The connection allows up to 30 mgd of water to flow between the two water systems in the event of critical shutdowns for emergency repairs or maintenance and construction activities.

Alameda County Water District Brackish Groundwater Desalination Facility in Fremont – Since the 1970's, ACWD has pumped groundwater near the bay in an effort to control historic saltwater intrusion so that fresh water from other parts of the basin can move in and take its place. This brackish groundwater was then discharged back to San Francisco Bay. Beginning in the early 2000's ACWD started treating the brackish groundwater using reverse osmosis, and using the water for its potable water supply. In 2010, ACWD expanded the facility which now produces 10 mgd.

San Jose/Santa Clara Water Pollution Control Plant - **Recycled Water Production** – The field trip participants toured the treatment process that produces tertiary recycled water for South Bay Water Recycling. The recycled distribution water system consists of over 100 miles of pipelines, 5 pump stations, and 10 million gallons of storage.

Stanford University Water Efficiency Projects – Stanford has a number of innovative water conservation projects. Since 2000, Stanford has reduced their domestic water use from 2.7 to 2.1 mgd despite adding more than 1 million square feet of new academic buildings. The field trip included a visit of the treatment facility that provides reuse of cooling tower blow-down water for non-potable uses.

The Field Trip Organizing Committee and mobile Resource Speakers for the tour included Greg Bartow, SFPUC; Anona Dutton, Bay Area Water Supply and Conservation Agency; Elizabeth Flegel, City of Mountain View; John Karachewski and Brian Lewis, Dept. of Toxic Substances Control; John McHugh, Santa Clara Valley Water District; and Tim Parker, Parker Groundwater. Special thanks to Mary Megarry for all of her help on the field trip logistics.

GRA Sponsored Event

The 2011 North American Environmental Field Conference and Exposition:

Advances and Innovations in Environmental Site Characterization, Sampling, Monitoring & Remediation Technology

JANUARY 10 - 13, 2011
SAN DIEGO, CALIFORNIA

Highlights of the 2011 Event:

- A high-energy conference featuring 58 papers, presented by some of the world's foremost authorities in the field, discussing cutting-edge field-based technologies and methods for environmental site characterization, sampling, monitoring, and remediation
- More than 75 hours of interactive indoor workshops on topics ranging from new environmental applications of direct-push technology to advances in hydraulic conductivity testing to improved drilling and borehole grouting methods to innovative soil and ground-water sampling methods to site remediation using surfactants and enhanced oxidation techniques (and much, much more!)
- More than 30 hours of hands-on, interactive outdoor workshops and equipment demos featuring the latest environmental field methods and equipment
- An educational exposition featuring 39 indoor exhibits and 15 outdoor exhibits showcasing state-of-the-science environmental field equipment and services
- A busy social calendar throughout the event, which will make it possible for you to network with colleagues and make new business contacts during your stay in san diego.

For a complete event schedule, please check http://www.envirofield-conference.com/full event schedule.pdf. GRA members receive a special discount and pay only $725 until January 1, 2011.

Dates & Details

GRA EVENTS & KEY DATES

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

GRA Board Meeting
Feb. 12, 2011 | Sacramento, CA

GRA Legislative Symposium & Lobby Day
Apr. 20, 2011 | Sacramento, CA

GRA Symposium
Environmental Forensics – Tracking Contaminants in Groundwater
Apr. 2011 | Southern California

28th Biennial Groundwater Conference & 20th Annual GRA Meeting
Oct. 5-6, 2011 | Sacramento, CA

GRA's Legislative Symposium and Lobby Day All Day at the Capitol

WEDNESDAY, APRIL 20, 2011

Agenda will include:

- Kick-off with morning Keynote by groundwater industry leader
- Briefings on important current legislative issues of interest to groundwater professionals
- Lunch Keynote to be delivered by Legislator
- Dialogue with key legislators on the future of California groundwater
- Visits with legislators and decision makers at the Capitol, including your local representatives to educate them on the concerns and technical expertise of GRA members

Contact Duncan McFetridge, GRA Legislative Advocate, (DMcFetridge@bhfs.com) or (916) 441-1232 for further information or to register.

Wells and Words

By David W. Abbott, P.G., C.Hg., and William E. (Bill) Motzer, Ph.D., P.G., Todd Engineers

Water Quality Detection and Fingerprinting Methods

In this column, David Abbott has provided us with descriptions and information on water well design, construction, installation, and evaluation. So now that you have installed "the best water well in the world," which is giving you a fantastic well yield at a generous pumping rate with a well efficiency of 85%, you collect your water sample and submit it to an ELAP laboratory for chemical analyses (see *Wells and Words* in summer 2007 *HydroVisions* for suggestions). Upon receiving the analyses, you compile them into a table in your report (noting that all of the constituents are below MCLs). So is that all there is to it? The answer, of course is no; your report may be incomplete and the reasons may be more complicated than just submitting data. For example, you may have to determine water quality of a basin over a large geographical area, temporal trends in water quality, water quality of groundwater source(s), or all of the above. To do this you must be able to plot and interpret your data using the appropriate diagrams, which employ the major and minor ions typically analyzed in water quality investigations. Analyses are generally returned in milligrams per liter (mg/L) or micrograms per liter (µg/L), and for many of the plotting techniques the analytical data must be converted to millequivalents per liter (meq/L) or moles per liter (moles/L). However, such chemical data are virtually meaningless until they are analyzed and displayed through appropriate geochemical plotting techniques to reveal geochemical relationships and trends. In general, there are two types of graphical methods: (1) those that describe abundance or relative abundance of cations and anions, and (2) those that show variability patterns; these can be illustrative or statistical. The most useful methods are described below.

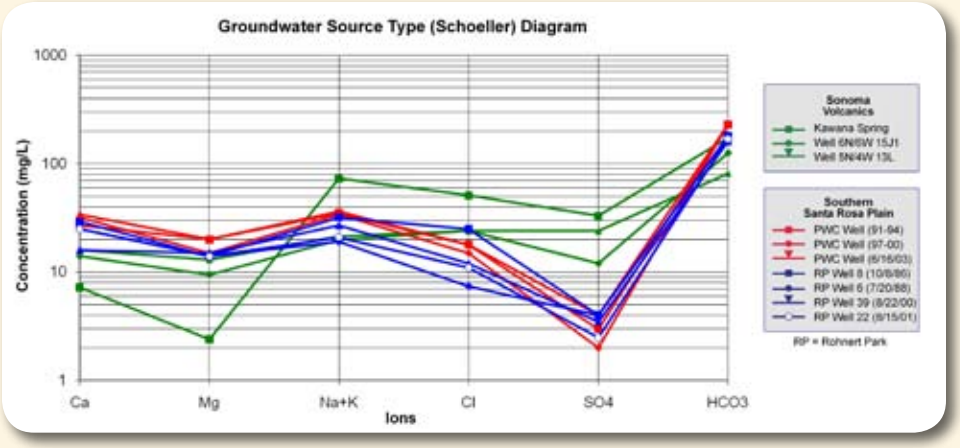

Figure 1: *Groundwater sources diagram showing distinctive signature for groundwater from two different sources.*

Trilinear (Piper) Diagrams are familiar to most hydrogeologists, and are useful for comparing water quality analyses. Cation (calcium, magnesium, and sodium+potassium) concentrations in meq/L are expressed as a percentage of total cations on a left-hand triangle and anions (carbonate+bicarbonate, sulfate, and chloride+nitrate) concentrations in meq/L are plotted on a right-hand triangle. The cation-anion plot is then projected onto a central diamond-shaped area, which combines both cation and anion distributions. The intersection of the cation and anion lines can be drawn as a circle with its diameter proportional to the total dissolved solid concentration of the analysis. Groundwater with similar geochemistry will generally group together and can be classified (i.e., groundwater from different sources may be identified by their bulk chemical compositions).

Stiff Diagrams are straight-line plots of cation and anion concentrations also calculated in meq/L. They are constructed using four parallel horizontal axes on each side of a vertical axis. Cation and anion data are plotted and the individual points are connected to produce a polygonal pattern; each water analysis may have a unique pattern or shape. For example, most natural groundwater forms an arrowhead shape with the point facing to the right, brine and/or seawater forms a T-shape and water that has undergone ion exchange forms a backward check mark. The relative size of the characteristic stiff diagram is proportional to the total dissolved solids (TDS); a larger stiff indicates higher TDS. The polygonal shapes can be drawn on a map adjacent to the water sample collection sites, enabling visualization of geographic patterns.

Diagrams and plots that are not as commonly used as Trilinear and Stiff diagrams, but which may be more useful in determining water sources and water quality trends, are described below.

Water source (Schoeller) diagrams are graphs used to fingerprint water sources. In many situations groundwater solute sources may be indistinguishable from surface-water solute sources except perhaps by concentration. Schoeller diagrams can be used to identify water sources by plotting log concentrations on the y axis in either mg/L or meq/L (consistently) against ions on the x axis with cations (on the left) and anions (on the right). In Figure 1, note that

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Wells and Words – *Continued*

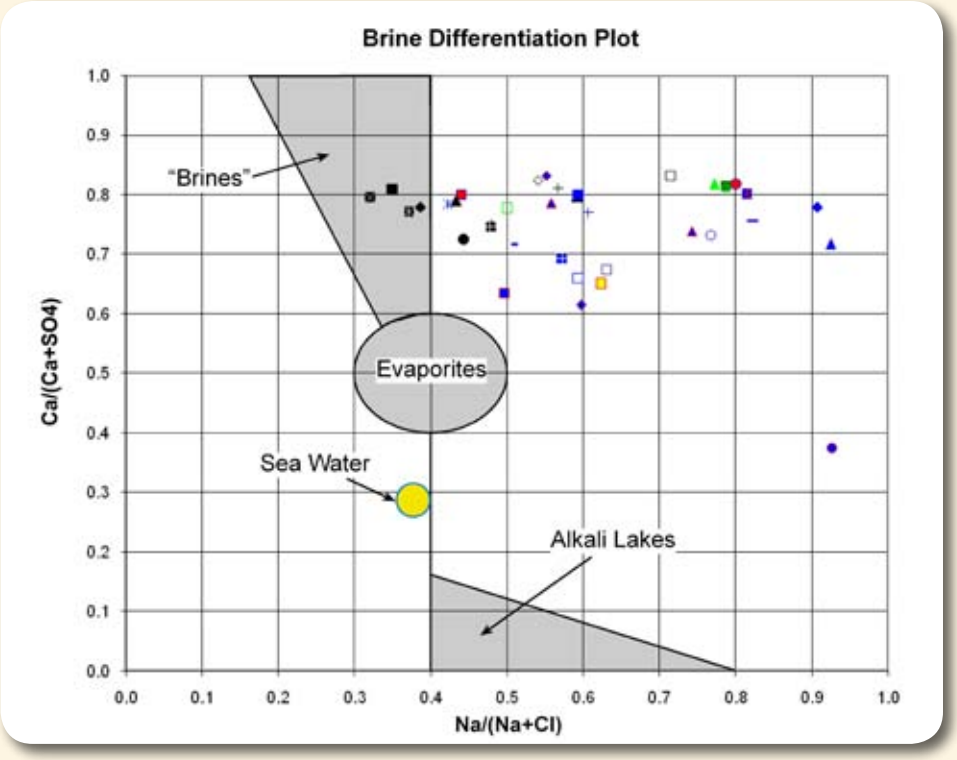


Figure 2: *Brine differentiation plot (BDP) showing fields for groundwater either impacted from or derived brines, evaporates, and alkali lakes.*

groundwater derived from the Sonoma volcanics (green lines) has a distinctly different geochemical signature from groundwater derived from alluvial sources (red and blue lines).

Brine differentiation plots (BDP) were developed by Arthur W. Hounslow (*Water Quality Data*, 1995, Lewis Publishers) (Figure 2) to differentiate between brine-contaminated waters and waters of other origins using the major constituents commonly available in a water analysis. Molar concentrations of calcium are divided by calcium plus sulfate on the y axis and sodium divided by sodium plus chloride on the x axis. The fields for brines, evaporates, and sea water can be shown. The BDP allows for waters to be plotted in a finite range from 0 to 1.0 on each axis and to determine potential mixing of different water types. For example, Figure 3 shows that process-, sea-, and background ground-waters have distinctive signatures; therefore, a mixing line can be drawn between seawater and process water. Also note that water quality data from several monitoring wells representing background groundwater plot along another mixing line. In this case, the BDP was used to determine relative amounts of the three dominant water types (baseline groundwater prior to recycled water injection, blended water, and seawater) over time to determine if the injected process water was having an effect.

But, you say, I have groundwater contaminated with an inorganic compound (e.g., nitrate) or petroleum hydrocarbons. What diagrams are useful in these situations? We'll describe these in a future article, so keep reading *HydroVisions*.

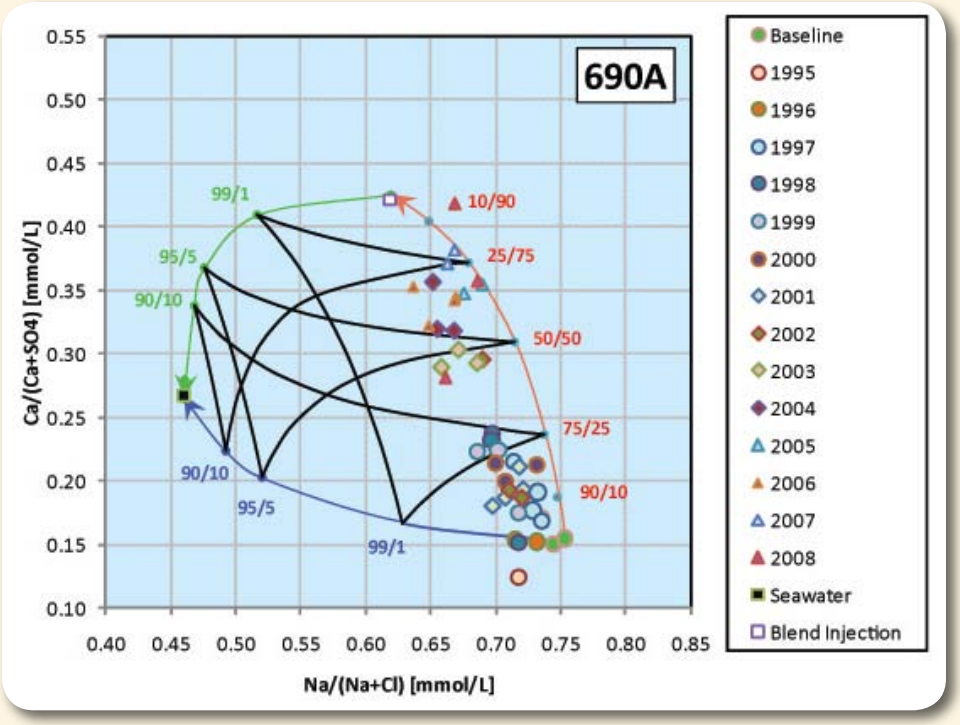


Figure 3: *BDP showing mixing lines for a three component mixture: groundwater (green) blended injected water (white), and seawater (black). Mixing line trend over time shows that groundwater is approaching the injected water concentration. Actual concentration curves (in percent) have been plotted.*

Legislative Update

By Tim Parker, GRA Legislative Committee Chairman, Chris Frahm and Duncan McFetridge, GRA Legislative Advocates

The 2010 Legislative Session ended on August 31st, marking the end of yet another acrimonious year during which the Governor and the Legislature failed to enact an on-time budget or any major policy initiatives. 2010 also marked the end of Governor Schwarzenegger's second and final term as Governor.

On November 2nd, former Governor Jerry Brown defeated Republican Meg Whitman on a platform of job creation and putting California's fiscal house in order. Governor-elect Brown will inherit a state budget with a $10 billion structural deficit and unemployment at 12.4%, the third-highest unemployment rate in the country. Although both the Assembly and Senate will continue to be controlled by the Democrats, the Capitol will welcome nearly 40 new members when they are sworn in to office in December.

Following is a brief recap of legislative issues and other matters that are important to GRA and its members.

2010 Sponsored Legislation

AB 2304(Huffman) – Vetoed – GRA partnered with the California Groundwater Coalition (CGC) to co-sponsor legislation that would have required the mapping and identification of recharge areas in groundwater management plans. The bill also would have required water supply agencies to provide these maps to local land-use planning agencies and to expand public notification when preparing and approving groundwater management plans. The bill represented a modest but important step in groundwater management and policy.

Despite passing the Assembly and Senate by comfortable margins, the Governor vetoed the bill stating that it would negatively impact private property. Given the election of Governor-elect Brown, the author has indicated interest in reintroducing this measure in the coming legislative session.

2010 Tracked Legislation

SB 918(Pavley) (Water Recycling) – Requires the State Department of Public Health to develop and adopt uniform water recycling criteria for (1) indirect potable water reuse for groundwater recharge, and (2) surface water augmentation, under certain conditions. *Status: Chaptered into Law*

SB 1173 (Wolk) (Recycled Water) – Would prohibit a person or public agency from using raw or potable water for non-potable municipal or industrial uses, irrigational of landscaping, floor trap priming, cooling towers, and air conditioning devices a waste or unreasonable use of water if recycled water is available. *Status: Vetoed*

AB 1834(Solorio) (Rainwater Capture) – Enacts the Rainwater Capture Act of 2010, authorizing a landowner to install, maintain, and operate a rainwater capture system meeting specified requirements. Requires the State Water Resources Control Board to initiate a process to develop recommendations for state and local agencies to encourage and facilitate the installation of such systems for non-potable uses and place them on its internet website. *Status: Vetoed*

State Budget

After the longest budget delay in state history, legislative leaders and the Governor finally agreed to a budget in October. The budget made substantial reductions to close a $19 billion deficit without raising taxes or fees. In addition, the budget agreement scales back pension benefits for new state employees. Despite these cost reductions, California still has an ongoing structural budget deficit of at least $10 billion that the next Governor and Legislature will have to face. Passage of Proposition 50, which changes the budget vote threshold from 2/3rds to majority vote, will help eliminate some of the political gridlock in passing a budget on time. Passing new or extending existing taxes, however, still requires a 2/3rds vote of the Legislature.

Water Bond

In August, the Legislature passed a measure to delay the water bond, which was the foundation of the 2009 comprehensive water bill package, to the 2012 ballot. While he has indicated "nuanced" support for a peripheral canal, Governor-elect Brown also has said that any canal must protect the Delta's ecosystem and be paid for by those that would benefit, not taxpayers. His plan also calls for programs to facilitate water transfers to farmers, increase water recycling and water conservation, and improve groundwater supplies. He also has stated that the water bond will have to be renegotiated to reduce the size and scope of the bond measure.

Looking Ahead

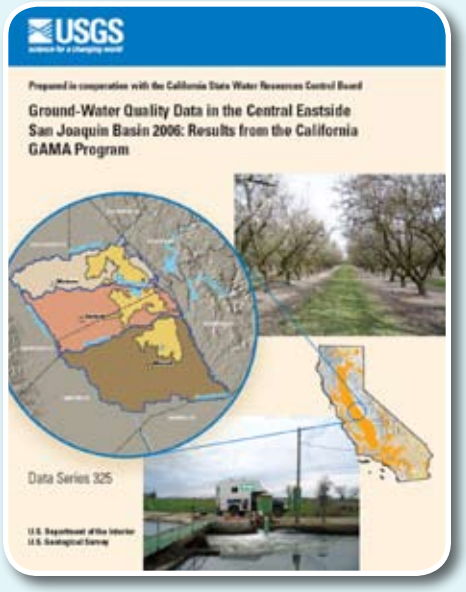
In 2011, the Governor and Legislature will continue to face difficult issues, including finding solutions to the state's chronic budget deficits and addressing California's water and infrastructure challenges. Given the large number of new legislators, GRA and its members will continue to play an important role in educating and advancing sound groundwater policy. As the new Administration takes shape and the Legislature is seated, we will continue to keep GRA members apprised of the evolving political landscape in Sacramento. In the meantime, mark your calendars for next year's *Legislative Symposium and Lobby Day* which will be held on April 20, 2011!

The Federal Corner

By John Ungvarsky, U.S. EPA

Nutrients in the Nation's Streams and Groundwater

This report presents an assessment of the occurrence and distribution of nutrients in the Nation's streams and groundwater provided by the National Water-Quality Assessment Program of the United States Geological Survey (USGS). Although the use of artificial fertilizer has supported increasing food production to meet the needs of a growing population, increases in nutrient loadings from agricultural and, to a lesser extent, urban sources have resulted in nutrient concentrations in many streams and parts of aquifers that exceed standards for protection of human health and (or) aquatic life, often by large margins.



GAMA Assessment Report Available for Central Eastside Study Unit

USGS has just released the Priority Basin Project Data Summary and Assessment Report, and informational Fact Sheets, for the Central Eastside study unit (Modesto, Turlock, and Merced area). This work was completed as part of the CA State Water Board's Groundwater Ambient Monitoring and Assessment (GAMA) Program. These and other GAMA reports and fact sheets can be found on the GAMA web site. The assessment report provides a status of groundwater quality using data collected by the USGS and existing water quality data from the California Department of Public Health. The assessment report characterizes the quality of groundwater from the primary aquifer accessed by wells, not necessarily the actual drinking water delivered to consumers.

Treating Contaminants of Emerging Concern: A Literature Review

EPA has published the results of an extensive review of the recent literature on wastewater treatment technologies and their ability to remove a number of chemical contaminants of emerging concern (CECs). EPA is also making available the data from this literature review. The report discusses 16 of the over 200 CECs present in the database, and the average percent removals achieved by full-scale treatment systems that employ six of the more than 20 reported treatment technologies. Wastewater treatment plant operators, designers, and others may find this information useful in their studies of ways to remove CECs from wastewater. The report is not designed to promote any one technology, nor is it intended to set agency policy or priorities in terms of risk. The literature review and the searchable file were peer-reviewed for completeness and usability.

From Lab to Consumer – EPA Research at Work

Arsenic is an odorless, tasteless element that enters groundwater through erosion of natural deposits or from human-made sources such as agricultural and industrial runoff. Arsenic is a human carcinogen; chronic exposure to low levels of arsenic has been linked to skin, kidney, lung and bladder cancers, as well as neurological and cardiovascular effects. The EPA allowable limit for arsenic in drinking water of 10 parts per billion, established by EPA in 2001, impacted around 5,000 water systems, the majority of them serving fewer than 10,000 people. Recognizing the technical and financial burden the new standard could impose on small drinking water systems, EPA, with additional Congressional earmark funding, conducted a technology demonstration program to test a variety of arsenic-removal technologies in small systems across the country. Beginning in 2003, EPA drinking water specialists worked with communities at 50 sites in 27 states to select an optimum removal technology. The technology selection depended on variables such as the quality of the local source waters, estimated capital and operating costs, the quantity and type of waste produced and the disposal options available. Two examples are provided below. For more information, please go to the Arsenic Research website.

Arsenic Removal from Drinking Water by Iron Removal

This report documents the activities performed and the results obtained from January 30, 2006 to April 29, 2007 at the EPA Arsenic Removal Technology Demonstration site in Sabin, MN. Publication No. EPA/600/R-10/033.

Arsenic Removal from Drinking Water by Coagulation/Filtration

This report documents the activities performed during, and the results obtained from the arsenic removal treatment technology demonstration project at the Town of Felton, DE. Publication No. EPA/600/R-10/039.

Continued on the following page…

The Federal Corner – *Continued*

New Cost and Performance Information on Cleanup Technologies

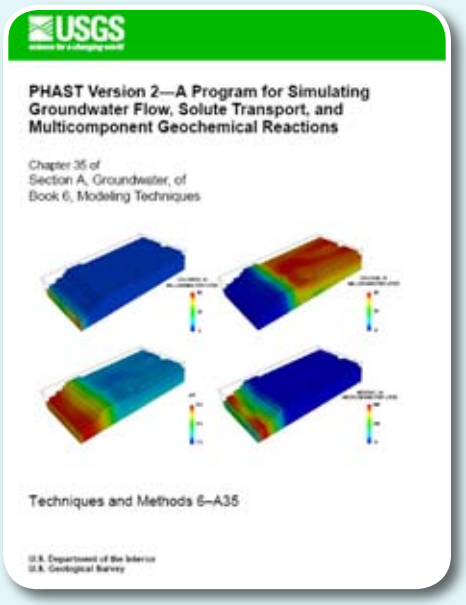
The Federal Remediation Technologies Roundtable (FRTR) recently announced the release of 26 new case study and technology assessment reports. These reports document the cost, performance, and lessons learned in implementing a wide range of hazardous waste site cleanup technologies in the field, ranging from large-scale demonstrations to full-scale applications. The remediation case studies and general technology assessment reports and other related FRTR information are available at the FRTR web site.

Test/QA Plan for Verification of Nitrate Sensors for GW Remediation Monitoring

The purpose of this test/QA plan is to specify procedures for a verification test applicable to commercial nitrate sensors. Environmental sensors are small, transportable analytical devices that provide data in real time, are rugged enough to withstand a wide range of weather conditions, operate remotely, acquire data continuously or on demand, and provide processed data directly to the user. Underlying any approach to the reduction of nitrogen in the environment (i.e., groundwater) is the need to measure concentrations in a timely and useful manner. This verification test evaluates a newer approach to monitoring of groundwater in a monitoring well, and in an end-of-tile bioreactor using environmental sensors. Publication No. EPA/600/R-10/104.

Program for Simulating Groundwater Flow, Solute Transport, and Multicomponent Geochemical Reactions

The purpose of this document is to provide the user with information about the capabilities and usage of the reactive-transport simulator PHAST (PHREEQC And HST3D). The computer program PHAST simulates multicomponent, reactive solute transport in three-dimensional saturated groundwater flow systems. PHAST is a versatile groundwater flow and solute-transport simulator with capabilities to model a wide range of equilibrium and kinetic geochemical reactions. PHAST is applicable to the study of natural and contaminated groundwater systems at a variety of scales ranging from laboratory experiments to local and regional field scales. PHAST is not suitable for some types of reactive-transport modeling; in particular, PHAST is not appropriate for unsaturated-zone flow and does not account for flow and transport of gas or nonaqueous-liquid phases.



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.

Green Chemistry – A Harder Look

By Bart Simmons

In a previous column, we discussed sustainable chemistry, which has been variously and broadly defined. The terms sustainable chemistry and green chemistry have unfortunately been used synonymously. However, Green Chemistry, unlike sustainable chemistry, is based on widely accepted principles (modified from Anastas and Warner, *Green Chemistry*, 1998):

- It is better to prevent waste than to treat or clean up waste after it is formed
- Synthesis should include all reagents in the final product
- Synthesis should include reagents and products of low toxicity
- Products should be effective, but of lower toxicity
- Reduce the use of auxiliary substances, e.g., solvents
- Energy consumption should be minimized
- Use renewable raw materials or feedstocks
- Minimize derivitization
- Use catalysts rather than reagents
- Products should be non-persistent and degradable
- Use real-time in-process monitoring
- Substances should be chosen to minimize accidents, including releases, explosions, and fires.

Green Chemistry, of course, will not prevent all environmental problems. Legacy sites, e.g., PCBs in the Hudson River, mercury in rivers and estuaries from the Gold Rush, and acid mine drainage, will persist. Naturally-occurring substances of concern, e.g., asbestos, arsenic, manganese, and selenium, will still pose significant risks.

In addition, there are the devilish details about how Green Chemistry will be implemented. In one case, some ionic solvents which had been touted as greener solvents were found to be more toxic to fish than the chlorinated solvents they were meant to replace (*Naturenews*, 3 November 2005).

Hurdles for green products and processes will be acceptance by industry, government and consumers. The success stories are abundant. However, Joseph DeSimone, reviewing green replacement solvents, concluded that: "Environmental advantages alone probably will not enable alternative solvents to achieve widespread applicability" (*Science*, 279, 799-803, 2002). In other words, alternative processes and products may need to be better as well as greener.

What does all this mean to groundwater? Certainly, many greener processes have already been implemented in remediation. Replacing pump-and-treat with natural attenuation or *in situ* treatment are successful examples. In time, the use of Green Chemistry will hopefully result in smaller releases and groundwater contamination with less persistent, less toxic substances.

The popularity of Green Chemistry is clear; however, several issues must be resolved:

- What should be the role of government vis-à-vis industry?
- Will the imperfect tools of risk assessment be adequate for predicting human health and environmental impact of alternative processes and products?
- How accurately will life cycle analysis predict future impacts?
- How much will it cost, and who will bear the cost?

Green Chemistry has been embraced by the public, industry, and government. There is much hard work remaining to resolve the substantial issues. The alternative processes and products probably will need to be not only greener, but also better.

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

WRCA Prepares to Move to Southern California Update October 2010

By Linda Vida, WRCA Director and Paul Atwood, Archivist & Head of Technical Services

Dear Friends, Colleagues, and Supporters of WRCA…

The Water Resources Center Archives (WRCA) is currently a work in progress.

Many changes have been decided since July 16, 2010 when the University of California Division of Agriculture and Natural Resources (ANR) announced its decision regarding WRCA's future home. Following a thorough review of the three proposals that were submitted from UC Berkeley, Davis and Riverside to house WRCA, UC Riverside was selected as the new academic home.

The UC Riverside campus (UCR) is partnering with California State University, San Bernardino (CSUSB) to continue to provide access to and development of this world-renowned collection. In fact, the move will allow UCR and CSUSB to build a statewide collaborative network that will enhance access to WRCA's unique materials. This network will not diminish services to the UC campuses, but will increase support for water research agendas of the UC and CSU campuses and external clientele of WRCA.

Throughout August and September of 2010, a transition team was meeting to gather information and propose a strategy for the move. The transition team will shepherd WRCA through the complex process of moving the physical collection and the online catalogs, archival collection guides, WRCA web site, several databases, the On Water blog, and the Clearinghouse for Dam Removal Information.

Although some access points may change, virtual use of catalogs (via OCLC and Melvyl) and digitized content will remain largely unaltered and available to the public throughout the move. The web site and catalogs will remain accessible at UC Berkeley until we are positive that the files have transferred correctly and are accessible at UCR.

Moving a library is a complex, time-consuming process that necessitates limited access to the physical collection for several months before and after the move. Below is a fairly accurate timeline concerning access to WRCA collections.

October 15, 2010 – WRCA facilities will close and all services will be suspended except for digital interlibrary loan (ILL).

November 15, 2010 – Digital ILL will be suspended.

January 3-17, 2011 – WRCA collections and equipment will be moved from UCB to UCR. WRCA will be completely moved out of O'Brien Hall by January 31, 2011.

April 25, 2011 –WRCA resources will be formally available at the UCR Orbach Science Library and CSUSB Pfau Library.

Thank you all for your continued support of WRCA and for your patience. WRCA looks forward to serving UC, CSU and the California water community for years to come from its new location in Southern California.

We plan to send out another update about the transition in January 2011.

WRCA website: http://www.lib.berkeley.edu/WRCA/
On Water blog: http://blogs.lib.berkeley.edu/wrca.php
Facebook: http://www.facebook.com/pages/Berkeley-CA/Water-Resources-Center-Archives/163647453707

NGWA 2010 Ground Water Expo and Annual Meeting this December in Las Vegas

By Cliff Treyens, NGWA Public Awareness Director

The National Ground Water Association's Ground Water Expo and Annual Meeting heads back to Las Vegas December 7-10, 2010. In addition to kicking off the 2011 William A. McEllhiney Distinguished Lecture Series in Water Well Technology, those attending the NGWA Expo and annual meeting can see the last presentation of the 2010 Henry Darcy Distinguished Lecture Series in Ground Water Science. The 2010 Henry Darcy Distinguished Lecturer is Timothy D. Scheibe, Ph.D., a staff scientist in the Hydrology Technical Group of the Pacific Northwest National Laboratory. His lecture is titled "Beyond the Black Box: Integrating Advanced Characterization of Microbial Processes with Subsurface Reactive Transport Models."

Additionally, more than 70 workshops will be provided, including:

- Best Suggested Practices for Groundwater Sampling work session
- Impacts of Shale and Coalbed Gas Extraction on Groundwater
- Water Architecture and Urban Planning: A Balance of Technology and Behavior
- Dissolved Oxygen Sensing Technologies
- Aquifer Characterization Tests and Transducer Data Collection
- In-Situ Groundwater Arsenic Removal Using Iron Oxide-Coated Sand
- Challenges to Exempt Wells: An Update
- Hydrogeology 101.

Concurrent with the Expo and annual meeting is NGWA's Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Remediation® Forum on December 9. The keynote address by Evan Nyer of ARCADIS is titled "Closure of Petroleum Sites: Looking to the Future." The forum will explore future trends/technologies governing site closures and recent state actions on site closures. The forum also will provide an opportunity to interact with regulators, oil company representatives, and remediation professionals.

Conference topics include:

- Case studies of cost-effective remediation projects
- Characterization and remediation of contaminants at surface water/groundwater interfaces
- Effective investigation tools and techniques
- How the industry can best respond to regulator concerns
- Site closure.

For more information, visit www.ngwa.org.

GRA Welcomes the Following New Members

AUGUST 11, 2010 – NOVEMBER 23, 2010

Anderson, Karli	University of California, Irvine
Argyridou, Anna	Genesis Engineering & Redevelopment, LLC
Bowery, Michael	Delta Consultants
Brommenschenkel, Frank	Frank B & Associates
Buche, Brock	City of Fresno – DPU/Water
Byler, Nicholas	Student
Cardone, Martin	City of San Bruno
Chimoutite, Indre	Conestoga Rovers and Associates
Crozier, Carrie	Conestoga Rovers and Associates
Daverin, John	Eastern Municipal Water District
Diaz, Stephanie	University of California, Santa Barbara
Fischer, Cynthia	City of Fresno – DPU/Water
Frederick, Jesse	WZI Inc.
Garlow, Richard	
Grippa, Jennifer	Kleinfelder
Haney, Rob	Envirogen Technologies, Inc.
Hard, Edward	California Department of Food and Agriculture
Heard, Ken	City of Fresno – DPU/Water
Holden, Lia	Delta Consultants
Houghton, Candice	Sacramento State
Hriciga, Damian	MACTEC
Jurek, Anne	San Jose State University
Kaminsky, Jonathan	Luhdorff & Scalmanini Consulting Engineers
Knapp, Glenn	City of Fresno – DPU/Water
Kulesza, Dana	Central Valley Water Board
Little, Bob	City of Fresno – DPU/Water
Mawer, Chloe	Stanford University
Mazzoli, Theodore	Shaw Environmental, Inc.
Melancon, Nyree	
Minas, Shant	Applied Earth Sciences
Neary, Leigh	ARCADIS-US
Newman, James	Napa County Environmental Management
North, Katharine	UC Davis
Odlum, Nick	Stanford University – Dept. of Geophysics
Patton, Kent	Pace Analytical Services
Piper, Jane	Piper Environmental Group, Inc.
Platt, Evan	EBA Engineering
Powell, Stanley	Kronick Moskovitz Tiedemann and Girard
Querin, Martin	City of Fresno – DPU/Water
Raab, Leo	Weck Laboratories, Inc.
Reason, Michael	GeoLogic Associates
Reinhardt, Mark	City of San Bruno
Sager, Jeannette	UC Davis
Sapp, Jason	GeoLogic Associates
Shaw, Jay	Accutest Laboratories
Simons, Andy	Geosyntec Consultants
Siren, Deke	E2 Environmental, Inc.
Snyder, Jessi	Self-Help Enterprises
Snyder, Scott	Jonas and Associates
Soo, Kit	MWH Global
Staples, Michele	Jackson Demarco Tidus Peckenpaugh
Studer, James	AECOM
Tatum, Chris	WDC Exploration & Wells
Taylor, Hope	Larry Walker Associates
Thurber, James	Geotechnical Consultants, Inc.
Williams, Steve	AECOM
Worland, Matthew	GHH Engineering, Inc.
Wright, Michael	ROKEN Engineering Services
Zhao, Kun	Environ Int. Corp.

GRA Extends Sincere Appreciation to the Co-Chairs and Co-Sponsors for the October 2010 *Advanced Tools Workshop for In-Situ Remediation*

CO-CHAIRS

Rula Deeb, Malcolm Pirnie Inc.
Tom Mohr, Santa Clara Valley Water District

CO-SPONSORS

Microbial Insights, Inc.
Microseeps, Inc.
Regenesis

GRA Extends Sincere Appreciation to the Chair for its November 2010 Course, *Interpreting Non-Detect Data Correctly*

CHAIR

David Abbott

GRA 2011 Officers Elected

The GRA Board of Directors elected the following officers for 2011: William Pipes, President; Sarah Raker, Vice President/Treasurer; Ted Johnson, Secretary. Congratulations to all of you for being elected.

2010 Contributors to GRA – Thank You

FOUNDER *($1,000 and up)*
AMEC Geomatrix
Brownstein Hyatt Farber Schreck
Environmental Resolutions, Inc.
Malcolm Pirnie
Nossaman LLP
Roscoe Moss Company
DrawingBoard Studios

PATRON *($500-$999)*

CORPORATE *($250-$499)*
David Abbott
ARCADIS, U.S., Inc.
Luhdorff & Scalmanini Consulting Engineers
MACTEC Engineering & Consulting, Inc.
Parker Groundwater
Bob Van Valer

CHARTER *($100-$249)*
Aegis Groundwater Consulting, LLC
Jeriann Alexander
Charles Almestad
Stanley Feenstra
Brian Wagner

SPONSOR *($25-$99)*
Richard Amano
Cathy Aviles
Thomas Ballard
Jenifer Beatty
Duane Blamer
Richard Booth
Michael Bowery
Frank Brommenschenkel
Kevin J. Brown
BSK Associates
Michelle Buller
Steve Campbell
Bob Cleary
Nova Clite
Condor Earth Technologies, Inc.
Timothy Crandall
Roger Dockter
Jessica Donovan
EMAX Laboratories, Inc.
Martin Feeney
Geoff Fiedler
Fred Flint
John Fortuna
Alvin Franks
Scott Furnas
Jacob Gallagher
Richard Garlow
Miguel Garcia
Mark Grivetti
Sarah Grossi
Gary Halbert
Thomas Harter
Hopkins Groundwater Consultants, Inc.
H2O Engineering, Inc.
Kelly Houston
HydroFocus, Inc.
Carol Kendall
Michele Kinaan
Jo Anne Kipps
Taras Kruk
Bruce Lewis
John McAssey
Sally McCraven
Robert Martin
Jean Moran
Alex Naugle
Joseph Oliver
Oliver Page
Tim Parker
PES Environmental, Inc.
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Bryan Pilkington
Iris Priestaf
Eric Reichard
Craig Sandefur
William Sedlak
Pawan Sharma
Jay Shaw
Marc Silva
Linda Spencer
Phyllis Stanin
Chris Tatum
Versar, Inc.
Jon Wactor
Christopher Watt
Daniel Wendell
Wildermuth Environmental
Michael Wright
Gus Yates
Frederick Yuki
Anthony Zampiello
William Zavora
Ryan Zukor

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Megan Abadie
Angela Carmi
Robert Niblack
Joni Kropf
Dana Kulesza
Chloe Mawer
Katharine North
Laura Roll
Tim Rumbolz
Allen Waldman

Celebrate GRA's 20th Year – Renew Your Membership

It's time to renew your GRA membership for 2011. Don't miss out on being a part of GRA's 20th year! You can renew online via GRA's Web site, www.grac.org, or you can request a hard copy dues renewal invoice from Kevin Blatt at dbadmin@grac.org. To save time and effort, GRA recommends that you renew online as the process is secure and seamless. It will also help GRA to keep related expenses to a minimum.

Thank you for your interest and continued participation in protecting and improving California's groundwater resources.

GRA Extends Sincere Appreciation to the Co-Chairs and Sponsors for its September 2010 19th Annual Conference and Meeting, *Thinking Outside the Pipe: Exploring and Protecting Local Water Supplies*

CO-CHAIRS
Brian Lewis, Department of Toxic Substances Control
Tim Parker, Parker Groundwater
Tom Mohr, Santa Clara Valley Water District

CO-SPONSORS
Erler & Kalinowski, Inc.
MWH

REFRESHMENT SPONSOR
Weiss Associates

Help Match a Challenge Grant to GRA's Scholastic Fund!

Dear GRA Member,

We have only until the end of 2010 to match a $2,500 challenge grant offered by Steve Zigan (see letter to the right). To facilitate this challenge, GRA and the Water Education Foundation (WEF) are creating a partnership that will allow your charitable scholastic donations to be fully tax-deductible under WEF's 501(c) 3 charitable organization status.

For nearly a decade, GRA's Branches have been engaged in the Scholastic Fund Program that benefits local academic programs and their students through scholarships and other scholastic support to the departments involved in California groundwater research. GRA has been supporting Branch scholastic efforts using your contributions made as part of the annual membership drive. Thus far, GRA's members and sponsors have contributed over $30,000 to the educational needs of California's groundwater students.

On behalf of GRA and the Education Committee, I want to thank Steve Zigan for his generous contribution, and I want to thank you for supporting GRA's commitment to students. Watch for this tax-deductible donation option on your annual membership renewal.

Thomas Harter

Thomas Harter
Chair, GRA Education Committee
ThHarter@ucdavis.edu

Dear GRA Member,

I encourage you to support the Groundwater Resources Association of California's (GRA's) Scholastic Fund in a special end-of-2010 drive. In 2011, GRA will celebrate its 2O-year anniversary, and we want members and future members to be part of this milestone occasion. I am offering GRA a personal $2,500 challenge donation to significantly raise the level contributed to GRA's Scholastic Fund.

GRA's Branches have been leading the fundraising efforts for academic scholarships and other scholastic support. Sponsorships of Branch events have resulted in major contributions to the funds that have been distributed in support of groundwater science education at academic institutions and student attendance at groundwater events. These Branch funds are also matched by your direct contributions to GRA's Scholastic Fund, particularly during the annual membership renewal drive.

Several examples reflect GRA's support to the next generation of geoscientists. GRA's Southern California Branch arranged for GRA scholarships in 2008 and 2009 to one undergraduate and three graduate Cal State Fullerton students. These scholarships paid for field studies and laboratory analyses on hydrogeologic issues in the Mojave Desert and for a theoretical groundwater study on contaminant transport. In Northern California, the San Francisco Branch recently sponsored 5 students from three universities to attend GRA's 19th Annual Conference. These students also attended the special GRA Collegiate Groundwater Colloquium which provides a high quality platform for graduate students to present their work. Two of the students supported by the San Francisco Branch also attended the post-meeting field trip.

GRA's Scholastic Funds are beginning to benefit students throughout the state. The students who have received support greatly appreciate the opportunity to learn about important water resource issues in California. It is time for us to do more.

I want to take this opportunity to encourage you to make your contribution to GRA's Scholastic Fund at a level well beyond your regular contribution. I have personally pledged $2,500 as a fundraising challenge. Over the past two years, member contributions to GRA's Scholastic Fund (other than event sponsorships) have totaled about $2,500 annually. I challenge GRA's membership to double its contributions to the Scholastic Fund to $5,000 from members this year – together we would grow the fund to at least $7,500!

I hope that you can join me in building GRA's Scholastic Fund and make 2010 the best ever for funds that support and engage students in a lifelong interest in groundwater!

Steve M. Zigan

Launch of GRA Distinguished Lecture Series

DAVID KEITH TODD LECTURE SERIES

GRA is pleased to launch a new Distinguished Lecture Series. The series is named the *David Keith Todd Lecture Series* in honor and recognition of Dr. Todd's enormous contributions to groundwater science and technology. GRA held Dr. Todd in the highest esteem for his contributions and awarded him GRA's Lifetime Achievement Award. Fittingly, the *David Keith Todd Lecture Series* is being launched in coordination with activities to celebrate GRA's 20th Anniversary.

A key objective of the *David Keith Todd Lecture Series* is to foster interest and excellence in groundwater science and technology through GRA-sponsored lectures at California universities and local and statewide GRA events. The new Lecture Series also complements a key GRA Education Committee goal, which is to develop scientific educational programs that promote the understanding and implementation of groundwater assessment, protection, and management.

Northern and Southern California Lecturers – Dr. John Bredehoeft and Dr. Prem Saint

In designing the new lecture series, the GRA Education Committee decided to award two lecturers each year. One lecturer will focus on presentations in the northern part of the state, while the other lecturer will focus on lectures in the southern part of the state. Each lecturer will provide a minimum of five lectures, including two at GRA Branch Meetings, two at academic institutions, and a "wrap-up" lecture at the GRA Annual Conference. In 2011, that will be the *28th Biennial Groundwater Conference* and *20th GRA Annual Meeting* (scheduled for October 5-6, 2011 in Sacramento).

For 2010/2011, Dr. John Bredehoeft of The Hydrodynamics Group was nominated and accepted to be the Northern California lecturer. For 32 years, Dr. Bredehoeft devoted time to scientific research and high-level management positions with the U.S. Geological Survey (USGS). In 1995, when he retired as a Senior Research Geologist from the USGS, he established the above firm, located in Sausalito, where he continues to do consulting. While at the USGS, Dr. Bredehoeft and his colleague, George Pinder, developed and published the first widely used numerical groundwater flow model for which they received the Horton Award of the American Geophysical Union. They also developed the first widely used contaminant transport model for which they received the Meinzer Award of the Geological Society of America. In addition to doing research with the USGS, Dr. Bredehoeft has held a number of teaching positions; he has taught at the University of Illinois, Stanford, the University of California at Santa Cruz, and San Francisco State University.

Dr. Bredehoeft will be presenting on the topic "Conjunctive Use: The Impact of Pumping Wells on a Nearby Stream." He will describe the impact on streamflow of a well pumping from an alluvial aquifer associated with the stream. This classic hydrogeology problem was first solved by Theis in 1941 with an analytical solution and using the principles of superposition. Glover and Balmer sim-

Continued on the following page…

Launch of GRA Distinguished Lecture Series – *Continued*

plified the analytical solution in 1954 by showing it to be an error function. Economic studies that Dr. Bredehoeft was involved in at "Resources for the Future" in the 1970s demonstrated that the output from the combined system, wells and stream, could be doubled through effective management. Dr. Bredehoeft will elaborate on how the problem is still misunderstood by many hydrogeologists, and many myths remain, even though various investigators have addressed facets of this problem for more than 7 decades.

Dr. Prem K. Saint, Professor Emeritus at California State University, Fullerton has generously accepted his nomination as the southern California lecturer. Dr. Saint was involved for over 40 years in teaching and research in groundwater hydrology, water quality, hazardous waste management, geothermal energy and watershed management, with projects in Southern California, East Africa, and India. He has a Ph.D. from the University of Minnesota and Bachelor's and Master's degrees from the University of London, England. He also worked for the Kenya Ministry of Water Development as a hydrologist in charge of the Rift Valley Area, and he worked as a senior hydrogeologist developing groundwater supplies for urban and rural communities and for wildlife.

Dr. Saint will be presenting on the topic of "Groundwater: A Historical and Global Perspective." Based on his 40 years of field work in East Africa, India, Britain and Southern California, he will trace the history of concepts dealing with groundwater development, water pollution investigations, and constructed wetland design and management in different cultural and political settings. In South Asia and Africa, groundwater has been used for irrigation and water supplies using qanats (underground tunnels) and bouris (water tanks) for hundreds of years. With the rapid urbanization and increased groundwater pumping, coupled with global climatic changes and shrinking Himalayan glaciers, water shortages and water pollution will be a far greater challenge than energy and mineral shortages in the 21st Century.

Additional biographical information about the lecturers and abstracts of their presentations will be available soon at www.grac.org.

Sponsors

The program will be funded through co-sponsors that wish to support the Lecture Series.

GRA thanks Malcolm Pirnie for its generous support of the first year of the *David Keith Todd Lecture Series*.

GRA Recognizes California State Senator Fran Pavley as 2010 Kevin J. Neese Award Recipient

The Groundwater Resources Association of California 2010 Kevin J. Neese Award was provided to California State Senator Fran Pavley for leadership in the enactment of the comprehensive, statewide groundwater level monitoring legislation in California. The bill, SBX7-6—Groundwater Level Monitoring—was chaptered November 6, 2009 as part of the historic Delta Legislative Package. For the first time in the state of California, which annually pumps nearly one-fifth of the groundwater in the nation, the enacted legislation creates a statewide groundwater elevation monitoring program. This bill lays the foundation for understanding California's groundwater-level trends, where the problems and greatest needs are, and makes that information visible and available to the groundwater industry and the public. There have been various attempts over the past several years to implement a groundwater monitoring bill, all of which were vetoed by the Governor (SB178-2008, SB1640-2006, SB820-2005). The legislative intent of SBX7-6 is to have systematic monitoring and public reporting of groundwater elevations in all groundwater basins and subbasins in order to understand statewide groundwater level trends. GRA expressed appreciation for the expertise Senator Pavley and her staff bring in consideration of groundwater legislation, and for Senator Pavley's leadership as Chair of the Senate Committee on Natural Resources and Water.

Dennis O'Connor, left, accepts GRA's Kevin J. Neese award on behalf of Senator Fran Pavley, presented by Tim Parker.

The Kevin J. Neese Award is presented to recognize significant accomplishment by a person or entity within the most recent 12-month period that fosters the understanding, development, protection and management of groundwater. Previous Kevin J. Neese Award recipients include:

- 2009 - USGS California Water Science Center for the report titled "Groundwater Availability of the Central Valley Aquifer" (USGS Professional Paper 1766)
- 2008 - Orange County Water District for its Groundwater Replenishment System (GRS)
- 2007 - University of California Cooperative Extension (UCCE) Groundwater Hydrology Program for its efforts to engage scientists, regulators, farm advisors, dairy industry representatives, and dairy farmers to better understand the effects of dairy operations on water quality
- 2006 - Senator Sheila Kuehl for her work to improve the production and availability of information about the state of our groundwater resources
- 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.

Dennis O'Connor, Chief Consultant to the California Senate Committee on Natural Resources and Water, accepted the award on behalf of Senator Pavley. Mr. O'Connor expressed deep appreciation on behalf of Senator Pavley, and also appreciation to GRA on continued efforts to provide information to the legislature on groundwater related issues.

Dr. John Cherry Awarded GRA's 2010 Lifetime Achievement Award

By Murray Einarson, AMEC Geomatrix

Dr. John Cherry, Emeritus Professor at the University of Waterloo and Adjunct Professor at the University of Guelph, has been awarded GRA's 2010 Lifetime Achievement award for his many contributions in the field of contaminant hydrogeology. Dr. Cherry, co-author of the well-known textbook Groundwater and more than 200 peer-reviewed technical papers, received the award in person at GRA's Annual Meeting in Burlingame on September 16, 2010.

Presenting the award were Bill Pipes, GRA President, and Murray Einarson, both from AMEC Geomatrix. Murray Einarson, one of Dr. Cherry's former graduate students, summarized some of Dr. Cherry's many attributes that have made him the "father of contaminant hydrogeology" and a unanimous choice for receiving GRA's prestigious Lifetime Achievement Award.

Vision: Throughout his career, Dr. Cherry has had an uncanny ability to identify and focus his research on topics that turned out to be crucial to the field on contaminant hydrogeology. This started with field studies that shed light on the key processes that control the fate and transport of dissolved solutes flowing in sand and gravel aquifers. The next chapter in his field research focused on aquitards—an area of study largely ignored by water resource professionals at that time—because he recognized the importance of aquitards in controlling groundwater flow systems and protecting groundwater resources. Dr. Cherry and his team then studied the behavior of dense non-aqueous phase liquids (DNAPLs) in the subsurface and the dissolved plumes emanating from DNAPL source zones. Most recently, Dr. Cherry and his colleagues have performed key laboratory, modeling, and field studies that have advanced our knowledge of the behavior and significance of organic contaminants in fractured rock environments.

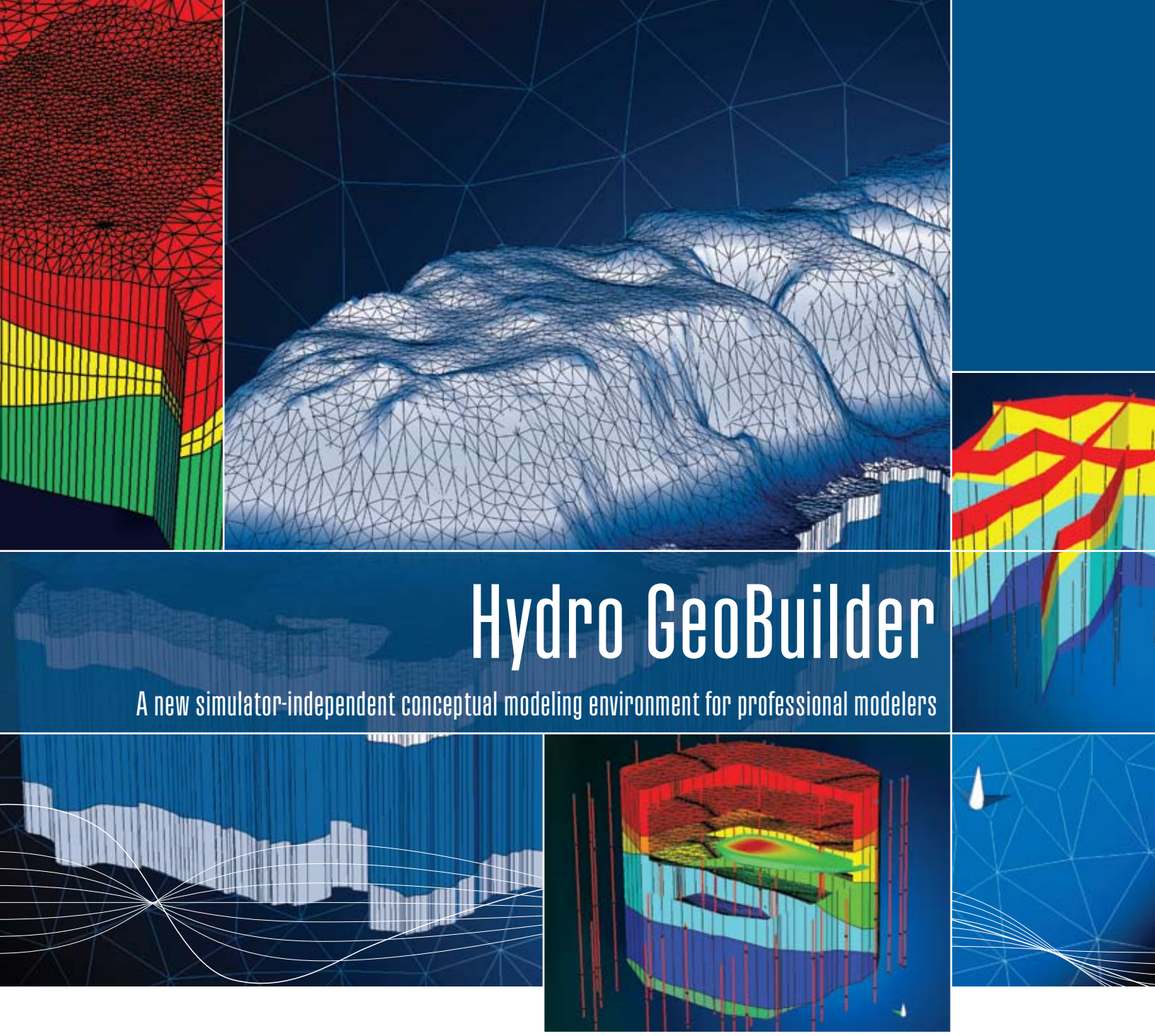
Left to right: Bill Pipes presents the Lifetime Achievement Award to John Cherry with assistance from Murray Einarson.

Commitment to field research: At a time when most contaminant hydrogeologists were performing laboratory sand-tank experiments or building analog computer models, Dr. Cherry and his team designed and performed some of the most elegant and well-monitored controlled-release field experiments that have ever been performed. As a result, Dr. Cherry and his team made many of the key discoveries in the field of contaminant hydrogeology. Those field experiments were ambitious in scope, and were made possible by using innovative subsurface characterization and monitoring technologies that Dr. Cherry's team developed. These technologies include direct push (DP) soil coring equipment, multi-level monitoring wells, and the Waterloo Groundwater Profiler. These technologies have since been commercialized, which has made high-resolution characterization and monitoring possible at non-research sites.

Collaboration: Many attribute Dr. Cherry's early successes at the University of Waterloo to the strong spirit of collaboration that he fostered. He assembled diverse teams of researchers consisting of geologists, engineers, geochemists and numerical modelers to work on research projects that he conceived. Many who know him remark on his generosity as a collaborator, always inclusive rather than exclusive, and focusing credit for the successes of his team on others rather than himself.

Communication: Dr. Cherry is truly an amazing communicator. He has a gift of being able to present complex ideas in a very simple way that makes them seem obvious. His books and technical papers are some of the best ever published and are the most cited in our field. His writing is very clear and often includes conclusions that make you nod your head and think "that makes so much sense." Students listening to his lectures leave the auditorium not only knowing the results of his research but, more importantly, understanding the significance of it.

In his acceptance speech, Dr. Cherry highlighted the importance California has played in his professional career, starting in the early 1960s when he obtained his MS in Engineering Geology at UC Berkeley. He then reflected on the time he spent on sabbatical at Stanford in the 1970's working on the manuscript of Groundwater with his co-author Alan Freeze. He then briefly described his close working relationship with DTSC and others working at a fractured-rock research site in California. In closing, Dr. Cherry praised GRA's strong history of supporting groundwater education and expressed his opinion that GRA is now considered one of the premier groundwater organizations in the world.



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Sacramento

By Tom Ballard,
Branch Secretary

At the August meeting, the Sacramento Branch welcomed Geological Society of America Birdsall-Dreiss 2010 Distinguished Lecturer Dr. Susan S. Hubbard. Dr. Hubbard is a senior scientist at Lawrence Berkeley National Laboratory, where she leads the Environmental Remediation and Water Resources Program. Her research focuses on advancing the use of geophysical methods for shallow subsurface characterization and monitoring, with a particular emphasis on development of data integration methods and application of those methods to water resource and environmental-remediation problems. She co-edited the first book on hydrogeophysics, has published over 60 papers on this topic, and is the recipient of the 2009 Frank Frischknecht award for leadership in innovation in near-surface geophysics.

The title of Dr. Hubbard's talk was "Toward X-Ray Vision: Geophysical Signatures of Complex Subsurface Processes." The talk focused on the relatively new fields of hydrogeophysics and biogeophysics, which strive to use geophysical datasets to characterize subsurface hydrogeological and biogeochemical processes. Because some geophysical attributes are sensitive to

hydrological and biogeochemical properties that govern flow and transport, geophysical methods hold potential for minimally invasive characterization and monitoring of complex subsurface processes. Several key components are required for such quantitative characterization, including high quality geophysical datasets, petrophysical models, frameworks to integrate disparate datasets, and attention to scale issues. Dr. Hubbard reviewed these key components and presented several examples that illustrated how hydrogeophysical and biogeophysical methods can be used to gain significant insights into subsurface bacterial transport and feedbacks between biogeochemical transformations and flow characteristics. Field examples illustrated during Dr. Hubbard's talk included Department of Energy cleanup sites at Rifle, Colorado; Hanford, Washington; and Oak Ridge National Laboratory in Tennessee.

San Francisco

By Abigail McNally,
Branch Secretary

Mike H. Mehmert presented his 2010 McEllhiney Lecture, "You Drill a Hole – You Develop a Well," on October 20, 2010. Mr. Mehmert is a member of NGWA and an active Well Standards Committee member. He is the Director of Sales and Marketing–Well Products at Johnson Screens, a Weatherford Company, and has more than 38 years of consulting, contracting, and manufacturing experience—primarily in the groundwater industry.

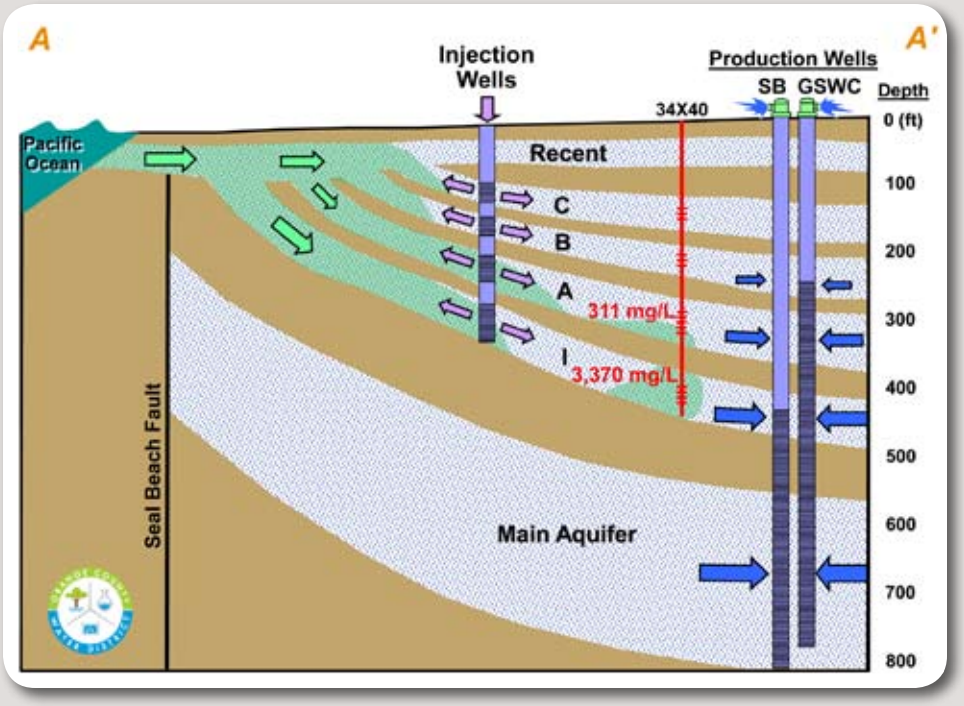
Mr. Mehmert reflected on his career and selected the topic of well development for this lecture series, because it is an extremely important task that is frequently underappreciated in the groundwater industry. He summarized various drilling methods, the importance of proper well design (including selection of grain size and thickness of the filter pack), and the need for proper development in completing a successful well. Every drilling method alters and damages the borehole and surroundings, and careful well development is required to restore the hydraulic properties of the aquifer and improve the performance of the well. The benefits of proper well development include increased yield, operational efficiency, and optimal service life, especially for high-capacity wells. Mr. Mehmert also addressed negative drilling impacts, including their causes and the consequences when not addressed. Mr. Mehmert's concluded by challenging industry professionals to improve and standardize well development practices, to educate clients about the importance of this critical task, and to ensure that an adequate budget is negotiated to properly complete this work.

Southern California

By Paul Parmentier,
Branch Secretary

The Southern CA Branch held its summer meeting on August 18th, in Santa Ana, with Water Development Corporation as the scholarship sponsor. Mr. Tim Sovich, P.E., from the Orange County Water District, presented "Evaluating Expansion Needs for the Alamitos Seawater Intrusion Barrier." The Alamitos Barrier, initially installed in 1965, is located at the boundary between Orange and Los Angeles counties. Several agencies jointly operate and fund the barrier, where about 6,000 acre-feet per year are injected to prevent seawater intrusion into inland groundwater extraction zones. This is the smaller of the two barriers operated in Orange County; the Talbert Barrier injects about 36,000 acre-feet annually. The Alamitos Barrier, which includes 43 injection and 221 monitoring wells, has been expanded since 1965, but additional injection is needed.

The hydrogeologic setting consists of several aquifers dipping inland to the northeast away from the Newport-Inglewood Fault Zone, locally referred to as the Seal Beach Fault, which behaves as a natural barrier effectively sealing the deeper aquifers from the ocean. The shallow aquifers are hydraulically connected to the ocean via their mergence with the "Recent Aquifer" as shown in the schematic cross-section.



Elevated Salinity found inland of barrier in the A and I zones.

A 13-layer groundwater flow and transport model, a joint effort by the Orange County Water District (OCWD), the Los Angeles County Department of Public Works (LACDPW) and the Water Replenishment District (WRD), was calibrated to 11 years of water-level data and subsequently was expanded to include solute transport of chloride and recycled water . Conservative transport was assumed, i.e., no retardation, sorption, or chemical reaction of either chloride or recycled water. The transport model predicted that the injected water, typically about 50% reclaimed water, reached the Seal Beach extraction wells (about 1 mile from the barrier) in about 5-6 years.

Three barrier expansion scenarios focused on maintaining protective groundwater elevations of about 5 feet above mean sea level in each zone at the proposed barrier expansion locations. Model results suggested that about 2,000 acre-ft/yr of additional injection along the existing alignment was needed to prevent eastward intrusion through the barrier into Orange County, and about 3,600 acre-ft/yr of additional injection was required to fully prevent intrusion around the ends of the barrier into both Orange and Los Angeles counties.

The Sierra Nevada

In 1984, the Nature Conservancy first acquired wild lands for the Cosumnes River Preserve to protect the last remaining undammed river on the Sierra Nevada's western slope. The broad floodplain of the lower river harbors rare valley oak riparian forest and several thousand acres of seasonal and perennial freshwater wetlands that are used by resident and migratory birds. Less than 4% of each community remains intact in California. In addition, the Conservancy along with public, private and non-profit partners has created more than 1,500 acres of new wetlands, participated in reforestation projects, removed levees along the river in order to restore natural flooding processes, and worked with local farmers in developing sustainable agricultural practices. The free-flowing nature of the river allows frequent and regular winter and spring overbank flooding that fosters the growth of native vegetation and the wildlife dependent on those habitats.

The river's floodplain is at risk from the threat of urban encroachment, being located near Interstate 5 about 25 miles south of Sacramento. The Nature Conservancy and seven governmental and non-profit partners manage the Cosumnes River Preserve, which is approximately 40,000 acres (62 square miles) in size. Additional information about the Cosumnes River Preserve and the Nature Conservancy is available at:

http://www.cosumnes.org/
http://www.nature.org/wherewework/northamerica/states/california/preserves/art6318.html

Photograph by John Karachewski, PhD (DTSC).