

HYDROVISIONS

Volume 16, No. 3

GROUNDWATER RESOURCES ASSOCIATION
OF CALIFORNIA

Fall 2007

GRA's Groundwater Storage Symposium - Challenges and Solutions

BY TIMOTHY K. PARKER, TED JOHNSON, ERIC REICHARD, AND CHRIS PETERSEN

Groundwater is one of California's most important natural resources. Consider that:

- ▲ California uses more groundwater today than any other state, with nearly one-fifth of all groundwater withdrawals in the nation, averaging 15 million acre-feet annually;
- ▲ Nearly half of California's overall drinking water supply comes from groundwater;
- ▲ Groundwater meets about 30 percent of California's urban and agricultural water demand in an average year, and supports an even larger percentage of use in drought years;
- ▲ Groundwater provides water for the environment, including wetland habitat, springs, and other important natural resources;
- ▲ The potential amount of groundwater storage in California is far greater than that stored in the state's surface reservoirs; and groundwater is the only source of water supply in many areas of the state.

The demands of an ever-increasing population (most recently projected to be 60 million in 2050), a growing realization that the challenges of the Delta and the long-term reliability of the State Water Project may not be solvable in the near future, and longer dry periods resulting from climate change demand new approaches to more strategically utilize groundwater storage space available in

subsurface reservoirs. This means filling the available subsurface storage space in the wet years and withdrawing the stored groundwater in dry years. Effective use of our available groundwater storage is an essential component of a long-term, safe and reliable water supply for all Californians.

GRA held the 3rd symposium in its very successful Water Resources Series on June 20 and 21, 2007, at the Westin Hotel in Long Beach, California. Entitled *Increasing Groundwater Storage to Meet California's Future Demand - Challenges and Solutions*, the symposium drew 123 attendees, predominantly from locations throughout California, but also from as far away as New York, Florida, and Malaysia, to the beautiful backdrop of coastal Long Beach. Experts, researchers, state agencies, and stakeholders from academia, consulting, water supplies, and the legal

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arena presented papers and engaged in lively discussions on the science and policy of groundwater storage, the current legal and regulatory challenges, water quality issues, and integrated water management. The symposium was organized into 8 sequential sessions over two days, which are described in detail below.

The evening before the symposium included a Southern California Branch Dinner at a local brew pub and featured an excellent technical discussion by Dan Ponti, US Geological Survey (USGS), on the use of legacy seismic data and detailed borehole data to assess the sequence stratigraphy of the West and Central Coast basins; Dan also described the potential hydrogeologic implications of the sequence stratigraphy framework. The day following the sym-

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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.



President's Message

BY THOMAS K.G. MOHR

Human Complexity and Groundwater Management

The theme of the 26th University of California Biennial Groundwater Conference and GRA's 16th Annual Meeting, "California's Water Future: Expanding the Role of Groundwater," promises to profile many of the challenges to effective groundwater management in California. The physical challenges can be daunting: combating saline intrusion with a shrinking supply of fresh water, addressing emerging contaminants, optimizing extraction to avoid overdraft and subsidence, and facing these tasks armed with limited data on geologic heterogeneity, seasonal variability, and long-term changes in land use and climate. Advances in the sciences that contribute to understanding groundwater systems have yielded technical solutions to solve many of the problems in the realm of the hydrogeologic framework. For example, improved laboratory analytical methods, high-resolution basin characterization, improved models for flow and transport, and stochastic approaches to represent heterogeneity and uncertainty have all enabled more robust estimation of groundwater processes. But it is perhaps the human complexity of our social, political and legal system that presents the more formidable challenge to implementing groundwater management solutions.

Science serves us well when employed to support the interests of an individual stakeholder to a groundwater management challenge. As soon as two or more

stakeholders are involved around a single issue, each employing their own scientists, the human complexity begins to surpass the natural complexity of the problem. How well do the decision making processes available in government and the legal system allow the optimal solution to arise from conflicting science-based positions? The elusive 'optimal solution' usually lies between the interest-based positions, but each party is bound to aggressively pursue the solution that best serves their interests. This leaves the decision to disengaged judges or Water Board members, who have less familiarity with the subtleties of the problem.

Many of us in the groundwater profession are actors on the stage where groundwater problems are resolved, passionately adhering to our respective scripts, but very few are engaged in determining the plot. As geologists, engineers, regulators, industry representatives, even lawyers, what do we know about bringing diverse interests together in a room and, at the end of the day, walking out with a solution that appropriately incorporates the myriad interests of the stakeholders? There is a substantial body of conflict resolution knowledge available to resolve multi-interest resource allocation problems, yet few in the resource management professions are knowledgeable and experienced in this area. Example solution frameworks include stakeholder collaborative models and the Nominal Group Technique (NGT).

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

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DNAPL 2

Source Zone Characterization and Removal

NOVEMBER 14-15, 2007

The Groundwater Resources Association of California (GRA) is pleased to present this follow-on symposium to the well-received inaugural Dense Nonaqueous Phase Liquid (DNAPL) Source Zone Characterization and Remediation Symposium in December 2005. (Go to <http://www.grac.org/dnapl2005.asp> to read about the 2005 event.) Like its predecessor, DNAPL 2 will focus on the technical and regulatory challenges faced by professionals involved with characterizing and remediating DNAPL source zones. Experts from academia, regulatory agencies, consulting, and industry will participate in moderated speaker and poster sessions. The combination of invited speakers and experts from these key areas make this an important event for all professionals involved in decision-making on DNAPL projects. Confirmed speakers include: Dr. Andrew Coleman, Electric Power

Research Institute (EPRI); Dr. David Ellis, DuPont; Mr. Paul Hadley, California Department of Toxic Substances Control; Dr. Michael Kavanaugh, Malcolm Pirnie; Dr. Bernard Kueper, Queen's University; Dr. David Major, GeoSyntec Consultants Inc.; Mr. Seth Pitkin, Stone Environmental Inc.; and Dr. Gary Wealthall, British Geological

Survey. This symposium will provide a valuable forum for dissemination of leading-edge research and innovative field applications that demonstrate advances in source zone characterization, and especially source zone remediation. 💧

Upcoming Events

Save the Date

Back by Popular Demand:

DNAPL 2: Source Zone Characterization and Removal

Long Beach, CA • November 14-15, 2007

Planned Symposium topics include:

- ▲ Source zone characterization and monitoring using high-resolution techniques
- ▲ Predicting source zone architecture and persistence
- ▲ Characterization and remediation strategies for deep aquifer systems
- ▲ Characterization and remediation challenges for non-chlorinated DNAPLs
- ▲ Mass flux determination/implications for source zone removal
- ▲ DNAPL site closure strategies

26th Biennial Groundwater Conference

& 16th Annual Meeting of the Groundwater Resources Association of California

California's Water Future: Expanding the Role of Groundwater

September 18-19, 2007
Sacramento Convention Center
Sacramento, CA

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Wells and Words

BY DAVID W. ABBOTT, P.G., C.HG.
TODD ENGINEERS

Part 2: Some simple and helpful observations on basic inorganic groundwater chemistry

This article is Part 2 of the [Wells and Words](#) column, including Table 1, published in the Summer 2007 issue of HydroVisions. The presentation of water quality data is vital to the understanding and interpretation of the data (see Edward R. Tufte, *Visual Explanations*, 1997).

An alternative presentation of tabulated water quality data shown in Table 1 of the previous column is provided in Table 2. The less-than (<0.006, <0.05, <1, etc.) designations within Table 1 have been replaced with an innocuous symbol, the asterisk; a column listing the instrument detection limit (IDL) has been added for each analyte. When the IDL is reported as in Table 1, we recognize explicitly that the ions may exist in the solution at relatively small concentrations. The alternative presentation shown in Table 2 recognizes that data interpretation can be more easily accomplished using a simpler tabulation of inorganic and physical properties. The tables contain the same information, but Table 2 is less cluttered and easier to interpret both for the reader and the analyst.

The IDL of a constituent can vary with the laboratory used, associated analytical methods, and elevated concentrations of water quality parameters. When varying IDLs are reported, the individual IDL can be replaced with either a range or the largest IDL. This practice is applicable for inorganic ions, which usually are found at detectable concentrations in groundwater, and has been successful with anthropogenic organic compounds and other low-level constituents.

Technical Corner

TABLE 2

IDL

W-1

W-2

W-3

W-4

MAJOR CATIONS mg/L						
Calcium	Ca		51	16	10	39
Magnesium	Mg		44	7	2	22
Sodium	Na		140	92	80	484
Potassium	K		4	5	2	4
Sum of Cations meq/L			12.363	5.504	4.195	24.912
MAJOR ANIONS mg/L						
Bicarbonate	HCO ₃		230	190	160	322
Chloride	Cl		79	65	17	620
Sulfate	SO ₄	<1	210	13	35	*
Sum of Anions meq/L			10.371	5.169	3.831	22.789
MINOR IONS mg/L						
Iron	Fe		0.120	0.310	0.710	0.948
Manganese	Mn		0.003	0.180	0.025	0.172
Fluoride	F		0.20	0.27	8.00	0.10
Boron	B	<0.5	*	*	*	8.22
Nitrate as	NO ₃	<2	*	*	11	1
Nitrite as nitrogen		<0.4	*	*	*	*
Carbonate	CO ₃	<1	*	*	*	13
PHYSICAL PROPERTIES mg/L						
Total Hardness as Ca	CO ₃		310	68	36	188
Total Alkalinity as Ca	CO ₃		230	160	130	335
Total Dissolved Solids	TDS		690	340	270	1,410
Electrical Conductivity µmhos/cm	EC		1,100	550	430	2,600
pH Units			8.1	7.6	7.9	8.4
Apparent Color		<2	*	6	*	>70
Odor Units		<1	*	2	*	*
Turbidity NTU			0.21	0.88	9.10	12.70

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Legislative Update

BY CHRIS FRAHM AND
PAUL BAUER, HATCH & PARENT,
AND TIM PARKER,
SCHLUMBERGER WATER SERVICES

As predicted by GRA last year, the subject of groundwater and groundwater storage is fully in the spotlight in Sacramento this year. GRA has actively engaged on the subject of groundwater storage through activities at the capitol including the Annual Legislative Symposium and Legislative visits, input and testimony on pertinent bills, and the recent groundwater storage symposium.

Senate Bill 59 by Senator Dave Cogdill, sponsored by Governor Schwarzenegger, failed to pass out of the Senate earlier this year, but remains the platform for the Governor's campaign for a comprehensive water package. SB 59's inclusion of surface storage has prompted the Democrats to focus more keenly on opportunities to develop groundwater storage.

As of this writing, the Legislature is in a total meltdown due to the Budget Crisis. The Assembly passed the Budget on Friday July 20th around 2 o'clock in the morning and then promptly left town. However, the State Senate has been unable to muster the 27 votes required to approve the Budget passed by the Assembly. No Senate Republicans have voted for the Budget, leaving the Democrats two votes short for passage. The Republicans have raised a number of issues including further cuts and reigning-in the Attorney General on AB 32 enforcement. Tempers are frayed, not only between the Administration and the Legislature, but between the Assembly and Senate.

In the background of the Budget Crisis are a number of other issues including the water bond, prison and health-care reform. The bond issues, including implementation of the bonds voters approved last November, will

be the main focus when the Legislature returns from Summer Recess. To foreshadow these negotiations, the Governor has gone on a statewide water tour promoting the need for water conservation and improvements to our statewide infrastructure. His focus has been primarily on surface storage and a Delta fix. In the meantime, Senator Don Perata (D-Oakland), the President Pro Tem of the Senate, sent a letter to the Governor on July 16th outlining his plan for a water bond package.

SB 1002 by Senator Perata is the Proposition 84 implementation bill working its way through the Legislature. GRA and California Groundwater Coalition testified in the Assembly Water, Parks and Wildlife Committee in support of the legislation. SB 1002, among many other things, allocates \$200 million of the \$1 billion in Prop 84 Integrated Regional Water Management Planning fund for groundwater purposes. The bill passed with Democratic support and Republican opposition. GRA is working with Senator Perata's Senior Staff to examine the possibility of amending this language so that concerns raised by op-

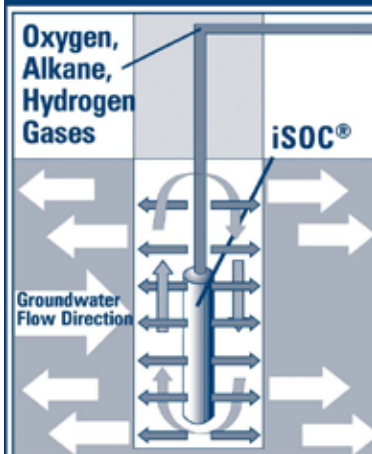
ponents are addressed. Our chief mission is to ensure that appropriate funding is provided for groundwater.

SB 178 by Senator Darrell Steinberg (D- Sacramento) (Chairman of the Senate Natural Resources and Water Committee) passed from the Assembly Water, Parks and Wildlife Committee after Senator Steinberg agreed to amendments requested by the California Farm Bureau. Accepting the Farm Bureau's amendments greatly increases the likelihood that the bill will be signed by Governor Schwarzenegger this year. After the gubernatorial vetoes of SB 820 and SB 1640, sponsored by Senator Kuehl, it was clear that negotiating with the Farm Bureau would be necessary. The amendments will be posted on the GRA website when available.

Chris Frahm and Paul Bauer, Hatch & Parent, GRA Legislative Advocates, may be reached at cfrahm@hatchparent.com and pbauer@hatchparent.com, respectively. Tim Parker, Schlumberger Water Services, is GRA Legislative Committee Chair. He may be contacted at tparker2@slb.com. 💧

California Legislative Corner

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2007 CCGO/California Section AIPG California State Science Fair Awards

BY JIM JACOBS,
ENVIRONMENTAL BIOSYSTEMS

For the past 7 years, the California Section of AIPG has judged the State Science Fair awards at the California Science Center, which is located within Exposition Park adjacent to the University of Southern California campus in Los Angeles. The judging was held on May 22, 2007.

On behalf of the California Council of Geoscience Organizations (CCGO), AIPG California Section Vice President David Sadoff presented Tierney R. Burke, with the CCGO/AIPG Senior Division award. The title of her presentation was *Shear Wave Velocity Determined by Refraction Microtremor Surveys in the Oxnard Plain to Assess Earthquake Risk*. Ms. Burke evaluated the variation of geologic materials near the Earth's surface and determined that these materials can have a significant effect on ground motion from earthquakes.

Refraction microtremor (ReMi) ambient noise recordings made on 140-m-long lines of standard refraction equipment were used to determine 30 meter (100 ft) average shear wave velocities and one-dimensional shear wave profiles down to depths of 100 meters. SeisOptReMi software allowed wavefield transformation data processing. ReMi processing involved velocity spectral analysis, Rayleigh phase-velocity dispersion picking, and shear wave velocity modeling. Measurements were compared with Uniform Building Code (UBC/IBC) site classifications and downhole measurements by USGS. A shear wave velocity contour map of the site area was prepared to analyze



Paul Enriquez and Dave Sadoff present Tierney R. Burke with the State Science Fair Senior Division award.

From left to right: Paul Enriquez, State Science Fair Junior Division Winner Aradhana Sinha, and Dave Sadoff.



area variation. Forty three field test measurements in this study produced shear wave velocities between 180 and 360 m/sec which classified in the UBC/IBC class D group. Refraction microtremor method surveys throughout the Oxnard Plain showed shear wave velocities decrease as one moves in a southwestward direction away from the mountains. A higher-velocity zone was identified along the course of the Santa Clara River, and a lower-velocity zone along the slow-moving Calleguas Creek on the eastern side of Camarillo.

According to Ms. Burke, the dense population and active tectonics of southern California necessitate extensive seismic hazard evaluations that include precise earthquake location determinations, path, and site effect studies. The seismic refraction method is well suited for general site investigations for soil dynamics and earthquake engineering

purposes. ReMi surveys performed in this study provided a more extensive assessment of shear wave velocities in the Oxnard Plain than previously reported. Ms. Burke will be attending the University of California at Davis this fall.

For her project, Ms. Aradhana Sinha evaluated the adsorption of pollutants in different soil types, earning the CCGO/AIPG Junior Division Award. The purpose of this experiment was to determine the effects of soil type and pollutant viscosity on retention of these pollutants in soils. The information gained from this experiment might be of interest to farmers, gardeners and botanists who deal with soil pollution problems. In her experiment, Ms. Sinha placed 200g of each type of soil and 100ml of each type of pollutant in separate cups. She waited until the soil was completely saturated, then put the saturated soil on a filter for 15 minutes;

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USEPA Happenings

BY JOHN UNGVARSKY, EPA

Arsenic Rule Compliance Success Stories

EPA has released eleven Arsenic Rule Compliance Success Stories, highlighting public water system experiences in meeting the revised drinking water standard. These water systems utilized innovative or lower cost approaches to meeting the revised 10 ppb maximum contaminant level for arsenic. The lessons learned will assist the 1,700 public water systems still seeking a sustainable Arsenic Rule compliance solution. EPA has also developed a new fact sheet, *Arsenic and Your Distribution System*, to help owners and operators understand and respond to issues that may arise with arsenic and their distribution system when treatment is installed or modified. For more information, go to: <http://www.epa.gov/safewater/arsenic/compliance.html>.

Changes in Water Quality Associated with Artificial Recharge and Groundwater Banking

Groundwater banking projects, which are slated to increase in number and extent, especially in California's Central Valley, require assessment of potential changes in water quality during artificial recharge and subsurface storage. Lawrence Livermore National Laboratory is near completion of a study addressing water quality change by using tracers of water mass and analyzing a wide variety of water quality parameters in surface water and recently recharged groundwater. For more information, contact Brad Esser at bkesser@llnl.gov or 925-422-5247.

Breaking the Age Barrier: New Research in Groundwater Quality

USEPA NRMRL hydrologists are pioneering the measurement of naturally occurring radioactive isotopes to determine the age of groundwater. A

breakthrough in field collection and laboratory measurement has permitted a new 85Kr isotope method to detect groundwater as young as 2 years and as old as 50 years. The new 85Kr method has been applied to selected watersheds where occurrences of arsenic and lead have prompted hydrologists to ask whether, and how, the groundwater will flush these materials out over time. For further information, contact Patricia Schultz at schultz.patricia@epa.gov or 513-569-7966.

Bioremediating Perchlorate in Contaminated Groundwater

USEPA's National Risk Management Research Laboratory (NRMRL) drinking water researchers are testing alternative bioremediation approaches to make perchlorate removal easier and more cost effective. They are using a continuous-flow membrane biofilm reactor in which hydrogen gas is supplied through the membrane to a biofilm growing on the outside of the membrane. The goal is to cost-effectively reduce the perchlorate concentrations by 90 percent. For further information, contact Patricia Schultz (see above).

Federal Legislative/Regulatory Corner

Preliminary Regulatory Determinations for the Second Drinking Water Contaminant Candidate List (CCL 2)

EPA has evaluated available occurrence, exposure, and health effects information for the 51 contaminants on CCL 2 and announced preliminary determinations for 11 of these 51 contaminants. For more information, see: http://www.epa.gov/safewater/ccl/reg_determine2.html.

High Efficiency Toilets

Americans waste about \$5 billion per year on water utility bills by flushing old, inefficient toilets. WaterSense, a program sponsored by the USEPA, is helping consumers identify high-performance, water-efficient toilets that can reduce water use. Under federal law, toilets must not exceed 1.6 gallons per flush (gpf). High-efficiency toilets (HETs) use less than 1.3 gpf. The WaterSense label can be used on HETs certified by independent laboratory testing. For a complete list see http://www.epa.gov/watersense/pp/find_het.htm.

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 and NV. For information on any of the above topics, please contact John at 415-972-3963 or ungvarsky.john@epa.gov.



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Mercury Legacy

BY BART SIMMONS

Mercury was probably the first metal smelted by ancient humans, and it has been used in human industry ever since. Mercury was used as a drug for the treatment of syphilis; as the saying went: "One night with Venus, and a lifetime with Mercury." The nursery rhyme with the line: "Rub-a-dub-dub, three men in a tub, turn them out knaves all three" may refer to the burning of cinnabar (mercuric sulfide) in an inverted tub to dose the unfortunate victims of syphilis. Solutions of mercuric nitrate were used in the felt industry, and mercury poisoning became endemic, creating "mad hatters."

Mercury forms an amalgam with gold; this led to its use by the 49ers to recover gold in sluice boxes in the mining of the Mother Lode. The mercury was then boiled off to recover the gold. The resulting runoff of mercury-contaminated water has created a classic legacy problem of environmental contamination. Mercury's affinity for gold, high conductivity, and other properties made it a critical resource at one time, and it was stockpiled in huge quantities by the federal government in case of war or other emergency.

Minamata disease, the result of unregulated discharges and biological

Chemist's Corner

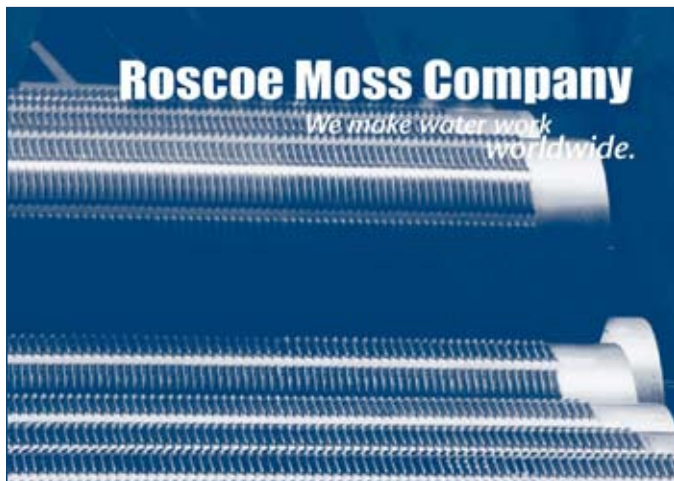
transformation into methyl mercury, was discovered in 1956. The tragic consequences included severe birth deformities in the children of exposed Japanese women.

According to the San Francisco Water Resources Control Board, 1,000 pounds per year of mercury are released by Bay floor erosion, and runoff from the Central Valley watershed contributes almost the same amount. Urban storm runoff contributes 353 pounds per year, and residential and industrial wastewater produces a relatively minor 40 pounds.

Mercury in groundwater can also be a source of surface water contamination. Researchers at the Woods Hole Oceanographic Institution found that a subterranean estuary that drains into Waquoit Bay in Cap Cod, Massachusetts contributes large amounts of mercury (*Environ. Sci. Technol.* 2007, 41, 3090-3095).

The mercury legacy problem is a challenge to current environmental regulation. Government intervention tends to be based on requiring responsible parties to clean up the impacts of past discharges (site mitigation) and regulation of current industrial discharges. But in this case, current discharges are minor compared with the legacy contribution to the problem. The State Water Resources Control Board is to be complimented for taking a large view of the problem. Mercury which was generated by gold miners behaves the same as mercury from contemporary industry, and an intervention should be based on the entire problem, whether it was contributed in the 19th, 20th, or 21st centuries.

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GRA's Groundwater Storage Symposium - Challenges and Solutions – Continued from Page 1

posium featured a thought-provoking field trip on local groundwater storage and management issues, led by **Ted Johnson**, Water Replenishment District of Southern California, and **Eric Reichard**, USGS, which is described at the end of this article.

Session 1: Perspectives on the Science and Policy for California Groundwater Storage

The first session, moderated by **Tim Parker**, Schlumberger Water Services and GRA Director, included three keynote presentations which provided an excellent overview and linkages between global climate change, state water resources, and policy for groundwater storage. **Dr. Bill Patzert**, an avid surfer and colorful scientist at California Institute of Technology NASA Jet Propulsion Laboratory in Pasadena, discussed the evidence that he has collected and reviewed indicating that California has heated up by almost two degrees Fahrenheit in the last 50 years. The newest and largest of the natural variability patterns to be gleaned from the available data is the Pacific Decadal Oscillation, or PDO. In contrast to El Nino and La Nina, which are patterns confined to the tropical Pacific Ocean, the PDO is basin-wide, from the Americas to Asia, from the Arctic to Antarctica. Decadal droughts and their impacts on terrestrial and ocean ecosystems are profoundly affected. Likely scenarios developed on the basis of decades of climate research include mega-droughts in the American West and excessive rainfall in other Pacific regions; either scenario is serious. What is clear from the climate research of the past few decades is that humans are tinkering with a delicately

balanced climate. We are wedded to our present civilization and infrastructure, and will not adapt easily to Super El Ninos or Ultra La Ninas. Groundwater storage will play a key role in our future water supply.

Kamyar Guivetchi, DWR Manager of Statewide Water Planning, gave an excellent overview of the California Water Plan Update 2005, including planning scenarios involving climate change and flood hazards, integrated regional water management strategies with diversified water portfolios, and integrating flood management benefits. Kamyar discussed the role of conjunctive management in water supply reliability, and detailed some successful examples in Sacramento, Kern, and Orange Counties, emphasizing the need for groundwater management, planning for long-term supplies, and integrating land-use planning with protection of recharge areas.

Tam Doduc, Chair, State Water Resources Control Board, discussed current state thinking on water quality and water rights concerns, and other issues related to groundwater storage. Technical challenges include the recharge water variability, recovered water beneficial uses, and adequate information on site subsurface conditions. Water quality issues include disinfection by-products, mobilization of salts and inorganics; water rights considerations include surface water diversion permitting, and groundwater space ownership and rights. Regulatory and policy issues include regulating based on recharge water type, type of project and point of compliance. Tam asked for feedback from

the GRA membership on a range of topics: whether there should be a statewide policy for groundwater storage, consistency in dealing with issues, and coordination with recycled water policy under development.

At the end of the session there was a brief discussion on the US EPA Underground Injection Control (UIC) Program, which was established under the Safe Drinking Water Act to protect underground sources of drinking water from unsafe injection practices. The UIC Program works with state and local governments to oversee underground injection of waste in order to prevent contamination of drinking water resources. Under the UIC, all ASR wells should provide inventory information to US EPA. Additional UIC program and contact information is available at <http://www.epa.gov/region09/water/groundwater/uic.html>.

Session 2: Groundwater Storage Policy - Legal Aspects, Rules and Regulations

This session was moderated by **Rob Saperstein**, Hatch & Parent, who provided an overview of some of the legal aspects, rules and regulations for groundwater storage in California. Considering California's continuing and growing state of overdraft and limited opportunities for additional future surface storage, underground storage is essential for water supply reliability. Property rights versus public interest and the right to storage space and ownership engenders a continuing legal debate over groundwater storage. Related yet-to-be-resolved issues include potential water quality impacts, water rights, export/area of origin, and third party impacts from high water levels.

Pamela Creedon and **Gerard Thibeault**, Executive Officers of the Central Valley and Santa Ana Regional Water Quality Control Boards (RWQCB), respectively, gave overviews of groundwater storage permitting approaches in their respective regions. In the Central Valley, RWQCB is currently mainly concerned with ASR projects which involve source and receiving waters of different qualities, especially in cases where MCLs may not be stringent enough. The ASR applicant is required

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to characterize groundwater and injection water quality, survey groundwater users, delineate the “bubble,” (zone of injected water around the well), demonstrate control over the bubble, meet water quality objectives at the edge of the bubble, monitor to verify compliance, and develop and implement a contingency plan if not meeting compliance conditions. The RWQCB then adopts a conditional waiver of waste discharge requirements (WDR) with a monitoring and reporting program.

In the Santa Ana area, RWQCB is currently concerned with the regulation of salt from water imported into basins, especially those closed basins with an existing very high adverse salt balance, and ASR projects. For salt management, the Santa Ana Watershed was divided into management zones, and volume-weighted zone analyses of TDS and nitrate concentrations were completed for the entire watershed, taking into account local hydrogeologic conditions. This approach was used to look at historical and current salinity values to determine if basin management objectives were being met. A similar approach is being considered for the regulation of recharge water from the State Water Project, Colorado River, and inter-basin transfers. State contractors have proposed doing this under a cooperative agreement with the RWQCB (versus a waste discharge requirement) where recharging agencies agree to model effects of groundwater basin water quality from all proposed recharge activities, and prevent or mitigate violations of objectives as appropriate. This proposal is currently under consideration by water agencies’ boards and counsel. For ASR projects in the Santa Ana Region, the regulatory approach is dictated by quality of recharge water, basin objective, and assimilative capacity. If recharge water quality is better than the basin objectives and ambient quality, then a waiver is very likely. If recharge water quality is better than the objectives but poorer than ambient quality, then the level of assurance of capture and extraction is important; if there is a high assurance of re-capture, then a waiver is likely; if not, WDR is likely. If recharge water quality is poorer than the basin objectives, then assurance of re-capture is critical, regulation is likely, and may include approaches using: assimilative capacity of the basin; cooperative agreement with anti-degradation analysis; or individual WDRs.

Paul Williams, District Engineer with the California Department of Health Services (recently renamed the California Department of Public Health), discussed DHS’ role in groundwater storage projects. DHS is involved with (recycled) groundwater recharge projects planned and operated for the purpose of recharging a groundwater basin as a source of domestic supply. Draft Groundwater Recharge Reuse regulations are available on the DPH website at <http://www.dhs.ca.gov/ps/ddwem/waterrecycling/PDFs/rechargeregulationsdraft-01-04-2007.pdf>.

Rob Saperstein also provided a brief overview on conjunctive use issues in the Central Basin, on behalf of Ed Casey. The ongoing conference theme was reiterated that the potential for groundwater storage is much greater, many times the existing surface water space of 42 million acre feet. However, groundwater storage

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presents some challenges, and key issues in the Central Basin include who has right to use storage space and who can manage use of storage space. Litigation ensued involving pumpers and several public agencies (Water Replenishment District of Southern California, Central and West Coast Basin Municipal Water District, Department of Water Resources/Court Watermaster, and the L.A. County Public Works), and in the 2003 court decision on the right to use storage space, the court found mutual prescription and equitable apportionment doctrines do not apply, and the court rejected the theory that storage rights attach to groundwater rights.

Session 3: Existing and Planned Groundwater Storage Projects in California and Abroad - Part 1

This session, moderated by **Greg Hamer**, Geomatrix Consultants, commenced with a presentation on groundwater management in the Yuba River Basin, by **Jeff Weaver**, MWH, Inc. Jeff described the Yuba River Basin, historical groundwater-surface water irrigation practices in the Yuba River Basin, historical groundwater substitution transfers from Yuba County Water Agency (YCWA), future groundwater operations, and proposed next steps. Historical groundwater level trends indicated overdraft in South Yuba Basin until the commencement of surface water deliveries following completion of Bullards Bar Dam in 1970; groundwater levels have subsequently risen to pre-1950 levels. Substitution transfers have been used to provide surface water deliveries of up to 80 thousand acre-feet (TAF) out of the YCWA on several occasions. The Proposed Lower Yuba River Accord (draft EIR/IS, released June 2007) includes a long-term transfer program between YCWA, CA DWR, and Reclamation, which would improve the water supply reliability to State (CVP and SWP) water contractors, and would include both stored-water and groundwater substitution transfers (up to 180 TAF in a single year of combined stored-water and groundwater substitution transfers, and up to 90 TAF of groundwater substitution transfers in a single year).

Erin Cole, Las Vegas Valley Water District (LVVWD), gave a comprehensive

presentation on operation and maintenance of ASR wells in the Las Vegas Valley. LVVWD has a total of 93 wells, with 32 pumping only wells, 35 dual-use, and 25 injection-only. The LVVWD recharge program consists of diverting water from Lake Mead, treating to drinking water standards, delivery to Las Vegas Valley via the same distribution system that serves LVVWD customers, and recharging groundwater directly through wells completed in the Las Vegas Springs alluvial aquifer. LVVWD has been successful in increasing the water levels in the valley by as much as 100 feet through the recharge program. A drawback of the recharge program is increased well clogging requiring more frequent maintenance (well development, well rehabilitation, chemical treatment), and more equipment and related higher maintenance costs, on which Erin provided detailed and very useful information.

David Ringle, MWH, Inc., described the conjunctive use program for Elsinore Groundwater Basin, a major source of water supply for Elsinore Valley Municipal Water District (EVMWD), Elsinore Water District, and other local groundwater producers. As the basin is in overdraft conditions, EVMWD adopted a groundwater management plan in 2005, along with an associated conjunctive use program to restore depressed groundwater water levels and increase water supply reliability during droughts. The conjunctive use program includes groundwater recharge through ASR wells; conversion of one well and construction of three new wells has been partially funded under Proposition 13 grants, with assistance from Metropolitan Water District (MWD). It is expected that 12,000 acre-feet of storage and 4,000 acre-feet per year of additional dry-year supply will be available to MWD. An additional four wells were converted for injection by EVMWD; the ASR program is in the initial operating and monitoring phase.

A new methodology for calculating the annual change in groundwater storage and level of accumulated overdraft, based on a three aquifer layer approach, was presented by **Tim Sovich**, Orange County Water District (OCWD). In the Orange County Groundwater Basin there are generally

three aquifers, with a pressure area and a forebay area; most of the groundwater storage change occurs in the forebay area of the shallow aquifer. GIS software is used to calculate the three-layer storage change by digitizing the existing hand-contoured water level maps, generating a grid from the contours, calculating the difference between two years, and using the OCWD Basin Model storage coefficient grids. The storage change is equal to the water-level change times the storage coefficient times the surface area. In addition to developing an improved methodology for calculating the annual storage change in the basin, an operational strategy was developed that sets guidelines for the basin's usable operating range and optimal level of accumulated overdraft for long-term basin management.

Session 4: Existing and Planned Groundwater Storage Projects in California and Abroad - Part 2

Eric Reichard, USGS, moderated session 4. **Owen Kubit** and **Shay Overton** (Provost and Pritchard Engineering Group) jointly described how they have used data from hollow stem auger drilling, cone penetration tests (CPT), and soil testing to assess potential artificial recharge sites within the Kings River Conservation District. They illustrated the important linkage between depositional environments and surficial deposits.

Ed Lin (Todd Engineers) described the analyses and targeted data collection used to identify priority locations for managed aquifer recharge in the Three Valleys area of San Bernardino County. A supply and demand assessment indicated that Ames Valley should be the focus area. Electrical resistivity and time-domain electromagnetic (TEM) surveys helped identify areas of coarse-grained deposits suitable for recharge and fault traces which could disrupt groundwater movement.

An overview of water resources management in the Salt River Valley in Arizona was next provided by **Mario Luria** (Salt River Project). He illustrated the complexity of the surface water/groundwater system, which includes six reservoirs, 330 miles of canals, and 250 wells. Large-scale aquifer storage was implemented in this area in 1994, with the Granite Reef Un-

derground Storage Project, and in 2006, the New River Agua Fria Underground Storage Project (NAUSP) began operation.

Rick Iger (Kern County Water Agency) described the Kern County Water Banking programs, with an emphasis on drought planning. Kern County has significantly expanded its programs since the 1987-92 drought. Important attributes of their recharge programs are the availability of recharge water from multiple sources, and the ability to pump recovered water into the California Aqueduct.

Thamer Mohammed (Universiti Putra, Malaysia) came the farthest distance to attend the meeting. He closed the first day of the meeting with an overview of groundwater conditions in Malaysia. As most domestic demand in Malaysia is met by groundwater, he presented a survey of well yields and water quality throughout the country.

Session 5: Aquifer Storage and Recovery for Groundwater Storage

Session 5 was moderated by **Ted Johnson**, GRA Board member and Chief Hydrogeologist at the Water Replenishment District of Southern California. The session was designed specifically for two pioneers of aquifer storage and recovery (ASR), including **David Pyne** of ASR Systems and **Tom Missimer** of Schlumberger Water Services. Each speaker was given 45 minutes so that they could go into more detail on their great experience and knowledge on this topic.

David Pyne's talk was titled "ASR and the Quest for Water Supply Sustainability." He emphasized that many areas of the world do not have water supplies that are sustainable, and therefore new technologies, such as ASR, should be developed

to meet their water needs. He provided a definition of ASR, which is essentially the injection and recovery of water from the same well – a definition which was debated later by other speakers (such as injection into one well and recovery from another well, or recharge through ponds, channels, etc.) This highlighted the need for developing a common definition agreed upon in the water supply community. David described case studies of some of the 72 operational ASR well fields in the United States, and described many of the economical, environmental, and water supply sustainability benefits of ASR. In addition, he described how fresh water can safely be stored in a brackish groundwater aquifer, and covered some of the water quality aspects of ASR that have been under discussion lately, such as arsenic mobilization.

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Tom Missimer followed with a talk titled “*Aquifer Storage and Recovery Design Concepts - Keys to Success*.” He emphasized that ASR projects must be properly investigated, planned, and have realistic expectations to be successful. A thorough study of the aquifer zones, including heterogeneity, hydraulic properties, and geochemistry, is crucial to understand how the water will be stored and recovered. As the geology controls the reservoir type and behavior, he compared and contrasted the differences in ASR expectations in various settings, including carbonate aquifer systems, siliciclastic systems, and fractured rock systems. The scale of the testing program also affects the accuracy of the projected ASR system efficiency. One of his main points was that “The key to developing a successful ASR project is the aquifer characterization and determination of the aquifer reservoir properties - insufficient aquifer hydraulic assessment leads to unsuccessful ASR projects.”

Time was allowed at the end of the session for a lively discussion and debate between the two speakers, a “point / counter point” which allowed the speakers to elaborate on some of the main points in their presentations and defend their stance if challenged by the other speaker. Unfortunately, time ran out; the session easily could have continued for another hour.

Session 6: Water Quality and Groundwater Storage

Peter Murphy, Kennedy-Jenks Consultants, moderated this session. The first project described MTBE-contaminated groundwater extraction, remediation, and treated effluent reinjection, and was presented by Paul Tornatore, Haley & Aldrich. As part of his approach, Paul assessed the intrinsic ability of the aquifer to degrade MTBE below the detection limit (<0.5 ug/L). This precedent-setting project, initiated in August 2005, involved re-injection of treated water approved by LARWQCB; active remediation is projected to be completed in 2 years. More than 20.7 million gallons (98% of which was treated water) has been re-injected into groundwater at this location since the project was initiated in August 2005, with no indication of aquifer mounding.

Mosen Mehran, Ph.D., Rubicon Engineering Company, provided a presentation on their approach to modeling contaminant sources prior to the final site selection of a groundwater recharge basin in the La Jolla area of Orange County. The project involves a proposed recharge basin of just under 6 acres with potential recharge of 9,000 acre-feet per year. The recharge basin is adjacent to a PCE soil and groundwater contaminant source site

with a plume of about 1.8 mile in length and average groundwater concentration of approximately 90 ug/L PCE; the site is currently undergoing pump-and-treat remediation. Results of the study suggested that the shallow-zone PCE concentrations decrease more rapidly under recharge scenarios; the shallow-zone plume deflected to the southeast, and there was no predicted impact on the principal aquifer of interest.

Tracy Nishikawa, USGS, presented results from data collection and modeling in the Warren subbasin about 100 miles east of Los Angeles. Intensive data collection, using heat dissipation probes, tensiometers, and lysimeters, enabled detailed characterization of the unsaturated zone, including the distribution of nitrates from septic sources. Installing artificial recharge sites in some locations could cause groundwater levels to rise and intercept the nitrates in the unsaturated zone.

Rebecca Overacre, Carollo Engineers, presented an overview on a multi-team, multi-site study assessing changes in water quality during ASR with reclaimed water. The team partners included ASR Systems, Southern Nevada Water Authority, CSIRO – Australia, University of South Florida, PBS&J, and several others, and included sites in Arizona, Florida, and Australia. Findings of the study indicated TOC, nutrients, DO, THMs and HAA all usually declined with time; biochemical activity near the wellhead showed the potential for ASR as further treatment of water quality issues; and aquifer characterization is critical.

Lunch Speakers

Paul S. Bauer, Hatch & Parent, GRA Legislative Advocate, provided an update on GRA and CGC Legislative efforts, which is presented in the Legislative Update section of this *HydroVisions* (page 5). In addition, Tim Brick, Chairman of the Board, Metropolitan Water District (MWD) of Southern California, talked about the role of storage and conjunctive use in the MWD service area, and provided a short report on what MWD is doing to address the recent shutdown of the State Water Project pumps. Future actions include preparation of the Delta Action Plan; the DAP team has been assembled, and timing of solutions looking

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ahead to next year is being prepared. The MWD Board of Directors has become fully engaged in the Delta issues, and there is no question that California is in the process of significant changes in planning for and managing water supplies. Regarding the surface storage debate and SB 59 likely outcomes, this could engender a legislative bond, but an initiative seems more likely. Environmental groups are united in opposition and have indicated their intent to oppose any measure advocating surface storage. Many concerned groups want to explore groundwater storage potential first, which is one of the reasons that the California Groundwater Coalition was formed; MWD was the proud sponsor of GRA's Legislative Symposium and Lobby Day last March. In the service area, MWD has had a long history of exploring groundwater storage and conjunctive use as part of the resources plan. MWD has invested in Semitropic and other programs outside their service area, and today, MWD has many long term storage programs in place with plans to expand and add more, and has recently completed a study of groundwater capabilities in the MWD service area. In closing, Chairman Brick thanked the Groundwater Resources Association for inviting him to present Metropolitan's program for groundwater. He also thanked the California Groundwater Coalition for its efforts to ensure that groundwater will have a seat at the table in Sacramento, and he indicated Metropolitan looks forward to continuing their proud partnership in working with these organizations.

Session 7: Tools for Planning

Chris Petersen, MWH, Inc, moderated Session 7, which started off with a presentation by Nick Gatti, Water Resources Planner, Kern County Water Agency, on how KCWA does groundwater accounting with their groundwater banking project, and the inherent difficulties. Some of the challenges include interrelated banking programs, many participants with different circumstances and drivers, and competition among participants. The accounting fundamentals include tracking daily transactions, reconciling the books, and invoicing. The three key tools used in the accounting are MS Excel workbooks,

MS Excel macros, and basic communications (phone/fax/email). The tracking of transactions includes fields for district, water type, amount, transaction type, project, schedule, data repository, and a summary of scheduled operations.

Victor Harris presented and described an innovative tool being applied by MWH, most currently for the Los Angeles Department of Water and Power in the Owens Valley. The tool is being applied by the project team to develop resource-based management strategies that integrate traditional groundwater and surface water techniques with emerging ecological dynamics techniques. Victor explained that the team is using an eco-modeling tool to evaluate the role of ecological successional dynamics, grazing, precipitation, nutrients, fire, and numerous other stressors to differentiate and quantify their potential impacts on the groundwater basin. The tool is being linked to Modflow to fully simulate the impacts on groundwater resulting from ecological dynamics at the surface.

Using high resolution electrical methods (surface geophysics) to evaluate the feasibility of artificial recharge sites was the subject of the presentation by John

Jansen, Senior Scientist, Aquifer Science & Technology. Case studies were part of extensive hydrogeologic investigations being conducted by Mojave Water Agency (MWA) to assess feasibility of groundwater storage, and included the Oro Grande Wash near Victorville and the Ames, Means and Johnson Valleys near Yucca Valley. Field methods were high-resolution electrical resistivity surveys and time domain electromagnetic induction (TEM) surveys, which, combined, provided a cost effective method to cover a lot of ground while mapping geology, wetting front, general grain-size distribution, and faults.

A proprietary, comprehensive, 3-dimensional hydrogeologic conceptual model and groundwater flow model for the upper Mojave River basin was discussed by Lance Eckhart, Senior Hydrogeologist with MWA. The flow model will be used to simulate a variety of potential scenarios for the Upper Mojave River Well Field and Water Supply Project (also known as R³) to assist in the final project design and to answer a broad spectrum of questions related to design, operations, maintenance and possible environmental issues. Key datasets incorporated into the model include cumulative hydrostratigraphic map-

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GRA's Groundwater Storage Symposium - Challenges and Solutions – Continued from Page 15

ping, legacy geophysical logs, b-hum study (driller's descriptions in numeric format), advanced geophysical logging (petroleum-type log), surface geology/digital elevation models, current/historic gravity geophysical surveys, evapotranspiration estimates, current/historic Mojave River infiltration tests, and multi-level monitoring well data. The project has taught that one should model systems, not projects, where possible; that vast amounts of data already exist; and that one should attempt to collect any and all available data and honor it by putting it to good use.

Kurt O. Thomsen, KOT Environmental Consulting, provided an overview of a mapping method the author has developed, based on the information contained in readily available well records, which consists of converting subjective stratigraphic descriptions listed in the well records to objective numerical values that facilitate computer automated analysis. The approach uses average hydraulic conductivity values for basic materials. The author

has also developed mapping protocols and techniques enabling construction of stratigraphic models that describe aquifer systems in great detail.

Session 8: IRWMPs and Groundwater Management

Moderating Session 8 was **Jim Strandberg**, Malcolm Pirnie and GRA Vice President, and led off with **Norm Shopay**, California Department of Water Resources, who provided an overview of DWR's conjunctive water management program, and how groundwater storage fits into integrated regional water management plans (IRWMP). Norm's presentation covered Integrated Regional Water Management Plans, Conjunctive Water Management, the State's role in groundwater management (data programs, partnerships, responsibility for managing grant funds), and included some recent example projects. An interesting fact included in Norm's presentation was that there were 173 IRWMP projects submitted in round one of Prop 50; of the \$380 million requested, \$129 million was for groundwater projects.

The San Francisco Bay Area IRWMP (Plan), with a mission of "working together to enhance sustainable water resources management to support a high quality of life in the Bay Area," was the subject of a presentation by **Rosalyn Stewart**, Jones & Stokes. Groundwater issues in the Bay Area include: overdraft and saltwater intrusion, high levels of total dissolved solids, and non-point-source pollution. The Plan, which was completed in November 2006 with the help of two planning grants totaling \$838,000, contains 116 projects and regional priorities, including groundwater demineralization, groundwater recharge, and groundwater storage and recovery projects, was recently awarded a \$12.5 million implementation grant under Prop 50. The Plan is a good example of how IRWMPs provide a venue for increasing groundwater storage through coordinated, collaborative regional integration of planning and implementation.

Hector Bordas, Los Angeles County Department of Public Works, discussed the Greater Los Angeles IRWMP (Plan). Complex water and environmental issues in the Plan area include groundwater pumping in excess of natural recharge, importation of the majority of drinking water supplies, contaminated urban and stormwater discharges, and significant loss of coastal wetlands. The Plan was adopted in December 2006 under a \$1.5 million planning grant and nearly \$1 million in local funding, and has received a \$25 million Prop 50 implementation grant. The Plan contains over 1,500 projects in a database, includes a prioritization framework under development, and membership, governance, and leadership roles and responsibilities are under consideration.

Jim Blankey, WRIME, finished up the session and symposium by giving an overview of the development of the Upper Kings River IRWMP, an approach to collaboration toward regional sustainability, and a presentation including the history, issues and solutions. The area of the IRWMP includes very productive farmland, growing cities (Fresno, Clovis), largely allocated surface water supplies, stressed groundwater supplies, and an increasing population. Priority problems and issues

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identified to address in the IRWMP are overdraft, water supply reliability, degradation of water quality, urban development, protection of water rights, sustainability of agricultural economy, flooding threats to life and property, protection of the environment, and environmental justice. Solutions to the problems and issues are regional management based; addressing water, land use, and environmental resource issues as interrelated and of regional scope; engaging a local Water Forum; developing an Integrated Regional Water Management Plan; using an integrated groundwater-surface water model and GIS for analysis; and finally, implementing the plan and future projects under a Joint Powers Authority.

Several recurring themes were present in the symposium sessions:

- 💧 Groundwater is a key piece of the state's water puzzle;
- 💧 Conjunctive use is an effective water management tool;
- 💧 Groundwater basins can provide storage and increased water supply;
- 💧 Cleanup and monitoring is needed to ensure high quality groundwater resources;
- 💧 Climate change threatens water supply reliability; and,
- 💧 More funding is needed to continue to improve our groundwater storage capabilities and improve water supply reliability in the state.

Time will tell as to how effective we are at getting additional groundwater storage projects in place. One certainty is that groundwater professionals will be busy well into the distant future.

GRA would like to thank the sponsors of the event, including Schlumberger Water Services, Layne Christiansen Company, MWH, Earth Tech, Hopkins Groundwater Consultants, Inc., and TestAmerica Analytical Testing Corp. A binder with copies of the speakers' slides was produced for the symposium. For a copy of the binder and information about other GRA programs, visit the GRA website at www.grac.org or call the main GRA office in Sacramento, California at (916) 446-3626.

Groundwater Storage Field Trip

Following the two day conference, an optional third day field trip was offered, titled "Managed Aquifer Recharge – LA Style." The field trip focused on groundwater recharge, storage, and recovery in the Central and West Coast basins of coastal Los Angeles County. It emphasized the topics covered in the earlier conference, and provided the 31 attendees exposure to real world, operating facilities to put water into the ground and take it out.

The trip started with GRA Board members **Ted Johnson** and **Eric Reichard** providing an overview of the hydrogeology of the Central and West Coast basins, including the challenges of overdraft, seawater intrusion, managed aquifer recharge, recycled water use, and loss of imported supply, along with solutions derived by the basins' managers and computer tools developed by the USGS for performing basin optimization runs.

The tour continued to the San Jose Creek Water Reclamation Plant in Whittier, where **Earle Hartling** of the Los Angeles County Sanitation Districts guided the group through the process of turning primary sewage effluent into highly treated, tertiary effluent that can be used for groundwater recharge at the nearby spreading grounds as well as other "purple pipe" projects, such as landscape and golf course irrigation.

Sterling Klippel of the Los Angeles County Department of Public Works then gave the group a tour of the County's spreading grounds in Pico Rivera, which cover over 1,000 acres that have been preserved since the 1930s for groundwater recharge. In addition to the approximately 50,000 acre feet per year (afy) of locally-derived storm water that the County captures and recharges at the spreading grounds each year, they also receive ap-



Rubber dam owned by Water Replenishment District of Southern California. Inflated (top) and deflated (bottom).

proximately 50,000 afy of recycled water and 25,000 afy of imported water that is purchased by the Water Replenishment District of Southern California (WRD) to help make up the basin overdraft. Mr. Klippel gave an impressive live demonstration to the group by deflating one of the County's rubber dams that are used in the river channel to halt water flow and induce recharge.

Following lunch, the tour continued to WRD's Leo J. Vander Lans Water Treatment Facility in Long Beach, which provides advanced treatment of tertiary recycled water and turns it into highly purified water that is used for direct injection into the Alamitos Seawater Barrier along the coast. **Dr. Paul Fu** of WRD guided the group through the treatment process, which includes microfiltration, reverse osmosis, and ultra violet light. About 3,000 afy is produced by the plant for injection into the barrier wells, which halts seawater from intruding into the coastal aquifers.

Continued on page 18

GRA's Groundwater Storage Symposium - Challenges and Solutions –

Continued from Page 17



Dr. Paul Fu, Water Replenishment District, guides field trip attendees through treatment process.

The use of the recycled water offsets the need for potable water that has historically been used at the barrier.

The trip then continued to the City of Long Beach's Groundwater Treatment Plant, where **Liza Gutierrez** gave the group an overview and tour of the City's water supply system, which relies on 28 active wells and additional imported water from Metropolitan Water District to serve a half million people. Much of the groundwater produced by the aquifers under the City is of high quality, but has a brownish color due to deep organics. The color is removed at the plant through a flocculation process which produces crystal clear water. The City has also pioneered a patented desalination process using a double pass nanofiltration system instead of traditional reverse osmosis to remove the salt from ocean water and make it potable at a much lower cost. The trip concluded with a stop at the City's new ASR well to help manage aquifer recharge and provide a reliable supply when imported sources are reduced during times of drought.

The field trip ended at an optional rest stop at a local watering hole, to stay in con-

junction with the theme of the conference. GRA extends a very special thanks to all of the speakers and also to the Water Replenishment District of Southern California for sponsoring the field trip and lunch.

Timothy K. Parker, Principal Hydrogeologist of Schlumberger Water Services, is based in Sacramento, California. Past President of GRA, he currently serves on the GRA Board and is Chair of the Legislative Committee; he is the GRA Liaison to the California Groundwater Coalition, serves on the Board of the Association of Groundwater Scientists and Engineers (AGWSE) Division of the National Ground Water Association, and also serves on the Board of the American Ground Water Trust. He may be reached at tparker2@slb.com.

Ted Johnson (tjohnson@wrd.org) is with the Water Replenishment District of Southern California.

Eric Reichard (egreich@usgs.gov) is with the USGS.

Chris Peterson (Chris.E.Petersen@us.mwhglobal.com) is with MWH. 💧

2007 California Section CCGO/AIPG California State Science Fair Awards

— Continued from Page 6

the residual pollutant was then measured. What Ms. Sinha discovered was that sand, the most porous soil, had retained the largest amount of pollutants; the less porous materials retained smaller amounts of pollutants. Ms Sinha's experiments also indicated that there was an inverse relationship between viscosity and retention of pollutants.

The California Section of AIPG supports these awards, which consist of \$250 for each winner. Both Dave Sadoff and Paul Enriquez are geologists who work at AIG Consultants and they donated their day to judge the Science Fair exhibits. Encouraging the youngest generation in earth science has been an important goal of this awards program.

James A. Jacobs is the Chief Scientist of Environmental Bio-Systems and Director of Client Services. He may be reached at 415-381-5195 or by email at augerpro@sbcglobal.net. 💧

GRA's 2006 Annual Financial Statement is Now Online.

To review the statement,
please go to the GRA Web site
at www.grac.org/financials.

President's Message — Continued from Page 2

A few years ago, the Santa Clara Valley Water District employed a portion of the proceeds from a judgment against a polluter to convene a technical stakeholder meeting focused upon the best approaches to monitoring for fuel oxygenates in groundwater. The meeting was facilitated by the National Water Research Institute in Costa Mesa, which expertly and relentlessly guided about 25 representatives from industry, regulatory agencies, academia, water utilities, and others through the NGT process. It was an exhausting but exhilarating three-day effort - we brainstormed until our brains wouldn't storm anymore! Each idea surrounding the central question was clearly heard and considered by all present, and methodically ranked by the participants. Every contribution was recorded on flip charts and quickly transcribed into packets to facilitate break-out discussions and focus groups. At the end of the process, a number of good solutions rose to the surface, and all ideas were archived in the final document. No method is perfect and there were frustrations; however, all learned a great deal about others' positions. The focused problem-solving approach used in NGT forces each stakeholder to more carefully consider the merits of opposing positions, and creates openings for potential resolution.

The optimal solutions to groundwater management challenges may at times be limited by lack of data or understanding of how hydrologic systems work. The Department of Water Resources has been the state's data backbone, providing reliable and consistent monitoring and basin assessments for decades. The complexity of the menu of problems to be solved (see the Annual Meeting agenda!) requires sophisticated interpretation of data from DWR and others to forecast outcomes and impacts to collective stakeholders and beneficial uses such as agriculture, ecosystem protection, recreation, municipal supply, industry, and others. Efforts by independent academics can rise above some of the political noise to consider long term implications of trends in water use, legal decisions, and climate change. The UC Davis Center for Watershed Science provides one such effort to see the forest for the trees. The Center's *Modeling and Analysis*

of California's Hydrologic Resources and Operations (MACHRO) focuses on providing and applying models and data to develop insights for water policy and management, working cooperatively with the agencies, NGOs, and others to develop solutions to water and environmental problems in California.

The list of groundwater management challenges to which these types of solutions can be applied is seemingly without end. Should we regulate stormwater quality for potential impacts to groundwater quality? As municipalities and developers engineer greater controls for stormwater management, who retains the water rights? As we inevitably move toward indirect potable reuse, how much advanced treatment of recycled water is enough? Can we accomplish the social engineering required to achieve public acceptance of recycled water? Should state funds be used to underwrite coastal desalination plants with high energy costs when nearby brackish groundwater is not being developed? Will the increasing salinity in some groundwater basins lead this civilization down the path of those preceding us who met their demise due to salt? Will we ever overcome the disparity of perceived risks from contaminants regulated at different levels in different states? The high cost of

redundancy of effort - 50 states solving the same problem with 50 sets of dedicated staff - should at some point be managed and controlled for the greater good. The inefficiencies inherent to our planning and permitting processes also impose high costs to those who seek to implement solutions. Perhaps the most difficult challenge is integrating groundwater awareness into land-use planning. Today projects are being challenged based on the carbon emissions they will cause. Consideration should also be given to the carbon emissions associated with a project's increased demand for imported water, paving of natural groundwater recharge areas, and effects on the timing and volume of runoff.

Managing human complexity has become an essential element in the groundwater problem-solving toolbox. As we hear the problems of climate change, saline intrusion, and other challenges profiled at the UC Biennial/GRA Annual meeting, let's listen for answers to how we will resolve conflicts in the manner most likely to yield a collaborative, stakeholder based solution.

Thomas Mohr is GRA's President and a hydrogeologist with the Santa Clara Valley Water District. Your comments are welcome: tmohr@valleywater.org; 408-265-2607x2051. 💧



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Wells and Words—Continued from Page 4

Table 2 allows for a simple visual understanding of the data leading to simple and important conclusions. For example, in Table 2, 15 trace ions were analyzed for four solutions (60 individual analyses). Only 13 (22%) were actually detected and are distributed between Al, As, Ba, Cr, Cu, Pb, Se and Zn, while the other 47 analytes were below the IDL. W-3 and W-4 exhibit the most trace ions detected (6 and 4, respectively), whereas W-1 and W-2 have the fewest trace ions. Also, W-3 and W-4 have the highest turbidity, implying that turbidity may falsely enhance the concentration of trace ions. Patterns like this can be easily identified with a modified table such as Table 2.

Increased turbidity usually results in increases in the number of detected trace ions and their concentrations but does not appear to impact major ions; but be wary of all samples having elevated turbidity concentrations. It is not surprising that samples analyzed with elevated turbidity often show elevated Al since most geologic materials, and thus colloids, are composed of aluminosilicates.

In summary, collection of the data and presentation of the data are two important aspects of meaningful interpretations of groundwater quality analyses. The best way to prevent ambiguous laboratory results is to avoid turbidity and collect clear and turbid-free groundwater samples (< 0.1 NTU) from properly designed and fully developed wells. Every groundwater analysis must include turbidity measurements to correctly evaluate detected trace ion concentrations. 💧

TABLE 2 – Continued

		IDL	W-1	W-2	W-3	W-4
TRACE IONS mg/L						
aluminum	Al	<0.05	*	*	0.670	0.614
antimony	Sb	<0.006	*	*	*	*
arsenic	As	<0.002	0.003	*	0.004	0.011
barium	Ba	<0.1	*	0.100	0.041	0.339
beryllium	Be	<0.001	*	*	*	*
cadmium	Cd	<0.001	*	*	*	*
chromium	Cr	<0.01	*	*	0.012	*
copper	Cu	<0.05	*	*	0.007	*
lead	Pb	<0.0002	*	*	0.001	*
mercury	Hg	<0.001	*	*	*	*
nickel	Ni	<0.01	*	*	*	*
selenium	Se	<0.005	0.005	*	*	*
silver	Ag	<0.01	*	*	*	*
thallium	Tl	<0.001	*	*	*	*
zinc	Zn	<0.05	*	*	*	0.082

IDL - Instrument detection limit.

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Global Warming and Water Utilities

BY STEVEN HOCH AND CHRISTOPHER FOSTER
HATCH & PARENT- LOS ANGELES

Whether or not you believe that global warming is real or is affected by human activity, it is an issue that must be confronted by water utilities. The confrontation will have several fronts, including politics and customer relations, water supply and quality, and capital and cost. There are no magic solutions that take care of all these issues, and therefore a water utility would be wise to address all of them in some coordinated fashion, based on the utility's size, location, source, and financial ability. When you break down each impact, they are indeed circular, and depending on the severity of global warming it will test our society's ability to cope. Because of the importance of water, water utilities will be among the first of the societal changes that may have to be confronted.

Politics and customer relations

There is a growing populist movement concerning global warming, and there are expectations that all public and private industries will respond in some manner to the issue. Obviously, any such action will impact supply and quality, capital and cost. In California, AB 32 (Nunes, D-LA), which requires that the state's global warming emissions be reduced to 1990 levels by 2020, is the epitome of the political statement on global warming at this time. Over the next decade water utilities, like any other business, will be affected. While the California Air Resources Board (CARB) regulations are not yet out, an educated guess of what may impact water utilities includes carbon reduction from fleet operations, an increase in pumping efficiency to lessen electrical usage, and restrictions on emissions from air strippers and other related devices.

By January 1, 2008 CARB must adopt regulations defining the sources of greenhouse gas emissions which will be subject to the initial phase of mandatory reporting. In addition to power plants, utilities, oil refineries and cement plants, the initial

reporting facilities will likely include co-generation plants producing at least 1 MW per year and stationary facilities emitting at least 25 metric tons of CO₂ per year. Facilities not falling within these definitions are still strongly recommended to quantify their CO₂ emissions in order to document and verify required reductions. By January 1, 2008 CARB must determine the level of greenhouse gas emissions from 1990 that must be achieved by 2020.

Water supply and quality

If the warming of our planet occurs, as most predict, it's axiomatic that there will be changes in weather patterns. These changes are said to cause more rain and less snow, and lead to an increase in early snow melts. Reservoirs will be filled to capacity earlier than normal, and earlier snow melting may change the traditional timing of water available from snow runoff. Also, this change in pattern will change seasonal loads carried in streams, and with it a change in quality. The impact on the Delta has been well discussed. Groundwater will be impacted by a different recharge pattern, and with fluctuations in groundwater levels contaminant concentrations may

well be impacted. Agricultural practices will change dramatically and, as far as water is concerned, may have to adapt to price and/or seasonal availability patterns. In turn, such changes will affect runoff and what is carried with it.

Capital and cost

Simply put, adaptation to the changes described herein will cost a great deal of money. New capital investments must be made and the cost of mere supply will increase. In turn, rates will likely increase, which may be a stabilizing influence on water usage, though customers will likely object to paying more for a formerly plentiful and relatively cheap necessity. This, of course, brings us back where we started: politics and customer relations.

Water utilities should lead the way in forming plans to ensure that this chain does not snap. The GRA membership is capable of being in the vanguard of this major issue confronting us all.

Steven Hoch and Christopher Foster are attorneys with Hatch & Parent- Los Angeles. Steven may be reached at SHoch@HatchParent.com. ♪

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Call for Nominations for Director Seats Open in 2008

The Association is now soliciting nominations for GRA Board of Director candidates to run for five (5) seats that commence service January 1, 2008. The Nominating Committee has established the following criteria for nominating and selecting candidates for the final ballot that will be presented to the GRA membership for voting.

Minimum Qualifications for Director Nominees

- ▲ Active Regular Member of GRA at the time of nomination.
- ▲ Recognized leader in a groundwater-related field, which may include regulation, evaluation, development, remediation or investigation of groundwater, groundwater supplies or related technology; science education; and groundwater law or planning.
- ▲ Significant contributor to the field of groundwater resources in California.
- ▲ Prior contributions and leadership role in a GRA Branch, GRA committees or GRA program activities, or like experience with a similar organization.

Nominating Guidelines and Procedures

1. Directors and members of GRA may nominate themselves or another member as prospective candidates to run for the Board as described below.
2. Nominations must be submitted in writing to GRA and accompanied by:
 - A statement from the nominee addressing the following questions:
Why are you interested in serving on the GRA Board of Directors?
What qualifications and experience do you have for serving as a Board member?
What specific skills or expertise do you bring to GRA and the GRA Board (e.g., leadership skills, fund-raising, financial management, etc.)?
What experience do you have serving on similar boards of directors?
What level of time commitment can you make to GRA?
 - Current curriculum vitae.
 - A letter of recommendation from a current Director or Regular Member.
3. The Nominating Committee will review all nominations and evaluate the nominees based upon their response to the above questions and their qualifications. The Committee will conduct interviews, if deemed necessary.
4. The Nominating Committee shall recommend a slate of nominees for presentation to the GRA Board of Directors for approval. The recommended slate of nominees shall correspond to the number of available Director openings each year.
5. The approved slate of nominees shall be presented to the GRA membership in ballot form in accordance with the GRA bylaws.

To declare your desire to be nominated or to nominate someone other than yourself, please follow the guidelines in section number two above and forward the material to Kathy Snelson, GRA Executive Director, via email (executive_director@grac.org), fax (916-442-0382) or mail (915 L Street, Suite 1000, Sacramento, CA 95814) no later than October 8, 2007.

Should you have any questions or need additional information about the GRA Director Call for Nominations, please contact Kathy Snelson at (916) 446-3626. ▲

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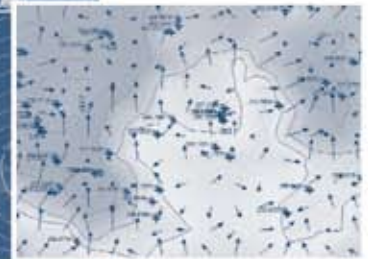
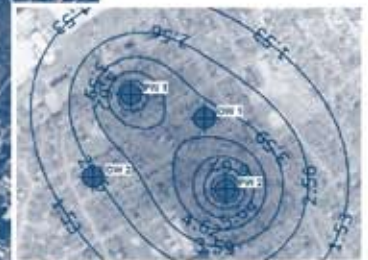
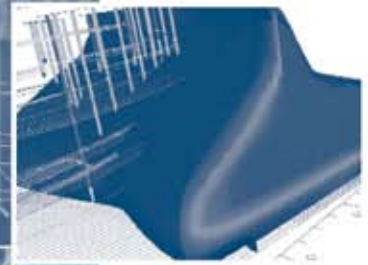
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Sacramento Branch Highlights

BY STEVE LOFHOLM,
BRANCH SECRETARY

The April meeting featured **David Dauwalder**, P.E. an Engineering Manager at Nolte Associates, Inc. in Sacramento, and the Northern California Vice President, and Past President, of the California Onsite Wastewater Association (COWA). Mr. Dauwalder gave a presentation titled “*On-Site Wastewater Rule Update (AB885) and the Protection of Groundwater.*” Assembly Bill 885 (AB885) requires that the State Water Resources Control Board (SWRCB) develop statewide regulations for onsite wastewater systems (OWS). California is one of only two States that do not have statewide regulations for OWS; the difficulty in writing statewide regulations is due to the diverse hydrogeologic and geopolitical conditions

throughout the State. Each of the 58 counties has the permitting authority to regulate OWS; the Regional Water Quality Control Boards retain the responsibility to protect the groundwater and surface waters of the state. Many counties have very successful OWS ordinances and policies, but without statewide OWS regulations there is no consistency, particularly for advanced or performance based designs. Groundwater protection and monitoring is a major element of AB885. Upstream and downstream monitoring wells for subsurface wastewater dispersal areas are expected to be required. Regulations for engineered ‘performance based’ systems for sites which do not meet the conditions for a ‘standard’ onsite system are anticipated, with RWQCB providing review and permitting support for the counties.

At the May meeting, **Jason Phillips**, an Interim Program Manager for the Bureau of Reclamation, provided an update on the San Joaquin River Restoration Settlement. The Bureau of Reclamation is responsible

for overseeing the implementation of the San Joaquin River Restoration Program. Following an 18-year lawsuit, a “Stipulation of Settlement” was reached in September 2006 by the U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council (NRDC), and the Friant Water Users Authority (FWUA). The Settlement received Federal court approval in October 2006 and federal legislation was re-introduced on January 4, 2007, by California members of Congress to authorize Federal agencies to implement the Settlement. The San Joaquin River Restoration Settlement is based on two goals, to restore and maintain fish populations, and to reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

To implement the Settlement, an ambitious restoration program has been developed for the 150-mile segment of California’s second-largest river. The San Joaquin



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River Restoration Program encompasses many groups and widespread implementation efforts and includes representatives from three federal agencies: the Bureau of Reclamation, the Fish and Wildlife Service, and National Marine Fisheries Service. The federal agencies partner with two of California's State agencies, the Department of Water Resources and Department of Fish and Game, who are providing expertise on river management and fish biology to assist in revitalizing the river and its fish populations.

The June Branch meeting featured a presentation by J.C. Isham entitled, "*Cleaning Up the Mother Lode, the Reclamation of the Jamestown Mine.*" Mr. Isham is a Geology Manager at Shaw Environmental, and a member of the California State Mining and Geology Board (SMGB). The Jamestown Mine has operated discontinuously since the late 1840s near the city of Jamestown, California. The original underground lode gold mine was converted to an open pit mining operation that operated about 1987-1994. The principal features of the mine include three mine pits, a tailings management facility (TMF), rock storage, and several retention ponds. The Jamestown Mine Reclamation Project was awarded as a guaranteed fixed-price contract to Shaw Environmental Liability Solutions, L.L.C. (SELS) in July 2006 by the Jamestown Trust. The work currently being conducted at the mine includes dewatering of the TMF and transferring the water to the Harvard Pit, closure and capping of the TMF in compliance with California State requirements, evaluating and characterizing the rock storage area, conducting a site investigation to determine the extent of impacts to groundwater, and evaluating applicable water treatment technologies. 💧

San Francisco Branch Highlights

BILL MOTZER, PRESIDENT

April 2007 Meeting

Brian Lewis, Chief of Geological Services Unit, Department of Toxic Substances Control (DTSC) presented the *2nd Annual DTSC Regulatory Update* to 49 members, nonmembers, and students. At DTSC, Mr. Lewis is responsible for providing geological support for permitting, closing, and remediating hazardous waste sites. For this annual update, he addressed some of the emerging issues that are both DTSC and RWQCB priorities.

Mr. Lewis reviewed DTSC's current Brownfields program. He described DTSC's revision of its draft guidance document on indoor air intrusion and the issuance of a revised document by the end of 2007. Guidance document updates include using California Health Screening Levels (CHSLs) for plume characterization, eliminating the 100-foot buffer in favor of using site-specific data, new recommendations for soil vapor sampling, and in some cases using soil matrix and/or groundwater data instead of soil vapor. DTSC is evaluating requirements for using active or passive vapor barriers for sites with indoor air quality risks because the use of membrane vapor barriers will no longer be permitted. DTSC is also re-evaluating alternative requirements for co-mingled plumes to bring them more in line with U.S. EPA regulations. DTSC continues improving its EnviroStor database, used in locating DTSC-regulated contaminated sites. EnviroStor is currently available online at: www.envirostor.dtsc.ca.gov. In 6 to 12 months, DTSC plans to complete a more comprehensive database. Finally, the agency is assessing emerging

technologies, including nanotechnology, green chemistry (to minimize generated waste), and pharmaceutical wastes. Slides from such DTSC-hosted conferences are available at the home web page at: www.dtsc.ca.gov.

June 2007 Meeting

Thirty-three members and nonmembers and one student attended the June 28th meeting. Our speaker, Dr. John Karachewski, Senior Project Hydrogeologist at Weiss Associates, presented: *California Geoscapes*. John is an accomplished professional geologist, photographer, and guidebook author (with Doris Sloan: *Geology of the San Francisco Bay Region*, 2006, www.ucpress.edu). In approximately 70 unique and very colorful slides, he gave us an excellent overview of California geology and hydrogeology. The tour began in southern California at Mugu Lagoon and the Oxnard Plain, where groundwater extraction has caused considerable sea water intrusion. In addition to numerous slides of our colorful natural treasures, we viewed the Malakoff Diggins State Historical Park (alluvial gold deposits), the California Aqueduct, and my favorite, the waterfalls at McArthur-Burney Falls State Park, which discharges over one million gallons of water per day. John explained that the secret of taking good geoscape photography is in the lighting; early morning and evening have the best light. He ended the program with a beautiful photograph of Lassen Peak in Lassen Volcanic N.P. John's photography can be viewed at: <http://www.geoscapeshotography.com>.

The San Francisco Branch will not have meetings in August and September so that our members may enjoy their summer vacations. 💧

Southern California Branch Highlights

BY PAUL PARMENTIER,
BRANCH SECRETARY

May 15th, 2007

Roy Herndon, Hydrogeologist with the Orange County Water District (OCWD), presented a talk to our branch members on “*Geochemical Imaging of Flow Near an Artificial Recharge Facility*,” an in-depth study of groundwater migration patterns in the vicinity of the main recharge basins used by OCWD. These basins, located north of Highway 91, are former gravel quarries used by OCWD to recharge local underlying aquifers. To determine the groundwater migration rates and directions of lateral and vertical flow, the OCWD conducted a series of groundwater age-dating and geochemical tracer studies. By using Tritium and Helium concentrations, OCWD demonstrated the spread of groundwater laterally as much as 5 miles and vertically to about 300 feet below the basins within a 25-year period. OCWD determined that oxygen isotope data could be used as an existing tracer. To design induced tracer tests, OCWD evaluated various chemicals as potential tracers by focusing on specific tracer criteria including: no toxicity, low or no ambient background concentrations, low-level analytical detection capabilities, and demonstrated migration rates similar to groundwater. With technical support provided by Lawrence Livermore Laboratories and UC Santa Barbara, OCWD selected Xenon isotopes to evaluate infiltration from the recharge basins, and sulfur hexafluoride (SF₆) to estimate re-

charge under the Santa Ana River bed. The studies demonstrated the effectiveness of the recharge operations, showed the rapid migration rate of groundwater, and also pinpointed localized lithologic distinctions that are useful in the management and operation of the recharge facilities.

June 19th, 2007

“*Application of Sequence Stratigraphy to Refining Aquifer Architecture in the Los Angeles Basin*” by Dan Ponti, U.S. Geological Survey

Dr. Daniel Ponti of the USGS presented a talk to the Southern California Branch members as a pre-conference presentation prior to the state-wide 3rd Symposium in GRA’s *Water Resources Series: Increasing Groundwater Storage to Meet California’s Future Demand Challenges and Solutions*, held in Long Beach (Ed: see article on page 1 for a detailed description of the talks).

Dr. Ponti described the detailed sequence stratigraphy studies being done in the Long Beach area of Los Angeles, in cooperation with the Water Replenishment District. The sequence stratigraphy evaluation of data from boreholes drilled and geophysical surveys done in this area focus on chronologically related units, rather than lithologic correlation. This analysis requires an understanding of area-wide geography at the time of deposition, and also allows for the re-construction of the subsurface, including faults, folds, unconformities, etc. Supported by impressive graphics, the talk presented the investigation methods and the methods used to interpret the findings, which demonstrate the historic deformation of sedimentary layers under the general Los Angeles area. The study, by identifying the lateral boundaries and shape of the aquifers, has important

practical implications on groundwater usage issues: i.e., the distribution and relative geometry of aquifers susceptible to sea water intrusion, the presence of fault barriers and folds, and the potential reduction in thickness of low-permeability layers that retard vertical migration of contaminants and represent areas of potential vulnerability. Sequence stratigraphy studies will also influence the Aquifer Storage and Recovery (ASR) projects planned in many areas of the Los Angeles Basin. For more information a complete report on recent investigation activities related to this study can be found at: <http://pubs.usgs.gov/of/2007/1013/>.

Other Events

Southern California is also the seat for the second conference on Environmental Information Management Systems (EIMS II) on August 22, 2007, and the Second DNAPL Characterization conference in November. Several Southern Branch GRA members are also participating as guest speakers in a summer UC Irvine Extension class entitled “Groundwater Contamination Issues in Southern California.”

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Dates & Details

GRA MEETINGS AND KEY DATES

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

GRA 16th Annual Meeting/ 26th Biennial Groundwater Conference	September 18-19, 2007 Sacramento, CA	GRA Symposium <i>Site Closures</i>	February 2008 San Francisco/Bay Area
GRA Board Meeting	November 3, 2007 Lakewood, CA	GRA Legislative Symposium & Lobby Day	March 19, 2008 Sacramento, CA
GRA Symposium <i>DNAPL 2 – Source Zone Characterization & Removal</i>	November 14-15, 2007 Long Beach, CA	GRA Symposium <i>Emerging Contaminants</i>	June 2008 East Bay Area (No. CA)
GRA Course <i>Groundwater & Watersheds</i>	January 22-24, 2008 Davis, CA	GRA 17th Annual Meeting & Conference	September 2008 Location TBD



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