Groundwater Resources Association of California

HYDRO VISIONS

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"Compounds of Emerging Concern in Groundwater" – The 25th Symposium in GRA's *Series on Groundwater Contaminants*

Symposium Highlights and Summary

By Elisabeth L. Hawley, P.E., ARCADIS; Leigh Neary, ARCADIS; Shaily Mahendra, Ph.D., University of California Los Angeles; and Rula A. Deeb, Ph.D., BCEEM, ARCADIS

GRA recently hosted a symposium on compounds of emerging concern (CECs) in groundwater. This 1.5-day event was held February 7-8, 2012 at the Hilton Hotel in Concord, California (CA). The event focused on key groundwater contaminants, including hexavalent chromium (Cr(VI)); 1,2,3-trichloropropane (1,2,3-TCP); 1,4-dioxane; perfluorinated compounds (PFCs); nanomaterials; pharmaceuticals and personal care products (PPCPs) and more. The symposium was attended by over 150 participants from consulting, industry, academia, national laboratories, regulatory agencies, and law firms. Conference co-chairs included Dr. Rula A. Deeb of ARCADIS and Dr. Samuel Brock of the Air Force Center for Engineering and Environment (AFCEE). Sponsors included AECOM, AMEC, ARCADIS and Battelle. Cooperators included AFCEE and the California Department of Toxic Substances Control (DTSC). The eight conference sessions and student poster competition are described in more detail below.

Symposium co-chair Dr. Samuel Brock of AFCEE

Session 1 – CECs in Groundwater: Key Technical and Regulatory Challenges

Dr. Samuel Brock of AFCEE presented an Air Force perspective on key CECs within the context of the current Air Force paradigm shift towards fence-to-fence performance-based remediation. Emerging contaminants and other emerging issues have the potential to impact cleanup schedules, increase cost, alter technical approaches or re-open sites. Dr. Brock described two examples: 1,4-dioxane and PFCs. A recent study of Air Force sites documented the co-occurrence of 1,4-dioxane in 18% of wells containing 1,1,1-trichloroethane (1,1,1-TCA) and/or trichloroethylene (TCE). The Air Force is assessing PFC presence and fate at fire training areas, participating in round-robin analytical studies, and identifying toxicological data gaps and value derivations. For both 1,4-dioxane and PFCs, the Air Force is developing sampling guidance and funding demonstration/validation projects.

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

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Behind the Scenes

By Sarah Raker

GRA is made up of volunteers who donate their time and energy to lead the organization by setting and overseeing the strategic and technical direction; developing GRA's technical workshops, symposia, lecture series, and annual meetings; preparing articles for *HydroVisions*, the quarterly newsletter; and serving on GRA's Board of Directors and various committees. But it takes more than volunteers to manage GRA, to consistently provide high quality events for our members and the public, and to keep the organization growing and vital. How do we do it?

GRA's Executive Director Kathy Snelson and her staff Mary Megarry, both with Nossaman LLP, have been working with GRA since 2000 and have been integral to GRA's success. As described in GRA's bylaws, the Executive Officer "is responsible for working with the Board and supporting its direction, managing the programs and operations of the association, managing fiscal resources, and coordinating professional relations."

Who is Kathy? She received a bachelor's degree in psychology from California State University, Sacramento. She also attended San Diego State University where she was a two-time All America (top 12 tennis players from Division I colleges in the U.S.) in tennis. Kathy's tennis career began at age 10 (late by today's standards) and took her to over 25 states. She also represented the U.S. in the World University Games in Mexico City. Kathy now enjoys golf and working on her 6-acre ranch in Browns Valley, which is about an hour from Sacramento.

Kathy has extensive experience in organizational formation, strategic planning, fund development, membership development, public outreach and grassroots advocacy. She has worked closely with non-profit coalitions and associations since 1992, and has proved successful at working with boards of directors to build systems and structures that facilitate fulfillment of organizational missions.

> Annually, GRA accomplishes many strategic, organizational and legislative initiatives that require many volunteers with a variety of expertise and experience.

I asked Kathy what challenges she sees for GRA in 2012; in reply, Kathy stated, "Finding and guiding the volunteers needed to lead and coordinate the many important initiatives that the Board of Directors and Committees have developed. Annually, GRA accomplishes many strategic, organizational and legislative initiatives that require many volunteers with a variety of expertise and experience. GRA Directors and Committee members are highly dedicated and very professional and industry aware, so proposed projects and initiatives have consistently increased."

Who is Mary? She has been with Nossaman for 10 years. Before Nossaman, Mary was with the Site Restoration Group at Aeroject, where she was involved with projects relating to groundwater and soil contamination and treatment. Her 17-year career at Aeroject was a perfect segue to working with GRA, and she appreciates the opportunity for continued involvement in such an important issue for California. Mary is grandmother to four granddaughters and one grandson. When she isn't at Nossaman, Mary and her family enjoy camping and fishing. We look forward to seeing Mary at most GRA events and appreciate her enthusiasm.

I would also like to thank two outgoing Board members for their dedication and service to GRA. Dr. Jean Moran, professor at California State University East Bay, Department of Earth & Environmental Sciences, has been on the Board for the past six years. As Co-Chair of the Education Committee, Jean revitalized the committee by reaching out to professors and students and encouraging them to participate in GRA events and programs. She formed a network of hydrogeology and earth science scholars who help promote GRA's mission. Jean initiated the Col-

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Behind the Scenes – Continued

legiate Groundwater Colloquium, which allows students to present their research at events and workshops. The Colloquia and event receptions provide students with excellent opportunities to showcase their research, and offer attendees opportunities to learn from the frontier of groundwater science. Jean will continue her involvement in GRA's events.

And special thanks to Bill Pipes, consultant with AMEC Environment & Infrastructure, Inc., who served as President of GRA from 2010–11, and as a member of the Board since 2004. GRA was hit hard in 2009 during the worldwide financial crisis, as were many in the groundwater industry, and was challenged to maintain its fiscal heartiness. Bill inherited GRA's first loss of net income and decline in membership and attendance at GRA-sponsored events. With Bill's leadership and encouragement, GRA has bounced back and is beginning to experience positive growth. Prior to serving as President, Bill was Co-chair of the Membership and Communication Committees. It's been my pleasure to serve as Vice President alongside Bill and I look forward to his continued involvement.

Please welcome Abigail McNally, GRA's newest Board member. Abigail is a consultant with Confluence Environmental, Inc. and has been an active member of GRA's San Francisco Branch since 2001, where she served as Secretary and is currently Vice President. Among her many interests and talents, Abigail teaches modern dance and plays the banjo. We look forward to working with Abigail on the Board and absorbing her vibrant energy.

Sarah Raker, *GRA President*

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Jody A. Shoemaker of U.S. Environmental Protection Agency (EPA) Office of Research and Development National Exposure Research Laboratory summarized EPA's approach to developing analytical methods for CECs in drinking water, collecting reliable occurrence data under the Unregulated Contaminant Monitoring Rule (UCMR), and determining if a regulation is warranted under the Contaminant Candidate List (CCL). CCL 3 contains 104 chemicals or chemical groups. Dr. Shoemaker described the process EPA uses for method development and provided details on several recently-developed analytical methods for 1,4-dioxane; perfluorinated alkyl acids, and over 150 pesticides.

Dr. David Mazzera, the Assistant Chief of the California Department of Public Health Division of Drinking Water & Environmental Management, provided a CA perspective on CECs and drinking water. Among currently unregulated contaminants, 1,2,3-TCP is most frequently detected at concentrations above the Notification Level, followed by boron and vanadium. CA is in the process of developing a Maximum Contaminant Level (MCL) for 1,2,3-TCP based on the current public health goal (PHG) of 0.7 nanograms per liter (ng/L). A draft MCL should be available for public comment in mid-2013. In contrast, 1,4-dioxane has no PHG and no MCL under consideration. Dr. Mazzera described legal implications of CA notification levels and emphasized the importance of effective communication strategies.

A federal perspective on CEC regulation was provided by **Bruce Macler** of EPA Region 9. Mr. Macler provided a status update on regulations currently under development for TCE, perchloroethylene (PCE), other carcinogenic volatile organic compounds (VOCs) and perchlorate. An EPA work group has started to evaluate group regulation of carcinogenic VOCs for ease and cost savings; however, the ultimate form of such a regulation is unclear. EPA is in the process of developing an MCL goal (MCLG) for perchlorate and is facing the key challenge of clarifying their mandate to protect sensitive sub-populations. Approximately 35 compounds on the CCL 3 have sufficient occurrence and health effects data, and are therefore candidates for regulatory determinations in 2012. Potential regulatory candidates include N-nitrosodimethylamine (NDMA) and other nitrosamines (detected in 25% of public water systems), 1,2,3-TCP, chlorate and strontium.

Christopher Berka of Bingham McCutchen LLP described some of the legal challenges that CECs pose, particularly under CA law. To illustrate some of these complexities, he described a hypothetical case in which a tenant legally disposed of wastes during the 1960s. Since that time, the property was sold and the current site owner discovered contamination during discussions with a potential buyer. The current owner is now paying several million dollars for cleanup and wants to recover costs from the original tenant. Mr. Berka then described various legal frameworks for determining liability, including contractual issues, common law concepts such as nuisance and trespass, and the role of statutes that have clarified liability over the years. In summary, issues are complex and courts are often split with unresolved issues, particularly with respect to unregulated contaminants.

Session 2 – Chromium: Site Investigation and Remediation

Dr. John Izbicki of the U.S. Geological Survey described the use of δ^{53} Cr isotopic compositions to help delineate native and contaminated groundwater in the Mojave Desert of CA. With chromium being the 17th most abundant mineral in the earth's crust, numerous sources of naturally-occurring chromium are present, particularly in alluvial aquifers originating from the San Gabriel Mountains and in coastal areas of CA. Background groundwater concentrations sometimes exceed the CA MCL for total chromium of 50 micrograms per liter (µg/L); Cr(VI) concentrations are generally higher in older, alkaline, oxic groundwater. The δ^{53} Cr isotope composition typically observed in rock (near 0 per mil) contrasts to that observed in groundwater, where Cr(VI) has been reduced to trivalent chromium (Cr(III)) (1 to 5 per mil). The apparent fractionation factor (ε_{app}) can be used to assess plume margins where Cr(VI) reduction has occurred. It may be more difficult to assess plume margins resulting from advective mixing in oxic environments.

Anja Verce of Weiss Associates presented a case study where up to 613 µg/L Cr(VI) were detected downgradient of a former landfill. Background Cr(VI) concentrations measured in groundwater were up to 180 µg/L; site soils contained naturally-occurring total chromium at 400 milligrams per kilogram (mg/kg), and 1,900 mg/kg manganese and manganese oxides that are known to oxidize Cr(III) to Cr(VI). A soil leaching test showed that the landfill's presence had altered site geochemistry, leading to a release of naturally-occurring chromium from soils and increased potential for oxidation by manganese oxides. In-situ bioremediation was not an appropriate remedial strategy because manganese solubilization could contribute to a re-oxidation of Cr(III) after the aquifer returned to oxic conditions.

Eric Rowney of MWH discussed a synergistic application of in-situ and ex-situ treatment technologies for removing Cr(VI) from groundwater. A former cooling tower manufacturer in Stockton, CA was operating an ex-situ treatment system capable of removing Cr(VI) and other metals. As a complementary approach to reduce treatment timeframes, MWH implemented an in-situ treatment involving 509 reme-

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dial injection borings with a reagent comprised of 3% calcium polysulfide coupled with 2% ethanol. The ex-situ and in-situ systems worked synergistically to promote hydraulic control of the intermediate zone, and to accelerate mass reduction of the plume.

Kevin Sullivan of PG&E presents an update on Cr(VI) treatment at Hinkley, CA

Kevin Sullivan of Pacific Gas & Electric presented remediation methods employed to reduce Cr(VI) groundwater concentrations in Hinkley, CA. Treatment methods include in-situ reactive zone (IRZ) to mediate reduction of Cr(VI) to Cr(III), and agricultural treatment to reduce Cr(VI) in the root zone of common crops. Challenges in developing a final remedy include ongoing revisions to chromium standards, historically established background concentrations, a legacy of agricultural pumping, and lack of significant onsite natural attenuation mechanisms.

Session 3 – Hexavalent Chromium: Analytical Issues and Ex-Situ Treatment

Dr. Andrew Eaton of MWH summarized the occurrence and analysis of Cr(VI), based on 10 years of CA monitoring data. According to an EPA study, total chromium occurs in 18% of drinking water sources nationwide at a concentration of greater than 10 µg/L, and Cr(VI) occurs in 11% of CA drinking water sources at 10 µg/L or greater. More than 80% of tested samples contain Cr(VI) at concentrations greater than 0.05 µg/L (compared with the CA PHG of 0.02 µg/L). Total chromium is typically higher in groundwater than surface water, and its composition in groundwater is more likely to consist predominantly of Cr(VI). Additional data will be available following the likely inclusion of both Cr(VI) and total chromium in the upcoming UCMR3, with monitoring starting in 2013.

Dr. Nicole Blute of Malcolm Pirnie, the Water Division of ARCADIS U.S., discussed an advanced water treatment research program for Cr(VI) in drinking water led by the City of Glendale, CA. The Research Program included a series of bench, pilot, and demonstration studies. The bench-scale study highlighted the importance of removing Cr(III) from treated water to prevent reoxidation to Cr(VI) by chloramines in the distribution system. During the pilot-scale study, weak-base anion exchange (WBA), and reduction, coagulation, and filtration (RCF) were proven to remove Cr(VI) to the target concentration of 5 µg/L. The demonstration phase assessed full-scale treatment effectiveness, optimization of O&M procedures, disposal strategies for treatment residuals, and verification and improvement of cost estimates. Additional studies are underway to assess microfiltration, resins, and absorptive media.

Session 4 – 1,4-Dioxane

Thomas K. G. Mohr of the Santa Clara Valley Water District and author of a recent book on 1,4-dioxane and other solvent stabilizers began the session with a discussion of current and historical sources of 1,4-dioxane contamination. Traditionally, 1,4-dioxane has been implicated along with chlorinated solvents like 1,1,1-TCA because of its historical use as a solvent stabilizer. Mr. Mohr described some of the challenges associated with 1,4-dioxane groundwater remediation, including ineffectiveness of traditional pump and treat systems that employ air stripping or granulated activated carbon. New sources of 1,4-dioxane are being identified as analytical techniques advance (e.g., EPA Method 522), leading to the concern that 1,4-dioxane may be ubiquitous in the environment. Mr. Mohr also discussed the addition of 1,4-dioxane to CCL 3, which will result in UCMR data from water utilities across the country.

Dr. Phillip Gedalanga of University of California, Los Angeles (UCLA) presented his research on the design of quantitative polymerase chain reaction (qPCR) assays to indicate potential 1,4-dioxane biodegradation. Analysis of the recently-sequenced genome of *Pseudonocardia dioxanivorans* CB1190, a bacterium that can use 1,4-dioxane for growth, revealed a number of putative monooxygenase genes that may serve as potential biomarkers for 1,4-dioxane degradation. The DNA sequence for the tetrahydrofuran monooxygenase (THM) was conserved in several previously-reported 1,4-dioxane-degrading bacteria. Consequently, THM was chosen as the primary target enzyme. Preliminary results demonstrated a high degree of correlation with 1,4-dioxane degradation rates in established microcosms bioaugmented with 1,4-dioxane-oxidizing CB1190 or the methane-oxidizing strain *Methylosinus trichosporium* OB3b. Results suggest that certain monooxygenases can be used as reliable biomarkers for 1,4-dioxane biodegradation in the environment.

Rebecca Mora of AECOM Environment, Inc. presented the results of a field-scale study on 1,4-dioxane bioremediation. Several locations at Air Force Plant (AFP) 44, near Tucson AZ, were previously evaluated for monitored natural attenuation (MNA) and indicated likely 1,4-dioxane and TCE biodegradation under aerobic condi-

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tions. Subsequent laboratory studies were conducted to quantify the intrinsic biodegradation rates of 1,4-dioxane and TCE in microcosms constructed from soil and water samples collected from AFP 44. 1,4-dioxane biodegradation rates were calculated from a subset of microcosms that were stimulated with additional electron donor (50% v/v methane:air) or electron acceptor (air only), or augmented with known dioxane-degrader *P. dioxanivorans* CB1190 or 1,4-dioxane-cometabolizer *M. trichosporium* OB3b. Results demonstrated significant biomass increase and dioxane degradation under bioaugmented and biostimulated test conditions. However, natural attenuation was not observed within the early period for which degradation rates were available. This study yielded 1,4-dioxane biodegradation rates under various treatment conditions.

Session 5 – Perfluorinated Compounds

Virginia Yingling of the Minnesota Department of Health presented a decade of PFC investigation and remediation in Minnesota near a former (1940s–2002) 3M facility. PFC wastes were disposed of on-site and at three major off-site areas. PFCs of concern include perfluorooctanoic acid (PFOA), perfluoroctane sulfonic acid (PFOS), perfluorobutyl acid (PFBA) and other PFCs. PFCs do not break down in the environment and do not readily sorb to aquifer materials. As a result, the plumes are extremely large, covering over 100 square miles, impacting groundwater in four different aquifers and approximately 1,000 private wells. PFBA is the most widespread. Dr. Yingling presented several aspects of the conceptual site model and described how the understanding of PFC sources, fate and transport has evolved. Dr. Yingling reported that PFC concentrations in blood have decreased by 13–26% where area residents are now receiving treated drinking water.

Virginia Yingling of the Minnesota Department of Health

Jennifer Sepulvado of the Colorado School of Mines presented laboratory results illuminating subsurface transport characteristics of PFCs, including the role of organic carbon, competitive effects for sorption sites and the role of non-aqueous phase liquid (NAPL) in PFC transport. To investigate the fate of aqueous fire-fighting foam (AFFF) that reaches groundwater, Ms. Sepulvado has developed a conceptual model of the subsurface and formulated several research questions. As expected, PFC retardation increased with chain length. Sorption isotherms in loamy sands and loams indicated that sorption site limitation and competitive sorption may be factors at higher PFC concentrations in soils with low organic carbon content. The presence of NAPL increased PFC retardation in the subsurface, independent of NAPL composition.

Dave Woodward of AECOM presented an Australian perspective on PFOA and PFOS as CECs. Mr. Woodward emphasized the high-profile nature and implications of PFCs, including widespread detection globally in human blood and the variety of potential sources and occurrence of these compounds. In Australia, PFC guidelines have not yet been established. Australians may view existing U.S. standards as overly conservative and are debating about environmental impacts of AFFF and other PFCs versus societal benefits. Australian regulators are waiting for a report from the Department of Sustainability, Environment, Water, Population and Communities; meanwhile, the Western Australia Department of Environment and Conservation has stated that PFC-impacted materials must be destroyed rather than taken off-site for disposal, resulting in accumulation of wastes and wastewaters at several sites.

Session 6 – Nanomaterials

Dr. Jeffrey Wong from CA DTSC described the process of regulating chemicals and nanomaterials. Nanomaterials are currently regulated using a single size-based definition. This is a limited view that does not encompass all properties unique to nanoscale, such as surface area, reactivity, and toxicity. Dr. Wong proposed an alternative regulation method that would use an improved chemical registry system. This system would include all emerging chemicals and their material properties such that regulation could be based on scientifically rigorous characteristics of nanomaterials.

Dr. Shaily Mahendra of UCLA emphasized the environmental applications and implications of nanoscale materials and nanotechnology. Due to widespread use and unregulated disposal of industrial and commercial products, nanomaterials may be CECs for water resources projects. Dr. Mahendra illustrated microbial impacts of nanomaterials by summarizing two research projects: interactions between copper nanoparticles and algae, and quantum dots and bacteria. Nanoparticle characterization techniques, electron microscopy, and gene expression studies were used to assess the transformation and toxicity of metallic nanoparticles on microbial viability. Novel high-throughput techniques for monitoring the growth and adenosine triphosphate (ATP) content of microbes were also described.

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Dr. Arturo A. Keller of Bren School, UC Santa Barbara and UC Center for Environmental Implications of Nanotechnology described various studies of fate, transport, and toxicity of several important nanoparticles conducted within the center. Dr. Keller reported that aqueous matrix determines the stability and bioavailability of the nanoparticles. Dissolvent organic content and low ionic strength are favorable for stable suspension of nanoparticles. Mobility of nanoparticles in the environment significantly increased if nanoparticles were coated with organic functional coatings. These studies yielded fundamental understanding that could be applied to effectively inject nanomaterials into the subsurface for environmental remediation, or to arrest nanoparticle transport in groundwater.

Session 7 – 1,2,3-TCP and PPCPs

Dr. Eric Suchomel of Geosyntec Consultants presented recent advances in 1,2,3-TCP remediation technologies. 1,2,3-TCP is both mobile and persistent in the subsurface. Dr. Suchomel gave an overview of numerous treatment technologies assessed in laboratory-scale and pilot-scale studies over the past decade and highlighted activated persulfate and zerovalent zinc (ZVZ) as promising. Alkaline-activated persulfate resulted in greater than 98% reduction in 1,2,3-TCP in about seven days. However, the high-pH control degraded 80% of 1,2,3-TCP over the same time period, indicating significant base-catalyzed hydrolysis. A bench-scale column study showed 95% degradation of 1,2,3-TCP after 12 weeks of ZVZ column operation. A pilot-scale ZVZ permeable reactive barrier is planned for installation in spring 2012.

Dr. David Hokanson of Trussell Technologies discussed the occurrence and removal of PPCPs with a focus on groundwater. PPCPs are present in wastewater streams and concentrations are expected to increase with population growth. The California Department of Public Health has drafted groundwater recharge and reuse regulations that require a demonstration of 90% removal of PPCPs (surface spreading) and a demonstration of 0.5-log removal of 1,4 dioxane as an indicator constituent in the use of advanced oxidation processes (AOP). Treatment technologies, such as reverse osmosis, nanofiltration, and AOP have been effective in removing PPCP compounds.

Session 8 – Other CECs

Henry Barrientos of Santa Clara Valley Water District (SCVWD) and **J. Wesley Hawthorne** of Locus Technologies described a recycled water irrigation and groundwater study conducted at SCVWD's Santa Clara and Llagas sub-basins. During the study, PFCs, PPCPs, NDMA, perchlorate, several cations and anions, E. coli, and other CECs were considered with respect to potential occurrence in recycled water and groundwater impact. The evaluation included a literature and data review, soil attenuation modeling, laboratory bench tests, a field pilot study, evaluation of groundwater degradation potential, and recommendations for the monitoring program and best management practices. Study results identified sensitive areas of the basin and indicated the need for continued monitoring. SCVWD is constructing an advanced treatment facility to improve the quality of recycled water.

Dr. Srinivasa Varadhan of ARCADIS, U.S. presented an overview of sulfolane, a compound developed by Shell in the 1960s to sweeten acidic or sour natural gas; it is also used in some refineries, as a solvent in the plastics industry, and in the production of some herbicides and fungicides. It is currently regulated in Texas and Canada; health advisory levels have been established in Alaska and CA. Sulfolane is miscible in water with limited volatility and sorption to soil; however, sulfolane will biodegrade rapidly under aerobic conditions. Dr. Varadhan presented an overview of treatment technologies and details of a case study of biological granular activated carbon (bioGAC) treatment to optimize sulfolane removal. By increasing dissolved oxygen concentrations throughout the bioGAC system and converting the system configuration from parallel to series, the capacity and reliability of sulfolane treatment was improved.

Alidina Mazahirali, from the King Abdullah University of Science and Technology, presented findings on the role of biodegradable carbon (BDOC) in attenuating CECs during managed aquifer recharge projects. A soil column study was conducted to investigate the effect of different blends of organic carbon on CEC attenuation. Results indicated that some compounds were better removed under low BDOC conditions,

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Alidina Mazrahirali discusses EDCs with Dr. Tomofumi Kurobe

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some were equally removed in both high and low BDOC conditions, and others were not significantly removed. Mr. Mazahirali also investigated microbial composition and diversity in soil column samples. Results indicated greater biological diversity in the low BDOC columns. Field samples collected from river systems in the U.S. and Saudi Arabia showed very similar microbial data in the infiltration zone (high BDOC) and unsaturated riverbed samples (low BDOC), verifying laboratory results.

Dr. James Hunt of UC Berkeley (UCB) provided a forward-looking perspective to contaminant emergence from the energy sector. Dr. Hunt encouraged conference attendees to reflect on past emerging contaminants such as methyl tertiary butyl ether (MTBE), dibromochloropropane (DBCP), 1,2,3-TCP, perchlorate and Cr(VI), which emerged as concerns based on health effects and detection. Studying these compounds has also expanded our understanding of subsurface transport processes. Looking ahead to potential future groundwater threats, Dr. Hunt described key trends in California's energy market and explored potential future contaminants associated with thermal energy storage and battery systems. Examples include nitrate and fluoride salts used to pack thermal storage tanks, and compounds used in lithium batteries, such as lithium hexafluorophosphate and 1-butyl-3-methylimidazolium hexafluorophosphate, or [bmim]PF6.

Student Poster Competition

New to this GRA event was a flash poster presentation by student researchers as part of a student paper competition. Six students from four universities each gave a one-minute summary of their poster presentations during the conference program. Students then provided attendees with details during conversations at their posters. Cash prizes were awarded to all six participants, thanks to our generous corporate sponsors: Arcadis-US; Bingham McCutchen, LLP; CH2M Hill; and Geosyntec Consultants.

Nancy S. Tseng of UCLA and **Erika Houtz** of UCB tied for first place with their research on PFCs. Ms. Tseng's research focused on PFOA biotransformation by bacteria and fungi. She isolated several viable microbes from PFOA-contaminated soil. Monooxygenase-expressing bacteria were unable to transform PFOA under study conditions. However, Ms. Tseng identified fungal isolates that grew better in the presence of 10 mg/L PFOA, suggesting adaptation or utilization of PFOA.

Ms. Houtz's research focused on quantification of precursors to perfluorinated carboxylates and sulfonates in AFFF formulations. AFFF is a life-saving material used by the military and municipalities to extinguish fuel-based fires. The use of AFFF above unlined soil has led to high concentrations of AFFF-derived PFCs in underlying groundwater, including PFOA and PFOS. Despite reformulations, newly-manufactured proprietary AFFF may contain fluorochemicals that can abiotically or biologically transform to PFCs. To measure potential PFC precursors in AFFF, Ms. Houtz developed a chemical oxidation method to convert precursors to measurable products. Results indicate that many AFFF formulations contain high concentrations of fluorochemicals that may transform to PFCs. The precursor analysis tool can be used to quantify PFC precursors as potential ongoing sources of PFCs in AFFF-impacted groundwater.

Second place was awarded to **Dr. Julia Regnery**, a post-doctoral researcher from the Colorado School of Mines, for her research illustrating removal kinetics of 14 CECs, primarily PPCPs, during artificial recharge and recovery of reclaimed water (treated wastewater). Knowledge on CEC fate and transport in the subsurface is essential for designing and assessing water recharge facilities. Dr. Regnery's work focused on CECs having different degrees of biodegradability and sorption; well-adapted soil columns were used under controlled geochemical and hydrological conditions representative of full-scale recharge systems. Different experimental setups (e.g., oxic vs. anoxic conditions, low vs. high dissolved organic carbon) were chosen to manipulate and trigger the removal of substance groups with redox-dependent degradation behavior. Resulting biotransformation rate constants were calculated, and then were applied to field monitoring data to validate the approach. Since removal of CECs during recharge is driven by subsurface hydrogeochemical conditions (e.g., redox zones, temperature, and availability of dissolved organic carbon) and retention time, changes in these parameters can enhance biotransformation.

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Left to right: Dr. Tomofumi Kurobe, Dr. Julia Regnery, Erika Houtz, Nancy Tseng, Jennifer Sepulvado, and Peerapong Pornwongthong.

"Compounds of Emerging Concern in Groundwater" – *Continued*

Third place was awarded to **Peerapong Pornwongthong** of UCLA for his work validating the use of compound-specific isotope analysis (CSIA) as a diagnostic tool for 1,4-dioxane biodegradation. In many biochemical processes, lighter isotopes tend to react more rapidly than heavy isotopes, causing the enrichment of heavy isotopes as the reaction progresses. CSIA examines the alteration of isotope ratios during biodegradation of various organic contaminants. Mr. Pornwongthong and colleagues established the first method for determining the enrichment of ^{13}C during biodegradation of 1,4-dioxane, a probable human carcinogen. The novel CSIA method was successfully applied to assess biodegradation of 1,4-dioxane in pure cultures and environmental samples. This technology will be immediately useful for environmental engineers and regulators to validate natural or enhanced remediation of 1,4-dioxane at polluted sites.

Jennifer Sepulvado, a Ph.D. candidate at Colorado School of Mines, presented her research on the occurrence and fate of PFCs in soil following the land application of municipal biosolids. EPA's recent implementation of soil and drinking water screening guidance values for PFOA and PFOS reflects the growing concerns regarding the presence of these persistent and bioaccumulative chemicals in the environment. Previous work established the presence of PFCs in biosolids. Ms. Sepulvado investigated the occurrence and fate of PFCs from land-applied municipal biosolids by evaluating the levels, mass balance, desorption, and transport of PFCs in underlying soils at various biosolids loading rates. Laboratory desorption experiments indicate that the leaching potential of PFCs decreases with increasing PFC chain length. Trace levels of PFCs were also detected in soil cores from biosolids-amended soils to depths of 120 cm, suggesting potential movement of these compounds within the soil profile.

Tomofumi Kurobe, a post-doctoral research fellow at UC Davis, described his development of bioassay tools to predict the aquatic effects of complex mixtures of endocrine-disrupting compounds (EDCs) on aquatic organisms. EDCs often found in municipal wastewater compromise development and/or sexual maturation of aquatic organisms by mimicking or antagonizing the actions of natural hormones. A bioassay using a model organism can be a powerful tool as it enables prediction of the presence of EDCs in water through biological responses, and also of potential impacts on aquatic organisms due to EDC exposure. Dr. Kurobe investigated gene expression patterns of medaka larvae exposed to six prototypic chemicals (17- Estradiol, ICI 182780 (Faslodex), 11-ketotestosterone, Flutamide, 3,3′,5-Triiodo-L-thyronine, and Amiodarone) using a custom medaka microarray chip, including DNA probes to EDC exposure responsive genes. Groundwater samples obtained from a domestic well near a septic system in CA were used to demonstrate EDC identification power of the assay. Results demonstrate that the medaka system is capable of screening, classification and identification of uncharacterized EDCs in ambient water.

Experimental set-up used to test CSIA method in environmental microcosms degrading 1,4-dioxane.

Dates & Details

GRA EVENTS & KEY DATES

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

GRA-Cast *Other States' Approaches to Addressing Abandoned and Improperly Constructed Wells: Minnesota, Nevada, Oregon and Texas*
Mar. 14, 2012 | Webcast

GRA-Cast *California Statewide Groundwater Elevation Monitoring (CASGEM) Program*
Mar. 27, 2012 | Webcast

GRA Legislative Symposium & Lobby Day
Apr. 25, 2012 | Sacramento, CA

GRA Symposium *Salt/Nitrate*
Jun. 13-14, 2012 | Fresno, CA

GRA Conference *Oil & Water – Do They Mix in California? Hydraulic Fracturing and Water Resources – A California Perspective*
Jul. 24-25, 2012 | Long Beach, CA

GRA Conference *Managing Wells in California – Time to Raise the Bar?*
Aug. 23-24, 2012 | Sacramento, CA

GRA Course *Principles in Groundwater Flow and Transport Modeling*
Sep. 11-13, 2012 | Redwood City, CA

GRA *21st Annual Meeting & Conference*
Oct. 4-5, 2012 | Rohnert Park, CA

GRA Symposium *Investigation and Remediation of Dry Cleaner Release Sites*
November 2012 | CA

MARK YOUR CALENDARS

The 26th Symposium in GRA's *Series on Groundwater Contaminants:*

"Salt and Nitrate in Groundwater: Finding Solutions for a Widespread Problem"

JUNE 13-14, 2012
RADISSON HOTEL & CONVENTION CENTER, FRESNO, CA

In collaboration with the Central Valley Regional Water Board

Co-sponsored by the University of California Water Institute and Erler & Kalinowski, Inc.

The United Nations' visit to Tulare County and subsequent report on safe drinking water and sanitation for low-income communities in the San Joaquin Valley highlighted growing concerns about the decades-old problems of salt and nitrate in California's groundwater. Nitrate concentrations in groundwater exceeding the drinking water standard pose a difficult challenge for disadvantaged communities and in private water supply wells that serve rural residences. Salt accumulating in the soil and groundwater in the San Joaquin Valley threatens agricultural viability and the sustainability of California's water systems.

This Symposium will focus on finding solutions to these problems, featuring topics such as:

- The research and work conducted by the University of California and others in response to SBX2 1 (Perata, 2008) to compile, analyze, and synthesize nitrate data and assess potential solutions, their estimated costs, and challenges facing California to address this issue
- The challenges in finding solutions from the perspective of the state agencies, local governmental bodies, environmental justice groups, private business interests, and researchers and consultants
- The impact of the State Water Board's Recycled Water Policy on salt and nutrient management across the State
- Cutting-edge strategies, technologies, and solutions that are being implemented to control, manage, treat, and consolidate salt.

Look for the **Call for Posters** and further details on the GRA website, www.grac.org.

For more information, contact Michael Steiger (650-292-9100; msteiger@ekiconsult.com), Thomas Harter (530-752-2709; thharter@ucdavis.edu), or Vicki Kretsinger (530-661-0109; vkretsinger@lsce.com).

SAVE THE DATE

GRA 21st Annual Conference & Meeting

OCTOBER 3-5, 2012

October 4-5, Conference and Meeting | October 3, Optional Field Trip and Dinner
DoubleTree by Hilton Hotel, Rohnert Park, CA

Special Features and Preliminary Topics Include:

- California Water Plan Update 2013: DWR's Plans for Significantly Enhancing Groundwater Information, including State-Wide Inventory of Groundwater Management Plans and Program Activities, Approach to Estimating the Change in Storage in Basins/Sub-basins, and Climate Change Impacts on Groundwater Supply and Storage
- Advances and Updates in Data Management: CASGEM and GeoTracker
- ACWA's Groundwater Management Framework Action Plan Priorities
- Water in the West Joint Program of the Woods Institute for the Environment and Bill Lane Center for the American West at Stanford University: Best Management Practices for Groundwater
- Stanford University and Queensland University, Australia: Comparative Groundwater Law and Policy
- Addressing Abandoned and Improperly Constructed Wells in California
- AB 359: Mapping Groundwater Recharge Areas
- SB918: Adopting Uniform Health Standards for Recycled Water
- Groundwater Recharge and Storage: State Water Board Recycled Water Policy, Central Valley Regional Water Board Draft ASR General Order, California Water Commission Hearings
- CV-SALTS and the SBX2-1 State Water Board Nitrate Study: Progress to date, and State-wide Implications
- State Water Board Groundwater Strategy
- 2012 David Keith Todd Lecturers: Dr. John Cherry and Dr. Bill Alley
- Collegiate Groundwater Colloquium
- Optional pre-conference Field Trip led by the Sonoma County Water Agency
- Optional pre-conference Dinner: Mixing Wine and Local Geology.

Co-Sponsor – Sonoma County Water Agency

Luncheon Sponsor – INTERA Incorporated

Cooperating Organizations – University of California Water Institute, California Department of Water Resources, Cal/EPA Department of Toxic Substances Control, Water Education Foundation, US Geological Survey, Association of California Water Agencies

Call for Abstracts Coming Soon

More details will be available on GRA's website, www.grac.org, as they develop.

PLAN ON ATTENDING...

GRA's Legislative Symposium and Lobby Day

Raising the Bar on Groundwater Management

WEDNESDAY, APRIL 25, 2012

Agenda will include:

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

Contact Duncan McFetridge, GRA Legislative Advocate, DMcFetridge@bhfs.com or (916) 594-9703 for further information.

Wells and Words

By David W. Abbott P.G., C.Hg., Senior Hydrogeologist, Daniel B. Stephens & Associates, Inc.

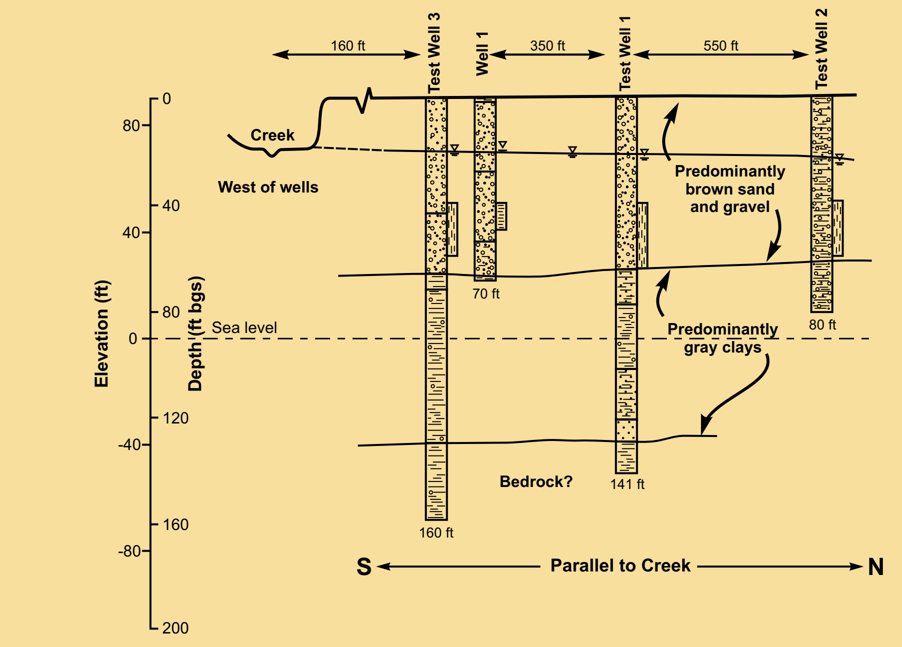
Applying the Right Tools for Evaluation and Development of Groundwater Resources – rigs, equipment, and construction materials

Two case histories are presented where improperly selected tools, drilling methods, and construction materials were used to install wells or borings to characterize, identify, and develop groundwater (GW) resources; but first, some background. A water well is defined as an artificial excavation (pit, hole, or tunnel), generally cylindrical in form, often walled-in, sunk (drilled, dug, driven, bored, or jetted) into the ground to a depth so as to penetrate water-yielding rock or soil and to allow the water to be pumped to the surface.[1] Well installations can be accomplished using a variety of tools and drilling methods in various combinations. Selection of the correct drilling method is a function of the hydrogeology, purpose of the well, project goals, monetary constraints, and regulations.

Well diameter (ϕ) can range from less that 1″ (for monitoring) to greater than 42,″ and depths can range from less than 5 feet (ft) to thousands of feet. C.F. Tolman[2] describes a hand-dug well that was constructed between 1527 and 1540 in Orvieto, Italy; the well is 42 ft ϕ × 200 ft deep with 248 steps. Well construction requires machinery and materials; proper selection of these is vital to project success. Because the purpose of a well (or boring) is to bring water to the ground surface for development or investigation of subsurface properties and/or water quality constituents, every installation is a scientific effort that lacks the convenience, control, and precision of laboratory work.

Early in my life, working on pre-owned automobiles, I learned to use the proper tool for a project. It did not take me long to realize that bleeding brakes should never be conducted using a vise-grip or any other tool but a 3/8″ box end (preferred) or open-end wrench[3] for most models; invariably, using improper tools will strip the bleeder screw resulting in a more serious problem. Similarly, well drilling, construction, and development require the right combination of tools; these tools should be selected carefully for the job, goals, and project. There are over 30 types and combinations of tools used to drill a well. These tools range from shovel/pick to more sophisticated and expensive drilling rigs. Table 1 shows a list of some of these tools.[4]

Figure 1: Case Study of "dry holes" and Improper Use of Drilling Equipment



Case History 1: a City installed three 8″ ϕ steel-cased test wells (TWs) in the late 80s. The TWs were located on a fluvial terrace about 20 ft above and about 160 ft from an ephemeral creek controlled by releases from an upstream dam. The TWs ranged in depth from 80 to 160 ft (Figure 1). The perforations were "machine punched." The TWs were installed using direct air rotary drilling methods with casing hammer (ARCH). The casing hammer advances the casing as the well is drilled. After the TWs were installed, the contractor reported to the City that there was no GW in the area; the City asked me to evaluate the results. I recommended to the City that a cable-tool drilled well installed 30 ft from one of these "dry test wells" might be successful; the City approved my recommendation. Well 1 was constructed using a 16″ ϕ steel casing to a depth of 70 ft; the 0.150″ and 0.250″ aperture size screens were installed from 40 to 50 ft using the pull-back method. The static water level was about 22 ft reflecting the elevation of the creek. After development, the well yield was 820 gallons per minute (gpm) with about 13 ft of drawdown (dd), for a specific capacity of 63 gpm per ft of dd. Stories like this lead to the conclusion that the

Continued on the following page…

Wells and Words – *Continued*

Table 1: Summary of Drilling Methods Available for Well Installation

	Hydraulic Rotary			
Other	**Direct Rotary**	**Reverse Rotary**	**Percussion**	**Auger**
Hand dug	Casing hammer w/air	Open hole	Cable tool	Hollow stem
Direct push	Down-the-hole hammer	Dual tube	Sonic	Large diameter
Drive point	Directional drilling	Down-the-hole-hammer	Jetting and driving	Screened stem
Back hoe	Dual rotary	Dual wall	Open hole	Solid stem (flight)
	Hydraulic percussion			Bucket
	Rotary wash			Post hole
	Open hole			Dutch (hand)
Fluids	Air	Air		
	Foam	Foam		
	Inorganic mud	Inorganic mud		
	Organic mud	Native mud	Native mud	

Note: Shading denotes no personal experience in use of the drilling method.

wrong tool (ARCH), and/or casing (machine punched perforations), was used to install and construct the TWs. The right tool (cable tool) was used to produce a successful well, and the City proceeded using cable tool drilling to develop a 3,200 gpm well field with five wells near the "dry test wells;" the well field continues to operate and serve the City today.

Case History 2 illustrates the use of the wrong tool to characterize the base of an aquifer tapped by an existing well field. In the mid-90s, the City approved a drilling program of five 2″ ϕ monitoring wells to determine the depth of bedrock (BR) and to evaluate GW elevations. The well field had been used by the City since 1905. Based on previous drilling records, the depth to BR was between 65 and 100 ft. The City recommended using hollow stem auger (HSA); the borings refused to advance beyond the top of the coarse-grained (gravel) aquifer resulting in total depths ranging from 28 to 39 ft. To verify the total thickness of the aquifer, two direct mud rotary borings were installed about 10 ft from the HSA borings; both rotary borings were drilled to 57 and 63 ft before encountering BR. A significant portion of the aquifer was missed using the HSA method designed for geotechnical investigations of fine-grained shallow sediments, and modified for environmental investigations.

Only the proper choice and combination of drilling equipment and methods will produce the best results. Future installments of *Wells and Words* will discuss some of the advantages and disadvantages of many of these drilling methods, tools, and rigs. I have had the opportunity to experience most of these methods, and there is no substitute for practical onsite experience with different types of drilling rigs and methods. How many productive aquifers have been missed because of improper drilling methods? Re-evaluation of written-off well field sites could yield adequate quantities of potable water, and appropriate well drilling and construction designs can provide a better understanding of aquifer systems and help achieve optimization of well yields. Exposure to and experience with many of these methods enables the hydrogeologist to best optimize the drilling method and well design for successful projects.

[1]American Geological Institute (AGI), 1987, Glossary of Geology, Editors: Robert L. Bates and Julia A Jackson, Alexandria, VA.

[2]Tolman, C.F., 1937, Ground Water, McGraw-Hill Book Company, New York, 593 p.

[3]Chilton Book Company, 1971, Chilton's Auto Repair Manual 1954-1963, Radnor PA.

[4]Bloetscher, Frederick, Ph.D, P.E., Muniz, Albert, P.E., and Largey, John, 2007, Siting, Drilling, and Construction of Water Supply Wells, American Water Works Association, Denver, CO, 206 p.

Quarterly Legislative Update

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

With the 2011 legislative session in the books, 2012 is quickly shaping up to be a politically dynamic year. While the budget and the state's chronic deficits will continue to dominate the politics in Sacramento, other politically charged issues such as pension reform and the water bond will force the legislature to make some very difficult decisions. Notwithstanding these challenging economic times, Governor Brown is pursuing big ticket, politically charged infrastructure projects such as the Delta Conveyance Facility and High Speed Rail. In addition, California voters will, for the first time ever, face a perfect storm of electoral politics – a new open primary system coupled with newly created political boundaries during a Presidential election year. Finally, GRA will continue its work on important issues such as well log reports and its continuing education of policy makers on the importance of solid groundwater policy in California.

Budget Update

Governor Brown came into office last year and faced an immediate $26.6 billion budget gap and future budget deficits of $20 billion a year. In January of 2011, Governor Brown proposed a budget that combined deep cuts with a temporary extension of some existing taxes. In the end, the taxes were not extended and massive cuts—totaling $16 billion—were enacted. The 2011 budget laid the foundation for fiscal stability, cutting the annual budget shortfall from $20 billion to $5 billion or less.

Governor Brown's 2012 budget, released in January, retains existing cuts and adds new ones. Governor Brown will ask the voters this year to approve a temporary tax increase on the wealthy, a modest and temporary increase in the sales tax, and to guarantee that the new revenues be spent only on education.

Water Bond

Governor Brown has indicated that he would support a delay of the $11 billion water bond that is scheduled to appear on the November 2012 ballot. The Governor is concerned that the bond is too large and a statewide general obligation bond is not immediately necessary because ratepayers in several water districts would foot the bill for a conveyance project—likely a pipeline or canal—to move water through or around the Sacramento-San Joaquin River Delta.

Assembly Speaker John Perez has indicated that he would like to see the water bond move forward, but at a reduced price tag; other Democrats would like to see the water become more "green."

Republicans who supported the Water Bond because of the bond's storage provisions are opposed to efforts to reduce the amount of the bond if it means reducing or eliminating those provisions. Given the fragile coalition of Democrats and Republicans that passed the bond in 2009, it is unlikely that any major changes in the water bond will occur during 2012, other than simply removing it from the November ballot. However, doing so would require a 2/3 vote in both the Senate and the Assembly.

Elections/Campaigns

2012 will be an unprecedented election in California politics. The *new Open Primary*, coupled with new district lines for Assembly, Senate, Congressional and Board of Equalization districts during a *Presidential election year* has the potential to fundamentally change the political and ideological make-up of the State Legislature and California Congressional delegation.

The first major test of California's new Top Two primary system will occur in the June primary election. Proponents of California's new open primary system believe that it will result in more moderate and less ideological candidates in office and help encourage more voters to participate. That is because the new open primary law requires that the Top Two vote getters in the primary, regardless of party and regardless of whether a candidate gets 51% of the vote, move on to the general election.

Continued on the following page…

Quarterly Legislative Update – *Continued*

In addition to the open primary, California voters will also have an opportunity to vote for their elected officials in newly drafted Senate, Assembly, Congressional and Board of Equalization districts. These new district boundaries were drafted by 14 citizens with a myriad of backgrounds, skills and from varied geographic locations. They drew district boundaries based on criteria designed to preserve communities of interest and to make legislative and congressional races more competitive.

Groundwater Legislation in 2012

GRA will once again pursue legislation to make well log information available to the public. Last year, GRA sponsored SB 263 (Pavley), which provided the public with unlimited access to well log information. Unfortunately, the bill was amended on the Assembly floor at the end of the legislative session, which significantly limited public access to the information and imposed fines on those that illegally obtained or provided the information obtained from well logs. These amendments prompted the Governor to veto the bill with the following veto message:

"I am returning SB 263 without my signature. The original intent of this bill recognized that wise management and use of groundwater supply requires public disclosure of well logs. Unfortunately, as amended, this bill now unduly restricts the use of these reports and imposes severe criminal penalties for disclosure.

California is the only western state that does not provide ready access to well reports. That should be changed. I am directing the Department of Water Resources to work with the author to ensure responsible public access to well logs."

GRA and its advocates are currently working with the Governor's office and Senator Pavley to introduce legislation that resembles the original intent of SB 263 and is consistent with the Governor's veto message.

Looking Ahead

As the upcoming legislative year begins to take shape, we will continue to keep GRA members apprised of the evolving political and policy landscape in Sacramento. Please mark your calendars for this year's ***Legislative Symposium and Lobby Day***, which will be held on April 25th (see Page 12). We will bring together leading water and groundwater experts in California government and provide GRA members with a comprehensive update on the latest in groundwater policy.

The Federal Corner

By Kelly Manheimer, U.S. EPA

TCE Toxicity Reassessment

In late September, EPA announced the results of the toxicity re-assessment of TCE (trichloroethylene), a hazardous cancer-causing chemical that pollutes water and air at over 700 Superfund sites. TCE is one of the most common man-made chemicals found in the environment, and its movement from contaminated ground water and soil into the indoor air of overlying buildings is of serious concern. It's been 24 years since the last EPA assessment of TCE, and recent evidence on cancer risk and other non-cancer health effects from exposure to TCE has resulted in a lowering of the toxicity value and applicable screening levels. The key change, however, is the inclusion of a short-term exposure effect, which could apply to as short a period as 24 hours. The toxicity values reported in the TCE assessment will be considered in revising EPA's Maximum Contaminant Level of 5 parts per in drinking water.

EPA Releases Final Health Assessment for Tetrachloroethylene (PCE)

EPA has posted the final health assessment for PCE to their Integrated Risk Information System (IRIS) database. PCE is a chemical solvent widely used in the dry cleaning industry, cleaning of metal machinery, and manufacturing. Confirming longstanding scientific understanding and research, the final assessment characterizes PCE as a "likely human carcinogen." EPA sets limits for the amount of PCE allowed in drinking water; toxicity values reported in the IRIS assessment will be considered in revising EPA's Maximum Contaminant Level for PCE. For more information, see: http://www.epa.gov/iris/subst/0108.htm.

EPA Creates Largest Coastal No-Discharge Zone in the Nation

EPA approved a state proposal to ban all treated and non-treated sewage discharges from large cruise ships and most other large ocean-going ships to state marine waters along California's coastline, which could greatly reduce the contribution of pollutants still found in treated vessel sewage. For more information, please see: http://www.epa.gov/region9/water/no-discharge.

Novel Device Removes Heavy Metals from Water

A technique variously described as electrowinning, electrolytic removal/recovery, or electroextraction works by using an electrical current to transform positively charged metal ions (cations) in contaminated water into a stable, solid state where they can be easily separated from the water. The main drawback to this technique is that there must be a sufficient concentration of metal cations in the water for it to be effective. Metals also can be removed via simple chemistry, using hydroxides and sulfides to precipitate the metal ions from the water as sludge. The technique is scalable and has viable commercial applications, especially in the environmental remediation and metal recovery fields. See the news release at: http://news.brown.edu/pressreleases/2011/12/cep.

Handbook to Help Water Utilities Plan for Sustainability

EPA has released "Planning for Sustainability: A Handbook for Water and Wastewater Utilities" to help utilities ensure that water infrastructure projects across the nation are sustainable and support the long-term sustainability of the communities these utilities serve. For additional information, visit: http://water.epa.gov/infrastructure/sustain/sustainable_systems.cfm.

2010-2011 Climate Change and Water Progress Report

EPA has released the "U.S. EPA National Water Program Strategy: Response to Climate Change 2010–2011 National and Regional Highlights of Progress." This is the third and final progress report covering the 2008 version of EPA's climate change strategy. The report is available at: http://water.epa.gov/scitech/climatechange/implementation.cfm.

NRC/EPA Report on Expanding Water Supply through Reuse of Municipal Wastewater

The National Research Council has released a report co-sponsored by EPA on "Water Reuse: Potential for Expanding the Nation's Water Supply through Reuse of Municipal Wastewater." The report highlights the potential that reuse of municipal wastewater can play in augmenting traditional water supplies. EPA agrees that advancements in water treatment processes make reuse of municipal wastewater a more viable option when risks are appropriately managed. For more information, visit: http://dels.nas.edu/Report/water-reuse/13303.

Continued on the following page…

The Federal Corner – *Continued*

EPA PCB TMDL Handbook Released

EPA has issued the "Polychlorinated Biphenyl (PCB) Total Maximum Daily Load (TMDL) Handbook," which provides EPA regions, states, and other stakeholders with updated information for addressing waters impaired by PCBs. PCBs rank sixth among the national causes of water quality impairment in the country, and of the 71,000 waterbody-pollutant combinations listed nationally, over 5,000 (8%) are PCB-related. This handbook identifies various approaches to developing PCB TMDLs and provides examples from around the country. The PCB TMDL Handbook is available at: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/pcb_tmdl_handbook.pdf.

Reservoir Storage: New Methods to Measure Capacity, Sedimentation

A new method of measuring the storage capacity and sedimentation of Loch Lomond Reservoir, Santa Cruz, shows promises to help water managers more effectively assess changes in water-storage capacity in similar basins with steep, narrow drainages in mountainous terrain. The method employs a combination of bathymetric scanning using multibeam-sidescan sonar, and topographic surveying using laser scanning. The techniques employed in the study help improve understanding of the quantitative effects of increased sedimentation rates on reservoir storage capacity. This study was a cooperative effort between the USGS California Water Science Center and the City of Santa Cruz. A report describing this new method can be found online at http://pubs.usgs.gov/sir/2011/5141/.

Kelly McCarty Manheimer is Chief of the CA Sites Superfund Section at the U.S. Environmental Protection Agency, Region 9. She works in the Superfund Division and oversees cleanup activities at many Superfund sites in CA. For information on any of the above topics, please contact Kelly at 415-972-3290 or manheimer.kelly@epa.gov.

Endocrine Disrupting Chemicals (EDCs)

By Bart Simmons

Environmental contamination with endocrine-disrupting chemicals (EDCs) is known to cause developmental, growth, and reproduction problems in fish and other species. Recent media attention for EDCs has focused on synthetic industrial chemicals: bisphenol A (BPA), bisphenol B, bisphenol F (all used in some plastics), nonylphenol (primarily a degradation product of detergents), tributyltin (used in marine paint), polybrominated diphenyl ethers (PBDEs, used as flame retardants), and triclosan (an antimicrobial used in hand soaps). The human health effects allegedly caused by synthetic EDCs include neurological problems in newborns, prostate cancer, breast cancer, and obesity. Concern about EDC residues in food have helped boost demand for organic food.

> "Human urine is generally considered to be the main source of natural and synthetic estrogens in the aquatic environment."

However, the potency of industrial chemicals is often far less than the potency of natural estrogens. Natural estrogens include the steroids estrone (E1), 17-β estradiol (E2), and estriol (E3). Of the total population, women excrete 80% of the total natural estrogens. In addition, oral contraceptives include the synthetic analogue 17-R-ethinyl estradiol (EE2). Human urine is generally considered to be the main source of natural and synthetic estrogens in the aquatic environment. Other sources of estrogens are veterinary drugs (E2 and zeranol, a synthetic steroid); cancer therapy drugs (Tamoxifen, diethylstilbestrol [DES]); and hormone replacement drugs (conjugated equine estrogens [CEE2] – the origin of the name for the commercial drug Premarin® is PREgnant MARes' urIne). The use of DES in cancer therapy is declining, but it is still used in some prostate cancer therapy. It has been linked to vaginal cancer in the daughters of women who took DES during pregnancy.

E1, E2, EE2, and nonylphenol have been found in surface water sources for drinking water. The EDCs have generally not been detected in drinking water, but one German study found all four of these EDCs in finished drinking water.

Livestock excrete the same natural estrogens (E1, E2, and E3) as humans, and elevated estrogen levels have been found in surface and groundwater downstream of farms and agricultural land. Animal waste contains EDCs in about 20 times the amounts found in human sewage. E2 has been found in groundwater and springs near land treated with beef, chicken and pig manure. Natural and artificial hormones are used to increase weight gain in cattle. However, the Food and Drug Administration has found that the residues of the natural hormones in meat are within the variability of hormone levels present in the meat naturally. The associated excretion of synthetic hormones in feces is likely much less than the excretion of natural hormones.

Some pesticides have endocrine-disrupting potential, including atrazine, vinclozolin, and some organochlorine pesticides, such as DDT. These compounds have low potency compared with the natural estrogens, but some, such as atrazine, are present at high concentrations in water relative to natural estrogens. Plants produce phytoestrogens, which may pose an estrogenic risk in agricultural areas.

A variety of EDCs have been identified in surface water and groundwater. The relative risk of these compounds is a function of both estrogenic potency and concentration. Estrogenic risk in wastewater treatment effluent has contributions from natural estrogens, synthetic estrogens, industrial chemicals, and naturally-occurring phytotoxins. A major source of environmental estrogenic risk appears to be from naturally-occurring estrogens in manure generated by agricultural operations. Although public and political attention may be focused on industrial chemicals, understanding environmental risk for EDCs will require study of both industrial and natural sources.

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

One Mouse Click to Help a Groundwater Student!

By Lisa Kullen and John Karachewski

For over a decade, GRA's Branches have promoted the Scholastic Fund Program that aims to encourage academic interest in groundwater issues. The fund benefits students through support to academic departments, scholarships, research grants, travel awards to GRA conferences, and subsidized registration for Branch meetings. To encourage donations to this important program, GRA partnered with the Water Education Foundation (WEF) in 2010 to create a Scholastic Fund Program under WEF's 501(c)(3) status. Donations can be made using the website, http://www.watereducation.org/secure/GRAScholastic.asp.

Companies that provide groundwater-related products and services, and individual GRA members, also provide critical financial support by sponsoring or contributing funds at local Branch meetings. In 2011, the Sacramento Branch raised $1,600, the San Francisco Bay Branch raised $1,750, the Southern California Branch raised $750, and the San Joaquin Valley Branch raised $750, for a combined total of $4,850.

Individual member contributions collected through the GRA-WEF Scholastic Fund Program are used as an incentive to match the Branches' fundraising efforts. Participating Branches distribute the scholastic funds through their own local programs, typically during the year following the fundraising effort. In 2009, GRA's Scholastic Fund Program awarded $3,000 in scholarships to students. In 2010, the total award doubled to $6,055, and in 2011, a whopping $10,066 was awarded to support students. With ongoing fundraising efforts at the Branch and statewide levels, the program continues to increase its assistance to students and academic departments. This amazing achievement is due to the generosity of GRA's members and corporate donors!

In 2011, GRA awarded research grants to: Erik Cadaret of CSU Fullerton, who is studying hydrogeology and geochemical interactions in the Sheep Creek fan area to investigate the potential for artificial recharge; Tal Golan, who is pursuing a Masters Degree with focus on hydrogeology-related databases for several basins in the Mojave Desert; Katy O'Donnell, an undergraduate student at CSU Sacramento, who is working with the USGS to research groundwater and heat flow near Mammoth Lakes for her senior thesis; Jennifer Kurashige of Cal Poly Pomona, who will sample springs in the San Gabriel mountains; and Adam Hawkins, who is studying the use of fiber optic probes for measuring temperatures in geothermal systems. The scholarship fund has also sponsored student attendance at GRA conferences and dinner meetings for 45 students from five universities in northern California.

GRA's Program is encouraging the students of today to study groundwater issues important to our mission in order to become the groundwater professionals and GRA members of tomorrow. Your contribution to the GRA-WEF Scholastic Fund Program can help us achieve this goal. Please consider making your contribution today. The GRA Home Page will lead you to the secure donation web site (http://grac.org/scholasticfund.asp). It's just one click to further groundwater education in California!

Sacramento Branch Meeting 2011 Scholastic Fund Sponsors:

- Advance Field Systems
- BC Laboratories, Inc.
- Blaine Tech Services
- California Laboratory Services
- EnviroTech
- Fugro West, Inc.
- Gregg Drilling & Testing, Inc.

San Francisco Branch Meeting 2011 Scholastic Fund Sponsors:

- Accutest
- BESST Inc.
- Blaine Tech Services
- Confluence Environmental Field Services
- Gregg Drilling & Testing, Inc.
- Kiff Analytical
- RSI Drilling
- WDC Exploration & Wells

Southern California Branch Meeting 2011 Scholastic Fund Sponsors:

- American Integrated Services
- Kennedy-Jenks
- Regenesis
- Miscellaneous service providers
- Southern California Branch

San Joaquin Valley Branch Meeting 2011 Scholastic Fund Sponsors:

- Meeting Attendees

Lists of individual donors have been included in previous editions of *HydroVisions*, and future editions will list more recent donors.

GRA Requests Nominations for the 2012 "Lifetime Achievement" and "Kevin J. Neese" Awards

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

1. To provide recognition to individuals who have demonstrated leadership and continuous dedication in groundwater hydrology
2. To provide recognition for unique contributions to groundwater hydrology in 2011–2012.

All nominations for the Lifetime Achievement and Kevin J. Neese Awards must be received by David W. Abbott (dabbott@dbstephens.com or 607 Chetwood Street, Oakland, CA 94610-1433) no later than **Friday, June 22, 2012**.

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

The GRA Awards will be presented to the recipients selected by the GRA Board of Directors during the 21st Annual Meeting in Rohnert Park, Sonoma County, CA, October 4-5, 2012.

Awards

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

Previous Lifetime Achievement Award recipients include:

2011 - Joseph C. Scalmanini

2010 - Dr. John A. Cherry

2009 - Dr. T.N. Narasimhan

2008 - Dr. Perry L. McCarty

2007 - Dr. Herman Bouwer

2006 - Glenn A. Brown

2005 - Dr. Luna P. Leopold

2004 - Dr. John D. Bredehoeft

2003 - Rita Schmidt Sudman

2002 - Thomas W. Dibblee

2001 - Carl J. Hauge

2000 - Dr. Joseph H. Birman

1999 - Dr. David Keith Todd

1998 - Eugene E. Luhdorff, Jr.

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

Previous Kevin J. Neese Award recipients include:

2011 - Sacramento County Environmental Management Department Abandoned Well Program for their leadership in successfully developing and systematically implementing a county-wide program to identify and inventory abandoned wells, believed to be the first of its kind in California.

2010 - Senator Fran Pavley for leadership in the enactment of the comprehensive, statewide groundwater level monitoring legislation in California.

2009 - USGS Water Resources Science Center for the recently completed report titled "Groundwater Availability of the Central Valley Aquifer" USGS Professional Paper 1766.

2008 - Orange County Water District for its Groundwater Replenishment System (GRS), a new water purification plant that produces 70 MGD of near-distilled-quality water each day.

2006 - Senator Sheila Kuehl for her work to improve the production and availability of information about the state of our groundwater resources, information on which reasonable and sensible groundwater management may be developed.

2004 - California Department of Water Resources for publication in 2003 of its updated Bulletin 118: "California's Groundwater".

2002 - Glenn County Water Advisory Committee for formulating a significant groundwater management ordinance that was adopted by the Glenn County Board of Supervisors.

2001 - American River Basin Cooperating Agencies and Sacramento Groundwater Authority Partnership for fostering the understanding and development of a cooperative approach to regional planning, protection and management of groundwater.

2000 - Board of Directors of the Chino Basin Watermaster for delivering a remarkable OBMP that created a consensus-based approach for making water supplies in the Chino Basin more reliable and cost effective.

1999 - Governor Gray Davis for his work and leadership in addressing MTBE.

GRA Welcomes the Following New Members

NOVEMBER 30, 2011 – FEBRUARY 21, 2012

Abreau, Joe	Pacific Surveys, LLC
Adams, Katrina	Treadwell and Rollo, A Langan Company
Adams-Lowe, Shirley	Jacobs/TYBRIN Corp/Delpi Research Inc.
Anderson, Timothy	Sonoma County Water Agency
Angius, Robert	Alpha Analytical Inc.
Brown, Damon	Stantec Consulting
Bunn, Amoret	Pacific Northwest National Laboratory
Byler, Tess	Hydrometrics Water Resources Inc.
Cao, Oanh	McCampbell Analytical
Carter, Caroline	
Choate, Leslye	Sonoma County Environmental Health
Christensen, Kent	Ducommun AeroStructures
Conti, Edward	Integral Consulting Inc.
Cook, Jeremy	Siemens Water Technologies
Day, Dan	V&A
Driscoll, Trey	Dudek & Associates, Inc.
Elliott, Mark	City of Sacramento
Epple, Eric	ARCADIS
Escobar, Mauricio	Roux Associates, Inc.
Farley, Stephen	CH2M HILL
Fram, Miranda	U.S. Geological Sruvey
Fruciano, Edana	Alpha Analytical Inc.
Gardner, Randy	Alpha Analytical Inc.
Ghinani, Mahmood	URS Corporation
Goltz, Ian	
Hanks, Audra	California Regional Water Quality Control Board
Henry, Dave	Wayne Perry, Inc.
Hewitt, Caitlin	Haley & Aldrich
Hodson, Judie	Woodward Drilling Co.
Holder, Jason	Fitzgerald Abbott & Beardsley, LLP
Horn, Christine	McCampbell Analytical
Houser, Matt	Blaine Tech Services
Hundt, Stephen	University of Arizona, Hydrology and Water Resources
Jacobs, Olivia	Clearwater Group
Jordan, Greg	North Coast Laboratories, Ltd.
Judy, Tom	QED Environmental Systems
Kirnan, Tarah	
Kohnke, Michael	Shell Global Solutions
Kruck, Emil	Horizon Environmental, Inc.
Lafferty, Mark	Chevron
Leiter, Adam	Wayne Perry, Inc.
Magee, Brian	ERM-West Inc.
McCarthy, Thomas	MWH Americas
Mendoza, Laura	Wayne Perry, Inc.
Mendoza, Meg	Erler & Kalinowski, Inc.
Miller, Jennifer	Vista Analytical Laboratory
Najm, Issam	WQTS, Inc.
Nelson, Rob	Clearwater Group
Newman, James	
Pantoja, Mark	TechLaw, Inc.
Plett, James	AQI-VER, Inc.
Price, Sarah	Ninyo & Moore
Provance, David	Johnson Wright, Inc.
Ridder, Michael	Pacific Surveys, LLC
Robins, Todd	Sher Leff LLP
Robrock, Kristin	Exponent
Rodriguez, Jenna	UC Davis
Rodriguez, Noah	Chico State University
Sarmiento, Diane	CH2M HILL
Scalmanini, Jenna	Luhdorff & Scalmanini C.E.
Schlegel, Brandon	Horizon Environmental, Inc.
Schumacher, Michael	Pacific Surveys, LLC
Shultz, Mike	AECOM
Sidhu, Harry	TestAmerica
Simantob, Shayan	Ami Adini & Associates, Inc.
Sison, Ted	SCS Engineers
Smith, Julie	CSU Sacramento
Spiszman, Jacalyn	California Department of Toxic Substances Control
St.Clair, Stuart	URS Corporation
Steiger, Michael	Erler & Kalinowski, Inc.
Stuart, Steven	Dudek & Associates, Inc.
Sullivan, Kevin	PG&E
Sultan, Rachel	
Tracy, Andrew	
Tseng, Nancy	UCLA
Van Natta, Monica	UL, LLC (Underwriters Laboratories)
Van Vlear, John	Voss, Cook & Thel, LLP
Whalen, Brian	Sierra West Consultants, Inc.
White, Paul	Sierra Tech Services
Wieland, Denise	
Wilder, Arron	Clearwater Group
Williams, Susan	County of Sacramento

2012 Contributors to GRA – Thank You

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2012 Directors Election Results

The election for GRA's 2012 Board of Directors is officially completed. Board incumbents Ted Johnson, Vicki Kretsinger, Brian Lewis, Emily Vavricka and David Von Aspern were re-elected, and Abigail McNally was elected as a new director.

Jean Moran and William ("Bill") Pipes retired from the Board at the end of 2011. Jean served for six years and Bill served for eight years on the Board. GRA extends its sincere appreciation to Jean and Bill for their dedicated service.

Continue GRA's Success Into Its 21st Year By Renewing Your Membership!

It's not too late to renew your GRA membership for 2012. You can renew online via GRA's Web site, www.grac.org, or you can request a hard copy dues renewal invoice from Kevin Blatt at dbadmin@grac.org. To save time and effort, GRA recommends that you renew online as the process is secure and seamless. It will also help GRA to keep related expenses to a minimum.

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

GRA Extends Sincere Appreciation to the Co-Chairs and Sponsors for the February 2012 Symposium *Compounds of Emerging Concern in Groundwater*

CO-CHAIRS

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Dr. Rula Deeb, ARCADIS U.S., Inc.

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Sacramento

By Troy Turpen,
Branch Secretary

The Sacramento Branch did not hold a meeting in October to encourage members to attend the Biennial Groundwater Conference and 20th GRA Annual Meeting, held in Sacramento.

November's speaker was Casey Meirovitz of Luhdorff and Scalmanini who presented *Hydrogeology in a Mixed-Up World: The Importance of Considering Geologic Heterogeneity in Evaluating Groundwater Flow and Groundwater/Surface Water Interactions*. A growing body of research has shown that geologic heterogeneity can have a significant influence on groundwater flow, transport, and groundwater/surface water interactions. An investigation into the depositional setting of the Cosumnes River and greater southern Sacramento County was presented as a case study. As one of the last undammed rivers in California, the Cosumnes River has received considerable attention from the scientific community. Of particular interest has been declining flows in the late summer to early fall, which restrict fall run Chinook salmon migration. Over a half century of groundwater level decline has caused the surrounding water table to drop well below the river channel. An in-depth hydrostratigraphic analysis of the local and regional geologic setting of the Cosumnes River suggests that (1) the local groundwater system was formed by the glacially-dominated American River fan and the non-glacial Cosumnes River fan; (2) the migration of the American River to the south has left deep, coarse-grained, incised valley fill deposits in what would otherwise be considered Cosumnes fan sediments; (3) these incised valley fill deposits influence groundwater/surface water interactions along the Cosumnes River; and (4) these deposits may present an opportunity for the enhanced management of fall flows in the Cosumnes River benefiting fall run Chinook salmon migrations.

The December meeting was the annual joint holiday meeting with the Sacramento Chapter of the Association of Environmental and Engineering Geologists, and featured Ms. Amber Kuss, Assistant Center Lead for the NASA Ames DEVELOP Program. Under this program, students and young professionals work on earth science research, are mentored by science advisors from NASA and partner agencies, and share their results with local communities. Ms. Kuss presented *Groundwater Storage Estimates Using GRACE Satellite Data, a Hydrological Model, and Groundwater Levels in California*.

To effectively manage groundwater resources in California's Central Valley, managers require good estimates of groundwater storage changes over time. Under current California law, well owners are not required to report groundwater extraction rates, making estimation of groundwater extraction difficult. This study explored the use of remotely sensed data for deriving groundwater storage estimates. The Gravity Recovery and Climate Experiment (GRACE) is a pair of satellites that measure gravity anomalies on earth to estimate changes in total water storage (TWS). From 2002–2009, GRACE was used to measure changes in TWS for the Sacramento and San Joaquin River Basins. Additional hydrologic components were used to calculate groundwater storage changes, including soil moisture, snow pack, and surface water storage. These results were compared with those from two tools used by the California Department of Water Resources (DWR), the Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Geographical Information System Change in Storage Tool (GIS CST). At the Central Valley aquifer scale, it was found that groundwater storage estimates were comparable for GRACE (-21.63 ± 3.54 km^3) and C2VSIM (-17.56 ± 2.63 km^3). However, the GRACE processing methods can produce drastically different results, and recent studies suggest that error estimates of GRACE data for the Central Valley may be increased. Furthermore, the GIS CST (used only in the Sacramento River Basin) produced results that varied significantly from both GRACE and C2VSIM. While the use of GRACE has provided large-scale estimates of groundwater storage necessary for water resource management, this work also underscores the need for higher resolution satellite data that are applicable to smaller scales.

San Francisco

By Jacob Gallagher
Branch Secretary

Each year the Regional Water Quality Control Board's regulatory update is the highest attended meeting for the San Francisco Branch; this year was no different, and we're off to a fantastic start. Stephen Hill brought everyone up to date on changes within the Board's organization, and presented accomplishments for 2011, and goals for guidance, policies and plans for 2012. Alec Naugle discussed the current state of the Board's DOD program.

The state budget continues to have an impact on the Board's activities. Twenty percent of their budget comes from the general fund, thus resources available to focus on low priority and new sites have been reduced. A bright spot is that Region 2 is hiring again after several years of staff attrition. Mr. Hill mentioned that Region 2 will be focusing efforts on PCB site cleanups going forward. This focus is being driven by current PCB levels in the bay and storm water, and fish advisories. Actively identifying upland PCB sites to control runoff will be emphasized.

Once again the ongoing effort to update Environmental Screening Levels (ESLs), particularly for vapor intrusion levels, was a hot topic. The finalization of changes has been stalled, so 2008 levels remain in effect for the time being. An external workgroup meeting and backfilling the vacant toxicologist position remain hurdles to the finalized update.

Mr. Hill outlined the much anticipated Low-Threat UST Case Closure Policy's General and Media Specific Criteria. The Policy is very close to adoption; CEQA and Scientific Peer Reviews are currently in progress. Following public comment and hearings, the Board hopes to adopt the policy in 2012. The CA Office of Administrative Law still needs to provide input as well.

Although the Board's DOD program has been in place for over 20 years, this was the first time it was presented during the annual regulatory update Branch meeting. The Region 2 program covers 179 groundwater plumes at 418 active cleanup sites across 40 facilities. Of those plumes, 75% are in remediation (32% active, 43% passive). The program boasts several important successes: namely, 42 of 44 landfills have been closed, and half of the total DOD land has been transferred (as of 2010). Several prime real estate portions of various facilities enjoyed "early transfer," although this type of transfer is less common recently, mostly due to legal and insurance challenges.

The Branch thanks Cascade Drilling, the scholastic sponsor.

Southern California

By Emily Vavricka,
Branch Secretary

In November, Adam Hutchinson of the Orange County Water District (OCWD) presented the OCWDs recharge activities. As part of its responsibility for managing the groundwater basins that provide most of northern and central Orange County's drinking water, OCWD maintains one of the most advanced managed aquifer recharge systems in the world. This water replaces groundwater that is pumped from about 400 wells belonging to local water agencies, cities and other groundwater users.

Mr. Hutchinson's presentation included a review of historical recharge performance, changing sources of recharge water, water conservation at Prado Dam, and impacts of recharge with highly treated recycled water from the Groundwater Replenishment System. Recharge primarily occurs through (1) recharge basins, mostly former gravel mining quarries; and (2) seepage from the Santa Ana River. Mr. Hutchinson pointed out that, although intuitively one would think that deeper pits are better for recharge, OCWD has found that shallower pits are easier to maintain and are preferable. Silting-up of the bottom of all recharge areas presents a major cost and scheduling challenge. Mr. Hutchinson discussed efforts underway to increase

facility performance and provided an assessment of alternative recharge methods. Ongoing basin clogging projects include the removal of sediments through the use of cloth filters and riverbed filtration. Alternative recharge methods he discussed included subsurface recharge galleries and transfer wells, both of which aim to convey shallow groundwater to a deeper aquifer that has a lower water level. This approach would ultimately increase capacity in the shallow aquifer for more surface-water recharge. Mr. Hutchinson also provided a benefit/cost ratio and sensitivity analysis to give GRA members a sense of what the cost savings are from recharge activities compared to purchasing water.

The GRA Southern California Branch would like to thank the meeting's scholastic sponsor, American Integrated Services.

San Luis Reservior

Nestled in the grassy foothills of the Diablo Range and western San Joaquin Valley near historic Pacheco Pass, the San Luis Reservoir is an off-stream artificial lake that stores water taken from the San Joaquin-Sacramento River Delta. Completed in 1967, the 12,700-acre reservoir is a joint use federal-state facility, being a part of both the Central Valley Project (Delta–Mendota Canal) and California State Water Project (California Aqueduct). Depending on water levels, the reservoir is up to nine miles long from north to south, and five miles wide. At the eastern end of the reservoir is the San Luis Dam, or the B.F. Sisk Dam, the fourth largest embankment dam in the United States, which allows for a total capacity of over 2,000,000 acre-ft. The San Luis Reservoir is the largest off-stream reservoir in the United States. Water is pumped into the reservoir during the wet season (October through March) and released into the conveyance facilities during the dry season (April through September) when demands are higher.

San Luis Reservoir State Recreation Area is noted for boating, fishing, board sailing, camping, and picnicking. The California Department of Water Resources operates a visitor center at the Romero Overlook along Highway 152, which provides information on the reservoirs and water projects.

For additional information about San Luis Reservoir State Recreation Area refer to http://www.parks.ca.gov/?page_id=558. For additional information about Pacheco State Park refer to http://www.parks.ca.gov/?page_id=560.

Photograph by John Karachewski, PhD (DTSC)
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