GROUNDWATER RESOURCES ASSOCIATION OF CALIFORNIA

HYDRO VISIONS

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Managed Aquifer Recharge in the Urban Environment: Technical and Policy Challenges

Summary of GRA Symposium held May 22-23, 2013

By Tim Parker with an introduction by Peter Dillon, CSIRO

Overall Impressions
by Peter Dillon, CSIRO

Dr. Peter Dillon, CSIRO Land & Water, presents the morning keynote on leading research on stormwater management and recharge in Australia

California is a hotbed of technical innovation with a history of over 75 years of successful innovation in groundwater recharge methods in response to severe water challenges. There is a culture of water agencies planning 20 years ahead, facing up to large uncertainty in supply due to climate change and lack of certainty in water entitlements and various approval processes. This horizon allows time for development of highly creative solutions by utilities that actively seek out and engage with a gifted pool of researchers from a number of universities and government agencies. California has an interesting dichotomy of exceptionally high levels of protection for groundwater quality yet no protection of groundwater quantity state-wide. In this lawyers' paradise, there are adjudications on water sharing in 23 basins that require court rulings for changing allocations. Groundwater levels in many southern basins are in decline and the extent of innovation and investment by utilities, in the absence of state-wide policies to secure water resources, is paradoxical. This speaks volumes for the pioneering spirit in this frontier state that should be watched closely by utilities around the world. This symposium benefited from the participants of ReNUWIT (Reinventing the Nations Urban Water Infrastructure), a partnership between academics and industry that includes the role of groundwater recharge in urban areas as a means of bridging stormwater management and aquifer replenishment. In California, this has been given a boost from permitting of

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High Resolution Tools and Techniques for Optimizing Groundwater Extraction for Water Supply

Summary of GRA Symposium held June 19, 2013

By Rob Gailey, Noah Heller, Mike Vivas, and Roy Herndon

The sixth symposium in GRA's *Series on Tools and Technologies* was held on June 19, 2013 in Garden Grove, California. This symposium focused on application of high resolution methods to improve the performance of water supply wells with respect to the quantity and quality of produced groundwater. The one-day set of eleven oral and four poster presentations was organized by a committee that included **Chris Bonds** of the California Department of Water Resources (DWR), **George Chien** of the California Department of Public Health (CDPH), **Murray Einarson** of Haley and Aldrich, **Rob Gailey** of The Source Group, **Carl Hauge** of DWR (retired), **Noah Heller** of BESST, **Roy**

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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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GRA's Legislative Advocates Are Key to Our Success

By Sarah Raker

GRA's Annual *Legislative Symposium and Lobby Day*, held April 24, 2013 in Sacramento, was a huge success! As described in greater detail in Tim Parker's article in the summer 2013 issue of *HydroVisions*, speakers addressed California's increased need to develop its water, gas, and energy supplies and protect our valuable groundwater resource in the process. Thanks to GRA's legislative advocates, the event was very well conceived and well managed. Speakers were diligently plucked from their busy schedules at the Capitol and escorted to the Citizen Hotel with minutes to spare for their presentations. State legislators and government officials held our attention all day with dynamic presentations covering controversial topics followed by lively discussions. We met freshman members who expressed their commitment to learn more about how groundwater issues are impacting their districts and their need for GRA to educate them about this precious resource. GRA's legislative advocates will play a fundamental role in their education.

Chris Frahm of Brownstein Hyatt Farber Schreck has been GRA's leading Legislative Advocate for 13 years. Chris works closely with key policy leaders and decision-makers to support development of sound water law and policy. Chris' team includes Rosanna Carvacho and Greg Wesley, who are part of Brownstein's government relations group; they are both highly experienced in navigating the California Legislature and the state's complex government agencies. In addition to organizing GRA's Annual Legislative Symposium and Lobby Day, Chris and her team serve in several major roles to help GRA accomplish its mission.

The legislative advocates educate legislators, agencies and the Governor's office and staff about groundwater issues of significance and pursue the passage or defeat of all legislation identified as a priority by GRA. How are GRA's legislative priorities identified? GRA's Board Policy Principles and Legislative Guidelines, adopted by the GRA Board and Legislative Committee, guide GRA's legislative advocates when they evaluate proposed legislation that may affect GRA and/or its members. As described in the policy, "Legislation that meets or fails to meet the principles set forth in the Guidelines may be supported or opposed by the GRA Legislative Committee, accordingly. Legislation that does not appear to meet the principles set forth in the Guidelines or that has complex or varied implications will continue to be presented to GRA's Board of Directors and Legislative Committee in advance of any position being taken." Please go to GRA's website for details on GRA's specific guidelines and legislative process: http://grac.org/legislation.asp.

Once legislation is identified, the legislative advocates work closely with GRA's Legislative Committee, chaired by Tim Parker, to prepare letters of support or opposition, and to advocate GRA's positions on issues in legislative hearings and forums, with the Governor's office, and by visiting legislators and staff. Recent efforts have included: comments to the Chairman of the Assembly Water, Parks & Wildlife Committee on Proposed Policy Principles for Developing a Water Bond; support for the specific provisions of AB 69 (Perea) that deal with groundwater monitoring; opposition (unless amended) to AB 145 (Perea), legislation that would transfer the entire California Drinking Water Program from the Department of Public Health to the State Water Resources Control Board; comments on California Department of Conservation Division of Oil, Gas, and Geothermal Resources' pre-rulemaking discussion draft regulations on hydraulic fracturing; support for SB 620 (Wright) that removes the statutory limited on the Water Replenishment District's annual reserve fund; support for SB 658 (Correa) that helps clarify Orange County Water District's ability to do cost recovery for groundwater remediation activities; and presentation to the Science of Storage Hearing, Select Committee on Regional Approaches to Addressing the State's Water Crisis.

Chris and her team also track bills of interest, coordinate GRA's monthly Legislative Committee conference calls, prepare reports to the GRA membership through California's Legislative Update in *HydroVisions*, and report directly to

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GRA's Legislative Advocates Are Key to Our Success – *Continued*

the GRA Board and its members during GRA's Annual meetings. I highly recommend you attend the latter, which will include a concise snapshot of the key groundwater issues facing California today. You'll laugh. You'll cry. But mostly you'll be amazed that anything gets accomplished in government. At least we can rely on our legislative advocates to keep groundwater issues at the forefront of the conversation.

I recently spoke with Chris about how to keep the conversation going in Sacramento given the revolving door and challenges of term limits. She says the process has really changed over the years as a result of term limits, including fewer policy hearings and less time to educate legislators. There is also, increasingly, a lot of misinformation on the internet and elsewhere that makes deliberation of complex groundwater issues even more complicated. Locals are passionate about their water supply during these times of increased groundwater use, cost to the consumer, and accountability expected on the part of water suppliers.

Based on her past experience, Chris is very excited that the recently-elected legislators could be in office for 12 years under the new term limits. Of the 47 new members sworn in for the 2013-2014 session, 39 are freshman—the largest freshman class since 1966. Chris is enthusiastic about educating them on groundwater issues so we can protect this resource, and develop much-needed long-term solutions to California's water supply challenges.

My special thanks to Chris, Rosanna, and Greg for all their hard work as GRA's legislative advocates!

Cheers – Sarah Raker,
GRA President

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this process under municipal separate storm sewer systems (MS4).

Managed Aquifer Recharge: Technical, Policy and Regulatory Challenges – *moderated by Andrew Fahlund, Executive Director of Stanford's Water in the West Program*

Richard Atwater, Exec. Dir., Southern CA Water Committee, discussed stormwater capture opportunities in southern California. He showed a probability exceedence diagram for the last 20 years with harvested stormwater ranging from 200,000 to 1,000,000 AFY (median of 395,000 AFY) in the Metropolitan Water District service area, where the available groundwater storage capacity was 3 MAF. He showed evaluations done at various scales, including rain barrels (tanks), micro-ecosystems (rain gardens), power-line easements used for recharge basins, and adjustments to upstream flood-control dam (Whittier Narrows) operating rules to allow releases for increased recharge. These demonstrated very strong economies of scale, with large-scale basins yielding 10,000AFY at $125/AF, whereas some micro-scale systems approached $1,000,000/AF. Capital investments have been estimated at $1.2B with annual operating costs of $10 to $15M to achieve an additional 200,000 to 300,000 AFY. This yields an approximate cost of $400/AF, compared to about $1,000/AF for imported water.

Ted Johnson, Chief Hydrogeologist of the Water Replenishment District of Southern California (WRD), presented *75 Years of Managed Aquifer Recharge in Southern California*. With dramatic population growth and increased pumping in the early 1900s, the Los Angeles Coastal Plain sustained over 150 feet in groundwater-level declines from 1935–1960, accompanied by seawater intrusion along the coast and inland.

MAR opening session panel with Tim Parker, Parker Groundwater, discussing MAR policy, regulatory challenges and possible solutions

Los Angeles County built spreading grounds and seawater barrier wells; the WRD was formed in 1959 by local vote to eliminate pumping overdraft; and the Court adjudicated pumping rights, but at levels higher than the natural basin yield. Spreading water sources include rainfall (54,000 AFY), recycled water (50,000 AFY), and imported water (21,000 AFY). Seawater-barrier water sources include potable water (10,500 AFY), and advanced-treated recycled water (17,500AFY). The current and future significant challenges for WRD include (1) loss of imported water due to drought environmental factors, (2) predicted reduction in stormwater opportunities from climate change, and (3) increased competition for recycled water. To address these challenges, WRD developed the Water Interdependence Now (WIN) program for gaining independence from imported water supplies through replacement with recycled water and stormwater capture, which will decrease demand by up to 34,000 AFY on the Delta and Colorado River. The WIN is a collection of 6 solo or partnered regional and local-scale projects, from expanding spreading for stormwater capture to increasing recycled water production. WIN will cost about $200 million, but is necessary to maintain local groundwater resources.

Bruce Phillips of PACE Advanced Water Engineering described a *Watershed Infiltration and Hydromodification Management Plan* (WIHMP) that considers the whole catchment and uses an interactive GIS tool to link information on soil, aquifers, depth to water table, pollution plumes, etc., to maximize the groundwater benefits and avoid problems. It considers the local hydrologic cycle before and after development to estimate cumulative impacts in planning, and aims to design systems that mimic pre-development water management volumes and quality. Results showed that small-scale low-impact developments (LIDs) were relatively inefficient on their own and that achieving balances over a larger scale would be more economical. New MS4 Stormwater Infiltration Permit requirements present compliance challenges, including physical limitations of sites for infiltration, maximizing water benefits, and as-yet unknown maintenance requirements to assure long-term effectiveness.

Tim Parker, Principal of Parker Groundwater, described legal and regulatory challenges and options for

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change in MAR policy. He described impact of climate change on the future snow pack, and ongoing storage depletion in aquifer systems, as key drivers for MAR. About 60MAF of storage depletion has occurred in 40 years in the Tulare Basin. The other side of the coin is that this creates storage space in aquifers for MAR. There are 23 adjudicated basins where courts decide on adjustments to allocations, and 4 special districts where negotiated agreements exist. California has about 118 groundwater management plans covering only about 20% of the state. To receive state money a plan is required. There is a need to create an inventory of groundwater replenishment, and the use of this water, e.g., for baseline supplies or for drought and emergency-supply reserves. We have information on groundwater quality degradation – trace elements are widespread (As, B, Cr, Mn, U), as is nitrate. For aquifer augmentation with potable water, the State Water Resources Control Board has developed a state-wide process that requires a waste discharge permit, even though the water may be recovered for drinking supplies. Ownership of source water and recharged water is contestable, with many agencies involved. Tim recommended raising the bar on groundwater management, raising the profile of groundwater in the state and federal government, and aligning mandates and policies in permitting.

Design, Optimization, Instrumentation and Monitoring of Managed Aquifer Recharge Systems – *moderated by Thomas McCarthy, MWH Global*

Hybrid Managed Aquifer Recharge Systems: Enhancing the Removal of Chemicals of Emerging Concern? was given by **Julia Regnery**, NSF Engineering Research Center, ReNUWIt, Colorado School of Mines. The study focuses on engineering natural treatment systems, and includes the design and operation of MAR systems, such as riverbank filtration and soil aquifer treatment, by developing an understanding of the boundary conditions, developing laboratory and field-scale data on removal rates for chemicals of emerging concern (CECs), and utilizing contaminant transport models. Results suggest that 'starved conditions' characterized by low BDOC result in high decay of CECs, and sequential aquifer recharge and recovery induces enhanced removal kinetics.

Orange County Water District's *Sustainable Managed Aquifer Recharge System Design* was discussed by **Adam Hutchinson** of OCWD. Planning and designing a sustainable MAR system requires clarity of purpose and information to draw upon. OCWD has moved from deep recharge basins, which can provide storage, flood protection and recreation, to shallower basins for ease of maintenance (draining and cleaning). All recharge facilities clog; thoughtful design must address clogging prevention and cleaning. Low-impact development (LID) best management practices (BMPs) mimic or preserve natural drainage processes to manage stormwater and include: surface infiltration basins, infiltration trenches, bioretention and planters, dry wells, permeable pavement, subsurface infiltration galleries, and rain gardens. It remains to be seen how well LID BMPs are designed to address clogging.

New Directions of Restoration and Enhancement of Groundwater Recharge in Urban Environments Using Highly Distributed Real-Time Control, the longest presentation title at the symposium, was presented by **Marcus Quigley**, Principal Brookline. The purpose of this research was to find the least expensive, most flexible means for monitoring and controlling the physical environment using integrated, dynamic real-time data streams. Examples included the OptiRTC service platform of NOAA and USGS for internet-based weather and other data sources. He concluded that the merging of informa-

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Visitors from Mexico and a local enjoy dinner at the MAR Symposium – from left to right: Dr. Herrera, Center for Research in Advanced Materials (CIMAV), Chihuahua, Mexico; Carmen Julia Navarro, The Water Utilities of Cuidad Juarez (JMAS), Chihuahua, Mexico; Dr. Fernando González, Engineering Institute, National Autonomous University of Mexico (UNAM), Mexico City, Mexico; Adriana Palma Nava, Engineering Institute, UNAM, Mexico City, Mexico; and Edwin Lin, Todd Engineers, California.

Managed Aquifer Recharge in the Urban Environment: Technical and Policy Challenges – *Continued*

Enjoying the MAR Reception and posters are left-to-right, Rosemary Knight of Stanford University, Beth Lamb of North Coast Regional Water Quality Control Board, and Sarah Raker of AMEC Environment & Infrastructure, Inc. & GRA President.

tion technology and infrastructure will be increasingly important in the future, and that low-cost, reliable, and highly functional sensors will transform regulation, enforcement, and our understanding of environmental systems.

Andy Campbell of Inland Empire Utilities Agency provided an overview of *Multi-Agency Communication in the Operation of a Regional Recharge Program* in the Chino Groundwater Basin, involving San Bernardino County Flood Control District, the Chino Basin Watermaster and Water Conservation District, and IEUA. The Chino Groundwater Basin is a 500–1000 foot thick alluvial basin with approximately 5 MAF total storage, a production of 150–190 TAF and a safe yield of approximately 140TAF (excluding MAR). Agreements between the parties specify the operation and maintenance of five treatment facilities, a compost facility, a groundwater desalter, and 19 recharge facilities using stormwater and recycled water for aquifer replenishment.

Regional Water Quality Changes from Recycled Water Recharge: Central and West Coast Basin, presented by **Edwin Lin** of Todd Engineers, focused on the Salt and Nutrient Management Plan (SNMP) prepared for the Water Replenishment District of Southern California. The SNMP encompasses the West Coast and Central Basins, which include high-density urban land use, multiple water sources (groundwater and imported water), municipal irrigation (groundwater, imported and increasing recycled water), and MAR (stormwater, imported and increasing recycled water). The hydrogeology is well characterized due to adjudication, replenishment efforts and 50 years of active management. The main change in future water sources is the ongoing increased supply of tertiary and advanced-treated recycled water; this is projected to reduce salt loading. The SNMP indicates that assimilative capacity thresholds and Basin Plan Objectives will not be exceeded under projected future loading conditions, which incorporates future improvements in the West Coast Basin.

Stanford Geophysics Professor **Rosemary Knight**, acknowledging her co-author **Adam Pidlisecky**, University of Calgary, presented *A Tale of Two Recharge Ponds*, focused on Harkins Slough Recharge Pond, Watsonville, CA (operated by Pajaro Valley Water Management Agency), and the Prarie Waters Project, Aurora, CO. The challenge investigated on the Harkins Slough Recharge Pond was that recharged water did not appear to be reaching the 12 recovery wells near the pond, and infiltration was decreasing with time. Three near-surface electrical conductivity probes were installed to 70mm to help measure infiltration rates, followed by shallow seismic acquisition, CPT survey, and installation of deep conductivity probes. Results revealed a thin, laterally-extensive clay layer above the screen of the recovery wells, indicating mounding and lateral movement of recharge water. The geophysical data will be incorporated into flow-model calibration. The tale of Prarie Waters Project involves the capture of river water (80% treated wastewater), infiltration into soil-aquifer-treatment cells, followed by recovery and final treatment for potable supply. The challenge is low recovery rates (about 20%). Electrical resistivity surveys and conceptual modelling using drillers' logs and Petrel revealed clayey materials in the shallow subsurface and limited sands, explaining the poor recovery rate.

An evening reception was followed by dinner and a presentation by **Dr. Peter Dillon** of CSIRO Land and Water on *Managed Aquifer Recharge in Australia: Drivers and Progress*. From the Australian perspective, MAR in the US is characterized by extensive entrepreneurial endeavour and forward thinking, many large projects with long track records, water banking a reality for drought supplies, and regulations on water quality for MAR that appear to regard aquifers

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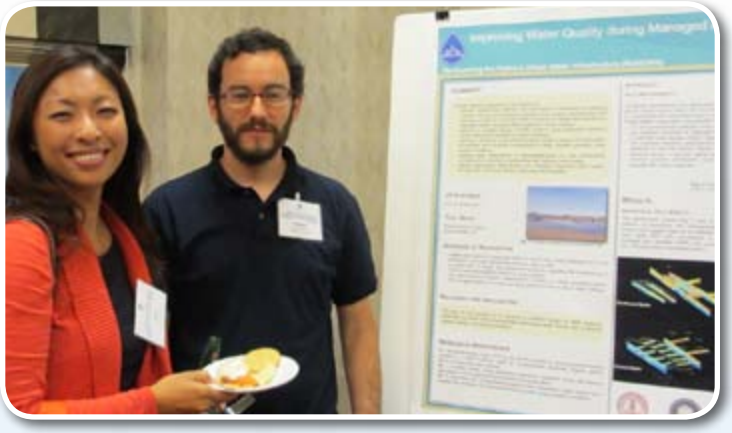
as inert. In Australia, urban MAR is just emerging, water banking is not embraced, national strategies and initiatives that address risk-based water-quality management and water-resources sharing are in place, and preliminary results of guideline applications show promise for MAR success. Drivers for MAR in Australia include increased water storage and security, low-cost water supply, aquifer replenishment, seawater barrier, avoidance of evaporation and vector issues, turning wastewater into a resource, and improving supply reliability and public confidence. Currently, Australian urban MAR projects include stormwater and recycled water, soil aquifer treatment, infiltration galleries with stormwater and recycled water, and amount to less than 20,000 AFY, but have the potential for 325,000 AFY. Australia has developed MAR as a key component of the National Water Quality Management Strategy, for which the ten-year drought Australia experienced was a strong driver to prepare, and has developed MAR Water Resources Policy Framework to address water rights, periodic allocations, and conditions for capture, recharge, recovery and end use. Australia has guidelines and policy framework in place, but has only reached about 5% of its potential; current challenges include funding sources, and competition between natural and engineered systems.

The risk-based approach, *Managed Aquifer Recharge and Stormwater Use Options* national research project, supported by the Australian National Water Commission, Goyder Institute for Water Research, CSIRO, City of Salisbury, Adelaide and Mount Lofty Ranges Natural Resources management Board and United Water International, was the subject of the morning keynote delivered by **Dr. Peter Dillon**, CSIRO. The objectives of this research project are to assess options for stormwater use in Adelaide considering economics, environmental consequences, and community acceptance, resulting in a nationally transferable methodology to expedite the most valued uses of stormwater in a safe and efficient approach. Project components include risk assessment and management options, public understanding and acceptance, net benefits, infrastructure impacts, development of satellite sites and technology transfer. Research in progress includes pathogen fate and microbial ecology evolution in aquifers, hydraulics of flushing, geochemistry, trace organics, net benefits evaluation, social acceptance, pipe biofilm evaluation and disinfection requirements, and development, review and audit of risk assessment and management plans. Conclusions of the more than two years of research, which will be reported by the Goyder Institute of Water Research, are that while MAR with stormwater is already underway in South Australia for non-potable uses, the National Water Quality Management Strategy Guidelines provide methodology and this study provides new information on pathogens and other hazards to allow risk management plans for wider uses, including drinking water.



Amy Kwong of West Yost Associates and Andrew Pidlisecky of University of Calgary enjoy posters and the reception

Stormwater Capture and Managed Aquifer Recharge session – *moderated by Professor David Sedlak, UC Berkeley, and Deputy Director of ReNUWIt*

Stormwater Capture, Treatment and Recharge: An Academic Perspective was presented by Professor **Dick Luthy** of Stanford University and the Engineering Research Center for ReNUWIt, acknowledging his co-author **David Sedlak**. The Center is undertaking research to develop technologies for safe, sustainable urban water infrastructure. Research is being undertaken in natural and engineered systems, and is informed by a deeper understanding of institutional frameworks. Example projects include engineering wetlands for improved water treatment and membrane bioreactors for distributed water treatment. Working in close partnership with utilities, water service providers, equipment manufacturers and international research partners, great ideas are converted into practical and sustainable solutions to problems facing urban water systems.

Professor **Andrew Fisher** of UC Santa Cruz described GIS and other tools for *Identification and Investigation of MAR Project Sites for Use of Captured Stormwater*. His discussion focused on the Pajaro Valley Groundwater Basin, which is in chronic groundwater-level decline due to over-pumping. A regional-scale map of MAR suitability was developed using GIS data on surficial geology, soil infiltration capacity, land use (roughness), and slope, and employing a modified approach for weighting surface and subsurface data in the analysis. He concluded that after completing regional GIS analyses, modelling and field studies can be helpful in

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Neal Shapiro, City of Santa Monica, provides revealing information on the City's extensive LID and stormwater management efforts

further assessing MAR project viability and impacts, and that successful MAR projects require accurate assessment of infiltration properties and site-specific measurements to determine vertical and horizontal flow parameters.

Sustainable Watershed Management of Dry & Wet Weather Runoff in a Highly Urbanized Environment was presented by **Neal Shapiro**, City of Santa Monica. The drivers for the City of Santa Monica to address urban runoff are water-quality impacts to the coastal environment, and peak runoff events that were difficult to control with the past runoff systems. The City developed several objectives, including the harvesting of urban runoff for treatment and reuse, treatment of all dry-weather and some wet-weather runoff, connecting land-use design with hydrology and surface hydraulics, and conversion of waste into a valuable resource. Education, prevention, ordinances, treatment, maintenance, enforcement and funding were required to achieve these objectives. An astounding number of best management practice (BMP) projects have been implemented, including pervious pavement, rain gardens, small and large infiltration facilities, and green roofs and parking facilities. The City also has developed the Santa Monica Urban Runoff Recycling Facility (SMMURF), an operational educational facility that recycles up to 500,000 gallons per day through a rotating drum, grit chamber, dissolved air flotation, microfiltration and reverse osmosis, and UV radiation, and has a waterfall and reservoir.

Keith Lilley of Los Angeles County Department of Public Works presented *Infrastructure Improvements to Enhance Stormwater Capture and Recharge*, which provided a summary of improvements to dam infrastructure and spreading grounds, enhancements to seawater barriers, and increased cooperation with other agencies. Los Angeles Flood Control District owns and operates 14 major dams, 162 debris basins, 500 miles of open channels and 27 spreading facilities. The Big Tujunga Dam improvements included new discharge valves with low-flow capability to supplement streamflow and enhance habitat. Hansen spreading grounds improvements included deepening and consolidation of 20 basins into 6, interbasin structure replacement and rubber-dam system installation. Similar improvements were made at the Santa Anita spreading grounds. Cooperative efforts include the development of an Integrated Regional Water Management Plan, and joint operation of the 290 seawater intrusion barrier wells along the coastal plain.

Where does the Water Go and What Does it Matter Anyway? – *session moderated by Professor Dick Luthy of Stanford University and the Engineering Research Center for ReNUWIt*

Key Factors for a Successful Water Bank, Kern County Water Authority (KCWA) was presented by **Jon Parker**, KCWA General Manager. Located in southern San Joaquin Valley and overlying the Kern River alluvial aquifer, the Kern Water Bank consists of 70 shallow recharge basins averaging 2 feet deep and covering 11 square miles, sitting atop a very productive sand, gravel, and silt aquifer with no extensive clays. Groundwater levels have fluctuated from less than 50 feet below ground surface to nearly 300 ft bgs. There are 84 20-inch-diameter recovery wells averaging 750 feet in depth with 28 miles of piping. The bank recharges an average of 500,000 AFY at an average infiltration rate of 0.3 feet per day, and recovers an average of 240,000 AFY. Key factors in the successful operation of the water bank include physical factors described above and institutional factors, including agreements with other basin and

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Dick Luthy, Stanford and ReNUWIt, presents details of Stanford and ReNUWIt's MAR research

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downstream stakeholders and wildlife agencies, which address operation, mitigation monitoring and permitting. The bank also includes significant environmental benefits and is recognized as one of the top five freshwater wetlands in the state.

The City of Fresno's Urban Aquifer Recharge Program: Past, Present and Future was presented by **Glen Knapp**, City of Fresno Public Utilities. Fresno relies primarily on groundwater for urban water supply, and has approximately 260 supply wells in the urban area. A cone of depression has formed in the Fresno area and groundwater levels have dropped nearly 100 feet from 1930–2010. Fresno has developed goals to help address groundwater-level declines, including balancing the City's groundwater use by 2025, optimizing the use of surface-water and groundwater supplies, MAR, increasing water conservation, and incorporating recycled water use. Fresno has implemented water metering, is encouraging xeriscape landscaping, and has made improvements on their Leaky Acres spreading facilities to address clogging. Leaky Acres comprises 26 ponds averaging 5.5 feet deep on 225 acres, and has recharged 5,000–20,000 AFY since 1985.

When Lawyers Play Engineer, Legal Considerations in Groundwater Banking was the subject of Downey Brand attorney **David Aladjem**. After establishing the need for increasing groundwater storage in California, David provided a comprehensive description of the legal principles and reviewed the case law for groundwater banks, including water rights ownership, agreements, institutional and technical framework, accounting rules and finances. Examples included the Kern Water Bank, adjudications, AB3030/SB1938 groundwater management plans, and integrated regional water management plans.

Attorney David Aladjem, Downey Brand, gives a legal view on MAR

The Luncheon Keynote was delivered by **Fran Spivey-Weber**, Board Member and Vice Chair, State Water Resources Control Board. Ms. Spivey-Weber discussed the understanding of the SWRCB on the importance of groundwater in California's water supply, the need for increased recycled water and the SWRCB Recycled Water Policy, and the necessity for increasing groundwater recharge and storage. The SWRCB is developing a groundwater strategy and will be sharing information on that in the coming months.

Rula Deeb introduces lunch keynote SWRCB Vice-Chair Fran Spivey-Weber

Understanding Local Conditions and the Relationship to MAR – *session moderated by Jim Strandberg, EKI Consulting*

Jay Jasperse, Chief Engineer of Sonoma County Water Agency (SCWA), presented their *Riverbank Filtration & MAR System*. SCWA is a wholesale water supplier to approximately 600,000 people and operates one of the largest riverbank filtration systems, which is located on the Russian River. The riverbank filtration system facilities include 6 collector wells, 7 vertical wells, 5 infiltration ponds, and an inflatable dam, which provides treatment through natural infiltration through alluvial sediments at a peak production capacity of 100 MGD. SCWA has conducted a variety of investigations to assess streambed permeability dynamics, clogging, and pathogen transport, including spontaneous potential surveys; installation and monitoring of seepage meters, sediment traps, and piezometers; cryocores and temperature profiling; and column studies for pathogen transport. Key results have helped to optimize collector-well performance, indicate a high capacity for cryptosporidium removal in shallow aquifer materials, and further demonstrate the riverbank filtration system as a reliable method of providing high-quality potable water from the Russian River.

Intrinsic and Extrinsic Tracers for Tracking Water Quality Changes During Managed Aquifer Recharge was presented by Professor **Jean Moran** of CSU East Bay. In many regions, 3-D characterization of the groundwater regime is limited by coarse well spacing or borehole lithologic logs of low quality. Additionally, for older wells, lithologic logs may not be available, but the wells can be sampled for chemical and isotopic constituents. In these situations, a thorough analysis of trends in chemical and isotopic constituents can be a key component in characterizing the re-

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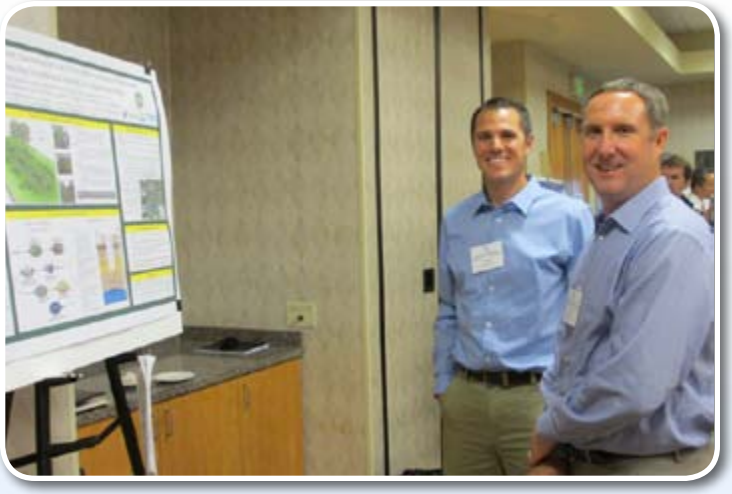
gional groundwater system. On a basin or subbasin scale, especially in areas of intensive groundwater management where MAR is important, introduction of an extrinsic tracer can provide a robust picture of groundwater flow. Dissolved gases are particularly good tracers since a large volume of water can be tagged, there are no real or perceived health risks associated with the tracer, and a very large dynamic range allows for low-level detection of tagged water. Recent applications of extrinsic tracers, used in concert with intrinsic chemical and isotopic tracers (e.g., tritium-helium, sulfur hexafluoride and stable isotopes of oxygen, hydrogen, carbon and nitrogen), demonstrate the power of chemical analyses in interpreting regional flow regimes.



Casey Mierowitz, Luhdorf & Scalmanini, discusses his poster on stormwater management using dry wells with Mark Nordberg, California Department of Water Resources

Ken Minn of East Bay Municipal Utility District (EBMUD) presented *Remote Sensing and Subsurface Exploration of the South East Bay Plain Basin*, which focuses on investigations for the EBMUD's Bayside Groundwater Project aquifer storage and recovery facility. Completed in 2009, the Bayside Groundwater Project is a dry-year supply facility that can store 1 MGD during wet years and recover 1MGD during dry years, with consideration for a future expansion to a 2–10 MGD facility. Local groundwater was a major part of the water supply from the 1860s to the 1930s, when surface water from the Sierra Nevada became available. Studies that form the foundation for the Project, many of which were completed in partnership with the US Geological Survey, include detailed hydrogeology and geochemistry field investigations and aquifer testing, high-resolution seismic reflection and refraction, and subsidence monitoring using a new dual extensometer and remote sensing via Interferometric Synthetic Aperture Radar (InSAR). Results of the studies have provided significant information for design, planning, permitting, coordination and outreach activities, and guide the current and future efforts on the project.

Using Dynamic Modeling to Optimize MAR Operations was presented by **Marcelo Reginato** of CH2MHill. The model developed for Orange County Water District (OCWD) is a planning tool that helps decision makers and operators achieve a better understanding of the system under current conditions, and to optimize the system under future conditions. Based on GoldSim software, the model is demand-driven, where the demand was set to the percolation capacity of the OCWD recharge system, which includes recharge basins, 1,100 wetted areas, 5 diversion points from the Santa Ana River, 8 pump stations and 26,000 AF of storage capacity. Steps to develop the model included defining the system facilities, capacities, and operational rules; defining sources waters; development of percolation equations, water routing parameters and rules; and model validation. The GoldSim model was successfully constructed to simulate the operations of the large, complex OCWD recharge system and provides a powerful tool for evaluating the benefits of a wide variety of potential optimization steps in the future.

MARK YOUR CALENDAR

"Compounds of Emerging Concern in Groundwater"

FEBRUARY 2014
NORTHERN CALIFORNIA

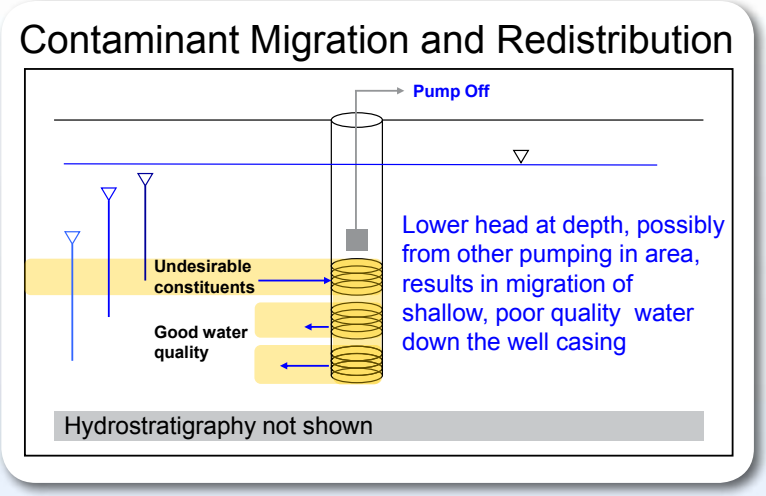
Watch GRA's Web site for program details.

High Resolution Tools and Techniques for Optimizing Groundwater Extraction for Water Supply – *Continued from page 1*

Herndon of the Orange County Water District, **Brian Lewis** of the California Department of Toxic Substances Control (DTSC), **Sarah Raker** of AMEC Environment and Infrastructure, **Jim Strandberg** of Erler and Kalinowski, and **Mike Vivas** of DTSC (retired). The organizing committee worked in cooperation with the DTSC, DWR, CDPH, and United States Geological Survey (USGS). Co-sponsors for the event were AMEC Environment and Infrastructure and The Source Group.

The oral presentations were divided into five sessions plus a lunchtime talk. In the opening session, **Murray Einarson** of Haley and Aldrich presented a historical comparison of the development and use of high resolution approaches for characterizing the subsurface in both the environmental and water resources industries. Mr. Einarson concluded by suggesting that water supply wells of the future may be designed to address much of what has been learned from the application of high resolution methods in recent years.

The second session, *Higher Resolution Data Collection Technology and Data Analysis Techniques*, was moderated by **Dr. John Izbicki** of the USGS, and consisted of two presentations and a panel discussion. **Tony Morgan** of the United Water Conservation District discussed profiling water supply wells under dynamic (pumping) conditions. His focus was on (1) flow profiling using dye tracers and spinner flow meters, and (2) concentration profiling using depth-discrete sampling. Mr. Morgan explained how the various tools worked, provided case examples, and indicated that application of these methods is particularly helpful where economic and political pressures exist. **Noah Heller** of BESST discussed profiling water supply wells under ambient (non-pumping) conditions. His focus was on evaluating the extent to which water supply wells act as vertical conduits for contaminant migration when they are not actively pumped. Mr. Heller identified a variety of tools that could be used to evaluate conduit flow in wells and provided case examples. After the presentations, Dr. Izbicki, Mr. Morgan and Mr. Heller formed a discussion panel. Points made during the preceding presentations were clarified and further explored by the panelists and the audience.



Contaminant migration and redistribution. Rob Gailey, The Source Group, Inc.

The third session, *Water Supply Case Studies – Hydraulics*, was moderated by **Rob Gailey** of The Source Group, and consisted of two presentations. **Yemia Hashimoto** of AMEC Environment and Infrastructure discussed the use of electromagnetic flow meters to perform flow profiling in water supply wells under both pumping and non-pumping conditions. Ms. Hashimoto described the process of flow profiling using this tool and provided case examples that included characterizing variations in horizontal hydraulic conductivity along the well screen. Approaches for surmounting challenges posed by well conditions were also discussed. **Peter Leffler** of Fugro Consultants addressed the interpretation of water-supply-well flow profiling results in cases where groundwater heads vary along the well screen. Case-specific data presented made it clear that where wells are screened across multiple water-bearing zones, flow and water-quality contributions from these zones can be significantly influenced by the groundwater heads present in each zone.

For the lunchtime presentation, **Dr. Izbicki** discussed the use of well-bore flow evaluations in regional groundwater studies. A comparison of electromagnetic flux, heat-pulse flow meter, spinner flow meter and tracer technologies was presented in terms of logistics and testing results. Details related to quality assurance were addressed for the spinner flow meter and dye tracer methods. A variety of case examples was presented that addressed well-screen clogging over time, the effect of heterogeneity in hydraulic conductivity on recovery of injected water, interpretation of basin hydrostratigraphy, identification of strata in which contaminants migrate, estimation of variations in hydraulic conductivity along well screens, and predicting the efficacy of performing well modifications to improve water quality. Dr. Izbicki concluded by suggesting future research topics and emphasizing that one should be prepared to be surprised when conducting a water-supply-well profiling project.

The fourth session, *Water Supply Case Studies – Well Operations and Maintenance*, was moderated by **Mike Vivas** of DTSC and consisted of two presentations. **Don Hanson** of Clear Creek Associates addressed extending the operating life of wells through well-screen and other types of rehabilitation. Several case

Continued on the following page…

High Resolution Tools and Techniques for Optimizing Groundwater Extraction for Water Supply – *Continued*

examples were presented that showed impacts to production wells from a variety of causes, and various approaches for rehabilitating well problems (mechanical and chemical clogging, structural failure and sand intrusion) were discussed. The importance of obtaining baseline data on wells when evaluating and planning well rehabilitation was stressed. **Rob Gailey** of The Source Group covered the use of high-resolution well profiling data to evaluate vertical flow through production wells while they are not actively pumped. Several case examples involving data collected using spinner flow meter, dye tracer and depth-discrete sampling were presented, and the results of groundwater flow and transport modeling were presented to illustrate the potential impacts to groundwater quality in cases where wells act as migration conduits for contaminants. Suggestions for managing the impacts of vertical migration through wells were made, including evaluating flow through casings and gravel packs, making operational or structural changes, and collecting confirmatory information on destroyed wells. It was noted that there are regulations aimed at preventing inactive wells from acting as migration conduits, but that meeting the intent of the regulations may be limited by varying levels of compliance, the level of regulatory enforcement and changes in groundwater conditions.

The final session of the symposium, *Water Supply Studies – New Insights*, was moderated by **Roy Herndon** of the Orange County Water District, and consisted of three case studies on water supply issues related to water quality vulnerability and impacts. **Keith Halford** of USGS led off with a presentation on the characterization and modeling of arsenic impacts to a production well in the Antelope Valley. Arsenic was found to enter the well in specific depth intervals, and well modification through blocking targeted screen intervals appeared to be

Mike Vivas moderates Session 4
Credit: Debra Cerda, BESST Inc.

a viable option for reducing the arsenic concentration at the wellhead. A new aquifer simulation tool (AnalyzeHOLE) was used to assess the potential benefit of modifying the well through evaluation of flow to the well and resulting water quality for scenarios with and without the potential modification. **Dr. Jean Moran** of California State University East Bay presented several examples where tritium-helium age dating analysis in wells can provide a basis for assessing well vulnerability to anthropogenic contaminants, since older groundwater is less likely to be significantly impacted by anthropogenic chemicals. She explained that long-screened wells with younger mean or mixed ages are more likely to contain anthropogenic compounds; the analysis of tritium-helium age data can be improved when combined with additional techniques, including analysis of additional isotopes, vertical flow and concentration profiling, use of extrinsic tracers, and numerical modeling. **Roy Herndon** of the Orange County Water District concluded the session with the "life story" of a municipal production well that was found to be impacted by seawater intrusion. A summary was presented that addressed the well construction, indications of increasing salinity, down-hole methods used to assess the flow and quality characteristics of the well and potential well modifications, and attempts at well modification. Current investigation of the nature and extent of the seawater intrusion was also discussed; the primary concern for the district is the characterization and ultimate remediation of a previously undetected area of seawater intrusion.

Posters were viewed during breaks and also during the mixer that concluded the event. These presentations addressed topics ranging from reviews of and improvements to existing well profiling methods to presentation of relatively new and emerging techniques. Given the relatively small number of attendees at the event (less than 50), the atmosphere was conducive to in-depth discussion of the topics at hand. Reviews of the overall event were quite positive.

Dates & Details

GRA EVENTS & KEY DATES

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

29th Biennial Groundwater Conference and GRA 22nd Annual Meeting
Oct. 8-9, 2013 | Sacramento, CA

GRA Workshop
Collaborative Leadership: Negotiating Relationships to Improve Water Resources Planning
Nov. 4, 2013 | Sacramento, CA

GRA Board Meeting
Nov. 16, 2013 | Sacramento, CA

GRA Symposium
Compounds of Emerging Concern in Groundwater
Feb., 2014 | Northern CA

GRA Conference
Groundwater Issues and Water Management: Strategies Addressing the Challenges of Sustainability in CA
Mar. 4-5, 2014 | Sacramento, CA

29th Biennial Groundwater Conference & GRA 22nd Annual Meeting

California's Groundwater Future in the Balance: Integrating Quantity & Quality in a Changing Climate

OCTOBER 8-9, 2013
RED LION/WOODLAKE CONFERENCE CENTER HOTEL | SACRAMENTO, CA

CO-SPONSORS
AMEC | WEST YOST ASSOCIATES

CONFERENCE ORGANIZING ENTITIES:
California Department of Water Resources | Water Education Foundation
UC Water Institute | Association of California Water Agencies
State Water Resources Control Board | Regional Water Quality Control Boards
US Geological Survey | California Department of Toxic Substances Control
US Bureau of Reclamation | California Department of Public Health
California State University East Bay

About the Conference

For more than 50 years, the Biennial Groundwater Conference has provided policy-makers, practitioners, researchers, and educators the opportunity to learn about the current policies, regulations, and technical challenges affecting the use and management of groundwater in California. This year's conference will focus on the challenges that California faces in integrating various aspects of water quantity and quality in a changing regulatory, political, and environmental climate. Collaborative efforts have initiated integration of groundwater into the framework for California Water Plan Update 2013, and with many basins in decline and Delta through-flows constrained, groundwater policy and regulatory discussions in the coming years are expected to increase significantly in fervor and frequency.

The two-day Conference features a plenary session, concurrent sessions with policy and technical presentation, and a final general assembly.

Opening Plenary Session – Day 1

- Mark Cowin, Director, California Department of Water Resources
- Lester Snow, Executive Director, California Water Foundation
- Caren Trgovcich, Chief Deputy Director, California State Water Board

Concurrent Session Topics – Day 1

- Groundwater Quality: Coordinating State, Regional and Local Programs
- Recent Innovations in Groundwater Remediation to Improve Supply Reliability
- Department of Water Resources' Role in California's Groundwater
- Hydraulic Fracturing: A Threat to California's Groundwater Resources?
- Chronic Groundwater Level Declines: Options for Improved Management for Protection of Water Supply and Quality
- Collegiate Groundwater Colloquium

Continued on the following page…

California's Groundwater Future in the Balance: Integrating Quantity & Quality in a Changing Climate – *Continued*

Concurrent Session Topics – Day 2

- Southern California David Keith Todd Lecturer
- Impacts of Groundwater Pumping on Surface Water: Supply, Environmental, and Legal Considerations
- Strategies to Sustainably Manage Groundwater Quality and Quantity in an Uncertain Climate Future
- Northern California David Keith Todd Lecturer
- Integrated Planning and Groundwater Management
- Groundwater Quality Treatment: Advancements Toward Improved Supply Reliability

General Session – Day 2

Statewide Plans, Proposed Actions and Water Bond Funding Framework: What's the Future Hold for California's Groundwater Reservoirs?

The past couple years has seen a greatly increased level of statewide water activity including development of a Delta Plan, Bay Delta Conservation Plan, Water Plan Update 2013, the Governor's proposal for two sub-Delta tunnels, and more recently, discussions in the Assembly to develop a framework for a 2014 Water bond and the preparation of a Statewide Water Action Plan by the Administration. Certainly, a Delta solution is critical to the State's water future, but it is just one component of a broader set of actions needed to address overall ecosystem health and water supply reliability in California. The Statewide Water Action Plan is required to ensure state resources and leadership focus on a portfolio of management strategies including: expanding groundwater recharge, storage and cleanup; surface water storage; local resources development; increasing conservation, water reuse and efficiency; protecting water rights; promoting regional self-sufficiency and transfers; climate change adaptation; and enhancing water quality.

Where does groundwater sit in this complex of plans, proposed actions, and funding framework? Is groundwater still the invisible reservoir that will get the short end of the stick on resources? Or will funding and actions include expanding groundwater recharge and storage, measures to address chronic groundwater level declines, and contaminated groundwater clean up?

Collegiate Groundwater Colloquium

GRA seeks to increase participation by university and college faculty and students in its programming. The Collegiate Groundwater Colloquium presents students who are conducting highly relevant research in the general area of the conference theme. The Colloquium and reception provide students with an excellent opportunity to showcase their research and attendees an opportunity to learn from the frontier of groundwater science. For more information, please contact Dr. Jean Moran at jean.moran@csueastbay.edu.

Additional Information

Contact Jim Strandberg (jstrandberg@ekiconsult.com; 510-452-1308) or Chris Petersen (cpetersen@westyost.com; 530-792-3239).

Register For This Event: http://www.grac.org/amreg
Draft Program Agenda: http://www.grac.org/amagenda.pdf
Hotel Information: http://www.grac.org/amhotel.pdf
Sponsor Exhibitor Opportunities: http://www.grac.org/se.doc

Groundwater Resources Association & Association of California Water Agencies

Present the 2nd Symposium in the Series on Groundwater Management

Collaborative Leadership: Negotiating Relationships to Improve Water Resources Planning

A Workshop designed to provide attendees with the fundamentals for collaborative leadership and stakeholder involvement; a must for professionals working with the public and multiple stakeholder groups in today's complex natural resources management environment.

FEATURING EXPERIENCE AND LESSONS LEARNED FROM:
Celeste Cantú, General Manager, Santa Ana Watershed Project Authority
Grant Davis, General Manager, Sonoma County Water Agency
David Orth, General Manager, Kings River Conservation District

Workshop Leaders from the Center for Collaborative Policy, CA State University, Sacramento:
Gina Bartlett, Managing Senior Mediator and Dave Ceppos, Associate Director

NOVEMBER 4, 2013 | 9:00-4:30
SHERATON GRAND HOTEL, SACRAMENTO, CA

REHS PROGRAM APPROVED | 7.3 CEU HOURS AVAILABLE

Nearly all water resource planning and program implementation activities involve public meetings and stakeholder involvement due to the public nature of water and environmental policy and laws. Many water issues and projects are complex and thorny, causing uncertainty and angst among local stakeholders with a whole set of different perspectives and opinions. Collaborative leadership and policymaking are critical skill sets for public employees, particularly executives, and mid-level managers. Attendees will have an opportunity to learn from several key water industry leaders and the Sacramento State University's Center for Collaborative Policy - a nationally recognized consensus-building organization working statewide on California's thorniest conflicts. Attendees will learn how to develop collaborative leadership competencies, and how to apply them by following a collaborative policy making method. You will also learn how to build networks and manage collaborative groups. This event will serve to educate water, groundwater, and planning professionals and elected officials on some of the key tenets of stakeholder involvement, collaborative leadership through a mix of presentations, work groups, and interactive exercises in a one-day event.

Who Should Attend

People who have a role and interest in managing water resources and groundwater: Agency Staff, Land Use Planners, Technical Consultants, Elected Officials, Boards of Directors and Boards of Supervisors

Additional Information

Contact Gina Bartlett gina@ccp.csus.edu (415) 255-6085, Dave Ceppos dceppos@ccp-csus.edu (916) 445-2079, Tim Parker tim@pg-tim.com (916) 596-9163.

SAVE THE DATE

Groundwater Issues and Water Management — Strategies Addressing the Challenges of Sustainability in California

A GRA Conference Organized in Cooperation with USCID
The U.S. Society for Irrigation and Drainage Professionals

MARCH 4-5, 2014 | SACRAMENTO, CA

About the Conference

The last few decades have seen mounting water management challenges, particularly those associated with increased reliance on groundwater resources throughout the West. This growing reliance on groundwater is due largely to the expansion of permanent crops, more intensive irrigation practices, increased urban and environmental competition for water supplies, and reduced surface-water supplies due to drought and increasing regulatory restrictions. Coupled with overdraft, land subsidence and other ongoing issues associated with groundwater use, this increased reliance on groundwater resources heightens the concern over the long-term sustainability of the resource.

GRA, in cooperation with the United States Committee on Irrigation and Drainage (USCID), a nonprofit international professional society that aims to foster sustainable, socially acceptable and environmentally responsible irrigation, drainage and flood control systems and practices for providing food, clothing and shelter to the people of the United States and the World, are organizing a Conference that provides a unique opportunity for attendees to access simultaneously the technical and policy challenges facing groundwater resources.

This Conference will address a wide range of issues that are linked to groundwater resources and management challenges, including the interaction between surface and groundwater, groundwater banking and conjunctive use, the continued investment in water resources infrastructure and modern irrigation technologies, meeting water quality objectives, and managing floodwaters for beneficial use. We are soliciting papers and presentations that synthesize these issues in an important conference relevant to today's water managers.

Who Should Attend?

The co-located Conference will provide an ideal forum for irrigation districts, academia, consultants, regulators, and federal, state and municipal water managers to learn about new ideas and technologies available to deal with the issues related to the challenges of groundwater resources and water management in California and throughout the West. The Sacramento setting provides an excellent opportunity to share these ideas, given its history as the center of state government, proximity to extensive irrigated lands and an abundance of water resources quantity and quality challenges.

Conference Format

A half-day field tour on Tuesday morning (March 4, 2014) will be followed by lunch and joint USCID/GRA Plenary Sessions featuring a wide range of presentations specifically for irrigation managers and groundwater professionals. Presentations during concurrent USCID and GRA Technical Sessions and a Poster Session will occur on Wednesday, March 5, 2014. Participants at the USCID and GRA Conferences may attend the Wednesday concurrent Technical Sessions of either organization. USCID will continue Conference activities on Thursday and Friday (March 6 and 7). Friday, March 7 includes a day-long study tour of Sacramento-area water activities. Each organization is independently administering their Conference. GRA participants that desire to stay for the Thursday sessions and/or the Friday field trip will have the opportunity to purchase registration for the additional day, or days, from USCID.

For Conference Topics and Other Information

http://grac.org/giwm.asp

For additional information contact Chris Petersen (cpetersen@westyost.com; 530-792-3239), Steve Phillips (sphillip@usgs.gov; 916-278-3002) or Vicki Kretsinger Grabert (vkretsinger@lsce.com; 530-661-0109).

Wells and Words

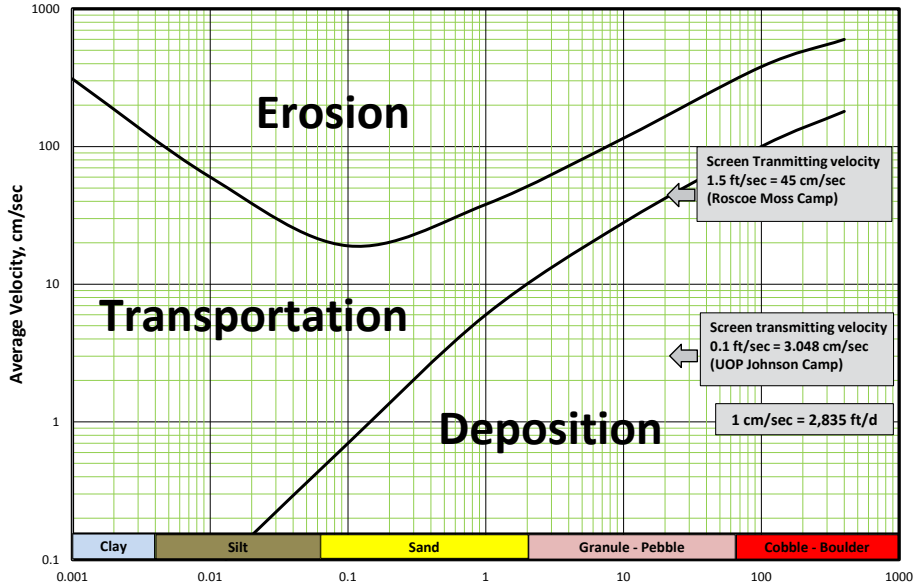
By David W. Abbott P.G., C.Hg., Senior Hydrogeologist, Daniel B. Stephens & Associates, Inc.

Why does groundwater have zero turbidity? – Hjulströms Diagram and applications to groundwater

Why does groundwater ordinarily have zero turbidity (turbid-free), or is crystal clear? The simplest answer is that groundwater velocities (v_{gw}) typically range from two meters per year to two meters per day[1] (i.e., 0.22 to 79 inches per day; 0.018 to 6.6 feet per day; or 0.0000063 to 0.0023 centimeters per second [cm/sec]) and the flow is characterized as laminar, in contrast to the turbulent flow typical of higher-velocity and agitated surface waters. During laminar flow, stream lines remain distinct and the flow direction at every point remains unchanged with time.[2] Significantly greater v_{gw} can occur in lava tubes and limestone caverns, karstic terrains, and adjacent to pumping wells where turbulent flow may occur. During turbulent flow, stream lines are confused and heterogeneously mixed,[2] marked by wildly irregular motion.[3] Simply put, the clarity of groundwater should be crystal clear because v_{gw} are too slow to overcome the initial inertial state (at rest) of clay, silt, sand and gravel in the aquifer. Furthermore, groundwater samples that are not crystal clear are not fully representative of in-situ groundwater quality. Note that groundwater can have color (the absorption of light rays), which is different than measured turbidity (the scattering of light rays).

Hjulströms (phonetically pronounced Joule-strums) Diagram[4] (Figure 1) shows the macro-physics of the movement and erosion of particles from a streambed, for example, at a depth of one meter.[5] This diagram is often presented in introductory stratigraphy and sedimentation geology classes to explain sedimentary rock textures and their origin. Hjulströms Diagram is plotted on full-logarithmic-scale graph paper with grain size in millimeters (mm) along the X axis (ranging from 0.001 [clay] to 1,000 mm [boulders]) and velocity in cm/sec along the Y axis (ranging from 0.1 to 1,000 cm/sec). There are three regimes delineated on the graph representing erosion, transportation, and deposition. The critical velocity (v_c) defines the lower boundary of the erosion field where the velocities are high enough to overcome the inertia and to place the particles in suspension for transportation; when the velocity drops to the upper boundary of the deposition field, the particles fall out of suspension. Figure 1 also shows that once the particle is entrained in the water column a lower velocity can transport the particle. Note that the upper range of vgw (0.0023 cm/sec) is at least four orders of magnitude lower than the v_c for erosion to occur. Typical v_{gw} are not shown on this diagram because they are too low to be relevant to particle erosion in surface water, and in most groundwater environments.

Figure 1: Hjulströms Diagram



The Hjulströms effect refers to the erosion resistance of clay- and silt-sized sediments because of their cohesive properties, whereas granule- to boulder-sized sediments resist erosion because of their mass. Cohesive forces are well-developed in most muds composed of clay and fine-grained carbonate minerals and are more difficult to erode.[5] Similarly, the mass of gravels and larger particles makes them difficult to erode. Thus, erosion and entrainment of clay, silt, and gravel-sized sediments requires a higher velocity than that needed for medium-sized particles (i.e., sand). In summary, the most erodible sediments are fine to medium sand; both finer (silts and clays) and coarser (granules, pebbles, cobbles, and boulders) particles are more difficult to move and erode.

However, the v_{gw} near a pumping well can approach the range of velocities shown on the Y axis of Figure 1. The recommended screen-entrance velocity designed for a new well is 0.1 or 1.5 feet per second (3.048 to 45 cm/sec),

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Wells and Words – *Continued*

depending on which technical guidance the designer prefers to believe.[6] Note that on Figure 1 the lower velocity (3.048 cm/sec) is about one order of magnitude lower than the minimum v_c for erosion to occur, whereas the higher velocity (45 cm/sec) is greater than the v_c for the mid-silt through sand-sized particles. Well designs using the lowest possible entrance velocity will optimize well longevity and maximize well efficiencies for a longer period of time,[6] and result in zero-turbidity water at designed well yields if well development has been complete and effective.

Geochemical interpretation can be significantly affected by analyzing water that is not crystal clear. The common practice is to reduce water turbidity in the laboratory using a 30-micron filter paper. Filtering water may not remove all of the colloids; a better process would be to use a centrifuge. Elevated-turbidity or sandy groundwater does not represent the in-situ groundwater quality, but rather some combination of the water, sediment, and colloidal chemical compositions. When analyzing unnaturally-occurring muddy or elevated-turbidity groundwater, even with filtering devices, be careful in the water quality interpretations—particularly for minor ions (iron, manganese, and fluoride), and trace ions (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc). In general, analytical measurements for the major cations (calcium, magnesium, and sodium) and anions (bicarbonate, chloride, and sulfate) are less prone to being impacted by elevated turbidity. My mentor in the applied science of groundwater was a stratigrapher who recognized this and would say: always strive to collect and analyze groundwater samples that are crystal clear if your desire is to measure the dissolved fraction in groundwater; throw out or do not analyze samples that have elevated turbidity.

Summarizing, it can be concluded that nearly all groundwater should have zero turbidity and that when turbidity and/or sand occurs in groundwater samples the well is improperly designed, not fully developed, or pumped at rates to high for the well that result in near-well turbulence. In addition, pumping water that is elevated in turbidity or contains sand for long periods of time can result in the catastrophic breakdown and collapse of the aquifer materials, resulting in near-well subsidence and complete and irreversible well failure.

[1] Todd, David K., 1980, *Groundwater Hydrology* (2nd edition), John Wiley and Sons, NY, 535 pages.

[2] American Geological Institute, 2005, *Glossary of Geology* (5rd Edition), Editors: Klaus K.E. Neuendorf, James P. Mehl, Jr., and Julia A. Jackson, American Geological Institute, Alexandria, VA, 779 pages.

[3] MeKechnie, Jean L. (editor), 1979, *Webster's New Twentieth Century Dictionary of the English Language* (unabridged) (2nd edition), Williams Collins Publishers, Inc., USA

[4] Krumbein, W.C. and L.L. Sloss, 1963, *Stratigraphy and Sedimentation* (2nd Edition), W.H. Freeman and Company, San Francisco, CA, 660 pages.

[5] Blatt, Harvey, Gerard Middleton, and Raymond Murray, 1972, *Origin of Sedimentary Rocks*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 634 pages.

[6] See *HydroVisions*, Summer 2009, Volume 18, Number 2 for a more thorough discussion on recommended well screen entrance velocities.

Legislative Update

By Tim Parker, GRA Legislative Committee Chairman,
Chris Frahm and Rosanna Carvacho, GRA Legislative Advocates

After the on-time passage of a balanced budget, the Legislature took a break; after returning from the summer break, the Legislature will have a very busy period, working to pass bills before adjourning for the year on September 13. During the next month and a half, hundreds of bills will be sent to Governor Brown, who must sign or veto them by October 13. In addition to bills, the Legislature has made it clear that the water bond will be a major topic of discussion. The discussions may culminate in the crafting of a new water bond, which would also be sent to Governor Brown for his signature, placing it on the November 2014 ballot and replacing the current water bond measure.

GRA Legislative Positions

SB 620 (Wright) – SB 620 removes the statutory limitation on the Water Replenishment District (WRD) of Southern California's annual reserve fund, which requires that 80% of reserves be spent on the purchase of imported water. GRA supports SB 620 because the current limitation is inconsistent with the goals and objectives of WRD and the state water plan to reduce dependence on imported water. SB 620 is currently in the Assembly and will be heard in the Assembly Water, Parks and Wildlife and Appropriations Committees in August.

SB 658 (Correa) – SB 658 clarifies that the Orange County Water District can recover all clean-up costs for the Orange County groundwater basin. GRA supports timely remedial activities to enhance the long-term beneficial use of California's groundwater resources. SB 658 is critical to the remediation of pollutants to ensure a safe water supply for the residents of Orange County. This bill failed to pass out of the Senate by the deadline and cannot move forward until January of 2014.

AB 69 (Perea) – A provision of AB 69 requires the State Water Resources Control Board (SWRCB) to develop a public information program on groundwater quality monitoring and assessment in the state, and to put this information on the SWRCB website. GRA supports this provision of AB 69 because collecting and compiling groundwater data and putting it in a public place is an important step towards making groundwater quality a higher priority in California. AB 69 is currently in the Senate and is awaiting a hearing in the Senate Agriculture Committee.

AB 145 (Perea) – AB 145 will move the entire California Drinking Water Program from the Department of Public Health (DPH) to the State Water Resources Control Board (SWRCB). GRA is concerned that by transferring this program out of DPH, the policing power that DPH currently has will be lost. GRA has taken a position of oppose, unless amended to move only the Safe Drinking Water State Revolving Fund to the SWRCB. AB 145 is in the Senate and will be heard in the Senate Appropriations Committee in August. The Brown Administration has recently released its own reorganization proposal for the state's drinking water program that would move the Drinking Water Technical Programs Branch, the northern and southern California Drinking Water Field Operations Branches, and the Environmental Laboratory Accreditation Program (collectively, the Drinking Water Program) from DPH to the SWRCB. For further details, please contact GRA's legislative advocates at Brownstein Hyatt Farber Schreck.

Water Bond

Currently, the November 2014 ballot includes a measure asking the voters to authorize general obligation bond funding totaling $11.14 billion for water infrastructure. Originally, the bond measure was scheduled to be on the November 2010 ballot and, since then, has been delayed twice.

In May, Assembly Speaker John Perez appointed a working group made up of members of the Democratic caucus to lead a program to brief Democratic Assemblymembers on the water bond and water issues generally. After passage of the 2013-14 budget, he appointed Assemblymember Anthony Rendon to Chair the Water Bond Working Group. In July, Assemblymember Rendon, who is also Chair of the Assembly Water, Parks and Wildlife Committee, presented the Assembly's proposed *Principles for Developing a Water Bond* to the Assembly Water, Parks and Wildlife Committee. These principles are: (1) bond funding is for future state investment that accomplishes critical statewide water policy priorities; (2) increase accountability for spending of state water bond funding; (3) respect existing California water rights, including area-of-origin protections; and (4) establish policy prohibiting use of water bond funding for construction or mitigation of new water conveyance facilities in the Delta.

GRA's Legislative Committee has submitted comments to the Assembly Water Bond Working Group in response to its proposed Principles expressing the need for groundwater resources to be considered as part of the bond discussions.

Continued on the following page…

Legislative Update – *Continued*

Statewide Water Action Plan (SWAP)

GRA has joined with the California Groundwater Coalition to author a letter to Mark Cowin, Director of the Department of Water Resources (DWR), asking for both associations to be included in the statewide water action plan (SWAP) discussions. It came to our attention that ACWA and DWR were convening meetings with the goal of creating a statewide water plan. Given the need for groundwater to be a fundamental part of any comprehensive water plan for California, we have asked that GRA and CGC be included in these meetings going forward. We will in any case continue to monitor the SWAP and keep the GRA Legislative Committee and membership informed.

More Changes in the Legislature

In May, Assemblymember Norma Torres (D-Pomona) was elected to the Senate to fill a vacancy in the 32nd Senate District. Senator Torres' departure from the Assembly created a vacancy in the 52nd Assembly District, for which a Special Election will be held on September 24.

The vacancy in the 80th Assembly District, vacated by now-Senator Ben Hueso, was filled on May 21st with the election of Assemblymember Lorena Gonzalez (D-San Diego). Gonzalez was appointed to serve as a member of the Assembly Water, Parks and Wildlife Committee.

The Senate's vacancy in the 16th Senate District, since Senator Michael Rubio resigned in February, was filled on July 23 by Republican farmer Andy Vidak.

Lastly, both the Senate and the Assembly have vacancies from the election of Senator Curren Price and Assemblymember Bob Blumenfield to the Los Angeles City Council. The Special Primary Elections for the 26th Senate District and 45th Assembly District will be held on September 17th and, if needed, the Special General Election will be held on November 19.

With all these changes in the Legislature, committee membership and chairs are also continually changing. We will keep you informed of how the changes affect the committees most important to GRA.

Looking Ahead

This year's Legislative Session is quickly coming to an end. The Legislature will adjourn for the year on September 13 and will re-convene in January of 2014. As the Legislative Session wraps up, GRA's Legislative Committee and its Legislative Advocates will continue to monitor issues and legislation important to GRA.

Finally, this is a reminder that GRA's 22nd Annual Meeting will be held October 8-9 in Sacramento, in conjunction with the 29th Groundwater Biennial Conference. GRA's Legislative Advocates and Legislative Committee Chairman will be giving the annual legislative update as part of the October 9 meeting lunch program. We hope to see you there!

The Federal Corner

By Jamie Marincola, U.S. EPA

New CLU-IN Focus Area on Optimizing Site Cleanups

EPA has launched a new web space on optimizing site cleanups in support of the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*. The Strategy makes fundamental changes to Superfund remedial program business processes to take advantage of newer tools and strategies that promote more effective and efficient cleanups. The new website provides technical resources, including an overview of optimization principles, practices and methods; site-specific reports for sites where optimization reviews have been performed; information on upcoming training and events; searchable guidance and publications; links to relevant federal and state optimization web resources; and contact information for EPA headquarters and Regional technical experts. Browse the website at http://clu-in.org/optimization.

U.S. EPA's State-of-the-Science Workshop on Mercury Remediation in Aquatic Environments – September 26, 2013 in San Francisco, CA

EPA is planning a state-of-the-science workshop to investigate the latest in remediation techniques for mercury contaminated sites in aquatic environments. The workshop will be held on Thursday, September 26th at the EPA office in San Francisco and online via webinar. The workshop will include examination of key mechanisms linking source loads, methylation, and bioaccumulation of mercury to guide future remediation decisions; and the effects of current remediation practices on levels of mercury in fish tissue. EPA is hoping to assess whether removing these mercury sources will have a real effect on fish tissue levels, and to evaluate the key mechanisms contributing to decreased mercury levels. The workshop is open to everyone and there is no registration fee. For more information and to register, visit http://www.trainex.org/hg.

Cuyama Valley Groundwater Study Reveals Subsidence, Complex Geology, Other Challenges

Initial findings from an ongoing study evaluating groundwater availability in the Cuyama Valley groundwater basin show continued decreases in aquifer water levels and associated land subsidence of up to 12mm annually in areas where substantial groundwater pumping occurs. Additionally, water quality throughout the Cuyama Valley is affected by natural contaminants that come in contact with aquifer-system water, such as sulfates (mineral salts containing sulfur), arsenic and trace metals, according to the cooperative study by the U.S. Geological Survey and the Santa Barbara County Water Agency. "The findings will provide a better understanding of the quality and quantity of groundwater in the Cuyama Valley Basin, where groundwater is the only source for domestic, agricultural and municipal water use," said Randall Hanson, research hydrologist and project chief with the USGS. To learn more, visit http://ca.water.usgs.gov/news/2013/CuyamaValleyGroundwaterStudy.html.

EPA New Urban Waters Grantees and Video Series

Nine new organizations have received an award under EPA's 2011/2012 Urban Waters Small Grants competition, bringing the total number of awards under this competition to 55. These awards support projects in 36 states and Puerto Rico, and amounts range from $30,280 to $60,000, totaling $3.2 million for projects that will contribute to improving water quality and community revitalization. EPA's Urban Waters program, through its federal partnership, seeks to reconnect urban communities, particularly those that are overburdened or economically distressed, with their waterways by improving coordination among federal agencies and collaborating with community-led revitalization efforts to improve the nation's water systems and promote their economic, environmental and social benefits. EPA has also released Urban Waters Voices, which is a series of 12 video interviews featuring locally led efforts to restore urban waters in communities across the United States. These videos feature local efforts and strategies to improve urban water quality while advancing local community priorities. Watch the videos at http://www2.epa.gov/urbanwaters/urban-waters-voices.

California's Drinking Water Improvement Plan approved by EPA

Following a finding of noncompliance in April 2013, the California Department of Public Health submitted a Corrective Action Plan to EPA to address concerns over the management of the California Drinking Water State Revolving Fund. The California DWSRF is a loan program that provides low-cost financing to eligible entities within the state for public and private water system infrastructure projects needed to protect public health. The Plan, which outlines how CDPH plans to disburse $800 million during the next three years to help water systems deliver safe drinking water to their communities, was approved by EPA on July 23rd. To read EPA's approval letter, visit http://www.epa.gov/region9/water/grants/CDPHNoticeofApprovalofCorrectiveAction.pdf.

Jamie Marincola is an Environmental Engineer at the U.S. Environmental Protection Agency, Region 9. He works in the Water Division on Clean Water Act permitting and community outreach. For more information on any of the above topics, please contact Jamie at 415-972-3520 or marincola.jamespaul@epa.gov.

TICs – How to Get Them, What to Do with Them

By Bart Simmons

In a much earlier column, the Chemist's Corner discussed Tentatively Identified Compounds, or TICs, which are reported by labs. Here's an update.

TICs are substances that are reported by a lab, but not necessarily with high confidence of identification, and with an approximate concentration. They are not target compounds—if you want a list of target compounds, contact the lab; it may be very different than the list in the EPA method. TICs are most commonly encountered in gas chromatography-mass spectrometry (GC-MS) analysis, but generally are not reported by commercial labs unless specifically requested. If requested, the lab will do searches in the NIST/EPA/NIH library or the Wiley mass spectral library. The instrument operator makes the call on whether a match is close enough to report as a TIC. Labs do what their clients request. Some notorious TICs, e.g., methyl-t-butyl ether (MTBE), were not reported by commercial labs because they were not in the client's request. I once received a call from a commercial lab chemist who was doing testing for NPDES compliance, and was finding large concentrations of glycol ethers, but not reporting them because they were not requested. The chemist said he felt "funny" about that. However, the legal advice to labs has been that they have no obligation to report TICs unless their client makes the request.

The EPA Contract Lab Program requirements for GC-MS testing include searching for up to 30 peaks per test, and reporting TICs as estimated concentrations. The concentration is estimated by assuming the same response factor as the nearest internal standard. The EPA guidance for data review says that TIC results should be qualified with an "NJ" flag – "N" meaning a presumptive identification (used for TICs only) plus "J" for estimated concentration. However, commercial labs typically offer GC-MS +10 or +20, rather than 30 largest peaks. The price for +10 TICs may be about $50 per sample, in addition to the test charge.

Some states, e.g., the New Jersey Department of Environmental Protection, have developed specific reporting requirements for TICs.

TICs may include artifacts from sampling and testing, e.g., acetone, and dichloromethane (common lab solvents), phthalates (plasticizers), and siloxanes (bleed from GC columns). Since artifacts may also appear in blanks, EPA data review guidance says to not report a compound unless it is present at greater than ten times the concentration in a blank. Aside from artifacts, TICs may be reported as unidentified, hydrocarbon, C7 aromatic, polynuclear aromatic hydrocarbon, and many other generic descriptions. They may also be by-products from chemical manufacture, like p-chlorobenzene sulfonic acid (p-CBSA) from DDT manufacture; reaction products, like mesityl oxide from acetone; naturally occurring compounds, like terpenes; or stabilizers, such as 1,4-dioxane. To confirm the identification and to get reliable concentrations, a few options are to (1) Compare the tentative identification with other site chemicals, (2) ask a chemist or toxicologist for assistance in the identification or toxicity, and/or (3) ask the lab to obtain a standard of the compound, and use it to calibrate the appropriate equipment. Test methods for specific compounds can be found on the National Environmental Methods Index www.NEMI.gov. Most TICs are not interesting, but a few are.

Thanks to Tom Mohr for input.

Bart can be reached at bartonps@aol.com.

Protect Your Groundwater Day is September 10

By Cliff Treyens, NGWA Public Awareness Director

It's that time of year again, and the National Ground Water Association (NGWA) is inviting groundwater stakeholders to partner with it to promote one of NGWA's two signature public awareness events—Protect Your Groundwater Day on September 10. Protect Your Groundwater Day is a time when NGWA and its partners educate members of the public about what they can do to preserve and protect groundwater to meet human and environmental needs. This is an important message—not just for household well owners who rely on privately owned and managed water wells for safe drinking water, but also for people on public water systems whose daily habits have an impact on groundwater quality.

Being a promotional partner is easy; just commit to promoting groundwater protection in connection with Protect Your Groundwater Day. That's it! Precisely how you do this is up to you. Common ways in which our promotional partners get the word out is through their Web sites, social media, newsletters, news releases, and events.

Organizations can adapt their messages to meet specific groundwater priorities, or simply use the following tools and messages NGWA provides:

- Print logo
- Web logo
- News release
- Poster
- Flier
- Video
- Water use calculator app.

Organizations that support Protect Your Groundwater Day range from government agencies at the federal, state and local levels to public health interests, environmental concerns and agricultural groups.

Protect Your Groundwater Day has grown tremendously. In 2012, nearly 300 Web sites promoted it—this is just one indication of the nationwide, even global reach Protect Your Groundwater Day has had.

Take advantage of this ready-made event to promote the important message of groundwater protection to the public. Contact NGWA Public Awareness Director Cliff Treyens at ctreyens@ngwa.org to be listed as a promotional partner. Provide a Web or Facebook address that your listing can link to.

Symphony of the Soil

A Multi-Film Project by Deborah Koons Garcia
Review by David Von Aspern, Sacramento County EMD

Introduction

Several months ago, I attended at the historic Guild Theater in Sacramento, CA, an advance screening of the feature-length documentary *Symphony of the Soil*, by filmmaker Deborah Koons Garcia, best known for her internationally acclaimed 2004 film, *The Future of Food*. This film is now showing in limited venues through this fall. As a geologist by training and someone who follows sustainability topics and participates in year-round gardening and poultry raising, it seemed as though the film would have natural appeal. And boy, did it ever, now that I've seen it! Did you ever stop to think that most of Planet Earth is mineral in nature? And yet natural processes turn rock and inorganic materials into a thin veneer of soil that, when healthy and sound, is teeming with life—so much so that it can be tempting to view soil as a seemingly living thing, or at least a thriving ecosystem.

Overview

Symphony of the Soil is a 104-minute documentary that explores the complexity, mystery and science of soil. The film portrays soil as a protagonist of our planetary story and includes interviews with esteemed soil scientists, farmers and activists. The film shows that soil is akin to a complex living organism and is a foundation of life on earth. Yet most people are soil-blind and "treat soil like dirt." Through the knowledge and insights revealed in this film, we can come to respect, even revere, this miraculous substance, and appreciate that treating the soil right can help solve some of our most pressing environmental and food-supply problems.

David Von Aspern moves materials from one bin to the other, which helps get oxygen to the composting process.

Details

The first third of *Symphony of the Soil* is devoted to soil science—the birth of soil, the life cycle of soil, physical components of soil, the soil orders, microorganisms that cycle nutrients, soil and plants, and interrelationships of the many members of the soil community, including humans. Soil science is increasingly cutting-edge and relevant. Advances in technology, such as electron microscopes and satellite images, allow soil examination in ever greater detail. Soil is seemingly alive, and its health and survival are intricately connected to that of all life.

The film covers the physical formation of soil, from the glacial flour of Norway to active volcanism in Hawaii and the soil that develops from its tephra. The film clearly shows the differences among soils ranging in age from 50 years to 4 million years. As soil matures and gains in organic content, the film takes us to some of the most fertile land in the world, including the Palouse of Washington State and California's Great Central Valley. The film describes the billions of microorganisms that create the cycles of fertility in soil; one way the film does so is by colorful hand-painted animation. Various processes such as photosynthesis and the nitrogen cycle also are discussed. The second third of the film focuses on our human relationship with soil, especially our use of soil as an agricultural medium. One scholarly interviewee declares that agriculture is a "dance with nature" and explains why we must give back to the soil, returning to it what we remove in the form of crops; this concept is known as Sir Albert Howard's "Law of Return."Various wholesome farming practices are explored, including reduced tilling, composting, crop rotation and the use of cover crops.

Continued on the following page…

Symphony of the Soil – *Continued*

David Von Aspern's family uses a legume cover crop between rows of wine grapes at their small farm near Lockeford, CA.

Cover crops are legumes planted to replenish nitrogen availability in the soil. Traditional agriculture involves much tilling, an operation that allows for seeding and enhanced irrigation infiltration, but at the same time is costly for the farmer, destroys the natural soil structure, and harms macro-organisms. It is looking more and more like 'no-till' or 'low-till' operations offer better soil health and agricultural production over the long term. The film explores a variety of farming systems, such as organic agriculture, permaculture and biodynamic farming.

At the Rodale Institute, for example, we see their 30-year field trials comparing industrial practices with organic methods, and learn how soil with organic matter in it vastly improves water use. MacArthur Fellow Dr. David Montgomery leads us through a history of agriculture and the use and misuse of soil through the ages. The founder of Star Route Farms, the first certified organic farm in California, tells us about his evolving techniques for enhancing soil fertility. One of the owners of Full Belly Farm in California's beautiful Capay Valley talks about the value of animals on the farm and the incorporation of both their grazing functions (weed control) and manure production into organic operations. The film reports on the latest science about the environmental and health effects of the toxic chemicals and nitrates so prevalent in industrial farming today. This section of the film also covers such topics as biofuels, genetic engineering, the overuse of nitrogen, and the crucial role soil plays in sequestering carbon.The third portion of the film explores 'bigger picture' ideas, including climate change, water use, human and ecosystem health, and a variety of other topics that support the case for treating soil with care. Topics as diverse as seeds and seed-saving to reclaiming arable land from fields that became the "town dump" during the Revolutionary War. Even the admirable dynamic between chef and grower is discussed in the film. Two fundamentally different outcomes for soil occur under agriculture: improvement or degradation. Agriculture is not necessarily destructive; the outcome depends on how one treats the soil. The film ultimately raises consciousness about how we think about and treat our soil. We see that destructive land-use practices degrade the soil and that we must take responsibility for protecting and improving soil for the generations to come. This heightened, science-based awareness can inform our responses to proposed U.S. Farm Bill policies, improve our backyard gardening skills and educate us about the consequences of our food choices on the environment.

Healthy, biologically-rich near-surface materials enhance the earth's natural ability to hold carbon in the soil, thus reducing the emission of greenhouse gasses into the atmosphere and helping to alleviate global climate change. Understanding and respecting the power and potential that soil has to help solve environmental problems is essential. Once people have that understanding and appreciation, they will move towards appropriate action and lifestyle choices.

Content adapted from "Press Kit" materials at:
http://www.symphonyofthesoil.com

Media Contact:
Sarah Gonzalez, Lily Films,
(415) 383-0553, sarah@lilyfilms.com

Resources for Learning
More Biodynamic Farming and Gardening Association
http://www.biodynamics.com

Dig It!
The Smithsonian's national exhibit about Soil
http://forces.si.edu/soils/

Food Democracy Now
Dedicated to building a sustainable food system
http://www.fooddemocracynow.org/

Soil Association (U.K.)
http://www.soilassociation.org

Soil Science Society of America
https://www.soils.org/about-soils/

Transition US
Seeking to build a resilient society without fossil fuels
http://transitionus.org/

United States Department of Agriculture,Natural Resources Conservation Service
http://www.soils.usda.gov

GRA Welcomes the Following New Members

MAY 24, 2013 – AUGUST 22, 2013

Afshari, Soheil	Rubicon Engineering Corporation
Allen, Emily	California State University, Long Beach
Calhoun, Michael	Haley & Aldrich, Inc.
Cherene, Andrew	WorleyParsons
Crozier, Carrie	Parsons
Elkins, Brad	EOS Remediation
Halford, Keith	U.S. Geological Survey
Halpern, Andrew	BESST, Inc.
Harnish, Laura	CH2M HILL
Herman, Kevin	Sacrament State / Wood Rodgers
Hogshead, David	Rubicon Engineering Corporation
Kadi, Christopher	
Nelson, David	Steptoe & Johnson
Nigro, Steve	Regenesis
Parker, Jonathan	Kern Water Bank Authority
Pelz, Isaac	WSP Environmental
Poynor, Scott	Geological Science & Technology
Punsoni, Andrew	Vironex, Inc.
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Rolfe, Tara	Wildermuth Environmental
Spencer, Jean	UC Berkeley
Spivy-Weber, Frances	California State Water Resources Control Board
Webb, Caroline	UC Davis
White, Nicky	California State University, Long Beach
Williams, Emily	BESST, Inc.
Wong, Meredith	BESST, Inc.
Zeferjahn, Tanya	CSULB

GRA Extends Sincere Appreciation to the Chair, Legislative Advocates and Sponsors for its April 24, 2013 Legislative Symposium and Lobby Day

CHAIR
Tim Parker, Parker Groundwater

LEGISLATIVE ADVOCATES
Chris Frahm,
Brownstein Hyatt Farber Schreck
Rosanna Carvacho,
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GRA Extends Sincere Appreciation to the Co-Chairs and Sponsors for its May 22-23, 2013 Symposium

Managed Aquifer Recharge in the Urban Environment: Technical and Policy Challenges

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Tim Parker, Parker Groundwater

CO-SPONSOR
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SouthEarth Strategies, Inc.

2013 Contributors to GRA – Thank You

(as of 8/23/13)

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GRA Extends Sincere Appreciation to the Co-Chairs and Sponsors for its June 19, 2013 Symposium
High Resolution Tools and Techniques for Optimizing Groundwater Extraction for Water Supply

CO-CHAIRS
Rob Gailey,
The Source Group, Inc.
Noah Heller, BESST, Inc

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Call for Nominations for Director Seats Open in 2014

The Association is now soliciting nominations for GRA Board of Director candidates to run for five (5) seats that commence service January 1, 2014. 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 on 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 and forward the material to Kathy Snelson, GRA Executive Director, via email (executive_director@grac.org), fax (916-442-0382) or mail (621 Capitol Mall, 25th Floor, Sacramento, CA 95814) no later than October 7, 2013.

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

Sacramento

By Troy Turpen,
Branch Secretary

April's meeting featured the 2013 David Keith Todd Lecturer Dr. Jay Lund of UC Davis with his presentation *Can We Stop Undermining Our Water Supplies? Groundwater and California's Water Future* in conjunction with the Sacramento Branch's Annual Scholastic Event. Dr. Lund's groundwater work involves the integration of groundwater management with the management of surface water, water demands, and the environment. His research is in applying systems analysis and economic ideas to water resource and environmental problems, and he has led development and application of a large-scale optimization model for California's water supply. Dr. Lund has been a principal author of several major books and reports on the Sacramento-San Joaquin Delta and California water policy, and is a frequent contributor to www.CaliforniaWaterBlog.com.

Dr. Lund's presentation covered groundwater's diverse roles in water management in California, current and growing issues for groundwater supply and management, and promising approaches to integrating groundwater into broader water and environmental management, along with surface water, demands, and infrastructure. Political and scientific challenges for accomplishing such management were also discussed. The Sacramento Branch looks forward to next year's Annual Scholastic Event and more presentations from current California State University, Sacramento Geology students.

May's meeting featured the presentation *Designing Production Wells to Optimize Performance and Efficiency* by Kevin McGillicuddy, P.G., of the Roscoe Moss Company. Mr. McGillicuddy is the Chief Hydrogeologist for the Roscoe Moss Company, has nearly 30 years of experience working as a groundwater specialist, and has worked as a technical liaison to municipal water agencies, groundwater consultants, and water well contractors for the Roscoe Moss Company since 1996. Mr. McGillicudy's presentation highlighted the critical components of the well design process: material selection; formation sampling; gravel pack selection; slot size selection; and well development, and how these processes can maximize the well's production potential with minimal losses, allowing greater cost efficiency in well operation.

June's meeting attendees were treated to a lively *Ninth Annual DTSC Regulatory Update*, and to *The Future of UXO Remediation: A Firestorm of Technological Development and Future Widespread Use at All Munitions Impacted Sites*, presented by Dan Ward and Steve Sterling from the California Department of Toxic Substances Control. Mr. Ward is the Branch Manager for the Engineering and Special Projects Office at DTSC, with over 25 years of service at DTSC. Mr. Sterling is a Senior Engineering Geologist with DTSC's Sacramento Regional Office Geological Services Unit, with more than 22 years of experience in environmental protection with DTSC. The discussions of current and upcoming DTSC initiatives and topics of interest were very informative, and the presentation ended with a bang with Mr. Sterling's discussion of a radically new method, called Advanced Classification, developed for the remediation of military sites with potential buried unexploded ordnance (UXO); this is a true game-changer in the remediation of military munitions response sites and is scheduled to be implemented throughout the U.S. in the years ahead.

The Sacramento Branch again thanks our Scholastic Sponsors for these meetings: California Laboratory Services (CLS), EnviroTech Services, and Woodward Drilling! Our Scholastic Sponsors continue to allow the Sacramento Branch to financially support Geology students at California State University, Sacramento.

San Francisco

By Jenny Cherney
Branch Secretary

In June, Dr. Kenneth R. Lajoie, who enjoyed a 30-year-long career as a Geologist at the USGS in Menlo Park before retiring in 2000, presented *The Natural and Unnatural History of the San Francisco Bay*. Dr. Lajoie discussed how the last ice age, roughly 20,000 years ago, changed what we now know as San Francisco Bay. At the height of the last ice age, sea level was about 120 m lower than it is today and there was no San Francisco Bay. As the climate warmed, sea level rose at rates as high as 1m per century. Dr. Lajoie indicated that there is evidence of four previous bays dating back to about 430,000 years, although the present San Francisco Bay formed about 10,000 years ago and reached its present size within the last 2,000 years.

Dr. Lajoie discussed the structure of San Francisco Bay basin, which consists of several broad, interconnected valleys bounded by linear ridges uplifted along seismically active faults, all parts of the San Andreas Fault system. Crustal compression has produced the Berkeley Hills and the Santa Cruz Mountains separated by the bay block that subsides between them. According to Dr. Lajoie, the Central Valley has only drained through the bay basin for the past 560,000 years. Prior to that time, Corcoran Lake occupied the Central Valley and spilled through a narrow pass into the Salinas Valley and into Monterey Bay. As crustal

Continued on the following page…

San Francisco – *Cont.*

movements tilted the Coast Ranges northward, Corcoran Lake was forced to spill over a lower divide to the north, resulting in a catastrophic flood that cut the deep gorge referred to as Carquinez Strait.

According to Dr. Lajoie, the oldest archeological sites around the bay date to about 5,000 years ago. It is likely that humans entered the future Bay Area at least 15,000 years ago and small camp sites probably exist on the continental shelf and beneath the muds of the present bay. He discussed how the rapidly expanding European population in the1800s through1900 impacted the bay, decimating the local native-American population, hunting harbor seals and sea otters to near extinction, and severely reduced the numbers of salmon and sturgeon in the bay. According to Dr. Lajoie, people have severely polluted the waters of the bay and have converted most of its bounding salt marshes for anthropogenic uses. He discussed how the challenge of the immediate future is to preserve what little remains of San Francisco Bay.

In July, Derrik Williams, the president of HydroMetrics Water Resources Inc. in Oakland, presented *Hydrogeologic Considerations for Developing Effective Groundwater Recharge Policies*. Mr. Williams discussed the importance of mapping and quantifying natural groundwater recharge to successful groundwater management. The difficulty of measuring recharge directly leads to recharge estimates that are often based on assumptions, some which are valid and some which are questionable. He argued that these assumptions can and have led to land-use policies that can be counterproductive to groundwater managers.

Mr. Williams focused on recharge in urban areas and land-use policies that can enhance urban supplies. He reviewed the current understanding of the influences of urbanization on groundwater recharge from both a quantity and quality perspective. Mr. Williams compared what is known about recharge with existing policies and recently passed legislation requiring mapping of recharge zones. He argued that, based on our understanding of recharge mechanisms, we can outline what hydrogeologists should consider when negotiating with land-use planners, and how they should be influencing land-use policy.

Southern California

By Emily Vavricka,
Branch Secretary

In June, the meeting featured California State University Long Beach Geology Professor Matt Becker. Dr. Becker, who is the Conrey Endowed Chair in Hydrogeology, presented *Fluid Flow in Fractured Formations: Implications for groundwater contamination, geothermal energy, and enhanced oil recovery*. For over 20 years, Dr. Becker has been studying fluid flow in fractured rock. He talked about how uneven fluid flow is a common hindrance to efficient groundwater remediation, geothermal heat extraction and/or enhancing oil recovery in fractured formations. This uneven flow might cause problems in engineered systems that rely on well-to-well circulation, such as pump-and-treat systems, geothermal circulation, and waterflooding. Under

forced gradients, water can channelize, leading to poor circulation or short-circuiting of fluid flow. This results in poor sweep efficiency, and although this problem is common across industries, predicting and improving sweep efficiency is troublesome.

Dr. Becker's presentation was well attended by GRA members and students from CSU Long Beach. The GRA Southern California Branch would again like to thank National Exploration, Wells and Pumps, who sponsored the Branch Scholastic Fund for the June meeting. The Branch would also like to thank both GRA members and non-members in attendance at the June meeting. Active participation of local Branch members is important for the long-term health of the organization. The Branch encourages everyone to contribute through regular meeting attendance, providing ideas for speakers and events, and active participation at the officer level.

Mono Lake

Mono Lake is a large, saline-soda lake located in a desert basin at the base of the Sierra Nevada Mountains east of Yosemite National Park. Mono Lake is amongst the oldest lakes in North America based on sediments that underlie a 760,000-year-old ash layer associated with the Long Valley eruption. During the last ice age, the lake may have been 900 feet deep as shown by shorelines above the town of Lee Vining (upper left). Recent volcanic eruptions have occurred within the lake at both Pahoa Island and Negit Island during the past 500 years.

During the past century, the elevation and salinity of the lake have varied due to climatic cycles and water diversion from tributary streams by the Los Angeles Department of Water and Power (DWP). In 1941, at the start of water exports, the lake's surface elevation was at 6,417 feet above sea level and the average salinity was approximately 50 grams per liter (g/l) (compared to a value of 31.5 g/l for the world's oceans). In January 1982, when the lake reached its lowest level of 6,372 feet, the salinity had doubled to about 100 g/l. As of early August 2013, the lake level was at 6,381.6 feet. The lake has a pH of 10 and contains chlorides, carbonates, and sulfates.

In 1994, the California State Water Resources Control Board modified DWP's water diversion license to protect Mono Lake and its tributary streams. The regulatory decision also required restoration of stream and waterfowl habitat in the Mono Basin. Mono Lake is currently in a long-term transition to higher lake levels with a target goal of 6,392 feet, which triggers changes in water export rules. As long as Mono Lake remains above 6,380 feet on April 1 of each year, DWP is permitted to export 16,000 acre-feet of runoff from tributary streams. Exports are cut back to 4,500 acre-feet when Mono Lake is below 6,380 feet, and zero export is mandated when the lake falls below 6,377 feet.

Photograph taken atop Negit Island
(GPS coordinates of estimated location: 38.020036°N and 119.051758°W)
by John Karachewski, PhD (DTSC), www.geoscapesphotography.com.

Additional information about Mono Lake is available at:
Mono Basin National Forest Scenic Area
Mono Lake Tufa State Natural Reserve
Mono Lake Committee