2013 Underground Injection Control Conference

Aquifer Management & Underground Injection

SARASOTA, FL JANUARY 22-24, 2013

The UIC Conference is the place to be to learn the latest information about underground injection control. We cover UIC topics from both a technical and regulatory perspective including the most recent changes to state and federal requirements and guidance.

We offer the only Class I Operator Training Course in the United States.

At this event you will have a chance to talk to regulatory officials from state, local and federal government officials as well as people who manage groundwater quality and quantity and stormwater or work with oil and gas, chemical, uranium mining, and other industries that utilize underground injection.

Registration at http://www.gwpc.org/events
for the 2013 Injection Control Conference

- CO_2 Geosequestration
- Hydraulic Fracturing
- Class I Training
- Aquifer Storage and Recovery
- Stray Gas & Water Quality
- Low Impact Development & Stormwater
- Well Integrity Workshop
- Class I, II, III, & V Issues
- Induced Seismicity
- RBDMS Data Mining for Oil, Gas, Class II & VI UIC Wells
- Aquifer Exemptions
- Injection & Deep Groundwater

Some sessions still accepting abstracts. Send to abstracts@gwpc.org

The Ground Water Protection Council will hold its annual UIC Conference at the Lido Hotel in Sarasota, FL.

- JANUARY 22-24, 2013
- SARASOTA, FLORIDA

Hotel & conference registration information available at www.gwpc.org/events

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Oklahoma City, OK 73142
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Preliminary agenda… *Aquifer Management & Underground Injection* (subject to changes based abstract submittals)

<table>
<tr><td colspan="4">Tuesday, January 22</td></tr>
<tr>
<td>8:30 -3:00</td>
<td>Class I UIC Operator Training
Steve King, Subsurface Technologies
Part 1 – Power Point presentation/training, Class overview/basics
- History of Injection and Overview of UIC Program
- Permitting
- Petitioning
- Siting Criteria, Geology, and Reservoir Properties
- New Class I Well Construction Well Repair & Workovers
- Operating Procedures
- Fluid Quality
- Inspections
- Mechanical Integrity Testing
- Reservoir Testing
This is an interactive course. Questions from the participants are encouraged.

Part 2 – Roundtable well discussion
We are planning an interactive UIC roundtable discussion and training session to cover areas of interest to each and every person attending. If you have a specific well problem or just an area you may like to get a more thorough understanding, please let us know and we will cover those items. If you do not have a specific item you want covered we also encourage you to attend.

Class I Operator training we offer at this event each year</td>
<td>FracFocus 2.0 Training
(Train the Trainer)
John Veil, Veil Environmental
- Updates on progress of 2.0 implementation
- Changes from FF 1.0 to 2.0
- New features of FF 2.0
- The new xml system and why it will be better
- Step by step process for uploading and modifying records
- Demo's of registration by type, record entry and modification, recalculations of % mass, and state data downloading
- The quick guide, training slides, and how to use them

An opportunity to learn about training tools for those who will be doing user training including: Oil & Gas Agencies, Oil & Gas Associations, Registered Agents and other industry representatives</td>
<td>Well Integrity Workshop
Dan Arthur, ALL Consulting
Well integrity may be one of the most important fundamental and critical issues specific to the ongoing successful development of oil & gas resources. At no point in the history of oil & gas development has well integrity been under such scrutiny as it is today. Incidents such as the Macondo well blowout in the gulf and concerns over stray gas and groundwater contamination due to hydraulic fracturing and production operations have resulted in a strong re-focus at how wells are designed, drilled, and tested. This has yielded considerable new insights with regard to the subject of well integrity.

This workshop will address issues such as:
- Choosing equipment and testing methods
- QA/QC planning
- Using Standard Procedures for Field Implementation of testing
- Drilling and Completion Program Evaluations
- Assessing annular pressure and pressure trends
- Assessing annular gas vent rates
- Cement evaluation
- Quality Assurance for well integrity tests
- Determining validity of tests performed
- Planning and evaluating the adequacy of cement
- Surface Casing testing
- Intermediate and Production Casing Considerations
- Testing and evaluating various mechanical integrity tests
- Isotopic gas sampling and analysis
- Water sampling and analysis
- Well evaluation methods
- LEL monitoring when gas is being vented
- Safety issues specific to gas venting

A NEW training specifically for the O&G/Class II folks</td>
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<tr>
<td>3:30-5:30</td>
<td colspan="3">State/EPA Roundtable Discussion of UIC Issues (State & EPA Regulatory Agency Officials Only)

USEPA Panelists: **Ann Codrington**, and **Peter Grevatt**, EPA Office of Ground Water & Drinking Water
State Panelists: TBA</td>
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<table>
<tr><th colspan="3">Wednesday, January 23</th></tr>
<tr><td>8:00-9:30</td><td colspan="2">Aquifer Management & Underground Injection
Introductions: Mike Paque, GWPC Executive Director & Stan Belieu, Nebraska Oil & Gas and GWPC President
GAO Studies on Unconventional Oil and Gas Development: Key Environmental and Public Health Requirements and Risks - Liz Beardsley & Micah McMillan, GAO
Facts & History of the US UIC Program – Bill Bryson – Kansas Geological Survey, and Bob VanVoorhees, Underground Injection Technology Council
USEPA Office of Ground Water & Drinking Water Update – Peter Grevatt, Director Office of Ground Water & Drinking Water invited
Deep Groundwater: What we know and need to know – USGS invited</td></tr>
<tr><td>10:00-
12:00</td><td>Aquifer Storage and Recovery:
- Technical
<u>Abstract 8</u>: Solving the Problem of Elevated Arsenic Concentrations in Water Recovered from ASR Systems – Results from Long Term Testing in Three ASR Wellfields in Florida - Gregg W. Jones, SW Florida Water Management District

<u>Abstract 9</u>: Water Quality Improvements During Aquifer Storage Recovery Cycle Testing at the Kissimmee River ASR Pilot Site, Okeechobee, FL - June E. Mirecki, Ph.D., P.G., US Army Corps of Engineers

<u>Abstract 13</u>: Future Implications of Utilizing Dedicated Pumps for Groundwater Sampling - Christine Batchelder, Groundwater Essentials, & Craig Intelisano, Proactive, Bradenton, FL USA

- Policy & Regulation
<u>Abstract 1</u>: Petition for an Aquifer Exemption at the L-63N (Taylor Creek) ASR System Okeechobee County, Florida - Robert T. Verrastro, South Florida Water Management District

<u>Abstract 16</u>: The 14-Year Aquifer Exemption Experience for the City of West Palm Beach ASR Program - Mark B. McNeal, ASRus, LLC</td><td rowspan="2">GROUNDWATER RESEARCH & EDUCATION FOUNDATION
A SPECIAL session for seismologists, regulators, and other stakeholders presented by the Ground Water Research & Education Foundation
Assessing and Managing the Risk of Induced Seismicity by Deep Underground Injection
- Studies: Researchers presenting findings and research strategies

<u>Abstract 22</u>: Potential for Induced Seismicity within Oklahoma - Austin Holland, Oklahoma Geological Survey

<u>Abstract 23</u>: Preliminary Report on the Northstar #1 Class II Injection Well and the Seismic Events in the Youngstown, Ohio Area – Tom Tomastik, Ohio DNR

<u>Abstract 7</u>: Induced Seismicity Potential and Energy Technologies - Robin K. McGuire, Lettis Consultants International, Inc.

<u>Abstract 19</u>: Disposal of Hydraulic Fracturing Flowback Fluid by Injection into Subsurface Aquifers Triggers Guy-Greenbrier Earthquake Swarm in Central Arkansas - Scott Ausbrooks, Arkansas Geological Survey

- Industry: State of the art technology used to limit risk
Industry Panel Discussing Case Histories and a Process for Managing the Risk Associated with Potentially Induced Seismicity TBA</td></tr>
<tr><td>1:30-4:00</td><td>Desalination Concentrate & UIC and other Class I

<u>Abstract 17</u>: Florida’s Diverse Use of Class I Injection Wells - Mark B. McNeal, ASRus, LLC

<u>Abstract 5</u>: Desalination Concentrate Disposal Using Injection Wells: Technical Challenges - Robert G. Maliva, Schlumberger Water Services

<u>Abstract 6</u>: Workshop Summary for Desalination Concentrate Management Policy Analysis for the Arid West Project”; WateReuse and Water Research Foundations, CHIWAWA Members, and others. (WateReuse Project No. 11-09) - Hector Gonzalez, El Paso Water Utilities</td></tr>
</table>

	Abstract 10: Florida's Class I Water Treatment Injection Wells - **Joseph L. Haberfeld**, Florida Department of Environmental Protection Abstract 14: Industrial Injection Well Disposal of Leachate from Ash Monofill, Class I, and Class III Landfills Lee/Hendry County, Felda, Florida, Solid Waste Disposal Facility -**Susan Bodmann**, MWH, and **Ed Rectenwald**, MWH Abstract 25: Apparent Upward Migration Determination: Multi-level Diagnostic Strategies That Can Save Your Deep Injection Well - **Kirk Martin** & **Stewart Magenheimer** CDM Smith	- *Regulatory Panel Discussion* Abstract 24: Ohio's New Class II Regulations and Its Proactive Approach to Seismic Monitoring and Induced Seismicity – **Tom Tomastik**, Ohio DNR **Stuart M. Ellsworth**, Colorado Oil & Gas Conservation Commission
4:00-5:00	**State of the Art Class I Injection Technology** Applied Innovations / Solutions Based Approach to UIC Regulated Well Drilling – **Youngquist Brothers, Inc.** Fort Myers, FL	State/EPA Panel USEPA Panelists: **Ron Bergman**, EPA Office of Ground Water & Drinking Water State Panelists: TBA - EPA Hydraulic Fracturing Study - Diesel Guidance - Other O&G and Groundwater issues
5:45-7:30 **Evening Reception** *... for Sponsorship Opportunities ...* http://www.gwpc.org/events		

Thursday, January 24		
8:00-9:10	Class I, III, & V UIC Issues & Discussion *This is opportunity to offer attendees to bring up issues related to Class I, III, V, and VI that are NOT covered elsewhere on the agenda*	Class II UIC Issues & Discussion - NEW GWPC Class II Peer Review Initiative - Risk Based Data Management System (RBDMS) Update *This is opportunity to offer attendees to bring up issues related to Class II*
9:30-11:00	Class V UIC Issues Stormwater, Low Impact Development & UIC USEPA Panelist: **Jeff Jollie**, EPA Office of Ground Water & Drinking Water Abstract 12: Stormwater Discharges, Underground Injection Controls (UIC), and Potential impacts to Groundwater within the City of Portland, Part 1: Vadose and Saturated Zones Modeling - **Matt Kohlbecker**, & Heidi Blischke, GSI; and Barb Adkins, Joel Bowker, City of Portland, OR Class V Saltwater Intrusion Barrier Abstract 15: South Hillsborough Aquifer Recharge Program (SHARP), Hillsborough County - T. Barton Weiss, P.G., James Duncan, P.E., Philip Waller, P.E., **Michael Weatherby**, MWH Americas	Oil & Natural Gas: UIC and Aquifer Management - *Class II UIC* Abstract 3:The Evolution of Class II Salt Water Disposal (SWD) Wells as part of the Shale Revolution - **Greg Casey**, Dan Arthur, Mark Layne, and Dave Bockelmann, ALL Consulting - *Water Quality & Quantity Impacts* Abstract 4:The Critical Link between Aquifer Exemptions and the Sustainability of Water Resources as Part of Unconventional Resource Development **Dan Arthur**, ALL Consulting Abstract 2:The Use of Modeling for Lifecycle Water Management Planning in Shale Development - **David Alleman**, Dan Arthur, Jeff Cline, and Bill Hochheiser all of ALL Consulting - *Other Potential Impacts from Oil and Gas Production* Stray Gas Incidence & Response A Review of GWPC's Stray Gas Incidence & Response Forum - **TBA** Working Toward Rational, Consistent, Science-Based Risk Assessment Protocols: **TBA** Abstract 11: Determination of Stray Gas Origin Using the Conceptual Hydrogeologic Model **Matt Kohlbecker**, GSI Water Solutions
11:00-12:20	Class VI UIC Implementation Update from EPA - **Bruce Kobelski, Molly Bayer, and Lisa McWhirter**, EPA Office of Ground Water & Drinking Water Abstract 26: Building Out the Framework for CCS Deployment Practical Approaches for Implementing Early Stage CCS Projects, **Bob Van Voorhees**, Carbon Sequestration Council Abstract 21: Challenges Due to Uncertainty with Class VI Permitting - **Andrew Duguid**, Schlumberger Carbon Services Geospatial Analysis of Natural and Engineered Data in support of risk assessment for CO2 storage and unconventional resource development **Kelly Rose**, Jennifer Bauer, Corinne Disenhof, and Angela Goodman Abstract 18: Systematic Assessment of Wellbore Integrity for CO_2 Geosequestration in the Midwestern U.S. - **Joel Sminchak**, Neeraj Gupta, and Mark Moody Battelle	
1:30-3:00	Aquifer Exemptions Round Table EPA Moderator: **Ann Codrington**, State Moderator: TBA - Regulatory challenges - What do we know about the science? - What next?	

Abstract 1

Petition for an Aquifer Exemption at the L-63N (Taylor Creek) ASR System
Okeechobee County, Florida

Robert T. Verrastro, P.G.

Author's Bio: Mr. Verrastro is a Lead Hydrogeologist at the South Florida Water Management District in West Palm Beach, Florida. His responsibilities include implementation and evaluation of Aquifer Storage and Recovery technology throughout south Florida as a component of the Comprehensive Everglades Restoration Program and other state initiatives. Mr. Verrastro has been a professional geologist for 30 years and has conducted numerous projects involving groundwater exploration, aquifer analysis, geophysical evaluations, water supply development, well construction, and subsurface injection, storage and recovery. Prior to joining the SFWMD, he was employed at Geraghty & Miller, Montgomery Watson, and Conoco, Inc.

Abstract: This project involves reactivation of the L-63N Aquifer Storage and Recovery (ASR) system, which was originally constructed and operated by the SFWMD during the late 1980's. The ASR well was constructed to recharge, store and recover water within the saline, highly transmissive, "middle" part of the Floridan Aquifer System (FAS) now recognized as the Avon Park Permeable Zone.

The project succeeded in obtaining UIC and NPDES permits and a Minor Aquifer Exemption to allow some recharge to occur without disinfection. A series of relatively short test cycles demonstrated that high-capacity ASR could be implemented in the area and also the effectiveness of the ASR process in removal and inactivation of surface water microbiota, without the need for disinfection. The essential results of the test cycles indicated that:

- total and fecal coliforms were significantly reduced but not completely eliminated
- recovery efficiency for successive cycles increased from 22 to 36 percent
- total phosphorus reduction was approximately 30 percent, but nitrogen reduction was negligible

The ASR system has now been inactive for nearly 20 years. A new phase of the project was initiated in 2006 as part of the Northern Everglades initiative. The objective is to reactivate the ASR system using as many of the original components as possible – and to continue evaluating process of microbial inactivation in the subsurface. Since the ASR well is completed in deeper, saline portion of the Floridan aquifer, it is uniquely constructed to allow for continued testing without disinfection. Presently, a petition for a minor aquifer exemption is pending at the office of the EPA in Atlanta. This petition is supported by the FDEP and requests a temporary, limited aquifer exemption to provide for continued research into the fate of microorganisms in aquifers.

The Use of Modeling for Lifecycle Water Management Planning in Shale Development

Authors: David Alleman, Dan Arthur, Jeff Cline, and Bill Hochheiser all of ALL Consulting

Lead Author Bio: Mr. Alleman is a Senior Environmental Scientist specializing in environmental issues related to fossil energy development. He has managed a wide array of projects involving produced water and the potential environmental impacts associated with fossil energy development, especially unconventional oil and gas resources. Mr. Alleman recently served as the project manager for three U.S. Department of Energy (DOE) research projects regarding the use of alternative water sources, water lifecycle management, and produced water treatment, re-use, and disposal related to shale resource development. He has also supported a number of projects that include water management, water treatment, waste disposal, permitting, compliance, safety, and regulatory issues in all of the major shale plays in North America.

Abstract: Managing water through the shale development process can be more complicated than is often anticipated. In the process of developing shales, water must be sourced, tracked, transported, blended, staged, used, produced, and recycled/disposed. Operators must plan for the pace of development, water requirements for drilling and fracturing must be defined (volume and quality), water losses (e.g., evaporation) must be accounted for, water conditioning and/or treatment must be designed and planned, transportation must be arranged (e.g., trucking, overland piping, etc.), storage must be arranged, permitting must be completed, and many other tasks. The complexity of the planning process has created a demand for a variety of modeling techniques to be used to more easily facilitate the planning process and to allow for change management when drilling and/or completion plans are modified. Determining the pace of water and storage demand alone can be complicated, but when considering the volume of water required in a very short timeframe for high volume hydraulic fracturing (HVHF), planning must be spot on.

As part of three separate U.S. Department of Energy (DOE) research projects, ALL Consulting (along with many cooperators) have developed models that ease the water management planning process. This includes the Water Planning Tool (originally developed for Coal Bed Methane water planning), Water Blending and Scale Affinity Model, Water Treatment Catalog, along with others. This paper will present these and other tools while also discussing the challenge of lifecycle water management.

The Evolution of Class II Salt Water Disposal (SWD) Wells as part of the Shale Revolution

Authors: Greg Casey, Dan Arthur, Mark Layne, and Dave Bockelmann, ALL Consulting

Lead Author Bio: Mr. Casey is a registered professional petroleum engineer specializing in oil and gas operations projects, engineering analysis and planning, and environmental issues related to the petroleum production industry. He has over 26 years of experience managing diverse projects and programs in the petroleum, environmental, and water resources industries. Mr. Casey serves as Vice President and manages the Houston operations.
Mr. Casey has managed and participated in an assortment of projects in the Petroleum, Deep Injection, and Oil Remediation Industries across the United States, the United Kingdom, and in the Middle East. He is a recognized expert in oilfield produced water management and disposal, commercial salt water disposal, and the injection well field. Mr. Casey's expertise in oilfield produced water management is the result of his work with numerous operators and water management companies to facilitate the onsite delivery, storage, and transport of produced water and drilling mud.

Abstract: As the development of shales has grown from early development in the Barnett and Bakken shales, the need for Class II Salt Water Disposal (SWD) wells has become a critical link in the success of shale gas and oil development. The vast majority of shale wells are hydraulically fractured using a water-based system with water volumes ranging from approximately 200,000 to 500,000 barrels of water per well. Depending on a variety of factors, such as the play and area within a specific play, 10 to 50 percent of the water used for fracturing may be produced during the flowback process with more produced throughout the life of the well. The combination of active drilling combined with large water production volumes in many areas has created a critical niche for disposal wells and has spawned a variety of issues. For example, some areas of the country do not have ideal geology for disposal wells causing produced water to be transported large distances for disposal, treatment has sparked questions relative to waste classification, induced seismicity has been alleged in some areas, permitting requirements have become more stringent in some areas, multiple state agencies have been overwhelmed with permit applications, trucks in some areas have had to wait multiple days simply to unload, questions regarding water tracking have arisen, and other issues. This paper will present information on the role of Class II SWDs with shale development and discuss several of the issues that have arisen through this process.

The Critical Link between Aquifer Exemptions and the Sustainability of Water Resources as Part of Unconventional Resource Development

Author: Dan Arthur, ALL Consulting

Author Bio: Mr. Arthur is a registered professional petroleum engineer specializing in fossil energy, planning/engineering analysis, and environmental issues. He has over 25 years of diverse experience that includes work in industry, government, and consulting. Mr. Arthur is a founding member of ALL Consulting and has served as the company's President since its inception in 1999. In 2010, Mr. Arthur was appointed to serve as a Sub-Group Leader for a National Petroleum Council study on North American Resource Development. His Sub-Group focuses on technology that is and will be needed to address development and environmental challenges through the year 2050. Mr. Arthur was also appointed to a U.S. Department of Energy Federal Advisory Committee on Unconventional Resources. Further, Mr. Arthur was nominated by the U.S Department of Energy to serve on the U.S. Environmental Protection Agency's Advisory Committing on Hydraulic Fracturing.

Abstract: Development of Unconventional Resources in the United States is likely to require one to three million additional wells to be drilled and completed. Each of these wells will require hydraulic fracturing and it's likely that the vast majority will require the use of water for drilling and fracturing activities. Although current development leverages highly on fresh water for these activities, it is likely that poorer quality water will assume a larger role as development progresses. Sourcing, recycling, and disposal of this water requires innovation, such as has been undertaken already in several plays around the world and in the United States. Technically innovative and sustainable concepts, such as "Groundwater Cycling" has gained considerable attention as a solution. In the Horn River Basin of British Columbia, the DeBolt Aquifer is being used as both a water source and disposal zone as is the Dakota Aquifer in the Bakken play. The concept is also being assessed in the Shublik on Alaska's North Slope, the Mississippi-Lime play in Kansas, the Eagle Ford Shale play in south Texas, as well as other plays. Many of these sustainable alternatives, as well as other concepts, require current aquifers meeting the definition of an Underground Sources of Drinking Water (USDWs) to be exempted. This paper will describe the critical role of aquifer exemptions with regard to water sustainability and unconventional resource development.

Desalination Concentrate Disposal Using Injection Wells: Technical Challenges

Robert G. Maliva and Wm. Scott Manahan

Authors bios:

Robert Maliva is a Principal Hydrogeologist with Schlumberger Water Services, based in Fort Myers, Florida. Dr. Maliva specializes in underground injection control (UIC) projects and has been either the project manager or technical lead on numerous ASR and disposal injection well projects. He has considerable experience in all aspects of UIC projects including feasibility assessments, exploratory well programs, system design, permitting, construction supervision and management, and environmental impact assessments. Robert Maliva completed his Ph.D. in geology at Harvard University and has held research positions at the University of Cambridge, England, and University of Miami, Florida.

Scott Manahan has over 24 years of experience in subsurface exploration including hydrologic assessment, well construction, and commercial, remedial, and domestic water treatment. His extensive experience and engineering background have made him a specialist in aquifer performance testing, hydraulic analysis, injection and production well construction, wellfield design, and pumping system design.

Abstract

Economical and environmentally sound disposal of produced concentrate is a critical feasibility issue for desalination projects, particularly in inland areas where surface-water outfalls are not viable. Injection well disposal of concentrate can be a solution, but requires favorable local hydrogeological conditions. The key technical issue is to optimize injection well design to provide the target disposal capacity and ability to continuously operate over the life of the desalination plant

Shallow Class V injection wells are used to serve small desalination systems and discharge into permeable formations typically located less than 200 ft below land surface (bls). Deep high-capacity Class I injection wells discharge into high-permeability zones containing saline water that are usually greater than 1,000 ft deep. Isolation of the concentrate is achieved by overlying confining strata and the relatively high-density of the concentrate, which results in a low buoyancy and thus low tendency for upwards migration. Deep high-capacity injection wells are common in South Florida where RO concentrate is injected into fractured dolostone generally located below 2,500 ft bls.

Deep, high-pressure injection wells discharge in moderate permeability formations under high injection pressure (often greater than 1,000 psi). Well capacities are relatively low, which may necessitate a reduction of the concentrate volume by secondary reverse osmosis treatment. Management of aquifer clogging is a major issue and the injection capacity may be reduced by physical clogging, mineral precipitation (scaling), and clay dispersion and swelling. Aquifer characterization is critical to determine the size of the reservoir, location of permeable zones, and evaluation of potential adverse fluid-rock interactions. Well design and development are important to maximize well performance and minimize skin damage. Injection wells used in oil and gas production may be suitable for concentrate disposal, but are often designed to handle much smaller flows than those generated by municipal desalination facilities.

Workshop Summary for Desalination Concentrate Management Policy Analysis for the Arid West Project"; WateReuse and Water Research Foundations, CHIWAWA Members, and others.

(WateReuse Project No. 11-09)

Hector Gonzalez, El Paso Water Utilities, Manager of Government Affairs.

With many areas facing increasing water demands and limited access to traditional water supplies, desalination of brackish groundwater provides an important option for meeting water supply needs for inland locations. In the arid west and other areas, desalination is a logical candidate because it is based on proven technologies, exhibits declining costs, and is becoming increasingly competitive with other alternatives.

Regulatory and disposal policy constraints that limit the desalination of brackish waters will be defined during this project. Important outcomes of this project will include insights into the technical, economic, environmental, and other relevant consequences of the existing regulatory and policy framework, and specific, potential policy modifications that protect both public health and the environment while enabling broader development of brackish water desalination.

A two-day inter-active workshop was planned and conducted to identify barriers, solutions, and practical path forward for addressing the challenges of concentrate management (CM) for inland municipal desalination. Representatives from water utilities, state and federal regulatory and water management agencies, research organizations, technical consultancies, and research universities were assembled to review the information and analyses generated from the research team's prior efforts (including Issue Papers circulated to the participants). The workshop was located at the EPWU Tech H2O Learning Facility, in El Paso. The workshop was held on October 25 and 26, 2012.

The workshop was very productive, and several key ideas were developed and explored by the diverse suite of nearly 50 participants. The workshop relied extensively on breakout group brainstorming and deliberations. The first set of breakout group activities focused on describing the barriers to CM from inland water utility desalting, with each of the five groups examining different aspects and CM options. Two breakout groups explored deep well injection (DWI) issues under Class I of the underground injection control (UIC) program, another group explored issues related to UIC-related options for DWI other than Class I (e.g., Class II, V, and "VII"), a fourth group focused on high recovery approaches and the associated impacts on CM options, and the fifth group explored cross-cutting (alternative regulatory) policy issues. This presentation will describe in detail the major conclusions derived by each break-out group.

INDUCED SEISMICITY POTENTIAL AND ENERGY TECHNOLOGIES

Robin K. McGuire

Robin K. McGuire, Ph.D, PE, NAE, was a Member of National Research Council Committee on Induced Seismicity Potential in Energy Technologies. He has studied and published in the field of earthquake risk analysis for 30 years. He is a Senior Principal, Lettis Consultants International, Inc., Boulder, Colorado 80305.

Induced seismicity refers to earthquakes caused by, or triggered by, human activities. A 2012 study by the National Research Council indicates that induced seismicity associated with fluid injection or withdrawal is caused by changes in the crustal stress field. If this change in crustal stress field occurs in the presence of faults with specific properties and orientations, and with a critical state of stress in the crust, earthquakes can occur. Changes in the crustal stress field can result from increased or decreased pore fluid pressure associated with fluid injection or withdrawal from energy-related operations, and can occur from changes in crustal mass if large amounts of oil and/or gas are removed from a petroleum field over years or decades.

If seismicity is induced, the factor that appears to have the most direct correlation to induced earthquake magnitude is the net fluid balance (total balance of fluid introduced into or removed from the Earth's crust). Larger volumes of fluid can affect the crustal stress field over a larger volume, thereby potentially triggering a larger earthquake. Additionally, larger volumes of fluid injected into the crust can migrate large distances in all directions and thereby encounter crustal faults and stress states conducive to triggering an earthquake.

Three major findings emerged from the study:
(1) as presently implemented, the process of hydraulic fracturing a well for shale gas recovery does not pose a high risk for inducing felt seismic events;
(2) injection for disposal of waste water derived from energy technologies does pose some risk for induced seismicity, but only a small fraction of disposal wells are associated with induced seismicity; and
(3) carbon capture and storage may have potential for inducing large earthquakes, due to the large volumes of injected fluids envisioned for future large-scale carbon storage projects.

Solving the Problem of Elevated Arsenic Concentrations in Water Recovered from ASR Systems – Results from Long Term Testing in Three ASR Wellfields in Florida

Gregg W. Jones

Bio - Gregg was employed by the Southwest Florida Water Management District for 22 years where he oversaw water supply planning, minimum flows and levels, resource assessment programs, and efforts to promote the development of aquifer storage and recovery. Gregg left the District in 2007 to direct the water resources practice with Cardno ENTRIX in Tampa, Florida. Gregg has a B.S. and M.S. in geology and is completing his Ph.D. research in arsenic and aquifer storage and recovery at the University of South Florida.

Abstract - An impediment to the development of ASR systems in Florida is the leaching of arsenic from the aquifer matrix into stored water in concentrations that exceed the 10 ug/L maximum contaminant level (MCL). The elevated arsenic concentrations are thought to result from the displacement of reduced native groundwater in the storage zone with injected oxygenated surface water that dissolves arsenic-rich pyrite in the limestone matrix. Arsenic concentration trends in water recovered from 27 ASR wells in three wellfields in Florida and the mechanisms responsible for the trends were investigated. A number of the wells were in operation since the late 1980s and experienced over 20 recharge/recovery cycles. Analysis of recharge and recovery volumes and the resulting arsenic concentrations in recovered water for each cycle for each well validated current conceptual models of the mechanisms that control arsenic mobilization and sequestration. In addition, although the analysis showed that the MCL has been consistently met in only 3 of the 27 wells, relatively minor changes to operational protocols could result in the MCL being met in most wells after only a few additional cycles. The conclusion of the investigation is that the arsenic MCL can be met in ASR wells following a testing period where the wells are subjected to a significant number of carefully managed cycles. However, a more prudent and efficient course of action may be to employ new technologies that condition recharge water prior to injection. This would prevent arsenic mobilization and insure that the arsenic MCL could be immediately achieved regardless of whether the wells were new or in service for a long period of time.

Water Quality Improvements During Aquifer Storage Recovery Cycle Testing at the Kissimmee River ASR Pilot Site, Okeechobee, FL

June E. Mirecki, Ph.D., P.G., US Army Corps of Engineers – Jacksonville District, 701 San Marco Blvd., Jacksonville FL 32207,
June.E.Mirecki@usace.army.mil

The Kissimmee River ASR (KRASR) pilot site was constructed and operated to determine the feasibility of storing large volumes of lightly treated surface water in the upper Floridan aquifer. This stored water resource would provide additional water supply for ecosystem restoration during droughts, which is a major goal of the Comprehensive Everglades Restoration Plan (CERP). ASR implementation in the CERP (and elsewhere in Florida) have been hindered as a result of potential water-quality degradation during cycle testing, primarily the result of arsenic mobilization. At KRASR, four cycle tests have been conducted, accompanied by a robust water-quality monitoring program. Water-quality data obtained during these cycle tests has enabled a detailed evaluation of water-quality changes during ASR cycle testing in the upper Floridan aquifer (UFA).

Water-quality changes result when oxic recharge water reacts with minerals and native groundwater in the sulfate-reducing upper Floridan aquifer. Recharge water composition at KRASR is characterized by elevated concentrations of dissolved organic carbon, iron, and phosphorus compared to drinking water and native UFA water. As a result, water-quality changes at the KRASR system differ significantly from those observed at potable ASR systems. KRASR cycle test results show two important water-quality trends. First, arsenic is mobilized, but the condition where ground water concentrations exceed the 10 µg/L criterion is temporary. Under sulfate-reducing conditions, arsenic is re-precipitated with iron sulfide minerals during late recharge and storage phases. Arsenic concentrations in recovered water are in compliance with the regulatory criterion during cycle tests 2 and 3 (cycle test 4 is incomplete). Secondly, phosphorus concentrations are reduced during cycle tests. The mean phosphorus concentration in treated surface water samples is 67 µg/L +/- 42 µg/L (n=54); the mean phosphorus concentration in recovered water is 7.9 µg/L +/- 10 µg/L (n=39). The likely mechanisms for phosphorus attenuation are precipitation as apatite, or microbiological uptake.

BIO

June Mirecki is the Senior Hydrogeologist with the Jacksonville District of the US Army Corps of Engineers. She currently serves as Technical Lead for the ASR projects in the Comprehensive Everglades Restoration Plan. She is also a contributing hydrologist/geochemist on other projects that study flow and quality of the Biscayne Aquifer. She currently serves as an Associate Editor for the peer—reviewed journals *Engineering and Environmental Geosciences* and *Applied Geochemistry.* Dr. Mirecki earned a Ph.D. in Geology (Geochemistry) from the University of Delaware and is a professional geologist registered in Florida.

Florida's Class I Water Treatment Injection Wells

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Abstract

Florida has 74 Class I wells which are used to dispose of desalination concentrate or a combination of concentrate and municipal effluent. This method of disposal has been used for concentrate since 1984, with most wells being constructed between 1990 and the present. There is a need for these wells because salt water intrusion has forced utilities to use brackish groundwater for potable supply. Surface water regulations are difficult to meet for the disposal of desalination concentrate, especially by large water treatment plants. These wells inject beneath the Underground Source of Drinking Water. They are considered non-municipal Class I injection wells by the U.S. EPA and require a tubing and packer with a fluid-filled annulus, fluid seal design, or an approved alternative design. Desalination injection wells are owned by city and county utilities as well as private utilities, disposing of 200,000 to several million gallons of reject water per day. The salinity of injected fluid ranges from approximately 3000-20,000 mg/L total dissolved solids. Ionic concentrations are intermediate between the brackish source waters and the saline water of the injection zone. Required on-site monitoring of desalination injection systems is similar to that used at Class I municipal injection systems. Parameters include the major cations and anions as well as radionuclides. The potential for upward fluid movement is considerably less at desalination injection wells compared to municipal wells due to the greater density of injected fluid and the lesser volumes injected in desalination wells. The main operational problem with desalination wells has been the maintenance of internal mechanical integrity. The corrosive nature of the concentrate has led to tubing and packer failures. Solutions include the use of plastic tubing, a different packer design, and alternative well designs.

Biography

JOSEPH L. HABERFELD

UIC Program manager and Professional Geologist, Florida Department of Environmental Protection (DEP), Tallahassee, Florida. He has worked all aspects of utilizing injection wells for wastewater disposal and Aquifer Storage and Recovery in Florida, including hydrogeologic evaluation, well construction methods, ground water monitoring, permitting, and compliance. Prior to joining DEP, he worked for 9 years as a petroleum geologist in the Gulf Coast and Permian Basin in the areas of development, exploration and enhanced oil recovery. He was educated at the State University of New York at Fredonia (B.S. Geology, 1975) and Southern Illinois University (M.S. Geology, 1977).

Determination of Stray Gas Origin Using the Conceptual Hydrogeologic Model

Matt Kohlbecker, RG

Biographies:

Matt Kohlbecker, R.G., is a hydrogeologist for GSI Water Solutions, Inc. Mr. Kohlbecker has collected stray gas samples from over 50 domestic, irrigation and municipal water wells throughout the Pacific Northwest, and analyzed the source of the stray gas using a combination of isotopic, geochemical, and hydrogeologic techniques.

Abstract:

Contamination of shallow aquifers by stray gas from an accumulation at depth is increasingly a public concern. The occurrence of stray gas in a shallow aquifer could be related to anthroprogenic activity (natural gas drilling activities), or could be naturally-occurring (seepage along a fault or shallow bacterial processes). In some geographic areas, regulators require baseline testing of water wells within some distance of a gas well prior to drilling or well stimulation. Baseline testing data allows for a relatively straightforward assessment of whether methane contamination in a water well is due to natural or anthroprogenic causes. However, baseline testing data is not always available, so multiple lines of evidence must be evaluated to establish the origin of stray gas (i.e., isotopic data, geochemical data, wellhead testing, anecdotal information from the well owner). A Conceptual Hydrogeologic Model (CHM) is another tool for evaluating the source of stray gas. Stray gas is transported by groundwater in a predictable manner, and gas composition is dependent on physical and chemical conditions during transport. The CHM has been used to determine if the nature of gas occurrence in shallow groundwater is consistent with anthropogenic sources or natural occurrence. The key elements of a CHM include an inventory of pathways along which hydrocarbon gases could be transported, analysis of groundwater flow directions and geology to determine the direction that hydrocarbon gas would be transported by shallow groundwater (laterally and vertically), and gas geochemistry (isotopic composition, gas wetness, and gas concentration) as it relates to the pressure and temperature conditions during transport. CHMs have been developed and applied to determining the source of stray gas in the Columbia Basin of Oregon and Washington (natural source), and in Garfield County, Colorado (anthropogenic source).

Stormwater Discharges, Underground Injection Controls (UIC), and Potential impacts to Groundwater within the City of Portland
Part 1: Vadose and Saturated Zones Modeling

Matt Kohlbecker, Heidi Blischke, Barb Adkins, Joel Bowker

Biographies:

Matt Kohlbecker, R.G., and Heidi Blischke, R.G., are hydrogeologists with GSI Water Solutions, the City's consultant for the UIC Program. Barbara Adkins has been with the City of Portland for 5 years and manages the Underground Injection Control (UIC) Program. Joel Bowker, R.G., has been with the City for over 10 years and is the hydrogeologist for the UIC Program. The City and GSI worked together in the development of vadose and groundwater fate and transport models to evaluate potential impacts to groundwater from stormwater discharges.

Abstract:

In 2005, the City of Portland was issued the first Water Pollution Control Facility (WPCF) permit for UICs in the nation. Protection of groundwater as a beneficial resource is one of the main requirements of this permit. This presentation discusses the technical approach used by the City to demonstrate that stormwater discharges from City rights of way to the subsurface are protective of human health and the environment, and do not impact groundwater as a beneficial use.

Conditions of the City's UIC WPCF permit require that a UIC has a minimum vertical separation between a UIC and groundwater as well as a minimum horizontal setback between a UIC and domestic water well. If a UIC does not meet either of these requirements the City must demonstrate that discharges are protective of groundwater, or the UIC system has to be retrofitted or decommissioned. As a result the City used UIC stormwater monitoring data to conduct pollutant fate and transport modeling in unsaturated soils above the water table (vadose zone) and in saturated soils below the water table (saturated zone). In the vadose zone, pollutant attenuation was simulated using an analytical fate and transport model based on the Advection Dispersion Equation (ADE) that was developed for the City. In the saturated zone, pollutant attenuation was simulated using the United States Geological Survey (USGS) finite-difference numerical groundwater modeling code MODFLOW and contaminant fate and transport code MT3D. Both models simulated pollutant attenuation from dispersion, biodegradation, and sorption. The models were developed using conservative assumptions for simulating pollutant attenuation, and input parameters were selected from scientific literature to be representative of the subsurface geology in City limits. This talk will discuss results of both modeling efforts and provide technical information used to support UIC program implementation (presented in part 2 by Barb Adkins).

Future Implications of Utilizing Dedicated Pumps for Groundwater Sampling

Christine Batchelder, Groundwater Essentials, Bradenton, FL USA
Craig Intelisano, Proactive, Bradenton, FL USA

Christine Batchelder Bio: Christine has 15 years of sales and marketing experience within the manufacturing technology, federal government and aviation industries. Groundwater Essentials is an international distributor of groundwater monitoring equipment and supplies.

Craig Intelisano Bio: Craig has 22 years of experience as an owner, entrepreneur and technology innovator for the groundwater monitoring industry. Craig's expertise ranges from product innovation, technology improvement and "hands on" engineering experience leading to several industry patents.

The use of dedicated in-place pump systems for groundwater sampling has been slow to become the norm in the environmental industry. This has been largely because of the lack of knowledge and comfort with low-flow (aka low-stress or no-purge) groundwater sampling. Many variables need to be examined when understanding the long term implications of the use of dedicated installed equipment. Variables and factors include energy use (solar), labor efficiency, sample consistency, long term environmental concerns due to waste considerations, among others.

Regulatory and site considerations often are not well understood and therefore lead to confusion and dismissal of the option for dedicated pumps. We need just to step back and determine all future contributing factors to the lifetime cost AND environmental impact of NOT using a dedicated in-place installed pump system will have. Any type of environmental discipline that requires long term monitoring such as MNA, remediation and other In-Situ technologies should be partnered with a sustainable cost effective dedicated monitoring pump system.

In addition to long term monitoring, those situations where conditions mandate consistent, reliable sample integrity are also prime candidates for dedicated pump systems. Other site conditions such as land ownership play an important role in the choice to use dedicated pump systems. Regulatory requirements stop at mandating dedicated pump systems yet consistently recommend their use throughout published guidance.

Underground injection operating sites used as an example of a model for determining the use of dedicated pumps would lend itself to this decision while also assisting in the ability to expand required monitoring to further enhance public confidence. As we look at the determining factors, based on variables we can see dedicated pump systems have a life cycle cost impact across all considered concerns. Therefore when considering the appropriateness of a dedicated pump system we can prepare a matrix of these factors and compare life cycle costs.

Industrial Injection Well Disposal of Leachate from Ash Monofill, Class I, and Class III Landfills Lee/Hendry County, Felda, Florida, Solid Waste Disposal Facility

Keith Howard, P.E.-Lee/Hendry County, Khalid Nazeer, P.E.-MWH, Alec Hart, C.H.M.M.-MWH, Thomas Frew, P.E.-MWH, Jon Pohl, P.E.-MWH, Denise Garcia, P.E.-MWH, Susan Bodmann, PG, PMP-MWH, and Ed Rectenwald, PG-MWH

Susan Bodmann, P.G., PMP is a licensed Geologist in the State of Florida. She has worked for MWH for the past 25 years. She is experienced in all aspects of supply, monitoring and disposal well planning, design, permitting, and construction and has worked on both the east and west coasts of southeast and central Florida extensively. She has planned and completed numerous hydrogeologic studies to evaluate water quality, aquifer parameters and hydrogeologic conditions to determine technical suitability for municipal and industrial purposes.

Khalid Nazeer, P.E. is a licensed Civil Engineer with over 30 years of environmental management, regulatory negotiations, permitting, compliance and engineering experience. His technical expertise is in process development, cost analysis, engineering design, construction management, startup, and training associated with pollution control facilities in numerous industrial categories including pharmaceutical, iron and steel, metal finishing, aluminum, adhesives, paints, chemicals, food, and joint industrial/municipal facilities. Extensive experience in designing, troubleshooting, and upgrade of industrial wastewater treatment facilities.

ABSTRACT

Lee County operates the Lee/ Hendry Solid Waste Disposal Facility (SWDF) in Felda, Florida. The facility covers 2.9 square miles and comprises three types of solid waste management operations, Class I and Class III landfills and an Ash Monofill. The three operations have dedicated landfills and segregated leachate streams and storage ponds. Six holding ponds, two per disposal area, are utilized for leachate storage prior to treatment and disposal. Existing treatment systems incorporate equalization, clarification, filtration, microfiltration (MF) and reverse osmosis (RO) technologies. Lee County desired the operational flexibility to maintain separate leachate streams from different landfill areas and blend leachate as necessary to increase treatment efficiency, meet discharge requirements and reduce the need for off-site leachate disposal.

In 2009, a leachate characterization study was conducted to better define leachate streams generated from the landfill cells, holding ponds, and process streams. The characterization effort focused on assessment of the leachate source characteristics and flows to evaluate the performance of the existing treatment system and develop a long-term plan for treatment and disposal. The study identified six alternative treatment/disposal options to expand capacity and lower operational and life-cycle costs. Two of the alternatives included final disposal of the leachate to a deep injection well system.

Use of a deep well injection well for final leachate disposal would eliminate off-site disposal as a primary disposal method and would provide Lee County operational flexibility. Evaluation of treatment alternatives indicated that disposal of pre-treated leachate by deep well injection was cost competitive compared to the existing systems. A deep injection well system was permitted and constructed at the SWDF along with a leachate holding pond where leachates from the six existing ponds could be mixed and controlled before final deep well disposal.

South Hillsborough Aquifer Recharge Program (SHARP), Hillsborough County

T. Barton Weiss, P.G., James Duncan, P.E., Philip Waller, P.E., Michael Weatherby, P.G.

Michael Weatherby, P.G. is a Principal Hydrogeologist and Project Manager for MWH Americas. Mr. Weatherby is involved in many applications of groundwater hydrology, geology, and engineering. His 21 years of experience lie in injection well design, permitting, construction, and testing, aquifer storage recovery (ASR) technology, groundwater supply, wellfield expansion, water resource evaluations, and various types of permitting and funding activities. Mr. Weatherby is experienced with many hydrogeologic simulation computer models and pump test analysis programs. Mr. Weatherby has also conducted training for operators on the proper operation, monitoring, and reporting of data from new injection wells.

ABSTRACT

West Central Florida has exhibited declining groundwater levels in the Upper Floridan aquifer over the last 50 years in the area of southern Hillsborough County and western Polk County. These water level declines have caused saltwater intrusion along the coastal area of Hillsborough County. The Southwest Florida Water Management District (District) designated the Southern Water Use Caution Area (SWUCA) in this area to limit additional groundwater withdrawals and implemented a recovery strategy to mitigate the Most Impacted Area (MIA) that exhibited the highest decline water levels.

During the evaluation of mitigation options that would address these declining water levels, the District initiated an aquifer recharge feasibility study in 2008 to identify recharge concepts that may provide the highest level of beneficial use of locally available reclaimed water flows. This study concluded that coastal aquifer recharge can be a viable permittable solution to support recovery of declining water levels, in the SWUCA. The District implemented a regulatory water level mitigation policy that would allow groundwater mitigation offset credits to be earned for up to 90 percent of the regional water level improvements within the SWUCA which may be used to develop future water supplies further inland.

The County has taken the regional initiative by implementing an aquifer recharge pilot project, the South Hillsborough Aquifer Recharge Program (SHARP), to beneficially utilize available reclaimed water as a saltwater intrusion barrier. The benefits of coastal aquifer recharge include creating a saltwater intrusion barrier system to mitigate the advancement of saltwater inland, the reduction of reclaimed water discharges and the improvement of water levels in the SWUCA and MIA. Finally mitigation offset credits will be obtained and used to provide a higher reliability to the County's reclaimed water system during the dry months, or used to develop additional inland groundwater withdrawals currently not allowed today.

THE 14-YEAR AQUIFER EXEMPTION EXPERIENCE FOR THE CITY OF WEST PALM BEACH ASR PROGRAM

Mark B. McNeal, P.G.
Chief Executive Officer
ASRus, LLC
Tampa, FL

The City of West Palm has constructed an Aquifer Storage Recovery (ASR) well capable of storing and recovering up to 8 Million Gallons per Day (mgd) of surface water from Clear Lake. This is believed to be the highest capacity ASR well worldwide. The well is designed to store water in a brackish water (5,000 mg/L Total Dissolved Solids) permeable unit within the upper Floridan aquifer at a depth of approximately 1,200 feet. No other existing or anticipated groundwater users are completed into this aquifer within the one-mile area of review. The minor aquifer exemption process was worked through with the Florida Department of Environmental Protection (FDEP) over a 14-year period, including public notice without any objection. The exemption requested authorization to pump untreated surface water into this zone without disinfection, thereby introducing relatively low concentrations of coliform bacteria into this aquifer on a temporary basis. Coliform bacteria is expected to die-off within a few weeks of storage, rendering the costly disinfection at the surface an unnecessary expense and use of chemicals unwarranted. The exemption petition was submitted to EPA Region IV where it was not supported and EPA requested that the application be withdrawn. This was a huge disappointment as this exemption process was considered to be an important tool for not only the City to manage its water resources but the ramifications for Florida were considered to be far-reaching. This presentation will discuss the process used, the outcome, and implications of this decision on the water management opportunities lost in Florida for the foreseeable future.

FLORIDA'S DIVERSE USE OF CLASS I INJECTION WELLS

Mark B. McNeal, P.G.
Chief Executive Officer
ASRus, LLC
Tampa, FL

Florida relies heavily on the use of Class I injection wells for managing its industrial and municipal wastestreams. Protection of our surface water bodies, estuaries, and coastlines is paramount to ecological and economic interests, such as tourism. With over 200 Class I industrial and municipal injection wells from the Florida Keys to the Florida Panhandle, over one-third of the Class I injection wells in the United States are located in Florida. Class I municipal injection wells ranging in depth from approximately 600 feet to 4,000 feet have become commonplace along the southern coastal areas, deemed by most utilities as the most environmentally sound and cost effective method of managing excess domestic wastewater, much of which is treated to public access reuse standards but is not seasonally needed for irrigation or other use. Concentrate from membrane facilities has also primarily discharged to Class I industrial injection wells since the late 1980's and continues to allow use of our abundant brackish water resources for public water supply. State regulations make discharge of these concentrate streams to surface water impractical, if not impossible. Recently, Florida's power industry has begun constructing Class I industrial injection wells into deeper zones previously not seriously considered. These wells are completed to depths of up to 8,000 feet using carbonate and clastic aquifers with specific injectivities ranging from less than 1 to 1,000's of gpm/psi increase. Coupling of one Class I industrial injection well with a carbon geosequestration demonstration project was also designed and permitting nearly completed. This presentation will provide an overview to the successful historical use of Class I injection wells in this tropical paradise.

Systematic Assessment of Wellbore Integrity for CO_2 Geosequestration in the Midwestern U.S.

Joel Sminchak, Neeraj Gupta, and Mark Moody
Battelle, Columbus, Ohio

Joel Sminchak, Neeraj Gupta, and Mark Moody work in the Energy Systems Department at Battelle Memorial Research Institute. They have been active in research on hydrogeologic, engineering, regulatory, and risk issues associated with the deep-well injection of CO_2 to reduce greenhouse gas emissions and for enhanced oil recovery.

A systematic assessment is being completed to determine the condition of plugged and abandoned wellbores in the Midwestern United States in relation to CO_2 geosequestration applications. Overall, the project is designed to address perceptions that many areas in the Midwest are not suitable for geosequestration due to old oil and gas wells. Specifically, the project will utilize available industry and regulatory data to evaluate well integrity based on items such as well age, depth, construction methods, materials, and location. Project methods include collection and analysis of well records, evaluation of sustained casing pressure from Class II injection wells and/or gas storage wells, and analysis of well integrity in relation to CO_2 storage targets. The project addresses wellbore issues from field evaluation of plugged wells to CO_2 storage field siting, and mitigation measures for compromised wellbores. Technical items such as cement degradation, cracks and microannulus, acid-gas zones, channeling, casing corrosion, wellhead leaks, and sustained casing pressures will be evaluated with historical well records, field monitoring of selected gas storage and/or Class II injection wells, and review of regulatory information. The project will focus on areas in northeastern Ohio and southern Michigan as case studies. However, project results may benefit many areas for both improved oil recovery and CO_2 storage, because the work covers technical issues for both applications. In addition, the project has significant synergies with other ongoing work in the region, especially the regional mapping and large-scale testing under Midwestern Regional Carbon Sequestration Partnership (MRCSP). This project is supported by U.S. Department of Energy National Energy Technology Laboratory (Award DE-FE0009367) and Ohio Department of Development Office of Energy (Grant CDO-D-13-1).

Disposal of Hydraulic Fracturing Flowback Fluid by Injection into Subsurface Aquifers Triggers Guy-Greenbrier Earthquake Swarm in Central Arkansas

Scott Ausbrooks, Arkansas Geological Survey

Scott Ausbrooks is a Registered Professional Geologist who currently serves as the Geohazards and Environmental Geology Supervisor for the Arkansas Geological Survey. Currently he is co-investigator on the Guy-Greenbrier earthquake swarm and its potential relationship to induced/triggered seismicity from nearby SWDs. He assisted in the installation of the temporary seismic stations in the Guy-Greenbrier area. Mr. Ausbrooks served as project leader and provided oversight during installation of the Arkansas Seismic Network. He also drafted the Earthquake Response Plan and the Clearinghouse Annex for the Arkansas Geological Survey. He is also project leader to update the geology on approximately two-hundred (200) 7.5-minute geologic worksheets in Northeast Arkansas. Mr. Ausbrooks conducts numerous “Earthquake 101” and “Overview of the NMSZ” presentations to various groups and organizations, while working with several agencies and organizations involved in NMSZ research and mitigation projects. He is currently drafting the Earthquake Response Plan and the Clearinghouse Annex for the Arkansas Geological Survey. Mr. Ausbrooks’ previous experience includes geologic mapping; quality control sampling for quarries; preparation of geological reports for bridge replacement projects; landslide studies; drill core inspections; monitoring well driller; technical writing; geotechnical logging; surveying; and environmental consulting.

Stephen Horton, The Center for Earthquake Research and Information at the University of Memphis, shorton@memphis.edu

Hydraulic fracturing flowback fluid is being injected under pressure into subsurface strata in an expanding number of UIC disposal wells across the United States. Since the first UIC Class II disposal well became operational in response to the Fayetteville Shale unconventional natural gas play in north-central Arkansas in April 2009, portions of the play area, has experienced an increase in the rate earthquakes. Localized portions of the area have a long history of seismic activity including earthquake swarms in the early 1980’s and 2001, so the current earthquake-rate increase may simply reflect another peak in a natural cycle. However, a spatial and temporal correlation between post 2009 earthquakes and the start of injection at several UIC wells, around the towns of Guy and Greenbrier, motivated the Arkansas Geological Survey (AGS) and the Center for Earthquake research and Information (CERI) to install a temporary seismic array in early September 2010 to monitor for potential induced/trigger earthquakes in the vicinity of two newly activated (July and August, 2010) UIC wells. Intense earthquake activity within 6 km of both disposal wells began September of 2010. A previously unknown fault, the Guy-Greenbrier fault, has now been illuminated by over a thirteen-hundred earthquakes ($M \leq 4.7$). Plausible hydraulic connectivity exists between the UIC well injection intervals and the nearby Guy-Greenbrier fault via a regional orthogonal joint and fracture system in the Paleozoic and older rocks. Earthquake frequency along the fault indicates a strong correlation with the volume and pressure of injection at the wells and is the most probable cause of the current seismicity.

GAO Studies on Unconventional Oil and Gas Development: Key Environmental and Public Health Requirements and Risks

Liz Beardsley and Micah McMillan, GAO

Presenters: Liz Beardsley is a Senior Attorney with GAO in Washington D.C. Her docket includes the agency's water work, such as review of EPA Safe Drinking Water Act and Clean Water Act programs, and various Corps of Engineers Civil Works projects and programs. For GAO's 2012 study of key environmental and public health requirements for oil and gas development, she prepared the federal law analysis and appendices. She holds a J.D. from the University of Virginia School of Law, and a B.S. in Civil Engineering from Stanford.

Micah McMillan is a Senior Analyst with GAO's Natural Resources and Environment team. His work includes water infrastructure funding, domestic and international climate change policy, and the environmental impacts of biofuels production. He is the analyst-in-charge of GAO's ongoing review of EPA's Underground Injection Control Program. He holds Master's degrees in environmental policy and environmental science from the Indiana University School of Public and Environmental Affairs.

Abstract: Technological improvements have allowed the extraction of oil and natural gas from onshore unconventional reservoirs such as shale, tight sandstone, and coalbed methane formations. GAO was asked by the Senate Environment and Public Works Committee and other congressional requesters to review environmental and public health requirements for unconventional oil and gas development and to describe federal and state requirements and challenges, if any, that federal and state agencies reported facing in regulating oil and gas development from unconventional reservoirs. In addition, GAO was asked to determine what is known about the size of shale oil and gas resources, environmental and public health risks associated with development of these resources. GAO issued two reports in September 2012 on these questions. GAO found that, as with conventional oil and gas development, requirements from eight federal environmental and public health laws may apply to unconventional oil and gas development. However, exemptions or limitations in regulatory coverage affect the extent to which six of these environmental or public health laws apply to unconventional resources. For example, oil and gas well sites are generally exempt from Clean Water Act stormwater discharge permits. Similarly, while the Resource Conservation and Recovery Act governs the management and disposal of hazardous wastes, wastes that are generated from oil and gas wells are not subject to the hazardous waste regulations. Oil and gas development, both conventional and unconventional, pose inherent risks to the environment and public health. The extent of these risks associated with unconventional shale oil and gas development is unknown, however, in part because different studies do not take into account cumulative effects. For example, the studies that GAO examined did not take into account cumulative effects on air quality at specific sites. Finally, the extent and severity of risks may vary across and within shale basins because of location- and process-specific factors. This presentation summarizes GAO's 2012 reports and describes the scope of ongoing work related to protection of groundwater resources under the Underground Injection Control program.

Challenges Due to Uncertainty with Class VI Permitting

Andrew Duguid, Philip Jagucki, & Ryan Choquette, Schlumberger Carbon Services

Andrew Duguid: Since joining Schlumberger Carbon Services Dr. Duguid has worked on many aspects of CO_2 sequestration with an emphasis on the permitting of new wells and the integrity of old wells. Dr. Duguid has been involved with designing and analyzing of wellbore integrity problems related to carbon sequestration. Projects have included CO_2 wellbore integrity field studies near in Wyoming, Michigan, and Colorado in the United State and Buracica, Brazil. He is currently the Principle Investigator of a US Department of Energy funded project titled "Quantification of Wellbore Leakage Risk Using Non-destructive Borehole Logging Techniques". Dr. Duguid has authored or coauthored several papers and presentations on wellbore integrity and CO_2-cement interactions. He earned a Ph.D. in Civil and Environmental Engineering from Princeton University and Master's degrees and a Bachelor's degree in Civil and Environmental Engineering and Nuclear Engineering from Ohio State University.

Philip Jagucki is a project manager with Schlumberger Carbon Services and is located in Columbus, Ohio. He has a Bachelor's degree in geology from Virginia Tech and a Master's degree in geology (with a focus on hydrogeology) from Ohio State University. He has more than 25 years of experience in environmental consulting and has worked on a variety of public and private projects. Since 2003, he has been working on deep saline CO_2 storage projects.

Ryan Choquette: As manager of midstream engineering, Ryan Choquette is responsible for developing carbon dioxide (CO_2) fields for Tenaska. Mr. Choquette also provides engineering support regarding the evaluation and development of natural gas storage and midstream projects for Tenaska entities.

Mr. Choquette joined Tenaska in 2008 and served as a manager of project coordination, leading the evaluation of developing a depleted gas reservoir into a large natural gas storage field, and coordinating due diligence on energy related projects, including power plants, gas storage fields and natural gas midstream projects. Mr. Choquette has more than 14 years of experience as an engineer and manager, primarily in the energy industry. This experience includes serving as project engineer on four natural gas storage expansion projects, performing cost estimates, optimizing designs and providing emergency response leadership.

Mr. Choquette earned a Bachelor of Science in mechanical engineering from the University of Nebraska—Lincoln. He represents Tenaska at the Midwest Geological Sequestration Consortium, and is a member of the American Society of Mechanical Engineers.

Abstract

Experience developing Class VI permit material and applications has highlighted areas in the permitting process that represent challenges for potential operators. The challenges arise from uncertainty within the regulation and permitting process, limited availability of site-specific geological information, and within the engineering considerations that must be addressed to meet the permit requirements.

Uncertainty within the regulation and permitting process is, in part, due to the regulation itself. For example, the regulations (and guidance) are fairly specific in regards to data required to inject but are not specific as to the amount and quality of data that are necessary to receive a permit to construct. In areas with no nearby offset wells, the applicability of the nearest usable data will be uncertain until the first well is constructed. Geologically, the location of the lowest underground source of drinking water (USDW) will be in question until a well is constructed and, because the engineering design of the well is based on the depth of the lowest USDW, the design cannot be finalized until the well is drilled. These uncertainties seemingly lead to an unwritten requirement for a stratigraphic test well. However, given the range of natural subsurface variability, data collection using a stratigraphic test well may not provide sufficient improvement to make the investment worthwhile. Instead, a more prudent and effective method may be to employ engineering practices and factors of safety to develop a conservative data set that will likely initially overestimate the modeled area of review. We will discuss these uncertainties and engineering practices and how they are affecting the permitting process of a proposed commercial injection project in the Illinois Basin.

Potential for Induced Seismicity within Oklahoma

Austin Holland, Oklahoma Geological Survey

Austin Holland is a research seismologist with the Oklahoma Geological Survey (OGS). He has been with the OGS since January of 2010. He is currently finishing his Ph.D .at the University of Arizona where his focus was primarily on measuring deformation of the Earth using high precision GPS. He received his Masters of Science in Geophysics from the University of Texas at El Paso, and his Bachelors of Science in Geology from the University of Idaho. He worked at the Department of Energy's Idaho National Laboratory for 12 years in the seismic monitoring program.

Abstract

Currently, the likely cases of induced seismicity identified in Oklahoma can be associated with hydraulic fracturing. In one well-documented case, a local resident felt several earthquakes. This sequence had sixteen earthquakes of magnitude 2.0 or greater, with a clear temporal relationship to fluid injection associated with hydraulic fracturing. In addition, recent work has been done to identify the likelihood of other similar occurrences within Oklahoma. This work suggests that such cases are rare, but could occur in as many as 2% of stimulated wells.

Identifying earthquakes potentially associated with injection at UIC Class II wells is much more difficult. There are more than 7,000 UIC injection wells operating within Oklahoma many of these have been operating for long durations. Earthquake rates within Oklahoma have increased dramatically within the last few years, and it has been suggested that these earthquakes are in response to fluid injection. Regionally there are not good correlations to changes in injection and the occurrence of earthquakes. However, localized examples of induced seismicity have been suggested. Results will be presented demonstrating potential links to injection and discuss the challenges associated with identifying induced seismicity within Oklahoma.

Preliminary Report on the Northstar #1 Class II Injection Well and the Seismic Events in the Youngstown, Ohio Area

Tom Tomastik, Ohio DNR, Division of Oil & Gas Resources Management

Tom Tomastik received his BS and MS degrees in geology from Ohio University in 1979 and 1981. From 1982 to 1988, Mr. Tomastik was employed as a consulting geologist involved in oil and gas exploration and development in southeastern Ohio. Since December of 1988, Tom has been employed by the Ohio Department of Natural Resources, Division of Oil and Gas Resources Management, UIC Section. He is responsible for all of the Underground Injection Control (UIC) duties, which include performing independent reviews of applications for Class II saltwater injection, secondary and enhanced recovery projects, and Class III salt-solution mining wells in Ohio. Tom also plans and implements highly complex groundwater conflict investigations involving oil and gas investigations. He provides technical expertise to the general public, oil and gas industry, governmental agencies and officials regarding Federal and State regulations, oil and gas and injection well construction, well operations, and groundwater contamination investigations. He has authored or co-authored articles on various aspects of Ohio's oil and gas industry, groundwater investigations, injection, solution mining, and geology.

Between March 17 and December 31, 2011, eleven seismic events occurred in the Youngstown, Ohio area possibly being induced by the Northstar #1 Class II saltwater injection well. A magnitude 4.0 seismic event occurred on December 31st in the Youngstown area, and the Director of the Ohio Department of Natural Resources requested the operator to cease injection operations at the Northstar #1 Class II injection well. In an effort to determine if the seismic events were induced, the Ohio Department of Natural Resources immediately initiated a study to evaluate the geology of the area, review the history of the Class II injection well program, and interpretation of seismic monitoring and evaluation of the downhole testing data. In March of 2012, the Ohio Department of Natural Resources issued a preliminary report indicating that a number of coincidental circumstances appear to make a compelling argument for the Youngstown-area seismic events to have been induced by injection operations at the Northstar #1 Class II injection well. Passage of new Class II saltwater disposal well rules that went into effect on October 1, 2012, makes Ohio's Class II injection well program one of the most stringent regulatory programs in the United States.

Ohio's New Class II Regulations and its Proactive Approach to Seismic Monitoring and Induced Seismicity

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In July of 2012, Ohio's Governor issued an Executive Order implementing more stringent Class II saltwater disposal regulations to protect the health and safety of Ohio's citizens. Legislation was initiated to draft new rules to strengthen Ohio's Class II saltwater disposal well program and these new rules went into effect on October 1, 2012. Some of the changes to the rules for newly permitted Class II saltwater disposal wells include: 1) continuous monitoring for mechanical integrity, 2) geological evaluation for potential faulting, 3) prohibition of injection into the Precambrian basement rocks, 4) possible requirement for pressure fall-off testing, seismic surveys, or seismic monitoring, and 5) downhole spinner or radioactive tracer survey. To further strengthen the Class II saltwater injection well program, the Ohio Department of Natural Resources, Division of Oil and Gas Resources Management (Division) has begun a proactive approach to seismic monitoring around Class II injection wells. The Division will be installing portable seismic stations around newly permitted Class II saltwater disposal wells in advance of initiation of injection operations and will begin seismic monitoring prior to injection. The Division will then continue to monitor for seismic activity for approximately six months after injection operations commence. A total of six portable seismic stations have been purchased to date, with the potential for purchasing an additional 20 stations for deployment. All stations will have the capability of real-time monitoring for location and identification of microseismic events.

Apparent Upward Migration Determination: Multi-level Diagnostic Strategies That Can Save Your Deep Injection Well

Kirk Martin P.G. and **Stewart Magenheimer** P.G. CDM Smith

When upward fluid migration is detected in a municipal wastewater injection well system, facility operators often face the unpleasant prospect of having to invest significant capital in filtration and disinfection upgrades to address non-compliance. However, there may be other options available that can address these issues for a fraction of the cost of process upgrades. The additional disposal options afforded by 40 CFR Part 146.15 to address regulatory non-compliance issues due to upward migration in Florida are:

- Advanced Wastewater Treatment (AWT) - This option requires the affected facilities provide advanced wastewater treatment in the form of additional filtration and high-level disinfection, and demonstrate that the injected fluids would not cause the Underground Source of Drinking Water (USDW) to exceed the national primary drinking water regulations and other health-based standards.

- Hydrogeologic Demonstration - This approach requires demonstration that the injection would not cause the USDW to exceed the national primary drinking water regulations and other health-based standards. Failure to accomplish this demonstration requires treatment of the injectate to such a level that the fluids would not cause exceedances in the USDW (option 1).

The advantages and disadvantages of the two approaches can be distilled down to certainty and cost. The first approach has the advantage of a higher probability of achieving regulatory compliance, but at substantial capital cost to construct AWT improvements. For the hydrogeologic demonstration, the costs associated with this approach are relatively less typically (engineering study and remedial construction), however, establishing reasonable assurance with the regulatory agencies that the system will operate in compliance is less certain.

Multi-level data analysis strategies can be developed to assess if upward migration has occurred and if the original system design is compatible with the hydrogeology as it is currently understood. Based on these evaluations, it may be determined that the evidence of upward migration can be ascribed to ambient conditions, mechanical integrity issues, or incompatibilities in the injection system design with the site hydrogeology. Once the causal factors have been determined, appropriate remedial actions can be identified and undertaken to restore system compliance.

Examples of successfully employing the hydrogeologic approach have been recently demonstrated in Brevard County, Florida. These case studies have shown that this approach using a wide range of diagnostic methods can lead to cost effective outcomes where the factors contributing to an indication of upward fluid migration can be identified and remediated for substantially less than the estimated process improvement costs. In one case, a utility in Brevard County was able to address an upward migration non-compliance issue for a cost of less than 10% of the estimated process upgrades costs by correctly identifying the cause of the upward migration and performing remedial activities. Analytic methods included: 3-D fluorescence spectroscopy, chemical fingerprinting, groundwater age dating, robust lithologic and geophysical evaluations, and refined transport modeling that lead to an improved understanding of the hydrogeochemical flow regime. The resulting savings to the facility operator were literally millions of dollars of capital that can now be deployed for other pressing system needs.

Building Out the Framework for CCS Deployment Practical Approaches for Implementing Early Stage CCS Projects

Bob Van Voorhees, Carbon Sequestration Council

Bob Van Voorhees has worked in the environmental and energy fields since the early 1970's. His legal and consulting practices have included environmental litigation, counseling, and representation on regulatory, legislative and compliance matters in the air, water, hazardous waste, toxic substance, underground injection, and occupational safety and health areas. He has worked with clients, primarily in the petrochemical and petroleum industries, in achieving broad policy objectives in rulemaking and judicial review proceedings. He has represented clients in challenges to regulations and standards in the United States Supreme Court and in the United States Courts of Appeals and District Courts. He has also defended clients in civil and criminal enforcement actions before administrative agencies and in courts at both the federal and state levels. The Ground Water Protection Council (GWPC)—the national association of state ground water protection and underground injection control programs—presented its Award of Excellence in Ground Water Protection to him in 1996 for his outstanding contribution in the development of sound national regulations for underground injection control. During the last decade, he represented the State of Kuwait and the Kingdom of Saudi Arabia in presenting claims before the United Nations Compensation Commission for environmental damages incurred as a result of the invasion and occupation of Kuwait and Saudi Arabia by Iraq in 1990-91. Currently, he is the Manager of Underground Injection Technology Council and of the Carbon Sequestration Council. During the past four years he has facilitated multi-stakeholder discussions to develop consensus recommendations among environmental nongovernmental organizations, industry and government regulators regarding regulatory frameworks for geologic sequestration (or storage) of carbon dioxide streams and for hydraulically fractured hydrocarbon production wells. He continues his law practice as Of Counsel to Bryan Cave LLP and works as a consultant through Robert F Van Voorhees PLLC.

The Environmental Protection Agency (USEPA) and some States are beginning to implement, frameworks for permitting and regulating Carbon Capture and Storage (CCS) projects and geologic sequestration (GS) wells in anticipation of significant deployment of the technology as a means for achieving reductions of CO_2 emissions at large sources. Today there are no completed commercial CCS projects that involve capture at a power plant and geologic storage, but a host of pilot, demonstration, and other small scale projects are being conducted to further develop the technology and implement specific projects. In the process of deploying these projects, issues have arisen regarding the proper permitting steps for pilot and other demonstration scale projects, including the nine Phase III demonstration projects proceeding under the U.S. Department of Energy (DOE) Regional Carbon Sequestration Partnership (RCSP) program and similar projects. These demonstration projects are providing invaluable information regarding the suitability of different geologic settings, project designs, and technological methods. They involve smaller amounts of injection and shorter time durations than full-sized commercial scale projects, yet they face many of the same requirements for planning, provision of site information, financial assurance and post-injection stewardship as will commercial scale projects. The result is that practical steps need to be devised as these projects proceed both to satisfy new regulatory requirements and to preserve the core scientific and technical elements of each demonstration project. Permitting and compliance issues are imposing unanticipated hurdles to implementing and completing these early projects as originally designed. Practical solutions for addressing those hurdles could allow the projects to proceed and enable future experimental projects to move forward more effectively rather than be ruled out. The presentation will describe the potential hurdles, discuss the most significant lessons learned and present recommendations for avoiding future problems.