Wastewater Treatment and Related Modeling Workshop Participants

Carl Adams, Principal, ENVIRON International Corporation

Carl Adams is considered one of the leading international experts on industrial wastewater management. Adams is the inventor and holder of three patents involving advanced industrial wastewater treatment technology. These patents are installed in over 85 applications in 18 countries. Adams has been a consultant/director to more than 1,000 US and foreign industrial wastewater management projects in 32 countries; author of over 100 technical publications and presentations and co-author and editor of four books and engineering manuals, regarding industrial wastewater treatment design and management. His major client base is the petroleum and petrochemical, organic chemicals and coking industries. He has worked with over 90 refineries in North America, South America, China, India, Europe and the Middle East. His special areas of technical expertise include: aerobic and anaerobic treatment of high strength and high salt industrial wastewaters, nitrification-denitrification, membrane technology, chemical oxidation, source control and water recycle and reuse. Adams is an expert in the development of cost-effective volatile organic compounds (VOC) control technologies for fugitive off-gases at industrial wastewater treatment facilities, especially refineries and petrochemical plants. Although not a modeler, he is very experienced with the application of VOC gaseous partitioning models, such as WATER9 and Toxichem+. As Inventor and Director of the VOC BioTreat team for ENVIRON, he won three national and global awards for innovativeness and furthering knowledge of cost-effective environmental controls.

Thomas Angelo, Director, Water Pollution Control Department, Warren, Ohio

Thomas Angelo is the Director of the Water Pollution Control Department in Warren, OH. He is a Certified Class IV Wastewater Operator with expertise in treatment of industrial and municipal wastewater, with over 29 years of professional experience. He has worked through the city and affiliations throughout the State of Ohio to develop practices and methods to enhance and promote the techniques of wastewater collection, pollution control and solids waste handling and disposal. In 2009, he began research on oil-field brines, for treatment and disposal in municipal wastewater treatment facilities and surface water. In 2010, he developed and implemented an eight-week live-pilot study to clearly identify the amount of brine that Warren can receive without causing Wastewater Treatment Plant or surface water quality issues. In December of 2010, Warren became the first and only Wastewater Treatment Plant in Ohio to treat and discharge hydraulic fracturing flowback water into the Mahoning River which it still does to date. He is currently the President of the Ohio Water Environment Association (OWEA), which is a State member to the Water Environment Federation. OWEA's 1,970 members include seasoned utility plant operators, mechanics, lab technicians, engineers, regulators, manufacturer's representatives and academic leaders. In the area of hydraulic fracturing and drinking water, he is especially interested in baseline water quality monitoring, flowback water quality, the effects of total dissolved solids from treatment to surface water and the potential transport of chemicals used in hydraulic fracturing to groundwater and surface water resources. He has developed an extensive river monitoring program that tests for multiple parameters throughout the Mahoning River/Beaver River watershed into the Ohio

River. The weekly monitoring of the river watershed has been ongoing since November of 2010. He has an Associate Degree in Electronics Engineering Technology from the ATES Technical Institute.

John Bailey, Manager, Water Division Permits Branch, Arkansas Department of Environmental Quality

John Bailey has more than ten years of experience in environmental engineering, which includes clean air and water regulations. He began his professional career as a permit writer for the Air Division at the Arkansas Department of Environmental Quality in 1996. In 2006, Bailey became supervisor of the Stormwater Section and in 2007 became supervisor of the National Pollutant Discharge Elimination System Permits Section in the Water Division at the Arkansas Department of Environmental Quality. In 2009, he was promoted to the Water Division Permits Branch Manager. He holds a BS in Chemical Engineering from the University of Arkansas.

Matthew Bruff, CDO and General Counsel, Altela, Inc.

Matthew Bruff, Co-founder of Altela, Inc., is a designer and manufacturer of disruptive clean technology to desalinate and decontaminate highly challenged petroleum and industrial wastewater. Altela's patented AltelaRain® technology desalinates highly-challenged, frac flowback, brackish and produced water without the energy intensive equipment, high temperatures or pressure of other water desalination technologies. Prior to Altela, Bruff worked at the U.S. Department of Energy's Sandia National Laboratories. Bruff has over 18 years of experience in both the natural resource and technology industries and has acquired many precedent-setting regulatory permits across the United States with respect to the treatment and beneficial re-use of oil and gas industry wastewater. Bruff is a named inventor on several patents (United States and international) dealing with novel enhanced systems, processes and methodologies for producing clean water. Bruff received a juris doctorate degree and MBA from the University of New Mexico.

Lawrence Cenegy, Senior Corrosion Engineering Advisor, Hess Corporation

As a Senior Corrosion Engineering Advisor, Lawrence Cenegy provides corrosion and water management support to HESS business units worldwide. Cenegy is currently involved in several unconventional resource water management projects involving water sourcing, application and reuse, and he is a member of the HESS-internal Water Advisory Technical Resource team. Prior to joining HESS, Cenegy held the position of CAPEX Projects Manager for Nalco Company, focusing on chemical treatment programs for both land-based and deepwater projects. Before that position, Cenegy was a Research Section Leader for Nalco Company and earlier for Exxon Chemical Company, managing group projects in the areas of water treatment and flow assurance. Cenegy's 35-plus years of industry experience includes projects in all the major oil production regions worldwide. Cenegy has co-authored over 15 technical papers and patents, and he is a member of the Society of Petroleum Engineers, National Association of Corrosion Engineers and American Chemical Society. Cenegy holds an undergraduate degree in Chemistry from the College of New Jersey and a MBA from the University of St. Thomas in Houston.

Thomas Chambers, Senior Facilities Engineer, Southwestern Energy Company

Thomas Chambers has 24 years of experience in a variety of fields: municipal, surveying, transportation, water treatment, land planning and development. He has worked in the oil and gas industry for the past four years, first with a research and development group tasked with developing a cost effective method of treating and recycling flowback and produced water, and secondly as an engineer for Southwestern Energy. He holds a BS in Civil Engineering from Memphis State University.

Nancy Coleman, Principal, Environmental Consultants

Nancy Coleman is an environmental toxicologist and public health professional with 30 years experience in risk assessment for environmental media, including groundwater, surface water and drinking water. Currently, she is the principal for Environmental Consultants in Oklahoma City and serves as the toxicologist for Chesapeake Energy Corporation. Coleman has been involved in development of criteria for selection of environmental acceptable hydraulic fracturing chemicals, risk evaluation of mixed production fluid releases and potential effects on soil, surface water and groundwater resources, evaluation of produced water quality data and evaluation of the potential fate and transport of hydraulic fracturing chemicals. Coleman presented a paper on produced water quality at the 2011 US EPA Chemical and Analytical Methods Technical Workshop for the Study of Hydraulic Fracturing and its Potential Impact on Drinking Water Resources. In 2012, Coleman presented papers at several national conferences on chemical disclosure of hydraulic fracturing chemicals, baseline water quality sampling programs and short-term intra-well variability in domestic water wells. Prior to entering consulting, she was the toxicologist and epidemiologist for the Oklahoma Department of Environmental Quality and its predecessor, the Environmental Division of the Oklahoma State Department of Health (1985-1994). She also has served as a sanitarian and as a laboratory manager for an environmental laboratory (1978-1985). Coleman's area of research activity includes the potential effects of chemicals utilized in the production of oil and natural gas on surface and groundwater resources, variability of naturally-occurring substances in domestic wells and risk evaluation of contaminants on potential drinking water supplies. She has served on the Oklahoma Corporation Commission Risk Task Force, Mid-Continent Oil and Gas Association Glycol Dehydration Study Committee, STAPPA Air Toxics Review Committee, API E&P Health Issues Group and several committees for the Oklahoma State Department of Education regarding science education. She is a member of the American Conference of Governmental Industrial Hygienists and a diplomat in the American Academy of Sanitarians. She has a degree in Environmental Health from Old Dominion University and a MPH in Environmental Health and a PhD in Environmental Toxicology from the University of Oklahoma Health Sciences Center.

George DeVaull, Principal Technical Expert, Environmental Soil and Groundwater Group, Shell Global Solutions US, Inc.

George DeVaull is the Principal Technical Expert in the Environmental Soil and Groundwater Group at Shell Global Solutions US, Inc., in Houston, TX. He has over 23 years of professional experience in fate, transport and risk evaluation of chemical releases to soils and groundwater.

The work has covered aspects of the petroleum industry from upstream exploration and production to retail service stations, in evaluation of legacy site impacts as well as in predictive estimates for new chemical applications, including preventive risk management. His publications have covered the chemical fate and transport of petroleum, petroleum-related chemicals, ethanol, MTBE and methane, on topics including biodegradation, subsurface vapor migration, non-aqueous phase liquid mobility and risk evaluation methods. He has authored the BioVapor model, which is being reviewed by US EPA for consideration in petroleum vapor intrusion guidance. He has presented numerous short courses for regulators across the US and in other countries in which Shell operates, many times in co-presentation with regulatory staff. Courses have included risk-based site management and natural attenuation of petroleum, MTBE and other chemicals. Since 2008 he has presented several courses per year on subsurface to indoor air petroleum vapor intrusion. He has a BS and MS in Mechanical Engineering and a PhD, all from University of Illinois at Urbana-Champaign.

Michael Dunkel, Director of Sustainable Development, Pioneer Natural Resources

Michael Dunkel is the Director of Sustainable Development for Pioneer Natural Resources. He is responsible for corporate water and air initiatives that promote long term sustainability. A major focus of the initiatives is finding an economically viable alternative to using fresh water for drilling and hydraulic fracturing. The study includes transportation, storage and treatment of produced water for recycling. Dunkel has presented on water management for the Texas House Hearing on Water, the Eagle Ford Task Force, the US EPA Water Acquisition Roundtable and other Oil and Gas conferences. Dunkel has held positions with Pioneer Natural Resources in engineering management, project management and business development over the last 15 years. His experience with Pioneer includes projects and developments in Tunisia, South Africa, Gabon and Argentina, before joining the Sustainable Development Group. Prior to Pioneer, Dunkel was employed at Marathon Oil in a variety of engineering and business development roles for 15 years. His involvement in successful developments covered Texas, Louisiana and North Africa. As a 30-year member of the Society of Petroleum Engineers (SPE), he was a founding member and officer of the SPE Section in Tunisia. Dunkel earned a BS in Mechanical Engineering from Rose-Hulman Institute of Technology.

Daniel Ertel, CEO, Eureka Resources, LLC

Daniel Ertel, a native of Williamsport, PA, is the CEO of Eureka Resources, LLC, located in Williamsport. Ertel began his career in R&J Ertel, Inc., a mechanical construction business founded in 1971 by his father. Ertel was instrumental in growing R&J Ertel from 5 employees in 1984 to 120 employees by 2007. R&J continues to do business in Pennsylvania and the surrounding states, providing design build mechanical services including engineering and sheet metal fabricating, excavating and piping services to a wide range of customers. Eureka and R&J Ertel, Inc., are two of several businesses that Ertel currently owns and operates. In 2007 the Marcellus Shale Play was introduced to the Lycoming County, PA, area. Realizing the critical need the industry had for water treatment, especially considering the high quality environment which might be adversely effected if sound solutions were not available, Ertel, along with two

business partners, decided to enter the gas well waste water business and formed Eureka Resources in July of 2008. Working with both local authorities and state environmental entities, Eureka opened their first centralized treatment plant on November 20, 2008. After extensive research, Eureka introduced the next generation of water treatment for the gas drilling industry in Pennsylvania. Eureka Resources signed its first contract with Fountain Quail Water Management in August of 2009 and opened its new expanded facility using mechanical vapor recompression technology in June of 2010. This plant produces water meeting or exceeding the newest PA DEP standards for discharge and reuse. Eureka has recently permitted two additional facilities with construction scheduled to be completed by the third quarter of 2013. These new facilities will incorporate state of the art crystallizer technology, as well as additional advanced treatment processes which will allow Eureka to recover even higher levels of clean reusable water, while also producing various by-products for industrial reuse and minimizing the remaining waste streams. Ertel graduated from Bucknell University in 1984 with a BS in Civil Engineering.

Peter Fyfe, Senior Facilities Engineer, Fayetteville Shale Division, Southwestern Energy Company

As Senior Facilities Engineer of Southwestern Energy Company's Fayetteville Shale Division, Peter Fyfe focuses on planning and executing water infrastructure development projects (water sourcing and treatment) in support of the development of the Fayetteville Shale in Arkansas. The primary objectives of these projects are to reduce the development cost while providing secure sources of water and treatment operations, which may be accomplished in a long term, sustainable manner. Fyfe has over 19 years of engineering/consulting experience in environmental engineering with a focus on industrial and municipal water and wastewater treatment. Over the course of his career, he has successfully worked with both the public and private sectors, often with both on the same project. He is experienced at permitting, designing and operating water and wastewater treatment facilities including a system with a goal of 100% recycle of wastewater and screening technologies for various treatment goals. He has experience with facility construction, startup and conducting operator training. He holds a BS in Civil Engineering from Lafayette College and a MEng in Environmental Health Engineering from the University of Texas at Austin.

Ganesh Ghurye, Engineering Associate, ExxonMobil Upstream Research Company

Ganesh Ghurye is an Engineering Associate at ExxonMobil Upstream Research Company. Following experience as a consulting engineer and as an academic staff researcher with a focus on water treatment and removal of arsenic and nitrate, he joined ExxonMobil in 2008, where he serves in the Environmental and Safety Technology Section. His current research interests include the evaluation and development of treatment technologies for wastewaters associated with unconventional gas and studies of the composition of wastewaters and wastewater treatment by-products from the production of unconventional gas. He is a member of the American Water Works Association where he serves on the Inorganics and Inorganic Contaminants Research Committees. He holds a PhD and MS in Environmental Engineering

from the University of Houston and BS degrees in Chemical Technology and Chemistry from Bombay University, India.

Marc Glass, Principal, Downstream Strategies, LLC

Marc Glass has over thirteen years of experience in environmental consulting and management, including nine years as a West Virginia Department of Environmental Protection Licensed Remediation Specialist. He is skilled in the evaluation and remediation of environmental contamination. Glass' experience includes Phase I and Phase II environmental site assessments, petroleum and chlorinated solvent site investigations, design and installation of monitoring well networks, aquifer testing, asbestos and biological remediation and project supervision, preparation of facility Spill Prevention Plans for above ground and underground storage tank facilities and mold investigation and remediation. Glass' experience includes management of remediation projects in the West Virginia Voluntary Remediation and Redevelopment Program and Pennsylvania Department of Environmental Protection Land Recycling Program.

Brent Halldorson, Chief Operating Officer, Fountain Quail Water Management

Brent Halldorson from Fountain Quail Water Management (FQWM) is a founding member of the Texas Water Recycling Association. FQWM pioneered water recycling in the very first shale play in the Barnett Shale. FQWM has been working with Devon Energy since 2004 and has recycled almost 1 billion gallons of saltwater back into freshwater for re-use. It has also been operating in the Marcellus Shale through Eureka Resources, LLC (Williamsport, PA). FQWM helped develop the first recycling permit in the state of Texas and was the first to obtain a state-wide recycling permit. FQWM has also worked with state regulators in Colorado, Arkansas and Pennsylvania. FQWM offered comments and expertise to the Texas Railroad Commission on their recent review of state recycling rules.

Christopher Harto, Energy and Environmental Analyst, Argonne National Laboratory

Christopher Harto has been an Energy and Environmental Analyst at Argonne National Laboratory since 2010. His work focuses on quantifying the environmental performance of energy technologies. Much of his recent work is related to the energy-water nexus. Recent projects have included estimating the life cycle water footprint of geothermal energy, life cycle assessment of produced water treatment and disposal systems and quantifying the risk to electricity generation from severe drought in the Western US. In the area of shale gas development and hydraulic fracturing, Harto has co-authored two white papers for the Department of Energy on the environmental impacts of shale gas development, one of which was recently released as a peer reviewed journal article. He is also a co-author of a life cycle assessment of water consumption for natural gas from conventional and shale plays that is currently being submitted for peer review publication. In 2009, as a student at Arizona State University, Harto was awarded the Central Arizona Project award for water research for his work on quantifying the water intensity of low carbon transportation fuels.

Thomas He, Environmental Geochemist, West Virginia University

Thomas He is an Environmental Geochemist at West Virginia Water Research Institute. He is currently working on projects related to environmental issues associated with returned hydraulic fracturing water and mining waste water, such as Selenium, Bromine and total dissolved solids (TDS). He is investigating novel treatment technologies for TDS treatment in order to lower the treatment cost of available technologies. He is conducting review on returned frac water composition in the Marcellus shale region and treatment technologies to enhance the reuse and recycle of fracturing water. He has extensive experience in geochemical modeling on speciation, dissolution and precipitation, redox reaction, as well as contaminants fate and transport. He has over seven years of experiences in environmental investigations projects related to basic scientific research on fate and transport of organic and inorganic contaminants in soil and water, and two years of experience on remediation projects in environmental consulting. He is experienced in geochemistry evaluation and monitored natural attenuation, and he has extensive experience in metals and chlorinated solvents remediation and waste water treatment related to mining, chemical, pharmaceutical and oil and gas industries. He is also actively involved in developing innovative remediation technologies for emerging contaminants (e.g., PFOA/PFOS, 1,4-dioxane). He has 23 peer-reviewed publications in prestige journals such as Environmental Science and Technology and Geochimica et Cosmochimica Acta. He has presented in over 16 national and international conferences.

Jason Heath, Technical Programs Manager, Ohio River Valley Water Sanitation Commission

Jason Heath is Technical Programs Manager at the Ohio River Valley Water Sanitation Commission (ORSANCO). ORSANCO is an interstate basin commission for the Ohio River. Heath's area of expertise is in water pollution control regulations and watershed management. ORSANCO recently adopted a water quality standard for total dissolved solids (TDS), in part to address water quality issues associated with the treatment and disposal of hydrofracing waste water. ORSANCO is currently working on development of a water quality standard for bromide which could also have implications regarding disposal of fracing waste water. ORSANCO recently completed a water quality study of the Ohio River for TDS and its constituents to determine the extent of impairment associated with TDS. In addition, ORSANCO has a Publically Owned Treatment Works Advisory Committee that provies represenation of municipal waste water utilities on the Ohio River. The Marcellus and Utica shales lie within the Ohio River Basin.

Thomas Kropatsch, Natural Resource Analyst, Wyoming Oil and Gas Conservation Commission

Thomas Kropatsch is a Natural Resource Analyst with the Wyoming Oil and Gas Conservation Commission (WOGCC) and is responsible for the implementation and regulation of the WOGCC environmental programs and oil and gas operator's compliance with the WOGCC's Rules and Regulations. He manages the WOGCC wastewater treatment program, which requires pre-approval of oil and gas operators or contractors who treat wastewater for re-use or recycling. The approval process includes a hearing to review the proposed treatment methods, equipment and sampling/analytical program. Kropatsch acts as the hearing examiner to review

the proposed treatment process and prepares orders authorizing the companies to treat flowback or produced waters for re-use, recycling or disposal. The order includes conditions the company must comply with during their treatment of the wastewater. These conditions are set to ensure the company remains in compliance with the rules and regulations of the WOGCC and include notifications of work, pre- and post-treatment sampling and analytical requirements and stipulations on where or how the treated wastewater may be re-used, recycled or disposed. He also reviews post-work treatment reports and analytical data to monitor compliance with the WOGCC rules and regulations. Kropatsch is also a hearing examiner for the WOGCC's Class II UIC program. As an examiner, he provides regulatory review and approval of new injection/disposal wells, requested increases in well injection pressure and approval for disposal of new sources of produced water or flowback water into Class II wells. Kropatsch provides technical and regulatory assistance to oil and gas operators within the state on remediation and/or disposal of exploration and production generated wastes, including petroleum contaminated soils, produced water and flowback water.

Dennis Lamb, CBM/Oil & Gas Group Supervisor, Water Quality Division, Wyoming Department of Environmental Quality

Dennis Lamb is the supervisor for the Coalbed Methane (CBM) and Oil and Gas Group for the Wyoming Department of Environmental Quality/Water Quality Division. This group permits, monitors and inspects Commercial Oilfield Water Disposal Facilities and CBM and oil and gas produced water treatment facilities statewide. Previous experience includes U.S. Geological Survey and private consulting. He is a professional geologist in Wyoming. Lamb has a BS and MS in Geological Engineering from the South Dakota School of Mines and Technology with emphasis on hydrogeology and geochemistry.

John Lucey, Executive Vice President of Engineering and Business Development, Heckmann Corporation

John Lucey is a professional engineer with 35 years of experience in the industrial water and wastewater treatment industry, the last five of which were in the unconventional oil and gas industry. He is the Executive Vice President of Engineering and Business Development for Heckmann Corporation, one of the leading water management companies in the US. The company owns two wastewater treatment facilities for oil and gas wastewater and have evaluated wastewater treatment at all of the major plays in the US where it operates. This includes the Bakken, EagleFord, Permian, Haynesville, Marcellus, Barnett, Mississippi Lime and Tuscaloosa Marine Shale. Lucey has spoken at numerous conferences on the topic of water and wastewater treatment for the unconventional oil and gas industry and is a member of the Marcellus Shale Coalition Waste Management Subcommittee.

Allison MacKay, Associate Professor, University of Connecticut, Storrs, CT

Allison MacKay is an Associate Professor of Civil and Environmental Engineering at the University of Connecticut in Storrs, CT. She is an environmental engineer with expertise in the fate of contaminants in natural and engineered systems with over 15 years of independent

research experience. Her work targets understanding of the roles of compound structure and physico-chemical properties and key characteristics of environmental systems on the phase transfer and transformation reactions that govern contaminant fates. The aim of this work is to develop predictive models of compound fate processes that are adaptable to many different compounds and/or environmental settings. Her work has a particular emphasis on contaminant fates in environmental settings with heavy anthropogenic alterations. Presently, she is examining impacts of effluent discharges on contaminant fates in perturbed river systems. MacKay's research is primarily experimental in nature and she has experience in analytical measurements of trace organic, heavy metal and metalloid contaminants and field sampling of groundwater, stormwater, river and surface water systems. She has also validated the application of physico-chemical fate models to predict contaminant fates in drinking water treatment processes. She is particularly interested in the fate treatment and management of chemicals used in the hydraulic fracturing process. She has a BASc in Engineering Science (Chemical Engineering), a SM in Civil and Environmental Engineering and a PhD in Environmental Engineering from Massachusetts Institute of Technology.

Earl Mattson, Research Scientist, Idaho National Laboratory

Earl Mattson is a Research Scientist at the Idaho National Laboratory. His research interests involve understanding fluid flow and chemical/heat transport in porous media. Developing quantitative descriptions of subsurface processes, characterization and porous media parameters that are based on laboratory and field testing. His initial research interest were in flow and transport of water and solutes in the vadose zone and have since evolved to include high temperature/pressure geomechanical behavior of fractures and unconventional fossil resources as a function of temperature, stress and geomechanical properties. He has worked on proppant rearrangement and embedment as a function of closure stress in shales, water flow and chemical transport in fractured basalt vadose zones, thermally reactive tracer evaluation in geothermal systems and product production and environmental consequences of in situ retorting of oil shale. A current research project is developing an understanding of water retention in proppant filled fractures in unconventional gas reservoirs and its effect on flowback and gas production. He has a PhD and MS in Hydrology from New Mexico Institute of Mining and Technology and a BS in Civil Engineering from the University of Minnesota.

Meagan Mauter, Assistant Professor, Carnegie Mellon University

Meagan Mauter's research interests lie at the intersection of energy and water. During her doctoral studies, Mauter performed research on next-generation membranes to reduce the energy consumption of water desalination processes. As an Energy Policy Fellow at the Harvard Kennedy School, she working on issues at the energy water nexus including water treatment technologies and firm behavior in unconventional resource extraction. Mauter combines her technical background in desalination to the emerging issue of brine management, raising new questions and offering new thinking on how to maximize shale gas resources while minimizing their short and long-term environmental impacts. Specifically, she has performed major studies evaluating how firm level management practices determine environmental outcomes in the Marcellus and performed economic analysis on impact mitigation technologies. After finishing undergraduate degrees in Civil and Environmental Engineering and History at Rice University,

Mauter completed a PhD in Chemical and Environmental Engineering in the laboratories of Menachem Elimelech and Chinedum Osuji at Yale University.

Rick McCurdy, Senior Engineering Advisor, Chesapeake Energy Corporation

Rick McCurdy is a Senior Engineering Advisor for Chesapeake Energy in Oklahoma City, OK. In this role, McCurdy is primarily responsible for oversight of Chesapeake's chemical usage in hydraulic fracturing and production operations and for evaluating new technologies in the area of water reuse and reclamation. McCurdy has over 32 years of experience working directly with specialty chemicals used in drilling, stimulation and production operations. McCurdy has also spent much of his career in treating oilfield water systems and has devoted a considerable amount of time over the last eight years to evaluating technology for the reclamation or reuse of produced brine in hydraulic fracturing operations. McCurdy has been one of the principal archtects behind Chesapeake Energy's industry leading Aqua Renew program that focuses on reuse and reclamation of produced fluids to offset fresh water usage in oilfield operations. Over the last several years, McCurdy has been invited to present his views on water reclamation technology to numerous industry groups.

Kent McManus, Vice President of Engineering, Eureka Resources, LLC

Kent McManus is a professional engineer who has been practicing for over 32 years. His experience encompasses industrial wastewater treatment, oil and gas development related permitting and compliance, due diligence; regulatory compliance assessments; site development and permitting; preparation of environmental assessments and environmental impact statements under SEQRA; solid and hazardous waste management; hazardous waste treatment; site investigation and remediation; landfill permitting, design, construction and closure; and brownfield site investigation and remediation. McManus has managed and performed a wide variety of industrial wastewater related bench and pilot scale treatability testing projects, feasibility studies, facility plans, designs and construction oversight projects for a variety of industrial sectors. He has prepared and presented multiple presentations on water management for oil and gas development projects, prepared water management planning documents and permitted oil and gas wastewater treatment facilities. McManus worked for Eureka as a consultant for several years before recently joining the company to assist with permitting, design and operation of oil and gas wastewater facilities. He has both BS and MS degrees from Clarkson College of Technology in Environmental Engineering.

Pete Miller, Water Resources Manager, Range Resources-Appalachia, LLC

Pete Miller is the Water Resources Manager at Range Resources in Canonsburg, PA. He is a Registered Professional Environmental Engineer in the State of Pennsylvania and is responsible for managing water resources from sourcing, transportation, treatment, storage, reuse and disposal for Range's southwestern Pennsylvania unconventional natural gas operations. He is active in assessing the current practices in water management and evaluating their sustainability against forecasted development activity levels. He is also knowledgeable of Pennsylvania's Water Management Plan and Oil & Gas Waste Management programs. His over 22 years professional experience is primarily focused on industrial water treatment and spans

across a broad range of industries, including; oil and gas, microelectronics, landfills, alternative energy and food and beverage among others. Prior to Range Resources he worked for such companies as USFilter, Veolia, Siemens Water Technologies and Tetra Tech NUS. Miller is also active in the Marcellus Shale Coalition and has been the Chairman of their Waste and Recycle Subcommittee for the past 3 years. He has a BS in Civil Engineering from the University of Pittsburgh (1992) and a MBA from Robert Morris University (2009), and is a Certified Project Management Professional (PMP) through the Project Management Institute.

Yves Pollart, Vice President of Environmental Engineering, Rettew Flowback, Inc.

Yves Pollart is a Vice President with Rettew Flowback, Inc. (RFI), based in Lancaster, PA. He is a registered engineer in 10 states, and is affiliated with eight engineering organizations nationwide, specializing in water and wastewater management and treatment for municipal, industrial and energy clients. Pollart has more than 32 years of environmental engineering experience, including key design of wastewater treatment plants, sanitary sewer systems, combined sewer systems and industrial pretreatment plants. He has extensive experience in the oil and natural gas industry, working on designs of surface water intakes, water transfer mains, water booster stations and both centralized and mobile flowback treatment facilities, including RFI's developed proprietary mobile treatment technology. Pollart is a strong proponent of water reuse and recycling efforts by the oil and natural gas industry. He oversees the daily operations of RFI's oil field services including water management for exploration and production companies throughout multiple shale plays. Each pad site's downhole chemistry requirements varies, so each water treatment/recycling plan is customized with Pollart's oversight. Familiar with the differences between water qualities of regional shale plays, he supervises the evaluation of appropriate water treatment technology for both flowback and produced water, including bag and mechanical filtration; physical/chemical treatment; membrane technology such as forward and reverse osmosis; electro-coagulation; thermal distillation processes and other emerging technologies. Pollart is also knowledgeable of regulations and regulatory agencies in the Marcellus and Utica Plays. He is particularly cognizant of the ongoing discussion and solutions to water and waste disposal options as a participant in the Marcellus Shale Coalition's Waste Management and Recycling Subcommittee. Pollart has served on several state, regional and national committees for engineering organizations, including the American Academy of Environmental Engineers, Central Pennsylvania Water Quality Association, Water Environment Federation, Marcellus Shale Coalition and American Association of Drilling Engineers. He has a BS in Civil Engineering from the Virginia Military Institute and a MEng in Environmental Pollution Control from The Pennsylvania State University.

Vikram Rao, Executive Director, Research Triangle Energy Consortium

Vikram Rao is Executive Director of the Research Triangle Energy Consortium, a non-profit in energy founded by Duke University, North Carolina State University, RTI International and University of North Carolina at Chapel Hill. Its mission is to illuminate national energy priorities, and those of the world by extension, and to catalyze research to address these priorities. Rao

serves on the board of Intelligent Well Controls Ltd. and also advises venture capitalist Energy Ventures AS, and firms BioLargo, Inc., Global Energy Talent Ltd. and Integro Earth Fuels, Inc. He retired as Senior Vice President and Chief Technology Officer of Halliburton Company in 2008 and followed his wife to Chapel Hill, NC, where she is on the faculty. Later that year he took his current position. He also serves on North Carolina Mining and Energy Commission and chairs the Water and Waste Management Committee. Rao's book Shale Gas: the Promise and the Peril was recently released by RTI Press and is intended to inform on the heated debate on fracturing for shale gas. Rao holds a BS in engineering from the Indian Institute of Technology in Madras, India, along with a MEng and a doctorate in Engineering from Stanford University. He is the author of more than 50 publications and has been awarded 30 US patents and foreign analogs.

Emily Reader, Engineering Geologist, Division of Oil, Gas and Geothermal Resources, State of California Department of Conservation

Emily Reader is an Engineering Geologist for the Department of Conservation's Division of Oil, Gas and Geothermal Resources for the State of California. Her primary role is assisting the Chief Deputy of the Division by conducting geological and engineering research and work in investigations and studies associated with special projects within the Division and preparing reports for briefing of the Chief Deputy. She is the technical expert and a research member of the team responsible for composing the proposed Hydraulic Fracturing Regulations for the State of California. She has performed in-depth research of standards and recommended practices from a scientific and regulatory perspective with regards to well construction, testing and monitoring to ensure adequate confinement and isolation of potential flow zones and fluids. With over three years of experience within the Division, she also worked as an Energy and Mineral Resources Engineer with extensive experience in regulating all operations of oil and natural gas fields to make sure their compliance with current California laws, regulations and policies on and offshore. In the field and in the office, she has evaluated subsurface condition of wells to confirm isolation of fluids between zones and identified problems associated with the mechanical integrity of wells. In the area of hydraulic fracturing she is particularly interested from a regulatory standpoint in well integrity testing, modeling and monitoring of hydraulic fracturing operations and water quality monitoring to ensure new hydraulic fracturing regulations are set in place to foster oil and gas production while providing preservation, good stewardship and protection of all California's resources. She has a BS in Geology from Texas Christian University and a MS in Geological Sciences from San Diego State University.

Andrew Stack, Research & Development Staff Member, Oak Ridge National Laboratory

Andrew Stack is a Research & Development Staff Member at Oak Ridge National Laboratory in Oak Ridge, TN. He is an aqueous geochemist/mineral surface geochemist with expertise in precipitation reactions, with 11 years of research and professional experience as a geochemist. He has worked to develop predictive kinetics models for the precipitation of sparingly-soluble

salts such as calcium carbonate and barium sulfate that are problematic scale-forming minerals during oil/gas production, as well as potential candidates for in situ engineered mineral precipitation in order to sequester toxic contaminants such as heavy metals and carbonates in particular are important for carbon sequestration. He has also researched the interactions of anaerobic iron-reducing organisms with iron minerals. He worked as a Hydrologist at the U.S. Geological Survey's Water Resources Division, where he sampled well-water, analyzed groundwater compositions and performed age dating as well as an environmental consulting firm. After his PhD, he was a Postgraduate Researcher in the Land, Air and Water Resources Department at UC Davis, followed by an Assistant Professor in the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. He has served on a number review panels for the National Science Foundation and the Department of Energy and is the Program Chair for the American Chemical Society's Geochemistry Division. In the area of hydraulic fracturing and drinking water, he is especially interested in developing in situ treatment strategies for the toxic metals barium and radium that are commonly found in flowback water. He has a BS in Geological Sciences: Geochemistry, a MS in Geology and a PhD in Geology from the University of Wyoming.

Thomas Starosta, Environmental Engineer Consultant, Pennsylvania Department of Environmental Protection

Thomas Starosta is a Professional Engineer and Environmental Engineer Consultant with the Pennsylvania Department of Environmental Protection. For the past ten years, he has been lead engineer for calculation of water quality-based effluent limits (WQBELs) for point source discharges to surface waters in Pennsylvania. WQBELs are the effluent limits for NPDES discharges that will assure that water quality standards and criteria for conventional and toxic pollutants will be protected in rivers and streams. He maintains the computer tools, models and technical documentation supporting the methods and bases for determination of WQBELs, and serves as a technical resource to support regional permit engineers and writers. He has broad experience related to NPDES permitting of natural gas and shale gas extraction wastewater discharges and the associated pollutants of concern, including total dissolved solids and its component solids. In addition to water quality concerns related to protection of aquatic life and potable water supply, he has been involved with controlling bromides based on their potential to produce disinfection byproducts during the chlorination process. His background in the nuclear power industry has helped Pennsylvania deal more effectively with the naturally occurring radiological materials contained in natural gas wastewater, including radium 226/228. Based on the unique threat to water quality posed by inadequately treated natural gas and shale gas extraction wastewater, Pennsylvania regulations have greatly restricted these discharges since 2010. He has a BS in Environmental Engineering Technology from Temple University with graduate work at Penn State University.

David Stewart, Chief Science Officer, Energy Water Solutions, LLC

David Stewart is the Chief Science Officer for Energy Water Solutions as well as the President and CEO of Stewart Environmental Consultants, LLC. He is an environmental engineer and has run an environmental testing laboratory for 35 years. In addition, he has done extensive research on the chemical characteristics of produced water and flowback water. He holds several patents in the

treatment of produced water and flowback waters. He is overseeing the design and construction of several water treatment facilities and is utilizing the anayltical analysis of several produced water and flowback waters in these designs. He has a BS and PhD in Environmental Engineering from Colorado State University, a MS in Environmental Engineering from the University of Arizona and a MBA from Colorado State University.

Enid J. (Jeri) Sullivan, Staff Scientist, Chemistry Division, Los Alamos National Laboratory

Jeri Sullivan is a Staff Scientist in the Chemistry Division of Los Alamos National Laboratory in Los Alamos, NM. She is an aqueous geochemist with expertise in characterization, treatment, use and the related economics of oil and gas produced water. She has 27 years of professional experience as an environmental chemist and over 15 years of experience in produced water treatment processes. This includes two patents and multiple publications and presentations on the treatment and use of produced water (PW), particularly organic treatment and removal and treatment of fracture flowback waters. She is currently developing, with industrial partners, a commercial treatment system (Organiclear) for removal of total organics from produced water. She participates in the Energy-Water Nexus Team (National Labs) and the Water Working Group for Carbon Sequestration, and is on the New Mexico Water Resources Research Institute annual water conference advisory board. Prior to her work at Los Alamos, she was a researcher at the Bureau of Economic Geology at the University of Texas-Austin, specializing in characterization and remediation of sites impacted by oil and gas operations, including soil and ground water contamination and tracing of saline and organic contaminants in ground water. She was an environmental consultant for over ten years, evaluating ground water contamination, risks and remediation at numerous Superfund, RCRA and petroleum contamination sites within the continental United States and Puerto Rico. She is a member of the American Chemical Society and the American Geophysical Union. She is a certified Professional Geologist and has a BA in Chemistry, a MS in Geochemistry and a PhD in Earth and Environmental Sciences/Hydrology from the New Mexico Institute of Mining and Technology.

D. Steven Tipton, Operations/Completion Engineer, Newfield Exploration Mid-Continent, Inc.

D. Steven Tipton is a registered professional engineer in Oklahoma and Texas with over 45 years experience primarily in drilling, completion and production operations throughout the US, Canada, Trinidad and Yemen. He has engineered and supervised the drilling and completion of several hundred horizontal wells in Oklahoma, Texas, Louisiana, North Dakota and New Mexico. He is currently employed by Newfield Exploration in Tulsa, OK. His primary responsibilities have included Drilling, Completion, Production and Water Management for the company's operations. Tipton is a primary mentor for newly hired engineers and summer interns, and provides technical expertise to the company's engineering staff. He has made presentations at numerous technical meetings and conferences on water management including the US EPA Technical Workshops for Hydraulic Fracturing in 2011, Society of Petroleum Engineers Advanced Technology Workshops, the University of Tulsa, the OIPA Unconventional Resource

Forum, Oil Sands Water Management Initiatives, Water Management for Shale Plays and in-house training at Newfield for new engineers and geoscientists.

Denise Tuck, Senior Product Champion, Halliburton Energy Services, Inc.

Denise Tuck is a Senior Product Champion for Production Enhancement. She provides technical support on chemistry and fluids for stimulation and hydraulic fracturing. Formerly, she held the positions of Environmental Compliance and Permitting manager and Global Chemical Compliance manager in Health, Safety and Environment for Halliburton. She joined Halliburton in 1990 and has over 30 years of experience in environmental pollution control systems design and regulatory permitting and compliance for the upstream and downstream oil and gas industry. She co-authored two sections in the National Petroleum Council report on Prudent Development "Realizing the Potential of North America's Abundant Natural Gas and Oil Resources." She has a BS in Chemical Engineering from Auburn University.

Patricia Werner-Els, Chief Science Officer, Advanced Waste & Water Technology

Patricia Werner-Els is the President of Environmental Quality Services (EQS), a full-service environmental testing, water treatment and waste management firm. In addition, she is Chief Science Officer at Advanced Waste & Water Technology (AWWT), an EQS-affiliate firm specializing in the removal of chemical and liquid waste, water and waste treatment options and disposal services. Both firms are located in Farmingdale, NY. Els brings more than 25 years of environmental industry expertise to these roles. She is a specialist in environmental testing topics and analytical service solutions pertaining to soil, water and air. Els has particular knowledge about impactful environmental testing and its importance to the preservation of our environment including water and wastewater analysis, groundwater monitoring, comprehensive site investigations, underground storage tanks and sediment and dredging material analysis. She is responsible for all laboratory operations, strategic direction and new business initiatives at EQS and AWWT. Els graduated from Farleigh Dickinson University.

Drue Ann Whittecar, Business Development Manager, National Oilwell Varco

Drue Ann Whittecar is a Business Development Manager at National Oilwell Varco in Houston, TX. She is an Environmental Scientist and Safety Engineer with expertise in the water lifecycle as it pertains to oil and gas. Whittecar has over 17 years of professional experience as an environmental scientist and a safety engineer. She has worked in several sectors including power generation, construction, defense contractor and most recently in oil and gas. She has evaluated environmental conditions at many industrial, construction and natural resource sites in the United States, Europe, Asia and India. She has served on a number of national and international committees. She is a member of the American Petroleum Institute, the Society of Petroleum Engineers, American Society of Safety Engineers and the Society of Women Engineers. In the area of hydraulic fracturing and drinking water, she is especially interested in baseline water quality monitoring, produced and flowback water quality and treatment and the potential transport of groundwater and surface water resources as well as the reuse of treated water. She has a BS in Safety Engineering from Montana Tech and an AAS in Environmental Science from Casper College.

Aaron Wilson, Research Scientist, Idaho National Laboratory

Aaron Wilson has 12 years of experience in organic and inorganic synthesis. As a PhD graduate student at University of Colorado at Boulder he worked in collaboration with researchers at the National Renewable Energy Laboratory. He was awarded a Post Doctoral Fellowship at the California Institute of Technology under the Methane Conversion Cooperative funded by BP. He completed a second post doctoral fellowship at National Health Institute developing bifunctional chelate agents. Since arriving at Idaho National Laboratory in 2010, he has been the PI on several projects in materials chemistry. One of these projects involved pioneering the switchable polarity solvent forward osmosis system, taking it from a hypothetical to a lab demonstrated technology in less than a year.

Lloyd Wilson, Research and Special Projects Coordinator, Bureau of Water Supply Protection, New York State Department of Health

Lloyd Wilson is an environmental scientist with more than 25 years of research and professional experience focused on preventing human exposure to contaminants in the environment. His work has involved assessing potential sources of exposure to various compounds through different media. He has overseen projects investigating asthma emergency room visits and ambient air pollutants, polychlorinated biphenyls in public drinking water supplies that use the Hudson River as a source of water, mold and indoor air quality issues, climate change and numerous other drinking water quality issues. For the last 5 years he has been evaluating potential concerns with impacts of high volume hydraulic fracturing used in development of gas and oil wells. Specifically, he has been involved with reviewing all aspects of the New York State Department of Environmental Conservation’s HVHF environmental impact statement. He received his PhD from the University at Albany School of Public Health in Toxicology and Occupational Health, where he also currently holds a position as an Assistant Professor.

Gary Wolinsky, Environmental Scientist, Chevron Energy Technology Company

Gary Wolinsky is an Environmental Scientist at Chevron's Energy Technology Company. He has more than 20 years experience in the effects of contaminants in surface waters. Wolinsky worked in the water quality standards, NPDES and impaired waters programs at US EPA Region 9 for 15 years and has spent the past seven years at Chevron. During his tenure as an environmental scientist, he has gained experience in data collection and assessment of environmental conditions in the United States, Latin America, Asia, Africa and Australia in a variety of settings affected by point and nonpoint sources of contaminants. Wolinsky has participated in a variety of technical committees domestically and internationally concerning water quality in marine and freshwater environments. He has a BA in Biology from UC Santa Cruz and a Masters in Environmental Studies from the Yale School of Environmental Studies.