25th Annual

FLORIDA REMEDIATION CONFERENCE

An NTCC Conference

November 7-8, 2019

Omni Orlando Resort at ChampionsGate

The Premier Soil and Groundwater Cleanup Conference of the Year in the Southeast

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ChampionsGate Golf Club, International Course, Orlando

Wednesday, Nov. 6, 2019

Day One, Thursday, Nov. 7, 2019

9:00 Opening Session

A Word from the Chair
Jim Langenbach, PE, BCEE, Senior Principal
Geosyntec Consultants Inc., Titusville

Keynote Address
NASA Kennedy Space Center's Remediation Program, a Perspective on 25 Years of Challenges, Innovations and Progress
Michael J. Deliz, PG, Remediation Program Manager
NASA John F. Kennedy Space Center

Break: 10:00 - 10:30

Session 2: Advancing the Understanding of PFAS and Emerging Contaminants

10:30 PFAS: Navigating Challenges, Best Practices and Current Affairs

Karla Buechler, Corporate Technical Director, Eurofins Test America, Sacramento, CA

PFAS are a family of synthetic fluorinated compounds that have been mass produced in the U.S. for decades dating back to the 1950s. PFAS are used in a wide variety of industrial and commercial applications such as textiles, aqueous film forming foams, metal plating, semi-conductors, paper and food packaging, coating additives, cleaning products, pesticides and personal care products. According to the U.S. Environmental Protection Agency, PFOA and PFOS pose potential adverse impacts to the environment and human health due to the bioaccumulative and persistent nature of the compounds. Production of the "legacy" long-carbon-chain molecules was largely phased out beginning in 2002 and over the course of the next thirteen years. The manufacturing of the next generation of fluorinated chemicals has brought new PFAS chemicals to the forefront of discussion, but little is know about their potential impact to human health. The chemistry of PFAS is unique and challenging. There is currently no consensus best method for all environmental matrices, but a multitude of varying approaches. This soup of non-validated methods and analytical approaches has left stakeholders with the challenging job of navigating their options and making the right choice for their project objectives. In the absence of federal regulation and guidance, and alongside the variations in analytical techniques, we see growing variation in actions being taken at the state level. States have proposed or promulgated limits for various compounds, all being different from one another and for differing matrices or programs. This presentation will provide an introduction to the chemistry, sources, history and regulation of PFAS, and aims to provide clarity around the mountain of analytical options and growing regulations.

10:45 A Vertical Recirculation Well System for In-Situ Removal of PFAS

William Kerfoot, PhD, Principal, Kerfoot Technologies Inc., Mashpee, MA

In the early 2000s, vertical recirculation wells injecting microbubble ozone were successfully tested to remove PCE and DCE to below MCLs for site closure. A modification of the recirculation well has been designed to inject peroxide-coated micro to nanobubble ozone to remediate PFAS from saturated soil and groundwater. The well is composed of a lower injection point that reduces adsorbed soil fractions and a four-inch overlying double well screen recirculation well.The pilot test location was divided into equal regions, the first containing the vertical recirculation well. A fraction of the recirculated groundwater containing residual Perozone®-3.0 is directed to an above-ground canister containing absorbent and activated carbon. The cleaned water is redirected to the outer cycle of incoming water. The adsorbed fraction within the canister of residual PFAS is decomposed in place at such a rate to not immediately require replacement of the activated carbon. The second region employed a standard pumping of groundwater to an activated carbon canister with return flow back to its side of the chamber. The well system has been tested on soils and groundwater contaminated by the first generation of firefighting foam, dominated by PFOS, PFHxS, PFHxA, PFOA and PFHpS. Precursors consisting of 6:2 and 8:2 fluorotelomer sulfonates were shown to be decomposed during injection. Groundwater pH was controlled within 6.0 to 7.5. Fluoride production was monitored during PFOS decomposition. Advances in groundwater flow measurement can depict and define the hydrogeological containment.

11:00 Cometabolic Treatment of Emerging Groundwater Contaminants

Paul Hatzinger, PhD, Director, Biotechnology Dev. and Applications Group, Aptim Federal Services LLC, Lawrenceville, NJ

Aerobic cometabolism can be a highly effective approach for the remediation of a variety of different emerging contaminants in groundwater, including 1,4-dioxane, 1,2-dibromoethane and N-nitrosodimethylamine. This approach is also applicable for numerous chlorinated solvents and their typical anaerobic degradation products, including trichloroethene, vinyl chloride and cis-dichloroethene. Cometabolic treatment typically entails adding air or oxygen and one of several different gases, e.g., methane, propane, ethane or ethene, that serve as primary growth substrates to an aquifer or bioreactor. Specific groups of bacteria with broad-specificity oxygenase enzymes utilize these gaseous substrates and cometabolically degrade the contaminants of concern. This approach is particularly attractive at sites in which initial contaminant concentrations are low and/or where the production of secondary products from anaerobic treatment approaches, e.g., sulfide, methane or dissolved metals, is undesirable. Recent laboratory and field studies conducted by our research group show that contaminants such as EDB and NDMA can be reduced to low part-per-trillion concentrations using this process. Factors that can influence the success or failure of cometabolic treatment include groundwater pH, the presence of adequate macro- and micro-nutrients and gas purity, among others.The method of distributing a primary substrate and nutrients where applicable is also critical to the efficacy of cometabolic treatment. Biosparging and groundwater recirculation with gas addition have proven very successful for in-situ field implementation.This presentation will provide an overview of the fundamentals of cometabolic processes and examples of successful field applications of this technology for treating 1,4-D, NDMA and EDB.

11:15 PFAS in Groundwater – Remediation Options

Viraj deSilva, PhD, PE, BCEE, Wastewater Treatment Director, SCS Engineers, Tampa

Contaminants of emerging concern, including per- and polyfluoroalkyl substances, are of interest to regulators, water treatment utilities, the general public and scientists. The chemical properties that make PFAS compounds ideal for fighting fires and repelling water also make them challenging to remediate using conventional techniques. While ex-situ technologies are viable, care must be taken to select treatment processes and design systems that are both effective and economically viable. Current ex-situ technologies rely on the removal of PFAS from aqueous solution using various binding agents in combination with absorbent media and/or reverse osmosis membranes. Once PFAS have concentrated within treatment media or concentrate streams, the resulting concentrate must be incinerated, landfilled or otherwise disposed of. The following alternatives for the treatment of PFAS will be presented in detail along with case studies and removal efficiencies:

1) GAC treatment, 2) Ion exchange treatment and 3) Reverse osmosis treatment. With the EPA positioned to take serious action on PFAS in late 2019, regulators in many states have already begun implementing measures of their own, while state and federal courts are beginning to address legal issues surrounding this emerging contaminant. These changes mean new potential liabilities and consequences for organizations that manufacture, use or sell PFAS or PFAS-containing products. The time to take action to protect your operations is now.

11:30 **PFAS Sites: How Uncertainties in Site Identification Influence Sampling Design and Remediation Strategies**

Rosa Gwinn, PhD, PG, Resource & Technology Manager, AECOM, Germantown, MD

In response to evolving federal and state drinking water regulations, many property owners are evaluating the potential presence of per- and polyfluoroalkyl substances from historic site practices. In response to regulatory requirements or public pressure, property owners are proactively evaluating their PFAS liabilities. Moreover, if a PFAS source negatively affects drinking water, then owners need to understand the magnitude of the source and the potential mitigation options. AECOM has performed hundreds of facility assessments for PFAS and will share this experience and how it affects remediation planning. Because releases of PFAS occurred years ago, there is inherent uncertainty in specifying the size, location and magnitude of potential sources of the regulated long-chain PFAS in the environment. Delineating groundwater impacts against the federal lifetime health advisories for drinking water is straightforward, but there is no regulatory driver against which to delineate soil or source zones. Instead, we will share statistical strategies for evaluating PFAS distribution that provide quantitative bounds on confidence. Mitigation may take the form of remediation or intervention. The site sampling strategy for bounding uncertainty informs which of the available mitigation technologies may be of benefit at a site. Sorption technology is conventional and readily scalable with the most field demonstrations worldwide. However, the disposal of spent adsorbents is associated with off-site liability. As for destructive technologies, only a few of them are proven effective or partially effective for PFAS, due to the unique chemical and physical properties of target compounds. This presentation will summarize the available PFAS remedial technologies for both water and soil treatment and provide information about their demonstration results, state of development and advantages, as well as their limitations.

11:45 **Analytical Review of High Concentration PFAS Treatment Projects**

AnnieLu DeWitt, Remediation Technology Business Dev. Mgr., Environmental Services, Clean Harbors, South Portland, ME

This presentation will relate the unique properties of high concentration PFAS treatment in wastewaters from multiple sources of AFFF releases in an industrial application, and review the challenges of taking very high concentration parts per billion and parts per million level influent water to non-detect effluents. It will also provide a review of the unique additional analyticals required to evaluate high concentration complex wastewaters and discuss how baseline analytical review can be applied to a broad range of high concentration sources. Analytical results from three different projects will be reviewed as well as the specific PFAS compounds most commonly found in different applications and breakthrough predictions based on structure and concentration.

12:00 - 1:00 ***Day One Luncheon*** *Sponsored by* ***Advanced Environmental Laboratories***

Session 3: Refining Conceptual Site Model Strategies

1:00 **Building Useful Conceptual Site Models Using 3D Modeling Technology**

Jim Depa, Senior Project Manager, St. John-Mittelhauser & Associates, a Terracon Company, Chicago, IL

A conceptual site model is a regulatory requirement for many large-scale environmental remediation projects, and acceptable CSMs can be built from nearly any type of field collected data. The objective was to use 3D modeling technology to build detailed, understandable and useful CSMs on three environmental investigation projects using different types of analytical and geophysical data. CSM #1 – Soil Analytical Data: A 3D volumetric model was built using soil analytical data from eight different contaminants of concern. Each contaminant was modeled individually and then combined to show the 3D volume of soil above each contaminant's applicable remediation objective. The CSM accurately calculated the volume of impacted soil and ensured that all the remedial exceedances were accounted for. CSM #2 – Geologic Data and Groundwater Elevation Data: A 3D hydrogeologic model was built from boring logs and groundwater elevation data from gauging events. The CSM explained how the interaction between the groundwater table and a thin clay unit in the subsurface created locations where free-phase LNAPL was being confined below the clay layer at some locations and collecting above it in others. CSM #3 – Laser Induced Fluorescence and Cone Penetrometer Test Data: A high-resolution 3D model was built from over 30,000 LIF and CPT data points. The CSM identified two very different sources of petroleum contamination based on their waveform signature and showed how the geology effected the migration of contamination in the subsurface.

1:20 **New Geophysical Imaging Tool for Environmental Site Assessment**

David Harro, PG, Director, Geologic Services, G3 Group, Odessa

Much of Florida is underlined by limestone aquifers. Erosional process affecting these aquifers results in the formation of sinkholes and karstic limestone. These karst formations are extensive and encompass entire physiographic regions. The weathering process in karst environment in many cases produces sinkholes that penetrate existing confining units, creating access into deeper aquifer system. Sinkholes are geologic hazards that are making the national news in Florida each year. Despite their notoriety, sinkholes are not often investigated on environmental sites that are in karst regions. The development of karst or sinkholes can provide vertical pathways directly into the Floridian Aquifer, our current primary source of drinking water. This pathway is directed into a focused area between the upper unconsolidated material and the limestone. The focused area is known as the throat of the sinkhole. One of the reasons that investigation of potential sinkholes on environmental impacted sites is not frequently performed is the inability to identify the locations of sinkhole or the throat of a sinkhole. In the past few years, a new approach to imaging the deep subsurface has become available. The multi-electrode resistivity implant technique, or MERIT, has been proven to provide high resolution geophysical imaging over conventional surface geophysical techniques. MERIT utilizes permeant implants that are placed in the subsurface using direct-push. The tomographic configuration of MERIT provides up to five-times higher resolution and twice the depth of standard electrical resistivity. Applications of this geophysical technology include imaging sinkholes, chemical injection and air injections, fate and transport modeling using MODFLOW or other finite element/difference models. The presentation will demonstrate the capability of the MERIT geophysical technology in case studies and lessons learned.

1:40 **Changing the Perspective on 30 Years of Granularity with HRCD**

Robert Schatzman, PG, Senior Project Manager, LS Sims and Associates Inc., Rockledge

Lance Robinson, PE, Chief Technology Officer, EN Rx Inc., Parrish

Monitoring well placement and spacing can be arbitrary and is often driven by practicality, feasibility and/or cost. Even in open areas, data gaps can exist due to cost saving practices. New technologies have remarkably improved the quality, quantity and density of data collection in the vertical profile. However, the horizontal layout remains compromised by cost and historical perspectives for practicality. The result of insufficient data quantity is never better than expected. The aerial averaging required when using data collected from only a vertical sampling regime can often lead to cost increases and failure. Vertebrae™ Well Systems are horizontal well systems capable of producing high resolution contaminant distribution data sets. The case study presented will illustrate how understanding the contaminant distribution horizontally is critical to site treatment. An Orlando area former dry-cleaning site has been characterized with shallow and intermediate plumes of 400 to 700 feet in length with different flow vectors. Vertebrae well systems installed to aid in defining the magnitude and extent of contamination added significant information that more precisely defined both plumes. This presentation will show how Vertebrae was unaffected by obstacles at the site and identified contaminant plumes properly under a strip shopping plaza and a four-lane highway. Vertebrae well systems are an effective tool to provide treatment but, more importantly, Vertebrae wells have the potential to provide more data to improve the conceptual site model allowing for better selection of a remedial strategy. Proper use of this tool during assessment can be critical in reaching site cleanup goals.

2:00 **Vapor Intrusion: How Many Vapor Samples Are Enough?**

Jim Fineis, PG, President, Total Vapor Solutions, Alpharetta, GA

Vapor intrusion continues to be a driving force in environmental investigations. There are many challenges that occur in conducting vapor intrusion investigations on either existing structures or undeveloped land. The primary questions that arise are: how many samples do we need to collect and where do we need to collect them? Developing a consistent and systematic approach to these questions will allow for company-wide consistency, statewide consistency and, importantly, will provide a bank lender with a level of assurance that enough samples have been collected. To achieve this goal, an extensive review of existing state guidelines was conducted and, based on the results of this research, a simple-to-use table was developed to help determine the proper number of samples to be collected. Where to collect the samples on a site is a more complex issue but providing a basic understanding of how vapor moves and what role if any biodegradation plays in where samples should be collected helps answer this question. A brief discussion will be provided regarding what role the current or future building type plays in the decision. What effect the source of the potential vapors has on the sampling locations, as well as the purpose of the samples, play a big role in determining the correct placement of the sample locations. Providing a basic understanding of these two issues allows for a better and more complete vapor intrusion assessment.

2:20 **Chemical Speciation: Insights for Site Assessment and Closure Strategies**

Nick Barnes, PE, Project Engineer, HSW Engineering Inc., Tampa

Zeke He, PhD, PE, Environmental Engineer; HSW Engineering Inc., Orlando

Contaminant compounds may be sequestered through adsorption, (co)precipitation and/or complexation, greatly affecting their potential uptake by humans and other receptors. Due to the changes in bioavailability and toxicity endpoints associated with variations in chemical speciation and oxidation forms, the potential risks and hazards associated with a contaminant in soil or water are often lower than if the contaminant is directly provided to humans or other receptors. In this presentation, we will present an overview of chemical speciation and its adaptations to environmental assessment and cleanup. For example, the toxicity of hexavalent state chromium, chromate or Cr(VI), is two orders of magnitude more than that of the lower oxidation form Cr(III). Conversion of Cr(VI) to relatively less toxic and mobile Cr(III) may be applied for chromate contamination management. The complexity and toxicity of cyanide chemistry make its management and remediation extremely challenging. With an insightful understanding of cyanide's speciation and associated toxicity endpoints, costs and timeframe associated with assessment and remediation can potentially be decreased, while achieving the same desired level of protection. Case studies of chemical speciation as applied to site assessment and risk-based remediation strategies will be presented.

2:40 **Chlorinated Solvent Forensics: Applying Multiple Lines of Evidence**

Joshua Richards, PG, CHMM, Program Manager, Pace Analytical Services, Indianapolis, IN

Utilizing environmental forensics can be beneficial when standard remedial practice and analytical data indicate complex situations are occurring. These complexities could be multiple sources under the same remedial umbrella, offsite contributions or comingled plumes, as well as stalled remediation projects. When implementing chlorinated solvent forensics, mainly via compound specific isotope analysis, complex sites can be progressed. The use of multiple assessment tools, in addition to CSIA, is beneficial to complete conceptual site models and close any data gaps that limit remedial progress. A two-dimensional look utilizing CSIA can substantiate ongoing remedial activities and give light to fine-tuning remedial action plans. This presentation will evaluate a complex site for source determination and timing of release utilizing an advanced site characterization tooling with the final argument solidified by CSIA indicating multiple off-site sources present.

Break: 3:00 - 3:30

Concurrent Session 4A: Speed Talks

3:30 **Well Flow Dynamics During Groundwater Sampling: A Comparison of Purge and Passive Sampling Approaches**

Sanford Britt, PG, CHG, Senior Hydrogeologist, QED Environmental Systems Inc., Dexter, MI

Contaminated groundwater decision trees depend on accurate and reliable groundwater sampling data. Low flow purging and sampling techniques were introduced to improve sampling data, limit purge volumes, reduce turbidity and agitation during sampling, and to improve repeatability. Passive, no-purge, approaches have likewise been introduced to improve sampling by limiting waste generation and improving cost structures. How do these methods reflect aquifer concentrations? Do they represent aquifer concentrations differently? How do the different approaches assure reliable groundwater data for remedial decision-making? U.S. Department of Defense Strategic Environmental Research and Development Program Project ER-1704 tested passive and dynamic sampling procedures in the lab, in the field and in model domains to better understand flow dynamics in wells.Results describe a flow field where water flows largely horizontally from the formation to the well, then flows vertically in the well bore to the pump intake during pumping, and also vertically due to tiny density contrasts when not pumping. Sampling results rely on these downhole flow dynamics. Normally, these effects are not known. Passive sampling approaches regularly yield similar results without purging, but care is necessary to understand whether stratification in the aquifer is maintained or homogenized in the unpurged well, or if stratification is partially maintained. Determination of these effects requires substantial effort and is probably not warranted for standard monitoring. However, the study is informative in that it explains some of the dynamics associated with why passive and active samples often yield similar chemical results and illustrates why practitioners must always pay attention to seemingly unimportant details such as slow purge parameter drift.

3:40 **Site Assessment Techniques with Vapor Pin**

Laurie Chilcote, Managing Director, Vapor Pin Enterprises, Plain City, OH

The Vapor Pin® is a high-quality, reliable sampling device that is installed in minutes using commonly available hand tools. Once installed, the leak-proof Vapor Pin is suitable for locating VOC sources below hard surfaces, collecting high-resolution data sets, differential pressure testing, radon mitigation testing, stray gas evaluations, sub-slab soil gas sampling, long term monitoring, continuous monitoring, vapor intrusion assessments and methane sampling on landfills. The Vapor Pin is also reusable. The fact that Vapor Pin is installed in a rapid, yet minimally intrusive manner, allows practitioners to cost-effectively gather high resolution active soil gas data sets. This increased site coverage provides a better understanding of the spatial variability beneath sites. A major advantage the Vapor Pin over other sub-slab vapor ports is that a leak-proof seal between the port and the concrete is formed immediately by the silicon sleeve that covers its outer edge. The FLX-VP Vapor Pin allows connection to a variety of sampling devices through a barb fitting, Swagelok® compression fitting, or quick connect valve. As a result, the Vapor Pin can be quickly and reliably connected to a wide variety of vapor screening instruments, evacuated canisters, bottle vacs, absorbent tubes, manometers, etc. In addition, a variety of attachments have been developed to allow for the collection of soil gas samples at greater depths and isolate VOC-impacted slabs. The Vapor Pin has become the standard tool for sub-slab investigations with tens of thousands in use in North America, South America, Australia, Europe, Africa and Asia.

3:50 **Lead Remediation Using Regenesis' PetroFix**

Wm. Gordon Dean, PE, Vice President, Advanced Environmental Technologies LLC, Tallahassee

The Strickland Property/Jefferson Food Mart site in Monticello, FL, was a former automobile sales facility. Two underground storage tanks containing leaded gasoline were discovered on March 5, 1987. Groundwater contamination was subsequently confirmed and the site was accepted into the state's Early Detection Incentive program. Lead was identified as a contaminant of concern in 2001 and lead contamination exceeding the groundwater cleanup target level has been identified in multiple wells since that time, currently exceeding the GCTL in three monitor wells. A pilot test using Regenesis' new product, PetroFix Liquid Activated Carbon, was approved by the Florida Department of Environmental Protection. A total of 240 pounds of PetroFix will be injected into six direct push technology injection points around the most contaminated well. Baseline and post-injection analytical results will be presented.

4:00 **Zero-Valent Iron Nanoparticles for In-Situ Groundwater Remediation**

Patrick Randall, PE, Vice President, Hepure, Hillsborough, NJ

This presentation will discuss our exclusive method for preparation of a Nano ZVI solution for injection, providing a solution to the most difficult issue inhibiting the widespread use on Nano ZVI. Chemically, NZVI works in the same way as micro or macroscopic ZVI placed in permeable reactive barriers. In comparison to macroscopic iron fillings, the advantage of iron nanoparticles lies in the small particle size and high specific surface area causing higher reactivity, better mobility in saturated zone, faster application and higher efficiency of decontamination process. However, the high reactivity of nanoparticles requires careful handling and processing of nZVI slurry in order to maintain its excellent properties. The degradation of nZVI—fast oxidation of zero-valent iron—is a known imperfection of the slurry products today. Unfortunately, the behavior of nZVI has not been fully understood in the past, which could lead to unsuccessful results. The current state of the technology allows the preparation and modification of nZVI slurry directly on-site just before the application, where aging behavior is now negligible. Particles of nZVI are applied in the form of aqueous suspension. Their effective concentration depends on the amount of pollutants, the chemico-physical properties of the groundwater and the geological conditions. The suspension can be applied by using an automatic dosing unit or by pumping slurry from the tank directly into the well. These application methods represent clean, simple-to-operate and environmentally friendly working processes. Due to the fact nZVI slurry is highly reactive and nanoparticles tend to age with time in water with the contribution of dissolved oxygen, it is necessary to apply freshly made suspensions of nZVI. Suspension/slurry of nZVI can be prepared on site using our dispersion units. The earlier the application of fresh manufactured material, the higher the reactivity and mobility of the nanoparticles. This technology has been used in the U.S. for several years.

4:10 **Pit Bottom Emplacement of Self-Activated Persulfate to Polish Excavation Remedy**

Mark Smith, Senior Field Manager, EHS Support, Tallahassee

The goal of this remedial action was to mix powdered self-activated persulfate-oxidizing agent Klozur® One into the soil-in-water slurry at the bottom of excavation pits prior to backfilling. This approach was designed to detoxify any chlorobenzenes, benzene or other VOCs remaining in water-saturated soil or groundwater within and around the excavation pits. This coupled technology remedy provided a polished removal of the pollutants remaining in soil and groundwater after the primary remediation component, excavation, was complete. Polishing is accomplished by mixing powdered persulfate into the soil-in-water slurry found in excavation pit-bottoms. Success will be measured by achieving groundwater standards for chlorobenzenes, benzene and other regulated VOCs in groundwater collected from monitoring wells MW-A2 and MW-29A for three consecutive monitoring events having a minimum interval of 90 days between sampling events. This presentation will include maps, remedy concept, photographs showing emplacement of powdered persulfate in one-ton supersacks, mixing with excavator, and backfilling, and discuss changes in groundwater concentrations after three months of persulfate emplacement.

4:20 **Significant Development Improvements for Horizontal Wells That Facilitate Additional Capabilities**

Wesley Wiley, PG, Senior Geologist, EN Rx Inc., Parker, CO

Well development is a critical part of the process of well installation. This is true for both vertical and horizontal wells. The development outcome can indicate characteristics about the well and the qualities of the geologic unit in which it is installed. In this presentation, we will explore the difference between the installation of vertical wells, horizontal wells and nested horizontal wells including subsequent development techniques. Documented development concerns for traditional single horizontal wells due to occlusion of the well slots and mud breakdown are addressed with a different technique for NHW installation. This technique eliminates the possibility of occlusion of the well slots and doubles the bore hole collapse, increasing performance and leading to the ability to redesign the performance of the wells screens to match different applications and to maximize open area. Several Florida sites will be used for data to compare the horizontal wells. Conclusions indicate that nested horizontal wells develop much quicker and provide more contact to the stratigraphy than traditional horizontal wells.

4:30 **Real-Time Data through Horizontal Soil Sampling**

Michael Sequino,Chief Technical Officer and Principal Engineer, Directional Technologies, Miramar Beach

Directional drilling continues to provide the environmental industry with alternatives to conventional assessment and remediation methods. Many environmental consultants may be unaware that soil sampling is possible during the directional drilling process. Collection of horizontal soil samples beneath buildings and other surface infrastructure allows for further assessment of areas inaccessible to vertical drilling methods. In addition, horizontal soil sample collection during directional drilling provides real-time data analysis that assists with determining where horizontal wells are ultimately placed. This presentation will highlight directional drilling technology for environmental sites with a focus on horizontal soil sampling. A brief case study will be presented describing implementation of horizontal soil sampling beneath an industrial facility. Further assessment and vapor mitigation were required at an industrial site due to subsurface impact from chlorinated solvents. The areas surrounding the building were previously assessed with vertical soil sampling methods. However, the soil beneath the northern portion of the building lacked appropriate assessment data due to the difficulties involved with accessing the sub-slab soil. Directional drilling with horizontal soil sampling provided additional site characterization. During directional boring advancement, soil samples were collected every five feet for plume delineation. Field analysis data were then used to determine the optimal placement for two horizontal soil vapor extraction wells.

4:40 **Horizontal Directional Well Installation for Sub-Slab Vapor Mitigation**

David Bardsley, PG, Vice President, Ellingson DTD, Bellefonte, PA

Indoor air quality is a substantial health and regulatory issue, and the installation of vapor mitigation systems for existing structures can be a significant challenge. Low-flow, negative pressure systems can be installed by penetrating the building floor, completing shallow vapor points and connecting the vapor points to a “whirly bird” on the building roof. This approach, although popular, is more like a band aid to the problem as remediation is not occurring. Horizontal wells are an efficient way to provide both a negative pressure barrier beneath the slab while also driving the remediation process forward by removing a meaningful amount of contaminant mass. Horizontal/directional drilling has been utilized in the environmental drilling industry for the installation of monitor and remediation systems since the late 1980s. Refinements in drilling equipment, steering/locating technology and blind well construction methods are providing consultants with a beneficial option for removing vapors from below a building slab. Challenges to successful implementation of the technology include the need for drilling and support equipment with a small footprint, the depth of the well below the building and the overall condition of the slab, foundation structures and sub-slab utilities. Benefits of the method include allowing for safe building occupancy along with mass removal, long screen sections, little or no impact to existing building operations and flexible well head entry locations. Several recent successful sub-slab horizontal well projects will be discussed.

Concurrent Session 4B: Petroleum Cleanup Optimization

3:30 **How to Estimate LNAPL Remediation Costs to Support Conditional Site Closure**

Stephen Hanks, PE, Senior Engineer, Wood, Pensacola

Modification of site closure options provided in Chapter 62-780, F.A.C., allows for No Further Action with Conditions for sites that exhibit light non-aqueous phase liquid, if it can be demonstrated that the LNAPL does not present a potential risk to human health or the environment and it is not cost effective to remove. An analytical model was used to estimate the potential cost for cleaning up an LNAPL plume using the current recovery strategy as well as an alternative recovery strategy. The LNAPL Distribution and Recovery Model developed by the American Petroleum Institute was setup and calibrated using existing site data, and estimated that recovery of LNAPL would cost over $2 million. The findings of the LDRM simulations were the basis of the NFAC proposal that was approved by the regulatory agency. Items to be discussed include LNAPL transport and distribution, regulatory framework, the development of a conceptual site model, data needs for model calibration, field data collection procedures, model calibration techniques, methods to verify model outputs, development of proposed remediation scenarios, estimation of remediation costs, and site restrictions for conditional closure.

3:45 **Performance of a New Activated Carbon Amendment for Bioremediating Petroleum-Impacted Soils**

Chad Northington, PE, Southeast District Manager, Regenesis, Tallahassee

The treatment of petroleum contamination using injectable activated carbon amendments is increasing in popularity, in part due to the rate with which drops in contaminant concentrations are usually seen after application. Rapid removal of contamination from groundwater by adsorption is attractive, yet in-situ biodegradation is often also needed to properly manage higher contamination levels frequently seen in petroleum sites. Here we present a new activated carbon-based amendment that combines micron-sized activated carbon with nitrate and sulfate salts serving as electron acceptors. Multiple field case studies will be reviewed where PetroFix was injected by low-pressure direct-push methods in areas with elevated total petroleum hydrocarbons in the diesel and gasoline range. Groundwater samples were monitored at baseline and at regular intervals post-application for standard chemical and geochemical parameters, as well as by QuantArray® Petro from Microbial Insights for quantification of the bacterial communities. The removal of petroleum from the groundwater by adsorption onto the activated carbon does not appear to have a negative effect on biodegradation. Additionally, the conditions in the treatment area appear to be favorable for long-term biodegradation of the remaining hydrocarbons. The results thus far indicate that PetroFix is a powerful amendment capable of treating sites contaminated with moderate amounts of petroleum hydrocarbons. The placement of activated carbon with electron acceptors under low pressure conditions ensures good amendment coverage in the high flux zones where contaminants migrate and promotes biodegradation by the microbial community in place.

4:00 **Best Value for the State: Identifying Non-Program Related Contamination at PRP Sites**

Donna Beares, PG, Project Manager, Gannett Fleming, Jacksonville

PRP sites can have long histories dating back to the 1980s when petroleum discharges were discovered and reported. Discharges often involved tanks that were installed in the 1970s where there may have been multiple tank farms containing various grades of petroleum products. Over the years, a PRP site may have had many uses with the potential for subsequent discharges of petroleum products or introduction of anthropogenic compounds into soil and groundwater. Also, site lithology and regional groundwater quality may increase the background concentration of certain secondary contaminants such as iron and manganese.Therefore, it is the best value for the state to identify these compounds during the site assessment to scale remedial actions accordingly and avoid costly cleanup and/or monitoring of non-PRP contaminants. Identifying fuel additives from the original discharge may distinguish a plume from subsequent non-PRP related discharges. For example, additives such as lead and MTBE have specific production ranges and can be definitive when dating a petroleum plume. Anthropogenic influences, such as BaP and other PAHs, have potential to be mistakenly characterized as part of the original discharge. The horizontal and vertical distribution of PAHs in relation to former tank pits or other site features must be considered when evaluating the extent of the PRP-related discharge. Several case studies will be presented where subsequent releases, background concentration or other anthropogenic influences were identified during the site assessment and how this information was considered in development of a site remedial and closure strategy.

4:15 **Funding the Remediation of Petroleum-Contaminated Property to Facilitate Redevelopment**

Scott Graf, PG, Principal and Environmental Department Manager, Terracon, Tampa

Terracon was selected by developer HRI to provide environmental and geotechnical consulting services for a 1.03-acre parking lot located across from City Hall in downtown Tampa, purchased for $7.5M. The proposed redevelopment included a $100 million, 17-story hotel with a parking garage and retail shops. The redevelopment was complicated by impacts from two separate historic on-site petroleum storage facilities. Concurrent with on-going site assessment activities, the Florida Department of Environmental Protection started the Advance Cleanup for Redevelopment program to encourage expedited cleanup associated with development of petroleum-contaminated sites. Terracon, on behalf of HRI and the city of Tampa, submitted ACR applications and funding was approved for $1 million of the total estimated $2.3 million cleanup cost. Remedial activities conducted at the site included the removal of eight underground storage tanks, source removal of 9,300 tons of petroleum-contaminated soil requiring dewatering and sheet piling, solid chemical oxidizer mixed with backfill to address residual petroleum impacts, and application of an in-situ chemical oxidizer via direct-push injection in areas that were not accessible to excavate. Source removal and backfill activities were completed prior to the groundbreaking ceremony in February 2019. In addition to funds from the ACR program, the city of Tampa entered into a Brownfield Site Rehabilitation Agreement with the DEP and received approval for a $500,000 Voluntary Cleanup Tax Credit application for work completed in 2018, which is the maximum that can be claimed on an annual application.

4:30 **Integrating Multi-Technology Surfactant-Enhanced Bioremediation and Oxidation Approaches for Treatment of Petroleum Hydrocarbons**

Dan Socci, Chief Executive Officer, EthicalChem, South Windsor, CT

A major limiting factor in remediation of hydrocarbon contaminants is their relatively low solubility in water. Enhancing the solubility of contaminants by use of surfactants can significantly improve the efficiency of bioremediation, free product removal and chemical oxidation treatment approaches. Combined application of surfactant and nutrients at sites with petroleum impacts can greatly enhance bioremediation of petroleum hydrocarbons. Surfactants desorb and emulsify the tightly sorbed, hydrophobic contamination from soil into the aqueous phase while the nutrients facilitate the stimulation and proliferation of micro-organisms that will degrade hydrocarbon contamination. To enhance contaminant removal using a combined surfactant and low concentration hydrogen peroxide solution, reduction in viscosity, loosening of the NAPL and buoyancy are achieved to facilitate contaminant removal via extraction. For chemical oxidation applications, a combined oxidant-surfactant solution, the delivery of contaminants to oxidants in the aqueous phase can be optimized via contaminant desorption and emulsification by the surfactants. Liberation of the sorbed hydrophobic contaminants and emulsification into the aqueous phase as small particles significantly increase surface area available for reactions with oxidants, improves soil and groundwater remediation effectiveness. This presentation will discuss field implementation of multiple surfactant-enhanced technologies that include Surfactant Enhanced Bioremediatoin, the patented SEPR™, Surfactant Enhanced Product Recovery, and S-ISCO®, Surfactant-enhanced In Situ Chemical Oxidation, technologies integrated to implement an innovative treatment approach for remediating subsurface petroleum impacts at an active gas station. Field implementation of sequenced applications of SEPR and S-ISCO at a creosote site will also be discussed. Additionally, this presentation will draw upon independent research by the University of Madrid highlighting the benefit of a combined surfactant-oxidant and optimized surfactant selection approach for remediation.

4:45 **In-Situ LNAPL Treatment Following Pipeline Transmission Rupture**

William Brab, CPG, PG, Senior Geologist, AST Environmental Inc., Midway, KY

Failure of a 16-inch stopple fitting at a petroleum pipeline transmission meter station in Michigan resulted in the release of approximately 1,700 barrels of gasoline fuel in June 2000. Approximately 1,400 barrels of fuel were recovered using vacuum trucks, booms and underlain dams. Approximately 30,000 tons of impacted soil were removed to approximately four feet where accessible. Free product recovery via groundwater extraction capable of up to 25,000 gallons per month and long-term groundwater monitoring was conducted at the facility following the release. The groundwater extraction system was shut down in 2012. Due to access issues and compatibility concerns with multiple buried pipelines through the area of remediation, an innovative technology was required that could be implemented within the constraints present . BOS 200® was selected as the remedial technology. The selected option had to remove LNAPL and provide significant reductions in total sorbed and dissolved phase mass, control further plume migration beyond the area of treatment and be implemented without compromising the integrity of the buried petroleum transmission lines. Additional characterization was conducted in September 2013 to further quantify and define the vertical and horizontal extent of total mass at the facility. It was determined that two injection events of BOS 200 would be required to accomplish the site clean-up goals. Measurable LNAPL was present in numerous soil borings/monitoring points completed during the characterization, and VOC and TVPH concentrations in soil exceed C_{SAT} threshold guidelines. The initial injection was performed in April 2014. The second injection event was completed in April 2016. One year following the completion of the first injection event, resampling of soil and groundwater was performed to determine mass removal and reestablish the baseline for the second injection event. Total sorbed mass removal estimates across the treatment area averaged approximately 85 percent and 65 percent for benzene and Total Volatile Petroleum Hydrocarbons, respectively. Dissolved phase mass removal estimates averaged approximately 85 percent and 65 percent for benzene and TVPH, respectively. Performance groundwater monitoring has continued quarterly since completion. Results as of the December 2018 groundwater monitoring event indicate average benzene removal at 82 percent and TVPH at 92 percent when compared to pre-injection analytical data. The occurrence of LNAPL is now sporadic and isolated to an occasional sheen in two monitoring wells within the source area compared to year-round persistence with measurable thickness in five monitoring wells prior to treatment. This talk will emphasize that remediation is only effective if there is an accurate conceptual site model; infrastructure dictates the investigative and remedial objectives and efforts; remediation of total contaminant mass is not confined within regulatory clean-up standards; and remediation technology and implementation is dynamic—there is no "one-size-fits-all" approach for every site.

5:00 Day One adjourns
FRC 2019 Reception in Exhibit Hall *Sponsored by* ***Vertebrae Well Systems***

FLORIDA REMEDIATION CONFERENCE 2019

Day 2

Day Two, Friday, Nov. 8, 2019

8:30 Day Two Opening Session

Utilizing Florida Brownfield Resources to Improve Technical and Regulatory Outcomes, Avoid Consultant Negligence Claims and Increase Company Profitability
Michael Goldstein, Principal, The Goldstein Environmental Law Firm PA, Coral Gables

Session 5: Young Professionals

8:50 The Metabolic Miracle: A Bioremediation Refresher

Anthony Giannetti, Client Services Manager, Cascade, Philadelphia, PA

Bioremediation is among the most common in-situ treatment remedies for sites contaminated with organic compounds, particularly petroleum hydrocarbons and chlorinated solvents. Harnessing or supplementing the power of natural microbial degradation is a flexible, low-cost, sustainable and effective method of treatment for a range of contaminants. Because of the well-established track record of the technology, practitioners in the environmental industry often implement the treatment without completely understanding the process. There is an assumed level of knowledge about how and why injection of cultures, nutrients and food sources produce laboratory analytical data indicating a decreased concentration of contaminants. But what is really happening in the stages between injection and sampling? What are those microbes doing to the contaminants? We'll explore the driving forces behind the incredible biogeochemical metabolic processes and provide useful insight into electron acceptor pathways and cometabolism, and provide the latest on genetic modification for targeted treatment. To support application of this new knowledge, we'll touch on how the basic processes inform our selection of the specific conditions and parameters that can be monitored and manipulated to produce optimal remediation performance.

9:00 Expedited Site Rehabilitation of TRPH-Impacted Soils

Davis Lofton, PhD, EIT, AMASCE, Senior Staff Engineer, Geosyntec Consultants Inc., Houston, TX

During closure of a facility located in the Florida Panhandle, total recoverable petroleum hydrocarbon concentrations were detected above applicable soil cleanup target levels. Due to contractual requirements, environmental impacts needed to be remediated within 12 months to allow for site redevelopment. Geosyntec was retained to perform site assessment activities, prepare a site assessment report, negotiate assessment and cleanup requirements with the Florida Department of Environmental Protection, and oversee remedial action implementation and documentation. Environmental site assessment activities included soil and groundwater sampling. Soil sampling results delineated an approximate 1,700-square-foot area with TRPH fraction concentrations above applicable SCTLs to a maximum depth of four feet below land surface. Groundwater sampling results indicated TRPH concentrations were less than the residential groundwater cleanup target level. Since groundwater was not contaminated, sampling of an adjacent stream was not necessary. After meeting with DEP to discuss the findings and remedial options, a site assessment report documenting site assessment activities and requesting no further action for site groundwater was submitted to DEP. Following DEP approval of the SAR, a request for proposal that included an excavation design was prepared. Since dewatering was not necessary, a remedial action approval order was not required. The excavation was performed and approximately 468 tons of soil were excavated and disposed at a Class I landfill. A source removal report documenting the excavation and confirmation soil sampling was submitted. DEP issued a site rehabilitation completion order approximately one year after initiating assessment activities.

9:10 ASCTLs, and Innovative Soil Management and Remediation Techniques in Golf Course Redevelopment

Sanaul Khan, Staff Professional, SCS Engineers, Boca Raton

SCS Engineers assessed and is remediating approximately 66 acres of land located in Delray Beach, FL, formerly operated as a golf course and historically used as agricultural land. Due to the historic application of legally applied pesticides, herbicides and fertilizers used in the maintenance of crops and golf course features, remnants of arsenic and pesticides required soil management efforts during site redevelopment into an age-restricted (55 years and over) community. Based on residential age usage, SCS presented and was subsequently approved by the Florida Department of Environmental Protection to apply alternative soil cleanup target levels of 8.6 mg/kg and 4.4 mg/kg for arsenic across the site. To achieve the ASCTLs, soil blending techniques are being implemented to blend down residual surficial soil concentrations commonly affected by historical applications. Prior to redevelopment, SCS conducted several pilot test studies to demonstrate that proposed soil blending techniques would effectively reduce arsenic concentrations below the applicable ASCTLs. The site is proposed for restriction via non-conventional means whereas lasting Homeowner Association care will prevent residents from handling or maintaining soil and standard groundwater restrictions will prevent the usage of groundwater for personal use. Specific site development characteristics such as creation of deep, boundary surrounding lakes will limit further impacted groundwater migration to site boundaries. The integration of GIS and Trimble technologies for this type of redevelopment has allowed SCS to assess, track and manage site soils more accurately and efficiently.

9:20 One Man's Wastewater is Another Man's Treasure: Water Reuse Options for a Hydraulic Control System

Jaclyn Vu, PE, Environmental Engineer, JEA, Jacksonville

Alexis Johnson, Senior Staff Engineer,Geosyntec Consultants Inc., Jacksonville

The JEA Northside Generating Station in Jacksonville, FL, provides electricity for the city of Jacksonville and portions of three adjacent counties. The facility was constructed in the mid-1960s and borders tributaries of the St. Johns River and a tidal marsh within the Timucuan National Ecological and Historic Preserve. The NGS is under a Resource Conservation and Recovery Act consent order where the corrective action objective for groundwater is the attainment of groundwater and surface water cleanup target levels for arsenic, nickel and vanadium at the downgradient property boundary. Hydraulic control of impacted groundwater along the perimeter of the site was implemented using five vertical groundwater extraction wells strategically placed to mitigate off-site discharge of metals exceeding the GCTLs and SWCTLs. Typical groundwater recovery systems result in large volume waste streams with high disposal costs. But Geosyntec collaborated with JEA on an innovative approach for the reuse of extracted groundwater as part of their plant operations. The NGS hydraulic control system was constructed to allow diversion of extracted groundwater prior to off-site disposal without interruption to control system operation or installation of significant additional infrastructure. At design flow rates, water reuse could provide up to approximately 11,000 gallons per day of supplemental process water for the facility and decrease discharge to JEA's publicly owned treatment works by the same volume, providing a more sustainable, closed-loop system and reducing overall project costs by up to $218,000 per year.

9:30 CVOC Contaminated Zone Remediation with the use of Zero Valent Iron and Bentonite

Peter Moretuzzo, PE, Project Manager, Geo-Solutions, St. Petersburg

The project at a former dry-cleaning facility was completed outside the state of Florida and included in-situ chemical reduction of chlorinated volatile organic compound contaminated soils. The rotary soil mixing was completed using a Delmag RH28 drill rig fitted with a nine-foot diameter auger to mix zero-valent iron and bentonite with the site soils. The RSM was completed from five feet to 45 feet below an average existing ground surface. The target volume of contaminated soil treated was 9,037 cubic yards, however, a total of 10,304 cubic yards were mixed in order to provide complete coverage of the target zone. In total, the 10,304 cubic yards of soil were mixed with 277,400 pounds of bentonite and 369,000 pounds of ZVI, which equates to an overall bentonite addition of 1.05 percent by dry weight of soil and an overall ZVI addition of 1.40 percent by dry weight of soil using an assumed dry soil density of 95 pounds per cubic foot. For quality control testing, wet samples of the freshly mixed soil/bentonite were collected immediately after column completion at a frequency of one sample for every 500 cubic yards of mixing completed with a minimum of one sample each day of mixing. The samples were spaced out within the treatment area with the hope of providing a good representation of the entire treatment area. These samples were collected using an in-situ sampler that attaches to the drill rig auger. The grab samples were separated for QC analytical and magnetic separation testing to ensure the target ZVI addition was met.

9:40 What Does PFAS mean to You?

Kollan Spradlin, PE, CHMM, Professional Engineer, SCS Engineers, Tampa

Perhaps you have heard about expectations for new regulations on chemicals of concern. Or maybe you have heard that PFAS remediation is going to be the next big industry focus. This presentation will be a short technical overview of what PFAS is, a brief history of PFAS and a look into a 3M PFAS production facility in Alabama. Perfluoroalkyl substances are a family of chemicals originally licensed by 3M in the 1940s and used by Dupont and other manufacturers to produce products such as Teflon, fire-fighting foam, wire insulation and liquid-resistant textiles used in waterproof clothing. Increased usage, as well as an advancement in laboratory detection technologies, led to a surge in the documented presence of the PFAS chemicals in the environment in the early 2000s. The ability to document the presence of the chemicals has led to a more thorough understanding of the human health and environmental risks associated with the chemical products in recent years. As these chemicals become more stringently regulated, consultants, industry partners and regulators face increased pressure to manage previous releases and mitigate future human exposure to PFAS chemicals.

9:50 Implementing Bioremediation to Address Trichloroethene Source Zones at a Legacy Hydraulic Containment Site

James Mills, MS, Senior Staff Professional, Geosyntec Consultants Inc., Tampa

Historical trichloroethene releases resulted in the contamination of the surficial aquifer at the Precision Fabricating & Cleaning Co., or PFC, site in Cocoa, FL. Site assessment investigations revealed the presence of onsite source areas and an associated downgradient dissolved plume that migrated offsite. In 2002, a hydraulic containment system was implemented to provide flux control at the PFC property line in conjunction with natural attenuation monitoring of the downgradient dissolved plume offsite. An enhanced in-situ bioremediation strategy was implemented in 2015 that included bioaugmentation and biostimulation with the remedial objectives of reducing onsite TCE source zone concentrations in a limited and known area, and facilitating the proposed shutdown of the hydraulic containment system. The success of the 2015 limited EISB event in effectively promoting reductive dechlorination in a known source zone (the combined remedy approach was presented at the 2016 Florida Remediation Conference) led to the design and implementation of a subsequent EISB event conducted in May 2019. The remedial objectives of the May 2019 event were to reduce TCE concentrations in known and suspected source zones onsite and targeted zones offsite with elevated concentrations above groundwater cleanup target levels and facilitate the shutdown of the hydraulic containment system. The May 2019 EISB event included bioaugmentation with the KB-1® dechlorinating anaerobic microbial culture from SiREM Laboratory, and biostimulation with the SRS®-FRL slow release emulsified vegetable oil electron donor from Terra Systems Inc. KB-1 and SRS-FRL were injected at multiple discrete intervals through temporary direct push technology injection points. Prior to the injection event, the hydraulic containment system was shutdown with regulatory approval. The shutdown marked approximately 17 years of operation in which the objective of hydraulic containment was achieved, yet mass removal was asymptotic and additional remedial measures were warranted to reduce source area concentrations and meet site cleanup objectives. The shutdown reached another important milestone in transitioning from active hydraulic containment to passive long-term monitoring at the site. This presentation will provide up-to-date performance monitoring results associated with the remedial design implementation. Additionally, the presentation will include strategies, lessons learned and considerations for bioremediation implementation and remedy optimization.

10:00 Designing Away Common In-Situ Bioremediation Complications

Lydia Ross, MS, PE, Technical Support Engineer, EOS Remediation, Research Triangle Park, NC

Emulsified vegetable oil has been injected at thousands of sites over the past decade to treat chlorinated solvents, chromium, uranium, nitrate, perchlorate, explosives and other contaminants. These systems can provide very high levels of treatment, however, all in-situ remediation technologies invite a host of complications depending on the complexities of each site. With technical expertise and available design tools, you can "design away" many of the common possible complications with using EVO for in-situ source or barrier remediation. This presentation will cover preemptive measures to ensure remediation success using available design tools and many years of field experience. Best practices and specific examples from Southeast regional sites will be shared to demonstrate how good design can accommodate adjusting pH in acidic aquifers, avoiding injection well fouling, improving contact efficiency and optimizing well spacing for reducing total project cost. Additional topics to be covered include assessment data that can be collected prior to design, the formulas and equations from existing ESTCP and EOS Remediation LLC design tools that can be utilized to calculate EVO and amendment quantities and specific injection protocols that can be followed in the field to maximize distribution and minimize potential for well fouling. Where available, local Florida case studies will be presented to illustrate lessons learned.

Break: 10:10 - 10:30

Concurrent Session 6A: Remediation and Modeling Case Studies

10:30 ERH Remediation in Interstate Median

Kevin Novello, Project Manager, TRS Group Inc., Longview WA

A tanker truck overturned in 2014, releasing approximately 1,200 gallons of trichloroethylene into an interstate median, between the east and west bound travel lanes. Contaminated surface soil from the area was excavated a few feet below ground surface. The median is only 60 feet wide and has steep slopes towards the center drainage ditch that restricted the potential depth of excavation in order to maintain the integrity of interstate lanes. In subsequent investigations, TCE impacts were detected to a depth of almost 40 feet below ground surface. The soil consisted predominantly of a very tight clay with minor lenses of silty clay underlain by a drinking water aquifer. The maximum concentration of TCE in soil was 1,100 mg/kg, which was identified at 32-33 feet bgs. The total, potential mass of TCE was estimated at 14,500 pounds based on a maximum of 1,200 gallons of TCE. The remediation goal was established at 0.073 mg/kg TCE in soil, which is the state's risk-based screening standard for soil protective of groundwater. Alternative remedial technologies were evaluated and electrical resistance heating was selected. Injection in tight clays was believed to be technically impracticable and further soil removal would have resulted in significant risk to the structural integrity of the interstate. ERH minimized risks and had the ability to treat both saturated and unsaturated soils and remove TCE in low permeability soils. The proposed ERH remediation zone within the median was 6,015 square feet. The treatment depth ranged from 0 to 40 feet bgs, resulting in a treatment volume of approx. 8,100 cubic yards. Thirty-nine electrodes with co-located vapor recovery screens were installed to a maximum depth of 42 feet bgs. An additional 20 independent vapor recovery wells and six temperature monitoring points were also installed within the remediation zone. An impermeable liner was installed over the remediation zone at the surface. A vapor/liquid treatment system was installed north of the interstate. Treatment system power cables, vacuum piping and other equipment was installed under the interstate to connect the equipment in the remediation zone with the treatment system. The electrodes were energized to heat the soil, while a vacuum was established in the remediation zone to extract vapors to the treatment system. Removed TCE vapor was captured on vapor-phase granular activated carbon. The ERH system operated for 281 days, inputting 2,134,090 kWh of energy to achieve the treatment goal of 0.073 mg/kg TCE. The ERH remediation applied 121 percent of the estimated energy to achieve the clean-up objective. Based upon PID analysis of soil vapors recovered during ERH operations, approximately 8,638 pounds of TCE was removed from the treatment volume during the remediation. The system heated the soils within the treatment volume to design temperatures that effectively removed CVOCs from the subsurface for capture and treatment. Throughout the project, site and public safety were maintained while minimizing hazards associated with operations on an interstate highway. The results demonstrate that ERH remediation can achieve aggressive remediation goals in tight clay, in a challenging location in a relatively short time frame.

10:45 Leveraging Warm Water from Source Area Thermal Remedy for Combined Biotic/Abiotic Degradation of CVOCs

Dan Bryant, PhD, PG, Director, Woodard & Curran, East Windsor, NJ

We sought to enhance remediation of a concentrated chlorinated VOC plume downgradient from a source undergoing thermal remediation by leveraging the warm water migrating from the thermal treatment area. The warm water was expected to increase microbial activity and abiotic degradation reaction rates, release organic carbon and increase desorption of CVOCs. We utilized Provect-IR, a reagent that couples biotic and abiotic remedies—a solid, fermentable carbon source to stimulate anaerobic biodegradation—with zero-valent iron for chemical reduction. The abiotic ZVI reactions will ensure continued treatment if groundwater became too warm and inhibited microbial activity. The thermal remedy was operated from December 2017 to July 2018. Two reactive treatment zones were constructed immediately downgradient of the thermal area by injecting 148,500 pounds of Provect-IR into 325 discrete intervals among 57 boring locations in February and April 2018. Injection targeted a transmissive sand zone approximately 16 to 50 feet below grade. Performance was tracked by monitoring groundwater temperature, microbiological activity and analysis of CVOCs and redox-sensitive groundwater parameters. One year after shutdown, temperature has increased over 25°C in portions of the downgradient plume and have started to plateau. Groundwater samples collected one and two months after injection but before thermal shutdown, and four and seven months after injection, after thermal shutdown, show groundwater is strongly reducing and microbial activity remains high. TCE and cis-DCE concentrations are reduced two to four orders of magnitude in the upgradient treatment zone and in the deep interval in the downgradient treatment zone. In the downgradient shallow zone, TCE concentration is reduced by 50 percent but cis-DCE has increased nearly three times. This is attributed to less effective reagent distribution, but degradation is occurring. Temperature and groundwater monitoring will continue in order to evaluate the ongoing progress and document degradation rates and the contribution of elevated groundwater temperatures.

11:00 Effective Distribution of Emulsified Vegetable Oil in the Subsurface

David Alden, PE, Technical Services Manager, Tersus Environmental Inc., Wake Forest, NC

Emulsified vegetable oil is a well-used substrate to address chlorinated solvents in aquifers that is only effective for enhanced bioremediation if it is adequately distributed through the contaminated subsurface. Understanding factors affecting emulsion stability, fate and transport in the subsurface allows the adequate design of an injection system. Many projects have failed due to design oversimplification, improper bench scale test interpretation, unexpected geochemical interactions and overall poor hydraulic design. Different well-studied consideration used in the early bio-stimulation era will be discussed, as well as deeper analysis of the behavior of oil droplets in an aqueous phase as a colloidal suspension, including pore-blocking mechanisms and the effects of droplet size, fluid velocity, NAPL buoyancy and other surfactant-oil-water-soil interactions. Filtration becomes a prevalent factor in the underground hydrodynamic analysis of EVO flow. Zeta potentials, the difference between bulk fluid and stationary fluid layer attached to droplet surface, allows quantifying the effectiveness of EVO flow and experimental results can be used to better predict EVO flow behavior and optimize an injection strategy.

11:15 Combined Remedy Treatment of Multi-Chemical Solvent Plume in Fine-Grained, Low Permeability Sediments

William Brab, CPG, PG, Remediation Geologist, AST Environmental Inc., Midway, KY

A former chemical plant operating at this site since 1957, stored, repackaged and distributed chemicals including but not limited to hydrogen peroxide, methylisobutyl carbinol or MIBC, tetrachloroethene, acetone, ethanol and diesel fuel. In the early 1980s, approximately 29,000 pounds of MIBC was released into the environment. Response to the release was to cover the area with black plastic and then sand. Reportedly, as a follow-up, neither free product nor soils were removed. Numerous investigations completed between 1991 and 1999 identified approximately 10 halogenated solvents present in soil vapor, groundwater and soil. Dual-phase extraction was utilized from 2000 to 2010 with limited results. Alternative remedial technology was evaluated in 2011, and the selected technologies involved a combination of ex-situ and in-situ methods to achieve the site cleanup goals in a multi-phased approach. High-density qualitative soil and groundwater sampling was conducted in 2011 and 2012 to refine the existing conceptual site model. High density soil and groundwater sampling verified vertical and horizontal distribution of contaminant mass on and off-site. Significant unsaturated mass confirmed a sustained NAPL source for potential vapor intrusion issues in adjacent residential properties and a dissolved solute plume downgradient further off-site. A phased approach utilizing combined remedies was selected as the remedial option for the facility. Interim corrective action was completed in 2013 and 2014 and included an off-site in-situ permeable reactive barrier utilizing Trap & Treat® BOS 100® to capture dissolved impacts leaving the facility, and shallow soil mixing activated persulfate to mitigate unsaturated soil impacts adjacent to source media. Full-scale Phase 1 conducted in December 2016 utilized Trap & Treat BOS 100 + ERD to mitigate saturated source mass soil and groundwater impacts. Full-scale Phase 2 completed in September 2018 included additional off-site source and dissolved-phase treatment utilizing Trap & Treat BOS 100 + ERD. The presentation will discuss the development of the CSM over time and highlight the remedial action as a site-specific case study example. Lessons learned and relevant data presented will include benefits of high-density indiscriminate (regardless of field screening/field observations) soil and groundwater sampling for qualitative analysis in the laboratory. Remedial evolution will highlight the development, selection and use of a new cutting-edge application of cometabolic synergy: granular activated carbon impregnated with metallic reactive iron coupled with an enhanced reductive chlorinating biological component. The limiting factor in most abiotic remediation technologies is the finite amount of reducing material, in this case metallic iron. Improvements to the BOS 100 platform will be specifically discussed as part of this case study and remedial technology evaluation.

11:30 The Use of MODFLOW to Design a Groundwater Extraction System for MTBE Remediation

Brandon Poiencot, PE, Project Engineer, Golder Associates, Jacksonville

Golder completed site assessment and source removal activities at a former gas station in North Florida. Historically, methyl tert-butyl ether was only detected onsite above groundwater cleanup target levels on one occurrence. Downgradient compliance wells began to report

MTBE levels above GCTL shortly after source removal activities. Golder was tasked to delineate this MTBE plume. Following direct push technology groundwater sampling activity, MTBE was detected in an area to the southeast of the former gas station. MTBE was detected above GCTL in samples from the DPT sampling and existing monitoring wells in two different aquifer units: a shallow unit, approximately 30 feet below ground surface, and an intermediate unit approximately 75 feet bgs and approximately 500 feet downgradient from the former gas station. The soil types for the shallow and intermediate aquifer units are sand and limestone, respectively, and make up the typical surficial aquifer system throughout the region. Golder continued monitoring the plume on a semi-annual basis under the assumption that the plume would naturally attenuate. The plume persisted with little migration beyond the initial plume delineation. After four years of monitoring, regulators and the property owner agreed to develop a remedial action plan to address the offsite MTBE plume. Golder proposed to design and install a groundwater pump-and-treat system to remove and treat the plume. As part of the system design, Golder utilized MODFLOW to simulate the existing surficial groundwater system and predict the number of extraction wells and pumping rates for each well in order to capture the MTBE plume. The groundwater model was developed in two stages. First, a low-resolution model was created to simulate the general groundwater behavior of the entire watershed that encompassed the site. Once the regional model was calibrated, Golder moved on to the second stage of development, using the mesh refinement tool to create a finer meshed model that focused on the site and proposed extraction wells. Particle tracking via MODPATH was utilized in the fine-mesh model to display the capture of the MTBE plume. Pumping rates from each of the proposed extraction wells were optimized to achieve capture of all the particles placed along the assumed limits of the MTBE plume. The presentation will review the development, calibration and optimization of both stages of the groundwater model.

Concurrent Session 6B: Iron Amendment Treatment Technologies

10:30 One Permeable Reactive Zone, Two Years, 365 Feet and Complete Mass Flux Reduction by Biogeochemical Reductive Dechlorination

James Studer, PE, Principal Technology Consultant, InfraSUR LLC, Albuquerque, NM

A decades-old groundwater tetrachloroethylene plume extends 1,200 feet from a back-diffusion-fed fractured bedrock zone to an off-facility surface waterway within unconsolidated sediments. The geology and hydrology are complex. Pre-remediation-detected PCE concentrations ranged from approximately 100 ug/L at the source to 10 ug/L and less at the stream intercept. The plume was attenuating but not necessarily shrinking. The potential is high for the weathered bedrock to naturally attenuate PCE and transformation products via abiotic reactions with reactive minerals such as magnetite. However, mineral-based abiotic transformations do not appear significant at this site and surface water/groundwater interaction appears to be more important. PCE concentrations along the stream were above the state regulatory remediation guideline and therefore remediation was deemed necessary. Various in-situ groundwater treatment technologies were evaluated at bench-scale and a micro-scale ZVI pilot test program was completed. Biogeochemical Reductive Dechlorination was selected and documented in the RODs for this plume and other plumes at the facility. Design-basis characterization including intensive biogeochemical characterization of core was completed and a phased full-scale permeable reactive zone installation was completed. In January 2017, four borings were advanced to 50 feet below grade, followed by straddle packer direct pressurized injection of aqueous solution containing fast and slow release carbon-based electron donor, sulfate, iron and pH modification. Process and performance assessment monitoring conducted over a two-year period demonstrate disruption of previously unknown concentrated PCE mass in the general source area resulting in 500 percent increase in dissolved-phase PCE. A complex series of reactions involving BiRD led to complete elimination of the PCE, with no vinyl chloride production, over 365 feet from PRZ to a critical down-gradient performance well.

10:45 Shifts in Magnetic Susceptibility and Physical Trends of Experimental ZVI PRBs Exposed to High c-VOC-Impacted Groundwater

Alexander Korff, Engineer, Product Development, Hoganas Environment Solutions, Cary, NC

Most common causes of permeable reactive barrier failure are due to losses in reactivity of zero-valent iron media and hydraulic conductivity changes. Those are related to complex mineral formation on the surface of ZVI media, possibly affecting electron transfer rates and reducing overall porosity and permeability. To better understand the performance of various ZVI media, two Cleanit® media and one conventional, regrind iron media were evaluated during a six-month column test. Groundwater impacted with high levels of chlorinated volatile organic carbons, tetrachloroethene and trichloroethylene as well as associated daughter products was used to simulate an in-situ PRB with ZVI. Flow-through columns were set at a rate of 0.3 mL/min to simulate one-foot-per-day groundwater velocity associated with the site. The c-VOC concentrations were measured along the length of the columns, and effluent samples were analyzed for cations and anions. The porosity of each column was estimated before and after the long-term test using a bromide tracer test. After the completion of the six-month test, columns were dismantled and the inner ZVI media were dried anaerobically for further analysis. The magnetic susceptibility of the dried media was measured and compared with fresh media as well as reference iron hydroxides. The dried PRB media also underwent acid-digestion and instrumental analyses to evaluate shifts in iron and mineral contents. Various increases in iron hydroxide and groundwater species concentrations and quantifiable changes in magnetic susceptibilities of the PRB media were observed in the ZVI over the length of the simulated PRBs.

11:00 Optimization and Performance of ZVI Amendments for In-Situ Chemical and Biological Reduction

Gary Birk, PE, Managing Partner, Tersus Environmental Inc., Wake Forest, NC

In-situ chemical reduction is an innovative environmental remediation technique used for soil and groundwater contamination that involves the placement of a reductant or reductant-generating material in the subsurface to reduce the concentrations of targeted environmental contaminants to acceptable levels. Zero-valent iron is most commonly used for remediating halogenated ethenes and ethanes, pesticides, energetic compounds and some metals/metalloids into harmless end products. The process combines both biological processes and ZVI particle-driven abiotic pathways to chemically reduce the contaminants. The incorporation of ZVI enhances remediation by enabling various chemical reduction pathways and for halogenated ethenes limits the formation of undesirable breakdown products such as cis-DCE and vinyl chloride. Sulfide-modified zero-valent iron is attracting more attention due to its ability to achieve much higher contaminant removal efficacy than unmodified ZVI due to its selectivity to pollutants over water. Without sulfidation, ZVI will generate both H2 to promote biological processes and electrons for abiotic pathways. With sulfidation, the production of electrons for abiotic pathways will dominate the reactions. Sulfide-modified zero-valent iron forms FeS, which promotes the abiotic pathways. FeS is highly reactive with chlorinated organic compounds. Tetrachloroethene is mainly reduced by FeS to acetylene via â-elimination (dominating reaction), to trichloroethene via hydrogenolysis and to 1,1-dichloroethene via á-elimination. TCE transforms to acetylene also via â-elimination (dominating reaction) and to DCE via hydrogenolysis. The presentation will include results and lessons learned from the latest field implementations for optimizing ZVI amendments to maximize remediation effectiveness and minimize project cost.

11:15 Full-Scale Remediation of Subsurface Chromium Impacts with Multiple Media

Bob Kelley, PhD, Vice President, Hepure, Hillsborough, NJ

A full scale in-situ treatment program was implemented to remediate hexavalent chromium impacts at a former metal plating facility. Chromium impacts were present in soil and groundwater in a complex hydrogeological system that consists of multiple lithological units within the overburden and bedrock. In-situ reductant amendments were selected to convert Cr(VI) to Cr(III) to reduce contaminant toxicity and mobility. These amendments were injected into the vadose zone using direct push injection with pneumatic fracturing to deliver zero valent iron to create a long-lasting reactive barrier preventing further migration of Cr(VI) into the overburden groundwater. Ferrous sulfide was selected as the saprolite groundwater treatment amendment based on laboratory treatability studies that confirmed the effectiveness of both sulfide and ferrous iron at reducing Cr(VI). The injection monitoring showed that pH, ORP and sulfide were good indicators of CPS transport into a well. Most wells where significant reductions in chromium concentrations were observed also showed a sustained period of depressed ORP and an increase in sulfide concentrations. Total chromium concentrations have also been greatly reduced in the saprolite with a limited zone of moderate concentrations remains within the deeper bedrock.

11:45 Remediation of Lakes, Rivers and Canals for Impacted Water Quality Using an Innovative Ferrate-Based Treatment System

Thomas Waite, PhD, PE, President and Founder, Ferrate Solutions Inc., Melbourne

High valence (+4 through +7) oxo anions of iron called ferrates, FeO_x^{y-}, have been studied by chemists for over 300 years. Commercial utilization of these unusual compounds has been extremely limited, primarily because of their inherent instability. However because of the high valence iron in these compounds, they are strong oxidants and because the residual from any chemical reaction is ferric iron, the most common element on earth, they should be commercially useful especially for environmental applications. For over 40 years, tens of thousands of publications have shown ferrate's effectiveness in environmental applications. All this research with subsequent pilot demonstrations has been performed utilizing small quantities of laboratory-synthesized ferrate compounds. Despite the astounding results observed with ferrate treatment of water, wastewater, sludge and industrial wastes, inexpensive commercial sources of a ferrate compound have never been available in the marketplace. After many years of research and experimentation in full-scale pilot studies, Ferrate Solutions engineers have designed proprietary blends of inexpensive commercially available feedstock chemicals that, when reacted together under proprietary conditions, can produce a concentrated ferrate solution that is stable for weeks. This allows a workable solution of ferrate to be continuously generated nearby its point of use. Ferrate treatment of agricultural runoff in canals has shown that it can reduce both phosphorus and nitrogen via precipitation and oxidation reactions by greater than 98 percent. At the same time color, TSS, organic toxins and heavy metals are also removed. This presentation will describe results from full scale treatment of runoff water and dredge sediment water, as well as other environmental applications.

12:00 ***Day Two Luncheon*** *Sponsored by* ***The Goldstein Environmental Law Firm PA***

Concurrent Session 7A: Innovative Remedial Approaches

1:45 The Hybrid Remedial Approach

Sean Rome, Operations Manager, TRC Solutions, St. Augustine

A growing number of complex, large scale site remediation projects are becoming increasing difficult to complete. Site complexities such as geotechnical challenges, groundwater chemistry, water treatment and often unnecessary involvement from external stakeholders has created a challenging environment to achieve cleanup. The Hybrid Remedial Approach is a remedial technology flow process designed to address these complexities for safe and efficient site closure. Attendees of this presentation will gain insight into what HRA is and when and how to employ it, learn what HRA technologies are available and learn how to drive the HRA selection process. In addition, a case history using HRA on a coal combustion residuals remediation site will be presented.

2:00 Post-Hurricane Maria and Remediation Efforts to Address Chlorination/ Non-Chlorinated VOCs and 1,4 Dioxane Impacts at Puerto Rico Facility

Bradley Pekas, PG, PE, Senior Engineer and Team Leader, Trihydro Corp., Tampa

This presentation provides an update to the ongoing remedial investigation of chlorinated and nonchlorinated volatile organic compounds including 1,4 dioxane at an industrial facility in Puerto Rico. These technical discussions start where we left off in late 2017 following Hurricane Maria (an FRC 2017 presentation). This presentation includes: (1) a review of post-hurricane site cleanup actions; (2) a discussion of the operation, performance and modification of the ozone/in-situ chemical oxidation pilot study system to address the off-site 1,4-dioxane plume; (3) a review of bench-scale testing of potential direct versus cometabolism for 1,4 dioxane, and (4) a preliminary technology screening for the plant site/source area remedies. In 2017, Hurricane Maria not only damaged the above-grade, ozone pilot remediation system but also impacted several features of the monitoring network that were located, inspected, and repaired or replaced. The ozone remediation system was also modified and expanded to prevent the preferential offsite migration of 1,4 dioxane within a paleo-stream channel. A combination of in-situ and ex-situ remediation alternatives were screened for the plant site and source areas of chlorinated, non-chlorinated VOCs and 1,4-dioxane including in-situ chemical oxidation using permanganate, persulfate or both; in-situ bioremediation under anaerobic or aerobic conditions; and various ex-situ technologies such as soil vapor extraction, air sparging and dual-phase extraction. The bench-scale testing results for aerobic bioaugmentation or cometabolic degradation of 1,4-dioxane provided favorable results. The site-specific challenges encountered, site observations and data evaluation, and the final remedies proposed for this site will be addressed in this talk.

2:20 A Simplified Approach to Closure of Legacy C&D Areas at Power Industry Facilities – RBCA, Solid Waste Rules and the Old Dump Guidance

Ryan Tuttle, PG, Project Geologist, Geosyntec Consultants Inc., Tampa

Legacy construction and demolition debris areas at power generating facilities are unique as these sites can fall under either RBCA or solid waste rules after assessment completion following the Guidance for Disturbance and Use of Closed Landfills or Waste Disposal Areas in Florida. The Crystal River Energy Complex and Anclote Power Plant operated by Duke Energy had legacy C&D areas of interest to the regulatory community, with contaminants that could be related to either waste, buried waste, or natural and anthropogenic background. These case studies will describe the use of historical forensics to define time lines for disposal activities and to identify rules that were in place during the C&D area operational timeframe. Developing a defensible argument for the use of alternate cleanup target levels while also eliminating contaminants of concern due to background conditions enabled closure of the sites without entering the Ch. 62-780, F.A.C., rule process.

2:40 Mitigation of Vapor Intrusion Preferential Pathways for a Challenging Industrial Building

Joseph Corsello, PE, Project Manager, Sanborn, Head & Associates Inc., Boston MA

Assessment and mitigation of a large, old industrial building impacted by vapor intrusion of volatile organic compounds presented an unusual challenge. A building addition constructed over an existing VOC plume created hidden and unusual preferential pathways that contributed to elevated levels of VOCs in indoor air. An initial sub-slab vapor assessment revealed the presence of VOCs in the vadose zone soil gas beneath the building. As a preemptive mitigation measure, a sub-slab depressurization system was designed and constructed to control cross-building slab pressure gradients and mitigate the VI pathway. Following construction of the SSD system, startup indoor air monitoring was conducted with a field-portable gas chromatograph to obtain real-time continuous and discrete sample data. Using the GC, several VI preferential pathways created from the construction of the building addition were identified as major contributors of VOCs to indoor air. These pathways, including an old subsurface sewer pipe, several abandoned downspouts from the original building and the interstitial space within a cinder block wall and between the existing building and the addition, were not influenced by the SSD system and required additional mitigation measures. These mitigation methods, including installation of new sewer drain covers, downspout seals and a vacuum pipe to depressurize the block wall interstitial space, were implemented. Following an iterative process of mitigating the preferential pathways and then re-screening indoor air for VOCs with the field-portable GC, indoor air quality eventually improved and indoor air samples were collected, the results of which indicated achievement of indoor air guidelines.

Concurrent Session 7B: In-Situ Oxidation Tools and Technologies

1:45 Combined ISCO and Stabilization/Solidification for Full-Scale Remediation of a Coal Tar Source Area

Jeff Roberts, MSc, Operations Manager, SiREM, Guelph, Ontario, Canada

In-situ stabilization/solidification involves mixing contaminated soils with binders such as Portland cement, thereby decreasing the mobility and toxicity of contaminants. While ISS has a demonstrated track record at hundreds of sites, it does not typically destroy contaminants. ISS in combination with in-situ chemical oxidation, or ISCO-ISS, is an attractive option offering the possibility of contaminant destruction as well as stabilization of untreated residuals. This approach was tested for application at a former gas works site in Denmark where a full-scale ISCO-ISS remedy was implemented to destroy coal tar contamination, including benzene in groundwater, and to reduce hydraulic conductivity and improve soil strength. A rigorous pre-design bench-scale test was conducted to measure the performance of ISCO-ISS in samples collected from the site, including the impact on BTEX, sVOCs and phenolic compounds. The bench tests determined optimum dosages of ISCO-ISS amendments, the potential for using Portland cement as an alkaline activator for persulfate, reductions in leaching of coal tar contaminants, reductions in hydraulic conductivity and increases in unconfined compressive strength of the stabilized material. Specific technical challenges included managing interferences of persulfate chemistry with cement chemistry and determining the optimal application sequence of amendments. Based on the success of the bench-scale test, the ISCO-ISS remedy proceeded to pilot test and full-scale implementation in 2018. Results to date indicate that ISCO-ISS, using Portland cement base-activated persulfate, was a successful and cost-effective technology for treating the coal tar source area. The information gained from the bench-scale laboratory study was critical to the successful design of the pilot study and ultimately the full-scale implementation. Building on this successful project, guidance and recommendations for applicability of ISCO-ISS to other sites, lessons learned and refinements for implementation in future projects will be shared.

2:10 Treating 1,4 Dioxane with Activated Potassium Persulfate

Brant Smith, PE, PhD, Technical Applications Manager, ISCO, PeroxyChem, Philadelphia, PA

1,4 dioxane has emerged as a contaminant of concern at numerous sites. It is most commonly found at sites co-mingled with the chlorinated solvents it was used to stabilize, along with their daughter products. The co-mingling of 1,4-dioxane with chlorinated solvents can make treatment of the entire contaminated site more complex as 1,4-dioxane is typically treated using an oxidative radical pathway and several of the chlorinated solvents are best treated with a reductive pathway. In several instances, this has led to sites where the chlorinated solvents were treated only to expose the untreated 1,4-dioxane. Alkaline-activated potassium persulfate was evaluated at two separate sites contaminated with a mixture of 1,4-dioxane, chlorinated ethenes and chlorinated ethanes. The sites were first evaluated in a series of column reactors where site groundwater was run through the columns until the potassium persulfate had been consumed. One of the sites subsequently had a successful field pilot test with alkaline-activated potassium persulfate applied with a full-scale application in 2018. The data indicate hydrated lime-induced alkaline-activated potassium persulfate reduced 1,4-dioxane, chlorinated ethenes and the chlorinated ethanes concentrations to below detection limits. Field data not only evaluated treatment effectiveness but also the persistence of potassium persulfate compared to the site's groundwater velocity. Field data indicated that the potassium persulfate was persisting as expected based on the observed groundwater velocities, and that 1,4-dioxane was treated to below the detection limit at the PRB and significantly reduced down gradient.

2:35 ISCO Generator for Continuous Production of Reactive Oxygen Species to Remediate Soil and Groundwater – Ideal for PRB Applications

Jim Mueller, PhD, President, Provectus Environmental Products Inc., Freeport, IL

New technologies are desired for safe, cost-effective remediation of soil and water impacted by a wide variety of organic contaminants including rapidly emerging contaminants. Ideally, an in-situ technology can be effectively employed in deep aquifers and mixed lithologies to easily manage large, dilute plumes often found in remote areas. Other benefits include low cost, small footprint, minimal energy consumption, low maintenance and no external chemical requirements. One such method involves integrated electro-chemical reactions under controlled conditions. Direct oxidation at semiconductor films coupled with enhanced electro-Fenton oxidation is achieved electro-chemically and controlled remotely. Secondary effects include enhanced contaminant desorption and stimulated biogeochemical destruction. Rapid oxidation of chlorinated solvents and petroleum hydrocarbons has been observed at pilot and full scales, and future applications could address perchlorate, perflourinated compounds, 1,4-dioxane, pharmaceuticals and other challenging contaminants. The EBR® system is comprised of subsurface electrodes with high catalytic activity for O2 generation that is constantly reduced to form H2O2. An additional electrode is used as a constant source of Fe cations via forced corrosion and effective Fe2+ formation from Fe3+. The system radius of influence is self-propagating and increased by imposing an effective constant flux across the well interface due to boundary conditions effects and high chemical potential, in addition to the existing natural dispersion and advection forces. Furthermore, electro-osmosis induces groundwater flow between coupled wellbores yielding a more complete approach to aquifer remediation, especially in fine-grained, low-permeability materials that typically harbor sorbed residuals because electro-kinetics enhances the mobilization and therefore the availability of the contaminants. In terms of secondary processes to help manage contaminant rebound, the co-mobilization of nutrients and the oxidative nature of the method supports accelerated aerobic bioremediation. Successful implementation of the EBR technology at several sites has resulted in rapid site closure. The method was inspected by the Water Authority of Israel and its use is widely approved. For example, one study conducted by the Israeli Geological Survey and the Israeli Water Authority found that the electrolysis system induced rapid change in the biochemical conditions on the site. Anaerobic wells rapidly turned aerobic. As a result, from this change, a significant decrease in the concentrations of MTBE from 68 mg/L to less than 0.04 mg/L was associated with a change in its isotopic composition. Assuming that the isotopic enrichment constant in the process of groundwater MTBE breakdown equals the enrichment, constant obtained from microbial experiments in the laboratory, then more than 96 percent of the MTBE underwent oxidative destruction. Similar results from various full-scale remediation projects will be presented along with information on cost and processing. Lastly, we will present the idea of non-uniform electro-kinetics via a polarity exchange technique to intermittently reverse electric currents to prevent significant pH changes and discuss potential applications for other contaminants under various site conditions.

Break: 3:00 - 3:15

Session 8: Annual Regulatory Panel

3:15 *Moderator:* Joe Applegate, PG, Senior Principal Hydrogeologist, Geosyntec Consultants Inc., Tallahassee

Speakers:

Natasha Lampkin, FCCM, FCCN, Program Administrator, Petroleum Restoration Program
Division of Waste Management, Florida Dept. of Environmental Protection, Tallahassee

Wilbur Mayorga, PE, Division Chief, Environmental Monitoring and Restoration Division, Miami-Dade County, Miami

Graham Witt, Team Leader, PRP Contract Management Team 5 (Northstar), Tallahassee

John Wright, PE, Chief Engineer, Petroleum Restoration Program
Division of Waste Management, Florida Dept. of Environmental Protection, Tallahassee

5:00 **FRC 2019 Conference adjourns**