SHORT COURSES

SUNDAY, APRIL 8, 2018

8:00 a.m.–5:00 p.m. (all-day)

- Sequence Stratigraphic Concepts and their Application to Conceptual Site Models and Remedial Strategies: A Hands-On Training (page 82)
- Update on Current High-Resolution Site Characterization (HRSC) Technology, 3-D Data Modeling, and Applying HRSC Data to Remedial Design (page 83)
- ITRC Training: Managing PFAS Contamination at Your Site: Site Characterization, Sampling, Fate and Transport, along with Remedial Alternatives (page 83)
- Are Advanced Molecular Biological Tools the "Next Best Thing" for Assessment of Remediation? (page 84)

8:00 a.m.-noon (half-day)

- ITRC Training: Using Groundwater Statistics and Geospatial Analysis for Remediation Optimization—An ITRC Course (page 85)
- ITRC Training: Integrated DNAPL-LNAPL Site Characterization and Tools Selection (page 86)
- Life Cycle Assessment and Green Sustainable Remediation: How to Choose and Use the Right Tool (page 87)
- Remediation of Contaminant Mass in Low-Permeability Materials (page 88)

1:00-5:00 p.m. (half-day)

- Effective Design, Construction and Maintenance of Environmental Remediation Wells (page 89)
- New ITRC Guidance: Remediation Management of Complex Sites (page 90)
- Introduction to Stakeholder Engagement: Using Social Methodology to Strengthen Your Relationships with the Public (page 90)

TUESDAY, APRIL 10, 2018

2:00– 6:00 p.m. (half-day)

- Accelerating Technologies to Market with Environmental Technology Verification (ISO 14304) (page 91)
- DronED: Learning on Regulatory Environments, Technology, and Data Management Solutions (page 92)
- Innovative Visualization and Modeling Methods for Optimizing In Situ Remediation (page 93)
- ITRC Training: Characterization and Remediation in Fractured Rock (page 94)
- ITRC Guidance: Bioavailability of Contaminants in Soil—Considerations for Human Health Risk Assessment (page 95)
- Natural Source Zone Depletion: New Conceptual Models and Assessment Methods (page 95)
- Stratigraphic Flux: A Method for Determining Migration Pathways at Complex Sites (page 96)

Register online at www.battelle.org/chlorcon.

Prospective attendees should register by February 23, 2018. If insufficient registrations have been received for a given course by that date, the course will be canceled, and registrants will have the option of transferring to other courses or having their fees refunded. Maximum discounts apply to fees paid by February 23. Course registrations will be accepted as long as space is available. Registration cancellations received by February 23 will be refunded less a $50 service fee. Cancellations after February 23 will not be refunded, but paid no-shows will receive all course materials. Substitutions will be accepted at any time, preferably with advance notice. Course materials will include the instructors' presentation slides and other supporting materials as appropriate to the course, such as references from the literature, reprints, files or publicly available software.

Sunday, April 8, 2018

8:00 a.m.–5:00 p.m.
(1-hour break at noon for lunch on own)

Sequence Stratigraphic Concepts and their Application to Conceptual Site Models and Remedial Strategies: A Hands-On Training

Instructors:
Junaid Sadeque, Ph.D. (AECOM)
Ryan Samuels, MS (AECOM)

Objective: This course will provide hands-on training on how to use environmental sequence stratigraphy to develop more accurate conceptual site models (CSMs) and remediation strategies. The potential audience includes environmental professionals and students engaged in remediation projects.

Overview: Sequence stratigraphy has arguably revolutionized stratigraphic analysis in the oil and gas industry since the 1970s, but to date, few environmental companies have utilized this power tool. Although some of us are gradually catching up with sequence stratigraphic concepts, the paradigm of lithostratigraphy is still prevalent in the environmental community. This significantly limits our ability to construct accurate CSMs and develop effective investigation/remedial strategies.

In this course, participants will be made aware of the pitfalls of lithostratigraphy and demonstrate the predictive ability of sequence stratigraphy in accurately determining contamination flow paths. Besides lecturing on the fundamental concepts, the student will be provided with ample opportunity to try out the techniques of sequence stratigraphy using real data from the environmental industry. At the end of the day, the participant will go home with a better understanding of how sequence stratigraphy can be properly implemented into investigation and remediation projects.

Outline:

Introductions

1. Lecture: Impact of stratigraphy in groundwater modeling
    a. What's wrong with lithostratigraphy?
    b. Basic definitions and jargons of sequence stratigraphy
    c. Exercise 1: Short discussion on concepts
2. Lecture: Stratigraphic surfaces and their recognition criteria in borehole cores and logs
    a. Exercise 2: Identification of key stratigraphic surfaces
3. Lecture: Alluvial fans, channels and deltas: how to recognize in subsurface
    a. Exercise 3: Identifying depositional environment in the subsurface
4. Special Guest Lecture: The role of Sequence Stratigraphy in Mass Flux calculations
5. Special Guest Lecture: Application of Sequence Stratigraphy in PFAS investigation
6. Lecture: How to correlate? Pitfalls, challenges and solutions
7. Lecture: The role of modern analogs for environmental sequence stratigraphy
    a. Exercise 4: Correlation exercise using CPT logs/bore-hole data and modern analogs

Laptops are **not required** for this course. Colored pencils and paper for the exercises will be provided.

Sunday, April 8, 2018

8:00 a.m.–5:00 p.m.
(1-hour break at noon for lunch on own)

Update on Current High-Resolution Site Characterization (HRSC) Technology, 3-D Data Modeling, and Applying HRSC Data to Remedial Design

Instructor:
John V. Fontana, PG (Vista GeoScience)
Daniel Pipp (Geoprobe Systems)

Objective: This course will review the current state of technology regarding direct-push subsurface imaging tools, including: the membrane interface probe (MIP), low-level MIP, electrical conductivity (EC), hydraulic profiler tool (HPT), combined tools (MiHPT), and the new optical image profiler (OIP) tool for identifying nonaqueouse-phase liquid (NAPL) fluorescence. The course is intended for environmental consultants, professionals and regulators who want to design/plan HRSC surveys, enhance their interpretation of the resulting data logs, conduct data quality reviews, examine 3-D models, and then apply the data to remedial site characterization and design projects.

Overview: Over the past 20 years, site characterization has benefited from the development of direct-push enabled subsurface investigation tools such as the electrical conductivity (EC) probe, hydraulic profiler tool (HPT), and membrane interface probe (MIP). These tools have been around for several years, and in recent years, have advanced to include the low-level MIP tool (LL-MIP), combined tools (MiHPT), and the new optical image profiler (OIP) tool for identifying NAPL fluorescence. A single probe can now log three or more chemical sensors, soil conductivity, hydraulic pressure and flow, hydraulic conductivity, all in a single borehole push. In addition, these tools have become significantly more robust over recent years, enabling greater productivity. Data are collected at a vertical density of 20 data points per foot of borehole, so the vertical resolution is indeed high. Highly detailed logs of these data provide insight and resolution that cannot be seen in the physical examination of a core, or from three laboratory samples from the same core. Today's inexpensive computer power allows us to input and process hundreds of thousands of data points into a complex 3-D model, giving us the ability to finally peer underground, and see "what is going on." The course will review the current state of the technology, including new tools, recent advancements, and how to obtain and review quality control data from a service provider. It will also cover data interpretation, and important considerations when creating 3-D models of these data, and how to interpret these models. Finally, the course will cover applications for initial and supplemental site characterization projects, and remedial design projects.

Outline:

1. Review of HRSC technology. EC, MIP, LL-MIP, HPT, and OIP: How they work and what they tell us
2. Chemical sensor instrumentation and the MIP tool: Identifying VOCs
3. Optical imaging profiler: A new UV fluorescence tool for LNAPL identification, and other potential applications
4. Soil and groundwater (hydrogeologic) characteristics using the data from the EC and HPT tools
5. Digging into the data using the Geoprobe's DI Viewer Software
6. Interpreting Logs: How to interpret combined responses from all the different sensor data
7. Quality Control: What to ask for, how to review it, and how to interpret it.
8. 3-D Models: Putting log data into 3-D model software. How to properly render data into meaningful images
9. Some really cool examples of what HRSC data can reveal such as finding confined LNAP below the water table, mapping a methane plume from a gas line release or landfill
10. How to acquire and apply HRSC data for initial site investigations, supplemental data, and remedial design

Laptops are **required** for this course.

Sunday, April 8, 2018

8:00 a.m.–5:00 p.m.
(1-hour break at noon for lunch on own)

ITRC Training: Managing PFAS Contamination at Your Site: Site Characterization, Sampling, Fate and Transport, along with Remedial Alternatives

Instructors:
Robert Mueller, M.S. (New Jersey Dept. of Environmental Protection)
Christopher Higgins, Ph.D. (Colorado School of Mines)
William DiGuiseppi, PG (CH2M Hill)
Dora Chiang, Ph.D., P.E. (AECOM)
Stewart Abrams, P.E. (Langan Engineering)
Virginia Yingling (Minnesota Department of Health)

Objective: Per- and poly-fluoroalkyl substances (PFAS) are an emerging group of contaminants that present unique issues with site characterization, sampling and analysis, fate and transport, and remedial alternatives. Regulators, site managers, facility owners, consultants, technology developers, and other stakeholders will all benefit from this state-of-the-art presentation.

Overview: In 2017, the Interstate Technology and Regulatory Council (ITRC) assembled a team of over 300 PFAS experts drawn from industry, academia, state and federal agencies, consulting, and the U.S. departments of defense and energy. This team developed six fact sheets that provide an overview on PFAS naming conventions, sources and uses, regulatory trends, site characterization, fate and transport, and treatment technologies; these will form the basis of this training. The training will begin with an overview of PFAS in the environment, then will concentrate on three key elements for characterizing and managing PFAS-impacted sites—site characterization (including sampling and analysis), complex mechanisms that impact fate and transport, and current and potential remediation technologies. The trainers will present the recommended approaches that should be taken once PFAS contamination is identified.

PFAS in the Environment—PFAS is a family of chemicals that may include as many as 3000+ compounds. The sources and general chemistry of those PFAS thought to be the most environmentally relevant will be highlighted and current knowledge regarding their potential ecological and human health risks will be presented. Precursors that degrade to ecologically important PFAS also will be considered

Site Characterization—What are the unique aspects of PFAS that pose challenges to getting good site data? This section will cover:

- Sampling Procedures: This element introduces state-of-the-art knowledge on proper sampling techniques, sample preparation procedures and transport to the laboratory. The most recent research will be presented to prepare attendees to acquire the best data for their site, while avoiding false positives and false negatives.
- Laboratory Procedures: A description of the various laboratory analytical techniques will be presented along with guidance on interpretation of results.
- Data Accuracy: Common cross contamination and other issues that can be frequently encountered during sampling and laboratory analysis which unduly bias selection of management actions.

Fate and Transport—How do PFAS move in air, soil, groundwater, and surface water? What are the unique PFAS transport mechanisms that complicate creating a conceptual site model (CSM)? How does the presence of precursors affect the CSM? All of these elements will be presented to help understand these contaminants in the environment.

Treatment & Remediation—Proven treatment and remediation approaches for PFAS are still largely limited to separation and destruction technologies, which will be presented individually. The potential approaches for combining technologies to increase technical and economic feasibility also will be evaluated. Design considerations and performance evaluation will be presented for those technologies that are proven and demonstrated. Current research in emerging (but not yet field-proven) remediation technologies also will be introduced. Case studies will be presented that demonstrate how each of these elements can be applied in the field.

Outline:
1. Overview of the ITRC PFAS team describing the six fact sheets and current team work products in development.
2. Overview of PFAS in the environment
3. Site charaterization
4. Sampling of air, water, soil, and biota
5. Laboratory analyses
6. Fate and transport
7. Treatment and remediation technologies
8. Further research needs

Laptops are **<u>not required</u>** for this course.

Sunday, April 8, 2018

8:00 a.m.–5:00 p.m.
(1-hour break at noon for lunch on own)

Are Advanced Molecular Biological Tools the "Next Best Thing" for Assessment of Remediation?

Instructors:
Kate Kucharzyk, Ph.D. (Battelle)
Dora Taggart (Microbial Insights)
Frank Loeffler, Ph.D. (University of Tennessee and ORNL)
Robert Hettich, Ph.D. (ORNL)
Mandy Michalsen, Ph.D., P.E. (USACE)
John Wilson (Scissortail Environmental Solutions, LLC)
Rebecca Reiss, Ph.D. (New Mexico Tech)
Heather Rectanus, Ph.D., P.E. (Battelle)

Objective: The objective of this course is to present information on the advanced molecular biological tools (MBTs) such as metagenomic sequencing, shotgun and targeted proteomics and their application in monitoring of contaminant degradation. The potential audience includes environmental professionals, state and federal regulators and commercial clients who are interested to learn more about the basics of the analyses, application and data interpretation for assessment of contaminant degradation at their sites.

Overview: Use of MBTs for quantification and detection of biomarkers, especially DNA, proteins and lipids, in environmental samples has been rapidly increasing over the last few decades. MBTs are being used by remediation professionals to aid remedial design, assess remedial performance, and perform long-term monitoring of biologically-based degradation technologies. The goal of MBT application is measuring temporal and special changes of microorganisms and their activity. The quantitative level of information is invaluable to understand and interpret contaminant biodegradation.

Conventional MBTs typically used in microbial diagnostics include quantitative polymerase chain reaction (qPCR) and microarrays. qPCR provides information on the abundance of target organisms and specific genes. Genes commonly identified using this technique typically are the functional genes responsible for the production of enzymes that can break down the contaminant of interest. qPCR can therefore determine if the organisms responsible for biodegradation are abundant and if the potential for biotic MNA pathways exist at a site.

Most recent efforts have extended genome-based science by large-scale genome sequencing, often called metagenomics, which provides insight into whole community sequence information on microbial members from various ecological niches. Integration of metaproteomics or whole community proteomics seeks to identify functional expression of the metagenome and gives a snapshot of community metabolic activities at the moment of sampling. While metagenomic sequencing can define the microbial and/or gene composition and inform about the potential molecular machinery, it does not reveal details on its actual function. Metaproteomics provides the most direct measure of microbial activity. It allows detection of proteins of interest, providing information on molecular processes utilized by microorganisms to sustain the metabolic processes required for life. These two techniques represent the cutting-edge of experimental genome science and each are rapidly developing.

As additional research is realized, integration of metagenomic and metaproteomics may one day provide the ability to derive in situ rate estimates from quantifiable biomarker measurements. This could eliminate the need to collect time series concentration data to model and calculate attenuation rates, and foster a predictive understanding of plume development and contaminant longevity. In future applications, employing these analyses may provide quantitative information about the abundance and activity of relevant microorganisms in one assay, monitor changes in response to treatment over time, and may correlate quantitative molecular analyses with in situ contaminant degradation rates. All of this knowledge taken together will feed into long-term management strategies and facilitate site closure.

Outline:
Opening statements

1. Conventional MBTs (qPCR) versus metagenomics
2. Advanced MBTs
3. Microarrays and metatranscriptomics
4. Discovery proteomic
5. MRM proteomics
6. Integrated approach to estimating degradation rates using MBTs
7. Utility of MBTs in environmental projects: case studies

Laptops are **not required** for this course.

Sunday, April 8, 2018
8:00 a.m.–noon

ITRC Training: Using Groundwater Statistics and Geospatial Analysis for Remediation Optimization – An ITRC Course

Instructors:
Harold Templin, LPG (Indiana Dept. of Environmental Management)
Chris Stubbs, Ph.D., P.E. (Ramboll Environ)
Lizanne Simmons, PG (Kleinfelder)
Randall Ryti, Ph.D. (Neptune and Company, Inc.)
Edward Winner, Ph.D. (Kentucky Dept. for Environmental Protection)
David Becker (USACOE)

Objective: This course will present groundwater statistical methods and geospatial analyses as a tool to evaluate remediation optimization opportunities. State regulators and other practitioners, including stakeholders will benefit from gaining greater confidence using groundwater statistics and geospatial analysis for remediation optimization.

Overview: Statistical techniques may be used throughout the process of cleaning up contaminated sites to give an amount of certainty to decisions and provide opportunities to optimize remediation activities. It is challenging for practitioners, who are not experts in statistics, to interpret and use statistical techniques. This short course is specifically for environmental project managers who review or use statistical calculations for reports, or make recommendations or decisions based on statistics. The class will encourage and support project managers and others who are not statisticians to apply key aspects of the statistical approach to groundwater data and to answer common questions on monitoring optimization.

This short course will also introduce geospatial analysis approach to support remediation optimization. Unlike traditional statistical analysis, geospatial methods incorporate the spatial and temporal dependence between nearby data points, which is an important feature of almost all data collected as part of an environmental investigation. The results of geospatial analyses add lines of evidence for decision making about optimization opportunities in environmental sites across all project life cycle stages in all media for different sizes and types of sites. Through this course, project managers can use geospatial analysis to assess optimization opportunities by evaluating available data and site needs to determine if geospatial analyses are appropriate for a given site, identifying optimization questions where geospatial methods can contribute to better decision making through selection of appropriate geospatial method(s) and software, and explaining what the results mean for better decision making.

This short course is based on the ITRC's Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation (RPO-1, 2004, http://itrcweb.org/GuidanceDocuments/RPO-1.pdf) guidance document, and Groundwater Statistics and Monitoring Compliance (GSMC-1, 2013, http://www.itrcweb.org/gsmc-1) and Geospatial Analysis for Optimization at Environmental Sites (GRO-1, 2016, http://gro-1.itrcweb.org/) web-based guidance documents.

Outline:

1. Introduction
   a. Opportunities to Apply Statistics and Geospatial Analysis in Optimization
   b. Getting Ready to Apply Statistics
   c. Fundamentals of Geospatial Methods
2. How to Apply Optimization Questions for: Monitoring, Site Characterization, Remediation, and Closure
   a. Application Examples
   b. How to Use the GSMC Document and Putting GRO into Practice

Laptops are **not required** for this course.

Sunday, April 8, 2018

8:00 a.m.–noon

ITRC Training: Integrated DNAPL-LNAPL Site Characterization and Tool Selection

Instructors:
Michael B. Smith (Vermont Dept. of Environmental Conservation)
Naji Akladiss, P.E. (Maine Department of Environmental Protection)
Tamzen W. Macbeth, PhD, P.E. (CDM Smith)
Ryan Wymore, P.E. (CDM Smith)
Heather Rectanus, Ph.D, P.E. (Battelle)

Objective: This workshop will present the ITRC guidance document of this same title. The workshop will focus on recent advances in the understanding of NAPL contaminant fate and transport, and introduce the ITRC's Integrated Site Characterization approach, including the importance of high-resolution characterization. The potential audience is all environmental professionals, including regulators, site owners, consultants, and stakeholders.

Overview: Sites contaminated with NAPLs present significant environmental challenges and have proven to be recalcitrant to remediation, especially where sites have been contaminated with DNAPLs. This workshop will begin by presenting the new NAPL conceptual site model (CSM). Our industry can no longer address NAPL and dissolved phase contamination separately, but rather they need to be considered together. Experience gained at these sites has driven us to update overall our understanding of NAPL and dissolved phase contamination. This includes the controlling role of small geologic heterogeneities on the fate and transport of NAPL and associated dissolved phase contamination.

Properties of NAPLs and associated aqueous, sorbed, and vapor phase contamination, and how they partition throughout the subsurface will be presented. Mechanisms that control the flow of NAPLs in the subsurface including solubility, capillary entry pressure, saturation and residual saturation, wettability and interfacial tension will be discussed. The workshop will present the DNAPL life cycle models of "higher" solubility DNAPLs such as chlorinated solvents, and the "lower" solubility DNAPLs such as coal tars and creosotes. The latest characterization approaches for sites contaminated with LNAPLs will also be presented.

A detailed module describing the objectives-based integrated site characterization (ISC) process that will both clarify how to collect appropriate scale data, and what types of data are collected with an emphasis on geology where appropriate will be presented as well as how to manage, analyze, and integrate the large geological-hydrogeological and contaminant databases that can be developed using the ISC approach.

A live demonstration will be given of the ITRC site characterization tools table that will help guide site characterization efforts as a resource that will represent many characterization tools, what they are used for, how geology affects tool choices, and references to more information on the tools.

Outline:

1. Introduction
2. NAPL Site Conceptual Model
3. Effect of NAPL Types and Properties on Contaminant Fate and Transport
4. NAPL Presence, Fate, and Transport
5. 14 Compartment Model
6. DNAPL Life Cycle
7. Integrated Site Characterization Process: Planning, Tools Selection, Implementation/Update CSM
8. Present an Interactive Tools Table

Laptops are **not required** for this course.

Sunday, April 8, 2018

8:00 a.m.–noon

Life Cycle Assessment and Green Sustainable Remediation: How to Choose and Use the Right Tool

Instructors:
Andrew D. Henderson, Ph.D. (Noblis, Inc.)
Michael S. Bruckner, MS, LCACP (Noblis, Inc.)

Objective: Remediation professionals are faced with a number of tools that can be used to integrate sustainability considerations into remediation programs. This course will provide participants with A) an overview of how these tools quantify the sustainability of remediation approaches, B) strategies to choose among these tools, and C) an overview of how to access and apply the tools using case studies of chlorinated site remediation.

Overview: Regulatory and public pressures are increasing demands for avoiding negative impacts from site cleanup. ITRC Technical/Regulatory Guidance provides a variety of approaches to assess and minimize these impacts, including green and sustainable remediation (GSR) and life cycle assessment (LCA). Given variations in stakeholder needs, regulatory demands, site variability, and the developing nature of the sustainability field, practitioners need to able to choose the correct tool for the job and apply that tool efficiently.

SiteWise™ and Spreadsheets for Environmental Footprint Analysis (SEFA) are two GSR tools; LCA is a broader method for sustainability but requires training and often the use of specialty software. When used properly, and matched to concrete goals, such tools can create economic, environmental, and social win-win situations. This course will discuss the theory underpinning quantified sustainability, as well as explore the strengths and weaknesses of the following tools (note that this list focuses on publicly available software and data). Participants in the course will gain a conceptual understanding of possible approaches, strategies to select the appropriate tool to evaluate sustainability, and hands-on experience applying these tools.

- SiteWise™ (the Navy, the Army Corps of Engineers, and Battelle)
- Spreadsheets for Environmental Footprint Analysis (SEFA) (USEPA)
- Sustainability Analysis Scoring Factors (the Department of Defense)
- openLCA (open source LCA software + publicly available data)

- USEtox (open source LCA software for estimating impact from chemical releases)
- Social-LCA (applying approaches from United Nations Environmental Programme [UNEP] to remediation)

Outline:

1. Introduction and course goals
2. Why would we quantify sustainability of remediation?
    a. Regulatory and other drivers
3. How do we quantify sustainability?
    a. Relative versus absolute sustainability
    b. Metrics for quantification
4. Existing approaches for assessing remediation
    a. GSR: SiteWise™, SEFA
    b. LCA: openLCA
    c. LCA-derived tools:
        i. Scoring Factors
        ii. USEtox
        iii. Social-LCA
5. Case studies and class exercises
    a. Discussion of lessons learned during case studies
6. Summary and discussion

Laptops are **required** for this course.

Sunday, April 8, 2018

8:00 a.m.–noon

Remediation of Contaminant Mass in Low-Permeability Materials

Instructors:
James Wang, Ph.D., P.E. (Geosyntec)
Bill Slack, Ph.D., P.E. (FRx, Inc.)
Gary Wealthall, Ph.D. (Geosyntec)
Steffen Nielsen (TerraTherm, Inc.)
David Gent, Ph.D., P.E. (U.S. Army Corps of Engineers)

Objective: This short course will provide information specifically related to remediation in low-permeability materials (e.g., clay and fractured rock), including modeling and conceptual site model development for remedial design, as well as remediation technologies suitable for such challenging materials. The potential audience includes environmental site/program managers, regulators, and remediation practitioners.

Overview: Instructors will cover topics related to challenges and benefits of remediating contaminant sources in low-permeability materials, including development of a conceptual site model (CSM) supporting remedial design, as well as processes and applications of several in situ remediation technologies particularly suitable for these challenging materials.

The life-cycle of a CSM demands iterative improvement of understanding as the project proceeds, based on systematic procedures. Data gap assessment and uncertainty analysis are the structural elements in the life-cycle of a CSM, and proper management of these CSM elements is particularly challenging and critical for sites with low-permeability zones. The course will examine some pitfalls in evolution of the CSM life-cycle and present examples of CSMs that have been developed to meet the design, implementation and performance assessment of increasingly sophisticated remedial technologies. Tools for quantifying contaminant mass and phase partitioning with focus on low-permeability geology will also be discussed.

Various environmental fracturing technologies have been demonstrated to effectively facilitate in situ remediation of low-permeability materials. The mechanisms, techniques, and applications of environmental fracturing will be discussed, including the current spectrum of proppant materials, fracture emplacement methodologies, and remedial applications.

An in-depth explanation of several thermal technologies will be provided, including thermal conductive heating (TCH), steam-enhanced extraction (SEE), and electrical resistive heating (ERH), which are often considered as effective alternatives for low-permeability materials and bedrock. Remedial design approaches and tools, as well as guidelines for evaluating strengths and weaknesses of each technology with considerations of challenging site conditions will be presented.

Electrokinetic (EK) transport of remediation amendments in the subsurface relies on ion migration and electroosmosis, which are electrochemical mechanisms relatively independent of soil's hydraulic conductivities. Therefore, EK transport can achieve effective distribution of select amendments in low-permeability and heterogeneous subsurface formations. The course will present the fundamentals of EK technology, its engineering implementation, and example projects.

Outline:

1. Overview of challenges and benefits of addressing contaminant sources in low-permeability materials;
2. Conceptual site model development for sites with low-permeability zones;
3. Modeling of low-permeability and complex geology to support remedial design;
4. Fracturing-facilitated in situ remediation;
5. Electrokinetic-enhanced delivery of amendments for in situ remediation; and
6. In situ thermal remediation technologies.

Laptops are **not required** for this course.

Sunday, April 8, 2018

1:00 p.m.–5:00 p.m.

Effective Design, Construction and Maintenance of Environmental Remediation Wells

Instructors:
Fred Payne, Ph.D. (Arcadis)
Marc Killingstad, P.E. (Arcadis)
Jay Erickson, PG (Arcadis)

Objective: The objective of this course is to provide information and guidance to attendees on the design, installation, and maintenance of effective groundwater extraction and injection wells (i.e., environmental remediation wells) to achieve maximum performance during remediation of impacted soil and groundwater and to lower life cycle costs. The primary audience will be environmental professionals but the course will also be of significant interest to state and federal regulators as well as private- and public-sector stakeholders who are vested in cleanup efforts of contaminated sites where environmental remediation wells are employed as part of the overall strategy.

Overview: Groundwater extraction and injection wells (broadly, environmental remediation wells) are utilized at many groundwater remediation sites. For most sites, these wells require significant investments. If they are properly designed, constructed, and maintained, they can perform at a high level for many years, ultimately reducing remedial time frames and project life cycle costs. Meanwhile, inadequate design, construction, and maintenance can generate a significant additional cost burden for projects through high operating costs, premature replacements, and extended remedial time frames.

While our overall approach and underlying principles are generally based on those employed by the drinking water supply industry, environmental remediation well design and construction requirements are different. The primary difference, relative to the water supply industry, is that environmental remediation wells are often required to perform in less than ideal conditions—very poor and oftentimes unfavorable water quality and hydrogeologic conditions.

Clearly, implementation of any in situ soil and groundwater remedy under such adverse conditions is going to be critically dependent on the use of remediation wells to support both extraction of contaminated groundwater and/or injection of reagents (or treated water). Therefore, the importance of high-quality environmental remediation well design, installation, and maintenance cannot be overstated.

Based on collective experience acquired over many years, a methodology has been developed which has been proven to result in high quality environmental remediation wells. Whether they are intended for extraction or injection, the primary goal of the design, installation, and maintenance approach is to establish and maintain a free-flowing connection (i.e., maximum hydraulic communication) between the well and aquifer to effectively advance remediation of contaminated groundwater.

Outline:

1. Purpose: Present systematic approach to design, construct and maintain high-quality environmental remediation wells considering optimal performance and life cycle costs
    a. Differences: Water Supply versus Remediation
    b. Life Cycle Costs
2. Well Design Components
    a. Requirements
    b. Aquifer Setting
    c. Life Expectancy
    d. Maintenance/Access
    e. Materials/Compatibility
3. Well Installation
    a. Drilling Methods
    b. Pilot Hole/Screening
    c. Well Components
    d. Well Development

4. Well Maintenance
    a. Purpose/Importance
    b. Proactive versuss Reactive
    c. Processes Affecting Performance
    d. Metric/Performance Tracking
    e. Re-development/Rehabilitation

Laptops are **not required** for this course.

Sunday, April 8, 2018

1:00 p.m.–5:00 p.m.

New ITRC Guidance: Remediation Management of Complex Sites

Instructors:
Rula A. Deeb, Ph.D., BCEEM (Geosyntec Consultants)
Carl Spreng (Colorado Department of Public Health and Environment)
John Price (Washington State Department of Ecology)
David Alden, P.E. (Tersus Environmental)
Charles Newell, Ph.D. (GSI Environmental)

Objective: This course will provide a framework based on adaptive site management principles for remediation management of complex sites. It will also identify and integrate technical and nontechnical challenges into site objectives, remediation approach, and develop a performance-based action plan to guide long-term management. This training will interest state and federal regulators at complex sites, environmental professionals, and public and tribal stakeholders.

Overview: At some sites, complex site-specific conditions make it difficult to fully remediate environmental contamination. Both technical and nontechnical challenges can impede remediation and may prevent a site from achieving federal- and state-mandated regulatory cleanup goals within a reasonable time frame. For example, technical challenges may include geologic, hydrogeologic, geochemical, and contaminant-related conditions as well as large-scale or surface conditions. In addition, nontechnical challenges may also play a role such as managing changes that occur over long time frames, overlapping regulatory and financial responsibilities between agencies, setting achievable site objectives, maintaining effective institutional controls, redevelopment and changes in land use, and funding considerations.

This short course and associated ITRC guidance, Remediation Management of Complex Sites, provide a recommended process for remediation management at complex sites, termed “adaptive site management”. Adaptive site management is a comprehensive, flexible, and iterative process of remediation management that is well-suited for complex sites, where there is significant uncertainty in remedy performance predictions. Adaptive site management includes periodically evaluating and adjusting the remedial approach, which may involve multiple technologies at any one time and changes in technologies over time. Comprehensive planning and scheduled periodic evaluations of remedy performance help decision makers track remedy progress and improve the timeliness of remedy optimization, reevaluations, or transition to other technologies/contingency actions.

Participants will learn how to apply the guidance to improve decision making and remediation management at complex sites. The guidance is intended to benefit a variety of site decision makers, including regulators, responsible parties and their consultants, and public and tribal stakeholders. Case studies will be used to describe real-world applications of remediation and remediation management at complex sites.

Outline:
1. Introduction
2. Site challenges
3. Remediation potential assessment
4. Adaptive remedy selection
5. Long-term management
6. Interactive Q&A session

Laptops are **not required** for this course.

Sunday, April 8, 2018

1:00 p.m.–5:00 p.m.

Introduction to Stakeholder Engagement: Using Social Methodology to Strengthen Your Relationships with the Public

Instructors:
Reanne Ridsdale, M.A., B.A., Ph.D. Candidate (Ryerson University)
Melissa Ann Harclerode, Ph.D., ENV SP (CDM Smith)

Objective: Navigating the world of social impact assessment and stakeholder collaboration can be difficult, vague, and views can often be polarizing, however, with proper methodology and guidance, meaningful engagement can enhance project outcomes, streamline processes, and create trusting partnerships among stakeholders. Participants will learn the current state-of-the-art methods and processes for conducting meaningful stakeholder engagement with an opportunity to practice using vetted tools. The potential audience includes environmental professionals, regulators, potentially responsible parties (PRPs), community members, and other stakeholders (such as property developers and non-profit interest groups).

Overview: Engaging public opinion on projects is a large and complicated task. In order to understand the best course of action, practitioners will need to gain an understanding of stakeholder context. There are various complex socio-political and socio-economic barriers to meaningful engagement. Understanding the context of affected stakeholders by the remediation project, practitioners can better collaborate on which method would be most effective for engagement, and how to implement that process.

Through the process of understanding stakeholder context of the site, and through meaningful engagement, a complex remediation project may lead to a revitalization in the community, which may result in an increased perception of urban sustainability, increased tax base for the municipality, gentrification of older neighborhoods, and improvements in quality of life through ecological restoration.

This course will focus on a broad overview of stakeholder engagement and social methodologies that can help practitioners and proponents in project decision making. The course will outline the role, purpose, and benefit of stakeholder engagement, touch upon the role of risk perception of impacted community members, and provide engagement planning and societal impact assessment tools. The course will go from background and theory to case studies and testing live tools. Breakout sessions will be comprised of: (1) utilizing multi-criteria decision analysis for identifying project sustainability objectives and remedy performance metrics; (2) a walk through of a community involvement plan; and (3) charrette to incorporate stakeholder needs into site end use.

Most projects require some sort of stakeholder engagement as required by international, federal, state/provincial, and municipal law. Understanding the methods and processes that are required for stakeholder engagement, will greatly benefit your project outcomes, ability to tender, and your company's reputation. This course is applicable to many practitioners and is a great entry level course for engineers and scientists. No social science background is needed.

Outline:

1. Familiarize remediation practitioners with the concept of meaningful stakeholder engagement and understanding socio-cultural contexts of project participants.
    a. Background to stakeholder engagement;
    b. Understanding barriers to participation;
    c. Understanding the role of urban sustainability.
2. A hands on introduction to social engagement tools that will assist:
    a. in identifying stakeholder groups;
    b. aid in selecting sustainable indicators;
    c. overview of current tools and methodology
    d. walk through of a community involvement plan;
    e. perform two assessments;
    f. help in selecting an acceptable remedy, and;
    g. have input for future land use design.

Laptops are **not required** for this course.

Tuesday, April 10, 2018

2:00-6:00 p.m.

Accelerating Technologies to Market with Environmental Technology Verification (ISO 14304)

Instructors:
John Neate, BSc, MES (VerifiGlobal)
Amy Dindal, PMP (Battelle)

Objective: The objective of this course is to present the new ISO 14034 standard, including principles, procedures, and benefits of environmental technology verification (ETV) and how this can facilitate market acceptance and regulatory approval of innovative technologies. The targeted audience includes technology developers, vendors, solution providers and clean-tech investors, as well as technology buyers, users, managers, regulators, and agencies.

Overview: The new ISO 14034 ETV standard, published in November 2016, provides a specified framework for the evaluation of environmental technologies. The process outlined in the standard provides legitimacy to third-party verification of environmental technology performance claims.

Use of the standard offers the following benefits:

- Robust verification: A functional quality-assured process for technology performance verification, supported by effective testing and verification protocols;
- Reciprocity and acceptance: Effective engagement of stakeholders and other interested parties when identifying relevant performance parameters, with greater potential for reciprocity and acceptance of test methods, performance data and verification results across multiple jurisdictions;
- Market adoption: Accelerated market adoption of verified technologies by a broader range of users across different sectors, particularly when considering proposed solutions and potential outcomes that involve trade-offs and risks.

For the 'clean-tech' industry and environmental technology companies, independent verification based on the ISO 14034 ETV standard provides credible evidence that technologies perform as claimed, which helps convince potential clients, as well as regulators, of the legitimacy and value of these verified technologies.

For industries and governments that require technologies to prevent, control and remediate pollution, and/or improve environmental performance, independent verification based on the ISO 14034 ETV standard provides credible performance information, which informs choices and helps justify decisions.

Illustrative examples of how ISO 14034 is being applied will be provided.

Outline:
Part 1: Introduction to ISO 14034 and Its Benefits

1. What is independent technology performance verification and how does it differ from other technology evaluation processes?
2. What is the ISO 14034 standard and why is it useful?
3. How can ISO 14034 verification be used to support transparent, evidence-based decisions and value-based procurement?
4. How can ISO 14034 verification assist in gaining market acceptance and approval?
5. How can ISO 14034 help technology companies access international markets?z

Part 2: ISO 14034 Process Requirements

1. Who conducts performance testing and verification and what are the specific roles and responsibilities?
2. What are the conformity requirements when conducting performance testing and verification in accordance with ISO 14034?
3. What needs to be considered when specifying the performance parameters for a verification plan in accordance with ISO 14034?
4. What needs to be considered when conducting performance testing in order to generate verifiable performance data?
5. How can stakeholder expectations be managed to achieve positive performance verification outcomes?

Laptops are **not required** for this course.

Tuesday, April 10, 2018

2:00-6:00 p.m.

DronED: Learning on Regulatory Environments, Technology, and Data Management Solutions

Instructors:
Jeffrey Popiel (Geotech Environmental Equipment, Inc.)
Paul Eaton (Geotech Environmental Equipment, Inc.)
Andrew Lindemann (Geotech Environmental Equipment, Inc.)
Rob Rebel, P.E. (LT Environmental)

Objective: Rapidly advancing technology has made it possible to employ pilotless aircraft "drones" for commercial operations. This workshop will provide facility managers, engineers, and professionals with information on navigating regulatory environments, and how drones enhance safety by eliminating the need to employ people at height, in remote, hazardous or toxic environments.

Overview: This course examines the fundamental concepts and techniques of unmanned aircraft systems (UAS) in the environmental industry. An effective pilot must understand: airspace, weather, human factors, risk, and general avionics. In addition, the class examines the variations of UAS technologies and future technologies along with the types of sensors that are used and how. Special consideration will be given to understanding how the technology can be applied in the field with first hand case study examples and review of the most common field challenges while evaluating how to overcome them. Furthermore, the benefits of using UAS, their cost, and resource saving abilities will be explored.

Outline:

1. Regulatory
    a. Part 107
        i. Airspace where UAS are operated
        ii. Aerodynamics: Review on the nature of avionics
        iii. Weather: Review on how environmental factors affect flight
        iv. Human Factors: Mental and physical state of a remote pilot
2. Hardware
    a. Various platform technologies: multi-rotor, helicopter, fixed wing
    b. Remote sensors: RGB, Thermal, MultiSpectral, Communications, LiDAR
3. Data Management
    a. Storage: cloud versus hard drive
4. Business Case
    a. Insurance, Hardware Costs, Software, Staff, etc.
5. Case Study Examples
    a. Brownfields redevelopment environmenal site survey, Denver, Colorado
    b. Infrastructure mapping at an industrial site, Weld County, Colorado
    c. Engineering design and operations plan development for an oilfield truckwash, Fort Lupton, Colorado.

Laptops are **<u>not required</u>** for this course.

Tuesday, April 10, 2018

2:00-6:00 p.m.

Innovative Visualization and Modeling Methods for Optimizing In Situ Remediation

Instructors:
Grant R. Carey, Ph.D., P.E. (Porewater Solutions)
Larry M. Deschaine, Ph.D., P.E. (HGL)

Objective: This course will demonstrate innovative new methods that can be used to optimize in situ remediation based on real-world case studies. This course is intended for practitioners and regulators involved with site remediation. A modeling background is not required for this course.

Overview: Specific topics in this short course include:

- Using mass flux/mass discharge to define attainable goals for in situ remediation, based on a meta survey of numerous case study sites.
- Use of a radial diagram visualization method and free Visual Bio software to delineate where biodegradation is occurring in groundwater.
- Use of a simple (and free) nonaqueous-phase liquid (NAPL) depletion model for supporting source zone natural attenuation remedies, and for estimating remediation timeframe of various technologies used to enhance NAPL dissolution rates, including case studies at both LNAPL and DNAPL sites.
- Review of the effect of back-diffusion on remediation timeframe, and long-term management and remediation strategies that mitigate back-diffusion effects.
- A mass balance assessment of natural attenuation at Plattsburgh Air Force Base, including the effects of methanotrophic cometabolism on volatile organic compound biodegradation.
- Case study review of emulsified oil injection at Charleston Naval Weapons Station including the application of specialized visualization and modeling tools.
- Modeling of the successful perfluorooctanoic acid (PFOA) and perfluorooctyl sulfonate (PFOS) in situ remediation at a site using PlumeStop® Liquid Activated Carbon™.
- Use of contact time as a metric for optimizing injection strategies.
- Introduction to physics-based management optimization (PBMO): Developing optimal exit strategies remains elusive when using only a heuristic trial and error approach. Computational optimization tools provide this optimal exit strategy capability development and implementation. This segment describes the motivation, technology, and speed improvements gained by using optimization tools. Optimal remedial design and documented site closure examples are provided. This optimization technology was recently recognized as the Grand Prize Award winner for Research in the 2017 American Academy of Environmental Engineers and Scientists competition.

Outline:

1. Background on benefits and limitations of in situ remediation technologies
    a. How to define attainable goals for in situ remediation
2. Innovative visualization method to delineate where biodegradation is occurring in groundwater.
3. Using the NAPL depletion model to support source zone natural attenuation and remediation timeframe estimates
4. Introduction to the In-Situ Remediation Model (ISR-MT3DMS) for evluating remedy performance.
    a. Case study of emulsified oil injection at Charleston Naval Weapons Station
    b,. Case study of PlumeStop® injection for in situ remediation of a PFOS/PFOA source zone
    c. Using contact time to improve remediation efficiency
5. PBMO for optimizing in situ remediation

Laptops are **not required** for this course.

Tuesday, April 10, 2018

2:00-6:00 p.m.

ITRC Training: Characterization and Remediation in Fractured Rock

Instructors:

Michael B. Smith (Vermont Dept. of Environmental Conservation)
Naji Akladiss, P.E. (Maine Department of Environmental Protection)
Tamzen W. Macbeth, Ph.D., P.E. (CDM Smith)
Ryan Wymore, P.E. (CDM Smith)
Nathan Hagelin, L.E.P. (Wood PLC)
Dan Bryant, Ph.D. (Woodard & Curran)

Objective: This course will present the ITRC Characterization and Remediation in Fractured Rock Technical Regulatory Guidance document as a 4-hour short course. The document and training will seek to demystify sites in contaminated fractured rock by providing background, tools, and characterization and remediation strategies in fractured rock to help obtain functional and absolute goals. The audience includes state and federal regulators, environmental professionals, problem holders, and stakeholders.

Overview: The problem statement is, that while our understanding of the distribution, fate and transport, and remediation of contamination in unconsolidated materials have improved such that many sites are reaching remedial objectives, similar success in fractured and weathered crystalline and sedimentary bedrock remain allusive, and meeting rigorous remedial goals may be considered impracticable by some parties.

In the recent past, however, there have been significant advances in bedrock characterization, including new investigation tools, as well as advances and successes in bedrock remediation and a growing inventory of successes and lessons learned in challenging fractured bedrock environments. Setting and meeting realistic characterization and remediation goals in fractured rock sites is feasible with the understanding of the unique characteristics of fractured rock sites.

This training is a detailed presentation of the ITRC document of the same name. The course will focus on the similarities and differences of the conceptual site models for unconsolidated materials and fractured rocks. This will help guide the training and demystify fractured rock characterization and remediation to develop the skills necessary to develop adequate and detailed CSMs for fractured rock sites.

The training will also provide characterization and remediation strategies designed specifically for fractured rock sites, and present an interactive tools table that will help practitioners pick the correct tools to address their site-specific characterization needs.

Outline:

1. Introduction
2. Fractured Rock CSM Considerations
3. Fluid Flow in Bedrock
4. Contaminant Fate and Transport
5. 21 Compartment Model
6. Integrated Fractured Rock Characterization Including How to Define and Collect Appropriate Scale Data
7. Present an Interactive Characterization Tools Table
8. Remedy Development for Contaminated Fractured Rock
9. Monitoring
10. Summary

Laptops are **not required** for this course.

Tuesday, April 10, 2018

2:00-6:00 p.m.

ITRC Guidance: Bioavailability of Contaminants in Soil — Considerations for Human Health Risk Assessment

Instructors:
Claudio Sorrentino, Ph.D. (California Department of Toxic Substances Control)
Valerie Hanley, Ph.D. (California Department of Toxic Substances Control)
Kevin Long, M.S. (Ramboll)
Barrie Selcoe, MPH (CH2M)

Objective: This training describes the general concepts of the bioavailability of contaminants in soil, reviews the state of the science, and discusses how to incorporate bioavailability into the human health risk assessment process. The short course focuses specifically on lead, arsenic, and polycyclic aromatic hydrocarbons (PAHs). The participants will learn how to select and use methods to evaluate site-specific bioavailability of contaminants in soil through case studies and how such information can be integrated in the human health risk assessment to inform risk management decisions and improve the efficiency of the use of the resources available.

Overview: Participants will learn to:

- Value the ITRC document as a “go-to” resource for soil bioavailability
- Apply the decision process to determine when a site-specific bioavailability assessment may be appropriate
- Use the ITRC Review Checklist to develop or review a risk assessment using soil bioavailability
- Consider factors that affect arsenic, lead and PAH bioavailability
- Select appropriate methods to evaluate bioavailability
- Use tools to develop site-specific bioavailability estimates and incorporate them into human health risk assessment

Outline:

1. General introduction of bioavailablitity and bioaccessibility and their importance for human health risk assessment and risk management
2. Review of regulatory background
3. Soil characteristics that play a role in the contaminants’ bioavailabiilty (pH, mineralogy, particle size, etc.)
4. Decision Process: how do decide when to use site-specific bioavailability evaluation and which method to use in vivo evaluation (Bioavailability) and in vitro evaluation (Bioaccessibility)
5. Contaminant-specific methods and approaches:
    a. Lead
    b. Arsenic
    c. Polycyclic aromatic hydrocarbons (PAHs)
6. How to integrate site-specific bioavailability in the human health risk assessment
7. Case studies

Laptops are **required** for this course.

Tuesday, April 10, 2018

2:00-6:00 p.m.

Natural Source Zone Depletion: New Conceptual Models and Assessment Methods

Instructors:
Parisa Jourabchi, Ph.D. (Golder Associates Ltd.)
John Wilson, Ph.D. (Scissortail Environmental Solutions, LLC)
Matthew Lahvis, Ph.D. (Shell)
Natasha Sihota, Ph.D. (Chevron)
Sanjay Garg (Shell)
Harley Hopkins (ExxonMobil)
Ian Hers, Ph.D. (Golder Associates)
Barbara Wilson (Scissortail Environmental Solutions, LLC)

Objective: This course will present information on the conceptual site model, the collection of measurement data, the analysis of data and use of models for estimation of natural source zone depletion (NSZD) rates and composition change of petroleum hydrocarbon source zones. The potential audience includes environmental professionals, state and federal regulators managing petroleum hydrocarbon contaminated sites, individuals and associations that manage contaminated lands.

Overview: There is increasing interest in NSZD as a remedial technology for sites impacted with petroleum hydrocarbons. An improved understanding of NSZD can lead to more optimized and sustainable site management and informed remedial decision-making. This course will combine theory and knowledge on the science combined with practical tools and tips for conducting NSZD assessments.

The course learning objectives are:

1. Understand the role of NSZD in the overall site management strategy.
2. Develop an improved knowledge of NSZD processes and mass loss and compositional change.
3. Gain practical knowledge on methods for estimation of NSZD rates including learning how to design and conduct field programs.
4. Understand data analysis methods and be able to conduct basic model calculations for NSZD estimation.
5. Develop improved understanding of enhanced biodegradation methods and potential benefits based on sustainability and life cycle considerations. The role of NSZD in site management and mechanisms of mass depletion and compositional change will be presented. The conceptual site model for NSZD will be described, including aerobic and anaerobic biodegradation, and saturated zone processes such as degassing and ebullition.

An integrated approach to estimation of NSZD rates including measurement and modeling methods for the vadose and saturated zones will be presented followed by the three primary vadose zone methods, the gradient, CO_2 efflux and temperature methods; each will be described in detail with case study examples provided.

The role and use of NSZD models will be demonstrated including examples and case studies. Each course participant will be provided the Vadose Zone Biodegradation Loss (VZBL) model developed by Dr. John Wilson and Golder. An introduction to enhanced biodegradation methods will be provided together with life cycle method of analysis for comparison of NSZD to other remediation methods.

Outline:

1. Purpose and rationale for NSZD assessment
2. Integration of NSZD in site management process
3. Conceptual site model and theoretical basis for NSZD
4. Vadose-zone measurement methods for NSZD estimates
5. Saturated-zone measurement methods and control volume concept
6. Modeling approaches and tools
7. Enhanced biodegradation methods and comparison to NSZD using lifecycle approach
8. Introduction to sustainability considerations
9. Case studies

Laptops are **required** for this course.

Tuesday, April 10, 2018

2:00-6:00 p.m.

Stratigraphic Flux: A Method for Determining Migration Pathways at Complex Sites

Instructors:
Joseph Quinnan, PE, PG (Arcadis)
Patrick Curry, PG, CPG (Arcadis)
Nicklaus Welty, PG, CPG (Arcadis)

Objective: The objective is to present information on applying smart characterization techniques to develop three-dimensional, flux-based conceptual models to focus remedies and reduce total life-cycle costs. The potential audience includes environmental professionals, state and federal regulators, and stakeholders engaged in remediating complex sites.

Overview: Stratigraphic flux enables development of quantitative, flux-based conceptual site models that are founded in sequence stratigraphy, and high-resolution hydraulic conductivity and contaminant distribution measurements. The result is a three-dimensional graphical mapping of relative contaminant flux and classification of transport potential that is easy for all stakeholders to understand. The stratigraphic flux graphical model is based on a hydrofacies classification system that describes transport potential in three segments of the aquifer: transport zones—where 90% of the groundwater flow occurs and transport rates are measured in feet per day; slow advection zones—where 9% of the groundwater flow occurs and transport rates are measured in feet per year; and storage zones—where less than 1% of flow occurs, and diffusion tends to dominate transport.

The hydrofacies architectures are based on stratigraphy, and transport potential is defined by grouping facies by orders of magnitude classes in hydraulic conductivity. By combining the hydrofacies architecture with contaminant concentration distributions, one can map relative contaminant flux to define and target the complex pathways that control contaminant transport and cleanup behavior. The results allow you to focus and optimize your remedies, reducing total life cycle costs and understanding potential risks before you remediate.

This workshop will provide training in smart characterization tool selection, data analysis and visualization approaches, and illustrate the concepts through a series of case studies. The training was developed through AFCEC funding on BAA 967 to address remediation of complex sites. A training guide and slides will be provided to course participants.

Outline:

1. Session 1: Return on Investigation
    a. Moving from Conventional to Smart characterization
    b. Return on Investigation
    c. Stratigraphic Flux
    d. Investigation Design and Interpretation of Data
2. Session 2: Stratigraphic Flux Background and Tools
    a. The Mass Flux Perspective
    b. Measuring Permeability
    c. Measuring Concentration
    d. Adaptive Investigation
3. Session 3: Method and Data Analysis
    a. Interpreting High Density Data and Geology
    b. Modeling Mass Flux
4. Session 4: Air Force Plant 4 - Chrome Pit 3:
    a. Background
    b. Stratigraphic Flux Approach and Methodology
    c. Results of testing
    d. Stratigraphic Flux Model
    e. Summary

Laptops are **<u>not required</u>** for this course.