ON THE LEVEL

Water Monitoring News and Updates

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High Quality Groundwater and Surface Water Monitoring Instrumentation

IN THIS ISSUE

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Working to Quantify and Overcome Uncertainty

The theme of this year's Symposium was "Enhanced Monitoring and Remedial Methods for Contaminated Groundwater". It became clear that enhancing monitoring and remedial approaches involves recognizing "uncertainty" as a factor in all contaminated site assessments.

It was put forth that heterogeneity in the subsurface affects the level of uncertainty in any groundwater study - when determining flow velocities, understanding how contaminants move, calculating mass discharge, determining flux, knowing how an amendment will behave, or assessing remedial performance.

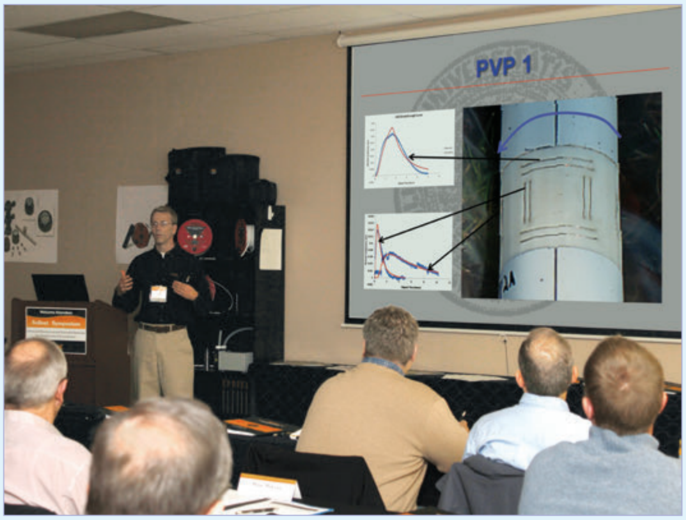
Each of the speakers acknowledged uncertainty as a limitation, but their work and research is aiming to overcome this. They provided examples, through tools they have developed or studies they have completed, which help to lessen uncertainty. Tools that capture smaller scale variances and high-resolution data provide characterizations that are more accurate, and including uncertainty estimates in study results and remedial performance assessments provides outcomes that are more realistic.

For more highlights from the Symposium, visit: http://www.solinst.com/Symposium/

Collaborating for Results

Listening to the speakers at the 2011 Symposium, it became clear that getting results requires a collaborative effort. During his presentation, Jim Barker highlighted this by introducing a combined initiative that is currently taking place in the province of Ontario. The Southern Ontario Water Consortium is a development platform for new water technologies that includes support from 8 universities, over 70 companies (including Solinst), and the Ontario Government. The growing project includes facilities across the Grand River Watershed for the testing and development of drinking water solutions, wastewater purification, ecotoxicological analysis, watershed management, and sensor development.

Assessment of Groundwater Velocity Measurements with PVPs



The Point Velocity Probe (PVP) measures groundwater velocity at the centimeter scale.

Rick Devlin kicked-off the Symposium with a presentation that stressed the importance of groundwater velocity measurements, especially for contaminant hydrogeology. Through case study examples, Rick showed that measuring velocity is essential in determining the fate and transport of contaminants, which in turn, helps focus remediation efforts in the right direction.

Traditional velocity estimates are based on gradients, hydraulic conductivity and Darcy's Law. However, these techniques fail to detect the small-scale variances in the subsurface, and average flow over a large area. To overcome this, a method of direct velocity measurement is needed.

To fill this need, Rick led the development of the Point Velocity Probe (PVP). The PVP is a device based on the movement of a saline tracer around a PVC casing. With the PVP placed in the ground, flow travels around the probe body, picking up the tracer at an injection port, and moving it to detectors on the casing. The time it takes the tracer to flow from the injection port to the detectors is data logged at surface. Velocity can be calculated using this data.

Rick's presentation took the audience through the testing and evolution of the PVP. It started as a simply constructed tool, to one that can be used for multilevel applications. He discussed unique "sandbox" tests that showed positive results in the lab, and looked at field testing undertaken at the Canadian Forces Base, Borden, Ontario, Canada.

Using these field tests, Rick compared the results of the PVP against other velocity estimation methods. His experiments showed that the PVP is a feasible tool for measuring high-resolution velocity data in non-cohesive material in the subsurface.

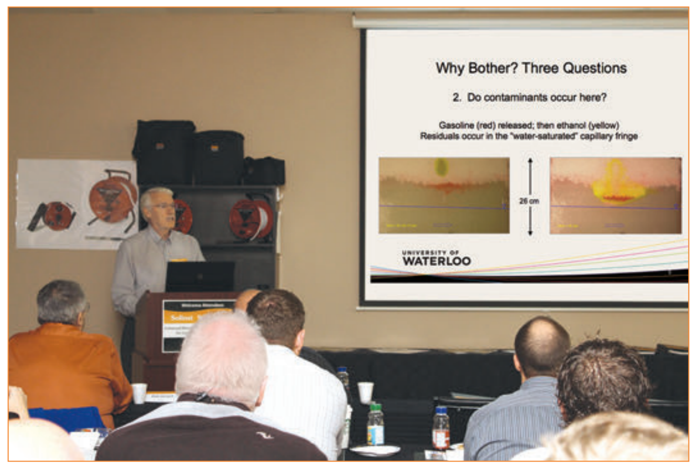
ABOUT THE SPEAKER - J.F. Devlin, Ph.D.
University of Kansas

Rick is a professor with the Geology Department at the University of Kansas. His work has lead to the development of the point velocity probe (PVP) for measuring groundwater velocity at the centimeter scale.

The Capillary Fringe:
Monitoring & Remediation this Neglected Zone

Jim Barker focused his discussion on how contaminants behave in the capillary fringe. The capillary fringe is the zone of soil immediately above the water table. Groundwater is pulled up from the water table by capillary action, filling the pores at the base of the zone. As a result, part of the capillary fringe can be fully-water-saturated, but held under negative pressure.

Jim noted that lateral flow and transport in the capillary fringe has been well documented, but what is not well studied, is the transport of organic compounds. This was the focus of work done by one of his graduate students. Jim presented the results of two release experiments done in the unsaturated zone at the CFB Borden aquifer. He showed how different fuel mixtures (containing gasoline, MTBE, ethanol, and hydrocarbons) are transported in the capillary fringe, and evaluated the effectiveness of three different sampling techniques.



The sampling techniques that were reviewed were fully screened monitoring wells, soil coring, and multilevel wells instrumented with ceramic porous cups (suction lysimeters). It was evident that the fully screened monitoring wells were not able to sample water from the capillary fringe. The other monitoring approaches did yield useful data. The data obtained from the pore water of the suction lysimeters and the calculated concentrations from the soil cores, showed similar results.

The results showed that residual LNAPLs such as gasoline occurred in the "water saturated" capillary fringe, while the dissolved contaminants did move laterally. The lateral movement of both ethanol and the hydrocarbon compounds was found to be significant in the capillary fringe.

The movement of ethanol was entirely above the water table, while concentrations of benzene were found above and below the water table down gradient from the spill zone. Ethanol increases the solubility of volatile organic compounds (VOC), including benzene. This study has great significance as more ethanol-based gasoline is being used, thus potentially reaching the subsurface.

ABOUT THE SPEAKER - Jim Barker, Ph.D.
University of Waterloo

Jim is an adjunct professor with the Earth and Environmental Sciences Department at the University of Waterloo. Jim's presentation was based on his and graduate student Juliana Freitas' research.

Characterizing DNAPL Source Zones for Remedial Performance Assessment

Gary Wealthall gave a very informative talk on dense non-aqueous phase liquid (DNAPL) source zones. He provided an overview of the characteristics of a DNAPL zone, and tools and techniques that can be used to characterize a source zone.

Because of their low solubility, high density and viscosity, DNAPLs tend to persist due to mass transfer limitations to groundwater. Gary showed a study example where 90% of the VOCs were found in the DNAPL source zone, and only 10% in the actual plume. This helped illustrate his point that estimating the mass of the DNAPL source zone is important in determining whether remedial objectives are being met.

Gary discussed his findings from the Source Area BioREmediation (SABRE) project. The SABRE project was a collaborative study undertaken by an international, multidisciplinary team. The project included a highly detailed characterization of a trichloroethene (TCE) source zone, and aimed to quantify DNAPL mass before and after enhanced in situ bioremediation. This involved detailed monitoring, sampling, numerical modeling and statistical analysis.

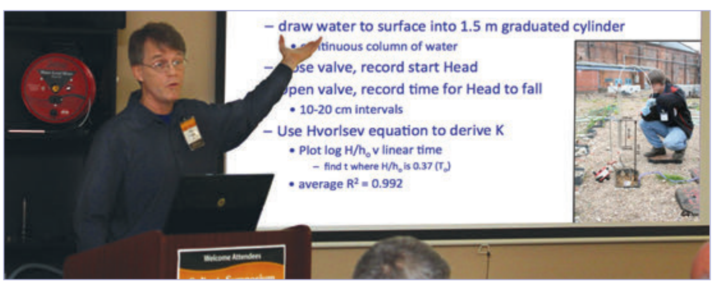
"All mass estimates are wrong…it's just a matter of by how much!" Gary stressed that there is no single technique to characterize a DNAPL zone. Characterizations are typically not completely clear, and the resolution decreases with increasing depth and heterogeneity. Therefore, quantifying the uncertainty of the mass estimates should also be considered.

The SABRE site helped in the development of an uncertainty-based performance metric for quantifying the treatment of a trichloroethene DNAPL source zone. The three stage approach taken at the SABRE site involved the use of 3D models to map where the DNAPL might exist, calculate the volume of the subsurface impacted by DNAPL, then quantify mass of DNAPL before and after treatment. A combination of standard sampling and monitoring techniques and 3D visualization helped estimate the uncertainty and DNAPL mass distribution.

ABOUT THE SPEAKER - Gary Wealthall, Ph.D.
Geosyntec

Gary is currently undertaking remedial investigation projects for a number of clients at DNAPL sites in North America and Europe, including the development of a new evaluation tool for remedial alternatives selection at complex DNAPL megasites.

Treatment Performance Assessment Using Conventional Wells and Multilevel Transects



Ryan Wilson used the SABRE project to base his discussion on treatment performance assessment (PA). According to Ryan, PA is about asking questions: Is the treatment working? Why or why not? Is risk reduced? When can treatment stop? Are processes sustainable? Is sufficient mass reduced? What do trends indicate? How can we optimize treatment? How reliable are estimates?

Ryan looked at the use of long screened wells and multilevel well transects at the SABRE site, and what information each monitoring approach provided for answering the above questions.

Two conventional long screened monitoring wells were placed down gradient of each other. The chemical concentrations found the in groundwater was different in each well, which was an indication they were not on the same flow path. The wells did provide some insight on the biogeochemical processes involved in the remediation and did indicate temporal trends, but the quantitative data had a lot of uncertainty associated.

Two multilevel transects were used on site, one in the source zone and the other in the plume zone. The multilevel transects showed the spatial distribution of the contamination. They were also used to make estimates of mass discharge and uncertainty. Instead of using a uniform velocity for the entire site, hydraulic conductivities measured at each multilevel port were combined with point concentration measurements to give mass discharge estimates with reduced uncertainty.

Ryan stressed, that an accurate performance assessment requires multiple lines of evidence including qualitative, semi-quantitative, and quantitative. Using both conventional monitoring and multilevel well samplers provides the data needed to assess and manage remediation projects, and reduce uncertainty in estimates of the remediation progress.

ABOUT THE SPEAKER - Ryan Wilson, Ph.D.
AMEC

Ryan has 18 years of groundwater contamination assessment and remediation experience, primarily as an academic investigator. His research has focused on the fate, transport and remediation of petroleum hydrocarbons and chlorinated solvents.

The Effects of Heterogeneity & Delivery Methods on Remediation

To begin his presentation, Rick discussed the current trends in groundwater remediation. Over the past decade, in situ methods have greatly increased in popularity. Although the use of these approaches is growing, Rick pointed out some limitations. Geological heterogeneity is a limitation to determining hydrogeological aspects of a contaminated site, and how a reagent will be distributed.

Rick presented the results of comparison field studies that used different oxidants, and tested how injection methods effect their distribution.

Rick's results showed that direct push methods were more effective than injection wells at getting the oxidant to the target remediation zone. However, each method had minimal vertical distribution. The experiments also showed that Permanganate extended further from the injection zone than Persulphate, and that the radius of influence was greater using direct push methods over injection wells.

Persistence and distribution are both effected by oxidant demand. The contaminants in the soil, groundwater, and the soil itself will all have demand for oxygen. Soil oxygen demand depends on texture, and mineralogy – fine-grained materials with higher organic and clay content have higher demand. The higher the demand, the faster the oxidant is used-up. As such, the persistence and distribution of the oxidants was greater in coarser grained material.

These study results provide insight on how to overcome the limitations of heterogeneity. Choosing methods that best suit the site, and oxidants that persist and are distributed where needed. Rick also suggested distribution enhancements, including sequential treatments such as injecting an amendment into the contaminated zone, then following up with enhanced bioremediation. Increasing distribution and persistence is important to ensure issues such as back diffusion are cleaned-up.

ABOUT THE SPEAKER - Rick McGregor, M.Sc.
InSitu Remediation Services Ltd.

Rick is a Hydrogeologist with 21 years experience in the area of groundwater and soil remediation. He currently manages numerous in situ remediation programs around the globe including projects in Saudi Arabia, Brazil and North America.

Monitoring Water & Contaminant Fluxes in Surface, Subsurface & Hyporheic Systems

Contaminant mass flux is the measurement of the concentration and flow of contaminants from a source area, represented as mass per unit area per unit time. Contaminant flux measurements show how much, how fast, and where a contaminant is moving – more than you can get from traditional groundwater grab samples.

Kirk started his presentation by discussing the many uses of flux data at contaminated sites, including the following:

- Determining site mass balance and source characterization - mass leaving the source zone and mass in the plume
- Prioritizing sites for remediation and targeting objectives
- Input data for models and controlling the remedial process
- Remedial performance assessment

Kirk reviewed the passive fluxmeter (PFM), which he helped develop. The PFM measures flux in various environments; including unique designs for different contaminates in groundwater, surface water (Passive Surface Water Fluxmeter), hyporheic systems (Passive Sediment Fluxmeter), and in fractured rock (Fractured Rock Passive Fluxmeter).

The basic design concept is a permeable cartridge that is placed in a screened well. A mesh tube in the cartridge is filled with a predetermined amount of sorbent/tracer mixture. When placed in a monitoring well, the PFM intercepts groundwater passively. The sorbent retains dissolved contaminants, and tracer is leached out. After a period of time, the PFM is removed from the well, and from the tracer remaining, tracer eluted, and contaminant sorbed, time-averaged contaminant flux and cumulative groundwater flux can be calculated.

Kirk presented case studies where the PFM has been successful in measuring a TCE source zone, uranium flux, microbial biomass flux, and where ambient tracers were successfully used. Kirk stressed that flux measurement should be combined with other traditional characterization and remedial assessment approaches to optimize the information obtained from a contaminated site.

ABOUT THE SPEAKER - Kirk Hatfield, Ph.D.
University of Florida

Kirk currently serves as the Director of the new Engineering School of Sustainable Infrastructure and Environment and Director of the Florida Water Resources Research Center and member of the Board of Directors of the National Institutes of Water Resources.

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