ON THE LEVEL

Water Monitoring News and Updates

Solinst®

High Quality Groundwater and Surface Water Monitoring Instrumentation

IN THIS ISSUE

SPECIAL EDITION
WINTER 2014

Where is the Contamination Going?

The theme of the 2013 Solinst Symposium was "High Resolution, Depth-Discrete Groundwater Monitoring - Benefits and Importance". A common topic of discussion with the speakers at the Symposium, was the need for high resolution, depth-discrete data sets in order to better characterize and develop conceptual models for contaminated sites.

The research findings presented by the speakers, showed that multiple levels of depth-discrete data across a site, is required for determining contaminant pathways, flow directions and velocities, etc. Repeated and different types of tests need to be done to obtain the best understanding of a site. Whether it is a fractured rock site dealing with DNAPL transport in groundwater, or another medium such as gas, it is imperative to collect as much data as possible, both spatially and temporally.

It was mentioned multiple times, that it is easy to figure out where the contamination *is,* and where it has *been*, but what is difficult, is to determine where the contamination is *going*. Knowing where the contamination is going is important in order to determine risks to potential receptors, and how to best go about remediating the site.

For more information about the 2013 Solinst Symposium, please visit:
http://www.solinst.com/Symposium/Symposium2013/

Where is the Industry Headed?

To get the Symposium started, Gary Wealthall provided a brief history of the evolution of high resolution tools and methods for groundwater monitoring.

Gary presented a time-line of key developments in groundwater monitoring technologies, from the introduction of conventional monitoring wells in the 1950's, to the late 1970's when the first multilevel groundwater monitoring systems were produced.

He also touched on the important studies, presentations, and research papers that have brought the groundwater monitoring industry to where it is today.

Continued on page 2...

Where is the Industry Headed?

Continued from page 1.

Since the introduction of multilevel systems, Gary noted there have been significant advances in understanding hydrogeological processes. Overall, the use of multilevel systems has provided a better understanding of contamination in groundwater, including DNAPL plume behavior.

Research has shown that using transects of multilevel systems across a contaminated site is invaluable for quantifying hydraulic parameters. Transects have been successfully used to perform tracer tests as well as flux based assessments.

Although there has been a great gain of knowledge through the use of multilevel systems, Gary asked the question: where the industry is headed next? He noted that there has been a time-gap since the latest technological advancement. Since the introduction of the Solinst CMT System in 1999, there has not been a significant new technology introduced to the market.

Gary feels that there is definitely room in the marketplace for a new high resolution, depth-discrete groundwater monitoring technology - especially as the remediation industry moves forward with more sophisticated technologies that require more sophisticated data sets.

Gary also feels that knowledge and hands-on work with multilevel systems should be a prerequisite for training future hydrogeologists. Currently there is a lack of guidance and education on the benefits and understanding of what is involved in installing and monitoring complex multilevel systems. Gary's introduction definitely got everyone thinking!

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

Gary has over 20 years experience in contaminant hydrogeology research and practice. He is currently working with Geosyntec Consultants, and is an Adjunct Professor in Environmental Engineering at the University of Guelph.

Straddle Packer Testing for Hydraulically Characterizing Rock Boreholes

While completing his Ph.D. at the University of Waterloo, Patryk designed packer testing equipment to be used for conducting hydraulic tests in fractured rock, for contaminant transport studies.

He was the first of the speakers to mention that the goal of his research is to "understand the existing contaminant distribution and predict future contaminant behavior".

ABOUT THE SPEAKER - Patryk Quinn, Ph.D.
University of Guelph

Using a straddle packer setup, he was able to perform four types of hydraulic tests in the same discrete borehole interval:

- Constant Head Step Tests
- Slug Tests
- Pumping Tests
- Recovery Tests

Patryk was able to perform all of these tests without having to remove the packers from the well. With the equipment, he was able to record the pressure above, within, and below the discrete interval to monitor the packer seals during the tests. For all of these tests and results, Patryk stressed the importance of determining which fractures are actually conveying water.

He repeated each test multiple times in each discrete-zone using varying pressures and flow rates. By repeating the tests, he found that he could obtain more accurate calculations of T values (transmissivity), fracture apertures, and average linear groundwater velocity.

Patryk noted that Darcy's Law is not only for use in porous subsurface media calculations, but that it can also be used for determining average linear groundwater velocity for fractured media.

With each test, he assessed the non-ideal effects that occurred, such as non-Darcian flow and fracture dilation/contraction, and compared the results of each test to get the most representative T values.

Patryk Quinn is currently a Professional Engineer working as a senior research scientist in the School of Engineering at the University of Guelph in the G360 Research Group.

Diavik Waste-Rock Research Project:
High Resolution Gas Pressure & Concentration Monitoring

Richard provided a very interesting presentation on the work he is doing at the Diavik Diamond Mine in the Northwest Territories. The project aims to help better understand acid mine drainage in cold climates.

At the mine, three experimental piles of waste-rock have been created in order to determine the processes controlling sulphate oxidation and metal release in the low-sulphide rock piles. There is one large to-scale pile, and two smaller test piles.

Because of the location of the mine, it was found that the core of these rock piles becomes frozen (permafrost), so they have to predict the thickness of the active layer. In addition, the nature of the large grains makes these waste-rock piles very heterogenous.

Each of the test piles are heavily instrumented. Lysimeters with drains were constructed for the bases of each test pile, before the waste-rock was carefully piled on top. Each pile has effluent water collection systems, suction lysimeters, thermistors, TDR soil moisture probes, permeability balls, thermal conductivity ports, tensiometers, and gas sampling lines.

The instruments were distributed throughout the piles in three dimensions. Since the project started in 2006, measurements have been taken from every minute to every month. This provides a "rich and comprehensive data set" that is both spatially and temporally robust.

Two of the piles are instrumented with automated gas sampling systems that collect concentration measurements daily and pressure measurements every minute.

With all the data collected, they were able to capture annual freeze/thaw cycles in the piles. They were also able to develop a relationship between wind-induced pressure gradients and gas flow throughout the test piles.

This wind-induced gas transport had a significant influence on heat and water transport processes. They also found that there is a larger than expected active zone, due to the highly permeable rock and wind driven gas transport.

ABOUT THE SPEAKER - Richard Amos, Ph.D.
University of Waterloo

Richard Amos is a Research Assistant Professor in the Department of Earth and Environmental Sciences at the University of Waterloo.

Developing Conceptual Models for Flow & Transport in Bedrock

Kent's presentation focused on a small scale (~10 m x 10 m plot) study in which he developed three distinct site conceptual models for a fractured bedrock site, using different depth-discrete hydraulic and tracer transport measurements.

Kent reiterated the point that "tracking where contamination has gone is easy (now); predicting where it will go next, [is] much more difficult". While defining what a conceptual site model is, Kent emphasized the fact that a model should be able to accurately predict off-site migration of contaminants and allow for risk analysis.

The first site model was based on single-well tests. Constant-head tests were performed in 87 depth-discrete intervals, amongst 5 boreholes drilled in a star formation at the field site. Discrete fractures were interpreted using a borehole camera and cores.

The second model was based on inter-well tests. 61 pulse interference tests were done between two boreholes.

The third model was based on inter-well tracer experiments. Three different methods were employed for these experiments: radial divergent, natural gradient, and injection-withdrawl. A total of 11 experiments were performed using a fluorescein dye.

When comparing the conceptual site models from each method, it was found that the first two methods identified three pervasive horizontal sheeting fractures. Method two, however, showed an additional sub-horizontal fracture and smaller fracture apertures (lower hydraulic conductivity).

The tracer test method identified three discontinuous horizontal sheeting fractures, and one sub-horizontal fracture. It was found that the fracture features are not connected between all boreholes.

In the end it was found that the constant head method over-predicted the fracture connections. While the pulse interference methods did provide a better estimate of solute transport, it still over-predicted fracture connections. The tracer methods, however, showed that even though pressure is transmitted between boreholes, those fractures don't necessarily transport solutes. Kent noted that a similar study needs to be done on a larger scale with inclined boreholes.

ABOUT THE SPEAKER - Kent Novakowski, Ph.D.
Queen's University

Kent is a Professional Geologist, Professor and the Head of the Department of Engineering at Queen's University.

Delineation of Hydrogeologic Units at a Contaminated Fractured Rock Field Site

Over a 20 year period, beginning in 1950, an estimated 72,700 L of mixed Dense Non-Aqueous Phase Liquids (DNAPLs) were release into the subsurface at a site in southern Wisconsin. At the site, the DNAPL penetrated to 56 m below ground surface, accumulated in fractured sandstone, and formed a dissolved phase plume that migrated down gradient and stretched almost 4 km.

Jessica's presentation focused on the field work that she has completed at the site. The goal of her research was to use a high-resolution method of measuring head at depth-discrete zones in order to calculate vertical gradients across the site. These vertical gradients were used to delineate hydrogeologic units in the subsurface.

Jessica used 9 multilevel systems with a number of discrete zones to obtain the high resolution head profiles. As an example, one multilevel system had 46 sampling zones in 129.5 meters of bedrock - approximately 3.6 zones for every 10 meters.

The head profiles were measured several times a year, over multiple years. Jessica showed profiles measured in 2003, 2009, and 2011. The results of each year showed the head profiles were similar and repeatable.

Jessica combined the measured vertical gradient zones with the known stratigraphy in the area, and was able to delineate 8 hydrogeologic units.

ABOUT THE SPEAKER - Jessica R. Meyer, Ph.D.
University of Guelph

Jessica then compared the hydrogeologic unit conceptual site model that was created, with high resolution contaminant concentration profiles of the DNAPL. The comparison showed that the hydrogeologic units based on the vertical gradients and stratigraphy, could clearly be related to the contaminant distribution.

This shows that the data collected will be critical in determining the fate of the contamination and help select the best method for remediation.

Jessica recently received her Ph.D. from the School of Environmental Sciences at the University of Guelph and has degrees in environmental geology and hydrogeology.

Round-Table Discussion: Education is Key

At the close of the 2013 Solinst Symposium, a round-table was held with the attendees and guest speakers. A common theme in the discussions was *education*.

First, it was mentioned that there are not enough educational opportunities for practitioners in the groundwater industry. This Symposium, and other events like it, are needed within our industry.

Another major point of discussion was the perceived gap between research findings, and implementing successful techniques in practice. There are very few guidance documents that educate practitioners on the best methods to perform depth-discrete groundwater investigations.

Practitioners attending the conference also agreed that it is hard to sell high resolution monitoring methods to their clients, as it is difficult to get across the cost/benefit analysis of these techniques. Clients need to be educated on what positives these methods, such as using multilevel systems, can provide, for what appears to be a huge monetary investment. More case studies and findings from research need to be made available to practitioners in order to also educate their clients.

It was discussed that regulators in Canada need to take a more active role in determining where guidance documents are needed, and making these best practice documents available to practitioners. It would also be helpful if a regulator created an example case study that showed how they successfully worked with a client using high resolution groundwater monitoring techniques.

The question "why is there such a knowledge gap" was asked. A troubling answer was that fewer people are working in the hydrogeology field, as field work has become much more expensive to perform.

Addressing the issues discussed during the round-table will be key in keeping the industry moving forward.

For further information contact: Solinst Canada Ltd.
Tel: +1 (905) 873-2255; (800) 661-2023 Fax: +1 (905) 873-1992; (800) 516-9081
35 Todd Road, Georgetown, Ontario Canada L7G 4R8
Web Site: www.solinst.com E-mail: instruments@solinst.com